Michael J. Friedel

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[ResearchGate](https://www.researchgate.net/profile/Michael_Friedel3) | [Google Scholar](https://scholar.google.co.nz/citations?user=X28pSF8AAAAJ&hl=en) | [LinkedIn](https://www.linkedin.com/in/michael-j-friedel-phd-3a7425aa/) | [ORCID](http://orcid.org/0000-0003-2357-6523)

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| **PROFILE** | |
|  | As Associate Professor of Research at the [University of Colorado](https://clas.ucdenver.edu/physics/about-us/faculty-and-staff-directory), Senior Research Geophysicist at the [University of Hawaii](https://www.higp.hawaii.edu/hggrc/about-hggrc/), and Associate Researcher at [Semeion Centro Ricerche](http://www.semeion.it/wordpress/en/staff/), IT, I propose, develop, and apply approaches and software that assimilate, discover, and predict linkages and their response to climate, hydrologic and biogeochemical cycles and geophysical systems that inform sustainable earth, energy, and environmental management. My research and consultancy uses artificial intelligence (genetic programming, learn-heuristics, machine/deep learning, metamodeling, multimodal machine learning, and physics-informed learning), physics-based numerical (forward/inverse) and uncertainty quantification methods. I help design, collect, and integrate big data including direct (physical, chemical, biological) and indirect (geophysical and remote sensing) measurements across environmental sensor networks (space, airborne, surface, borehole) to improve predictability.   |  |  |  |  | | --- | --- | --- | --- | | **EDUCATION** | | | | |  | **Degrees** | | | |  |  | PhD, Water Resources Science, University of Minnesota | 1999-2002 | |  |  | Dissertation: [Estimation of coupled water, heat, & solute transport parameters](https://doi.org/10.1016/j.jhydrol.2005.02.013) |  | |  |  | MS, Geo-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, Geosciences, University of Wisconsin | 1980-1983 | |  |  | **Postgraduate Training** MBA (mini), University of St Thomas, United States |  |   Prior to these roles, I was Senior Computational Scientist at [Pacific Northwest National Laboratory](https://essd.pnnl.gov/staff/staff_info.asp?staff_num=3653), USA; the Environmental Data Analytics Science Leader at [Lincoln Agritech](https://www.lincolnagritech.co.nz/) - Lincoln University and Senior Research Scientist at [GNS Science](https://www.gns.cri.nz/), NZ; and Senior Research Scientist and Supervisory Scientist at [US Geological Survey](https://www.usgs.gov/centers/gggsc), USA. During this period, I successfully developed and applied physics-based numerical and machine learning workflows to test hypotheses and answer questions across various spatial themes: climate and land-use change, ecosystem, energy and minerals, natural hazards, solid-earth, and water science. This work resulted in 120 publications, 156 conference presentations, and $35M+ research grants, most recent funding for applications of artificial intelligence to geothermal projects for the Department of Energy. During this period, I managed multimillion-dollar national/international multidisciplinary projects with academic appointments as Adjoint Associate Professor in the School of Geography, Environment, and Earth Sciences at Victoria University of Wellington, NZ; and Mathematical and Statistical Sciences at the University of Colorado, USA. I also served as Instructor in the Department of Geography and Environmental Sciences at the University of Colorado, USA; and Visiting Professor developing and teaching courses and mentoring students for the Geology Department at Colorado College, USA; Department of Environmental Science, University of Kuopio, FN; and Geosciences Institutes at the Universities of Brasilia and Campinas, BR. | |

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| |  |  |  |  | | --- | --- | --- | --- | | **PROFESSIONAL EXPERIENCE** | | | | |  | **Academic Appointments** | | | |  |  | Associate Professor – Research, Dept. of Physics, University of Colorado Associate Professor - Adjoint, Math & Statistical Sciences, University of Colorado | 2021-present | |  |  | Research Geophysicist – Hawai‘i Grndwtr & Geothrml Res Cntr, University of Hawaii : [University of Hawaiʻi at Mānoa](https://www.researchgate.net/institution/University_of_Hawaii_at_Mnoa)  Department: [Hawaii Institute of Geophysics and Planetology](https://www.researchgate.net/institution/University_of_Hawaii_at_Mnoa/department/Hawaii_Institute_of_Geophysics_and_Planetology)  , University of Hawaii  Associate | 2020-present | |  |  | 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-present | |  |  | 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](http://www.semeion.it/wordpress/en/) | 2018-present | |  | Senior Computational Scientist, [Pacific Northwest National Laboratory](https://www.pnnl.gov/) | 2019-2020 | |  | Data Analytics Science Leader, Environmental Research, [Lincoln Agritech](https://www.lincolnagritech.co.nz/) Ltd | 2017-2019 | |  | Senior Hydrogeophysicist, Hydrogeology, [Inst of Geological and Nuclear Sciences](https://www.gns.cri.nz/) | 2014-2017 | |  | Senior Research Geophysicist, (1) Crustal Geophysics & Geochemistry Science Center, and (2) Central Mineral & Environmental Resource, [US Geological Survey](https://www.usgs.gov/) | 2005-2014 | |  | Visiting Scientist,Geoscience Australia, Groundwater Innovation, AU | 2016 | |  | Visiting Scientist**,** Empresa Brasileira de Pesquisa Agropecuária, Satellite, 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, Colo. 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 | |

