Annual Report 1997-98

National Research Center
for Statistics and the Environment

NRCSE

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1. Summary

The second year of Center activities has constituted a building phase. The Center is now starting to build a reputation in the statistical community. During this year we have made considerable effort to give the work at the Center a national (and international) character. We have had several visitors, and expect that aspect of Center activities to keep growing.

At the Center offices on campus there is a lot of activity. More than a dozen graduate students are involved in Center work. Many of these students have offices in or near Center space. About half a dozen local researchers have (or sometimes share) desk space in Bagley Hall, and all visitors have desk space there. It is cramped, but full of vitality.

We first outline some of our outreach activities during the year, then describe the current research projects, outline some of the administrative and infrastructure details, and sketch an outlook towards the future of the Center.

2. Outreach activities

A variety of activities have served to make the statistical community as well as the campus community aware of Center activities. Here we focus on some of the more tangible outreach activities such as seminars, web page, and workshops.

2.1 Seminars

The Center seminar series continued with speakers including Center members and visiting faculty. The seminar series was organized as an official University course, and had about half a dozen registered students. The attendance was down from the previous year, with most seminars having 20-30 attending.

During the year we added the service of maintaining streaming video and speaker slides on the web (http://nrcse-svr.stat.washington.edu/seminars/nrcse-video.htm). The service requires a special plugin which is available for free download at the web site. The most popular seminars have been those of Chris Glasbey, Statistics Scotland, on image warping (40 requests outside the washington.edu domain) and of Joel Reynolds, NRCSE, on Pareto optimal model assessment (32 requests). While it is not generally possible to resolve where each visit originates, out of resolvable addresses 1/3 came from .edu (mainly US educational institutions), slightly fewer from the com-

mercial .com and .net domains, while about a quarter came from European Union sites and 8% from .gov (US government sites).

A complete list of seminars is given in Appendix A.

During the year, a committee was formed to study the seminar organization and structure. The committee report is available at http://www.stat.washington.edu/NRCSE/events/exec/proposal.html. The main recommendations were

- to have faculty members organize the seminars with about half the seminars each quarter falling into a coherent theme
- to develop a Center newsletter
- to use seminars as a focal point for Center communication and interaction

These recommendations have been implemented. The Center newsletter is available at http://www.stat.washington.edu/NRCSE/general/newsletter-1.pdf

2.2 Web site

The Center site at the World-Wide Web (http://www.stat.washington.edu/NRCSE/) is a key part of its informational outreach. We devote a lot of energy towards maintaining as accurate as possible a description of the work going on at the Center. Among the features we are implementing are

- web-based tutorials in basic and advanced statistical methodology
- web-based demonstrations of Center-developed software
- web-based research discussion groups

On the web site we are also maintaining repositories of software (under construction) and of technical reports (http://www.stat.washington.edu/NRCSE/resource/papers.html).

2.3 Workshops and conferences

2.3.1 Combining Information From Programs That Monitor Ecological And Natural Resources

Organizer: Joe Sedransk, Case Western Reserve University
Co-organizers: Tony Olsen, EPA; Loveday Conquest, U. of Wash./NRCSE

The workshop took place November 21-22, 1997, at the University of Washington Seattle campus. It was based upon the above theme proposed by Joe Sedransk. Additional participants included Phil Larsen (EPA Corvallis), Steve Rathbun (University of Georgia), Hans Schreuder

(Rocky Mountain Forest and Range Experiment Station), Denis White (Oregon State University), Nick Chrisman (Univ. of Washington), Mark Kaiser (Iowa State), Jim Karr (Univ. of Washington), Adrian Raftery, Dale Zimmerman (Univ. of Iowa), Gary Oehlert (University of Minnesota), Mark Handcock (Penn State), Abdel El-Shaarawi (National Water Research Institute, Canada). The purpose of the workshop was to clarify issues and set a research agenda regarding combining multiple sources of information in environmental monitoring programs. Topics included the following: integrating probability samples and judgment samples to evaluate the conditions of the nation's aquatic resources; adoption of probability-based designs for combining data across time in water quality monitoring programs; integrating the USFS Forest Inventory and Analysis and NRCS Natural Resources Inventory to enrich knowledge of the nation's natural resources base; combining information across a multi-organization biodiversity research program; defining ecological integrity and measuring biological condition to assess ecological health; tolerance relations as a potential tool for regional monitoring in the absence of probability based samples; Bayesian synthesis methods for deterministic simulation models; combining environmental time series from multiple measurement systems. A host of attendant problems were discussed, including issues of missing data, scientific reasons for merging surveys as well as political burdens of merging; how best to do this; and how to best use concomitant information. Collaborative relationships were established for continuing this kind of research. Participants were also urged to apply for grants as NRCSE visitors.

As a follow-up project, the Center is funding a graduate student at Penn State University to work on improved understanding of stream and river systems in the United States by combining information from separate monitoring surveys, available contextual information on hydrologic systems, and remote sensing information. The project supervisor is Mark Handcock at Penn State (see section 3.1.1 below).

2.3.2 Environmental Monitoring Surveys Over Time

Co-organizers: Tony Olsen, EPA; Sarah Nusser, Iowa State University; Ray Czaplewski, USDA Forest Service Rocky Mountain Research Station; Loveday Conquest, U. of Washington/NRCSE

The conference, "Environmental Monitoring Surveys over Time", was held April 20-22, 1998, on the University of Washington campus in Seattle, Washington. The conference was organized and partially supported by the National Research Center for Statistics and the Environment (NRCSE); additional funding was provided by the Natural Resources Inventory and Analysis Institute of the US Dept. of Agriculture's (USDA) Natural Resources Conservation Service, and the Inventory and Monitoring Institute of the USDA Forest Service. Approximately 65 statisticians, biometricians, and environmental scientists exchanged state-of-the-science information in a series of 14 invited paper sessions. The objective of the conference was to provide a summary of the current state of statistical methodology for conducting longitudinal natural resource and environmental

surveys; it was organized around design and analysis issues, social science issues pertinent to natural resources.

 Invited paper sessions discussed current surveys for a number of natural resources, proposed modifications for surveys, and discussed promising approaches for future surveys. Sessions addressed terrestrial surveys, human population and institutional surveys, aquatic and avian surveys, remote sensing, watershed surveys, integrating different surveys, non-sampling errors, database construction and dissemination, and statistical estimation issues. Also included were perspectives from longitudinal surveys in other subject matter areas as a means of providing cross-fertilization between natural resource survey scientists and those involved with surveys of agricultural production, economic indicators, and human populations.

Of particular interest were discussions on potential survey design modifications which would enable annual estimates to be obtained for Forest Inventory and Analysis (FIA) and National Resource Inventory (NRI) programs. Selected papers from the conference will appear in a 1999 special issue of the *Journal of Agricultural Biological, and Environmental Statistics*. Some speaker overheads, and all the abstracts for the presentations at the conference are available at the NRCSE web site (http://nrcse-svr.stat.washington.edu/NRCSE/CEMSOT/cemsot.html).The meeting agenda can be found in Appendix C.

2.3.3 7th International Meeting on Statistical Climatology

Program chair: Peter Guttorp, NRCSE
Steering committee chair: Francis Zwiers, Canadian Climate Center
Local organizer: Richard Lockhart, Simon Fraser University, Canada

The 7th International Meeting on Statistical Climatology took place at Whistler resort in British Columbia, Canada, May 25-29, 1998. About 150 participants from six continents participated.

The series of meetings on statistical climatology started as an ISI satellite meeting in Japan in 1979. Since 1983 the meetings have been held every three years. These meetings are unique in that they are not run by any scientific organization. Since 1987 the meetings have been organized by a free-standing steering committee, currently chaired by Francis Zwiers. Support is sought from a variety of organizations, and co-sponsorship is usually sought from national and international statistical and meteorological scientific societies. The late Allan Murphy of Oregon State University was instrumental in initiating and maintaining this series of talks, and the meeting was dedicated to his memory.

The program of the Whistler meeting was arranged with two plenary special invited sessions per day, in which prominent climatologists and statisticians gave in-depth presentation, followed by

two invited discussants (one statistician and one climatologist). The format with invited discussants, while common in statistics, was a (popular) novelty to many of the climatologists. There were parallel invited and contributed sessions at other times of the day.

The statistical special invited talks emerged with a theme: Bayesian hierarchical modeling as a tool for managing moderately large climatological data sets. Doug Nychka and Mark Berliner, the present and former directors of the Geophysical Statistics Project at the National Center for Atmospheric Research in Boulder, Colorado, USA, illustrated the approach with some applications, but the tour de force came with some Pacific surface temperature predictions presented by Chris Wikle (NCAR) and Noel Cressie (Iowa State). The predictions for April-September, 1998, based on data through March, can be seen at the conference web site, http://www.stat.washington.edu/peter/7IMSC where the abstracts and some papers also are available.

Among the climatological special invited papers were discussions of neural networks applied to remote sensing problems (Vladimir Krasnopolsky), and the North Atlantic counterpart to El Nino/Southern Oscillation (Tony Barnston).

The NRCSE support for this conference included maintaining the web site, automatic posting of abstracts, and editing of the abstract booklet and program. Among NRCSE participants were Jim Hughes, Chris Bretherton, Barnali Das and Peter Guttorp. The program can be found in Appendix C.

2.4 Conference presentations

A number of Center members and graduate students have given presentations and organized sessions at national and international meetings of various scientific organizations. These include the Society of Toxicology annual meeting, the Novartis symposium on environmental statistics, the Interface conference, the Joint Statistical Meetings, and the 7th International Meeting on Statistical Climatology. A detailed list of presentations is given in Appendix C.

2.5 Professional service

David Ford has made a substantial contribution to the White Paper on Model Assessment now submitted to the EPA Science Policy Council. The crucial contribution was to illustrate how different programs within EPA were all considering model assessment and developing approaches to it, but each had a different emphasis and/or used different terms. By defining different components of "uncertainty" it was possible to illustrate to the diverse members of the EPA team involved in preparing and critiquing the White Paper that an overall EPA policy could be developed

that still permitted the necessary flexibility that the programs needed. The White Paper is being discussed by the Science Policy Council on 5 November, 1998.

Peter Guttorp participated on a site visit committee for the Superfund Remediation project at University of California at Davis. This resulted in a joint committee report to the project officers with recommendations for the upcoming renewal application to the EPA for funding.

Gerald Van Belle has been involved in several activities related to the Health Effects Institute. He is Chair of the Oversight Committee for the National Morbidity and Mortality Air Pollution Study. In addition he is a member of the research committee, and chaired a meeting of NMMAPS and APHEA researchers in London, England, July 15, 16, 1998. (APHEA=Air Pollution and Health–a European Approach)

2.6 Honors and awards

Alison Cullen, School of Public Affairs, received the Outstanding Young Scientist award of the International Society of Exposure Analysis at their annual meeting in Boston, 1998.

Loveday Conquest, Fisheries, was chosen as the first director of the newly formed Teaching Academy at the University of Washington. The Academy consists of winners of the UW Distinguished Teaching Award.

June Morita, Statistics/Management Science, received the American Statistical Association Chapter Service Award at the national meeting in Dallas, 1998.

2.7 Other

One of the important focuses of the Center is on educational outreach. Two of the main projects are development of multimedia modules for teaching environmental statistics and curriculum development on the scientific method, using environmental and ecological illustrations (section 3.1.2) We are assisting the EPA Region X office with a jointly funded graduate student intern for consulting help. We are also developing some web-based course material at a graduate level, and a course in Environmental Statistics using a case-based pedagogical approach. In addition, visitor Michael Phelan taught a course for graduate students in Environmental Statistics with emphasis on economic analysis for the Statistics department during Summer quarter of 1998. We hope to be able to teach such a course each summer.

We have continued our research links with the Washington State Department of Ecology, mainly in the area of air pollution (specifically ozone and car exhaust). These research projects are joint with the University of Washington Statistical Consulting Center.

We are continuing work on developing links with local industry. A natural link already exists to the Boeing Company through our visitor Dean Billheimer, who spends one day a week at the Center. We are working on furthering these links through a variety of joint projects with the Departments of Statistics, Applied Mathematics, and Mathematics. A recently funded NSF proposal (joint between the three departments) is aimed at vertical integration of education and research, and will provide vehicles for involving undergraduates, graduate students, and postdocs, in research group activities.

Center members are actively participating in the University of Washington Program on the Environment (http://tao.atmos.washington.edu/PoE/), a multidisciplinary undergraduate (in the future also graduate) program focusing on a broad spectrum of environmental issues. In addition, several Center members are active in the Puget Sound Region Simulation Model (http://www.cqs.washington.edu/prism), a research program to develop a comprehensive model of physical and social development in the greater Puget Sound region, as well as in other university-wide multidisciplinary projects.

3. Research activities

NRCSE is developing as a *national* research center using a strategy with three components. First, guidelines for funding Center members to work on specific research projects (section 3.1) specify the importance of identified EPA contacts to ensure the relevance of the projects to the EPA mission. Second, the Center is emphasizing its growing visitors program with researchers from outside the University of Washington visiting the Center to set up joint research programs with one or more Center members (section 3.2). Third, Center members work on joint proposals with researchers in other insititutions nationwide. We have adopted a national perspective in our increasing activity building and maintaining contacts with other researchers in environmental statistics. In addition, the Center computing staff is continiuing to evaluate and implement tools for collaborative research at a distance.

3.1 Internal funding

Center members are entitled to submit proposals to the Center once a year, usually in March. A total of 11 proposals were submitted, all of which received at least partial funding. Some projects were also continuing from the previous year.

