8th International Meeting on

Statistical Climatology

University of Lüneburg

12 to 16 March 2001

Schedule, Abstracts, Participants

MONDAY 12.3.2001

Plenary session: Stochastic Climate Models

9:00 Greg Holloway
9:45 Comment: Jin-Song von Storch
10:00 Comment: Andreas Hense

10:15 Coffee break

10:45 Claude Frankignoul
11:15 Norm McFarlane

11:45 Lunch
13:00 Poster introduction

Session 1: Stochastic Climate Models

14:30 G.V. Alekseev:
To the nature of red noise in the climatic series
14:50 P. Carl:
Frequency Modulation in the Instrumental Record
15:10 Anatoly I. Chavro:
Statistical algorithms for solving inverse problems on predictability of regional climate
15:30 Carsten S. Frederiksen:
Validating Interannual Variability in Atmospheric General Circulation Models

15:50 Coffee break

16:20 Richard Kleeman:
The character of prediction utility in dynamical systems relevant to climate and weather
16:40 Till Kuhlbrodt:
Stochastic dynamics in a simple model of seasonal open ocean deep convection
17:00 Frank Kwasniok:
Prediction of ENSO using an optimized mixture of linear models
17:20 Adam Monahan:
Simple Stochastic Models of the Thermohaline Circulation

Session 2: Statistics, Models and Data Assimilation

14:30 Sylvia Antunes:
Improvement of prediction using SSA methods in addition to MEM: Case of NAO study
14:50 Ulrich Callies:
On the interrelationships between multisite climatic temperature forecasts obtained from downscaling regional sea-level-pressure fields
15:10 Peter Challenor:
Model Error and Uncertainty
15:30 Youmin Chen:
The Winter Temperature Downscaling Experiments Using Canonical Correlation Analysis in China

15:50 Coffee break

16:20 Dan Cornford:
On-line Gaussian Processes and their Potential in Data Assimilation
16:40 Traute Crueger:
Statistical Downscaling of Largescale GCM Data to Local Ice Accumulation in Greenland
17:00 Mojca Dolinar:
Spatialisation of 24 hours precipitation with 100 years return period
17:20 S. El Adlouni:
Bayesian estimate of halphen type a law's parameters

18:00 Icebreaker-Party at the university

TUESDAY 13.3.2001

Plenary session: Statistics, Models and Data Assimilation

9:00 Geir Evensen
9:45 Comment: Carlos Pires
10:00 Comment: Christian Lajaunie

10:15 Coffee break

10:45 Valerie Isham
11:15 Jean-Paul Chilès

11:45 Lunch

Session 1: Stochastic Climate Models

13:00 Juan Pedro Montavez:
EMAD: An Empirical Model of the atmospheric Dynamics
13:20 Nityanand Singh:
On the Natural Regularity and Predictability of Terrestrial and Extra-Terrestrial Parameters
13:40 Jun-Ichi Yano:
Stochastic Tropical Atmospheric Boundary-Layer Dynamics: Convective Downdrafts and Recovery, Discharge-Recharge Processes, and 1/f-Noise

Session 2: Statistics, Models and Data Assimilation

13:00 Christoph Gebhardt:
Variational Assimilation of botanical proxy Data for the Reconstruction of Palaeoclimate
13:20 Nikolaus Groll:
How realistic is GCM-simulated precipitation?
13:40 Andreas Hense:
Homogenisation and Interpolation of incomplete climatological Data with simple physically based Models
14:00 Ramon A.Quintana-Gomez
Trends of Maximum and Minimum Temperatures in Northern South America
14:20 Heike Hoffmann
Investigation of Spatial and Temporal Ozone Immission Structures under Stochastic-Deterministic Model Assumptions
14:40 I. Hoteit
Reduced-order schemes for data assimilation in oceanographiy based on the Kalman filter

15:00 Coffee break

15:30 Richenda Houseago-Stokes
Cloudiness and sea surface temperature: tackling the problem of missing values
15:50 Radan Huth
Removing errors in simulated distributions of climate elements using a non-parametric adjustment procedure
16:10 Ian Iolliffe
Simplified EOFs - three alternatives to rotation
16:30 J.M. Jones
Reconstruction of large-scale climate
16:50 Gennady A. Kivman
On a probabilistic interpretation of variational data assimilation and model error estimation
17:10 Leonid Lopatoukhin
Statistical presentation of wind wave climate
17:30 J. Mateu
Model-based spatial modelling of climatological data

Session 3: Extreme Value Analysis

13.00 Daniel Gellens
Regional GEV-growth curves of yearly precipitatation depths in Belgium for durations ranging from 10 minutes to 30 days

13.20 Leila M. V. Carvalho
Extreme precipitation events in southeastern South America and the relationships with summertime large-scale South American Stationary Systems (SASSY)

13.40 Shaleen Jain
Diagnosis of variations in the climate-related flood risk - Some results from the Interior Western United States

14.00 Tiba Kabanda
The Climatological Probability of Drought in Northern Province of South Africa

14.20 S.S. Kandalgaonkar
Statistical Analysis of Point Discharge Current at Different Time Scale Over the Pune Region

14:40 S.S. Kandalgaonkar
A Dedacal Study of Premonsoon Seasons Thunderstorms Over Pune Region by Using Markov Chain Model

15.00 Xiolan Wang
Trends of Atlantic wave extremes as simulated in a 40-year wave hindcast using kinematically reanalyzed wind fields

15.30 Coffee break

15.50 Gary D. Skwira
Hurricane Landfall Winds Along the United States Gulf and Atlantic Coasts: Monte Carlo Simulations

16.10 Eva Bauer
Simulation of ocean wave climate changes through wind variance changes on different timescales

16.30 P.Lionello
Frequency and Intensity of Mediterranean Cyclones in a doubled CO2 scenario

16:50 P.Lionello
Extreme waves and surge events in a doubled CO2 scenario in the Adriatic Sea

17.10 Niklas Sjöblom
Extreme value analysis of absolute minimum temperature and minimum dew-point temperature at Sodankylä, Finland

17.30 Won-Tae Kwon
Observed Changes in Temperature Extremes of Korea

WEDNESDAY 14.3.2001

Plenary session: Extreme Value Analysis

9:00 Adri Buishand

9:45 Comment: Hans Alexandersson

10:00 Comment: David Stephenson

10:15 Coffee break

10:45 Lynda Chambers

11:15 Richard Chandler

11:45 Rick Katz

12:15 Lunch

Session 2: Statistics, Models and Data Assimilation

13:30 Miroslaw Mietus
The role of atmospheric large-scale circulation over Europe and North Atlantic in sea level variability on the Polish coastal zone

13:50 S. De Iaco
Space-time variograms and a functional form for total air pollution measures
14:10 Carlos Pires
Performance of four-dimensional variational assimilation and dynamical instability, experiments on a quasi-geostrophic model
14:30 Budong Qian
A multisite self-consistent Weather Generator for Impact Studies in Portugal
14:50 Joao Rio
Monthly mean forecasts of rainfall and temperature in Portugal
15:10 Radhika Ramachandran
Sensitivity Studies on Wind Measurement Errors in Mesoscale Model Simulations

15:30 Coffee break

16:00 Julien Sénegas
Building the bridge between sequential data assimilation and geostatistics: the stationarity issue
16:20 Leonard A. Smith
Public Debate and Climate Model Products: Whereof must one be silent?
16:40 Tamas Szentimrey
Multiple Analysis of Series for Homogenization (MASH). Seasonal Application of MASH. Automatic using of Meta Data
17:00 Clemente A. S. Tanajura
A data assimilation method with a coupled ocean-land-atmosphere model and its impact on the ocean state and on medium-range predictions
17:20 Karl E. Taylor
Assessing Model Skill in Climate Simulations

Session 3: Extreme Value Analysis

13:30 Janos Mika
XXth Century Behaviour of Temperature and Precipitation Extremes in Hungary
13.50 Lucie Vincent
Homogenized Daily Temperatures for Trend Analyses in Extremes over Canada
14.10 Joanna Wibig
The analysis of extreme temperature distributions on the example of Poland
14.30 Jan Kyselà
Comparison of 20- and 50-year return values in GCM-simulated, downscaled and observed temperature series
14.50 Jaroslava Kalvová
Test on the probability distribution of maximum air temperatures
15.10 Luis Gimeno
Three Approaches to determine extreme years of Global Atmospheric Temperature

15:30 Coffee break

16.00 E. P. Campbell
Bayesian Statistical Modelling of Nonlinear Climate Processes
16.20 Jesœs Abaurrea
Modelling and characterizing extreme drought events
16.40 Jürgen Grieser
Extremes in Instationary Time Series
17.00 Henrique Oliveira Pires
Comparison of Several Methods for the Estimation of Extreme Value Distribution in Time Series with Trends
17.20 Philippe Naveau
The Possible Influence of Large Volcanic Eruptions on El Nino

Session 4: Simulation Models

13:30 Ulrich Achatz
Simplified atmosphere models with realistic variability

13:50 Konrad Bogner
Modelling of Temporal Rainfall by the Use of Stochastic Point Process Models in View of Scaling

14:10 Harold E. Brooks
Statistical Modelling of Tornado Occurrence

14:30 Udo Busch
A method to extend the temporal validity of nested regional climate simulations

14:50 Aristita Busuioc
Stochastic generation of daily precipitation

15:10 Stephen Charles
Statistical Downscaling of Daily, Multi-Site Precipitation in Tropical and Sub-Tropical Climates

15:30 Coffee break

16:00 Ildiko Dobi-Wantuch
Stochastic Weather Generator Model for Simulation of Multiple Meteorological Time Series

16:20 Martin Dubrovsky
Interdiurnal and interannual variability in stochastic daily weather generator: Modelling and the role in agricultural and hydrologic studies

16:40 R. Garcia
Temperature predictability in the greater Mediterranean area

17:00 Friedrich Wilhelm Gerstengarbe
A new validation scheme for the evaluation of climate model outputs

17:20 Clare Goodess
The construction of multi-site and multi-variate scenarios for Mediterranean regions based on Monte Carlo simulations with a conditional weather generator

THURSDAY 15.3.2001

Plenary session: Simulation Models

9:00 Jim Hughes

9:45 Comment: Francis Zwiers

10:00 Comment: Hans von Storch

10:15 Coffee break

10:45 Ruben Pasmanter

11:15 Ed Waymire

11:45 Lunch

Session 2: Statistics, Models and Data Assimilation

13:00 Martin Widmann
How realistic is GCM-simulated precipitation?

13:20 Abebe Yeshanew
Spatio-temporal patterns of Meteosat Satellite Thermal Infrared Derived Convective Clouds over Ethiopia as Described by PCA & MVC

13:40 Francis Zwiers
Skill of seasonal hindcasts as a function of the ensemble size

Session 3: Extreme Value Analysis

13.00 Monika Lakatos
Determining extreme sets in multivariate distributions

13:20 Albert R. Boehm
The Probability Of An Extreme In A Correlated Time-Space Domain

13.40 Peter Bissolli
Climate extremes in Germany and its relation to the objective weather type classification of the German Weather Service

14.00 Judit Bartholy
Statistical methods and case studies investigating extreme climatology of the Carpathian Basin

Session 4: Simulation Models

13:00 Anders Grimvall / Asa Forsman
Simulation of multivariate time series of meteorological data

13:20 Andreas Hense / Martin Kappler
Modelling the probability of precipitation using the Marcov chain MonteCarlo technique

13:40 Radan Huth
Reproduction of variance in statistical downscaling: inflation vs. noise addition

14:00 Anders Nordgaard
Simulating meteorological data by block resampling

14:20 Guillermo Obregon
The Amazon climate: A multiscale and nonstationary processes

14:40 Arnt Pfizenmayer
First indication of anthropogenic climate change in local wave conditions in the North Sea

15:00 Coffee break

15:30 Susanne Theis
Ensemble Predictions with a Limited-Area Mesoscale Atmospheric Model - Implications for the Interpretation of its Direct Model Output

15:50 Marina Timofeyeva
Modeling stochastic structure of local climate as downscaling of GCM fields

16:10 Hans von Storch
Numerical experimentation with regional atmospheric models

Session 5: Decision Making and Detection of Anthropogenic Climate Change

13:00 Myles Allen
Exploiting the emerging signal of anthropogenic climate change in probabilistic climate forecasting

13:20 Ajay Singh
Significance of Anthropogenic Radiative Forcings in Simulation of Temporal Pattern of Surface Air Temperature in Monsoon Climate

13:40 Katrine Krogh Andersen
Decadal variations of Greenland precipitation over the past 1400 years

14:00 Auguste Boissonnade
Lessons taught from the Homogenization of 200 US First Order Stations

14:20 Roxana Bojariu
North Atlantic osccillation projection on regional climate predictability

14:40 Bernard Cornélis
What influences decision-makers in drought prone areas when allocating water resources?

15:00 Coffee break

15:30 Nathan Gillett
Assessing uncertainty in anthropogenic signal estimates using space-time and trend-based optimal detection approaches

15:50 Stephen Jewson / Anders Brix / Rodrigo Caballero
Applications of Statistical Climatology in Finance

16:10 Christopher J. Paciorek
Trends in northern hemisphere winter cyclone activity based on a comparison of cyclone indices

16:30 Heiko Paeth
Signal analysis of the atmospheric mean temperature 500/1000 hPa north of 55 N between 1949 and 1994
16:50 James Risbey
Expert Assessment of Uncertainties in Detection and Attribution of Climate Change
17:10 Christine Ziehmann
A Maximum Entropy Approach for Extracting Forecast Probabilities from Finite Ensembles

19:00 Conference Dinner at Hotel Seminaris

FRIDAY 16.3.2001

Plenary session: Decision Making

9:00 Granger Morgan
9:45 Comment: Myles Allen
10:00 Comment

10:15 Coffee break

10:45 Klaus Hasselmann
11:15 Mark Berliner
11:45 Chris Forest

12:15 Lunch

Session 5 Decision Making and Detection of Anthropogenic Climate Change

13.20 Silvia A. Venegas
Coupled Sea Ice and Atmosphere Variability in the Weddell Sea, Antarctica
13:40 Reiner Schnur
A Multi-Index Bayesian Approach to Climate Change Detection and Attribution
14:00 V.A. Semenov
Changes in statistical properties of daily precipitation in transient climate change experiments with a coupled atmosphere-ocean GCM
14:20 N.A. Sontakke
Near Two Centuries Monsoon Rainfall Variations across India: Reconstructed Past and Predicted 10-year Future
14:40 Tim Staeger
Statistical detection of the anthropogenic greenhouse signal in observed global and regional climate data fields

15:00 Coffee break

15:30 Daithi Stone
Trends in the Diurnal Temperature Range in the CCCma Coupled Model
15:50 P.W. Thorne
Detection of the causes of recent trends in radiosonde temperatures
16:10 Andreas Walter
Signal Analysis and Detection Studies Using Neural Networks
16:40 Xiaogu Zheng
Potentially Predictable Patterns
17:00 Olga Zolina
Extratropical cyclone variability in the Northern Hemisphere winter from the NCEP/NCAR Reanalysis data

Stochastic Climate Models

To the nature of red noise in the climatic series
G.V. Alekseev (Arctic and Antarctic Research Institute, St.-Petersburg, Russia)

It is considered the forming of low-frequency components in the climatic spectra of atmospheric characteristics that was named low-frequency weather noise. The base of approach is statistical model of weather variability that include individual weather disturbances (IWD). This IWD are re-presented with help of self-model function including constant shape function and set of IWD parameters (amplitude, duration, time of IWD start). It is known that spectrum of a process described of such model depends on spectrum shape of individual disturbance. On the base of experiments with proposed model was shown that as a rule spectrum of many IWD with duration T has a maximum at periods much more than T. Averaging of time series including IWD amplifies this effect. In this connection it should be noted that low-frequency rise of climatic spectra could be more consequence of transfer of local structures energy to the low-frequency part of spectra in response to linear procedures of spectral analysis and averaging than real low-frequency variability.

Frequency Modulation in the Instrumental Record
P. Carl (Institute for Freshwater Ecology and Inland Fisheries, Research Association Berlin of the Leibniz Society, Berlin, Germany)

Multiple cyclic forcing and the climate system`s internal oscillatory capabilities (or nature), from intraseasonal to decadal and longer, may bear complex, evolving modal structures as found in energy density spectrograms (resp. 'scalograms`) throughout the instrumental record. Customary methods used to visualize features in the time-frequency plane, including "Short-Time" (windowed) Fourier and Wavelet Transforms (STFT, WT), are suited to provide a qualitative view of these evolutions. The question arises to what extent such apparent structural nonstationarities reflect anharmonic (maybe anthropogenic) climate drifts and/or just higher-order cyclostationarity comprising the frequency domain itself via systematic frequency modulation (FM). As a basic conception of communication, FM of a carrier mode might be a principle at work in climatic signal transmission as well---and might even hint at topological constraints (i.e. geometrical structures in the back) of the system`s phase space trajectories. Recent paleoclimatic studies hint at harmonic FM of Milankovich cycles, and the challenging departure since about the 40th from apparent astronomical control of the phase of the seasonal cycle, as found in temperature records of the instrumental period, deserves further clarification.
Reconstruction from time series of the score behind the 'sounds' of climate and climatic change (and inference on respective 'castings') calls for high-resolution, quantitative, joint analyses of multiple signal attributes among which the dimensions of modulation must not be neglected. Adaptive waveform ("Matching Pursuit"; MP) analysis using a highly redundant dictionary of frequency-modulated Gabor atoms has been applied to this end to a representative set of climatic time series of the 19/20th centuries. FM-MP "structure books" covering all parameters of these (non-orthogonal) decompositions - a sort of empirical time series models in a seven-dimensional signal space - are provided and discussed. Comparison is made to the WT which yields a time-scale energy distribution 'as is', and to the STFT which provides a spectrogram that relies (as the FT heavily does) on mutual interference of Fourier modes. Like the STFT, the MP method interprets the energy density distribution in terms of its dictionary, but overcompleteness of the latter and intrinsic provision of nonstationarity relaxes massive interferences to modest here. Unlike WT, the MP approach bears "scale" as a truly independent parameter, resulting in localizations that only depend on the scale of a (partial) signal, not on its specific position in the fre-quency domain; spectrograms provide high resolution throughout.
Deep FM is generally found to fit best into WT energy density distributions of the instrumental record as far as considered. This is a surprise which might underscore the potential topological aspects mentioned. Though the signal space has to be further extended to include harmonic amplitude modulation (AM) and modulated drifting modes at least, and the high demand on resolution poses resource problems which call for massively parallel computation, another surprise at the present stage of analysis is a clear phase coincidence between leading modes of both insolation and temperatures since the 70th. The phase of leading 'slow' modes points to decadal scale cooling ahead (but a conservative projection is intrinsic to the method). The problem of Global Warming is 'preserved', however, in second-rank modes of growing signal energy which should be taken seriously with a view on their next warming phase.

Statistical algorithms for solving inverse problems on predictability of regional climate
Anatoly I. Chavro, Yegor V. Dmitriev (Institute for Numerical Mathematics RAS, Russia)

New algorithms for solving inverse problems on the restoration of small-scale structure of geophysical fields in separate regions by large, space- and time-averaged fields are proposed. The algorithms are multi-dimensional statistical models for forecasting small-scale structure of most probable anomalies of geophysical fields in separate regions using space-averaged values of global fields (or low-frequency component part of the spectrum), which can be predicted by the general circulation models with rough resolution.

The problems are solved in the frameworks of linear models. It was supposed that anomalies of regional climate of field f are connected with global averaged field x as x =Af+n (1) where A is a linear operator and n is the error of such representation. An operator R is constructed on the base of a priory information such that acting on equation (1) one can get a best (in a sense of mean-square error) estimation of the regional field f=Rx.
To construct R we used the methods of reduction [1] or statistical regularization [2].The proposed methods also allow to control the reliability of statistical models for solving the inverse problem. The results of numerical experiments of the restoration of the regional values of such geophysical fields as mean surface temperature, high-frequency component of H500 field and precipitation. The proposed methods allow to restore over 70% of anomalies of geophysical fields using the large-scale values predicted by the general circulation models.

Validating Interannual Variability in Atmospheric General Circulation Models
Carsten S. Frederiksen[1] and Xiaogu Zheng[2] ([1]Bureau of Meteorology Research Centre, Melbourne, Australia; [2]National Institute of Water and Atmospheric Research, Wellington New Zealand)

This paper is an effort to explore general statistical procedures for validating the inter-annual variability in ensembles of atmospheric general circulation model simulations forced by observed sea surface temperatures (SSTs). The method relies on being able to decompose the interannual variance of a seasonal mean of daily meteorological values into three parts: a forced component, a low frequency internal source component and a weather-noise component. How well models reproduce the interannual variability of the components of seasonal means is a topic of great interest. Ideally, in assessing, or validating, a model's simulation of climate variability, the emphasis should be on the extent to which the forced component of variation is correctly simulated since this is potentially predictable. Here, we propose an estimation method for the correlation coefficient between the SST-forced components of simulated and observed seasonal-means. The technique has been applied to DJF and JJA seasonal means of 200hPa geopotential heights using daily data from an ensemble of 4 runs of the Bureau of Meteorology Research Centre (BMRC) AGCM for the period 1958 - 1991. We have taken as our "proxy" observed data the daily 200hPa geopotential height field from the National Centre for Environmental Prediction (NCEP) and National Centre for Atmospheric Research (NCAR) reanalyses over the same period.

The character of prediction utility in dynamical systems relevant to climate and weather
Richard Kleeman (Courant Institute for Mathematical Sciences)

A new parameter of dynamical system predictability is introduced which measures the potential utility of predictions. It is shown that this parameter satisfies a generalized second law of thermodynamics in that for Markov processes utility declines monotonically to zero at very long forecast times. Expressions for the new parameter in the case of Gaussian prediction ensembles are derived and a useful decomposition of utility into dispersion (roughly equivalent to ensemble spread) and signal components (roughly equivalent to ensemble mean squared) is introduced. Earlier measures of predictability are shown to have only considered the dispersion component of utility. A variety of simple dynamical systems with relevance to climate and weather prediction are introduced and the behavior of their potential utility is analyzed in detail. For the (stochastic) climate systems examined here, the signal component is at least as important as the dispersion in determining the utility of a particular set of initial conditions. The simple ``weather" system examined (the Lorenz system) exhibited different behavior with the dispersion being more important than the signal at short prediction lags. For longer lags there appeared no relation between utility and either signal or dispersion. On the other hand there was a very strong relation at all lags between utility and the location of the initial conditions on the attractor.

Stochastic dynamics in a simple model of seasonal open ocean deep convection
Till Kuhlbrodt (Potsdam Institute for Climate Impact Research, Climate System Dept., Potsdam, Germany)

Aspects of open ocean deep convection variability are explored with a two-box model of convective mixing in a water column. In order to locate the model in a region of parameter space relevant to the real ocean, it is fitted to observational data of the Labrador Sea. Seasonal cycles in the boundary conditions allow for a realistic model fit without changing the basic dynamics of the model. The model suggests that Labrador Sea in the years 1964--1974 is close to a bistable regime where convection is either `on' or `off'. The role of high-frequency atmospheric variability in triggering convection events is simulated by adding a noise term to the surface buoyancy forcing. Depending on the underlying deterministic model state, the effect of the added noise is very different. First, when the deterministic model state is convective, the noise leads to shorter convection events that are, however, more efficient in cooling the deep ocean. Second, when the deterministic state is non-convective, the noise induces convection events, and for an optimal noise level a maximum vertical density gradient is achieved. Third, for the bistable deterministic state the noise leads to jumps between the two model states of annual convection and stable stratification. Here, the dependence of the mean residence times in either state on model parameters is studied. This reveals a mechanism for

scale interaction between the synoptic and the decadal timescale.
The results highlight the crucial role of the high-frequency surface forcing for the ocean's long-term variability and its climatological mean state.

Prediction of ENSO using an optimized mixture of linear models
Frank Kwasniok (Leibnitz-Institut für Atmosphärenphysik, Kühlungsborn, Germany)

A novel statistical prediction scheme for ENSO is presented. The predictor-predictand relationship is modelled by a mixture of linear regression models. Each model is associated with a probability distribution describing its domain of influence in phase space. The joint probability distribution of predictors and predictands is approximated by interpolation among the models. The locations and the prediction coefficients of the models are determined by maximizing the likelihood of observing a given learning data set using an expectation-maximization procedure.
Unlike many other techniques, the method offers forecasts of prediction errors. Two applications of the concept described above to prediction of sea surface temperature indices are presented. Firstly, a linear ENSO prediction model is constructed from observational data which takes into account the annual cycle by conditioning the regression coefficients on the phase of the annual cycle. Secondly, a state dependent modelling approach is tried, i. e., the model coefficients depend on some ENSO-related variables. A cross-validated prediction skill is estimated and compared with that of other prediction schemes.

Simple Stochastic Models of the Thermohaline Circulation
Adam Monahan (Humboldt-Universitaet zu Berlin)

Since the pioneering work of Stommel, simple deterministic models have played a central role in shaping our understanding of the thermohaline circulation (THC). In particular, THC dynamics is often analysed within the context of dynamical systems theory. The presence of even weak stochastic perturbations can qualitatively alter the character of variability in simple models of the THC. This talk will address some of these effects of stochasticity, including relative stabilisation of regimes and stochastic induction of sensitivity to initial conditions.

Statistics, Models and Data Assimilation

Improvement of prediction using SSA methods in addition to MEM: Case of NAO study
Sylvia Antunes[1], H. Oliveira Pires[1,2] e Alfredo Rocha[2] ([1]Instituto de Meteorologia, R. C ao Aeroporto, Lisboa, [2]Universidade de Aveiro)

Singular Spectral Analysis (SSA) is a method that allows the separation of series in isolated components some identified as trend, other as components with characteristics of periodicity. Using selected significative components, grouped or isolated, this method includes the reconstruction of series. Reconstructed components are noisily reduced and present a regular behaviour and these are the characteristics that permit the improvement in prediction.
The method consists in fitting AR predictors estimated by Maximum Entropy Methods (MEM) to selected reconstructed components rather to the original series. In order to guarantee the independence of data the predictors are estimated using half of the series and tested in the remaining part. The procedure is applied separately for each of the components and the final forecast is obtained by summing the forecasts corresponding to each component.
The North Atlantic Oscillation index, obtained using the Island pressure series and the recently corrected pressure series of Lisbon is used to perform this study.

On the interrelationships between multisite climatic temperature forecasts obtained from downscaling regional sea-level-pressure fields
Ulrich Callies (Institute for Hydrophysics, GKSS Research Center; Geesthacht, Germany)

A case study of evaluating the information content of climatic temperature forecasts at four European stations, obtained from downscaling regional sea-level-pressure information, is presenteded. Forecasts are informative in the sense of this study if a great proportion of observed temperature variability can be attributed to these forecasts subsequent their post-calibration based on a linear regression model. As observations at different locations are generally correlated, each forecast delivered for one particular site will be informative about other sites as well. Even when the respective local forecasts are found to be best adapted to the conditions at a particular station, it will generally be benecial to establish a multiple-calibration scheme that involves additional information from forecasts delivered for other locations. The technique of fitting conditional mo-dels is used to measure incremental information obtained by consulting several forecasts. Its application also allows the determination whether additional information gained from forecasts delivered for other sites is genuine or if it is merely mediated by correlated observations.
Results of conditional independence modelling are con-trasted with the results of other techniques that describe the inter-relationship between data by introducing artificial variables obtained from optimum coordinate transformations (empirical orthogonal function and canonical correlation analyses).

Model Error and Uncertainty
Peter Challenor (Southampton Oceanography Centre, Southampton)

Climate research is increasingly dependent upon com-plex numerical models. While such models give reasonable estimates of the state of the climate system as yet we do not have any measure of uncertainty, such as confidence limits, on such estimates. One approach is to run the models many times and use the resulting ensemble to evaluate the uncertainty. However realistic models are expensive to run and it is impossible to create ensembles that are large enough to allow the uncertainty to be evaluated properly. In this paper an alternative is proposed. A Bayesian approach is taken and the output of the climate model is represented by a Gaussian process. A limited number of model runs are needed to characterise the Gaussian process which is then used to calculate the probability density function (pdf) of a model output given the pdf of some model inputs (which could be the forcing function or uncertain internal model parameters). The technique is illustrated with a simple climate model (where we can run a large enough ensemble to validate the method). The extension of such methods to large state-of-the-art models is discussed.

The Winter Temperature Downscaling Experiments Using Canonical Correlation Analysis in China
Youmin Chen (Agrometeorology Institute, Chinese Academy of Agric Sciences, Beijing, China)

High quality monthly temperatures at 147 stations in China and the NCAR/NCEP reanalysis circulation data during winter (the average of Dec. Jan. Feb) of 1951/52-1997/98 are applied in this paper. With the canonical correlation analysis (CCA) technique being employed, the downscaling model with East Asia circulation as predictor and the monthly temperature as predictand were established. Some experiments with different PC truncations and different CCA modes retained were conducted in order to find the optimum downscaling model. It is found that as many as possible PC truncation and 4-6 CCA modes can make the better model skill. The optimum model was found with 13 PC truncation in predictors and 8 PC truncation in predictand and also 5 CCA modes retained. The validation results with cross-validation method were compared between the models with and without detrending to the raw data. There are markedly different model skills for different sub-area of this country, changing from 10% to 70% in Brier-based score. The distribution of model skill score is rather consistent with topography characteristics, in that the northern China and eastern China have a relatively higher skill for its easy impact subject to circulation, while in the area where the sharp orographic relief can impede airflow from Siberian high, the model skill is low. Therefore the model results indirectly reflect the impact of topography on downscaling skill. The downscaling model partially capture the temperature trend change even when the raw data are detrended, but a better-simulated trend can be reached if the raw data trends are retained for developing models, which can lead to a better downscaling skill.

On-line Gaussian Processes and their Potential in Data Assimilation
Dan Cornford, Lehel Csato and Manfred Opper (Computer Science, Aston University, Birmingham)

Recently, methods have been proposed that use online algorithms for training Gaussian processes, based on a Bayesian probabilistic framework. The online method is an iterative algorithms for updating the mean function and covariance kernel, which removes the requirement for large matrix inversion. When combined with a sparsity heuristic, the algorithm has been shown to produce small generalisation errors on standard regression and classification problems. In this paper we illustrate the application of this method for assimilating scatterometer observations to retrieve wind fields using an online algorithm. We show how the algorithm may be adapted to cope with the multi-modal nature of the distribution of the local wind vector given the local scatterometer observations. The local wind vector probability distribution is modelled using a mixture density network. Since the method used will track a local Gaussian mode in the posterior distribution of the wind field given the scatterometer observations, we show how the algorithm could be used to sample from this posterior distribution. We go on to show how sparsity can be used to select a restricted set of spatial locations, which capture the variability in the full wind field model but reduces redundant computational and storage requirements. We suggest this may be a useful pre-processing tool for general data assimilation systems where the observations have spatially variable redundancy, which is often the case for remotely sensed observations. By reducing the number of data points required to represent the field in question in a pre-processing step more time is available for a more complete data assimilation system.

