



Nevada NSF EPSCoR ACES (\$58,000) with Satoko Kurita, January 2004  
 In-situ Bioremediation of Contaminated Soil.

UNR Junior Faculty Research Award (\$15,000), August 2002  
 Determining Modes in the LANS-Alpha Model.

NSF Postdoctoral Fellowship (\$68,000) with Edriss Titi, January 1999  
 Averaged Lagrangians, Camassa-Holm Equations and Turbulence

IU Mathematics Department Fellowship (\$1200), August 1997

Nominated for GAANN Fellowship, August 1997

The IU Mentoring Program, August 1996

David A. Rothrock Teaching Award (\$100), April 1994

**Graduate and Undergraduate Students Supervised:**

Beau Smith, *In progress*

Ph.D. Thesis: *title to be determined*

Hongquan Li, *In progress*

Undergraduate Honors Thesis: *The Order of Convergence of a Robust Secant-like Iterative Scheme for Finding Zeros of Higher Multiplicity.*

James Clifford, 2018

Undergraduate Honors Thesis: *Use of Approximate Set Differences to Infer the Movement of Objects in Point Clouds*

Beau Smith, 2017

Masters Thesis: *Symmetry-breaking perturbations on the global attractor of the Kuramoto–Sivashinsky equation*

Jordan Blocher, 2016

Masters Thesis: *Time Averaged Measurements in Data Assimilation.*

Masakazu Gesho, 2013

Masters Thesis: *A Numerical Study of Continuous Data Assimilation for the 2D Navier–Stokes Equations Using Nodal Points.*

Xander Henderson, 2013

Masters Thesis: *Assouad Dimension and the Open Set Condition.*

Chris Wingard, 2009

Masters Thesis: *Exact Filtering of Measurement Errors in Dynamical Systems.*

Kevin Hayden, 2007

Masters Thesis: *Discrete in Time Coupling and Synchronization of the Lorenz System.*

**Refereed Publications:**

1. Spectral Filtering of Interpolant Observables for Discrete-in-time Data Assimilation (with Emine Celik and Edriss Titi), accepted for in the SIAM Journal on Applied Dynamical Systems.
2. Stochastic model error in the LANS-alpha and NS-alpha deconvolution models of turbulence, International Journal of Numerical Analysis and Modeling, No. 6, 2018, pp. 811-833.

