Microsoft® Research
Faculty Summit
10
YEAR ANNIVERSARY

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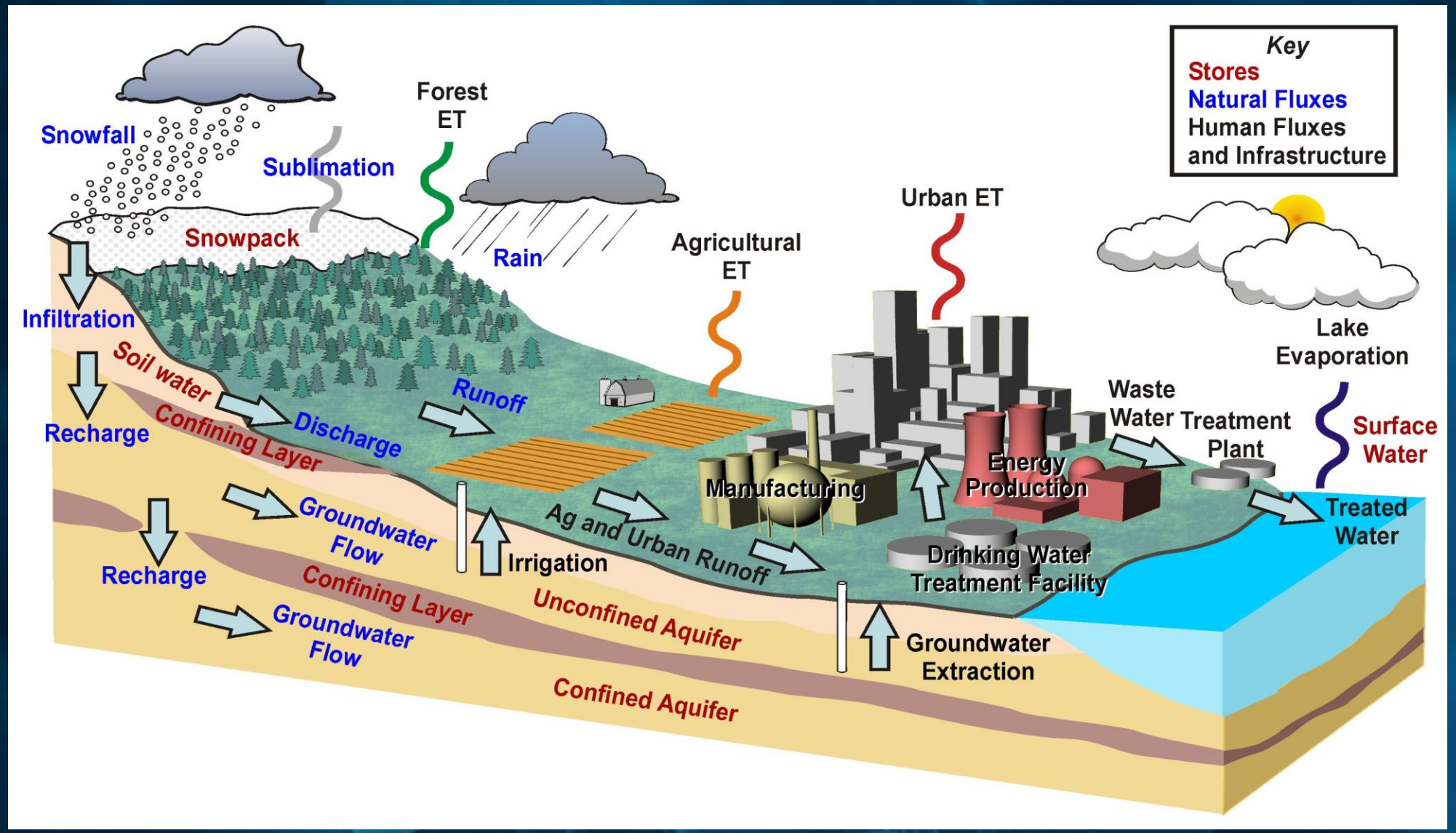
Water for a Thirsty World: How Can Information Technology Help?

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


Key
Stores
Natural Fluxes
Human Fluxes and Infrastructure
Snowfall
Sublimation
Forest ET
Rain
Snowpack
Infiltration
Soil water
Recharge
Confining Layer
Discharge
Runoff
Agricultural ET
Urban ET
Lake Evaporation
Waste Water Treatment Plant
Surface Water
Manufacturing
Energy Production
Treated Water
Drinking Water Treatment Facility
Ag and Urban Runoff
Irrigation
Groundwater Flow
Recharge
Confining Layer
Unconfined Aquifer
Groundwater Extraction
Groundwater Flow
Confined Aquifer

Protect Ecosystems and Manage

Predict Water Availability and Quality

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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)

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- 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

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Account	FY09 ($M)	Stimulus ($M)	FY10 request ($M)
Research and related activities	$5,183	$2,500	$5,733
Education and human resources	845	100	858
MREFC	152	400	117
Operations and management	294		318
National Science Board	4		4
Inspector General	12	2	14
Total	$6,490	$3,002	$7,045

NSF FY2010 Budget Summary http://tinyurl.com/qebc7u

Accumulation and Ablation Inferred From Snow Pillow Data, Tuolumne Meadows (TUM) and Dana Meadows (DAN)

