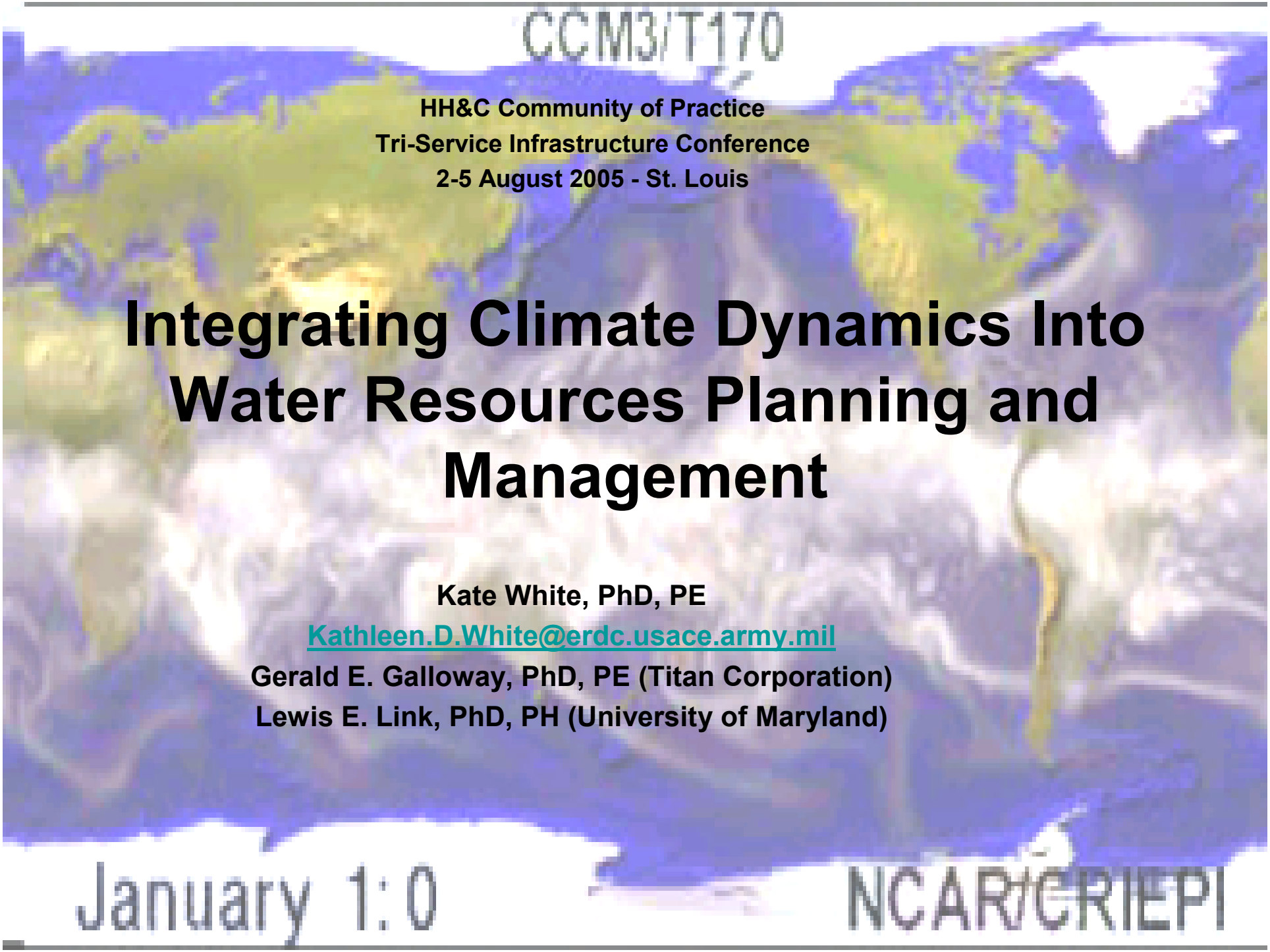


HH&C Community of Practice
Tri-Service Infrastructure Conference
2-5 August 2005 - St. Louis

Integrating Climate Dynamics Into Water Resources Planning and Management

Kate White, PhD, PE
Kathleen.D.White@erdc.usace.army.mil
Gerald E. Galloway, PhD, PE (Titan Corporation)
Lewis E. Link, PhD, PH (University of Maryland)

Corps Workshop on Climate Impacts
(November 2004, Baltimore)

- Purpose: To discuss the ramifications of climate variability and change on water management
- On-Site Attendees and presenters:
  - NAB, SPK, LRE, LRD, HQUSACE, ERDC, IWR,
  - Universities of Maryland and Washington
  - Scripps Oceanographic Institute
  - NOAA, NASA, NWS, and USGS
- Virtual attendees and presenters (via Live Meeting):
  - NWW, NWS, NWP, SWF, SWG, SAJ, SAD
  - University of Washington
- Supported by Flood and Coastal Storm Damage Reduction Research Program
- Outcomes:
  - MFR to HQUSACE
  - Technical Report
  - White Paper on Corps Policy Relative to Climate Variability

Key Presenters

- **General Galloway:**
  - **Major challenges range from aging water infrastructure and overuse of groundwater to climate change**
  - **Primary issue in the US is the distribution of supply and demand, not the quantity of water available**
  - **Reduction in monitoring and assessment programs is a significant barrier to gaining the understanding required to solve climate-related issues**
  - **Policy challenges:**
    - **Formulate policy that provides the necessary flexibility and incorporates public values into water management without destabilizing investor's expectations**
    - **AWRA National Water Policy Dialogue points out the critical need for a holistic and watershed approach to water management and more effective collaboration between agencies**

