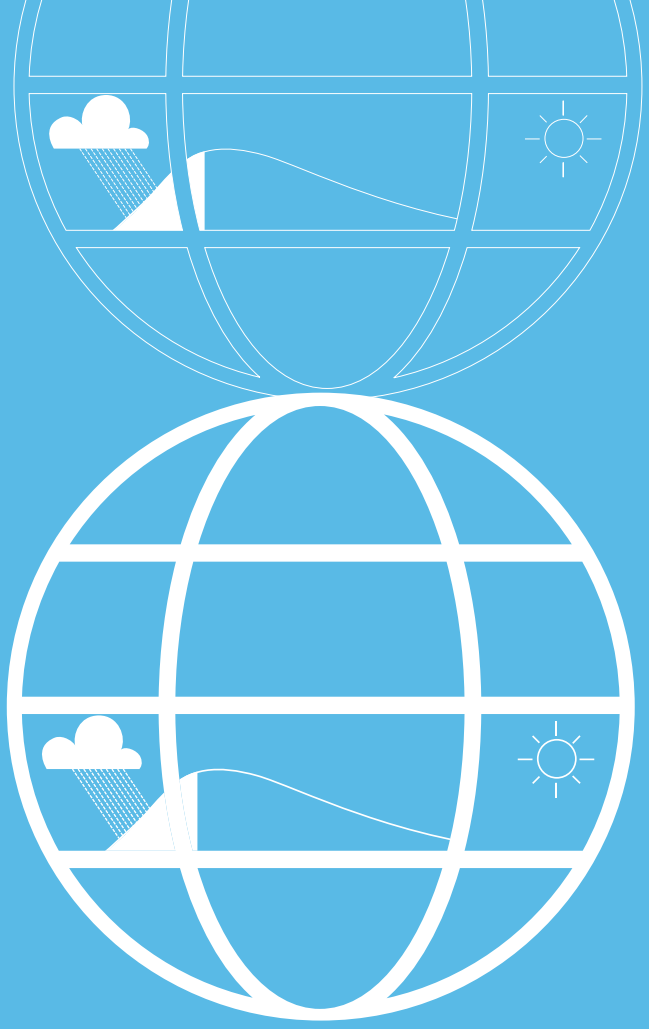
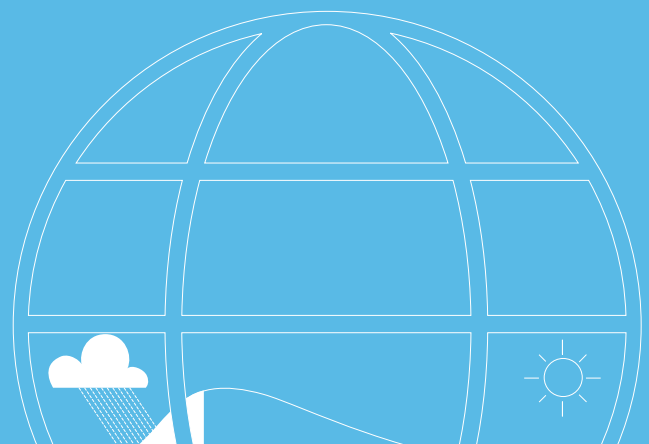


12th International Meeting on Statistical Climatology

24-28, June 2013 Jeju, Korea

PROGRAM & ABSTRACT



12th International Meeting on Statistical Climatology

24-28, June 2013 Jeju, Korea

ORGANIZED BY

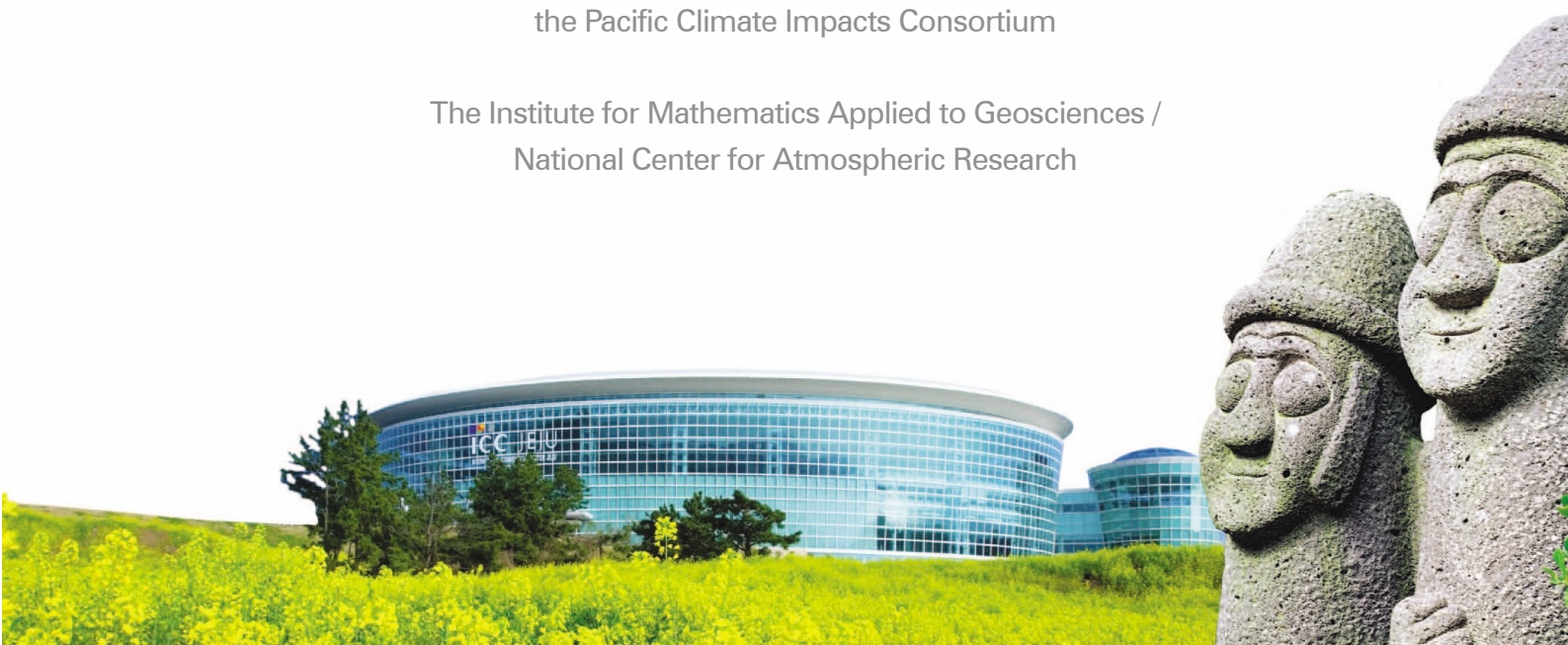
The National Institute of Meteorological Research
and the IMSC Steering Committee

SPONSORED BY

The Korea Meteorological Administration

The Korean Meteorological Society, the Korean Statistical Society,
the Pacific Climate Impacts Consortium

The Institute for Mathematics Applied to Geosciences /
National Center for Atmospheric Research



PROGRAM OVERVIEW

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(26 June)</th><th>Thursday
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(28 June)</th><th></th></tr>
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<tr><td>08:30-09:00</td><td rowspan="3">Plenary Session 7</td><td rowspan="3">Plenary Session 9</td><td rowspan="3">Plenary Session 11</td><td rowspan="3">Plenary Session 6</td><td>08:30-09:00</td></tr>
<tr><td>Welcome Address</td><td rowspan="3">Plenary Session 1</td><td>09:00-09:30</td></tr>
<tr><td>09:00-09:30</td><td>09:30-10:00</td></tr>
<tr><td>09:30-10:00</td><td>10:00-10:30</td><td>Coffee Break</td><td>Coffee Break</td><td>Coffee Break</td><td>Coffee Break</td><td>10:00-10:30</td></tr>
<tr><td>10:30-11:00</td><td>Coffee Break</td><td rowspan="2">Plenary Session 2</td><td rowspan="2">Plenary Session 3</td><td rowspan="3">Session 10</td><td rowspan="3">Session 11</td><td rowspan="3">Session 6</td><td rowspan="2">Plenary Session 10</td><td>10:30-11:00</td></tr>
<tr><td>11:00-11:30</td><td rowspan="3">Plenary Session 5</td><td>11:00-11:30</td></tr>
<tr><td>11:30-12:00</td><td rowspan="2">Plenary Session 8</td><td rowspan="2">Plenary Session 4</td><td>11:30-12:00</td></tr>
<tr><td>12:00-12:30</td><td>12:00-12:30</td></tr>
<tr><td>12:30-13:00</td><td rowspan="3">Lunch</td><td rowspan="3">Lunch</td><td rowspan="3">Lunch</td><td rowspan="11">Tour</td><td rowspan="3">Lunch</td><td>12:30-13:00</td></tr>
<tr><td>13:00-13:30</td><td>13:00-13:30</td></tr>
<tr><td>13:30-14:00</td><td>13:30-14:00</td></tr>
<tr><td>14:00-14:30</td><td rowspan="3">Session 1</td><td rowspan="3">Session 8</td><td rowspan="3">Session 5</td><td rowspan="3">Session 7</td><td rowspan="3">Session 9</td><td rowspan="3">Session 3</td><td rowspan="3">Session 10</td><td rowspan="3">Session 11</td><td>14:00-14:30</td></tr>
<tr><td>14:30-15:00</td><td>14:30-15:00</td></tr>
<tr><td>15:00-15:30</td><td>15:00-15:30</td></tr>
<tr><td>15:30-16:00</td><td colspan="3">Poster Session 6, 7, & 9 with Coffee Break</td><td colspan="3">Poster Session 3, 10, & 11 with Coffee Break</td><td rowspan="8"></td><td>15:30-16:00</td></tr>
<tr><td>16:00-16:30</td><td colspan="3" rowspan="2">Poster Session 1, 5, & 8 with Coffee Break</td><td rowspan="2"></td><td>16:00-16:30</td></tr>
<tr><td>16:30-17:00</td><td rowspan="3">Session 7</td><td rowspan="3">Session 9</td><td rowspan="3">Session G</td><td rowspan="3">Session 7</td><td rowspan="3">Session 9</td><td rowspan="3">Session 11</td><td>16:30-17:00</td></tr>
<tr><td>17:00-17:30</td><td rowspan="2">Session 1</td><td rowspan="2">Session 8</td><td>17:00-17:30</td></tr>
<tr><td>17:30-18:00</td><td>17:30-18:00</td></tr>
<tr><td>18:00-18:30</td><td>18:00-18:30</td></tr>
<tr><td>18:30+</td><td colspan="2">Welcome Dinner</td><td colspan="3">Banquet supported by NIMR/KMA</td><td>18:30+</td></tr>
</table>

Halla Hall Samda A Hall Samda B Hall Room 303

MEETING SESSIONS

Session 1
Data Homogenization and Climate Trends/Variability Assessment
Xiaolan Wang, Matilde Rusticucci

Session 2
Next Generation Climate Data Products
Richard Chandler, Douglas Nychka

Session 3
Reconstruction and Interpretation of Past Climates
Gabi Hegerl, Bo Li

Session 4
Spatial and Spatiotemporal Modelling
Hee-Seok Oh, Richard Chandler

Session 5
Non-linear Methods for Climate Analysis
Andrea Toreti, Reik Donner, Alex Cannon

Session 6
Forecasting and Forecast Verification
Ian Jolliffe, Chris Ferro

Session 7
Ensemble Methods and Uncertainty Quantification
Steve Sain, Irina Mahlstein, Retto Knutti

Session 8
CMIP5 Model Evaluation, Prediction, and Projection
Won-Tae Kwon, Claudia Tebaldi

Session 9
Detection and Attribution, Downscaling, and Impacts
Bryson Bates, Seung-Ki Min

Session 10
Weather and Climate Extremes - Statistical Modeling and Event Attribution
Francis Zwiers, Gabi Hegerl, Xuebin Zhang

Session 11
Large-Scale Climate Variability and Teleconnections
Sang-Wook Yeh, Renguang Wu, Kwang-Yul Kim

Monday, 24 June, 2013

08:00-08:50 **Registration**
08:50-09:00 **Welcome Address**

Plenary Session

Session 1 Data Homogenization and Climate Trends/Variability Assessment

ROOM: HALLA

09:00-10:30 **Chair: Xiaolan Wang**

Chris Atkinson[1] and Nick Rayner[1]
– Assigning bias adjustments and uncertainties to observations from different components of the ocean observing system to create a prototype integrated database of temperature and salinity
[1] *Met Office Hadley Centre*

Kate Willett[1] and the Benchmarking and Assessment Working Group
– An overview of benchmarking data homogenisation procedures for the International Surface Temperature Initiative
[1] *Met Office Hadley Centre*

Jaxk Reeves[1] and Guannan Wang[1]
– Changepoint detection in climate series via quantile regression procedures
[1] *University of Georgia*

QiQi Lu[1]
– Changepoint detection in categorical time series
[1] *Virginia Commonwealth University*

10:30-11:00 **Coffee Break**

Session 5 Non-linear Methods for Climate Analysis

ROOM: HALLA

11:00-12:30 **Chair: Andrea Toreti**

Julie Carreau[1] 
– Machine learning and extremes in climate studies
[1] *IRD HydroSciences Montpellier*

Christian Franzke[1] 
– Nonlinear atmospheric circulation regimes and extreme events
[1] *British Antarctic Survey*

Anastasios A. Tsonis[1] and Karsten Steinhaeuser[2] 
– A climate model intercomparison at the dynamics level
[1] *University of Wisconsin-Milwaukee*
[2] *University of Minnesota*

12:30-14:00 **Lunch**

Parallel Session

Session 1 Data Homogenization and Climate Trends/Variability Assessment

ROOM: SAMDA-A

14:00-15:40 **Chair: Richard Chandler**

14:00-14:20 **Victor Venema**[1], Enric Aguilar[2], Renate Auchmann[3], Ingeborg Auer[4], Theo Brandsma[5], Barbara Chimani [4], Alba Gilabert[2], Olivier Mestre[6], Andrea Toreti[7], and Gregor Vertacnik[8] 
– Parallel measurements to study inhomogeneities in daily data
[1] *University of Bonn, Meteorological Institute*
[2] *University Rovira i Virgili, Center for Climate Change*
[3] *University of Bern, Institute of Geography,*
[4] *Zentralanstalt für Meteorologie und Geodynamik*
[5] *Royal Netherlands Meteorological Institute*
[6] *Météo-France, Direction de la Production*
[7] *Justus-Liebig Universitaet, Giessen*
[8] *Slovenian Environment Agency*

14:20-14:40 **Rachel Warren**[1] 
– Assessing robustness of daily temperature datasets through benchmark testing of homogenisation algorithms
[1] *Met Office Hadley Centre*

14:40-15:00 Wenhui Xu[1], **Qingxiang Li**[1], Xiaolan L. Wang[2], Su Yang[1], Lijuan Cao[1], and Yang Feng[2]
– Homogenization of Chinese daily surface air temperatures and analysis of trends in the extreme temperature indices

[1] *National Meteorological Information Center, China Meteorological Administration*
[2] *Climate Research Division, Environment Canada*

15:00-15:20 **Yung-Seop Lee**[1], Hee-Kyung Kim[1], Jung-In Lee[1], Jae-Won Lee[2], and Hee-Soo Kim[2]
– Homogeneity test and adjustment of Korean seasonal temperature data
[1] *Dongguk University-Seoul*
[2] *Korea Meteorological Administration*

15:20-15:40 **Nestor Ricardo Bernal Suarez**[1]**.,** Juan S. Barrios M[1]., and Marcos A. Ramos C[1]
– Homogenization of monthly precipitation time series: A proposal for identifying neighborhood meteorological stations for Bajo Magdalena climatic region in Colombia (South America)
[1] *Distrital University Francisco José de Caldas*

15:40-16:40 Poster session with coffee break

16:40-18:20 Chair: Xiaolan Wang

16:40-17:00 **Ralf Lindau**[1] and Victor Venema[1]
– Break Position Errors in Climate Records
[1] *University of Bonn, Meteorological Institute*

17:00-17:20 **Markus G. Donat**[1], Lisa V. Alexander[1], Hongang Yang[1], Jana Sillmann[1], and Simon Wild[1]
– Novel global datasets of observed temperature and precipitation extremes: analysis of long-term changes and comparison to reanalyses and climate model data
[1] *University of New South Wales*

17:20-17:40 **Dáithí Stone**[1], Christopher Lennard[2], Mark Tadross[2], Michael Wehner[1], and Piotr Wolski[2]
– First contributions to the climate of the 20th century detection and attribution project
[1] *Lawrence Berkeley National Laboratory*
[2] *CSAG, University of Cape Town*

17:40-18:00 **Jianmin Shao**[1] and Henry Brocklehurst[1]
– Automated Statistical Model-based Spatial Data Quality Control
[1] *Vaisala Ltd.*

18:00-18:20 **Fatemeh Rahimzadeh**[1] and Mojtaba Nassaji Zavareh[2]
– Effects of adjustment for non climatic discontinuities on determination of temperature trends and variability over Iran
[1] *Atmospheric Science and Meteorological Research Center (ASMERC)*
[2] *Academic staff of Technical & Vocational Higher Education Institut*

Session 8 CMIP5 Model Evaluation, Prediction, and Projection

ROOM: SAMDA-B

14:00-15:40 **Chair: Won-Tae Kwon**

14:00-14:20 **Jonas Bhend**[1] and Penny Whetton[2]
– Effective constraints for regional climate change projections
[1] *CSIRO Climate Adaptation Flagship*
[2] *CSIRO Marine and Atmospheric Research*

14:20-14:40 **Julien Cattiaux**[1] and Christophe Cassou[2]
– Projected changes in the Northern Annular Mode: why do CMIP3 and CMIP5 disagree?
[1] *CNRM-GAME / CNRS-MeteoFrance, Toulouse, France.*
[2] *CERFACS / CNRS, Toulouse, France*

14:40-15:00 **Kate Marvel**[1]
– Detecting precipitation changes in CMIP5 models and observations at multiple spatial scales
[1] *Lawrence Livermore National Laboratory*

15:00-15:20 **MinHo Kwon**[1]
– Genesis frequency of tropical cyclones in the CMIP5 climate models: Use of genesis potential index
[1] *Korea Institute of Ocean Sciences and Technology*

15:20-15:40 **Myoungji Lee**[1]
– Validation of CMIP5 multimodel ensembles through the smoothness of climate variables
[1] *IAMCS, Texas A&M University*

15:40-16:40 **Poster session with coffee break**

16:40-18:20 **Chair: Hyun-Suk Kang**

16:40-17:00 **Andrea Toreti**[1], Philippe Naveau[2], Matteo Zampieri[3], Anne Schindler[1], Enrico Scoccimarro[3,4], Juerg Luterbacher[1], Henk A. Dijkstra[5], Silvio Gualdi[3,4], and Elena Xoplaki[1]
– Global precipitation extremes projected by high-resolution CMIP5 models
[1] *Justus-Liebig University of Giessen*
[2] *Laboratoire des Sciences du Climat et de l'Environnement, IPSL-CNRS*
[3] *Centro Euro-Mediterraneo sui Cambiamenti Climatici*
[4] *Istituto Nazionale di Geofisica e Vulcanologia*
[5] *Dept. of Physics and Astronomy, Utrecht University*

17:00-17:20 **Soyoung Jeon**[1] and William D. Collins[1]
– Spatial dependence between extreme precipitations in CMIP5
[1] *Lawrence Berkeley National Laboratory*

17:20-17:40 **Julien Cattiaux**[1], Hervé Douville[1], and Yannick Peings[1]
– European temperatures in CMIP5: origins of present-day biases and future uncertainties.
[1] *CNRM-GAME / CNRS-MeteoFrance*

17:40-18:00 **M. Menendez**[1], J. Perez[1], and F.J. Mendez[1]
– Skill of global climate models for regional statistical downscaling
[1] *Environmental Hydraulics Institute "IH-Cantabria", Universidad de Cantabria*

18:00-18:20 **Ting Hu**[1]
– Intercomparison of precipitation characteristics in CMIP5 simulations with observation and reanalysis over China
[1] *Beijing Climate Center*

Session 5 Non-linear Methods for Climate Analysis

ROOM: 303

14:00-15:20 **Chair: Andrea Toreti**

14:00-14:20 **Anne Schindler**[1], Andrea Toreti[1], Douglas Maraun[2], and Jürg Luterbacher[1]
– Spatio-temporal analysis of extreme precipitation via Kernel regression Generalized Probability Weighted Moments (KerGPWM)
[1] *University of Giessen*
[2] *Leibnitz Institute of Marine Sciences at the University of Kiel*

14:20-14:40 **M.R. Jones**[1], R. W. Katz[1], and B. Rajagopalan[1]
– Exploring multi-annual regimes in total and extreme Argentinian precipitation using hidden Markov models
[1] *NCAR*

14:40-15:00 **Ah-Yeon Park**[1]
– Trends in stratospheric ozone profiles using functional mixed models
[1] *University College London*

15:00-15:20 **E Jin Kim**[1]
– Comparison AIC according to humidity indicators in model of association between humidity and respiratory disease
[1] *Seoul National University*

15:20-16:40 **Poster session with coffee break**

18:20 + **Welcome Dinner**

Poster Sessions

Session 1 Data Homogenization and Climate Trends/Variability Assessment

1. **María Paula Llano**[1] and Walter Vargas[1]
   – Temporal variability of statistical parameters of winter temperatures in Buenos Aires, Argentina
   [1] *University of Buenos Aires*

2. Ken Liang[1], **Richard E. Chandler**[1], and Bryson Bates[2]
   – Spatio-temporal rainfall trends in southwest Western Australia
   [1]*University College London*
   [2]*CSIRO*

3. Ki-Seon Choi[1] and **Il-Ju Moon**[2]
   – Changes in tropical cyclone activity that has affected Korea Since 1999
   [1] *Korea Meteorological Administration*
   [2] *Jeju National University*

4. Petr Štěpánek[1,2], **Pavel Zahradníček**[1,2], Petr Skalák[2], and Aleš Farda[2]
   – Experiences with data quality control, homogenization and gridding of daily records of various meteorological elements in the Czech Republic
   [1] *Czech Hydrometeorological Institute*
   [2] *Global Change Research Centre AS CR*

5. **Myoung Hee Lee**[1] and Jae Won Lee[1]
   – Operational quality management for climate data in KMA using applied statistics
   [1] *Korea Meteorological Administration*

6. **Olle Räty**[1] and Jouni Räisänen[1]
   – Methods for projecting daily precipitation in changing climate: Cross-validation tests with ENSEMBLES models
   [1] *University of Helsinki*

7. **Kamoru A. Lawal**[1], Daithi A. Stone[2], Tolu Aina[3], Cameron Rye[4], and Babatunde J. Abiodun[1]
   – Investigating the trends in the potential spread of seasonal predictability over South Africa provinces
   [1] *CSAG,University of Cape Town*
   [2] *Lawrence Berkeley National Laboratory*
   [3] *Oxford e-Research Centre, University of Oxford*
   [4] *University of Oxford*

8. **Kassahun Gebremedhin Mantose**[1]
– Climate variability and its impact on crop production over southern region of Ethiopia: A case of study Sidama and Gedeo zone
[1] *Arba-Minch University*

Session 5 Non-linear Methods for Climate Analysis

1. **Il-Sang Ohn**[1], Young-Eun Yi[1], Youn-Hee Lim[1], Yasushi Honda[2], Yue-Liang Leon Guo[3], Bing-Yu Chen[3], and Ho Kim[1]
– The best-fitting meteorological variables for use in time-series studies of temperature and mortality
[1] *Graduate School of Public Health, Seoul National University*
[2] *Faculty of Health and Sport Sciences, University of Tsukuba*
[3] *Environmental and Occupational Medicine, National Taiwan University*

2. **Kiho Jeong**[1]
– Forecasting weather volatility using support vector machine GARCH Model
[1] *School of Economics and Trade, Kyungpook National University*

3. **Andrea Toreti**[1], Michelle Schneuwly-Bollschweiler[2,3], Markus Stoffel[2,3], and Juerg Luterbacher[1]
– Atmospheric forcing of debris flows: a non-linear approach
[1] *Justus-Liebig University of Giessen*
[2] *Institute for Environmental Sciences, University of Geneva*
[3] *Institute of Geological Sciences, University of Bern*

4. **Ji- Hye Shin**[1], Youn-Hee Lim[2], and Ho Kim[1]
– Effects of DTR (Diurnal Temperature Range) on circulatory and respiratory diseases mortality in six metropolitan Korean cities
[1] *Seoul National University*
[2] *Insitutue of Health and Environment, Seoul National University*

5. **M. Nassaji Zavareh**[1], F. Rahimzadeh[2], and B. Ghemezcheshme[3]
– The reconstruction of daily maximum and minimum temperatures using nearest neighborhood and ANN techniques (case study: West of Tehran province)
[1] *Academic staff of Technical & Vocational Higher Education Institute*
[2] *Atmospheric Science and Meteorological Research Center (ASMERC)*
[3] *member of Soil Conservation and Watershed Research Institute*

6. **Masoud Moradi**[1], H. A. Ghayoor[2], and J. Khoshhal[2]
– Survey of the affective parameters on the stream flow using the Artificial neural network in dehgolan catchment, Kurdistan, Iran
[1] *University of Mohaghegh Ardabili*
[2] *University of Esfahan*

Session 8 CMIP5 Model Evaluation, Prediction, and Projection

1. **Gang Wang**[1], Dietmar Dommenget[1], and Claudia Frauen[1]
   – An evaluation of the CMIP3 and CMIP5 simulations in their skill of simulating the spatial structure of SST variability
   [1] *Monash Unciversity*

2. **Hyo-Shin Lee**[1], Hee-Jeong Baek[1], and ChunHo Cho[1]
   – Future projection of ocean heat content and steric sea level simulated by HadGEM2-AO under Representative Concentration Pathways
   [1] *National Institute of Meteorological Research/Korea Meteorological Administration*

3. **Hyun-Young Jo**[1], SuChul Kang[1], and Kyo-Moon Shim[1]
   – Bias correction and downscaling of CMIP5 model using CA
   [1] *APEC Climate Center*

4. **Koteswara Rao Kundeti**[1], Sudhir Sabade[1], Ashwini Kulkarni[1], Savita Patwardhan[1], Krishna Kumar Kanikicharla[1]
   – Projected changes in extreme precipitation and temperature indices over India from CMIP5-ESM models
   [1] *Indian Institute of Tropical Meteorology*

Tuesday, 25 June, 2013

Plenary Session

Session 7 Ensemble Methods and Uncertainty Quantification

ROOM: HALLA

08:30-10:00 **Chair: Steve Sain**

Douglas Nychka[1] and Tamara Greasby[1]
– Mining spatial structure in regional climate
[1] *National Center for Atmospheric Research*

Marianna Demetriou[1] and Richard E. Chandler[1]
– Combing information from multiple climate simulators to obtain estimates of global surface air temperature change, under a probabilistic Bayesian framework
[1] *University College London*

Ed Hawkins[1]
– Uncertainties in near-term climate projections
[1] *University of Reading*

10:00-10:30 **Coffee Break**

Session 2 Next Generation Climate Data Products

ROOM: HALLA

10:30-11:30 **Chair: Richard Chandler**

Matthew Menne[1], Peter Thorne[2], Jared Rennie[2], **Kate Willett[3]**, and Jay Lawrimore[1]
– The International Surface Temperature Initiative
[1] *NOAA/National Climatic Data Center*
[2] *Cooperative Institute for Climate and Satellite Studies, North Carolina State University*
[3] *UK Met Office*

Finn Lindgren[1]
– Practical use of stochastic models for spatial climate and weather reconstruction
[1] *University of Bath*

Session 8 CMIP5 Model Evaluation, Prediction, and Projection

ROOM: HALLA

11:30-12:30 **Chair: Won-Tae Kwon**

Penny Whetton[1], Jonas Bhend, and Ian Watterson[1]
– CMIP5-based climate change projections to support Natural Resource Management planning in Australia
[1] *CSIRO Marine and Atmospheric Research*

Xiaolan Wang[1], Yang Feng[1], and Val R. Swail[1]
– Changes in global ocean surface wave heights as projected using multi-model CMIP5 simulations
[1] *Climate Research Division, Environment Canada*

12:30-14:00 **Lunch**

Parallel Session

Session 1 Data Homogenization and Climate Trends/Variability Assessment

ROOM: HALLA

14:00-15:20 **Chair: Richard Chandler/Doug Nychka**

14:00-14:20 **Nicholas Cavanaugh**[1]
– Regional trends in the statistical distributions of daily temperature
[1] *Scripps Institution of Oceanography*

14:20-14:40 **Xiaolan Wang**[1]**,** Yang Feng[1], and Lucie Vincent[1]
– Observed changes in one-in-20 year extremes of Canadian air surface temperatures
[1] *Climate Research Division, Science and Technology Branch, Environment Canada*

14:40-15:00 **Jouni Räisänen**[1] and Olle Räty[1]
– Projections of daily mean temperature variability in the future: cross-validation tests with ENSEMBLES regional climate simulations
[1] *University of Helsinki*

15:00-15:20 **Youmin Chen**[1]
– The observed climate change and its future scenarios simulated with ECHAM model at various CO_2 emission in South Korea
[1] *Henan University*

15:20-16:20 **Poster session with coffee break**

Session 7 Ensemble Methods and Uncertainty Quantification

ROOM: SAMDA-A

16:20-17:40 **Chair: Steve Sain**

16:20-16:40 **Alexey Karpechko**[1], Douglas Maraun[2], and Veronika Eyring[3]
– Improving Antarctic total ozone projections by a process-oriented multiple diagnostic ensemble regression
[1] *FMI*
[2] *GEOMAR*
[3] *DLR*

16:40-17:00 **Philip G. Sansom**[1], David B. Stephenson[1], and Chris A. T. Ferro[1]
– On using emergent constraints to reduce structural uncertainty in climate change projections
[1] *University of Exeter*

17:00-17:20 **Steve Sain**[1]
– Uncertainty, spatial statistics, and climate model ensembles
[1] *NCAR*

17:20-17:40 **Jussi S. Ylhäisi**[1], Jouni Räisänen[1], and Luca Garré
– Uncertainty analysis of CMIP3 and CMIP5 ensembles using analysis of variance
[1] *University of Helsinki*

Session 8 CMIP5 Model Evaluation, Prediction, and Projection

ROOM: SAMDA-B

14:00-15:20 **Chair: Penny Whetton**

14:00-14:20 **Ying Shi**[1] and Chonghai Xu[1]
–The projection of temperature and precipitation over China under RCP scenarios using a CMIP5 multi-model ensemble
[1] *National Climate Center, China Meteorological Administration*

14:20-14:40 **Hyun-Suk Kang**[1], Jun-Seong Park[1], Yu-Kyung Hyun[1], and ChunHo Cho[1]
– Regional climate projection over East Asia within the CORDEX framework
[1] *National Institute of Meteorological Research/Korea Meteorological Administration*

14:40-15:00 **Yingjiu Bai**[1], Ikuyo Kaneko[1], Hikaru Kobayashi[1], Kazuo Kurihara[2], Izuru Takayabu[2], Hidetaka Sasaki[2], and Akihiko Murata[2]
– High resolution regional climate model (NHRCM-5 km) simulations for Tokyo, Japan
[1] *Graduate School of Media and Governance, Keio University*
[2] *Meteorological Research Institute*

15:00-15:20 **Seung-Ki Min**[1,2] and Seok-Woo Son[3]
– Multi-model attribution of the Southern Hemisphere Hadley cell widening: CMIP3 and CMIP5 models
[1] *School of Environmental Science & Engineering, Pohang University of Science & Technology*
[2] *CSIRO Marine and Atmospheric Research*
[3] *School of Earth and Environmental Sciences, Seoul National University*

15:20-16:20 **Poster Sessions with Coffee Break**

Session 9 Detection and Attribution, Downscaling, and Impacts

ROOM: SAMDA- B

16:20-18:00 **Chair: Nikos Christidis**

16:20-16:40 **Aurélien Ribes**[1] and Laurent Terray[2]
– Regularised optimal fingerprinting and attribution of global near-surface temperature changes
[1] *CNRM-GAME/ CNRS-MeteoFrance*
[2] *CERFACS*

16:40-17:00 **Alexis Hannart**[1], Aurélien Ribes[1], and Philippe Naveau[1]
– Dealing with covariance uncertainty in optimal fingerprinting
[1] *CNRS (Centre National de la Recherche Scientifique)*

17:00-17:20 **Dáithí Stone**[1] and the IPCC WGII AR5 Chapter 18 Author Team
– Synthesising detection and attribution assessments across multiple systems
[1] *Lawrence Berkeley National Laboratory*

17:20-17:40 **Felix Pretis**[1] and David F. Hendry[1]
– Model selection and shift detection: General to specific modelling in climatology
[1] *Institute for New Economic Thinking at the Oxford Martin School, University of Oxford*

17:40-18:00 Armineh Barkhordarian[1] and **Hans von Storch**[1]
– Consistency of recent climate change and expectation as depicted by scenarios over the Mediterranean region
[1] *Institute of Coastal Research, Helmholtz-Zentrum Geesthacht*

Session 5 Non-linear Methods for Climate Analysis

ROOM: 303

14:00-15:20 **Chair: Andrea Toreti**

14:00-14:20 **Frank Kwasniok**[1]
– Predicting critical transitions from time series using non-stationary modelling
[1] *University of Exeter*

14:20-14:40 **Lukas Gudmundsson**[1] and Sonia I. Seneviratne[1]
– Machine learning for hypothesis testing in earth system sciences: The case of large-scale hydrology
[1] *Institute for Atmospheric and Climate Science, ETH Zurich*

14:40-15:00 **Ying Lut Tung**[1], Chi-Yung Tam[1,2], Soo-Jin Sohn[3], and Jung-Lien Chu[4]
– Improving the seasonal forecast for summertime South China rainfall using statistical downscaling
[1] *School of Energy and Environment, City University of Hong Kong*
[2] *Guy Carpenter Asia-Pacific Climate Impact Centre, City University of Hong Kong*
[3] *APEC Climate Center*
[4] *National Science and Technology Center for Disaster Reduction*

15:00-15:20 **Yun Li**[1], Hua Lu[2] , Martin J. Javis[2], Mark A. Cliverd[2], and Bryson Bates[2]
– Non-linear and non-stationary influences of geomagnetic activity on the winter North Atlantic Oscillation

[1] *CSIRO Mathematics, Informatics and Statistics*
[2] *British Antarctic Survey*
[3] *CSIRO Marine & Atmospheric Research*

15:20-16:20 **Poster Sessions with Coffee Break**

General Session

ROOM: 303

16:20-18:00 **Chair: Richard Chandler**

16:20-16:40 **Yan Li**[1]**,** Lin Mu[1], Kexiu Liu[1], Zengjian Zhang[1], and Dongsheng Zhang[1]
– Construction of sea surface temperature product based on observation data in Offshore China Sea during 1960-2011
[1] *National Marine Data and Information Service, State Oceanic Administration of China*

16:40-17:00 **David Masson**[1] and Christoph Frei[1]
– Spatial analysis of daily precipitation in the Alpine Region: A new method based on Kriging, multi-scale topographic predictors and circulation types
[1] *Federal Office of Meteorology and Climatology MeteoSwiss*

17:00-17:20 **E. Koch**[1] and P. Naveau
– A precipitation generator based on a frailty-contagion approach
[1] *ISFA and CREST*
[1] *LSCE (CNRS)*

17:20-17:40 **Youmin Chen**[1], Matthias Themessl[2], and Andreas Gobiet[2]
– Using the Quantile Mapping to improve a weather generator
[1] *Henan University*
[2] *Wegener Center for Climate and Global Change and Institute for Geophysics, University of Graz*

17:40-18:00 **Bohlool Alijani**[1], Hamideh Afsharmanesh[1] and Mehdi Taghiloo[1] (withdrawal)
– Statistical analysis of long-term precipitation amounts for fitting proper statistical distribution (case study Iran)
[1] *Kharazmi University of Tehran*

Poster Sessions

Session 6 Forecasting and Forecast Verification

1. R. M. Williams[1], C. A. T. Ferro[1], and **F. Kwasniok**[1]
   – A comparison of ensemble post-processing methods for extreme events
   [1] *University of Exeter*

2. **Hyun-Ju Lee**[1], Soo-Jin Sohn[1], and Jin-Ho Yoo[1]
   – Evaluation of the retrospective seasonal prediction skill of individual climate models in APCC seasonal forecast system
   [1] *APEC Climate Center*

3. **Stanislava Kliegrova**[1]**,** Ladislav Metelka[1], Radmila Brozkova[1], and Ales Farda[2]
   – Validation of a regional climate model ALARO-Climate
   [1] *Czech Hydrometeorological Institute*
   [2] *Global Change Research Centre AS CR, CzechGlobe*

4. **Monica Alexandra Rodrigues**[1]
   – Weather Research and Forecasting (WRF) model performance over Portugal
   [1] *University of Aveiro – CESAM*

Session 7 Ensemble Methods and Uncertainty Quantification

1. **Hongwei Yang**[1] and Bin Wang[2,3]
   – Reduction of uncertainties in regional climate downscaling through ensemble forcing
   [1] *APEC Climate Center*
   [2] *Department of Meteorology, University of Hawaii at Manoa*
   [3] *International Pacific Research Center, University of Hawaii at Manoa,*

2. **Kaoru Tachiiri**[1], Julia C. Hargreaves[1], James D. Annan[1], Chris Huntingford[2], and Michio Kawamiya[1]
   – Temperature rise and allowable carbon emissions for medium mitigation scenario RCP4.5
   [1] *Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology*
   [2] *Centre for Ecology and Hydrology*

3. **M.-S. Suh**[1], S.-G. Oh[1], D.-K. Lee[2], S.-J. Choi[3], S.-Y. Hong[4], J.-W. Lee[4], and H.-S. Kang[5]
   – Development and evaluation of deterministic ensemble methods using simulation results of five RCMs over CORDEX-East Asia based on IPCC RCP scenarios
   [1] *Kongju National University*
   [2] *School of Earth and Environmental Sciences, Seoul National University*
   [3] *Korea Institute of Atmospheric Prediction Systems*
   [4] *Yonsei University*
   [5] *National Institute of Meteorological Research/ Korea Meteorological Administration*

4. **Tokuta Yokohata**[1], James D. Annan[2], Matthew Collins[3], Charles S. Jackson[4], Hideo Shiogama[1], Masahiro Watanabe[5], Seita Emori[1], Masakazu Yoshimori[5], Manabu Abe[1], Mark J. Webb[6], and Julia C. Hargreaves[2]
   – Uncertainty in single-model and multi model ensembles
   [1] *National Institute for Environmental Studies, Center for Global Environmental Research*
   [2] *Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology*
   [3] *College of Engineering, Mathematics and Physical Sciences, University of Exeter,*
   [4] *The University of Texas at Austin, Institute of Geophysics*
   [5] *University of Tokyo, Atmosphere and Ocean Research Institute*
   [6] *Met Office, Hadley Centre*

Session 9 Detection and Attribution, Downscaling, and Impacts

1. **Hyerim Kim**[1], Sang-Wook Yeh[2], and Baek-Min Kim[1]
   – Role of sea ice extent reduction to climate change over the North Pacific
   [1] *Korea Polar Research Institute*
   [2] *Hanyang University*

2. **G. Fioravanti**[1] and F. Desiato[1]
   – Model Output Statistics precipitation downscaling over a set of Italian stations
   [1] *ISPRA, AMB-MPA*

3. **Hyojin Lee**[1], Yeomin Jeong[1], and Yoobin Yhang[1]
   – Application of Kernel method to statistical downscaling: case study for South Korea
   [1] *Climate Analysis Team, APEC Climate Center*

4. Jonathan Eden[1], Martin Widmann[1], Geraldine Wong[2], **Douglas Maraun**[2], Mathieu Vrac[3], and Thomas Kent[1,2]
   – Comparison of GCM- and RCM-MOS corrections for simulated daily precipitation
   [1] *School of Geography, Earth and Environmental Sciences, University of Birmingham*
   [2] *Helmholtz Centre for Ocean Research Kiel (GEOMAR)*
   [3] *Laboratoire des Sciences du Climat et de l'Environnement*

5. **Yeo-Min Jeong**[1], Hyojin Lee[1], Yoobin Yhang[1], and Ara Koh[1]
   – Comparison of dynamical and statistical downscaling for dry season over Southeast Asia
   [1] *APEC Climate Center*

6. **Douglas Maraun**[1]
   – Can quantile mapping be used for downscaling? Consequences for the characterisation of dry spells and extreme events
   [1] *GEOMAR Helmoltz Centre for Ocean Research*

7. **Zuzana Rulfová**[1,2] and Jan Kyselý[1,2]
   – Simulation of convective and stratiform precipitation in regional climate models
   [1] *Institute of Atmospheric Physics AS CR, Prague, Czech Republic*
   [2] *Technical University, Liberec, Czech Republic*

Wednesday, 26 June, 2013

Plenary Session

Session 9 Detection and Attribution, Downscaling, and Impacts

ROOM: HALLA

08:30-10:00 **Chair: Bryson Bates / Seung-Ki Min**

Nikos Christidis[1]
– Attribution of recent trends in regional extremes and extreme events
[1] *Met Office Hadley Centre*

Francis Zwiers[1]
– Is our ability to understand the causes of changes in precipitation extremes improving?
[1] *Pacific Climate Impacts Consortium, University of Victoria*

Bruce Hewitson[1]
– Downscaling: high expectations, limits of predictability, and new efforts
[1] *Marine Research Institute, University of Cape Town*

10:00-10:30 **Coffee Break**

Session 3 Reconstruction and Interpretation of Past Climates

ROOM: HALLA

10:30-11:20 **Chair: Bo Li**

Martin Tingley[1]
– Arctic temperature extremes over the last 600 years
[1] *Harvard University*

Jason Smerdon[1]
– Assessing spatial skill in climate field reconstructions and why it matters
[1] *Lamont-Doherty Earth Observatory, Columbia University*

Session 4 Spatial and Spatiotemporal Modelling

11:20-12:35 **Chair: Richard Chandler** **ROOM: HALLA**

Philippe Naveau[1], A. Sabourin[1], E. Bernard[1], O.mestre[1], and M. Vrac[1]
– Analysis of heavy rainfall in high dimensions
[1] *CNRS-LSCE IPSL*

Mikyoung Jun[1]
– Matérn-based nonstationary cross-covariance models for global processes
[1] *Texas A&M University*

Jaeyong Lee[1]
– Dependent species sampling models for spatial density estimation
[1] *Seoul National University*

