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PROFILE - Updated 22 August 2018

I am the Data Analytics Science Leader at [Lincoln Agritech](#), Lincoln University (NZ), Associate Researcher at [Semeion Institute](#), (IT), and member of the [Center for Computational and Mathematical Biology](#), University of Colorado (USA). In these roles, my research *aim* is to provide transdisciplinary solutions to grand challenges in Earth and Environmental Systems Science. My research *objectives* are to characterize, predict, forecast, and interpret the influence of natural and human pressures on, and feedbacks among, the anthrosphere, atmosphere, biosphere, geosphere, and hydrosphere across spatiotemporal scales using computationally-intelligent workflows. Intelligent workflows combine artificial-adaptive systems (evolutionary and machine-learning) with process-based (numerical) and statistical models to produce a single transdisciplinary product that informs decision makers and drives adaption strategies for system sustainability. I participate in the design, collection, and integration of big data including direct (physical, chemical, biological) and indirect (geophysical and remote sensing) measurements to improve theory, scalability, and predictability.

Prior to my current roles, I successfully developed and applied Computationally-Intelligent workflows to answer questions in seven Earth and Environmental System themes: climate and land-use change, ecosystem, energy and minerals, natural hazards, solid-earth, and water science. This work resulted in 120 peer-reviewed publications, 148 conference presentations, and \$25M+ research grants. During this period, I had an H-index score of 11 and academic appointments as Adjoint Associate Professor in Mathematical and Statistical Sciences, University of Colorado, USA and School of Geography, Environment, and Earth Sciences, Victoria University, NZ. I served as Visiting Professor in Geosciences Institutes at the University of Brasilia and University of Campinas, BR; Center for Environmental Studies, University of Campinas, BR; and Member of the Center for Computational & Mathematical Biology, University of Colorado, USA; and held senior research positions with the Institute of Geological and Nuclear Science, NZ; and the US Geological Survey. I have ongoing research collaborations in AU, BR, CN, IT, NZ and USA.

EDUCATION

Degrees

PhD, Water Resources Science University of Minnesota	1999-2002
Dissertation: Estimation of coupled water, heat, & solute transport parameters	
MS, Geological Engineering University of Minnesota	1989-1991
Thesis: Simultaneous water and heat transfer model development and application	
MS, Geosciences, Geophysics/Hydrogeology University of Wisconsin	1983-1986
Thesis: A numerical investigation of Rayleigh-wave ground motion	
BS, Geology Geosciences	1979-1983

Postgraduate Training

MBA (mini), University of St Thomas, United States.	1996
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PROFESSIONAL EXPERIENCE

Academic Appointments

Associate Professor - Adjoint, Math & Statistical Sciences, University of Colorado	2014-2017
Associate Professor - Adjunct, Geog & Environmental Science, Victoria University	2014-2017
Associate Professor - Visiting, Geosciences Institute, University of Brasilia	2013
Associate Professor - Visiting, Geosciences Institute, University of Campinas	2013
Associate Professor - Visiting, Center Environ Studies, University of Campinas	2013
Associate Professor - Visiting, Center Meteor & Clim Res, University of Campinas	2012
Advisory Member, Center for Comp & Math Biol, University of Colorado	2010-2014
Instructor, Geography & Environmental Science, University of Colorado	2009
Assistant Professor - Visiting, Geosciences Institute, University of Brasilia	2008
Assistant Professor - Visiting, Environmental Sciences, University of Kuopio	2007
Member, Graduate School, Colorado School of Mines	2006-2009
Assistant Professor - Visiting, Middle East Peace Process, US Department of State	2006
Assistant Professor - Visiting, Hohai University	2005
Member, Graduate School, University of Colorado	2004-2009
Assistant Professor - Visiting, Energy and Fluid Sci, University of Central America	2003-2006
Assistant Professor - Visiting, Geology, Colorado College	2003
Research Assistant, US Army High Perform Comp Cent, University of Minnesota	1995-1996

Non-Academic Appointments

Associate Researcher, Earth and Environmental Systems, Semeion Institute	2018-present
Data Analytics Science Leader, Environmental Research, Lincoln Agritech Ltd	2017-present
Senior Hydrogeophysicist, Hydrogeology, Inst of Geological and Nuclear Sciences	2014-2017
Senior Research Geophysicist, (1) Crustal Geophysics & Geochemistry Science Center, and (2) Central Mineral & Environmental Resource, US Geological Survey	2005-2014
Visiting Scientist, Geoscience Australia, Groundwater Innovation, AU	2016
Visiting Scientist, Empresa Brasileira de Pesquisa Agropecuária, Satellite Mon, BR	2012
Visiting Scientist, Hydrogeology & Water Economy Institute, KG	2010
Visiting Scientist, USGS National Training Center, USA	2010
Visiting Scientist, Geological Survey of Brazil, Groundwater Section, BR	2008
Senior Research Hydrologist, Colorado Water Science Center, US Geological Survey	2001-2005
Supervisory Res Hydrologist, Illinois Water Science Center, US Geological Survey	1997-2001
Research Geophysicist, Geotechnology, US Bureau of Mines	1986-1997

PROFESSIONAL ACTIVITY

Research prizes, fellowships, awards and appointments

Foreign travel grant, North Atlantic Treaty Organization	2018-2007
Letter of appointment, Southern University of Science and Technology, China	2017-present
Foreign travel grant, US Department of State, USA	2014-
Leadership Training (20 of 10,000 employees), US Geological Survey, USA	2013
Foreign travel grants, North Atlantic Treaty Organization, Turkey & Azerbaijan	2007

PUBLICATIONS (* ISI Web of Science)

1. Iwashita, F., **Friedel, M.J.**, Ferreira, F.J.F, 2017, A self-organizing map approach to characterize hydrogeologic properties of the Serra-Geral transboundary fractured aquifer, Hydrology Research Journal. DOI: 10.2166/nh.2017.221 [IF: 1.8] *
2. **Friedel, M.J.**, Buscema, M., Vicente, E., Iwashita, F., Koga-Vicente, A., 2017, Mapping fractional soils and vegetation components from Hyperion satellite imagery using an unsupervised machine-learning workflow, International Journal of Digital Earth, 11(7), 670-690. .10.1080/17538947.2017.1349841 [IF: 3.0] *
3. **Friedel, M.J.**, 2016, Estimation and scaling of hydrostratigraphic units: application of unsupervised machine learning and multivariate statistical techniques to hydrogeophysical data, Hydrogeology Journal, 24, 2103-2122. doi: 10.1007/s10040-016-1452-5. [IF: 2.1] *
4. Tindall, J., **Friedel, M.J.**, 2016, Transport of Atrazine and Dicamba through silt and loam soils, Global Journal of Earth Science and Engineering, 3, 27-42. DOI: 10.15377/2409-5710.2016.03.01.3 [IF: 1.1] *
5. Tindall, J., **Friedel, M.J.**, 2016, Transport of Atrazine versus Bromide and δO^{18} in sand, Journal Water, Air, & Soil Pollution, 227-294. DOI 10.1007/s11270-016-2983-z. [IF: 1.7] *
6. **Friedel, M.J.**, Esfahani, A., Iwashita, F., 2015, Toward real-time 3D mapping of surficial aquifers using a hybrid modeling approach, Hydrogeology Journal, 24(1), 211-229. [IF: 2.1] *
7. Esfahani, A.A., **Friedel, M.J.**, 2014, Forecasting conditional climate-change using a hybrid approach, Environmental Modelling & Software, 52, 83-97. [IF: 4.4] *
8. **Friedel, M.J.**, 2014, Data-driven modeling of background and mine-related acidity and metals in river basins, Environmental Pollution, 184, 530-539. [IF: 5.1] *
9. Moreira, L.P., **Friedel, M.J.**, França G.S., 2013, Uncertainty analysis in the joint inversion of receiver function and surface-wave dispersion, Paraná Basin, southeast Brazil. Bulletin of Seismological Society of America, 103 (3), 1981-1992. [IF: 2.1] *
10. **Friedel, M.J.**, Iwashtia, F., 2013, Hybrid modeling of spatial continuity for applications to environmental inverse problems, Environmental Modelling & Software, 43, 60-79. [IF: 4.4] *
11. **Friedel, M.J.**, 2012, Hybrid modeling to predict the economic feasibility of mining undiscovered porphyry copper deposits. Applied Soft Computing 13, 1016-1032. [IF: 3.5] *
12. **Friedel, M.J.**, 2012, Data-driven modeling of surface temperature anomaly and solar activity trends, Environmental Modelling & Software, 37, 217-232. [IF: 4.4] *
13. **Friedel, M.J.**, Souza, O.F., Iwashita, F., Yoshinaga, S. P, Silva, A M, 2012, Data-driven modeling for groundwater exploration in fractured crystalline terrain, Northeast Brazil, Hydrogeology Journal, 20(6), 1061-1080. [IF: 2.1] *
14. **Friedel, M.J.**, Asch, T., Oden, C. 2012, Hybrid analysis of multiaxis electromagnetic data for discrimination of munitions and explosives of concern. Geophysical Journal International, 190(2), 960-980. [IF: 2.4] *

15. Iwashita, F., **Friedel, M.J.**, Rebeiro, G.F., Fraser, S.J., 2012, Intelligent estimation of hydrogeologic properties, *Geoderma*, 170, 1-10. [IF: 4.0] *
16. **Friedel, M.J.**, 2011, Modeling hydrologic and geomorphologic responses across post-fire landscapes using a self-organizing map approach, *Environmental Modeling and Software*, 26(12), 1660-1674. [IF: 4.4] *
17. **Friedel, M.J.**, 2011, A data-driven approach for modeling post-fire debris-flow volumes and their uncertainty, *Environmental Modelling & Software*, 26(12), 1583-1598. [IF: 4.4]
18. Iwashita, F., **Friedel, M.J.**, Souza-Filho, C.R., Fraser, S.J., 2011. Hillslope chemical weathering across Paraná, Brazil: A data mining-GIS hybrid approach. *Geomorphology* 132(3-4), 167-175. [IF: 2.7] *
19. **Friedel, M.J.**, 2008, Regularized joint inverse estimation of extreme rainfall events in ungaged coastal basins of El Salvador, *Natural Hazards Journal*, 46(1), 15-34. [IF: 1.8] *
20. **Friedel, M.J.**, Smith, M.E., Erazo, A.M., and Litke, D., 2008, Probable flood predictions in ungaged coastal basins of El Salvador, Special issue: Methodologies in Hydrologic Modeling, *Journal of Hydrologic Engineering*, 13(5), 321-332. [IF: 1.8] *
21. Figueroa, M., Tindall, J.A., and **Friedel, M.J.**, 2007, Comparison of $^{18}\text{O}\delta$ composition of water extracted from suction lysimeters, centrifugation, and azeotropic distillation, *Journal Water, Air, & Soil Pollution*, 184(1-4), 63-75. [IF: 1.7] *
22. Liu, L., **Friedel, M.J.**, and Tindall, J.A., 2007, Biodegradation of PAHs and PCBs in soils and sludges, *Journal of Water, Air, & Soil Pollution*, 181(1-4), 281-296. [IF: 1.7] *
23. Liu, L., Tindall, J.A., **Friedel, M.J.**, and Zhang, W., 2007, Biodegradation of organic chemicals in soil/water microcosms system: model development, *Journal of Water, Air, & Soil Pollution*, 178(1-4), 131-143. [IF: 1.7] *
24. **Friedel, M.J.**, 2006, Predictive streamflow uncertainty in relation to calibration-constraint information, model complexity, and model bias, *International Journal of River Basin Management*, 4(1), 1-15. [IF: 1.8] *
25. Tindall, J.A., Weeks, E.P., **Friedel, M.J.**, and Nutt, A., 2005, Part 2: A field study of enhanced remediation of toluene in the vadose zone via a nitrate-rich nutrient solution, *Journal of Water, Air, & Soil Pollution*, 168(1-4), 359-389. [IF: 1.6] *
26. Tindall, J.A., **Friedel, M.J.**, Szmajter, R.J., and Cuffin, S.M., 2005, Part 1: Enhanced Bioremediation of Toluene in the Unsaturated Zone of A Shallow Unconfined Aquifer, *Journal of Water, Air, & Soil Pollution*, 168(1-4), 325-357. [IF: 1.6] *
27. Stearns, M., Tindall, J.A., Cronin, G., **Friedel, M.J.**, and Berquist E., 2005, Effects of Coal-Bed Methane Discharge Waters on the Vegetation and Soil Ecosystem in Powder River Basin, Wyoming, *Journal of Water, Air, & Soil Pollution*, 167(1-4), 33-57. [IF: 1.6] *
28. **Friedel, M.J.**, 2005, Coupled inverse modeling of vadose zone water, heat, and solute transport: calibration constraints, parameter nonuniqueness, and predictive uncertainty, *Journal of Hydrology*, 312(1-4), 148-175. [IF: 3.5] *
29. Scott, D.F., Williams, T.J., **Friedel, M.J.**, and Denton, D.K., 1999, Seismic tomography as a tool for measuring stress in mines, *Mining Engineering*, 51(1), 77-80. [IF: 1.0] *
30. **Friedel, M.J.**, Scott, D.F., and Williams, T.J., 1996, Temporal imaging of mine-induced stress changes using seismic tomography, *Journal of Engineering Geology*, 46, 131-141. [IF: 2.6] *
31. Scott, D.F., Williams, T.J., **Friedel, M.J.**, and Denton, D.K., 1997, Relative stress conditions in an underground pillar, Homestake Mine, Lead, SD, *International Journal of Rock Mechanics and Mining Sciences*, 34(3), 653-654. [IF: 2.3] *
32. **Friedel, M.J.**, Scott, D.F., Jackson, M.J., Williams, T.J., 1996, 3-D tomographic imaging of anomalous conditions in a gold mine, *Journal of Applied Geophysics*, 36(1), 1-17. [IF: 1.4] *

