Simulating the photochemical pollution above the Greater Athens Area and Ozone source apportionment during an air quality episode with the MM5/CAMx model

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Introduction

- The Greater Athens Area (GAA) has undergone significant changes.
- Despite measures taken photochemical and particulate air pollution episodes continue to occur.
- Few modelling studies exist due to the lack of up-to-date, accurate and detailed emission inventory.
- Construction of the Flexible Emission Inventory for Greece and the GAA (FEI-GREGAA) from 2006 – 2012.

Objectives

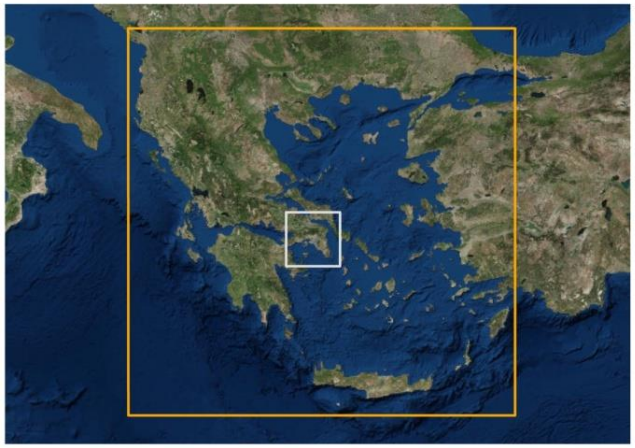
- Simulations with the MM5/CAMx modeling system for typical photochemical and particulate pollution summer episodes in the GAA.

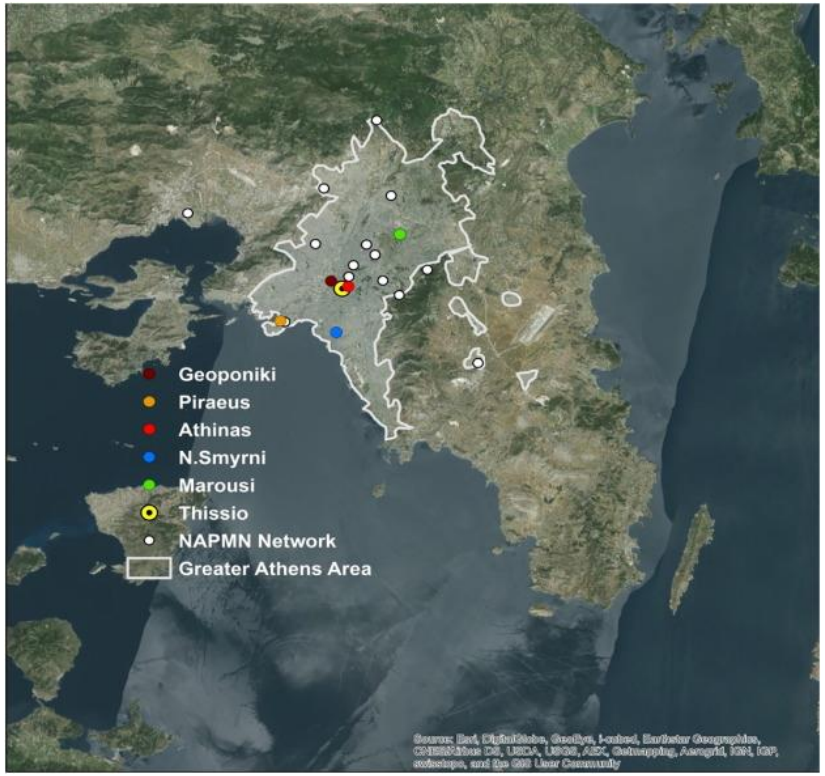
- Study the dispersion characteristics of pollutants above the GAA.

- Estimate the impact of different sources on the formulated pollutant levels.

- Compare the modelled results with real time measurements.

Region - *Study Area Characteristics*





Background information

- O3, NOx and PM data from the Athens Air Quality Monitoring Network, Mesogeia and Thriassion Plains were analysed from 2003 – 2012.
- Stations characterisation was Urban Traffic, Suburban, Urban Background, Suburban Background, Industrial
- O3 mean annual concentrations have been rising in the suburban background stations (from 69 to 81μg/m3). More episodes occur there especially during the summer.
- Almost constant and lower in the Athens basin (58 to 61μg/m3)
- Ozone episodes continue to appear, may vary in duration and be in parallel with PM.