12:35-14:00 **Lunch**

Parallel Session

Session 7 Ensemble methods and uncertainty quantification

ROOM: SAMDA-A

14:00-15:40 **Chair: Steve Sain**

14:00-14:20 **D. J. McNeall**[1], P. G. Challenor[2], J. R. Gattiker[3], and E. J. Stone[4]
– The potential of an observational data set for calibration of a computationally expensive computer model
[1] *Met Office Hadley Centre*
[2] *University of Exeter*
[3] *Los Alamos National Laboratory,*
[4] *University of Bristol*

14:20-14:40 **Pat Sessford**[1]
– Quantifying sources of variation in multi-model ensembles: A process-based approach
[1] *University of Exeter*

14:40-15:00 **Yaeji Lim**[1] and Hee-Seok Oh[1]
– Independent component regression for seasonal climate prediction: An efficient way to improve multimodel ensembles
[1] *Seoul National University*

15:00-15:20 Reto Knutti[1], **David Masson**[2] and Andrew Gettelman[3]
– Climate model genealogy: Generation CMIP5 and how we got there
[1] *Institute for Atmospheric and Climate Science, ETH Zurich*
[2] *Federal Office of Meteorology and Climatology MeteoSwiss*
[3] *National Center for Atmospheric Research*

15:20-15:40 **Douglas Maraun**[1]
– When will trends in European mean and heavy precipitation emerge from internal variability?
[1] *GEOMAR Helmoltz Centre for Ocean Research*

15:40-16:40 Poster session with coffee break

16:40-17:40 Chair: Steve Sain

16:40-17:00 **Joseph D Daron**[1] and David A Stainforth[2]
– The role of initial condition ensembles in quantifying model climate under climate change
[1] *Climate System Analysis Group, University of Cape Town*
[2] *Grantham Research Institute on Climate Change and the Environment, London School of Economics*

17:00-17:20 **Alexis Hannart**[1] and Michael Ghil[1]
– Detection of nonlinearity in the global temperature response of IPCC models
[1] *CNRS (Centre National de la RechercheScientifique)*

17:20-17:40 **Jean-Philippe Vidal**[1] and Benot Hingray[2]
– Sub-sampling ensembles of downscaled climate projections
[1] *Irstea, UR HHLY, Hydrology-Hydraulics Research Unit*
[2] *CNRS/UJF-Grenoble 1/G-INP/IRD*

Session 9 Detection and Attribution, Downscaling, and Impacts

ROOM: SAMDA-B

14:00-15:40 Chair: Seung-Ki Min

14:00-14:20 **Jung Choi**[1] and Seok-Woo Son[1]
– Effects of internal climate variability on the Hadley cell width
[1] *Seoul National University*

14:20-14:40 **Kyung-On Boo**[1], Ben Booth[2], Young-Hwa Byun[1], Johan Lee[1], ChunHo Cho[1], Soo-Hyun Park[1], Sung-Bo Shim[1], and Sung-Bin Park[1]
– Aerosols impact on the multi-decadal SST variability simulation over the North Pacific
[1] *Korea Meteorological Administration*
[2] *Met Office Hadley Centre*

14:40-15:00 **Cheng-Ta Chen**[1], Shou-Li Lin[1], Shih-Hao Luo[1], and Yu-Shiang Tung[1]
– Regionalization of future projections on the high-impact weather and climate extremes
[1] *National Taiwan Normal University*

15:00-15:20 **Surendra Rauniyar**[1], Bertrand Timbal[1], and Yang Wang[1]
– Improvement to a statistical downscaling technique by redefining the calendar seasons
[1] *Centre for Australian Weather & Climate Research*

15:20-15:40 Mingyi Zhang[1,2], **Ki-Hong Min**[2,3], Qingbai Wu[1], Jianming Zhang[1], and Jon Harbor[2]
– A new method to determine the upper boundary condition for a permafrost thermal model: An example from the Qinghai-Tibet Plateau
[1] *State Key Laboratory of Frozen Soil Engineering,Chinese Academy of Sciences*
[2] *Purdue University*
[3] *Center for Atmospheric Remote Sensing, Kyungpook National University*

15:40-16:40 Poster session with coffee break

16:40-18:20 Chair: Bryson Bates

16:40-17:00 **Douglas Maraun**[1]
– Nonstationarities of regional climate model biases in European seasonal mean temperature and precipitation sums
[1] *GEOMAR Helmoltz Centre for Ocean Research*

17:00-17:20 **Sabine Radanovics**[1], Jean-Philippe Vidal[1], Eric Sauquet[1], Aurélien Ben Daoud[1], and Guillaume Bontron[1]
– Defining predictand areas with homogeneous predictors for spatially coherent precipitation downscaling of climate projections
[1] *Irstea, UR HHLY Hydrology and Hydraulics Research Unit*

17:20-17:40 **Renate Wilcke**[1], Andreas Gobiet[1], and Thomas Mendlik[1]
– A detailed evaluation quantile mapping on multivariance RCM output
[1] *University of Graz*

17:40-18:00 **Andrew E. Harding**[1], Rob Brooker[2], Alessandro Gimona[2], and Simon Tett[1]
– An analytical ranking of risk for sites of scientific interest under climate change

[1] *Grant Institute, University of Edinburgh*
[2] *James Hutton Institute*

18:00-18:20 J. Losada[1], F.J. Mendez[1], **M. Menéndez[1]**, R. Mínguez[1], J. Perez[1], Y. Guanche[1], C. Izaguirre[1], and A. Espejo[1]
– Regional wave climate changes and coastal impacts from a dynamical downscaling of the past and statistical downscaling projections
[1] *Environmental Hydraulics Institute "IH-Cantabria", Universidad de Cantabria*

Session 3 Reconstruction and Interpretation of Past Climates

ROOM: 303

14:00-15:45 **Chair: Bo Li**

14:00-14:15 **Fabrice Lambert**[1]
– Reconstruction of global atmospheric dust concentrations from dust flux measurements in paleoclimatic archives
[1] *Korea Institute of Ocean Science and Technology*

14:15-14:30 **Jianghao Wang**[1], Julien Emile-Geay[1], Adam D. Vaccaro[1], and Dominique Guillot[1]
– Impacts of methodology and source data on large-scale temperature reconstructions
[1] *University of Southern California*
[2] *Stanford University*

14:30-14:45 **Hong Yin**[1] and Hongbin Liu[1]
– Summer temperature reconstruction since A.D. 1530 from tree-ring maximum density in eastern Tibetan Plateau, China
[1] *National Climate Center, China Meteorological Administration*

14:45-15:00 A. Bunde[1], U. Büntgen[1], J. Ludescher[1], J. Luterbacher[1], and **H. von Storch**[1]
– Rethinking the colour of precipitation
[1] *Institute of Coastal Research*

15:00-15:15 **Johannes P. Werner**[1], Andrea Toreti[1], and Jüerg Luterbacher[1]
– Stochastic models for climate field reconstructions using instrumental data
[1] *Department of Geography, Justus Liebig University Giessen*

15:15-15:30 **Julia C. Hargreaves**[1], James D. Annan [1], Masa Yoshimori[2], and Ayako Abe-Ouchi[1,2]
– Can the Last Glacial Maximum constrain climate sensitivity?
[1] *Research Institute for Global Change, JAMSTEC*
[2] *Atmosphere and Ocean Research Institute, Tokyo University*

15:30-15:45 L. Scarascia[1], R. Garcia-Herrera[1], S. Salcedo-Sanz[1], and **P. Lionello**[1]
– Reconstruction of long time series of monthly temperature values by statistical methods: an application to Europe and the Mediterranean region
[1] *University of Salento*

15:45 -16:40 Poster session with coffee break

Session 11 Large-Scale Climate Variability and Teleconnections

ROOM: 303

16:40-18:10 Chair: Kwang-Yul Kim

16:40-16:55 **Young-Kwon Lim**[1]
– Impact of the dominant large-scale teleconnections on winter temperature variability over East Asia and their relation to Rossby wave propagation
[1] *NASA Goddard Space Flight Center*

16:55-17:10 **Michael DeFlorio**[1], D.W. Pierce[1], D.R. Cayan[1], and A.J. Miller[1]
– Western U.S. Extreme Precipitation Events and Their Relation to ENSO and PDO in CCSM4
[1] *Scripps Institution of Oceanography, UCSD*

17:10-17:25 **Daehyun Kim**[1], Jong-Seong Kug[2], and Adam H. Sobel[1,3]
– Propagating vs. Non-propagating Madden-Julian Oscillation Events
[1] *Lamont-Doherty Earth Observatory, Columbia University*
[2] *Korea Institute of Ocean Science and Technology, Ansan*
[3] *Department of Applied Physics and Applied Mathematics, Columbia University*

17:25-17:40 **Andrew D. King**[1,2], Nicholas P. Klingaman[3,4], Lisa V. Alexander[1,2], Markus G. Donat[1,2], Nicolas C. Jourdain[1,2], and Penelope Maher[1,2]
– Investigating the drivers of extreme rainfall variability in Australia
[1] *ARC Centre of Excellence for Climate System Science, University of New South Wales*
[2] *Climate Change Research Centre, University of New South Wales*
[3] *National Centre for Atmospheric Science, University of Reading*
[4] *Walker Institute for Climate System Research, University of Reading*

17:40-17:55 **Celine Bonfils**[1], B. D. Santer[1], and T. J. Phillips[1]
– Drought-conducive mode of variability and teleconnections under climate change
[1] *AEED/PCMDI, LLNL*

17:55-18:10 **Yun Li**[1], Jianping Li[2], and Juan Feng[2]

– A teleconnection between the reduction of rainfall in southwest Western Australia and North China

[1] *CSIRO Mathematics, Informatics and Statistics, CSIRO Climate Adaptation Flagship*

[2] *Institute of Atmospheric Physics, Chinese Academy of Sciences*

Poster Sessions

Session 3 Reconstruction and Interpretation of Past Climates

1. **Ha-Young Bong**[1] and Soon-Il An[1]

   – ENSO changes in CMIP5/PMIP3 simulation during the Midholocene and preindustrial periods

   [1] *Department of Atmospheric Sciences, Yonsei University*

Session 10 Weather and Climate Extremes - Statistical Modeling and Event Attribution

1. **Dáithí Stone**[1], Christopher Lennard[1], Mark Tadross[1], and Piotr Wolski[1]

   – The weather risk attribution forecast for July 2013

   [1] *Lawrence Berkeley National Laboratory*

2. Jan Kysely[1,2], **Jan Picek**[2], and Romana Beranova[1,2]

   – Climate change scenarios of temperature extremes evaluated using extreme value models based on homogeneous and non-homogeneous Poisson process

   [1] *Institute of Atmospheric Physics*

   [2] *Technical University*

3. **Jong-hwa Lee**[1], Seung-Ki Min[2], Hee-Jeong Baek[1], and ChunHo Cho[1]

   – Relations of extreme temperature with large-scale climate variability during winter in Korea using non-stationary GEV with covariate

   [1] *National Institute of Meteorological research/KMA*

   [2] *Pohang University of Science and Technology*

4. **Kyoungmi Lee**[1], Hee-Jeong Baek[1], and ChunHo Cho[1]

   – A study of climate extremes changes in Korea using quantile regression

   [1] *National Institute of Meteorological Research, Korea Meteorological Administration*

5. **Pardeep Pall**[1]

   – First steps towards attribution of trends in European flood risk

   [1] *Lawrence Berkeley National Laboratory*

6. **Yun Am Seo**[1], Jun Jang [1], Jeong-Soo Park[1], and Bo-Yoon Jeong[2]
   – A Generalized Gumbel Distribution
   [1] *Chonnam National University*
   [2] *National Cancer Center Control Institute*

7. **Youngsaeng Lee**[1], Sanghoo Yoon[1,2], Md. Sharwar Murshed[1,3], Maeng-Ki Kim[4], ChunHo Cho[5], Hee-Jeong Baek[5], and Jeong-Soo Park[1]
   – Spatial modeling of the highest daily maximum temperature in Korea via max-stable processes
   [1] *Department of Statistics, Chonnam National University*
   [2] *School of Mathematics, University of Southampton*
   [3] *Department of Business Administration, Northern University Bangladesh*
   [4] *Kongju National University*
   [5] *National Institute of Meteorological Research, Seoul, Korea*

8. **Manish Kumar Goyal**[1], Donald H. Burn[2], and C.S.P.Ojha[3]
   – Extreme precipitation event simulation based on k-Nearest Neighbour Weather Generator using Gamma Kernel
   [1] *Indian Institute of Technology, Guwahati*
   [2] *University of Waterloo*
   [3] *Indian Institute of Technology, Roorke*

Session 11 Large-Scale Climate Variability and Teleconnections

1. **Yeon-Hee Kim**[1], Maeng-Ki Kim[1], William K. M. Lau[2], Kyu-Myong Kim[3], and ChunHo Cho[4]
   – Asian-North Pacific atmospheric circulation associated with Korean winter temperature regime shift in the late 1980s
   [1] *Dept. of Atmospheric Science, Kongju National University*
   [2] *Laboratory for Atmosphere, NASA Goddard Space Flight Center*
   [3] *Morgan State University*
   [4] *National Institute of Meteorological Research*

2. **Hera Kim**[1] and Sang-Wook Yeh[1]
   – Changes in the relationship between ENSO and PDO in accordance with their periodicity under global warming
   [1] *Department of Marine Sciences and Convergent Technology, Hanyang University*

3. **Hyun-Su Jo**[1], Sang-Wook Yeh[1], and Cheol-Ho Kim[2]
   – Changes in the relationship between the western tropical Pacific and the North Pacific SST across 1998/99 North Pacific regime shift
   [1] *Hanyang University*
   [2] *Korean Ocean Research & Development Institute*

4. **Il-Ju Moon**[1] and Ki-Seon Choi[2]
   – Relationship between the frequency of tropical cyclones in Taiwan and the Pacific/North American pattern

[1] *College of Ocean Science, Jeju National University*
[2] *National Typhoon Center, Korea Meteorological Administration*

5. **Kie-Woung Lee**[1] and Sang-Wook Yeh[1]
   – Changes in global precipitation-temperature relationship by natural versus anthropogenic forcing
   [1] *Hanyang University*

6. Ki-Seon Choi[1] and **Il-Ju Moon**[2]
   – Connection between the genesis frequency of tropical cyclones over the western North Pacific and summer rainfall over Northeast Asia
   [1] *National Typhoon Center, Korea Meteorological Administration*
   [2] *College of Ocean Science, Jeju National University*

7. **Hye-Yeong Jang**[1] and Sang-Wook Yeh[1]
   – Changes in the air-sea interactions over South China Sea and its relationship with Northeast Asia summer monsoon
   [1] *Hanyang University*

8. **Il-Ju Moon**[1] and Ki-Seon Choi[2]
   – Two climate factors in May that affect Korean rainfall in September
   [1] *College of Ocean Science, Jeju National University*
   [2] *National Typhoon Center, Korea Meteorological Administration*

9. **Jeong Sang**[1], Maeng-Ki Kim[1], William K. M. Lau[2], Kyu-Myong Kim[3], and Woo-Seop Lee[4]
   – Impacts of absorbing aerosols on the snowpack over the Tibetan Plateau and Indian summer monsoon
   [1] *Department of Atmospheric Science, Kongju National University*
   [2] *Laboratory for Atmospheres, NASA Goddard Space Flight Center*
   [3] *Mogan State University*
   [4] *APEC Climate Center*

10. **Sungbo Shim**[1], Yoo-Rim Jung[1], Hee-Jeong Baek[1], and ChunHo Cho[1]
    – Climate feedback of anthropogenic aerosols over East-Asia using HadGEM2-AO
    [1] *National Institute of Meteorological research/KMA*

Thursday, 27 June, 2013

Plenary Session

Session 11 Large-Scale Climate Variability and Teleconnections

08:30-10:00 **Chair: Sang-Wook Yeh / Renguang Wu** **ROOM: HALLA**

Sang-Ik Shin[1]
– On the nature of global atmospheric response to the tropical SST forcing
[1] *University of South Florida*

Jin-Song von Storch[1] and Daniel Hernández-Deckers[1]
– Energetics responses to increases in greenhouse gas concentration
[1] *Max-Planck Institute for Meteorology*

Peter Greve[1], Boris Orlowsky[1], and Sonia I. Seneviratne[1]
– Investigating changes in dryness by a comprehensive synthesis of available data sets
[1] *Institute for Atmospheric and Climate Science, ETH Zurich*

10:00-10:20 **Coffee Break**

Parallel Session

Session 10 Weather and Climate Extremes - Statistical Modeling and Event Attribution

ROOM: SAMDA-A

10:20-12:00 **Chair: Francis Zwiers**

10:20-10:40 **Seung-Ki Min**[1,2], Wenju Cai[2], and Penny Whetton[2]
– Influence of climate variability on seasonal extremes over Australia
[1] *School of Environmental Science & Engineering, Pohang University of Science & Technology*
[2] *CSIRO Marine and Atmospheric Research*

10:40-11:00 **Leone Cavicchia**[1], Silvio Gualdi[1], and Hans von Storch[2]
– A long-term climatology of "Mediterranean hurricanes"
[1] *CMCC (Centro Euro-Mediterraneo sui Cambiamenti Climatici)*
[2] *HZG (Helmoltz-Zentrum Geesthacht)*

11:00-11:20 **Pao-Shin Chu**[1] and Xin Zhao[1]
– Bayesian forecasting of typhoon intensity over the western North Pacific: A track-pattern clustering approach
[1] *University of Hawaii*

11:20-11:40 **Piotr Wolski**[1], Daithi Stone[2], Mark Tadross[3], and Bruce Hewitson[1]
– Sensitivity of extreme rainfall events in Africa attributable to anthropogenic radiative and SST forcing
[1] *CSAG, University of Cape Town*
[2] *Lawrence Berkeley National Laboratory*
[3] *Green-LECRDS, United Nations Development Programme – GEF*

11:40-12:00 **Barbara Tencer**[1], Andrew J. Weaver[1], and Francis W. Zwiers[2]
– Joint occurrence of daily temperature and precipitation extreme events over Canada
[1] *School of Earth and Ocean Sciences, University of Victoria*
[2] *Pacific Climate Impacts Consortium, University of Victoria*

Session 11 Large-Scale Climate Variability and Teleconnections

ROOM: SAMDA-B

10:20-12:20 **Chair: Sang-Wook Yeh**

10:20-10:40 **Jong-Seong Kug**[1], Yoo-Geun Ham[2], Jong-Yeon Park[1], and Fei-Fei Jin[3]
– Atlantic roles on ENSO development
[1] *Korea Institute of Ocean Science and Technology(KIOST)*
[2] *Global Modeling and Assimilation Office, NASA/GSFC*
[3] *Department of Meteorology, University of Hawaii*

10:40-11:00 **Renguang Wu**[1]
– Impacts of ENSO and North Atlantic SST on Northeast China summer temperature variations
[1] *Institute of Space and Earth Information Science, the Chinese University of Hong Kong*

11:00-11:20 **Karin Lutz**[1], Joachim Rathmann[1], and Jucundus Jacobeit[1]
– Warm and cold water events in the tropical Atlantic Ocean and teleconnections to the tropical Pacific
[1] *Institute of Geography, University of Augsburg*

11:20-11:40 **G. W. K. Moore**[1], I.A. Renfrew[2], and R.S. Pickart[3]
– Multi-decadal mobility of the North Atlantic Oscillation
[1] *University of Toronto*
[2] *University of East Anglia*
[3] *Woods Hole Oceanographic Institution*
[1] *KOPRI*

11:40-12:00 **Ji-Won Kim**[1] and Sang-Wook Yeh[2]
– Favorable connections between the atmospheric structures over the North Pacific and central Pacific warming
[1] *Yonsei University*
[2] *Hanyang University*

12:00-12:20 **Gwangyong Choi**[1]
– Changing Global Circumpolar Vortex
[1] *Major of Geography Education, Jeju National University*

Session 6 Forecasting and Forecast Verification

ROOM: 303

10:20-12:20 **Chair: Chris Ferro**

10:20-10:40 **Nicholas Cavanaugh**[1], Aneesh Subramanian[1], and Arthur Miller[1]
– Forecasting of the Madden-Julian Oscillation with Linear Stochastic Climate Models
[1] *Scripps Institution of Oceanography, UCSD*

10:40-11:00 **Dong Wook Kim**[1], Myoung-Seok Suh[1], and Chansoo Kim[1]
– Analysis of bias-correction of monthly temperature from RCM climate over model South Korea
[1] *Kongju National University*

11:00-11:20 **Frank Kwasniok**[1]
– Post-processing probabilistic forecasts: A variational approach
[1] *University of Exeter*

11:20-11:40 **Ian Jolliffe**[1] and David Stephenson[1]
– Sampling uncertainty in verification measures for binary deterministic forecasts
[1] *University of Exeter*

11:40-12:00 **Douglas Maraun**[1], Martin Widmann[1], Rasmus Benestad[1], Sven Kotlarski[1], Elke Hertig[1], Joanna Wibig[1], and Jose Gutierrez
– VALUE - Validating and Integrating Downscaling Methods for Climate Change Research
[1] *GEOMAR Helmholtz Centre for Ocean Research Kiel*

12:00-12:20 **Mohan K. Das**[1,2], Md. Mizanur Rahman[1], Wassila Thiaw[3], and Simon Mason[1]
– Forecasting of Seasonal Rainfall over Bangladesh Using Climate Predictability Tool
[1] *SAARC Meteorological Research Centre (SMRC)*
[2] *Jahangirnagar University*
[3] *CPC/ National Oceanic and Atmospheric Administration*
[4] *International Research Institute (IRI)*

12:20-18:30 **Tour**

18:30 + **Banquet supported by NIMR/KMA**

Friday, 28 June, 2013

Plenary Session

Session 6 Forecasting and Forecast Verification

ROOM: HALLA

08:30-10:00 **Chair: Ian Jolliffe**

JD Annan[1], JC Hargreaves[1], and K Tachiiri[1]
– Observational assessment of climate model performance
[1] *JAMSTEC*

Thordis Thorarinsdottir[1]
– Using proper divergence functions to evaluate climate models
[1] *Norwegian Computing Center*

Christopher Ferro[1]
– Evaluating decadal hindcasts: why and how?
[1] *University of Exeter*

10:00-10:30 **Coffee Break**

Session 10 Weather and Climate Extremes - Statistical Modeling and Event Attribution

ROOM: HALLA

10:30-12:00 **Chair: Francis Zwiers**

G.W.K. Moore[1]
– A unified view of the Greenland flow distortion and its impact on barrier flow, tip jets and coastal oceanography
[1] *University of Toronto*

Emily Wallace[1]
– Predicting extreme daily weather events a season ahead: the role of circulation
[1] *Met Office Hadley Centre*

Frank Kwasniok [1]
– Regime-dependent modelling of extremes in the extra-tropical atmospheric circulation
[1] *University of Exeter*

12:00-13:30 **Lunch**

Parallel Session

Session 10 Weather and Climate Extremes - Statistical Modeling and Event Attribution

ROOM: SAMDA-A

13:30-15:10 **Chair: Francis Zwiers**

13:30-13:50 **Jan Picek**[1]
– Bayesian techniques for Poisson process models of extreme events
[1] *Technical University of Liberec*

13:50-14:10 **Jeong-Soo Park**[1], Yun Am Seo[1], Youngsaeng Lee[1], Maeng-Ki Kim[2], ChunHo Cho[3], and Hee-Jeong Baek[3]
– Assessing changes in observed and future projected precipitation extremes in South Korea
[1]*Department of Statistics, Chonnam National University*
[2] *Department of Atmospheric Science, Kongju University*
[3] *National Inst. of Meteorological Research/KMA*

14:10-14:30 **Anne Schindler**[1], Douglas Maraun[2], Andrea Toreti[1], and Jürg Luterbacher[1]
– Changes in the annual cycle of heavy precipitation events across the UK in future projections
[1] *Department of Geography, University of Giessen*
[2] *Leibnitz In-stitute of Marine Sciences at the University of Kiel*

14:30-14:50 **Barbara Casati**[1] and Ramon de Elia[1]
– Regional climate projections of temperature extremes in the context of the CMIP3 ensemble
[1] *Consortium Ouranos*

14:50-15:10 Geraldine Wong[1], **D. Maraun**[1], M. Vrac[2], M. Widmann[3], and J. Eden[3]
– A stochastic model output statistics approach for correcting and downscaling precipitation including its extremes
[1] *GEOMAR Helmoltz Centre for Ocean Research*
[2] *Laboratoire des Sciences du Climat et de l'Environnement (LSCE-IPSL/CNRS)*
[3] *University of Birmingham*

Session 11 Large-Scale Climate Variability and Teleconnections

ROOM: SAMDA-B

13:30-15:10 **Chair: Renguang Wu**

13:30-13:50 **Joo-Hong Kim**[1]

– Joint quasi-decadal mode in summer and early autumn over the subtropical western North Pacific : precipitation, tropical cyclones, and sea surface temperature

[1] *KOPRI*

13:50-14:10 **Erik Swenson**[1]

– Interaction between the AO and ENSO Modoki and implications for seasonal prediction

[1] *APEC Climate Center*

14:10-14:30 **Sang-Wook Yeh**[1], So-Min Lim[2], Hyun-So Jo[1], Ji-Hyun So[1], Eun-Chul Chang[3], and Hyun-Suk Kang[2]

– Recent changes in the atmospheric teleconnections from the tropics to the polar region: Warm pool SST and AO

[1] *Hanyang University*
[2] *NIMR/KMA*
[3] *AORI*

14:30-14:50 **Yeon-Hee Kim**[1], Maeng-Ki Kim[1], ChunHo Cho[2], William K. M. Lau[3], and Kyu-Myong Kim[4]

– Possible cause of the winter temperature regime shift in the late 1980s over the Northern Hemisphere

[1] *Kongju National University*
[2] *National Institute of Meteorological Research/KMA*
[3] *Laboratory for Atmosphere, NASA Goddard Space Flight Center*
[4] *Morgan State University*

14:50-15:10 **Radan Huth**[1,2], Andreas Philipp[3], and Christoph Beck[3]

– Recent progress in the research on classifications of atmospheric circulation patterns achieved within international project COST733

[1] *Charles University, Prague*
[2] *Institute of Atmospheric Physics*
[3] *University of Augsburg*

12th International Meeting on Statistical Climatology

Monday, 24 June, 2013

MON TUE WED THU FRI

Assigning bias adjustments and uncertainties to observations from different components of the ocean observing system to create a prototype integrated database of temperature and salinity

Chris Atkinson and Nick Rayner

Met Office Hadley Centre, UK.

As part of the European FP7 project ERA-CLIM, a new prototype database of ocean temperature and salinity observations (1900-present) has been created to support the assimilation of ocean observations in future coupled climate reanalyses. The database is 'integrated', in that it brings together surface and sub-surface components of the ocean observing system which have traditionally been treated separately for climate monitoring purposes. The surface observations are taken from version 2.5.1 of the International Comprehensive Ocean Atmosphere Data Set (ICOADS 2.5.1) and the subsurface observations are taken from version 4 of the Met Office Hadley Centre EN dataset (EN4). In bringing together observations from multiple observation types and platforms, it is necessary to understand and where possible adjust for any biases that may exist between different instruments, to ensure the observations are homogenous in space and time. We apply to the ICOADS 2.5.1 temperature observations best available bias adjustments and uncertainties, which are taken from the Met Office Hadley Centre HadSST3 dataset. The bias model developed for HadSST3 is extended to other observations in the database, however in many cases it is not yet possible to populate fully all the components of this model for a particular observation due to limitations in our understanding of the ocean observing system. Further problems arise in situations where necessary observation metadata are missing; in these cases best estimate bias adjustments have to be applied. The framework of this prototype database highlights such gaps in our present knowledge of ocean observations and is flexible enough to incorporate gradual improvements in our understanding as they occur. This presentation will discuss the motivation for, and the concept and creation of our integrated prototype database, highlight some of the difficulties and issues encountered in its design and creation, and outline further work that would benefit future versions of this database.

An overview of benchmarking data homogenisation procedures for the International Surface Temperature Initiative

Kate Willett (UK Met Office Hadley Centre) and the Benchmarking and Assessment Working Group

http://www.surfacetemperatures.org/benchmarking-and-assessment-working-group#Members

Inhomogeneity is a major problem for climate data and long-term trend analysis. While progress in detection of, and correction for inhomogeneities is continually advancing, monitoring effectiveness on large networks and gauging respective improvements in climate data quality is non-trivial. Validation efforts have typically been made to create a few synthetic stations or small networks of stations with artificially added errors. Some tests have been conducted using stations with 'known' inhomogeneities. However, there is currently no internationally recognised means of robustly assessing the effectiveness of homogenisation methods on real data.

As part of the International Surface Temperature Initiative (ISTI), the Benchmarking and Assessment Working Group is working on creating global sets of monthly mean temperature benchmarks, analogous to the raw data in the ISTI land meteorological databank (stage 3) (http://www.surfacetemperatures.org/databank). This comprises four major tasks:

1) Create >40000 synthetic benchmark stations that look and feel like the real global temperature network, but do not contain any inhomogeneities – analog-known-worlds

2) Design a set of error models which mimic the main types of inhomogeneities found in practice, and combined them with the analog-known-worlds to give analog-error-worlds

3) Engage with dataset creators to run their homogenisation algorithms on the analog-error-world stations as they have done with the real data

4) Present an assessment to the dataset creators of how effective their methods were at returning the analog-error-worlds back to the analog-known-worlds, looking at a range of spatial scales.

In short, we intend to facilitate use of a robust, independent and useful common benchmarking and assessment system for temperature data-product creation methodologies to aid product intercomparison and improvement, together with uncertainty quantification.

Changepoint Detection in Climate Series via Quantile Regression Procedures

Jaxk Reeves

Statistics Department, University of Georgia
Athens,GA USA 30602

Much previous work on homogenization of climate data series revolves around attempts to detect shifts in mean responses, particularly those that are due to undocumented changepoints. Many such techniques have been proposed, and they generally work well if the climate series is long enough and the AMOC (At Most One Change) assumption is true. However, in recent years, there has been a desire to develop change detection procedures which are responsive not only to changes in the mean, but also to changes over time in particular quantiles, τ. While a change in any quantile, unless accompanied by an opposite direction change elsewhere in the distribution, would lead to a change in mean, tests which focus solely on statistically significant mean changes may be less powerful or slower to react than tests specifically designed to detect quantile shifts. This could be particularly important for cases like global warming, where there is some evidence that there have been more severe increases in the lower tails of the temperature distributions than in the upper tails.

Quantile estimation of changepoints is somewhat more difficult than mean estimation in that one must have fairly complete data at a fine level (typically daily) rather than an annual average, which is frequently quite sufficient to detect trends in means. While such data are not necessarily hard to procure, they tend to be highly serially auto-correlated, making statistical analysis more challenging than is the case with annual data. A more severe challenge is that naive application of standard quantile regression programs will frequently not yield correct estimates for standard errors for model coefficients, even in the case where the changepoint times are known. This work will explain how correct estimates for standard errors can be calculated in this case, and then extend the results to developing test statistics and critical values in the more realistic case where quantile changepoint times, if any, are unknown. Examples of common pitfalls will be given; a particularly pernicious problem is that quantile regression may work very poorly when data are recorded at discrete levels.

Changepoint Detection in Categorical Time Series

QiQi Lu

Virginia Commonwealth University

Detecting changepoints in a categorical time series has become a very active research area of statistical climatology. This talk introduces a X^2max test for changes in a sequence of independent multinomial series. The method is used to identify changes in the tropical cyclone record in the North Atlantic Basin over the period 1851-2008. This X^2max test works well when there is no temporal trends presented in the categorical data. However, for example, the temporal trends are often observed in the 11-categorical sky-cloudiness condition data in Canada. To take into account the trends and extra variability in the categorical data, we have developed a likelihood-ratio test for detecting a change in the ordinal categorical data using an extended cumulative logit model. Moreover, we have extended this method to account for autocorrelation and seasonality, which are inherent features of most climate variables. These methods are applied to a read sky-cloudiness data in Canada.

Machine Learning and Extremes in Climate Studies

Julie Carreau

IRD HydroSciences Montpellier

Machine learning proposes non-parametric algorithms which make only smoothness assumptions and take advantage of large amount of data to uncover the structure of the data generating process. Such algorithms have shown to be successful in numerous application domains such as health and image and voice recognition. However, in hydrology or climate studies, the data is often heavy-tailed and thus include extreme values. In such cases, direct use of non-parametric algorithms might not be of much help because extreme values are intrinsically rare. Extreme value theory (EVT) has put forward sound parametric models for extremes based on asymptotic distributional properties. For univariate distributions, there are two main models. The generalized extreme value (GEV) distribution is appropriate, under certain assumptions, for the maxima over a block of observations. The generalized Pareto distribution (GPD) is suited to model exceedances over a high threshold.

Two different ways of combining machine learning and extreme value models are presented. In the first approach, a smooth extension of the GPD is introduced. This hybrid distribution can then be employed as a mixture component and allow the joint estimation of the central part and extremal part of the distribution. The mixture of hybrids can be made conditional by seeing its parameters as functions of covariates. These functions can be implemented with neural networks. The conditional mixture has shown to be useful at modeling river runoff and precipitation conditionally on covariate information.

In the second approach, a spatial extreme quantile estimation is proposed for rainfall. The first step consists in building a climate space where two sites are close if they are similar in rainfall distribution. Similarity is dened in terms of the Kolmogorov-Smirnov (KS) statistic computed on the rainfall maxima from two sites. Multidimensional scaling is applied to the KS statistics to provide a low dimensional embedding space where two sites are close if their KS statistic is small. A neural network is trained to map a site with no observations from its spatial coordinates to the embedding space coordinates. A distance between sites can be defined in the climate space and used to weight the log-likelihood estimator of GEV parameters. This provides a mean to interpolate the distribution of extreme rainfall at sites with no observations.

This is joint work with : Yoshua Bengio, Stéphane Girard, Philippe Naveau, Eric Sauquet and Mathieu Vrac.

Nonlinear Atmospheric Circulation Regimes and Extreme Events

Christian Franzke

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Society is increasingly impacted by natural hazards which cause huge damages in economic and human terms. Many of these natural hazards are weather and climate related. In my presentation I will show that nonlinear atmospheric circulation regimes affect the propensity of extreme wind speeds and storms. These regimes are systematically identified by a Hidden Markov Model (HMM) using a persistence criterion. The regime states are associated withdistinct changes in the storm tracks and the frequency of occurrence of cyclonic and anticyclonic Rossby wave breaking. Consequently, the regime states also affect the occurrence of extreme events and also favour the serial clustering of storms. Serial clustering means that storms come in bunches and, hence, do not occur independently. This suggests that traditional extreme value statistics can no longer reliably be applied to estimate return periods of extreme events. The use of waiting time distributions for extreme event recurrence estimation will be discussed. I will also show evidence for long-range dependence of the atmospheric circulation.

Extreme value statistics are based on the premise that extreme events are iid but this is rarely the case in natural systems where extreme events tend to cluster. Thus, no account is taken of memory and correlation that characterise many natural time series; this fundamentally limits our ability to forecast and to estimate return periods of extreme events.

In my presentation I will discuss two possible causes of this clustering: (i) The propensity of extreme events to depend on large-scale circulation regimes and (ii) the long-range correlation properties of surface windspeeds enhances the likelihood of extreme events to cluster. These two characteristics affect the return periods of atmospheric extreme events and have thus societal impacts.

A climate model intercomparison at the dynamics level

Anastasios A. Tsonis[1] and Karsten Steinhaeuser[2]

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[2] Department of Computer Science & Engineering, University of Minnesota, Minneapolis, MN 55455 USA.

Until now, climate model intercomparison has focused primarily on annual and global averages of various quantities or on specific components, not on how well the general dynamics in the models compare to each other. In order to address how well models agree when it comes to dynamics they generate, we have adopted a new approach based on climate networks. We have considered 28 pre-industrial control runs as well as 70 20th-century forced runs from 23 climate models and have constructed networks for the 500 hPa, surface air temperature (SAT), sea level pressure (SLP), and precipitation fields for each run. Then we employed a widely used algorithm to derive the community structure in these networks. Communities separate “nodes” in the network sharing similar dynamics. It has been shown that these communities, or sub-systems, in the climate system are associated with major climate modes and physics of the atmosphere. Once the community structure for all runs is derived, we use a pattern matching statistic to obtain a measure of how well any two models agree with each other. We find that, with possibly the exception of the 500 hPa field, the consistency for the SAT, SLP, and precipitation fields is questionable. More importantly, none of the models comes close to the community structure of the actual observations (reality). This is a significant finding especially for the temperature and precipitation fields, as these are the fields widely used to produce future projections in time and in space.

Parallel measurements to study inhomogeneities in daily data

Victor Venema (1), Enric Aguilar (2), Renate Auchmann (3), Ingeborg Auer (4), Theo Brandsma (5), Barbara Chimani (4), Alba Gilabert (2), Olivier Mestre (6), Andrea Toreti (7), and Gregor Vertacnik (8)

(1) University of Bonn, Meteorological Institute, Bonn, Germany,
(2) University Rovira i Virgili, Center for Climate Change, C3, Tarragona/Tortosa, Spain,
(3) University of Bern, Institute of Geography, Bern, Switzerland,
(4) Zentralanstalt für Meteorologie und Geodynamik, Austria,
(5) Royal Netherlands Meteorological Institute, The Netherlands,
(6) Météo-France, Direction de la Production, Toulouse, France,
(7) Justus-Liebig Universitaet, Giessen, Germany,
(8) Slovenian Environment Agency, Ljubljana, Slovenia.

Daily datasets have become a focus of climate research because they are essential for studying the variability and extremes in weather and climate. However, long observational climate records are usually affected by changes due to nonclimatic factors, resulting in inhomogeneities in the time series. Looking at the known physical causes of these inhomogeneities, one may expect that the tails of the distribution are especially affected. Fortunately, the number of national and regional homogenized daily temperature datasets is increasing. However, inhomogeneities affecting the tails of the distribution are often not taken into account.

In this literature review we investigate the physical causes of inhomogeneities and how they affect the distribution with respect to its mean and its tails. We review what is known about changes in the distribution from existing historical parallel measurements. We discuss the state of the art in the homogenization methods for the temperature distribution. Finally, we provide an overview of the quality of available daily datasets that are often used for studies on changes in extremes and additionally describe well-homogenized regional datasets.

As expected, this review shows that the tails of the distribution are more affected by changes in monitoring practices than the means. Many often-used daily datasets are not homogenized (with respect to the distribution). Given the strong interest in studying changes in weather variability and extremes and the existence of often large inhomogeneities in the raw data, the homogenization of daily data and the development of better methods should have a high research priority.

This research would be much facilitated by a global reference database with parallel measurements. The climate community, and especially those involved in homogenization, bias correction and the evaluation of uncertainties, should take an active role to foster the compilation of such a reference database. We have started an initiative collecting parallel datasets. Its aims will be explained and its progress will be presented.

Assessing robustness of daily temperature datasets through benchmark testing of homogenisation algorithms

Rachel Warren
University of Exeter

Inhomogeneities in temperature records can easily confound attempts to investigate how our climate is changing. This issue has been investigated at the annual, seasonal and even monthly scales and is still an area of growing research. Attempts to produce robust homogeneous daily temperature sets are still in their infancy, especially for large regions where automation of homogenisation processing becomes necessary. Working alongside current research projects at the UK Met Office to assess robustness of monthly temperature datasets through benchmark testing, this work will feed into the International Surface Temperature Initiative's (www.surfacetemperatures.org) aim to create 'multiple, long, high-resolution, traceable data products that are robust to varying non-climatic influences'. In particular this work will look at using statistical validation methods to assess homogenisation algorithms through benchmarking on synthetic data where the underlying truth of the system can be known, with the aim that these algorithms can then be applied to real-world data to meet the International Surface Temperature Initiative's goal.

While still in its early stages, this work focuses on methods for producing realistic synthetic station data for large regions/networks that mimic real-world station behaviour and real-world inhomogeneities in terms of internal variability and spatial relationships. Achieving realistic station behaviour and characteristics of inhomogeneities on the daily scale is far more complex than for monthly means due to the greater variability, requiring innovative use of geo-spatial statistical methods to both describe these behaviours and to model synthetic analogues. With the creation of such data comes the opportunity to benchmark the performance of daily homogenisation algorithms, allowing judgements of their relative strengths and weaknesses and an evaluation of their applicability in different data situations.

Supervisors: Professor T. C. Bailey, University of Exeter, Professor Ian Jolliffe, University of Exeter, Dr Kate Willett, UK Met Office Hadley Centre

Homogenization of Chinese daily surface air temperatures and analysis of trends in the extreme temperature indices

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[2] Climate Research Division, Science and Technology Branch, Environment Canada, Toronto, Ontario, Canada

This study first homogenizes time series of daily maximum and minimum temperatures recorded at 825 stations in China over the period from 1951 to 2010, using both metadata and the penalized maximum t test with the first order autocorrelation being accounted for to detect changepoints, and using the quantile-matching algorithm to adjust the data time series to diminish non-climatic changes. Station relocation was found to be the main cause for non-climatic changes, followed by station automation. The effects of non-climatic changes on estimation of trends in the annual mean and extreme indices of temperature are illustrated. The data homogenization is shown to have improved the spatial consistency of estimated trends.

Using the homogenized daily minimum and daily maximum temperature data, this study also analyzes trends in extreme temperature indices. The results show that the vast majority (85-90%) of the 825 sites have experienced significantly more warm nights and less cold nights since 1951. There have also been more warm days and less cold days since 1951, although these trends are less extensive. About 62% of the 825 sites were found to have experienced significantly more warm days, and about 50%, significantly less cold days. None of the 825 sites were found to have significantly more cold nights/days or less warm nights/days. These indicate that the warming is stronger in nighttime than in daytime and stronger in winter than in summer. Thus, the diurnal temperature range was found to have significantly decreased at 49% of the 825 sites.

Homogeneity Test and Adjustment of Korean Seasonal Temperature Data

Yung-Seop Lee[1] . Hee-Kyung Kim[2] . Jung-In Lee[3]. Jae-Won Lee[4] . Hee-Soo Kim[5]

[123] Department of Statistics, Dongguk University-Seoul, Seoul, Korea
[45] KMA Meteorological Resources Division, Seoul, Korea

Climate data can be contaminated by non-climatic factors such as the station relocation or new instrument replacement. For a trusted climate forecast, it is necessary to implement data quality control and test inhomogeneous data. For homogeneity test in this study, we proposed an adjusted SNHT method and compared with traditional SNHT and MLR method. Before the homogeneity test, a reference series was created by *d* index to measure the seasonal temperature series relationship between the candidate and surrounding stations. The proposed method is demonstrated using daily mean temperatures, daily minimum temperatures and daily maximum temperatures measured in each season and climatological stations. After comparing three homogeneity tests, the traditional and the adjusted SNHT method, we found the adjusted SNHT method was slightly superior to the traditional ones. Finally, we adjusted inhomogeneous seasonal temperature series applying a correction factor before an identified break point year.

