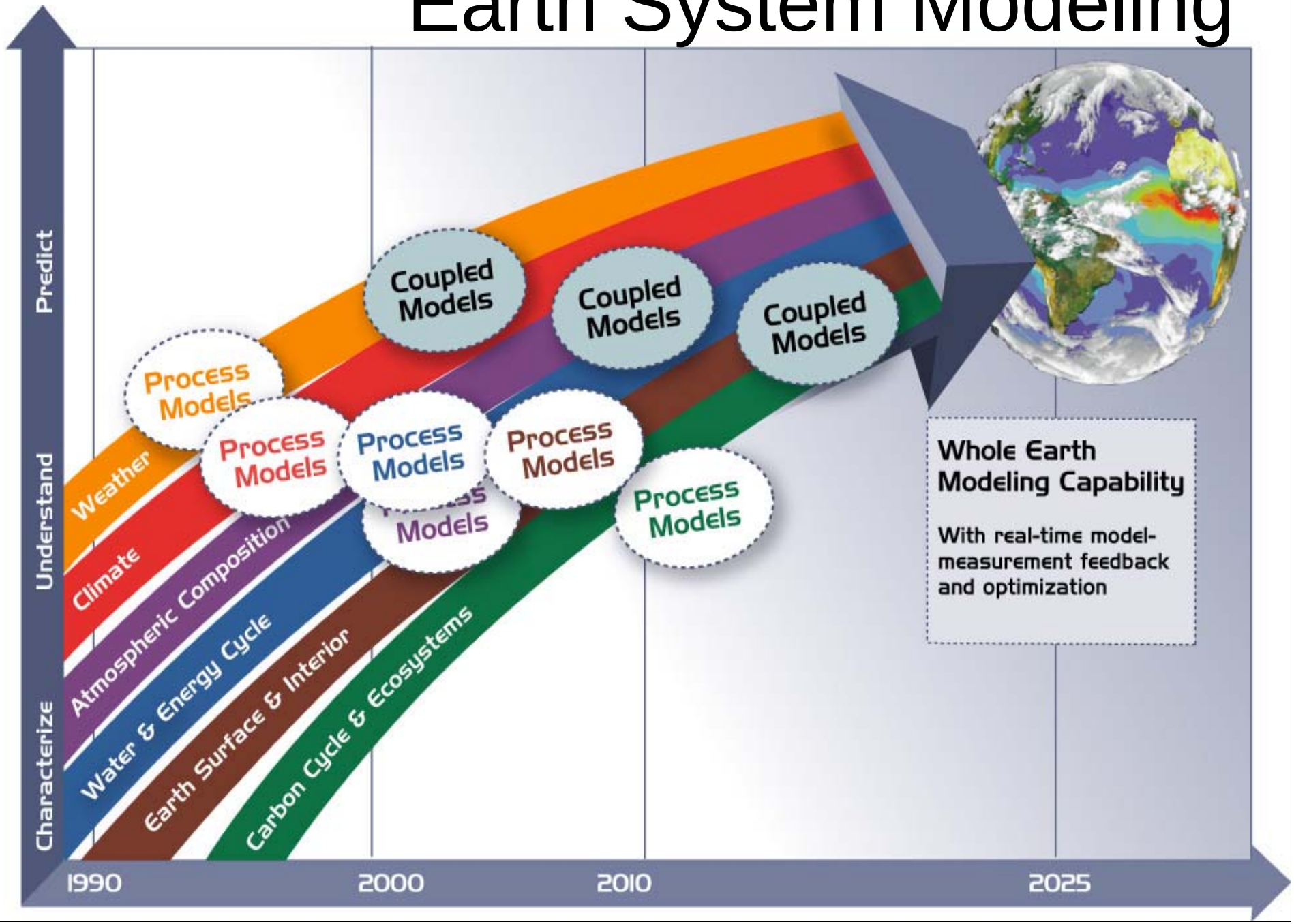
Earth System Modeling



MAP Modeling Environment Development Path

"The Holy Grail"

