Shane D. Ross

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Professional Preparation:

- **California Institute of Technology**, B.S., Physics 1998
- **California Institute of Technology**, Ph.D., Control and Dynamical Systems 2004
- **University of Southern California**, NSF Mathematical Sciences Postdoc 2004-2006
  Department of Aerospace and Mechanical Engineering

Appointments:

- **Virginia Tech**
  - Department of Aerospace and Ocean Engineering
    - Professor 2019-
  - Department of Mathematics, Affiliate Professor 2018-
  - Department of Mechanical Engineering, Affiliate Professor 2011-
  - Interdisciplinary Center for Applied Mathematics, Affiliate Professor 2011-
  - Department of Biomedical Engineering and Mechanics
    - Affiliate Professor 2019-
    - Professor & Director of Engineering Mechanics graduate program 2016-2019
    - Associate Professor 2014-2016
  - Department of Engineering Science and Mechanics
    - Associate Professor 2012-2014
    - Assistant Professor 2006-2012

Career Highlights:

- Funding: $15 million, $4.2M personal share, from NSF, NASA, USSF, USDA, AFRL, NIH
- Prestigious NSF CAREER Award in Dynamical Systems Program
- US Space Force funded educational and research network for beyond GEO operations
- NSF HAZARDS (Collaborative multi-university, interdisciplinary grant with MIT, Berkeley)
- NSF Data Science Corps (Multi-university undergraduate education grant with HBCUs)
- High-Impact Scholarship: 100 journal publications, 7,000 citations, h-index 40
- Top 100 article in media attention in 2020 out of 3.4 million papers published that year
- Several articles in *Nature* journals, *Scientific American*, other high-profile outlets
- Multiple AIAA Best Paper Awards and multiple NASA Innovation Awards
- Authored open-access book on space mission design in the 3-body problem
- Many Teaching Awards: including two Virginia Tech Certificates of Teaching Excellence
- Youtube Videos: Educating thousands 24 hours a day through free online lectures
- Social Media: 40,000 followers; posts and videos receive 1M views per year
- Excellent Mentorship: 15 PhDs & 3 post-docs advised, 6 (33%) are now professors

Visiting Positions

- Visiting Scholar, University of California San Diego, Department of Mechanical and Aerospace Engineering, Aug-Dec, 2022.
- Visiting Faculty, Instituto de Ciencias Matemáticas (ICMAT – Institute of Mathematical Sciences), Universidad Autónoma de Madrid, Spain, Aug-Dec, 2013.
- Visiting Faculty, Centre de Recerca Matemàtica (CRM – Center for Mathematics Research), Universitat Autónoma de Barcelona, Spain, Nov-Dec, 2008.

Awards, Prizes, and Recognition

- 2022 Certificate of Teaching Excellence, Virginia Tech College of Engineering
- 2017 Excellence in Research Award, Virginia Tech College of Engineering Dean's Award
- 2017 Leader in Research Award, Virginia Tech Dept. of Biomedical Engineering & Mechanics
- 2015 Virginia Tech Scholar of the Week
- 2015 Leader in Scholarship Award, Dept. of Biomedical Engineering and Mechanics
- 2012 Liviu Librescu Prize, Dept. of Engineering Science and Mechanics
- 2012-2015 Faculty Fellow, Virginia Tech College of Engineering Dean's Award
- 2012 Certificate of Teaching Excellence, Virginia Tech College of Engineering
- 2012-2017 NSF CAREER Award (Faculty Early Career Development Program)
- 2011 Plenary Speaker on Computational Methods in Dynamics at Abdus Salam International Centre for Theoretical Physics, Trieste, Italy
- 2011 Keynote Speaker at Lorentz Centre Workshop on Coherent Structure and Dynamical Systems, Leiden, The Netherlands
- 2010 Outstanding New Assistant Professor, Virginia Tech College of Eng. Dean's Award
- 2009 Invited Speaker at British Science Festival
- 2009 Virginia Tech Faculty Authors Recognition List
- 2008 Invited Speaker at Zurich Physics Colloquium
- 2008 Virginia Tech Faculty Scholar of the Week
- 2005 Recognized for interdisciplinary research accomplishments in NSF press release, Mathematics Unites the Heavens and the Atom (Sept 29, 2005)
- 2004-2006 NSF Mathematical Sciences Postdoctoral Research Fellow
- 2004 Everhart Lecture Series Winner, 'The Interplanetary Transport Network', Caltech, 2004
- 2003 NASA Space Act Award, 'Low-Energy Interplanetary Transfers Using Lagrangian Points'
- 2002 NASA Innovation Award, 'Low-Energy Transfer from Near-Earth to Near-Moon Orbit'
- 2001 AIAA/AAS Best Paper Award by American Astronautical Society/American Institute of Aeronautics and Astronautics Astrodynamics Specialist Conference, Quebec City, Canada
- 1998 NASA Innovation Award, 'Planetary Capture and Interplanetary Transfer Using the Invariant Manifold Structures Around L1 and L2'

Faculty interviews, requests to interview, and offers, other than present position

- Stanford University
- University of Michigan
- Texas A&M University
- University of California, San Diego
- MIT
- University of Maryland
- University of California, Irvine
- University of Illinois

Selected Publicity

In addition to several Virginia Tech press releases, below are listed some selected works describing the work of Dr. Ross in the popular press.

