

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

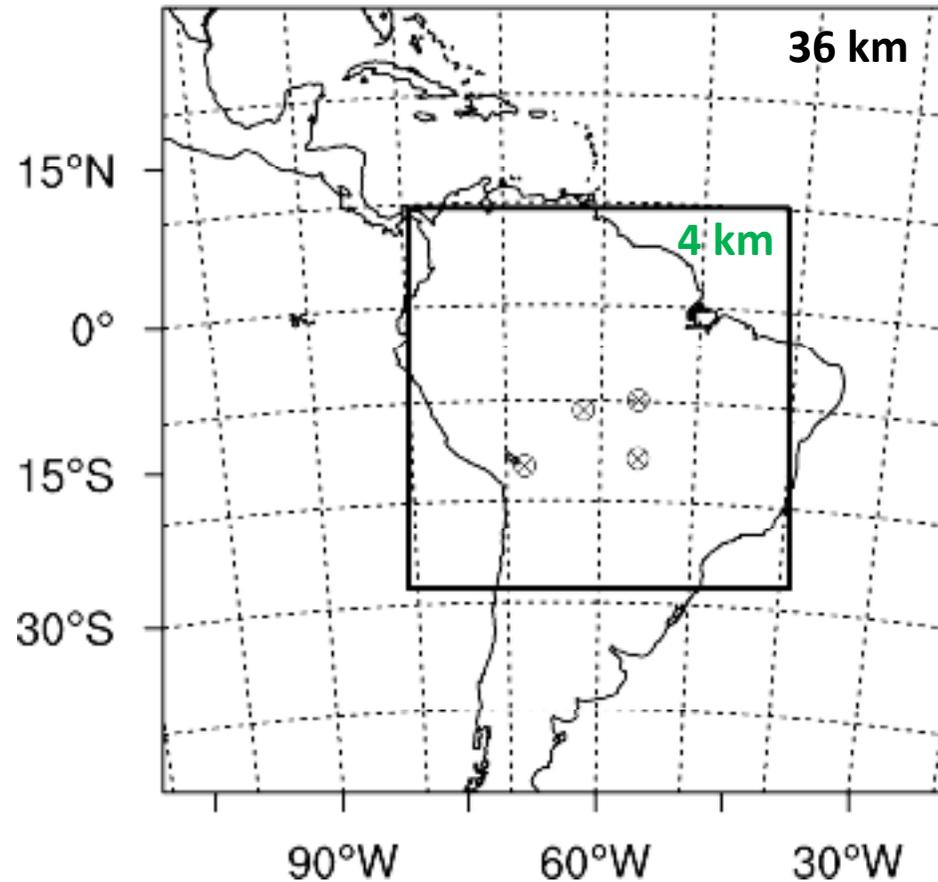
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Introduction

- 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

Physics scheme	Description
Microphysics	Lin et al. with prognostic cloud droplet number included
Cumulus	Grell-Devenyi ensemble
Longwave radiation	RRTM (Rapid Radiative Transfer Model)
Shortwave radiation	Goddard shortwave
Surface-layer	Monin-obukhov (Janjic Eta)
Land surface	Unified Noah land-surface
Boundary layer	Mellor-Yamada-Janjic (Eta) TKE

WRF-Chem setup: aerosol and chemistry

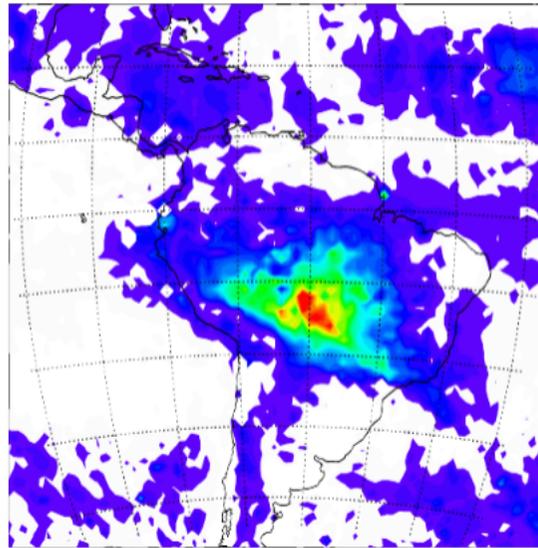
- **Chemical driver:** RADM2 (Regional Acid Deposition Model, Version 2)
- **Aerosol driver:** MADE/SORGAM (Modal Aerosol Dynamics Model for Europe)
- **Global anthropogenic emissions:** RETRO (.5x.5 degree) chemical composition over the past 40 years and EDGAR (1x1 degree)
- **Wildfire emissions:** 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:

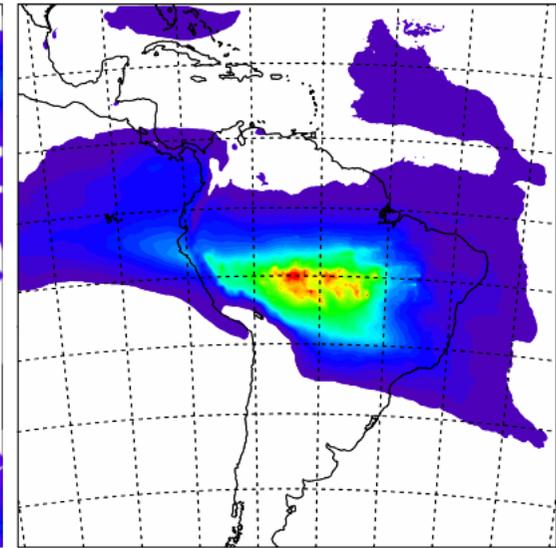
8-day averaged AOT



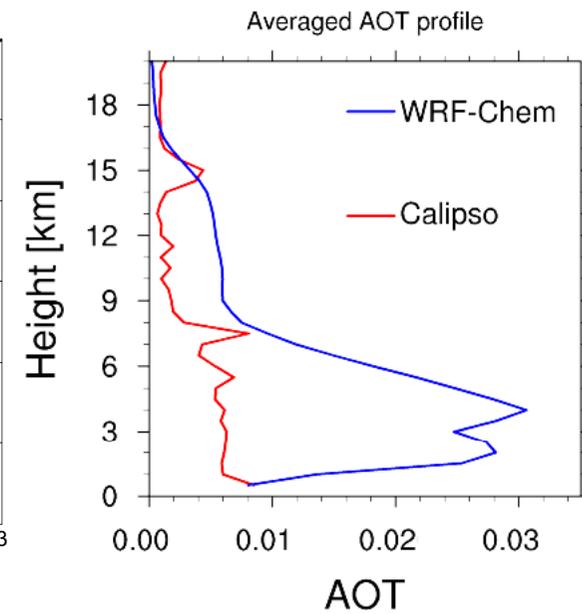
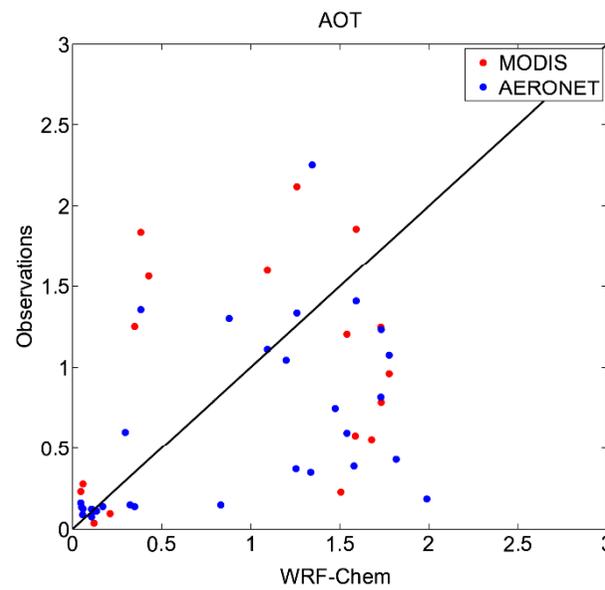
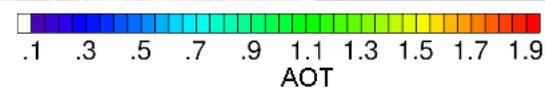
GOES fire count
(WF_ABBA)



