The Community Hydrologic Modeling Platform (CHyMP and CSDMS): Thanks for doing all the hard work

Jay Famiglietti
UC Center for Hydrologic Modeling, University of California, Irvine, USA

Presented at the
CSDMS Modeling for Environmental Change Workshop
14-17 October, 2010

UNIVERSITY OF CALIFORNIA CENTER FOR HYDROLOGIC MODELING

Hydrologic modeling is at a crossroads:

The scope of the problems that we must address far outstrips our current capabilities to address them

- Climate and population growth are already posing significant threats to a reliable supply of clean, fresh water in many regions around the world.
- IPCC models predict, and observations are now starting to show, that the water cycle is intensifying, which means more intense precipitation at high and low latitudes, along with mid-latitude drying and prolonged drought
- Groundwater depletion is a global phenomenon
- And, to make matters worse, we really don't know how much water we have and how its supply/distribution is changing in space and time

Consequently there is a critical need to accelerate the development of the next generation of hydrological models in order to address priority questions like:

- *What are the impacts of changing climate, population growth and land use change on the availability of freshwater resources? Will there be enough available fresh water for the U. S. and global populations in the decades to come?*
- *How can water management best adapt to changes in global and regional hydrology, for example, the decreasing snowpack in the Western U. S.? What are the local- to global-scale feedbacks of new management strategies?*
- *What are the full 'Earth system' implications (e.g. regional climate, ecological and food production changes) for large-scale energy production alternatives that are linked to the water cycle, e.g. biofuels? What are the water requirements of significantly increased feedstock production?*
- *Is increased water storage on land a credible component of a strategy to manage current rates of global sea level rise?*

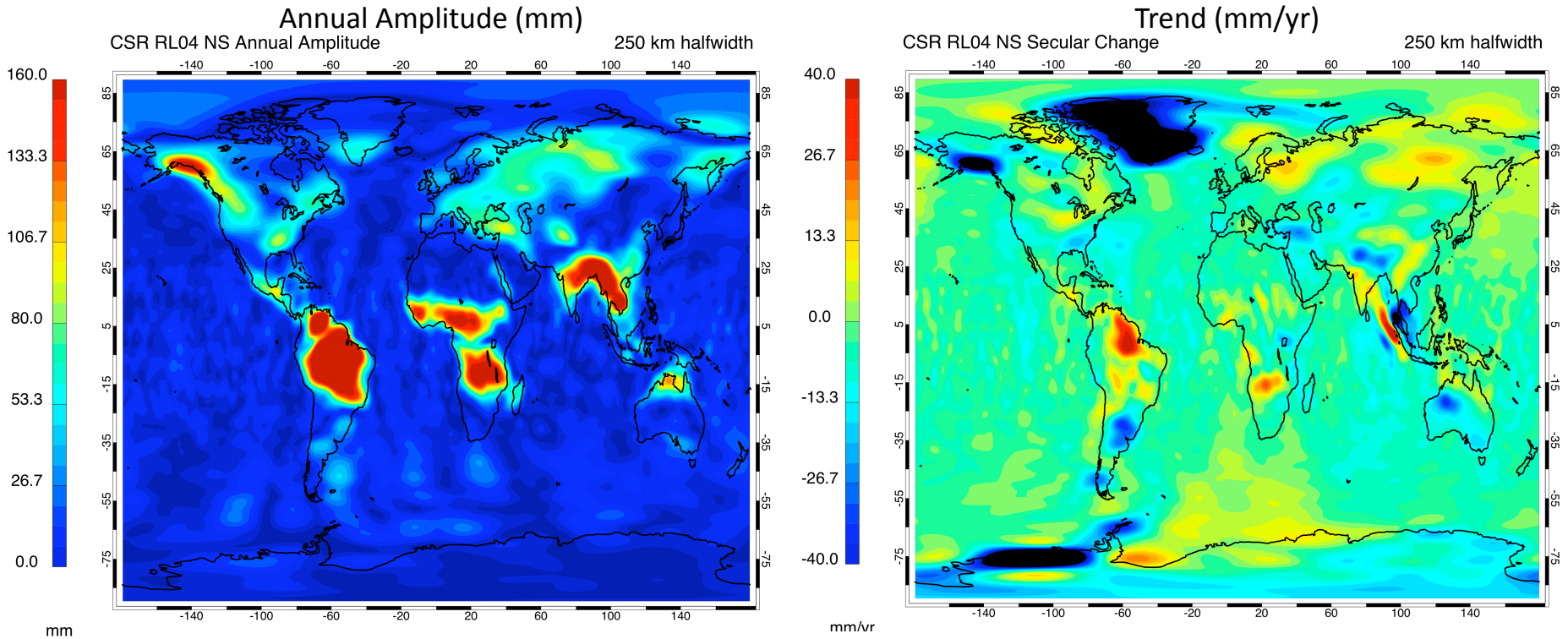
Moreover, remote sensing is revealing a picture of the first look at the water landscape that points to a very clear picture of

