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Working Group 2 - Emissions
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Spatiotemporal distribution of anthropogenic and biogenic emissions over Greece - A GIS approach

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Introduction

✓The Greater Athens Area has significantly changed in recent years due to large scale infrastructure works.

✓Photochemical and particulate pollution episodes continue to appear.

✓Limited numerical studies of pollutant dispersion above the GAA due to the lack of detailed and updated emissions data.

✓Development of an updated emission inventory, with open structure (FEI-GREGAA) for the years 2006-2012.

✓Use as input data to the photochemical CAMx model for Greece and the GAA.

Introduction

Earlier efforts to develop such databases for Greece and the GAA

✓resulted from temporal and spatial annual low resolution data (50x50km^2) from (EMEP) *(Aleksandropoulou et al. 2004, 2011)* – reference year 2007,

✓the reference year was old (2003) without updated traffic volume data *(Markakis et al. 2010),*

✓only consisted of annual emissions not spatially and temporally allocated *(Progiou and Ziomas 2011, 2012),*

Introduction

Objective	• Quantitative and qualitative conclusions concerning the type of sources that contribute to the air quality of the GAA • Applications with photochemical models
Pollutants	• CO, NOx, PM, SO_2, NH_3, NMVOC and biogenic VOCs
Spatial scale	• 6x6 km^2(Greece) and 2x2 km^2 (Athens)
Data sources	• Official data provided by national authorities
Period	• 2006-2012 (in updating process)
Methodology	• EMEP/EEA Emission Inventory Guidebook 2013 • Development of a methodology for the spatial mapping of emissions • Development of temporal coefficients for the GAA

Grids

Greece

Greater Athens Area (GAA)

General Methodology – Anthropogenic emissions

SNAPS 1, 3, 4, 5, 9:

➢Industrial activity data were collected by the European Pollutant Release and Transfer Register (E-PRTR, eprtr_v5.1, http: //prtr.ec.europa.eu/)

SNAP 2 - Small combustion

➢Top down: Data from the National Energy Data System of the Ministry of Reconstruction of Production, Environment and Energy (NEDS-MRPEE) and Odyssee - Mure project

SNAP 7 – Road Transport

➢Bottom-up for the GAA: Tier 3 approach (COPERT 4), Total number of vehicles (DoT, ELSTAT etc), Min. Max. T, RH, Annual fuel consumption (MRPEE), traffic flow data (KDK).

General Methodology – Anthropogenic emissions

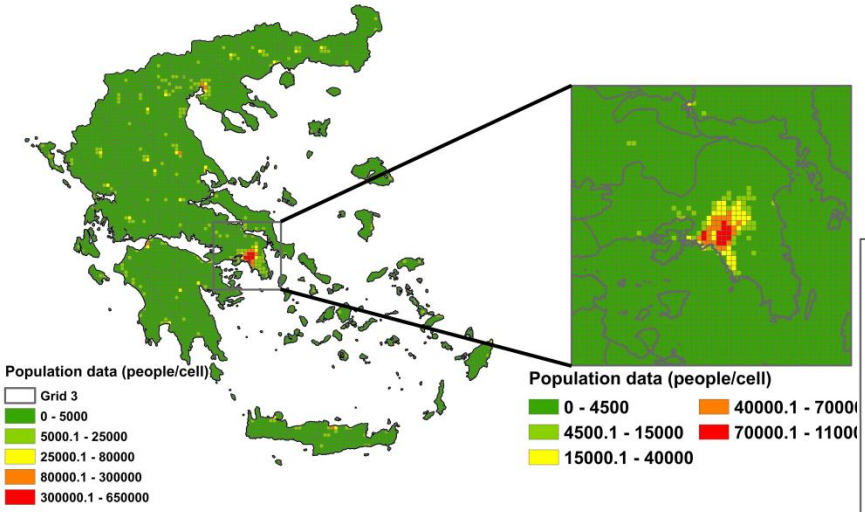
SNAP 8 – Navigation, Aviation, Off-road vehicles

- Bottom-up: Tier 2, Seasonal emissions estimation (10 ship types, 85 Greek ports) EUROSTAT
- Bottom-up: Tier 2 , emissions estimated on a monthly scale for the 38 Greek airports (Eurostat Database, Greek Civil Aviation Authority)
- Top-down: Tier 1 (Eurostat Database)

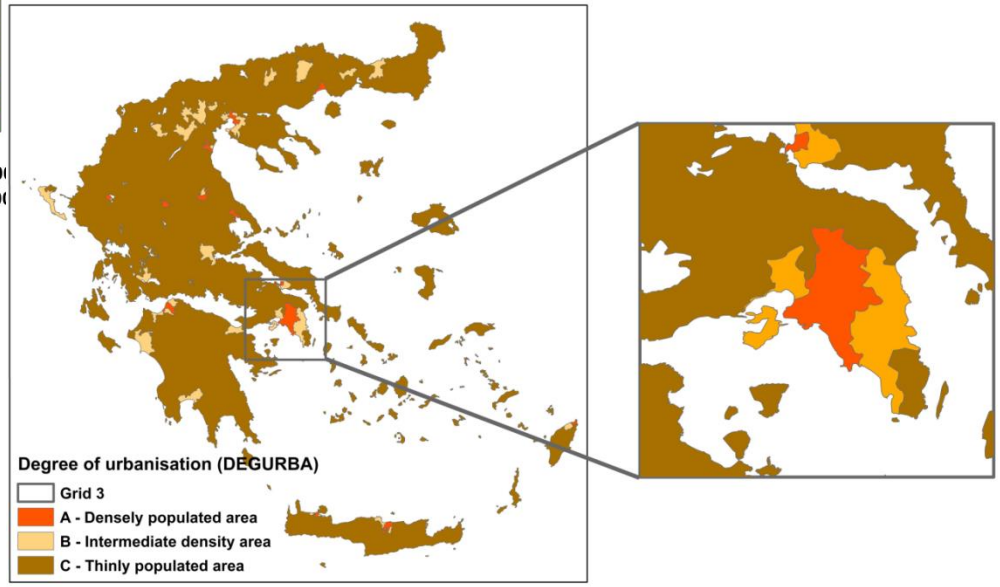
SNAP 10- Agriculture

- Bottom-up: Tier 1, annual population of animals by prefectures, amount of N applied, agricultural crop areas (Eurostat, ELSTAT)

