Oral presentations

**Date:** Mon, Dec 10  
**Time:** 8:45 AM - 9:00 AM  
**Location:** Walter E Washington Convention Center  146A  
**Session:** Hydrochronology: Advances in Tracer Methods and Modeling of Residence Times in Hydrology I  
**Title:** H11G-04 – Hydrologic connectivity in snow-dominated basins as a function of climate  
Fang, Zhufeng; Carroll, Rosemary W H; Schumer, Rina; Harman, Ciaran J; Wilusz, Daniel C; Williams, Kenneth Hurst

**Date:** Mon, Dec 10  
**Time:** 9:15 AM - 9:30 AM  
**Location:** Walter E Washington Convention Center  146C  
**Session:** Advances in Understanding Land–Atmosphere Interactions in a Changing Environment I  
**Title:** H11B-06 – Using integrated, continental scale hydrologic simulation to unravel interconnections and feedbacks (Invited)  
Maxwell, Reed M; Condon, Laura E; Smith, Steven G; Forrester, Mary Michael; Tijerina, Danielle; Foster, Lauren; FitzGerald, Katelyn; Collins, Caitlin; Gochis, David J

**Date:** Mon, Dec 10  
**Time:** 3:25 PM - 3:40 PM  
**Location:** Walter E Washington Convention Center  156  
**Session:** Modeling of Reactive Transport Processes Across Scales I  
**Title:** H13E-08 – A Reactive Transport Modeling Approach for Understanding Concentration-Discharge in East River, Colorado  
Xu, Zexuan; Molins, Sergi; Dwivedi, Dipankar; Siirila-Woodburn, Erica R; Carroll, Rosemary W H; Svayatskiy, Daniil; Moulton, John D; Steefel, Carl I

**Date:** Mon, Dec 10  
**Time:** 5:00 PM - 5:15 PM  
**Location:** Walter E Washington Convention Center  146B  
**Session:** Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes Across Scales I  
**Title:** H14D-05 – Biogeochemical Controls on River Water Quality: Quantifying Dynamic Surface-Subsurface Interactions using Reactive Transport Models (Invited)  
Dwivedi, Dipankar; Steefel, Carl I; Arora, Bhavna; Newcomer, Michelle E; Moulton, John D; Dafflon, Baptiste; Faybishenko, Boris; Fox, Patricia M; Nico, Peter S; Spycher, Nicolas; Carroll, Rosemary W H; Williams, Kenneth Hurst

**Date:** Tue, Dec 11  
**Time:** 8:00 AM - 8:15 AM  
**Location:** Walter E Washington Convention Center  146A  
**Session:** Innovations in Subsurface Contaminant Transport and Remediation I  
**Title:** H21D-01 – In Situ Hydroxyapatite Permeable Reactive Barrier Performance at the Old Rifle, CO Uranium Processing Mill Site - A field test has been performed to assess the effectiveness of the Sandia National Laboratories patented <em>in situ</em> hydroxyapatite permeable reactive barrier and source area treatment technology to remediate uranium at the Old Rifle, CO site  
Rigali, Mark; Williams, Kenneth Hurst

**Date:** Tue, Dec 11  
**Time:** 10:20 AM - 10:35 AM  
**Location:** Walter E Washington Convention Center  101  
**Session:** Applications in Snow Hydrology: Linking Seasonal Snow to Natural Processes and Society I  
**Title:** H22B-01 – The Influence of Snow Accumulation on Groundwater Flux to Streams in a Colorado River Headwater Basin  
Carroll, Rosemary W H; Bearup, Lindsay A; Fang, Zhufeng; S2428, Jülich; Schumer, Rina; Deems, Jeffrey S; Brown, Wendy; Gothic, ; Bill, Markus; Dong, Wenning; Williams, Kenneth Hurst

**Date:** Wed, Dec 12  
**Time:** 10:20 AM - 10:35 AM  
**Location:** Walter E Washington Convention Center  149AB  
**Session:** Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons I  
**Title:** B32A-01 – Multi-scale Investigations of the Impact of (Early) Snowmelt on Water and Nitrogen Cycles at the mountainous East River Watershed, CO (Invited)  
Hubbard, Susan S.; Arora, Bhavna; Brodie, Eoin; Dafflon, Baptiste; Sorensen, Patrick; Steltzer, Heidi; Wilmer, Chelsea; Wu, Yuxin
Date: Wed, Dec 12 Time: 10:35 AM - 10:50 AM | Location: Walter E Washington Convention Center 149AB
Session: Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons I
Title: B32A-02 – Uncovering the metabolic processes driving microbial activity beneath the snowpack and mechanisms of microbial biomass turnover and nitrogen release following snowmelt  
Brodie, Eoin; Beller, Harry R; Bouskill, Nicholas; Chakraborty, Romy; Hao, Zhao; Hoyt, David W; Karaoz, Ulas; Tfailly, Malak; Wu, Yuxin; Sorensen, Patrick

Date: Wed, Dec 12 Time: 10:50 AM - 11:05 AM | Location: Walter E Washington Convention Center 149AB
Session: Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons I
Title: B32A-03 – Plant trait, vegetation, ecosystem, and landscape responses to earlier snowmelt and foresummer drought: long-term monitoring and experiments reveal the drivers of carbon exchange in a Colorado watershed  
Enquist, Brian Joseph; Henderson, Amanda; Sloat, Lindsey; Patterson, Lorah Beth; Lamanna, Christine; Wilmer, Chelsea; Duran, Sandra Milena; Wainwright, Haruko Murakami; Brodie, Eoin; Steltzer, Heidi; Williams, Kenneth Hurst; Hubbard, Susan

Date: Wed, Dec 12 Time: 1:40 PM - 1:55 PM | Location: Walter E Washington Convention Center 146B
Session: Groundwater–Surface Water Interactions: Identifying and Integrating Physical, Biological, and Chemical Patterns and Processes Across Systems and Scales III
Title: H33F-01 – Linking Snowmelt and Nitrogen Cycling to Vegetation Community Dynamics along a Hillslope Transect (Invited)  
Arora, Bhavana; Brodie, Eoin; Mekonnen, Zelalem Amdie; Tokunaga, Tetsu K; Wan, Jiamin; Steltzer, Heidi; Wu, Yuxin; Steefel, Carl I

Date: Thu, Dec 13 Time: 10:50 AM - 11:05 AM | Location: Walter E Washington Convention Center 101
Session: Diagnostics, Sensitivity, and Uncertainty Analysis of Earth and Environmental Models II
Title: H42B-03 – Sensitivity and Model Reduction of Simulated Snow Processes: Contrasting Observational and Parameter Uncertainty to Improve Prediction  
Ryken, Anna; Bearup, Lindsay A; Jefferson, Jennifer; Maxwell, Reed M; Williams, Kenneth Hurst

Date: Thu, Dec 13 Time: 2:40 PM - 2:46 PM | Location: Walter E Washington Convention Center 209A-C
Session: Data and Information Services for Interdisciplinary Research and Applications in Earth Science I
Title: IN43A-11 – A brokering approach to integrate diverse environmental datasets for online visualization, modeling and analysis  
Varadharajan, Charuleka; Hendrix, Val; Agarwal, Deb

Date: Thu, Dec 13 Time: 3:10 PM - 3:25 PM | Location: Marriott Marquis Marquis 12-13
Session: Near-Surface Geophysics in the Critical Zone I
Title: NS43A-07 – Quantifying the role of bedrock in the functioning of a mountainous watershed through integration of geophysical and other data sets  
Uhlemann, Sebastian; Dafflon, Baptiste; Minsley, Burke J; Ulrich, Craig; Peterson, John E; Wainwright, Haruko Murakami; Hubbard, Susan

Date: Fri, Dec 14 Time: 5:45 PM - 6:00 PM | Location: Walter E Washington Convention Center 154AB
Session: Computational Methods and Tools for Model–Data Integration I
Title: H54A-08 – Using Sensitivity Analysis as a Tool to Determine the Need for Regeneration of Hydrological and Biogeochemical Predictions  
Arora, Bhavana; Faybishenko, Boris; Agarwal, Deb

Poster presentations

Date: Mon, Dec 10 Time: 8:00 AM - 12:20 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Modeling the Critical Zone: Integrating Processes and Data Across Disciplines and Scales I Posters
Title: EP11C-2077 – Understanding Contrasting Concentration-discharge (CQ) Behaviors in a Seasonally Snow-covered Watershed  
Zhi, Wei; Li, Li; Kaye, Jason P; Management, ; Dong, Wenming; Brown, Wendy; Gothic, ; Steefel, Carl I; Williams, Kenneth Hurst
Date: Mon, Dec 10  Time: 8:00 AM - 12:20 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Coupled Groundwater–Surface Water Processes in Continental-Scale Models Posters
Faybishenko, Boris; Tokunaga, Tetsu K; Dwivedi, Dipankar; Christensen, John Neil; Dafflon, Baptiste; Tran, Anh Phuong; Wan, Jiamin; Dong, Wenming; Hobson, Chad; Arora, Bhavna; Steefel, Carl I; Carroll, Rosemary W H; Wainwright, Haruko Murakami; Versteeg,

Date: Mon, Dec 10  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Advancing Catchment Science: Process Understanding and Societal Benefits from Long-Term Observation and Experimentation III Posters
Title: H13J-1870 – The East River, Colorado Community Watershed: Hydrobiogeochemical Studies Spanning Scales and Disciplines
Williams, Kenneth Hurst; Brown, Wendy; Carroll, Rosemary W H; Chadwick, K. Dana; Dafflon, Baptiste; Deems, Jeffrey S; Dong, Wenming; Falco, Nicola; Hubbard, Susan; Li, Li; Minsley, Burke J; Newcomer, Michelle E; Rowland, Joel C; Steltzer, Heidi; Sutfin, N

Date: Tue, Dec 11  Time: 8:00 AM - 12:20 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes Across Scales II Posters
Title: H21K-1808 – A New Vibrational Analysis with Near-Infrared Spectroscopy using Supervised Machine Learning
Polussa, Alexander; Hao, Zhao; Chadwick, K. Dana; Wu, Xiaoqin; Chakraborty, Romy; Brodie, Eoin

Date: Tue, Dec 11  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes Across Scales II Posters
Title: H21K-1796 – Data Driven Identification of Environmental Hot Moments through Regimes Shift
Chen, Jiancong; Dafflon, Baptiste; Arora, Bhavna; Newcomer, Michelle E; Hubbard, Susan S; Rubin, Yoram

Date: Tue, Dec 11  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Groundwater–Surface Water Interactions: Identifying and Integrating Physical, Biological, and Chemical Patterns and Processes Across Systems and Scales V Posters
Title: H23K-2081 – Heterogeneity in River-Groundwater Mixing, Microbiology, and Geochemistry in an Alpine Riverbed during Baseflow
Nelson, Amelia; Wilkins, Michael J; Saup, Casey Morrisroe; Bryant, Savannah R; Harris, Kira; Williams, Kenneth Hurst; Sawyer, Audrey H

Date: Tue, Dec 11  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Groundwater–Surface Water Interactions: Identifying and Integrating Physical, Biological, and Chemical Patterns and Processes Across Systems and Scales V Posters
Title: H23K-2101 – Modeling Seasonal Surface Water-Groundwater Mixing Controls on Organic Carbon Processing in Hyporheic Zones
Bryant, Savannah R; Wilkins, Michael J; Briggs, Martin A; Saup, Casey Morrisroe; Nelson, Amelia; Gabor, Rachel S; Williams, Kenneth Hurst; Sawyer, Audrey H