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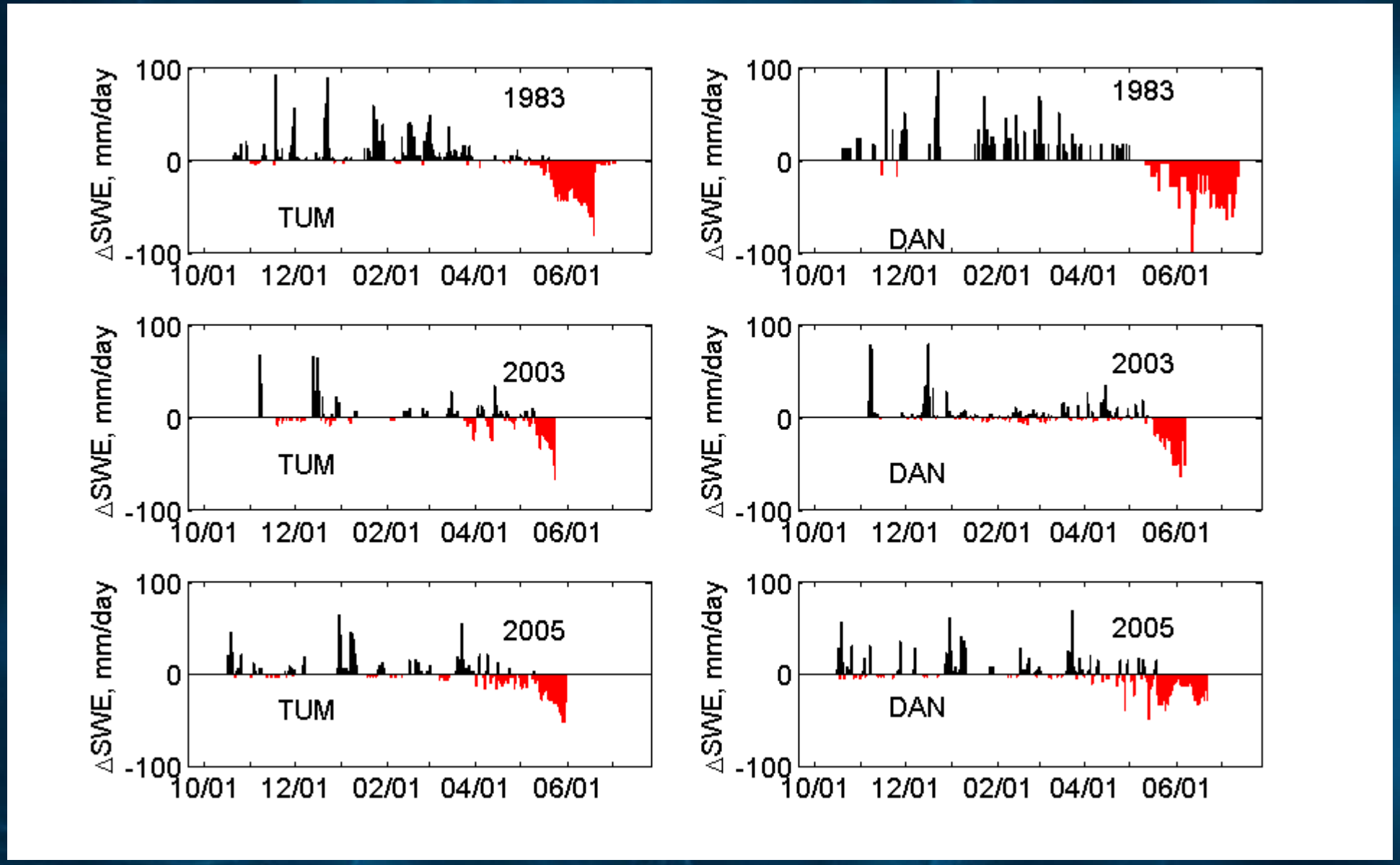

