

Annual Report 1996-97

National Research Center for Statistics and the Environment



NRCSE

The NRCSE was established in 1997 through a cooperative agreement with the United States Environmental Protection Agency which provides the Center's primary funding.





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1. Summary

The first year of Center activities has constituted a building phase. Since the academic year schedule of Center members largely was set when the award of the agreement was announced, research work in earnest did not start until the summer of 1997. In the meantime the Center moved in to temporary campus space, procedures for internal and external funding were developed and put in place, and considerable amounts of effort were put into telling the community about the Center in conference presentations, articles and notices in bulletins of scientific organizations, and using the web page.

Below we first outline some of our outreach activities, 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 organized a seminar series with speakers including local consultants, EPA Region X and Washington Department of Ecology staff, Center members and visiting faculty. The seminar series was organized as an official University course, and had about half a dozen registered students. An informal summer seminar series featured mainly Center visitors. Attendance during the academic year varied from 20 to 60, with an average attendance of about 40 in Autumn quarter, 35 in Winter quarter, and 30 in Spring quarter. The highest attendance was for talks by Joe Felsenstein, UW Genetics; Dennis Lettenmaier, UW Civil Engineering; David Ford, UW Forestry; and a panel discussion on setting ozone standard with panel members from University of Nottingham, University of British Columbia, EPA North Carolina (by phone connection), Washington Department of Ecology, and UW. A complete list of seminars is given in Appendix A.

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. Much care went into designing the web site to have a consistent look between pages, and be easy to navigate. We still 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 working on being able to implement are



- synchronous access to Center seminars
- repository of audio recordings of seminars
- web-based tutorials in basic statistical methodology
- web-based demonstrations of Center-developed software
- easy access to environmentally related news stories

2.3 Workshops

We expect workshops to be one of our most productive work modes/.. In particular, a workshop format allows for intensive interaction between Center members and visitors. During our first year we organized or helped organize two workshop; one to set the research agenda of the Center, and one to discuss modeling tropospheric ozone in the Pacific Northwest.

2.3.1 Initial EPA-NRCSE workshop

An initial workshop with EPA personnel and Center researchers was held at the University of Washington January 21-22, 1997. Participants included EPA scientists Guth, Warren, Saint, Benjey, Cox, Eder, LeDuc, Brown, Flatman, Olsen, Setzer, Nussbaum and Goodman, while Center members present were Guttorp, Sampson, Raftery, Madigan, van Belle, Cullen, Nyerges, Leroux, Faustman, Sheppard, Hughes, Percival, Ford, Conquest, Karr and Thompson. In addition Joel Reynolds from the UW Statistics department, Graham Wood from New Zealand, advisory committee members Paul Switzer from Stanford University and Abdel El-Sharaawi from Canadian Inland Waters, Center consulting associates Marker, Clickner, Millard and Peterson, and several UW graduate students were in attendance. The format consisted of presentations from EPA researchers and Center members about interesting research problems. A detailed agenda is available in Appendix B.

2.3.2 Cascadia Tropospheric Ozone Peer Review Workshop

A workshop on modeling tropospheric ozone in the Pacific Northwest region with some 50 participants was co-sponsored by the Center and the Washington Department of Ecology Air Quality Section. The main topic were current efforts to model ozone production and transport in the region, using modern meso-scale atmospheric models together with the CALPUFF and CALTRANS models. The meeting agenda can be found in Appendix B.



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 for Risk Analysis annual meeting, EPA Statisticians meeting, the EMAP research conference, the Interface conference, the Joint Statistical Meetings, Environmetrics, the International Statistical Institute biennial meeting, and SPRUCE IV. A detailed list of presentations is given in Appendix C.

2.5 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 (see section 3.1.2) and a course in basic statistical techniques for EPA Region X. We are hoping to be able to assist Region X with a permanent graduate student assistant for consulting help. We are also developing some web-based course material at a graduate level.

We have developed some research links with the Washington State Department of Ecology, mainly in the area of air pollution (specifically ozone, carbon monoxide, and car exhaust). These research projects have generally been joint with the University of Washington Statistical Consulting Center.

Paul Sampson and Peter Guttorp reviewed the CASTNET proposal for the Environmental Protection Agency.

A local citizen's group interested in noise monitoring at the Boeing Field/King County airport in Seattle contacted the Center to get some help with designing a noise study. Our visitor Dean Billheimer was able to assist them with the initial setup.

We are working on developing links with local industry. A natural link already exists to the Boeing Company through our visitor Dean Billheimer, who spends two afternoons a week at the Center. We are working on furthering these links through a variety of joint projects with the Department of Statistics.

Center members are actively participating in the University of Washington Program on the Environment, 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 (PRISM), a research program to develop a comprehensive model of physical and social development in the greater Puget Sound region.



3. Research activities

In order to build a national Center, we are using a two-pronged approach. First, Center members can be funded to work on specific projects. Our guidelines specify the importance of having identified contacts with EPA personnel to ensure the relevance of the projects. Second, our visitors program is built around having researchers from outside the University of Washington visit the Center to set up a joint research program with one or more Center members. In this way we hope to build and maintain contacts with researchers in environmental statistics nationwide and internationally. The Center computing staff is working on evaluating and implementing tools for collaborative research at a distance.