**PUBLICATIONS** (\* ISI Web of Science, \*\* Student, Post-Doc, Visiting Scientist)

1. **Friedel, M.J.**, Buscema, M., *in revision*, Joint multiphysics-decision tree learning for efficient variably saturated subsurface transport parameter estimation with improved accuracy and reduced order model simulations, Journal of Hydrology (submitted 12/2020)
2. **Friedel, M.J.**, Rechden, R., 2020, Estimated Ultimate Recovery Using the Digital Analogue Shale Model, In proceedings: SPE/AAPG/SEG Unconventional Resources Technology Conference. URTEC-2020-2976-MS. <https://doi.org/10.15530/urtec-2020-2976>
3. **Friedel, M.J**., Wilson, S.R., Close, M.E., Buscema, M., Abraham, P., Banasiak, L., 2019 Comparison of four learning-based methods for predicting groundwater redox status, Journal of Hydrology, 580, 124200 <https://doi.org/10.1016/j.jhydrol.2019.124200> [IF: 4.5] \*
4. Iwashita, F.\*\*, **Friedel, M.J.**, Ferreira, F.J.F, 2018, A self-organizing map approach to characterize hydrogeologic properties of the Serra-Geral transboundary fractured aquifer, Hydrology Research Journal. 49(3), 794-814. <https://doi.org/10.2166/nh.2017.221> [IF: 2.5] \*
5. **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. <https://doi.org/10.1080/17538947.2017.1349841> [IF: 3.0] \*
6. **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. <https://doi.org/10.1007/s10040-016-1452-5>. [IF: 2.6] \*
7. 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. <https://doi.org/10.15377/24095710.2016.03.01.3>

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1. Tindall, J., **Friedel, M.J.**, 2016*,* Transport of Atrazine versus Bromide and δO18 in sand, Journal Water, Air, & Soil Pollution, 227-294. <https://doi.org/10.1007/s11270-016-2983-z>.[IF: 1.8] \*
2. **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. <https://doi.org/10.1007/s10040-015-1318-2> [IF: 2.64] \*
3. Esfahani, A.A. \*\*, **Friedel, M.J.**, 2014, Forecasting conditional climate-change using a hybrid approach, Environmental Modelling & Software, 52, 83-97. <https://doi.org/10.1016/j.envsoft.2013.10.009> [IF: 4.8] \*
4. **Friedel, M.J.**, 2014, Data-driven modeling of background and mine-related acidity and metals in river basins, Environmental Pollution, 184, 530-539. <https://doi.org/10.1016/j.envpol.2013.09.036>

[IF: 6.8] \*

1. 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. <http://dx.doi.org/10.1785/0120120167> [IF: 2.3] \*
2. **Friedel, M.J.**, Iwashita, F. \*\*, 2013,Hybrid modeling of spatial continuity for applications to environmental inverse problems, Environmental Modelling & Software, 43, 60-79. <https://doi.org/10.1016/j.envsoft.2013.01.009> [IF: 4.8] \*
3. **Friedel, M.J.,** 2012, Hybrid modeling to predict the economic feasibility of mining undiscovered porphyry copper deposits. Applied Soft Computing 13, 1016-1032. [https://doi.org/10.1016/ j.asoc.2012.09.019](https://doi.org/10.1016/%20j.asoc.2012.09.019) [IF: 5.5] \*
4. **Friedel, M.J.**, 2012, Data-driven modeling of surface temperature anomaly and solar activity trends, Environmental Modelling & Software, 37, 217-232. <https://doi.org/10.1016/j.envsoft.2012.04.016> [IF: 4.8] \*
5. **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. https://doi.org/10.1007/s10040-012-0855-1 [IF: 2.64] \*
6. **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. <https://doi.org/10.1111/j.1365-246X.2012.05522.x> [IF: 2.8] \*
7. Iwashita, F. \*\*, **Friedel, M.J.**, Rebeiro, G.F., Fraser, S.J., 2012, Intelligent estimation of hydrogeologic properties, Geoderma, 170, 1-10. <https://doi.org/10.1016/j.geoderma.2011.11.002> [IF: 4.8] \*
8. **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. <https://doi.org/10.1016/j.envsoft.2011.07.001> [IF: 4.6] \*
9. **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. [https://doi.org/10.1016/ j.envsoft.2011.07.014](https://doi.org/10.1016/%20j.envsoft.2011.07.014) [IF: 4.8]
10. 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. <https://doi.org/10.1016/j.geomorph.2011.05.006> [IF: 3.9] \*
11. **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.   
    https://doi.org/10.1007/s11069-007-9179-1 [IF: 2.4] \*
12. **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. <https://doi.org/10.1061/(ASCE)1084-0699(2008)13:5(321)> [IF: 1.8] \*
13. Figueroa, M. \*\*, Tindall, J.A., and **Friedel. M.J.**, 2007, Comparison of 18Oδ composition of water extracted from suction lysimeters, centrifugation, and azeotropic distillation, Journal Water, Air, & Soil Pollution, 184(1-4), 63-75. <https://doi.org/10.1007/s11270-007-9399-8> [IF: 1.9] \*
14. 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. <https://doi.org/10.1007/s11270-006-9299-3> [IF: 1.9] \*
15. 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. <https://doi.org/10.1007/s11270-006-9185-z> [IF: 1.8] \*
16. **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. <https://doi.org/10.1080/15715124.2006.9635281> [IF: 1.4] \*
17. 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. <https://doi.org/10.1007/s11270-005-3584-4> [IF: 1.9] \*
18. 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: 1.9] \*
19. 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. <https://doi.org/10.1007/s11270-005-0588-z>

