Recent NRC/BASC Reports - Their Relevance for Management of Water Resources”

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Issues Treated

- How Federal Government / Science Community organized to study climate and what reports have been coming out lately
- Conclusions relevant to water resources

What is the National Research Council?

- NRC Article I, PURPOSE

The purpose of the National Research Council is to help improve public policy, understanding, and education in matters of science, technology, and health. The National Research Council shall be the principal operating agency of the National Academy of Sciences and of the National Academy of Engineering for service in the national interest and for furnishing scientific and technical advice to governmental and other organizations.

What is the US Global Research Program?

- Set up by act of Congress in 1990 under administration of George H. W. Bush
- Requires every 4 years a National Climate Assessment (NCA): i.e., the Global Change Research Act of 1990 requires a report to the President and the Congress that evaluates, integrates and interprets the findings of the $2.6 billion USGCRP every four years.
- Develops a Strategic Plan –finalized this year
- The NRC Committee to Advise the USGCRP has reviewed this plan and the NRC Panel to Review the National Climate Assessment will start reviewing the NCA at same time as public review period (special panel needed to avoid conflict of interest).

GOAL 1. ADVANCE SCIENCE

- **Advance scientific knowledge of the integrated natural and human components of the Earth system.**

Integrated observations and modeling, necessary to better understand the behavior and interaction of the natural and human components of the Earth system and their response to global change - increasingly emphasize integrating physical, biological, and social science research, and developing reliable knowledge of the causes and consequences of global change at regional and global scales to help assist and inform adaptation and mitigation decisions..

GOAL 2. INFORM DECISIONS

- **Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.**

Use of scientific knowledge in support of adaptation and mitigation decision making, translating and providing research results (from Goal 1) into information, formats, and results that are policy relevant, usable, and accessible to decisionmakers, and facilitate meaningful engagements and partnerships between scientists and decisionmakers. The program and its member agencies will provide global change information, tools, and services needed to make decisions.

GOAL 3. SUSTAINED ASSESSMENTS

- **Build sustained assessment capacity that improves the United States' ability to understand, anticipate, and respond to global change impacts and vulnerabilities.** The USGCRP will conduct and participate in national and international assessments to evaluate past, current, and likely future scenarios of global change and their impacts, as well as how effectively science is being used to support and inform the United States' response to change. The USGCRP will integrate emerging scientific understanding of the Earth system into assessments and identify critical gaps and limitations in scientific understanding.

Goal 4. COMMUNICATE AND EDUCATE

- **Advance communications and education to broaden public understanding of global change and empower the workforce of the future.** use its research results to communicate with and educate stakeholders in ways that are relevant to their lives and needs. The program and its member agencies will adopt, develop, and share best practices in communication that enhance stakeholder engagement. Educational efforts will support development of a scientific and general workforce able to use global change knowledge in their personal and professional lives.

Global Change and Extreme Hydrology

Testing Conventional Wisdom

NRC Water Science and Technology Board

- **UNDERSTANDING HOW CLIMATE CHANGE WILL IMPACT HYDROLOGY**
- —the movement, distribution, and quality of water—is one of the grand challenges facing the climate and water science communities.
- The basic laws of physics demonstrate that as climate warms, Earth's atmosphere will hold more moisture. This threatens to increase the occurrence of severe storms, potentially leading to more extreme floods and droughts

The Way Forward

From a planning standpoint, uncertain flood or drought frequencies cause major problems with projects that have long life-spans, such as dams, levees, and sewers. One solution to this problem is to construct infrastructure in smaller units that have shorter expected longevities or design re-visit times (on the order of 10-20 years).

In addition, engineers can use reconstructions of conditions during past periods of climate change, based on historical or paleohydrologic records—evidence of hydrologic systems as they existed during previous periods of Earth history—to design projects that could adapt to predicted future conditions. Such strategies have been used to avoid future flood damage to urban areas;

Understanding Flood and Drought Risk

Risk is a combination of the likelihood that a hazard will occur, and the exposure of assets to damage. In the past, researchers placed considerable emphasis on the probability component of risk, as illustrated by the idea of the “100-year flood.”

