RÉSUMÉ

MICHEL LOUGE

1. Summary

I currently operate a single-owner consulting company, **Michel Louge LLC**, which advises industrial clients worldwide on instrumentation for measuring instantaneously the local bulk density in flows of gas-solid suspensions, powders and grains, as well as their moisture and/or solvent content. The company also provides consultation on powder drying, fluidization, and other technical subjects mentioned in this résumé.

2. Cornell service

At Cornell, my collaborators and I conducted sponsored research on gas-solid flows and heat transfer, granular mechanics, particle impact, alpine and desert geophysics, porous media, capillarity, and chemical kinetics (section 8). These activities involved the development of theory, the conduct of numerical simulations and experiments in the lab and in microgravity, the creation of new instrumentation, the construction of laboratory facilities, and the organization of field expeditions.

I received uninterrupted major funding since 1987 from agencies including the NSF, the DoE, NASA, USARO, and the Qatar National Research Foundation. Research interests and results are found at this site. Publications and citation metrics are linked to my ORCID number 0000-0002-1155-9163, Google Scholar profile, or ResearcherID A-4380-2018.

At Cornell, I taught and developed graduate and undergraduate service courses in Heat Transfer, Mechanical Synthesis, Combustion, Fluid Mechanics, Engines, and Senior Laboratory (details in section 7).

I served as chair of every standing committee of the Sibley School, and as chair or member of several college and university committees (section 5). In M&AE, I held administrative posts as Associate Director of Undergraduate Programs, Director of Graduate Research, and Director of Master of Engineering programs. As such, for example, I orchestrated the first accreditation of the School under ABET 2000. My family and I served as Faculty-in-Residence on North Campus. I received the Carpenter Advising award in 2011.

As for outreach, I held administrative and academic posts at other institutions during sabbaticals (section 5), volunteered as Associate Editor for two journals, transferred instrumentation technology to prominent industrial companies, and was elected Powder

Date: May 25, 2025.

Flow consultant for the International Fine Particle Research Institute, a non-profit grant-awarding consortium of firms involved in powder R&D (section 6).

3. Education

- Diplôme d'Ingénieur, École Centrale des Arts et Manufactures, Paris, France (1978).
- M.S., Mechanical Engineering, Stanford University, Stanford, CA (1979).
- Ph.D., Mechanical Engineering, Stanford University, Stanford, CA (1985).
  Thesis 'Shock-tube study of cyanide species kinetics and spectroscopy'.
  Advisor: Ronald K. Hanson.

4. Appointments

- Professor, Mechanical and Aerospace Engineering (M&AE), Cornell University, 1998-present. Members of the fields of Mechanical Engineering, Aerospace Engineering, and Electrical Engineering.
- Assistant Professor, M&AE, 1985-1991. Associate Professor, M&AE, 1991-1998.
- Visiting Scientist, Merck, Sharp & Dohme, West Point, PA, Process Analytical Technologies, May 2018-present
- Visiting Scientist, IUEM, IFREMER, and the Universite de Brest under the ISBlue program, June 2019 campagne Bankable on underwater sand dunes of the Iroise Sea aboard the ship Cotes-de-la-Manche.
- Distinguished Professor, College of Engineering and Computer Science, VinUniversity, Hanoi, Vietnam, January-March 2020.
- Visiting Professor, Tsinghua University, Center for Combustion Energy, Beijing, China, Fall 2017 and 2018. Teaching and research.
- Distinguished Visiting Fellow of the Royal Academy of Engineering, Department of Civil Engineering, University of Nottingham, UK, 2014. Research.
- Professor, 'Classe Exceptionnelle', CentraleSupélec, Paris, France, 2012-2013. Academic consulting, teaching and research.
- Professor, 'Première Classe', Université de Rennes 1, Rennes, France, 2005-2006. Research and teaching.
- Visiting Professor, Institut de Physique de Rennes, Rennes, France, 1998-2011. Research.
- Visiting Professor, Université de Provence, Marseilles, France, 1991-1992. Industrial R&D.

5. Administrative, editorial and outreach activities

- Academic consultant to the Executive Committee of the École Centrale des Arts et Manufactures, Paris, 2012-2013. Advised the Director on university governance upon relocation to its new Saclay campus and its merger with the École Supérieure d'Électricité to create the new institution CentraleSupélec.

- Advisory panel chair for its 'Laboratoire de Génie des Procédés et Matériaux', 2008. Convener of a focus group for stakeholders. Recommendation on laboratory restructuration and hiring.
- Faculty in Residence, Cornell University, 2007-2011. Residential programs and advising.
- Associate Director for Undergraduate Affairs, Mechanical Engineering, Cornell University, 2003-2005 and 2009. Curricular deployment of M&AE faculty. Orchestrated the first ABET 2000 accreditation of M&AE at Cornell.
- Director, Master of Engineering Program, Mechanical Engineering, Cornell, 1999-2003. Negotiated tuition returns that achieved sustainable funding for the Sibley School.
- Associate Director of Graduate Programs, Mechanical Engineering, Cornell, 1993-1996. Computerized student records, modernized recruitment, and established the first group visit to streamline admissions.
- Cornell committees: Presidential Commission on Undergraduate Education (1987–1989); Chair, Reserve Officer Training Corps Relations Committee (1988–1991); Library Board (1989–1993); Traffic Advisory Board (1995–1997); Rugby Club advisor (1988–1991); Engineering Committee on International Relations (2003–2005; 2006–2008); International Studies Advisory Council (2003–2004); Chair, College Master of Engineering Committee (2006–2008); Faculty Senator (2006–2009 and 2015–2018); University Appeals Panel (2008–2013); Residential Program Houses Committee (2008–2010); Council on Mental Health (2009–2015).

- Associate Editor, J. Geophysical Research - Earth Surface, 2014-2024.
- Associate Editor, Mechanics Research Communications, 2007-2020.

- Guest Editor (with Alexandre Valance, Institut de Physique de Rennes), Special Issue of Compte-Rendus Physique (journal of the French Academy of Sciences) on Granular Materials (2014).
- Chair of the second Gordon Conference on Granular and Granular-Fluid Flow in Colby College, Maine, June 27 to July 2, 2004, sponsored by NSF funding.
- Leader of the US delegation to the NASA-sponsored 2nd International Conference on the Formation and Migration of Dunes, Nouakchott, Mauritania, Feb 2001.
- Outreach to DeWitt Middle School, Ithaca, NY (2000-2012).
- Substitute teacher, Ithaca City School District, 2023-present. Teacher of STEM and language classes from grades 9 to 12.
- Frequent reviewer for journals in multiphase physics, academic promotions and funding agency panels.