Date: Tue, Dec 11  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Coupled Dynamics of Physical, Biological, Geomorphic, Hydrologic, and Chemical Processes in the Hyporheic Zone over a Range of Spatial and Temporal Scales II Posters
Title: H23H-1979 – Transient Anoxic Micro-zone Development in an Alpine Stream
Ghosh, Ruby N; Ball, Terry; Bright, Bruce; Freeman, Michael J; Matusz, Mathew E; Nehil-Puleo, Kieran; Shooltz, Dean D; Newcomer, Michelle E; Dwivedi, Dipankar; Williams, Kenneth Hurst
Date: Tue, Dec 11  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)

Session: Groundwater–Surface Water Interactions: Identifying and Integrating Physical, Biological, and Chemical Patterns and Processes Across Systems and Scales V Posters
Title: H23K-2074 – Differential C-Q Analysis: Including the Impact of Lateral Storage and Hydrologic Transients on Solute Concentration within a Mountainous Headwater Catchment
Burrus, Madison; Arora, Bhavna; Newcomer, Michelle E; Steefel, Carl I

Date: Wed, Dec 12  Time: 8:00 AM - 12:20 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)

Session: Runoff Generation Processes: Integrating Observations and Processes over Variable Scales II Posters
Title: H31L-2103 – Constraining the Depth and Temporal Distribution of Subsurface Flow and Transport Along a Hillslope Transect
Tokunaga, Tetsu K; Wan, Jiamin; Brown, Wendy; Kim, Yongman; Williams, Kenneth Hurst; Dong, Wenming; Bill, Markus; Conrad, Mark E; Christensen, John; Tran, Anh Phuong; Xu, Zexuan; Faybischenko, Boris; Arora, Bhavna; Lavy, Adi; Romero, Sergio Carrero; Gilber

Date: Wed, Dec 12  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)

Session: Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons II Posters
Title: B33M-2856 – Early Snowmelt Timing Controls the Magnitude of Soil Nutrient Flux and Microbial Community Turnover During the Winter-Spring Transition
Sorensen, Patrick; Beller, Harry R; Bill, Markus; Bouskill, Nicholas; Brodie, Eoin; Conrad, Mark E; Karaoz, Ulas; Polusza, Alexander; Steltzer, Heidi; Wang, Shi; Williams, Kenneth Hurst; Wilmer, Chelsea; Wu, Yuxin

Date: Wed, Dec 12  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)

Title: H51T-1583 – Impacts of heterogeneity on water and energy fluxes at high resolutions using a fully-integrated hydrologic model
Trutner, Sarah; Maxwell, Reed M; Maher, Katharine

Date: Fri, Dec 14  Time: 8:00 AM - 12:20 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)

Session: Computational Methods and Tools for Model–Data Integration Posters
Title: H51O-1512 – Watershed Functioning Zonation: Advanced Watershed Characterization across Scales
Wainwright, Haruko M; Falco, Nicola; Dafflon, Baptiste; Ulrich, Craig; Uhlmann, Sebastian; Arora, Bhavna; Siirila-Woodburn, Erica R; Minsley, Burke J; Carroll, Rosemary W H; Williams, Kenneth Hurst; Hubbard, Susan

Date: Fri, Dec 14  Time: 1:40 PM - 6:00 PM | Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Session: Sensor Networks in Hydrology II Posters
Title: H53P-1805 – A Dissolved Oxygen and Temperature Monitoring System for Remote, Autonomous, In-situ Studies of River and Subsurface Environments Over Multiple Seasons.  
Shooltz, Dean; Ghosh, Ruby N; Freeman, Michael J; Williams, Kenneth Hurst
Date: Fri, Dec 14  Time: 1:40 PM - 6:00 PM  |  Location: Walter E Washington Convention Center Hall A-C (Poster Hall)

Session: Understanding the Biogeochemistry of Nitrogen Inputs and Outputs from Molecular to Global Scales II Posters
Title: B53K-2207 – Spatial and temporal dynamics of nitrogen in a mountainous watershed  
Bouskill, Nicholas; Maavara, Taylor; Bill, Markus; Brodie, Eoin; Conrad, Mark E; Sorensen, Patrick; Steefel, Carl I; Tokunaga, Tetsu K; Wan, Jiamin; Williams, Kenneth Hurst

Sessions Convened

Date: Mon, Dec 10  Time: 8:00 AM - 12:20 PM  |  Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Convened Session: EP11C – Modeling the Critical Zone: Integrating Processes and Data Across Disciplines and Scales I Posters  
Li, Li; Arora, Bhavna; Vereecken, Harry

Date: Mon, Dec 10  Time: 4:00 PM - 6:00 PM  |  Location: Walter E Washington Convention Center 146B
Convened Session: H14D – Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes Across Scales I  
Arora, Bhavna; Wainwright, Haruko M

Date: Mon, Dec 10  Time: 4:00 PM - 6:00 PM  |  Location: Walter E Washington Convention Center 147A
Convened Session: EP14A – Modeling the Critical Zone: Integrating Processes and Data Across Disciplines and Scales II  
Li, Li; Arora, Bhavna; Vereecken, Harry

Date: Tue, Dec 11  Time: 8:00 AM - 12:20 PM  |  Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Convened Session: H21K – Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes Across Scales II Posters  
Arora, Bhavna; Wainwright, Haruko M

Date: Tue, Dec 11  Time: 1:40 PM - 6:00 PM  |  Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Kurz, Marie J; Gomez-Velez, Jesus D; Wondzell, Steven M; Herzog, Skuyler; Dwivedi, Dipankar

Date: Wed, Dec 12  Time: 10:20 AM - 12:20 PM  |  Location: Walter E Washington Convention Center 149AB
Convened Session: B32A – Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons I  
Contosta, Alexandra; Nelson, Sarah J.; Rezanezhad, Fereidoun; Sorensen, Patrick; Space,

Date: Wed, Dec 12  Time: 1:40 PM - 3:40 PM  |  Location: Walter E Washington Convention Center 146B
Convened Session: H33F – Groundwater–Surface Water Interactions: Identifying and Integrating Physical, Biological, and Chemical Patterns and Processes Across Systems and Scales III  
Kurz, Marie J; Gomez-Velez, Jesus D; Wondzell, Steven M; Herzog, Skuyler; Dwivedi, Dipankar

Date: Wed, Dec 12  Time: 1:40 PM - 6:00 PM  |  Location: Walter E Washington Convention Center Hall A-C (Poster Hall)
Convened Session: B33M – Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons II Posters  
Contosta, Alexandra; Nelson, Sarah J.; Rezanezhad, Fereidoun; Sorensen, Patrick; Space,
H11G-04: Hydrologic connectivity in snow-dominated basins as a function of climate
Monday, December 10, 2018
8:45 AM - 9:00 AM, Walter E Washington Convention Center 146A

Zhufeng Fang(1), Rosemary W H Carroll(1), Rina Schumer(2), Ciaran J Harman(3), Daniel C Wilusz(3) and Kenneth Hurst Williams(4)

(1) Desert Research Institute Reno, Reno, NV, United States, (2) Desert Research Institute, Reno, NV, United States, (3) Johns Hopkins University, Environmental Health and Engineering, Baltimore, MD, United States, (4) Colorado School of Mines, Golden, CO, United States

Presenter: Zhufeng Fang

Abstract: Snowmelt is the principal control on the timing and magnitude of water flow through alpine watersheds. The effect of precipitation type and quantity on storage and hydrologic connectivity in mountainous systems is explored by combining observed d18O in rain, snowmelt and streamflow with numerical model and inverse techniques applied to time-variable transient travel time distributions (TTD) using StorAge Selection functions (SAS). Hydrologic simulations for a Colorado River headwater basin (85 km2) span years 2006 to 2017 to test a diverse set of snow accumulation scenarios. Results indicate more young water is released from storage during wet years than during dry years. Wet years also increase hydrologic connectivity to simultaneously flush older water from the basin. During years with reduced snowpack, flow paths are inactivated and snowmelt remains in the subsurface to become older water that is potentially reactivated in subsequent wet years. Incremental warming in hydrologic model simulations was used to evaluate TTD sensitivity to changing precipitation from snow to rain. Years with basin average effective precipitation above 3.25 mm d-1 are resilient to temperature increases up to 10°C with respect to annual water partitioning and streamflow TTD. In contrast, years with less precipitation are sensitive to increased temperatures with water-limited conditions exacerbated through marked increases in the fraction of inflow lost to evapotranspiration. The consequence is to further decrease hydrologic connectivity in the basin and to propagate this effect longer into the future. Subsequently, the lag-response of droughts in snow-dominated basins is expected to extend under warming.
H11B-06: Using integrated, continental scale hydrologic simulation to unravel interconnections and feedbacks (Invited)
Monday, December 10, 2018
9:15 AM - 9:30 AM, Walter E Washington Convention Center 146C

Reed M Maxwell(1), Laura E Condon(2), Steven G Smith(3), Mary Michael Forrester(4), Danielle Tijerina(4,5), Lauren Foster(4), Katelyn FitzGerald(6), Caitlin Collins(7) and David J Gochis(6)


Presenter: Reed Maxwell

Abstract: Understanding the movement of water in the earth system is important for sustaining ecosystems, municipal, agricultural and industrial consumption. Continental scale simulations water flow through rivers, streams and groundwater are powerful tools that can provide this insights into complex systems. A growing number of approaches to hydrologic simulation provide both challenges and opportunities to understand which processes dominantly link seemingly disparate components of the hydrologic cycle such as groundwater and the lower atmosphere. Here we explore these connections using a suite of model configurations operated within a larger software framework. Specifically, we present a model coupling framework built upon the integrated hydrology model ParFlow and WRF-Hydro. Differences in simulated physical connections with model configuration highlight the sensitivity of modeled interactions to model parameterizations. This is further demonstrated with a series of water and land cover perturbations which investigate modeled response to water stress across spatial scales physical settings. Shifts in insight with resolution and scale, moving from highly instrumented headwaters catchments out to the continent are shown demonstrating the need for scale dependent approaches.
PA11A-11: Linking Scientific Research with Stakeholder Participation for Improved Water Supply Forecasting in the Upper Gunnison River, Colorado
Monday, December 10, 2018
9:49 AM - 10:00 AM, Marriott Marquis  Marquis 3-4

Rosemary W H Carroll, Desert Research Institute, Division of Hydrologic Sciences, Reno, NV, United States, Frank Kugel, Upper Gunnison River Water Conservancy District, Gunnison, CO, United States, Jeffrey S Deems, University of Colorado, Boulder, CO, United States, David Gochis, National Center for Atmospheric Research, Boulder, CO, United States, Logan Karsten, National Center for Atmospheric Research, Boulder, United States, Joe Busto, Colorado Water Conservation Board, Denver, CO, United States, Reed M Maxwell, Colorado School of Mines, Geology & Geological Engineering, Hydrologic Science & Engineering, Golden, CO, United States and Kenneth Hurst Williams, Lawrence Berkeley National Laboratory, Berkeley, CA, United States

