Present time air dispersion model results

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Mitigating Air Pollution in the Mediterranean Port Cities
The results of CAIMANs Project
Venice, 12th June 2015

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Programme cofinancé par le Fonds Européen de Développement Régional
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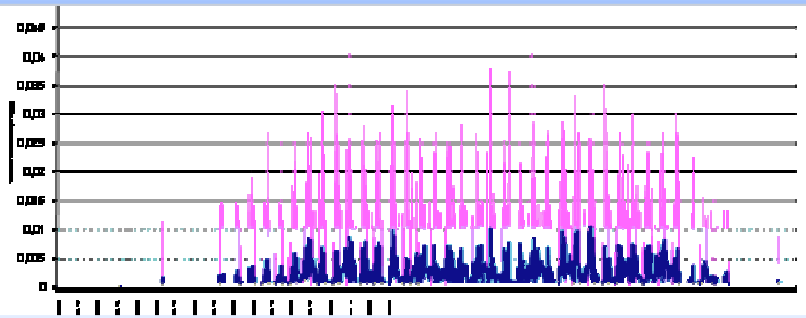
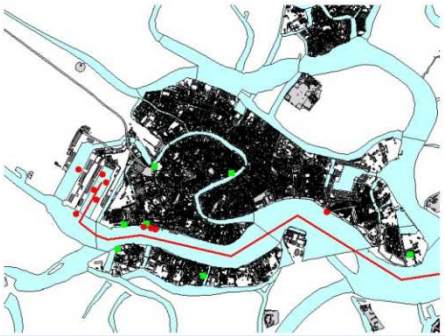
Outline

- **Description of the modelling approach in each area**
- **Present time (2013) concentration maps for most relevant pollutants**
- **Outcomes intercomparison**

The CAIMANs modelling steps

1. DB harbour (passenger) traffic → Macro and micro pollutant emissions estimations for present and future scenarios with or without mitigations
[ARPAV code EMEP/EEA, 2013]

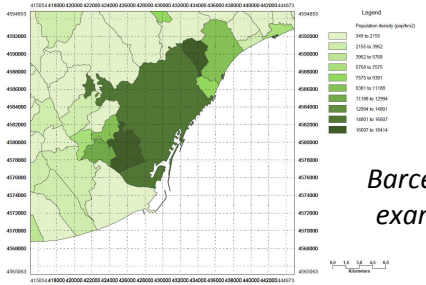




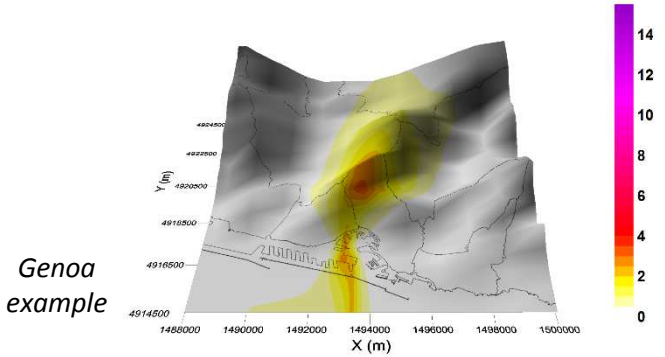
Venice example

2. Docks and routes localisation

3. Parameterisation of plume emissions in hotelling, manoeuvring and cruise phases



Barcelona example



Genoa example

4. High resolution (100 m) air dispersion modelling [CALPUFF (Ve, Tsk, Bcn), ADMS (Ms, Ge)]

5. Population exposure maps

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Statistics calculated from modelling outcomes and AQ limits

Annual Air Quality Limits (AQL)

- ✓NO2 = 40 µg/m^3
- ✓PM10 = 40 µg/m^3
- ✓PM2.5 = 25 µg/m^3
- ✓Pb = 0.5 µg/m^3
- ✓As = 6 ng/m^3
- ✓Ni = 20 ng/m^3
- ✓Cd = ng/m^3
- ✓BaP = 1 ng/m^3

Daily AQL

✓SO2 = 125 µg/m^3 exceeded 3 days/year (i.e. 99.2 percentile of daily concentrations timeseries)

✓PM10 = 50 µg/m^3 exceeded 35 days/year (i.e. 90.4 percentile of daily concentrations timeseries)

Hourly AQL

✓NO2 = 200 µg/m^3 exceeded 18 days/year (i.e. 99.8 percentile of hourly concentrations timeseries)

✓SO2 = 350 µg/m^3 exceeded 24 days/year (i.e. 99.7 percentile of hourly concentrations timeseries)

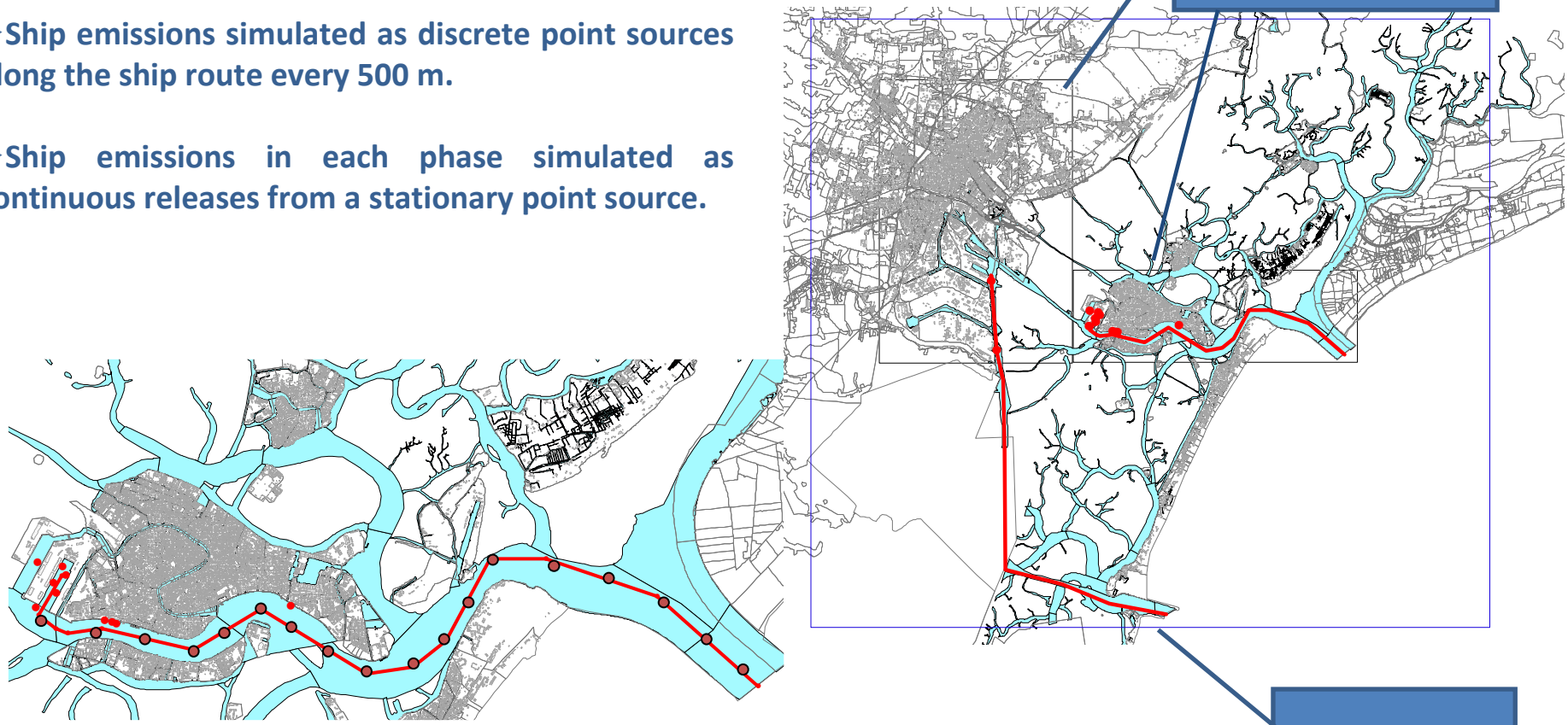
The modelling approach in Venice

Model	**Calpuff v5.8**
Domain	**23.5x23 km^2 with 500 m res + around 10000 receptors with 100 m res**
Meteorology	**CALMET driven by ARPAV and SYNOP meteorological station data**
Simulated species	**NO2, SO2, PM, BaP, As, Pb, Cd, Ni**
Chemical mechanism	**Updated RIVAD/ISORROPIA scheme**
Aqueous phase transformations	**No**
Dry/Wet removal mechanism	**Yes**
Terrain and kinematic effects/Froude number adjustment.	**No**