- The fingerprint of human water management
- Changes in the intensity of the water cycle

Here are some examples from my own research using data from the GRACE mission

Amplitude and Trend of Terrestrial Water Storage from GRACE (~2002-2009)

UCCHM

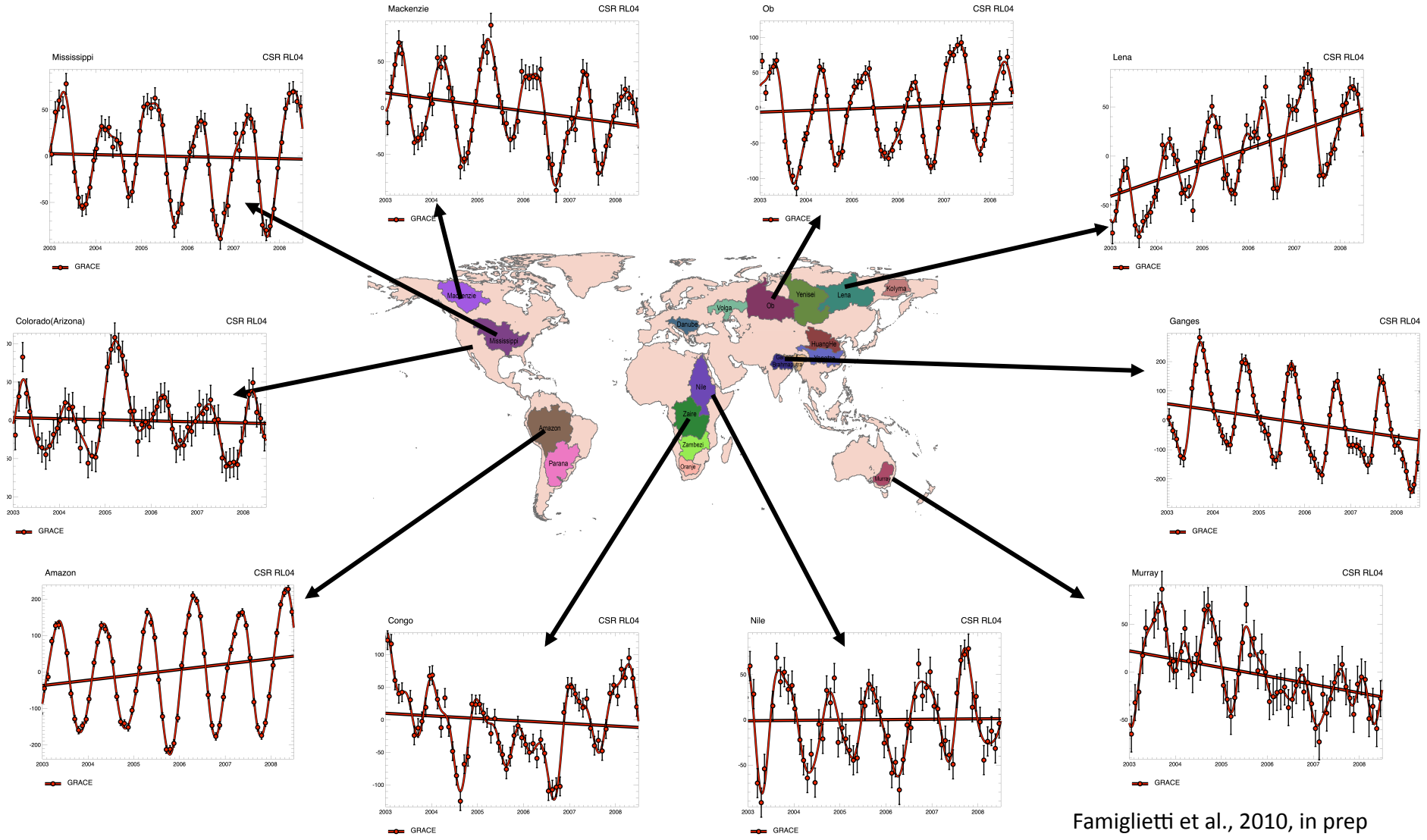


- *First global look at magnitude of water storage variations*
- *Reveal important information on storage that is typically not captured by models: glacial melt, reservoir release, groundwater mining, etc.*
- *Important trends emerging*
- *Data are ripe for understanding hydroclimatological variations, for data assimilation, for pointing to model enhancements, and for informing sustainable water management*