33. **Friedel, M.J.**, Jackson, M.J., and Olson, M.S., 1996, Tomographic imaging of coal pillar behavior: observations and implications. *International Journal of Rock Mechanics and Mining Science*, 33(1), 279-290. [IF: 2.3] *
34. **Friedel, M.J.**, Jackson, M.J., Scott, D.F., and Williams, T.J., 1995, 3-D tomographic imaging of anomalous conditions in a deep silver mine, *Journal of Applied Geophysics*, 34(1), 1-21. [IF: 1.4] *
35. **Friedel, M.J.**, 1993, Scale-Dependence in the hydrologic design of in situ copper leaching operations. *Society for Mining, Metallurgy, and Exploration Transactions*; 294, 1918-1926. [IF: 1.2]
36. Hanson, J.C., Tweeton, D.R., **Friedel, M.J.**, and Dahl, L., 1993, A geophysical field experiment for detecting and monitoring conductive fluids. *Geophysics: The Leading Edge*. 12(9), 930-937. doi.org/10.1190/1.1436980 [IF: 1.6] *
37. **Friedel, M.J.**, and Schmidt, R.D., 1992, Effect of unsaturated conditions on the hydrology of in situ copper leaching, *Mining Engineering*, 2(11), 3-8. [IF: 1.1]
38. **Friedel, M.J.**, and Thill, R.E., 1991, U.S. Bureau of Mines Research on the Kasier Effect for determining stress in rock, *Journal of Acoustic Emission*, 10(1-2), S77-S89 [IF: 1.2]

Invited Book Chapters

39. **Friedel, M.J.**, 2011, Climate change effects on ecosystem services in the United States – issues of national and global security. In: Baba, A., Tayfur, G., Howard, K.W.F., Friedel, M.J., Chambel, A., 2011, *Climate Change and its Effect on Water Resources – Issues of National and Global Security*, NATO Science for Peace and Security Science Series C. Environmental Security, vol. 3, Springer, Dordrecht, The Netherlands, 318 p. DOI 10.1007/78-94-007-1143-3_1
40. **Friedel, M.J.**, 2006. Reliability in estimating urban groundwater recharge through the vadose zone: managing sustainable development in arid and semiarid regions. In: Tellam, J.H., Rivett, M.O., and Israfilov, R.G. (eds), *Urban groundwater management and sustainability*. NATO Science Series, IV. Earth and Environmental Sciences, Springer, Dordrecht, The Netherlands, vol. 74, 169-182.
41. **Friedel, M.J.**, 2006, Urbanization effects on ecological integrity in the Upper Illinois River Basin, USA. In: Baba, A., Howard, K.W.F., and Gunduz, O. (eds), 2006, *Groundwater and Ecosystems*, NATO Science Series, IV. Earth and Environmental Sciences – vol. 70, Springer, Dordrecht, The Netherlands, 71-92
42. Westman, E., **Friedel, M.J.**, Williams, E., and Jackson, M.J. 1995, Seismic tomography to image coal structure stress distribution. U.S. Bureau of Mines Technology Transfer Seminar: Mechanics and Mitigation of Violent Failure in Coal and Hard Rock Mines, of Coal Pillar Behavior, U.S. Bureau of Mines Special Publication 01-95, Coeur d' Alene, ID; Price, UT, Norton, VA; May, pp.105-119.
43. Scott, D.F., **Friedel, M.J.**, Jackson, M.J., and Williams, E., 1995, Use of Tomographic imaging as a tool to identify areas of high stress in remnant ore pillars in deep underground mines. U.S. Bureau of Mines Technology Transfer Seminar: Mechanics and Mitigation of Violent Failure in Coal and Hard Rock mines, of Coal Pillar Behavior, U.S. Bureau of Mines Special Publication, 01-95, Coeur d' Alene, ID; Price, UT, Norton, Va; May, pp. 323-335.

Refereed Reports

44. **Friedel, M.J.**, Moreira, L.P., 2016, Joint-inverse framework with PEST examples to improve subsurface modeling. GNS Science Report 2016/46, 69 pp.
45. **Friedel, M.J.**, 2016, Improved groundwater system mapping and characterization workflows using machine-learning and evolutionary techniques, GNS Science International Limited Consultancy Report 2016/13, 26 pp.
46. Daughney, C., Rissman, C., **Friedel, M.J.**, Morgenstern, U., Hodson, R., van Der Raij, Rodway, E., Martindal, H., Pearson, L., Townsend, D., Kees., L., Moreau, M., Millar, R., Horton, T., 2015, Hydrochemistry of the Southland Region, GNS Science Report 2015/24, 214 pp.
47. **Friedel, M.J.**, Finn, C.A., and Horton, J.D., 2015, Hydrogeologic map of the Islamic Republic of Mauritania, Synthesis of hydrologic data, and chemical hydrologic map of the Islamic Republic of Mauritania: Phase V, deliverables 56, 57, and Added Value), chap. C of Taylor, C.D., ed., Second projet de renforcement institutionnel du secteur minier de la République Islamique de Mauritanie (PRISM-II): U.S. Geological Survey Open-File Report 2013–1280-C, 23 p., 2 pl., scale 1:1,000,000, <http://dx.doi.org/10.3133/ofr20131280>. [In English and French.]
48. Vicente, L.E., **Friedel, M.J.**, Iwashita, F., Koga-Vicente, A., 2013, Mapeamento de características de solos tropicais utilizando Self-Organizing Map aplicado à dados hiperespectrais, SBSR Brazilian Remote Sensing Symposium, April 2013, Foz do Iguacu, PR, Brazil. [Proceedings]
49. Iwashita, F., **Friedel, M.J.**, Souza Filho, C.R., Fraser, S. J., 2011, Using self-organizing maps to analyze high-dimensional geochemistry data across Paraná, Brazil. In: Proceedings 15th Simpósio Brasileiro de Sensoriamento Remoto. Curitiba, Brazil, pp. 115-129.
50. **Friedel, M.J.**, 2008, Hydrologic model calibration strategy for the Islamic Republic of Mauritania, Africa, USGS Open File Report, 2008-1173, 13 pp.
51. **Friedel, M.J.**, and Tindall, J.A., 2008, Reconnaissance study of water quality in the mining-affected Aries River basin, Romania, USGS Open File Report, 2008-1176, 36 pp.
52. **Friedel, M.J.**, and Linard, J.I., 2008, Initial sediment transport model of the mining-affected Aries River basin, Romania, USGS Open File Report, 2008-1171, 23 pp.
53. **Friedel, M.J.**, 2008, Environmental stratification and water-quality monitoring design, Mauritania, Africa, USGS Open File Report, 2008 -1137, 13 pp.
54. **Friedel, M.J.**, 2008, Inventory and review of existing PRISM hydrogeologic data for the Islamic Republic of Mauritania, Africa, USGS Open File Report, 2008-1138, 51 pp.
55. **Friedel, M.J.**, 2008, Hydrogeology of the Islamic Republic of Mauritania, Africa, USGS Open File Report, 2008-1136, 43 pp.
56. Elliot, J., Smith, M.E., **Friedel, M.J.**, and D. Litke. 2005, Post-fire hydrologic hazards study for the 2002 Hayman, Coal Seam, and Missionary Ridge wildfires, Colorado, U.S. Geological Survey, Science Investigations Report 2004-5300, 125 pp.
57. **Friedel, M.J.**, 2004, Simulated effects of the proposed Sulphur Gulch reservoir operations on Colorado River quantity and quality near Grand Junction, Colorado. U.S. Geological Survey Fact sheet, FS 2005-3031, 4 pp.
58. **Friedel, M.J.**, 2004, Stochastic modeling of the effects that Sulphur Gulch Reservoir may have on Colorado River quantity and salinity near Grand Junction, Colorado. U.S. Geological Survey, Science Investigation Report 2004-5253, 62 pp.
59. Arnold, T., **Friedel, M.J.**, and Warner, K.L., 2001, Hydrogeologic inventory of the upper Illinois River Basin – creating a large data base from well construction records. Illinois State Geological Survey Circular SP-1101, pp. 22-29
60. **Friedel, M.J.**, 2001, Simultaneous inverse estimation of coupled water, heat, and solute transport parameters with model validation and predictive analysis – applications to ground-water studies in

- arid and semi-arid regions of the U.S., Ph.D. Dissertation, University of Minnesota, Department of Water Resources Science, 253 pp. (Copyright 2001)
61. **Friedel, M.J.**, 2000, Documentation and verification of VST2D: a model for simulating transient, variably saturated, water-heat-solute Transport in heterogeneous, anisotropic, ground-water systems, U.S. Geological Survey, Water-Resources Investigations Report 00-4105, 125 pp.
 62. Warner, Kelly L., Terrio, P., King, R., Groschen, G., Arnold, T., Morrow, W.S., **Friedel, M.J.**, and Harris, M.A., 2000, Potential drinking water concerns in ground and surface water in the Illinois River basin; U.S. Geological Survey perspective from the National Water Quality Assessment, Illinois water supplies; is the well running dry? Program and abstracts, pp.12-13
 63. Arnold, T., and **Friedel, M.J.**, 1999, Effects of land use on recharge potential of surficial and shallow bedrock aquifers in the Upper Illinois River Basin, U.S. Geological Survey Water-Resources Investigations Report, 00-4027 18 pp.
 64. **Friedel, M.J.**, 1998, Upper Illinois River Basin, National Water Quality Assessment study unit, U.S. Geological Survey Fact Sheet, FS-072-98, 4 pp.
 65. Nieber, J.L., **Friedel, M.J.**, and Sharratt, B.S., 1997, Modeling equations for two-dimensional coupled heat, fluid, and solute transport in variably-saturated, variably-frozen soils, Cold Regions Research Laboratory Special Report 97-10. In: Proceedings International symposium on physics, chemistry and ecology of seasonally frozen soils, Fairbanks, Alaska, June 10-12, pp. 140-146.
 66. **Friedel, M.J.**, Scott, D.F., and Williams, T.J., 1997, Investigation of a rock-burst site, Sunshine Mine, Kellogg, Idaho. In: Proceedings Of the 4th International Symposium on Rockbursts and Seismicity in Mines, Gibowicz and Lasocki (eds), Balkema, Krakow, Poland, August 11-14, pp. 311-314.
 67. Scott, D.F., Williams, T.J., and **Friedel, M.J.**, 1996, Application of seismic tomography to underground mining: part 1, Workshop: Annual International Meeting: Society of Exploration Geophysics Annual Meeting, Denver, CO, Nov. 15, pp. 2053-2056
 68. Williams, T. J., Scott, D. F., and **Friedel, M.J.**, 1996, Application of seismic tomography to underground mining: Part 2, 66th Annual International Meeting: Society of Exploration Geophysics, Denver, CO, Nov. 1, pp. 2057-2059.
 69. Jackson, M.J., **Friedel, M.J.**, Tweeton, D.R., Scott, D.F., and Williams, T.J., 1995, Imaging underground mine structures using seismic tomography. In: Proceedings Symposium on Application of Geophysics to Engineering and Environmental Problems, Mar, 1995, pp. 112-127.
 70. Jackson, M.J., **Friedel, M.J.**, Tweeton, D.R., Scott, D.F., and Williams, T.J., 1995, Three-dimensional imaging of underground mine structures using geophysical tomography, with tests for resolution and robustness. In: Proceedings of 3rd Canadian Conference on Computer Applications in the Mineral Industry, Montreal, Quebec, Canada, October 22-25, pp. 23-32.
 71. **Friedel, M.J.**, Scott, D.F., Jackson, M.J., Williams, T.J., and Killen, S.M., 1995, 3-D Seismic tomographic investigation of mechanical conditions in a deep US gold mine. In: Proceedings Mechanics of Jointed and Faulted Rock - 2, Vienna Austria, April 13-17, pp. 689-695.
 72. **Friedel, M.J.**, 1995, SWHT: Simultaneous Water and Heat Transfer, U.S. Bureau of Mines, Open File Report 85-95, 28 pp.
 73. **Friedel, M.J.**, 1995, Spatial variability of flow and transport properties at the Mineral Park mine-waste impoundment, U.S. Bureau of Mines Open File Report 84-95, 21 pp.
 74. Moyle, P.R., Fay, J.M., and **Friedel, M.J.**, 1994, Integrated geophysical characterization of mine-waste sites in the Coeur d' Alene Mining District, ID. In: Proceedings Symposium on Application of Geophysics to Engineering and Environmental Problems, March 27-31, pp. 857-868.
 75. **Friedel, M.J.**, Jackson, M.J., Williams, E., Olson, M.S., 1994, Tomographic imaging of coal pillar conditions: observations and implications. Society for Mining, Metallurgy, and Exploration Annual Meeting, February 14-17, Albuquerque, NM, Preprint 94-110, 17 pp.