- Time Series at the Beach, Data Skeptic podcast episode, 30,000 listeners, 06/28/2021
- Virginia Tech researchers still have much to learn from flying snakes, 10/15/2020
- A trans-Atlantic journey: how microbes and dust travel from Africa to the Americas, 9/1/2020
- Let me clear my throat: Capturing coughing sounds provides data for predicting epidemiological trends, 7/31/2020
- Uncovering hidden flow patterns in coastal waters likely leads to faster disaster response 6/16/2020
- NSF grant provides new research opportunities for underserved students. *News Break*, 1/2/2020
- USDA grant to study transport of pollen from hemp, switchgrass, *Augusta Free Press*, 10/7/2019
- Interview with David Schmale and Shane Ross, Virginia Tech Researchers on Microbe Research Using Drones and Fluorescent Dye, mydeardrone.com, UAV & Drone Interviews, 2019
- 'Virginia Tech high-flying microbe research featured in special issue of Scientific American', *VT News*, July 11, 2019
- *Scientific American Special Edition: Wild Ideas in Science*, Summer 2019, feature article.
- NSF promotional video, 'Streamlining ocean rescue: using drones and dummies', February 26, 2019. https://bit.ly/2BTYkBT
- Two researchers earn grant to streamline simulation of fluid contamination disasters, 11/28/2018
- Feature article in *Scientific American*, "High-Flying Microbes", February 2017
- "New techniques promise better containment of damaging contaminants from environmental disasters", *Augusta Free Press, GeosNews, NZ Health Tec, HighBeam*, Sep 8, 2015
- *Scientific American*, "Walls of Water", July 2013
- "Shane Ross Garners CAREER Award to Advance Understanding of Fluid Flows, from Blood Inside the Body to Oil Spills in Bodies of Water", *TMC Net*, Feb 9, 2012
- "Microbes travel through the air; it would be good to know how and where", *NSF Press Release, Science Daily, Newswise*, Sep 9, 2011
- "Pollution dispersion research aids understanding of 2002 break-up of Antarctic ozone hole", *AAAS Eureka*, 5/24/2010; among most popular AAS news releases, 30,000 hits by August
- "New research could help model Gulf oil spill dispersion", *ABC News, San Francisco*, 5/24/2010
- *Times of London*, "Celestial 'surfing' offers hope of cheap and efficient space travel" Sep 2009
- *Telegraph*, "Scientists unveil plan designed to cut cost of space travel", Sep. 10, 2009
- *Astronomy*, "How scientists discovered a solar system 'superhighway'", November 2008
- *Milwaukee Journal-Sentinel*, "Hitchhiking through space", July 31, 2006
- *American Scientist*, "The Interplanetary Transport Network", May-June 2006
- *New Scientist*, "Ride the celestial subway", March 27, 2006
- *Science*, "Tube Route: Gravitational superhighway snakes through solar system", Nov, 2005
- *Notices of the American Mathematical Society*, "Ground Control to Niels Bohr", Oct. 2005
- *Science Daily*, "Math Unites The Celestial And The Atomic", September 28, 2005
- *Science News*, "Navigating Celestial Currents", April 18, 2005

Significant Publications (∼7,000 citations, h-index ≥40 [Google]): shaneross.com/papers

102. Khandelwal, P.C., Ross, S.D., Dong, H., Socha, J.J. [2023]. Convergence in Gliding Animals: Morphology, Behavior, and Mechanics. In: Bels, V.L., Russell, A.P. (eds) *Convergent Evolution*. Fascinating Life Sciences. Springer, Cham. DOI 10.1007/978-3-031-11441-0_13

101. Yeaton, I.J., Ross, S.D., and Socha, J.J. [202-] Quasi-steady aerodynamic theory underpredicts glide performance in flying snakes, *Journal of Experimental Biology*, under revision.

100. Jarvis, A., Mardi, A.H., Foroutan, H., and Ross, S.D. [202-] Atmospheric transport structures shaping the "Godzilla" dust plume, under review.

99. Pretorius, I., Schou, W.C., Richardson, B., Ross, S.D., Withers, T.M., Schmale, D.G., and Strand, T.M. [2023] In the Wind: Invasive Species Travel along Predictable Atmospheric Pathways, *Ecological Applications* **e2806**. DOI 10.1002/eap.2806

98. Moeltner, K., Fanara, T., Foroutan, H., Hanlon, R., Lovko, V., Ross, S.D., Schmale III, D.G. [2023] Harmful algal blooms and toxic air: The economic value of improved forecasts, *Marine Resource Economics* **38**(1). DOI 10.1086/722598

97. González-Rocha, J., Bilyeu, L., Ross, S.D., Foroutan, H., Jacquemin, S., Ault, A.P., Schmale III, D.G. [2023] Sensing atmospheric flows in aquatic environments using multirotor small uncrewed aircraft system (sUAS), *Environmental Science: Atmospheres* **3**, 305. DOI 10.1039/D2EA00042C

96. E. Hanlon, S.J. Jacquemin, J.A. Birbeck, J.A. Westrick, C. Harb, H. Gruszewski, A.P. Ault, D. Scott, H. Foroutan, S.D. Ross, J. González-Rocha, C. Powers, L. Pratt, H. Looney, G. Baker, D.G. Schmale III [2022] Drone-based water sampling and characterization of three freshwater harmful algal blooms in the United States, *Frontiers in Remote Sensing*, **3**:949052. Special Research Topic: Women in Remote Sensing, DOI 10.3389/frsen.2022.949052

95. L. Bilyeu, B. Bloomfield, R. Hanlon, J. González-Rocha, S. Jacquemin, A.P. Ault, J. Birbeck, J. Westrick, H. Foroutan, S.D. Ross, C. Powers, D.G. Schmale III [2022] Drone-based particle monitoring above two harmful algal blooms (HABs) in the USA. *Environmental Science: Atmospheres*, **2**, 1351-1363. DOI 10.1039/d2ea00055e

94. J. Fitzgerald, S.D. Ross [2022] Geometry of transit orbits in the periodically-perturbed restricted three-body problem, *Advances in Space Research*, **70**, 144-156. DOI 10.1016/j.asr.2022.04.029 Preprint available for free at arXiv:2203.16019

93. S.D. Ross, J. Fish, K. Moeltner, E.M. Bollt, L. Bilyeu, T. Fanara [2022] Beach-level 24-hour forecasts of Florida red tide-induced respiratory irritation, *Harmful Algae*, **111**, 102149. DOI 10.1016/j.hal.2021.102149 Preprint available for free at arXiv:2105.11342

92. C.N. Hill, S.D. Ross, A. Peebles, R.M. Queen [2022] Continuous similarity analysis in patient populations, *Journal of Biomechanics* **131**, 110916. DOI 10.1016/j.jbiomech.2021.110916

91. E.M. Bollt, S.D. Ross [2021] Is the Finite-Time Lyapunov Exponent Field a Koopman Eigenfunction? *Mathematics* **9**, 2731. DOI 10.3390/math9212731

90. J. Zhong, S.D. Ross [2021] Transition criteria and phase space structures in a three degree of freedom system with dissipation, *Journal of Physics A: Mathematical and Theoretical*, **54**, 365701. DOI 10.1088/1751-8121/ac16c7 Preprint available for free at arXiv:2106.01339

