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Linking IAV, IAM, and ESM: Results of a Interagency Workshop

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25 July 2016

*Thanks to
- Bob Vallario, Gary Geernaert, and Alex Ruane (and other interagency group members)
- Ian Kraucunas, Alex Ruane, Claudia Tebaldi, and Ian Sue Wing (and other science group members)
- Several workshop participants who are also present in Snowmass today

PNNL-SA-

Topics

1. Problem statement: why a multi-model framework for impacts analysis?
2. Workshop overview
   - Use perspectives
   - Typology of uses
   - Capabilities
   - Vision for framework
   - Development approach: Community of practice

Why couple IAV-IA-ES models?

- Evidence is accumulating regarding the need to couple IAV, IA, and ES models to explore tightly coupled human-environment systems affected by multiple stresses

Results differ between single-sector and integrated models of impacts

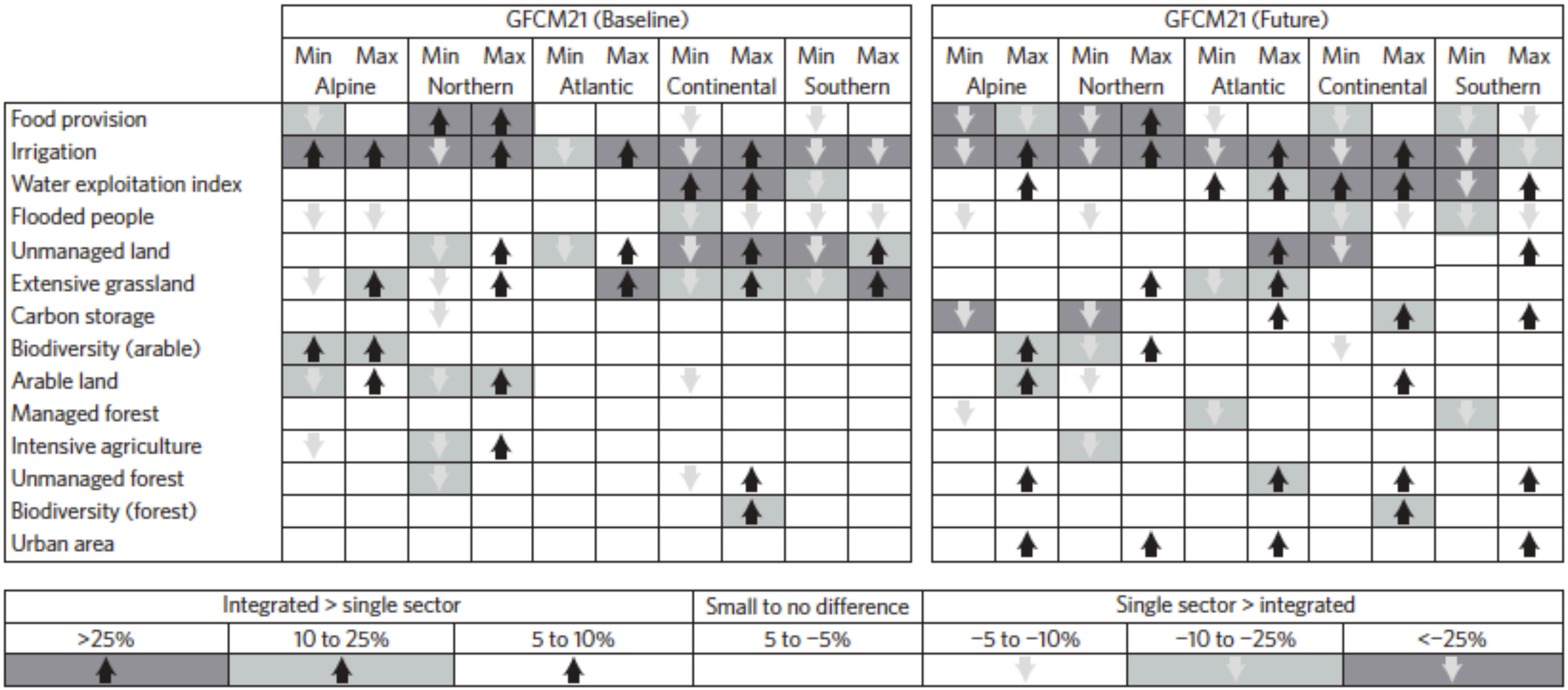

Figure 4 | Differences between single-sector and integrated model impact indicators for the five European regions used in the Europe Chapter of the PCC AR5[1]. Positive differences indicate that the integrated model produces higher values than single-sector models; negative differences indicate that the single-sector model values are greater. Both positive and negative differences are presented relative to baseline levels at the regional scale. Based on the GFCM21 climate model combined with baseline or future socio-economics.

