

Curriculum Vitae

Upmanu Lall

Alan & Carol Silberstein Professor of Engineering,

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Biography

Dr. Upmanu Lall has broad interests in hydrology, climate dynamics, applied statistics, water resource systems analysis, risk management and sustainability. He is motivated by challenging questions at the intersection of these fields, especially where they have relevance to societal outcomes or to the advancement of science towards innovative application. His current research covers 3 major initiatives that are developed through the Columbia Water Center.

The **Global Water Sustainability Initiative** is focused on an assessment of global water scarcity and risk, and innovations across scales – from farmer's field to reservoir optimization to national policy modifications to international trade – to develop real world solutions to an impending global water crisis. This includes the development of new agro water and chemical sensor systems to improve water use efficiency and reduce non-point source pollution as well as field studies on how to get farmers to use them; comprehensive modeling and optimization of regional crop and energy facility siting to improve water sustainability and income; field experiments of water/energy pricing policy changes; participatory reservoir management using climate scenarios, elicited stakeholder values, option contracts and insurance; and models for replicable community managed rural drinking water systems. Active field research projects are in India, China, Brazil and Peru.

The Global Flood Initiative is motivated by two factors. *First*, the incidence of extreme floods around the world is driven by large scale moisture transport from the tropical oceans, and understanding the climate controls on the generation of such moisture, its transport, and convergence is essential to improving our understanding of the recurrent and concurrent global patterns of floods, as well as their prediction in the short term and under a changing climate. To predict floods one looks at the source of the extreme rainfall rather than the hydrology of floods after it rains. A hypothesis is that floods in many places in the world may be concurrently generated or suppressed by a few underlying mechanisms. Developing a physics based understanding of these processes is critical for statistically modeling the dynamic or time varying risk associated with floods in a changing climate. *Second*, for today's global supply chains, floods that disrupt material sourcing, production, transportation or distribution channels can have significant economic impacts in areas far removed from the locations experiencing direct property loss. Understanding and modeling supply chain losses and their impacts on global food and manufactured goods supplies is important. Ways to predict and manage this risks using physical infrastructure; warning, response and recovery design; inventory and supply chain management and financial instruments such as index insurance, and catastrophe bonds is being explored.

America's Water is driven by the goal of developing sustainable water management and infrastructure design paradigms for the 21st century recognizing the linkages between urban functioning, food, water, energy and climate. It seeks to pull together a comprehensive understanding of the issues facing water infrastructure in the USA. These include: the financing of and investment in the replacement of aging infrastructure; pricing and allocating water given changing values and climate; the management of the total urban water cycle through new technologies and network topologies; groundwater depletion and national food and economic futures; and novel opportunities for flood risk management and non-point source pollution mitigation. The initiative looks back over the last century to understand how man and nature interacted to generate the current state of water in the country to provide a basis for steering future regional and national development and novel technologies targeted at the key issues identified.

These programmatic initiatives are backed by research on systems level modeling of hydrology, climate, agronomy and economics. Innovative modeling tools are being developed and field tested. Dr. Lall has pioneered the application of techniques from (a) nonlinear dynamical systems, (b) nonparametric methods of function estimation and their application to spatio-temporal dynamical systems, (c) Hierarchical Bayesian models, (d) systems optimization and simulation and (e) the study of multi-scale climate variability and change as an integral component of hydrologic systems. He has published in journals that focus on hydrology, water resources, climate, physics, statistics, development, policy and management science. He has taught a wide variety of courses at 3 Universities. He has been engaged in high level public and scientific discussion through the media, the World Economic Forum, and with governments, foundations, development banks, and corporations interested in sustainability. He has served on several national and international panels. He was one of the originators of the Consortium of Universities for the Advancement of Hydrologic Science, and is currently the President of the Natural Hazards Focus Group of the American Geophysical Union.

Academic Training

University of Texas 1980-1981

Austin, TX *PhD. Civil & Environmental Engineering*
Dissertation: Value of data in relation to uncertainty and risk

University of Texas 1977-1980

Austin, TX *M.S. Civil & Environmental Engineering*
Thesis: Mathematical models for water-energy systems

Indian Institute of Technology 1971-1976

Kanpur, U.P., India *B. Tech. Civil Engineering*

Honors and Awards

John R. Parks Teachers Fellowship, College of Engineering, University of Utah 1982-1983

Outstanding Researcher, Dept. of Civil & Environ. Eng., Utah State University 1995-1996

Research Excellence Award, College of Engineering, Utah State University 1995-1996

Borland Lecture on Hydrology, AGU Hydrology Days 2006

Kim Award for Faculty Involvement, Columbia University 2008

ASCE Arid Lands Hydrology Research Award 2010

Henry Darcy Medal, European Geophysical Union 2014

Teaching Experience

Undergraduate: Hydrology^{1,2}, Water Resources Eng.^{1,2}, Computations & Computer Analysis¹, Fluid Mechanics Lab.¹, Operations Research II¹, Systems Analysis for Civil Eng¹, Water Project Analysis¹, Statistics in Water Resources¹, Water Resource Systems Analysis¹, Groundwater Engineering², Earth Resources and the Environment³, A Better Planet by Design³, Hydrosystems Engineering³

Graduate: Optimization of Large Systems¹, Applied Probability Theory¹, Statistical Decision Theory¹, Hydro-electric Power¹, Stochastic Hydrology^{1,2}, Groundwater Hydrology^{1,2}, Groundwater Contaminant Transport², Groundwater Quantity and Quality Modeling², Spatial Hydrologic Analysis², Physical Hydrology^{2,3}, Low Frequency Hydro-Climatic Variability², Environmental Statistics², Hydroclimatology², Water Management and Development³, Environmental Data Analysis³, Complexity Science³

¹University of Utah, ²Utah State University, ³Columbia University

Employment Record

Columbia University

<i>Director, Columbia Water Center</i>	2008-date
<i>Alan & Carol Silberstein Professor of Engineering</i>	2005-date
<i>Chair, Civil Eng. & Eng. Mechanics</i>	2009-2010
<i>Chair, Earth & Environmental Eng.,</i>	2003-2006
<i>Professor, Civil Eng. & Eng. Mechanics,</i>	2002-date
<i>Professor, Earth & Environmental Eng.,</i>	2001-date
<i>Senior Research Scientist, International Research Institute for Climate & Society</i>	2001-date
<i>Visiting Prof., Columbia Earth Institute</i>	1999-2001
<i>Adjunct Res. Scientist (LDEO.)</i>	1997-99

