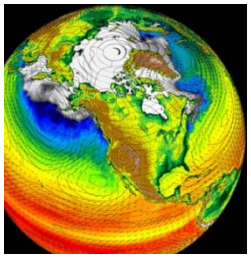


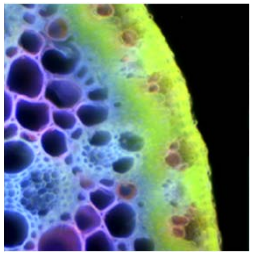
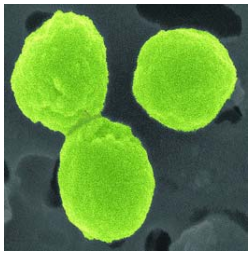

Workshop Brief: Integrated Assessment (IA) and Impact, Adaptation, and Vulnerability (IAV) Modeling

Bob Vallario

U.S. Department of Energy
Office of Science
Office of Biological & Environmental Research

Climate and Environmental Sciences Division

BERAC
October 2016

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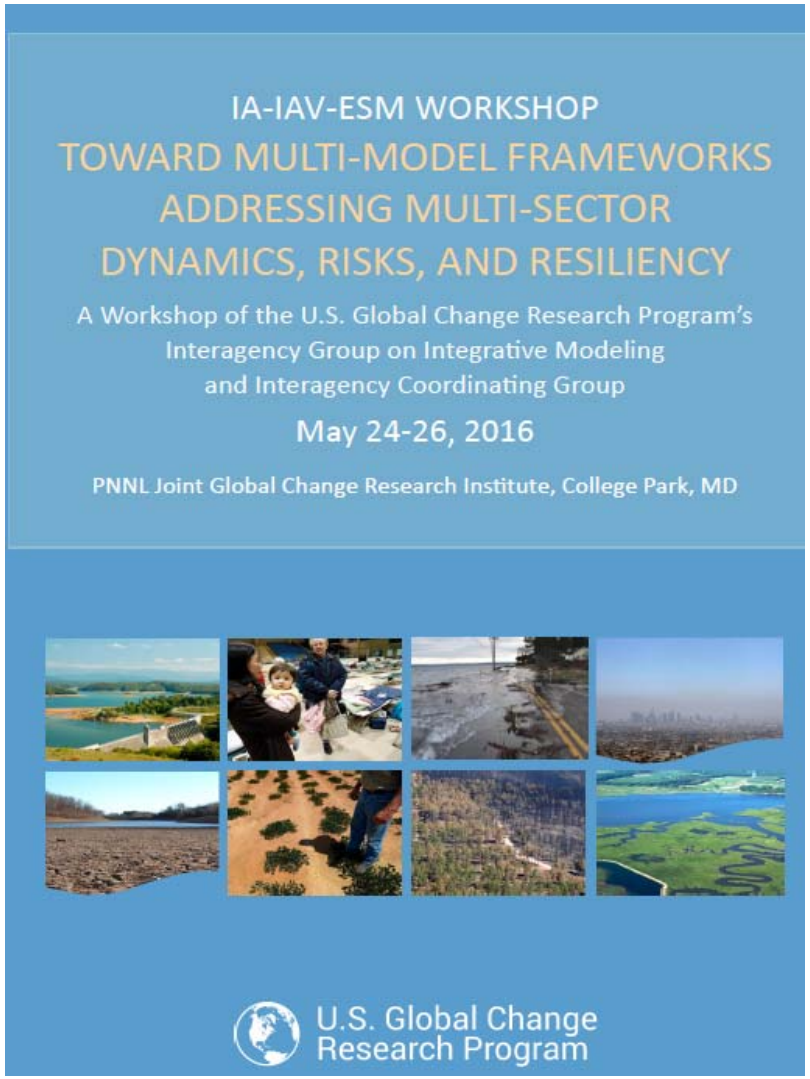
Workshop Overview



- Sponsored/led by DOE and organized by USGCRP interagency group with external science committee
- Over 50 experts: federal government, academia, national labs, and private organizations
- Organized around a representative set of societally relevant scientific topics/questions

