

**Summary of CUAHSI Science Workshop  
Chicago, IL  
13 January 2002**

The meeting convened in the Chicago O'Hare Hilton at 8:30 am CST.  
Participants were:

Allen Bradley (University of Iowa)  
Jim Butler (University of Kansas)  
Bill Eichinger (University of Iowa)  
Robyn Hannigan (Arkansas State University)  
Anton Kruger (University of Iowa)  
Marshall Moss (CUAHSI)  
Ken Potter (University of Wisconsin)  
Frank Schwartz (Ohio State University)  
Steve Silliman (University of Notre Dame)  
Laura Toran (Temple University)  
Scott Tyler (University of Nevada Reno)  
Al Valocchi (University of Illinois)  
Rich Vogel (Tufts University)  
Claire Welty (Drexel University)  
and John Wilson (New Mexico Tech)

Ken Potter and Marshall Moss gave a brief review of the status of the consortium, its current situation with respect to planning its science programs, and the 5-point approach that is being used to gather grassroots input to the science plan. The eight 5-point statements that have been posted on the CUAHSI web site were then critiqued by the group as a basis for initiating a broad ranging discussion of the science that CUAHSI could facilitate with proactive programs of infrastructure in the hydrologic sciences.

The remainder of the morning was filled with a group discussion that addressed the following points:

**Some additional science questions**

- How can streamflow be estimated "everywhere"? What are the ecological and societal impacts of "NOT having the ability to estimate streamflow"?
- What are the impacts of climate change/variability on X over the next 100 years?
- What are the impacts of land surface change on X over the next 100years?
- How should errors impact our predictions, and does our naivete regarding error structure misstate our confidence in prediction?

- Can we "validate" our models, and, if we do, why do we have so many models?
- How do we restore, preserve, and improve the quantity, quality, and security of our nation's water resources? How do we sustain the quantity, quality, and security of our nation's water resources?

## Comments

- Questions should have societal impacts (not necessarily!).
- Packaging must be meaningful to a general audience, as well as general scientific community.
- Change point 1 of 5-pointer from "Problem" to "Question"
- Scale is always a way to broaden a narrow topic.
- What should be our organizing principle? Answer: Description, understanding, and prediction of hydrologic processes.
- Not all science is hypothesis driven (Baconian science); it can be driven by new technology.
- When it comes to error structure analysis, are we naïve?
- We have "so many" models ... is there a message here?
- We (especially practitioners) often use overly simple models because we don't have the data to support a more sophisticated model. But is the simple model still okay for the purpose?
- Question should address two things:
  1. the relevant societal (human and environment) question
  2. related science questions
 

*examples, for IRIS, 1. seismic hazard and 2. structure of earth*
- You have to convince the "whole" community that these are the right questions.
- Four audiences:
  1. hydrologist
  2. general science community
  3. practitioners
  4. public and politicians
- Many major societal questions deal with water supply in the most general sense, i.e. including hazards and ecosystems, as well as water resources.

- Identify and minimize threats; avoid the word "threats"
- For introductory comments in future workshops we need a vision of what carrying out this research would be like in the CUAHSI future. Audience: hydrologic scientists.

Before breaking for lunch, the group divided into three sub-groups to address three separate topics over lunch and continuing into the early afternoon. The topics were: (a) ideas for a network of hydrologic observatories, (b) expected outcomes for CUAHSI, and (c) a 5-pointer on hydrologic estimation. The reports of these three sub-groups are provided as appendices to this summary.

In late afternoon, each of the sub-groups made a presentation of its deliberations that were discussed by the group as a whole. These discussions were captured in the reports of the sub-groups.

