NEAR-TERM EXPERIMENTAL DESIGN (2005-2030)

A major goal for 25-year model projections is to provide better guidance about the likelihood of changes in climate extremes at regional scales. Meeting this challenge will require understanding the processes that produce extremes related to the hydrological cycle, and on understanding relevant atmospheric and oceanic processes that operate on appropriate timescales. Regional-scale predictions will require finer-resolution spatial models that incorporate simple chemistry, aerosols, and dynamic vegetation. On this short timescale, carbon cycle feedbacks would be small and a carbon cycle component would not be included.

Determining the significance of regional changes, and especially those of climate extremes, will require numerous simulations in an ensemble approach. Given that scenarios of long-lived greenhouse gases do not differ substantially prior to 2030, a single, midrange scenario will be used here for model predictions. On this short timescale, additional experiments are possible with higher resolution models. For example, several scenarios for precipitation extremes and short-lived gases to study their effects on weather could be provided for low, medium, and high emissions projections as perturbations around the standard scenario, and testing hypotheses (e.g., targeted emissions reduction or overshoot strategies, injecting sulfur into either the stratosphere or troposphere) with model experiments to mitigate climate change.

Interactions and feedbacks to the climate system will nevertheless need to be explored with ESMs to try and ascertain unintended consequences on other Earth system model components such as ecosystems and atmospheric chemistry. These near-term simulations could use a coupled initialization: state close to the present day state of the climate system, though the utility of this approach is still being explored by the modeling communities as a research question. This strategy will incorporate past climate forcings to account for (1) radiative imbalances that produce short-term committed climate change, (2) the facilitation of model verification; and (3) the logistics involved with the coupled assimilation/initialization process.

LONG-TERM EXPERIMENTAL DESIGN (2005-2100 AND BEYOND)

Longer-term projections quantify feedbacks in the Earth system related to climate outcomes that could be affected by various socioeconomic and policy considerations. Carbon cycle feedbacks are important on this timescale and would be included for these experiments, though atmospheric chemistry and aerosols would be calculated simply or prescribed. Three experiments are proposed:

1. Long-Term Benchmark Stabilization: in this experiment, both AOGCMs and ESMs are run with a scenario of prescribed CO₂ concentrations leading to stabilization (Figure 4).

2. Carbon Cycle Response to Increasing Emissions: This experiment is similar to Experiment 1, with the exception that the atmospheric CO₂ concentrations are held constant at pre-industrial levels for radiative calculations in the atmosphere, but other ESM components respond to the increasing CO₂ concentrations from Experiment 1 (Figure 5). The derived emissions from Experiment 2 represent the carbon cycle feedback reacting only to the prescribed increasing atmospheric CO₂ concentrations, and do not include the forced emissions from Experiments 1 and 2 provides an indicator of the magnitude of the carbon cycle feedback in terms of those different emissions.

3. Emissions-Driven Carbon Cycle/Climate: This experiment is driven by emissions rather than by concentrations. Each ESM calculates the concentrations resulting from an idealized prescribed standard emissions time series (e.g., 1% per year for CO₂) with a fully interactive carbon cycle.

Previously, scenarios have started with socioeconomic-economic considerations evolving to emission scenarios, then concentrations were derived and the models were run to produce climate changes that were used by IPCC Working Group II (WGI) scientists for climate impact studies (Figure 6). The proposed strategy for climate change stabilization experiments instead begins with concentrations and goes back to socioeconomic

WHAT IS THE CURRENT STATUS OF CLIMATE AND EARTH SYSTEM MODELS?

In 2006, the Analysis Integration and Modelling of the Earth System (AIMES) core project of the International Geosphere-Biosphere Programme (IGBP) and the Working Group on Coupled Models (WGC) of the Working Group of the Intergovernmental Panel on Climate Change (IPCC) led a series of workshops towards the use of Earth System Models (ESMs) including Atmospheric Ocean General Circulation Models (AOGCMs) in climate change assessments (Hill et al. 2007). Today, standard climate models evolved from atmosphere-ocean models, to AOGCMs, including components that simulate the coupled atmosphere, ocean, land, and sea ice (Figure 2). Some modeling centers are now incorporating carbon cycle models into AOGCMs in a move towards an Earth System Model (ESM) capability. Additional candidate components to include in ESMs are aerosols, chemistry, ice sheets, and dynamical vegetation (e.g., Cox et al. 2000; Friedlingstein et al. 2006). The scenario approach used in Intergovernmental Panel on Climate Change (IPCC) Assessment Reports to date developed atmospheric concentrations and their derived emissions based on story lines (IPCC 2001: Inception Report). AOGCMs have been used for an integrated assessment approach. The motivation is to develop a next-generation experimental design that follows on prior strategies, with increased coordination and collaboration between climate, integrated assessment, mitigation and adaptation communities. We present a two-phase strategy for near-term and longer-term climate change simulations for AOGCM and ESMs (Figure 3).

OBSERVATIONAL APPROACH: Uncertainties build up: start with socioeconomic

Forward Approach: Uncertaity grows: start with concentrations leading to climate system response (Figure 3)