Global Scenario Development in the “Post Mauritius” World

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Acknowledgements

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Overview

- New global scenarios?
- IPCC's "catalytic" approach & Mauritius decision
- Emergent experimental design
- Issues for further exploration
- Next steps

New Global Scenarios?

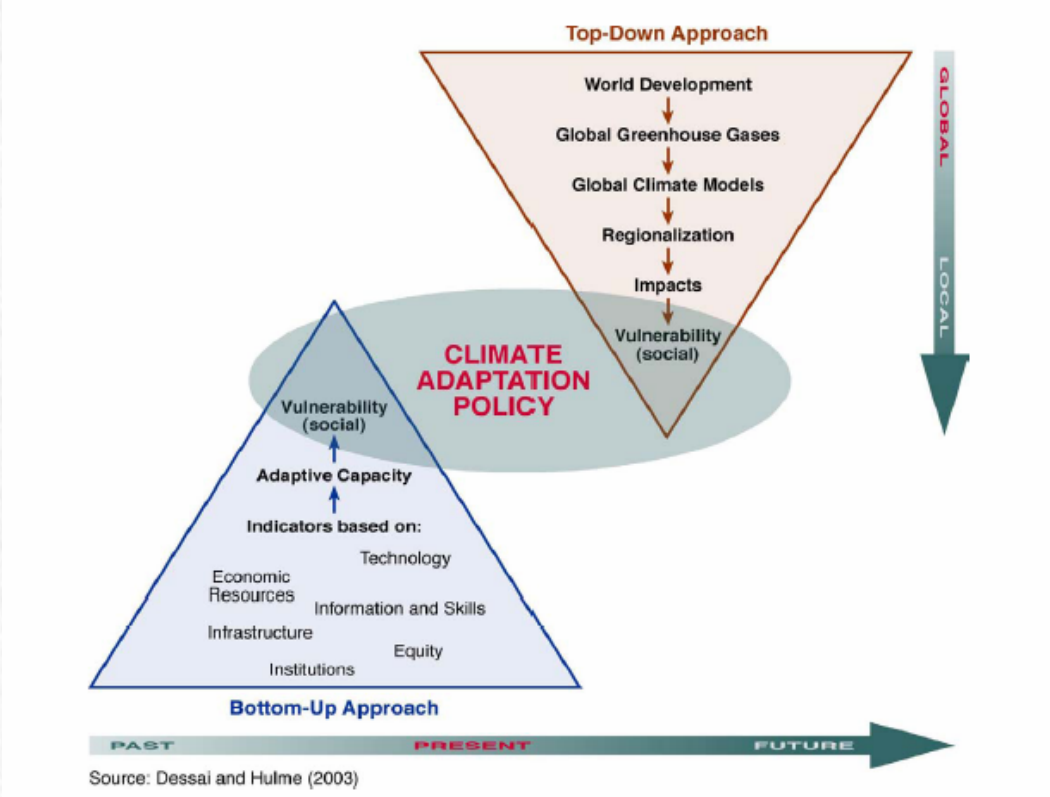
- Explore disciplinary science issues
- Broad utility for coordinating research across climate, impacts/adaptation, and mitigation
- IPCC AR5 coordination
- Top-level question to be addressed:
  - What would be the avoided damage and reduced risks (at the global and regional levels) of reducing GHG emissions to different stabilization levels over different time profiles?

Addressing this Question Requires Assessing Adaptation and Mitigation:

- For different time periods (eg 2020s, 2050s,2080s)
- For different systems: ecosystems, health, food, water, etc.
- For different socio-economic pathways (e.g., demographics, economic circumstances, technology futures, social conditions, etc.)
- For different environmental conditions (e.g., regional pollution, land use, etc.)
- For different amounts of emissions reduction
- Over varying time profiles

Scenario Information Needs

- GCM and mitigation analysis communities information needs are well defined
- Impacts/Adaptation community information needs for socio-economic details for assessing adaptive capacity needs to be clarified
- Global process needs to make provisions for needs of participating communities



IPCC's Past Central Role in Scenario Development

1990 1992 1994 1996 2000 2001 2004-2007

SA90

IS92

Evaluation (SR on Radiative Forcing)

Panel decision on new scenarios

Special Report EmissionScenarios (SRES)