6. Industrial experience

- Powder Flow consultant, International Fine Particle Research Institute, a global network of companies and academics with active research programs in particle science and technology, 2003-2009 and 2015-present. Advisor on IFPRI grant funding priorities. Co-chair of IFPRI workshops on Powder Flow (Bremen, 2003; Amsterdam, 2017; Purdue University, 2023).
- Consultant, Merck, Sharp and Dohme, pharmaceutical powder instrumentation, 2001, 2016-present.
- Consultant, ArcelorMittal, 2023-present.
- Consultant, Capacitec, Inc., development of capacitance instruments to record the stratigraphy of snow packs under an SBIR Phase I and II from the US Army Research Office, 1997-2001. Recipient of a Pentagon Quality Award, 2002.
- Other clients in powder technology: Maersk Oil in Qatar (2013–2017) Pall Corporation (2012), Procter & Gamble (2001), Inhale Pharmaceuticals (2001), Huntsman Tioxide (2000), UOP (1999), Praxair (1997), Swiss Institute for Snow and Avalanche Research (1996), 3M (1995), Exxon (1995-1997), Norton (1996), CANMET (1994), Dow Corning (1994-1999), ABB Combustion Engineering (1988-1990), Shell Oil (1991), Shell Laboratorium Amsterdam (1992), Électricité de France (1992), Amoco (1990), Cabot (1987).
- Visiting Scientist, CNIM group, circulating fluidized bed combustion, La-Seyne-sur-Mer, France.
- Process Development Engineer, Shell, The Hague, the Netherlands, 1984-1985.
- Officer, French Naval Reserve, 1979-1999. Last rank: Capitaine de Corvette (Lieutenant Commander). Officer of the watch. Deep underwater operations. Tours on the BISM Triton (saturation diving support ship), GISMER (deep diving group), Emeraude Red Crew (nuclear attack submarine), La Marne (tanker), L'Aigle (mine hunter), Commandant Bouan (Destroyer).

7. Teaching and mentoring

- Cornell M&AE 4230 Intermediate Fluid Mechanics (2022).
- Cornell M&AE 5430 Combustion Processes (1985–2019).
- Cornell M&AE 4272 Fluids/Heat Transfer Laboratory (1985–2018).
- Université de Rennes 1, France, Fluid Mechanics (2006).
- Tsinghua University, Undergraduate Thermodynamics (2017, 2018).
- CentraleSupélec, Paris, France, Transferts Thermiques (2012).
- Cornell M&AE 4230/4231/5230 Intermediate Fluid Mechanics (2022, with R. Bhaskaran).
- Cornell M&AE 3240 Heat Transfer (2008-2018).
- M&AE 6020: Foundations of Fluid Mechanics II (2011, 2012, 2015, with S. Pope).
- Université de Rennes 1, Methods of Modern Research, (summer 2007–2008).
- Cornell M&AE 449 Combustion Engines and Fuel Cells (2007).
- Cornell M&AE 6510 Advanced Heat & Mass Transfer (1988-1997, 2021).
- Cornell M&AE 101 Naval Ship Systems (1988–2010, with Cornell NROTC).

- Cornell M&AE 2250 Mechanical Synthesis (1998–2016, with Cornell colleagues).

- Graduate students: Epaminondas Mastorakos (1989), Catherine Acree-Riley (1989), Michael Opie (1990), Hongder Chang (1991), Subramanyam Iyer (1991), Jamaludin Mohd. Yusof (1992), D. Jeffrey Lischer (1993), Samuel Foerster (1993), Stéphane Martin-Letellier, Mark Tuccio, Vincent Bricout (2000), Elizabeth Griffith (2000), Haitao Xu (2003), Xinglong Chen (2005), Cian Carroll (2011), Jin Xu (2015), Shilpa Sahoo (2021).
- Visitors and post-docs: Lili Gu (Tsinghua, 2015), Barbara Turnbull (2007–2008), Frédéric Beaud (Électricité de France, 1992), Khédidja Allia (Université dAlger, 1991), Hongder Chang (1991–1992).

- Design project advisor to over 150 undergraduate and Master of Engineering students since 1985. Co-authored archival articles with 26 undergraduate and M.Eng. students. Project team advisor: Odysseus Space (1999–2005); Baja SAE (2009–2012); Hyperloop (2015–2016), Bill Nye's Solar Noon Indicator on the East face of Rhodes Hall.

- Recipient of Cornell's Kendall S. Carpenter Memorial Advising Award, 2011.

8. Research

Archival articles below illustrate my contributions to gas-solid fluidization, granular flows, particle impact, heat transfer, nanoparticles, instrumentation, desert microbiology, sand dunes, snow science, chemical kinetics, spectroscopy, and capillary phenomena. This research involved laboratory experiments, field expeditions, microgravity platforms, numerical simulations, models, and the development of theory. I involved many undergraduate and M.Eng. students, included 26 as co-authors, and advised 17 graduate students. According to Google Scholar, the resulting articles have been cited over 4000 times, while 12 of them (noted in red) have been cited over 100 times.

(1) Desert microbiology; hyper-arid regions and desertification research. Sponsor: Qatar National Research Foundation.

Our motivation is to work against desertification by stabilizing sand dune with microbes. In general, our project has looked at moisture and heat inside sand dunes, toward understanding how microbes and higher animals survive in hyper-arid sand environments. In particular, our collaborators Anthony Hay of the Cornell Department of Microbiology, and Renée Richer and Sara Abdul-Majid of Weill-Cornell Medicine in Qatar, have characterized microbes capable of metabolizing urea in Qatar sand dunes through a process called "Microbe-Induced Calcite Precipitation" (MiCP), see for example de Jong et al.

Our field work on mobiles sands considered interior phenomena seldom addressed in the literature, specifically the transfer of heat and moisture deep within mobile dunes. For example, we acquired for the first time deep temperature and humidity time-histories with probes sunk below the leeward avalanche face of a mobile barchan dune in the Qatar desert, emerging windward after 15 months of burial.

Our unique capacitance instruments with unprecedented sensitivity to low moisture also allowed us to develop and validate a definitive model for vapor infiltration through the surface of desert sands. Because sands have similar properties than pharmaceutical powders, instrument and model are both the subject of our on-going collaboration with Merck.

