The results of CAIMANs project

Maps on population exposure

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Mitigation Air Pollution in the Mediterranean Port Cities
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med
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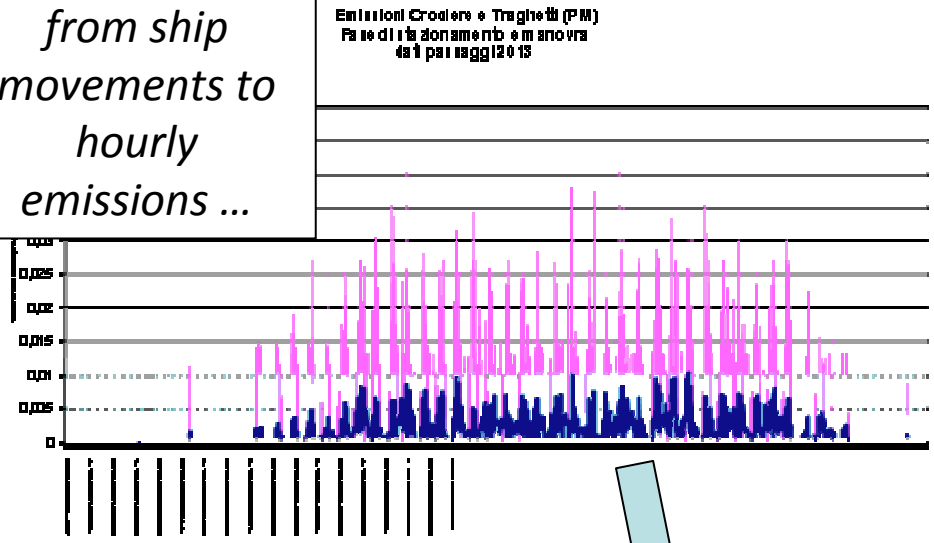
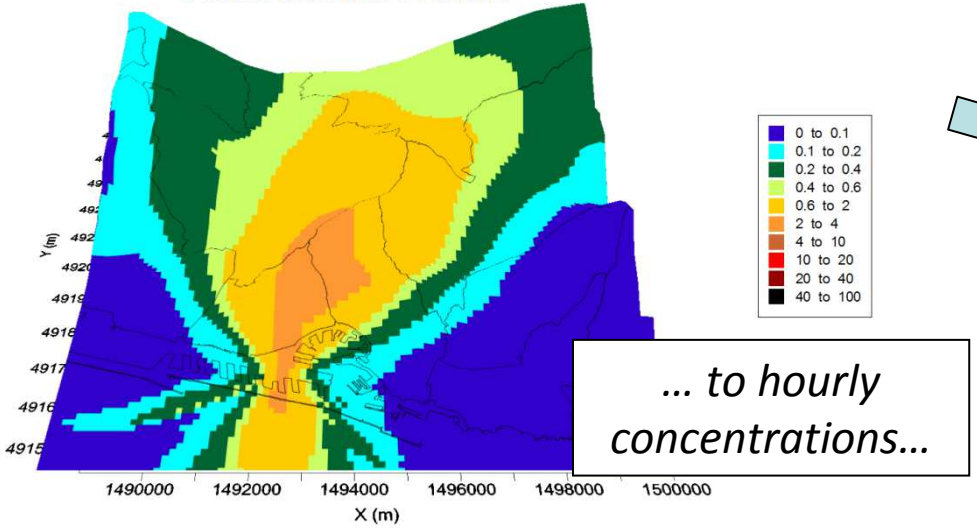
idaea

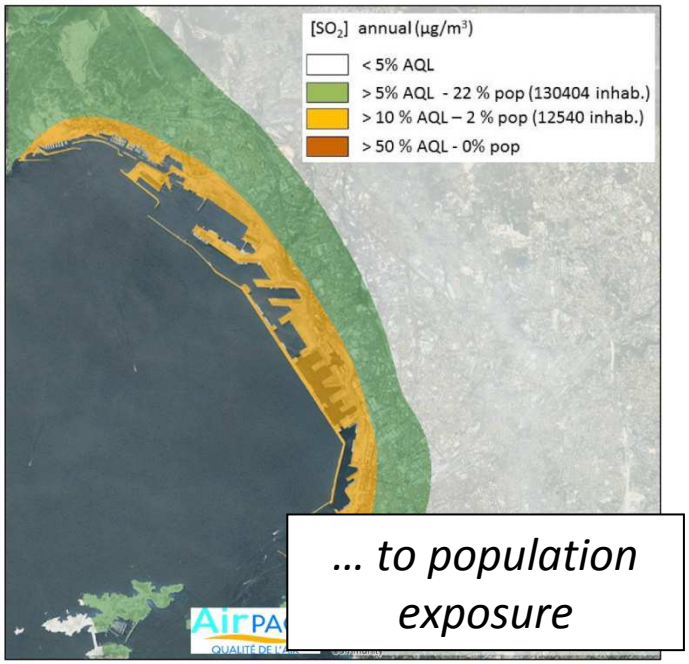
Summing up the CAIMANs methodology

from ship movements to hourly emissions …





… to hourly concentrations…



… to population exposure

European Air Quality Standards

The Air Quality Standards

Pollutant	*Concentration*	*Averaging period*	*Legal nature*	*Permitted exceedences each year*
Fine particles (PM2.5)	25 µg/m3	1 year	Target value entered into force 1.1.2010 Limit value enters into force 1.1.2015	n/a
Sulphur dioxide (SO2)	350 µg/m3	1 hour	Limit value entered into force 1.1.2005	24
	125 µg/m3	24 hours	Limit value entered into force 1.1.2005	3
Nitrogen dioxide (NO2)	200 µg/m3	1 hour	Limit value entered into force 1.1.2010	18
	40 µg/m3	1 year	Limit value entered into force 1.1.2010*	n/a
PM10	50 µg/m3	24 hours	Limit value entered into force 1.1.2005**	35
	40 µg/m3	1 year	Limit value entered into force 1.1.2005**	n/a
Lead (Pb)	0.5 µg/m3	1 year	Limit value entered into force 1.1.2005 (or 1.1.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m3 limit value applied from 1.1.2005 to 31.12.2009)	n/a
Carbon monoxide (CO)	10 mg/m3	Maximum daily 8 hour mean	Limit value entered into force 1.1.2005	n/a
Benzene	5 µg/m3	1 year	Limit value entered into force 1.1.2010**	n/a
Ozone	120 µg/m3	Maximum daily 8 hour mean	Target value entered into force 1.1.2010	25 days averaged over 3 years
Arsenic (As)	6 ng/m3	1 year	Target value enters into force 31.12.2012	n/a
Cadmium (Cd)	5 ng/m3	1 year	Target value enters into force 31.12.2012	n/a
Nickel (Ni)	20 ng/m3	1 year	Target value enters into force 31.12.2012	n/a
Polycyclic Aromatic Hydrocarbons	1 ng/m3 (expressed as concentration of Benzo(a)pyrene)	1 year	Target value enters into force 31.12.2012	n/a

*"Humans can be adversely affected by exposure to air pollutants in ambient air. In response, the European Union has developed an extensive body of legislation which establishes **health based standards and objectives** for a number of pollutants in air. […]. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times."*

http://ec.europa.eu/environment/air/quality/standards.htm

CAIMANs approach

Pollutant concentrations maps

passenger ships contributions to ambient air quality levels

100% of AQL

50% of AQL

10% of AQL

5% of AQL

increasing relevance of the contribution of the passenger ships emissions to the ambient air concentrations, respect to the AQLs.

Population exposure maps

number of inhabitants exposed to the various thresholds of AQLs.