The current work at the Center can be divided into six areas:

1. Ecological impact

2. Education and outreach

3. Model assessment

4. Space-time modeling

5. Sampling and design

6. Standards and regulatory impact

The Center has a technical report series which is available on the web at
http://www.stat.washington.edu/NRCSE/resource/papers.html

3.1.1 Ecological and environmental impact

Biological monitoring

PI: Peter Guttorp.
EPA connection: Tony Olsen
Center researchers: Dean Billheimer, Jim Karr.
Research assistants: Mariabeth Silkey, Florentina Bunea.

This project deals with the statistical analysis of compositional data in space and time. Among the applications are realistic simulations of benthic population data for streams in order to derive statistical properties of measures of water quality such as the Index of Biotic Integrity (IBI). The statistical aspects of the project focuses on the Billheimer model of space-time compositional data, which the Master's thesis of Mariabeth Silkey (1998) used to assess trends and design aspects of the EMAP benthic monitoring project in Delaware Bay, and the use of graphical models to assess the components of the IBI. Recent work includes an assessment of the statistical variability of the IBI (Bunea and Guttorp, 1998, manuscript in preparation).

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Ecological Assessment of Riverine Systems by Combining Information from Multiple Sources

PI: Mark Handcock, Penn State University
Co-investigators: Joe Sedransk, Case Western
EPA researcher: Tony Olsen
Research Assistant: James McDermott, Penn State University

The objective of the project is to improve understanding of the biological integrity of stream and river systems in the United States Mid-Atlantic Region by combining information from separate monitoring surveys, available contextual information on hydrologic units and remote sensing information. The investigators are collaborating with the Mid-Atlantic Regional Assessment of Climate Change Impacts (MARA) project at the Pennsylvania State University on the construction of the data sets (http://lumen.deasy.psu.edu/mara). The MARA study is being conducted as part of the U.S. National Assessment, under the auspices of the U.S. Global Change Research Program. The NRCSE project is developing spatial statistical models for measures of biotic integrity on the streams and rivers in the MARA region. The collaboration should ensure that the case study can be interpreted in the context of the MARA study and easily explored using the standardized data sets available on the WWW.

Hydrologic effect of land use change

PI: Dennis Lettenmaier
EPA researcher: Iris Goodman
Research assistant: Laura Bowling

There is a perception in the Pacific Northwest that the frequency and severity of flooding has increased in the western Cascades due to forest harvest. Field studies have shown that substantial changes in snowmelt during rain-on-snow events can occur following the removal of forest cover due to differences in snow accumulation as a result of canopy interception changes, and enhanced latent and sensible heat transfer associated with increased wind at the snow surface. However, field studies are of necessity essentially snapshots; at the watershed scale, the effects of vegetation changes on any particular flood are complicated by variations in antecedent snow accumulation, spatial differences in temperature and precipitation during the storm, and the area-elevation distribution of the watershed.

From a statistical standpoint, retrospective assessment of the effects of logging on streamflow is a classical trend detection problem. An analysis of changes in annual maxima (AMS) and peaks-over-threshold (POT), uncorrected for climatic trends, was conducted for 26 Western Washington

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basins, ranging in size from 13.8 km^2 to 1560 km^2 using the non-parametric Mann-Kendall test. The basins were classified into three categories based on record length. Statistically significant increases in AMS or POT were found in 5 basins with short records (1960-1996), 4 basins with medium records (1945-1996) and 3 basins with long records (1930-1996). A short record length makes the trend analysis more sensitive to climate variability. Two techniques were used to correct for the potential influence of climatic trends: paired catchment analysis and analysis of model residuals.

Paired catchment analysis requires that adjacent, similar watersheds be identified that have had much different logging histories. Since both basins are driven by the same sequence of meteorological events, analysis of the discharge difference series should filter out systematic climate variations. Seven basin pairs were selected based on vegetation differences as predicted by Washington Department of Natural Resources canopy cover classifications. Significantly increasing trends in annual maxima were found for two of the basin pairs.

An alternative approach is to control for the effects of climate variability by analyzing the residuals of flood peaks predicted using a deterministic, spatially distributed hydrologic model with fixed vegetation (Wigmosta et al., 1996; Storck et al., 1995; 1996). The residual series (simulated less observed discharge) should filter out any systematic effects due to climate. An analysis of model residuals for the main stem Snoqualmie River detected a statistically significant increase in the smaller storms of the POT series.

These results are summarized in a journal article (Bowling et al., 1998) submitted to Water Resources Research.

Comparison of multivariate methods for seasonal mean temperature prediction

PI: John M. Wallace
Research assistant: Mary Fishel

Mary Fishel has completed her comparison of the performance of canonical correlation analysis (CCA) and singular value decomposition (SVD) analysis for statistical prediction of seasonal mean temperature over the contiguous United States and is now in the process of writing up her results for her M.Sc. thesis and ultimately for publication. To summarize her results briefly: CCA is now performed operationally at the National Centers for Environmental Prediction. In Fishel's tests CCA performed much better on the dependent data set, as expected, and the two methods perform quite comparably when applied to independent data.

3.1.2 Education and outreach

Center Computing

PI: David Madigan
Center researchers: Peter Guttorp
Research staff: Erik Christiansen, Peter Sutherland
Research assistant: Tamre Cardoso

The main outreach tool this group maintains is the web page. In addition, the group has put seminars on the Web, investigated long distance collaborative computing tools, and developed long-range plans for the Center computing facilities. Work is in progress on a system for making Center-related software available to the community and adding web-based discussion tools to the web site. In particular, graduate student Tamre Cardoso has ported Doug Nychka's (NCAR) package FUNFITS, a collection of programs based in S-PLUS (on Unix) for curve and function fitting and spatial design, to run under S-PLUS version 4.0 for Windows. The Windows version is available as a self-extracting zip file. A current version is available on the NRCSE ftp server (ftp://nrcse-svr.stat.washington.edu).

Democracy project

Co-PIs: Alison Cullen and June Morita
Research assistant: Lynn Coriano

Together with the Public Broadcasting System a group of UW faculty and graduate students are working on several multimedia modules for teaching environmental statistics. In these modules K-12 students will collect and manipulate environmental data for application to policy questions about water conservation. The results of this project, both web-based and printed curricular materials, are intended for the PBS Democracy Project (http://www.pbs.org/point/democracy/).

A graduate student at the School of Public Affairs, Lynn Coriano, wrote her MPA degree project on the topic "An Opportunity in Education: Promoting the Environment". She explored the approach to environmental education currently in practice in the US and in particular Washington state. In her conclusions she recommends that environmental education be infused into the classroom in all subject areas. She identified a lack of curriculum materials and teacher preparation as preventing fuller environmental education at the present. There are many opportunities for web based lessons and quantitative exercises with the environment as the major theme. As a practi-

cum related to this degree project she developed 5 lesson plans for use with grades 6-8 in a unit titled "Quantitatively-Based Watershed Lesson Plans".

Scientific method curriculum

PI: June Morita
Research assistants: Kathryn Kelsey and Ashley Steel

This project, which is jointly funded by the Discuren Foundation and NRCSE, is developing and implementing a 10 week curriculum for middle and high school students about the process of scientific research–from hypotheses and research design to statistical analysis and presentation–using structured activities and long-term independent research projects. The curriculum materials are being piloted at two of Seattle's schools, and will be implemented in a variety of middle schools in Seattle school district in spring of 1999.

Statistics course for Region X

Co-PIs: Peter Guttorp, Paul Sampson
EPA contacts: Patricia Cirione, Dianne Ruthruff, EPA Region X.
Center researcher: Steve Millard (PSI)
Research assistant: Kris Ryding

The Center was approached during the summer of 1997 by personnel from the regional EPA office in Seattle about developing an introductory to intermediate series of lectures and computing exercises for office personnel. Due to timing problems, the original plan, which involved Center researchers Loveday Conquest and June Morita, could not be implemented. Instead, center affiliate Steve Millard (Probability, Statistics & Information) will be teaching the course. Kris Ryding, a QERM graduate student, has been hired jointly by the Center and the Region to serve as a statistical consultant at the regional office.

Spatial processes in ecology and environmental science web page
PI: David Ford
Research assistant: Tamre Cardoso

This project continues the *Point process manual* project from last year. We have conducted a web page search and located web pages that provide information on spatial statistics. We have prepared a draft web site that is not currently available to the public. This will be used and de-

veloped during Winter Quarter when "Spatial Processes in Ecology" will be taught as a graduate course at the University of Washington. Substantial additions will be made and the web site will be made public after then.

Bayesian statistics tutorial

PI: Peter Guttorp
EPA connection: George Flatman
Research staff: Peter Sutherland

A prototype chapter of the Bayesian statistical methods tutorial has been developed. It has been made available for limited alpha-testing on the web. Work is in progress on the tools needed to implement the tutorial, and on methods for distribution.

Markov Chain Monte Carlo demonstration tools

PI: Dean Billheimer
Research staff: Peter Sutherland

We are developing software tools to aid the implementation of Markov Chain Monte Carlo (MCMC) algorithms for statistical inference. These tools build on the JAVA-based architecture developed in 1997. Our goal is a framework to easily implement hierarchical models for two types of applications: analysis of designed experiments and time series. To date, our work has focused on two activities. First is the standardization of programming conventions and computational methods. Existing algorithms are being redesigned to improve their ability to adapt to greater variety of data formats and to offer greater range of model structure. Additionally, methods of automating 'first pass' model tuning are being added. These methods allow a researcher to explore initial model parameters and view descriptive statistics of MCMC output. Our goal is to provide the researcher guidance in MCMC parameter selection.

Our second major activity has been in developing graphical representations of MCMC model output. Several projects at the center require similar high-dimensional visualization components. These components are being designed to integrate into the Bayesian tutorial and the graphical interface work being done for SPlus, as well as the MCMC model framework. To date, components for viewing histograms, ternary diagrams, and a general data translator to handle several standard data formats have been developed.

Quantitative Literacy Project

PI: June Morita
Center researcher: Peter Guttorp

In conjunction with the outreach activities of the Center, the goal of quantitative literacy for all citizens is important. The main target group for this project is school children and their teachers. The Center has offered minor support to June Morita for her work on activity-based mathematics education. The publication Morita (1999) is a result of this.

3.1.3 Model assessment

Stochastic precipitation model

Co-PIs: Peter Guttorp and Jim Hughes
Center researcher: Chris Bretherton
Research assistant: Enrica Bellone

In assessment of global warming, much use is made of deterministic models of general atmospheric and oceanic circulation. These general circulation models generally are on too coarse a scale to produce realistic precipitation scenarios on local (or meso-) scales. We are developing stochastic models of precipitation that use atmospheric pressure and temperature data as input, and produce precipitation forecasts at observation stations or at unobserved sites as output.

Enrica Bellone, a graduate student in the department of Statistics and funded by the NRCSE, has been working under the supervision of NRCSE members Peter Guttorp and Jim Hughes to develop such models. In previous work Hughes et al (1998) developed a nonhomogeneous hidden Markov model for relating precipitation occurrences to atmospheric circulation. The present work extends these results to include precipitation amounts. Preliminary results were presented at the Sixth International Conference on Precipitation (Bellone et al, 1998, contributed poster) and a manuscript is in preparation. Related work has been carried out by NRCSE member Jim Hughes and colleagues from Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO). Bryson Bates and Stephen Charles, both of the CSIRO Land and Water Division in Perth, Australia, visited the NRCSE in June of 1998 to work with Dr. Hughes on developing models for downscaling precipitation in western Australia. Preliminary results on this work were presented at the Sixth International Conference on Precipitation (Charles et al., 1998b, contributed) and two manuscripts have been submitted (Charles et al., 1998a, Charles et al., 1998b)

Assessment of environmental fate and transport models

Co-PIs: Alison Cullen and Adrian Raftery
Center researcher: Chris Bretherton
EPA researcher: Allan Marcus
Research assistant: Samantha Bates

A Superfund clean-up is underway at the New Bedford Harbor site in Massachusetts, where marine sediments are contaminated with poly-chlorinated biphenyls (PCBs). Harbor dredging at the site and subsequent transport and deposition may result in human exposure via air, soil and ingestion of locally grown foods. Sampling of households and farms around the site in 1994 and 1995 yielded produce, air and soil samples which in turn provided measurements of PCB concentration in soil, outdoor air and root, leafy and vine plants. A probabilistic exposure assessment in which average annual exposure to local inhabitants is assessed, is underway at the site. This assessment requires distributions for PCB concentration in soil and in root, leafy and vine plants. The work has resulted in one paper: Vorhees et al., 1997. In the coming year, the Bayesian technique will be used to incorporate both prior knowledge and likelihoods in order to find posterior distributions of PCB concentration in leafy, root and vine plants.

Ongoing collaboration between Cullen and Bretherton involves improving the development of distributions of contaminant concentration representing annual averages from data in which dependency is present among daily measurements. In a second collaboration, a simple compartmental model for PCB concentration in soil (adapted by Cullen, 1992) serves as the basis for the application of the Bayesian Synthesis method of Raftery. This method incorporates both prior knowledge and likelihoods for the soil model inputs and a likelihood for the soil model output in order to find posterior distributions of PCB concentration in soil. It uses Monte Carlo simulation from the prior distributions for the model inputs and resamples these with weights determined by both the air and soil likelihoods. In this way, the posterior distribution of PCB concentration in soil incorporates both expert/prior knowledge of the model inputs and the observed data.

In December 1998 at the Society for Risk Assessment (SRA) Annual Meeting in Arizona, Bates will present a paper titled "A Bayesian Synthesis Approach to assessing exposure to PCBs in New Bedford Harbor," co-authored by Cullen and Raftery. Bates received a Student Travel Award from the SRA for this work. Cullen will present a paper entitled "Developing Distributions of Annual Average Concentration with Dependency among Daily Values," co-authored by Christopher Bretherton.

