GMI and CCM Convective Transport Evaluation

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Objectives

• 1) Evaluate the convective transport of tracers and wet scavenging of soluble species in the GEOS-5 CCM using comparisons between a series of cloud-resolving model simulations for particular observed convective events and simulations conducted with a Single-Column Model version of GEOS-5.

• 2) Perform sensitivity studies in the Single-Column Model to determine optimal improvements in the representation of the convective transport and wet scavenging processes.

• 3) Evaluate convective transport in existing GMI CTM simulations using data from convective field experiments.

• 4) Implement the suggested improved convection and scavenging algorithms in the full GEOS-5 model and run multiple-year simulations with the CCM and off-line GMI CTM.

• 5) Use NASA satellite data to evaluate the global simulations with the improved model.

• 6) Analyze global simulations to determine the net effect of convection on tropospheric ozone under present day conditions and in future climates.
GEOS Parameterized Convection

- **GEOS-4:** Hack shallow convection
  Zhang and McFarlane deep convection
  used for initial “Aura” GMI simulations

- **GEOS-5:** Relaxed Arakawa Schubert (RAS) convection
  GEOS-5.1 – used for GMI offline simulations
  GEOS-5.2 (MERRA) – being used for new GMI runs
  some tuning of RAS done for 5.2
  GEOS-5 (Fortuna) – being used in GEOS-5 CCM
  only significant changes affecting convection were in
  prognostic cloud scheme: increased re-evaporation of grid-scale
  and convective precipitation; reformulation of critical relative
  humidity used to calculate grid-scale condensation/sublimation.
Evaluation Procedures

- **GMI CTM**
  Has been driven by GEOS-5.1 DAS data
  Compare tracer profiles from GMI directly with aircraft data from convective field missions (e.g., TC4, AMMA)
  Perform similar comparison for GMI driven by GEOS-4 DAS
  Compare GEOS-4 and GEOS-5.1 cloud tops, cloud mass fluxes

- **GEOS-5 CCM**
  Select specific events from convective field experiments to simulate tracer transport in detail using a cloud-resolved model (Weather Research and Forecast (WRF) model)
  Simulate tracer transport in same events using Single Column Model (SCM) option of GEOS-5 Fortuna 2.1 (forced by MERRA)
  Evaluate SCM tracer using WRF results
  Adjust RAS parameters to improve agreement
GEOS-4 vs. GEOS-5.1 Upward Cloud Mass Flux Profiles

July 31
Detrainment

July 29

Aug 5
Detrainment

July 24
August 8 PM
GEOS-5.1
WB-57
Cloud Mass Flux at 200 hPa

GEOS-5.1

MERRA

Fortuna 2.2
Cloud Mass Flux at 300 hPa

GEOS-5.1

MERRA

Fortuna 2.1
Cloud Mass Flux at 400 hPa

GEOS-5.1

MERRA

Fortuna 2.1
Physics:
- Cu parameterization:
  Kain-Fritsch scheme (for the outer grid only)
- Cloud microphysics:
  Goddard microphysics 3ice-Graupel
- Radiation:
  New Goddard radiation scheme for both longwave and shortwave
- PBL parameterization:
  Mellor-Yamada-Janjic TKE scheme
- Surface Layer:
  Monin-Obukhov (Janjic)
- Land Surface Model:
  Noah land-surface

Resolutions: 18, 6 and 2 km
Grid size: 391x271, 424x412, 466x466, and 61 vertical layers
\( \Delta t = 18 \) seconds
Starting time: 00Z 08/06/2006
Initial and Boundary Conditions:
NCEP/GFS, no data assimilation
WRF-Calculated Radar Reflectivity

COMDBZ (dBz) and 900mb Wind (m/s) at 9h
G9Z06AUG2006

COMDBZ (dBz) and 900mb Wind (m/s) at 20h
20Z06AUG2006
Summary

• Convection in GEOS-5.1 DAS detrained at lower altitudes than in GEOS-4

• Insufficient detrainment of boundary layer tracer in upper troposphere in GMI CTM driven by GEOS-5.1 DAS fields, as demonstrated by comparisons with TC4 $O_3$ aircraft observations

• GEOS-5.1 convection location better than in GEOS-4 in TC4 region; GEOS-5.1 cloud tops lower than in GEOS-4

• MERRA convective mass fluxes weaker than GEOS-5.1 in upper troposphere. Fortuna 2.2 convective mass fluxes much stronger than MERRA.

• Fortuna 2.1 SCM tracer simulation shows too much detrainment in middle troposphere and insufficient in upper troposphere in comparison with WRF cloud-resolved simulation

• Next step – adjust RAS parameters in SCM to achieve better tracer profile simulation