Current and Future Urban Air Quality Monitoring
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Development of a Cost Efficient Policy Tool for reduction of Particulate Matter in Air

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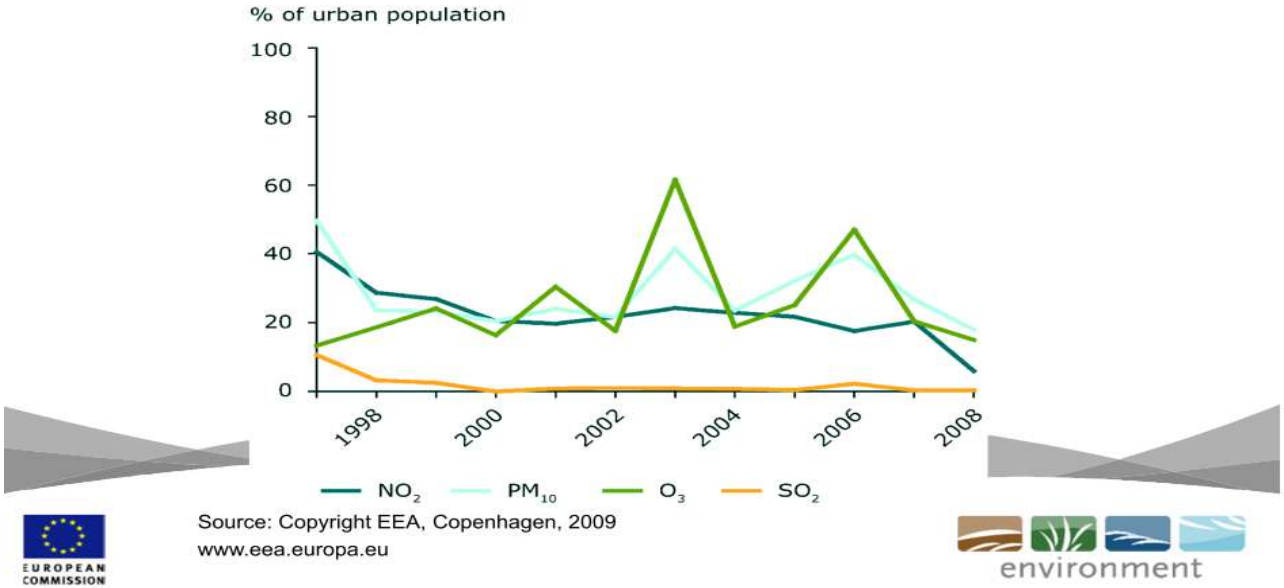
Introduction

- $PM_{2.5}$ and PM_{10} ambient concentration levels are still a major environmental problem in several urban areas in the E.U.
- New evidence of particulate matter long term impacts on human health continues to emerge.
- The Commission of E.C. is moving towards the implementation of the thematic strategy on air Pollution while a large part of the urban population in the E.U. continues to be exposed to PM concentration levels above limit values



ACEPT-AIR Project – Objectives (I)

The Development of a Cost Efficient Policy Tool for reduction of Particulate Matter in Air (**ACEPT-AIR**) aims to enable Authorities

- to **assess the reduction** of key environmental pollutants, as well as their interdependencies centered around **PM** levels
- to respond in a competent way to environmental issues, specific to **particulate matter** atmospheric concentrations.

Create a Policy Tool which will:

- Contain a database of PM concentrations, source apportionment studies results and emission inventories
- Create a historical record of control measures / changes in emissions and provide results in measured concentration reductions apportioned to changes in every accounted source
- Allow the policy makers to evaluate the effects of control measures applied on specific emission sources as well as plan new ones.

ACEPT-AIR Project – Objectives (II)

Three urban areas have been selected for study:

- Athens Metropolitan Area
- Thessaloniki Metropolitan Area
- Greater Volos Area

National Authorities will have to re-evaluate the present environmental policies and measures and develop new ones.

Urban areas and some industrial regions in Greece are among those in the E.U. with a high number of limit values exceedances in PM_{10} ambient concentrations.

Actions involved (I)

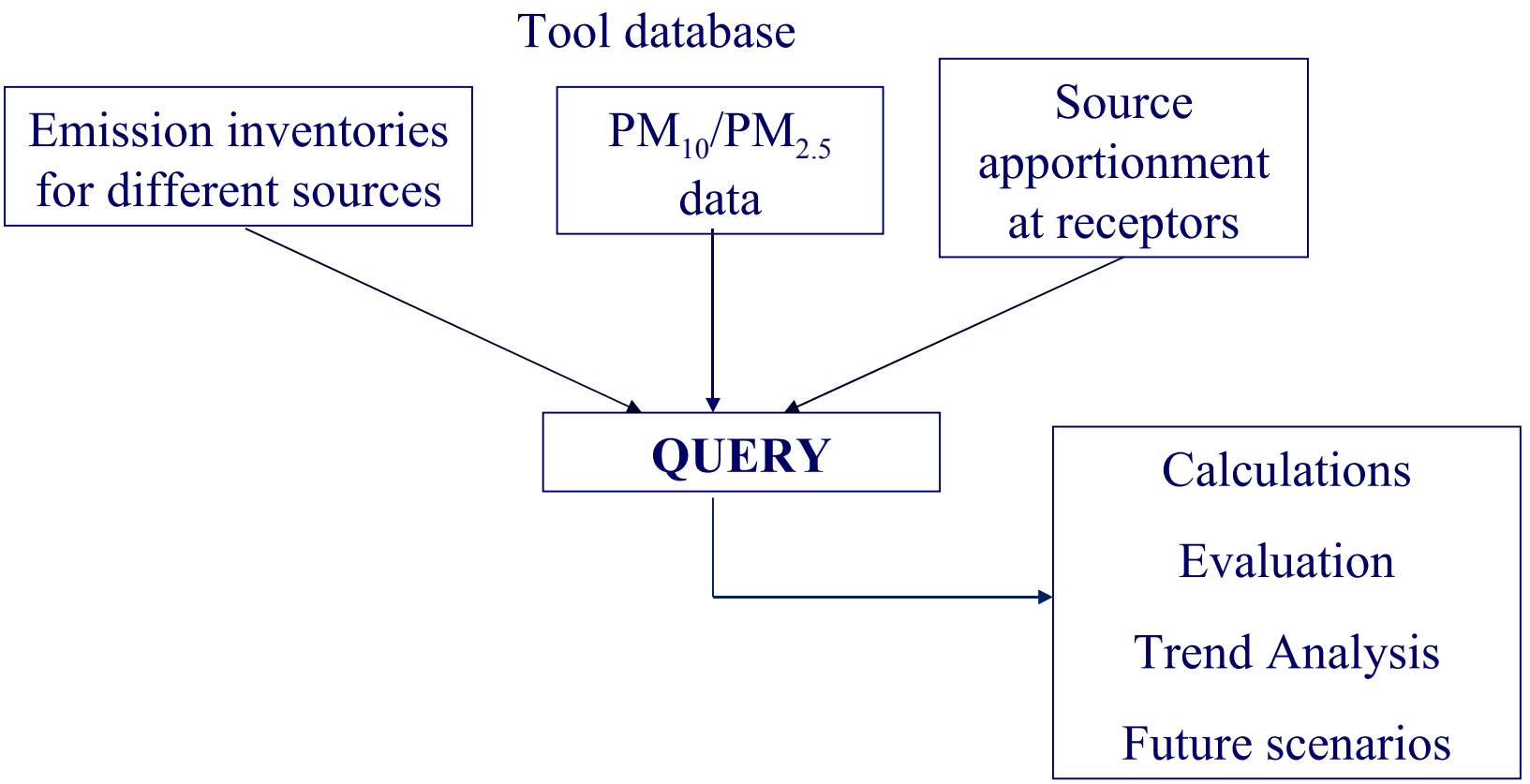
The project is implemented through the following Actions:

- Creation of a database of PM_{10} and $PM_{2.5}$ concentrations and chemical speciation for the three urban areas (Athens, Thessaloniki and Volos)
  - Collection and quality control of historical data
  - Execution of two aerosol campaigns (during warm and cold period) at the three urban centers

- Application of state of the art source apportionment techniques based on the developed databases and receptor modeling

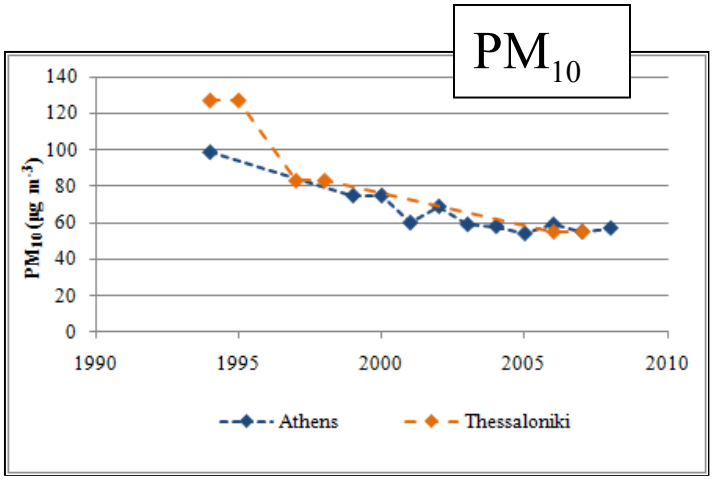
- Compilation of emission inventories for natural and anthropogenic sources for the three areas

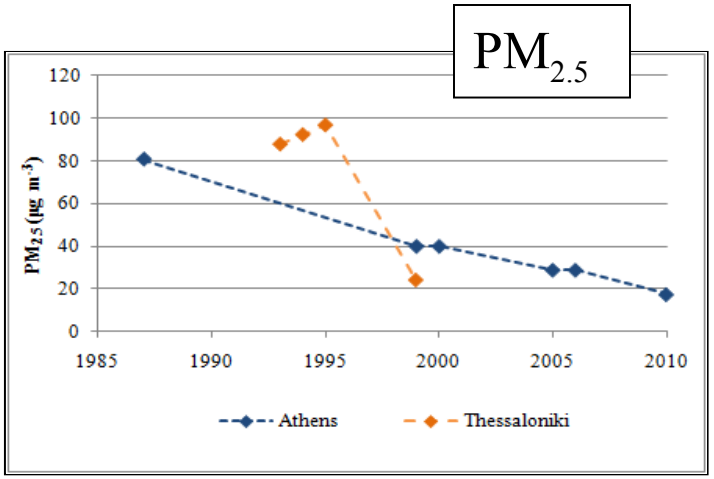
Concept and functions for the ACEPT-AIR Policy Tool Operational Platform



Historical PM concentrations database

- Long term trends are showing levels to fall but still hovering around target values