Particulate matter field study in Slovakia

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PI: Alison Cullen
Collaborator: Michael Brauer, UBC, Canada; Eleanora Fabianova, Eva Mikhalikova, Peter
Miskovic, Frantiska Hruba, SUHE, Slovakia.
EPA researcher: John Vandenberg

Recent interest in the levels of and health effects associated with airborne particulate matter expo-
sure have sparked studies in the US and worldwide. Working with local scientists we are exam-
ining new measurements of PM2.5 taken by personal monitors in occupational settings, both in-
dustrial and office type, and in the home, by researchers at the SUHE (Institute for Epidemiology
and Hygiene) in Banska Bystrica, Slovakia. This work also involves Michael Brauer at UBC and
John Vandenberg at HERL, EPA, and has received funding from the Joint Fund for
US/Czech/Slovak Science and Technology. Regression analyses will be carried out in the com-
ing year to identify factors influencing particulate matter exposure in Slovakia and to support the
standard setting process.

The research team visited Seattle in August 1998 to discuss preliminary results and to plan next
steps. At this meeting the group prepared a talk for the ISEA (International Society of Exposure
Analysis) annual meeting in Boston. The talk entitled "US-Slovak Cooperation in Environmental
Health Risk Assessment: Preliminary Estimates of Personal Exposure to Particles and NO2 in
Banska Bystrica, Slovakia " was presented by Eva Mikhalikova. Further analysis was planned
and a talk describing additional analyses will be presented by Frantiska Hruba at the Society of
Risk Analysis Annual Meeting in Phoenix in December 1998.

At the request of EPA's Vandenberg, NCRSE hosted additional meetings between the visitors and
researchers from UW involved in PM work including: Jane Koenig, Tim Larsen, Lianne Shep-
pard, Sally Liu, and Dave Kalman, as well as Tim Nyerges of UW Dept. of Geography's GIS in
decision making group. During these sessions Vandenberg highlighted the interests and needs of
EPA anticipated in this area.

Operational evaluation of air quality models

PI: Paul Sampson
EPA connections: Sharon LeDuc, Brian Eder, Larry Cox
Center researchers: Peter Guttorp, Joel Reynolds, Wendy Meiring
Research assistants: Ruth Grossman, Doris Damian

This project aims at developing tools for model assessment, using model runs from the SARMAP
air quality model for the San Joaquin Valley in Central California. The model assessment work
focuses on fitting a nonstationary space-time covariance structure to observed data, and using this

covariance to estimate (with specified uncertainty) the ozone levels in the grid squares for which the model produces output. We will pursue these ideas using RADM and MODELS-3, where longer runs of the model will enable us to also compare the covariance structure of the model output to the covariance structure inferred from the data. The project was presented at the Novartis symposium on environmental statistics in London, and the presentation is available as a technical report (Sampson and Guttorp, 1998).

Recent work (not reported in the symposium-based technical report) includes empirical modeling of temperature effects on the San Joaquin Valley ozone monitoring data for more precise spatial estimates or interpolations. In addition, the development of a Bayesian estimation methodology using Markov Chain Monte Carlo for the nonstationary spatial covariance model of Sampson and Guttorp is under development.

Assessment of toxicodynamic models

PI: Elaine Faustmann
EPA researchers: Woody Setzer and Chris Lay
Center researchers: Brian Leroux, Scott Bartell, Rafael Ponce

1. IEUBK modeling of lead pharmacokinetics

The last twenty years have seen the development of numerous models for predicting the kinetics of lead in the human body. These models are necessary because health effects have historically been linked to specific blood lead concentrations, while pollution control and industrial hygiene efforts are most easily directed at environmental (e.g. air, water, soil, and food) lead concentrations. Exposure models and toxicokinetic models provide the quantitative link between environmental concentrations and biomarkers such as blood lead concentration.

Toxicokinetic models are particularly useful when toxicant exposure patterns are temporally complex or when the distribution of a toxicant in the body is significantly affected by physiologic changes such as normal human growth, pregnancy, and aging. Childhood lead exposure kinetics appear to be influenced by both temporal complexity and normal physiologic growth. In addition, children are particularly susceptible to the neurotoxic effects of lead, which may include increased blood pressure, colic, encephalopathy, intelligence quotient deficit, and aggressive behavior . Because of these factors, and because children typically engage in mouthing behavior that results in higher lead exposures than for most adults, childhood lead toxicokinetic models play a prominent role in regulatory decisions and standards regarding environmental lead.

EPA requested that the NRCSE review childhood toxicokinetic lead models and suggest additional validation strategies. The agency is particularly interested in validation of its own model, the Integrated Exposure and Uptake Biokinetic lead model (IEUBK), which predicts blood lead concentrations for children ages 0 to 7 based on environmental lead concentrations.

One of the most controversial parameters in exposure models is the soil ingestion rate. Experimental estimates are usually determined from tracer studies, in which aluminum, silicon, titanium, and other rare earth elements are measured in the diet, urine, and feces. Steady state conditions are assumed, and mass balance approaches are used to estimate the rate of soil ingestion. Soil ingestion rate estimates derived in these studies vary by several orders of magnitude, appear to fluctuate daily for each monitored individual, and are highly dependent on the tracer and statistical model selected .

An alternative to the tracer study is the use of pollutant biomonitoring studies that include environmental measurements. We have obtained data from one such study, the Urban Soil Lead Abatement Demonstration Project (USLADP), in which children's blood lead concentrations were monitored for two years following the replacement of contaminated yard soil with soil with lower lead content . A perturbation analysis is being conducted using a previously developed toxicokinetic model (Bartell, 1996) to estimate a soil ingestion rate for each child in the USLADP study. The model includes a probabilistic uncertainty analysis component that assesses the impacts of parameter uncertainty of each child's predicted soil ingestion rate.

We have recently completed the model runs for this analysis, and are now compiling the results. We are preparing "Estimation of soil ingestion rates from observed blood lead loss following soil remediation" for submission to *Environmental Health Perspectives* by January 31, 1999. Results will also be presented as "Uncertainty and variability in childhood soil ingestion rates estimated from USLADP blood lead levels" at the International Society for Risk Analysis annual meeting in 1999.

*2. A toxicodynamic model of 5-fluorouracil-induced developmental neuro*toxicity in the fetal rat

The chemotherapeutic agent 5-fluorouracil (5-FU), and other fluoropyrimidines, are known teratogens in a number of species. Among the most prevalent developmental effects of fluoropyrimidine exposure are dose- and stage- dependent hindlimb effects. Shuey et al reported a sequential biochemical and cellular alterations following 5-FU exposure in the developing limbs (Shuey et al., 1994). These effects elicited by 5-FU were later integrated into an empirical model (Shuey et al., 1994).

A biologically-based dose response model for developmental toxicants has been developed by Leroux et al. (1996). Unlike other empirical models, this model simulates developmental out-

comes based on stochastic probability distribution of crucial developmental events such as cell differentiation, cell cycle and cell death. The pattern of malformation rate is predicted as a function of critical number of committed cells in a both dose- and time-dependent fashion. Because this model incorporates events that are common targets of many developmental toxicants, the potential application of this model to simulate the toxicity of other developmental toxicants is implicated.

The goal of current studies are to apply the Leroux model to simulate the developmental toxicity of 5-FU and methylmercury . Evaluation of the model parameters for 5-FU toxicity will be largely based on experimental data reported by Shuey et al. (1994) and other recent work from Dr. Setzer's group.

The framework of the model for the developmental toxicity of 5-FU is based on the original Leroux model. Digit agenesis at term will be used as the developmental toxicity endpoint, and will be modeled in a function of cell numbers of committed Y cell on Day 17. By use of *in vivo* data from the literature and the *in vitro* laboratory studies (Shuey et al., 1994), four types of model parameters were evaluated: (1) cell numbers during gestational Day 14 to Day 17; (2) cell transformation rate; (3) cell death rate; (4) cell cycling rate.

Recent experimental findings pertaining to the current modeling work were requested via email from Dr. Setzer's group.

Dr. Setzer's group forwarded their recent results on the effect of 5-FU exposure on cell cycle distribution. For example, their studies demonstrated an increased percentage of cells in the S phase, accompanied by a decrease in the G1 phase following 5-FU treatment. This information, however, did not indicate the alteration of cell cycle kinetics, or cell cycling rate by 5-FU. To obtain the cell cycling rate of control and 5-FU exposed limb cells, a critical model parameter of Leroux model, several assumptions have to be made as discussed in the following sessions.

Although their recent results included a complete measurement of the total protein and DNA, they were measurements form the whole embryos. To calculate cell numbers in the developing limb, protein values of embryonic limb from their previous publication (Shuey et al., 1994) were used.

Studies are currently underway in Dr. Setzer's group to determine the pharmocokinetics behavior of 5-FU. A simple PK model has been developed. Once their studies are complete, information on actual concentrations available to fetus during gestational Day 14 to Day 17 will be useful in further refining the current model.

3. A linked toxickinetic-toxicodynamic model of methylmercury-induced developmental neuro-toxicity in the fetal rat

Previous work conducted in this laboratory has led to the development of a toxicodynamic model of methylmercury-induced developmental neurotoxicity. Methylmercury is a naturally occurring organometal that is of concern because of the large population exposed through fish consumption and because epidemiological studies implicate even low levels, such as those expected among subsistence fish consumers, with adverse neurobehavioral development. Because the toxicodynamic model that has been developed is biologically based, it may be generally applied to agents that cause developmental toxicity through interference with cell proliferation. Such models could also allow cross-species extrapolations based on the incorporation of species-specific rates in model variable parameters; future applications of the pharmacodynamic model to other developmental neurotoxicants such as 5-fluorouracil should allow us to explore these issues. Such biologically-based models can thus reduce uncertainty, identify research needs, and improve estimates of developmental risks to humans from environmental exposures.

During the last year we have performed simulation testing of model variables to assess model sensitivity. We have examined all model assumptions and variable parameter estimates to determine their impact on model predictions. This analysis demonstrated sensitivity of the model to both the rates of cell division and the assumption of the critical number of cells for proper mid-brain functioning. Example results from this sensitivity analysis are presented in the appendix. Of interest are refining estimates of the number of starting cells in the GD 12 rat midbrain, estimation of the fraction of cells dividing over GD12-17 (currently assumed to be a constant 55%), refined estimates of cell division over GD12-17, and improved methods for identification of differentiating cells.

To complement the existing toxicodynamic model, Mr. Lewandowski and others have developed a toxicokinetic model to predict maternal and fetal disposition of methylmercury during gestation; this toxickokinetic model is linked with the existing toxicodynamic model (see paper in appendix for diagrams and detailed description). The idea underlying the development of such a biologically based toxicokinetic-toxicodynamic model would be that one could relate a whole body dose, that is delivered by various routes of exposure, to an observable effect on the developing fetus.

The linking of the toxicokinetic and toxicodynamic elements of the model occurs using recursive model solutions over short intervals of time. For any given methylmercury dosing pattern, the fetal brain methylmercury concentrations predicted by the toxicokinetic model during each time step is used by the toxicodynamic model in propagating the effects of exposure on cell death, dif-

ferentiation or division. Because maternal and fetal physiology change as gestation proceeds, parameters for model variables are adjusted to account for fetal growth and gestational stage. This is an important development to the model because many of the toxicokinetic and toxicodynamic properties used to parameterize model variable change as gestation proceeds. This modeling effort serves as the basis for Mr. Lewandowski's dissertation research. Preliminary results of these efforts have been presented at the Society of Toxicology Annual Meeting, 1998 and the IUTOX Congress, 1998.

Developing methodology for assessment of medium and large scale environmental models

PI: David Ford
EPA researchers: Sharon LeDuc, Bill Benjey
Center researcher: Joel Reynolds
Research assistant: Marianne Turley

During the past year our principal task has been to develop software, and an associated manual, for Pareto Optimization of ecological models. There have been three component tasks: (i) development of an improved evolutionary search software for the Pareto front, (ii) development of an appropriate ecological computer model for use in conjunction with the manual, (iii) writing the manual itself.

(i) *Development of improved evolutionary search software for the Pareto front: POMAC_Evolve.*

An evolutionary computation optimization program, POMAC_Evolve, was developed and coded. While some of the data structures and general program outline were adapted from earlier prototype code (Reynolds, 1997), deficiencies were found which necessitated the selection of a new search algorithm and subsequent complete code redevelopment and writing.

The algorithm used in the prototype code was found to be susceptible to 'genetic drift' - the stochastic search became unduly focused on a small region of the parameter space. As the goal of POMAC is to survey the full Pareto Front rather than just find a restricted region of the Front, it was essential to revise the fitness assignment to each parametrization in order to avoid restricting the optimization search too quickly to a small region. The technique of fitness sharing (or niche sharing), which basically downweights the fitness measure of a parametrization by a function of how many other parametrizations are 'nearby' in the objective or criteria space, was incorporated into the new code in order to overcome this difficulty.

POMAC_Evolve searches out a model's Pareto Optimal Front using a non-dominated sorting algorithm (Srinivas and Deb, 1995), the most promising evolutionary computation multi-objective optimization algorithm appearing in our review of the current literature. The code is running and undergoing debugging and initial algorithm investigation.

(ii) *Development of an appropriate ecological computer model for use in conjunction with the POMAC software and manual.*

It is important that the POMAC manual be instructive, not only in how to use the technique but for its scientific value. This can best be done by applying the technique to an existing model but one that is simple enough for readers to understand but sufficiently complex that problems with the more usual types of model assessment can be illustrated.

During the past year, the plant competition model from Ford and Diggle (1981) has been translated from FORTRAN to C to be the working program for testing the POMAC program. This is a frequently cited model in the ecology literature. Unusually for ecological models parameter values were obtained using Simplex optimization against an integrated measurement of the outcome of competition. The model code is included with the manual as a sample for users. It has been well annotated so that users unfamiliar with the C language may be able to discern the structure and flow of the program.

