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CONTRIBUTION OF EMISSIONS SOURCES FROM SHIPPING IN THE PORT AREA OF BRINDISI, ITALY

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reseaux
RESearch for Environmental Applications Using eXperiments and simulations

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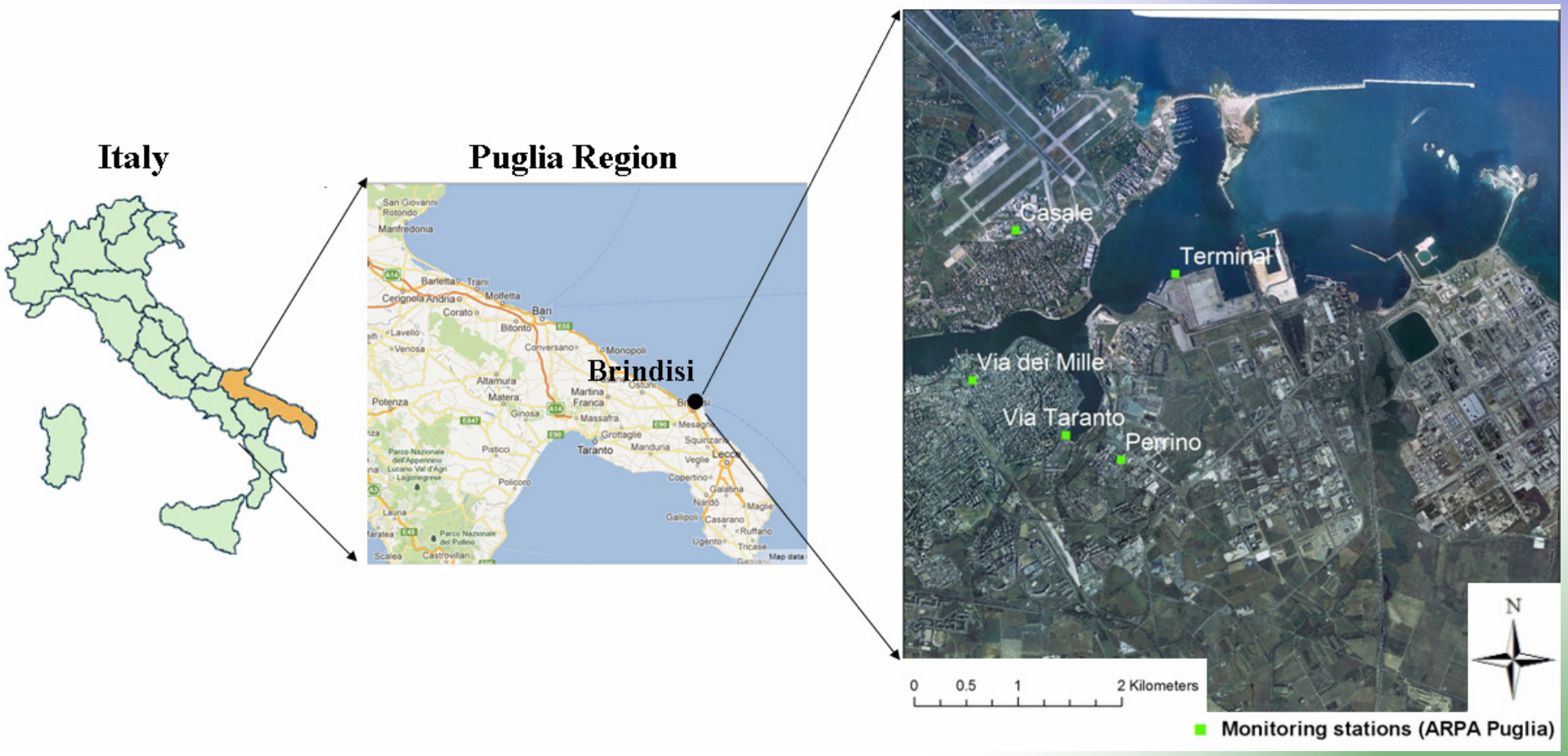
CESAPO

Contribution of Emission Sources on the Air quality of the Port-cities in Greece and Italy

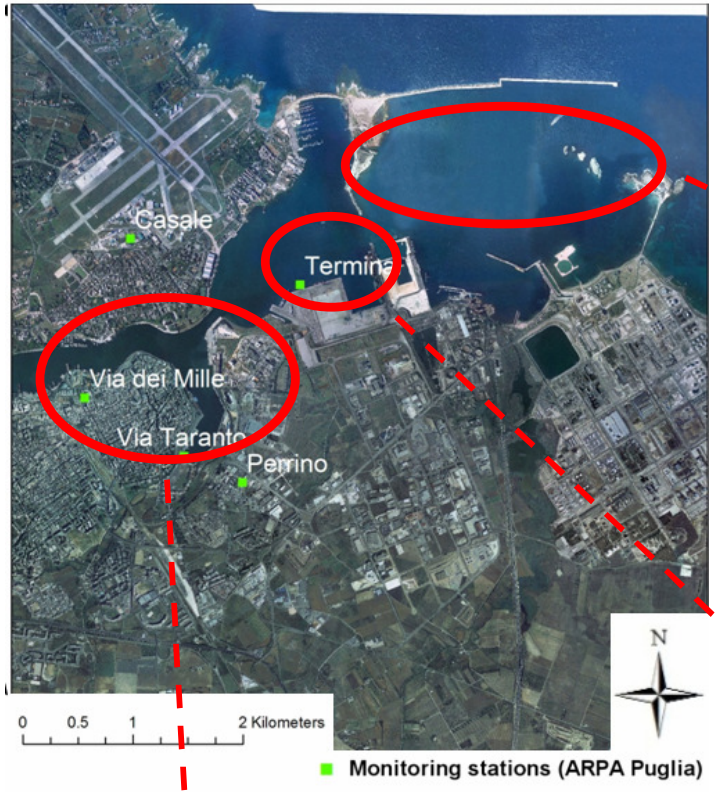
outline

- The study area and the modelling approach
- Compilation of the 2010/2011 emission inventory (gases and particulate) as input for local scale simulations
- Local scale dispersion modelling in the Brindisi harbour