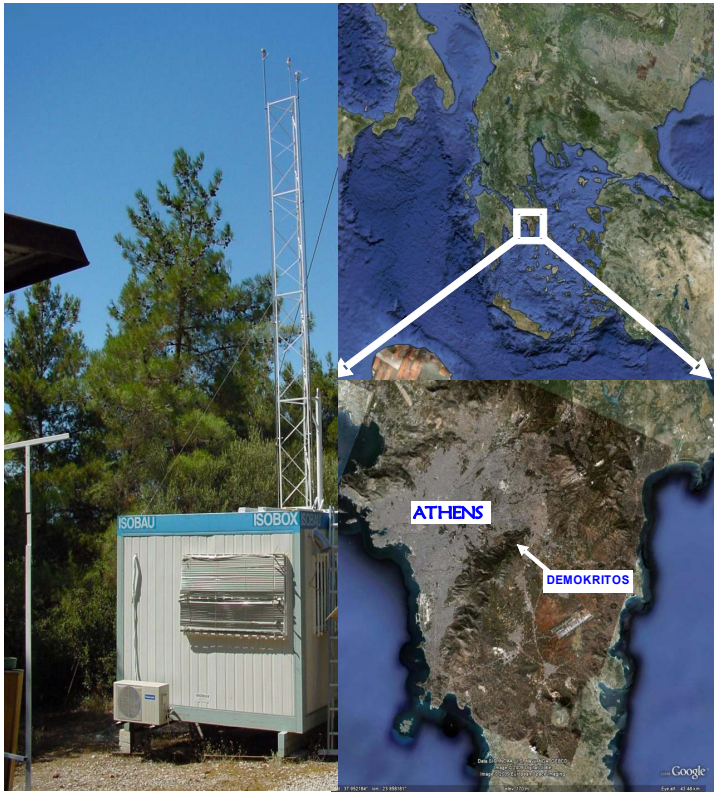


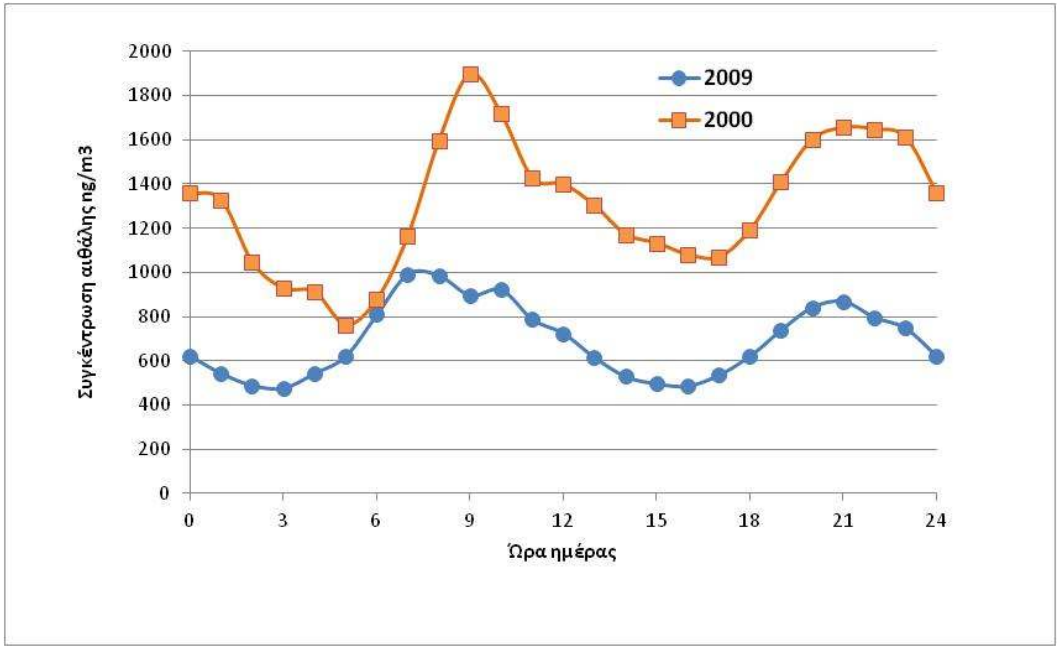
Pollution episode

Africal dust intrusion

Clear day

Long term observations of black carbon 24h mean cycle at the Demokritos Global Atmosphere Watch regional contributing station Show a marked reduction for key aerosol pollutants such as Black Carbon





Can we relate emissions and emission reductions to corresponding concentration levels and trends?

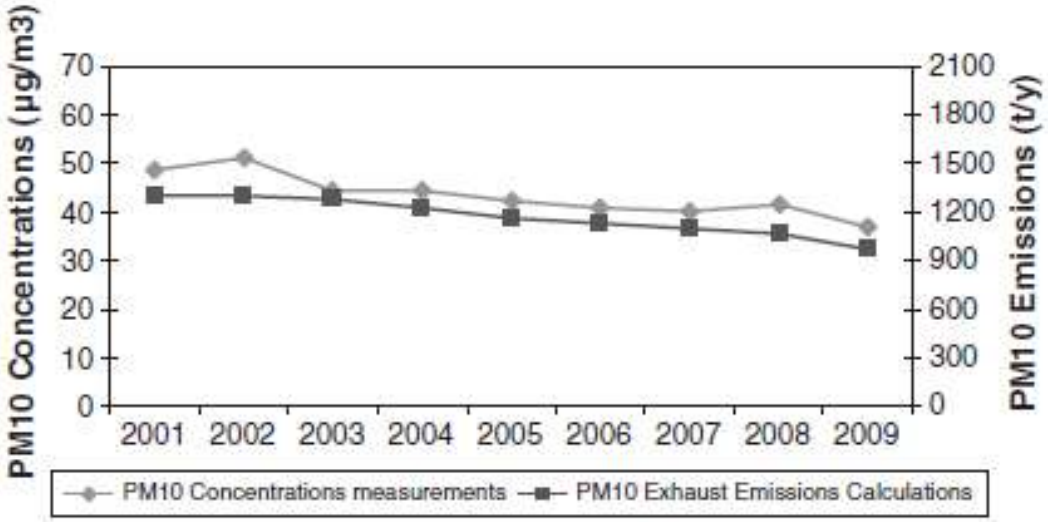
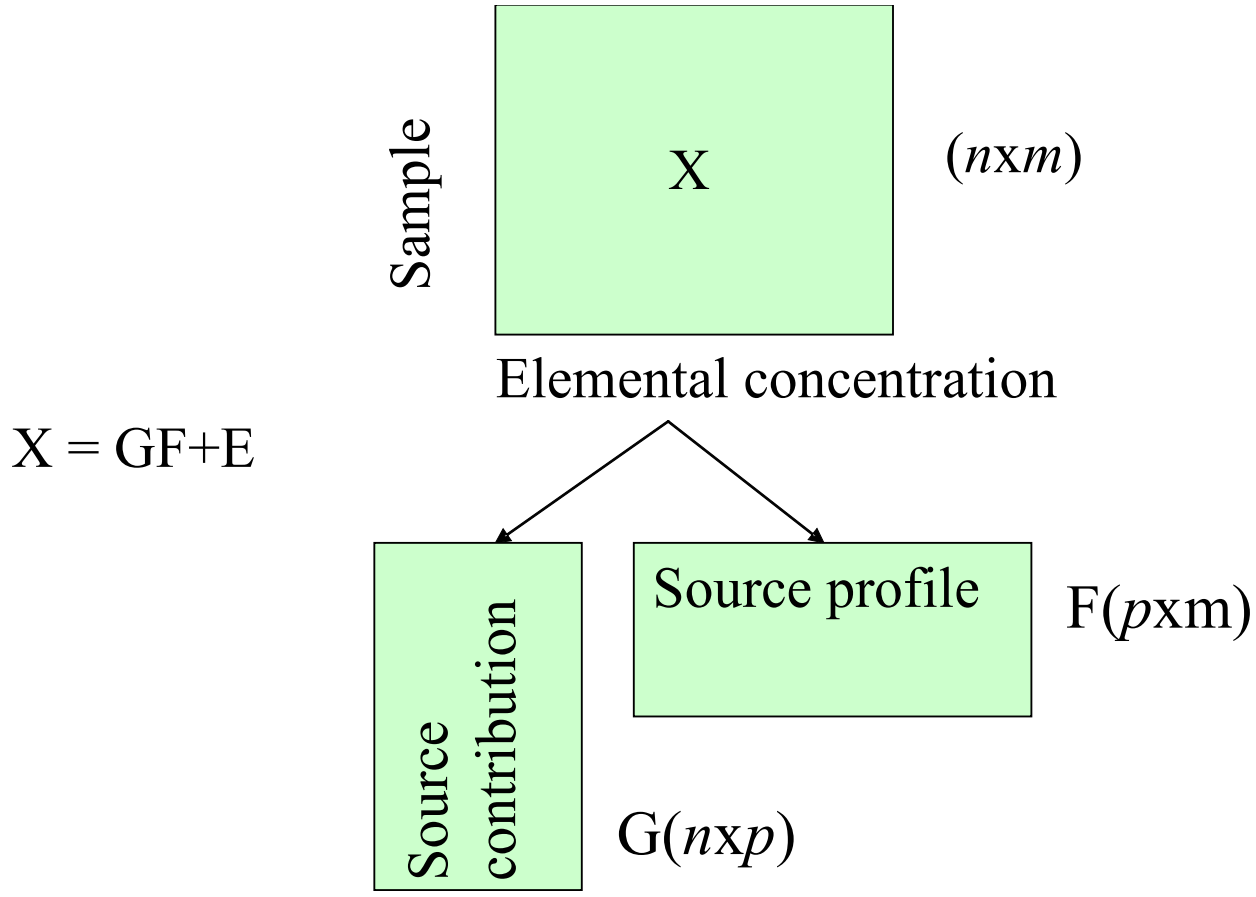