Source Parameterization in CALPUFF

➢**Ship emissions simulated as discrete point sources along the ship route every 500 m.**

➢**Ship emissions in each phase simulated as continuous releases from a stationary point source.**



Source Parameterization in CALPUFF

Cruise ships:

- Stack Height = 30 m for ships < 90 kT GT ; = 60 m for ships >= 90 kT GT
- Diameter = 1.5 m; Exit T = 160ºC; Exit v = 10 m/s

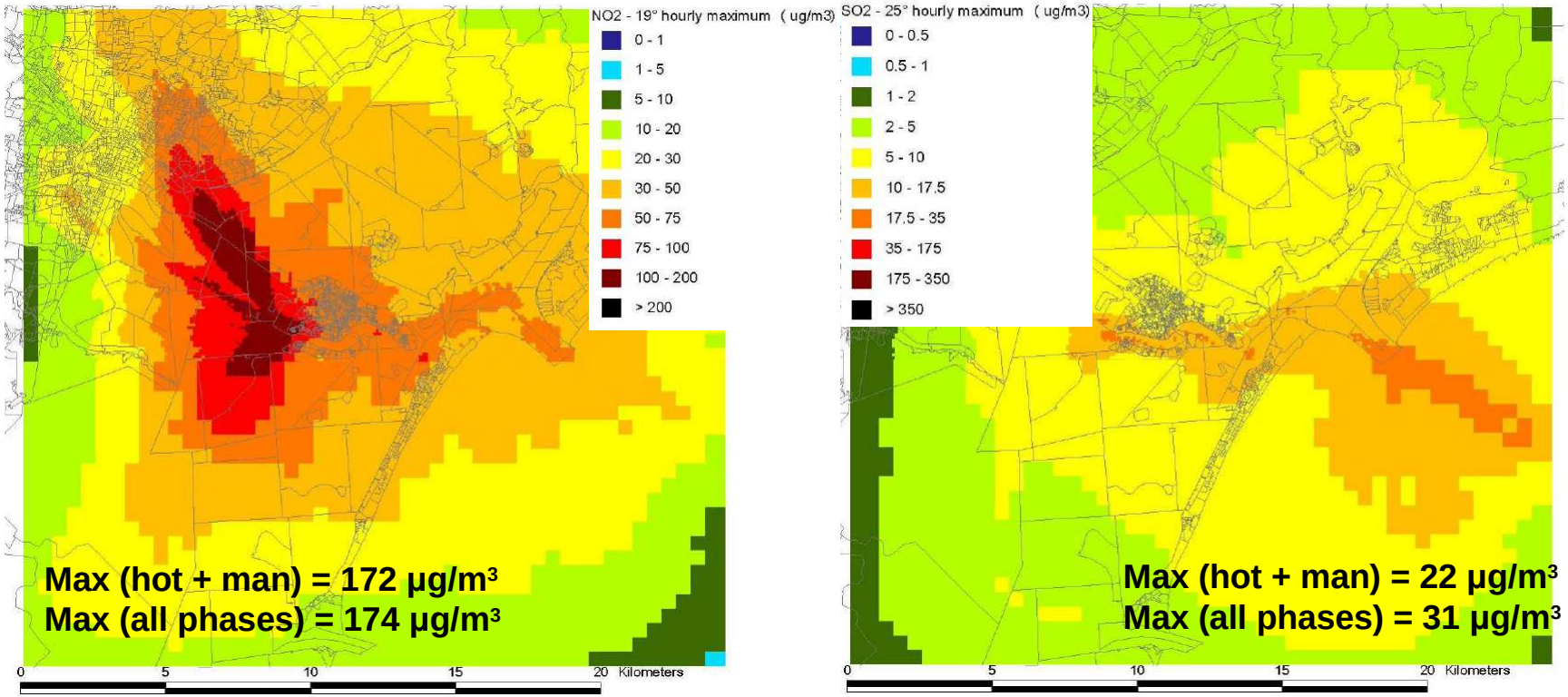
Ro-Pax vessels:

- Stack Height = 30 m
- Diameter = 1.5 m; Exit T = 160ºC; Exit v = 10 m/s

Ferry boats:

- Stack Height = 10 m
- Diameter = 0.7 m; Exit T: 160°C; Exit v = 10 m/s

Present time results for Venice

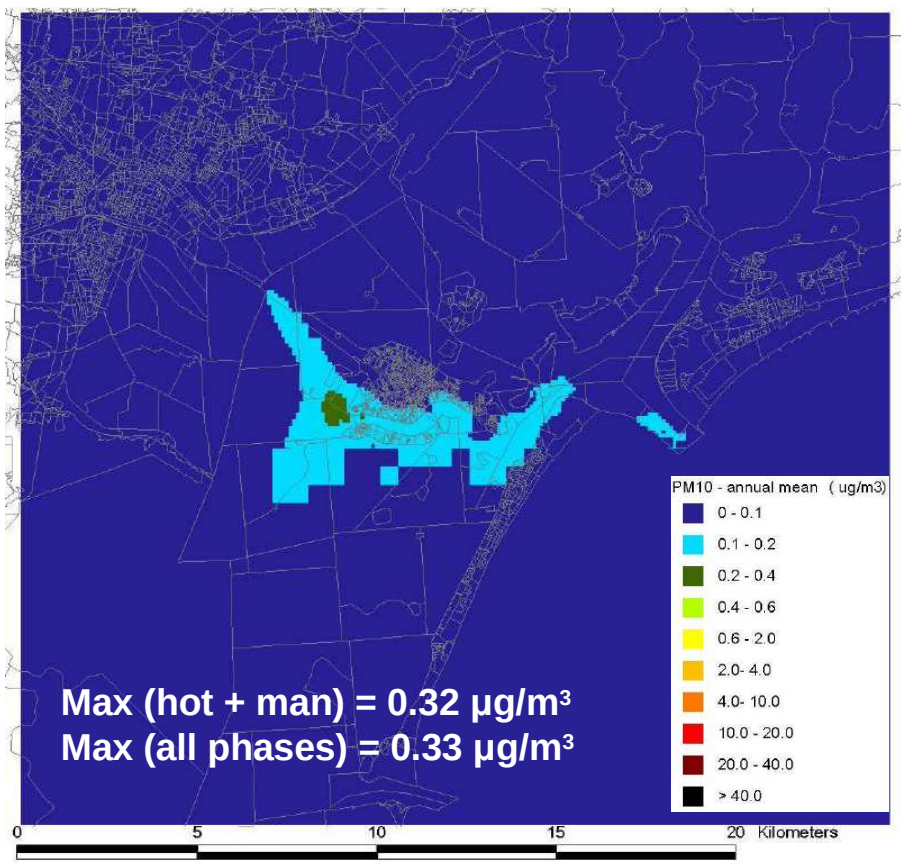


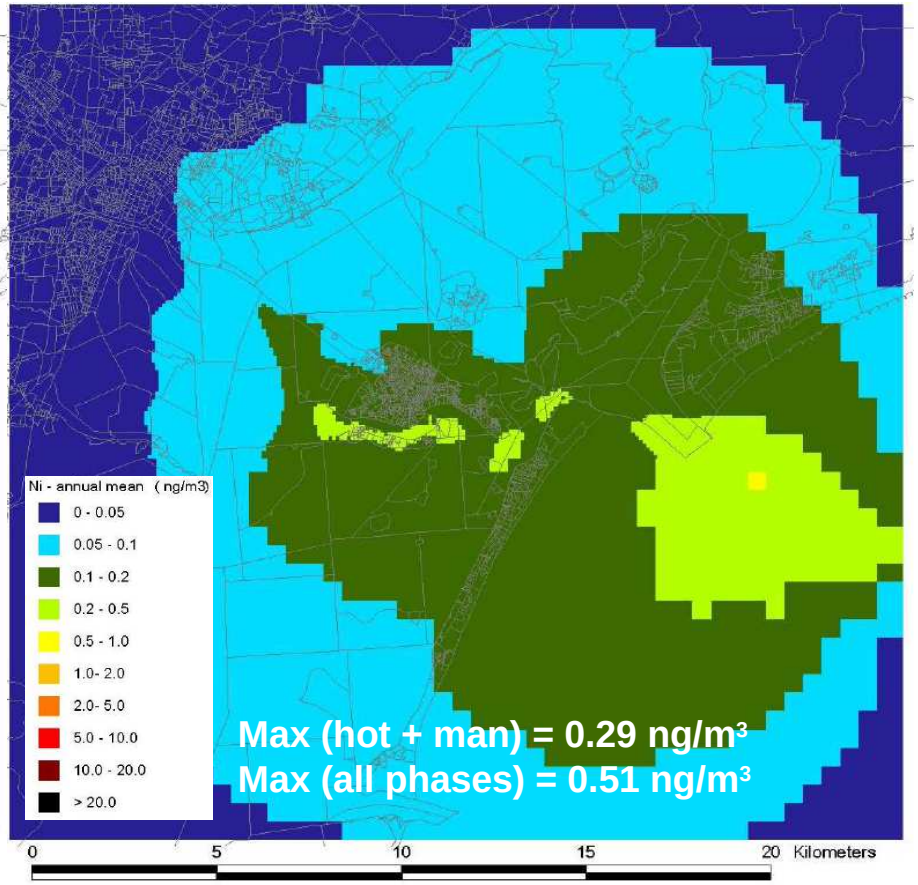
➢Maximum hourly NO_2 concentrations are estimated close to the cruise terminal (172 µg/m³, 86% of the hourly AQL); considering also the contribution from the emissions during the cruising phase beyond the lagoon entrance, the maximum concentration calculated the domain is 174 µg/m³ (87% of AQL).

➢ During the 2013 season the Blue Flag2 agreement was established (usage of low sulphur content fuel not only during hotelling but also during the maneuvering phase. The maximum contribution on the SO_2 hourly concentrations calculated in the lagoon area is 22 µg/m³ (6% of the hourly AQL).

➢ Over the Venice historical center, the 99.8 percentile of the hourly NO_2 concentrations ranges between 50 and 120 µg/m³ (25% to 60% of AQL), whereas the 99.7 percentile of the hourly SO_2 concentrations ranges between 7 and 16 µg/m³ (2% to 5% of AQL).

Present time results for Venice

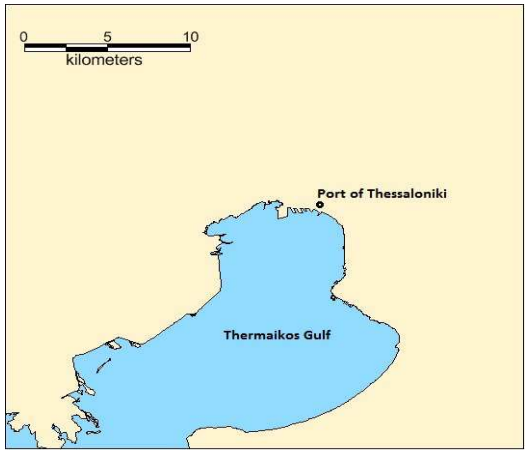


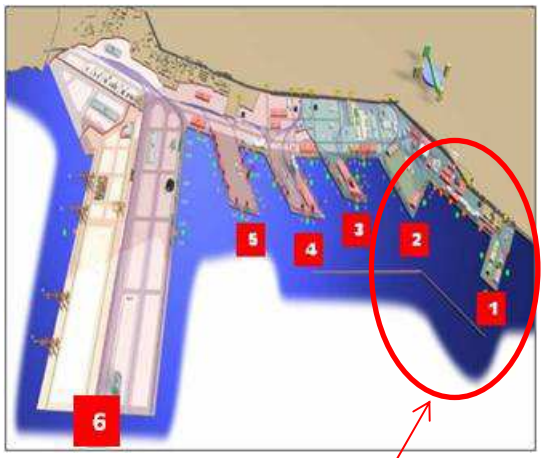


➢ The contribution of passenger ships to PM10 concentration is not particularly relevant (less than 1% of the annual AQL).

➢ Also the contribution to micropollutants concentration is generally not significant and less than 0.1% of the annual AQL for lead, cadmium, arsenic and benzo(a)pyrene. The micropollutant with highest concentrations is nickel, for which the maximum value in the domain represents around 1.5% of its annual AQL.

The modelling approach in Thessaloniki





Passenger terminal

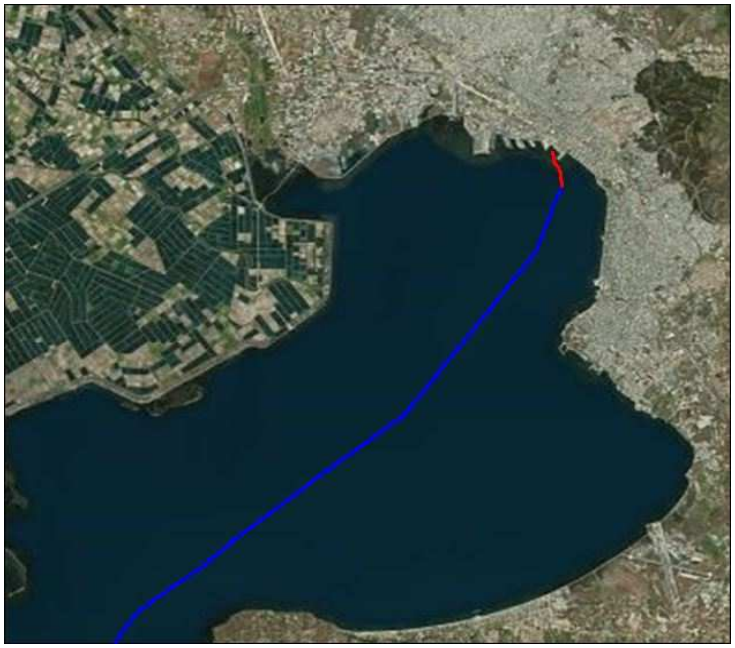
Model	**Calpuff v6.4**
Domain	**30x30 km**
Meteorology	**CALMET driven by WRF**
Simulated species	**NO2, SO2, PM, BaP, As, Pb, Cd, Ni**
Chemical mechanism	**Updated RIVAD/ISORROPIA scheme**
Aqueous phase transformations	**Yes**
Dry/Wet removal mechanism	**Yes**
Terrain and kinematic effects/Froude number adjustment.	**Yes**
Grid resolution	**100m**