the study area



the study area



External zone

Main activity: industrial

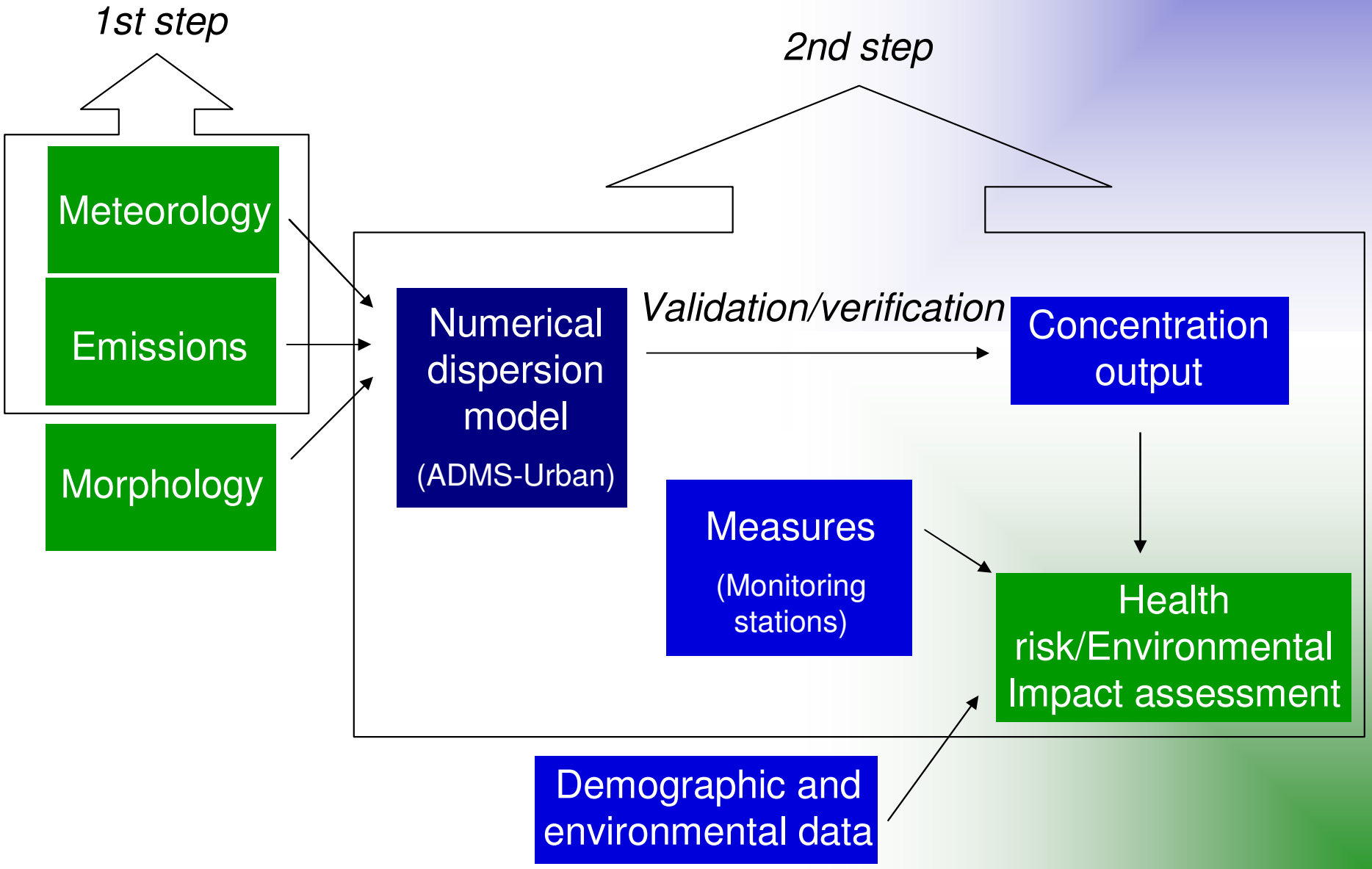
Internal zone

Main activity: tourism

Middle zone

Main activity: commercial

the modelling chain

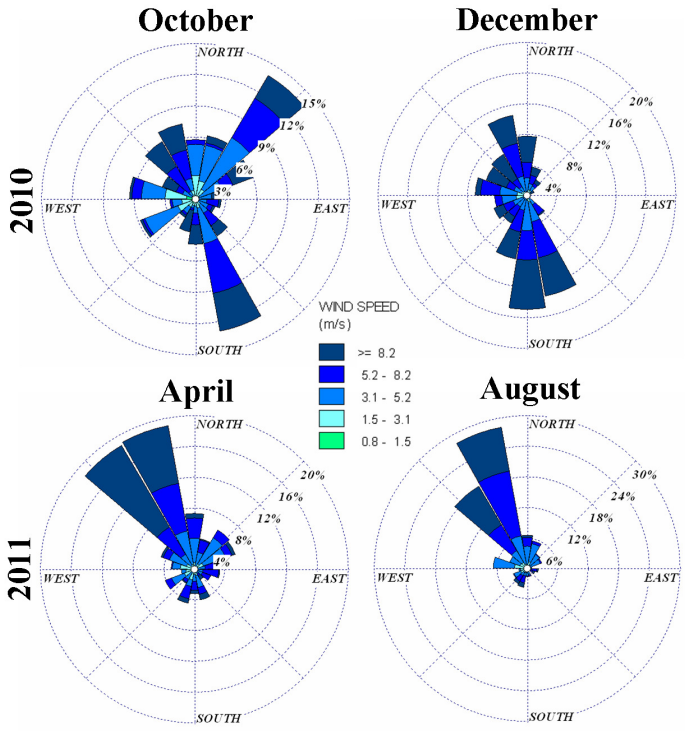


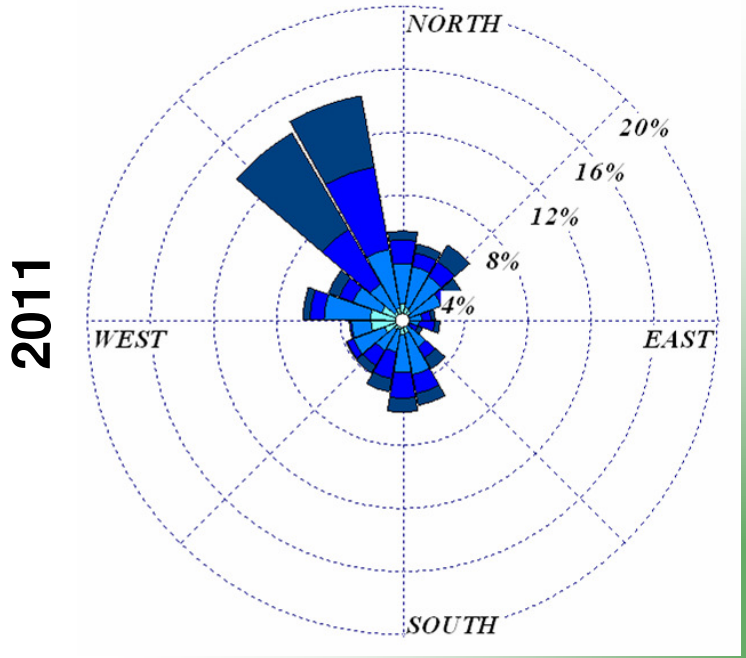
meteorology

➢Weather station located at the **Brindisi military airport** LIBR (height 10m)

➢**Meteorological data** include:
- •wind velocity (ms^{-1})
- •wind direction (degrees)
- •precipitation (mm)
- •temperature (°C)
- •relative humidity (%)
- •cloud cover (octave)

Year	*Period of missing meteorological data*	*Meteorological data missing*
2010	From 01-Jan to 16-Jul From 14-Oct to 25-Oct From 02-Nov to 17-Nov	All data Velocity and Wind Direction Velocity and Wind Direction
2011	From 03-Mar to 27-Mar From 21-Sep to 11-Oct	Velocity and Wind Direction Velocity and Wind Direction





Contribution of emissions sources from shipping in the port area of Brindisi, Italy

emissions

Collection of traffic data

✓ **Traffic data** for the years 2010/2011: arrivals and departures by date and time, ship name, gross tonnage, provenance and mooring (from Avvisatore Marittimo of the Brindisi harbour http://www.porto.br.it/bpi/index.php)

2301 ships (2010)

2322 ships (2011)

6 febbraio 2012

Lista navi partite dal: 01/01/2010 al: 31/12/2010

No.	Nome Nave	Ban	Partenza	Ultimo accosto	Note partenza	Lun.	Lar.	GT	Pescaggio
1	VERONICA LINE	CY	01/01/2010 23.16	CARBONIFERA NORD .		112,00	20,00	7.838	0,00
2	MV SUDE AKANSU	TU	02/01/2010 10.06	RADA		85,00	11,00	1.750	
3	VERONICA LINE	CY	02/01/2010 23.51	CARBONIFERA NORD .		112,00	20,00	7.838	0,00
4	RED STAR 1	PN	03/01/2010 00.16	NUOVA RAMPA TRAGHETTI .		99,48	18,32	5.678	0,00
5	IONIAN SPIRIT	VC	03/01/2010 00.41	VECCHIA RAMPA TRAGHETTI 1		101,00	17,20	6.748	0,00
6	SAIL	BZ	03/01/2010 09.00	BANCHINA DI RIVA .		108,00	15,00	2.068	