[IF: 1.9] \*

1. **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. <https://doi.org/10.1016/j.jhydrol.2005.02.013> [IF: 4.5] \*
2. 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. [https://pubs.er.usgs.gov/ publication/70021952](https://pubs.er.usgs.gov/%20publication/70021952) [IF: 1.0] \*
3. **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. [https://doi.org/10.1016/ S0013-7952(96)00107-X](https://doi.org/10.1016/%20S0013-7952(96)00107-X) [IF: 4.8] \*
4. 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. <https://doi.org/10.1016/S1365-1609(97)00235-9> [IF: 4.2] \*
5. **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. <https://doi.org/10.1016/S0926-9851(96)00027-4> [IF: 2.0] \*
6. **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. <https://doi.org/10.1016/0148-9062(95)00061-5> [IF: 4.2] \*
7. **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. <https://doi.org/10.1016/0926-9851(95)00007-O> [IF: 2.0] \*
8. **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: 1.1]
9. 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. <http://dx.doi.org/10.1190/1.1436980> [IF: 0.73] \*
10. **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]
11. **Friedel, M.J.**, and Thill, R.E., 1991, U.S. Bureau of Mines Research on the Kaiser Effect for determining stress in rock, Journal of Acoustic Emission, 10(1-2), S77-S89 [IF: 1.0]

Invited Book Chapters

1. **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. <https://doi.org/10.1007/978-94-007-1143-3_3>
2. **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. <https://doi.org/10.1007/1-4020-5175-1_13>
3. **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 <https://doi.org/10.1007/1-4020-4738-X_6>
4. 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. <https://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/sp01-95.pdf>
5. 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. <https://www.cdc.gov/niosh/nioshtic-2/20024631.html>

Refereed Reports (\*\* Student, Post-Doc, Visiting Scientist)

1. **Friedel, M.J.,** 2020, Science-informed learning strategies for multi-scale subsurface data assimilation, visualization and simulation of CO2 injection and storage, White Paper, FE SMART Initiative, Department of Energy, 7 p.
2. Robinson, J., Mackley, R., Rockhold, M., Johnson, T., Jaysaval, P., **Friedel, M.**, 2020, Geophysical methods for stratigraphic identification, PNNL – 29182, 24 p.
3. Vrabie D.L., S. Peles, S.G. Abhyankar, T.C. Johnson, and **M.J. Friedel**. 2019. Data-Model Convergence Application Flows. PNNL-SA-149186. Richland, WA: Pacific Northwest National Laboratory.
4. **Friedel, M.J**., Moreira, L.P. \*\*, 2016, Joint-inverse framework with PEST examples to improve subsurface modeling. GNS Science Report 2016/46, 69 pp. <http://shop.gns.cri.nz/sr_2016-046-pdf/>
5. **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.
6. 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. <http://shop.gns.cri.nz/sr_2015-024-pdf/>
7. **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.]
8. 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 Iguaçu, PR, Brazil. [Proceedings]
9. 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.
10. **Friedel, M.J.**, 2008, Hydrologic model calibration strategy for the Islamic Republic of Mauritania, Africa, USGS Open File Report, 2008-1173, 13 pp.
11. **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.
12. **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.
13. **Friedel, M.J.**, 2008, Environmental stratification and water-quality monitoring design, Mauritania, Africa, USGS Open File Report, 2008 -1137, 13 pp.
14. **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.
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1. **Friedel, M.J**., Regionalization workflow for predicting 3D groundwater-redox status at the national scale using sparse data: New Zealand case study.
2. **Friedel, M.J.**, Modeling mineral-resource effects on aquatic ecosystems using machine learning and multivariate statistical techniques: Application to Central Colorado, USA.
3. **Friedel, M.J.**, Intelligent scaling of ground-water recharge measurements.
4. **Friedel, M.J.**, Machine-learning paradigm for predicting climate-change effects on ground-water recharge in the Midwestern United States.
5. **Friedel, M.J.**, Modeling warm-season persistence of the El Niño-Southern Oscillation phenomena over the past 2,000 years.

**CONFERENCE PRESENTATIONS** (\*\* Student, Post-Doc, Visiting Scientist)

1. **Friedel, M.J.**, Buscema, M., 2020, Abstract ID: [H076-16- Multiphysics-informed learning algorithm for vadose zone transport modeling](https://agu2020fallmeeting-agu.ipostersessions.com/?s=3D-0A-7C-76-D7-25-FF-AE-B3-05-22-30-D1-4A-23-CB&token=3R5DjoiMptSdWt4M8roEC.0lKa.LFb8QJks0XfTMibQ)*,* [Session H076 - Scientific Machine Learning and Physics-informed Data-driven Methods for Flow, Transport, and Coupled Processes across Temporal and Spatial Scales III eLightning](https://agu.confex.com/agu/fm20/meetingapp.cgi/Session/107733), American Geophysical Union, San Francisco, CA, 7-11 December 2020.
2. **Friedel, M.J.**, [2020, Multiphysics-informed learning algorithm for vadose zone transport modeling – preliminary results*,* KGML workshop, Hydrology Session part 2 (YouTube at 45.08 minutes](https://www.youtube.com/watch?v=GF9ghOOAXo0))*,* Harnessing the data revolution: [Knowledge guided machine learning: A framework for accelerating scientific discovery (Workshop)](https://sites.google.com/umn.edu/kgml/workshop/hydrology-details), Minneapolis, MN, August 2020. [INVITED]
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134. **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.
135. **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]
136. 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)
137. 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)
138. **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.
139. 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)
140. 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)
141. 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)
142. 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)
143. 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.
144. 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.
145. **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]
146. **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.)
147. **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.
148. 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)
149. **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]
150. **Friedel, M.J.** and Schmidt, R.D., 1991, Effect of an unsaturated setting on the hydrology of in situ opper 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.)
151. 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)
152. **Friedel, M.J.** and Hanson, J.C., 1990, Assessment of ground penetrating radar for detecting hazardous abandoned mine openings and related features. Proceedings12th Annual National Abandoned Mine Land Conference, Breckenridge, CO, September, pp. 87-55.
153. **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.
154. 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]
155. 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]
156. 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]
157. **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.

