Evolution of Particulates and Aerosol Radiative Forcing Over Mexico using the WRF-chem Fully-Coupled Meteorology-Chemistry-Aerosol Model

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Objectives

Use a 3-D model and field data to address scientific questions of interest to MAX-Mex and MILAGRO including:

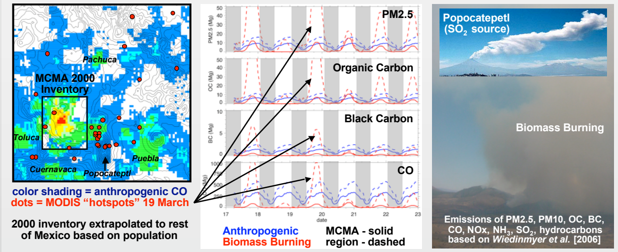
- What is the relative contribution of anthropogenic, biomass burning, and volcanic sources on particulate concentration and composition over the central plateau?
- What is the fate of particulates downwind of Mexico City?
- What are the differences between the observed and simulated aerosol optical properties?
- What are the largest uncertainties in aerosol radiative forcing and their potential impact on regional climate?

WRF-chem

- simulations use PNNL modules: CBM-Z trace-gas photo-chemisty mechanism, FAST-J photolysis scheme, MOSAIC sectional aerosol model, and aerosol-radiation feedbacks
- 3 two-way nested domains: Δx = 22.5, 7.5, 2.5 km
- 6-day simulation period, 06 UTC 17 March - 06 UTC 23 March, when upper-level winds were primarily southwesterly
- simulation period encompasses 6 G-1 and 3 C-130 flights
- boundary conditions from MOZART global chemistry model

size and number distribution, composition, aerosol water → refractive indices → Mie theory → 3-D τ_λ, ω_o, and g → scattering and absorption of shortwave radiation

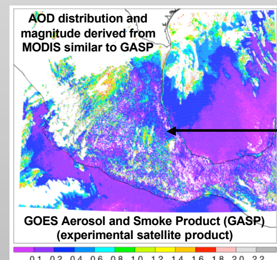
Emissions



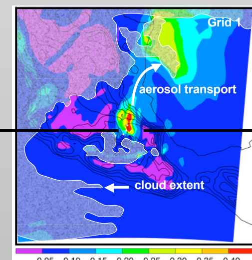
Results

- predicted particulate distribution and transport toward the NE qualitatively similar to aircraft and satellite information, but assimilation of meteorological measurements needed to more closely follow local details of plume each day
- particulate mass (and consequently τ_λ) too low in general
- ϖ_o too low within downwind city particulate plume
- simulated magnitude of SO_4, NO_3, NH_4, and BC similar to observed, but afternoon OC too low on non-fire days
- largest uncertainties associated with SOA (no SOA treatment in MOSAIC), followed by emissions and transport
- grid 1 only simulation signifcantly underestimatnes local τ_λ

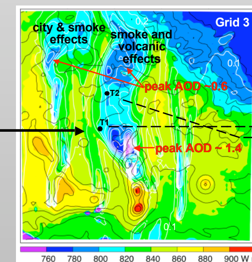
Observed AOD 21 UTC 19 March



Predicted AOD (400 nm)

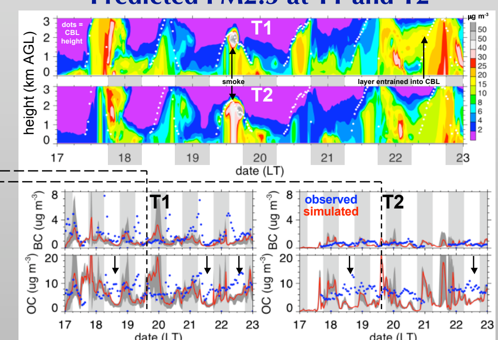


Predicted Radiation & AOD (400 nm)



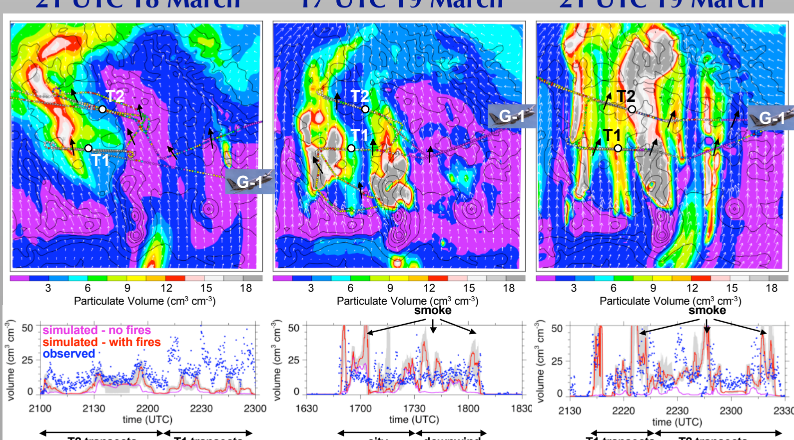
shortwave radiation reduced by as much as 100 W m^{-2}

Predicted PM2.5 at T1 and T2

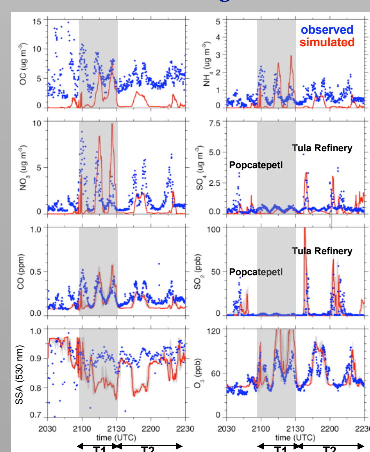


Observed and Predicted Particulate Volume (< 2.5 µm)

21 UTC 18 March — 17 UTC 19 March — 21 UTC 19 March



Afternoon G-1 Flight 20 March



preliminary AMS data (OC, NH_4, NO_3, SO_4) provided by Lizbeth Alexander

Observed and Predicted Particulate Volume (< 2.5 µm)

17 UTC 20 March — 21 UTC 20 March — 17 UTC 22 March