

Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009



Carbon, Biogeochemistry and Climate: Overview

Presented by
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GFDL provides critical support for NOAA Goals

NOAA's Climate Goals:

- **Understand climate variability and change** to enhance society's ability to plan and respond
- Protect, restore, and manage the use of coastal and ocean resources through an **ecosystem** approach to management

GFDL has added a focus on Climate-Ecosystems interactions

These interactions can be broken into 3 parts:

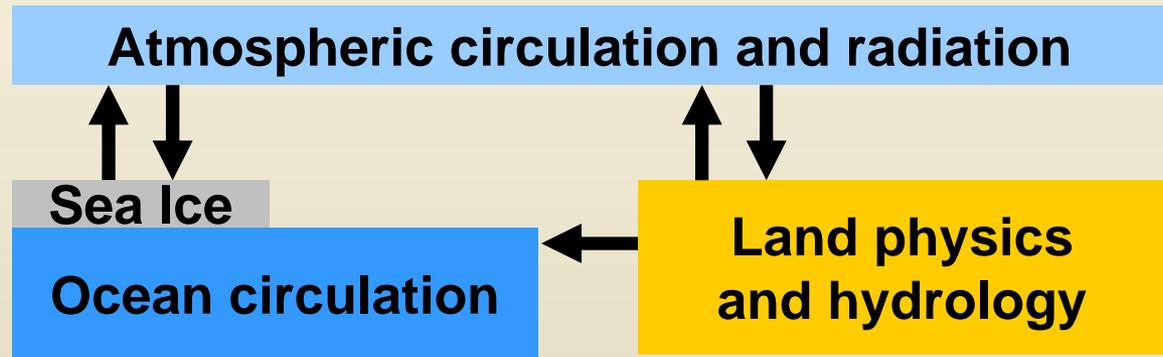
- 1. The impacts of climate changes on ecosystems**
- 2. The influence of ecosystem changes on climate**
- 3. Interactions between human activities, ecosystems, and climate**

Humans are impacting the chemical composition of the atmosphere and ocean

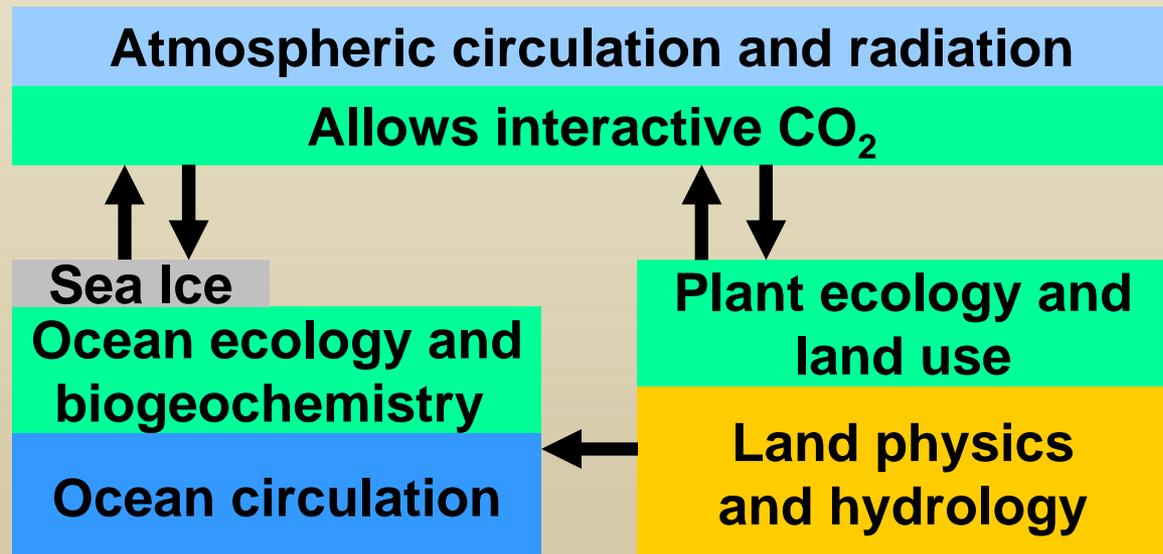
- **What happens to the carbon we emit?**
 - The ocean and land have been taking up about 1/2 of what we emit.
 - Will this ecosystem service continue?
- **What is the magnitude of the impacts and feedbacks?**
- **How large are the uncertainties?**
 - Land plant CO₂ fertilization
 - Southern Ocean uptake