Source Parameterization in CALPUFF

➢**Ship emissions simulated as discrete point sources along the ship route (accounting for the ship velocity).**

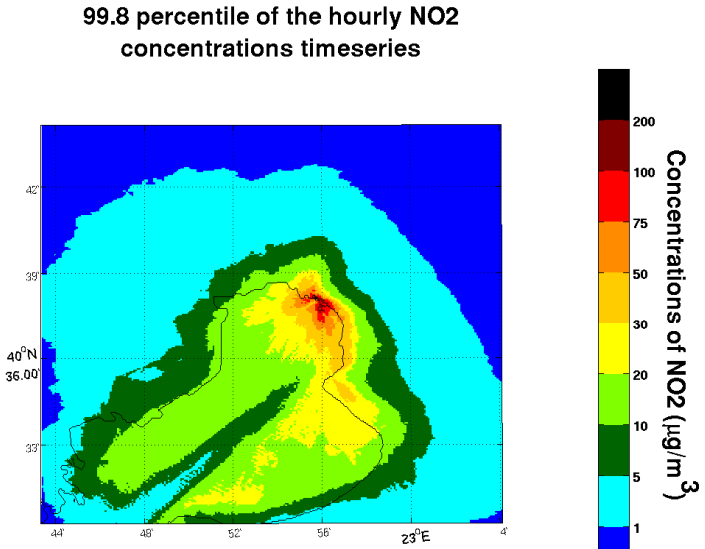
➢**Ship emissions in cruising and maneuvering operation modes released in the atmosphere as instantaneous emission puffs every 1 minute.**

➢**Ship emissions in the hotelling phase simulated as continuous releases from a stationary point source.**

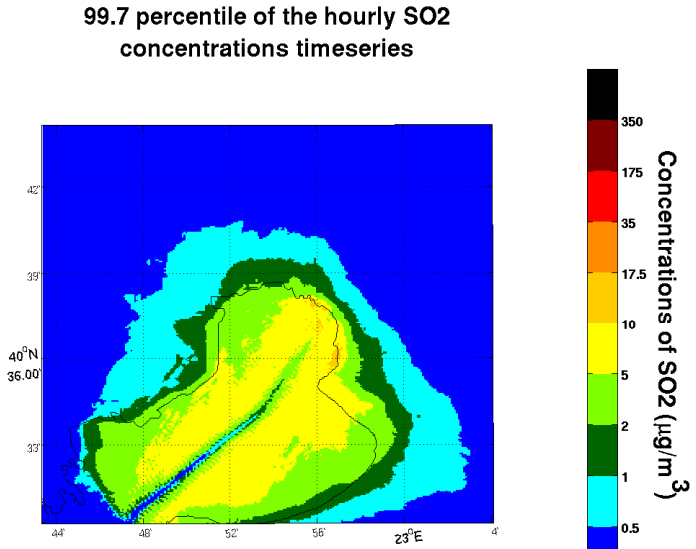


- **Blue line: Cruising mode**
- **Red line: Manouevering mode**

Present time results for Thessaloniki



Max = 270 μg/m3



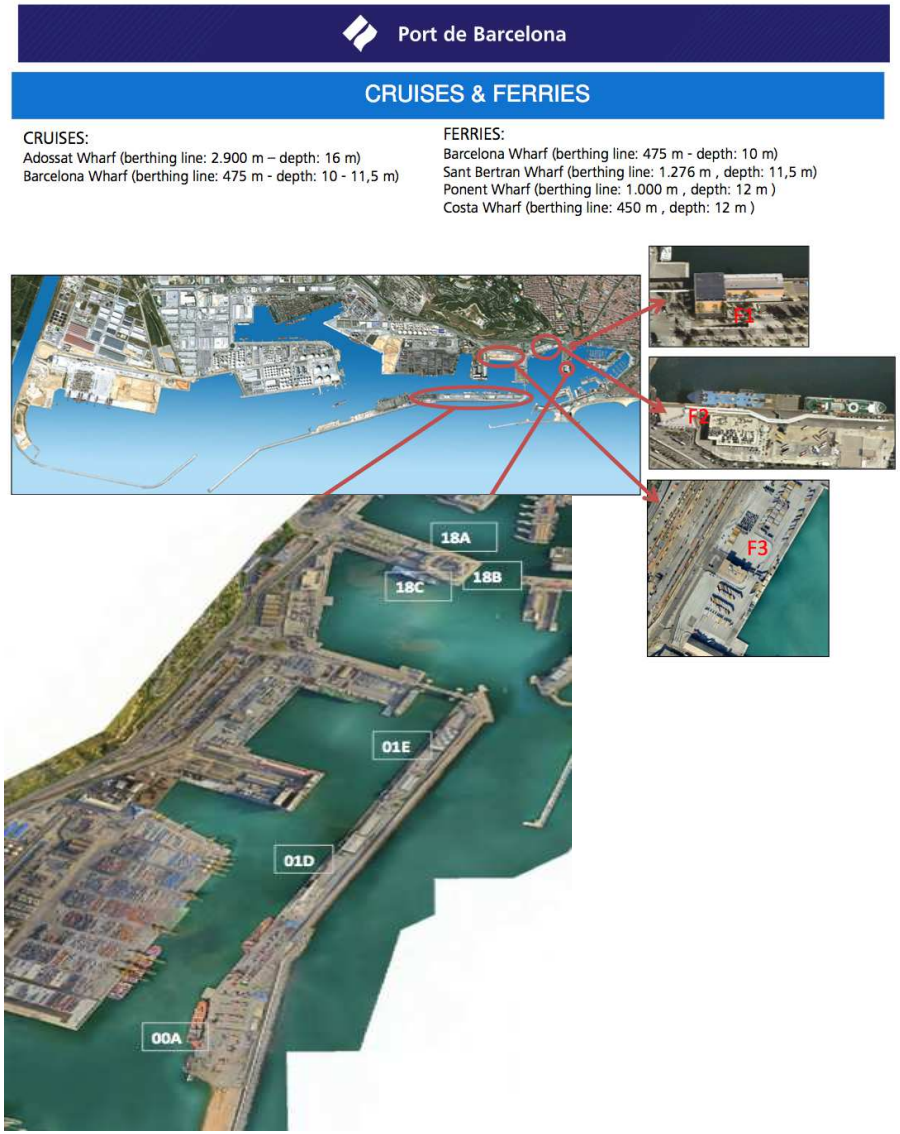
Max = 24 μg/m3

➢Domain-wide maximum value for the NO2 and SO2 statistics estimated close to the passenger terminal (135% and 7% of the hourly AQLs, respectively).

➢Over the urban center of Thessaloniki the 99.8 percentile of the hourly NO2 concentrations timeseries takes values that range between 20 and 100 μg/m3 (10% - 50% of AQL).

➢The 5% of the hourly AQL for NO2 (i.e. 10 μg/m3) is exceeded mostly over the city center of Thessaloniki, the east coast and the greater part of the maritime areas of the modeling domain.