Harrison, P. A., R. W. Dunford, et al. (2016). "Climate change impact modelling needs to include cross-sectoral interactions." Nature Clim. Change **advance online publication.**

Challenge: Managing complexity across sectors and scales

- Evidence is accumulating regarding the need to couple IAV, IA, and ES models to explore tightly coupled human-environment systems affected by multiple stresses
- As more processes and scales are incorporated, modeling challenges grow

Example interdependencies – climate change and urban systems focus

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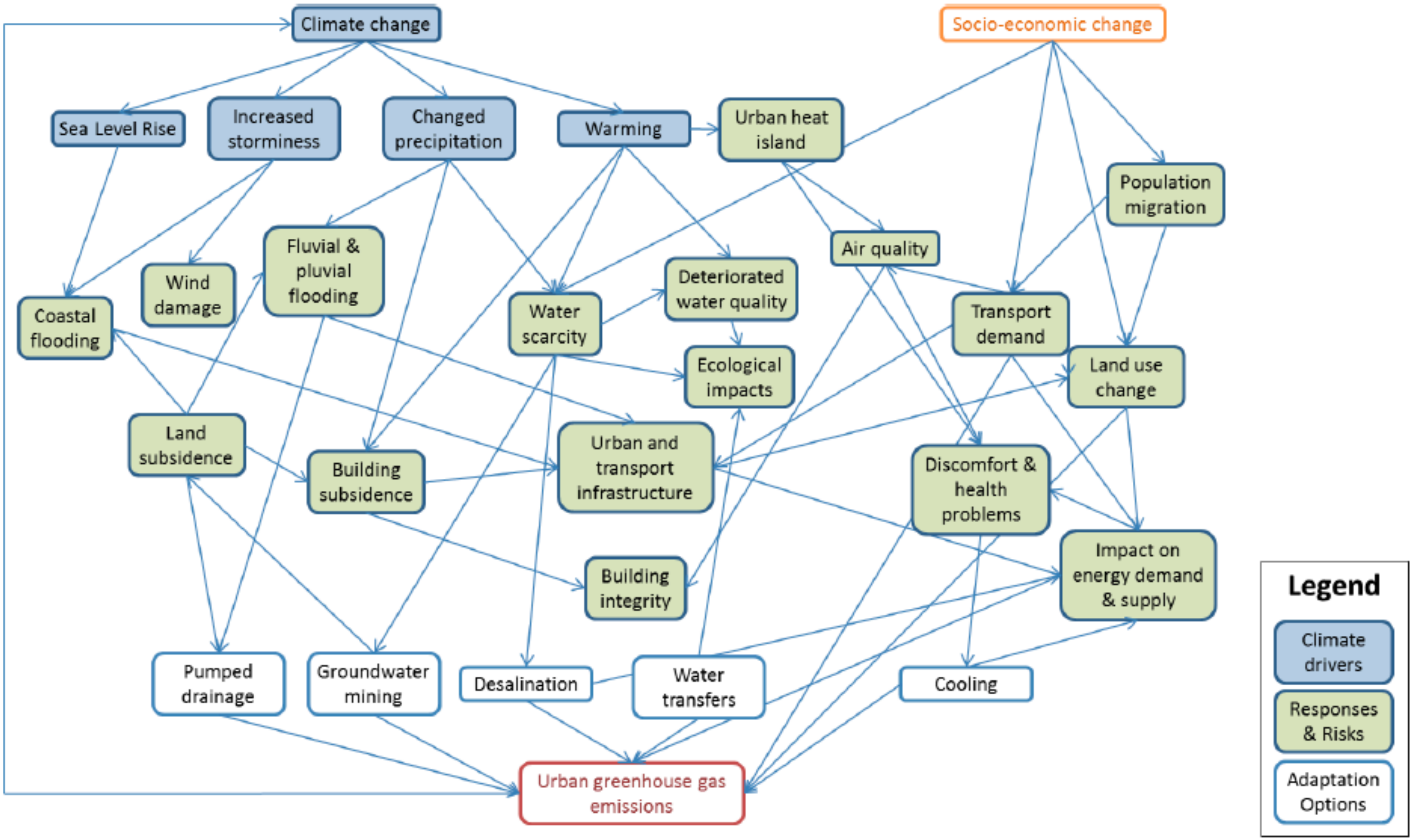

Source: Dawson, R. (2015). "Handling Interdependencies in Climate Change Risk Assessment." Climate 3(4): 1079.

