Leslie M. Smith

University of Wisconsin
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Education

9/88   Ph.D., Applied Mathematics, Massachusetts Institute of Technology, Cambridge, MA. Thesis title: *An upper bound with correct scaling laws for turbulent shear flows*; Advisor: Professor Willem V. R. Malkus.

6/83   B.A. in Physics, Harvard University, Cambridge, MA.

Present Positions

since 7/02   University of Wisconsin, Madison, WI.
                  Professor, Departments of Mathematics

Previous Positions

7/02 - 5/20   University of Wisconsin, Madison, WI.
                   Professor, Departments of Mathematics and Eng. Physics

6/12-5/14   Chair, Department of Mathematics
6/05-5/08   University of Wisconsin, Madison, WI.

8/18-5/19   Brown University, Division of Applied Mathematics.
                 IBM Visiting Professor

6/04-5/05   Visiting Scientist, Center for Nonlinear Studies, Los Alamos National Laboratory, Los Alamos, NM.

7/97-6/02   University of Wisconsin, Madison, WI.
                 Associate Professor, Departments of Math. and Mech. Eng.

7/93-6/98   Yale University, New Haven, CT.
                 Assistant Professor, Department of Mechanical Engineering.

9/91-6/93	Princeton University, Princeton, NJ. Research Associate, Program in Applied and Computational Mathematics and Department of Mechanical and Aerospace Engineering. Advisors: Steven A. Orszag & Victor Yakhot.
5/91-8/91	Université Libre de Bruxelles, Bruxelles, Belgium. Visiting research scientist in the Department of Statistical Physics.
9/88-4/91	The Center for Turbulence Research, Stanford University & NASA/Ames Research Center, Stanford, CA. Post-doctoral fellow, Advisor: William C. Reynolds.

Teaching Activities

since 1998	University of Wisconsin: Math 801 Topics in Applied Mathematics: Rotating Stratified Fluid Flow with Application to Atmosphere-Ocean Dynamics Math 705 Mathematical Fluid Dynamics Math 703 Methods of Applied Mathematics Dynamics Seminar: Geophysical Turbulence (with Atmospheric and Oceanic Sciences and Physics) Math 319 Techniques in Ordinary Differential Equations Math 322 Applied Analysis II (Intro to PDEs) Math 320 Linear Algebra and Differential Equations Math 213 Calculus and Differential Equations Math 221 Calculus: FIG leader for Socio-Economic Inequality and Career Choice (Math 221, Chem 109, Sociology 134) Mechanical Engineering 563 Fluid Mechanics Mechanical Engineering 363 Fluid Mechanics Engineering Physics 548 Engineering Analysis II
'93-'97	Yale University: Fluid Mechanics The Statistical Physics of Turbulence Ordinary and Partial Differential Equations with Applications Introduction to Computing for Scientists and Engineers Faculty Advisor for Perspectives on Science: MegaScience and Public Policy Supervisor for Senior Theses: development of computer software for engineering design of turbulent flow system

'83-'87	Massachusetts Institute of Technology, Department of Mathematics. Teaching assistant: Complex Variable Theory and Methods of Applied Mathematics (undergraduate and graduate levels).
1985	Woods Hole Oceanographic Institute & Massachusetts Institute of Technology joint program, Woods Hole, MA. Instructor: Partial Differential Equations (graduate level).

Current Grants

7/19-6/22	PI with co-PI S. Stechmann, *Atmospheric Dynamics with Phase Changes and Extreme Rainfall Events.* National Science Foundation, Division of Mathematical Sciences. $400K

Previous Grants

6/15-11/19	PI with co-PIs J. Martin (UW-Madison, AOS) & S. Stechmann (UW-Madison, Math), *Minimal Models for Investigating the Influence of Latent Heat Release on Mid-Latitude Dynamics.* National Science Foundation, Physical and Dynamical Meteorology. $750K
7/12-6/19	co-PI with A. Seeger (PI) & A. Denissov (co-PI), *RTG: Analysis and Applications.* National Science Foundation, Division of Mathematical Sciences. $1,168,483
1/12-12/15	co-PI with S. Kurien (LANL), A. Pouquet (NCAR) & R. Ecke (LANL), *Parameter Studies of Boussinesq Flows.* DOE Innovative and Novel Computational Impact on Theory and Experiment (INCITE): 34,000,000 core hours on the IBM Blue Gene/Q at Argonne National Laboratory.
9/10-9/14	PI with co-PIs S. Kurien (LANL) & A. Pouquet (NCAR), *CMG Collaborative Research: Analysis and Modeling of Rotating, Stratified Flows.* National Science Foundation, Collaborations in Mathematics and Geoscience. $900,000.
9/10-9/14	*Inertia-gravity Waves in Geophysical Flows.* National Science Foundation, Division of Mathematical Sciences. $252,810