For example, we report in a recent article intriguing data of wide-ranging applications to desertification, planetary exploration, agriculture, pharmacy and food processing, such as the discovery of evanescent waves. The article also demonstrates that desert surfaces breathe humid air, but exchange less moisture with the atmosphere than expected.

- Louge, M.Y., A. Valance, J. Xu, A. Ould el-Moctar, and P. Chasle (2022). Water vapor transport across an arid sand surface - non-linear thermal coupling, wind-driven pore advection, subsurface waves, and exchange with the atmospheric boundary layer, *J. Geophys. Res. Earth Surf.*, **127**, e2021JF006490, doi:10.1029/2021JF006490, data set curated at the Cornell eCommons.

The article was featured in a story published by the Cornell Chronicle and relayed by online blogs and sites.

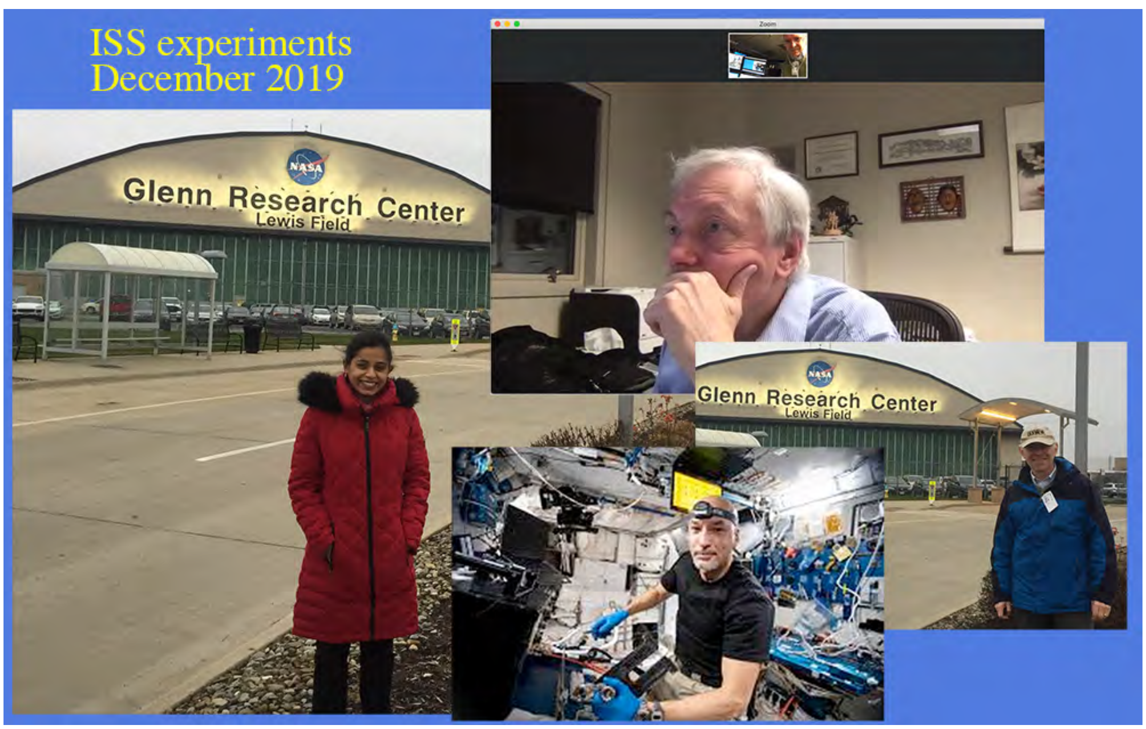
- Valance, A., J. Fang, S. Harnett, F. Porte-Agel, and P. Chasle (2024). Evolution of turbulent boundary conditions on the surface of large barchan dunes: Anomalies in aerodynamic roughness and shear velocity, aeolian threshold, and the role of dune skewness, *J. Geophys. Res. Earth Surf.*, **129**, e2023JF007599, doi:10.1029/2023JF007599, data set curated at the Cornell eCommons.
- S. Abdul Majid, M. F. Graw, A. Chatziefthymiou, H. Nguyen, R. Richer, M. Louge, A. A. Sultan, P. Schloss, A. G. Hay (2016). Microbial Characterization of Qatari Barchan Sand Dunes, *PLoS ONE*, **11**, e0161836, doi:10.1371/journal.pone.0161836.
- Louge, M. Y., A. Valance, A. Ould el-Moctar, J. Xu, A. G. Hay, and R. Richer (2013). Temperature and humidity within a mobile barchan sand dune, implications for microbial survival, *J. Geophys. Res.*, **118**, doi:10.1002/2013JF0028396.
- Musa, R. A., S. Takarrouht, M. Y. Louge, J. Xu, and M. E. Berberich (2014). Pore pressure in a wind-swept rippled bed below the suspension threshold, *J. Geophys. Res. Earth Surf.*, **119**, doi:10.1002/2014JF003293.

- Louge, M. Y., A. Valance, A. Ould el-Moctar, and P. Dupont (2010). Packing variations on a ripple of nearly monodisperse dry sand, *J. Geophys. Res.*, **115**, F02001, doi:10.1029/2009JF001384.
- Louge, M. Y., A. Valance, H. Mint Babah, J.-C. Moreau-Trouvé, A. Ould el-Moctar, P. Dupont, and D. Ould Ahmedou (2010). Seepage-induced penetration of water vapor and dust beneath ripples and dunes, *J. Geophys. Res.*, **115**, F02002, doi:10.1029/2009JF001385.

(2) Capillarity and unsaturated porous media. Sponsor: NSF, NASA (International Space Station).

Our research on unsaturated porous media has experimental and theoretical components. Experiments focus on the inertial phase of imbibition into porous media, carried out in an experiment aboard the International Space Station with results and data archived at the Cornell eCommons.

Our theoretical work exploits statistical mechanics to predict the retention behavior of unsaturated porous media from known surface energy and pore geometry. We also use the statistical mechanics to elucidate the behavior of the hysteretic gas-solid-liquid triple contact line with or without electrowetting.



- Louge, M.Y. and Wang, Y. (2024). Statistical Mechanics of Electrowetting, *Entropy*, **26(4)**, 276, doi:10.3390/e26040276.
- Louge, M.Y. (2017). Statistical mechanics of the triple contact line, *Phys. Rev E*, **95**, 032804, doi:10.1103/PhysRevE.95.032804.
- Louge, M.Y. and S. Sahoo (2017). Model of inertial spreading and imbibition of a liquid drop on a capillary plate, *AIChE J.*, **63**, 5474–5481, doi:10.1002/aic.15953.
- Steub, L., J. Kollmer, D. Paxson, A. Sack, T. Pöschel, J. Bartlett, D. Berman, Y. Richardson, and M. Y. Louge (2017). Microgravity spreading of water spheres on hydrophobic capillary plates, *EPJ Web of Conferences*, **140**, 16001, doi:10.1051/epjconf/201714016001.
- Xu, J. and M. Y. Louge (2015). Statistical mechanics of unsaturated porous media, *Phys. Rev E*, **92**, 062405, doi:10.1103/PhysRevE.92.062405.

