New capabilities of GEOS-Chem for the study of chemistry-climate interactions

Loretta J. Mickley, Harvard

1. Application of meteorological fields from past and future climates

INPUT
- GHG and aerosol content
- Sea level, topography

GISS GCM
- Physics of the atmosphere
- Qflux ocean or specified SSTs

GEOS-Chem
- Emissions
- Chemical scheme
- Deposition

We have the ability to apply both future IPCC scenarios + paleo greenhouse gas levels to the GISS GCM (and CCSM3).

Alexander, Sofen, Murray, Kaplan, Mickley, Wu, Jacob, Pye, Seinfeld, Liao, Streets, Fu, Byun, Rind, Yoshitomi, Schmidt, Youn
2. Application of changing land cover to GEOS-Chem

We can apply land cover from future or past (ice age) climates. Wu et al., 2009.

Wu, Kaplan, Tai, Mickley, Murray, Alexander, Sofen
3. Application of changing area burned to GEOS-Chem

**INPUT**
- GHG and aerosol content
- Sea level, topography

**GISS GCM**
- Physics of the atmosphere
- Qflux ocean or specified SSTs

**GEOS-Chem**
- Emissions
- Chemical scheme
- Deposition

**Area burned prediction scheme**
- Uses observed relationships between meteorology and area burned

2000-2050 change in surface OC concentrations

We can simulate the effect of changing climate on wildfire emissions. Spracken et al. 2009

Logan, Spracklen, Hudman, Mickley
4. Archival of finely time-resolved meteorological and chemical fields for use in regional models

This is the basic GCAP (Global Change and Air Pollution) setup.

One issue in downscaling global meteorology is how much to nudge regional model within the domain.

Jacob, Wu, Pye, Seinfeld, Streets, Rind, Byun, Fu, Kim, Lam, Varotsos, Giannopolous, Nolte, Gilliland, Leung, Gustafson, Mickley

- 2000-2050 IPCC scenarios for ozone precursors, BC, OC, SO$_2$ (Streets)
- 2000-2050 mercury emissions, based on IPCC storylines (Streets)
- 1950-2000 BC + OC emissions (Bond)
- 1950-2000 EDGAR emissions of NOx and SO$_2$.


Circles show observations from IMPROVE + CASTNET.

Streets, Leibensperger, Sturges
6. Calculation of the aerosol indirect effect using GEOS-Chem aerosol output.

We use a parameterization based on the GISS-TOMAS aerosol model to calculate the indirect effect.

Parameterization:

\[ N_c = A m_i^B \]

GISS-TOMAS

GEOS-Chem

- Emissions
- Chemical scheme
- Deposition

\[ m_i = [\text{SO}_4^{2-}] + [\text{NO}_3^-] + [\text{SeaSalt}] + [\text{OC}] \]
Technical issues for the Chem-Climate Working Group.
Becky Alexander and Loretta Mickley, co-leaders.

• GCAP model resolution: when is finer better?
• Interannual variability + ensembles: how can you tell when you have a signal?
• Need for GCAP wiki.
• Downscaling to regional climate models: how much nudging is optimal within the regional model domain?
• Cyclone tracking: how best to show changes in cyclone frequency.
• Beyond GISS: met fields from other climate models.
• GCAP model weaknesses: e.g., overestimate of surface ozone, underestimate of nitrate over the US., misplacement of Bermuda High, more . . .