1/09-12/11	co-PI with S. Kurien (LANL), M. Taylor (Sandia) & R. Balakrishnan (Argonne), *Numerical Study of Multiscale Coupling in Low-Aspect Ratio Rotating Stratified Turbulence.* DOE Innovative and Novel Computational Impact on Theory and Experiment (IN-CITE): 25,000,000 core hours on the IBM Blue Gene/P at Argonne National Laboratory.
8/05-7/09	co-PI with Z. Liu (UW-Madison, AOS), S. Kurien (LANL) & B. Wingate (LANL), *Multi-Scale Modeling in Geophysical and Climate Modeling.* DOE Multi-Scale Mathematics Research and Education. $846,058
8/05-7/09	PI with co-PIs S. Kurien (LANL) & B. Wingate (LANL), *Non-Hydrostatic Effects and New Diagnostics for the Long-Time Dynamics of Rotating and Stratified Flows.* National Science Foundation, Collaborations in Mathematics and Geoscience. $455,332
9/05-8/08	co-PI with C. Rutland (UW-Madison, ME), *LES Modeling for Engineering and Geophysical Flows with Rotation.* National Science Foundation, Division of Engineering. $180,000
7/03-6/07	*Mechanisms for the Formation of Coherent Structures From Small-Scale Turbulence in Anisotropic Flows.* National Science Foundation, Division of Mathematical Sciences $180,000
7/05-6/07	*Dispersive-Wave Turbulence and the Long-Time Prediction of Geophysical Flows.* UW Vilas Associate Award. $38,395
9/05-8/06	co-PI with S. Jin (UW), J. Rossmanith (UW), F. Waleffe (UW), *Multiscale Computations in Astrophysics, Geophysics, Hydrodynamics, Kinetic and Quantum Applications.* National Science Foundation, Super-Computing Environments in the Mathematical Sciences. $73,000
9/00-8/03	*Wave Turbulence in Atmospheric and Oceanic Flows.* National Science Foundation. $200,000
4/96-4/00	*Numerical Studies of Three-Dimensional Turbulence in Small-Aspect-Ratio Domains.* National Science Foundation. $197,858
10/93-10/96	*A Two-Scale Approach to $\bar{\mathcal{K}} - \bar{\mathcal{E}}$ Modeling for Nonequilibrium Turbulence.* Office of Naval Research. $106,039

6/99-5/00	*Numerical Study of Large-Scale Dynamics in Stratified and Rotating, Stratified Turbulence Forced at Small Scales.* Wisconsin Alumni Research Fund. $14,589
10/99-9/00	*The Formation of Cyclones from Background Noise in Rotating Turbulence: Experiments in a Rotating Tank.* Abbott Laboratories, Illinois. $2,000
5/01-7/31	*Generation of Slow, Large Scales in Forced, Rotating, Stratified Turbulence.* National Center for Supercomputing Applications. 10000 Origin2000 hours
4/99-3/00	*The Structures and Statistics of Stratified Turbulence Forced at Small Scales.* National Center for Supercomputing Applications. 9150 Origin2000 hours
8/96-8/98	Computer time for *Small-Aspect-Ratio Turbulence and The Modeling of Geophysical Flows.* The Cornell Theory Center. 10,000 SP2 hours
10/95-10/97	Computer time for *The Crossover from Two- to Three-Dimensional Turbulence and the Modeling of Geophysical Flows.* The Maui High Performance Computing Center. 6,000 SP2 hours
8/95-8/96	Computer time for *Small-Aspect-Ratio Turbulence and The Modeling of Geophysical Flows.* The Cornell Theory Center. 2,000 SP2 hours
8/93-8/95	Computer time for *High Resolution Simulations of Passive Scalar Transport in Atmospheric Flows.* The Maui High Performance Computing Center. 2,000 SP2 hours
5/91-10/91	*Exploration of the Cusp Behavior of the RNG Eddy Viscosity Near the Cutoff Wavenumber.* Air Force Office of Scientific Research.

Research Interests

Applied mathematics; Theory, modeling and numerical computations of fluid dynamical systems with applications in atmosphere/ocean/climate sciences and engineering.

Honors

- Honored Instructor Award Spring 2020
  (for Math 320 during covid-19 transition to online)

- Van Vleck Prize 2011-2015

- Fellow, American Physical Society, since 2008

- UW Vilas Associate Award, 2005-2007

Submitted to Refereed Journals

- Hernandez-Duenas, G., Lelong, P. & Smith, L. M. 2021 Wave and Vortical Mode Contributions to Tracer Dispersion in Ocean Sub-mesoscales, submitted to *The Journal of Physical Oceanography*.

Refereed Journal Publications

- Zhang, Y., Smith, L.M. & Stechmann, S. 2021 Effects of Clouds and Phase Changes on Fast-Wave Averaging: A Numerical Assessment, to appear in *Journal of Fluid Mechanics*.

- Zhang, Y., Smith, L.M. & Stechmann, S. 2021 Fast-Wave Averaging with Phase Changes: Application to Moist Atmospheric Dynamics, *Journal of Nonlinear Science* **31**

- Kooloth, P., Smith, L. M. & Sondak, D. 2021 Coherent Solutions and Transition to Turbulence in Two-Dimensional Rayleigh-Bénard Convection, *Physical Review Fluids* **6**, 013501, arXiv:2006.14132. This article was chosen as an *Editor's Suggestion*: Optimal, exact coherent structures have been shown to tightly bound the scaling of heat transport in two-dimensional turbulent Rayleigh-Bénard convection. These optimal solutions are unstable, but it is of interest to detect their signature in turbulent flow fields. Here, a direct link is established between the exact coherent structures that optimize heat transport and transition to turbulence in two-dimensional Rayleigh-Bénard convection.

- Hu, R., Edwards, T., Smith, L.M. & Stechmann, S. 2021 Initial Investigations of Precipitating Quasi-Geostrophic Turbulence with Phase Changes, *Research in Mathematics* **8**: 6, https://doi.org/10.1007/s40687-020-00242-3.

- Wetzel, A., Smith, L.M., Stechmann, S., Martin, J. & Zhang, Y. 2020 Potential Vorticity and Balanced and Unbalanced Moisture, *Journal of the Atmospheric Sciences* **77**, 1913-1931.

- Tran, M.-B., Craciun, G., Smith, L. M. & Boldyrev, S. 2020 A reaction network approach to the theory of acoustic wave turbulence, *Journal of Differential Equations* **269**, 4332-4352.

- Edwards, T., Smith, L.M. & Stechmann, S. 2020 Atmospheric Rivers and Water Fluxes in Precipitating Quasi-geostrophic Turbulence, *Quarterly Journal of the Royal Meteorological Society* **146**, 1960-1975.

- Edwards, T., Smith, L.M. & Stechmann, S. 2020 Spectra of Atmospheric Water in Precipitating Quasi-Geostrophic Equations, *Geophys. Astrophys. Fluid Dyn.*, DOI: 10.1080/03091929.2019.1692205.

