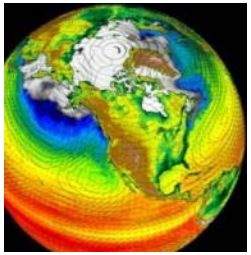
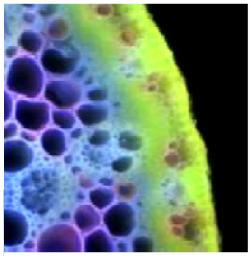
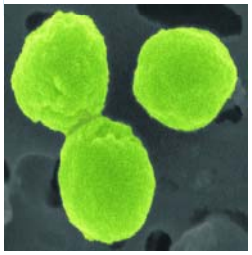


Community Modeling and Long-Term Predictions of the Integrated Water Cycle

September 24 – 26, 2012 Washington DC

Report to BERAC, 22 February, 2013
Renu Joseph

Workshop Organizers: Renu Joseph, Bob Vallario, David Lesmes

Why Water?

- Water underlies and influences many important climate processes and feedbacks – a leading cause of uncertainty in projecting future climate

Water vapor and cloud feedback

Snow-albedo feedback

Aerosol-cloud interactions

Carbon-water interactions

- Water is essential for energy systems, ecosystem services, and a wide range of life sustaining and other critical human activities

- Regional water cycles are influenced by natural variability as well as a significant human component

Importance and Relevance

Why DOE?

- The Energy-Water Connection

Why this Workshop?

- CESD's strategic plan emphasized the need for water cycle dynamics to be included in the Community Earth System Model (CESM) and the Global Change Assessment Model (GCAM).

- The current capability lacks integrated dynamic modeling of surface and subsurface hydrological and land use and water demands components.

- What is new here, relative to similar workshops in the past?
  - To understand the science needs to develop strategies that address **the long-term predictions of the integrated water cycle**
  - Leverage off the successes of previous workshops
  - Different perspectives and interests represented at the workshop => many different answers to this question.

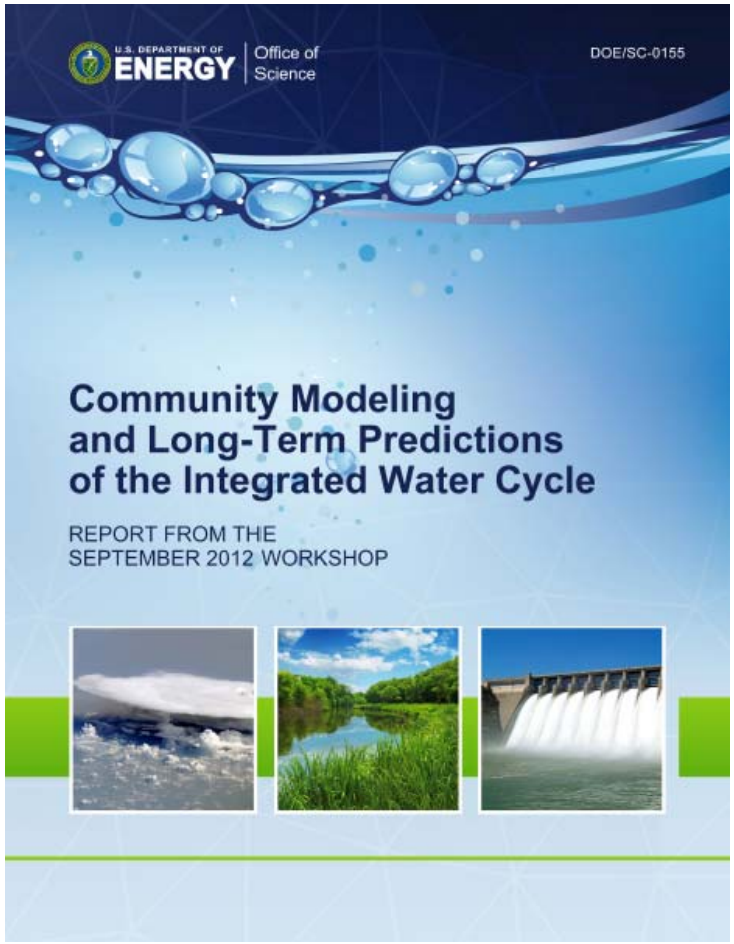
Strategic Plan- Supporting Objectives

- "Develop, test, and analyze simulations of the integrated water cycle, including feedbacks and interactions among components and systems, the relative roles of global and local human and natural processes, and projections of shifts in means and extremes"
- "Advance understanding and process representation of the couplings involving energy, carbon, and water cycles, and improve dynamical representations of these cycles to better represent climate forcings at the interfaces of terrestrial, aquatic, and urban systems"
- "Develop improved high-resolution climate models and companion data sets that are capable of projecting, with increased level of skill and certainty, seasonal to decadal estimates of precipitation and water availability, wind speeds, cloud cover, and likelihood of extreme events such as droughts, floods, and storm surges, on scales relevant to DOE stakeholders"