The workshop concluded with a critique by the participants of the structure and format of the Chicago workshop, which had been developed as a model for the conduct of five additional regional workshops as well as for potential workshops on each of the campuses of the CUAHSI Member Universities. The main feedback was (1) that subsequent workshops probably would need a more comprehensive opening presentation because they would include a much greater percentage of people who were not as familiar with CUAHSI as were the Chicago participants, and (2) that the organizers of the subsequent workshops would like to have a more specific list of the potential “deliverables” for their workshops from the CUAHSI leadership.

The workshop concluded at approximately 4:30 pm CST.

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Breakout group on Hydrologic Observatories

C. Welty, J. Butler, A. Krueger, M. Moss, and J. Wilson

**Attributes that hydrologic observatories should have, and issues associated with the attributes**

**1. Measurements of baseline data – for "planned serendipity"**

a. Make measurements at consistent and appropriate space and time scales

(1) at each observatory

(2) across all observatories

*Issue: "Consistent and appropriate" must evolve through iteration. This cannot be prescribed in early rfps, but need to allow for evolution. Prescribe "oversampling" and allow this to evolve to coarser sampling as needed.*

b. Preserve comparable (space/time) data and characterize error structure

*Issue: Need to develop standard CUAHSI instruments and calibration standards, against which nonstandard instruments can be compared.*

c. Ensure measurement redundancy where necessary, e.g., precipitation measurement

*Issue: Need to develop redundancy protocols for different measurements and instruments.*

d. Need to set standards for data collection, recording, archiving

*Issue: Need to develop standards.*

e. Need to collect real-time data and make available real-time (over web)

f. Decide what measurements ought to be made at all sites vs. some sites, as baseline data.

**2. Protocols for campaign/individual investigator measurements**

a. Calibration – use standard CUAHSI instruments for inter-calibration of nonstandard instruments.

- b. Data must be released within a specified interval of time (e.g., one or two years) e.g., see LTERS.

*Issue: Need to develop appropriate time limitation.*

- c. Encourage PIS to allow students to work on other PI projects (i.e., make measurements), to broaden the student experience.

*Issue: How to implement this.*

### **3. A network (not just an agglomeration of sites, but an interconnected network)**

- a. The sites should represent diverse hydrologic regimes.

Example characteristics that should be diverse: topography, geology, geomorphology, vegetation, climate, soils, land use

- b. Need to coordinate synoptic sampling.
- c. Should be used to answer regional and continental-scale questions.

Example questions:

(1) What is the role of the land phase of the hydrologic cycle in carbon sequestration?

(2) How important is the long-term groundwater storage and fluxes to and from groundwater in controlling long-term climate variability?

(3) How can remote sensing be used to monitor hydrologic conditions in ungaged watersheds?

### **4. Mobile vs. fixed observatory sites**

### **5. Scales of sites**

- a. Need to decide on appropriate scale – watershed vs. river basin
- b. Obviously could choose a very large-scale site and then work on various smaller scales within that site.

### **6. Number of sites**

- a. Should have a long-term plan, even if this cannot be implemented all in one phase
- b. One observatory per region ? (6 total?)

Discussion of “expected outcomes” of CUAHSI  
Chicago Regional Workshop, Jan 13, 2002

SUBGROUP: Laura Toran, Frank Schwartz, Robin Hannigan, Rich Vogel, Allen Bradley

Our group discussed the expected outcomes of CUAHSI by trying to answer the following questions:

What is the ten-year vision for CUAHSI?

What can researchers expect to see as benefits in the two-year time frame?

**We addressed four of the CUASHI thrusts: information systems, measurement, observatories, and education.**

Long Term Outcomes: These have been stated elsewhere and are briefly summarized here.

In the ten-year time frame, information systems will provide researchers with online access to data from long term monitoring and experiments. These data will be in ready to use form. Images and tools for data interpretation will also be available. There are of course many existing databases of this nature already available and in development. Seamless links to companion databases will be provided to researchers.

The measurement technology program will provide equipment for loan, access to lab analyses, and training (in conjunction with education). The equipment will allow for higher density data collection, as well as new measurement technology possibly allowing for greater automation, more incremental sampling, and improved processing. Protocols for measurement comparison and standards are needed. We envision at least one equipment center (a building) possibly with some satellites.