76. **Friedel, M.J.**, and Wedepohl, E., 1994, Case studies of radio wave tomography at base metal and gold ore bodies in the USA and Southern Africa. Society of Mining Metallurgy, & Exploration Annual Meeting, Preprint 94-143, Albuquerque, NM, 1994, March 27-31, pp. 32-44.
77. Tweeton, D.R., Hanson, J.C., **Friedel, M.J.**, Dahl, L.J., Lee, D.O., Wayland, R.J., and Sternberg, B.K., 1994, A field test of electromagnetic geophysical techniques for locating simulated in situ mining lixiviant, U.S. Bureau of Mines Report of Investigation 9505, 35 pp.
78. Jackson, M., Wedepohl, E., **Friedel, M.J.**, and Hauser, K., 1993, Forward modeling of electromagnetic wave propagation in layered media: implications for cross-borehole radio-wave detection of voids in coal measure rocks. In: Proceedings 4th Tunnel Detection Symposium, Golden CO, September 20-24, pp. 399-412.
79. Nieber, J.L, **Friedel, M.J.**, and Munir, H.M., 1993, VARSAT2D: Finite-element analysis of variably saturated 2-dimensional flow, U.S. Bureau of Mines Information Circular 9373, 35 pp.
80. Hauser, K.L., and **Friedel, M.J.**, 1993, Geophysical techniques applied to cavity detection at the Wharf Mine, Lead, South Dakota. In: Proceedings 4th Tunnel Detection Symposium, Golden, CO., September 20-24, pp. 617-636.
81. **Friedel, M.J.**, and Jackson, M.J., 1993, Application of seismic tomography for assessing yield pillar stress conditions. In: Proceedings of 12th Conference on Ground Control in Mining, Lakeview Resort and Conference Center, Morgantown, WV, August 3-5, pp. 292-301.
82. **Friedel, M.J.**, Jessop, J.A., and Thill, R.E., 1992, Mining applications of seismic tomography. Society of Exploration Geophysics Annual Meeting, November 10-14, pp. 58-62.
83. Thill, R.E., **Friedel, M.J.**, Jessop, J.A., and Jackson, M.J., 1992, Integrated geophysics and geotomography for ground control applications. In: Proceedings 4th Ground Control Symposium, Southern Illinois University, Mt.Vernon, IL, November 2-4, pp. 51-69.
84. Tweeton, D.R., Hanson, J.C., **Friedel, M.J.**, and Dahl, L.J., 1992, Field tests of geophysical methods for monitoring the flow patterns of leach solution. In; Proceedings Engineering Foundation Conference, In Situ Recovery of Minerals II, October 25-30, Santa Barbara, CA, pp. 179-199.
85. Jessop, J.A., Borek, D.L., Jackson, M.J., Tweeton, D.R., and **Friedel, M.J.**, 1992, Evaluation of a stope leaching site using geotomography. In: Proceedings Engineering Foundation Conference, In Situ Minerals Recovery-II, Santa Barbara, CA, October 25-30, pp. 599-616.
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2. **Friedel, M.J.**, Minsley, B., Moreria, Lucas P., 2018, From stochastic airborne EM inversion to geologic model: application of a two-step machine learning workflow, Hydrological Society Annual Conference, Christchurch, New Zealand, 4-7 December.
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5. **Friedel, M.J.**, Daughney, C., 2016, Statistical robustness of machine-learning estimates for characterizing a groundwater-surface water system, Southland, New Zealand, Achieving deep learning by systemizing machine learning with big data engines I, Poster IN11B-1619, Earth and Space Science Informatics, American Geophysical Union, San Francisco, CA, 2016.
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23. **Friedel, M.J.**, 2014, Modeling the effects of stressors on aquatic ecosystems, H11H-1251, Soil and Water: Delivering Valuable Ecosystem Services: Land Use Effects (Oral), 2014 Water Symposium, Integration: The Final Frontier, November 25, 2014, Blenheim, NZ.
24. Rawlinson, Z., **Friedel, M.J.**, Westerhoff, R., 2014, Mapping hydrogeological properties using helicopter electromagnetic (HEM) data In Otago, New Technologies (oral), 2014 Water Symposium, Integration: The Final Frontier, November 25, 2014, Blenheim, NZ. (Presented by Rawlinson)
25. **Friedel, M.J.**, Esfahani, A., 2013, Influence of global volcanic processes on climate modulation in the southwestern US, 132-2 (205), Session 132, T24. Climate Change in the Interior Western United States from the Last Glacial Maximum to the Holocene (Posters), Geological Society of America, Joint Annual Meeting, Denver, Colorado, 27-30 Oct. 2013.
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27. **Friedel, M.J.**, 2013, Big data integration for regional hydrostratigraphic mapping, H11H-1251, Regional groundwater systems: advances in modeling, characterization, and applications I Posters, American Geophysical Union, December 2013, San Francisco, CA.

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29. **Friedel, M.J.**, 2014, Uncertainty and upscaling in rainfall-recharge modeling, NIWA Rainfall Recharge Workshop, Christchurch, NZ, August 26, 2014 (no abstract).
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33. Esfahani, A.A., **Friedel, M.J.**, 2012, A fractal approach to the climate of southwestern United States, 29th IUGG Conference on Mathematical Geophysics, Poster Session 1, Informatics, Edinburgh, Scotland, 13 June [INTERNATIONAL] (Presented by Esfahani)
34. Moreira, L., **Friedel, M.J.**, Franca, G., 2012, Joint inversion of receiver function, surface wave dispersion, and magnetotelluric data for 2D crustal modeling, Nonlinear geophysics session NG31B-1582, American Geophysical Union, December 2012, San Francisco, CA.
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37. **Friedel, M.J.**, 2012, Remote detection, classifying, and imaging using a hybrid paradigm, U.S. Department of Army, Engineer Research Development Center, 14 November, 2012, Arlington, Virginia. [INVITED] (no abstract)
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40. **Friedel, M.J.**, Schmidt, T.S., Smith, K., Mast, M.A., 2012, Development of Aquatic-Mining Ecosystem Models Using Computational Intelligence, poster presentation (abstract #30), USEPA Hardrock Mining Conference: Advancing Solutions for a New Legacy, Denver, CO, 3-5 Apr.
41. Moreira, L.P., **Friedel, M.J.**, França G.S., 2012, Uncertainty in crustal imaging of the Paraná Basin. European Geosciences Union General Assembly, PSD5.5 - Active seismic investigations of the Earth's crust, poster XY487, 24 April.
42. Vicente, E., **Friedel, M.J.**, Iwashita, F., 2011, Landscape discrimination in Brazil using hyperion data and a self-organizing map approach, Union session (U22b) oral presentation at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec. (Presented by Vicente)

43. Iwashita, F., **Friedel, M.J.**, Fraser, S., 2011, Application of soft computing in hydrogeologic characterization of the Serra Geral-Guarani aquifer system, Parana state, Brazil, Union session (U22b) oral presentation at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec. (Presented by Iwashita)
44. **Friedel, M.J.**, 2011, Applications of soft computing in undiscovered global porphyry copper assessments, Union session (U22b) oral presentation at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec. [INVITED]
45. **Friedel, M.J.**, 2011, Computational intelligence in earth systems – applied soft and hybrid modeling, U.S. Department of Army, Engineer Research Development Center, 30 November, 2011, Vicksburg, Mississippi. [INVITED] (no abstract)
46. Asch T., **Friedel, M.J.**, 2011, ALLTEM UXO discrimination results from the Aberdeen proving ground using a hybrid generalized neural analysis standard dipole inversion classification scheme, In: Advances in Classification Methods for Military Munitions Response, Symposium on the Application of Geophysics to Engineering and Environmental Problems, April 12, Charleston, South Carolina. (Presented by Asch)
47. Esfahani, A. **Friedel, M.J.**, 2011, A fractional climate forecast for southern and southwestern United States, Land-climate interactions from models and observations: Implications from past to future climate, poster session CL2.15, European Geosciences Union General Assembly, 3-7 April, 2011, Vienna, Austria. [INTERNATIONAL]
48. Moreira, L.P., **Friedel, M.J.**, 2011, Joint inversion of receiver function, surface wave dispersion, and magnetotelluric data for 2D crustal modeling, The Lithosphere-Asthenosphere Boundary (LAB) Dilemma, poster session GD2.4/SM4.1/TS10.2, European Geosciences Union General Assembly, 3-7 April, 2011, Vienna, Austria. [INTERNATIONAL]
49. Esfahani, A. **Friedel, M.J.**, 2011, A fractional climate forecast for southern and southwestern United States, Land-climate interactions from models and observations: Implications from past to future climate, poster session CL2.15, European Geosciences Union General Assembly, 3-7 April, 2011, Vienna, Austria.
50. **Friedel, M.J.**, Long, K., 2011, A data-driven economic filter for stochastic mineral assessments, Soft Computing Techniques in Geosciences, poster session NP1.3/ESSI21, European Geosciences Union General Assembly, 3-7 April, Vienna, Austria. [INTERNATIONAL]
51. **Friedel, M.J.**, 2011, El Niño-Southern Oscillation (ENSO) phenomenon – event reconstruction and analysis over the past 2000 years, ENSO – Dynamics, predictability, poster session NP2.1, European Geosciences Union General Assembly, 3-7 April, Vienna, Austria. [INTERNATIONAL]
52. Iwashita, F., F., **Friedel, M.J.**, Souza Filho, C.R., Fraser, S. J., 2011, Using self-organizing maps to analyze high-dimensional geochemistry data across Paraná, Brazil. In: Proceedings 15th Simpósio Brasileiro de Sensoriamento Remoto. Curitiba, Brazil. [INTERNATIONAL] (Presented by Iwashita)
53. **Friedel, M.J.**, 2010, Post-fire debris flow prediction using a two-step hybrid approach, U.S. Geological Survey, 3rd Modeling Conference, Denver Colorado, June, 2010.
54. **Friedel, M.J.**, 2010, Intelligent post-fire hydrologic and geomorphic landscape modeling, U.S. Geological Survey, 3rd Modeling Conference, Denver, Colorado, June, 2010.
55. **Friedel, M.J.**, 2010, Intelligent exploration for shallow groundwater in fractured rock systems, U.S. Geological Survey, 3rd Modeling Conference, Denver, Colorado, June, 2010.
56. **Friedel, M.J.**, 2010, Forecasting climate change effects on ground water recharge using an unsupervised artificial neural network, U.S. Geological Survey, 3rd Modeling Conference, Denver, Colorado, June, 2010.
57. Brown, P. and **Friedel, M.J.** 2010, Overview of new Monte Carlo software for quantitative mineral resource estimation, U.S. Geological Survey, 3rd Modeling Conference, Denver, Colorado, June, 2010. (Presented by Brown)

58. Brown, P. and **Friedel, M.J.**, 2010, Test results comparing the new US Geological Survey Monte Carlo quantitative resource estimation simulation software application to MARK3, U.S. Geological Survey, 3rd Modeling Conference, Denver, Colorado, June, 2010. (Presented by Brown)
59. Iwashita, F., Silvana A., Vieira Monteiro, A.M., **Friedel, M.J.**, 2010, Evaluating the effects of positioning errors on the accuracy of species distribution models using synthetic data, U.S. Geological Survey, 3rd Modeling Conference, Denver, Colorado, June, 2010. (Presented by Iwashita)
60. Iwashita, F., **Friedel, M.J.**, Carlos de Souza-Filho, 2010, Surveying soil chemical weathering in Parana state/Brazil: A data mining-GIS hybrid approach, U.S. Geological Survey, 3rd Modeling Conference, Denver, Colorado, June, 2010. (Presented by Iwashita)
61. Manning, A., **Friedel, M.J.**, Verplanck, P.L., Todd, A.S., 2010, Applying numerical modeling to evaluate the significance of climate and hydrology in the formation of natural acid-rock drainage in mineralized watersheds. Session 74: Integrated approaches to modeling geochemical, hydrological, and ecological processes in watersheds, Geological Survey of America, Joint Annual Meeting, Denver, Colorado, 31 October - 3 November 2010. (Presented by Manning)
62. **Friedel, M.J.**, 2010, Nonlinear modeling of coupled watershed processes using a data-driven approach, Session 74: Integrated approaches to modeling geochemical, hydrological, and ecological processes in watersheds, Geological Survey of America, Joint Annual Meeting, Denver, Colorado, 31 Oct.- 3 Nov, 2010.
63. Koga-Vicente, A., **Friedel, M.J.**, 2010, Comparison of empirical and data driven hydrometeorological hazard models on coastal cities of São Paulo, poster NH51A-1220 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec. (Presented by Koga-Vicente)
64. **Friedel, M.J.**, 2010, Hindcasting 2000 years of Pacific sea and land surface temperature changes, poster H21G-1125 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.
65. Esfahani, A.A., **Friedel, M.J.**, 2010, The fractal nature of climate change - 2000 years in retrospect, H21G-1126 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.
66. Iwashita, F., **Friedel, M.J.**, Ribeiro, G.F., Fraser, S.J., de Souza-Filho, C.R., 2010, Using self-organizing maps to predict soil texture and hydraulic conductivity in the Poços de Caldas, Modelagem numérica e experimental de processos geológicos, Grande Área: MÉTODOS E TÉCNICAS EM GEOLOGIA, 45^o Congresso Brasileiro de Geologia, Belem, Brazil, October 26-31. [INVITED, INTERNATIONAL] (Presented by Iwashita)
67. Moreira, L.P., França G.S., **Friedel, M.J.**, 2010, Joint inversion of receiver function and surface waves using a regularized Gauss-Marquardt-Levenberg nonlinear method, EOS Trans. AGU, 91(26), Jt. Assem. Suppl., Abstract, S21A-O4: 8–13 August, Foz do Iguaçu - PR, 85862–210, Brazil. [INTERNATIONAL] (Presented by Moreira)
68. **Friedel, M.J.**, 2010, Climate change effects on ecosystem services in the United States – issues of national and global security, NATO Advanced Study Workshop – Climate change Effect on Water Supplies – Issues of National and Global Security, Izmir, Turkey, Sept.1-5, 2010. [INTERNATIONAL, KEYNOTE]
69. Johnson, R.H., Manning, A.H., and **Friedel, M.J.**, 2009, Evaluating the utility of watershed-scale numerical models in the U.S. Geological Survey’s mineral, environmental assessment project, Toward More Effective Use of Ground Water Modeling II: Improved Conceptual Models and Data Integration 2009 Ground Water Summit: The Science and Engineering Conference, April 21, 2009. (Presented by Johnson)
70. **Friedel, M.J.**, 2008, Overview of USGS groundwater research activities, INMET, Brasilia, Brazil – Invitation to speak about USGS and personal research [INVITED] (no abstract)