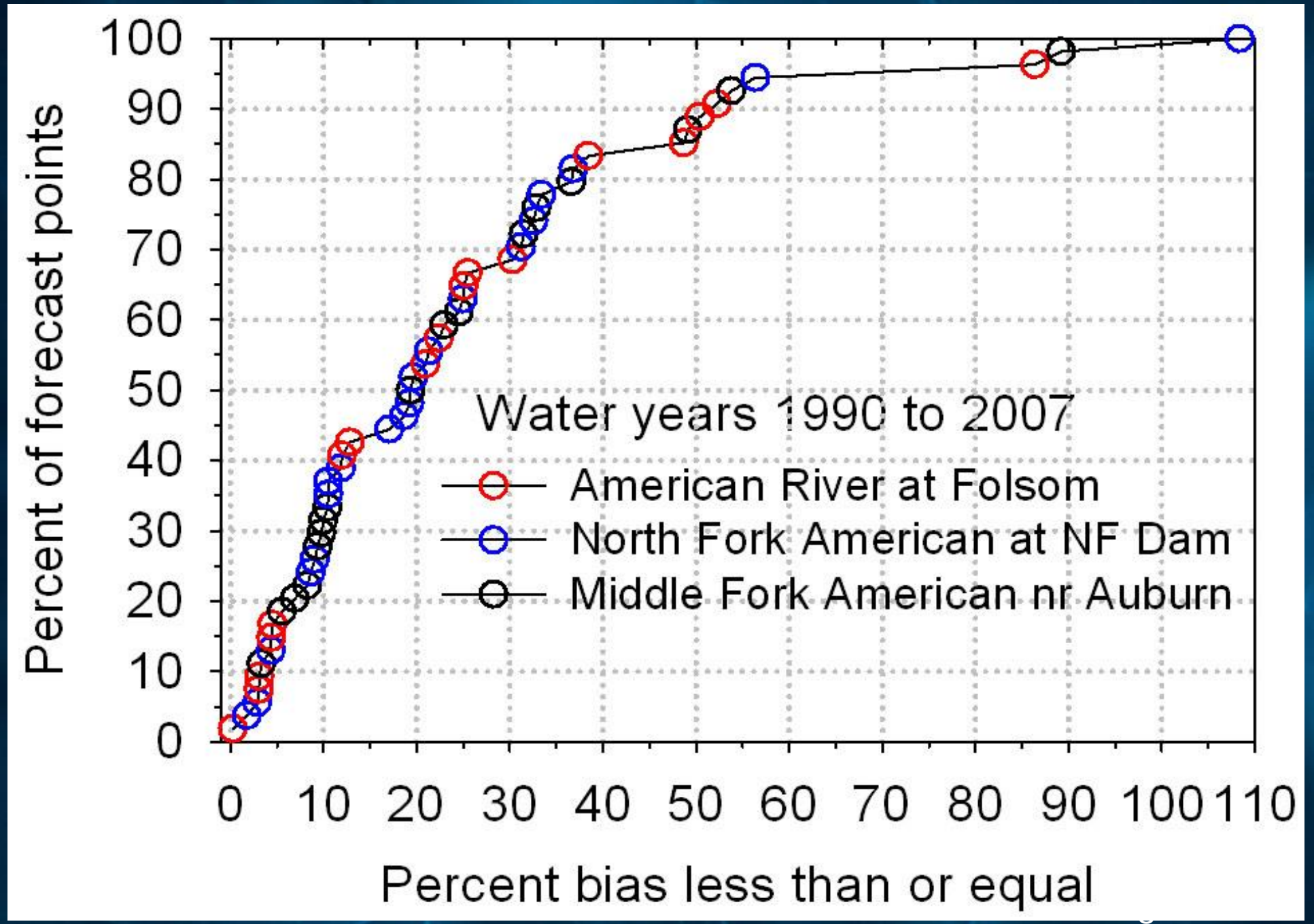

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Snow Redistribution and Drifting

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ars

Global Hypoxia

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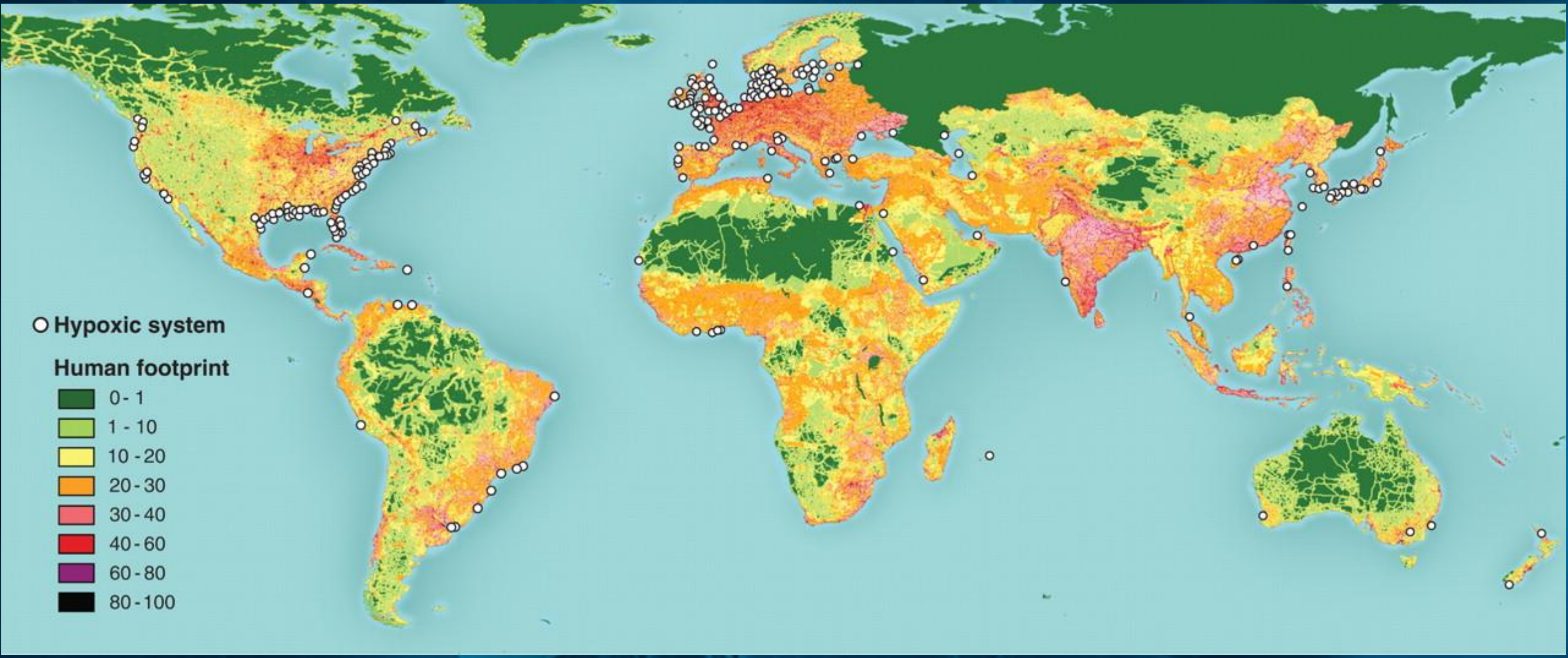

