Biomass Burning Aerosol Effects on Clouds and Precipitation in the Dry Season of South America

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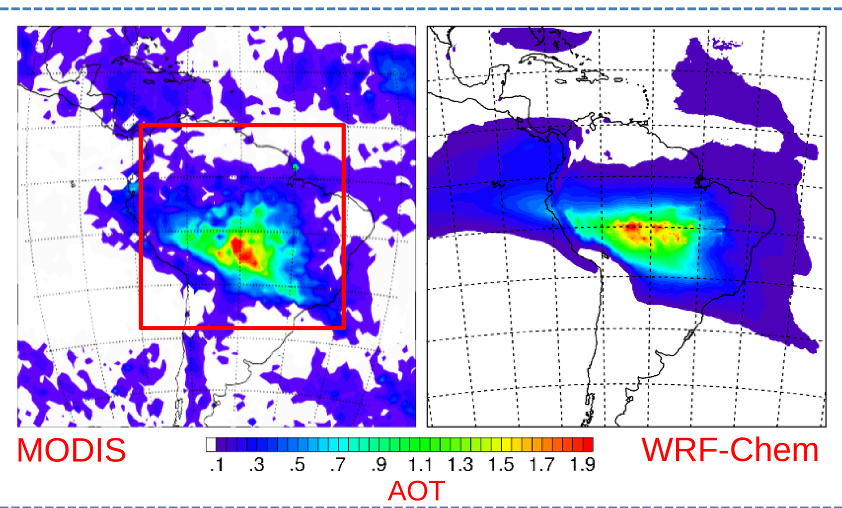
1. Motivation

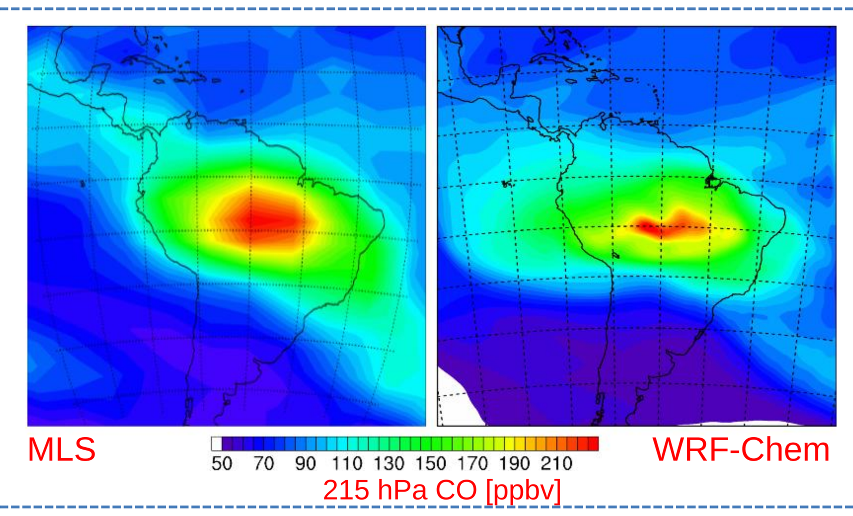
- ❑ Jiang et al. (2008) showed observational evidence of aerosol effects on clouds and precipitation in the dry season of South America, but the physical mechanisms were unclear.
- ❑ Limited modeling studies were conducted with coupled aerosol-cloud-precipitation interactions.

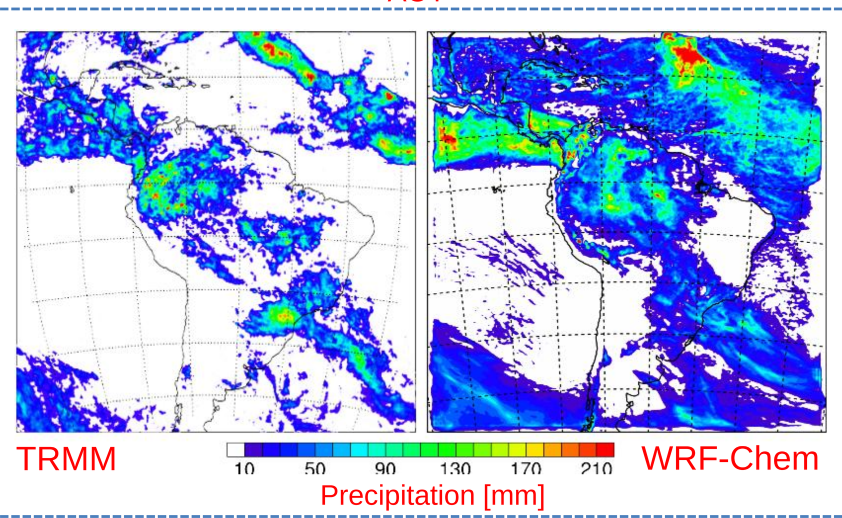
2. Model configuration and experiment design

