Project Summary

1. Project Overview

Our limited ability to predict the water cycle in weather, climate, and Earth System models (ESMs) is at least partially attributed to inadequate representations of the land branch of the water cycle. The hydrology community has traditionally focused on plot, hillslope and catchment scales, and thus their collective wisdom has not been fully tapped to advance large-scale water cycle research. To bridge this community and knowledge gap, we propose a collaborative project between CUAHSI (Consortium of Universities for the Advancement of Hydrologic Science, Inc.) representing the academic hydrology community, and NCAR (National Center for Atmospheric Research) leading weather, climate and ESM development and applications. We propose to form a Hydrology Process Team (HPT) with the following focused tasks: (1) A first synthesis workshop at NCAR with ~30 leading scientists from the hydrology and atmospheric science communities; the objective is to develop state-of-science synthesis of hydrologic processes and recommend best ways to represent them in large-scale models; (2) Implement synthesis recommendations in the Community Land Model (CLM), supporting a postdoc and a software engineer to complete the coding; (3) Test/benchmark progress in CLM water cycle simulations with observations, bringing in the rich set of hydrologic observations yet to be tapped for testing large-scale water cycle models, e.g., from the NSF-funded Critical Zone Observatories (CZOs), and the research watersheds of USDA, USGS and USFS; (4) Conduct CLM/CESM simulations to demonstrate new model capabilities in addressing long-standing science questions; and (5) A final synthesis workshop; based on the results of benchmarking and demonstration of new science capabilities (or lack of), the synthesis team will analyze model deficiencies and recommend future model development and observation priorities.

2. Intellectual Merit (Pertaining to INSPIRE)

Pertaining to INSPIRE, the proposed project emphasizes the integration of diverse communities, disciplines, processes and scales with a common interest in large-scale water cycle. As such, its scope spans more than one science area under existing NSF programs. The interdisciplinary nature, its potential to transform model capabilities to predict the water cycle and its functions in the Earth's climate system, and the potential high risk arising from coordinating among multiple members and communities, makes it an appropriate candidate for the NSF INSPIRE program.

The project's potentially transformative power is exemplified by the success of the Climate Process Teams (CPTs) over the past decade, which has rallied the climate science communities to overcome difficult and long-standing challenges in advancing climate models. Although the land branch of the water cycle was not targeted by the past CPTs due to the lack of participation by the hydrologic science community in large-scale research, the opportunity is now present for us to take on this challenge.

3. Broader Impacts

(1) A new generation of large-scale water cycle models can directly impact our answers to many society-relevant questions such as freshwater availability in the future. (2) We will strive to engage early-career scientists as leaders; the large-picture, synthesis-type, trans-discipline and cutting-edge research spans the entire discovery process of observation, theory, model and application, offering an exciting and wholesome environment to learn and grow. (3) The project will contribute to the CLM/CESM tutorial for the user community by enriching its water cycle contents and broadening ESM applications to water cycle research. (4) Through the project we build a community practice to break disciplinary boundaries and cooperate on key science challenges facing all; there are few better examples than the water cycle that truly transcend and connect all branches of Earth science through the movement of water. (5) The synthesis products will inform all large-scale model advances beyond CLM/CESM and mark a milestone in large-scale water cycle research. (6) The project will be a pilot for the CUAHSI community modeling initiative, building a culture to support other community models such as a community watershed model.