An Earth System Model (ESM) closes the carbon cycle

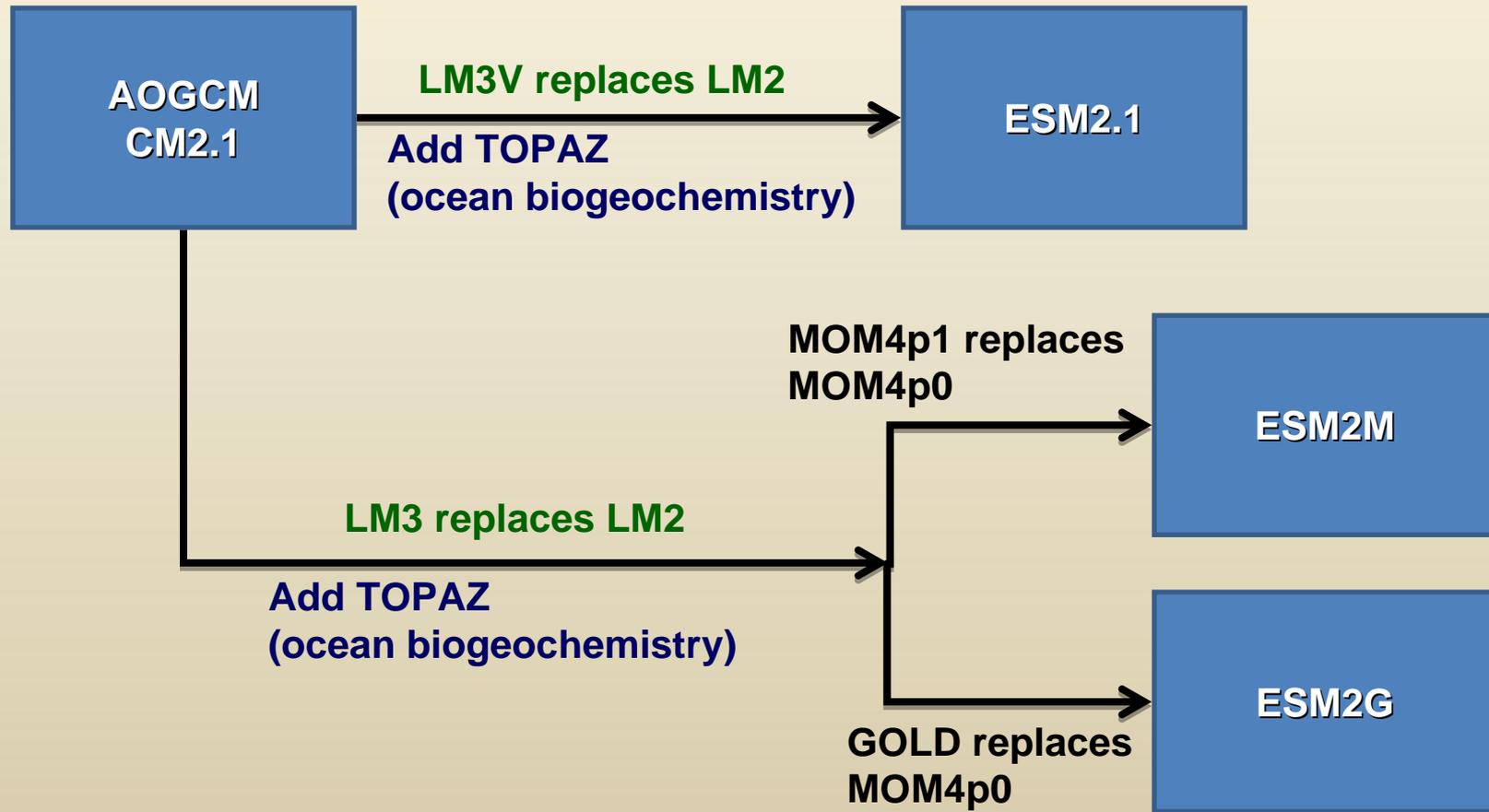
Climate Model



Earth System Model



We have developed three new ESMs



All models use a 2° atmosphere and 1° ocean

- **ESM2.1 - running**
 - Backup for ESM2M and ESM2G
 - Useful for science projects
 - Historical + Future projection
