Contributo delle emissioni da traffico navale nell'area del porto di Brindisi alla concentrazione di particolato atmosferico: un approccio modellistico nell'ambito del progetto CESAPO

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motivation

- emissions of gases and particulate from ships are a large and growing contribution to the total emissions from the transportation sector
- different studies estimate the impact of ship emissions on air pollution in the Mediterranean Area, also investigating the dependence from the applied inventory (Marmer et al., 2009)
- harbours are located near industrial area and near densely populated city

✓ impact on air quality and health

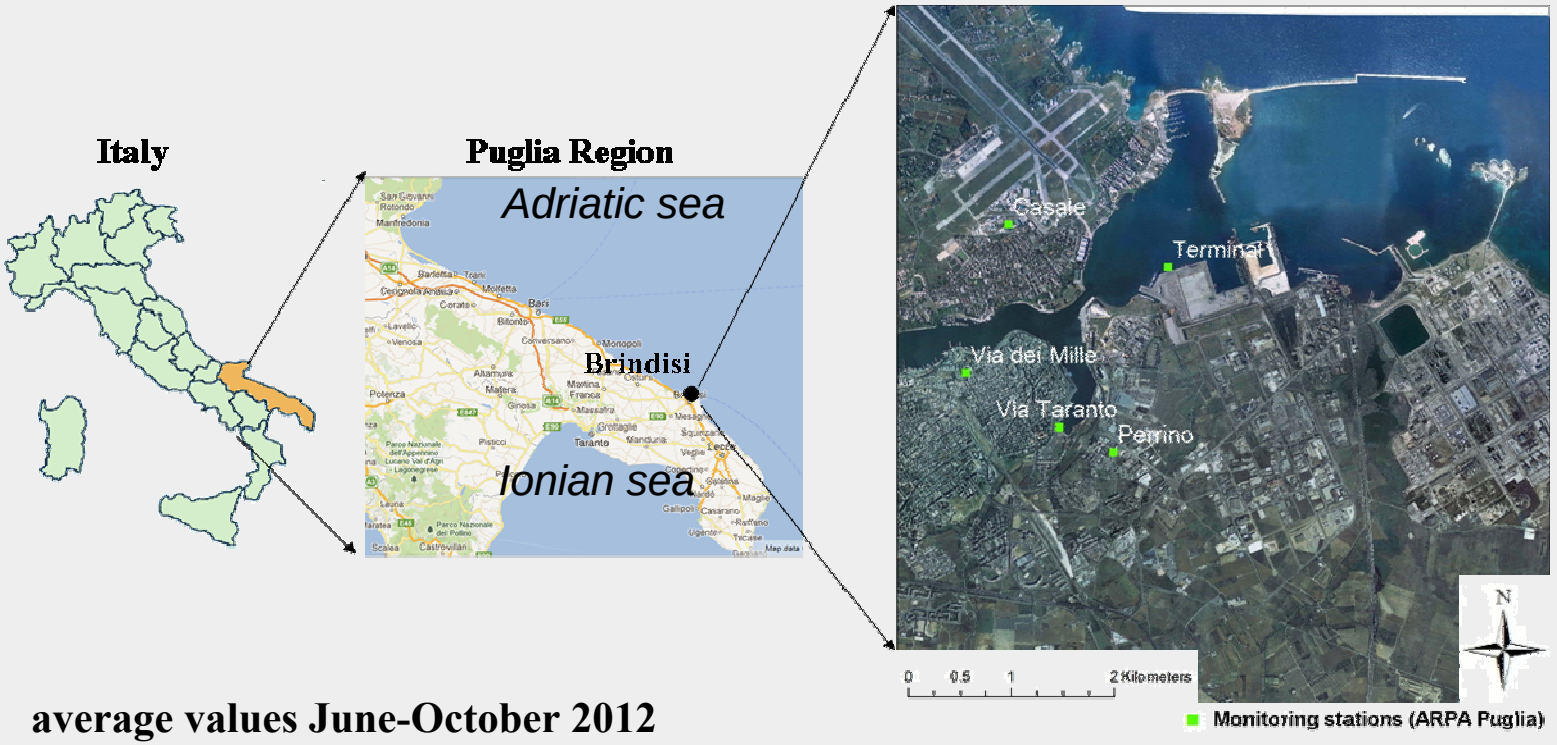
CESAPO project

European Territorial Cooperation Programme Greece-Italy 2007-2013

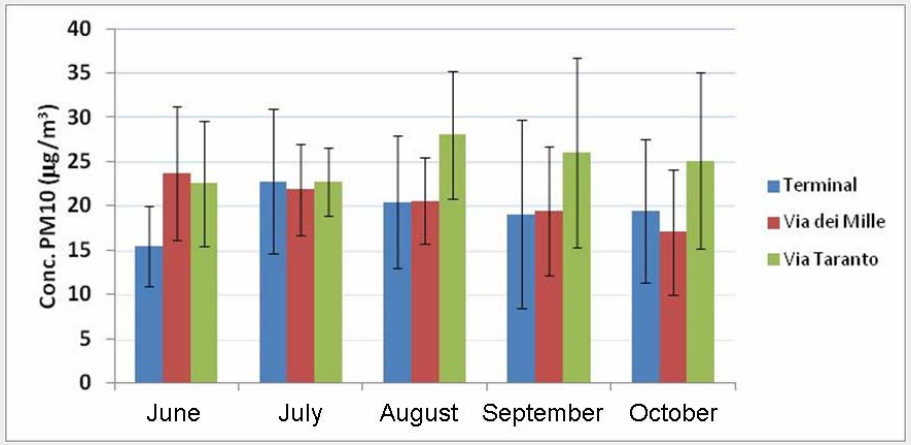
CESAPO (Contribution of Emission Sources on the Air Quality of the Port-cities in Greece and Italy - http://www.cesapo.upatras.gr)

- To understand the levels of air pollution in Patra and Brindisi using a state-of-the-art integrated approach between experimental data and advanced numerical model simulations
- To estimate the emission source attribution
- To assess the environmental impact of the pollutants emissions from the maritime transport and the activities within the harbor
- To study the impacts on air quality of different scenarios of development
- To share knowledge, experiences and tools between the project partners
- To consolidate a network of communication among the local and environmental authorities, the research institutions and the public

the study area



average values June-October 2012

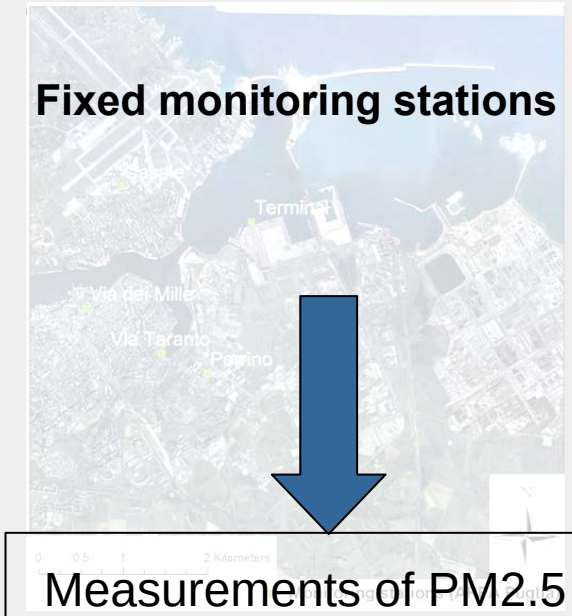


fixed monitoring stations

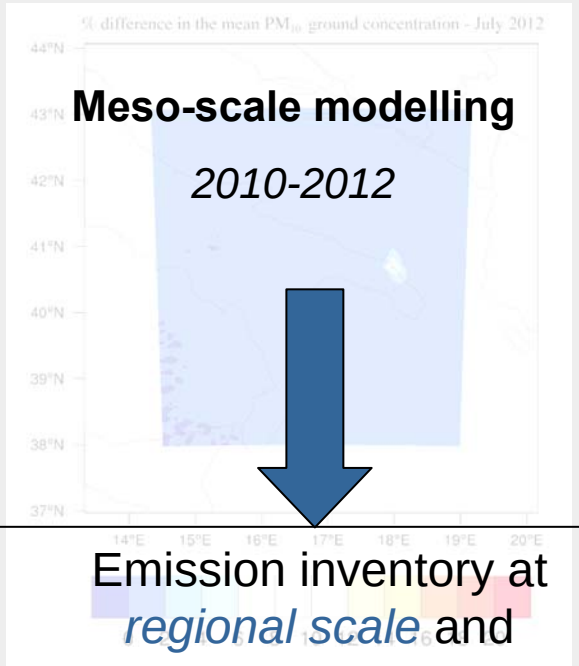
ARPA Puglia
www.arpa.puglia.it

	PM_{10} (µg/m³)	Dev. Std. (µg/m³)
Terminal	19	8.3
Via dei Mille	20	6.6
Via Taranto	25	8.7

