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APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN THE TARANTO AREA (SOUTH ITALY)

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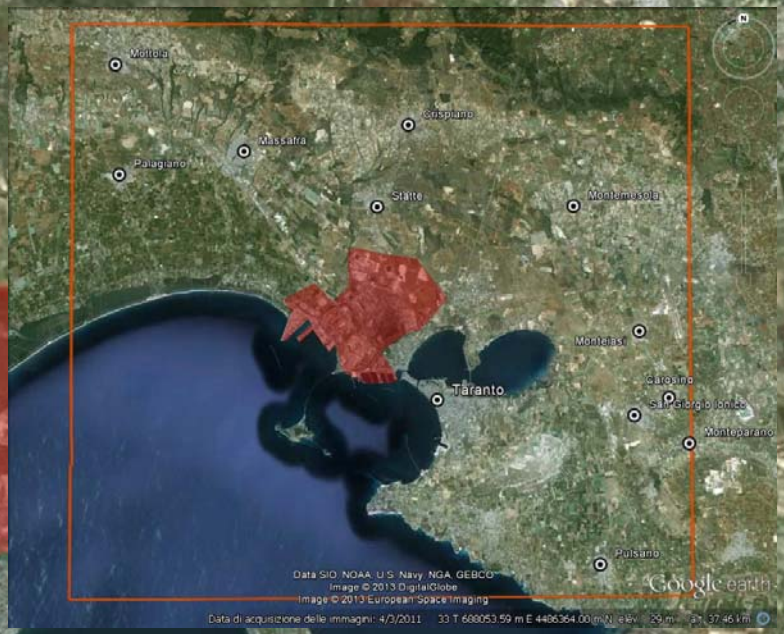
The studied area



- One of the areas at high environmental risk in Italy for air pollution .

✓ Environmental monitoring campaigns and industrial emissions measures have shown a widespread environmental pollution in the Taranto area (Arpa Puglia, 2007-2012) with regard in particular to the POP's ;

✓ Epidemiological studies showed higher mortality level and short-term health effects on people living in the Taranto area (Pirastu et al., 2011).

6.26 km

Image © 2013 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2013 European Space Imaging
Data di acquisizione delle immagini: 4/3/2011 33 T 688063.68 m E 4483984.13 m N elev 16 m

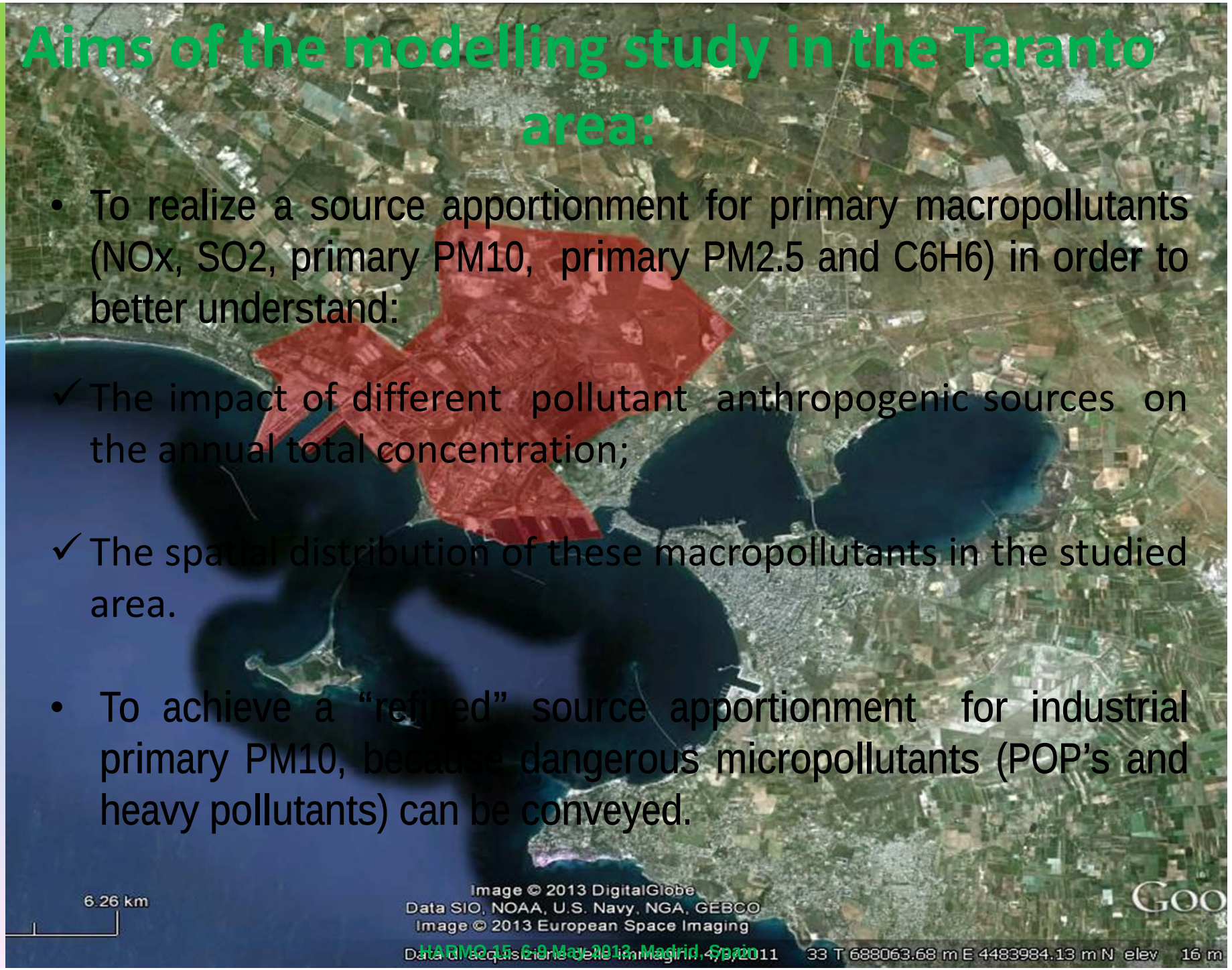
Aims of the modelling study in the Taranto area:

- To realize a source apportionment for primary macropollutants (NOx, SO2, primary PM10, primary PM2.5 and C6H6) in order to better understand:

✓ The impact of different pollutant anthropogenic sources on the annual total concentration;

✓ The spatial distribution of these macropollutants in the studied area.

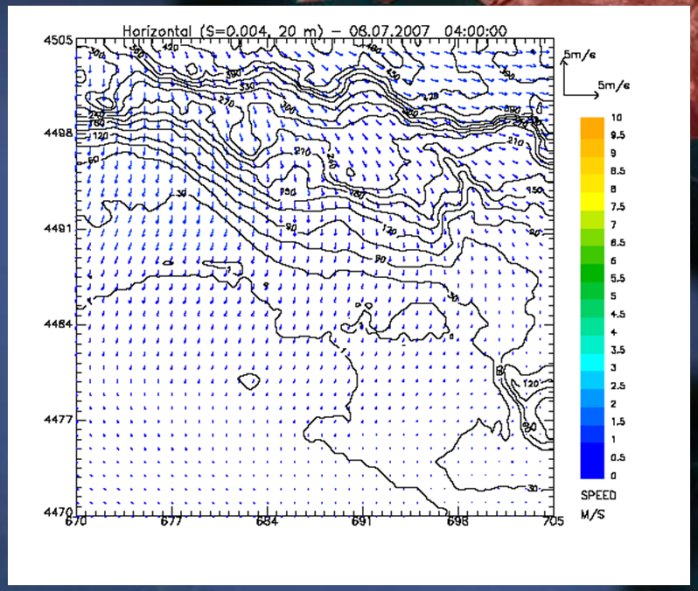
- To achieve a "refined" source apportionment for industrial primary PM10, because dangerous micropollutants (POP's and heavy pollutants) can be conveyed.



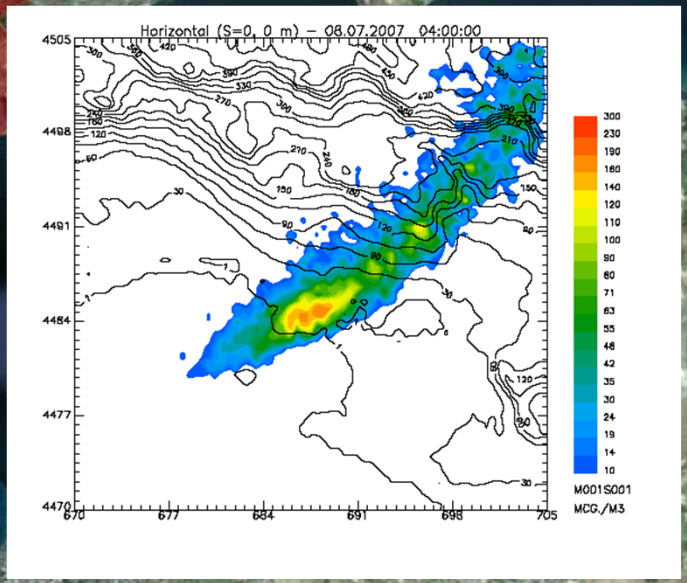
The approach: the Lagrangian particle SPRAY model

- Able to reconstruct the local primary pollutant concentration fields in presence of non-homogenous and non-stationary meteorological conditions.
- In this study the Lagrangian particle model SPRAY is used: this model is included in the FAIRMODE document "Modelling of Nitrogen Dioxide (NO2) for air quality assessment" and in the MDS – "Model Documentation System" database.