 - Last Glacial Maximum (LGM)
- **ESM2M and ESM2G very nearly complete**
 - Starting spin-ups for IPCC runs
 - Land use changes will also be included
 - Use of 2 different ocean components allows investigation of heat and carbon uptake uncertainties

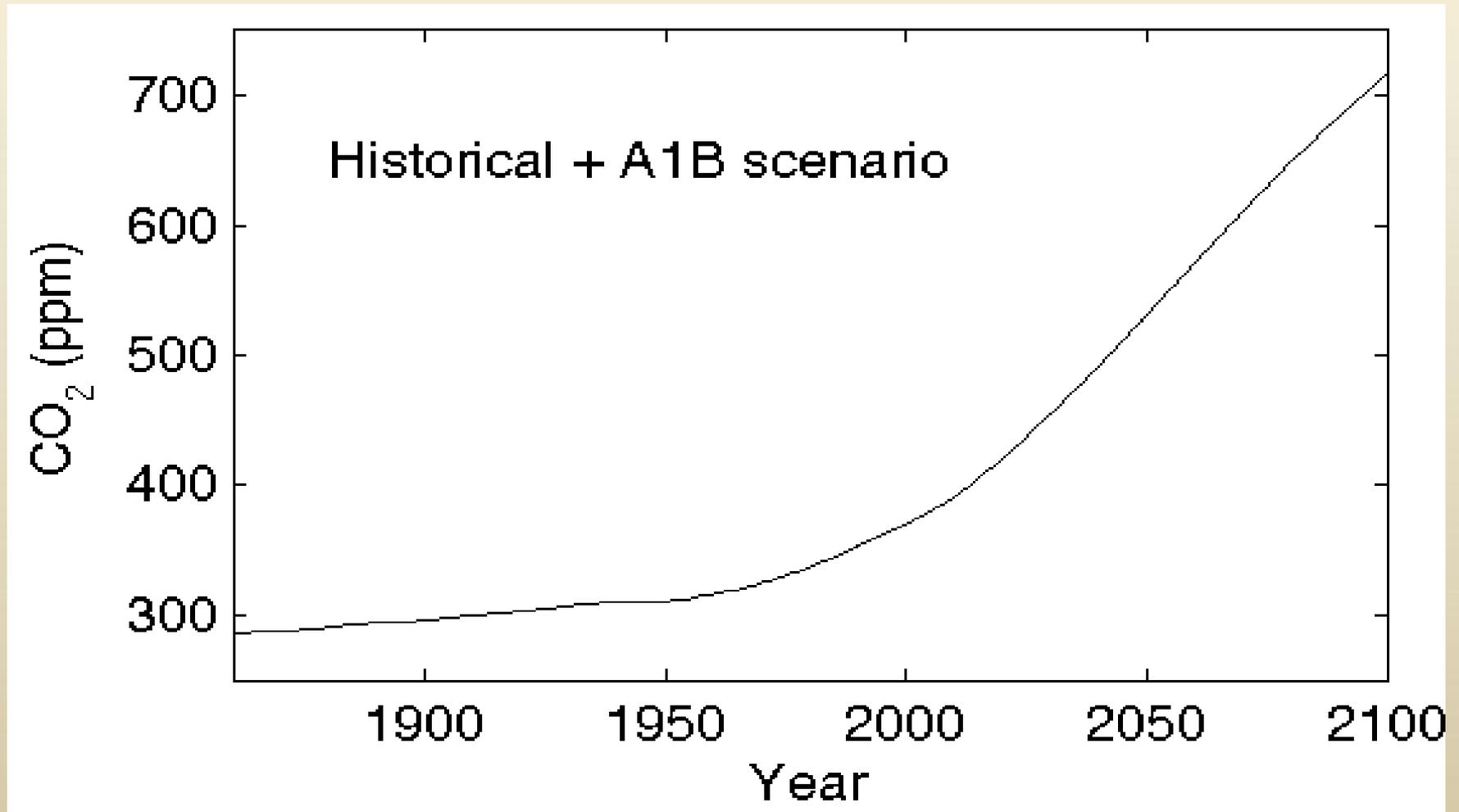
ESM2.1 has produced a successful simulation of climate change