Types of interdependencies to consider

- Functional: one system is connected to another (water for cooling, energy for pumping water, …)
- Physical: interaction through a physical system (atmosphere-air quality) or infrastructure attribute (freight and passenger rail travel affected by system capacity)
- 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.

A framework of modeling tools for research and research applications

- Evidence is accumulating regarding the need to couple IAV, IA, and ES models to explore tightly coupled human-environment systems affected by multiple stresses
- As more processes and scales are incorporated, modeling challenges grow
- Can we develop a systems framework that brings together data, models, and analytic capabilities in a toolkit to enable independent teams to explore science and use-inspired questions in a coordinated way?
  - What sorts of problems would such a framework be useful for?
  - What resources and functionality are needed?
  - What efforts are already underway and how could they be built upon?

Agenda and participants

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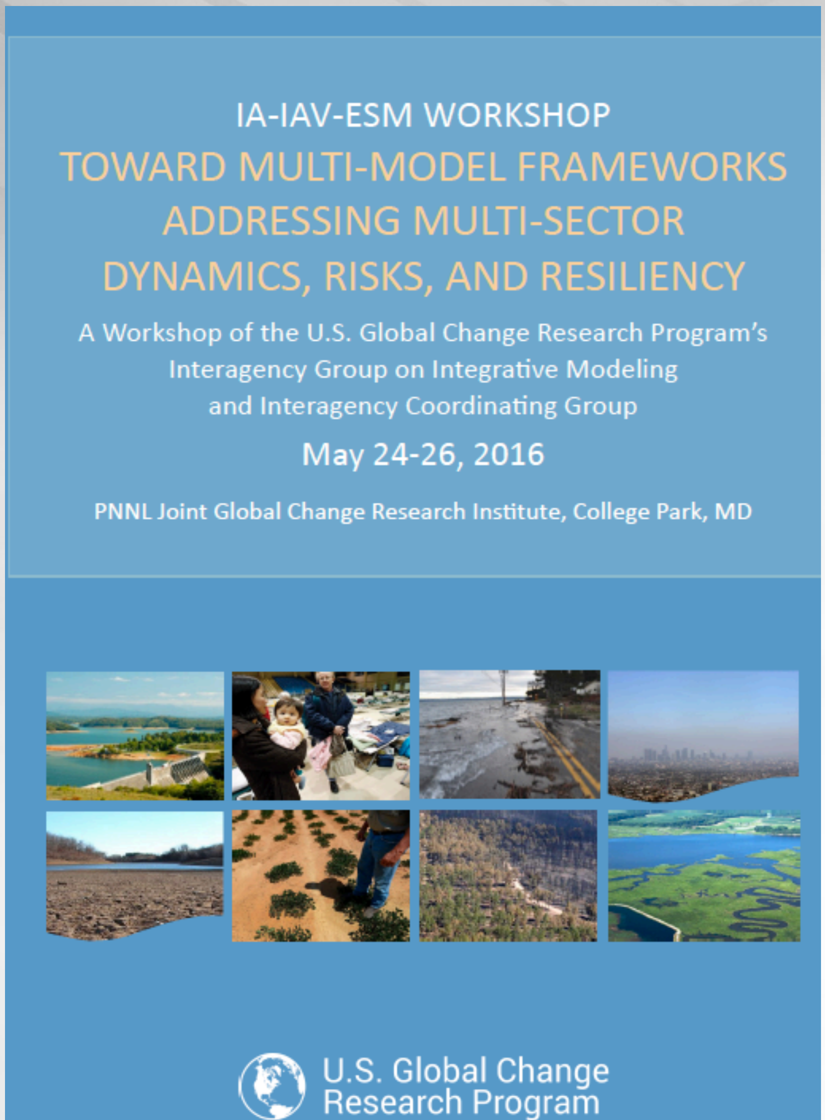