Keywords
Homogeneity test, d index, data quality control, SNHT, MLR.

* This work was funded by the Korea Meteorological Administration Research and Development Program under Grant CATER 2012-3120.

HOMOGENIZATION OF MONTHLY PRECIPITATION TIME SERIES: A PROPOSAL FOR IDENTIFYING NEIGHBORHOOD METEOROLOGICAL STATIONS FOR BAJO MAGDALENA CLIMATIC REGION IN COLOMBIA (SOUTH AMERICA)

Néstor R. Bernal S[1]., Juan S. Barrios M[2]., Marcos A. Ramos C[3].

Distrital University Francisco José de Caldas,

[1] Statistician - MSc. Meteorology; Professor of Statistics, Environmental Engineering, Faculty of Natural Resources and Environment, Bogotá, D.C., Colombia (South América)

[2, 3] Students, Environmental Engineering

This paper proposes a process of homogenization of monthly precipitation time series, it includes four stages: i) Estimation of missing values using ARIMA and additive outliers framework, ii) Detection of changes of mean for each month using Worsley test, iii) Identification of neighborhood meteorological stations using Moran Index for estimation of spatial correlation of annual precipitation, although three criteria were included for identification of neighborhood for two meteorological stations: they must located in same watershed (hidrological subzone), same interval of annual precipitation and same altitudinal interval, iv) homogenization process using curve double mass methodology. The results shows that 68,25 kms was radius of spatial correlation for Bajo Magdalena climatic region, this stage related of neighborhood between meteorological stations was implemented using a Macro - Excel® spreadsheet; the homogenization it is illustrated for 6 meteorological stations.

Keywords

Homogenization, detection of changes, neighborhood between meteorological stations, radius of spatial correlation.

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Break Position Errors in Climate Records

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Long instrumental climate records suffer from inhomogeneities due to, e.g., relocations of the stations or changes in instrumentation, which may introduce sudden jumps into the time series. These inhomogeneities may have influences in both directions: masking true or introducing spurious trends. Homogenization algorithms use the difference time series of neighboring stations to identify breaks. Modern multiple break point methods search for the optimum segmentation, which is characterized by minimum internal variance within the segments and maximum external variance between the segment means.

We analyze the accuracy of these homogenization methods and concentrate on the uncertainty in the position of the break. Due to unavoidable random noise in the difference time series, the segmentation method may find a slightly shifted break position, which attains a higher external variance than the true one. Not only direct neighbors of the true break needs to be considered, but all neighbors; that one with the largest external variance will be chosen as erroneous optimum. The variances of shifted segmentations are describable by a sum over a successively expanded sequence of a normal distributed random variable minus a term, which grows linearly with the length of the sequence. Such a process is known as Brownian motion with drift. Thus, the probability distribution of break position deviations can be largely described by the time of the maximum of a Brownian motion with drift, where the jump height to noise ratio defines the drift size.

Novel global datasets of observed temperature and precipitation extremes: analysis of long-term changes and comparison to reanalyses and climate model data

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We present two newly developed observational global gridded data sets for monitoring changes in climate extremes. One dataset, GHCNDEX, is based on meteorological data archived in the Global Historical Climatology Network (GHCN)-Daily dataset, the world's largest repository of daily in situ observations of temperature and precipitation. The other, HadEX2, incorporates only high-quality homogeneous station data. Climate extremes indices are calculated from the daily station time series before the indices are interpolated onto global grids.

Based on these data sets, we analyse how temperature and precipitation extremes have changed during the past century. We compare the results across the two datasets, as well as to climate extremes indices calculated from global reanalyses data and climate models.

We find generally good agreement between the observational datasets on global to (sub-) continental spatial scales. The temperature indices show consistent and wide-spread warming trends over much of the globe, as reflected by e.g. increasing numbers of warm days and nights and fewer cold days and nights, higher extreme temperature values and longer warm spell durations. Extreme precipitation indices are characterized by a higher variability than extreme temperatures, and changes are spatially more heterogeneous. However, on global average we also find a tendency towards stronger precipitation, and larger areas with significant trends towards wetter conditions than areas with drying trends.

Larger differences are found for some of the reanalyses results, particularly during the pre-satellite era. For the NCEP1 reanalysis we document spurious values of maximum temperature which seem to make this dataset unsuitable for the analysis of warm temperature extremes. We conclude that there is high robustness of the observational results since the middle of the 20th century, but reanalyses seem suitable for this kind of global analysis of climate extremes only during the most recent 3 decades when satellite data are used for assimilation. The ensemble of CMIP5 climate simulations generally shows a comparable tendency of changes, however there is also a large inter-model spread.

First contributions to the Climate of the 20th Century Detection and Attribution Project

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This talks presents results of a pilot effort in preparation for the international WCRP CLIVAR Climate of the 20th Century (C20C) Detection and Attribution Project. The C20C project will produce large ensembles of simulations of the climate we have experienced using multiple atmospheric models driven by observed boundary conditions, as well as large ensembles of simulations for various estimates of the climate that might have been had human activities not interfered with the climate system. These ensembles will allow characterisation of how anthropogenic emissions have contributed to the risk of extreme weather events over the past half century, as well as discerning changes in seasonal predictability and in the frequency of extreme events during that period.

Here we report on an early contribution using three atmospheric models, examining how anthropogenic greenhouse gas emissions have contributed to the risk of various events during the 2009-2011 period. A near-identical experimental protocol has been followed with all three models, according to the proposed protocol for the C20C project, allowing for a indication of the importance of model selection for assessment of attributable risk, and the degree to which estimates of attributable risk using the time-slice atmospheric modelling approach vary from year to year.

Automated Statistical Model-based Spatial Data Quality Control

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Good data quality is crucial to various meteorological applications and climatological studies. While techniques of data quality control (DQC) on observations at a single station have been well developed, DQC on multiple stations is relatively weak because of difficulties in assessing the influence of localised topographical and environmental effects on the observations. This paper developed a fast and efficient spatial data quality control (SDQC) algorithm based on observations at multiple stations. Near surface level observations of temperatures, relative humidity, wind, precipitation and visibility were collected from different regions varying from flat terrain, to coastal, mountainous and urban environments. The data cover the period from July 2011 to end of February 2012 with number of samples varying from 3755 to 17023. The data collected were then used to verify the SDQC algorithm. It is found that the SDQC algorithm is able to detect effectively sensor errors in various environments The percentage of detected errors to total number of available samples varies from zero to 0. 66%. The algorithm was also compared to conventional single station based DQC algorithms. The results show that the innovative and automated SDQC algorithm, which is light in calculation, is able to identify faulty observational data effectively and instantly. This means that it is ideal for real-time applications where constant monitoring of data quality is important and instant usage of data is critical (e.g. in high impact weather monitoring and prediction). The study also shows that for non-continuous variables like precipitation, the SQDC algorithm is less effective.

Keywords
data quality, spatial analysis, statistics, algorithm, sensor error

Effects of adjustment for non climatic discontinuities on determination of temperature trends and variability over Iran

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In situ observations of surface air temperature at 55 weather stations in Iran are analysed for homogeneity and trends over the period 1960-2010. Among them 32 stations have data available for the whole period. The other 23 stations with shorter records are used only to confirm variability during overlapping periods. Discontinuities in the temperature series relate mostly to relocation and changes of environmental conditions at individual stations. These changes alter the statistical characteristics of temperature, including the mean, variance, and frequency distribution and introduce uncertainties in spatially averaged trends. This article determines new estimates of temperature trends over Iran after the detection of artificial change points and application of homogenization.

The regional trend of temperature is estimated using seasonal and annual minimum and maximum temperature from stations that have identical variability across the country. The country may be segmented to 10 such regions in terms of trends and variability of temperature. There is little doubt that temperatures have increased in all regions at nearly equal rates of 0.4-0.5 and 0.2-0.3 (°C /decade) for minimum and maximum temperature, respectively in Iran. The finding in earlier work of a few individual stations with negative trends is found to be due to artificial effects like relocation.

Keywords
Iran, temperature, homogeneity, non climatic discontinuity, adjustment

Effective constraints for regional climate change projections

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Ongoing climate change will eventually manifest in observed time series. Therefore, it seems natural to ask to what extent recent climate change is informative of future expected change. At global to continental scales, recent observed warming has been shown to offer useful constraints for future projections. Here we assess to what extent information on recent observed subcontinental to local change constrains projections of future expected climate change.

We first analyse the relationship between aspects of recent regional change and future projected change in near-surface temperature and precipitation across a subset of models in the CMIP5 dataset. Preliminary results suggest that recent regional change explains less than 40% of the variance in future climate in most regions and seasons. At present, observed regional climate change therefore provides only weak constraints for future projections. The greenhouse gas (GHG) component of recent change, however, provides much stronger constraints. This highlights the differences in the regional response to non-GHG forcing across different models and the need to understand the causes of observed regional change.

The existence of a strong link between variability in recent regional features and future climate change, however, is only one element for effective constraints. In addition, the signal-to-noise ratio of recent changes and existence of significant differences between the observed and simulated trends in some models are important as well. Therefore, we apply recent observed regional change as a constraint for future projections. We validate the method in a perfect model framework using alternative models from CMIP5 as pseudo-observations. Finally, we compare the observationally-constrained projections to unconstrained projections and contrast these results with projections constrained by traditional model evaluation based on the recent observed climatology.

Projected changes in the Northern Annular Mode: why do CMIP3 and CMIP5 disagree?

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A crucial challenge in climate studies consists in determining how climate change may affect the preexisting natural modes of atmospheric variability. In Northern extratropics, the leading pattern of the atmospheric dynamics is known as the Northern Annular Mode (NAM), often computed as the first Empirical Orthogonal Function of sea-level pressure (SLP) or geopotential height at 500mb (Z500). The NAM strongly controls the intraseasonal-to-interannual variability of the surface climate by modulating the mid-latitude jet stream, especially in wintertime. In particular, temperature extremes over North-America or Eurasia are generally associated with anomalous persistences of either positive or negative phase of the NAM, as illustrated during recent cold winters of 2009/10 and 2010/11.

Here we compare the fate of the NAM in both previous (CMIP3) and new (CMIP5) generations of multi-model projections for the twentyfirst century, under similar scenarios of greenhouse gas and aerosol concentrations (SRESA2 and RCP8.5). As shown in many studies, CMIP3 projections exhibited a positive NAM trend, albeit we show that this response differ between surface (SLP) and aloft (Z500). In contrast CMIP5 projections rather reveal a negative trend, especially in the Z500 NAM index. We show that this CMIP3/CMIP5 discrepancy is associated with (i) a faster Arctic sea ice loss in early winter, leading to a stonger thermal expansion of the lower troposphere over the polar region, and (ii) a positive trend in the Pacific - North-American oscillation (PNA) resulting from a higher Western Tropical Pacific warming. We finally discuss the role of the difference in emission scenarios (SRES vs. RCP) by investigating NAM responses in 1%-CO_2 idealized experiments.

Detecting precipitation changes in CMIP5 models and observations at multiple spatial scales

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Almost all models participating in the Coupled Model Intercomparison Project phase 5 (CMIP5) predict both an intensification of the global hydrological cycle and a shift in the observed large-scale patterns of global precipitation. However, efforts to understand observed changes using multiple models are hindered by both model bias and observational uncertainty. For example, the expansion of subtropical dry zones may be robust across all models, but biases in large-scale circulation lead to cancellation of trends in the multi model average. Additionally, we cannot simply concatenate multiple control run datasets to understand internal climate “noise” without introducing spurious modes of variability due to shifts in feature locations across models. On the observational side, the lack of reliable global data, particularly for evaporation, impedes detection and attribution of hydrological cycle changes. In order to minimize these challenges, we utilize a new spatial filtering method to isolate physical processes dominant at different spatial scales. We assess CMIP5 model performance at these scales, evaluating errors in variability and pattern correlation. We then demonstrate how a targeted choice of spatial filter can remove both small- and large-scale noise, leading to “cleaner” data for detection and attribution purposes. This “clean” data shows robust poleward shifts of the model dry zones and storm tracks as well as a widening of the tropical belt in both models and observations over the period 1979-2011.

Genesis frequency of tropical cyclones in the CMIP5 climate models: use of genesis potential index

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The potential for tropical cyclogenesis in a given oceanic and atmospheric environments can be represented by genesis potential index (GPI). Using 18 Coupled Model Inter-Comparison Project phase 5 (CMIP5) models, the annual cycle of GPI and interannual variability of GPI are analyzed in this study. In comparison, the annual cycle of GPI calculated from reanalysis data is revisited. In particular, GPI differences between CMIP5 models and reanalysis data are compared and the possible reasons for the GPI differences are discussed. ENSO (El Nino and Southern Oscillation) has a tropical phenomenon, which affects tropical cyclone genesis and passages. Some dynamical interpretations of tropical cyclogenesis are suggested using that GPI is a function of four large-scale parameters. GPI anomalies in El Nino or La Nina years are discussed and the most contributable factors are identified in this study. In addition, possible dynamics of tropical cyclogenesis in the Northern Hemisphere Pacific region are discussed using the large-scale factors.

Validation of CMIP5 multimodel ensembles through the smoothness of climate variables

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In spatial modeling, the smoothness of spatial processes is often of interest, especially when we focus on the small scale variability of the process or prediction at unobserved sites. For geophysical processes such as climate variables, it is common that such smoothness varies spatially.

Recently, Lee (2012) proposed a statistical method to estimate the smoothness of spatial processes by local likelihood approximation. The method takes advantage of the fact that nearby observations contain most information on the smoothness of a variable, and the local likelihood approximates a composite likelihood by conditioning on the one or two neighboring observations. The approach has two main advantages. First, it is general in the sense that it does not assume a certain parametric form of covariance functions. Second, it is computationally efficient even for large irregularly spaced data, while statistically more efficient than the estimates based on the existing least squares method.

We apply this method to various climate variables from CMIP5 multi-model ensembles and estimate their smoothness over the 22 climate regions considered in Giorgi and Francisco (2000). Our preliminary result indicates that the smoothness of climate variables changes significantly over different climate regions and the estimates from different multi-model ensembles also vary significantly.

This is a joint work with Mikyoung Jun (Texas A&M University) and Marc Genton (KAUST).

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Global precipitation extremes projected by high-resolution CMIP5 models

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The development of adequate risk reduction strategies for precipitation extremes is strongly dependent on the availability of a reliable characterisation of the current behaviour and potential future changes of these extremes. We carry out a seasonal assessment of daily extremes using historical simulations and projections under two RCP scenarios from eight high resolution Global Climate Models participating to the Coupled Model Intercomparison Project Phase 5. The analysis is performed in the frame of the Extreme Value Theory combining a Generalised Pareto approach for modelling the excesses with the Generalised Probability Weighted Moments method and a modified Anderson-Darling test for the estimation of the parameters and the goodness-of-fit, respectively.

In the historical period, reliable estimations cannot be obtained for large areas over the tropics and subtropics, while lower inter-model variability and good agreement with available gridded observations are evident over northern Eurasia, the Euro-Mediterranean region and North America. For projections at the end of the 21st century, a consistent and reliable increase of 25- and 50-year return levels is estimated over the mid and high latitudes of both hemispheres for all seasons. The maximum increase of 50-year return levels is estimated for autumn over the high latitudes of the Northern hemisphere: 45% with respect to the reference period 1966-2005.

Spatial Dependence between Extreme Precipitations in CMIP5

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One of the objectives in the Coupled Model Intercomparison Project Phase 5 (CMIP5) is to facilitate the historical attribution and future projection of climate extremes and to advance our understanding of the impacts of extreme events on society and the environment. Extreme value theory concerns the application of statistical methodologies to understand low-frequency but high-impact extreme events in climate data. In particular, spatial modeling of climate extremes has been investigated to account for regional patterns of extremes and to characterize the dependence among locations based on the extreme value theory. However, there has been relatively little study of changes in the spatial correlation of extreme precipitation from CMIP5 projections on seasonal timescales and across emission scenarios.

In this study we analyze the dependence structure of extreme precipitation from CMIP5 model experiments, and we estimate extremal coefficients to quantify the spatial dependence of the rainfall distribution “tails”. We also focus on the patterns of spatial dependence in northern California to understand the influence of Atmospheric Rivers (ARs), narrow atmospheric systems with elevated water vapor that cause severe downpours and flooding over much of the western coastal United States. This study yields the connections between the spatial dependence in extreme precipitation and the properties of the ARs making landfall along the Pacific coast.

European temperatures in CMIP5: origins of present-day biases and future uncertainties.

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European temperatures and their projected changes under the 8.5 W/m2 Representative Concentration Pathway (RCP8.5) scenario are evaluated in an ensemble of 33 global climate models participating in the fifth phase of the Coupled Model Intercomparison Project (CMIP5). Respective contributions of large-scale dynamics and local processes to both biases and changes in temperatures, and to the inter-model spread, are then investigated from a recently proposed methodology based on weather regimes.

On average, CMIP5 models exhibit a cold bias in winter, especially in Northern Europe. They overestimate summer temperatures in Central Europe, in association with a greater diurnal range than observed. The projected temperature increase is stronger in summer than in winter, with the highest summer warming occurring over Mediterranean regions. Links between biases and sensitivities are evidenced in winter, suggesting a potential influence of snow cover biases on the projected surface warming. A brief analysis of daily temperature extremes suggests that the intra-seasonal variability is projected to decrease (slightly increase) in winter (summer).

Then, in order to understand model discrepancies in both present-day and future climates, we disentangle effects of large-scale atmospheric dynamics and regional physical processes. In particular, in winter, CMIP5 models simulate a stronger North-Atlantic jet stream than observed and, in contrast with CMIP3 results, the majority of them suggest an increased frequency of the negative phase of the North-Atlantic Oscillation under future warming. While large-scale circulation only has a minor contribution to ensemble-mean biases or changes, which are primarily dominated by non-dynamical processes, it substantially affects the inter-model spread. Finally, other sources of uncertainties, including the North-Atlantic warming and local radiative feedbacks related to snow cover and clouds, are briefly discussed.

Skill of Global Climate Models for Regional Statistical Downscaling.

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Global climate models (GCMs) can be used to connect global scale predictions with regional dynamics by downscaling methods. Because the largest source of uncertainty on downscaled projections is the choice of the GCMs, the aim of this study is to evaluate the skill of the GCMs within Coupled Model Intercomparison Project (CMIP) phases 3 and 5. The study is focus on the European Atlantic region.

Statistical downscaling methods are routinely used in climate projections since their low computational cost enables multi-model ensemble. One of the most popular statistical downscaling methods used for climate change applications is the weather pattern-based approach. The weather pattern approach characterizes synoptic classifications on environmental phenomena and it is based on the study of the relationships between general atmospheric circulation and regional climates (surface environment). A map-pattern classification has been used in this work to i) evaluate the performance of the GCMs and ii) downscale ocean wave climate from the best GCMs.

One variable that summarizes the synoptic atmospheric dynamics and directly reflects the atmosphere-ocean interaction is the sea level pressure (SLP); therefore 100 weather types have been characterized from daily SLP fields. The weather types were obtained from K-means clustering algorithm after reduction of dimensionality from principal component analysis. The reliability of GCMs to reproduce the spatial patterns and temporal transition has been investigated by a set of tests: i) the skill of GCMs to reproduce the most important synoptic situations, ii) the skill of GCMs to reproduce the historical inter-annual time-scale variability, and iii) the consistency of GCMs experiments during 21st century projections.

This study indicates that the most skilled GCMs in the south European Atlantic region are UKMO-HadGEM2, ECHAM5/MPI-OM, MIROC32HIRES and MRI-CGCM2.3.2 for CMIP3 scenarios, and ACCESS1.0, EC-EARTH, HadGEM2-CC, HadGEM2ES, MPI-ESM-P and CMCC-CM for CMIP5 scenarios. These models are recommended for the estimation of regional multi-model projections of surface ocean variables in North eastern Atlantic region. Results of multi-model wave climate under several climate scenarios have also been estimated and different behavior and changes have been found for the analyzed domain.

Intercomparison of precipitation characteristics in CMIP5 simulations with observation and reanalysis over China

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Current variability of precipitation over China is analyzed using outputs of 27 models of the Coupled Model Intercomparison Project phase 5 (CMIP5) and compared with observational estimates for the period 1961-2005. Analysis focuses on selected regions of China for winter (DJF) and summer (JJA) and the whole year. In addition to comparing results from the different CMIP5 models, we also compare simulated precipitation with those obtained from observed and reanalysis precipitation. Based on the observations, results reveal that no significant long-term change in the country-averaged annual precipitation was seen for the period 1961-2005. However, an obvious tendency of drying in the Yellow River Basin and the North China Plain in terms of precipitation has been found, and the largest drop in precipitation occurred in Shandong Province. Meanwhile, an insignificant wetting trend in the Yangtze River Basin and most parts of western China could be detectable. For the Yangtze River Basin, the increased annual precipitation mainly resulted from the significant rising of summer rainfall, though winter precipitation also tended to increase. By comparison of CMIP5 simulations with the observation and reanalysis, we found that the spatial distributions of precipitation show good agreement over most areas of China, although the magnitude and location of the rainfall belts differ among the reanalysis, observation and CMIP5 simulations over South and West China. Some CMIP5 models behave consistently better over some regions compared with others. And the CMIP5 multi-model mean (MMM) has the ability to manifest the spatial characteristics of the annual and seasonal precipitation over China, although the magnitude is underestimated in general.

Spatio-temporal analysis of extreme precipitation via Kernel regression Generalized Probability Weighted Moments (KerGPWM)

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Understanding climate variability is necessary for interpreting any projections of future climate. Especially changes in the frequency and intensity of climate extremes are of interest for instance for risk management. Rare by denition, the study of the variability of extreme events is challenging.

To describe the variability of extremes, a common approach utilizing extreme value statistics, is to include well-chosen covariates in the parameters of an extreme value distribution via a parametric form. For instance, for trend assessment, the parameters depend linearly on the time. With Maximum Likelihood estimation (MLE) it is then straightforward to estimate the parameters. However, a priori knowledge of the type of the para-metric form is necessary to yield estimates. Additionally, MLE is slow for large data sets, not robust to outliers and more disturbingly optimization can lead to aberrant estimates. For Identically and Independently Distributed (i.i.d.) extreme value statistics, there exist different approaches to circumvent MLE for instance with the method- of-moments. For nonstationary extremes, Smith et al. (2013) propose to combine generalized probability weighted moments with Kernel regression to model the dependence of the scale parameter of the Generalized Pareto Distribution(GPD) on covariates (KerGPWM).

Here we apply the KerGPWM method to estimate the spatio-temporal variability of German heavy precipitation events. We let the scale parameter of the GPD vary with covariates such as time, latitude and longitude. We present results on the analysis of approximately 5000 time-series over Germany, most of which cover the period 1961-2012. We aim at identifying seasons as well as regions for which a trend in the return levels of precipitation extremes is detectable and at identifying covariates mirroring the spatial variability of heavy precipitation events.

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Exploring multi-annual regimes in total and extreme Argentinian precipitation using hidden Markov models

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NCAR

The humid and semi-arid area of the Argentinian Pampas is influence by many external factors, of which ENSO is the major single source of seasonal to interannual climate variability. The region has also experienced marked inter-decadal climate variability and significant increases in annual precipitation until recently; however, it is unclear whether the variations form part of a longer term gradual trend, or arise from “regime shifts”. Recent increases in precipitation expanded the boundary of rainfed agriculture towards drier regions and have contributed to major changes in land use. However, these evolutions in land use may not be sustainable if the climate returns to a drier epoch, as suggested by recent drought.

Statistical analyses of annual to decadal climate variability are often modeled in terms of deterministic shifts in the mean or variance of a time series, using techniques such as change-point analysis. Instead, we use a fully probabilistic approach based on “hidden” mixtures of distributions, in which there is a probability of randomly shifting from hidden state to another during each year. We examine historical meteorological observations for evidence of trends and/or multiple climatic regimes to support the agricultural community in decision making over the next 10-30 years. Temperature statistics, such as annual daily maximum/minimum or maximum/minimum daily temperature range demonstrate clear trends consistent with both increases in global mean temperature and their associated atmospheric responses, and well documented urban heat island effects. While the seasonal temperature statistics tally well with seasonal measures of ENSO, there is little other evidence of multiple climatological states. In contrast there are few statistically significant trends in seasonal and annual precipitation statistics, and correlation with ENSO is less significant, but hidden states reflecting dry and wet years are more apparent in the >60 year time series.

Closer examination of the annual and seasonal total wet day count and total precipitation reveal a significant improvement (tested using the AIC and BIC) in data representation when mixtures of two or more Gaussian or Poisson distributions are fitted. This supports the hypothesis that multiple states exist giving rise to wetter or drier years. “Regime-like” behavior can be introduced into the hidden mixture model through a Markov chain to allow for temporal persistence in the hidden states (i.e. a hidden Markov model; HMM), in addition to dependence on atmospheric covariates such as ENSO. The ultimate focus of this research is on the high impact weather phenomena which can have catastrophic consequences for agriculture. Therefore, we will extend the mixture models and HMMs to apply to temperature and precipitation extremes using Extreme Value Theory.

Trends in stratospheric ozone profiles using functional mixed models

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We consider the modeling of altitude dependent patterns of ozone variations over time. Umkher ozone profiles from 1978 to 2011 are investigated at two locations: Boulder (USA) and Arosa (Switzerland). The study consists of two statistical stages. First, we approximate ozone profiles using a functional principal component analysis, which penalizes excessive roughness of the shape of the ozone profiles. Secondly, we estimate the effects of covariates - month, year (trend), quasi biennial oscillation (QBO), solar cycle, arctic oscillation (AO) and the 15 E1 Nino/Southern Oscillation (ENSO) cycle - on the principal component scores of ozone profiles over time using Generalized Additive Mixed Effects Models (GAMMs) incorporating a more complex error structure that reflects the observed seasonality in the data. The analysis provides more accurate estimates of influences and trends, together with enhanced uncertainty quantification. We are able to capture fine variations in the 25 time evolution of the profiles such as the semi-annual oscillation. We conclude by showing the trends by altitude over Boulder. The strongly declining trends over the period 2003-2011 for altitudes of 32-64 hPa show that stratospheric ozone is not yet fully recovering.

Comparison AIC according to humidity indicators in model of association between humidity and respiratory disease

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Background

Humidity is important one of the meteorology and there are relative humidity and absolute humidity of humidity indicators. Studying which one indicators is suitable to model we analyzed association between humidity and respiratory disease which is sensitive to humidity

Aim

The purpose of this study examined Akaike information criterion of the model according to humidity variable which is relative humidity and absolute humidity respectively.

Method

We used the generalized additive model (GAM) to analyze data which is daily weather and asthma emergency department visit in Korea from 2007 to 2011 for humidity effect on respiratory disease. Using emergency department visit data of 6 cities, we analyzed to setmodel with humidity indicators, which are absolute humidity and relative humidity respectively after controlling air pollution condition, temperature and adjusted epidemic Swine influenza terms. Calculating moving average each of variables we controlled lag effect.

Result

Among 6 cities, Daegu, Incheon and Kwangju cities did not show significant results about humidity effect on respiratory emergency visit. In Busan and Incheon cities, AIC was calculated in the model with absolute humidity is lower (Busan: 9555.77, Incheon: 1635.4) respectively than that of using relative humidity. On the other hand, Seoul is shown higher AIC in model with using absolute humidity than that of relative humidity model.

Conclusion

This study examined AIC of model according to absolute humidity and relative humidity variables respectively. Busan and Incheon cities show lower AIC in the absolute humidity model. However AIC of Seoul is lower in relative humidity than that of absolute humidity model.

TEMPORAL VARIABILITY OF STATISTICAL PARAMETERS OF WINTER TEMPERATURES IN BUENOS AIRES, ARGENTINA

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The main objective of this work is to study the variability of the maximum and minimum temperatures of the winters in Buenos Aires city with emphasis on the behaviour of the winters length and intensity. The daily series of maximum and minimum temperatures of the Buenos Aires Central Observatory station (BACO) are used for this purpose. They cover the period from 1909 to 2009. The data from nearby stations (Aeroparque, Ezeiza and El Palomar) are used to complete the study (period 1959-2009).

The analysis of trends in different stations shows that they are positive. The effect of the trend is observed in the changes of the distributions of both temperature and daily amplitudes. The study of the daily amplitude along the century shows a decreasing. It would indicate that the city has mainly an effect of attenuating of the minimum temperature.

The existence of this trend and a particular study with monthly average temperature data (1865-2006) allows to select the first 20 years of information as a "natural state" of Buenos Aires city (period 1909-1928).

For the specific study it is necessary a smoothing of internal variability of each year through a harmonic analysis. Twenty years of natural state information is used to define the cold semester, represented by the days in which temperatures are below the annual average value. This value is taken as a reference to define the duration of the cold season in the remaining years of the record. As expected by the existence of this trend, cold season's duration decreases along the years, showing a noticeable inter annual variability. The intensity of each cold semester is also studied. As a second approach to the study of winter variations the distributions of extreme sequences are analyzed, both the cold and the warm ones, defined by the use of maximum and minimum temperatures. The warming that the city suffers is clear and it is modifying the temperature distributions and presenting fewer cold sequences, but also can be found particular years with long cold sequences of maximum temperatures at the end of the period.

Assuming the existence of this trend due to urban warming, it is removed to make the winters comparable. The length and intensity of cold semesters is again analyzed by the variability of the distributions moments, which are in this case negative binomial.

The series of temperatures in winter exhibit persistence in both inter and intra annual observation. For this analysis autocovariance function is used. In the cold semesters of each year a 75% of the days exhibit persistence of temperature values while the remaining reflects the negative change of covariance. The latter represents the passage of cold fronts over the area.

The results show that it is feasible to fit models to distributions of daily maximum and minimum temperature to describe changes through time.

Keywords
winter, temperatures, variability, extremes.

Spatio-temporal rainfall trends in southwest Western Australia

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Rainfall across southwest Western Australia has declined markedly over the past five decades, with noticeably drier winter conditions in the wettest months of the year (May to July). The spatial extent and intensity of the decline has accelerated rapidly since 2000. This has had serious implications for water resources and forest management, biodiversity and agricultural productivity in the north-eastern wheatbelt. It is therefore important to establish robust and reliable methods for describing rainfall variability and trends in space-time as their application can inform decision-making processes. Regression analysis is particularly useful in this context, and two approaches are considered here. First, a nonparametric representation of the trend, within the framework of generalized additive models, is used to investigate average rainfall changes in both time and space. This approach allows for inter-site dependence and therefore ensures valid statistical inference. Second, quantile regression is used to study changes in different aspects of the rainfall distribution. This approach offers more flexibility in modelling the data, and facilitates investigation of changes in the tails of the rainfall distribution. The proposed procedures are appealing to practitioners, as they do not involve the fitting of complicated spatio-temporal models, are computationally convenient to work with, and provide important information about changes in extremes as well as means. Indeed, preliminary results from the first approach have already underpinned the decision by Western Australian planners to proceed immediately with a $A450 million expansion of a new seawater desalination plant.

Changes in Tropical Cyclone Activity that has Affected Korea Since 1999

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This study investigated the annual frequencies of tropical cyclones (TCs) that affected Korea during summer (June-September) over the last 60 years. Using a statistical change-point analysis, we found that significant regime shifts occurred in 1999 and 2005, as well as in the mid-1960s and mid-1980s. Focusing on the recent TC activities, this study analyzed the differences between the high-frequency period from 1999 to 2004 (P1) and the low-frequency period from 2005 to 2010 (P2). The analysis reveals that TCs during P2 tended to occur, move, and recurve farther to the west in the western North Pacific (WNP). This is because the WNP high (WNPH) expanded farther to the west during P2 compared to P1; as a result, more TCs made landfall on the west coast of the Korean peninsula (KP) during P2. In contrast, during P1, TCs tended to make landfall more frequently on the south coast of the KP. This implies that the recent TC tracks landing on the KP shifted gradually to the northwest. The analysis of streamlines at 500 hPa show that an anomalous northerly strengthened in the KP due to the formation of an anomalous anticyclone and an anomalous cyclone to the west and east of the KP, respectively. These anomalies played a role in blocking TCs from moving to the KP. At 850 hPa, the anomalous anticyclonic circulation was strengthened in most of WNP. This circulation formed an unfavorable environment for TC genesis, reducing the TC genesis frequency during P2. We verified this low convective activity in the WNP during P2 by analyzing the outgoing longwave radiation, vertical wind shear, and sea surface temperature.

Experiences with data quality control, homogenization and gridding of daily records of various meteorological elements in the Czech Republic

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Quality control and homogenization has to be undertaken prior to any data analysis in order to eliminate any erroneous values and non-climatic biases in time series. In recent years, considerable attention was paid to daily data since it can serve, among other conventional climatological analysis, as non-biased input into extreme value analysis, correction of RCM outputs, etc. In this work, we describe and then apply our own approach to data quality control of station measurements, combining several methods: (i) by analyzing difference series between candidate and neighbouring stations, (ii) by applying limits derived from interquartile ranges and (iii) by comparing the series values tested with "expected" values – technical series created by means of statistical methods for spatial data (e.g. IDW, kriging). Because of the presence of noise in series, statistical homogeneity tests render results with some degree of uncertainty. In this work, the use of various statistical tests and reference series made it possible to increase considerably the number of homogeneity test results for each series and, thus, to assess homogeneity more reliably. Inhomogeneities were corrected on a daily scale. In the end, missing values were filled applying geostatistical methods; thus, the so-called technical series for stations were constructed, which can finally be used as quality input into further time series analysis. These methodological approaches are applied to daily data, for various meteorological elements within the area of the Czech Republic in the period 1961–2010, which allows demonstrate their usefulness. Series were processed by means of the developed ProClimDB and AnClim software (http://www.climahom.eu).

Acknowledgment

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Operational Quality Management for Climate Data in KMA Using Applied Statistics

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Utilization of climate data and information is important for human activities and security. Scientific monitoring and analysis of climate data is essential to understand climate change and to provide information to support decision making of national socio-economic policies. Quality Management process is applied to climate data to ensure the quality requirements are fulfilled before distribution to users.

In this paper, the operational quality control process for climate data in KMA will be introduced. Climate data quality control in the daily system of the historical climate network can be grouped into five general categories that are executed in the following order : plausible value check, internal consistency check, temporal consistency check, spatial consistency check, and summarization check.

Climatological range checks for precipitation and temperature will be explained. The time series for temperature are analyzed using mean, standard deviation and sigma to detect suspicious data.

Spatial regression checks for temperature and spatial corroboration checks for precipitation will be explained. The spatial regression check employs regression to verify the data quality. The spatial corroboration check examines correlation between target observation and neighbor values.

KMA has constructed operational quality control processes to verify the data quality grade and is willing to service the climate data with the quality grade to both general users and climatological researchers to maximize the utilization of data.

Methods for projecting daily precipitation in changing climate: Cross-validation tests with ENSEMBLES models

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Nine statistical projection methods for daily precipitation were tested for their ability to refine future climate projections using intermodel cross-validation. The evaluation was made using six RCM-GCM pairs selected from the ENSEMBLES data set. Five of the methods use the so-called delta change approach, while the remaining four methods are applied as bias correction methods. The complexity of the projection methods ranges from simple time mean scaling to more sophisticated and flexible quantile mapping algorithms. Results were calculated separately for South and North Europe in order to take the different precipitation climatology in these areas into account.

Cross-validation statistics indicate that the relative performance of the methods depends on time, location and the part of the distribution. Due to the large variability in daily precipitation, the benefit gained from using projection methods in contrast to the present-day precipitation climatology is marginal, but increases towards the end of the century. Although differences in the performance are small, bias correction methods generally perform better in adjusting the projections, especially in the late 21st century conditions. From individual methods, the overall performance is best for a non-parametric quantile mapping method using the bias correction approach. Due to the uncertainties in the projection methods, it was also tested whether the projections could be further improved by combining individual methods in the same manner as multi-model ensembles are built. The main finding is that the results are slightly improved, which suggests that using several methods in parallel could be beneficial when constructing future climate projections.

In addition to the cross-validation tests, real-world projections for several stations were calculated. From these projections, the importance of projection method uncertainties was assessed by decomposing the total variance into three components: model, method and the interaction term. The results show that although large part of the uncertainty comes from the differences between individual models, method uncertainty is non-negligible, and grows larger towards the upper tail of the distribution. Thus, to take the uncertainty into account, several projection methods should be used, especially when precipitation intensities in the upper tail of the distribution are of primary interest.

Investigating the Trends in the Potential Spread of Seasonal Predictability over South Africa Provinces

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This study assesses the existence and importance of long-term trends in the potential predictability of the South African seasonal climate in a quasi-stochastic atmospheric system. It analyses the spread of a large initial-condition ensemble of atmospheric model simulations covering a 50-year period, specifically examining monthly near surface air temperature and rainfall. Standard deviation and the distance between the 90th and 10th percentiles are used as contrasting measures to quantify the ensemble spreads of the simulations. Inter-annual variability and trends of the measured spreads are then investigated and compared. Results indicate a narrowing of the width of the ensemble, implying increasing potential predictability for precipitation over inland provinces, particularly from late austral spring to mid summer. Trends in temperature spread exhibit coastal-inland provinces dichotomy. It exhibit narrowing tendencies along the coasts and widening in inland provinces, except for winter when the reverse holds. These results imply that further understanding of how predictability is changing over time in forecast systems might improve interpretation of current skill in the light of evaluation of past skill.

Key words
Predictability. Ensemble spread / width. South Africa. Seasonal climates. Range of possibilities. Standard deviation. Uncertainty.

Climate Variability and Its Impact on Crop Production over Southern Region of Ethiopia: A Case of Study Sidama and Gedeo zone

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Climate variability is one of the principal factors that influence the crop productivity in land preparing, sowing or planting, and harvesting. In addition, the moisture contents and nutrient status of soil with crop production and in a time of growing period depend on climate. For this reason, assessing the variability of climate and its impact on crop production is the aim of this paper over Sidama and Gedeo Zones in southern region of Ethiopia. This study uses 8 meteorological stations historical recorded rainfall data within 17 years, downscaled General Circulation Model data of 25 to 30 and 17 years, crop yield data have been used. This data analyzed by using different software's like Instat, SPSS, Microsoft Office Excel, and Matlab.

The trend analysis of annual and kirmet rainfall has shown slight increase and belg rainfall has slightly decreased for the period of 1980 to 2009. However, these changes one not statistically significant.

Coefficient of variation of rainfall ranging between 0.66 and 0.85 shows high interannual variability as well much more intra- seasonal variability on Bega and Belg than Kiremt.

The precipitation concentration index (PCI) over study area ranges between 12 and 14 .According to Oliver (1980), this indicates high concentration of rainfall distribution.

Kiremt rainfall positively correlated with 3-months lag of southern oscillation index while negatively correlated with 3-month lag Nino3.4sea surface temperature anomaly whereas, Belg rainfall negatively correlated with 3-month lag of southern oscillation index and positively correlated 3-month lag Nino3.4sea surface temperature anomaly. This indicates that these two parameters could used as potential indictors in monthly rainfall predictions in this region up to 3 months in advance.

Annual areal rainfall shows relatively low coefficient of correlation with production with production of cereals. Belg rainfall shows statistically significant correlation in maize, wheat, barley and haricot-bean. Similarly kiremt rainfall is shown to have significant impact on the production of maize, teff, barely and haricot bean.

Based on these results regression equation have been tilted to predict cereal production from rainfall that have shown good strength of overall relation (R2) value between rainfall and cereal production.

Keywords

Climate variability, crop production, El-Nino and La-Nina year, CV, PCI, standardized rainfall anomaly and regression

The best-fitting meteorological variables for use in time-series studies of temperature and mortality.

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Background

The effect of temperature on mortality has become significant health problem, especially in light of climate change. Thus, many studies have investigated the effect of temperature on mortality.Most studies have estimated the effect of temperature on mortality using the daily mean temperature and relative humidity, although some studies have used a temperature percentile rather than temperature and absolute humidity rather than the relative humidity. This study sought to determine the best variables for use in studies of the association between temperature and mortality.

Methods

To clarify which variables perform best, we compared four models consisting of combinations of daily mean temperature (T) or the temperature percentile (TP) and the relative humidity (RH) or the absolute humidity (AH). The basis of the models was a generalized additive model with the variables of temperature and humidity variables.The model also includes some confounding factors such as time trends and days of week. The study areas were 15 cities in Taiwan, Japan, and Korea. We compared Akaike information criterion (AIC) values of the four models to determine which produced the best fit.

Results

Model (T, RH) and model (T, AH) produced the minimum AIC values for six of the 15 cities studied. When comparing the models using the same humidity variables but different temperature variables, the models including the temperature percentile performed better in Taiwan, but the models including temperature performed better in Korea and Japan. When comparing the models using the same temperature variables but different humidity variables, in most cases the models with absolute humidity produced smaller AIC values than the models with relative humidity.

Conclusions

This study suggests that absolute humidity is preferable to relative humidity in models designed to investigate the relationships between temperature and mortality. The use of a temperature percentile instead of temperature is advised only for studies in hot and humid cities.

Forecasting Weather Volatility Using Support Vector Machine GARCH Model

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Recently, there is a rising interest in weather volatility as the weather pattern is becoming more volatile. This raises another interest in how to measure the weather volatility. In finance, this has been a key issue in research for a long time since volatility is a key variable in portfolio optimization, securities valuation and risk management. Much attention of academics and practitioners has been focused on modeling and forecasting volatility in the last few decades. So far in the literatures, the predominant model of the past is the GARCH model by Bollerslev (1986), who generalizes the seminal idea on ARCH by Engle (1982), and its various extensions. The popularity of GARCH model is due to its ability to capture volatility persistence or clustering. However, some empirical studies report that GARCH model provides poor forecasting performances. To improve the forecasting ability of GARCH model, some modified approaches have been advocated by innovating the model specification and estimation. This paper focuses on support vector machines (SVM) based GARCH model among the modified GARCH models. SVM developed by Vapnik and his co-workers (1995, 1997) is gaining popularity in prediction since it seeks to achieve a balance between the training error and generalization error, leading to better forecasting performance. Recently Chen et al. (2011) proposed the SVM based GARCH using a recurrent SVM procedure and showed that the recurrent SVM-GARCH models significantly outperform the competing models in both simulation and real data applications of one-period-ahead volatility forecasting. This paper applies the model to time series of observed daily mean temperature to estimate the daily temperature volatility.