Key Presenters

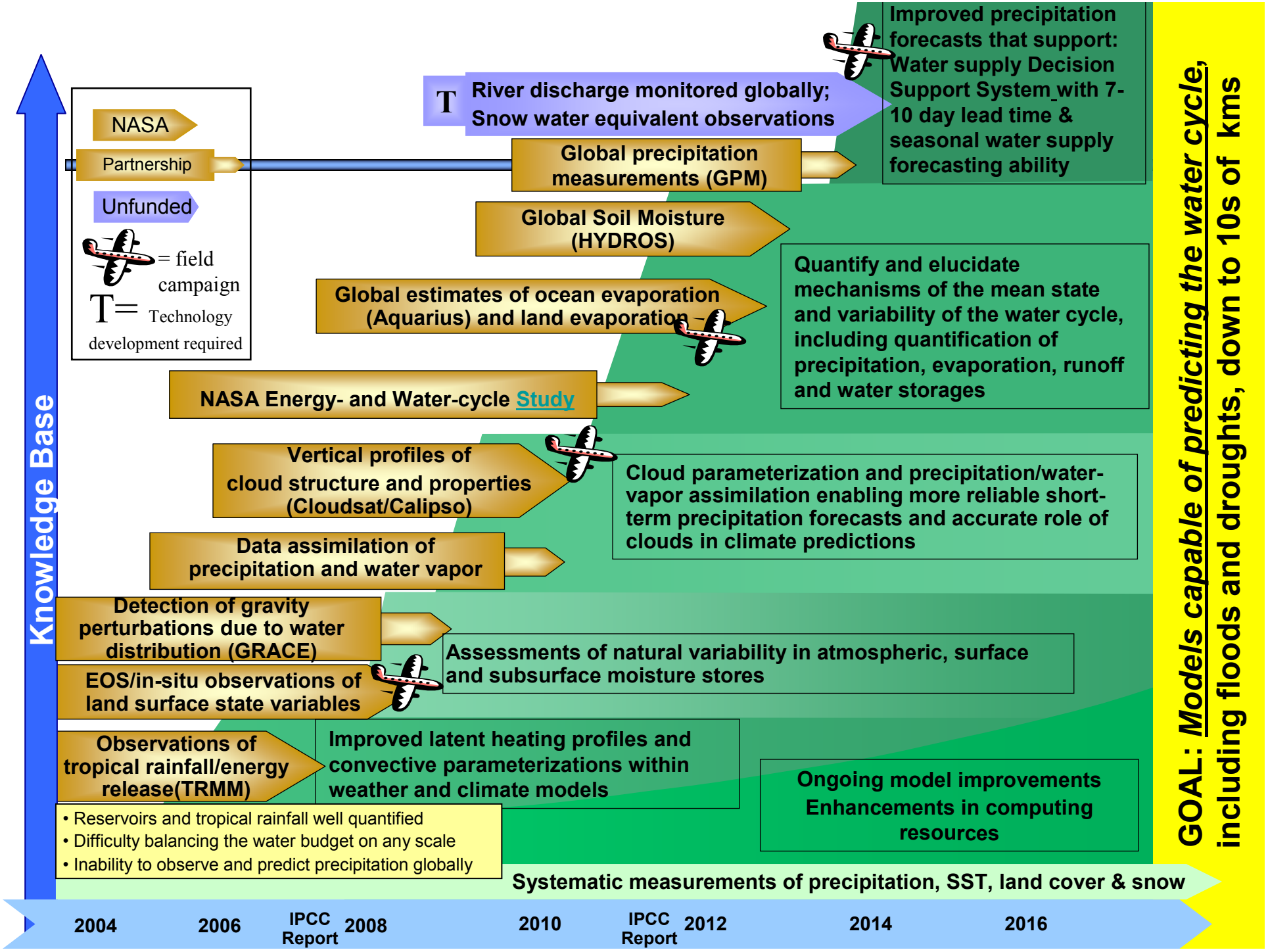
- Jerry Webb (HQUSACE)
  - New business model (2012)
    - One Headquarters (Washington and the Divisions)
    - Regional Business Centers
    - Regional Integration Teams
    - Communities of Practice
  - Corps requires future capability to carry out long term analyses in addition to day to day and seasonal operations and water management
  - Risk and uncertainty and other aspects of climate impacts must be included under the CWMS Modernization
- Harry Kitch (HQUSACE)
  - Project planning process
  - Introduction of performance management concepts into water management projects
  - Improved guidance for planners is required to respond to significant water challenges that appear to be climate driven
    - Devil's Lake
    - Colorado River water allocation
  - We need to better justify federal investments for long term uncertainties

Key Presenters

- Gene Stakiv (IWR):
  - Corps involvement in International Panel on Climate Change
    - Adaptation/adaptive management (no regrets)
    - Autonomous adaptation (cumulative, ad hoc tactical adjustments)
    - Plan new investments with a capability for capacity expansion
    - Operate existing structures/systems for optimal use
    - Modifying processes and demands
  - Perceives big gap between the science community doing global circulation modeling and the Corps water manager
- Rolf Olsen (IWR):
  - Upper Mississippi River Flow Frequency Study to update 100 yr floodplain
    - Examined the climate induced flow variability and flow frequency change on the Upper Miss and Missouri Rivers
    - Not enough compelling evidence to deviate from current guidance in Bulletin 17 B
  - Middle Mississippi River study on climate impacts and inland navigation
    - Climate variability was found to affect flood frequency with or without anthropogenic change.

Other Agencies

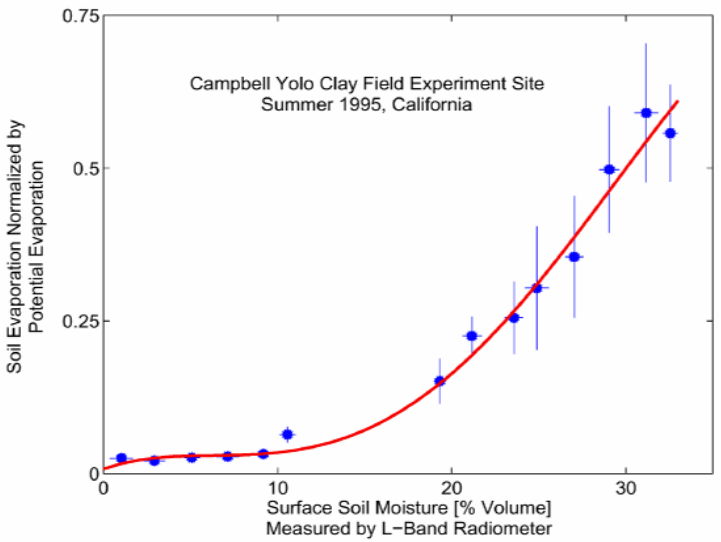
- Dr. Jared Entin – NASA Water and Energy Cycle Missions
- Dr. Don Cline – NWS National Operational Hydrologic Remote Sensing Center (NOHRSC)
- Dr. Ed O'Lenic – NOAA Climate Prediction Center / NCEP
- Dr. Tom Huntington – USGS Augusta ME
- Dr. Dan Cayan - Scripps


Knowledge Base
NASA
Partnership
Unfunded
= field campaign
T= Technology development required
T River discharge monitored globally; Snow water equivalent observations
Global precipitation measurements (GPM)
Improved precipitation forecasts that support: Water supply Decision Support System with 7-10 day lead time & seasonal water supply forecasting ability
Global Soil Moisture (HYDROS)
Global estimates of ocean evaporation (Aquarius) and land evaporation
Quantify and elucidate mechanisms of the mean state and variability of the water cycle, including quantification of precipitation, evaporation, runoff and water storages
NASA Energy- and Water-cycle Study
Vertical profiles of cloud structure and properties (Cloudsat/Calipso)
Cloud parameterization and precipitation/water-vapor assimilation enabling more reliable short-term precipitation forecasts and accurate role of clouds in climate predictions
Data assimilation of precipitation and water vapor
Detection of gravity perturbations due to water distribution (GRACE)
EOS/in-situ observations of land surface state variables
Assessments of natural variability in atmospheric, surface and subsurface moisture stores
Observations of tropical rainfall/energy release(TRMM)
Improved latent heating profiles and convective parameterizations within weather and climate models
Ongoing model improvements Enhancements in computing resources
• Reservoirs and tropical rainfall well quantified
• Difficulty balancing the water budget on any scale
• Inability to observe and predict precipitation globally
Systematic measurements of precipitation, SST, land cover & snow
2004
2006
IPCC Report 2008
2010
IPCC Report 2012
2014
2016
GOAL: Models capable of predicting the water cycle, including floods and droughts, down to 10s of kms

