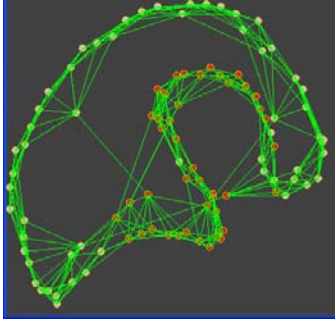# ROBERT J. GLASS, Jr.
Senior Scientist
Curriculum Vitae
December, 2011

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Web sites: http://www.sandia.gov/CasosEngineering/glass.html
www.sandia.gov/CasosEngineering
www.sandia.gov/nisac/amti.html
www.sandia.gov/FlowVis&ProcessLab (in progress)

EDUCATION

Cornell University, M.S. (1985) and Ph.D. (1988), Agricultural and Biological Engineering
- Interdisciplinary program emphasizing fluid flow and chemical transport in environmental systems, e.g., soil, rock formations, groundwater, lakes, streams, atmosphere, oceans, with course work in Civil & Environmental Engineering, Mechanical & Aerospace Engineering, Applied Mathematics, Chemical Engineering, and Agricultural and Biological Engineering.
- MS Thesis title: "A Study of Wetting Front Instability in Layered Porous Media."
- PhD Dissertation title: "Wetting Front Instability in Unsaturated Porous Media."
- Advisors: J.-Y. Parlange, J.A. Liggett, T.S. Steenhuis, and R.D. Miller

Yale University (1981-82), School of Forestry and Environmental Studies
- Emphasis on hydrology, groundwater flow, earth surface processes, and soil science with courses in Applied Engineering Mathematics and Geology.

Haverford College, B.S. (1980), Biology-Ecology
- 5 year self-designed major in biology-ecology with core courses at Haverford, Bryn Mawr, Swarthmore, and University of Pennsylvania (Biology:12, Geology:6, Chemistry:5, Math:3, Physics:2).
- Senior Research Project: January-June 1980. Apprenticeship in tropical field ecology, Parque Nacional Santa Rosa, Costa Rica. Advisors: D. Kessler, Haverford College and D. Janzen, University of Pennsylvania.

RESEARCH

General Research Focus and Path of Development: Self organized spatial-temporal structure in non-equilibrium systems, the control of such systems, and defining and solving problems (engineering) within non-equilibrium, physical-socio-technical systems. From 1988 until 2003, this research focused primarily on physical systems and subsurface environmental problems where poorly understood phenomena such as multi-phase and multi-component flow instabilities create large scale transport pathways within heterogeneous and fractured rock formations. This work led to the development of a variety of new experimental methods to quantitatively visualize flow structure within laboratory and field experiments, and modeling approaches such as extended continuum, modified invasion percolation, hybrid and complexity science based to model the flow and transport processes discovered. Beginning in 2004, this research extended to the analysis and control of complex interdependent adaptive systems as embodied by many critical infrastructures and behavioral systems. Research results have demonstrated the value of applying the problem definition and solution approaches of engineering to the vastly complex physical-socio-technical systems which we must understand to design a secure future for the nation and the globe. Such systems are all Complex Adaptive Systems of Systems (CASoS) and a new and growing initiative to define the discipline of "CASoS Engineering" at Sandia has begun. This initiative has fueled a CASoS Engineering pilot at Sandia, "Phoenix," since the Fall of 2008.

Division of Energy, Nonproliferation and High Consequence Security, Sandia National Laboratories (SNL) Albuquerque, NM, January 2008 to present. Responsibilities include: developing and leading the *CASoS Engineering Initiative* and its *Phoenix Pilot*; formulating and conducting basic and applied research; securing research funds external/internal; research project management. *Senior Scientist Level (SS)* awarded in 2010 for leadership and achievements in CASoS Engineering.

- **CASoS Engineering Initiative and Phoenix Pilot:** developing and leading an expanding research team focused on building the discipline of CASoS Engineering and instantiating its practice within Sandia. Currently the Phoenix Pilot is orchestrating 10+ projects, includes 20+ members on site (with 5+ graduate/undergraduate students), and multiple collaborators in universities, government and industry. Example applications range from: assessment of cascading failure in multi network infrastructure such as power grids, economic supply networks, and telecommunications (with colleagues at the National Infrastructure Simulation and Analysis center, NISAC); design of robust and resilient large scale national emergency response policies for the Veterans Health Administration (with the Department of Veterans Affair's Chief Officer of Public Health and Environmental Hazards); assessment and design of tobacco control policies for the Food and Drug Administration (with the Director for Center for Tobacco Products); assessment of competitive strategies (with the Department of Defense's Joint Improvised Explosive Device Defeat Organization); analysis of global financial system stability given ongoing changes in fiscal and monetary policies (with colleagues at NISAC); assessment of the global energy system for national security applications (with direction from Sandia's Laboratory Directed Research and Development program, LDRD); and mitigation policy design and evaluation for bovine tuberculosis (with the New Mexico Livestock Board). Our website for the Initiative allows access to background, papers and presentations: www.sandia.gov/CasosEngineering.

National Infrastructure Simulation and Analysis Center (NISAC), Sandia National Laboratories (SNL) Albuquerque, NM, January 2004 to December 2007. NISAC is a joint Sandia and Los Alamos National Laboratory center funded by the Department of Homeland Security. Responsibilities included: developing and leading the *Advanced Modeling and Techniques Investigations (AMTI)* effort; formulating and conducting basic and applied research; securing research funds external/internal; research project management.

- **Advanced Modeling and Techniques Investigations (AMTI):** developed and led a research team in complex adaptive infrastructures and behavioral systems that focused on problems in coupled evolving telecommunication, transportation, power (electricity, natural gas, petroleum), health care, financial/business, and social networks. Example applications included: effects of network topology on congestive failure of high voltage power grids and communication networks (with colleagues at NISAC); community containment strategies for pandemic influenza subsequently adopted as first-line national policy for pandemic response (with the White House Homeland Security Council); and national and global monetary policy influence on congestion and cascades within national large value payment systems (trillions of dollars per day) linked through international foreign exchange markets (with the Federal Reserve Bank of New York, the European Central Bank, and the national Banks of Finland and France). AMTI has been absorbed into the CASoS Engineering Initiative, our archival web site allows access to some papers and presentations: www.sandia.gov/nisac/amti.html.

Geosciences Center, Sandia National Laboratories (SNL), Albuquerque, NM, August 1988 to December 2003. Responsibilities included: developing and leading the *Flow Visualization and Process Laboratory (FVPL)*; formulating and conducting basic and applied research; securing research funds external/internal; research project management. *Distinguished Level (DMTS)* awarded in 1998 for development of the FVPL, its leadership and research achievements across a wide range of topics in fluid mechanics applied to subsurface systems.

- **Funding developed:** variety of Department of Energy (DOE) sources including the Geosciences Program of Basic Energy Sciences (BES), the Environmental Management Science Program (EMSP), the Yucca Mountain Project (YMP), the Waste Isolation Pilot Plant (WIPP), the International Program of the Office of Civilian Radioactive Waste Management (IP-OCRWM), the Sandia Laboratory Directed Research and Development Program (LDRD), the Sandia Environmental Restoration Program (ER), the Uranium in Soils Integrated Demonstration Project (UID), and the Idaho National Engineering and Environmental Laboratory ESR Program (INEEL ESR). Additionally, worked to fund DOE fellowships for graduate students in a variety of DOE programs including the EPSCoR and OCRWM Traineeship Programs. Funding levels between 700K and 2000K per year from 1990 to 2003.

- **Major area of scientific research:** fluid flow and contaminant/energy transport processes within unsaturated and saturated subsurface zones including unconsolidated layered alluvial deposits, glacial till, and fractured rock. Research emphasis placed on laboratory and field experimentation in conjunction with analytical and numerical modeling. Selected research topics (and sponsors) were:
  - Large scale transport pathway process delineation within thick vadose zones including heterogeneous alluvial sediments (ER, EMSP), fractured glacial till (UID), fractured tuff (YMP), and fractured basalt (INEEL ESR)
  - Single and two-phase flow and transport through single fractures, fracture networks, and fracture-matrix networks (BES, YMP, WIPP, INEEL ESR, IP-OCRWM)
  - Gravity-driven and viscous instability/fingering in porous media and fractures (BES, YMP)
  - Multi-component diffusion, convection, and enhanced vapor diffusion in porous media and fractures (EPSCoR, BES, LDRD)
  - Physics of DNAPL movement and remediation in heterogeneous alluvial deposits (EMSP, LDRD)
  - Modified Invasion Percolation modeling (pore to facies scale, fracture to fracture network scale) of immiscible displacements including "unsaturated" air/water and "saturated" DNAPL/water systems (YMP, LDRD, EMSP, BES, WIPP)

- **Flow Visualization and Processes Laboratory (FVPL):** initiated, developed, and led the "*Flow Lab*" at Sandia. The facility supported controlled systematic experimentation at bench-scale and field-scale focused on subsurface flow and transport process understanding/discovery, and the development of new theoretical and numerical modeling approaches embodying this understanding/discovery. Bench-scale experimentation incorporated self designed, state-of-the-art quantitative flow and transport visualization techniques that made use of high resolution image acquisition and analysis as well as a variety of unique apparatus and techniques for system parameter control and state variable measurement. Large-scale field studies incorporated sensor arrays (transducers, TDR, solute and colloid samplers) and geophysical arrays (ERT, cross-borehole GPR) for monitoring and visualizing flow and transport in the subsurface. Numerical modeling spanned standard continuum to self-developed non-standard extended physics continuum and discrete approaches including modified invasion percolation, cellular automata, complexity based (sand-pile-like) and hybrid continuum-discrete approaches. The Flow Lab group included scientists from Sandia, academia and other national labs, as well as graduate and undergraduate students. The facility was housed in a custom designed lab complex (10,000 sq. ft) that included: computational and data visualization lab; sample preparation and wet lab; shop where most of our state-of-the-art equipment was hand fabricated; standard hydraulic properties measurement lab; flow visualization labs including seven light transmission test stands for fracture, micro-model and sand slab multiphase flow and solute transport experiments; x-ray lab; darkroom; and offices. The FVPL no longer exists. However, we have kept it "virtually" alive through an archival website where we have documented our groundbreaking work, our funders, papers and presentations, and the people of the "Flow Lab": www.sandia.gov/nisac/FlowVis&ProcessLab (in progress).