Background information

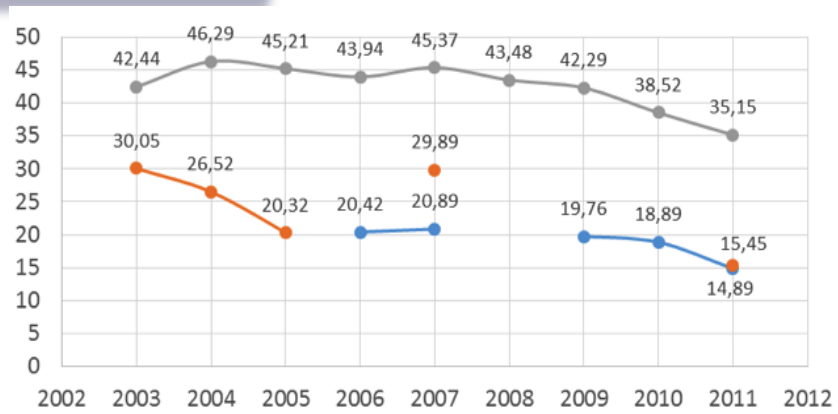
- NO_2 pollution episodes occurred until 2009 throughout the year except in August in traffic stations.

- O_3 pollution episodes are frequent in peripheral stations, especially in the warm period with no decreasing trend.

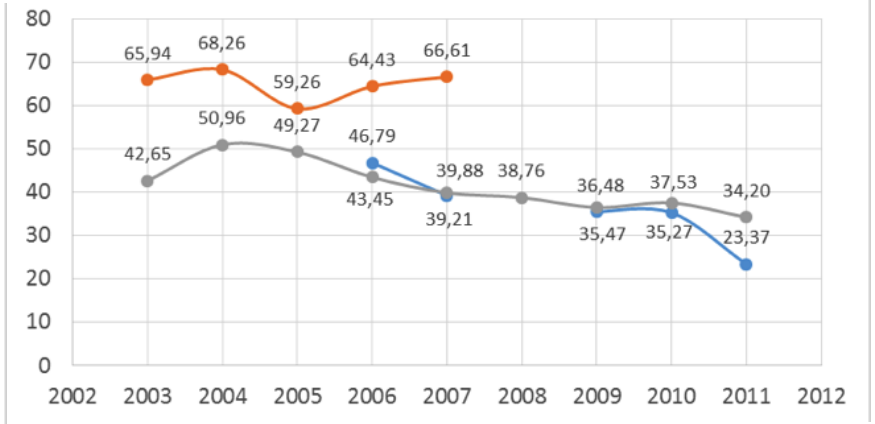
- PM_{10} pollution episodes occur throughout the year across the GAA and may last for several days. The most persistent occurred in 2007 and 2008.

- All episodes are associated with low wind speeds of southerly or southwesterly direction mainly. High temperatures lead to higher O_3 levels.

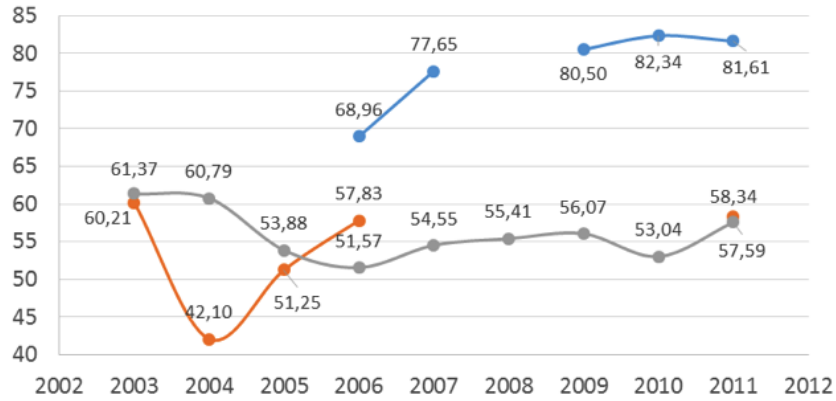
Background information



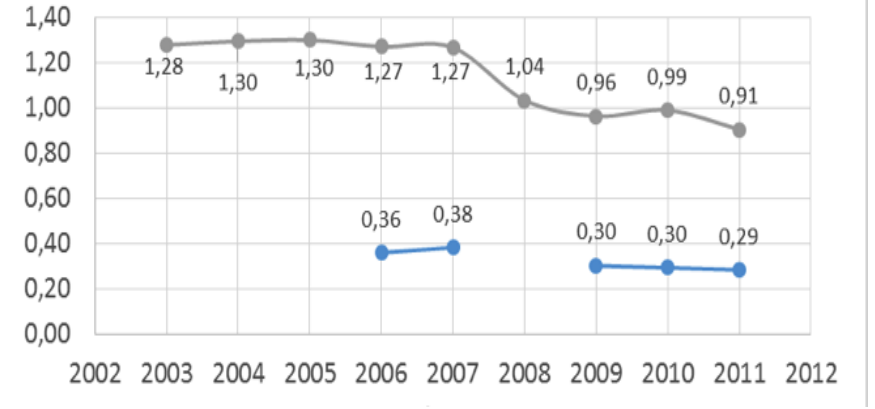
Evolution of NO_2 levels above the GAA (μg/m^3)



Evolution of PM_{10} levels above the GAA (μg/m^3)



Evolution of O_3 levels above the GAA (μg/m^3)



Evolution of CO levels above the GAA (mg/m^3)

Background Information

- NO_2 pollution episodes occurred until 2009 throughout the year except in August in traffic stations.

