Impact of cumulus parameterization options on simulated cloud albedo, ozone, and $PM_{2.5}$ in regional- to urban-scale WRF-CMAQ simulations

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Introduction

Over the past several decades, the horizontal scale of numerical air quality simulations, such as those performed using the Community Multiscale Air Quality Model (CMAQ), has progressively decreased to the now common regional-scale of 12x12 km.

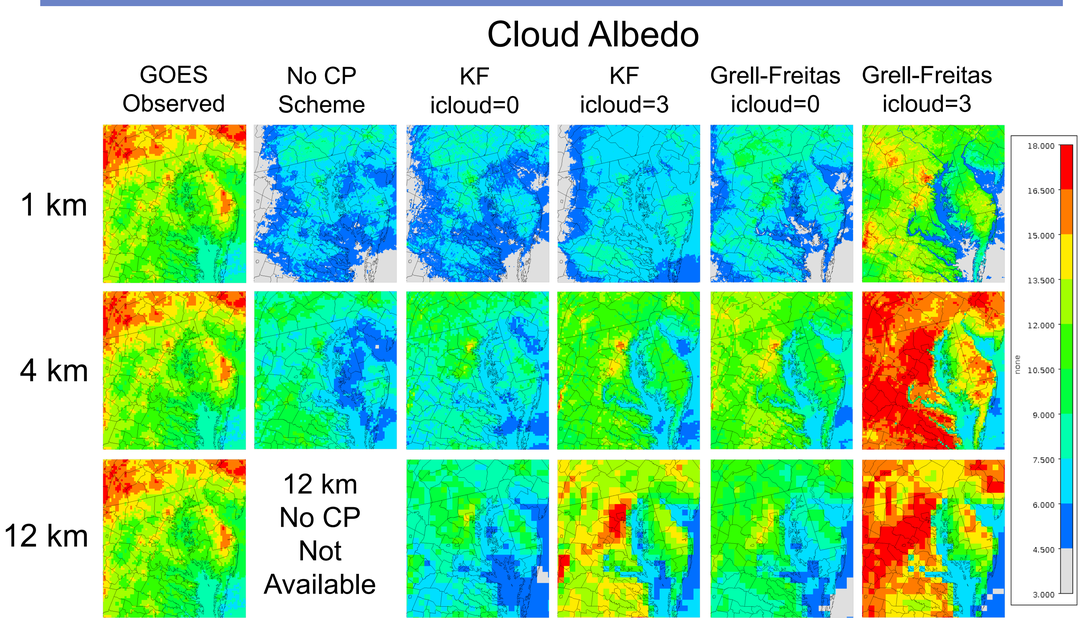
However, ever increasing computing power and the need to address issues such as ozone and fine particulate matter ($PM_{2.5}$) in residual non-attainment areas and city-scale health impacts from air pollution, have led to finer-scale air quality simulations (e.g. 1 km x 1 km) exploring finer-scale simulations to better inform decision makers and health scientists.

