FINAL TECHNICAL REPORT: PROJECT 2

LOCAL INFERENCE

PERIOD COVERED BY FINAL REPORT: October 1, 2001 - September 30, 2006
DATE OF FINAL REPORT: December 15, 2006
EPA COOPERATIVE AGREEMENT NUMBERS: CR 829095 & CR 829096
PROGRAM NAME (TITLE): SPACE-TIME AQUATIC RESOURCES MODELING AND ANALYSIS PROGRAM (STARMAP)
PROJECT TITLE: Local Inference
INVESTIGATORS: F. Jay Breidt (Principal Investigator, CSU), Jean Opsomer (ISU), Richard A. Davis, (CSU), and Jennifer A. Hoeting (CSU)
INSTITUTIONS: Colorado State University (CSU), Oregon State University (OSU), and Iowa State University (ISU)
RESEARCH CATEGORY: Research Program on Statistical Survey Design and Analysis for Aquatic Resources
PROJECT PERIOD: October 1, 2001 - September 30, 2006
OBJECTIVE OF RESEARCH: To Develop Hierarchical Spatio-Temporal Models for *Local Inferences* about Aquatic Resources
TITLE: Local Inferences from Aquatic Studies

FUNDING: This project was jointly funded by STARMAP at Colorado State University and DAMARS at Oregon State University, and cooperated with work at Iowa State University funded by DAMARS.

SUPPLEMENTAL KEYWORDS: Kernel regression, thin plate splines.

RELEVANT WEB SITE: http://www.stat.colostate.edu/starmap

1. ACCOMPLISHMENTS of PROJECT 2: LOCAL ESTIMATION

This Project had an overall goal of developing hierarchical spatio-temporal models for local inferences about aquatic resources. The project was conducted jointly with a DAMARS project on development of nonparametric model-assisted estimators for data obtained in probability surveys of aquatic resources. Accomplishments include

- Extension of nonparametric model-assisted and model-based estimators for standard survey problems and for small area estimation problems;
- Adaptation of deconvolution methods for spatial distribution function estimation;
- Development of new state-space models and estimation methods for stream networks; and
- Development of a novel algorithm (*spatial Lasso*) for selection of covariates and neighborhoods from GIS data in spatial regression problems.

The extensions of the nonparametric model-assisted methodology allow for a variety of complex designs and for incorporation of the major smoothing techniques in use today (including spline-based regression, additive models and semi-parametric models). The methods were applied to the general problems of estimation of population means, totals, and distribution functions. In many surveys, estimators are desired for small domains within the overall population. Because a survey often is not designed to provide reliable estimators for such small domains, the estimation requires the assumption of a model for the population. Investigators in this Project adapted the nonparametric methodology used in the model-assisted context to this situation, and showed how this approach generalizes existing small area estimation methods.

In addition to studying estimation of the distribution function in the design-based setting using nonparametric model-assisted estimators, we also considered deconvolution, which is the estimation of the cumulative distribution function (cdf) of a variable given noisy measurements of that variable and distributional information about the measurement noise. We treated this problem as one of constrained Bayes estimation, which we extended to hierarchical Bayesian spatial models and studied under aggregation of small areas.

Because of the natural flow of water in a stream network, characteristics of a downstream reach may depend on characteristics of upstream reaches. The flow of water from reach to reach provides a natural time-like ordering throughout the stream network. Investigators in this Project developed a state-space model to describe the spatial dependence in this tree-like structure with ordering based on flow. The model formulation is flexible, allowing for a variety of spatial and temporal covariance structures in the state and measurement equations. They also derived a variation of the Kalman filter and smoothe to allow recursive estimation of unobserved states and prediction of missing observations on the network, as well as computation of the Gaussian likelihood. The state-space formulation is extensible to non-linear and non-Gaussian processes. The Project investigators also developed several models of within-stream dependence, including network analogues of autoregressive-moving average models and of structural models, and fitted those models to real and simulated data.