Community Modeling ⇔ Community Frameworks

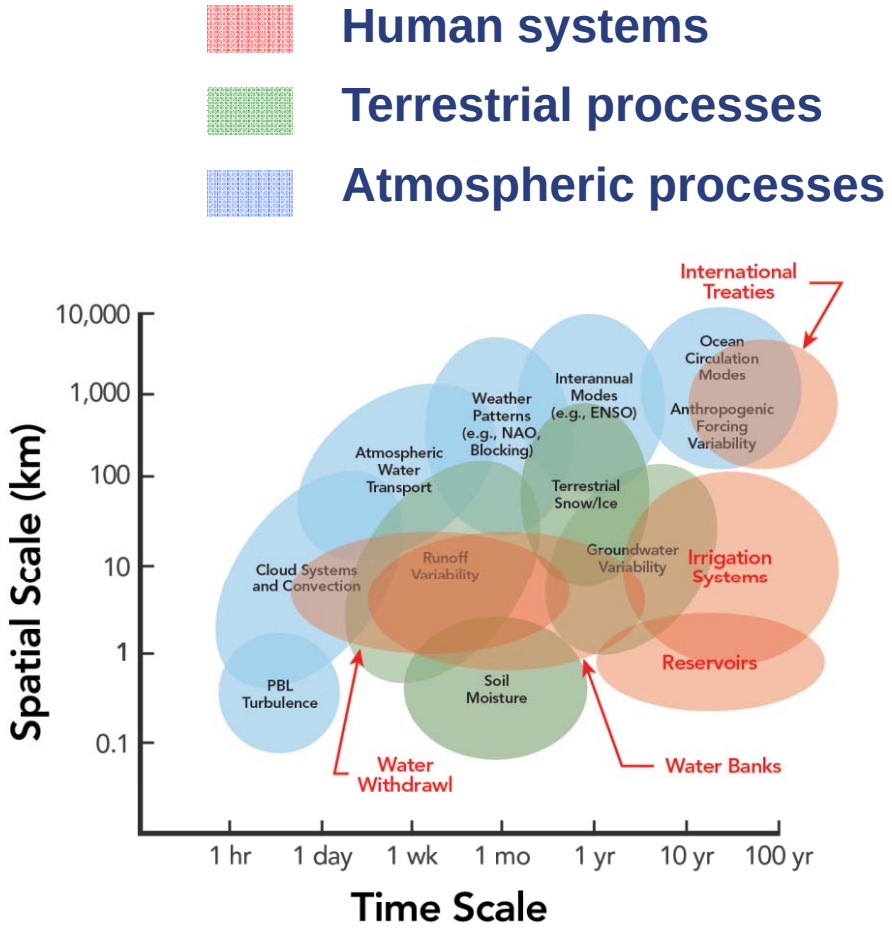
Workshop Goal

- Goal: Identify challenges of next generation human-earth system models for improving long-term predictions of the **regional-scale integrated water cycle**
- Co-chairs:
  - L. Ruby Leung, PNNL
  - Bill Collins, LBNL
  - Jay Famiglietti, UC Irvine
- ~ 80 invited participants including representatives from 8 agencies
- Culminated with an interagency panel discussion



What is the Integrated Water Cycle

- The *integrated water cycle* consists of:
  - Natural Processes: Water budget involving natural terrestrial and atmospheric processes of the earth system
  - Human systems: Water budget involving human systems and human influences on the natural processes/system