UNIVERSITY APPOINTMENTS, TEACHING AND ADVISING

William J. Perry International Security Fellow, Stanford University, Center for International Security and Cooperation (CISAC), September 2011 to August 2012. Activities include:
- *Research*: Understanding Global Interdependency to Promote International Security
- *Teaching*: "Modeling Complex Systems", Department of Management Science and Engineering, to be taught Spring Quarter 2012

Visiting Lecturer, Università di Roma "La Sapienza," 18-21 October 2010. Taught 4 day short course in Complex Adaptive Systems of Systems (CASoS) Modeling and Engineering.

Adjunct Professor, Uniformed Services University of the Health Sciences, Bethesda, Maryland, Spring 2008 to present. Advising graduate students in PhD research and serving on graduate committees.

Adjunct Professor, Department of Earth and Planetary Sciences, University of New Mexico, Fall 1991 to Spring 1996. Advised graduate students and taught graduate courses in

- "Vadose Zone Hydrology" (Spring semesters 1992 and 1994) class incorporated field trips and a large scale field infiltration and transport class project with supporting individual projects using air permeameters, tension permeameters, standard lab hydraulic property measurement, and numerical simulation.
- "Problems in Hydrology " last covered the topic of hydraulic property variability: observation and models.
- "Independent Problems" emphasis on numerical simulation and physical experimentation.

Adjunct Professor, Department of Earth and Environmental Sciences, New Mexico Institute of Mining and Technology, Fall 1993 to Spring 2004. Advised graduate students, served on graduate committees.

Adjunct Professor, Department of Environmental and Natural Resource Science, University of Nevada Reno NV, Fall 1997 to Spring 2000. Advised graduate students, served on graduate committees.

Adjunct Professor, Department of Civil, Environmental and Architectural Engineering, University of Colorado, Boulder, Fall 1999 to Spring 2004. Advised graduate students, served on graduate committees.

Adjunct Professor, Department of Civil Engineering, University of New Mexico, Spring 2001 to Spring 2002. Advise graduated students, served on graduate committees.

Graduate Research Advisor, mentored graduate students often as research advisor at Sandia through DOE and Sandia fellowship programs from universities across the country and abroad (U. of Nevada, Reno: M. Nicholl, A. Carey, C. Cooper; U. of Arizona: D. Norton; New Mexico Tech: V. Tidwell, C. Roepke, R. Holt, K. Baker, J. Sigda; U. of New Mexico: M. Eliassi, S. Pringle, S. Foltz, J. Brainard, D. Fox; U of Colorado: R. Detwiler; U of Texas: D. Burns; Michigan Tech: L. Zhong; Danish Technical University: A. Mortensen; U of Wisconsin: T. Strand; U of Idaho: T. Wood; Seoul National U: S-H Ji; Uniformed Services University: V. Davey).

Undergraduate Research Advisor, mentored over 30 undergraduates from UNM, NMTech and other universities from across the country in research projects at Sandia. Received an award for excellence from Sandia in 1993 in support of Sandia's undergraduate educational mission.

HONORS AND AWARDS

- *William J. Perry International Security Fellowship*, Stanford University, Center for International Security and Cooperation (CISAC), awarded March 2011 for 2011-12 academic year
- *Sandia Award for Excellence*, Sandia National Laboratory, Spearheading Community health efforts in CASoS Engineering, 2010
- *Senior Scientist*, Sandia National Laboratories, less than 0.5% of Sandia staff achieve this distinction, 2010
- *Sandia Award for Excellence*, Sandia National Laboratory, Building the Discipline of CASoS Engineering and Initiation of the Phoenix Pilot as a first step in the implementation of the CASoS Engineering Roadmap, 2009
- *Sandia Award for Excellence*, Sandia National Laboratory, Leading CASoS Engineering Roadmap Effort commissioned by Director of SNL 6300 for the Vice President of SNL 6000, 2008
- *Sandia Award for Excellence*, Sandia National Laboratory, International Effort in Payment Systems with the US Federal Reserve Bank of New York, European Central Bank, Band of Finland and Bank of France, 2007
- *Letter of thanks,* the White House (Dr. Rajeev Venkayya, Senior Director for Biodefense Policy, Homeland Security Council, and Special Assistant to the President for Biodefense) to Tom Hunter, President and Laboratory Director of Sandia National Laboratories, for contributions to Avian Influenza Pandemic Preparation, 2007
- *Special Award*, International Conference of Payment Systems Specialists, Bank of Finland, Transformative contributions in network applications, 2007
- *Special Act & Service Award*, National Institutes of Health, Institute of Allergy and Infectious Diseases, Contributions to the Design of the Discovery Channel (TV) Challenge on Pandemic Mitigation, 2006
- *Sandia Award for Excellence*, Sandia National Laboratory, Contributions to Avian Influenza Preparation, 2006
- *Sandia Award for Excellence*, Sandia National Laboratory, Building Research Collaboration in Payment Systems with Federal Reserve Bank of New York, 2005
- *Sandia Award for Excellence*, Sandia National Laboratory, Creation of the Advanced Methods and Techniques Investigations (AMTI) Task within NISAC for Complex Systems Analysis of Infrastructures, 2004
- *Sandia Award for Excellence*, Sandia National Laboratory, Defining Research and Development Directions for Modeling and Simulation of Complex, Interdependent Adaptive Infrastructures for NISAC, 2003

- *Distinguished Level*, Sandia National Laboratories, less than 10% of Sandia staff achieve this distinction, 1998
- *Outstanding contributions in Geosciences Research*, US DOE Basic Energy Sciences, 1997
- *Sandia Award for Excellence*, Sandia National Laboratory, Integrating Undergraduates into Ongoing Research Projects within the Flow and Transport Processes Laboratory, 1993
- *Sigma Xi*, Scientific Honor Society, 1990
- *Gamma Sigma Delta*, Agricultural Honor Society, 1988
- *Phi Kappa Phi*, Academic Honor Society, 1985
- *Klingenstein Award*, Haverford College, Sea turtle research on Ossabaw Island, Georgia, 1978
- *Summer Exploration Scholarship*, U.S. Dept. of Education, Marine Biology Expedition, 1975