Statistical Downscaling of Largescale GCM Data to Local Ice Accumulation in Greenland
Traute Crueger, Hans v. Storch (GKSS Research Center, Geesthacht, Germany)

Object of the work is the creation and investigation of local 'Artificial Ice Core' accumulation estimated from GCM data. Using GCM runs performed with different CO2 concentrations and solar forcing, the natural and anthropogenic influence on ice accumulation shall be investigated. For estimation of the artificial ice accumulation a statistical downscaling model is developed. In this presentation the statisti-

cal technique and an application for one north Greenland ice core are described.
The statistical technique is based on a multiple linear regression using yearly accumulations as predictant and principle components (PCs) of seasonal averaged largescale fields as predictors. In order to separate temperature from dynamic effects on precipitation the streamfunction (500hPa) and temperature (500hPa, 700hPa) fields are tested as predictors.
We vary the boundaries and the months of the fields, whose mean are used for the EOF expansion. This way the patterns with the highest correlations between their PCs and the ice accumulation are found. The PCs of these patterns are used as predictors for the multiple linear regression. The parameters for which the explained variance is highest (after cross-validation) are part of the final form of the model.
The data used to develop the model are the monthly NCEP-Reanalysis and yearly accumulations of Greenland ice cores from 1948-1992. The cores were obtained and analyzed by the Alfred Wegener Institute for Polar and Marine Research Bremerhaven, Germany (AWI). For one core from the northern slope of the Greenland ice sheet the greatest part (65% explained variance after validation) of the yearly variability of the ice core accumulation is described by the third and second EOF pattern of the 500hPa streamfunction field averaged from May to August. The area of the streamfunction field reaches from northeast America to west Asia. The patterns correspond well to the synoptic conditions leading to precipitation in northern Greenland investigated otherwise. The influence of the temperature on ice accumulation in northern Greenland seems to be small.
An 'Artificial Ice Core' is estimated by applying the regression model to a 1000 year coupled atmosphere/ocean GCM control run.

Spatialisation of 24 hours precipitation with 100 years return period

Mojca Dolinar[1], Damijana Kastelec[2] ([1]Hydrometeorological institute of Slovenia, Ljubljana, Slovenia; [2]University of Ljubljana, Biotehnical Faculty, Ljubljana, Slovenia)

The information about heavy precipitation amount and the probability of its occurrence is valuable especially in hydrology and civil engineering. Since the network of precipitation registration stations is not dense, it is very difficult to provide representative data to the customer. In order to be able to respond on customer requests we wanted to make a digital map of 24-hour precipitation with 100 years return period with resolution 1 km.
For analysis we used the data from

* 360 stations with daily precipitation measurement (precipitation is measured once per day at 7 a.m.)
* 50 stations with precipitation registration instruments (precipitation is measured every five minutes)

Gumbel method was used for calculating 24-hours precipitation with 100 years return period for all stations with registration instruments. As the first step we analysed the correlation between 24-hours precipitation with 100 years return period and extreme daily precipitation. The preliminary spatial analysis was made to find out the dependence of extreme precipitation on some geographical variables. In general, a positive trend was evident on altitude. The subregions were defined regarding the residuals (difference to station measurements) of regression with altitude.
Different methods of spatial interpolation were tested:

* cokriging - taking the maximum daily precipitation as covariable
* universal kriging - taking the maximum daily precipitation as external drift

Cross-validation technique was used to determine the appropriate variogram model. The kriging predictions were calculated in the grid with 1 km resolution. We used the altitude data from the digital relief model with the same grid. For the kriging predictions we considered different influential surroundings and the most efficient was chosen with cross-validation technique.

Bayesian estimate of halphen type a law's parameters

S. El Adlouni[1], A. Bouzianeà, D. Ouazarà, A. Zoglat[1] ([1] Faculte des Sciences-Rabat; Ecole Mohammadia d'Ingenieurs, Rabat, Morroco)

The Halphen distributions family has some statistical properties that make them appropriate for modeling some hydrological series. In particular, the Halphen type A law is a useful tool in extreme value analysis.
Despite of the large set of distributions used in hydrology, none is judged globally adequate for adjusting hydrological series. The 3-parameter distributions (Halphen type A, B, and B-1) developed by Halphen (1941) meet some specific requirements for fitting these series. However, the literature about these distributions is very restrictive and it seems that, except the papers by Halphen (1941), Halphen (1955) and Morlat (1956), there is no work that has rigorously explored in detail their mathematical and statistical properties.
In their paper Perreault et al. (1997) present a complete study and pointed out some interesting mathematical and statistical properties of the Halphen type A distribution. This is a member of the exponential distributions family, so that the maximum likelihood estimation of its parameters is appropriate and easy to proceed. As a measure of estimators accuracy we consider the bias and standardized error. These two statistics involve the

parameters and their estimators, we reviewuate them using simulations. In this work we give a method for generating Halphen type A distributed samples. Using these samples we study some parameters estimators properties. In the second part we use a Halphen type A law with a Bayesian framework, to improve the estimations of the maximum likelihood, especially for samples with small size. To compute bayesian estimators we uses Monte Carlo Markov Chains algorithms (MCMC). To conclude we point out some pertinent remarks.

Stochastic Climate Models

EMAD: An Empirical Model of the atmospheric Dynamics

Juan Pedro Montavez and Jin Song von Storch (Meteorological Institute of Hamburg University)

In this work we present a hybrid model consisting of an ocean GCM (HOPE-G) and an empirical model of the atmospheric dynamics (EMAD). The goal is to extract, in a most complete way, the air-sea interaction processes represented by a fully coupled AO-GCM and express the statistical properties of these processes in terms of a simple model (EMAD).

EMAD is formulated for the global ocean, i.e. including the regions covered by sea ice. The model is able to generate the heat, fresh water and momentum fluxes to drive the ocean model, and to response to the surface conditions given by the ocean. The formulation of the model consist of two parts, a deterministic part formulated in a truncated EOF space and a stochastic part formulated in the physical space. The model is fitted to 200 years of daily data from an integration with the coupled ECHO-G GCM. The skill of the model is better than a persistence model.

The model is able to produce realistic responses of the atmosphere to oceanic anomalies related to ENSO and polynyas. Finally a coupled HOPE/-EMAD run has been performed. Using cross-correlation functions between SST and surface fluxes, it is shown that the hybrid model is able to reproduce the most features of the air-sea interaction processes obtained in the fully coupled ECHO-G GCM.

On the Natural Regularity and Predictability of Terrestrial and Extra-Terrestrial Parameters

Nityanand Singh (Indian Institute of Tropical Meteorology, Pashan, Pune, India)

Extrapolation of dominant modes of fluctuations after fitting suitable mathematical function to the observed long period time series is one of the approaches to long-term weather or short-term climate prediction. Experiences suggest that reliable predictions can be made from such approaches provided the time series being modelled possesses considerable regularity. Choice of the suitable function is also an important task of the time series modelling-extrapolation-prediction (or TS-MEP) process. Perhaps equally important component of this method is the development of effective filtering module. The filtering mechanism should be such that it effectively suppresses the high frequency, or unpredictable, variations and carves out the low frequency mode, or predictable, variation of the given series. By incorporating a possible solution to those propositions a new TS-MEP method has been developed in this paper. A Variable Harmonic Analysis (VHA) has been developed to decompose the time series into sine and cosine waveforms for any desired wave resolution within the data length (or fundamental period). In the Classical Harmonic Analysis (CHA) the wavelength is strictly an integer multiple of the fundamental period. For smoothing the singular spectrum analysis (SSA) has been applied. The SSA provides the mechanism to decompose the series into certain number of principal components (PCs) then recombine the first few PCs, representing the dominant modes of variation, to get the smoothed version of the actual series.

Twenty-four time series of terrestrial and extra-terrestrial parameters, which visibly show strong regularity, are considered in the study. They can be broadly grouped into five categories: (i) inter-annual series of number of storms/depressions over the Indian region, seasonal and annual mean northern hemisphere land-area surface air temperature and the annual mean sunspot number (chosen cases of long term/short trends or oscillation); (ii) monthly sequence of zonal wind at 50-mb, 30-mb and 10-mb levels over Balboa (representative of quasi-biennial oscillation); (iii) monthly sequence of surface air temperature (SAT) over the Indian region (strongly dominated by seasonality); (iv) monthly sequence of sea surface temperature (SST) of tropical Indian and Pacific Oceans (aperiodic oscillation related to El Ni–0/La Ni–a); (v) sequence of monthly sea level pressure (SLP) of selected places over ENSO region (seasonality and aperiodic oscillation). Best predictions are obtained for the SLP followed by SAT and SST due to strong seasonality and/or aperiodic oscillations. The predictions are found satisfactory for the lower stratospheric zonal wind over Balboa, which displays quasi-periodic oscillations. Because of a steep declining trend a reliable prediction of number of storms/depressions over India is possible by the use of the method. Prediction of northern hemisphere surface air temperature anomaly is not found satisfactory.

Stochastic Tropical Atmospheric Boundary-Layer Dynamics: Convective Downdrafts and Recovery, Discharge-Recharge Processes, and 1/f-Noise

Jun-Ichi Yano and Richard Blender (Meteorolo-gisches Institut, Universitaet Hamburg, Hamburg, Germany)

It was recently shown by the authors (manuscript submitted to J. C.) by analyzing TOGA-COARE

sonde data that the tropical convective variability measured as CAPE (convective available potential energy) varies as 1/f-noise for the time scale of 1-100 days. Variability of the surface moisture and, to a lesser extent, temperature are responsible for this 1/f-noise behavior of CAPE. It is speculated that stochasticity of convective downdrafts, which suddenly dry and cool the surface boundary-layer, and the following sudden recovery is the main physical mechanism. This mechanism may be further idealized as a discharge-recharge process, which can be, furthermore, regarded as a type of self-criticality. In order to generate a 1/f-noise from a random series of such pulse-like events, these time intervals must be close to Gaussian distribution (rather than Poisson) with the mean interval corresponding to the minimum period for the 1/f-noise. The present paper reports on the statistical analysis of the TOGA-COARE research vessel surface observations, which are frequent enough (1-15 min) to resolve the individual downdraft events.

Statistics, Models and Data Assimilation

Variational Assimilation of botanical proxy Data for the Reconstruction of Palaeoclimate

Christoph Gebhardt (Meteorologisches Institut der Universität Bonn, Germany); Norbert Kühl (Institut für Paläontologie, Universität Bonn, Germany); Andreas Hense (Meteorologisches Institut der Universität Bonn, Germany); Thomas Litt (Institut für Paläontologie, Universität Bonn, Germany)

The terrestrial palaeorecords of botanical fossils (e.g. pollen, macro fossils) serve as proxy data which provide important information that can be used for the reconstruction of near-surface palaeoclimate. However, a spatially coherent reconstruction is often hampered by a relatively sparse number of fossil sites and by factors influencing each fossil record on a regional scale. In this case, a reconstruction of climatological fields requires additional information like a background field or dynamical constraints. We present a simple two-dimensional variational assimilation of the proxy data resulting in a reconstructed climate which is consistent with the observed palaeovegetation as well as with large-scale features of the atmospheric dynamics.
In a first step, transfer functions quantifying the relation between climate and the botanical proxy data are found by combining a gridded climatology of 30-year (1961--1990) monthly means with distribution maps of the recent vegetation. This results in Bayesian transfer functions describing conditional probabilities for the existence of the important species given certain climatic states. Thus a most probable geographical distribution of each species can be related to a given climate. The deviation of this conditional vegetation from the actually observed palaeovegetation is described in a cost function which is minimized in dependence of the climatic state by a variational approach. The implementation of the conditional probabilities leads to a non-quadratic cost function interpretable as a maximum-likelihood function. A simplified dynamical model and a first-guess field of the palaeoclimate are implemented as weak constraints. The reconstructed climate is found at the minimum of the cost function.
The method is tested on European palaeobotanical data to reconstruct temperatures of two time slices of the Eemian interglacial (È 125-115 kyears BP) which are characterized by relatively stable climatic and vegetational conditions similar to the present time.

How realistic is GCM-simulated precipitation?

Nikolaus Groll, Martin Widmann (Institute of Hydrophysics, GKSS Research Centre, Geesthacht, Germany)

Our goal is to understand how useful GCMs are for estimating regional precipitation variability from changes in the synoptic-scale flow.
The first step is to assess how well the NCEP reanalysis data captures precipitation variability. The rationale behind this is that the NCEP reanalysis can be thought of as a proxy for an ideal general circulation model (GCM) which nearly perfectly represents the synoptic-scale flow, but in which areas of complex topography are not sufficiently resolved. Reanalysis precipitation is entirely calculated according to the model physics and parameterisations, and is not adjusted to observations.
Precipitation fields from the NCEP reanalysis have therefore been evaluated using high-resolution gridbox datasets for precipitation in Oregon and Washington, as well as over the Alps. The reanalysis captures precipitation varability on time scales of months to years accurately. Nevertheless there are over- and underestimations of the seasonal means, which affect not only spatial scales up to a few model gridcells over Oregon and Washington, but also the total area mean over the Alpine region. These systematic biases can be mainly attributed to the poor representation of the topography in the NCEP model.
To determine how well precipitation variability is represented in GCMs that are used for climate change studies, the ECHAM4 model has been investigated. In contrast to the NCEP Reanalysis the sequence of atmospheric states in the ECHAM4 control run is not directly related to the observed states. In order to allow for a comparison of simulated and observed precipitation, we developed an analog-based resampling method (ABR). This method selects for each observed day the most similar day from the control run (with respect to the SLP field over a specified region). The observed precipitation can then be compared with the simulated precipitation of the analog day. ABR is currently applied to SLP fields over the North Atlantic Ocean and Europe in order to compare ECHAM4 simulated precipitation with observed precipitation over the Alps.

Our results show that simulated precipitation might be a good predictor for regional precipitation downscaling.

Homogenisation and Interpolation of incomplete climatological Data with simple physically based Models

Andreas Hense, Christoph Gebhardt (Meteorologisches Institut, Universität Bonn,Bonn, Germany)

A characteristic of climatological data sets like the Comprehensive Ocean Atmosphere Data set COADS is the incompleteness in space and time. Furthermore, even data sets like the Climate Research Unit (CRU) temperature data set may suffer from insufficient sampling on the sub-monthly time scale leading to unrepresentative data with respect to neighbouring grid points.
We will present a simple but physically based interpolation method ("data model") to interpolated and homogenize existing climatological data sets up to an a-priori selected spatial scale. For the COADS 1950-1994 in the Atlantic we analyse wind (vector and velocity) and sea level pressure using an optimal averaging procedure and an Ekman wind model as a dynamic constraint. The data model is formulated through a variational approach. The first result is that the artificial trends in the wind data set can be reduced taking into account the pressure information but unfortunately as a second result it turns out that the simple Ekman model is insufficient even on the monthly time scale due to the omission of curvature effects. The interpolation and homogenization of the CRU temperature data is again done in a variational framework. A two dimensional advection diffusion model defines modes which are used as a projection basis. The amplitudes are estimated from the available data under the constraint that the resulting tendencies of the advection-diffusion model are minimal in the least square sense. This data model is such efficient that Monte Carlo methods like cross validation can provide a quality control by detecting unrepresentative data and estimating an a-posteriori error measure of the derived complete fields.
Results will be presented for the period 1881-1998 and the area 2.5S to 77.5N.

Trends of Maximum and Minimum Temperatures in Northern South America

Ramon A. Quintana-Gomez (Department of Earth Sciences, Universidad de los Llanos Ezequiel Zamora, Barinas, Estado Barinas, Venezuela)

Investigation of Spatial and Temporal Ozone Immission Structures under Stochastic-Deterministic Model Assumptions

Heike Hoffmann (Graduate School of Spatial Statistics, Freiberg, University of Mining and Technology, Germany)

Spatial and temporal properties of ozone immission structures are studied under stochastic-deterministic model assumptions. The given data are the half-hour averages of pollutants and meteorological parameters at 30 monitoring stations from 1995 to 1999. The sites are irregularly distributed over Saxony, concentrated in the strongly loaded areas (with respect to primary pollutants), in the cities and along the moutain ranges along the Czech-German boundary (Ore Mountains). The target of the work is the production of maps of the ozone load for half-hour intervals.
In the given case spatial interpolation is rather difficult because of the heterogenity of the monitoring network. This concerns the spatial distribution of the stations as well as their representativeness, which differs for city stations, outskirts stations and land stations. Originally the monitoring network was constructed to observe the maximum concentrations of the primary pollutants like nitrogen oxides or sulphur dioxide; therefor stations are missing at positions where extreme point concentrations of ozone are expected (in the lee of the big cities). Big problems also result from the fact that some stations close together (e.g. three stations in the city of Leipzig) are located in regions of different air-chemical regimes, what leads to a special kind of trend in the data.
Despite these difficult circumstances, the Saxonian ozone data could be nevertheless spatio-temporally trend-corrected by methods such as meanpolishing following Cressie so that finally geostatistical procedures for stationary processes could be used. In particular, a reasonable variogram could be estimated showing sufficient correlations between the ozone values at neighbouring stations. The long range of the variogram of more than one hundred kilometers is in accordance with what is known about the spatial process of ozone distribution.
These spatial investigations were combined with temporal analyses. In particular, the temporal investigations were carried out for the whole data set as well as for single stations respectively seasons, leading to interesting relationships which are useful for the prediction of the ozone distribution.

Reduced-order schemes for data assimilation in oceanographiy based on the Kalman filter

I. Hoteit and D.T. Pham (Laboratoire de Modelisation et Calcul, Grenoble, France)

Brute-force implementation of the extended Kalman (EK) filter in realistic ocean models is not possible because of its prohibitive cost. To remedy to this problem, different degraded forms of the EK filter, which basically reduce the dimension of the system through some kind of projection onto a low dimensional subspace, have been proposed. The main principle of our contribution is to study the usefulness of the evolution in time of the reduced-order state space. We will therefore compare the theoretical and practical aspects of the singular evolutive extended Kalman (SEEK) filter introduced by Pham et al. and the reduced-order

extended Kalman (ROEK) filter introduced by Cane et al.. Indeed, the reduced state space of the SEEK filter is let to evolve in time according to the model dynamic while the evolution of the reduced space of the ROEK filter is replaced, and thus remains fixed in time, by the evolution of the error in the reduced dynamic defined by the reduced space. On the other hand, the SEEK and the ROEK filters remain expensive in real operational oceanography. Hoteit et al. have proposed different degraded forms of the SEEK filter to reduce its cost. Their approach consists in simplifying the evolution of the reduced space, which is the most expensive part of the SEEK filter. To reduce the cost of the ROEK filter, we introduce the use of an autoregressive statistical model to let the error evolve in the reduced space, which is the most expensive part of this filter. Finally, using a twin experiments approach, these filters have been implemented and tested by assimilating altimetric data in a realistic setting of the OPA model in the tropical Pacific ocean.

Cloudiness and sea surface temperature: tackling the problem of missing values

Richenda Houseago-Stokes and Peter Challenor (Southampton Oceanography, Centre Southampton, UK)

Sea surface temperature from infra red radiometers on satellites is an important climate variable. Unfortunately, because of cloud, the data set contains many missing values. This makes it difficult to apply Principal Component Analysis to look at the dominant modes of variability. We investigate two solutions to this problem. The first is to interpolate the missing data using spatial optimal interpolation on the non-missing data and apply standard methods to evaluate the empirical orthogonal functions (EOF's). The other method is to use the recently developed method of Probabilistic Principal Component Analysis and apply the EM algorithm. This algorithm enables us to estimate the EOF's and the missing values simultaneously. To test the two methods we compare them on data where we have simulated missing values by deleting points at random and thus know the true results. We then apply them to fifteen years of sea surface temperature data in the North Atlantic from the Advanced Very High Resolution Radiometer (AVHRR) on US satellites.

Removing errors in simulated distributions of climate elements using a non-parametric adjustment procedure

Radan Huth[1], Jan Kyselà[1,2] ([1] Institute of Atmospheric Physics, Prague, Czech Republic; [2] Dept. of Meteorology and Environment Protection, Charles University, Prague, Czech Republic)

We propose a method that allows one to adjust a simulated (GCM-simulated or downscaled) distribution of any climate element to its observed counterpart. The method is non-parametric and consists in fitting equally-spaced percentiles in the observed and simulating distributions and linearly interpolating between them. The only assumption it makes is that percentiles of a distribution (not values themselves) are simulated correctly.
The method is applied to daily temperature and precipitation at several sites in central Europe, simulated by two GCMs and a downscaling procedure. The statistical moments (up to the fourth) of the simulated temperature distributions after the adjustment are very close to those observed, even if the simulated distributions themselves were severely distorted relative to observations. On the other hand, the temporal and spatial structure of the simulated temperatures (e.g., lag-1 autocorrelations, day-to-day variability, spatial autocorrelations, frequency and duration of extreme periods) are not affected by the adjustment. For precipitation, the numbers of dry days are corrected after the adjustment and the probabilities of a wet-to-wet and dry-to-wet transitions are considerably improved.
A modification of the method is applied to 2xCO2 GCM simulations. It assumes that GCMs correctly simulate the temperature difference between the future and present climate for the equally spaced percentiles. We show that the method successfully removes GCM's errors from the temperature series.
In validation studies of GCM-simulated or downscaled climate variables for the purposes of impact assessments, the main emphasis is put on the first two statistical moments of their distributions. We argue that a detailed validation of them is of secondary importance as one can easily adjust their distributions to fit the observations. Instead, the validation studies should put much more emphasis on temporal and spatial structure of the variables, for which such an adjusting method does not exist.

Simplified EOFs - three alternatives to rotation

Ian Iolliffe (University of Aberdeen, UK); Mudassir Uddin (University of Karachi, Pakistan); Karen Vines (Open University, UK)

Principal component analysis (PCA) is widely used in atmospheric science, and the resulting empirical orthogonal functions (EOFs) are often rotated to aid interpretation. We describe three methods that provide alternatives to the standard two-stage procedure of PCA followed by rotation. The techniques are illustrated on a simple example involving Mediterranean sea surface temperature.
The first method compresses the usual two stages into one, by successively maximizing a criterion that combines variance and simplicity. The second technique is based on an idea from regression, the LASSO (Least Absolute Shrinkage and Selection Operator). Our technique adds a constraint on the sum of absolute values of elements in an EOF to the usual PCA optimisation problem, which has the effect of driving some elements to zero. Our third approach seeks high variance EOFs such that the elements of each EOF are proportional to (hopefully low-valued) integers. The approach achieves

this by applying a series of variance maximising but "simplicity-preserving" transformations to an initial set of particularly simple, but not necessarily high variance, initial EOFs.
Each technique is shown to provide different simplified interpretations for the major sources of variation in a data set. Comparisons will be made between the three methods and with standard PCA and its rotated version. We conclude that all three techniques have advantages compared to the usual two-stage rotation.

Reconstruction of large-scale climate
J.M. Jones (GKSS Research Centre, Geesthacht, Germany)

It is aimed to reconstruct those large-scale patterns of extratropical circulation which are strongly linked to variability in proxy data. Current work is centered on the Antarctic circumpolar circulation. Using canonical correlation analysis we found promising relationships between tree ring chronologies from Argentina, Chile and New Zealand, and large-scale climate patterns representing the Antarctic circumpolar circulation for sea level pressure and 850hPa geopotential height, taken from the NCEP reanalysis. This work shall also be extended to Northern Hemisphere circulation modes. The suitability of other proxy records, such as ice core and coral data, for incorporation into these reconstructions is also being investigated. Preliminary analysis of Greenland ice core accumulation shows links with large-scale Northern Hemisphere atmospheric circulation. These reconstructions are the first stage of DATUN (Data Assimilation through Upscaling and Nudging). The aim of the DATUN method is to obtain a physically based, best guess for the large-scale states of the atmosphere during the Late Holocene with annual temporal resolution. The second stage of this methodology is nudging the large-scale variability of a GCM towards the results from the upscaling.

On a probabilistic interpretation of variational data assimilation and model error estimation
Gennady A. Kivman (Alfred-Wegener-Institut for Polar- and Marine Research, Bremerhaven, Germany)

Estimating the model error statistics is a fundamental problem of variational data assimilation (VAR). It cannot be solved without understanding of the VAR in probabilistic terms. A serious deterrent to the use of the probability theory is that probabilities for the data and for the model variables are conceptually diverse quantities. In environmental studies, the former may be treated as relative frequencies while the latter generally express degrees of believe. Thus, it is difficult to give an interpretation to probabilities on the joint data-model state space and to view the VAR as an application of Bayes' theorem.
Restoration of the probability interpretation of the VAR may be achieved by transferring the information provided by the data onto the model state space as another degree of believe. Then, having two probability distributions over the same space, we may apply the probability theory to the probabilities themselves. This leads to a natural criterion of compatibility of the data with the model solution for given data and model uncertainties. Contrary to the chi2 criterion, it is applicable to any probability distributions.
As the probabilities on the model state space are viewed as degrees of belief, the principle of maximum entropy should be employed to estimate statistical parameters of the model errors since it yields the least unbiased solution for assigning probabilities. It turns out that if the compatibility criterion is fulfilled, the prediction made with the VAR may be expressed as the mean with respect to an operator valued probability measure of what is told by the data and by the model. Maximization of a generalization of Shannon's entropy for such probabilities is proposed to use for estimating the model error statistics. The performance of this approach is compared with other techniques widely used in the VAR such as the maximum likelihood and the generalized cross-validation.

Statistical presentation of wind wave climate
Leonid Lopatoukhin[1,2] , Valentine Rozhkov[1], Ê Alexander Boukhanovsky [1,3]
([1] State Oceanographic Institute; [2] St. Petersburg State University (Dep. Oceanology); [3] Institute of High Performance Computing and Data Base, Russia)

1. Existence of 40 years (1957-1996) of reanalysis of meteorological data and verified spectral wave models allows to calculate the ensemble of spatial-temporal wind and wave fields in a grid points.
2. Vector wind field V(r,t) is specified by mean mV(r,t), variance DV(r,t), covariance KV(r,?,t,?), where r is vector of spatial coordinates, ? – vector of displacement between the grids, t- time, ? -lag. Invariant of tensors DV(?), KV(?) are used for cartographic presentation. The annual variations of wind speed are represented as the expansions of mV (t), DV(t), KV(t,?) by the trigonometric basis in accordance with the theory of periodically correlated random processes.
3. A set of 9 values (h,?,?)i , is used for parameterization of complicated fields of wind wave and swell spectra S(?,?,r,t). Here i=1, 2, 3 indexes for wave height h, periods ? and directions ? for wind waves (i=1) and swells (i=2, 3), calculated by mean of the moments mjk(j,k = 0, 1, 2) of truncated spectra S(?,?) and peak frequency. Such a change of S(?,?) to a set of 9 random values ? simplify the treatment the results of calculations. Besides, applying of both the theory of non-random function S(?,?) = S(?,?,?) of random arguments ? and method of statistical linearization propose the approach for classification of climatic wave spectra.

4. Annual maxima of wave heights and wind speed are recorded in different months and from different directions. The ensemble of values (h, ?) ? (|V|,?) is a mixture of distribution and Monte-Carlo simulation of random values and function is used.
5. Synoptic variability of waves is connected with a sequence of storms and weather windows and it parametric representation (in accordance with a theory of random outlier) may be given in a system ? of four random values {h+ ,h- ,?,?}. Where h+ ,h-Ê the value of outlier (up and down), ?,? - duration of outlier. Method of estimations of wind and wave extreme with different return periods is proposed and based on the results of analysis of distributions ?.

Model-based spatial modelling of climatological data

J. Mateu [1], P. Juan [1], C. Antolin [2,3], C. Ano [3]
([1] Department of Mathematics, Universitat Jaume I, E-12071 Castellon, Spain; [2] Department of Vegetal Biology, Universitat de Valencia, Burjassot, Spain; [3] CIDE-Centre for Desertification, Cami de la Marjal s/n., Albal (Valencia), Spain)

The problem of estimation and prediction of a spatial stochastic process, observed at irregular locations in space, is considered. The statistical model proposed is a mixture of two components, one involving a non-parametric term, accounting for a deterministic trend given by exogenous variables, and a parametric component defining the purely spatial random variation. Several well known statistical models such as the full interactive model, ridge-regression or neural-network regression are particular cases of the proposed modelization. Field variables usually show spatial dependence among observations which is an important drawback to traditional statistical methods. However, geostatistical techniques analyze and describe the spatial dependence and quantify the scale and intensity of the spatial variation providing the essential spatial information for local estimation. Geostatistics is principally the application of regionalized variable theory.
The estimation process is developed in a two-step procedure, first addressing the estimation of the non-parametric component, and then the estimation of the parametric term from the residual stochastic process. The proposed methodology is applied to model the spatial process of rain intensity (rainfall erosivity) in a mediterranean region. Some other related processes like elevation or distance to the sea are also considered. These variables are considered to be highly important in the mechanisms and processes of erosion by water in Mediterranean environments.

Extreme Value Analysis

Regional GEV-growth curves of yearly precipitatation depths inÊ Belgium for durations ranging from 10 minutes to 30 days

Daniel Gellens, Gaston Demarée (Royal Meteorologuical Institute of Belgium, Brussels, Belgium)

A regional L-moments approach has been used to study the yearly extreme k-days amounts in Belgium. Two different datasets originating from two networks are available for this purpose: the dense climatological network yielding yearly extremes of k-days precipitation amounts (with k= 1, ..., 30 days); and the sparser hydrometeorological network equipped with recording raingauges with a time step of 10 minutes. The latter dataset provided the yearly extremes for durations ranging from 10 minutes through 7 days.
The regional homogeneity of the distribution being verified, the growth curves of the regional GEV-distributions have been established. This allows for the comparison of the extreme value distributions based upon yearly extremes from the two datasets (including an "experimental" assessment of the Herschfield factor H) and the sharp determination of the curve parameter of the GEV-distribution for a large range of durations.

Extreme precipitation events in southeastern South America and the relationships with summertime large-scale South American Stationary Systems (SASSY)

Leila M. V. Carvalho[1,2], Charles Jones[1], Brant Liebmann[3] ([1]Institute for Computational Earth System Sciences (ICESS), University of California, Santa Barbara, California, USA; [2]Dept. of Atmospheric Sciences, University of Sao Paulo, Sao Paulo, Brazil; [3]NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado,USA)

The South Atlantic Convergence Zone (SACZ) is characterized by a wide range of temporal variability, from synoptic to intraseasonal and interannual scales. Our recent study has objectively identified the occurrence of South American Stationary Systems (SASSY) during austral summer. SASSY events are characterized by persistence of two or more days and large geographic extension over southeast Brazil. This study investigates the occurrence of extreme precipitation events in southeast South America and the relationships with the SASSY. Daily Outgoing Longwave Radiation (OLR) and precipitation data derived from surface stations from the states of the South and Southeast Brazil (1979 to 1999) are used to determine the frequency of occurrence of extreme precipitation events. Whenever the daily precipitation for a certain period exceeds a given percent of the climatological mean for that period, it is considered as an event. This presentation will focus on the spatial and temporal variability of the SASSY in association with extreme precipitation events.

Diagnosis of variations in the climate-related flood risk - Some results from the Interior Western United States

Shaleen Jain, Martin Hoerling, Gary Bates, Randall Dole (NOAA/CIRES Climate Diagnostics Center, Boulder, CO)

In the interior western United States, spring floods (i.e., peak streamflow) reflect an interesting integration of the seasonal-to-interannual climate variations (through winter snowpack development) and Springtime weather patterns (responsible for the snowmelt). Consequently, trends and year-to-year variations in the flood magnitude and timing may be cast in a climate-related risk assessment framework. We present a detailed empirical-statistical assessment of this climate-flood problem, with special emphasis on the sensitivity of flood peaks to: (a) large-scale climate signal during winter and Spring, and their potential predictability, and (b) regional hydrologic features (e.g., elevation and drainage area of river basins).
The observed flood probability distribution is examined for preferred tail behavior, consequent to the known modes of seasonal-to-interannual climate variability. Some potential application areas for such studies (including water resources management, stream ecology, hydraulic design, and emergency response) are discussed.