3.1 Internal funding

During its first year, Center members were entitled to submitting proposals to the Center twice, by October 1 and by March 1. The former deadline mainly covered student support, while the latter was the first real opportunity for Center members to propose considered approaches to the problems discussed in the original Center research proposal to the EPA and at the initial EPA-NRCSE workshop. A total of 18 proposals were submitted, 16 of which received at least partial funding.



The current work at the Center can be divided into five subgroups:

1. Ecological impact
2. Education and outreach
3. Model assessment
4. Space-time modeling
5. Sampling and design

While some of our research topics fall naturally under one of these categories, other span more than one of the headings. In this section we will follow the classification used on our web page while discussing all our current projects.

3.1.1 Ecological impact

Biological monitoring

PI: Peter Guttorp.

EPA researchers: Tony Olsen, Melissa Hughes

Center researchers: Dean Billheimer, Jim Karr.

Research assistants: Mariabeth Silkey, Kristen Ryding, Florentina Bunea.

This project deals with the statistical analysis of compositional data in space and time. Among the applications are analysis of deep sea benthic macroinvertebrates for the effect of mining on the ocean floor; 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); evaluation of insect repopulation of the Mt. Saint Helens eruption zone. The statistical aspects of the project focuses on the Billheimer model of space-time compositions, and development of new methodology for analyzing high-dimensional contingency tables. A paper, *Natural variability of benthic species in the Delaware Bay*, recently appeared in *Environmental and Ecological Statistics*.

Hydrologic effect of land use change

PI: Dennis Lettenmaier

EPA researcher: Iris Goodman

Research c: Laura Bowling

The objective of this study is to determine the extent to which changes in streamflow have occurred in western Washington forested catchments in the last 50 years, and where changes have occurred, to determine the extent to which forest harvesting is responsible. From a statistical standpoint, retrospective assessment of the effects of logging on streamflow is a classical trend detection problem. The "noise" from which the signal must



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be extracted results from variability in storm characteristics over the period of analysis, as well as antecedent conditions.



Statistical analysis of surface ozone

Operational evaluation of air quality models

PI: Paul Sampson

EPA researchers: Sharon LeDuc, Brian Eder, Larry Cox, Dave Holland

Washington Department of Ecology researchers: Cris Figueroa-Kaminsky, Clint Bowman

Center researchers: Peter Guttorp, Joel Reynolds, Wendy Meiring, Mary Lou Thompson

Research assistants: Barnali Das, Ruth Grossman

This project has two aspects: developing tools for model assessment, using model runs from the SARMAP project in Central California, and developing and assessing tools for meteorological adjustment of ozone data, using Washington Department of Ecology data. 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 work on meteorological adjustment of data employs a powerful multivariate tool, the singular value decomposition, to produce regional meteorological patterns. In addition, we are pursuing a thorough literature review and expect to be able to compare a variety of methods proposed for meteorological adjustment. The review is an invited paper for *Atmospheric Environment*, and we expect to organize a workshop on this topic sometime in 1998. The project has produced three submitted papers (all with the visitor Wendy Meiring as first author; see section 3.3 below).

Analysis of CO data in Spokane

PI: Peter Guttorp

Washington Department of Ecology researchers: Chris Bowman, Doug Schneider

A DOE study of CO in downtown Spokane, WA, involved a set of portable samplers in addition to the permanent monitoring sites in order to evaluate the representativeness of the permanent sites. Our analysis used kriging techniques to assess the adequacy of the siting. A report entitled *Statistical analysis of Spokane CO data* is available on the web site. (The original analysis of these data was performed without use of NRCSE facilities).

Setting environmental standards.

PI: Mary Lou Thompson

EPA researcher: Larry Cox

Center researchers: Peter Guttorp, Paul Sampson

Research assistant: To be named



The debate surrounding the change in ozone standards illustrates many of the difficulties in translating scientific studies into practical policy decisions. This project intends to study ways of setting standards that makes use of the information available in a way that takes proper account of uncertainties in knowledge and understanding of the process, in measurement of the pollutants, and in enforcement rules. While the initial work will focus on ozone and particulate matter data, the intent is to produce a methodology that can be applied to a variety of environmental concerns.

Remote sensing and automobile emissions

PI: Paul Sampson

Washington Department of Ecology researchers: Doug Brown, Kerry Swayne, Tom Olsen

Research assistant: Jake Wegerlin

A study of remote sensing technology for field measurement of automobile emissions is being carried out for the Washington State Department of Ecology. This study aims to validate remote sensing device (RSD) field measurements of automobile emissions against EnviroTest measurements taken at Department of Ecology Emissions Check stations. Ideally, if there should be sufficient correlation of the RSD field measurements with the EnviroTest measurements, adjusting for any possible relevant field measurement factors such as vehicle acceleration or weather, a statistical calibration (inverse regression) could be used for compliance assessment and/or "clean screening". A final report to the Department of Ecology is now being prepared.