Atmospheric forcing of debris flows: a non-linear approach

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Debris flows are mass movements involving a rapidly flowing mixture of rock debris and water occurring in steep, confined channels all over the world. They are usually triggered by long and/or intense rainfall events, but their mechanisms as well as the associated large scale atmospheric circulation are still poorly understood.
Using a new database of 113 events occurred in the southern Swiss Alps, geopotential height at 500 hPa and Sea Level Pressure from the 20th Century Reanalysis, we analyse the large scale atmospheric forcing connected with those events. Anomalies of geopotential height during the debris events are derived by using a penalized spline over the entire time period. A Genetic K-means algorithm is then applied and two atmospheric patterns associated with debris flow events identified.
Afterwards, a nonlinear support vector classifier (nSVC, that is mainly based on separating hyperplanes combined with the Mercer Kernel Map) is trained and applied to the collected daily anomalies of geopotential height associated with wet but no debris flow days. This method reveals a strong relationship of the two identified patterns with debris flow events. Indeed, their occurrence during wet but no debris flow days is limited to 11.8% and 18.1% , respectively.

Effects of DTR(Diurnal Temperature Range) on Circulatory and Respiratory diseases Mortality in Six Metropolitan Korean Cities

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Background

A positive association between DTR and mortality has been already studied and DTR was found to be risk factors for circulatory and respiratory diseases. However, few studies have been conducted to examine the effects of DTR on specific diseases mortality.

Aims

We examine effects of DTR on circulatory and respiratory diseases mortality in six metropolitan korean cities.

Methods

I evaluated meteorological and mortality data from 6 metropolitan cities in Korea from 2000 to 2010. I applied generalized additive model(GAM) for quantifying the estimated effects of DTR on mortality after adjusting for mean temperature, mean humidity, mean air pressure, mean pm10, day of week, seasonal and long-term trend.

Results

Most areas showed similar patterns of effects according to age groups and diseases. We confirmed a significant association between DTR and diseases mortality. In a scale of percentage change of mortality with an increase of 1^{O}C, the pooled effects considering regional heterogeneity in total age were 0.77%(95%CI, 0.6-1.0%), 1.17%(95%CI, 0.8-1.5%), 1.80%(95%CI, 1.2-2.4%), for total(except accidental deaths), circulatory and respiratory diseases mortality, respectively. Especially the relationship was shown more obviously in the elderly group above 75 years and respiratory diseases mortality had the best values in every age group I distinguished.

Conclusions

This study demonstrated that DTR contributes increasing the circulatory and respiratory diseases mortality especially elderly people.

The Reconstruction of Daily Maximum and Minimum Temperatures Using Nearest Neighborhood and ANN Techniques (Case Study: West of Tehran Province)

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Lengthy time series are needed for analysis of time variation, trend of extreme events, risk estimation and possible events. One of the most imperative time series in geographical and climate Sciences are daily maximum and minimum temperatures. Using these parameters daily evapotranspiration estimation is carried out, and water balance and thereby, climatic changes are studied. Uncommon or irregular years deficiency in statistical data and error of measurement, altogether cause variation in time series. Therefore, reconstruction of time series can be regarded as a basic tool for reconstruction of such data. This article reconstructs daily temperatures to nearest neighbor and also artificial neural network methods have been adapted for five stations in the west of Tehran province. In the nearest neighborhood method the correlation matrix between maximum or minimum daily temperatures. Neural networks technique used in this research is a multilayer feed forward network with back propagation algorithm and hidden layer.

Results indicated that artificial neural network technique had least mean absolute error compared to the nearest neighbor method in all station. With the increment of the station distance the estimated error was increased in the nearest neighbor method. Accuracy and validity of the two methods in estimating daily maximum proved to be more than the daily minimum temperature.

Keywords

time series, maximum and minimum temperature, nearest neighborhood method, artificial neural network method, West of Tehran

Survey of the affective parameters on the stream flow using the Artificial neural network in dehgolan catchment, Kurdistan, iran

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A deficit in precipitation (meteorological drought) can result in a recharge deficit, which in turn causes lowered surface flow and a deficit in groundwater discharge. Given the importance of water in human life, regulating the access to reliable and sustainable water resources and planning proper consumption are essential for every designated region. There are two types of limitations that result from a natural phenomena or improper management by human. This phenomenon is evident when the above mentioned two factors emerge together. The purpose of this study is to identifying the climatic conditions that affect the flow in Dehgolan basin. The applied dataset in this study is the Precipitation, temperature, evaporation and runoff recorded in stations located at the Dehgolan basin. Drought occurrence was calculated using SPI index and other climatic variables normalized too. Then operative climatic conditions on surface flow studied using the artificial neural network in MATLAB environment as the method of feed forward back propagation. The highest correlation coefficient and proper mean square error for the input parameters obtained in an input model include: SPI in half year time scale, flow in the last months, temperature and evaporation in the synchronic month. Compare the multiple regression method and artificial neural networks shows higher correlation coefficient in artificial neural network.

Keywords

SPI, Surface flow, ANN, Dehgolan basin

An evaluation of the CMIP3 and CMIP5 simulations in their skill of simulating the spatial structure of SST variability

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The natural sea surface temperature (SST) variability in the global oceans is evaluated in simulations of the Climate Model Intercomparison Project Phase 3 (CMIP3) and CMIP5 models. In this evaluation, we examine how well the spatial structure of the SST variability matches between the observations and simulations on the basis of their Empirical Orthogonal Functions (EOF)-modes. We compare the models and observations against simple null hypotheses, such as isotropic diffusion (red noise) or a Slab Ocean model, to illustrate the models skill in simulating realistic patterns of variability.

Some models show good skill in simulating the observed spatial structure of the SST variability in the tropical domains. However, most models show substantial deviations from the observations and from each other in most domains and particular in the North Atlantic and Southern Ocean on the longer time scale. The CMIP5 ensemble shows some improvement over the CMIP3 ensemble, mostly in the tropical domains. The spatial structure of the SST modes of the CMIP3 and CMIP5 super ensemble is more realistic than any single model.

Future projection of ocean heat content and steric sea level simulated by HadGEM2-AO under Representative Concentration Pathways

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Key words
Future projection, RCP, HadGEM2-AO, CMIP5, Sea level rise

Sea level change is an important indicator of changes in the Earth's climate system and a long-term response of climate change induced by anthropogenic forcing. Since starting observation of sea level with tide gauge from 1880, global-averaged sea level has been increased about 21cm, with an average rate of rise about 1.6mm/yr over the 20th Century and is dramatically increased to 3.1mm/year during recent decade for 2000-2009 (Church and White, 2011). We use seven members of historical runs and three members of four RCP scenarios simulated by HadGEM2-AO in estimating the ocean heat content and steric sea-level changes. To estimate the sea-level change by steric effect, we use the following;

$$h_{\text{steric}}(x,y,t) = \int_{-H}^{0} \frac{\rho_0(x,y,z) - \rho(x,y,z,t)}{\rho_0(x,y,z)} \mathrm{d}z \qquad (1)$$

where $\rho_0(x,y,z)$ is the reference density; ρ_0 is a function of the reference temperature T_0, reference salinity S_0 and depth z. $\rho(x,y,z,t)$ is a non-linear function of temperature and salinity. Here, we use equation of ocean states by Jackett and McDougall (1995). Observed global sea level trend due to thermal expansion is estimated about 0.42 ± 0.12 mm/year for 1961-2003 and 1.6 ± 0.5 mm/year for the recent decade 1993-2003. Ensemble mean steric sea-level change of 1.6 mm/yr shows good approximation to the observed trend especially for the period of 1993-2003.

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Bias correction and Downscaling of CMIP5 model using CA

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We investigate the future changes in East Asia using Constructed Analogues (CA)method.
The CA statistical forecast method is based on the premise that an analogue for a given coarse-scale daily weather (target) pattern can be constructed by combining the weather patterns for several days (predictors) from a library of previously observed patterns. It can be used to study impacts of climate changes and climate variability, so this study statistically downscales and corrects the bias of daily temperature, maximum and minimum temperature, precipitation and daily surface downwelling shortwave radiation data from CMIP5 model over East Asia using CA method.
Based on these downscaled historical (1979~2005), rcp4.5, rcp8.5 (2021~2047)data from nine CGCMs, we analyze the changes in future climate.
To gain a reliable result, the raw and statistically downscaled model outputs for the current climate are compared with observations. The result shows that the linearly downscaled constructed patterns are similar to observed patterns. In other words, the downscaled result reasonably captures the temporal and spatial distribution of the current temperature and precipitation associated with topography. This provides reliability in assessments of regional changes over East Asia.
In the future climate, the results for downscaled temperatures and precipitation display an increasing trend over East Asia, especially the most significan tincrease in rcp8.5.
In order to quantify the future changes, ensemble of nine CGCMs are compared against current observations, which shows an increase in the entire region. The spatial patterns in future climate predicts by all CGCMs are similar ensembles.

Projected Changes in Extreme Precipitation and temperature indices over India from CMIP5-ESM Models.

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The economy and livelihood of the people in India depend on the amount and distribution of rainfall received during the summer monsoon season June through September. India being the densely populated developing country is more vulnerable to climate change impacts. The global warming has profound impact on Indian summer monsoon mean climate as well as extreme weather events which may affect both natural and human systems significantly, and therefore it is important to examine if and how climate extremes are changing in warming environment.

This study assesses the performance of some Earth System Models (CanESM2, CNRM-CM5, HadGEM2-ES, IPSL-CM5-MR, MIROC-ESM, MPI-ESM-LR, NorESM1-M) from the Coupled Model Inter comparison Project Phase 5(CMIP5) in present and future climate conditions. The changes in extreme indices have been examined for the future periods 2016-2035, 2046-2065 and 2080-2099 with respect to 1986-2005 (base line) under two RCPs (Representative Concentrate Pathways) - RCP4.5 and RCP8.5 simulations. We analyzed the Projected changes in precipitation indices such as CDD (Consecutive Dry Days), R20mm (Heavy precipitation Days), RX1day (Highest one day precipitation amount) and SDII (Simple Daily Intensity Index) along with the changes in the frequency of moderate-to-extreme daily temperatures, namely the number of days exceeding the 90th and not reaching the 10th percentile of daily minimum (tn90, tn10) and maximum (tx90, tx10) temperature, for both cold and warm seasons. The observations show an increase in warm extremes and a decrease in cold extremes over many regions that are generally well captured by the models. There is a large uncertainty in the model projections on both spatial as well as temporal scales; this may be because of some regional differences between model and observations as well as due to local forcing or changes in climate dynamics. The results indicate a significant change in frequency and intensity of both temperature and precipitation extreme indices over many parts of the Indian subcontinent which may have impact on health, biodiversity and water resources in this region.

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MON TUE WED THU FRI

Mining spatial structure in regional climate.

Douglas Nychka and Tamara Greasby

National Center for Atmospheric Research

The interest in the regional effects of climate change has motivated the analysis of large spatial and space-time data that are the result of numerical models. Typically the model output involves grids of several thousand points and standard methods of spatial statistics break when applied to these large data sets. Moreover, the need to interpret variation in multi-model ensembles further increases the computational demands. Finally, the comparison of climate model experiments to observational data is also problematic because one must account for differences in support and also the irregularity of the surface records in time and space. This talk will present a flexible spatial model based on fixed rank Kriging that can handle a large number of spatial locations and also include nonstationary spatial dependence. This feasible using compactly supported basis functions and spatial dependence based on Markov random fields. Using this method we estimate the change in the seasonal cycle of temperature over the US from climate simulations from the North American Regional Climate Change and Assessment Program (NARCCAP). Part of this analysis is to account for topography and other covariates and to determine the effect of specific pairings of global and regional models on the results.

Combining information from multiple climate simulators to obtain estimates of global surface air temperature change, under a probabilistic Bayesian framework

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University college London

To make projections of future climate, there is increasing use of "multi-model ensembles" (MMEs) in which information from many different climate simulators, such as Atmosphere-Ocean General Circulation Models, is combined. The question then arises as to how best to combine the information. Issues to be considered include the fact that none of the currently available simulators can simulate the true climate perfectly, and that they do not cover the whole range of possible climate modelling decisions; moreover, different simulators have different credibility in representing different climate parameters. To address these issues, Chandler (2013) proposes a probabilistic, Bayesian framework for summarizing true climate,while explicitly quantifying uncertainty, using information from a MME and actual climate observations. Under the proposed framework, each simulator is weighted based on: its internal variability, its consensus with the rest of the simulators, the internal variability of the true climate and the shared simulator discrepancies with the actual climate. Inference about true climate is enclosed in the derived posteriordistribution. The work presented here illustrates three implementations of the proposed framework,using information from observations, along with projections of yearly mean global surface air temperature from a suite of climate simulators from the CMIP5 experiment. The firstone is a “poor man’s” implementation, which provides a quick and easily-computed approximation of the required posterior distribution. However, the approximations result in neglecting part of the uncertainty. To fully-capture the uncertainty, a computationally intensive fully-Bayesian analysis must be carried out. The work here compares two implementations of this full analysis with that of the “poor man’s version”, to obtain estimates of yearly mean global surface air temperature change. The focus is mainly to observe whether the simplified “poor man’s” version yields “adequate” approximations to the posterior of interest. The uncertainty under the three implementations is expressed in the form of predictive distributions of yearly mean global surface air temperature, evaluated from the derived posterior under each implementation.

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Uncertainties in near-term climate projections

Ed Hawkins

University of Reading

Natural climate variability plays a key role in how climate evolves through time, especially on regional spatial scales which are of interest to users of climate information. This talk will quantify the uncertainties in projections of future climate and illustrate the importance of climate variability in understanding past and future changes. Specific questions that will be addressed include: (i) how important are initial conditions for near-term climate projections? (ii) when might we expect the climate signal to emerge from the background climate variability? (iii) how reliable are our forecasts, and how can we use observations to constrain them? and (iv) how can we use climate projections to inform about future impacts, using a case study of crop yields.

The International Surface Temperature Initiative

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Providing climate services requires a suite of monitoring products that range from the hourly to century timescales and from the local to global spatial scales. Moreover, society expects openness and transparency in the processes used to develop these products as well as comprehensive uncertainty estimates. To make progress in developing such products, the International Surface Temperature Initiative has recently begun the creation of a single, consolidated international databank of worldwide surface meteorological observations. To date, the focus has been on creating a monthly resolution land surface temperature databank; however,subsequent versions will consider daily and sub-daily data as well as additional meteorological elements as resources permit. Experience with other climate monitoring products and from other research disciplines suggests that a range of approaches for addressing artifacts (inhomogeneities) in the data is required both to quantify the uncertainty of trends and to meet the needs of a variety of applications. By centralizing the data collection effort, the databank is envisioned as helping to facilitate the participation of numerous investigators in the creation of new, more comprehensive surface temperature data products. Here we discuss the nature of the first release of the monthly temperature database, a sample product derived from the database, plans for constructing analogs of that data for benchmarking homogenization algorithms, and potential ways to participate in this initiative.

Practical use of stochastic models for spatial climate and weather reconstruction

Finn Lindgren

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Analysis of regional and global mean temperatures based on instrumental observations has typically been based on aggregating temperature measurements to grid cells. Due to the uneven data coverage, this makes analysis of the associated uncertainties difficult. An alternative is to use a model based approach, where the climate and weather are modeled as random fields. Together with probabilistic observation models for the different types of measurements, direct numerical optimisation and integration can then provide the desired temperature reconstructions and associated uncertainties.

The inherent non-stationary nature of global climate and weather can be modeled via locally specified stochastic partial differential equations, using the Markov representations developed by Lindgren et al (2011). In contrast to more traditional methods for spatial statistics, this approach allows for computationally efficient calculations, using the R-INLA software package for direct Bayesian inference. The method allows the use of covariate information, such as elevation, in both the expectation and non-stationary covariance parameters of the spatial model components.

CMIP5-based Climate Change Projections to support Natural Resource Management Planning in Australia

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CSIRO Marine and Atmospheric Research

Over the past twenty years, CSIRO has had the leading role in providing national climate change projections designed to serve the needs of adaptation planning in Australia. In 2007 they released, with the Bureau of Meteorology (BoM), regional projections based on CMIP3 using a probabilistic approach and statistical methods. These projections have been widely cited and used in Australian adaptation work. Along with a broader team at CSIRO and BoM, the authors are using the CMIP5 ensemble (as well as downscaled data) to provide updated climate change projections for Australia to be completed by June 2014. This time the projections will be aimed specifically at supporting the needs of natural resource management (e.g. ecosystems, agriculture and water resources) as the work is being conducted as part of a larger government initiative in this sector. As a result of feedback and consultation since the 2007 release and as part of the current project, new methods of developing and presenting probabilistic information are being developed for this project. A key component of this is balancing scientific constraints with the demands of users for information that is easy for users to understand and relevant to their work. The presentation will illustrate some of the CMIP5-based projection products under development for this project.

Changes in Global Ocean Surface Wave Heights as Projected Using multi-model CMIP5 Simulations

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In this study, projections of possible future changes in ocean surface significant wave heights (Hs) that correspond to changes in mean sea level pressure (MSLP) as simulated in the CMIP5 experiments are obtained statistically. A multivariate regression model with lagged dependent variable is used to represent the relationship between 6-hourly ocean surface significant wave heights (Hs) and the corresponding 6-hourly MSLP fields (including a geostrophic wind energy index). Being positive values and not normally distributed, both wave heights and the geostrophic wind energy index are separately subjected to a data adaptive Box-Cox transformation before being used in the model fitting. The statistical model is calibrated using the ERA-Interim reanalysis of Hs and MSLP fields for 1981-2000, and is validated using the ERA-Interim reanalysis of Hs and MSLP for 2001-2010. The relationship is then used to project 6-hourly Hs using 6-hourly MSLP fields taken from the CMIP5 archive. Annual means and maxima of Hs are derived from the resulting 6-hourly Hs and then analyzed to infer changes therein. Historical, RCP4.5 and RCP8.5 scenario simulations by 20 global climate models are analysed in this study. Almost all models have similar root mean square (RMS) errors that reflect the combined contributions of seasonal cycle errors and low-frequency variability errors, with the exception of HadGEM2-ES, which has a much high RMS error.

The results show that (1) the “observed” climates of both the annual mean and maximum Hs are very well reproduced by the statistical downscaling of CMIP5 simulations, although the statistical model is more skillful and less biased in the mid-high latitudes than in the tropics; and that (2) the global average of Hs shows no significant change, but increases are very likely in the southern high latitudes (south of 45°S) and in the tropical eastern Pacific, with very likely decreases in the mid-latitude North Atlantic. Greater changes are associated with RCP8.5 than with RCP4.5 scenario simulations.

Regional Trends in the Statistical Distributions of Daily Temperature

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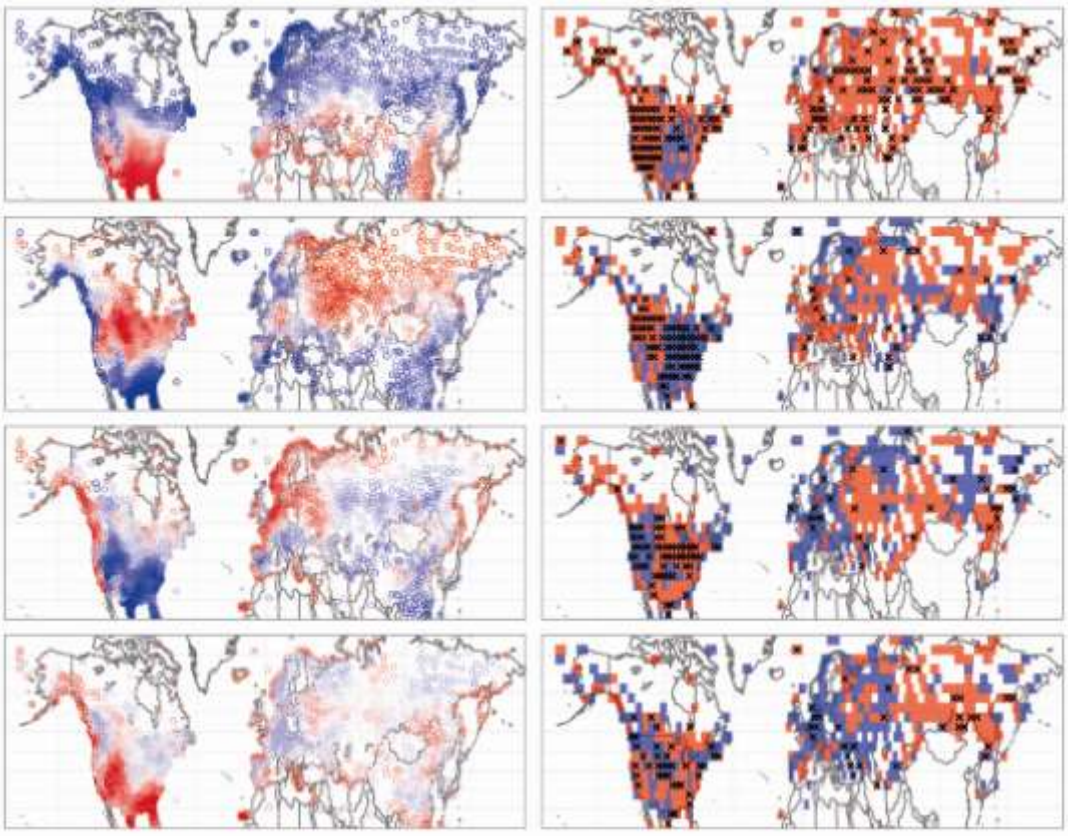
Trends in the evolutions of anomaly probability distribution functions (PDFs) of the averages of daily station maximum (Tmax) and minimum temperatures (Tmin), common proxies for average daily temperatures, are calculated from NOAA's Global Historical Climatology Network Daily (GHCND) dataset for each season relative to a 1961-1990 climatology.
Distribution trends are represented as generalized linear regression coefficients on the mean, variance, skewness, and kurtosis values tabulated from decade length time bins over the twentieth century assuming auto-regressive structure. The coefficients are supplemented with estimates of trend significance. A principal component analysis is performed on each of the moments to provide insight into both geographic structure and the time evolution of leading modes of variability.

The GHCND data suggests that daily PDFs of Tavg are non-Gaussian, and that these distributions have undergone systematic shifts over the twentieth century. When plotted geographically, distributional regions as well regional trends in the characterizing central moments over time are clearly evident. This work suggests that regional shifts in temperature distributions with climate change may occur in addition to the shifts suggested simply by changes in climatic mean. This work also suggests that further analysis in the context of extreme value theory is needed to more fully understand the evolution of tail behaviors in the climate system.



Sample Figure: Analysis for mean, variance, skewness, and kurtosis (top to bottom) for JJA. The left panels are scaled climatological moments, and the right panels are sign of trend with hatchmarked regions of 95% significance.

Observed changes in one-in-20 year extremes of Canadian surface air temperatures

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This study applies a recently developed GEV-tree (a tree of Generalized Extreme Value distributions) approach to a newly homogenized Canadian daily surface air temperature data set, to assess changes in temperature extremes over the last century (1910-2010) and the last 50 years (1960-2010). Changes in one-in-20 year extremes (i.e., 20-year return values, denoted as RV20yr) are estimated from the most suitable GEV distribution chosen from a GEV-tree that consists of both stationary and non-stationary (with polynomial trends) distributions. The annual extremes analyzed include the annual maxima and minima of daily minimum temperatures (TNx and TNn), and of daily maximum temperatures (TXxand TXn). Usually, the annual minima, TNn and TXn, occur in nighttime and daytime of winter, and the annual maxima, TNx and TXx, in nighttime and daytime of summer, respectively. The results show that warming is strongest in the extreme low temperatures, with a 115-station average rate of increase of about 3.5°C per century for RV20yr of TNn, and weakest in the extreme high temperatures, at about 0.5°C per century for RV20yr of TXx. The average rate of increase for RV20yr of TXn and TXn is about 1.9°C and 1.2°C per century, respectively, and about 1.5°C per century for the annual mean temperatures. The warming is stronger in winter than in summer; it is also stronger in nighttime than in daytime of the same season.

Projections of daily mean temperature variability in the future: cross-validation tests with ENSEMBLES regional climate simulations

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Because of model biases, projections of future climate need to combine model simulations of recent and future climate with information on observed climate. Here, ten methods for projecting the distribution of daily mean temperatures are compared, using six regional climate change simulations for Europe. Cross validation between the models is used to assess the potential performance of the methods in projecting future climate. Delta change and bias correction type methods show similar cross-validation performance, with methods based on the quantile mapping approach doing best in both groups due to their apparent ability to reduce the errors in the projected time mean temperature change. However, as no single method performs best under all circumstances, the optimal approach might be to use several well-behaving methods in parallel. When applying the various methods to real-world temperature projection for the late 21st century, the largest intermethod differences are found in the tails of the temperature distribution. Although the intermethod variation of the projections is generally smaller than their intermodel variation, it is not negligible. Therefore, it should be preferably included in uncertainty analysis of temperature projections, particularly in applications where the extremes of the distribution are important.

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The observed climate change and its future scenarios simulated with ECHAM model at various CO2 emission in South Korea

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By employing several climate data sets, such as the reanalysis data from ECMWF and NCEP; the CRU interpolation data; and the TRMM remote sensing data, focusing on the variables of temperature and precipitation, we carry out the trend analysis and abrupt change analysis. All these data was first arranged on the grid of 0.25 degree, and the area-weighted average as a whole in the study area was evaluated. It shows that temperature increased by 1.4 degC and precipitation increased by 193 mm during the 20th century.There are two abrupt changes occurred in temperaturein the year 1947 and 1988 respectively; while the year of 1952 was identified as having an abrupt change for precipitation.

In addition, the climate scenario data simulated witht he ECHAM model was used for future climate projection in South Korea. We used two data sets, respectively from AR4 (ECHAM5) and CMIP5 (ECHAM6). At various CO2 emission scenarios labeled with A1B, A2 and B1 from AR4 and labeled with RCP26, RCP45 and RCP85 from CMIP5, the temperature would increase by from 0.04 to 4.75 degC during the 21th century. The precipitation does not manifest the remarkable change at various CO2 emissions. Therefore, it is expected that the future climate change would bring more severe drought for South Korea.

IMPROVING ANTARCTIC TOTAL OZONE PROJECTIONS BY A PROCESS-ORIENTED MULTIPLE DIAGNOSTIC ENSEMBLE REGRESSION

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Accurate projections of stratospheric ozone are required, because ozone changes impact on exposures to ultraviolet radiation and on tropospheric climate. Unweighted multi-model ensemble mean (uMMM) projections from chemistry-climate models (CCMs) are commonly used to project ozone in the 21 th century, when ozone-depleting substances are expected to decline and greenhouse gases expected to rise. Here, we address the question whether Antarctic total column ozone projections in October given by the uMMM of CCM simulations can be improved by using a process-oriented multiple diagnostic ensemble regression (MDER) method. This method is based on the correlation between simulated future ozone and selected key processes relevant for stratospheric ozone under present-day conditions. The regression model is built using an algorithm that selects those process-oriented diagnostics which explain a significant fraction of the spread in the projected ozone among the CCMs. The regression model with observed diagnostics is then used to predict future ozone and associated uncertainty. The precision of our method is tested in a pseudo-reality, i.e. the prediction is validated against an independent CCM projection used to replace unavailable future observations. The test shows that MDER has a higher precision than uMMM, suggesting an improvement in the estimate of future Antarctic ozone. Our method projects that Antarctic total ozone will return to 1980 values around 2060 with the 95% confidence interval ranging from 2040 to 2080. This reduces the range of return dates across the ensemble of CCMs by more than a decade and suggests that the earliest simulated return dates are unlikely.

On using emergent constraints to reduce structural uncertainty in climate change projections

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When projecting century scale climate change it is commonly assumed that the climate change response is independent of the climate mean state.
However, for some parts of the climate system feedback mechanisms exist that constrain the response to depend strongly on the mean state. Previous studies have quantified these emergent constraints using differences between models and used them to constrain the future climate change response.

We present a statistical framework for representing a multi-model en-semble that incorporates emergent constraints to help account for structural uncertainty in the climate change response. The statistical framework uses variations between different models and also between different runs of each model to estimate the emergent constraint, thus providing greater precision than existing methods. By specifying a model for the whole ensemble we are able to quantify both structural uncertainty and internal variability. Therefore, the projections include uncertainty from both sources and provides a more consistent assessment of the total uncertainty.

The modelling framework is applied to CMIP5 projections of cyclone frequency over the North Atlantic and Europe. The storm tracks simulated by the CMIP5 models are generally too zonal and extend too far into Europe. On the fianks of the storm track, where the deviation from observations is greatest, the climate change response is found to depend strongly on the historical mean state of the storm track. Up to 50% of the structural uncertainty in the response in these regions can be accounted for by the historical mean states. Adjusted projections are presented based on a comparison with ERA-40 reanalysis data.

Uncertainty, spatial statistics, and climate model ensembles

Steve Sain

UCAR / NCAR

There are many sources of uncertainty that arise with climate model ensembles and projections of future climate. The statistical analysis of these ensembles presents a number of challenges, including the size and complexity of the spatial-temporal fields that make up climate model output. In this talk, I will discuss these challenges within the context of two regional climate model experiments: one focused on temperature change over North America while the other explores the role of model parameterization and resolution on precipitation. A statistical framework for evaluating sources of uncertainty will be presented, and this framework is based on an underlying spatial model that incorporates a multi-resolution basis with a regularization based on a Markov random field prior distribution on the coefficients.

Uncertainty analysis of CMIP3 and CMIP5 ensembles using analysis of variance

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For analysing the uncertainty in climate model ensembles, we apply the method proposed by Hawkins and Sutton (2009) to the CMIP5 ensemble and compare the results with those for the CMIP3 ensemble. The method separates the total variance into three additive subcomponents: internal, model and scenario. The analysis is done for seasonal values of mean temperature and accumulated total precipitation. The analysed subset consists of all models which had simulations available for all different future forcing scenarios (SRES for CMIP3, RCP for CMIP5).

Total variance in the ensemble projections increases with lead time over the 21st century. The global mean total variance of the CMIP5 ensemble is larger than the one for CMIP3, regardless of the season. This finding applies both for temperature and precipitation projections. The difference in the total variance between the two ensembles grows larger towards the end of the century. The same applies also for the individual subcomponents, excluding internal variability which the method treats as constant with time. For the CMIP5 models, which are forced with 4 RCP scenarios in contrast of 3 SRES scenarios used to force the CMIP3 models, the fractional contribution of the scenario subcomponent to the total variance is larger than in the CMIP3 ensemble. This difference in the scenario uncertainty is noticeable already before the middle of the 21st century after which it grows larger towards the end of the century. For CMIP5 temperature simulations, globally averaged scenario variance typically exceeds model variance before the end of the 21st century.

In both the CMIP3 and CMIP5 ensembles, internal variability has for all lead times a much larger importance for the total uncertainty of precipitation than of temperature. For precipitation, scenario uncertainty is the smallest for all lead times whereas modelling uncertainty dominates on the long time scales. Modelling subcomponent makes its largest relative contribution to uncertainty near the sea-ice borderline for temperature while being more evenly distributed for precipitation. The fractional contribution of scenario variance is the largest over the low latitudes for temperature and over the high latitudes for precipitation.

Our results confirm the findings from the previous uncertainty studies: The potential to

narrow down the uncertainty by means of developing the models and the analysis methods is much larger for precipitation than for temperature as the scenario uncertainty is not very important for precipitation projections in most regions of the world. On the contrary, the socio-economic uncertainties strongly constrain the accuracy of temperature projections for the late 21 st century. The use of four RCP emissions scenarios instead of three SRES scenarios used in CMIP3 has dramatically increased scenario uncertainty for temperature projections in CMIP5. The attempts to develop the climate models through the inclusion of new processes and the improvement of resolution have also lead to increased modelling uncertainty in the CMIP5 ensemble. This emphasizes the non-linear behaviour of comprehensive climate system models and illustrates the difficulty of improving the accuracy of deterministic climate predictions.

The Projection of Temperature and Precipitation over China under RCP Scenarios using a CMIP5 Multi-Model Ensemble

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Climate changes in 21st century China are described based on the projections of 11 climate models under Representative Concentration Pathway (RCP) scenarios. The results show that warming is expected in all regions of China under the RCP scenarios, with the northern regions showing greater warming than the southern regions. The warming tendency from 2011 to 2100 is 0.06°C/10a for RCP2.6, 0.24°C/10a for RCP4.5, and 0.63°C/10a for RCP8.5. The projected time series of annual temperature have similar variation tendencies as the new greenhouse gas (GHG) emission scenario pathways, and the warming under the lower emission scenarios is less than under the higher emission scenarios. The regional averaged precipitation will increase, and the increasing precipitation in the northern regions is significant and greater than in the southern regions in China. It is noted that precipitation will tend to decrease in the southern parts of China during the period of 2011–2040, especially under RCP8.5. Compared with the changes over the globe and some previous projections, the increased warming and precipitation over China is more remarkable under the higher emission scenarios. The uncertainties in the projection are unavoidable, and further analyses are necessary to develop a better understanding of the future changes over the region.

Keywords

projection, RCP scenarios, China

Regional Climate Projection over East Asia within the CORDEX Framework

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Coordinated Regional Downscaling Experiment (CORDEX) sponsored by WCRP has been conducted to provide a coordinated set of regional climate downscaling (RCD)-based projections for worldwide regions. Korea Meteorological Administration (KMA) plays an important role in leading regional downscaling experiment for CORDEX-East Asia as well as management of its data bank for archiving and redistributing outcomes from CORDEX-East Asia's activities. Five regional climate models were used to produce regional projection with the large-scale lateral boundary forcing simulated by the HadGEM2-AO, which is one of the CMIP5 model. From the results of CORDEX-EA projections with 50 km's resolution, compared to the current climate, the East Asian summer monsoon is expected to be stronger in the future because of the intensified thermal contrast between land and ocean. Discussion on the strengths and weakness of dynamical regional downscaling based on the results from CORDEX-EA and a few suggestions for further directions will be given in this talk.

High resolution regional climate model (NHRCM-5 km) simulations for Tokyo, Japan

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Recently local governments have an increasing need to take extensive and effective local measures to adapt to regional climate change. Regional climate models (RCMs), perhaps with double-nesting, can be used to go to spatial scales of 10 kilometers or less. However, the inability to access the new high solution climate change information and apply it in the right context can be a significant hurdle. A basic tool to support decision-making seems necessary, which would enable exchanges of high-quality climatic data and information in understand-able forms available to non-expert citizens.

This study aims: 1) to characterize a Geographic Information System (GIS) based approach to assessing vulnerabilities to regional climate change using observed and projected data, for decision-making; and 2) to document how to adjust the bias using observed data to provide specialized yet understandable climate change information to assist local decision-makers in clarifying regional priorities within a wide array of adaptation options.

To take into account local priorities and issues, projections were from a 5 km-mesh, non-hydrostatic, cloud system-resolving regional climate model (NHRCM-5 km, 5 km resolution), following the Special Report on Emissions Scenarios (SRES) A1B scenario. Those were dynamically downscaled results from the MRI-AGCM3.2S. The MRI-AGCM3.2S is an Atmospheric General Circulation Model for AMIP (Atmospheric Model Intercomparison Project) conducted under Coupled Model Intercomparison Project—Phase 5 (CMIP5). Tokyo, Japan, was chosen for this pilot study.

Tokyo is a megacity with a population of 13.22 million as of 1 January 2013, and covers an area of 2,188.67 km^2. The number of people aged 65 or older in Tokyo is 2.63 million, or 20.76 % of the total population, which includes 9.0 % of the total population of the elderly in Japan (as of 1 January 2012).

In this paper, results illustrate qualitative agreement in projection of summer daily mean temperatures, the adjusted root mean square (RMS) errors and bias of monthly temperature

in summertime are 0.162°C and 0.008°C, respectively. The mean temperature increase at Okutama-machi, a sparsely populated mountainous region (area 225.63 km^2; population 5,830 as of 1 January 2013) to the northwest of the city of Tokyo, with the highest peak (2,017 m), is the greatest of any area in Tokyo. In comparing near future time period (2015–2039) and future time period (2075–2099) conditions, August monthly mean temperature will increase more than 0.7–0.9 °C and 2.6–2.9 °C, and monthly precipitation by 43–70 % and 25–41 %, respectively. However, the root mean square (RMS) errors and bias of percentage change for monthly precipitation in summertime are 26.8 % and 4.3 %, respectively. Additionally, the bias adjustment using observations (daily climatic data) during 1979–2013 is discussed.

Multi-model attribution of the Southern Hemisphere Hadley cell widening: Major role of ozone depletion

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It has been suggested that the Hadley cell has been widening during the past three decades in both hemispheres, but attribution of its cause(s) remains challenging. By applying an optimal fingerprinting technique to 7 modern reanalyses and 49 coupled climate models participating in the CMIP3 and CMIP5, here we detect an influence of human-induced stratospheric ozone depletion on the observed expansion of the Hadley cell in the Southern Hemisphere summer. The detected signal is found to be separable from other external forcings that include greenhouse gases, confirming a dominant role of stratospheric ozone in the SH-summer climate change. Our results are largely insensitive to observational and model uncertainties, providing additional evidence for a human contribution to the atmospheric circulation changes.

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Regularised optimal fingerprinting and attribution of global near-surface temperature changes

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Optimal _ngerprinting has been the most widely used method for climate change detection and attribution over the last decade. The Regularised Optimal Fingerprinting (ROF) is a new version of the optimal _ngerprint method, which avoids the projection of the data onto k leading empirical orthogonal functions.
As a _rst step, we present this new version and show how it can be applied to the attribution problem. We show that ROF is more accurate than the standard method, in a mean squared error sense. Then, ROF is applied to global near-surface temperatures in a perfect model framework. Improvements provided by this new method are illustrated by a detailed comparison with the results from the standard method. These results support the conclusion that ROF provides a much more objective and somewhat more accurate implementation of optimal _ngerprinting in detection and attribution studies. As a second step, ROF is used to analyse global near-surface temperature changes based on recent simulations from the Coupled Model Intercomparison Project 5. The analysis of global mean temperature shows that changes can be robustly detected and attributed to anthropogenic inuence. Discrimination between greenhouse gases and other anthropogenic forcings, based on the global mean only, is more di_cult due to collinearity of temporal response patterns. Using spatio-temporal data provides less robust conclusions with respect to detection and attribution, as the results tend to deteriorate as the spatial resolution increases. More importantly, some inconsistencies between individual models and observations are found in this case. Such behaviour is not observed in a perfect model framework, where pseudo-observations and the expected response patterns are provided by the same model. However, using response patterns from a model other than the one used for pseudo-observations may lead to the same behaviour as real observations. These results suggest that additional sources of uncertainty, such as modeling uncertainty or observational uncertainty, should not be neglected in detection and attribution.

Keywords
Detection, attribution, climate change, optimal _ngerprints, global temperature.

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Dealing with covariance uncertainty in optimal fingerprinting

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The optimal fingerprinting linear regression framework, which is often used in detection and attribution studies, requires to estimate the covariance matrix associated to internal climate variability. The classic approach to this estimation problem is to use a pseudo-inverted truncation of the empirical covariance matrix obtained from control runs of a climate model. The fact that the order of the truncation in this approach has been shown to significantly influence the result of the analysis and yet is determined partly arbitrarily, has recently motivated the development of an alternative method which avoids this issue by using instead a regularized, invertible and well-conditioned estimate of the covariance matrix known as the Ledoit-Wolf estimator. However, while they differ in their treatment of covariance estimation, both approaches are similar in that they straightforwardly use their respective covariance estimate for estimation of the regression coefficients β and of its confidence intervals, as if the covariance was perfectly known.

We argue here that in doing so, both approaches inherently neglect an important uncertainty source in the estimation of β: the uncertainty associated to the estimation of the covariance itself. Because the latter is performed on a small sample, this uncertainty may be high which may cause existing methods to substantially underestimate the uncertainty level associated to β. Such underestimation, if substantial, could be quite problematic in the context of D&A.

Here we propose a modified version of the linear regression model that addresses this problem. Our strategy consists in explicitly building into the same statistical model the estimation of the covariance and the estimation of the regression coefficients. Based on this joint covariance-regression model, we derive a new estimator of β and of its confidence intervals which has a closed form and can be easily implemented. We apply the proposed method for optimal fingerprinting of surface temperature and we compare the obtained results with previous optimal fingerprinting studies using the same data.

Synthesising detection and attribution assessments across multiple systems

Dáithí Stone and the IPCC WGII AR5 Chapter 18 Author Team

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The detection and attribution of impacts of observed climate change on natural and human systems both provides evidence for concern over climate change and provides calibration for predictions of future impacts. Typical detection and attribution studies examine a single component of a local system, but more general synthesis assessments, which cover multiple regions and systems, are also of interest in understanding the full impact of climate change. Any synthesis must be able to deal in some way with different concepts of detection and attribution across disciplines, varying standards of evidence, both quantitative and qualitative evidence, the division and aggregation of impacts, and selection effects.

This talk will propose a qualitative approach to synthesis assessment of detection and attribution research. This approach starts with experts assessing the confidence in various statements concerning the detection and attribution of impacts, with conclusions expressed using a small set of calibrated confidence levels. Assessments are made both for detection and for attribution. A collection of these assessments, pooled and classified according to various criteria, is then assessed by the collective characteristics in a two-dimensional matrix, with confidence in detection and confidence in attribution being the two dimensions. The talk will conclude with a discussion, and solicitation, of proposals for facillitating the implementation of such syntheses and for making them more informative.

Model Selection and Shift Detection: General to Specific Modelling in Climatology

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1 Introduction

Research in climatology regularly deals with complex systems and non-stationary data, making it near-impossible to correctly specify an appropriate model *a-priori.* Further, the impact of un-modelled structural changes in time series on model estimates is rarely considered. Methods based on model selection can provide a comprehensive solution to these challenges, and provide an agnostic data-driven methodology.

We introduce an empirical approach to modelling in climatology using automatic model selection. The methodology is based on an extended general to specific approach which allows for more variables than observations and is an alternative to methods in the sparse modelling literature. The general to specific approach enables non-stationarity to be tackled both via any unit roots and through the simultaneous detection of outliers and structural breaks in the form of impulses and step-shifts without forcing any to be significant or to be excluded. As a result, the main relevant explanatory variables are determined and their magnitudes estimated, while irrelevant factors are dropped from the model. The methodology can be used to attribute variation to a small set of relevant variables when starting from a large set of potential variables, while accounting for un-modelled structural changes.

To demonstrate, these methods are applied to determine the human contribution to atmospheric carbon dioxide measured at Mauna Loa (Tans & Keeling, 2013), and to model long term interactions between temperature and other factors using ice core records over the past four hundred thousand years (see Jouzel et al., 2007). In future applications the methodology could also be used in the field of downscaling to determine the best set of predictor variables.