Soil Moisture - HYDROS

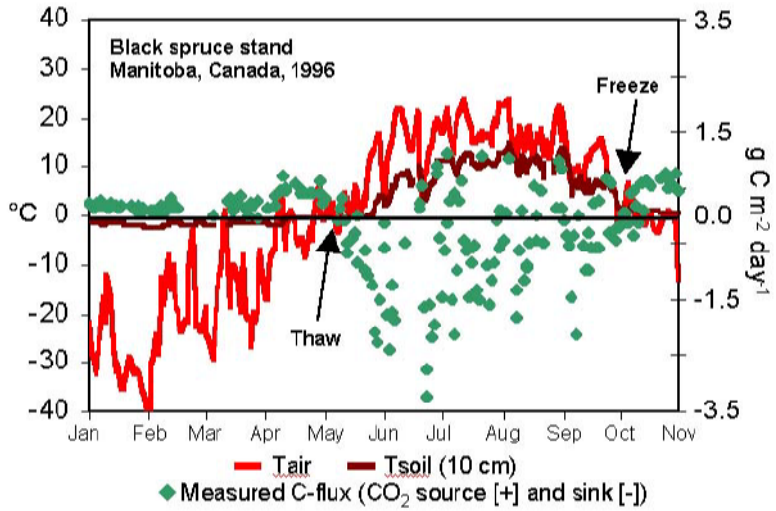
Soil Moisture a critical omission in observations suite (NASA, NOAA, USDA)

Water Cycle



Soil Moisture Strongly Influences Evaporation Rate and thus the Water and Energy Exchanges between Land & Atm.

Carbon Cycle

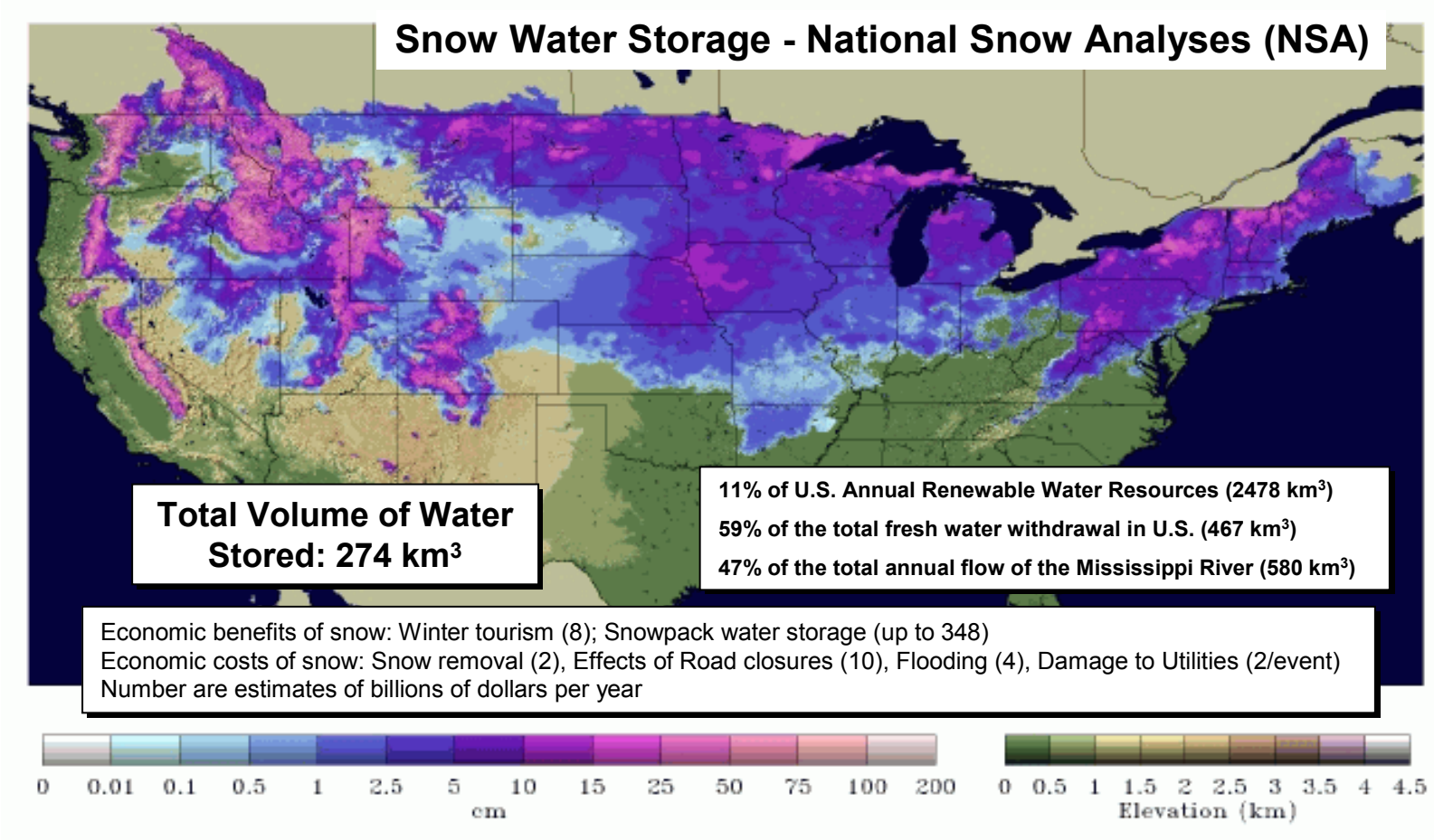


Freeze/Thaw Condition Influences Growing Season Length and thus the Carbon Balance.

Addresses Priority Soil Moisture Data Requirements Across Agencies

NASA: Monitor Process - Global Water, Energy, and Carbon Cycles
NOAA: Improve Weather and Climate Predictions: Flood and Drought
DoD: Applications in All Three Services (e.g. Terrain trafficability, Fog)
USDA: Agricultural Management, Drought Impact Mitigation

Snow – Liquid Water Equivalent



Preliminary information from "The Value of Snow and Snow Information Services" – Office of the chief economist (NOAA, 2004)

