Efforts made on the improvement of air quality simulation in mega cities: a focus on simulation of ozone

PI: Xiaoqin Shi

Abstract: with permeant growing of mega cities, human activities conducted by large population in mega cities are spreading to a larger spatial area with higher intensity. Worsened air quality in mega cities needs a relatively good air quality model to serve effective measures applied on aviation, traffic, medical care and so on. This study is dedicated to understanding anthropogenic effects in mega cities on atmosphere dynamics and concentration of atmospheric pollutants (e.g. ozone) and further improving air quality simulation in Mega cities, in a case of Beijing. Efforts are made on several aspects, e.g. emissions, urban heat, land use, resolutions and so on.

Anthropogenic emissions of air pollutants evolve depending on human activities, e.g. emissions from traffic diurnally vary through the day with traffic volume which is determined by daily commute of citizens. A work has been done to apply sector-dependent temporal profiles to anthropogenic emissions and inject emissions of energy sector and industrial sector to certain height above surface layer. In addition, complexity and intensity of urban human activities indicates high spatial variability of anthropogenic emissions in urban area. But present emission inventories mostly have a resolution of larger than 10km, which means a grid cell of 10^2km including downtown area emits same amount of pollutants across the area. To solve this problem, emissions downscaling is needed to be done combining with reducing horizontal resolution of model. This study is developing a top-down downscaling method to map emissions with a resolution of 10km to 1km utilizing proxy data, e.g. land use type, population, road map and so on. How downscaled emissions improves the simulation of air quality will be a future work.

Urban heat has profound effects on pollutants diffusion by acting as an extra energy source of the atmosphere and modifying atmospheric stability in Planetary Boundary Layer (PBL). Especially at night, shallow convection due to warmer ground than atmosphere bring pollutants up and consequently reduce concentration of surface pollutants. Diffusion of surface pollutants nonlinearly affects atmospheric chemistry and further change concentration of secondary pollutants. A sensitivity test was done by setting a constant positive surface heat flux in urban. As expected, surface convection and height of PBL increase obviously during 15:00-19:00, but the effect on pollutants, especially ozone, is not significant. Next, urban parameterization embedded in WRF-chem need to be tested, which applies diurnal surface heat flux in urban area and has much strong heat flux in some hours of the day in urban area than previous sensitivity test.

Types of land use in model determines which parameterization scheme the model applies. The more recent land use data better represents urban spread and correspondingly vegetation shrink. Due to fast growing of megacities in recent years, the standard land use input to WRF need to be updated. The effect of land use update on pollutant concentration simulation in mega cities is unclear. A newer land use data from local source will be processed to WRF-required format and then applied to a test run. For making sure that increasing model vertical resolution in PBL could improve simulation of pollutants concentration, a test run doubling the first ten layers from bottom was done. When emissions are only injected to surface layer in model, shallower surface layer (higher resolution) increases contribution of emissions to pollutant tendency in surface layer.