Project cofinancé par le Fonds Européen de Développement Régional

Project co-financed by the European Regional Development Fund

Air Quality Status in Venice
Start Up Report
(WP 3.2)

February 2011

APICE Project Startup (WP3)

Area : VENICE

Partnership
Lead Partner: **ARPA Veneto**
Contacts:
Scientific Coordinator: Salvatore Patti
Support to scientific coordination: Francesca Liguori
Expert in aerosol monitoring: Aurelio Latella
Expert in air monitoring and quality assurance for air monitoring: Alessio De Bortoli
Expert in Chemical Transport Models: Silvia Pillon and Elena Elvini
Expert in meteorological models: Alberto Della Fontana
Expert in Emission Inventory: Laura Susanetti and Stefania De Vettori
Expert in Air Quality Assessment and Analysis: Giovanna Marson, Erika Baraldo and Luca Zagolin

Financial Manager: Antonella Spolaore
Support to financial management: Lucia Da Rugna

Partner Name**: Veneto Region–Spatial planning and Parks department**
Project Manager: Tiziana Quaglia
Pierpaolo Campostrini, CORILA Managing director, EU Marine Integrated policy, environmental research issues, stakeholder participation, public administration involvement
Matteo Morgantin, CORILA, data processing
Elena Gissi, IUAV University of Venice, Urban Planning

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Contents

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

1. Capitalization of the existing field data

1.1 Air quality network

1.2.1 Monitoring stations

In the Venetian area air pollution monitoring has been an important issue since the early seventies, given the vicinity between the fragile environmental of the lagoon, the monumental heritage of the historical city and the huge industrial area of Porto Marghera. The first air quality network implemented was in fact a private industrial one (EZI, association of industries in Porto Marghera) mainly devoted at that time to monitor SO_2 concentrations.
The public air network started in the late eighties and moved to ARPAV's management in 1999, when the Environmental Agency settled in the Veneto Region.
Inside the municipality of Venice, that includes the large mainland of Mestre, at the date of 31/12/2009 the ARPAV's air quality network retained 8 fixed monitoring stations and one site for PM2,5 measurements (Fig 1. Monitoring sites in the Venetian area. and Tab 1); at the same date the industrial network presented 13 stations with air pollutants monitors (Fig 1 and Tab 2) and 5 stations with meteorological monitors and a site with a wind profiler and a temperature radio acoustic sounding system (Fig 1 andTab 3).
In the Venetian area there are also some meteorological stations, belonging to the regional meteorological network operated by ARPAV Meteo Centre of Teolo (CMT-ARPAV). For the wind regime description of the study area data of the two nearest stations to Venice - equipped with anemometers at 10 meters above the ground - are used. These stations are: Stat. n. 230, Valle Averto, sited on the inner boundary of the Venetian lagoon, less than 20 km South-West from the historical city and Stat. n. 160 Cavallino, sited about 10 km Est from the historical city in front of the open Adriatic sea on the narrow land which is the outside boundary of the lagoon (Fig 1).

Tab 1. ARPAV's Air Quality Monitors in Venice and its mainland.

Station	Place	Description	Start	End	Type	gaseous pollutants	PMx and micropollutants
Parco Bissuola	Mestre	Mainland Urban Area	1994		UB	SO2, NOx, CO, O3, BTEX	PM10 (G&A), PAH, Elements
F.lli Bandiera	Marghera	Mainland Urban Area	1994		UT	NOx, CO	
Sacca Fisola	Venice	Historical city	1994		UB	SO2, NOx, O3	PM10 (A)
Lago di Garda	Malcontenta	Industrial surroundings	2008		IS	SO2, NOx, CO	PM2.5 (G)
Moranzani	Malcontenta	Industrial surroundings		October 2008	IS	SO2, NOx	PM2.5 (G)
Circonvallazione	Mestre	Mainland Urban Area	1985	June 2009	UT	NOx, CO, BTEX	PM2.5 (A)
Tagliamento	Mestre	Mainland Urban Area	2007		UT	SO2, NOx, CO	PM10 (G), PAH,Elements
Lissa	Mestre	Mainland Urban Area	2004		UB		PM2.5 (G)

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Legend Tab 1			
Pollutants	Measurenment methods	Type of station	
SO2	ultraviolet fluorescence (EN 14212:2005)		Urban Background
NOx	chemiluminescence (EN 14211:2005)		Urban Traffic
CO	non-dispersive infrared spectroscopy (EN 14626:2005)		Industrial Suburban
O3	ultraviolet photometry (EN 14625:2005)		
BTEX	gas chromatography (EN 14662:2005)		
PM2,5	Standard gravimetric (EN 14907:2005)		
PM10	Standard gravimetric (EN 12341:1999) and automatic β-gauge sampler		
IPA	X		
HM	X		

Tab 2. EZI's Air Quality Monitors in Venice and its mainland.

Number	Name	Place	Description	Pollutants
3	Fincantieri-Breda	Porto Marghera	Industrial Area	SO2, NOx, PM10
5	Agip-Raffineria	Porto Marghera		SO2, PM10
8	Enel-Fusina	Porto Marghera		SO2, NOX
10	Enichem ss.1	Porto Marghera		SO2, NOx, PM10
12	Montefibre	Porto Marghera		SO2, PM10
15	CED Ente Zona	Porto Marghera		SO2, NOx, O3, NMHC
16	Sirma	Porto Marghera		SO2
17	Marghera	Marghera	Mainland Urban Area	SO2, NOx, PM10
19	Tronchetto	Venice	Historical city	SO2
20	S. Michele	Venice		SO2
21	Giudecca	Venice		SO2, NOx, PM10
25	Moranzani	Malcontenta	Industrial surroundings	SO2, PM
26	Campagnalupia	Campagnalupia	Rural area	SO2, NOx, O3, NMHC