Ground level wind



Hourly ground level NOX concentration from stack emissions simulated by SPRAY



Emission data

- Simulated emission sources were divided into 4 categories: the harbour, residential heating, traffic and industry.
- The emission input data were derived from the 2007 Regional Atmospheric Emission Inventory (Arpa Puglia, 2011).

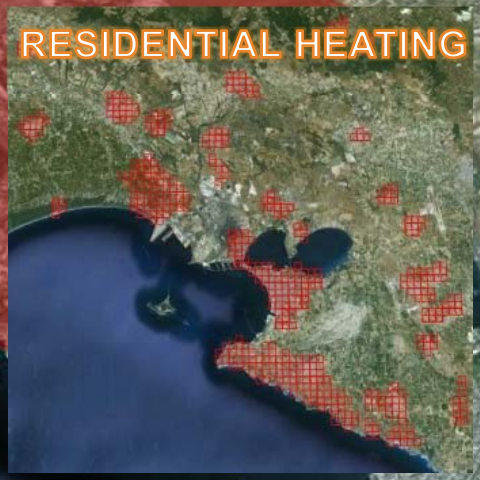


Table 1. Total yearly emissions for industrial sources, road traffic, residential heating and harbour activities.

Emission sources	PM10 (Mg/year)	PM2.5 (Mg/year)	C6H6 (Mg/year)	NOx (Mg/year)	SO2 (Mg/year)
Industrial activities	6460	4376	287	20439	24285
Road transport	317	274	66	3634	25
Harbour	403	381	5	3384	3041
Domestic heating	232	224	43	222	48

Industrial Sources

- A bottom-up approach has been used.
- In the simulation we have included the emissions from:

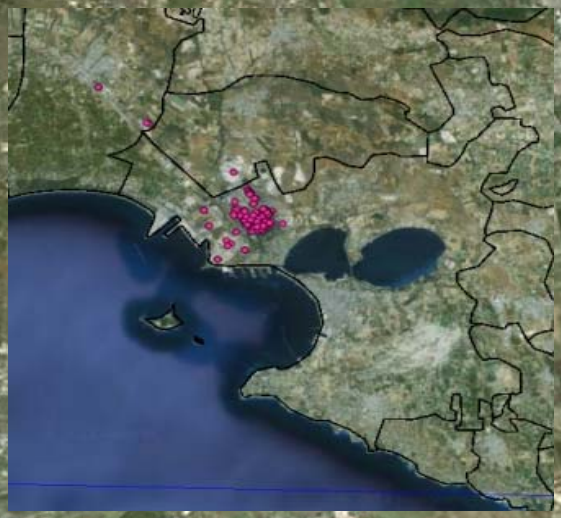
✓ 238 stacks with height from 6m to 210m

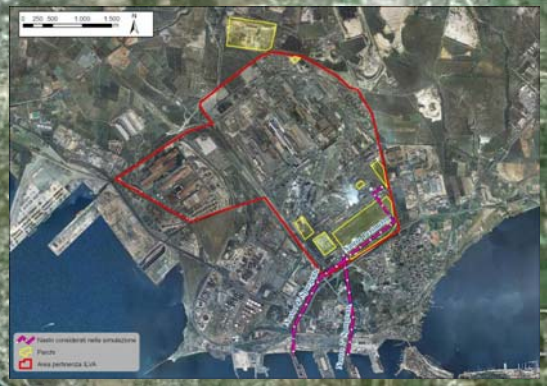
✓ 16 areal sources:

a) **5 hot buoyant** from steel works i.e. coke ovens, sintering plant, blast and basic oxygen furnaces;

b) **11 cold** from petroleum processing products, wind erosion in mining parks, the handling on the conveyors and transport of materials.

✓ The 3 linear sources are the conveyors located closest to the urbanized area

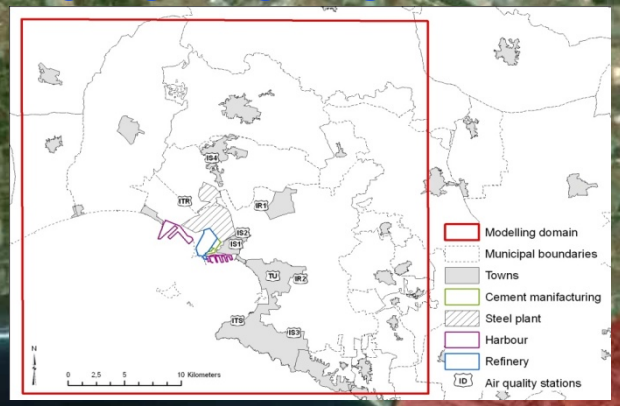




Modelling System Set Up 1/2

APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

SIMULATION DOMAIN



Meteorological profiles supplied for 2007 by the national Minni project (www.minni.org)

Topography and surface roughness

SWIFT

Computation of the 3D meteorological fields over grid.

Grid (Nx ,Ny , Nz): 71x 71x 15

Lx x Ly= 30 km x 30 km

Δx=Δy=500m

Top Domain = 5000m

Landuse

SURFPRO

Computation of 2D turbulence parameters

Emissions

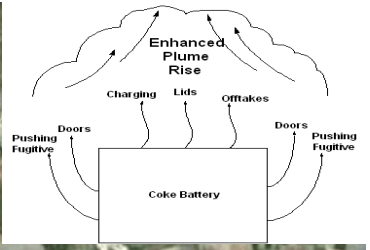
SPRAY

Computation of 3D short term hourly concentrations fields

6.26 km

Image © 2013 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2013 European Space Imaging
Data di acquisizione delle immagini: 4/7/2011 33 T 688063.68 m E 4483984.13 m N elev 16 m

Modelling System Set Up 2/2

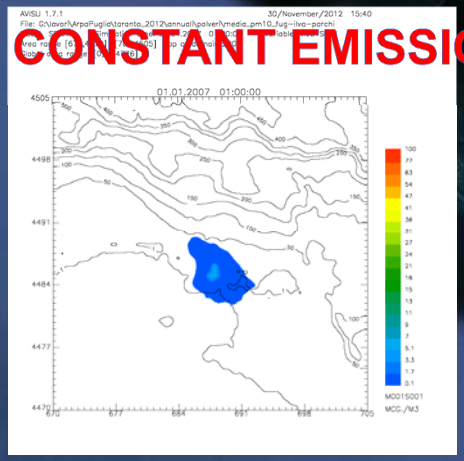


The hot buoyant areal industrial emissions were subjected to plume rise. For the coke ovens, specific algorithms developed by EPA were considered and included in SPRAY.

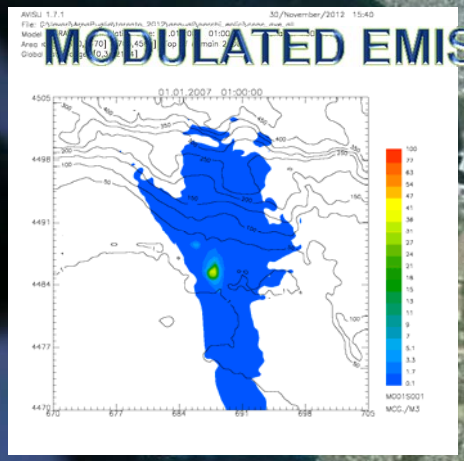
All the areal industrial emissions were considered constant with the exception of the dust emissions generated by the wind erosion of mineral deposits.
The PM10 emissions generated by the wind erosion of mineral deposits were calculated and modulated hourly as a function of wind gusts magnitude on mineral storage piles (EPA, 1997).

PM10 ANNUAL GROUND AVERAGE CONCENTRATION BY WIND EROSION

CONSTANT EMISSION



MODULATED EMISSION



On daily temporal scale the use of the modulated emission allows to reproduce the acute pollution phenomenon, named *wind day*.