The Climatological Probability of Drought in Northern Province of South Africa
Tiba Kabanda (School of Environmental Sciences, University of Venda, Thohoyadou, South Africa)

This paper presents a study of the climatology of drought in the Northern Region of South Africa. Drought is described as a rare and severe event, therefore the frequency of occurrence and intensity need to be explained by using a criterion that will distinguish normal dry spells from real drought. The paper is intending to describe such methods. The study examines the geographical variability of dry spells in the area of study and analyses drought (seasonal) in detail to reveal its frequency, coverage, and persistence. Rainfall stations in the region are the point-source data samples that represent the study region. All stations were intercorrelated to produce blocks of highly correlating sites. The site characteristics depict different physical proportions such as geographical location and elevation. Rainfall data for 40 years is used in this study.
The study employs standardised precipitation Index (SPI) in the analysis because it allows the determination of the rarity of an episode in terms of probability. The results obtained from the study reveal spatial-temporal distribution of drought within the study area.

Statistical Analysis of Point Discharge Current at Different Time Scale Over the Pune Region
S.S. Kandalgaonkar, M.I.R. Tinmaker, M.K. Kulkarni (Indian Institute of Tropical Meteorology, Pune, India)

Thunderstorm is an important weather phenomenon for the understanding of the many issues related to the atmospheric electricity. As the storm forms and dissipates several complex cloud physical and electrical processes such as charge separation, precipitation formation, occurrence of lightning and point discharge current are taking place. The nonlinear conduction current flowing from the atmosphere to the surface of the earth when the electric field is sufficiently strong is called Point Discharge Current (PDC). In the present paper minute interval data of Point Discharge Current (PDC) collected for a total of 65 thunderstorm days occurred during 6 years period (1972-1977) at Pune (18¡ 32'N, 73¡ 51'E, 559 m asl) has been subjected to statistical analysis namely frequency distribution at different time scale (distribution during the total diurnal period). The total diurnal period (0000 - 2359 IST) is divided into 3 distinct time intervals i.e. afternoon (1400-2100 IST); night time (2100-0759 IST) and day time (0800-1400 IST). These three time intervals are practically consistent with the requirement of separating the diurnal period into convective and non-convective atmospheric regimes. Gaussian Model (computer base), is applied and the results suggested that the distribution is normal and the chi-square value obtained (5.2008) is less than the standard table value (9.542) for 22 degrees of freedom. From this result it is seen that the hypothesis applied to the present data set holds good. Since it is a normal distribution the data has been subjected to Fischer's test for the skewness and kurtosis. The results thus obtained revealed that the distribution is found to be normal with negative skewness and exhibits the property of leptokurtic distribution. The sustained occurrence of negative and positive PDC at the end of the storm day in second and third category of time interval may be due to the presence of space charges of either polarity.

A Dedacal Study of Premonsoon Seasons Thunderstorms Over Pune Region by Using Markov Chain Model
S.S. Kandalgaonkar, M.K. Kulkarni, M.I.R. Tinmaker (Indian Institute of Tropical Meteorology, Pune, India)

Probabilistic description of the thunderstorm phenomena in the premomonsoon season over Pune (18¡ 32'N, 73¡ 51'E, 559 m asl) region has been studied with the help of Markov Chain Models. The daily thunderstorm data of pre-monsoon season for a period of 11 years i.e. from (1970-1980) have been subjected to the Markov Chain models of first, second and third order. Use of Akaike's Information Criterion (AIC) clearly indicated that the first order Markov Chain Model is the best which described the atmospheric process of thunderstorm phenomena over the Pune region. This is based on the decision procedure depending upon the principle of maximum likelihood. The steady state probabilities and mean recurrence time of dry and wet days have also been calculated for first and second order

models for each separately and also for the total of 11-years. These computations revealed that the observed and theoretical values of steady state probabilities realistically consistent.

Trends of Atlantic wave extremes as simulated in a 40-year wave hindcast using kinematically reanalyzed wind fields

Xiaolan Wang* and Val R. Swail (Network Strategies Division, AMWSD Meteorological Service of Canada, Downsview Ontario, Canada)

In this study, both seasonal and monthly extremes of wave height in the North Atlantic are analyzed. The analysis is based on a 40-year (1948-1997) numerical hindcast using an intensive kinematic reanalysis of wind fields. Changes in the ocean wave extremes are identified by performing the Mann-Kendall test, and are further related to changes in the atmospheric circulation (sea level pressure) by means of Redundancy Analysis. The month-to-month variability of trends is also revealed.

The results show that the trend patterns of wave extremes vary greatly from month to month. Generally, changes are most extensive in January and March for the northern North Atlantic, and in July and October for the central and/or subtropical North Atlantic. In January and March, significantincreases of wave extremes in the northeast North Atlantic are closely related to changes in the North Atlantic Oscillation (i.e., the deepening of the Icelandic low and the strengthening of the Azores high) during the last four decades. In June, July and November, the trend pattern features significant increases of wave extremes in the ocean off the North America coast; and it features a large area of significant increases in the subtropical North Atlantic in October. Changes in the other months are of little field significance. Generally, increases of ocean wave height are associated with an anomaly low pressure over the region.

The results also indicate that the ocean off the North America coast has roughened in August, November and December during the recent decades, experiencing higher wave extremes.

Since the kinematic reanalysis of winds correctly re-assimilates in situ surface wind data, intensifys wind fields in extratropical storms as necessary, and includes tropical cyclone boundary layer winds, the resulting wave hindcast shows greater rates of changes than those identified from a wave hindcast using the NCEP reanalyzed winds for the same period.

Especially, more significant increases are detected for the ocean off the Canadian coast in summer, and for the central North Atlantic in fall.

Hurricane Landfall Winds Along the United States Gulf and Atlantic Coasts: Monte Carlo Simulations

Gary D. Skwira*, Douglas A. Smith+ and Richard E. Peterson* (Wind Science and Engineering Program, Texas Tech University, Lubbock, TX, USA; *Department of Geosciences, +Department of Civil Engineering)

While hurricane landfalls along the United States Gulf and Atlantic Coasts have had a greater impact in recent years, they remain a relatively infrequent phenomenon. At a particular location the record of past occurrence is too sparse to provide meaningful statistics to use in planning for future landfalls.

In order to exploit the historical database more extensively, Monte Carlo simulations have been carried out. Using tropical cyclone characteristics compiled by Ho et al. (1987), probability density functions were assembled for storm speed and direction, central pressure and radius of maximum wind. After random selection of parameters from the probability density functions, a tropical cyclone wind field model (Holland et al. 1991) was initialized to obtain the horizontal winds.

Simulated propagation of the model cyclone then allowed the time history of wind speed and direction at landfall to be tabulated at specific locations. Repeated random sampling allowed a 1000-storm climatology to be generated.

The simulation results are portrayed for 20 sites along the United States Atlantic and Gulf coasts. The contrasting simulated climatologies are discussed in terms of the meteorological and physical settings as well as the impacts for planning and design.

Simulation of ocean wave climate changes through wind variance changes on different timescales

E. Bauer[1],R. Weisse[2] ([1]PIK, Potsdam; [2]GKSS, Geesthacht, Germany)

The observed mean ocean wave height in the North Atlantic has grown significantly over the past 30-40 years. Since no corresponding growth of the mean wind forcing was observed, the effect of wind variance changes on two different timescales was tested. Test cases were conducted with the wave model WAM using ECMWF-Reanalysis wind fields. The varying balance of the wave generation and wave dissipation processes suggested to estimate the effect of storm frequency changes on daily timescales and of high-frequency wind variance changes on hourly timescales. First, the storm frequency changes were simulated by modifying the time intervals between succeeding storm events. Second, the high-frequency wind variance was simulated by a quasi-realistic wind generator developed from measurements with 20-minutes time resolution. The two simulation studies revealed a mean wave height growth with decreasing storm frequency on the one hand, and with increasing high-frequency wind forcing on the other hand. To explain the observed wave height growth in the North Atlantic support is provided by independent observations of growing duration of westerly weather patterns in connection with the intensifying North Atlantic Oscillation (NAO) during that period. So, the first simulation helps to identify mechanisms inducing wave climate changes whereas the second simulation yields an estimate of modelling uncertainty.

Frequency and Intensity of Mediterranean Cyclones in a doubled CO2 scenario

P.Lionello (University of Lecce), F.Dalan (University of Padua)

The analysis is based on two 30-year long global simulations carried out with the ECHAM 4 model at the DMI (Danish Meteorological Institute): a CTR (control) experiment, which reproduces the present climate, and a CO2 experiment which simulates the effect of a doubled atmospheric CO2 content. Both experiment were carried out at T106 resolution.

An assessment of the variations in the cyclonic activity is, obviously, important. The atmospheric cyclones are a potential source of major damages in the Mediterranean area, because of their association with storm surges, high wind waves, intense precipitation and floods.

The method is based on the search of the pressure minima in the T106 slp (sea level pressure) fields, available at time intervals of 6 hours. The search is based on the partitioning of the slp fields in depressions by the identification of sets of steepest descent paths leading to the same slp minimum.

To each depression has been associated a trajectory, obtained by following the location of its slp minimum in time. The procedure results in a list of cyclones, their trajectories, initial and final points, and the sequences of their pressure minima, of the areas covered, and of the maximum geostrophic wind at the sea surface.

The analysis shows that: 1) the total number of cyclones in the CTR experiment is in acceptable agreement with the ERA-15 data and it can be considered an acceptable reproduction of the present climate. 2) There is a statistically significant decrease in the total number of cyclones in the CO2 experiment. This suggests that the CO2 doubling would result in a milder climate in the Mediterranean Area.

The interannual variability of the cyclonic activity remains comparable to the difference between the two scenarios, so that a mild year of the present scenario and a stormy year of the doubled CO2 scenario have an equivalent number of cyclones.

No significant change in the geographic distribution of the cyclones has been found. The simulation with CO2 doubling presents a few intense events that suggest a possible intensification of extreme cyclones. The number of events is, anyway, too small to have a reliable statistical significance.

Extreme waves and surge events in a doubled CO2 scenario in the Adriatic Sea

P.Lionello (University of Lecce), E.Elvini, A.Nizzero (University of Padua)

The Venetian littoral, the flat northern coast of the Adriatic Sea, is particularly vulnerable to extreme marine events. An intensification or a change of the regimes of storm surges and waves, due to the increased CO2 content in the atmosphere, would require the reorganization of the coastal defenses for the protection of an economically important area and a unique historical heritage.

This analysis is based on 30 year long simulations of the wave field and of the storm surge in the Adriatic Sea using the information provided by the global (T106) time slice simulations of the CTR and CO2 scenario carried out by DMI.The wave field simulations have been carried out using the WAM model at 1/6 degs. resolution. The surge simulations have been carried out with a barotropic shallow water model at 1/12 degs resolution.

A crucial element for the accurate reproduction of surge events and of the wave field is the quality of the surface wind. Unfortunately, the T106 resolution is absolutely inadequate for the reproduction of the surface wind field in the Adriatic Sea. Therefore, it is not possible to use directly the T106 wind fields for the evaluation of surges and waves scenarios.

The wind fields used for the regional simulations have been obtained by statistical downscaling of the T106 slp fields. The downscaling was based on the CCA analysis of the ERA-15 T106 slp fields and of the regional surface wind fields produced by the BOLAM (BOlogna Limited Area Model) at a resolution of 25km.

The 30 year long simulation carried out with WAM and with the surge model have been used for an analysis of the distribution of the extreme values. The results show a significant diminished intensity of the extreme events. It appears that the diminished cyclonic activity results also in a diminished danger of coastal floods (ignoring the effect of the sea level rise) and a diminished intensity of the wave regime. The evaluation of the surge scenarios should be considered cautiously, because of the systematic underevaluation (not yet quantitatively assessed) of surge events at the Venetian littoral present in the CTR scenario.

Extreme value analysis of absolute minimum temperature and minimum dew-point temperature at Sodankylä, Finland

Jaakko Helminen, Niklas Sjöblom (Finnish Meteorological Institute (FMI), Helsinki, Finland)

On January 29, 1999 new record low absolute minimum temperatures were reached at several sites in Finnish Lapland with severe impacts on local energy supply. This led to the need to re-estimate the corresponding recurrence values. The results based on the peak-over-threshold (POT) approach of the absolute minimum temperature at Sodankylä for periods 1908-1998 and 1908-2000 will be presented and compared. The other interesting question in this context to be asked is how low the absolute minimum temperature can reach all in all. As such limit the minimum dew-point temperature will be considered as it represents the temperature value at which the formation of shallow ice crystal fog will stop further cooling due to long-wave radiation at the ground. To clarify the question of the lowest possible absolute minimum temperature values the POT-analysis results of the minimum

dew-point temperature will be presented and discussed as well.

Observed Changes in Temperature Extremes of Korea

Won-Tae Kwon, Hee-Jeong Baek*, Byung-Choel Choi (Meteorological Research Institute, Korea Meteorological Administration; * Seoul National University, Korea)

Changes in mean, maximum and minimum temperature with daily resolution are calculated with 14 stations data (with relatively long records) in Korea. In the twentieth century, temperature in Korea is increasing and especially in Seoul, the minimum temperature has shown a large increase. Since 1980's the trends in minimum, maximum, and as well as mean temperatures become steeper than the earlier decades. Ullung-do, an Island station, shows no trend until 1980's but indicates an increasing trend since then. The temperature increases during the twentieth century are between 1¼C for rural and island stations, and 2¼C for large metropolitan areas. Another prominent change occurs in daily temperature ranges, showing decreasing trend due to a large increase in minimum temperature. We also analyzed the changes in extremely warm and cold days, and freezing days (T < 0¼C) and hot summer days (Tmin > 25¼C). The numbers of extremely warm day and hot summer day are increased and this trend is more prominent during 1990's. The numbers of extremely cold day and freezing day have decreasing trends and the trends show sharp drops in 1950's and 1980's. And total numbers of extremely warm and cold days are increasing with time, which suggests that the climate of Korea has become more extreme in recent decades. We will present the detailed results from station data and also mid-tropospheric data.

Statistics, Models and Data Assimilation

The role of atmospheric large-scale circulation over Europe and North Atlantic in sea level variability on the Polish coastal zone

Miroslaw Mietus (Institute of Meteorology and Water Management, Maritime Branch, Gdynia, Poland)

An extensive study concerning the relationship between large-scale pressure field over Europe and North Atlantic and climatic and sea level variability on the Polish coast has been carried out for the time span of the last century and in case of expected increase of the CO2 concentration.
EOF analysis of mean sea level on the Polish coast shows that there is generally one dominating mode of spatial variability explaining more than 90 per cent of variance in each season (only in summer 87 per cent). The leading mode presents increasing deviation from the long-term mean when moving from the western part of the coast towards east. The second mode explains 7-8 per cent of variance. Variability of the first principal components of annu-al time series contains statistically significant trends.
The first pair of canonical patterns for annual mean explains 23 per cent of variance of regional sea level pressure and 95 per cent of the sea level variance at Polish coast. The correlation between patterns equals 0.74. The first canonical map of sea level pressure presents the Northern and Central Europe under the influence of pressure system with center over Finland. The rest of continent and Atlantic Ocean are under the influence of a weaker and more extend pressure system with center over Atlantic Ocean, west of Brittany. Such pattern is responsible for the changes of water amount in the Baltic Sea. The corresponding canonical map of sea level is similar to its well-known first empirical orthogonal function.
Monthly and daily variability of sea level were reconstructed by means of canonical correlations patterns or redundancy patterns. They remain in good and very good agreement with in situ observations (from the years 1947-95) in all seasons of the year expect of summer. Correlations coefficients between reconstructed time series and in situ measurements reach to 0.88. Reconstructed time series reveal positive trends in the nearly 100 years 1899-1995. Reconstructed positive trends are caused by an intensification of westerly flow over the Baltic Sea Basin and due to increasing stability of westerly flow. An increase in the range of sea level variability is also confirmed by tendency in increase of higher level percentiles.
In case of increasing CO2 concentration a continuation of nowadays-existing mean sea level rise is expected. ECHAM1/LSG pre-industrial experiment shows that there is expected slight increase of sea level rise in the respect to control run. In the end of 6th decade of 21st century a jump of sea level in range of 4-6 cm may have place. ECHAM3 time-slice experiment shows that the mentioned rise might be additionally accelerated by 0.7-0.9 cm decade-1 in the respect to 1xCO2 concentration. The same tendencies are expected for minimum and maximum sea level values. The expected increase of percentiles should be lower the increase of mean sea level, however range of their variability should be greater.

Space-time variograms and a functional form for total air pollution measures

De Iaco, S.[1], Myers, D. E.[2], Posa, D.[3,4]
([1] Universita di Chieti, Pescara - Italy; [2] University of Arizona, Tucson AZ - USA; [3] Universitˆ di Lecce, Lecce - Italy; [4] IRMA - CNR, Bari - Italy)

There are different ways to quantify Total Air Pollution (TAP) for a region. Spatial averages, over a region of interest, or temporal averages, for a specified time period, could be considered for each contaminant or for a weighted average of several contaminants. Such averages might be interpreted as the total mass of contamination for a time period

and a geographic region. Knowing the possible sources and their individual emissions would allow a comparison to determine if pollution is flowing into or out of a region. The comparison might also be used to determine if there are un-identified sources.
As an application of quantifying total air pollution, data for NO, NO2 and CO collected in the Milan District, Italy are used to generate a combined indicator of pollution, TAP1. The weightings are obtained by multiple PCA analyses of the daily concentration levels. The first components are treated as data in space-time and a space-time product-sum variogram is fitted to the data. Using this model and the dual form of kriging, i.e., Radial Basis Functions, a functional form for the TAP1 concentrations inspace-time could be obtained. Using this functional form, spatial and temporal integrals produce measures of total air pollution over a region in space for a specified time period. Using the specified legal limits on the three contaminants, a limit is generated for TAP1. In turn this can be used to identify the region in space-time where the maximum for TAP1 is exceeded.

Performance of four-dimensional variational assimilation and dynamical instability, experiments on a quasi-geostrophic model
Carlos Pires (CGUL, - Centro de Geofisica da Universidade de Lisboa, Lisboa, Portugal)

We perform four-dimensional variational assimilation (4DVAR) of artificially generated noisy observations on a multi-level quasi-geostrophic model in the perfect model setting. The quality of analyses and corresponding forecasts are specially improved with the extension of the assimilation period Ta up to 8-10 days (Pires et. al. 1996; Swanson et. al., 1998). One obtains an explicit formula of the covariance matrix C of the assimilation error, showing its dependence on the assimilation period length Ta, the flow instability and the temporal observation density. An approximation of the leading eigen structure of C is obtained using the linear and adjoint models. This approximation is compared to that obtained by statistical estimation of C trough the generation of a large set of different realizations of observation errors. The test is performed for a blocking case in the Atlantic sector where the present is put a few days before the blocking onset. The 4DVAR assimilated solutions are able to track the blocking transition if Ta is sufficiently extended to the past. The eigenstructure of C tends to the space spanned by the asymptotic Lyapunov vectors at the present time. However the assymptotic limit of C is obtained in practice for a finite useful assimilation period Tau depending much on the recent dynamical instability of the flow during the assimilation period. Weak instabilities are favorable to small 4DVAR analysis errors and large useful assimilation periods, especially if that occurs recently in the assimilation period. We access the analysis errors, data assimilability and predictability for different patterns of dynamical instability, measured by the leading finite singular values of the linear propagator. The effect of observation density is also accessed, especially near the tracking of large flow instabilities. In a real setting, this study can help to put limits of data assimilability and predictability of 4DVAR assimilated solutions.

A multisite self-consistent Weather Generator for Impact Studies in Portugal
Budong Qian, Jo‹o Corte-Real, Hong Xu (ICAT, Faculty of Sciences, University of Lisbon, Portugal)

Through previous studies done in past years, downscaling of precipitation and temperature for Portugal, from large-scale output of GCMs including both control and transient (scenario) runs, has essentially been achieved (Corte-Real et al., 1999). However, previous downscaling studies were developed site by site, not taking into account in a consistent way, the interrelationships between precipitation and temperature, while some models designed for impact studies, such as hydrological models, require spatially distributed precipitation scenarios consistent with temperature scenarios as well. Stochastic weather generators have been developed either to model climate elements (such as precipitation, temperature and radiation in many studies) at a given site or to simulate multisite distributions of a specific element such as precipitation (Wilks, 1999). In this contribution, a stochastic downscaling model, developed for continental Portugal, for obtaining spatially distributed regional precipitation scenarios consistent with temperature scenarios and conditioned on daily circulation patterns is presented and validated. Implications of the model for impact studies are also discussed.

Monthly mean forecasts of rainfall and temperature in Portugal
Joao Rio, Carols Pires (CGUL, - Centro de Geofisica da Universidade de Lisboa, Lisboa, Portugal)

We assess the quality of monthly mean forecasts of rainfall and temperature in Portugal using a simple and low-cost statistical model. The statistical predictors are extracted from the NCEP Reanalysis of the daily 1000hPa geopotential height field (z1000). EOF analysis is performed on the North Atlantic-Europe area selecting the leading 10 PCs at the forecast time as predictors. The monthly cumulated rainfall and the monthly mean temperature are computed in three complementary regions: north, center and south, from which we compute the distribution terciles. That quantities are then classified in one of the three classes: above, normal, below. The forecast is based on the analogue method using the angle between the predictors vector as similarity function. The search for analogues is performed in cross validation on a daily basis from data within a period centered at the same month of

the forecast time. If the angle is below a given threshold then that day is considered an analogue. The predicted class is the most populated from the pool of chosen analogues. The forecast method is the one-step PC method presented by Vautard et. al. (1996). Contingency tables with forecast/observed classes are built for each region and variable from which we compute the LEPS (Liner Error In Probability Space) to access the forecasts quality. This score vanishes for constant or random forecasts and it is one for correct forecasts. The results show higher scores for the cumulated precipitation, especially in winter months, which is associated to the occurrence of large-scale patterns favourable to frontal rainfall. In contrast, precipitation in summer which is mostly associated to local conditions which are not captured by the chosen oredictors. Further work is ongoing as we intend to increase the number of data stations and the predictor information (e.g. using sea surface temperature in the Atlantic).

Sensitivity Studies on Wind Measurement Errors in Mesoscale Model Simulations

Radhika Ramachandran, Prakash M Dolas (Space Physics Laborator, Vikram Sarabhai Space Centre, Trivandrum, India)

Large errors in radiosonde sounding data find a mention in literature from time to time. Pressure levels have to be determined accurately for obtaining heights through the hydrostatic relation, for example. Temperature and humidity along with the winds are the other independent fields measured by a radiosonde.

We have initiated wind forecast studies for the south west monsoon regime, comprising the months of June, July and August in India .The domain centre of the study is the coastal station Chennai (13.1¡ N, 80.3¡ E), located off the Bay of Bengal.

The wind regime at Chennai during this period is characterised by low level westerly jet centred around the height of 2.5 km and the tropospheric easterly jet (TEJ) with core centred around 16 km. The average maximum in the westerly regime is about 10 m/s while in the TEJ, the average easterly maximum is about 35 m/s. The upper tropospheric westerlies extend at least up to 35 km in the stratosphere. TEJ has an azimuth very close to 90 ¡ with a steadiness factor of 98 % while the low - level westerly jet has an azimuth close to 285 ¡ with a steadiness factor of 94 %.

Presently we are conducting 2D and 3D simulations using the meso- scale Advanced Regional Prediction Systems (ARPS) model. This is a non-hydrostatic, fully compressible primitive equation model in a generalised terrain following co-ordinate system developed by the Centre for Analysis and Prediction of Storms (CAPS), Oklahoma, USA. In this study we will discuss the effect of the errors in the initialising wind field on the wind forecast.

Building the bridge between sequential data assimilation and geostatistics: the stationarity issue

Julien Sénegas, Hans Wackernagel (Centre de Geostatistique, Ecole des Mines de Paris, Fontainebleau, France)

A central issue in spatio-temporal prediction is the modeling of the spatial covariance. This problem is solved differently in sequential data assimilation and in geostatistics. In the first approach, regardless of the algorithm used, the spatial structure is propagated forward in time by means of the physical model (Bennett, 1992, Evensen, 1997), so that the spatial covariance at a given time step is the result of an initial structure and the dynamics of the system. In the second approach, the inference of the spatial structure relies on an assumption of spatial stationarity (or homogeneity) which makes it possible to compute an experimental covariance on the basis of a single realization. However, the assumption of stationarity is often too strong, and several extensions have been proposed, like the Intrinsic Random Functions (Matheron, 1973) or more recently a spatial deformation model (Guttorp and Sampson, 1994).

The present paper points out the respecting advantages of these two types of methodologies and indicates how they can benefit from each other. From a geostatistical point of view, the update algorithm used in sequential data assimilation can indeed be seen as a very powerful tool to generate a nonstationary spatial covariance, liable to take into account local variations like those induced by topography, meteorology, time dependent variables or boundary conditions. Conversely, stationary spatial covariances are of ten used in data assimilation to model the system noise, for which at least the stationarity assumption should be tested. We show how a reasonable use of the physical properties of the variables can serve, in both fields, the modeling of the spatial structure, especially when the available data are scarce in space.

Several examples from hydrodynamics will be given to illustrate these features.

Public Debate and Climate Model Products: Whereof must one be silent?

Leonard A. Smith (Centre for the Analysis of Time Series, London School of Economics, London, UK)

Climate modelling holds distinction in the physical sciences in that it applies quantitative methods to produce detailed predictions which can only be refined and evaluated in-sample. This raises the justified scepticism of statisticians, although climate scientists can hardly be held responsible for the time constants set by the problem at hand. They can, however, be held accountable for which model products (in particular the level of detail in any forecast) are supplied to policy makers and to the public. This paper argues for a robust attempt to establish which model products might prove re-

alistic (i.e. what are the smallest space and time averages can be discussed?).
A statistician may well ask why it has taken so many years to fit the Earth's global mean surface temperature (~128 points) given models with 2^20 degrees-of-freedom and an uncounted number of parameters? The response, of course, is to appeal to the Laws of Physics: the number of free degrees-of-freedom are many fewer than the number of variables; both variables, parameterisations, and parameter values are constrained by "the physics" and the resulting simulation yields a realistic reproduction of the entire planet's climate system to within reasonable bounds. But what bounds? exactly?
This paper sketches a framework with which to quantify those bounds. We define, for example, a temporal credibility ratio: the smallest time-step in the model divided by the the shortest duration over which some model variable must be averaged if it is to compare favourably with observations. For a single model run under transient forcing scenario, there are good reasons that this ratio must be small on statistical grounds; most of these reasons vanish if an ensemble of runs are made. The statistics of bounding boxes in moderate dimensional spaces is discussed, and the likely number of ensemble members required to capture reality is noted. This provides a direct measure, for example, of the (in)ability of a model to provide insight on regional changes: if a model cannot capture regional variations in the data on which the model was constructed (that is, in-sample) claims that out-of-sample predictions of such regional averages should be used in policy making are vacuous. Related points will also be touched upon, including questions such as resource allocation: is it better to have the best guess available (with no meaningful quantitative estimate of its reliability whatsoever), or to estimate the likely range of outcomes, further qualified by evidence of how well this particular event (climate variable) can be simulated in this particular model?

Multiple Analysis of Series for Homogenization (MASH). Seasonal Application of MASH. Automatic using of Meta Data

Tamas Szentimrey (Hungarian Meteorological Service, Budapest, Hungary)

The MASH (Multiple Analysis of Series for Homogenization) method is a relative homogeneity test procedure that does not assume the reference series are homogeneous. Possible break points and shifts can be detected and adjusted through mutual comparisons of series within the same climatic area. The candidate series is chosen from the available time series and the remaining series are considered as reference series. The role of series changes step by step in the course of the procedure. Several difference series are constructed from the candidate and weighted reference series. The optimal weighting is determined by minimizing the variance of the difference series, in order to increase the efficiency of the statistical tests. Providing that the candidate series is the only common series of all the difference series, break points detected in all the difference series can be attributed to the candidate series.
A new multiple break points detection procedure has been developed which takes the problem of significance and efficiency into account. The significance and the efficiency are formulated according to the conventional statistics related to type one and type two errors, respectively. This test obtains not only estimated break points and shift values, but the corresponding confidence intervals as well. The series can be adjusted by using the point and interval estimates. Since a MASH program system has been developed for the PC, the application of this method is relatively easy. The paper focuses on new developments of MASH which are connected with two special problems of the homogenization of climatic time series. One of them´is the relation of monthly, seas onal and annual series.
The problem arises from the fact, that the signal to noise ratio is probably less in case of monthly series than in case of derived seasonal or annual ones. Consequently the inhomogeneity can be detected easier at the derived series although we intend to adjust the monthly series.
The second problem is connected with the usage of meta data in the course of homogenization procedure. The developed version of MASH system makes possible to use the meta data information - in particular the probable dates of break points - automatically. The decision rule is based on the confidence intervals given for the break points.

A data assimilation method with a coupled ocean-land-atmosphere model and its impact on the ocean state and on medium-range pre-dictions

Clemente A. S. Tanajura, Konstantin P. Belyaev (Laboratorio Nacional de Computao Cientifica (MCT/LNCC), Petrpolis, RJ, Brazil)
Ben P. Kirtman (Center for Ocean-Land-Atmosphere Studies (IGES/COLA), Calverton, MD, USA)

A data assimilation method based on the well-known Kalman filter scheme is considered with the COLA coupled ocean-land-atmosphere model. This method is applied to assimilate in situ observations of surface and subsurface temperatures from the PIRATA project. Results of the assimilation produce a new corrected temperatureÐsalinity ocean state, which can be used to estimate different oceanographic quantities. In particular, the present paper contains new reconstructed meridional heat fluxes, and focus on the tropical Atlantic Ocean. One-month forecast experiments during 1999 have been performed. The impact of the assimilation on the forecasted temperature profiles of the upper 500 meters is investigated.

Assessing Model Skill in Climate Simulations
Karl E. Taylor (Program for Climate Model Diagnosis and Intercomparison (PCMDI), Lawrence Livermore National Laboratory, Livermore, CA, USA)

Although skill scores in the weather forecast community are routinely used to assess model performance, this practice is rather uncommon in the climate modeling community. Skill scores have been proposed, but there is little agreement or even understanding of the relative merits of various scores. Most skill scores are related in some way to the common second-order statistics that characterize the degree of pattern correspondence between simulated and observed fields (e.g., correlation, RMS difference, and ratio of variance). A family of new measures of model skill is proposed, which allows one to specify the relative importance placed on succcessfully simulating the correct amplitude of variations compared to obtaining a high correlation. The scores account for the limits to potential agreement between models and data that result from unforced (internal) variabilty and observational errors. The use of these skill scores is illustrated by applying them to output from the Atmospheric Model Intercomparison Project (AMIP), in which models were forced by observed sea surface temperatures and sea ice cover. An assessment of the relative merits of about 20 models participating in the project will be given, both in terms of their ability to simulate the climatological mean state and the year to year deviations from that state. An ensemble of independent realizations of the simulated climate obtained from a single model will then be used to assess the statistical signficance of apparent differences in model skill and to estimate fundamental limits to agreement that must result from unforced variability. The limitations of using a single measure to quantify a model's skill in simulating an observed field will also be discussed, and the use of a new diagram to simultaneously show several measures of skill will be described.

Extreme Value Analysis

XXth Century Behaviour of Temperature and Precipitation Extremes in Hungary
János Mika, Tamás Szentimrey (Hungarian Meteorological Service, Budapest, Hungary); Judit Bartholy, Rita Pongrácz (Eötvös Lóránd University, Dept. Meteorology, Budapest, Hungary); László Szeidl (Department of Mathematics, University of Pécs, Hungary)

Monthly extremes are analysed at ten stations representing 93,000 sq. km of the country. Ten and 30 years' statistics of four characteristics are parallelly computed and evaluated. These are: the mean; the year of new record setting; the range between the two extremes of opposite sign in the 10 or 30 years' period; and frequency of extremes defined as ± 10 % of the empirical distribution.