**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](http://www.springer.com/environment/global+change+-+climate+change/book/978-94-007-1142-6), 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, Machine Learning Geothermal Portfolio Review Panel, GTO, Department of Energy, 2020
* 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 groundwater liability committee, U.S. Bureau 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 Estudious de Territoriales, 2003

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| **PROFESSIONAL ACTIVITY** | | | |
| **Research prizes, fellowships, awards and appointments** | | |
| Research Associate, Machine Learning, Earth & Environmental Sciences, Semeion Institute, Rome Italy  Letter of appointment, Strategic Big Data Consultant, SUSTECH Environmental Ltd, Southern University of Science and Technology, China | 2018-present  2017-2019 |
| 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, 2008 |

**Training Courses** – Developed and delivered

**Short Courses**

Big data analytics for groundwater modeling, Beijing Water International/Peking University, China, 2018

Airborne-electromagnetic resistivity inversion, Geological Survey of Brazil and Campinas University, 2016

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 analysis

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

**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](http://www.uku.fi/ympti/english/), Finland, 2007
* *M*ulticomponent reactive transport modeling for mining environments,  [Dept. of Environmental Science, University of Kuopio](http://www.uku.fi/ympti/english/), 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. Fabio Iwashita University of the Andes, CO 2018

Dr. Lucas Moreira Federal Institute of Education, BR 2016

Dr. Lucas Moreira University of Brasilia, BR 2015

Dr. Cleyton Carnerio University of Sao Paulo, BR 2013

Co-Advisor

Dr. Andrea Koga-Vicente University of Colorado, USA 2014

Dr. Eduardo Vicente University of Colorado, USA 2014

**Graduate Students**

Co-Advisor

Daniela Lins University of Campinas, BR PhD In progress

Raul Rechden Victoria University, NZ PhD 2014-2017

Lucas P. Moriera University of Brasilia, BRl PhD 2010-2013

Fabio Iwashita University of Campinas, BR PhD 2009-2011

Andréa Koga Vicente University of Campinas, BR PhD 2009-2010

Mark E. Smith Colorado State University, USA PhD 2007-withdrew

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 2006-2007

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

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, BR PhD 2008

**Undergraduate Students**

Akbar Eshfani University of Colorado, USA BS 2010

Morgan Erlich University of Colorado, USA BS 2009

**Invited Seminars**

Arhus University, GEUS, Hydrogeophysical mapping using data analytics 2019

Environment Canterbury (NZ), Regional Council, Using SkyTEM data to improve mapping of

aquifer characteristics 2019

Ventures Southland and Environment Southland Regional Council (NZ), Using SkyTEM data

to improve mapping of aquifer characteristics 2019

Pacific Northwest National Laboratory, Subsurface Science & Technology Group, (USA),

Transdisciplinary innovation for knowledge discovery in earth, energy, environment 2019

Peking University (CN),Machine learning,exploration and new energy sources 2018

Southern University of Science and Technology (CN), Transdisciplinary Innovation and Discovery

In Earth and Environmental Sciences 2018

Beijing Technology and Business University, Beijing Key Laboratory of Big Data Technology

For Food Safety (CN), Intelligent landscape classification by Machine Learning & Hyperion Data 2018

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 –data2knowledge 2016

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 (NZ), Computationally intelligent solutions in hydrogeology 2014

Swiss Technical University (CH), New frontiers in experimental hydrogeology 2014

University of Campinas (BR), Forecasting climate change using a hybrid approach 2013

University of Campinas (BR), Climate change – applications of soft and hybrid modeling 2012

University of Brasilia (BR), Numerical modeling strategies in resource assessments 2008

University of Campinas (BR), Overview of hydrogeologic studies at the USGS 2008

Central American University (ES), Simulating hurricane-induced coastal flooding 2006

Central American University (ES), Estimating rainfall in ungauged coastal basins 2006

Hungarian Academy of Sciences (HU), Effects of urbanization on biological integrity 2005

Hohai University (CN), Simulated effects of Sulphur Gulch reservoir operations 2005

Hohai University (CN), Parameter estimation, model calibration, and uncertainty analysis 2005

Hohai University (CN), Predicting effects of urbanization on ecological integrity 2005

Hohai University (CN), Improved estimation of recharge through the vadose zone 2005

University of Colorado (USA), Unsaturated-zone flow and transport modeling 2004

University of Colorado (USA), Coupled-inverse modeling to assess artificial recharge 2004

University of Minnesota (USA), Stochastic simulation and optimization of reservoir parameters 2002

University of Minnesota (USA), Estimating coupled water-heat-solute transport parameters 2002

University of Minnesota (USA), Simulating urbanization effects on ecological integrity 2001