Hypoxic Volume Per Unit N Is Increasing

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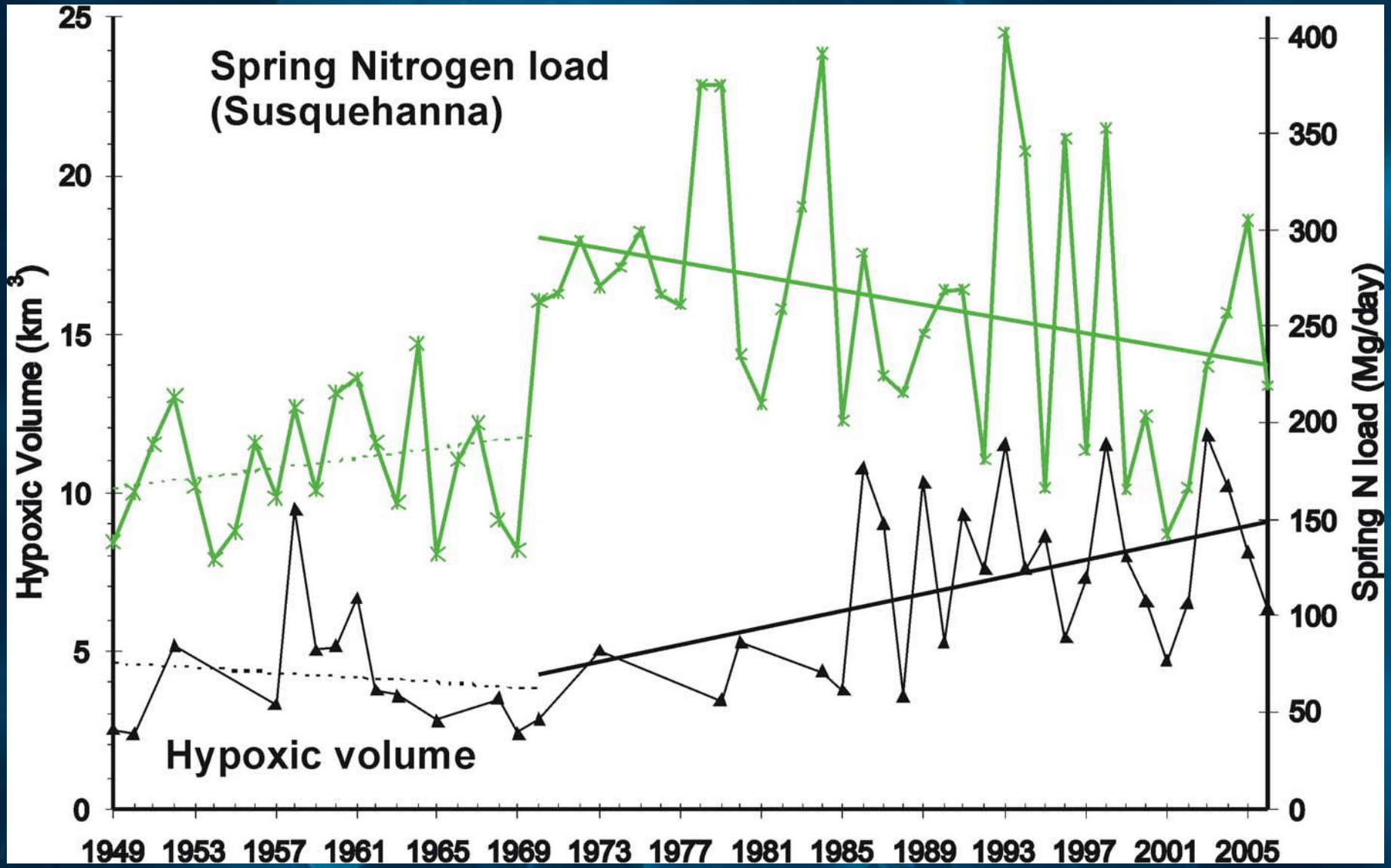

Urban Stormwater and Wastewater

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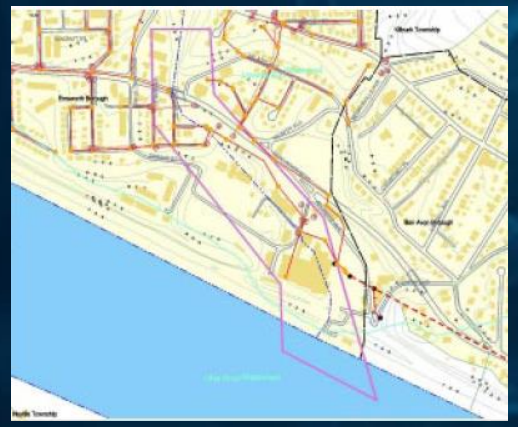
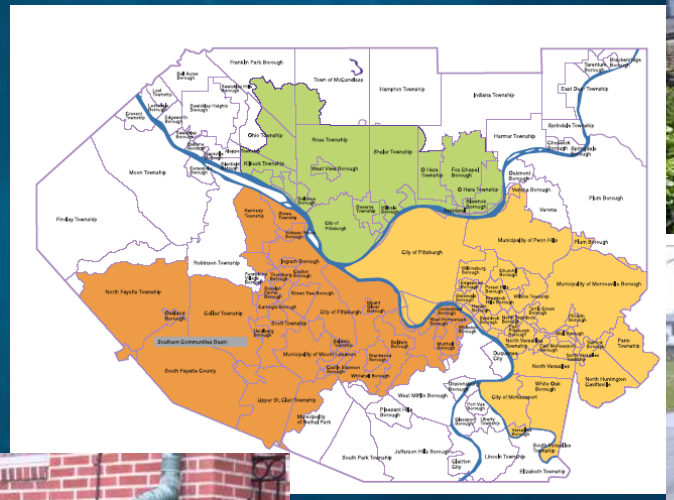
Field scale sewershed management





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

Science Progress vs. Funding (Conceptual)