3.1.2 Education and outreach

Center Computing

PI: David Madigan

Center researchers: Peter Guttorp, Tim Nyerges

Research staff: Erik Christianson, Peter Sutherland

The main outreach tool this group maintains is the web page. In addition, the group is planning to put seminars on the Web, implement tools for easy access to environmental news in areas of interest to the Center, and develop long-range plans for the Center computing facilities

Democracy project

Co-PIs: Alison Cullen and June Morita

Research assistants: Lynn Coriano and Max Savishinsky



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Jointly with the Public Broadcasting System and the American Statistical Association a group of UW faculty and graduate students are working on several multimedia modules for teaching environmental statistics. In these modules third through eighth grade 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/>).



Statistics course for EPA Region X

Co-PIs: Loveday Conquest and June Morita
EPA researchers: Diane Ruthruff, Jim Adamski
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. The course development is likely to start in January, 1998, with the course being taught starting in April, 1998. Part of the preparatory work will be to have the research assistant develop contacts and obtain relevant data sets at the regional office.

Point process manual

PI: David Ford
Research assistant: Elizabeth Freeman

This projects aims to develop distance learning tools for point process analysis, including data sets, software manual, and tutorial scripts. The development is tied to an on-campus course in *Spatial processes in ecology*.

Bayesian statistics tutorial

PI: Peter Guttorp
Center researcher: David Madigan
EPA researcher: George Flatman
Research staff: Peter Sutherland

George Flatman at EPA Las Vegas brought to our attention the need to develop a tutorial in Bayesian statistics with environmental emphasis. Work on this has commenced, using hypertext tools to create a cross-referenced, interactive tutorial that can be easily disseminated either on the Web or by CD-ROM. A preliminary section illustrating some of the tools used was demonstrated at the Joint Statistical Meetings in Anaheim, August 1997.

Markov chain Monte Carlo demonstration

PI: Dean Billheimer
Research staff: Peter Sutherland

Tools for demonstrating Markov chain Monte Carlo calculations are being developed using the JAVA programming language. The tools include graphical displays of prior and posterior distributions, and simple sliders to change parameter values and data values to enable the user to develop a better understanding of the effect of such changes on the fi-



nal inference. A preliminary version of the tools was demonstrated at the Joint Statistical Meetings in Anaheim, August 1997.

Several programs written for this and the previous projects are in accordance with the component architecture specification being developed for the Java language. By keeping within the guidelines of this specification these components can be easily reused as individual programs, or combined within a larger framework.

3.1.3 Model assessment

Stochastic precipitation model

PI: Jim Hughes

Center researchers: Peter Guttorp, Dennis Lettenmaier

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. The model is based on the concept of weather states, that summarize the atmospheric behavior, and uses a hidden Markov model with nonstationary transition probabilities. A paper, *A Nonhomogeneous Hidden Markov Model for Precipitation*, by Hughes, Guttorp and Charles, is under revision for *Applied Statistics*.

Assessment of environmental fate and transport models

Co-PIs: Alison Cullen and Adrian Raftery

Research assistant: Samantha Bates

This project will integrate two ideas: the Bayesian synthesis assessment method applied to risk assessment and other environmental models, and validation of environmental fate and transport models (those leading to estimates of toxicant intake) using site specific information from the New Bedford Harbor Superfund site. In particular, we will develop the Bayesian synthesis method in the context of models for predicting the nature and levels of contaminants across media.

Assessment of toxicodynamic models

PI: Elaine Faustmann

EPA researchers: Woody Setzer and Chris Lay



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Center researchers: Brian Leroux, Scott Bartell, Rafael Ponce

Two current projects deal with developmental toxicity models for methylmercury, and assessment of the EPA integrated Exposure and Uptake Biokinetic Model. Furthermore the group has met with Woody Setzer and Chris Lau (October 16-17, 1997) to develop a collaborative research agenda for toxicity modeling of 5-FU and methylmercury. The basic stochastic model describes the cellular processes using Markov processes. These are then used in conjunction with a toxicokinetic model to generate model predictions for litters.



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

The Environmental Protection Agency develop and use complex multi-parameter models of ecological and environmental processes to make predictions about such phenomena as transport and deposition of pollutants and their effects on public health. Such models contain many functions not all of which have an undisputed place in the model. Typically, estimation of multiple parameters during calibration is made from limited data or even from data which itself has been produced by models). This makes such models vulnerable to the problems of (1) non-uniqueness, where different models may fit particular data sets equally well; and (2) accommodation, where an apparently acceptable model calibration may be achieved due to unrecognized distortion of parameter estimates. As a solution to these problems we have developed a methodology for the use of simulation models, the Pareto Optimal Model Assessment Cycle (POMAC) that recognizes: (a) models must be constructed for a particular purpose from an available knowledge and data base; (b) the incompleteness of such models. We will develop this methodology further, and apply it to large-scale models such as RADM or Models-3.