Presenter: Rosemary Carroll

Abstract: The Colorado River is a major water source and economic engine for seven western U.S. states. The majority of its water originates in snow-dominated headwaters of Colorado, Utah and Wyoming. These headwater basins are considered especially vulnerable to climate change. The Upper Gunnison River (UG) is a significant tributary of the Colorado River and is an important component of the Colorado River Storage Project. Climate induced non-stationarity in system behavior is pushing current water supply forecast models toward greater uncertainty. This compounds the difficulties in managing the river system for diverse water uses, planning for anticipated mid-century supply gaps as well as meeting downstream legal compact obligations. The Lawrence Berkeley National Laboratory Science Focus Area (SFA) and its collaborating institutions are conducting research in the UG with a focus on how climate induced changes in hydrology and vegetation affect non-linear export of water and solutes. Research relies on stakeholder participation for feedback and support on environmental monitoring, as well as a direct link to management planning decisions being conducted as part of the Colorado Water Plan. We highlight ongoing research done in conjunction with the Colorado Water Conservation Board and the Upper Gunnison River Water Conservancy District for improved observations of snow accumulation and melt across spatial and temporal scales. These observations then inform integrated hydrologic models for better constraint on water and energy budget partitioning and improved water supply forecasting. Specifically, we will present ESP forecasts for 2017 (wet) and 2018 (dry) water years as an assessment of experimental National Water Model performance with, and without, NASA’s Airborne Snow Observatory as input. The iterative approach between research planning and stakeholder priorities allows scientific outcomes to benefit the largest possible group and inform policy for improved water and environmental management of these critical headwater systems.
H13E-08: A Reactive Transport Modeling Approach for Understanding Concentration-Discharge in East River, Colorado
Monday, December 10, 2018
3:25 PM - 3:40 PM, Walter E Washington Convention Center 156

Zexuan Xu(1), Sergi Molins(2), Dipankar Dwivedi(1), Erica R Siirila-Woodburn(3), Rosemary W H Carroll(4), Daniil Svyatskiy(5), John D Moulton(5) and Carl I Steefel(1)

(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)Lawrence Berkeley National Lab, Berkeley, CA, United States, (3)Organization Not Listed, Washington, DC, United States, (4)Desert Research Institute Reno, Reno, NV, United States, (5)Los Alamos National Laboratory, Los Alamos, NM, United States

Presenter: Zexuan Xu

Abstract: Concentration-discharge (C-Q) relationships have been used in previous studies to understand the geochemical processes controlled by hydrolog. Field observational data indicate that some aquatic geochemical components, such as sulfate and calcium, exhibit distinct characteristics under snowmelt and baseflow conditions. Subsurface geologic structure and mineral composition may have a strong influence on C-Q relationships and geochemical responses with different water infiltration and groundwater level scenarios. This study seeks to test this conceptual model in a quantitative manner with an integrated-hydrology reactive transport model (RTM). For this purpose, a high-resolution (50-meter) RTM is developed and applied using the Advanced Terrestrial Simulator (ATS) coupled with PFLOTRAN via the Alquimia interface. The RTM quantitatively simulates the integrated hydrology, solute transport and chemical reactive processes with the interaction between surface and subsurface Copper Creek, one of the largest catchments in the watershed of East River, Colorado. The simulations are performed on NERSC supercomputers owing to the large computational requirements of the model. Two key minerals and geochemical processes, including calcium dissolution and pyrite oxidation, are examined with river discharge under the scenarios of precipitation, snowmelt and groundwater level fluctuations. This study aims to understand the interactions of hydrology and major subsurface geochemistry processes, provide insights to the variability of water quality in a watershed scale under a changing climate environment.
H14D-05: Biogeochemical Controls on River Water Quality: Quantifying Dynamic Surface-Subsurface Interactions using Reactive Transport Models (Invited)

Monday, December 10, 2018
5:00 PM - 5:15 PM, Walter E Washington Convention Center 146B

Dipankar Dwivedi(1), Carl I Steefel(1), Bhavna Arora(2), Michelle E Newcomer(3), John D Moulton(4), Baptiste Dafflon(1), Boris Faybishenko(1), Patricia M Fox(2), Peter S Nico(5), Nicolas Spycher(2), Rosemary W H Carroll(6) and Kenneth Hurst Williams(7)


Presenter: Dipankar Dwivedi

Abstract: Biogeochemical transformations at the groundwater-surface water interface play an indispensable role in the export of carbon, nitrogen, nutrients, and metals to the river system, thereby influencing river water quality. The specific objectives of this study were to (1) examine how transient hydrogeological conditions control redox zonation, (2) how hydrological flow paths, microbial activity, and sediment compositions influence biogeochemical processes within the groundwater-surface water interface, and (3) quantify subsurface geochemical export to the river system. To identify hydrological and biogeochemical drivers affecting biogeochemical transformation at the groundwater-surface water interface and subsurface export, we developed a biotic-abiotic reaction network and incorporated it into the reactive transport simulator PFLOTRAN. We performed reactive flow and transport simulations to describe the hyporheic exchange of carbon, nitrogen, and iron fluxes at two distinct hydrologic settings: (a) the Rifle floodplain, characterized by relatively flat topography, and (b) the lower East River site, characterized by rolling-to-mountainous topography and multiple meanders. Simulation results showed that flow dynamics and mineralogical composition of sediments significantly control the export of carbon, nitrogen, and iron to the river system. In particular, in the riparian corridor of the Rifle floodplain, short duration flow reversal and the presence of naturally reduced zones are critical factors affecting the formation of chemical zonation. In the intrameander region of the lower East River, with low-water conditions promoting reducing conditions, groundwater velocity resulting from river-stage fluctuations, control the reductive potential of the lateral redox zonation.
H21D-01: In Situ Hydroxyapatite Permeable Reactive Barrier Performance at the Old Rifle, CO Uranium Processing Mill Site - A field test has been performed to assess the effectiveness of the Sandia National Laboratories patented *in situ* hydroxyapatite permeable reactive barrier and source area treatment technology to remediate uranium at the Old Rifle, CO site

Tuesday, December 11, 2018
8:00 AM - 8:15 AM, Walter E Washington Convention Center 146A

*Mark Rigali*, Sandia National Laboratory, Albuquerque, NM, United States and *Kenneth Hurst Williams*, Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States

**Presenter**: Kenneth Williams

**Abstract**: In Situ Hydroxyapatite Permeable Reactive Barrier Performance at the Old Rifle, CO Uranium Processing Mill Site

*Mark J. Rigali*, **Kenneth H. Williams**, **Robert C. Moore**, **James E. Szecsody**, **Jon R. Luellen** Sandia National Laboratories, Albuquerque, NM**Lawrence Berkley National Laboratories, Berkley CA** Pacific Northwest National Laboratories, Richland, WA** AECOM, Denver, COA field test has been performed to assess the effectiveness of the Sandia National Laboratories patented in situ hydroxyapatite (Ca10(PO4)6(OH)2) permeable reactive barrier (PRB) and source area treatment (SAT) technology to remediate uranium at the former Old Rifle uranium mill processing site near Rifle, Colorado (USA). Uranium ore was processed at the site from the 1940s through the late 1950s. Mill facilities and associated uranium mill tailings previously stored there have all been removed. However, groundwater in the alluvial aquifer beneath the site still contains slightly elevated concentrations of uranium (150 ppb) and the site is currently used for field tests to study uranium behavior in groundwater and to investigate potential uranium remediation technologies. The technology being investigated in the current work is relies on the in situ formation of hydroxyapatite in subsurface sediments. The process involves co-injecting two solutions into the subsurface: the first is a mixture of calcium complexed by citrate and the second is a sodium phosphate solution. After the solutions are co-injected, indigenous sediment microorganisms biodegrade the citrate and release the calcium, which is then able to react with sodium phosphate to form a poorly crystalline hydroxyapatite precipitate. Subsequently, this precipitate serves two roles: it serves as a SAT by preventing uranium leaching from uraniferous minerals in the sediment and acts as a PRB by sorbing and removing uranium from solution. Here we report on the performance of this technology at the Old Rifle site more than one year after its deployment.

*Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-NA0003525.*
H22B-01: The Influence of Snow Accumulation on Groundwater Flux to Streams in a Colorado River Headwater Basin

Tuesday, December 11, 2018
10:20 AM - 10:35 AM, Walter E Washington Convention Center 101

Rosemary W H Carroll, Desert Research Institute, Division of Hydrologic Sciences, Reno, NV, United States, Lindsay A Bearup, Colorado School of Mines, Golden, CO, United States, Zhufeng Fang, Forschungszentrum Jülich GmbH, Jülich 52428, Germany, Rina Schumer, Desert Research Institute, Reno, NV, United States, Jeffrey S Deems, University of Colorado, Boulder, CO, United States, Wendy Brown, Rocky Mountain Biological Laboratory, Gothic, United States, Markus Bill, Lawrence Berkeley National Lab, Berieley, CA, United States, Wenming Dong, Lawrence Berkeley National Laboratory, Earth Science Division, Berkeley, CA, United States and Kenneth Hurst Williams, Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States

Presenter: Rosemary Carroll

Abstract: Climate induced modifications to snow accumulation, melt and subsequent water budget partitioning is expected to decrease stream flow from snow-dominated watersheds. Watersheds more dependent on groundwater could be buffered against climate extremes to enhance resilience for downstream water and environmental management. However, uncertainty exists regarding the role of groundwater contributions in these topographically complex systems. Our conceptual understanding of hydrologic partitioning to either runoff or recharge is complicated by the difficulty of quantifying snow distribution and melt at the watershed scale along with the tight coupling of vegetation structure to climate and topography. We combine snow observations across spatial and temporal scales with chemical and isotopic observations, groundwater gas tracers, and integrated hydrologic models of the East River, CO to explore first-order controls on groundwater flux to streams, age of hydrologically active groundwater, and hydrologic sensitivity of mountain systems to warming across a gradient of precipitation inputs. Results indicate groundwater flux is an important source of headwater streamflows with a direct, and scale-dependent, relationship to snow water equivalent. We find groundwater recharge increases in basins of high relief and within the upper sub-alpine where maximum snow accumulation is coincident with reduced conifer cover and lower canopy densities. Ages derived from gas tracers (SF6, CFCs) collected in shallow groundwater align with a baseflow-age experiment to suggest groundwater in streams is
B32A-01: Multi-scale Investigations of the Impact of (Early) Snowmelt on Water and Nitrogen Cycles at the mountainous East River Watershed, CO (Invited)

Wednesday, December 12, 2018
10:20 AM - 10:35 AM, Walter E Washington Convention Center 149AB

Susan S. Hubbard(1), Bhavna Arora(1), Eoin Brodie(1), Baptiste Dafflon(1), Patrick Sørensen(1), Heidi Steltzer(2), Chelsea Wilmer(2), Yuxin Wu(1)

and the Watershed Function SFA Team, (1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)Fort Lewis College, Durango, CO, United States

Presenter: Susan Hubbard

Abstract: While watersheds are recognized as the Earth’s key functional unit for assessing and managing water availability and quality, developing a predictive understanding of how watersheds respond to perturbations is challenging due to the complex nature of watersheds. This is particularly true in mountainous watersheds, where extreme lateral gradients in hydrogeology, biogeochemistry and vegetation (HBCV) often exist, and where earlier snowmelt can potentially lead to changes in HBCV interactions that affect water, nutrient and carbon cycles. The Watershed Function Project, which is being carried out in the snow-dominated East River, CO headwaters mountainous catchment of the Upper Colorado River Basin, aims to develop a predictive understanding of watershed response to perturbations such as early snowmelt. We are using multi-scale observations and models to explore watershed response to snowmelt timing in the Winter/Spring shoulder season. In recent years, the East River has experienced very different snowfall and snowmelt timing, and an experiment was performed that advanced snowmelt by 10+ days. At the smallest scale, below-snow measurements acquired during winter and through snowmelt are revealing a significant correspondence among snowmelt infiltration, microbial biomass dynamics and N release. Measurements from a suite of above-and-below ground point sensors indicate the critical control of soil thermohydrology on microbial respiration during the shoulder season. Monitoring of plant leaf emergence timing indicates that earlier snowmelt leads to greater synchrony in greening within and across elevations and can decouple HBCV interactions. Coincident daily autonomous electrical resistance tomography and land surface imaging datasets are providing an unprecedented ‘window’ to view above and below ground interactions. Finally, models are being used to integrate information about coupled HBCV processes as a function of position in the landscape. Early results indicate the influence of snow distribution and snowmelt timing on growing season evapotranspiration and vegetation nitrogen demand, and also indicate hotspots and hot moments of N dynamics. More information about the Watershed Function project is provided at watershed.lbl.gov
B32A-02: Uncovering the metabolic processes driving microbial activity beneath the snowpack and mechanisms of microbial biomass turnover and nitrogen release following snowmelt

