

Welcome to...



*June 2 – 5, 2024
Princeton University
Princeton, New Jersey, USA*

Conference Organizing Committee



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Dr. Chunmiao Zheng
Southern University of
Science and Technology,
China

Welcome to MODFLOW and More 2024: AI, Global Change, and the Future of Groundwater Modeling

The **MODFLOW** conference series unites cutting-edge developments and practical applications of hydrologic models related to groundwater. The conference series **takes its name from MODFLOW**, one of the original and most widely used groundwater modeling codes. However this is just a starting point, **there are a broad array of well-established groundwater and hydrologic models**, we seek to foster communication among conference participants using all types of models. Our conference **brings together model users and developers to exchange ideas on the latest innovations in hydrologic model applications, discuss the capabilities and limitations of currently available codes, and explore directions for future developments. The conference series does not stop with groundwater modeling, rather we encourage community participation by developers and users of all types of models in diverse applications**, to help evolve the modeling capabilities of our profession.

Keynote presentations will be given by:

- **Ruben Juanes**, 2024 InterPore Kimberly-Clark Distinguished Lecturer, Professor of Civil and Environmental Engineering, Professor of Earth, Atmospheric, and Planetary Sciences, MIT.
Man-mad Earthquakes and the Energy Transition
- **Christa Peters-Lidard**, Director, Sciences and Exploration Directorate at NASA Goddard Space Flight Center.
Data Driven Hydrology: From Assimilation to Digital Twins
- **Holly Michael**, Director, Delaware Environmental Institute, and Professor, Unidel Fraser Russell Career Development Chair for the Environment, University of Delaware.
Untangling complexity at the land-sea margin
- **Laura Condon**, Associate Professor, Hydrology and Atmospheric Sciences, University of Arizona.
Panel: The Future of Groundwater Modeling Education.
- **Ty Ferré**, University Distinguished Professor and Interim Associate Head, Hydrology and Atmospheric Sciences, Joint Professor, Environmental Science-Extension, University of Arizona.
Panel: The Future of Groundwater Modeling Education.
- **Kenneth Belitz**, 2023 Birdsall-Dreiss Distinguished Lecturer, Research Hydrologist, Water Resources Mission Area, U.S. Geological Survey.
Applications of Ensemble Tree Machine Learning to Hydrogeology: Not Just a Black Box.

The conference includes featured presentations by:

- **Mary Hill**, Managing Water Supplies from Natural Systems
- **Matt Tonkin**, Some lessons learned litigating models
- **Chunmiao Zheng**, Groundwater Research at a Crossroads: A Global Perspective
- **Erica Siirila-Woodburn**, Is old groundwater buffering mountain streamflow?
- **Xingyuan Chen**, Beyond the flows: modeling carbon cycling from batch to watershed scales
- **Stefan Kollet**, Groundwater Modeling in the Global Energy and Water Exchanges (GEWEX) project: Closing the Terrestrial Water Cycle from the Regional to the Global Scale
- **Sorab Panday**, A Case of Oysters
- **James Rumbaugh**, The Model Crashed, Send Help: 35 Years of MODFLOW Technical Support
- **Otto Strack**, An Analytical Model for Fractured Flow in Impermeable Rock
- **Christopher Green**, Combining process and statistical models for decision-support estimation of nitrate in Wisconsin wells
- **Nick Engdahl**, Granular and Indeterminate: Maybe quantum-like mathematics really are useful for hydrogeology too
- **Steve Berg**, Transforming Integrated Hydrologic Models into Digital Twins
- **Lauren Foster**, Unraveling Complexity: How Numerical Models and AI Can Work Together to Expand the Frontiers of Hydrologic Research
- **Xiaofan Yang**, An integrated hydrologic modeling testbed in the Heihe River Basin
- **Laura Condon**, Integrated hydrologic modeling at the continental scale: scientific advances, research opportunities and the need for community infrastructure
- **Christian Langevin**, One Platform, Many Models: MODFLOW 6 as a Modular Hydrologic Simulator
- **Jeremy White**, Exploring strategies for robust assimilation of imprecise parameter information
- **Andrea Brookfield**, Recent advances in integrated models: Integration of new domains

General sessions are on the following topics:

- Advances in Integrated Hydrogeologic Modeling
- Application of Hydrologic Models to Mining and Resource Extraction Problems
- Coastal Aquifers, Sea Water Intrusion and Groundwater Consequences of Sea Level Rise
- Contaminant Transport: Model Development and Case Studies; and Occurrence, Transport, and Health Risks of Emerging Contaminants in Groundwater
- Data-Driven Modeling and Machine Learning
- Data-Driven Modeling and Time Series Analysis
- General Applications of Groundwater Models
- Groundwater and Climate Change; Implications of Human Activities on Water Quantity and Quality; and Modeling Agriculture and Water Resources
- Large-Scale Groundwater Modeling
- Modeling Surface-water/Groundwater Interaction
- Multi-Model Analysis, Parameterization, Sensitivity Analysis, and Uncertainty
- Simulation Code Verification, Benchmarking, and Intercomparisons
- Supporting Sustainable Water Management with Hydrologic Models
- The Analytic Element Method to the Rescue: Developments and Applications
- Using Integrated Modeling to Understand and Manage Water Supply, Water Quality, and Ecology

June 2 – 5, 2024
Integrated GroundWater Modeling Center (IGWMC)
Scientific Advisory Committee



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University of Waterloo
Canada



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Sunday, June 2

Opening Reception: Refreshments and Hors D'oeuvres, Friend Center, 4:30 – 6:00pm

Introduction

Introduction by Michael Celia

InterPore's Kimberly-Clark Distinguished Lecture

Ruben Juanes

Professor of Civil and Environmental Engineering; Professor of Earth, Atmospheric, and Planetary Sciences, MIT