(3) Instruments for geophysical and industrial applications. Sponsors: US DoE, Qatar National Research Foundation, US Army Research Office.

An important prerequisite for conducting experiments in gas-solid systems is to develop instruments capable of recording the principal variables in these systems. Notably, we created dielectric measurements of solid volume fraction for a variety of applications (industrial plants, snow pack, sand dunes) and refined optical fiber techniques for fluidized beds.

A fruitful collaboration with Merck has led to the development of instrumentation, such as the level sensor described in the article below, which allows feedback control in continuous pharmaceutical manufacturing.

- William Blincoe, Michel Yves Louge, Jasdeep Mandur, Anthony S. Tantuccio (2020). Non-invasive continuous capacitance level detector, *International Patent WO2021126680A1*.

- M. Y. Louge, J. Mandur, W. Blincoe, A. Tantuccio, R. F. Meyer (2021). Non-invasive, continuous, quantitative detection of powder level and mass holdup in a metal feed tube, *Powder Technology*, **382**, 467–477, doi:10.1016/j.powtec.2020.12.068.

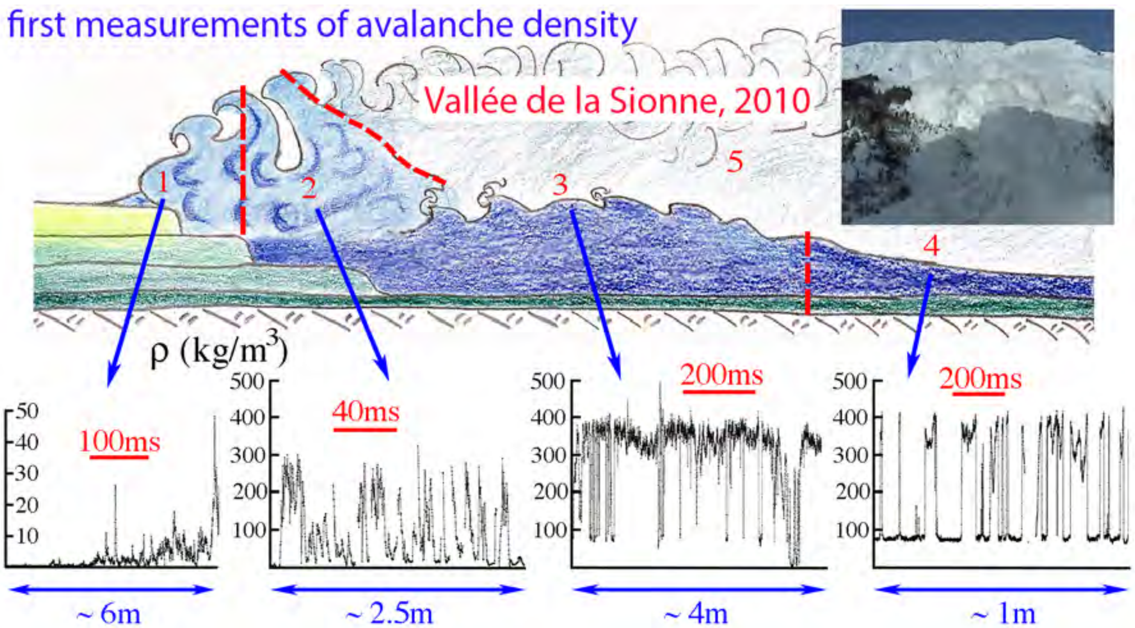
Another pharmaceutical appplication is the 'Smart Tray', a modification of traditional metal trays used to remove residual solvents from powders produced in spray dryers. Unlike existing trays, the Smart Tray monitors the water or solvent content of the powder and allows users to decide when to interrupt the drying process for optimum product quality and best performance. The following article describes the technique in detail:

- Louge, M.Y., Mandur, J., Grigorov, P., Blincoe, W., Lamberto, D., Bower, C. and Meyer, R.F., 2024. Non-Invasive, Continuous, Quantitative Detection of Solvent Content in Vacuum Tray Drying. *The AAPS Journal*, **26(5)**, p.89. doi:10.1208/s12248-024-00944-4.

This technique to record the moisture or solvent content in powders originated in our field research on snow packs and deserts. Our collaboration on the Smart Tray was covered in a news release of the Cornell Chronicle and subsequent articles in the online press.

Earlier papers on instrumentation described the technique. They included:

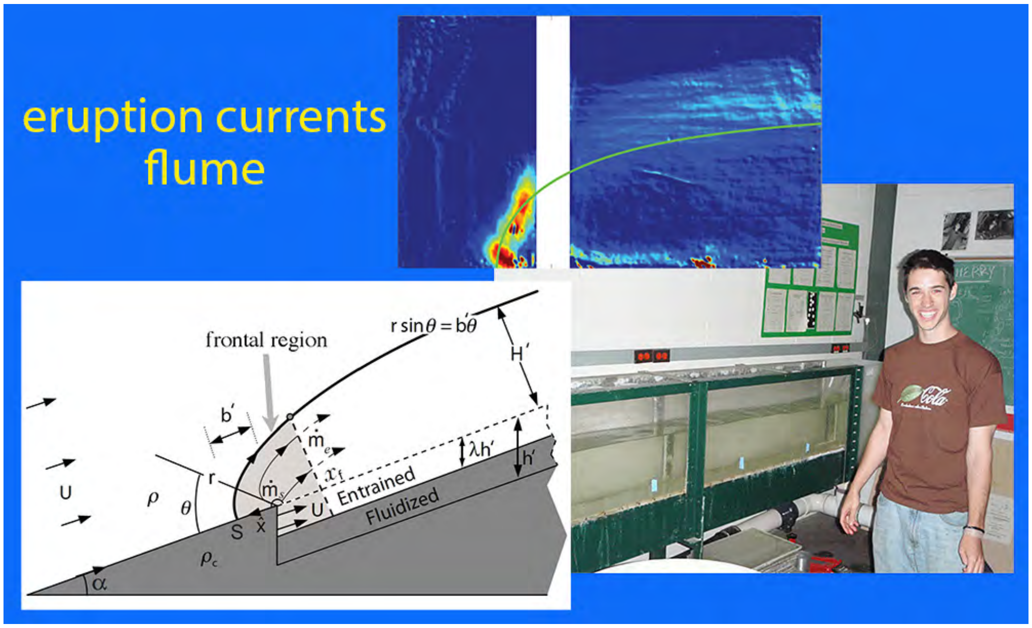
- A. E. Griffith, M.Y. Louge and J Mohd. Yusof (2000). Simultaneous, non-invasive measurements of convective heat transfer and solid volume fraction at the wall of an entrained gas-solid suspension, *Rev. Sci. Instrum.*, **71**, 2922–2927, doi:10.1063/1.1150711.
- Louge M.Y., Foster R.L., Jensen N. and Patterson R. (1998). A portable capacitance snow sounding instrument, *Cold Regions Science and Technology*, **28**, 73–81, doi:10.1016/S0165-232X(98)00015-9.
- Dent, J. D., Burrell, K. J., Schmidt, D. S., Louge, M. Y., Adams, E. E., and Jazbutis, T. G. (1998). Density, velocity and friction measurements in a dry-snow avalanche, *Annals of Glaciology*, **26**, 247–252, doi:10.3189/1998AoG26-1-247-252, 135 citations.
- Louge M.Y., Steiner R., Keast S.C., Decker R., Dent J. and Schneebeli M. (1997). Application of capacitance instrumentation to the measurement of density and velocity of flowing snow, *Cold Regions Science and Technology*, **25**, 47–63, doi:10.1016/S0165-232X(96)00016-X.
- M. Louge (1997). Experimental Techniques, chapter 9 in *Circulating Fluidized Beds*, J. Grace, T. Knowlton and A. Avidan, eds, Blackie Academic & Professional, pp. 312–368, ISBN:0751402710.
- M. Louge, M. Tuccio, E. Lander, and P. Connors (1996). Capacitance measurements of the volume fraction and velocity of dielectric solids near a grounded wall, *Rev. Sci. Instrum.*, **67**, 1899–1877, doi:10.1063/1.1146991.
- Lischer, D.J. and Louge, M. (1992). Optical fiber measurements of particle concentration in dense suspensions: calibration and simulation, *Applied Optics*, **31**, 5106–5113, doi:10.1364/AO.31.005106.



- Louge, M.Y., Iyer, S.A., Giannelis, E.P., Lischer, D.J. and Chang, H. (1991). Optical fiber measurements of particle velocity using Laser-Induced Phosphorescence, *Applied Optics*, **30**, 1976–1981, doi:10.1364/AO.30.001976.
- Louge M. and Opie M. (1990). Measurements of the effective dielectric permittivity of suspensions, *Powder Tech.*, **62**, 85–94, doi:10.1016/0032-5910(90)80026-U.
- Acree Riley, C. and Louge, M.Y. (1989). Quantitative capacitive measurements of voidage in dense gas-solid flows, *Particulate Science & Tech.*, **7**, 51–59, doi:10.1080/02726358908906523.
- M.Y. Louge (August 13, 1996). Guarded capacitance probes for measuring particle concentration and flow, **US Patent 5546006**, licensed to Capacitec for industrial solid concentration and moisture measurements.
- M.Y. Louge (October 17, 1995). Guarded capacitance probes for measuring particle concentration and flow, **US Patent 5459406**.

(4) Snow avalanches: field experiments and modeling. Sponsors: Petroleum Research Fund.

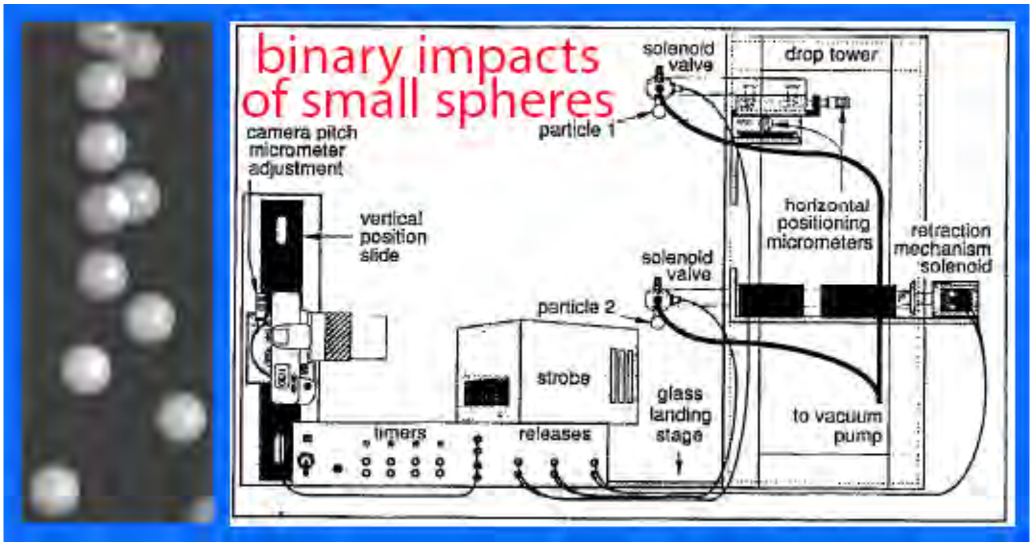
Eruption currents are driven by massive frontal entrainment. A dramatic example is the front of a powder snow avalanche. Although these phenomena resemble gravity currents generated as a heavier fluid is released into a lighter one, their fluid mechanics is radically different. This is why Barbara Turnbull, Cian Carroll and I



coined the term "eruption currents" to describe them.

We deployed our unique capacitance instrumentation to measure the density and velocity of snow. The work led to the development of a probe for rapidly charting the stratigraphy of snow packs. It is also used by the WSL Institute for Snow and Avalanche Research SLF at their Vallée de la Sionne avalanche facility in Switzerland (see figure above).