Spatial allocation of emissions



The 2011 population census data (Source: Eurostat)



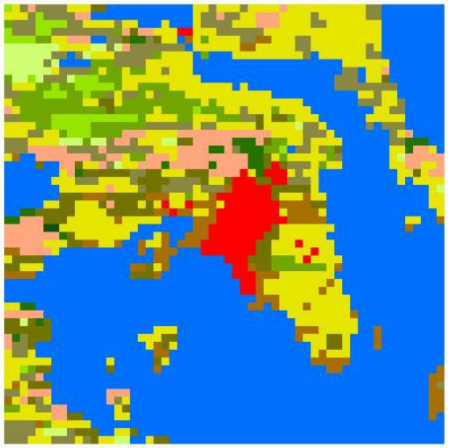
The degree of urbanisation (Source: Eurostat)

Spatial allocation of emissions

Land use

USGS LULC Categories

- 1 Urban and Built-Up Land
- 2 Dryland Cropland and Pasture
- 3 Irrigated Cropland and Pasture
- 4 Mixed Dryland/Irrigated Cropland and Pasture
- 5 Cropland/Grassland Mosaic
- 6 Cropland/Woodland Mosaic
- 7 Grassland
- 8 Shrubland
- 9 Mixed Shrubland/Grassland
- 10 Savanna
- 11 Deciduous Broadleaf Forest
- 14 Evergreen Needlelleaf Forest
- 15 Mixed Forest
- 16 Water Bodies



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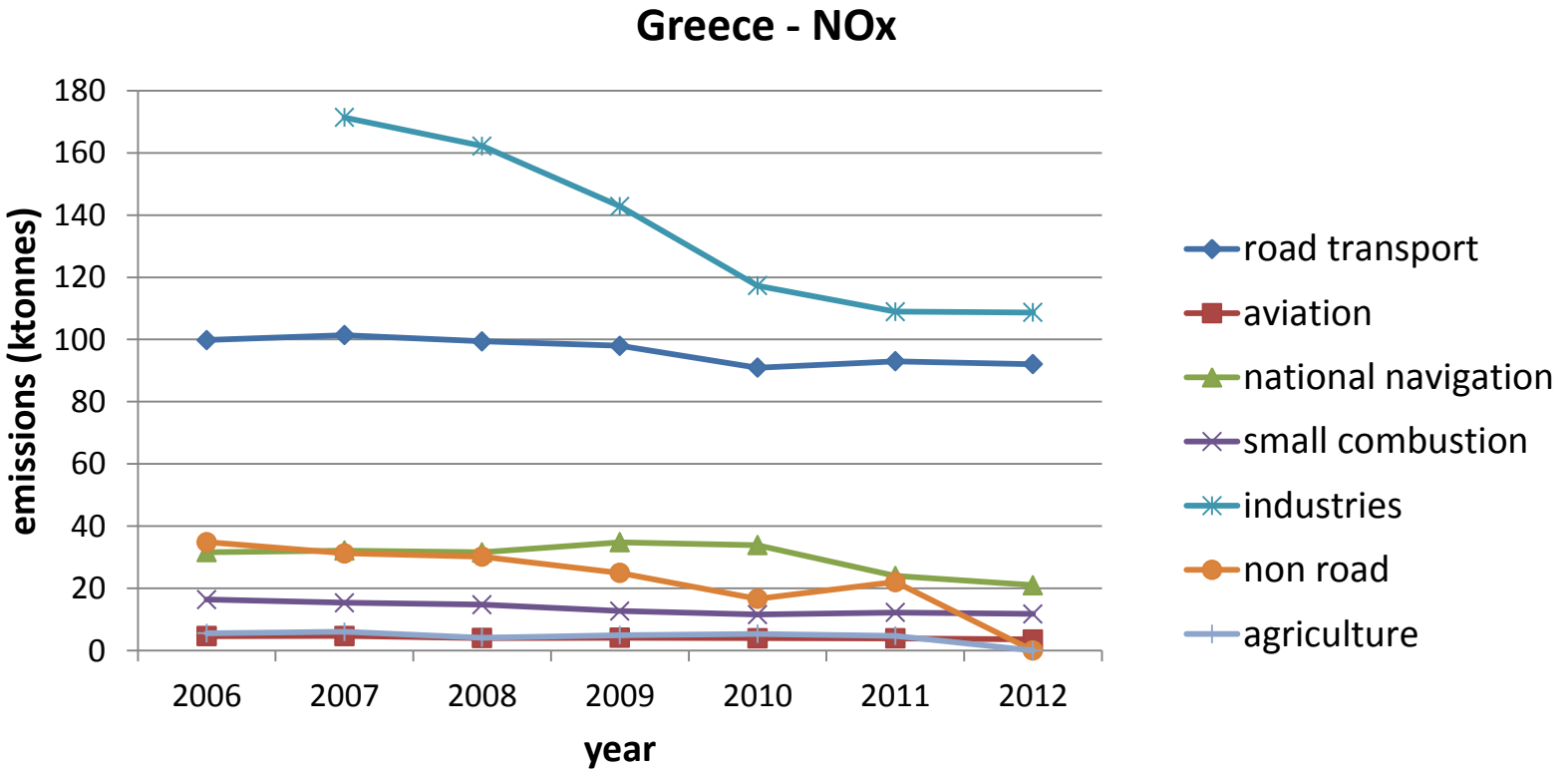
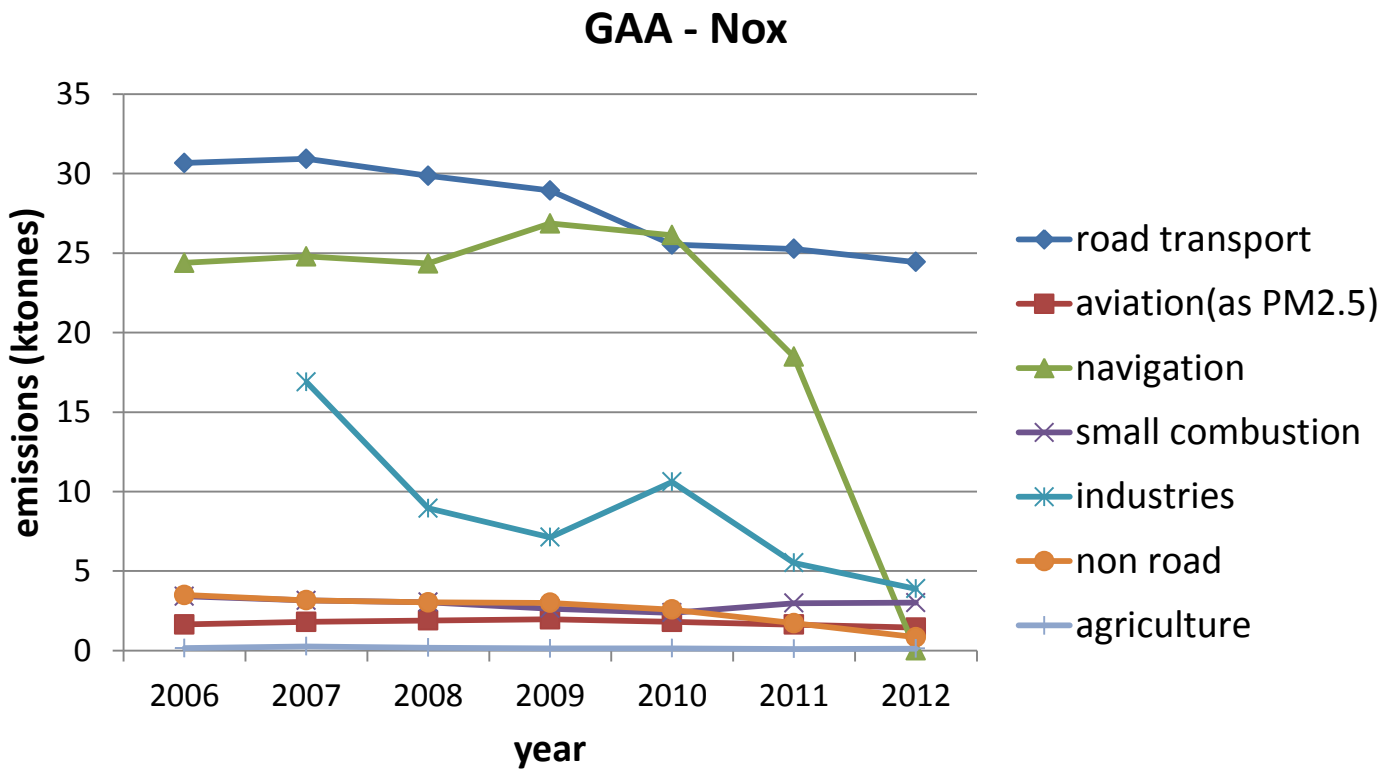
Annual variation of emissions