RECENT SERVICE

- *Team co-Lead*, Sandia Enterprise Security Roadmap, 2010
- *Invited Participant,* Second NSF Workshop on Advocating for an Incentive and Transformative Recovery in National STEM Education, Sedona, 2010
- *Invited Member*, Geoscience Review Panel, Basic Energy of Sciences, Department of Energy, 2010
- *Invited Participant,* First NSF Workshop on Advocating for an Incentive and Transformative Recovery in National STEM Education, New York City, 2009
- *Team lead*, Phoenix Pilot effort to build the discipline of CASoS Engineering at Sandia, 2009
- *Invited Participant*, Joint IED Defeat Organization (JIEDDO-DoD) Workshop on Agent Based Modeling, 2009
- *Invited Participant*, George Mason University and NSF Headquarters Meeting on Megacities, 2009
- *Invited Participant*, Formulation of Energy and Climate Policy: Toward an Open and Transparent Process, at the Woodrow Wilson International Center for Scholars in Washington DC, 2009
- *Invited Panelist*, 2009 Upper Gila River Environmental Flows Science Forum, New Mexico Interstate Stream Commission, 2009
- *Participant*, Sandia National Labs 6300 Energy Systems Modeling Group, 2009
- *Participant*, Sandia National Labs 1400 Decision Support Roadmap, 2009
- *Invited Participant*, NSF Workshop on Megacities & Education, 2009
- *Invited Participant*, NSF Workshop on Opportunities and Challenges in Uncertainty Quantification for Complex Interacting Systems, 2009
- *Invited Participant*, Military Operations Research Society (MORS) Workshop on Risk-Informed Decision Making, 2009
- *Participant*, Sandia National Laboratories Systems Dynamics Guild, 2009
- *Invited Participant*, University of Southern California Workshop on Megacities, 2008
- *Team Lead*, Sandia Complex Adaptive Systems of Systems Roadmap, 2007-2008
- *Invited Participant*, NSF Workshop on Complex Interacting Systems for a Sustainable Future, June, 2007
- *Organizing Committee Member*, Sandia Workshop on Agent Based, Discrete and Game Modeling, 2007-2008
- *Invited Panelist*, Modeling Community Containment for Pandemic Influenza Workshop, Institute of Medicine of the National Academies of Science, Washington, DC., October, 2006
- *Chief Coordinator*, 2006 Upper Gila River Environmental Flows Science Forum, New Mexico Interstate Stream Commission, 2006-2007
- *Invited Panelist*, New Directions for Understanding Systemic Risk, National Academies of Science and the Federal Reserve Bank of New York, New York, May, 2006
- *Member*, Sandia Laboratory Directed Research and Development Evaluation Committee, 2005
- *Invited Member*, Committee of Visitors, Basic Energy of Sciences, Department of Energy, 2005
- *Participant*, Sandia National Laboratories Energy Futures Workshop, 2005
- *Associate Editor*, Vadose Zone Journal, 2003 to 2004
- *Organizing Committee Member*, Gordon Research Conference on Modeling Flow through Permeable Media, 2002 to 2004
- *Advisory Board Member*, Idaho National Engineering and Environmental Laboratory's Subsurface Science Initiative focused on the Vadose Zone, 2000 to 2004
- *Working Group Member*, Sandia Geosciences Research and Development, 2000 to 2002
- *Invited Participant*, DOE complex wide Vadose Zone Roadmap formulation, 2000
- *Co-Author*, White Paper for DOE's Basic Energy Sciences Geosciences Program on Subsurface Computational Initiative, 1998
- *Co-Organizer*, Symposium in Nonlinear Processes in the Geosciences, DOE Basic Energy Sciences, 1997

- *Member*, Sandia National Laboratories Recruitment Committee, 1995-1997
- *Reviewer* for BMC Public Health, Journal of Epidemiology, Emerging Infectious Diseases, Water Resources Research, Advances in Water Resources, Journal of Contaminant Hydrology, Journal of Hydrology, Vadose Zone Journal, Geophysical Research Letters, and proposals for NSF, DOE, PRE, WWRA and EPA.

PEER REVIEWED JOURNAL PUBLICATIONS

76. Renault, F., W.E. Beyeler, R.J. Glass, K. Soramäki and M.L. Bech, Congestion and Cascades in Interdependent Payment Systems, *International Journal of Central Banking*, in review.

75. Fox, D.T., R.J. Glass, T.Q. Wood, Mechanisms Causing Pressure-Saturation Hysteresis in a Horizontal Unsaturated Rough Walled Fracture, *Water Resources Research*, in review.

74. Perlroth, Daniella J., Robert J. Glass, Victoria J. Davey, Alan M. Garber, Douglas K. Owens, Health Outcomes and Costs of Community Mitigation Strategies for an Influenza Pandemic in the U.S, *Clinical Infectious Diseases*, http://www.journals.uchicago.edu/doi/abs/10.1086/649867, 50:165–174, DOI: 10.1086/649867, *expedited publication*, 2010.

73. Feighner BH, Eubank S, Glass RJ, Davey VJ, Chrétien J-P, Gaydos JC. Infectious disease modeling and military readiness, *Emerging Infectious Diseases,* http://www.cdc.gov/eid/content/15/9/e1.htm, Volume 15, Number 9, September 2009.

72. Detwiler, R. L., H. Rajaram, and R. J. Glass (2009), Interphase mass transfer in variable aperture fractures: Controlling parameters and proposed constitutive relationships, *Water Resources Research*, 45, W08436, doi:10.1029/2008WR007009, 2009.

71. Davey, V.J., R.J. Glass, H.J. Min, W.E. Beyeler and L.M. Glass, Effective, Robust Design of Community Mitigation for Pandemic Influenza: A Systematic Examination of Proposed U.S. Guidance, *PLoSOne*, http://www.plosone.org/article/fetchArticle.action?articleURI=info:doi/10.1371/journal.pone.0002606, 3(7): e2606. doi:10.1371/journal.pone.0002606, *highly accessed*, 2008.

70. Glass, L.M., and R.J. Glass, Social contact networks for the spread of pandemic influenza in children and teenagers, *BMC Public Health*, http://www.biomedcentral.com/1471-2458/8/61, BMC Public Health, 8:61, doi:10.1186/1471-2458-8-61, February 14, 2008.

69. Davey, V.J., and R.J. Glass, Rescinding Community Mitigation Strategies in an Influenza Pandemic, *Emerging Infectious Diseases*, http://www.cdc.gov/eid/content/14/3/365.htm, Volume 14, Number 3, March 2008.

68. Beyeler W.E., R.J. Glass, M.L. Bech, and Soramäki K., Congestion and cascades in payment systems, *Physica A,* 15 Oct. 2007; v.384, no.2, p.693-718.

67. Soramäki K., M.L. Bech, J. Arnold, R.J. Glass, and W.E. Beyeler, The topology of interbank payment flows, *Physica A,* 1 June 2007; vol.379, no.1, p.317-33.

66. Glass, R.J., L.M. Glass, W.E. Beyeler, and H.J. Min, Targeted social distancing design for pandemic influenza, *Emerging Infectious Diseases*, http://www.cdc.gov/ncidod/EID/vol12no11/06-0255.htm, Vol. 12, No. 11, *expedited publication*, November 2006.

65. Ji, S-H; Nicholl, M.J.; Glass, R.J.; Lee, K-K, Influence of simple fracture intersections with differing aperture on density-driven immiscible flow: Wetting versus nonwetting flows, *Water Resources Research*, v.42, no.10, October 2006.

64. LaViolette, R.A., W.E. Beyeler, R.J. Glass, K.L. Stamber, and H.Link, Sensitivity of the resilience of congested random networks to rolloff and offset in truncated power-law degree distributions, *Physica A*, 1 Aug. 2006; vol.368, no.1, p.287-93.

63. Nicholl, M.J., and R.J. Glass, Experimental observations of gravity-driven fingering during immiscible displacements within a rough-walled fracture, *Vadose Zone Journal,* 4 (4): 1123-1151 NOV 2005.

62. Detwiler, R., H. Rajaram, and R.J. Glass, Satiated relative permeability of variable aperture fractures, *Physical Review E.*, 71 (3): Art. No. 031114 Part 1 MAR 2005.

61. Wood, T.R., M.J. Nicholl, and R.J. Glass, Influence of fracture intersections under unsaturated, low flow conditions, *Water Resources Research*, 41 (4): Art. No. W04017 APR 27 2005.

60. Glass, R.J., J.R. Brainard, and T-C.J. Yeh, Infiltration in unsaturated layered fluvial deposits at Rio Bravo: Macroscopic anisotropy and heterogeneous transport, *Vadose Zone Journal*, 4 (1): 22-31 FEB 2005.

59. LaViolette, R.A., R.J. Glass, D. Peak, and D.L. Stoner, Self organized network of chemical reactions: A Model of contaminated converging and diverging flows in fractured media*, Journal of Physical Chemistry B*, 108, 19657-19662, 2004.

58. LaViolette, R.A., and R.J. Glass, Self organized spatial-temporal structure within the fractured vadose zone: Influence of dynamic overloading at fracture intersections, *Geophysical Review Letters*, 31, L18501, doi:10.1029/2004GL020659, 2004.

57. Glass, R.J., and R.A. LaViolette, Self organized spatial-temporal structure within the fractured vadose zone: Influence of fracture intersections, *Geophysical Review Letters*, 31, L15501, doi:10.1029/2004GL019511, 2004.

56. Ji, S.-H., M.J. Nicholl, R.J. Glass, and K.-K. Lee, Influence of a simple fracture intersection on density-driven immiscible flow: Wetting vs. nonwetting flows, *Geophysical Research Letters*, 31, L14501, doi:10.1029/2004GL020045, 2004.

55. Glass, R.J., M.J. Nicholl, H. Rajaram, and B. Andre, Development of slender transport pathways in unsaturated fractured rock: Simulation with Modified Invasion Percolation, *Geophysical Review Letters*, 31, L06502, doi:10.1029/2003GL019252, 2004.

54. Wood, T.R., R.J. Glass, T.R. McJunkin, R.K. Podgorney, R.A. Laviolette, K.S. Noah, D.L. Stoner, R.C. Starr, and K. Baker, Unsaturated Flow Through a Small Fracture-Matrix Network: Part 1, Experimental Observations, *Vadose Zone Journal,* 3:90-100, 2004.

53. Glass, R.J., H. Rajaram, R.L. Detwiler, Immiscible displacements in rough-walled fractures: Competition between roughening by random aperture variations and smoothing by in-plane curvature, *Physical Review E*, doi: 10.1103/PhysRevE.68.061110, 2003.

52. Glass, R.J, M.J. Nicholl, H. Rajaram, and T.R. Wood, Unsaturated flow through fracture networks: Evolution of liquid phase structure, dynamics, and the critical importance of fracture intersections, *Water Resources Research*, 39(12), 1352, doi:10.1029/2003WR002015, 2003.

