The Community Hydrologic Modeling Platform:
An EarthCube White Paper Describing the Vision for CHyMP

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The goal of this white paper is to describe the vision for the Community Hydrologic Modeling Platform (CHyMP). CHyMP is a CUAHSI-led effort to accelerate the development of the nation's hydrologic modeling assets in support of advancing the water sciences and the ability to address key water-related questions of societal relevance. The CHyMP effort, a term which we use broadly to represent a coordinated and comprehensive model, data, human and cyberinfrastructure (CI) development activity, has recently completed its workshop stage. Reports from the Scoping (*Famiglietti et al*., 2009), Community (*Famiglietti et al*., 2010) and Implementation (*Famiglietti et al*., 2011) workshops are available at cuahsi.org. Brief meeting reports are also given by *Famiglietti et al.* (2008) and *Arrigo* (2011). The goal of this white paper is to provide a brief synopsis of CHyMP, including certain elements that could be integrated within EarthCube. It is also meant to provide a broader overview of how the white papers by *Murdoch et al.* (2011), *Fan et al.* (2011) and *Hooper* (2011) fit within vision for CHyMP.

At its core, CHyMP proposes to construct both a model development or CI platform, and a Community Water Model (CWM). Other key, related activities will also be required, for example, benchmarking and the development of a comprehensive description of continental hydrography and hydrostratigraphy.

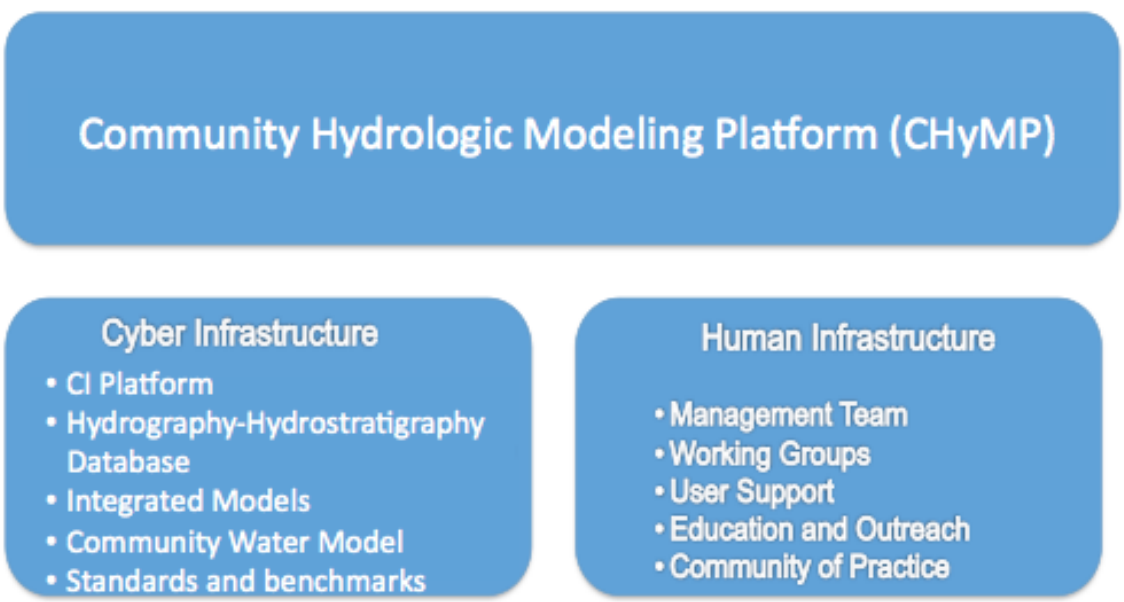

Figure 1*. A framework for the major elements of CHyMP*

Figure 1 shows a schematic of proposed elements of CHyMP.

Three broad activities are described here in order to help define what EarthCube can become. These include the CWM, the CI platform, and the hydrography-hydrostratigraphy dataset. Their tight integration, as well as their relation to other, ongoing research projects, is also described. This integration offers what we believe is an important realization of EarthCube, namely the three dimensional representation of the terrestrial water environment using tightly-coupled data and models.

A Community Water Model for the water sciences

Simply stated, the water sciences lack a community model analogous to the WRF (Weather Research and Forecasting) model in meteorology, or the CESM (Community Earth System Model) in global climate modeling. It will be difficult for the water sciences to advance rapidly, or to keep pace with the need to adapt and evolve water management strategies, if each new PI project requires the re-development of an existing code (which for several reasons, may be inaccessible). With the CWM we propose to develop, distribute and support a modeling framework that a) integrates all major components of the natural and managed water cycles; b) allows for process representation across multiple scales (i.e. upscaling and downscaling) up to the continental scale; and c) can readily link to models of other disciplines, for example, in climate or biogeochemistry. The full vision for all model capabilities is given in the CHyMP workshop reports.