71. **Friedel, M.J.**, 2008, Methods for predicting wildfire-induced debris flows, Integrated Wildfire, presentation to USGS Central Region management, Snow Mountain Ranch, Tabernash, CO, Sept. 11, 2008. [INVITED] (no abstract)
72. **Friedel, M.J.**, 2008. Hazards and risks – flooding, 2nd USGS Modeling conference, National Hazards Panel, Perdido Beach, Alabama, February, 2008. [INVITED, KEYNOTE]
73. **Friedel, M.J.**, 2008, Application of stochastic modeling to forecast likely urbanization effects on ecological integrity in the Upper Illinois River Basin, USA, Extended abstract, United States Geological Survey, 2nd Modeling Conference, Gulf Shores, Alabama, February, 10-15, 2008
74. **Friedel, M.J.**, 2008, Joint inverse modeling to estimate extreme rainfall events and their uncertainty in ungauged coastal basins, El Salvador, Central America, Extended abstract, United States Geological Survey, 2nd Modeling Conference, Gulf Shores, Alabama, February, 10-15, 2008
75. **Friedel, M.J.**, 2008, Joint inverse modeling to estimate flood-flow depths and their uncertainty in ungauged coastal basins, El Salvador, Central America, Extended abstract, United States Geological Survey, 2nd Modeling Conference, Gulf Shores, Alabama, February, 10-15, 2008
76. **Friedel, M.J.**, Souza, O.F., Yoshinaga, S. P, Silva, A M, 2008, Application of a joint inversion strategy to improve electromagnetic imaging of hydrogeologic structures in Northeastern Brazil, EOS Trans. AGU, 89(53), Fall Meet. Suppl., Abstract, NS31A-1224.
77. **Friedel, M.J.**, 2008, Quantifying ground-water recharge using a coupled water-heat-solute transport model: optimal nonlinear parameter estimation, nonuniqueness, and predictive uncertainty, Trans. AGU fall meeting, San Francisco, CA, Dec 10, 2008.
78. Johnson, R.H., and **Friedel, M.J.**, 2008, Factoring uncertainty into restoration modeling of in-situ leach uranium mines, 330-8, Hydrogeology III - Uranium, Metals, and Other Contaminants in Groundwater, Geological Society of America, 2008 Joint Annual Meeting, 5-9 Oct. 2008. (Presented by Johnson)
79. **Friedel, M.J.**, 2008, Numerical modeling strategies in resource assessments – past, present, and future. SP 41. Modelagem numérica e experimental de processos geológicos, Grande Área: MÉTODOS E TÉCNICAS EM GEOLOGIA, 44^o Congresso Brasileiro de Geologia, Curitiba, Brazil, October 26-31. [INTERNATIONAL, KEYNOTE]
80. Tindall, J.A., Figueroa-Johnson, M., and **Friedel, M.J.**, 2007, Comparison of soil-water sampling techniques, Trans. AGU, 83(42), Fall Meet. Suppl., H53F-1489. (Presented by Tindall)
81. **Friedel, M.J.**, 2007, Assessment and management of mining-related environmental risks with applications, University of Kuopio, Kuopio, Finland [INVITED, INTERNATIONAL]
82. **Friedel, M.J.**, 2007, Overview of hazards risk mitigation and emergency preparedness project, Bucharest, Romania, presentation to World Bank Experts, stakeholders, and concerned citizens, 2007. [INVITED, INTERNATIONAL]
83. **Friedel, M.J.**, 2006, Overview of hazards risk mitigation and emergency preparedness project, Bucharest, Romania, presentation to World Bank Experts, stakeholders, and concerned citizens, January 2006. [INVITED, INTERNATIONAL] (no abstract)
84. **Friedel, M.J.**, 2005, Combined groundwater-geophysical inverse modeling to reduce predictive uncertainty, presentation as part of Groundwater Resources Program research initiative in Linking Geologic Models to MODFLOW, DFC, Bldg 53, Central Region conference room, F1216, Lakewood, CO, presentation to regional groundwater specialist (A. Burns) and invited scientists, June 16, 2005. [INVITED (no abstract)]
85. Figueroa, M., Tindall, J.A., and **Friedel, M.J.**, 2006, Comparison of $d^{18}O$ composition of water extracted from suction lysimeters, centrifugation, and azeotropic distillation, Trans. AGU, 83(42), Fall Meet. Suppl., H13-6703 (Presented by Figueroa)

86. Little, J., Tindall, J.A., and **Friedel, M.J.**, 2005, Scaling relations between laboratory and field scale hysteretic measurements for a coarse sandy loam soil, *Trans. AGU*, 83(42), Fall Meet. Suppl., H13-6703. (Presented by Little)
87. **Friedel, M.J.**, 2005, Effects of Coal-bed methane discharge waters on vegetation and soil ecosystem in Powder River Basin, Wyoming, USA, International Symposium on Methodology in Hydrology, Nanjing, China, Oct. 30 - Nov. 2, 2005. [INTERNATIONAL, KEYNOTE]
88. **Friedel, M.J.**, 2005, Simultaneous estimation of recurrent rainfall amounts in ungaged coastal basins of El Salvador, International Symposium on Methodology in Hydrology, Nanjing, China, Oct. 30 - Nov. 2, 2005. [INTERNATIONAL, KEYNOTE]
89. **Friedel, M.J.**, 2005, Probable flooding in ungaged coastal basins of El Salvador, International Symposium on Methodology in Hydrology, Nanjing, China, Oct. 30 -Nov. 2, 2005. [INTERNATIONAL, KEYNOTE]
90. **Friedel, M.J.**, 2005, Urbanization effects on ecological integrity in the Upper Illinois River Basin, USA, NATO Advanced Study Workshop - Groundwater and Ecosystems, Canakkale, Turkey, Sept. 5-7, 2005. [INTERNATIONAL, KEYNOTE]
91. Little, J., Tindall, J.A., and **Friedel, M.J.**, 2004, Correlated moisture content, pressure and temperature data for development of hysteretic moisture retention curves, *Trans. AGU*, 83(42), Fall Meet. Suppl., H33B-0464. (Presented by Little)
92. **Friedel, M.J.**, 2004, Reliability in urban ground-water recharge estimates through the vadose zone: managing sustainable development in arid and semiarid regions, NATO Advanced Study Institute - Management and Sustainable Development of Urban Groundwater Systems, Baku, Azerbaijan, Aug. 10-20, 2004. [INTERNATIONAL, KEYNOTE]
93. **Friedel, M.J.**, 2003, Potential post-fire debris flow hazards associated with Wulfsohn and Golenwood alluvial fans, Glenwood Springs, Colorado, presentation to Mayor and city council, May 28, 2003. [INVITED] (no abstract)
94. **Friedel, M.J.**, 2003, Predicting maximum likely debris flows: from pre-fire streamflow measurements to post-fire hazard mapping, presentation at Colorado Stream Gauging Symposium, 2003, Breckenridge, CO, May 8, 2003. [INVITED]
95. **Friedel, M.J.**, 2002, Application of genetic algorithms and programming to water resource problems, oral and cyber presentation to USGS earth scientists, USGS National Training Center, Lakewood, CO, December 4, 2002. (no abstract)
96. **Friedel, M.J.**, 2002, Stochastic modeling of quantity and quality of Colorado River streamflow following development and operation of Sulphur Gulch reservoir, presentation to Denver Water and Northern Colorado Water Conservancy District management and engineers, and attorneys of Trout-Whitman, Loveland, CO, November 22, 2002. [INVITED] (no abstract)
97. **Friedel, M.J.**, 2002, Application of stochastic simulation to assess the effects of development and operation of Sulphur Gulch reservoir on changes in Colorado Water Quality, presentation to Denver Water and Northern Colorado Water Conservancy District management and engineers, Denver Water, Denver, CO, August 9, 2002. [INVITED] (no abstract)
98. **Friedel, M.J.**, 2002, Drought effects on water quantity and quality. U.S. Geological Survey drought workshop, Pueblo, CO, July 2002. [INVITED]
99. **Friedel, M.J.**, 2002, Drought effects on water quantity and quality. U.S. Geological Survey drought workshop, Greeley, CO, July 2002. [INVITED]
100. **Friedel, M.J.**, 2002, Transport model parameter nonuniqueness and its effect on recharge prediction in a coupled variably saturated ground-water system. U.S. Geological Survey artificial recharge workshop, Sacramento, CA, April 2002.

101. **Friedel, M.J.**, 2002, Coupled ground-water model calibration and predictive analysis - space age technology or science fiction? U.S. Geological Survey, Recharge Estimation Workshop, Lakewood, CO, February 26, 2002. [INVITED]
102. **Friedel, M.J.**, 2002, Salinity issues in Western United States. Proceedings Western drought effects on water quantity and quality. American Institute of Hydrology, Minneapolis, MN, August 9, 2002. [INVITED]
103. **Friedel, M.J.**, 2002, Quantifying ground-water recharge using a coupled water-heat-solute transport model: optimal nonlinear parameter estimation, nonuniqueness, and predictive uncertainty, Trans. AGU fall meeting, San Francisco, CA, Dec 10, 2002.
104. **Friedel, M.J.**, 2002, Quantifying ground-water recharge using a coupled water-heat-solute transport model: nonlinear parameter estimation, nonuniqueness, and predictive uncertainty, Trans. AGU, 83(42), Fall Meet. Suppl., H21D-0860, 2002.
105. **Friedel, M.J.**, 2001, Developed and presented seminar on Model calibration and simulation of urbanization and its effects on ecological integrity. U.S. Geological Survey, Colorado-District, Denver, CO, Jan. 2001. [INVITED] (no abstract)
106. **Friedel, M.J.**, 2001, Developing an Urbanization TMDL ... good, bad, and the ugly. Upper Illinois River Basin - National Water Quality Assessment liaison meeting, Chicago, IL, April 20, 2001. (no abstract)
107. **Friedel, M.J.**, 2001, Overview of VST2D model applications and future extensions to regional ground-water specialists and ground-water resources program management, Lakewood, CO, Oct. 9, 2001. [INVITED] (no abstract)
108. Arnold, T., **Friedel, M.J.**, and Warner, K.L., 2001, Hydrogeologic inventory of the upper Illinois River Basin – creating a large data base from well construction records. Geological Society of America April 22, 2001 in Bloomington, Illinois. (Presented by Arnold)
109. **Friedel, M.J.**, 2001, Salinity overview of water resources in the South Platte River Basin, A Colorado Salinity/Selenium Symposium and Workshop, Soil Water Conservation Society, Colorado Springs, CO, October 4, 2001. [INVITED] (no abstract)
110. **Friedel, M.**, 1999, VST2D – Variably saturated water-heat-solute transport model. U.S. Geological Survey - Unsaturated Zone Interest Group, Menlo Park, CA, Jan. 13, 1999. [INVITED] (no abstract)
111. **Friedel, M.J.**, 1999, Ground-water risk assessment – Cyprus mine tailings impoundment. U.S. Geological Survey - Unsaturated Zone Interest Group, Menlo Park, CA, Jan. 13, 1999. [INVITED]
112. **Friedel, M.J.**, 1998, Developed and presented seminar on land use gradient study: predicting the effects of urbanization on water quality. U.S. Geological Survey, National Water Quality Assessment Leadership Team, Reston, VA, Dec. 1998. [INVITED] (no abstract)
113. **Friedel, M.J.**, 1998, Probabilistic assessment of source drinking water in the Upper Illinois River Basin. U.S. Geological Survey, National Water Quality Assessment Leadership Team, Reston, VA, Dec. 1998. [INVITED] (no abstract)
114. Nieber, J.L., **Friedel, M.J.**, and Sharratt, B.S., 1997, Modeling equations for two-dimensional coupled heat, fluid, and solute transport in variably saturated, variably-frozen soils, CRREL Special Report 97-10: Proceedings International symposium on physics, chemistry and ecology of seasonally frozen soils, Fairbanks, Alaska, June 10-12, pp. 140-146. [INVITED]
115. Scott, D.F, Williams, T.J., and **Friedel, M.J.**, 1996, Application of seismic tomography in underground mining, Proceedings 15th International Conference on Ground Control in Underground Mining, Golden, CO, Aug. 13-15. [INVITED]
116. Williams, T. J., Scott, D. F., and **Friedel, M.J.**, 1996, Application of seismic tomography to underground mining: Part 2, 66th Annual International Meeting: Society of Exploration Geophysics, Denver, CO, Nov. 15. pp. 2057-2059. (Presented by Williams)