89. J. Zhong, S.D. Ross [2021] Global invariant manifolds delineating transition and escape dynamics in dissipative systems: an application to snap-through buckling, *Nonlinear Dynamics* **104**, 3109-3137. DOI 10.1007/s11071-021-06509-w Preprint available for free at arXiv:2010.11095

88. J. Zhong, S.D. Ross [2021] Differential correction and arc-length continuation applied to boundary value problems: examples based on snap-through of circular arches, *Applied Mathematical Modelling* **97**, 81-95. DOI 10.1016/j.apm.2021.03.027 Preprint at viXra:2004.0300

87. G.K. Nave, Jr., N. Hall, K. Somers, B. Davis, H. Gruszewski, C. Powers, M. Collver, D.G. Schmale III, S.D. Ross [2021] Wind dispersal of natural and biomimetic maple samaras, *Biomimetics* **6**, 23. DOI 10.3390/biomimetics6020023

86. J. González-Rocha, A.J. Sosa, R. Hanlon, A.A. Allen, I. Rypina, D.G. Schmale III, S.D. Ross [2021] Multirotor-assisted measurements of wind-induced drift of irregularly shaped objects in aquatic environments, *Applied Ocean Research* **110**, 102538. DOI 10.1016/j.apor.2021.102538. Preprint available for free at arXiv:2012.13665

85. X. Xie, P.J. Nolan, S.D. Ross, C. Mou, T. Iliescu [2020] Lagrangian reduced order modeling using finite time Lyapunov exponents, *Fluids* **5**(4), 189. DOI 10.3390/fluids5040189

84. I.J. Yeaton, S.D. Ross, G.A. Baumgardner, J.J. Socha [2020] Undulation enables gliding in flying snakes, *Nature Physics* **16**, 974-982. DOI 10.1038/s41567-020-0935-4

83. P.J. Nolan, M. Serra, S.D. Ross [2020] Finite-time Lyapunov exponents in the instantaneous limit and material transport, *Nonlinear Dynamics* **100**, 3825-3852. DOI 10.1007/s11071-020-05713-4. Preprint available for free at arXiv:1904.06817

82. M. Serra, P. Sathe, I. Rypina, A. Kirincich, S.D. Ross, P. Lermusiaux, A. Allen, T. Peacock, G. Haller [2020] Search and rescue at sea aided by hidden flow structures, *Nature Communications* **11**, 2525. DOI 10.1038/s41467-020-16281-x.

81. J. González-Rocha, S.F.J. De Wekker, S.D. Ross, C.A. Woolsey [2020] Wind profiling in the lower atmosphere from wind-induced perturbations to multirotor UAS, *Sensors* **20**, 1341. DOI 10.3390/s20051341.

80. P.J. Nolan, H. Foroutan, S.D. Ross [2020] Pollution transport patterns obtained through generalized Lagrangian coherent structures, *Atmosphere* **11**, 168. DOI 10.3390/atmos11020168

79. J. Zhong, S.D. Ross [2020] Geometry of escape and transition dynamics in the presence of dissipative and gyroscopic forces in two degree of freedom systems, *Communications in Nonlinear Science and Numerical Simulation*, **82**, 105033. DOI 10.1016/j.cnsns.2019.105033. Preprint available for free at arXiv:1907.10728

78. D.G. Schmale, S.D. Ross [2019] High-flying microbes, *Scientific American Special Editions: Wild Ideas in Science* **28**(3s), 12-17, July 2019.

77. Y. Xu, L.N. Virgin, S.D. Ross [2019] On experimentally locating saddle-points on a potential energy surface from observed dynamics, *Mechanical Systems and Signal Processing* **130**, 152-163. DOI 10.1016/j.ymssp.2019.05.002

76. L. Barbieri, S.T. Kral, S.C.C. Bailey, A.E. Frazier, J.D. Jacob, J. Reuder, D. Brus, P.B. Chilson, C. Crick, C. Detweiler, A. Doddi, J. Elston, H. Foroutan, J. González-Rocha, B.R. Greene, M.I. Guzman, A.L. Houston, A. Islam, O. Kemppinen, D. Lawrence, E.A. Pillar-Little, J. Reuder, S.D. Ross, M. Sama, D.G. Schmale III, T.J. Schuyler, S.W. Smith, S.

Waugh, C. Dixon, S. Borenstein, G. de Boer [2019] Intercomparison of small unmanned aircraft system (sUAS) measurements for atmospheric science during the LAPSE-RATE campaign, *Sensors* **19**, 2179. DOI 10.3390/s19092179

75. G.K. Nave, S.D. Ross [2019] Global phase space structures in a model of passive descent, *Communications in Nonlinear Science and Numerical Simulation* **77**, 54-80. DOI 10.1016/j.cnsns.2019.04.018

74. G.K. Nave, P.J. Nolan, S.D. Ross [2019] Trajectory-free approximation of phase space structures using the trajectory divergence rate, *Nonlinear Dynamics* **96**, 685-702. DOI 10.1007/s11071-019-04814-z

73. P.J. Nolan, H.G. McClelland, C.W. Woolsey, S.D. Ross [2019] A method for detecting atmospheric Lagrangian coherent structures using a single fixed-wing unmanned aircraft system, *Sensors* **19**, 1607. DOI 10.3390/s19071607

72. P.J. Nolan, J. Pinto, J. González-Rocha, C.N. Vezzi, S.C.C. Bailey, G. De Boer, C. Diehl, R. Laurence III, C.W. Powers, H. Foroutan, S.D. Ross, D.G. Schmale III [2018] Coordinated unmanned aircraft systems (UAS) and ground-based weather measurements to predict Lagrangian coherent structures (LCSs), *Sensors* **18**, 4448. DOI 10.3390/s18124448

71. S.D. Ross, A.E. BozorgMagham, S. Naik, L.N. Virgin [2018] Experimental validation of phase space conduits of transition between potential wells, *Physical Review E* **98**, 052214. DOI 10.1103/PhysRevE.98.052214

70. J. Zhong, L.N. Virgin, S.D. Ross [2018] A tube dynamics perspective governing stability transitions: An example based on snap-through buckling, *International Journal of Mechanical Sciences* **149**, 413-428. DOI 10.1016/j.ijmecsci.2017.10.040