6.26 km

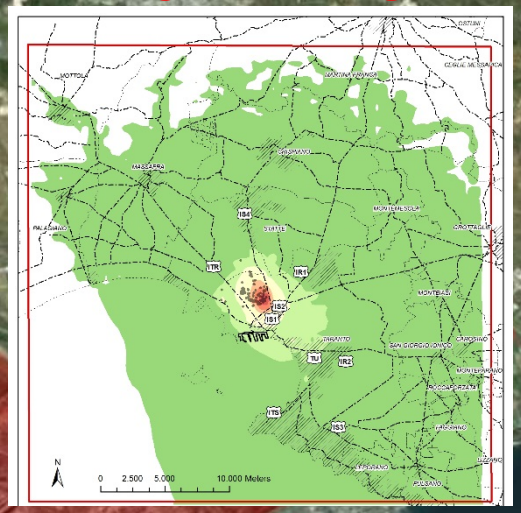
Image © 2013 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2013 European Space Imaging
Data di acquisizione delle immagini: 4/7/2011 33 T 688063.68 m E 4483984.13 m N elev 16 m

Results and discussion

SOURCE APPORTIONMENT FOR PRIMARY PM10

APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

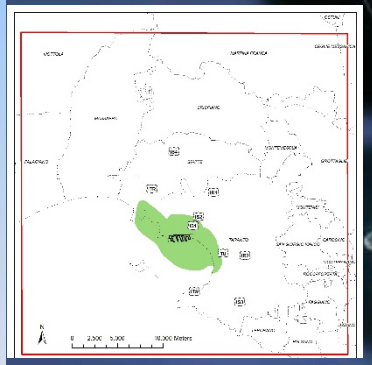
TOTAL ANNUAL AVERAGE MAP



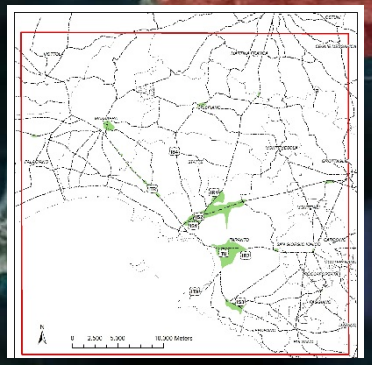
Legend

Modelling domain	PM10
Municipal boundaries	ug/m3
Towns	0 - 1
Air quality stations	1,1 - 10
	10,1 - 20
	20,1 - 30
	30,1 - 40
	40,1 - 50
	50,1 - 60
	60,1 - 70

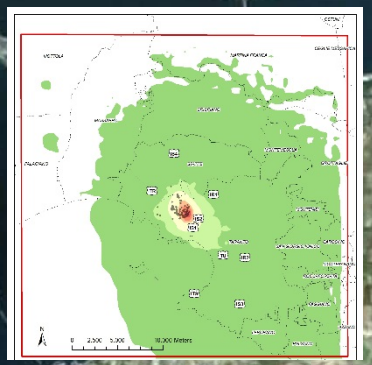
THE HARBOUR



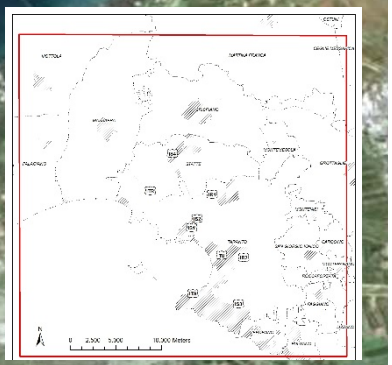
TRAFFIC



INDUSTRY



RESIDENTIAL HEATING



Industry is in the Taranto area the most contributor on the total annual concentration for primary PM10.

6.26 km

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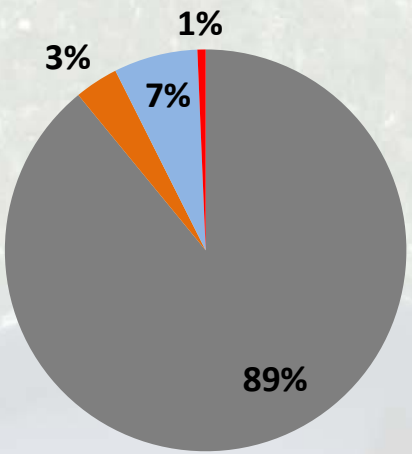
APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

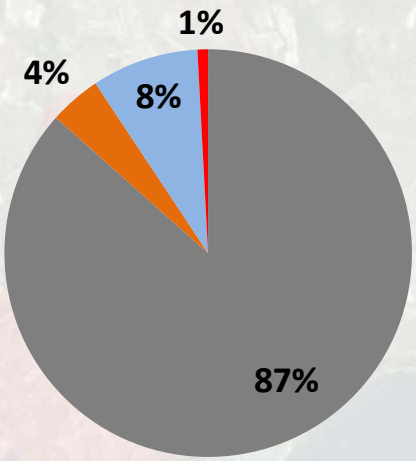
SOURCE APPORTIONMENT AT INDUSTRIAL SITE (VIA MACHIAVELLI)

APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

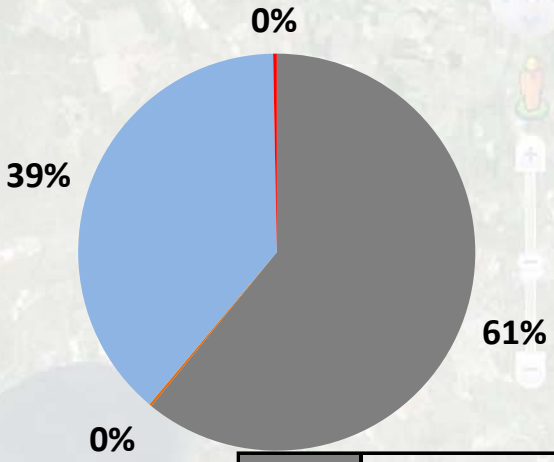
PM10
28 µg/m3



PM2.5
21 µg/m3

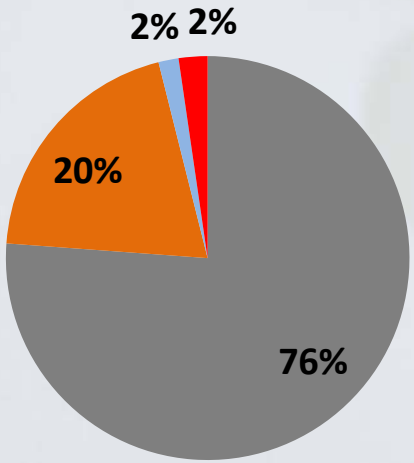


SO2
37 µg/m3

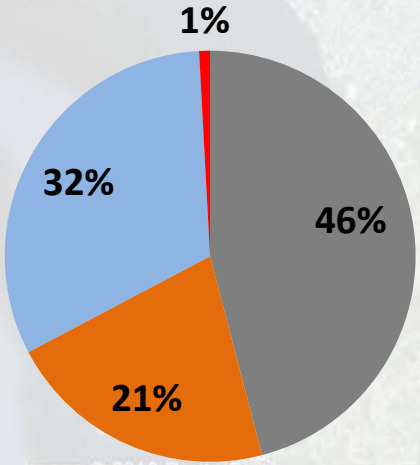


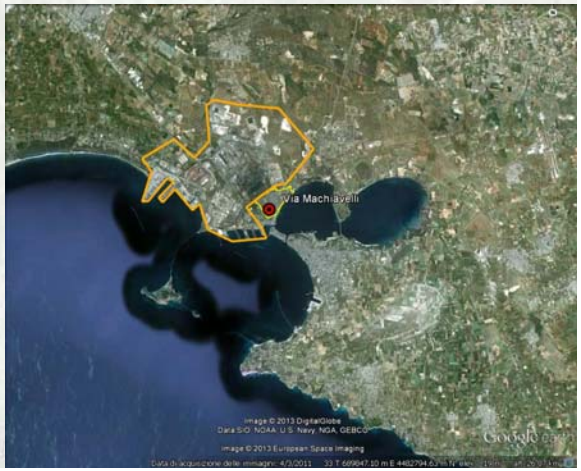
	Industry
	Traffic
	Residential Heating
	Harbour

Benzene
1.4 µg/m3



NOx
49 µg/m3





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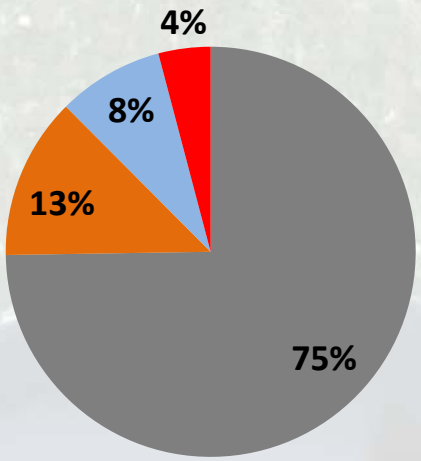
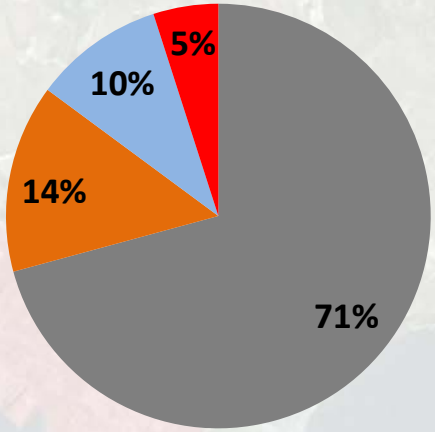
SOURCE APPORTIONMENT AT URBAN-TRAFFIC SITE (VIA ALTO ADIGE)

APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

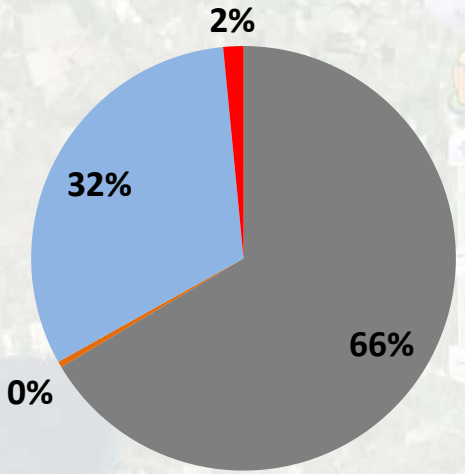
PM10
9 µg/m3

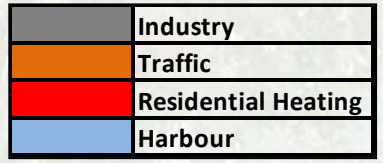


PM2.5
8 µg/m3

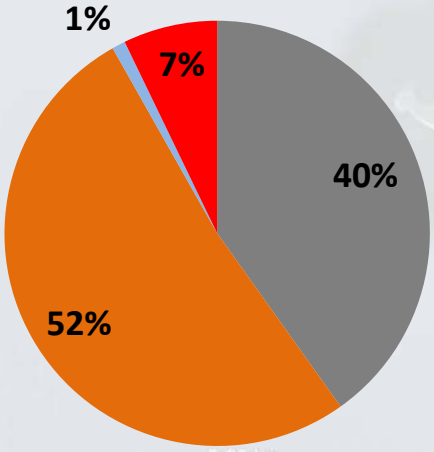


SO2
19 µg/m3

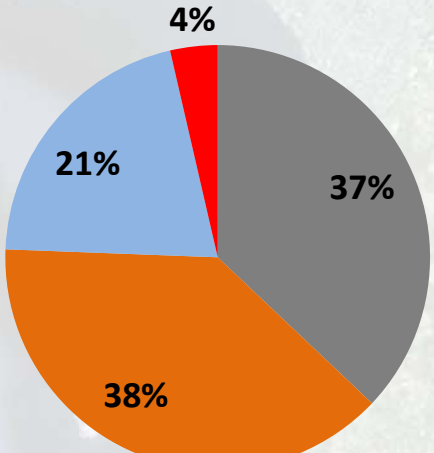


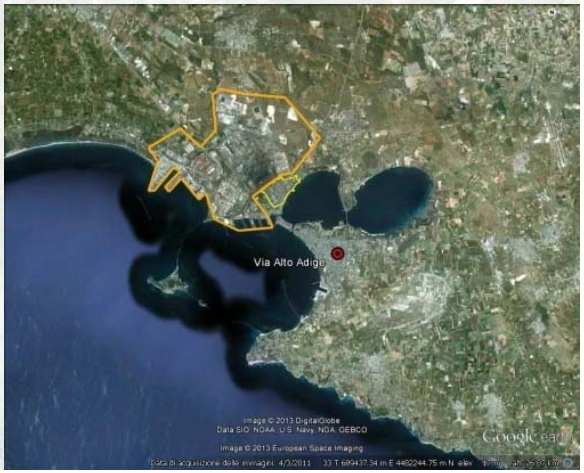


Benzene
1 µg/m3



NOx
32 µg/m3





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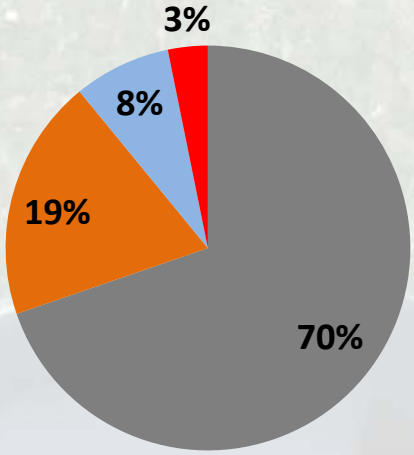
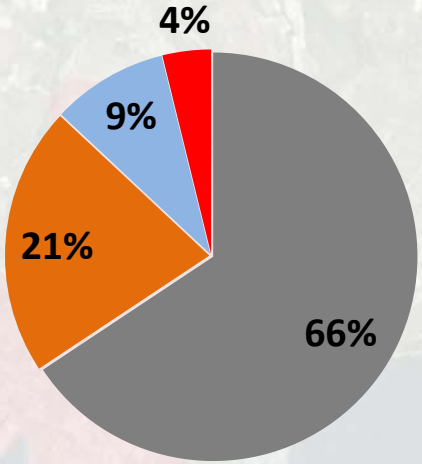
SOURCE APPORTIONMENT AT BACKGROUND SITE (TALSANO)

APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

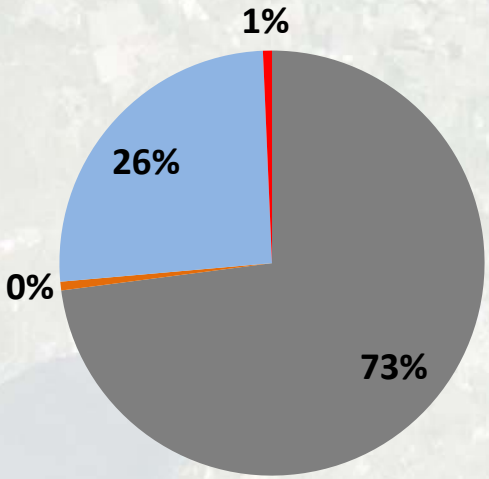
PM10
5 µg/m3



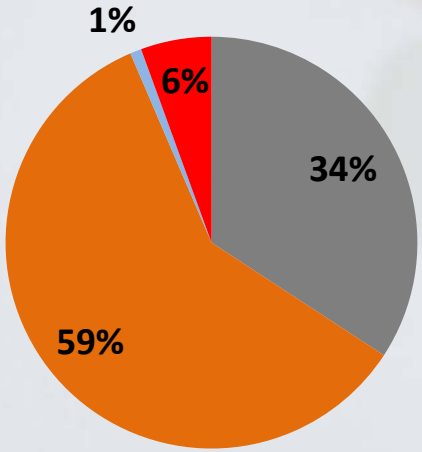
PM2.5
4 µg/m3



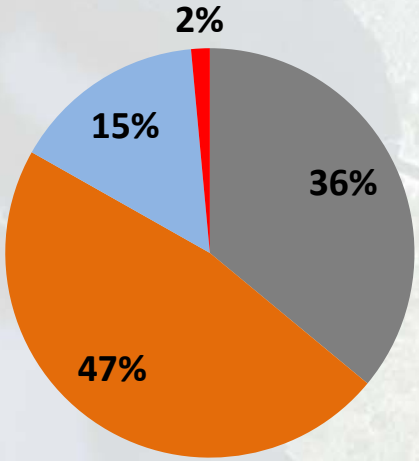
SO2
12 µg/m3



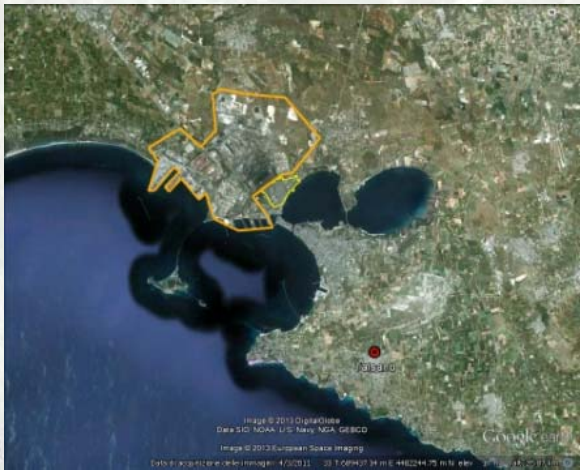
Benzene
0.5 µg/m3



NOx
22 µg/m3



	Industry
	Traffic
	Residential Heating
	Harbour



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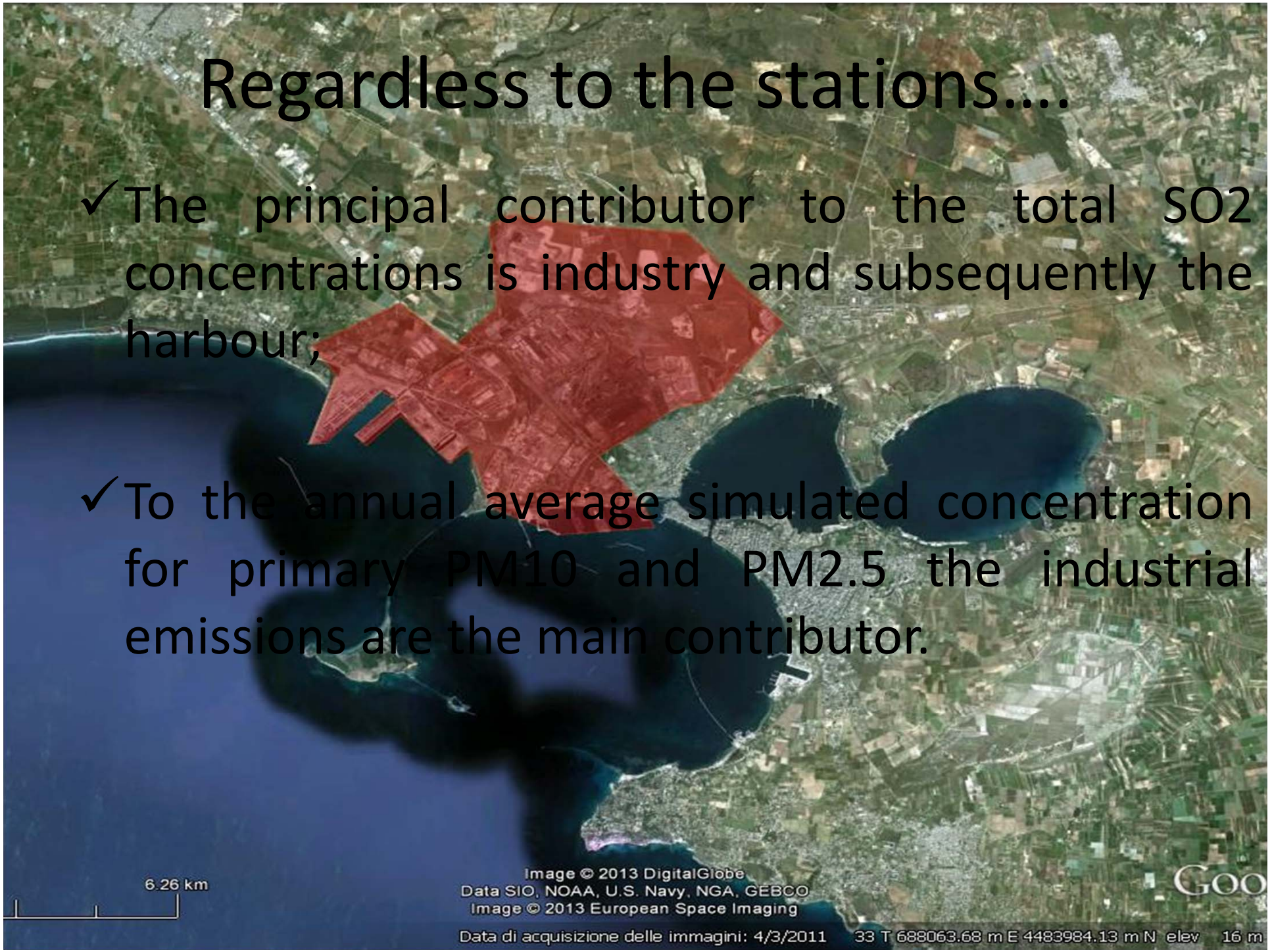
Regardless to the stations….

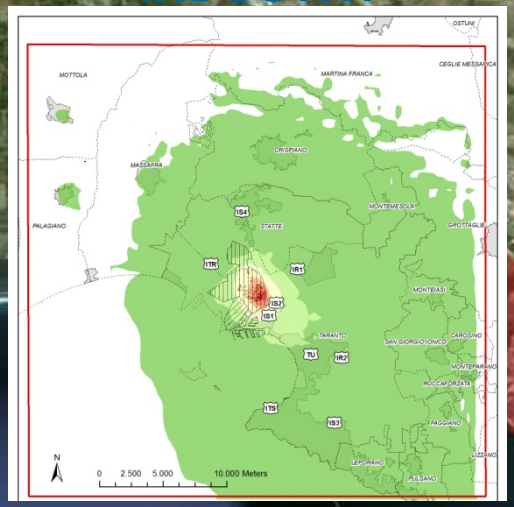
- ✓The principal contributor to the total SO2 concentrations is industry and subsequently the harbour;
- ✓To the annual average simulated concentration for primary PM10 and PM2.5 the industrial emissions are the main contributor.

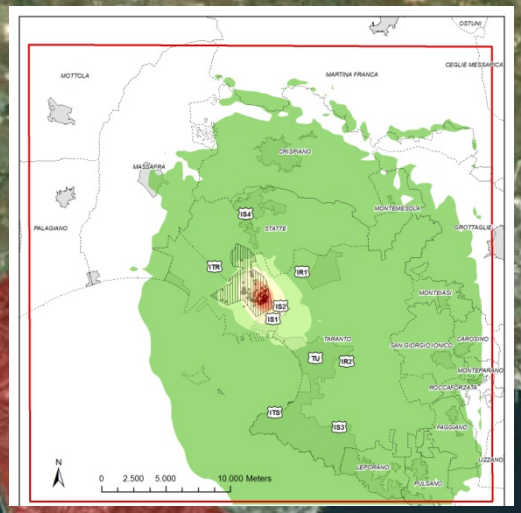


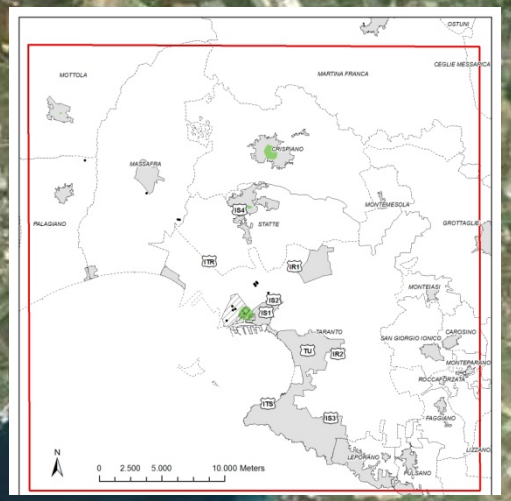
SOURCE APPORTIONMENT FOR INDUSTRIAL PRIMARY PM10

APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

INDUSTRY = STEEL PLANT + OTHER INDUSTRIES

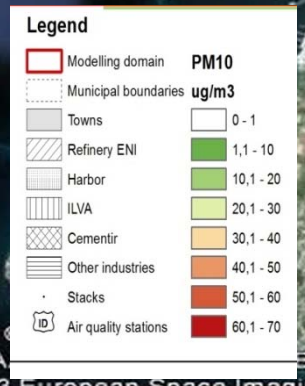






Industrial PM10	Paolo VI	Via Archimede	Via Machiavelli	SS7Wind	Via Alto Adige	Talsano	Capo San Vito	Statte	Casa Circondariale
Steel Plant	96%	98%	97%	95%	96%	94%	94%	96%	95%
Other Plants	4%	2%	3%	5%	4%	6%	6%	4%	5%

At the all monitoring stations the steel plant emissions account for over 90% of the industrial primary PM10 concentrations.



Stations	type
IS1- Via Machiavelli	Industrial suburban
IS2 - Via Archimede	Industrial suburban
IS3 – Talsano	Industrial suburban
IS4 – Statte	Industrial suburban
IR1 - Paolo VI	Industrial rural
IR2 - Casa Circond.	Industrial rural
ITR - SS7 Wind	Industrial/traffic rural
ITS - San Vito	Industrial/traffic suburban
TU - Via Adige	Traffic urban

