Evaluation of the WRF-Chem Simulations for South American Biomass Burning Using Multi-satellite Observations

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Introduction

• Jiang et al. (2008) showed observational evidence of aerosol effects on clouds and precipitation in the dry season of South America, but the physical mechanisms were unclear.

• Only a few recent studies are conducted with thermodynamic conditions and aerosol concentrations varied simultaneously.

• A fully coupled meteorology-chemistry-aerosol mesoscale model (e.g.: WRF-Chem) has been shown to capture regional cloud variations better than uncoupled models.

• Multi-satellite observations (MLS, TES, MODIS, TRMM, AIRS, CloudSat, CALIPSO, etc.) provide valuable sources to evaluate the aerosol, chemistry, clouds and precipitation simulations in the WRF-Chem.
WRF-Chem setup

- **Horizontal resolution**: 36 km (4 km)
- **Initial time**: Sep. 15, 2006
- **Simulation period**: 9 days (3 days)
- **Vertical levels**: 28
- **Top of atmosphere**: 50 hPa
- **Initial and boundary conditions**: FNL (meteorology) and MOZART (chemistry)
WRF-Chem setup: physics

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<th>Physics scheme</th>
<th>Description</th>
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<td>Microphysics</td>
<td>Lin et al. with prognostic cloud droplet number included</td>
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<td>Cumulus</td>
<td>Grell-Devenyi ensemble</td>
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WRF-Chem setup: aerosol and chemistry

- **Chemical driver**: RADM2 (Regional Acid Deposition Model, Version 2)
- **Aerosol driver**: MADE/SORGAM (Modal Aerosol Dynamics Model for Europe)
- **Global anthropogenic emissions**: RETRO (.5x.5 degree) chemical composition over the past 40 years and EDGAR (1x1 degree)
- **Wildfire emissions**: WF_ABBA locations and plume rise model with modification
- Gas phase, aerosol, wet scavenging, vertical turbulent mixing and cloud chemistry
- **Feedback from aerosols to radiation**
Aerosol:

- 8-day averaged AOT

- MODIS WRF-Chem

- GOES fire count (WF_ABBA)

- AOT profile comparison:
  - WRF-Chem
  - Calipso

Graphs and maps showing aerosol distribution and comparison between different datasets.
Chemistry:

8-day averaged CO at 215 hPa

8-day averaged O3 at 215 hPa
Precipitation:

8-day precipitation total

TRMM

WRF-Chem

Domain-averaged 3-hr precipitation

Mean: 0.46 mm
0.42 mm
Clouds:

8-day averaged IWC at 215 hPa (~11 km)

8-day averaged H2O at 215 hPa
Sensitivity to Model Resolution

Domain-averaged 3-hr precipitation

Cloud water content
Summary

• The model simulations approximately reproduce the distributions of aerosols and chemical tracers in response to convection.

• The modeled precipitation agrees with satellite measurement, in both magnitude and distribution.

• The patterns of upper tropospheric water vapor and ice clouds are approximately reproduced. But the magnitude are not well represented. The modeled CWC is comparable to CALIPSO, but weaker than CloudSat.

• In 4 km simulation, the Lin et al. microphysics scheme overestimates precipitation, especially the amounts of graupel and rain water (consistent with Wu and Petty, 2010).

• Given the reasonable performance in the WRF-Chem, we can use the model to examine the aerosol effects on clouds and precipitation by varying the emission amount.