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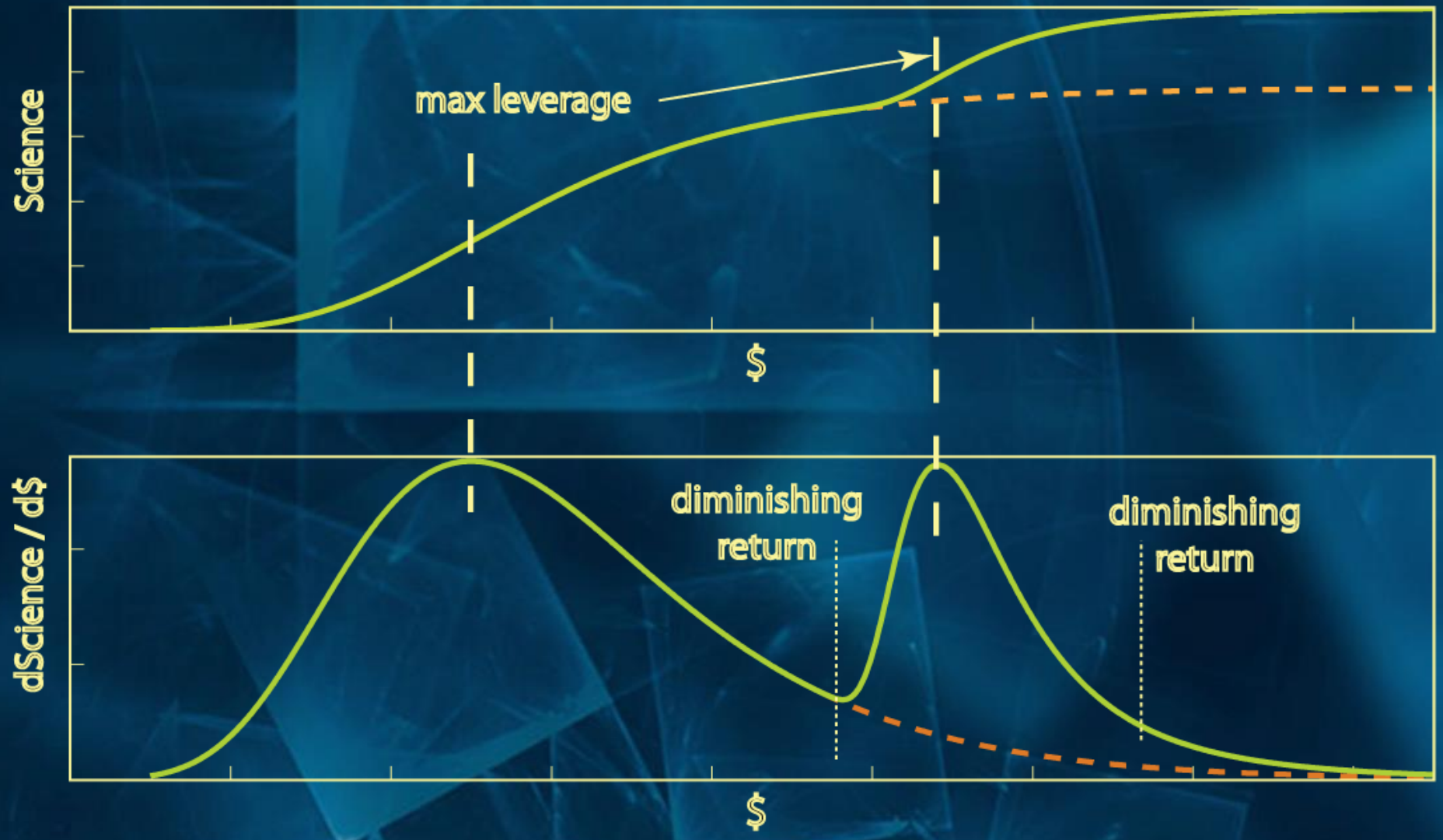

The Data Cycle Perspective, from Creation to Curation

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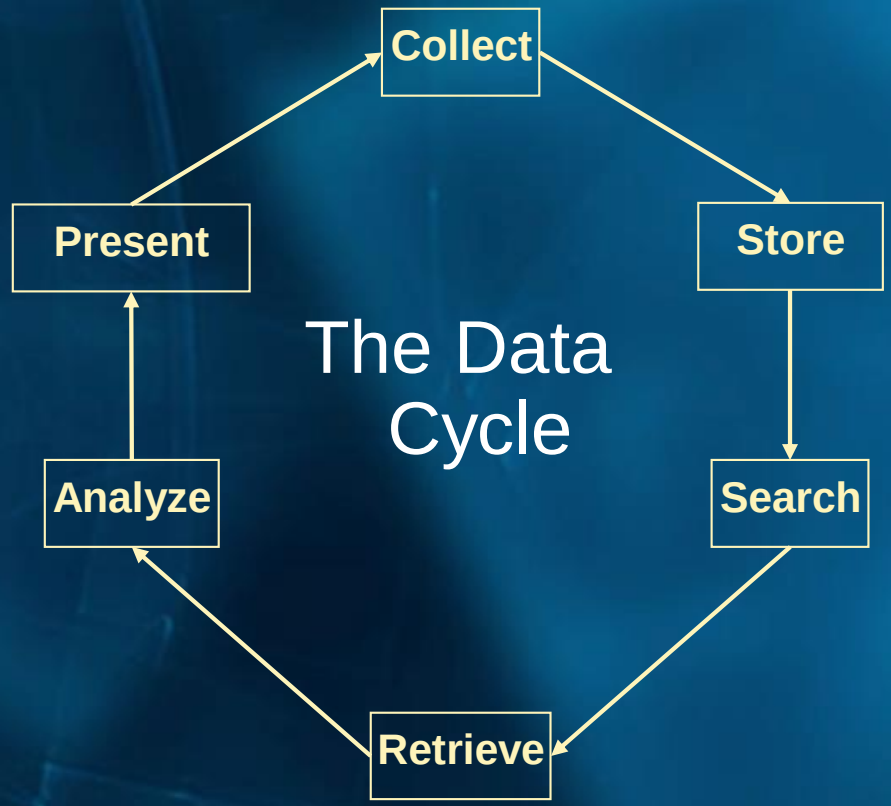
- The science information user:
  - I want reliable, timely, usable science information products
    - Accessibility
    - Accountability
- The funding agencies and the science community:
  - We want data from a network of authors
    - Scalability
- The science information author:
  - I want to help users (and build my citation index)
    - Transparency
    - Ability to easily customize and publish data products using research algorithms