3.1.4 Space-time models

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

PI: Lianne Sheppard

EPA researchers: Larry Cox, Dave Holland, Sharon LeDuc, Jim Quackenboss

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. We will evaluate the air pollution predictions both using cross-validation techniques to assess the accuracy of the prediction when a single location is left out, and also in terms of improvements to the health effects analysis. In order to assure that improvements in the health effects analysis are not due to hidden biases, these evaluations will be conducted on simulated as well as observed data.



Use of personal monitors to assess health effects of particulate matter exposure

PI: Alison Cullen

EPA researcher: John Vandenberg

Center researcher: Tim Nyerges

Recent interest in the levels of and health effects associated with airborne particulate matter exposure have sparked studies in the US and worldwide. Working with local scientists we are examining new measurements of PM_{2.5} taken by personal monitors in occupational settings, both industrial 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 HERTL, EPA and has received funding from the Joint Fund for US/Czech/Slovak Science and Technology. Regression analyses will be carried out in the coming year to identify factors influencing particulate matter exposure in Slovakia and to support the process of standard setting process eventually. The entire research team will come to Seattle in August 1998 to meet with additional NCRSE statisticians and the UW Department of Geography's GIS in decision making group, as well as to prepare presentations for the ISEA meeting in Boston which will be held that month.

Modeling time series of multiply censored data

PI: Mary Lou Thompson

EPA researcher: John Warren

Center researcher: Bruce Peterson (Terastat)

The statistical practices of chemists are designed both to minimize the probability of misidentifying 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.).

3.1.5 Sampling and design

Composite sampling



PI: Gerald Van Belle

Center researcher: Steve Edland

Composite sampling, defined as the pooling of field samples prior to measurement or laboratory analysis, is a simple and straightforward method of enhancing sampling programs in situations where estimates of variability are less important. We will extend the methodology from the log-normal case to a variety of distributions, and examine the composite sampling strategy in assays with limits of detection. Among important applications is routine monitoring of ground water for presence of metals (and other toxic substances) at the Hanford Reservation's tank farm. If the tanks are in stable condition there should be no leakage or contamination. Samples are taken at regular intervals and could be pooled. If there is no leakage then the pooled sample should be negative. A paper by Griffith et al., entitled *Contributions to Composite Sampling*, has been submitted to *Ecological and Environmental Statistics*.

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) is a two-phase sampling procedure involving initial ranking of each of m samples of size m (often via a relatively cheap or fast method of measurement), followed by observing (often using a more accurate and more expensive method of measurement) the first order statistic from the first sample, the second order statistic from the second sample, and so on, until the m^{th} order statistic from the m^{th} sample yields a secondary sample of size m from the initial m^2 data points. The goal of our research is to determine a set of conditions under which RSS is the appropriate statistical methodology to implement when trying to collect environmental data. We will consider ranking costs as well as analytic costs in our work. Assessing effects of errors in ranking could increase the usefulness of RSS for environmental managers. We also plan to apply RSS to data on habitat measurements for streams and estuarine areas in Washington and Oregon.

3.1.6 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). A working group in biological monitoring of benthic invertebrates has been meeting regularly for three years, and is continuing under Center auspices. In addition, the precipitation group,



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the health effects group, the covariance modeling group and the ozone group have regularly scheduled meetings which are announced on the web page and open to any interested members of the campus community. There are also regular journal clubs associated with various Center activities.



3.2 Visitors

It is the stated intent of the Center to have a vigorous and stimulating visitors program. The first set of visitors joined the Center during the summer of 1997, and included

- Sandra Bird, EPA Georgia (work on integration of sociological and biological/chemical models)
- Wendy Meiring, NCAR (work on ozone modeling and covariance estimation)
- Pascal Monestiez and Denis Allard, Université de Avignon, France (work on covariance estimation and kriging)
- Dean Billheimer, Boeing (work on Markov chain Monte Carlo and on biological monitoring)

Several proposals from potential visitors for the academic year 1997-98 were received. Most of them will be funded. Priority is given to researchers who are intending to work with specified Center researchers or research projects. In addition, we expect to invite potential collaborators and influential environmental statisticians for shorter visits in order to establish contacts that can result in further joint work.

3.3 Research products

Although the Center has been in a building phase during its first year, a variety of products have been produced. The following is a partial list of Center funded research products.

- J. Besag, J. L. Moffett, S. D. Byers and W.-H. Li (1997): Probabilistic classification of forest structures by hierarchical modelling of the remote sensing process. Submitted for publication.
- D. Billheimer, T. Cardoso, E. Freeman, P. Guttorp, H.-W. Ko and M. Silkey (1997): Natural variability of benthic species in the Delaware Bay. *Environmental and Ecological Statistics* 4: 95-115.
- A. C. Cullen and H. C. Frey (1997): *The Use of Probabilistic Techniques in Exposure Assessment*. Book manuscript (xx+422 pp.).
- W. Griffith, S. Edland, and G. Van Belle: Contributions to Composite Sampling. Submitted to *Environmental and Ecological Statistics*.
- P. Guttorp, W. Meiring, and P.D. Sampson (1997): Contribution to discussion of R.J. Carroll, R. Chen, T.H. Li, H.J. Newton, H. Schmiediche, N. Wang and E.I. George



