

Modeling of Mexico City Air Pollution and Outflow with WRF-Chem

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Abstract: We use a newly developed regional chemical/transport model (WRF-Chem) to study the air pollutions in mega cities and their effect on surrounding areas. The model is based on a state of the art regional dynamical/transport model, the Weather Research Forecasting (WRF) model developed by multiple institutes (including NOAA, NCAR, etc.). The detailed description of WRF-Chem is given by Grell et al. [2004]. The model includes on-line calculation of dynamical inputs (winds, temperature, boundary layer, clouds etc.), transport (including advective, diffusive, and convective processes), dry and wet deposition, gas phase chemistry (RADM2), aerosol formation, radiation and photolysis rates (TUV), and surface emissions. The resolution of the model is flexible, ranging from a few kilometers to hundred kilometers. In this study, we use a 6x6 km resolution located around Mexico City to study the air pollution inside the city and the outflow of the city plume. Mexico City is a very polluted city. The estimated emission of CO and NO_x is about 3200000 and 202000 tons/year, respectively. As a result, the mobile in Mexico City has significant affect on the air-pollution inside the city and the outflow in the surrounding area. In this study, the scientific focus will be on: (1) the role of NO_x and VOCs in controlling O₃, (2) daytime vs. nighttime chemistry, (3) effect of urban heat island on chemistry, (4) the long-range transport of the city plume, and (5) the impact of rural biogenic emission and biomass burning on the city plume.

The model result shows that city emission of NO_x has a strong influence on the ozone concentrations inside the city, and the model simulation has a fairly agreement with the observed ozone diurnal variation of the ozone concentration in the PBL. Figure 1 shows that there is a strong ozone diurnal cycle. The maximum ozone concentration (190 ppbv) occurs at afternoon due to photochemical production of ozone associated with the NO_x emission. In early morning, NO_x has high concentration due to high mobile traffic and low PBL, while ozone concentration has a minimum concentration (about 10 ppbv),

indicating that with a low photochemical activity condition, emission of NO_x plays an important role to destroy ozone in the city.

In the surrounding area of the Mexico City, there are high biomass burning activities and biogenic emissions. The biomass burning occurs in spring, and emits a high volume of NO_x and CO. The biogenic emission emits a significant amount of hydrocarbons such as isoprene. Figure 2 shows the calculated NO_x and isoprene concentrations in the surrounding areas in April. After the city plume is transported into the surrounding areas, the polluted air is mixed with NO_x and hydrocarbons produced by biomass burning and biogenic emissions. As a result, O₃ production is enhanced. Figure 3 shows that the ozone concentrations in the plume is significantly enhanced at the far-end plume due to the NO_x emission of biomass burning, and is significantly impacted at the near-end plume due to the biogenic emission of hydrocarbons.