- Gamba, I., Smith, L.M. & Tran, M.-B. 2020 On the Wave Turbulence Theory for Stratified Flows in the Ocean, *Mathematical Models and Methods in Applied Sciences* **30**, 105–137, arXiv:1709.08266

- Marsico, D., Smith, L.M. & Stechmann, S. 2019 Energy Decompositions for Moist Boussinesq and Anelastic Equations with Phase Changes, *The Journal of the Atmospheric Sciences* **76**, 3569–3587.

- Wetzel, A., Smith, L.M., Stechmann, S. & Martin, J. 2019 Balanced and Unbalanced Components of Moist Atmospheric Flows with Phase Changes, *Chinese Annals of Mathematics Series B* **40**, special issue in honor of Andrew Majda, 1005–1038.

- Hernandez-Duenas, G., Smith, L.M. & Stechmann, S. 2019 Weak- and Strong-Friction Limits of Parcel Models: Comparisons and Stochastic Convective Initiation Time, *Quarterly Journal of the Royal Meteorological Society* **145**, https://doi.org/10.1002/qj.3557

- Wetzel, A., Smith, L.M. & Stechmann, S. 2019 Discontinuous Fronts as Exact Solutions to Precipitating Quasi-Geostrophic Equatiions, *SIAM J. Applied Mathematics* **79**, DOI: 10.1137/18M119478X

- Smith, L.M. & Stechmann, S. 2017 Precipitating Quasi-Geostrophic Equations and Potential Vorticity Inversion with Phase Changes, *J. Atmos. Sci.* **74**, 3285-3303.

- Wetzel, A., Smith, L.M. & Stechmann, S. 2017 Moisture Transport in Baroclinic Waves: Linear Analysis of Quasi-Geostrophic Dynamics, *Mathematics of Climate and Weather Forecasting* **3**, 287-50.

- Sondak, D., Smith, L.M. & Waleffe, F. 2015 Optimal Heat Transport in Rayleigh-Bénard Convection, *J. Fluid Mech.* **784**, 565-595.

- Hernandez-Duenas, G., Smith, L.M. & Stechmann, S. 2015 Stability and Instability Criteria for Idealized Precipitating Hydrodynamics, *J. Atmos. Sci.* **72**, 2379-2393.

- Waleffe, F., Boonkasame, A. & Smith, L.M. 2015 Heat Transport by Coherent Rayleigh-Bénard Convection, *Phys. Fluids* **27** 051702.

- Hernandez-Duenas, G., Smith, L.M. & Stechmann, S. 2014 Investigation of Boussinesq Dynamics Using Intermediate Models Based on Wave-Vortical Interactions *J. Fluid Mech.* **717**, 576-611.

- Kurien, S. & Smith, L.M. 2014 Effect of Rotation and Domain Aspect-Ratio on Layer Formation in Strongly Stratified Boussinesq Flows *The Journal of Turbulence* **15**, 241-271.

- Remmel, R., Sukhatme, J. & Smith, L.M. 2014 Nonlinear Gravity Wave Interactions in Stratified Turbulence, *Theoret. Comput. Fluid Dyn.* **28**, 131-145.

- Hernandez-Duenas, G., Majda, A., Smith, L.M. & Stechmann, S. 2013 Minimal Models for Precipitating, Turbulent Convection, *J. Fluid Mech.* **717**, 576 - 611.

- Sukhatme, J., Majda, A. & Smith, L.M. 2012 Two-Dimensional Moist Stratified Turbulence, *Phys. Fluids* **34**, 036602.

- Deng, Q., Smith, L.M. & Majda, A.J. 2012 Tropical Cyclogenesis and Vertical Shear in a Moist Boussinesq Model, *J. Fluid Mech.* **706**, 384-412.

- Kurien, S. & Smith, L.M. 2011 Asymptotics of Unit Burger Number Rotating and Stratified Flows for Small Aspect Ratio. *Physica D* **241**, 149 - 163.

- Remmel, M., Sukhatme, J. & Smith, L.M. 2010 Nonlinear Inertia-Gravity Wave-Mode Interactions in Three Dimensional Rotating Stratified Flows, *Communications in Mathematical Sciences* **8**, 357 - 376.

- Liu, W., Bretherton, F., Liu, Z., Smith, L.M., Lu, H. & Rutland, C.J. 2010 Breaking of progressive internal gravity waves: Convective instability and shear instability, *Journal of Physical Oceanography*, doi: 10.1175/2010JPO4432.1

- Sukhatme, J. & Smith, L.M. 2009 Local and Nonlocal Dispersive Turbulence, *Phys. Fluids* **21**. 056603.

- Remmel, M. & Smith, L.M. 2009 New Intermediate Models for Rotating Shallow Water and an Investigation of the Preference for Anticyclones, *J. Fluid Mech.* **635**, 321-359.

- Lu, H., Rutland, C.J. & Smith, L.M. 2008 A Posteriori Tests of One-Equation LES Modeling of Rotating Turbulence, *International Journal of Modern Physics C* **19**, 1949-1964.

- Sukhatme, J. & Smith, L.M. 2008 Effects of Dispersion on Vortical and Wave Modes in 3D Rotating Stratfied Flows: Large-Scale Forcing, *Geophysical and Astrophysical Fluid Dynamics* **102**, 437-455.

- Lu, H., Rutland, C.J. & Smith, L.M. 2007 A-Priori Tests of One-Equation LES Modeling of Rotating Turbulence, *Journal of Turbulence* **8**, N 37.

- Sukhatme, J. & Smith, L.M. 2007 Self-Similarity in Decaying Two-Dimensional Stably Stratified Adjustment, *Phys. Fluids* **19**, 036603.