Utah State University

<i>Professor, Civil & Environmental Eng.,</i>	1995-2001
<i>Associate Director, Utah Water Research Lab.,</i>	1997-2001
<i>Associate Professor, Civil & Environmental Eng.</i>	1988-95
U.S.G.S., Salt Lake City, UT <i>Hydrologist</i>	1988-89

University of Utah

<i>Associate Professor, Civil & Environmental Eng.</i>	1987-88
<i>Assistant Professor, Civil & Environmental Eng.</i>	1981-87

ISMAL, Ranchi, India <i>Prestressed Concrete Development Engineer</i>	1976-77
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Publications: <http://scholar.google.com/citations?user=JA0o2TUAAAJ&hl=en>

Refereed Journal Publications

1. Ho, M., Lall, U., Sun, X. and Cook, E. R. (2017), Multiscale temporal variability and regional patterns in 555 years of conterminous U.S. streamflow. *Water Resour. Res.* doi:10.1002/2016WR019632
2. Lu, M., U. Lall, A. W. Robertson, and E. Cook (2017), Optimizing multiple reliable forward contracts for reservoir allocation using multitime scale streamflow forecasts, *Water Resour. Res.*, 53, doi:10.1002/2016WR019552.
3. Ceylan, G , Lall, U . (2017). Amerika Birleşik Devletleri'ndeki Minimum Akım Trendleri. *Türkiye Su Bilimleri ve Yönetimi Dergisi*, 1 (1), 71-89.
4. Bonnafous, L., U. Lall, and J. Siegel (2017), An index for drought induced financial risk in the mining industry, *Water Resour. Res.*, 53, doi:10.1002/2016WR019866.
5. Ho, M., Lall, U., Allaire, M., Devineni, N., Han Kwon, H., Pal, I., Raff, D. and Wegner, D., (2017), The future role of dams in the United States of America. *Water Resources Research*, doi:10.1002/2016WR019905.
6. Russo, T. A., & Lall, U. , Depletion and response of deep groundwater to climate-induced pumping variability. *Nature Geoscience*. doi:10.1038/ngeo2883, 2017.
7. Lall, U.; Devineni, N.; Kaheil, Y., An empirical, nonparametric simulator for multivariate random variables with differing marginal densities and nonlinear dependence with hydroclimatic applications, *Risk Analysis*,36,1,57-73, 2016
8. Lu, M., and Lall, U. (2016). Tropical Moisture Exports, Extreme Precipitation and Floods in Northeast US. *Hydrol. Earth Syst. Sci*, 1-40.
9. Zeng, H., Sun, X., Lall, U. and Feng, P., Nonstationary extreme flood/rainfall frequency analysis informed by large-scale oceanic fields for Xidayang Reservoir in North China. *Int. J. Climatology* . doi:10.1002/joc.4955, 2016