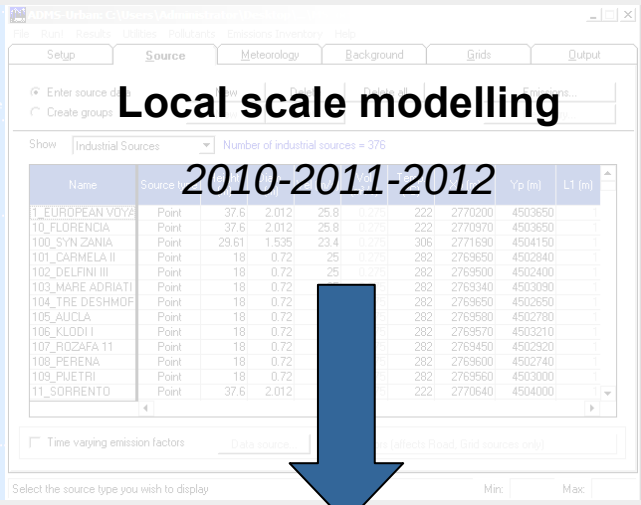
modelling approaches



Measurements of PM2.5 and PM_{10}



Emission inventory at *regional scale* and calculation PM_{10} and $PM_{2.5}$ concentrations

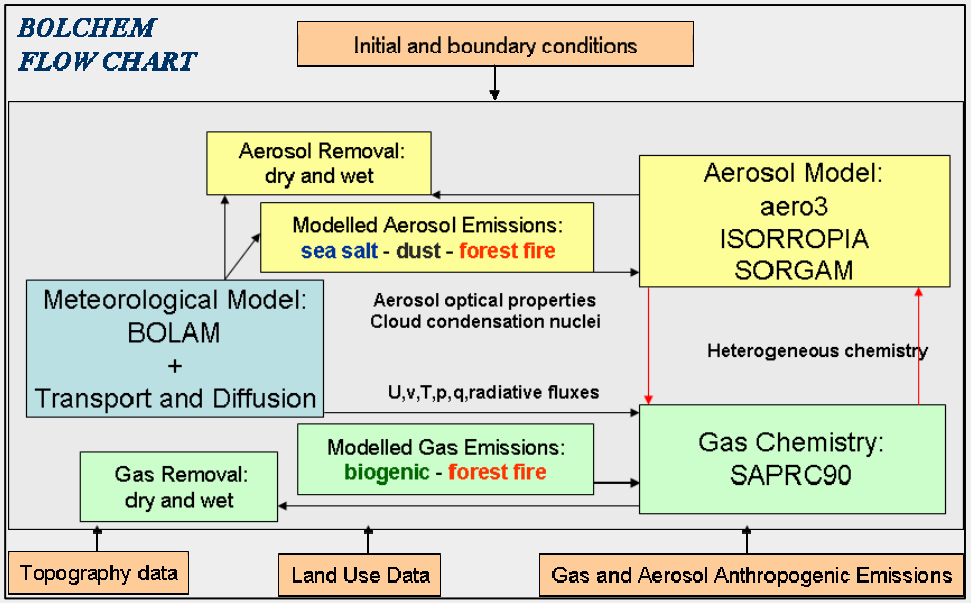


Emission inventory at *local scale* and calculation of PM_{10} concentrations

Estimation of the contribution of shipping emissions to local pollutant concentrations in the area of Brindisi port

mesoscale modelling: BOLCHEM

Mircea M. et al., Atmospheric Environment 42, 1169-1185



AERO3 *(Binkowski et al. 2003)*

Modal approach: particle size distribution represented as the superposition of three lognormal subdistributions:

Aitken mode (0.01 -0.1 µm)

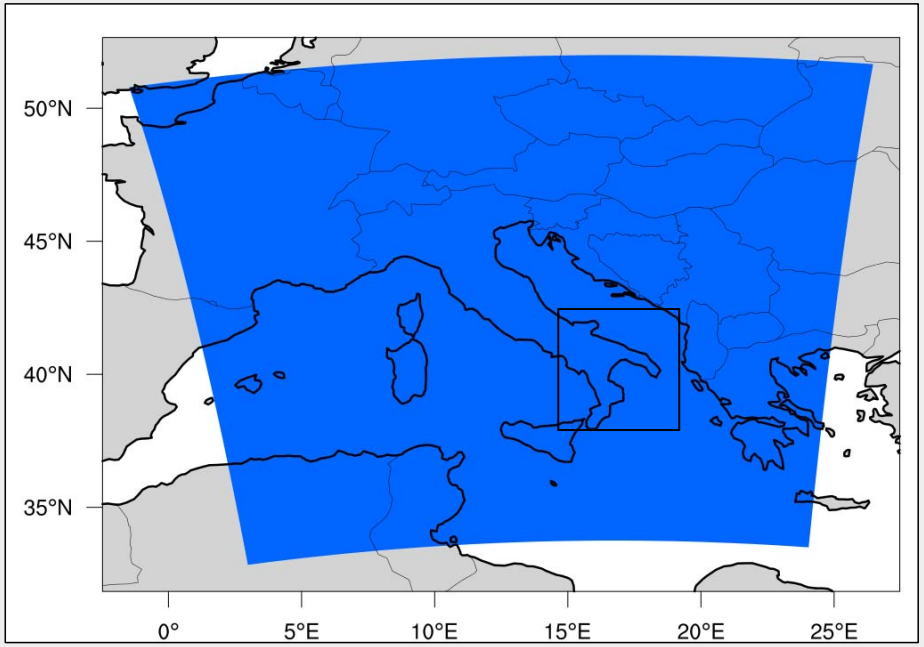
Accumulation mode (0.1-2.5 µm)

Coarse mode (2.5-10 µm)

- **predict particle number, total surface area, total mass for each mode**

- **$PM_{2.5}$ is the sum of Aitken and Accumulation modes, PM_{10} is the sum of all three modes**
- **aerosol particles are internally mixed**
- **PM2.5 and PM10:**
  - **Primary Components: organic aerosol, elemental carbon, unspeciated anthropogenic (in $PM_{2.5}$)**
  - **Secondary Components: sulfate aerosol, ammonium aerosol, nitrate aerosol, SOA**
- **coarse mode: anthropogenic dust, sea salt, (natural dust, wild-fire)**
- **aerosol processes: Nucleation, Coagulation, Condensation**
- **secondary Inorganic Aerosol: equilibrium model ISORROPIA ammonia-sulfate-nitrate-water-system**
- **secondary organic aerosol: Gas/particle partitioning SORGAM**

mesoscale modelling: *one way nested simulation*

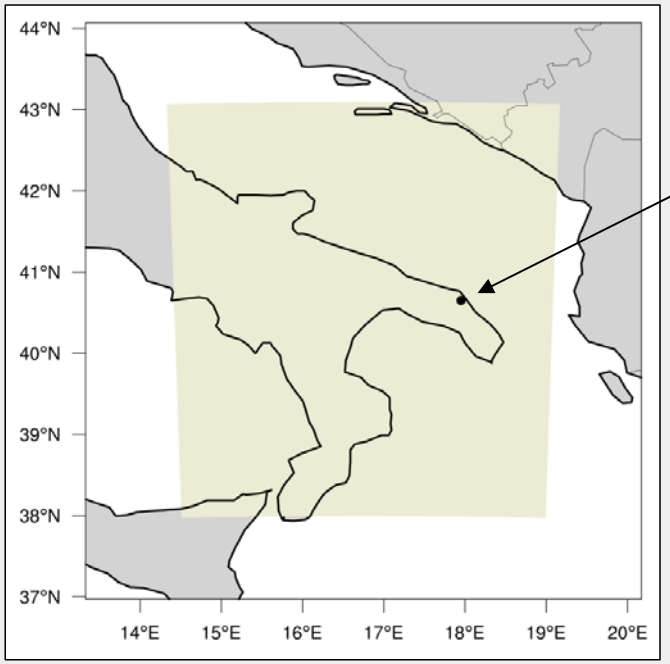


mother simulation:

***geographical domain*: includes Italy**
(3º E-24º E, 34º N-51º N)
***spatial resolution*: 0.25° X 0.25° (72x74 grid points)**
***BC and IC for meteorology* supplied by ECMWF**
***BC and IC for chemistry*: climatologic data**
***Antropogenic emissions*: TNO data set, 2007**
***Natural emissions*: calculated run time**

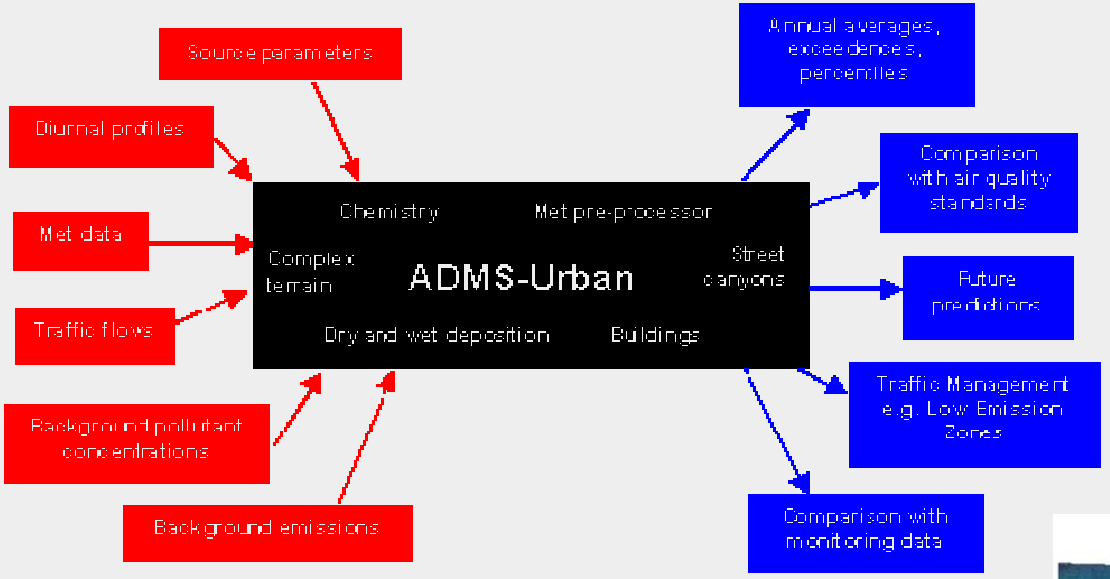
nested simulation:

***geographical domain*: includes Puglia region (14.50º E-18.975º E, 38º N-42.98º N)**
***spatial resolution*: 0.06°X 0.06° (60x86 grid points)**
***BC and IC for meteorology and for chemistry:* taken from mother simulation**
***Antropogenic emissions*: regional inventory INEMAR 2007-EMEP 2007-ISPRA 2007**
***Natural emissions*: calculated run time**



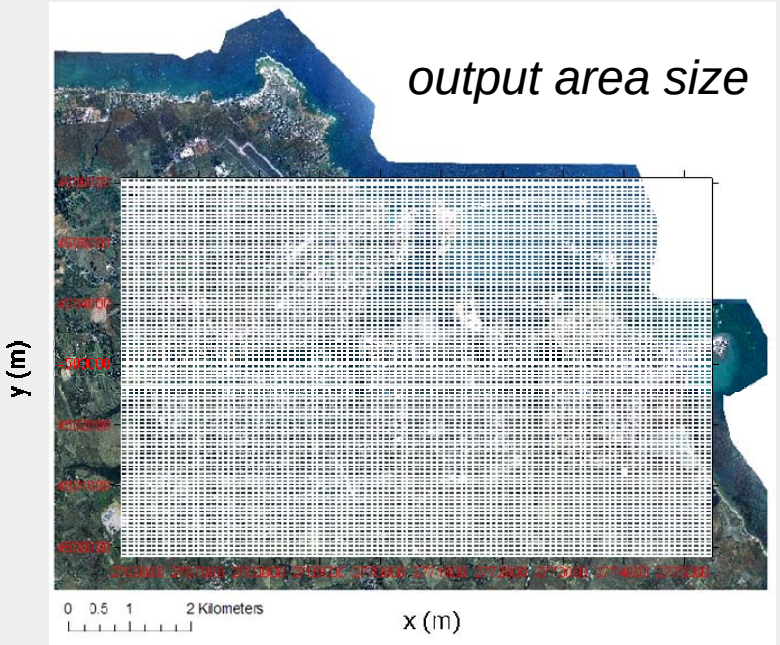
local scale modelling: ADMS-Urban

(CERC Ltd, www.cerc.co.uk)



Simulation metodology

- *input*: emissions and meteorological data
- *surface roughness* z_0: 0.75m
- *background – no chemical reactions*
- *output area size: 13km x 7km (selected output at 4m)*
- *spatial resolution*: ~130m x 70m (100x100 grid points)



ships emission emissions input

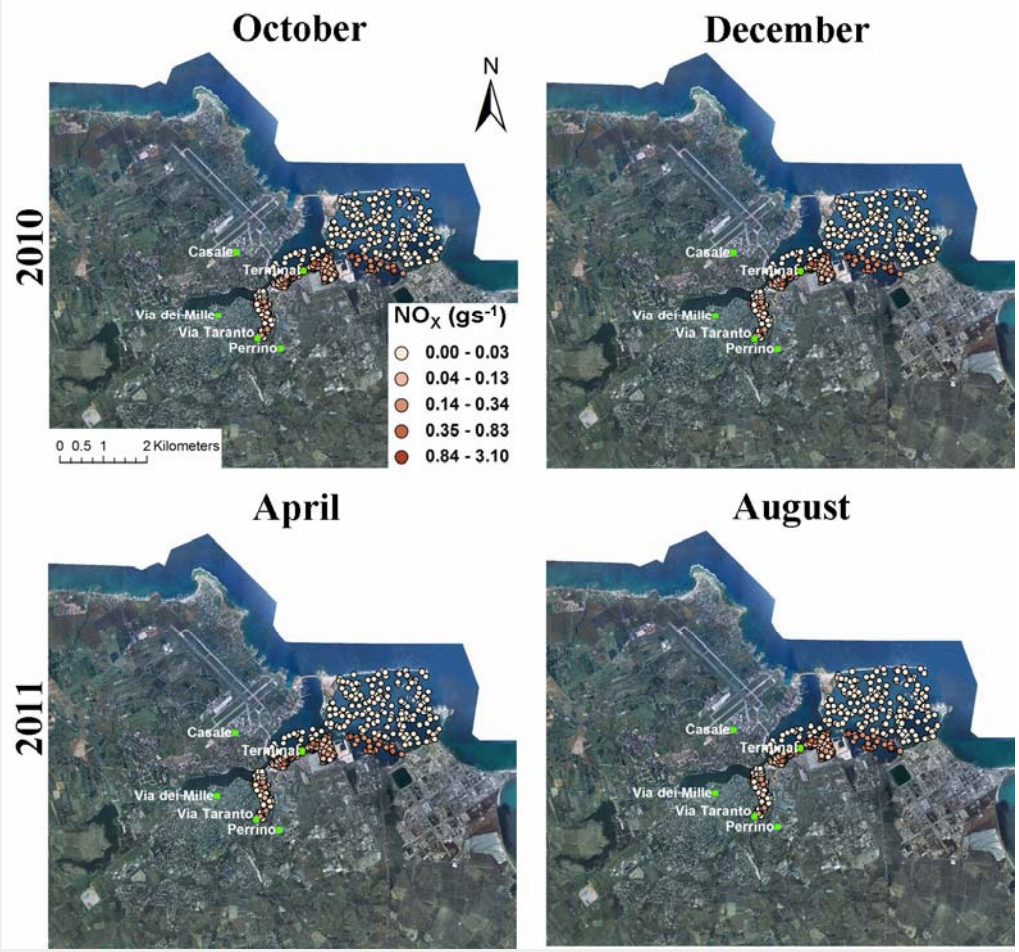
BOLCHEM

external zone	37,12%
middle zone	4,44%
inner zone	58,44%

	manouvering	hotelling
SO_2	4,74%	95,26%
NO_x	4,57%	95,43%
COVNM	6,46%	93,54%
CO_2	4,94%	95,06%
PTS	6,36%	93,64%

ADMS

Splitted into four areas using a Gis sw and ships have been positioned randomically in each area



local scale modelling: emissions

Collection of traffic data

✓ **Traffic data**: from Avvisatore Marittimo of the Brindisi harbour (http://www.porto.br.it/bpi/index.php)

2301 ships (2010)

2322 ships (2011)

2249 ships (2012)

✓ **Emission factors** depending on the type of ship and on the phase in which it is located (*European Commission Report*, 2002)

✓ **MEET methodology** (phases, characteristics, consumption) for the estimation of emissions

Trozzi C, Vaccaro R. TECHNE report MEET RF98, Methodologies for estimating air pollutant emissions from ships, August 1998.

