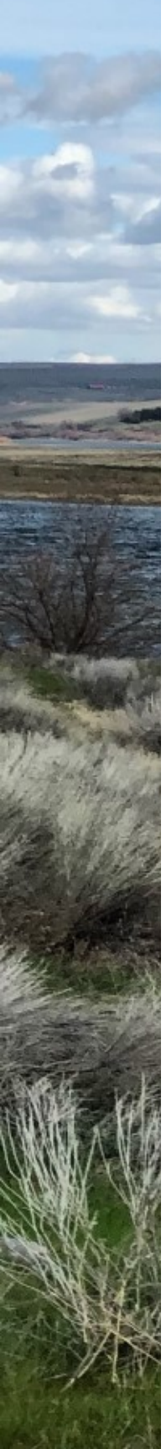

Integrated Hydro-Terrestrial Modeling: Opportunities & Challenges for Advancing a National Capability for the U.S.

Results of an Inter-Agency Workshop
Hosted by NSF
September 4-6, 2019

Tim Scheibe

Pacific Northwest National Laboratory

U.S. DEPARTMENT OF ENERGY BATTELLE

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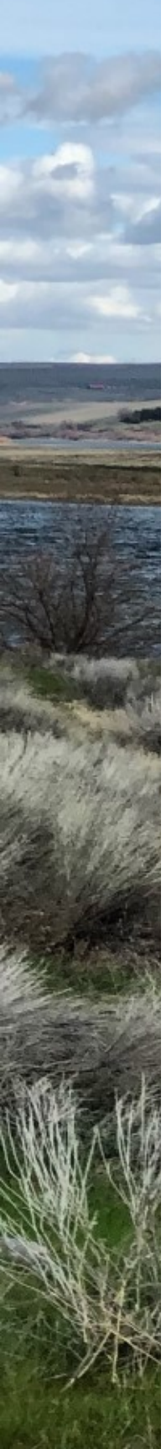
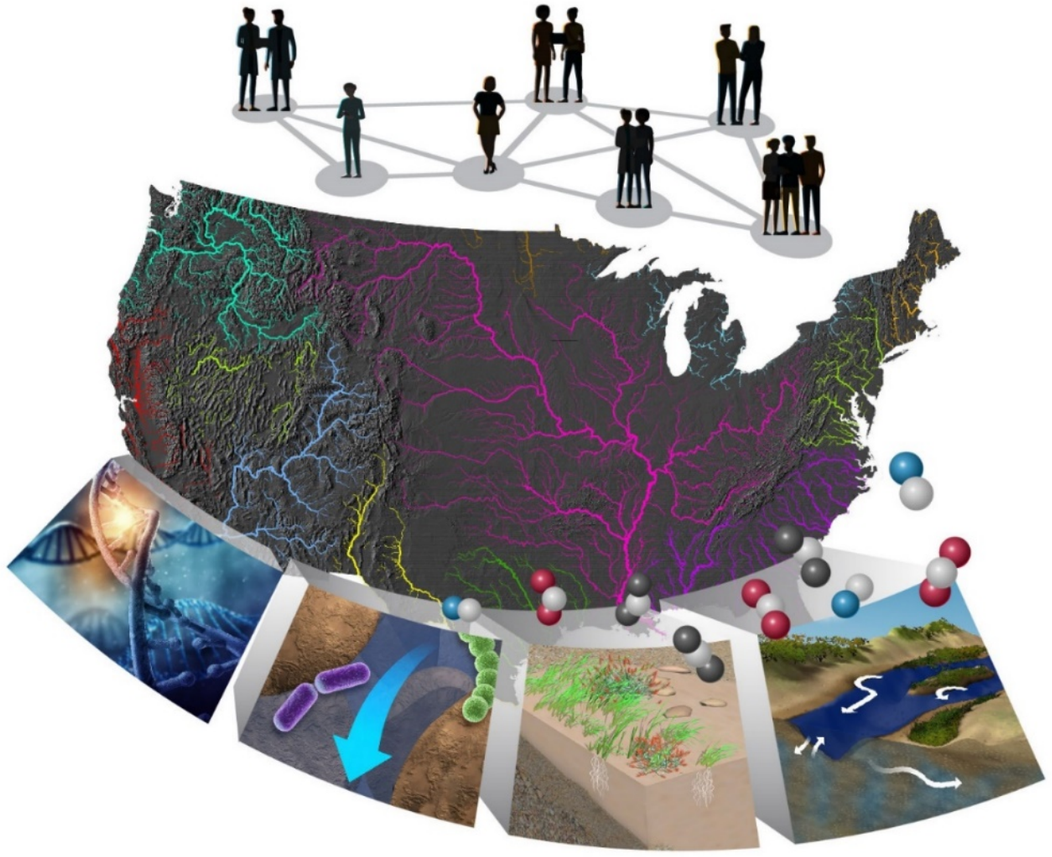
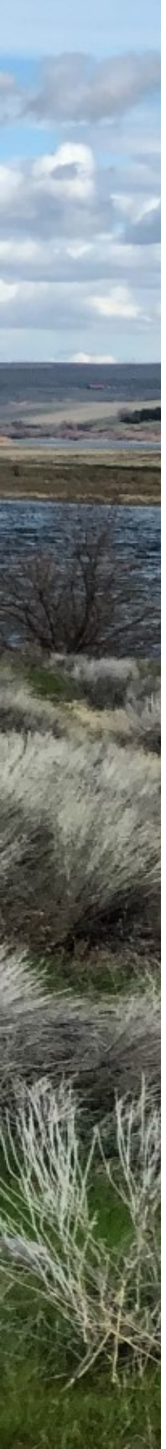