Organizing the Data Cycle

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- 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)

Observatories and Facilities

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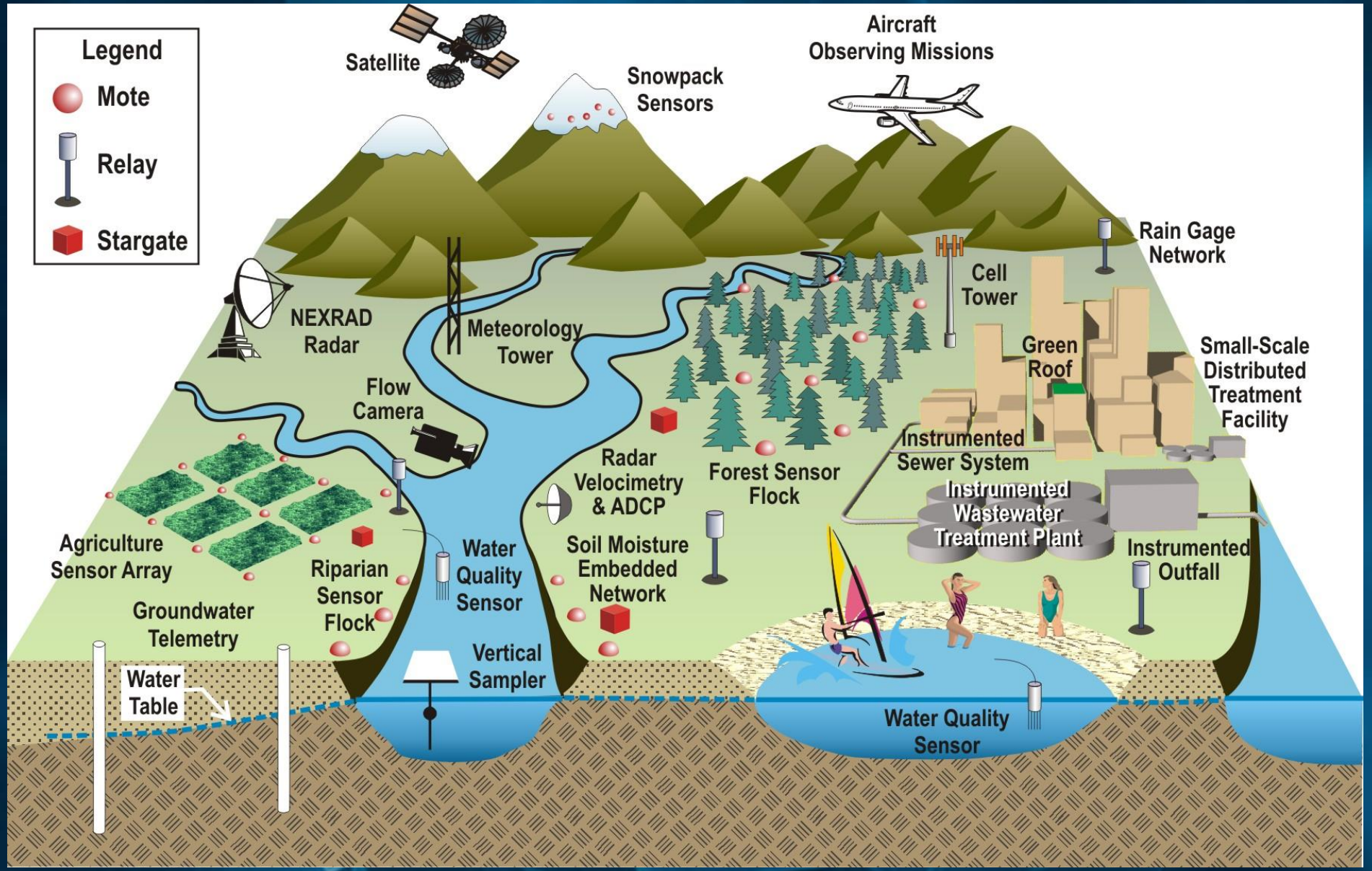