Emission rate (gs^{-1}) — **2011**

	Hotelling		Manoeuvring		Total	
	NO_X	PM	NO_X	PM	NO_X	PM
April	30.0	4.1	0.7	0.1	30.7	4.2
August	43.4	5.7	1.2	0.2	44.6	5.9
October	37.7	5.1	0.9	0.2	38.6	5.3
December	38.4	5.3	0.9	0.2	39.3	5.5
Whole year	34.7	4.7	0.9	0.2	35.6	4.9

➢**emissions in the hotelling phase are higher than those in the manoeuvring phase** and contribute of more than 95% to the total emission rates

➢**PM_{10} emission rates are more than 80% lower than NO_X**

Mesoscale modelling: simulations

Nested simulation:
two run:

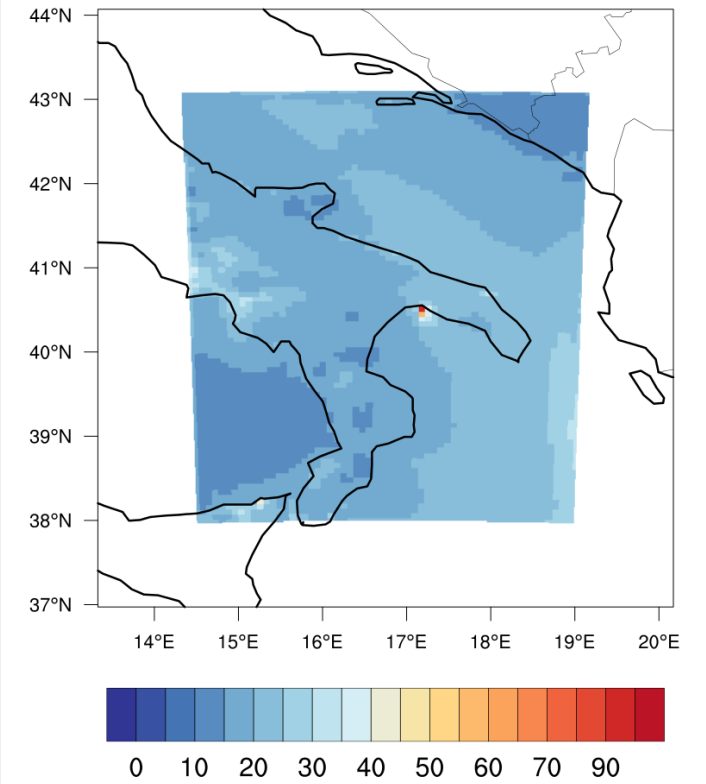
- **base simulation including anthropogenic emissions from all sources → C**
- **switching off the ship emissions from port of Brindisi → C_{bg}**

✓ **difference between the concentration fields produced by the two runs → ships contribution**

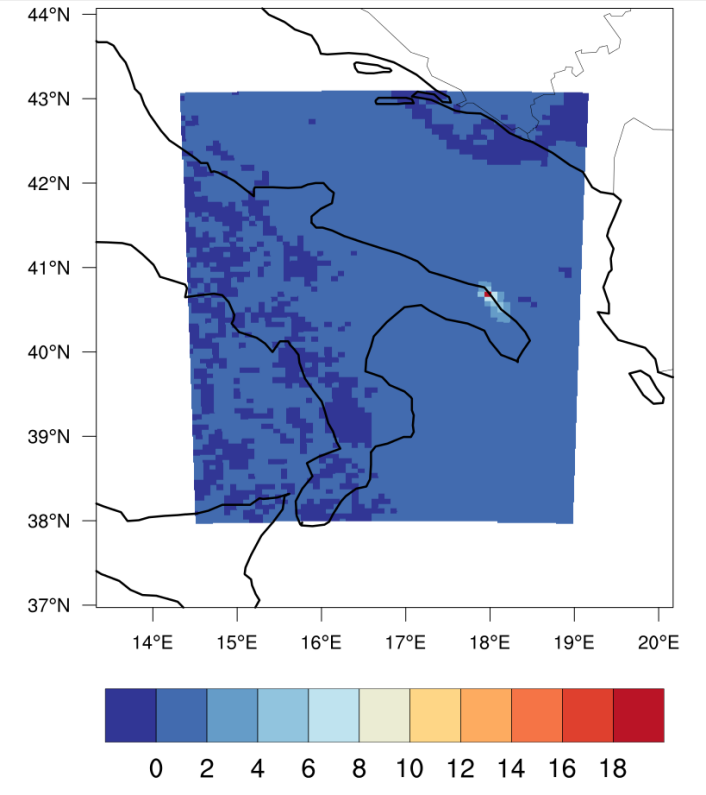
$$\Delta C\% = 100(C - C_{bg}) / C$$

July 2010

PM_{10} concentration (µg m^{-3})



ship emissions contribution %

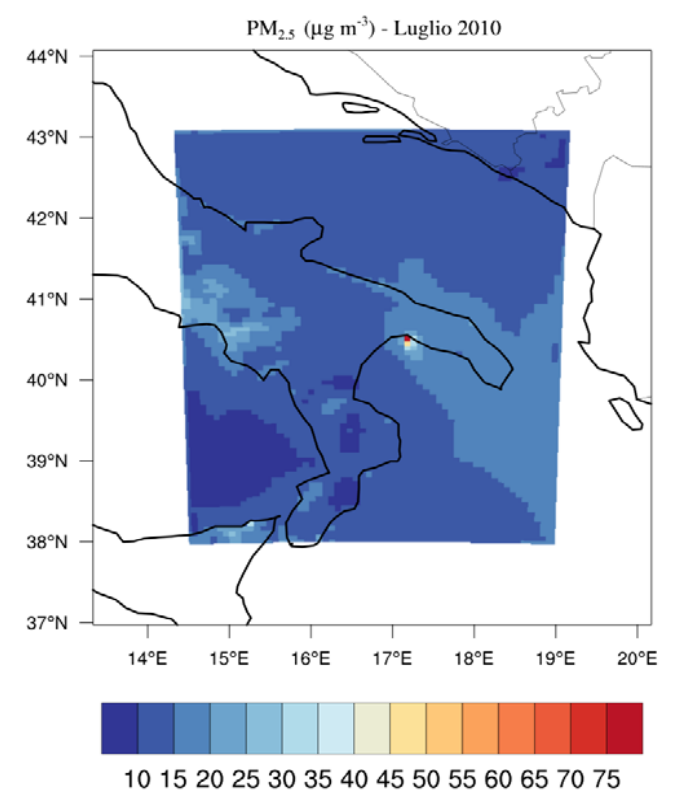


- ***monthly mean (left) value of PM_{10} ground concentrations (µg m^{-3}) for base simulation and relative ship emissions impact (%) (right)***