Four considerations are quantified, namely the long-term changes, characterised by variations of the 10 years' statistics; the representativity of previous 30 years periods; the effect of homogenisation; and the spatial synchronity of extremes at the 10 stations in Hungary.

Some typical questions from the 4 x 4 ones:

* Which decades exhibited much more (less) record settings than the theoretical 1/N ?
* Did the frequency of extremes change monotonously or in correlation to the global trends ?
* Did the homogenisation change the distribution of new records or the ± 10 % extremes ?
* Can we estimate the monthly ranges from previous (i.e. 10 years old) 30 years periods ?
* Do the new monthly record setting occur parallelly in such a relatively small area ?

For preliminary conclusion, one can establish that, although even the 30 years periods exhibited considerable variability in Hungary, neither the frequency, nor the departure from the mean increased with time or with the global temperature in the past century.

Homogenized Daily Temperatures for Trend Analyses in Extremes over Canada
Lucie Vincent, Xuebin Zhang, Barrie Bonsal and Bill Hogg (Climate Research Branch, Environment Canada)

A database of long-term and homogenized monthly temperatures has been created for climate change analyses over Canada. A technique based on regression models was developed to identify "inhomogeneities" in individual annual maximum and minimum temperature time series using surrounding stations. The inhomogeneities were often step changes caused by factors such as changes in the station exposure, location, instrumentation, and observing program. Using this technique, it was possible to divide the tested series into homogeneous segments at the identified steps. Monthly adjustment factors, derived from the regression models, were applied to bring each segment into agreement with the most recent homogeneous part of the series.
Recent work has involved the adjustments to daily maximum and minimum temperatures. Reliable daily datasets are essential for the accurate description of spatial and temporal characteristics of extreme temperature related variables. Adjustment of daily temperatures has raised several concerns mainly due to the large variability in day to day temperature, particularly at high latitude stations. An approach was investigated using linear interpolation between "target values" derived from the monthly adjustment factors. This approach has two main advantages. First, it doesn‘t require the use of a daily reference series (which is often difficult to produce), and second, the average of the daily adjustments over a particular month is equal to the

monthly adjustment factor. Therefore, homogenized daily temperatures compatible with the homogenized monthly datasets can be obtained.
To assess the impact of these daily adjustments on extreme temperatures, trends in the percentage of days above (below) the 95th (5th) percentile have been computed for maximum and minimum daily temperatures both before and after adjustment. Seasonal trend maps were then examined for various periods of time. Preliminary results show that the inhomogeneity having the greatest impact on the trends during the past five decades is associated with the 1961 change to observing window at principal stations. An overall assessment of Canadian temperature extremes indicates no consistent trends in the number of extreme hot summer days, but significant trends toward fewer days with extreme low minimum temperatures during the last century.

The analysis of extreme temperature distributions on the example of Poland

Joanna Wibig (Department of Meteorology and Climatology University of Lodz)

The surface air temperature of the world has warmed by about 0.3-0.6oC since the 19th century. This warming trend should be associated with the variation of daily extreme temperatures. There are indications of the rise of the daily minimum and maximum temperature in some areas. Bràzdil at al. (1996) have shown that in Poland the linear increase in mean seasonal daily maximum temperature is slightly higher than that of daily minimum temperature in all seasons but autumn during the period 1951-1990. Wibig (2000) has shown the increase of minimum temperature at some stations in Poland in a longer period. Therefore the changes are not uniform even on the area of Poland. The question arise: has the frequency of extreme events changed during the present century? If so, the extremes in temperature can have significant social and economic impacts. Nicholls et al. (1996) states that although there is no evidence for global changes they probably exist on the regional scale. These changes can manifest not only as a shift of the mean value but also as variation in other parameters of the extreme values distribution. The aim of this paper is to fit the theoretical distribution to the records of daily extreme temperature and the of extreme temperature for the longer period (season, year) and analyze the long-term course of parameters of such distributions. Several distributions and fitting methods were tested and the results were compared.

Comparison of 20- and 50-year return values in GCM-simulated, downscaled and observed temperature series

Jan Kyselà[1,2], Radan Huth[1] ([1]Institute of Atmospheric Physics AS CR, Prague, Czech Republic; [2]Dept. of Meteorology and Environment Protection, Charles University, Prague, Czech Republic)

Extreme weather and climate events severely influence ecosystems and human society. High and low temperature extremes are among the most frequently investigated extreme events. Nevertheless, relatively little work has been done as regards extremes of surface temperature in GCM and downscaling studies even though it appears to be clear that impacts of climate change would result mainly from changes in climate variability and extreme events. This study concentrates on the comparison of 20- and 50-year return values of daily maximum and minimum temperatures in (i) observation, (ii) GCM simulated control climates (ECHAM3 and CCCM2 GCMs are employed), (iii) statistical downscaling from observation, and (iv) statistical downscaling from GCMs. As for the area involved, several sites in central Europe and the nearest gridpoints corresponding to the stations are analyzed. Observations cover the period 1961-1990.
The downscaling method used is a stepwise multiple regression of 500 hPa height and 1000/500 hPa thickness gridpoint values over most of Europe and adjacent Atlantic Ocean. Two methods of enhancing the downscaled variance to become equal to that observed are compared, namely the inflation of variance and white noise addition. Since downscaled temperature series reproduce the observed means and variances, for a fair comparison between GCMs and downscaling the distributions of GCM-produced temperatures were re-sized to have the observed mean and standard deviation.
Extreme value analysis is performed by fitting the Gumbel distribution and/or the generalized extreme value (GEV) distribution to the sample of annual extremes of maximum and minimum temperature. Various methods of the estimation of parameters of extreme value distribution are intercompared, including the method of L-moments and maximum likelihood method.
The comparison among GCM-simulated, downscaled and observed 20- and 50-yr return values of temperature does not appear to be sensitive to what statistical method of the estimation of parameters of extreme value distribution is used, although individual return values are influenced by the choice of the method. The skill of both GCMs in reproducing extreme high and low temperatures is limited. The statistical downscaling from GCMs tends to improve the results although it generally yields extremes that are too moderate compared to observed values (this holds for downscaling both from observation and GCMs). White noise addition in downscaling from observation leads to more realistic return values of maximum and minimum temperature than variance inflation.

Test on the probability distribution of maximum air temperatures

Jana Jureková[1], Jan Picek[2], Jaroslava Kalvová[1*] ([1]Charles University in Prague, [2]Technical University in Liberec, Czech Republic; *Dept. of Meteorology and Environment Protection, Faculty

of Mathematics and Physics, Charles University, Praha, Czech Republic)

If we are interested in the extreme values of temperatures or precipitation, the tails of the underlying probability distribution are more interesting than its central part. Hence, a specific test on the shape of tails is desirable. After a collection of observations, we would first like to decide whether the distribution is light- or heavy-tailed, and what can be the value of its Pareto index. More specifically, our problem is to decide whether the summer daily maximum temperatures at the Czech Republic stations belong to the domain of attraction of the Fréchet rather than of the Gumbel extreme value distributions. In accordance with the previous investigation of the authors, we suppose that the vector of the summer daily maximum temperatures X(n) follows the autoregression model of order 1, [Image] (1)
t=0, ± 1, ± 2, É, where { et } is a sequence of independent random variables, identically distributed with distribution function F and density (innovation density) f, generally unknown. The hypothesis states that - log(1 - F(x)) ~ m á log x as x ¨´ , where 0< m £ m0, m0 prescribed. A finite value of m means that the distribution function F has a heavy right tail and belongs to the domain of attraction of the Fréchet distribution. The proposed test is based on the tail behavior of the extreme autoregressive quantiles of the model (1). The asymptotic null distribution of the test criterion is normal and the test is consistent against the alternative of lighter tails as well as of the exponential tails. The test is applied to the series of the daily maximum temperatures at the Czech Republic station in the period 1961 - 1998.

Three Approaches to determine extreme years of Global Atmospheric Temperature

Luis Gimeno[1,*], Juan A–el [1], Higinio Jorge[1], Pedro Ribera[1], David Gallego[2], Ricardo Garcia[2], Emiliano Hernandez[2] ([1]Universidad de Vigo. Facultad de Ciencias de Orense, Orense, Spain; [2]Universidad Complutense de Madrid. Facultad de Ciencias Fisicas, Madrid. Spain; *Corresponding author)

Global atmospheric temperature is usually computed from the average of a combination of land air temperature anomalies and sea surface temperature anomalies . Both components of the dataset are expressed as anomalies from 1961-90, as this makes computation much easier. In this work a daily 2.5¼ latitude x 2.5¼ longitude grid box temperatures from NCAR-NCEP reanalysis at three pressure levels (850, 500 and 200 hPa) and for the period 1958-1998 were used to determine extreme years of global atmospheric temperatures by means of three different approaches: 1) The difference between the world surface area with positive temperature anomalies from 1961-90 and the world surface area with negative temperature anomalies from 1961-90, 2) The global number of hot days (number of days with temperatures exceeding the 90 percentile from 1961-1990) and the number of cold days (number of days with temperatures being lower than the 10 percentile from 1961-1990 and 3) The percentage of world area with annual temperature exceeding the 90 percentile from 1961-1990 and the percentage of world surface area with annual temperature being lower than the 10 percentile from 1961-1990.

Bayesian Statistical Modelling of Nonlinear Climate Processes

E. P. Campbell, Y. Li (CSIRO Mathematical and Information Sciences, , Wembley, Australia)

Nonlinear statistical methods have enjoyed rapid development during the 1990s, and offer great potential as a tool for climatologists seeking relationships of predictive value. A key issue still to be resolved however is predictor selection. In the time series context this requires selection both of optimal predictors and their lags. A powerful new methodology for model selection within a Bayesian framework, known as reversible jump Markov chain Monte Carlo, has emerged in the statistical literature in the late 1990s. We show how this methodology can be used to identify and fit nonlinear time series models, and illustrate the approach using threshold models for monthly rainfall. We show how our approach can be generalised to select nonparametric nonlinear time series models.

Modelling and characterizing extreme drought events

Jesœs Abaurrea, Ana Carmen Cebrian (Dpto. Metodos Estad’sticos, Universidad de Zaragoza, Ed. Matemáticas. Pedro Cerbuna, 12., Zaragoza, Spain,)

The aim of this work is to develop a stochastic model to analyze the occurrence and severity of meteorological drought events. The description of the characteristics of droughts by probability distributions provides measures such as the inter-drought recurrence time, the expected duration or deficit and the return values, which are helpful in water resource management.
In order to define a drought event we use an operational definition based on the comparison of a stochastic process, s(t), describing the hydrological state of the system and a threshold, u(t), which represents a critical level for the process. For the analysis of long-term meteorological droughts presented in this work, we use as signal the monthly moving annual rainfall. The proposed model, based on results from Extreme Value Theory and Excess over Threshold methods, is a compound Poisson cluster process, CPClP, which combines a Poisson Cluster process, to represent the drought occurrence, with a vector series composed by three random variables -duration, deficit and maximum intensity- to describe the drought magnitude. Six Spanish monthly rainfall

series of about one hundred years long are studied to check this model.
The fitted CPClP model is also used as the basis to characterize the largest drought event to occur in a given period of time. This characterization requires the knowledge of the distribution of the maximum in samples of random size. Results about this issue in samples with Poisson size are presented for some of the most frequent distributions in environmental applications.

Extremes in Instationary Time Series
Jürgen Grieser (Institute for Meteorology and Geophysics, University Frankfurt, Germany)

Extreme values of meteorological variables threaten human life and property. Thus, knowledge of the statistical features of extremes is important. The concerned variables are the waiting time distribution, return period and risk. These variables are easily obtained if the underlying meteorological variable is independent and identically distributed.
Otherwise the probability to exceed a threshold is not constant. It is demonstrated that the widely used return periods are not a useful variable in this case. However, if the meteorological variable itself has a certain temporal structure also the probability to exceed a threshold changes in time in a determined way.
It is shown that the statistical features of extremes can be drawn from the statistical features of the meteorological variable itself. The latter one may be taken from observations or from model runs. Two real world examples demonstrate that the statistical features of extreme values may change considerably even if the mean features of the underlying meteorological variable have only slightly changed.

Comparison of Several Methods for the Estimation of Extreme Value Distribution in Time Series with Trends
Henrique Oliveira Pires, Joao Pestana Ferreira (Instituto de Meteorologia, Lisboa, Portugal)

The method of Peaks Over Threshold (POT) for extreme value statistics, where the number of peaks is modelled by a Poisson distribution and the value over the threshold by an exponential distribution is compared with methods based on extreme value asymptotic distribution theory.
Estimation is made using Gumbel distribution (extreme value Type I) with just a location and a dispersion parameters and, also, using the generalised von Mises distribution where there is also a shape parameter; von Mises-Jenkinson distribution reduces to Gu mbel when this shape parameter is null.
The influence of trends, which is essential in a changing climate, is evaluated by fitting, using maximum likelihood estimation, the Gumbel model and the generalised von Mises-Jenkinson distribu-tion, but allowing for a linear variation of the location parameter with time. The maximum likelihood equations are solved by numerical methods. The maximums of the likelihood achieved can then be compared. As an example we use a 100 years time series of the air temperature in Lisbon where there is a very significant increasing trend.

The Possible Influence of Large Volcanic Eruptions on El Nino
Philippe Naveau (National Center for Atmospheric Research, Boulder, USA)

The El-Nino Southern Oscillation (ENSO) is the largest source of inter-annual climatic variability on a global scale. To determine if large tropical eruptions influence the ENSO by introducing an external forcing associated with a cooling period, or if deviations from the El-Nino cycle are only due to random noise is of primary interest to the paleoclimate and climate change communities. Hence, the aim of this talk is to investigate the statistical association between the ENSO and volcanic eruptions.
To study the historical behavior of El-Nino events over a long period of time 1525-1987, we use the data set constructed by Quinn and Neal (1995). To assess volcanic activities from 1525 to 1991, we work with the VEI (Volcanic Explosivety Index) that describes the occurrences and the intensity of volcanic eruptions (Newhall and Self 1982, updated by Simkin and Siebert 1995).
To investigate the existence of a potential link between these two signals, we develop a variety of statistical models that can take into account the special characteristics of our data (e.g., volcanic eruptions seem to occur in clusters). The most complex model is a Hidden Markov Model (HMM) that is based on two main components: the observations and some hidden atmospheric states. The advantages of such a process is its flexibility and its capabilities to model a variety of dependence structures between the ENSO and VEI. Finally, to remove the risk of over-parameterization, we compare different HMM's to simpler models (independent Bernouilli processes and Markov Chains) by using model selection techniques.

Simulation Models

Simplified atmosphere models with realistic variability
Ulrich Achatz (Leibniz-Institut fuer Atmosphaerenphysik an der Universitaet Rostock e.V., Kuehlungsborn, Germany); J.D. Opsteegh (KNMI, De Bilt, The Netherlands)

The realism of climate simulations by general circulation models is partly due to their use of an enormous number of degrees of freedom. Unfortunately this leads to an (ever increasing) loss of transparency of specific model results and low integration speeds, hampering both progress on basic understanding of the climate system and the

applicability of GCMs for climate impact assessment studies. There is therefore a need for complementary climate models of low or intermediate complexity which can reproduce the atmosphere's behavior based on simplified descriptions. In the light of its important role it seems desirable that internal climate variability is also captured. Up to now there is no low- or intermediate-complexity climate model which satisfies this demand. Here progress might be brought by so-called reduced models utilizing realistic dynamics in combination with an optimal set of basis patterns and a good parameterization of the impact of scales and processes not explicitly resolved. The patterns are chosen such that they can give a rather complete description of the climate attractor but simultaneously neglect highly improbable realizations of unrealistic states. A good candidate for this are empirical orthogonal functions (EOF). Achatz and Branstator (1999) have recently shown that the empirical etermination from a GCM data set of linear parameterizations of the effect of ageostrophy, unresolved vertical and horizontal scales, and unresolved physics can improve a reduced quasigeostrophic two-layer model projected onto EOFs such that it is able to reproduce the internal variabiity of the GCM not only in midlatitudes but also in the tropics. In oder to also include the nonlinear tropical dynamics we have built on this result and developed a corresponding model class based on the primitive equations. Comparison with the climatology of a conventional GCM (ECHAM3) shows good agreement. Models based on 500 and as few as 30 EOFs will be discussed with respect to the simulation of the seasonal dependence of mean state and fluxes, and to the reproduction of recurrent anomalies.

Modelling of Temporal Rainfall by the Use of Stochastic Point Process Models in View of Scaling

Konrad Bogner (Institute of Hydrology, University of Agricultural Research,Vienna, Austria)

Clustered rectangular point process models and various modifications are investigated in detail regarding the assessment of fit. Besides testing the agreement between observed properties and those used in fitting the model, but examined at different levels of aggregation, the generalized extreme value analysis is applied to compare simulated and observed extreme rainfall. In former publications a lack of fit for extreme values of hourly aggregation levels is reported sometimes. However the investigated modifications, like the incorporation of third order moments in the fitting procedure, indicate an improvement and better agreement for small time intervals also. Furthermore assessment of fit is made for simulated series of sub-hourly time resolution considering the extreme values. There are considerable differences between observed and simulated properties at these levels of aggregation. Therefore the method of wavelet transform is applied to reveal the self similarity and fractal pattern of rainfall time series. The combination of these analysis of stochastic point process models and the scale of fluctuation will facilitate to improve the disaggregation possibilities and to identify the limits of applicability of point process models.

Statistical Modelling of Tornado Occurrence

Harold E. Brooks (NOAA/National Severe Storms Laboratory Norman, Oklahoma)

Tornadoes are rare events at any location. Possible changes in the distribution over time could have significant effects on public safety. Unfortunately, the quality of data collection has changed dramatically over the years in many countries (e.g., annual tornado reports in Germany have increased by a factor of 5-10 in the last 50 years). As a result, changes in the "true" distribution of tornadoes can be hard to distinguish from changes in the reporting. It appears, however, that the conditional distribution of tornadoes by intensity is relatively consistent in many countries for tornadoes rated F2 or higher on the Fujita damage scale, decreasing logarithmically with increase F-scale value. This consistency allows us to make some estimate of the degree of underreporting in different locations. For instance, it appears likely that only about 15% of French tornadoes are currently in their database.
A 75-year record of significant tornadoes (those rated F2 or higher) in the United States has provided input to a variety of statistical models of tornado occurrence that allow us to estimate the range of variability. The first model is a Markov chain model of occurrence of at least one significant tornado anywhere in the United States on a daily basis. It provides estimates of the probability of long runs of consecutive days with or without tornadoes. The second model uses an estimate of the probability of a significant tornado on a daily basis on a grid in the US, based on a simple kernel density estimation technique. Those daily probabilities are then modelled using a beta distribution, and the beta distributions used to generate a long model run that provides estimates of tornado occurrence and, of particular interest, the interannual variability.

A method to extend the temporal validity of nested regional climate simulations

Udo Busch and Dietrich Heimann (DLR Oberpfaffenhofen, Institut für Physik der Atmosphäre, Germany)

This study introduces a statistical-dynamical extrapolation scheme (SDE) for nested regional climate model simulations. The method is based on a cluster analysis weather-type classification scheme. Predictor is the 500~hPa geopotential height and predictands are the regional surface temperature and precipitation.
For the validation of the scheme a 30-year GCM simulation of the Hadley Centre with a contin-

uously nested regional climate model (RCM) is used. The basic features of the regional development in Central Europe are quite well reproduced by the SDE. A comparision of the SDE and the direct RCM output shows only a deviation of 0.13~K for the decadel mean winter temperature and 8~\% for the decadel mean winter precipitation of the greater Alpine Region. The SDE estimation of the interannual variability of the mean winter precipitation shows an excellent reproduction for the North Sea area and a slight underestimation for the greater Alpine area.
The results of the SDE are two dimensional available with the resolution of the nested regional climate model. With the application of the SDE the regional climate model has to be nested only for a few years to get 30-year climatological statistics. This render the possibility to obtain regional scale information for the length of GCM experiments. 30-year GCM time-slice experiments with different CO_2 concentrations could be compared within the regional scale. The comparison and validation of regional models with different model physics and parametrizations is possible for a higher number of model runs including the possibility to cover time spreads of climatological periods (i.e. 30-years).

Stochastic generation of daily precipitation

Aristita Busuioc[1], Hans von Storch[2] and Rodica Tomozeiu[1] (1 National Institute of Meteorology and Hydrology, Bucharest, Romania; 2 Institute of Hydrophysics, GKSS Research Center, Geestacht, Germany)

The paper presents a stochastic model conditioned by the large-scale climatic distributions to generate daily precipitation amount. With such a model, numerous statistically equivalent but in its details different realization of long sequences of daily rainfall can be generated. The model uses a first order Markov chain combined with a downscaling model based on the canonical correlation analysis (CCA) to link the local precipitation with large-circulation. Precipitation occurrence is described by a two-state, first-order Markov chain. The precipitation either occurs or it does not (the two states) and the conditional probability of precipitation occurrence depends only whether precipitation occurred in the previous day. There are two parameters describing the precipitation occurrence process: the transition probabilities of a wet day following a dry day and the probability of a wet day following a wet day. Variation of precipitation amount on wet days is characterized using gamma distribution, which has two parameters: the shape parameter and the scale parameter. Therefore the stochastic precipitation generation model depends on four parameters. To link the four parameters by the large-scale circulation, represented by the sea level pressure on the European scale, a regression model based on the canonical correlation analysis have been used. This model has been tested for the winter (January) daily precipitation amount at the Bucharest station over 1901-1994. It was found that, for the independent data set (1901-1950), two model parameters (mean precipitation amount for wet days and the probability of a wet day following a wet day) are not very well estimated over 1901-1930 interval. This result could be explained by the fact that before 1931 these parameters describe another precipitation regime (as urbanization effect) or these parameters are no so strongly dependent on the large-scale circulation. Testing of model for other months (seasonally stratified) and other station placed in same geographical conditions are in progress.

Statistical Downscaling of Daily, Multi-Site Precipitation in Tropical and Sub-Tropical Climates

Stephen P. Charles[1], Bryson C. Bates[1], Stephen J. Crimp[2] and James P. Hughes[3] ([1]CSIRO Land and Water, Wembley, Australia; [2]Queensland Department of Natural Resources, Indooroopilly, Australia; [3]Department of Biostatistics, University of Washington, Seattle, USA)

Regional climate simulation is becoming increasingly important as the scientific and policy community require realistic projections of the potential regional impacts of climate change. Although general circulation models (GCM) and limited area models (LAM) simulate large-scale atmospheric processes reasonably well, they tend to overestimate the frequency and under-estimate the intensity of daily precipitation, and thus fail to reproduce the observed precipitation statistics at the spatial and temporal scale required for regional impacts assessment. Statistical downscaling can overcome these limitations – by relating regional- or point-scale precipitation to large-scale atmospheric fields. The nonhomogeneous hidden Markov model (NHMM) is a statistical downscaling model previously shown to reproduce daily precipitation probabilities, spatial patterns in precipitation occurrence, wet and dry spell length statistics, and the probability distributions of precipitation amounts at multiple sites in temperate midlatitude regions (Pacific north-west USA and south-western Australia).
Here, we apply the NHMM to tropical and sub-tropical regions in Australia where precipitation is generated by a much wider variety of mechanisms including monsoon, coastal and upper troughs, tropical cyclones, fronts, and localised convective systems. The literature contains very few examples of statistical downscaling in tropical regions. A suite of observed atmospheric predictors (derived from NCEP/NCAR Reanalysis data), encompassing measures of atmospheric flow, moisture content, and stability, provide NHMMs that reproduce the observed summer and winter precipitation statistics for tropical, sub-tropical continental, and sub-tropical maritime regions in Queensland, Australia. Future work will compare downscaled simulations generated from the observed atmospheric predictors with those generated from the corresponding LAM atmospheric predictors.

Stochastic Weather Generator Model for Simulation of Multiple Meteorological Time Series

Ildikó Dobi-Wantuch, János Mika (Hungarian Meteorological Service, Budapest, Hungary); László Szeidl (Department of Mathematics, University of Pécs, Hungary)

This work presents the development of a daily, stochastic weather generator point-model, which is based on precipitation occurrences, as a driving parameter. The model, simulating diurnal series of maximum, mean and minimum temperature, precipitation, sunshine duration, cloudiness, relative humidity, wind speed and air pressure, is recommended for use in climate change impact studies in Hungary.

The first problem, to solve, is the suitable modeling of wet and dry sequences, since, as we are going to discuss, some often used simulation approaches do not appropriately work in our climate. Considering the frequently occurring long dry periods in Hungary, duration of sequences without measurable precipitation is modeled by mixed Poisson and geometric distributions.

Another important aspect is the preservation of the first four moments and the correlation structure of the empirical time series. In order to retain these statistical features for all variables, we applied various uni- and multi-variate methods.

To prepare the data vectors for further modeling, first we standardized the series considering the annual cycle of the means and standard deviations by applying Fourier transformation. Next, a centralization for conditional averages, depending on the serial number of the given day within the dry or wet series, is performed, since this dependence is also significant in several respects.

Factor analysis and test of normality suggest that three of the variables, namely maximum temperature, relative humidity and air pressure, can be parallelly modeled as a weakly stationary, 3-dimensional process which can be fairly well described by an AR(1) model. However, the other six climate elements have non-normal distributions. This recognition drives us to accept a multivariate extension of the Johnson distribution. This technique already matches the necessary statistics for the given elements and climatic region.

Interdiurnal and interannual variability in stochastic daily weather generator: Modelling and the role in agricultural and hydrologic studies

Martin Dubrovsky[1], Josef Hejzlar[2], Jan Kysely[3], Josef Buchtele[4], Zdenek Zalud[5], Daniel Marvan[6]
([1]Institute of Atmospheric Physics AS CR, Hradec Kralove, Czech Republic (CR), [2]Hydrobiological Institute AS CR and Faculty of Biological Sciences USB, Ceske Budejovice, CR; [3]Institute of Atmospheric Physics AS CR, Prague, CR; [4]Institute of Hydrodynamics AS CR, Prague, CR; [5]Mendel University of Agriculture and Forestry, Brno, CR; [6]Faculty of Mathematics and Physics, Charles University, Prague, CR)

Met&Roll is a WGEN-like four-variate (precipitation, solar radiation, temperature maximum, temperature minimum) stochastic daily weather generator used to provide synthetic weather series for models simulating growth of crops and forests and hydrological regime in present and changed climate conditions. The previous version of the generator was found not to satisfactorily reproduce interdiurnal and interannual variability of the weather series. Two questions are raised in this contribution: (1) What is an effect of these imperfections on results obtained by the models (growth models, hydrological models) feeded by the synthetic weather series? (2) How to improve the generator's performance?

In the first part, improvements of Met&Roll aiming to better reproduction of statistical structure of the weather series are introduced: (i) To better reproduce interdiurnal variability of the weather series, correlations among solar radiation and daily extreme temperatures are allowed to vary during a year and the Markov chain of the third order (instead of the first order) is used to model precipitation occurrence. (ii) As the generator was found to underestimate interannual variability of monthly means, the underlying mathematical model was split in two steps: In the first step, time series of monthly means of the four variables is generated using first-order four-variate autoregressive model. In the second step, daily weather series is generated using the monthly means produced in the first step. Impact of the new features of the generator on the statistical structure of synthetic daily weather series will be demonstrated.

In the second part, effect of the interdiurnal and interannual variability of daily weather series on crop yields simulated by growth models (CERES and WOFOST) and on stream hydrology and stream water quality simulated by SAC-SMA hydrological model will be shown.

Temperature predictability in the greater Mediterranean area

R. García, E. Hernández, T. Muñoz, P. Ribera* and L. Gimeno* (Dto Física de la Tierra II, Universidad Complutense, Madrid Spain; Dto Física Aplicada, Universidad de Vigo, Campus de Orense, Orense, Spain)

Long-range statistical forecasting of annual and seasonal average temperatures in an area centered over the Mediterranean Sea has been considered from two different approaches intended to forecast annual or seasonal average temperature values several months in advance. The methods are Optimate Climate Normals (OCN) and an extension of it called Climate Normal Functions (CNF). Both of them attempt to forecast temperatures from the past behavior of its own time series. They have been applied to a dataset of monthly averaged temperatures from 151 observatories from Europe and Africa distributed around the Mediterranean area, covering the period 1955-1990.

This study makes use of annually and seasonally averaged values. For every observatory, OCN and FCN have been computed for each averaging period. Next, cluster analysis has been applied to classify similitudes in the predictability characteristics. Three predictability patterns have been identified: in the Northern area and 8 yr period has been detected; the North Atlantic Oscillation seems to be the most important influence. In the Eastern area the predictability coefficients reach their maximum at the longest average periods. Finally, the aera closest to the Mediterranean shows a one year persistence as the most characteristic feature.

A new validation scheme for the evaluation of climate model outputs

F.-W. Gerstengarbe, M. Kücken, P.C. Werner (Potsdam-Institute for Climate Impact Research, Potsdam, Germany)

Model validation plays an important role in the development of climate models. The validation encompasses a simple optic comparison, the use of generalising measurement figures (e.g. root mean square error - RMSE) and the application of fully developed statistical methods. The latter often require relatively high calculation time so that they are rarely used for evaluation purposes. Nevertheless, the evaluation of complex correlations can only be done with such complex methods. In order to make progress here, a method is presented in the following which is based on a multivariate pattern recognition and provides measurement figures for quality evaluation that can be easily interpreted and whose spatial distribution and temporal development serves to derive information on possible sources of error.

The question that should be answered by the new method is: How well can a model represent defined complex structures of a climate regime?

In a first step the validation conditions are defined and the selected parameters are grouped in patterns for a reference field at each grid point of a model area via n time steps by means of a cluster analysis algorithm. It has then to be investigated how far the same parameter combination of the simulated field, i.e. the climate model output, reflects these patterns. This is done by a distance measurement which provides information about the assignment of the grid points to the clusters of the reference field. Thus, one receives a yes/no answer: the simulated value either corresponds with the one of the reference field (the grid point belongs to the same cluster as in the analysis) or the same grid points of the reference field and the simulated field belong to different cluster. In order to specify this yes/no answer, each degree of deviation, standardised to 0;1 (0 – no deviation, 1 – largest deviation with a statistical security of 95%) will be determined in addition.

The effectiveness of the method is presented by a comparison of the quality of different regional climate models.

The construction of multi-site and multi-variate scenarios for Mediterranean regions based on Monte Carlo simulations with a conditional weather generator

C.M. Goodess and J.P. Palutikof (Climatic Research Unit, University of East Anglia, Norwich, UK)

Empirical methods for downscaling GCM output offer relatively simple and computationally efficient means of constructing scenarios with a high spatial and temporal resolution. However, relatively few downscaling studies have addressed the problem of constructing scenarios which are consistent between sites and between variables on a day-by-day basis. Here, a three-stage method for the construction of self-consistent daily temperature and rainfall scenarios which has been developed and tested for two study areas in southeast Spain and southern Italy is described.

First, daily rainfall scenarios were constructed for a key site in each study area using a conditional weather generator in which rainfall occurrence depends on both the circulation type and on whether the previous day was wet or dry. Each simulation set consists of 1000 runs, i.e. a Monte Carlo approach is taken. This has a number of advantages:

- a range of scenarios can be provided and the level of uncertainty can be indicated, for example by calculating quantile values;
- ranked pairs can be used as climate scenarios, thus taking some account of systematic errors in the downscaling models and underlying GCMs; and,
- non-ranked pairs can be used in climate sensitivity studies, for example to maximise the changes in a particular season.

Second, daily rainfall scenarios for a network of sites in each study area were constructed using an analogue approach, based on a reference scenario for each key site, i.e. by sampling from the observed data conditional on the circulation type and whether the key site was wet or dry.