(iii) *The POMAC manual.*

The target audience for the POMAC software is ecological and environmental modelers many of whom have had little or no instruction in optimization. The manual starts with a definition of the problem of optimization and illustrates some important features of how it can be used, e.g., that a single assessment criterion must be selected, and then proceeds to illustrate why considering multiple assessment criteria can be valuable.

Model assessment using repeated model fitting

PI: David Ford
Research assistant: Zoe Edelstein, University of Chicago undergraduate.

An important problem in the assessment of ecological and environmental models is that of repetition of the complete process of model fitting to new data sets. Where second data sets are available they are not treated as replicates but typically the question is asked: "Using the same set of parameters as obtained from fitting to the model to the first data set (i.e., obtained during calibration) does the model fit the second set?" This is referred to as validation. That such a procedure

is not "validation", in the sense that a "successful" fit renders the model to be "true" is now generally accepted. But the question remains of what value a "second" data set is. A similar problem is faced when modelers take a single data set and break it in two and "fit" the model to one segment and seek to "test" the model against the second.

We have available a process model of plant competition that is fit to experimentally obtained data. The model has many characteristics of typically ecological and environmental models: it is stochastic and it predicts changes in the system modeled over time. Over the summer we conducted glasshouse experiments to provide two further instances of the data so that we now have four. We can now fit the model to obtain four sets of fitted parameters. We intend to treat these parameter sets as members of an ensemble and explore how such ensembles can be treated, both statistically and in interpretation of the system being modeled. This approach, of considering repetitions of the data as each producing a set of fitted parameters, brings a different perspective to the concept of model assessment that we will develop in future. The situation is similar to fitting a time series model to repeated realizations of a time series, though with an important difference. In time series from ecological systems the variation is often such that the order of the model changes, not necessarily by a great deal but sufficient to complicate comparison between model fits. In process models the structure of the model remains constant.

3.1.4 Space-time models

Imputing air pollution exposure over space and time for use in analyses of health effects

PI: Lianne Sheppard
Center researchers: Peter Guttorp, Paul Sampson
Research assistant: Doris Damian

A Bayesian approach to imputing air pollution exposure data is applied to monitoring data from Seattle. We are developing methods that allow for data missing at random due to temporary equipment failure and for data missing by design over time. Our focus is on methods that are computationally feasible for multiple years of daily observations from multiple monitoring stations.

During the year, progress has made assimilating the data set and developing a model for PM in the greater Seattle metropolitan area. We have also turned our attention to the health effects modeling aspect and discussed integrating the exposure modeling into that effort.

Statistical analysis of surface ozone

PI: Paul Sampson
Washington Department of Ecology researchers: Chris Figueroa-Kaminsky, Clint Bowman
Center researchers: Peter Guttorp, Joel Reynolds
Research assistants: Barnali Das

The NRCSE/ Washington Department of Ecology jointly sponsored project to adjust meteoro-logically the surface ozone network observations for Western Washington over the last 20+ yrs and assess time trends has been completed. Besides the results of the analysis, of interest to re-searchers and agency managers in the region, the project produced a new methodology, canonical covariance analysis (based on using the singular value decomposition), for meteorological ad-justment of surface ozone observations when presented with both a spatial network of ozone monitors and a spatial network of meteorological stations.

During the year the project has resulted in one presentation (by Barnali Das at 7IMSC) and one technical report (Reynolds et al., 1998) on the methodological developments and the subsequent results. The technical report will be submitted for publication, but the authors are awaiting the completion of a second application of the methodology to data from the Chicago metropolitan area (see the review paper description below).

A review of statistical adjustment of ozone for meteorological variables

Co-PIs: Joel Reynolds, Peter Guttorp, Paul Sampson, Mary Lou Thompson
EPA researcher: Larry Cox
Research assistants: Barnali Das, David Caccia

We are in the process of producing a review of the statistical literature on the meteorological ad-justment of surface ozone observations. The review consists of a summary and an evaluation of the methodologies present in the literature, together with a comparison of four selected methods applied to the Chicago metropolitan ozone data network. This comparison is based largely on an application to 10 years of Chicago area ozone and meteorological data which have been consid-ered in applications of other methods in the literature. As a related project, Joel Reynolds and David Caccia are applying the Canonical Covariance Analysis technique developed for the NRCSE / Washington Department of Ecology ozone adjustment project (see above) to the Chi-cago area observations. A draft of the review has been produced, though the final version awaits completion of the Chicago area analysis.

Modeling time series of multiply censored data

PI: Mary Lou Thompson
EPA researchers: John Warren, David Farrar, Timothy Barry
Center researcher: Bruce Peterson (Terastat)
Research assistant: Kerrie Nelson

The statistical practices of chemists are designed both to minimize the probability of mis-identifying a sample compound and the probability of falsely reporting a detectable concentration. In environmental assessment, trace amounts of contaminants of concern are thus often reported by the laboratory as "non-detects" or "trace", in which case the data may be multiply left-censored. We consider the observations on each individual as being a nonhomogeneous Markov chain with three states: "non-detect", "trace" and "detect". Given the presence of "detect", the distribution of the observed measurements is modeled by some appropriate parametric form. This allows estimation of the parameters of the "detects" distribution and the proportion of censored values as a function of covariates (such as time, rural vs. urban etc.).

There has been considerable interest in this topic from colleagues at the EPA and we have had input from David Farrar and Timothy Barry regarding our research plan for the coming year. Kerrie Nelson, a graduate student in Statistics, has joined the project as an RA. The study generating the time series data that motivated the project is still in progress and we are focusing in the meanwhile on developing and implementing regression techniques for double censored data to a study of children's exposure to pesticides that was carried out in Eastern Washington. We are currently considering a maximum likelihood approach and an extension of the Buckley-James methodology to double censoring.

Development of a global covariance function

PI: Peter Guttorp
Center researcher: Paul Sampson
Research assistant: Barnali Das

When dealing with global stochastic processes (such as temperature), most work to date has (implicitly or occasionally explicitly) been focusing on covariance structures that are isotropic, or rotation invariant. In many situations such an assumption is not reasonable, if only for the fact that Earth has a rotational direction. This project involves finding methods to simulate nonstationary processes on the globe as well as estimating covariances from real data. The work to date has focused on the simulation part. In order to start work at a realistic estimation problem, we have obtained some data from Scott Doney of NCAR.

3.1.5 Sampling and design

**Comparison of ranked set sampling to alternative sampling designs
and investigation of its usefulness in environmental monitoring**

PI: Loveday Conquest
EPA researcher: Barry Nussbaum
Center researcher: David Marker (Westat)
Research assistant: Nicolle Mode

Ranked set sampling (RSS, McIntyre 1952) is a two-phase sampling procedure that reduces the number of samples required from a more exacting and expensive measurement by using expert knowledge or other frugal measurement to select the sampled values. The current project is an extension of work funded by NRCSE for 1997-98 which was completed last summer. The past RSS proposal consisted of three phases [1] literature review of previous work, [2] theoretical examination of RSS, and [3] application to a real data set. Based upon the first phase and in collaboration with statistical scientist Barry Nussbaum at EPA, we focused upon cost analysis of RSS for normal and skewed data (with and without errors in ranking) including a real data set of stream habitat. A paper based on this work (Conquest et al., 1998) has been submitted to the journal *Environmetrics* for publication, and a seminar summarizing our work was given as part of the NRCSE seminar series on May 19, 1998. The current research will compare theory and simulation to real ecological data and give guidelines for researchers and managers to use when designing a study. Specifically, we will investigate the cost-effectiveness of ranked set sampling on real ecological data sets, investigate a modified RSS estimator for use with ecological data, and give specific information for researchers that want to use RSS in the field.

3.1.6 Standards and Regulatory Impact

Statistical aspects of setting and implementing environmental standards

Co-PIs: Peter Guttorp, Paul Sampson, Mary Lou Thompson
EPA researcher: Larry Cox
Research Assistant: David Caccia

The debate surrounding the change in ozone standards illustrates many of the difficulties in translating scientific studies into practical policy decisions. This projects studies ways of setting standards that makes use of the information available in a way that takes proper account of un-

certainties in knowledge and understanding of the process, in measurement of the pollutants, and in enforcement rules. While the initial work has focused on ozone and particulate matter data, the intent is to produce a methodology that can be applied to a variety of environmental concerns. Products of this project include presentations at the Novartis workshop on Environmental Statistics in London (Larry Cox), at the Joint Statistical Meetings in Dallas (Mary Lou Thompson), and at the Newton Institute workshop on Environmental Statistic and Technology (Larry Cox). A paper has been produced for the proceedings of the Novartis workshop (Cox et al., 1998).

We are also considering questions of statistical monitoring network design and their relevance to siting of air quality monitors in the context of air quality standards. Presentations on the background issues were presented by Paul D. Sampson at the Joint Statistiscal Meetings in Dallas and in the NRCSE seminar series this past fall. In addition, new approaches to simulated annealing calculations for optimal monitor siting are being developed by David Caccia.

Environmental health regulation of particulate matter:
Application of the theory of irreversible investments

PI: Michael J. Phelan

Environmental health policy decisions are characterized by irreversibility and uncertainty of an economic, ecological and biomedical nature. Economic analysis of problems of this kind fall within the framework of the theory of irreversible investments as applied to the sunk costs and sunk benefits of environmental regulation. The proposed research describes an application of the basic theory to problems associated with the regulation of particulate matter in environmental health policy.

The first line of investigation models the social costs of regulation in light of current scientific, medical and economic understanding of problems associated with particulate matter. A particular emphasis is given to representation of health effects. All such models involve however some uncertain parameters, so a second line of investigation integrates modern practices of stochastic inference with sequential policy designs. An important goal is to characterize fully the role of uncertainty and information on the design and implementation of policy, particularly learning strategies designed to address key uncertainties. The analytical tools will be implemented numerically using MATHEMATICA.

The research has produced a technical report, Phelan (1998).

3.1.7 Working groups

Much of the cross-disciplinary work at the Center is done in working groups that meet at regularly scheduled times (weekly or less frequently, depending on the group). The precipitation group, the health effects group, the standards group and the ozone groups have regularly scheduled meetings which are announced on the web page and open to any interested members of the campus community.

3.2 Visitors

It is the stated intent of the Center to have a vigorous and stimulating visitors program. The visitors during the second year included

- Wendy Meiring, NCAR (work on software implementation; with Sampson and Guttorp)

- Dean Billheimer, Boeing (work on Markov chain Monte Carlo and on biological monitoring; with Guttorp)

- Phillippe Jamet and Jasha Osterbaan, Ecole des Mines de Paris, France (deterministic models; environmental characterization; with Sampson)

- Steve Smith and Bryson Bates, CSIRO, Perth, Australia (work on precipitation modeling; with Hughes)

- Peter Green, University of Bristol, UK (Markov chain Monte Carlo; with Guttorp and Hughes)

- Chris Glasby, University of Edinburgh, UK (image warping; with Sampson)

- Michael Phelan, Chapman University (environmental economics; joint with Statistics department)

- Noel Cressie, Iowa State University, and Merlise Clyde, Duke University (particulate matter air pollution; with Sheppard, Guttorp, Van Belle, Thompson and Sampson)

- Per Sørensen, Technical University of Denmark (remote sensing image processing; with Sampson and Ford)

- Eva Mikhalikova, Peter Miskovic, Frantiska Hruba, SUHE, Slovakia (particulate matter monitoring; with Cullen)

We are continuing to pursue invitations to prominent researchers to visit the Center for short or extended periods of time. During the academic year 1998-9 Merlise Clyde from Duke University will be on a sabbatical leave at NRCSE to pursue research interests in Bayesian model selection and particulate matter air pollution, and Di Cook from Iowa State University will be visiting for six weeks during Autumn 1998, working on high-dimensional dynamic graphics with environmental applications.

3.3 Research products

The following is a partial list of Center funded research products during the year.

Billheimer, D., Guttorp, P. and Fagan, W. F. (1998): Statistical Analysis and Interpretation of Discrete Compositional Data. Submitted to *Journal of the Royal Statistical Society.*

Bowling, L., Storck, P., and Lettenmaier, D. P. (1998): Assessment of the hydrologic effects of logging in the Pacific Northwest. Submitted to *Water Resources Research*, 1998.

Charles SP, Bates BC, Whetton PH, Hughes JP (1998a) Validation of downscaling models for changed climate conditions: case study of southwestern Australia. Submitted to *Climate Research.*

Charles SP, Bates BC, Hughes JP (1998b) A spatio-temporal model for downscaling precipitation occurrence and amounts. Submitted to *Journal of Geophysical Research*.

 EF Melvin, JK Parrish, LL Conquest (1998): Novel Tools to Reduce Seabird Bycatch in Coastal Gillnet Fisheries. Submitted to *Conservation Biology*.

Lawrence H. Cox, Peter Guttorp, Paul D. Sampson, David C. Caccia and Mary Lou Thompson (1998) A Preliminary Statistical Examination of the Effects of Uncertainty and Variability on Environmental Regulatory Criteria for Ozone . To appear in a volume on Environmental Statistics published by the Novartis Foundation.

Cullen, A. and Frey, H. (1998): *Probabilistic Techniques in Exposure Assessment: A Handbook for Dealing With Variability and Uncertainty in Models and Inputs*, Publishing.

Hughes JP, Guttorp P, Charles SP (1998) A nonhomogeneous hidden Markov model for precipitation. *J. Royal Stat. Soc.*, Series C, in press.

L. Kirkland, D. Hoffmeyer, H. Allender, L. Zaragoza, J. LaVeck, T. Barnwell, J. Fowle, J. Rowe and D Ford (1988): Science Policy Council Model Acceptance and Peer Review White Paper Working Group. *The Nature and Scope of Issues on Adoption of Model Acceptability Criteria.* EPA DRAFT.