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10. Fishman, R., U. Lall, V. Modi, and N. Parekh, "Can Electricity Pricing Save India's Groundwater? Field Evidence from a Novel Policy Mechanism in Gujarat," *Journal of the Association of Environmental and Resource Economists* 3, no. 4 (December 2016): 819-855., DOI: 10.1086/688496
 11. Steinschneider, S.; Lall, U.; Spatiotemporal Structure of Precipitation Related to Tropical Moisture Exports over the Eastern United States and Its Relation to Climate Teleconnections, *Journal of Hydrometeorology*,17,3,897-913,2016
 12. Etienne, E.; Devineni, N.; Khanbilvardi, R.; Lall, U.; Development of a Demand Sensitive Drought Index and its application for agriculture over the conterminous United States, *Journal of Hydrology*, 534, 219-229,2016.
 13. Parhi, P.; Giannini, A.; Gentine, P.; Lall, U.; Resolving contrasting regional rainfall responses to El Nino over Tropical Africa, *Journal of Climate*, 29, 4, 1461-1476, 2016.
 14. Steinschneider, S.; Lall, U.; El Niño and the U.S. precipitation and floods: What was expected for the January–March 2016 winter hydroclimate that is now unfolding?, *Water Resources Research*, 10.1002/2015WR018470, 2016.
 15. Sahoo, S.; Russo, T.; Lall, U.; Comment on "Quantifying renewable groundwater stress with GRACE" by Alexandra S. Richey et al., *Water Resources Research*, 2016
 16. Ward, PJ; Kumm, M; Lall, U; Flood frequencies and durations and their response to El Niño Southern Oscillation: Global analysis, *Journal of Hydrology*, 539, 358-378, 2016
 17. Haraguchi, M.; Lall, U; Watanabe, Kenji; Building Private Sector Resilience: Directions After the 2015 Sendai Framework, *Journal of Disaster Research* Vol 11(3), 535, 2016
 18. Alfredo, Katherine; Montalto, Franco A; Bartrand, Timothy; Wolde-Georgis, Tsegay; Lall, Upmanu; Using a Participatory Stakeholder Process to Plan Water Development in Koraro, Ethiopia, *Water*, 8, 7, 275, 2016
 19. Ho, M; Parthasarathy, V; Etienne, E; Russo, TA; Devineni, N; Lall, U; America's water: Agricultural water demands and the response of groundwater, *Geophysical Research Letters*, 43, 14, 7546-7555, 2016
 20. Kwon, Hyun-Han; Lall, Upmanu; A copula-based nonstationary frequency analysis for the 2012–2015 drought in California, *Water Resources Research*, 52, 7, 5662-5675, 2016
 21. Lima, Carlos HR; Lall, Upmanu; Troy, Tara; Devineni, Naresh; A hierarchical Bayesian GEV model for improving local and regional flood quantile estimates, *Journal of Hydrology*, 2016
 22. Yuan, Xiao-Chen; Sun, Xun; Lall, Upmanu; Mi, Zhi-Fu; He, Jun; Wei, Yi-Ming; China's socioeconomic risk from extreme events in a changing climate: a hierarchical Bayesian model, *Climatic Change*, , 13-Jan, 2016
 23. Kwon, Hyun-Han; Lall, Upmanu; Kim, Seong-Joon; The unusual 2013–2015 drought in South Korea in the context of a multicentury precipitation record: Inferences from a nonstationary, multivariate, Bayesian copula model, *Geophysical Research Letters*, 43, 16, 8534-8544, 2016.
 24. Cioffi, F., Conticello, F., & Lall, U. (2016). Projecting changes in Tanzania rainfall for the 21st century. *International Journal of Climatology*, (10.1002/joc.4632).
 25. Cioffi, F., Lall, U., Rus, E., & Krishnamurthy, C. K. B. (2015). Space-time structure of extreme precipitation in Europe over the last century. *International Journal of Climatology*, 35(8), 1749-1760.
 26. Devineni, N., Lall, U., Etienne, E., Shi, D., & Xi, C. (2015). America's water risk: Current demand and climate variability. *Geophysical Research Letters*, 42(7), 2285–2293.
 27. Devineni, N., Lall, U., Xi, C., & Ward, P. (2015). Scaling of extreme rainfall areas at a planetary scale. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 25(7), 75407.
 28. Dong, L., Xiong, L., Lall, U., & Wang, J. (2015). The effects of land use change and precipitation change on direct runoff in Wei River watershed, China. *Water Science and Technology*, 71(2), 289–295.
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29. Nakamura, J., Lall, U., Kushnir, Y., & Rajagopalan, B. (2015). HITS: Hurricane intensity and track simulator with North Atlantic Ocean applications for risk assessment. *Journal of Applied Meteorology and Climatology*, 54(7), 1620-1636.
 30. Haraguchi, M., & Lall, U. (2015). Flood risks and impacts: A case study of Thailand's floods in 2011 and research questions for supply chain decision making. *International Journal of Disaster Risk Reduction*, 14, 256–272.
 31. Kavvas, M. L., Govindaraju, R. S., & Lall, U. (2015). Introduction to the Focus Issue: Physics of Scaling and Self-similarity in Hydrologic Dynamics, Hydrodynamics, and Climate. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 25(7), 75201.
 32. Lima, C. H. R., Lall, U., Jebara, T., & Barnston, A. G. (2015). Machine Learning Methods for ENSO Analysis and Prediction. In *Machine Learning and Data Mining Approaches to Climate Science* (pp. 13–21). Springer International Publishing.
 33. Lima, C. H. R., Lall, U., Troy, T. J., & Devineni, N. (2015). A climate informed model for nonstationary flood risk prediction: Application to Negro River at Manaus, Amazonia. *Journal of Hydrology*, 522, 594–602.
 34. Lu, M., Tippett, M., & Lall, U. (2015). Changes in the seasonality of tornado and favorable genesis conditions in the central United States. *Geophysical Research Letters*, 42(10), 4224–4231.
 35. Lu, M., Lall, U., Kawale, J., Liess, S., & Kumar, V. (2016). Exploring the Predictability of 30-Day Extreme Precipitation Occurrence Using a Global SST–SLP Correlation Network. *Journal of Climate*, 29(3), 1013-1029.
 36. Merz, B., Vorogushyn, S., Lall, U., Viglione, A., & Blöschl, G. (2015). Charting unknown waters—On the role of surprise in flood risk assessment and management. *Water Resources Research*, 51(8), 6399–6416.
 37. Pal, I., Robertson, A. W., Lall, U., & Cane, M. A. (2015). Modeling winter rainfall in Northwest India using a hidden Markov model: understanding occurrence of different states and their dynamical connections. *Climate Dynamics*, 44(3-4), 1003–1015.
 38. Parhi, P., Giannini, A., Gentile, P., & Lall, U. (2015). Resolving contrasting regional rainfall responses to El Niño over tropical Africa. *Journal of Climate*, (2015).
 39. Robertson, A. W., Kushnir, Y., Lall, U., & Nakamura, J. (2015). Weather and Climatic Drivers of Extreme Flooding Events over the Midwest of the United States. *Extreme Events: Observations, Modeling, and Economics*, 113–124.
 40. Steinschneider, S., & Lall, U. (2015). Daily Precipitation and Tropical Moisture Exports across the Eastern United States: An Application of Archetypal Analysis to Identify Spatiotemporal Structure. *Journal of Climate*, 28(21), 8585.
 41. Steinschneider, S., & Lall, U. (2016). El Niño and the U.S. precipitation and floods: What was expected for the January--March 2016 winter hydroclimate that is now unfolding? *Water Resources Research*, (10.1002/2015WR018470).
 42. Sun, X., & Lall, U. (2015). Spatially coherent trends of annual maximum daily precipitation in the United States. *Geophysical Research Letters*, 42(22), 9781–9789.
 43. Vogel, R. M., Lall, U., Cai, X., Rajagopalan, B., Weiskel, P. K., Hooper, R. P., & Matalas, N. C. (2015). Hydrology: The interdisciplinary science of water. *Water Resources Research*, 51(6), 4409–4430.
 44. Zhang, Y., Yang, N., & Lall, U. (2016). Modeling and simulation of the vulnerability of interdependent power-water infrastructure networks to cascading failures. *Journal of Systems Science and Systems Engineering*, (10.1007/s11518-016-5295-3), 1–17.
 45. Farnham, David J; Lall, Upmanu; Predictive Statistical Models Linking Antecedent Meteorological Conditions and Waterway Bacterial Contamination in Urban Waterways, *Water Research*, 2015,
 46. Dong, Leihua; Xiong, Lihua; Lall, Upmanu; Wang, Jiwu; The effects of land use change and precipitation change on direct runoff in Wei River watershed, China 2014 *IWA Publishing*