**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, Volunteer for Science, USGS 2010

Intern advisor to Morgan Erlich, Volunteer for Science, USGS 2009

Advisor to Erin Wallin, Visiting Scientist, USGS 2006-2008

**GRANTS –** PI – Principal Investigator, CoI – Co investigator

Funded

1. Department of Energy, National Laboratory Program, Artificial Intelligence and Decision Support for Complex Systems, LAB 20-2321: Innovative Subsurface Learning and Hawaiian Exploration using Advanced Tomography (ISLAND HEAT)(CoI). Funding: 2021-2023, $3.3M (WBS3.1.1.15).
2. Department of Energy, Pacific Northwest National Laboratory, FY20 Laboratory Directed Research and Development - Physics Informed Machine Learning for Energy and Environment Directorate Applications, Physics-informed learning for reduced-order vadose zone transport modeling of Hanford 300 area, (PI). Funding: 2020, $40k (NF2564).
3. Department of Energy, Pacific Northwest National Laboratory, Deep Vadose Zone Program, Automated Travel-time Picking using Unsupervised Machine Learning (PI). Funding: 2019, $30k (ND5853, NC0426).
4. Ministry for Business, Innovation, and Employment, NZ, 2018 Endeavor Fund Research Program, Unraveling critical for freshwater contamination. (CoI). Funding: 2018-2023, $7.8M (LVLX1802).
5. Environment Southland, Proposal for the design of methodologies to refine the Quaternary in the Southland Leapfrog 3D geological model (CoI). Funding: 2016-2017, $55k (17GW971).
6. Geoscience Australia, Improved groundwater system mapping and characterization workflows using machine-learning and evolutionary techniques II (PI). Funding: 2016-2017, $183k (CMCG4889A/D2017-15889).
7. Geoscience Australia, Improved groundwater system mapping and characterization workflows using machine-learning and evolutionary techniques I (PI). Funding: 2015-2016, $40k (GMCG4889A-001922)
8. GNS Science, Strategic Development Fund, Our rising tide – evaluating the regional impact of sea level change in New Zealand (CoI). Funding: 2016-2017, $150k.
9. Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil, Hierarchical scenarios of climate change from the perspective of evolutionary landscape dynamics (CoI). Funding: 2013-2014, $35k.
10. 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 (CoI). Funding: 2013, $31k.
11. US Department of Army, Engineer Research Development Center, Reliability of geophysical instrument response to unexploded ordnance, Funding: 2012-2013 (PI). $250k.
12. 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
13. State of Nebraska, Estimation of Subsurface Attributes Using Hydrogeologic and Geophysical Measurements (Hydrogeologic Framework for Glacial Aquifers) (PI). Funding: 2011, $25k.
14. National Council for Scientific and Technological Development, CNPQ, Improved crustal and upper mantle imaging using disparate geophysical data and joint inverse techniques (CoI). Funding: 2010-2011, $32k.
15. 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 (CoI). Funding: 2010, $65k.
16. US Geological Survey, Mineral Resource Program Seismic-magnetotelluric joint inversion to improve understanding of sediment-hosted gold deposits (Battle Mountain-Eurkea mineral belt, Carlin-trend), northern Nevada (CoI). Funding: 2014, $150k.
17. US Geological Survey, Mineral Resources Program Joint inversion of disparate data (CoI). Funding: 2013 $175k.
18. World Bank, Technical assistance with water-resource assessment, Mauritania (CoI). Funding: 2011-2012, $100k.
19. US Army, Strategic Environmental Research and Development Program, UXO Discrimination (CoI). Funding: 2010-2011, $40k.
20. 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 (CoI). Funding: 2009-2010, $50k.
21. Civilian Research & Development Foundation, Evaluation of measures to mitigate groundwater flooding in Bishkek region of Kyrgyzstan (CoI). Funding: 2009-2010, $68k.
22. US Geological Survey, Mineral Resources Program, Stochastic mineral-resource software development (PI). Funding: 2008-2011, $1M.
23. US Geological Survey, Mineral Resources Program Alternate modeling paradigms and methods to evaluate uncertainty (CoI). Funding: 2006-2012, $500k.
24. World Bank, Technical assistance with mineral and water-resource assessment, Mauritania (CoI). Funding: 2006-2008, $1.2M.
25. US Department of State, Technical assistance to Middle East process (CoI). Funding: 2005, $68k.
26. World Bank, Technical assistance with hazards risk mitigation and emergency preparedness, Romania (CoI). Funding: 2005-2007, $900k.
27. US Geological Survey, Mineral Resources Program, National Maps - source/process studies of selected contaminants associated with mineral deposits (CoI). Funding: 2005-2007, $150k.
28. United Nations Development Program, Technical assistance with real time flood warning system, Haiti (CoI). Funding: 2005-2006, $120k.
29. US Department of Army, Strategic Environmental Research and Development Program, Tensor magnetic gradient system (CoI). Funding: 2005-2006, $55k.
30. US Department of Homeland Security, Federal Emergency Management Agency, Post-wildfire flood potential in Willow & Mitchell creek watersheds (CoI). Funding: 2004-2005, $135k.
31. US Department of Health, National Institute of Occupational Health, Development of predictive equations using knowledge discovery techniques (PI). Funding 2003-2004, $37k
32. US Agency for International Development, Office of Federal Disaster Assistance, Technical assistance with coastal flood predictions, El Salvador (CoI). Funding: 2003-2004, $65k.
33. US Geological Survey, Venture Capital Fund, Improvements to conceptual wildfire-induced flood models (PI). Funding: 2003-2004, $35k.
34. US Geological Survey, National Water Quality Assessment Program, Preferential flow and transport in the High Plains aquifer (PI). Funding: 2003-2004, $74k
35. 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.
36. US Department of Homeland Security, Federal Emergency Management Agency, Post-wildfire technical assistance (PI). Funding: 2002-2004, $550k.
37. 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
38. US Geological Survey, Toxics Program Variably-saturated transport in 2-dimensions - VST2D (PI). Funding: 1999, $35k
39. US Geological Survey, National Water Quality Assessment Program, Upper Illinois River Basin study (PI). Funding: 1997-2001, $8M
40. US Department of Agriculture, Agricultural Research Service, Vadose-zone leaching of agricultural chemicals (PI). Funding: 1996, $36k.
41. US Department of Health, National Institute of Occupational Health, Tomographic imaging of deep underground metal mines (PI). Funding: 1996, $48K
42. US Bureau of Mines, Advanced Mining Program In situ leach mining of unsaturated Chalcocite ore (PI). Funding: 1990-1995, $450k
43. 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
44. US Bureau of Mines, Abandoned Mine Land Program, Cavity detection using geophysical methods, Funding: Abandoned Mine Land Program (PI). Funding: 1989-1993, $575k
45. 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
46. US Bureau of Mines, Advanced Mining Program, Geomechanical and geophysical technology for evaluating rock masses for in situ mining (PI). Funding: 1985-1994, $960k
47. Friedel, et al., Annual work plans, Upper Illinois River Basin, USGS: 2001, 110 pp ($1.9M); 2000, 102 pp. ($1.8M); 1999, 193 pp. ($1.7M); 1998, 65 pp. ($1.4M); 1997, 23 pp. ($750K)

