



Nicholas Ouellette

Associate Professor of Civil and Environmental Engineering

 Curriculum Vitae available Online

CONTACT INFORMATION

- **Administrator**

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Bio

BIO

Nick Ouellette is broadly interested the behavior of complex systems far from equilibrium. In particular, a running theme in his research is dynamical self-organization. He seeks both to understand the physical principles that govern the spontaneous emergence of low-dimensional structure in high-dimensional systems and to harness this self-organization for engineering applications. His current research includes studies of turbulent flows in two and three dimensions, in both simple and complex fluids; the transport of inertial, anisotropic, and active particles in turbulence; the erosion of granular beds by fluid flows and subsequent sediment transport; and quantitative measurements of collective behavior in insect swarms and other animal groups.

Before coming to Stanford in 2015, Ouellette spent seven years on the faculty in Mechanical Engineering and Materials Science at Yale University, where he won the Yale Provost's Teaching Prize in 2014. Before beginning his faculty career, he held postdoctoral positions at the Max Planck Institute for Dynamics and Self-Organization and in the Physics Department at Haverford College.

ACADEMIC APPOINTMENTS

- Associate Professor, Civil and Environmental Engineering
- Member, Bio-X
- Member, Wu Tsai Neurosciences Institute

PROFESSIONAL EDUCATION

- Ph.D., Cornell University , Physics (2006)
- M.S., Cornell University , Physics (2005)
- B.A., Swarthmore College , Physics and Computer Science (2002)

LINKS

- Environmental Complexity Lab: <http://web.stanford.edu/~nto>

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The Environmental Complexity Lab studies self-organization in a variety of complex systems, ranging from turbulent fluid flows to granular materials to collective motion in animal groups. In all cases, we aim to characterize the macroscopic behavior, understand its origin in the microscopic dynamics, and ultimately harness it for engineering applications. Most of our projects are experimental, though we also use numerical simulation and mathematical modeling when appropriate. We specialize in high-speed, detailed imaging and statistical analysis.

Our current research includes studies of turbulence in two and three dimensions, with a focus on coherent structures and the geometry of turbulence; the transport of inertial, anisotropic, and active particles in turbulence; the erosion of granular beds by fluid flows and subsequent sediment transport; quantitative measurements of collective behavior in insect swarms and bird flocks; the stability of ocean ecosystems; neural signal processing; and uncovering the natural, self-organized spatiotemporal scales in urban systems.

Teaching

COURSES

2018-19

- Chaos and Turbulence: CEE 363B (Win)
- Hydrodynamics: CEE 262A (Aut)
- Measuring and Predicting Spatial Patterns: BIOS 276 (Win)
- Physics of Cities: CEE 6 (Spr)

2017-18

- Chaos and Turbulence: CEE 363B (Win)
- Discussion: Science and the Law: LAW 682D (Spr)
- Hydrodynamics: CEE 262A (Aut)
- Physics of Cities: CEE 6 (Spr)

2016-17

- Chaos and Turbulence: CEE 363B (Win)
- Mechanics of Fluids: CEE 101B (Aut)
- Mechanics of Fluids: CEE 162A (Aut)
- Physics of Cities: CEE 6 (Spr)
- Seminar in Fluid Mechanics: ENGR 298 (Win)

2015-16

- Chaos and Turbulence: CEE 363B (Spr)
- Mechanics of Fluids (No Lab): CEE 101X (Aut)
- Mechanics of Fluids (with lab): CEE 101N (Aut)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Valerie Troutman