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47. Renard, Benjamin; Lall, Upmanu; Regional frequency analysis conditioned on large-scale atmospheric or oceanic fields. *Water Resources Research*, 50(12), 9536-9554, 2014.
 48. Lima, Carlos HR; Lall, Upmanu; Troy, Tara J; Devineni, Naresh; A climate informed model for nonstationary flood risk prediction: application to Negro River at Manaus, Amazonia, *Journal of Hydrology*, 2015
 49. Steinschneider, Scott, and Upmanu Lall. "A hierarchical Bayesian regional model for nonstationary precipitation extremes in Northern California conditioned on tropical moisture exports." *Water Resources Research* 51.3 (2015): 1472-1492.
 50. Karamperidou, Christina; Cane, Mark A; Lall, Upmanu; Wittenberg, Andrew T; Intrinsic modulation of ENSO predictability viewed through a local Lyapunov lens, *Climate Dynamics*, 42, 2-Jan, 253-270, 2014.
 51. Chen, X; Hao, Z; Devineni, N; Lall, U; Climate information based streamflow and rainfall forecasts for Huai River basin using hierarchical Bayesian modeling, *Hydrology and Earth System Sciences*, 18(4), 1539-1548, 2014.
 52. Merz, B; J Aerts, Karsten Arnbjerg-Nielsen, M Baldi, A Becker, Adeline Bichet, G Blöschl, LM Bouwer, Achim Brauer, F Cioffi, JM Delgado, M Gocht, F Guzzetti, S Harrigan, K Hirschboeck, C Kilsby, W Kron, H-H Kwon, U Lall, R Merz, K Nissen, P Salvati, T Swierczynski, U Ulbrich, A Viglione, PJ Ward, M Weiler, B Wilhelm, M Nied; (2014) Floods and climate: emerging perspectives for flood risk assessment and management, *Natural Hazards and Earth System Sciences*, 14(7), 1921-1942
 53. Robertson, Andrew W; Baethgen, Walter; Block, Paul; Lall, Upmanu; Sankarasubramanian, Arumugam; de Souza Filho, F de Assis; Verbist, Koen MJ; (2014) Climate risk management for water in semi-arid regions, *Earth Perspectives* 11(12)
 54. Lall, Upmanu; (2014) Debates—The future of hydrological sciences: A (common) path forward? One water. One world. Many climes. Many souls, *Water Resources Research*, 50(6), 5335-5341.
 55. Cioffi, Francesco; Lall, Upmanu; Rus, Ester; Krishnamurthy, Chandra Kiran B; (2014) Space-time structure of extreme precipitation in Europe over the last century, *International Journal of Climatology*
 56. Pal, Indrani; Robertson, Andrew W; Lall, Upmanu; Cane, Mark A; (2014) Modeling winter rainfall in Northwest India using a hidden Markov model: understanding occurrence of different states and their dynamical connections, *Climate Dynamics*, 13-Jan 2014
 57. Lu, M., Lall, U., Schwartz, A., & Kwon, H. (2013). Precipitation predictability associated with tropical moisture exports and circulation patterns for a major flood in France in 1995. *Water Resources Research*, 49(10), 6381–6392.
 58. Oludhe, C., Sankarasubramanian, A., Sinha, T., Devineni, N., & Lall, U. (2013). The Role of Multimodel Climate Forecasts in Improving Water and Energy Management over the Tana River Basin, Kenya. *Journal of Applied Meteorology & Climatology*, 52(11).
 59. Pal, I., Lall, U., Robertson, A. W., Cane, M. A., & Bansal, R. (2013). Predictability of Western Himalayan river flow: melt seasonal inflow into Bhakra Reservoir in northern India. *Hydrology and Earth System Sciences*, 17(6), 2131–2146.
 60. Devineni, N., S. Perveen, and U. Lall (2013), Assessing chronic and climate-induced water risk through spatially distributed cumulative deficit measures: A new picture of water sustainability in India, *Water Resour. Res.*, 49, doi:10.1002/wrcr.20184.
 61. Huh, W. T. and Lall, U. (2013), Optimal Crop Choice, Irrigation Allocation, and the Impact of Contract Farming. *Production and Operations Management*. doi: 10.1111/poms.12007
 62. Merz, B., H. Kreibich, U. Lall, (2013) Multi-variate flood damage assessment: a tree-based data-mining Approach, *Nat. Hazards Earth Syst. Sci.*, 13, 53–64, 2013, doi:10.5194/nhess-13-53-2013
 63. Devineni, N., Lall, U., Pederson, N., & Cook, E. (2013). A Tree Ring based Reconstruction of Delaware River Basin Streamflow using Hierarchical Bayesian Regression. *Journal of Climate*, (2013).
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64. Pederson, Neil, Andrew R. Bell, Edward R. Cook, Upmanu Lall, Naresh Devineni, Richard Seager, Keith Eggleston, Kevin P. Vranes, (2013): Is an Epic Pluvial Masking the Water Insecurity of the Greater New York City Region? . *J. Climate*, 26, 1339–1354. doi: <http://dx.doi.org/10.1175/JCLI-D-11-00723.1>
 65. Kwon, H.-H., de Assis de Souza Filho, F., Block, P., Sun, L., Lall, U. and Reis, D. S. (2012), Uncertainty assessment of hydrologic and climate forecast models in Northeastern Brazil. *Hydrol. Process.*, 26: 3875–3885. doi: 10.1002/hyp.8433
 66. Pal, Indrani, Upmanu Lall, Andrew W. Robertson, Mark A. Cane, Rajeev Bansal, (2013) Diagnostics of Western Himalayan Satluj River flow: Warm season (MAM/JJAS) inflow into Bhakra dam in India, *Journal of Hydrology* Volume 478, 25 January 2013, Pages 132–147.
 67. Kawale, J.; Liess, S.; Kumar, V.; Lall, U.; Ganguly, A., (2012) "Mining time-lagged relationships in spatio-temporal climate data, " *Intelligent Data Understanding (CIDU)*, 2012 Conference on , vol., no., pp.130, 135, 24-26 Oct. 2012 doi: 10.1109/CIDU.2012.6382194
 68. Nakamura, Jennifer, Upmanu Lall, Yochanan Kushnir, Andrew W. Robertson, Richard Seager, (2013): Dynamical Structure of Extreme Floods in the U.S. Midwest and the United Kingdom. *J. Hydrometeorol*, 14, 485–504. doi: <http://dx.doi.org/10.1175/JHM-D-12-059.1>
 69. Woonghee Tim Huh , Stergios Athanassoglou , Upmanu Lall, Contract farming with possible renegeing in a developing country: Can it work? *IIMB Management Review*, Volume 24, Issue 4, December 2012, Pages 187–202.
 70. Pal, Indrani, Upmanu Lall, Andrew W. Robertson, Mark A. Cane, Rajeev Bansal, (2012), Predictability of Western Himalayan River flow: melt seasonal inflow into Bhakra Reservoir in Northern India, *Hydrol. Earth Syst. Sci. Discuss.*, 9, 8137–8172, 2012, doi:10.5194/hessd-9-8137-2012
 71. Karamperidou, Christina, Francesco Cioffi, Upmanu Lall, 2012: Surface Temperature Gradients as Diagnostic Indicators of Midlatitude Circulation Dynamics. *J. Climate*, 25, 4154–4171. doi: <http://dx.doi.org/10.1175/JCLI-D-11-00067.1>
 72. Wu, Zhaodan, Upmanu Lall, and Min Zhao, (2013) A Worldwide Comparison of Water Use Efficiency of Crop Production, *Applied Mechanics and Materials* Vols. 275-277 (2013) pp 2718-2722, doi:10.4028/www.scientific.net/AMM.275-277.2718
 73. Karamperidou, Christina, Victor Engel, Upmanu Lall, Erik Stabenau, Thomas J. Smith III, (2013), Implications of multi-scale sea level and climate variability for coastal resources, *Regional Environmental Change*, doi:10.1007/s10113-013-0408-8.
 74. Fishman, R., Siegfried, T., Raj, P., Modi, V., Lall, U., W00L05 Over-extraction from shallow bedrock versus deep alluvial aquifers: Reliability versus sustainability considerations for India's groundwater irrigation (doi 10.1029/2011WR010617), *Water Resources Research*, 48, 6, 2012
 75. Kwon, H.H., Lall, U., Engel, V., Predicting foraging wading bird populations in Everglades National Park from seasonal hydrologic statistics under different management scenarios, *Water Resources Research*, 47, 9, W09510, 2011
 76. Lall, U., Visionary Reflections from a Crystal Clear Pool of Water Scientists, *Journal of Contemporary Water Research and Education*, 123, 1, 4, 2011 (reprinted from Water Resources Update)
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 78. Zhou, M., Tian, F., Lall, U., Hu, H., Insights from a joint analysis of Indian and Chinese monsoon rainfall data, *Hydrology and Earth System Sciences*, 15, 8, 2709, 2011
 79. Sidhu, RS, Vatta, K., Lall, U., Climate Change—Its Impact On Agriculture Productivity And Livelihood: The Policy Response—Climate Change Impact and Management Strategies for Sustainable Water-Energy-Agriculture Outcomes in Punjab, *Indian Journal of Agricultural Economics*, 66, 3, 328, 2011
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 83. Apipattanavis, S., Rajagopalan, B., Lall, U., Local Polynomial–Based Flood Frequency Estimator for Mixed Population, *Journal of Hydrologic Engineering*, 15, 9, 680-691, 2010
 84. Lima, C.H.R., Lall, U., Climate informed long term seasonal forecasts of hydroenergy inflow for the Brazilian hydropower system, *Journal of Hydrology*, 381, 1, 65-75, 2010
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 86. Siegfried, T., Sobolowski, S., Raj, P., Fishman, R., Vasquez, V., Narula, K., Lall, U., Modi, V., Modeling irrigated area to increase water, energy, and food security in semiarid India, *Weather, Climate, and Society*, 2, 4, 255-270, 2010
 87. Gong, G., Wang, L., Condon, L., Shearman, A., Lall, U., A Simple Framework for Incorporating Seasonal Streamflow Forecasts into Existing Water Resource Management Practices¹, *JAWRA Journal of the American Water Resources Association*, 46, 3, 574-585, 2010
 88. Taylor, R., Longuevergne, L., Harding, R., Todd, M., Hewitson, B., Lall, U., Hiscock, K., Treidel, H., Sharma, K.D., Kukuric, N., Groundwater and global hydrological change-current challenges and new insight, *Hydrocomplexity: New Tools for solving Wicked Water Problems*, 338, 2010, 51-61, 2010
 89. Khalil, A.F., Kwon, H.H., Lall, U., Kaheil, Y.H., Predictive downscaling based on non-homogeneous hidden Markov models, *Hydrological Sciences Journal–Journal des Sciences, Hydrologiques*, 55, 3, 333-350, 2010
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Presentations (too many to list)