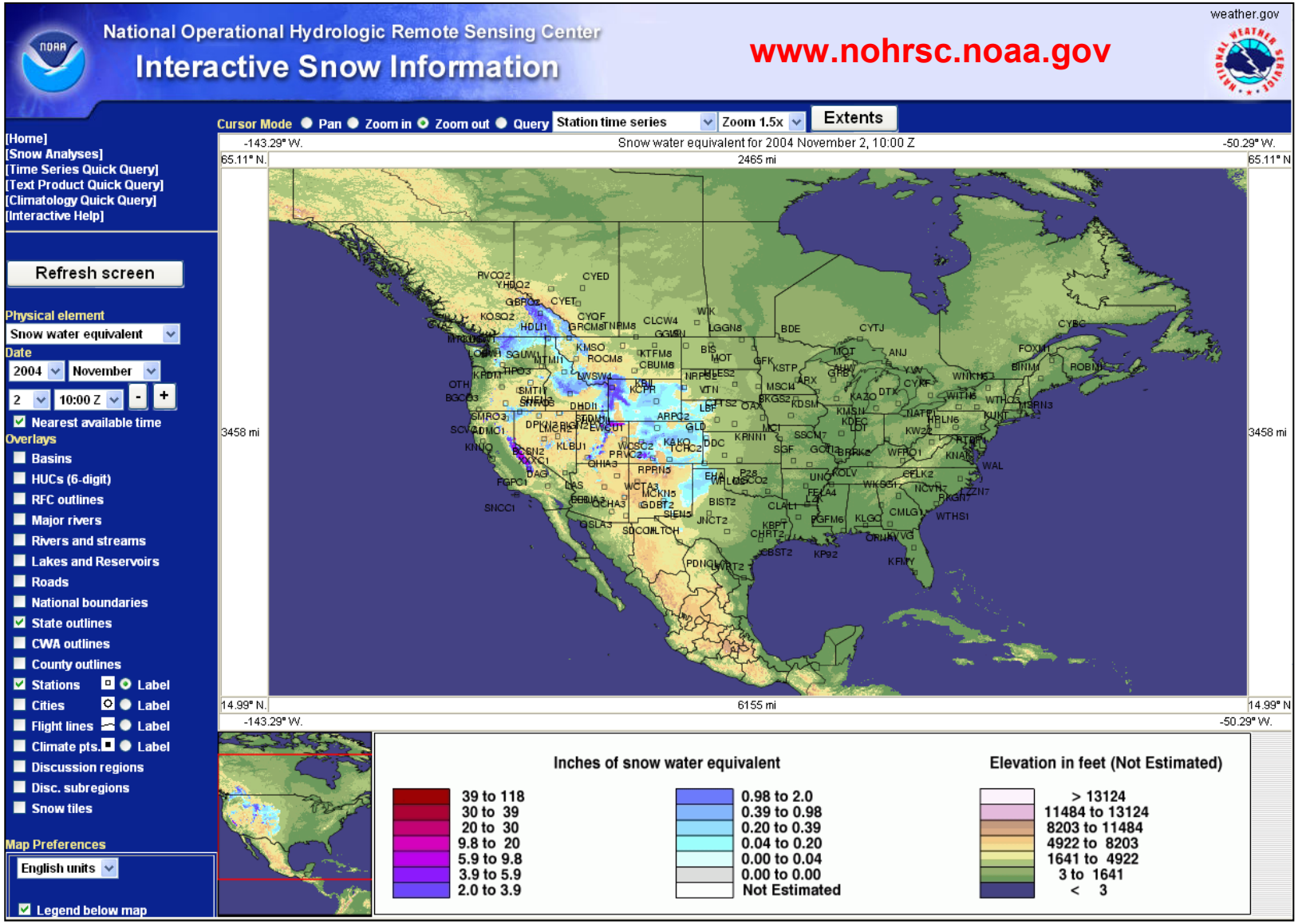
"..improved snow information and services have potential benefits greater than $1.3 billion annually." "…investments that make only modest improvements in snow information will have substantial economic payoffs."

NOHRSC Products

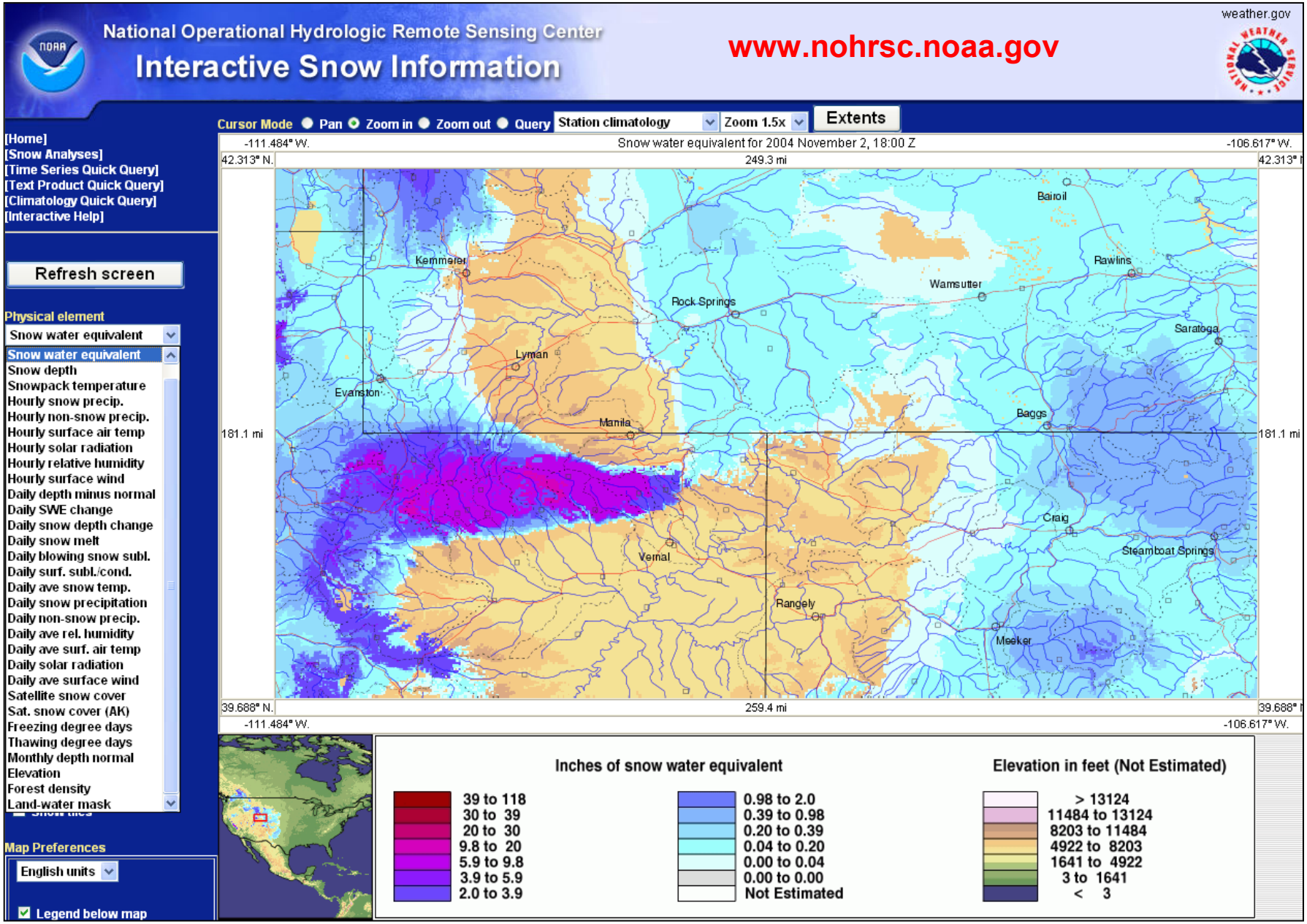
- National Snow Analyses (NSA)
  - **Snow modeling and data assimilation system for U.S.**
    - **Overview of the data, modeling framework and products**
- Interactive Snow Information System (Snow-Info)
  - **Web-based mapping and data querying system for NSA information**
    - **Overview of functions and capability**
- New Climate Diagnostic Tools in Snow-Info
  - **Monthly normal snow-depth maps for U.S.**
  - **Daily departure-from-normal snow-depth maps for U.S.**
  - **Snow-depth climatology and NSA time-series for 4000 stations**