Man-made Earthquakes and the Energy Transition

Friend Center, 6:00 – 7:00 PM

Conference Check-In

Conference check-in begins Sunday, June 2 at 4:30pm

Monday, June 3

Time	Friend 101	COS 104
8:00	Welcome and Opening Address	Opening in Friend 101
	Featured Presentation	Featured Presentation in Friend 101
8:05	Steven Berg Transforming Integrated Hydrologic Models into Digital Twins	
8:25	Data-Driven Modeling and Machine Learning Chaired by: Laura Condon and Lauren Foster	Advances in Integrated Hydrogeologic Modeling Chaired by: Steve Berg and Nick Engdahl
8:30	<u>Bennie Minnema</u> , Panagiotis Mavritsakis, Jonathan Nuttall Revolutionizing groundwater reconnaissance studies with AI-versions of existing MODFLOW models	<u>Joseph Hughes</u> , Martijn Russcher, Liv Herdman, Paul Misut, Kalle Jahn Dynamic Compound Flooding Simulation on Long Island, New York, USA
8:45	<u>Kate Richards</u> , Jeff Randall, Joanna Moreno Using Covariance Matrix Adaptation Evolution Strategy to Optimize an Expanded Remediation Capture System	<u>Amelia Peeples</u> , Reed Maxwell Assessing subgrid channel formulations in a coupled surface-groundwater model
9:00	<u>Yueling Ma</u> , Laura Condon, Stefan Kollet, Reed Maxwell Large-Scale Groundwater Resource Monitoring Using Machine Learning	<u>Eric Morway</u> , Alden Provost, Christian Langevin, Joseph Hughes, Martijn Russcher, Chieh-Ying Chen, Wesley Bonelli, Michael Reno, Yu-Feng Lin Heat Transport Modeling with MODFLOW 6
9:15	<u>Xiao Xia Liang</u> , Erwan Gloaguen, Philippe Renard, Julien Straubhaar, Celia Trunz Graph Neural Network to Forecast Karst Spring Discharge	<u>Joshua Larsen</u> "D-Any" - an algorithm for performing flow accumulation and stream network delineation on non-uniform and unstructured grids
9:30	<u>William Gottobrio</u> , Roselyne Laboso, Cliff Baines, Skyler Sorsby Machine Learning as an Extension of Groundwater-Model Sensitivity Analysis	<u>Rodrigo Pérez-Illanes</u> , Daniel Fernández-García MODPATH-RW: A Random Walk Particle Tracking Code for Solute Transport in Heterogeneous Aquifers
9:45	<u>Yifei Zong</u> , David Barajas-Solano, Alexandre Tartakovsky Randomized Physics-informed Machine Learning for Uncertainty Quantification in Partial Differential Equations Problems	<u>Mike Müller</u> , Lúcia Pedrosa, Martin Binder, Christian Engelman Better Groundwater Models with MODFLOW 6 and Dynamic Boundary Conditions
10:00	Coffee Break	
	Featured Presentations	Featured Presentations in Friend 101
10:20	Laura Condon Integrated hydrologic modeling at the continental scale: scientific advances, research opportunities and the need for community infrastructure	
10:40	Otto Strack An Analytical Model for Fractured Flow in Impermeable Rock	

Monday, June 3

11:00	Data-Driven Modeling and Time Series Analysis Chaired by: Christopher Green and Xingyuan Chen		Application of Hydrologic Models to Mining and Resource Extraction Problems: The Analytic Element Method to the Rescue: Developments and Applications Chaired by: Otto Strack and James Rumbaugh	
11:05	<u>TBD</u>	TBD	<u>Huite Bootsma</u> , Joeri van Engelen	QGIS-Tim: Recent developments on a QGIS plugin for TimML and TTim
11:20	<u>Raoul Collenteur</u> , Martin Vonk, Ezra Haaf	Can I have your signature? Introducing the Pastas groundwater signatures module and how to use it	<u>David Brakenhoff</u> , Mark Bakker	Getting rid of the grid: local refinement of MODFLOW 6 with analytic elements
11:35	<u>Cristian Ortiz</u> , Rodolfo Ordoñez, Mauricio Muñoz, Andrés Pucheu, Jose Montt	Environmental mitigation system operation based on numerical and stochastic models	<u>Erik Toller</u> , Otto Strack	Implementation and Applications of an Analytical Model for Fractured Flow in Crystalline Rock
11:50	<u>William Gottobrio</u> , Roselyne Laboso, Skyler Sorsby, Cliff Baine	Empirical Forecasting Methods for Practical Dewatering Assessments	<u>Mario Soriano</u> , James Saiers, Reed Maxwell	Sensitivity of physics-based and machine learning approaches for simulating groundwater vulnerability to contamination from unconventional oil and gas development
12:05			<u>Grady Konzen</u> , Kate Richards, PJ Nolan, Cole Mayer	Vadose Zone Modeling to Evaluate Fate and Transport of Mine Effluent
12:25	Lunch – Friend Courtyard			
14:00	Lunch Keynote – Friend 101 <u>Christa Peters-Lidard</u> Director, Sciences and Exploration Directorate at NASA Goddard Space Flight Center Data Driven Hydrology: From Assimilation to Digital Twins			
14:30	Transition			
	Featured Presentations		Featured Presentations in Friend 101	
14:35	<u>Andrea Brookfield</u> Recent advances in integrated models: Integration of new domains			
14:55	<u>Stefan Kollet</u> Groundwater Modeling in the Global Energy and Water Exchanges (GEWEX) project: Closing the Terrestrial Water Cycle from the Regional to the Global Scale			
15:15	Large-Scale Groundwater Modeling Chaired by: Laura Condon and Stefan Kollet		Groundwater and Climate Change Chaired by: Andrea Brookfield and Erica Siirila-Woodburn	
15:20	<u>Martijn Russcher</u> , Joseph Hughes, Christian Langevin, Alden Provost, Jarno Verkaik, Wesley Bonelli, Joshua Larsen, Eric Morway, Michael Reno	Parallel Computing with MODFLOW 6	<u>Michael Morphew</u> , Rosemary Knigh	Your ET Model Matters: Examining Variability in Evapotranspiration Estimates Across California's Central Valley using OpenET
15:35	<u>Frank Tsai</u> , Shuo Yang, Mohammed Elkhakany	Toward Regional-Scale High-Resolution Unstructured Groundwater Modeling with MODFLOW 6 for the Lower Mississippi-Gulf Region	<u>Brian Mailloux</u> , Kazi Matin Ahmed, Afsana Akter, Sarah Blau, Benjamin Bostick, Bruce Buccholz, Imtiaz Choudhury, Charles Harvey, Madeleine Killough, Mahfuz Khan, Maggie C. Y. Lau Vetter, Rajib Mozumder, Katharine Scanlan, Greg Slater, Elizabeth Trembath-Reichert, Alexander van Geen	Radiocarbon analysis of RNA, DIC, DOC, and Methane indicates young reactive carbon is entering deep pumped aquifers
15:50	Chen Yang, Xiaolang Zhang, Zhongwang Wei, Laura Condon, <u>Reed Maxwell</u>	Building and evaluating a high-resolution, integrated groundwater-surface water ParFlow modeling platform of continental China (CONCN): leveraging global datasets in a data-poor region	<u>Evan Christianson</u> , Lanya Ross	Use of regional models to evaluate potential hydrogeologic changes under future climates for water supply planning