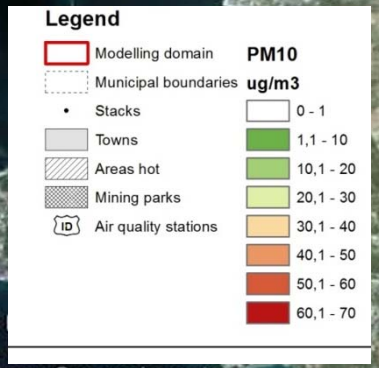
SOURCE APPORTIONMENT FOR PRIMARY PM10 FROM STEEL PLANT

APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

STEEL PLANT = Stack emissions + Hot areal sources + Cold areal sources

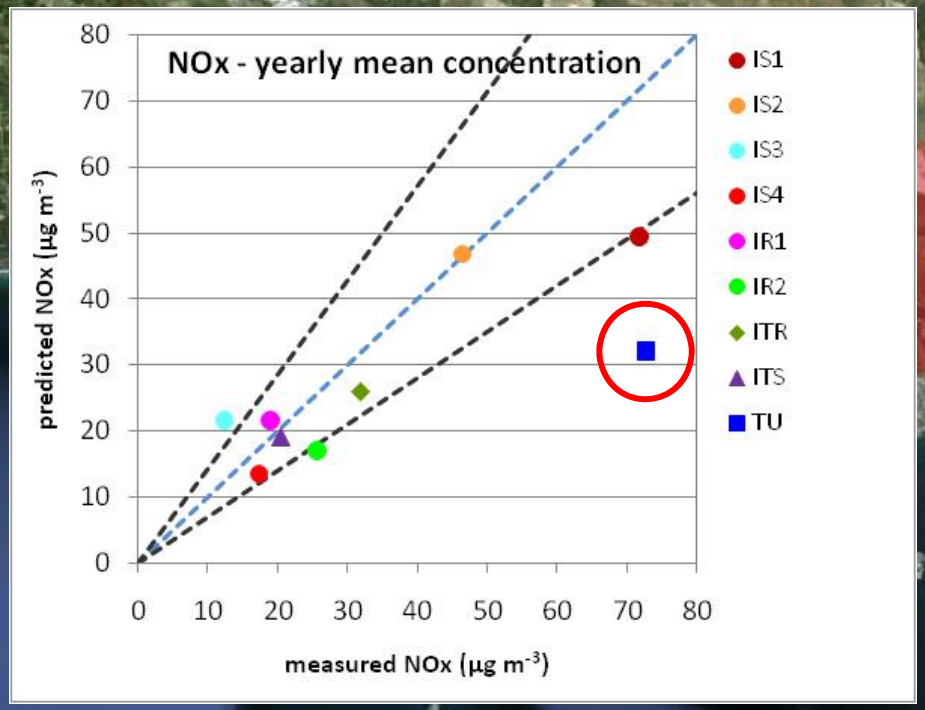
	Paolo VI	Via Archimede	Via Machiavelli	SS7Wind	Via Alto Adige	Talsano	Capo San Vito	Statte	Casa Circondariale
Stack emissions	54%	39%	41%	52%	58%	63%	62%	58%	58%
Warm areal emission	39%	48%	45%	33%	36%	33%	32%	35%	36%
Cold areal emissions	7%	13%	15%	15%	6%	5%	6%	6%	6%

The cold areal emissions have the shortest range impact; with increasing distance from the industrial area the relative impact of stack emissions becomes more important.



Stations	type
IS1- Via Machiavelli	Industrial suburban
IS2 - Via Archimede	Industrial suburban
IS3 – Talsano	Industrial suburban
IS4 – Statte	Industrial suburban
IR1 - Paolo VI	Industrial rural
IR2 - Casa Circond.	Industrial rural
ITR - SS7 Wind	Industrial/traffic rural
ITS - San Vito	Industrial/traffic suburban
TU - Via Adige	Traffic urban

Scatterplot measured vs.predicted concentrations for NOx



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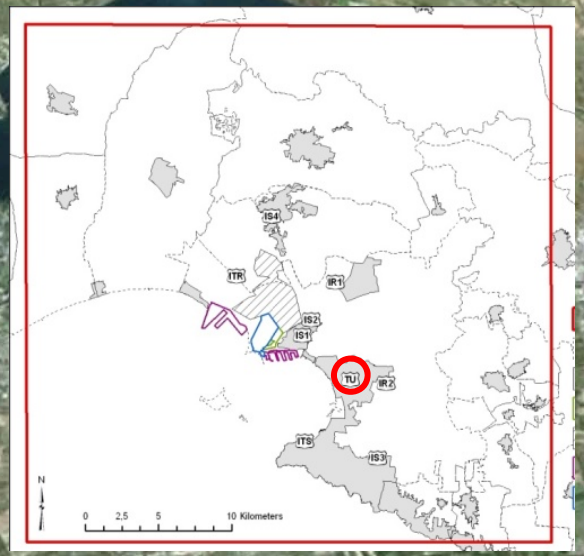
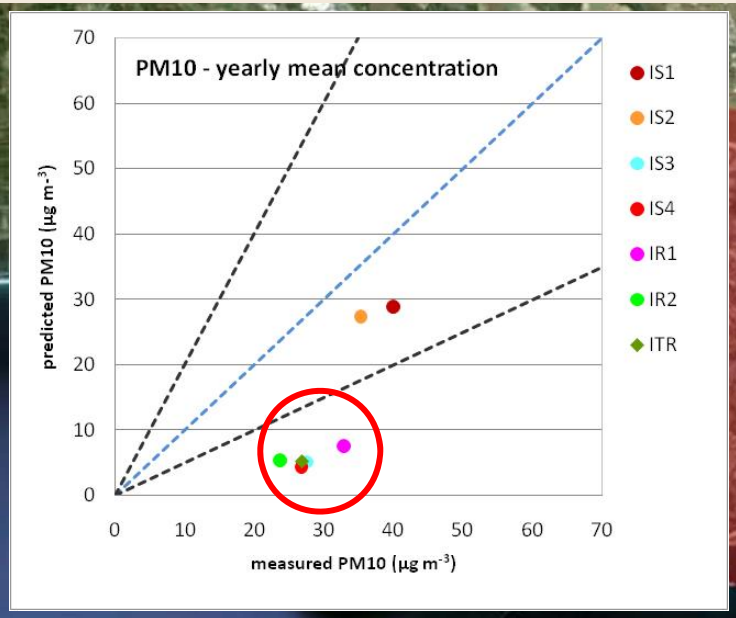


The overall performance is quite good: there is only a slight tendency of the model to underestimate the mean concentration for the urban traffic site TU, probably because in that area the traffic emission data are not adequately detailed.

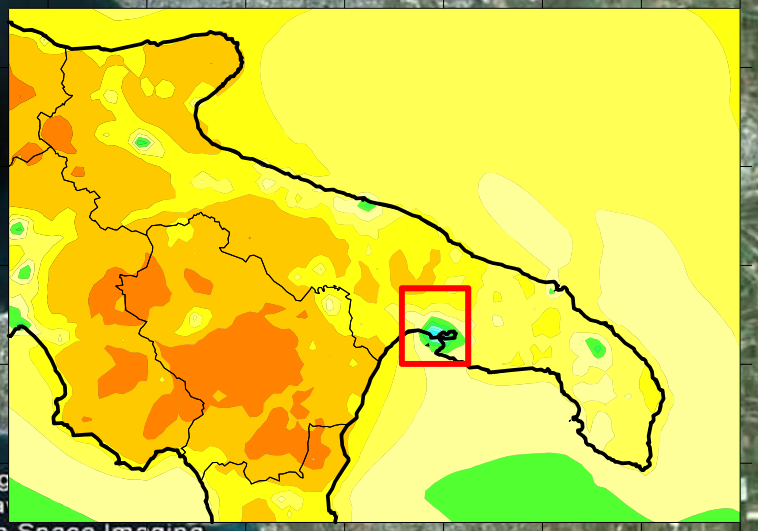
Scatterplot measured vs.predicted concentrations for PM10



The PM10 underestimation is more considerable at greater distance from industrial areas. This is likely due to the regional background contribution which was not taken into account by Lagrangian model.

In the Taranto area the regional background contribution behaves in a complementary way to the total primary PM10 simulated by SPRAY .