Fully Interactive
Earth System Model

Multi-component Models

Component Models

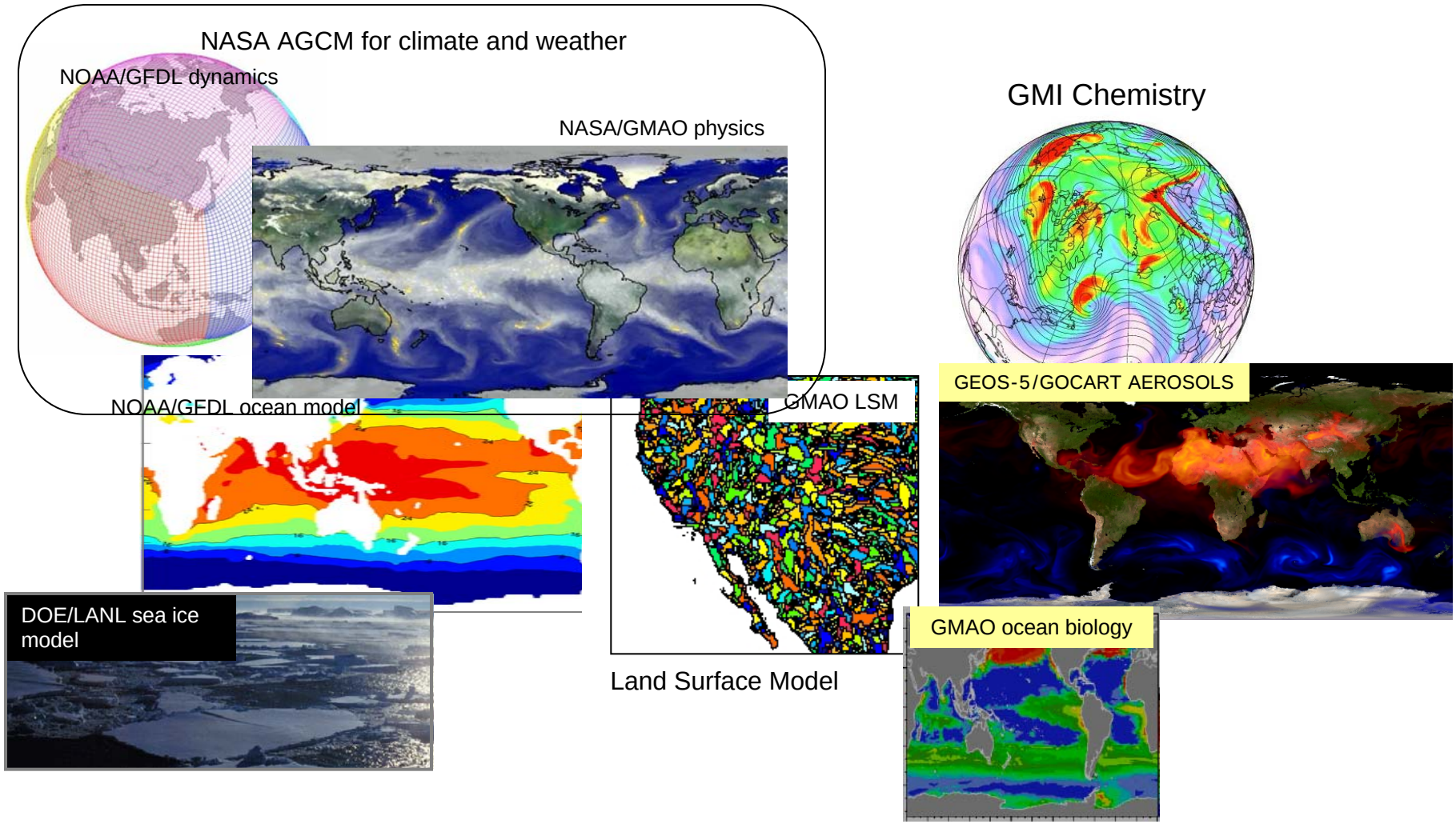
Process Models

MAP – Modeling, Analysis and Prediction program

- Seeks an understanding of the Earth as a complete, dynamic system
- Emphasis on climate and weather
- Key questions include:
  - How is the Earth system changing?
  - What are the forcing mechanisms driving observed changes?
  - How does the Earth system respond to natural and human-induced changes?
  - What are the consequences of Earth system change to society?
  - What further changes can be anticipated, and what can be done to improve our ability to predict such changes through improved remote sensing, data assimilation, and modeling?