Table 2
Linear best fit equation for NO_x, NO_2 and NO concentration and emission variations, average yearly change (%) and correlation coefficients.

	Linear best fit equation		Average yearly change (%)		Correlation coefficient
	Emissions	Concentrations	Emissions	Concentrations	
NO_x	−859.26∗x+46,500	−2.2106∗x+135.46	−1.79%	−1.58%	0.95
CO	−12,049∗x+365,195	−0.1438∗x+3.6847	−3.24%	−3.86%	0.96
PM_{10}	−40.868∗x+1376	−1.4824+50.737	−2.72%	−2.68%	0.91

Long term emission trends in Athens for the previous decade (Progiou &Ziomas, 2011)
Science of the Total Environment 410-411 (2011) 1–7

Source apportionment first principles



Results from Source apportionment studies in Greece

Major sources:

- **S1**: Road/Urban dust,
- **S2**: Traffic,
- **S3**: Oil Combustion / Industry
- **S4**:Biomas burning / waste
- **S5**: Marine,
- **S6**: Secondary/ Unidentified

Area / (PM) fraction	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*	*SA Model*
Thes 1994 TSP*	4-9	4-5	21-42			44-70	APCA
Thes 1994 TSP*	7-11	4-5	25-33			54-66	FA/MR
Thes 2002 fine	28	38	14			20	APCA
Thes 2002 coarse	**57**	**9**	**26**			**8**	**APCA**
Thes 2003 PM10*	18-22	45-65	10-35				CMB
Thes 2007 PM10*	20-25	23-39	20-38	1-4	1	13-15	CMB
Athens 2002 fine	19	30	14	11	19	7	PMF
Athens 2002 coarse	**54**	**8**			**16**	**22**	**PMF**
Volos 2001 fine	30		27		20	23	PMF
Volos 2008 PM10*	3-12	28-40	15-39	22-27	1-2	2-9	CMB

Organization of CURRENT source apportionment studies

Development of an intensive measurement protocol :

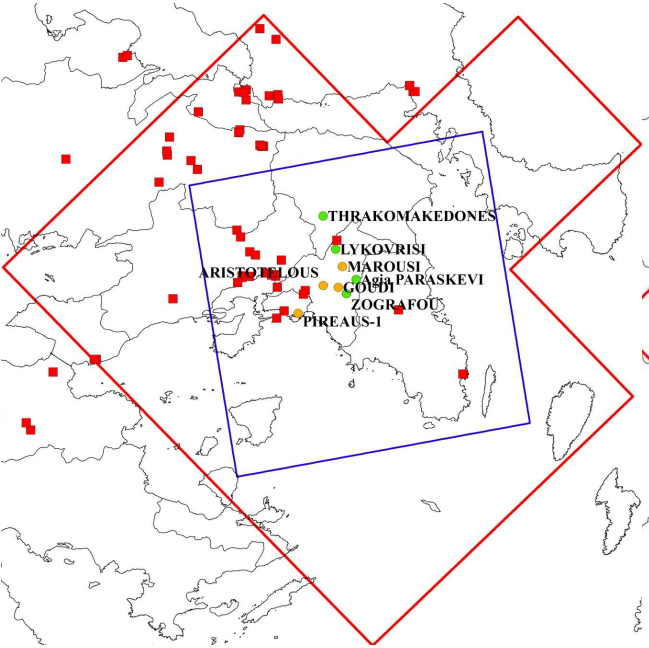
- Measurement locations: 2 sites in Athens Metropolitan area
  2 sites in Thessaloniki Metropolitan area
  1 site in Volos
- Measurement period: June - September 2011 (summer campaign)
  January - February 2012 (winter campaign)
- Sampling of 2 size fractions: PM_{10} and $PM_{2.5}$
- Two kind of filters for chemical characterization of aerosol:
  - Anions / cations by Ion Chromatography
  - Major and trace elements by Atomic Absorption Spectrometry and X-Ray Fluorescence
  - Elemental (EC) and organic carbon (OC) by Thermal / Optical analysis

- Collection of PM samples from representative sites and test of spatial aerosol distribution in Athens and Thessaloniki, by the use of the APTL-CERTH mobile laboratory (Mobilab).