7	RINELLA M	IT	03/01/2010 10.30	MOLO POLIMERI 12		180,00	32,00	25.804	
8	VERONICA LINE	CY	04/01/2010 00.34	CARBONIFERA NORD .		112,00	20,00	7.838	
9	RED STAR 1	PN	04/01/2010 00.52	VECCHIA RAMPA TRAGHETTI 1		99,48	18,32	5.678	0,00
10	ODIN FINDER	IT	04/01/2010 06.25	SANT'APOLLINARE .		46,45	9,00	600	
11	SIREN	CY	04/01/2010 20.01	TERRARE 1		144,00	24,00	14.540	0,00
12	IONIAN SPIRIT	VC	04/01/2010 23.56	CARBONIFERA NORD .		101,00	17,20	6.748	0,00
13	VERONICA LINE	CY	05/01/2010 00.26	NUOVA RAMPA TRAGHETTI .		112,00	20,00	7.838	0,00
14	RED STAR 1	PN	05/01/2010 00.41	VECCHIA RAMPA TRAGHETTI 1		99,48	18,32	5.678	0,00
15	NORGAS ALAMEDA	HK	05/01/2010 15.00	MOLO POLIMERI 12		125,00	20,00	8.720	
16	QUEEN ZENOBIA	PN	05/01/2010 21.30	NUOVO SPORGENTE IPEM		156,00	25,00	16.770	
17	IONIAN SPIRIT	VC	06/01/2010 00.01	CARBONIFERA NORD .		101,00	17,20	6.748	0,00
18	RED STAR 1	PN	06/01/2010 03.11	VECCHIA RAMPA TRAGHETTI 1		99,48	18,32	5.678	0,00
19	VERONICA LINE	CY	06/01/2010 05.01	NUOVA RAMPA TRAGHETTI .		112,00	20,00	7.838	0,00
20	CORAL LEAF	NL	06/01/2010 08.48	MOLO POLIMERI 7		108,00	17,00	5.440	
21	GO PUBLIC	BF	06/01/2010 12.30	COSTA MORENA DIGA TESTATA		223,70	32,20	38.180	
22	SYN MAIA	IT	06/01/2010 16.24	MOLO POLIMERI 12		99,00	15,00	3.983	
23	ELLY T.	CY	06/01/2010 19.19	TERRARE 2		141,70	23,50	12.338	0,00
24	SIREN	CY	06/01/2010 19.38	TERRARE 1		144,00	24,00	14.540	0,00
25	IONIAN SPIRIT	VC	07/01/2010 00.31	NUOVA RAMPA TRAGHETTI .		101,00	17,20	6.748	0,00
26	VERONICA LINE	CY	07/01/2010 00.51	CARBONIFERA NORD .		112,00	20,00	7.838	0,00
27	RED STAR 1	PN	07/01/2010 01.06	VECCHIA RAMPA TRAGHETTI 1		99,48	18,32	5.678	0,00
28	EFE YAGIZ 3	TU	07/01/2010 07.31	RADA		72,00	13,00	1.942	
29	GAZ SYMPHONY	PN	07/01/2010 19.00	NUOVO SPORGENTE IPEM		135,00	21,40	8.997	
30	SIDER PINK	LI	07/01/2010 23.45	COSTA MORENA EST CENTRO		139,00	25,00	11.674	
31	VERONICA LINE	CY	08/01/2010 00.06	CARBONIFERA NORD .		112,00	20,00	7.838	0,00