Wednesday, December 12, 2018
10:35 AM - 10:50 AM, Walter E Washington Convention Center 149AB

Eoin Brodie(1), Harry R Beller(1), Nicholas Bouskill(2), Romy Chakraborty(3), Zhao Hao(1), David W Hoyt(4), Ulas Karaoz(2), Malak Tfailly(5), Yuxin Wu(2) and Patrick Sorensen(1)

(1) Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2) Lawrence Berkeley National Lab, Berkeley, CA, United States, (3) Lawrence Berkeley Nat’l Lab, Berkeley, CA, United States, (4) Pacific Northwest National Laboratory, Richland, WA, United States, (5) Pacific Northwest National Laboratory, Environmental Molecular Sciences Laboratory and Biological Sciences Division, Richland, WA, United States

Presenter: Eoin Brodie

Abstract: In mountainous systems with seasonal snow-cover, snowmelt coincides with a large pulse of nutrients originating from microbial mineralization of organic matter beneath the snowpack, and from turnover of microbial biomass during snowmelt. Vegetation phenology in these systems is regulated by environmental cues such as photoperiod, soil and air temperature, such that plant nutrient uptake and biomass production are highest, and typically in sync with microbial biomass turnover and nutrient release. The metabolic processes regulating organic matter mineralization and assimilation under-snow by soil bacteria and fungi, as well as the mechanisms of microbial biomass turnover during snowmelt, have not been characterized previously. As part of the Watershed Function Scientific Focus Area (SFA) at the Lawrence Berkeley National Laboratory (LBNL), one goal is to determine the metabolic processes fueling microbial activity beneath the snowpack and the factors contributing to microbial biomass turnover and N release following snowmelt. Using a range of approaches including metagenomics, metatranscriptomics, and spectrometric methods such as FT-ICR MS and NMR, we are building a conceptual model of microbial metabolism and turnover in these systems. Initial results suggest that fermentation is an important process under snow and immediately following snowmelt with volatile fatty acids (acetate, formate) and other volatile organic compounds (VOCs), with ethanol, acetone, methanol and isopropanol also prominent. Colorimetric assays indicated an increase in primary amine concentrations following snowmelt and corresponded with FT-ICR MS detection of polypeptides and amino sugars. NMR detection of mono-, di-, and tri-methylamine also indicated these as potentially important organic N species. Other compounds known to function as cryoprotectants (e.g., sarcosine) were also detected. Analysis of recovered microbial genomes and their transcriptomes are ongoing and are being used to identify the microorganisms and pathways involved in organic matter transformation under snow and the mechanisms of microbial biomass turnover that likely fuels early season plant productivity.
B32A-03: Plant trait, vegetation, ecosystem, and landscape responses to earlier snowmelt and fosummer drought: long-term monitoring and experiments reveal the drivers of carbon exchange in a Colorado watershed

Wednesday, December 12, 2018
10:50 AM - 11:05 AM, Walter E Washington Convention Center 149AB

Brian Joseph Enquist(1), Amanda Henderson(1), Lindsey Sloat(2), Lorah Beth Patterson(3), Christine Lamanna(4), Chelsea Wilmer(5), Sandra Milena Duran(6), Haruko Murakami Wainwright(7), Eoin Brodie(8), Heidi Steltzer(5), Kenneth Hurst Williams(9) and Susan Hubbard(8)

(1)University of Arizona, Tucson, AZ, United States, (2)University of Minnesota, Wahroonga, Australia, (3)University of Arizona, Tucson, United States, (4)World Agroforestry Centre (ICRAF), Nairobi, Kenya, (5)Fort Lewis College, Durango, CO, United States, (6)University of Arizona, Ecology and Evolutionary Biology, Tucson, AZ, United States, (7)Lawrence Berkeley National Lab, Berkeley, CA, United States, (8)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (9)Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States

Presenter: Brian Enquist

Abstract: Both hydroclimate and plant traits are hypothesized to play an important role in terrestrial ecosystem carbon exchange. Climate in the Rocky Mountains can be characterized by an early (fosummer) drought that occurs after snowmelt and lasts until the start of the summer monsoon season during the mid-summer. Climate change is predicted to hasten snow melt dates and heat up summer months but also shift functional composition of vegetation. For the southwest United States the result is a longer time between snowmelt and when the summer rains start up. Here we assess ‘how does the length and severity of the fore-summer drought affect carbon fluxes in the montane and subalpine zones that differ in their trait composition?’ Climate change models predict an increase in the length and severity of this dry period due to earlier snowmelt dates, rising air temperatures, and shifts in the start and/or intensity of the North American monsoon. However, it is unknown how changes in the severity of this early season dry period will affect ecosystem carbon exchange. To assess the importance of early season drought, we combined data from watering, temperature, and snowmelt manipulations with 15 years of ecosystem carbon exchange data across an elevational gradient at the Rocky Mountain Biological Laboratory in Gothic, Colorado. Long-term trends reveal that earlier snowmelt dates lead to a decrease in net ecosystem productivity, in part because of the positive effect on early growing season drought conditions. Manipulating the strength of the fore-summer drought by watering, warming, and snowmelt manipulation revealed that snowmelt date and the timing of growing season precipitation is more important than temperature and species diversity in the total amount for determining cumulative NEP. Our results also show that the trait composition of montane and alpine plant communities also have more of a major influence on carbon exchange than variation in climate suggesting that long-term shifts in plant community trait composition can alter hydroclimatic sensitivities of vegetation. Our results highlight the central role of the plant trait composition as well as snowmelt date and fosummer drought in determining rates of carbon exchange and the potential for an increasingly negative balance of carbon in subalpine meadows under future climate change.
**H33F-01: Linking Snowmelt and Nitrogen Cycling to Vegetation Community Dynamics along a Hillslope Transect (Invited)**

Wednesday, December 12, 2018

1:40 PM - 1:55 PM, **Walter E Washington Convention Center 146B**

*Bhavna Arora(1), Eoin Brodie(1), Zelalem Amdie Mekonnen(2), Tetsu K Tokunaga(3), Jiamin Wan(4), Heidi Steltzer(5), Yuxin Wu(6) and Carl I Steefel(1)*

*1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)University of Alberta, Edmonton, AB, Canada, (3)Lawrence Berkeley Natl Lab, Berkeley, CA, United States, (4)Univ of California, Berkeley, CA, United States, (5)Fort Lewis College, Durango, CO, United States, (6)Lawrence Berkeley National Lab, Berkeley, CA, United States*

**Presenter:** Bhavna Arora

**Abstract:** Changes in the hydrologic cycle, particularly early snowmelt or reduced snowpack are hypothesized to disrupt coupled plant-microbial behavior, possibly due to the temporal discontinuity between microbial nutrient release and vegetation greening around the snowmelt period. The objective of this work is to quantify the influence of variations in snowmelt timing and snowpack depth on nitrogen fluxes and plant phenology along a lower montane hillslope site in the East River catchment, Crested Butte, CO. In particular, this study compares the process couplings and mechanisms that guide nitrogen fluxes and plant behavior for an average hydrologic year (e.g., 2016), a deep snowpack (e.g., 2017) or an unusually sparse and early melting snowpack year (e.g., 2018) as observed at the East River site. For this purpose, a hillslope-to-floodplain transect model has been developed using ecosys - a comprehensive plant ecosystem model that can account for surface energy exchange, microbial metabolism, vegetation phenology/physiology, as well as vertical and lateral hydrologic and biogeochemical fluxes. Ecosys results demonstrate distinct spatial signatures of hydrological and biogeochemical fluxes along the hillslope transect, with greater evapotranspiration rates and higher soil water storage in the floodplain as compared to upslope regions. Further, as would be expected, shallow soil layers and deeper saprolite show prolonged saturation during high snow years, such that water availability in deeper saprolite extends through the monsoon season. In low snow years, evapotranspiration driven pre-summer drought occurs post-snowmelt. Consistent with observations, simulated results indicate that water deficit in surface soils in low snow years adversely impacts forb production and favors deep rooting shrubs altering vegetation nitrogen demand depending on slope. Simulation results therefore indicate that the timing of post-snowmelt precipitation is critical in sustaining plant productivity and dictating the length of the growing season. Overall, these findings demonstrate the significant spatial and temporal connection between snowmelt-associated nutrient release and vegetation community along the hillslope.
H42B-03: Sensitivity and Model Reduction of Simulated Snow Processes: Contrasting Observational and Parameter Uncertainty to Improve Prediction

Thursday, December 13, 2018
10:50 AM - 11:05 AM, Walter E Washington Convention Center 101

Anna Ryken, Colorado School of Mines, Golden, CO, United States, Lindsay A Bearup, Bureau of Reclamation Denver, Denver, CO, United States, Jennifer Jefferson, Department of Natural Resources Wisconsin, Madison, CO, United States, Reed M Maxwell, Colorado School of Mines, Geology & Geological Engineering, Hydrologic Science & Engineering, Golden, CO, United States and Kenneth Hurst Williams, Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States

Presenter: Anna Ryken

Abstract: The hydrology of high-elevation, mountainous regions is poorly represented in Earth Systems Models (ESMs). In addition to regulating downstream water delivery, these ecosystems play an important role in the storage and land-atmosphere exchange of water. Water balances are sensitive to the amount of water stored in the snowpack (snow water equivalent, SWE), as much of Colorado’s water supply is derived from snowmelt. In an effort to resolve this hydrologic gap in ESMs, this study seeks to better understand how uncertainty in both model parameters and forcing affect simulated snow processes. To better understand parameter uncertainty and assess model performance, this study conducts a sensitivity analysis, using active subspaces, on model inputs (meteorological forcing and model input parameters) for a widely used snow model under and between canopy. Observations from an AmeriFlux tower at the Niwot Ridge research site are used to force an integrated single-column hydrologic model, ParFlow-CLM. This study found that trees can mute the effects of sublimation causing the evergreen needleleaf model to be sensitive primarily to hydrologic forcing; humidity in the winter and radiation and air temperature in the summer months. However, bare ground simulations were most sensitive to snow parameters along with radiation as these are unblocked by canopy. The bare ground model is most sensitive to overall changes to the linear combination of input parameters, which means radiation observations and snow parameterizations are of great importance for obtaining accurate hydrologic model results. Humidity measurements are also important, but the change in SWE of the evergreen needleleaf simulations was less than that of the bare ground simulations.
IN43A-11: A brokering approach to integrate diverse environmental datasets for online visualization, modeling and analysis
Thursday, December 13, 2018
2:40 PM - 2:46 PM, Walter E Washington Convention Center 209A-C

Charuleka Varadharajan(1), Val Hendrix(1) and Deb Agarwal(2)

(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)LBNL, Berkeley, CA, United States