CAIMANs thresholds

LONG TERM	NO_2	SO_2	PM10	PM2.5	Ni	Pb	As	Cd	B(a)P
	µg/m³	µg/m³	µg/m³	µg/m³	ng/m³	ng/m³	ng/m³	ng/m³	ng/m³
100% AQL	*40*	*20*	*40*	*25*	*20*	*500*	*6*	*5*	*1*
50% AQL	*20*	*10*	*20*	*12.5*	*10*	*250*	*3*	*2.5*	*0.5*
10% AQL	*4*	*2*	*4*	*2.5*	*2*	*50*	*0.6*	*0.5*	*0.1*
5% AQL	*2*	*1*	*2*	*1.25*	*1*	*25*	*0.3*	*0.25*	*0.05*

SHORT TERM	NO_2	SO_2	SO_2 (daily)	PM10
	µg/m³	µg/m³	µg/m³	µg/m³
100% AQL	*200*	*350*	*125*	*50*
50% AQL	*100*	*175*	*62.5*	*25*
10% AQL	*20*	*35*	*12.5*	*5*
5% AQL	*10*	*17.5*	*6.25*	*2.5*

Concerning ship emissions, NO_2 and SO_2 are pollutants of major concern

present scenario

n° inhab.	NO_2	SO_2	PM10	PM2.5	Ni	Pb	As	Cd	B(a)P
Barcelona (n° of inhabitant in the modeling domain: 3280290)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	86,323	0	0	0	0	0	0	0	0
5% AQL	408,977	61,040	0	0	0	0	0	0	0
Marseilles (n° of inhabitant in the modeling domain: 588132)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	70,768	937	0	0	0	0	0	0	0
5% AQL	259,667	66,786	0	0	381	0	0	0	0
Genoa (n° of inhabitant in the modeling domain: 193183)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	0	0	0	0	0	0	0	0	0
5% AQL	4,360	0	0	0	0	0	0	0	0
Venice (n° of inhabitant in the modeling domain: 252500)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	0	0	0	0	0	0	0	0	0
5% AQL	2,430	0	0	0	0	0	0	0	0
Thessaloniki (n° of inhabitant in the modeling domain: 688617)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	0	0	0	0	0	0	0	0	0
5% AQL	579	0	0	0	0	0	0	0	0

n° inhab.	NO_2 hourly c.	SO_2 hourly c.	SO2 daily conc.	PM10 daily conc
Barcelona				
AQL	0	0	0	0
50% AQL	1,761	0	0	0
10% AQL	403,925	0	0	0
5% AQL	2,238,281	0	0	12,165
Marseilles				
AQL	0	0	0	0
50% AQL	0	0	0	0
10% AQL	588,132	82,806	2	0
5% AQL	588,132	488,066	79,557	0
Genoa				
AQL	62	0	0	0
50% AQL	101	0	0	0
10% AQL	16,200	0	0	0
5% AQL	30,830	0	0	0
Venice				
AQL	0	0	0	0
50% AQL	2,430	0	0	0
10% AQL	224,000	0	0	0
5% AQL	251,000	15	0	0
Thessaloniki				
AQL	290	0	0	0
50% AQL	3,848	0	0	0
10% AQL	167,814	0	0	0
5% AQL	314,760	145	0	0

Generally, the exposure slight increases in the future scenario

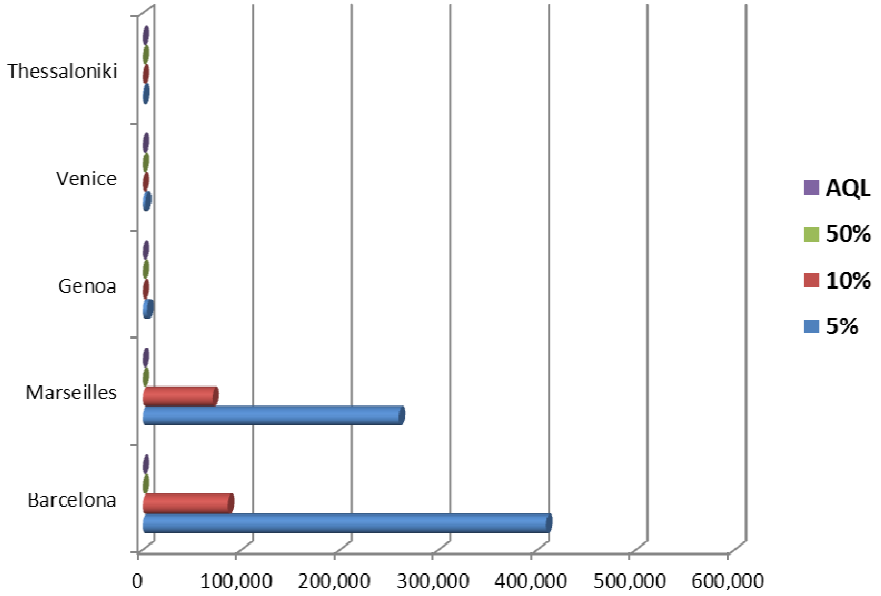
baseline future

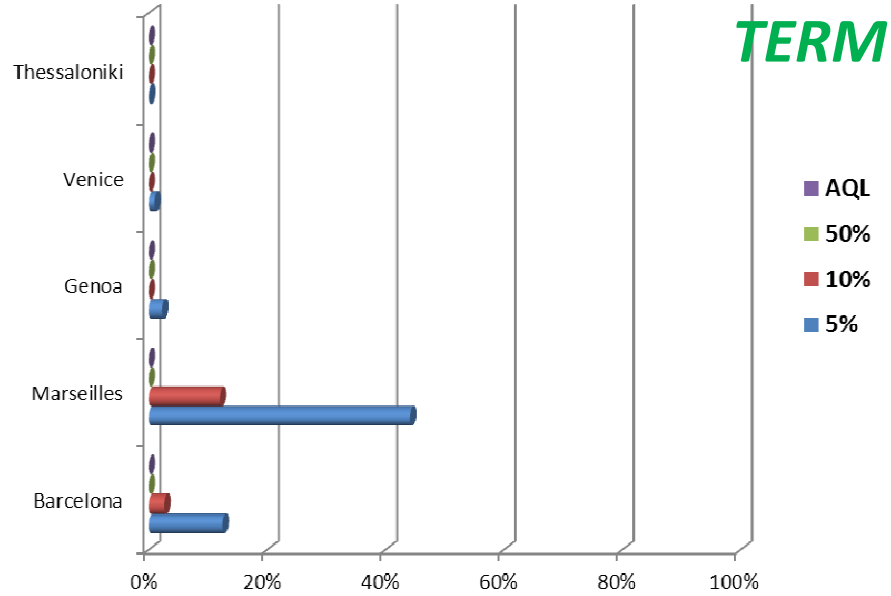
n° inhab.	NO_2	SO_2	PM10	PM2.5	Ni	Pb	As	Cd	B(a)P
Barcelona (n° of inhabitant in the modeling domain: 3280290)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	114,389	0	0	0	0	0	0	0	0
5% AQL	529,429	108,758	0	0	0	0	0	0	0
Marseilles (n° of inhabitant in the modeling domain: 588132)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	98,627	12,540	0	0	3	0	0	0	0
5% AQL	334,736	130,404	0	3	10,208	0	0	0	0
Genoa (n° of inhabitant in the modeling domain: 193183)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	0	0	0	0	0	0	0	0	0
5% AQL	8,350	0	0	0	0	0	0	0	0
Venice (n° of inhabitant in the modeling domain: 252500)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	0	0	0	0	0	0	0	0	0
5% AQL	3	0	0	0	0	0	0	0	0
Thessaloniki (n° of inhabitant in the modeling domain: 688617)									
AQL	0	0	0	0	0	0	0	0	0
50% AQL	0	0	0	0	0	0	0	0	0
10% AQL	1,303	0	0	0	0	0	0	0	0
5% AQL	12,478	0	0	0	0	0	0	0	0

n° inhab.	NO_2 hourly c.	SO_2 hourly c.	SO_2 daily conc.	PM10 daily conc.
Barcelona				
AQL	0	0	0	0
50% AQL	2,081	0	0	0
10% AQL	485,140	0	0	0
5% AQL	2,492,547	0	0	22,250
Marseilles				
AQL	0	0	0	0
50% AQL	0	0	0	0
10% AQL	588,132	215,834	41,253	0
5% AQL	588,132	578,361	194,573	3
Genoa				
AQL	62	0	0	0
50% AQL	230	0	0	0
10% AQL	17,635	0	0	0
5% AQL	35,881	0	0	0
Venice				
AQL	0	0	0	0
50% AQL	180	0	0	0
10% AQL	217,000	0	0	0
5% AQL	251,000	1530	0	0
Thessaloniki				
AQL	2,027	0	0	0
50% AQL	33,910	0	0	0
10% AQL	299,436	145	0	0
5% AQL	452,645	1,013	290	290