51. Detwiler, R., R.J Glass and W.L. Bourcier, Experimental observations of fracture dissolution: the role of Peclet number on evolving aperture variability, *Geophysical Research Letters*, 30(12), 1648, doi:10.1029/2003GL017396, 2003.

50. Holt, R.M., R.J. Glass, J.M. Sigda, and E.D. Mattson, Influence of centrifugal forces on phase structure in partially saturated media, *Geophysical Research Letters*, 30(13), 1692, doi:10.1029/2003GL017340, 2003.

49. Eliassi, M., and R.J. Glass, Reply to Comment by DPCSS on: On the continuum-scale simulation of gravity-driven fingers in unsaturated porous media: The inadequacy of the Richards equation with standard monotonic constitutive relations and hysteretic equations of state, *Water Resources Research*, 39(9), 1263, doi:10.1029/2002WR001785, 2003.

48. Eliassi, M., and R.J. Glass, Reply to Comment by B&N on: On the continuum-scale simulation of gravity-driven fingers in unsaturated porous media: The inadequacy of the Richards equation with standard monotonic constitutive relations and hysteretic equations of state, *Water Resources Research*, 39(9), 1250, doi:10.1029/2002WR001753, 2003.

47. Ji, S.H., I.W. Yeo, K.K. Lee, and R.J. Glass, Influence of ambient groundwater flow on DNAPL migration in a fracture network: Experiments and simulations, *Geophysical Research Letters*, 30(10), 1504, doi:10.1029/2003GL017064, 2003.

46. Eliassi, M., and R.J. Glass, On the porous continuum-scale simulation of gravity-driven fingers in unsaturated materials: Numerical solution of a hypo-diffusive governing equation that incorporates a hold-back-pile-up effect, *Water Resources Research*, 39(6), 1167, doi:10.1029/2002WR001535, 2003.

45. Tidwell, V.C., R.J. Glass, C. Chocas, G. Barker, and L. Orear. Capillary barrier performance: Experiments in context of Yucca Mountain emplacement drifts, *Journal of Contaminant Hydrology,* 62-63:287-301, 2003.

44. Glass, R.J, and L. Yarrington, Mechanistic modeling of fingering, nonmonotonicity, fragmentation, and pulsation within gravity/buoyant destabilized two-phase/unsaturated flow, *Water Resources Research*, 39(3), 1058, doi:10.1029/2002WR001542, 2003.

43. Holt, R.M., J.L. Wilson, and R.J. Glass, Error in unsaturated stochastic models parameterized with field data, *Water Resources Research,* 39(2), 1028, doi:10.1029/2001WR000544, 2003.

42. LaViolette, R.A, R.J. Glass, T.R. Wood, T. R. McJunkin, K. S. Noah, R. K. Podgorney, R. C. Starr, and D. L. Stoner, Convergent flow observed in a laboratory-scale unsaturated fracture system, *Geophysical Research Letters*, 30(2), 1083, doi:10.1029/2002GL015775, 2003.

41. Wood, T.R., M.J. Nicholl, and R.J. Glass, Fracture intersections as integrators for unsaturated flow, *Geophysical Research Letters*, 29(24), 2191, doi:10.1029/2002GL015551, 2002.

40. Glass, R.J., M.J. Nicholl, S.E. Pringle, and T.R. Wood, Unsaturated flow through a fracture-matrix-network: Dynamic preferential pathways in meso-scale laboratory experiments, *Water Resources Research*, 38(12), 1281, doi:10.1029/2001WR001002, 2002.

39. Yeh, T.-C. J., S. Liu, R.J. Glass, K. Baker, J. Brainard, D. Alumbaugh, and D. LaBreque, A geostatistically based inverse model for electrical resistivity surveys and its applications to vadose zone hydrology, *Water Resources Research*, 38(12), 1278, doi:10.1029/2001WR001204, 2002.

38. Holt, R. M., J.L. Wilson, and R.J. Glass, Spatial bias in field-estimated unsaturated hydraulic properties, *Water Resources Research,* 38(12), 1311, doi:10.1029/2002WR001336, 2002.

37. Alumbaugh, D., L.Paprocki, J.R. Brainard, R.J. Glass, and C. Rautman, Estimating initial moisture contents using cross-borehole ground penetrating radar: A study of accuracy and repeatability, *Water Resources Research*, 38(12), 1309, doi:10.1029/2001WR000754, 2002.

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27. Roepke, C., R.J. Glass, J. Brainard, M. Mann, K. Kriel, R. Holt and J. Schwing, Transport Processes Investigation: A necessary first step in site scale characterization plans, *Proceedings of Waste Management 95*, Feb 26 - March 7, Tucson, AZ, session 27, paper #20, 1995 (SNL paper SAND95-0289C).

26. Nicholl, M.J. and R.J. Glass, Effective media models for unsaturated fractured rock: A field experiment, *Proc. 6th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 30 - May 5, Las Vegas, NV, pp. 39-40, 1995 (SNL paper SAND94-2826C).

25. Glass, R.J., and M.J. Nicholl, Near drift two-phase flow processes within regionally saturated fractured rock, *Proc. 6th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 30 - May 5, Las Vegas, NV, pp. 212-216, 1995 (SNL paper SAND94-2873C).

24. Glass, R.J., V.C. Tidwell, A.L. Flint, W.P. Peplinski, and Y. Castro, Fracture-matrix interaction in Topopah Spring Tuff: Experiment and Numerical Analysis, *Proc. 5th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, May 22-26, Las Vegas, NV, pp. 1905-1914, 1994 (SNL paper SAND94-0443C).

23. Nicholl, M.J., and R.J. Glass, 1994, Wetting phase permeability in a partially saturated horizontal fracture, *Proc. 5th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, May 22-26, Las Vegas, NV, pp. 2007-2019, 1994 (SNL paper SAND93-2774C).

22. Ho, C.K., K.S. Maki and R.J. Glass, Studies of non-isothermal flow in saturated and partially saturated porous media, *Proc. 5th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, May 22-26, Las Vegas, NV, pp. 2481-2491, 1994 (SNL paper SAND93-4045C).

21. Martin, K.A., D.C. Baird, and R.J. Glass, Infiltration into thick unsaturated alluvial deposits: a preliminary study, *Proc. of the 1993 National Conf. on Hydraulic Engineering and International Symposium on Engineering Hydrology*, San Francisco, CA, July 25-30, 1993, Engineering Hydrology Volume, pp. 174-179, 1993.

20. Nicholl, M.J., R.J. Glass, and H.A. Nguyen, Small-scale behavior of single gravity driven fingers in an initially dry fracture, *Proc. 4th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 26-30, Las Vegas, NV, pp. 2023-2033, 1993 (SNL paper SAND92-2790C).

19. Nicholl, M.J., R.J. Glass, and H.A. Nguyen, Wetting front instability in an initially wet unsaturated fracture, *Proc. 4th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 26-30, Las Vegas, NV, pp. 2061-2071, 1993 (SNL paper SAND92-2791C).

18. Glass, R.J., Modeling gravity driven fingering in rough-walled fractures using modified percolation theory, *Proc. 4th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 26-30, Las Vegas, NV, pp. 2042-2053, 1993 (SNL paper SAND92-2792C).

17. Reimus, P.W., R.J. Glass, and B.A. Robinson, Aperture characteristics, saturated fluid flow, and tracer transport calculations for a natural fracture, *Proc. 4th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 26-30, Las Vegas, NV, pp. 2009-2017, 1993 (SNL paper SAND92-2793C).

16. Foltz, S.D., V.C. Tidwell, R.J. Glass, and S.R. Sobolik, Investigation of fracture matrix interaction: Preliminary experiments in a simple system, *Proc. 4th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 26-30, Las Vegas, NV, pp. 328-326, 1993 (SNL paper SAND92-2670C).

15. Springer, E.P., M.D. Siegel, P.L. Hopkins, and R.J. Glass, Testing models of flow and transport in unsaturated porous media, *Proc. 4th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 26-30, pp. 336-348, 1993 (SNL paper SAND92-2797C).

14. Norton, D.L., and R.J. Glass, Full-field dye measurement within saturated/unsaturated thin slabs of porous media, *Proc. 4th Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 26-30, Las Vegas, NV, pp. 1066-1075, 1993 (SNL paper SAND92-2795C).

13. Nicholl, M.J., R.J. Glass and H.A. Nguyen, Gravity-driven fingering in unsaturated fractures, *Proc. 3rd Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 12-16, Las Vegas, NV, pp. 321-331, 1992 (SNL paper SAND91-1985C).

12. Glass R.J., and D.L. Norton, Wetted region structure in horizontal unsaturated fractures, *Proc. 3rd Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 12-16, Las Vegas, NV, pp. 717-726, 1992 (SNL paper SAND91-2030C).

11. Tidwell, V.C. and R.J. Glass, X-ray absorption and transmitted light as two-dimensional, full-field moisture sensing techniques, *Proc. 3rd Int. Conf. of High Level Rad. Waste Manag.*, American Nuclear Society, April 2-16, Las Vegas, NV, pp. 1099-1110, 1992 (SNL paper SAND91-1983C).

