Sensitivity of Ozone and Particulate Matter Concentrations in Greater Athens Area, Greece

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ABSTRACT: Sensitivity of ozone and particulate matter concentrations to their precursor emissions (i.e., NO_x, VOCs, SO_2 and NH_3) on regional air quality over Athens (Greece) using the Community Multiscale Air Quality (CMAQ) Modeling System is investigated. Particulate matter concentration is more sensitive to SO_2 and NO_x emissions. Gas emitted SO_2, is oxidized to sulfuric acid, which reacts with ammonia to form ammonium sulfate while gas emitted NO_x, is oxidized to nitric acid, which reacts with ammonia to form ammonium nitrate. When NO_x and VOCs mix in the presence of sunlight ground level ozone is formed. The response of ambient ozone formation to reductions in NO_x and VOC emissions depend on NO_x sensitive and VOC sensitive regimes.

INTRODUCTION

The Athens Larger Urban Zone (ALUZ) is one of the most populous Larger Urban Zones in the EU with a population of more than 4 million inhabitants. As most metropolitan areas in the world, ALUZ faces air pollution problems.

These problems are the result of high population density, the accumulation of major economic activities, the topography and the intense sunshine, which contributes particularly during the summer months.

Although the concentrations of most pollutants (i.e., SO_2, NO_2, CO, Pb, and benzene) were bellow the EU air quality limits in 2008 according to the most recent report of the Hellenic Ministry for the Environment on air quality in Athens, ozone (O_3) and particulate matter (PM) remain an issue of concern.

The objective of this study is to assess the sensitivity of O_3 and $PM_{2.5}$ (particulate matter with aerodynamic diameter less than 2.5μm) concentrations to their precursor emissions on regional air quality over ALUZ. The information provided here will enhance the ability of air quality managers to consider appropriate emissions reductions in their mitigation planning.

METHODOLOGY

The Community Multiscale Air Quality model (CMAQ) (Byun and Schere, 2006) ver. 4.7 with the CBIV chemical mechanism is used to simulate pollutant concentrations (i.e, O_3 and $PM_{2.5}$) over the modeling domain (Figure 1).

The domain is divided in 103 × 103 cells of 1 km × 1 km resolution while 14 vertical layers are employed in the simulations.