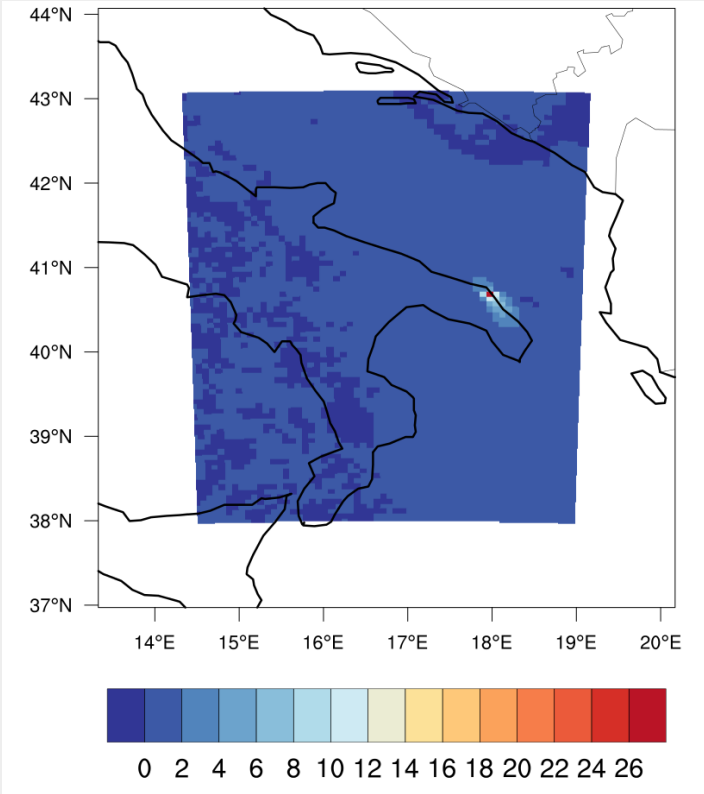
	C(µgm^{-3}) BOLCHEM	C(µgm^{-3}) measured	ΔC% BOLCHEM
Via Taranto	**27.62**	**27.41**	**12.73**
Casale	**27.93**	**26.37**	**13.15**
Via dei Mille	**26.71**	**27.99**	**10.51**
Terminal	**28.68**	**21.83**	**15.41**
Media	**27.73**	**25.9**	**12.95**

July 2010

$PM_{2.5}$ concentration (µg m^{-3})



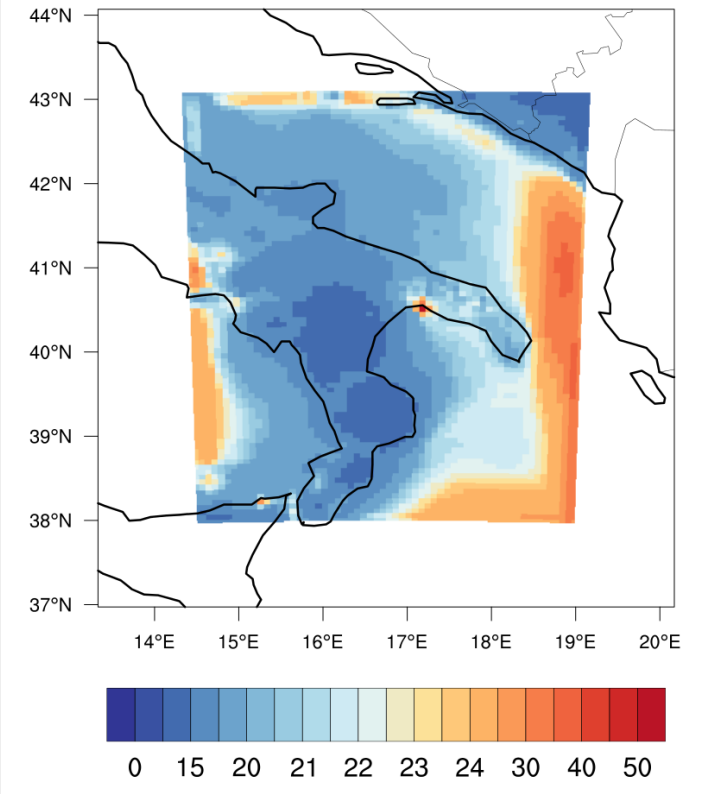
ship emissions contribution %



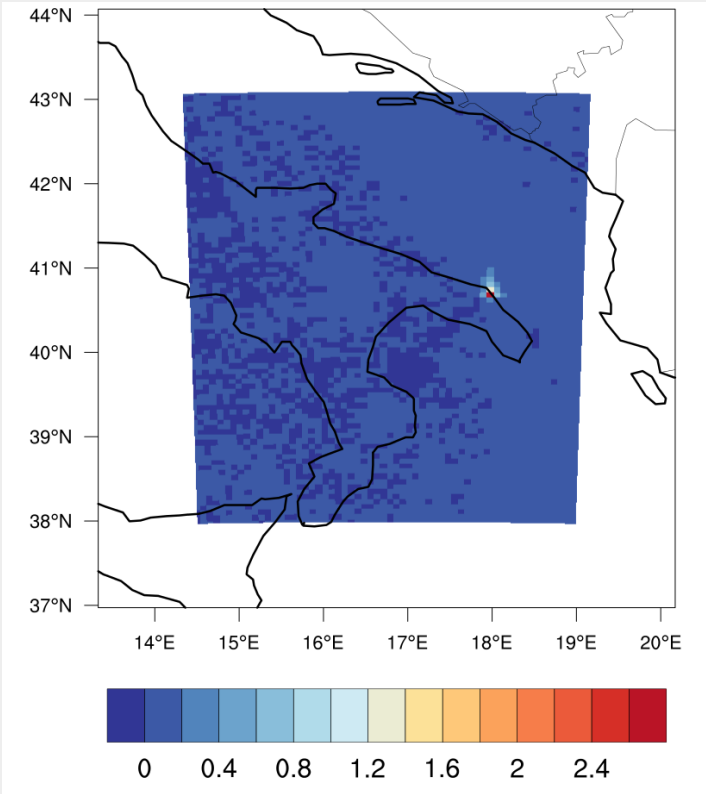
- ***monthly mean (left) value of $PM_{2.5}$ ground concentrations (µg m^{-3}) for base simulation and relative ship emissions impact (%) (right)***

December 2010

PM_{10} concentration (µg m^{-3})



ship emissions contribution %

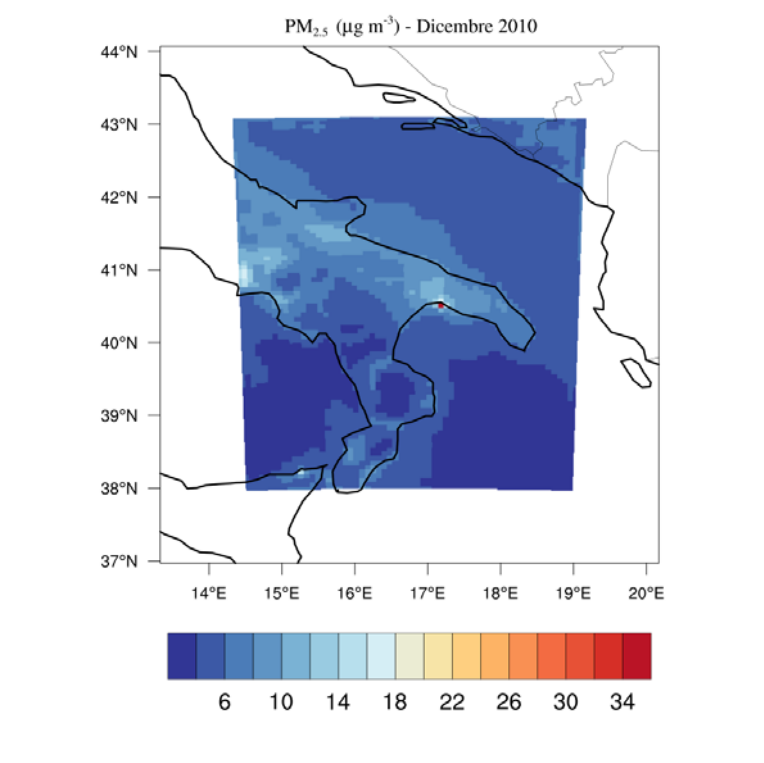


- ***monthly mean (left) value of PM_{10} ground concentrations (µg m^{-3}) for base simulation and relative ship emissions impact (%) (right)***