UCIrvine
University of California, Irvine

UCCHM

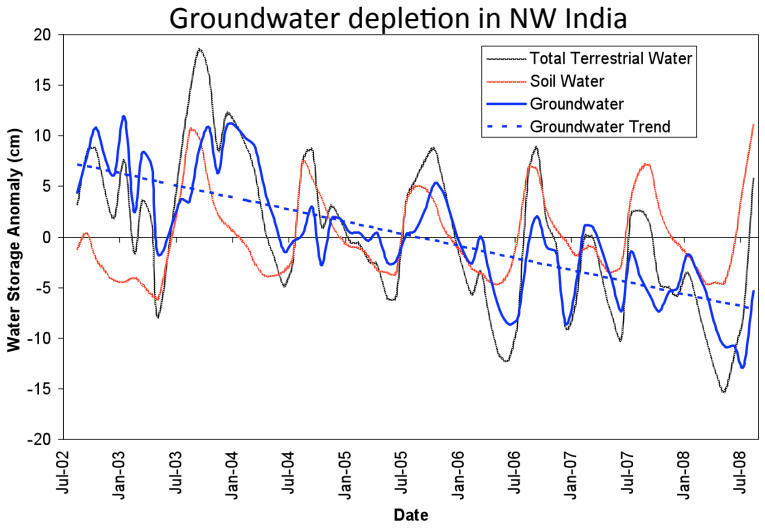
Interannual variations and emerging trends from GRACE, 2002-2008



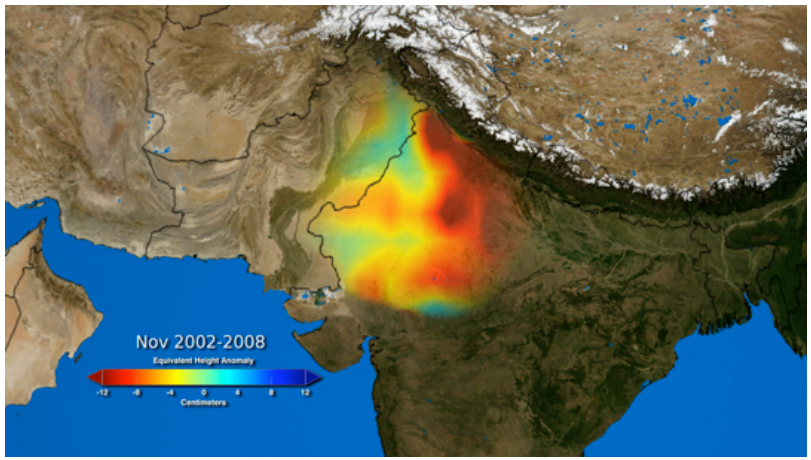
Famiglietti et al., 2010, in prep

Data from the GRACE mission have been used in several previous studies to monitor groundwater storage changes, including those in:

- Illinois [*Yeh et al.,* 2006]
- Mississippi River Basin [*Rodell et al.*, 2007]
- High Plains Aquifer [*Strassburg et al.*, 2007]
- Oklahoma [*Swenson et al.*, 2008]
- India [*Rodell et al.*, 2009, *Tiwari et al.*, 2009]



Rodell et al., 2009



Pattern of groundwater depletion in NW India

Arguably, our models are not up to the task of addressing these and a host of other questions related to climate, energy, environment, sustainability, security, etc

- New paradigms are required to exploit advances in computing power, structure, the evolving structure of the internet, and the access to information
- More comprehensive integration of model processes and of natural and human systems is required.
- It is time to move into the next-generation of models that build on the firm foundation of the current generation

What is CHyMP?

UCCHM

- The Community Hydrologic Modeling Platform (CHyMP) effort is a new, grassroots effort to build the community and secure the funding base to accelerate the development of integrated continental-to-global scale model community models in order to address the issues we have just discussed, as well as many, many more

- CHyMP Vision -- Seamless prediction across spatial and temporal scales of the quantity and quality of water at every point on and in the land surface

- We are very much looking at an NCAR-like community modeling activity that includes model research and development, access to high performance computing, regular release of codes, a working group structure for input and feedback, benchmarking and standards, regular workshops, etc

- We are only in the workshop stage, in fact following the CSDMS path a few community workshops (Rationale, Science, Implementation) and then moving forward to NSF – perhaps where CSDMS was a decade ago

- A strong tie to CSDMS will be essential

What is CHyMP?