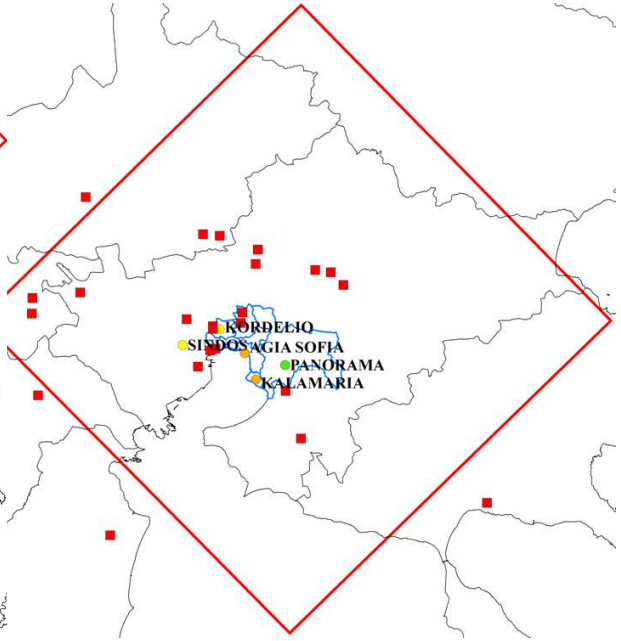
Construction of emission inventories

Study areas

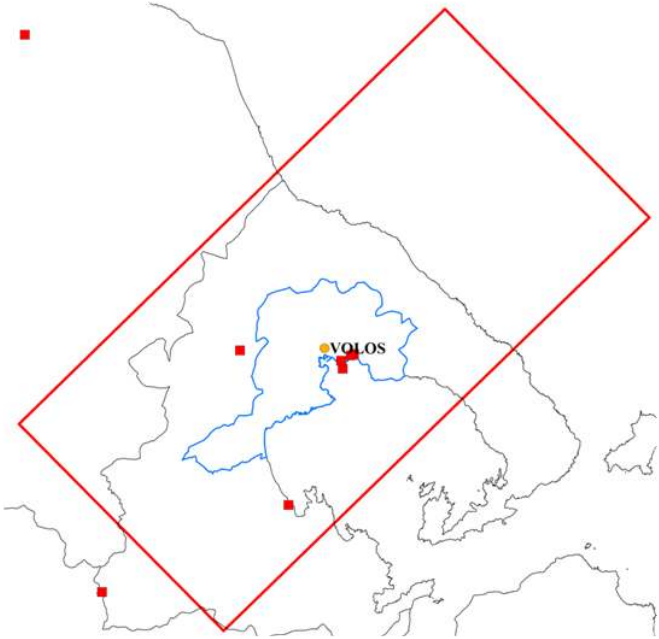
Athens



Thessaloniki



Volos



- LPS
- Traffic station
- Industrial station
- Background station

Area of Interest

Domain covering conurbation; used in spatial disaggregation

Anthropogenic emissions

(Lazaridis, TUC and AXON Envirogroup)

- Annual (Mg/yr) gaseous pollutants (NOx, SOx, NMVOCs, CO, and NH_3) and particulate matter ($PM_{2.5}$ and $PM_{2.5-10}$) emissions from anthropogenic sources (SNAP 1-10) were derived from the UNECE/EMEP/CLRTAP database (spatial analysis 50×50km^2) for the period 2000-2009.
- Emissions from LPS were obtained from the E-PRTR database (v3.3).
- The spatial resolution of emissions from each source category (sectors by SNAP 97) was increased (1×1km^2 grid for 2008; smaller geographical unit for TMA and GVA for 2007) using surrogate spatial datasets:
  - Population density by LAU1 or NUTS3 (EEA),
  - Landcover map,
  - Location and emissions of LPS (EPER and E-PRTR),
  - Road network (modified and updated Openstreetmap 2009 data over AMA),
  - Emission weighting factors by sector and landcover class (Goodwin et al., 2009).
- Emissions from agriculture were estimated (activity data from EL.STAT. Database).

Emissions from natural sources (**M. Lazaridis, TUC**)

- Input data:
  - Landcover map (EEA),
  - Meteorological parameters values (Temperature, RH, Air velocity, Photosynthetically active radiation),
  - Soil texture map (ESDB v2.0 2004).
- **Windblown dust** emissions are estimated using the methodology of Choi et al. (2008) with the equation (Westphal et al., 1987 modified by Park and In, 2003 and Liu and Westphal, 2001)
- **Marine aerosol**

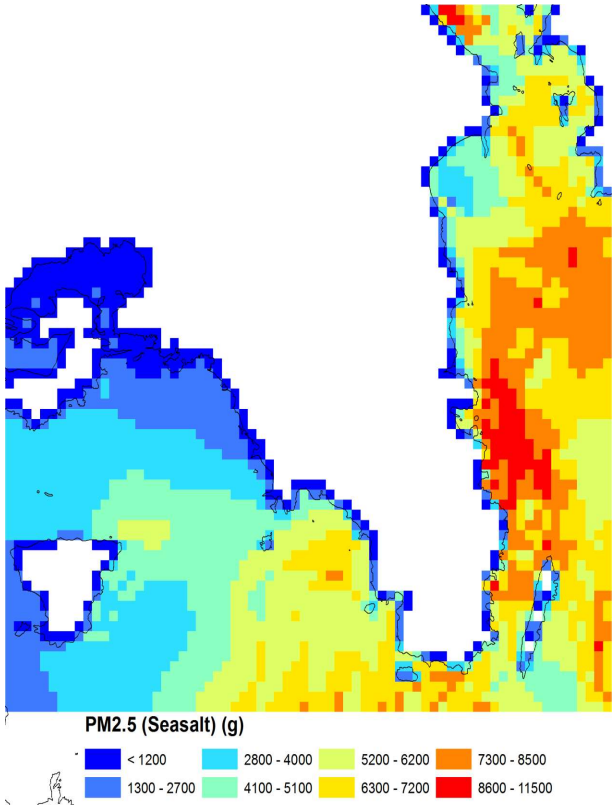
  Open-ocean emissions are computed per grid cell according to Grini et al. (2000), Monahan et al. (1986) and Smith et al. (1993)