Geographic Information Systems (GIS) organize spatial data in multiple two-dimensional arrays called layers. In many applications, a response of interest is observed on a set of sites in the landscape, and it is of interest to build a regression model from the GIS layers to predict the response at unsampled sites. Model selection in this context then consists not only of selecting appropriate layers, but also of choosing appropriate neighborhoods within those layers. Project investigators formalized this problem and proposed the use of Lasso (Least absolute shrinkage and selection operator) to simultaneously select variables, choose neighborhoods, and estimate

parameters. They incorporated spatial smoothness in selected coefficients through use of a priori spatial covariance structure, leading to a modification of the Lasso procedure. The LARS algorithm, which can be used in a fast implementation of Lasso, was also modified to yield a fast implementation of spatial Lasso. The spatial Lasso performed well in numerical examples, including an application to prediction of soil moisture. The work reported in this paragraph was done in cooperation with investigators working under Project 3.

A number of graduate students were involved in this research, including Ji-Yeon Kim and Curtis Miller (Iowa State University), Alicia Johnson, Siobhan Everson-Stewart, Mark Delorey, and Bill Coar (Colorado State University). Work also involved a postdoctoral fellow, Giovanna Ranalli (Colorado State University), plus two junior researchers (Hsin-Cheng Huang, Academica Sincia and Nan-Jung Hsu, National Tsing-Hua University).

The results of this Project were communicated to diverse audiences, ranging from state-level aquatic scientists to international investigators. Section 5 lists those communications, organized by type of communication.

2. SIGNIFICANCE OF ACCOMPLISHMENTS

This Project has developed statistical analysis tools of relevance to aquatic scientists concerned with surveys, and spatial-temporal modeling. The client community for the results of this research program consisted of aquatic monitoring scientists in state, tribal, federal, and more local agencies charged with monitoring aquatic resources in compliance with the Clean Water Act. Such aquatic scientists will be assisted by affiliated statisticians and landscape ecologists.

3. STAKEHOLDERS AND USERS OF RESULTS

There are many potential users of the methods developed by STARMAP and DAMARS under this joint Project. The two Programs have organized and presented a number of conferences or parts of conferences directed specifically at potential users. Program personnel also have participated in a number of conferences at the invitation of potential users. Some of the conferences are explained in more detail under Project 4, Outreach and Extension.

4. HOW PRODUCTS WILL FURTHER SCIENCE/ MANAGEMENT OF RESOURCES

The statistical analysis tools (products) developed and disseminated by this Project provide aquatic scientists and affiliated statisticians with expanded and more defensible ways to draw inferences to local concerns from wide-area surveys than were available prior to this Project. These tools extend previously available spatial-temporal methods to accommodate the branching nature of streams and rivers.

5. LISTING OF SPECIFIC COMMUNICATIONS RELATED TO LOCAL ESTIMATION

Note that this list is a subset of the entire output list from STARMAP; the complete list, supplied as a separate document as a part of this final report, provides internal links to most of the presentation materials, technical reports, and some manuscripts. Published material ordinarily was copyrighted by the publisher, so access to it usually is restricted to subscribers of that publication. The subset below includes all communications related to local estimation.

