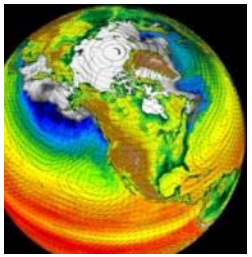

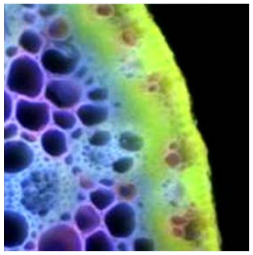
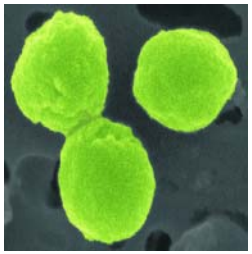

Community Modeling and Long-term Predictions of the Integrated Water Cycle

Crosscutting Breakout Templates

Washington DC

September 24-26, 2012

Charge to the crosscutting groups:

Integrative Modeling Challenges (IMCs)

Discuss and recommend synergistic research activities to address Integrative Modeling Challenges (IMCs) that cut across all six topics of the workshop. Our goal is to robustly test and advance modeling capabilities that will lead to an improved scientific understanding of the critical systems and their interactions, long-term prediction of the integrated water cycle and the more effective use of models for decision support.

Charge to the crosscutting groups:

Discussions should include aspects such as:

- Hypothesis driven modeling experiments and predictability studies
- Multi-scale, multi-system needs for science and decision support
- Model development needs
- Data/observation needs
- Model intercomparison, testing and evaluation
- Computational requirements (e.g., computing resources, common software infrastructure for model/data development)
- Software infrastructure (e.g., tools for model/data integration and interoperability)
- Data management and visualization
- Strategies for interactions with the users

Crosscutting Group B

- Kristen Averyt
- Jared Bales
- Bill Collin
- Wade Crow
- Noah Diffenbaugh
- Leo Donner
- **Chris Forest (day 2)**
- Inez Fung
- Auroop Ganguly
- Pierre Gentine
- Kathy Hibbard
- **Patrick Reed (day 2)**
- Bill Riley
- Adam Schlosser
- Siegfried Schubert
- Peter Thornton
- Eric Wood
- **Rob Wood (day 1)**
- Shaocheng Xie
- Craig Zamuda
- **Xubin Zeng (day 1)**

Crosscutting Group B (Day 1)

- **Develop model frameworks/hierarchy driven by actionable requirements to predict the water cycle for different user needs. Develop "limits of predictability" for the climate system.**
  - *How to improve the physical and integrated models to simulate high frequency riverflow observed in rivers globally.*
  - *Develop observationally-based metrics at appropriate spatial and temporal scales to address specific user-driven needs for prediction of key aspects of the water cycle.*
  - *Uncertainty quantification of the model components and integrated model*
  - *Identify the "low hanging fruit" targets for prediction over the coming decades?*
- **Applications to evaluate coordinated use of model frameworks/hierarchy for actionable stakeholder needs.**
  - *Apply/integrate physical (global/regional climate model), integrated assessment models and engineering models (e.g. applied models for future energy needs) for treatment of water cycle*
  - *Determine extent to which human influence should be represented as a boundary condition or as a fundamentally-integrated component*

Crosscutting Group B

IMC B.1 Limits of Predictability, Model Hierarchy, & Evaluative applications

Key Features/Topic Relevance

A. User inspired modeling goals
B. Deconvolution of controls/errors
C. Find prediction bounds while improving capabilities

Scientific Impacts

A. Improve our prediction/understanding of key prediction targets
B. Improve our leverage of boundary organizations to set user needs based modeling goals
C. Hierarchy of models with flexibly formulated and interchangable components for hypothesis testing across alternative structure/parameterization choices

Approaches/Leveraging

A. Flexible, interchangable model components
B. Careful consideration of data services needed for comparisons/benchmarking
C. Ensemble-based performance evaluations and sensitivity analysis

User Impacts

A. Understand bounds on expectations for predictability
B. Better address risk-based decisions
C. Clearer communication on model controls and uncertainties

Research Elements

- Hypothesis driven modeling experiments and predictability studies
  - Ensemble of models forced with initial or boundary conditions uncertainty—baseline against single models.
  - Coupled model perturbed ensemble which component controls across prediction timescales and spatial scales (road mapping exercise). Add components to determine % variance controlled.
  - Experiments with systematic varying of component representations within one or more models (alternative parameterizations).
  - Try to target key phenomena (atm rivers, high freq river flow, resolution challenges). Hypothesis that increases in resolution can enhance predictive performance. Can we replicate observed frequencies? UK floods caused by atm rivers; fundamental improvement in models in western pacific improve our ability to predict storms in western US?
- Multi-scale, multi-system needs for science and decision support
  - Error at small scales attributable to what? Need to de-convolve errors at scale of decisions and errors at larger scales—cleave problem in two
  - Diagnosing errors across hierarchy of models—avoiding high performance from compensating errors
  - Linking smaller scale decision support needs to large scale model development

