Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009

Atmospheric Chemistry and Physics Synthesis and Future Directions

Presented by

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Atmospheric Physics and Chemistry - Synthesis

Recent Accomplishments:

- Antarctic ozone hole recovery predicted for ~2070
- Modeled "significant" stratospheric cooling appears by early 20th century
- Methane reduction is a win-win for climate and air quality
- 2-step dissolution mechanism explains a wide range of iron solubility in dust
- Controls on Asian emissions may significantly impact future US summertime warming
- On-line interactive aerosols in AM3/CM3 in good agreement with observations
- Aerosol-cloud interactions produce realistic cloud drop concentrations in AM3/CM3 and dominate aerosol cooling (indirect effects)
- CM3 is driven by emissions of short-lived species, has interactive aerosols with explicit cloud droplet activation, coupled stratospheric-tropospheric chemistry, dynamic vegetation and comprehensive hydrology
- Satellite spectral radiance enables a new metric for verifying climate models

Future Research Directions

- In the next 18 months CM3 will be integrated for at least 3000 model years to generate a base-state climate and produce multiple simulations of historical climate and multiple projections of future climate

The Next 5 Years Will Also Focus On:

- Improving existing and incorporating missing individual components of the atmospheric model to clarify their role in and contribution to the earth’s climate and air quality
- Completing the atmospheric chemistry-climate loop to evaluate the nature, size and sensitivity of air quality–climate interactions and feedbacks
- Increasing horizontal and vertical resolution to improve physical and chemical realism and enhance our understanding of regional climate forcing, change and air quality

Improving Atmospheric Physics and Chemistry Components

- Use high-spectral-resolution in the radiation code to evaluate the climate model's radiation budget and investigate the accuracy of feedbacks
- Develop self-consistent radiation codes for heating-cooling (climate) and photodissociation (chemistry)
- Address cloud feedbacks, improve cloud radiative properties and include the indirect effect in deep convection, by incorporating multi-moment microphysics (including ice) in all cloud schemes
- Implement a new parameterization of both boundary layer mixing and cloud macrophysics to reduce cloud-related deficiencies in surface energy balance
- Increased realism of global aerosols distributions and properties:
  - More accurate physical representation of the formation of nucleation mode particles, of aerosol activation and of wet removal
  - Microphysical and optical accounting of internal mixing of multiple species
- Use satellite data (e.g., CO, aerosols,…) to evaluate large-scale tracer transport and distributions (already changed)

Completing the Atmospheric Chemistry – Climate Cycle

- **Complete the coupling of vegetation, physical climate and atmospheric chemistry models to address:**
  - vegetation emissions of reactive compounds
  - soil biogenic emissions of NOx
  - biomass burning emissions of gases and particles
  - formation of secondary organic aerosols

- **Include aerosol surface emission and deposition in the dynamic vegetation module of AM3/CM3 and account for aerosols on snow**

- **Couple the oceanic sources of sulfur directly to ocean biogeochemistry**

HIGHER RESOLUTION

- Higher resolution (1.0 and 0.5 degree) versions of CM3 will be developed to realistically simulate key physical processes and to predict and assess regional climate at spatial scales approaching those of interest to policymakers

- Higher resolution is also required to capture non-linearities in emissions and chemistry that will improve air quality simulations and predictions

- In the next session, Isaac Held will discuss GFDL’s current efforts and future plans for higher resolution model development

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