***PUBLICATIONS and ACCEPTED MANUSCRIPTS*:**

- Breidt, F.J., J.D. Opsomer, A.A. Johnson, and M.G. Ranalli. Semiparametric model-assisted estimation for natural resource surveys. Preprint Series #05-05, Department of Statistics, Iowa State University. To appear in *Survey Methodology* (Accepted November 29, 2006).
- Andrews, B., R.A. Davis, and F.J. Breidt (2007). Rank-based estimation for all-pass time series models. To appear in the *Annals of Statistics* April, 2007.
- Breidt, F.J., N.-J. Hsu, and S.M. Ogle (2006). Semiparametric mixed models for increment-averaged data with application to carbon sequestration in agricultural soils. To appear in the *Journal of the American Statistical Association*.
- Brockwell, P.J., R.A. Davis, and V. Yang (2007). Continuous-time Gaussian autoregression. To appear in *Statistica Sinica* **17**:.
- Wang, H. and M.G. Ranalli (2006). Low-rank smoothing splines on complicated domains. To appear in *Biometrics* **62**:
- da Silva, D.N. and J.D. Opsomer (2006). A kernel smoothing method to adjust for unit nonresponse in sample surveys. *Canadian Journal of Statistics* **34**: .
- Breidt, F.J., N.-J. Hsu, and W.J. Coar (2006). A diagnostic test for autocorrelation in increment-averaged data with application to soil sampling. To appear in *Environmental and Ecological Statistics* **13**:.
- Opsomer, J.D., F.J. Breidt, G.G. Moisen, and G. Kauermann (2006). Model-assisted estimation of forest resources with generalized additive models. To appear in the *Journal of the American Statistical* **101**: as a Discussed Paper in Applications and Case Studies.
- Francisco-Fernandez, M., M. Jurado-Exposito, J.D. Opsomer, and F. Lopez-Granados (2006). A nonparametric analysis of the distribution of Convolvulus arvensis in wheat-sunflower rotations. *Environmetrics* **17**:849-860.
- Pratesi, M., N. Salvati, and M.G. Ranalli. P-splines M-quantile small area estimation: assessing the ecological conditions of lakes in the Northeastern US. Proceedings, Conference on Spatial Data Methods for Environmental and Ecological processes, Foggia, Italy, September 14-15, 2006
- Andrews, B., R.A. Davis, and F.J. Breidt (2006). Maximum likelihood estimation for all-pass time series models. *Journal of Multivariate Analysis* **97**: 1638-1659
- Hoeting, J.A., R.A. Davis, A.A. Merton, and S.E. Thompson (2006). Model selection for geostatistical models. *Ecological Applications* **16**: 87-98.
- Breidt, F.J., G. Claeskens, and J.D. Opsomer (2005). Model-assisted estimation for complex surveys using penalized splines. *Biometrika* **92**: 831-846.
- Montanari, G.E. and M.G. Ranalli (2005). Nonparametric methods for sample surveys of environmental populations. Proceedings of the Meeting of the Italian Statistical Society on Statistics and the Environment. September 21-23, 2005, Messina, Italy **CLEUP**: 147-158.
- Breidt, F.J. and N.-J. Hsu (2005). Best mean square prediction for moving averages. *Statistica Sinica* **15**: 427-446.
- Francisco-Fernandez, M. and J.D. Opsomer (2005). Smoothing parameter selection methods for nonparametric regression with spatially correlated errors. *Canadian*

Journal of Statistics **33**: 279-295.

- Opsomer J.D. and C.P. Miller (2005). Selecting the amount of smoothing in nonparametric regression estimation for complex surveys. *Journal of Nonparametric Statistics* **17**: 593-611.
- Montanari, G.E. and M.G. Ranalli (2005). Nonparametric model calibration estimation in survey sampling. *Journal of the American Statistical Association* **100**: 1429-1442.
- Hall, P. and J.D. Opsomer (2005). Theory for penalised spline regression. *Biometrika* **92**: 105-118.
- Kauermann, G. and J.D. Opsomer (2004). Generalized cross-validation for bandwidth selection of backfitting estimators in generalized additive models. *Journal of Computational and Graphical Statistics* **13**: 66-89.
- Opsomer, J.D., F.J. Breidt, G. Claeskens, G. Kauermann, and M.G. Ranalli (2004). Nonparametric small area estimation using penalized spline regression. *Proceedings of the Section on Survey Research Methods* [CD-ROM], Alexandria, VA. American Statistical Association: 4127-4134.
- da Silva, D.N. and J.D. Opsomer (2004). Properties of the weighting cell estimator under a nonparametric response mechanism. *Survey Methodology* **30**: 45-55.
- Opsomer, J.D., C. Botts and, J.Y. Kim (2003). Small Area estimation in a watershed erosion assessment survey. *Journal of Agricultural, Biological and Environmental Statistics* **8**:139-152.
- Opsomer, J.D. and F.J. Breidt (2003). Nonparametric estimation in complex surveys with auxiliary information. *Proceedings of the 54th Session of the International Statistical Institute.* Available only on conference CD
- Davis, R.A., W.T.M. Dunsmuir, and S.B. Streett (2003). Maximum likelihood estimation for an observation driven model for Poisson counts. *Biometrika* **90**: 770-790.