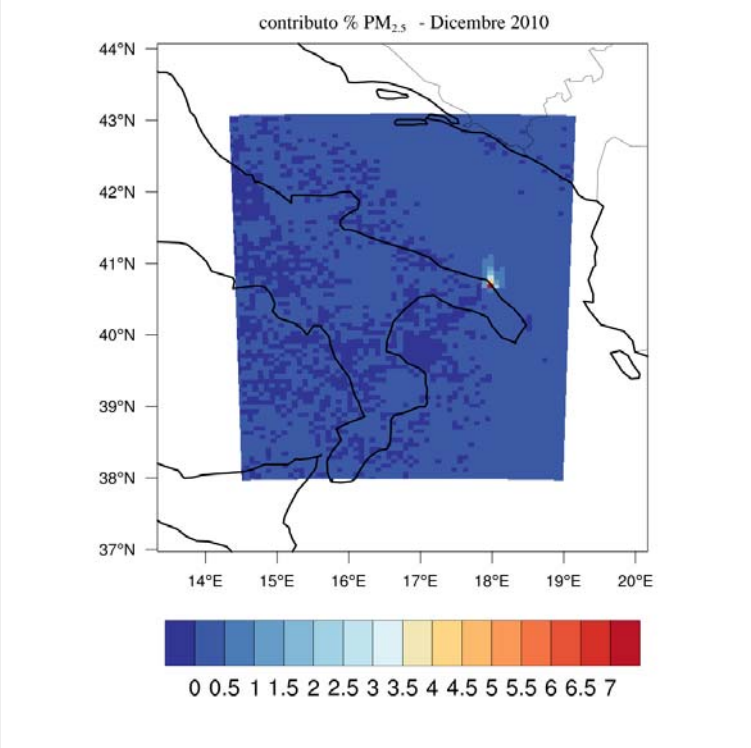
	C(µgm^{-3}) BOLCHEM	C(µgm^{-3}) measured	ΔC% BOLCHEM
Via Taranto	**21.12**	**27.75**	**1.51**
Casale	**21.19**	**24.88**	**1.63**
Via dei Mille	**20.93**	**24.81**	**1.15**
Terminal	**21.34**	**22.65**	**1.93**
Media	**21.32**	**25.02**	**1.55**

December 2010

$PM_{2.5}$ concentration (µg m^{-3})



ship emissions contribution %

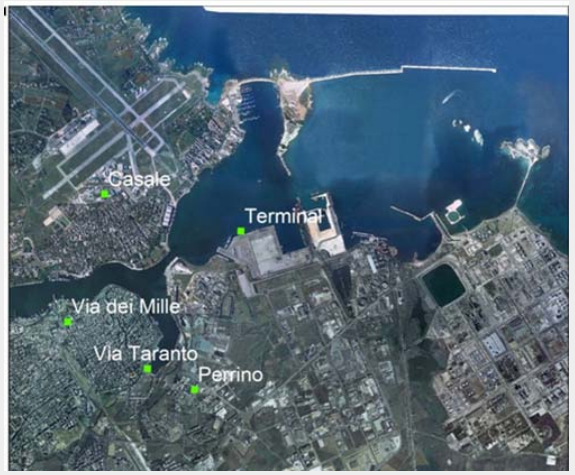


- ***monthly mean (left) value of $PM_{2.5}$ ground concentrations (µg m^{-3}) for base simulation and relative ship emissions impact (%) (right)***

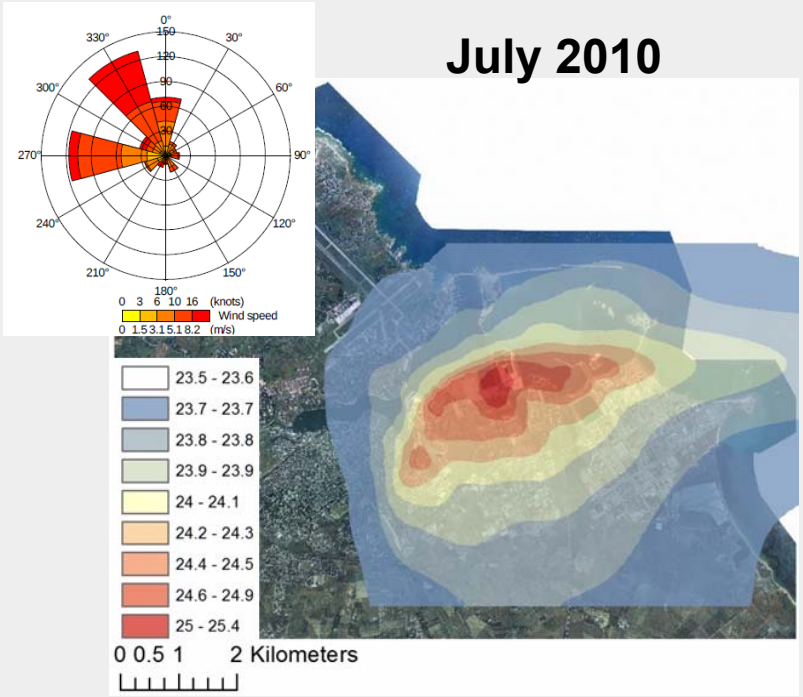
BOLCHEM-ADMS-Urban: ship emissions contribution

***spatial resolution*: ~130m x 70m**

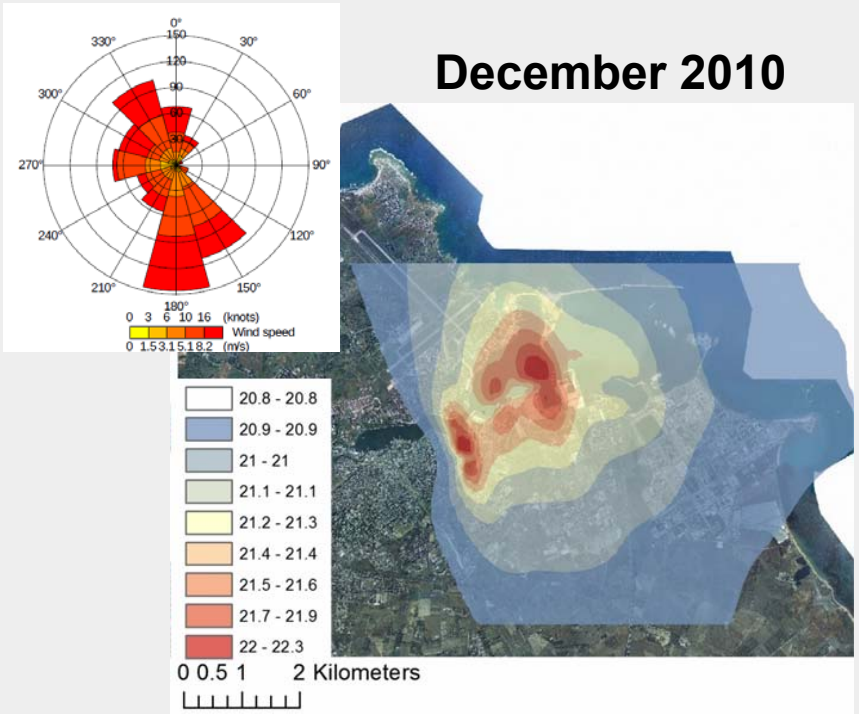
Primary PM10 (%)	July 2010	December 2010
Via Taranto	1	1
Casale	<1	1
Via dei Mille	< 1	< 1
Terminal	3	2
Average	***1***	***1***



