Geophysical Statistics Project at NCAR
External Advisory Panel Meeting
8 - 9 September 2003
FLEISHMANN BUILDING, Mesa Lab

All GSP members and visitors are invited to attend the open sessions on Monday and closing remarks on Tuesday 11:30

Monday, September 8

8:30 Rick Katz, Doug Nychka, Joe Tribbia, GSP PIs
Introductions:
Doug Nychka, GSP Project Leader
NCAR/GSP Overview

9:00 Sarah Streett, GSP postdoc
An Observation Driven Model for Precipitation Occurrence with a Spatial Extension

9:45 Reinhard Furrer, GSP Postdoc
Covariance Tapering for Large Spatial Problems

10:15 - 10:30 BREAK

10:30 Reinhard Furrer, GSP Postdoc
Inverse Problems for Sources and Sinks of CO2: Sensitivity Analysis of the Transport Model

11:00 Steve Sain, Mathematics CU-Denver
Modeling Soil Water Profiles: Estimation, Simulation, and Application to Crop Modeling

11:30 Claudia Tebaldi, NCAR Project Scientist
Interpolating Climate Model Experiments

12:00 - 1:30 LUNCH - Mesa Lab Cafeteria

1:30 Uli Schneider, GSP Postdoc
Advances and Applications in Perfect Sampling (PhD Thesis)
Extremes in Hourly Precipitation

Monday, September 8 (continued)

2:00 Tomoko Matsuo, GSP Postdoc
Optimal Interpolation Analysis of High-latitude Ionospheric Electrodynamic Variables (PhD Thesis)

2:30 Thomas Lee and Curtis Storlie, Statistics CSU
Segmenting and Tracking Coherent Features in Turbulent Flow

3:00 - 3:30 BREAK

3:30 Tim Hoar, NCAR Associate Scientist
A Demonstration of DART -- the Data Assimilation Research Testbed

4:00 Larry Winter, NCAR Associate Director
Role of mathematical sciences at NCAR

5:00 End formal presentations and discussion

6:30 Panel meets in closed session for drinks, dinner and discussions
Dolan's Restaurant, 2319 Arapahoe Avenue

Tuesday, September 9

8:30 PIs will be available to field questions

9:00 Doug Nychka
Future directions:
Renewal funding and the Mathematics Institute for the Geosciences at NCAR

9:30 Open discussion among GSP Pis and Panel

10:15 - 10:30 BREAK

10:30 Closed discussion among Panel

11:30 Closing comments by Panel to GSP

12:00 End of panel visit

An Observation Driven Model for Precipitation Occurrence with a Spatial Extension

Sarah Streett

Stochastic weather generators play an important role in the assessment of climate on agriculture. Of particular importance is the model used for precipitation occurrence since the remaining weather variables are often modeled conditionally based on this event. An observation driven model for occurrence is introduced and results depicting the model's capability of generating realistic precipitation patterns are shown. Spatial extensions of the model are also discussed.

Covariance Tapering for Large Spatial Problems

Reinhard Furrer

Interpolation of a spatially correlated random process is used in many areas. The best unbiased linear predictor, often called the Kriging predictor in geostatistical science, requires the inversion of the covariance matrix of the observations. Optimal covariance models decay exponentially with increasing distance but remain positive. Hence the matrix is full but has a majority of very small entries. We show that tapering the correct covariance matrix with an appropriate compactly supported covariance function reduces the computational burden significantly, still has an asymptotic optimal mean squared error and provides an accurate approximation to the optimal predictor.

Inverse Problems for Sources and Sinks of CO2: Sensitivity Analysis of the Transport Model

Reinhard Furrer

To model the present and future climate it is indispensable to have an understanding of the carbon cycle. The carbon cycle itself depends on the flux of carbon from varied sources and sinks. Some sources depend strongly on anthropogenic activities such as land-use and the direct emissions of CO2 from fossil fuels while others are natural such as decomposition of organic matter. Some major sinks for carbon are the ocean and respiration of vegetation. It is impossible to quantify directly and on a large scale the sinks and sources of carbon, but they can be estimated indirectly by solving an inverse problem based on carbon concentration measurements.

This project considers the statistical issues related to solving the inverse problem. At the core of the inversion is a complicated forward operator relating time varying fluxes of CO2 to observed concentrations at specific locations. In dynamical terms, the forward equation has the form of a transport model taking observed (analysis) winds as input and advecting CO2. As a first step, we analyze the sensitivity of the transport model and determine limits on how well CO2 fluxes can be resolved over space. We also discuss the identifiability of different errors sources, such as model error verses measurement error.