✓ **Emission factors** for the main pollutants depending on the type of ship and on the phase in which it is located, independently by engine type and fuel used (*European Commission Report*, 2002)

MANOEUVRING	NO_x	SO_2	CO_2	HC	PM	sfc	NO_x	SO_2	CO_2	HC	PM
	in g/kWh						in kg/tonne fuel				
A11 Liquefied Gas	7.4	13.5	887	0.9	2.1	279	32	49	3179	3.7	7.8
A12 Chemical	13.3	12.1	710	1.5	2.2	223	60	54	3179	6.9	9.9
A13 Oil	12.0	12.8	754	1.4	2.3	237	55	54	3179	6.4	9.7
A14 Other liquid	13.3	12.0	706	1.6	2.3	222	60	54	3179	7.1	10.2
A21 Bulk dry	14.3	11.7	688	1.7	2.3	217	66	54	3179	7.8	10.6
A22 Bulk dry/oil	13.5	11.4	708	1.6	2.2	223	62	52	3179	7.3	10.1
A23 Self-discharging bulk dry	12.0	12.5	751	1.1	1.9	236	54	53	3179	5.2	8.2
A24 Other bulk dry	13.9	11.6	695	1.6	2.3	219	64	53	3179	7.6	10.4
A31 General cargo	13.1	12.0	709	1.6	2.3	223	59	54	3179	7.0	10.2
A32 Passenger/general cargo	12.8	12.2	718	1.4	2.1	226	57	54	3179	6.2	9.2

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

emissions

MEET Methodology

(Methodology for Estimate air pollutant Emissions from Transport)

✓ Bottom-up approach: detailed data of individual sources of pollutants are available (types of ships, fuel consumption, traffic for each phase, emission factors)

✓ Definition of **phases** in which the ship is: manoeuvring, hotelling (and navigation)

✓ Definition of **characteristics** of the ship: name, type, gross tonnage and consumption in different phases

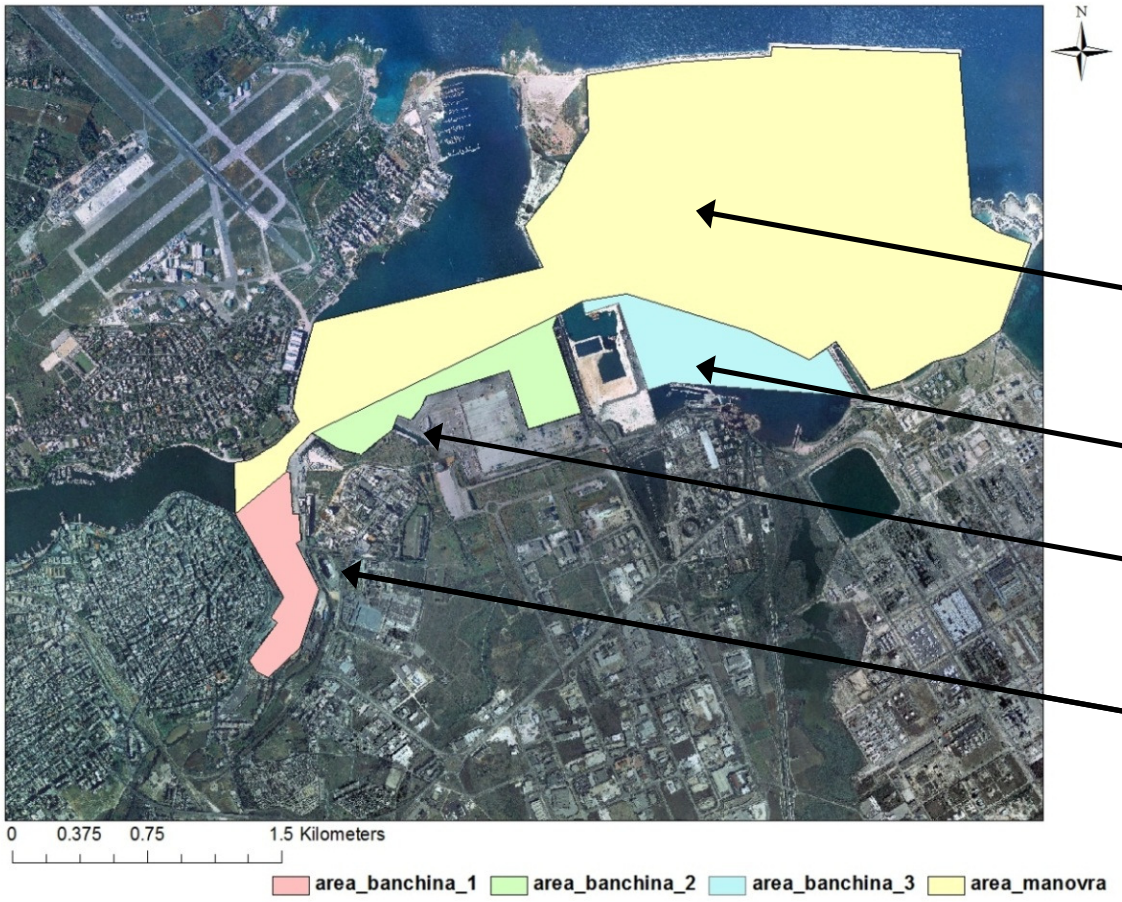
✓ Calculation of **consumption** in different phases