LTHOs will have been established at about 6 locations. In addition many smaller study areas will be available to researchers. Every member will have visited or conducted research at an LTHO.

Many educational benefits will come from the program such as student fellowships, visitor exchange, inexpensive workshops and training, video or online courses. A coordinator of education programs will be in place to foster and coordinate these programs.

Short Term Outcomes: In the two-year time frame, more specifics are needed. We have suggested some short-term goals, but would like to see discussion and consensus on the priorities. Some areas need further detailing.

For information systems, we'd like to see an example watershed online with a varied suite of data. The existing databases should be linked. A data-sharing ethic will be established as the mode of operation.

In measurement technology, the equipment that can have immediate impact should be available. We would like to see the regional workshops review the list compiled by the measurement technology committee, and develop priorities in conjunction with science planning. A plan for equipment sharing and repair must be in place.

By the end of two years the first two observatory sites will be selected, and instrumentation will have begun. In addition, at least a dozen smaller hydrologic stations will be in place. The design of these smaller stations will be determined by science needs, such as isotope data in rainfall and other continental scale data needs (fill in other examples). There is also an educational component of providing members who don't have access to field sites with a basic suite of monitoring tools (e.g., piezometers, rain gage, stream gage, lysimeters, and more) for demonstrations and to jump start new research.

Finally, the education program will fund about a dozen 1 to 3 year fellowships for students (Masters or PhD). These fellowships will encourage students to embark on hydrology research and provide a relatively fast infusion of excitement in the field. A CUAHSI committee, with a view to forwarding the science plan, would review proposals.

In addition, the education program will hold at least two workshops, probably associated with a national society meeting. Topics might be statistics, GIS, a new measurement technology. Regional workshops should survey attendees to find popular topics. We would also like to see discussion of other long and short term needs in the community. This is an opportunity for new ideas to surface.

## **REMOTE SENSING OF THE SPATIAL AND TEMPORAL VARIABILITY OF HYDROLOGIC PROCESSES**

### **1. Statement and Significance of the Problem**

**There is need for an understanding of the magnitude and impact of integrating satellite data and imagery with local scale measurements.**

Nearly every hydrologic process is characterized by variability both in space and time. This variability has a major impact on our ability to measure these processes and thus our ability to make useful and accurate predictions for a wide range of applications, such as flood and drought prediction, agriculture growth, and soil erosion to name just a few. Remote sensing can, in principle, provide measurements of hydrologic parameters over large areas. However, there are issues relating to calibration and interpretation of remotely sensed data. In most cases, there is a wide disparity between the footprints of traditional point measurements and remotely sensed data. Because of the large footprints of remotely sensed data, one data pixel may represent a wide range of hydrologic conditions.

This problem is related to the larger problem of how does one measure some parameter that is characterized by a wide range of spatial and temporal time scales and interactions. There are many examples of this in hydrology today. The question of how to scale up from individual measurements of evaporation from point instruments or aircraft to are larger scale value has prompted a large number of papers in recent years. Similarly, with the launching of the aqua satellite, the interpretation of microwave soil moisture measure estimates with pixel sizes more than 100 km in size has prompted a number of field experiments to work on the problem.

### **2. Elements currently missing that are required for a solution**

At present, there is not an understanding of the uncertainty associated with integrating up from point measurements to a larger area value. For many hydrologic parameters, there is a lack of consensus with respect to the scales at which the parameter must be measured in order to have a meaningful estimate. For a given measurement scale, there is also no consensus on the density or placement of measurement instruments to obtain the measurement. And having these measurements, there is no consensus on how to determine the areally averaged value from them.