- O_3 pollution episodes are frequent in peripheral stations, especially in the warm period with no decreasing trend.

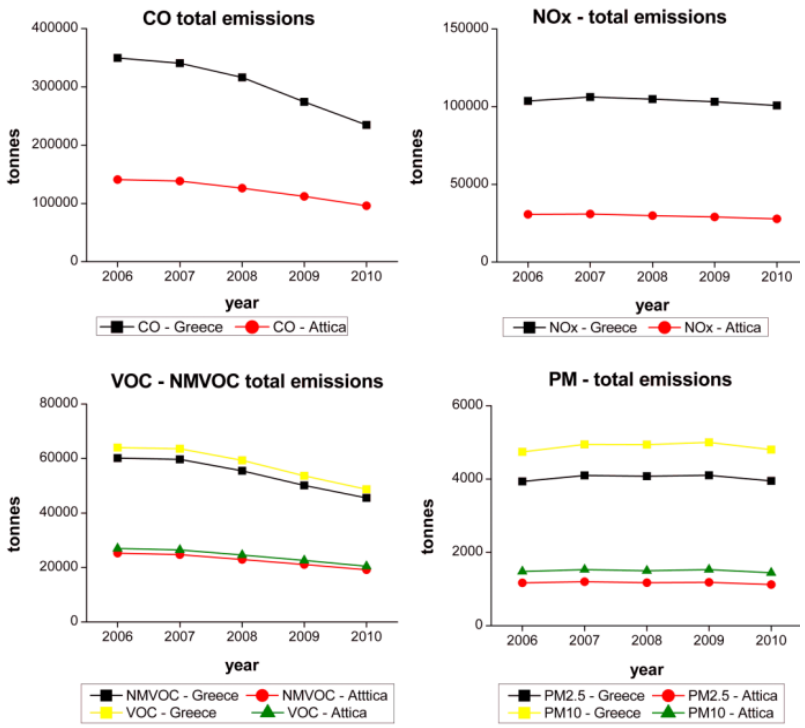
- PM_{10} pollution episodes occur throughout the year across the GAA and may last for several days. The most persistent occurred in 2007 and 2008.

- All episodes are associated with low wind speeds of southerly or southwesterly direction mainly. High temperatures lead to higher O_3 levels.

Methodology-*Description of F.E.I.-GREGAA*

- F.E.I. - GREGAA (Flexible Emission Inventory for Greece and the GAA) *Period:* 2006-2010,
- *Spatial and temporal scale:* 6x6km^2 for Greece and 2x2km^2 for the GAA , 1hour
- *Methodology:* EMEP/EEA Emission Inventory Guidebook 2009 and 2013 for 10 SNAP levels: SO_2, NO_x, CO, PM_{10}, $PM_{2.5}$, NMVOCs, VOCs, NH_3 and CO_2.
- *Annual emissions:* Official, accurate, analytical data (traffic fleet, airplane fleet etc.)
- *Spatial and temporal allocation:* proxy values per source category (degree of urbanization, population density, updated land use, road types and seaways).

Methodology-*Description of F.E.I.-GREGAA*



Annual variation of emissions in Greece and the GAA

Methodology – *Initial and Boundary Conditions*

Model: Comprehensive Air quality Model with extensions – CAMx emission, dispersion, chemical reaction and removal of pollutants in the troposphere.

Domain: Three nested grids of resolution18×18, 6×6 and 2x2 km^2 covering Europe, Greece and the GAA, respectively.