www.nohrsc.noaa.gov

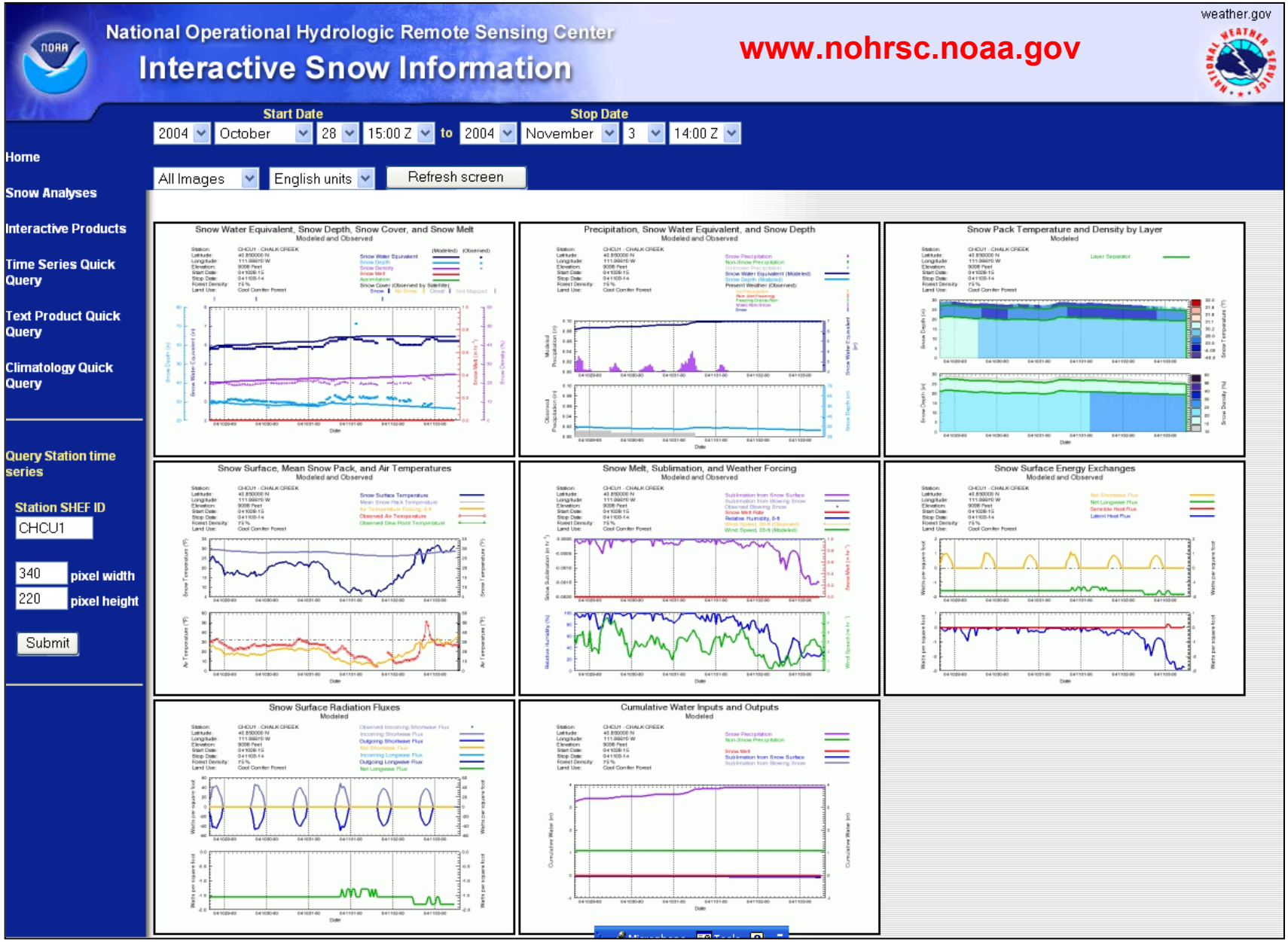
Interactive Snow Information System



Interactive Snow Information System



Interactive Snow Information System

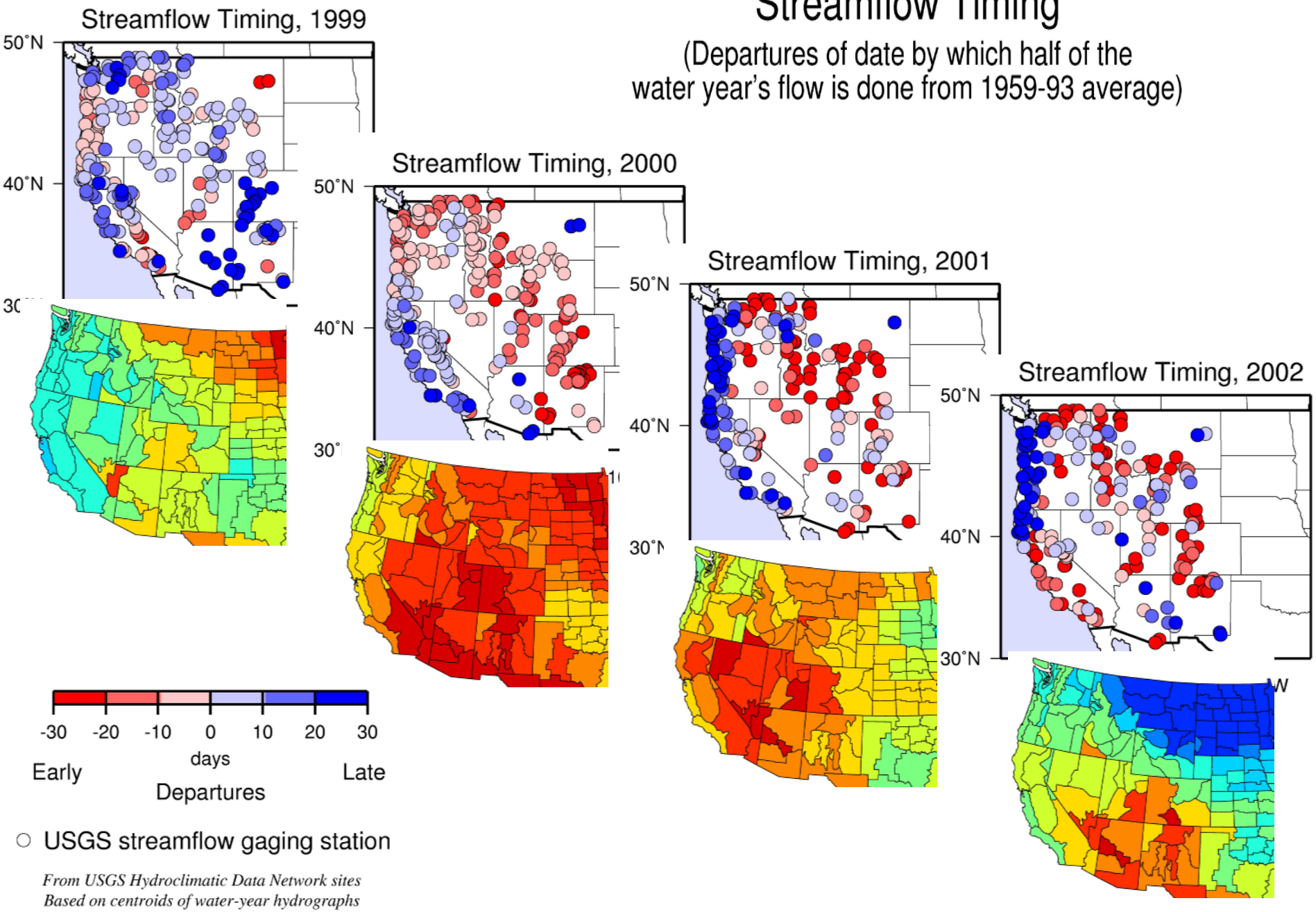


Huntington (USGS): Summary of Ongoing Hydrologic Changes

- **New England**
  - Advances in timing of lake and river ice-out
  - Decreases in number of days that ice affects flow
  - Advances in timing of snowmelt-dominated high spring flow
  - Decreases in river ice thickness
  - Decreases in the ratio of snow-to-total precipitation