Third, multi-site daily temperature scenarios were constructed using a transfer function method, with free atmosphere variables as predictors in multiple regression models. The principle of consistency is maintained by constructing transfer functions separately for wet days and dry days. The latter information was available from the multi-site rainfall scenarios.

The final scenarios are considered more plausible than the raw GCM changes. This approach is, however, affected by a number of problems which are common to all empirical downscaling approaches (i.e. stationarity, overdispersion, data availability and the reliability of GCMs). A number of ways in which the method could be further refined and developed to reduce these problems are proposed.

Statistics, Models and Data Assimilation

Reconstructing large-scale variability from paleoclimatic evidence by means of pattern nudging

Martin Widmann [1], Hans von Storch [1], Ingo Kirchner [2] ([1] GKSS Research Center, Geesthacht, Germany, [2] Max-Planck-Institute for Meteorology, Hamburg, Germany)

Pattern nudging is the second step of the newly developed Data Assimilation Through Upscaling and Nudging (DATUN) technique. The aim of DATUN is to obtain a physically-based, best guess for the large-scale states of the atmosphere during the Late Holocene with annual temporal resolution. DATUN uses statistical upscaling models to estimate continental-scale and hemispheric climate variability from climate proxy records. In a second step, which is the subject of this presentation, the large-scale variability of a GCM is nudged towards these estimates.
Commonly used nudging procedures relax model states towards a target field that is prescribed at every gridpoint. However, this approach is problematic in the context of paleoclimatic reconstructions, since the historic atmospheric states are only incompletely known. To overcome this difficulty, we developed a nudging method that is purely defined in a pattern space. Only large-scale patterns are nudged and the synoptic-scale variability is therefore expected to be undamped but consistent with the large-scale forcing. Pattern nudging has been implemented in the ECHAM4 model and tested using prescribed states of the Arctic Oscillation. An evaluation of these test runs will be presented. This work is undertaken as part of the German project KIHZ (Klima in Historischen Zeiten, Climate in Historical Times).

Spatio-temporal patterns of Meteosat Satellite Thermal Infrared Derived Convective Clouds over Ethiopia as Described by PCA & MVC

Abebe Yeshanew (Senior Meteorologist, National Meteorological Services, Addis Ababa, Ethiopia)

Convective clouds with top temperature at -40¡ C thresholds are derived from Meteosat satellite thermal infrared channels over Ethiopia from July to September fro the year 1988, 1989 and 1990. The duration of convective activity (cold cloud duration, CCD) maintaining its top cloud temperature at -40¡ C threshold are summed up to every dekad (8, 9, 10 or 11 days depending on the month considered).
The standardised values of the duration of convective activity is subjected to principal component analysis to cull the most dominant and important signals from the dataset. The first two principal components are selected based on the break point of the eigenvalues verse the eigenvector components plot. The first two principal components explained 83% of the total variance. The most dominant spatial mode reveals a dipole structure whereas the second depicts a tripole spatial configuration. The two spatial modes of principal component analysis are used in a minimum variance cluster analysis (MVCA) to delineate areas where CCD is homogeneous in space. Here, the cubic clustering criterion (CCC) is used to determine the number homogeneous region. Based on CCC and MVC, four regions of convective activity regions are defined. The defined convective regions show different temporal characteristics of the duration of convective activities over the country. The convective activity regime with maximum CCD is located over western and central parts of the country. Whereas, the region characterised by minimum occurrence of convective clouds entails northern, northeastern, southern, southeastern parts of Ethiopia.

Skill of seasonal hindcasts as a function of the ensemble size

F.W. Zwiers and V.V. Kharin (Canadian Centre for Climate Modelling and Analysis, Victoria, BC, Canada)

Forecast skill as a function of the ensemble size is examined in a 24-member ensemble of northern winter (DJF) hindcasts produced with the second generation general circulation model of the Canadian Centre for Climate Modelling and Analysis. These integrations are initialized from the NCEP reanalyses at 6 hour intervals prior to the forecast season. The sea surface temperatures that are applied as lower boundary conditions are predicted by persisting the monthly mean anomaly observed prior to the forecast period. The potential predictability that is attributed to lower boundary forced variability is estimated.
The forecast skill in the first 2 weeks, which originates predominately from the initial conditions, is greatest for relatively small ensemble sizes. The forecast skill increases monotonically with the ensemble size in the rest of the season. The skill of DJF 500 hPa geopotential height hindcasts in the Northern Hemisphere and in the Pacific/North America sector improves substantially when the ensemble size increases from 6 to 24. A statistical skill improvement technique based on the Singular Value Decomposition method is also more successful for larger ensembles.

Extreme Value Analysis

Determining extreme sets in multivariate distributions

Monika. Lakatos (Hungarian Meteorological Service); I. Matyasovszky (Department of Meteorology, Eötvös Loránd University, Budapest)

The term extremes is simply defined as events having small probabilities at the tail(s) of an underlying density function. Consider a multivariate random variable with probability density function $f(x)$. For any $0<\varepsilon<1$ an extreme set T is defined as

$T:\{x; f(x) < c\}$ such that $\int_T f(x)dx = \varepsilon$,

where $c=c(\varepsilon)$. When the analytical form of f is kownn the task to obtain T is straightforward. Without knowing the form, which is a typical case, an estimate of the density is needed. Therefore, a procedure is developed to determine T using a kernel type estimator for f. The methodology is applied to air temperature and wetness data in order to define critical dry and warm conditions.

The Probability Of An Extreme In A Correlated Time-Space Domain

Albert R. Boehm

Consider an area with weather observations at a limited number of points and over a limited period of record. Questions: What is the probability during a specified target period in the future that there will be:

A: An extreme anywhere in the area?

B: A specified fraction or more will experience an extreme?

C: An extreme will persist during some fraction of the target period?

D: Extremes will exist beyond some penalty function which could be complicated and is fitted to specific requirements such as crop growth or heating load.

Case 1: The area is homogeneous and correlation is isotropic in space and stationary in time. This case can be handled by fitting the probability of an extreme at point and modeling correlation structure. Questions A, B, C and some forms of D can be answered with the CUB algorithm defined at the 5IMSC 1992. CUB depends on the eigenvalues of the domain correlation matrix. More complicated forms of D can be simulated.

Case 2: The area is heterogeneous and the probability may have a seasonal variation, but correlation is isotropic in space and stationary in time. In effect, the spatial and time domain consists of sub regions that differ in their extreme probability but are correlated. Since the heterogeneous probability will be less than if all the domain were at the highest probability but greater than if all the domain were at the lowest probability, a weighted mean can be used as an approximation. Since the correlation is assumed known, a conditional probability of a lesser sob-domain being extreme given that a greater sub-domain is not extreme can be calculated.

Case 3. The domain is undergoing climate change or fluctuation. This complicated case has an elegant solution: Take into account all possible changes (including no change) each weighed by the probability it will occur.

Climate extremes in Germany and its relation to the objective weather type classification of the German Weather Service

Peter Bissolli, Udo Baum (Deutscher Wetterdienst, Offenbach, Germany)

Climate extremes can be attributed to special features of certain weather types. For the area of Germany, such weather types can be described using the objective weather type classification of the German Weather Service. This classification provides 40 standard weather types, but, by using special indices, it is possible to define other special extreme weather types too.

This presentation discusses the following aspects:

1. how to define climate extremes in Germany,
2. how to define extreme weather types,
3. how to find relations between extreme weather types and climate extremes.

The definition of these extreme events is mainly based on frequency distributions of different climate elements (daily temperature maximum and minimum, daily wind speed maximum, daily precipitation amount and daily snow depth) and weather type indices (indices of advection, cyclonality and humidity). In addition, the spatial variability of climate elements within Germany is taken into account. Advantages and disadvantages of these defined extremes are discussed, from a statistical point of view as well as from a climatological-practical one.

The relation between weather types and climate extremes can be defined by probability distributions. Considering that the weather type classification also provides forecasts of weather types, the forecast skill of these probability distributions can be estimated.

Statistical methods and case studies investigating extreme climatology of the Carpathian Basin

Judit Bartholy[1], Laszlo Szeidl[2] ([1]Dept. of Meteorology Eotvos Lorand University, Budapest Hungary; [2]Dept. of Mathematics University of Pecs, Hungary)

One of the most challenging topics of the global change research is predicting future changes in extreme climatological values. An overview of the statistical methodology will be presented that can provide scientific and reliable answer to the following questions: how the extreme values and their occurrences can be modelled, what kind of problems may occur investigating climatic fields of a given meteorological parameter, etc. The presentation will focus on the extremes of climate of the Carpathian Basin. Monthly temperature data observed at 16 stations will be examined, furthermore, precipitation measurements from 162 and 8 stations located in Hungary will be used in monthly and daily scale evaluation, respectively. In this region the precipitation trends evaluated during last decades seems to be inconsistent. Beyond extreme

value analysis of precipitation, variability and fluctuation characteristics will be determined. Spatial distributions will be mapped of various statistical characteristics for all seasons. Time series will be also analyzed separately as robust and extreme. Distributions of extreme, robust and full time series will be compared. Asymptotic approach will be applied to precipitation and temperature time series using Gumbel distribution model. Model parameters will be estimated by method of moments. Return values will be determined for pre-set periods, e.g., 10, 20, 50 years, which thresholds will be exceeded once in average during that period. More detailed investigations will be carried out for the two sensitive regions of the Carpathian Basin, namely, the drainage basin of the shallow Lake Balaton and Sio, and the Hungarian Great Plain. In the present climatic conditions the water balance of these regions tends to be negative, and therefore it is likely that the global change may affect them the most.

Simulation Models

Simulation of multivariate time series of meteorological data

Asa Forsman, Claes Björklund and Anders Grimvall (Department of Mathematics, Linkšping University, Linköping, Sweden)

A great variety of models used in the environmental sciences are driven by meteorological data. This implies that simulations involving synthetic meteorological inputs can play an important role in several different contexts. First, such simulations can be used to determine the joint distribution of an arbitrary set of response variables. Secondly, simulations followed by statistical analyses of the response to different inputs can be used to elucidate the dynamic behaviour of complex models. In the present paper, we discuss how the statistical characteristics of a given multivariate time series of meteorological data can be transferred to arbitrary amounts of synthetic data. In particular, we describe a procedure involving the following steps: (i) transformation of the marginal distribution of each of the meteorological variables to a standardised normal distribution; (ii) fitting of a vector auto-regressive model to the transformed data; (iii) simulation of new observations according to the fitted auto-regressive model; (iv) transformation of the data thus generated to synthetic meteorological data. A nonparametric resampling method that preserves the rank correlations of the different meteorological variables is also described. In both cases, seasonality is handled by dividing the original data sets into subsets representing the different months of the year. An empirical data set comprising thirty years of daily data regarding temperature, precipitation, vapour pressure, wind speed, and cloudiness was used to illustrate the methods proposed. Examination of observed and simulated data revealed only marginal differences in the statistical characteristics of the two types of data.

Modelling the probability of precipitation using the Marcov chain MonteCarlo technique

Martin Kappler (Fachbereich Statistik, Universität Dortmund); Andreas Hense (Meteorologisches Institut Universität Bonn); Siegfried Schach (Fachbereich Statistik Universität Dortmund)

Although precipitation simulated in atmospheric models is calculated deterministically, the interactions between the rain generating processes in space and time require a probabilistic interpretations of precipitation forecasts. This is especially true for high resolution weather forecast models like the Lokal-Modell LM of the German Weather Service DWD which has presently a horizontal resolution of 7 km. We will show results for forecasts of hourly accumulated rain fall from the LM as input to a postprocessing model which describes rainfall events as outcomes from Bernoulli trials with an unknown probability (PoP probability of precipitation) to be estimated from the data.
The postprocessing model is set up as a hierarchical Bayesian network with three levels. The logit-transformed Bernoulli probability (level 1) is parametrized as a normally distributed variable where the expectation is parametrized (level 2) linearily in terms of a-priori chosen variables like orographic height, orographic gradient in wind direction and the precipitation field in the neighborhood of the 1 hour backward trajectory. Lastly the regression coefficients (level 3) are characterized by the uninformative normal density function with expectation zero and a large variance. The Bayesian network and the specification of the above given conditional and priori densities allows the calculation of the a-posterior density for the unknown parameters conditioned on the data of simulated precipitation. The parameter estimation is done by a Gibbs sampling of the a-posteriori density with the help of a Monte Carlo simulation (Markov chain Monte Carlo). Data are takenonly from a quarter of the model domain such that the remaining parts can be used for validation. The estimated values for the regression coefficients show that the gradient in wind direction and the backward trajectories are the most important external variables. Taking the Brier skill score for the validation shows that the postprocessing model is clearly better than persistency or a PoP estimated from a simple spatial average.

Reproduction of variance in statistical downscaling: inflation vs. noise addition

Radan Huth[1], Jan Kyselý[1,2] ([1]Institute of Atmospheric Physics, Prague, Czech Republic; [2]Dept. of Meteorology and Environment Protection, Charles University, Prague, Czech Republic)

Statistical downscaling models can explain only a part of the variance of the original (observed) time

series. Therefore, the variance of the downscaled series is underestimated. Two methods of enhancing the downscaled variance to become equal to that observed are in common use: (i) inflation of variance, consisting in multiplying downscaled anomalies by the ratio of the observed and downscaled standard deviations, and (ii) noise addition, consisting in adding a random process (noise) to the downscaled series. The variance inflation appears to be a physically doubtful concept as it assumes that all the local variability originates from large-scale variability, which apparently is not correct.
The comparison of the two approaches is conducted for daily maximum temperatures in May to September and daily minimum temperatures in November to March at six central European stations for a 30-year period. The downscaling method used is a stepwise multiple regression of 500 hPa height and 1000/500 hPa thickness gridpoint values over Europe and adjacent parts of the Atlantic Ocean. The random process added to the time series is a white noise process. The evaluation is based on (i) lag-1 autocorrelations, (ii) standard deviation of day-to-day temperature changes, (iii) characteristics of persisting extreme events (heat and cold waves), and (iv) spatial correlations.
It is shown that the downscaling with variance inflation reproduces persistence characteristics of minimum temperature correctly, whereas overestimates persistence of maximum temperature. The addition of a white noise process results in a severe underestimation of persistence (overestimation of day-to-day variations) in both seasons. Similar results apply to spatial correlations.
We argue that although the variance inflation is not correct from a physical point of view, it results in much less biased temporal and spatial autocorrelations than if a white noise process is added, and therefore, inflation should be given preference if one is concerned with temporal and spatial structure of downscaled quantities.

Simulating meteorological data by block resampling
Anders Nordgaard, Asa Forsman, Anders Grimvall (Department of Mathematics, Linköping University, Linköping, Sweden)

Validation of statistical models used to simplify complex mechanistic models needs large-scale data generation. In this paper we use a block resampling method to generate "new" series of data from a long series of multivariate meteorological observations. The method is based on the matched-block bootstrap method suggested by Carlstein et al (1998) where blocks of data are resampled according to a Markov chain. The transition probabilities are computed using a Mahalanobis distance measure.

The Amazon climate: A multiscale and nonstationary processes
Guillermo O. Obregón, Carlos Nobre (Centro de previsão de Tempo e Estudos Climáticos - CPTEC / Instituto Nacional de Pequisas Espaciais – INPE, Cachoeira Paulista, São Paulo – Brazil)

The goal of this work is to examine the climatic complexity of the western part of Amazon basin related to both the ENOS and NAO phenomenon based on monthly level of the Negro river at Manacapurú-Manaus (Q) from 1903 to 1999. The Morlet wavelet transform (WT) and the probability density function (PDF) are used as a tools. The WT shows that on Amazon basin exist four regimes of quasi-periodic oscillation. The 2-3 yr cycles and the 5 yr cycles are in agreement with the ENOS signal. The quasi-decadal cycles appears linked to the NAO, principally before 1940, and the quasi-bi-decadal cycles, remaining any abrupt climatic change in time, seems to be associated with both the ENOS and NAO. The PDFs between Q vs SOI, and Q vs NAO shown distinctive multimodatity indicating the nonlinear response of Q to these phenomenona or at least a weak direct relationship.

First indication of anthropogenic climate change in local wave conditions in the North Sea
Arnt Pfizenmayer (Institute for Coastal Research, GKSS Research Centre; Geesthacht, Germany)

In the central North Sea we observe an increase in the frequency of eastward propagating waves in the recent four decades. To assess the significance of this change the wave statistic for this century was reconstructed with a statistical model. With a linear multivariate technique (redundancy analysis) monthly mean air pressure fields over the North Atlantic and Western Europe were downscaled on the intramonthly frequency of directional wave propagation. When compared against this reference, the recent change appears statistically significant at the 5% level.
In order to investigate the reason for this local climatic change, reconstruction was compared with the downscaled results of a control and transient GCM scenario (ECHAM4-OPYC3) and with results obtained in a high resolution time slice experiment with increased concentrations of greenhouse gases and aerosols. Both estimates are qualitatively consistent with the changes observed in the last decades. We suggest that the recent increase of eastward propagation is a local manifestation of anthropogenic global climate change.

Ensemble Predictions with a Limited-Area Mesoscale Atmospheric Model - Implications for the Interpretation of its Direct Model Output
Susanne Theis, Andreas Hense (Meteorologisches Institut der Universität Bonn, Bonn, Germany); Ulrich Damrath, Volker Renner (Deutscher Wetterdienst, Offenbach, Germany)

The atmosphere is a chaotic system. In principle, this aspect has always to be taken into account whenever an atmospheric forecast is produced and interpreted. One possibility of dealing with the intrinsic uncertainty of the forecast is the generation of ensemble predictions. The principle of ensemble prediction is to forecast the impact of the uncertainty of initial conditions on the uncertainty of the forecast. This is usually done by running several numerical forecasts from slightly different initial states. Certainly, one could also imagine to vary other parameters than the initial conditions, for example the boundary conditions at the ground, such as roughnesslength or albedo. This method is especially interesting in the context of limited-area, high-resolution atmospheric models which are nested within a global model.
The increase of forecast resolution is substantially governed by the quantitative specification of the boundary conditions at the ground. Many of these boundary conditions cannot be quantified with downright certainty. We have produced ensemble predictions by slightly perturbing the roughnesslength and the orography of a limited-area mesoscale weather forecast model (horizontal resolution: 7km). The results reveal that small-scale features of only a few gridboxes' size are not deterministically predictable. This implies that small-scale predictions by deterministic regional climate models might be subject to a considerable amount of uncertainty, as well. Whenever the direct output of a deterministic forecast model contains a non-negligible amount of stochastic information, it must be interpreted in a statistical way. Ensemble predictions, however, are not always realizable, because they demand an enormous amount of computer capacities. As a temporary solution, we have developed a method which postprocesses the direct model output statistically. The method requires the data of one numerical simulation only. It will be validated against experimentally conducted ensemble predictions.

Modeling stochastic structure of local climate as downscaling of GCM fields

[1,2]Marina Timofeyeva and [1]Rachael Craig. (Department of Geology, Kent State University, Kent, Ohio; UCAR/NOAA/National Weather Service, Silver Spring, Maryland)

The Kent State University Local Climate Model (KSU LCM) is a statistical downscaling procedure that relates a suite of dependent variables (stochastic structure of local climate) using canonical correlation analysis to a suite of independent variables (derived from insolation, a DEM and GCM velocity, geopotential heights and SST). Our method differs from the other techniques of downscaling (e.g., Zorita and von Storch, 1999) as it uses a semi-Lagrangian approach to represent the regional climate controls at the point where climate is modeled.
The stochastic structure of daily temperature is represented by (1) parameters of the best fit of insolation to maximum daily temperature, (2) parameters of the third order autoregressive (AR3) model fit to the residuals from the insolation model, (3) variance of the residuals of the AR3 model; and, (4) mean and variance of temperature range. Stochastic structure of daily precipitation is represented by: (1) probability of wet, trace, and dry days, and (2) parameters (mean and variance) of the (log-normal) distribution assumed for daily precipitation and conditioned on the estimated probability of wet days.
The KSU LCM suite of independent variables comprises surface, upwind, and downwind variables computed using CCM3 boundary conditions. Surface variables represent local topography and radiation balance. Upwind variables are: radiation balance air temperature and its meridional gradient, average gradient in saturation vapor pressure, speed, div and curl of velocity as well as orographic controls. Downwind (30 km) variables represent blocking effects.
The transfer function was calibrated (using 434 stations in an elevation- and climate-division-stratified sample) and tested (using 1290 stations) for climate of the western U.S. and Mexico using a control run of CCM3 for boundary conditions.
This new model allows high temporal (one day) and spatial ($1km^2$) resolution solutions of climate for much of western North America for any time period for which CCM3 solutions are available, e.g. 6ka paleoclimate and future climate scenarios. Similar solutions can be used for other GCMs when calibrated with their control runs.

Numerical experimentation with regional atmospheric models

Hans von Storch, Ralf Weisse (Institute of Coastal Research, GKSS Research Centre, Germany)

While the need for determining the climatic noise with the help of multiple runs in numerical experimentation with global models is acknowledged since the 1970s, regional atmospheric modelers in the past have designed experiments usually as a simple pair of "control" and "experimental" simulation. The effect of the experimental modification is then considered as being described by the difference between the two simulations. This approach assumes implicitly that the state of the regional atmosphere in such models would be determined by the boundary conditions, that no "noise" would be generated on regional scales. However, this assumption is invalid as is shown by examples. For long-term differences the noise level is indeed rather small, but for episodes large differences in the synoptic configuration (e.g. with respect to the speed of cyclones) intermittently emerge.
The problem is demonstrated with the case of the effect of an interactive ocean surface wave field on the formation of extratropical storms. In previous studies, this interaction was claimed to cause storms to intensify (through increased latent heat fluxes) or damped (through increased momentum

flux) cyclogenesis, but a ensemble simulation indicates that the found effects are mostly random.

Decision Making and Detection of Anthropogenic Climate Change

Exploiting the emerging signal of anthropogenic climate change in probabilistic climate forecasting

Myles Allen (Space Science & Technology Department, Rutherford Appleton Laboratory, Chilton, Didcot, UK)

Significance of Anthropogenic Radiative Forcings in Simulation of Temporal Pattern of Surface Air Temperature in Monsoon Climate

Ajay Singh (School of Management, Indian Institute of Technology- Bombay, Powai, India)

Augmentations in greenhouse gas concentrations since pre-industrial era have led to a positive radiative forcing of climate, tending to warm the surface and to produce other changes of climate. Tropospheric aerosols have led to a negative direct forcing and possibly also to a negative indirect forcing of a similar magnitude. Primarily the negative forcing is focused in particular regions and subcontinental areas, it can have continental to hemispheric scale effects on climate patterns. All India Summer Monsoon plays very critical role in many of socio-economic activities in the Indian Subcontinent. Surface air temperature in the monsoon climate is important for number of reasons including its significance in agriculture, industry and planning. An accurate and reliable portrayal of change in the temperature due to climate change is therefore very important in the perspective of impact of climate change on socio-economic system and environmental system.

The ability of current generation of global climate models, in their long-term simulations, to replicate the observed atmospheric behavior on a wide range of spatial and time scales provides support in applying these models to the regional climate change projections induced by anthropogenic radiative forcings. The ability of a coupled atmosphere ocean climate model (ECHAM3 + LSG) at T21 resolution to simulate the temporal pattern in area-averaged annual mean surface air temperature over Indian subcontinent in three different numerical experiments viz.; control, GHG and GHG plus aerosol is examined. The significance of anthropogenic radiative forcings in the simulation of temporal pattern of the temperature has been examined. The model has superior skill in reproducing the observed trend and interannual variability in area-averaged annual mean surface air temperature during the past century in GHG plus aerosol experiment. The model's ability to simulate the observed pattern in the temperature over the area of interest could be improved by better representation of meso-scale forcings such as monsoon trough, complex orography and parameterization scheme for convection and land surface processes in the model.

Decadal variations of Greenland precipitation over the past 1400 years

K. K. Andersen and P. D. Ditlevsen, (Department of Geophysics, Copenhagen, Denmark)

In the accumulation zone of the Greenland ice sheet the annual accumulation rate is registered in the firn and subsequently in the ice. The annual layer thickness may be identified through identification of the annual cycle in the isotopic climate signal and other annually varying parameters. The snow is however subject to wind drifting which introduces rather large 'glaciological noise' to the signal.

We developed a method to estimate the noise in accumulation records derived from ice cores. This method was then applied to the annually resolved accumulation records from four independent deep ice cores. In this way we have extracted a precipitation record for Greenland covering the period from 555 AD to 1973 AD with decadal resolution.

Lessons taught from the Homogenization of 200 US First Order Stations

Auguste C. Boissonnade, Ph.D.[1] and Larry Heitkemper[2] ([1]Risk Management Solutions, Inc. Menlo Park, California, USA; [2]EarthSat Corporation, Washington D.C., USA)

Weather conditions have an enormous impact on agricultural, energy, and indirectly retail businesses. Study of historical weather observations is one of the means for assessing the likelihood of potential impact weather could have on these businesses. The most common weather index, Cooling degree-day or Heating degree-day, used in assessing weather impact is derived from the daily minimum and maximum temperature at a given well-manned station over a 5 to 7-month period. New financial instruments called weather derivatives, based on the likely future behavior of the weather index, have been developed and are currently traded in financial markets for hedges against the weather risk. All these instruments are very dependent on historical and future observations of weather data at given weather stations.

Large volatility is present in such assessment of weather risk due to the large uncertainty in predicting weather beyond a few days but also in the uncertainty on the quality of recorded observations for the purpose of weather risk assessment. Historical temperature data may contain missing or erroneous values. Furthermore, changes in location and/or instrumentation for most weather stations have caused increase or decrease in temperature observations. Such discontinuities can make historical data misleading relative to how weather is being recorded under present day-conditions.

A 1 1/2 year joint project between Risk Management Solutions and Earth Satellite Corporation

was undertaken for homogenization of time series for more than half of the available First and Second Order stations in the US over the time period (1950-1999). Results of the homogenization study were reviewed with the local meteorologists in charge.
This paper presents findings of this project, a comparative analysis of several methods for detecting and assessing the magnitude of discontinuities and present conclusions regarding the quality of available meta databases. In addition, a summary of the impact of instrumentation changes over the past three decades is presented. Readjustment of climatological data for particular locations is also presented. Emphasis on the importance and problems of homogenization of such time series in weather risk is made. Suggestions for further research with potential benefits in a better assessment of weather risk are also outlined.

North Atlantic osccillation projection on regional climate predictability

Roxana Bojariu and Daniela Paliu (National Institute of Meteorology and Hydrology, Bucharest, Romania)

NAO is the dominant mode of variability over the Atlantic-European region. A number of studies have shown that most of cooling in the northwest Atlantic and the warming across Europe and over Eurasia since the mid 1970s results from changes in the NAO. However, a more detailed regional projection of NAO related climate fluctuations and predictability is still needed.
In the present study, a NAO related behavior is identified when the predictive potential of winter is assessed using a multifield analog technique based on large and local climate state vectors. The hindcast experiment have been done for the interval 1962-1989 using seasonal means of temperature and precipitation anomalies from 62 Romanian stations, geopotential heights at 500 mb over the Atlantic-European sector and sea surface temperatures (SSTs) from the North Atlantic. The autumn thermal anomalies in a large part of Romanian territory are significantly well predicted from the previous winter. A larger scale perspective of this behavior is investigated by performing canonical correlation analysis (CCA) for air surface temperature over Europe, in November and sea level pressure (SLP) over Northern Hemisphere in January. Temperature and SLP data for the interval 1961-2000 are extracted from NCEP re-analyses. This source of autumn predictability over Romanian regions seems to be related to the interannual persistence of one NAO, more pronounced in the latest decades of 20th century.
Many studies have shown that both phases of NAO are associated with basin-wide changes in the intensity and location of the North Atlantic jet stream and storm track. Changes in the intensity and location of North Atlantic jet stream may be caused by processes such as changes in sea surface temperature and/or in the extent of ice sheet at high latitudes. The NAO physical mechanism involved in the November/January signals seems to be more related to Arctic atmospheric processes such as 70 days oscillation identified in the geopotential height at 500 mb level. The 70 days oscillation might be triggered or locked up by the seasonal cycle in the special context of orographic conditions and air-land interaction over high latitudes areas.

What influences decision-makers in drought prone areas when allocating water resources?

Bernard Cornélis (Département de Géomatique – Université de Liège)

At an operational level, computerised decision support systems implement Bayesian statistics, fuzzy logic, neural networks, genetic algorithms, data based or model based management systems,… Nevertheless, these concepts barely leave the technical and scientific circles. When it comes to human decision makers, the results of these processes, if they reach them, is just one more information which can be taken into account or not. In the field of climatology, just like in major environmental issues, lack of information are important, and induce a great uncertainty. The four techniques used to appreciate uncertainties of consequences are probabilities, imprecise probabilities, possibilities and unknown possibilities. In this case as well, not all the decision makers have access to such systems or trust them.
This contribution can be seen as an attempt to formalise the way current decision makers deal with a potential climatic event. Different types of private and public decision makers, ranging from farmers to Members of the European Parliament, were asked during an interview to allocate water resources to their territory of action. Through this pragmatic exercise, several ideas were tested: would the spatial characteristics of their territory influence the repartition; would their decision behaviour change under uncertainty; would the integration in time modify their answer. After completing the allocation scenarios, they were asked to comment their decisions. Besides, several “neutral” questions relating to the use of water, to drought and to their territory were asked. Analysis of this survey shows that, instead of basing their decisions on math models and measured info, lay decision makers base their decisions on their moral values and their representation of the issue.

Assessing uncertainty in anthropogenic signal estimates using space-time and trend-based optimal detection approaches

Nathan Gillett, Gabi Hegerl, Myles Allen

The ‚optimal fingerprinting' approach to the detection of anthropogenic climate change involves the regression of some observed diagnostic onto the same diagnostic derived from perturbed integrations of a GCM. Both time/space and trend-based diagnostics have been used in published

studies. While results from both approaches generally indicate that the influence of greenhouse gases and sulphate aerosol is detectable in global surface temperature over the past fifty years, they have lead to different estimates of the amplitude of these `signals'. The goal of the present work is to understand these differences in results. A first step is to transform those results that are based on stepwise regression to multiregression. By eliminating other differences in the analysis, relating to the data used and filtering, we establish the relative importance for detection of the linear trend and residual components of the response to the forcings. An additional reason for differences in results based on different model simulations relates to the differing indirect sulphate aerosol response (that due to changes in cloud properties) in the ECHAM4 and HadCM3 models. By examining the spatial and temporal characteristics of this response in each model, we better characterise the causes of differences between published results on the detection of anthropogenic sulphate aerosols, and assess which differences are sensitive to the detection approach used.

Applications of Statistical Climatology in Finance

Stephen Jewson, Anders Brix (Risk Management Solutions)

Statistical models of meteorological phenomena are used widely in the fields of banking, insurance and re-insurance to help estimate both climatological and state-dependent financial risk. An overview is given of methodologies used in this area, including very large ensemble simulations, optimal combinations of climatological and forecast information, and final metric optimisation of forecasts.
A number of examples are given including:
1)Real-time hurricane loss forecasting: the need for ensembles of size in excess of 10,000 and how these ensembles can be created; how deterministic forecasts can be used to condition these ensembles.
2)Extratropical wind-storm risk estimation: the distribution of numbers of wind-storms and the importance of seriality.
3)Weather derivative pricing methods: daily and index models for weather derivative pricing and the pros and cons of different methods for incorporating forecasts.