**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*, *II, III;* Hydrology session H14E/ H13O (oral), H11H (poster), 2013
* *Characterization of Groundwater Systems*, Hydrology H11K/H12A/H13B (oral/ poster sessions), 2012
* *Advanced Computational Modeling Paradigms for Hydrologic Systems*, Hydrology poster, 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 sessions U22a/U22b, 2011
* *Water Resources Science and Strategies for Adaptation to Climate Variability and Change I/II/III*, Hydrology poster session (H21G)/oral session H21G/oral session (H24F), 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, 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 Ground-Water, Mineral, and Petroleum Resources*, Near Surface geophysics poster session, NS31A, 2008
* *Multi-Scale Unsaturated Zone Flow and Contaminant Transport Processes*, Hydrol poster 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*, Hydrol poster sess, H33, 2006
* *Spatial Relations Between Plants, Soil, and Water in the Vadose Zone*, Hydrol poster sess, H12, 2005
* *Preferential flow and transport in variably saturated porous media*, Hydrology oral sess, H13I, 2005
* *Preferential flow and transport in variably saturated porous media*, poster/oral (H33B/H33A), 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

**PROFESSIONAL ASSOCIATIONS**

American Geophysical Union

European Geosciences Union

International Association of Hydrological Sciences

New Zealand Hydrological Society

Society of Exploration Geophysicists

**RESEARCH EXPERIENCE**

**Associate Research Professor –** Physics Department 1/15/2021–present

University of Colorado Denver, CO

Scientific Leader/Investigator: I am leading development of multi-institutional, multi-national scientific proposals for submission to the US National Science Foundation and NZ Ministry for Business, Industry, and Employment for transdisciplinary solutions to Earth, Energy, and Environmental grand challenges. Proposals include Intelligent forecasting of climate change effects on aquatic freshwater biology across the USA, Intelligent forecasting of climate change on annual scale-dependent groundwater recharge quantity and quality worldwide, and Intelligent real time airborne characterization of surficial aquifers worldwide.

Key Collaborators: USA: University of Colorado (Math & Statistics), University of Hawaii, US Geological Survey; CN: Peking University, Beijing Water International; DK: Aarhus University NZ: National Institute of Water and Atmospheric Research, Golder, regional and city councils to be determined.

**Senior (Hydro)Geophysicist –** Hawai‘i Groundwater & Geothermal Resources Center 11/1/2020–present

University of Hawaii Manoa, HI

Scientific Leader/Investigator: I develop and apply multiphysics numerical inverse, unsupervised machine learning, and multimodal machine and deep learning methods for discovery, characterization and prediction of groundwater and geothermal resources.

Key Contributions - Machine Learning/Numerical/Statistical Methods:

* Play fairway data assimilation, analysis, and prediction of geothermal resource
* Innovative subsurface *learning* and Hawaiian geothermal exploration using advanced tomography

Key Collaborators: National Renewable Energy Laboratory, Pacific Northwest National Laboratory, US Geological Survey; NSF EPSCoR

**Associate Researcher –** Earth, Energy, and Environmental Systems 1/1/2018 – Present

[Semeion Research Institute](http://www.semeion.it/wordpress/en/) Rome, IT

Scientific Leader/Investigator: I develop and contribute to a program vision and serve as the intellectual lead for Earth, Energy, and Environmental analytics; secure external team and Institute support in areas of applied artificial intelligence including data integration, physics informed learning, and multimodal transfer learning. I cultivate Institute and cross-sector partnerships; serve as primary technical liaison with Semeion partners, including faculty and researchers, federal and state agencies, and industry partners. I help advance Institute data science capabilities, including collaborating with the high-performance computing community. I participate in program administration; support and build the Analytics team (core staff, post-docs, graduate students, and undergraduate interns); manage key efforts for the institute; facilitate collaboration between Semeion teams; and mentor university postdocs, research scientists, and student interns. I successfully lead national and international interdisciplinary teams; and perform high performance computing in Linux, Windows, and virtual environments; and perform shell, Python, and batch scripting; and Fortran programming.