  - No change in summer low flow
- **Northern Hemisphere (20th Century)**
  - Decreases in snow cover extent
  - Increases in precipitation
  - Increases in stream flow
  - Intensification of the Global Hydrologic Cycle

Streamflow Timing

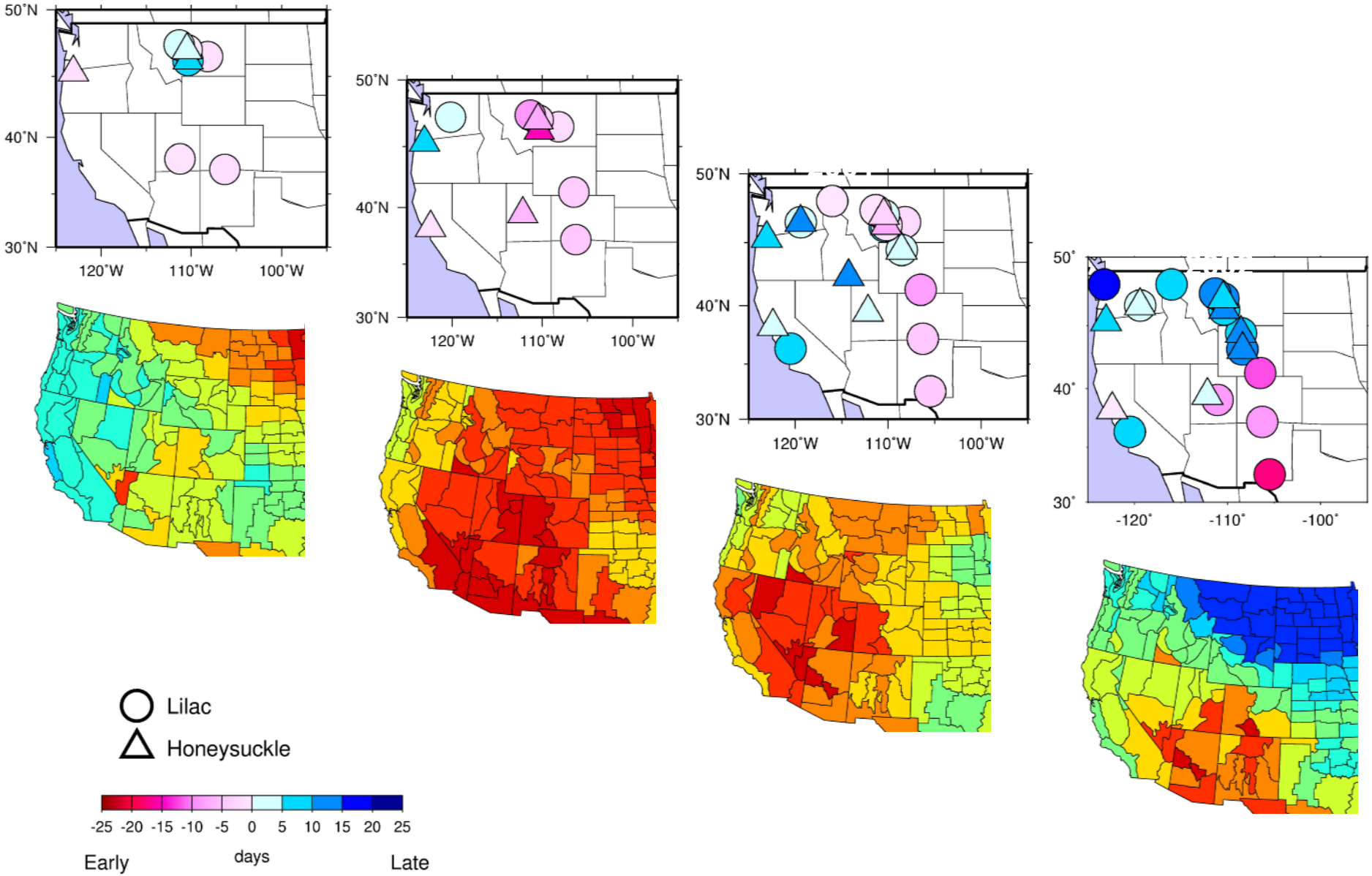
(Departures of date by which half of the water year's flow is done from 1959-93 average)



From USGS Hydroclimatic Data Network sites
Based on centroids of water-year hydrographs
Calculated by Dr. M. Dettinger and Dr. D. Cayan
California Applications Program 2/20/2002