The modelling approach in Barcelona



Model	**Calpuff v6.4**
Domain	**30x30 km**
Meteorology	**CALMET driven by WRF**
Simulated species	**NO2, SO2, PM, BaP, As, Pb, Cd, Ni**
Chemical mechanism	**Updated RIVAD/ISORROPIA scheme**
Aqueous phase transformations	**Yes**
Dry/Wet removal mechanism	**Yes**
Terrain and kinematic effects/Froude number adjustment.	**Yes**
Grid resolution	**100m**

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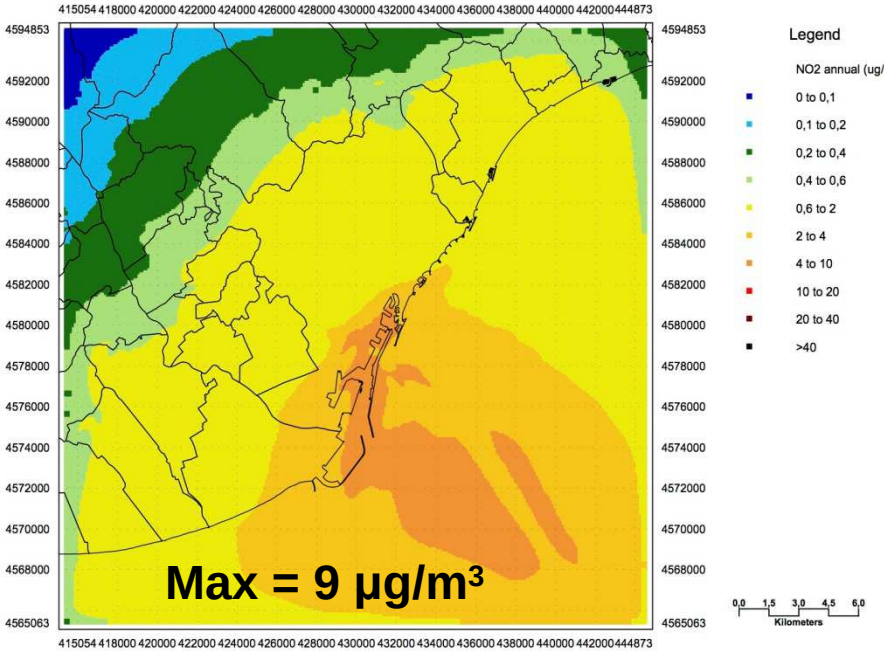
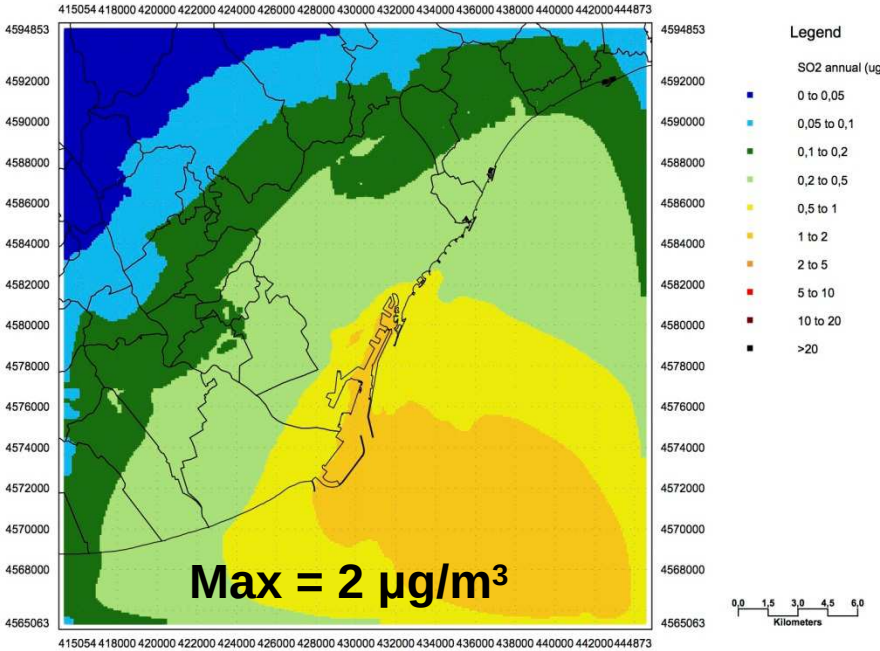
NO_2, annual mean concentrations ($\mu g/m^3$) (AQ limit 40 $\mu g/m^3$)



SO_2, annual mean concentrations ($\mu g/m^3$) (AQ limit 20 $\mu g/m^3$)



The annual values are strongly influenced by the maneuvering phase. Maximum annual values are found near the Buoy “S”, where the approach to the Addosat Wharf begins. The pollutants that play an important role from an annual perspective are the NO_2 (9.2 $\mu g/m^3$; 23.1% of AQL), SO_2 (1.7 $\mu g/m^3$; 8.5% of AQL), and nickel (1.29 ng/m^3; 6.5% of the AQL).

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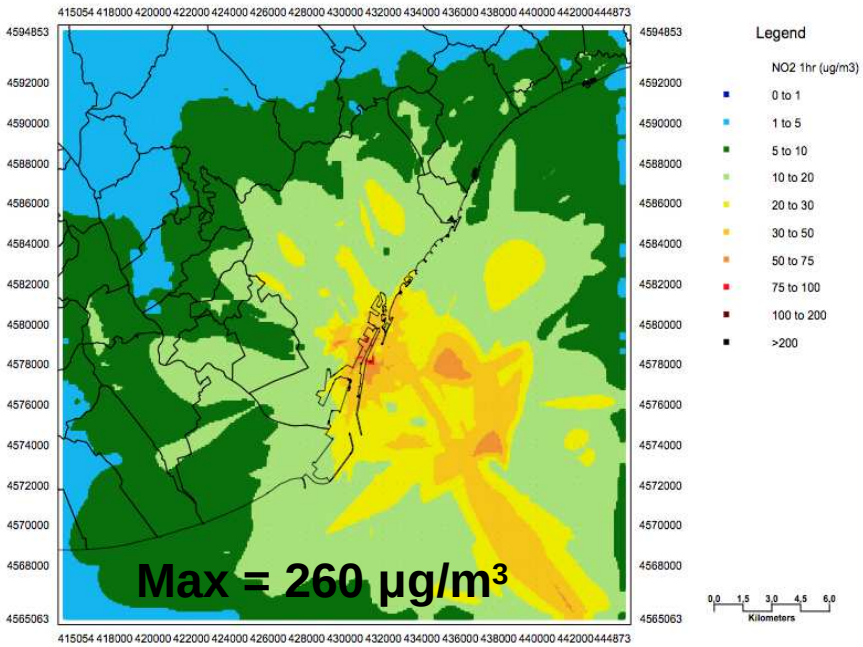
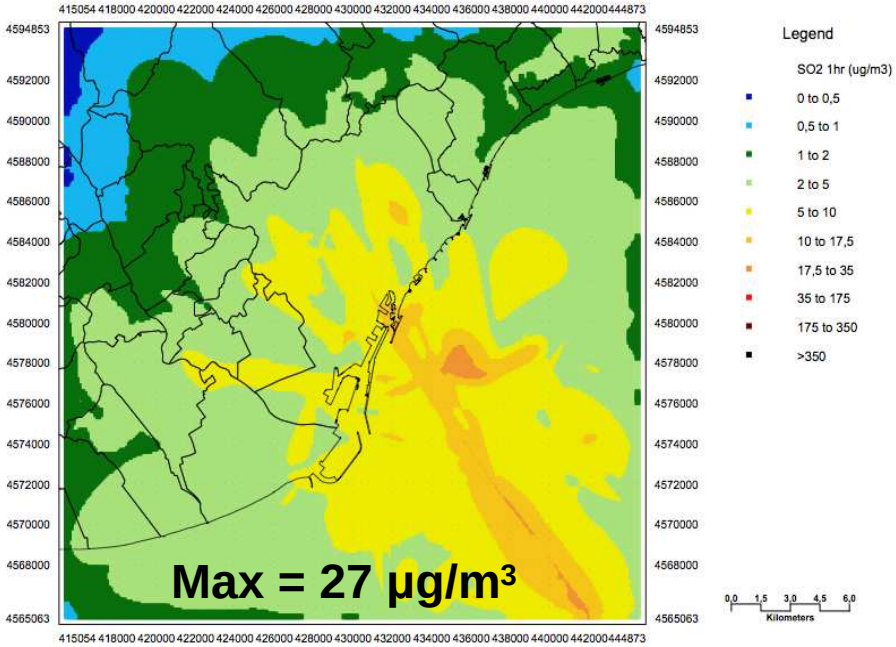
NO_2, percentile 99.8 of the 8760 hourly concentrations (µg/m³) (AQ limit 200 µg/m³)



The 1-hour average NO_2 surface concentrations can reach up to 260 µg/m³ just over the coastline, exceeding considerably the AQL (129% of AQL). The central part of the port is affected the most, with concentrations ranging from 75 to 100 µg/m³ (37.5% to 50% of AQL).

