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Particulate matter source apportionment for the urban center of Thessaloniki (Greece) using the WRF-CAMx modeling system

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INTRODUCTION

The main aim of this work is the investigation of the contribution of different emission sources to the concentrations of Particulate Matter (PM) in Thessaloniki (Figure 1). More emphasis is given on the contribution of the **maritime/harbor activities** for which any existing information is very limited. PM is a key pollutant in the urban atmosphere of Thessaloniki. The 24-h EU limit value for PM10 is frequently exceeded in the urban monitoring sites, ranking the city among the most polluted in Europe regarding PM10.

Figure 1. The city of Thessaloniki and the Source Apportionment sites of interest.

MODELLING SYSTEM

- The modeling system used consisted of the photochemical air quality model **CAMx** off-line coupled with the mesoscale meteorological model **WRF**. The application of CAMx was extended to include the tool Particulate Source Apportioning Technology (PSAT) in order to provide PM source apportionment among specific source categories.
- The modeling system was applied over a 10km resolution grid that covered the Balkan Peninsula and over a 2km grid over Thessaloniki. There were 17 vertical layers extending up to 10 km above ground level.
- The gaseous and PM chemical boundary conditions for the Balkan domain were taken from the **IFS-MOZART** global modeling system.

POLLUTANT EMISSSION DATA

- A 2km spatial resolution anthropogenic gaseous and PM emission inventory for the port city of Thessaloniki was compiled for the reference year 2008 (Liora et al 2011) using the anthropogenic emission model **MOSESS** (developed by LAP-AUTH) (Markakis et al 2009). The calculation of emissions for almost all sources was based mainly on activity data provided by local and national authorities.
- Emphasis was given on the estimation of pollutant emissions from the **various activities and sources inside the area of the harbor** (stockpiles, (un)loading operations, harbor machineries etc) as well as from the **maritime transport** (cargo, passenger ships, tugs etc) (reference year 2010).
- A **Natural Emission MOdel (NEMO)** driven by WRF was also used to calculate the biogenic NMVOCs, sea salt and wind-blown dust emissions (Poupkou et al., 2010).
- The emission sources apportioned for Thessaloniki were the following:

  i. Road transport
  ii. Maritime/Harbor activities
  iii. Central heating
  iv. Industries
  v. Windblown Dust
  vi. Biogenic NMVOCs
  vii. Left over sources (e.g. industrial and construction machineries, waste treatment, agriculture, solvent use, distribution of fuels).