  Sea-shore emissions are computed per grid cell in the surf zone (50 m) according to de Leeuw et al. (2000), modified by Zhang et al. (2005)

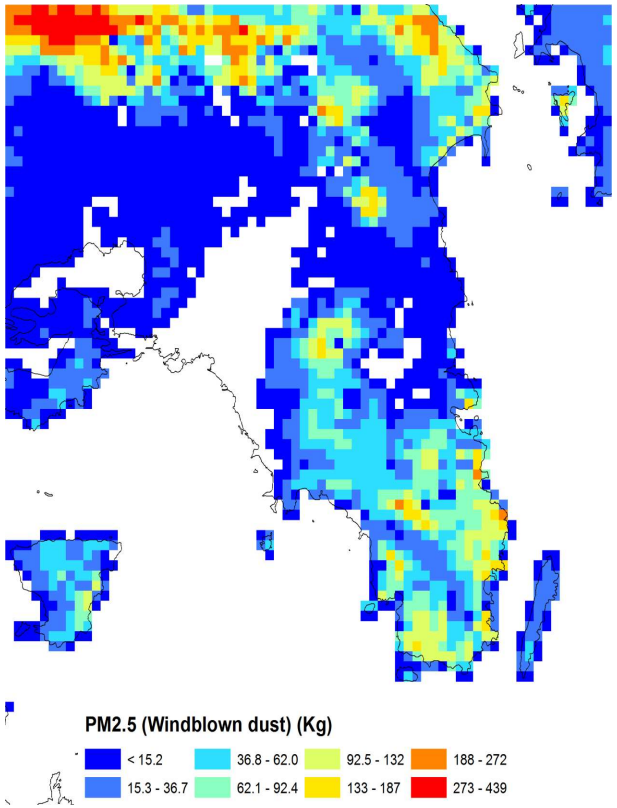
- **Emissions from natural sources BVOCs (isoprene, monoterpenes and OVOCs)**

  Monthly emissions are estimated using the methodology presented in the EMEP/CORINAIR Guidebook (2007) but with different foliar biomass densities and emission potentials for the growing (summer) and dormant (winter) season

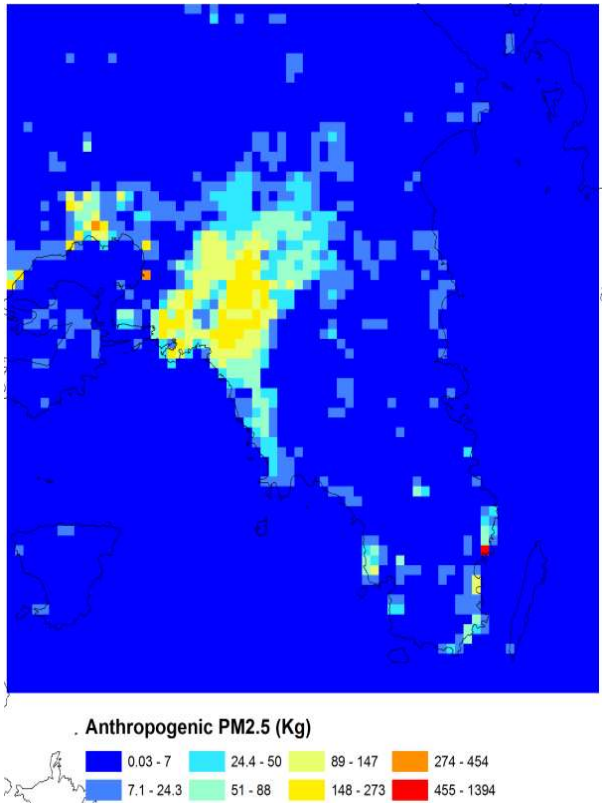
Results: Anthropogenic and Natural $PM_{2.5}$ (2008) for Athens Metropolitan area



12.6 Mg



105.6 Mg

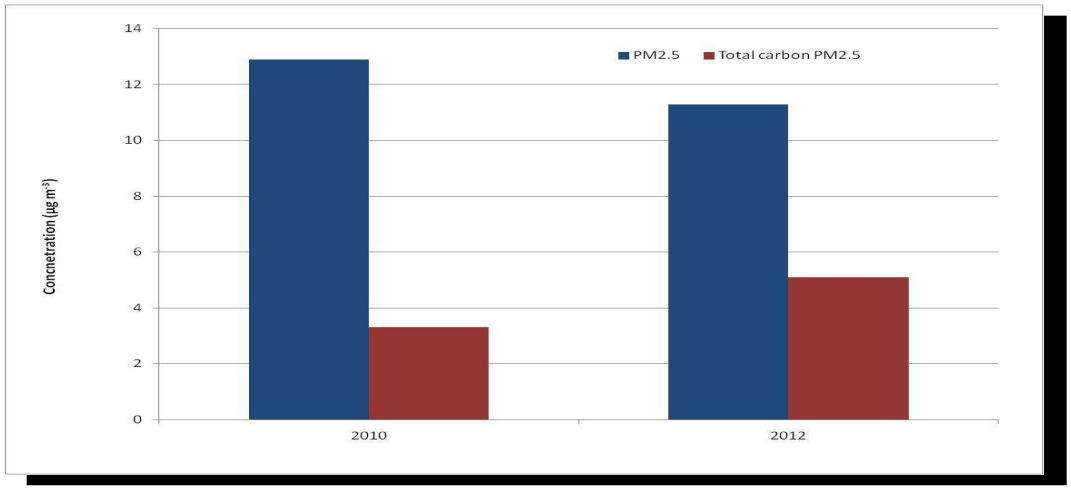


39.1 Mg

- Forest fires (2000-2007) → increase windblown dust emissions by 1.65%.