- Smith, L.M. & Lee, Y. 2007 A Mechanism for the Formation of Geophysical and Planetary Zonal Flows, *J. Fluid Mech.* **576**, 405-424.

- Kurien, S., Smith, L.M. & Wingate, B. 2006 On the Two-Point Correlation of Potential Vorticity in Rotating and Stratified Turbulence, *J. Fluid Mech.* **555**, 131-140.

- Smith, L.M. & Lee, Y. 2005 On Near-Resonances and Symmetry Breaking in Forced Rotating Flows at Moderate Rossby Number, *J. Fluid Mech.* **535**, 111-142.

- Lee, Y. & Smith, L.M. 2003 Stability of Rossby Waves in the β-Plane Approximation, *Physica D* **179**, 53-91.

- Smith, L.M. & Waleffe, F. 2002 Generation of Slow, Large Scales in Forced, Rotating, Stratified Turbulence, *J. Fluid Mech.* **451**, 145-168.

- Smith, L.M. & Waleffe, F. 1999 Transfer of Energy to 2D Large Scales in Forced, Rotating 3D Turbulence. *Phys. Fluids* **11**, 1608-1622.

- Smith, L.M. & Yakhot, V. 1997 The Onset of Intermittency in Two-Dimensional Decaying Turbulence. *Phys. Rev. E.* **55**, 5458

- Smith, L.M., Chasnov, J. & Waleffe, F. 1996 The Crossover From Two- to Three-Dimensional Turbulence. *Phys. Rev. Lett.* **77**, 2467

- Sirovich, L., Smith, L.M. & Yakhot, V. 1995 Energy Spectrum of Homogeneous and Isotropic Turbulence in Far Dissipation Range. *Phys. Rev. Lett.* **72**, 344

- Smith, L.M. & Yakhot, V. 1994 Finite-Size Effects in Forced Two-Dimensional Turbulence. *J. Fluid Mech.* **274**, 115

- Salmon, R. & Smith, L.M. 1994 Hamiltonian derivation of the nonhydrostatic pressure-coordinate model. *Q. J. R. Meteorol. Soc.* **120**, 1409

- Smith, L.M. & Yakhot, V. 1993 Bose Condensation and Small-Scale Structure Generation in a Random Force Driven 2D Turbulence. *Phys. Rev. Lett.* **71**, 352

- Smith, L.M. & Yakhot, V. 1993 Short and long-time behavior of eddy-viscosity models. *Theor. and Comput. Fluid Dynamics* **4**, 197

- Yakhot, V. & Smith, L.M. 1992 The renormalization group, the ϵ-expansion, and derivation of turbulence models. *J. Sci. Comput.*, **3**, 35

- Smith, L.M. & Reynolds, W.C. 1992 On the Yakhot-Orszag renormalization group method for deriving turbulence statistics and models. *Phys. Fluids A* **2**, 362

- Smith, L.M. & Reynolds, W.C. 1991 The dissipation-range spectrum and the velocity-derivative skewness in turbulent flows. *Phys. Fluids A* **3**, 992

- Smith, L.M. 1991 Turbulent Couette flow profiles that maximize the efficiency function. *J. Fluid Mech.* **227**, 509

- Malkus, W.V.R. & Smith, L.M. 1989 Upper bounds on functions of the dissipation rate in turbulent shear flow. *J. Fluid Mech.* **208**, 497

Invited Publications

- Smith, L.M. & Woodruff, S.L. 1998 Renormalization Group Methods in Turbulence. *Annual Reviews of Fluid Mechanics* **30**, 275

Refereed Conference Proceedings

- Smith, L.M. & Remmel, M. 2007 Structure Formation in Rotating and Stratified Flows, Computational Physics and New Perspectives in Turbulence, accepted with revisions, IUTAM 2006 Proceedings, Springer-Verlag.

- Smith, L.M. 2001 Numerical Study of Two-Dimensional Stratified Turbulence, Advances in Wave Interaction and Turbulence, *Cont. Math.* **283**, eds. Milewski, P.A., Smith, L.M., Tabak, E.G., & Waleffe, F., Amer. Math. Soc., Providence, RI.

Technical Reports

- Smith, L.M. & Reynolds, W.C. 1991 Derivation of the $\bar{\mathcal{K}} - \bar{\mathcal{E}}$ model equations using the renormalization group method. *CTR Annual Research Briefs*.

- Smith, L.M. & Reynolds, W.C. 1990 Progress in understanding the renormalization group skewness and $\bar{\mathcal{K}} - \bar{\mathcal{E}}$ models. *CTR Annual Research Briefs*, 51.

- Smith, L.M. & Reynolds, W.C. 1989 Development of the renormalization group analysis of turbulence. *CTR Annual Research Briefs*, 81.

- Smith, L.M. & Reynolds, W.C. 1988 Renormalization group analysis of turbulence. *CTR Annual Research Briefs*, 29.

- Smith, L.M. 1985 A Hamiltonian formulation of the anelastic equations. *Proceedings of the Summer Program in Geophysical Fluid Dynamics* (Woods Hole Oceanographic Institute).

Other Professional Activities

- Co-organizer of Mathematical aspects of turbulence: where do we stand?, The Isaac Newton Institute for Mathematical Sciences, Spring 2022.

- Chair, L&S Dean Search and Screen Committee, UW-Madison, 2020

- Math Alliance Faculty Mentor, since 2019

- Fluid Dynamics Prize Committee (2019 Vice-Chair, 2020 Chair), American Physical Society, Division of Fluid Dynamics.

- Co-organizer of Moist Processes in the Atmosphere, Oberwolfach, Germany, Feb. 17-23, 2019.

- Co-organizer of Kinetic Models with Applications in the Natural Sciences, UW-Madison, April 29 - May 2, 2018.

- Co-organizer of a special session on The Role of Water in Shaping Features of the Weather/Climate System, the 98th Annual Meeting of the American Geophysical Union, Austin, TX, Jan. 7-11, 2018.