- Organized by USGCRP interagency group with science committee input
- Over 50 experts: federal government, academia, national labs, and private organizations
  - Broad range of expertise
- Eight breakouts discussed a representative set of example questions/problems to explore the capabilities required
  1. Concentrated and connected infrastructure (Day 1 focus)
  2. Drought and increased variability of water supply (Day 2 focus)
- Cross-cutting themes and synthesis in additional groups and plenary

Representative cases (1)

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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

Representative cases (2)

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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

User typology

- Define information needs and hence functional scientific requirements
- Example: Reservoir resilience affected by drought/extremes

Typology Field	Examples
User perspective	Water planners and engineers at state/city scales; water system owners/operators
Key parameters/metrics	Resilience (recovery time); robustness (reliability); costs/regrets/ benefits of operations/resource allocations; tradeoffs in economic and engineering performance measures
Drivers/uncertainties	Climate-impacted hydrology; changing land use; water demand management; renewable energy use; demographic/ socioeconomic impacts on demand; dietary preference and agricultural demand; resource management polices; institutional effectiveness
Alternatives Under Consideration	Change in operations/resource allocations; investments in infrastructure; land use policy; demand management programs

Capabilities

- Identify available capabilities and gaps
  - Identify common systems and core framework components that will benefit from more organized, interagency development
  - Begin to develop index of models and other resources
- 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
- Identified spatial (dimensionality, extent, resolution) and temporal characteristics, type of model, examples, etc.
- Common themes across multiple areas:
  - Represent shocks and non-linear processes
  - Characterize uncertainty
  - High resolution
  - Nested
  - Flexible

Space-time scales of capabilities: atmospheric/ terrestrial processes and human systems

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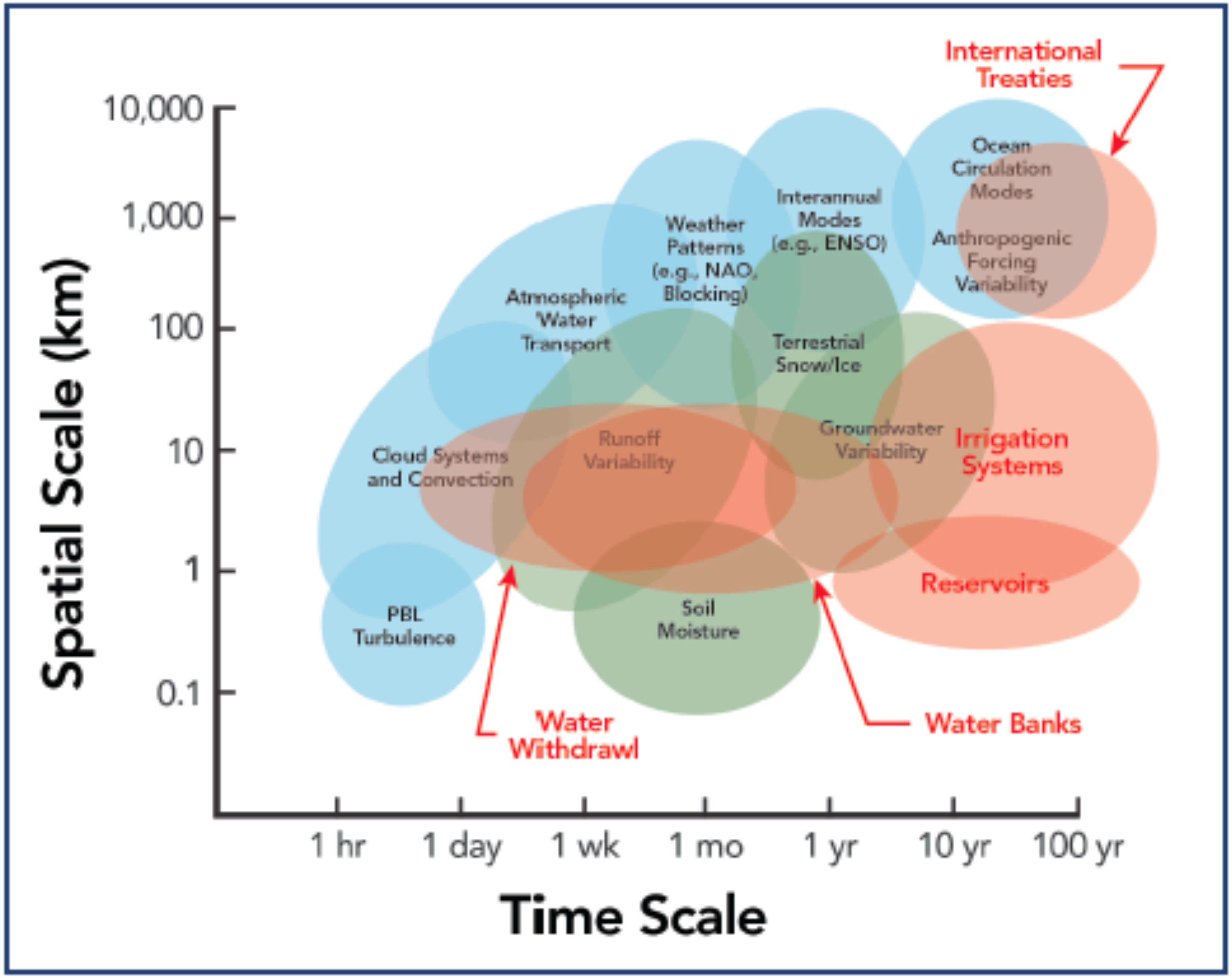

