Troy Butler

CONTACT INFORMATION

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RESEARCH INTERESTS/SPECIALTIES

- Computational error estimation and sensitivity analysis for numerical solutions of differential equations specifically performing a posteriori analysis using adjoint operators
- Probabilistic inversion, model sensitivity, and uncertainty quantification for nonlinear systems, including models from biology, chemistry, climate, geometry, and ecology with the specific goal of parameter estimation

EDUCATION

Colorado State University, Fort Collins, Colorado USA

Ph.D., Mathematics, August 2009

- Dissertation Topic: "Computational Measure Theoretic Approach to Inverse Sensitivity Analysis: Methods and Analysis"
- Advisor: Don Estep

M.S., Mathematics, May 2005

- Thesis Topic: "Numerical Continuation Using Broyden's Method"
- Advisor: Eugene Allgower

B.S., Electrical Engineering, Magna Cum Laude, May, 2003

EMPLOYMENT

Assistant Professor **Fa. 2013 - present**
Department of Mathematics and Statistical Sciences, University of Colorado Denver

Research Scientist **Fa. 2012 - Su. 2013**
Department of Statistics, Colorado State University

Instructor for STAT 315: Statistics for Engineers and Scientists **Fa. 2012 - Sp. 2013**
Department of Statistics, Colorado State University

Research Associate **Fa. 2011 - Su. 2012**
Institute for Computational Engineering and Sciences (ICES)
Computational Hydraulics Group, The University of Texas at Austin

Instructor for ASE 311: Engineering Computation **Fa. 2011**
Aerospace Engineering department, The University of Texas at Austin

ICES Postdoctoral Fellow **Fa. 2009 - Fa. 2011**
Institute for Computational Engineering and Sciences (ICES)
Computational Hydraulics Group, The University of Texas at Austin

Graduate Research Assistantship **Su. 2006, Fa. 2007, Su. 2008 - Su. 2009**
Colorado State University
Source of support: Department of Energy (DE-FG02-05ER25699) and the National Science Foundation (DGE-0221595003, MSPA-CSE-0434354).

Graduate Teaching Assistantship **Fa. 2003 - Su. 2005, Sp. 2008**
Colorado State University

Grader for STAT 521: Stochastic Processes I **Sp. 2008**
Department of Statistics, Colorado State University

FUNDING

High Performance Computing Modernization Program, Department of Defense, $66,321, *Uncertainty Quantification for HPCMP CREATE*, T. Butler (PI). **2014-16**

Nuclear Energy University Programs, Department of Energy, $38,498, *Multiscale modeling and uncertainty quantification for nuclear fuel performance*, T. Butler (PI - subcontract through Colorado

State University). **2013-14**

Division of Mathematical Sciences, National Science Foundation, $550,000 total ($57,020 UCD subcontract through Colorado State University), *Data-Driven Inverse Sensitivity Analysis for Predictive Coastal Ocean Modeling (NSF DMS-1228206)*, C. Dawson (lead PI); **T. Butler**, D. Estep and J. Westerink (Co-PIs). **2012-15**

Department of Energy, Office of Science, Advanced Scientific Computing Research, Mathematical Multifaceted Integrated Capability Centers (MMICCs) program, $12,500,000 total, *DiaMonD: An Integrated Multifaceted Approach to Mathematics at the Interfaces of Data, Models, and Decisions (DE-SC0009286)*, O. Ghattas and K. Wilcox (lead PIs); D. Estep, C. Gable, M. Gunzburger, B. Sumpter, L .Ying (institutional PIs); G. Biros, C. Dawson, R. Juanes, Y. Marzouk, R. Moser, J.T. Oden (Co-PIs); **T. Butler** (investigator on original grant and PI on $151,902 (est.) subcontract through Colorado State University for 2014-17). **2012-17**

Honors and Awards

J. Tinsley Oden Faculty Research Fellowship **Fa. & Su. 2013**
Research fellowship awarded by ICES funding travel to The University of Texas at Austin to collaborate with ICES faculty, researchers, and students on advanced research in computational engineering, mathematics, and sciences. Awarded separately $5,000 in Su. 2013 and $3,000 in Fa. 2013.