- University Curriculum Committee 2014-2017 (Vice Chair 2015-2016; Chair 2016-2017), UW-Madison.

- Organizer of NSF-RTG workshop on Coherent and Turbulent Convection, Madison, WI, May 27-29, 2015.

- Organizer of an SIAM Mini-symposium on Modeling and Prediction of Geophysical Flows, SIAM Conference on Nonlinear Waves and Coherent Structures, Churchill College, Cambridge, UK, August 11-14, 2014.

- Co-organizer of an AIMS Mini-symposium on Waves and Convection, the 9th AIMS Conference on Dynamical Systems, Differential Equations and Applications, Orlando, FL, July 1 - 5, 2012.

- Co-organizer of an AMS-IMS-SIAM Joint Summer Research Conference in Mathematical Sciences, *Dispersive Wave Turbulence*, held at Mount Holyoke College, South Hadley, MA, June 11-15, 2000.

- Editorial Boards (current): *Journal of Nonlinear Science*, *Mathematics of Weather and Climate Science*

- Associate Editor (2002-2008): *Communications in Mathematical Sciences*

- Associate Editor (2009-2019): *Journal of Turbulence*

- Member, American Mathematical Society; American Physical Society, Division of Fluid Dynamics; Society for Industrial and Applied Mathematics

- Nominating Committee, American Physical Society, Division of Fluid Dynamics 2005-2006

- External Affairs Committee, American Physical Society, Division of Fluid Dynamics 2003-2004

- Member, Mathematics Design Team, a WI state committee to make recommendations for strengthening state standards for High School Mathematics in partnership with Academic Diploma Project and Partnership for 21st Century Skills, 2007-2008

- Member, Madison Metropolitan School District Algebra Committee, 2003-2004

- WARF Research Committee, 1999-2002

- Co-organizer of an AMS-IMS-SIAM Joint Summer Research Conference in Mathematical Sciences, *Dispersive Wave Turbulence*, held at Mount Holyoke College, South Hadley, MA, June 11-15, 2000.

- Co-organizer of A Network of Mentors in Mathematics (with Gloria Mari-Beffa), providing mentorship and mathematical projects for girls in Madison high schools and middle schools, 2004-2009

- Fellow, Geophysical Fluid Dynamics Summer Program, Woods Hole Oceanographic Institute. Research project:*a Hamiltonian formulation of the anelastic equations for use in meteorological and astrophysical contexts*, 1988

Invited Lectures and Seminars

- Spring 2022, Mathematical Aspects of Turbulence: Where Do We Stand?, The Isaac Newton Institute for Mathematical Sciences, Cambridge, UK.

- March 2021, workshop on Confronting Climate Change, Institute for Mathematical and Statistical Innovation, University of Chicago, Illinois. *Probing the Dynamical Role of Water Using a Balanced-Unbalanced Decomposition for Mid-Latitudes* (online).

- March 2021, Applied Mathematics Seminar, University of Colorado, Boulder.

- January 2021, Transport and Mixing in Complex and Turbulent Flows, Institute for Pure and Applied Mathematics (IPAM), Los Angeles, CA.

- September 2020, Conference on Convection, University of Leeds, Leeds, UK (postponed).

- September 2020, G.I. Taylor Medal Symposium in honor of Katepalli Sreenivasan, Annual Meeting of the Society of Engineering Sciences, Minneapolis, MN, *Coupling between Balanced and Unbalanced Components of Atmospheric Flows with Water* (online).

- August 2020, Wave Turbulence Seminar series, organized by researchers at Princeton, MIT and Courant, *Dispersive Waves in Moist Boussinesq Flows with Phase Changes* (online).

- August 2020, Mini-symposium on Moist-Driven Flows, Clouds and Convection, SIAM Conference on Mathematics of Planet Earth, Garden Grove, CA, *Balanced and Unbalanced Decompositions of Moist Atmospheric Flows with Phase Changes* (online).

- July 2020, Workshop on Mathematical Advances in Geophysical Fluid Dynamics, Oberwolfach, Germany, *Fast Wave Averaging with Phase Changes: Application to Moist Atmospheric Dynamics*, (online).

- January 2020, Mechanics Seminar, UW-Madison, *Modeling Atmospheric Flows with Phase Changes of Water*.

- July 2019, Conference on Scientific Grand Challenges and New Perspectives in Applied Mathematics in honor of Andrew Majda's 70th birthday, University of Victoria, Canada, *A QG Model with Latent Heat Release and Precipitation.*

- April 2019, Applied Math seminar at the University of New Hampshire, *Modeling of Atmospheric Convection with Phase Changes.*

- March 2019, Colloquium in the Department of Applied Mathematics, University of Waterloo, Canada, *Modeling of Atmospheric Convection with Phase Changes.*

- October 2018, LCDS Seminar, Lefschetz Center for Dynamical Systems, Brown University, Providence, RI, *Modeling the Dynamics of Atmospheric Convection with Phase Changes.*

- May 2018, Rotating Convection: From the Lab to the Stars, The Lorentz Center, Leiden, The Netherlands, *Modeling of Atmospheric Convection with Phase Changes.*

- November 2017, Frontiers in Turbulence, a conference for the 70th birthday of Katepalli Sreenivasan, Denver, Co, *Minimal Modeling of Atmospheric, Moist Convection with Phase Changes.*

- May 2017, Workshop on Geophysical Fluid Dynamics, Oberwolfach, Germany, *Precipitating Quasi-Geostrophic Equations.*

- March 2017, Workshop on Nonlinear Waves and Chaos, San Diego, CA *Precipitating Convection with Fast Cloud Microphysics.*

- October 2016, American Mathematical Society Fall Sectional Meeting, Special Session on Modeling and Predicting the Atmosphere, Oceans, and Climate, Minneapolis, MN, *Precipitating Convection with Fast Cloud Microphysics.*