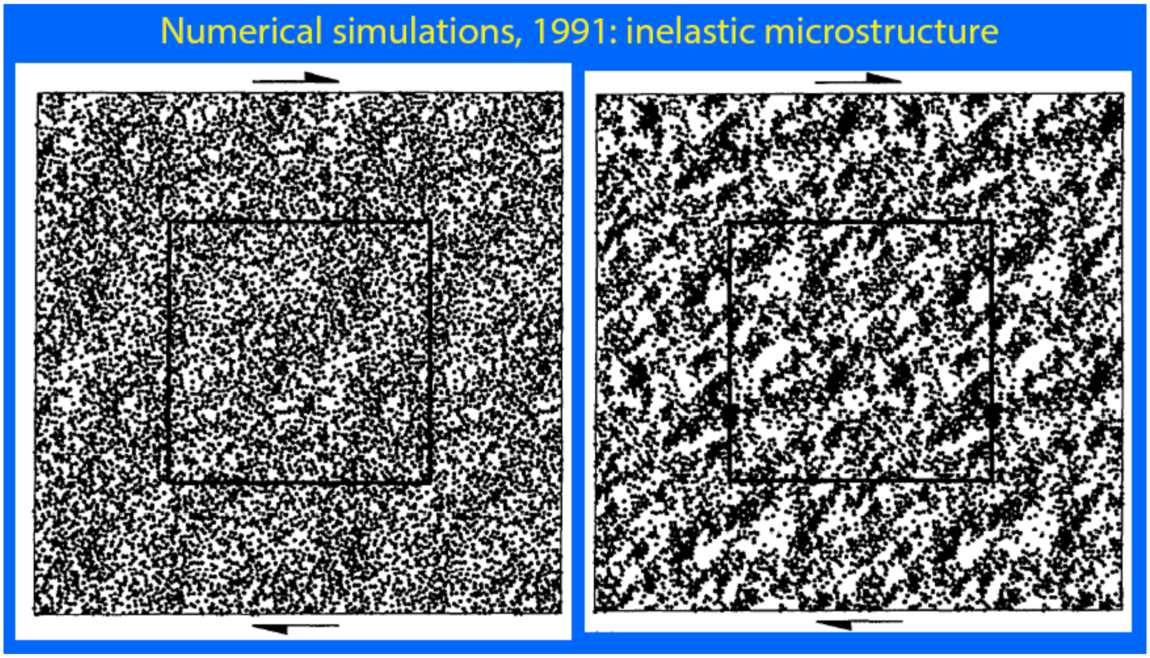
- B. Sovilla, J. N. McElwaine, and M. Y. Louge (2015). The structure of powder snow avalanches (Structure des avalanches en aérosol), *Compte-Rendus de Physique*, **16**, 97–104, doi:10.1016/j.crhy.2014.11.005.
- C.S. Carroll, M.Y. Louge, and B. Turnbull (2013). Frontal dynamics of powder snow avalanches, *J. Geophys. Res.*, **118**, 1–12, doi:10.1002/jgrf.20068.
- C.S. Carroll, B. Turnbull, and Louge, M. Y. (2012). Role of fluid density in shaping suspension currents driven by frontal particle blow-out, *Phys. Fluids*, **24**, 066603, doi:10.1063/1.4725538.
- M.Y. Louge, B. Turnbull and C.S. Carroll (2012). Volume growth of a powder snow avalanche, *Annals of Glaciology*, **53**, 57–60, doi:10.3189/2012AoG61A030.
- Louge, M. Y., C.S. Carroll, and B. Turnbull (2011). Role of pore pressure gradients in sustaining frontal particle entrainment in eruption currents – the case of powder snow avalanches, *J. Geophys. Res.*, **116**, F04030, doi:10.1029/2011JF002065.



(5) Impact of small spheres: measurement of restitution and friction coefficients. Sponsors: US DoE, NASA.

We developed at Cornell a unique facility to measure the behavior of small spheres upon impact. Unlike previous work involving impacts of a single sphere on a flat plate, our experiment can also evaluate the properties of binary collisions between two spheres colliding in mid-air. Although this facility has elicited more than 900 citations in the literature, no other group has managed to emulate this apparatus for binary collisions. We are working with a small company to reproduce it.

- C.M. Sorace, M.Y. Louge, M.D. Crozier, and V.H.C. Law (2009). High apparent adhesion energy in the breakdown of normal restitution for binary impacts of small spheres at low speed, *Mechanics Res. Comm.*, **36**, 364–368, doi:10.1016/j.mechrescom.2008.10.009.
- M.Y. Louge and M.E. Adams (2002). Anomalous behavior of normal kinematic restitution in the oblique impacts of a hard sphere on an elasto-plastic plate, *Phys. Rev. E*, **65**, 021303, doi:10.1103/PhysRevE.65.021303, 107 citations.
- M. Y. Louge, C. Tuozzolo and A. Lorenz (1997). On binary impacts of small liquid-filled shells, *Phys. Fluids*, **9**, 3670–3677, doi:10.1063/1.869504.
- A. Lorenz, C. Tuozzolo and M.Y. Louge (1997). Measurements of impact properties of small, nearly spherical particles, *Experimental Mechanics*, **37**, 292–298, doi:10.1007/BF02317421, 175 citations.
- S.F. Foerster, M.Y. Louge, H. Chang, and K. Allia (1994). Measurements of the collision properties of small spheres, *Phys. Fluids*, **6**, 1108–1115, doi:10.1063/1.868282, 616 citations.



(6) Numerical simulations of granular flows. Sponsors: US DoE, NASA.

Grains interacting through binary collisions behave as a "granular gas", in which they interact through collisions involving two of them at a time. A crucial concept in granular gases is the "granular temperature," resembling the kinetic energy k of turbulence, and measuring the fluctuation energy of agitated grains. A challenge to theory is the formation of particle clusters. In collaboration with Mark Hopkins, our numerical simulations, reported in a highly-cited article, showed that clusters can arise from energy dissipation in binary collisions.

- Louge, M.Y. (1994). Computer simulations of rapid granular flows of Spheres interacting with a flat, frictional boundary, *Phys. Fluids*, **6**, 2253–2269, doi:10.1063/1.868178, 139 citations.
- Hopkins M., Jenkins J. and Louge M. (1993). On the structure of three-dimensional shear flows, *Mechanics of Materials*, **16**, 179–187, doi:10.1016/0167-6636(93)90041-O.
- M. Louge, J. Jenkins and M.A. Hopkins (1993). The relaxation of the second moments in rapid shear flows of smooth disks, *Mechanics of Materials*, **16**, 199–203, doi:10.1016/0167-6636(93)90043-Q.
- Hopkins, M.A. and Louge M. (1991). Inelastic microstructure in rapid granular flows of smooth disks, *Phys. Fluids A*, **3**, 47–57, doi:10.1063/1.857863, 350 citations.

- Louge M., Jenkins J.T. and Hopkins M. (1990). Computer simulations of rapid granular shear flows between parallel bumpy boundaries, *Phys. Fluids A*, **2**, 1042–1044, doi:10.1063/1.857642.