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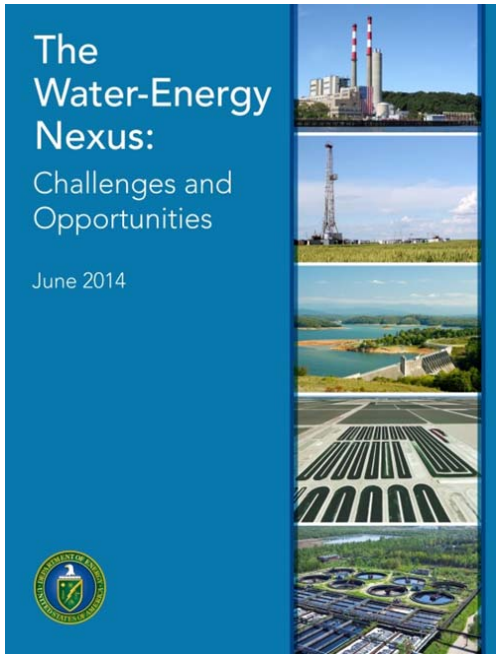
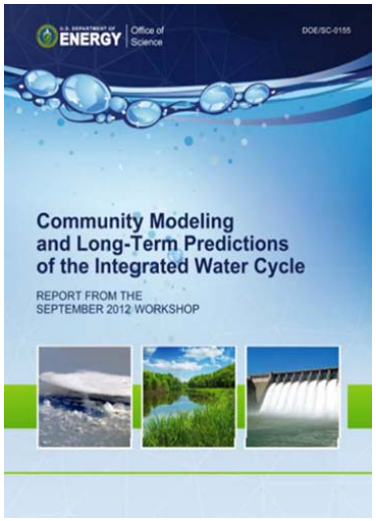
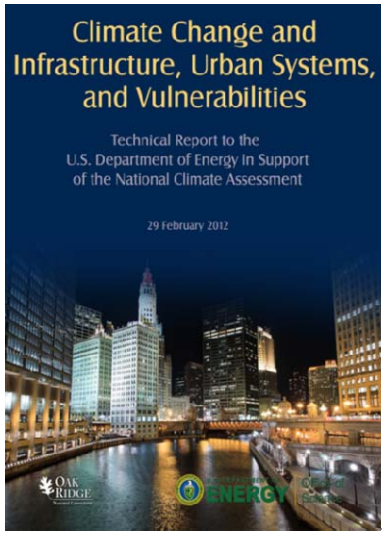
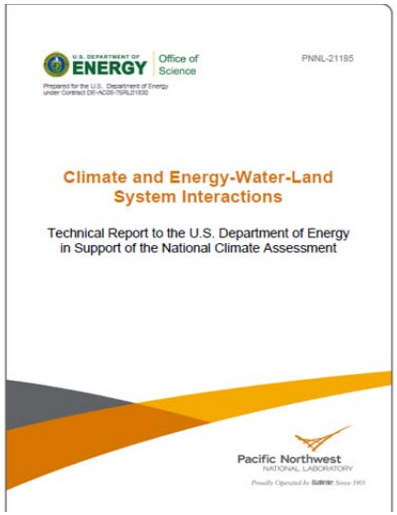
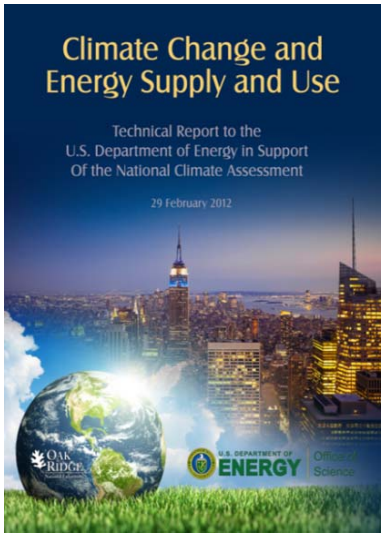
Context –Scientific Publications and Motivations











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Context – DOE Broad Interests…from Science to Solutions

Energy Technology Pathways

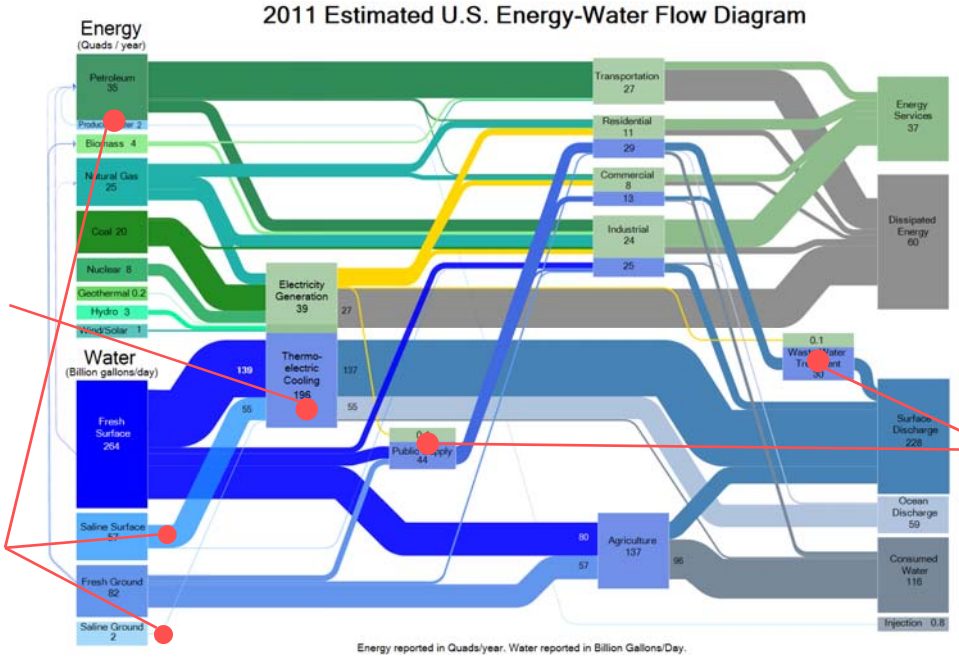
Climate Change (Mitigation and Adaptation)

Forces and Stressors– A Challenge in Modeling Complex Systems

Technology Solutions

Water-Efficient Cooling

Energy-Optimized Treatment, Management, and Beneficial Use of Nontraditional Waters