Postdoctoral Faculty Sponsor

Hangjian Ling, Kasper van der Vaart

Publications

PUBLICATIONS

- **Costs and benefits of social relationships in the collective motion of bird flocks.** *Nature ecology & evolution*
Ling, H., McIvor, G. E., van der Vaart, K., Vaughan, R. T., Thornton, A., Ouellette, N. T.
2019
- **Three-dimensional time-resolved trajectories from laboratory insect swarms** *SCIENTIFIC DATA*
Sinhuber, M., van der Vaart, K., Ni, R., Puckett, J. G., Kelley, D. H., Ouellette, N. T.
2019; 6
- **Orientation dynamics of nonspherical particles under surface gravity waves** *PHYSICAL REVIEW FLUIDS*
DiBenedetto, M. H., Koseff, J. R., Ouellette, N. T.
2019; 4 (3)
- **Flowing crowds** *SCIENCE*
Ouellette, N. T.
2019; 363 (6422): 27–28
- **Flowing crowds.** *Science (New York, N.Y.)*
Ouellette, N. T.
2019; 363 (6422): 27–28
- **Local linearity, coherent structures, and scale-to-scale coupling in turbulent flow** *PHYSICAL REVIEW FLUIDS*
Fang, L., Balasuriya, S., Ouellette, N. T.
2019; 4 (1)
- **Response of insect swarms to dynamic illumination perturbations.** *Journal of the Royal Society, Interface*
Sinhuber, M., van der Vaart, K., Ouellette, N. T.
2019; 16 (150): 20180739
- **Response of insect swarms to dynamic illumination perturbations** *JOURNAL OF THE ROYAL SOCIETY INTERFACE*
Sinhuber, M., van der Vaart, K., Ouellette, N. T.
2019; 16 (150)
- **Simultaneous measurements of three-dimensional trajectories and wingbeat frequencies of birds in the field.** *Journal of the Royal Society, Interface*
Ling, H., McIvor, G. E., Nagy, G., MohaimenianPour, S., Vaughan, R. T., Thornton, A., Ouellette, N. T.
2018; 15 (147)
- **Preferential orientation of spheroidal particles in wavy flow** *JOURNAL OF FLUID MECHANICS*
DiBenedetto, M. H., Ouellette, N. T.
2018; 856: 850–69
- **Simultaneous measurements of three-dimensional trajectories and wingbeat frequencies of birds in the field** *JOURNAL OF THE ROYAL SOCIETY INTERFACE*
Ling, H., McIvor, G. E., Nagy, G., MohaimenianPour, S., Vaughan, R. T., Thornton, A., Ouellette, N. T.
2018; 15 (147)
- **Probing the strain-rotation balance in non-Newtonian turbulence with inertial particles** *PHYSICAL REVIEW FLUIDS*
Sinhuber, M., Ballouz, J. G., Ouellette, N. T.
2018; 3 (8)
- **Critical scaling near the yielding transition in granular media** *PHYSICAL REVIEW E*
Clark, A. H., Thompson, J. D., Shattuck, M. D., Ouellette, N. T., O'Hern, C. S.
2018; 97 (6)