117. Scott, D. F., Williams, T.J., and **Friedel, M.J.**, 1996, Application of seismic tomography to underground mining: Part 1, 66th Annual International Meeting: Society of Exploration Geophysics, Denver, CO, Nov. 15, pp. 2053-2056. (Presented by Scott)
118. Scott, D.F., **Friedel, M.J.**, Jackson, M.J., and Williams, E., 1995, Use of tomographic imaging as a tool to identify areas of high stress in remnant ore pillars in deep underground mines. U.S. Bureau of Mines Technology Transfer Seminar: Mechanics and Mitigation of Violent Failure in Coal and Hard Rock mines, of Coal Pillar Behavior, U.S. Bureau of Mines Special Publication, 01-95, Coeur d' Alene, ID; Price, UT, Norton, Va; May, pp. 323-335. [INVITED]
119. Westman, E., **Friedel, M.J.**, Jackson, M.J., and Williams, E., 1995, Imaging coal structure stress distribution with seismic tomography. U.S. Bureau of Mines Technology Transfer Seminar: Mechanics and Mitigation of Violent Failure in Coal and Hard Rock Mines, of Coal Pillar Behavior, U.S. Bureau of Mines Special Publication 01-95, Coeur d' Alene, ID; Price, UT, Norton, VA; May, pp.101-119. [INVITED]
120. Jackson, M.J., **Friedel, M.J.**, Tweeton, D.R., Scott, D.F., and Williams, T.J., 1995, Imaging underground mine structures using seismic tomography. Proceedings Symposium on Application of Geophysics to Engineering and Environmental Problems, March 1995, pp. 112-127. (Presented by Jackson)
121. **Friedel, M.J.**, Scott, D.F., Jackson, M.J., Williams, T.J., and Killen, S.M., 1995, 3-D seismic tomographic investigation of mechanical conditions in a deep US gold mine, Proceedings Mech. Jointed and Faulted Rock-2, Vienna Austria, April 13-17, pp. 689-695. [INVITED, INTERNATIONAL]
122. Jackson, M.J., **Friedel, M.J.**, Tweeton, D.R., Scott, D.F., and Williams, T.J., 1995, Three-dimensional imaging of underground mine structures using geophysical tomography with tests for resolution and robustness. Proceedings CAMI '95: 3rd Canadian Conference on Computer Applications in the Mineral Industry, Montreal, Quebec, Canada, October 22-25. [INVITED]
123. Moyle, P.R., Fay, J.M., and **Friedel, M.J.**, 1994, Integrated geophysical characterization of mine-waste sites in the Coeur d' Alene Mining District, ID. Proceedings Symposium on Application of Geophysics to Engineering and Environmental Problems, March 27-31, pp. 857-868. (Presented by Moyle)
124. **Friedel, M.J.**, and Wedepohl, E., 1994, Case studies of radio wave tomography at base metal and gold ore bodies in the USA and Southern Africa. Society of Mining Metallurgy, & Exploration, Albuquerque, NM, 1994, March 27-31, pp. 32-44. [PRESENTED]
125. **Friedel, M.J.**, 1994, Integrated-geophysical technology for void detection and geological/hydrological characterization. U.S. Bureau of Mines - Abandoned Mine Land Geophysical Workshop, Minneapolis, MN, March 24, 1994.
126. **Friedel, M.J.**, 1994, 3D tomographic imaging of anomalous conditions in a deep mine. Paper presented at Symposium on Application of Geophysics to Engineering and Environmental Problems, Boston, MA, March 20-25, 1994, pp. 92-107.
127. **Friedel, M.J.**, Jackson, M.J., Williams, E., Olson, M.S., 1994, Tomographic imaging of coal pillar conditions: observations and implications. Society of Mining Metallurgy, & Exploration Annual Meeting, February 14-17, Albuquerque, NM, Preprint 94-110, 17p.
128. **Friedel, M.J.**, and J. Jackson, M.J., 1993, Application of seismic tomography for assessing yield pillar stress conditions. Paper presented at Twelfth Conference on Ground Control in Mining, Lakeview Resort and Conference Center, Morgantown, WV, August 3-5, 1993, pp. 292-301. [INVITED]
129. Hauser, K.L., and **Friedel, M.J.**, 1993, Geophysical techniques applied to cavity detection at the Wharf Mine, Lead, South Dakota. Proceedings 4th Tunnel Detection Symposium, Golden, CO., pp. 617-636. (Presented by Hauser)
130. Jackson, M., Wedepohl, E., **Friedel, M.J.**, and Hauser, K., 1993, Forward modeling of electromagnetic wave propagation in layered media: implications for cross-borehole radio-wave detection of voids in

- coal measure rocks. Proceedings 4th Tunnel Detection Symposium, Golden CO, pp. 399-412. (Presented by Jackson)
131. **Friedel, M.J.**, Jessop, J.A., and Thill, R.E., 1992, Mining applications of seismic tomography. Proceedings 62nd Annual International Meeting: Society of Exploration Geophysics, New Orleans, LA, November 10-14, pp. 58-62.
 132. Thill, R.E., **Friedel, M.J.**, Jessop, J.A., and Jackson, M.J., 1992, Integrated geophysics and geotomography for ground control applications. Proceedings 4th Ground Control Symposium, Southern Illinois University, Mt.Vernon, IL, November 2-4, pp. 51-69. (Presented by Thill)
 133. Jessop, J.A., Borek, D.L., Jackson, M.J., Tweeton, D.R., and **Friedel, M.J.**, 1992, Evaluation of a stope leaching site using geotomography. Proceedings Engineering Foundation Conference, In Situ Minerals Recovery-II, Santa Barbara, CA, October 25-30, pp. 599-616. (Presented by Jessop)
 134. Schmidt, R.D., Early, D., III, and **Friedel, M.J.**, 1992, Analysis and implications of dynamic transmissivity conditions during in situ copper leaching. Proceedings Engineering Foundation Conference, In Situ Recovery of Minerals II, Santa Barbara, October 25-30, pp. 259-286. (Presented by Schmidt)
 135. Tweeton, D.R., Hanson, J.C., **Friedel, M.J.**, and Dahl, L.J., 1992, Field tests of geophysical methods for monitoring the flow patterns of leach solution. Proceedings Engineering Foundation Conference, In Situ Recovery of Minerals II, October 25-30, Santa Barbara, CA, pp. 179-199. (Presented by Tweeton)
 136. Jackson, M.J., Tweeton, D.R., and **Friedel, M.J.**, 1992, Approaches for optimizing the use of available information in crosshole seismic tomographic reconstruction. Proceedings GeoTech '92 Geo-Computing Conference, Denver, CO, August 31-September 3, pp. 130-143.
 137. Jessop, J.A., **Friedel, M.J.**, Tweeton, D.R., and Jackson, M.J., 1992. Fracture detection with seismic crosshole tomography for solution control in a stope. Proceedings Symposium on Application of Geophysics to Engineering and Environmental Problems, Oakbrook, IL, April 26-29, pp. 487-587.
 138. **Friedel, M.J.**, M. Jones, P.M., and Schmidt, R.D., 1992, Geostatistical analysis of dynamic transmissivity during in situ copper leaching. Proceedings 23rd International Symposium on Applications of Computers in Mining Industry, April 7-11, pp. 49-61. [INVITED]
 139. **Friedel, M.J.**, 1992, Scale-dependence In the hydrologic design of in situ copper leaching operations: Paper presented at Society for Mining, Metallurgy, and Exploration annual meeting, Reno, Nevada, Feb. 18, 1992. (published as Friedel, M.J., 1993, Scale-Dependence in the Hydrologic Design of In Situ Copper Leaching Operations. Society of Mining Engineers Transactions, Vol. 294, pp 1918-1926.)
 140. **Friedel, M.J.**, Jessop, J.A., and Thill, R.E., 1991, Igneous rock mass fracture delineation using common offset radar reflection. Proceedings 61st Annual International Meeting: Society of Exploration Geophysics, November 10-14, pp. 504-506.
 141. Hanson, J.C., Tweeton, D.R., **Friedel, M.J.**, and Dahl, L.J., 1991, A field test of electromagnetic methods for the detection of conductive plumes. Annual International Meeting: Society of Exploration Geophysics, November 10-14, pp. 569-572. (Presented by Hanson)
 142. **Friedel, M.J.** and Hanson, J.C., 1990, An integrated geophysical approach to detection of abandoned mine openings. Proceedings 12th Annual National Abandoned Mine Land Conference, Breckenridge, CO, September 15, pp. 57-86. [PRESENTED]
 143. **Friedel, M.J.** and Schmidt, R.D., 1991, Effect of an unsaturated setting on the hydrology of in situ copper leaching. Society for Mining, Metallurgy, and Exploration Ann. Mtg., Preprint 91-161, Denver, CO, February 25-28, 11 pp. (published as Friedel, M.J., 1992, Effect of Unsaturated Conditions on the Hydrology of In-Situ Copper Leaching. Society of Mining Engineers Transactions, Vol. 294, pp 1029-1036.)

144. Schmidt, R.D. and **Friedel, M.J.**, 1991, Application of computers for analysis of in situ leach mining hydrology, Proceedings Indo-U.S. Symposium on Computers in the Mining Industry, Dahnbad, India, November 11-13, pp. 121-135. [INVITED, INTERNATIONAL] (presented by Schmidt)
145. **Friedel, M.J.** and Hanson, J.C., 1990, Assessment of ground penetrating radar for detecting hazardous abandoned mine openings and related features. Proceedings 12th Annual National Abandoned Mine Land Conference, Breckenridge, CO, September, pp. 87-55.
146. **Friedel, M.J.**, 1990, Common offset radar profiling for detection of fractures igneous rock. Poster presented at Geophysical Solutions to Geologic Problems of Continental Interiors: A Minnesota Workshop, Minnesota Geologic Survey, Minneapolis, Minnesota, March 4-6, pp 12-15.
147. Schmidt, R.D., **Friedel, M.J.**, and Behnke, K., 1990, Hydrologic considerations of underground in place copper leaching. Society for Mining, Metallurgy, and Exploration Ann. Mtg., Preprint 90-179, Salt Lake City, UT, February 26-March 1, 12 pp. [PRESENTED]
148. Jessop, J.A., R.E. Thill, and **Friedel, M.J.**, 1990, Acoustic site characterization studies for in situ mining. Society for Mining, Metallurgy, and Exploration Annual Meeting, Preprint 90-184, Salt Lake City, UT, February 26-30, 11 pp. [PRESENTED]
149. Thill, R.E., **Friedel, M.J.** and Hanson, J.C., 1990, Mining geophysics: a research perspective. Proceedings International Symposium on Borehole Geophysics in Petroleum, Hydrology, Mining, and Engineering Applications, Tucson, AZ., February 1-3, 5 pp. [INVITED]
150. **Friedel, M.J.**, and R.E. Thill, 1990, U.S. Bureau of Mines research on the Kaiser Effect for determining stress in rock. Proceedings in International Joint Meeting, 1st Workshop on AE in Civil Engineering and 2nd Workshop on AE and Rock Fracture Mechanics, Kumamoto City, Japan, Oct. 29-31, pp. 54.