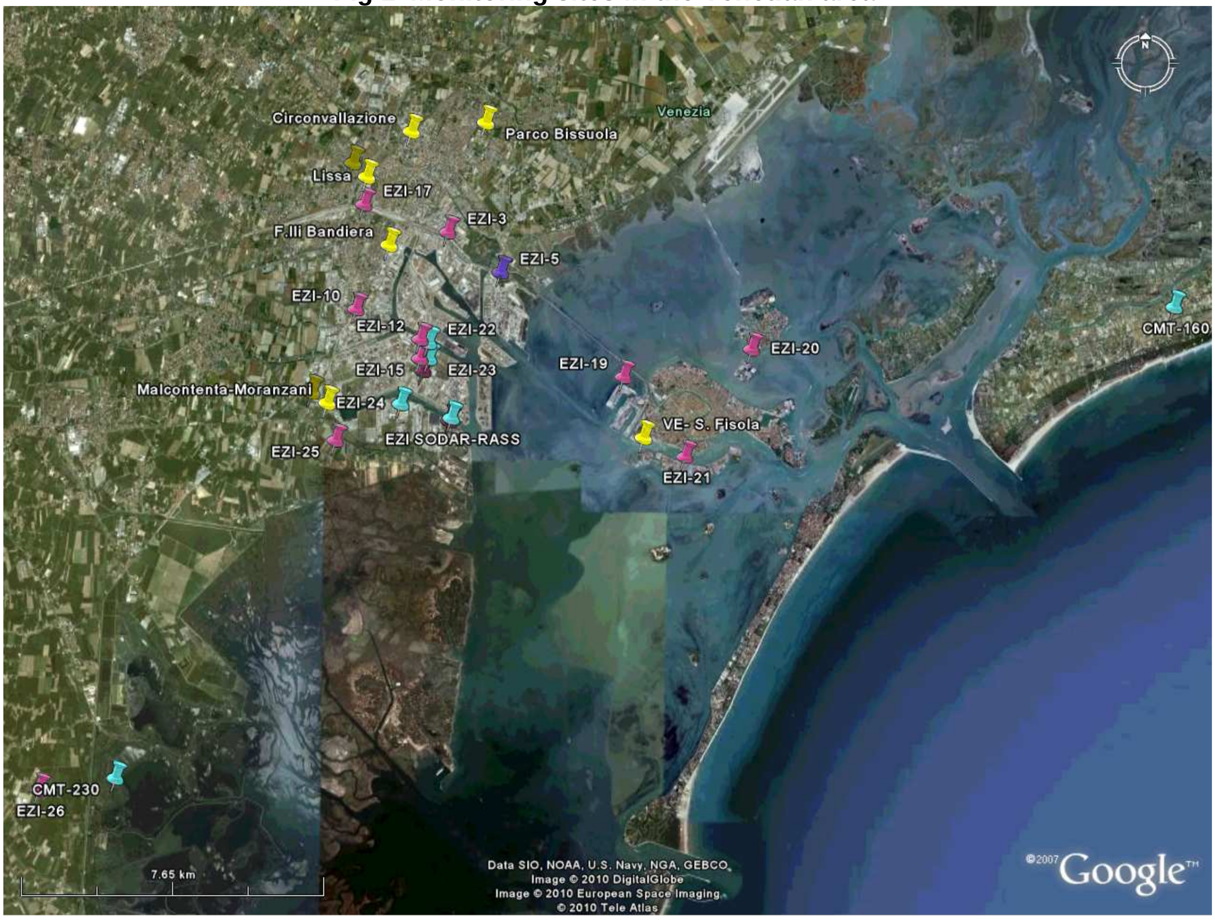
Tab 3 EZI's Meteorological Monitors in Venice and its mainland.

Number	Name	Parameters	Height above ground (m)	Place	Description
5	Agip	T, Ws, WD, P		Porto Marghera	Industrial Area
22	Torre Pompieri	Ws, WD	40	Porto Marghera	Industrial Area
23	CED	T, PREC, P, RAD, RH	6, T: 10-70-140	Porto Marghera	Industrial Area
24	Vesta	Ws, WD	35	Porto Marghera	Industrial Area
	SODAR	Ws, WD	Vertical profile	Porto Marghera	Industrial Area
	DOPPLER	T	Vertical profile	Porto Marghera	Industrial Area

Legend: T: Temperatures; Ws: Wind speed; WD: Wind Direction; P: Pressure; PREC: Precipitation; RAD: Solar Radiation;RH: Relative Humidity.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 1. Monitoring sites in the Venetian area.



Legend:

yellow marker: ARPAV Air Quality stations

fuchsia marker: EZI Air Quality Stations

light blue marker: meteo stations (EZI and ARPAV)

violet marker: EZI Station meteo and Air Quality

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 2. Zoom to the study area.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Both the ARPAV and EZI networks have gone through little changes in the next months of 2010. The ARPAV's network, together with the regional one to which it belongs, is going to a overall process of optimisation with likely some monitors relocations.

Due to the presence of the important industrial area of Porto Marghera (oil refinery, cracking and petrochemical plants, refineries, incinerators, thermal power plants, metal production and processing plants) just at the inner boundary of the lagoon and in the proximity of the historical city of Venice, an Integrated System for Environmental Monitoring and Emergency Management (SIMAGE) has been running since a few years.

One of the component of the SIMAGE is an air quality monitoring network, dedicated to industrial chemical compounds, for prompt survey and evaluation of accidental releases from the chemical plants. As continuous monitoring instruments DOAS (Differential Optical Absorption Spectroscopy), gas chromatographs and PAS photoelectric sensors for PAH are installed in 5 different sites; as remote control sampling devices, to be switch on for the follow up of accidental episodes: canisters, PM10/PM2.5 low volume samplers, PM10/PUF high volumes samplers and bulk deposimeters.

1.2.2 Meteorological description of the study area

Venetian area is characterized by a continental climate, only partially mild by the Adriatic see and the wide Venetian lagoon. As in the whole Po valley winter is harsh and summer is hot, with very high level of humidity in both the seasons.

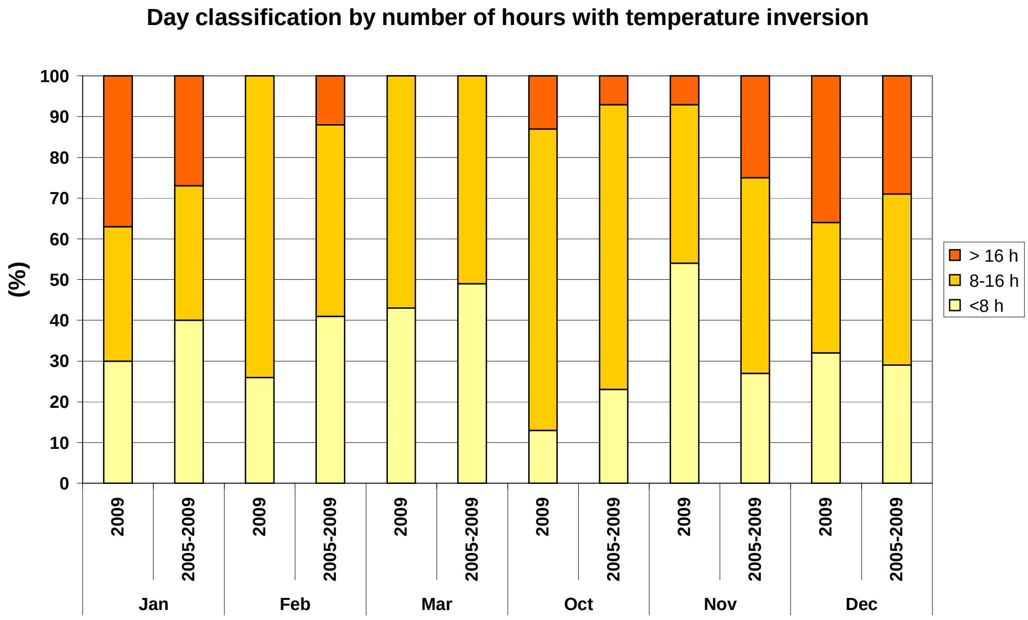
On a European scale the Po Valley can be viewed as an hot spot in relation to air pollution issues, especially PM10 concentrations during the cold season, with frequent occurrences of low wind and high static stability conditions, often accompanied by marked temperature inversions (Ferrario *et alt.* 2010).

In the following graph (Fig 3) cold months are classified by the percentage of days with three different lenght of the temperature inversion. The three classes are days with less than 8 hours of temperature inversion (< 8 h), days with temperature inversion from 8 to 16 hours (8-16 h) and days with temperature inversions holding over 16 hours (> 16h). The classification is applied on cold months of year 2009 as well as of the period 2005-2009. Even if data used for this classification are recorded by the ARPAV-CMT's radiometer situated in the rural area of Padoa, the pattern can be considered typical of the near Venetian study area, too.