69. R.B. Pietsch, H. Grothe, R. Hanlon, C.W. Powers, S. Jung, S.D. Ross, D.G. Schmale [2018] Wind-driven spume droplet production and the transport of *Pseudomonas syringae* from aquatic environments, *PeerJ* **6**:e5663. DOI 10.7717/peerj.5663

68. F. Jafari, S. Tahmasian, S.D. Ross, J.J. Socha [2017] Control of gliding in a flying snake-inspired n-chain model, *Bioinspiration & Biomimetics* **12**, 066002. DOI 10.1088/1748-3190/aa8c2f

67. K. Onozaki, H. Yoshimura, S.D. Ross [2017] Tube dynamics and low energy Earth-Moon transfer in the 4-body system, *Advances in Space Research* **60**, 2117-2132. DOI 10.1016/j.asr.2017.07.046

66. S. Naik, F. Lekien, S.D. Ross [2017] Computational method for phase space transport with applications to lobe dynamics and rate of escape, *Regular and Chaotic Dynamics* **22**(3), 272-297. DOI 10.1134/S1560354717030078

65. I.J. Yeaton, J.J. Socha, S.D. Ross [2017] Global dynamics of non-equilibrium gliding in animals, *Bioinspiration & Biomimetics* **12**, 026013. DOI 10.1088/1748-3190/aa60e2

64. D.G. Schmale, S.D. Ross [2017] High-flying microbes: Aerial drones and chaos theory help researchers explore the many ways that microorganisms spread havoc around the world, *Scientific American* **316**, 40-45, February 2017. DOI 10.1038/scientificamerican0217-40

63. S. Naik, S.D. Ross [2017] Geometry of escaping dynamics in nonlinear ship motion, *Communications in Nonlinear Science and Numerical Simulation* **47**, 48-70. DOI 10.1016/j.cnsns.2016.10.021

62. R.F. David, A.E. BozorgMagham, D.G. Schmale, S.D. Ross, L.C. Marr [2016] Identification of meteorological predictors of *Fusarium graminearum* ascospore release using correlation and causality analyses, *European Journal of Plant Pathology* **145**, 483-492. DOI 10.1007/s10658-015-0832-3

61. P.C. Fino, A.R. Mojdehi, K. Adjerid, M. Habibi, T.E. Lockhart, S.D. Ross [2016] Comparing postural stability entropy analyses to differentiate fallers and non-fallers, *Annals of Biomedical Engineering* **44**, 1636-1645. DOI 10.1007/s10439-015-1479-0

60. A.E. BozorgMagham, S.D. Ross, D.G. Schmale [2015] Local finite-time Lyapunov exponent, local sampling and probabilistic source and destination regions, *Nonlinear Processes in Geophysics* **22**, 663-677. DOI 10.5194/npg-22-663-2015

59. D.G. Schmale, S.D. Ross [2015] Highways in the sky: Scales of atmospheric transport of plant pathogens, *Annual Review of Phytopathology* **53**, 591-611. DOI 0.1146/annurev-phyto-080614-115942

58. A.J. Prussin, L.C. Marr, D.G. Schmale, R. Stoll, S.D. Ross [2015] Experimental validation of a long-distance transport model for plant pathogens: application to *Fusarium graminearum*, *Agricultural and Forest Meteorology* **203**, 118-130. DOI 10.1016/j.agrformet.2014.12.009

57. A.E. BozorgMagham, S.D. Ross [2015] Atmospheric Lagrangian coherent structures considering unresolved turbulence and forecast uncertainty, *Communications in Nonlinear Science and Numerical Simulation* **22**(1-3), 964-979. DOI 10.1016/j.cnsns.2014.07.011

56. S.G. Raben, S.D. Ross, P.P. Vlachos [2014] Experimental determination of three-dimensional finite-time Lyapunov exponents in multi-component flows, *Experiments in Fluids* **55**, 1824. DOI 10.1007/s00348-014-1824-3

55. B. Lin, S.D. Ross, A.J. Prussin, D.G. Schmale [2014] Seasonal associations and atmospheric transport distances of fungi in the genus *Fusarium* collected with unmanned aerial vehicles and ground-based sampling devices, *Atmospheric Environment* **94**, 385-391.

54. F. Jafari, S.D. Ross, P.P. Vlachos, J.J. Socha [2014] A theoretical analysis of pitch stability during gliding in flying snakes, *Bioinspiration & Biomimetics* **9**, 025014.

53. A.J. Prussin, N.A. Szanyi, P.I. Welling, S.D. Ross, D.G. Schmale [2014] Estimating the production and release of ascospores from a field-scale source of *Fusarium graminearum* inoculum, *Plant Disease* **98**, 497-503.

52. A.J. Prussin, Q. Li, R. Malla, S.D. Ross, D.G. Schmale [2014] Monitoring the long distance transport of *Fusarium graminearum* from field-scale sources of inoculum, *Plant Disease* **98**, 504-511.

51. S.G. Raben, S.D. Ross, P.P. Vlachos [2014] Computation of finite-time Lyapunov exponents from time-resolved particle image velocimetry data, *Experiments in Fluids* **55**(1), 1-14.

50. A.E. BozorgMagham, S.D. Ross, D.G. Schmale [2013] Real-time prediction of atmospheric Lagrangian coherent structures based on uncertain forecast data: an application and error analysis, *Physica D* **258**, 47-60.

49. P. Tallapragada, S.D. Ross [2013] A set oriented definition of the finite-time Lyapunov exponents and coherent sets. *Communications in Nonlinear Science and Numerical Simulation*, **18**(5), 1106-1126.

48. B. Lin, A.E. BozorgMagham, S.D. Ross, D.G. Schmale [2013] Small fluctuations in the recovery of fusaria across consecutive sampling intervals with unmanned aircraft 100 m above ground level, *Aerobiologia* **29**, 45-54.

47. P. Grover, S.D. Ross, M.A. Stremler, P. Kumar [2012] Topological chaos, braiding and bifurcation of almost-cyclic sets, *Chaos* **22**, 043135.

46. Z. Hasnain, C. Lamb, S.D. Ross [2012] Capturing near-Earth asteroids around Earth. *Acta Astronautica* **81**, 523-531.