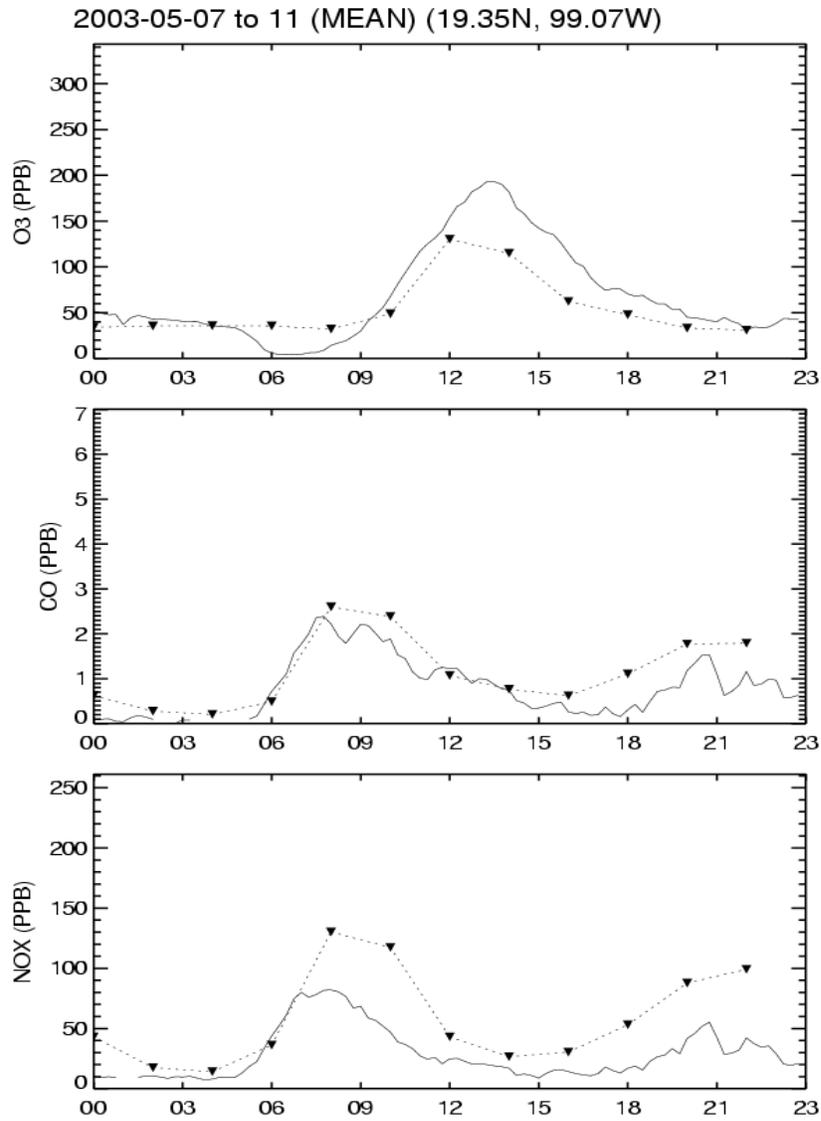
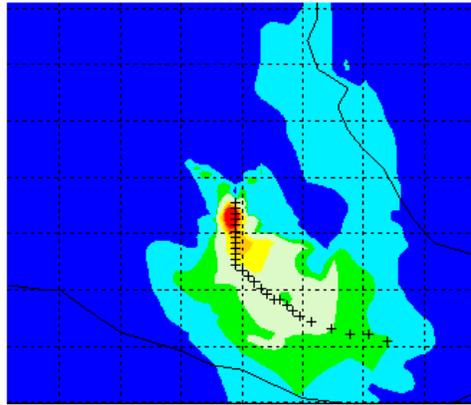
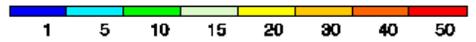
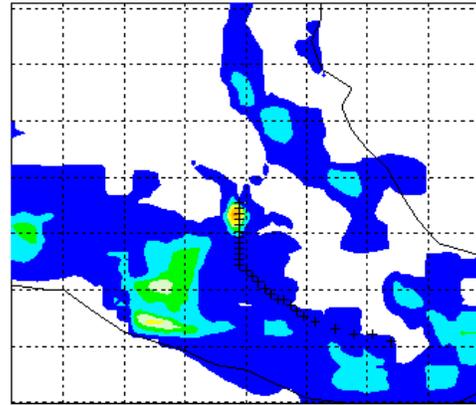


Figure 1, Calculated (solid line) and observed O₃, CO, and NO_x concentrations at surface station (19.35N, 99.07W) of the Mexico City averaged during May/7 and May/11, 2003.

City CO (ppb)



City + Biomass NOx (ppb)



Biogenic Isop (ppb)

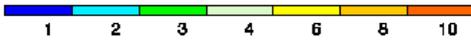
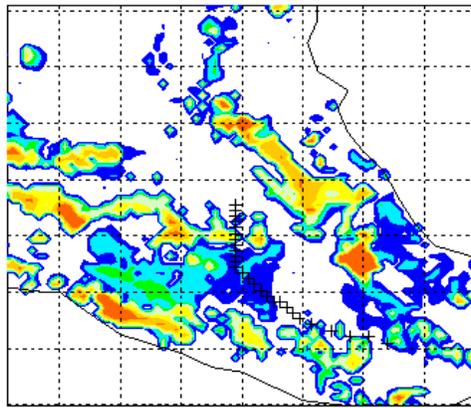


Figure 2, Calculated CO (due to emission of the city), NOx (due to emission of the city and biomass burning), and isoprene (due to biogenic emission) concentrations at the surface in surrounding areas of the Mexico City. The crosses indicate a trajectory of city plume.