Sustainable Low-Energy Water Utilities

Policy and Institutional Changes

Land Use & Land Cover Change

Stakeholder and Consumer Preferences

Population/ Migration

Urbanization & Infrastructure Dynamics

Regional Economic Development

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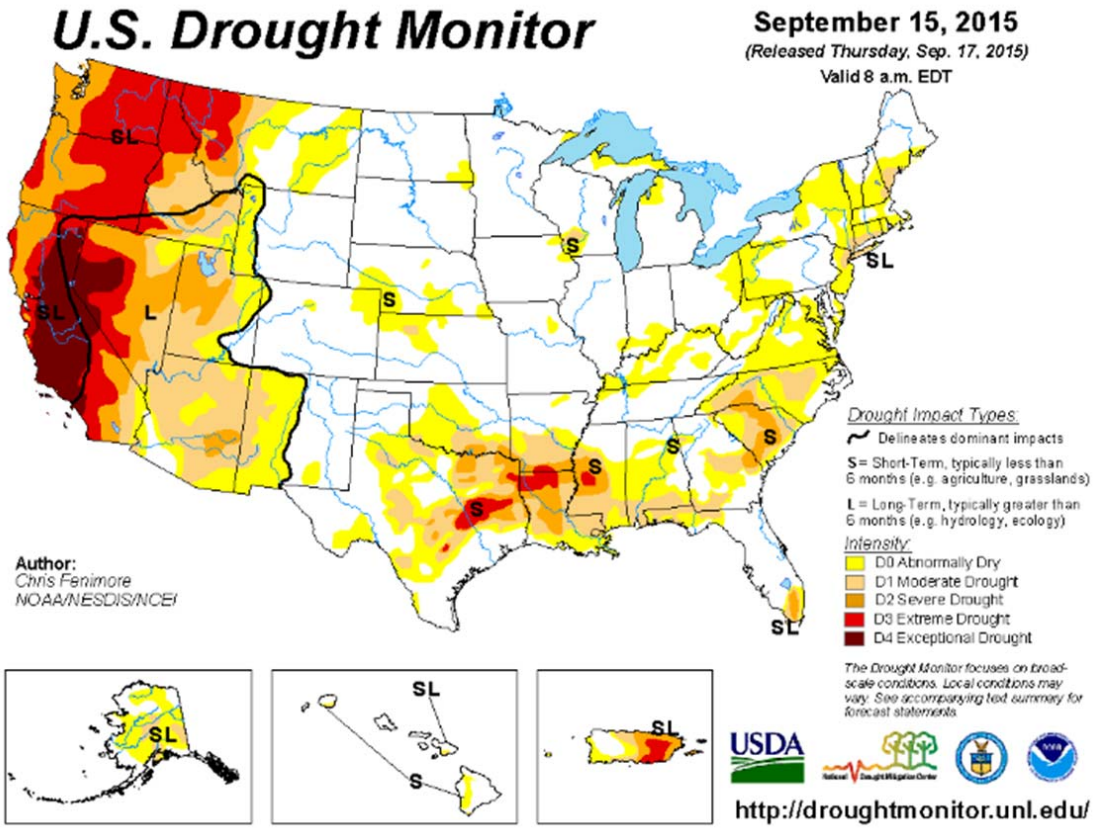
Context – Natural Hazards, Disruptions, and the Growing Imperative

- California drought is cited as the worst recorded in **1200 years***
- California recently passed Italy and the Russian Federation to become the world's 8th-largest economy.



* "How unusual is the 2012–2014 California drought?," Geophysical Research Letters, Daniel Griffin and Kevin J. Anchukaitis, December 2014.

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Context – The Flip Side…and Concentrated, Connected Infrastructure

Over four days in 2014 (Aug. 8-11) 70,000+ U.S. structures were damaged in the Midwest, Northeast, Mid-Atlantic.*

The number of flooding days in the U.S. has increased markedly since the middle of last century, by as much as 900 percent in Annapolis and Baltimore.**

* Global Catastrophe Recap, Aon Benfield, September 2014.