During these periods of persistent temperature inversions PM10 daily concentrations often reach and exceed 100 $\mu g/m^3$.

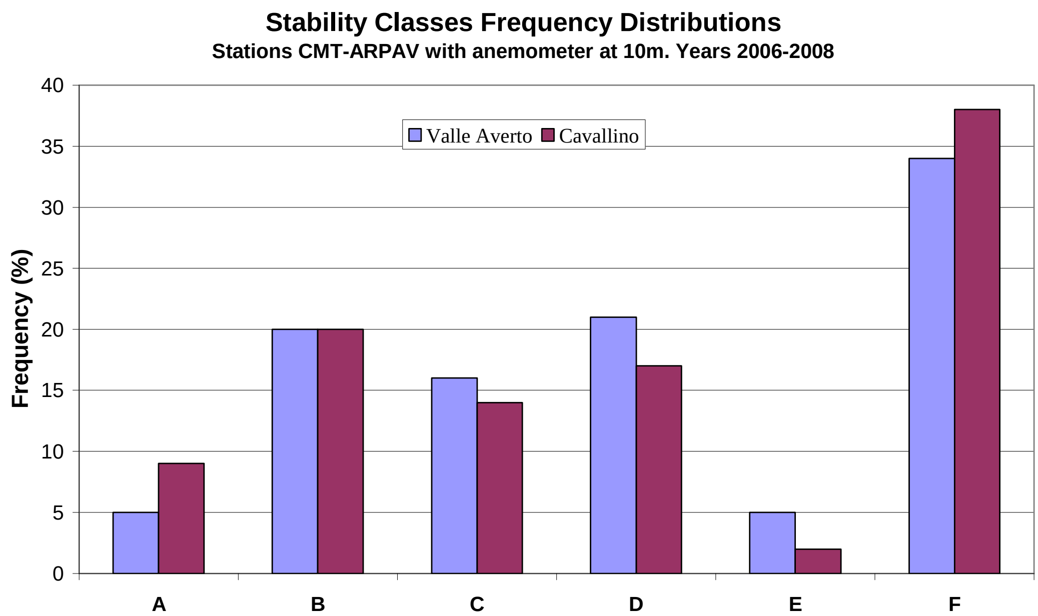
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 3. Classification of the day by number of hours with temperature inversion during cold months (elaboration by ARPAV-CMT)



In Fig 4 frequency distribution of atmospheric stability classes for the two ARPAV meteorological stations near Venice are reported. The classification method is based on surface windspeed, daytime incoming solar radiation and nighttime cloud cover, as reported in Tab 4.
The frequency distributions are similar on the two sites, with a prevalence of the stable class F.

Fig 4. Frequency distribution of stability classes for the 2 meteorological stations near Venice (elaboration by ARPAV-CMT).



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Tab 4. Methodology for stability classes definition.

Daytime									Nighttime		
Solar radiation (W/m^2)							sunset-1h sunrise+1h		Cloud cover (octas)		
Wind speed (m/s)	>750	600<<750	450<<600	300<<450	150<<300	<150		Wind speed (m/s)	0-3	4-7	8
0<<1	A	A	A	B	B	C	D	<1	F	F	D
1<<2	A	A	B	B	B	C	D	<2	F	F	D
2<<3	A	B	B	B	C	C	D	<3	F	E	D
3<<4	B	B	B	B	C	C	D	<4	E	D	D
4<<5	B	B	C	C	C	C	D	<5	E	D	D
5<<6	C	C	C	D	D	D	D	<6	D	D	D
>6	C	C	D	D	D	D	D	>6	D	D	D

In the following figures wind roses for the two mentioned stations of the ARPAV meteorological network are shown.

For both stations ten-years period (1999-2009) records are plotted at first as a whole (Fig. 5 and 6), then stratifying the records by:

- hot and cold six months of a year (from Fig. 7 to 10) ;
- diurnal hours, from 7 am to 7 pm (Fig. 12 and 15);
- morning hours, form 0 am to 6 am (Fig 11 and 14);
- night hours, form 8 pm to 11 pm (Fig. 13 and 16)

The stratified analysis bears out a completely different wind regimes, both in terms of intensity and in terms of directions, for the two sites during hot and cold months of the year as well as during diurnal or nocturnal hours of the day.
The phenomenon, typical of a coastal site, has obviously important implications for the source apportionment studies that APICE is going to apply on the Venetian area.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 5. Ten-years wind roses at Stat. n. 230 Valle Averto

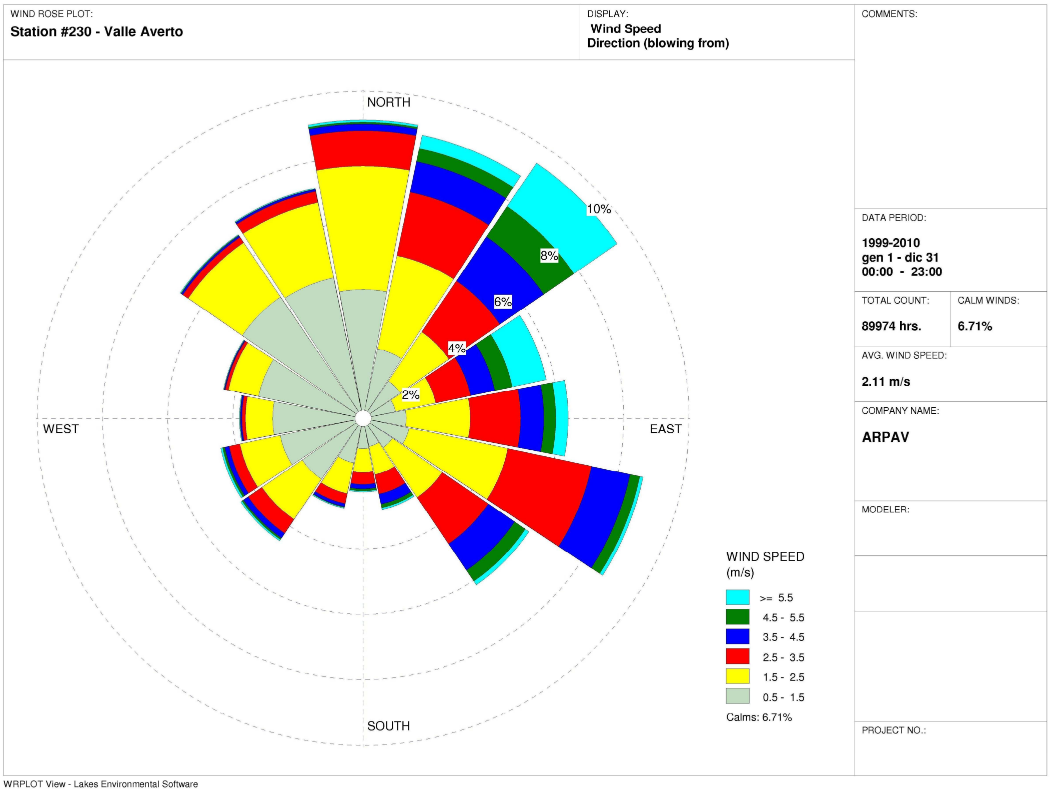
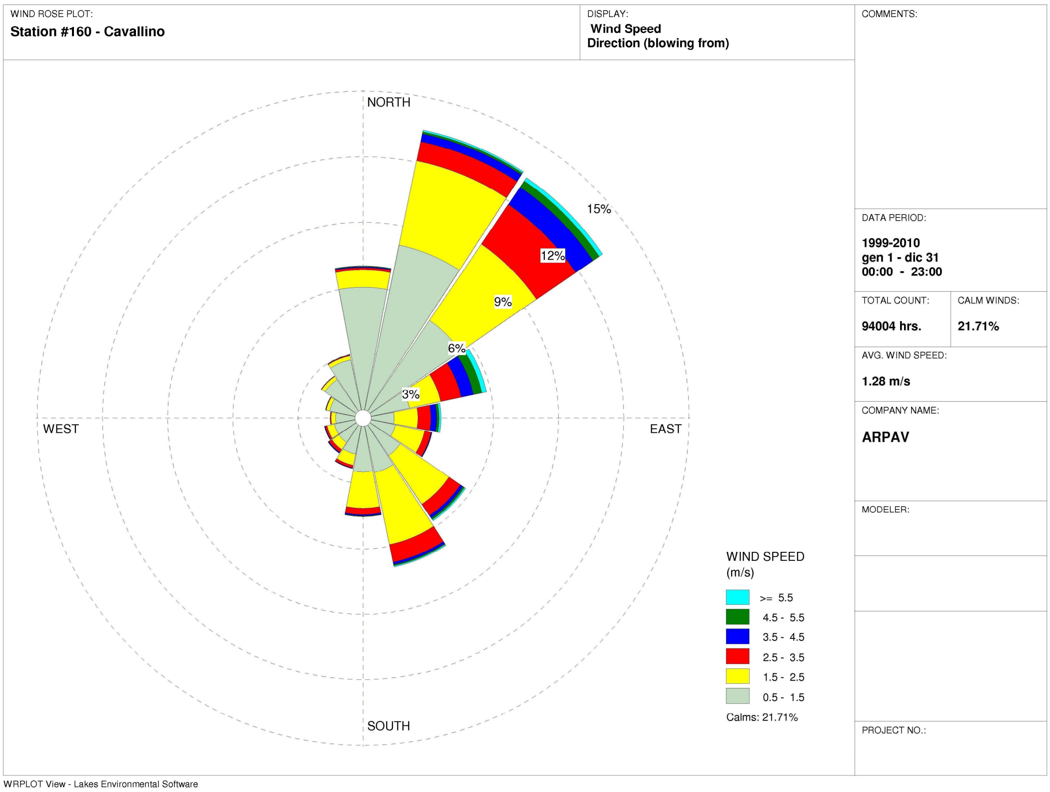