- July 2016, Summer School on Advances in Geophysical and Astrophysical Turbulence in honor of Annick Pouquet, Institute of Cargèse, Corsica, *Lecture 1: Minimal Models for Precipitating, Turbulent Convection; Lecture 2: A Precipitating Quasi-Geostrophic Approximation.*

- July 2016, NewTURB Meeting, University of Rome Tor Vergata, Rome, Italy, *Minimal Models for Precipitating, Turbulent Convection.*

- July 2016, 11th AIMS Conference on Dynamical Systems, Differential Equations and Applications, mini-symposium on Classical and Geophysical Fluid Dynamics, Orlando, FL *A Precipitating Quasi-Geostrophic Approximation.*

- September 2015, Colloquium in the Department of Atmospheric and Oceanic Sciences, US-Madison. *Minimal Models for Precipitating, Turbulent Convection.*

- August 2015, International Congress on Industrial and Applied Mathematics, mini-symposium Mathematics of Climate: from the Tropics to Antarctica, Beijing, China. *Minimal Models for Precipitating, Turbulent Convection.*

- April 2015, PDE/Applied Math Seminar, Indiana University Bloomington. *Minimal Models for Precipitating, Turbulent Convection.*

- October 2014 Geophysical and Astrophysical Turbulence, Institute for Pure and Applied Mathematics, University of California, Los Angeles. *Minimal models for precipitating turbulent convection.*

- August 2014 Plenary lecture, SIAM Nonlinear Waves and Coherent Structures, Churchill College, Cambridge, UK. *Minimal models for precipitating turbulent convection.*

- November 2013 International Conference on Zonal Flows in Geophysical and Astrophysical Fluids, Research Institute for Mathematical Sciences, Kyoto University, Japan. *Generation of Zonal Jets by Three-Wave Near-Resonant Interactions.*

- April 2013 Widely Applied Mathematics seminar at the Harvard University, Cambridge, MA. *On the Spontaneous Generation of Inertia-Gravity Waves.*

- April 2013 Applied Mathematics Colloquium at the Massachusetts Institute of Technology, Cambridge, MA. *On the Spontaneous Generation of Inertia-Gravity Waves.*

- February 2013. Workshop on Geophysical Fluid Dynamics, The Mathematics Research Center, Oberwolfach, Germany. *On the Spontaneous Generation of Inertia-Gravity Waves.*

- October 2012 Colloquium at the University of Colorado. *Minimal models for precipitating organized convection.*

- July 2012. Mini-symposium on Recent Developments on Turbulence, the 9th AIMS Conference on Dynamical Systems, Differential Equations and Applications Orlando, Florida. *Aspect ratio effects on layer thickness in stratified turbulence.*

- May 2012. Pedagogical invited lecturer at the Workshop on Connections between Rotating, Stratified Turbulence and Climate: Theory, Observations, Experiments, and Models, NCAR, Boulder, CO. *Minimal models for precipitating organized convection.*

- April 2012. Mini-symposium: Insight into Geophysical Fluid Dynamics through Analysis and Computation at the Eighth International Conference on Scientific Computing and Applications, University of Nevada, Las Vegas. *Minimal models for precipitating organized convection.*

- January 2012. Colloquium at the Center for Atmosphere Ocean Science, Courant Institute of Mathematical Sciences, New York University. *Simplified moist 3D Boussinesq dynamics for the hurricane embryo.*

- July 2011. Geophysical Fluid Dynamics Summer Program, Woods Hole Oceaographic Institute, Woods Hole, MA. *A hierarchy of PDE reduced models for rotating stratified flows.*

- June 2011. Workshop on Applied Analysis and Applied PDE, University of Victoria. *Simplified moist 3D Boussinesq dynamics for the hurricane embryo.*

- June 2011. Workshop on Applied Analysis and Applied PDE, University of Victoria. *A hierarchy of PDE reduced models for rotating stratified flows.*

- May 2011. Mini-symposium on Waves in Stratified Flow at the SIAM Dynamical Systems Conference, Snowbird, UT. Generation of shear flows by three-wave interactions in stratified flows.

- May 2011. BIRS Workshop on Organized Tropical Convection and Large-scale Circulation: Theory, Modeling, and Observations, Banff Research Station, Banff, Canada. *Simplified moist 3D Boussinesq dynamics for the hurricane embryo.*

- Aug. 2010. Workshop on Mathematical Theory and Modelling in Atmosphere-Ocean-Science, The Mathematics Research Center, Oberwolfach, Germany.

- Feb. 2010. Workshop on Analysis and Computation of Incompressible Fluid Flow, Institute for Mathematics and Its Applications, University of Minnesota. *New PDE reduced models for geophysical flows.*

- Feb. 2010. Colloquium at Rensselaer Polytechnic Institute, Troy, NY *New PDE reduced models for geophysical flows.*

- Sept. 2009. Colloquium at the University of Michigan, Ann Arbor, MI, *Waves in the atmosphere and oceans.*

- July 2009. Invited lecture at Institut de Recherche sur les Phénomènes Hors Équilibre, CNRS, Marseille, France. *Waves and coherent structures in rotating and stratified flows.*

- April 2009. Workshop on Multiscale Modeling for the Tropics, Banff International Research Station for Mathematical Innovation and Discovery (BIRS), Banff, Alberta, Canada.

- July 2008. Principal Lecturer for the 2008 Summer School sponsored by the National Center for Atmospheric Research (NCAR/IMAGe) on Theory and Modeling in Geophysical Fluid Dynamics, Boulder, CO.