** "'Nuisance flooding' an increasing problem as coastal sea levels rise," NOAA, July 2014.

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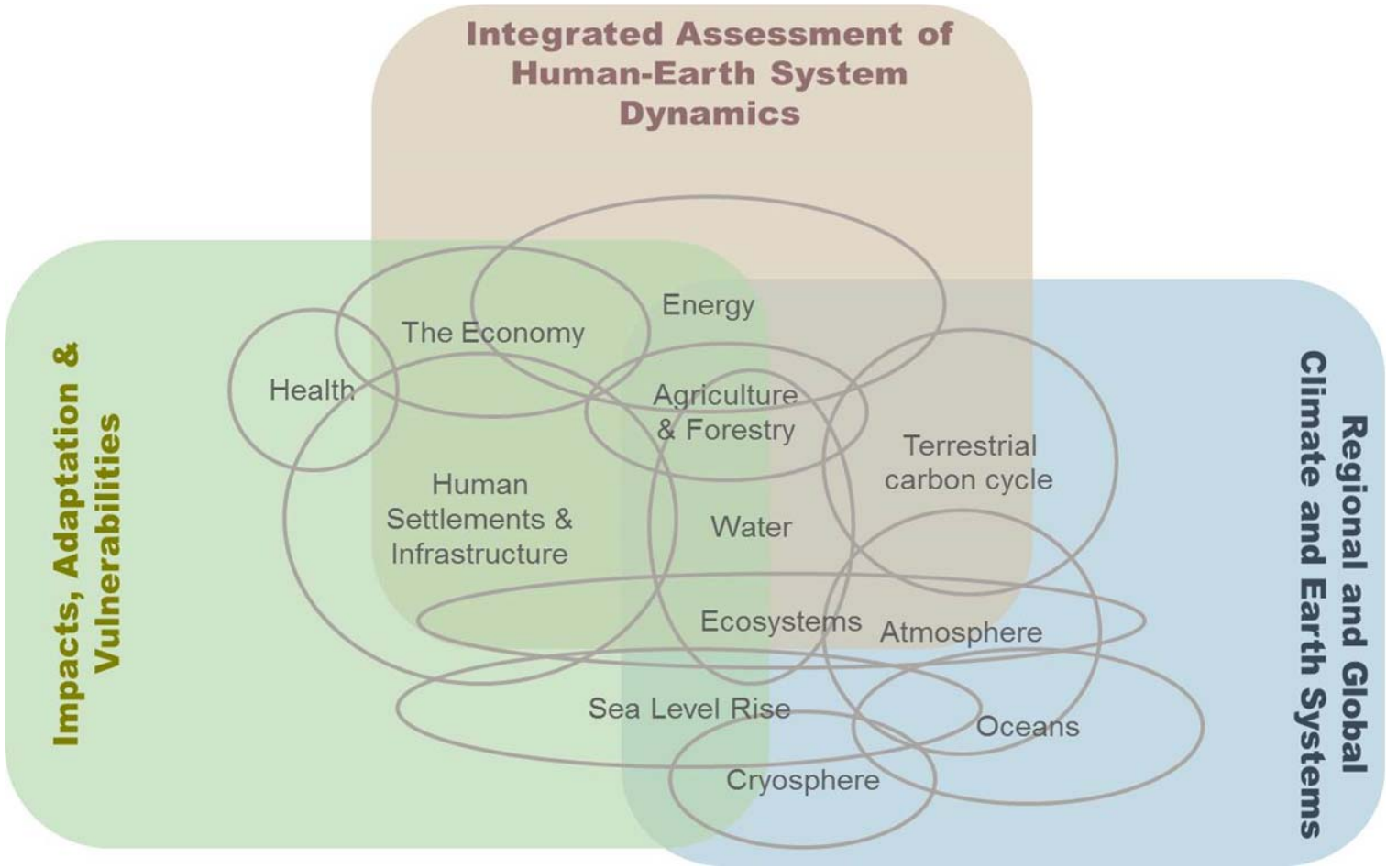
Context – Convergence of Scientific Communities and Modeling Domains



J. Edmonds, PNNL, with modifications

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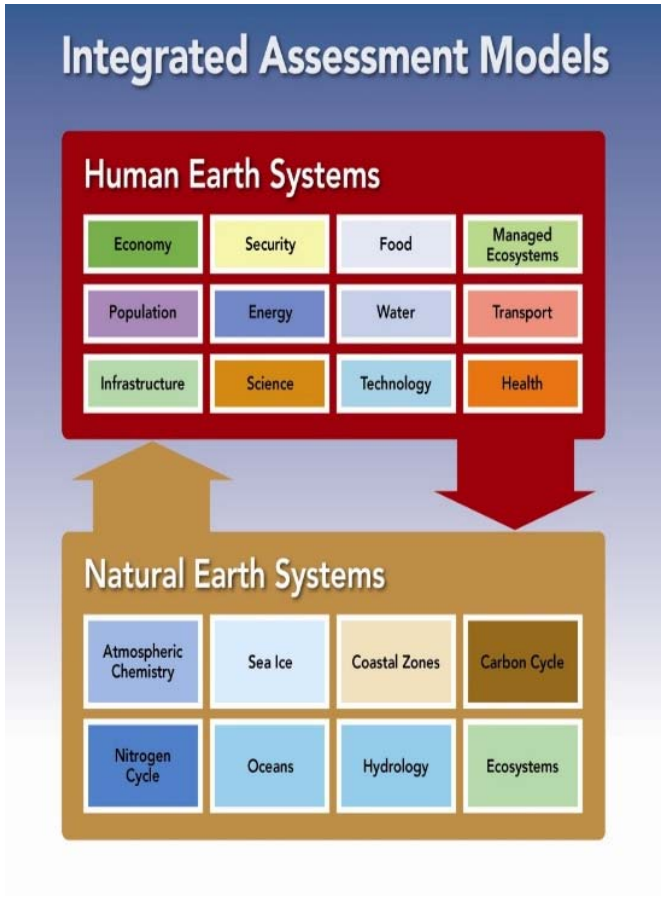
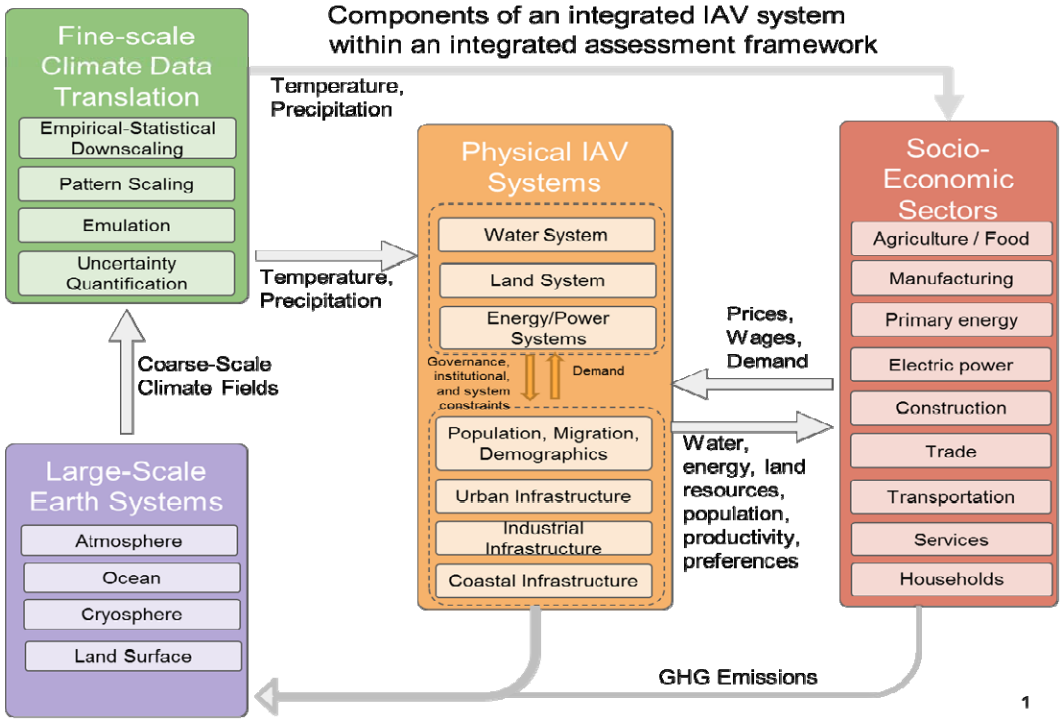
Integrated Assessment Research – Three Emerging Emphases