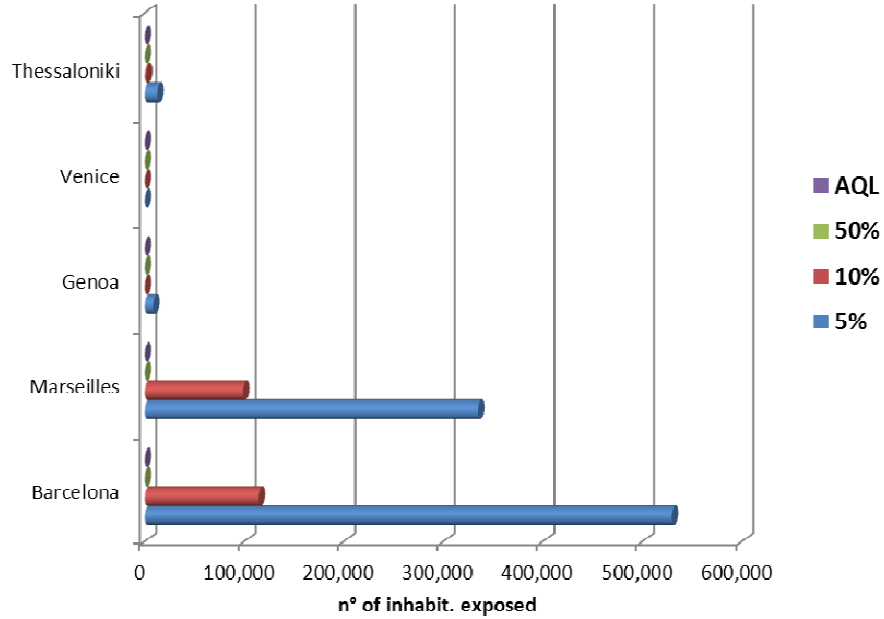
NO_2 long term exposure - Present scenario

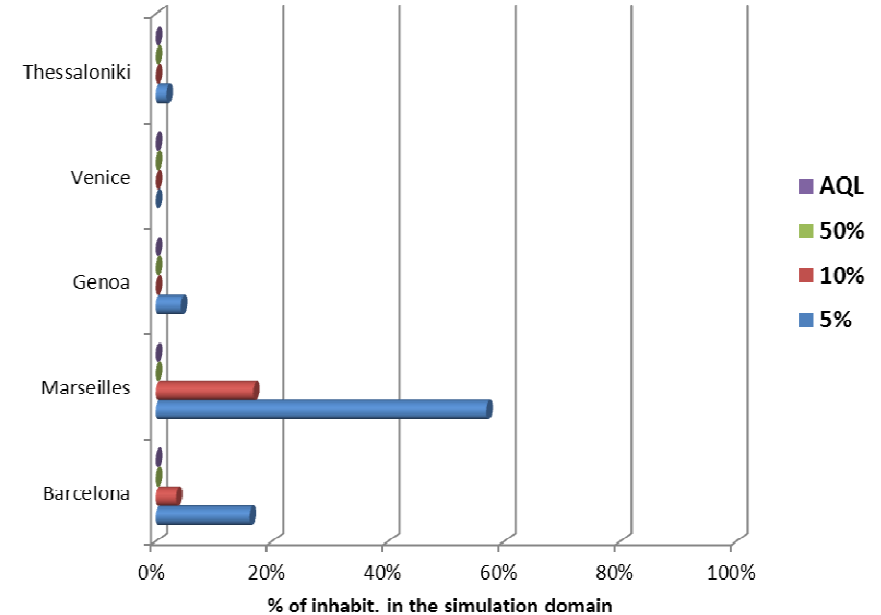
LONG TERM





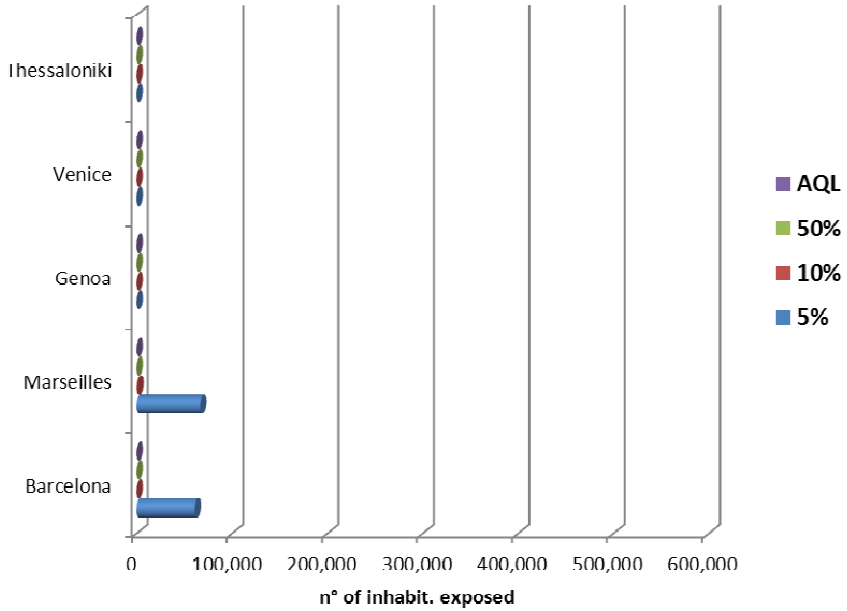
NO_2 long term exposure - Future baseline scenario

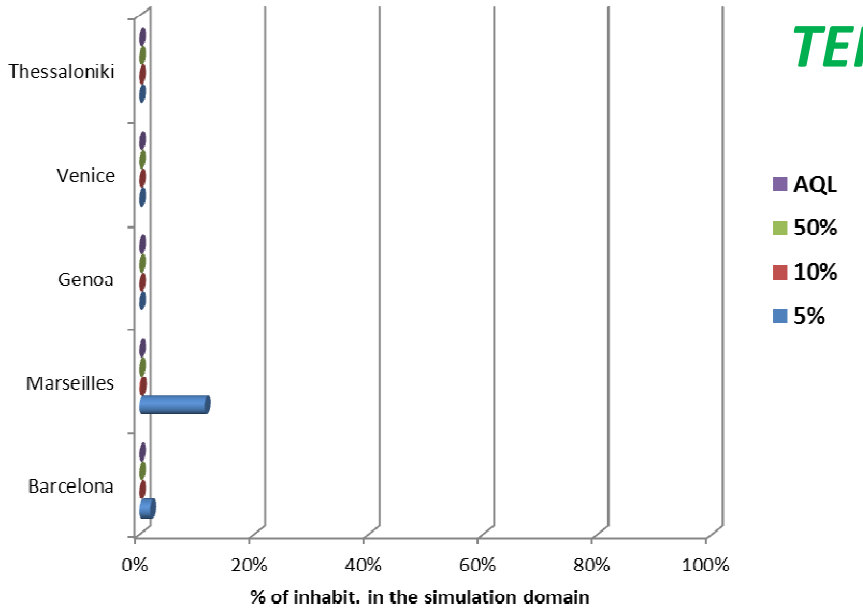




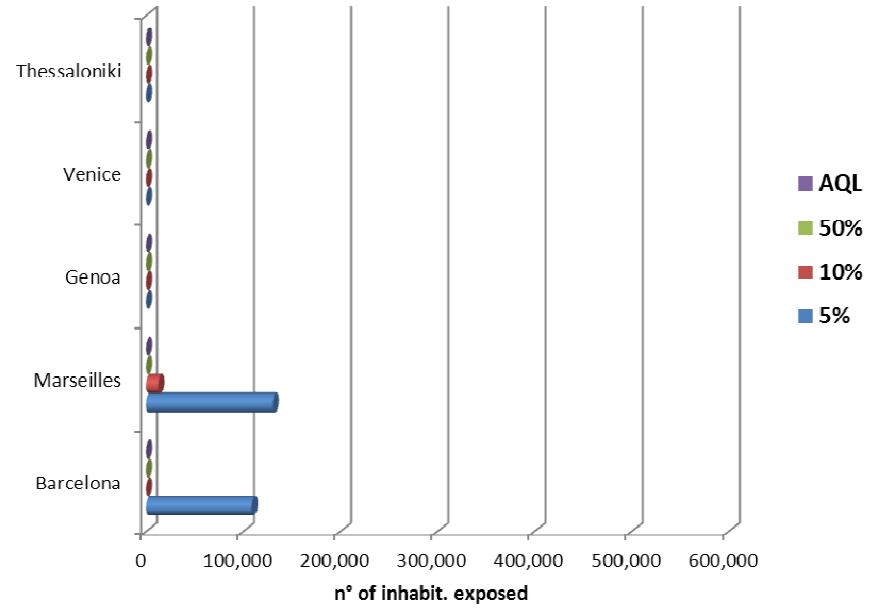
SO_2 long term exposure - Present scenario

