Poster Abstracts

1. Evaluating complex groundwater controls using an integrated hydrologic model of the Continental US

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We assess complex spatial patterns in the physical controls of groundwater depth and flux using results from an integrated groundwater surface water simulation of the majority of the continental US. Results illustrate clear multi scale behavior and regional shifts in the relative control of topography, geology and climate on water table depth and groundwater flux. In agreement with previous studies, this groundwater simulation demonstrates relatively greater topographic control and more significant groundwater exchanges with streams in the arid west than in the humid east. We also apply a novel, k-regression algorithm to the simulated system to simultaneously identify spatial subsets of grid cells with similar relationships between explanatory variables and groundwater metrics while quantifying behavior using multiple linear regression. The combination of this statistical approach with the large-scale, high-resolution groundwater simulation allows us to quantitatively evaluate groundwater behavior across an unprecedented range of climates and physical settings. Results highlight complex spatial patterns in the relationships between groundwater and controlling variables; further demonstrating the historic difficulty in developing spatially contiguous classifications of groundwater behavior. This work highlights the potential for integrated hydrologic models to improve our ability to simplify large heterogeneous systems.

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2. An Evaluation of Extratropical Cyclone Statistics in CESM Using CLIVAR-type Experiments

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Extratropical cyclones (ETCs) are phenomena associated with transient low-pressure systems occurring in the mid-latitudes, known for producing damaging levels of wind, precipitation, low temperatures, and flooding. ETC statistics from the Community Earth System Model (CESM) are assessed using an automated detection and characterization-based approach. This approach is applied to multi-year global simulations with static climatological forcing using experiments developed by the US Climate Variability and Predictability (CLIVAR) project. The CLIVAR experiments include (a) present-day greenhouse gas concentration and sea surface temperatures (SSTs), (b) doubled atmospheric carbon dioxide concentration, (c) increased global SSTs by 2 degrees, and (d) a combination of (b) and (c). These configurations are simulated using the global Community Atmosphere Model (CAM) version 5.1 at two horizontal resolutions, approximately 100 km and 25 km at the equator. Across all detection schemes and resolutions, we find statistical significance for decreasing extratropical cyclone counts in both hemispheres when SSTs increase by 2 degrees and when elevated SSTs are coupled with a doubling of carbon dioxide.

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3. Resolving Spatiotemporal Climate Change Impacts to San Joaquin Basin Hydrology

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Predicted changes to California's climate over the coming decades are expected to affect distribution, timing, and type of precipitation. This shift in timing and amount of water, particularly that originating from mountain sources, will affect the hydrology of the intensively farmed Central Valley and reliability of supply for growing urban areas on the coast and in the valley. Previous studies have assessed potential impacts of future climate scenarios on Sierra mountain and central valley hydrology through GCM-LSM coupling as well as lumped and semi-distributed hydrologic models. However, little work has been done to simulate the propagation of potential climate change impacts through the full hydrologic system at a refined spatial and temporal resolution in a manner that fully captures the mechanistic interconnection between the surface and subsurface. The integrated hydrologic model ParFlow, coupled with the land surface model CLM, is used in this study to evaluate the impact of changed climate scenarios over the San Joaquin basin in central California at 1 km horizontal resolution. Simulation results allow diagnosis of impacts to critical water budget components including streamflow, groundwater-surface water exchange, and valley recharge.

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4. Tempest: Mesoscale Test Validation and the Effect of Order of Accuracy on Pressure Gradient Errors

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Climate and weather simulations are steadily pushing below 10 km of horizontal resolution. This change has the primary effect of invalidating the hydrostatic approximation often used to simulate large scale weather systems. Here, we present a new method based on finite elements to discretize the vertical dynamics of the non-hydrostatic atmosphere. In particular, we look at the so-called pressure gradient force errors that occur in the presence of steep topography. Lastly, we outline a few of the questions that remain in the development of high-order methods for atmospheric simulation.

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5. Alternative Water Management Increases Water Use Efficiency, Decreases Greenhouse Gas Emissions, and Reduces Arsenic Uptake in Rice

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There is increasing pressure on agricultural systems to reduce their environmental impact while maintaining crop productivity, especially given the global nature of many environmental consequences. Agriculture is responsible for a significant portion of anthropogenic greenhouse gas (GHG) emissions. Rice cultivation has a higher global warming potential (GWP) than other cereal crops, largely due to the high methane (CH4) emissions associated with continuous flooding. Alternate wetting and drying (AWD) of fields has been shown to significantly reduce CH4 emissions, but its effects on nitrous oxide (N2O) emissions and rice yield have been more variable. In this study, the CH4 and N2O emissions, yield, water use, and N fertilizer responses were evaluated in California and Arkansas for conventional continuously flooded fields and different AWD management practices. In California AWD reduced CH4 emissions by approximately 60 – 80%, while N2O emissions accounted for less than 20% of the total GWP. As there was no difference in grain yields or N fertilizer response between AWD and conventional management practices, AWD reduced yield-scaled GWP by 60 – 75%. In Arkansas AWD significantly reduced CH4 emissions while N2O emissions remained low and thus reduced total GWP by 50 – 90%. While rice grain yields for two of the AWD treatments were similar to the conventional yield, the AWD treatment that allowed field to dry the most before re-flooding showed lower grain yields. All AWD treatments showed 20 – 60% lower water use than the conventional system. Overall, proper AWD management practices can significantly reduce GHG emissions, maintain rice grain yields at similar N application rates, and reduce water use.