(7) Granular and gas-solid flow theory. Sponsors: US DoE, NASA, International Fine Particle Research Institute.

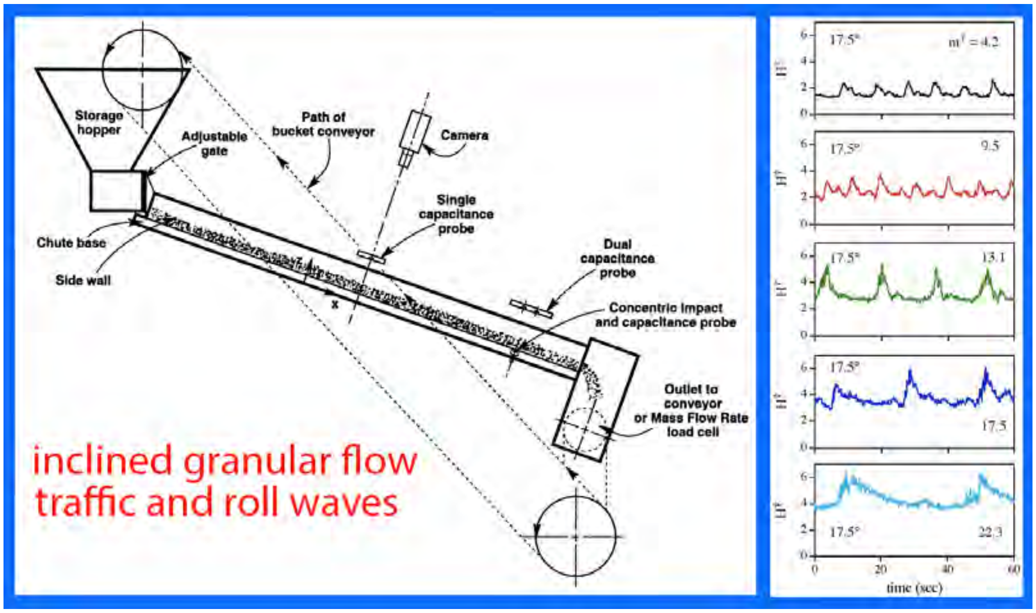
Beside experiments on circulating fluidization, we also collaborated with Jim Jenkins to study the interactions of gases and solids that are sufficiently agitated to affect the surrounding gas, but that are too massive to be moved significantly by it. We considered fluid mechanics and heat transfer in dense suspensions, with applications to the pneumatic transport of massive particles.

- Louge, M.Y. (2012). Phonon conductivity along a column of spheres in contact – Relation to volume fraction invariance in the core of granular flows down inclines, *Granular Matter*, **14**, 203–208, doi:10.1007/s10035-011-0296-x.
- H. Xu, R. Verberg, D. Koch and M. Louge (2009). Dense, bounded shear flows of agitated solid spheres in a gas at intermediate Stokes and finite Reynolds numbers, *J. Fluid Mech.*, **618**, 181–208, doi:10.1017/S0022112008004333.
- R. Delannay, M. Louge, P. Richard, N. Taberlet, and A. Valance (2007). Towards a theoretical picture of dense granular flows down inclines, *Nature Materials*, **6**, 99–108, doi:10.1038/nmat1813, 130 citations.
- Louge, M.Y. (2003). Model for dense granular flows down bumpy inclines, *Phys. Rev. E*, **67**, 061303, doi:10.1103/PhysRevE.67.061303, 130 citations.
- J. T. Jenkins and M. Louge (1997). On the flux of fluctuation energy in a collisional grain flow at a flat, frictional wall, *Phys. Fluids*, **9**, 2835–2840, doi:10.1063/1.869396, 131 citations.
- Louge, M.Y., Mastorakos, E. and Jenkins, J.T. (1991). The role of particle collisions in pneumatic transport, *J. Fluid Mech.*, **231**, 345–359, doi:10.1017/S0022112091003427, 304 citations.

(8) Granular flow experiments: inclined flows and microgravity. Sponsors: US DoE, NASA.

We conducted experiments on NASA's KC-135 microgravity aircraft to validate theoretical models and numerical simulations. To this day, this constitutes the only instance where experiments, simulations and theory have been reconciled based on independently measured impacts parameters. We also developed and tested another facility to investigate interactions between gases and agitated solids in microgravity.

The flows of grains down rough inclined planes ("chutes") serve as a model for geophysical phenomena such as rock slides, dunes and avalanches. They are also



used in passive industrial solids conveying of ores and grains. In a highly-cited article, we distinguished three principal categories of grains flows on inclines, depending whether the base is rough, flat-frictional, or erodible. At Cornell, we conducted research on all three flow categories with a combination of experiments, theory, and numerical simulations. We constructed laboratory facilities and designed special instruments for these flows.

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(9) Granular heat transfer: experiments, simulations and theory. Sponsor: NASA.

We carried out research on heat transfer in gas-solid suspensions and agitated granular media. Our results highlighted the role of particle agitation and turbulence in enhancing heat transfer in gas-solid flows. We also extended our analyses to suspensions of nanoparticles.

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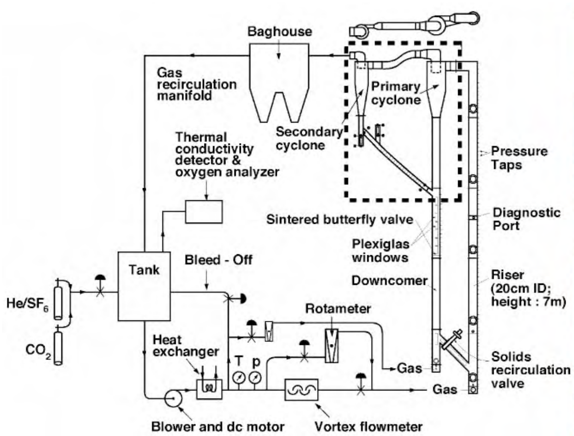
(10) Circulating gas-solid fluidization in a facility recycling CO_2, He and SF_6 to study scale-up and pressurized operations. Sponsors: NSF, US DoE, Électricité de France.