Integrated Hydro-Terrestrial Modeling (IHTM)

Multi-agency data and simulation products that provide the basis for understanding and managing complex water systems (R2O2R).



- ✓ Enhance national capability for prediction and scenario-building;
- ✓ Advance the water-related missions (collectively and individually) of the water mission agencies;
- ✓ Advance science through integration of best process understanding

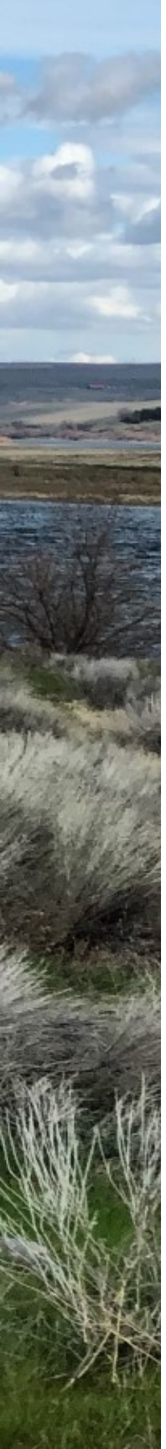


Roots of the IHTM Workshop

- The Subcommittee* on Water Availability and Quality (SWAQ) was chartered in a 2004 National Academies report "*to advise and assist the Committee and the NSTC on policies, procedures, plans, issues, scientific developments, and research needs related to the availability and quality of water resources of the United States.*"

  - Reduce fragmentation of hydro-terrestrial modeling and data infrastructure across Federal agencies to enhance integrated and multi-scale problem-solving of priority water resources challenges, including sustaining water resources in water stressed areas and supporting water sub-cabinet foci.
  - Organize a workshop to socialize the vision, develop the computational and data requirements, and identify agency roles and coordinating principles for the IHTM community. This workshop will also feature nutrient pollution case studies.

*Under the Office of Science and Technology Policy, National Science and Technology Council, Committee on Environment, Natural Resources, and Sustainability



Preparation for the IHTM Workshop

SWAQ member agencies and others provided input to guide workshop planning:

- Hydro-Terrestrial Modeling Survey
- Use Cases (~60)
- Definition of three national Priority Water Challenges