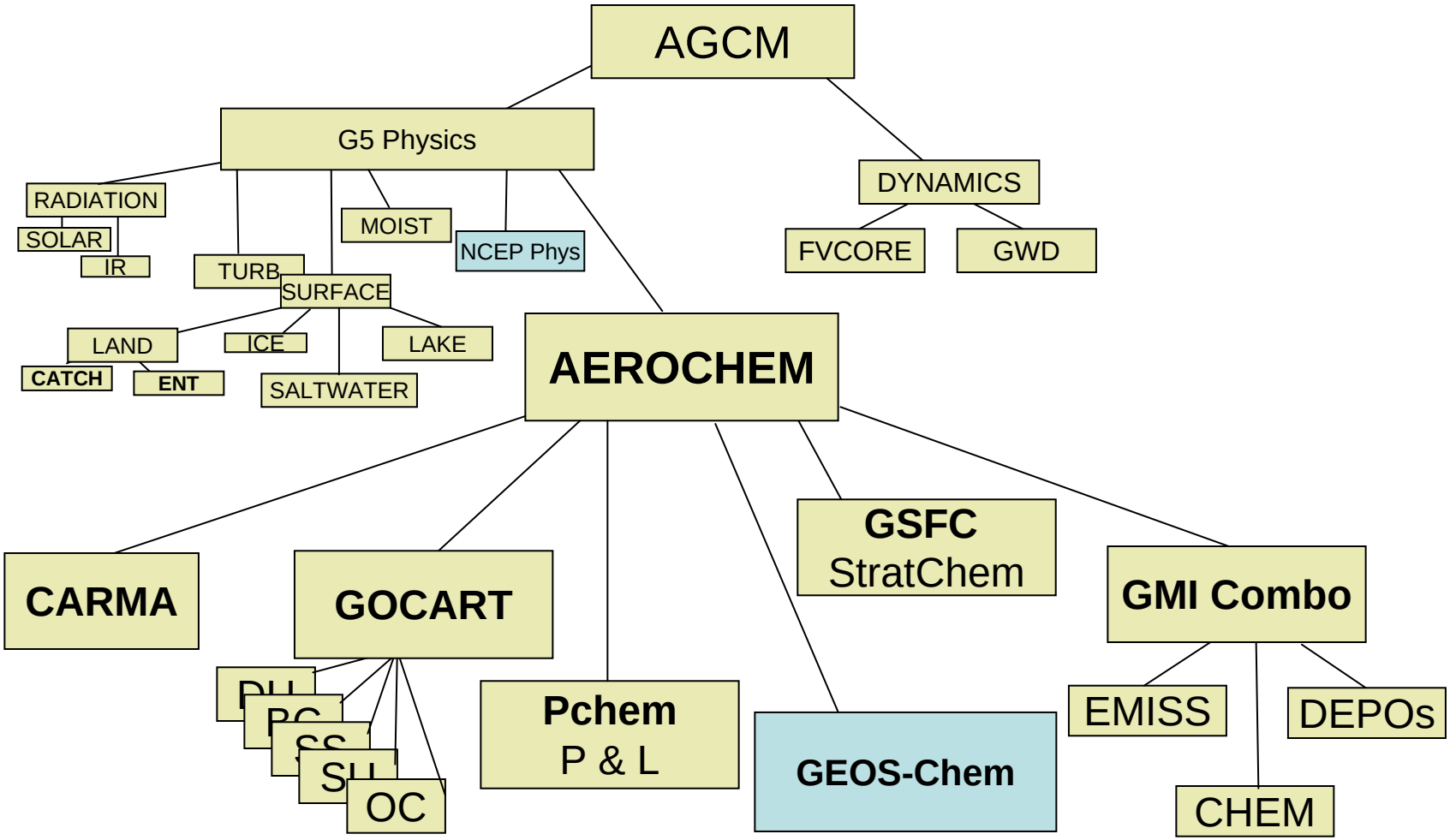
The MAP program supports *observation-driven modeling* that integrates the research activities in NASA's Earth Science Program

NASA ESM Example: GEOS-5 AOGCM integrates components from different sources using ESMF - a systems engineered structure, allowing collaborative exchange of model elements



With assimilation components and satellite data
$\Rightarrow$ science + future mission design

GEOS-5 On-Line Atmospheric Chemistry



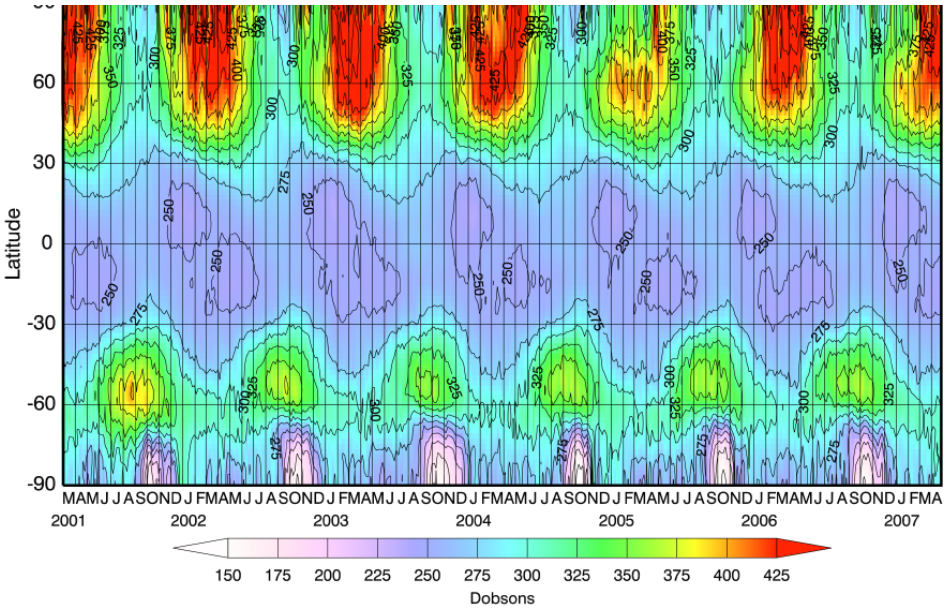
Components integrated through **MAPL** toolkit for **Earth System Modeling Framework**