MODIS

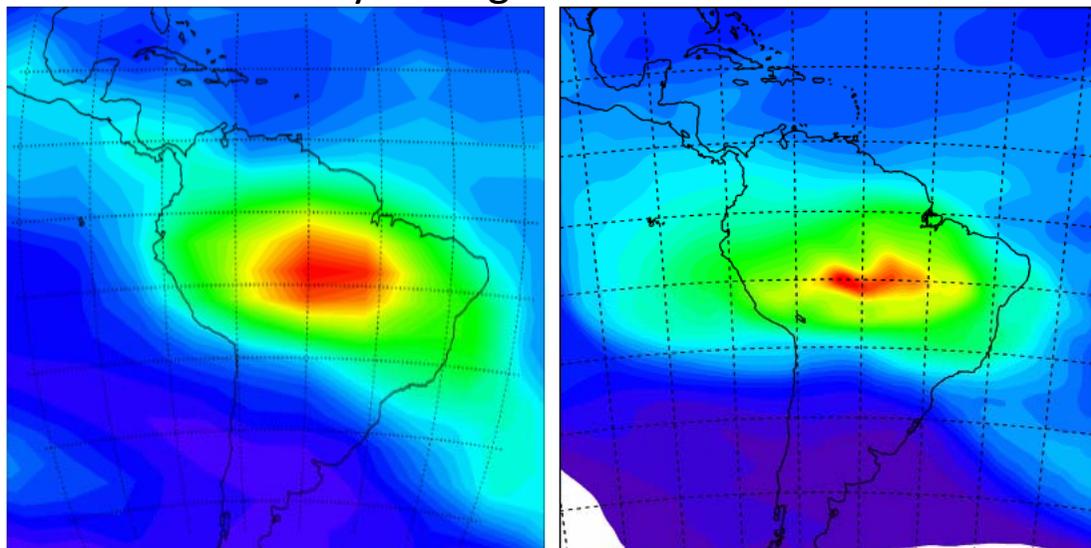


WRF-Chem

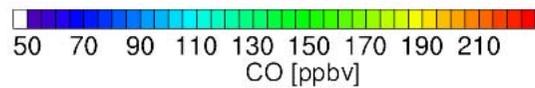


Chemistry:

8-day averaged CO at 215 hPa

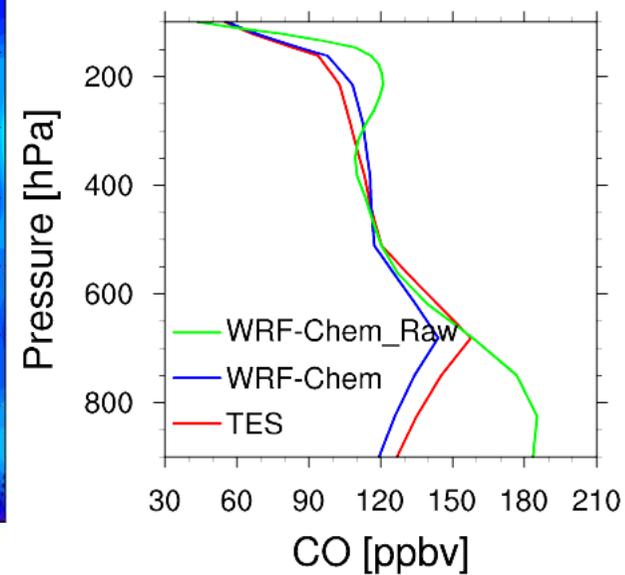


MLS V3

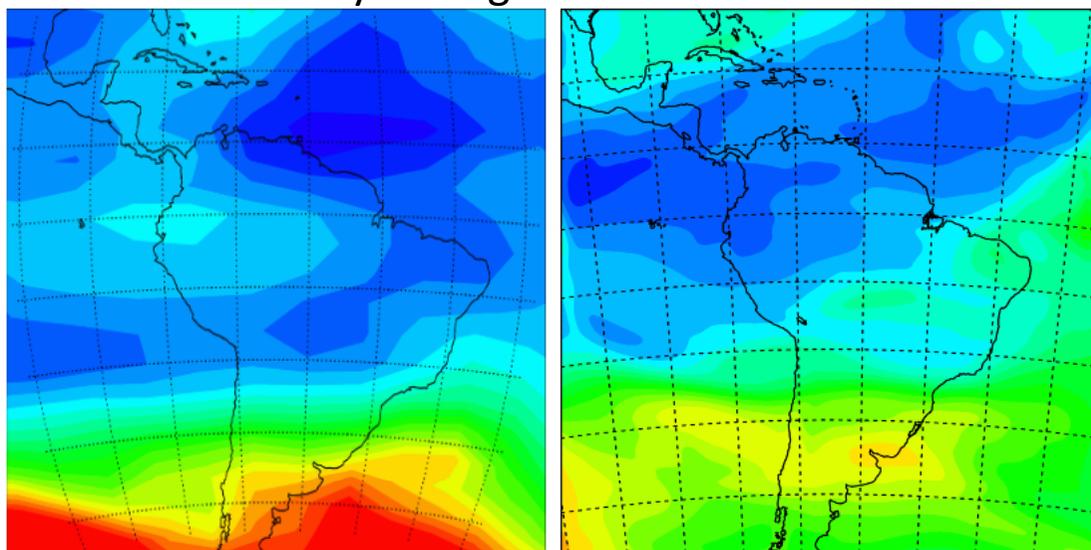


WRF-Chem

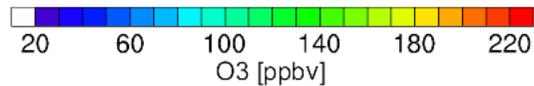