Lewandowski, TA, Bartell, SM, Pierce, CH, Ponce, RA, and Faustman, EM (1998) Toxicokinetic and toxicodynamic modeling of the effects of methylmercury on the fetal rat [abs.]. *The Toxicologist*, **42**(1-S), No. 683.

Lewandowski, TA, Bartell, SM, Pierce, CH, Ponce, RA, and Faustman, EM (1998) Effect of tissue binding uncertainty on a PBTK model of methylmercury in the fetal rat [abs.]. *Toxicological Letters*, **95**(Suppl. 1), No. P2F148.

Mode, N., Conquest, L. and Marker D. (1998): Ranked set sampling for ecological research: Accounting for the total cost of sampling. Submitted to *Environmetrics.*

Morita, J.M. (1999): Capture and Re-Capture Your Students' Interest in Statistics. Submitted to *Mathematics Teaching in the Middle School.*

Greg Nothstein, Dave Kalman, Gerald van Belle, Gardner Brown, Tim Larson (1988): An Evaluation of Public Willingness to Pay for Improvements in Visibility and Air Quality in the Pacific Northwest.

Phelan, M. (1998): Environmental health policy decisions: the role of uncertainty in economic analysis. NRCSE Technical Report NRCSE-TRS No. 12.

Reynolds, Joel H., B. Das, P. D. Sampson, P. Guttorp (1998): Meteorological Adjustment of Western Washington and Northwest Oregon Surface Ozone Observations with Investigation of Trends. NRCSE Technical Report NRCSE-TRS No. 15.

Reynolds, J. H., E. D. Ford (1999): Multi-Criteria Assessment of Ecological Process Models. *Ecology* **80**(2).

Reynolds, Joel H. (1998): Causal Systems in Ecology. Letter in reply to Science's Compass essay. *Science*, 15 May, **280**: 988-989.

Sampson, P. D. and Guttorp, P. (1998): Operational Evaluation of Air Quality Models**.** To appear in a volume on Environmental Statistics published by the Novartis Foundation.

Steel, E. A., and Guttorp, P. (1998): Modeling juvenile chinook salmon migration using a simple Markov chain. Submitted to *Journal of Agricultural, Biological and Environmental Statistics.*

Sheppard L, Levy D, Norris G, Larson TV, Koenig JQ (1999). Effects of ambient air pollution on non-elderly asthma hospital admissions in Seattle, Washington, 1987-1994. *Epidemiology*, Jan 1999.

Vorhees , D.V., Cullen, A.C. and L.M. Altshul (1997) Exposure to Polychlorinated Biphenyls in Residential Indoor Air and Outdoor Air Near a Superfund Site, *Environmental Science & Technology*, **31**:3612-3618.

4. Administration

The fairly simple administrative structure of the Center seems to be sufficient to allow Center business to be performed smoothly. No additional administrative staff is currently contemplated.

4.1 New members

The following new members have been elected during the year:

Chris Bretherton, Applied Mathematics and Atmospheric Sciences.
Patrick Heagerty, Biostatistics.
June Morita, Statistics and Management Science.
Joel Reynolds, Statistics.
John M. Wallace, Atmospheric Sciences.

4.2 Advisory and Executive committees

4.2.1 Advisory committee

The Center advisory committee, as outlined in the original Center proposal, consists of three representatives of statistical professional organizations, and three representatives of the US Environmental Protection Agency. The main purpose of this committee is to assist the Center director

and its executive committee to extend the vision and scope of the Center activities. The advisory committee currently has three members: Paul Switzer (Stanford University) representing the Institute for Mathematical Statistics; Abdel El-Shaarawi (Canadian Inland Waters Institute) representing the International Environmetric Society; and Lawrence Cox, representing the American Statistical Association. The US EPA has not yet chosen any representatives to the committee.

The advisory committee met with acting director, Paul Sampson, during the Joint Statistical Meetings in Dallas in August, 1998. Agenda items prepared for review at the meeting were: the 1997-98 annual report; the upcoming events at NRCSE, including the PM Workshop scheduled for October and a workshop with EPA researchers tentatively planned for February, 1999; plans for the next Executive Committee election; an update on the NRCSE Newsletter; plans for the revamped NRCSE weekly seminar series; and a review of the office space situation for NRCSE in Bagley Hall. Other specific topics of discussion included the relationship between NRCSE and NISS, and the relationships between NRCSE researchers and EPA personnel. In particular, Sampson explained the Center's intention to require in future member proposals explicit plans for Center researchers to visit and make presentations at EPA labs.

Paul Switzer reported on his attendance at the EPA statistician's meeting. Larry Cox was positive on plans for the next EPA workshop and encouraged setting dates as soon as possible. He emphasized the importance of journal publications in the assessment of the Center. He also supported publication of NRCSE seminars and videotaping of both the upcoming PM workshop and the planned EPA workshop.

 On the subject of the current focus on particulate matter research, Larry Cox noted that NRCSE might be considered as a "sixth PM center" in addition to the 5 PM centers that are soon to be established. Whether to strive for this status, or to consider an explicit link with one of the 5 PM centers (once awarded) should be considered. There was also discussion of the Federal Advisory Committee Act and NRCSE's possible relationship with, or contributions to the sub-committee on environmental statistics. Cox suggested that NRCSE might write a "white paper" on particulate matter statistical issues based on the upcoming workshop with suggestions to the agency.

 On other topics, it was noted that if the Center had plans to move beyond its current situation as a primarily EPA-based (or EPA-limited) center, this is the year to do the planning. Paul Switzer noted some of the environmental areas that are not major research foci, including groundwater and toxic waste [although there is some work in these areas on campus, especially toxic waste in connection with the CRESP program]. Abdel El Shaarawi suggested that the Center bring in people/researchers from other agencies.

4.2.2 Executive committee

The task of the executive committee is prioritizing research proposals in order to advise the director on funding decisions; to elect new members of the Center; and to assist the director in setting goals and directions of Center activities. This committee is elected by the membership, generally to three year terms. Current members are Alison Cullen (Public Affairs), David Ford (Forestry), Paul Sampson (Statistics), and Gerald Van Belle (Environmental Health). Sampson's and Van Belle's terms expire at the end of year 2. The agendas and decisions of the executive committee meetings are recorded on the web site http://www.stat.washington.edu/NRCSE/ people/execcom.html.

4.3 Space

The Center has been allocated permanent space on the fourth floor of Bagley Hall. This space is shared with the Program on the Environment and the graduate program in Quantitative Ecology and Resource Management. The intent of the Center is that all researchers (including research assistants) who so wish may have access to a desk at the Center, adequate computing equipment and support, and reasonable office support. In addition, most visitors would be housed at the Center, although long-term visitors working with a Center member who does not use Center facilities may be housed in the member's department or laboratory.

4.4 Hiring

The Center has recently hired its first postdoctoral research fellows: Eun Sug Park from Texas A&M, and Kevin Brand from Harvard University. Dr. Park will be pursuing problems in identification of polluters from monitoring profile data, while Dr. Brand will be working on problems associated with human health risk analysis.

4.5 Relations to other statistical research groups

4.5.1 NCAR (National Center for Atmospheric Research)

Many of the activities in the Geophysical Statistics Project at NCAR, directed by Doug Nychka, are related to Center research activities. For example, work on precipitation modeling, covariance modeling, and global climate modeling is closely related to work at the Center. We are currently working on posting software of interest to both groups on the Web,

4.5.2 NISS (National Institute for Statistical Sciences)

There are close research links, particularly in the area of air quality modeling, between NRCSE and NISS. We intend to strengthen these links by having annual joint workshops or symposia in environmental statistics, by cooperating in major research proposals, and by exchange of researchers and postdocs. For example, the Center participated in a proposal to the National Science Foundation for funding for a Mathematics Research Center in Statistics, housed at and organized by NISS.

5. Forward view

One of our main themes during year 3 of the Center will be research on particulate matter (PM) air pollution. The implementation of the PM-2.5 standard in 2002 means that quality research on health effects, monitoring network design, the spatial distribution of PM-2.5 and its relation to other air pollutants can have profound impact on the setting of the standard. Among the activities planned for the year are:

- PM science workshop October 19-22, 1998
- PM focus of the presentations in the Autumn quarter seminar series
- A directed research program, with additional funding from the EPA, involving researchers from North Carolina, Ohio State, Iowa State, Duke, Washington, Chapman and the EPA. The first aim is a special issue of *Environmetrics.*
- Two long-term visitors with PM focus: Merlise Clyde from Duke, and Allan Marcus from the EPA.
- A panel discussion on research direction for PM work at the Joint Statistical Meetings in Baltimore next August.

We intend to have similar focus activities in future years.

The EPA will be judging the Center performance at the end of year 3. Consequently it is of utmost importance that Center researchers cooperate with EPA researchers, and that work done at the Center is viewed as relevant to the EPA mission. We are currently discussing a variety of ways of informing the EPA community of our work, and the implementation of such plans will receive high priority during the year.

In addition to the PM workshop mentioned above, we are considering running workshops in other topics, including the meteorological adjustment of air pollution data, and sampling techniques for environmental monitoring.

The Center is being considered as organizers for the 2001 Environmetrics conference. The planning work will probably start during the coming year.

We are anticipating a continuing increase in the interest from researchers to visit NRCSE. In addition we put considerable effort into inviting researchers whose work fits well in with or complements Center research work. The system whereby the Director can make quick decisions on short visits has worked well, and will continue.

We intend to experiment with CD production of interesting software, tutorials, and workshops. For example, we anticipate to be able to distribute virtually all of the presentations at the PM workshop on a CD using a format similar to that used on the seminar web page. The CD will be made available to the community at cost or free.

The executive committee has discussed the possibility of producing a series of position papers on important issues in environmental statistics. It will probably be necessary to contact a commercial publisher to produce this series. Another possibility is to maintain an electronic environmental statistics journal, perhaps in conjunction with ASA and TIES.

Appendix A. Seminars

AUTUMN QUARTER 1997

October 7: James B. Hatfield, Hatfield and Dawson Broadcast and Communications Consulting Engineers. "Electromagnetic Fields and Human Health"

October 14: Tony Rossini, University of South Carolina, "ESS and Literate Programming: Computer Environments for Effective Statistical Programming and Data Analysis"

October 21: Jeffrey Richey, UW Oceanography, "PRISM and the NRCSE: A (Spatial) View to the 21st Century in Puget Sound"

October 28: Doug Bright, Royal Roads University, Victoria, BC. "Environmental Science and Management in the Georgia Basin Coastal Zone: Tales of a Bottom Feeder"

November 4: James Hilden-Minton, National Institute of Statistical Sciences, "Multilevel Monitoring of Drinking Water Systems"

November 18: George Hampson, Woods Hole Oceanographic Institute. "Land Development vs. Environmental Health of a Small New England Island. Nantucket Harbor Study: Benthic Animal Communities and Habitat Quality"

November 25: William Lavely, UW International Studies and Sociology, "Infant Mortality in China: A Multilevel Model"

December 2: Marina Alberti, UW Urban Design and Planning, "Measuring Urban Sustainability"

December 9: Robin Matthews, Western Washington University, "Problems and Issues in Quantifying Ecological Risk"

WINTER QUARTER, 1998

January 13: Richard C. Pleus, Ph.D., Senior Toxicologist and Principal, Delta Toxicology/Intertox, "Foul odor or adverse health effect? Odor investigation of a Portland cement plant"

January 27: Dr. Robert Francis, Professor, UW School of Fisheries, "Climate and Large Marine Ecosystems: A Statistical View"

February 3: Dr. Thomas M. Leschine, Assoc. Prof, UW School of Marine Affairs, "Ranking and Rating Systems in Environmental Management: An Organizational Learning Perspective"

February 10: Dr. Russell P. Herwig, Research Assist. Prof., UW School of Fisheries, "Knock, Knock, Who's There? Microbial Communities in Contaminated Puget Sound Sediments"

February 17: Thomas Lumley, Ph.C., UW Department of Biostatistics, "Marginal regression modelling of space and time data"

February 24: Dr. Joel Reynolds, UW Department of Statistics, "Pareto Optimal Model Assessment and Statistics: Thoughts from applying POMAC to a stochastic process model"

March 3: Dr. Charles Fowler, NOAA, "Sustainability: Empirical Examples and Management Implications"

March 10: Dr. Philippe Jamet, Ecole des Mines de Paris, "Macroscopic phenomenologies and implicit approaches in the quantification of mass transport in the geosphere"

March 24: Jasha Oosterbaan, Ecole des Mines de Paris, "Application of geochemical prospecting and exploratory data analysis methods in characterization at contaminated sites"

SPRING QUARTER, 1998

April 7: Bill Wright, Montgomery Watson Americas. "Application of Statistics and Probability to Environmental Problem Solving With An Emphasis on Risk Assessment: Case Histories and Reflections."

April 14: Manon Faucher, Environmental Adaptation Research Group, University of British Columbia. "The Climatology of Surface Marine Winds Near the Western Coast of Canada."

April 21: Elaine Faustman, Ph.D., Environmental Health, UW.

April 28: Steve Smith, Ph.D., National Marine Fisheries Service. "Factors Affecting Survival and Travel Time of Migrating Juvenile Salmonids in the Lower Snake River."

May 5: Annette Hoffman, Ph.D., Washington State Department of Fish and Wildlife. "A Statisticians Role in Resource Management."

May 12: Andrew Gelman, Department of Statistics, Columbia University, "Statistical issues in home radon mapping and remediation decisions"

May 19: Loveday Conquest, Ph.D., and Nicolle Mode, Quantitative Ecology and Resource Management (QERM), UW. "Ranked Set Sampling—What is it and is it any good?"

May 26: Samantha Bates, Department of Statistics, UW. "The Bayesian Synthesis Approach to Environmental Risk Assessment: Separating Uncertainty and Variability."

June 2: Chris Glasbey, Biomathematics and Statistics Scotland, Edinburgh, "Problems in image warping"

Appendix B. Center member presentations

All presentations are invited talks unless specifically noted.