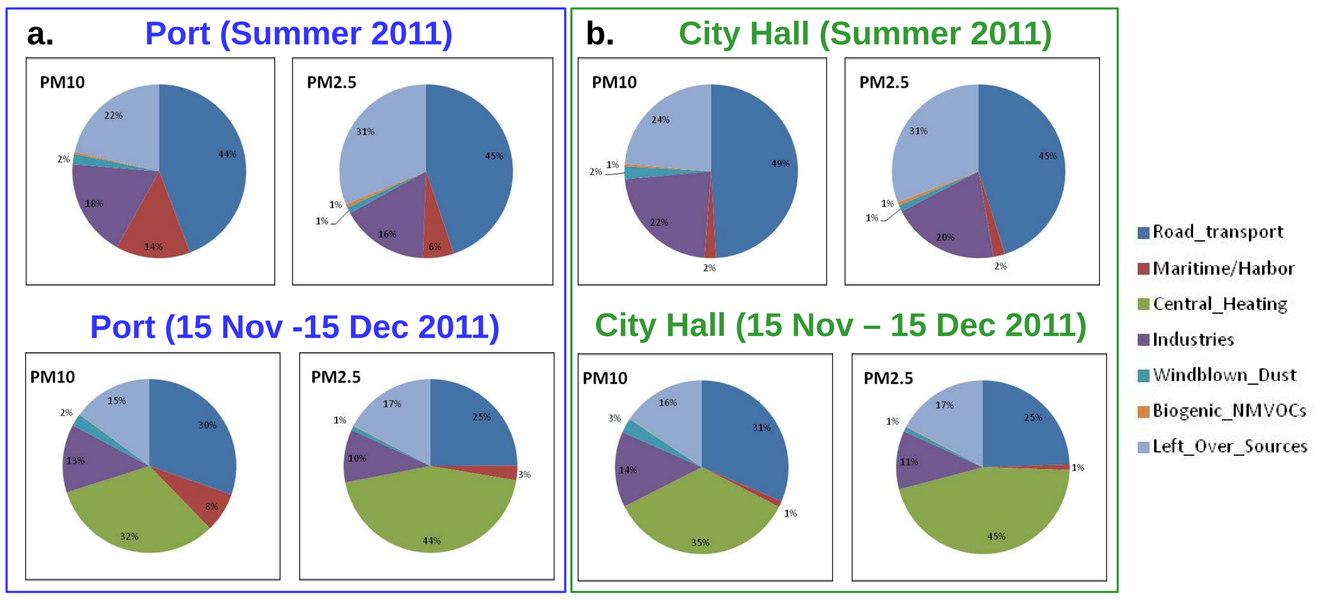

Figure 2. Source Apportionment for PM10 and PM2.5 during summer and wintertime in the Port and City Hall.

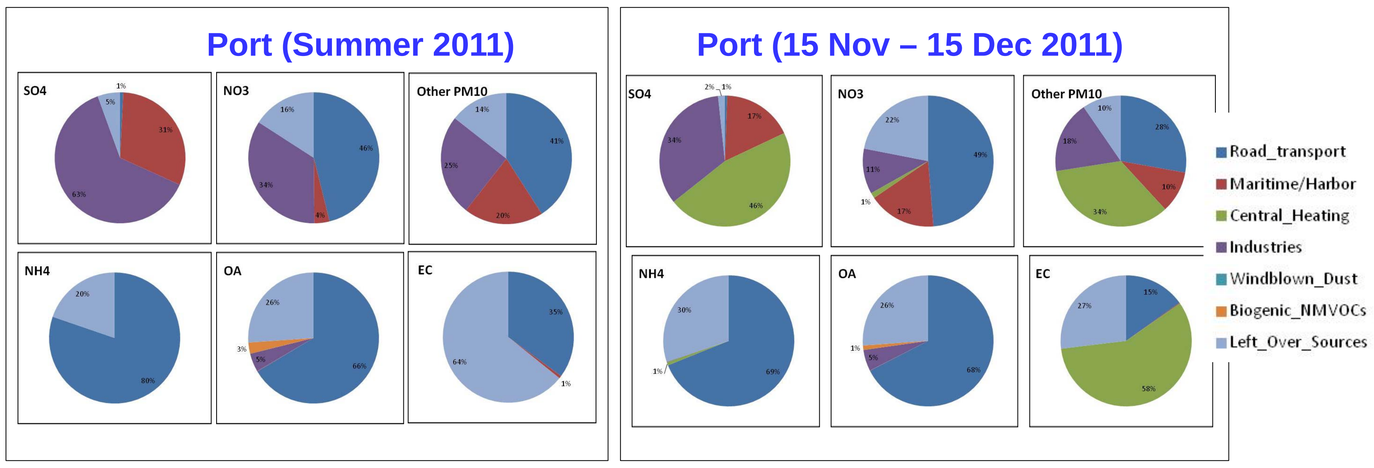

Figure 3. Source Apportionment for the PM2.5 chemical species (except for the Other PM representing the PM10 fraction) in the Port.

SIMULATION PERIODS

- 1) Summer 2011, 2) 15 November to 15 December 2011.

SOURCE APPORTIONMENT RESULTS AND CONCLUSIONS

✓ The pollution transported to Thessaloniki from emission sources **outside** the study domain is **not** examined.

1. **Port area** (Figure 2a)

Summer
- Road transport: Highest contribution to the PM10 and PM2.5 mean concentrations.
- Maritime/Harbor activities: Moderate contribution (14%) to the PM10 and small contribution (6%) to the PM2.5 average levels.

Winter
- Road transport and Central heating: Equal contribution (~30%) to the PM10 mean values.
- Central heating: Highest contribution to the PM2.5 average concentrations.
- Maritime/Harbor activities: Small contribution to the PM10 (8%) and the PM2.5 (3%) mean levels.

2. **City Hall area** (Figure 2b)

- Similar results with the **Port** area except for the contribution of the Maritime and Harbor activities to the PM mean concentrations being very small both during summer and wintertime.

3. **Source Apportionment for the PM Chemical Species in the Port area** (Figure 3)

Maritime/harbor activities have greater contribution to the concentrations of:

- Sulfates ($SO4^-$): Due to the fuels used (mainly for shipping)
- Nitrates ($NO3^-$): Probably of secondary origin
- Other PM10: Due to the harbor activities like (un)loading and handling of materials.