UNIVERSITY TEACHING

Undergraduate

- *Quantitative Hydrogeology*, Dept. of Geology, Colorado College, 2003
- *Unsaturated zone hydrology*, Dept. Environmental Science, University of Colorado, 2004-2008 (guest lecturer - numerical modeling section)
- *Applied Statistics for the Natural Sciences*, Dept. of Environmental Science, University of Colorado, CO, 2009
- *Artificial Adaptive Mathematical Models in Medicine and the Environment*, Dept of Mathematical and Statistical Sciences, University of Colorado, 2013

Post-graduate

- *Modeling Coastal Water Flooding, Mud and Debris Flows*, Central American University, Dept. Energy & Fluid Science, El Salvador, 2003
- *Model Calibration and Predictive Analysis in Earth Science*, Central American University, Dept. Energy & Fluid Science, El Salvador 2004, 2005
- *Assessing and Managing Risks Associated with Hazards in our Environment*, Central American University, Dept. Energy & Fluid Science, El Salvador, 2005
- *Advanced Concepts in Watershed Management*, Central American University, Dept. Energy & Fluid Science, El Salvador, 2006
- *Assessing and Managing Environmental Risks*, Central American University, Dept. Energy & Fluid Science, El Salvador, 2006
- *Ecological Risk Assessment*, Dept. Env. Sci., University of Kuopio, Finland, 2007
- *Multicomponent reactive transport modeling for mining environments*, Dept. of Environmental Science, University of Kuopio, Finland, 2007

- *Model fitting, calibration, uncertainty analyses in the geosciences*, Geosciences Institute, University of Brasilia, Brazil, 2008
- *Model fitting, calibration, uncertainty analyses in the geosciences*, Geosciences Institute, University of Campinas, Brazil, 2008
- *Hydrogeophysics*, Geosciences Institute, University of Brasilia, Brazil, 2008
- *Hydrogeophysics*, Geosciences Institute, University of Campinas, Brazil, 2008
- *Groundwater modeling*, Geosciences Institute, University of Brasilia, Brazil, 2013
- *Multivariate statistics, machine-learning, and hybrid modeling*; Geosciences Institute, University of Brasilia, Brazil, 2013
- *Applied modeling and uncertainty analysis in earth science*, Center for Env. Studies, University of Campinas, Brazil, 2013

UNIVERSITY SERVICE

Post-doctoral

Advisor

Dr. Lucas Moreira	Federal Institute of Education, Brazil	2016
Dr. Lucas Moreira	University of Brasilia, Brazil	2015
Dr. Cleyton Carnerio	University of Sao Paulo, Brazil	2013

Co-Advisor

Dr. Andrea Koga-Vicente	University of Colorado	2014
Dr. Eduardo Vicente	University of Colorado	2014

Graduate Students

Co-Advisor

Daniela Lins	University of Campinas, Brazil	PhD	In progress
Raul Rechden	Victoria University, NZ	PhD	2014-2017
Lucas P. Moriera	University of Brasilia, Brazil	PhD	2010-2013
Fabio Iwashita	University of Campinas, Brazil	PhD	2009-2011
Andréa Koga Vicente	University of Campinas, Brazil	PhD	2009-2010
Mark E. Smith (withdrew)	Colorado State University, USA	PhD	2007
Akbar Eshfani	University of Colorado, USA	MS	2012-2013
Maria A. Figueroa	University of Colorado, USA	MS	2006-2007
Justin Little	University of Colorado, USA	MS	2006
Maria Stearns	University of Colorado, USA	MS	2003-2004
Chuenamol Sethaputra	University of Colorado, USA	MS	2002-2004
Elizabeth Murphy	University of Illinois, USA	MS	2001-2002

Undergraduate Students

Akbar Eshfani	University of Colorado, USA	BS	2010
Morgan Erlich	University of Colorado, USA	BS	2009

Committee member

Akbar Eshfani	University of Colorado, USA	MS	2013
Erin Wallin	Colorado School of Mines, USA	PhD	2008
Oderson A. De Souza Filho	University of Campinas, Brazil	PhD	2008

Invited Seminars

Peking University, CN, Machine learning, exploration, and new energy sources	2017
Southern University of Science and Technology, CN, Transdisciplinary Innovation and Discovery In Earth and Environmental Sciences	2017

Beijing Technology and Business University, Beijing Key Laboratory of Big Data Technology For Food Safety, Intelligent landscape classification by Machine Learning & Hyperion Images	2017
University of Andes, CO, Transdisciplinary discovery in geoscience	2017
University of Rosary, CO, Earth-system data science program vision	2017
University of Hawaii, USA, Transdisciplinary solutions in hydrogeology – data2knowledge2016	
Tblisi State University, GA, Role of large earthquakes on aquifer dynamics	2016
University of Colorado, USA, Computationally-intelligent solutions in hydrogeology	2015
Tblisi State University, GA, Alternate modeling paradigms in hydrogeology	2015
University of Colorado, USA, Computationally-intelligent solutions in hydrogeology	2015
GNS Science, New Zealand, Computationally-intelligent solutions in hydrogeology	2014
Swiss Technical University, Switzerland, New frontiers in experimental hydrogeology	2014
University of Campinas, Brazil, Forecasting climate change using a hybrid approach	2013
University of Campinas, Brazil, Climate change – applications of soft and hybrid modeling	2012
University of Brasilia, Brazil, Numerical modeling strategies in resource assessments	2008
University of Campinas, Brazil, Overview of hydrogeologic studies at the USGS	2008
Central American University, El Salvador, Simulating hurricane-induced coastal flooding	2006
Central American University, El Salvador, Estimating rainfall in ungauged coastal basins	2006
Hungarian Academy of Sciences, Hungary, Effects of urbanization on biological integrity	2005
Hohai University, China, Simulated effects of Sulphur Gulch reservoir operations	2005
Hohai University, China, Parameter estimation, model calibration, and uncertainty analysis	2005
Hohai University, China, Predicting effects of urbanization on ecological integrity	2005
Hohai University, China, Improved estimation of recharge through the vadose zone	2005
University of Colorado, Unsaturated zone flow and transport modeling	2004
University of Colorado, Coupled-inverse modeling to assess artificial recharge	2004
University of Minnesota, Stochastic simulation and optimization of reservoir parameters	2002
University of Minnesota, Estimating coupled water-heat-solute transport parameters	2002
University of Minnesota, Simulating urbanization effects on ecological integrity	2001
Radford University, Mining applications of seismic tomography	1996
University of California, Dynamic transmissivity during in-situ copper leaching	1992
Columbia University, Geotomographic applications in mining	1992
Michigan Technological University, In-situ mining	1991
University of Wisconsin, Mining applications of geotomography	1991

GRANTS

Under review

1. Data-driven forecasting of climate-change impacts on freshwater ecosystems across New Zealand and the Earth, 2018 Smart Ideas Fund, Ministry for Business, Innovation, and Employment, NZ.
2. Critical pathways: the role of dynamic contaminant transfers to lower order streams. Submitted to 2018 Endeavor Fund Research Program, Ministry for Business, Innovation, and Employment, NZ (Col). Funding: 2018-2023, \$8.9M. Note: This study develops simulation models and tools applicable from field to watershed scales that extend field research and serve as decision support tools for producers, agricultural industry, cooperative extension, and action agencies. Status: Science Innovation review passed (May, 2018); Science Impact under review (tbd Sept, 2018).

Funded

1. Environment Southland, Proposal for the design of methodologies to refine the Quaternary in the Southland Leapfrog 3D geological model (Col). Funding: 2016-2017, \$55k (17GW971).

2. Geoscience Australia, Improved groundwater system mapping and characterisation workflows using machine-learning and evolutionary techniques II (PI). Funding: 2016-2017, \$183k (CMCG4889A/D2017-15889).
3. Geoscience Australia, Improved groundwater system mapping and characterisation workflows using machine-learning and evolutionary techniques I (PI). Funding: 2015-2016, \$40k (GMCG4889A-001922)
4. GNS Science, Strategic Development Fund, Our rising tide – evaluating the regional impact of sea level change in New Zealand (Col). Funding: 2016-2017, \$150k.
5. Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil, Hierarchical scenarios of climate change from the perspective of evolutionary landscape dynamics (Col). Funding: 2013-2014, \$35k.
6. Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil, Evaluation of uncertainty in Amazonian gold occurrence using airborne radiometric data and soft computing (Col). Funding: 2013, \$35k.
7. US Department of Army, Engineer Research Development Center, Reliability of geophysical instrument response to unexploded ordnance, Funding: 2012-2013 (PI). \$250k.
8. US Department of Army, Engineer Research Development Center, Near real-time imaging of heterogeneity in a glacial aquifer (Geophysical Remote Sensing – “The Chameleon”) (PI). Funding: 2012-2013, \$68k
9. State of Nebraska, Estimation of Subsurface Attributes Using Hydrogeologic and Geophysical Measurements (Hydrogeologic Framework for Glacial Aquifers) (PI). Funding: 2011, \$25k.
10. National Council for Scientific and Technological Development, CNPQ, Improved crustal and upper mantle imaging using disparate geophysical data and joint inverse techniques (Col). Funding: 2010-2011, \$35k.
11. North Atlantic Treaty Organization, Water and environmental security: NATO advanced research workshop: climate-change effects on water resources– issues of national and global security, Izmir, Turkey (Col). Funding: 2010, \$65k.
12. US Geological Survey, Mineral Resource Program Seismic-magnetotelluric joint inversion to improve understanding of sediment-hosted gold deposits (Battle Mountain-Eureka mineral belt, Carlin-trend), northern Nevada (Col). Funding: 2014, \$150k.
13. US Geological Survey, Mineral Resources Program Joint inversion of disparate data (Col). Funding: 2013 \$175k.
14. World Bank, Technical assistance with water-resource assessment, Mauritania (Col). Funding: 2011-2012, \$100k.
15. US Army, Strategic Environmental Research and Development Program, UXO Discrimination (Col). Funding: 2010-2011, \$40k.
16. Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil, Joint evaluation and prediction of subsurface attributes from hydrogeologic and airborne geophysical measurements using data mining and knowledge discovery techniques (Col). Funding: 2009-2010, \$50k.
17. Civilian Research & Development Foundation, Evaluation of measures to mitigate groundwater flooding in Bishkek region of Kyrgyzstan (Col). Funding: 2009-2010, \$68k.
18. US Geological Survey, Mineral Resources Program, Stochastic mineral-resource software development (PI). Funding: 2008-2011, \$1M.
19. US Geological Survey, Mineral Resources Program Alternate modeling paradigms and methods to evaluate uncertainty (Col). Funding: 2006-2012, \$500k.
20. World Bank, Technical assistance with mineral and water-resource assessment, Mauritania (Col). Funding: 2006-2008, \$1.2M.
21. US Department of State, Technical assistance to Middle East process (Col). Funding: 2005, \$68k.

22. World Bank, Technical assistance with hazards risk mitigation and emergency preparedness, Romania (Col). Funding: 2005-2007, \$900k.
23. US Geological Survey, Mineral Resources Program, National Maps - source/process studies of selected contaminants associated with mineral deposits (Col). Funding: 2005-2007, \$150k.
24. United Nations Development Program, Technical assistance with real time flood warning system, Haiti (Col). Funding: 2005-2006, \$120k.
25. US Department of Army, Strategic Environmental Research and Development Program, Tensor magnetic gradient system (Col). Funding: 2005-2006, \$55k.
26. US Department of Homeland Security, Federal Emergency Management Agency, Post-wildfire flood potential in Willow & Mitchell creek watersheds (Col). Funding: 2004-2005, \$135k.
27. US Department of Health, National Institute of Occupational Health, Development of predictive equations using knowledge discovery techniques (PI). Funding 2003-2004, \$37k
28. US Agency for International Development, Office of Federal Disaster Assistance, Technical assistance with coastal flood predictions, El Salvador (Col). Funding: 2003-2004, \$65k.
29. US Geological Survey, Venture Capital Fund, Improvements to conceptual wildfire-induced flood models (PI). Funding: 2003-2004, \$35k.
30. US Geological Survey, National Water Quality Assessment Program, Preferential flow and transport in the High Plains aquifer (PI). Funding: 2003-2004, \$74k
31. Northern Colorado Water Conservancy District and Denver Water, Stochastic modeling of the effects that Sulphur Gulch reservoir may have on Colorado River near Grand Junction, CO (PI). Funding: 2002-2004, \$976k.
32. US Department of Homeland Security, Federal Emergency Management Agency, Post-wildfire technical assistance (PI). Funding: 2002-2004, \$550k.
33. US Geological Survey, National Water Quality Assessment Program, Agricultural land-use survey - understanding effect of drought on dry-land wheat farming (PI). Funding: 2001-2002, \$150
34. US Geological Survey, Toxics Program Variably-saturated transport in 2-dimensions - VST2D (PI). Funding: 1999, \$35k
35. US Geological Survey, National Water Quality Assessment Program, Upper Illinois River Basin study (PI). Funding: 1997-2001, \$8M
36. US Department of Agriculture, Agricultural Research Service, Vadose-zone leaching of agricultural chemicals (PI). Funding: 1996, \$36k.
37. US Department of Health, National Institute of Occupational Health, Tomographic imaging of deep underground metal mines (PI). Funding: 1996, \$48K
38. US Bureau of Mines, Advanced Mining Program In situ leach mining of unsaturated Chalcocite ore (PI). Funding: 1990-1995, \$450k
39. US Bureau of Mines, Advanced Mining Program, Characterization and remediation of acid mine drainage from a metal-mine waste impoundment (PI). Funding: 1991-1995, \$550k
40. US Bureau of Mines, Abandoned Mine Land Program, Cavity detection using geophysical methods, Funding: Abandoned Mine Land Program (PI). Funding: 1989-1993, \$575k
41. US Bureau of Mines, Health and Safety Program, Assessment of damage and integrity of mine structures, Funding: Health and Safety Program (PI). Funding: 1986-1995, \$780k
42. US Bureau of Mines, Advanced Mining Program, Geomechanical and geophysical technology for evaluating rock masses for in situ mining (PI). Funding: 1985-1994, \$960k

Training Courses – Developed and delivered

Short Courses

Airborne-electromagnetic resistivity inversion

Big data analytics for groundwater modeling
Coastal unconfined flooding and debris-flow
Digital signal processing
Ecological risk assessment
Geostatistical analysis
Inverse modeling and genetic programming
Mining applications of seismic tomography
Multivariate geostatistical
Nonlinear parameter estimation and uncertainty analysis
Numerical modeling of flow in the vadose zone
Peak-flood frequency analysis and rainfall-runoff ungauged basins
Quantitative mineral resource modeling
Rainfall-runoff model calibration
Reactive flow and transport
Seismic imaging for spatial imaging of mine-tailings
Stochastic assessment of urbanization of water quality
Unsteady confined and unconfined modeling of coastal water flooding
Unconfined-water and debris-flow modeling
Water-budget modeling and analysis
Watershed model calibration and predictive analysis