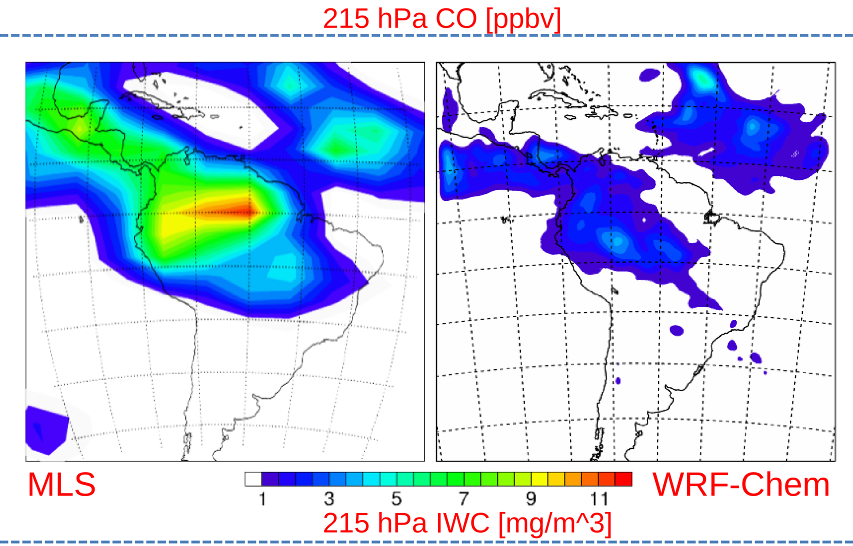
- ❑ Time period: Sep. 15 to Sep. 24, 2006
- ❑ Horizontal resolution: 36 km and 4 km
- ❑ Initial and boundary conditions: FNL (meteorology) and MOZART (chemistry)
- ❑ Physics:
  - ➢ Lin et al. microphysics with prognostic cloud droplet number
  - ➢ Grell-Devenyi ensemble cumulus
  - ➢ RRTMG longwave scheme
  - ➢ Goddard shortwave scheme
- ❑ Chemistry:
  - ➢ RADM2 chemistry and MADE/SORGAM aerosols
  - ➢ Anthropogenic emissions: RETRO and EDGAR
  - ➢ Wildfire emissions: WF_ABBA and a plume rise model with modification
  - ➢ Gas phase, aerosol, wet scavenging, vertical trubulent mixing and cloud chemistry
  - ➢ Feedback from aerosols to radiation
- ❑ Experiments:
  - ➢ PC: polluted case
  - ➢ CC: clean case (without biomass burning emission)
  - ➢ PCNR: polluted case without feedback from aerosols to radiation.

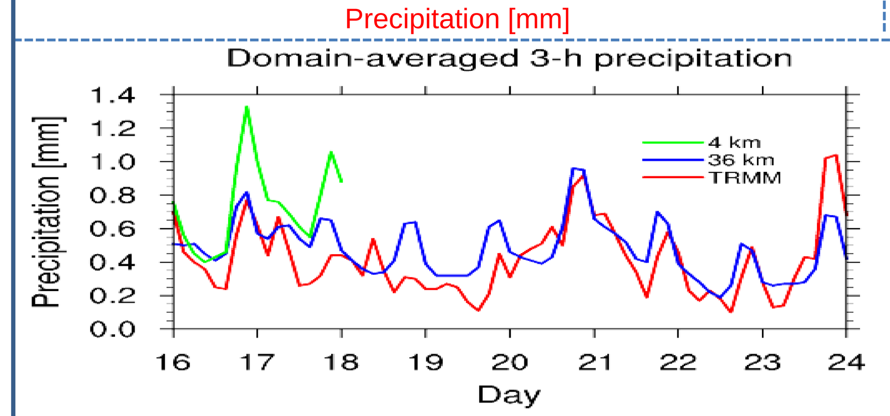
3. Model evaluation using multi-satellite observations