Peter Guttorp: *A National Research Center on Statistics and the Environment.* University of California at Berkeley Statistics colloquium, February, 1998.

T. A. Lewandowski: *Toxicokinetic and toxicodynamic modeling of the effects of methylmercury on the fetal rat.* Society of Toxicology annual meeting, March 1998.

Peter Guttorp: *Some research problems in environmental statistics* and *Some research approaches in environmental statistics.* Centre de Recherches Mathématiques Workshop on Applications of Spatial Statistics in Earth, Environmental and Health Sciences, Montréal, April 1998.

Paul Sampson: *Tropospheric Ozone, Air Quality Standards, Photochemical Models and Air Quality Monitoring Data* and *Spatio-Temporal Statistical Modeling of Hourly Tropospheric Ozone Data for Operational Evaluation of a Photochemical Model.* Centre de Recherches Mathématiques Workshop on Applications of Spatial Statistics in Earth, Environmental and Health Sciences, Montréal, April 1998.

Dean Billheimer: *Natural Variability of Benthic Species Composition I & II.* Centre de Recherches Mathématiques Workshop on Applications of Spatial Statistics in Earth, Environmental and Health Sciences, Montréal, April 1998.

Paul D. Sampson: *Operational evaluation of air quality models.* Novartis Foundation Symposium on Environmental Statistics: Analyzing Data for Environmental Policy, and RSS Open Meeting, London, May 1998.

Paul D. Sampson: *Spatio-temporal models and methods for the operational evaluation of air quality models.* Society for the Interface on Computer Science and Statistics, Minneapolis, May 1998.

Jim Hughes: *Statistical downscaling of precipitation: An example using the AMIP simulations.* 7th International Meeting on Statistical Climatology, Whistler, BC, Canada May 1998.

Chris Bretherton: *Effective Degrees of Freedom and Significance Testing for Data with Strong Spatial and Temporal Correlations* . 7th International Meeting on Statistical Climatology, Whistler, BC, Canada May 1998.

Barnali Das: *Adjusting Surface Ozone for Meteorology: Incorporating Regional Information using the SVD*. 7th International Meeting on Statistical Climatology, Whistler, BC, Canada May 1998.

Enrica Bellone: *A stochastic model for precipitation amounts at multiple stations.* Sixth International Conference on Precipitation, Hawaii, June 1998

Stephen Charles: *A spatio-temporal model for downscaling precipitation occurrence and amounts*. Sixth International Conference on Precipitation, Hawaii, June 1998

Lianne Sheppard: *Estimation of Exposure Effects in Occupational Studies with Multiplicative Measurement Error in Grouped Exposures.* WNAR annual meeting, San Diego, June 1988.

Don Percival: Wavelet variance and covariance analysis of processes with stationary increments. IMS Western Regional meeting, San Diego, June 1988.

Simon Byers, Julian Besag: *Bayesian mapping of risk, with an application to prostate cancer.* WNAR annual meeting, San Diego, June 1988.

Ford, E.D. *Tales from the Frontier.* Keynote Address to the North American Forest Biology Workshop, July 1998.

T. A. Lewandowski: *Effect of tissue binding uncertainty on a PBTK model of methylmercury in the fetal rat.* IUTOX congress, July, 1998.

Reynolds, Joel H. *Assessing Ecological Process Models using the Pareto Optimal Model Assessment Cycle*. Contributed paper, VII International Congress of Ecology (INTECOL). Florence, Italy, July 1998.

Ford, E.D. and Turley, M. *Model Assessment* at EPA Athens Georgia, and the National Institute for Statistical Sciences. North Carolina, June, 1998.

Paul Sampson: *Monitoring Network Design and Air Quality Standards* . Joint Statistical Meetings, Dallas, Texas, August 1998.

Mary Lou Thompson: *Setting Environmental Standards: A Statistical Evaluation of the US Ozone Standard* . Joint Statistical Meetings, Dallas, Texas, August 1998.

Gerald Van Belle: *Statistics and Mandated Science*. Joint Statistical Meetings, Dallas, Texas, August 1998.

Loveday Conquest *Effects of Commercial Salmon Net Fisheries on Protected Seabirds.* Joint Statistical Meetings, Dallas, Texas, August 1998.

Gerald Van Belle: *Environmental Epidemiology and Environmental Policy.* International Society for Clinical Biostatistics, Dundee, Scotland, August 1998.

Lianne Sheppard *Health effect estimates with multiplicative exposure error and grouping*. Contributed paper, International Symposium On Epidemiology In Occupational Health meeting, Helsinki, Finland, September 1998.

Peter Guttorp: *Some research problems at NRCSE*. Seminar at Department of Statistics, University of Stockholm and contributed paper at Statistics Sweden Methodology Conference, September-October 1998.

Ford, E.D. *Purpose and Problems involved in long term ecological and environmental research.* Final Summary Paper for the Conference: Long-term Silvicultural Research Sites: Promoting the Concept —Protecting the Investment. Victoria, British Columbia, October 1998.

Appendix C. Workshop agendas

Environmental Monitoring Surveys Over Time

MONDAY, APRIL 20 _____

Opening Remarks: 8:30–8:45 a.m.
Chair: Loveday Conquest
   Peter Guttorp, NRCSE and University of Washington
   Loveday Conquest, NRCSE and University of Washington, Workshop logistics

SESSION 1: 8:45–9:45 a.m.
PLENARY SESSION
Chair: Loveday Conquest
   Environmental Surveys Over Time
   Wayne Fuller, Iowa State University

SESSION 2: 10:00–11:45 a.m.
TERRESTRIAL SURVEYS
Chair: Ray Czaplewski
   Overview of National Natural Resource Monitoring Programs
   Anthony R. Olsen, US EPA Western Ecology Division

   Design and Estimation for the National Resources Inventory
   Sarah Nusser, Iowa State University

   USDA Forest Service Strategic Level Forest Inventory and Monitoring
   Andy Gillespie, USDA Forest Service

Discussant: Steve Stehman, SUNY College of Environmental Sciences and Forestry

SESSION 3: 1:00–2:15 p.m.
PERSPECTIVES FROM HUMAN POPULATION AND INSTITUTIONAL SURVEYS
Chair: Sarah Nusser
   Design Features of the Survey of Income and Program Participation (SIPP) and the Survey of Program Dynamics (SPD)
   Franklin Winters, US Census Bureau

   The Agricultural Management Study: A Multi-Purpose Survey of Resource and Economic Management of Farms
   Carol House, USDA National Agricultural Statistics Service (NASS)
Discussant: John Eltinge, Texas A&M University

SESSION 4: 2:30–3:45 p.m.

AQUATIC AND AVIAN SURVEYS
Chair: Tony Olsen

Surveying Breeding Duck Populations in North America
Graham Smith, US Fish & Wildlife Service

Spatially Restricted Surveys Over Time for Aquatic Resources
Donald L. Stevens, Jr., Dynamac Corporation; Anthony R. Olsen, US EPA Western Ecology Division

Discussant: Lyman McDonald, WEST, Inc.

SESSION 5: 4:00–5:15 p.m.
REMOTE SENSING AND SURVEYS
Chair: Ray Czaplewski

Organizing and Interpreting Statewide Satellite Imagery Over Time
Bill Befort and Jim Rack, Forestry Division, Minnesota Department of Natural Resources

Merging Forest Inventory Data with Satellite-Based Information in Utah
Gretchen Moisen, USFS Intermountain Research Station; Thomas C. Edwards, Jr., USGS BRD Utah State University; Tracey Frescino, USFS Intermountain Research Station

Discussant: Dean Thompson, NRCS Natural Resources Inventory and Analysis Institute

Joint Conference Dinner at Ivar's Salmon House (optional)

TUESDAY, APRIL 21 _____

SESSION 6: 8:00–9:45 a.m.
DESIGN ISSUES IN AQUATIC AND WATERSHED SURVEYS
Chair: Tony Olsen

A Multi-Year Lattice Sampling Design for Maryland-Wide Fish Abundance Estimation
Douglas Heimbuch, John Seibel, Harold Wilson, PBS&J; Paul Kazyak, Maryland Department of Natural Resources

Current Applications of Sampling for Watershed and Riparian Health Assessment
Jean Opsomer, Iowa State University

Trend Detection in Repeated Surveys of Ecological Resources
N. Scott Urquhart, Oregon State University; Thomas M. Kincaid, Dynamac Corporation

Discussant: Joe Sedransk, Case Western Reserve University

SESSION 7: 10:00–11:45 a.m.
ANNUALIZED MODIFICATIONS TO TERRESTRIAL SURVEYS
Chair: Ray Czaplewski

The Annual Forest Inventory System
Ronald E. McRoberts, USFS North Central Forest Experiment Station

The Southern Annual Forest Inventory System
Gregory A. Reams, USDA Forest Service Southern Research Station; Paul C. Van Deusen, NCASI, Northeast Regional Center, Tufts University

Annualizing the National Resources Inventory
F. Jay Breidt and Wayne A. Fuller, Iowa State University

Discussant: Scott Urquhart, Oregon State University

SESSION 8: 12:45–2:00 p.m.
SURVEY INTEGRATION PANEL DISCUSSION
Chair: Loveday Conquest

Hans Schreuder, USFS Rocky Mountain Research Station
Jeff Goebel, NRCS
Carol House, USDA NASS
Anthony Olsen, US EPA Western Ecology Division
Paul Geissler, USGS BRD
Bill Williams, BLM

Discussant: Tim Gregoire, Virginia Polytechnic and State University

SESSION 9: 2:15–3:30 p.m.
NONSAMPLING ERRORS
Chair: Sarah Nusser

Some Methods for Evaluating the Quality of Survey Data

Paul P. Beimer, Research Triangle Institute

Nonsampling Errors in EMAP: How Large, How Intractable?
Virginia Lesser, Oregon State University

Discussant: Lynne Stokes, University of Texas at Austin

SESSION 10: 3:45–5:30 p.m.
DATABASE CONSTRUCTION AND DISSEMINATION
Chair: Tony Olsen

Database Design Considerations for the Forest Inventory and Analysis Program
Mark H. Hansen, USDA, Forest Service

Imputation in the National Resources Inventory
F. Jay Breidt and Kevin W. Dodd, Iowa State University

Processing and Analyzing Data from the Survey of Income and Program Participation (SIPP)
Barry Fink, US Census Bureau

Discussant: Dan Carr, George Mason University

WEDNESDAY APRIL 22 _____

SESSION 11: 8:00–9:45 a.m.
STATISTICAL ESTIMATION: APPROACHES
Chair: Loveday Conquest

> Composite Estimation: An Example from the Current Population Survey
> Stephen M. Miller, US Bureau of Labor Statistics

> Modeling Time Series of Small Area Survey Estimates
> Mark Otto and Bill Bell, US Census Bureau

> Small Area Estimators for Environmental Surveys
> David A. Marker, Westat, Inc.

Discussant: John Eltinge, Texas A&M University

SESSION 12: 10:00–11:45 a.m.
STATISTICAL ESTIMATION: APPLICATIONS
Chair: Sarah Nusser

> Combining Results from Different Surveys Drawn Using a Coordinated Design
> Phillip S. Kott, USDA National Agricultural Statistics Service

> Bayesian Inference for Estimating Hunting Success Rates Based on Survey Data
> Zhuoqiong He and Dongchu Sun, Missouri Department of Conservation and University of Missouri-Columbia

> Spatio-Temporal Modeling and Design: Applications to Environmental Data
> Christopher K. Wikle, National Center for Atmospheric Research

Discussant: Mark Handcock, Pennsylvania State University

SESSION 13: 1:00–2:15 p.m.
STATISTICAL ESTIMATION: ANNUALIZED INVENTORIES
Chair: Tony Olsen

> A Comparison of Annual Survey Design Alternatives and Estimation Methods
> Charles T. Scott, US Forest Service; Michael Köhl, Swiss Federal Institute for Forest, Snow and Landscape Research

> Forest Monitoring with Multivariate Time-Series of Remotely Sensed Areal Estimates, Field Observations and Prediction Models under Dependent and Heteroscedastic Measurement and Prediction Errors
> Raymond L. Czaplewski, USDA Forest Service Rocky Mountain Research Station

Discussant: Paul Van Deusen, NCASI, Northeast Regional Center, Tufts University

SESSION 14: 2:30–3:30 p.m.
CONCLUDING PANEL DISCUSSION
Chair: Organizing Committee

> Summary comments from Chairs of prior sessions

7th International Meeting on Statistical Climatology

MONDAY, MAY 25

Opening Remarks   **Sea Ballroom**   **8:30 - 8:45**
Organizing committee

Special Invited Lectures: **Sea Ballroom**   **8:45 - 10:00**
Chair: Peter Guttorp, University of Washington, USA

8:45   Linda O. MEARNS, NCAR, USA
       The effect of spatial and temporal resolution of climate change scenarios on
       changes in frequencies of climatic extremes

9:30   Discussants: Francis Zwiers, Canadian Centre for Climate Modelling and
                   Analysis, Canada
                   Roger Davidson, University of Victoria, Canada

Coffee break   **Atrium**   **10:00 - 10:30**
The coffee breaks are provided in part by the Canadian Institute for Climate Studies

Allan Murphy Memorial Session   **Sea Ballroom**   **10:30 - 12:45**
Chairs: Dan Wilks, Cornell University, USA and Martin Ehrendorfer, University of Wien, Australia

10:30   Robert L. WINKLER, Duke University, USA
       Probability Forecasting: The Legacy of Allan Murphy

10:50   Barbara G. BROWN, NCAR, USA
       The evolution of forecast verification concepts and practices through the contributions of Allan Murphy

11:10   Richard W. KATZ, NCAR, USA
       Economic value of weather and climate forecasts: contributions of Allan Murphy

11:30   Seijo KRUIZINGA, Royal Meteorological Institute, The Netherlands
       Allan Murphy, footprints in Europe

11:50 Francis ZWIERS, Canadian Centre for Climate Modelling and Analysis, Canada
Contributions at the interface between atmospheric and statistical science

12:10 Discussants: Dan Wilks, Cornell University, USA
Martin Ehrendorfer, University of Wien, Austria

12:30 General discussion

Contributed session: Homogenization   McGuire A   10:30 - 11:30
Chair: Wendy Meiring, NCAR, USA

10:30 Nathaniel B. GUTTMAN, National Climatic Data Center, USA
Constructing a homogeneous time series for the calculation of U.S. climatic normals

10:42 Ramon A. QUINTANA-GOMEZ, Universidad Nacional Experimental de los Llanos Ezequiel, Venezuela
Changes in evaporation patterns detected in northernmost South America. Homogeneity testing

10:54 Vicky SLONOSKY, University of East Anglia, UK
A comparison of homogenization techniques

11:06 Tamas SZENTIMREY, Hungarian Meteorological Service, Hungary
Multiple analysis of series for homogenization (MASH)

11:18 Lucie A. VINCENT, Environment Canada
Assessment of the technique for identification and adjustment of inhomogeneities in Canadian temperature series

Contributed Session: Ensembles   McGuire A   11:30 - 12:42
Chair: Wendy Meiring, NCAR, USA

11:30 Won-Tae KWON, Meteorological Research Institute, Korea
Seasonal forcasting experiments over Korea using linear regression model

11:42 Vincent MORON, IMGA-CNR, Italy
An analysis of a super-ensemble

11:54 Xiaolan WANG, Canadian Centre for Climate Modelling and Analysis, Canada
Interannual variability in an ensemble of GISST simulations conducted with the CCC GCM2

12:06 Michael WEHNER, Lawrence Livermore Laboratory, USA
How large do ensembles of climate simulations need to be?