- (1997): Trends in ozone exposure in Harris County, Texas. *Journal of the American Statistical Association* **92**: 405-408.
- J. P. Hughes, P. Guttorp, and S. P. Charles (1996): A Nonhomogeneous Hidden Markov Model for Precipitation. Under revision for *Journal of the Royal Statistical Society, Series C*.
- L. Knorr-Held and J. Besag (1997): Modelling risk from a disease in time and space. Submitted for publication.
- W. Meiring, P. Guttorp, and P. D. Sampson (1997): Computational Issues in Fitting Spatial Deformation Models for Heterogeneous Spatial Correlation. To appear, *Proceedings of the 29th Symposium on the Interface: Computing Science and Statistics*.
- W. Meiring, P. Guttorp, and P. D. Sampson (1997): Space-time estimation of grid-cell hourly ozone levels for assessment of a deterministic model. Submitted to *Environmental and Ecological Statistics*.
- W. Meiring, P. Guttorp and P. D. Sampson (1997): On the validity and identifiability of spatial deformation models for heterogeneous spatial correlation structure. Submitted to *Mathematical Geology*.
- L. Sheppard, D. Levy, G. Norris, T. V. Larson and J.Q. Koenig (1977): Effects of ambient air pollution on non-elderly asthma hospital admissions in Seattle, Washington 1987-1994. Submitted to *Epidemiology*.
- M. Silkey and N. Nur (1997): Do mist nets measure breeding density? To appear, *Condor*.
- H. Tjelmeland and J. Besag (1977): Markov random fields with higher-order interactions. To appear, *Scandinavian Journal of Statistics*.

4. Administration

Much of the first year of Center activities was spent setting up administrative routines, such as proposal submission dates, evaluation criteria, payroll coordination etc. The executive committee was instrumental in setting these policies, and the administrative details were expertly handled by our Secretary Supervisor.



4.1 Executive and advisory committees

4.1.1 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 National Water Research 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 had its first meeting during the ORD-NRCSE workshop in January, 1997.

4.1.2 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).

4.2 Space

The Center started with off-campus space about 10 minutes walk from campus. Sooner than expected, after about two months, surge space in Bagley Hall on campus was made available. This space is shared with the cross-disciplinary graduate program in Quantitative Ecology and Resource Management. Another group with space adjacent to ours is the newly created Program on the Environment, which is developing undergraduate and graduate curricula in Environmental Science. At the time of application for Center funding, the University offered new space for the Center in the Chemistry Library Building. We are expecting to move in to this space by September of 1998.

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.



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4.3 Hiring

The Center office is competently managed by our Secretary supervisor, Gerri Goedde. She was selected from a group of four interviewed candidates.

During the first year it became increasingly obvious that the Center was in need of a computer systems specialist. After advertising and interviewing the four top candidates, one was hired but resigned after a few weeks. We were allowed to fill the position from the original pool of applicants without readvertising, and hired Erik Christianson.

The third staff position, which we just filled, is a research programmer/software engineer. We hired Peter Sutherland, who was our Web master during the first year of the Center.

We do not currently anticipate hiring any more staff.



4.4 Relations to other statistical research groups

4.4.1 NCAR (National Center for Atmospheric Research)

Many of the activities in the Geophysical Statistics Project at NCAR in Boulder, Colorado, 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 hoping to develop close ties with this group, perhaps by joint funding of postdoctoral researchers who can spend some part of their tenure at each of the research centers.

4.4.2 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, David Ford (Forestry) is going to spend some time at NISS during the coming year, in order to pursue research on model assessment.

5. Forward view

The plans for the current academic year are exciting. We are aiming at increasing our visibility in the community by holding several workshops. In addition, we are planning and co-sponsoring scientific conferences, increasing the activity in our visitors program, enhancing tools for long distance scientific collaboration, and considering developing an electronic publication series.

5.1 Workshops

We are planning 3 workshops during the academic year 1997-98. The first one, entitled *Combining Information From Programs That Monitor Ecological And Natural Resources*, is organized by Joseph Sedransk at Case Western University, and will take place at the University of Washington November 21-22, 1997. A larger workshop, entitled *Environmental Monitoring Surveys Over Time*, is tentatively planned for April, also at the University of Washington. The third workshop is still in the planning stages. It will be concerned with meteorological adjustment of air quality data, and is likely to be taking place at NISS in North Carolina. No date has been set yet.

5.2 Conferences

The Center is co-sponsoring the 7th International Meeting on Statistical Climatology which takes place at Whistler Resort in British Columbia, Canada, in May of 1998. Peter Guttorp is the program chair. In addition, the Center will host the Fifth SPRUCE conference at the University of Washington, tentatively scheduled for June or July 1999. Peter



Guttorp is co-chair of the program committee with Jim Zidek at the University of British Columbia in Vancouver, and Mary Lou Thompson is the local arrangements chair.