CONFERENCES, CONFERENCE SESSIONS, WORKSHOPS ORGANIZED

American Geophysical Union, San Francisco, CA

- *Computationally Intelligent Solutions Resource Questions in Earth Science* (IN016), Earth and Space Science Informatics (Session ID: 24874), 2017
- *Achieving Deep Learning by Systemizing Machine Learning with Big Data Engines I* ORAL (IN11B), Earth and Space Science Informatics (Session ID: 16826), 2016
- *Achieving Deep Learning by Systemizing Machine Learning with Big Data Engines II* Poster (IN14A), Earth and Space Science Informatics (Session ID: 16437), 2016
- *Regional Groundwater Systems: Advances in modeling, characterization, and applications I*, Hydrology session H14E (oral), 2013
- *Regional Groundwater Systems: Advances in modeling, characterization, and applications II*, Hydrology session H13O (oral), 2013
- *Regional Groundwater Systems: Advances in modeling, characterization, and applications II*, Hydrology session H11H (poster), 2013
- *Characterization of Groundwater Systems*, Hydrology oral sessions H11K and H12A (oral), and H13B poster session, 2012
- *Advanced Computational Modeling Paradigms for Hydrologic Systems*, Hydrology poster session H21A, 2012
- *Uncertainty Assessment, Optimization, and Sensitivity Analysis in Integrated Hydrologic Modeling as Applications of Hydroinformatics III*, Hydrology oral session H34D, 2011
- *Computational Intelligence in Earth and Space Systems*, Union poster session U22a, 2011
- *Computational Intelligence in Earth and Space Systems*, Union oral session U22b, 2011
- *Water Resources Science and Strategies for Adaptation to Climate Variability and Change III*, Hydrology oral session H24F, 2010
- *Water Resources Science and Strategies for Adaptation to Climate Variability and Change II*, Hydrology oral session H21G, 2010
- *Water Resources Science and Strategies for Adaptation to Climate Variability and Change I*, Hydrology poster session H21G, 2010
- *Climate Change Effects on Ecosystem Services – Issues of Global Security*, Natural Hazards oral session, H93, 2010
- *Quantitative Resource Assessments – Past, Present, and Future*, Natural Hazards oral session, NH17, 2010
- *Advanced Inverse Strategies for Improved Characterization and Assessment of Groundwater, Mineral, and Petroleum Resources I*, Near Surface geophysics poster session, NS31A, 2009
- *Advanced Inverse Strategies for Improved Characterization and Assessment of Groundwater, Mineral, and Petroleum Resources I*, Near Surface geophysics oral session, NS41A, 2009
- *Relationship of Natural and Anthropogenic Hazards to National and Global Security*, Public Affairs poster session, PA21B, 2009
- *Application of Joint Inverse Methods for Improved Characterization and Assessment of Groundwater, Mineral, and Petroleum Resources*, Near Surface geophysics poster session, NS31A, 2008
- *Multi-Scale Unsaturated Zone Flow and Contaminant Transport Processes*, Hydrology poster session H13F, 2008
- *Improved Estimation and Prediction in Earth Science Through Integration of Multiple Data Sets and Model Types*, Near surface geophysics oral session, NS43A, 2007
- *Preferential flow and transport in variably saturated porous media*, Hydrology poster session, H33,

2006

- *Spatial Relations Between Plants, Soil, and Water in the Vadose Zone*, Hydrology poster session, H12, 2005
- *Preferential flow and transport in variably saturated porous media*, Hydrology oral session, H13I, 2005
- *Preferential flow and transport in variably saturated porous media*, poster (H33B) and oral (H33A) sessions, 2004
- *Model Calibration, Parameter Nonuniqueness, and Predictive Uncertainty Associated With Flow and Transport in Variably Saturated Media*, hydrology poster session, H12A, 2003

NATO Advanced Research Workshop: Environment and Environmental Security, Izmir, Turkey:

- *Empirical, Numerical, Soft, and Hybrid Modeling*, Climate change Effect on Water Supplies, Issues of National and Global Security, 2010
- *Climate change Effects on Water Resources*, Issues of National and Global Security, 2010

NATO Advanced Study Workshop: Groundwater and Ecosystems, Canakkale, Turkey

- *Water Quality*, 2005

NATO Advanced Research Workshop: Regional Overviews, Baku, Azerbaijan

- *Urban Groundwater Management and Sustainability*, 2004

Methods in Hydrology, Hohai University, Nanjing, China

- *Flood predictions in ungauged basins*, Oral session, International Symposium, 2005

OTHER TECHNICAL ACTIVITIES

WebEx Seminars

Quantitative (stochastic) mineral-resource assessment software

Colorado Water Science Center seminar series

Watershed model calibration and predictive analysis

Model calibration and predictive analysis for watershed models

Simulation of urbanization and its effects on ecological integrity

Stochastic framework for assessing effects of urbanization of water quality

Technical Advisor

Intern advisor to Akbar Eshfani, USGS Volunteer for Science 2010

Intern advisor to Morgan Erlich, USGS Volunteer for Science 2009

Advisor to Erin Wallin, USGS Visiting Scientist 2006-2008

PROFESSIONAL ASSOCIATIONS

American Geophysical Union

European Geosciences Union

International Association of Hydrological Sciences

New Zealand Hydrological Society

Society of Exploration Geophysicists

SCIENTIFIC SERVICE– 2000 to present

- *Editorial board member*, Open Civil Engineering Journal, Bentham Science publishers, 2007-2014
- *Co-editor*, NATO Advanced Research book on Climate Change and its Effect on Water Resources-Issues of National and Global Security, NATO Science for Peace and Security Science Series C. Environmental Security, vol. 3, Springer, Dordrecht, The Netherlands, 318 p., 2013
- *Journal reviewer*: Groundwater Journal, Journal of Hydrology, Vadose Zone Journal, Water Resources Research, Jour Applied Geophysics, Jour Engineering Geology, Journal of Coal Geology
- *Proposal reviewer*: Israel Science Foundation, US Geological Survey, US Environmental Protection Agency, US Bureau of Mines, others

Peer-Review and Expert Panels

- Member, National Hazards Panel, U.S. Geological Survey, 2008
- Member, research grade evaluation panel, U.S. Geological Survey, 2005
- Member, research grade evaluation panel, U.S. Geological Survey, 2004
- Chair, Annual liaison meetings, budget conference calls, project reviews, Upper Illinois River Basin, National Water Quality Assessment Program, U.S. Geological Survey, 1997-2001

Selection and planning committees

- Member, Committee on unsaturated zone for hydrology, American Geophysical Union, discipline, planning, proposal selection: 2004, 2005, 2006, 2007, 2008, 2009, 2010
- Member, Program direction, planning, and technical review committee, senior staff, Colorado Water Science Center U.S. Geological Survey: 2001, 2002, 2003, 2004
- Member, Agricultural flow and transport program committee, direction and long-range planning, National Water Quality Assessment U.S. Geological Survey: 2002, 2003
- Member, Program direction, planning, and technical review committee, Illinois Water Science Center U.S. Geological Survey: 1997, 1998, 1999, 2000, 2001
- Member, Reactive unsaturated zone transport model development program committee, direction and long-range planning, U.S. Geological Survey, National Research Program, 2001
- Member, Characterization of hazardous waste sites using geophysical technology committee, long-range planning, Environmental Technology Program, Bureau of Mines, 1995
- Member, Well-drilling guidelines to reduce liability for groundwater pollution committee, U.S. Bureau of Mines, 1995
- Member, Ground control committee, proposal selection, and funding; Health and Safety program, U.S. Bureau of Mines 1993, 1994, 1995

Government Assistance

- Australia, Geoscience Australia, 2016, 2017
- Brazil, Centro de Pesquisas Meteorológicas e Climáticas, University of Campinas, 2013, 2012
- Brazil, Geosciences Institute, University of Campinas, 2012
- Brazil, Empresa Brasileira de Pesquisa Agropecuária, Campinas, 2012
- Kyrgyzstan, Hydrogeology and Water Economy Problems Laboratory, 2007
- Portugal, European research consortium, 2008
- Georgia, Seismic Monitoring Center and Ministry for Education and Science, 2008
- Brussels, European Union, Mine Waste Directive task group member, 2007
- Mauritania, Ministre du Petrole, de L' Energie et des Mines, 2006
- Romania, Romanian National Agency for Mineral Resources, 2006
- El Salvador, Servicio Nacional Estudios de Territoriales, 2003

RESEARCH EXPERIENCE

Data Analytics Science Leader

Lincoln University, Lincoln Agritech Ltd, Environmental Research Group

11/15/2017–present
Hamilton, NZ

Scientific Leader: I lead team of scientists and engineers in broad research area to develop groundwater and hydrologic simulation models and tools applicable across watershed scales that extend field research and serve as decision support tools for producers, agricultural industry, Ministry for the Environment, and Ministry of Business, Innovation and Employment. Other aspects involve assessing adequacy of current research and commercial work; provide thought leadership to identify future directions and funding opportunities; lead development of proposals and partnerships (indigenous people, NZ regional councils and crown research Institutes, international organizations and universities); develop, mentor, and coach team members; and represent the Institute at briefings, meetings, and conferences.

Scientific Investigator: I conduct environmental research on topics related to improving agricultural ground- and surface-water quantity and quality management across pore, catchment, and national scales. I develop and apply computationally-intelligent workflows to characterize, predict, and interpret the influence of natural and human pressures on the hydrosphere, geosphere, biosphere, and atmosphere. These workflows provide transdisciplinary risk and decision-based solutions by integrating disparate and sparse environmental data by combining evolutionary, machine learning, numerical, and statistical methods. In applying workflows, I participate in the design, collection, and integration of *big data* including direct (physical, chemical, biological) and indirect (geophysical, groundwater, water quality, and remote sensing) field observations (space, airborne, surface, borehole) to improve understanding, scalability, and predictability. I typically obtain indirect observations through numerical inversion (standard and joint) of field measurements for use in these workflows. Some examples include developing conceptual models (land-surface features and subsurface hydrostratigraphy) used in developing numerical *groundwater flow and transport models* including initial parameter values and calibration constraints; use calibrated models to evaluate and optimize management strategies; perform end-member mixing analysis as novel groundwater flow and transport model constraint; and predict spatial redox conditions across New Zealand.

Key Projects:

- Transfer pathway partitioning – Agricultural contaminant transfer and attenuation potential
- Groundwater mitigation – Nitrate mitigation methods for alluvial aquifers
- Our Land & Water– Integrating, scaling and transferability of agricultural catchment hydrology
- Precision agriculture – Remote classification vegetation/soils and crop yield prediction
- Remote mapping - Airborne 3D characterization of groundwater systems including uncertainty
- Fluxes and flows - Identifying lithologic controls on GW/SW interaction and nitrate reduction

Key Collaborators: Australia (Geoscience Australia), China (Beijing Water International; Institute of Quality and standard for Agricultural Products; Key state laboratory for pesticide residue detection), Italy (Semeion Institute), New Zealand (Aqualinc, GNS Science, ESR, Hawkes Bay Regional Council; Ministry of Business, Innovation and Employment; private sector companies, farmers and farming groups), USA (United States Geological Survey-Denver; University of Colorado-Denver).

Senior Research Hydrogeophysicist

Institute of Geological and Nuclear Science, Hydrogeology Department

6/1/2014–11/15/2017

Lower Hutt, NZ

Science leader/manager: Applied hydrogeophysical and computational knowledge to assess adequacy of ongoing research and commercial work and development of future directions. Identified and led strategic program activities including funding initiatives, proposal development, and partnerships with indigenous people, Crown Research Institutes, international organizations and universities. Coordinated project planning and review processes to ensure on-time completion of work products. Represented the Institute at briefings, meetings, and conferences.

Scientific investigator: Developed and applied machine learning and advanced computational methods to integrate big data for transdisciplinary solutions to challenges in climate and agricultural land-surface change, ecosystem, environment, and water sciences. Planned, developed, and maintained program of research and cooperative investigations involving groundwater, hydrological, hydrometeorological, and geophysical survey design and data collection; performed geophysical inversions; *groundwater flow and transport modeling*, geostatistical and statistical modeling and simulation; and uncertainty quantification analysis and interpretation. Facilitated accomplishments in combination with mentorship of junior staff, doctoral candidates, and visiting scientists; presented and published scientific findings nationally and internationally.