Presenter: Charuleka Varadharajan

Abstract: In order to gain a scientific understanding of and ability to predict environmental processes over decadal to century time scales, it is increasingly becoming necessary to integrate diverse and disparate observational and simulation datasets, from various disciplines including hydrology, meteorology, geochemistry, genomics across a range of spatial and temporal scales. Data integration is challenging problem due to differences in the structure and formats of environmental data types, and the manner in which data are served by various data sources. Here, we describe BASIN-3D (Broker for Assimilation, Synthesis and Integration of environmental Diverse, Distributed Datasets), a brokering software designed to provide unified access to a diverse set of data sources and environmental data types. BASIN-3D is a Python/Django application, which connects to distributed data sources in real-time via web services, dynamically retrieves subsets of data as needed for scientific analysis/modeling, and transforms the data streams into uniform, abstracted formats to provide an integrated view. The broker enables users to always have access to the latest data from each of the sources, but to deal with the data as if all of the data were integrated in local storage. We present two different applications that are served by the BASIN-3D framework. The first is a data portal designed for the U.S. Department of Energy’s Watershed Function Scientific Focus Area that enables users to retrieve field observations from multiple data sources, and explore integrated watershed datasets using interactive, Javascript-based visualizations. The second is a service designed for the Japanese Atomic Energy Agency to enable execution of modeling codes that use radiation monitoring data sets collected after the Fukushima accident. The use of broker intermediary enables clients such as the portal or simulation tool to use a standardized approach for data retrieval, and to avoid customizations required for the data type or source.
NS43A-07: Quantifying the role of bedrock in the functioning of a mountainous watershed through integration of geophysical and other data sets

Thursday, December 13, 2018
3:10 PM - 3:25 PM, Marriott Marquis  Marquis 12-13

Sebastian Uhlemann(1), Baptiste Dafflon(1), Burke J Minsley(2), Craig Ulrich(1), John E Peterson(1), Haruko Murakami Wainwright(1) and Susan Hubbard(1)

(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)USGS Geology, Geophysics, and Geochemistry Science Center, Denver, CO, United States

Presenter: Sebastian Uhlemann

Abstract: Climate change, severe weather phenomena, and land-use change are impacting upon the hydrological, biological and geochemical functioning of watersheds worldwide. This has severe impacts not only on the actual watershed but cascades further downstream, affecting water availability, carbon cycling, and nutrient and metal loading. However, watershed dynamics and functioning is still poorly understood. To address this uncertainty, the Watershed Function Scientific Focus Area (SFA) is developing a predictive understanding of how mountainous watersheds retain and release water, nutrients, carbon, and metals. Focused on the East River, CO mountainous headwaters catchment in the Upper Colorado River Basin, the SFA is developing understanding and tools to measure and predict how droughts, early snowmelt, and other perturbations impact downstream water availability and biogeochemical cycling at episodic to decadal timescales. A critical aspect of this challenge is quantifying the influence of bedrock on subsurface flow and transport over a range of space and time scales, and the associated impact on downgradient water availability and water quality. Here we present an approach linking detailed geophysical studies, conducted within a subsystem of the East River watershed, with geological, wellbore, and aerial data to obtain a watershed-scale understanding of the physical properties of the subsurface of the East River watershed. The local subsystem geophysical data, comprising seismic (P-wave refraction and surface wave methods) and electrical resistivity data, highlight potential preferential pathways for subsurface flow and variability in weathering and fracture density. These results are in agreement with shallow drilling logs and hydrological monitoring data and confirm the impact of weathering on subsurface flow dynamics. By linking those results with geological observations, topographic data, and recently acquired, spatially extensive airborne electromagnetic data, we are aiming to extrapolate the knowledge that we gained on the site-scale to the watershed scale, which is by far more important to address flows and perturbations from mountainous to down-streams areas. The methodology developed at the East River watershed should be transferable to many other watersheds worldwide.
H54A-08: Using Sensitivity Analysis as a Tool to Determine the Need for Regeneration of Hydrological and Biogeochemical Predictions
Friday, December 14, 2018
5:45 PM - 6:00 PM, Walter E Washington Convention Center 154AB

Bhavna Arora(1), Boris Faybishenko(1) and Deb Agarwal(2)

(1) Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2) LBNL, Berkeley, CA, United States

Presenter: Bhavna Arora

Abstract: Hydrological and biogeochemical predictions, such as predictions of dynamically-evolving groundwater plumes or carbon/nutrient fluxes in heterogeneous aquifers, require periodic improvements of conceptual and numerical models, as new field data or model parameters become available. The ingestion of new data in numerical simulations may help with reducing the uncertainty and improving the accuracy of predictions. In order to assure robustness of model results and obtain the desired accuracy, one needs to evaluate whether addition of new input data would improve the outcome of model predictions, and what minimum observations are needed to parameterize the model to capture the entire (relevant) range of hydrological and biogeochemical conditions. In this study, we quantified the sensitivity of a 2-D high-resolution transect model developed for the Rifle floodplain site in Colorado, as criteria for regeneration of hydrological and biogeochemical predictions. To determine when and where data regeneration is required, we used the 2-D transect model developed in the numerical code ToughReact, and tested it for different data addition/update scenarios. Our results indicate that adding certain microbial pathways, such as chemolithoautotrophic reactions, and temperature variations significantly impacted predictions of carbon dynamics. Similarly, we determined that the model predictions were highly sensitive to certain model parameters, such as porosity, hydraulic conductivity of the hydrostratigraphic units, oxygen and nitrate content, and inhibition constants. We also determined that the sensitivity of model predictions to model parameters was dependent on variations in geomorphological conditions. In particular, the sensitivity of predictions was higher at upslope regions, where recharge boundary conditions are applied, compared to the downslope area. The application of the sensitivity analysis is recommended to determine whether and when regeneration of model predictions is required.
Session Convening

EP11C: Modeling the Critical Zone: Integrating Processes and Data Across Disciplines and Scales I Posters
Monday, December 10, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Primary Convener: Li Li
Conveners: Bhavna Arora; Harry Vereecken
Chair(s): Li Li; Harry Vereecken; Bhavna Arora

H14D: Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes Across Scales I
Monday, December 10, 2018
4:00 PM - 6:00 PM, Walter E Washington Convention Center 146B

Primary Convener: Bhavna Arora
Conveners: Haruko Wainwright
Chair(s): Bhavna Arora; Haruko Wainwright

EP14A: Modeling the Critical Zone: Integrating Processes and Data Across Disciplines and Scales II
Monday, December 10, 2018
4:00 PM - 6:00 PM, Walter E Washington Convention Center 147A

Primary Convener: Li Li
Conveners: Bhavna Arora; Harry Vereecken
Chair(s): Li Li; Harry Vereecken
Session Convening

H21K: Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes Across Scales II Posters
Tuesday, December 11, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Primary Convener: Bhavna Arora
Conveners: Haruko Wainwright
Chair(s): Bhavna Arora; Haruko Wainwright

H23K: Groundwater–Surface Water Interactions: Identifying and Integrating Physical, Biological, and Chemical Patterns and Processes Across Systems and Scales V Posters
Tuesday, December 11, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Primary Convener: Marie Kurz
Conveners: Jesus Gomez-Velez; Steven Wondzell; Skuyler Herzog
Chair(s): Marie Kurz; Jesus Gomez-Velez; Dipankar Dwivedi

B32A: Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons I
Wednesday, December 12, 2018
10:20 AM - 12:20 PM, Walter E Washington Convention Center 149AB

Primary Convener: Alexandra Contosta
Conveners: Sarah Nelson; Fereidoun Rezanezhad; Patrick Sorensen
Chair(s): Alexandra Contosta; Patrick Sorensen
Session Convening

H33F: Groundwater–Surface Water Interactions: Identifying and Integrating Physical, Biological, and Chemical Patterns and Processes Across Systems and Scales III
Wednesday, December 12, 2018
1:40 PM - 3:40 PM, Walter E Washington Convention Center 146B

Primary Convener: Marie Kurz
Conveners: Jesus Gomez-Velez; Steven Wondzell; Skuyler Herzog
Chair(s): Marie Kurz; Dipankar Dwivedi

B33M: Impacts of Winter Climate Change on Hydrobiogeochemical Dynamics of Terrestrial and Aquatic Systems During the Winter and Shoulder Seasons II Posters
Wednesday, December 12, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Primary Convener: Alexandra Contosta
Conveners: Sarah Nelson; Fereidoun Rezanezhad; Patrick Sorensen
Chair(s): Alexandra Contosta; Patrick Sorensen


**EP11C-2077: Understanding Contrasting Concentration-discharge (CQ) Behaviors in a Seasonally Snow-covered Watershed**

Monday, December 10, 2018

8:00 AM - 12:20 PM, *Walter E Washington Convention Center, Hall A-C (Poster Hall)*

**Wei Zhi, Pennsylvania State University Main Campus, Department of Energy and Mineral Engineering, University Park, PA, United States, Li Li, Pennsylvania State University Main Campus, Department of Civil and Environmental Engineering, University Park, PA, United States, Jason P Kaye, Pennsylvania State University, Department of Ecosystem Science and Management, University Park, PA, United States, Wenming Dong, Lawrence Berkeley National Lab, Earth and Environmental Sciences Area, Berkeley, CA, United States, Wendy Brown, Rocky Mountain Biological Laboratory, Gothic, United States, Carl I Steefel, Lawrence Berkeley National Laboratory, Berkeley, CA, United States and Kenneth Hurst Williams, Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States**

**Presenter:** Wei Zhi

**Abstract:** Concentration-discharge (CQ) relationship bears the convoluted signature of hydrological and biogeochemical processes at the watershed scale. Contrasting CQ behavior have been observed for different chemicals at different watersheds yet the underlying mechanism of such contrasts remains elusive. In this work, a coupled hydrological and biogeochemistry model (bioRT-Flux-PIHM) is developed to understand key controls of CQ behaviors in Coal Creek watershed (Colorado), where data have shown flushing behavior (i.e., concentration rises with increasing discharge) for dissolved organic carbon (DOC) and nutrients (e.g., nitrogen and phosphorus) and dilution behavior (i.e., concentration decreases with increasing discharge) for geogenic species (e.g., Na, Cl, Mg, and Ca). Coal Creek is seasonally snow-covered with the spring snowmelt dominating the annual water balance. The calibration of water model estimates an average of 37% of groundwater (in contrast to shallow soil water) contribution to the stream annually. The calibrated model shows that the relative composition and fluxes of groundwater versus shallow soil water is key to generate contrasting CQ behaviors. In particular, the predominance of organic-rich soil water in the stream during spring melt results in high DOC concentration at high discharge, whereas the organic-poor groundwater under dry conditions lead to low DOC concentration at low discharge. The opposite is true for Na that is originated from the dissolving Na-containing albite in the groundwater. A Monte-Carlo simulation of 500 runs that randomly sample across the uncertainty range of volume fractions of SOC and albite (0.1% to 10%) and across the range of groundwater DOC and Na concentration (0.1 to 10 mg/L). The analysis reveals that at the groundwater level for Coal Creek, flushing behaviors occur at the high concentration ratio of soil water to groundwater (1.8 to 200) while dilution behaviors occur with low concentration ratio range of 0.01 and 0.6. Chemostatic behaviors occurs in between these ranges. These results underscore the importance of flow paths in influencing stream chemistry, and conversely the usefulness of chemistry data in illuminating water flow paths.