Annual variation of emissions

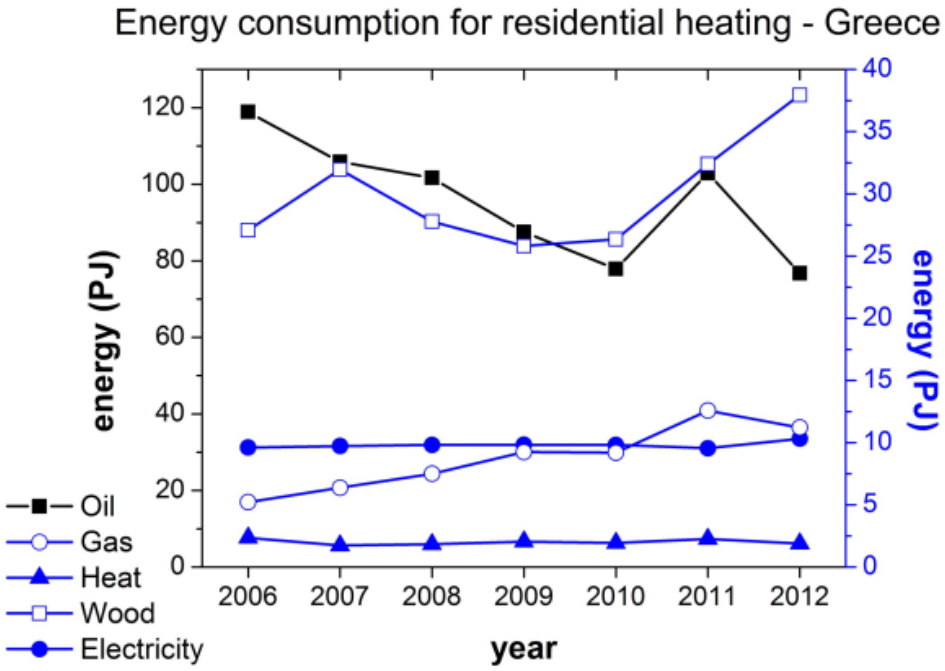


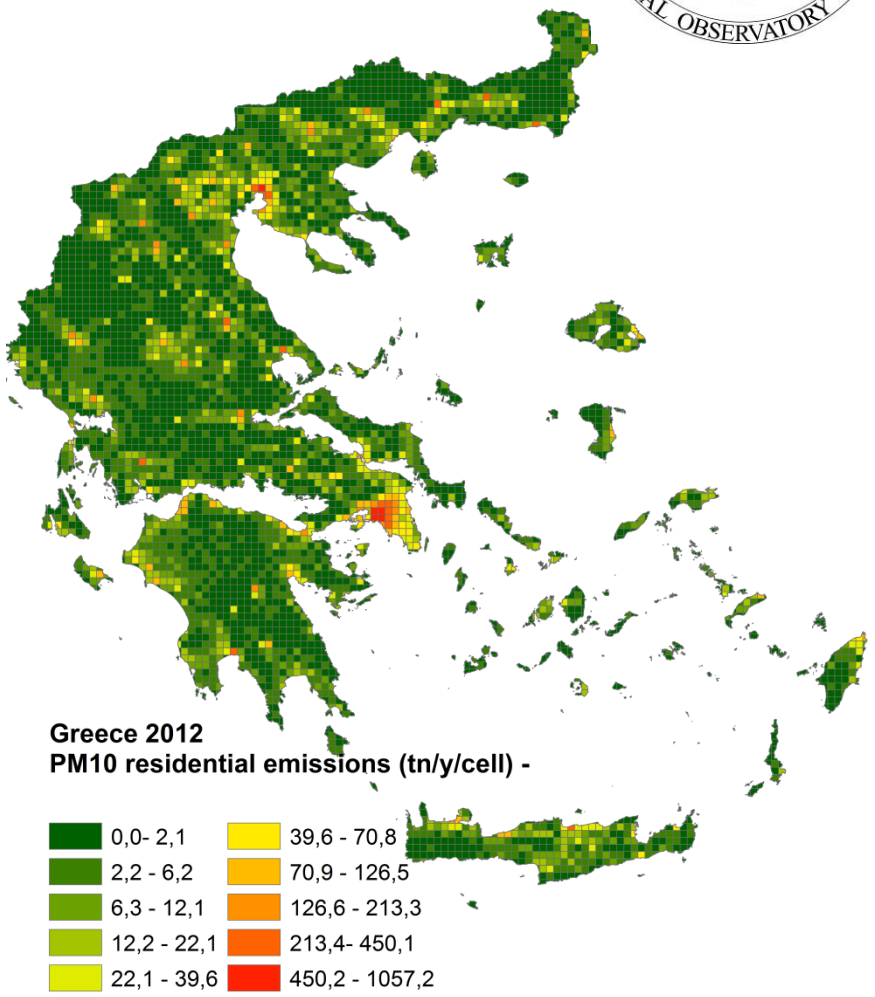
Anthropogenic emissions

Why is it important to use
detailed and ***updated*** emissions data?

Case: Small combustion

SNAP2 - Small combustion





Biomass consumption for residential heating increased by 37% while the oil consumption decreased by 24%.