TAR mitigation scenarios

AR4 assessment of implications of SRES and stabilization scenarios

IPCC's Mauritius Decision on Scenarios (April 2006)

- Noted:
  - The need for new emission scenarios, to be available well before completion of a possible AR5
  - The importance of coordination among and by the scenario development groups
- Decided that IPCC will:
  - "Catalyze" not create new scenarios
  - Prepare a technical paper to identify "benchmark" emission scenarios for potential use by climate modeling groups
  - Hold an "expert meeting" to explore (a) characteristics of scenarios; (b) plans in the scientific community and (c) enhancement of developing country/EIT involvement

Considerations in Establishing a New Process for Global Scenarios

- Use resources efficiently
  - Minimize demands for coordinated "community" runs
- Permit groups to do some science
- Allow creativity and variation
- Facilitate rigorous intercomparison
- Increase developing & transition economy country participation

Research Community Efforts to Self-Organize Scenario Development

- Several model and scenario development activities have occurred since Mauritius. These include the Aspen Global Change Institute (AGCI) workshop organized by J. Meehl and K. Hibbard in August 2006, and subsequent discussions
- AGCI explored the incorporation of earth-system model components (carbon cycle, chemistry, aerosols, dynamic vegetation) in GCMs (atmosphere, ocean, land, and sea ice; AOGCM) for climate change projections
- Purpose was to identify new components, establish communications across groups, develop experimental designs, specify model requirements, and assist IPCC

Proposed Experiments for Coordinated Work

AGCI proposed two classes of experiments, each focused on defined scientific questions:

1. Near-Term (2005-2030)
2. Longer term (to 2100 and beyond)

Since AGCI, the proposal has been discussed and refined at several international, interdisciplinary meetings, including WGCM/AIMES, C4MIP, ESSP, TGICA, and others

Short-Term Experimental Design (2005-2030)

A prime goal of projections for the next 25 years is to provide better guidance on the likelihood of changes in regional extremes and hydrology

•Finer- resolution models (about 0.5° to 1° horizontal resolution, and increased vertical resolution and domain) with:

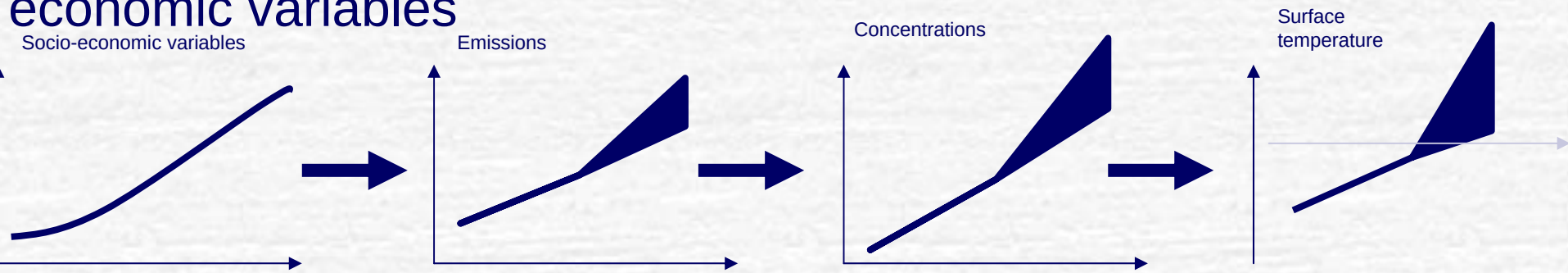
- simple atmospheric chemistry
- aerosols
- dynamic vegetation
- (no carbon cycle on this timescale)

- Ensemble simulations of at least 10 members for each scenario
- Improved process representation and higher resolution are needed, thus compromises to make the simulations computationally feasible
- Initialization will require accurate ocean data and possibly soil moisture and sea ice
- A single mid-range GHG scenario would be run with variants for pollutants (aerosols and short-lived gases) as perturbations around the standard scenario. Geo-engineering hypotheses could be tested as well.