- **Generalized Lagrangian coherent structures** *PHYSICA D-NONLINEAR PHENOMENA*
Balasuriya, S., Ouellette, N. T., Rypina, I. I.
2018; 372: 31–51
- **Remifentanyl and Nitrous Oxide Anesthesia Produces a Unique Pattern of EEG Activity During Loss and Recovery of Response** *FRONTIERS IN HUMAN NEUROSCIENCE*
Eagleman, S. L., Drover, C. M., Drover, D. R., Ouellette, N. T., MacIver, M.
2018; 12: 173
- **Shoaling internal waves may reduce gravity current transport** *ENVIRONMENTAL FLUID MECHANICS*
Hogg, C. R., Egan, G. C., Ouellette, N. T., Koseff, J. R.
2018; 18 (2): 383–94
- **Transport of anisotropic particles under waves** *JOURNAL OF FLUID MECHANICS*
DiBenedetto, M. H., Ouellette, N. T., Koseff, J. R.
2018; 837: 320–40
- **Influence of lateral boundaries on transport in quasi-two-dimensional flow** *CHAOS*
Fang, L., Ouellette, N. T.
2018; 28 (2): 023113
- **Tensor geometry in the turbulent cascade** *JOURNAL OF FLUID MECHANICS*
Ballouz, J. G., Ouellette, N. T.
2018; 835: 1048–64
- **Critical scaling near the yielding transition in granular media.** *Physical review. E*
Clark, A. H., Thompson, J. D., Shattuck, M. D., Ouellette, N. T., O'Hern, C. S.
2018; 97 (6-1): 062901
- **Do complexity measures of frontal EEG distinguish loss of consciousness in geriatric patients under anesthesia?** *Frontiers in Neuroscience*
Eagleman*, S. L., Vaughn*, D. A., Drover, D. R., Drover, C. M., Cohen, M. S., Ouellette, N. T., MacIver, B.
2018
- **Do Complexity Measures of Frontal EEG Distinguish Loss of Consciousness in Geriatric Patients Under Anesthesia?** *Frontiers in neuroscience*
Eagleman, S. L., Vaughn, D. A., Drover, D. R., Drover, C. M., Cohen, M. S., Ouellette, N. T., MacIver, M. B.
2018; 12: 645
- **Determining the onset of hydrodynamic erosion in turbulent flow** *PHYSICAL REVIEW FLUIDS*
Salevan, J. C., Clark, A. H., Shattuck, M. D., O'Hern, C. S., Ouellette, N. T.
2017; 2 (11)
- **Characterizing free-surface expressions of flow instabilities by tracking submerged features** *EXPERIMENTS IN FLUIDS*
Mandel, T. L., Rosenzweig, I., Chung, H., Ouellette, N. T., Koseff, J. R.
2017; 58 (11)
- **Multiple stages of decay in two-dimensional turbulence** *PHYSICS OF FLUIDS*
Fang, L., Ouellette, N. T.
2017; 29 (11)
- **Phase Coexistence in Insect Swarms** *PHYSICAL REVIEW LETTERS*
Sinhuber, M., Ouellette, N. T.
2017; 119 (17): 178003
- **Are midge swarms bound together by an effective velocity-dependent gravity?** *EUROPEAN PHYSICAL JOURNAL E*
Reynolds, A. M., Sinhuber, M., Ouellette, N. T.
2017; 40 (4)
- **Role of grain dynamics in determining the onset of sediment transport** *PHYSICAL REVIEW FLUIDS*
Clark, A. H., Shattuck, M. D., Ouellette, N. T., O'Hern, C. S.
2017; 2 (3)

- **Hyperbolic neighbourhoods as organizers of finite-time exponential stretching** *JOURNAL OF FLUID MECHANICS*
Balasuriya, S., Kalampattel, R., Ouellette, N. T.
2016; 807: 509-545
- **Advection and the Efficiency of Spectral Energy Transfer in Two-Dimensional Turbulence.** *Physical review letters*
Fang, L., Ouellette, N. T.
2016; 117 (10): 104501-?
- **Long-range acoustic interactions in insect swarms: an adaptive gravity model** *NEW JOURNAL OF PHYSICS*
Gorbonos, D., Ianculescu, R., Puckett, J. G., Ni, R., Ouellette, N. T., Gov, N. S.
2016; 18
- **Concentration effects on turbulence in dilute polymer solutions far from walls.** *Physical review. E*
de Chaumont Quitry, A., Ouellette, N. T.
2016; 93 (6): 063116-?
- **Stretching and folding in finite time.** *Chaos*
Ma, T., Ouellette, N. T., Bollt, E. M.
2016; 26 (2): 023112-?
- **Correlating Lagrangian structures with forcing in two-dimensional flow** *PHYSICS OF FLUIDS*
Ouellette, N. T., Hogg, C. A., Liao, Y.
2016; 28 (1)
- **Swarm dynamics may give rise to Lévy flights.** *Scientific reports*
Reynolds, A. M., Ouellette, N. T.
2016; 6: 30515-?
- **On the tensile strength of insect swarms.** *Physical biology*
Ni, R., Ouellette, N. T.
2016; 13 (4): 045002-?
- **Mixing and sink effects of air purifiers on indoor PM2.5 concentrations: A pilot study of eight residential homes in Fresno, California** *AEROSOL SCIENCE AND TECHNOLOGY*
Cheng, K., Park, H., Tetteh, A. O., Zheng, D., Ouellette, N. T., Nadeau, K. C., Hildemann, L. M.
2016; 50 (8): 835-845
- **Velocity correlations in laboratory insect swarms** *EUROPEAN PHYSICAL JOURNAL-SPECIAL TOPICS*
Ni, R., Ouellette, N. T.
2015; 224 (17-18): 3271-3277
- **Optimal directional volatile transport in retronasal olfaction** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
Ni, R., Michalski, M. H., Brown, E., Ngoc Doan, N., Zinter, J., Ouellette, N. T., Shepherd, G. M.
2015; 112 (47): 14700-14704
- **Onset and cessation of motion in hydrodynamically sheared granular beds** *PHYSICAL REVIEW E*
Clark, A. H., Shattuck, M. D., Ouellette, N. T., O'Hern, C. S.
2015; 92 (4)
- **Correlations between the instantaneous velocity gradient and the evolution of scale-to-scale fluxes in two-dimensional flow** *PHYSICAL REVIEW E*
Liao, Y., Ouellette, N. T.
2015; 92 (3)
- **Intrinsic Fluctuations and Driven Response of Insect Swarms** *PHYSICAL REVIEW LETTERS*
Ni, R., Puckett, J. G., Dufresne, E. R., Ouellette, N. T.
2015; 115 (11)
- **Time-Frequency Analysis Reveals Pairwise Interactions in Insect Swarms** *PHYSICAL REVIEW LETTERS*
Puckett, J. G., Ni, R., Ouellette, N. T.