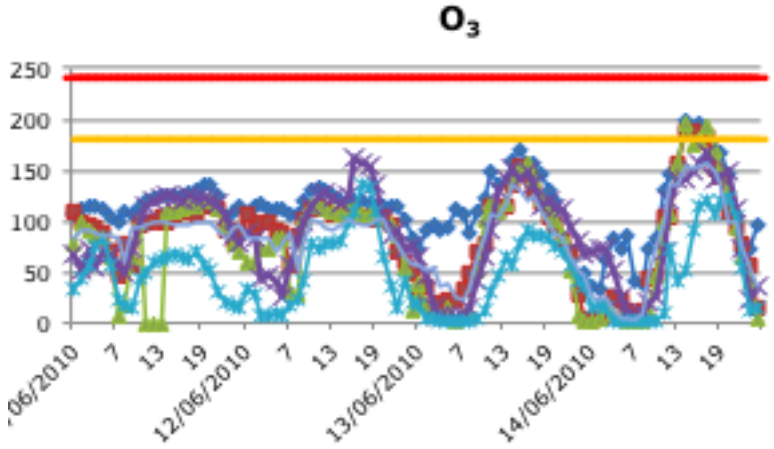
Simulation period: (two-day spin), 00.00 UTC 10/6/2010 to 24.00 UTC 20/6/2010

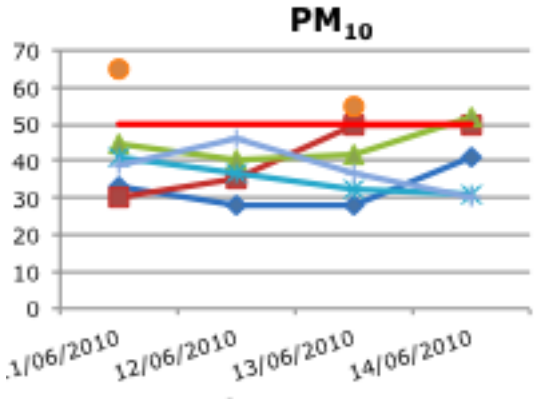
Meteorological Inputs: temperature, wind, pressure, humidity, and cloud/rain) by Mesoscale Meteorological Model MM5.

Initial and boundary conditions: 50 ppb for O_3, 0.1ppb for NOx, 200ppb for CO and 1.5 ppb for SO_2.

Chemistry: Carbon Bond (CB06)-CF mechanism

Methodology - *Air Quality Conditions*

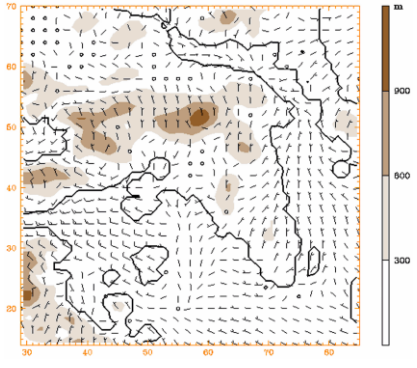
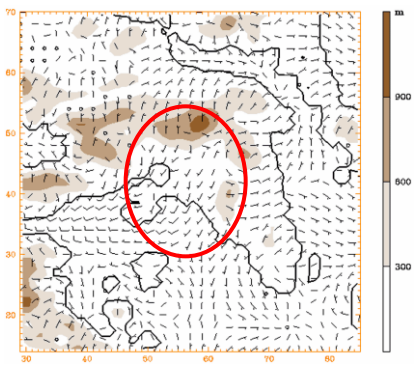
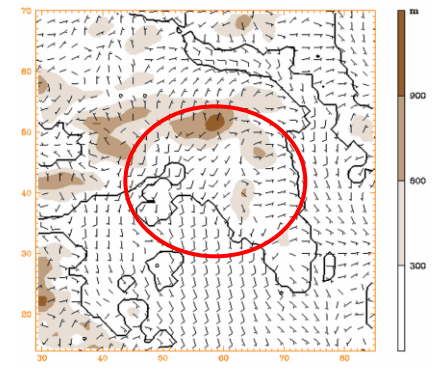
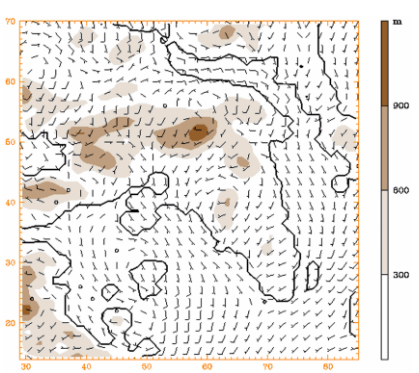