45. M.L. Tanaka, S.D. Ross [2012] Using topological equivalence to discover stable control parameters in biodynamic systems, *Computer Methods in Biomechanics and Biomedical Engineering* **15**(8), 875-884.

44. D.G. Schmale, S.D. Ross, T.L. Fetters, P. Tallapragada, A.K. Wood-Jones, B. Dingus [2012] Isolates of *Fusarium graminearum* collected 40-320 meters above ground level cause Fusarium head blight in wheat and produce trichothecene mycotoxins, *Aerobiologia* **28**,1-11.

43. S.D. Ross, P. Tallapragada [2012] Detecting and exploiting chaotic transport in mechanical systems. In *Applications of Chaos and Nonlinear Dynamics in Science and Engineering*, Vol. 2, S. Banerjee, L. Rondoni, M. Mitra (eds.), Springer, pp. 155-183.

42. P. Tallapragada, S.D. Ross, D.G. Schmale [2011] Lagrangian coherent structures are associated with fluctuations in airborne microbial populations, *Chaos* **21**, 033122.

41. C.E. Bohland, D.G. Schmale, S.D. Ross [2011] Caging the Blob: Using a Slime Mold to Teach Concepts about Barriers that Constrain the Movement of Organisms, *American Biology Teacher* **73**(9), 537-541.

40. M.A. Stremler, S.D. Ross, P. Grover, P. Kumar [2011] Topological chaos and periodic braiding of almost-cyclic sets, *Physical Review Letters* **106**, 114101.

39. C. Senatore, S.D. Ross [2011] Detection and characterization of transport barriers in complex flows via ridge extraction of the finite time Lyapunov exponent field, *International Journal for Numerical Methods in Engineering* **86**, 1163-1174.

38. W. Koon, M. Lo, J. Marsden, S.D. Ross [2011] *Dynamical Systems, the Three-Body Problem, and Space Mission Design*, Marsden Books, ISBN 978-0-615-24095-4.

37. F. Lekien, S.D. Ross [2010] The computation of finite-time Lyapunov exponents on unstructured meshes and for non-Euclidean manifolds, *Chaos* **20**, 017505.

36. S.D. Ross, M.L. Tanaka, C. Senatore [2010] Detecting dynamical boundaries from kinematic data in biomechanics, *Chaos* **20**, 017507.

35. M.L. Tanaka, S.D. Ross, M.A. Nussbaum [2010] Mathematical modeling and simulation of seated stability, *Journal of Biomechanics* **43**, 906-912.

34. S. Jerg, O. Junge, S.D. Ross [2009] Optimal capture trajectories using multiple gravity assists, *Communications in Nonlinear Science and Numerical Simulations* **14**(12), 4168-4175.

33. P. Grover, S.D. Ross [2009] Designing trajectories in a planet-moon environment using the controlled Keplerian map, *Journal of Guidance, Control, and Dynamics* **32**(2), 436-443.

32. M.L. Tanaka, S.D. Ross [2009] Separatrices and basins of stability from time series data: an application to biodynamics, *Nonlinear Dynamics*, **58**(1-2), 1-21.

31. M.L. Tanaka, M.A. Nussbaum, S.D. Ross [2009] Evaluation of the threshold of stability for the human spine, *Journal of Biomechanics* **42**(8), 1017–1022.

30. P. Tallapragada, S.D. Ross [2008] Particle segregation by Stokes number for small neutrally buoyant spheres in a fluid, *Physical Review E* **78**, 036308.

29. J.A. Norris, A.P. Marsh, K.P. Granata, S.D. Ross [2008] Revisiting stability of 2D passive biped walking: local behavior, *Physica D: Nonlinear Phenomena*, **237**(23), 3038–3045

28. C. Senatore, S.D. Ross [2008] Fuel-efficient navigation in complex flows, *Proc. of 2008 American Control Conference*, 1244-1248.

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26. P. Newton, S.D. Ross [2006] Chaotic advection in the restricted four-vortex problem on a sphere, *Physica D: Nonlinear Phenomena* **223**, 36-53.

25. S.D. Ross [2006] Optimal flapping strokes for self-propulsion in a perfect fluid, *Proc. of 2006 American Control Conference*, 4118–4122.

24. S.D. Ross [2006] The interplanetary transport network, *American Scientist* **94**(3), 230–237. DOI 10.1511/2006.59.230

23. J. Marsden, S.D. Ross [2006] New methods in celestial mechanics and mission design, *Bulletin of the American Mathematical Society* **43**(1), 43–73.

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21. F. Gabern, W. Koon, J. Marsden, S. Ross [2005] Theory and computation of non-RRKM lifetime distributions and rates in chemical systems with three or more degrees of freedom, *Physica D: Nonlinear Phenomena*, **211**, 391–406.

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18. S.D. Ross, W. Koon, M. Lo, J. Marsden [2005] Application of dynamical systems theory to a very low energy transfer, *Spaceflight Mechanics 2004* **119**, 2991-3003.

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16. S.D. Ross [2004] *Cylindrical manifolds and tube dynamics in the restricted three-body problem*, PhD thesis, California Institute of Technology.

15. W. Koon, J. Marsden, S. Ross, M. Lo, D. Scheeres [2004] Geometric mechanics and the dynamics of asteroid pairs, *Annals of the New York Academy of Sciences* **1017**, 11–38. DOI 10.1196/annals.1311.002

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13. G. Gómez, W. Koon, M. Lo, J. Marsden, J. Masdemont, S.D. Ross [2003] Invariant manifolds, the spatial three-body problem and petit grand tour of jovian moons, *International Conference on Libration Point Orbits and Applications* (eds. G. Gómez, M.W. Lo, J.J. Masdemont), 587-601.

12. S.D. Ross [2003] Statistical theory of interior-exterior transition and collision probabilities, *International Conference on Libration Point Orbits and Applications* (eds. G. Gómez, M.W. Lo, J.J. Masdemont), 637-652.

11. R. Serban, W. Koon, M. Lo, J. Marsden, L. Petzold, S. Ross, R. Wilson [2002] Halo orbit mission correction maneuvers using optimal control, *Automatica* **38**, 571–583.