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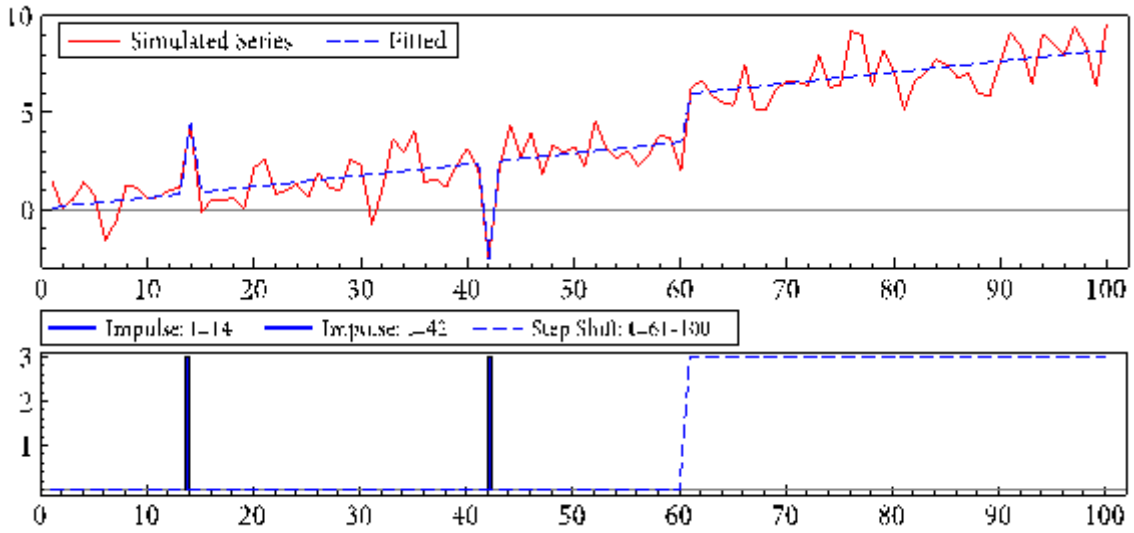
Figure 1: Automatic Detection of Impulses and Step Shifts



2 Methodology

We introduce a modelling methodology that can handle more variables (*N*) than observations (*T*). General to specific modelling relies on the theory of reduction in which the basic principle is to reduce a very general model to a specific one (see Hendry, 1995). First, we define a set of *N* variables that include the local data generating process (ad- missible given current data) as a nested model. Second, starting with that general model as a good approximation of the overall properties of the data, reduce its complexity by removing insignificant variables through an automatic tree search, while checking that at each reduction the validity of the model is preserved. Through recent developments (e.g. Doornik, 2010; Hendry & Johansen, 2012), more variables than observations can be considered by searching over blocks of subsets of variables.

Empirical models often face a large number of potential unknown unknowns. For a given series of (possibly) non-stationary data, there might be an unknown number of location shifts for unknown durations. Therefore, we employ two new methods of detecting and modelling previously unknown shifts as a direct result of being able to handle more variables than observations called Impulse Indicator Saturation (IIS) and Step Indicator Saturation (SIS).

IIS adds to the set of candidate variables a zero/one indicator variable for every observation in the sample, such that for *T* observations there are *T* variables added that correspond to $1\{j=t\}$ indicators (Hendry et al., 2008). Using model selection, only indicators that deviate significantly from the estimated model will be retained. For example, this could capture the un-modelled efiects of volcanic eruptions.

SIS extends this methodology to cover step-shifts - we consider selecting significant step

indicators to capture longer location shifts (see Hendry & Pretis, 2013b). By in-cluding a complete set of step indicators $S = \{1t \leq jt\}, j = 1, \ldots, T\}$, a step shift of any magnitude at any point in time can be detected without prior specification. The rise of anthropogenic greenhouse gas emissions could be considered a step-shift increase.

The principle of IIS and SIS, using simulated data, is illustrated in Figure 1. Two impulses and a step shift (with a magnitude of three standard deviations of the error term) are identified without prior knowledge, and allow for accurate estimation of the underlying trend. Over-fitting is no concern: when no breaks occur, the rate of expected incorrectly retained break indicators in IIS and SIS can easily be controlled: it is equal to the significance level of selection. For example, for a time series of 100 observations and significance of p = 0.01, on average only a single indicator will be spuriously retained.
Given the complexities in climate time series, large scale extended general to specific model selection together with impulse and step indicator saturation thus leads to an agnostic data-driven modelling methodology.

3 Applications

We consider two applications to demonstrate our methodology. First, using a large set of potential variables, based on Hendry & Pretis (2013a), we empirically determine con-tributions to atmospheric CO_2. Second, we estimate a long-run climate system while accounting for structural breaks based on ice core data.

Mauna Loa: Atmospheric Carbon Dioxide

Estimating the determinants of atmospheric CO_2 is traditionally a challenge due to the complex systems of data involved. Carbon dioxide is a highly autocorrelated, non-stationary time series, and globally there exist a large number of potential carbon sources and sinks. There is mixed evidence in the literature on human contributions to atmo-spheric CO_2: the long-term trend is widely attributed to human factors, while the main seasonal fluctuations are thought to be driven by the biosphere. However, the statistical measures applied are often somewhat unsatisfactory due to the complexities of dealing with large numbers of variables. Without being restricted by *a priori* selection of ex-planatory variables, our approach selects over a number of natural carbon sources and sinks: vegetation, temperature, weather phenomena, as well as accounting for dynamic transport. This allows for an estimate of the human contribution to CO_2 as measured by industrial output indices and fossil fuel use for different geographical areas. The re-sulting estimates describe the direct effects on CO_2 growth within the estimated model and the proportional contribution of each factor. We find that natural factors alone can-not explain either the trend or all the variation in CO_2 growth-industrial production components driven by business cycles and shocks are highly significant contributors.

Paleoclimate: Ice Core Record

Given the human impact on the greenhouse gas CO_2, we then look at the effect of radiative forcing of greenhouse gases on global temperature. Estimates of temperature or climate sensitivity to radiative forcing are often based on the historic ice-core record. However, the ice-core time series exhibit multiple structural breaks, which if un-modelled lead to inconsistent estimates of the sensitivity parameters. Thus, we employ impulse and step indicator saturation to estimate a co-integrated system of temperature, greenhouse gases, Earth's orbit and other relevant explanatory factors over the past four hundred thousand years. A large number of previously un-modelled location shifts are detected and controlled for through the use of impulse and step indicators. This leads to a significant estimate of the temperature response to greenhouse gas concentrations.

4 Conclusion

Automatic model selection with extended general to specific modelling, as well as im-pulse and step-indicator saturation, can provide tools to successfully model complex non-stationary relationships in climate research. Modelling CO_2, we find that, without prior restrictions, natural factors are necessary but not suffcient in explaining CO_2 growth-industrial production components are highly significant and consistently selected in esti-mated models. In turn, while accounting for un-modelled location shifts, in a long-run system of the past four hundred thousand years, we find a strong effect of greenhouse gas concentrations on the temperature record.

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Consistency of recent climate change and expectation as depicted by scenarios over the Mediterranean region

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The principle aim of this study is to tackle the question, whether the recent change is a plausible harbinger of future change that is, we examine to what extent the observed climate trends in the Mediterranean region are already an indication of the conditions described by the climate change scenarios at the end of this century.

We have determined that recently observed warming over the Mediterranean region has very likely an anthropogenic origin and thus will likely continue, albeit not in a monotonous manner. We conclude that anthropogenic (Greenhouse gases and tropospheric Sulphate aerosols, GS) forcing is a plausible explanation for the observed warming in the Mediterranean region (except winter). The consistency analysis of surface specific humidity (q), which is an important factor in human thermal comfort, indicates that the increases in annual and seasonal q over this region are very unlikely to be due to natural variability or natural forcing alone and that the large-scale component (spatial-mean) of the anthropogenic forcing has a detectable and dominant influence in the observed trends of q (except winter).

In contrast, the expectation of future precipitation change is different from the observed trends. While the influence of GS signal is detectable in winter and early spring, observed precipitation changes are several times larger than the projected response to GS forcing. The most striking inconsistency, however, is the contradiction between projected drying and the observed increase in precipitation in late summer and autumn, irrespective of the observed data set used. Natural (internal) variability as estimated from 9,000 years control integrations cannot account for these inconsistencies.

The analysis of large-scale circulation patterns, in terms of mean and extreme sea-level pressure and Geopotential height at 500~hPa, confirms the inconsistency detected for precipitation. These significant shortcomings in our understanding of recent observed changes of precipitation complicate communication of future expected changes in the Mediterranean.

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Predicting critical transitions from time series using non-stationary modelling

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Statistical techniques for predicting critical transitions in dynamical systems from time series are discussed. Firstly, a parametric model of the (marginal) probability density of a scalar variable is built from data, allowing for trends in the parameters to model a slowly evolving quasi-stationary probability density. These trends are then extrapolated to predict the nature and timing of structural changes in the probability density of the system. Secondly, a non-stationary stochastic dynamical model of the system is derived, incorporating trends in the drift and diffusion parameters. In the simplest case, this is noise-driven motion in a onedimensional non-stationary potential landscape, but also higher-dimensional reconstructions based on time-delay embeddings are considered. Probabilistic predictions of future tipping of the system are made based on ensemble simulations with the estimated models.

Machine Learning for hypothesis testing in earth system sciences: The case of large-scale hydrology

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In recent years the dynamics of fresh water storages and fluxes on large, continental, scales have received increasing attention. These variables are an integral part of the earth system: they constrain ecosystem processes and influence weather through land-atmosphere interactions. Unfortunately, current attempts to model fresh water on large scales are hampered by uncertainties in the characterization of the terrestrial system. These are related to both the representation of relevant processes (e.g. infiltration of water into soil) as well, as to estimates of associated land parameters (e.g. soil types). To assess whether improved land parameter estimates – or – a refinement of model physics are more likely to increase model performance, we confront our current perception hydrological systems with the radical "Constant Land Parameter Hypothesis (CLPH)". This hypothesis assumes that hydrological variability at any location in space is a function of past and present atmospheric forcing only, and does not depend on location-specific land parameters. We demonstrate, using machine learning techniques (Random Forests), that space-time fields of monthly runoff in Europe can be skilfully estimated using atmospheric forcing alone, without accounting for locally varying land parameters. The resulting runoff estimates are used to benchmark state-of-the-art process models. These are found to have inferior performance, despite their process representation, accounting for locally varying land parameters. Finally, we show that typically considered land parameters (soil types and topography) do not contain sufficient information to increase the predictive skill of the Random Forest model. The results suggest that progress in the theory of hydrological systems is likely to yield larger improvements in model performance than more precise land parameter estimates. While improved physically-based models are under development, the proposed statistical model can be used to produce full space-time estimates of monthly runoff in Europe, contributing to practical aspects of the discipline including water resources monitoring and seasonal forecasting.

Improving the Seasonal Forecast for Summertime South China Rainfall Using Statistical Downscaling

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The performance of various seasonal forecast systems in predicting the station-scale summer rainfall in South China (SC) was assessed, and was compared with that based on a statistical downscaling scheme. Hindcast experiments from 11 dynamical models covering the period of 1983 to 2003 were taken from the APEC Climate Center (APCC) multi-model ensemble (MME). Based on observations, singular value decomposition analysis (SVDA) showed that SC precipitation is strongly related to the broad-scale sea level pressure (SLP) variation over Southeast Asia, western North Pacific and part of the Indian Ocean. Analogous co-variability was also found between model hindcasts and the observed station precipitation.

Based on these results from SVDA, a statistical downscaling scheme for predicting SC station rainfall with model SLP as predictor was constructed. In general, the statistical scheme is superior to the original model prediction in two geographical regions, namely western SC (near Guangxi) and eastern coastal SC (eastern Guangdong to part of Fujian). Further analysis indicated that dynamical models are able to reproduce the large-scale circulation patterns associated with the recurrent modes of SC rainfall, but not the local circulation features. This probably leads to erroneous rainfall predictions in some locations. On the other hand, the statistical scheme was able to map the broad-scale SLP patterns onto the station-scale rainfall anomalies, thereby correcting some of the model biases. Overall, our results demonstrate how SC summer rainfall predictions can be improved by tapping the source of predictability related to large-scale circulation signals from dynamical models.

Non-linear and Non-stationary Influences of Geomagnetic Activity on the Winter North Atlantic Oscillation

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The relationship between the geomagnetic aa index and the winter North Atlantic Oscillation (NAO) has previously been found to be non-stationary, being weakly negative during the early 20th century and significantly positive since the 1970s. The study reported here applies a statistical method called the Generalised Additive Modelling (GAM) to elucidate the underlying physical reasons.

We find that the relationship between *aa* index and the NAO during the Northern Hemispheric winter is generally non-linear and can be described by a concave shape with a negative relation for small to medium *aa* and a positive relation for medium to large *aa*. The non-stationary character of the *aa*-NAO relationship may be ascribed to two factors. Firstly, it is modulated by the multi-decadal variation of solar activity. This solar modulation is indicated by significant change points of the trends of solar indices around the beginning of solar cycle 14, 20 and 22 (i.e. ~1902/1903, ~1962/1963, and ~1995/1996). Coherent changes of the trend in the winter time NAO followed the solar trend changes a few years later. Secondly, the *aa*-NAO relationship is dominated by the *aa* data from the declining phase of even-numbered solar cycles, implying that the 27-day recurrent solar wind streams may be responsible for the observed *aa*-NAO relationship. It is possible that an increase of long-duration recurrent solar wind streams from high latitude coronal holes during solar cycles 20 and 22 may partially account for the significant positive *aa*-NAO relationship during the last 30 years of the 20th century.

Construction of sea surface temperature product based on observation data in Offshore China Sea during 1960-2011

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Aiming at the shortage of available long-term and direct observation sea surface temperature (SST) data on the research of climate change in Offshore China Sea, a high-quality SST product named COISST were developed which was monthly 1°x1° gridded from Jan 1960 to Dec 2011 at the area (100-150°E，0-50°N). In this product, the SST of coastal observing stations of China, National Marine Comprehensive Investigation Data and International Cooperation and Exchange Data applied by State Oceanic Administration (SOA) of China which have been processed more carefully and homogeneities adjust were merged into the SST of International Comprehensive Ocean-Atmosphere Data Set (ICOADS) using the Optimum Interpolation (OI). Compared to the international representative three SST products, this product effectively reduced the sparse and uncertainties data in the Offshore China Sea, especially at the coastal area. This product captured the main patterns of the SST distribution as well as its variability on seasonal and interannual scales. All these results were coincident with many earlier researches. Moreover, our product seemed to be much reliable due to the fact that the dataset was mostly based on observation. Thus, the product provided a useful new dataset for ocean and climate studies.

Key words

sea surface temperature, Offshore China Sea, dataset, Optimum Interpolation

Spatial Analysis of Daily Precipitation in the Alpine Region: A New Method Based on Kriging, Multi-Scale Topographic Predictors and Circulation Types.

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A wide range of applications related to the Alpine climate need an accurate representation of the spatial and temporal variations of observed precipitation. A convenient basis for such applications are grid datasets derived from rain gauge measurements. However, their construction is challenged by the complexity of the Alpine topography and the small-scale nature of precipitation patterns. Moreover, rain-gauges are unevenly distributed with height (more stations located in rain-shielded valleys). This involves a risk that interpolations are biased and implies that relationships of precipitation with topography need be modeled as part of an interpolation method. This study presents a new method for the spatial analysis of daily precipitation in the Alps by means of circulation-type dependent precipitation-topography relationships. This development is part of the EU-project EURO4M (European Reanalysis and Observations for Monitoring).

The precipitation data has been gathered specially for the EURO4M project and consists of about 6000 daily station records (1971-2008). The data is stratified according to 9 different types of an objective circulation-type classification. In each type, the distribution of precipitation is considered as a linear model with topographic elevations and the scalar product of mean wind with the topographic gradient (upslope wind) as predictors. The predictors are considered at several spatial scales. The dependences are modeled by Kriging with External Drift (KED), i.e. allowing for correlated residuals. The topographic predictors are built from the Shuttle Radar Topography Mission dataset (SRTM, 250m resolution) and scale-dependent versions of the elevations and gradients were obtained by kernel filtering. Maps of daily precipitation are finally produced on a regular 5x5 km^2 grid using the circulation-type composites as a climatological reference. A systematic evaluation of the new method and a comparison with alternative methods (PRISM, Ordinary Kriging) is undertaken from a leave-one-out cross-validation and several skill measures.

Preliminary results for a quasi-two-dimensional sub-section of the Alps illustrate the potential of the new method compared to earlier approaches. Depending on the type of mesoscale circulation, we find that the topography can explain a large fraction of the spatial variability, confirming the hypothesis that explicit modeling of the coarse-scale component has a relevant influence on the fine-scale precipitation component. In addition, KED is found to be the best method among the other techniques according to several performance metrics.

A precipitation generator based on a frailty-contagion approach

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The purpose of this paper is to elaborate a precipitation generator. A frailty-contagion model is used for the intensity. This approach allows us to take into account both large and small scale spatial effets as well as temporal dynamic. The common factor depends on weather regimes defined via an index built on observable variables. The dummy variables representing presence/absence of precipitation are gathered into a matrix depending also on weather regimes and whose temporal evolution follows an "agent-based model" aiming to take into account precipitations propagation. The methodology is applied on simulated data and measurements made in the northern part of French Brittany. Its performance is assessed on a validation data set.

Key words
precipitations generator, common factor, contagion, spatial temporal dependence, weather regimes, agent-based models

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Using the Quantile Mapping to improve a weather generator - reconstruction of the daily weather process

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We developed a weather generator (WG) by using statistical and stochastic methods, among them are quantile mapping (QM), Monte-Carlo, auto-regression, empirical orthogonal function (EOF). One of the important steps in the WG is using QM, through which all the variables, no matter what distribution they originally are, are transformed into normal distributed variables. Therefore, the WG can work on normally distributed variables, which greatly facilitates the treatment of random numbers in the WG.

Monte-Carlo and auto-regression are used to generate the realization; EOFs are employed for preserving spatial relationships and the relationships between different meteorological variables.

We have established a complete model named WGQM (weather generator and quantile mapping), which can be applied flexibly to generate daily or hourly time series. For example, with 30-year daily (hourly) data and 100-year monthly (daily) data as input, the 100-year daily (hourly) data would be relatively reasonably produced. Some evaluation experiments with WGQM have been carried out in the area of Austria and the evaluation results will be presented.

Statistical analysis of long-term precipitation amounts for fitting proper statistical distribution (case study Iran)

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Statistical distribution of rainfall is essential for Statistics phenomenon because all accurate estimates or forecasts of rain for drought and wet years are based on a statistical distribution. In this research we have tried find appropriate statistical distribution out of species based on the three tests namely Anderson Darling test, Kolmogorov - Smirnov and Chi-square. The aim of this study was to select the best frequency distribution and statistical distribution of precipitation with varied climates in Iran. Topographic, geographic location, such as angles and length of exposure to natural radiation, as well as natural green coverage made climate variability in Iran. Thus, using the monthly rainfall of 43 synoptic stations during the long-term period from 1952 to 2005 and using the software Esay fifty (Math Wave Easy Fit Professional) statistical distribution estimated for the six climate regions of (A, B, C, D, E , F), respectively. The results based on statistical testsindicated that the Kolmogorov - Smirnov test has more power than chi-square test. Likewise, Chi-square test which is suitable for univariate distributions and testing that targets fitness or test statistic based on the empirical distribution function (EDF) is not used. In addition, Anderson Darling test has designated to calculate the values with unknown variance.

In conclusion, for zone A (humid and temperate Caspian) Distribution of Log-Pearson 3 and for Zone B (semi-arid climate) Johnson SB distributionand for zone C (climate Zagros) Burr distribution are the best statistical distribution. District D (Region desert a beach too hot) Gamma statistical distribution, for zone E (domestic hot desert climate) Johnson SB distribution and for zone F (semi-arid climate warming) Gen. Gamma distributions are most appropriate statistical distribution. Therefore, it was found that for dry areas B, D, E, F, most appropriate statistical distribution Gamma, / Johnson SB / Gen. Gamma, are while in the Caspian and Zagros (A, C) were distributed Burr, Log-Pearson 3 distribution statistics are appropriate. levels of skewness in a, B, C, are less than one while in D, E, F is greater than one.

Keywords

statistical distribution fitting, statistical analysis, regional climate, precipitation, Iran

A comparison of ensemble post-processing methods for extreme events

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Ensemble post-processing methods are used in operational weather forecasting to form probability distributions that represent forecast uncertainty. Several such methods have been proposed in the literature, including logistic regression, ensemble dressing, Bayesian model averaging and nonhomogeneous Gaussian regression. We conduct an imperfect model experiment with the Lorenz 1996 model to investigate the performance of these methods, especially when forecasting the occurrence of rare, extreme events. We show how flexible bias-correction schemes can be incorporated into these post-processing methods, and that allowing the bias correction to depend on the ensemble mean can yield considerable improvements in skill when forecasting extreme events. In the Lorenz 1996 setting, we find that ensemble dressing, Bayesian model averaging and nonhomogeneous Gaussian regression perform similarly, while logistic regression performs less well.

Evaluation of the retrospective seasonal prediction skill of individual climate models in APCC seasonal forecast system

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The Asia Pacific Economic Cooperation Climate Center (APCC) has collected dynamic ensemble seasonal prediction data of sixteen operational research institutions from nine member economics to use input of the APCC Climate Prediction System since 2007. They have produced one-month lead 3-month mean climate forecastswith four deterministic (based on ensemble mean) and one probabilistic (based on ensemble mean and ensemble spread) forecasts and disseminated it to APEC member economies every month. In recently, several individual climate models of research institutes have improved their seasonal forecast system based on the physical basis. But we don't know how much have the individual climate models improved and what is the model behavior for seasonal climate prediction. Therefore it needs to quantitatively assess the performance of individual climate models during hindcast period(1983~2003).

In order to this study, first, we will verify the performance of the individual climate models in APCC according to the SVSLRF (Standardized Verification System for Long–Range Forecasts) methodology from WMO. The mean Squared Skill Score (MSSS) is related to phase errors (through the correlation), amplitude errors (through the ratio of the forecast to observed variances) and overall bias error, respectively. Further information about MSSS and ROC (Relative operating characteristic) is detailed in http://www.wmo.int/.

Data used for assessing the performance of models include the National Centers for Environmental Prediction (NCEP)-Department of Energy (DOE) reanalysis 2 (Kanamitsu et al., 2002), Climate Prediction Center Merged Analysis of Precipitation (CMAP) (Xie and Arkin, 1997) and NOAA Optimum Interpolation (OI) Sea Surface Temperature (SST) V2 (Reynolds et al. 2002) for the period 1983-2003.

They can be useful in assessment of individual climate and understanding the multi-model ensemble seasonal prediction as we can knowthe strengths and weaknesses of the individual climate models.

Keywords

Seasonal forecast, Hindcast, Individual model , Prediction skill

Validation of a regional climate model ALARO-Climate

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The RCM (Regional Climate Model), ALARO Climate/CZ, is being created from the numerical weather prediction model ALARO, which is operationally run at the Czech Hydrometeorological Institute. It is intended to operate at the spatial resolution of 4 to 7 km, while keeping its ability to be executed at a common contemporary resolution of 20 to 50 km. Better results than those achieved with the current ALADIN-Climate/CZ are expected, namely thanks to the improved simulation of the water cycle, turbulent transport and radiation transfer.

An important task in the process of developing a model is a comparison of a model-simulated climate with reality, that is, validation. Percentiles of modeled and observed temperatures (1961-1990) are compared and cluster analysis is applied on differences between them. Maps of Europe with clusters of grid points where differences between percentiles behave similarly are presented for each month as a way of validation. A discussion about these differences in terms of geography and orography may also be beneficial for further development of the model.

Weather Research and Forecasting (WRF) Model Performance over Portugal

Monica Alexandra Rodrigues

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Established in 1756 the Demarcated Douro Region, became the first viticulturist region to be delimited and regulated under worldwide scale. The region has an area of 250000 hectares, from which 45000 are occupied by continuous vineyards (IVDP, 2010). It stretches along the Douro river valleys and its main streams, from the region of Mesão Frio, about 100 kilometers east from Porto town where this river discharges till attaining the frontier with Spain in the east border. Due to its stretching and extension in the W-E direction accompanying the Douro Valley, it is not strange that the region is not homogeneous having, therefore, three sub-regions: Baixo Corgo, Cima Corgo and Douro Superior. The Baixo Corgo the most western region is the “birthplace” of the viticulturalist region.

The main purpose of this work is to evaluate and test the quality of a criterion developed to determine the occurrence of frost. This criterion is to be used latter by numerical weather forecasts (WRF-ARW) and put into practice in 16 meteorological stations in the Demarcated Douro Region. Firstly, the criterion was developed to calculate the occurrence of frost based on the meteorological data observed in those 16 stations. Time series of temperatures and precipitation were used for a period of approximately 20 years. It was verified that the meteorological conditions associated to days with frost (SG) and without frost (CG) are different in each station. Afterwards, the model was validated, especially in what concerns the simulation of the daily minimal temperature. Correcting functions were applied to the data of the model, having considerably diminished the errors of simulation. Then the criterion of frost estimate was applied do the output of the model for a period of 2 frost seasons. The results show that WRF simulates successfully the appearance of frost episodes and so can be used in the frost forecasting.

Reduction of uncertainties in regional climate downscaling through ensemble forcing

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The atmospheric branch of the hydrological cycle associated with the East Asian summer monsoon is intricate due to its distinct land-sea configurations: the highest mountains are to its west, the oceans are to its south and east, and mid-latitude influences come from its north. Remarkable differences are yielded in dynamical downscaling of 1998 East Asian summer monsoon with the Weather Research and Forecast (WRF) model forced by NCEP-R2 and ERA-40. The differences are primarily caused by uncertainties in the water vapor influx across the lateral boundaries over the Bay of Bengal and the Philippine Sea in the reanalyses. The seasonal water vapor convergence into the model domain computed from the ERA-40 reanalysis is 47% higher than that from the NCEP-R2 reanalysis. The biases may be reduced by using an ensemble average of NCEP-R2 and ERA-40 as lateral boundary forcing. The multiyear simulation forced by NCEP-R2, ERA-40, JRA-25, and their ensemble mean confirms this conclusion. An optimal ensemble method-- Bayesian model averaging is later used for 1998 case. Four reanalyses, their ensemble mean, and their BMA ensemble mean were used as the lateral boundary forcing in the later case. We used satellite water–vapor-path data as observed truth-and-training data to determine the posterior probability (weight) for each forcing dataset using the BMA method. The experiment forced by the equal-weight ensemble reduced the circulation biases significantly but reduced the precipitation biases only moderately.

However, the experiment forced by the BMA ensemble outperformed not only the experiments forced by individual reanalysis datasets but also the equal-weight ensemble experiment in simulating the seasonal mean circulation and precipitation. These results suggest that using ensemble forcing is an effective method for reducing the uncertainties in lateral-boundary forcing and improving model performance in regional climate downscaling.

Temperature rise and allowable carbon emissions for medium mitigation scenario RCP4.5

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Using an ensemble of simulations with an intermediate complexity climate model and in a probabilistic framework, we estimate future ranges of temperature change and carbon dioxide (CO_2) emissions for RCP4.5 concentration pathway. Uncertainty is first estimated by allowing modelled equilibrium climate sensitivity, aerosol forcing and intrinsic physical and biogeochemical processes to vary within widely accepted ranges. Results are then further constrained by comparison against contemporary measurements. Despite this additional constraining, the resulting range of temperatures for RCP4.5 remains large; by year 2300 global warming since pre-industrial is estimated as 1.5 - 3.9 and 1.8 - 4.0 K (5-95% percentiles; unconstrained and constrained respectively). Allowable CO_2 emissions at the time of peak emission period are projected to be 6.7 - 13.3 and 9.0 - 12.8 PgC/yr (same percentiles and configurations). After year 2100, very low net emissions are required, and direct sequestration of carbon dioxide may be necessary to offset any minimum emissions for society to function. For many parameter sets, the land will turn into a carbon source within the 21st century, while the ocean will be kept as a carbon sink. The uncertainty in cumulative allowable emissions is very large even after constraint, and the temperature rise for a given total emission is difficult to predict. The parameter which most significantly effects the allowable emissions is climate sensitivity, followed by vertical oceanic diffusivity and the Gent-McWilliams thickness of the ocean. Some carbon-cycle related parameters (e.g., maximum photosynthetic rate and respiration's temperature dependency of vegetation) also have significant effects. For land carbon storage, which strongly influences allowable emissions, major reductions are seen in northern high latitudes and the Amazon basin even after atmospheric CO_2 is stabilised, while for ocean carbon uptake, the tropical ocean regions have negative carbon uptake and relatively large uncertainty.

Development and evaluation of deterministic ensemble methods using simulation results of five RCMs over CORDEX-East Asia based on IPCC RCP scenarios

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The seasonal mean temperature and precipitation over South Korea are projected with six ensemble methods using simulations from five regional climate models (RCMs) over the CORDEX East Asia domain with a 50 km horizontal resolution for 25-year (1981–2005) present and 44-year (2006–2049) future climate. All the simulations for present and future climate were performed using the results of HadGEM2-AO based on the representative concentration pathway (RCP: 4.5/8.5) scenarios. All five RCMs capture the spatial distribution of seasonal mean temperature and precipitation well over South Korea, but they show a systematic cold bias and their performances are clearly dependent on season, model, and geographic location. Six ensemble methods, two equal weighted method (EW_NBC, EW_ABC) and multivariate linear method (WE_MLR), two different weighted method (WE_RaC, WE_Tay) and trend correction method (WE_Trend), were developed and evaluated using the simulated and observed temperature and precipitation over South Korea. The simulation skills of RCMs were determined using the observation data of training period (1981-2005) and the projection skills of ensemble methods were evaluated the observation data of test period (2006-2010). The evaluation results showed that all the six ensemble methods significantly improved the projection skills irrespective of variables and seasons. However, the EW_NBC showed the least projection skill because the number of ensembles is small and all the ensemble members have systematic biases. And the WE_MLR and WE_Trend methods showed more sensitivity to the training period and season than other four ensemble methods. In general, the WE_RaC and WE_Tay showed the best projection skills both in stability and accuracy. More detailed results including development processes of ensemble methods and projected ensemble climate change will be discussed in the presentation.

Uncertainty in single-model and multi-model ensembles

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We investigate the performance of the newest generation multi-model ensemble (MME) from the Coupled Model Intercomparison Project (CMIP5). We compare the ensemble to the previous generation models (CMIP3) as well as several single model ensembles (SMEs), which are constructed by varying components of single models. These SMEs range from ensembles where parameter uncertainties are sampled (perturbed physics ensembles) through to an ensemble where a number of the physical schemes are switched (multi-physics ensemble). We focus on assessing reliability against present-day climatology with rank histograms, but also investigate the effective degrees of freedom (EDoF) of the fields of variables which makes the statistical test of reliability more rigorous, and consider the distances between the observation and ensemble members. We find that the features of the CMIP5 rank histograms, of general reliability on broad scales, are consistent with those of CMIP3, suggesting a similar level of performance for present-day climatology. The spread of MMEs tends towards being “over-dispersed” rather than “under-dispersed”. In general, the SMEs examined tend towards insufficient dispersion and the rank histogram analysis identifies them as being statistically distinguishable from many of the observations. The EDoFs of the MMEs are generally greater than those of SMEs, suggesting that structural changes lead to a characteristically richer range of model behaviours than is obtained with parametric/physical-scheme-switching ensembles. For distance measures, the observations and models ensemble members are similarly spaced from each other for MMEs, whereas for the SMEs, the observations are generally well outside the ensemble. We suggest that multi-model ensembles should represent an important component of uncertainty analysis.

Role of sea ice extent reduction to climate change over the North Pacific

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Satellite observation reveals that Arctic sea ice extent has been overall reduced since 1978, and the rate of the reduction was accelerated in twenty one century. This change would result in climatic change not only over the Arctic and the vicinity of the region but also over remote region through various mechanism such as cold surges in winter over East Asia and heat waves in summer over North America and Asia. A slab ocean model (SOM) coupled to NCAR Community Atmosphere Model (CAM3.0) is used to study climate response specifically over the North Pacific to change of the Arctic sea ice extent. The couple model is modified to fix sea ice concentration and SST (sea surface temperature) regressed by the relationship of the two variables from observation over the Arctic and evolve them communicating with atmosphere elsewhere. And heat budget analysis is performed in order to seek for responsible component of thermodynamic equation such as sensible heat flux, latent heat flux, surface net longwave radiation and surface net shortwave radiation, to the change. The component responsible is to be latent heat flux via wind-evaporation-sea surface temperature (WES) feedback.

Model Output Statistics precipitation downscaling over a set of Italian stations.

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Several studies underline the vulnerability of the European continent and specifically of the Mediterranean area, with respect to climate changes. However, the evaluation at local scale of their impacts relies on valuable punctual projections for the main climatological parameters. Despite General Circulation Models and Regional Climate Models represent the primary source of information for the scientific community for the investigation of climate changes, it is well known that their large scale projections does not meet the needs of the subjects (e.g. policy makers and scientists) involved in the assessment of climate change impacts. This is particularly true for precipitation, a parameter characterized by high spatial and temporal variability. In this work we illustrate the results of statistical downscaling for precipitation according to the Model Output Statistics approach (MOS). "Statistical downscaling" is a generic term for a wide range of statistical methods employed to overcome the gap between large scale projections and local scale demands. MOS is a statistical downscaling method which consists in the adjustment of RCM output according to the climatology of each point station. Several MOS methods have been developed over the last years. In this work we implemented three methods (Direct Method, Local Scale Intensity Method and Quantile Mapping) to downscale precipitation projections of eight RCMs of the ENSEMBLE project. The projections follow the A1B scenario and have a spatial resolution of 25 kms. The downscaling process was run over a set of 32 Italian stations, with a uniform distribution over the Italian Peninsula and satisfying quality and temporal completeness criteria. The three MOS methods were calibrated over the period 1961-1980 and validated over the following 20 years(1981-2000). The performance of each downscaling method is investigated in terms of bias and variability with respect to the original large scale RCM projections. Finally, some examples of site specific precipitation projections for the period 2036-2065 are illustrated.

Application of Kernel method to Statistical Downscaling: case study for South Korea.

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Climate Analysis Team, APEC Climate Center

Downscaling method is used for obtaining the finer grid-scale data from large-scale data. Statistical downscaling method can reduce the difference between the hindcast and the oberserved data by capturing the highest correlated region among station data. However, this method requires Global Climate Models (GCM) for capturing data, and it still suffers over-fitting and fishing problems.

Statistical downscaling using kernel method directly computes the mean from large scale data near the target area, which can solve existing statistical downscaling problems.

This study compared downscaling methods with two different approaches. First approach was based on statistical downscaling and second was on dynamical downscaling. Statistical downscaling method uses canonical correlation analysis and simple linear regression that are developed by the Asia-Pacific Economic Cooperation Climate Center (APCC) team. Second approach was using the Weather Research and Forecasting (WRF) model as a dynamical downscaling. These downscaling models were initialized by APCC CCSM3.

In this case study, predictand is temperature that has been observed in regions of Busan and Seoul, South Korea. Steps of applying kernel method are firstly comparing the correlation coefficient to see the similarities between the station data, and then running the Friedman test to see the difference between the station data and the result of three models. Finally, Wilcoxon test is applied to see the specific difference between the station data and each model.

We expect that kernel method developed in this project is more powerful than other downscaling methods and requires less computing time.

Keywords

kernel, K-nearest neighborhood, downscaling, Friedman, Wilcoxon

Comparison of GCM- and RCM-MOS corrections for simulated daily precipitation

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Understanding long-term changes in daily precipitation characteristics, particularly those associated with extreme events, is an important component of climate change science and impact assessment. Estimates of such changes are required at local scales where impacts are most keenly felt. However, the limited spatial resolution of General Circulation Models (GCMs) makes direct estimates of future daily precipitation unrealistic. A popular downscaling approach is to use GCMs to drive high-resolution Regional Climate Models (RCMs). Whilst able to simulate precipitation characteristics at smaller scales, RCMs do not represent local variables and remain limited by systematic errors and biases.

It is possible to apply statistical corrections, known as Model Output Statistics (MOS), to RCM-simulated precipitation. The simplest form of MOS (including bias correction) follows a 'distribution-wise' approach in which the statistical link is derived between long-term distributions of simulated and observed variables. However, more sophisticated MOS methods may be performed 'event-wise' using, for example, multiple linear regression to derive links between simulated and observed sequences of day-to-day weather. This approach requires a fitting period in which the simulated temporal evolution of large-scale weather states matches that of the real world and is thus limited to either reanalysis-driven RCMs or nudged GCM simulations.

Event-wise MOS has been applied to both GCMs and RCMs earlier and here we present the first direct comparison of the skill of the two approaches. This will help to understand how much value is added by the computationally expensive RCM step compared to a purely statistical downscaling that uses only input from GCMs. Our specific method is a stochastic, event-wise MOS method. We use a 'mixture' model, combining gamma and generalised Pareto distributions, to represent the complete (extreme and non-extreme) precipitation distribution. This is combined with a vector generalised linear model (VGLM) in order to estimate the precipitation distribution based on one or more predictors. GCM-MOS models are fitted using an ECHAM5 simulation nudged to ERA-40 for the period 1958-2001.

Our results are based on several stations in the United Kingdom and we use cross-validation, and quantile verification and continuous ranked probability scores. Our findings suggest that, for this setup, precipitation from a nudged GCM performs better than RCM precipitation when used as a predictor for point-scale precipitation. Further work will focus on the inclusion of multiple predictors, spectrally-nudged RCM runs, spatial coherence, and application to other parts of Europe.

Comparison of dynamical and statistical downscaling for dry season over Southeast Asia

Yeon-Min Jeong, Hyojin Lee, Yoobin Yhang, and Ara Koh
APEC Climate Center

Downscaling method is widely used to create high resolution data from GCM/reanalysis coarse resources (100km ~), which includes statistical and dynamical methods. This downscaling is important because spatially coarse datasets often misrepresent feature of important meteorological variables. Our attention primarily is directed at surface climate variables: precipitation and surface air temperature produced by dynamical and statistical downscaling method during the dry season over Southeast Asia. These two are the most basic variables to be predicted at seasonal time scales to generate seasonal outlook. Statistical downscaling method uses canonical correlation analysis and simple linear regression developed by the Asia-Pacific Economic Cooperation Climate Center (APCC) team. This approach requires long-term data measurements. Monthly high resolution grid (0.5°x0.5°) precipitation and temperature data (CRU TS3.10) for the period from 1901-2009 were used for the observed datasets (predictand). The CRU data does not include ocean area and contains 3294 grid points on lands for the selected research domain (lon: 80~130, lat: -12 ~30.5). Datasets simulated by APCC/CCSM3 for Jun, Jul, Aug, and JJA during the 27-year period from 1983-2009 were considered. For dynamical downscaling, the Weather Research and Forecasting (WRF, version 3.4), is used with a 15-km horizontal resolution nested in a larger 45km horizontal resolution focusing on Indonesia in Southeast Asia. This simulation is performed with APCC/CCSM3 data as initial and boundary condition for comparison with statistical downscaling method. Evaluation of forecast skill added by both the dynamical and statistical downscaling methods will be investigated.

Can Quantile Mapping be Used for Downsaling? Consequences for the Characterisation of Dry Spells and Extreme Events.

Douglas Maraun

GEOMAR Helmholtz Centre for Ocean Research Kiel

Quantile mapping is routinely applied to correct biases of regional climate model simulations compared to observational data. If the observations are of similar resolution as the regional climate model, quantile mapping is a feasible approach. But if the observations are of much higher resolution (e.g., point data), quantile mapping also attempts to bridge this scale mismatch. Here I show for daily precipitation, that such quantile mapping based downscaling is not feasible but introduces similar problems as inflation of perfect prog downscaling: precipitation is a very scattered process in space, and the variability on point scales is in general much higher than that on grid-box scales. Quantile mapping does not see which fraction of the point scale variability is explained by the grid box variability, but systematically biased, and which fraction is small scale random variability. Quantile mapping inflates the explained variability, but does not add any random variability. As a consequence, (1) the spatial and temporal structure of the corrected time series is misrepresented, (2) the drizzle effect for area means is over-corrected, i.e., the spatial extent of dry areas is over-estimated, (3) the spatial extent of extremes is over-estimated and (4) trends are inflated. At an aggregated scale (e.g., a river catchment), dry spells will be too long and the magnitude of extreme events might be heavily overestimated, leading to a potentially severely biased risk estimate of low river gauge levels and floods. To overcome these problems, stochastic bias correction approaches are required.

D Maraun, Bias Correction, Quantile Mapping and Downscaling. Revisiting the Inflation Issue. J Climate, 26(6), 2137-2143, 2013

Simulation of convective and stratiform precipitation in regional climate models

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Regional climate models (RCMs) driven by global climate models (GCMs) are tools widely used for modelling regional climate change. Many studies deal with evaluation of precipitation characteristics in their outputs. However, little attention has been paid to ability of climate models to reproduce characteristics of convective and stratiform (large-scale) precipitation amounts although these are simulated separately through cumulus and large-scale precipitation parameterizations. The probable reason is the lack of long-term series of precipitation data disaggregated according to their origin into convective and stratiform.

We propose an algorithm disaggregating 6-hour precipitation amounts into predominantly convective and stratiform based on analysis of past and present weather conditions (such as type of clouds and weather state) from the SYNOP data. Efficiency of the algorithm is tested, and disaggregated precipitation amounts are analyzed with respect to their characteristics and distributions of extremes at weather stations in the Czech Republic over 1982-2010. Extreme value analysis is applied for estimating high quantiles of precipitation amounts. The results from the observed data are used for evaluation of convective and stratiform precipitation characteristics in an ensemble of RCM simulations for the recent climate.

12th International Meeting on Statistical Climatology

Wednesday, 26 June, 2013

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Attribution of recent trends in regional extremes and extreme events

Nikos Christidis

Met Office Hadley Centre

Several detection and attribution studies in recent years have employed optimal fingerprinting to investigate the human contribution to the observed warming in temperature extremes over the last few decades. The dominant anthropogenic influence was first detected on quasi-global scales. In smaller sub-continental regions the effect of external climatic forcings is more difficult to detect as internal variability tends to dominate over the forced response. Using constraints from global attribution analyses, regional distributions of the annual mean temperature with and without the effect of anthropogenic forcings were constructed, which indicate that human influences have at least quadrupled the likelihood of having a record breaking year in almost all the regions examined.