Fig 6. Ten-years wind roses at Stat. n. 160 Cavallino



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 7. Stat. n. 230 Valle Averto. Hot half-year wind rose on ten-years period data.

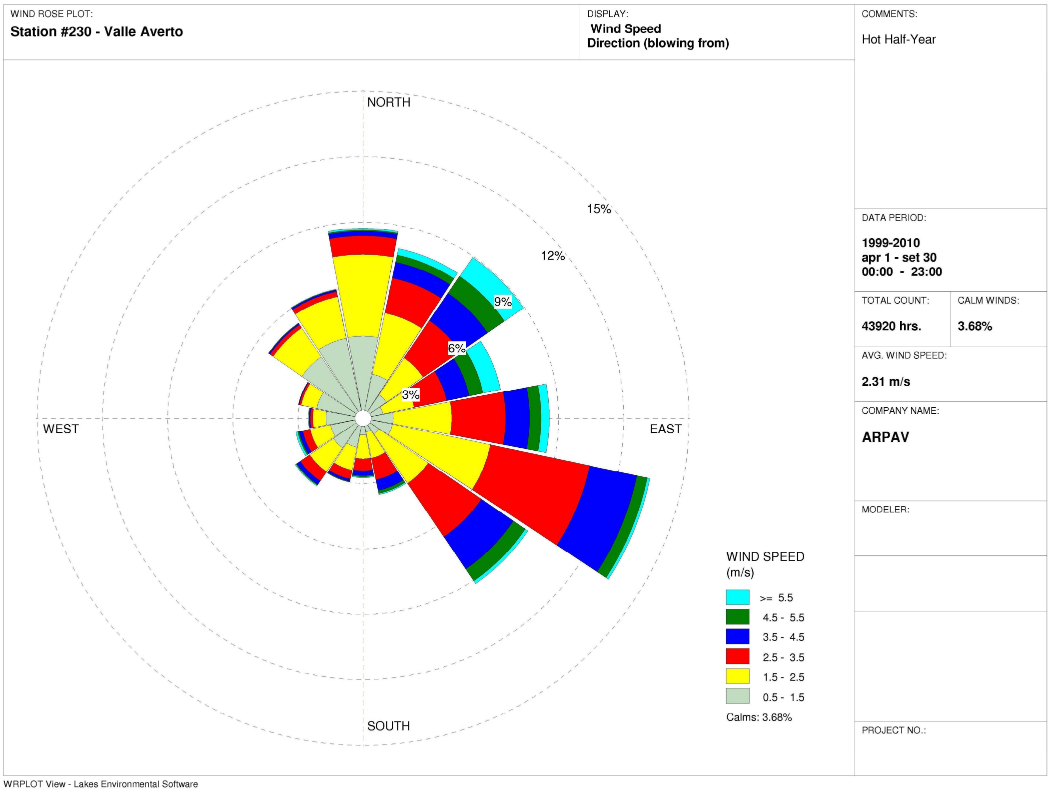
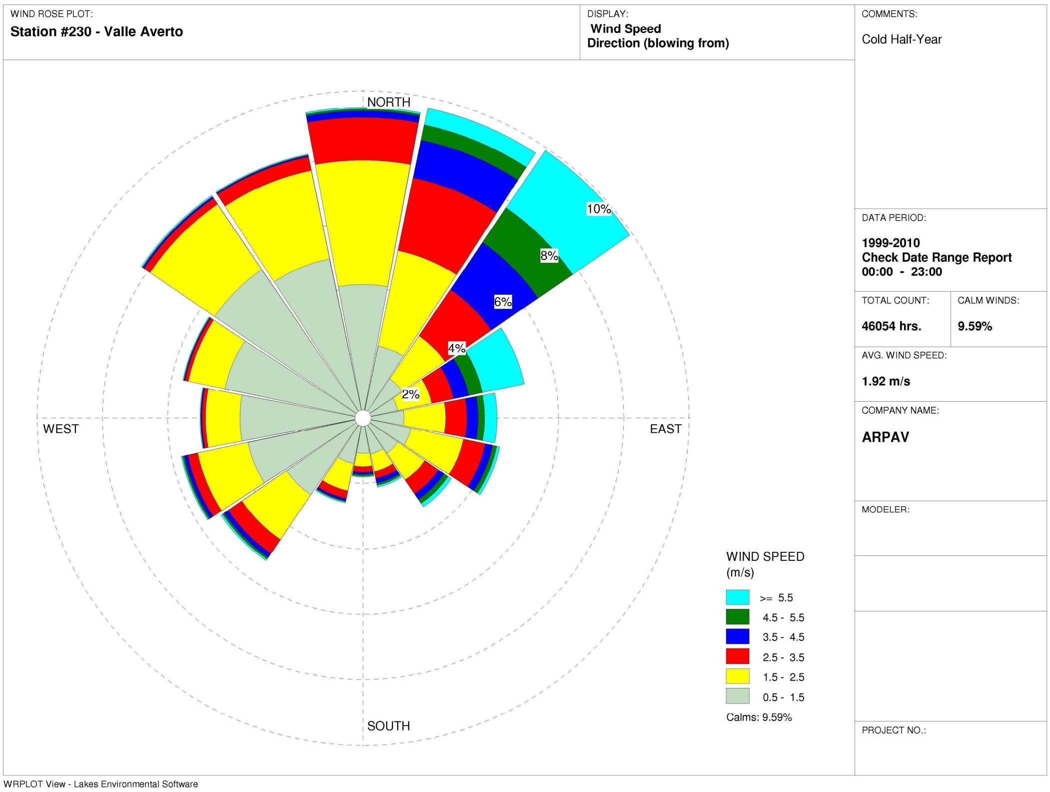