12:18 Elena YULAEVA, University of California at San Diego, USA
Ensemble Seasonal Climate Prediction: Model Intercomparison and Likelihood Estimation

12:30 Christine ZIEHMANN, University of Potsdam, Germany
Comparison of the ECMWF ensemble with an ensemble consisting of four operational models

Contributed session: ENSO-related phenomena   McGuire B   10:30 - 11:42
Chair: Talagrand, Ecole Normale Supérieure, France

10:30 Judit BARTHOLY, Eotvos Lorand University, Hungary
Comparing ENSO related PNA and NAO signals

10:42 Christine MARTINEU, EDF/DER/Environment Dept., France
Relations between NAO, PNA, and ENSO oscillations in seasonal winter simulations with four AGCMs

10:54 Olga C. PENALBA, University of Buenos Aires, Argentina
The Southern Oscillation impact on rainfall in the central-east of Argentina

11:06 Amir SHABBAR, Environment Canada
ENSO-related precipitation characteristics in Canada

11:18 Risheng WANG, Environment Canada
Characteristics of El Nino-La Nina variability in a low dimensional phase space derived from observational data

11:30 Takmeng WONG, NASA/Langley Research Center, USA
Analysis of ENSO Events using Earth Radiation Budget Experiment Observations

Contributed Session: Climate Modeling   McGuire B   11:42 - 12:30
Chair: Olivier Talagrand, Ecole Normale Supérieure, France

11:42   Ulrich ACHATZ, University of Rostock, Germany
A quasigeostrophic model with empirical linear corrections and reduced order for climate simulations

11:54   Juergen GRIESER, J.W. Goethe-University, Germany
Signal analysis of global and hemispheric mean temperature variations by means of an energy balance model

12:06   Robert JACOB, University of Wisconsin-Madison, USA
Decadal and multi-decadal variability in a coupled ocean-atmosphere model

12:18   Frank KWASNIOK, Max-Planck Institute for Meteorology, Germany
Quasigeostrophic low-order models of large-scale atmospheric flow

Special Invited Lecture   Sea Ballroom   14:15 - 15:30

Chair: Francis Zwiers, Canadian Centre for Climate Modelling and Analysis, Canada

14:15   Mark BERLINER, Ohio State University, USA
Bayesian methods in atmospheric sciences

15:00   Discussants: Hans von Storch, GKSS, Germany
Richard Lockhart, Simon Fraser University, Canada

Coffee break   Atrium   15:30 –16:00

Invited Session: Climate Variability and Extremes Sea Ballroom   16:00 - 17:45

Organizer/Chair: Richard Smith, University of North Carolina, USA

16:00   Thomas R. KARL, National Climate Data Center, USA (presented by Ned GUTTMAN)
Climate extremes and natural disasters: trends and loss reduction prospects

16:30   Clive ANDERSON, University of Sheffield, UK
Linking rainfall extremes of different durations

17:00   Richard L. SMITH, University of North Carolina, USA
Trends in meteorological extremes

17:30   General discussion

Invited Session: Analog Methods   McGuire A   16:00 - 17:45

Organizer/Chair: Hans von Storch, GKSS, Germany

16:00   Grant BRANSTATOR, NCAR, USA
Predicting atmospheric transient eddy fluxes given the seasonal mean state

16:30   Klaus FRAEDRICH, University of Hamburg, Germany
Analog-forecasting: error recycling and metric adaption

17:00   Huug M. van den DOOL, NMC, USA
Review of possibilities and limitations of natural and constructed analogues

17:30   General discussion

Contributed Session: Forecasting   McGuire B   16:00 - 17:48

Chair: Connely Baldwin, Utah State University, USA

16:00   Frederic ATGER (presented by Olivier TALAGRAND), ECMWF, UK
Reliability and resolution of probabilistic forecasts based on Ensemble Prediction Systems

16:12   Harold E. BROOKS, NOAA/ERL/National Severe Storms Laboratory, USA
Practical upper and lower bounds on skill of forecasts of hazardous weather

16:24   Josip JURAS, Geophysical Institute, Croatia
Persistence-climatology forecasts for meteorological elements with irregular empirical distributions

16:36   Ignacio LOZANO, University of Alcala, Spain
Classification of storms off the north coasts of the Iberian peninsula

16:48   Benyang TANG, University of British Columbia, Canada
Seasonal forecasts of sea surface temperatures of tropical Pacific - Comparing neural networks and canonical correlation analysis

17:00 Laurence WILSON, Environment Canada
A verification method for ensemble forecasts

17:12 Juying CHEN, Chinese Academy of Meteorological Sciences, China
Discussion of the successful prediction method on floods/droughts in regions of China

17:24 Nityanand SINGH, Indian Institute of Tropical Meteorology, India
Variability and prediction of the Indian northeast monsoon

17:36 Neelima A. SONTAKKE, Indian Institute of Tropical Meteorology
Climate variability and multi-year prediction of SW monsoon rainfall over North East India

Ice breaker   Atrium   17:45 – 19:30
Sponsored by IBM Canada. Cash bar.

TUESDAY, MAY 26

Special Invited Lecture   Sea Ballroom   9:00 - 10:15
Chair: Richard Lockhart, Simon Fraser University, Canada

9:00   Douglas NYCHKA, NCAR, USA
       Spatial statistics, hierarchical models and massive datasets

9:45   Discussants: Richard W. Katz, NCAR, USA
                        Noel Cressie, Iowa State University, USA

Coffee break   Atrium   10:15 – 10:45

Invited Session: Climate Change Dectection I   Sea Ballroom   10:45 - 12:30
Organizer/Chair: Ben Santer, Lawrence Livermore National Laboratory, USA

10:45   Gerald R. NORTH, Texas A&M University, USA
       Detecting forced climate signals in the surface temperature field

11:15   Simon TETT, Hadley Centre for Climate Prediction and Research, UK
       Causes of twentieth century climate change

11:45   Myles R. ALLEN, Rutherford Appleton Laboratories, UK
       Fingerprinting techniques in the detection and attribution of climate change

12:15 General discussion

Contributed Session: Downscaling I   McGuire A   10:45 - 12:09
Chair: Barnali Das, University of Washington, USA

10:45   Aristita BUSUIOC, National Institute of Meteorology and Hydrology, Romania
       Verifying the validity of statistical downscaling procedures in climate change applications

10:57   Dimitrios GYALISTRAS, University of Berne, Switzerland

Temporal downscaling - a method to reduce the climatic input requirements of impact models

11:09   James P. HUGHES, University of Washington, USA
Statistical downscaling of precipitation: An example using the AMIP simulations

11:21   Julie M. JONES, Climatic Research Unit, University of East Anglia, UK
Investigation of the climatic influence on air and precipitation chemistry over Europe, and applications to a downscaling methodology to assess future acidic deposition

11:33   J. P. PALUTIKOF, Climatic Research Unit, University of East Anglia, UK
Multi-site multi-variable climate change scenarios

11:45   Budong QIAN, University of Lisbon, Portugal
Downscaling of precipitation from HADCM2 Regional Weather Regimes

11:57   D. S. WILKS, Cornell University, USA
Statistical downscaling of daily precipitation using stochastic weather models

Contributed Session: Time Series Analyses   McGuire B   10:45 - 12:09

Chair: Chris Glasbey, BioSS, UK

10:45   Alan CHIANG, University of Wisconsin-Madison, USA
Comparison of climate model output and historical global temperatures via smoothing spline ANOVA

10:57   Stefan GÜSS, GKSS Research Centre, Germany
Cyclo-stationary maximum cross covariance analysis

11:09   Hauke HEYEN, GKSS Institute of Hydrophysics, Germany
Detecting possible relationships between the interannual variability in ecological timeseries and climate records using a multivariate statistical approach - a case study on Helgoland Roads zooplankton

11:21   Jianping HUANG, Atmospheric Environment Service, Canada
Multiresolution spectral analysis and its application to studying the relationship between NAO and ENSO

11:33   Lynne SEYMOUR, University of Georgia, USA

A trend analysis of United States temperatures

11:45   Xuebin ZHANG, CBB, Atmospheric Environment Service, Canada
Interannual and interdecadal variability of Pacific SST as revealed by singular spectrum analysis

11:57   Xiaogu ZHENG, National Institute of Water and Atmospheric Research, New Zealand
Structural time series models and trend detection in global and regional temperature series

Special Invited Lecture   Sea Ballroom   14:00 - 15:15
Chair: Peter Guttorp, University of Washington, USA

14:00   Peter J. GREEN, University of Bristol, UK
Markov chain Monte Carlo methods

14:45   Discussants: Paul D. Sampson, University of Washington, USA
James P. Hughes, University of Washington, USA

Coffee break   Atrium   15:15 – 15:45

Invited Session: Climate Change Detection II   Sea Ballroom 15:45 - 17:30
Organizer/Chair: Ben Santer, Lawrence Livermore Laboratory, USA

15:45   Gabriele HEGERL, University of Washington, USA
Detection of anthropogenic climate change: Results and problems

16:15   Francis W. ZWIERS, Canadian Centre for Climate Modelling and Analysis, Canada
Climate Change Detection: A Review of Techniques and Applications

16:45   Tim BARNETT, Scripps Institute, USA
No title available

17:15   General discussion

Contributed Session: Extreme Values   McGuire A   15:45 - 17:21

Chair: Vicky Slonosky, University of East Anglia, UK

15:45 Connely BALDWIN, Utah State University, USA
Non-parametric forecasting of snowpack in Utah, USA

15:57 Roger R. DAVIDSON, University of Victoria, Canada
Statistical prediction of seasonal cold temperature for locations in British Columbia

16:09 Marjana GAJIC-CAPKA, Meteorological and Hydrological Service, Croatia
Variability and trend in precipitation extremes

16:21 D. GELLENS, Royal Meteorological Institute of Belgium
Trend analysis of k-day extreme precipitation over Belgium by means of principal components

16:33 B. C. HEWITSON, University of Cape Town, South Africa
Climate change and circulation modes related to extreme events

16:45 Alberto Solana ORTEGA, SCIC, Spain
Entropy based inference of models for recurrence of extreme events applied to climate variability analysis

16:57 Heikki TUOMENVIRTA, Finnish Meteorological Institute, Finland
Long-term changes in Nordic and Arctic extreme temperatures

17:09 Martin A.J. Van MONTFORT, Wageningen Agricultural University, The Netherlands
Evaluating EV1-techniques for estimating upper quantiles of TCEV-data

Contributed Session: Multivariate Analysis   McGuire B 15:45 - 17:33

Chair: Stefan Güss, GKSS, Research Centre, Germany

15:45   Ulrike BURKHARDT, Reading University, UK
Measuring the intensity of a storm track - An EEOF approach

15:57   Rosa Hilda COMPAGNUCCI, University of Buenos Aires, Argentina
Principal sequence patterns of 1000 hPa geopotential height fields

16:09   Barnali DAS, University of Washington, USA
Adjusting surface ozone for meteorology: incorporating regional information using the SVD

16:21   C. A. GLASBEY, BioSS, UK
Modelling multivariate spatio-temporal weather data using latent Gaussian processes

16:33   Arthur M. GREENE, Columbia University, USA
Multivariate analysis of mountain glacier equilibruim-line altitudes using gridded climate data

16:45   Wendy MEIRING, NCAR, USA
Functional data analysis of vertical ozone profiles

16:57   Belen Rodriguez de FONSECA, Universidad Complutense de Madrid, Spain
Cross validation of different discriminant analysis methods used in statistical climatology

17:09   W. C. THACKER, Atlantic Oceanographic and Meteorological Laboratory, USA
Principal Predictors for Low-Dimensional Modelling

17:21   Michael TOBIS, Argonne National Laboratory, USA
New technologies for very large empirical decompositions of simulated climate

WEDNESDAY, MAY 27

Special Invited Lecture   Sea Ballroom   9:00 - 10:15
Chair: Francis Zwiers, Canadian Centre for Climate Modelling and Analysis, Canada