- Long 1860 control
 - Atm pCO₂ drift less than 10ppm per 100 yrs
 - Climate similar to CM2.1
- Historical + Future (A1B & A2) runs

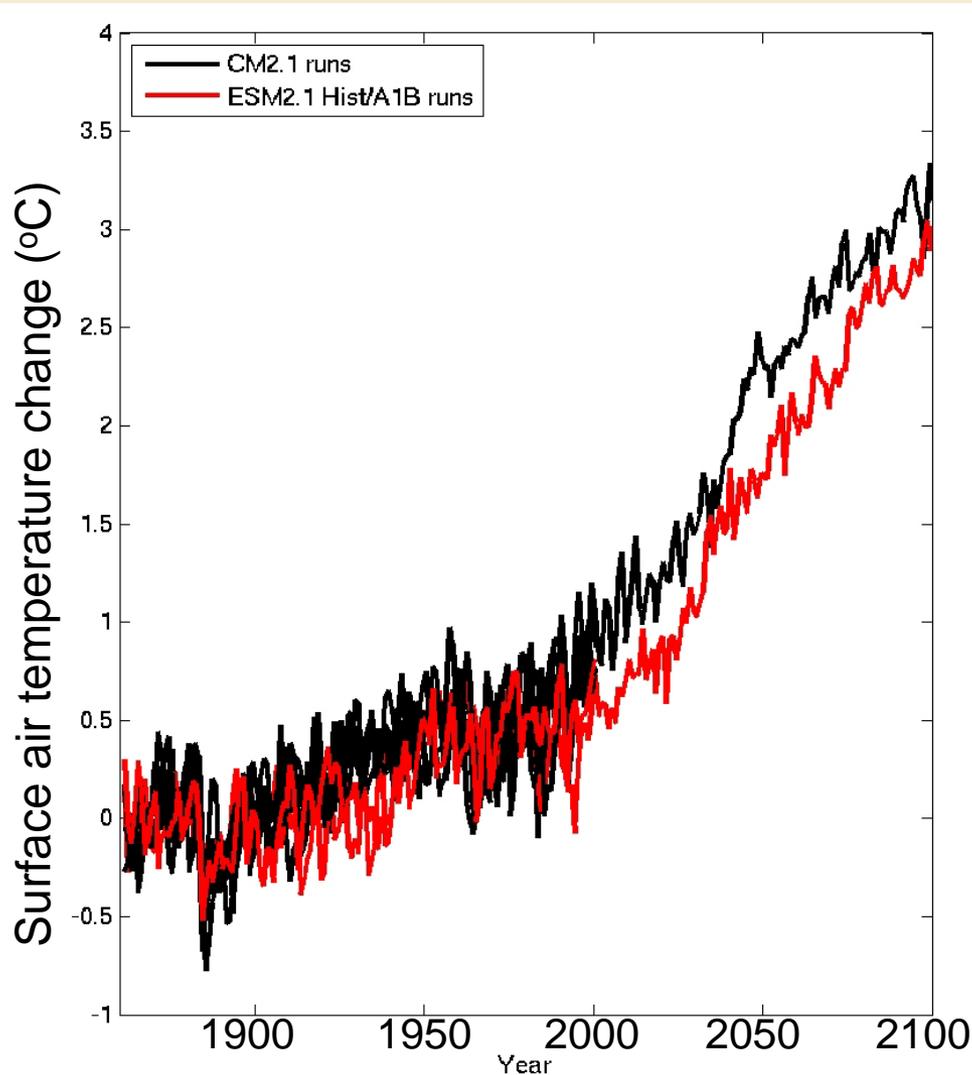
Purpose: document model, evaluate model performance, investigate impacts, feedbacks and uncertainties