Ozone and particulates daily variations during the modelled period

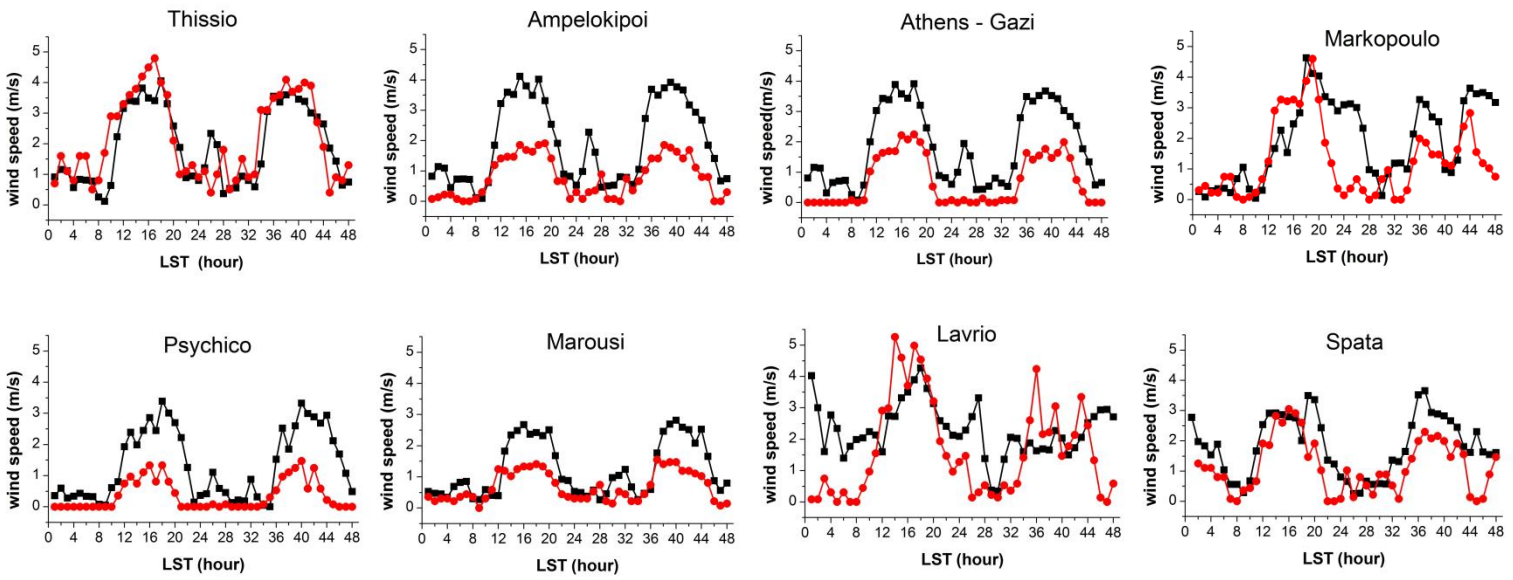
Methodology – *Meteorological Conditions*



6.00LST 12.00LST 15.00LST 21.00LST

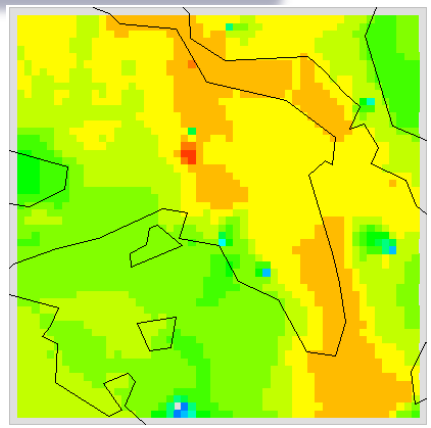
Results



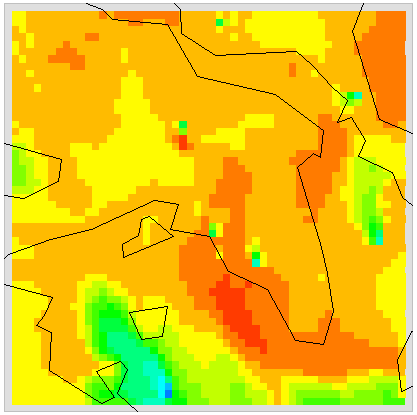
Comparison of the modeled (black line) and observed (red line) wind speeds at the NOA stations across the GAA