Key Contributions - Machine Learning/Numerical/Statistical Methods:

* Applied machine learning to predict expected ultimate recovery for unconventional shale gas
* Implemented multiphysics-informed learning for reduced order variably saturated transport
* Investigated multimodal deep learning for 3D characterization of subsurface systems
* Numerical modeling of downstream effects for flow ramping at Long Draw Reservoir – in progress
* Performed sediment transport field reconnaissance of Skyline ditch – in progress
* Article, Joint multiphysics-decision tree learning for efficient variably saturated subsurface transport parameter estimation with improved accuracy and reduced order model simulations (in revision)
* eLightning presentation, Multiphysics-informed learning algorithm for vadose zone transport modeling*,* American Geophysical Union, December 2020. (invited)
* Keynote presentation,[Multiphysics-informed learning algorithm for vadose zone transport modeling – preliminary results*,* Knowledge Guided Machine Learning workshop, Hydrology Session part 2 (YouTube at 45.08 minutes](https://www.youtube.com/watch?v=GF9ghOOAXo0))*,* Minneapolis, MN, August 2020. (invited)
* Member, Machine learning geothermal portfolio review panel, Geothermal Technologies Office, Department of Energy, 2020

Key Collaborators: Brazil (Federal University of Brasilia, Federal University of Santa Catarina), Geothermal Technologies Office -Department of Energy; PEMEX, University of Hawai’i, US Forest Service

**Senior Computational Scientist** – Hydrogeophysics 7/20/2019–8/17/2020

Pacific Northwest National Laboratory, Subsurface Science & Technology Group Richland, WA, USA

Scientific Leader/Investigator: Led development of integrated research initiatives, white papers, scopes of work, letters of intent, and proposals for earth, energy, and environmental system sustainability research with annual project budgets to ~$1.1M. Led multiphysics, machine/deep learning research conducted within multidisciplinary (biological, climate, geomechanical, geological, geophysical, hydrogeological) teams. Set technical direction in hydrogeophysical monitoring and data assimilation, integration, and prediction methods to characterize surface and subsurface properties and processes. Participated on committees such as the artificial intelligence/machine learning strategy working group. Led and/or participated on groundwater and hydrogeophysical research projects; used high performance Linux, Windows, and virtual environments; developed shell, Python, R, and batch scripting, and Fortran programs; and ran forward models including E4D (resistivity tomography) and STOMP (multiphysics groundwater and geothermal).

Key Contributions - Machine Learning/Numerical/Statistical Methods:

* Automated seismic travel-time picking by machine learning for fracture imaging
* Electrical resistivity tomography for detection of leaks and groundwater contamination
* Innovative subsurface learning and Hawaiian exploration using advanced tomography (FY21-23, $3.3M).
* Multimodal machine learning for real time subsurface characterization of deep unsaturated zone at Hanford nuclear waste site
* Next generation scientific computing capability through multidisciplinary software and hardware co-design methodology
* Physics-informed learning for reduced-order coupled groundwater transport modeling
* Science-informed learning strategies for multi-scale subsurface data assimilation, visualization and simulation of CO2 injection and storage – white paper

Key Collaborators: Demark (Hydrogeophysics Group, Aarhus University), Italy (Semeion Institute), USA (National Renewable Energy Technology Laboratory, Geothermal Technologies Office - Department of Energy; Crustal Imaging, US Geological Survey-Denver; Math & Statistics, University of Colorado).

**Environmental Data Analytics Science Leader** 11/15/2017–7/15/2019

Lincoln University, Lincoln Agritech Ltd, Environmental Research Group Hamilton, NZ

Scientific Leader: I led scientists and engineers in broad research area to develop coupled groundwater, hydrologic and vadose simulation models, and tools applicable across catchment 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 with annual budget to ~$2.6M. Other aspects involved assessing adequacy of current research and commercial work; provide thought leadership to identify future directions and funding opportunities; led development of funded proposals and partnerships; developed, mentored, and coached team members; and represented the Institute at briefings, meetings, and conferences.

Scientific Investigator: I designed and participated in multidisciplinary, multi-institutional, scientific studies that provided answers to National Challenges involving human activities and associated changes (land use intensification, climate change) on freshwaters (groundwater - surface water) and their links to aquatic and terrestrial ecosystems. Developed and applied innovative methods to discover, quantify, and predict linkages and interactions among climate, hydrological and biogeochemical cycles across spatiotemporal scales that inform decision makers and drive adaption strategies for water security and ecosystem sustainability. Employed artificial-adaptive systems (evolutionary, machine-learning, learn-heuristics, metamodeling, and multimodal transfer learning), process-based (traditional/joint numerical) and statistical (Bayesian and stochastic) methods, *big data* collected across *multiscale* environmental networks, and software for transdisciplinary answers to questions related to: (1) the efficacy of field-scale agricultural practices designed to prevent nutrient and/or agrochemical loss; (2) how land use and climate change effect hydrological and biogeochemical processes that govern water quality and aquatic ecosystem function; and (3) how hydrologic, chemical and biological processes interact at the aquatic-terrestrial interface. Led the design, collection, and integration of big data including direct (physical, chemical, biological) and indirect (geophysical and remote sensing) measurements collected across *multiscale* environmental networks (space, airborne, surface, and borehole) to improve theory, scalability, and predictability. Developed and taught courses on data analytics in agroecosystem modeling. 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 Contributions - Machine Learning/Numerical/Statistical Methods:

* Applied machine learning to evaluate natural/anthropogenic controls on GW/SW interaction and nitrate reduction Southland, NZ
* [Compared four machine learning-based methods to predict 3d regional groundwater redox status across agriculturally dominated regions](https://doi.org/10.1016/j.jhydrol.2019.124200)
* Employed physics-informed learning to map 3D hydrostratigraphy with airborne EM measurements
* [Estimated uncertainty in subsurface groundwater models](https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/619814) by helicopter electromagnetic informed learning
* Predicted pathway partitioning by groundwater modeling by chemistry-assisted mixing constraints
* Obtained funding for Unravelling sub-catchment scale nitrogen delivery to waterways (CoI: FY18-23, NZD $7.8M)
* Identified climate/land-use change signals in urbanizing freshwater ecosystems by machine learning

Key Collaborators: Australia (Geoscience Australia), Brazil (Federal University of Brasilia, Federal University of Santa Catarina, University of Campinas, Empresa Brasileira de Pesquisa Agropecuária), China (Beijing Water International; Institute of Quality and standard for Agricultural Products), Denmark (Aarhus University), Italy (Semeion Institute), New Zealand (Aqualinc, GNS Science, ESR, Environment Canterbury, Environment Southland, Hawkes Bay Regional Council, Tasman Regional Council, Waikato Regional Council, Ventures Southland; Ministry of Business, Innovation and Employment; private sector companies), USA (United States Geological Survey-Denver; University of Colorado-Denver).