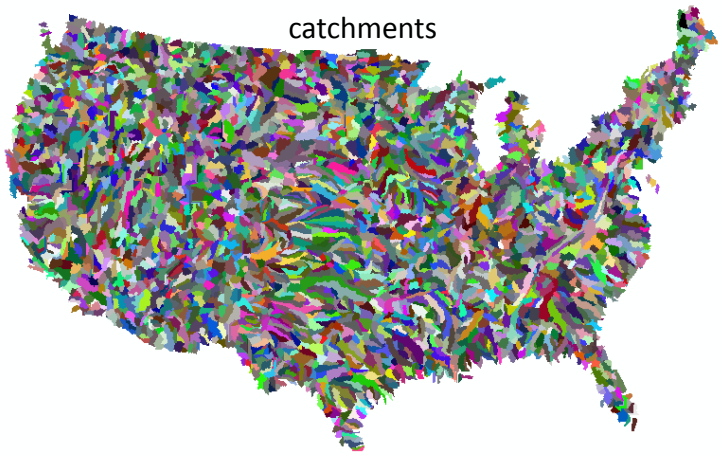
UCCHM

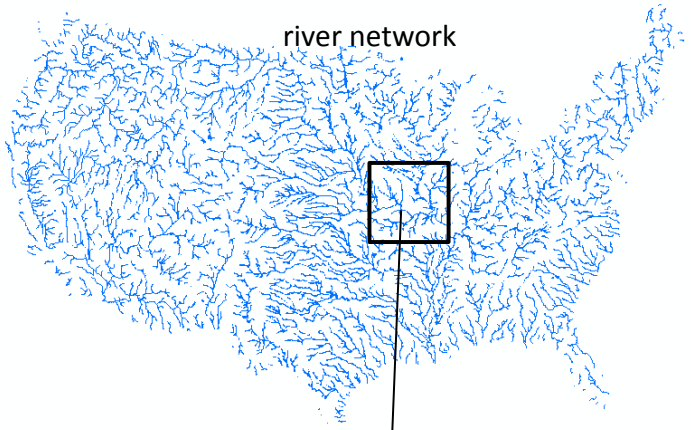
We expect that the major elements of CHyMP will be:

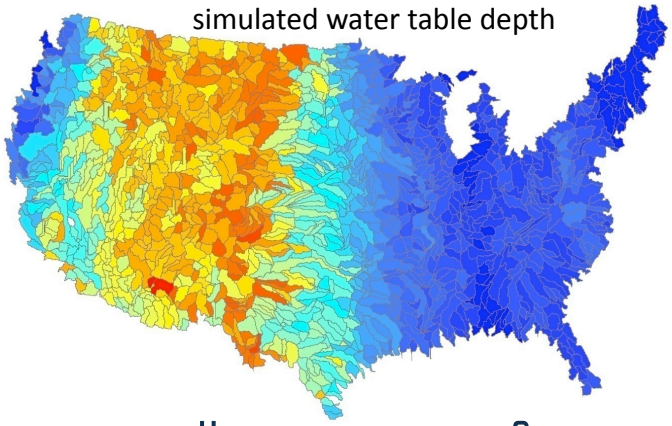
- A platform of modular components that can be linked together to form integrated water cycle models across of range of space-time scales
- The development of National Water Model that includes all major components of the natural and managed hydrologic cycle
- The development of key datasets that are currently missing, e.g. continental hydrostratigraphy, including soil depth
- Close integration with other CUAHSI activities, in particular Water Data Services, and other community efforts including CSDMS, NCAR CCSM/CLM, NOAA CHPS/IWRS, USGS, etc.
- The ability to link to models from other disciplines, including climate, ecology, biogeochemistry, human behavior, economics, etc.
- HPC compatible/scalable and access to high performance computing
- Adoption of standards, development of benchmarks, establishment of Community of Practice
- Community engagement and input through working groups and annual meetings

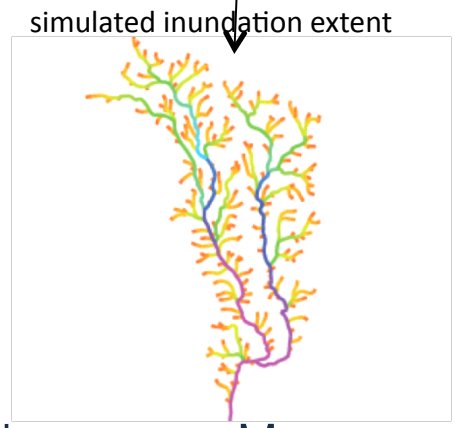
Template for a National Water Model

UCCHM

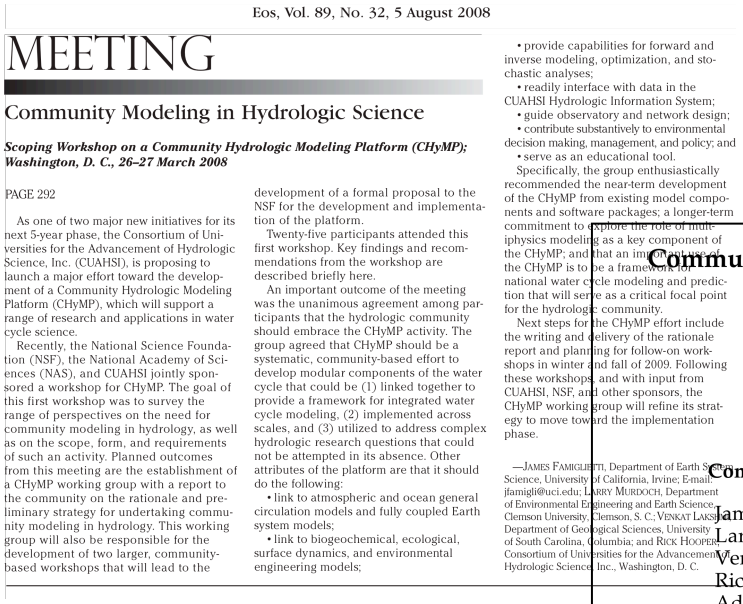








Workshop Reports



Eos, Vol. 89, No. 32, 5 August 2008

MEETING

Community Modeling in Hydrologic Science

Scoping Workshop on a Community Hydrologic Modeling Platform (CHyMP); Washington, D. C., 26–27 March 2008

PAGE 292

As one of two major new initiatives for its next 5-year phase, the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), is proposing to launch a major effort toward the development of a Community Hydrologic Modeling Platform (CHyMP), which will support a range of research and applications in water cycle science.