SO_2, percentile 99.7 of the 8760 hourly concentrations (µg/m³) (AQ limit 350 µg/m³)



The region with the highest SO_2 max. 1-hr concentrations is found around the Buoy “N” (together with the last part of cruising, where the ships still consume BFO as a fuel). This area comprises the root of maneuvering for the north pier, and has the highest concentrations over the domain, with 26.7 µg/m³ (about 7.6% of AQL).

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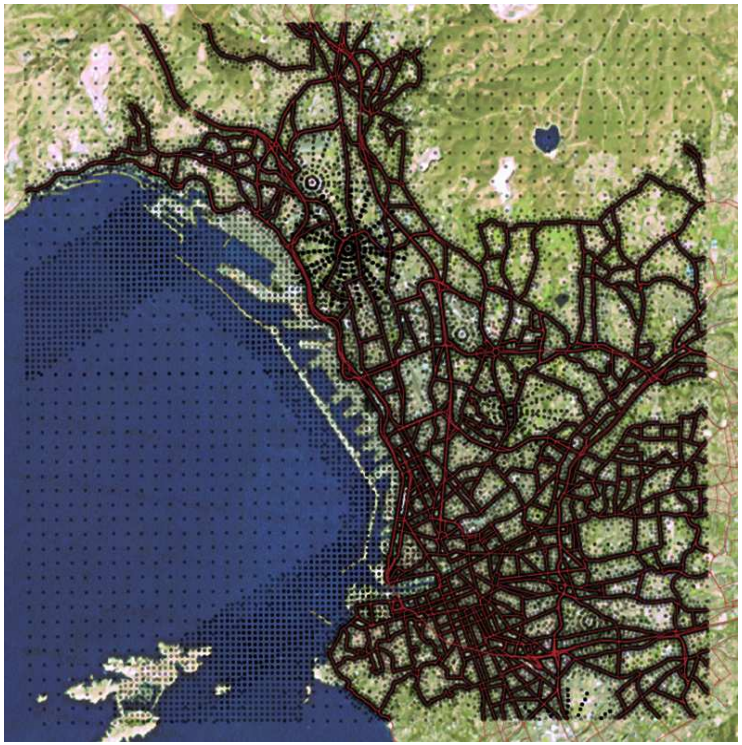
The modelling approach in Marseilles

Model	**ADMS Urban v3.1**
Domain	**12x12km**
Meteorology	**Hourly observation (from national network – METEO France)**
Simulated species	**NO2, SO2, PM, BaP, As, Pb, Cd, Ni**
Chemical mechanism	**GRS (Generic Reaction Set – [NO, NO, COV, O3])**
Aqueous phase transformations	**No**
Dry/Wet removal mechanism	**Yes**
Terrain and kinematic effects/Froude number adjustment.	**No**
Grid resolution	**Adaptive resolution – from 5m close to sources to 100m for the background**

Source Parameterization in ADMS



ADMS Urban simulation area and receptor points (grey dots).

- Ship emissions simulated as volumic sources (20-50m) to represent different ship configurations (height and location of stacks)

- Grid resolution: Adaptive resolution – from 5m close to sources to 100m for the background

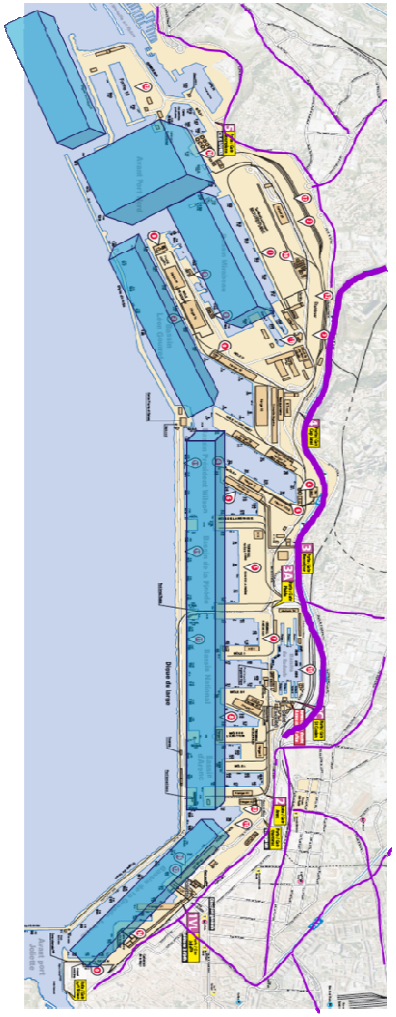


Illustration of the ship source representation (blue) in ADMS

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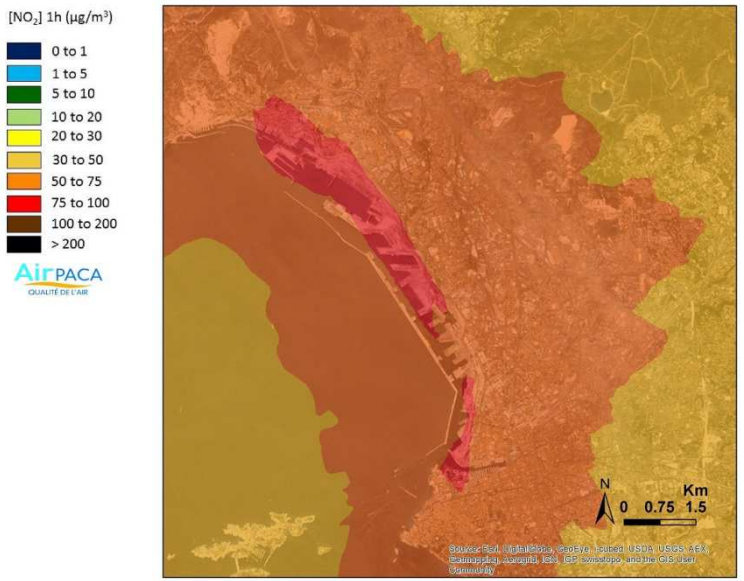
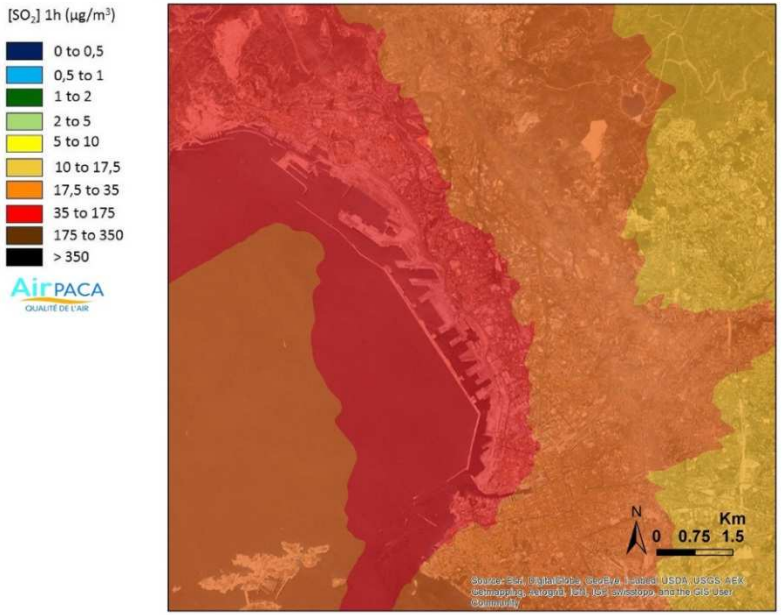
Present time results for Marseilles