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9. Siegel, M.D., P.L. Hopkins, and R.J. Glass, Design of an intermediate scale experiment to validate unsaturated-zone transport models, *Proc. 3rd Int. Conf. of High Level Rad. Waste Manag.*, American Nuclear Society, April 12-16, Las Vegas, NV, pp. 1972-1984, 1992 (SNL paper SAND91-2098C).

8. Glass, R.J., and V.C. Tidwell, Research program to develop and validate conceptual models for flow and transport through unsaturated, fractured rock, *Proc. 2nd Int. Conf. of High Level Rad. Waste Manage.*, American Nuclear Society, April 28 - May 3, Las Vegas, NV, pp. 977-987, 1991 (SNL paper SAND90-2261C).

7. Glass, R.J., Laboratory research program to aid in developing and testing the validity of conceptual models for flow and transport through unsaturated porous media, *Proc. of the GEOVAL-90 Symposium on Validation of Geosphere Flow and Transport Models*, Stockholm, Sweden, May 14-17, 1990, pp. 275-283, 1990 (SNL paper SAND89-2359C).

6. Bell, J., J.S. Selker, T.S. Steenhuis, and R.J. Glass, Rapid moisture measurements in thin sand slabs, *Am. Soc. Ag. Eng.* Paper No. 90-2635. ASAE St. Joseph, MI, 1990 (SNL paper SAND91-0476C).

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4. Parlange, J-Y., T.S. Steenhuis, R.J. Glass, T.L. Richard, N.B. Pickering, W.J. Waltman, N.O. Bailey, M.S. Andreini, and J.A. Throop, The flow of pesticides through preferential paths in soils, *New York's Food & Life Science Quarterly*, Cornell University, Ithaca, NY, Vol. 18, no. 1&2, pp. 21-24, 1988.

3. Glass, R.J., J-Y. Parlange, and T.S. Steenhuis, Water infiltration in layered soils where a fine textured layer overlays a coarse sand, *Proc. of the International Conference on Infiltration Development and Application*, Yu-Si Fok Editor, Water Resources Research Center, University of Hawaii, pp. 66-81, 1987.

2. Oosting, G.H., R.J. Glass, and T.S. Steenhuis, Preferential solute transport through layered soil systems, *Am. Soc. of Ag. Eng.* Paper No. 87-2624. ASAE, St. Joseph, MI, 1987.

1. Glass, R.J. and T.S. Steenhuis, Factors influencing infiltration flow instability and movement of toxics in layered sandy soils, *Am. Soc. of Ag. Eng.*, Paper No. 84-2508, ASAE, St. Joseph, MI, 1984.

INVITED SCIENTIFIC PRESENTATIONS

60. Plenary Session of the 2011 Association for Public Policy Analysis and Management (APPAM) Fall Research Conference: Seeking Solutions to Complex Policy and Management Problems, Washington DC, "Designing Influence in Complex Adaptive Systems of Systems or CASoS Engineering," November 2011. [http://www.sandia.gov/CasosEngineering/docs/RJG_APPAM_11_4_11.pdf]

59. Plenary Session of the 6th IEEE International Conference on Systems of Systems Engineering (SoSE), Albuquerque, New Mexico, "Complex Adaptive Systems of Systems (CASoS) Engineering: Mapping Aspirations to Problem Solutions, June 28, 2011. [http://www.sandia.gov/CasosEngineering/docs/RJGlassSOSEpresentation_final.pdf]

58. Seminar in Interdisciplinary Biological and Biomedical Sciences (SiBBs), University of New Mexico, Albuquerque, New Mexico, University of New Mexico, "Introduction to Complex Adaptive Systems-of-Systems (CASoS) Engineering," March 2, 2011.

57. Communication Middleware for Monitoring Financial Critical Infrastructure – International Cooperation Aspects: 1st Workshop on Information Sharing for Financial IT Infrastructure: Barriers and Opportunities, Rome, Italy, "Engineering Change in Socio-Technical Systems," October 11, 2010. [http://www.sandia.gov/CasosEngineering/docs/CoMiFin_EngineeringChange_Glass_10_2010.pdf]

56. Seminar in Complex Systems, Department of Computer Science, University of New Mexico, Albuquerque, New Mexico, "Complex Adaptive Systems of Systems (CASoS) Engineering," April, 2010.

55. Center for Simulation and Modeling, Center for National Preparedness, the Department of Industrial Engineering and the Graduate School of Public Health, University of Pittsburgh, Pittsburgh, Pennsylvania, "Complex Adaptive Systems of Systems (CASoS) Engineering," December, 2009.

54. Plenary Session of the 2009 International System Dynamics Conference, Albuquerque, New Mexico, "Pandemic Influenza and Complex Adaptive System of Systems (CASoS) Engineering," July, 2009.

53. George Mason University and NSF Headquarters, Meeting on Megacities & Education, "Complex Adaptive Systems of Systems (CASoS) Engineering," July, 2009

52. The Network: How a map can prevent the next financial crisis, New Republic Magazine, Interview on "Financial Payment System Network Structure," June, 2009. [http://www.tnr.com/article/economy/the-network]

51. DHS-Economics Council, "Complex Adaptive Systems of Systems (CASoS) Engineering," April, 2009.

50. Military Operations Research Society (MORS) Workshop on Risk-Informed Decision Making, "Complex Adaptive Systems of Systems (CASoS) Engineering," April, 2009. [http://www.mors.org/events/rid.aspx]

49. NSF Workshop on Opportunities and Challenges in Uncertainty Quantification for Complex Interacting Systems, "Wrangling with Uncertainty in Complex Adaptive Systems of Systems (CASoS) Engineering," April, 2009. [http://venus.usc.edu/UQ-Workshop09/Glass.ppt]

48. University of Southern California Workshop on Megacities, "Designing Solutions in an Interdependent World: CASoS Engineering," November, 2008.[http://megacities.usc.edu/research/workshop-2008/]

47. University of Southern California, Los Angles, California, "Modeling Critical Infrastructures with Networked Agent-based Approaches," January, 2008.

46 Grinnell College, Grinnell Iowa*,* "Yucca Mountain and the Storage of High-Level Nuclear Waste", March 2007.

45. Modeling Community Containment for Pandemic Influenza, Institute of Medicine of the National Academies of Science, Washington, DC., "Design of community containment for pandemic influenza", October, 2006.
Workshop: http://www.iom.edu/CMS/3793/37624.aspx
Presentation: http://www.iom.edu/CMS/3793/37624/37630/38059/38116.aspx

44. New Directions for Understanding Systemic Risk, National Academy of Sciences and the Federal Reserve Bank of New York, "The Topology of Interbank Payment Flows," May, 2006
Workshop: https://www.newyorkfed.org/registration/research/risk/agenda.cfm
Presentation: https://www.newyorkfed.org/registration/research/risk/BechEtAl.ppt

43. Delft Technical University, Delft, Netherlands, "Critical Infrastructure Protection: Modeling, Simulation and Analysis," August, 2005.

42. University of Stockholm (KTH), Stockholm, Sweden, "Critical Infrastructure Protection: Modeling, Simulation and Analysis," August, 2005.

41. European Central Bank (ECB), Frankfurt, Germany, "Critical Infrastructure Protection: Modeling, Simulation and Analysis," August, 2005.

40. Center for the Experimental Study of Subsurface Environmental Processes, Colorado School of Mines, Golden Colorado, "Process Driven Structure in Subsurface Flow and Transport," September, 2003.

39. American Geophysical Union Fall 2002 Meeting, San Francisco, California, "Process based uncertainty in vadose zone flow and transport," December, 2002.

38. Gordon Research Conference on Modeling Flow through Permeable Media, Andover, New Hampshire, "Interaction of two-phases within fractures," August, 2002.

37. Department of Geological Engineering, University of Wisconsin, Madison Wisconsin, "Scientific Adventures in the Subsurface," May, 2002.

36. Department of Geology, University of Wisconsin, Madison, Wisconsin, "DNAPL Migration and Remediation Physics," May, 2002.

35. American Geophysical Union Fall 2001 Meeting, San Francisco, California, "Fingering, Nonmonotonicity, Fragmentation, and Pulsation Within Gravity/Buoyant Destabilized Unsaturated/Two-phase Flow Systems: Near-Pore Scale Simulation Using Modified Invasion Percolation," December, 2001.

34. Geological Society of America Annual Meeting 2000, Reno, NV, "Immiscible Displacements in Heterogeneous Porous Media, Fractures, and Fracture Networks: Experimental Systems and Modified Invasion Percolation Models," November, 2000.

33. Department of Civil Engineering, University of New Mexico, Albuquerque, New Mexico, "Process driven structure in subsurface flow and transport," October, 2000.

32. Department of Agricultural and Biological Engineering, University of Idaho, Moscow/Idaho Falls, Idaho, "Unsaturated flow through fractured rock: Experiments, processes and integrative thoughts," July, 2000.

31. Department of Geological Engineering and Sciences, Michigan Technological University, Houghton, Michigan, "Structure in subsurface flow and transport," July, 2000.

30. Department of Earth and Environmental Sciences, Hydrology Program, New Mexico Institute of Mining and Technology, Socorro, New Mexico, "Percolation approaches for two phase flow in porous and fractured media," March, 1998.