✓Calculation of **emissions** in different phases

✓Estimation of the characteristics of the stacks of ships (height and diameter, exit velocity and temperature) (**point sources**)

emissions

➢ The port area has been splitted into four areas using a Gis sofware and ships have been positioned randomically in each area



manoeuvring area

area 3

area 2

area 1

hotelling phase

emissions

Emission sources

reference months

	2010		2011	
	Group	Ship by Ship (SbS)	Group	Ship by Ship (SbS)
April	83 - 87	155 - 159	81 - 85	143 - 147
August	96 - 104	286 - 294	61 - 71	279 - 291
October	85 - 86	170 - 171	96 - 107	180 - 192
December	72 - 80	146 - 154	54 - 60	200 - 205
Whole year	N/A	2215 - 2301	618 - 689	2246 - 2322

hotelling phase

manoeuvring phase (total number of ships)

Group: ships having the same characteristics (tonnage, stack height and diameter, exit velocity and temperature) have been grouped into one single point source

Ship by ship: each ship has been taken as one single point source

emissions

Emission rates

Emission rate (gs^{-1})	2010								
	Hotelling			Manoeuvring			Total		
	NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}
August	36.4	35.4	5.3	1.7	1.7	0.3	38.1	37.1	5.6
October	32.8	31.1	4.5	1.3	1.2	0.2	34.1	32.3	4.7
December	35.0	33.4	4.8	1.2	1.2	0.2	36.2	34.6	5.0
Whole year	34.3	32.9	4.9	1.4	1.4	0.2	35.7	34.3	5.1
	2011								
	Hotelling			Manoeuvring			Total		
	NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}	NO_X	SO_2	PM_{10}
April	30.0	28.4	4.1	0.7	0.7	0.1	30.7	29.1	4.2
August	43.4	41.2	5.7	1.2	1.2	0.2	44.6	43.4	5.9
October	37.7	36.0	5.1	0.9	0.9	0.2	38.6	36.9	5.3
December	38.4	37.2	5.3	0.9	0.9	0.2	39.3	38.1	5.5
Whole year	34.7	33.0	4.7	0.9	0.9	0.2	35.6	33.9	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 and SO_2**, with NO_X being slightly larger than SO_2
- **seasonality is found to play a major role**, as summer emissions are about 10% larger compared to winter ones. This is linked to the tourisms activity which leads to a substantial increase in the number of passenger ships in summer months