2015; 114 (25)

- **Long-range ordering of turbulent stresses in two-dimensional flow** *PHYSICAL REVIEW E*
Liao, Y., Ouellette, N. T.
2015; 91 (6)
- **Empirical questions for collective-behaviour modelling** *PRAMANA-JOURNAL OF PHYSICS*
Ouellette, N. T.
2015; 84 (3): 353-363
- **Measurements of the coupling between the tumbling of rods and the velocity gradient tensor in turbulence** *JOURNAL OF FLUID MECHANICS*
Ni, R., Kramel, S., Ouellette, N. T., Voth, G. A.
2015; 766
- **Onset and cessation of motion in hydrodynamically sheared granular beds.** *Physical review. E, Statistical, nonlinear, and soft matter physics*
Clark, A. H., Shattuck, M. D., Ouellette, N. T., O'Hern, C. S.
2015; 92 (4): 042202
- **Long-range ordering of turbulent stresses in two-dimensional flow.** *Physical review. E, Statistical, nonlinear, and soft matter physics*
Liao, Y., Ouellette, N. T.
2015; 91 (6): 063004
- **Correlations between the instantaneous velocity gradient and the evolution of scale-to-scale fluxes in two-dimensional flow.** *Physical review. E, Statistical, nonlinear, and soft matter physics*
Liao, Y., Ouellette, N. T.
2015; 92 (3): 033017
- **Determining asymptotically large population sizes in insect swarms** *JOURNAL OF THE ROYAL SOCIETY INTERFACE*
Puckett, J. G., Ouellette, N. T.
2014; 11 (99)
- **Extracting turbulent spectral transfer from under-resolved velocity fields** *PHYSICS OF FLUIDS*
Ni, R., Voth, G. A., Ouellette, N. T.
2014; 26 (10)
- **Searching for effective forces in laboratory insect swarms** *SCIENTIFIC REPORTS*
Puckett, J. G., Kelley, D. H., Ouellette, N. T.
2014; 4
- **Impact fragmentation of model flocks** *PHYSICAL REVIEW E*
Miller, P. W., Ouellette, N. T.
2014; 89 (4)
- **Geometry of scale-to-scale energy and enstrophy transport in two-dimensional flow** *PHYSICS OF FLUIDS*
Liao, Y., Ouellette, N. T.
2014; 26 (4)
- **Direct observation of Kelvin waves excited by quantized vortex reconnection** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
Fonda, E., Meichle, D. P., Ouellette, N. T., Hormoz, S., Lathrop, D. P.
2014; 111: 4707-4710
- **Alignment of vorticity and rods with Lagrangian fluid stretching in turbulence** *JOURNAL OF FLUID MECHANICS*
Ni, R., Ouellette, N. T., Voth, G. A.
2014; 743
- **Stability of model flocks in turbulent-like flow** *NEW JOURNAL OF PHYSICS*
Khurana, N., Ouellette, N. T.
2013; 15
- **Lagrangian coherent structures separate dynamically distinct regions in fluid flows** *PHYSICAL REVIEW E*