July 2010

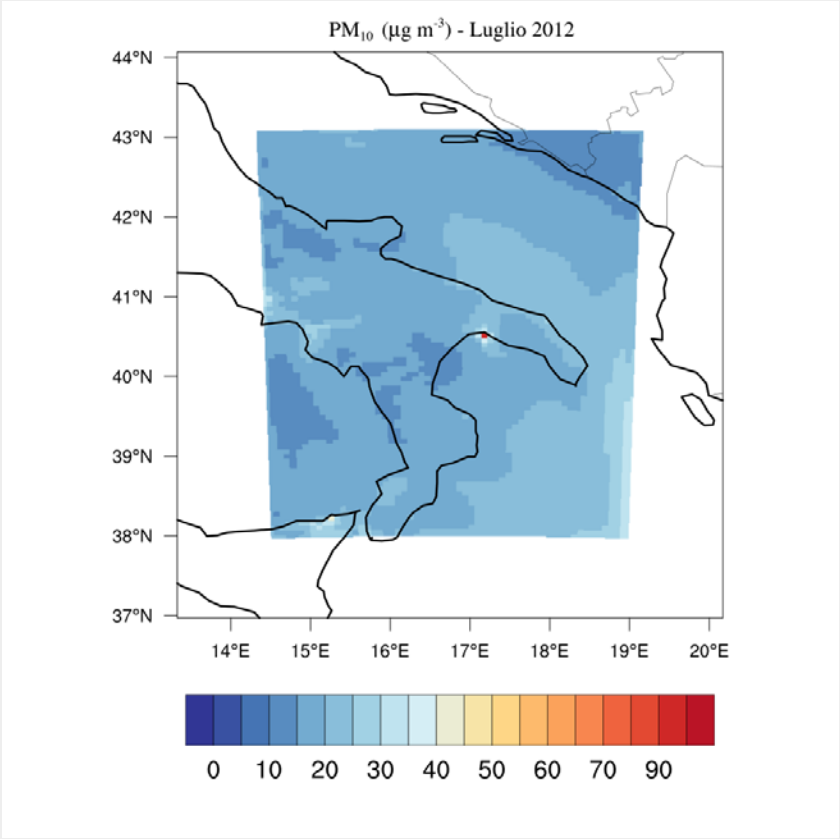


December 2010

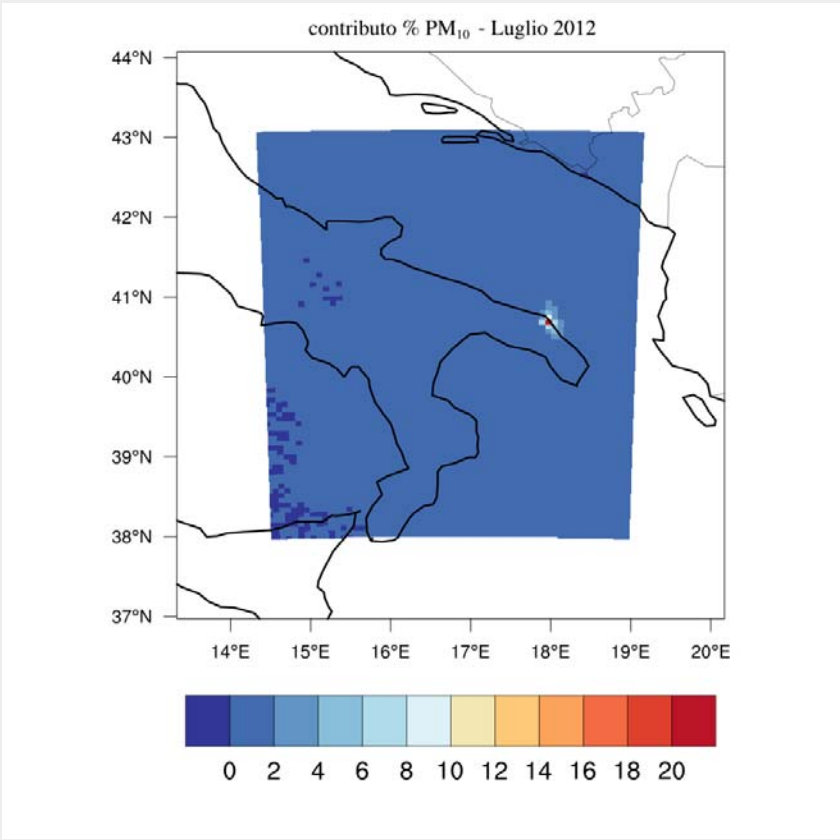


July 2012

PM_{10} concentration (µg m^{-3})



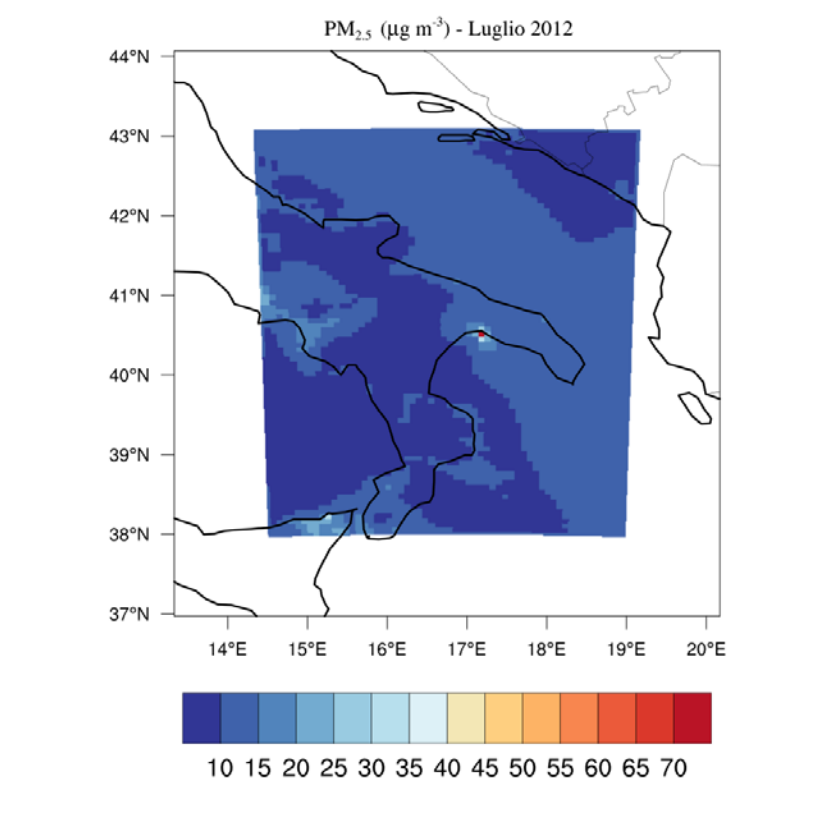
ship emissions contribution %



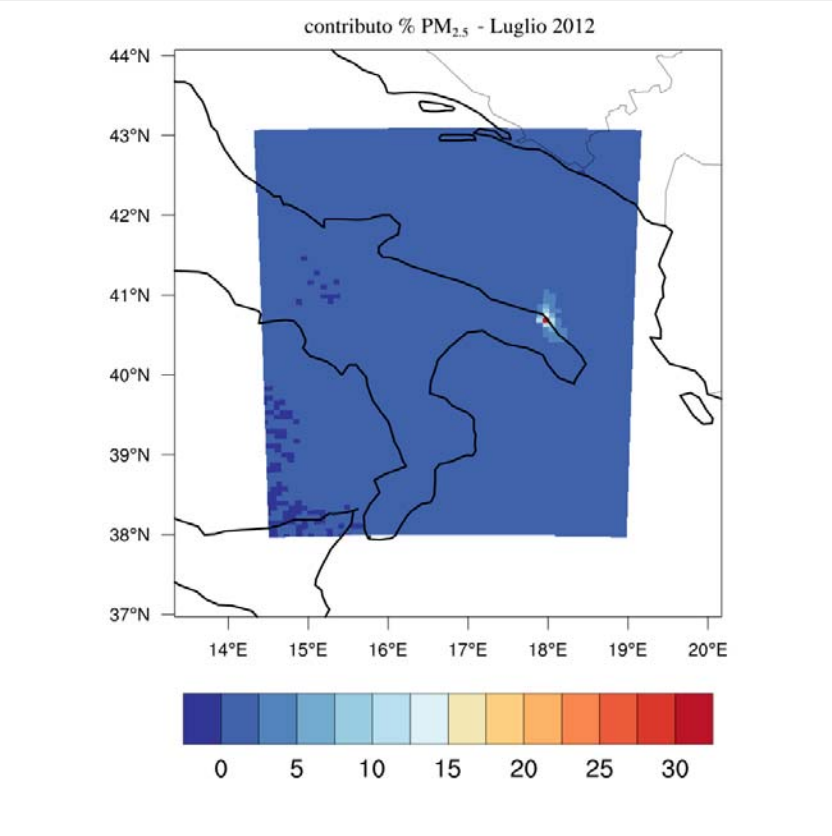
- ***monthly mean (left) value of PM_{10} ground concentrations (µg m^{-3}) for base simulation and relative ship emissions impact (%) (right)***

July 2012

$PM_{2.5}$ concentration (µg m^{-3})