Grants Awarded: ~\$35 million as PI or co-PI

1. *Building Capacity for Rapid Financial Response to Natural Hazards* (Lall, U., PI) **World Bank, \$149,493**. 10/16 to 5/17.
2. *A Water Resources Decision Support System To Reduce Drought Vulnerability And Enable Adaptation To Climate Variability And Change In Pernambuco* (Lall, U., PI) **Inter-American Development Bank, IDB C0106-15, \$630,318**, 7/15/2015-6/17/2017.
3. *Feasibility of Decentralized Water Systems in Mexico City*, **Rotoplas, \$96,284**, (U. Lall, PI), 2/5/2016-11/14/2016
4. *Collaborative Research: P2C2--Multi-Site Paleo-Reconstruction of Missouri River Streamflows from Tree Ring Data AGS-1404188*, **NSF, \$268,050**, (PI: Cook, E., CO-PIs: Lall, U., Pederson, N.), 7/14 to 6/2017
5. *Climate-Informed Estimation Of Hydrologic Extremes For Robust Adaptation To Non- Stationary Climate Conditions*, **DOD-SERDP/Univ of Massachusetts, Amherst, \$388,575**, (Lall, U., PI), 9/21/2015-9/20/2018.
6. *America's Water– The Changing Landscape of Risk, Competing Demands and Climate*, **NSF, \$2.49 million**, U. Lall (PI), L. Goddard, N. Devineni, M. Gerrard, E. Cook, T. Troy, B. O'Flaherty, M. Levy (co-PIs), 9/1/14 to 7/31/17.