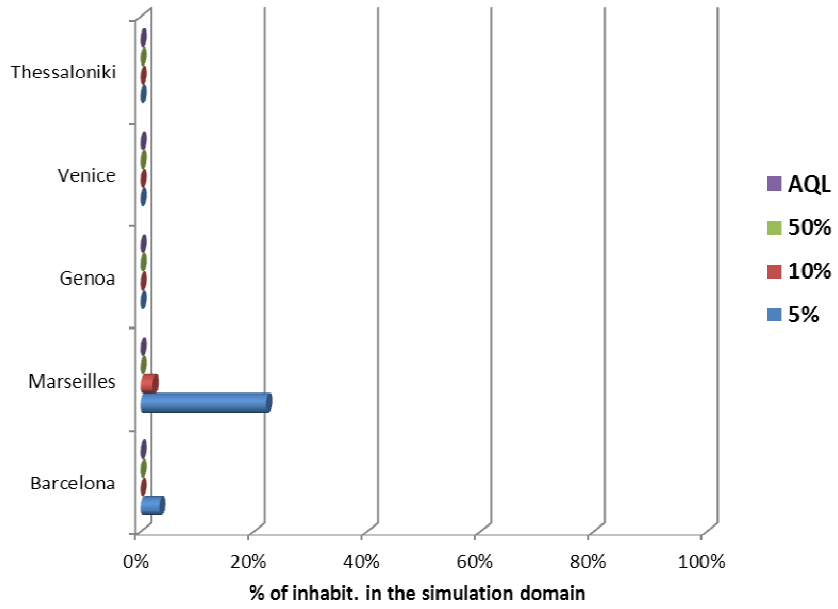
LONG TERM





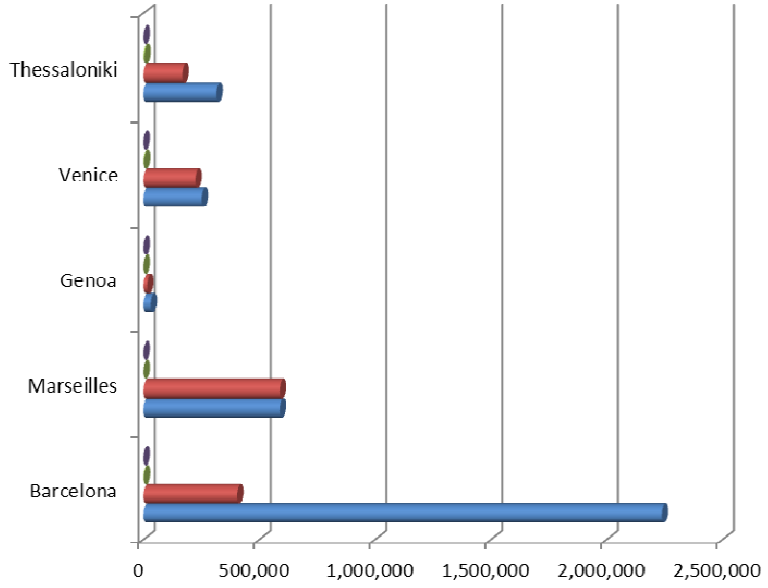
SO_2 long term exposure - Future baseline scenario

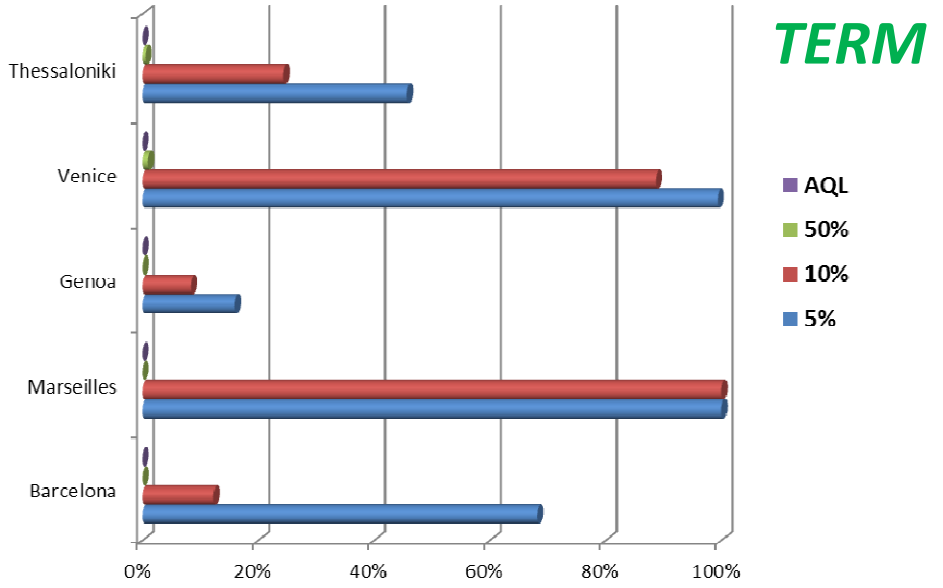




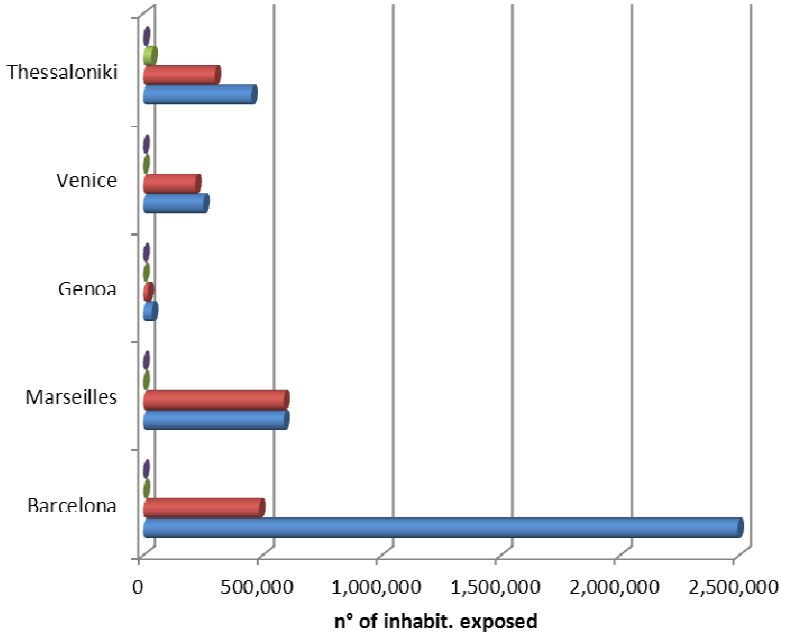
NO_2 short term exposure - Present scenario