Averaged CO profile



8-day averaged O3 at 215 hPa

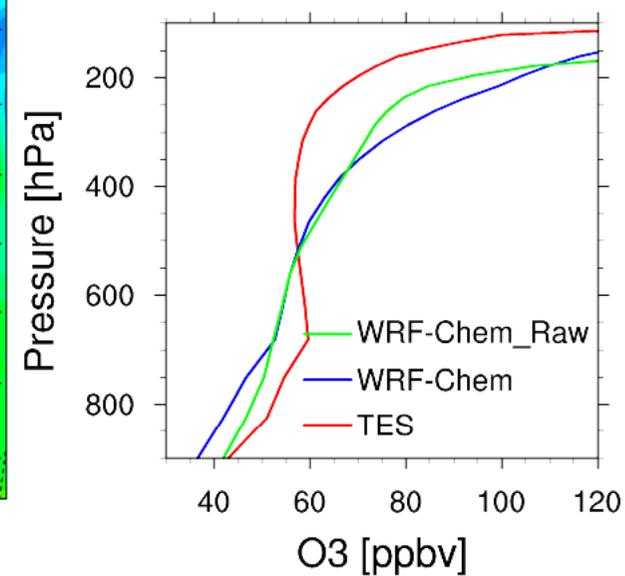


MLS V3



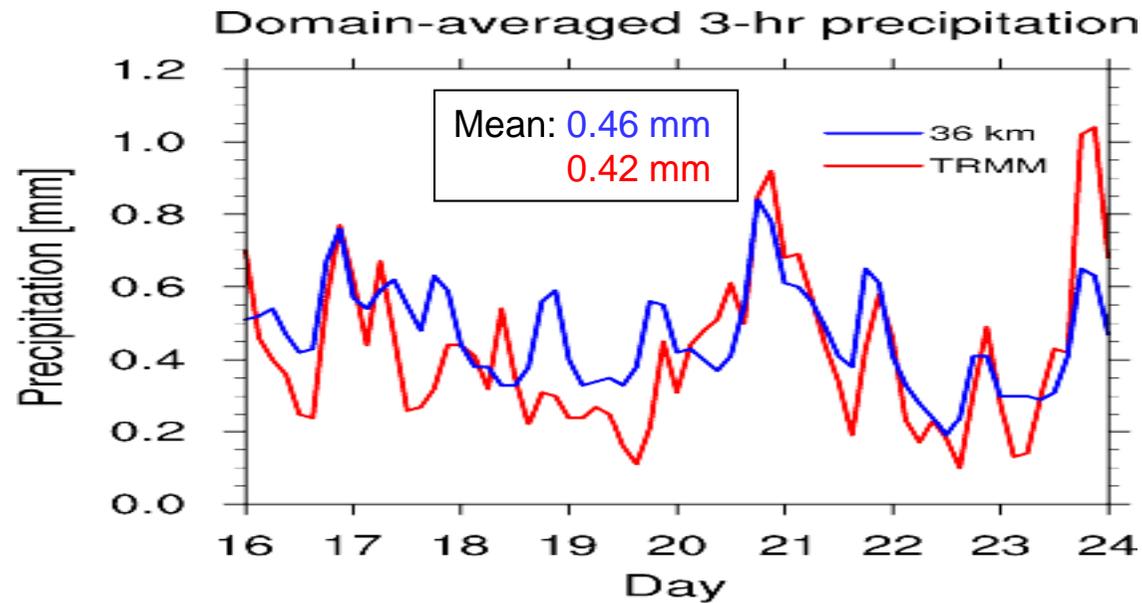
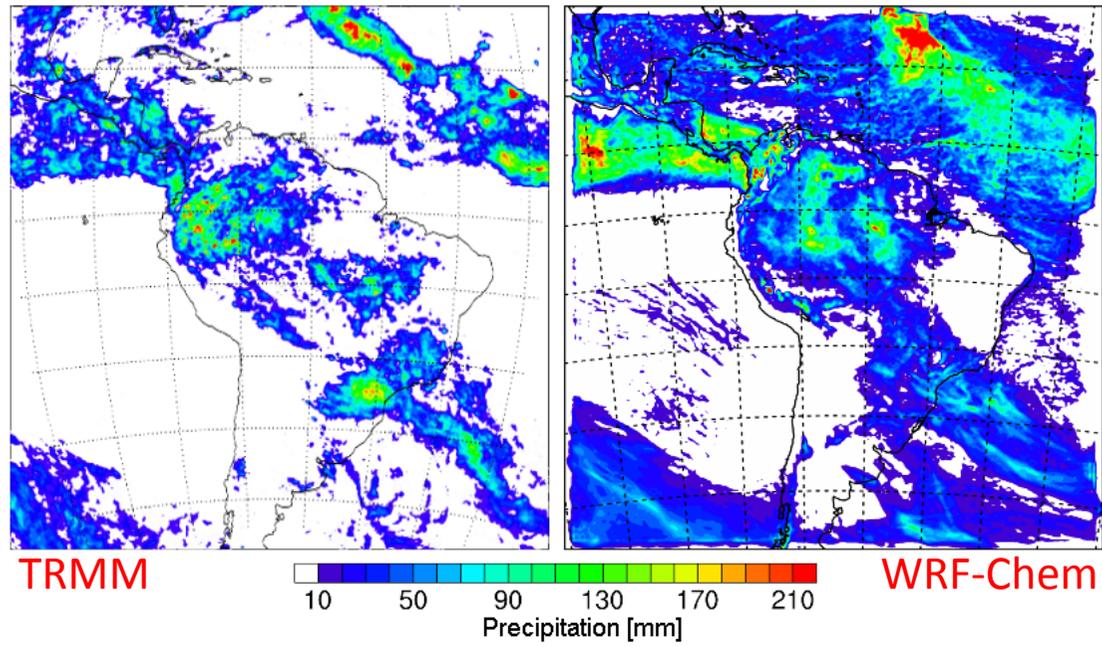
WRF-Chem