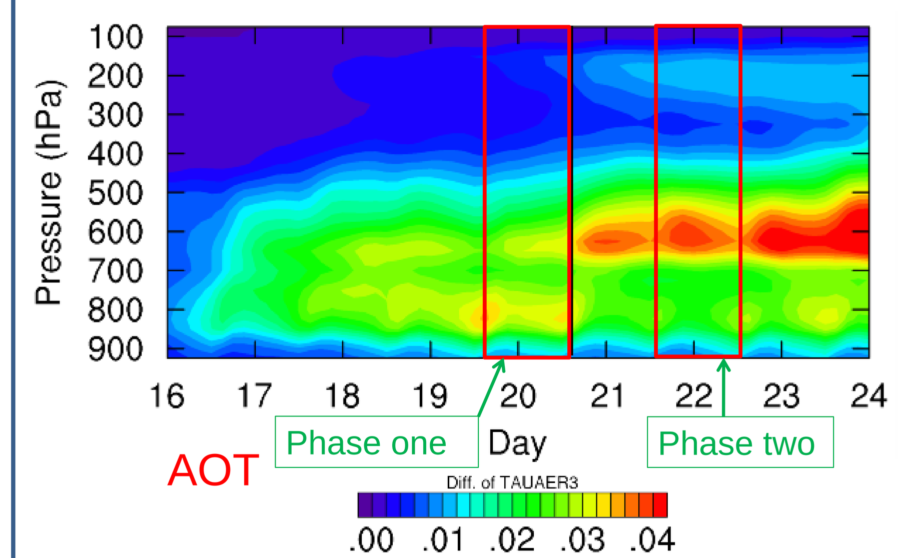


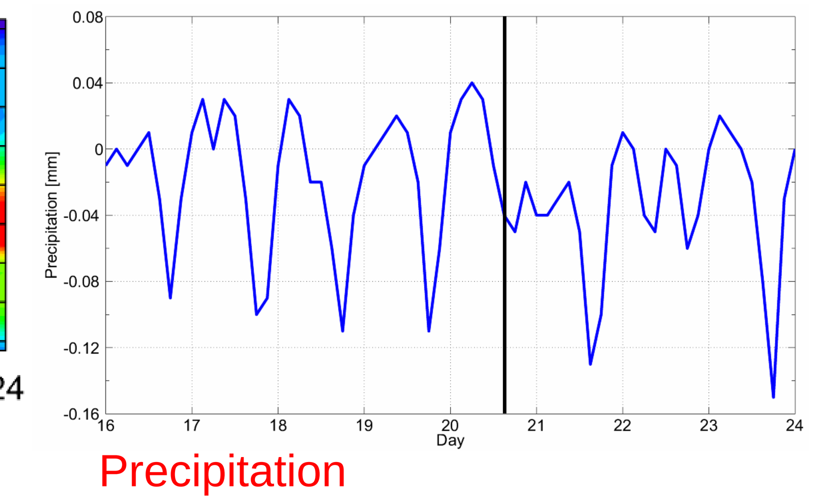


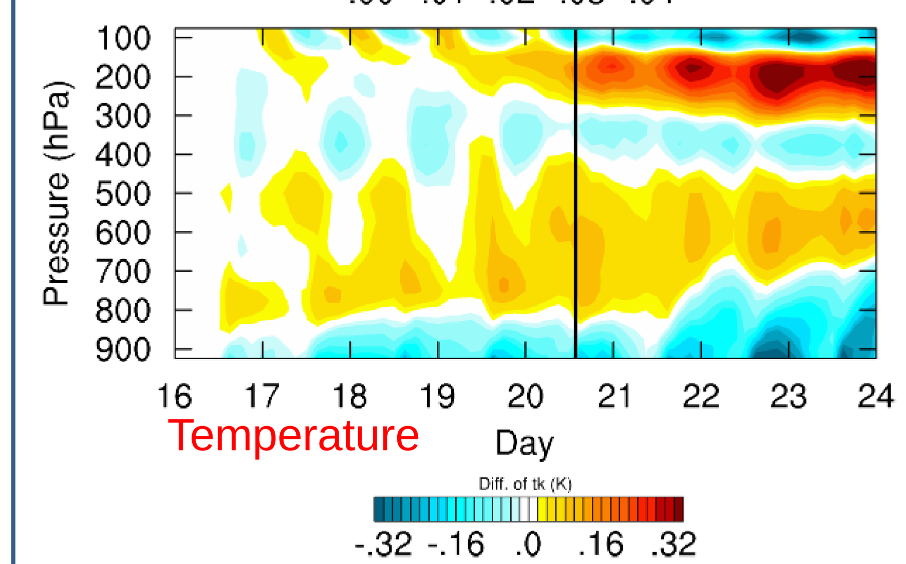


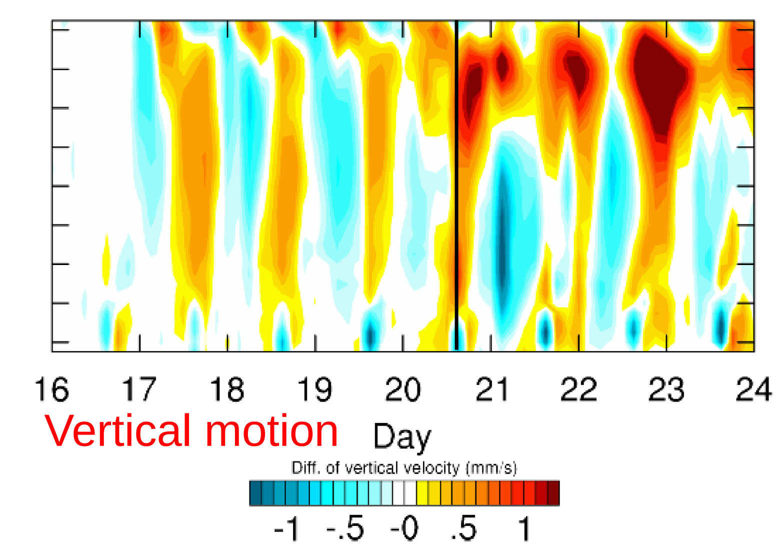
- ➢ All validation map data are 8-day