Another recent advance in attribution research is the development of an ensemble methodology to infer how anthropogenic influences change the odds of specific high-impact extreme events. A new system has been developed in the Hadley Centre for this kind of event analyses based on the latest atmospheric model HadGEM3-A. Large ensembles of simulations are generated that represent the actual climate as well as a hypothetical climate without the effect of anthropogenic forcings. These ensembles provide the likelihood of the event under consideration in these two types of climate, from which the change in the odds can be estimated. First applications of the new system will be presented, including studies of the 2010 Moscow heatwave, the 2010/11 cold winter in the UK and the March 2012 extreme rainfall over Eastern Australia.

Is our ability to understand the causes of changes in precipitation extremes improving?

Francis Zwiers,

Pacific Climate Impacts Consortium, University of Victoria
Victoria Canada.

This talk surveys some recent advances in detection and attribution research on precipitation extremes. Improved observational and climate model datasets are being assembled for a historical period that extends to the end of the first decade of the 21st century. Trends in observed precipitation extremes are difficult to detect in station records due to the inherently noisy nature of precipitation, but records tend to show intensification over time roughly following the Clausius Clapeyron relation. The observed intensification and link to temperature change suggests that anthropogenic forcing on the climate system may have played a role. This is supported by an emerging body of detection and attribution research linking changes in mean and extreme precipitation to historical forcing. Nevertheless, it remains challenging to detect the effects of external forcing on precipitation for a number of reasons.

Downscaling: high expectations, limits of predictability, and new efforts

Bruce Hewitson

University of Cape Town, South Africa

Anyone engaged with stakeholder communities on questions of climate change adaptation will be familiar with the hunger for downscaled information. The expectation that high resolution and more data equate to more information is a common characteristic among stakeholders. Unfortunately, the actual information content is undermined by contradiction between methods, problems of hidden assumptions, weakness in the observational and/or driving GCM data, and a range of other potential shortcomings arising either from the method or mode of application. Yet, with the imminent release of the IPCC AR5 and the growth of comprehensive multi-model multi-method downscaling initiatives (such as CORDEX), the expectation among the user communities of new actionable information for adaptation, decision making, and policy development is very high.

To consider the current downscaling information value, we first examine initial results from the multi-model dynamical downscaling undertaken with Regional Climate Models (RCMs) in the CORDEX activity for Africa, with a view to considering the veracity of the models skill in capturing relevant information of the regional climate. While the results suggest that the time and space aggregates present a favourable view of the models skill, secondary issues do raise concern and include factors such as model simulation of diurnality, propagation of teleconnections, or variance as a function of time scales. Full understanding of the anomalies is, however, complicated by the uncertainty of the historical observed record and the differences between the different gridded data sets of past climate.

Within CORDEX the statistical downscaling initiative lags that of the dynamical approach, but a draft experimental framework for the statistical approaches has been developed, and progress is being made in developing the multi-method statistical downscaling to complement the dynamical downscaling. Here we consider a new statistical downscaling method which treats the continuum of data samples in an othrogobnalized n-dimensional data space, and use this to explore two fundamental issues of downscaling that constrain or undermine the information value of the derived data product. First are the limits to predictability as a function of weather state, scale, and location, and poses the question of to what degree does local scale natural variability limit the potential of downscaling to produce relevant information on the climate change signal? Second is an examination of the degree

of non-stationarity of the predictors that are derived from the Global Climate Models. This is particularly pertinent to statistical downscaling which is trained on historical data, and hence vulnerable to significant non-stationarity in the predictors (although RCMs are not immune to this either). Results indicate value for downscaling, but also that there is a strong need to assess and communicate the limits of information in the data products, and raises important accountability issues in the current growth of climate services.

Arctic temperature extremes over the last 600 years

Martin Tingley

Harvard University

Determining the probability that an event like the 2010 Russian heat wave is unprecedented in the paleoclimatic record requires a statistical treatment that permits for the imputation of temperatures in space, accounts for uncertainties in the instrumental and proxy observations, and permits for a probabilistic assessment of extreme values. Here I present a Bayesian Hierarchical reconstruction of Arctic and sub-Arctic temperature anomalies over the last 600 years that meets these necessary conditions for making inferences on extremes. Results show that a number of years in the last decade feature summer conditions that are without precedent in the last 600 years. These and other recent warm extremes, which exceed in frequency and magnitude those expected from a stationary climate, can be accounted for by a change in the mean temperature alone, with no change in the variance, and by considering the distribution of extremes in the full context of space-time variability.

Assessing Spatial Skill in Climate Field Reconstructions and Why it Matters

Jason Smerdon

Lamont-Doherty Earth Observatory

Spatiotemporal maps of climatic variables are fundamental tools of climate research. Many of the observations that underlie these spatiotemporal fields are nevertheless only available for several years to multiple decades prior to present day. Any attempts to characterize climate variability and dynamics on mulitdecadal to centennial timescales therefore require alternative forms of information to extend estimates of climatic fields further into the past. The last several millennia comprise a period when high-resolution (seasonal to annual) and broadly distributed paleoclimatic proxies are available. These critical characteristics make possible the reconstruction of spatiotemporal maps of temperature and hydrological variables that extend one to two-thousand years into the past. Such products are vital for informing dynamical insights on multidecdal and centennial timescales, the time periods of greatest relevance for quantifying forced and internal climate variability during the 21st century. I will discuss the utility of CFRs and the important role that they are poised to play in characterizations of climate variability and change. I will highlight recent advances in CFR methodologies and assessments of their spatial performance. The spatial performance of many CFR methods indicates limits on the ability of currently employed techniques to extract information from sparse and noisy proxy observations. Large-scale mean indices are also shown to be insufficient for characterizing spatial uncertainties in CFRs, indicating that spatially-resolved error metrics are necessary for evaluating CFR field skill. Improvements in proxy sampling in undersampled regions are also shown to be vital for improving spatial skill. Collectively, these findings are guiding efforts to improve large-scale CFRs through the application of new methodologies, expanded proxy networks and robust quantification of uncertainties.

Analysis of heavy rainfall in high dimensions

Philippe Naveau (joint work with A. Sabourin and E. Bernard, O.mestre, M. Vrac)

CNRS-LSCE IPSL

One of the main objectives of statistical climatology is to extract relevant information hidden in complex spatial-temporal climatological datasets. In impact studies, heavy rainfall are of primary importance for risk assessment linked to floods and other hydro- logical events. At an hourly time scale, precipitation distributions often strongly differ from Gaussianity. To identify spatial patterns, most well-known statistical techniques are based on the concept of intra and inter clusters variances (like the k-meansalgorithm or PCA's) and such approaches based on deviations from the mean may not be the most appropriate strategy in our context of studying rainfall extremes. One additional difficulty resides in the dimension of climatological databases of hourly recordings that may gather measurements from hundreds or even thousands of weather stations during many decades. A possible avenue to fill up this methodological gap resides in taking advantage of multivariate extreme value theory, a well-developed research field in probability, and to adapt it to the context of spatial clustering. In this talk, we proposeand study two step algorithm based on this plan. Firstly, we adapt a Partitioning Around Medoids (PAM) clustering algorithm proposed by Kaufman to weekly maxima of hourly precipitation. This provides a setof homogenous spatial clusters of extremes of reasonable dimension. Secondly, we fine-tune our analysisby fitting a Bayesian Dirichlet mixture model for multivariate extremes within each cluster.

We compare and discuss our approach throughout the analysis of hourly precipitation recorded in France (Fall season, 92 stations, 1993-2011).

Matérn-based nonstationary cross-covariance models for global processes

Mikyoung Jun*

Many physical processes such as climate variables and climate model errors on a global scale exhibit complex nonstationary dependence structure, not only in their marginal covariance but their cross covariance. Flexible cross covariance model for processes on a global scale are critical for accurate description of the physical processes as well as improved prediction. We propose various ways for producing cross covariance models, based on Matérn covariance model class, that are suitable for describing prominent nonstationary characteristics of the global processes and compare their performances to some of existing models. We show two examples of applications of these models, joint modeling of surface temperature and precipitation, as well as, joint modeling of errors of climate model ensembles.

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Dependent Species Sampling Models for Spatial Density Estimation

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We consider Bayesian nonparametric models for the inference of spatially varying densities based on mixtures of dependent species sampling models. The species sampling model is a discrete random probability distribution represented as the sum of the random support points with random weights. The spatial dependency is introduced by modeling the weights through the conditional autoregressive model. The proposed models are illustrated in two simulated data sets and show better performance than the density estimation methods for which the dependency is not incorporated. The proposed method is also applied to Climate Prediction Center Merged Analysis of Precipitation (CMAP) data of 33 years over Korea. The probability density functions of the precipitation over grid points are estimated.

The potential of an observational data set for calibration of a computationally expensive computer model

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We measure the potential of an observational data set to constrain a set of inputs to a complex and computationally expensive computer model. We use an ensemble of output from a computationally expensive model, corresponding to some observable part of a modelled system, as a proxy for an observational data set. We argue that our ability to constrain inputs to a model using its own output as data, provides a maximum bound for our ability to constrain the model inputs using observations of the real system.

The ensemble provides a set of known input and output pairs, which we use to build a computationally efficient statistical proxy for the full system, termed an emulator. We use the emulator to predict and rule out "implausible" values for the inputs of held-out ensemble members, given the output. As we have the true values of the inputs for the ensemble, we can compare our constraint of the model inputs with the true value of the input for any ensemble member. The measures have the potential to inform strategy for data collection campaigns, before any real-world data is collected, as well as acting as an effective sensitivity analysis.

We use an ensemble of the ice sheet model Glimmer to demonstrate our metrics. The ensemble has 250 model runs with 5 uncertain input parameters, and an output variable representing the pattern of the thickness of ice over Greenland. We have an observation of historical ice sheet thickness that directly matches the output variable, and offers an opportunity to constrain the model. We show that different ways of summarising our output variable (ice volume, ice surface area and maximum ice thickness) offer different potential constraints on individual input parameters. We show that combining the observational data gives increased power to constrain the model. We investigate the impact of uncertainty in observations or in model biases on our metrics, showing that even a modest uncertainty can seriously degrade the potential of the observational data to constrain the model.

Quantifying sources of variation in multi-model ensembles: A process-based approach

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The representation of physical processes by a climate model depends on its structure, numerical schemes, physical parameterisations and resolution, with initial conditions and future emission scenarios further affecting the output. The extent to which climate models agree is therefore of great interest, with greater confidence in robust results across models. This has led to climate model output being analysed as ensembles rather than in isolation, and quantifying the sources of variation across these ensembles are the aims of many recent studies. Statistical attempts to do this include the use of various different variants of the mixed-effects analysis of variance or covariance (mixed-effects ANOVA/ANCOVA), usually focusing on identifying variation in a variable of interest due to model differences such as their structure or the carbon emissions scenario. Quantifying such variation is important in determining where models agree or disagree, but further statistical approaches can be used to diagnose the reasons behind the agreements and disagreements by representing the physical processes within the climate models. A process-based approach is presented that uses simulation with statistical models to quantify the sources of variation in multi-model ensembles. This approach is a general framework that can be used with any generalised linear mixed model (GLMM), which makes it applicable to use with statistical models designed to represent (sometimes complex) physical relationships within different climate models. The variation in the response variable can be decomposed into variance due to (1) variation in driving variables, (2) variation across ensemble members in the relationship between the response and the driving variables, and (3) variation unexplained by the driving variables. The method is demonstrated using vertical velocity and specific humidity as drivers to explain wet-day precipitation over the UK using an ensemble from the UK Met Office Hadley Centre. The variation in the precipitation is found to be due mainly to the variation in the driving variables rather than due to variation across ensemble members in the relationship between the precipitation and the driving variables.

Independent Component Regression for Seasonal Climate Prediction: An Efficient Way to Improve Multimodel Ensembles

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This paper considers the problem of predicting seasonal climate values from observations and multimodel ensembles. The conventional principal component regression (PCR) has been used to build a statistical relation between observations and multimodel ensembles and then to predict future climate values when the number of variables is very large which is common in climate research. However, principal component analysis (PCA), pre-required for performing PCR, assumes that information of data should be retained by the second moment of them. It is too stringent to climate data. In this paper, we present a new prediction method that can adapt to non-normal and high dimension data. The proposed method is based on a combination of independent component analysis (ICA) and regularization techniques. The main benefits of the proposed method are that (1) it provides a statistical relationship between multimodel ensembles and observations, which are not normally distributed; and (2) it is capable of evaluating the contribution of models for prediction by selecting suitable models rather than considering all models. We apply the proposed method to the study of the prediction of future precipitation for the boreal summer (June-July-August; JJA) through 20 years (1983-2002) on both global and regional scales.

Climate model genealogy: Generation CMIP5 and how we got there

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A new ensemble of climate models is becoming available and provides the basis for climate change projections. Here we show a first analysis indicating that the models in the new ensemble agree better with observations than those in older ones, and that the poorest models have been eliminated. Most models are strongly tied to their predecessors, and some also exchange ideas and code with other models, thus supporting an earlier hypothesis that the models in the new ensemble are not independent of each other, nor independent of the earlier generation. Based on one atmosphere model, we show how statistical methods can identify similarities between model versions and complement process understanding in characterizing how and why a model has changed. We argue that the inter-dependence of models complicates the interpretation of multi model ensembles, but largely goes unnoticed.

When will trends in European mean and heavy precipitation emerge from internal variability?

Douglas Maraun

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When communicating information on climate change, the use of multi-model ensembles has been advocated to sample uncertainties over a range as wide as possible. To meet the demand for easily accessible results, the ensemble is often summarised by its multi-model mean signal. In rare cases, additional uncertainty measures are given to avoid loosing all information on the ensemble spread, e.g., the highest and lowest projected values. Such approaches, however, disregard the fundamentally different nature of the different types of uncertainties and might cause wrong interpretations and subsequently wrong decisions for adaptation. Whereas scenario and climate model uncertainties are of epistemic nature, i.e., caused by an in principle reducible lack of knowledge, uncertainties due to internal climate variability are aleatory, i.e., inherently stochastic and irreducible. As wisely stated in the proverb "climate is what you expect, weather is what you get", a specific region will experience one stochastic realisation of the climate system, but never exactly the expected climate change signal as given by a multi model mean. Depending on the meteorological variable, region and lead time, the signal might be strong or weak compared to the stochastic component. In cases of a low signal-to-noise ratio, even if the climate change signal is a well defined trend, no trends or even opposite trends might be experienced. Here I express the signal to noise ratio as the time, when climate change trends will exceed the internal variability. The time of emergence (TOE) provides a useful measure for end users to assess the time horizon for implementing adaptation measures. Furthermore, internal variability is scale dependent - the more local the scale, the stronger the influence of internal climate variability. Thus investigating the TOE as a function of spatial scale could help to assess the required spatial scale for implementing adaptation measures. As a case study, I analyse a multi model ensemble of regional climate projections for mean and heavy precipitation over Europe. In northern Europe, positive winter trends in mean and heavy precipitation, in southwestern and southeastern Europe summer trends in mean precipitation emerge already within the next decades. Yet across wide areas, especially for heavy summer precipitation, the local trend emerges only late in the 21st century or later. For precipitation averaged to larger scales, the trend in general emerges earlier.

Douglas Maraun, When will trends in European mean and heavy precipitation emerge? Env. Res. Lett., , 2013.

The role of initial condition ensembles in quantifying model climate under climate change

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Can today's global climate model ensembles characterize the 21st century climate of their own "model-worlds""? This question is at the heart of how we design and interpret climate model experiments for both science and policy support. We present findings which suggest that today's climate model ensembles are significantly too small to characterize changing climate. Furthermore, the research demonstrates that applying a traditional definition of climate, as a distribution or average over time, can be substantially misleading. To resolve these issues, and account for nonlinear climate system behaviour and the presence of long term modes of variability, we require a fundamentally different approach to climate modelling experimental design. We challenge the assumptions of Cox and Stephenson, 2007 (Web of Science citation count: 53) and a subsequent, related study by Hawkins and Sutton, 2009 (Web of Science citation count: 139) arguing that existing interpretations of climate model output are limited by an insufficient exploration of intrinsic climate uncertainties.

Building on important work from the nonlinear dynamics community (Broer *et al* 2002, Rial *et al* 2004), and revisiting the wisdom of scientists such as Edward Lorenz (Lorenz 1968, Lorenz 1976), our findings demonstrate the value of insight gained from analysis of low-dimensional models analogous to the climate system. Using an idealised model that exhibits behaviour similar to that of the atmosphere and ocean, we explore the implications of initial condition ensemble size and of commonly applied assumptions, for the quantification of a model's climate. Small ensembles are shown to be misleading in non-stationary conditions which parallel climate change, and sometimes also in stationary situations analogous to an unforced climate. The results show that ensembles of several hundred members may be required to characterize a model's climate and inform robust statements about the relative role of different sources of climate prediction uncertainty. From a policy making perspective, our results illustrate that relying on single or small ensembles of climate model simulations is likely to lead to overconfidence and potentially poor decisions.

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Detection of nonlinearity in the global temperature response of IPCC models

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There is consensus on the fact that the climate system is nonlinear. Yet, the view that usually prevails is that nonlinear effects remain sufficiently small under present and future climate change so that the temperature response can decently be considered linear as a first approximation under ‘average’ scenarios of future climate change. However, few studies explicitly attempted to estimate quantitatively, at the planetary scale, the strength of climate nonlinearity.

Here, we propose a statistical method for quantitatively evaluating the strength of nonlinearity based on an ensemble of simulations of present and future climate. The method focuses on the joint distribution $p(T_0, \Delta T)$ of T_0, the initial state absolute temperature of the Earth, and ΔT, the future global temperature response to a prescribed radiative forcing perturbation. Based on simple theoretical considerations, we establish that the existence of nonlinearity induces a characteristic distorsion in the shape of this joint distribution, i.e. in the structure of the dependence between T_0 and ΔT, as well as in some characteristics of the marginal distributions of both T_0 and ΔT. Then, we design an inference procedure that detects the presence, and evaluates the statistical significance, of these indirect ‘fingerprints’ of nonlinearity into an ensemble of model simulated values of T_0 and ΔT.

Applying the method to the CMIP3 model ensemble, we find nonlinearity to be considerably higher than in previous estimates, suggesting that the linear approximation does break down under future climate change, if our estimate is correct. Further, we discuss some important implications for climate modeling as well as for climate change mitigation and adaptation policy, that a high level of nonlinearity such as the one suggested by our results would have.

Sub-sampling ensembles of downscaled climate projections

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Increasingly large ensembles of GCM simulations are becoming available for climate change impact studies, through multi-model and multi-run ensembles or perturbed physics ensembles. Moreover, advances in statistical downscaling make it now possible to downscale such large ensembles to the spatial resolution relevant for impact models. Additionally, many downscaling methods are themselves stochastic, which may again increase the size of downscaled projections ensembles. The computational cost of processing such large ensembles through impact models like physically-based distributed hydrological models may however be prohibitive. If recommandations for selecting GCM simulations from large ensembles have been recently proposed, there are still numerous open questions on how to adequately sample downscaled ensembles of such simulations.

This work proposes a sub-sampling approach undertaken for providing a set of downscaled projections over the Durance catchment (southern French Alps) for building informed adaptation scenarios in water resource management. 30 transient runs from the ENSEMBLES Stream2 GCMs under the A1B emissions scenario have been downscaled over the Durance catchment by three variants of the K-nearest neighbours resampling approach: an analog method, a weather type method and a regression-based method (Lafaysse *et al*., 2013). 100 downscaled realizations have been stochastically generated by each method for all GCM runs (1 to 6 runs from 4 different GCMs).

The approach selected here aims at preserving the relative contributions of the four different sources of uncertainties considered, namely (1) GCM structure, (2) large-scale natural variability, (3) structure of the downscaling method, and (4) catchment-scale natural variability. Given the relatively low sample size of the first three sources, this approach focused on sub-sampling 10 realizations of each downscaling method by applying a conditioned Latin Hypercube Sampling (see e.g. Christierson *et al.,* 2012) and therefore preserving the statistical distribution of the 100 realizations. Many open choices-nature of the conditioning variables (future values/changes), associated temporal and spatial scales- have

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been carefully made by assessing their relevance for water resource management.
The effect of conditioning the sampling on climate responses in temporally and spatially integrated variables-changes in catchment-scale winter/summer and interannual mean precipitation and temperature between two time slices-has been validated by assessing the response in more extreme independent variables like changes in the annual precipitation with an exceedance probability of 0.8 and in maximum consecutive dry days. A transient analysis of variance moreover confirmed the effectiveness of the approach in preserving the relative contribution of uncertainty sources for various climate variables.

Critically, this approach allows to propagate the sources of uncertainty through impact models while reducing the associated computational burden. However, in order tomeet actual constraints of the impact community, there is an urgent need for producing guidelines for sub-sampling multi-level ensembles of downscaled climate projections, i.e. 3D arrays of combinations in emissions scenarios, GCMs and downscaling methods.

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Effects of internal climate variability on the Hadley cell width

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Hadley cell (HC) is a thermally forced mean meridional circulation at low latitudes. The changes in HC width could affect not only the large-scale atmospheric circulation (e.g. jet streams and storm tracks) but also the precipitation patterns affecting natural ecosystems, and hydrologic cycles. Generally, it has been suggested that the HC width has been affected by the various internal climate variability; El Nino-Southern Oscillation (ENSO); warming of sea surface temperature; stratospheric ozone depletion; changes in the extra-tropical weather systems and a change in the vertical temperature structure of the troposphere. However, so far, the role of internal climate variability on HC has not been fully understood. In this study, we investigate the effects of internal climate variability on the HC width variability by using the statistical method. First, we define the HC edge and width indices, and calculate its variance. There are differences between the variances of Northern Hemispheric edge and Southern Hemispheric edge. For instance, the variance of Northern Hemispheric edge is more efficiently reduced than that of Southern Hemisphere edge when the ENSO signal is removed. This hemispheric asymmetry will be discussed in this study. Furthermore, the most important internal climate variability affecting HC width will be investigated in this study.

Aerosols Impact on the Multi-decadal SST Variability Simulation over the North Pacific

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Aerosol emission by the anthropogenic source has increased in the 20th century and the effects on climate have received much attention for understanding of historical climate change and variability. Aerosols contribute to change solar radiation at the surface directly and indirectly enhance radiative effect through cloud properties changes, altering surface climate and large-scale atmospheric circulation as well. Recently Wang et al.[2012] showed the Pacific decadal scale variability is able to be affected by the aerosols. Since climate response in global warming is modulated by decadal variability and the Asian monsoon circulation changes are known to be affected by anthropogenic aerosols [Lau et al., 2006; Ramana et al., 2010], aerosol impact over the Pacific needs to be studied. Recently relation between the aerosols and the North Atlantic climate variability is reported. In particular, it is known to be better represented when indirect effect by anthropogenic emitted aerosols is considered [Booth et al, 2011]. Motivated by the previous studies, this study investigates aerosol effect with indirect effect by anthropogenic aerosol emission over the Pacific.

In this study, comparison between historical run and fixed aerosol experiments using HadGEM2-AO shows that multidecadal variability in historical run is closer to the observed ERSST variability over the North Pacific. In detrended SST anomalies, warming and cooling in the period during the 20th century are reproduced in aerosol forced historical simulation. The climate variability is partly related by the shortwave changes in response to aerosols emission. There is cooling effect, directly. Here, we are interested in indirect cloud property changes and the Pacific SST variability. The emitted aerosols contribute to decrease cloud droplet radius and increase cloud fraction and cloud albedo. The reduced shortwave radiation accompamies SST cooling over the North Pacific and large scale cyclonic atmospheric circulation. The anthropogenic aerosol effects are distinct after 1920s, when anthropogenic emission grows rapidly. Since 1920s, the Pacific SST anomalies between historical run and fixed aerosol experiments shows discrepancy. Recent studies suggest that aerosol process can drive pronounced multi-decadal variability in historical North Atlantic climate variability and show that the forced variability appears in the Atlantic and the North Pacific as well. This study confirms their result that the consistent results are presented over the North Pacific.

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Regionalization of Future Projections on the High-Impact Weather and Climate Extremes

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Changes in the frequency or intensify of extreme weather and climate events could have much more profound impacts on both human society and the natural environment. The IPCC 4th assessment report concludes that frequency (or proportion of total rainfall from heavy falls) of heavy precipitation events are very likely to increase over most areas as the climate warms. These future projections are mainly reply on the simulation of extreme rainfall distribution in the current generation of climate model. It is often argued that relatively low resolution climate model can't properly reproduced the high-impact weather extremes. This raises issues on the reliability of their future projections on extremes. In response to the question, very high resolution version of climate models run under the time-slices experiment design or fine-scaled regional climate models forced by global model result from lateral boundaries are used to explore the problem. Although it generally matched better with station rainfall data or high-resolution gridded observational analysis, the cost of such high resolution model runs are excessive to be affordable to create multi-models and multiple-member ensembles that better sample the uncertainty in future climate projections.

Recently high temporal and spatial resolution ground station analysis and satellite estimates are available for climate study. The length of data record are starting to provide enough sampling on the extreme weather events. It is well known that there is spatial scaling issue concerning the study on the extreme weather events and climate indices. By studying the statistical properties that link the different spatial scale in the observational data, one can develop method for regionalization of the extreme weather and climate indices. Applying the methodology to the CMIP5 climate model simulations, it is possible to derive very high resolution extreme statistics based on observational relationship. The extreme climate indices simulated from different resolution models in the CMIP5 experiments can then be compared directly with high resolution observation. The result should be welcomed by the community working on the impact and adaptation study that need more local projection on the extreme events.

Improvement to a Statistical Downscaling Technique by Redefining the Calendar Seasons

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To provide finer locale scale climate change projections for regional impact studies, the Australian Bureau of Meteorology (BoM) has developed a statistical downscaling model (SDM) using the idea of a daily meteorological analogue. The choice of a single best analogue is based on the closest neighbour using a simple Euclidean metric. It has been applied extensively to CMIP3 general circulation models (GCMs) and currently provides Australia-wide daily high resolution gridded (5 km) climate information of essential surface variables (i.e., rainfall, T_{max} and T_{min}). In general, the SDM has reproduced the mean values for each predictand accurately, however, has shown a tendency to underestimate the observed variance for all predictands. This underestimation leads to a well known dry bias in the reconstructed observed rainfall, but it is also visible in an underestimation of the year to year variability for temperature which raises the prospect that future warming produced by SDM would also be underestimated. The variance underestimation has been dealt with using an inflation factor; such factors developed for rainfall and temperature can reduce the underestimation of daily variance, but does not seem to improve the reproduction of the year to year variability.

A novel approach has been tried, where the current SDM has been modified so that daily analogues are allowed to be searched outside the calendar season. Not only does this approach provide a larger pool of analogue to search from, it also provides a higher likelihood of finding an analogue for the more extreme days within a season by linking them to days observed in an adjacent season. The approach is tested with existing optimal combination of predictors and the geographical area, however with different calendar window sizes to find out the optimum window size for each predictand and for each season and region. The model is able to pick an analogue day outside the season with a lower Euclidean distance. Furthermore, the skill of the modified SDM is evaluated using a range of metrics on different time scales such as daily, interannual and long-term. The updated SDM has shown accurate simulation of the observed means and produced the reasonable daily variance, daily extremes and magnitude of future warming without any inflation factor. Although, it has shown significant improvement in seasonal variance, a seasonal inflation factor is still required to fully capture the range of inter-annual variability and to ensure that Australia-wide future warming trends are consistent with the host models. The particular cases of the inability of the method to produce new extremes for hottest day since being limited by the existing observed record requires an additional correction in addition to this modification of the code and currently being assessed.

A New Method to Determine the Upper Boundary Condition for a Permafrost Thermal Model: An Example from the Qinghai-Tibet Plateau

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Assessing possible permafrost degradation related to engineering projects, climate change and land use change is of critical importance for protecting the environment and in developing sustainable designs for vital infrastructure in cold regions. A major challenge in modeling the future degradation of permafrost is finding ways to constrain changes in the upper thermal boundary condition over time and space at appropriate scales. Here, we report on an approach designed to predict time series of air, ground surface and shallow ground temperatures at a spatial scale on the order of 10^2 m^2 for engineering design of a railway or highway project. The approach uses a regional-scale atmospheric model to downscale global climate model output, and then stepwise multiple regression to develop an equation that provides a best-fit prediction of site-specific observational data using bi-linearly interpolated output from the atmospheric model. This approach bridges the scale difference between atmospheric climate models and permafrost thermal models, and allows for a wider range of factors to be used in predicting the thermal boundary condition. For a research site located in Beiluhe, China, close to the Qinghai-Tibet Railway, a comparison of model predictions with observational data not used in the construction of the model shows that this method can be used with a high degree of accuracy to determine the upper boundary condition for a permafrost thermal model. Once a model is constructed, it can be used to predict future changes in boundary condition parameters under different greenhouse emission scenarios for climate change.

Key Words

upper boundary condition, permafrost thermal model, regional climate model, regression model, Qinghai-Tibet Plateau

Nonstationarities of regional climate model biases in European seasonal mean temperature and precipitation sums

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Bias correcting climate models implicitly assumes stationarity of the correction function. This assumption is assessed for regional climate models in a pseudo reality for seasonal mean temperature and precipitation sums. An ensemble of regional climate models for Europe is used, all driven with the same transient boundary conditions. Although this model-dependent approach does not assess all possible bias non-stationarities, conclusions can be drawn for the real world. Generally, biases are relatively stable, and bias correction on average improves climate scenarios. For winter temperature, bias changes occur in the Alps and ice covered oceans caused by a biased forcing sensitivity of surface albedo; for summer temperature, bias changes occur due to a biased sensitivity of cloud cover and soil moisture. Precipitation correction is generally successful, but affected by internal variability in arid climates. As model sensitivities vary considerably in some regions, multi model ensembles are needed even after bias correction.

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Defining predictand areas with homogeneous predictors for spatially coherent precipitation downscaling of climate projections

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Statistical downscaling aims at finding relationships between large-scale predictor fields and local precipitation (predictand), that is needed for climate change impact studies. For distributed hydrological modelling the downscaled precipitation spatial fields have furthermore to be coherent over possibly large river basins. This study addresses this issue by grouping coherent predictand areas in terms of optimised predictor domains over the whole of France, for an analogue downscaling method developed by Ben Daoud et al. (2011).

This downscaling method is based on analogies on different variables: temperature, relative humidity, vertical velocity and geopotentials. The method is built taking these predictor variables from ERA40 at 2.5 degree resolution and local precipitation over 608 climatologically homogeneous zones in France are taken from the Safran near-surface atmospheric reanalysis (Vidal et al., 2010). The predictor domains for each zone consist of the nearest grid cell for all variables except geopotentials for which the optimum domain is sensitive to the predictand location. For large catchments with diverse meteorological influences it is thus beneficial to optimise the predictor domains individually for areas with different influences (e.g. Timbal et al., 2003). The drawback is that different predictor domains may provide inconsistent values between elementary zones. This study therefore aims at reducing the number of different predictor domains by grouping the predictand areas that may use the same predictor domain.

The geopotential predictor domains were first optimised for each of the 608 zones in the Safran data separately. The predictive skill of different predictor domains is evaluated with the Continuous Ranked Probability Skill Score (CRPSS) for the 25 best analogue days found with the statistical downscaling method averaged over 20 years. Rectangular predictor domains of different sizes, shapes and locations are tested, and the 5 ones that lead to the highest CRPSS for the zone in question are retained. The 5 retained domains were found to be equally skillfull with a maximum difference of around 1% of CRPSS on average, and are thus all candidates for clustering predictand zones.

An objective procedure has then been implemented for clustering zones together, based on their sharing a common predictor domain inside their 5 near-optimal domain ensemble. For zones sharing several near-optimal predictor domains, the aim was to minimise the number of disjoint predictand areas. Furthermore solutions that lead to more similar sized areas were preferred. This procedure defines areas with natural spatial coherence and reduces the number of different predictor domains using a procedure based on objective rules, unlike most of studies where this is done either subjectively or arbitrarily. It allowed to reduce significantly the number of independent zones and to identify large homogeneous areas encompassing relatively large river basins. Further developments will address the issue of spatial coherent downscaling for predictand areas that do not share any near-optimal predictor domains.

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A detailed evaluation of quantile mapping on multivariate RCM output

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Following the urgent need for consistent, bias free, and high quality meteorological variables in the climate impact community, erroneous climate model output (global and regional climate models; GCM and RCM) is used to be bias corrected more often. Statistical approaches for bias correction, like quantile mapping (QM) are therefore powerful tools and often used in recent studies. However, the application of bias correction methods like QM is heavily discussed because it is assumed that statistical bias correction interferes with the inter-variable, spatial, and temporal consistency and the distribution of GCM and RCM outputs. In this study the strengths and weaknesses of QM are discussed. QM has been applied on multiple meteorological variables (temperature, precipitation, wind speed, relative humidity, and global radiation) of RCM output (reanalysis and GCM driven) as this is of great interest and use to climate change impact studies. The temporal consistency, which is important e.g. to high resolving hydrological studies, is investigated by discussing the RMSE and autocorrelation of single variables.The effect of statistical bias correction on inter-variable relations has been investigated with focus on inter-variable correlation of raw and bias corrected RCM output for the past and two future periods. The results of split sample tests indicate that QM is applicable on future climate scenarios. In our implementation QM strongly improves the bias of RCM outputs while retaining the inter-variable dependencies and temporal structures.

An analytical ranking of risk for sites of scientific interest under climate change

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Scottish Natural Heritage (SNH) keeps a database of 'Notifiable Features', all of which are under some degree of environmental management due to a protected local species, a site of geological importance, or another form of special scientific interest. European legislation dictates that Scottish Natural Heritage should maintain the health of these features, even under uncertain climate change. An analytical ranking of the Notifiable Features list has been produced, according to the risk posed by climate change over the next seventy years, in order to help SNH fulfil its mandate through the proper prioritisation of management options.

Any procedure used to produce a ranked list of this type must combine information regarding sensitivity, adaptability, and exposure. We have used expert knowledge regarding the sensitivity of a given site or set of sites, site monitoring and connectivity data, and validated regional climate model information (from HadRM3) regarding the future climatology of Scotland. Two analytical approaches have been employed, the first a simple hierarchical system of vulnerability and risk scores, and the second a Bayesian Belief Network, which is more adept at maintaining and providing information on the uncertainty embedded in the use and production of multiple data sources. These two methods have been applied first to a subset of sites (181 in the Southern Highlands) and then to a full list of over 1800 features, making it the first study of its type to offer a statistical approach to climate relevant management support, at the feature-level, across a nation-wide target area.

Regional wave climate changes and coastal impacts from a dynamical downscaling of the past and statistical downscaling projections

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The characterization of local wave climate is of paramount importance for the estimation of coastal flooding, erosion rates, design of marine structures, etc. Downscaling is the method to obtain wave climate information at high spatial resolution. Dynamic downscaling, based on the use of numerical wave generation and propagation models, is perhaps the most widely used methodology. An alternative approach is statistical downscaling that can be conducted by means of the weather pattern-based approach. The aim of this work is to estimate the changes in wave climate and their impacts in the North-Eastern Atlantic coast.

First, a regional historical reconstruction (1950-2010) based on dynamic downscaling (numerical propagation models) has been developed. Hourly records of sea-state parameters have been validated against observations. Historical trends and a short-term extrapolation are estimated. On the second hand, a statistical downscaling method is developed based on weather-pattern classification. The statistical approach is validated against dynamical and it is applied to get multi-model ensemble projections. Short-term (2010-39), mid-term (2040-69) and long-term (2070-99) changes were estimated from multi-model ensemble under several climate scenarios.

Finally, the statistical tool C3Sim (www.c3sim.ihcantabria.com) is developed to evaluate changes on coastal impacts such as beach retreatment, extreme design return levels, overtopping on breakwaters, changes on armour layers weights and damage distribution from a probabilistic point of view. The methodology uses estimated changes of environmental variables to infer future statistics of impacts by means of point estimation method. The results of this work are available in a web-viewer: www.c3e.ihcantabria.com.

Reconstruction of global atmospheric dust concentrations from dust flux measurements in paleoclimatic archives

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Aerosols are the second most potent agent affecting anthropogenic radiative forcing after greenhouse gases. However, despite some progress in the field, the uncertainty of aerosol impact on climate remains much larger than for other species. The total atmospheric dust load is an important factor for the radiative budget of the atmosphere, and for the micronutrient supply to terrestrial and marine ecosystems.

We have collected published dust flux measurements from marine sediment cores, ice cores, loess fields, and peat bogs. These measurements are interpolated to two global grids of average Holocene and Last Glacial Maximum (LGM) climatic conditions using a kriging algorithm that assigns an interpolation uncertainty to each grid point. We then use dust depositional parameters from dust models to reconstruct Holocene and LGM atmospheric dust concentrations. We use dust simulations from two different coupled GCMs (CAM3-CCSM3 and SPRINTARS-MIROC) to give an idea of the uncertainties due to model parameters. Our reconstructions suggest that glacial atmospheric dust loads are underestimated in climate models, especially in high latitudes and in North America. Radiative forcing calculations using the reconstructed dust concentrations show a strong opposite signal north and south of the limit of the Laurentide ice sheet, suggesting an important role for dust in glacial North American climate.

Impacts of methodology and source data on large-scale temperature reconstructions

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Climate field reconstructions (CFRs) of the past millennium can provide insight into dynamical causes of low-frequency climate variability. However, large discrepancies among existing reconstructions [Solomon et al., 2007, Chap 6] preclude robust inference about past climates. The causes of such discrepancies are well-known: source data and statistical approaches differ in all cases, and it is still unclear which aspect accounts for most of the divergence. Here we disentangle methodological and source data uncertainties with focused experiments.

First we examine the effects of different methodological choices. Starting with the network of Mann et al. [2008] (hereinafter M08), we perform temperature reconstruction using four different CFR techniques: RegEM-TTLS [Schneider, 2001], the Mann et al. [2009] implementation of RegEM-TTLS (hereinafter M09), Canonical Correlation Analysis [Smerdonet al., 2010, CCA] and GraphEM [Guillot et al., In revision].

Next we explore the impacts of input source data and the way they are pre-processed. Building upon the network of Mann et al. [2008], we use the latest publicly archived datasets to assemble an updated proxy network with expanded spatial-temporal coverage (58 more proxies than the M08 network, of which 28 are located in the tropics and 11 are available within at least the past 1500 years). We then investigate the effects of: (1) screening for divergence [D'Arrigo et al., 2008] in tree ring series, (2) controlling for skewness in the source data via a power transform [Emile-Geay and Tingley, In prep] and (3) controlling for spurious feature selection by multiple correlation tests [Ventura et al., 2004]. In each of these cases, we perform reconstructions with the four CFR techniques, and compare our reconstructionswith existing ones.

Preliminary results show that reconstructed patterns of temperature change are highly sensitive to procedural choices. Results are greatly method-dependent even with identical inputs. For instance, the reconstructed pattern of sea-surface temperature difference between the Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA) is La Niña-like

with RegEM TTLS (as in [Mann et al., 2009]), El Niño-like with GraphEM, and neutral with CCA. The magnitude of the globally-averaged MCA warmth is also greatly method-dependent. Additionally, the late 20th century temperature is anomalous, but not unprecedented, in the past millennium. Each reconstruction thus provides only a weakly-informative constraint for global climate model simulations. In order to further confirm these conclusions, we will discuss a better representation of uncertainties in CFRs.

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Summer Temperature Reconstruction since A.D. 1530 from Tree-ring Maximum Density in Eastern Tibetan Plateau, China

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Tree-ring samples of purplecone spruce [*Picea purpurea*], Kawanishi spruce [*Picea balfouriana*] and Abies squamata were collected at five sites in eastern Tibetan Plateau. Maximum latewood densities (MXD) were measured by X-ray densitometry. A regional standard chronology (RC) was established based on the five MXD chronologies. The regional standard chronology was significantly correlated with summer temperatures (July-September). We reconstructed mean summer temperature for the period 1530-2009 A.D. in the study area. The reconstruction could account for 53.6% of the summer temperature variance during the instrumental period (1962 - 2009). In the past 480 years, there were 4 cold periods and 4 warm periods. Comparisons with other paleoclimatic proxies from the surrounding area imply that the reconstruction series have a high degree of confidence. Moreover, the reconstruction could reflect the summer temperature changes at large-scale regions.

Rethinking the colour of precipitation

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Precipitation variation can affect ecological systems, agricultural yields and human societies among various spatiotemporal scales[1]. Paleoclimatic insight on the persistence of wet and dry conditions is relevant to assess perspectives and drivers of ongoing climate change. Since systematic instrumental data are limited to the last century only, the main data sources of precipitation variability over the past millennium are proxy-based reconstructions and outputs from climate model simulations. Here we address, if these sources reflect a consistent picture of past precipitation variability. In fact, they do not.

We compare tree ring-based reconstructions from North America[2], Central Europe[3] and High Asia[4] with forced model simulations and instrumental measurements. To quantify the temporal rhythm of each precipitation record[5], we first consider the persistence lengths *l* that are defined by the numbers of successive years in each record during which precipitation is either below or above the median (dry or wet period). It is known that in uncorrelated data (white noise), the persistent length is distributed exponentially, i.e. its frequency of occurrence decreases exponentially with increasing *l*. We show that the persistence lengths derived from model simulations and instrumental observations resemble white noise (Fig. 1c,d). In contrast, the length distribution of the reconstructions is quite broad and thus indicative for strong multi-annual and multi-decadal persistence (pink noise) (Fig.1a). Long-term persistent[7] data with Hurst exponents ~0.8-0.9 do indeed reveal similar behaviour (Fig. 1b).

We further quantify average precipitation patterns after wet or dry periods of certain lengths. Data without persistence mirror temporal insensitivity, whereas systems with memory exhibit more (less) precipitation after wet (dry) periods. The reconstructions indicate a strong dependence on previous conditions (Fig. 1 insets), again comparable to long-term persistent data with Hurst exponents~0.8-0.9, while the simulations and observations again resemble white noise behaviour. These essential differences also derive from more advanced mathematical techniques like wavelet and detrended fluctuation analysis[5], and further appear robust in extreme year statistics (Supplementary Information). The reconstructed extremes cluster in time, while the model and observational extremes occur more randomly distributed.

Accordingly, there is no consistent picture of past precipitation variability emerging from the main two data sources. The course of millennium-long model simulations of regional precipitation variability is supported by instrumental measurements of the last century, suggesting that the appearance of dry and wet periods generally follows white noise behaviour. It is likely that tree-ring width chronologies overestimate the true precipitation memory, since

tree growth is rather influenced by the (red) fluctuations in soil moisture availability than by (white) changes in rainfall. Nevertheless, at the same time reveal independent lines of palaeoclimatological and ecological evidence long-term changes in the Earth's hydrological cycle[6], which likely caused prolonged episodes of relative drought at regional to continental scales[7,8].