3. Continuity of Pullback and Uniform Attractors (with Luan Hoang and James Robinson), *Journal of Differential Equations*, Vol 264, Issue 6, 15 March 2018, pp. 4067–4093.
4. Data Assimilation Using Noisy Time-Averaged Measurements (with Jordan Blocher and Vincent Martinez), *Physica D*, Volumes 376–377, August 2018, pp. 49–59.
5. Some Results in Support of the Makeyev Conjecture (with Jonathan Fraser and James Robinson), *Real Analysis Exchange*, Vol. 42, No. 2, 2017, pp. 253–268.
6. Lower bounds on blowing-up solutions of the 3D Navier-Stokes equations in  $H^{3/2}$ ,  $H^{5/2}$  and  $B^{2,15/2}$  (with David McCormick, James Robinson, Jose Rodrigo, Vidal-Lopez and Yi Zhou) *SIAM Journal on Mathematical Analysis*, Vol. 48, No. 3, 2016, pp. 2119–2132.
7. A Computational Study of a Data Assimilation Algorithm for the Two-dimensional Navier–Stokes Equations (with Masakazu Gesho and Edriss Titi), *Communications in Computational Physics*, Volume 19, no. 4, 2016, pp. 1094–1110.
8. A Simple Example Concerning the Upper Box-counting Dimension of a Cartesian Product (with James Robinson), *Real Analysis Exchange*, Volume 40.2, 2016, pp. 449–452.
9. Generalised Cantor Sets and the Dimension of Products (with James Robinson and Nicholas Sharples), *Mathematical Proceedings of the Cambridge Philosophical Society*, Volume 160, 2016, no. 1, pp. 51–75.
10. On the Continuity of Global Attractors (with Luan Hoang and James Robinson), *Proceedings of the American Mathematical Society*, Volume 143, 2015, no. 10, pp. 4389–4395.
11. On the Assouad Dimension of Self-similar Sets with Overlaps (with Jonathan Fraser, Alexander Henderson and James Robinson), *Advances in Mathematics*, Volume 273, 2015, pp. 181–214.
12. Continuous Data Assimilation with Stochastically Noisy Data (with Hakima Bessaih and Edriss Titi), *Nonlinearity*, **28** (2015), 729–753.
13. Continuous Data Assimilation Using General Interpolant Observables (with A. Azouani and E.S. Titi), *Nonlinear Science*, **24** (2014), 277–304.
14. Discrete data assimilation in the Lorenz and 2D Navier–Stokes equations (with K. Hayden and E.S. Titi), *Phys. D*, **240**:18 (2011), 1416–1425.
15. Almost Bi-Lipschitz Embeddings and Almost Homogeneous Sets, (with James Robinson), *Trans. Amer. Math. Soc.*, **362**:1 (2010), 145–168.
16. The Normal Form of the Navier–Stokes Equations in Suitable Normed Spaces (with Ciprian Foias, Luan Hoang and Mohammed Ziane), *Ann. Inst. H. Poincaré Anal. Non Linéaire*, Vol. 26, No. 5, 2009, pp. 1635–1673.
17. Determining Modes and Grashof Number in 2D Turbulence—A Numerical Case Study (with Edriss Titi), *Theoretical and Computational Fluid Dynamics*, Vol. 22, No. 5, 2008, pp. 327–399.

18. Viscosity Versus Vorticity Stretching: Global Well-posedness for a Family of Navier–Stokes-Alpha-like Models (with Edriss Titi), *Nonlinear Anal.*, Vol. 66, No. 11, 2007, pp. 2427–2458.
19. On the Solutions to the Normal Form of the Navier–Stokes Equations (with Ciprian Foias, Luan Hoang and Mohammed Ziane), *Indiana Univ. Math. J.*, Vol. 55, No. 2, 2006, 631–686.
20. On a Leray-alpha Model of Turbulence (with Alexey Cheskidov and Edriss Titi), *Proc. R. Soc. Lond. Ser. A Math. Phys. Eng. Sci.*, Vol. 461, No. 2055, 2005, pp. 629–649.
21. Determining Modes for Continuous Data Assimilation in 2D Turbulence (with Edriss Titi), *J. Stat. Phys.*, Vol. 133, No. 5/6, December 2003, pp. 799–839.
22. Bouligand Dimension and Projections with Almost Lipschitz Inverse, *Pacific J. Math.*, Vol. 202, No. 2, 2002, pp. 459–474.
23. A Connection Between the Camassa–Holm Equations and Turbulent Flows in Channels and Pipes (with Shiyi Chen, Ciprian Foias, Darryl D Holm, Edriss S Titi, and Shannon Wynne), *Phys. Fluids*, **11**:8 (1999), 2343–353.
24. The Camassa–Holm Equations and Turbulence (with Shiyi Chen, Ciprian Foias, Darryl D Holm, Edriss S Titi, and Shannon Wynne), *Phys. D*, Vol. 133, No. 1-4, 10 Sept. 1999, pp. 49–65.
25. The Camassa–Holm Equations as a Closure Model for Turbulent Channel Flow (with Shiyi Chen, C. Foias, D.D. Holm, E.S. Titi, and S. Wynne), *Phys. Rev. Lett.*, **81**:24 (1998), 5338–5341.
26. Finite Fractal Dimension and Hölder–Lipschitz Parametrization (with C. Foias), *Indiana Univ. Math. J.*, **45**:3 (1996), 603–616.