Recently, the National Science Foundation (NSF), the National Academy of Sciences (NAS), and CUAHSI jointly sponsored a workshop for CHyMP. The goal of this first workshop was to survey the range of perspectives on the need for community modeling in hydrology, as well as on the scope, form, and requirements of such an activity. Planned outcomes from this meeting are the establishment of a CHyMP working group with a report to the community on the rationale and preliminary strategy for undertaking community modeling in hydrology. This working group will also be responsible for the development of two larger, community-based workshops that will lead to the development of a formal proposal to the NSF for the development and implementation of the platform.

Twenty-five participants attended this first workshop. Key findings and recommendations from the workshop are described briefly here.

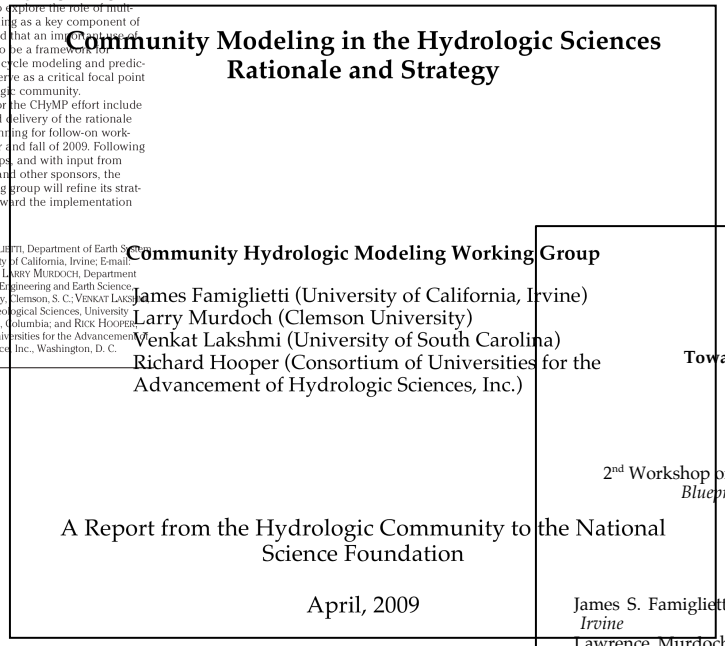
An important outcome of the meeting was the unanimous agreement among participants that the hydrologic community should embrace the CHyMP activity. The group agreed that CHyMP should be a systematic, community-based effort to develop modular components of the water cycle that could be (1) linked together to provide a framework for integrated water cycle modeling, (2) implemented across scales, and (3) utilized to address complex hydrologic research questions that could not be attempted in its absence. Other attributes of the platform are that it should do the following:

- link to atmospheric and ocean general circulation models and fully coupled Earth system models;
- link to biogeochemical, ecological, surface dynamics, and environmental engineering models;
- provide capabilities for forward and inverse modeling, optimization, and stochastic analyses;
- readily interface with data in the CUAHSI Hydrologic Information System;
- guide observatory and network design;
- contribute substantively to environmental decision making, management, and policy; and
- serve as an educational tool.

Specifically, the group enthusiastically recommended the near-term development of the CHyMP from existing model components and software packages; a longer-term commitment to explore the role of multiphysics modeling as a key component of the CHyMP; and that an important purpose of the CHyMP is to be a framework for national water cycle modeling and prediction that will serve as a critical focal point for the hydrologic community.

Next steps for the CHyMP effort include the writing and delivery of the rationale report and planning for follow-on workshops in winter and fall of 2009. Following these workshops, and with input from CUAHSI, NSF, and other sponsors, the CHyMP working group will refine its strategy to move toward the implementation phase.

—James Famiglietti, Department of Earth System Science, University of California, Irvine; E-mail: jfamigli@uci.edu; Larry Murdoch, Department of Environmental Engineering and Earth Science, Clemson University, Clemson, S. C.; Venkat Lakshmi, Department of Geological Sciences, University of South Carolina, Columbia; and Rick Hooper, Consortium of Universities for the Advancement of Hydrologic Science, Inc., Washington, D. C.