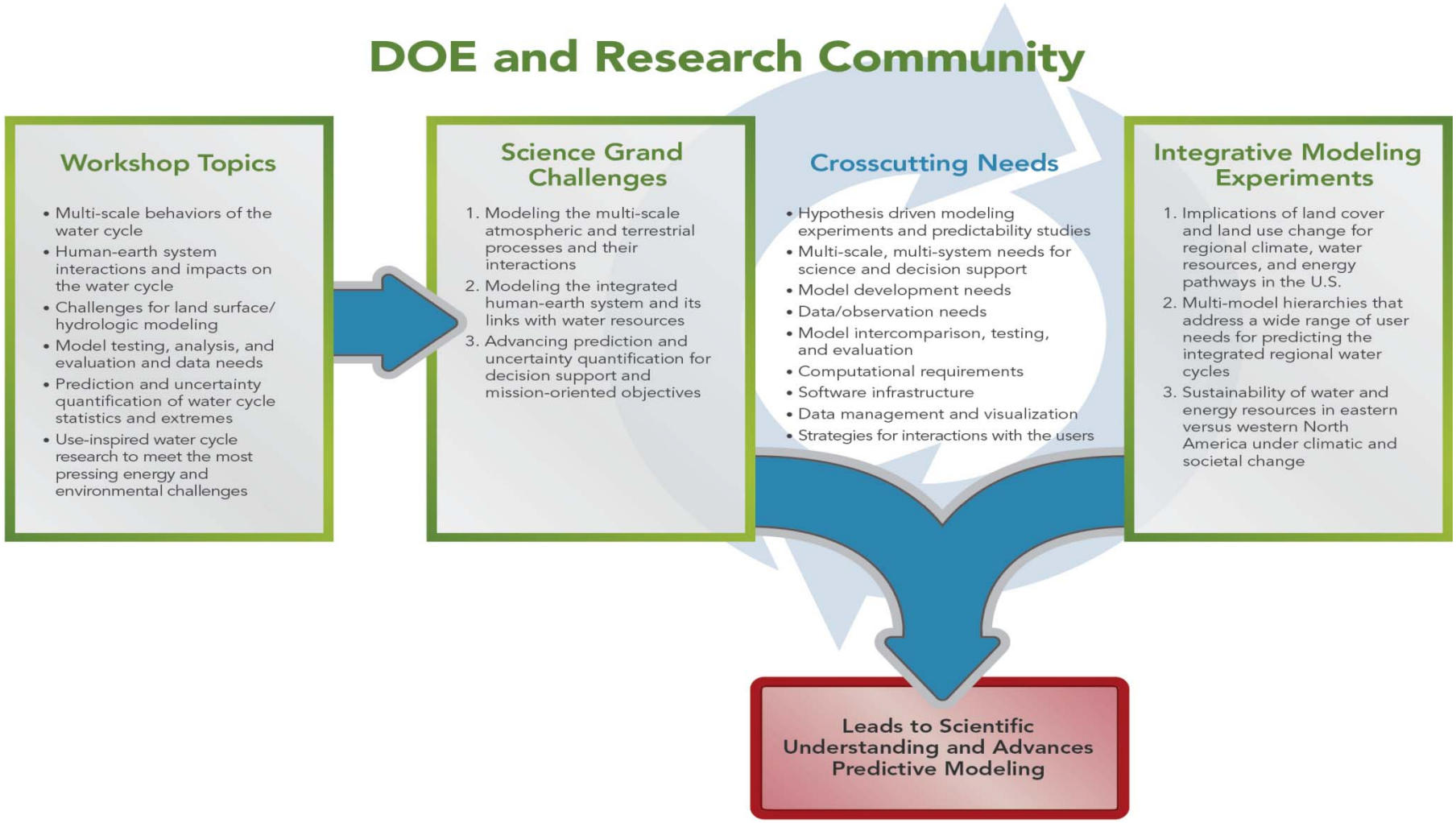


Long term: seasonal – decadal – century

Workshop Topics and CESD Capabilities

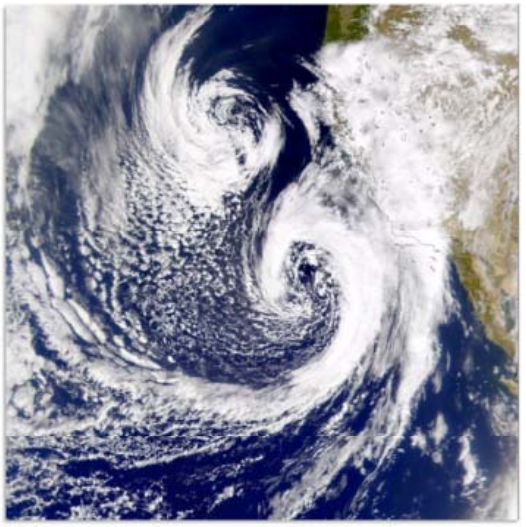
- Topic 1: Multi-scale behaviors of the water cycle
  - All CESD Programs
- Topic 2: Human-earth system interactions and impacts on the water cycle
  - Integrated Assessment Research
- Topic 3: Challenges for land surface/hydrologic modeling
  - Terrestrial Ecosystem Science, Subsurface Biogeochemical Research, Earth System Modeling, Regional and Global Climate Modeling
- Topic 4: Model testing, analysis, and evaluation and data needs
  - Earth System Modeling, Regional and Global Climate Modeling, Integrated Assessment