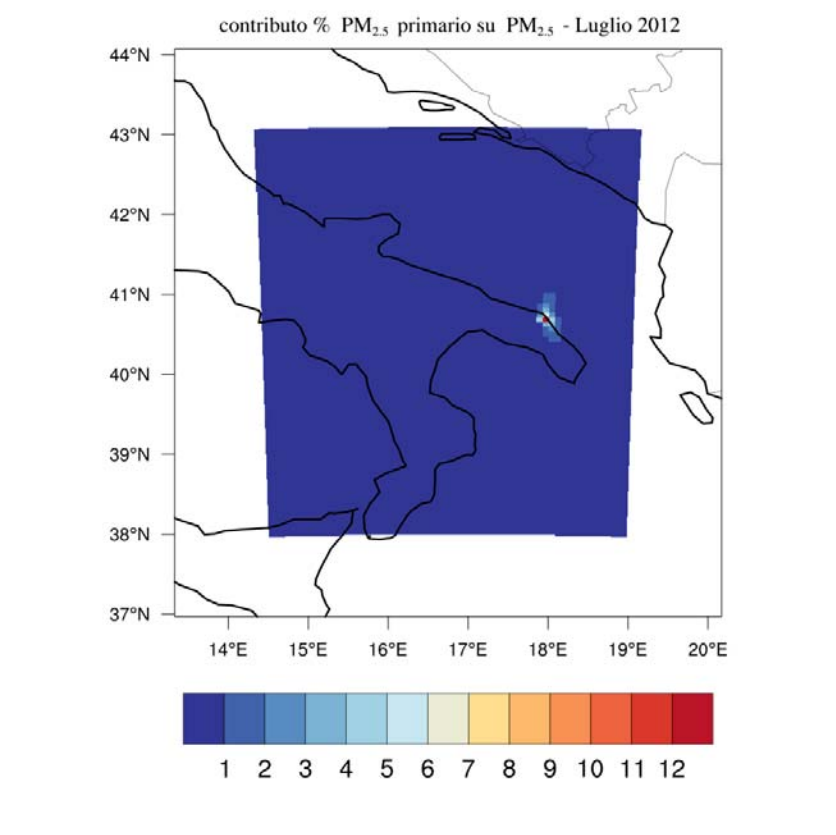
ship emissions contribution %



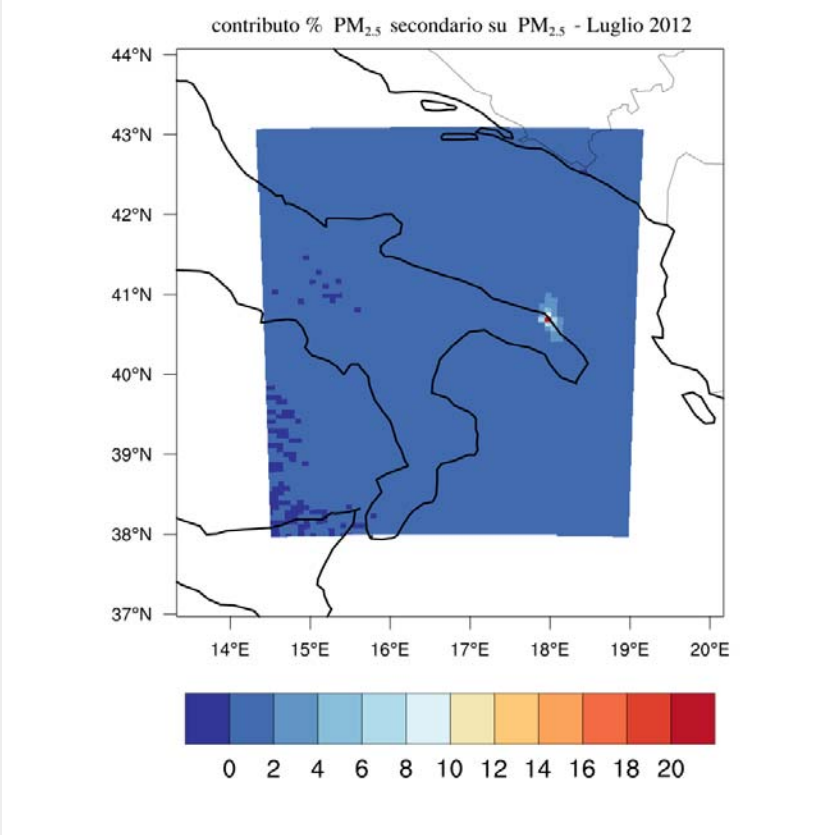
- ***monthly mean (left) value of $PM_{2.5}$ ground concentrations (µg m^{-3}) for base simulation and relative ship emissions impact (%) (right)***

July 2012

ship emissions contribution % of primary $PM_{2.5}$

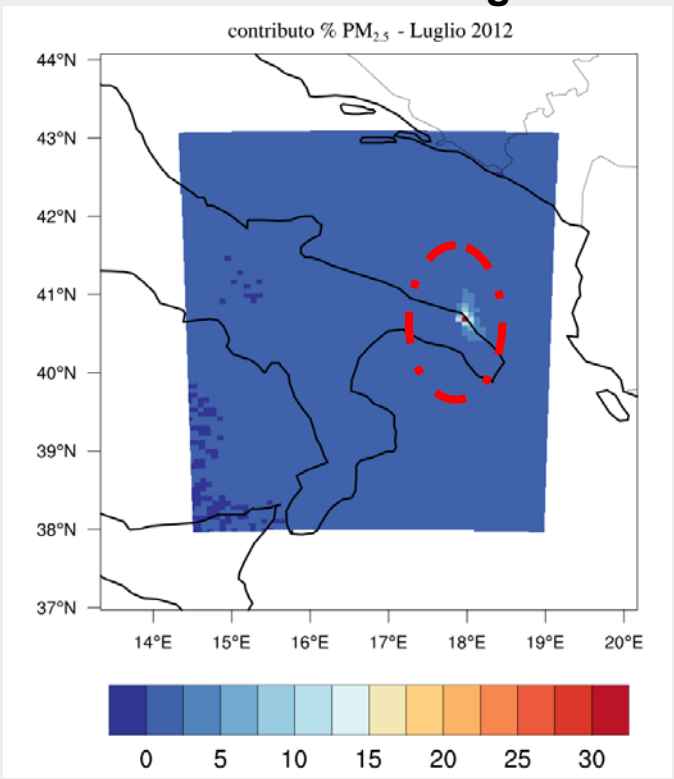


ship emissions contribution % of secondary $PM_{2.5}$

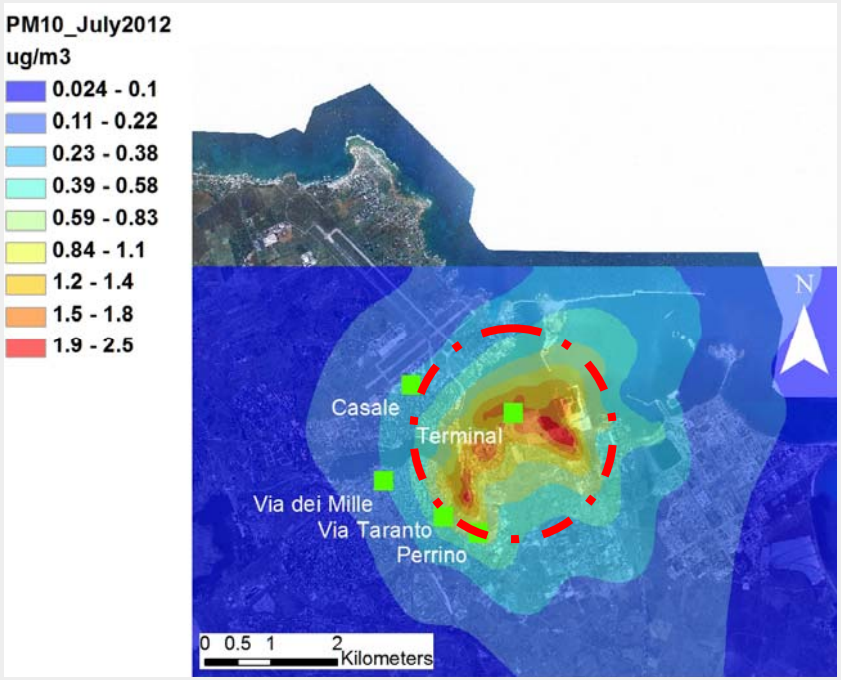


- ***relative ship emissions impact (%) of primary PM2.5 (left) and secondary (right) PM2.5 on PM2.5 monthly mean ground concentration***

Meso-scale modelling



Local scale modelling



- *Port emissions influence* over a *regional domain*
- The impact is higher on the secondary $PM_{2.5}$ than on the primary $PM_{2.5}$

- Local-scale simulations provide *detailed and accurate information* in the area
- Individuation of *high pollution spots (due to shipping emissions)* (e.g. located in the hotelling area)

acknowledgements

- the European Territorial Cooperation Programme Greece-Italy 2007-2013 **CESAPO** (Contribution of Emission Sources on the Air Quality of the Port-cities in Greece and Italy)
- the Cambridge Environmental Research Consultants (**CERC Ltd**) for making available ADMS-Urban model
- the **Avvisatore Marittimo of Brindisi port** for providing traffic maritime data
- the **Italian Air Force** for providing meteorological data
- Mr. **Raffaele Quarta**, Ms. **Laura Cezza** and Dr. **Adelaide Dinoi** for their help in the modelling activities


Thank you for your attention
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