Trends in northern hemisphere winter cyclone activity based on a comparison of cyclone indices

Christopher J. Paciorek (Department of Statistics, Carnegie Mellon University); James S. Risbey (Department of Engineering and Public Policy, Carnegie Mellon University); Richard D. Rosen (Atmospheric and Environmental Research, Inc. Cambridge, Massachusetts); Valerie Ventura (Department of Statistics, Carnegie Mellon University)

We investigate northern hemisphere extratropical winter cyclone activity using a variety of indices calculated from the NCEP/NCAR reanalysis data. We ask whether these indices provide similar measures of cyclone activity and what each index suggests about trends in cyclone activity during 1949-1999. The indices are Eady growth rate at 500 hPa, temperature variance at 500 hPa, the 95th percentile of surface wind speeds, and counts of both storms and intense storms. Eady growth, temperature variance, and extreme winds are reasonably well-correlated over the storm-track regions and northern parts of North America and Eurasia, but poorly correlated elsewhere. These three indices also show moderately-strong correlations with the two storm count indices over much of the storm-track regions, but only when the storm index is offset 10 degrees to the north of the other index. We analyze simple linear regressions of the indices against time using the False Discovery Rate (FDR) procedure. Eady growth, temperature variance, and extreme winds show significant increases over the mid-latitude storm-track regions as well as over parts of Eurasia, while temperature variance shows decreases over the polar latitudes of the North Pacific. Extreme winds at the sigma 995 level of the reanalysis model and geostrophic winds calculated from sea level pressure show unexplained jumps in the 1950s that account for most of the increases seen in the wind index. Poisson regressions of the two storm count indices against time are suggestive of increases over the oceanic storm-tracks, but it is difficult to distinguish these increases from statistical chance. Given the difficulties with the extreme winds index, it is difficult to draw conclusions about human impacts from our results, apart from the evidence for increased cyclone activity over the storm-track regions. Results from Global Climate Models (GCMs) that compare control and enhanced CO2 scenarios suggest poleward and downstream shifts in the storm-tracks with increased CO2. The models also suggest the possibility of fewer but stronger cyclones. The Eady growth and temperature variance indices provide some evidence for increased downstream cyclone activity over the storm-track regions. The storm count indices do not suggest a decrease in the number of events, but provide weak evidence for an increase in more intense events over the storm-tracks.

Signal analysis of the atmospheric mean temperature 500/1000 hPa north of 55 N between 1949 and 1994

Heiko Paeth, Andreas Hense (Meteorologisches Institut, Universität Bonn, Bonn, Germany)

The lower tropospheric mean temperature 500/1000 hPa is examined in the northern hemisphere high latitude region north of 55 ffi N with regard to a climate change signal due to anthropogenic climate forcing as a supplement to previous studies which concentrated on near surface temperatures. An observational data set of the German Weather Service (DWD) is compared with several model simulations including different scenarios of green-

house gas and sulphate aerosol forcing derived from the two recent versions of the coupled climate model in Hamburg, ECHAM3/LSG and ECHAM4-/OPYC. The signal analysis is based on the optimal fingerprint method by Hasselmann (1979,1993), which supplies a detection variable with optimal signal-to-noise ratio. The natural variability measures are derived from the corresponding long-term control experiments. From 1970 onward, we find high trend pattern analogies between the observational data and the greenhouse-gas induced model simulations. The fingerprint of this common temperature signal consists of a predominate warming with maximum over Siberia and a weak cooling over the North Atlantic reaching an estimated significance level of about 99 %. The additional forcing by sulphate aerosols decreases the correlation of this climate change simulation with the observations. The natural variability constitutes about 30 % of the conforming trend patterns. The signal-to-noise ratio is best over the oceans while the tropospheric temperatures over the land masses are contaminated by strong noise. There is evidence that the temperature signal is independent of the initial conditions and the model version.

Expert Assessment of Uncertainties in Detection and Attribution of Climate Change

James Risbey (University of Utrecht, Department of Science, Technology and Society, Utrecht, The Netherlands)

The issue of whether, and to what extent, human-induced increases in greenhouse gases have caused climate changes is contentious. Studies of this issue have focused first on `detecting' climate change against the background of natural variability, and further on `attributing' any detected signal to increases in greenhouse gases or other possible causes. Communication of the science and role of uncertainties on this issue has been hindered by the lack of explicit formal approaches for making overall conclusions on detection and attribution. We have developed a protocol to quantify uncertainties in each component of the detection and attribution process and to provide a structured way to make overall conclusions. Here we present results on detection and attribution of climate change from analysis of expert judgements obtained using the protocol, highlighting areas of convergence and divergence among experts. We show that, among a broad spectrum of experts, probabilities of detection are uniformly very high (> 95%) for some lines of evidence and high (> 85%) for others. Further, there is near consensus that greenhouse forcing is responsible for more than half the warming in global mean temperature this century. For the other lines of evidence examined, greenhouse forcing makes smaller contributions with more spread among expert assessments.

A Maximum Entropy Approach for Extracting Forecast Probabilities from Finite Ensembles

M.S. Roulston[1], L.A. Smith[1] and C. Ziehmann[2] ([1]Mathematical Institute, Oxford University, UK; [2]Institute of Physics, Potsdam University, Germany)

A maximum entropy method is presented for incorporating prior information, in the form of a climatological probability distribution, into a probabilistic forecast generated by an ensemble prediction system. The approach is to find the probability distribution that is as close as possible to the climatology, in the relative entropy sense, while being consistent with the ensemble according to the chi-squared test. The result is that low-probability events, too rare to be expected in an N member ensemble, are assigned finite probabilities based on climatology.

An information theoretic skill score is also introduced. This `ignorance' score is equal to the number bits that are required to describe truth in a data compression scheme designed around the probabilistic forecast. It is also related to the rate of return achieved by a gambler betting optimally (proportionally) on possible outcomes.

The maximum entropy method is illustrated in several chaotic systems. Both perfect and imperfect ensembles are considered, the latter both under perfect and under imperfect models. It is shown that this method can reduce the variability in forecast skill obtained when ensembles are small. The average forecast skill, as reflected by Brier Score or by the ignorance is largely unaffected. The reduction in variance is achieved by systematically improving the worst forecasts. This reduction occurs both with perfect and with imperfect ensembles.

Coupled sea ice and atmosphere variability in the Weddell Sea, Antarctica

Silvia A. Venegas (Danish Center for Earth System Science (DCESS), Niels Bohr Institute for Astronomy, Physics and Geophysics, University of Copenhagen, Denmark); Mark R. Drinkwater (Oceans/Sea-Ice Unit, ESTEC Earth Sciences Division (APP-FSO), Noordwijk, The Netherlands)

A frequency-domain singular value decomposition is performed on 20 years (1979-1998) of satellite observations of sea ice concentration and drift together with sea level pressure reanalysis data in the Weddell Sea, Antarctica, in order to determine the dominant timescales of variability in the region. The interannual timescale (periods of 3-4 years) is found to dominate the ice and atmospheric fluctuations. This variability is a regional manifestation of the Antarctic Circumpolar Wave in the Weddell sector of the Southern Ocean.

Interannual variations of sea ice concentration and drift are driven largely by anomalous atmospheric patterns, which alternatively enhance or reduce the meridional wind circulation to the east of the Antarctic peninsula. Thermodynamic processes (ra-

pid ice growth in open water areas), dynamic processes (ice ridging/rafting due to ice convergence) and geographic constraints all play significant roles in the formation of summer ice concentration anomalies in the southern Weddell Sea every 3-4 years. These ice anomalies are exported northwards out of the Weddell basin approximately one year later, and then advected eastwards before diffusing in the ice margin.
A low-frequency signal (presumably a quasi-decadal oscillation) is also detected, although its significance is fairly speculative in a 20-yr record. Ice variability on this timescale results from a change in the shape of the Weddell gyre circulation which occurred around 1990, likely associated with large-scale variations of the ocean-atmosphere system.

A Multi-Index Bayesian Approach to Climate Change Detection and Attribution

Klaus Hasselmann, Reiner Schnur (Max Planck Institute of Meteorology, Hamburg, Germany)

In the conventional optimal fingerprinting approach to detection and attribution (D&A) of anthropogenic or other externally forced climate change, the observations are projected onto a low-dimensional phase space spanned by one or a few expected climate change signal patterns which are rotated away from high natural climate noise. A detection test is performed by assessing whether the null hypothesis that an observed value in this reduced space is within the interval of natural variability can be rejected at a certain confidence level or not. This test is most powerful in a one-dimensional sub-space. For the attribution of a detected change one tests whether the detected climate change is consistent with the predicted signals of alternative candidate mechanisms. The number of signal patterns must be kept small to achieve statistical significance. The uncertainties of the predicted signals enter only in the attribution test.
Here, an alternative, Bayesian approach is presented which leads to a basically different optimal filtering strategy. One considers the impact of evidence (i.e. observed data) on the subjectively defined prior probability that the hypothesis of an externally forced climate change signal is true. The resulting posterior probability depends on the ratio of the likelihoods of observing the data for the complementary cases that the hypothesis is true or false. There exists no longer a formal separation between detection and attribution, and the statistical uncer-tainties of the predicted signal play an equally important role as those associated with natural variability. There is also no need to project onto a strongly reduced sub-space spanned only by the signal patterns of the hypotheses being tested. Nonetheless, a technique is presented to weight the observed data such that the impact of the evidence on the posterior probability is maximized. This leads also to a dimensional reduction, but one which is normally less severe.
Results are presented for the simultaneous application of the Bayesian D&A framework to several climate change indices. The approach is particularly appropriate for indices whose statistical uncertainty can be estimated only subjectively, such as sea level, sea ice, glaciers, extremes, etc. As example we have chosen indices based on annual means and the annual cycle of surface temperature and precipitation and the diurnal cycle of temperature, as well as ocean heat content. The results are compared with the conventional D&A approach.

Changes in statistical properties of daily precipitation in transient climate change experiments with a coupled atmosphere-ocean GCM

V.A. Semenov and L. Bengtsson (Max Planck Institute for Meteorology, Hamburg, Germany)

Statistical properties of daily precipitation distribution are analyzed using data of the coupled atmosphere-ocean ECHAM4/OPYC3 general circulation model transient climate change experiments. Two different climate forcing mechanisms are applied. In the GHG experiment the forcing is due to the changing concentrations of the greenhouse gases only. In the GSDIO experiment in addition to the GHG the direct and indirect effects of the anthropogenic sulfur aerosol and changes in the tropospheric ozone are taken into account. Statistical properties of daily precipitation for different seasons are described by parameters of a simple statistical model based on the gamma distribution. The efficiency of the gamma distribution model is estimated. Global trends of the mean precipitation, precipitation intensity, wet day probability and the gamma distribution parameters are analyzed for the present (1950-2000) and future (2000-2050) climates.
Particular attention is paid to the extreme precipitation events. Simulated characteristics for the present climate are compared to the available observations. For the future climate the differences of the hydrological cycle and daily precipitation distribution changes due to different climate forcing mechanisms are investigated.

Near Two Centuries Monsoon Rainfall Variations across India: Reconstructed Past and Predicted 10-year Future

N.A. Sontakke (Indian Institute of Tropical Meteorology, Pashan, India)

Long period rainfall reconstructions are vital for numerous purposes such as climate variability and prediction, cross comparision with climatological proxies and so on. Owing to high spatial variability, the representativeness of the summer monsoon rainfall for the entire country is limited. In order to develop an effective system for monsoon rainfall studies the country has been divided into six zones i.e. North West India, (NWI), North Central India (NCI), North East india (NEI), West Peninsular india (WPI), East Peninsular India (EPI) and South Peninsular India (SPI). Empirical Orthogonal Func-

tion (EOF) and Cluster Analysis of ubiquitous 306 raingauges has been carried out for this classification. By applying an objective technique 'selecting a subset of few gauges whose mean showed the highest CC with the all gauges mean series' total 116 optimum number of gauges have been fixed for real time updating of the different zonal series and reconstruction from 1871. The different zonal series are extended as far as possible backward prior to 1871 by applying the objective technique on the limited meager available gauges. The NEI and EPI series are extended back to 1848, the NWI to 1844, the NCI to 1842, the WPI to 1817 and SPI to 1813. The all-India series from 1871 onwards is prepared from the are-weighted mean of the six zones and well agrees with the series prepared with all the gauges. The series is extended back to 1813 by objective technique on the avalilable gauges. The examination of these series up to 1999 in detail reveals interesting results in relation to the chan pattern of monsoon circulation in the present century with respect to global warming.
The low frequency smoothed series up to 1999 obtained through binomial low-pass filters plus the series from 2000-2009, filled with the long term mean is subjected to Variable Harmonic Analysis (VHA). VHA is a modification of classical harmonic analysis. An objective technique is applied to select few harmonics whose linear combination showed a correlation coefficient of ~ 0.85 with the smoothed series. The rainfall amount generated from the selected harmonics predicts the rainfall fluctuations from 2000-2009. The rainfall series actual and predicted from the earliest to 2009 will be presented.

Statistical detection of the anthropogenic greenhouse signal in observed global and regional climate data fields

T. Staeger, J. Grieser, C.-D. Schönwiese (Institut für Meteorologie und Geophysik, J.W. Goethe Universität Frankfurt a.M.)

This study deals with the analysis of climate observational data of the last 100 years and their attribution to anthropogenic and natural forcings. The data include annual, seasonal and monthly means (totals) of surface air temperature, sea level pressure and precipitation. The spatial resolution reaches from global means over area means on a global scale (only temperature and pressure data) to grid points on the European scale.
First an EOF analysis of the data fields is performed. Thereafter the PC timeseries are used as target variables in a sucsessive/multiple regression analysis, where the following forcings are used as potential regressors: Greenhouse gases (GHG), tropospheric sulfate aerosol, explosive volcanism, solar activity, ENSO and NAO.
For each forcing and target variable tempo-spatial fields of signal amplitudes and signal-to-noise ratios are obtained. The unexplained variance was split up into structured and unstructured components, the latter being an estimation for climate noise.
It can be seen, that the total explained and the GHG-attributed variance is maximum in case of global averaged temperature data and is reduced in less spatial averaged and other than temperature data (and is minimal in case of European precipitation).
The detection of the anthropogenic greenhouse signal suceeds in the global mean temperature data in 1973 with a probability of 99.9%. In European data NAO is dominant. It is an open question whether there exists a GHG-NAO coupling on the European scale, which aggravates the detection of the GHG signal here. On the other hand the detection of the GHG signal suceeds much better in the area mean data on the global scale. In 42 out of 72 areas the probability for a climate change exceeds 95%. Solar forcing reveals to be weak in most cases.

Trends in the Diurnal Temperature Range in the CCCma Coupled Model

Daithi A. Stone, Andrew J. Weaver (School of Earth and Ocean Sciences, University of Victoria, Canada)

Recent analyses of the global surface temperature record have revealed that late 20th century increases have been characterised by the daily minimum temperature increasing at a faster rate than the daily maximum temperature. These differential trends have resulted in a decrease in the diurnal temperature range (DTR), the magnitude of which is comparable to the increase in mean temperature.
Despite the importance of these trends in the context of climate change, they have not yet been extensively examined in numerical simulations of coupled general circulation models due to technical limitations. The Canadian Centre for Climate Model-ling and Analysis first generation coupled general circulation model has recently been integrated under a variety of anthropogenic forcing scenarios. An examination of the temporal trends in the DTR in these integrations, their spatial characteristics, their similarity to observations, and their relation to trends in clouds, specific humidity, aerosols, and radiative forcing, will be presented.

Detection of the causes of recent trends in radiosonde temperatures

P.W.Thorne[1], P.D.Jones[1], S.F.B.Tett[2], M.R.Allen[3], D.E.Parker[2], T.D.Davies[1], and T.J.Osborn[1]
([1]Climatic Research Unit, UEA, Norwich, UK.; [2]Hadley Centre for Climate Prediction & Research, Meteorological Office, Bracknell, Berkshire, UK; [3]Rutherford Appleton Laboratory, Chilton, Didcot, UK.)

Previous climate change detection and attribution studies have considered either changes in surface temperatures, or zonally averaged radiosonde temperatures. We contend that in so treating the radiosonde temperatures these latter studies have ignored

valuable information, as the observed temperature changes are zonally heterogeneous. In considering the full fields we hypothesise that the power to discriminate between competing forcing mechanisms will be enhanced. Here initial results are presented from an optimal detection study that includes information on longitudinal as well latitudinal variations in upper air temperatures. This study uses the Hadley Centre's globally gridded HadRT radiosonde dataset and compares this to two versions of the Hadley Centre's GCM, HadCM2 and HadCM3. A number of input diagnostics are utilised in our analysis. We comment upon which signals are detected and implications for intra- and inter-model consistency considerations arising from our analysis.

Signal Analysis and Detection Studies Using Neural Networks

Andreas Walter (Institute of Meteorology and Geophysics, Johann-Wolfgang Goethe University, Frankfurt, Germany)

The climate system is considered to operate in a complex, non-linear way. The higher the complexity of a system is, the more complicated statistical investigations of such a system are. Because of their capability to model multiple non-linear input-output relations Neural Network Models (NNM) are an appropriate tool for investigations of the climate system. We apply the most widely used NNM architecture, the Backpropagation Network (BPN), with and without an additional Momentum-Term to analyze the dynamics of the climate system on a global, hemispheric and regional scale and compare these results to those carried out by a traditional multiple linear regression (MLR). The NNM is able to explain up to 88% of variance and the residuals can be treated as noise. The extracted natural (Volcanism, El Ni~no, solar activity) and anthropogenic (CO2, Sulfate and combined influence) signals show reasonable time structures and amplitudes, e.g. BPN global: CO2: +1.11 K, SO4--: -0.36 K, combined CO2 & SO4--: +0.79 K. In a second step these modeling techniques are applied to the EOF-transformed representation of global spatio-temporal temperature anomalies and signal analysis are perfomed on this sacale, too. Using the signal-to-noise ratio a detection variable is defined and it is shown that NNM find a significant higher anthropogenic influence in larger areas than MLR does.

Potentially Predictable Patterns

Xiaogu Zheng[1] and Carsten S. Frederiksen[2] (1 National Institute of Water and Atmospheric Research, Wellington, New Zealand; 2Bureau of Meteorology Research Centre, Melbourne, Australia)

A modified EOF analysis is proposed for studying long-range potentially predictable patterns of meteorological seasonal mean fields, that is, the patterns arising from slowly varying external forcings and slowly varying internal dynamics. Using 500-hPa heights over the North Pacific/North America region, it is demonstrated that the spatial patterns derived by the modified EOF analysis are more closely related to slowly varying external forcings and slowly varying internal dynamics, and therefore are more potentially predictable than those derived by the conventional EOF analysis, rotations of EOFs or low-pass filtering. The proposed modified EOF analysis is particularly suitable for analysing regional atmospheric fields in the extratropics.

Extratropical cyclone variability in the Northern Hemisphere winter from the NCEP/NCAR Reanalysis data

Olga Zolina, Sergey Gulev, Sergey Grigoriev (P.P.Shirshov Institut of Oceanology, RAS, Moscow)

The winter climatology of Northern Hemisphere cyclone activity was derived from 6-hourly NCEP/-NCAR Reanalysis data for the period from 1958 to 1999, using software which provides a better accuracy of cyclone identification in comparison to numerical tracking schemes. Cyclone characteristics over the Kuroshio and Gulfstream are very different than those over the continental North America and the Arctic. Analysis of Northern Hemisphere cyclones shows secular and decadal-scale changes in cyclone frequency, intensity, life time and deepening rates. The western Pacific and Atlantic are characterized by the increase in cyclone intensity and deepening during 42-year period, although the eastern Pacific and continental North America demonstrate opposite tendencie s in most of cyclone characteristics. There is an increase of the number of cyclones in the Arctic and in the western Pacific and a downward tendency over the Gulfstream and subpolar Pacific. Decadal scale variability in the cyclone activity over the Atlantic and Pacific exhibits the south-north dipole-like patterns. Atlantic and Pacific cyclone activity associated with NAO and PNA is analysed. Atlantic cyclone frequency demonstrates a high correlation with NAO and reflects the NAO shift in the mid 1970s, associated with considerable changes in European storm tracks. The PNA is largely linked to the eastern Pacific cyclone frequencies, and controls cyclone activity over the Gulf region and North American coast during the last two decades. Assessment of th e accuracy of the results and comparison with those derived using numerical algorithms, shows that biases inherent in numerical procedures, are not negligible.

Poster contributions to the 8 International Meeting on Statsitical Climatology

An Explanation for the Multidecadal, Winter Rainfall Decline Over South-Western Australia

Bryson C. Bates[1], Stephen P. Charles[1], James P. Hughes[2], and Edward P. Campbell[3]
([1]CSIRO Land and Water, Wembley, WA 6913, Australia; [2]Department of Biostatistics, University of Washington, Seattle WA 98195, USA; [3]CSIRO Mathematical and Information Sciences, Wembley, WA 6913, Australia)

There has been a decline in 'winter' (May–October) rainfall over south-western Australia (SWA) since about the middle of the 20th century. Since the mid 1970s, this decline has had important consequences for water resources management and agriculture and forestry. The links between the rainfall decline and changes in atmospheric circulation are investigated using the NCEP-NCAR reanalysis dataset that spans 1958–98, observed daily rainfall series for 30 sites across the region, and a nonhomogeneous hidden Markov model (NHMM) fitted to the period 1978–92 and validated for 1958–77. The NHMM defines stochastic conditional relationships that link daily multi-site precipitation to a discrete set of weather states (patterns). The transition from one state to another is conditioned on a relatively small number of atmospheric variables (predictors) derived from the reanalysis dataset.

Our analysis consisted of three parts: (1) the use of a nonparametric jump detection algorithm for identifying any spurious jumps in the predictor series; (2) comparisons of the predictor series and NHMM weather state sequence for 1958 to mid–70s with those for mid–70s to 1998; and (3) a sensitivity analysis to investigate whether the rainfall decline since the mid–70s can be attributed to the behaviour of a single predictor.

Our results indicate that: (1) there are no spurious jumps in the reanalysis data used; (2) the atmospheric predictor series for the mid–70s to 1998 are quite different to those for 1958 to the mid–70s; (3) there is very strong evidence of changes in the mean probability of occurrence of two out of six weather states; and (4) the changes in weather state frequency, and hence rainfall, are due to a combination of changes in several atmospheric variables rather than any one predictor. Possible mechanisms underlying the change in atmospheric circulation will be discussed.

Statistical Downscaling to Monthly Precipitation in the Northwestern of South America (Colombian Region)

Nestor R. Bernal S. (Nacional University of Colombia)

In climate change studies the global circulation models of Atmosphere (GCMAs) enable one to simulate the global climate, with the field variables being represented on a grid ponits 300 km apart. One particular interest concerns the simulation of possible changes in rainfall and surface air temperature due to an asummed increase of greenhouse gases. However , the models yield the climatic proyections on grid points that in most cases do not correspond to the sities of major interest. To achieve local estimates of the climatological variables, methods like the one known as statistical downscaling are applied. In this article we show a case in point related to monthly precipitation by applying canonical correlation analysis (CCA) to some regions in the Northwestern of South America (Colombian Region).

Better Quality of StatisTical Downscaling Models Without Preceding PC-Analyses For Predictands?
Example: Rainfall Assessments for Namibia

U. Beyer (Institute of Geography, University of Wuerzburg, Wuerzburg)

This contribution presents results of regional rainfall assessments for Namibia under conditions of man-made enhanced greenhouse warming, obtained in the context of the DFG-post-graduate program „Joint Geoscientific Research in Africa“. Relations between large-scale atmospheric circulation and Namibian summer-rainfall are established by multiple regression analyses. For this purpose PCs of geopotential heights (300,500,1000hPa) and monthly rainfall data of Namibia (84 stations) are linked by stepwise multiple regression analyses for every station or alternatively every PC of the station data, on a monthly base (November – March) during a 30-year calibration period. After verifying these statistical relations in an independent period, stations with regression models of sufficient quality (significant correlations r>0.4 between observed and modelled data) are selected and used to assess local rainfall for greenhouse gas-scenarios from simulated ECHAM4tr-T42 geopotential heights data. In case of preceding PCA for rainfall data no selection is possible – all PCs have to be included to calculate future rainfall. Information about model quality exists, but can not be used to get higher reliability in this downscaling approach. Independent of the procedure, results for climate conditions of increasing CO_2-concentrations compared to a reference period (1961-90) show a light increase of rainfall in parts of Namibia for December, only small changes in January and significant increases in February especially in the eastern regions, but a distinct decrease in March all over the country. These findings point to an intensified, more accentuated rainy season, however the amount of rainfall remain more or less the same under conditions of enhanced greenhouse warming.

Multiple Non-linear Statistical Model for Estimating Mean Maximum Urban Heat Island in a Medium-Sized Town Szeged, Hungary

Zsolt Bottyán, János Unger (Department of Climatology and Landscape Ecology, University of Szeged, Szeged, Hungary)

This study examines the spatial and quantitative influence of urban factors on the surface air temperature field of the medium-sized city of Szeged, Hungary using of mobile measurements under different weather conditions between March 1999 and February 2000. This city of about 178 000 is situated in a low, flat flood plain along the Tisza River.

Efforts have been concentrated on the determination of spatial distribution of mean maximum urban heat island (UHI) intensity and modelling it in space.

During our work we have been determined correct, existing relationship between rural parameters and mean max. UHI intensity by means of multiple non-linear regression analisys.

The results indicate strong relationship exists between urban thermal excess and land-use features such as built-up ratio, gradient of built-up ratio, sky-view factor and distance from city's centre as well. On the other hand the role of water surface is negligible in this case.

The model is based on three non-linear regression equations which are calculated in the studied periods distinguishing heating and non-heating seasons within the one-year period in the studied area.

Thus our model is very useful because the predicted seasonally spatial distribution of mean max. UHI intensity field differences less than 0.2 C on average from the measured UHI field .

In the interest of practical application – on the basis of our previous results - we have been developed this model to predict seasonally mean max. UHI intensity field considering only the geographical position within the studied area.

The reliability of this model is studying connection with another city which has similar invariable urban parameters, like Szeged.

Application of factor analysis for quantification of climate forcing processes in the Baltic Sea region

Arunas Bukantis Dept. Of Hydrology and Climatology of Vilnius University, Vilnius Lithuania)

The article represent a discussion of methods based on factor analysis (FA) and used for identification of climate-forming factors and quantitative evaluation of their importance. The work was performed using the data from seven meteorological stations in the eastern part of the Baltic Sea region: average monthly values of different meteorological parameters (average maximal and average minimal values of air temperature „T1" and „T2", atmospheric pressure „P", wind speed in the height 10 m „v", monthly precipitation „Q", duration of sunshine „S" and partial pressure of water vapour „e"). FA has revealed that the initial variables joined into two main groups – meteorological complexes, whereas the variability of meteorological parameters and their mutual relations throughout the year are determined by two main factors: advection factor joining T1, T2 and e variables and baric-radiational - P, S, Q. The portion of dispersion formed by the both factors in the variability of meteorological elements make up on the average 70-85% of their total dispersion. In cold seasons (November-February) the advection factor is the dominating one, forming 44-54% of the total dispersion, whereas the importance of the second factor is 1,5-2 times smaller. In the rest of the year the influence of baric-radiational factor increases (forms 30-40% of dispersion in variables) and almost equals the importance of advection factor. The remaining 15-25% of dispersion in meteorological elements are, presumably, formed by local meso- and microfactors. The both meteorological complexes, as it has turned out during orthogonalization of factors in FA, exist almost independent of each other (in cold seasons in particular), i.e., it is possible to distinguish two most important types of climate-forming processes in the eastern part of the Baltic Sea region. One of them is advection process related with the input of various air masses whose features are best reflected by air temperature and humidity. The other process mostly takes place within one air mass: air mass transformation, vertical mixing, formation of clouds and related precipitation and input of solar radiation. Thus, FA is not confined only to systematisation of input data. It is helpful in objectivization of climate-forming peculiarities and, in this particular case - in confirmation of the theory about climate-forming processes in the eastern in the eastern part of the Baltic Sea region and quantitative evaluation of the importance of the climate-forming processes themselves.

A New Approach of Interpolation and Prediction of Climate Time Series

Hong-Xing Cao, Xiao-Jing Jia (Chinese Academy of meteorological Sciences, Beijing ,China)

By use of an observed data series a new time series modeling has been proposed. Firstly, a nonlinear ordinary differential equation can be retrieved from the data series based on a criterion of bilateral difference forecasts, secondly taking the retrieved differential equation as a dynamic kernal, a model, which is called data-based mechanistic self-memory model (abbreviated as DAMSM), can be established on basis of the self-memorization principle. The DAMSM can be applied to an temporal interpolation of climatic observed data in default of an observation and to a climate prediction.

Modeling of the inter-annual forecast of the precipitation in summer over Yangtze Delta was carried out, By utilizing the seasonal precipitation for 1951 to 1998, the retrieved differential equation was obtained, which is

Dx/dt=-0.638x(t-1)+0.569x(t-3)-0.512x(t-4)+0.281x(t-5)+0.334x(t-7) +0.277x(t-5)2

The hindcast of the DAMSM of the summer precipitation over the Yangtze Delta was computed ,its RMS (root mean square) error is 75.3 mm which is better than that by the autoregressive (AR) model.
Besides, the models of the aviation transport and sunspot were established too ,the prediction accuracies are all quite satisfactory.

Wind Field Retrieval From Scatterometer Data
Dan Cornford, David J. Evans and Ian T. Nabney

It is well known that radar backscatter can be used to estimate the near surface wind vector over the ocean. In recent years several satellites have been deployed carrying scatterometers to provide data for retrieval of wind fields and subsequent assimilation into numerical weather prediction models. This paper addresses the question of whether there is sufficient information in the scatterometer observations alone to uniquely determine the "true" surface wind vector field. This is difficult because the retrieved local wind vectors have several ambiguous solutions for a given scatterometer observation. We use a Bayesian approach to combine the local scatterometer observations with a global wind field prior. The prior model is a Gaussian process with parameters estimated from several years of numerical weather prediction model data. We show how direct local inverse models, based on mixture density networks, can be used efficiently in the retrieval procedure. The posterior distribution of the wind field has high dimension, with several distinct modes. We show how to sample from these distributions and illustrate the performance of several sampling algorithms on toy problems. Many of the existing algorithms are shown to perform badly on the toy problems, because the modes of the posterior are well separated in the high dimensional space. We show that in most cases the posterior distribution of the wind field has two dominant modes one of which is typically close to the numerical weather prediction model wind field (which is not used at any point in the retrieval procedure). We also discuss the effect of increasing the number of local observations considered in the retrieval, which may improve the chance of retrieving the "true" wind field.

Homogenization and Quality Control in State Space Models
Thomas K. Friedli, Evi Schuepbach, Tania Steiner, Jürg R. Hüsler (Department of Mathematical Statistics and Actuarial Sciences, University of Berne, Bern, Switzerland)

Long-term surface ozone records may provide essential information on changes in lower tropospheric ozone over time. The homogeneity of such records is commonly assessed by analysing the difference series of neighbouring stations with statistical tests such as the Buishand, Alexandersson or Easterling-Peterson test. These approaches generally suffer from the lack of readily available nearby reference stations and hence, these test procedures were often applied to original surface ozone records without differencing with a nearby reference station.
Using surface ozone data at Jungfraujoch (JFJ, 3580 m asl) and Zugspitze (ZUG, 2960 m asl) in the Alps, we show that high-elevation surface ozone records display significant serial correlations which may seriously affect the absolute and relative homogeneity testing. Hence, we review some existing parametric and nonparametric homogeneity tests and present their performance on simulated surface ozone records, with inclusion of multiple outliers and level shifts.
It is evidenced that none of these tests perform satisfactory, neither for absolute nor for relative homogeneity testing.
Structural models in state space form provide a suitable and sufficiently flexible statistical framework for the unified analysis and homogeneity testing of time series records. Using surface ozone data at JFJ and ZUG, we show how to estimate, test and validate structural models in state space form including multiple structural breaks. The performance of this modelling approach is assessed on simulated surface ozone series with inclusion of multiple outliers and level shifts.