averages from Sep. 16 to Sep. 24, 2006.
- ➢ The following figures are domain-averages within the red box shown in the MODIS AOT figure.

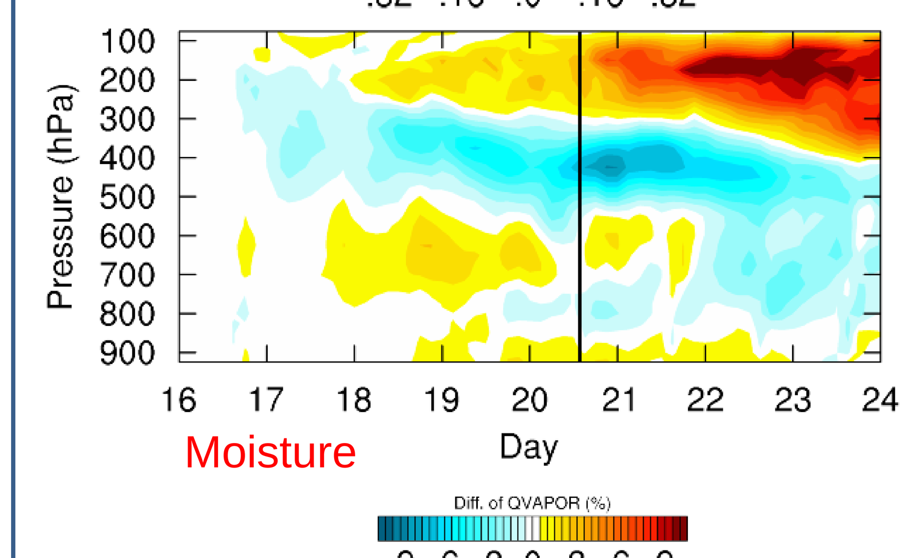
4. Aerosol total effects (PC-CC)