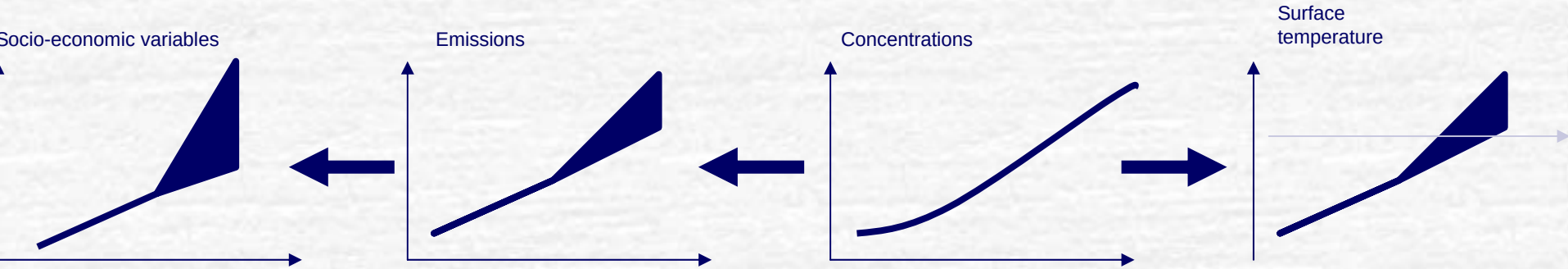
Long-Term Experimental Design (2100 and Beyond)
WHAT ARE CARBON CYCLE FEEDBACKS ON CLIMATE SYSTEM?

- Two stabilization benchmark scenarios are proposed: (1) high case ~700 ppm, (2) low case ~400 ppm, and (3) an optional midrange case ~550 ppm. At least one ensemble per scenario
  - low radiative forcing with gridded land use/high socio-economic capacity to adapt (e.g., mitigation, stabilization B1)
  - high radiative forcing w/gridded land use/low capacity for adaptation; (e.g., A2, A1 Fossil Intensive)
- For each, two (and possibly an optional third) experiment would be conducted
- Model run characteristics:
  - Lower resolution AOGCM and/or ESM (roughly 2^{o}) w/pre-industrial spinup including 20th century experiments with natural and anthropogenic forcings (at least 10 ensemble members)
  - Models will include terrestrial and ocean carbon cycle, dynamic vegetation as available, chemistry and aerosols
  - Concentrations prescribed to 2100, stabilized after 2100 to 2300

Forward approach: Start with socio-economic variables



"Reverse approach": start with stabilization scenario concentrations



Source: Meehl, Hibbard, et al.

Experiments to Explore Climate-Carbon Cycle Interactions

- Experiment 1: Carbon cycle responds to increasing CO_2 concentrations and temperature changes
  - A benchmark scenario of prescribed CO_2 concentrations drives models which produce CO_2 fluxes from land and ocean along with modeled climate change; no feedback from carbon cycle to atmosphere
  - The CO_2 fluxes from this experiment (e.g., land/ocean CO_2) are used to derive emissions that are returned to WG3 to derive mitigation policies to achieve the desired emissions

  (emissions = rate of change of concentrations + CO_2 flux).
- Experiment 2: Carbon cycle responds only to increasing CO_2 concentrations
  - Time-evolving CO_2 concentrations from Experiment 1 are input to the carbon cycle, and land-ocean CO_2 fluxes are saved
  - Comparing the derived emissions from Experiments 1 and 2 provides an indicator of the magnitude of the carbon cycle/climate feedback in terms of those different emissions

Climate-Carbon Cycle Experiments (continued)

- Experiment 3 (optional): Carbon cycle responds to both atmospheric carbon feedback and temperature
  - Simulation driven by emissions rather than concentrations—each ESM calculates concentrations from standard idealized emissions scenarios (e.g., 1% pa)
  - Fully interactive carbon cycle
  - Determine the magnitude of the carbon cycle AND climate feedback in terms of temperature change
  - In this experiment, CO_2 will evolve distinctly from the original prescribed CO_2 scenario (of Experiment 1)
  - The temperature difference between experiments 1 and 3 defines the magnitude of the carbon cycle feedback on temperature

Assessing Additional Levels

- This approach assumes that the pattern of climate change can be scaled for stabilization levels between the three benchmark levels selected for examination
- It is also stated (assumed) that some GCM groups will run additional scenarios in between the three agreed levels

Summary of Proposed Experiments

Short-Term Experimental Design: (2005-2030), single scenario, one experiment

Experiment	Inputs	CO_2 Affects:	Model Features	Output
Short-Term Experiment: ***Air-quality and regional analyses of extremes***	Single GHG scenario, possible variation of pollutants	Climate →	High resolution AOGCM/ESM (0.5 to 1º) no carbon cycle, simple chemistry and aerosols, possibly dynamic vegetation Coupled initialization ~1950-2005 →	Regional projections: extreme climate events, air quality