10. C. Jaffé, S. Ross, M. Lo, J. Marsden, D. Farrelly, T. Uzer [2002] Statistical theory of asteroid escape rates, *Physical Review Letters* **89**, 011101. DOI 10.1103/PhysRevLett.89.011101

9. W. Koon, M. Lo, J. Marsden, S. Ross [2002] Constructing a low energy transfer between Jovian moons, *Contemporary Mathematics* **292**, 129–145.

8. G. Gómez, W. Koon, M. Lo, J. Marsden, J. Masdemont, S.D. Ross [2001] Invariant manifolds, the spatial three-body problem and space mission design, *Astrodynamics 2001* **109**, 3-22.

7. W. Koon, M. Lo, J. Marsden, S.D. Ross [2001] Resonance and capture of Jupiter comets, *Celestial Mechanics and Dynamical Astronomy* **81**, 27–38. DOI 10.1023/A:1013398801813

6. W. Koon, M. Lo, J. Marsden, S.D. Ross [2001] Low energy transfer to the Moon, *Celestial Mechanics and Dynamical Astronomy* **81**, 63–73. DOI 10.1023/A:1013359120468

5. M.W. Lo, S.D. Ross [2001] The Lunar L1 Gateway: Portal to the stars and beyond *AIAA Space 2001 Conference*, Albuquerque, New Mexico.

4. W. Koon, M. Lo, J. Marsden, S.D. Ross [2000] Shoot the moon, *AAS/AIAA 10th Space Flight Mechanics Meeting* **105**, 1017-1030, Paper No. AAS 00-166.

3. W. Koon, M. Lo, J. Marsden, S.D. Ross [2000] Heteroclinic connections between periodic orbits and resonance transitions in celestial mechanics, *Chaos* **10**, 427–469. DOI 10.1063/1.166509

2. W. Koon, M. Lo, J. Marsden, S.D. Ross [1999] The Genesis trajectory and heteroclinic connections, *Astrodynamics 1999* **103**, 2327-2343.

1. M. Lo, S.D. Ross [1998] Low Energy Interplanetary Transfers using the Invariant Manifolds of L1, L2 and halo orbits, *AAS/AIAA Space Flight Mechanics Meeting 1998* **99**, 551-561, Paper No. AAS 98-136.

Courses Taught

Student teaching evaluations are above Virginia Tech average

- Dynamics II - Lagrangians and 3-D Rigid Body Motion / ESM 3124 (2010-2015)
- Space Vehicle Dynamics (Attitude Dynamics) / AOE 3144 (2021-2024)
- Solving Big Problems with Big Data / AOE 3984 (2021)
- Nonlinear Dynamics and Chaos / AOE 4514 (ESM 4114) (2021, 2023)
- Interdisciplinary Topics in Engineering and Biology / GRAD 5134 (2014)

- Intermediate Dynamics (Lagrangian and Rigid Body Dynamics) / ESM 5314 (2007-2020)
- Fundamentals of Mechanics (Intro Mechanics for Non-Engineers) / ESM 5984 (2012)
- Advanced Dynamics (Hamiltonian & Nonlinear Dynamics) / AOE/ESM 6314 (2007-2020)
- Frontiers of Dynamical Systems (Group Project Based Course) / ESM 6984 (2013-2014)

Leadership – Highlights From 2016-2019, Ross was the director of Virginia Tech's Engineering Mechanics Graduate Program, with 75 graduate students. Under Ross' leadership, the following accomplishments occurred in 2016-2019.

- *Nearly Triple Applications Growth.* Using new digital marketing strategies, Ross reversed a downward trend in applications to the program. While all other Virginia Tech engineering graduate degree programs saw their application numbers generally decrease over this time, the total number of applications ($\sim$100) for engineering mechanics in 2019 was 3 times what it was in 2016, the highest demand for engineering mechanics graduate program on record, and the number of domestic applicants more than tripled the best previous number.
- *Prospective Student Weekend.* Ross initiated a new Prospective Student Weekend in the Fall, to encourage graduate applications from high-achieving college seniors from across the U.S. In its inaugural year (2017), we had 50 applicants, and were able to bring in 15 students to visit with faculty, hear about research, tour labs, meet our students and get excited about our program and Virginia Tech.
- *Securing Early Multi-Year Offers to Enhance Student Diversity.* With financial assistance of the Virginia Tech College of Engineering and the Grad School, Ross secured several multi-year offers for high quality prospective students who enhance departmental diversity, including an Associate GEM Fellow, an ICTAS Fellow, and Cunningham Doctoral Scholar.
- *Revised Engineering Mechanics PhD Curriculum.* Ross oversaw the governance process for a new and improved Engineering Mechanics PhD curriculum, meant to increase flexibility and diversity in the applicant pool. This governance process included 3 new courses, and some revisions to existing courses, and a new format for the preliminary exam. The revised curriculum was made official in 2017.
- *Initiated Engineering Mechanics Graduate Student Organization.* Previously the engineering mechanics graduate students had no student organization. Ross helped initiate the new graduate student organization, Graduate Engineering Mechanics Society (GEMS). Ross mentored the group's founder and president, Gary Nave. The organization will allow EM students to network and pursue professional development activities, and should help with student retention via an improved sense of solidarity and community.

Outreach and Professional Service – Highlights

- Dr. Ross serves as an Advisory Board Member for the SIAM Activity Group on Dynamical Systems (SIAM = Society for Industrial and Applied Mathematics)
- Dr. Ross founded an interdisciplinary graduate education program on biological transport (called Biotrans) that began in 2010 and has now cross-trained over 25 PhD students at the engineering-biology interface. He helped shepherd the program's transition to sustained internal funding, contributing to an infrastructure of interdisciplinary discovery at the intersection of engineering and biology which will have impacts for years to come.
- Dr. Ross co-founded an NSF-funded education and research program focused on innovative undergraduate engagement (Data Science Corps: Engaging Undergraduates in Data and Decisions Research at the Engineering/Biology Interface). With an academic year and summer

research experience, in partnership with HBCUs such as Morehouse and Morgan State, we host 20 fully-funded undergrad researchers each summer to work on projects on data science applied to biological questions, a sort of undergraduate version of Biotrans.