Results

O_3 – 14/06/2010



12.00LST



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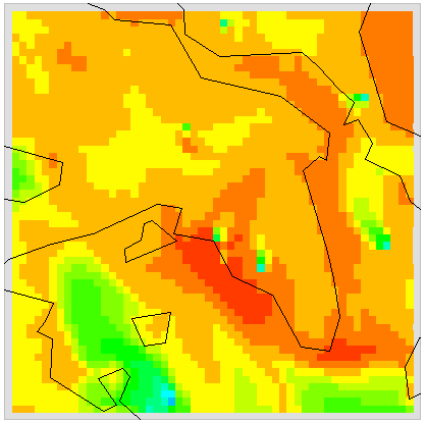
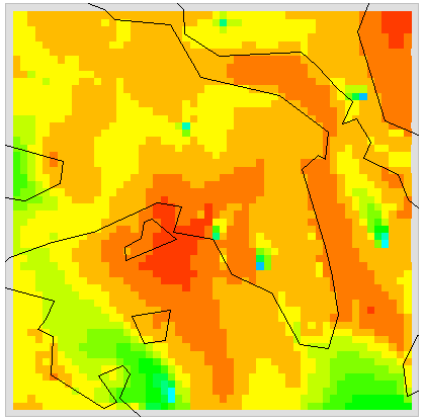
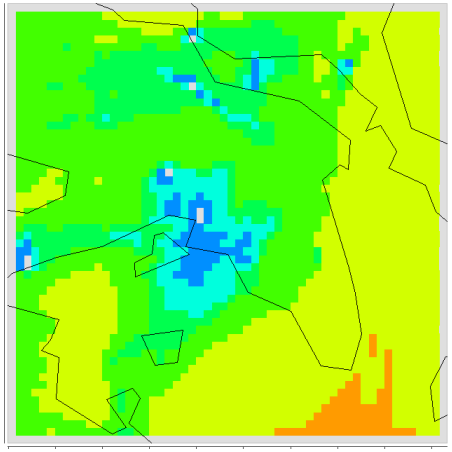


16.00LST

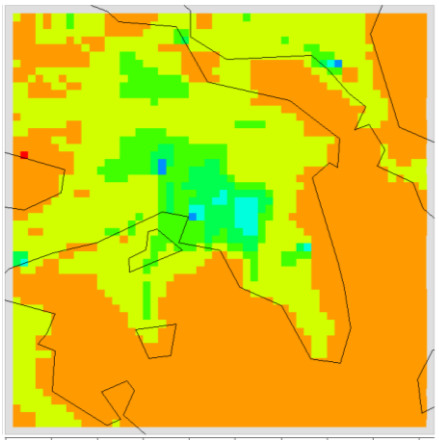


18.00LST

O_3 – 19/06/2010



09.00 LST



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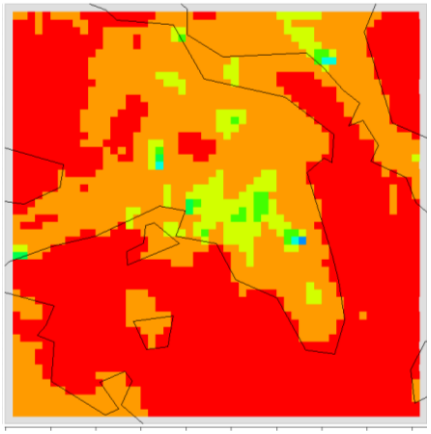

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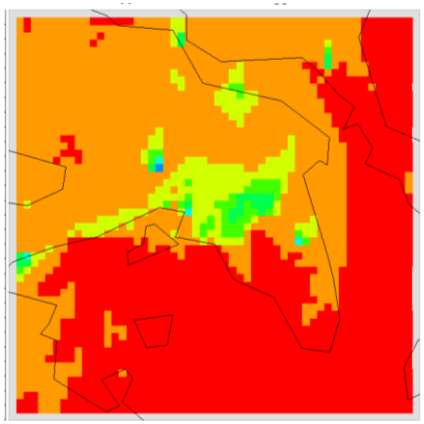
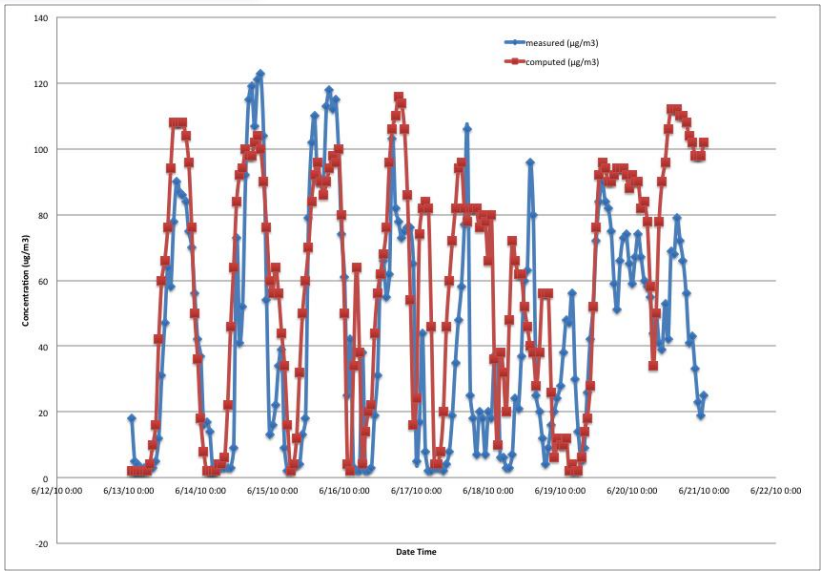