IAMs

EWN and IAV Data-Knowledge Systems

Multi-Sector, Multi-Model IAV Models



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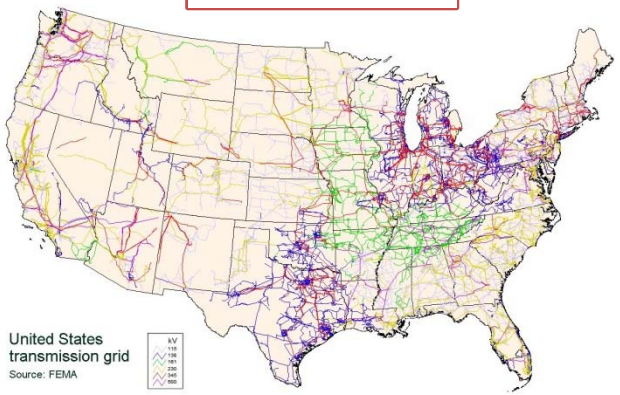
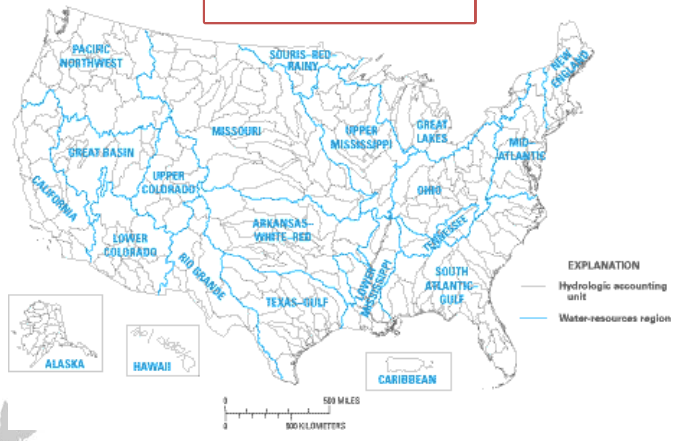
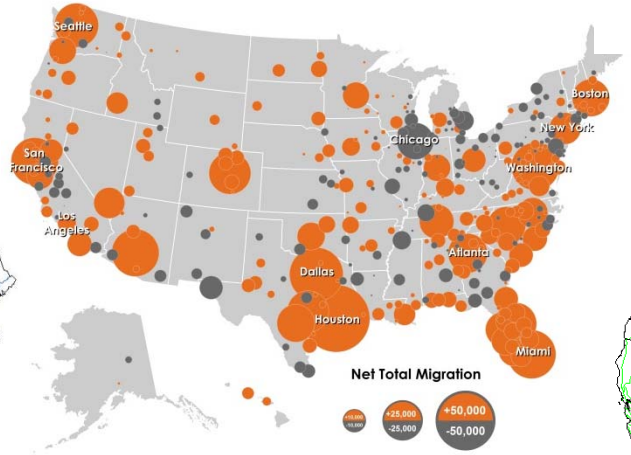
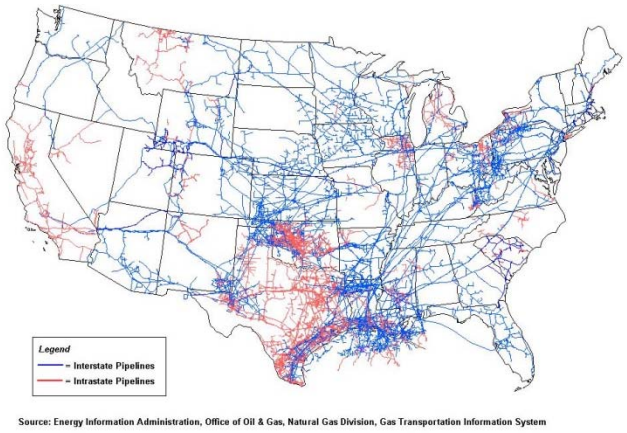
Integrated Assessment Research – Systems Dynamics and Multi-Scale Interactions





