Dealing with Climate Model Uncertainty in Adaptation Planning

Chris Weaver
EPA Office of Research and Development and
U.S. Global Change Research Program

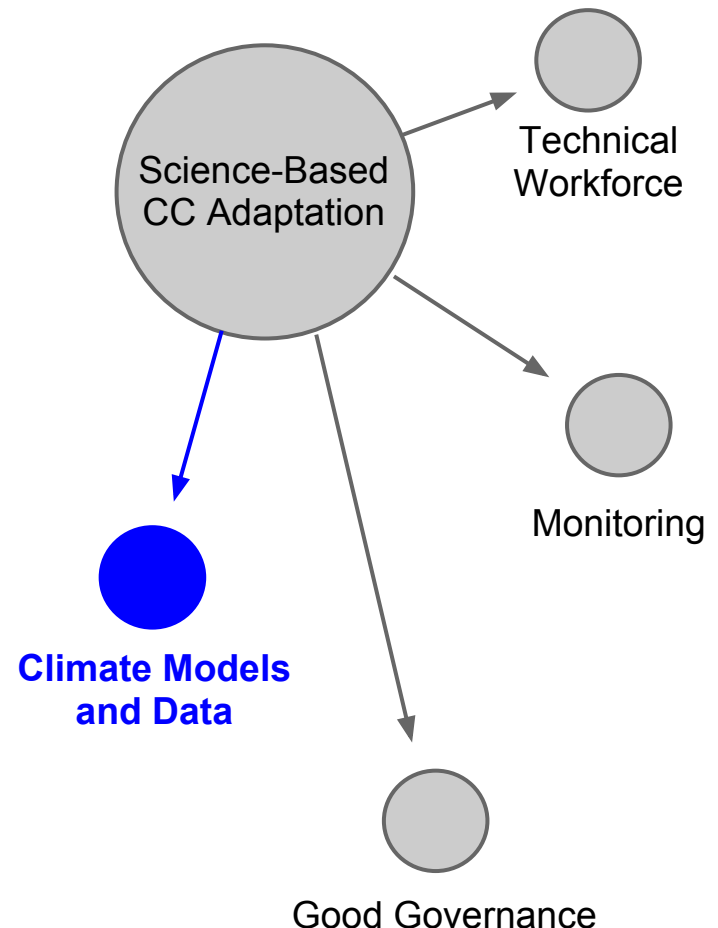Overcoming the Uncertainty Barrier to Adaptation - Webcast #2

17 April 2013

National Need for Information to Support Climate Adaptation

Often need quantitative, analytical guidance to support certain kinds of decisions in adapting natural resource management, environmental protection, public health, infrastructure, disaster preparedness,, etc.

- The climate science and **climate modeling enterprise** has key role to play here, but ...
- **What data, what models, do we downscale, how to deal with uncertainty?**
- **Analysis paralysis**

Science-Based CC Adaptation

Technical Workforce

Monitoring

Climate Models and Data

Good Governance

- "I know that climate change is something I need to pay attention to, but how do I sort through the information and data that are out there to identify what's most relevant to me?"

- "What kind of predictions do climate models make for my region/watershed?"

- "How 'good' are these models?"

- "Which is the 'best' model?"

- "Do I need to do downscaling to have accurate information for my region?"

- "Is it true that these model simulations are so uncertain that we cannot use their output for anything practical?"

- "If I'm not getting accurate, regional-scale predictions from climate science, what good is it to me?"