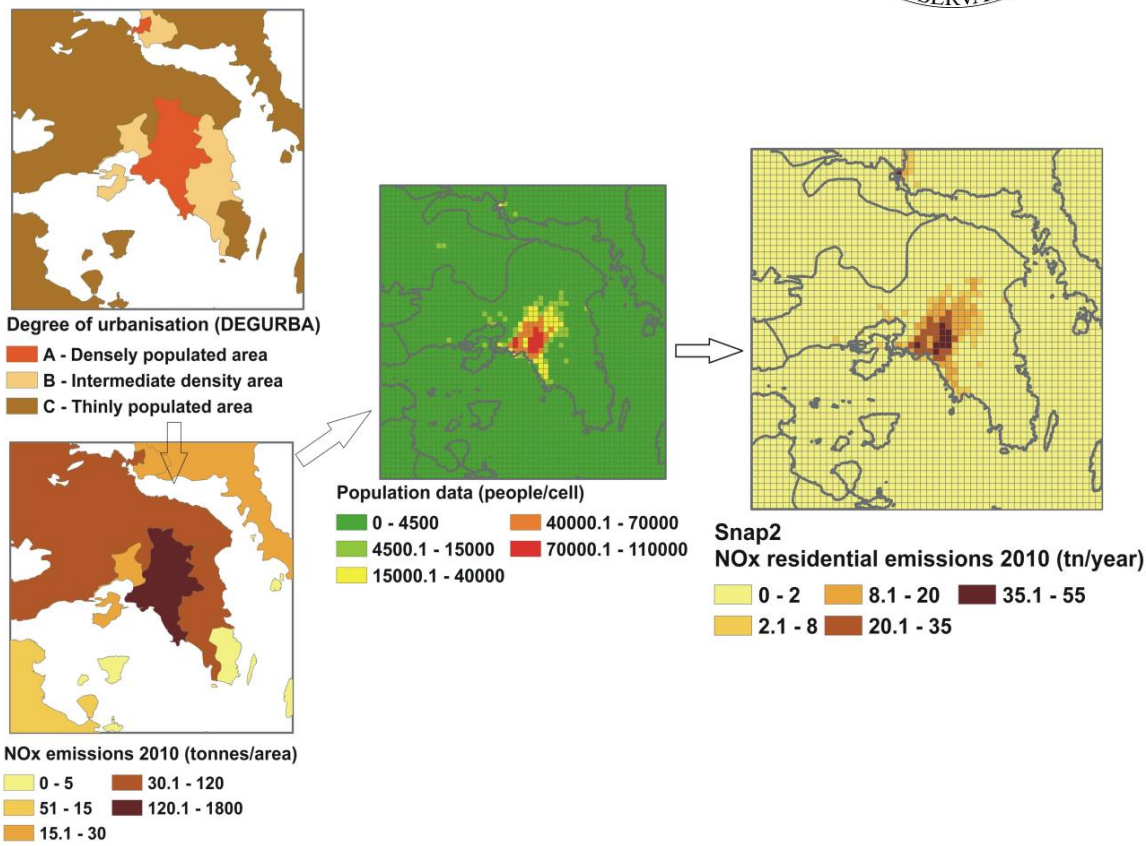
SNAP 2 – Spatial allocation

Spatial allocation

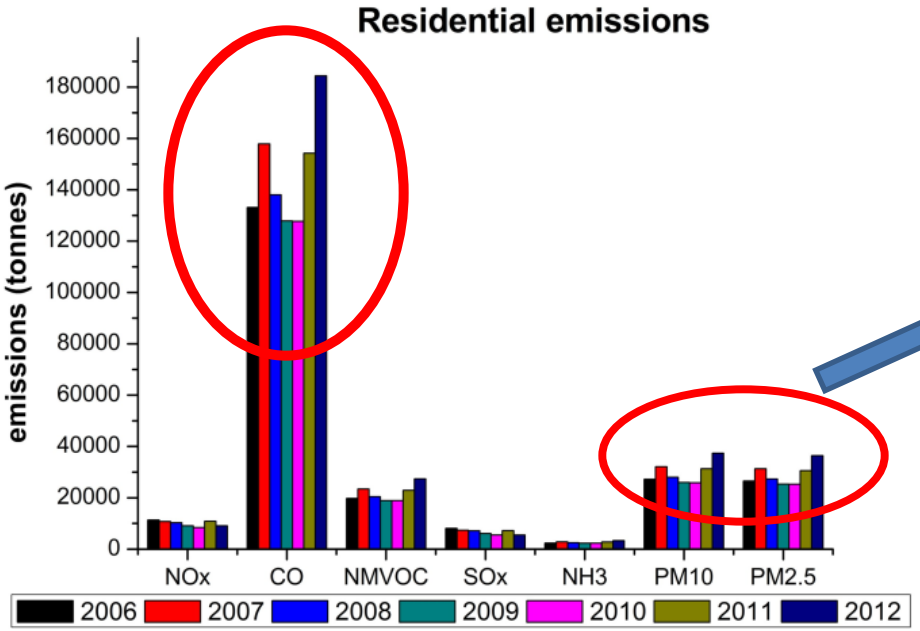
✓The degree of urbanization (DEGURBA),

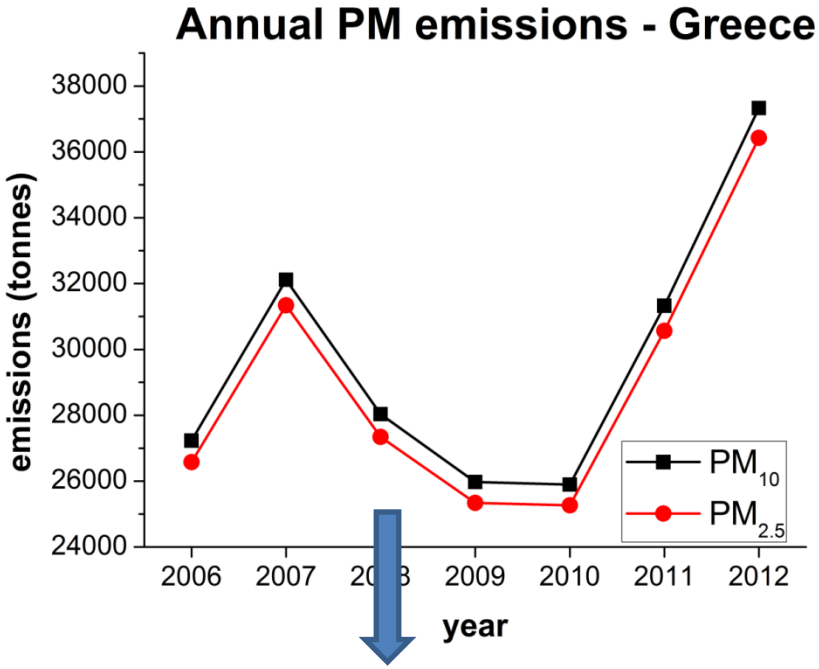
✓The 2011 population density data (Eurostat) and

✓A survey conducted by the Greek Statistical