There has been much less emphasis on developing well-defined measures of vulnerability to hazards, which in this context means susceptibility to and ability to cope with losses caused by extremef oods or droughts.

Vulnerability depends in part on social factors, and is constantly evolving. For example, the construction of dams and levees might decrease the probability of a flood, but could increase vulnerability by creating a false sense of security that results in the construction of buildings in flood-risk areas.

Without research to better understand all the dimensions of risk, the design of effective climate change adaptation strategies will remain unrealized.

Recent NRC BASC Reports about climate

Himalayan Glaciers: Climate Change, Water Resources, and Water Security (2012)

Scientific evidence shows that most glaciers in South Asia's Hindu Kush Himalayan region are retreating, but the consequences for the region's water supply are unclear, this report finds. The Hindu Kush Himalayan region is the location of several of Asia's great river systems, which provide water for drinking, irrigation, and other uses for about 1.5 billion people. Recent studies show that at lower elevations, glacial retreat is unlikely t...

A National Strategy for Advancing Climate Modeling (2012)

Climate models will need to evolve substantially to deliver climate projections at the scale and level of detail desired by decision makers, this report finds. As climate change has pushed climate patterns outside of historic norms, the need for detailed projections is growing across all sectors, including agriculture, insurance, and emergency preparedness planning. Despite much recent progress in developing reliable climate models, there ar...

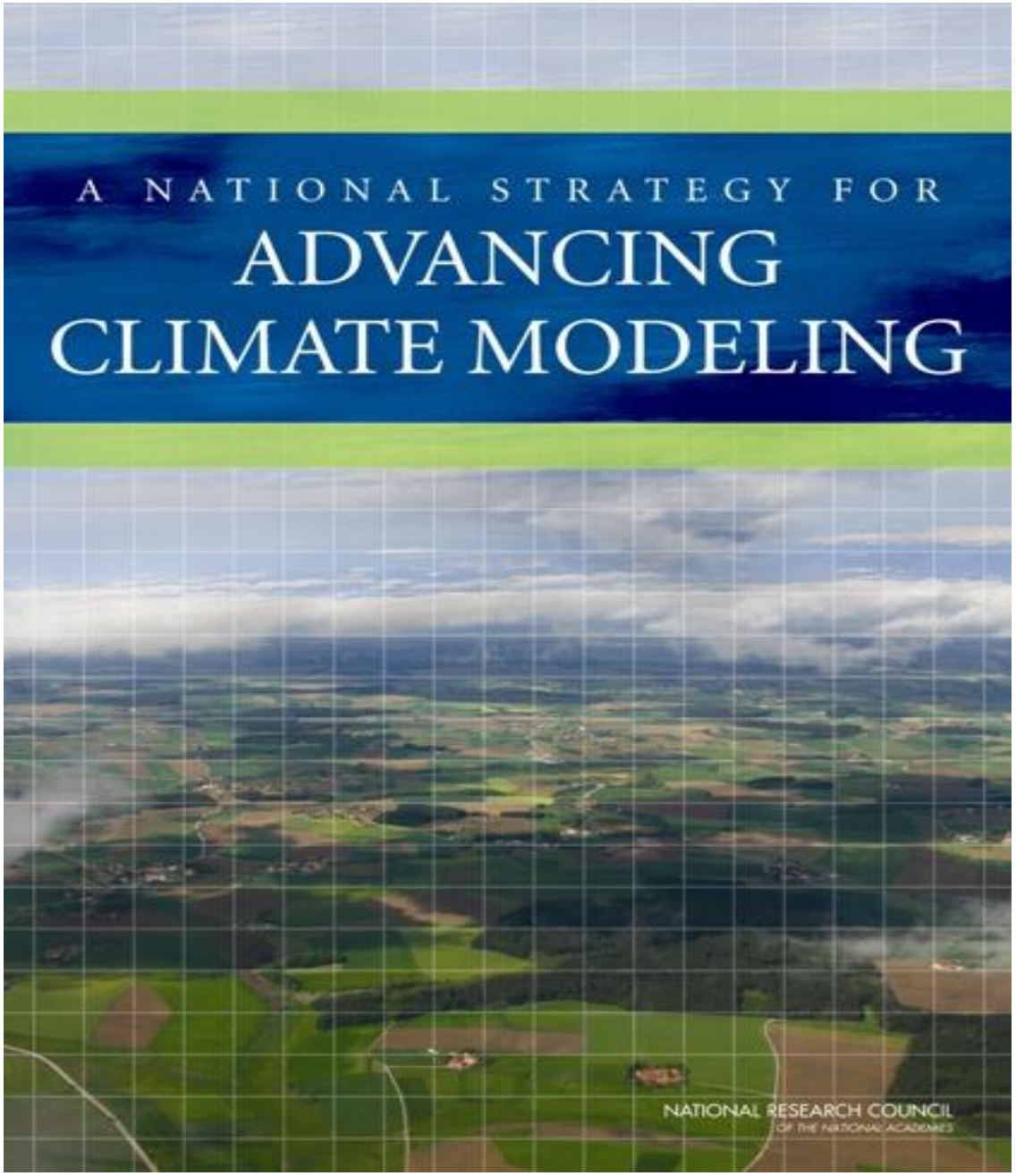
- **A Review of the U.S. Global Change Research Program's Strategic Plan (2012)**