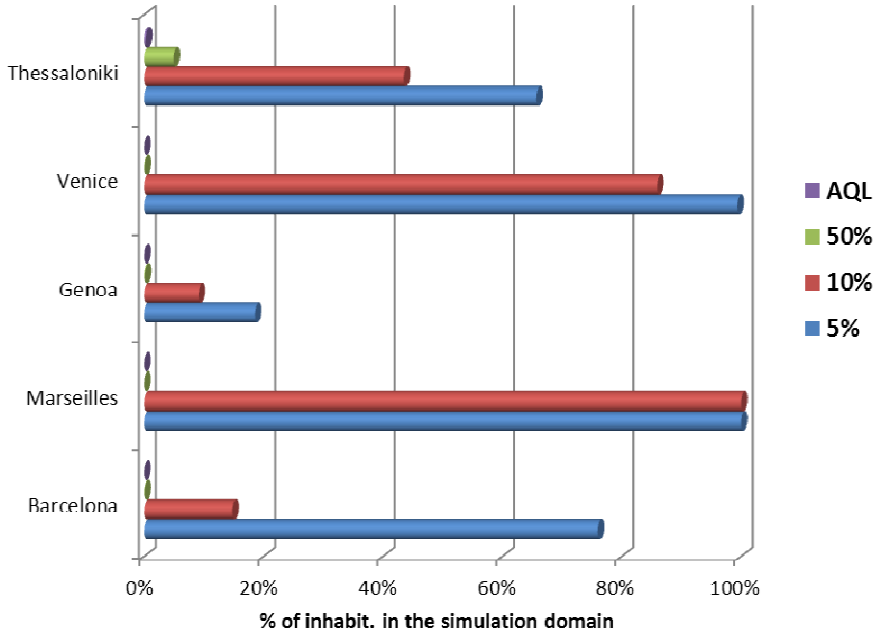
SHORT TERM



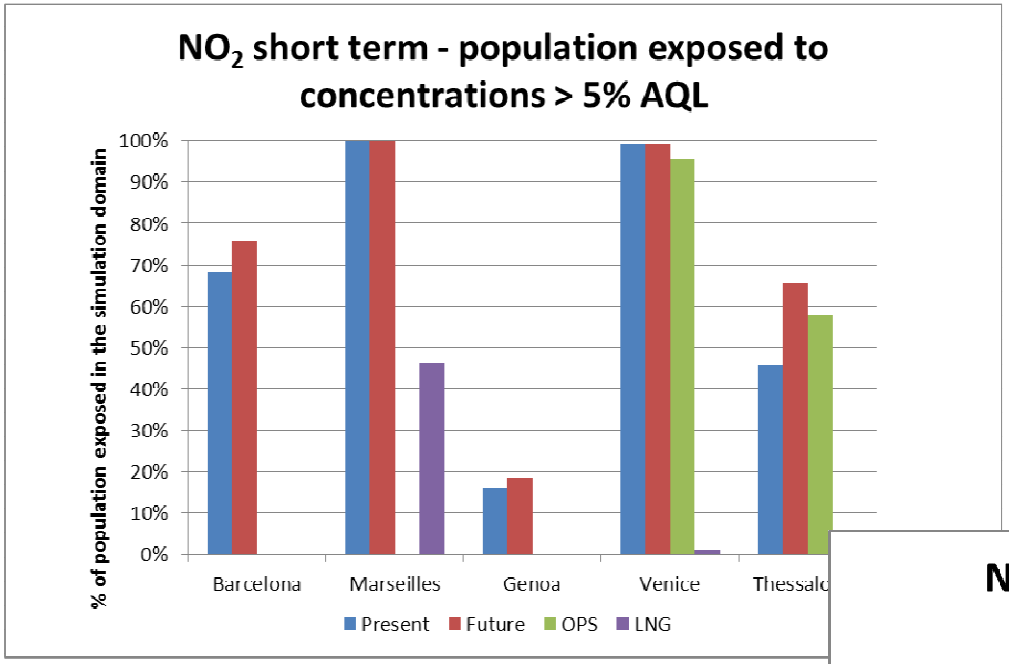


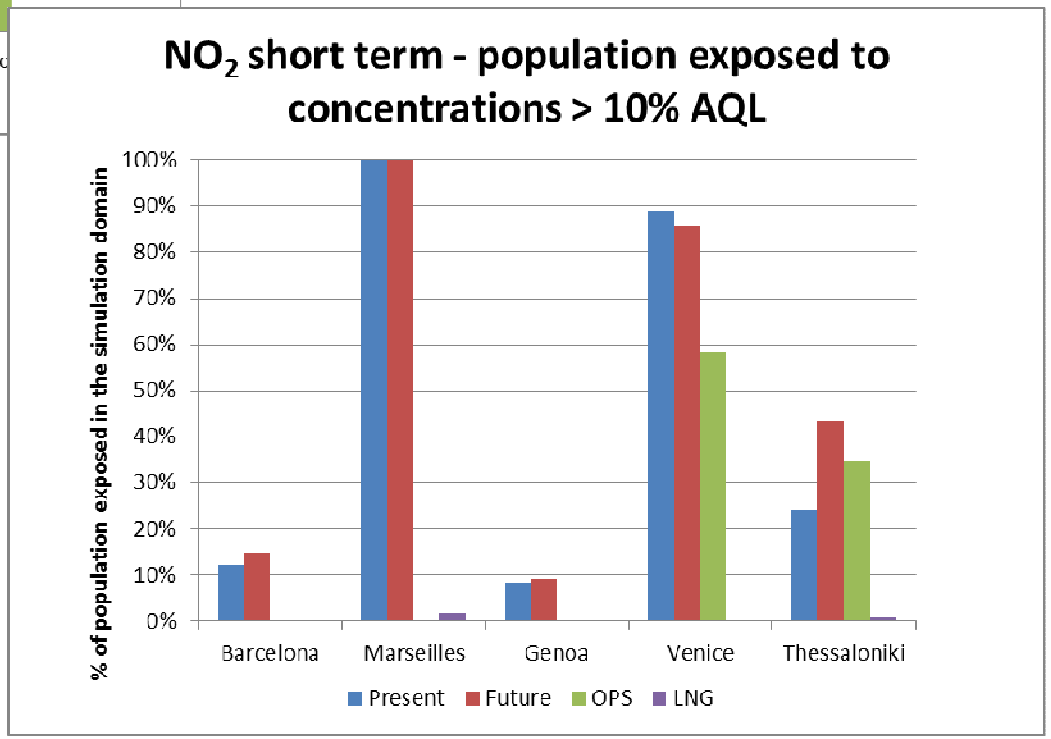
NO_2 short term exposure - Future baseline scenario





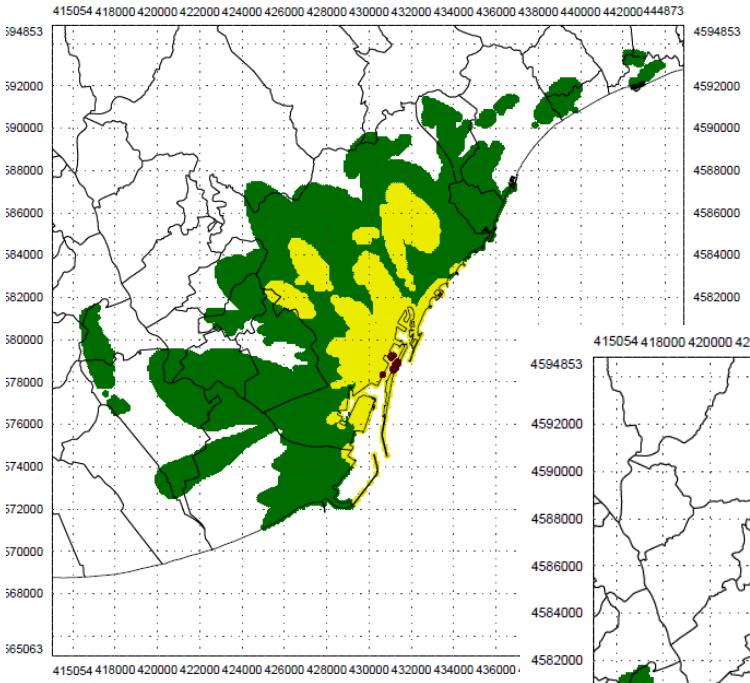
NO_2: population exposed in the mitigation scenarios





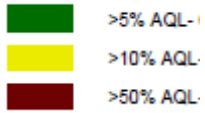
The On Shore Power supply scenario had been analysed in Thessaloniki, Venice and Genoa, where it had been studied for both cruise ships and Ro-Pax.