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6. Investigating the Hydrogeologic Controls on Memory and Feedbacks to Climate Change in Mountain Groundwater Systems: An Integrated Modeling Approach

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Rising global temperatures are profoundly impacting alpine environments by shifting the precipitation type and the timing of peak snowmelt runoff. Uncertainty in the magnitude of these shifts translates to uncertainty in how climate change affects timing of snowmelt runoff, and hence availability of surface water during the remainder of the year. Integrated hydrologic models are useful tools for capturing these feedbacks by closing the loop between atmosphere, land surface, and subsurface dynamics. Recent integrated models have been used to predict streamflow response to climate change in mountain basins, however these models assume that shallow, local flow paths comprise the majority of recharge and baseflow to streams. Several studies have challenged this assumption with discordant groundwater ages and hysteresis loops, suggesting that deep, regional flow paths may play a more substantial role even at the local stream scale. This would have considerable implications for predicted responses to climate change in alpine basins, as deep, regional groundwater would initially buffer perturbations, but exhibit greater memory over the long-term. The goal of this study is to understand how various hydrogeological settings will control the relative feedbacks to climate change. This research uses three simplified, conceptual hillslope models: a fast draining, low storage, granodiorite similar to that of of the Sierra Nevada or Himalayan mountain range, a slow draining, high storage basalt of the Cascade or Andes Range, and a vertically homogeneous base case. The relative response of these hillslopes to three future climate scenarios: warm, warm and dry, and warm and wet are tested using ParFlow, an integrated surface water-groundwater model, coupled with CLM, a land surface model. These models will help quantify the relative feedbacks of deep groundwater in various hydrogeologic settings and will ultimately be scaled up to assess the 3-D, transient response of deep groundwater to climate change in a regional alpine system.

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7. Characterizing Sierra Nevada Snowpack Using Variable-Resolution CESM

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Snowpack is crucial for the western USA, providing around 75% of the total fresh water supply (Cayan et al., 1996) and buffering against seasonal aridity impacts on agricultural, ecosystem, and urban water demands. The resilience of the California water system is largely dependent on natural stores provided by snowpack. This resilience has shown vulnerabilities due to anthropogenic global climate change. Historically, the northern Sierras showed a net decline of 50-75% in snow water equivalent (SWE) while the southern Sierras showed a net accumulation of 30% (Mote et al., 2005). Future trends of SWE highlight that western USA SWE may decline by 40-70% (Pierce and Cayan, 2013), snowfall may decrease by 25-40% (Pierce and Cayan, 2013), and more winter storms may tend towards rain rather than snow (Bales et al., 2006). The volatility of Sierran snowpack presents a need for scientific tools to help water managers and policy makers assess current and future trends. A burgeoning tool to analyze these trends comes in the form of variable-resolution global climate models (VRGCMs). VRGCMs serve as a bridge between regional and global models and provide added resolution in areas of need, eliminate lateral boundary forcings, provide model runtime speed up, and utilize a common dynamical core, physics scheme and sub-grid scale parameterization package. A cubed-sphere variable-resolution grid with 28km and 14km horizontal resolutions over the western USA were developed for use within the Community Earth System Model (CESM) atmospheric (CAM5.3) and land (CLM4.0) components. A 25-year climatology (1980-2005) was assessed across a multitude of model, observational, and reanalysis datasets for major snowpack metrics such as snow water equivalent (SWE), snow depth (SNOWDP), snow cover (SNOWC), snowfall (SNOWF) and two-meter surface temperature (2mST). The variable-resolution framework showed comparable results to other widely used GCMs and RCMs and lends itself well to conducting future RCP scenario simulations to assess climate change and water availability impacts. The RCP simulations are currently in the preliminary stages.

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9. Characterizing Past and Future Flood Regimes of California's Cosumnes River: A Hydroinformatic Approach

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As the only major undammed river on the west slope of California's Sierra Nevada, with over 100 years of USGS streamflow data, and the location of several floodplain conservation and restoration efforts, the Cosumnes River offers a unique opportunity to study connections between a river's flow regime and floodplain functions. Flow regime, including frequency and magnitude of floods, and its interaction with the surrounding landscape are primary drivers of floodplain structure and ecosystem dynamics. However, these floodplain processes and functions are often altered by water management schemes, land uses, and hydroclimatic alteration induced by climate warming. Improved understanding of ecologically relevant aspects of flow regime and potential future alteration is central to managing floodplain ecosystems and their services. In order to describe the inundation regime of the lower Cosumnes River floodplain, California, this research moves beyond flood frequency analysis to examine other flood event characteristics and identify flood types using statistical cluster analysis. Floods are characterized using metrics of ecological relevance, such as magnitude, timing, duration, and total volume. To explore potential effects of climate change, non-stationary Generalized Extreme Value models are fit to historical floods based on temperature and precipitation at the monthly scale. Temperature and precipitation variables from downscaled Global Climate Models of the Coupled Model Intercomparison Project Phase-5 are then applied to develop flood distributions for climate change scenarios. These results are used to adjust the magnitude of clustered flood events identified in the historical record, and the sensitivity of the inundation regime to these changes is assessed. This research provides useful scientific insights for management and restoration efforts within the Cosumnes watershed and demonstrates the utility of applying these methods to other floodplain systems.

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