99,8 percentile of the hourly NO_2 concentration timeseries



Max = 80 µg/m³

99,7 percentile of the hourly SO_2 concentration timeseries



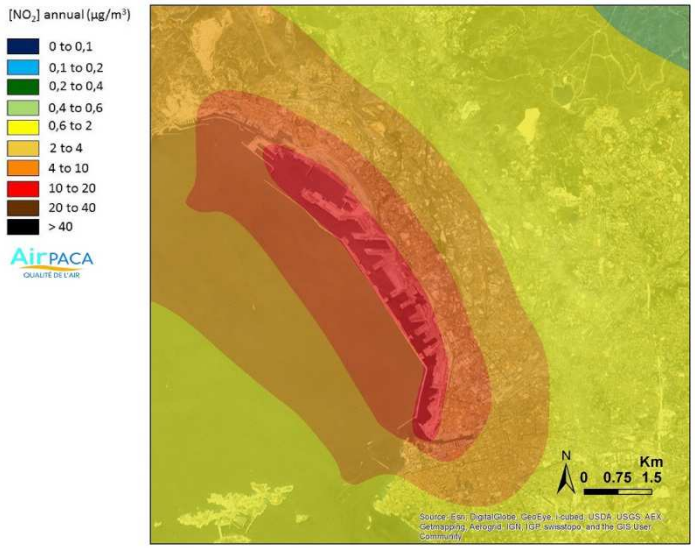
Max = 68 µg/m3

➢Domain-wide maximum values for the NO2 and SO2 statistics estimated close to port representing 40% and 19% of the hourly AQL for NO2 and SO2, respectively.

➢The 10% of the hourly AQL for NO2 (i.e. 20 µg/m3) is exceeded all over the city center of Marseille.

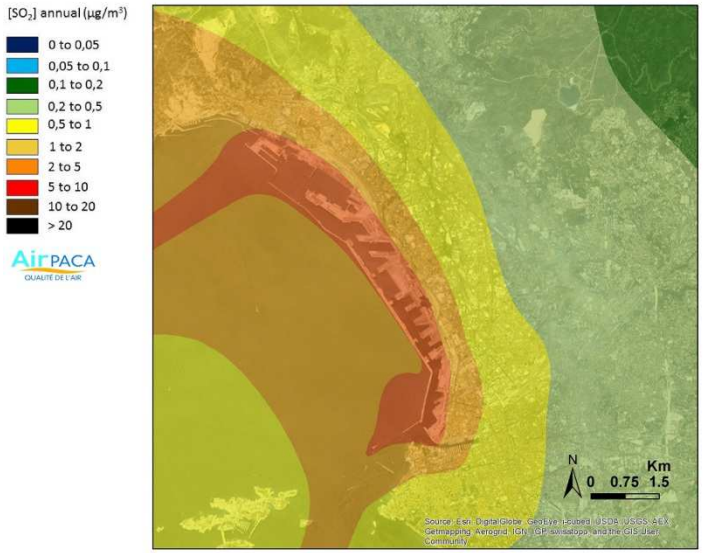
Present time results for Marseilles

Annual NO_2 concentration timeseries



Max = 15 µg/m³

Annual SO_2 concentration timeseries



Max = 3 µg/m3

➢Domain-wide maximum values for the NO2 and SO2 statistics estimated close to the port representing 38% and 16% of the annual AQL for NO2 and SO2, respectively.

The modelling approach in Genoa

Model	**ADMS v4.0**
Domain	**10x10 km**
Meteorology	**FLOWSTAR driven by WRF (1km x 1km)**
Simulated species	**NO2, SO2, PM, BaP, As, Pb, Cd, Ni**
Chemical mechanism	**NO/NO2 balance**
Aqueous phase transformations	**No**
Dry/Wet removal mechanism	**Yes**
Complex terrain	**Yes**
Grid resolution	**100m**

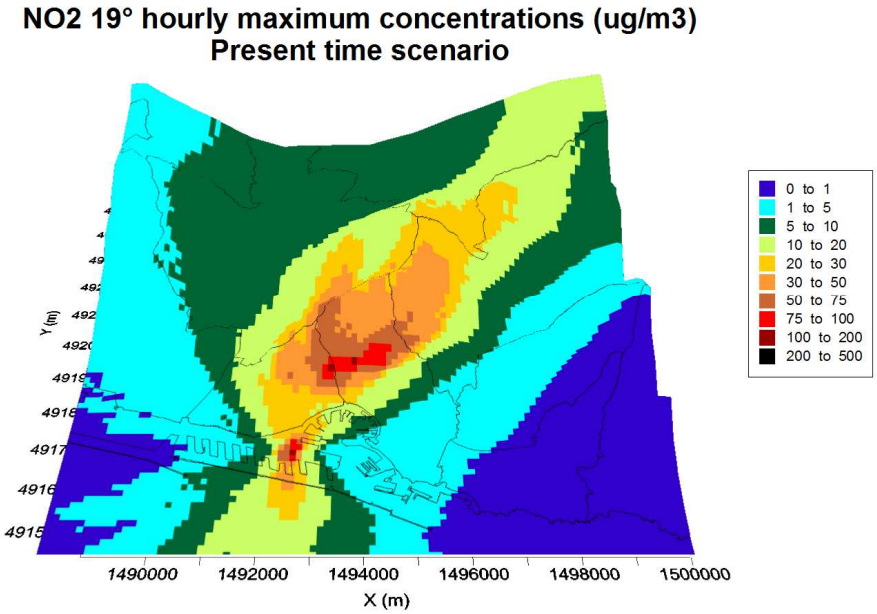
Source Parameterization in ADMS

➢Ships in hotelling phase described as buoyant line sources (width 5 m, length 30 m). Height is 60 m for cruise ships and 30 m for other passenger ships

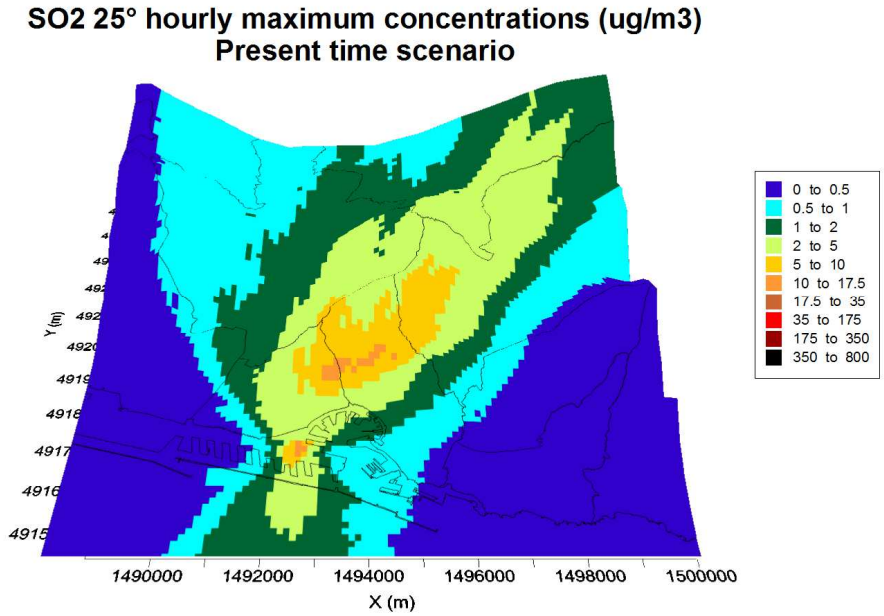
➢Ships in maneuvering phase described as buoyant line sources (width 10 m, height 60/30 m). The total length of the maneuvering phase is assumed to be 3200 m.