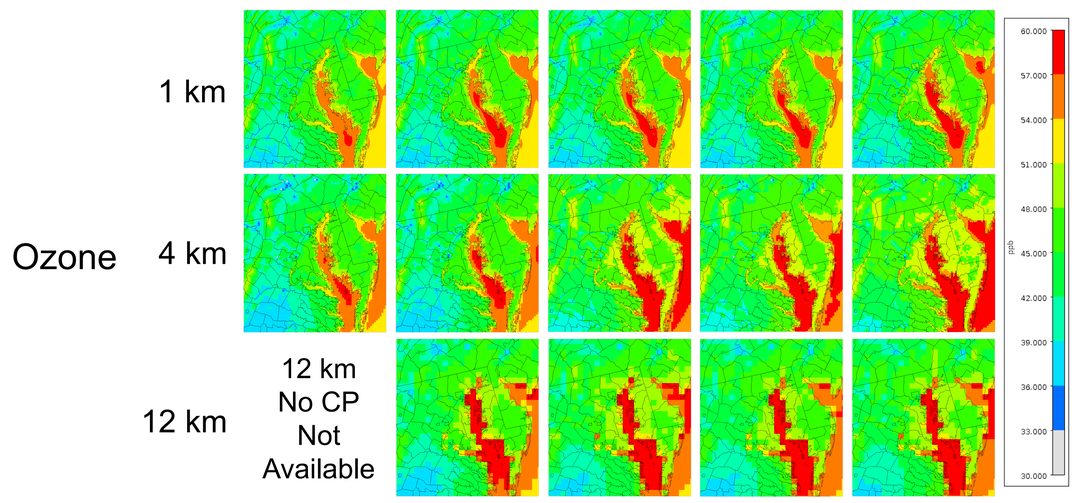
Methods

Here we examine the impact of several cumulus parameterization (CP) options available in the Weather Research and Forecasting (WRF) model in an effort to improve the simulation of clouds and air quality at fine scales. Specifically, these options are: no CP scheme (NoCP); Kain-Fritsch (KF); Grell-Freitas; and icloud=0 and icloud=3, which affects the cloud fraction for microphysics clouds.

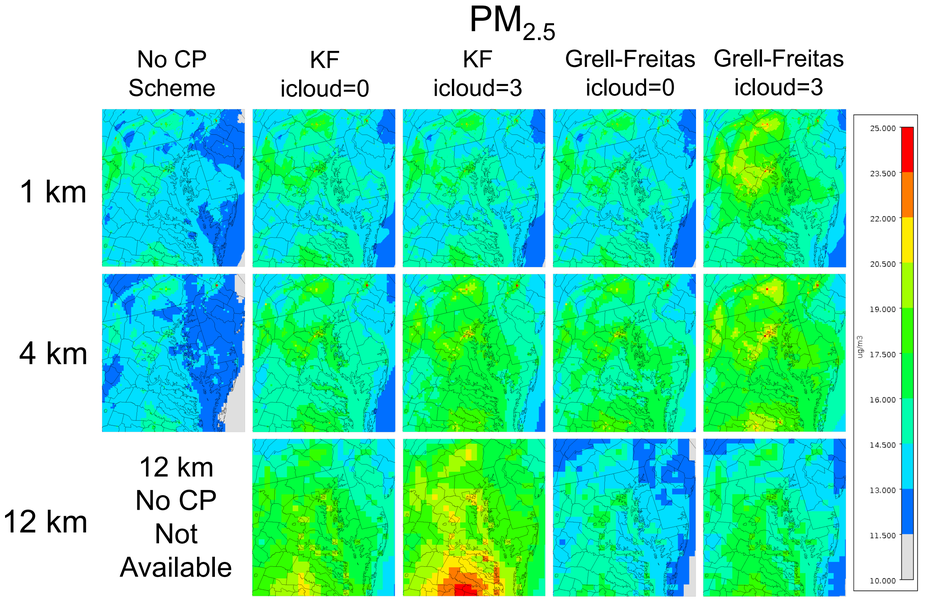
We perform a series of coupled WRF-CMAQ model simulations using WRF v3.8.1 and CMAQ v5.2.1 for July 2011 over the Baltimore-Washington D.C. region employing various combinations of the CP options at 12 km, 4 km and 1 km horizontal grid resolution. We then examine the monthly average cloud albedo, ozone and $PM_{2.5}$ from each simulation and note differences in each.

Impact of CP Options on Cloud Albedo and Ozone





Impact of CP Options on $PM_{2.5}$



Summary and Future Work

Cloud albedo varies significantly with CP options and grid resolution
- WRF tends to underestimate cloud albedo for most CP/icloud options

Grell-Freitas with icloud=3 results in greatest simulated cloud albedo
- Results in improved performance at 1 km, overestimation at 4 and 12 km

Ozone various slightly with CP options
- Unclear why ozone does not change more significantly with changes in albedo

$PM_{2.5}$ shows much greater sensitivity to CP option than ozone
- Increased in-cloud aqueous SO_4^{2-} production contributes to increased $PM_{2.5}$

Future work include:
- Examining the correlation between simulated cloud albedo and ozone and $PM_{2.5}$ in greater detail
- Possibly applying a similar experiment to southern California for winter 2013

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