ICES Postdoctoral Fellowship **Fa. 2009 - Su. 2011**
Two-year research fellowship awarded by ICES at the University of Texas at Austin.

Interdisciplinary Research Trainee **Fa. 2005, Sp. 2006, Fa. 2006 - Su. 2007**
Source of Support: NSF IGERT Grant DGE-0221595, Program for Interdisciplinary Mathematics, Ecology, and Statistics (PRIMES).

Graduate Teaching Award **2004-2005**
Award voted by departmental faculty for outstanding instruction by a graduate student.

Journal Articles

A comparison of ensemble Kalman filters for short range storm surge forecasting, M.U. Altaf, T. Butler, T. Mayo, X. Luo, C. Dawson, A.W. Heemink, I. Hoteit, Vol. 142, No. 8, (2014), pp. 2899-2914

A measure-theoretic computational method for inverse sensitivity problems III: Multiple Quantities of Interest, T. Butler, D. Estep, S. Tavener, C. Dawson, J.J. Westerink, SIAM/ASA Journal on Uncertainty Quantification, Vol. 2, (2014), pp. 174-202

Data Assimilation within the Advanced Circulation (ADCIRC) Modeling Framework for the Estimation of Manning's Friction Coefficient, T. Mayo, T. Butler, C. Dawson, I. Hoteit, Ocean Modelling, Vol. 76, (2014), pp. 43-58

Propagation of uncertainties using improved surrogate models, T. Butler, C. Dawson, and T. Wildey, SIAM/ASA J. Uncertainty Quantification, Vol. 1, No. 1, (2013), pp. 164-191

Improving Short-Range Ensemble Kalman Storm Surge Forecasting Using Robust Adaptive Inflation, M.U. Altaf, T. Butler, X. Luo, C. Dawson, T. Mayo, and I. Hoteit, Monthly Weather Review, Vol. 141, No. 8, (2013), pp. 2705-2720

A numerical method for solving a stochastic inverse problem for parameters, T. Butler and D. Estep, Annals of Nuclear Energy, Vol. 52, (2013), pp. 86-94

Data Assimilation within the Advanced Circulation (ADCIRC) Modeling Frameowork for Hurricane Storm Surge Forecasting, T. Butler, M.U. Altaf, C. Dawson, I. Hoteit, X. Luo, and T. Mayo, Monthly Weather Review, Vol. 140, No. 7. (2012), pp. 2215-2231

Reparameterization for statistical state estimation applied to differential equations, T. Butler and M. Juntunen, Journal of Computational Physics, Vol. 231, (2012), pp. 2641-2654

A posteriori error analysis of parameterized linear systems using spectral methods, T. Butler, P. Constantine, and T. Wildey, SIAM Journal on Matrix Analysis and Applications, Vol. 33, (2012), pp. 195-209

A computational measure-theoretic approach to inverse sensitivity problems II: A posteriori error analysis, T. Butler, D. Estep, and J. Sandelin, SIAM Journal on Numerical Analysis, Vol. 50,

(2012), pp. 22-45

A measure-theoretic computational method for inverse sensitivity problems I: Method and Analysis, J. Breidt, T. Butler, and D. Estep, SIAM Journal on Numerical Analysis, Vol. 49, (2011), pp. 1836-1859

A posteriori error analysis of stochastic differential equations using polynomial chaos expansions, T. Butler, C. Dawson, and T. Wildey, SIAM Journal on Scientific Computing, Vol. 33, (2011), pp. 1267-1291

JOURNAL ARTICLES (REVIEW/REVISION)

Utilizing Error Estimates and Adaptive Surrogate Models to Accurately Predict the Probabilities of Events, T. Butler and T. Wildey, in review

Quantifying Uncertainty in Material Damage from Vibrational Parameters, T. Butler, A. Huhtala, M. Juntunen, in review

Definition and solution of a stochastic inverse problem for the Manning's n parameter field in hydrodynamic models, T. Butler, L. Graham, D. Estep, C. Dawson, J.J. Westerink, in review

JOURNAL ARTICLES (IN PREP)