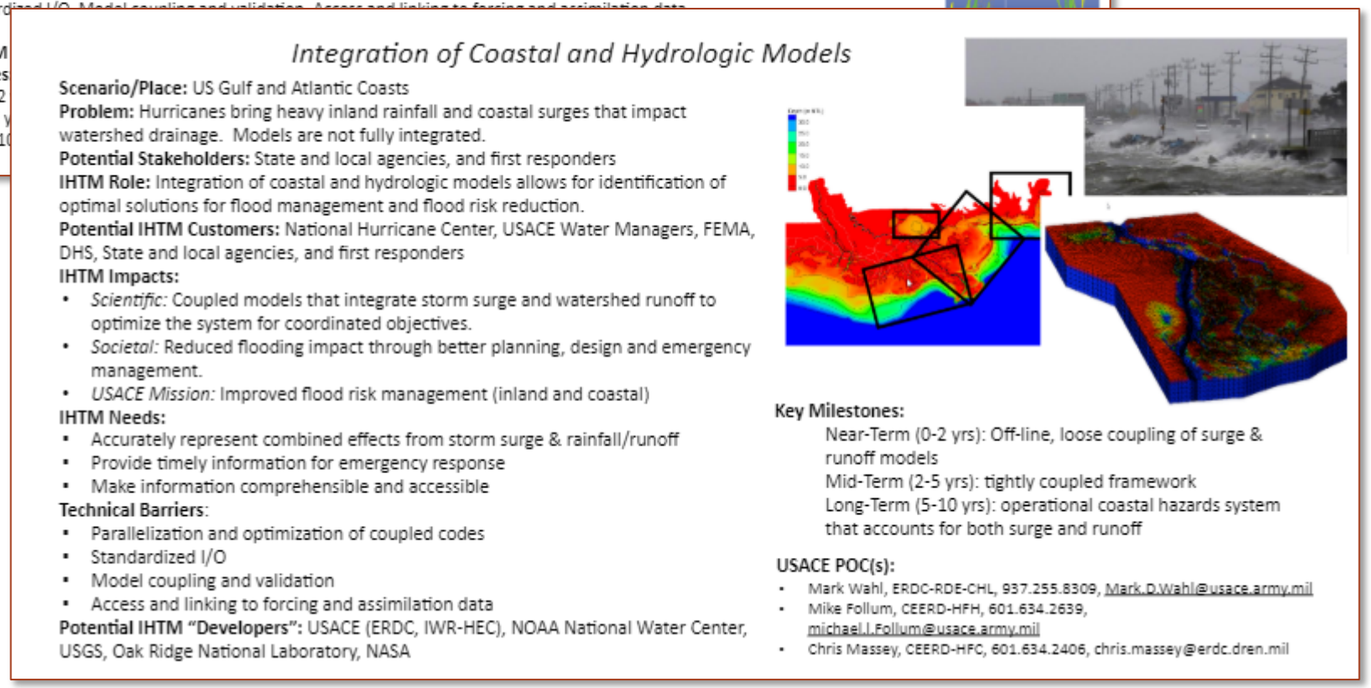
Nutrient Loading in the Mississippi Basin

Scenario/Place: Mississippi River Basin
Problem: The hypoxic zone in the Gulf of Mexico forms every summer and is a result of excess nutrients from the Mississippi/Atchafalaya River and seasonal stratification (layering) of waters in the Gulf.
Potential Stakeholders: Communities, States, Industry, Agriculture.
IHTM Role: Integration of hydrologic and hydraulic models, groundwater , ecosystem models, and plant growth and agricultural management models across agencies could allow integrated solutions to develop policy to reduce the size of the hypoxic zone.
Potential IHTM Customers: USDA, EPA, USACE, State Environmental Agencies, and the Mississippi River/Gulf of Mexico Hypoxia Task Force.
IHTM Impacts:
- *Scientific:* New basin scale ecohydrological models that simultaneously consider geographic, environmental, and land management factors.
- *Societal:* Coordinated tools to develop comprehensive agricultural management policy to mitigate hypoxia.
- *USDA mission*: Tools for use in Farm Bill debate and in setting national conservation policy.

IHTM Needs:
- National dataset of agricultural management practices.
- Seamlessly couple/develop surface, groundwater, and land management components and data types
- Flexibility to transfer output and visualize key information of interest by different stakeholders.