Main challenges:

- Unravel the relative contribution of the multiple anthropogenic and other sources to the observed PM air concentrations,
- Verify representative coverage of the source apportionment studies in time and space or quantify the limitations
- Document the relative contribution of secondary (**Sei**) aerosol particles to those from primary emissions (**Ei**), by taking into account the atmospheric processes which contribute secondary and primary PM at a given receptor site.
  - $\mathbf{Si} = a*\mathbf{Ei} + b*\mathbf{Sei} + e$



Potential Secondary PM formation

Pollutant	Aerosol Formation Potential*
Primary PM	1
SO_2	0.54
NOx	0.88
NH_3	0.64
NMVOCs	0.02

*According to the methodology of de Leeuw (2002) Values on European level

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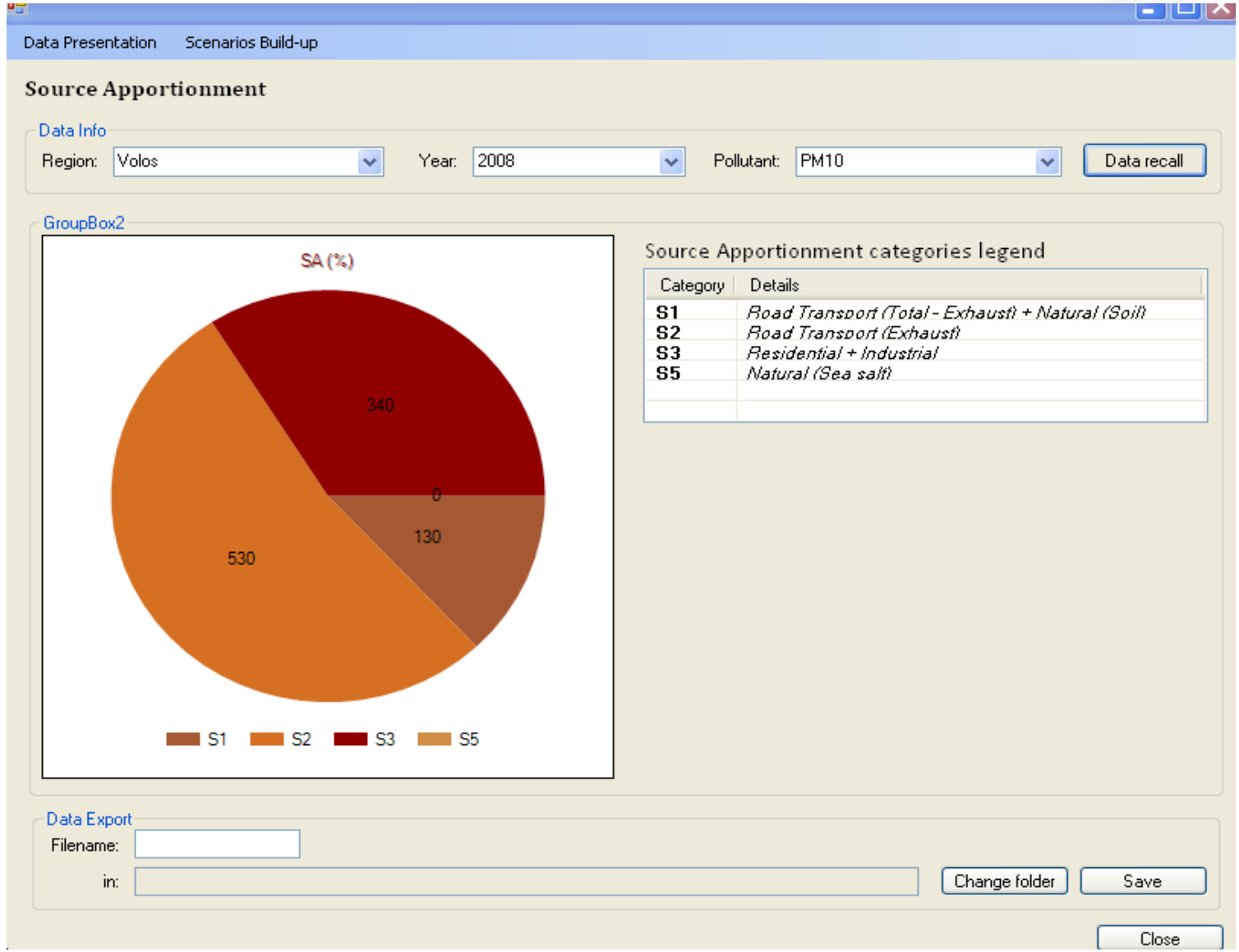