Solving Stochastic Inverse Problems using Sigma-Algebras on Contour Maps, T. Butler, D. Estep, T. Wildey, S. Tavener, C. Dawson, L. Graham, in preparation

GRADUATE INTERDISCIPLINARY EXPERIENCE

Served as project team manager for an interdisciplinary research team for the PRIMES program. The team studied latent processes in generalized linear models used to de-list grizzly bears in the greater Yellowstone ecosystem. **Su. 2006**

GRADUATE TEACHING EXPERIENCE

Asst. Prof., University of Colorado Denver **Sp. 2014 - Present**

Instructor, Colorado State University **Fa. 2008**

- *MATH 7663: Finite Difference Methods for Partial Differential Equations* **Sp. 2014**
- *Short Course on Sensitivity Analysis* **Fa. 2008**
  Designed and taught three week course on sensitivity analysis aimed at graduate students studying ecology, statistics, and mathematics while a graduate student at Colorado State University. Responsible for the creation of lectures and MATLAB code exploring topics in forward and inverse sensitivity analysis using examples taken from articles in ecological journals.

UNDERGRADUATE TEACHING EXPERIENCE

Asst. Prof., University of Colorado Denver **Sp. 2014 - Present**

Instructor, Colorado State University **2003-2008, Fa. 2012**

Instructor, The University of Texas at Austin **Fa. 2011**

- *MATH 4310: Introduction to Real Analysis I* **Sp. 2014**
- *STAT 315: Statistics for Engineers and Scientists* **Fa. 2012 - Sp. 2013**
- *ASE311: Engineering Computation* **Fa. 2011**
- *M340: Ordinary Differential Equations* **Sp. 2008**
- *M261: Calculus III for Physical Sciences (multi-variable calculus)* **Su. 2005**
- *M161: Calculus II for Physical Sciences* **Sp. 2005**
- *M160: Calculus I for Physical Sciences* **Fa. 2003, Sp. 2003, Fa. 2004**
- *M130: Math in the Social Sciences* **Su. 2004**

ADVISING

M.S./Ph.D. Advisor, University of Colorado Denver **Sp. 2014 - present**

- Timothy Henley, M.S. student **Sp. 2014 - present**
- Luke Gallione, Ph.D. student **Sp. 2014 - present**

Services to Profession

Minisymposia organizer

- A Posteriori Error Estimation for Reliable Uncertainty Quantification (co-organizer) at the SIAM Conference on Uncertainty Quantification, Raleigh, NC, April, 2012
- Inverse Problems for Coastal Engineering and Subsurface Flow (co-organizer) at the SIAM Annual Conference, Chicago, IL, July, 2014

Journal referee: SIAM Journal on Numerical Analysis (1), the Springer Journal of Computational Geosciences (13), the SIAM Journal on Scientific Computation (2), the Journal of Computational Physics (1), and the Journal of Applied Meteorology and Climatology (1).

Services to Department

Faculty colloquium organizer, University of Colorado Denver **Fa. 2013 - present**
Organized departmental faculty colloquium including scheduling and inviting speakers within the department to share research broadly to all departmental faculty and graduate students.

Statistics Search Committee (member), University of Colorado Denver **Fa. 2013 - Sp. 2014**
Member of search committee for Asst. Prof. position in statistics.

Analysis Preliminary Exam Committee (member), University of Colorado Denver **Fa. 2013 - present**
Designed and graded analysis preliminary exam.

Graduate Committee (member), University of Colorado Denver **Fa. 2013 - present**
Reviewed curricula, program requirements, recruited graduate students, organized faculty seminars for undergraduates at other universities to improve recruitment, organized meetings between faculty and industry representatives to form collaborative research/educational grants.

Mentor for Ph.D students, The University of Texas at Austin **Fa. 2009 - present**
Served as a mentor for Dr. Clint Dawson's Ph.D students Talea Mayo (Fa. 2009 - Fa. 2013) and Lindley Graham (Fa. 2011 - present). Aided in Talea Mayo's research of data assimilation using ensemble Kalman filters. Aidied Lindley Graham's research of novel UQ methods and interfacing to ADCIRC model framework in an HPC environment.