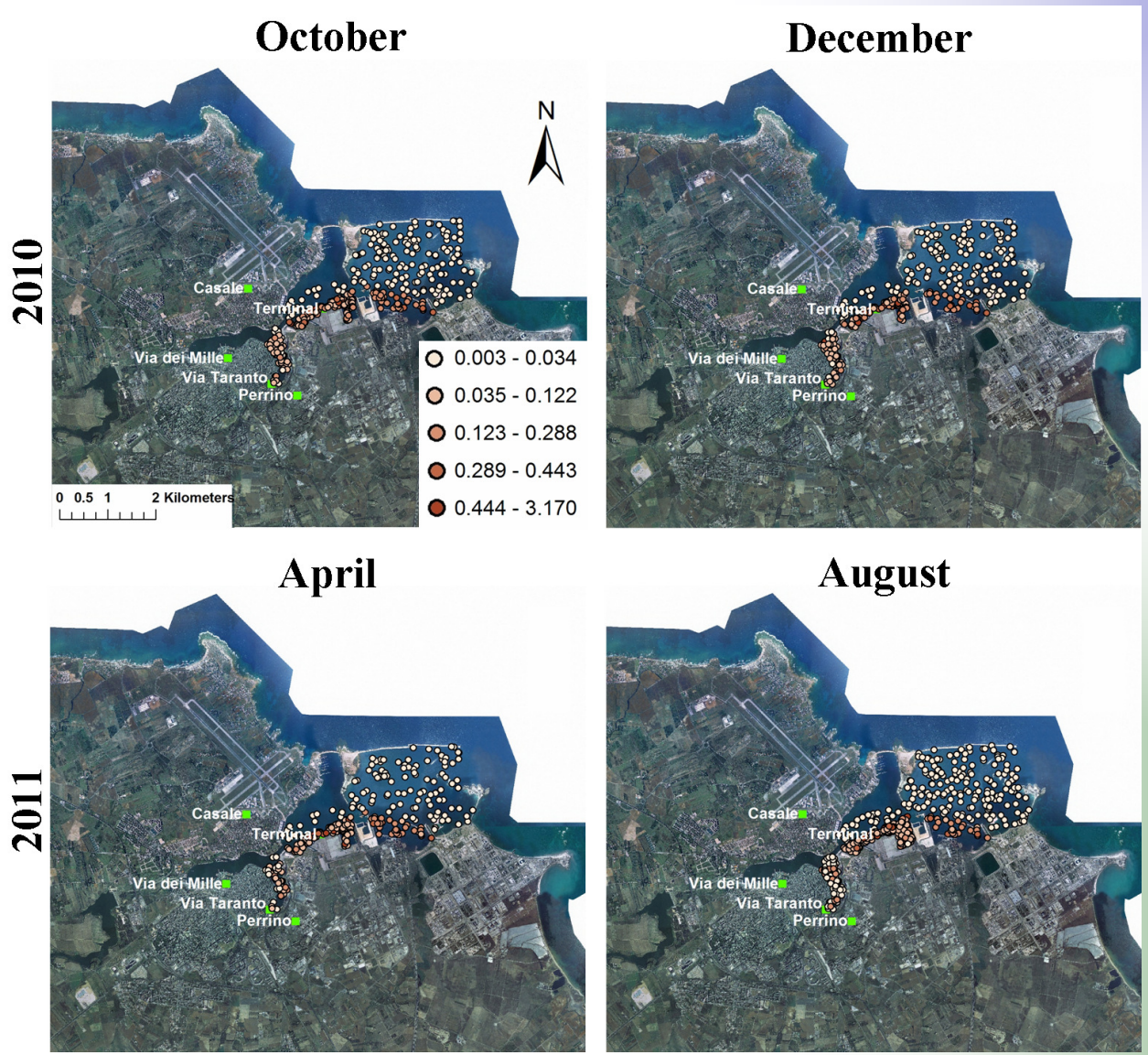
Ship by ship

CERC. EMIT USER Guide 2012. Available from Cambridge Environmental Research Consultant, Cambridge, UK. http://www.cerc.co.uk

emissions

Emission inventory (EMIT)

- NO_x
- SO_2
- PM_{10}



Ship by ship

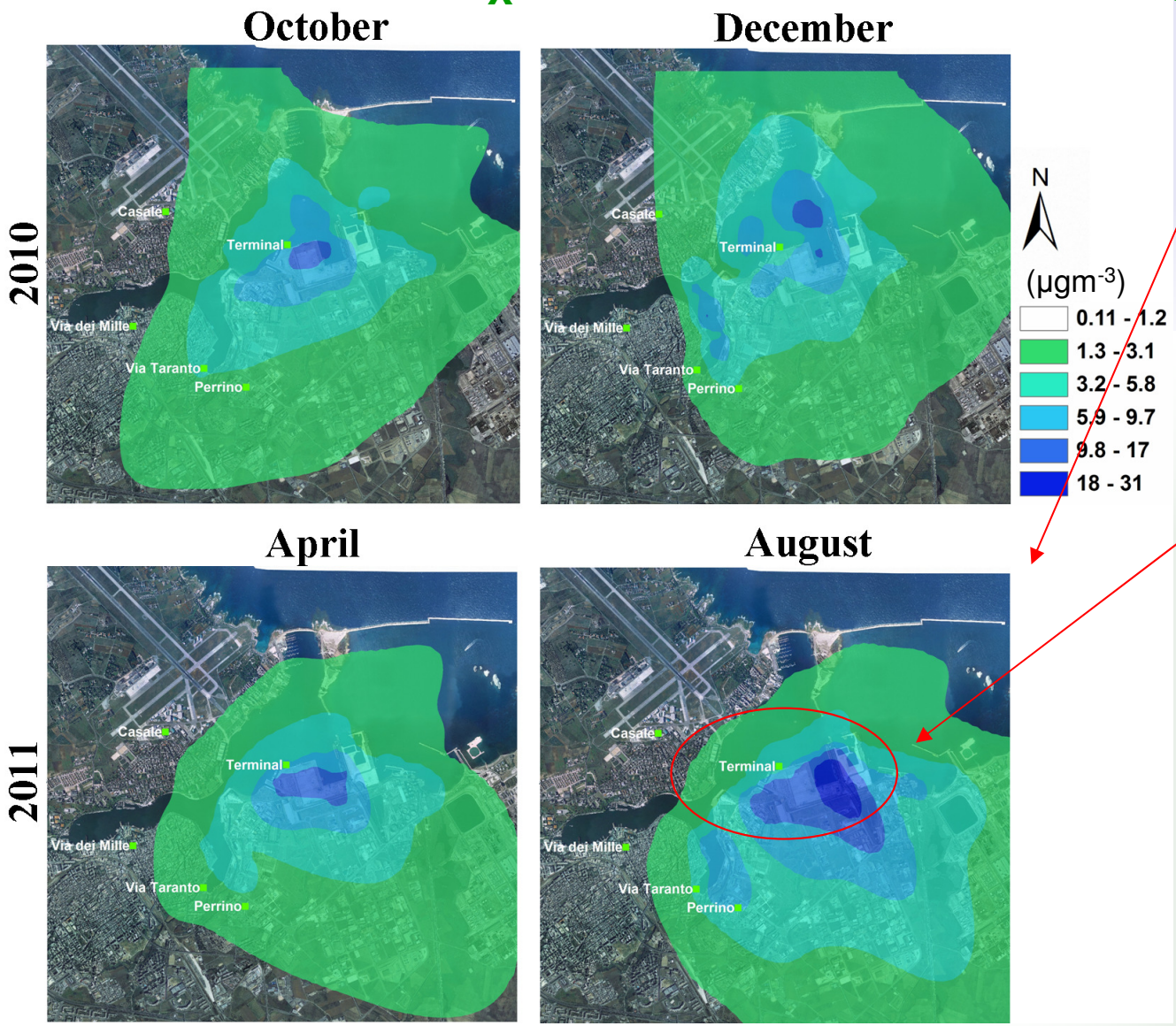
CERC. ADMS Urban USER Guide 2011. Available from Cambridge Environmental Research Consultant, Cambridge, UK. http://www.cerc.co.uk/

ADMS-Urban simulations

concentration output

on a grid of 100 x 100 cells covering an area of 13km x 7km (at an height of 4m)

NO_X mean concentration maps



- similar to the emission rate distribution, **seasonality is found to play a major role**, as summer concentrations are higher compared to the winter ones
- **high pollution spots** (due to shipping emissions) are located in the **hotelling area**