Monday, June 3

16:05	<u>Joeri van Engelen</u> , Frans Roelofsen, Luit Jan Slooten, Sunny Titus, Hendrik Kok, Huite Bootsma	The iMOD Suite: Make massive MODFLOW models	<u>Vivek Patil</u> , Gabriella Basso, Steven Catania, Christopher Catania, Timothy Ostapuk, Robert Vince	Carbon Utilization and Storage through Rehabilitation of Groundwater Wells
16:20	Coffee Break			
	Featured Presentations		Featured Presentations in Friend 101	
16:40	<u>Sorab Panday</u> A Case of Oysters			
17:00	<u>Software Demo Introductions</u>			
17:20	Transition			
17:30	SOFTWARE DEMONSTRATIONS AND POSTER RECEPTION Refreshments and Hors D'oeuvres – Carl A. Fields Center 5:30 – 7:30pm			

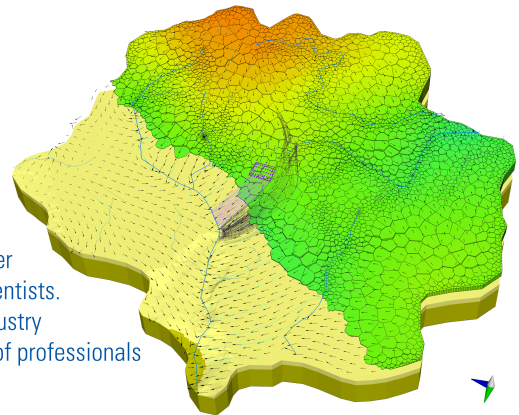
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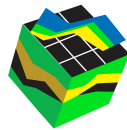
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Waterloo Hydrogeologic is in the business of developing specialized groundwater software for practical use by hydrogeologists, engineers, and environmental scientists. Since offering the first fully-integrated graphical modeling application in the industry over 30 years ago, our software has grown to be used worldwide by thousands of professionals



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Software Demonstration Session

Monday, June 3, 5:30 – 7:30 PM

1. Groundwater Modeling System (GMS) by Alan Lemon (Aquaveo)

GMS is a comprehensive software suite designed for developing and simulating groundwater flow and contaminant transport models. It integrates various modeling tools and techniques to provide a robust environment for hydrogeologists and environmental engineers to analyze subsurface hydrological processes. Key features of GMS include:

1. Pre-processing Tools: Facilitates the creation of conceptual models, importing and editing data, and building finite element and finite difference grids.

- GIS Integration
- Borehole/Cross Section tools for subsurface characterization

2. Modeling Engines: Supports popular groundwater modeling codes like MODFLOW, MT3DMS, HYDROGEOSPHERE, USG-Transport, and more.

3. Post-processing Tools: Provides visualization capabilities to interpret simulation results, including contour maps, cross-sections, and 3D views.

4. Calibration and Optimization: Assists in model calibration and parameter estimation to improve model accuracy and reliability.

GMS is widely used for a variety of applications such as water resource management, environmental impact assessments, and remediation system design. Its user-friendly interface and extensive support for different modeling approaches make it a valuable tool in the field of hydrogeology.

2. TTim for aquifer test analysis by Mark Bakker and David Brakenhoff (TUDelft)

TTim is an analytic element model for transient multi-layer flow. One of the main applications of TTim is the analysis of aquifer tests, from a single pumping well with variable discharge, to multi-layer systems with multiple pumping wells and multiple observation wells including other aquifer features such as rivers or areal infiltration. TTim can be applied to estimate the aquifer parameters for several different conceptual models using Python scripts, including visualization of the results. TTim is open-source and available from github.

3. Pastas by Raoul Collenteur (University of Graz, Austria and Mark Bakker Delft University of Technology)

Pastas is an open source Python package for processing, modeling and analyzing groundwater time series. The object-oriented structure allows for the quick implementation of new model components. Data-driven models can be created, calibrated, and analyzed with just a few lines of python code with the built-in optimization, visualization, and statistical analysis tools. This year, we will be introducing a few brand-new features of Pastas, such as the groundwater signatures module, new model structures, and more advanced parameter estimation methods.

4. Integrated Hydrologic Model by Jeff Geurink (Tampa Bay Water)

The Integrated Hydrologic Model (IHM) dynamically couples and integrates hydrologic processes of HSPF and MODFLOW through 11 integration pathways. HSPF simulates surface water processes, MODFLOW simulates groundwater processes, and IHM integration pathways facilitate dynamic mass-conserving transfers of baseflow, recharge, and storage domain between HSPF and MODFLOW. IHM integration pathways also dynamically update: (a) HSPF pervious upland parameters for soil storage, infiltration capacity, and ET as a function of simulated depth to water table from MODFLOW, and (b) MODFLOW parameters for river package stage as a function of simulated reach storage from HSPF and specific yield as a function of simulated depth to water table and soil moisture. IHM is well suited to landscapes where pervious land hydrologic processes are affected by near-surface water table conditions. IHM is also well suited to hydrologic conditions exhibiting active flow exchange between water bodies and the ground-water system.