- Dr. Ross has spoken to thousands of people at dozens of universities worldwide including MIT, Caltech, Stanford, Cornell, Princeton, UCLA, Duke, Univ. of Michigan, Univ. of Maryland, Texas A&M, UNC Chapel Hill, TU Munich, Univ. of Toronto, Univ. of Warwick, ETH Zurich, and Univ. of Barcelona, and at several prestigious international forums, including the British Science Festival and the Zurich Physics Colloquium. His research has been featured in the pages of *Science, Scientific American, New Scientist, Science News, American Scientist, Astronomy, the Times of London*, the BBC, and several other international news outlets, including those in India, Russia, Finland, Poland, Turkey, Brazil, and China.
- Dr. Ross have several 'popular science' level presentations, including to K-12 schoolchildren in southern California, underrepresented Math/Science Upward Bound high school students in the Los Angeles area, and a Distinguished Graduate Lecture on the future of space travel in 2004 in Pasadena, CA (available online as a video presentation), and a college-wide convocation at Centre College. Based on these lectures, wrote a feature article in *American Scientist* (2006), disseminating to a large audience recent work on the 'new' mathematics of space travel, which incorporates ideas of transport from fluid dynamics and chemistry.
- Dr. Ross' work on orbital dynamics initiated the dominance of dynamical systems methods for mission design among the international space flight mechanics community, particularly invariant manifold theory, for which he has received several awards from NASA. To widely disseminate these results, he co-authored an open-access book on the subject, *Dynamical Systems, the Three-Body Problem, and Space Mission Design.*
- Ongoing participation in several outreach activities in connection with dynamical systems theory and applications, including a multimedia web site (`www.whydomath.org`) that introduces mathematics and computational science topics at an upper high school / lower collegiate level. The web site focuses on exciting applications that showcase mathematics and computational science tools used to solve problems across a wide range of scientific and humanist disciplines.
- Research mentor for high school teacher and students. Mentored a high school teacher and high school students in 2017-2018 through a NSF RET (Research Experiences for Teachers) program "Biomechanics from molecular to organismal scales" at Virginia Tech. The project was on using additive manufacturing and off-the-shelf components to develop a bimodal payload dispersal platform inspired by the autorotation observed in maple seeds.
- Reviewer for NSF, NASA, AFOSR, ONR, and ARO (2008-present).
- Associate editor, *Communications in Nonlinear Science and Numerical Simulation* (2014-17)
- Invited technical reviewer for journals *Nature, Nature Physics, Scientific Reports, Physical Review Letters, Physical Review E, Applied Mechanics Reviews, Journal of Fluid Mechanics, Journal of the Royal Society Interface, Chaos, Physica D, Physics Letters A, Nonlinear Dynamics, Journal of Nonlinear Science, International Journal of Non-Linear Mechanics, Discrete and Continuous Dynamical Systems, Dynamical Systems: An International Journal, Applied Mathematical Modeling, Acta Astronautica, New Astronomy, Icarus, Advances in Space Research, Celestial Mechanics and Dynamical Astronomy, Autonomous Robots, Journal of Biomechanics.*
- Invited participant in an NSF-sponsored retreat/workgroup in August 2007 on cognitive and behavioral dynamics, which brought together a handful of dynamical systems experts and experts in the cognitive and behavioral sciences.
- Session co-organizer, "Theoretical, observational, and numerical techniques in geophysical flow analysis", AGU Fall Meeting, San Francisco, 2012

- Session organizer, "Geometric and probabilistic methods in flow dynamics", International Conference on Flow Dynamics (ICFD), Sendai, Japan, 2012
- Organizer of several venues related to biology and mechanics, including the minisymposium, "Mechanics in biology", Pan American Congress on Applied Mechanics, Port of Spain, Trinidad, 2012, and two USNCTAM AmeriMech workshops by the same name at Virginia Tech, in 2013 and in 2014
- Member of the Society for Industrial and Applied Mathematics, American Physical Society, American Astronautical Society, and American Institute of Aeronautics and Astronautics.

Graduate Students and Postdocs Advised

Graduated 15 Ph.D. students and 5 M.S. students. Currently advising 5 Ph.D. students and 4 M.S. students. 3 Post-docs advised. (Total individuals advised: 31, all at Virginia Tech).

31. Dr. Pranav Khandelwal, Post-Doc 2024-2026, Experiments and mechanics of gliding animals
30. Anjali Rawat, Ph.D., Aerospace Engineering, expected 2028
29. Mark Munson, M.S., Aerospace Engineering, expected 2023, currently at MIT Aero/Astro, Small Satellite Center Program Manager
28. Joe McCabe, M.S., Aerospace Engineering, expected 2024
27. Abdullah Braik, M.S., Aerospace Engineering, expected 2023
26. Mohamed Zakaria, Ph.D. (co-advised with Craig Woolsey), Aerospace Engineering, exp. 2026
25. Landon Bilyeu, Ph.D. (co-advised with David Schmale), School of Plant and Environmental Sciences, expected 2024
24. Nadhir Cherfaoui, M.S., Engineering Mechanics, expected 2023
23. Manu Nimmala, Ph.D. (co-advised w. Hosein Foroutan), Engineering Mechanics, exp. 2024
22. Albert Jarvis, Ph.D., Engineering Mechanics, expected 2024
21. Joshua Fitzgerald, Ph.D. 2023, Engineering Mechanics, currently at Aerospace Corporation
20. Matt Werner, M.S. 2022, Aerospace Engineering, currently at Aerospace Corporation
19. Kristen Tetreault, M.S. 2021, (co-advised with Jonathan Black), Engineering Mechanics
18. Dr. Javier González-Rocha, Post-Doc 2022, Aerospace Engineering, currently Asst. Professor at University of California, Santa Cruz
17. Jun Zhong, Ph.D. 2020, Engineering Mechanics, currently postdoc at Brown University
16. Peter Nolan, Ph.D. 2019, Engineering Mechanics, now Data Scientist, Lowe's Companies, Inc.
15. Nathaniel Hall, M.S. 2019, Engineering Mechanics, now Manufacturing Engineer, Kollmorgen
14. Gary Nave, Ph.D. 2018 (co-advised with Mark Stremler), Engineering Mechanics, currently professor at Colorado School of Mines
13. Isaac Yeaton, Ph.D. 2018 (co-advised with John Socha), Mechanical Engineering, currently a Research Engineer at the Johns Hopkins University Applied Physics Lab (JHU-APL)
12. Dr. Shibabrat Naik, Ph.D. 2016, Engineering Mechanics, Post-Doc 2018, currently professor at Hampton University
11. Renee Pietsch, Ph.D. 2016 (co-advised with David Schmale), Biology, currently at the Food and Drug Administration (FDA)
10. Amir E. BozorgMagham, Ph.D. 2014, Engineering Mechanics, currently Senior Decision Scientist, Analytics Strategy at Starbucks, Inc.