REGIONAL BACKGROUND CONTRIBUTION (%)
FOR TOTAL ANNUAL PM10 AVERAGE
MINNI 2007



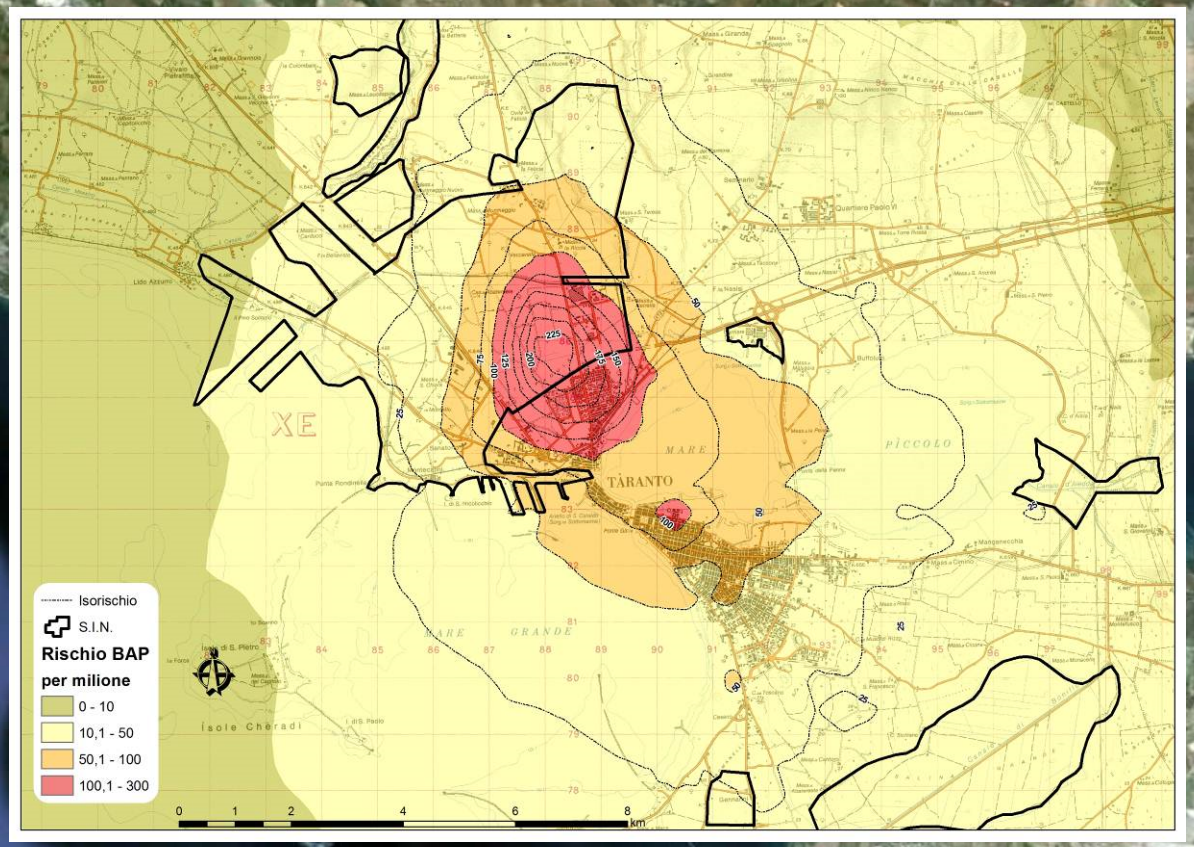
Conclusion

- ✓ This study improves knowledge about the impact of different pollutant sources on the Taranto area for primary macropollutants.
- ✓ The performance of the modelling system seems quite good.

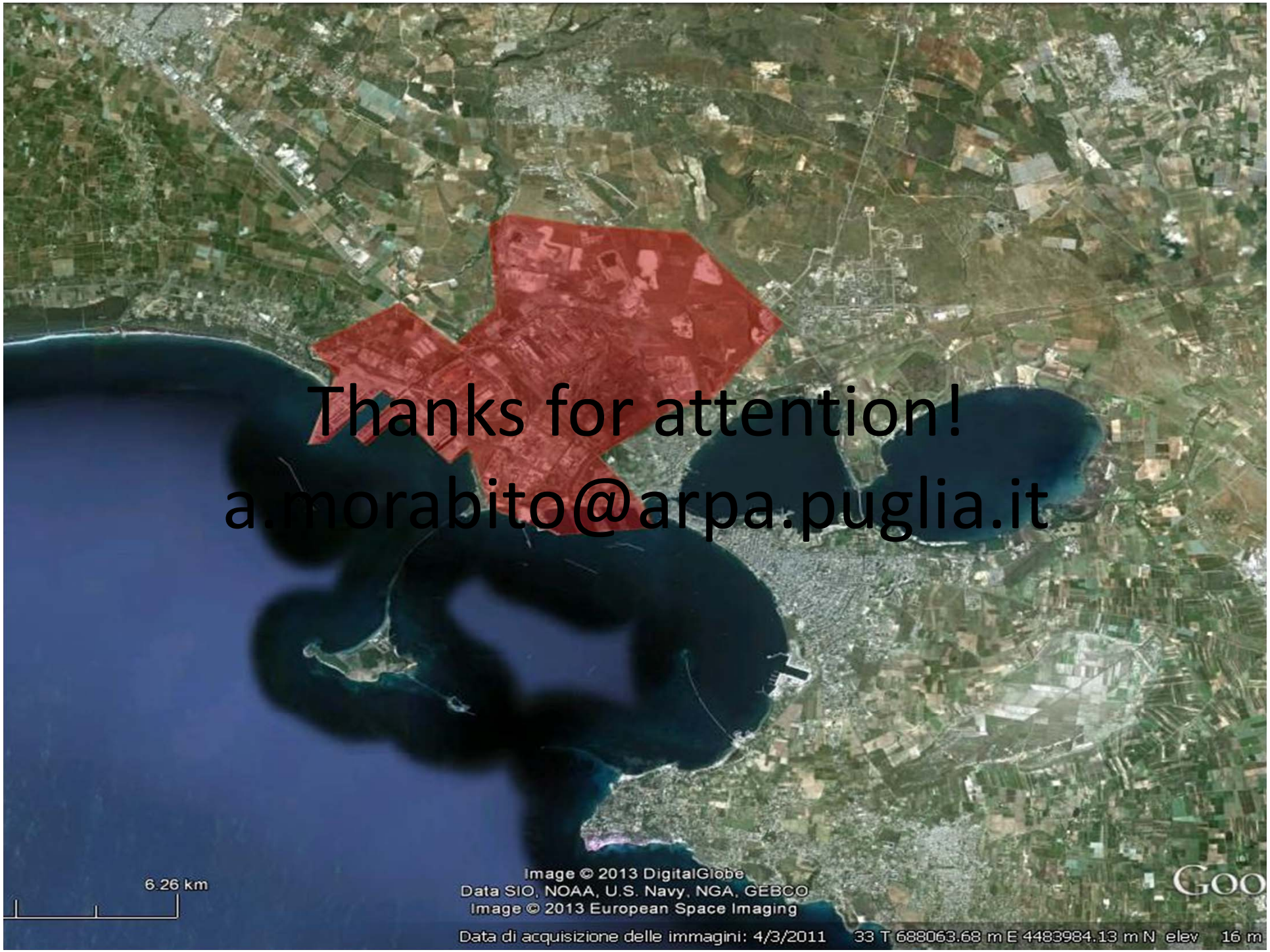
The results of this study have contributed to the remediation of air quality in the Taranto area (Regione Puglia, 2012).

This same modelling system now is using to realize the first Health Damage Evaluation about the steel plant, ordeined by a Regional Legislative Act (LR 21/2012, Regione Puglia) for the most polluting plants placed at Puglia region.
In particular the modelling system is used to evaluate the environmental exposure level of the resident population in the Taranto area to dangerous micropollutants (POP's and heavy metals) emitted by the steel plant (work in progress).

Work in progress



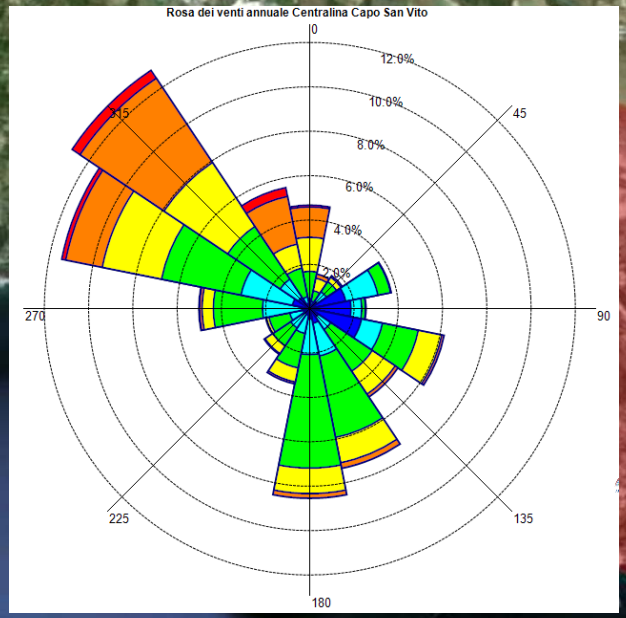
Carcinogenic health risk map (for million) attributable to inhaled benzoapyrene - 2010


Thanks for attention!
a.morabito@arpa.puglia.it
6.26 km
Image © 2013 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2013 European Space Imaging
Data di acquisizione delle immagini: 4/3/2011
33 T 688063.68 m E 4483984.13 m N elev 16 m

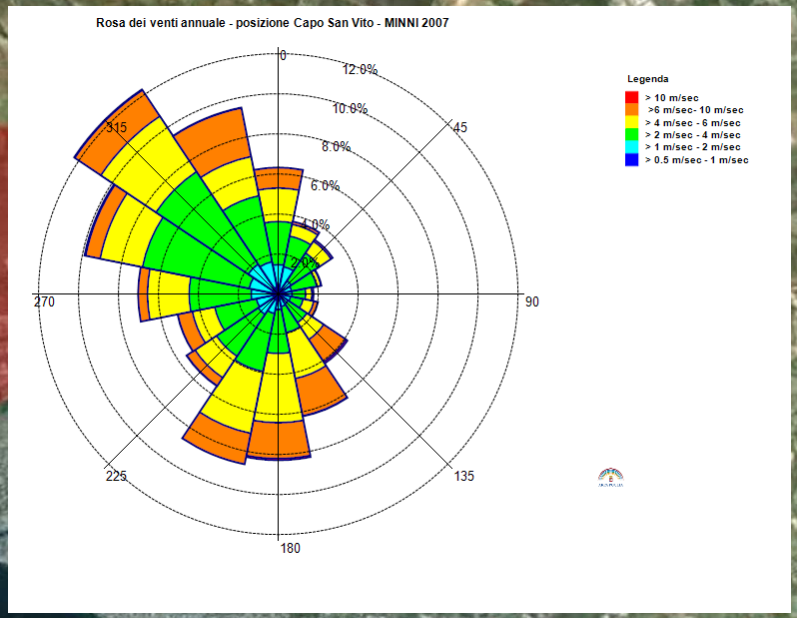
APPLICATION OF A LAGRANGIAN PARTICLE MODEL TO THE SOURCE APPORTIONMENT FOR PRIMARY MACROPOLLUTANTS IN TARANTO AREA