"Global change research" engages agencies and departments across the federal government in many diverse activities, coordinated by the U.S. Global Change Research Program (USGCRP). The USGCRP is developing a 10-year Strategic Plan to strengthen the Program's role in sustaining a strategically-driven, coordinated national effort. As independent advisor to the Program, a National Research Council committee has reviewed the draft Plan. The committe...

America's Climate Choices (2011)

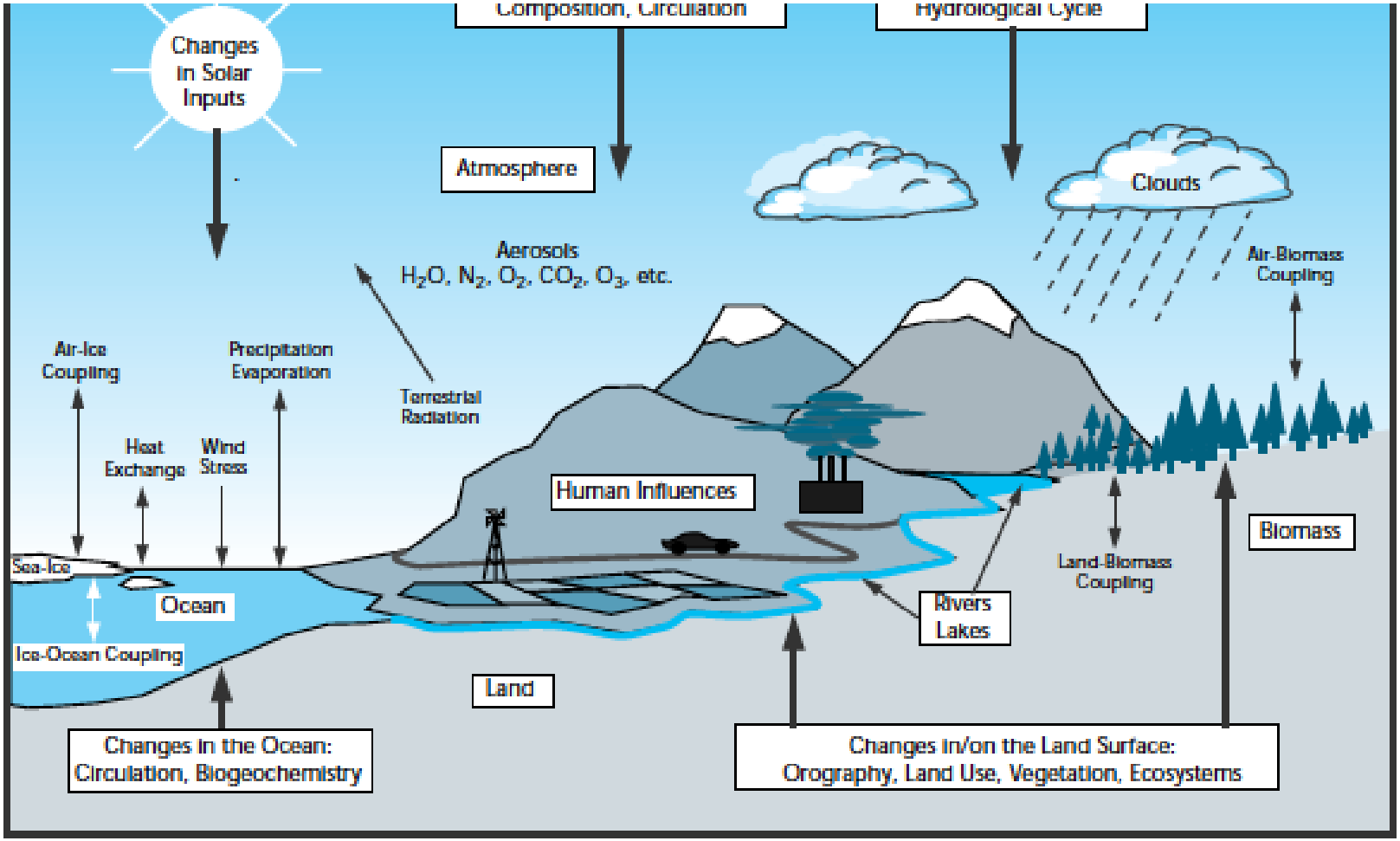
This final America's Climate Choices report is the conclusion of a five-report series that included: Advancing the Science of Climate Change Limiting the Magnitude of Climate Change Adapting to the Impacts of Climate Change Informing an Effective Response to Climate Change. Climate change is occurring, is very likely caused primarily by the emission of greenhouse gases from human activities, and poses significant risks for a range of human an...