5.3 Visitors program

As pointed out earlier, the visitors program is an essential part of the Center activities. In order to increase participation in this program, we are inviting leading researchers to pay a short visit to the Center in order to explore potential joint research projects. Among those who have tentatively agreed to a visit during the coming academic year are Noel Cressie, Iowa State University, Mike West, Duke University, G. P. Patil, Penn State University, Peter Green, University of Bristol, Tony Rossini, University of South Carolina, Steven Charles, CSIRO Australia. Several researchers have expressed interest in spending all or part of the academic year 1998-99 at the Center. Among those are Merlise Clyde, Duke University, G. P. Patil, Penn State University, and Dianne Cook, Iowa State University.

5.4 Electronic collaboration

The Center computing staff is evaluating various tools that are available for collaborative work over the Internet. We are currently testing Microsoft Netmeeting, a Windows 95 product that allows application sharing, a whiteboard application, video and audio connections. The research project on Ranked Set Sampling is likely to be the first to evaluate this technology, although some of the Center working groups are considering using the technology in order to allow EPA researchers to participate actively in group meetings. In addition we are considering a variety of options for broadcasting our seminars over the Internet.

5.5 Publications

The question of electronic publishing is of interest to Center researchers, and we are considering producing a series of publications, including workshop summaries, position papers, and tutorial materials, to be made publicly available over the Internet at no or minimal cost to the user.



Appendix A. Seminars

Autumn quarter, 1996

October 8 Peter Guttorp, NRCSE: The National Research Center for Statistics and the Environment (attendance approximately 50)

October 15 Joe Felsenstein, Genetics, University of Washington: Evolutionary trees of genes within species: how to use them, whether to use them. (60)

October 22 Patricia Cirone, John Yearsley, Bruce Duncan, Joe Goulet and Julius Nwosu, EPA Region X, Seattle: The Use of Statistical Techniques when Evaluating Uncertainty and Variability in Human Health and Ecological Risk Assessments. (50)

October 29 Jim Hughes, NRCSE: Modeling rainfall in SW Australia. (40)

November 5 David Ford, NRCSE: Developing Ecological Models for Practical Use (50)

November 12 Paul D. Sampson, NRCSE: Spatio-Temporal Analysis and Modeling of Tropospheric Ozone (40)

November 26 Jim Karr, NRCSE: Attaining Environmental Goals: Biological Monitoring in Theory and Practice. (40)

December 3: Milton Smith, Remote Sensing Laboratory , University of Washington: Remote sensing of the Amazon basin. (30)

December 10: Joel Reynolds, Statistics, University of Washington. How good is your model? or Process Model Assessment using Pareto Optimality (30)

Winter quarter, 1997

January 7 Steve Millard, Statistics, Probability and Information: Environmental Statistics package for S-Plus. (35)

January 14 Chris Frissell, University of Montana: Spatial Assessment of Biological Status and Biodiversity Loss (40)

January 21 Dennis Lettenmaier, NRCSE: Effects of Forest Management on flooding in the Western Cascades (50)



January 28 Ray Hilborn, Fisheries, University of Washington: Using hierarchic Bayesian meta-analysis to synthesize the existing knowledge on the recruitment dynamics of fish stocks (30)

February 4 Rick Edwards, Fisheries, University of Washington: Predicting watershed effects of human actions: the need for new statistical approaches at the land-river interface (35)

February 11 David Montgomery, Geology, University of Washington: Alluvial and bed-rock channels, forests, and river incision: never mind climate change, what about erosion change? (25)

February 18 Tim Nyerges, NRCSE: Toward a Theory of GIS-supported Collaborative Decision Making: Enhanced Adaptive Structuration Theory (35)

February 25 Alta Turner, CH2M Hill: Superfund Cleanup in a residential area: Digging out the bad dirt (20)

March 4 Bruce Peterson, Terastat: Calibration and the effect of measurement uncertainty on environmental decisions. (30)

March 11 Gerald van Belle, NRCSE: The Bivariate Normal—A Willing Suspension of Disbelief. (25)

Spring quarter, 1997

April 1 Alison Cullen, NRCSE: PCB Congener Levels and Profiles in Environmental Media near New Bedford Harbor - Measurements and Model Estimates (35)

April 8 Francis Zwiers, Environment Canada: Interannual variability and predictability in an ensemble of six weather models. (25)

April 22 (Earth Day) Maria Silkey, NRCSE: Developing the tools to meet the nations monitoring needs —a report on the Environmental Monitoring and Assessment Program's research symposium in Albany, New York. (25)

April 29 Pat Sullivan, International Pacific Halibut Commission: Individual Growth as a Factor Affecting Estimates of Halibut Abundance and Model Development Using Fournier's ADModelBuilder. (30)



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May 6 Panel Discussion on Federal Ozone Standards. Tony O'Hagan, University of Nottingham, Peter Guttorp, NRCSE, Jim Zidek, University of British Columbia, Larry Cox, EPA, and Clint Bowman, Washington Department of Ecology. (45)

May 13 Lianne Sheppard, NRCSE: Hospital Admissions during Ozone Excesses: the Seattle Story (35)

May 20 Peter Ward, Geology, University of Washington: Fluctuations in Biodiversity over Geologic Time (25)