Monday, December 10, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Boris Faybishenko(1), Tetsu K Tokunaga(1), Dipankar Dwivedi(1), John Neil Christensen(1), Baptiste Dafflon(1), Anh Phuong Tran(1), Jiamin Wan(1), Wenming Dong(1), Chad Hobson(1), Bhavna Arora(1), Carl I Steefel(1), Rosemary W H Carroll(2), Haruko Murakami Wainwright(1), Roelof Versteeg(3), Kenneth Hurst Williams(1), Philip E Long(4), Deb Agarwal(1) and Susan Hubbard(1)

(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)Desert Research Institute Reno, Reno, NV, United States, (3)Subsurface Insights, Hanover, NH, United States, (4)Lawrence Berkeley National Lab, Chelan, WA, United States

Presenter: Boris Faybishenko

Abstract: Temporal dynamics and spatial distribution of the groundwater recharge of alluvial aquifers are key components in modeling of the biogeochemical interaction between the floodplain vadose zone and groundwater. We present results of long-term investigations carried out at the Rifle field site (a former uranium mill tailings site) adjacent to the Colorado River, where field studies have yielded insight into hydrological and biogeochemical processes in the unsaturated zone and aquifer. The infiltration rate and groundwater recharge were evaluated based on a statistical analysis of (1) meteorological time series data (1985-2017), including precipitation and snowmelt data, as well as evapotranspiration determined from semi-analytical and modeling studies, and (2) radioisotopic measurements of groundwater samples collected in monitoring groundwater wells. We found that net infiltration and groundwater recharge estimated based on long-term meteorological data are comparable with those established from strontium isotopic investigation, and the site averaged annual net infiltration of precipitation ranges from 4.7% to 18%, with a mean of approximately 10%. To better understand the impact of spatially varying infiltration and groundwater recharge on biogeochemical processes, we performed a statistical principal component analysis and clustering zonation, and analyzed the groundwater level fluctuations and the nitrate-to-chloride ratio of groundwater samples collected in the monitoring wells across the floodplain. Results demonstrate that the regional groundwater flow and snowmelt are primary drivers of the interaction between the alluvial aquifer in the underlying Rifle floodplain and the Colorado River. Although snowmelt induced infiltration events do not instantaneously impact water levels in the aquifer, redox states (e.g., nitrogen dynamics) of the aquifer are highly sensitive to the temporal and spatial variations of the groundwater recharge. This study highlights the importance of the corroborative statistical analysis for representing temporal-spatial distribution of the infiltration and groundwater recharge in mechanistic and statistical biogeochemical models.
H13J-1870: The East River, Colorado Community Watershed: Hydrobiogeochemical Studies Spanning Scales and Disciplines
Monday, December 10, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Kenneth Hurst Williams(1), Wendy Brown(2), Rosemary W H Carroll(3), K. Dana Chadwick(4), Baptiste Dafflon(1), Jeffrey S Deems(5), Wenming Dong(6), Nicola Falco(7), Susan Hubbard(1), Li Li(8), Burke J Minsley(9), Michelle E Newcomer(10), Joel C Rowland(11), Heidi Steltzer(12), Nicholas A Sutfin(13), Tetsu K Tokunaga(14) and Haruko Murakami Wainwright(15)

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Presenter: Kenneth Williams

Abstract: Lawrence Berkeley National Laboratory and its collaborating institutions have established a "Community Watershed" in the headwaters of the East River near Crested Butte, Colorado (USA) designed to quantify processes impacting the ability of mountainous systems to retain and release water, nutrients, carbon, and metals. The East River Community Watershed spans a range of scales from hillslope to catena to catchment to basin, with surface water and groundwater linking a diversity of geomorphic compartments. Research is highly multi-disciplinary involving hydrologists, ecologists, geochemists, geomorphologists, remote sensing specialists, and climate scientists. Research is focused on both mechanistic and empirical studies assessing the impact of climate perturbations, such as early snowmelt and drought, on coupled processes as they relate to water availability and water quality. Stakeholder participation provides feedback and support on environmental monitoring and links to management planning decisions conducted as part of the Colorado Water Plan. Data collection activities and monitoring infrastructure are emplaced within the catchment so as to assess the aggregate impact of fine scale processes on large scale system behavior. Monitoring occurs over diversity of time scales from minutes to months to years, with observational data used to populate predictive models describing water and nutrient flows across nested scales of enquiry. Strong infrastructural investments in data and monitoring networks include dispersed stream gaging and water sampling, groundwater wells, elevation dependent meteorological stations, and drainage-specific fluxes of water, carbon, nitrogen, phosphorus, and heavy metals. Remote sensing datasets are used to assimilate plot-scale measurements made within the watershed through quantification of variations in snowpack depth, snow water equivalent, geologic composition and bedrock properties, and plant functional type distributions including leaf chemical composition. Optimized assimilation of these diverse datasets into predictive hydrobiogeochemical models describing the integrated functionality of the East River watershed represents a long-term goal of the collective project and one greatly enabled through the Community Watershed concept.
Tuesday, December 11, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Alexander Polussa(1), Zhao Hao(1), K. Dana Chadwick(2), Xiaoqin Wu(1), Romy Chakraborty(3) and Eoin Brodie(1)

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Presenter: Alexander Polussa

Abstract: Previous attempts using near-infrared techniques to spatially characterize chemical composition of plant biomass perform well within defined ecosystem or plant type but fail to address key challenges of accurate prediction and quantification of the underlying fundamental vibrational signatures. In this report, we use a supervised machine learning method that analyzes the fundamental relationships within the infrared spectroscopy to create a robust predictive model to generate mid-infrared (MIR, 4000–400 cm⁻¹) spectra using solely the near-infrared (NIR, 12800–4000 cm⁻¹) spectral data. The mid-IR spectra contain more distinctive and unique signatures related to the strong fundamental vibrational modes that have been widely used to classify and quantify biochemical components of lignocellulosic biomass. However, these measurements are not suitable for characterizing chemical compositions with high spatial resolution. Specifically, we collected near-infrared and mid-infrared spectra on senesced leaves in a mountainous mixed shrub system in Crested Butte, Colorado, and then trained a partial least squares regression model (PLSR) with mid infrared and near infrared spectrum to predict mid-infrared spectra using only the observed near-infrared spectra. We then used these predicted mid-infrared spectra to classify species composition of these samples, and further quantify the relative concentrations of macronutrients in the leaves which provide important sources in Nitrogen/Phosphorus/Carbon cycling. Using spatial near-infrared data in another system collected by the Airborne visible/infrared imaging spectrometer (AVIRIS) we were able to recreate spatial concentrations of these compounds. We validated our results from the original leaves collected from the ground with direct mid-infrared measurements, and together they revealed the accuracy of the model. We hope to continue to develop this method as a consistent tool to characterize landscapes using remote near-infrared spectral data.
H21K-1796: Data Driven Identification of Environmental Hot Moments through Regimes Shift
Tuesday, December 11, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Jiancong Chen(1), Baptiste Dafflon(2), Bhavna Arora(2), Michelle E Newcomer(2), Susan S Hubbard(2) and Yoram Rubin(1)

(1)University of California Berkeley, Berkeley, CA, United States, (2)Lawrence Berkeley National Laboratory, Berkeley, CA, United States

Presenter: Jiancong Chen

Abstract: Temporal variability observed in watershed hydrological and biogeochemical attributes in an environment can be attributed to non-linear and intricately coupled hydrological and biogeochemical processes. Regime shifts in these processes – that occur as a result of unique combination of hydrological events and biogeochemical conditions – can result in the formation of hot moments or short bursts of time that exhibit disproportionately higher reaction rates in a longer intervening time period. These HMs exhibit disproportionate influence on ecosystem dynamics as these time periods are associated with elevated environmental health risks or significant potential for contaminant removal. Thus identification of environmental HMs is vital for understanding the ecosystem dynamics and risk prevention and assessment. The objective of our study is to develop a predictive understanding of the development and occurrence of HMs through data-driven methodology. Hydrological and biogeochemical data acquired at East River Watershed in Colorado, were used for HMs identification and prediction. 3 years of hydrological and biogeochemical attributes, such as discharge, calcium, nitrate, have been used to facilitate our understanding of the watershed dynamics at East River Watershed. Principle Component Analysis (PCA) and time series analysis have been performed to identify the dominant hydrological and geochemical processes and the corresponding temporal scales. Hidden Markov Models (HMMs) have been applied to distinguish the temporal variability of these dominant processes and identify regime shifts. Through understanding the regime shifts, triggering events (arising regime) and sharp transitions (switching regimes) can be identified through data driven models. These triggering events and sharp transitions are usually the target time point and duration that contribute to HMs development and occurrence. Our data-driven method provides a unique perspective for detection of environmental HMs and understanding ecosystem dynamics in heterogeneous and temporally variable watershed environments.
H23K-2081: Heterogeneity in River-Groundwater Mixing, Microbiology, and Geochemistry in an Alpine Riverbed during Baseflow  
Tuesday, December 11, 2018  
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)  

Amelia Nelson(1), Michael J Wilkins(2), Casey Morrisroe Saup(1), Savannah R Bryant(1), Kira Harris(1), Kenneth Hurst Williams(3) and Audrey H Sawyer(1)  

(1)The Ohio State University, School of Earth Sciences, Columbus, OH, United States,  
(2)Colorado State University, Department of Soil and Crop Sciences, Fort Collins, United States, (3)Lawrence Berkeley National Laboratory, Berkeley, CA, United States  

Presenter: Amelia Nelson  

Abstract: The hyporheic zone, where river water and groundwater mix, has a large influence on river water quality. Hyporheic mixing varies spatially, which leads to gradients in microbial activity, community composition, and pore water chemistry. To assess how spatial changes in hyporheic influence microbial community structuring and geochemical conditions, we quantified hyporheic flow using vertical head gradients, heat tracing and sampled pore water for 16S rRNA gene sequencing and chemistry at 100 locations at high resolution (~3 m) along a 200 m meander of East River, Colorado (USA). Additionally, potential aerobic respiration rates were quantified at 50 locations using resazurin assays. Preliminary results at a small subset of locations revealed greater microbial community diversity and increased rates of aerobic respiration in streambed locations where oxic river water downwells. We expect high-resolution sampling to exhibit similar trends, where river-groundwater mixing should vary across streambed morphology and impact hydrobiogeochemical processes. Our findings will provide better understanding of how hydrology influences biogeochemical conditions in the hyporheic zone during baseflow conditions, which is expected to lengthen with climate change.
H23K-2101: Modeling Seasonal Surface Water-Groundwater Mixing Controls on Organic Carbon Processing in Hyporheic Zones

Tuesday, December 11, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Savannah R Bryant(1), Michael J Wilkins(2,3), Martin A Briggs(4), Casey Morrisroe Saup(5), Amelia Nelson(5), Rachel S Gabor(6), Kenneth Hurst Williams(7) and Audrey H Sawyer(5)

(1)Ohio State University Main Campus, Columbus, OH, United States, (2)Ohio State University Main Campus, School of Earth Sciences, Columbus, OH, United States, (3)Colorado State University, Soil and Crop Sciences, Fort Collins, CO, United States, (4)USGS Office of Groundwater, Hydrogeophysics Branch, Storrs, CT, United States, (5)The Ohio State University, School of Earth Sciences, Columbus, OH, United States, (6)Ohio State University Main Campus, School of Environment and Natural Resources, Columbus, OH, United States, (7)Lawrence Berkeley National Laboratory, Berkeley, CA, United States