A total of 8 reports in 2010, 5 of which summarized in "America's Climate Choices"


A NATIONAL STRATEGY FOR
ADVANCING
CLIMATE MODELING
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

- The “National Strategy for Advancing Climate Modeling “ report was initially requested by the intelligence community
- but then was also supported by all the Federal agencies (NOAA,NASA,DOE,NSF) concerned with climate modeling
- “to produce a strategic framework to guide the Nation’s climate modeling enterprise over the next 10-20 years.”

Climate Model



What does report contain?

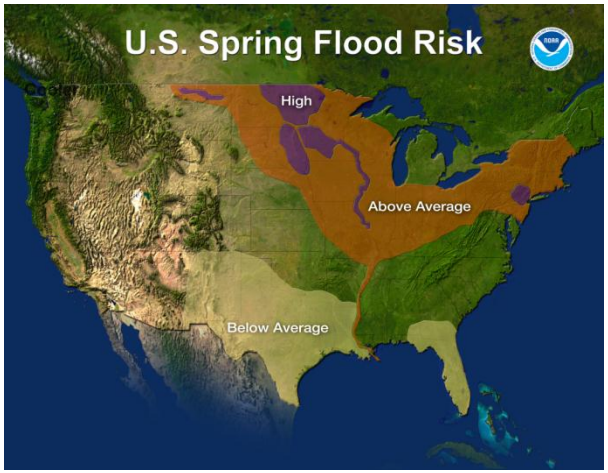
- Extensive descriptions of many of the processes described by climate models and the applications/needs these models address
- Some findings and recommendations- only time here to look at these: 4 main components
  - Common national software infra-structure.
  - National Forum for tighter coordination between US modeling groups
  - Unification of weather and climate modeling
  - Need “climate interpreters”

Drivers/Needs

- Decision makers needs for climate information
- Transition to radically new computing hardware
- Increase our understanding of the Earth system