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- Kelley, D. H., Allshouse, M. R., Ouellette, N. T.
2013; 88 (1)
- **Spatial structure of spectral transport in two-dimensional flow** *JOURNAL OF FLUID MECHANICS*
Liao, Y., Ouellette, N. T.
2013; 725: 281-298
 - **Generation of Lagrangian intermittency in turbulence by a self-similar mechanism** *NEW JOURNAL OF PHYSICS*
Wilczek, M., Xu, H., Ouellette, N. T., Friedrich, R., Bodenschatz, E.
2013; 15
 - **Quantifying stretching and rearrangement in epithelial sheet migration** *NEW JOURNAL OF PHYSICS*
Lee, R. M., Kelley, D. H., Nordstrom, K. N., Ouellette, N. T., Losert, W.
2013; 15
 - **Emergent dynamics of laboratory insect swarms** *SCIENTIFIC REPORTS*
Kelley, D. H., Ouellette, N. T.
2013; 3
 - **On the dynamical role of coherent structures in turbulence** *COMPTES RENDUS PHYSIQUE*
Ouellette, N. T.
2012; 13 (9-10): 866-877
 - **Effects of forcing geometry on two-dimensional weak turbulence** *PHYSICAL REVIEW E*
Liao, Y., Kelley, D. H., Ouellette, N. T.
2012; 86 (3)
 - **Interactions between active particles and dynamical structures in chaotic flow** *PHYSICS OF FLUIDS*
Khurana, N., Ouellette, N. T.
2012; 24 (9)
 - **Turbulence in two dimensions** *PHYSICS TODAY*
Ouellette, N. T.
2012; 65 (5): 68-69
 - **Spatiotemporal persistence of spectral fluxes in two-dimensional weak turbulence** *PHYSICS OF FLUIDS*
Kelley, D. H., Ouellette, N. T.
2011; 23 (11)
 - **Path Lengths in Turbulence** *JOURNAL OF STATISTICAL PHYSICS*
Ouellette, N. T., Bodenschatz, E., Xu, H.
2011; 145 (1): 93-101
 - **Neutrally buoyant particle dynamics in fluid flows: Comparison of experiments with Lagrangian stochastic models** *PHYSICS OF FLUIDS*
Sapsis, T. P., Ouellette, N. T., Gollub, J. P., Haller, G.
2011; 23 (9)
 - **Mechanisms driving shape distortion in two-dimensional flow** *EPL*
Quiry, A. d., Kelley, D. H., Ouellette, N. T.
2011; 94 (6)
 - **Separating stretching from folding in fluid mixing** *NATURE PHYSICS*
Kelley, D. H., Ouellette, N. T.
2011; 7 (6): 477-480
 - **Reduced Transport of Swimming Particles in Chaotic Flow due to Hydrodynamic Trapping** *PHYSICAL REVIEW LETTERS*
Khurana, N., Blawdziewicz, J., Ouellette, N. T.
2011; 106 (19)
 - **Rotation and alignment of rods in two-dimensional chaotic flow** *PHYSICS OF FLUIDS*
Parsa, S., Guasto, J. S., Kishore, M., Ouellette, N. T., Gollub, J. P., Voth, G. A.

2011; 23 (4)