29. American Geophysical Union Fall 1997 Meeting, San Francisco, California, "Immiscible displacements in heterogeneous porous media, fractures and fracture networks: experimental systems and modified invasion percolation models," ***EOS Trans. AGU*** 78(46):273 (H32F-4), 1997.

28. Symposium on Pore Scale Processes, Los Alamos National Laboratory, Los Alamos, New Mexico, "Two-phase flow in fractures," April, 1997.

27. Department of Nuclear and Chemical Engineering, University of New Mexico, Albuquerque, New Mexico, "Subsurface Flow and Transport: Are our conceptual models correct?" March, 1997.

26. Geological Society of America Annual Meeting 1996, Denver, Colorado, "Challenging and improving conceptual models for isothermal flow in unsaturated, fractured rock through exploration of small scale processes," *GSA Abstracts*, 28(7) A-416, 1996.

25. Gordon Research Conference on Modeling Flow through Permeable Media, Andover, New Hampshire, "Process-Determined Structure in Subsurface Flow and Transport," August, 1996.

24. Geo-Environmental Engineering Program, the Pennsylvania State University, State College, Pennsylvania, "Process determined structure in subsurface flow and transport," March, 1996.

23. Symposium on Fluid-Rock Interaction, Oak Ridge National Laboratories, Oak Ridge, TN, "Multi-phase flow through fractured rock," February, 1996.

22. American Geophysical Union Fall 1995 Meeting, San Francisco, California, "Two-dimensional Imaging Techniques for Measurement of Saturation and Concentration Fields in Porous Media and Fractures," *EOS Trans. AGU* 76(46):225 (H31D-5), 1995.

21. Hydrology Program, Mackay School of Mines, University of Nevada, Reno, Nevada, "Process determined structure in subsurface flow and transport," September, 1995.

20. Symposium on two-phase flow in fractures, Lawrence Berkeley Laboratories, Berkeley, California, "Buoyant gas invasion into regionally saturated fractured rock from drifts," April, 1995.

19. Institute of Ecosystem Studies, Millbrook, New York, "Subsurface flow and transport: From pore to formation scale," March, 1995.

18. Department of Agricultural and Biological Engineering, Cornell University, Ithaca, New York, "Unsaturated, fractured rock... low potential for agriculture but high potential for a nuclear waste repository," March, 1995.

17. Department of Hydrology, University of Arizona, Tucson, Arizona, "Challenging conceptual models for two-phase flow through fractured rock," February, 1995.

16. Earth Sciences Division, Lawrence Berkeley Laboratory, Berkeley, California, "Two-phase flow through fractured rock," November, 1994.

15. Department of Civil and Environmental Engineering, the Pennsylvania State University, State College, Pennsylvania, "Flow and transport through unsaturated fractured rock," June, 1994.

14. International Symposium on Fingered flow in unsaturated soil: From field to model, DLO Staring Centre for Integrated Land, Soil and Water Research, Wageningen, Netherlands, "Physics of Immiscible Fluid Buoyant Fingering within Porous Media: Scaling of Fingered Flow Behavior," April, 1994.

13. Geosciences Department, Hydrology Program, New Mexico Institute of Mining and Technology, Socorro, New Mexico, "Flow and Transport through Unsaturated Fractured Rock Formations," April, 1994.

12. Department of Astronomy and Physics, University of New Mexico, Albuquerque, New Mexico, "Physics of Fingering in Porous Media," March, 1994.

11. Symposium on two-phase flow in fractures, Lawrence Berkeley Laboratories, Berkeley, California, Keynote address: "Two-phase flow in fractures: State of the art, laboratory perspective," November, 1993.

10. Department of Civil and Environmental Engineering, University of New Mexico, Albuquerque, New Mexico, "Experimental approaches for exploration of vadose zone processes," April, 1993.

9. NRC Workshop on Flow and Transport through Fractured Rock, University of Arizona, Tucson, Arizona, "Flow structure within unsaturated fractures and fractured rock," January, 1993.

8. Department of Hydrology, University of Arizona, Tucson, Arizona, "Percolation modeling of gravity driven fingering in porous media," April, 1992.

7. Hydrology Program, Mackay School of Mines, University of Nevada, Reno, Nevada, "The Physics of Gravity Driven Fingering in Unsaturated Fractures," April, 1991.

6. WERC Hazardous/Radioactive Waste Management Video Conference, University of New Mexico, Albuquerque, New Mexico, "Gravity Fingering," May, 1991.

5. Earth Sciences Division, Lawrence Berkeley Laboratory, Berkeley, California, "The Physics of Wetting Front Instability in Porous Media and Fractures: Analysis using Modified Invasion Percolation," December, 1989.

4. California Department of Food and Agriculture and University of California Department of Toxicology, Sacramento, California, "Implications of Rapid and Far Reaching Vadose Zone Hydrologic Processes on the Monitoring and Modeling of Subsurface Contaminant Transport," July, 1989.

3. Department of Agronomy, Cornell University, Ithaca, New York, "Preferential flow in the Layered Vadose Zone," May, 1989.

2. Geosciences Department, Hydrology Program, New Mexico School of Mines and Technology, Socorro, New Mexico, "The Physics of Wetting Front Instability in Layered Unsaturated Porous Media," February, 1989.

1. New Mexico Department of Health and Environment, Environmental Improvement Division (Superfund), Santa Fe, New Mexico, "Wetting Front Instability in Unsaturated Porous Media and its Implication for the Modeling and Monitoring Practices," January, 1989.

CONTRIBUTED PRESENTATIONS AT SCIENTIFIC MEETINGS

In addition to presentations made at conferences where a paper was published in conference proceedings (see sections above), the following presentations have been made at national/international conferences most with published abstracts. Project meetings, where many presentations have been made, are not included.

131. Victoria J. Davey, Daniel C. Cannon and Robert J. Glass, The Effect of Healthcare Environments on a Pandemic Influenza Outbreak, *2010 Conference on Modeling for Public Health Action: From Epidemiology to Operations*, Centers for Disease Control & Preparedness, Atlanta, GA, December 2010.

130. Jacob A. Hobbs, Daniel C. Cannon, Leland B. Evans, Victoria J. Davey, and Robert J. Glass, Loki-Infect 3: A Portable Networked Agent Model for Designing Community-Level Containment Strategies, *2010 Conference on Modeling for Public Health Action: From Epidemiology to Operations*, Centers for Disease Control & Preparedness, Atlanta, GA, December 2010.

129. Thomas W. Moore, John M. Linebarger, Patrick D. Finley, Roger Mitchell, Walter E. Beyeler, Victoria J. Davey, and Robert J. Glass, A Complex Adaptive Systems Modeling Framework for Public Health Action Exemplified by the Veterans Affairs Modeling Object Oriented Simulation Environment, *2010 Conference on Modeling for Public Health Action: From Epidemiology to Operations*, Centers for Disease Control & Preparedness, Atlanta, GA, December 2010.
[http://www.sandia.gov/CasosEngineering/docs/MPHA_136_Moore_with_backup.pdf]

128. Aldo A. Zagonel, George P. Richardson, Mohammad Mojtahedzadeh, Nancy S. Brodsky, Theresa J. Brown, Stephen H. Conrad, and Robert J. Glass, Developing a theory of the societal lifecycle of cigarette smoking: Explaining and anticipating trends using information feedback, *2010 Conference on Modeling for Public Health Action: From Epidemiology to Operations*, Centers for Disease Control & Preparedness, Atlanta, GA, December 2010.

127. Robert J. Glass, Arlo L. Ames, Thomas W. Moore, S. Louise Maffitt, and Victoria J. Davey, Defining and Evaluating Threats and Designing Strategies for VA Healthcare, *2010 VHA Comprehensive Emergency Management Program Evaluation and Research Conference*, May 4-5, 2010. .
[http://www.sandia.gov/CasosEngineering/docs/RJG-VA_CEMPER_5-6-2010.pdf]

126. Victoria J. Davey, Cannon DC, Robert J. Glass, The Effect of Health Care Environments on a Disease Outbreak, *AFHSC & DoD-GEIS & JHU/APL Infectious Disease Modeling Meeting*, January 6-7, 2010.
[http://www.sandia.gov/CasosEngineering/docs/IDMM_GEIS_Jan2010.pdf]

125. Perlroth DJ, Glass RJ, Davey VJ, Garber A, and Owens DK, Health Outcomes and Costs of Community Mitigation Strategies for an Influenza Pandemic in the U.S, *31st Annual Meeting of the Society for Medical Decision Making*, October, Los Angles, California, 2009 (*received best of conference award*).
[http://smdm.confex.com/smdm/2009ca/webprogram/Paper4883.html]

124. Victoria J. Davey, Robert J. Glass, H. Jason Min, Walter E. Beyeler and Laura M. Glass, Effective, Robust Design of Community Mitigation for Pandemic Influenza: A Systematic Examination of Proposed U.S. Guidance, *DoD-GEIS & JHU/APL Infectious Disease Modeling Meeting*, May 12-13, 2008.

123. WE Beyeler, K Soramäki and RJ Glass, Effect of Learning and Market Structure on Price Level and Volatility in a Simple Market, International Society of Dynamic Games Workshop, Rabat, Morocco September 2007.