Note: No land use included – potential vegetation only

ESM2.1 forced with CO₂ concentration scenarios



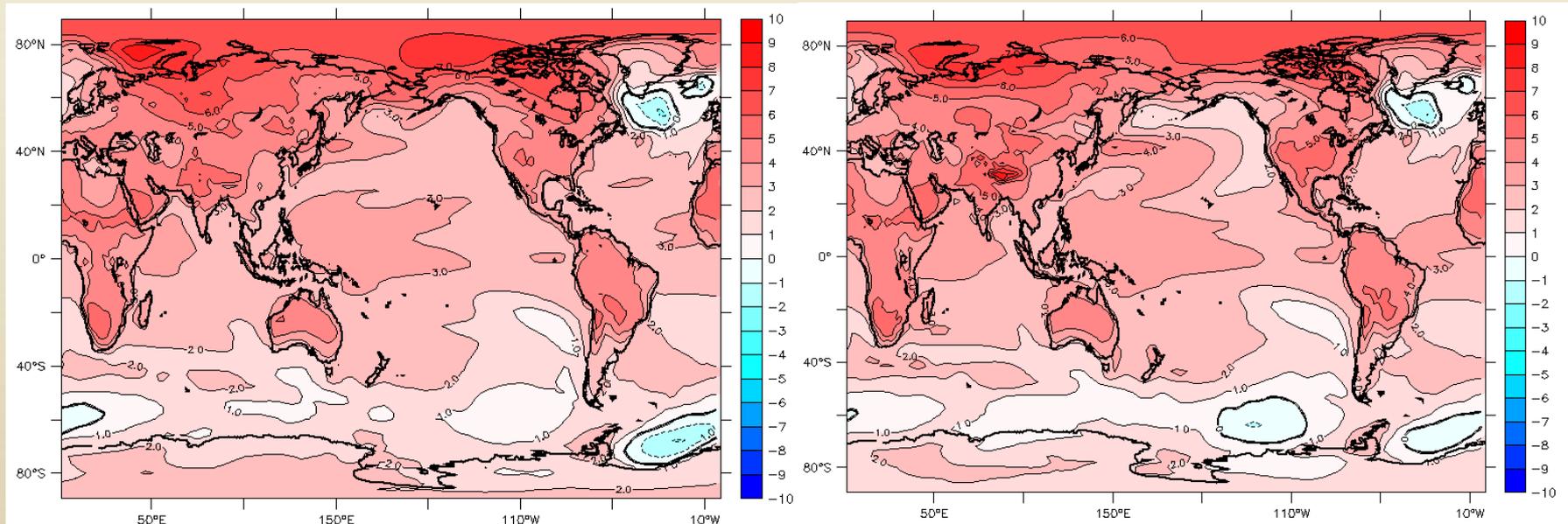
ESM2.1 Shows Similar Global Surface Air Temperature Response to CM2.1



- Response slightly smaller than CM2.1 in historical period
- Temperature increase similar magnitude in future

ESM2.1 warming pattern and magnitude very similar to CM2.1

Surface air temperature change (K)



CM2.1

ESM2.1

2081-2100 minus 100 yr average in control

Our effort requires a broad scope of collaboration

Major collaborators include:

- USGS – Milly group
- Princeton U – Pacala group
Sarmiento group
Hedin group
- U of New Hampshire – Hurtt group

Outline of Talks

- **Lori Sentman/Elena Shevliakova**
 - Land ecosystems and biogeochemical cycling
- **Chris Milly**
 - Hydrology, water resources and climate
- **Kirsten Findell**
 - Climate impacts of land cover change
- **John Dunne**
 - Ocean biogeochemistry
- **Charles Stock**
 - Ocean ecosystems and climate change

Other contributors include:

Krista Dunne, Stefan Gerber, Jasmin John, John Krasting,
Sergey Malyshev, Mike Spelman, Marian Westley + students + post-docs



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