Fig 8. Stat. n. 230 Valle Averto. Cold half-year wind rose on ten-years period data



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 9. Stat. n. 160 Cavallino. Hot half-year wind rose on ten-years period data.

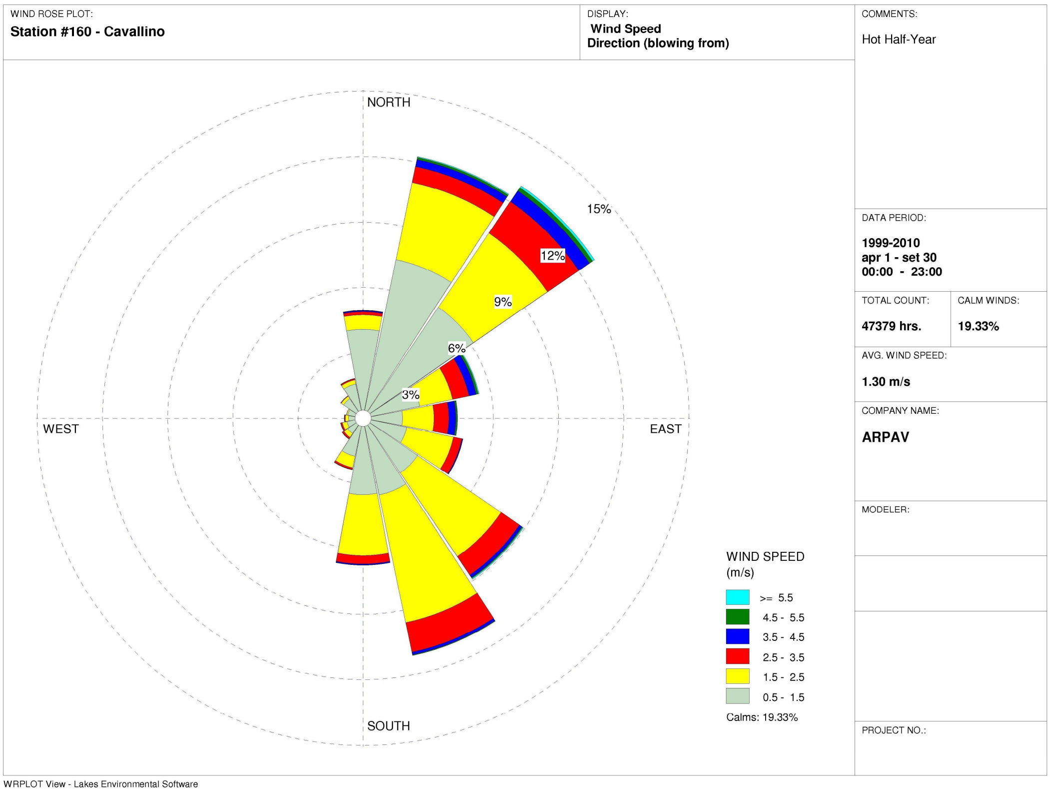
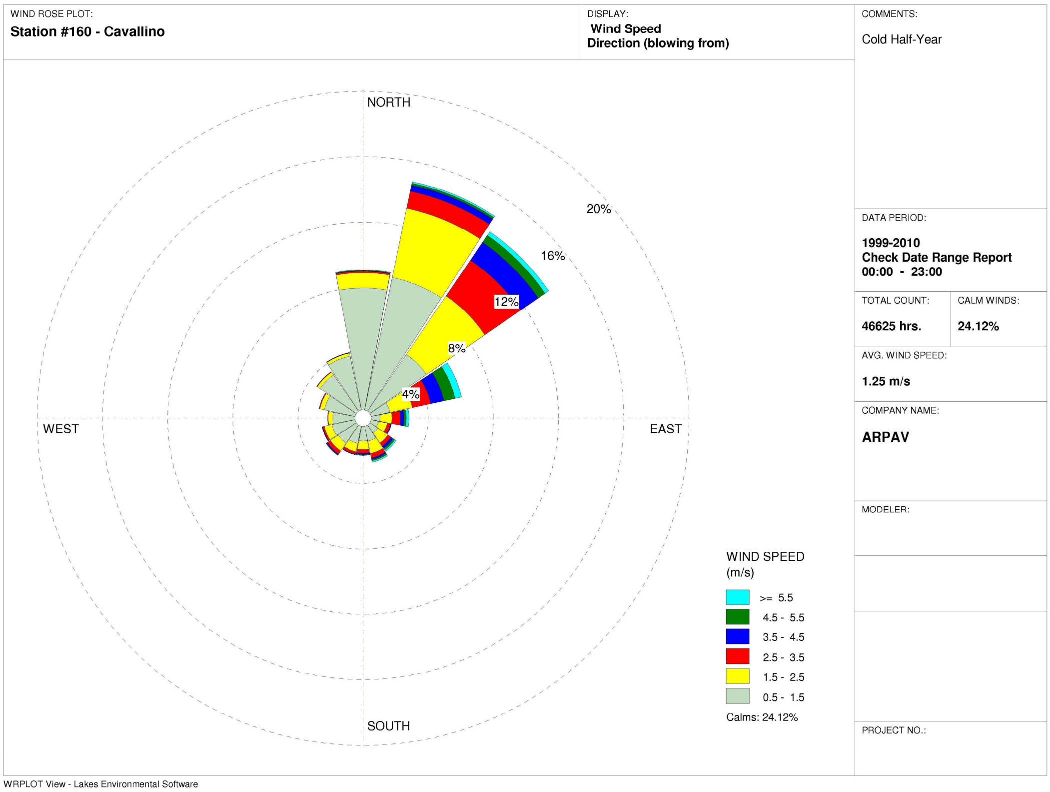


Fig 10. Stat. n. 160 Cavallino. Cold half-year wind rose on ten-years period data



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 11. Stat. n. 230 Valle Averto. Ten-years period wind rose on records between 0 am to 6 am.