5. ParFlow by Danielle Tijerina-Kreuzer, Nick Jadallah, Lauren Foster (Princeton University, Neptune, Inc.)

ParFlow is a numerical model that simulates the hydrologic cycle from the bedrock to the top of the plant canopy. It integrates three-dimensional groundwater flow with overland flow and plant processes using physically-based equations to rigorously simulate fluxes of water and energy in complex real-world systems. ParFlow is a computationally advanced model that can run on laptops and supercomputers and has been used in hundreds of studies evaluating hydrologic processes from the hillslope to the continental scale. Our code is open source and we promote a community of active users and developers interested in advancing computational hydrology and improving hydrologic understanding. In addition to core capabilities, we will highlight many new model advancements that include a complete Python integration (including running in Jupyter Notebooks), many different output formats (including NetCDF), and full GPU back-end capability.

Software Demonstration Session

Monday, June 3, 5:30 – 7:30 PM

6. HydroFrame by Amy Defnet, George Artavanis (Princeton University)

HydroFrame is a platform to facilitate easy interaction with large computationally intensive hydrologic models and massive simulated outputs. Our tools enable users to subset model inputs and outputs for any watershed in the US, run their own simulations, and visualize and analyze existing model outputs or newly generated results. We also develop free educational tools and lesson plans to teach students of all ages about groundwater and the hydrologic cycle.

7. HydroGEN by Bill Hasling (Princeton University)

HydroGEN is a tool for forecasting water availability. It uses cutting-edge machine learning and supercomputing capabilities to provide water managers and planners with the ability to predict water availability. Currently, our forecasts are seasonal but we hope to extend the models to forecast up to a year in advance. Current models use a limited set of variables; over time, the product will evolve to model bedrock to treetop. Users can create what-if scenarios that predict streamflow and soil moisture under a variety of climate and weather assumptions. These scenarios are essential input into strategic planning and risk analysis.

8. Groundwater Vistas Version 9 by Jim Rumbaugh (Environmental Simulations, Inc.)

Presenting the newly-released Groundwater Vistas Version 9, which includes new python capabilities, the new Pest_HP ENSI procedure, and what's new in MODFLOW-USG Version 2.3.0 and MODFLOW6 Version 6.4.x.

9. Hydrology Information Sources & Databases by Emily Wild (Princeton University)

Emily Wild is the Chemistry, Geosciences and Environmental Studies Librarian in the Princeton University Library. From 1996 to 2018, she was a hydrologist and librarian (physical scientist) at the U.S. Geological Survey, where she worked with MODFLOW field data collection, data/model archiving, publications, and beta testing software. She will be providing "MODFLOW and More" conference attendees with hydrology information sources, library research guides, data management information, and demonstrations of access to water data, imagery, and bibliographic databases.

10. ModelMuse by Richard Winston (U.S. Geological Survey)

ModelMuse is a public-domain graphical user interface for groundwater models. The demonstration will focus on the ability of ModelMuse to import MODFLOW 6 models and its support for PEST.

11. HydroGeoSphere, HydroGeoSphere-RealTime, HGS Interface by Jag Phagura (Aquanty, Inc.)

HydroGeoSphere (HGS): A hydrologic simulation engine for water resources engineers that integrates all key components of the terrestrial water cycle, seamlessly tracking the movement of water between surface water, soil water, and groundwater systems with a physics based numerical approach. As a fully physics-driven platform, HGS is the best modelling tool to evaluate the impact and risk associated with climate change for water resources.

HydroGeoSphere-RealTime (HGSRT): HGSRT is a cloud-based computing system that combines near-real-time field observations and remote sensing products with meteorological predictions to produce reliable, near real-time hydrological forecasts. With HydroGeoSphere at its core, the platform is robust and applicable to a wide range of hydrological environments.

HGS Interface (via GMS v10.8): The HGS Interface is a GUI for HydroGeoSphere that has been built into Aquaveo's flagship Groundwater Modeling System (GMS), one of the world's premier software packages for subsurface hydrological simulations. With the introduction of the extremely powerful HydroGeoSphere simulation engine, GMS v10.8 users will be able to construct fully-integrated groundwater-surface water models powered by HydroGeoSphere!

Poster Session

Monday, June 3, 5:30 – 7:30 PM

Advances in Integrated Hydrogeologic Modeling	
1. <u>Frank Tsai</u> , Aya Mohamed, Shuo Yang	Unstructured Centroidal Voronoi Tessellation for High-Resolution Groundwater Model Development
2. <u>Huite Bootsma</u> , Martijn Visser, Hendrik Kok	Ribasim: Simulating and coupling highly managed surface water to MODFLOW 6 for a renewed Netherlands Hydrologic Model
3. <u>Wesley Bonelli</u> , Alden Provost, Christian Langevin, Joseph Hughes, Martijn Russcher	A fully integrated particle tracking (PRT) model for MODFLOW 6
4. <u>Michael Rush</u> , Lauren Foster, Alan Lewis, Todd Umstot, Chris Wolf, Reed Maxwell	Modeling Fracture Flow using Flow Barriers in ParFlow-CLM
Application of Hydrologic Models to Mining and Resource Extraction Problems	
5. <u>Xiaomin Wang</u> , Christopher Neville	Analysis to Support the Design of Open-loop Geothermal Systems
Coastal Aquifers, Sea Water Intrusion and Groundwater Consequences of Sea Level Rise	
6. <u>Omowumi Erukubami</u> , Austin Farnum, Carolyn Voter	Assessment of Sea Level Rise Impacts on Shallow Groundwater in an Urban Coastal Environment
7. <u>Robin Voland</u> , Philippe Renard, Yvan Caballero	Saline intrusions in the Roussillon aquifer
Contaminant Transport: Model Development and Case Studies; and Occurrence, Transport, and Health Risks of Emerging Contaminants in Groundwater	
8. <u>Vladimir Prilepin</u>	Evaluating Matrix Diffusion to Support Remedial Design for a Complex Site
9. <u>Mike Müller</u>	Reactive Transport Modeling with PhreeqPy
10. <u>Hiroko Hort</u> , Sorab Panday	Optimizing Injection Well Locations with Complex Hydrogeology in Urban Areas
Data-Driven Modeling and Machine Learning	
11. <u>Mehdi Ghasemizade</u>	Machine Learning Model for Depth to Water Prediction in Owens Valley, California
The Analytic Element Method to the Rescue: Developments and Applications	
12. <u>Stephen Kraemer</u>	Managed Aquifer Recharge and Source Water Protection of Drinking Water Wells: An Incised Valley Fill Case Study