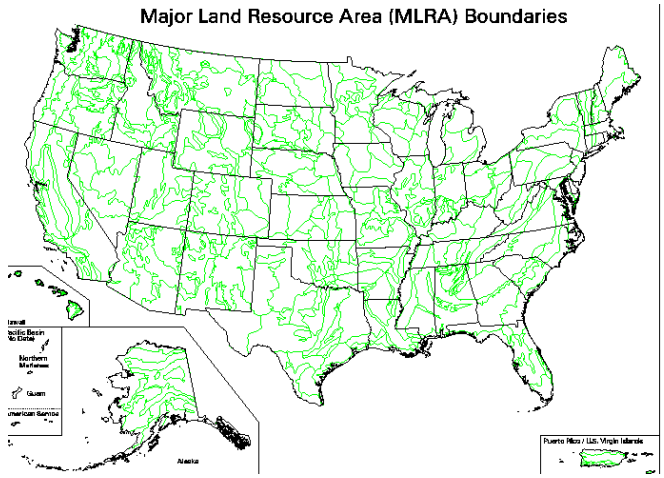


Natural Gas



Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

Land



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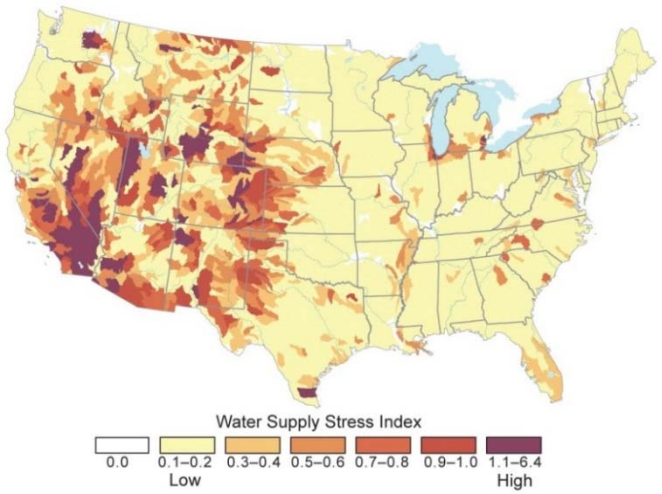
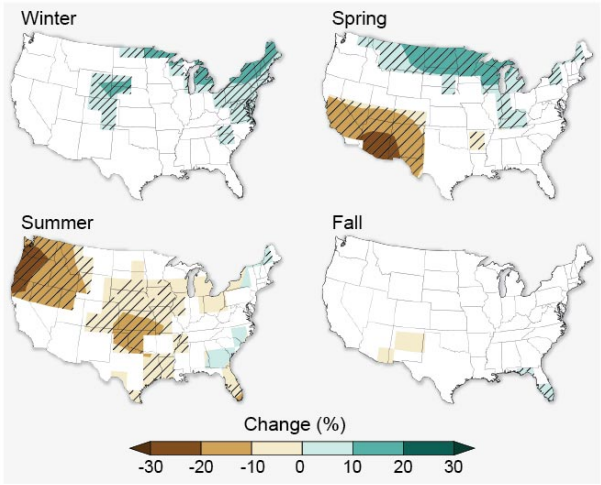
Integrated Assessment Research – Scales of IAV "Stressors" and Responses

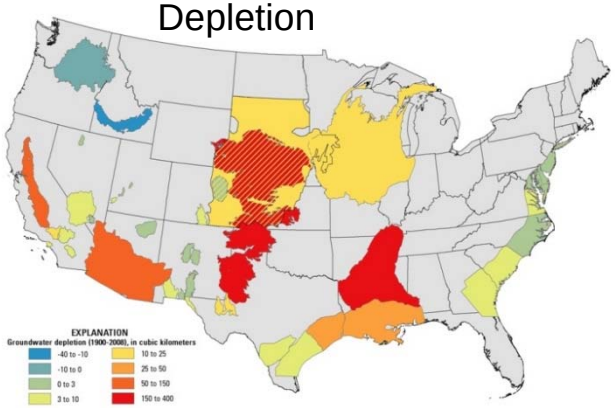
Water Stress in the U.S.