**U.S. Patents:**

27. Detecting CPU, FPU and Memory Subsystem Errors by Means of Deterministic Chaos, No. 12/657025, September 22, 2011.

**Other Creative Work:**

28. The Orthogonal Projection of Fractal Sets, UMI, Ph.D. Dissertation, Indiana University, 1999, 57 pages.
29. A Simple Example of a Continuous Function that is Nowhere Differentiable, *Classics on Fractals*, Edited by Gerald A Edgar, Addison-Wesley, 1993 (translation of Karl Kiesswetter, Ein einfaches Beispiel für eine Funktion welche überall stetig und nicht differenzierbar ist, *Math.-Phys. Semesterber*, **13** (1966), 216–221).

**Submitted Publications:**

30. Continuous Data Assimilation with Blurred-in-time Measurements of the Surface Quasi-geostrophic Equation (with Mike Jolly, Vincent Martinez and Edriss Titi), submitted.

**Publications in Preparation:**

- Symmetry-breaking perturbations on the global attractor of the Kuramoto-Sivashinsky equation (with Alexsey Cheskidov and Beau Smith), in preparation.
- A Moran Open-Set condition for Non-autonomous Iterated Function Systems, (with Xander Henderson, James Robinson and Nicholas Sharples), in preparation.
- The Numerical Performance of two Simple Data Assimilation Algorithm in the Presence of Noisy Observations (with Emine Celick and Michael Jolly), in preparation.

**Software Development:**

- `t1sim`, Perform discrete-in-time data assimilation experiments using general type-1 interpolant observables with stochastic noise, Written in C99 for execution on parallel clusters using MPI. January 2019 version consists of 1722 lines of code written by Olson.
- `gpudiff`, Use the new  $\mathcal{O}(n(\log n)^2)$  gridless recursive-boxing algorithm to compute approximate set differences based on the Hausdorff metric. Designed for parallel execution on CUDA GPU hardware. A version for SMP CPUs was also written. April 2018 version consists of 3777 lines of code written by Clifford and Olson.
- `lans`, Compute time evolution of residuals for LANS- $\alpha$  and LANS- $\alpha$  deconvolution models of turbulence. Written for execution on multi-core SMP hardware using the Intel/MIT Cilk parallel extensions to the C99 programming language. March 2015 version consists of 981 lines of code written by Olson.
- `cilkrts`, Port of the runtime library for the MIT/Intel Cilk parallel programming extensions of the gcc-5.1 compiler to the ARMv7-A architecture used in the Raspberry Pi 2B computer. Changes from March 2015 consisted of 261 lines of code.
- `pcc`, Contribution of unicode support for Anders Magnusson's continued development of the original Bell Labs Portable C Compiler. Changes consisted of about 300 lines of C code. The May 5, 2014 document <http://pcc.ludd.ltu.se/documentation/> by Olson describes the changes.
- `gpunav`, Perform continuous data assimilation experiments using nodal measurements of velocity, vorticity or stream functions for the 2DNS. Designed for parallel execution on CUDA GPU hardware with optimized control flow for GPU and zero memory copies between host and device memory per time step. May 2013 version consists of 2810 lines of C and CUDA code written by Gesho and Olson.
- `ns2d`, Perform continuous data assimilation experiments using Fourier mode coupling for the two-dimensional incompressible Navier–Stokes equations and  $\alpha$  models of turbulence. Designed for parallel computation of multiple approximating solutions  $u_j$  for parameter studies using OpenMPI and FFTW. August 2010 version consists of 8689 lines of C code written by Olson.
- `nuwi`, The Nuwi Exam Generator and online testing system. Developed and supported from 1996 to 1998 consisted of 23 030 lines of C and Pascal code including documentation written by Olson.