Groundwater VISTAS

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Tuesday, June 4

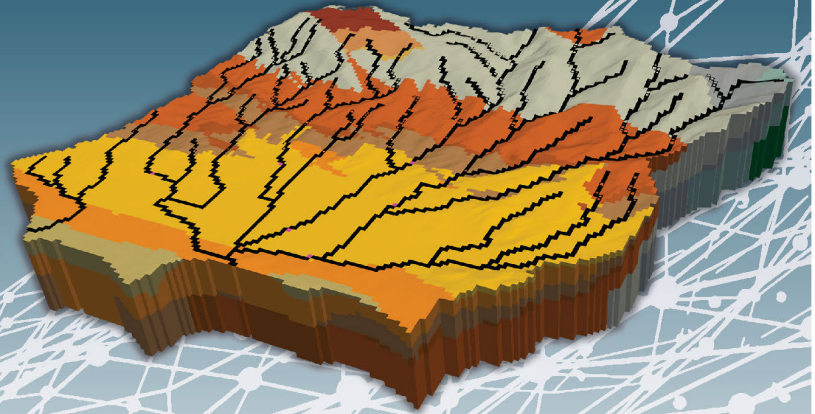
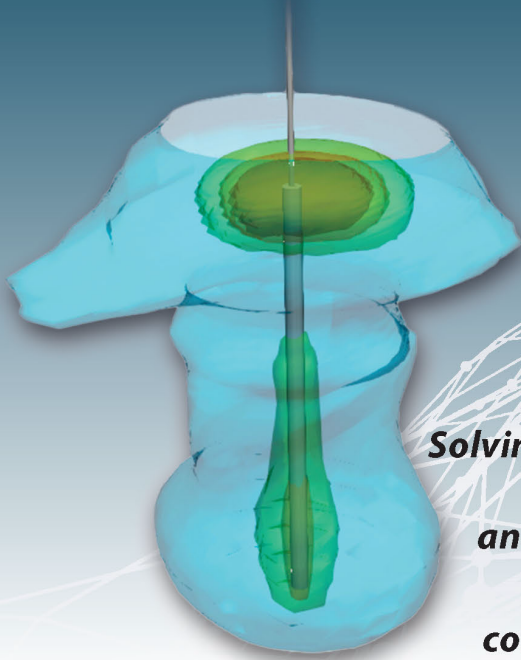
Time	Friend 101	COS 104	
8:00	Opening Comments	Opening in Friend 101	
	Featured Presentations	Featured Presentations in Friend 101	
8:05	Chunmiao Zheng Groundwater Research at a Crossroads: A Global Perspective		
8:25	Jeremy White Exploring strategies for robust assimilation of imprecise parameter information		
8:45	Modeling Surface-water/Groundwater Interaction I Chaired by: Stefan Kollet and Sorab Panday		Supporting Sustainable Water Management with Hydrologic Models I Chaired by: Andrea Brookfield and James Rumbaugh
8:50	<u>Ignacio Farias Gutierrez</u> , Marc F.P. Bierkens, Gualbert H.P. Oude Essink, Perry de Louw	Effects of Temporal Scaling on Modelled Groundwater Salinity and Salt Loads to Surface Water	<u>Katherine Markovich</u> , Cecile Coulon, Rui Hugman, Jeremy White Reliability-based optimization of an open pit mine dewatering system to support sustainable water management
9:05	<u>Saubhagya Rathore</u> , Jesus Gomez-Velez, Scott Painter	Exploring the Water Boundaries: Insights into Stream Network Expansion and Contraction from High-resolution Integrated Hydrologic Modeling	<u>Mike Fiener</u> , Nicholas Corson-Dosch Breathing life into groundwater models for supporting resource management through management optimization
9:20	Prashanth Khambhammettu, Scott Potter, Michael Kladias, <u>Jennifer Wahlberg</u>	The Hunt for PFAS: Modeling the Shenanigans of Groundwater-Surface Water Interactions	<u>Jonathan Traylor</u> , Leslie Duncan, Moussa Guira, Elizabeth Heal, Andrew Leaf Inset groundwater flow models to assess future water availability in the Cache and Grand Prairie Critical Groundwater Areas of northeastern Arkansas
9:35	Jeff Geurink, Hui Wang, Erin Hayes, Kay Parajuli	Continuous Improvement for the Integrated Hydrologic Model and Integrated Northern Tampa Bay Model	<u>Steffen Mehl</u> , Laura Foglia, Andrew Calderwood, Jose Tomas Diaz Casanueva Using innovative data to enhance the hydrologic model of a complex volcanic aquifer system to support Sustainable Groundwater Management
9:50	Coffee Break		
	Featured Presentations	Featured Presentations in Friend 101	
10:10	Matthew Tonkin Some lessons learned litigating models		
10:30	Christopher Green Combining process and statistical models for decision-support estimation of nitrate in Wisconsin wells		
10:50	Modeling Surface-water/Groundwater Interaction II Chaired by: Stefan Kollet and Sorab Panday		Supporting Sustainable Water Management with Hydrologic Models II Chaired by: Andrea Brookfield and James Rumbaugh
10:55	<u>Nick Jadallah</u> , Reed Maxwell	From High in the Sky to Deep Underground: Coupling Remote Sensing with Integrated Hydrologic Modeling to Highlight how Groundwater Pumping Impacts Streamflow in the UCRB	<u>Janet Barclay</u> , Madeleine Holland, John Mullaney Simulating groundwater-transported nitrogen loads in support of marine ecosystem management
11:10	<u>Edinsson Muñoz-Vega</u> , Heye Bogena, Stephan Schulz	Influence of conceptualization and parametrization for an integrated hydrologic model	E.J. Wexler, <u>Dirk Kassenaar</u> Simulation of Recharge and Groundwater Flow in the Extreme Arid Environment of the Najd, Sultanate of Oman
11:25	Thomas Harter, <u>Claire Kouba</u>	Multi-objective assessment of a stakeholder-defined portfolio of groundwater and stream management actions in an agricultural basin	<u>John Ellis</u> , Jacob Knight, Jeremy White, Michelle Sneed, Jason Ramage, Joseph Hughes The GULF 2023 Model and Ensemble: Land Subsidence Results for the Gulf Coast Aquifer System
11:40	<u>Jonathan Traylor</u> , Steve Regan, Jesse Dickinson	Integration of physical data to select appropriate coupling schemes between land surface and groundwater processes for the multiscale improvement of national scale models	<u>Alexandre Pryet</u> , Marc Saltel, Jean-Pierre Vergnes, Etienne Buscarlet, Olivier Cabaret Definition of Sustainable Yield under Climate Change by Reliability-based Optimization with a Surface-Subsurface Flow Model.
12:00	Lunch – Friend Courtyard		