Research Elements

- Model development needs
  - New parameterizations, numerical methods, scaling methodologies, need to understand scale dependence of parameterizations, coupling methods
  - Need to inform technical requirements for model based on elicited user needs.
  - New perspectives on model developments—mix of complexities, systematic simplification based on scale dependencies
  - Better characterization of uncertainties and behavioral controls
  - Clear communication of physics, algorithms, assumptions
- Data/observation needs
  - Need improved water—energy observations at broad time/space scales (precipitation—amount, intensity, duration, frequency); data set synthesis/creation
  - Benchmarking data to evaluate our process representations
  - Easy access to data that is well described including its uncertainties; expand to include socio-economic data when appropriate for contextual understanding
- Model Intercomparison, testing and evaluation
  - Idealized forcing scenarios, non-idealized forcing scenarios (virtual experiments and constrained by data)
  - Careful model archiving—should survey communities to determine needs; communicate with existing MIPs
  - End user targets/observations for evaluations

Research Elements

- Computational requirements (e.g., computing resources, common software infrastructure for model/data development)
  - Accounting for uncertainty will require dramatic increase resources
  - Higher resolution on land engages lateral transport can dramatically increase computational demands
  - Improved modularity in models for testing alternative component hypotheses
- Software infrastructure (e.g., tools for model/data integration and interoperability)
  - Improved modularity in models for testing alternative component hypotheses
  - Need easier ways to link to major community models for non-center researchers (facility were scientific community can contribute to assessments/development)
  - Standardization of input data and high resolution model output formats for effective access, use, and management
- Data management and visualization
  - Need better remote services for Petabyte level analysis and storage
  - Consider Google Earth scale dependencies and needs to tailor services
  - Expert support for interactive data visualization—improved visual analytics

Research Elements

- Strategies for interactions with the users

  (e.g., who are the users and what are their needs?; what frameworks or joint activities for researchers and users may lead to the improved use of models for decision support?)

  – Need to inform technical requirements for model based on elicited user needs.
  – Better characterization of uncertainties and risk thresholds impacting predictions for the cascade of users
  – Clear communication of physics, algorithms, assumptions
  – Need to clarify specific and efficient strategies for communicating with key user communities and decision makers
  – NOAA RISA's—show need to recognize the complexity and opportunities in user communication (climate services enterprise); can take a decade to build relationships; need to leverage boundary organizations with clear preexisting relationships and sustained support
  – Need to understand how they interact with other information providers, how do they perceive decision making process, may require dedicated people at the interface, need to be engaged in the model development/evaluation process—real stakeholders
  – Need to bound expectations based on limits of predictability and uncertainties

Crosscutting Group B

IMC B.2 Evaluative Applications

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Research Elements

- Hypothesis driven modeling experiments and predictability studies
  - …
  - …
  - …
- Multi-scale, multi-system needs for science and decision support
  - …
  - …
  - …

Research Elements

- Model development needs
  - …
  - …
- Data/observation needs
  - …
  - …
- Model Intercomparison, testing and evaluation
  - …
  - …

Research Elements

- Computational requirements (e.g., computing resources, common software infrastructure for model/data development)
  - …
  - …
- Software infrastructure (e.g., tools for model/data integration and interoperability)
  - …
  - …
- Data management and visualization
  - …
  - …

Research Elements

- Strategies for interactions with the users

  (e.g., who are the users and what are their needs?; what frameworks or joint activities for researchers and users may lead to the improved use of models for decision support?)

  – …
  – …
  – …

Crosscutting Group B (Day 1)

Integrative Modeling Challenge B.3

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Research Elements

- Hypothesis driven modeling experiments and predictability studies
  - …
  - …
  - …
- Multi-scale, multi-system needs for science and decision support
  - …
  - …
  - …

Research Elements

- Model development needs
  - …
  - …
- Data/observation needs
  - …
  - …
- Model Intercomparison, testing and evaluation
  - …
  - …

Research Elements

- Computational requirements (e.g., computing resources, common software infrastructure for model/data development)
  - …
  - …
- Software infrastructure (e.g., tools for model/data integration and interoperability)
  - …
  - …
- Data management and visualization
  - …
  - …

Research Elements

- Strategies for interactions with the users

  (e.g., who are the users and what are their needs?; what frameworks or joint activities for researchers and users may lead to the improved use of models for decision support?)

  – …
  – …
  – …

Crosscutting Group B (Day 1)

Integrative Modeling Challenge B.1

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Crosscutting Group B (Day 1)

Integrative Modeling Challenge B.2

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Crosscutting Group B (Day 1)

Integrative Modeling Challenge B.3

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Crosscutting Group B (Day 2)

Integrative Modeling Challenge B

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Research Elements

- Hypothesis driven modeling experiments and predictability studies
  - …
  - …
  - …
- Multi-scale, multi-system needs for science and decision support
  - …
  - …
  - …

Research Elements

- Model development needs
  - …
  - …
- Data/observation needs
  - …
  - …
- Model Intercomparison, testing and evaluation
  - …
  - …

Research Elements

- Computational requirements (e.g., computing resources, common software infrastructure for model/data development)
  - …
  - …
- Software infrastructure (e.g., tools for model/data integration and interoperability)
  - …
  - …
- Data management and visualization
  - …
  - …

Research Elements

- Strategies for interactions with the users

  (e.g., who are the users and what are their needs?; what frameworks or joint activities for researchers and users may lead to the improved use of models for decision support?)