122. F. Renault, WE Beyeler, RJ Glass **Congestion and Cascades in Coupled Payment Systems**, Bank of Finland 5th Payment and Settlement Simulation Seminar and Workshop. Helsinki, Finland, August 2007.

121. K Soramaki, WE Beyeler, ML Bech, RJ Glass, **Network Topology and Payment System Resilience - first results**, Bank of Finland 4th Payment and Settlement Simulation Seminar and Workshop, Helsinki, Finland, August 2006.

120. WE Beyeler, K Soramaki, ML Bech, RJ Glass, **Congestion and Cascades in Payment Systems**, Bank of Finland 4th Payment and Settlement Simulation Seminar and Workshop, Helsinki, Finland, August 2006.

119. K Soramaki, ML Bech, J Arnold, WE Beyeler, RJ Glass, Network relationships and network models in payment systems, Bank of Finland 3rd Payment and Settlement Simulation Seminar and Workshop, Helsinki, Finland, August 2005.

118. WE Beyeler, K Soramaki, ML Bech, RJ Glass, Modeling Banks' Payment Submittal Decisions, Bank of Finland 3rd Payment and Settlement Simulation Seminar and Workshop, Helsinki, Finland, August 2005.

117. RJ Glass, WE Beyeler, K Soramaki, ML Bech, J Arnold, Simulation and Analysis of Cascading Failure in Critical Infrastructure, Bank of Finland 3rd Payment and Settlement Simulation Seminar and Workshop, Helsinki, Finland, August 2005.

116. Glass, R.J., W.E. Beyeler, L.M. Glass, et al., Simulation and Analysis of Cascading Failure in Critical Infrastructure, In: *Working Together: R&D Partnerships in Homeland Security Conference*, Boston, May 2005. [http://www.sandia.gov/nisac/docs/Glass_annotatedpresentation.pdf]

115. Ji, S, Nicholl, M J Glass, R J, Lee, K The role of fracture intersections in DNAPL migration below the water table, *Eos Trans. AGU*, 84(46), Fall Meet. Suppl., Abstract H42F-1143, 2003.

114. Griffith, B C, Holt, R M, Glass, R J Generating Reproducible Heterogeneity for Laboratory Flow and Transport Experiments, *Eos Trans. AGU*, 84(46), Fall Meet. Suppl., Abstract H32A-0529, 2003.

113. Holt, R M, Glass, R J, Sigda, J M, Mattson, E D, Phase Structure in a Centrifugal Field: Impact of Capillary Heterogeneity and Angular Velocity, *Eos Trans. AGU*, 84(46), Fall Meet. Suppl., Abstract H22A-0909, 2003.

112. Fox, D.T., and R.J. Glass, Mechanisms for hysteresis in a horizontal unsaturated fracture with matrix imbibition, *EOS Trans. AGU* 83(47), Fall Meeting Supplement (H71B-0802), 2002.

111. Detwiler, R.L., H. Rajaram, and R.J. Glass, An investigation of the parameters controlling interphase mass transfer in variable aperture fractures, *EOS Trans. AGU* 83(47), Fall Meeting Supplement (H62G-08), 2002.
110. Cooper, C.C., R.J. Glass and S.W. Tyler, Multi Component Convection, *Gordon Research Conference on Modeling Flow through Porous media*, Andover, NH, August 7-11, 2002.

109. Nicholl, M.J., R.J. Glass, Fingering in Fractures, *Gordon Research Conference on Modeling Flow through Porous media*, Andover, NH, August 7-11, 2002.

108. Glass, R.J. and T.R. Wood, Transport within the earth's vadose zone: Process based issues for scaling, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (NG21A-0413), 2001.

107. Stoner, D.L., T.R. Wood, D. Peak, R.J. Glass, and R.A. LaViolette, The role of complexity in the prediction of contaminant transport in a fractured rock vadose zone, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (NG51A-0440), 2001.

106. Wood, T.R., T.R. McJunkin, R.K. Podgorney, R.J. Glass, R.C. Starr, D.L. Stoner, K.S. Noah, R.A. LaViolette, and J. Fairley, Assessment of surrogate fractured rock networks for evidence of complex behavior, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H52A-0364), 2001.

105. Nicholl, M.J., and R.J. Glass, Gravity destabilized fracture flow: Current understanding and extensions, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H52A-0366), 2001.

104. Eliassi, M., and R.J. Glass, Porous continuum-scale modeling of gravity-driven fingers in unsaturated porous materials: Extended flux laws and numerical simulations, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H52A-0377), 2001.

103. Orear, L., V.C. Tidwell, R.J. Glass, C.S. Chocas and G.T. Barker, Visual investigation of flow through a capillary barrier, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H52A-0378), 2001.

102. Pringle, S.E., R.J Glass, and M.J. Nicholl, Unsaturated flow through a fracture-matrix-network: Dynamic behavior of flow pathways, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H52E-01), 2001.

101. Brainard, J.R., T.-C. Yeh, and R.J. Glass, Infiltration into sandy alluvial deposits: Effects of moisture-dependent anisotropy? *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H31C-0263), 2001.

100. Fox, D.T., R.J. Glass, and K. Martinez, Pressure-saturation relations in a horizontal unsaturated fracture and the evolution of phase structure, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H12B-0290), 2001.

98. Detwiler, R.L., H. Rajaram, and R.J. Glass, An experimental and computational investigation of solute transport in satiated variable-aperture fractures, *EOS Trans. AGU* 82(47), Fall Meeting Supplement (H12B-0286), 2001.

97. Nicholl, M.J. and R.J. Glass, Current understanding of gravity-driven instability in discrete fractures, *2001 Annual meeting of the Geological Society of America*, Boston, MA, GSA Abstracts with programs, 11/1-11/10, 2001.

96. Glass, R.J., S.E. Pringle, and M.J. Nicholl, Unsaturated flow through a fracture-matrix network: Laboratory experiments at the meter scale, *2001 Annual meeting of the Geological Society of America*, Boston, MA, GSA Abstracts with programs,11/1-11/10, 2001.

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94. Nicholl, M.J. and R.J. Glass, Gravity destabilized fracture flow as a mechanism for rapid recharge in the vadose zone, *Eighth Biannual Unsaturated Zone Interest Group Meeting*, United States Geological Survey, Idaho Falls, Idaho, 7/30-8/2, 2001.

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RESEARCH FUNDING

Title: Integrating Community-Based Investigation with Systems-Based Conceptual and Computational Modeling to Understand and Prevent Childhood Obesity: An Interdisciplinary Synthesis
PIs: Davis (UNM), Glass (SNL)
Source of Support: National Institutes of Health Meeting Grant
Total Award Amount: 60K   **Total Award Period:**   FY 12-13
Location of Project: University of New Mexico and SNL

Title: A Complexity Science-Based Framework for Global Joint Operations Analysis to Support Force Projection
PIs: Lawton (SNL), Glass (SNL), Beyeler (SNL), Finley (SNL)
Source of Support: Laboratory Directed Research and Development, SNL
Total Award Amount: 1650K   **Total Award Period:**   FY 12-14
Location of Project: SNL

Title: Assessment and design of tobacco control policies through application of CASoS Engineering Principles
PIs: Glass (SNL), Brodsky (SNL)
Source of Support: Director for Center for Tobacco Products, Food and Drug Admin., US Dept. of Health and Human Services
Total Award Amount: 8300K   **Total Award Period:**   FY 10-14
Location of Project: SNL

Title: Design of robust and resilient public health policies for the VA community health with CASoS Engineering
PIs: Glass (SNL), Finley (SNL)
Source of Support: Chief Officer of Public Health and Environmental Hazards, US Department of Veterans Affairs
Total Award Amount: 3800K   **Total Award Period:**   FY 09-14
Location of Project: SNL

Title: Vulnerability of Multi-network Infrastructure to Cascading Failure: Design of Robustness to Orchestrated Attack using CASoS Engineering
PIs: Glass (SNL), Beyeler (SNL)
Source of Support: Laboratory Directed Research and Development, SNL
Total Award Amount: 1250K   **Total Award Period:**   FY 09-11
Location of Project: SNL

Title: Complex Adaptive Systems of Systems (CASoS) Engineering and Application to the Global Energy System
PIs: Glass (SNL), Beyeler (SNL), Goldsmith (SNL)
Source of Support: Laboratory Directed Research and Development, SNL
Total Award Amount: 1925K   **Total Award Period:**   FY 09-11
Location of Project: SNL

Title: Loki-Infect, a networked agent model for the design of influenza community containment policy
PIs: Glass (SNL)
Source of Support: Chief Officer of Public Health and Environmental Hazards, US Department of Veterans Affairs
Total Award Amount: 70K   **Total Award Period:**   FY 08-09
Location of Project: SNL

Title: Complex Adaptive Systems of Systems (CASoS) Engineering and Application to the Global Energy System
PIs: Glass (SNL)
Source of Support: Laboratory Directed Research and Development, SNL
Total Award Amount: 100K   **Total Award Period:**   FY 08
Location of Project: SNL