SUBMISSIONS

- Johnson, A.A., F.J. Breidt, and J.D. Opsomer. Estimating distribution functions from survey data using nonparametric regression. Preprint Series #04-07, Department of Statistics, Iowa State University. Submitted to the *Journal of Nonparametric Statistics* (September 20, 2006)
- Ranalli, M.G. and H. Wang. Application of graph theory to data mining: Curvilinear features extraction. Resubmitted to the *Journal of Computational and Graphical Statistics* (July, 2006).
- Opsomer, J.D., G. Claeskens, M.G. Ranalli, G. Kauermann, and F.J. Breidt. Nonparametric small area estimation using penalized spline regression. Preprint Series #05-01, Department of Statistics, Iowa State University. Resubmitted to the *Journal of the Royal Statistical Society, Series B* (2006)
- Opsomer, J.D. and M. Francisco-Fernandez. Finding local departures from a parametric model using nonparametric regression. Submitted to *Test* (2005). Available as preprint Series #05-02, Department of Statistics, Iowa State University.
- Kim, J.-Y., F.J. Breidt, and J.D. Opsomer. Nonparametric regression estimation of finite population totals under two-stage sampling. Under revision for *Survey*

Methodology. Available as Preprint Series #03-06, Department of Statistics, Iowa State University.

- Ranalli, M.G., H. Walker and H. Wang, As the crow flies or as the fish swims? A nonparametric bootstrap approach for spatial smoothing

MANUSCRIPTS

- Rodriguez-Yam, G., R.A. Davis, and L.L. Scharf. Efficient Gibbs Sampling for constrained linear regression. Under revision (2006).
- Opsomer, J.D. and M.G. Ranalli. Estimating nonresponse probabilities with p-splines. Working paper.
- Everson-Stewart, S., F.J. Breidt, and J.D. Opsomer. Nonparametric survey regression estimation in two-stage spatial sampling. Working paper.
- Hsu, N.-J. and F.J. Breidt (2005). Exact maximum likelihood estimation for non-Gaussian non-invertible moving averages. Working paper (2005)
- Delorey, M.J. and F.J. Breidt. Spatial ensemble estimates of temporal trends with application to acid neutralizing capacity. working paper - 2006.
- Huang, H.-C., N.-J. Hsu, D.M. Theobald, and F.J. Breidt. Spatial Lasso with applications to GIS model selection. In final preparation for submission to the *Journal of Computational and Graphical Statistics*.

TECHNICAL REPORTS

- Everson-Stewart, S. (2003). Nonparametric Survey Regression Estimation in Two-Stage Spatial Sampling. Masters Project Report, Department of Statistics, Colorado State University, Fort Collins. 49pp
- Johnson, A.A. (2003). Estimating Distribution Functions from Survey Data Using Nonparametric Regression. Masters Project Report, Department of Statistics, Colorado State University, Fort Collins. 69pp.

***PRESENTATIONS*:**

{Note: The first author listed in the citations below gave the presentation, unless subsequent author is marked with an * as the presenter.}