Authority (EL.STAT.) regarding the residential energy consumption for the period October 2011 - September 2012

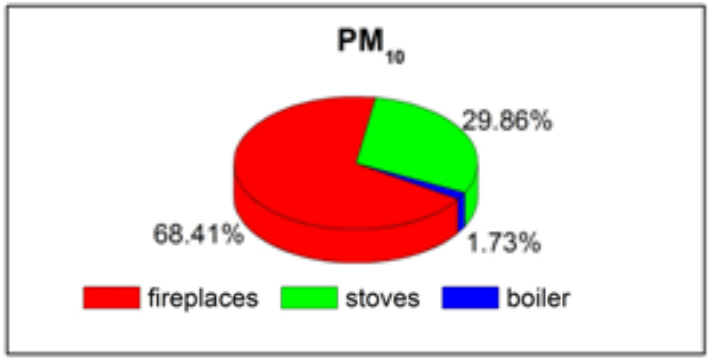


SNAP 2 - Results

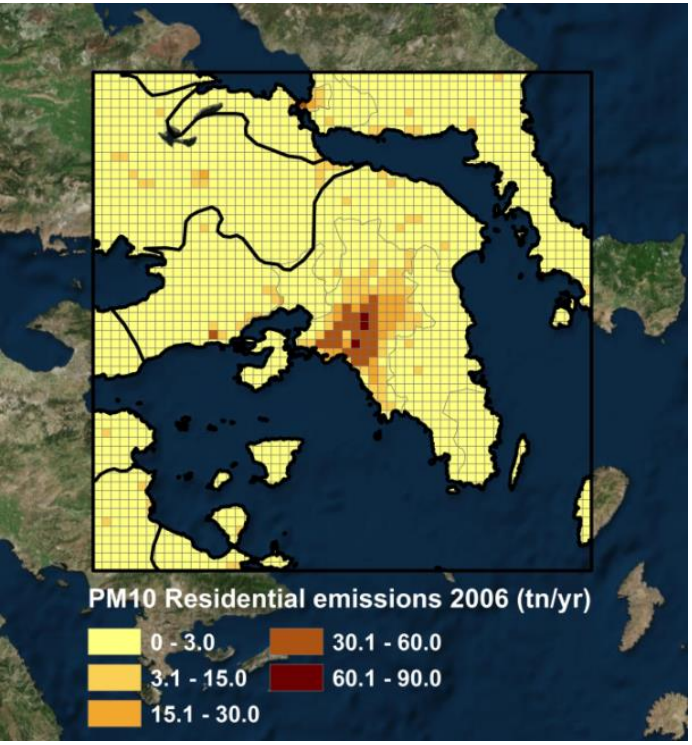


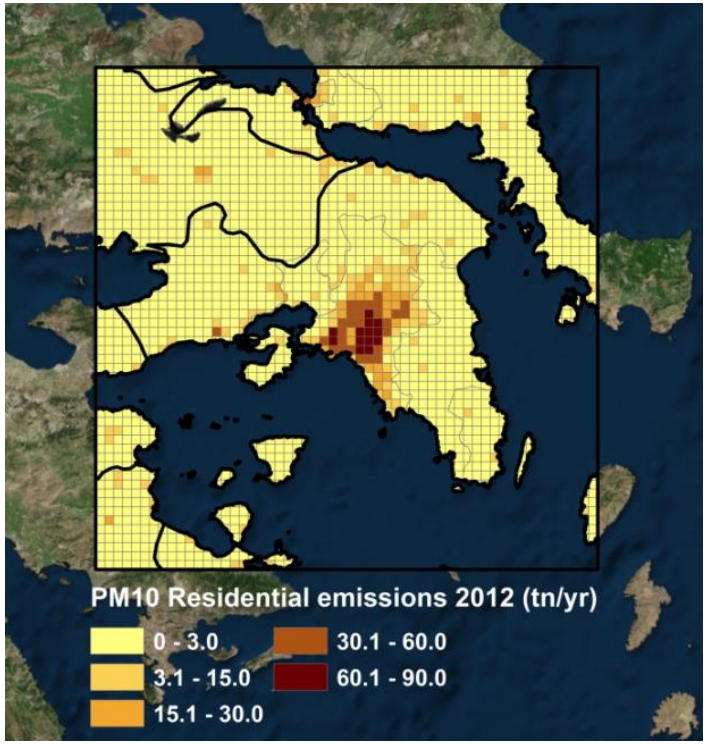


Annual variation of residential emissions for Greece.