Scientific and Technical Challenges for IHTM Development: Parallelization and optimization of coupled codes, Standardized I/O, Model coupling and validation, Access and linking to forcing and assimilation data

Potential IHTM
Key Milestones
Near-Term (0-2
Mid-Term (2-5 y
Long-Term (5-1



Integration of Coastal and Hydrologic Models

Scenario/Place: US Gulf and Atlantic Coasts
Problem: Hurricanes bring heavy inland rainfall and coastal surges that impact watershed drainage. Models are not fully integrated.
Potential Stakeholders: State and local agencies, and first responders
IHTM Role: Integration of coastal and hydrologic models allows for identification of optimal solutions for flood management and flood risk reduction.
Potential IHTM Customers: National Hurricane Center, USACE Water Managers, FEMA, DHS, State and local agencies, and first responders
IHTM Impacts:
- *Scientific:* Coupled models that integrate storm surge and watershed runoff to optimize the system for coordinated objectives.
- *Societal:* Reduced flooding impact through better planning, design and emergency management.
- *USACE Mission:* Improved flood risk management (inland and coastal)

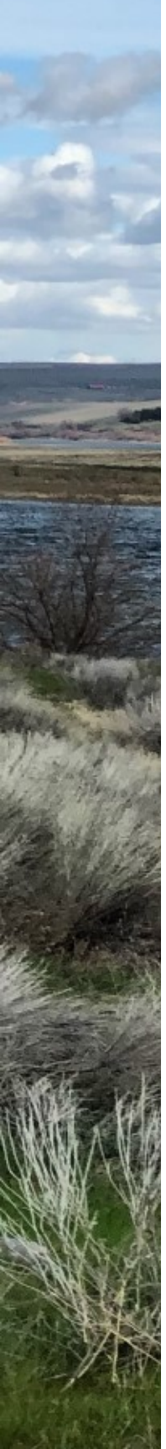
IHTM Needs:
- Accurately represent combined effects from storm surge & rainfall/runoff
- Provide timely information for emergency response
- Make information comprehensible and accessible

Technical Barriers:
- Parallelization and optimization of coupled codes
- Standardized I/O
- Model coupling and validation
- Access and linking to forcing and assimilation data

Potential IHTM "Developers": USACE (ERDC, IWR-HEC), NOAA National Water Center, USGS, Oak Ridge National Laboratory, NASA

Key Milestones:
Near-Term (0-2 yrs): Off-line, loose coupling of surge & runoff models
Mid-Term (2-5 yrs): tightly coupled framework
Long-Term (5-10 yrs): operational coastal hazards system that accounts for both surge and runoff

USACE POC(s):
- Mark Wahl, ERDC-RDE-CHL, 937.255.8309, Mark.D.Wahl@usace.army.mil
- Mike Follum, CEERD-HFH, 601.634.2639, michael.l.Follum@usace.army.mil
- Chris Massey, CEERD-HFC, 601.634.2406, chris.massey@erdc.dren.mil

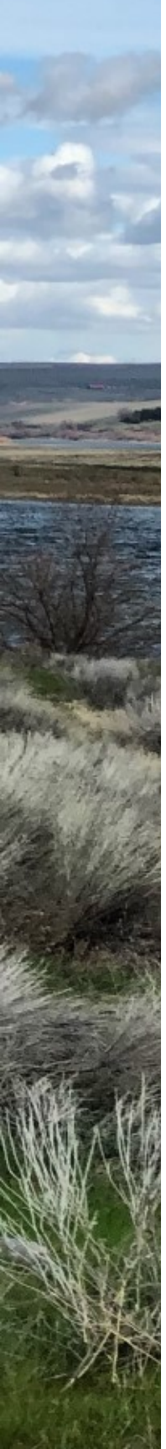


Workshop Participants From Several Agencies and Academia: Eager to Collaborate to Solve Water Problems

Interagency Leads:
David Lesmes (USGS)
Tim Schwerdtner (NSF)
Eli Pourbaix Georgiou (UCI)
Bob Vallario (DOE)
Harry Jenter (USGS)
Jessica Moerman (DOE-AAAS)

Workshop Co-Chairs:
Tim Schwerdtner (NSF)
Tom Torgersen (NSF)
Eli Pourbaix Georgiou (UCI)
Bob Vallario (DOE)
Harry Jenter (USGS)
Jessica Moerman (DOE-AAAS)