Title: Advanced Methods and Techniques Investigation (AMTI) for the modeling of National Infrastructure
PIs: Glass (SNL)
Source of Support: National Infrastructure Simulation and Analysis Center, US Department of Homeland Security
Total Award Amount: 3500K   **Total Award Period:**   FY 03-08
Location of Project: SNL

Title: Advanced conceptual models for unsaturated and two-phase flow in fractured rock
PIs: Nicholl (UI), Glass (SNL), Rajaram (UC), Wood (INL)
Source of Support: Environmental Management Science Program, US Department of Energy
Total Award Amount: 1100K   **Total Award Period:**   FY 03-05
Location of Project: SNL, University of Colorado, University of Idaho, INEEL

Title: The interaction of two fluid phases in fractured media
PIs: Glass (SNL), Rajaram (UC), Nicholl (UI)
Source of Support: Office of Basic Energy Sciences, Geosciences Program, US Department of Energy
Total Award Amount: 1200K   **Total Award Period:**   FY 02-04
Location of Project: SNL, University of Colorado, University of Idaho

Title: Physics of DNAPL migration and remediation in the presence of heterogeneities
PIs: Conrad (SNL), Glass (SNL)
Source of Support: Environmental Management Science Program, US Department of Energy
Total Award Amount: 900K   **Total Award Period:**   FY 01-04
Location of Project: SNL

Title: The physics of two-phase immiscible fluid flow in single fractures and fractured rock
PIs: Glass (SNL), Rajaram (UC), Nicholl (OSU)
Source of Support: Office of Basic Energy Sciences, Geosciences Program, US Department of Energy
Total Award Amount: 900K   **Total Award Period:**   FY 99-01
Location of Project: SNL, University of Colorado, Oklahoma State University

Title: Physics of DNAPL migration and remediation in the presence of heterogeneities
PIs: Conrad (SNL), Glass (SNL)
Source of Support: Environmental Management Science Program, US Department of Energy
Total Award Amount: 1200K   **Total Award Period:**   FY 97-00
Location of Project: SNL

Title: A hybrid hydrologic-geophysical inverse technique for the monitoring of leachates in the vadose zone
PIs: Alumbaugh (SNL), Glass (SNL), Yeh (UA), LaBrecque (UA)
Source of Support: Environmental Management Science Program, US Department of Energy
Total Award Amount: 2100K   **Total Award Period:**   FY 97-00
Location of Project: SNL and the University of Arizona

Title: New permameters for in situ characterization of unsaturated heterogeneous permeability
PIs: Wilson (NMT), Glass (SNL)
Source of Support: Environmental Management Science Program, US Department of Energy
Total Award Amount: 615K   **Total Award Period:**   FY 97-00
Location of Project: New Mexico Tech and SNL

Title: Two phase flow in fracture networks with field experimentation at Grimsel, Switzerland
PIs: Glass (SNL), Kinzelbach (ETH), Carrerra (Barcelona)
Source of Support: Internat'l Program, Office of Civilian Rad. Waste Management, US Department of Energy
Total Award Amount: 200K   **Total Award Period:**   FY 97-98
Location of Project: SNL, Grimsel Switzerland

Title: Two-phase immiscible fluid flow in fractured rock: The physics of flow processes in single fractures
PIs: Glass (SNL), Rajaram (UC)
Source of Support: Office of Basic Energy Sciences, Geosciences Program, US Department of Energy
Total Award Amount: 850K   **Total Award Period:**   FY 96-98
Location of Project: SNL and the University of Colorado

Title: Multi component convection in porous media
PIs: Glass (SNL), Tyler (UNR), Stockman (SNL)
Source of Support: Office of Basic Energy Sciences, Geosciences Program, US Department of Energy

Total Award Amount: 660K **Total Award Period:** FY 96-98
Location of Project: SNL and the University of Nevada at Reno

Title: Dense Non Aqueous Phase Liquid Migration
PIs: Glass (SNL), Conrad (SNL), Webb (SNL), Cox (SNL)
Source of Support: Laboratory Directed Research and Development, SNL
Total Award Amount: 900K **Total Award Period:** FY 94-96
Location of Project: SNL

Title: Kirkland Air Force Base Vadose zone characterization
PIs: Glass (SNL)
Source of Support: Environmental Restoration Program, Sandia National Laboratories
Total Award Amount: 500K **Total Award Period:** FY 93-95
Location of Project: SNL

Title: Transport Pathways Investigation
PIs: Glass (SNL)
Source of Support: Uranium in Soils Integrated Demonstration Project, US Department of Energy
Total Award Amount: 500K **Total Award Period:** FY 93-95
Location of Project: SNL and Fernald Ohio

Title: Near Drift Processes with field experimentation at the Hard Rock Laboratory, Sweden
PIs: Glass (SNL), Long (LBNL)
Source of Support: Internat'l Program, Office of Civilian Rad. Waste Management, US Department of Energy
Total Award Amount: 200K **Total Award Period:** FY 93-94
Location of Project: SNL

Title: Unsaturated Zone Model Development and Validation Task, Yucca Mountain Project
PIs: Glass (SNL)
Source of Support: Office of Civilian Radioactive Waste Management, US Department of Energy
Total Award Amount: 5000K **Total Award Period:** FY 89-95
Location of Project: SNL

GRADUATE STUDENT RESEARCH ADVISED

Victoria J. Davey, 2009, Ph.D. Uniformed Services University of the Health Sciences, 'Mitigation Strategies for Pandemic Influenza.' Currently Chief Officer of Public Health and Environmental Hazards at the US Department of Veterans Affairs.

Sung-Hoon Ji, 2004, Ph.D. Seoul National University, Seoul, Korea, 'Two phase flow in Fracture Networks.' Currently at the Korean Atomic Energy Research Institute, Republic of Korea.

Tyson Strand, 2003, Ph.D. Geology and Geophysics, University of Wisconsin, 'Pore-scale percolation modeling of two-phase flow in granular porous media.' Currently working in industry.

Kristine Baker, 2001, M.S. Hydrology, New Mexico Institute of Mining and Technology, 'Investigations of Direct and Indirect Hydraulic Property Laboratory Characterization Methods for Heterogeneous Alluvial Deposits: Application to the Sandia-Tech Vadose Zone Infiltration Test Site,' Currently a staff member at Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

Mehdi Eliassi, 2001, Ph.D. Nuclear and Chemical Engineering, University of New Mexico, 'On the continuum-scale numerical simulation of gravity-driven fingers in unsaturated porous materials,' Currently a staff member at Sandia National Laboratories, Albuquerque, New Mexico.

Scott E. Pringle, 2001, Ph.D. Civil Engineering, University of New Mexico, 'Experimental studies of two-solute double diffusive-finger convection in a Hele-Shaw cell,' Currently with a consulting firm in Irvine, California.

Donald Fox, 2001, M.S. Civil Engineering, University of New Mexico, 'Pressure/saturation relations in a horizontal unsaturated fracture and the evolution of phase structure,' Currently a staff member at Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

Russell L. Detwiler, 2000, Ph.D. Civil, Environmental, and Architectural Engineering, University of Colorado, 'An experimental and investigation of solute transport and nonaqueous-phase-liquid dissolution in discrete rough-walled fractures,' Currently staff member at Lawrence Livermore National Laboratories, Livermore, California.

Robert M. Holt, 2000, Ph.D. Hydrology, New Mexico Institute of Mining and Technology, 'Spatial bias in unsaturated hydraulic property estimates: Origin, impact, and relevance,' Currently an Associate Professor, Geological Engineering, University of Mississippi, Oxford, Mississippi.

Lirong Zhong, 1999, Ph.D. Geologic Engineering and Sciences, Michigan Institute of Technology, 'Surfactant enhanced non-aqueous phase liquids removal from saturated media,' Currently a staff member at the Pacific Northwest Laboratory, Hanford, Washington.

Clay A. Cooper, 1999, Ph.D. Hydrology, University of Nevada, Reno, 'Experimental investigation of double-diffusive finger convection in a Hele-Shaw cell,' Currently a staff member at the Desert Research Institute, Reno, Nevada.

James R. Brainard, 1997, M.S. Earth and Planetary Sciences, University of New Mexico, 'Vadose zone flow processes in heterogeneous alluvial fan deposits: Experimental design, data evaluation and error analysis,' Currently a staff member at Sandia National Laboratories, Albuquerque, New Mexico.

Craig Roepke, 1996, M.S. Hydrology, New Mexico Institute of Mining and Technology, 'Transport Processes Investigation: A necessary first step in site scale characterization,' Currently with the New Mexico Interstate Stream Commission.

Dennis L. Norton, 1995, Ph.D. Hydrology and Water Resources, University of Arizona, 'Evaluation, extension, and application of a full field light transmission technique for the investigation of hysteresis in thin homogeneous sand slabs,' Currently at large somewhere in the midwest.

Anne E. Carey, 1995, Ph.D. Hydrology, University of Nevada, Reno, 'Dispersion and electrolyte diffusion in sea water intrusion,' Currently an Associate Professor, Earth Sciences, Ohio State University, Columbus, Ohio.

Michael J. Nicholl, 1993, Ph.D. Hydrology, University of Nevada, Reno, 'Gravity driven instability in unsaturated fractures,' Currently an Associate Professor, Geological Sciences, University of Nevada, Las Vegas, Nevada.