  – …
  – …
  – …

Crosscutting Group C

- Julio Bacmeister
- Ana Barros
- **Dan Cayan (day 2)**
- **Martyn Clark (day 1)**
- Dave Easterling
- Dave Gochis
- Mohamad Hejazi
- Paul Houser
- Kathy Jacobs
- Jim Kinter
- **Steve Klein (day 1)**
- Ruby Leung
- Brian O'Neill
- Taikan Oki
- Christa Peters-Lidard
- Steve Regan
- Guido Salvucci
- Graeme Stephens
- **Vince Tidwell (day 2)**
- Kevin Trenberth
- Mike Wehner

Crosscutting Group C (Day 1)

Integrative Modeling Challenge C.1

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Crosscutting Group C (Day 1)

Integrative Modeling Challenge C.2

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Crosscutting Group C (Day 1)

Integrative Modeling Challenge C.3

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Crosscutting Group C (Day 2)

Integrative Modeling Challenge C

Key Features/Topic Relevance

A. ....
B. ....
C. ....

Approaches/Leveraging

A. ....
B. ....
C. ....

Scientific Impacts

A. ....
B. ....
C. ....

User Impacts

A. ....
B. ....
C. ....

Research Elements

- Hypothesis driven modeling experiments and predictability studies
  - …
  - …
  - …
- Multi-scale, multi-system needs for science and decision support
  - …
  - …
  - …

Research Elements

- Model development needs
  - …
  - …
- Data/observation needs
  - …
  - …
- Model Intercomparison, testing and evaluation
  - …
  - …

Research Elements

- Computational requirements (e.g., computing resources, common software infrastructure for model/data development)
  - …
  - …
- Software infrastructure (e.g., tools for model/data integration and interoperability)
  - …
  - …
- Data management and visualization
  - …
  - …

Research Elements

- Strategies for interactions with the users

  (e.g., who are the users and what are their needs?; what frameworks or joint activities for researchers and users may lead to the improved use of models for decision support?)

  – …
  – …
  – …

Crosscutting Group B (Day 1)

Needs for robust high resolution estimates of how hydrological cycle will change in future. Better integration of observational research with model development and evaluation. Consistency between process and large scale models.

Time-vs-space scale diagram of user needs in drought, where there is current predictive skill, predictability. What spatiotemporal scales are needed for drought prediction? Long term coming from ocean. Where is the bang-for-the-buck?

How do we develop models across scales that get at biogeochem. Develop metrics at different/appropriate scales for different metrics.

Recognition of deficiency in models. Where, for assessments on human impacts (food, energy), is detail needed? Where are critical interplays between model resolution, fidelity for decisionmaking?

Do we have the components necessary to build up the human-climate interactions for model development. Better use of existing obserfvational networks

Need to communicate with ourselves and other disciplines

Need to focus on variability in climate model predictions. How do we capture this variability in ways that are useful for decisionmakers? Capture key variability of phenomena, distributions etc.

Crosscutting Group B (Day 1)

Human dimension, legal regimes, impacts of decisionmaking can exceed natural variations.

High frequency variations in streamflow as a test for fast subsurface processes. Previous focus has been on lower frequencies (annual etc.). Diurnal cycle and other short scales can give information on shorter term fundamental physical processes.

Transport and transformation of water from land through estuaries out to the coastal ocean (sediment, nutrients, biogeochemical impacts).

What are the processes that regulate the impacts of climate change, and on what scales do they operate? How can we determine these processes using modeling? E.g. does heterogeneity of land cover regulate the temperature response to AGW? Snow-albedo feedback.

Crosscutting Group B (Day 1)

Reconciliation of predictions based upon completely different representations. This will apply to water in the near future. How to merge the communities?

Overall UQ issues given a hierarchy of models from simple models to extremely complex and coupled models with hydrology. How do we perform UQ analyses on said models? How will the decisionmaker make use of the wealth of information that will be provided to them?

Complexity vs fidelity. What level of complexity is sufficient for any given decision to be made? Needs to be done using a complex modeling approach. Need to test individual components and collective dynamics.

Coupled vs uncoupled models. Richness and emergent behaviors. Force models with complex and rich data.

Integrated assessment vs predictive models as two types of very different models. How do we compare these approaches?

Systematically assess the importance of resolution of key phenomena/predictions needed for the water cycle.

How can the community develop climate models frameworks that can deliver actionable projections?

In what ways, beyond changing large scale climate, are humans influencing their environment? How may these influences impact our vulnerabilities?

Human influence/interaction in addition to natural processes in shaping changes in the water cycle, and predictions and predictability of it.

Strategy for separating climate change from human influence on the water cycle. Land use changes and other human activities may be as significant.

Develop observationally-based metrics at appropriate spatial and temporal scales to address specific user-driven needs for prediction of key aspects of the water cycle.

Develop human-integrated earth system models that are consistent with biogeochemical processes across spatial and temporal scales?