Water for a Thirsty World: How Can Information Technology Help?

How can we protect ecosystems and better manage and predict water availability and quality for future generations, given changes to the water cycle caused by human activities and climate trends?

Jeff Dozier
Professor
Bren School, University of California, Santa Barbara
**Grand Challenges**

**Hydrologic Sciences:** Closing the water balance

**Engineering:** Integration of built environment water system

**Social Sciences:** People, institutions, and their water decisions

**WATERS Network science questions**

- How is fresh water availability changing, and how can we understand and predict changes?
- How can we engineer water infrastructure to be reliable, resilient and sustainable?
- How will human behavior, policy design and institutional decisions affect and be affected by changes in water?

**Resources needed to answer these questions and transform water science to address the Grand Challenges**

- Measurement of stores, fluxes, flow paths and residence times
- Water quality data throughout natural and built environment
- Synoptic scale surveys of human behaviors and decisions

**Observatories, Experimental Facilities, Cyber-infrastructure**
Status as NSF MREFC “Horizon” Project
(Major Research Equipment and Facilities Construction)

This year: produce science plan
- 15th May, in review by National Research Council
- Briefed on 15th June
Conceptual design (2 years)
- Requirements definition, prioritization, review
- Identify critical enabling technologies and high risk items
- Top-down parametric cost and contingency estimates and risk assessment
- Draft Project Execution Plan

Preliminary design/ readiness stage (2-3 years)
- Site selections in this stage
National Science Board approves – final design

Construction and Commissioning
- From MREFC account
Operation and maintenance
- From Directorates
Renewal/termination
## Context: the NSF Budget

### NSF FY2010 Budget Summary

<table>
<thead>
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<th>Account</th>
<th>FY09 ($M)</th>
<th>Stimulus ($M)</th>
<th>FY10 request ($M)</th>
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[NSF FY2010 Budget Summary](http://tinyurl.com/qebc7u)
Accumulation and Ablation Inferred From Snow Pillow Data: Tuolumne Meadows (TUM) and Dana Meadows (DAN)
Snow Redistribution and Drifting
Hypoxic Volume Per Unit N Is Increasing

Spring Nitrogen load (Susquehanna)
Urban Stormwater and Wastewater

Field scale sewershed management

Field scale green infrastructure (e.g., EPA's Urban Watershed Research Facility in Edison, NJ)
Science Progress vs. Funding (Conceptual)

- **Max Leverage**
- **Diminishing Return**

**Science**

**dScience / d$**
The Data Cycle Perspective, from Creation to Curation

The science information user:
- I want reliable, timely, usable science information products
  - Accessibility
  - Accountability

The funding agencies and the science community:
- We want data from a network of authors
  - Scalability

The science information author:
- I want to help users (and build my citation index)
  - Transparency
  - Ability to easily customize and publish data products using research algorithms
Organizing the Data Cycle

Progressive “levels” of data
- EOS, NEON, WATERS Network
  0 Raw: responses directly from instruments, surveys
  1 Processed to minimal level of geophysical, engineering, social information for users
  2 Organized geospatially, corrected for artifacts and noise
  3 Interpolated across time and space
  4 Synthesized from several sources into new data products

System for validation and peer review
- To have confidence in information, users want a chain of validation
- Keep track of provenance of information
- Document theoretical or empirical basis of the algorithm that produces the information

Availability
- Each dataset, each version has a persistent, citable DOI (digital object identifier)
Objectively identify “similar” thematic places that are comparable and can be intensively studied at a few (1-4) “observatories” in each:

- Capture the diverse hydrologic, engineering and social conditions that exist across the U.S.
- Set of variables that quantify hydrologic setting, both physical and human-influenced

**Example:** ISODATA clustering based on the Human-Influenced Water Environment Classification (HIWEC)

Hutchinson et al. 2009
Information Products, Hydrologic Example

- MODIS spectral radiance
  - Atmospheric correction
  - Surface reflectance
  - MODSCAG
    - Fractional snow cover
    - Snow albedo
      - Interpolation in space and time
        - Daily fractional snow cover
  - Clean-up
- Snow water equivalent (from pillows)
  - GOES cloud cover data
  - Spatially distributed snowmelt model
    - Surveys of heterogeneity around snow pillows
    - Daily snow albedo
      - Spatial interpolation
      - Snow depletion model
- Real-time spatially distributed snow water equivalent
- Retrospective heterogeneous snow water equivalent
- Energy-balance data (from flux towers)
  - Snow ablation model
Why Now?

- Addresses Grand Challenges in environmental research and integrates natural, engineering, and social science
- Water couples humans and natural systems as a balancing mechanism between human activity and sustainability
- Given the current state of water issues, the need to understand and predict is urgent
- Other federal agencies are making investments, so leveraging opportunities exist over the next decade
- Because of community readiness and technological advances, the ability to address this need (finally) exists
What Next?

- Thematic division (the many-colored map)
  - Multi-disciplinary workshop to get to community consensus
- Review enabling technologies and high-risk items
  - Sensors, satellites, surveys
- Review and select models to use in network design
  - Review datasets, models, and experience from testbeds and CZO investigations
- Education and outreach plan
- Cost and contingency estimates

- eScience infrastructure
  - Framework and facility to support higher-level data products
  - Community network
  - Identify research and development needs for WATERS Network
- Execution plan and strategy for selection in Preliminary Design phase
  - Observatories, facilities, surveys
- Examine options and identify management structure for MREFC