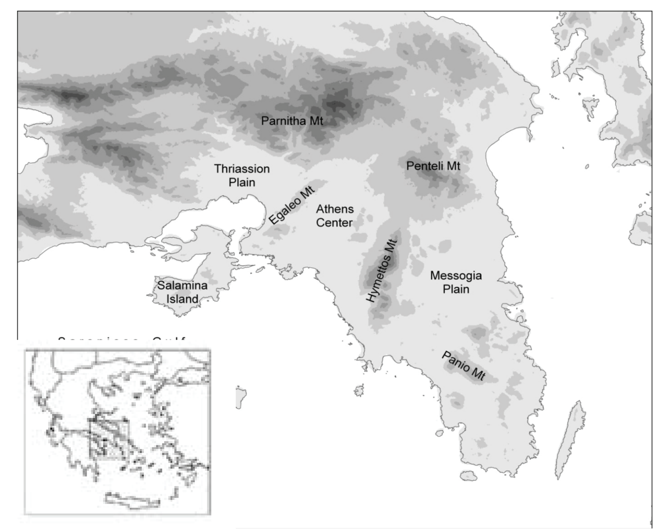
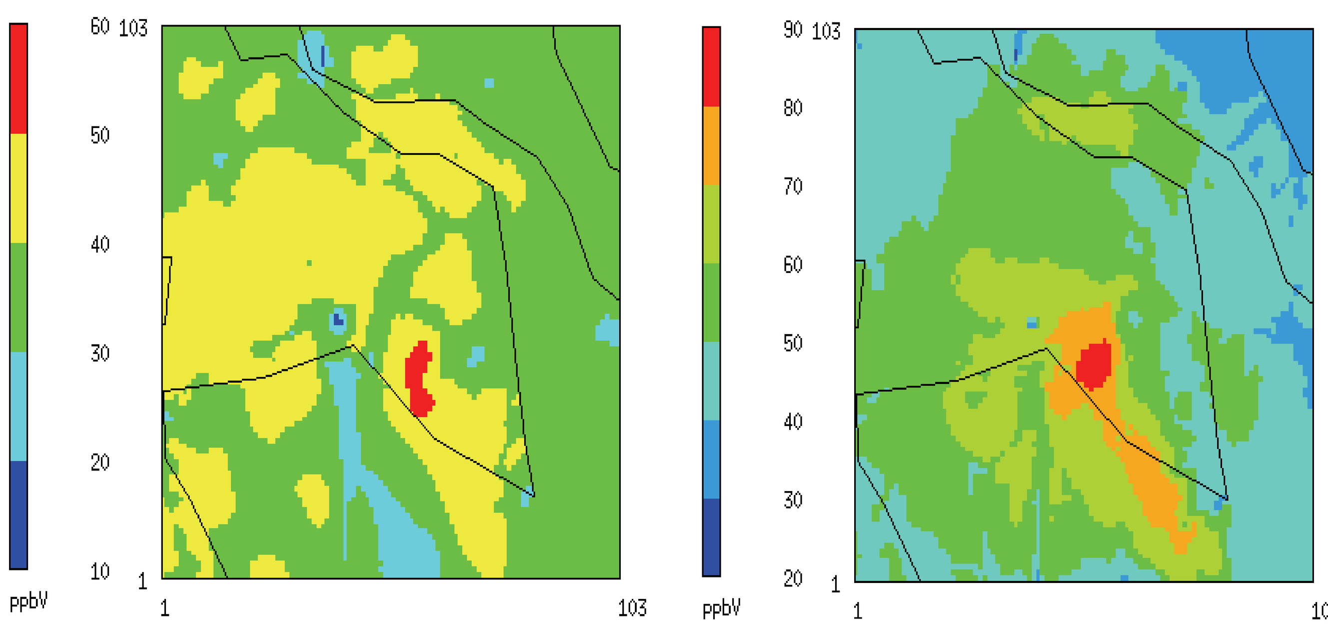


Figure 1: Modeling domain

The episode of June 24, 2003 has been selected in order to examine the responses of O_3 and $PM_{2.5}$ concentrations to emissions reductions of NO_x, VOCs, SO_2 and NH_3.

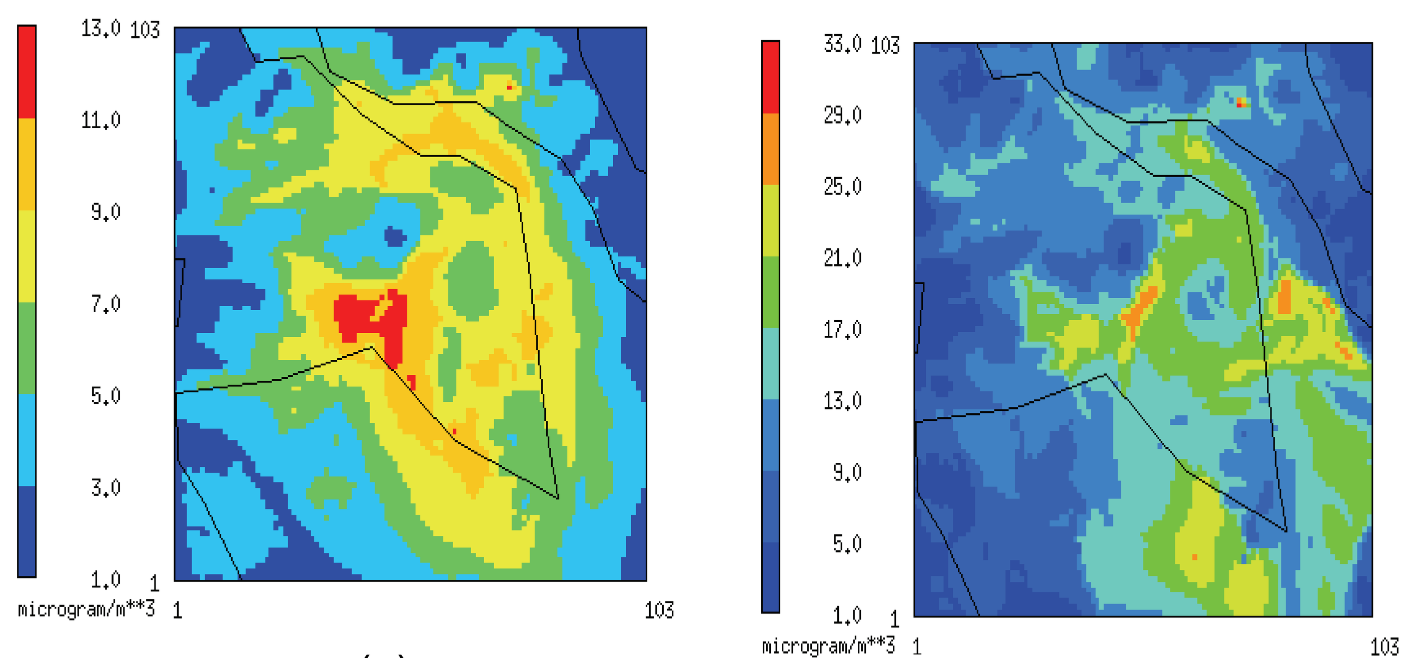
The Fifth Generation NCAR/Penn State Mesoscale meteorological Model (MM5) (Grell et al., 1994) is used to simulate the meteorology while an updated emission inventory based on our previous work (Sotiropoulou et al., 2004) is employed. A spin up time of one day was used to wash out errors in the initial conditions and to emphasize the physics and chemistry simulated by the model.