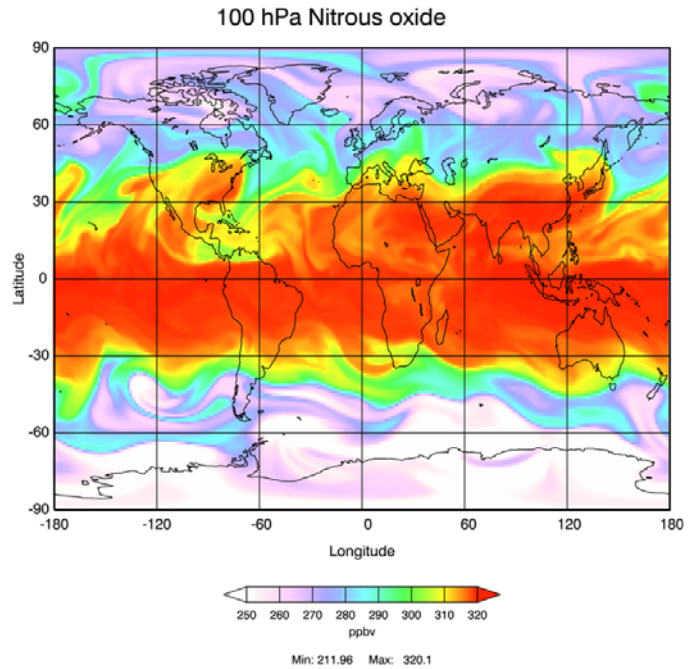
GEOS-CCM V3 (GEOS-5 + Combo chem) is being tested for simulations of the combined troposphere and stratospheric chemistry

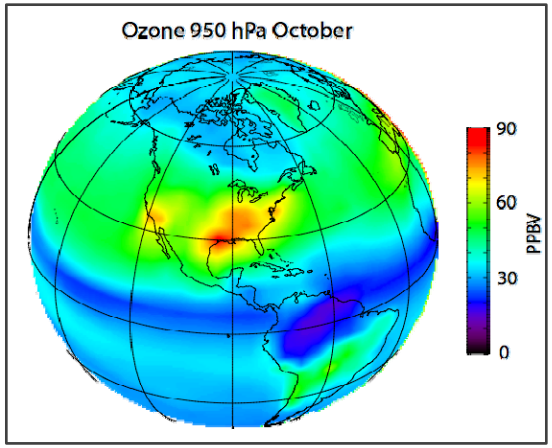
Zonally averaged Total Ozone

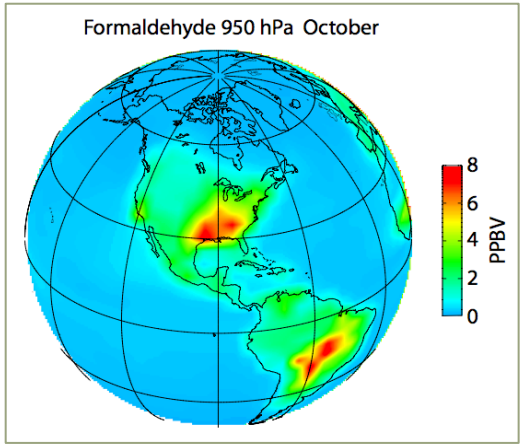
A coupled chemistry-climate simulation

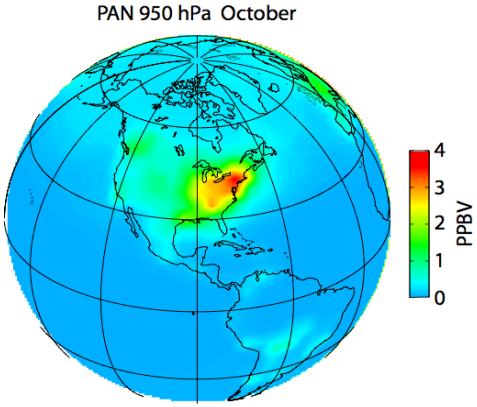
GEOS-5 with GMI troposphere-stratosphere chemistry