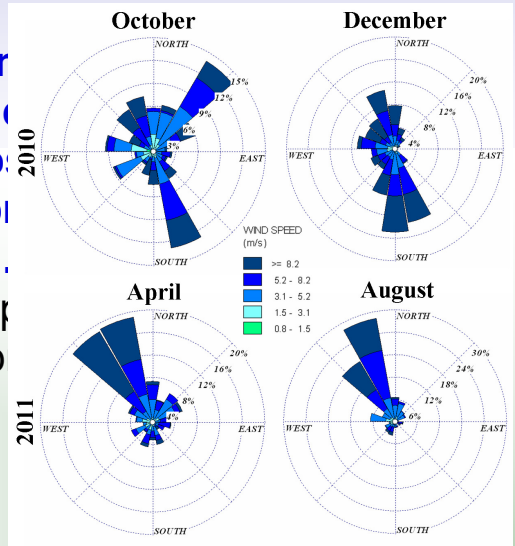
Ship by ship

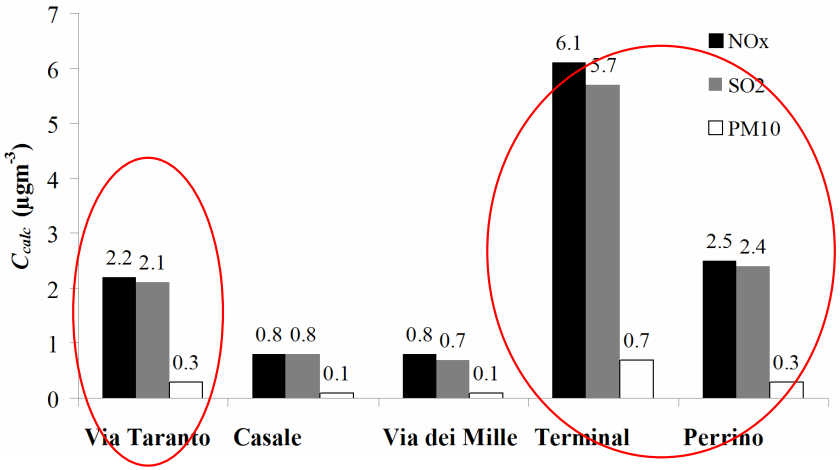
concentration output

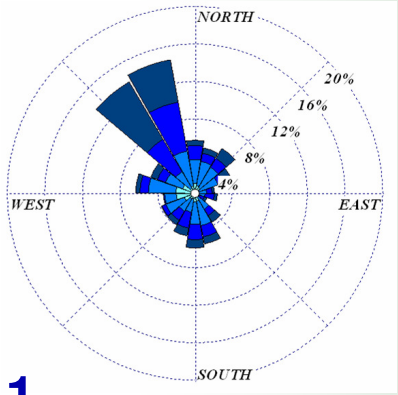
NO_X mean concentration

NO_X (μgm^{-3})	2011							
	April		August		October		December	
	Gr.	SbS	Gr.	SbS	Gr.	SbS	Gr.	SbS
Via Taranto	1.7	2.2	1.9	3.6	4.0	5.9	2.5	3.8
Casale	0.7	0.8	0.4	0.8	0.8	1.2	0.4	0.8
Via dei Mille	0.8	0.9	0.5	0.8	1.0	1.3	1.2	1.1
Terminal	5.5	5.6	3.4	3.9	8.4	6.7	15.0	9.8
Perrino	1.9	2.4	3.6	6.2	2.3	3.1	2.1	2.5

- **higher concentrations in October** (due to larger frequencies of high wind velocity blowing from north-west in August)
- **concer… using th… than tho… Group o… is ≥ 0.91.** Group typ… simulatio…







Group, 2011

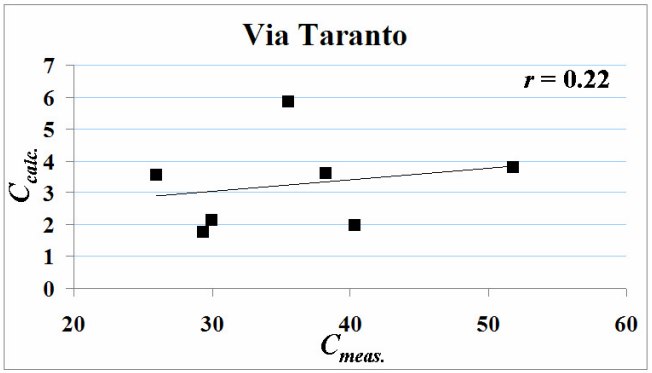
ship-emissions contribution

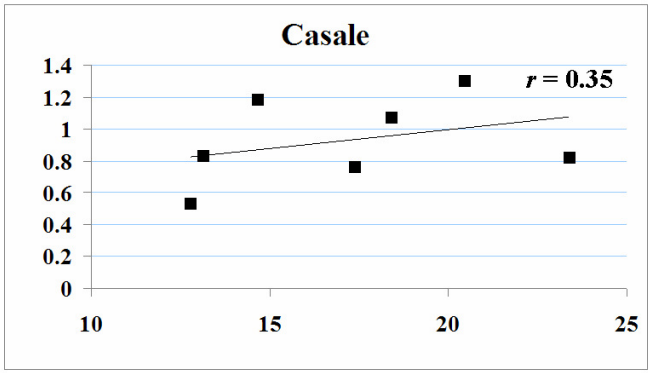
%	2010			2011				
	Aug.	Oct.	Dec.	Apr.	Aug.	Oct.	Dec.	Whole*
NO_X								
Via Taranto	6	10	5	7	14	17	7	**6**
Casale	4	6	6	6	4	8	4	**5**
Via dei Mille	3	2	< 1	3	3	3	2	**2**
Terminal	13	17	8	16	10	20	31	**17**
Perrino	N/A	N/A	N/A	12	29	13	8	**11**
Average	***7***	***9***	***5***	***9***	***12***	***12***	***10***	***8***
PM_{10}								
Via Taranto	1	3	1	1	2	3	2	**1**
Casale	< 1	1	1	1	< 1	1	1	**1**
Via dei Mille	1	1	< 1	< 1	< 1	1	< 1	**< 1**
Terminal	2	5	2	3	2	4	5	**3**
Perrino	N/A	N/A	N/A	1	3	2	2	**1**
Average	***1***	***3***	***1***	***1***	***2***	***2***	***2***	***1***