SNAP 2 - Small combustion





2006-2011: 8.5% and 9.0% of national CO and PM_{10} emissions are attributed to the GAA, because they are related to biomass burning which is very popular at the rural areas in Greece.

2012: the specific percentages were 12.0% and 12.5% respectively revealing the fact that wood burning increased.

EMEP VS FEI-GREGAA E.I.

Annual variation of PM_{10} emissions (in ktonnes) for Gr[illegible] – FEI-GREGAA

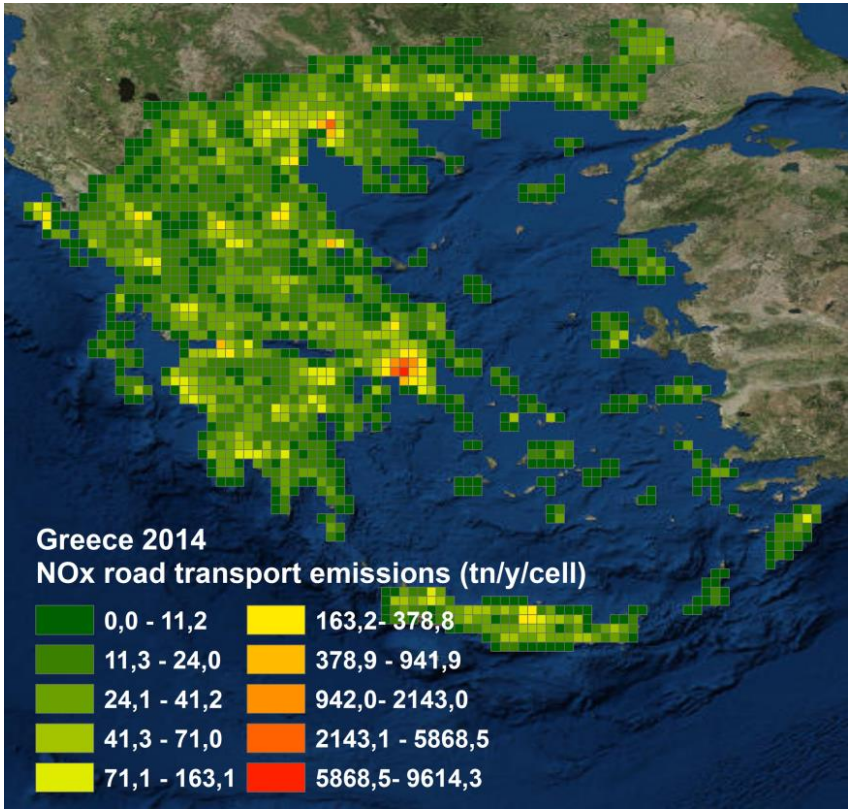
Year	Road transport	Aviation (as PM2.5)	Navigation	Small combustion	[illegible]ndustries	Non road transport	Agriculture	Total
2006	4.42	0.0110	1.80	27.84	-	1.80	0.86	*36.73*
2007	4.60	0.0087	1.83	32.65	3[illegible]71	1.62	1.25	*73.66*
2008	4.48	0.0049	1.78	28.55	2[illegible]36	1.56	1.24	*60.98*
2009	4.64	0.0044	1.96	26.39	[illegible].09	1.31	1.21	*53.60*
2010	4.30	0.0047	1.92	26.28	[illegible].86	1.15	3.80	*51.30*
2011	4.43	0.0041	1.48	31.52	12.98	0.86	3.80	*55.09*
2012	4.44	0.0038	1.3	37.64	12.61	0.00	3.72	*58.42*

PM_{10} emissions (in ktonnes) for Greece. (Source: WebDab - EMEP [illegible]ns database, updated in 2015).

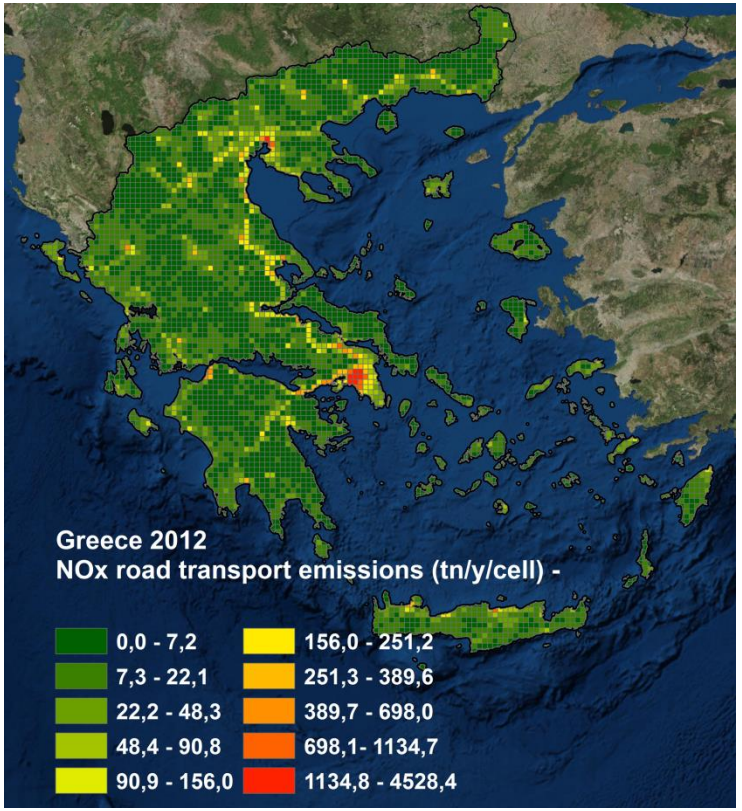
Year	Road transport	Other transpo[illegible]	Small combustion	[illegible]ndustries	Agriculture	Total
2006	7.29	6.18	13.25	[illegible].65	11.86	*80.22*
2007	7.00	5.9[illegible]	12.71	[illegible].75	11.89	*75.32*
2008	6.71	5.7[illegible]	12.17	[illegible].45	11.93	*71.01*
2009	6.42	5.5[illegible]	11.63	[illegible].16	11.96	*66.71*
2010	6.14	5.33	11.09	[illegible]7.86	11.98	*62.39*
2011	5.71	5.13	10.68	26.60	11.94	*60.07*
2012	5.29	4.93	10.27	25.35	11.90	*57.74*