4. **Maps of PM2.5 Source Apportionment** (Figure 4)

The Maritime/ harbor activities contribution to the mean concentrations over the sea is:

- High in summer: More than 50% for the PM2.5 (up to 50% for the PM10).
- Moderate in wintertime: Up to 20% for the PM2.5 (and the PM10).

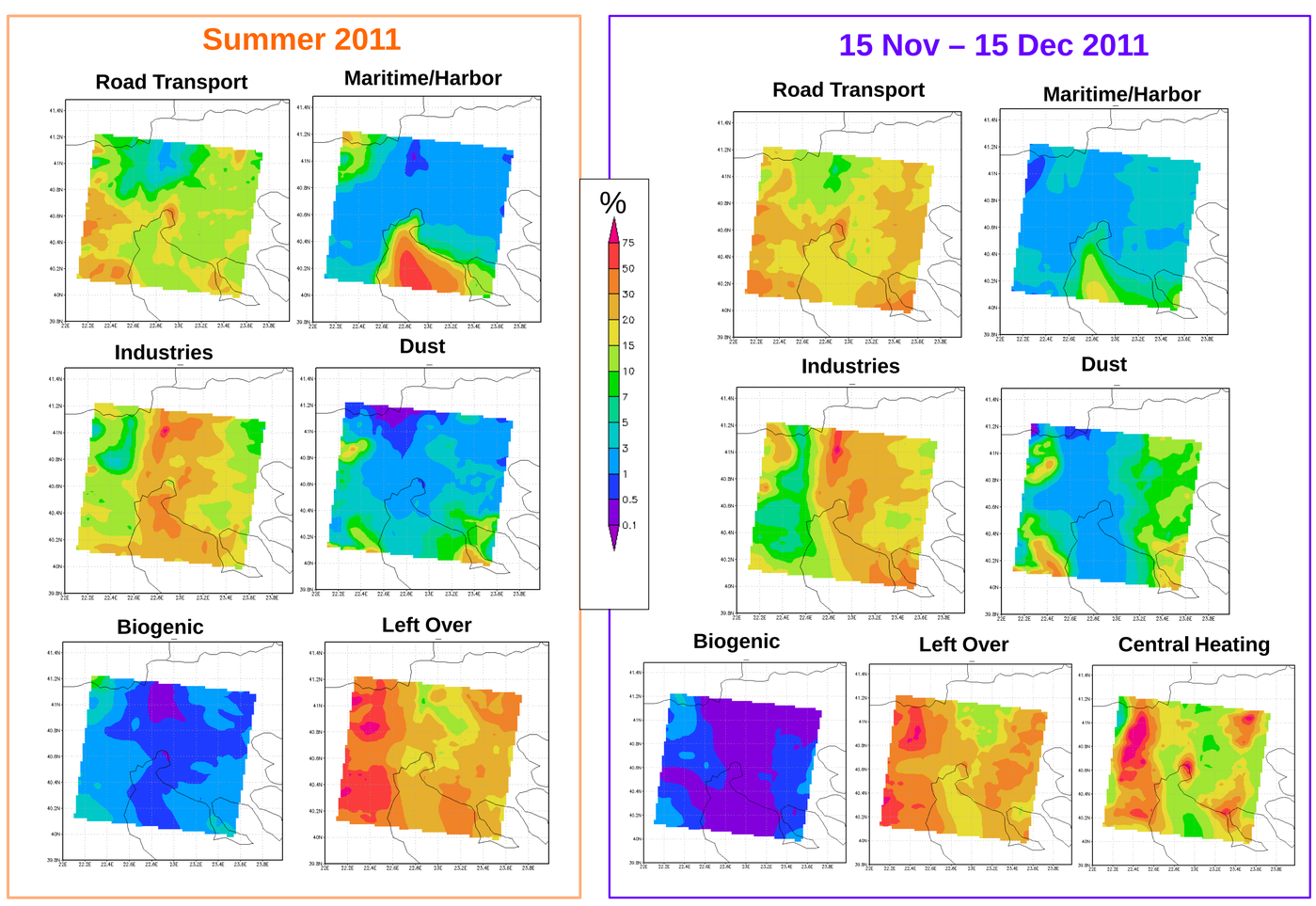

Figure 4. Spatial distribution of the % contribution of emission sources to mean PM2.5 concentrations in the study area.

References

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