- Opsomer, J.D. Nonparametric Variance Estimation for Systemic Samples. Seminar, Department of Statistics, Colorado State University, September 18, 2006
- Pratesi, M., N. Salvati, and M.G. Ranalli. P-splines M-quantile Small Area Estimation: Assessing the Ecological Conditions of Lakes in the Northeastern US. Conference on Spatial Data Methods for Environmental and Ecological processes, Foggia, Italy, September 14-15, 2006
- Breidt, F.J., R.A. Davis, N.-J. Hsu, and M. Rosenblatt. Another Look at Estimation for MA(1) Processes with a Unit Root. Prague Stochastics 2006, Prague, The Czech Republic, August 21-25, 2006
- Coar, W.J. and F.J. Breidt. Smoothing Through State-Space Models for Stream Networks. Joint Statistical Meetings, Seattle, WA, August 6-10, 2006 . Earlier versions of this presentation were given at the North American Benthological Society, Anchorage, Alaska, June 4-9, 2006 and Spring Meeting,

Colorado/Wyoming Chapter of the American Statistical Association, Boulder, CO, April 21, 2006

- Opsomer, J.D, F.J. Breidt, G. Moisen and G. Kauermann. Model-Assisted Estimation of Forest Resources with Generalized Additive Models. The *JASA* Applications and Case Studies Invited Session with prepared discussions. Joint Statistical Meetings, Seattle, WA, August 6-10, 2006
- Breidt, F.J., S.M. Ogle, and K.H. Paustian. Uncertainty Analysis for a US Inventory of Soil Organic Carbon Stock Changes. Workshop on Uncertainty in Ecological Analysis, Mathematical Biosciences Institute, The Ohio State University, Columbus, OH, April 3, 2006
- Breidt, F.J., H.-C. Huang, N.-J. Hsu, and D.M. Theobald. Spatial Lasso with Application to GIS Model Selection. Invited - ENAR Spring Meeting, Tampa, FL, March 28, 2006
- Breidt, F.J., R.A. Davis, N.-J. Hsu, and M. Rosenblatt. Laplace Likelihood and LAD Estimation for Non-invertible MA(1). Waseda Workshop on Time Series Analysis and Its Related Topics, Waseda University, Tokyo, Japan, January 23-25, 2006
- Ranalli, M.G. Low-rank Smoothing Splines on Domains with Unusual Shapes: Nonparametric Approximations for Estuaries and Nets of Rivers. Seminar, Department of Economics, Finance and Statistics, University of Perugia, Italy, January 13, 2006
- Breidt, F.J., R.A. Davis, N.-J. Hsu, and M. Rosenblatt. Laplace Likelihood and LAD Estimation for Non-invertible MA(1). NSF/NBER Workshop in Time Series, Heidelberg, Germany, September 22-24, 2005
- Montanari, G.E. and M.G. Ranalli. Nonparametric Methods for Sample Surveys of Environmental Populations. Invited talk, Annual Meeting of the Italian Statistical Society on Statistics and the Environment, September 21-23, 2005, Messina, Italy
- Delorey, M.J., F.J. Breidt, and J.D. Opsomer. Nonparametric, Model-Assisted Estimation for a Two-Stage Sampling Design. Fourth Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, September 7-9, 2005
- Ranalli, M.G. Acid Neutralizing Capacity CDF Estimation in the Northeastern Lakes Survey: A Nonparametric Model Calibrated Pseudo Empirical Maximum Likelihood Approach. Fourth Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, September 7 - 9, 2005
- Wang, H. and M.G. Ranalli. Low-rank Smoothing Splines on Complex Domains: Smoothing Estuaries. Fourth Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, September 7 - 9, 2005
- Opsomer, J.D., G. Claeskens, M.G. Ranalli, G. Kauermann, and F.J. Breidt. Small Area Estimation Using Penalized Spline Regression. Fourth Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, September 7 - 9, 2005
- Coar, W.J. and F.J. Breidt. State-Space Models for Within-Stream Network Dependence. Fourth Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, September 7 - 9, 2005