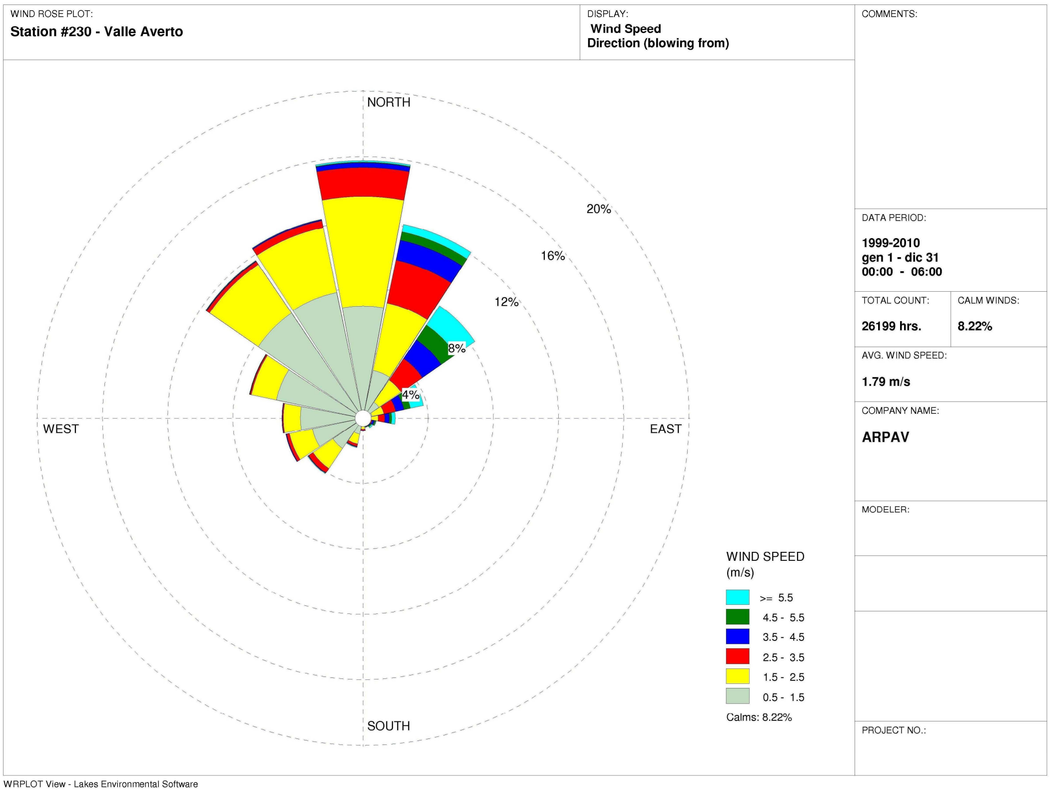
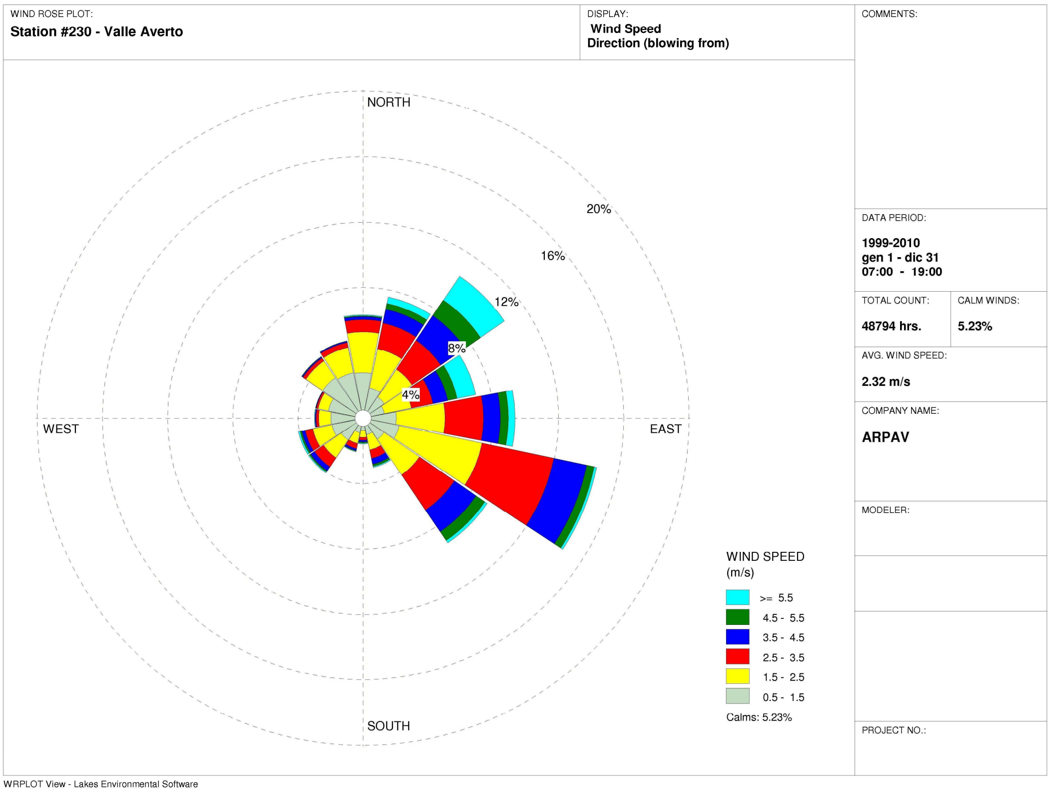


Fig 12. Stat. n. 230 Valle Averto. Ten-years period wind rose on records between 7 am to 7 pm.



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 13. Stat. n. 230 Valle Averto Ten-years period wind rose on records between 8 pm to 11 pm.