MODELING RESULTS



(a) (b)

Figure 2: O_3 daily average (a) and hourly maximum (b) concentrations on June 24, 2003



(a) (b)

Figure 3: $PM_{2.5}$ daily average (a) and hourly maximum (b) concentrations on June 24, 2003

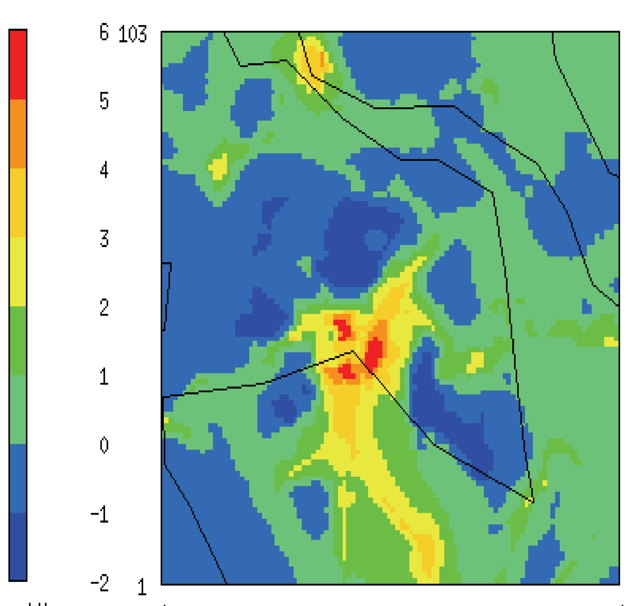


Figure 4: Δ_O_3 daily average concentrations for 30% NOx emissions reduction

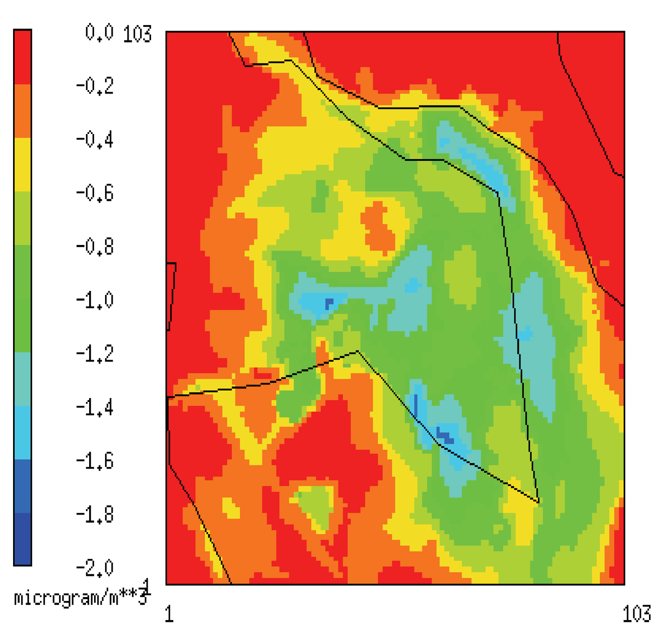


Figure 5: $\Delta\_PM_{2.5}$ in daily average concentrations for 30% NOx emissions reduction

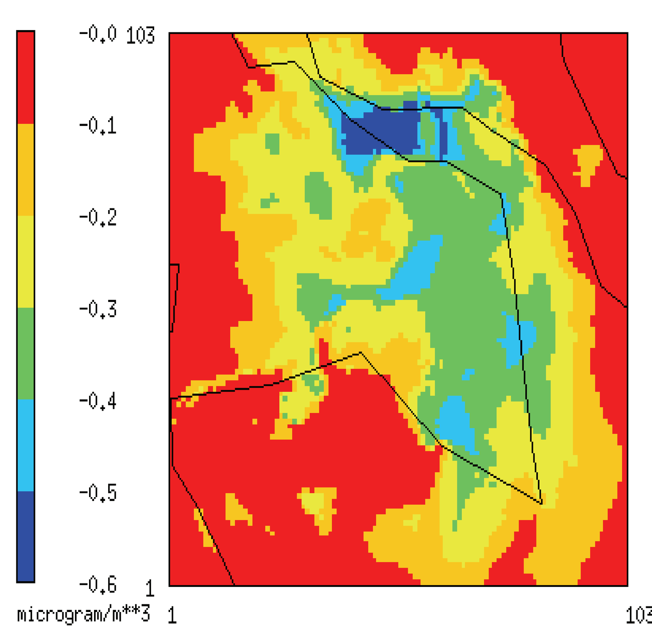


Figure 6: $\Delta\_PM_{2.5}$ in daily average concentrations for 30% SO_2 emissions reduction

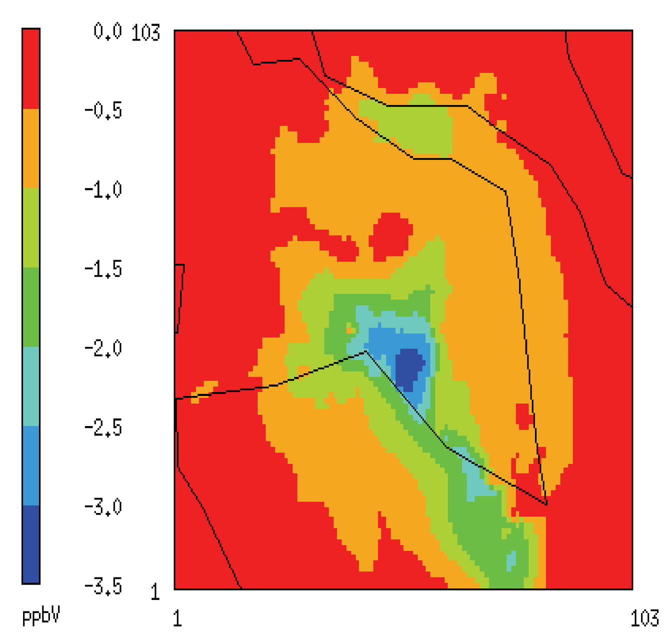


Figure 7: Δ_O_3 in daily average concentrations for 30% VOC emissions reduction

CONCLUSIONS

Control of VOC emissions is simulated to be the most effective way to reduce O_3 concentration mainly in the city center of Athens.

Control of NOx emissions is simulated to be the most effective way to reduce $PM_{2.5}$ concentrations but since the reductions in NOx emissions results in an increase of O_3 levels in the city center (VOCs limited area), the reduction in SO_2 emissions is suggested as a better way to be adopted in air pollution mitigation strategy.

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