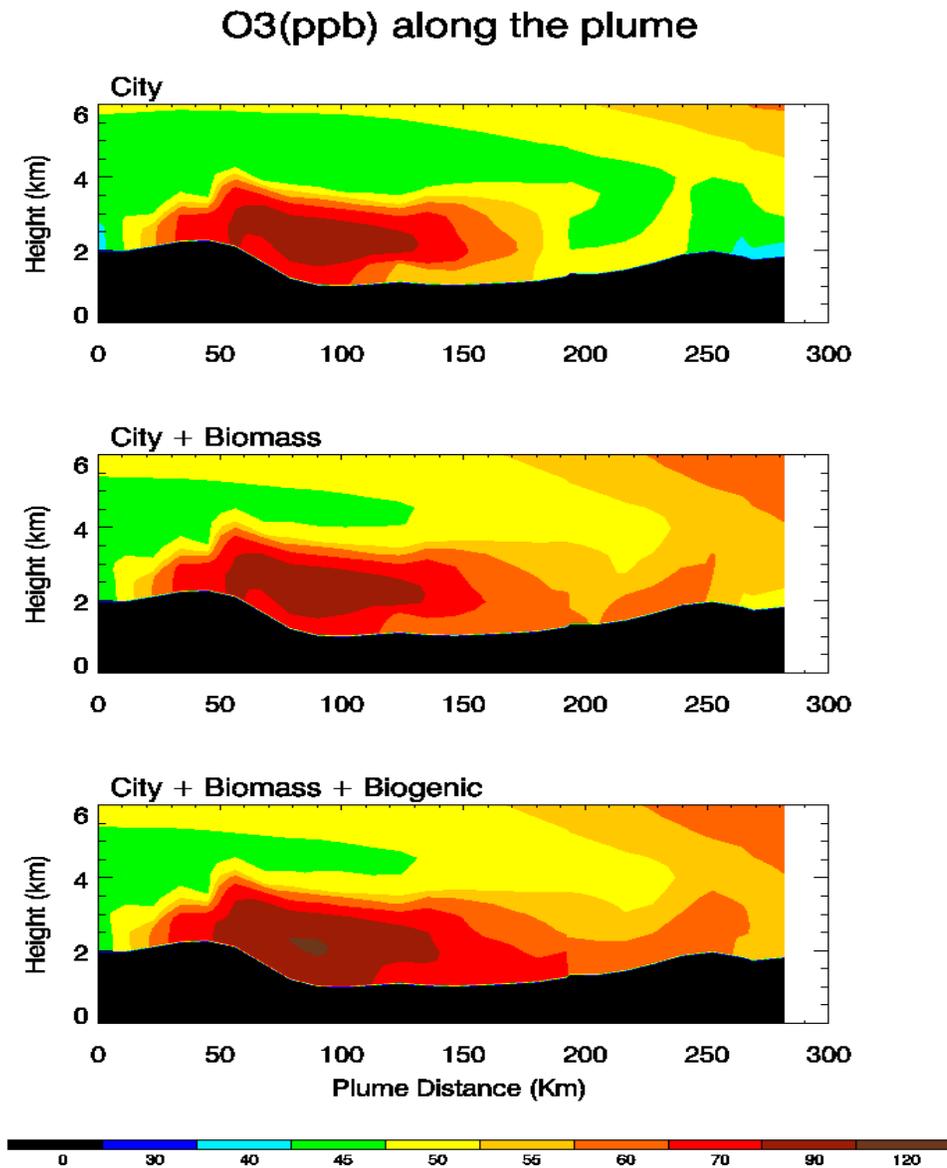


Figure 3, Calculated O₃ plume along the trajectory shown in Figure 2. The upper panel shows the ozone plume attributed by the city emission; the middle panel shows the ozone plume attributed by the city and biomass; and the lower panel shows the ozone plume attributed by the city, biomass burning, and biogenic emissions.