Projected Changes in Seasonal Precipitation



Groundwater Depletion



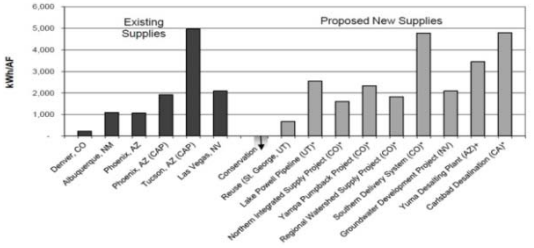
Present **Future**

Example: Growth in Energy Demands for Inter-basin pumping

Existing and Proposed Water Supply Projects

Abbreviation	Project Name
Cal. Aqu.	California Aqueduct
CAP	Central Arizona Project
Carlsbad Desal.	Carlsbad Desalination Plant
CUP	Central Utah Project
GDP	Groundwater Development Project
LPP	Lake Powell Pipeline
NISP	Northern Integrated Supply Project
RWSP	Regional Watershed Supply Project
SDS	Southern Delivery System
SJ-Chama	San Juan-Chama Project
WG	Windy Gap Firming Project
Yampa	Yampa Pumpback Project
YDP	Yuma Desalting Project

Energy Intensity of the West's Water Supplies



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Integrated Assessment Research – New/Emerging Foundational Capabilities

Data, Modeling, and Analysis

- **New Stanford led-multi-institutional Cooperative Agreement (CA)** awarded for multi-scale, -sector modeling framework
- **New SFA established under PNNL with LANL, NREL, UCAR, and other universities** on regional scale EWN/IAV modeling.
- **Two new CAs competed and awarded for university led multi-institutional teams addressing fine-scale climate analysis and human feedbacks for EWN**
- **PNNL-JGCRI Scientific Focus Area (SFA)** aligned around EWL, triennial review conducted, funding augmented in key areas.
- **MIT Cooperative Agreement supplement provided and renewal proposal under review** with focus on EWL interactions.
- **ORNL led data-knowledge system project** reviewed and initiated with collaborators: ANL, NASA DAAC (Columbia), others
- **Co-planning of Land-Modeling strategies spanning IARP/GCAM and ESM/ACME**
- **Major interagency/intra-agency EWN and IAV effort launched** through local and follow-up Snowmass workshops.

Pacific Northwest NATIONAL LABORATORY
OAK RIDGE National Laboratory
NREL
Sandia National Laboratories
Argonne NATIONAL LABORATORY
BERKELEY LAB
Stanford University
Massachusetts Institute of Technology
PennState
UCAR
IOWA STATE UNIVERSITY
UNIVERSITY OF MARYLAND
BOSTON UNIVERSITY
Cornell University
UCDAVIS UNIVERSITY OF CALIFORNIA
PURDUE UNIVERSITY
Stony Brook University
University of New Hampshire
UtahState University
UCLA
UNIVERSITY OF DELAWARE
TEXAS A&M UNIVERSITY
THE UNIVERSITY OF UTAH

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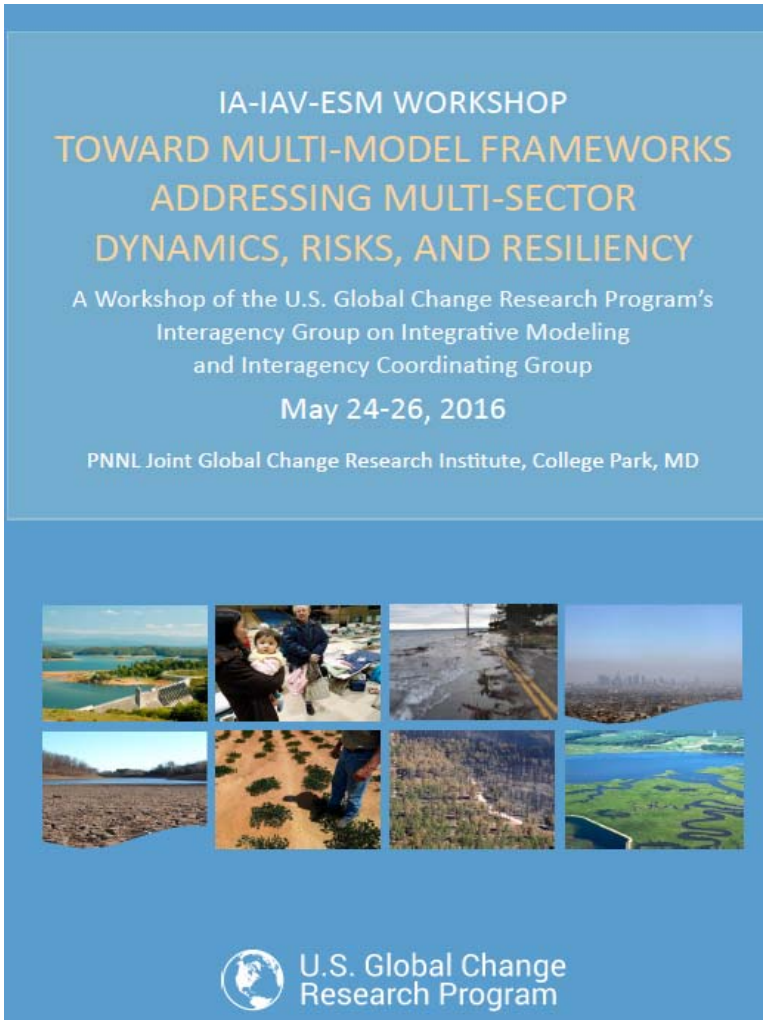
Workshop - Overview



Workshop – Goals & Strategies

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Goals:

Meet growing national/international need for understanding multi-sectoral interdependencies and the implications of climate and complex, interacting stressors:

- Incorporate evolution in society, economy, and environment in addition to changes in Earth systems, with a particular interest in **co-evolutionary pathways among interdependent systems**.
- Provide capacity for if-then analysis of technology and institutional options
- Improve fundamental understanding of cascading failures, modes of adaptation, and potential feedbacks (e.g., at the mitigation-adaptation interface).