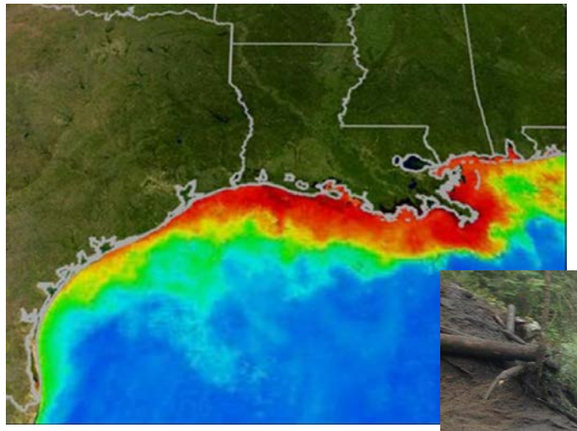
12th Workshop
Participants



Why Do We Need an IHTM?

- The science underlying water resources management is complex and crosses agency mission boundaries
- Similarly, the applied and operational aspects of water resources management do not fit neatly into agency missions

Priority Water Challenges

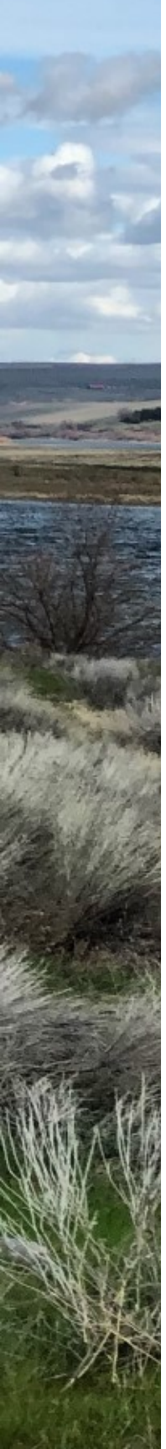


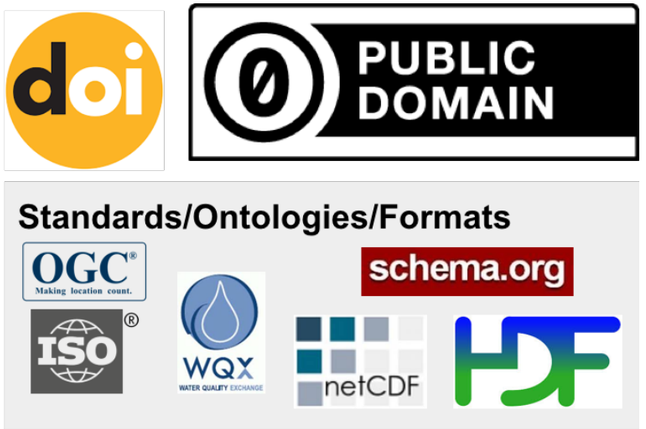
Excess Nutrients, Hypoxia and Harmful Algal Blooms

Extreme Weather-related Water Hazards

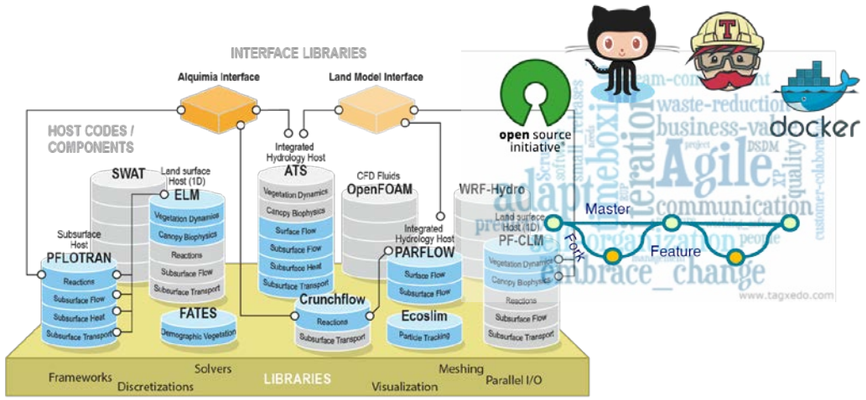
Water Availability in the Western US

The Priority Water Challenges Helped Identify Critical Needs in Four Key Technical Areas