The Essence of the Challenge

1. Future climate prediction is hard

2. And so is incorporating scientific information into real decision-making

3. How do we harness climate science and model data to processes of effective decision support?

The key:

- Turn the problem around: <u>start with decisions, not data</u>
- Adopt a participatory approach to identifying information and developing analytical approaches

Limits on understanding and computing power:

- Clouds, precipitation, storm systems, convection, diurnal cycle, ocean-atm interactions, land hydrology, major circulation patterns (e.g., ENSO, monsoons, etc.)
- Spatio-temporal resolution is part of the story - but also model complexity, integration length, ensemble size, specification of ICs
- Long timescales, fat tails, extreme events and disasters
- Socioeconomic changes will alter the trajectory of climate changes, with further feedbacks on human responses - highly unpredictable
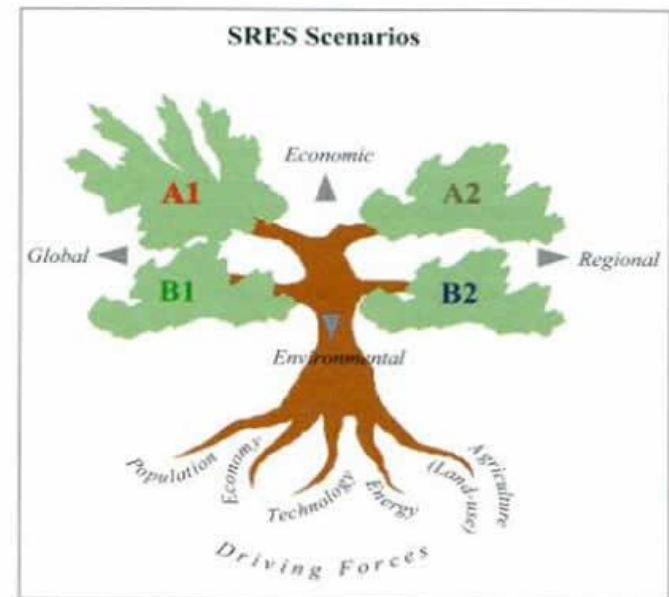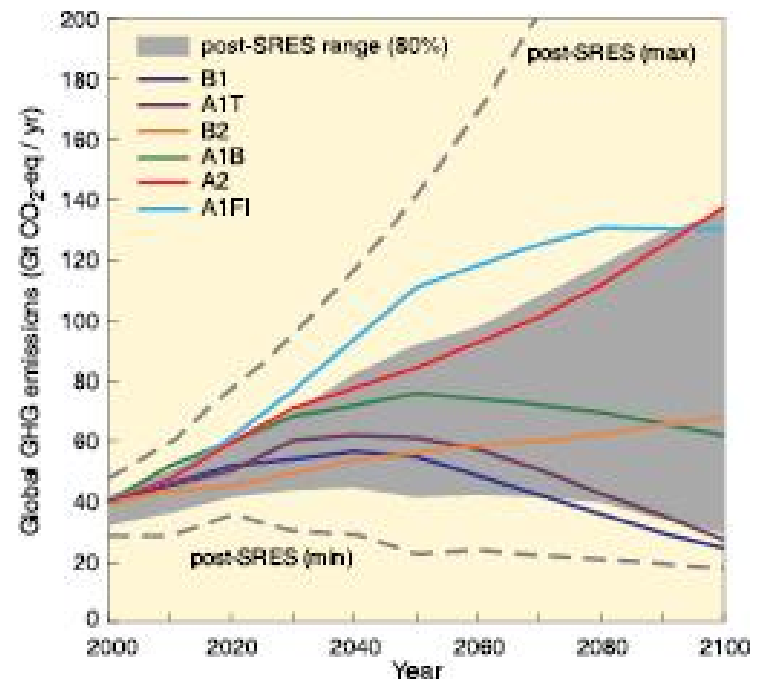
From IPCC

Limits on ability to know whether we're correctly simulating future states:

- Future climate is a state of the Earth system we haven't experienced yet
- May ultimately be impossible to calibrate a given climate model to ensure that it will produce a meaningful long-term forecast
- No model does a good job with every climate variable
- Just because a bunch of models agree doesn't mean we should believe them more
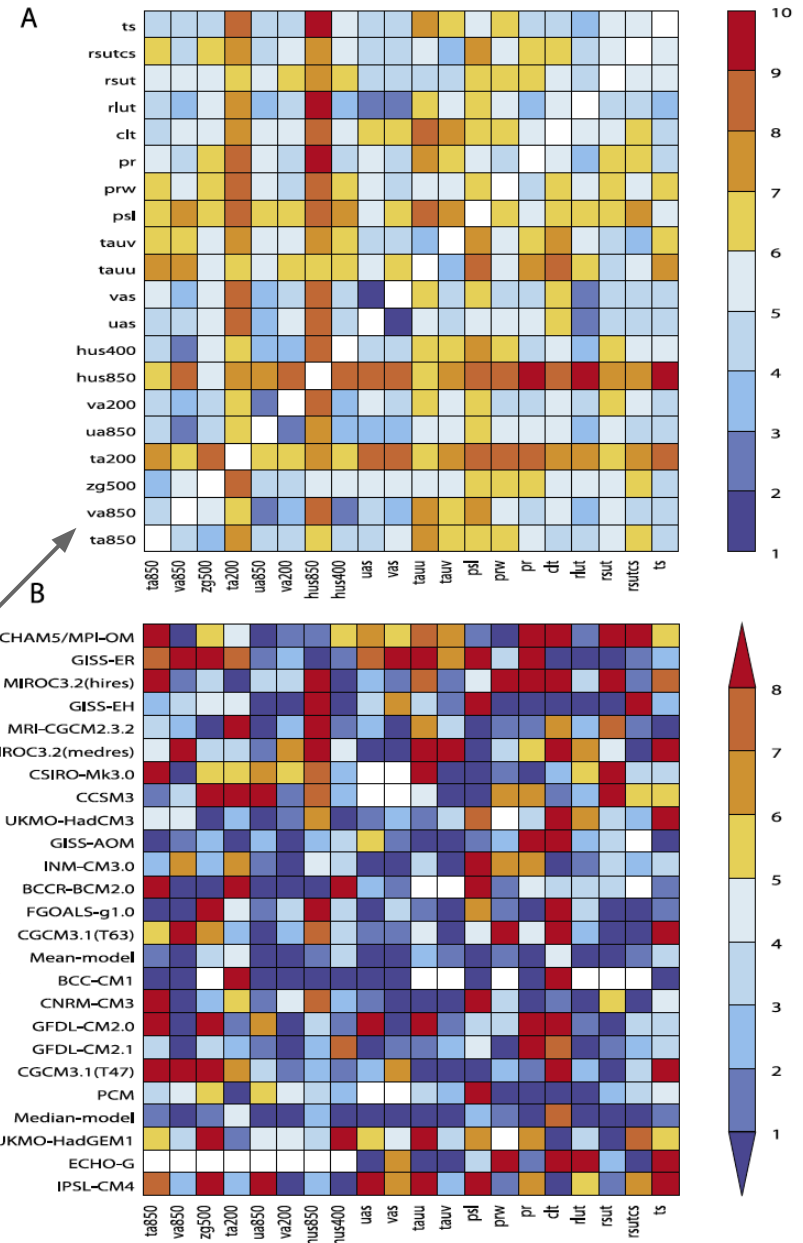
But modeling does have a lot to contribute to adaptation decision support even if they can't deliver accurate future predictions ...

1. Exploratory modeling to identify the possibility of important special cases in system behavior, such as extremes, thresholds, and surprises - types of risks we might need to be aware of/account for

2. Use this information to search for policy options capable of satisfactory performance in the face of such special cases, thereby expanding the space of choices for the decision-maker

3. Scenario generators: Evaluate proposed options over as wide a range of futures as possible to understand under what futures they might fail

A lot of the time you can accomplish this with relatively simple analyses of "off the shelf" model data - lots of good public archives and simple tools - along with simple conceptual understanding of the key drivers and endpoints in your system

... And So Is Climate-Related Decision Support

Large literature about how decisions are actually made explains whether and how scientific knowledge becomes part of that process:

- Scientific information only one part of a much broader system of decision-making practice
- Can be effective in influencing decision making, but only if perceived as 'credible, salient, and legitimate'
- These characteristics result from sustained process of close interaction among knowledge producers and users

Science-based **decision support is a social process**, rather than a set of products (data, tools, predictions)

Turn the problem upside-down:

- Start with the decision context, <u>not with future climate</u>

- With a team of scientists and stakeholders, <u>collectively develop understanding</u> of the sensitivity of your system and your decision to climate variability and change

- This process provides insight into the uncertainties that actually matter to your problem

- You can then use this insight to tailor selection of climate model information and other data - sample widely over <u>only those uncertainties important to your specific problem, and only to the level of detail needed</u>

- Inherently participatory: Increases the credibility, relevance, and legitimacy of the scientific information in the decision process

What the Decision Sciences Can Tell Us

Paradigm 1: "Predict Then Act"

- Figure out your best-guess future and design the best policy you can for that future
- Conceptual framework: Maximize expected utility
- Question: "What is most likely to happen?"

Paradigm 2: "Robust Decision-Making"

- Identify greatest vulnerabilities across full range of futures and identify the suite of policies that perform reasonably well across this range
- Conceptual framework: Minimize regret
- Question: "How does my system work and when might my policies fail?

What the Decision Sciences Can Tell Us

Paradigm 1: "Predict Then Act"

- Figure out your best-guess future and design the best policy you can for that future
- Conceptual framework: Maximize expected utility
- Question: "What is most likely to happen?"

Paradigm 2: "Robust Decision-Making"

- Identify greatest vulnerabilities across full range of futures and identify the suite of policies that perform reasonably well across this range
- Conceptual framework: Minimize regret
- Question: "How does my system work and when might my policies fail?

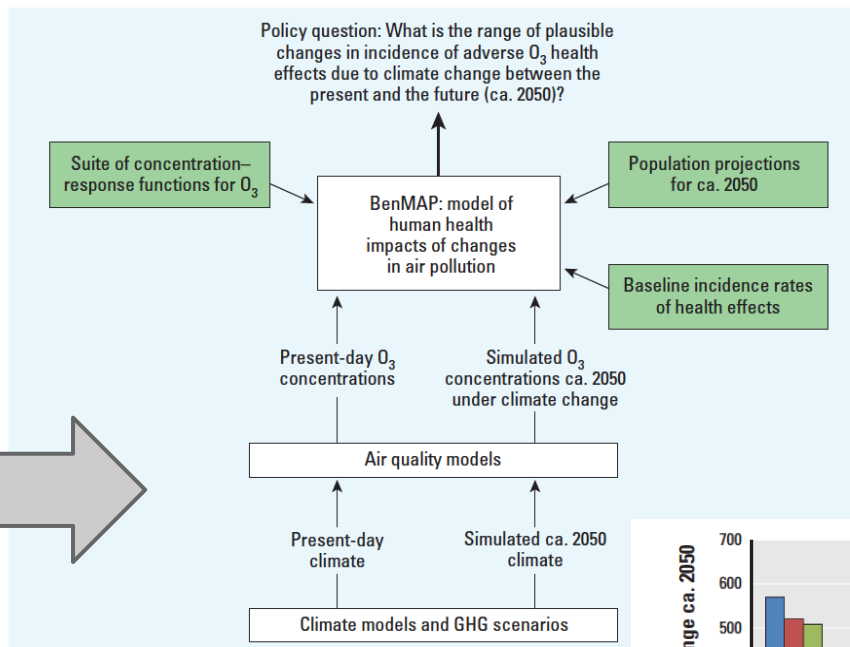*The best way to deal with uncertainty about the future is to understand your system/your decision better ...*

Policy question: What is the range of plausible changes in incidence of adverse O_3 health effects due to climate change between the present and the future (ca. 2050)?