- April 2008. PIMS workshop Waves in the Atmosphere and Ocean, *Wave-vortical mode interactions in atmosphere-ocean flows.*

- February 2008. Keynote speaker for NCAR/Image workshop Turbulent Theory and Modeling, *Wave-vortical mode interactions in atmosphere-ocean flows.*

- April 2007. Workshop on Stochastic Dynamical Systems and Climate Modeling, Banff International Research Station for Mathematical Innovation and Discovery (BIRS), Banff, Alberta, Canada, *Reduced models for wave and vortical interactions in stochastically forced dispersive systems.*

- April 2006. The University of Chicago, Department of Mathematics, *Multi-scale coupling in rotating and stratified flows.*

- Jan. 2006. AGU Chapman Conference on Jets and Annular Structures in Geophysical Fluids, Savannah, Georgia, *A mechanism for the formation of jets from small-scale forcing of beta-plane flow.*

- Dec. 2004. The Courant Institute of Mathematical Sciences, Workshop on Large-Scale Turbulence in the Atmosphere and Ocean, *On near-resonances and symmetry breaking in rotating turbulence at moderate Rossby numbers.*

- Sept. 2004. SIAM Mini-Symposium Speaker, Conference on Nonlinear Waves and Coherent Structures, Orlando, *On near-resonances and symmetry breaking in rotating turbulence at moderate Rossby numbers.*

- Aug. 2004. Workshop on Fluid Turbulence, Cascade Dynamics: Fundamentals and Modeling, Santa Fe, *On near-resonances and symmetry breaking in rotating turbulence at moderate Rossby numbers.*

- July 2003. University of California, Los Angeles, workshop on Subgrid Scale Turbulence Methods for Geodynamo Simulations, *Large-scale, coherent structures from small-scale noise in rotating and stratified flows.*

- June 2003. The Center for Nonlinear Studies, Los Alamos National Laboratory, *Large-scale, coherent structures from small-scale noise in rotating and stratified flows.*

- May 2003. SIAM Mini-Symposium Speaker, Utah Dynamical Systems, Utah, *Approximate slow manifolds including the vertically sheared, horizontal flow modes.*

- April 2003. University of Minnesota, Department of Mathematics, Distinguished Women in Science lecture series, *Anisotropic turbulence in geophysical flows.*

- August 2002. The Mathematics Research Center, Oberwolfach, Germany, conference on Mathematical Theory and Modelling in Atmosphere-Ocean Science, *Stability of Rossby waves in the β-plane approximation.*

- July 2002. Department of Engineering Physics, University of Wisconsin, Madison, *Anisotropic turbulence.*

- March 2002. University of Maryland, College Park, *Energy transfer to large scales in rotating, stratified turbulence forced randomly at small scales.*

- Feb. 2002. University of Minnesota, The Institute for Mathematics Applications. *Slow manifolds in rotating, stratified flows.*

- June 2001. Ecole Centrale de Lyon, Laboratoire de Mecanique des Fluides et d'Acoustique. *The limits of validity of the quasi-geostrophic equations.*

- Dec. 2000. The University of Wisconsin Madison, Chaos and Complex Systems Seminar. *The generation of large-scale flows from small-scale turbulence in the earth's atmosphere and oceans.*

- June 2000. Dispersive Wave Turbulence Conference, Mount Holyoke College, South Hadley, MA. *Energy transfer to large scales in rotating and stratified turbulence forced randomly at small scales.*

- May 2000. The Institute for Theoretical Physics, University of California, Santa Barbara. *The generation of large-scale structures in wave-turbulence systems forced randomly at small scales.*

- October 1999. The University of Minnesota, Department of Aerospace Engineering and Mechanics. *The generation of 2D large scales in 3D rotating turbulence forced randomly at small scales.*

- December 1998. The University of Michigan, Department of Mathematics. *The generation of 2D large scales in 3D rotating turbulence forced randomly at small scales.*

- November 1998. The University of Wisconsin, Department of Mechanical Engineering. *Rotating Turbulence.*

- November 1998. The University of Wisconsin, Department of Atmospheric and Oceanic Sciences. *The generation of 2D large scales in 3D rotating turbulence forced randomly at small scales.*

- October 1998. The Courant Institute for Mathematics, New York University. *The generation of 2D large scales in 3D rotating turbulence forced randomly at small scales.*

- January 1997 and November 1996. The University of Wisconsin at Madison. *The crossover from two- to three-dimensional turbulence.*

- July 1996. EPFL Workshop on Turbulence Modeling and the Theory of Hydrodynamic Instability, Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland. *Small-aspect-ratio 3D turbulence and the modeling of geophysical flows.*

- May 1996. The Massachusetts Institute of Technology. *The Crossover from two- to three-dimensional turbulence.*

- January 1996. ICASE, NASA Langley Research Center. *Forced rotating turbulence in small-aspect-ratio domains.*

- November 1995. The Department of Mechanical Engineering, Boston University, Boston. *Condensation in rotating small-aspect-ratio turbulence.*

- October 1995. The Department of Applied Physics, Columbia University, New York. *Condensation in rotating small-aspect-ratio turbulence.*

- October 1994. The Department of Mechanical Engineering, The University of California at Berkeley. *Finite-size effects in two-dimensional turbulence and the atmospheric spectrum.*

- August 1994. Los Alamos National Laboratory. *Finite-Size Effects in Two-Dimensional Turbulence and the Atmospheric Spectrum.*

- May 1993. The Department of Theoretical and Applied Mechanics, The University of Illinois. *The Modeling of Turbulent Flows Using The $\bar{\mathcal{K}} - \bar{\mathcal{E}}$ Equations.*

- April 1993. Department of Mechanical Engineering and Applied Mechanics, The University of Michigan. *The Modeling of Turbulent Flows Using The $\bar{\mathcal{K}} - \bar{\mathcal{E}}$ Equations.*

- April 1993. The Center for Fluid Dynamics, Brown University. *The Inverse Cascade to Structure Formation in Two-Dimensional Turbulence.*

- April 1993. Department of Mechanical Engineering, Yale University. *The Inverse Cascade to Structure Formation in Two-Dimensional Turbulence.*

