

Western Tri-State Consortium EPSCoR Innovation Working Group

Topic: Identifying the Most Relevant Spatial and Temporal Scales of Climate Change with Respect to Surface Hydrologic Processes

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Problem Statement

Predicting regional climate change and its impacts is of vital importance as we journey into a world of non-stationarity. Indeed, the IPCC, NSF, DOE, and many other organizations have identified regional climate change as one of the grand challenges humans will face in the 21st century. However, key questions remain on how best to determine the impacts of regional climate change. The goal of our IWG was to outline a clear path forward in approaching one of these key questions: what are the most relevant spatial and temporal scales of climate change with respect to surface hydrologic processes? To achieve this goal, experts in a broad swath of earth science fields congregated in a three-day workshop to distill what the essential problems and possible solutions are, identify who would be best suited to undertake these issues, and which grant opportunities and granting agencies would be more appropriate for the proposed research topics. Our IWG will help further our understanding of the effects climate change will have on our mountain sources of water, and as warming trends continue and droughts increase in intensity and frequency in the Western U.S., this will become of the utmost importance.

Ideas and Outcomes

This IWG was designed to bring together a multi-disciplinary group of atmospheric scientists, hydrologists, and ecohydrologists to tackle the critical issue at hand: identifying the most relevant spatial and temporal scales of climate change with respect to surface hydrologic processes. We determined that the following two questions are aspects of this topic that are key to further understanding climate change impacts and the scales at which they operate:

- 1) What role does storage (soil moisture, vadose zone, groundwater) play as a function of scale, will it change with dynamic climate, vegetation, and population, and how can it be manipulated to adapt to climate change?
 - a) To what extent do changes in storage upscale to climate variability?
 - b) How do response times (time constants) change with climate change?
 - c) At what time and space scales do interactions between different human and natural systems become most amplified?

- 2) What are triggers for drastic ecohydrological changes and at what spatial and temporal scale are they active?
 - a) At what spatial and temporal scales do thresholds in ecosystem vulnerability occur?
 - b) How will the frequency/intensity of episodic events change under a changed climate?
 - c) How will changes in spatial distribution of rain versus snow affect hydrologic response?

It was our concrete objective to develop and write proposals on the identified key issues by the June/July 2010 deadlines for NSF, NOAA, and/or NASA programs, which we are still targeting. Indeed, to answer the first question above, we are preparing a proposal for NSF RFP 10-554, Decadal and Regional Climate Prediction (DRCP) using Earth System Models (EaSM), due June 25, 2010. Our proposed title is, "The capacity and resiliency of groundwater storage to mitigate/modulate the regional and decadal impacts of climate change." Our hypothesis is that

failure to understand the role of groundwater in the climate system and incorporate the knowledge into climate models may lead to catastrophic consequences for water resources management. Our idea is well suited for the NSF DRCP-EaSM program, in which the goals are to: address key problems critical to linking relevant Earth system processes over a variety of spatial and temporal scales; and dramatically improve our predictive capabilities as well as our understanding of how small and large scale processes lead to non-linearities and activation thresholds.

We chose four distinct study sites to focus our efforts: the Santa Rosa, Humboldt, Boise River, and Rio Hondo Basins. At each site, we will develop a GSFLOW model, which is a Coupled Ground water and Surface-water FLOW model based on the USGS Precipitation-Runoff Modeling System (PRMS) and Modular Ground Water Flow Model (MODFLOW-2005). The coupled models will be driven by climate data that has been dynamically downscaled via the Weather Research and Forecasting Model (WRF), and that will convey a large array of IPCC climate change scenarios. After the models are built, we will either simplify or remove the vadose and regional groundwater zones to determine the impact of storage on surface water and energy fluxes for the various climate change scenarios, which will then be compared to the WRF surface fluxes to close the climate, groundwater, climate feedback loop. The unique aspect of our approach is in the synthesis across the various sites, such that we can identify the impacts of snow, location in the basin (headwater vs. valley), elevation, terrain, land use, water management systems, etc. A critical aspect of our research will be to potentially revise the land surface model within WRF to better represent groundwater processes.

Regarding the second question above, our hypothesis is that the use of multiple indicators of climate change, diagnosing high risk systems, will provide a more robust picture of climate change impacts, and that these indicators are strongly related to water. The unique aspect of our approach is to develop a technique to compare the many types of indicators, including creating conceptual models of how indicators may be related and assessing uncertainties associated with the indicators. Communicating the results of our investigation to stakeholders and the public will be used as a metric of the success of current environmental policies. Throughout our discussions, we determined that there was a need for additional research expertise in our group, particularly in the areas of ecology, biology, and statistics. Thus, we are attacking this question as follows:

- 1) We proposed a session at the Fall 2010 AGU Meeting, entitled, “Detecting thresholds of ecosystem resilience in a changing climate.” Our motivation was to survey the most recent research and interact with researchers active in this area by encouraging contributions from ecologists, biologists, hydrologists, socio-economists, atmospheric scientists, and remote sensing.
- 2) We are proposing a Western Tri-State Consortium IWG to further develop our idea, “Complementary indicators of ecohydrological thresholds of climate change.” The IWG proposal deadline is July 1, 2010, and we tentatively set the meeting to occur after AGU to include researchers we connect with during our session.

The IWG enabled our team to formulate innovative ideas centered on our broad theme and facilitated interactions among trans-disciplinary scientists, opening the door to future research activities – some stated here and some not. The stated research ideas meet an EPSCoR anticipated function by using EPSCoR infrastructure to advance groundbreaking, transformative research. Based on comments after the meeting, all of the participants felt the IWG was a great success, are excited about working together, and have plans for future collaborations.

Details of IWG Meeting

The IWG was held from May 25-27, 2010 at the Valles Caldera in Northern New Mexico. Our group of participants was from both EPSCoR states (New Mexico, Idaho, and Nevada) and a non-EPSCoR state (Colorado).

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¹ CSDMS - Community Surface Dynamics Modeling System