Averaged O3 profile



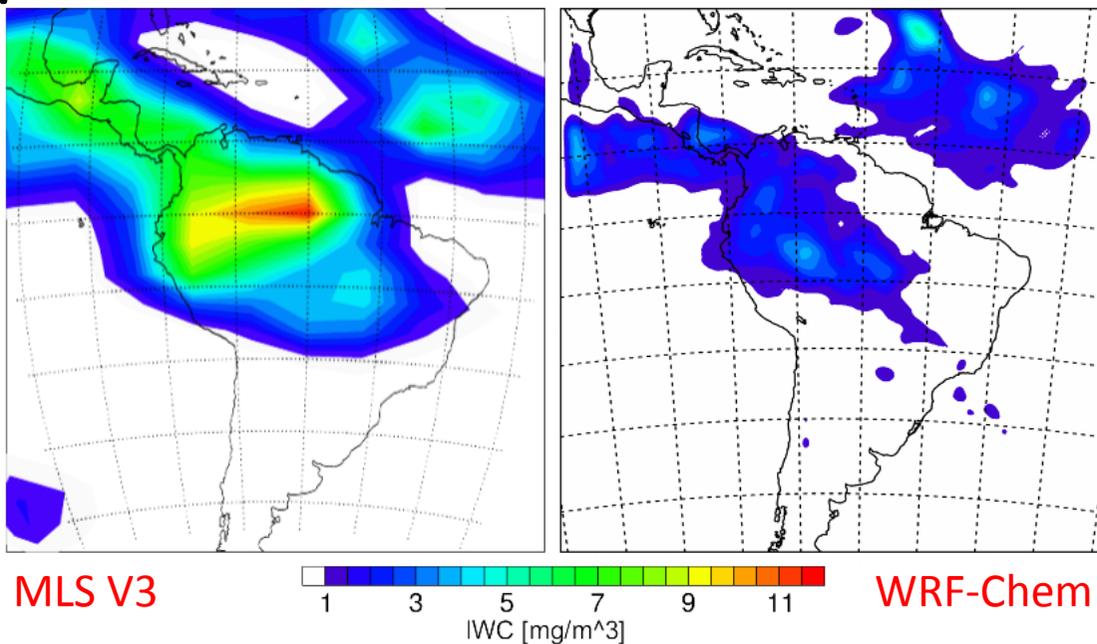
Precipitation:

8-day precipitation total

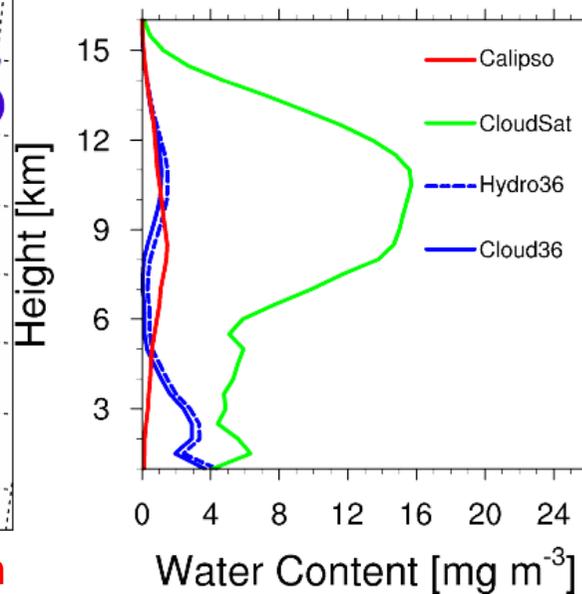


Clouds:

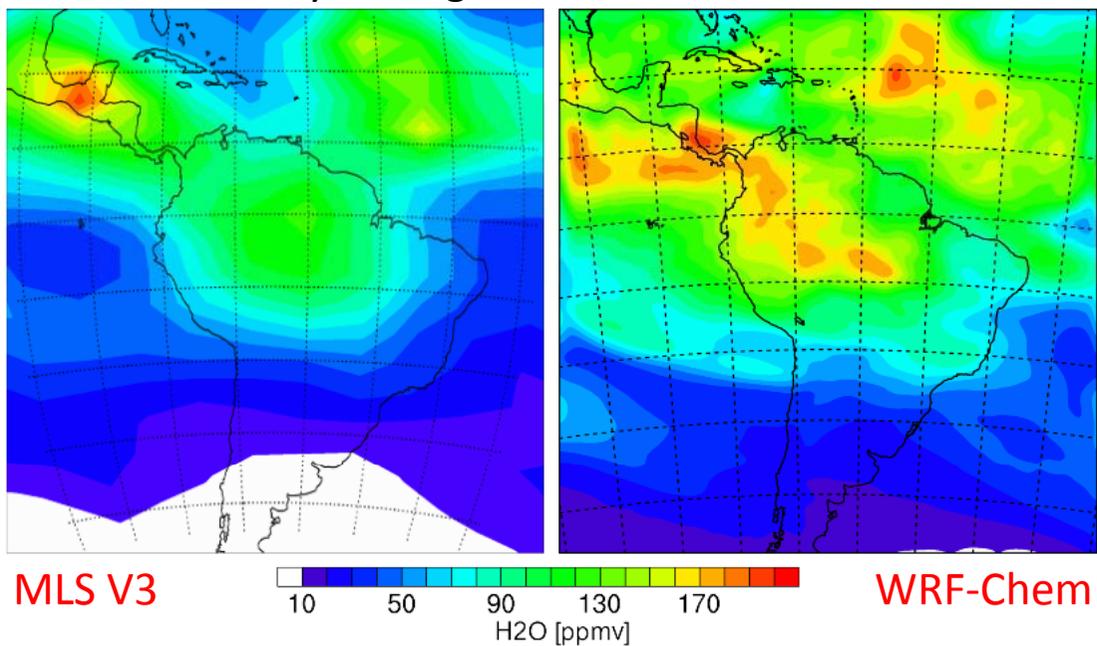
8-day averaged IWC at 215 hPa (~11 km)