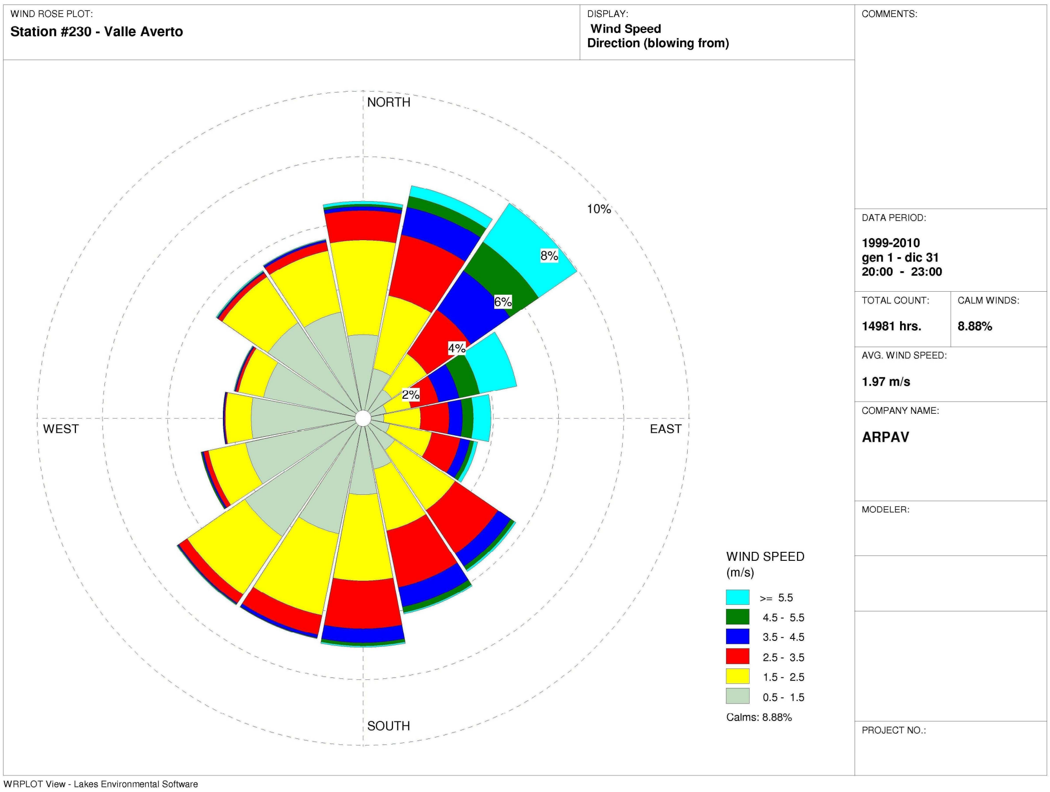
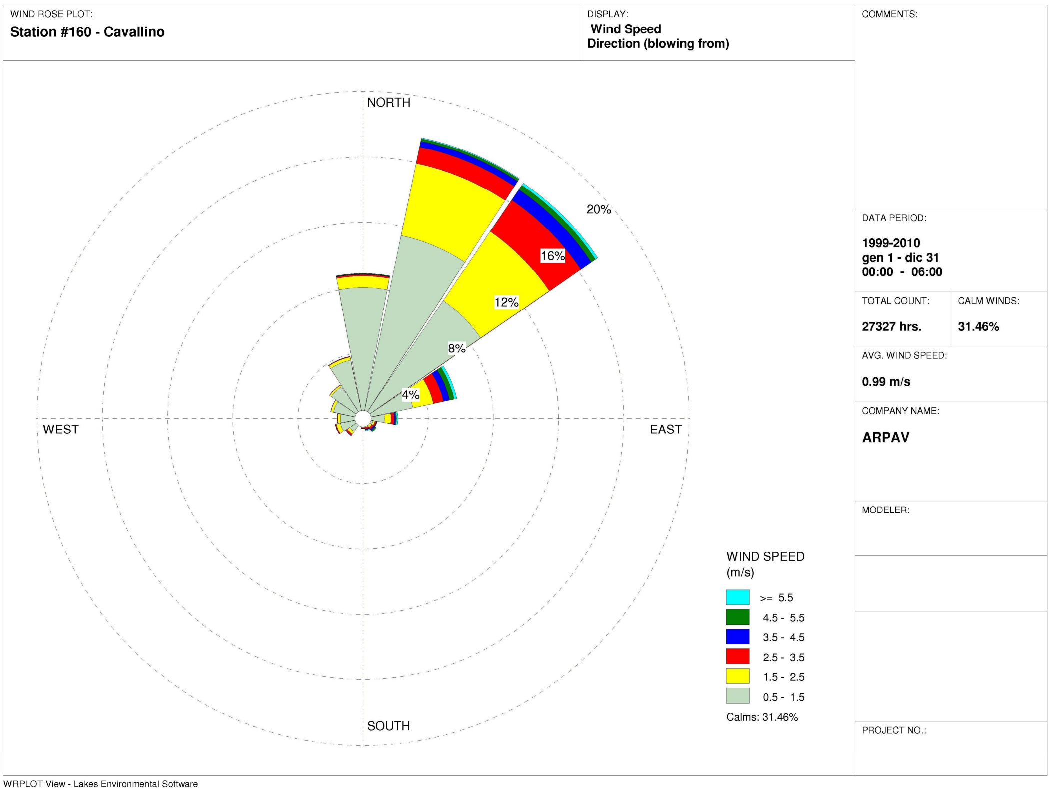


Fig 14. Sat. n. 160 Cavallino. Ten-years period wind rose on records between 0 am to 6 am



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 15. Sat. n. 160 Cavallino. Ten-years period wind rose on records between 7 am to 7 pm

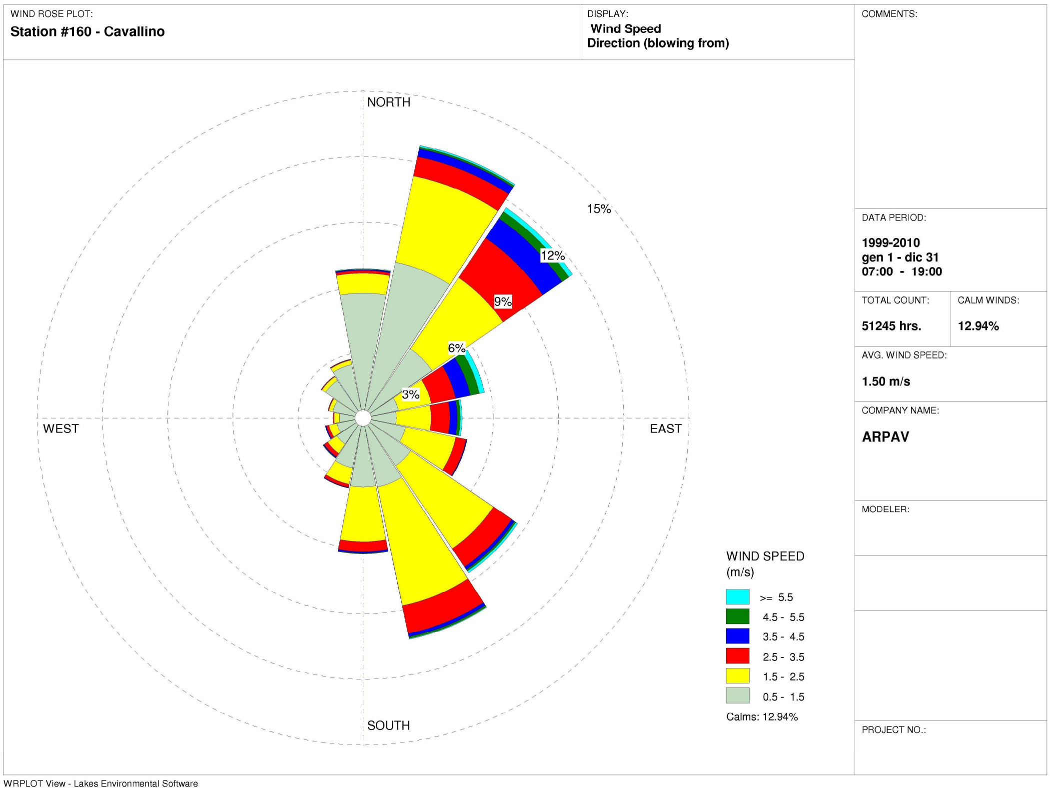
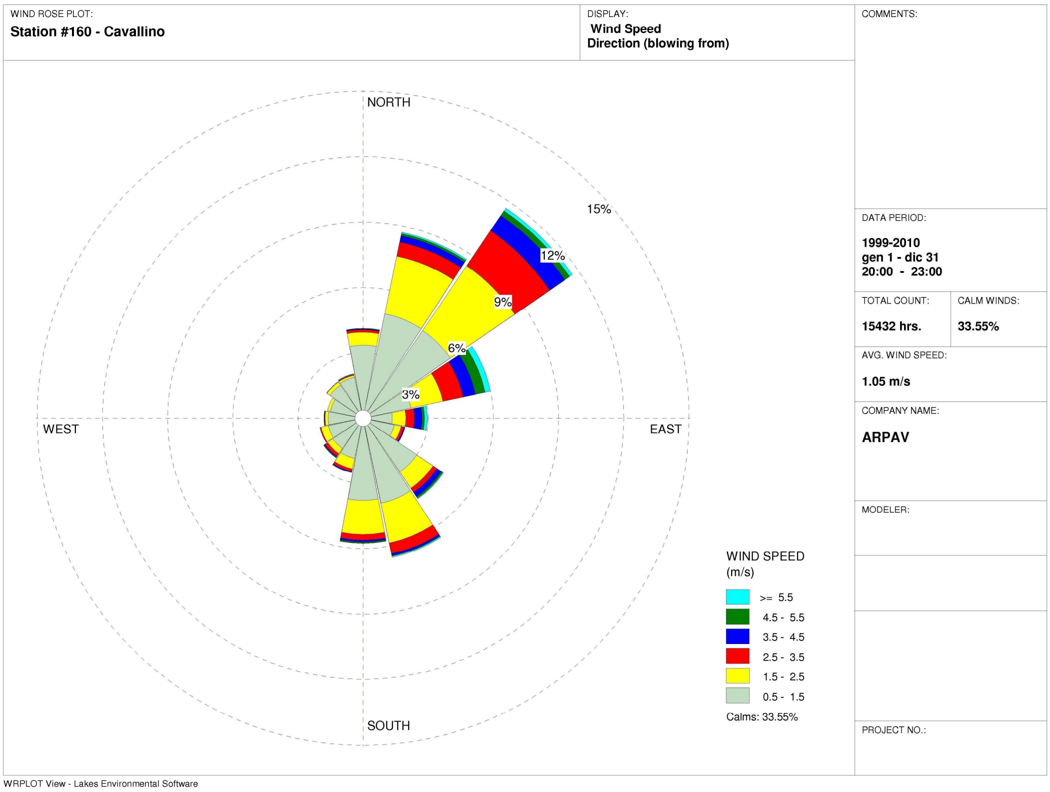