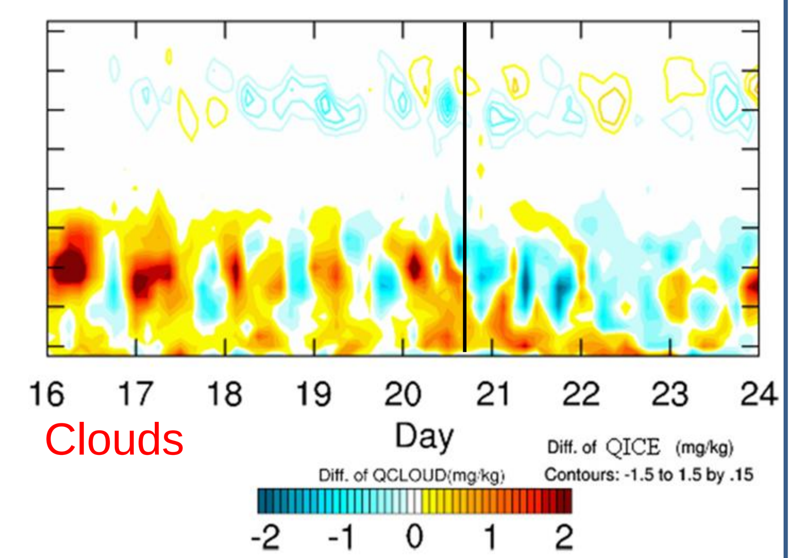






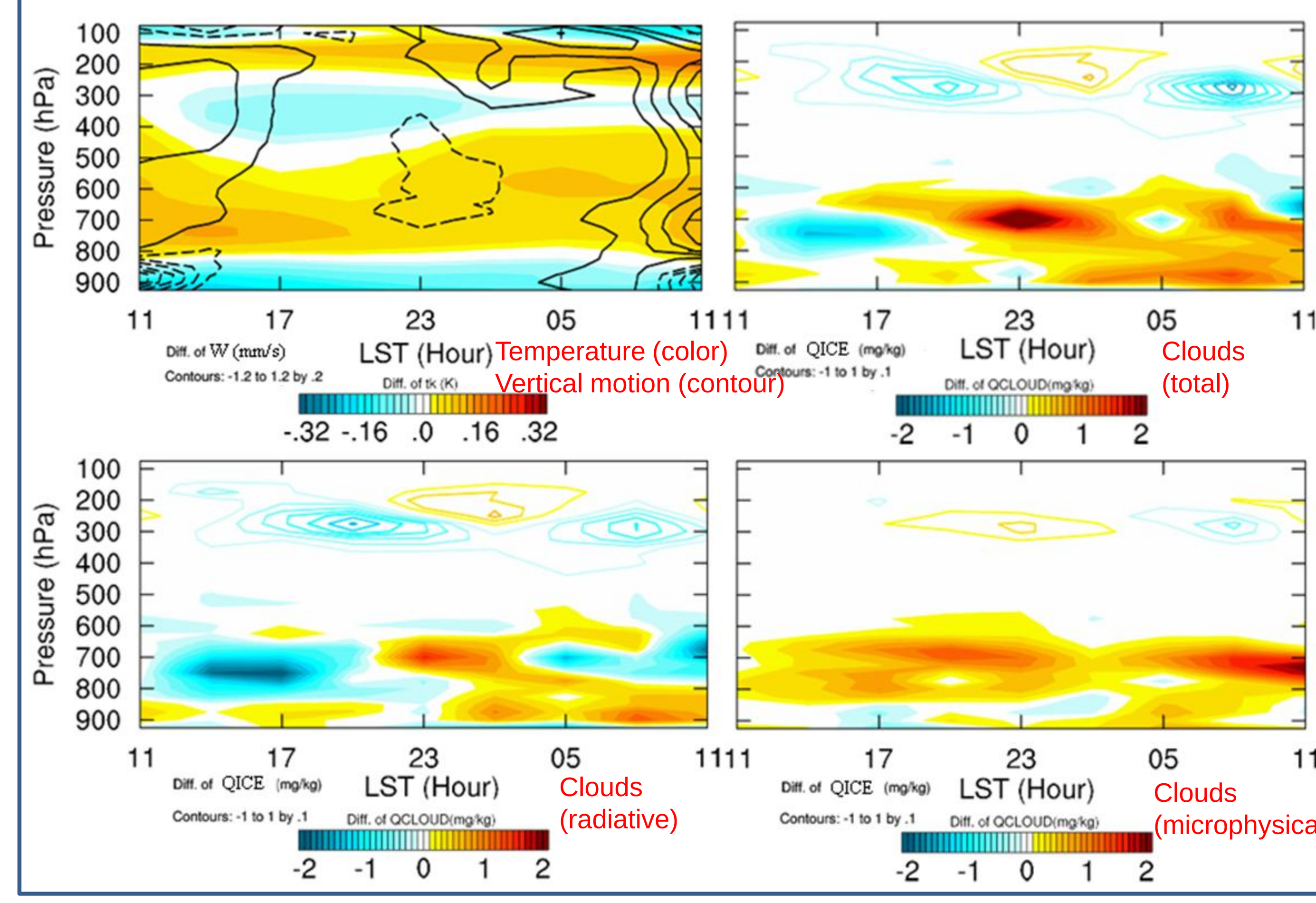






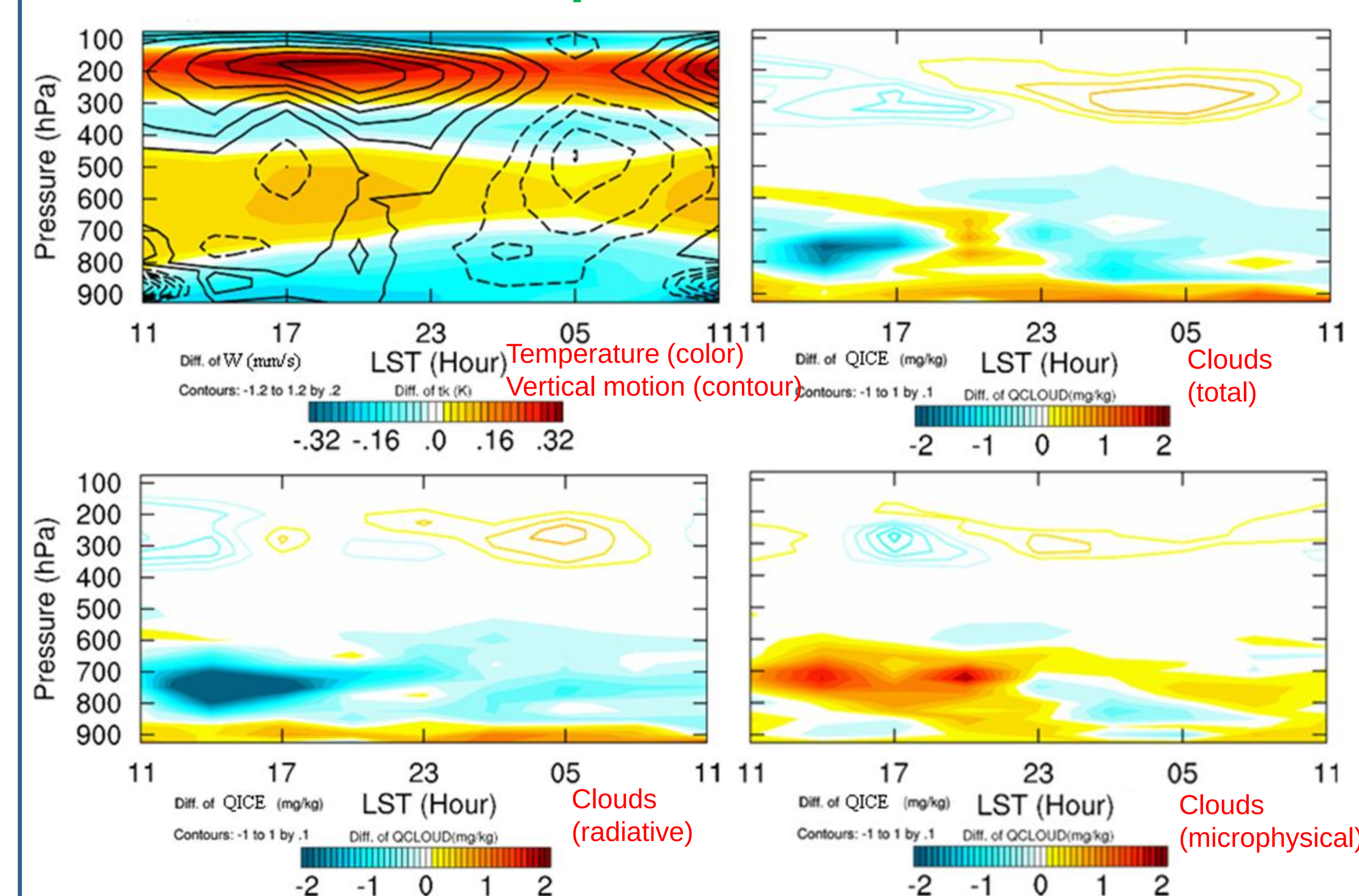
- ➢ Overall, the evolution of aerosols and their effects on local atmosphere show a clear signal of diurnal variation throughout the simulation, but with some different responses due to the difference of aerosol intensity and locations before and after 1500 UTC 20 Sep., 2006.
- ➢ We divide the simulation time period into two phases. In each phase, we select one typical day (shown in the figure of AOT difference) to look at the aerosol effects in detail.