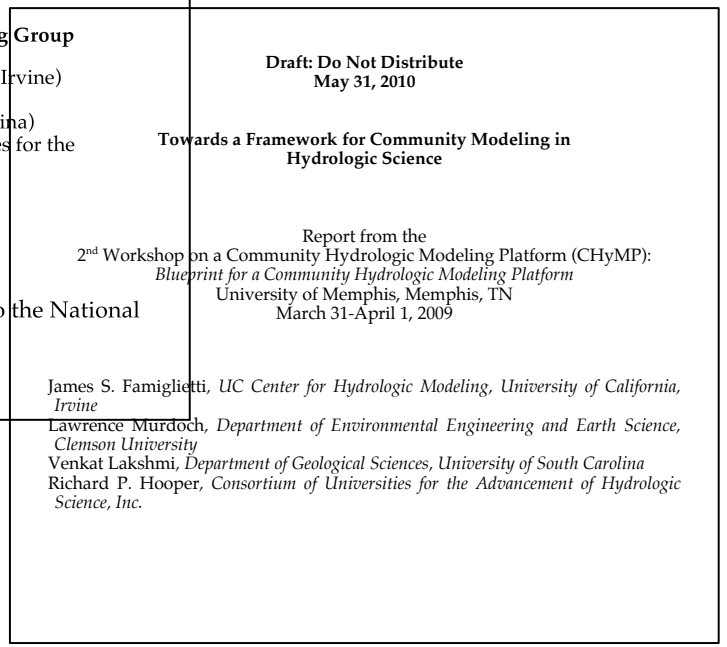
Community Modeling in the Hydrologic Sciences
Rationale and Strategy

Community Hydrologic Modeling Working Group

James Famiglietti (University of California, Irvine)
Larry Murdoch (Clemson University)
Venkat Lakshmi (University of South Carolina)
Richard Hooper (Consortium of Universities for the Advancement of Hydrologic Sciences, Inc.)

A Report from the Hydrologic Community to the National Science Foundation

April, 2009



Draft: Do Not Distribute
May 31, 2010

Towards a Framework for Community Modeling in Hydrologic Science

Report from the
2nd Workshop on a Community Hydrologic Modeling Platform (CHyMP):
Blueprint for a Community Hydrologic Modeling Platform
University of Memphis, Memphis, TN
March 31-April 1, 2009

James S. Famiglietti, *UC Center for Hydrologic Modeling, University of California, Irvine*
Lawrence Murdoch, *Department of Environmental Engineering and Earth Science, Clemson University*
Venkat Lakshmi, *Department of Geological Sciences, University of South Carolina*
Richard P. Hooper, *Consortium of Universities for the Advancement of Hydrologic Science, Inc.*

Reports available at cuahsi.org

Huge potential for collaboration and interaction with CSDMS

UCCHM

Like the surface processes community, the hydrologic community has a critical need for

- improved component models
- fully-integrated models
- a platform for component model coupling
- standards for code development and for coupling

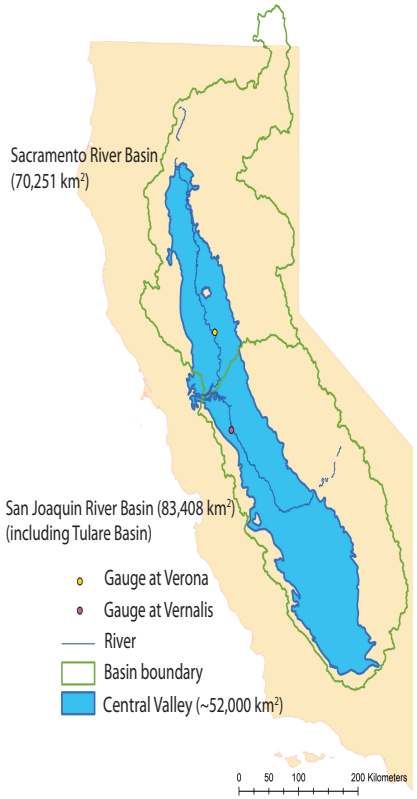
There is no need for CHyMP to reinvent the wheel: it could easily adopt CSDMS standards and architecture as appropriate.

Another area for interaction is dataset development: global soil (depth to bedrock) is a critical gap for large-scale modeling