Presenter: Savannah Bryant

Abstract: The hyporheic zone, where surface water and shallow groundwater mix, plays a leading role in carbon degradation in riverbeds. Seasonal changes in hyporheic exchange alter the supply of organic carbon and oxygen to streambed microbial communities, controlling residence times and degradation rates of various dissolved organic carbon (DOC) pools. We measured and modeled seasonal changes in hyporheic transport in the bed of an alluvial mountain river subjected to large spring snowmelt events (East River, Colorado USA). Continuous streambed temperatures were monitored vertically at three locations for approximately one year and used to evaluate temporal dynamics of vertical seepage rates. Additionally, seasonal depth-resolved pore water samples were collected from the locations of vertical profiles. Downwelling conditions in the streamed generally coincide with spring snowmelt, while upwelling conditions generally predominate during the fall baseflow season. Conservative solute concentrations indicate maximum river water penetration into the streamed during spring snowmelt conditions. Total DOC concentrations increase with depth and from spring snowmelt to baseflow seasons, indicating decreased microbial respiration. This inference was supported by resazurin-based aerobic respiration measurements in samples collected from the streamed. One-dimensional, transient reactive transport models were created to test the effects of different seasonal hyporheic dynamics on carbon transport. Preliminary results show less solute penetration under smaller snowmelt events, which are expected to become more common under a warming climate and shrinking snowpack. Oxygen penetration will likely be affected in a similar manner, limiting microbial respiration and carbon degradation at depth. We hypothesize that diminishing annual snowmelt pulses and a longer baseflow season will result in less efficient carbon retention in the hyporheic zone.
H23H-1979: Transient Anoxic Micro-zone Development in an Alpine Stream

Tuesday, December 11, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Ruby N Ghosh(1), Terry Ball(2), Bruce Bright(2), Michael J Freeman(3), Mathew E Matusz(2), Kieran Nehil-Puleo(2), Dean D Shooltz(3), Michelle E Newcomer(4), Dipankar Dwivedi(5) and Kenneth Hurst Williams(6)

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Presenter: Ruby Ghosh

Abstract: Biogeochemical processes in the hyporheic zone occur over a broad range of temporal and spatial scales. The experimental challenge lies in how to obtain in-situ and time-resolved data at these different scales from a remote field site. We present spatially resolved profiles of dissolved oxygen concentration and temperature at a resolution of one data point every five minutes over an entire hydrological year from the hyporheic zone of a snow-dominated sub-alpine stream in the East River watershed in southwestern Colorado, USA (the primary site of the Watershed Function Scientific Focus Area of Berkeley Lab). We obtained these datasets from an array of novel sensors located in the stream as well as buried within the streambed sediment, data being telemetered in real-time from the remote study site over a year-long period. We geocoded and analyzed these in-situ measurements of oxygen and temperature using spectral frequency analysis. Additionally, these data were used in a fully-coupled flow and reactive transport model with a Bayesian inversion procedure to predict coupled stream and hyporheic zone respiration. A time-lapse analysis of the oxygen profiles reveals the appearance and disappearance of anoxic micro-zones at the centimeter scale within the stream bed. Results suggest that the anoxic micro-zones move vertically over periods of days driven by processes such as snow melt and precipitation. These coupled hydrological processes lead to lateral flow in the hyporheic zone, representing a time-varying respiration contribution to the river. Overall, we provide new results highlighting the transient behavior of these anoxic micro-zones in the context of an unusual snow drought hydrological cycle. Efforts are underway to use these high-resolution oxygen and temperature data in mechanistic models to enhance process understanding in stream beds and hyporheic zones.
H23K-2074: Differential C-Q Analysis: Including the Impact of Lateral Storage and Hydrologic Transients on Solute Concentration within a Mountainous Headwater Catchment
Tuesday, December 11, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Madison Burrus(1), Bhavna Arora(2), Michelle E Newcomer(3) and Carl I Steefel(1)
(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)Lawrence Berkeley National Lab, Berkeley, CA, United States, (3)University of California Berkeley, Berkeley, CA, United States

Presenter: Madison Burrus

Abstract: Concentration-discharge (C-Q) relationships have been widely used as “hydrochemical tracers” to determine the variability in riverine solute exports across seasonal and annual time scales. However, these C-Q relationships are limited to investigations of solute transport dynamics at individual sampling stations, such that they create an incomplete understanding of the solute behavior upstream or downstream of the sampling station. The objective of this study is to apply differential C-Q relationships and assess spatial variability and solute behavior across multiple sampling stations, as well as investigate controls on solute variability. This study uses two years of water quality data from the East River—a high-elevation headwater catchment in Colorado—and compares applications of traditional and differential C-Q relationships. For the 2016 water year, ∆C-∆Q analysis indicates that calcium concentration decreased from upstream values noticeably during the peak rainy season, instead of accumulating downstream, as is expected of weathered solutes. In contrast, sulfate underwent little change in concentration downstream during the same time period, despite its reactivity. It is likely that sulfate coming from upstream station during peak river discharge reduces calcium concentration through Ca-SO4 precipitation. Later that same year when streamflow reduced to baseflow conditions, calcium notably accumulated downstream, further suggesting the influence of a tributary source of sulfate to the stream. Overall, the differential C-Q analysis is able to provide an improved understanding of the lateral inputs to and biogeochemical processing within the lower East River triangle.
H31L-2103: Constraining the Depth and Temporal Distribution of Subsurface Flow and Transport Along a Hillslope Transect
Wednesday, December 12, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Tetsu K Tokunaga(1), Jiamin Wan(1), Wendy Brown(2), Yongman Kim(3), Kenneth Hurst Williams(4), Wenming Dong(3), Markus Bill(5), Mark E Conrad(6), John Christensen(7), Anh Phuong Tran(1), Zexuan Xu(8), Boris Faybishenko(1), Bhavna Arora(1), Adi Lavy(9), Sergio Carrero Romero(8), Benjamin Gilbert(10), Roelof Versteeg(11) and Susan Hubbard(1)

(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)Rocky Mountain Biological Laboratory, Gothic, United States, (3)Lawrence Berkeley National Laboratory, Earth Science Division, Berkeley, CA, United States, (4)Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States, (5)Lawrence Berkeley National Lab, Berkeley, CA, United States, (6)Lawrence Berkeley National Lab, Berkeley, CA, United States, (7)Lawrence Berkeley National Laboratory, Energy Geosciences Division, Berkeley, United States, (8)Lawrence Berkeley National Laboratory, Berkeley, United States, (9)University of California, Berkeley, Berkeley, CA, United States, (10)Lawrence Berkeley National Laboratory, Energy Geosciences Division, Berkeley, CA, United States, (11)Subsurface Insights, Hanover, NH, United States

Presenter: Tetsu Tokunaga

Abstract: Subsurface flow of water in mountainous watersheds influences rates of river discharge and water quality, elemental cycling, and rock weathering. While subsurface water and solute fluxes are recognized to be important, little information is available on their spatial and temporal distributions. In order to improve understanding of subsurface distributions of fluxes, we are conducting studies along a lower montane hillslope that drains into the East River, a tributary to the Colorado River (Colorado, USA). At four stations along a 190 m transect, 10 m deep boreholes were drilled to obtain samples of soil, and underlying weathered and fractured Mancos Shale. Vertical profiles of hydraulic potentials and pore waters are being obtained to determine directions of fluxes and pore water chemistry. Lacking evidence for significant overland flow, the approach taken for this analysis estimates net recharge as the difference between precipitation and estimated evapotranspiration. Based on net recharge along the transect and subsurface influxes from upslope terrain, combined with measured hydraulic potentials and hydraulic conductivities, we estimated the hillslope's depth- and time-resolved contributions of flow and transport to the river. This analysis indicates that the transmissive fractured shale zone extends substantially deeper than 10 m below the surface. The measurements and calculations conducted for a sequence of substantially above-average and below-average snowpack years (water years 2017 and 2018, respectively) show that snowmelt recharge within the transect generated pulses of downslope fluxes through the weathered shale zone that amounted to about a third of the peak flow, and that downslope fluxes through the soil were only significant water year 2017. Subsurface solute fluxes into the river are being estimated based on the geochemically distinct chemistries of pore waters in the soil and weathered shale zone relative to the fractured shale.
B33M-2856: Early Snowmelt Timing Controls the Magnitude of Soil Nutrient Flux and Microbial Community Turnover During the Winter-Spring Transition

Wednesday, December 12, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Patrick Sorensen(1), Harry R Beller(1), Markus Bill(2), Nicholas Bouskill(3), Eoin Brodie(1), Mark E Conrad(3), Ulas Karaoz(3), Alexander Polussa(1), Heidi Steltzer(4), Shi Wang(1), Kenneth Hurst Williams(5), Chelsea Wilmer(4) and Yuxin Wu(3)

(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)Lawrence Berkeley National Lab, Berleley, CA, United States, (3)Lawrence Berkeley National Lab, Berkeley, CA, United States, (4)Fort Lewis College, Durango, CO, United States, (5)Colorado School of Mines, Golden, CO, United States

Presenter: Patrick Sorensen

Abstract: Nitrogen export from mountainous watersheds is controlled by well-coupled phenological interactions among soil-plants-microbes that are constrained by the depth and duration of the winter snowpack. The timing of snowmelt has been occurring earlier in many snow-dominated ecosystems, including the East River Watershed (e.g., 3.5 days decade-1) near the town of Crested Butte, Colorado. Advancement of the timing of snowmelt may result in a temporal asynchrony between historically coupled microbial nutrient release and plant nutrient demand in spring with the potential to increase N export from the East River Watershed. To determine the effect of early snowmelt-timing on microbial turnover and nutrient flush during the winter-spring transition period, we used black shade cloth to absorb solar radiation and experimentally induce early snowmelt-timing at a field-scale experiment at East River. Soils were sampled at 3 depths below the soil surface (0-5 cm, 5-15 cm, and > 15 cm) and dissolved pools of soil nutrients (e.g., NH4+, NO3-, DOC, P), microbial biomass C and N, and microbial community composition were measured at regular time-intervals. The black fabric cloth was placed on the Early Snowmelt plots in mid-March and resulted in an accelerated date of complete loss of snow (+ 10 days) in comparison to the Control treatment. In addition, the 2018 snowpack was one of the shallowest (max depth ~ 50 cm) recorded over the last 40 years at East River and resulted in a layer of soil frost extending well below the plant rooting zone. Frozen soil persisted up to the complete loss of snow in both Control and Early Snowmelt plots, but the accelerated snowmelt rate in the Early Snowmelt treatment caused the soils to thaw and become saturated by melt water prior to the Control. As such, the pulse of dissolved N (NH4+, NO3-, and Total Dissolved N) associated with snowmelt were temporally offset and occurred later in the Control compared to Early Snowmelt treatment. The magnitude of the soil nutrient pulse was much larger in 2017, which had one of the highest annual snowfall totals on record, compared to the year of our study, 2018. Together, these initial results demonstrate that early snowmelt strongly influences the magnitude and timing of soil nutrient flush as well as microbial community turnover at the winter-spring transition.
B33M-2857: Phenological responses to earlier snowmelt in a Colorado River Headwater Basin

Wednesday, December 12, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Chelsea Wilmer(1), Heidi Steltzer(2), Amanda Henderson(3), Lorah Beth Patterson(4), Brian Joseph Enquist(3), Wendy Brown(5), Rosemary W H Carroll(6), Haruko Murakami Wainwright(7), Eoin Brodie(8), Kenneth Hurst Williams(9) and Susan Hubbard(8)