[Community Modeling and Long-Term Predictions of the Integrated Water Cycle](http://tes.science.energy.gov/workshops/Water_Cycle_Report_High_Res.pdf)
http://tes.science.energy.gov/workshops/Water_Cycle_Report_High_Res.pdf

Workshop outcome: framework vision and approach

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- An interconnected system of models, data, analysis methods, and decision support capabilities that support building resilience in interdependent systems
  - Meet growing national/international need to prepare for impacts across interdependent systems, manage potential for cascading failures, feedbacks
- 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…

What might a community of practice look like?

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- Common elements
  - Repository of modeling components
  - Modeling tools/software environment
  - Computational resources
  - Data
  - Communications support for community activities (e.g., work groups)
  - Meetings
  - Educational resources/capacity building
- Examples:
  - CESM (more tightly focused on a single overarching science question – JF will provide overview)
  - Community Surface Dynamics Modeling System (CSDMS) (supports a wide range of independent science questions requiring surface dynamics)

log in | request account

CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

Search

Models | WMT | Supercomputing | Education | Data | Community | Meetings | Help | Wiki tools

Explore Earth's surface with community software

CSDMS for you
Join, What is CSDMS, Groups, ...

Get started with WMT
All about CSDMS Web Modeling Tool (WMT), ...

Contribute
Submit source code/data/education material, ...

Download
Models, Data, WMT, Education material, ...

Announcements
Jobs, In the news, Missives, ...

Help
Search, FAQ, Instructional videos, Contact, ...

Highlights from the Community

We congratulate **Dr. Anders Damsgaard**, who recently graduated from Aarhus University, Denmark, he is selected as the CSDMS Student Modeler of 2015. Damsgaard presents an outstanding modeling approach to granular flow and bed deformation, and applies the new technique to provide insights on glacier ice-bed interactions. Grain to grain dynamics and variation in meltwater pressure help explain stick and slip behavior of glaciers.

Damsgaard will present on his findings at the upcoming 2016 CSDMS Meeting. More...

Tweets

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Thank you all for contributing to the CSDMS 2016 annual report. Enjoy reading: csdms.colorado.edu/mediawiki/imag...

14 Jul

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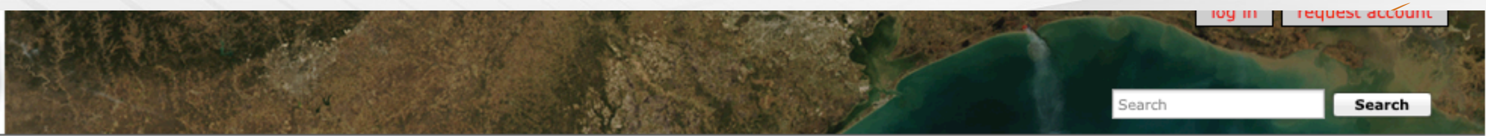
Mark Piper @mdpiper

The @CSDMS squirrel is enjoying a @sciencemagazine article.