- Breidt, F.J., H.-C. Huang, N.-J. Hsu, and D.M. Theobald. Spatial Lasso with Application to GIS Model Selection. Fourth Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, September 7-9, 2005
- Opsomer, J.D. F.J. Breidt, G. Claeskens, G. Kauermann, and G.M. Ranalli. Nonparametric Small-area Estimation Using Penalized Spline Regression. Joint Statistical Meetings, Minneapolis, MN, August 7 - 11, 2005
- Breidt, F.J. Extensions of Penalized Spline Regression for Natural Resource Monitoring Applications. Joint Statistical Meetings, Minneapolis, MN, August 7 - 11, 2005
- Ranalli, M.G., F.J. Breidt, and H. Wang. Low-rank Thin Plate Splines for Unusual Spatial Structures: Smoothing Estuaries and Stream Networks. WNAR/IMS Meeting, Fairbanks, AK, June 21 - 24, 2005
- Breidt, F.J., H.-C. Huang, N.-J. Hsu, and D.M. Theobald. Spatial Lasso with Application to GIS Model Selection. 2005 WNAR/IMS Meeting, Fairbanks, AK, June 21 - 24, 2005
- Davis, R.A., G.A. Rodriguez-Yam and T.C.M. Lee. Thoughts on Model Selection. Inaugural Alaska Consortium for Environmental Statistics (ACES), University of Alaska, Fairbanks, Alaska, March 25, 2005
- Opsomer, J.D., G. Claeskens, M.G. Ranalli, and F.J. Breidt. Small Area Estimation Using Penalized Spline Regression. Invited talk, International Biometric Society, Eastern North American Region meeting, Austin, TX, March 21, 2005.
- Ranalli, M.G. and H. Wang. Low-rank Smoothing Splines for Complex Domains and Manifold Recovery. Seminar, University of Virginia, Charlottesville, VA, March 4, 2005
- Ranalli, M.G., F.J. Breidt, and H. Wang. Low-rank Smoothing Splines on Complex Domains. Seminar, AED/NHEERL/EPA, Narragansett, RI, March 1, 2005
- Breidt, F.J. Semiparametric Mixed Models for Increment-Averaged Data with Application to Carbon Sequestration in Agricultural Soils. Computational Environmetrics Conference, Chicago, IL, October 21-23, 2004. Also presented at the Fifth Winemiller Symposium: New Developments of Statistical Analysis in Wildlife, Fisheries, and Ecological Research, University of Missouri, Columbia, MO, October 16, 2004
- Breidt, F.J. Small Area Estimation for Natural Resource Surveys. Monitoring Science and Technology Symposium, Denver, CO, September 21-24, 2004.
- Delorey, M.J. and F. J. Breidt. Distribution Function Estimation in Small Areas for Aquatic Resources: Spatial Ensemble Estimates of Temporal Trends in Acid Neutralizing Capacity. Monitoring Science and Technology Symposium, Denver, CO, September 21-24, 2004
- Opsomer, J.D. Two Applications of Nonparametric Regression in Survey Estimation. University of Lund, Lund, Sweden, September 21, 2004
- Breidt, F.J and J.D. Opsomer. Nonparametric Survey Regression Estimation Using Penalized Splines. Third Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Fort Collins, CO, September 10 - 11, 2004
- Opsomer, J.D., F.J. Breidt, and G. Claeskens. Nonparametric Small Area Estimation Using Penalized Splines. Joint Statistical Meetings, American Statistical Association. Toronto, ON, Canada, August 8, 2004