- Topic 5: Prediction, analysis, and uncertainty quantification of water cycle mean and extremes
  - Earth System Modeling, Regional and Global Climate Modeling, Integrated Assessment
- Topic 6: Use-inspired water cycle research to meet the most pressing energy and environmental challenges
  - DOE, EERE

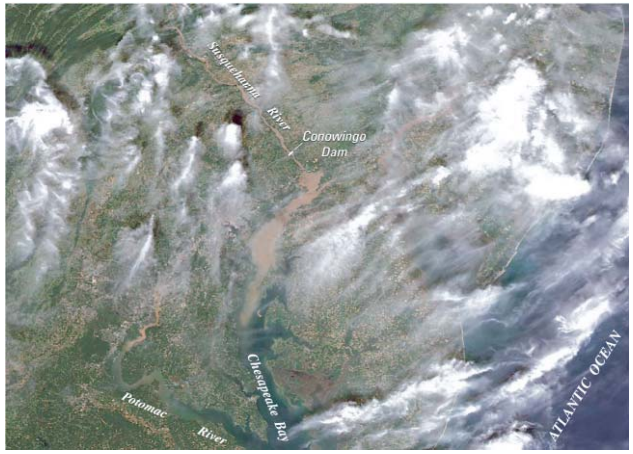
Workshop Outcome



Science Grand Challenge 1

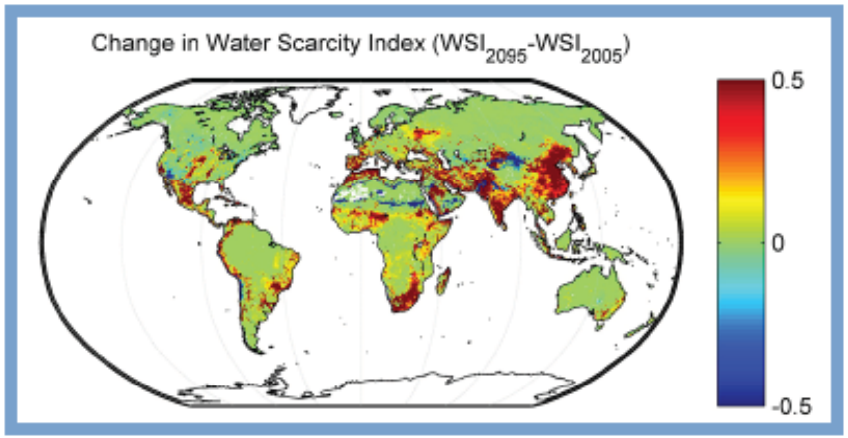
- **Modeling the multi-scale atmospheric and terrestrial processes and their interactions**
  - Understanding the scaling and scale interactions of atmospheric and terrestrial processes
  - Representing the multi-scale processes and the interactions across systems in earth system models
  - Model testbed, evaluation, and data needs