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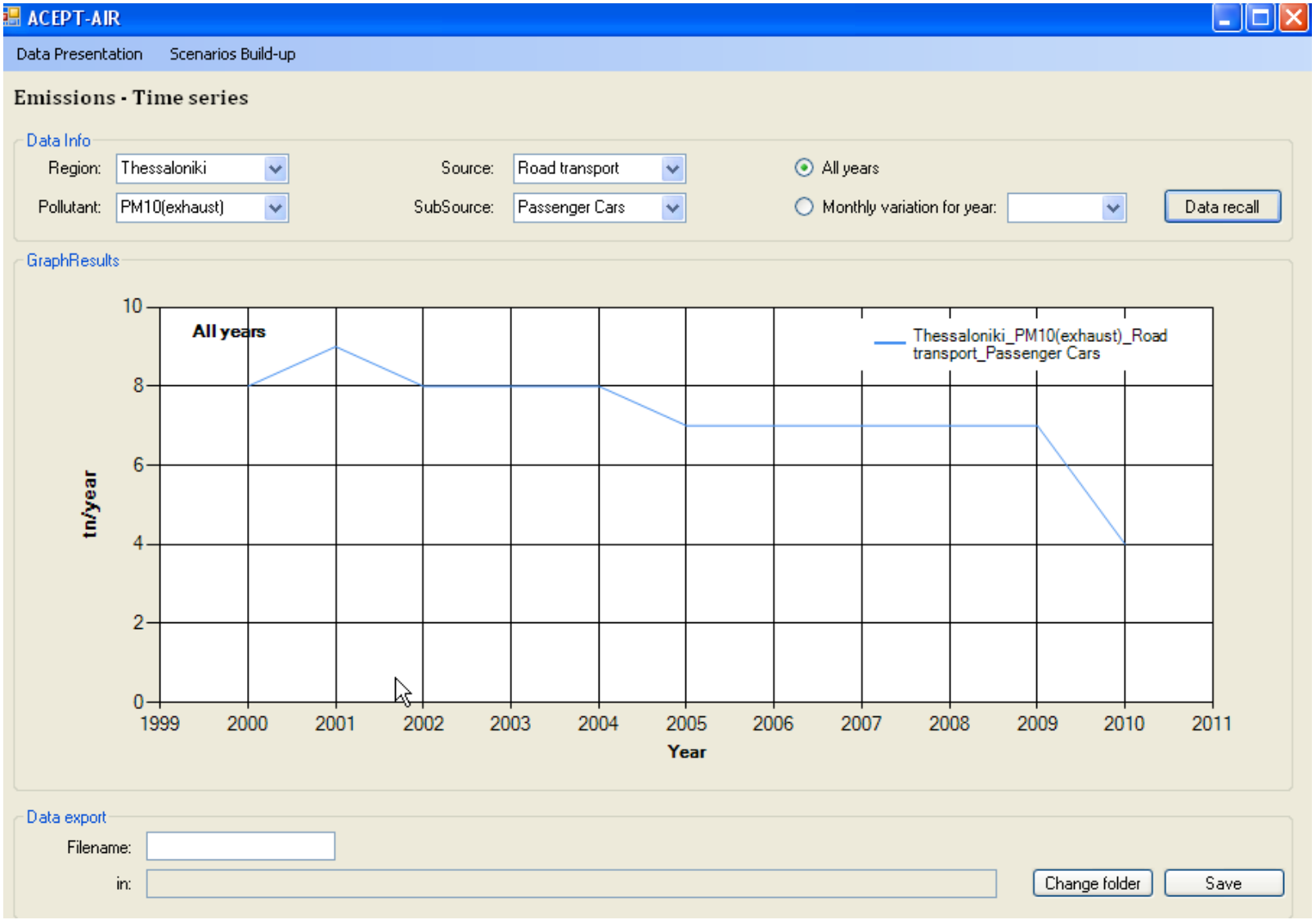

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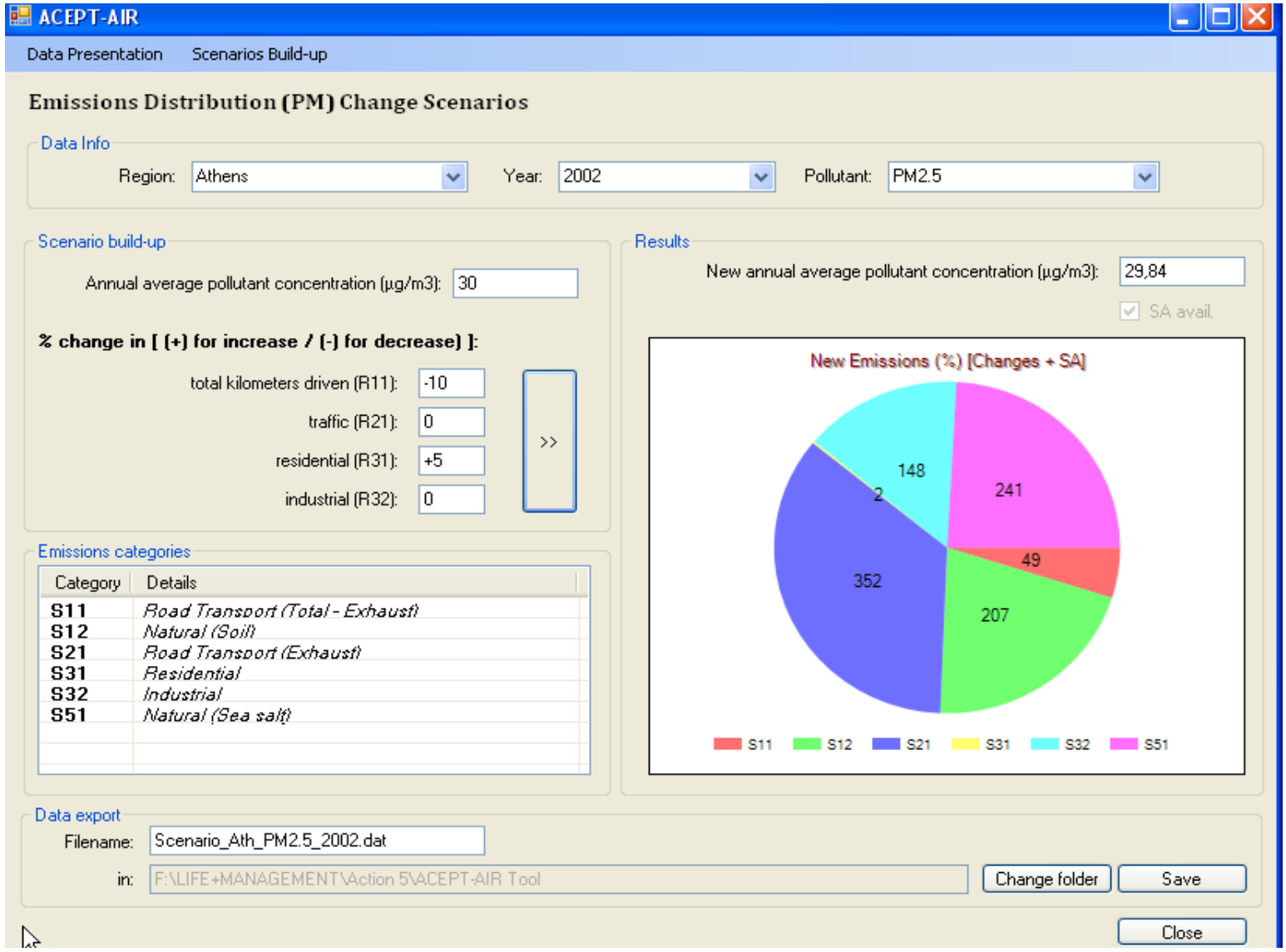

Thank you for your attention!

http://www.aceptair.prd.uth.gr/

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