Other important and distinguishing features of the CWM are 1) the incorporation of multiphysics modeling as an option in the CWM framework (Famiglietti et al, 2008, 2009; and see the EarthCube paper by Murdoch et al., 2011); 2) that a broad swath of the community will ultimately have access to a continental-scale modeling framework; and 3) that the CWM can be used for multiple process representation in addition to water cycle processes (e.g. carbon and nutrient transport in rivers) via its physically-based framework and through explicit linkage capabilities to models from other disciplines.

Such a model would be constructed and evolved by the water science community, and would ultimately serve as a reference model for other disciplines. For example, we anticipate that the climate community would look to the CWM for input on the performance of its land surface models, and for the development of new process modules. Furthermore, we believe that the water sciences will continue to maintain a strong need for both PI-models and a community model. Such has been the case in the atmospheric sciences, where PI's lead innovations, which are ultimately incorporated, via an open working group structure, into the community model.

Finally, a CWM clearly points to other critical needs within the CHyMP effort, namely a CI platform, a far better description of the terrestrial hydrosphere, benchmarking and supporting datasets.

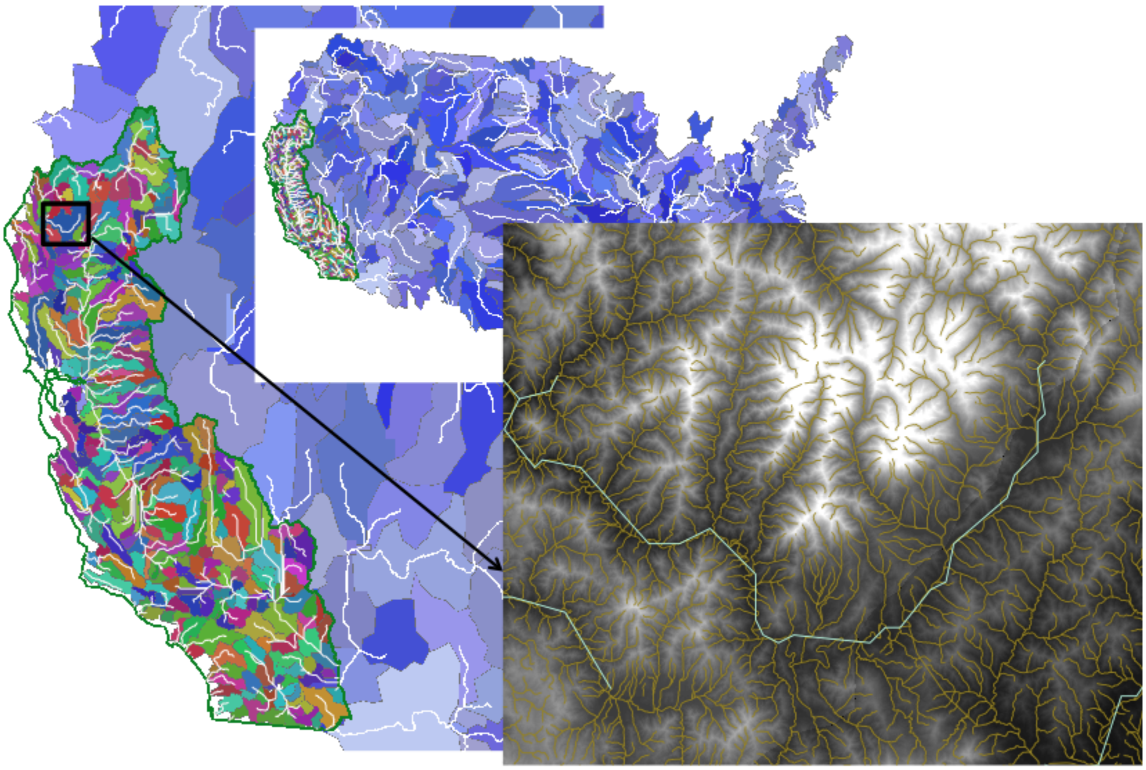

Figure 2. The hierarchical structure of river basins offers a natural multi-scale framework for a CWM.