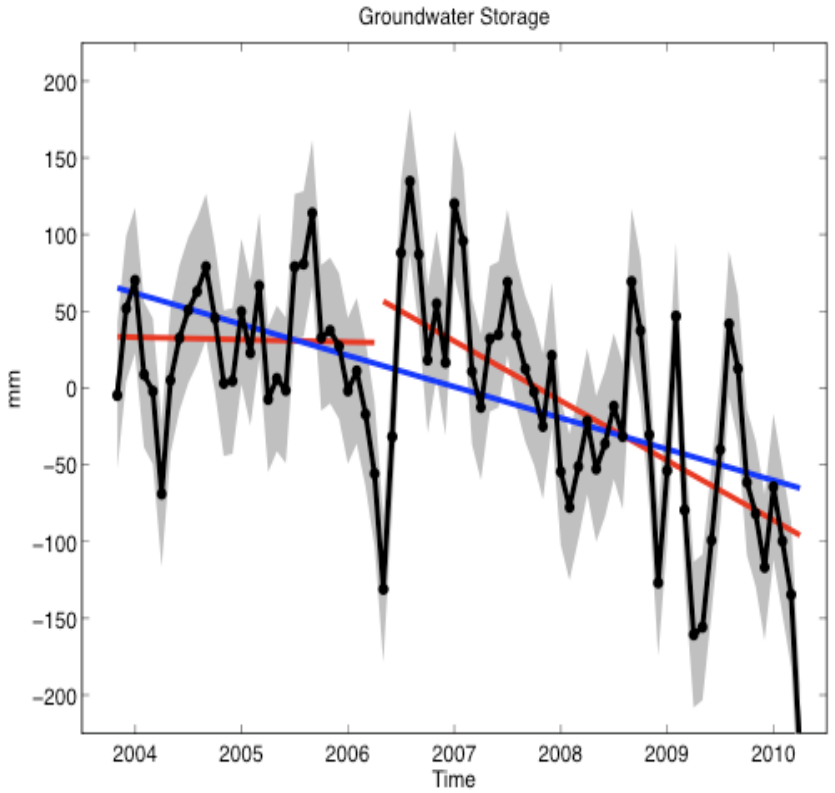
Huge potential for collaboration and interaction with CSDMS

UCCHM

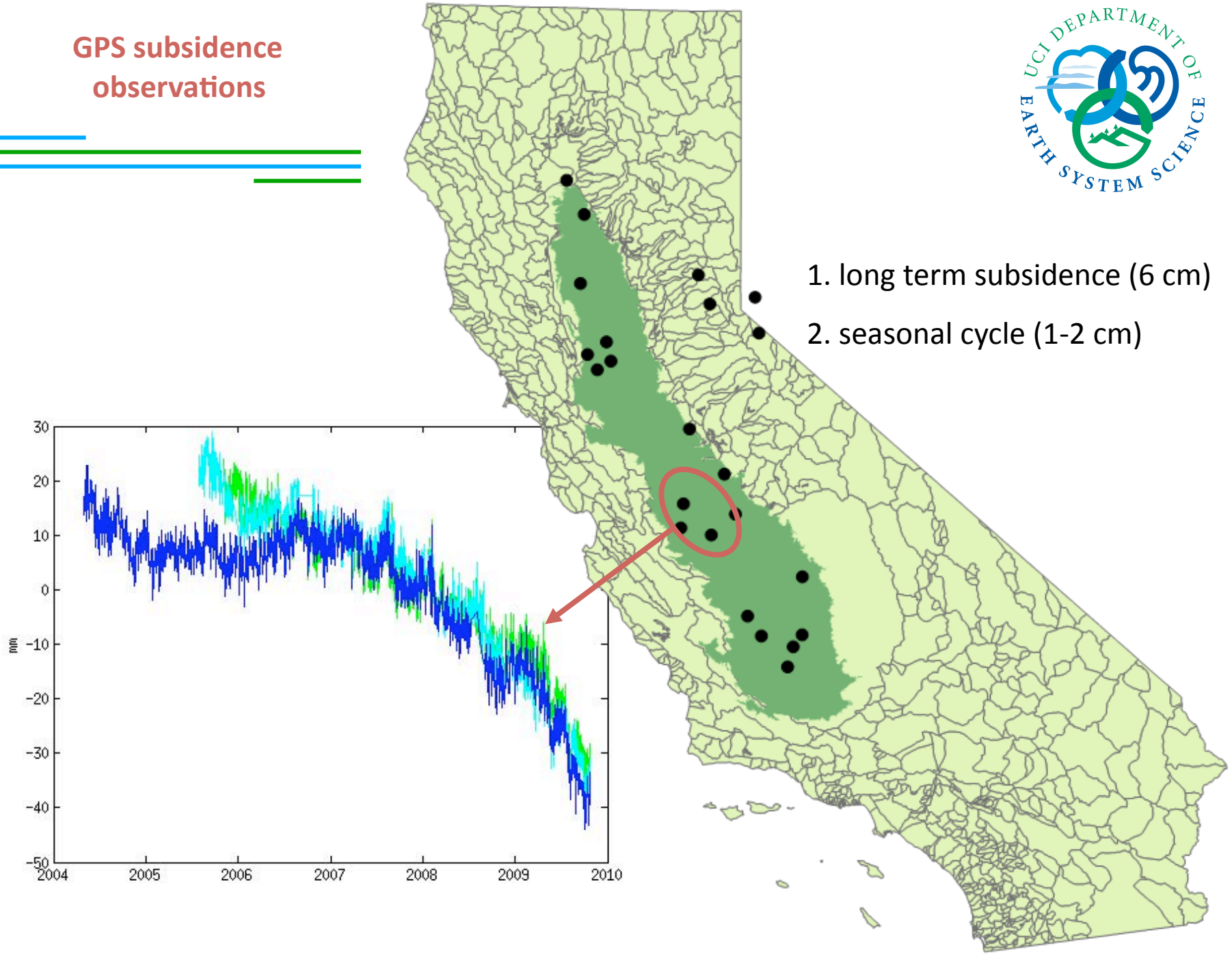
Coupling science question: land subsidence associated with groundwater depletion