Structure: Similar Environmental Themes for Sampling Design

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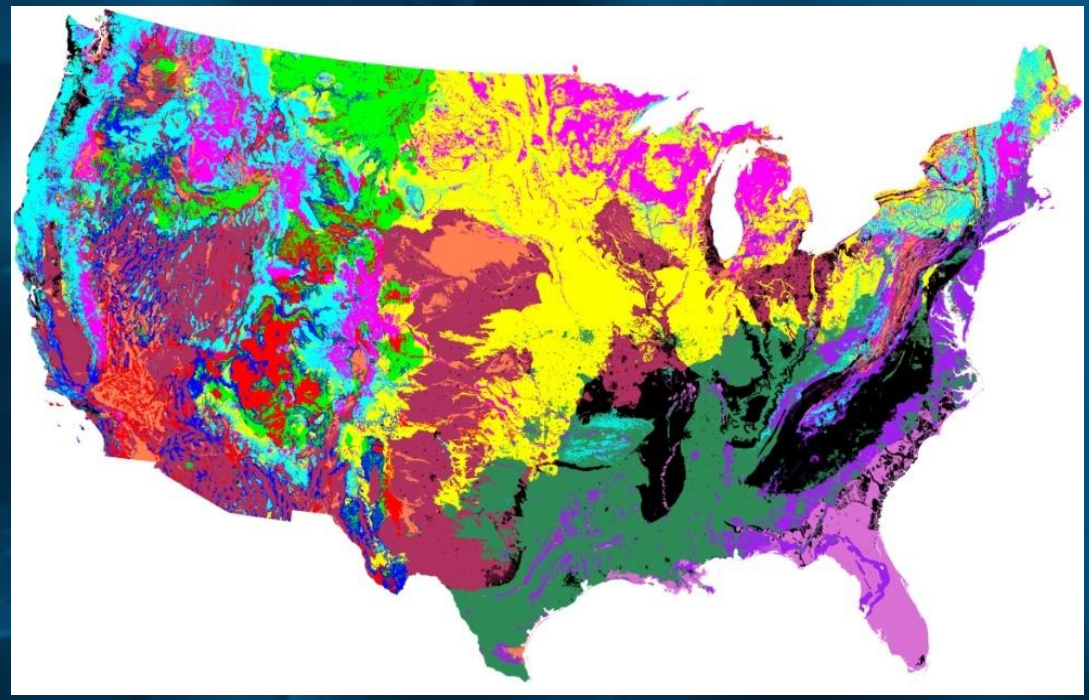
- Objectively identify “similar” thematic places that are comparable and can be intensively studied at a few (1-4) “observatories” in each
  - Capture the diverse hydrologic, engineering and social conditions that exist across the U.S.
  - Set of variables that quantify hydrologic setting, both physical and human-influenced
- Example: ISODATA clustering based on the Human-Influenced Water Environment Classification (HIWEC)

  Hutchinson et al. 2009



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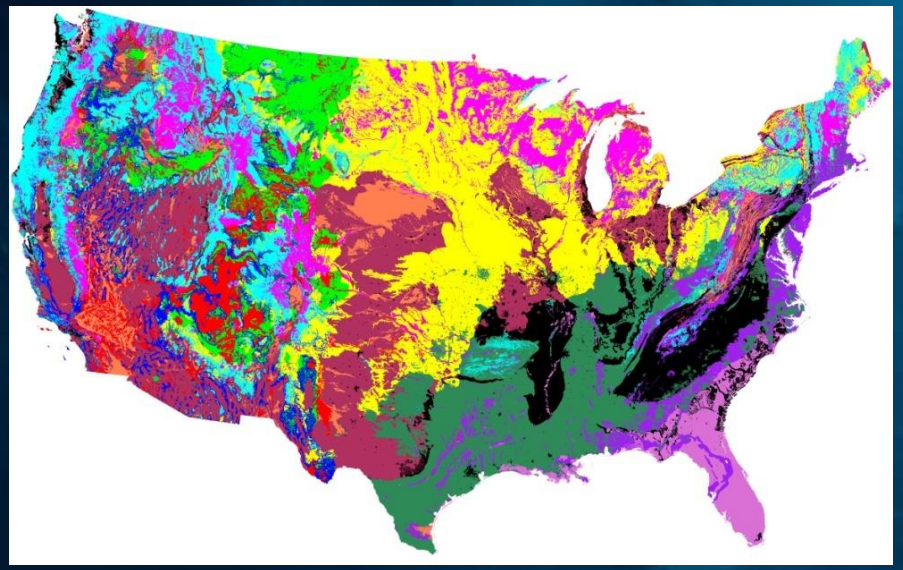
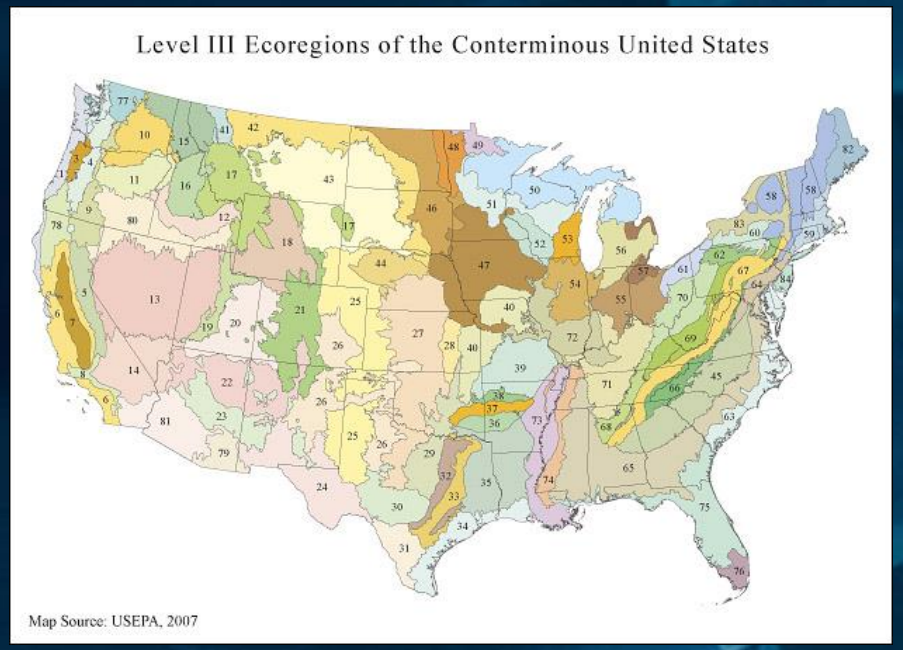
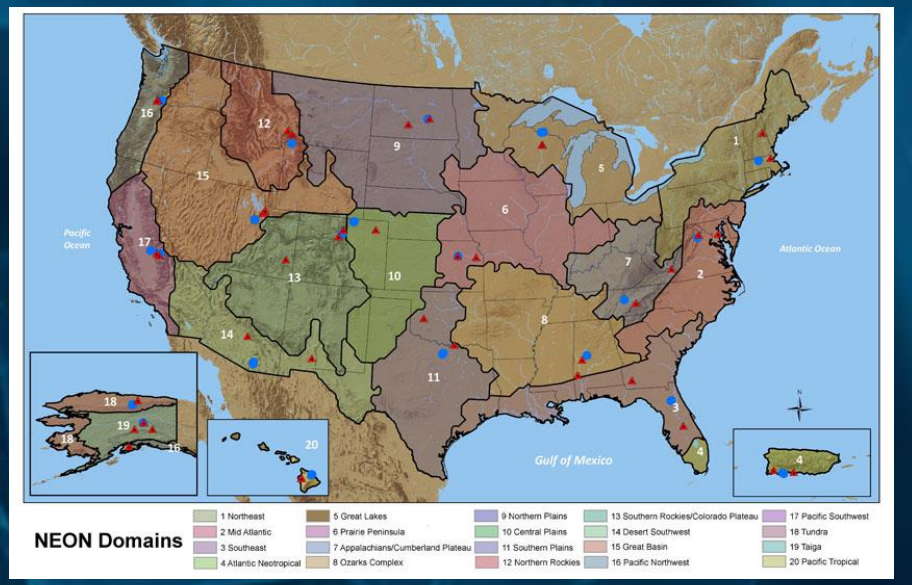