2013 scenario

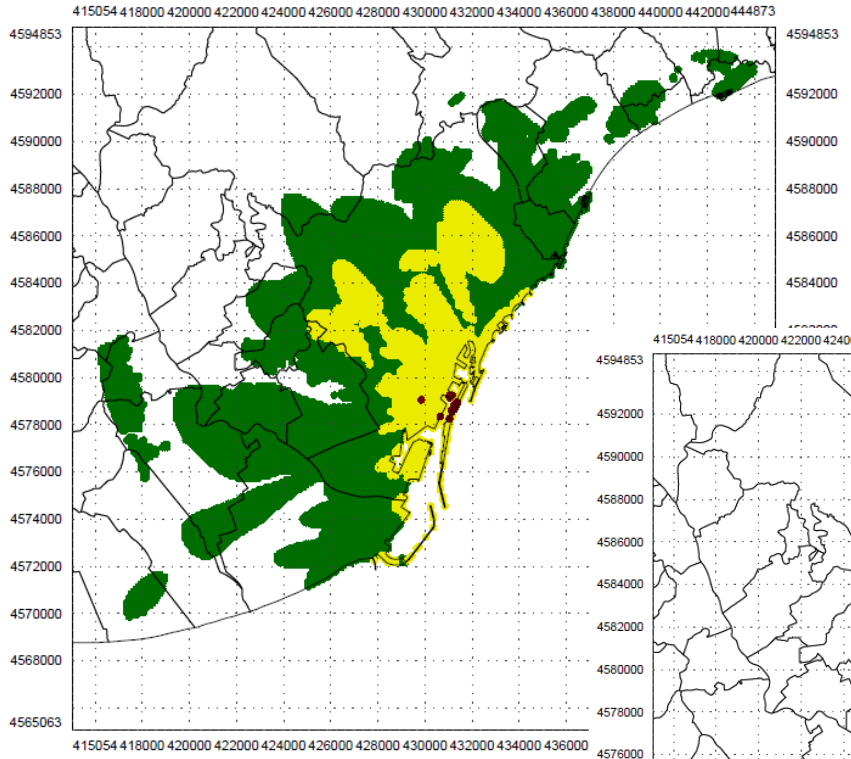


NO_2 short term exposure

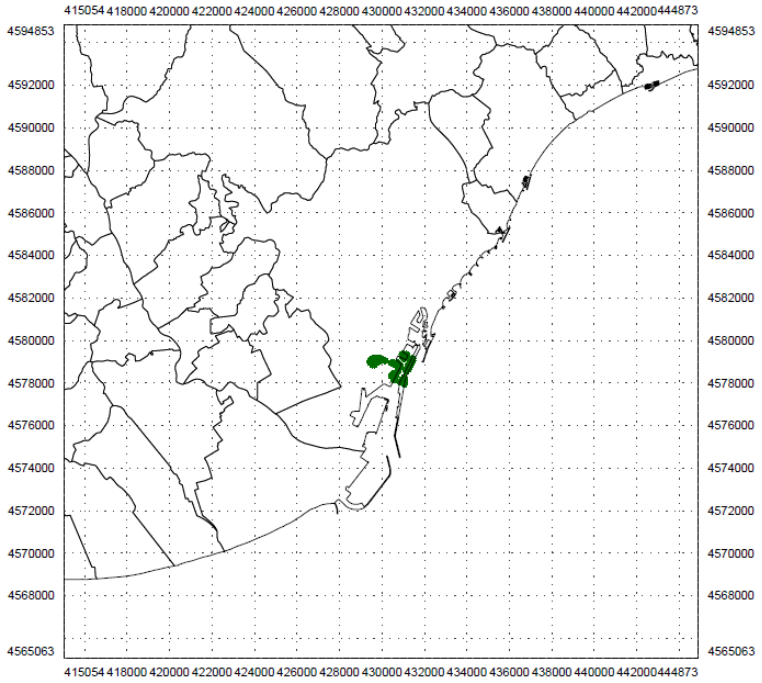
Barcelona



2020 scenario



LNG scenario

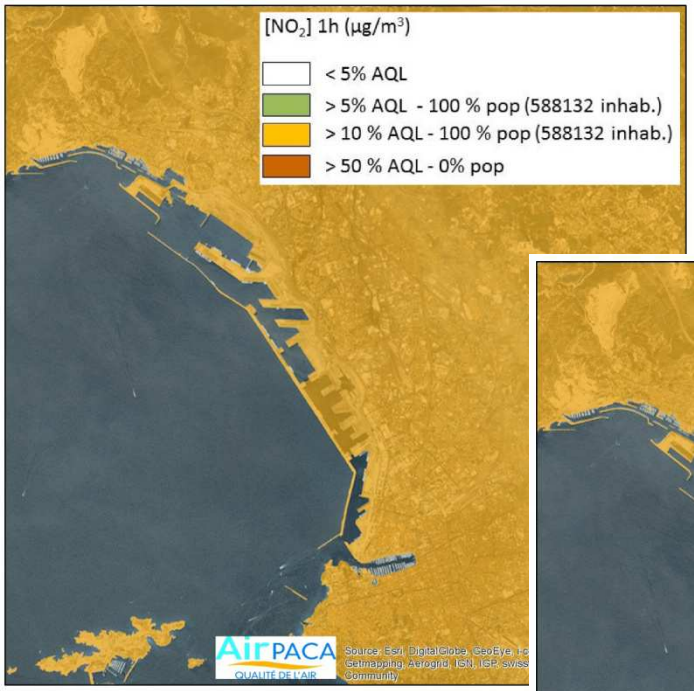


In the most populated harbour city of the project, the exposure to a noticeable contribution by passenger ships affects around 2.5 million people in the future scenario.