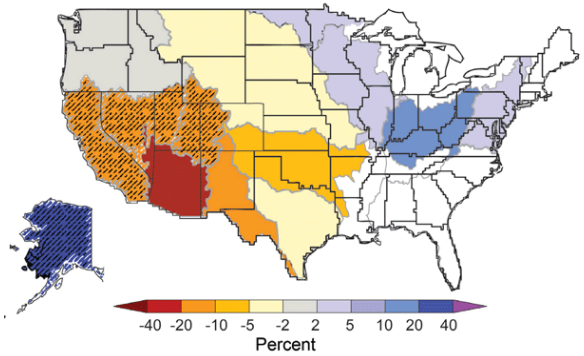
Need for Climate Information

- Weather = meteorological conditions at a given time in a given location
  - Temperature, precipitation, etc.
- Climate = average weather conditions over longer time scales
  - From seasonal to centennial
- Climate models = computer models that simulate past and future climate



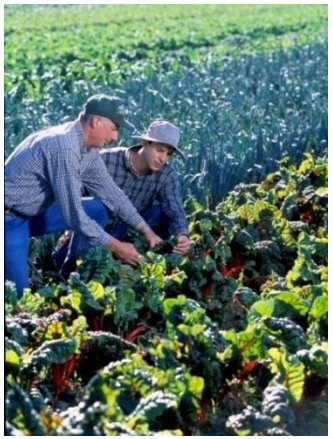
- **Climate models are crucial for providing climate information**
  - Only models can project into the future
- Short term climate predictions
  - e.g., seasonal flood risk predictions
- Longer term climate projections
  - e.g., runoff projections for mid-century

Projected changes in annual runoff 2041-2060



Need for Climate Information (cont.)

- Wide variety of users of climate information
  - Farmers
    - Decisions on irrigation needs (weeks/months)
    - Decisions on what crops to plant (years/decades)
  - Hydropower system managers
    - Millions of people rely on hydropower for electricity
    - Managers use climate info for water storage decisions and infrastructure planning
  - Insurance companies
    - Accurately reflecting risks from climate and weather related natural disasters is major issue for insurance industry
    - Floods, high winds, extreme precipitation, droughts, etc.
  - National security planners
    - e.g., Navy is planning for how climate change will impact their operating environments (like a seasonally ice-free Arctic), missions, and facilities
  - Other examples = mayors of large cities and infrastructure planners
- Economic impact is large
  - Billions of dollars at stake



Transition to radically new hardware-continued

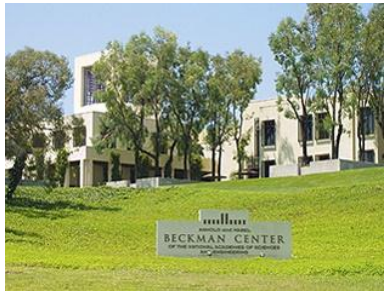
- Can only get 10 gigaflops out of a single processor – too much heat for cycling more than 3 gigahertz
- Need 2 million processors for worlds fastest computer (also $100M and 20 Megawatts of electricity).
- Within 10 years, expect to have exaflop computers (100 times faster than today-100 times more processors) but can't use more electricity-too expensive
- Stampede (10 petaflops) comes to Texas in a few months. How to write efficient programs for such?

Challenges of Current State of U.S. Modeling

- U.S. is leader in international climate modeling community
  - Climate Model Inter-comparison Projects (CMIP) are important part of climate model development
- Multiple modeling centers around the country
  - NCAR, NOAA (GFDL and NCEP), NASA (GISS and GSFC), etc.
  - Diverse approaches can help solve hard problems and address different missions
  - Lack of unification can be impediment to progress
- Size of investment
  - USGCRP estimate → ~$239M spent by federal agencies on "improving our capability to model and predict future conditions and impacts"
    - 11% of total climate research spending
  - Several hundred people working in climate model development

Committee Approach

- NAS report process
  - Formed committee Fall of 2010
  - Met with report sponsors January, 2011
  - 5 meetings through 2011
    - Engaged key stakeholders in climate modeling and user communities
    - Large community workshop with >50 people
    - Meetings involved dozens of speakers and attendees
    - International speakers, all key modeling centers
    - Interviews with key officials and scientists
  - Numerous teleconferences
  - Report writing through spring of 2012
  - Report review through summer of 2012