Suite of concentration–response functions for O_3

Population projections for ca. 2050

BenMAP: model of human health impacts of changes in air pollution

Baseline incidence rates of health effects

Present-day O_3 concentrations

Simulated O_3 concentrations ca. 2050 under climate change

Air quality models

Present-day climate

Simulated ca. 2050 climate

Climate models and GHG scenarios

Figure 1. The structure of the analysis of O_3-related impacts on human h... change. GHG, greenhouse gas.

- Scientific/modeling uncertainties in context of EPA RIA
- Mortality/morbidity benefits of regulation
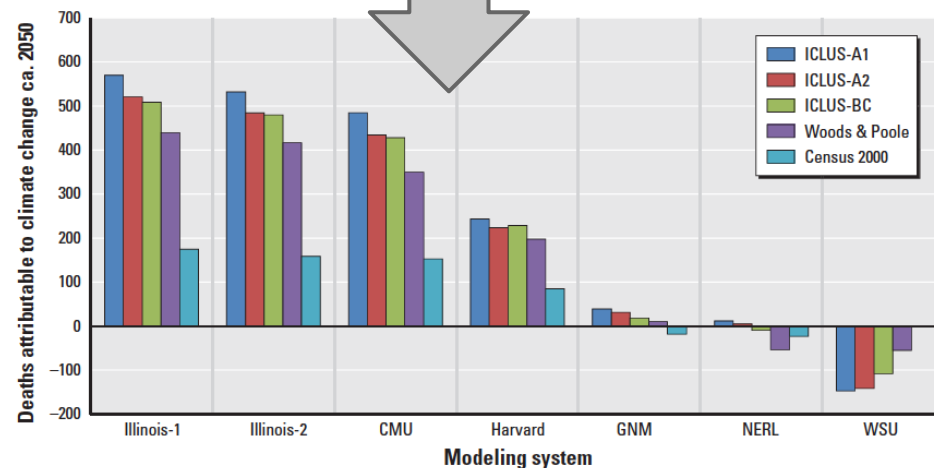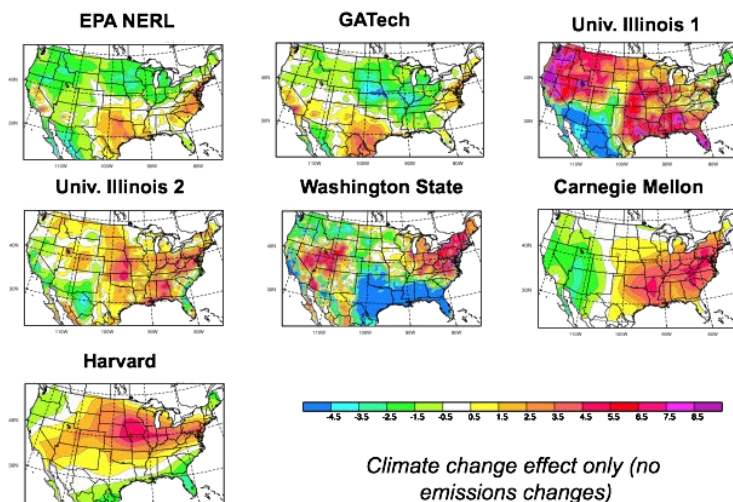Expose most critical uncertainties

EPA NERL
GATech
Univ. Illinois 1
Univ. Illinois 2
Washington State
Carnegie Mellon
Harvard

Climate change effect only (no emissions changes)

Deaths attributable to climate change ca. 2050

ICLUS-A1
ICLUS-A2
ICLUS-BC
Woods & Poole
Census 2000

Illinois-1   Illinois-2   CMU   Harvard   GNM   NERL   WSU

Modeling system

Figure 2. Estimated national summertime (June–August) O_3-related nonaccidental mortality due to simulated climate change between 2000 and ca. 2050 (C–R function from Bell et al. 2004). We estimated that –0.6 deaths were based on the WSU climate change model–air quality model and Census 2000 population data.

EPA Regulatory Impact Analysis for Future O3