Tuesday, June 4

13:15	Lunch Keynote – Friend 101 <u>Holly Michael</u> Director, Delaware Environmental Institute, and Professor, Unidel Fraser Russell Career Development Chair for the Environment, University of Delaware Untangling complexity at the land-sea margin			
13:45	Transition			
	Featured Presentations		Featured Presentations in Friend 101	
14:00	<u>Mary Hill</u> Managing Water Supplies from Natural Systems			
14:20	Coffee Break			
15:00	<u>Coastal Aquifers, Sea Water Intrusion and Groundwater Consequences of Sea Level Rise</u> Chaired by: Nick Engdahl and Xingyuan Chen		<u>Contaminant Transport: Model Development and Case Studies; and Occurrence, Transport, and Health Risks of Emerging Contaminants in Groundwater</u> Chaired by: Christopher Green and Matt Tonkin	
15:05	<u>Anner Paldor</u> , Ryan Frederiks, Paige Aldred, Sarah Dente, Rachel Housego, Holly Michael	Storm-surge groundwater salinization along the East and Gulf Coasts depends largely on two parameters, with non-monotonic relationships	<u>Vincent Carsillo IV</u> , Shane McDonald, Jeff Hansen, Jillian Troyer	Using a Groundwater Model to Evaluate the Effectiveness of Residual Chemical Removal and Estimate Exposure Point Concentration
15:20	<u>Angela Montoya</u> , Jorge Restrepo, Martina Rogers, Virginia Walsh	Automated Calibration of a Shallow Coastal Aquifer Density Dependent Transport Model and Preparation for 2070 Sea-Level Rise Model Scenarios, Miami-Dade County, Florida	<u>Miguel E. Valencia</u> , Michael C. Sukop	Simulation of Miami-Dade County Florida Septic Return Flows: from Particle Tracking to Solute Transport of Septic Effluents Based on the Urban Miami-Dade Groundwater Model
15:35	<u>Mark Bakker</u> , Sorab Panday, Ron Falta, Alan Lemon, Christian Langevin, Joseph Hughes, Chris Patterson	Towards a Reduced-Order Formulation for Seawater Intrusion in MODFLOW 6	<u>Cathy Wang</u> , Reed Maxwell	Nitrogen fate during agricultural managed aquifer recharge (Ag-MAR): modeling hydrologic and geochemical processes in a physically and chemically heterogeneous system
15:50	<u>Okke Batelaan</u> , Eddie Banks, Saskia Noorduijn, Vincent Post, Tim Munday, Camilla Sorensen, Kevin Cahill, Phillip Jolly, Joanna Ellis, Adrian Werner	3D variable-density groundwater flow and solute transport modeling with geophysics: Assuring fresh water resources for a tropical island	<u>Simin Akbariyeh</u> , Dave Estrella, Matt Spansky	Navigating Radium Transport: A Groundwater Case Study in Gas Hills, Wyoming
16:05	<u>Emily Wild</u>	Access and Use of Seawater-Intrusion Publications in Theses and Dissertations	<u>Nico Higgs</u> , Steven Mamet, Kevin Stanley, Steven Siciliano	Hardware-enabled AI-software to track, predict, and quantify groundwater risk and liability
16:20	<u>Nicole Blin</u> , Dan Corkran, Alexander Kirshen, Brendan Moran, David Boutt	Unveiling the Future of Coastal Massachusetts: Groundwater and Sea Level Rise Through Non-Structured Grid Modeling	<u>Pietro Mazzon</u> , Luca Alberti	Remediation time frame of a chlorinated ethenes plume using reactive transport modeling and uncertainty analysis
	Featured Presentation		Featured Presentation in Friend 101	
16:40	<u>Erica Siirila-Woodburn</u> Is old groundwater buffering mountain streamflow?			
17:00	Transition			
17:00	POSTER RECEPTION Refreshments and Hors D'oeuvres – Carl A. Fields Center 5:00 – 7:30pm			