Long-Term Experimental Design: (1870-2100 and beyond), two stabilization scenarios (low and high), three experiments

Experiment	Inputs	CO_2 Affects:	Model Features	Output
Long-Term Experiment 1: ***Quasi-inverse estimates of emissions***	Prescribed Atmospheric CO_2 Concentrations	Climate, Land/Ocean Carbon Fluxes →	Medium resolution AOGCM or ESM (~2º) w/carbon cycle, dynamic veg; Prescribed aerosols; Pre-industrial spinup →	Climate changes; Deduced land/ocean C fluxes
Long-Term Experiment 2: ***Carbon cycle feedbacks***	CO_2 concentrations: (a) Fixed at pre-industrial for climate system (b) From experiment 1 for carbon cycle	(a) Climate system (b) Carbon cycle →	Medium resolution AOGCM or ESM w/carbon cycle, dynamic veg; Prescribed aerosols; Pre-industrial spinup →	No climate change; land/ocean CO_2 fluxes are saved
Long-Term Experiment 3 (optional): ***Fully coupled models***	Derived CO_2 emissions from Experiment 2 w/fully coupled carbon cycle	Climate, Land/Ocean Carbon Fluxes →	Medium resolution ESM w/carbon cycle, dynamic veg; Prescribed aerosols; Pre-industrial spinup →	Climate & Biogeochemical Feedbacks to Climate and Carbon Cycle

Source: Meehl, Hibbard, et al.

AGCI Recommendations:

- An integrated effort is needed to produce past/current/future emissions of aerosols and ozone precursors that would ensure the use of consistent and documented data relevant to climate/carbon cycle/aerosol/chemistry communities. Assessment of regional climate change effects will require gridded emission data for aerosols and short-lived trace gases.
- WG2 and WG3 IPCC reports need to be lagged about 2 years behind a WG1 report to ensure that all 3 Working Groups are using as close to current generation model projections as possible.
- There is a need for a PCMDI-equivalent (data collection, archival, and distribution), for the WG2 and WG3 communities, or an expanded role for the IPCC DDC, and a WGCM-type community organizing mechanism for WG2 and WG3.
- WG2 and WG3 need to have input to selection of archived fields for analysis in the new integrations for AR5, in particular, a list of fields related to the carbon cycle.

Questions/Issues

1. Design: is it workable—in particular can the “reverse” approach work for energy/emissions modeling?
2. Radiative forcing: how should forcing be implemented, and how many stabilization levels are needed? (All WGs need to participate in
3. Atmospheric chemistry: how should short-lived species included in the long-term experiments?
4. Land use: how will scenarios be coordinated across climate, carbon cycle, and IAM communities?
5. Downscaling: how will experiments interact with dynamical downscaling (RCM) experiments?
6. Process: What infrastructure and institutions are needed to make this effort work? How

Next Steps

- A meeting report from AGCI has been submitted to EOS Transactions
- Energy/emissions and impacts/adaptation research communities must examine and shape the strategy, with feedbacks to ESM community
- Additional coordinating and intercomparison infrastructure will be needed
- IPCC will take a decision about the content of the technical paper, about which there is some debate
- IPCC Expert Meeting in September 2007 will examine how efforts are coming together and provide feedback to IPCC and other organizations regarding the feasibility of IPCC's catalytic approach and the emerging community proposal

Relevant Groups

- **ESSP** (Earth System Science Partnership)
- **WCRP** (World Climate Research Programme)
  - WGCM (Working Group on Coupled Models)
  - SPARC (Stratospheric Processes and their Role in Climate)
- **IGBP** (International Geosphere-Biosphere Programme)
  - AIMES (Analysis Integration and Modeling of the Earth System)
  - IGAC (International Global Atmospheric Chemistry program)
- IHDP (International Human Dimensions Research Programme)
- **EMF** (Energy Modeling Forum)/**Consortium**
- **IPCC**
  - TGNES (IPCC Task Group on New Emission Scenarios)
  - TGICA (Task Group on Data and Scenario Support for Impact and Climate Analysis)
  - Expert Meeting Steering Committee
- **Group(s) to coordinate impacts/adaptation research community?**