Human-impacted water environment classes

USGS hydrologic regions



US EPA ecoregions



NEON domains

Information Products, Hydrologic Example

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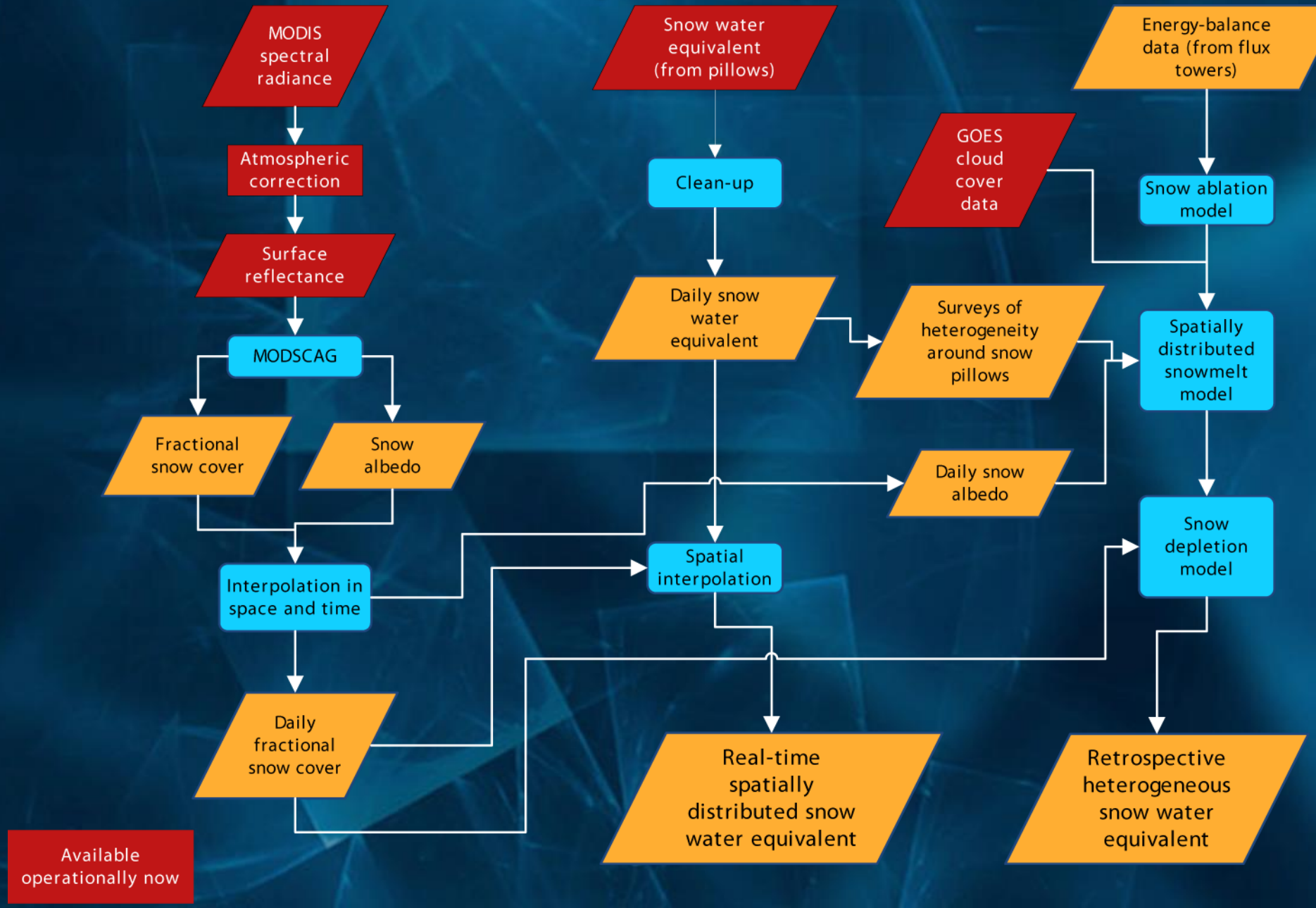

Why Now?

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- 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?

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- 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