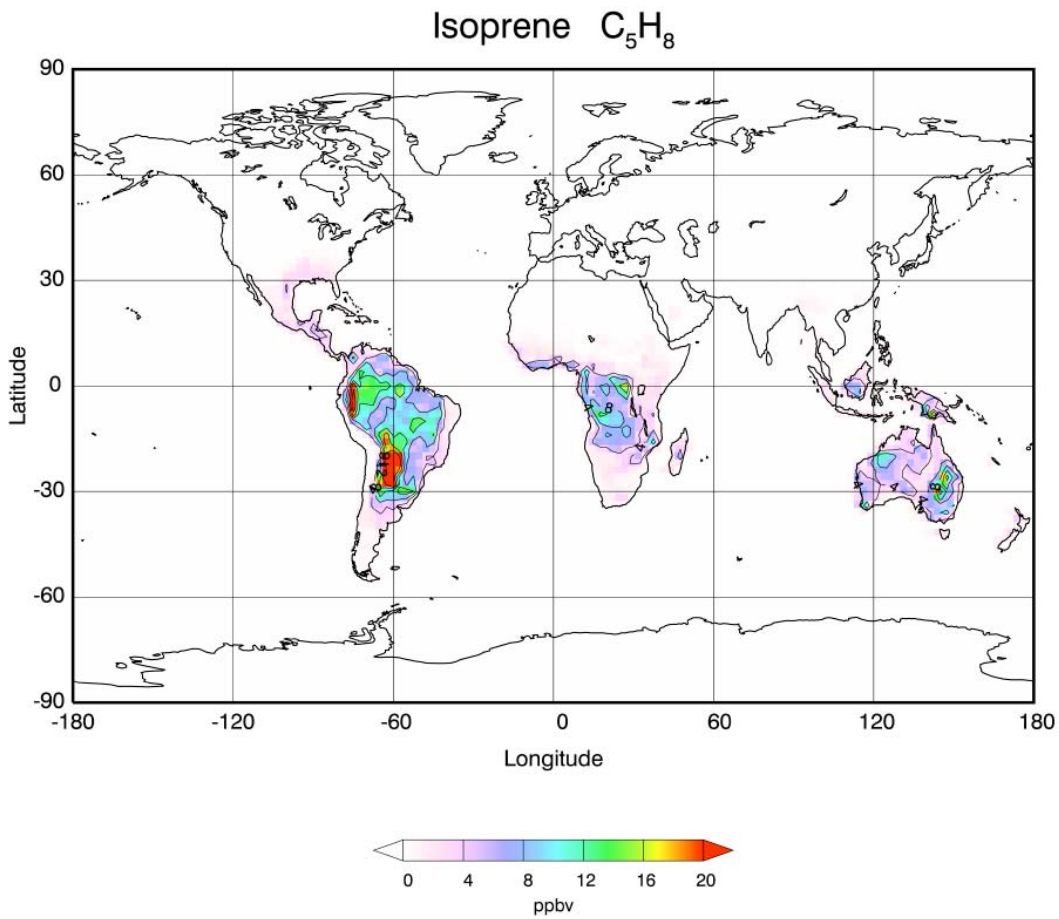






Pawson, Nielsen, Duncan, Stolarski, GSFC

GMI-COMBO Implemented in GEOS-5



Emissions of biogenic species such as isoprene are specified in our simulations.

An important challenge for our ESM activities is to develop representations of these emissions that respond to changes in vegetation and local climate.

Pawson, Nielsen, Duncan, Stolarski, GSFC

- Total GMI funding: ~2.25 - 2.5M/yr or so, depending.
  ACMAP contribution: ~400k/yr.
    - MAP interests in model development influence GMI activities.

- Standalone CTM:
    - Inconsistent with MAP goal of coupled ESM.
    - Phase out?
        - Depends on development of CTM capability in GEOS5.
            - Is replay mode only option?
        - Depends on need to address high-priority modeling goals (e.g., aircraft emissions climate effects.)

- Productivity:
    - 28 papers currently listed on GMI website, for 13 years of work.
    - Is this because GMI has always been everyone's second priority?
    - Focus on providing modeling services to instrument teams and model utilization for observational data analysis balance against continued model development.