- **Onset of three-dimensionality in electromagnetically driven thin-layer flows** *PHYSICS OF FLUIDS*
Kelley, D. H., Ouellette, N. T.
2011; 23 (4)
- **Using particle tracking to measure flow instabilities in an undergraduate laboratory experiment** *AMERICAN JOURNAL OF PHYSICS*
Kelley, D. H., Ouellette, N. T.
2011; 79 (3): 267-273
- **Scale-local velocity fields from particle-tracking data** *CHAOS*
Kelley, D. H., Ouellette, N. T.
2010; 20 (4)
- **Scale-Dependent Statistical Geometry in Two-Dimensional Flow** *PHYSICAL REVIEW LETTERS*
Merrifield, S. T., Kelley, D. H., Ouellette, N. T.
2010; 104 (25)
- **Bulk turbulence in dilute polymer solutions** *JOURNAL OF FLUID MECHANICS*
Ouellette, N. T., Xu, H., Bodenschatz, E.
2009; 629: 375-385
- **Detecting topological features of chaotic fluid flow** *CHAOS*
Ouellette, N. T., Gollub, J. P.
2008; 18 (4)
- **Transport of Finite-Sized Particles in Chaotic Flow** *PHYSICAL REVIEW LETTERS*
Ouellette, N. T., O'Malley, P. J., Gollub, J. P.
2008; 101 (17)
- **Universal intermittent properties of particle trajectories in highly turbulent flows** *PHYSICAL REVIEW LETTERS*
Arneodo, A., Benzi, R., Berg, J., Biferale, L., Bodenschatz, E., Busse, A., Calzavarini, E., Castaing, B., Cencini, M., Chevillard, L., Fisher, R. T., Grauer, R., Homann, et al
2008; 100 (25)
- **Lagrangian structure functions in turbulence: A quantitative comparison between experiment and direct numerical simulation** *PHYSICS OF FLUIDS*
Biferale, L., Bodenschatz, E., Cencini, M., Lanotte, A. S., Ouellette, N. T., Toschi, F., Xu, H.
2008; 20 (6)
- **Dynamic topology in spatiotemporal chaos** *PHYSICS OF FLUIDS*
Ouellette, N. T., Gollub, J. P.
2008; 20 (6)
- **Evolution of geometric structures in intense turbulence** *NEW JOURNAL OF PHYSICS*
Xu, H., Ouellette, N. T., Bodenschatz, E.
2008; 10
- **Acceleration correlations and pressure structure functions in high-reynolds number turbulence** *PHYSICAL REVIEW LETTERS*
Xu, H., Ouellette, N. T., Vincenzi, D., Bodenschatz, E.
2007; 99 (20)
- **Curvature fields, topology, and the dynamics of spatiotemporal chaos** *PHYSICAL REVIEW LETTERS*
Ouellette, N. T., Gollub, J. P.
2007; 99 (19)
- **Curvature of Lagrangian trajectories in turbulence** *PHYSICAL REVIEW LETTERS*
Xu, H., Ouellette, N. T., Bodenschatz, E.
2007; 98 (5)
- **Multi-particle statistics - lines, shapes, and volumes in high Reynolds number turbulence** *PROCEEDINGS OF THE 5TH INTERNATIONAL CONFERENCE ON NONLINEAR MECHANICS*

Xu, H., Ouellette, N. T., Bodenschatz, E.
2007: 1155-1161

- **Experimental measurements of Lagrangian statistics in intense turbulence** *11th EUROMECH European Turbulence Conference*
Xu, H., Ouellette, N. T., Nobach, H., Bodenschatz, E.
SPRINGER-VERLAG BERLIN, 2007: 1–10
- **Lagrangian particle tracking in high Reynolds number turbulence** *PARTICLE-LADEN FLOW: FROM GEOPHYSICAL TO KOLMOGOROV SCALES*
Chang, K., Ouellette, N. T., Xu, H., Bodenschatz, E.
2007; 11: 299-311
- **An experimental study of turbulent relative dispersion models** *NEW JOURNAL OF PHYSICS*
Ouellette, N. T., Xu, H., Bourgoin, M., Bodenschatz, E.
2006; 8
- **Small-scale anisotropy in Lagrangian turbulence** *NEW JOURNAL OF PHYSICS*
Ouellette, N. T., Xu, H., Bourgoin, M., Bodenschatz, E.
2006; 8
- **Multifractal dimension of Lagrangian turbulence** *PHYSICAL REVIEW LETTERS*
Xu, H. T., Ouellette, N. T., Bodenschatz, E.
2006; 96 (11)
- **The role of pair dispersion in turbulent flow** *SCIENCE*
Bourgoin, M., Ouellette, N. T., Xu, H. T., Berg, J., Bodenschatz, E.
2006; 311 (5762): 835-838
- **A quantitative study of three-dimensional Lagrangian particle tracking algorithms** *EXPERIMENTS IN FLUIDS*
Ouellette, N. T., Xu, H. T., Bodenschatz, E.
2006; 40 (2): 301-313
- **High order Lagrangian velocity statistics in turbulence** *PHYSICAL REVIEW LETTERS*
Xu, H., Bourgoin, M., Ouellette, N. T., Bodenschatz, E.
2006; 96 (2)