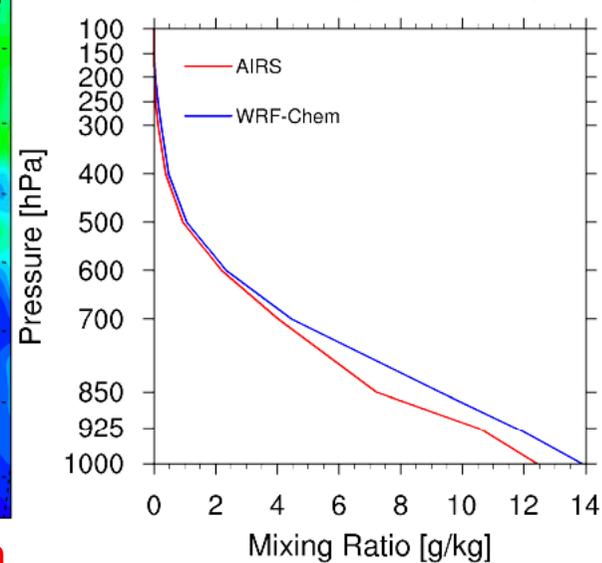
Cloud water content



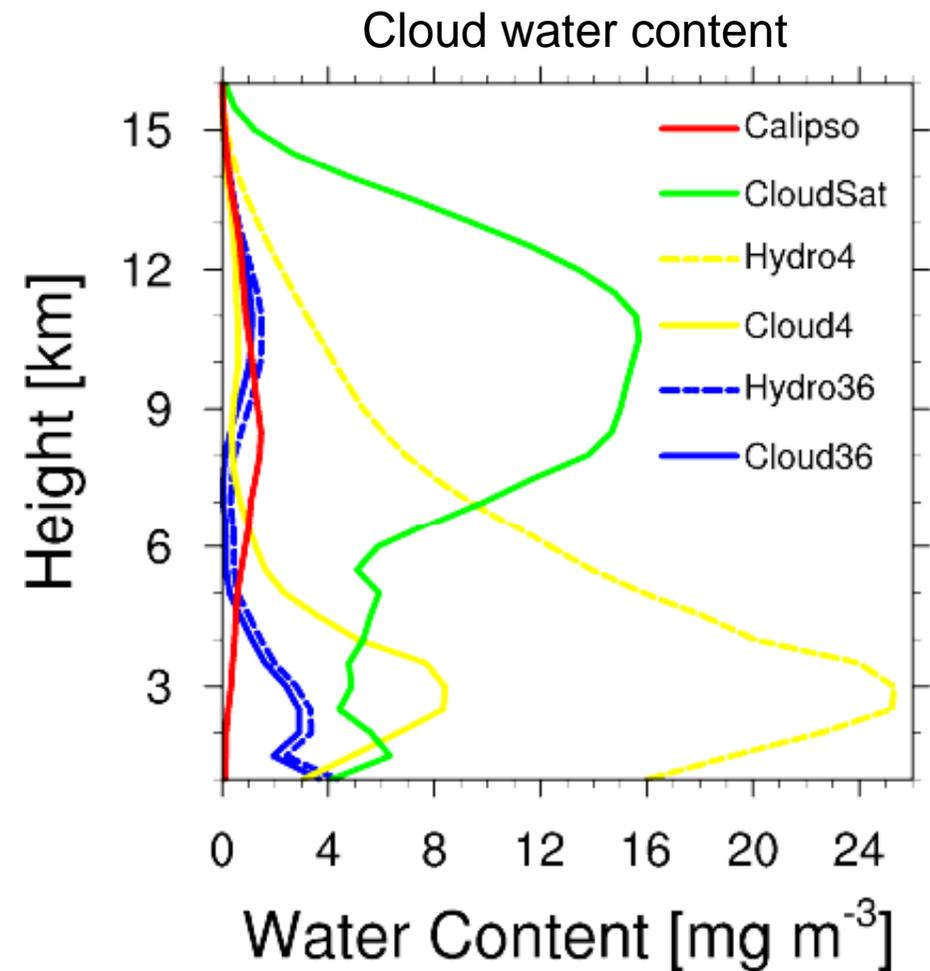
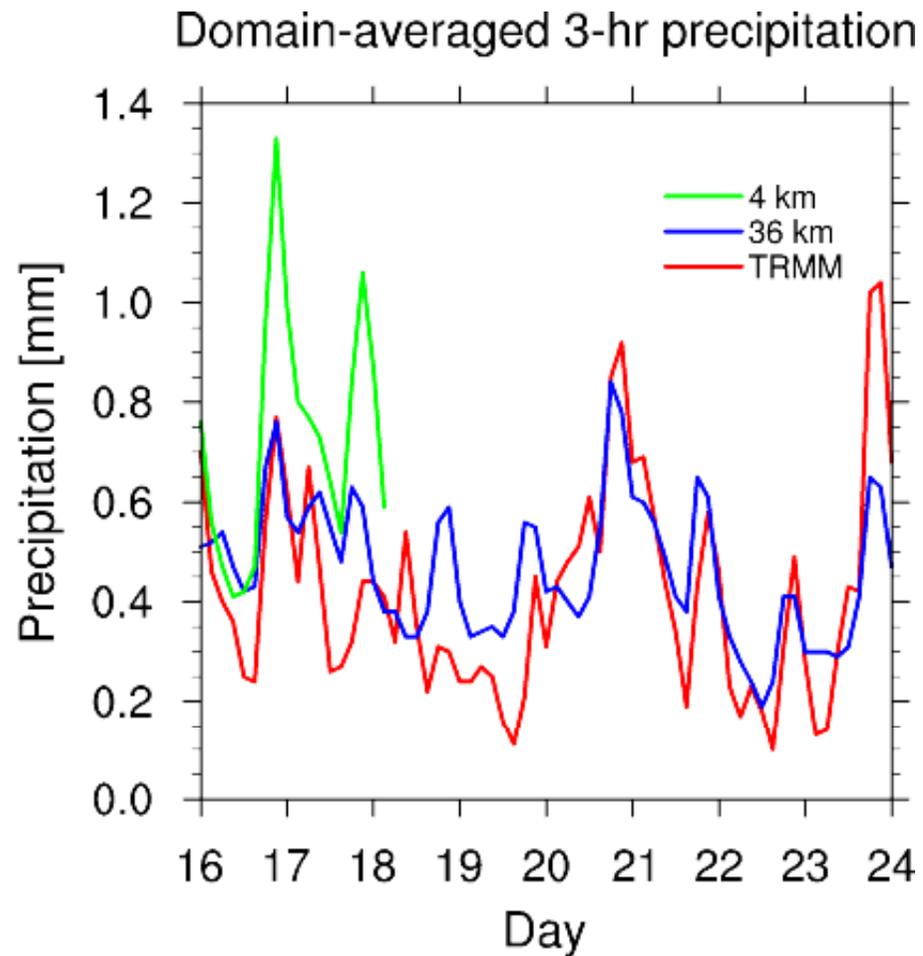
8-day averaged H2O at 215 hPa



Domain-averaged Water Vapor



Sensitivity to Model Resolution



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.