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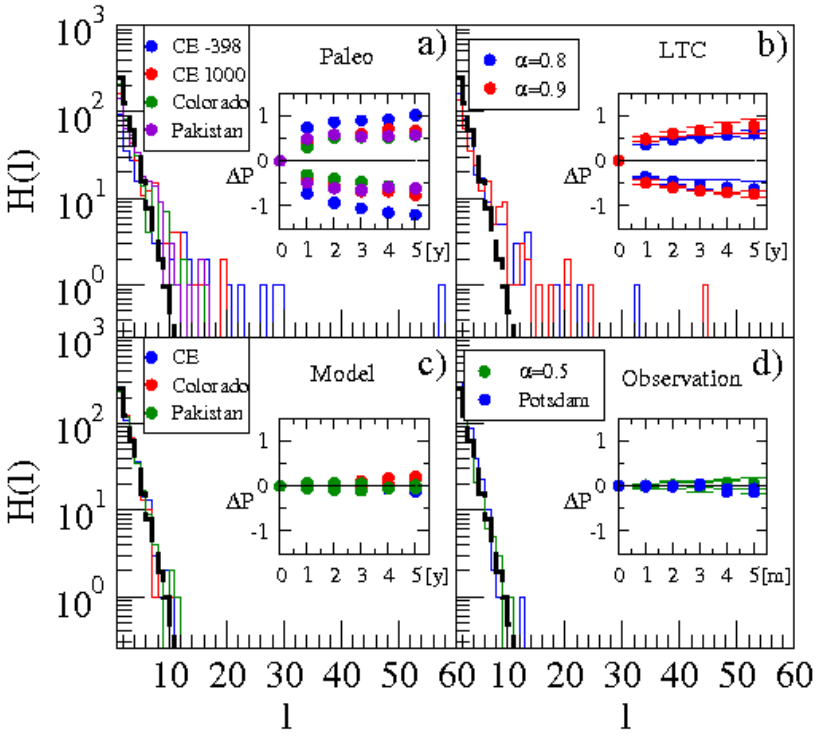

Fig. 1. The colour of precipitation. Histogram of persistence lengths of **(a)** tree ring-based precipitation reconstruction from Central Europe (396BC-604AC) and (985-1985), Colorado (1000-1988), and High Asia (1000-1998), as well as **(b)** synthetic long-term persistent data of comparable length (L=1000) with Hurst exponents of 0.8 and 0.9. **(c)** ECHAM6 precipitation output for the three proxy areas considered (885-1885), and **(d)** instrumental precipitation measurements (Potsdam, Germany, 1900-2000), together with generated white noise (green). Insets denote differences between the conditional mean precipitation (after 1-5 years where the precipitation is either below or above the median) and the mean precipitation, divided by the mean precipitation.

Stochastic Models for Climate Field Reconstructions using Instrumental Data

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A plethora of methods exists to derive climate field reconstructions. While a lot of recent discussions has focused on the inference mechanism (Smerdon et al. 2011, Christiansen et al. 2011), the stochastic model is at least as important. In contrast to methods that use large scale patterns over the full reconstruction domain, some recent reconstruction methods (Tingley+Huybers 2010a,b; Werner et al. 2013) rather use a localised stochastic description. The local stochastic model used therein was based on simple assumptions, nevertheless it could skillfully reconstruct most of the climate variability in the pseudo proxy experiments.

In this contribution we show how such a model could be derived from available observational data or at least be validated. Using long transient climate model runs, we assess how the results of a Kramers-Moyal-Expansion change with data availability under a changing climate. Finally we estimate the error introduced into the climate field reconstruction by deliberately using a too simple stochastic model.

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Can the Last Glacial Maximum constrain climate sensitivity?

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We use syntheses of proxy data for the Last Glacial Maximum both on land and ocean (MARGO Project Members, 2009; Bartlein et al., 2011; Shakun et al., 2012), combined with the ensemble of results from the second paleo- climate modelling inter-comparison project (PMIP2) to generate a spatially complete reconstruction of surface air (and sea surface) temperatures, obtaining an estimated global mean cooling of 4.0 ± 0.8 ◦C (95% CI). We then investigate the relationship between the Last Glacial Maximum (LGM) and climate sensitivity across the PMIP2 multi-model ensemble of GCMs, and find a correlation between tropical temperature and climate sensitivity which is statistically significant and physically plausible. We use this relationship, together with the LGM temperature reconstruction, to generate estimates for the equilibrium climate sensitivity. We estimate the equilibrium climate sensitivity to be about 2.5C with a high probability of being under 4C, though these results are subject to several important caveats. We propose that the forthcoming PMIP3 ensemble of models will provide a useful validation of the correlation presented here.

Reconstruction of long time series of monthly temperature values by statistical methods: an application to Europe and the Mediterranean region

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This study aims at constructing monthly temperature long time series on a large domain covering Europe and the Mediterranean region. The methodology is based on the small number of very long instrumental time series (such as those in Cadiz, Milano, Barcelona, Padua, Bologna, Prague,…) and the statistical links between them and the large number of short time series that available during the second half of the twentieth century. In this model the temperature data of very long time series are the predictors and those of the short time series the predictands. A successful method would allow reconstructing long time series of the predictands from the predictors. The differences among the values produced by the different methods provide an estimate of the uncertainty of the reconstruction. The transfer of the results on a lat-lon grid is used to describe the evolution of temperature over Europe and the Mediterranean region along the 19th and 20th centuries.

There are several methods potentially suitable for such reconstruction using either Linear Regression or Neural Networks combined with either with stepwise selection or PCA (principal component analysis) pre-filtering of the predictors. In this study the quality of the reconstruction computed using the different possible combinations is evaluated by computing the correlation and the RMS error with the original time series. The different methods of this study tend to have similar performances, a part for few negative combinations such as Linear Regression when based on heavily cross-correlated predictors, that is without a PCA prefiltering or a selection of the predictors. In general Linear Regression of PCA pre-filtered data is shown to be very robust and with results comparable and, in some cases, even better than neural Networks algorithms. Examples comparing the various methods are discussed and a preliminary reconstruction of the 19th century temperature evolution over Europe and the Mediterranean region is shown.

Impact of the dominant large-scale teleconnections on winter temperature variability over East Asia and their relation to Rossby wave propagation

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Monthly geopotential height for the past 33 DJFs archived in Modern Era Retrospective analysis for Research and Applications (MERRA) reanalysis is decomposed into the large-scale teleconnection patterns to explain their impacts on winter temperature variability over East Asia. Following Arctic Oscillation (AO) that explains the largest variance, East Atlantic/West Russia (EA/WR), West Pacific (WP) and El Niño Southern Oscillation (ENSO) are identified as the first four leading modes. While the northern part of East Asia north of 50°N is prevailed by AO and EA/WR impact, climate in mid-latitudes (30°N~50°N), which include Mongolia, northeastern China, Shandong area, Korea, and Japan is influenced by combined effect of the four leading teleconnections. ENSO impact on average over 33 winters is relatively weaker than the impact of other three teleconnections. WP impact characterizes winter temperatures over Korea, Japan, and central to south China (south of 30°N) mainly by advective process from the Pacific. Evaluation on the impact of each teleconnection for the selected years reveals that the most dominant teleconnection is not the same at all years, indicating a great deal of interannual variability.

The present study also explores the possible relation of the atmospheric teleconnection to the large-scale stationary wave propagation. EA/WR pattern is found to be strongly associated Rossby wave forced at the mid-latitude Atlantic (~40°N) as it is evidenced by upper-level wave activity fluxes and wavy nonlinear baroclinic model experiment. EA/WR pattern also tends to be better resolved when its wave train is embedded in the enhanced upper-level westerly flow in the mid-latitudes of 40°N~60°N.

Western U.S. Extreme Precipitation Events and Their Relation to ENSO and PDO in CCSM4

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Water resources and management over the Western U.S. are heavily impacted by both local climate variability and the teleconnected responses of precipitation to the El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO). In this work, regional precipitation patterns over the western U.S. and linkages to ENSO and PDO are analyzed using output from a CCSM4 pre-industrial control run and observations, with emphasis on extreme precipitation events. CCSM4 produces realistic zonal gradients in precipitation intensity and duration over the western U.S., with higher values on the windward side of the Cascade and Sierra Mountains and lower values on the leeward. Compared to its predecessor CCSM3, CCSM4 shows an improved teleconnected signal of both ENSO and the PDO to large scale circulation patterns over the Pacific/North America region and also to the spatial pattern and other aspects of western U.S. precipitation. The so-called “drizzle” problem persists in CCSM4 but is significantly improved compared to CCSM3. In particular, it is found that CCSM4 has substantially less precipitation duration bias than is present in CCSM3. Both the overall and extreme intensity of wintertime precipitation over the western U.S. show statistically significant linkages with ENSO and PDO in CCSM4. This analysis provides a basis for future studies using GHG-forced CCSM4 runs.

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Propagating vs. Non-propagating Madden-Julian Oscillation Events

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Basin-wide convective anomalies over the Indian Ocean (IO) associated with the Madden-Julian oscillation (MJO) sometimes propagate eastward and reach the west Pacific (WP), but sometimes do not. Long-term observations of outgoing longwave radiation and recent reanalysis products are used to investigate the difference between the propagating and non-propagating MJO events. IO convection onset events associated with the MJO are grouped into three categories based on the strengths of the simultaneous dry anomalies over the eastern Maritime Continent and the WP. The IO convection anomaly preferentially makes propagation to the east and reaches the WP when the dry anomaly is stronger.

Analysis of the column integrated moist static energy (MSE) budget shows that horizontal advection moistens the atmosphere to the east of the positive MSE anomaly associated with the active convection, and is of sufficient magnitude to explain the eastward propagation of the positive MSE anomaly associated with the IO convection. Interpretation is complicated, however, by lack of closure in the MSE budget. A residual term, of smaller but comparable magnitude to the horizontal advection, also moistens the column to the east of the positive MSE anomaly. Nonetheless, we decompose the horizontal advection term into contributions from different scales. We find that a dominant contribution is from free-tropospheric meridional advection by the instraseasonal time-scale wind anomalies. The positive meridional advection in between the convective and dry anomalies is induced by the anomalous poleward flow, which we interpret as part of the Rossby wave response to the dry anomaly, and the climatological MSE pattern, which peaks at the equator.

Investigating the drivers of extreme rainfall variability in Australia

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Australia is a land of severe floods and droughts experiencing great interannual to multidecadal variability in extreme rainfall. This variability in rainfall extremes can be related to a range of climate drivers. The aim of our study was to improve understanding of the teleconnections between climate drivers and extreme rainfall so forecasting of these events may improve. An empirical orthogonal teleconnection (EOT) method was applied to separate Australia into areas of coherent variability of monthly extreme rainfall. These EOT patterns were then correlated and partially correlated with a range of climate indices representing drivers such as ENSO and the Southern Annular Mode. Indices representing synoptic variability, including measures for the South Pacific Convergence Zone and the sub-tropical ridge, were also used. Fields of SSTs and of atmospheric variables from the Twentieth Century reanalysis were regressed on to each EOT to aid in diagnosing the mechanisms behind variability in extreme rainfall. Extreme rainfall variability in Australia is related to many different climate drivers, however ENSO tends to dominate, particularly during the warm season. The Indian Ocean Dipole and blocking tend to have stronger relationships with extreme rainfall during the winter. The background atmospheric and sea-surface conditions vary significantly for different regions of Australia and also seasonally. Strong ENSO and SPCZ signatures are observed in warmer months, whereas, in the cool season, there are fewer coherent features observed. Large-scale onshore moisture fluxes and strong near-surface convergence leading to vigorous convection are common features to extreme rainfall in many areas all year round. This study provides a comprehensive overview of the various mechanisms behind extreme rainfall variability across different areas of Australia which could lead to improved predictability of the occurrence of heavy rainfall events leading to flooding.

Drought-conducive mode of variability and teleconnections under climate change

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Oceanic modes of variability, as well as specific patterns of sea surface temperature anomalies (SSTAs) have been identified as major triggers of historical droughts (i.e., Hoerling and Kumar, 2003, Shin et al. 2010, Schubert et al. 2009). However, it is also anticipated that the hydrological cycle evolves in response to increasing greenhouse gases through thermodynamic or dynamical mechanisms (Held and Soden, 2006, Seager et al. 2007), potentially changing the relative contribution of the ocean as drought initiator. To lay the foundations for such investigations, we first need to assess the fidelity with which the coupled global climate models (CGCMs) capture the observed SST patterns and variability, as well as their teleconnections with historical droughts. We then can use CGCM projections of future climate change to assess whether the temporal features (amplitude, frequency) of the SST patterns, or the characteristics of the SST/drought teleconnections are likely to change in the future.

In this study, we (1) perform an EOF analysis of the 1900-1999 time series of the observed global SST field and identify an ENSO-like (ENSOL) drought-conducive mode of SST variability, and (2) evaluate the strength of the teleconnections between ENSOL and worldwide regional droughts observed over the same time period. We then (3) examine the ability of the coupled global climate models to reproduce the ENSOL mode in the current climate, and (4) assess whether those CGCMs that are able to replicate the ENSOL mode also better capture the historical SST/drought teleconnections. Finally, we (5) analyse the potential temporal variations in ENSOL and the associated drought teleconnections to be anticipated under further global warming. In addition, our methodology provides a concise metric for comparing diverse model climate simulations or for tracking evolving model performance changes.

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A teleconnection between the reduction of rainfall in southwest Western Australia and North China

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Rainfall in both southwest Western Australia (SWWA) and North China (NC) has been declining substantially since the mid-1960s, which leads to a series of droughts in both regions since then. Using observed rainfall datasets in China and Australia and the NCEP reanalysis dataset during 1951-2008, we show that the decline of SWWA rainfall is in early austral winter (MJJ, May-June-July) while the reduction of NC rainfall is in late boreal summer (JAS, July-August-September). We then examine the relationship between SWWA MJJ rainfall and NC JAS rainfall during 1951-2008, and find that a significant link exists between these two rainfall series with a correlation of 0.43 and this link remains after the data are detrended. In particular, this relationship accounts for up to 62% variance on interdecadal timescales, and seems to be driven by the poleward shift of the Southern Subtropical High Ridge (SSHR) and the Northern Subtropical High Ridge (NSHR) over longitudes (110°-150°E). The poleward shift of the SSHR may induce to an anomalous anti-cyclone centered near the south Australian coast resulting in anomalous easterlies of dry air to SWWA, while the poleward shift of the NSHR is associated with an anomalous anti-cyclone in East Asia near NC causing anomalous northeastlies of dry air to NC. The pole-ward shift of SSHR/NSHR may be linked to the warming sea surface temperatures (SSTs) in the tropical Indian-western Pacific. Our results suggest that the poleward shifts of the SSHR and the NSHR instigated by the warming SSTs in the tropical Indian-western Pacific may have partially attributed to the rainfall reduction in both regions.

This work was supported by the Australia-China Bilateral Climate Change Partnership through the Australian Department of Climate Change and Energy Efficiency, the 973 Program (2010CB950400), National Natural Science Foundation of China (41030961), and the Indian Ocean Climate Initiative Stage 3.

ENSO Changes in CMIP5/PMIP3 Simulation during the Midholocene and Preindustrial Periods

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During El Niño–Southern Oscillation (ENSO)events, the atmospheric response to sea surface temperature (SST) anomalies in the equatorial Pacific influences ocean conditions over the remainder of the global. Bjerknes Feedback has been successful in describing dynamical processes such as the thermocline, the zonal advection, and the Ekman feedbacks. Using these feedbacks, we study the specific mechanism over the two different time periods (6ka: midholocene experiment: warm period due to maximum inclination of Earth rotation axis, 0ka: preindustrial experiment: status of gases and aerosols is fixed at year 1850). There was distinctive feature in the 6ka that is different in the 0ka. CMIP3/PMIP2 6ka models indicated lower ENSO variability than 0ka variability. [*Tudhope et al.*, 2001; *McGregor and Gagan*, 2004; *Zheng et al.*, 2008] However, 2 (Csiro_mk36, Mri_cgcm3) of 11 new CMIP5/PMIP3 models have higher 6ka variability than 0ka variability at the Nino regions. To find difference-inducing component, we focus on Bjerknes stability index [*Jin et al.*, 2006] which takes its negative contributions from the mean upwelling and thermal damping and its positive contributions from feedbacks. Thermocline depths, mean climate states (wind stress, SST, precipitation), and ocean fluxes are contributing to ENSO changes.

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The weather risk attribution forecast for July 2013

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Lawrence Berkeley National Laboratory

Whenever an unusual weather event occurs these days, the question is immediately asked: "Are our emissions to blame for this event?" Unfortunately, real-time or near-real-time assessments so far have all been subjective, amounting to contradictory samples of expert opinion which place different weights on various indirect sources of evidence, different interpretations of the question, and criteria for event selection.

Here we will present the "attribution forecast" for July 2013 from an on-going systematic real-time system for examining how anthropogenic greenhouse gas emissions have contributed to weather risk in our current climate. By comparing real seasonal forecasts against parallel counterfactual seasonal forecasts of the climate that might have been had human activities never emitted greenhouse gases, this service responds proactively to the question: "Has this event been made more or less frequent by our emissions?" In presenting this information for July 2013, we will discuss what we have learned from four years of operation of this service.

Climate change scenarios of temperature extremes evaluated using extreme value models based on homogeneous and non-homogeneous Poisson process

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The study compares statistical models for estimating high quantiles of daily temperatures based on the homogeneous and non-homogeneous Poisson process, and their applications in global climate model (GCM) simulations. Both types of the models make use of non-stationary peaks-over-threshold method and the Generalized Pareto distribution (GPD) for modelling extremes, but they differ in how the dependence of the model parameters on time index is captured. The homogeneous Poisson process model assumes that the intensity of the process is constant and the threshold used to delimit extremes changes with time; the non-homogeneous Poisson process assumes that the intensity of the process depends on time while the threshold is kept constant (Coles 2001). The model for time-dependency of GPD parameters is selected according to the likelihood ratio test. Statistical arguments are provided to support the homogeneous Poisson process model, in which temporal dependence of the threshold is modelled in terms of regression quantiles (Kysely et al. 2010). Dependence of the results on the quantile chosen for the threshold (95-99%) is evaluated. The extreme value models are applied to analyse scenarios of changes in high quantiles of daily temperatures (20-yr and 100-yr return values) in transient simulations of several GCMs for the 21st century.

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Relations of extreme temperature with large-scale climate variability during winter in Korea using Non-stationary GEV with covariate

Jong-hwa Lee[1], Seung-Ki Min[2], Hee-Jeong Baek[1], and ChunHo Cho[1]

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During the winter of 2009-2010 when AO phase was strongly negative, which was record breaking event, East Asia, particularly Korea had been suffered from influences of the extreme cold weather. Nevertheless, correlation coefficient between the AO and surface air temperatures of Korea which are in situ data compiled by KMA is 0.36, which is of no significance (NIMR, 2011, 2012). It means that quantifying the relationship of temperature with AO was not clear in the mean sense. However minimum values of daily minimum temperature and daily maximum temperature had higher correlation coefficients. Therefore we have been focused on the extreme temperatures instead of averaged temperatures. Recently, revealing relationship of Extreme events with atmospheric circulation feature comes into the spotlight. Way to investigate the influence of large-scale atmospheric patterns or modes of climate variability, on extreme climate events is to include them as covariates in the extreme values methods (Sillmann et. al., 2011). And this approach is based on extreme value theory, suggested by Gumbel (1958).

In this presentation, the relationship of the extreme temperature with AO and Siberian High will be shown using extreme value analysis which is Non-stationary General Extreme Value (GEV) analysis with covariate. This study seeks to quantify the relative influence of the AO on the extreme winter temperature.

A study of climate extremes changes in Korea using quantile regression

Kyoungmi Lee, Hee-Jeong Baek, ChunHo Cho

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A traditional tool for analyzing the long-period trends in a climatic series is regression analysis. However, the regression analysis that is used in most studies for computing the climate trend is based on the least-squares method. This method only provides information about the trend of the average value regarding the dependent variable for every value of the independent variable. In contrast, the quantile regression, introduced by Koenker and Bassett (1978), is the regression analysis method for estimating the regression slopes for the values of any quantile from 0 to 1 of dependent variable distributions. This method provides a more complete picture for the conditional distribution of the dependent variable given the independent variable when both lower and upper or all quantiles are of interest, so it is especially useful in applications where extremes are important.

This study analyzed the changes in extreme temperature and precipitation in Korea using quantile regression. For the time series of temperature, the slopes in lower quantiles generally have a more distinct increase trend compared to the upper quantiles. The time series for daily minimum temperature during the winter season only shows a significant increasing trend in the lower quantile. This suggests that the warming in Korea during the winter season is mainly provided by the increase of temperature in the lower quantile. In the time series of annual precipitation in Seoul for the period of 1908~2011, the slopes in the upper quantiles have a more distinct increase trend compared to the lower quantiles. For the time series of daily precipitation from June to September, the slopes of the upper quantiles recently show an abrupt increase, indicating that the intensity of extreme daily precipitation in Seoul has increased recently. In the time series of daily maximum and minimum temperature for the period of 2011~2100, the slopes in the lower quantiles are projected to have a more distinct increase trend compared to the upper quantiles. For the time series of daily precipitation $\geqq$ 50 mm, the slopes of the upper quantiles in RCP8.5 scenario are projected to increase more abruptly than in RCP4.5 scenario.

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First steps towards attribution of trends in European flood risk

Pardeep Pall

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Whilst the event attribution field has developed noticeably in recent years, the attribution of small-scale hydrometeorological events – such as floods – remains limited. This is in part because of computational resources required to both resolve the relevant atmospheric processes in climate models, and to capture these relatively rare phenomena via the generation of large ensembles of model simulations [1].

A case study examining the record-wet autumn of 2000 in England & Wales attributed a substantial increase in the risk of floods over that region as a whole to anthropogenic greenhouse gas emissions [2]. A follow-up study on a catchment-by-catchment basis demonstrated that the significance of any increase deteriorates at these finer scales, primarily due to the insufficient resolution of the driving climate model, and also depends on the catchment characteristics [3].

Here we will extend these studies to examine attributable flood risk for several types of european catchment, and for several recent years – enabling assessment of spatio-temporal trends in attributable risk. We will present first results from this study, obtained using the CAM5.1 climate model output fed into a european flood model developed for the reinsurance industry – enabling assessment of attributable trends in financial losses due to flood damage.

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A Generalized Gumbel Distribution

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A generalized Gumbel distribution (GGD) is proposed as a special case of the four parameter kappa distribution (K4D). A description of the mathematical properties including moments, L-moments, and the asymptotic distribution of the extreme order statistics is provided. Relationships to Gumbel, generalized extreme value (GEV), and other distributions are given with graphical illustrations. The Monte Carlo simulation for performance evaluation of the estimation methods (method of the L-moment, and Maximum likelihood estimation) is presented. Fisher information matrix is calculated. We illustrate its applicability for extreme climatic data.

Spatial modeling of the highest daily maximum temperature in Korea via max-stable processes

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This paper examines the annual highest of daily maximum temperature in Korea by using data from 56 weather stations and employing a spatial extreme modeling. Our approach is based on the max-stable processes with Schlather's characterization. We divide the country into four regions for a better model fit and identify the best model for each region. The advantage of the spatial extreme modeling is that more precise and robust return levels and some indices of the highest temperatures can be obtained for observation stations and for locations with no observed data, and so help to determine the effects and vulnerability assessments, and for downscaling of extreme events.

Extreme Precipitation Event simulation based on k-Nearest Neighbour Weather Generator using Gamma Kernel

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Stochastic models are commonly used to generate synthetic sequences of weather variables so as to produce key statistical features of the observed characteristics of the historical record in time. Precipitation is the most crucial meteorological variable for many applications. The objective of this research is to develop and evaluate a weather generating model based on k-nearest neighbour with gamma kernel perturbation of simulated data. Perturbation in this work has been done using the gamma kernel. The selected value from K-NN approach is placed at the center of a gamma kernel. Then, a value is perturbed from the kernel density according to the smoothing principle of kernel density estimation. The performance of the proposed K-NN model was evaluated through application to data from the Upper Thames River Basin (UTRB). The K-NN algorithm was used to generate 500 synthetic sequences of length equal to the historical length with this data set for each station. The goal of simulation was to produce a data series that preserved the statistical attributes of the historic data while perturbing the existing data points. Box plots have been used to compare the statistics of interest between the computed from the simulated sequence and the observed record. An important aspect of the proposed model is that extreme events, such as high precipitation, can be simulated. This may be valuable aid in flood prediction models if their performance is evaluated based on synthetic sequences generated by the proposed model.

Asian-North Pacific atmospheric circulation associated with Korean winter temperature regime shift in the late 1980s

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In this study, we examine the relationship between the regime shift in the Korean winter temperature and long-term variation of atmospheric circulation on three different spatial scales: the North Pacific (NP), Asian-North Pacific (AN) and Northern Hemisphere (NH). Inter-decadal variation of Korean winter temperature is significantly correlated with the second principal component (PC) of EOF analysis of SLP in NP. Similar patterns are obtained as first EOF mode for AN and NH domains. By applying the regime shift detection algorithm to the aforementioned three leading modes, we find a drastic change of phase in the NP PC2 and AN PC1 timeseries in 1986 when a regime shift is detected in the Korean winter temperature. SLP regression maps of NP PC2 and AN PC1 resemble the North Pacific Oscillation (NPO)/West Pacific (WP) pattern. Results indicate that the strengthening of NPO/WP-like SLP pattern after 1986 may have caused the increased south easterlies that increase warm advection to the Korean Peninsula. Further analysis reveals that the enhanced NPO/WP-like SLP Pattern is linked to a drastic intensification of Ferrel cell after 1986. Consequently, the strengthening of the descending and ascending motion of the Ferrel cell causes the north-south oscillation pattern over NP, which is related to the Korean winter temperature regime shift.

Changes in the relationship between ENSO and PDO in accordance with their periodicity under global warming

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Yet El Nino and Southern Oscillation (ENSO) is a variability spatially limited to the tropics, its impacts onto the higher latitudes is considerable. For example, Pacific Decadal Oscillation (PDO), which is ENSO-like Sea Surface Temperature (SST) variability in North Pacific on the low-frequency timescales, is largely associated with ENSO through atmospheric teleconnection. However, the dominant time scale linking the two variabilities cannot exactly be determined because ENSO and PDO is dominant on interannual and decadal timescales, respectively. We examine how the ENSO–PDO relationship changes in accordance with their periodicity under global warming by analyzing Coupled Model Intercomparision Project Phase5 multi-model datasets. We compare the RCP4.5 with the historical run. By filtering the time series of ENSO index and PDO index, we examine how their linear relationship on interannual-to-decadal timescales changes under global warming.

Changes in the relationship between the western tropical Pacific and the North Pacific SST across 1998/99 North Pacific regime shift

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We examine changes in the relationship between the western tropical Pacific and the North Pacific sea surface temperature (SST) before and after the 1998/99 North Pacific regime shift. The North Pacific climate regime shift in the winter of 1998/99 is characterized by a dipole-like structure along 40°N where a significant warming in prominent in the southwestern and central North Pacific. After 1998/99 regime shift, the southwestern and central North Pacific SST is highly positively correlated with the western tropical Pacific SST. In contrast, such relationship is not found before 1998/99 regime shift. We argue that this phenomenon might be associated with the characteristic changes in the Kuroshio currents, which is originated from the western tropical Pacific, in terms of its intensity.

In addition, the variations of SST in the western tropical Pacific SST are associated with the North Pacific oscillation-like atmospheric circulation since 1998/99. In particular, a southward shift of the atmospheric center of action in the NPO may contribute to a warming in the central North Pacific. Therefore, we speculate that both the oceanicand atmospheric teleconnections play an important role to change in the relationship between the western tropical Pacific and the North Pacific SST after 1998/99.

Relationship between the frequency of tropical cyclones in Taiwan and the Pacific/North American pattern

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The frequency of tropical cyclones (TCs) in Taiwan during June to October (JJASO) is found to have a strong negative correlation with the Pacific/North American (PNA) pattern in the preceeding April. In the negative PNA phase, the anomalous cyclonic and the anomalous anticyclonic circulations are intensified at low latitudes and midlatitudes from East Asia to the North Atlantic, respectively, from April to JJASO. Particularly in East Asia, the anomalous southeasterly that converges between the anomalous anticyclone to the east of Japan and the anomalous cyclone to the east of Taiwan plays a decisive role in moving TCs not only to Taiwan, but also to the midlatitude coastal regions of East Asia as a result of the steering flow. In addition, the monsoon trough anomalies located in the low latitudes of East Asia generates TCs in the southeast quadrant of the subtropical western North Pacific (SWNP). The intensity of the TC in the negative PNA phase is stronger than that in the positive PNA phase due to the difference in the typical tracks of the TC in the western North Pacific according to the PNA phase.

Changes in global precipitation-temperature relationship by natural versus anthropogenic forcing

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Using three CMIP5 sets of historical single-forcing experiments with the Community Earth System Model version 1 (CESM1), we examine the relationship of precipitation-temperature over the globe. Three CMIP5 sets of historical single-forcing experiments include greenhouse gas forcing only, aerosol forcing only and natural forcing only including solar and volcano. According to previous studies, precipitation is likely to increase in high latitudes and the tropics and to decrease in subtropical regions, furthermore, such characteristic of precipitation differs by forcing type. We first examine how the precipitation-temperature relationship depends on forcing type by analyzing three sets of CESM1. In addition, we analyze the sea surface temperature gradients across the tropical Pacific Ocean in three sets of CESM1, which play a role to influence the amount of precipitation over the globe.

Connection between the genesis frequency of tropical cyclones over the western North Pacific and summer rainfall over Northeast Asia

Ki-Seon Choi[1] and Il-Ju Moon[2]

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The frequency of tropical cyclones (TCs) in Taiwan during June to October (JJASO) is found to have a strong negative correlation with the Pacific/North American (PNA) pattern in the preceeding April. In the negative PNA phase, the anomalous cyclonic and the anomalous anticyclonic circulations are intensified at low latitudes and midlatitudes from East Asia to the North Atlantic, respectively, from April to JJASO. Particularly in East Asia, the anomalous southeasterly that converges between the anomalous anticyclone to the east of Japan and the anomalous cyclone to the east of Taiwan plays a decisive role in moving TCs not only to Taiwan, but also to the midlatitude coastal regions of East Asia as a result of the steering flow. In addition, the monsoon trough anomalies located in the low latitudes of East Asia generates TCs in the southeast quadrant of the subtropical western North Pacific (SWNP). The intensity of the TC in the negative PNA phase is stronger than that in the positive PNA phase due to the difference in the typical tracks of the TC in the western North Pacific according to the PNA phase.

Changes in the air-sea interactions over South China Sea and its relationship with Northeast Asia summer monsoon

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We investigate the changes in the air-sea interactions over the South China Sea (SCS) by analyzing atmospheric and oceanic variables in the period of 1979-2011 during the boreal summer(June-July-August, JJA). It is found that a simultaneous relationship between sea surface temperature (SST) and precipitation over SCS during summer is changed before and after the late-1990s. While SST is negatively correlated with precipitation before the late-1990s, its correlation coefficient with SST and precipitation is positive after the 1990s. Further lead-lagged relationship indicates that the atmosphere is forced to respond passively to the SSTs before the late-1990s, which is in contrast to after the late-1990s. Also, it is found that changes in the air-sea interactions over SCS are associated with the changes in its relationship with Northeast Asia summer precipitation through the changes in local meridional circulations from SCS to the Northeast Asia. That is, a relationship of SCS SST – summer precipitation over Northeast Asia is changed from before the late-1990s to after the late-1990s.

Two climate factors in May that affect Korean rainfall in September

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This study revealed a high positive correlation between rainfall in Korea during September and the trade wind (TW)/Arctic Oscillation (AO) index in May that combines two climate factors, low-level TWs and the AO. This correlation was identified based on the difference in the 850-hPa streamline analysis between the positive and negative phases selected using the combined TW/AO index. In May, the spatial pattern of the anomalous pressure systems is similar to that in the positive AO phase. These anomalous pressure systems continue in June to August (JJA) and September, but the overall spatial distribution shifts a little to the south. Particularly in September, a huge anomalous anticyclone centered over the southeast seas of Japan strengthens in most of the western North Pacific region and supplies a large volume of warm and humid air to the region near Korea. This characteristic is confirmed by the facts that during the positive TW/AO phase, the subtropical western North Pacific high (SWNPH) is more developed to the north and that the continuous positioning of the upper troposphere jet over Korea from May to September strengthens the anomalous upward flow, bringing warm and humid air to all layers. These factors contribute to increasing September rainfall in Korea during the positive TW/AO phase. Because the SWNPH develops more to the north in the positive phase, tropical cyclones tend to make landfall in Korea frequently, which also plays a positive role in increasing September rainfall in Korea. The above features are also reflected by the differences in average rainfall between the six years that had the highest May Niño 3.4 indices (El Niño phase) and the six years that had the lowest May Niño 3.4 indices (La Niña phase).

Impacts of absorbing aerosols on the snowpack over the Tibetan Plateau and Indian summer monsoon

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In this study, we present observational evidences of aerosol induced accelerated snow melting in the western Tibetan Plateau (WTP) and associated changes in pre-monsoon rainfall over India subcontinent. Presented Indo-Gangetic Plain (IGP) regions, bounded by the high altitude Himalayan Mountains, are subject to heavy loading of absorbing aerosols, i.e., black carbon and dust. Recent modeling study suggests that radiative forcing from absorbing aerosols over IGP can lead to widespread warming of the atmosphere over the Tibetan Plateau (TP) and accelerated snowmelt in the western Tibetan Plateau (WTP) and Himalayas. In this study, based on TOMS AI and MODIS AOD during pre-monsoon season (April-May), high and low aerosol loading years are selected and used for composite analysis of rainfall, atmospheric circulation, and snow. The pre-monsoon seasons of high aerosol and low aerosol cases were markedly contrasting in terms of the aerosol loading over IGP. The warming of the TP in high aerosol cases compared to low aerosol cases was extensive, covering most of the WTP and Himalayas. This atmospheric warming is closely linked to patterns of the snow melt over TP. Consistent with the Elevated Heat Pump hypothesis, we find that increased loading of absorbing aerosols over IGP in the pre-monsoon season is associated with increased heating of the upper troposphere and accelerated snowmel tover Himalayas and the WTP in April-May. Composite analysis shows that the tropospheric heating by elevated dust and black carbon aerosols in the boreal spring can lead to widespread enhanced land-atmosphere warming, accelerated snow melt in the Himalayas and Tibetan Plateau, and enhanced precipitation in May-June over the northern India by dynamical feedback induced by absorbing aerosols.

Climate feedback of anthropogenic aerosols over East-Asia using HadGEM2-AO

Sungbo Shim, Yoo-Rim Jung, Hee-Jeong Baek and ChunHo Cho

National Institute of Meteorological research/KMA

Climate impact by anthropogenic drivers gives high concerns in climate change simulation. IPCC AR4 emphasized the role of aerosol on climate besides the greenhouse gases (GHGs) due to its negative significant radiative forcing. Unlike the long-lived GHGs, which are distributed uniformly over the globe, aerosol effects with the short lifetime appear more regional and less persistent than those of GHGs. East-Asia is densely populated region over 60 percentile of the world`s population and economically rapid developed regions. The rapid economic development accompanies heaviest aerosol-burden as well, exceed the levels of Western Europe and Eastern United States. This study is interested in climate feedback of anthropogenic aerosols over East-Asia through direct and indirect radiative process and uses HadGEM2-AO developed by the UK Met office. The rise in anthropogenic aerosols (sulfate, biomass-burning, organic carbon, and soot) was largely due to the increase in industrial activities (Figure 1). Sulfate aerosol is the dominant component, accounting for about 50% of total aerosol optical depth at 550 nm. In Figure2, cloud fractions distributions over East-Asia for 1900-1924 and 1980-2005 classified by ISCCP method. We find a persistent positive correlation between cloud fraction and aerosol optical depth and a negative correlation between cloud top pressure and aerosol optical depth. Particularly, aerosols have an influence on the amount of cloud cover (SC, ST, and NS) through the interaction with precipitation efficiency of warm clouds. Overall, the regional radiative forcing from aerosol-cloud interaction contributes a strong regional climate response, cooling the East-Asia regions by 1.2 ^{0}C on average during 1980-2005. Aerosols also reduce the solar flux reaching the land. Since 1950, the reduction over East-Asia is thought to total 4 W/m^{2}, with the biggest contribution occurring after 1980. Lower land temperature flattens the land-sea temperature gradient, thus weakening the monsoon effect. More detailed analysis will be shown at the conference.

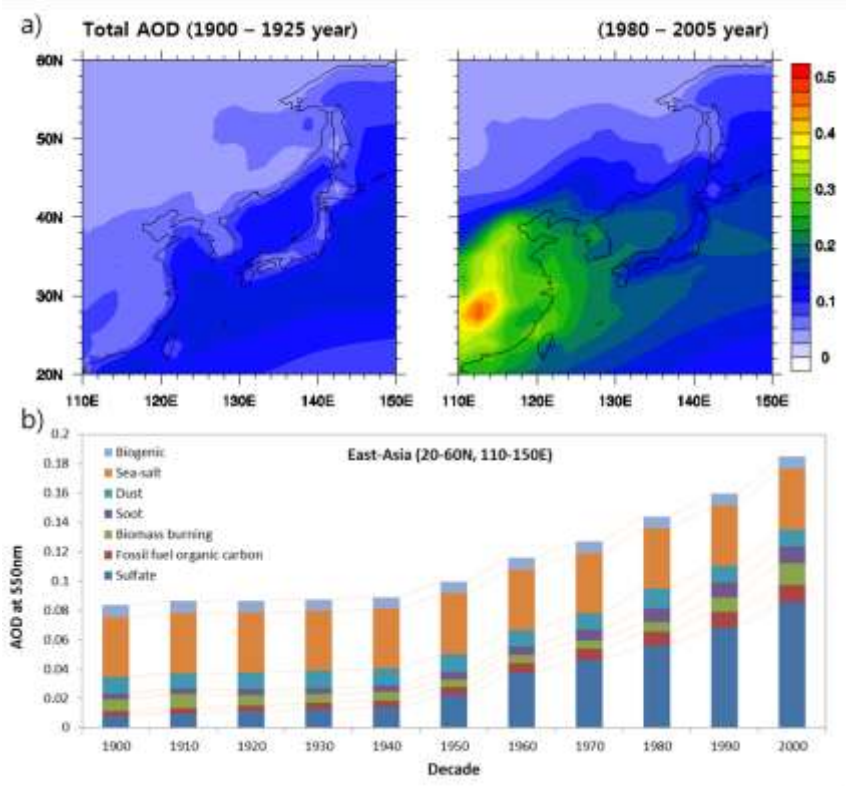

Figure 1. (a) Total AOD distribution over East-Asia for 1900-2925 and 1980-2005. (b) Changes in decadal mean AOD at 550 nm of 7 aerosols over East-Asia.

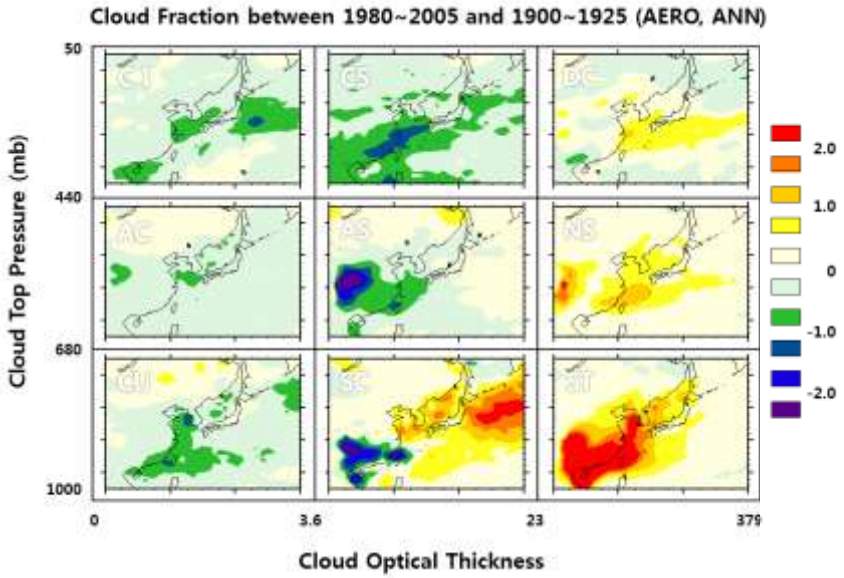

Figure 2. Cloud fraction distributionsdue to East-Asia anthropogenic aerosol sources classified by ISCCP method.

12th International Meeting on Statistical Climatology

Thursday, 27 June, 2013

MON TUE WED THU FRI

On the Nature of Global Atmospheric Response to the Tropical SST Forcing

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The global climate sensitivity to the tropical SST forcing was assessed from the extensive sensitivity experiments performed by using a MPIM atmospheric GCM, the ECHAM5, with localized SST anomaly “patches” prescribed throughout the tropical oceans. It is found that the global climate is most sensitive to the SST changes in central Pacific and the Indo-Pacific warm pool region, although the interannual SST variability is largest in the central and eastern tropical Pacific. The results from this sensitivity analysis also used to interpret the regional climate change responses around the globe.

To further understand the role of tropical SST forcing in observed global and regional climate variability, the global atmospheric responses to the patterns of tropical SST forcing were assessed and compared by using statistical methods, Generalized Feedback Analysis (GEFA) and Linear Inverse Modeling (LIM). It is found that LIM and GEFA are able to reproduce the major features of the atmospheric response in our patch experiments and that in the separate MPI-ECHAM5 simulations with prescribed tropical SST patterns. Thus the use of GEFA and LIM for the assessment of observed atmospheric response to the tropical SST forcing is justified and the results derived from LIM and GEFA will be discussed.

Energetics Responses to Increases in Greenhouse Gas Concentration

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Increasing greenhouse gas concentrations warms the troposphere. However, it is not clear whether this implies changes in the energetics. To study the energetics responses to CO2 increases, changes in the Lorenz energy cycle (LEC) are evaluated using climate chnage simulations performed with the coupled atmosphere-ocean model ECHAM5/MPI-OM. Equilibrium $2\times CO_2$ experiments and 10-yr transient experiments with 3% increase per year are analyzed. Globally, doubling of CO2 results in a decrease in the LEC strength, defined as the total conversion of available potential energy P into kinetic energy K, but also in an increase in the zonal-mean K. These lobal changes are a consequence of the strengthening of the LEC in the upper troposphere and the weakening of the cycle below. The two opposite responses result from the simulated warming pattern that shows the strongest warming in the upper tropical troposphere and in the lower troposphere at high latitudes. This warming structure causes changes in the horizontal temperature variance and in mean static stability, which increase zonal-mean P in the upper troposphere and decrease it below, triggering the two opposite responses via changes in baroclinic activity. In general, the lower-region weakening is stronger in the Northern Hemisphere, while the upper-region strengthening, and the increase of zonal-mean P and K, is stronger in the Southern Hemisphere. The former is more pronounced in the transient experiments but decreases in the stabilized $2\times CO_2$ climate.