GTA Mentor, Colorado State University **2008 - 2009**
Chosen by faculty as one of three senior graduate students to serve as a graduate teaching assistant (GTA) mentor in the pilot mentoring program. Responsible for observing, advising, and giving feedback on lesson planning and lectures to three first year GTAs.

Graduate Student Representative, Colorado State University **2007 - 2008**
Voted position by graduate student body in mathematics to represent graduate student interests and serve as an advocate for graduate students on the departmental graduate committee.

Math Day Volunteer, Colorado State University **2003 - 2009**
Served as timer and set up rooms. This is an annual event to promote interest and reward excellence in high school mathematics, strengthen ties and encourage communication between high school mathematics programs and the Department of Mathematics at Colorado State University, and recruit excellent mathematics students to Colorado State University.

Invited Presentations

Uncertainty Quantification with Generalized Polynomial Chaos and Adjoints, University of Colorado Denver Department of Mathematical and Statistical Sciences, CCM Seminar, October 22, 2013

A posteriori error analysis for an approximate distribution, University of Colorado Denver Department of Mathematical and Statistical Sciences, Data Assimilation Seminar, October 21, 2013

What are stochastic inverse problems for deterministic models?, Large-Scale Inverse Problems and Quantification of Uncertainty Workshop, Santa Fe, NM, May 22-24, 2013

Approximation and Use of Set-Valued Solutions to Stochastic Inverse Problems, Minisymposium on Numerical Methods for Stochastic Inverse Problems at the SIAM Conference on Computational Science and Engineering, Boston, MA, February 25-March 1, 2013

Utilizing Adjoints to Improve Propagation of Uncertainties through Surrogate Response Surfaces, Minisymposium on Adjoint Methods for Computational PDEs at the SIAM Conference on Computational Science and Engineering, Boston, MA, February 25-March 1, 2013

Stochastic Inverse Problems for Parameters of Physics-Based Models with Multiple Quantities of Interest, Colorado School of Mines, AMS Colloquium, February 14, 2013

Stochastic Inverse Problems for Parameters of Physics-Based Models, The University of Colorado Denver, Department of Mathematical & Statistical Sciences Colloquium, February 12, 2013

Applying a Non-intrusive Measure Theoretic Inverse Analysis to Storm Surge, Colorado State University, Department of Statistics Seminar, September 17, 2012

A Non-intrusive Alternative to a Computational Measure Theoretic Inverse, SAMSI UQ Transtion Workshop, Research Triangle Park, NC, May 21-23, 2012

A Non-intrusive Alternative to a Computational Measure Theoretic Inverse, Minisymposium on Inference for Models Using Set-valued Inverses at the SIAM Conference on Uncertainty Quantification, Raleigh, NC, April 2-5, 2012

Estimating and Bounding Errors in Distributions Propagated via Surrogate Models, Minisymposium on A Posteriori Error Estimation for Reliable Uncertainty Quantification (co-organizer) at the SIAM Conference on Uncertainty Quantification, Raleigh, NC, April 2-5, 2012

Data Assimilation within the ADvanced CIRCulation (ADCIRC) Modeling Framework for Hurricane Storm Surge Forecasting, Ocean Sciences Meeting, February 20-24, 2012, Salt Lake City, UT

Propagation of Numercal Errors and Probability Distributions Through Polynomial Approximated Response Surfaces, Department of Mathematical Sciences Seminar, George Mason University, February 1, 2012

Propagation of Numercal Errors and Probability Distributions Through Polynomial Approximated Response Surfaces, Department of Applied Mathematics Seminar, Naval Postgraduate School, January 26, 2012

Recent Advances and Applications of A Posteriori Error Estimates for Polynomial Chaos Expansions for Differential Equations, Minisymposium on Advances in the Predictive Simulation of Complex Systems at the International Conference of Industrial and Applied Mathematics, Vancouver, Canada, July 2011

A Posteriori Error Estimates for Polynomial Chaos Expansions of Response Surfaces for Differential Equations, Minisymposium on Numerical Methods for Stochastic Computation and Uncertainty Quantification at the SIAM Conference on Computational Science and Engineering, Reno, Nevada, February 2011