May 27th Nancy Neuerburg, King County Metro: Transit and Statistics—A Sampler. (20)

June 3 Paul Sampson, NRCSE. Where the Center is going (30)



National Research Center for Statistics and the Environment

Summer quarter, 1997

July 2 Sandra Bird, EPA Athens: ReVA – Ecological Assessment in NERL (attendance was not taken during the summer)

July 9 Denis Allard, University of Avignon, France: Spatial modeling of temperatures using land use data

July 16 Wendy Meiring, NCAR: Statistical challenges in analyzing stratospheric ozone data at mid-latitude

July 23 Peter Guttorp, NRCSE: The future of environmental statistics

July 30 Jan Beirlant, University of Leuven, Belgium: Practical analysis of extreme values (with applications to earthquakes, windspeed modelling)



Appendix B. Workshop agendas

ORD-NRCSE Environmental Statistics Workshop

309 Parrington Hall (the Forum), University of Washington
January 21-22, 1997

Tuesday, January 21

8:30 Welcome and Introductions Peter Guttorp/Larry Cox

8:45 About the Center Peter Guttorp

9:00 Technology Issues David Madigan

9:30-12:00 I. Space-Time and Meteorological Models

9:30 Space-time covariance Paul Sampson

9:50 Spatial/temporal modeling George Flatman
- spatial/temporal structures
- multicomponent geochemical fingerprint analyses of anion/cation mixtures

10:10 Spatial design and analysis Larry Cox
- spatial methods for design and evaluation of monitoring networks
- combining spatial and GIS methods for environmental assessment

10:30 Combining ecological data over spatial and temporal scales Tony Olsen

10:40 Aggregation techniques for decision support Brian Eder

10:55 Floor discussion

11:45 Lunch and Small Group Discussions I

1:00-3:15 II. Ecological Assessment

1:00 Ecological indicators Jim Karr

1:20 Space-time models for proportions Peter Guttorp

1:40 Ecological indicators Tony Olsen
-compositional data: its use in constructing ecological indicators

1:55 QA for regional scale assessments Iris Goodman



- 2:10 Ecological/landscape systems
- integration of ecological process models to assess consequences of landscape pattern
- statistical approaches to compare expected to observed values in landscape indicators
- statistical approaches to assess accuracy and confidence in various landscape composition and pattern indicators

Bob Brown

2:40 Floor discussion

3:15 Break

3:30-4:45 NRCSE Weekly Seminar (in Smith 211)

- 3:30 Effects of Forest Management on Flooding in the Western Cascades

Dennis Lettenmaier

4:40 Small Group Discussions II

5:30 Adjourn

7:30 Dinner at Ivar's Salmon House

Wednesday, January 22

8:00-11:30 III. Model Assessment

- 8:30 Assessing model uncertainty

Adrian Raftery

- 8:50 Model choice using Pareto optimality

David Ford

- 9:10 Model validation
- development of statistical methods for model validation when input variables are subject to error
- model validation and transport

Larry Cox

- 9:30 Estimation from data bases having differing quality assurance parameters

John Warren

- 9:45 The need for statistical tools to quantify uncertainties in inventories of emissions to the atmosphere

William Benjey

10:00 Floor discussion

10:45 Break

11:00 Small Group Discussions III



11:30 Lunch

12:30-2:15 IV. Environmental Sampling and Analysis

12:30 Environmental sampling

Loveday Conquest

12:50 Sampling methods, quality assessment and human exposure

David Marker and Bob Clicker

1:10 Sampling designs

Bob Brown

- efficient immunochemical measurement screens
- remote sensing sampling designs
- field sampling designs
- hazardous waste identification rule
- human exposure surveys

1:35 Meta-analytic methods for site characterization

Larry Cox

1:40 Floor discussion

2:00 Break and Small Group Discussions IV

2:30-5:00 V. Toxicology and Risk Assessment

2:30 Risk assessment

Alison Cullen

2:50 Ambient air pollution and health -- what can we learn about risks?

Lianne Sheppard

3:10 Toxicology I

Woody Setzer

- predictive quantitative dose-response models in neurotoxicology
- quantitative models of developmental toxicity
- correlation of immune system function data with resistance to diseases

3:35 Toxicology II

Dan Guth

- modeling the relationship between exposure and toxic severity using regression on ordinal response data
- ratios analysis for RfD uncertainty analysis
- exposure factor distributions and dermal exposure activity patterns

4:05 Risk assessment

George Flatman

- stochastic systems analysis of physiologically based pharmacokinetic (PBPK) and microenvironmental exposure/dose models
- Monte Carlo confidence bounds
- parameter estimation for compartmental models
- optimal status and trends monitoring using Bayesian analysis

4:20 Extensions of meta-analysis: hierarchical methods for

Larry Cox



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combining studies

4:25 Floor discussion

5:00 Closing Observations and Next Steps

Peter Guttorp/Larry Cox

5:15 Small Group Discussions V

6:00 Adjourn



Cascadia Tropospheric Ozone Peer Review Meeting

Day 1

7:45 Overview/Introduction

8:15 Mesoscale Modeling with MM5
Synoptic Scale Meteorology during Ozone Episodes
Cliff Mass and Ernie Recker, Atmospheric Sciences, UW