Statistical Analysis of Modern Climate Changes observed in the West and East Antarctic
Jagovkina, S. V.[1], Lagun, V. E.[2] ([1]Main Geophysical Observatory, St.-Petersburg, Russia; [2]Arctic and Antarctic Research Institute, St.-Petersburg, Russia)

The statistical analysis of temperature, pressure fields, precipitation and wind speed is executed for Russian Antarctic stations located in the East (Mirny) and in the West (Bellingshausen) Hemispheres. This analysis was made on the base of multiyear current registered meteorological data for all period of instrumental observations (1956-2000 for Mirny and 1968-2000 for Bellingshausen). Mirny Observatory is situated on the coast of Cape Davis at a small protrusion of Mirny Peninsula. Mirny Observatory is the main base of Russian studies in the Antarctic. The Bellingshausen station is situated on the Fildes Peninsula in the south - western part of King-George Island, being a part of the South Shetland Isles.
The tendencies of interannual climatic changes are identified with account of annual, seasonal, monthly and synoptic variations of considered parameters. The traditional methods of regressive and correlative analyses as well as methods of stochastic analysis of the ensemble of several periodically correlated random processes are used for interannual oscillation description and low-frequency trend determination. Obtained results are compared

with NCAR/NCEP Reanalysis (1958-1998) data set and hemispheric temperature anomaly time series. Statistical features of climatic parameters variation in Western and Eastern parts of Southern Hemisphere are demonstrated. Possible causes of determined climatic tendencies are discussed in connection with available data about cloudness regime, eddies synoptic activity and sea ice dynamics.

Statistical Forecasts of Summertime South American Stationary Systems (SASSY)

Charles Jones[1] and Leila M. V. de Carvalhol[2] (1 Institute for Computational Earth System Sciences (ICESS), University of California, Santa Barbara, CA; 2 Dept. of Atmospheric Sciences, University of São Paulo, Brazil)

The South Atlantic Convergence Zone (SACZ) is subjectively described as a convective region extending from the Amazon basin, passing over southeast Brazil and running towards the South Atlantic. The SACZ is characterized by a wide range of temporal variability from synoptic to intraseasonal and interannual scales. Our recent study has objectively identified the occurrence of South American Stationary Systems (SASSY) during austral summer. SASSY events are characterized by persistence greater than two days and large geographic extension over southeast Brazil. This presentation will discuss a statistical method to forecast the large-scale feature of convective activity in the SASSY region. Daily Outgoing Longwave Radiation (OLR) from the period January 1979 through December 1999 is used to develop and validate the statistical model. Examples of real-time forecasts will also be discussed.

Using of cluster analysis in processing of correlation coefficients

Stanislava Kliegrová, Ladislav Metelka (Czech Hydrometeorological Institut, Hradec Králové – Svobodné Dvory, Czech Republic)

The satisfactory predictors are looked for the long-term (seasonal) statistical forecasts for the Czech Republic territory. The relationships among sets of temperature (monthly value) in the Czech Republic and sets of SST (Sea Surface Temperature, in grid points 2x2°) in part of the Atlantic were described by the help of correlation coefficients. For "simplification" the cluster analysis was used in next processing, when the regions of the ocean with similar behaviour of significant correlation coefficients were found. Just possibility of using of K-means Clustering Method, that moves objects among k clusters with the goal (1) minimize variability within clusters, and (2) maximize variability among clusters, was explored in the paper. The objects, in our case, were sets of 12 correlation cofficients among set of monthly temperature in the Czech Republic (for one concrete month) and sets of monthly values of SST (stepwise for the same month, for preceding month, for more preceding month, and so on, to month about 11 months preceding the concrete month) for every grid point. Cluster analysis was computed for every our monthly temperature set separately and results were illustrated in maps.
For some one of these month was number of clusters clear, for some one was determination of the number more problematic. Just analysis of the polemic cases is main aim of the report.

A new look at the temporal structure of a time series

Ken-Chung Ko (Department of Geography, National Kaohsiung Normal University, Kaohsiung, Taiwan)

This study introduces a method in analyzing the temporal structure of quasi-periodic oscillations. The idea of the moving spectra will be adopted to study the temporal variation of a time series. The objective of this study is to look at different aspects of the spectral methods in order to detect the periodicity that could be hidden in regular spectra. Results show dramatic changes after applying normalization procedures and statistical tests to the moving spectra. Four idealized cases tested by the moving spectral method reveal that the moving spectral method can transform the time series into the temporal spectral structure.

Extreme value analysis applied on precipitation time series in the Czech Republic

Kveton, V. (Czech Hydrometeorological Institute, Prague, Czech Republic)

Yearly extremes of 1- to 7-days precipitation totals both from 8 long time series and 50 shorter time series (1961-1998) in the Czech Republic were analysed. Different observation period and different estimation method were used. Results are compared. Obtained experiences are discussed.

Statistical climatology and interannual variability of the extratropical cyclone parameters in the global atmosphere

Victor E. Lagun (Air-Sea Interaction Department, Arctic and Antarctic Research Institute, St. Petersburg, Russia)

The calculation of the global distribution and of the time variability of cyclone synoptic eddies parameters, including the space and time frequencies estimations, the depth, the linear size, the area, the velocity, the trajectory variability is made on the base of twice - daily mean sea level pressure and geopotential fields extracted from NCEP data sets for 1980-1998 period. The original methods for statistical analysis of meteorological fields were used to define the position of cyclones and anticyclones on the sphere. These numerical methods are based on traditional definition of synoptic

eddies boundaries as external closed isobars. The estimations of mean monthly, seasonal, annual and decadal synoptic climatology parameters for both hemispheres were carried out.
The analysis of different algorithms used for parameters estimations in synoptic statistical climatology is executed. The obtained results are compared with the known estimations for hemispheric parameters distributions of synoptic climatology and the differences in results due to including of small and mesoscale disturbances parameters in the statistics of extratropical cyclones are discussed. The tendency of the extratropical cyclones time variability under global warming conditions is estimated. The results demonstrate that the number of mature extratropical cyclones is increasing during the current period of global warming, and it is the important indicator of modern climate change. The possible reasons of synoptic eddy activity increasing are discussed.

Spatial Organization of Decadal and Bidecadal Rainfall Fluctuation on Southern North America and Southern South America

Omar Abel Lucero, Norma C. Rodriguez (Instituto Nacional del Agua and National University of Cordoba, Cordoba, Argentina)

The spatial organization of decadal and bidecadal components (fluctuations) of annual rainfall is identified in this research for two regions: 1) southern South America, and 2) southern North America (conterminous USA, southeastern Canada and northern and central Mexico). Findings indicate that these decadal and bidecadal components have highly-coherent wave-like spatial organization. Two types of organization of decadal and bidecadal components of annual rainfall were identified: a train of propagating fluctuations, and quasi-standing fluctuations. For decadal components, such patterns alternate in time. A widespread change in the spatial organization of decadal component of annual rainfall took place simultaneously in both continents in 1932. The bidecadal component is organized as standing fluctuations in southern North America; and as travelling fluctuations in southern South America The spatial pattern of decadal fluctuations of annual rainfall has 12- and 13-year cycles, and the spatial pattern of bidecadal fluctuations has predominantly 21- and 22-year cycles.

Interrelationship between Interdecadal Fluctuations in the Southern Oscillation and the Sea Surface Temperature of the Tropical Pacific

Omar Abel Lucero, Norma C. Rodriguez (Centro de la Region Semiárida (INA), and National University of Cordoba.Cordoba, Argentina)

Atmospheric fluctuations at decadal and interdecadal timescales on the Southern Oscillation and in the sea surface temperature of the tropical Pacific are the focus of this research. Analyses are based on the SOI (Southern Oscillation Index), and on Wright's SSTI (The SSTI is defined by the average anomaly of SST on a large part of eastern and central Tropical Pacific.) Analyses were carried out using the integral wavelet transform. This paper documents 1) The existence of a large amplitude modulation of the Southern Oscillation (AMSO). 2) A change in the relative phase between SOI and SSTI fluctuations at the decadal and bidecadal timescale, which occurred in mid-1930s.
Signals in the band of wavelet-period smaller than 10 years do not show indication of climate change throughout the period of study (almost a century-long data record). The controlling process on the variability of decadal component of SOI and SSTI during that period is AMSO (amplitude modulation of the Southern Oscillation). AMSO produces maximum amplitude of decadal components of SOI and SSTI in 1913-1917. Thereafter, these components have decreasing amplitude until about 1957. In early-1960s, decadal component of SOI and SSTI signals starts to amplify. AMSO has a major influence on the observed values of SOI and SSTI. The state of AMSO, and contributions from decadal, bidecadal, and tridecadal component of SOI and SSTI, account for major changes observed in this century in the SOI, and in the SSTI.

Variability of annual pressure and precipitation on Iberian Peninsula

M Dolores Manso Orgaz* and Liliana Caramelo** (*Depart. of Physics. University of Aveiro, Portugal; ** Depart. of Physics University of Trás-os-Montes and Alto Douro . Vila Real)

In this study we investigate the space and temporal variation of the annual precipitation and the annual pressure (at the sea-level), on the Iberian peninsula (IP) in 40 stations of 39 years. Using the technique of empirical orthogonal functions (EOFs) to obtain a regional precipitation and regional pressure. In order to obtain the structure of temporal variations we are using to spectral analysis of the principal components (PCs). We analysed the relationship between the observed time series and the following teleconnection indices: Oscillation of the North Atlantic (Gibraltar extension NAO-G and Ponta Delgada extension NAO-A) .We found two patterns for the annual pressures accounts for 86% of total variance; and four for the annual total precipitation account for 74% of the total variance. These leading PCs are associated with the following patterns: NAO-G, NAO-A, respectively. The isobaric gradient and the spectra show coherence of the first EOF of the annual pressure and of the annual total precipitation with the trimester of winter NAO-G. For the reconstruction of the series is provided a statistical model in function of the more significant oscillations.

Reproduction of dry and wet Periods by Stochastic Daily Precipitation Generators

D. Marvan[1], M. Dubrovsky[2] ([1]Faculty of Math. and Physics, Charles University, Prague, Czech Republic; [2]Institute of Atmospheric Physics, Hradec Kralove, Czech Republic)

Stochastic models used to generate the series of wet and dry days in daily weather generators are mostly based on Markov chains (MCs). Since the first-order MCs cannot satisfactorily reproduce the dis-tribution of the lengths of wet and dry spells (in addition, other weather characteristics, such as occurrence of hot and cold periods, derived from variables generated conditionally on the precipitation occurrence may be distorted too), the alternative approaches are employed. These include higher-order MCs, hybrid-order Markov chains and serial approach models. The present contribution aims to assess capability of several models (higher order Markov chains, hybrid-order Markov chains and serial approach model) to reproduce selected statistical characteristics precipitation occurrence series. The stress will be put on reproducing the long wet and dry spells. The fit of the synthetic vs. observed weather series is evaluated in terms of (i) summary measures (Wilcoxon, chi-square and Kolmogorov-Smirnov tests), (ii) maximum length of wet/dry spells, and (iii) frequency of occurrence of extremely long dry/wet spells.

In the second part of the contribution, the accuracy of the generators parameters estimated from the learning (observed) data will be assessed. This exercise is motivated by the problem, whether it is better to use simpler model (e.g., first order Markov chain) with less parameters (and greater accuracy) being derived from the learning data, or to use more sophisticated model with more parameters, which are, however, derived with lower accuracy from the learning sample. The combined effect of the size of the learning sample, type of the model and detailness of the representation of the annual cycle of the generator's parameters (one value per year/seasons/month) on the generators' performance will be therefore assessed.

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Semi-parametric statistical approaches for the analysis of climatological data

J. Mateu[1], C. Alvarez2, T. Sanfeliu[2], M.M. Jordan[3] ([1] Department of Mathematics; [2] Department of Experimental Sciences, Universitat Jaume I, E-12071 Castellon, Spain; [3] Department of Experimental Sciences, Universitat Miguel Hernandez, Elche, Spain)

An understanding of the ozone behaviour near surface layers is essential for a study of pollution surfaces. Controlling possible sources of air pollution has become a relevant goal in our increasingly degraded environment. Moreover, concentrations of atmospheric trace gases involved in forming ozone and nitrogen oxides change rapidly with several meteorological variables such as wind speed and direction, temperature, humidity and solar radiation. Thus, good statistical models which can handle with the intrinsic variability of climatological and/or meteorological data are clearly needed.

In this paper we set up the foundamentals to propose, build and further develop statistical models based on semi-parametric approaches. Particularly, a mixed formulation involving a non-parametric component based on locally weighted regression procedures which accounts for a possible deterministic trend, and a parametric component repre-senting the purely temporal random variation is proposed.

The data set analyzed comes from an area with typical mediterranean environmental conditions, so that our conclusions can be easily generalized to general mediterranean polluted environments.

Statistical Methods in climatology: an application to the longest precipitation series in Portugal

Solange Mendonça Leite (Geophysical Centre of the University of Lisbon, Portugal)

Instrumental climatic data are limited to the period from mid-twentieth century for the most regions in Iberian Peninsula, with a few data sets going back to late 19th century or early 20th century. Portugal, however, has one high-quality instrumental weather observation series going back to the middle 19th century.

This weather station was selected by an exhaustive search of documentation regarding instrumentation and observational practices. Statistical tests of the reliability of observing practices also have been applied in the selection process, as well as tests to detect inhomogeneities. The data set used is the most reliable available for monitoring precipitation trends during the last century and a half. With the availability of this long time series it is now possible to conduct much more detailed analyses. In this report we summarise these efforts using the weather station of Instituto Geofísico Infante D. Luís, in Lisbon. A trend analysis over the period 1856-1999 indicates a temporal pattern of precipitation variability. The statistical characteristics of precipitation monthly totals are analysed. Maximum entropy spectral analysis is applied to quantify the relative importance of decadal variability. An autorregressive model of order 45 is fitted to the 144-year precipitation series and the agreement between observed and estimated values is judged. The value of this model simulation as a source of regional climate scenarios should be considered in the context of other uncertainties in the global climate change scenarios which are used to drive them. These include the inherent variability of the climate system and the differences in sensitivity and in patterns of response between climatic elements.

Spatial patterns of the five-day rainfall all over North-Western Iberian peninsula

M. Andrés (Atmospheric Physics Department, University of Salamanca, Spain); Clemente Tomás (Atmospheric Physics Department, University of Salamanca, Spain); Fernando de Pablo (Atmospheric Physics Department, University of Salamanca, Spain); Solange Mendonça Leite (Geophysical Centre of the University of Lisbon, Portugal)

Precipitation is the climatic element which presents a higher spatial and temporal variability in the Iberian Peninsula. While the analyses of the temporal variability of the precipitation data sets is quite easy, the spatial variability is much more difficult to identify and to interpret, and even more when orography makes rainfall distributions even more complex. In this report we present a regionalization of Castilla y León, a region located in north-western Spain, using 5-day rainfall data sets. Daily values were available for 119 weather stations, during a 6-year period, from 1990 to 1995, considering the rainfall period between September and May. The region presents a characteristic orography which affects the final results. Principal Component Analysis (VARIMAX rotation) has been applied as an adequate method of regionalization. Six components were identified as statistically significant, explaining 82.6% of the total variance of the field. In order to identify which synoptic systems are related to each component, those cases in which the score was positive only in one of the components (while the remaining were negative) were selected. Thereafter, the synoptic situations associated with that 5-day group were analysed, looking for the main one and obtaining common patterns for each one of the components. We have also tried to identify the associated systems which affect the region when there were several components with positive values for a 5-day group.

The effects of large scale phenomena on local climate variability over Romanian territory

Daniela Mihaela Paliu, Roxana Bojariu, (National Institute of Meteorology, Hydrology and Water Management, Bucharest, Romania)

This paper aims to identify the effects of large scale variability modes such as North Atlantic Oscillation (NAO), East Atlantic Pattern (EA), East Atlantic/-West Russia Pattern (EA/WR), Scandinavian Pattern (SCA) and Polar/Eurasia Pattern (POL) on the occurrence of extreme temperature and precipitation anomalies over Romanian territory. The large scale phenomena are generally responsible for extended range predictability. However, the complex orographical characteristics of Romanian area due to the presence of Carpathian mountains which are standing against certain types of large scale circulation and modifies the relation between large scale phenomena and local variability and predictability.

Data sets consist of observed monthly temperature and precipitation amounts from 62 Romanian stations and indices of NAO, EA, EA/WR, SCA, POL taken from NCEP data. The analyzed time interval is 1961-1996. Statistical significant relationships between large and local scales are identified mapping the correlation coefficients between the large scale indices and local thermal and precipitation anomalies. Also, composite maps of precipitation and temperature anomalies over Romania territory have been derived depending on the opposite phases of the large-scale phenomena. The large/local scale relationships with predictive potential can be further used to develop a regionally-orientated methodology for extreme event risk's assessment .

Neural networks to predict atmospheric profiles

Nazario D. Ramirez-Beltran (Department of Industrial Engineering, University of Puerto Rico, Mayaguez); Jorge Gonzalez (Department of Mechanical Engineering, University of Puerto Rico, Mayaguez); Felipe Chong Rengifo (Department of Industrial Engineering, University of Puerto Rico, Mayaguez)

A methodology to predict climatic variables based on radiosonde and satellite observations is developed. The proposed methodology will contribute to mitigate the existing of very limited radiosonde data for the Caribbean. Satellite and radiosonde data from 1986 to 1999 were used to create the climate information required for a competitive neural network to identify the climatic observations associated to a typical day. A feedforward neural network was also designed to model the relationships among the inputs and outputs of an atmospheric dynamic system. Meteorological variables from two consecutive mandatory pressure levels were used to train a feedforward neural network for predicting the following variables geopotential height, air temperature, relative humidity and wind components in the Caribbean basin. The designed scheme has the capability of predicting five climatic variables from the sea surface up to 17 km of elevation. The developed neural network methodology was successfully tested by using satellite and radiosonde observations for the year 2000. Climatic observations and neural network predictions were very close indicating that the proposed methodology is a reliable tool for predicting atmospheric profiles.

Mid-term prediction of the daily maximum/minimum temperatures in South Korea using Dynamic Linear Models

Keon Tae Sohn (Pusan National University, Korea); Jeong Hyung Lee (Dong-A University, Korea); Byungsoo Kim (Inje University, Korea)

The mid-term(from +1 day to +10 day) prediction of the daily maximum/minimum temperatures in

South Korea was performed using the Dynmic Linear Models(DLM). Observations, which are 6-hour-interval data (including the daily maximum/minimum temperatures) from September 2 in 1999 to May 31 in 2000, and the simulated outputs of GDAPS(Global Data Assimilation and Prediction System) used at Korea Meteorological Administration, which are upto 240 hour-prediction, are used as training data of DLM. The DLM with a prior distribution consists of two equations and intial distributions; (1) state equation: $Y(t)=F(t)m(t)+v(t)$, (2) $m(t)=G(t)M(t-1)+w(t)$, (3) m(0) is a normal-variate with mean a(0) and variance C(0) where two independent random variables v(t) and w(t) have normal distributions with mean 0 and variances V(t) and W(t), respectively. In addition, V(t) has an inverse Gamma distribution, with two parameters n(0) and s(0), as a prior. Y(t) is an observation at time t, F(t) consists of input vaiables and m(t) means a dynamic coefficient vector. For estimating W(t) and m(t) dynamically, the discount factor and the well-known Kalman filtering are used.

For the selection of optimal DLM, some procedures are considered as follows; (1) to select initial values, a(0), C(0), n(0) and s(0), randomly. (2) to determine the transition matrix G(t), (3) to choose the components of F(t), (4) to find an optimal DLM under the selected F(t), with changing the value of discount factor(from 0.01 to 1.00), (5) to determine the optimal DLM among the all F(t)'s, (6) to perform the sensitivity analysis for the effect of initial values, and (7) interval estimation for forecasts. RMSE is used as a measure for the optimization.

As results, we can find that (1) the proposed DLM's are robust to the initial values from the sensitivity analysis, (2) the transition matrix G(t) seems to be an Identity matrix, (3) for the k-lead forecast, the optimal F(t+k)'s consist of Y(t), the estimate of Y(t+k) from DLM and the GDAPS(t+k) forecast, (4) RMSE's are 2.0 - 2.7 (for +1, +2, +3, +4), 2.6 - 3.0(for +5, +6, +7, +8), 3.0 - 3.8(for +9, +10), and (5) the forecasts using the proposed DLM are remarkably better than GDAPS forecasts.

Statistics in Agricultural Climatology – adapting a workshop for African needs

S. M. Gathara, C. Oludhe, S. B. Otengi, P. K. Runanu, R. D. Stern

A 10-week workshop on statistical methods in agroclimatology (SIAC) was given in Reading UK, from 1983 to 2000. In May 2000 SIAC was given for the first time at the Institute for Meteorological Research and Training (IMTR), in Nairobi, Kenya. This paper describes the lessons learned from this venture and the changes that are being made to tailor the 2001 course more to regional needs.

Many of these changes have followed from a train-the-trainer workshop run in October 2000. In addition to strengthening the resource team, this has led to a range of practical projects, described in the paper, on both data management and applications that are being conducted in the 6 months leading to the 2001 course. The main course software has also been upgraded.

Changes of large-scale atmosphere circulation during XX century and their influence on the climate in Ukraine

V.F. Martazinova, T. Sverdlik (Ukrainian Hydrometeorological Institute, Kiev, Ukraine)

The changes of the large-scale atmosphere circulation over Atlantic-Europe region and formed by it regional circulation and climate in Ukraine during XX century are considered.

The maps of mean monthly sea level pressure (SLP) for the 1881-1940, 1951-80, 1980-95 are analyzed. The patterns of mean SLP differences between 1881-1940 and 1951-80; 1980-95 and 1951-80 allowed to find identical tendency of the atmosphere circulation transformation during periods of global warming (at the beginning and at the end of the century) relatively stable period of global temperature course (at the middle of the century). The absolute values of the tendency at the end of the century in twice as much.

The changes of the large-scale and regional atmosphere circulation during recent decades are defined by shifting to the east of climate atmosphere centers of action (Azores, Siberian highs and European depression), that forms new weather conditions in Ukraine. As a result the present weather conditions on the territory of Ukraine are formed by eastern periphery of Azores high in all seasons and characterized by warm and wet winters and cool summers. These conclusions conform to the results of air temperature and precipitation time series analysis.

Hence this study has showed that of global and regional climate changes are connected with changes of the large-scale atmosphere circulation.

Validating a Downscaling Model of the Stochastic Structure of Daily Temperature

Marina Timofeyeva[1], Rachael Craig[2] ([1]UCAR, NOAA/NWS, Silver Spring, MD; [2]Dept. of Geology, Kent State University, Kent, OH)

We model daily maximum temperature with seven parameters: annual mean, phase shift and amplitude from solar insolation, weighted parameters (phis) of an AR(3) model of the residuals from the insolation model and residual variance (sigma). The model was calibrated with a stratified sample of instrumental records from the western U.S. and Mexico for 1979-1988. Three stations (high, low and middle elevations) from each climate division in the U.S. and from each one-degree grid cell in Mexico were selected for calibration; for a total of 434. Boundary conditions are defined by CO2 concentration, sea surface temperature, 500 and 1000 mb winds and geopotential height from the CCM3 T31 paleoclimate control run. Thirty-two predictor variables represent regional radiative and orographic controls on temperature for up to 1000km upwind

of the calibration locations as well as local and downwind (blocking) effects. The transfer function defining the downscaling relation was estimated by canonical regression.
The transfer function was validated with an independent sample of 1290 instrumental records from the same area and time period. Six separate analyses comprise the validation. We first tested skewness and kurtosis of the distribution of residuals (observed minus modeled). All variables but phase and phi(3) passed both tests. Those two variables showed very slight positive skewness. Secondly we computed paired t-statistics on randomly selected subsets of size 208 (giving precision in means of one degree C). We did not reject the null hypothesis that model and observed means are equal, except for one (of three) tests of phase. The third test considered the significance of correlation of residuals with each of the independent variables. One of the seven variables (sigma) passed fewer (89%) than 95% of the 384 tests performed. To detect possible spatial bias we examined (test four) the correlation of residuals with each of latitude, longitude and elevation. All passed. The fifth test considered a Q-mode correlation analysis of the ensemble of independent and dependent variables at all the stations. Correlation at 92% of the stations exceeds 0.7. We see no systematic pattern in the spatial distribution of stations with lower correlation. Finally (test six) we examined the spatial distribution of residuals and found no suggestion of systematic patterns related to geographic controls.

Statistical Decomposition of European Temperature Time Series

Silke Trömel, Jürgen Grieser, C.-D. Schönwiese (Institut für Meteorologie und Geophysik, Universität Frankfurt, Frankfurt /M., Germany)

One strategy to analyze climate variability in meteorological data, used in classical time series decomposition, is the search for prede ned components. We decompose monthly temperature time series into linear as well as nonlinear trends, the season cycle and its variations, harmonic components, episodic components, extreme events and noise. In contrast to extreme values our extreme events are not caused by trends or other well de ned changes in the mean, but they are unlikely to occur by chance and are independent from changes in the parameters of the distribution. It is very unlikely that they are in accordance with the feature of the time series. For the decomposition a stepwise regression is used which converges fast to robust estimaters. Our results show that the trend over Europe can be regarded as positive and linear, that positive phase shifts in the season cycle occur especially in the western and negative ones in the eastern Europe. In the north and northwest of Europe positive changes in the amplitude of the season cycle dominate, whereas negative ones are found in the eastern part and in central Europe. The overwhelming majoritiy of extreme events are detected in winter and represent extreme cold events. Besides, we found a signi cant increase of extreme cold events in the second part of the sampling time.

Coupled sea ice and atmosphere variability in the Weddell Sea, Antarctica

Silvia A. Venegas (Danish Center for Earth System Science (DCESS), Niels Bohr Institute for Astronomy, Physics and Geophysics, University of Copenhagen, Denmark); Mark R. Drinkwater (Oceans/Sea-Ice Unit, ESTEC Earth Sciences Division (APP-FSO), Noordwijk, The Netherlands)

A frequency-domain singular value decomposition is performed on 20 years (1979-1998) of satellite observations of sea ice concentration and drift together with sea level pressure reanalysis data in the Weddell Sea, Antarctica, in order to determine the dominant timescales of variability in the region. The interannual timescale (periods of 3-4 years) is found to dominate the ice and atmospheric fluctuations. This variability is a regional manifestation of the Antarctic Circumpolar Wave in the Weddell sector of the Southern Ocean.
Interannual variations of sea ice concentration and drift are driven largely by anomalous atmospheric patterns, which alternatively enhance or reduce the meridional wind circulation to the east of the Antarctic peninsula. Thermodynamic processes (rapid ice growth in open water areas), dynamic processes (ice ridging/rafting due to ice convergence) and geographic constraints all play significant roles in the formation of summer ice concentration anomalies in the southern Weddell Sea every 3-4 years. These ice anomalies are exported northwards out of the Weddell basin approximately one year later, and then advected eastwards before diffusing in the ice margin.
A low-frequency signal (presumably a quasi-decadal oscillation) is also detected, although its significance is fairly speculative in a 20-yr record. Ice variability on this timescale results from a change in the shape of the Weddell gyre circulation which occurred around 1990, likely associated with large-scale variations of the ocean-atmosphere system.