Research Projects:

- Conditional uncertainty in rainfall-recharge estimates
- Evolutionary-gradient numerical inverse solver
- Genetic-artificial neural network joint-inverse solver
- Estimation and scaling of hydrostratigraphic units from hydrogeophysical data
- Estimation of water fluxes at earth-atmospheric boundary with remote sensing
- Evaluating role of large earthquakes on aquifer dynamics
- Hydrogeophysical modeling of heat and fluid flow in geothermal systems
- Improved lateral crustal imaging with seismic and magnetotelluric data and models
- Imputation and clustering of sparse hydrogeophysical data
- Influence of climate, land-use, and land cover on flow, transport, and ecology
- Mapping soil and vegetation with machine-learning and EO-1 Hyperion satellite data
- Mapping geothermal/mineral resources by machine-learning and WorldView-3 satellite data
- Physical/biogeochemical interaction among groundwater, surface-water, and ecology
- Predicting aquatic species and metrics under climate change and urbanization
- Predicting groundwater recharge as function of stream flow and oxygen isotopes
- Reduced order analysis of multi-scale geophysical and geoenvironmental systems
- Scaling and estimation of hydrogeophysical data and processes
- Sea-level rise effects on coastal water supply (quantity/quality)
- Spatiotemporal downscaling of New Zealand climate station network
- Unconventional oil and gas prospecting with gravity, magnetics, and radiometrics
- Unconventional shale-gas prospecting with quantity, quality, maturation data
- Unsaturated-zone fate and transport of water, gas, solutes in dual porous media

Key Collaborators: Australia (Geoscience Australia), Brazil (Federal University of Natal; Empresa Brasileira de Pesquisa Agropecuária), China (Chinese Academy of Sciences; Sun Yat-sen University), Georgia (Tbilisi State University), Italy (Semeion Institute; University of Florence), New Zealand (Regional councils, Ministry of Business, Innovation and Employment), Spain (Institute of Environmental

Assessment and Water Research), USA (United States Geological Survey-Denver; University of Colorado-Denver).

Senior Research Geophysicist, GS-1315-14 10/1/2005 – 5/30/2014
U.S. Geological Survey, Crustal Geophysics & Geochemistry Science Center Denver, CO, USA
Central Mineral & Environmental Resources Science Center

Science leader/manager: Developed, participated, and led national and international research and consulting teams that characterized, monitored, and modeled the occurrence, distribution, and trends in quantity and quality of ground- and surface-water in response to natural and human pressures. Identified funding opportunities, led proposal development, developed and maintained partnerships (local, national, international), participated in short- and long-term strategic planning.

Scientific investigator: Designed studies and collected multidisciplinary measurements (aquatic biology, biogeochemistry, climate, ecology, geophysics, hydrology, hydrogeology, hydrometeorology, and remote sensing) in different configurations (borehole, surface, airborne, satellite); developed and applied data-driven workflows (combined evolutionary, machine learning, numerical, optimization, and statistical methods) for transdisciplinary solutions to questions in climate and land use, ecosystem, energy and minerals, natural hazard, crustal, and hydrologic (surface/ground water and vadose) sciences. Planned, developed, and maintained program of research and cooperative investigations involving geophysical, hydrogeologic and hydrologic survey design, data collection and monitoring; performed traditional and joint geophysical inversions, geostatistical modeling and simulation, and *groundwater and vadose zone flow and reactive transport modeling* analysis and interpretation. Provided mentorship (visiting scientists, post-doctoral fellows, and doctoral candidates at universities in the USA and abroad); and presented and published scientific findings through peer-reviewed venues.

Key Projects:

- Aquatic-mining ecosystem connectivity and response
- Biodegradation of organic compounds in porous media
- Climate-change effects on groundwater recharge
- Climate and hydrology in formation of acid-rock drainage
- Connectivity mapping among groundwater system variables
- Coupled watershed processes under climate change
- Detection and discrimination of unexploded ordnance
- Differentiating background and mine-related acidity and metals
- Dual permeability and reactive transport model development
- Economic feasibility of mining undiscovered mineral deposits
- Effect of climate-change impacts on coastal environments
- Efficacy of reactive barriers to mitigate mine-waste
- Flood-warning system for Haitian government
- Forecast change in ecological integrity for metropolitan Chicago, USA
- Forecasting post-fire debris and flood response in western USA
- Groundwater modeling of climate change on Bishkek region, Kyrgyz republic
- Hillslope weathering and shallow ground-water quality
- Hydrogeologic properties from magnetic resonance data
- Hydrogeologic map of Mauritania, Africa
- Imaging and quantifying uncertainty in lithospheric boundaries
- Infiltration and drainage equations for arid intermountain valleys

- Joint prediction of well yield (groundwater) in northeastern Brazil
- Joint inversion of seismic and magnetotelluric data for crustal imaging
- Joint estimation of extreme rainfall in coastal ungauged basins
- Landscape discrimination using remote sensing data and artificial adaptive systems
- Metal mine-waste speciation and toxicity effects on aquatic receptors
- Mineral-resource effects on aquatic ecosystems
- Multiphase fluid flow and transport
- Multivariate geostatistical modeling of spatially-limited data
- Post-fire debris-flow volumes and their uncertainty
- Modeling hydrologic and geomorphic hazards across post-fire landscapes
- Modeling reactive transport in Aries River basin tailings
- Near real-time airborne electromagnetic 3D imaging of surficial aquifers
- Optimization of stochastic reservoir operations
- Persistence of El Niño-Southern Oscillation over 2,000 years
- Predicting coastal hydro-meteorological hazards
- Predicting background and mine-related acidity and metals
- Probable flooding in ungauged basins
- Quantifying streamflow prediction uncertainty in ungauged basins
- Quantifying uncertainty in joint seismic crustal imaging
- Reconstruction of global temperature change and solar activity
- Reconstructing conditional trends in climate change at regional and global scales
- Sediment transport in mining-affected Aries River basin
- Scaling of ground-water recharge measurements
- Spatial continuity from spatially-limited data for numerical inverse problems
- Statistical reliability of geophysical instruments to unexploded ordnance
- Stresses on water-quality in existing and proposed mining watersheds
- Stochastic assessment of undiscovered mineral resources
- Tailings and waste dump inventory and risk prioritization for Romania
- Uncertainty in joint-inverse depth estimates of Moho
- Uncertainty in airborne estimates of gold mineralization
- Uncertainty in multi-component reactive groundwater systems
- Variably-saturated dual permeability gas, flow and transport modeling
- Vertical drainage and groundwater flow in arid intermountain valleys
- Water-quality response across hydrothermal alteration-mining gradient

Key Collaborators: Brazil (University of Campinas; University of Brasilia; Empresa Brasileira de Pesquisa Agropecuária, Geological Survey of Brazil), Finland (University of Kuopio, Geological Survey of Finland), Georgia (Tbilisi State University), Haiti (Geological Survey of Haiti), Italy (Semeion Institute), Kyrgystan (Research Institute of Irrigation, Hydrogeology and Water Economy), Mauritania (Ministre du Petrole, de L' Energie et des mines), Romania (Romanian National Agency for Mineral Resources), USA (Univ of Colorado-Denver).

Senior Research Hydrologist, GS-1315-13
U.S. Geological Survey, Colorado Water Science Center
leader/manager:

10/1/2001–9/30/2005
Denver, CO, USA Science

Participated in short- and long-term strategic planning; developed and maintained a program of research and cooperative hydrological investigations that included data collection, modeling, and

analysis; identified funding opportunities, led marketing strategies and proposal development, and developed partnerships among International, Federal, State, and local agencies, and national and international universities. Provided technical oversight to multiple hydrologic investigations and hydrologic research; applied knowledge of advanced hydrologic principles and related sciences to assess the adequacy of ongoing work and development of future directions; represented USGS at meetings and conferences; explained complex hydrologic and earth science information to a wide variety of individuals; coordinated project planning and review processes to ensure on-time completion of work products; resolved problems between employees and scientific collaborators; set goals and obtain buy-in from team members and those who supervised me.

Scientific investigator: Coordinated, led and participated on research teams that characterized, monitored, and modeled the occurrence, distribution and fate of water quality in surface and groundwater basins of Colorado and High-Plains aquifer. Proposed and designed field studies, conducted field sampling, collected data, and developed and applied modeling techniques and software for understanding effect of agricultural, wildfire, and reservoir stresses on hydro(geo)logic systems; mentored project chief and visiting post-docs and USGS scientists.

Key projects:

- Agricultural land-use study in South Platte River basin
- Calibration and predictive analysis of vadose zone models
- Enhanced remediation of toluene biodegradation in vadose zone
- Hydrologic risk assessment and flood protection for coastal basins
- Post-wildfire assistance to US Federal Emergency Management Agency
- Post-wildfire flood potential in Willow and Mitchell Creek watersheds
- Preferential flow and transport in the High Plains aquifer
- Probable effects of proposed reservoir on river quantity, quality, ecological integrity
- Satellite resolution and effects on wildfire-induced flood models
- Water and solute transport in variably-saturated dual porous soils
- Stratified sample design for water quality studies
- Stochastic optimization of reservoir operations for water-quality and ecological benefits

Key collaborators: Colorado Springs Utilities, Denver Water, Northern Water Conservancy District, USGS National Research Program, US Bureau of Reclamation, US Federal Emergency Management Agency, others.

Supervisory Hydrologist, GS-1315-13

10/1/1997-9/30/2001

U.S. Geological Survey, Illinois Water Science Center

Urbana, IL, USA

Science leader/manager: Assisted Director with short and long-term strategic resource and program planning; periodically assisted with Center operations and resource management in Director's absence. Promoted and prioritized hydrologic and water-quality work; coordinated and prepared scope of work and financial plans with annual budgets to ~\$2.0M; determined project staffing needs and hired scientists with experience in aquatic biology, data base administration, ecology, geomorphology, surface water, and groundwater data collection and modeling; determined assignments, awards, and promotions; reviewed and ensured timely completion and quality of technical proposals, work plans, presentations, and reports; and evaluated employee performance. Motivated scientific teams toward common goals; guided and participated in project designs, data collection, analyses, and interpretation; promoted team workshops on field data collection and modeling applications; identified, planned, promoted, and coordinated multi-state monitoring activities with cooperating companies, State and Federal agencies, National Synthesis Teams, and related studies; devised and promoted new scientific approaches; developed, participated and chaired reviews at science center, headquarter, and stakeholder meetings.

Scientific investigator: Developed and applied new predictive analytic and numerical modeling techniques and software for hydrologic, hydrometeorological and groundwater studies.

Key projects:

- Upper Illinois River Basin Study, National Water Quality Assessment Program
- Urban land-use gradient study in the Upper Illinois River Basin
- Development and application of variably-saturated mass and energy transport model
- Source-water risk assessment in the Upper Illinois River Basin
- Water-quantity testing and water-quality sampling/analysis (occurrence, distribution, trends)
- Regularized calibration and uncertainty analysis in surface and groundwater modeling

Key collaborators: Central Lake County Joint Action Water Agency, Illinois Environmental Protection Agency, Illinois State Water Survey, US Environmental Protection Agency, Northwest Suburban Municipal Joint Action Water Agency, others.

Research Geophysicist , GS-1315-13

6/1/1987 – 9/30/1997

U.S. Geological Survey, Twin Cities Research Center

Urbana, IL, USA

Science leader/manager/scientist: I promoted and prioritized work; coordinated and prepared the scope of work and financial plans with annual budgets to ~\$1.0M; lead, coordinated, mentored and participated in international transdisciplinary research and consulting team activities that characterized, monitored, and modeled the response of mining-related environmental and health & safety concerns. I designed geophysical (azimuthal, surface, borehole, crosshole, tomographic), groundwater and unsaturated zone studies; conducted packer, pump, slug testing, collected physical and chemical data; and developed and applied conceptual, predictive analytic and numerical modeling flow and transport techniques and software. My geophysical fieldwork supported solutions for engineering, groundwater, minerals, seismology, and vadose-zone studies.

Key data, methods and modeling: Some geophysical methods and modeling involved *electrical and electromagnetic* (controlled source audiomagnetotellurics, time and frequency domain electromagnetic, DC resistivity, ground penetrating radar, EM induction, induced polarization, magnetotelluric, radio

wave, time-domain reflectometry, and very low frequency); *potential fields* (gravity and magnetics); *seismic* (birefringence, guided waves, ray tracing, particle motion, refraction, reflection, surface wave); *seismology*: earthquake seismicity (natural and artificial, acceleration, dispersion, source location and rupture). Some hydrologic methods and modeling involved physical installation and development (lysimeters, piezometers, wells), physical testing (deformation, discharge, stress-strain, injection, infiltrometer, mechanical, pump, water level), saturated/unsaturated water-quality sampling (physical, chemical, biologic). In addition, I mentored scientists and collaborated with researchers at other federal agencies and universities.

Research projects:

- Acid-mine drainage studies
- Cavity and tunnel detection by geophysical methods
- Development and application of analytic-element model groundwater model software
- Development and application of finite-element model for coupled transport in freezing soils
- Development and application of geotomographic software for mining applications
- Geomechanical and geophysical technology for imaging fractured rock
- Geophysical assessments of mineral deposits
- Geophysical monitoring of injection/extraction of subsurface fluids
- Hydromechanical flow and reactive transport modeling in fracture rock
- Hydrothermal flow and transport modeling in porous and fracture rock
- Flow & transport modeling of in-situ leaching uranium, copper, and base sulfide deposits
- Modeling in-situ leach mining of tailings and fractured rock deposits
- Mine-structural integrity using geophysics (active/passive)
- Monitoring mining-induced stresses by seismic tomography
- Porous/fractured, saturated/unsaturated flow/transport methods/modeling
- Stochastic flow and transport in fractured rockmass

Key collaborators: Australia (Western Mining Corporation); South Africa (University of Johannesburg), USA (US Dept of Army, and various mining companies)

Curriculum Vitae
Michael J. Friedel, 5 September 2018