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Poster Session

Tuesday, June 4, 5:00 – 7:30 PM

<u>Broad Topics and Groundwater Modeling Posters</u>	
1. <u>Tom Glose</u> , Tylr Naprstek, Mike Plante, Roscoe Sopiwnik, Jon Mohr	Geologic models based on AEM and well log data provide simplified workflow to generate hydraulic conductivity fields for MODFLOW
2. <u>Roselyne Laboso</u> , Skyler Sorsby, William Gottobrio, Cliff Baine	Transitional Modeling from Construction to Closure Phases with Applications to a Waste Facility
3. <u>Metin Ozbek</u> , Nathan Voorhies, Tad Fox	Groundwater Management Through Numerical Optimization Using PBMO
4. <u>Leslie Gains-Germain</u> , Skyler Swanson, Charlie Carpenter, Mickey Rush, Gregg Occhiogrosso, Lauren Foster	ModelWatcher: A data and visualization pipeline for calibration of physical models
5. <u>Andrew Li</u>	From Groundwater Modeling to Groundwater Digital Twinning, Why Bother?
6. <u>Christopher Elofson</u> , Clara Smith-Salgado, Nathan Rossman, Dwight Douglas Haney, Michael P. Johnson	Using MODFLOW to Inform Collector Well Siting for a Multi-State Public Water Supply in the Missouri River Alluvial Aquifer of South Dakota
7. <u>Nathan Rossman</u> , Cynthia Maroney, Marty Stange, Keith Miller	Groundwater Modeling using MODFLOW, MODPATH, and MT3DMS to Improve the Efficiency of Treated Water Reuse at the Hastings Utilities Aquifer Storage and Recovery System
8. <u>Gare Ambrose-Igho</u> , Susan Rybarski	Transboundary Movement of Groundwater Between Niger and Nigeria in the Iullemeden Aquifer System
9. <u>Jamie Kim</u> , Yueling Ma, Reed Maxwell	Using a Regression-Enhanced Random Forest to Improve Groundwater Monitoring and Management
10. <u>Louisa Pawusch</u> , Wolfgang Nowak, Reed Maxwell	Reducing the Spinup Time of Hydrological Simulations by Integrating Machine Learning Techniques
<u>Groundwater and Climate Change; Implications of Human Activities on Water Quantity and Quality; and Modeling Agriculture and Water Resources</u>	
11. <u>Zhilin Guo</u>	Impacts of Long-term Nitrogen Input on Groundwater Quality in the North China Plain
12. <u>Annette Hein</u> , Jessica Rogers, Gilbert Barth	Numerical modeling allows sustainable use of groundwater to meet surface water obligations in dry Pecos River basin, New Mexico
13. <u>Zachary Hanson</u> , Jason Sun	Developing tools that support decision making in an agricultural and industrial productive community: simulation of subsidence within the coastal aquifers of Ventura County, California
14. <u>Jeremy McDowell</u> , Thomas Mack, Florence Cassassuce, Carlos Lim	Simulation of natural infrastructure in dryland streams for recharge augmentation in an arid environment
15. <u>Adwitiya Roy</u>	Groundwater and Climate Change
<u>Large-Scale Groundwater Modeling</u>	
16. Annemarie B�athge, Robert Reinecke, <u>Raoul Collenteur</u>	GROW: A Global Community Dataset for Large-Sample Groundwater Studies
17. <u>Michael Reno</u> , Christian Langevin, Joseph Hughes, Scott Paulinski, Martijn Russcher, Wesley Bonelli	Integrated support for NetCDF in MODFLOW
18. <u>Daniel Corkran</u> , David Boutt, Brendan Moran, Nicole Blin, Alexander Kirshen	Assessing Groundwater Rise in the Northeast US with a State-Wide Numerical Flow Model
19. <u>Sawsan Shatanawi</u> , Sasha McLarty	Quantifying the Contribution of Confined Groundwater Dynamics to the Terrestrial Water Budget in part of High Mountain Asia (HMA)
<u>Modeling Surface-water/Groundwater Interaction</u>	
20. <u>Prince Atiti</u> , Kennedy Doro	Assessing hydraulic connectivity within a multi-layered aquifer system using a MODFLOW based model
<u>Multi-Model Analysis, Parameterization, Sensitivity Analysis, and Uncertainty</u>	
21. <u>German Ibarra</u> , Jose Miguel Espinoza, Tomas Salazar	Uncertainty analysis applied to a hydrogeological model of a large-scale mining tailings storage facility
<u>Simulation Code Verification, Benchmarking, and Intercomparisons</u>	
22. <u>Sebastian Vazquez-Gasty</u> , Sorab Panday, Tirthankar Roy, Martijn Russcher, Alden Provost, Christian Langevin, Joseph Hughes	Exploring variably saturated flow formulations for MODFLOW
<u>Supporting Sustainable Water Management</u>	
23. <u>Stacey Law</u> , Michael LeFrancois	Using Existing Groundwater Flow Models to Make Real-Time Site Water Management Decisions
<u>Using Integrated Modeling to Understand and Manage Water Supply, Water Quality, and Ecology</u>	

24. <u>Max Rudolph</u> , François Miville, Marcus Genzel, Torsten Noffz, Philippe Renard, Thomas Reimann	Combining Stochastic Karst Conduit Network Generation and Pre-Processing to Enable the Scalable Application of the MODFLOW Conduit Flow Process
25. <u>Laura Rodriguez</u> , Peter Knappett, Hongbin Zhan, Rosario Sanchez	The Transboundary Flow Balance Index (TFBI) as a measure of the magnitude of groundwater flow across political boundaries