9:00   Noel CRESSIE, Iowa State University, USA
        **New directions in space-time modeling with applications to atmospheric
        science**

9:45   Discussants: Gabi Hegerl, University of Washington, USA
                        Ian Jolliffe, University of Aberdeen, UK

Coffee break   Atrium   10:15 – 10:45

Invited Session: Variational Methods   Sea Ballroom   10:45 - 12:30
Organizer: Grace Wahba, University of Wisconsin, USA
Chair: Doug Nychka, NCAR, USA

10:45   Joseph J. TRIBBIA, NCAR, USA
        Variational applications in atmospheric dynamics and prediction

11:15   Andrew F. BENNETT, Oregon State University, USA
        Testing climate models using variational assimilation

11:45   Grace WAHBA, University of Wisconsin, USA
        Variational methods in three and four dimensional climate data analysis problems

12:15   General discussion

Contributed Session: Climate Variability I   McGuire A   10:45 - 12:33
Chair: Brandon Whitcher, University of Washington, USA

10:45 P. ANTICO, University of Buenos Aires, Argentina
Monthly anomalies in geopotential height fields over southern South America

10:57 F. BIONDI, University of California at San Diego, USA
Evolutionary and Moving Response Functions in Dendroclimatology

11:09 Albert R. BOEHM, Nichols Research Corporation, USA
The climatological probability of clouds at altitude

11:21 Manon FAUCHER, Atmospheric Environment Service, Canada
On the climatology of surface marine winds near the western coast of Canada

11:33 George GRUZA, Institute for Global Climate and Ecology, Russia
Indices and indicators of climate variability and changes

11:45 Donald V. HANSEN, CIMAS/University of Miami, USA
Statistical estimation of salinity profiles

11:57 J. I. JIMENEZ, University of Granada, Spain
Contribution to the study of the climatic variability patterns in the South of Spain

12:09 T. A. KABANDA, University of Venda, South Africa
Climatic variation and malaria epidemic in South Africa

12:21 Matilde RUSTICUCCI, University of Buenos Aires, Argentina
Cold and heat waves over Argentina: Interannual to interdecadal variability

Contibuted Session: Precipitation I   McGuire B   10:45 - 11:45
Chair: Martin Widmann, University of Washington, USA

10:45 Annick DOUGUEDROIT, Institute of Geography, France
Evolution of the Mediterrannean Basin Rainfall Precipitationon

10:57 Sultan HAMEED, Institute for Terrestrial and Planetary Atmosphere, USA
Variation of precipitation and soil moisture in the lower Yellow River Valley 1736-1911

11:09 E. KLOPPER, South African Weather Bureau, South Africa
Prediction of the 1997/98 rainfall season in South Africa

11:21 C. Rodriguez PUEBLA, Titular University, Spain
Winter precipitation variability over the Iberian Peninsula and its relationship to atmospheric circulation in-dices

11:33 A. C. CHIPANSHI, University of Botasqwana
Nature of rainfall variability in Botswana over the 1961 to 1990 period

<u>Contributed Session: Climate Change Detection McGuire B   11:45 - 12:45</u>
Chair: Martin Widmann, University of Washington, USA

11:45 Shaleen JAIN, Utah State University, USA
Changes in the midwestern U.S. precipitation: observations and modeled greenhouse warming scenarios

11:57 J. F. GONZALEZ-ROUCO, Universidad Complutense de Madrid , Spain
Simulated and observed trends of precipitation in south-western Europe: evidence for climate change?

12:09 Hans VISSER and Jeljer HOEKSTRA, KEMA Sustainable, The Netherlands
Identifying key sources of uncertainty in climate change projections over 1990-2100

12:21 Nina M. DATSENKO, Hydrometeorological Research Centre of Russia
Detection and attribution of the current warming by means of wavelet transforms of the hemispheric and regional temperature time series

12:33 Esther RANKOVA, Institute for Global Climate and Ecology, Russia
Climate change during the 20th century for the Russian Federation

THURSDAY, MAY 28

Special Invited Lecture   Sea Ballroom   9:00 - 10:15
Chair: Richard Lockhart, Simon Fraser University, Canada

9:00   Vladimir KRASNOPOLSKY, NCEP, USA
       Neural networks for the empirical solution of remote sensing problems

9:45   Discussants: Eduardo Zorita, GKSS Research Centre, Germany
                            Doug Nychka, NCAR, USA

Coffee break   Atrium   10:15 – 10:45

Invited Session: Neural Networks   Sea Ballroom   10:45 - 12:30
Organizer: Jean Thiebaux, NOAA, USA
Chair: Vladimir Krasnopolsky, NCEP, USA

10:45   D. M. TITTERINGTON, University of Glasgow, UK
        Neural networks and statistics

11:05   Mark FRENCH, University of Kentucky, USA
        A neural network for environmental applications: incorporating theory and domain knowledge

11:25   Stephane COTE, HMR Inc., Canada
        Measurement of sea-surface velocities from sequential satellite sensor images using the Hopfield neural network

11:45   Louis KEINER, World Data Center, USA
        A neural network as a chlorophyll estimation algorithm for ocean color imagery

12:05   Dimitris TSINTIKIDIS, University of California at San Diego, USA
        Rainfall estimation from spaceborne microwave data using neural nets

Invited Session: Ensemble Forecasting   McGuire A   10:45 - 12:30

Organizers: Dennis Shea and Rol Madden, NCAR, USA
Chair: Dennis Shea, NCAR, USA

10:45   Martin EHRENDORFER, University of Wien, Austria
Ensemble forecasting for the prediction of the uncertainty of numerical weather forecasts

11:15   Zoltan TOTH, National Weather Service, USA
Operational aspects of ensemble forecasting

11:45   Olivier TALAGRAND, Ecole Normale Supérieure, France
Evaluation of meteorological ensemble prediction systems

12:15   General discussion

Contributed Session: Climate Variability II   McGuire B   10:45 - 11:57
Chair: Alfred Boehm, Nichols Research Group, USA

10:45   Scott M. ROBESON, Indiana University, USA
Comparison of temporal and unresolved spatial variability in multiyear averages of air temperature

10:57   H. Y. TSENG, ANWS OAA, R.O.C.
Using the GMS digital data to analyze the variation of cloud amount in the west Pacific and southeast Asia area

11:09   Ole Einar TVEITO, Norwegian Meteorological Institute, Norway
Climatological analysis for Norway by spatial statistics supported by GIS

11:21   Brandon WHITCHER, University of Washington, USA
Bivariate wavelet analysis with application to the Madden-Julian oscillation

11:33   Igor ZVERYAEV, Russian Academy of Science, Russia

Decadal and longer changes of the winter sea level pressure and related synoptic activity over the North Atlantic

11:45 P. ALLERUP and H. MADSEN, Danish Meteorological Institute, Denmark
Estimation accuracy on models for correcting precipitation

Special Invited Lecture   Sea Ballroom   14:00 - 15:15
Chair: Francis Zwiers, Canadian Centre for Modelling and Analysis, Canada

14:00 David R. BRILLINGER, University of California at Berkeley, USA
Point and marked point processes in meteorology

14:45 Discussants: Andy Solow, Woods Hole Oceanographic Institute, USA
Peter Guttorp, University of Washington, USA

Coffee break   Atrium   15:15 – 15:45

Invited Session: Multivariate Methods   Sea Ballroom   15:45 - 17:30
Organizers: Peter Guttorp, University of Washington, and Hans von Storch, GKSS
Chair: Peter Guttorp, University of Washington, USA

15:45 Christopher S. BRETHERTON, University of Washington, USA
Effective degrees of freedom and significance testing for data with strong spatial and temporal correlations

16:15 Hans WACKERNAGEL, Centre de Géostatistique, France
Checking multiple time series for intrinsic correlation

16:45 Hans von STORCH, GKSS, Germany
Redundancy analysis as a downscaling tool

17:15 General Discussion

Contributed Session: Neural Nets   McGuire A   15:45 - 16:21

Chair: Manon Faucher, Atmospheric Environment Services, Canada

15:45   William W. HSIEH, University of British Columbia, Canada
Connecting neural network models and dynamical models via adjoint data assimilation and spectral analysis

15:57   Adam H. MONAHAN, University of British Columbia, Canada
Nonlinear principal component analysis

16:09   Andreas WALTER, J.W. Goethe University of Frankfurt, Germany
Simulation of global and hemispheric temperature variations and signal detection studies using neural networks

Contributed Session: Spatial Statistics   McGuire A   16:21 - 17:33

Chair: Manon Faucher, Atmospheric Environment Services, Canada

16:21   Gerard BIAU, Université Montpellier II, France
Rainfall estimation by kriging in the EOF space of the SLP field

16:33   Miroslaw MIETUS, Institute of Meteorology and Water Management, Poland
Past, present and future wave climate in the Proper Baltic Sea Basin

16:45   David NOTT, University of New South Wales, Australia
Analysis of spatial covariance structure from monitoring data

16:57   Sam SHEN, University of Alberta, Canada
Optimal estimation of climate parameters

17:09   Thomas M. SMITH, NOAA, USA
Averaging of Surface Temperature

17:21   D. M. SONECHKIN, HMC, Russia
Scaling analysis of the spatial-temporal variations of the surface air temperatures of the northern Euroasia

Contributed Session: Downscaling II   McGuire B   15:45 - 17:09
Chair: Julie Jones, University of East Anglia, UK

15:45   Ulrich CALLIES, GKSS Research Centre, Germany
Comparing downscaling schemes: sufficiency and evaluation of relative information

15:57   Radan HUTH, Institute of Atmospheric Physics, Czech Republic
Statistical downscaling of daily local temperature from large-scale upper-air fields: Intercomparison of methods

16:09   William H. KLEIN, Bethesda, USA
Reconstruction of monthly mean 700 mb heights from surface data by reverse specification

16:21   Ricardo M. TRIGO, University of East Anglia, UK
Downscaling of precipitation, Tmax and Tmin over Portugal using a neural network model approach

16:33   Robert L. WILBY, NCAR, USA
Evaluating GCM predictors for statistical downscaling

16:45   Eduardo ZORITA, GKSS Research Centre, Germany
The analog method a a simple statistical downscaling techniques: comparison with linear, classification and neural network methods

16:57   Anatoly CHAVRO, Russian Academy of Sciences, Russia
Statistical model of an inverse problem in theory of climate

Special Invited Lecture: Sea Ballroom   17:45 -19:00
Chair: Peter Guttorp, University of Washington, USA

17:45   Jin-Song von STORCH, University of Hamburg, Germany
Variability of the present-day thermohaline circulation: spectral shapes and spatial scales

18:30   Discussants: Myles Allen, Rutherford Laboratories, UK
David Brillinger, University of California at Berkeley, USA

FRIDAY, MAY 29

Special Invited Lecture   **Sea Ballroom**   **8:45 - 10:00**
Chair: Richard Lockhart, Simon Fraser University, Canada

8:45   Anthony G. BARNSTON, NOAA, USA
        The North Atlantic oscillation: definition, climate effects, ¨ønteraction with ENSO

9:30   Discussants: Chris Bretherton, University of Washington, USA
                     Hans Wackernagel, Centre de Géostatistique, France

Coffee break   **Atrium**   **10:00 -
10:30**

Invited Session: Short Term Forecasting   **Sea Ballroom**   **10:30 -12:15**
Organizer/Chair: Barbara Brown, NCAR, USA

10:30   Judit BARTHOLY, Eötvos Lorand University, Hungary
         Retrospective summary of long-range forecasting in the central European region

11:00   Neville NICHOLLS, Bureau of Meteorology, Australia
         Statistical climate prediction in the Southern Hemisphere

11:30   Andrew SOLOW, Woods Hole Oceanographic Institute, USA
         A Bayesian scheme for El Nino prediction

12:00   General discussion

Invited Session: Classification and cluster analysis   **McGuire A**   **10:30 -
12:15**
Organizer/Chair: Ian Jolliffe, University of Aberdeen, UK

10:30   Gil H. ROSS, UK Meteorological Office, UK
         Clustering an ensemble into meaningful patterns for forecasters

10:50 Radan HUTH, Institute for Atmospheric Physics, Czech Republic
Applications of circulation classification methods in general circulation model studies

11:20 Kayo IDE, University of California at Los Angeles, USA
Mixture model clustering for multiple regimes in the northern hemisphere winter atmosphere

11:45 Ian JOLLIFFE, University of Aberdeen, UK
Cluster analysis: some recent developments and their relevance to climatology

Contributed Session: Precipitation II   McGuire B   10:30 - 12:06

Chair: Stephen Charles, CSIRO, Australia

10:30 Anne-Catherine FAVRE, Swiss Federal Institute of Technology, Switzerland
The Neyman-Scott Rectangular Pulses Model for precipitation : parameter estimation and confidence interval determination

10:42 Paul NORTHROP, University College London, UK
A stochastic model for spatial-temporal rainfall data

10:54 Nora E. RUIZ, University of Buenos Aires, Argentina
Some aspects of 200 hPa circulation over Argentina in relation to precipitation

11:06 Martin WIDMANN, University of Washington, USA
Relations between trends in Swiss wintertime precipitation and large-scale pressure and temperature changes

11:18 D. S. WILKS, Cornell University, USA
Low-frequency characteristics of several stochastic daily precipitation models

11:30 Abebe YESHANEV, National Meteorological Services Agency, Ethiopia
Specification and prediction of Ethiopian rainfall using S-mode component and canonical correlation analysis based on global sea surface temperature anomalies

11:42 Abdesselam ZAROUGUI, Universidad Complutense de Madrid, Spain
Regionalization of daily rainfall in Morocco.

10:54 S. D. DAHALE, Indian Institute of Tropical Meteorology, India
Stochastic modeling of shorter time scale rainfall over India

National Research Center for Statistics and the Environment