CyberInfrastructure platform

The Murdoch et al. (2011) white paper describes a vision for a CI platform. Such a platform will be essential for robust, reproducible model development, and as model-building tool for a wide swath of the water science community. The CHyMP workshops have clearly shown that many model development platforms are already in existence, so that CHyMP will not necessarily need to develop a new one. Rather, CHyMP will evaluate existing platforms, like that used by the CSDMS, in order to leverage NSF's considerable investment in that activity. Moreover, it will be important to include multiphysics solvers as well as component-based models and model elements on the platform. The Murdoch et al. (2011) paper describes the CI platform in more detail.

Hydrography and hydrostratigraphy

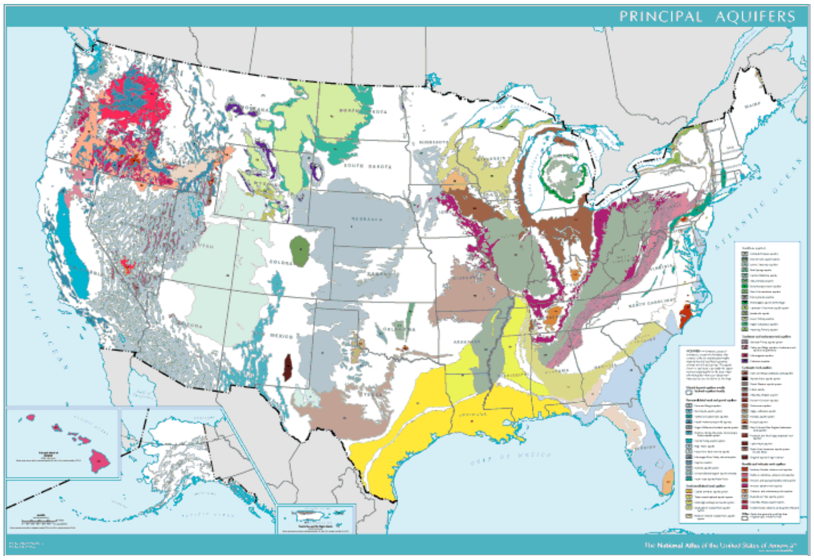

Figure 3. Principal aquifers of the United States. Continental-scale datasets of soils and aquifers are typically limited to two dimensions.

The Fan et al. (2011) white paper describes a vision for a 3-D digital, shallow crust. It is accurate to state that the scientific and environmental planning communities cannot answer critical questions of water sustainability unless we know how much water is actually stored on land, including on its surface, in soils and in aquifers. Current assessments are based on gross assumptions dating from the 1960's and '70's and are largely unrealistic. Therefore, an absolutely essential step in assessing water availability and for building accurate simulation tools is to compile state-wide, national and global datasets of soil depth-to-bedrock, aquifer thickness, and the associated soil and aquifer descriptive parameters. Available datasets must be identified, retrieved and compiled using common formats. Modern methods must be applied (e.g. seismic arrays, isotopic approaches, drilling) in unknown regions. The importance and scope of this task should not be underestimated. Bottled water is now more expensive than oil, yet the water environment remains embarrassingly poorly characterized, posing a serious limitation to advancing understanding of the terrestrial hydrosphere.

Other needs

EarthCube offers the possibility for major advances in the digital description and simulation of the terrestrial water environment, while simultaneously providing much-needed tools for water science and related researchers. The tight model-data coupling in the EarthCube environment will require close ties with dataset and platform activities mentioned here. Prototypes for this tight coupling are in development at the University of California Center for Hydrologic Modeling and demonstrate feasibility for a larger-scale CHyMP effort. Figure 4 shows a

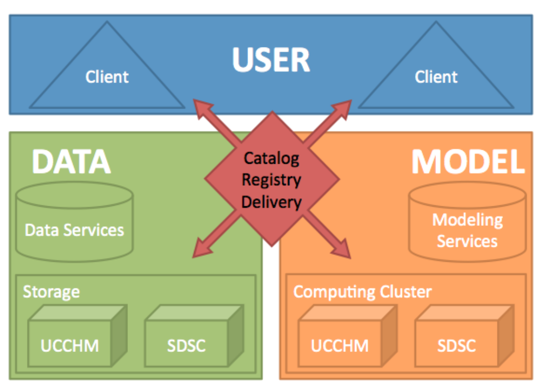

Figure 4. HIS-UCCHM prototype data-model server.

schematic for the coupling between a University of California Community Water Model, and an implementation of CUAHSI-HIS for the state.

Other key activities for CHyMP will include standardized datasets for model forcing and for parameter estimation, benchmarking activities to assess model performance, and a working group structure for community engagement. More details can be found in the CHyMP workshop reports and the previously mentioned white papers.

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