The new EMEP grid VS FEI-GREGAA

2014 EMEP Grid in 0.1°x0.1° (long-lat)



2012 FEI-GREGAA Grid in 6x6 km^2



Biogenic VOC emissions – General Methodology

Temperature data (www.meteo.gr)

Land use profiles

Photosynthetically active radiation (PAR) – www.solea.gr

Equations from Guenther et al., 1993

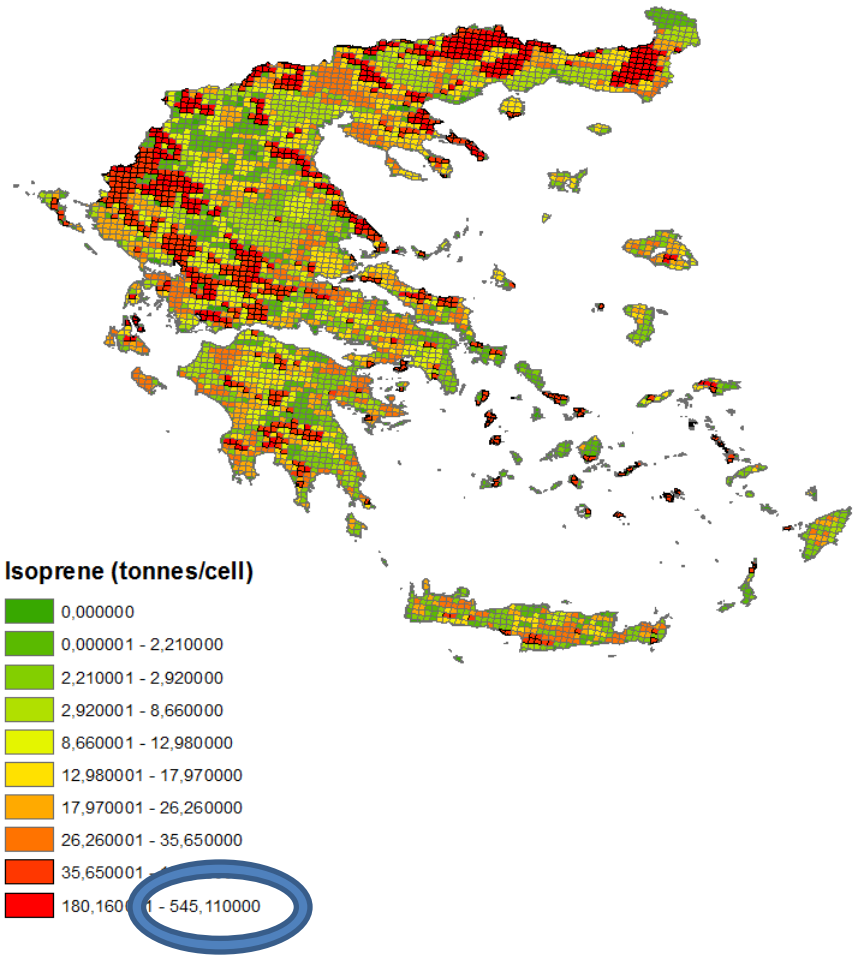
Foliar biomass density form Steinbrecher et al., (2009) – NatAir project