Observed Vs. modelled surface wind

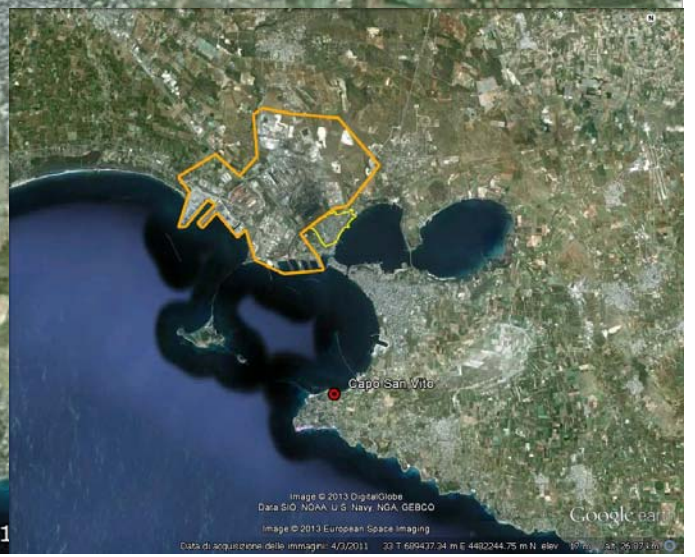
OBSERVED

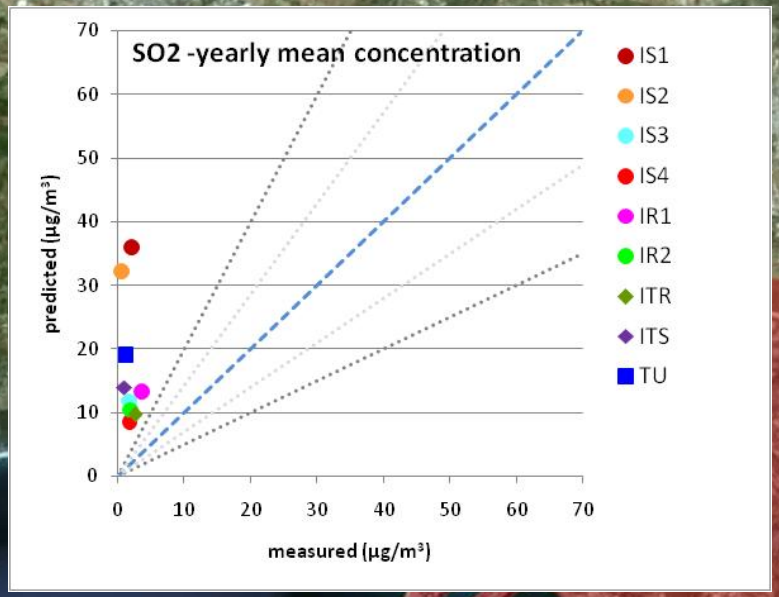


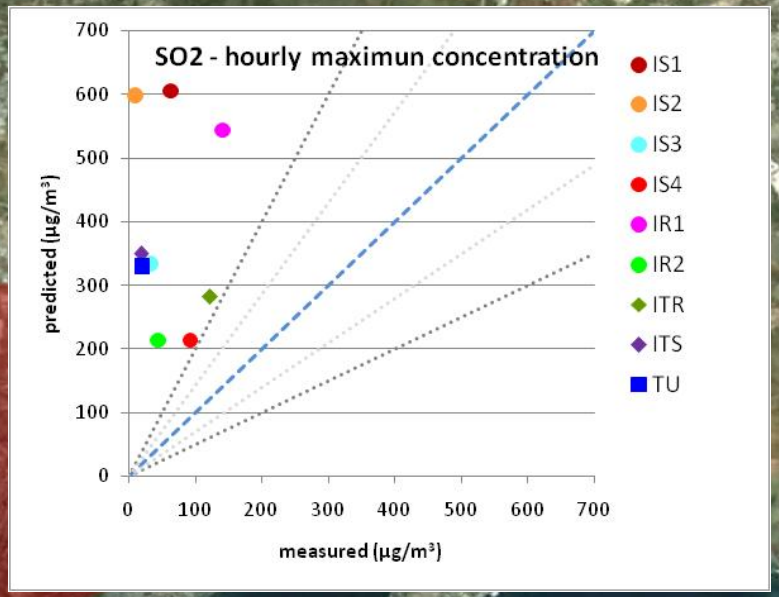
MODELLED

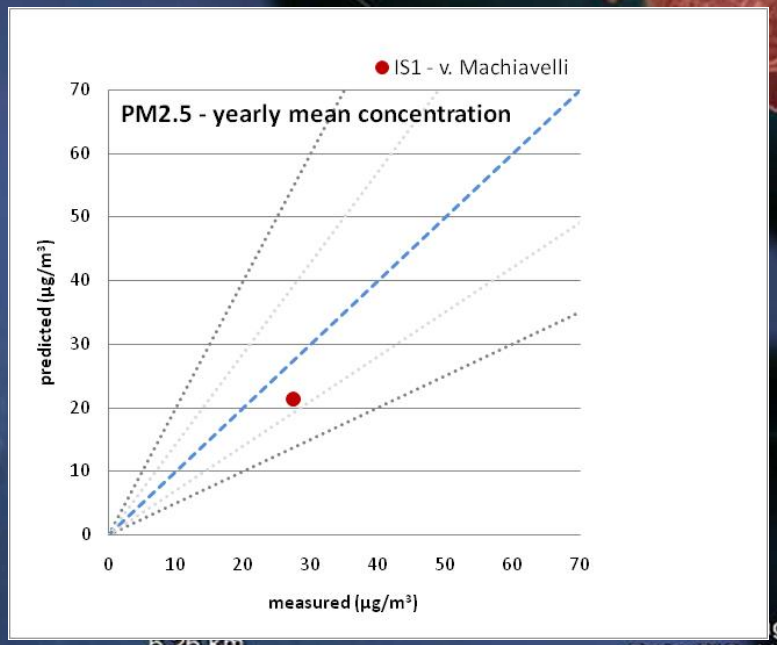


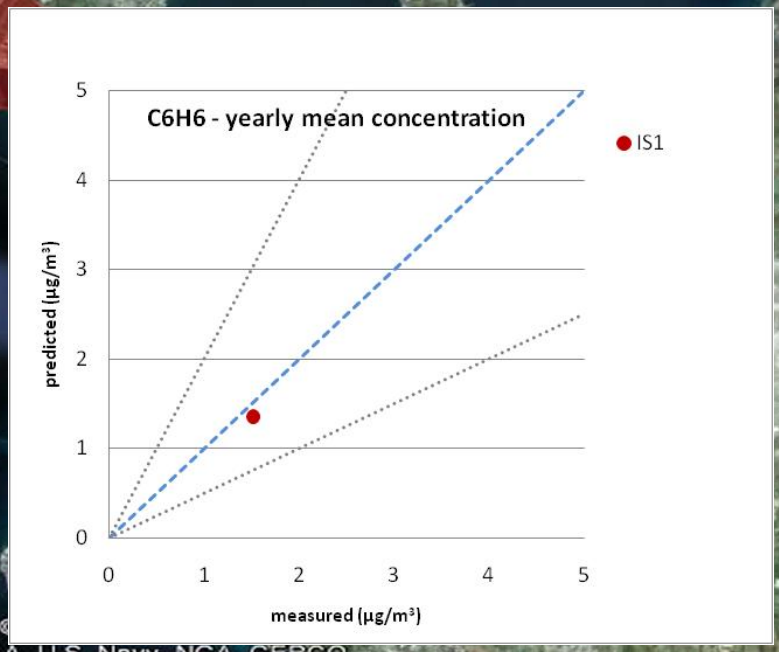
	Capo San Vito	Performance Goals (Emery,2001)
BIAS	0,8	≤ 0,5
RMSE	2,1	
IOA	0,8	











6.26 km

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2013 European Space Imaging

Data di acquisizione delle immagini: 4/3/2011 33 T 688063.68 m E 4483984.13 m N elev 16 m

Technical information

✓ Computer

2 cpu x 4 cores intel Xeon 64 bit 2 GHz

✓ Simulation times (hours)

Traffic 166 (linear) + 24 (diffuse)

Harbour 29

Cold areal emissions 14 (steel plant) + 6 (other industries)

Hot areal buoyant 18

Stack emissions 90

TOTAL 347 (14.4 DAYS).