9:15 Photochemical Grid Model Simulations
Brian Lamb, Laboratory for Atmospheric Sciences, WSU

10:15 Break

10:30 Questions

10:50 Adjusting surface ozone for meteorology and emissions
prior to the investigation of time trends
Joel H. Reynolds, Statistics Department, UW

11:35 Spatial Distribution of Ozone Dosages in Western Washington
Dave Peterson, College of Forest Resources, UW

12:20 LUNCH (on your own)

1:25 Questions

1:45 Hydrocarbon and Carbonyl Measurements
Hal Westberg, Laboratory for Atmospheric Sciences, WSU

2:30 Analysis of Ozone Precursor Data Sets
Halstead Harrison, Atmospheric Sciences, UW

3:15 Break

3:30 Tunnel Measurements and Chemical Mass Balance Analysis
Eric Fujita, University of Nevada, Desert Research Institute

4:15 Questions

4:35 Key Issues for Discussion
Peer review panel

5:00 Adjourn



6:30 Dinner Cruise and Reception

Day 2

Session 1.

9:00-12:00 Workgroups meet (Closed meeting)

12:00 LUNCH (on your own)

1:00 Round-table discussion (Closed meeting for scientists in workgroups)

Session 2.

9:00-10:00 Results from the Interview Process conducted throughout Cascadia
Regarding the Policy and Science Issues of Ozone and Fine Particulate
Jay Hayney, Systems Applications International

10:00 Discussion and Questions

10:45 Break

11:00 Important Cross Boundary Issues: Canadian Perspective
Bruce Thompson, Environment Canada

12:00 LUNCH (on your own)

Combined Sessions 1 and 2:

2:30 Summary and Findings of the Meeting
Peer Review Panel



Appendix C. Conference presentations

All presentations are invited talks unless specifically noted.

Alison Cullen: *A comparison of model estimates and measurements of PCB levels in soil and produce near New Bedford harbor*. Society of Risk Analysis annual meeting, New Orleans, Louisiana.

Alison Cullen: *Exposure to polychlorinated biphenyls in residential indoor air and outdoor air near a Superfund site*. Society of Risk Analysis annual meeting, New Orleans, Louisiana, contributed talk.

Peter Guttorp: Panel discussant on *Cooperative Agreements*, EPA Statisticians meeting, Richmond, Virginia.

Maria Silkey: Poster on *Evaluating a model of the benthic macroinvertebrate distribution in Delaware Bay*. EMAP research conference, Albany, New York.

Peter Guttorp: *A National Research Center on Statistics and the Environment*, 29th Symposium on the Interface: Computing Science and Statistics, Houston, Texas.

Wendy Meiring: *Computational Issues in Fitting Spatial Deformation Models for Heterogeneous Spatial Correlation..* 29th Symposium on the Interface: Computing Science and Statistics, Houston, Texas.

Julian Besag, Florentina Bunea, and Thomas Richardson: *Exact MCMC p-values for multi-dimensional contingency tables*. American Mathematical Society Conference on Graphical Models, Seattle, Washington.

Paul Sampson: *Spatio-temporal modeling for an hourly air quality monitoring network*. Joint Statistical Meetings, Anaheim, California.

Peter Guttorp: *A national research center on statistics and the environment*. Invited poster, Joint Statistical Meetings, Anaheim, California.

Peter Guttorp: Panel discussant on *The future of environmental statistics*. Joint Statistical Meetings, Anaheim, California.

Peter Guttorp: *Weather states, hidden Markov models, and precipitation modeling*. Joint Statistical Meetings, Anaheim, California

Gerald Van Belle: Discussant, *Environmental Epidemiology*, Joint Statistical Meetings, Anaheim, California.



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Julian Besag: *Disease mapping and risk assessment for public health decision making.*
EU/WHIO workshop, Rome, Italy.

Loveday Conquest: *Effects of commercial salmon net fisheries on protected seabirds.*
Environmetrics, Vienna, Austria.



Mary Lou Thompson: *Partial least squares analysis of neurotoxic effects of agrochemical exposure*. SPRUCE IV, Enschede, Holland, contributed talk.

Gerald Van Belle: *Composite sampling*. SPRUCE IV, Enschede, Holland, contributed talk.

Joel Reynolds: *Adjusting surface ozone for meteorology and emissions prior to the investigation of time trends*. Cascadia Tropospheric Ozone Peer Review Workshop, Seattle, Washington.

Alison Cullen: *Approaches to Uncertainty Analysis in Risk Assessment and Risk Communication*. Institute of Epidemiology and Hygiene, Banska Bystrica, Slovakia.

T. A. Lewandowski, C. H. Pierce, S. M. Bartell, R. A. Ponce, and E. M. Faustman. *Toxicokinetic and toxicodynamic modeling of the effects of methylmercury in the fetal rat*. Fourteenth Annual Meeting of the Pacific Northwest Association of Toxicologists, Ocean Shores, Washington, poster.