CSDMS

COMMUNITY SURFACE DYNAMICS MODELING SYSTEM



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Search | Search

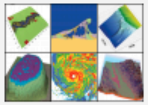
Models | WMT | Supercomputing | Education | Data | Community | Meetings | Help | Wiki tools

- Model repository
- Contribute a model
- Repository stats
- Version control
- FAQ

CSD pository

Watch about the full functionality of the model repository.

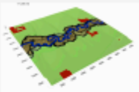
All models



Number of models: ***185***, Number of tools: ***79***, WMT compliant: ***21***

Type: All of the models mentioned below

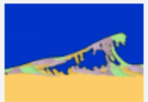
Terrestrial models



Number of models: ***76***, Number of tools: ***72***, WMT compliant: ***3***

Type: Landscape evolution models, avulsion models, sediment transport models, advection diffusion models, ice sheet evolution models, lithospheric flexure models, groundwater models, surface water-quality models, water balance models, etc.

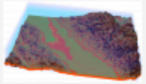
Coastal models



Number of models: ***58***, Number of tools: ***5***, WMT compliant: ***4***

Type: Coastline evolution models, delta sedimentation models, tidal flat models, storm surge models, plume models, tubidity current models, stratigraphic models, wave refraction models, etc.

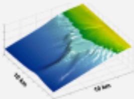
Hydrological models



Number of models: ***58***, Number of tools: ***43***, WMT compliant: ***17***

Type: Hydrologic models, stream avulsion models, flow routing models, groundwater models, fluvial sediment transport models, etc.

Marine models



Number of models: ***48***, Number of tools: ***6***, WMT compliant: ***2***

Type: Basin circulation models, gravity flow models, wave models, stratigraphy models, etc.

The CSDMS **Web Modeling Tool** (WMT) allows users to build and run coupled surface dynamics models on a high-performance computing cluster (HPCC) from a web browser on a desktop, laptop or tablet computer.

With WMT, a user can:

- select a Common Component Architecture (CCA) component model from a list to run in standalone mode,
- build a coupled model from multiple CCA components organized as nodes of a tree structure,
- view and edit the parameters for these model components,
- upload custom input files to the server,
- save models to a server, where they can be accessed on any computer connected to the web,
- share saved models with others in the community, and
- run a model by connecting to a remote HPCC where the components are installed.

Although WMT is web-based, the creation and configuration of a model can be done offline. Reconnection is necessary only when saving a model and submitting it for a run.

This article provides documentation for the components, forms, and controls of the WMT interface. For a short tutorial on using WMT, please see the WMT Tutorial.

Contents [hide]

The sign-in screen

The sign-in screen allows access to WMT. WMT always starts on this screen.

log in requ

CSDMS
COMMUNITY SURFACE DYNAMICS MODELING SYSTEM

Search

Models WMT Supercomputing Education Data Community Meetings Help

Data needs
Download
Contribute
Data tools

Data needs

The CSDMS Data Repository describes important data fields useful in CS[...]rovides links to data centers for download. CSDMS distinguishes between at least 3 data[...]
relevant for modeling:

1. boundary or initialization data,
2. model algorithm test or benchmark data, and
3. integrated datasets for model validation of coupled systems.

Model test files and validation files are explicitly solicited within the model submission process.

Some possible next steps…

- Identify common system elements for multiple use cases, a conceptual structure for human, natural, and climate system components, requirements for integration, decision support
- Inventory/screen/evaluate capabilities and gaps
- Establish metadata standards, coupling requirements for different uses/problem types:
  - Need a “clearing house” for sharing components, capabilities, knowledge developed
  - Create incentives to share documentation and open source standards
- Sensitivity testing and scenario analysis to establish what is important in coupling process representations, for what questions(s) and user(s)
- Develop and integrate new components consistent with framework standards

Relationship to this workshop

- Snowmass to focus on a subset of scientific issues:
  - Explore levels of complexity, coupling strategies for integrating different areas of modeling
  - Explore ideas for process, requirements, identification of metadata standards, etc.
- Some key questions:
  - For what science or user questions do the research communities believe the state of science is well enough developed to provide reliable information?
  - What can we learn from examples of integrated IAV-IA-ES modeling?
  - What do different areas of modeling need as inputs from other types of models? What can they provide to others?
  - Are there some component capabilities that would be useful for many problems that should be prioritized?
  - …

Discussion

Aspects of interdependency that need to be characterized

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