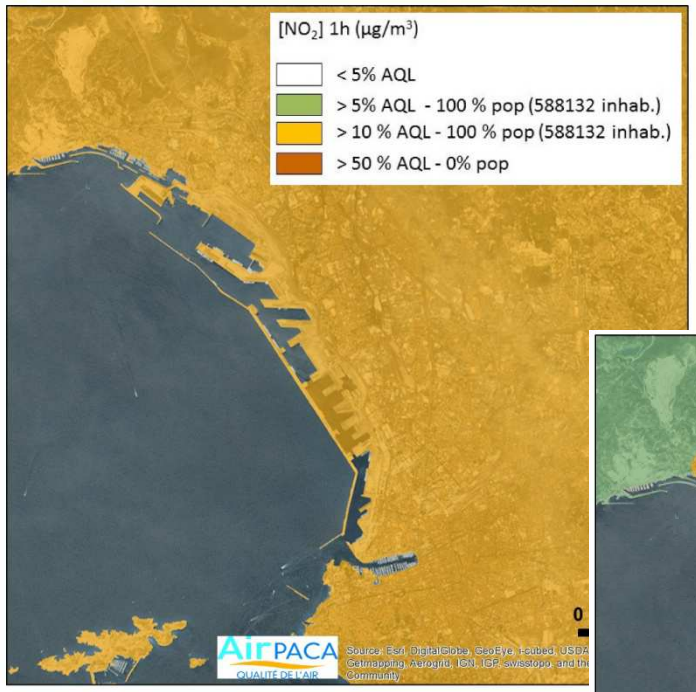
NO_2 short term exposure

Marseilles

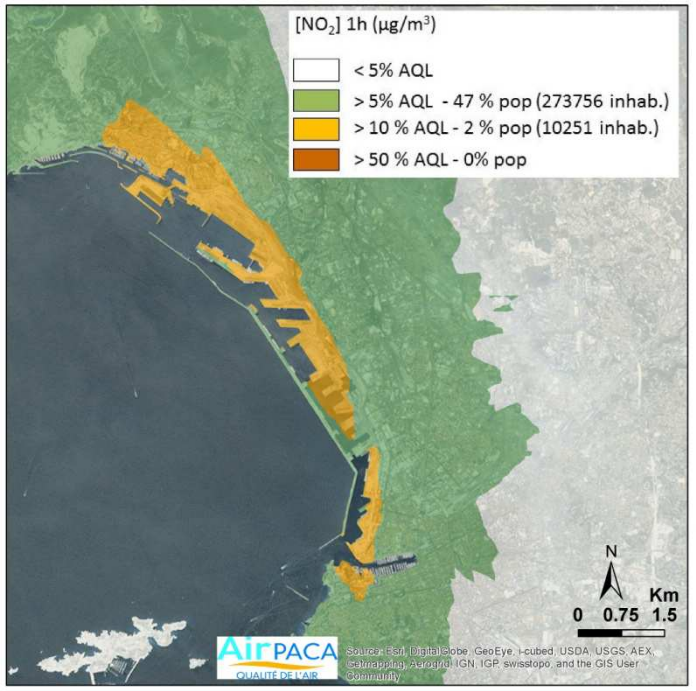
2013 scenario



2020 scenario

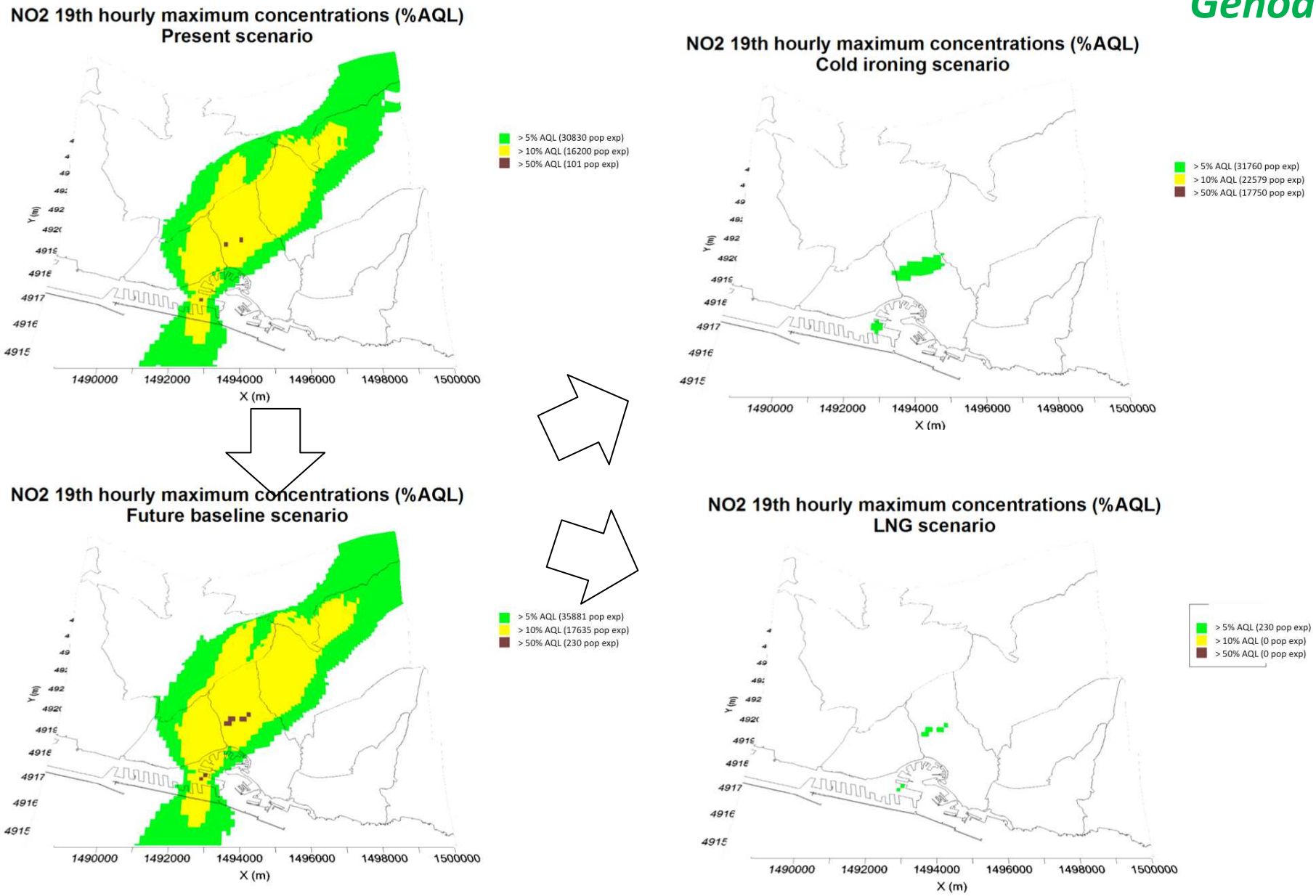


LNG scenario



In Marseilles, the exposure to concentrations > 10% of the AQL affects all the inhabitants in the simulation domain both in the present and future scenarios. The LNG scenario shows a drastic reduction in the number of people exposed to a significant contribution by passenger ships.

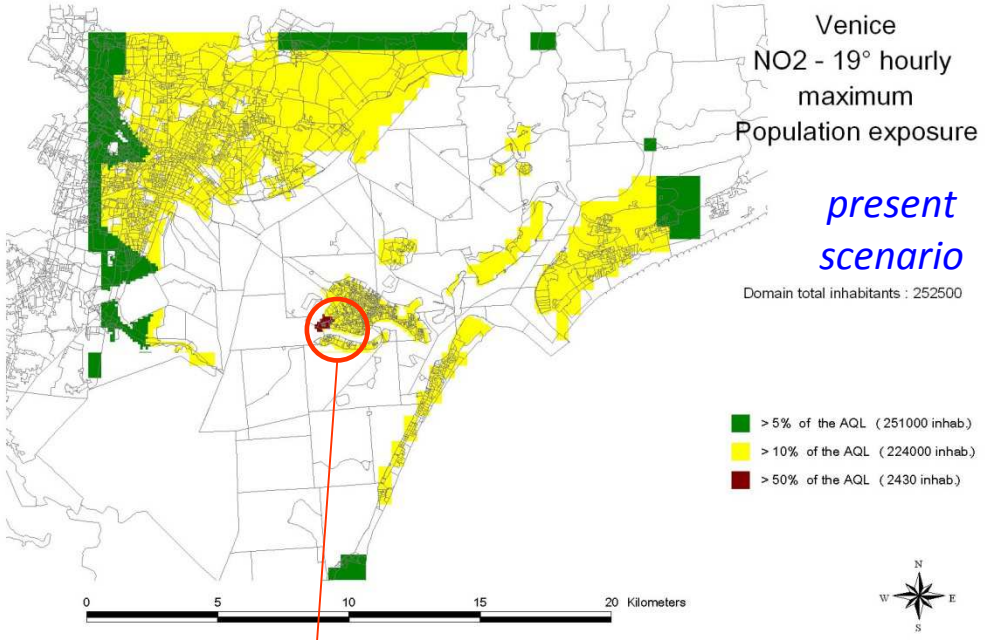
Genoa

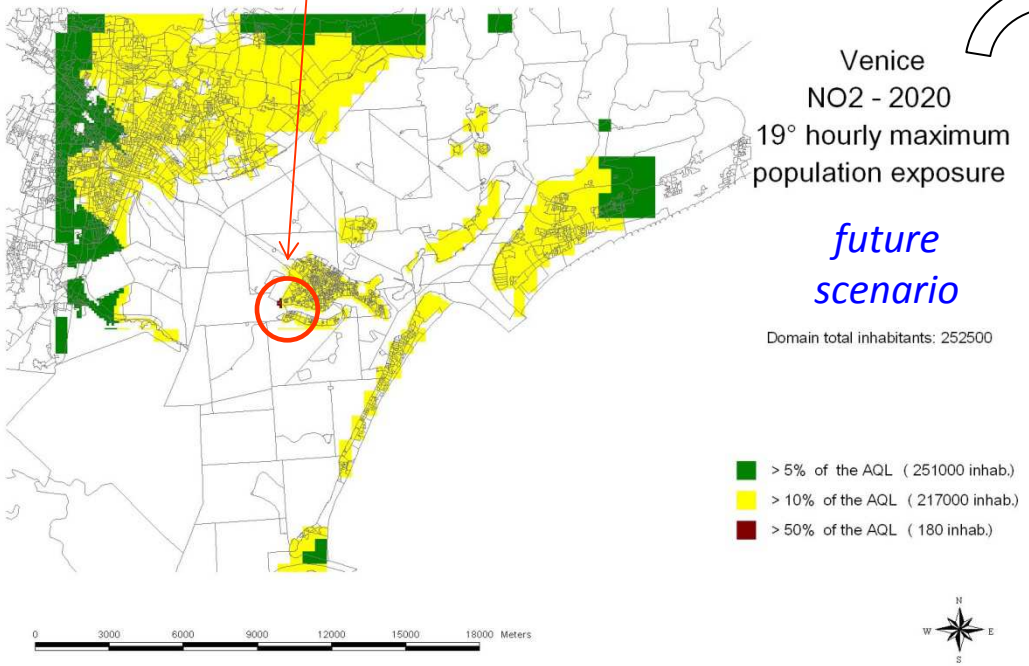


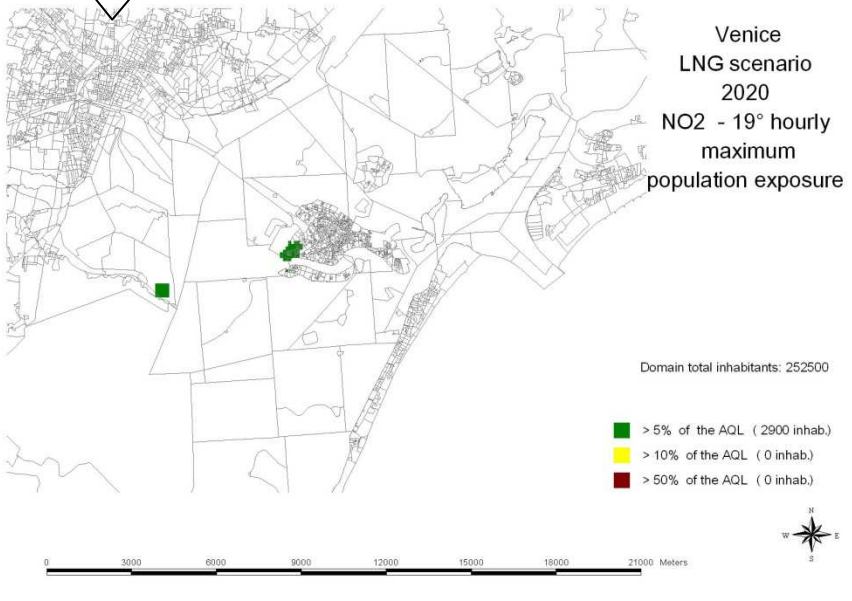
Both mitigation scenarios studied imply a drastic reduction of population exposed, highlighting the hotelling as the phase with major impact on short term concentrations.