Investigating changes in dryness by a comprehensive synthesis of available data sets

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Changes in the climatological land water balance affect a wide range of socio-economical sectors. Thus, the identification of regions undergoing a substantial increase or decrease in dryness is of major interest in climate science. Here we study changes in either precipitation (P) or potential evaporation (Ep) in relation to changes in evapotranspiration (E), thereby considering both the water and the energy balance. However, global estimates derived from observations or from models of P, Ep and especially E are characterized by high uncertainties, partly leading to inconsistent results in previous studies.

Our major objective is therefore to identify those regions which show robust trends across a large number of global data sets, yielding more than 700 possible combinations for E together with P and Ep for the period from 1948 to 2008. To examine the realism of the individual combinations of E, P and Ep, we evaluate them within the Budyko framework, which provides an empirical relationship between E/P and Ep/P. We use the combinations which perform well in this framework to study decadal changes in the water balance (ΔP - ΔE) and the energy balance (ΔEp - ΔE). Changes at the grid box level are quantified by the minimum Mahalanobis-distance between a fitted bivariate normal distribution to the estimates of the individual combinations of ΔP and ΔE (or ΔEp and ΔE, respectively), and the line of no change.

Our results reproduce findings from previous studies regarding long-term changes in the water balance, e.g. drying trends in the Mediterranean and East Asia and wetting in Central North America, but also highlight trends over India (drying), parts of Africa (drying) and Southeast South America (wetting).

Influence of climate variability on seasonal extremes over Australia

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It is well understood that Australian climate is affected by natural climate variability such as El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), and Southern Annular Mode (SAM), depending on seasons and regions. However, studies on extremes associated with natural climate variability remain limited. This study examines possible impact of natural climate variability on interannual changes in seasonal extremes of temperature and precipitation over Australia during 1957-2010. We conduct non-stationary Generalized Extreme Value (GEV) analysis where GEV parameters are specified as a linear function of modes of climate variability, and compare results with the case when climate variability are not considered. Results from station-based observations suggest that extreme responses overall resemble mean responses to climate variability, suggesting that similar teleconnection mechanisms for seasonal means are at work for changes in extremes.

Min, S.-K., W. Cai, and P. Whetton, 2013: Influence of climate variability on seasonal extremes over Australia. *J. Geophys. Res.*, **118**, 643-654, doi: 10.1002/jgrd.50164.

A long-term climatology of “Mediterranean hurricanes”

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Medicanes (*Med*iterranean hurri*canes*), strong mesoscale cyclones with tropical-like features (axis-symmetry, a warm core, a cloud-free eye surrounded by a spiral-shaped cloud cover, winds up to the hurricane speed), are known to develop occasionally over the Mediterranean Sea. Medicanes are often associated with extreme weather and can cause severe damage on coastal areas.

Medicanes are considered rare phenomena - the number of observed cases documented in the literature is around ten. However, due to the scarcity of observations over sea, and to the coarse resolution of the long-term reanalysis datasets, it is difficult to construct a homogeneous statistics of the formation of medicanes.

Using an approach based on the dynamical downscaling of global reanalyses, the statistical properties of medicanes (annual cycle, decadal and inter-annual variability, geographical distribution, trends) over the last six decades are studied in a systematic way. The linkage between the frequency of medicanes formation and synoptic patterns is investigated.

Applying the same downscaling procedure to the atmospheric fields produced by GCM, forced with future climate scenarios greenhouse gas concentration, the impact of climate change on the statistics of medicanes is estimated.

Bayesian forecasting of typhoon intensity over the western North Pacific: A track-pattern clustering approach

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A new approach to forecasting short lead times of tropical cyclone (TC) intensity using the Bayesian multiple regression model is proposed. This approach, based on TC track types, yields probabilistic forecasts of TC intensity up to 48 hours in advance at a 6-hr interval. Each TC path over the western North Pacific is modeled as a second-order polynomial function of the lifetime of TCs. Mathematically, for each track type, the set of coefficients of this polynomial function is presumably jointly Gaussian distributed. The space spanned by the parameters of the track type model is a linear combination of a set of distinct Gaussian distributions. Records for typhoon tracks over the western North Pacific are provided by the Central Weather Bureau (CWB) in Taiwan. The data for the predictions come from the numerical weather prediction model run by NOAA, namely the Global Forecast System (GFS), via the CWB. The GFS data are in 0.5 degree by 0.5 degree resolution and at 6-hr intervals for the period from 2008 to 2011.

The potential predictors can be divided into two categories: 1) those related to climatology, persistence, and trends of typhoon track pattern and intensity and 2) those related to current and future environmental conditions. Based on the predictor selection procedure, we generate the Bayesian regression model for each track type, respectively (named model cluster). For each simulation, we also generate another independent model, which adopts the same predictor selection procedure but without using the clustering classification (named model general). For comparison, the benchmark climatology and persistence (CLIPER) model is also developed. For 12-hr forecast, the “model cluster” generally has smaller mean absolute error relative to the “model general” and “CLIPER.” For longer lead times (up to 48-hr), the forecast skill of “model cluster” distinguishes itself even more than the other two benchmark forecast systems.

Sensitivity of extreme rainfall events in Africa attributable to anthropogenic radiative and SST forcing

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Attribution of extreme meteorological and hydrological events to climate change is a growing research area subject to intensive methodological development in the recent years. A "risk-based" approach to attribution examines how the probability of an event exceeding a certain threshold has been altered due to anthropogenic greenhouse gas emissions. This is done by comparing the probability of occurrence of events of given magnitude, obtained from an initial condition ensemble AGCM run under current observed ocean boundary and radiative forcings, with that obtained from an ensemble forced by pre-industrial GHG concentrations and SST adjusted to represent pre-industrial conditions (by subtracting an estimate of the SST warming attributable to emissions). Earlier studies indicate that the degree to which extreme rainfall and floods are attributable to anthropogenic emissions depends strongly on the choice of AGCM and on the estimate of attributable SSTwarming.

In this paper we present an experimental setup and results of an on-going study aimed at investigating the sensitivity of attribution statements to the radiative and ocean boundary forcings. In the study, HadAM3P AGCM is run for the 2008-2012 period with current observed CO_2 and aerosol concentrations representing observed (real-world) radiative forcing, and observed SST and sea ice concentrations representing the real-world ocean boundary forcing. Subsequently, the model is run in three counter-factual experiments: a) with pre-industrial radiative and adjusted ocean boundary forcing, b) with pre-industrial radiative and observed ocean boundary forcing, and c) with observed radiative and adjusted ocean boundary forcing. For each of these experiments, fraction of attributable risk for prescribed rainfall events over African domain is described by probability density functions. Their similarity and differences in space and time are then used to conclude about sensitivity of attribution statements to the radiative and ocean boundary forcings. Results could be used to increase robustness of attribution messages.

Joint occurrence of daily temperature and precipitation extreme events over Canada

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Temperature and precipitation extreme events have been separately studied around the globe since their occurrence severely impacts built and natural systems. Agriculture, energy demands, and human health, among other activities, can be affected by extremely high or low temperatures and by extremely dry or wet conditions. However, the simultaneous or proximate occurrence of both types of extremes could lead to more profound consequences. For example, a dry period can have more negative consequences on agriculture if it is concomitant with or followed by a period of extremely high temperatures.

In this study the joint occurrence of dry/wet conditions and high/low temperature events in Canada is analysed during the period 1971-2000 based on an observational dataset and regional climate simulations from the NARCCAP project. More than 70% of the stations showed a significant relation between daily temperature extremes and heavy precipitation. Observations show that heavy precipitation events (defined as daily precipitation greater that the 75th percentile) are more likely to occur together with a minimum temperature warm extreme (warm night, minimum temperature exceeding the 90th percentile) or a maximum temperature cold extreme (cold day, maximum temperature below the 10th percentile). The greater signal in the simultaneous occurrence of heavy precipitation events and warm nights (cold days) is seen in winter (summer) with an average of 21.4% (28.7%) of the days with extreme temperature events also registering heavy precipitation.

Regional climate simulations are in good agreement with observations, showing that the region that experiences the greatest amount of heavy precipitation events on days with extreme temperatures is the Pacific coast.

Given that projected changes in precipitation under a climate change scenario are more uncertain than projections in temperature changes, a thorough understanding of this relation may allow for a reduction in the uncertainties associated with projected changes in precipitation.

Atlantic roles on ENSO development

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El Niño events, the warm phase of the El Niño/Southern Oscillation (ENSO), are known to affect other tropical ocean basins through teleconnections. On the other hand, there are mounting evidences that temperature variability in the Atlantic Ocean may also influence ENSO variability. Here we use reanalysis data and general circulation models to show that sea surface temperature (SST) anomalies in the North Tropical Atlantic during the boreal spring can serve as a trigger for ENSO events. We identify a subtropical teleconnection in which North Tropical Atlantic warming can induce a low-level cyclonic atmospheric flow over the eastern Pacific that in turn produces a low-level anticyclonic flow over the western Pacific during the following months, cooling the equatorial Pacific through the easterlies over the equatorial western Pacific. Especially, this process seems to favor the development of a warm pool E1 Niño event with a centre of action located in the central Pacific, rather than the canonical event. We suggest that the identification of temperature anomalies in the North Tropical Atlantic could help to forecast the development of different types of El Niño events.

Impacts of ENSO and North Atlantic SST on Northeast China summer temperature variations

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El Niño-Southern Oscillation (ENSO) is one important factor for the summer climate anomalies in China. Northeast China (NEC) summer temperature tends to be lower (higher) than normal in El Niño (La Niña) developing years during 1950s through mid-1970s. The relationshipbetween the NEC summer temperature and ENSO is weakened or even becomes opposite in 1980s and 1990s. Before the late 1970s, ENSO affects the NEC summer temperature through modulating the South Asian heating and consequently the midlatitude Asian circulation. After the late 1970s, the connection between ENSO and the Indian summer monsoon and that between the South Asian heating and the midlatitude Asian circulation have been weakened. This leads to a weakening of ENSO impacts on the NEC summer temperature. It is found that the NEC summer temperature variations are closely related to a tripole North Atlantic sea surface temperature (SST) anomaly pattern in boreal spring in 1980s and 1990s. The tripole SST anomaly pattern has a weak correlation with NEC summer temperature during the 1950s through the mid-1970s, in sharp contrast to the 1980s and 1990s. This change is related to the difference in the persistence of the tripole SST pattern. Before the late 1970s, the tripole SST pattern weakened from spring to summer, and thus, the spring North Atlantic tripole SST pattern had a weak connection with NEC summer temperature. On the contrary, after the late 1970s, the tripole SST pattern displayed a tendency of persistence from spring to summer, contributing to circulation changes that affected NEC summer temperature. There are two factors for the persistence of the tripole SST pattern from spring to summer. One is the North Atlantic air-sea interaction, and the other is the persistence of SST anomalies in the eastern equatorial Pacific during the decay of ENSO. It is shown that the North Atlantic SST anomalies can have an impact on NEC summer temperature independent of ENSO. Analysis shows that, in many years during 1980s and 1990s, the North Atlantic and the tropical North Pacific SST anomalies can contribute in concert to the midlatitude Asian circulation changes and the NEC summer temperature anomalies. The former generates a wave pattern over the North Atlantic and Eurasia. The latter induces anomalous heating over the tropical western North Pacific that excites a meridional wave pattern over East Asia. These effects overcome those of the central and eastern equatorial Pacific SST anomalies, leading to a same-sign relationship between the NEC summer temperature and the central and eastern equatorial Pacific SST

anomalies. This contributes to the weakening of the connection between the NEC summer temperature and ENSO after the late 1970s.

Wu, R., S. Yang, S. Liu, L. Sun, Y. Lian, and Z.-T.Gao, 2010: Changes in the relationship between Northeast China summer temperature and ENSO. *J. Geophys. Res.*, **115**, D21107, doi:10.1029/2010JD014422.

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Warm and cold water events in the tropical Atlantic Ocean and teleconnections to the tropical Pacific

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So far two phenomena akin to the Pacific El Niño with high sea surface temperature (SST) anomalies have been described for the eastern tropical Atlantic, one of them centered in the equatorial region as part of the Atlantic zonal mode, also known as Atlantic Niño, and another one close to the coast of northern Namibia and Angola referred to as Benguela Niño. These tropical Atlantic SST anomalies are less frequent and less intense compared to the Pacific ones. However, like their Pacific counterparts, they have striking effects on regional rainfall patterns and on the west coast ecosystems and fisheries. Furthermore, recent studies found that tropical Atlantic SST variability may also affect the climate in the tropical Pacific and Indian Ocean basins.

Atlantic Niño and Benguela Niño have long been analyzed in separate studies and regarded as separate phenomena. Only recently, a strong link between both is suggested. Furthermore, impact studies on regional and global scales have been restricted to either the Atlantic or the Benguela Niño. This contribution introduces a new classification of warm and cold water events in the tropical Atlantic. It combines both Atlantic and Benguela Niños into three sub-types of one comprehensive Atlantic Niño. Based on this classification, links between Atlantic and Pacific warm water events are analyzed. This study is based on monthly observational data since 1951, including HadISST1.1 (1°x1° spatial resolution) and atmospheric variables from the NCEP-NCAR reanalysis dataset (2°x2°). All data were high-pass filtered to remove trends. Analyses are carried out based on overlapping 3-month seasons.

Bivariate correlation analysis as well as multivariate Canonical Correlation Analysis (CCA) are applied to analyze coupled variability of the Atlantic and Pacific Oceans. Furthermore, composite analysis is applied to study links between Atlantic and Pacific warm and cold water events.

Although there is no contemporaneous correlation between tropical Atlantic and Pacific SSTs, our results show a connection between Atlantic boreal winter SSTs and Pacific summer SSTs. Pacific warm events follow Atlantic cold events with a time lag of about 6 to 8 months.

Multi-decadal Mobility of the North Atlantic Oscillation

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The North Atlantic Oscillation (NAO) is one of the most important modes of variability in the global climate system and is characterized by a meridional dipole in the sea-level pressure field, with centers-of-action near Iceland and the Azores. It has a profound influence on the weather, climate, ecosystems and economies of Europe, Greenland, eastern North America and North Africa. It has been proposed that around 1980, there was an eastward secular shift in the NAO's northern center-of-action that impacted sea-ice export through Fram Strait. Independently it has also been suggested that the location of its southern center-of-action is tied to the phase of the NAO. Both of these attributes of the NAO have been linked to anthropogenic climate change. Here we use both the one-point correlation map technique as well as empirical orthogonal function (EOF) analysis to show that the meridional dipole that is often seen in the sea-level pressure field over the North Atlantic is not purely the result of the NAO (as traditionally defined) but rather arises through an interplay between the NAO and two other leading modes of variability in the North Atlantic region: the East Atlantic (EA) and the Scandinavian (SCA) patterns. We furthermore show that this interplay has resulted in multi-decadal mobility in the two centers-of-action of the meridional dipolesince the late 19th century. In particular, an eastward movement of the dipole has occurred during the 1930s-1950s as well as more recently. This mobility is not seen in the leading EOF of the sea-level pressure field in the region.

Favorable connections between the atmospheric structures over the North Pacific and central Pacific warming

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The Western Pacific Oscillation (WPO) teleconnection pattern, which consists of a north-south meridional dipole structure with one center located over the Kamchatka Peninsula and another broad center of opposite sign covering portions of southeastern Asian and the western subtropical North Pacific, is one of the primary modes for low-frequency variability in conjunction with the North Pacific Oscillation (NPO) variability over the North Pacific basin. In this study, the specific role of the WPO in changing the connection between the mid-latitude and tropical Pacific variability, as known as “Seasonal Footprinting Mechanism (SFM)”, is investigated during the period of 1958-2010. Firstly, similar to the NPO variability, the boreal wintertime WPO atmospheric forcing is able to generate the SFM process with stronger North Pacific Gyre Oscillation (NPGO) climate pattern. Secondly, in order to identify the specific role of the WPO, two conditional cases regarding the NPO and WPO are composed as follows: 1) the NPO only occurs without WPO (i.e., NPO_only) and 2) the NPO coincides with WPO (i.e., NPO+WPO), respectively. Using a conditional composite analysis, it is found that the characteristics of the NPO and WPO atmospheric structures are qualitatively different in their location and strength over the North Pacific. Furthermore, our result suggests that when the NPO and WPO simultaneously occur during the previous winter, a stronger NPGO mode is activated and results in the central Pacific warming during the following winter via the enhanced SFM process. In addition, it is revealed that the cause of the NPO+WPO-related atmospheric structure is significantly associated with the weakening of the cyclonic polar vortex via a result of the modified zonal index. A long-term coupled general circulation model analysis further verifies the observational results, showing a center-concentrated warming structure over the equatorial Pacific during the following winter when the NPO coincides with the WPO during the previous winter.

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Changing Global Circumpolar Vortex

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In this study, intra- and inter-annual cycles of circumpolar vortex (CV) in both hemispheres are examined in the context of climate change. Long-term (1948-2012) maps and statistics of daily/monthly CV size, perimeter and circularity ratio are produced from the NCEP/NCAR reanalysis I pressure data sets using the Geographic Information System (GIS). Analyses of monthly data show that the size and perimeter of Northern Hemisphere CV have shrunk particularly in spring and summer, while these changing patterns are less observable around the Antarctica. No obvious changes in the circularity ratio at both hemispheres indicate that abnormal temperature events such as cold surge in winter and heat waves in summer are still periodically repeated in the warmer climate. Projections of future global CV as well as the behaviors of observed daily CV will also be discussed in detail.

Keywords

circumpolar vortex, climate change, Geographic Information System (GIS)

Forecasting of the Madden-Julian Oscillation with Linear Stochastic Climate Models

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We investigate the skill of linear stochastic climate models in subseasonal MJO forecasts with lead times up to one month. Stochastic climate models have been shown to be competitive with coupled ocean-atmosphere global climate models (CGCMs) at 2-3 week lead times. They also are computationally inexpensive compared to CGCMs, allowing for the production of larger ensembles for probabilistic prediction relative to their counterparts. The linear inverse model (LIM) and extensions of LIM with non-Gaussian correlated additive and multiplicative noise (CAM) are examined. The correlation of the Real-time Multivariate MJO index of the forecast ensemble means against reanalysis observations are calculated and compared to those of a stationary climate. The probabilistic forecast skill of ensemble distributions for each model are similarly determined with a Brier-like score, and the results are compared.

Analysis of bias-correction of monthly temperature from RCM climate model over South Korea

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In this study, we analyze the effect of statistical bias correction when there is over-dispersion (or under-dispersion) and correlation between the observation and forecast. A simulation study is set up to examine how to affect on bias correction and then we apply to 240 months (from Jan. 1989 to December 2008) of simulation results from four regional climate models (RCM) with two boundary conditions over South Korea. The bias correction is obtained using data from 1989 to 1998 and applied to 2005 to 2008 forecasts. The corrected forecasts are assessed using quantile-quantile plot and quantile root mean squared error. Results show that it appropriately corrects the bias and performs well.

Keywords

Over-dispersion, Quantile Quantile plot, Regional climate model,
Statistical bias correction

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Post-processing probabilistic forecasts: a variational approach

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A novel approach to post-processing probabilistic forecasts is proposed and discussed. Starting out from the raw forecast distribution, well-defined corrections according to a variational principle are applied using sharpness as control parameter and the forecast is optimised for skill. The method is applicable to both discrete and continuous probabilistic forecasts. It is exemplified on simple mathematical systems and substantial skill improvements are demonstrated. Also predictions of rare, extreme events are considered.

Sampling Uncertainty in Verification Measures for Binary Deterministic Forecasts

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Numerous verification measures are in use for deterministic forecasts of binary events. Hogan and Mason (2011) has a non-exhaustive table of 18 measures including old favourites such as the hit rate or probability of detection, the false alarm rate and the critical success index and more recent suggestions such as the symmetric extremal dependency score. Sampling uncertainty associated with such measures is important when attempting to assess whether there are differences in skill between different forecasting systems, for example, but has often been neglected in the past. There has been greater awareness recently of the importance of sampling uncertainty and Hogan and Mason (2011) set an impressive example by tabulating (Table 3.5) error variances for 16 measures.

It is often not appreciated that a number of different data generating processes sampling schemes) are possible for the counts in tables formed by binary events and their forecasts, and any inference about the measures needs to take into account which sampling scheme is in operation. Hogan and Mason (2011) assume one particular sampling scheme in creating their table, but this scheme may not always be the appropriate one. The first part of this talk examines the implications of different sampling schemes on the uncertainty associated with some commonly used measures.

An additional complication affecting sampling uncertainty is that data may have serial dependence rather than the usual assumption of independence. In the second part of the talk the effect of serial dependence on performance measures is investigated using Markov chain simulation, and illustrated with some rainfall data. Serial dependence is shown to potentially have a greater effect on sampling uncertainty than differences in sampling schemes.

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VALUE - Validating and Integrating Downscaling Methods for Climate Change Research

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GEOMAR Helmholtz Centre for Ocean Research Kiel

Our understanding of global climate change is mainly based on General Circulation Models (GCMs) with a relatively coarse resolution. Since climate change impacts are mainly experienced on regional scales, high-resolution climate change scenarios need to be derived from GCM simulations by downscaling. Several projects have been carried out over the last years to validate the performance of statistical and dynamical downscaling, yet several aspects have not been systematically addressed: variability on sub-daily, decadal and longer time-scales, extreme events, spatial variability and inter-variable relationships. Different downscaling approaches such as dynamical downscaling, statistical downscaling and bias correction approaches have not been systematically compared. Furthermore, collaboration between different communities, in particular regional climate modellers, statistical downscalers and statisticians has been limited.

To address these gaps, the EU COST action VALUE (www.value-cost.eu) has been brought into life. VALUE is a research network with participants from currently 23 European countries running from 2012 to 2015. Its main aim is to systematically validate and develop downscaling methods for climate change research in order to improve regional climate change scenarios for use in climate impact studies. Inspired by the co-design idea of the international research initiative "future earth", stakeholders of climate change information have been involved in the definition of research questions to be addressed and are actively participating in the network. The key idea of VALUE is to identify the relevant weather and climate characteristics required as input for a wide range of impact models and to define an open framework to systematically validate these characteristics. The validation framework makes use of technqiues used in climate science but also exploits classical methods developed for forecast verification. Based on a range of benchmark data sets, in principle every downscaling method can be validated and compared with competing methods. The results of this exercise will directly provide end users with important information about the uncertainty of regional climate scenarios, and will furthermore provide the basis for further developing downscaling methods. This presentation will provide background information on VALUE and discuss the identified characteristics and the validation framework.

EU Cooperation in Science and Technology (COST) action VALUE, www.value-cost.eu

Forecasting of Seasonal Rainfall over Bangladesh Using Climate Predictability Tool

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Climate Predictability Tool (CPT) is developed by International Research Institute (IRI) of University of Columbia is made use of making seasonal weather forecasts for Bangladesh. It uses Canonical Correlation Analysis (CCA), in which predictors and and predictands are involved in making forecast using Model Output Statistics technique. The model is trained with 28 years of rainfall data collected from Bangladesh Meteorological Department (BMD) and temperature at 850 mb data of Multi Model Ensemble (MME) global products of Asia Pacific Climate Centre (APCC) in South Korea. The CPT has shown some potential to predict JJA (June-July-August) seasonal mean-rainfall over Bangladesh as a whole and over the selected stations in the western, southwestern and southeastern parts of Bangladesh as a whole and over the selected stations in the western, southwestern and southeastern parts of Bangladesh. Results reveal that forecasted rainfall of seven stations is overestimated and five stations are underestimated over Bangladesh. All Bangladesh observed and forecasted rainfall is almost same, where the forecast are within the acceptable range. CPT seems to be a better tool for predicting southwest monsoon rains in Bangladesh.

Key words

CPT, MME, JJA, predictor and predictand.

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Observational assessment of climate model performance

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JAMSTEC

Comparison of model outputs with observations of the climate system forms an essential component of model assessment and is crucial for building our confidence in model predictions. Methods for undertaking this comparison are not always clearly justified and understood. Here we show that the popular approach of comparing the ensemble spread to a so-called “observationally-constrained pdf” can be highly misleading. Such a comparison will almost certainly result in disagreement, but in reality tells us little about the performance of the ensemble. We present an alternative approach, and show how it may lead to very different, and rather more encouraging, conclusions. We additionally present some necessary conditions for an ensemble (or more generally, a probabilistic prediction) to be challenged by an observation.

Using proper divergence functions to evaluate climate models

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It has been argued persuasively that, in order to evaluate climate models, the probability distributions of model output need to be compared to the corresponding empirical distributions of observed data. Distance measures between probability distributions, also called divergence functions, can be used for this purpose. We contend that divergence functions ought to be proper, in the sense that simulating from the true climatological distribution is an expectation minimizing strategy. Score divergences that derive from proper scoring rules are proper, with the integrated quadratic distance and the Kullback-Leibler divergence being particularly attractive choices. Other commonly used divergences fail to be proper. In a case study, we evaluate and rank simulations of temperature extremes from the CMIP3 and CMIP5 multi-model ensembles in a comparison to re-analysis and observational data.

This is joint work with Tilmann Gneiting and Nadine Gissibl at Heidelberg University, and Jana Sillmann at the Canadian Centre for Climate Modelling and Analysis.

Evaluating decadal hindcasts: why and how?

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Extrapolating the performance of historical climate forecasts and hindcasts can be a poor guide to the performance of future climate predictions. Nevertheless, historical predictions do contain useful information about future performance. We propose a new approach to using this information to form quantitative judgments about future performance, thereby making explicit our answer to the question ‘how good are climate predictions?’ We also discuss how to extract this information by evaluating hindcasts. In particular, we show how measures of performance can be chosen to (1) avoid spurious skill arising from time trends, (2) provide a fair evaluation of ensemble forecasts, and (3) describe how performance varies with the timescale of the predicted quantity.

A unified view of the Greenland flow distortion and its impact on barrier flow, tip jets and coastal oceanography

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A new diagnostic is developed that allows for a more complete view of the atmospheric flow distortion that arises from the high topography of Greenland. This flow distortion results in the frequent occurrence of high speed surface wind events, known as tip jets and barrier winds along the southeast coast of Greenland. Unlike previous diagnostics, it is able to partition the occurrence frequency of easterly and westerly tip jets that form in the vicinity of Cape Farewell, the windiest location on the ocean's surface. In addition, the diagnostic clearly identifies the 2 locations along the southeast coast of Greenland where barrier flow is enhanced and confirms previous work that indicated that these locations are collocated with regions of steep coastal topography. It also results in the identification of new regions, the northeast and southeast coasts of Greenland as well as the southeast of Iceland, where tip jets and barrier flow exist. Along the northeast coast, these high speed wind events are proposed to be associated with the formation of the North East Water Polynya as well as contributing to the southward advection of sea ice. Along the southwest coast, the high speed wind events, which result in a reversal of the wind direction, may contribute to the enhanced oceanic eddy activity in the region that plays an important role in the oceanography of the Labrador Sea.

Predicting extreme daily weather events a season ahead: the role of circulation

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In 2012 it was demonstrated that the UK Met Office seasonal forecasting system was able to predict inter-annual fluctuations in the frequency of large scale extreme daily weather events a season ahead. This predictability is vital for early warning systems of high impact events, and is an important prerequisite for models used for event attribution. Since then the Met Office seasonal forecast system has been updated. Amongst other improvements, winter NAO/AO predictability has increased dramatically. I demonstrate the effect that this improvement in circulation has had on the model's ability to predict extreme weather events over the Northern Hemisphere winter.

Skilful representation of key processes lends credibility to predictions, especially at long range. Many studies on predictability of Northern Hemisphere seasonal variability have connected drivers with anomalies in atmospheric circulation. I will take this reasoning a step further by using cluster analysis to associate variability in extremes with variability in atmospheric circulation types. As well as increasing confidence in estimates of model skill, can this technique boost predictability and could it be used to identify causes of extremes on a routine basis?

Regime-dependent modelling of extremes in the extra-tropical atmospheric circulation

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The paper discusses data-based statistical-dynamical modelling of vorticity and wind speed extremes in the extra-tropical atmospheric circulation. The extreme model is conditional on the large-scale flow, consisting of a collection of local generalised extreme value or Pareto distributions, each associated with a cluster or regime in the space of large-scale flow variables. The clusters and the parameters of the extreme models are estimated simultaneously from data. The large-scale flow is represented by the leading empirical orthogonal functions (EOFs). Also temporal clustering of extremes in the different large-scale regimes is investigated using an inhomogeneous Poisson process model whose rate parameter is conditional on the large-scale flow. The study is performed in the framework of a three-level quasigeostrophic atmospheric model with realistic mean state, variability and teleconnection patterns. The methodology can also be applied to data from GCM scenario simulations, predicting future extremes.

Bayesian techniques for Poisson process models of extreme events

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Most previous studies that incorporated the Poisson process models in climatology were based on the maximum likelihood estimation. Bayesian methods of statistics are based on specifying a density function for the unknown parameters of the considered model, known as the prior density, and then computing a posteriori density for the parameters given the observations. That output – the posterior distribution of a parameter – provides a more complete inference than the corresponding maximum likelihood analysis . In the context of the extreme value analysis, the estimation of parameters of the GEV/GP distribution could be made on the basis of daily observations using the Poisson process model (e.g. Smith, 2000; Beirlant et al., 2004). The result is a posterior distribution and also the density function of future observations under the condition of the observed data. This way we could get the distribution of future annual maxima / threshold exceedances that allows both for the parameter uncertainty and randomness in future observations. On this basis we could also calculate an analog of the return level that incorporates uncertainty due to the model estimation. We will apply two popular MCMC methods: the Gibbs sampler and Metropolis-Hasting algorithm, see Beirlant et al. (2004).

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Assessing changes in observed and future projected precipitation extremes in south Korea

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Attempts to assess changes between observed and future projected daily rainfall extremes for 61 stations over Korea have been made with descriptive statistics and extreme value analysis. For the comparison, three different periods and data sets are considered: observation from 1981 to 2010 (period 0), simulation from 2026 to 2055 (period 1), and from 2071 to 2100 (period 2). Projected rainfalls are obtained from the RCP 4.5 and RCP 8.5 scenarios.

For comparison of extreme values, the 20 year and 50 year return levels and return period estimates were obtained by using the four-parameter kappa distribution, the method of L-moments, and regional frequency analysis.

From the descriptive statistics, we found that heavy rainfall events would increase in the future. The total precipitation is projected to unchange or slightly increase while the number of total rain days will be decreased by 19.5% with respect to the observation. The number of days with very light precipitation (less than 1mm) and with heavy rainfall (over 300mm) are projected to increase from the observation by about 40%, and by between 46% (for the period 1) and 224% (for the period 2), respectively. Whereas, the frequency between 1mm and 300mm is projected to decrease by 20%.

From the extreme value analysis, we found that it is likely that a 1-in-20 year and a 1-in-50 year annual maximum daily precipitation will become a 1-in-10 year and a 1-in-20 year event, respectively, by the end of 21st century.

Changes in the annual cycle of heavy precipitation events across the UK in future projections

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Knowledge of future changes of the intensity and timing of extreme precipitation is necessary for the development of adequate risk-reduction strategies, for insurance companies and for the management and planning of water resources. Dividing the analysis of changes in heavy precipitation into different seasons is too coarse to precisely detect and quantify subtle changes of timing and amplitude. Therefore, we explicitly analyze the annual cycle of heavy precipitation in response to anthropogenic greenhouse gases.

We investigate future changes in the annual cycle of heavy daily precipitation events across the British Isles in the periods 2021 â 2060 and 2061 â 2100, relative to present day climate. Twelve combinations of regional and global climate models forced with the A1B scenario are used. The annual cycle is modeled as an inhomogeneous Poisson process with sinusoidal models for location and scale parameters of the generalized extreme value distribution. Although the projections of peak times of the annual cycle vary considerably among regional simulations, at the end of the century a robust shift towards later peak times is likely to emerge for the south-east, while in the north-west there is evidence for a shift towards earlier peak times. In the remaining parts of the British Isles no changes in the peak times are projected. Reliable statements on changes in the strength of the annual cycle are not possible: firstly, the regional climate models show deficits in its representation, and secondly, the projections are contradictory and show a surprising dependency on the boundary conditions provided by the global simulations.

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Regional climate projections of temperature extremes in the context of the CMIP3 ensemble.

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Future climate projections of extreme events can help forewarn society from high-impact events and develop better adaptation strategies. Extreme Value Theory (EVT) provides a well established and robust framework to analyze the behaviour of extreme weather events for the present climate and future projections. In this study a non-stationary fit of Generalized Extreme Value (GEV) distributions are used to analyze the trend of extreme temperatures in the context of a changing climate, and compare it with the trend of average temperatures.

The analysis is performed for the climate projections of the Canadian Regional Climate Model (CRCM), under a SRES A2 emission scenario, over North America. Annual extremes of daily minimum and maximum temperatures are analyzed. Significant positive trends for the location parameter of the GEV distribution are found, indicating an expected increase in the extreme temperature values. The scale parameter of the GEV distribution, on the other hand, reveals that the variability of temperature extremes decreases. The trends of the annual minimum (maximum) temperatures are compared to the trends of the winter (summer) average temperatures. In some regions, extreme temperatures exhibit an increase significantly larger than that for the seasonal average temperatures.

The CRCM results are compared and framed in the context of the CMIP3 Global Climate Model projections. This enables us to locate the CRCM projections within the distribution of the CMIP3 ensemble projections, and assess the CRCM position within the CMIP3 climate projection uncertainty range.

A stochastic model output statistics approach for correcting and downscaling precipitation including its extremes

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Precipitation is the main source of freshwater strongly affecting river runoff, groundwater recharge and the water level of lakes and reservoirs. As such, it is an essential resource for ecosystems, agriculture and most human activities. Extreme precipitation is a major hazard causing damage to, for example, agriculture yield and infrastructure.

To assess the localised impacts of future changes in extreme precipitation, realistic high resolution scenarios of precipitation and its extremes are necessary. Global climate models provide knowledge on future climate change, however these models provide too coarse a resolution and do not represent extreme precipitation at the local-scale. To bridge the scale gap between global climate simulations and the local-scale observations, downscaling approaches are used. Dynamical downscaling nests a high-resolution Regional Climate Models (RCMs) into the global model over a limited area. However, simulations from the RCMs are systematically biased and cannot be directly applied.

Furthermore, RCMs produce grid box averages and thus are unable to represent precipitation variability at point scales, which is often used as input for hydrological models. Bias correction methods such as quantile mapping, can be used to correct systematic bias but as they are deterministic transformations, they often fail to correctly represent point scale variability Here we propose a novel framework for stochastic model output statistics that can both bias correct and downscale. A vector generalised linear model is developed and RCM grid box simulated precipitation is used to predict the full distribution of observed precipitation at the local scale. A logistic regression, a mixture of gamma and generalised Pareto distributions is used to model the bulk of the precipitation distribution and its extremes. To ensure a day-to-day weather sequence between observed and simulated time series which is necessary for a regression model, RCM simulations with observed boundary conditions are used. We also show that simulating from our statistical model generates time series which realistically represent statistical properties of observed local precipitation. Our model can be extended to include spatial dependence in a bivariate context.

Joint quasi-decadal mode in summer and early autumn over the subtropical western North Pacific : precipitation, tropical cyclones, and sea surface temperature

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Identification of low-frequency modes of large-scale climate variability on decadal time scales and longer is a necessary step for improving climate predictions through a better understanding of the slowly varying background mean state. In this context, this study tries to examine spatiotemporal quasi-decadal variations over the subtropical western North Pacific (WNP) domain as observed from the station-based precipitation data therein (e.g., South China, Taiwan, the Philippines, and small islands) and the best-track tropical cyclone (TC) records during June-October of the second half of the 20th century.

The precipitation and TC records reveal the existence of salient quasi-decadal and longer time scale variations in the WNP domain, which can be considered finger prints of various climate oscillations/trends over the large Indo-Pacific ocean domain. The spatiotemporal variation of seasonal TC formations emphasizes a quasi-decadal dipole-like mode between the northeastern South China Sea and the Philippine Sea. Interestingly, this leading mode of TC formations is found to vary in almost congruent with one of the leading modes in the precipitation records over mainland South China that represents quasi-decadal and longer time scale variations. These modes become a dominant leading component when a singular value decomposition (SVD) analysis is performed with the low-pass filtered (> 8-yr) data of the two parameters, which look to have finger prints of the sea surface temperature (SST) warming trend in the Indian Ocean and the SST decadal variability in the Pacific Ocean. Note that the latter is distinctive from the Pacific Decadal Oscillation that originates from the North Pacific Ocean.

The leading quasi-decadal mode in the relatively small region of Taiwan looks to covary with that in mainland South China in the 1960s and after late 1990s, but it shows a different periodicity in-between. This difference is attributed to tighter coupling of the leading quasi-decadal mode in Taiwan with the Central Pacific El Niño- or South Pacific decadal variability-related oscillation of the SST which has been noted in a recent study. This mode is also largely coupled to the leading quasi-decadal mode of TC formations, even though the spatial pattern of SVD eigenvector of TC in the northern South China Sea is slightly distorted and centered more on Taiwan. This reflects the leading quasi-decadal mode of TC formations is generally related with the precipitation variations over the South China region including some nearest Islands. On the other hand, the precipitation records in the Philippines and several islands surrounding the Philippine Sea show somewhat distinctive quasi-periodicity from the previous regions, again reflecting the finger prints of various climate oscillations/trends have strong regional dependency.

Interaction between the AO and ENSO Modoki and implications for seasonal prediction

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Past observational and modeling studies have demonstrated a link between tropical Pacific sea surface temperature (SST) associated with ENSO Modoki and the Arctic Oscillation (AO) of which causality and role for seasonal prediction is still not well understood. During boreal winter, the AO has a tendency to precede changes in the tropics associated with ENSO Modoki implying a degree of two-way interaction that is ignored under the paradigm that such teleconnections arise purely as tropically-forced response patterns. Despite constraints of their own, multivariate statistical methods such as Maximum Covariance Analysis (MCA) allow for a more objective isolation of such Observed relationships, and more importantly separation from conventional ENSO. In This study, The AO-ENSO Modoki relationship is investigated with a new statistical technique involving Co-variability between 500 hPa geopotential height and tropical precipitation. In a Similar manner, The relationship is examined as a diagnostic in 10 CGCM ensemble hindcast datasets of the APEC Climate Center. Consistency between model representation and prediction skill/reliability is examined, and Implications for predictability and real-time prediction are discussed.

Recent changes in the atmospheric teleconnections from the tropics to the polar region: Warm pool SST and AO

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We examine the atmospheric teleconnections from the tropics to the polar region with focusing on the warm pool sea surface temperature (SST) variations and Arctic Oscillation (AO). It is found that an increase of the warm pool SST is significant after the 1990s, concurrently, the variations of warm pool SST are closely associated with the AO-like atmospheric circulation during the boreal winter in comparison with previous periods. An increase of warm pool SST after the 1990s seems to act change the structure of atmospheric circulation in the middle and high latitudes such as the Aleutian low pressure along with sub-polar jet stream. We discuss how an increase of warm pool SST acts to change the atmospheric teleconnections from the tropics to the polar region using the observation and AGCM experiments.

Possible cause of the winter temperature regime shift in the late 1980s over the Northern Hemisphere

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In this study, we analyze the characteristics of the winter temperature regime shift (WTRS) over the Northern Hemisphere in the late 1980s using observation data and reanalysis data, and investigate the possible cause of the WTRS with a focus on mean meridional circulation, particularly, Ferrel cell. To detect the timing of regime shift, we adopt a regime shift index, which is based on determining the significance of differences between the mean values of two subsequent regimes. Results show that WTRS over the Northern Hemisphere mostly occurs during the period from 1986 to 1989 both at the surface and in the troposphere of mid-latitude. WTRS tends to occur early in low to mid latitude (30°N) and migrate to north (60°N) with time. Vertically, WTRS occur at the surface earlier and propagate to the upper troposphere with time. During the regime shift period (1986-1989), the temperature at the surface and in the troposphere significantly increase in the mid-latitude from 30°N to 50°N with maximum warming over 40°N, compared to the pre-regime shift period of 1976 to 1985. During the regime shift period, interestingly the latitudinal belts of the maximum warming coincide with an anomalous boundary between the Hadley and Ferrel cell. Moreoverthe northwards migration in WTRS occurrence corresponds with the enhancement and poleward migration of the Ferrel cell, indicating that an abrupt warming is strongly associated with adiabatic warming over the 30°-50°N latitude band and northwards transport of warm air associated with the intensification and migration of the Ferrel cell.

Recent progress in the research on classifications of atmospheric circulation patterns achieved within international project COST733

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Classifications of atmospheric circulation patterns (synoptic classifications) are one of the main tools of synoptic climatology. A wide range of methods have been developed and applied in a wide range of applications in recent decades. Here we describe main outputs and results of the recent European-wide project, “Harmonisation and Applications of Weather Types Classifications for European Regions” (COST733; COST referring to European Cooperation in Science and Technology). The results are based on a unified set of circulation classifications, which allows comparisons among different classifications, evaluation of the sensitivity of classifications to various methodological choices, and climatological as well as application-oriented studies. First, the database of classifications was created for 12 domains, altogether covering the whole of Europe. The classifications include (i) several subjective classifications, developed for various regions of Europe and (ii) objective (computer-assisted) classifications, differing in the classification method (18 different methods were applied, including cluster analysis, principal component analysis, threshold-based methods, leader algorithms, etc.), the number of types, variables used for classification, sequentiality of their definition (either individual daily patterns or their 4-day sequences are classified), and seasonality of their definition (the types are defined on an annual basis or separately for each climatological season). For each domain, over 420 classifications are thus made available. All the objective classifications are calculated from the ERA-40 reanalysis data for the period from September 1957 to August 2002. Second, the software to calculate and evaluate the classifications was produced. Third, the classifications were evaluated from various points of view. One reported in this contribution is their ‘synoptic-climatological applicability’, that is, the ability of classifications to describe surface climate conditions. The evaluation points to the fact that there is no superior classification or classification method. Nevertheless, some methods can be flagged as more or less suitable to particular purposes. Fourth, a large database of classifications is utilized in climate change research; namely, we answer the question on whether their frequency and persistence (lifetime) have changed recently. We argue that for such a purpose, the simultaneous use of multiple classifications is beneficial because this allows one to distinguish between real climatic features and pecularities or biases inevitably present in any single classification.