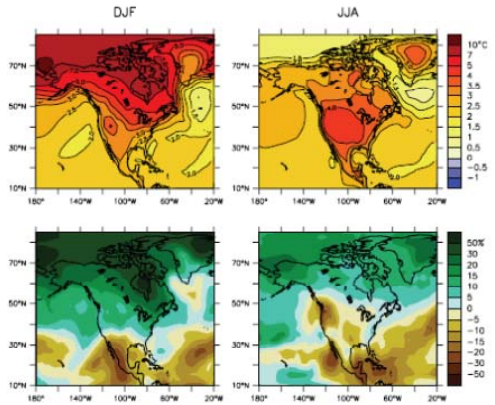
Science Grand Challenge 2

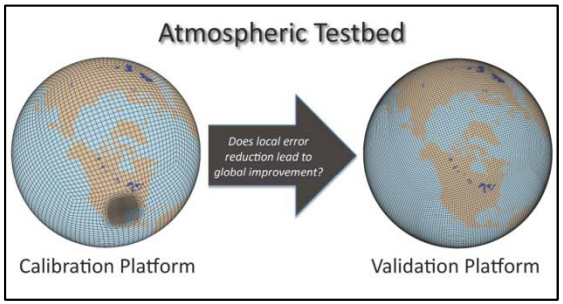
- **Modeling the integrated human-Earth system and its links with water resources**
  - Understanding the roles of human systems at different spatial and temporal scales in the coupled system
  - Representing the wide range of human-Earth system interactions across scales
  - Model testbed, evaluation, and data needs
  - Advancing understanding of the role of human-Earth interactions in water cycle changes

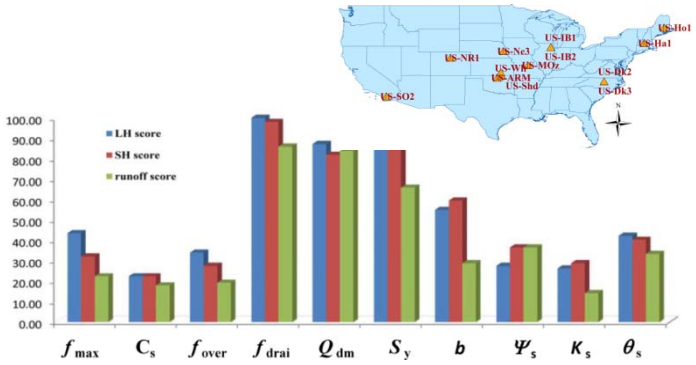


Science Grand Challenge 3

- **Advancing prediction and uncertainty quantification for decision support and mission-oriented objectives**
  - Advancing model predictions
  - Developing uncertainty quantification, metrics, and observations
  - Developing a team approach to use-inspired research





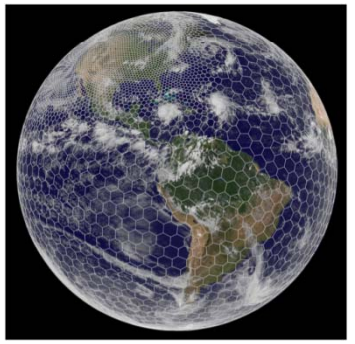


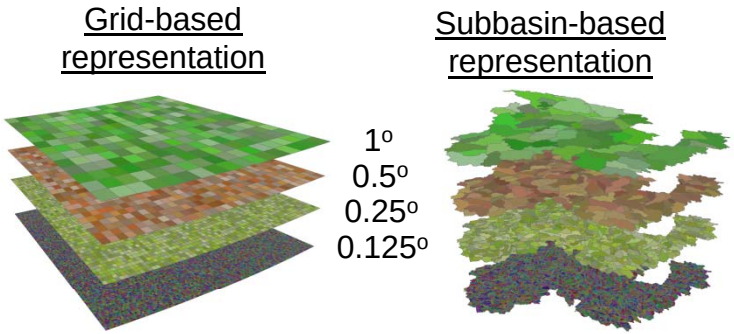
Integrative Modeling Experiment 1

- **Implications of land cover and land use change for regional climate, water resources, and energy pathways in the U.S.**
  - Impacts of changes in irrigation and land cover/land use on local to global climate
  - Effects of climate change and its socio-economic responses on irrigation practices and land cover/land use under various policy scenarios
  - Effects of droughts on irrigation investments and feedback onto climate and water resource availability

Integrative Modeling Experiment 2

- **Multi-model hierarchies to address a wide range of user needs for predicting the regional integrated water cycle**
  - Limitations on predictive skill and predictability in the space and time scales of the end use applications
  - Critical trade-offs among model resolution, complexity, and fidelity for decision making
  - Reconcile predictions from completely different representations of the underlying system dynamics
  - Quantify uncertainty across a hierarchy of models with different complexities