Lessons Learned from Past Reports

- Several reports in late 1990s/early 2000s examined how to improve effectiveness of U.S. climate modeling
  - Discussion in several reports since then
- Reports generally most useful if they include practical recommendations
  - Influence strategic thinking at program level
- Previous investments and efforts in common software infrastructure have paid substantial dividends
  - Have helped support social integration of the diverse climate modeling community by supporting bottom-up community co-operation
- Previous reports highlight need for routine and reliable climate information, products, and services
  - View outside the modeling community is also that more products are needed
- Bottom-up community governance offers new strategies for working-level decision making
  - Previous reports have consistently called for more coordination and consolidation of climate modeling agencies and institutions, but this has met with limited success

Institutional Arrangements

- Committee examined arrangement of climate modeling in U.S. agencies
- Strengths
  - Stability of support has allowed cadre of scientists to develop state-of-the-art models on long-term basis
  - Collaborative activities (e.g., Climate Process Teams) can effectively leverage talents in both universities and national labs
  - Healthy diversity of activity and benefits of competing approaches, especially to difficult scientific problems
- Weaknesses
  - Subcritical in key areas, especially in human resources
  - Potential duplication of efforts – multiple institutions solving similar software problems
- Why not a single U.S. climate modeling center?
  - Various agencies involved in climate modeling have differing missions
  - Can reduce much of redundancy in other ways (discussion of common software infrastructure to follow)
  - Potential for large disruptions in U.S. modeling capability, at least in near-term
- Risks of a move to a single U.S. climate modeling center significantly outweigh benefits, but there is a need to unify/consolidate current efforts.

Software Infrastructure

Currently

- Climate models run on large computers at individual modeling centers
  - Modeling centers each have "in-house" shared software infrastructure
- CMIP intercomparisons have improved understanding of model differences

Next 10-20 years

- Improvements in climate models increasingly achieved by combining multi-institution efforts.
- Using finer grids for climate models requires more computer power
  - Tenfold more calculations to halve the grid spacing.
  - Transition to massively parallel computing (no processor speedup, but billions of processors)
  - Will require adaptation of software infrastructure to run on these new types of machines

National Climate Modeling Forum

Recommendation

- Annual climate modeling "forum"
  - Organized by multi-agency organization; USGCRP as logical choice

Goal

- Bring together climate modelers and users
- Provide mechanism for different climate modeling communities (e.g. global and regional climate modelers) to work together
- Opportunities for continuing education of users and strategic discussion

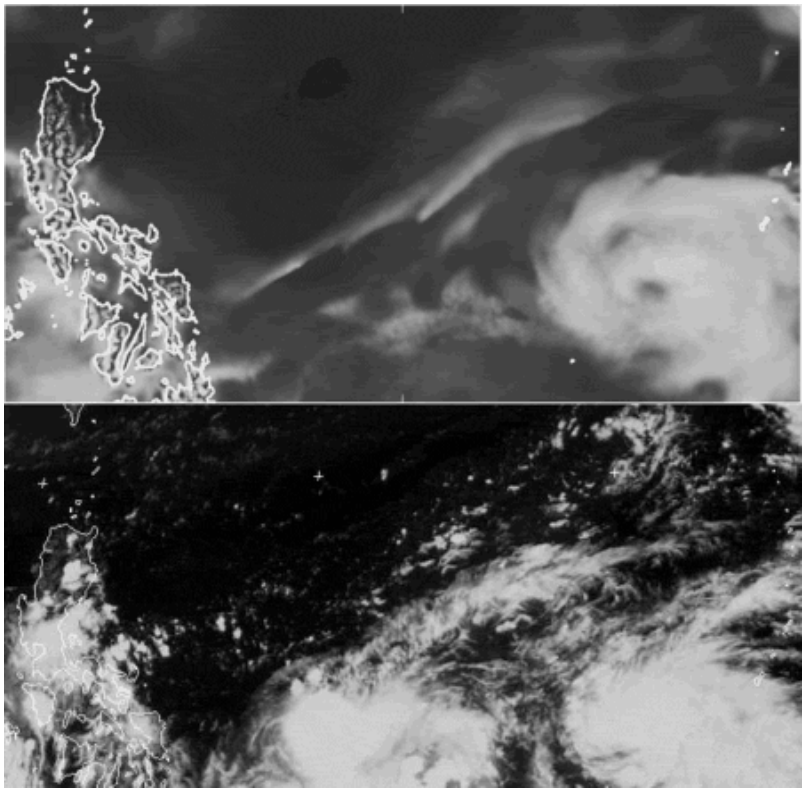
How is this meeting different?