- Breidt, F.J. , N.-J. Hsu and S.M. Ogle. A Semiparametric Stochastic Mixed Model for Increment-Averaged Data with Application to Carbon Sequestration in Agricultural Soils. (invited) 6th International Chinese Statistical Association International Conference, Singapore, July 29, 2004
- Opsomer, J.D. Penalized Splines and Small Area Estimation. Universidade da Coruña, A Coruña, Spain, July 23, 2004
- Opsomer, J.D. Theory and Methods for Nonparametric Regression Estimators. Seminar on Funding Opportunities in Survey and Statistical Research, Federal Committee on Statistical Methodology, Washington DC, June 21, 2004
- Breidt, F.J. Small Area Estimation for Aquatic Resources. Seminar, Western Ecology Division, Environmental Protection Agency, Corvallis, OR, June 2, 2004
- Breidt, F.J. Linking CWA sections 305(b)/303(d)- small area estimation. EMAP Symposium 2004, Newport, RI, May 3 - 7, 2004.
- Opsomer, J.D. Two Applications of Nonparametric Regression in Survey Estimation. Seminar, North Carolina State University, April 9, 2004
- Breidt, F.J., N.-J. Hsu, and S.M. Ogle. A Semiparametric Stochastic Mixed Model for Increment-Averaged Data with Application to Carbon Sequestration in Agricultural Soils. 2004. International Biometric Society, ENAR, Spring Meeting, Pittsburgh, PA, March 29, 2004
- Ranalli, M.G. Nonparametric Model Calibration Estimation in Survey Sampling. Seminar, Department of Statistics, Iowa State University, Ames, IA, February 17, 2004.
- Breidt, F.J. Small Area Estimation in Surveys Over Time: Using American Community Survey Data to Estimate Local Area Unemployment Characteristics. Invited talk, IMS/ASA's SRMS Joint Mini Meeting on Current Trends in Survey Sampling and Official Statistics, January 1-3, 2004, Calcutta, India
- Opsomer, J.D. Two Applications of Nonparametric Regression in Survey Estimation. University of Western Australia, Perth, Australia, November 6, 2003; Canberra Chapter of the Statistical Society of Australia, Canberra, Australia, October 28, 2003; University of New South Wales, Sydney, Australia, October 22, 2003
- Opsomer, J.D., F.J. Breidt, and S. Everson-Stewart. Nonparametric Small Area Estimation for the Northeastern Lakes Survey. Second Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, August 11 - 13, 2003
- Coar, W.J. , F.J. Breidt, R.A. Davis, and N.S. Urquhart. Predicting the Perennial Status of Western Streams. Second Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, August 11 - 13, 2003
- Delorey, M.J. and F.J. Breidt. Distribution Function Estimation in Small Areas for Aquatic Resources: Spatial Ensemble Estimates of Temporal Trends in Acid Neutralizing Capacity. Second Annual Conference on Statistical Survey Design and Analysis for Aquatic Resources, Corvallis, OR, August 11 - 13, 2003
- Breidt, F.J. and N.-J. Hsu. Semiparametric Small Area Estimation with Integrated Natural Resources Data. Invited talk, Joint Statistical Meetings, San Francisco, CA, August 3-7, 2003

- Delorey, M.J. and F.J. Breidt. Distribution Function Estimation in Small Areas for Aquatic Resources. Invited talk, Joint Statistical Meetings, San Francisco, CA, August 3-7, 2003
- Miller , C.P. and J.D. Opsomer. Bandwidth Selection in Local Polynomial Regression for Complex Survey Data. Joint Statistical Meetings, American Statistical Association. San Francisco, CA, August 5, 2003
- Johnson, A.A., F.J Breidt*, and J.D. Opsomer. Nonparametric Model-Assisted Estimation of Distribution Functions from Survey Data. Invited talk at the 31st Annual Meeting of the Statistical Society of Canada, Halifax, Nova Scotia, June 8-11, 2003
- Opsomer, J.D. and F.J. Breidt. Nonparametric estimation in complex surveys with auxiliary information, Invited talk at the XXXVèmes Journées de la Statistique, Lyon, France, June 2, 2003
- Urquhart, N.S. Spatial-Temporal Aspects of Water Quality. Invited talk at the Statistical and Applied Mathematical Sciences Institute and the Geophysical Project workshop on Spatio-Temporal Modeling, National Center for Atmospheric Research, Boulder, CO June 1 – 6, 2003
- Breidt, F.J. and M.J. Delorey. Spatial Ensemble Estimates of Temporal Trends in Acid Neutralizing Capacity. Invited talk at the Statistical and Applied Mathematical Sciences Institute and the Geophysical Project workshop on Spatial-Temporal Modeling, National Center for Atmospheric Research, Boulder, CO June 1-6, 2003
- Breidt, F.J., N.-J. Hsu, and S.M. Ogle. A Semiparametric Stochastic Mixed Model for Increment-Averaged Data with Application to Carbon Sequestration in Agricultural Soils. Invited talk at the spring meeting of the Colorado-Wyoming Chapter of the American Statistical Association, Boulder, CO, April 11, 2003
- Johnson, A.A. Semiparametric Model-Assisted Estimation of Distribution Functions in Surveys with Auxiliary Information. Student Paper Competition, Annual Meeting of the Colorado-Wyoming Chapter of the American Statistical Association, April 11, 2003
- Everson-Stewart, S.P., F.J. Breidt, and J.D. Opsomer. Nonparametric Survey Regression Estimation in Spatial Sampling. Student Paper Competition, Annual Meeting of the Colorado-Wyoming Chapter of the American Statistical Association, April 11, 2003
- Johnson, A.A., F.J. Breidt*, and J.D. Opsomer. Nonparametric Model-Assisted Estimation of Distribution Functions from Survey Data. Invited talk, Eastern North America Region, International Biometric Society, Tampa, FL, March 30 - April 2, 2003
- Johnson, A.A., F.J. Breidt, and J.D. Opsomer. Semiparametric Model-Assisted Estimation of Distribution Functions in Surveys with Auxiliary Information. Eastern North America Region, International Biometric Society, Tampa, FL, March 30 - April 2, 2003
- Everson-Stewart, S.P., F.J. Breidt, and J.D. Opsomer. Nonparametric Survey Regression Estimation in Two-Stage Spatial Sampling. Eastern North America Region, International Biometric Society, Tampa, FL, March 30 - April 2, 2003