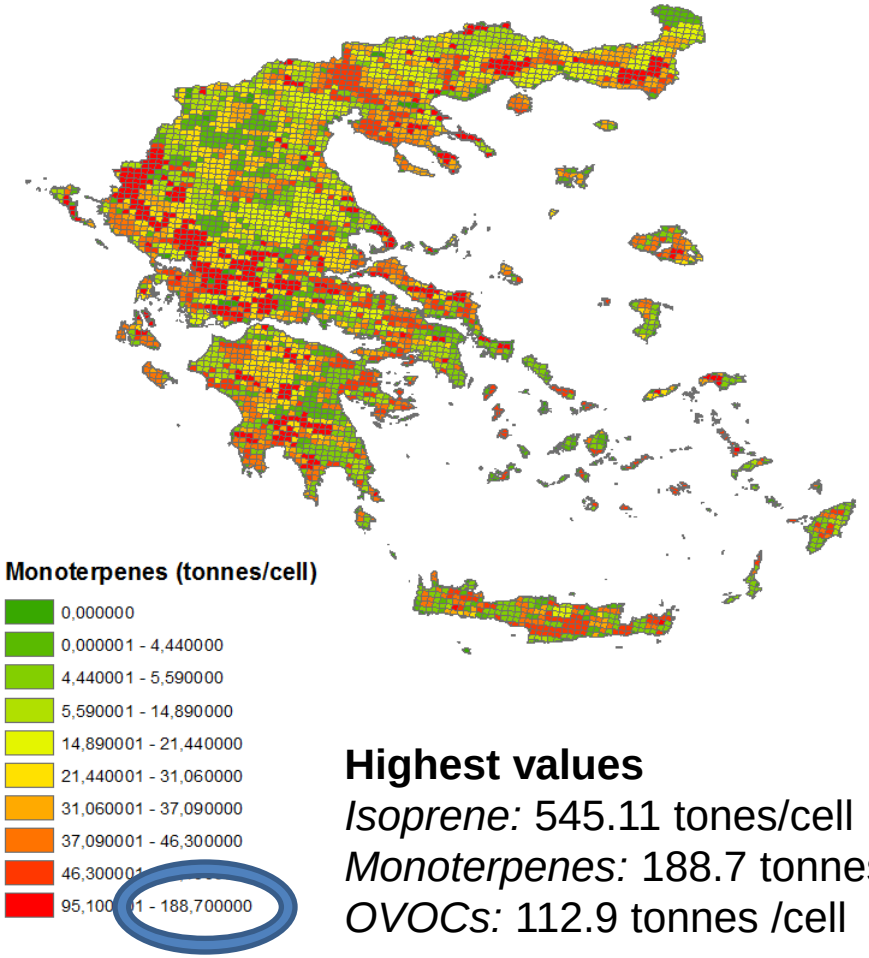
Monoterpenes

Isoprene

OVOCs

Biogenic VOC emissions – Annual values





Highest values

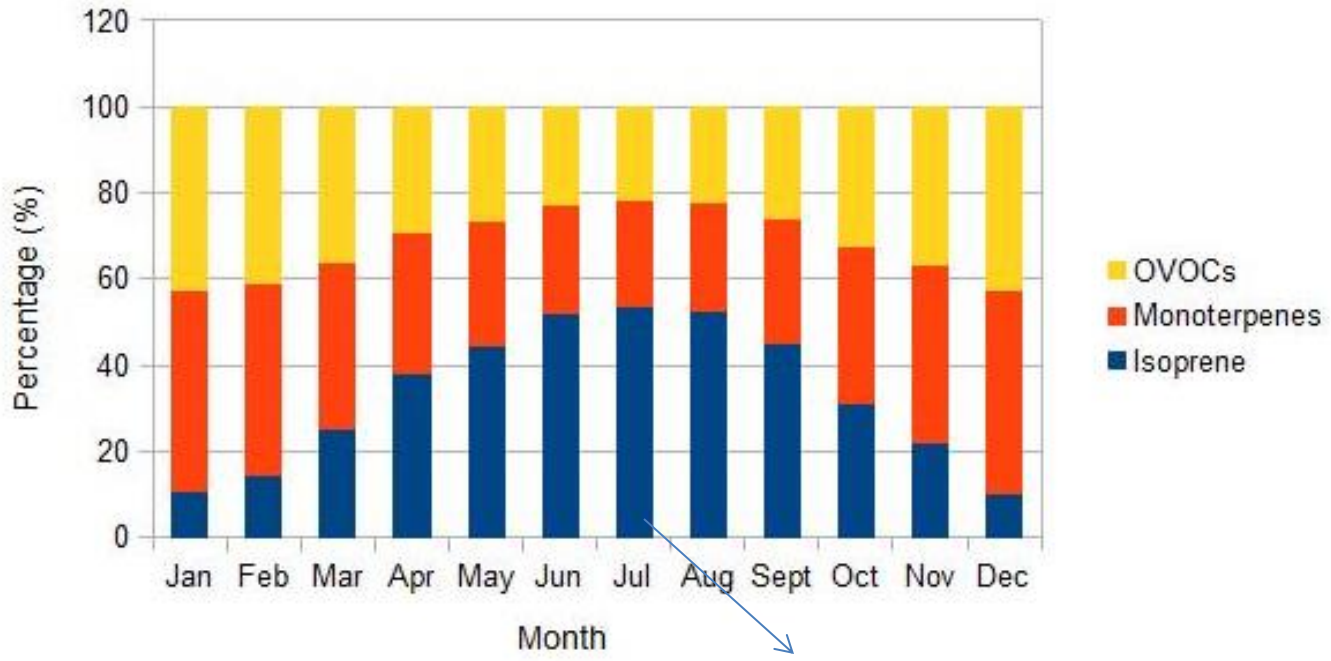
Isoprene: 545.11 tones/cell

Monoterpenes: 188.7 tonnes /cell

OVOCs: 112.9 tonnes /cell

Biogenic VOC emissions - Results

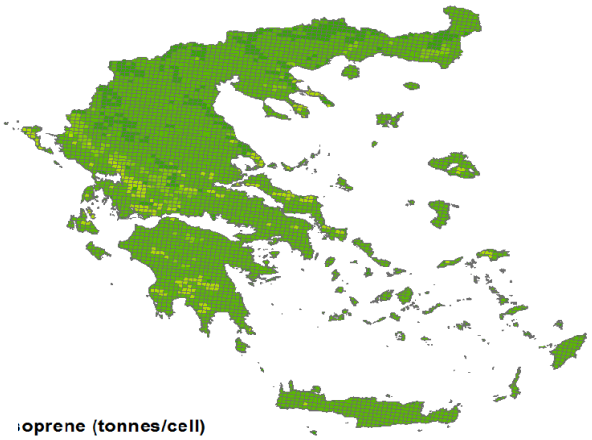
Monthly variation of OVOCs, Monoterpenes and Isoprene emissions percentages for Greece



Higher values for all BVOCs in July
Isoprene 53.6 %,
Monoterpenes 24.4 %
OVOCs 22%

Biogenic VOC emissions – Monthly isoprene emissions

January

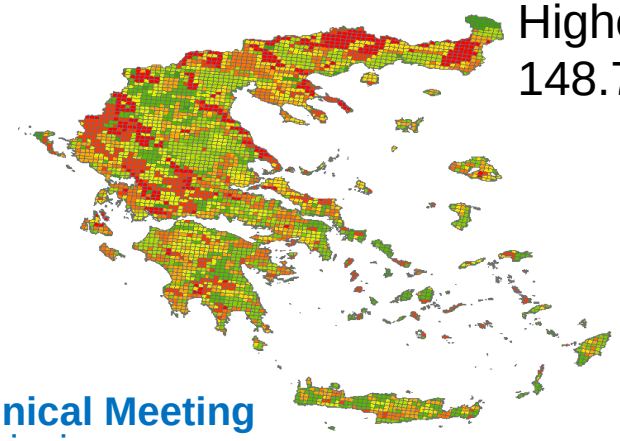


April

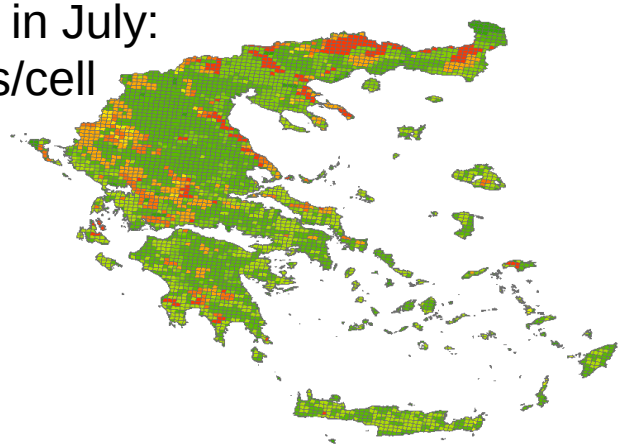
Isoprene (tonnes/cell)

- 0,000000
- 0,000001 - 0,600000
- 0,600001 - 0,800000
- 0,800001 - 2,200000
- 2,200001 - 3,200000
- 3,200001 - 4,400000
- 4,400001 - 7,000000
- 7,000001 - 9,300000
- 9,300001 - 45,400000
- 45,400001 - 149,000000

July



October



Highest value in July:
148.71 tonnes/cell

Biogenic VOC vs Anthropogenic VOCs

BVOCs and Anthropogenic VOCs in ktones/year for Greece

Isoprene	Monoterpenes	OVOCs	Total BVOCs	Total anthropogenic VOCs
220	132	120	472	325

Thank you!!!