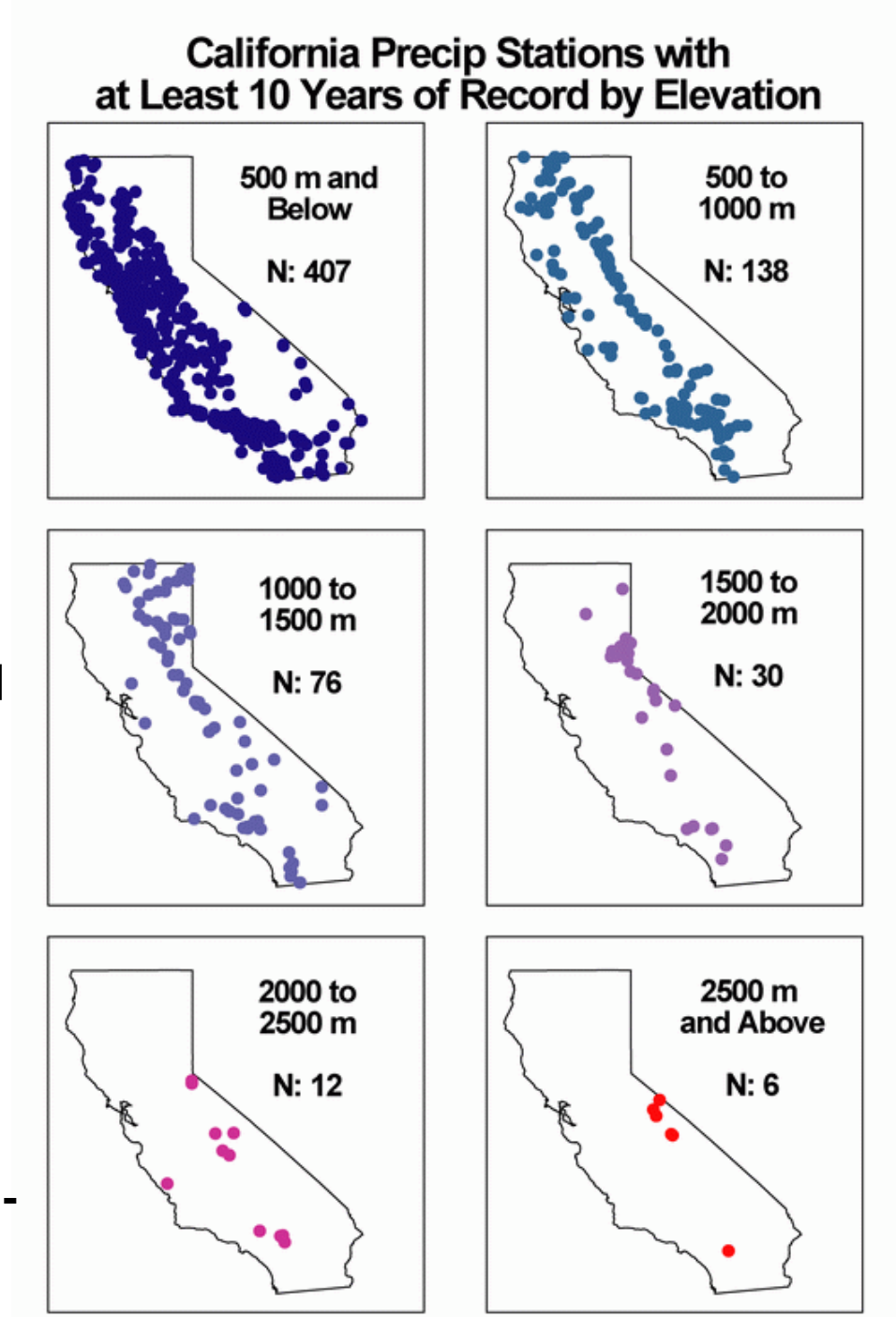
Lilac/Honeysuckle Phenology

(departures from 1983-1994 average phenological stage data)



Cayan: Summary

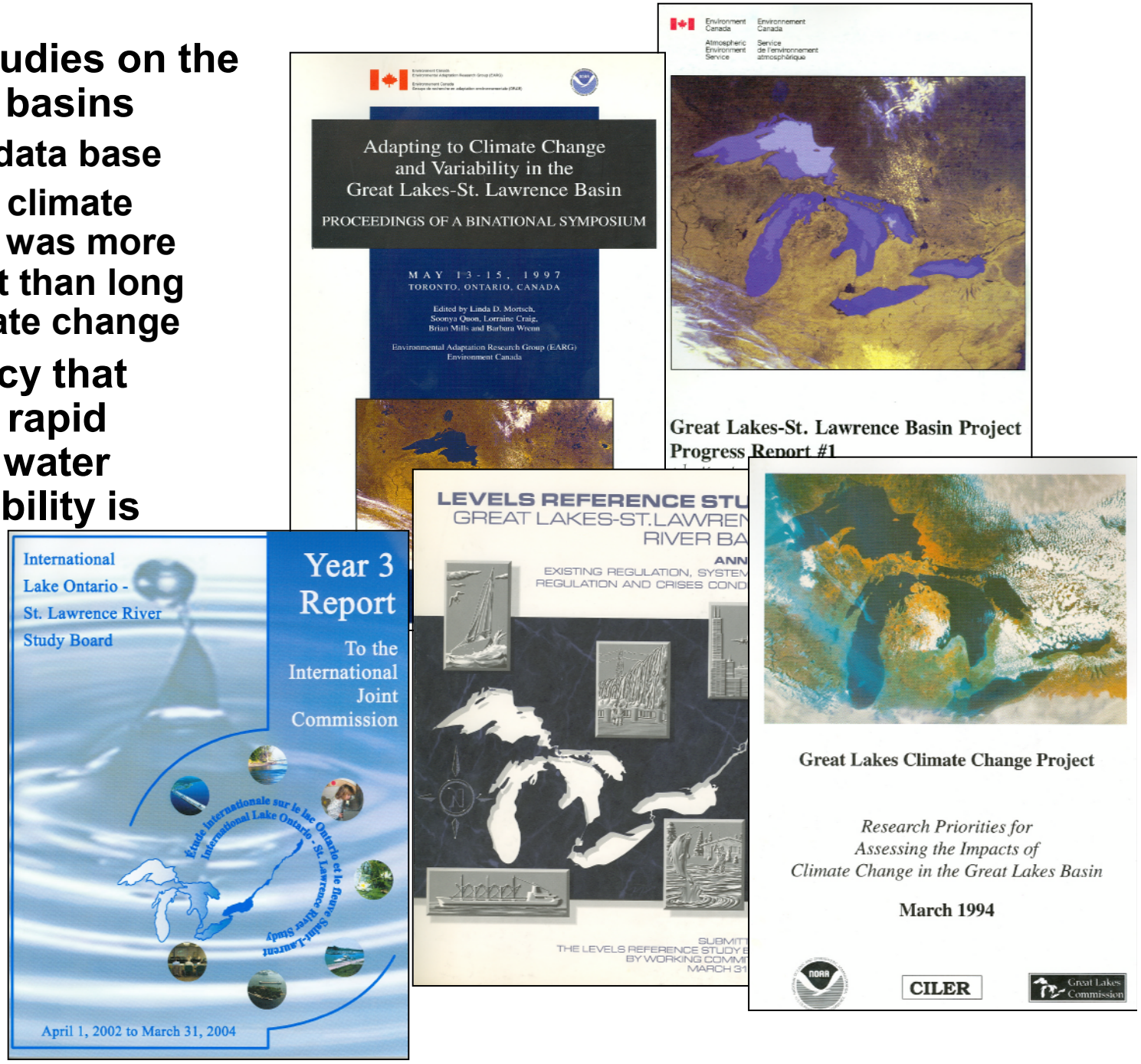
- Rain vs. snow is crucial to water issues in the West
- In CA Sierra Nevada, only 20-30 days deliver most of the year's water
- Timing of spring runoff 1-3 wks earlier in decades after 1977
- Not only early snowmelt but more immediate rainfall runoff occurred
- Trends have been a response to warming trends (not Δ precipitation)
- Need more & better monitoring at mid-high elevations
  - Most precipitation gauges are sited in low elevation population centers
  - Most concern is for climate in mid-high elevations



USACE Experiences

- John Kangas – LRD Great Lakes
- Stephen Brooks – SWF Texas Water Challenges
- Bob Collins – SPK Variability in Snow Affecting Reservoir Operations
- John Heitstuman – NWW Winter Rainfall on Frozen Ground
- Joan Pope – Coastal
- Steve Daly – R&D

- **Extensive studies on the Great Lakes basins**
  - **excellent data base**
  - **show that climate variability was more significant than long term climate change**
- **Flexible policy that allows more rapid response to water regime variability is needed**



Brooks: Texas Water Challenges

- Need for Future Water Supply
  - Population Projections
  - Water Demand/Supply Projections
  - Texas Senate Bill 1
  - Texas Water Plan – 2002
- Corps of Engineers Support for Texas Water Plan
  - Texas Water Allocation Assessment
- Current Watershed Studies
- Urban River Restoration