Similarly, given a measurement of some parameter (microwave emission, radar reflectivity, surface temperature, etc) that represents an “areal average” value (and usually the measured quantity is modified by the transmission through the atmosphere in some way), determining what this number means is still an open issue. Validation of remote sensing inversion methods and calibration of the instruments requires the ability to determine what the area average value actually is.

There is currently a lack of ground truth data sets with which these problems can be studied. While there have been many large-scale field campaigns for which a wide variety of parameters are measured, the time scales of these campaigns is too short to address these issues. Similarly, there are a number of large scale, long term measurement sites, but questions remain concerning the completeness of the measurement set and the density of instruments. The location of instrumented sites to measure one parameter may be inappropriate for another parameter.

Compounding the issue of what and how to measure area average values of hydrologic parameters is the problem that the scale over which the parameter should be measured may depend on the conditions at the time in the area. Nearly all hydrologic processes are highly interconnected. Developing models and understanding of physical processes requires the measurement of a wide range of parameters.

### **3. Means of providing the missing elements**

Concentrated measurement efforts are needed over a long period of time to develop and validate integrated, large area models and to validate remote sensing estimates. The siting, density, and measurement scales of the instruments will have to be determined based on the site. The set of measurements that will be required will include:

Recharge-Rainfall	Evaporation
Soil Moisture-Surface Temperature	Depth to water table
Soil characteristics/Soil Chemistry	Vegetation / canopy
Wind Speed/Dir.Net Radiation	Air Temperature/Humidity
Stream Flow	
Surface topography (at small, sub meter scales)	
Appropriate Model Parameters (will depend on specific problems)	

### **4. Sketch of an experimental design to address the problem**

The design of an experimental program to address the validation of models and remote sensing methods will require instrumentation of a number of small watersheds. The idea is that the results from one watershed must be reproducible in nearby watersheds. Because hydrologic processes tend to be organized by terrain features, and because the problem involves determining how to integrate up in scale, point instruments must be used with models. The modeling effort will help determine how to scale up, as well as how and where to measure. We anticipate that an iterative process will occur in which a model is developed for the given parameter. The model will be used to site instruments. Making the measurements will allow for improvement of the model. Having refined the model for one watershed, it will be used with nearby watersheds to determine the general applicability of the model.

If sufficient funds are available, three large scale sites would be desirable, each with a different geography and climate. While the Great Plains area of the United States offers a

simple, relatively homogeneous landscape, the bulk of the country and the world is not homogeneous. To be truly useful, models, algorithms, and remote sensing methods must be applicable to a wider range of surface types.

## **5. Expected outputs from the experiment and their impacts**

Validation sites with highly integrated and spatially resolved data sets will enable a wide range of studies that are of importance to hydrologists. These include:

- \* This effort will help develop models and validate models and remote sensing techniques in a wide range of fields. Long term, high quality, multi-scope, multi-scale measurement sets are not available. The applicability to hydrologic modeling is direct and clear, but these data sets and field sites will benefit researchers in related fields. Ecologists, and environmental engineers, for example, could use such sites and data sets.

- \* Data sets produced by this effort can be used for an in depth analysis of the prediction errors associated with uncertainties in the input data. Current hydrologic forecasting seldom includes the uncertainty in the predicted value. Long-term data sets seldom have uncertainties associated with the values. The results from analyses that use this data have uncertainties that may be large. Attempting to calibrate models or learn about physical processes from such data is fraught with difficulty. Results from such efforts must be questioned.

- \* The study of such problems as flow discharge and peak flows would follow naturally from the data sets collected by this effort.

- \* These types of sites are required if we are ever to realize the opportunities that remotely sensed data offer. Large scale observations by surface sensors and satellites offer the ability to monitor agricultural production, or to provide information for the management of surface water to name just two applications. To achieve this, remotely sensed data must be reliably and accurately inverted to obtain information that can be used in a practical sense. This will not be accomplished if detailed data sets are not available at a variety of scales (consider the problem of determining rainfall from radars).