- Not envisioned as a meeting of just presentations → working groups
- Not every modeler required to be there → probably representatives from all modeling centers though
- Other meetings do not currently bring U.S. modeling groups and user groups together in a focused way

Unified Weather-Climate Modeling Effort

Currently

- Typically models that operate on weather (< weeks) and climate (seasons to centuries) time scales are separate
  - Many of same physical processes are important in both
- Unified weather-climate prediction (aka "seamless") models increasingly used
  - UK Met Office as prime example
- Validation of climate models often limited by available observations
  - Performance on weather and seasonal timescales are useful tests of climate models



Next 10-20 years

- Increased need for climate model improvements

Unified Weather-Climate Modeling Effort

Recommendation

- Accelerated national modeling effort spanning weather to climate time scales
  - Would be one effort within U.S. modeling endeavor
  - Would be facilitated by collaboration among operational weather forecast centers, data assimilation centers, climate modeling centers, and the external research community

Goal

- Testing of 'fast physics (e. g. clouds, turbulence)' in climate model at weather time scales
- Reduced weather forecast errors due to 'climate drift'
- A powerful tool for better synthesizing observations into climate reanalyses
  - More efficient and effective advancements in weather climate models

Climate Interpreters

Currently

- Climate model output often difficult for users to access easily and interpret properly
- Some entities (public and private) providing translation of climate model information for users
  - But no quality assurance /certification of these information provides

Next 10-20 years

- Growing demand for climate information

Climate Interpreters

Recommendation

- Develop training program for climate model "interpreters"
  - Could involve degree or certificate program offered by universities
  - Possible accreditation through national organization (possibly AMS or AGU)

Goal

- Trained interpreters can facilitate two-way communication between climate modelers and users
  - Take technical findings and output from climate models and use them in diverse range of private and public-sector applications
  - Provide feedback to climate model developers of what information users desire
- Interpreters not envisioned as solution to all users needs/climate services
  - Rather, training program is crucial step that benefits any system that bridges climate modeling and user communities

3d US-UK Sackler Forum: 19-20 Sept. 2012 Integrated Assessment Models and the Future Needs of Climate Change Research

- Emphasis on understanding uncertainty for improving policy advice – policy makers would like single numbers to base their decisions on, but because of uncertainty, not possible
- Need to better characterize low probability- high impact events e.g. what are the fat tails of pdfs. Models inability to provide a serious flaw.
- Simple versus complicated models, e.g. acid rain legislation facilitated by simple bounding models.

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- **Key Findings**
- Although budget realities and practical challenges may constrain the proposed expansion of the USGCRP's scope, the committee encourages sustained efforts to expand the Program over time, along with efforts to better define what specific topics fall within the bounds of global change research.
- An effective global change research enterprise requires an integrated observational system that fully integrates the social and ecological sciences.
- Phasing in the newer elements of the Program will require identifying initial steps to develop critical science capacity that is currently lacking and to improve linkages between the production of knowledge and its use.
- The Program needs an overall governance structure with the responsibility and resources to broaden the Program as proposed in the Strategic Plan.

Conclusions for Texas Management of Water Resources

- Large national framework and sources of information
- Need to clarify what are the most important issues – models and model studies need to be tailored to the issues.
- Will always be large uncertainties as to the future – need to use adaptive decision making that accounts for current scientific understanding including uncertainty.
- Need more communication and scientists trained to interface climate modeling to needs of water resources.