5. Aerosol effects in phase one



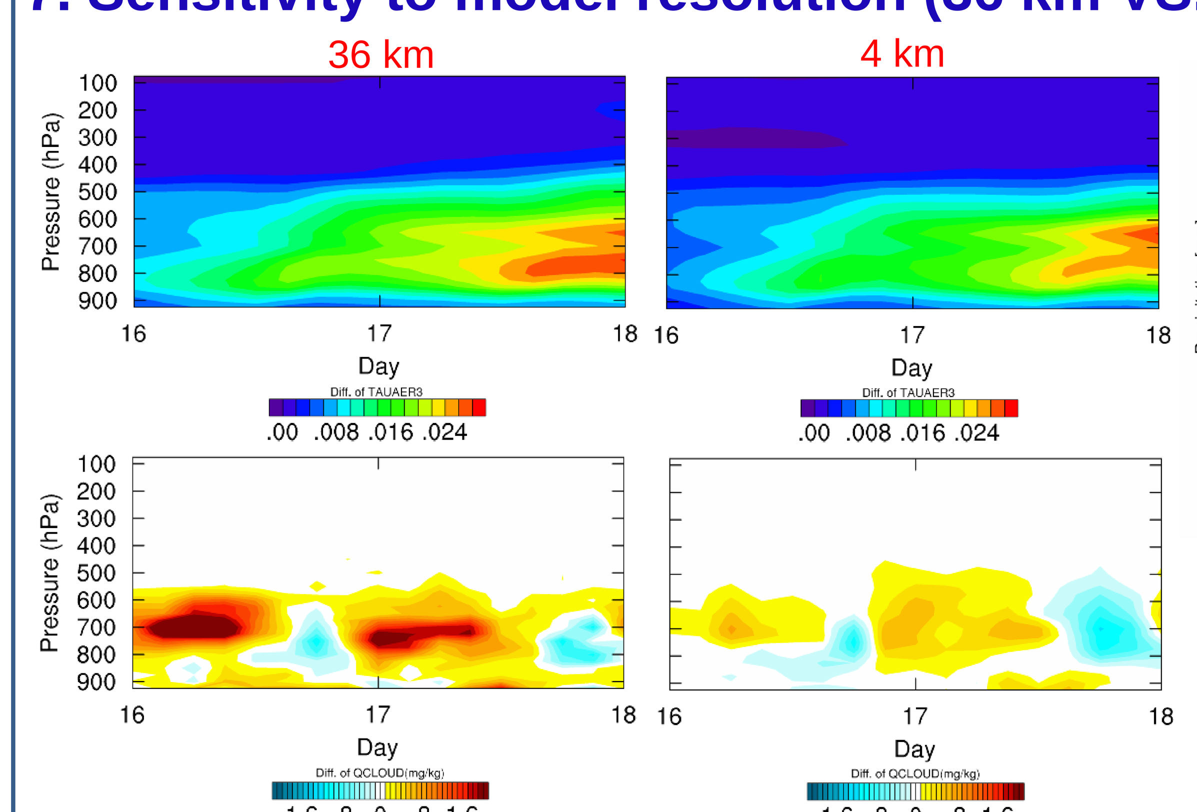
- ➢ In the afternoon, aerosols cool surface and PBL, and suppress vertical motion in the PBL by scattering and absorbing solar radiation.
- ➢ In the middle layer, aerosol warm the air, enhance vertical motion and evaporate clouds by absorbing solar radiation in the afternoon.
- ➢ The cloud decrease in the afternoon provides more moisture to form clouds at night when the warming effect is weakened.
- ➢ Ice clouds increase at night with slightly higher altitude.