Strategies:

A flexible framework of interconnected systems of models, data, and analysis methods:

- Understanding and development in a context of **use/user typologies**
- Build on agency-specific modeling capabilities across sectors
- Provide software, data, visualization, and other tools to facilitate integration
- Orient around compelling, issues and topics aligned with cross-agency interests
- Engage best talent across agencies and academic community
- Hard and soft coupling strategies

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Workshop – Session 1

Agency Example Uses: Concentrated and Connected Infrastructure	
	**1.1 Electric system reliability and demands affected by water quantity/quality |** Room 4102, Plenary ICG co-chair: Robert Vallario SSG co-chair: Scott Backhaus
	**1.2 Health services affected by cascading infrastructure failures and interdependencies |** Room 4056, Small Conference Room ICG co-chair: John Balbus SSG co-chair: Christopher Barrett
	**1.3 Coastal city inundation affected by sea level rise and extreme weather events |** Room 4046, "Classroom" ICG co-chair: Charles Covel SSG co-chair: Ali Abbas
	**1.4 Urban socioeconomic systems and vulnerable communities affected by heat waves and air quality events |** Room 3502, JGCRI Third Floor ICG co-chair: Jia Li SSG co-chair: Jennie Rice

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Workshop – Session 2

Agency Example Uses: Drought and Increased Variability of Water Supply	
	**2.1 Reservoir resilience affected by droughts, floods, and changing extremes |** Room 4102, Plenary ICG co-chair: Kate White SSG co-chair: Patrick Reed
	**2.2 State economies, including agriculture, affected by drought |** Room 4056, Small Conference Room ICG co-chair (facilitator listed first): Ronald Sands and Alexander Ruane SSG co-chair: Karen Fisher-Vanden
	**2.3 Planning for wildfire impacts and management under changing climate, environmental, demographic, and policy futures |** Room 4046, "Classroom" ICG co-chair: Linda Langner SSG co-chair: Claudia Tebaldi
	**2.4 Surface water quality and ecosystem services affected by droughts, floods, and changing land use/land cover trends |** Room 3502, JGCRI Third Floor ICG co-chair: Anne Grambsch SSG co-chair: Ian Kraucunas

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Workshop – Types of Interdependencies

- **Physical:** interaction through a physical system (climate-river routing, atmosphere-air quality) or infrastructure attribute (freight and passenger rail travel affected by system capacity)
- **Functional:** one system is connected to another (water for cooling, energy for pumping water, …)
- **Geographic:** proximity leads to correlated responses in multiple systems
- **Economic and financial:** e.g., supply chains; market impacts on multiple processes such as investment cycles, price structures, etc.
- **Institutional and policy:** a law or regulation affects multiple sectors and decisions or transactions
- **Social:** relations across social groups (individuals or organizations) affect vulnerability, coping, long-term adaptive capacity of other groups

Source: Dawson, R. (2015). "Handling Interdependencies in Climate Change Risk Assessment." Climate **3**(4): 1079.

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Workshop – Characteristics of Interdependencies

- Spatial scale
- Temporal scale
- Interaction strength
- Interaction complexity
- System state
- Range of perturbations
- Socioeconomic context

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Workshop – Preliminary Inventory of Capabilities

- Categories of capabilities identified:
  - 70-80 capabilities in 16 categories identified spanning climate, land, ecological, coastal, fluvial, surface hydrology, air quality, infrastructure sectors, agriculture, economic, demographic, institutional
- Common requirements across multiple areas:
  - **Represent shocks and non-linear processes**
  - **Characterize uncertainty**
  - **High resolution**
  - **Nested**
  - **Flexible**

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Workshop – Next Steps

- **Build a community practice and view framework development as a process built around science and capability requirements**
  - Importance of "use context" and maintaining connectivity with users to define required outputs and model components, coupling, data, analytic tools, visualization, decision support…
- **Develop regional test beds**
  - Clearly defined use of information
  - Model and data integration
  - Explicit processes for testing model validity and evaluating utility of the output for users
- **Resulting framework components**
  - Repository of modeling components/tools (including enabling software)
  - Data
  - Decision support tools
  - Educational resources/capacity building

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Final Note - Regional Test Beds

Features:

- Regional-scale DMA tools and multi-model frameworks centered around IAV models (including infrastructure models), IAMs, and ESMs.
- Focus on two topics/themes:
    1. ***Energy in Water-Stressed Regions***
    2. ***Connected Infrastructure Vulnerabilities (including but not limited to urban systems)***

- Three test beds in adjacent regions (or regions with significant teleconnections) to improve understanding of regional DMA resources, heterogeneity of DMA challenges, regional interdependencies, and **gradient** and "boundary" issues.
- One test bed designed and developed to be more detailed and robust, paving the way for growth into an **Integrated Field Laboratory (IFL)** incorporating observatories and data networks.
- Lab-led broader collaborations with engagement of regional research and stakeholder communities.
- Competitive awards with potential for multiple awards.
- Scoping in FY 16 with deployment beginning in FY17