Presenter: Chelsea Wilmer

Abstract: Plant emergence, growth, and flowering phenology in mountain meadow systems are driven by either snowmelt timing, temperature, photoperiod, or combinations of these. Historically, these systems have been characterized by short growing seasons due to late-lying snow. Plants of these systems evolved cues and other strategies as protection from cold- and drought-stress to survive, grow and flower across the historic range of climatic conditions. The East River, a headwater basin of the Colorado River, is experiencing increased spring air temperatures (mean daily +1.4°C/decade at SNOTEL #380, 1987-2018) and a greater frequency of dust deposition on the snowpack. Both processes are accelerating snowmelt with consequences for hydrologic processes and the associated soil, microbe, and plant ecology. Our research focuses on how earlier snowmelt extends the pre-monsoon drought to decouple cues for plant growth and flowering, and thereby alter plant phenology with impacts for hillslope biogeochemistry and watershed behavior. We recorded species’ leaf emergence and flowering dates in meadow plots across an elevation gradient from 2700-3600m during contrasting water years 2017 (wet) and 2018 (dry). In addition, we implemented a snowmelt experiment during the drought of 2018 within a subset of sites. The experiment successfully accelerated melt an additional 10 days prior to the control plots despite drought conditions and warm spring already accelerating snowmelt 3+ weeks over average conditions (SNOTEL #380 and #737). Greater synchrony was observed for leafing and flowering across elevations and among species within elevation as a consequence of the earlier melt year and after experimentally advanced snowmelt. Our observations in the spring and summer of 2018 showed that flowering, which for many species indicates a shift from allocating resources from growth to reproduction, was ‘stacked’, or occurring at the same time, across elevations. Phenological shifts from asynchronous to synchronous growth across elevational gradients impact hillslope biogeochemistry and watershed behavior with long-term outcomes for plant species’ survival.
NS43C-0851: Efficient and comprehensive hydrogeological characterization of remote stream corridors using drones
Thursday, December 13, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

John W Lane Jr(1), Martin A Briggs(1), Cian Dawson(2), Christopher Holmquist-Johnson(3), Eric A White(1) and Kenneth Hurst Williams(4)

(1)USGS Hydrogeophysics Branch, Storrs, CT, United States, (2)USGS Hydrogeophysics Branch, Rolla, MO, United States, (3)US Geological Survey, Fort Collins Science Center, Fort Collins, CO, United States, (4)Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States

Presenter: John Lane

Abstract: Reactive processes and aquatic habitat throughout stream corridors are controlled in part by the hydrodynamic template of groundwater/surface-water exchange. High-resolution topographic mapping of banks and bedform structure can be used to predict preferential exchange zones, while thermal infrared actually images discharge and mixing of waters when temperature gradients exist. We deployed a multi-rotor small unoccupied aircraft system (sUAS) along the montane Oh-Be-Joyful Creek, part of the East River DOE Science Focus Area, Gothic, Colorado, adjacent to a fault zone suspected of preferential groundwater flow. Visual imagery was collected with a GoPro Camera along approximately 200 m of the stream and adjacent hillslopes, and image stills from multiple flight lines were compiled into a larger “stitched”, georeferenced image. Structure from motion techniques were then applied to this high-resolution visual imagery to derive a time-specific digital elevation model. Large woody debris in the channel is included in the elevation model, and individual step/pool bedforms are visible. Radiometric thermal infrared data were collected along the same stream reach, and single images were compiled into larger georeferenced ortho images similar to the visible light data. During the afternoon of data collection in mid-August, mixed stream temperatures approached 15 °C, whereas discharge of groundwaters was found to be approximately 8 °C. Dozens of preferential groundwater discharge zones are identified at sub-meter scales, with the strongest apparent discharge associated with the fault zone. Infrared video was also collected and visible in real time to the sUAS operator on the control tablet thus enabling real-time observation of potential seepage zones during the flights. Video mode was also useful while hovering the sUAS, a capability not available for fixed wing sUAS, where dynamic mixing processes between groundwater discharge and stream water can be recorded. Within just a few hours we were able to comprehensively map the stream corridor structure and dynamic mixing of surface and groundwaters in an area difficult and dangerous to access on the ground. sUAS are now effectively bridging the ground-based and manned aircraft to satellite remote sensing scales.
H51T-1583: Impacts of heterogeneity on water and energy fluxes at high resolutions using a fully-integrated hydrologic model

Friday, December 14, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Sarah Trutner(1), Reed M Maxwell(1) and Katharine Maher(2)

(1)Colorado School of Mines, Geology & Geological Engineering, Hydrologic Science & Engineering, Golden, CO, United States, (2)Stanford-Geology & Env Science, Stanford, CA, United States

Presenter: Sarah Trutner

Abstract: Land cover, subsurface, and topographic heterogeneity have all been shown to control infiltration rates, subsurface flow, soil moisture, and energy flux distributions. Many hydrologic models operate at scales that may miss the variability of these parameters, often because of limited availability of computational resources and high-resolution data. The effects of small-scale heterogeneity on local water-energy balances is largely unknown, since smaller areas are often lumped completely into one or two cells of a larger-scale model. This work examines the influence of small-scale heterogeneity in an alpine microcatchment (250m x 300m) within the East River watershed near Crested Butte, CO, using a fully coupled groundwater-surface water model, ParFlow-CLM. Topography for the simulation was built from LiDAR data taken at 0.5m resolution, and soil parameters and plant functional types were assigned based on existing data for the area. Several ParFlow simulations were built with the available data. Three different grid resolutions (0.5m, 2m, and 5m) were used, both for computational convenience and to examine the importance of microtopography at the small scales in question. Additionally, both homogeneous and heterogeneous land cover and soil data were used in order to isolate the effects of heterogeneity in the model. The effects of the varied parameters on behaviors such as infiltration, soil moisture, and land-surface energy fluxes are examined and presented.
H51O-1512: Watershed Functioning Zonation: Advanced Watershed Characterization across Scales
Friday, December 14, 2018
8:00 AM - 12:20 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Haruko M Wainwright(1), Nicola Falco(2), Baptiste Dafflon(1), Craig Ulrich(1), Sebastian Uhlemann(1), Bhavna Arora(3), Erica R Siirila-Woodburn(4,5), Burke J Minsley(6), Rosemary W H Carroll(7), Kenneth Hurst Williams(8,9) and Susan Hubbard(1)

(1)Lawrence Berkeley National Laboratory, Berkeley, CA, United States, (2)Lawrence Berkeley National Laboratory, Berkeley, United States, (3)Lawrence Berkeley National Lab, Berkeley, CA, United States, (4)Polytechnic University of Catalonia, Barcelona, Spain, (5)Lawrence Berkeley National Laboratory, Earth Science Division, Berkeley, CA, United States, (6)USGS Geology, Geophysics, and Geochemistry Science Center, Denver, CO, United States, (7)Desert Research Institute Reno, Reno, NV, United States, (8)Lawrence Berkeley National Laboratory, Earth and Environmental Sciences Area, Berkeley, CA, United States, (9)Rocky Mountain Biological Laboratory, Gothic, CO, United States

Presenter: Nicola Falco

Abstract: Predictive understanding of watershed function and dynamics is often hindered by the heterogeneous and multiscale fabric of watersheds. In particular, ecohydrology and biogeochemical cycling involves complex hydrological-biogeochemical interactions occurring from bedrock-to-canopy, including geology, plants, microorganisms, organic matter, minerals, dissolved constituents, and migrating fluids. Understanding and quantifying such interactions across heterogeneous watersheds are critical for estimating and predicting integrated hydrological and biogeochemical responses – such as carbon and nutrient exports, water resources and quality – under climate changes and other perturbations. In this study, we develop novel watershed-characterization methodology to quantify complex watershed systems across scales, using advanced sensing, inversion, and machine learning approaches. Through explicitly bridging information derived from “on the ground” observations and remote sensing data, we catalyze the development of the fundamental scientific linkages among interacting processes in the watershed. We integrate multi-scale multitype datasets of surface geophysics (e.g. electrical, seismic), airborne electromagnetic survey, airborne LiDAR, airborne snow survey and satellite/UAV images collected over the East River Watershed (near Crested Butte, CO, USA). Particular focus is to quantify and distribute subsurface and biogeochemical properties by exploiting their co-variability among geology (based on electrical conductivity), geomorphology, and vegetation (i.e., plant functional types and their dynamics) that can be measured by remote sensing. We then perform cluster analyses to categorize hillslopes – functioning units within the watershed – into several representative zones that have distinct characteristics of those co-varied properties. We confirm the representativeness of the zonation based on the river water discharge and chemistry. By characterizing heterogeneous properties over the watershed, we aim to develop the new ‘watershed functioning zonation’ concept for model parameterization and validation of hydrological and biogeochemical simulations as well as for watershed characterization and experimental designs.
Friday, December 14, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

Dean Shooltz(1), Ruby N Ghosh(1), Michael J Freeman(1) and Kenneth Hurst Williams(2)

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Presenter: Ruby Ghosh

Abstract: Environmental sensor networks capable of taking data quickly enough to capture minute-scale fluctuations and durable enough to capture these data for many months are needed for studying seasonal and annual hydrology and biogeochemical dynamics across entire ecosystems. We report on a distributed sensor system for subsurface dissolved oxygen (DO) measurements used to investigate the role DO plays in catalyzing environmentally important biogeochemical reactions. We have adapted our fluorescence-based dissolved oxygen (DO) sensing technology for direct field measurements. Our optical DO probes can be deployed in fresh/salt water or be buried directly into soil/sediment for in-situ, concurrent observations of DO and temperature. A prototype network of four DO/temperature probes has been deployed in the East River watershed in Colorado, at the Berkeley Lab watershed function Scientific Focus Area, to provide high resolution monitoring of dissolved oxygen dynamics associated with ground/surface water exchange in the hyporheic zone. The system operates autonomously and on solar power, transmitting data over wireless networks to remote servers, providing DO and temperature data at 5 minute intervals. To better inform models of the watershed dynamics our data sets include meteorological parameters such as barometric pressure and air temperature. The sensor network has been operating continuously without human intervention for a yearlong period starting August 2017, including several freeze/thaw cycles of the river and the buried probes. We are demonstrating a scalable system for extended in-situ hydrology studies capable of operating in both river and hyporheic zones. Our goal is to enable cost and labor effective systems-scale maintenance-free remote observations of DO and other environmental parameters.
B53K-2207: Spatial and temporal dynamics of nitrogen in a mountainous watershed
Friday, December 14, 2018
1:40 PM - 6:00 PM, Walter E Washington Convention Center Hall A-C (Poster Hall)

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Presenter: Nicholas Bouskill

Abstract: Mountainous watersheds are characterized by substantial heterogeneity in geomorphology, soil texture, and vegetation that determine hydrological flow paths and residence times through distinct catchment subsystems. Despite advances in understanding the spatial and temporal drivers of biogeochemical cycling within snowmelt-dominated ecosystems, knowledge gaps remain. Here we describe ongoing work employing a combination field and laboratory approaches alongside multi-scale modeling to characterize and quantify the sources, transformations, and sinks of nitrogen, a major limiting nutrient, within the East River (CO) watershed. This work focuses on two distinct spatial scales, a hillslope to floodplain transect, and across the whole watershed. At the hillslope scale, we employ a combination of geochemistry, isotope geochemistry and molecular microbiology to identify and quantify specific mechanisms regulating the input (e.g., nitrogen fixation, Mancos shale weathering, or atmospheric deposition), retention (plant and microbial accumulation), transformation (mineralization, nitrification) and loss (denitrification or hydrological export) of nitrogen across temporal aridity gradients (capturing baseflow, snowmelt, drought, and monsoonal precipitation). At the scale of the watershed we use a semi-distributed mechanistic model to ask the question of how broad features of the landscape (e.g., topography, river sinuosity, soil properties) and biology determine the export of nitrogen (as NO3- or organic nitrogen) during distinct periods of the hydrograph. Our model output is benchmarked against high-resolution nitrate and organic nitrogen flux data collected along the East River and major tributaries over 3+ years. Overall, this work intends to improve understanding of the feedback between hydrological perturbation (in the formation and loss of snowpack) and biogeochemical processes to improve predictions of nitrogen export at the watershed scale.