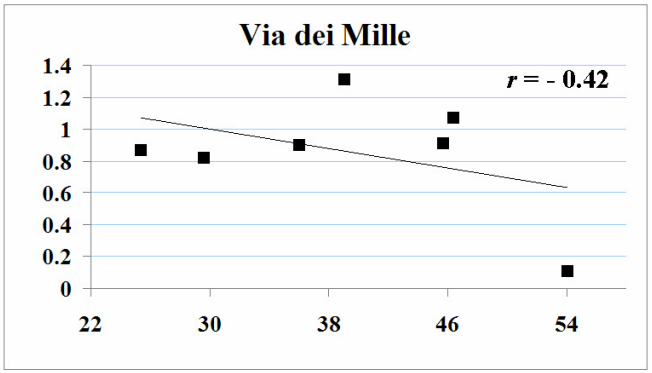
- average contributions of shipping emissions to mean concentrations are in the **range 5-12%**
- larger contributions in the monitoring stations closer or within the port area (Via Taranto, Terminal and Perrino), showing **peaks up to 30%**
- **seasonality is found to play a major role** on average contributions, which were 5-10% in winter and 7-12% in summer

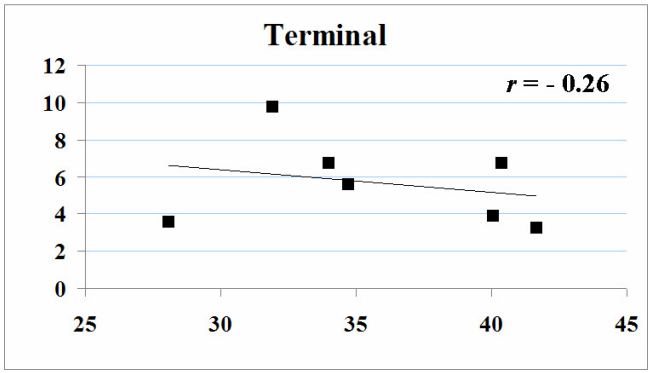
- average contributions are **below 3%,** with peaks of 5% in the port area

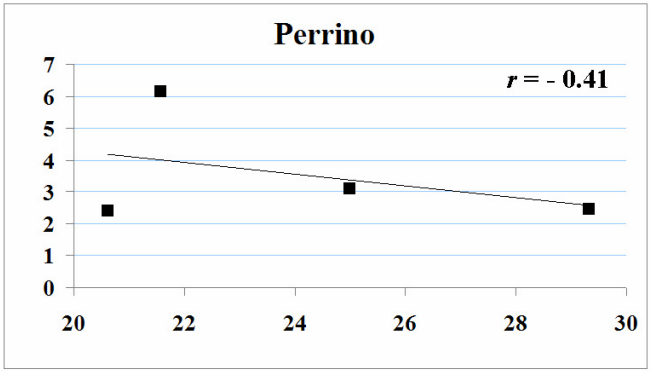
ship-emissions contribution

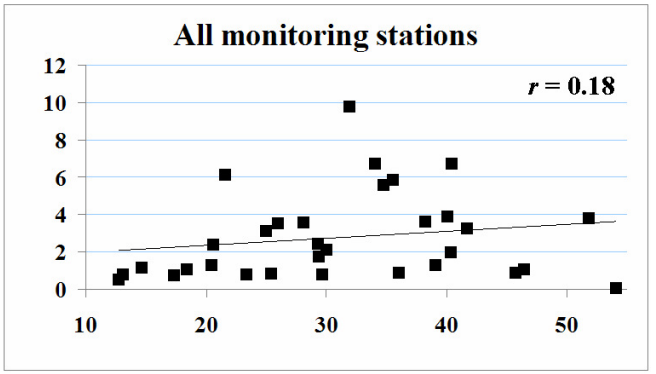












Overall there is no significant correlation, indicating that the increase/decrease of measured values cannot be directly linked to a increase/decrease in maritime traffic emissions during the year.

Ship by ship, all the reference months

conclusions

- **estimation of emission rates on the basis of the knowledge of local maritime traffic volume and some specific parameters of the ships**, such as engine type, time spent in port in the different phases, fuel consumption and gross tonnage

- in line with findings in Italian ports of Ravenna, Venice and Taranto, results for the Brindisi port show that
  - both **shipping pollutant emissions and related concentrations are strictly dependent on seasonality**. Larger average values were found in summer months due to the increase of tourist activities and passenger ship traffic in the port of Brindisi
  - **emissions in the hotelling phase contributed of more than 95% to the total emission rates**

- the statistical analysis suggested that **the increase/decrease of measured values cannot be directly linked to a increase/decrease in maritime traffic emissions during the year**

- at least for Italian ports, **NO_X and SO_2 from shipping sources needs to be carefully accounted for in the assessment of air quality in coastal/port cities**

This work has been developed thanks to the financial support of the European Territorial Cooperation Programme Grece-Italy 2007-2013 CESAPO (Contribution of Emission Sources on the Air quality of the Port-cities in Greece and Italy) project. The authors wish to thank the Cambridge Environmental Research Consultants (CERC Ltd) for making available ADMS-Urban model, the Regional Agency for Environmental Protection ARPA-Puglia for providing concentration data, the Avvisatore Marittimo of Brindisi port for providing traffic maritime data and the Italian Air Force for providing meteorological data.

THANK YOU

FOR

YOUR ATTENTION