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7. *Mining & Water Risk: Diagnosis, Benchmarking, and Quantitative Analysis Of Financial Impacts*, **NBIM, \$2.36 million**, U. Lall (PI), G. Iyengar, J. Blanchet, S. Thomashaussen (co-PIs), 11/1/14 – 12/31/17.
 8. *Development Of Adaptable Web Modules To Stimulate Active Learning In Hydrology Using Data And Model Simulations*, **NSF, \$98,324**, U. Lall (PI), 10/1/11-9/30/15.
 9. *Water Risk And Sustainability: Managing Water Risks Through The Supply Chain*, **PEPSICO, \$546,014**, U. Lall (PI) 2/11-1/16.
 10. *Improving Food And Livelihood Security Through Water-Energy-Agriculture Management Under Climate Change And Variability: A Field Demonstration In India*, **IDRC, \$150,967**, U. Lall (PI), 4/12-3/15.
 11. *Water-Agriculture-Livelihood Security in India*, (PI: Vatta, K., U. Lall), **USAID, \$1.73 million**, 6/1/2012-5/31/2017.
 12. *Columbia Water Center's 'Aquanauts' Education Program*, **Veolia Foundation, \$26350**, U. Lall (PI), 6/12-5/13.
 13. *Climate Informed Global Flood Risk Assessment And Updates*, **AIG, \$331,439**, U. Lall (PI), N. Devineni and T. Troy (co-PIs), 9/1/12, 8/31/13.
 14. *A Water Management Knowledge Network For The Urban Northeast*, **NOAA, \$79,658**, U. Lall (PI), N. Devineni (co-PI), 1/1/13-12/31/14.
 15. *Water Resource And Flood & Erosion Risk Mitigation Planning In Assam*, **Assam State Disaster Management Authority, \$333,903**, U. Lall (PI), T. Troy (co-PI), 1/13-1/15.
 16. *Multi-Purpose R&D Pilot Projects For Assessing The Feasibility Of Cost Effective And Sustainable Technologies For Drinking Water Storage And Distribution In Rural Areas Of Jharkhand*, **Government Of Jharkhand, India: Drinking Water & Sanitation Dept, \$347,076**, U. Lall (PI), Modi, V., Perveen, S. (co-PIs), 11/12-10/13.
 17. *Building Capacity To Manage Water Resources And Climate Risk In The Caribbean*, **LAC: ECPA/CRCA, \$741, 463**, Baethgen, W., (PI); Goddard, L., Lall, U., Perveen, S., Kelsey, R., co-PIs, 7/1/2012-6/30/2015.
 18. *Decadal Prediction And Stochastic Simulation Of Hydroclimate Over Monsoonal Asia*, **DOE, \$355,204**, Robertson, A., (PI), D'arrigo, R., Cook, E., Lall, U., Greene, A Co-Pi's), 9/1/11-8/31/2013
 19. *Northeast Urban RISA*, **NOAA, \$3,499,924**, C. Rosenzweig (PI), U. Lall, P. Kinney, S. Someshwar, L. Goddard, R. Chen, and Y. Kushnir (co-PIs), 10/1/2010 – 9/31/2016.
 20. *Climate Predictability of Extreme Floods*, **NOAA, \$439,230**, U. Lall (PI), Y. Kushnir, A Robertson, J. Nakamura (co-PIs), 6/1/2010 – 5/31/2013.
 21. *Reconstructing Climate From Tree Ring Data* **NSF, \$598,084**, A. Gelman (PI), E. Cook and U. Lall (co-PIs), 10/1/2009 – 9/30/2012.
 22. *Paleoclimate Shocks: Environmental Variability, Human Vulnerability, and Social Adaptation During The Last Millennium In The Greater Mekong Basin*, **NSF, \$1,401,351**, 8/1/2009-7/31/2013. Buckley, B., (PI); Anchukaitis, K., Cook, B., Heikkila, T., Lall, U., Cook, E., Levy, M.; (Co PIs)
 23. *How Can the Contribution of Climate Variability, Water Release Patterns, and Hydrologic Performance Indices towards Ecological Restoration Measures at the Everglades National Park be Best Quantified and Predicted?* **National Park Service, \$151,721**, U. Lall (PI), 4/08 to 5/13.
 24. *Improving rural water and livelihood outcomes in India, China, Africa, and Brazil*, **PepsiCo Foundation, \$6,000,000**, U. Lall (PI), T. Heikkila, V. Modi, J. Sachs (co-PIs), 1/01/08-5/31/10.
 25. *Sustainable Development of Water Resources in Ethiopia: Learning from doing in Koraro*, **Pulitzer Foundation, \$690,000**, U. Lall (PI), V. Modi, F. Montalto, P. Schlosser, P. Culligan (co-PIs), 7/01/07-10/31/11
 26. *Climate-Informed Adaptive Management and Planning to Meet Urban Water Supply and Flood Mitigation Goals in the Delaware River Basin*, **NOAA, \$299,842**, G. Gong (PI), C. Brown, P. Kolesar and U. Lall (co-PIs), 7/01/07-6/31/09
 27. *Water Security in Asia: Meeting the Challenge through Infrastructure Development & Climate Risk Management*, **Asian Development Bank, \$180,000**, J. Sachs (PI), C. Brown, T. Heikkila, U. Lall and T. Siegfried (co-PIs), 7/01/07-12/31/08
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28. *Climate and Weather Scenario Driven Strategies for the Adaptive Management of Everglades National Park Operations to Achieve Hydrologic and Ecologic Restoration Targets*, **National Park Service, \$498,000**, U. Lall (PI), 4/05 to 4/08.
 29. *Reforming Undergraduate Education in Environmental Engineering: Urban Studios as Knowledge Delivery Systems and Vehicles for Service Learning*, **NSF, \$999,494**, J. McGourty (PI), M. Castaldi, P. Culligan, G. Gong and U. Lall (co-PIs). 9/15/04-8/31/08
 30. *Impacts of Water Resource Management Choices in Cear, Brazil: Roles of Streamflow Forecasts, Rainfall Forecasts and Participatory Decision Making*, **NOAA, \$445,833**, K. Broad, PI, A. Pfaff and U. Lall, co-PIs, 10/03-9/05.
 31. *Climate Informed Water Resources Management for Ceara*, **FUNCEME, \$100,000**, S. Zebiak (PI), U. Lall, K. Broad, A. Pfaff, L. Sun (co-PIs) 9/03-12/04.
 32. *Analysis of climate variations and hydrologic prediction for the Everglades National Park*, **National Park Service, \$152,000**, 3/1/2003-2/28/2005. U. Lall (PI)
 33. *Attracting and Retaining Undergraduates to Engineer the Built Environment*, **NSF, \$375,000**, 9/1/2002-8/31/2004, U. Lall (PI), M. Garvin, A. Smyth, P. Sommer (co-PIs).
 34. *Climate Change and Variability: Assessment and Prediction for Streamflow in the Hydroquebec Region*, **Hydroquebec, \$200,000**, 6/1/2002-5/31/2004.
 35. *A Joint Graduate Program in Applied Mathematics and the Earth and Environmental Sciences*, **NSF, \$2,641,325**, L. Polvani (PI), V. de La Pena, U. Lall, D. Phong, M. Visbeck (co-PIs).