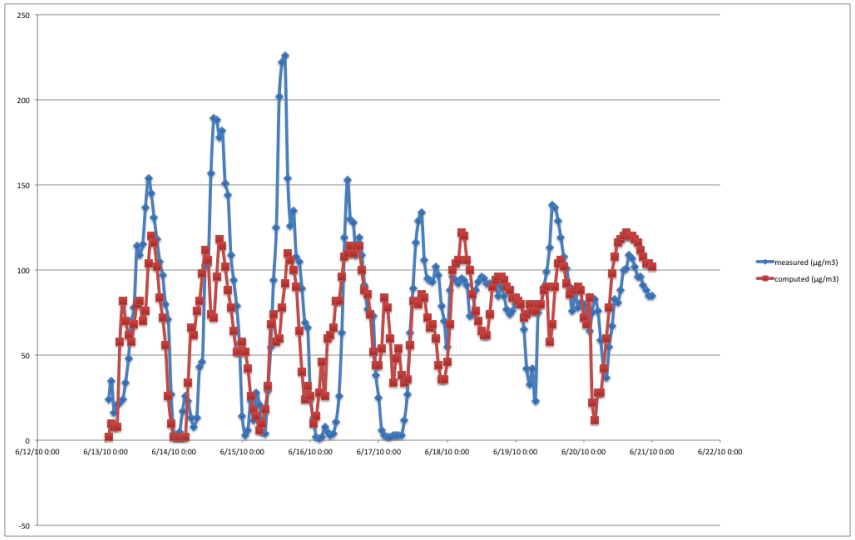
20.00LST

Results – *Comparing simulations with measured data*

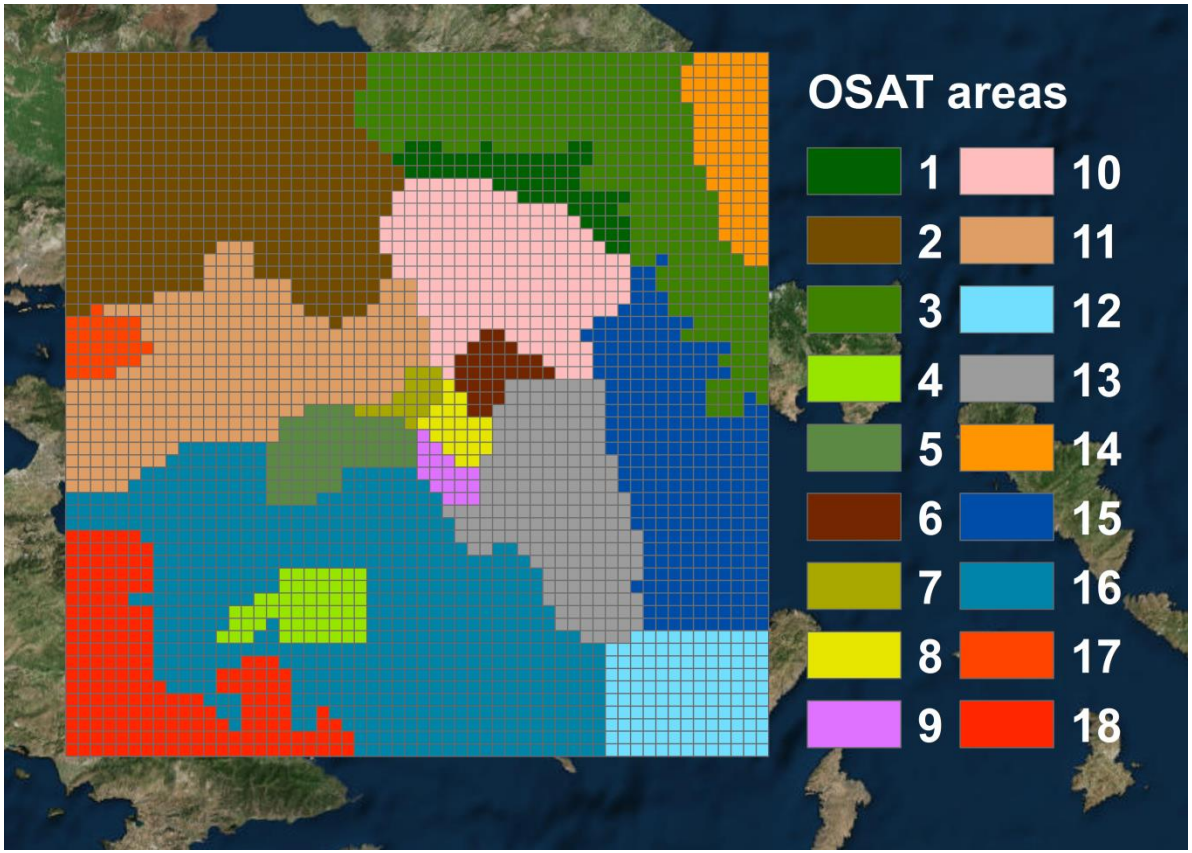


Southern suburbs

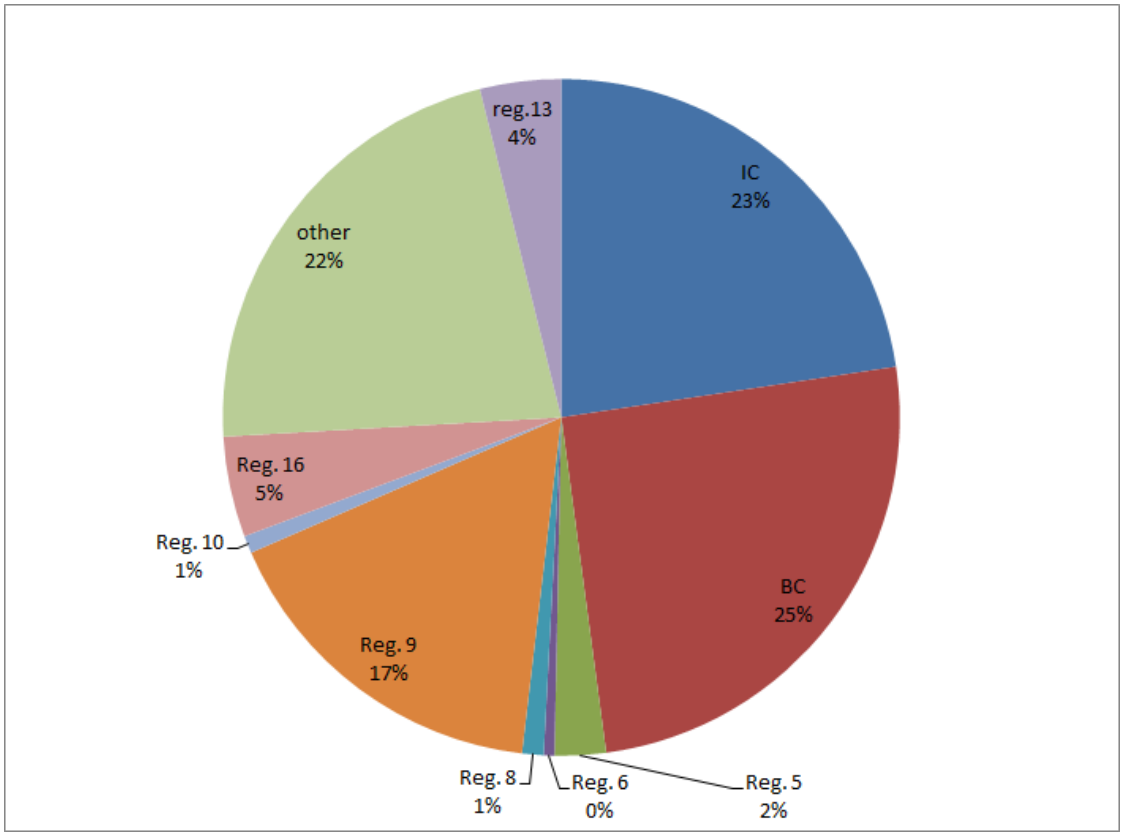
Northern suburbs



Results – *OSAT analysis*



Results – *OSAT analysis*



Contributions to O_3 concentration by source region at the receptor cell at 14:00

Conclusions

- The spatial disaggregation of emissions showed that the centre and suburbs are burdened with high CO, NOx, and PM_{10} emissions.

- Further development of the emission inventory to add biogenic emissions and update emission factors using targeted measurements.

- Comparison of CAMx results with measurements revealed a satisfactory agreement for the urban and rural stations.

- The O_3 plume penetrated the interior of the basin with the aid of the sea breeze mechanism.

Conclusions

- The character and concentration levels of the photochemical and particulate pollutants have not presented a significant decrease even though on average the emissions of primary pollutants have decreased.

- Different regions contribute to the ozone levels, the central and suburbs being significant.

- The air quality management of such a complex area requires the deep understanding of the impact of all sources with the combined effect of meteorology.

Conclusions

- Purpose: Short term air quality forecasting for Greece and Athens (in 2018)

- Pilot stage, comparison with AQMN data.

- Use FAIRMODE tools to ensure good quality of results and move to planning……

Thank you!

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