- Johnson, A.A. Estimating Distribution Functions from Survey Data Using Nonparametric Regression. Masters Seminar, Department of Statistics, Colorado State University, March 26, 2003
- Breidt, F.J. and J.D. Opsomer. Local Inferences via Nonparametric Model-Assisted Methods. First Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Colorado State University, Fort Collins, CO, September 21, 2002
- Everson-Stewart, S. Nonparametric Survey Regression Estimation in Two-Stage Spatial Sampling. First Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Colorado State University, Fort Collins, CO, September 21, 2002
- Johnson, A.A., F.J. Breidt, and J.D. Opsomer. Estimating Distribution Functions from Survey Data Using Nonparametric Regression. First Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Colorado State University, Fort Collins, CO, September 21, 2002
- Delorey, M.J. Semiparametric Mixed Models in Small Area Estimation. First Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Colorado State University, Fort Collins, CO, September 21, 2002

POSTERS

- Francisco-Fernandez, M. M. Jurado-Exposito, J.D. Opsomer, and F. Lopez-granados. A Nonparametric Analysis of the Distribution of Convolvulus Arvensis in Wheat-Sunflower Rotations. Displayed at the Computational Environmetrics Conference, Chicago, IL, October 21-23, 2004.
- Coar, W.J. and F.J. Breidt. Sampling Perennial Streams: An Application in Model Based Optimal Design. Displayed at the Third Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Colorado State University, Fort Collins, CO, September 10 - 11, 2004.
- Delorey, M.J. and F.J. Breidt. Distribution Function Estimation in Small Areas for Aquatic Resources. Displayed at the Graybill Conference, Colorado State University, Fort Collins, CO, June 17 - 18, 2004, and Third Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Colorado State University, Fort Collins, CO, September 10 - 11, 2004.
- Delorey, M.J. and F.J. Breidt. Nonparametric, Model-Assisted Estimation for a Two-Stage Sampling Design. Displayed at the Third Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Colorado State University, Fort Collins, CO, September 10 - 11, 2004.
- Breidt, F.J., S. Everson-Stewart, A.A. Johnson, and J.-D. Opsomer. Applications of Nonparametric Survey Regression Estimation in Aquatic Resources. Displayed at the Second Annual Conference on Statistical Survey Design and Analysis For Aquatic Resources, Oregon State University, Corvallis, OR, August 11 - 13, 2003.