- April 1993. Department of Mechanical and Aerospace Engineering, Rutgers University, *Two-dimensional turbulence in the zero-viscosity limit: an example of Gaussian turbulence.*

- March 1993. Department of Mathematics, The University of California at Irvine, *Two-dimensional turbulence in the zero-viscosity limit: an example of Gaussian turbulence.*

- October 1992. Mechanical and Aerospace Engineering Department, Princeton University. *Non-equilibrium modeling of turbulent flows.*

- March 1992. Department of Mechanical Engineering, Johns Hopkins University. *Fundamentals and applications of the renormalization group theory of turbulence.*

- March, 1992. ICASE, NASA Langley Research Center. *Fundamentals and applications of the renormalization group theory of turbulence.*

- February, 1992. Mathematics Department, Caltech University. *Fundamentals and applications of the renormalization group theory of turbulence.*

- February, 1992. Mathematics Department, University of Arizona at Tuscon. *Fundamentals and applications of the renormalization group theory of turbulence.*

- November 1991. Department of Mechanical Engineering, The University of Maryland at College Park. *Derivation of the $\bar{\mathcal{K}} - \bar{\mathcal{E}}$ model equations from renormalization group theory.*

- October 1991. Fluid Mechanics Series, The Levich Institute of the City College of New York. *Derivation of the $\bar{\mathcal{K}} - \bar{\mathcal{E}}$ model equations from renormalization group theory.*

- July 1991. Politecnico di Torino, Dipartimento di Ingegneria Aeronautica e Spaziale, Torino, Italy. *RNG and turbulence modeling.*

- May 1991 The von Karman Institute for Fluid Dynamics, Rhode-Saint-Genèse, Belgium. Lectures for the series New Approaches in the Description and Modeling of Turbulence, *Renormalization Group Theory and Turbulence Modeling.*

- August 1990. Summer Program at the Center for Turbulence Research. *The renormalization group method for deriving turbulence statistics and models.*

- April 1989. The Center For Turbulence Research. *Renormalization group analysis of turbulence.*

- October 1988. Fluid Mechanics Seminar, Stanford University. *Upper bound theory of turbulent shear flows.*

Post-Docs

A. Tiedrez	Convergence of moist Boussinesq to the precipitating quasi-geostrophic equations, partially supported by NSF DMS-1907667, 2020-2023.
A. Wetzel	Mathematics, Analysis of the FARE model for precipitating convection with asymptotically fast cloud microphysics, partially supported by NSF AGS-1443325, 2015-2019.
D. Sondak	Mathematics, Turbulence and unstable solutions of Rayleigh-Bénard convection, partially supported by NSF-RTG 8/13-6/16; Institute for Computational Science and Engineering, UT-Austin (1/16-7/17); Lecturer in Computational Science, Harvard University (since 8/17).
G. Hernandez	Mathematics, Analysis and modeling of rotating, stratified flows with and without moisture, partially supported by NSF-CMG 9/10-9/13; Assistant Prof. of Mathematics at UNAM, Mexico.
A. Boonkasame	Mathematics, Wall-bounded convection, partially supported by NSF 9/10-9/13; Assistant Professor at Prince of Songkla University, Thailand.
J. Sukhatme	Mathematics, Multi-scale modeling in rotating and stratified flows, supported by NSF-CMG 1/06-12/08; Associate Prof., Center for Atmospheric and Oceanic Sciences, India Institute for Science, Bangalore, India.
H. Lu	Mechanical Engineering, Numerical simulation of horizontal and vertical mixing in a rotating and stratified channel, co-advised with Christopher Rutland, supported by NSF-CTS 6/07-8/08; Associate Prof., Huazhong University of Science and Technology, China.

Current Students

Y. Zhang	Mathematics, Wave decompositions and fast-wave averaging for precipitating dynamics in the atmosphere, PhD expected May 2021.
P. Kooloth	Mathematics, The role of exact solutions for determining statistics of high-Rayleigh number turbulent convection, PhD expected May 2023.

Former Students

James Hu	Mathematics, Numerical Investigations of Precipitating Quasi-Geostrophic Turbulence with Phase Changes, B.A. Mathematics, May 2020, currently a PhD student at Notre Dame.
T. Edwards	Mathematics, Atmospheric Water in the Saturated Precipitating Quasi-geostrophic Equations., PhD June 2019, ClearEdge3D.
Q. Deng	Mathematics, Models of moist dynamics for the atmosphere, PhD August 2012, postdoctoral fellow at Courant Abu Dhabi (8/12 - 6/16); Associate Professor in the Ocean and Earth Science Department, Xiamen University, China (since fall 2016).
L. Wang	Mathematics, Detailed analysis and simulations of wave interactions in β-plane and rotating flows, PhD August 2011, Epic Systems Corporation.
M. Remmel	Mathematics, Reduced models and structure formation in the rotating shallow water and rotating Boussinesq equations, PhD May 2010, VIGRE postdoctoral fellow, University of California, Davis; currently working in the insurance industry.
H. Lu	Mechanical Engineering, Large-eddy simulation of strongly rotating turbulence, co-advised by Christopher Rutland, PhD May 2007; postdoctoral fellow at the St. Anthony Falls Laboratory, University of Minnesota; Swiss Federal Institute of Technology - Lausanne; currently Associate Professor at Huazhong University of Science and Technology.
C. McKay	Physics, The effects of stratification on the wind-driven ocean circulation, PhD July 2005; Associate Professor of Physics, Marietta College, Marietta, Ohio.

Y. Lee   Mathematics, Anisotropic energy transfer in beta-plane and rotating flows, PhD Dec. 2003; 2004-2006 Pacific Institute of Mathematical Sciences (PIMS) post-doc at Simon Fraser University, Vancouver, Canada; currently Director, Head of Traded Risk Model Development, Royal Bank of Scotland.