Need for Future Water Supply

- **Texas Senate Bill 1**
  - **Passed by 75th Texas Legislature in 1997**
  - **Established 16 regional water planning groups (RWPG)**
  - **Required development of water management strategies to meet projected regional shortages**
  - **Required update to regional water plans on 5-Year cycle**
  - **Initial regional water plans submitted January 2001**
  - **Texas Water Plan Adopted January 2002**

USACE Support for Texas Water Plan

- **Texas Water Allocation Assessment (TWAA) Initiatives:**
  - **Review of 16 Regional Water Plans**
  - **Brush Management Study**
  - **Brush Management - Phase II**
  - **Review of COE Water Supply Authorities**
  - **System Assessment of Corps Reservoirs – Sulphur Basin**
  - **Instream Flow Analyses – Brazos and Sulphur Basins**
  - **GIS-Based Decision Support System**
  - **Texoma Partial Reallocation Study**
  - **Rural Issues Study**
  - **Prioritization of Candidate Watersheds for Ecosystem Restoration**

Collins Summary:

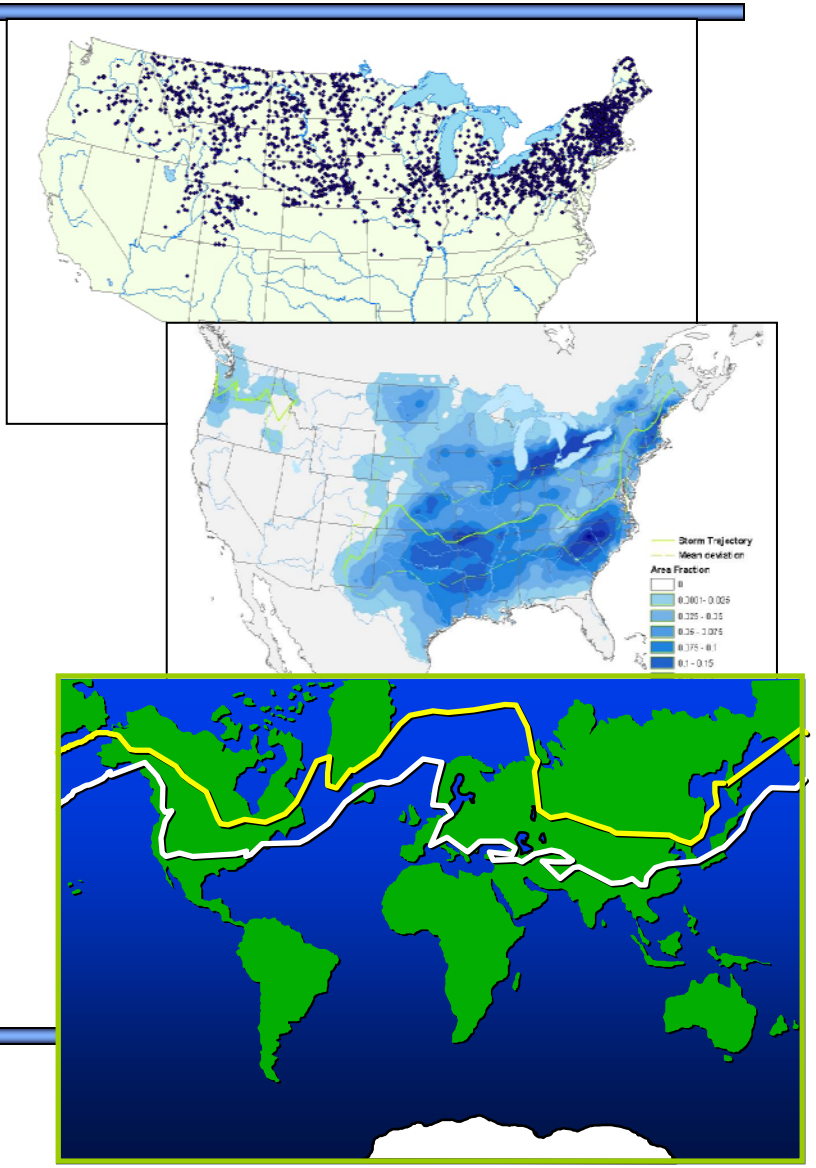
- Climate change is causing spring snowmelt to come earlier in the Central Valley
- Capturing spring snowmelt runoff without increasing flood risk requires us to be “smarter” water managers
- One possible adaptive management solution is to create more flexibility in water control diagrams by incorporating forecast information
- This strategy is currently being studied under the Folsom Dam Modifications Project
- This project could be an example that other Corps reservoirs follow in the future

Heitstuman Summary:

- Recent major NWW floods occur due to rain on frozen ground
- Flood characteristics
  - Short duration (7-10 days)
  - Nearly impervious floodplains
  - In many cases, higher elevation snowpack will show increased SWE after event, setting the stage for a subsequent flood on highly saturated or refrozen ground
- Generally generate > 2% chance annual flood, often the flood of record

Daly – ERDC Climate Studies (Mil & CW)

- **Climate statistics**
  - Impacts from climate variation and indices, precipitation, ice jams and severe storms
- **Climate modeling and impacts**
  - Ice and atmosphere physics in models for the IPCC
  - Modeled trends in climate, ice, precip and evaporation
- **Polar studies**
  - Arctic ice, permafrost, and glaciers shrinking
  - Changes in temps, snow, and vegetation
  - Changes monitored on land and by satellites



Summary of Workshop Observations

- Warming is accelerating and will continue
- While specific areas are responding differently, weather is becoming more energetic and more variable
- Climate is one of multiple forces that are shaping the future of water resource management
- Both variability and long term change are of concern
- Temporal and spatial mismatches of supply and demand that is the problem in water supply

Workshop Breakout Sessions

1. What aspects of climate variability are really significant to water resources management and the Corps of Engineers mission?
2. How do these important issues relate to the Civil Works Strategic goals and objectives?
3. How can the emerging knowledge and tools concerning climate change and variability be incorporated into the Corps water management business practices to assist in mission execution?
4. What are the next steps for the Corps to accomplish more effective water management in an environment of climate variability and change?

Workshop Recommendations

- Increase awareness of knowledge and capabilities concerning climate impacts and climate forecasting
- Establish alliances with individuals and organizations that have expertise to assist water managers
- Develop a Community of Practice to systematically and effectively incorporate climate in water resources planning and analysis (tonight)
- Conduct demonstration projects between the Corps R&D community and Districts to co-develop strategies that lead to more effective short and long term management of climate impacts in concert with the philosophy of holistic, watershed scale, systems approach to water resources management

Corps Workshop on Climate Impacts

(November 2004, Baltimore)

- Water resource mangers are faced with increasingly complex issues
  - climate dynamics
  - changes in supply and demand
  - other processes of globalization
- These issues demand a different framework for policy and practice
  - enable the Corps to address climate change/variability as an integral component to its planning and operations functions
  - can be evolved from the current water management capabilities
  - emerging and evolving policies, coupled to real situations and decisions
- Significant capabilities emerging that we can integrate and leverage
  - collaboration in technology and policy development
  - alliances for planning and operations
  - continual development and evolution of a national common operating picture and strategy for water resource management