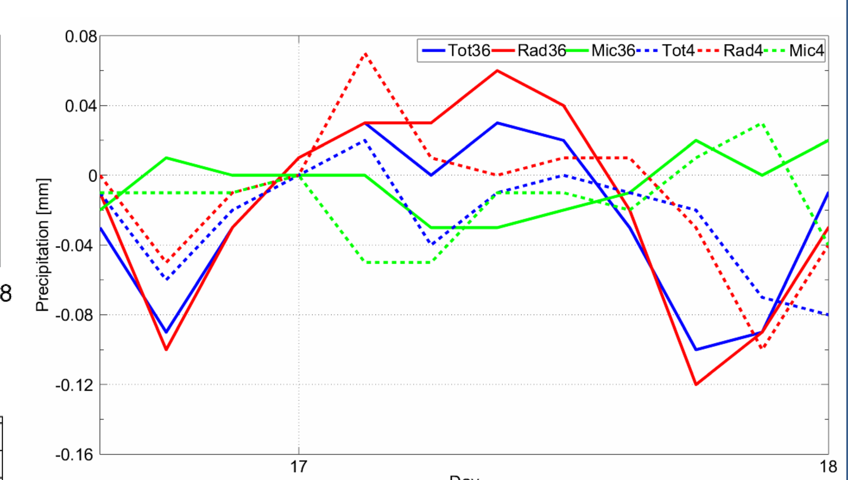
6. Aerosol effects in phase two



- ➢ The warming in the middle layers extends longer time. So the water clouds increase at night of phase one is not shown in phase two.
- ➢ When aerosols transport to the upper troposphere, significant warming and moistening are shown in the upper troposphere.
- ➢ More ice clouds increase at night.

7. Sensitivity to model resolution (36 km VS. 4 km)





- ➢ Contributed primarily by aerosol radiative effect, clouds and precipitation are suppressed in the afternoon while they are enhanced at night. This effect is shown at both 36 km and 4 km, albeit with different magnitude.

8. Conclusions

- ➢ The WRF-Chem simulations approximately reproduce the distributions of aerosols and chemical tracers in response to convection, but the magnitudes of modeled clouds are weaker than observations. The modeled precipitation agrees well with TRMM observations, in both intensity and temporal variation.
- ➢ Biomass burning aerosols cool the surface by scattering and absorbing solar radiation while they warm the middle-layer atmosphere by absorbing solar radiation.
- ➢ Contributed primarily by the aerosol radiative effect, surface precipitation is suppressed in the daytime while precipitation is enhanced at night, suggesting a delay of precipitation process.
- ➢ More cloud ice is shown at night with slightly higher altitude due to aerosol effects.
- ➢ When aerosols are transported to the upper troposphere, significant warming and moistening are shown in the upper troposphere.

Acknowledgements

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