**Teaching Experience:**

Undergraduate Courses

Honors Calculus I and II (10 semesters)  
Undergraduate Analysis I and II (5 semesters)  
Linear Algebra (3 semesters)  
Ordinary Differential Equations (5 semesters)  
Calculus I and II (3 semesters)  
Business Calculus (3 semesters)  
Mathematics for Elementary School Teachers (1 semester)

Combined Graduate/Undergraduate Courses

Partial Differential Equations (1 semester)  
Numerical Methods I and II (8 semesters)  
Advanced Linear Algebra (1 semester)

Graduate Courses

Fourier, Wavelet and Complex Variable Methods  
in Applied Mathematics I and II (2 semesters)  
Real Variables I and II (2 semesters)  
Partial Differential Equations I and II (2 semesters)  
Numerical Analysis I and II (2 semesters)  
Complex Variables (1 semester)

Independent Study and Overload

Real Analysis (Paige DePolo 2015)  
Complex Variables (Masakazu Gesho, Dol Nath and Yibo Xu 2012)  
Fourier Analysis (Cyrus Luciano 2010)  
Wavelet and Applications (Ruslana Dalinina 2008)  
Complex Variables (Suresh Kumar 2005)

**Department and University Service:**

Department

Computing Committee (2000–2003 and 2006–current)  
Applied Mathematics Website (2005–current)  
Hiring Committee (2002 and 2007)  
Thesis Committees (12 students)  
Qualifying Exams (5 exams)  
Beowulf Cluster (2001–2011)  
Future of Applied Mathematics (2005–2006)  
Open House Committee (2004)  
Merit Committee (2001)  
Graduate Committee (2000)

College

Curriculum Committee (2005–2009)  
Working Group on Computational Sciences (2010)

**Research and Teaching Related Service:**

- Consultant for PC Doctor  
Computer Memory Subsystem Reliability Testing (2007–2009)
- Outside Ph.D. Examiner for University of Warwick  
Eleonora Pinto de Moura (2010)
- Referee for Peer Reviewed Journals

**Community Service:**

- Built and programmed a Raspberry Pi controlled toy car  
UNR Engineering Days at Clay Middle School (2012)
- Taught 16 programming workshops  
Supplemental instruction at UNR (2012–2013)
- Website programmer for public service organization  
Council 4997 of the Knights of Columbus (2008–2012)
- Volunteer teacher at Our Lady of the Snows School  
8th Grade Yearbook Course (2007–2009)
- Volunteer teacher at Early Learning Center  
1st–3rd Grade Mathematics (2004–2005)

**Talks:**

1. *On the Residual Error in the NS-alpha Family of Turbulence Models*, Workshop on Data Assimilation of Determining Forms held at University of Minnesota on June 21, 2016 just before the 2016 IMA Workshop in Honor of George Sell.
2. *Data Assimilation Using Noisy Time-averaged Measurements*, SIAM Conference on Analysis of PDEs, Scottsdale, Arizona, December 7–10, 2015.
3. *Data Assimilation Using Time-averaged Measurements*, Oxford 38th Conference on Stochastic Processes and their Applications, July 15, 2015.
4. *Statistical Properties of the Residual Error in Turbulence Models*, 2015 Spring Western Section Meeting of the AMS in Las Vegas, April 18, 2015.
5. *Synchronization of Systems of Lorenz Equations using Time Averages* given at the Workshop on Navier–Stokes Equations and Data Assimilation, January 8, 2015 at Texas A&M University.
6. *Data Assimilation for the 2DNS Using Nodal Measurements*, 2014 AMS Sectional Meeting, Texas Tech University, Lubbock Texas, April 12, 2014.
7. *The Weak Separation Condition and Assouad Dimension: A precise Dichotomy on the Real Line*, Ergodic Theory and Dynamical Systems Seminar, University of Warwick, United Kingdom, February 11, 2014.
8. *Data Assimilation at the 2D NSE using Noisy Data*, Workshop on Nonlinear PDEs and Fluid Flows, University of Maryland, Baltimore County, January 20, 2014.
9. *Continuous Data Assimilation using Arbitrary Interpolant Observables*, Workshop on Navier-Stokes Equations, Indiana University, February 9, 2013.