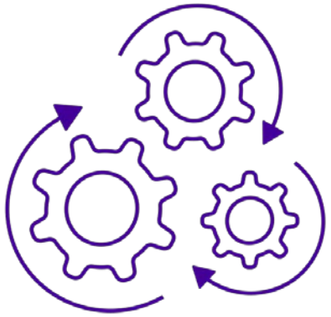




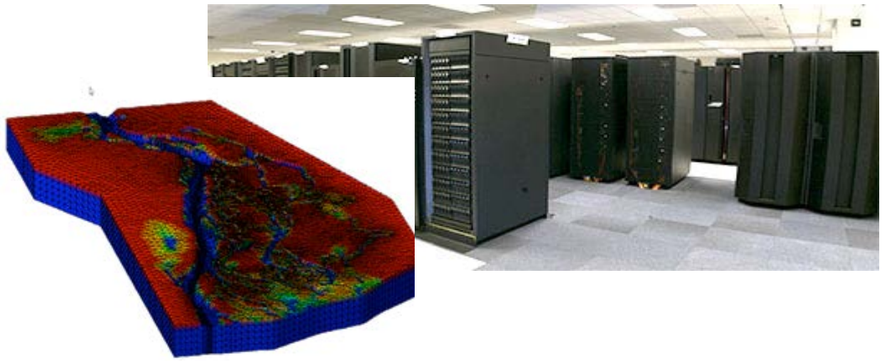
Data Management, Community Platforms, and Standards



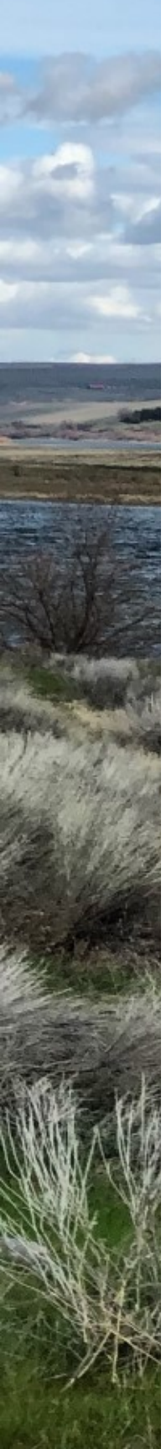
Software Engineering for Interoperability and Sustainability