9. Binbin Lin, Ph.D. 2013 (co-advised with David Schmale), Plant Pathology, Physiology and Weed Science, deceased
8. Samuel Raben, Ph.D. 2013 (co-advised with Pavlos Vlachos), Mechanical Engineering, currently Mechanical Engineer at the Food and Drug Administration (FDA)
7. Aaron J. Prussin, Ph.D. 2013 (co-advised with David Schmale), Plant Pathology, Physiology and Weed Science, currently Research Scientist at Virginia Tech
6. Tobias Dirksen, M.S. 2012, (co-advised with Mark Stremler, Hassan Aref, Tomas Bohr), Physics, Technical University of Denmark, currently Data Scientist at Frederiksberg Utility, Denmark.
5. Phanindra Tallapragada, Ph.D. 2010, Engineering Mechanics, currently Associate Professor at Clemson University
4. Piyush Grover, Ph.D. 2010, Engineering Mechanics, currently Assistant Professor at University of Nebraska-Lincoln; previously Senior Principal Research Scientist at Mitsubishi Electric Research Labs
3. Carmine Senatore, Ph.D. 2010, Engineering Mechanics, currently a Senior Associate at Exponent; previously Senior Research Scientist at the MIT Robotic Mobility Lab
2. Jeffrey Twigg, M.S. 2009, Engineering Mechanics, now Researcher at Army Research Lab
1. Martin Tanaka, Ph.D. 2008, Biomedical Engineering, currently Associate Professor at Western Carolina University

Competitive Grants – Highlights
PI/co-PI on externally sponsored research projects totaling $15 million

16. S.D. Ross (PI), A. Anderson, A. Rosengren, M. Gamba, R. Zanetti, "XGEO Robust and Adaptive Space Domain Awareness (xRADAR)", United States Space Force (USSF) and Air Force Research Lab (AFRL), 8/10/2023–8/09/2025, $1,400,000
15. S.D. Ross (PI), J.J. Socha, H. Dong, P.P. Vlachos, "Collaborative Research: Flying snakes: fluid mechanics of deforming articulated bodies", NSF Fluid Dynamics & Physiological Mechanisms and Biomechanics, 8/01/2020–7/31/2023, $639,919
14. H. Foroutan, S.D. Ross, D.G. Schmale, C. Gonzalez-Martin, D. Griffin (Co-PIs), "Multiscale Investigation of Microbial Biodiversity in Trans-Atlantic Dust (MITAS) Plumes", NASA Interdisciplinary Research in Earth Science, 9/01/2020–8/31/2023, $1,091,681
13. D.G. Schmale, S.D. Ross (Co-PIs), "HDR DSC: Engaging Undergraduates in Data and Decisions Research at the Engineering/Biology Interface", NSF Harnessing the Data Revolution, Data Science Corps, 10/01/2019–9/30/2022, $1,186,084
12. D.G. Schmale, S.D. Ross, H. Foroutan, N. Stewart (Co-PI), "Tracking the Long-Distance Transport of Wind-Dispersed Pollen from GE Switchgrass and Hemp using UASs (drones) and a LES Model", USDA NIFA BRAG, 9/01/2019–8/31/2022, $499,864
11. T. Iliescu, S.D. Ross (Co-PIs), "Data-Driven Computation of Lagrangian Transport Structure in Realistic Flows", NSF-Computational and Data-Enabled Science and Engineering in Mathematical and Statistical Sciences, 6/15/2018–5/31/2021, $200,000
10. S.D. Ross (PI), "Collaborative Research: A new framework for prediction of buckling and other critical transitions in nonlinear structural mechanics", NSF-Dynamics, Control and System Diagnostics, 9/1/2015–8/31/2019, Collaborative proposal with L. Virgin at Duke Univerisity, $561,994

9. T. Peacock, P.F. Lermusiaux, S.D. Ross, I. Rypina, S.C. Shadden (Co-PIs), "Hazards SEES: Uncovering the hidden skeleton of environmental flows: Advanced Lagrangian methods for hazards prediction, mitigation and response", NSF-AGS-SEES Hazards, 9/1/2015–8/31/2020, $2,811,000

8. S.D. Ross (PI), "Time-optimal control using front propagation methods", Virginia Space Grant Consortium, 8/10/2013-8/09/2014, $4,000

7. S.D. Ross (PI), "CAREER: Integrating geometric, probabilistic, and topological methods for phase space transport in dynamical systems", NSF-Dynamical Systems, 6/1/2012–5/31/2019, $432,953

6. S.D. Ross (PI), D.G. Schmale,"Dynamical Mechanisms Influencing the Population Structure of Airborne Pathogens: Theory and Observations", NSF-Dynamical Systems, 9/1/2011–8/31/2014, $429,931

5. S.D. Ross (PI), "Capture of an asteroid by way of a binary system", Virginia Space Grant Consortium, 5/16/2011-8/31/2012, $8,000

4. M. Stremler, R. Davalos, D. Cimini, S.D. Ross, D.G. Schmale, "IGERT: Multi-Scale Transport in Environmental and Physiological Systems (MultiSTEPS)", NSF, 7/1/2010 - 6/30/2017, $3,000,000

3. J. Socha, J. Harrison, M. Stremler, R. Davalos, S.D. Ross, P. Vlachos, I. Puri, R. De Vita, A. Staples, M. Agah, "EFRI-BSBA: Complex microsystem networks inspired by internal insect physiology", NSF, 1/1/2010 - 12/31/2014, $2,219,595

2. S.D. Ross, D.G. Schmale, PIs, "Atmospheric Transport Barriers and the Biological Invasion of Toxigenic Fungi in the Genus Fusarium", NSF-Environmental Biology, 8/15/2009 - 7/31/2012, $413,476

1. S.D. Ross (PI), "Motor control effects of exercise on recurrent back pain," Ohio State University Research Foundation (subaward from NIH R01), 6/01/2006-4/30/2008, $86,637