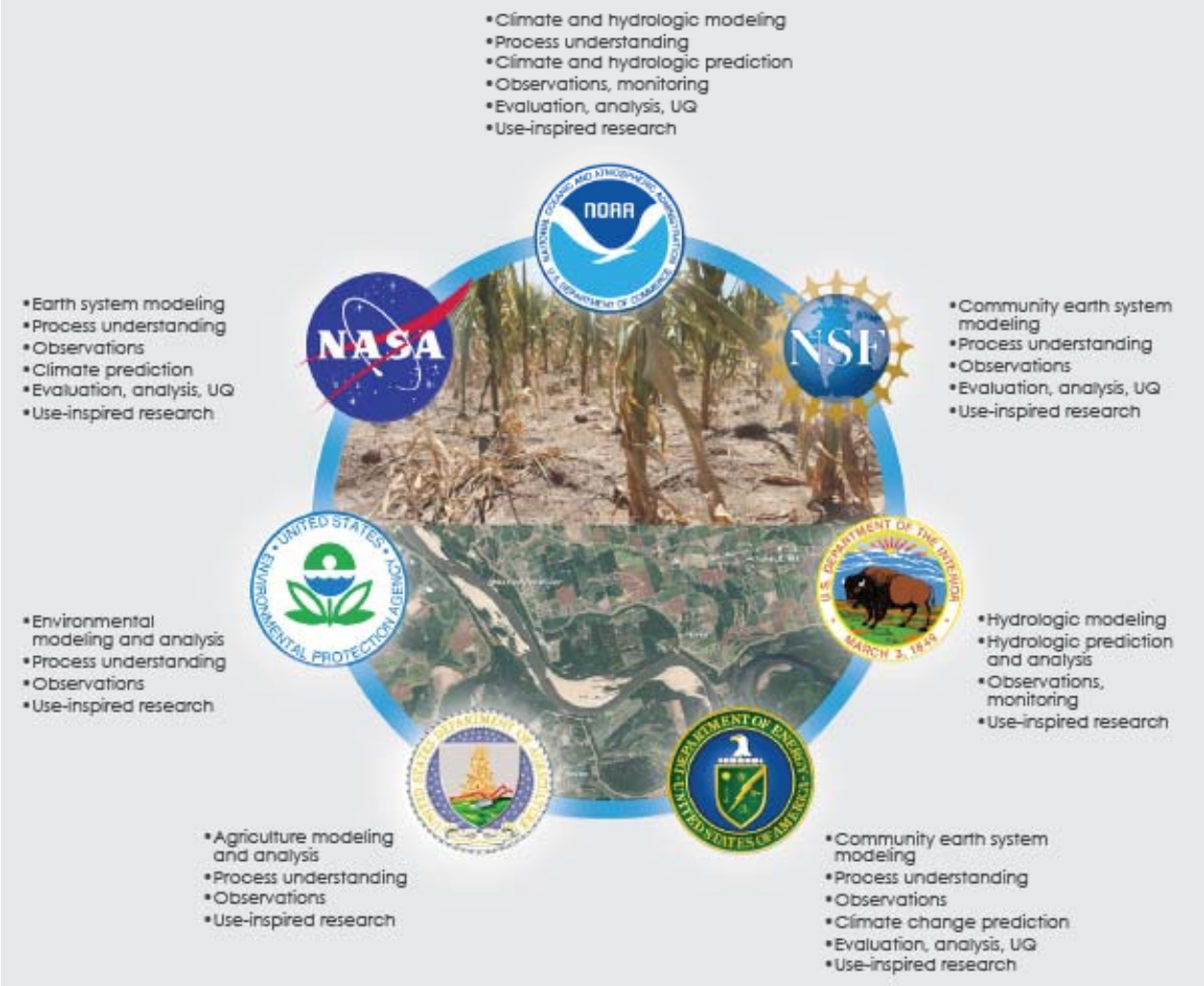


Integrative Modeling Experiment 3

- **Sustainability of water and energy resources in eastern vs western North America under climatic and societal changes**
  - Effects of climate change and projected human footprints on water and energy supplies in different parts of North America (NA)
  - New modeling capabilities to represent the fully integrated dynamic regional climate-water-energy system
  - Contrast the vulnerability and adaptability between the snow fed water cycle of western NA and the less seasonal precipitation regimes of eastern NA, each with their own profiles of human influence

East vs west power plant water withdrawal

Opportunities for Interagency Collaborations: Water Cycle Extremes



Next Steps

- Improve cross-modeling interoperability and build water cycle into the CESM components, most notably Community Land Model; couple with Community Land Model, Global Change Assessment Model, and ocean and ice components
- Topics will selectively be included in future solicitations
  - DOE
  - Other agencies
- Interagency Working Groups
  - USGCRP's Interagency Group on Integrative Modeling
  - National Climate Assessment

Questions