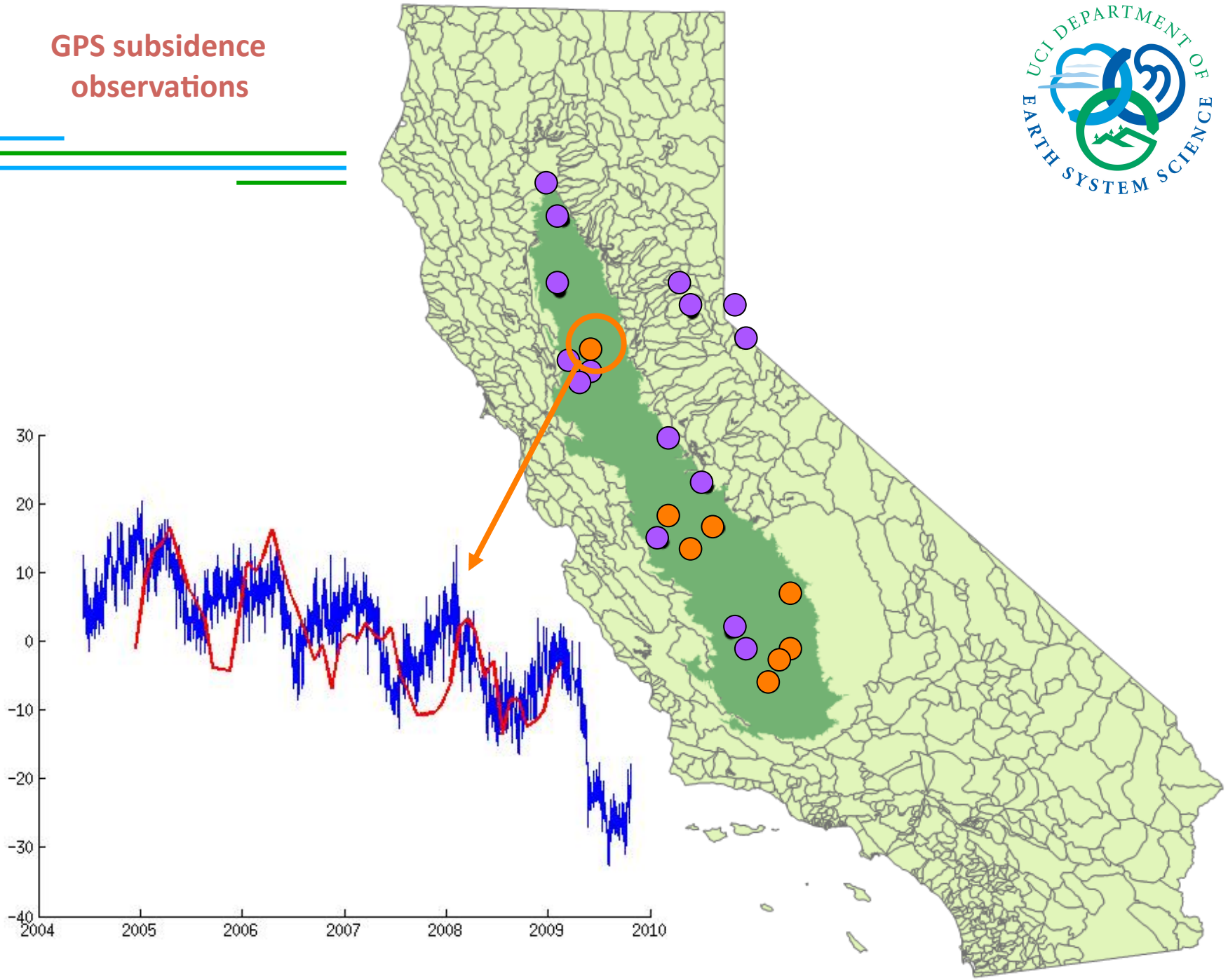
Groundwater depletion in California's Central Valley, 2003-2010



GPS subsidence observations



GPS subsidence observations



Role of remote sensing

UCCHM

I have not heard too much discussion about the use of InSAR, GPS, Lidar, and even truck-mounted Lidar, which have all shown tremendous potential for integratiion with models

Is there ongoing discussion within CSDMS on how to do this, either for comparison to model output, for doing inverse modeling, for model calibration or for data assimilation

Any of these will be critical for tacking problems such as the groundwater-land deformation problem

Parting comments

UCCHM

The UC Center for Hydrologic Modeling was founded last year to build the models to harness the hydrological expertise across the UC system to address California's water issues

A key contribution will be the development of a statewide model and a suite of component models that will essentially be a prototype CHyMP effort

So, the opportunities are already in place to initiate a CSDMS-miniCHyMP collaboration