Cross-Disciplinary Workflows: Analysis and Evaluation

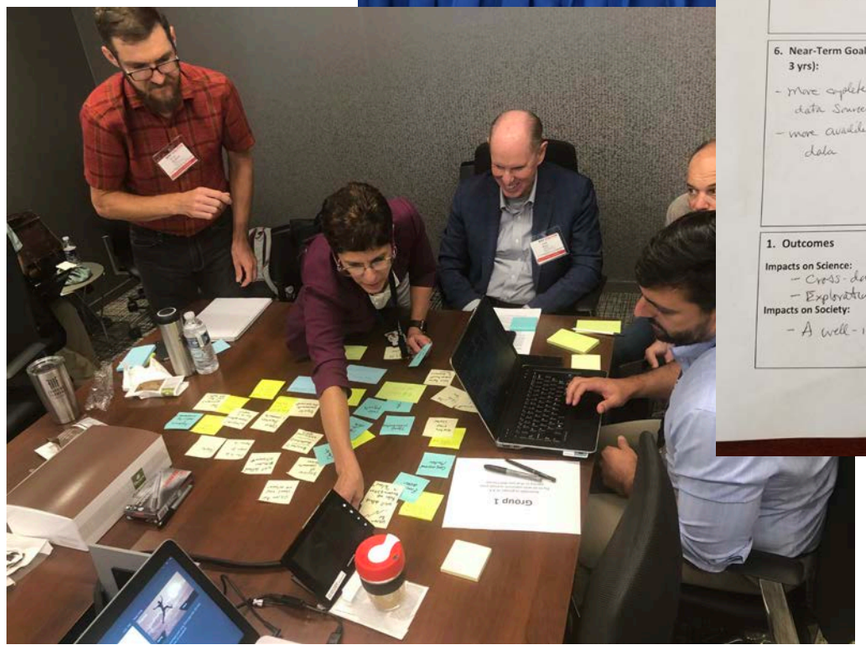


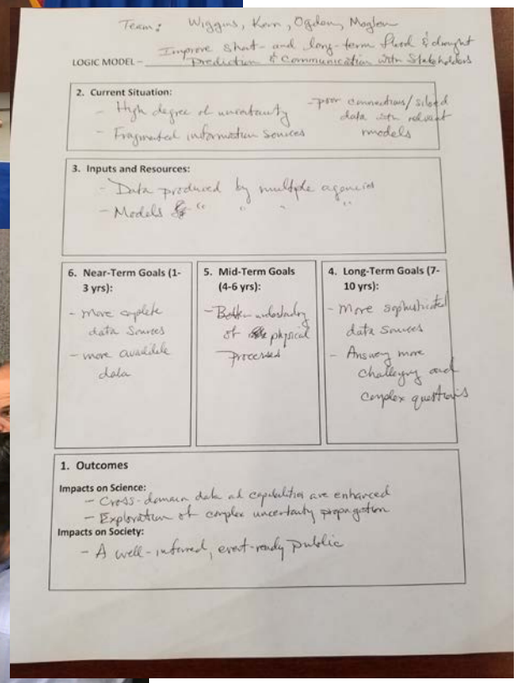
Building Computational Testbeds



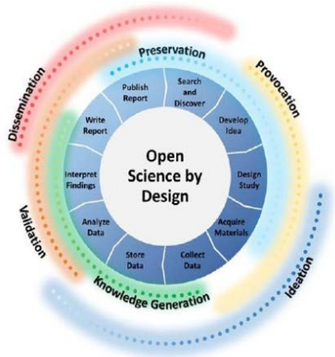
Three Days of Intensive Interaction

- **Plenary Presentations:**
  - Vision and Keynote Lectures
  - Framing Presentations – Setting the Stage for Breakouts
- **Breakout Sessions:**
  - (WHY) Priority Water Challenges
  - (HOW) Shepherds and Carpenters: Building and Maintaining Community Capacity
  - (MAKING IT HAPPEN) Organizational Challenges: Building a Sustainable IHTM Community





Building a Sustainable IHTM Community



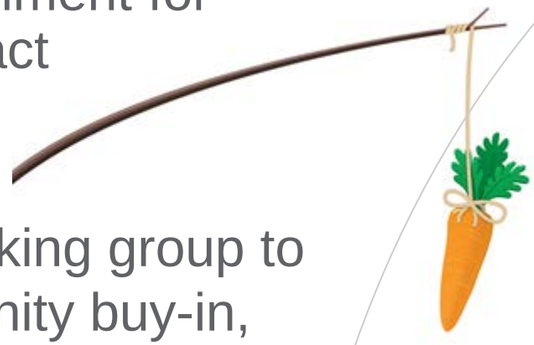
Long Term

Transform culture towards sharing data, co-developing models, and generating timely, coordinated forecasts for stakeholders

Agencies evolve business and funding practices and mission alignment for optimal impact

Mid Term

Determine and implement common data and model standards through communities of practice.

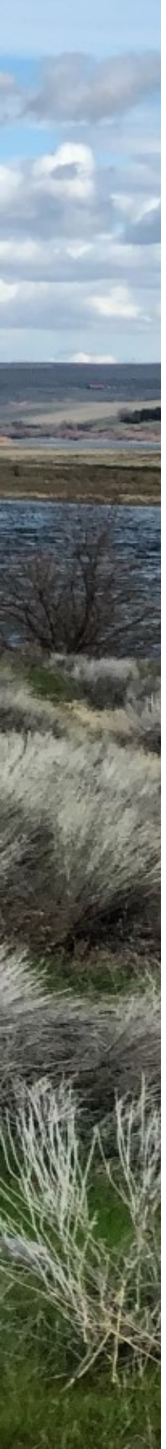


Near Term

Multi-agency working group to generate community buy-in, create incentives, and co-design a pilot project.

Interagency coordination (e.g., working group) on mission alignment, business & funding practices

Skin-in-the-game for early wins and pilot projects using flexible approaches



IHTM Post Workshop

Weekly telecons with writing team and interagency steering team

AGU Presentation December 2019

Report draft in final production and agency review (~30 contributors)

Initiate IHTM interagency use case(s) with available funds

Start IHTM technical working groups associated with use cases

Offer to provide IHTM briefings to interested agency sponsors

Thank You!