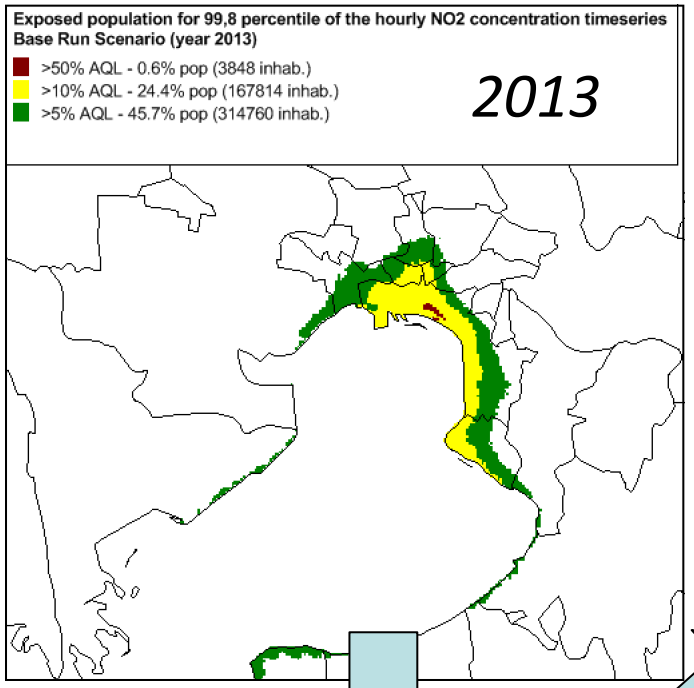
Venice

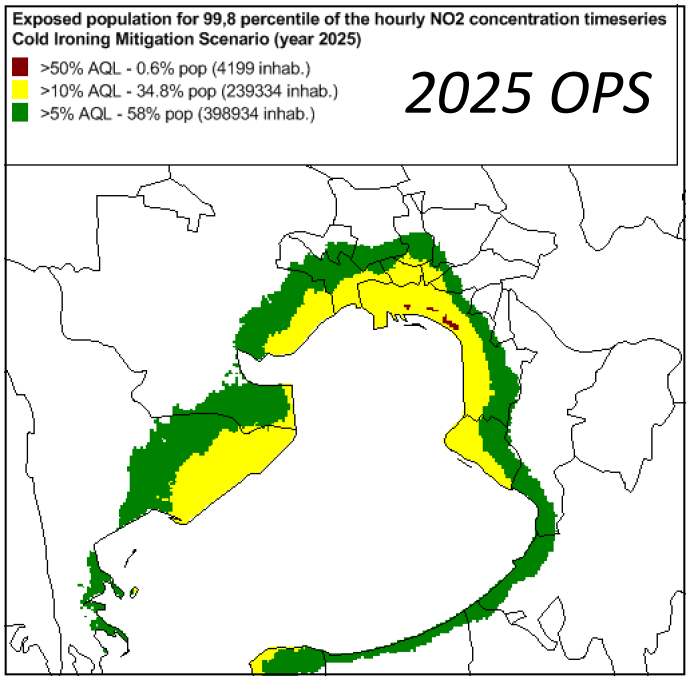
Differently from the other harbours, the exposure of population slightly decreases in the future scenario in Venice. The 2020 scenario foresees no cruise ship increment, the displacement of Ro-Pax terminal and, like in the other harbours, the fleet renewal.

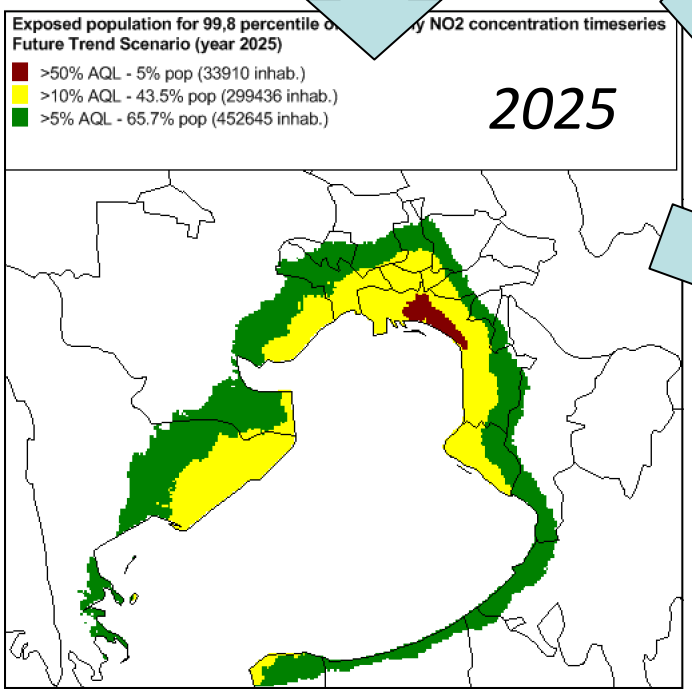


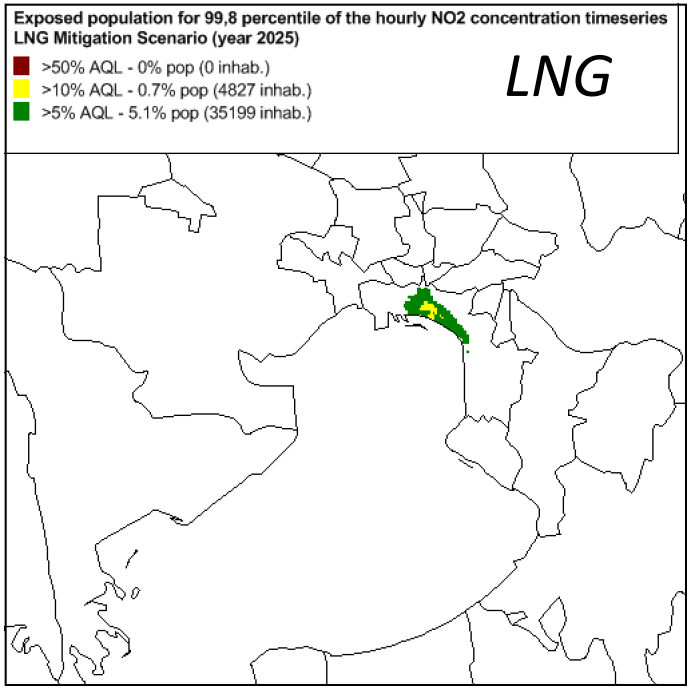












Thessaloniki

A relevant increase of passenger ship calls is foreseen in the next future; the OPS could significantly reduce the exposure to the 50% of ***NO_2 short term*** *AQL, whereas the LNG scenario entails a strong reduction of population directly affected by ship plumes.*

Final remarks

Focusing on the contribution of passenger ship emissions on population exposure, CAIMANs results highlight:

- The air pollutants of major concern are NO_2 and in lesser extent also SO_2, particularly in respect to the short term values
- generally the impact of PM and micropollutants is not particularly significant
- without mitigation actions the impact on population is estimated to increase in the future scenarios
- the LNG scenario implies a drastic reduction of population exposure

CAIMANs

Cruise and passenger ship Air quality Impact Mitigation ActioNs

THANK YOU FOR YOUR ATTENTION

Lead Partner: Environmental Protection Agency of Veneto Region ARPAV – Padoa (IT)
www.arpa.veneto.it

Partners:
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 - Institute of Environmental Assessment & Water Research IDAEA (ES) http://www.idaea.csic.es/