Modeling Soil Water Profiles: Estimation, Generation, and Application to Crop Modeling

Steve Sain

Deterministic models that predict yields for various agricultural crops require a number of inputs. One class of inputs is the water-holding characteristics of the soil. These characteristics are not extensively measured, although other soil characteristics such as the composition (percentage of sand, clay, and silt) are widely known. We develop a multivariate nonparametric regression model based on the soil composition and other covariates that can be used to estimate these water-holding profiles as well as characterize the variation in the water-holding characteristics and the error in these estimates. Simulating water-holding profiles from the model, we can assess the impact of variation in the soils (and ultimately climate and climate change) on the predicted yields.

Interpolating Climate Model Experiments

Claudia Tebaldi

The geographic patterns of climate change, defined as the difference between present and future multidecadal averages of temperature and precipitation, have been found to be nearly constant across different emission scenarios, provided the emissions are characterized mainly by long-lived, well mixed gases. This finding is the basis of pattern-scaling: if all that changes across different climate scenarios is the amplitude of the signal, not its geographical distribution, it may be feasible to approximate many different climate scenarios using a limited number of ocean-atmosphere general circulation model (AOGCM) experiments. Scaling climate projections from the A2 to the B2 emissions scenarios appears to work well retaining accuracy at regional scales. It is also possible to model the uncertainty of the scaled signals using a nonstationary Gaussian random field over the AOGCM grid.

Advances and Applications in Perfect Sampling
(PhD Thesis)

Uli Schneider

Perfect sampling algorithms are essentially Markov Chain Monte Carlo (MCMC) methods without statistical error: the usually tedious question of convergence which rises with regular MCMC techniques completely vanishes with the use of perfect sampling methods which - if applicable – enable exact simulation from the stationary distribution of a Markov chain. In my thesis I developed some 'advances' in this area including several variants of the independent Metropolis-Hastings algorithm which address accuracy, applicability, and computational cost of this method. 'Applications' of these advances include the use of perfect sampling algorithms for Bayesian variable selection.

Extremes in Hourly Precipitation

Uli Schneider

This project involves studying extreme values for (hourly) precipitation and assessing its impact to flooding. As a starting point we look at the precipitation observational record for the Front Range with the intent of improving the precipitation atlas used to assess flood hazards.

Optimal Interpolation Analysis of High-latitude
Ionospheric Electrodynamic Variables
(PhD Thesis)

Tomoko Matsuo

The Assimilative Mapping of Ionospheric Electrodynamics procedure, developed by Richmond and Kamide [1988], carries out an objective multivariate functional analysis of high-latitude ionospheric electrodynamic variables: electric fields, electric potential, ionospheric currents, and magnetic field perturbations. In the research from my thesis some technical improvements upon the traditional implementation of the optimal interpolation method are demonstrated for the storm period of January 9-11, 1997. These improvements include the use of a set of Empirical Orthogonal Functions (EOFs) of Matsuo et al. [2002] as basis functions that are derived from irregular spatial locations and also the application of the maximum-likelihood estimates for the error covariance parameters.

Segmenting and Tracking Coherent Features in Turbulent Flow

Thomas Lee and Curtis Storlie

One feature in the simulation of geophysical type fluids is the presence of eddies and vortices. It has become of interest in the past five years to describe these coherent structures (i.e., the number, size, shape, amplitude of vortices), and the scientific goal is to formulate a statistical model for these structures. A statistical problem is to segment the time slices from a numerical simulation of turbulence to reliably identify vortices. This model for the field is formulated as a multivariate multiple linear regression using a wavelet basis and individual vortex models are isolated through a model selection strategy. Besides static analysis of individual time slices, some promising new work on tracking vortices through a sequence of images will be presented. A general method for doing this is presented here which takes into account time dependency of the feature points along the same path. It can also incorporate knowledge about the points other than just location such as size, color, etc. This method is compared to that of Sethi and Salari on an idealized simulation of a vorticity field.

A Demonstration of DART -- the Data Assimilation Research Testbed

Tim Hoar

The Data Assimilation Research Testbed (DART) is designed to facilitate the combination of assimilation algorithms, models, and observation sets to allow increased understanding of all three. Jeff Anderson is the leader of the NCAR Data Assimilation Initiative and principal architect of the DART software. This demonstration will focus on ensemble filtering techniques for several low-order models due to time constraints. The DART software currently handles several "full-blown" GCM's and has a growing suite of diagnostic Matlab scripts.