**Senior Groundwater Scientist – Numerical Modeler**  6/1/2014–11/15/2017

Institute of Geological and Nuclear Science, Hydrogeology Department Lower Hutt, NZ

Science leader: I applied scientific knowledge to assess adequacy of ongoing research and commercial work and development of future directions. Identified and led strategic program development activities including funding initiatives, proposal development, and partnerships with indigenous people, regional councils, Crown Research Institutes, international organizations, and universities. Represented the Institute at briefings, meetings, and conferences.

Scientific investigator: I developed complex multidisciplinary scientific studies that addressed critical groundwater, surface-water and ecosystem issues in complex, large-scale hydrologic systems (catchment, region, nationwide). Used multiple innovative geophysical and hydrogeologic techniques to solve complex groundwater problems. Conducted stochastic inversion of airborne electromagnetic data to characterize heterogeneous groundwater systems based on probable resistivity/conductivity distributions. Applied aquifer-test analysis theory and interpretation techniques to determine aquifer hydraulic properties and geostatistical modelling to simulate the uncertainty in their spatial distribution. Conceptualized, developed and calibrated numerical models (vadose zone and groundwater flow) to evaluate flow and transport response to changes in natural and anthropogenic stresses including groundwater-surface water interactions. Applied parameter estimation, sensitivity, and uncertainty methods in the analysis of geophysical, groundwater, hydrologic, vadose zone, and watershed data and model responses. Conducted ground-water resource assessments involving the use and analysis of existing and new monitoring and geophysical data, geohydrologic framework characterizations, application of flow and recharge models, and predicting water balances. Conducted groundwater – surface water interaction studies. Developed and applied advanced workflows (involving machine learning, numerical, statistical and uncertainty methods) to integrate multidisciplinary data for answers involving effects of climate and land-surface change on ecosystem, environment, and water resources. Facilitated accomplishments in combination with guidance and training of field methods and modeling to junior staff, doctoral candidates, and visiting scientists. Presented and published findings at national and international venues.

Key Contributions - Machine Learning/Numerical/Statistical Methods:

* Classified vegetation/soils using Hyperion satellite measurements by unsupervised learning
* Conditional uncertainty in rainfall-recharge estimates
* Evolutionary-gradient numerical 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 physicochemical and 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 environmental 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 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 (Tblisi 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**  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 answers 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. Developed and taught courses on groundwater flow and reactive transport modeling (conceptualization, calibration, uncertainty). 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 Contributions - Machine Learning/Numerical/Statistical Methods:

* 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 (Tblisi 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**  10/1/2001–9/30/2005

U.S. Geological Survey, Colorado Water Science Center Denver, CO, USA Science

Leader/manager: 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 local, State, Federal, and International agencies, and 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. P**roposed 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 Contributions - Machine Learning/Numerical/Statistical Methods:

* 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.

**Chief, Upper Illinois River Basin, National Water Quality Assessment Program** 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. I promoted and prioritized water-quality research for Upper Illinois River Basin, National Water Quality Assessment Program; coordinated and prepared scope of work and financial plans with annual budgets to ~$2.0M; determined project staffing needs and hired multidisciplinary team 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: I developed multidisciplinary scientific studies that addressed critical groundwater, surface-water and ecosystem issues in complex, multistate hydrologic systems. I led the design of, and participated in, stratified environmental water-quality (biologic/aqueous/sediment) monitoring program (algae, macroinvertebrates, fist, habitat, major ions, nutrients, metals, pesticides, metabolites, isotopes, tracers, gases, and emerging contaminants), applied aquifer-test analysis theory and interpretation techniques to determine aquifer hydraulic properties and geostatistical modeling to simulate the uncertainty in their spatial distribution. I personally conceptualized, developed, calibrated, and used numerical models (watershed, hydrologic, vadose zone and groundwater flow) to evaluate flow and transport response to changes in natural and anthropogenic stresses including groundwater- surface water interactions and flooding. Applied parameter estimation, sensitivity, and uncertainty methods in the analysis of geophysical, groundwater, hydrologic, vadose zone, and watershed data and model responses. Conducted ground-water resource assessments (quantify and quality) involving the use and analysis of existing and new monitoring and geophysical data, geohydrologic framework characterizations, application of flow and recharge models, and predicting stochastic water quantity and quality balances. Conducted reach-scale groundwater – surface water interaction and land-use gradient studies. Developed and applied advanced workflows to assimilate multidisciplinary data to evaluate the effects of climate and land-surface change on catchment processes and water-resource quantity and quality and effects of water quality on ecosystem health. Facilitated accomplishments in combination with guidance and training of field methods, modeling and interpretation to junior staff including occurrence and distribution, water-quality state, trend, and risk analysis. Presented and published scientific findings at national and international venues.

Key Contributions – Mathematical/Machine Learning/Numerical/Statistical Methods:

* Upper Illinois River Basin Study, National Water Quality Assessment Program
* Urban land-use gradient study in the tri-state 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/Hydrologist** 6/1/1987 – 9/30/1997

U.S. Geological Survey, Twin Cities Research Center Minneapolis, MN, 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, cross-borehole, 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.

Key Contributions – Mathematical/ Numerical/Statistical Methods:

* 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)