Wednesday, June 5

Time	Friend 101	COS 104	
8:00	Welcome		
	Featured Presentation	Featured Presentation in Friend 101	
8:05	James Rumbaugh The Model Crashed, Send Help: 35 Years of MODFLOW Technical Support		
8:25	<u>Multi-Model Analysis, Parameterization, Sensitivity Analysis, and Uncertainty I</u> Chaired by: Jeremy White and Lauren Foster	<u>Broad Topics and Groundwater Modeling I</u> Chaired by: James Rumbaugh and Otto Strack	
8:30	<u>Rodolfo Ordoñez</u> , Mauricio Muñoz, Cristian Ortiz, Tomas Opazo Predictive uncertainty quantification using Data Space Inversion: Application and comparisons with the Iterative Ensemble Smoother	<u>Richard Winston</u> History of MODFLOW	
8:45	<u>Kerry Bardot</u> , Itsuo Camargo, Guillaume Pirot, Adam Siade, Jon-Philippe Pigois, Clive Hampton, James McCallum A geological-flow modelling workflow for complex structures including faults using LoopStructural, Flopy and unstructured grids	<u>Chieh-Ying Chen</u> , Eric Morway, Alden Provost, Christian Langevin, Joseph Hughes, Yu-Feng Lin Demonstration of the new MODFLOW 6 heat-transport model in simulations of 1D vertical heat propagation through the unsaturated and saturated zones driven by transient surface temperature and precipitation	
9:00	<u>Ludovic Schorpp</u> , Julien Straubhaar, Philippe Renard EROSim: A novel surface-based approach to represent aquifer heterogeneity in sedimentary formations	<u>Leland Scantlebury</u> , Thomas Harter Enhancing a Groundwater-Surface Water Model with Airborne Electromagnetic Data and Texture2Par	
9:15	<u>Peter Schillig</u> , Ronald Kent, Katie Mclain, Al Laase Applying Iterative Ensemble Smoother Modeling to Evaluate Dewatering Strategies at a Uranium Mill Tailings Disposal Site	<u>Jillian Troyer</u> , Cynthia Maroney, Shane McDonald, Mike Butterfield Cedar Lake Levee Construction Dewatering Evaluation and Contaminant Transport Analysis	
9:30	<u>Jesse He</u> , Jens Schumacher, Nelson Molina-Giraldo, Gordon MacMillan A Multimodel Prediction Workflow to Support Groundwater Management Decisions	<u>Ward Sanford</u> , Wes Zell Simulation of Watershed Travel-Time Distributions under Transient Flow Conditions	
9:45	Coffee Break		
	Featured Presentations	Featured Presentations in Friend 101	
10:05	Xingyuan Chen Beyond the flows: modeling carbon cycling from batch to watershed scales		
10:25	Nick Engdahl Granular and Indeterminate: Maybe quantum-like mathematics really are useful for hydrogeology too		
10:45	<u>Multi-Model Analysis, Parameterization, Sensitivity Analysis, and Uncertainty II</u> Chaired by: Jeremy White and Lauren Foster	<u>Broad Topics and Groundwater Modeling II</u> Chaired by: Christian Langevin and Mary Hill	
10:50	<u>Michael Ou</u> , Chris Muffels, Matt Tonkin, Vivek Bedekar Incorporating Kriging Errors through Sequential Gaussian Simulation for Pilot Point Parameterization	<u>Nina Egli</u> , Ludovic Schorpp, Philippe Renard Simplifying groundwater modeling workflows using the ArchPy approach	
11:05	<u>Max Rudolph</u> , Thomas Wöhling, Thorsten Wagener, Andreas Hartmann Accelerating Statistical Inversion for Groundwater Models: A Multi-Level Approach to GLUE	<u>Gordon MacMillan</u> , Jens Schumacher, Nelson Molina-Giraldo A Novel Analytical Solution for the Design of Nested Well Networks	
11:20	<u>Dave Estrella</u> , Chin Man Mok, Barbara Carrera, Bianca Mintz, Michael Basial Implementing Realizations of Heterogeneous Basalt into a Regional Groundwater Flow Model	<u>Vivek Bedekar</u> , Christopher Neville, Matthew Tonkin, Douglas Bartlett, Paul Plato Quantifying Source Contributions using a Unit-Concentration Method	
11:35	<u>Carlos Andres Rivera Villarreyes</u> On understanding the role of uncertainty behind the 3D geological structural models towards better groundwater modelling predictions	<u>Andrew Leaf</u> Modflow-setup: A Python package for rapid, reproducible, and robust groundwater modeling	
11:50	<u>Lijing Wang</u> The Influence of Floodplain Architecture on Local and Regional Hydrologic Responses to Beaver-Induced Inundation	<u>Shauna Hassan</u> , Blake Lytle-Goldstein, Roy Jensen, Min-Ying Chu Comparison of simulated hydraulic gradients obtained by two-dimensional vertical cross-sectional SEEP2D modeling and three-dimensional MODFLOW modeling for construction dewatering adjacent to the ocean	
12:05	Lunch – Friend Courtyard		

Wednesday, June 5

13:30	Lunch Panel/Discussion: The Future of Groundwater Modeling Education Laura Condon, Associate Professor, Hydrology and Atmospheric Sciences, University of Arizona Ty Ferré, University Distinguished Professor and Interim Associate Head, Hydrology and Atmospheric Sciences, Joint Professor, Environmental Science-Ext., University of Arizona			
14:00	Transition			
	Featured Presentations		Featured Presentations in Friend 101	
14:05	Christian Langevin One Platform, Many Models: MODFLOW 6 as a Modular Hydrologic Simulator			
14:25	Lauren Foster Unraveling Complexity: How Numerical Models and AI Can Work Together to Expand the Frontiers of Hydrologic Research			
14:45	Simulation Code Verification, Benchmarking, and Intercomparisons Chaired by: Sorab Panday and Christian Langevin		Using Integrated Modeling to Understand and Manage Water Supply, Water Quality, and Ecology Chaired by: Steven Berg and Erica Siirila-Woodburn	
14:50	<u>Sebastian Gries</u> , Gösta Hülsmann	ML-Based Linear Solver Control to Improve Performance of Groundwater Simulations	<u>Hiroko Hort</u> , Sorab Panday	Exploring PFAS Retention in the Vadose Zone: Insights from Modeling and Management Strategies
15:05	<u>Martin Vonk</u> , Raoul Collenteur, Frans Schaars, Sorab Panday, Mark Bakker	Benchmarking Pastas time series models using synthetic head series generated with a variably saturated model	<u>Danielle Tijerina-Kreuzer</u> , Yueling Ma, Chen Yang, Laura Condon, Reed Maxwell	Landcover driven groundwater depletion
15:20	<u>Francisco Caicha</u> , Salvador López, Cristian Godoy, Carlos Descourvieres, Ryan Jakubowski	Exploring MODFLOW-USG for the application of variably saturated flow processes at mining sites	<u>Adam Atchley</u> , Chuck Abolt, Rod Linn	Understanding complex wildland fire drivers and effects through physics-based modeling and machine learning enabled data set
15:35	<u>Alden Provost</u> , Kerry Bardot, Christian Langevin, James McCallum	Improving the Accuracy of MODFLOW 6 Flow Simulations by Ensuring Adequate Cell Connectivity and Accounting for Flow Refraction	<u>Lijing Wang</u>	Identifying representative traits in mountainous hillslopes through hydrologic modeling and data integration
15:50	<u>Jacob Bauer</u>	Use of the MODFLOW API for Re-Run and Time-Parallelization of MODFLOW Solutions		
16:05	<u>Michael Ou</u> , Vivek Bedekar, Matt Tonkin, Gilbert Barth	CHUMP: A Configuration-Based Postprocessing Framework for Automated Workflows		
16:25	Transition			
16:30	RAFFLE and Student Awards			
17:00	2023 Birdsall-Dreiss Distinguished Lecturer Kenneth Belitz Research Hydrologist, Water Resources Mission Area, US Geological Survey Applications of Ensemble Tree Machine Learning to Hydrogeology: Not Just a Black Box Friend Center 101, 5:00 – 6:00 PM			