Circulating fluidization is a technology for carrying out gas-solid reactions with high solid throughputs, such as coal combustion or catalytic cracking. Excellent contacting is achieved as solids are entrained in a vertical riser column by a stream of reactive gases at high velocity. Recognizing that limited understanding of circulating fluidized beds (CFB) rendered design extrapolations of pilot reactors to full-scale plants both empirical and expensive, we built at Cornell in 1986 the first cold circulating fluidized bed experimental facility capable of recycling any arbitrary mixture of inert gases at room-temperature (helium, air, CO_2, SF_6). In doing so, we matched the dimensionless numbers of our cold facility to those of industrial units operating at higher temperatures. By changing the gas composition and particle size, we could simulate an increase in the size of the industrial unit, thus allowing us to study effects of scale-up on CFB hydrodynamics with a single facility. We also used SF_6 to simulate pressurized circulating fluidization. The facility was decommissioned in 2002.



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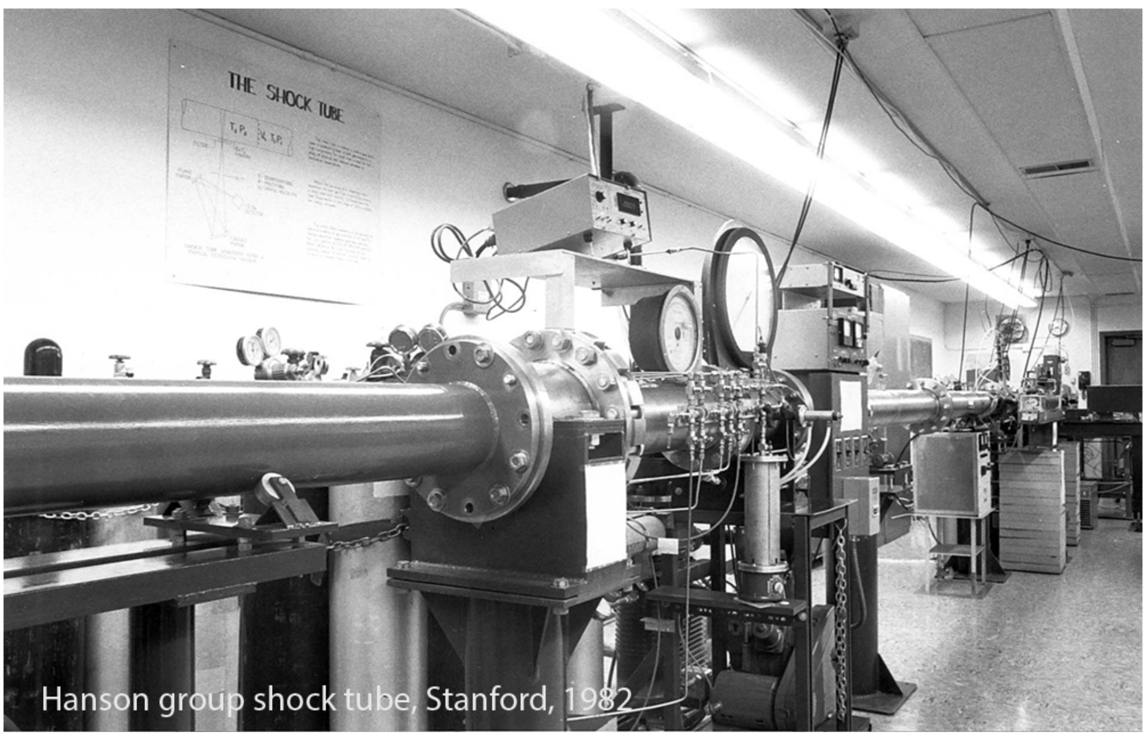
(11) Combustion, chemical kinetics and spectroscopy

Articles below were written during my graduate studies at Stanford in Ron Hanson's group. Their experimental results with a shock tube have been widely used to model the kinetics of formation of nitric oxides from combustion.



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9. Major funding and awards

- NSF-CASIS (2016-2021, with Olivier Desjardins). Inertial spreading and imbibition of a liquid drop through a porous surface, $300k.
- Qatar National Research Foundation (2013–2017), Microbial stabilization of mobile dunes for infrastructure protection and environmental preservation, NPRP 6-059-2-023, $1m.
- Qatar National Research Foundation (2010–2014), Understanding the link between moisture dynamics and microbial activity in mobile dunes, NPRP 09-546-2-206, $1m
- Best Environment Research Program of the Year, Qatar Foundation, 2011, $100k.
- ACS Petroleum Research Fund 47782-AC8 (2008-2012), The role of erosion at the head of turbidity currents – experiments and theory, $100k.
- NSF 0233212 (2003), U.S.-France Cooperative Research: Flows of Grains Down Inclined Channels, $21k.
- Recipient of a Pentagon Quality Award for SBIR contract DAAD19-00-C-0010 with Capacitec, Inc., 'A Multi-Parameter Snow Sounding probe', 2002.
- NASA NCC3-797 and NCC3-468, Studies of gas-particle interactions in a microgravity flow cell (1998–2005), $686k (with J.T. Jenkins).
- NASA NAG3-2705, Microgravity segregation in binary mixtures of inelastic spheres driven by velocity fluctuation gradients (1996–2000), $780k (with J.T. Jenkins).
- NASA NAG3-2112, Microgravity segregation in binary mixtures of inelastic spheres driven by velocity fluctuation gradients (2000–2005), $800k (with J.T. Jenkins).
- International Fine Particle Research Institute (IFPRI) Experimental rapid shear (1995, $100k); Collaboration grant with Sankaran Sundaresan (Princeton) (1998, $5k); Studies of gas-particle interactions in a microgravity flow cell (1999, $100k).
- US Department of Energy DE-FG22-95PC95228, University Coal Research Prgm, Pittsburgh Energy Technology Ctr (1995–1998, $400k, with L. Glicksman, MIT).
- US Department of Energy DE-FG22-93PC93216, University Coal Research Program, Pittsburgh Energy Technology Center (1993–1997, $200k).

- NSF 9512931 (1996), U.S.-France Cooperative Research: The mechanics and statistical physics of particle motion on an inclined, bumpy surface, $21k.
- US Department of Energy DE-AC22-91PC90183, Granular Flow Advanced Research Objective (1991–1995, $700k, with J. Jenkins).
- Électricité de France, Circulating fluidized bed combustion (1993, $68k).
- US Department of Energy DE-FG22-88PC88929, University Coal Research Program (1988, $390k).
- NSF 8809347 (1988), Research Initiation: A Systematic Investigation of Circulation Fluidized Bed Scale-Up, $69k.
- NSF 8704993 (1987), Engineering Research Equipment Grant: Pulsed Dye Laser Upgrade for Gas-Solid and Turbulent Flame Diagnostics, $24k.