 36. *Infrastructure for the Advancement of Hydrologic Science*, **NSF, \$ 678,730**, 9/01-8/04, R. C. Bales (PI), J. S. Selker, U. Lall, M. B. Parlange, M. W. Williams, C. J. Duffy (co-PIs).
 37. *Systems Approach to Earth and Environmental Engineering*, **Academic Quality Fund, Columbia Univ., \$380,000**, 6/01-6/04, U. Lall (PI), co-PIs : A. Sobel and M. Spiegelman, P. Sommer, A. Bagtzoglou, P. Duby, A. Gelman, P. Schlosser, P. Somasundran, N. Themelis, R. Versteeg & T. Yegulalp, A. Pfaff, D. Krantz
 38. *Development of a Benchmark Hydroclimatic Data base for N. America*, **NSF, \$15,000**, 5/01-4/02. , U. Lall (PI), E. Cook (co-PI).
 39. *Reconstruction of drought and streamflow over the coterminous United States from tree rings, with extensions into Mexico and Canada*, **NSF, \$310,947**, 8/00-7/03. , E. Cook (PI), U. Lall (co-PI).
 40. *Interannual and Interdecadal climate variations of floods in the Western United States*, **NSF, \$262,227**, 11/99-11/04, U. Lall (PI), B. Rajagopalan (co-PI).
 41. *Atlantic Basin Tropical Cyclones: Risk assessment using climate indicators*, **NOAA, \$125,689**, 9/99-9/01, Y. Kushnir (PI), B. Rajagopalan and U. Lall (co-PIs).
 42. *Devils Lake, N. Dakota- Climate Connections and Forecasts*, **USACE, \$12,000**, 1/99-2/00. U. Lall (PI)
 43. *Seasonal To Interannual Ensemble Streamflow Forecasts For Improved Sydney Water Supply Management*, **Sydney Water, AU\$90,000**, 2/98-11/98, A. Sharma (PI), U. Lall and I. Cordery (co-PIs).
 44. *Development Of A User Driven Decision Support System For Water Availability And Quality Management*, **DOE-INEEL, \$2.38 million**, 1/98-9/02, U. Lall (PI), D Stevens, Q Weninger, T Glover, J Kaluarachchi, D Tarboton co-PIs
 45. *The Changing Seasons? Detecting and Understanding Climatic Change*, **NSF, \$264,000**, 9/97-9/03, U. Lall (PI), B. Rajagopalan, M. Cane, M. Mann and J. Park (co-PIs).
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46. *Droughts in the Southwest and Large Scale Climate: Inferences and Prediction using Nonparametric Statistical Methods with Tree Ring and Historical Climate Data*, **NOAA Earth System History, \$219,400** , 9/97-1/01, E. Cook (PI), B. Rajagopalan, B. Ray and U. Lall (co-PIs).
 47. *Nonlinear Time Series Methods for Forecasting Yakima River Flows*, **U.S. Bureau of Reclamation, \$93,600**, 4/97-12/00, U. Lall (PI).
 48. *Field Investigations into Infiltration and Runoff Under Extreme Rainfall*, **Utah Division of Water Resources, \$25,000**, 1/96 -12/98, U. Lall (PI).
 49. *Nonlinear Dynamics of Streamflow: Classification, Predictability and Forecasting*, **NSF, \$212,000**, 7/95 to 7/98, U. Lall and H.D. I. Abarbanel (PIs).
 50. *Assessing Aquifer Heterogeneity and Groundwater Contamination Potential: Data, Methods and Utah Applications*, **USGS, \$122,000**, 7/94 to 7/96, U. Lall (PI).
 51. *Site Subsurface Characterization at Hill A.F. Base*, **U.S.A.F., \$7,200**, 6/94 to 10/94, U. Lall (PI).
 52. *Non-Parametric Stochastic Simulation Of Streamflow In The Colorado River*, **USGS, \$189,000**, 10/92 to 9/95, D. Tarboton (PI), U. Lall (co-PI).
 53. *Predictability And Variability Of Climate And Hydrology: Inferences From Great Salt Lake Dynamics*, **USGS, \$185,447**, 10/92 to 8/95, U. Lall (PI).
 54. *The Dynamics of Closed Basin Hydrology and Climate Variability*, **NSF, \$104,000**, 10/92 to 4/95, U. Lall (PI).
 55. *Subsurface Characterization Using Drill Log Data*, **Utah Division of Water Rights, \$5,500**, 6/92 to 6/93, U. Lall (PI).
 56. *Sharon Steel Groundwater Contamination Investigations and Remediation Design*, **Utah Division of Environmental Health, \$30,000** , 12/90-12/91, U. Lall (PI), M. W. Kemblowski , G. Urroz (co-PIs).
 57. *Kennecott Tailings - Groundwater Remediation And Natural Resource Damage Assessment*, **Utah Division of Environmental Health, \$30,000** , 10/90-6/91, U. Lall, (PI), L. D. James, M. W. Kemblowski (co-PIs).
 58. *Evaluation of hydraulic interconnections in heterogeneous multi-aquifer systems*, **USGS, \$74,900**, 9/90-9/92, M. W. Kemblowski (PI), U. Lall (co-PI).
 59. *Climatic variability and hydrology, inferences from the dynamics of the Great Salt Lake*, **Utah Mineral Lease Funds, \$13,133**, 7/90-7/91, U. Lall (PI).
 60. *Sharon Steel Groundwater Investigations*, **Utah Division of Environmental Health, \$30,500**, 4/90-12/90, M. W. Kemblowski (PI), U. Lall, G. Urroz (co-PIs).
 61. *Development of a mountain climate generator*, **U.S. Forest Service, \$800,000**, 9/89-12/95, D.S. Bowles (PI), G. Bingham, U. Lall, D. Tarboton (co-PIs).
 62. *Estimation of the space and time variability of non-point source ground water contamination*, **USGS, \$262,262**, 9/89-9/91, U. Lall (PI), K. Bosworth (co-PI)
 63. *Robust, efficient estimation and prediction of groundwater quality in Salt Lake County*, **Utah Mineral Lease Funds, \$18,585**, 7/89-7/91, U. Lall (PI).
 64. *Anaerobic Biotransformation and fate of heterogeneous organic pollutants in groundwater*, **USGS, \$109,500**, 7/88-7/90, S. Ghosh (PI), D. Schamber & U. Lall (co-PIs).
 65. *Parameter Estimation Models for Stream Drainage Systems*, **Utah Division of Water Rights, \$9,200**, 4/85 - 3/86, U. Lall (PI).
 66. *Strategies for the Conjunctive Management of Ground and Surface Waters*, **U.S. Bureau of Reclamation, \$122,000**, 9/84-9/87, U. Lall (PI).
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67. *Optimization Models for Multi-Reservoir Systems with Lower Bear River Basin Applications*, **Utah Div. of Water Resources, \$9,900**, 5/84 - 2/85, U. Lall (PI).
 68. *A Bilevel Optimization Model for Integrating Fare and Service Structures to Minimize Urban Transit Operation Deficits*, **Urban Mass Transit Authority, \$96,703**, 8/83 - 2/85, J.C. Yu (PI), U. Lall (co-PI).
 69. *Optimization Model for Conjunctive Regional Water Resource Development*, **University of Utah Research Committee, \$3,070**, 1/83-1/85, U. Lall (PI).