Statistical State Estimation Applied to Differential Equations: A Non-Dynamically Constrained Approach, Minisymposium on Data Assimilation and Inverse Problems in Geosciences at the 8th International Conference of Numerical Analysis and Applied Mathematics, Rhodes, Greece, September 2010

A Measure Theoretic Computational Approach for Inverse Sensitivity Problems, Workshop on Verification and Validation for Nuclear Systems Analysis, Myrle Beach, South Carolina, May 2010

Computational Measure Theoretic Approach to Inverse Sensitivity Analysis: Methods and Analysis, ICES Seminar, Institute for Computational Engineering and Sciences, The University of Texas at Austin, September 2009

Computational Measure Theoretic Method for Posterior Density Estimation, Graybill VIII and 6th International Conference on Extreme Value Analysis, Colorado State University, June 2009

A Sample-Free Method to Approximating a Probability Measure for Inverse Problems, Sandia National Laboratory, February 2009

Inverse Sensitivity Analysis, Lawrence Livermore National Laboratory, February 2009

A Computational Measure Theoretic Approach to Inverse Sensitivity Problems: Basic Method and Analysis, Inverse Problems Seminar, Department of Mathematics, Colorado State University, September 2008

Alternative Sampling Method of Posterior Distributions, NREL Model-Data Fusion Seminar, Natural Resource Ecology Laboratory, Colorado State University, March 2008

Selected Presentations

A Computational Measure Theoretic Approach to Inverse Sensitivity Analysis, SIAM Annual Meeting, Pittsburgh, Pennsylvania, July 2010

Probabilistic Inverses and Model Verification, 7th Hawaii International Conference on Statistics, Mathematics and Related Fields, Honolulu, Hawaii, January 2008

Statistical Inversion, Departmental Greenslope Seminar, Colorado State University, November 2007

Survey of Short Course on Sensitivity Analysis, Departmental Greenslope Seminar, Colorado State University, October 2007

Does exclusion of random error alter model inference? A case study using grizzly bears (Ursus arctos) of the Greater Yellowstone Ecosystem, PRIMES Summer Research Project Presentation, Colorado State University, November 2006

Numerical Continuation and Bratu's Equation, Departmental Greenslope Seminar, Colorado State University, March 2005

Conferences and Workshops Attended

Large-Scale Inverse Problems and Quantification of Uncertainty Workshop, Sante Fe, NM, May 2013

SIAM Conference on Computational Science and Engineering, Boston, MA, February 2013

SAMSI UQ: Transition Workshop, Research Triangle Park, North Carolina, May 2012

SIAM Conference on Uncertainty Quantification (co-organizer of Minisymposium on A Posteriori Error Estimation for Reliable Uncertainty Quantification), Raleigh, NC, April 2-5, 2012

Ocean Sciences Meeting, February 20-24, 2012, Salt Lake City, UT

International Conference of Industrial and Applied Mathematics, Vancouver, Canada, July 2011

SIAM Conference on Computational Science and Engineering, Reno, Nevada, February 2011

8th International Conference of Numerical Analysis and Applied Mathematics, Rhodes, Greece, September 2010

SIAM Annual Meeting, Pittsburgh, Pennsylvania, July 2010

Workshop on Verification and Validation for Nuclear Systems Analysis, Myrle Beach, South Carolina, May 2010

Workshop on Simulating the Spatial-Temporal Patterns of Anthropogenic Climate Change, Los Alamos Institute for Advanced Studies, Santa Fe, New Mexico, June, 2009

7th Hawaii International Conference on Statistics, Mathematics and Related Fields, Honolulu, Hawaii, January, 2008

Workshop on Data Assimilation for the Carbon Cycle, NCAR in Boulder, Colorado, July, 2007 and MSRI in Berkeley, California, July, 2006

Workshop on Mathematical Modeling of Infectious Diseases, York University in Toronto, Canada, June, 2006

Memberships

Society for Industrial and Applied Mathematics (SIAM) **2009-present**

American Mathematics Society **2003-2012**