➢Cruising phase not considered being outside the computing domain

Present time results for Genoa



Max = 270 µg/m³

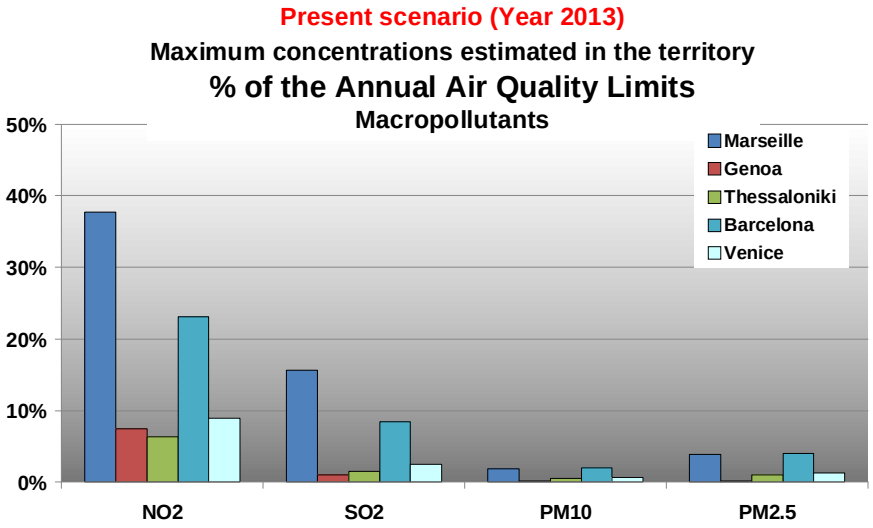


Max = 16 µg/m3

➢Domain-wide maximum values for the NO2 and SO2 statistics within the port and in neighboring districts, representing 135% and 4% of the hourly AQL for NO2 and SO2, respectively.

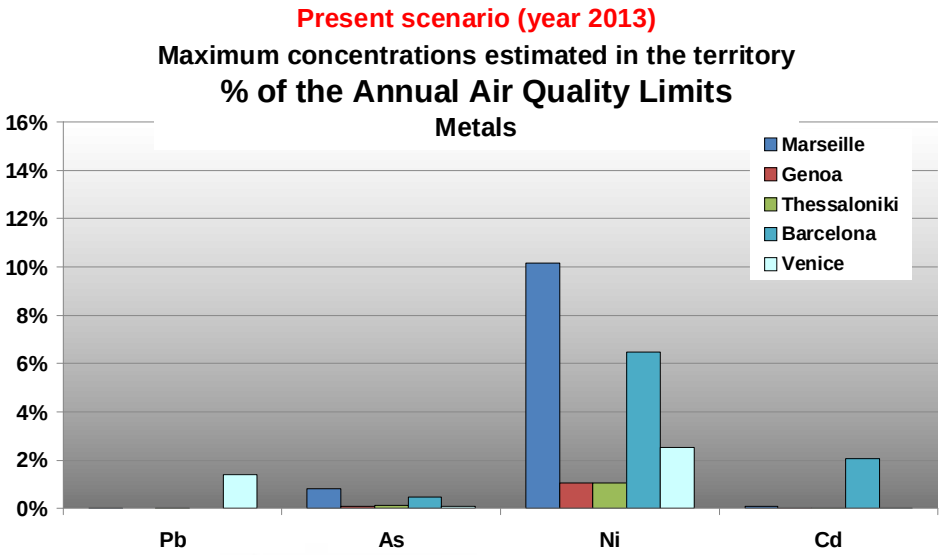
➢The 10% of the hourly AQL for NO2 (i.e. 20 µg/m3) is exceeded in a quite limited and not densely populated portion of the urban area.

Intercomparison of results



➢Concerning micropollutants, higher concentrations are found for Ni (10% of annual AQL in Marseille)

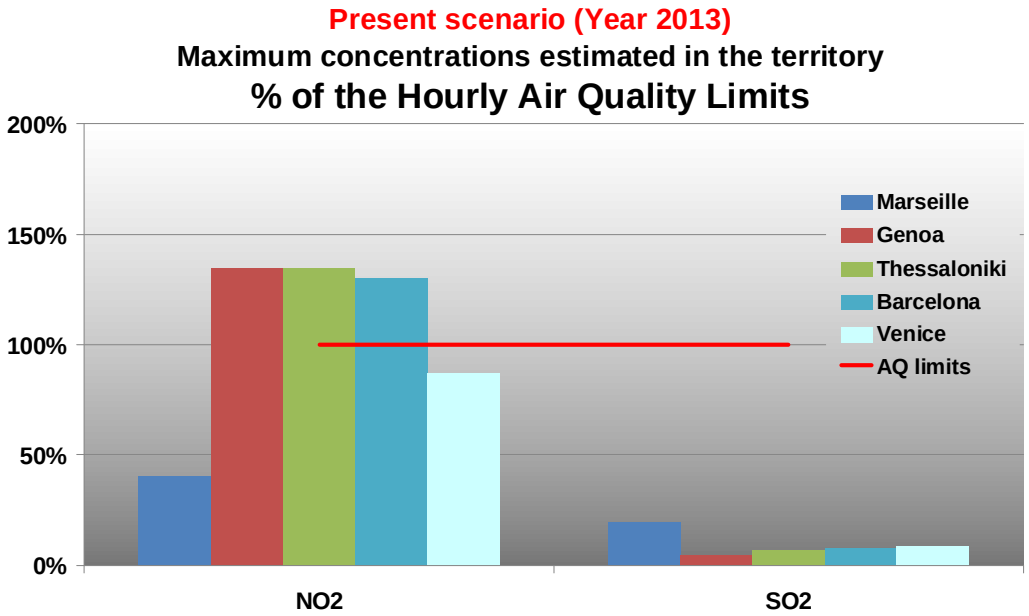
➢Modest contribution to Pb, As, Cd concentrations



➢Concerning macropollutants, NO2 and SO2 are the most critical ones

➢Modest contribution to PM concentrations from cruise and passenger ships

Intercomparison of results



➢Maximum hourly NO2 concentrations close to or exceeding AQL in all areas with the exception of Marseille (possible effect of the different source description?)

➢Modest but not negligible contribution to SO2 concentrations from cruise and passenger ships

Conclusions

➢Considering the current European air quality limits, the hourly NO2 concentrations induced by passenger ships emissions appear to be the main concern

➢Lower but not negligible contribution to SO2, PM and Ni concentrations

Mitigation actions are needed!

THANKS FOR YOUR ATTENTION!

CAIMANs
Cruise and passenger ship Air quality Impact Mitigation ActioNs

Lead Partner: Environmental Protection Agency of Veneto Region ARPAV – Padoa (IT) www.arpa.veneto.it
University of Genoa, Department of Physics (IT) www.labfisa.ge.infn.it
Aristotle University of Thessaloniki (GR) http://lap.physics.auth.gr
AIR PACA – Air quality observatory (FR) http://airpaca.org/
Spanish Research Council - IDAEA (ES) http://www.idaea.csic.es/

Mitigazione dell'inquinamento atmosferico in alcune città portuali del Mediterraneo.
I risultati del progetto CAIMANs
Venezia 12 Giugno 2015