Other Information

Professional Service

Participation in several NRC panel: Climate and Water Cycle; Flood Risks in the American River; Estimating and Communicating Uncertainty in Weather and Climate Forecasts; Committee on Preparing for the Third Decade (Cycle 3) of the National Water-Quality Assessment (NAWQA) Program; Modeling and uncertainty analysis for the restoration of the Everglades, Florida

Member Advisory Committee on Environmental Research and Education to the Director, the National Science Foundation

Member NSF Working Group on Water, Earth and Bios.

Moderator for President's Regional panel on global climate change.

President of the Natural Hazards Focus Group of the American Geophysical Union

Member World Economic Forum, Global Agenda Council on Water 2009-2011

Selected Invited talks and Keynotes at non-academic public events: World Bank, Stockholm Water Week, Singapore Water Week, American Water Intelligence, Water 2.0, NY Academy of Science, World Leaders Forum, UN World Water Forum; Shell Water-Energy Summit, American Water Summit, EU General Assembly, Sustainalytics, US Water Partnership, Rubin Museum, US Water Partnership, Water Innovations Alliance Foundation; American Water Summit; Financial Times Event on Water; Circle of Blue Webinars on Choke Point USA, Mining and Water; Water and Climate; Woodrow Wilson Center; USAID; Municipal Analysts Group of New York; CERES Investor Water hub; Interfaith Center on Corporate Responsibility; OECD-FICCI-ADB-2030WRG Seminar on Water Risk and Stewardship; NOAA MAPP; White House Water Forum; World Bank Water Week; Natural Conservancy Global Water Summit; Pro Publica-New America; several water and climate related movie screenings

Interviews: World Economic Forum, European Commission; Cathedral Church of Saint John the Divine; **Web:** GOOD; CBS Marketwatch; Statistics Views; Business Insider; CSR Wire; Bloomberg News; The McBride Network; Crains New York; Environment & Energy News; Circle of Blue; Big Think; Huffington Post; Vice.com; Growing Blue; RWL Water; Pub Publica Press – FACE HD; **Print:** The Guardian; Reuters, Xinhua News Agency; Economist, National Geographic, The Atlantic Magazine, Financial Times, NY Times, Washington Post, USA Today, Desert Sun; Asian Development Bank magazine, Christian Science Monitor; Times of India, The Hindu, The Tribune, Popular Science; GE Reports; **TV& Radio:** CBS, ABC News, CNN, PBS, NPR, BBC, WNYC, WNBC, Mundo TV, Rede Globo, Al Jazeera, ARISE TV, R-TV America; Interview for WLIW Documentary: Plagues and Perils of Salton Sea Earthsky.org; Namibia Press Agency

Corporate Advisory Boards: Xylem, Waterfund, Ketos

Editor in Chief: Water Security, 2016-date

Associate Editor: Water Resources Research, 1993-2002, ASCE J. of Hydrologic Engineering, 1994-2004.

Reviewer: Water Resources Research, Journal of Hydrology, Water Resources Bulletin, ASCE J. of Water Res. Plng. & Mgmt, ASCE J. of Hydraulics, Advances in Water Resources, Stochastic Hydrology & Hydraulics, Nordic Hydrology, J. of Computational and Graphical Statistics, Nature, Science, Environmental Research Letters, Geophysical Research Letters, Computational Statistics, Communications in Statistics, Journal of Climate, Hydrology & Earth System Science, Journal of Geophysical Research, NSF, USGS, DOE, NIGEC, EPA, NASA, NOAA. Served on NASA, NSF, EPA, and NOAA Review Panels.

Society Memberships

Societies and Committees: Member AGU, ASCE, AMS, ASA, SIAM, AAAS, AWWA. Committee Involvement with AGU and ASCE. President, AGU Group on Natural Hazards Member, Board of Directors, UCOWR and CUAHSI.

University Service

Administrative: Associate Director of Utah Water Research Laboratory; Chair, Department of Earth and Environmental Engineering, Columbia University. Chair, Civil Eng & Eng Mechanics, Director, Columbia Water Center, Associate Director, Applied Statistics Center

Committees: Participated in and chaired department, college and University committees for tenure and promotion, computer programs and labs, curricula, faculty search, undergraduate admissions, student affairs, research and development, PhD Qualifying exams, graduate theses, CAD/CAM, department Goals, directed Graduate Studies Program for Civil Eng..

Consulting

Clients include: R&M Consultants, Soldier Creek Coal Co., Coop Mining Co., Technical Advisory Service for Attorneys, Utah Division of Water Rights, Utah Division of Water Resources, Eckhoff, Watson & Praetor, UINTEX, U.S.G.S., Utah Division of Environmental Health, Keller-Bliesner Eng., Jason Associates, IWMI, U.S.B.R., FUNCEME, S. Florida Water Management District, Hazen and Sawyer, Tampa Bay Water, World Bank, UTE (Uruguay).

Project Areas Include: Geohydrology and Contaminant Transport, Flood Frequency Analysis and Control, Drainage, Mine Hydrology, Risk and Environmental Impact Assessment, Reservoir and Streamflow Analysis, Aquifer Management, Coal and Copper Mine Reclamation, Landfill/Incinerator site geo-hydrology evaluation, Stochastic Hydrology and Spatial Analysis, Stream network mass balances, Spatial interpolation, Climate Model Downscaling and Hydroclimatology, Climate Risk Analyses in support of Insurance products, Financial Instruments design for hedging climate risk for water and energy utilities.