10. *Discrete Data Assimilation Using Arbitrary Interpolants*, The 9th AIMS Conference on Dynamical Systems, Differential Equations and Applications, Orlando, Florida, July 2, 2012.
11. *Discrete in Time Data Assimilation for the 2D Navier–Stokes Equations*, Workshop on Navier–Stokes Equations, Texas A&M University, College Station, February 17, 2012.
12. *Discrete in Time Determining Modes for the 2D Navier–Stokes Equations*, The Conference on Topology, Embeddings and Attractors at Warwick’s centre in Venice June 14, 2011.
13. *Discrete Data Assimilation in the 2D Navier–Stokes Equations*, University of California, Irvine, May 16, 2011.
14. *Almost Bi-Lipschitz Embeddings and Almost Homogeneous Sets*, given at University of Southern California, November 10, 2006.
15. *Applied Mathematics at UNR*, given in the Graduate Student Seminar at University of Nevada Reno, October 5, 2006.
16. *The PDEWulf Beowulf Cluster*, a poster presented at the UNR departmental open house, February 14, 2005.
17. *The Number of Determining Modes in Numerical 2D Turbulence*, in the Applied Mathematics Seminar at Indiana on Jan 15, 2004.
18. *The Number of Determining Modes in 2D Turbulence*, SIAM Conference on Applications of Dynamical Systems in Snowbird Utah on May 30, 2003.
19. *Numerical Determining Modes*, Aerodynamics and Flight Mechanics Research Group Seminar Program at the University of Southampton on Jan 15, 2003.
20. *Determining Modes in the LANS- $\alpha$  Model*, Geometrical Mechanics and Turbulence Modeling Workshop in Santa Fe, New Mexico, Nov 9, 2002.
21. *The Number of Determining Modes in 2D Turbulence: A Computational Study*, The Fourth International Conference on Dynamical Systems and Differential Equations, May 25, 2002 UNC at Wilmington.
22. *Continuous Data Assimilation for 2D Navier–Stokes Equations*, UC Irvine, Applied and Computational Mathematics Seminar, April 15, 2002.
23. *The Number of Determining Modes in Numerical 2D Turbulence*, University of California, Santa Barbara, Applied Mathematics Seminar on March 11, 2002.
24. *The Number of Determining Modes in Numerical 2D Turbulence*, given at the session on Partial Differential Equations and Applications at the Western Section Meeting of the American Mathematical Society on Nov 10, 2001.
25. *The Number of Determining Modes in Numerical 2D Turbulence*, given at the University of Southern California Applied Mathematics Seminar on October 26, 2001.
26. *The Navier–Stokes alpha model of Turbulence*, given at the University of Nevada Reno Chemical Engineering & Mechanical Engineering Joint Research Seminar Series on February 23, 2001.



27. *Turbulence and the alpha-Model of the Navier–Stokes Equations*, given Dec 8, 2000 at the University of Missouri.
28. *The Hölder–Mañé Projection Theorem and some Applications*, given Dec 7, 2000 at the University of Missouri.
29. *Inertially Equivalent Finite Dimensional ODEs*, given Sept 1999 at the University of Nevada, Reno.
30. *Projection Theorems and the Reduction of Infinite Dimensional Dynamics to Finite Dimensions*, given Nov 1998 at Tata Institute of Fundamental Research.
31. *An up to date Report on the Connection between the Camassa–Holm Equations, Turbulent Channel, and Pipe Flows*, a talk given Aug 1998 at Los Alamos Center for Nonlinear Studies (with Shannon Wynne).
32. *Bouligand Dimension and Almost Lipschitz Embeddings*, given February 1998 at Los Alamos Center for Nonlinear Studies.