Participants' List 8. IMSC
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Ulrich ACHATZ
Leibniz-Institut fuer Atmosphärenphysik
an der Universitaet Rostock e.V.
Schlossstr. 6
18225 Kuehlungsborn, Germany
e-mail: achatz@iap-kborn.de

Christine ACHBERGER
Dept. of Earth Sciences
Physical Geography
Göteborg University
Box 460
40 30 Göteborg
Sweden

Ahmed ADJEZ
National Climate Center
P. O. Box 45, Hacen Badi
16200 El-Harrach
Algier, Algeria
e-mail: ahmed_adjez@hotmail.com

Nasser ALBALOUSHI
United nations Development programme
UAE/99/001 Project

Abdullah Aldhanhani
United nations Development programme
UAE/99/001 Project

Genrikh V. ALEKSEEV
AARI Arctic and Antarctic Research Institute
Ocean-Atmosphere Interaction Department
199397,Bering st.,38
St.-Petersburg, Russia
e-mail:alexgv@aari.nw.ru

Hans ALEXANDERSSON
Swedish Meteorological and Hydrological Institute,
Norrköping, Sweden
e-mail: hans.alexandersson@smhi.se

Katrine Krogh ANDERSEN
Department of Geophysics
Juliane Maries Vej 30
2100 Copenhagen O, Denmark
e-mail: kka@gfy.ku.dk

Sylvia ANTUNES
Instituto de Meteorologia
R. C ao Aeroporto
Lisboa, Portugal
e-mail: silvia.antunes@meteo.pt

Judit BARTHOLY
Dept. of Meteorology Eotvos Lorand University
P.O.Box 32
Budapest, H-1518, Hungary
e-mail: bari@ludens.elte.hu

Bryson C. BATES
CSIRO Land and Water
Private Bag
PO Wembley WA 6014 Australia
e-mail: bryson.bates@per.clw.csiro.au

Eva BAUER
Potsdam Institute for Climate Impact Research (PIK)
PO Box 601203
14412 Potsdam, Germany
e-mail: bauer@pik-potsdam.de

Thomas BENGTSSON
Geophysical Statistics Project
National Center for Atmospheric Research
Climate and Global Dynamics Division
P.O. Box 3000, Boulder, CO 80307-3000
USA
e-mail: tocke@ucar.edu

Mark BERLINER
Ohio State University, Dept. of Statistics
404 Cockins Hall, 1958 Neil Avenue
Columbus, OH 43210, USA
e-mail: mb@stat.ohio-state.edu

Nestor R. BERNAL S.
National University of Colombia
e-mail: nbernal@ideam.gov.co

Ulrike BEYER
Institute for Geography
University of Würzburg
Am Hubland
97074 Wuerzburg, Germany
e-mail: ulrike.beyer@mail.uni-wuerzburg.de

Peter BISSOLLI
FE24c1
Postfach 10 04 65
63004 Offenbach, Germany
e-mail: peter.bissolli@dwd.de

Albert BOEHM
e-mail: boehm@ziplink.net

Dr.Reinhard BOEHM
Zentralanstalt fuer Meteorologie und Geodynamik
Hohe Warte 38
A-1190 Wien, Austria
e-mail: reinhard.boehm@zamg.ac.at

Dr. Uwe BOEHM
Universitaet Potsdam
Unstitut fuer Physik
Postfach 60 15 53
14415 Potsdam, Germany
e-mail: boehm@pik-potsdam.de

Konrad BOGNER
Institute of Hydrology
University of Agricultural Research
Muthgasse 18
1190 Vienna, Austria
e-mail: bogner@edv2.boku.ac.at

Auguste BOISSONNADE
Risk Management Solutions Inc.
149 Commonwealth Drive
Menlo Park, CA 94025
California, USA
e-mail: augusteb@riskinc.com

Roxana BOJARIU
Institutul National de Meteorologie si Hidrologie
Sos. Bucuresti-Ploiesti 97
71 552 Bucharest, Romania
bojariu@meteo.inmh.ro

Katarina BORNE
Dept. of Earth Sciences
Physical Geography
Göteborg University

Box 460
40 30 Göteborg
Sweden

Zsolt BOTTYËN
Department of Climatology and Landscape Ecology
University of Szeged
University of Szeged
P.O. Box 653
6701 Szeged, Hungary
e-mail: zbottyan@solyom.szrfk.hu

Anders BRIX
Risk Management Solutions Inc.
Menlo Park
California, USA

Harold E. BROOKS
NOAA/National Severe Storms Laboratory
Halley, Circle
Norman, OK, USA
e-mail: brooks@nssl.noaa.gov

Adri BUISHAND
Royal Netherlands Meteorological Institute (KNMI)
De Bilt, The Netherlands

Arunas BUKANTIS
Dept. of Hydrology and Climatology of Vilnius
University
M.K.Ciurlionio St. 21/27
Vilnius 2009, Lithuania
e-mail: arunas.bukantis@gf.vu.lt

Aristita BUSUIOC
National Institute of Meteorology and Hydrology
Sos. Bucuresti-Ploiesti 97
71552 Bucharest, Romania
e-mail: busuioc@meteo.inmh.ro

Ulrich CALLIES
Institute for Hydrophysics
GKSS Research Center
21494 Geesthacht, Germany
e-mail: callies@gkss.de

Inés CAMILLONI
Dept. of Atmospheric Sciences
University of Buenos Aires
Argentinia
e-mail: inesc@at.fcen.uba.ar

Eddy CAMPBELL
CSIRO Mathematical and Information Sciences
Private Bag No. 5
Wembley, WA 6913, AUSTRALIA
e-mail: Eddy.Campbell@CMIS.CSIRO.AU

Hong Xing CAO
Chinese Academy of meteorological Sciences,
46 Baishiqiaolu
100081 , Beijing ,China
e-mail : caohx@netease.com

Carmen CAPILLA
Universidad Politecnica,
Depto. Estadistica e Investigacion Operativa Apartado
Apartado 22012-46071 Valencia, Spain
e-mail:ccapilla@eio.upv.es

Dr. Peter CARL
Institute for Freshwater Ecology
und Inland Fisheries (IGB)
Forschungsverbund Berlin
Hausvogteiplatz 5-7
10117 Berlin, Germany
e-mail: pcarl@spclim5.wias-berlin.de

Leila M. Vespoli de CARVALHO
Institute for Computational Earth System Science
(ICESS)
University of California
Santa Barbara, CA 93106
e-mail: leila@icess.ucsb.edu

Ana C. CEBRIAN
Institut de Statistique
Université Catholique de Louvain
Voie du Roman Pays, 20
B-1348, Louvain-la-Neuve
Belgium
e-mail: cebrian@stat.ucl.ac.be

Peter CHALLENOR
Southampton Oceanography Centre
Southampton, SO14 3ZH, UK
e-mail: Peter.G.Challenor@soc.soton.ac.uk

Lynda CHAMBERS
Bureau of Meteorology Research Centre
Melbourne, Australia

Richard CHANDLER
Dept. of Statistical Science
University College
Gower Street
London WC 1E 6BT, UK
e-mail: richard@stats.ucl.ac.uk

Stephen CHARLES
CSIRO Land and Water
Private Bag #5 Wembley WA 6913 Australia
e-mail: stephen.charles@per.clw.csiro.au

Rosane R. CHAVES
INPE – CPTEC - Rod. Pres. Dutra, Km 40
C. Paulista - SP - Brasil - CEP:12630-000, Brazil
e-mail: rosane@cptec.inpe.br

Anatoly CHAVRO
Institute for Numerical Mathematics RAS
8, Gubkin St.
Moscow, 117333, Russia
e-mail: chavro@inm.ras.ru

Youmin CHEN
Agrometeorology Institute
Chinese Academy of Agricultural Sciences
30 Baishiqiao Road
Beijing, 100081, China
e-mail: chenym@ns.ami.ac.cn
or: youmin.chen@263.net

Jean-Paul CHILES
Bureau de Recherches Géologiques et Minières
BRGM – 3, avenue Claude Guillemin
BP 6009, 45060 Orléans Cedec 2, France

Bernard CORNÉLIS
Département de Géomatique – Université de Liège
Place du 20-Août, 7
4000 Liège, Belgium
e-mail: Bernard.Cornelis@ulg.ac.be

Dan CORNFORD
Computer Science

Aston University
Aston Triangle
Birmingham B4 7ET, UK
e-mail: d.cornford@aston.ac.uk

Joao CORTE-REAL
Univ. Lisbon, Portugal
e-mail: jcr@fc.ul.pt

Traute CRÜGER
Meteorological Institute
University of Hamburg
Germany

Moses DAMOAH
- c/o Rev Joshua Damoah
Private-Mail Bag
Abesim – Sunyani-B/A
Ghana – W/A
- Kwaku Damoah
48 Yorkshire Road
Mitcham, Surrey CR4 1QD, UK

Utpal .K. DE
Jadavpur University
Calcutta, India
e-mail: deutpal@hotmail.com

Simona De ZOLT Sappadina
Department of Physics G. Galilei
via Marzolo 8
35131 Padova, Italy
e-mail: dezolt@pd.infn.it

Ildiko DOBI-WANTUCH
Hungarian Meteorological Service
1525 Budapest P. O. Box. 38, Hungary
e-mail: dobi.i@met.hu

Mojca DOLINAR, Hydrometeorological Institute of Slovenia, LJUBLJANA, Slovenia

Martin DUBROVSKY
Institute of Atmospheric Sciences
Husova 456
50008 Hradec Kralove
Czech Republic
e-mail: dub@ufa.cas.cz

Salaheddine EL-ADLOUNI
Univ. Mohammed V, Faculté des Sciences
Dép. de Mathématiques et Informatique.
BP. 1014; Rabat – Maroc
e-mail: s_adlouni@hotmail.com

Geir EVENSEN
Nansen Environmental and Remote Sensing Center,
Edvard Griegsvei 3a,
5037 Solheimsviken, Norway
e-mail: Geir-Evensen@nrsc.no

Frauke FESER
Institute of Hydrophysics
GKSS Research Centre
Geesthacht, Germany
e-mail: feser@gkss.de

Götz FLÖSER
GKSS Research Centre
Geesthacht, Germany
e-mail floeser@gkss.de

Dr. Ulrich FOELSCHE
Institute for Geophysics, Astrophysics, and Meteorology
University of Graz (IGAM/UG)
Universitaetsplatz 5
A-8010 Graz, Austria
e-mail: ulrich.foelsche@kfunigraz.ac.at

Chris FOREST
Massachusetts Instituts of Technology
Dept. Earth, Atmos. And Plan.
77 Massachusetts Avenue, Cambrigde,
MA 02139-4307 USA
e-mail: ceforest@MIT.EDU

Carsten S. FREDERIKSEN
Principal Research Scientist
BMRC Model Evaluation Group
Bureau of Meteorology Research Centre
Melbourne, Australia
e-mail: c.frederiksen@bom.gov.au

Thomas K. FRIEDLI
Institut für mathematische Statistik und
Versicherungslehre
Universität Bern
Sidlerstrasse 5
3012 Bern, Switzerland
e-mail: friedli@stat.unibe.ch

R. GARCîA
Dto F'sica de la Tierra II
Universidad Complutense
Madrid, Spain
e-mail: rgarcia@6000aire.fis.ucm.es

Christoph GEBHARDT, Meteorologisches Institut der Universität Bonn
Auf dem Hügel 20
53121 Bonn, Germany
e-mail:c.gebhardt@uni-bonn.de

D. GELLENS
Computer Centre
Royal Meteorological Institute of Belgium
Av Circulaire, 3
180 Brussels, Belgium
e-mail: D.Gellens@oma.be

Friedrich Wilhelm GERSTENGARBE
Potsdam-Institut für Klimafolgenforschung
POB 601203
14412 Potsdam, Germany
e-mail: gerstengarbe@pik-potsdam.de

Luis GIMENO
Universidad de Vigo, Facultad de Ciencias de Orense,
32004 Orense, Spain
Tfno: 988387208
Fax: 988387159
e-mail: l.gimeno@uvigo.es

Clare GOODESS
Climatic Research Unit
University of East Anglia
Norwich NR4 7TJ, UK
e-mail: c.goodess@uea.ac.uk

Jürgen GRIESER
Johann-Wolfgang Goethe Universität Frankfurt am Main
Institut für Meteorologie & Geophysik
Postfach: 11 19 32
D - 60054 Frankfurt a. M.
e-mail:Grieser@meteor.uni-frankfurt.de

Jürgen Grieser
Food and Agriculture Organization of the United Nations
SDRN - C 854 Via delle Terme di Caracalla
00100 Rome, Italy

Anders GRIMVALL
Department of Mathematics
Division of Statistics
Linköping University
SE-58183 Linköping, Sweden
e-mail: angri@mai..liu.se

Nikolaus GROLL
Institute of Hydrophysics
GKSS Research Centre
Postfach 1160
21494 Geesthacht, Germany
e-mail: groll@gkss.de

Peter GUTTORP
University of Washinton
Seattle, WA, USA
e-mail: peter@stat.washington.edu

Sven HARIG
Alfred-Wegener-Institut
Bussestraße 24
D-27570 Bremerhaven
Germany

Knut HARSTVEIT
Pb 43 Blindern
0313 OSLO, Norway
e-mail: knut.harstveit@dnmi.no

Urip HARYOKO
Meteorological and Geophysical Agency
Jl. Angkasa I No. 2
Jakarta, Indonesia
e-mail : urip_haryoko@hotmail.com

Klaus HASSELMANN
Max-Planck-Institute for Meteorology
Bundesstr. 55, 20146 Hamburg, Germany
e-mail: klaus.hasselmann@dkrz.de

Gabi HEGERL
Gabi Hegerl and Tom Crowley
Dept. of Oceanography
Texas A&M
College Station, TX 77843, USA
e-mail: paleo@cox-internet.com

Gabi HEGERL
University of Washinton
Seattle, WA, USA
e-mail: hegerl@atmos.washington.edu

Dr. Hermann HELD
Potsdam Institute for Climate Impact Research (PIK)
Telegrafenberg C4, 14473 Potsdam
14412 Potsdam, Germany
e-mail: held@pik-potsdam.de

Jaakko HELMINEN
Finnish Meteorological Institute
Helsinki, Finland
Jaakko.Helminen@fmi.fi

Andreas HENSE,
Meteorological Institute
University of Bonn
Auf dem Hügel 20
53121 Bonn, Germany
e-mail ahense@uni-bonn.de

Carme HERVADA i Sala
Fisica i Enginyeria Nuclear
L'escola industrial (UPC)
Colom 1
08222 Terrassa, Spain
e-mail: carme.hervada@upc.es

Heike HOFFMANN
Graduiertenkolleg Räumliche Statistik
Bernhard-v.-Cotta-Str. 2
09596 Freiberg, Germany
e-mail: hoffmann@merkur.hrz.tu-freiberg.de

Greg HOLLOWAY
Institute for Ocean Sciences
9860 West Sannich Road
Sidney, B.C. V8L 4 B2, Can.
e-mail: hollowayg@dfo-mpo.gc.ca

Ibrahim HOTEIT
Laboratoire de Modelisation et Calcul
Grenoble, France
e-mail: Ibrahim.Hoteit@imag.fr

Richenda HOUSEAGO-Stokes
James Rennell Division for Ocean Circulation and Climate
Southampton Oceanography Centre
Empress Dock
Southampton, SO14 3ZH, UK
e-mail: R.Houseago@soc.soton.ac.uk

Jim HUGHES
Dept. of Biostatistics
University of Washington
Mailstop 359931
Seattle, WA 98195
e-mail: hughes@biostat.washington.edu

Radan HUTH
Institute of Atmospheric Physics
Prague, Czech Republic
e-mail: huth@ufa.cas.cz

Knut A. IDEN
Norwegian Meteorological Institute (DNMI)
P.O.Box43 Blindern
N-0303 Oslo
Norway
e-mail: knut.iden@dnmi.no

Valerie ISHAM
Dept. Of Statistical Science
University College
Gower Street
London WC1E 6BT, UK
e-mail: valerie@stats.ucl.ac.uk

Shaleen JAIN
Cooperative Institute for Research in Environmental Sciences (CIRES)
University of Colorado
Campus Box 216
Boulder, CO 80303-0216 USA
E-mail: sjain@cdc.noaa.gov
Office: NOAA-CDC/David Skaggs Research Center, Room 1D-111

Stephen JEWSON
Risk Management Solutions, Inc.

Menlo Park
California, USA
e-mail: stephen.jewson@riskinc.com

Ian JOLLIFFE
University of Aberdeen, UK
e-mail: itj@math.abdn.ac.uk

Charles JONES
Assistant Researcher
Institute for Computational Earth System Science (ICESS)
University of California, Santa Barbara
CA 93106-3060, USA
e-mail: cjones@icess.ucsb.edu

Julie M. JONES
Institute of Hydrophysics
GKSS Research Centre
Postfach 1160
21494 Geesthacht, Germany
e-mail: jones@gkss.de

Eigil KAAS
Danish Meteorological Institute
Lyngbyvej 100
2100 Copenhagen, DENMARK
e-mail: ek@dmi.dk

Tiba KABANDA
School of Environmental Sciences, University of Venda
Private Bag, X5050, Thohoyadou, 0950, South Africa
e-mail: Kabanda@univen.ac.za

Jaroslava KALVOVA
Dept. of Meteorology and Environment Protection
Faculty of Mathematics and Physics
Charles University
V Holešovikách 2
180 00 Praha 8, Czech Republic
e-mail: jaroslava.kalvova@mff.cuni.cz

S.S. KANDALGAONKAR
Physical Meteorology and Aerology Division
Indian Institute of Tropical Meteorology
N.C.L. Post Office, Dr. Homi Bhabha Road
PUNE 411 008, India
e-mail: sskandal@tropmet.ernet.in

Mohammed-Said KARROUK
Universität Hassan II
Centre de Recherche de Climatologie
BP 8220 Oasis, MA-20103, Casablanca, Morocco
e-mail:karrouksaid@yahoo.com

Rick KATZ
Environmental and Societal Impacts Group
National Center for Atmospheric Research
Boulder, CO 80307
Colorado, USA
e-mail: rwk@ucar.edu

Frank KAUKER
Alfred-Wegener-Institute for Polar and Marine Research
Bussestr. 24
27570 Bremerhaven, Germany
e-mail: fkauker@awi-bremerhaven.de

Dr A.S.A. KHALIL
Chief Technical Advisor
United nations Development programme
UAE/99/001 Project

Gennady A. KIVMAN
Alfred-Wegener-Institut for Polar- and Marine Research
Bremerhaven,, Germany
e-mail: gkivman@awi-bremerhaven.de

Richard KLEEMAN
Courant Institute for Mathematical Science
New York University, USA
e-mail: kleeman@cims.nyu.edu

Stanislava KLIEGROVA
Czech Hydrometeorological Institut
Branch Hradec Králové
Dvorská 410
503 11 Hradec Králové - Svobodné Dvory, Czech Republic
e-mail: stanislava.kliegrova@chmi.cz

Ken-Chung KO
Department of Geography
National Kaohsiung Normal University
116 Ho-Ping First Road
Kaohsiung, Taiwan
e-mail: kko@nknucc.nknu.edu.tw

Till KUHLBRODT
Potsdam Institute for Climate Impact Research (PIK)
Climate System Dept.
Telegrafenberg, PO Box 60 12 03
14412 Potsdam, Germany
e-mail: kuhlbrodt@pik-potsdam.de

Ashwini KULKARNI
Indian Institute of Tropical Meteorology
Pashan, Pune 411008, India
e-mail : ashwini@tromet.ernet.in

Venerabilis KULULETERA
Tanzania Meteorological Agency
P.O.Box 3056
Dar es Salaam
Tanzania
e-mail: kululetera@hotmail.com

Vit KVETON
Czech Hydrometeorological Institute
Prague, Czech Republic
Na Šabatce 17
143 06 Prague 4, Czech Republic
e-mail: vit.kveton@chmi.cz

Frank KWASNIOK
Leibniz-Institut für Atmosphärenphysik
Schlossstrasse 6
18225 Kühlungsborn, Germany
e-mail: kwasniok@iap-kborn.de

Won-Tae KWON
Meteorological Research Institute
Korea Meteorological Administration, Korea
e-mail: wontk@metri.re.kr

Jan KYSELY
Institute of Atmospheric Physics
Prague, Czech Republic
e-mail: honza@ufa.cas.cz

Victor E. LAGUN
Air-Sea Interaction Department
Arctic and Antarctic Research Institute
Beringstr. 38
St. Petersburg 199397, Russia
e-mail: lagun@aari.nw.ru

Monika LAKATOS
Hungarian Metrological Service
e-mail: lakatos.m@met.hu

David R. LEGATES
Center for Climatic Research
University of Delaware
227 A Pearson Hall
Newark, DE, 19716, USA
e-mail: legates@udel.edu

Piero .LIONELLO
Dept. of Material Sciences
University of Lecce
Via per Arnesano
73100 Lecce, Italy
e-mail: lionello@pd.infn.it

Ulrike LOEPTIEN
Universität Kiel
Institut für Meteorologie
e-mail: uloeptien@ifm.uni-kiel.de

Leonid LOPATOUKHIN
State University (Dep.Oceanography),
199178, St.Petersburg, 10 Line, 33/35, Russia
e-mail: leonid@LL1587.spb.edu

Omar Abel LUCERO
Omar Abel Lucero
National University of Cordoba
Centro de la Región Semiárida (INA), Argentina
e-mail: Omarabellucero@yahoo.com
olucero@com.uncor.edu
olucero@gtwing.efn.uncor.edu

M Dolores MANSO ORGAZ
Depart. of Physics
University of Aveiro,
Portugal
e-mail: mariola@fis.ua.pt

Rol MADDEN
UCAR, Boulder, Colorado, USA
e-mail ram@ucar.edu

Ileana MARES
Constantin MARES
National Institute of Meteorology and Hydrology
Sos. Bucuresti-Ploiesti 97
Bucharest, 71552, ROMANIA
e-mail: imares@meteo.inmh.ro
cmares@meteo.inmh.ro

Jorge MATEU
Department of Mathematics
University Jaume I
Campus Riu Sec
12071 Castellon, Spain
e-mail: mateu@mat.uji.es

Istvan MATYASOVSZKY
Department of Meteorology
Eotvos Lorand University
1117 Budapest Pázmány Péter sétány 1/A
1364 Budapest, Hungary
e-mail: istvan.matyasovszky@elte.hu

Norm MCFARLANE
Canadian Centre for Climate Modeling and Analysis
Victoria, Canada
e-mail: norm.mcfarlane@ec.gc.ca

Solange MENDONCA LEITE
Physics Department
University of Tras-os-Montes e Alto Douro
PoBox 202
5000-911 Vila Real, Portugal
e-mail: solange@utad.pt

Miroslaw MIETUS
Institute of Meteorology and Water Management
Maritime Branch
Gdynia, Poland
e-mail: mietus@imgw.gdynia.pl

Janos MIKA
Hungarian Meteorological Service
H-1525 Budapest P. O. Box. 38.
(H-1024 Budapest Kitaibel P. u. 1), Hungary
e-mail: mika.j@met.hu

Adam MONAHAN
Institut fuer Mathematik
Humboldt-Universitaet zu Berlin
Unter den Linden 6
10099 Berlin, Germany

M. Granger MORGAN
Carnegie-Mellon University
5000 Forbes Ave., Pittsburgh
PA 15213, USA
e-mail: gm5d@andrew.cmu.edu

Manfred MUDELSEE
Institute of Meteorology
University of Leipzig
Stephanstr. 3
D-04103 Leipzig, Germany
e-mail: mudelsee@rz.uni-leipzig.de

Peter MÜLLER
Department of Oceanography
University of Hawaii, USA
e-mail: pmuller@iniki.soest.hawaii.edu

Bärbel MÜLLER-KARULIS
Marine Monitoring Centre
Institute of Aquatic Ecology
University of Latvia
8 Daugavgrivas
1007 Riga, Latvia
e-mail: baerbel@monit.lu.lv

Donald E. MYERS
Department of Mathematics
University of Arizona
Tucson, AZ 85721, USA
e-mail: myers@math.arizona.edu

Philippe NAVEAU
Geophysical Statistics Project
National Center for Atmospheric Research,
Climate and Global Dynamics Division
Boulder, CO, USA,
e-mail: pnaveau@cgd.ucar.edu

Lars NERGER
Alfred-Wegener-Institut
fuer Polar- und Meeresforschung
Rechenzentrum
Buergermeister-Smidt-Strasse 20
27568 Bremerhaven, Germany
e-mail: lnerger@awi-bremerhaven.de

Svetlana NIKULINA
Central Asian Research Hydrometeorological Institute
(SANIGMI)
Tashkent, Uzbekistan
e-mail: sanigmi@meteo.uz

Carlos NOBRE
Centro de Previso de Tempo e Estudos Climaticos
Cachoeira Paulista, Brasil
e-mail: nobre@cptec.inpe.br

Anders NORDGAARD
Statistics Division
Department of Mathematics
Linköping University
SE-581 83 Linköping, Sweden
e-mail: annor@mai.liu.se

Doug NYCHKA
Geophysical Statistics Project
National Center for Atmospheric Research
Climate and Global Dynamics Division
Boulder, CO, USA
e-mail: nychka@cgd.ucar.edu

Guillermo O. OBREGON
Centro de Previsao de Tempo e Estudos Climaticos
(CPTEC)
Instituto Nacional de Pesquisas Espaciais (INPE)
Rod. Presidente Dutra, km. 40
12630-000 Cachoeira Paulista, Sao Paulo, Brazil

Timothy J. OSBORN
Climatic Research Unit
School of Environmental Sciences
University of East Anglia,
Norwich NR4 7TJ, UK
e-mail: t.osborn@uea.ac.uk

Taha B. M. J. OUARDA

Christopher J. PACIOREK
Department of Statistics
Carnegie Mellon University
Pittsburgh, Pennsylvania, USA
e-mail: paciorek@stat.cmu.edu

Heiko PAETH
Meteorologisches Institut der Universität Bonn
Auf dem Hügel 20
53121 Bonn, Germany
e-mail: hpaeth@uni-bonn.de

Daniela Mihaela PALIU
National Institute of Meteorology and Hydrology
Sos. Bucuresti-Ploiesti 97
71552 Bucharest, Romania
e-mail: dpaliu@meteo.inmh.ro

Ruben PASMANTER
Faculty of Science
University of Amsterfdam
The Netherlands
e-mail: pasmant@wins.uva.nl

Sarath PEIRIS
e-mail: rescri@sri.lanka.net

Richard E. PETERSON, Chair
Professor of Atmospheric Science
Associate Director
Department of Geosciences
Wind Science and Engineering Program
Texas Tech University
Lubbock, TX 79409 USA
e-mail: richard.peterson@ttu.edu

Arnt PFIZENMAYER
Institute of Hydrophysics
GKSS Research Centre
Geesthacht, Germany
e-mail: pfitzenmayer@gkss.de

Carlos Alberto Leitao PIRES
CGUL, - Centro de Geofísica da Universidade de Lisboa
Rua da Escola Politécnica 58
1250 Lisboa, Portugal
e-mail: cpires@fc.ul.pt

Faculdade de Ciências
Departamento de Física, Edifício C8
Rua Ernesto de Vasconcelos - Campo Grande
1749-016 Lisboa Codex - PORTUGAL
e-mail cpires@fc.ul.pt

Henrique Oliveira PIRES
Instituto de Meteorologia
R. C ao Aeroporto
Lisboa, Portugal
e-mail: hop@esoterica.pt

Budong QIAN
ICAT - Faculty of Sciences
University of Lisbon, Portugal
e-mail: bdqian@fc.ul.pt;
jcr@fc.ul.pt; chingxu@fc.ul.pt

Radhika RAMACHANDRAN
Space Physics Laboratory
Vikram Sarabhai Space Centre
Trivandrum - 695 022
INDIA
e-mail:radhika@md3.vsnl.net.in

Nazario D. RAMIREZ-Beltran
Department of Industrial Engineering
University of Puerto Rico
Mayaguez Puerto Rico 00680
e-mail: na_ramirez@rumac.uprm.edu

Clarence RICHARDSON
Laboratory Director
Grassland Soil & Water Research Laboratory
808 E. Blackland Road
Temple, TX 76502, USA
richards@brc.tamus.edu

Pedro RIBERA
e-mail: pribera@uvigo.es

Joao RIO
Centro de Geofísica da Universidade de Lisboa;
PORTUGAL
e-mail : jrio@fc.ul.pt

James RISBEY
University of Utrecht
Department of Science, Technology and Society
Padualaan 14
3584 CH Utrecht, The Netherlands
e-mail: james@nwsmail.chem.uu.nl

Torben SCHMITH
Danish Meteorological Institute

Climate Research Division
Lyngbyvej 100
2100 Copenhagen Ø, DENMARK
e-mail: ts@dmi.dk

Vladimir A. SEMENOV
Max-Planck-Institut für Meteorologie
Bundesstr., 55
20146 Hamburg, Germany
e-mail: semenov@dkrz.de

Julien SÉNEGAS
Centre de Geostatistique
Ecole des Mines de Paris
77305 Fontainebleau
e-mail: senegas@cg.ensmp.fr

Amjad Majeed SHAH
Assistant Professor
Statistics Department
Islamia University Bahawalpur, Pakistan
e-mail: Amjee2001@yahoo.com

Ajay SINGH
School of Management
Indian Institute of Technology
Bombay,Powai
Mumbai-400076, India
e-mail: ajay@cc.iitb.ernet.in

NITYANAND SINGH
Indian Institute of Tropical Meteorology
Dr. Homi Bhabha Road
Pashan, Pune- 411 008, India
e-mail: nsingh@tropmet.ernet.in

Leonard A. SMITH
Centre for the Analysis of Time Series
London School of Economics
London, WC2A 2AE, UK
e-mail: lenny@maths.ox.ac.uk

Keon Tae SOHN
Pusan National University, Korea
e-mail: ktsohn@hyowon.cc.pusan.ac.kr

Neelima SONTAKKE
Indian Institute of Tropical Meteorology
Pashan, Pune-411008, India

Tim SPARKS
Centre for Ecology and Hydrology
Monks Wood, Abbots Ripton
Huntingdon
Cambridgeshire PE28 2LS, UK
e-mail: ths@ceh.ac.uk or t.sparks@ite.ac.uk

Tim STAEGER
J.-W. Goethe-Universitdt Frankfurt
Institut für Meteorologie und Geophysik
Arbeitsgruppe Meteorologische
Umweltforschung/Klimatologie
Postfach 11 19 32
D-60054 Frankfurt a.M., Germany
mail: staeger@meteor.uni-frankfurt.de

Christos N. STEFANAKOS
National Technical University of Athens
Dept. of Naval Architecture & Marine Engineering
P.O.BOX 64033
Zografos, 15710
Athens, Greece
e-mail: chstef@central.ntua.gr

Dietrich STOYAN
Institut für Stochastik
Bergakademie Freiberg, Germany
e-mail: stoyan@orion.hrz.tu-freiberg.de

Daithi STONE
School of Earth and Ocean Sciences
University of Victoria
PO Box 3055, Victoria
BC, V8W 3P6, Canada
e-mail: stone@ocean.seos.uvic.ca

Hans von STORCH
GKSS Research Centre
Geesthacht, Germany
e-mail: storch@gkss.de

Jin-Song von STORCH
Meteorologisches Institut der Universität Hamburg
Germany
e-mail: jinsong@gkss.de

Tatyana SVERDLIK
Ukrainian Hydrometeorological Institute,
37, Nauki av., Kiev, Ukraine
Phone: (044) 265 87 90
Fax: (044) 265 53 63
e-mail: nigmi2@mail.kar.net

Tamas SZENTIMREY
Climatological and Agrometeorological Division
Hungarian Meteorological Service
1525--Budapest P.O. Box 38, Hungary
e-mail: szentimrey.t@met.hu

Clemente A. S. TANAJURA, Laboratorio Nacional de
Computa ‹of Cient'fica, Petr—polis, Brazil

Karl E. TAYLOR
P.O. Box 808, L-264
Livermore, CA 94550
email: taylor13@llnl.gov

Jonathan TAYLOR
Lancaster University, UK

Susanne THEIS
Meteorologisches Institut der Uni Bonn
Auf dem Hügel 20
53121 Bonn, Germany
e-mail: susanne.theis@uni-bonn.de

Peter THORNE
Climatic Research Unit
School of Environmental Sciences
University of East Anglia
Norwich, NR4 7TJ, UK
e-mail: Peter.Thorne@uea.ac.uk

Marina TIMOFEYEVA
National Weather Service
1325 East West Hwy
Silver Spring, MD 20910 – 3283
e-mail: marina.timofeyeva@noaa.gov

Silke TRÖMEL
Johann Wolfgang Goethe Universität
Institut für Meteorologie und Geophysik
Robert-Mayer-Str. 1
60054 Frankfurt a.M.,
e-mail: S.Troemel@metteor.uni-frankfurt.deGermany

Heikki TUOMENVIRTA
Finnish Meteorological Institute
P.O. Box 503
00101 Helsinki, Finland
e-mail: heikki.tuomenvirta@fmi.fi

Silvia A. VENEGAS
Danish Center for Earth System Science (DCESS)
Niels Bohr Institute for Astronomy, Physics and Geophysics
University of Copenhagen, Denmark
e-mail: silvia@apollo.dcess.ku.dk

Lucie VINCENT
Climate Research Branch
Meteorological Service of Canada
4905 Dufferin Street
Downsview, Ontario, Canada
M3H 5T4
e-mail: Lucie.Vincent@ec.gc.ca

Aldo J. VIOLLAZ
Universidad Nacional de Tucuman
Argentina
e-mail: aviollaz@noanet.com.ar;
aviollaz@herrera.unt.edu.ar.

Hans Wackernagel
Ecole des Mines
Paris, France
e-mail: hans@cg.ensmp.fr

Andreas WALTER
Institute of Meteorology and Geophysics
Johann-Wolfgang Goethe University
Frankfurt/Main, Germany
e-mail: A.Walter@meteor.uni-frankfurt.de

Xiaolan (Leona) WANG
Network Strategies Division, AMWSD
Meteorological Service of Canada
4905 Dufferin Street, Downsview
Ontario, Canada M3H 5T4

Ed WAYMIRE
Oregon State University, Dept. of Mathematics,
Kidder Hall 368, Corvallis, OR 97331-4605, USA
e-mail: waymire@math.orst.edu

Joanna WIBIG
Dept. of Meteorology and Climatology
University of Lodz
Lipowa 81
90-568 Lodz, Poland
zameteo@krysia.uni.lodz.pl

Martin WIDMANN
Institute of Hydrophysics
GKSS Research Centre
Postfach 1160
21494 Geesthacht, Germany
e-mail: widmann@gkss.de

Lawrence WILSON
Environment Canada
e-mail: Lawrence.Wilson@ec.gc.ca

Katja WOTH

Jun-Ichi YANO
Meteorologisches Institut
Universität Hamburg
Bundesstrasse 55
D-20146 Hamburg, Germany
e-mail: blender@dkrz.de

Abebe YESHANEW
National Meteorological Services Agency
Addis Abeba, Ethiopia
e-mail: a_yeshanew@hotmail.com

Xiaogu ZHENG
The National Institute of Water and Atmospheric Research
301 Evans Bay Parade, Greta Point
P. O. Box 14901
Wellington New Zealand
e-mail: x.zheng@niwa.cri.nz

Christine ZIEHMANN
Universität Potsdam - Institut für Physik
Am Neuen Palais 10 - Haus 19
Postfach 601553
14415 Potsdam, Germany
e-mail: chriss@agnld.uni-potsdam.de

Olga ZOLINA
P.P.Shirshov Institute of Oceanology
Russian Academy of Science (IORAS)
36 Nakhimovsky ave.
117851 Moscow, Russia
e-mail: zol@gulev.sio.rssi.ru

Francis ZWIERS
Canadian Center for Climate Modelling and Analysis
Meteorological Service of Canada
c/o University of Victoria
PO Box 1700, STN CSC
Victoria, BC V8W 2Y2, Canada
e-mail fzwiers@ec.gc.ca