Fig 16. Sat. n. 160 Cavallino. Ten-years period wind rose on records between 7 pm to 11 pm.



In the following figures air temperature and precipitations, recorded at stations of the EZI industrial network, are reported. Meteorological parameters are reported as historical trends of annual data

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 19(Fig 17 and Fig 19) and as monthly data of year 2009 compared to correspondent multi-annual data (Fig 18 and Fig 20).

Fig 17. Annual mean air temperatures at Stat. EZI n. 23. Period 1973-2009 (elaboration by EZI).

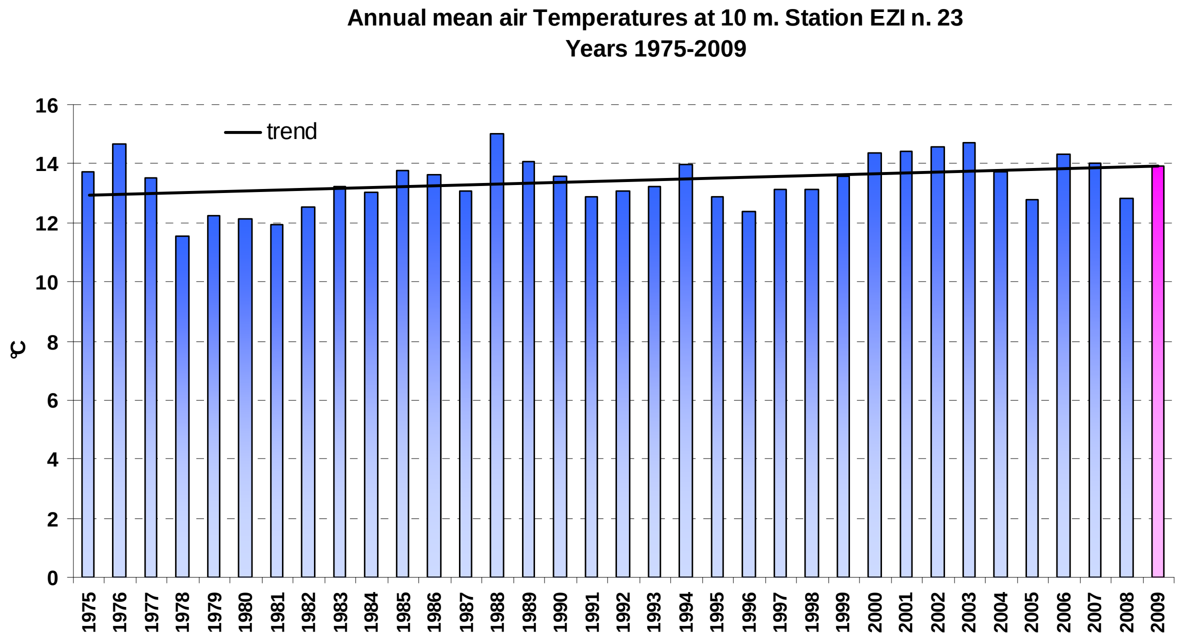
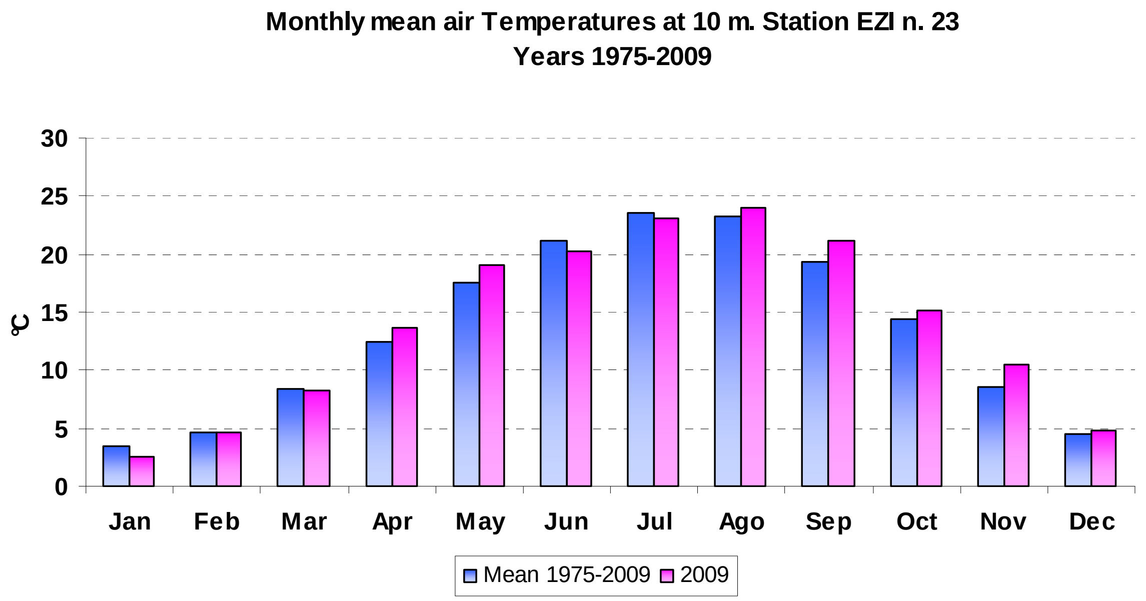


Fig 18. Monthly mean air temperatures at Stat. EZI n. 23. Comparison between 2009 averages and 1975-2009 averages.



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 19.Total annual precipitation at Stat. EZI n. 23. Period 1973-2009 (elaboration by EZI).

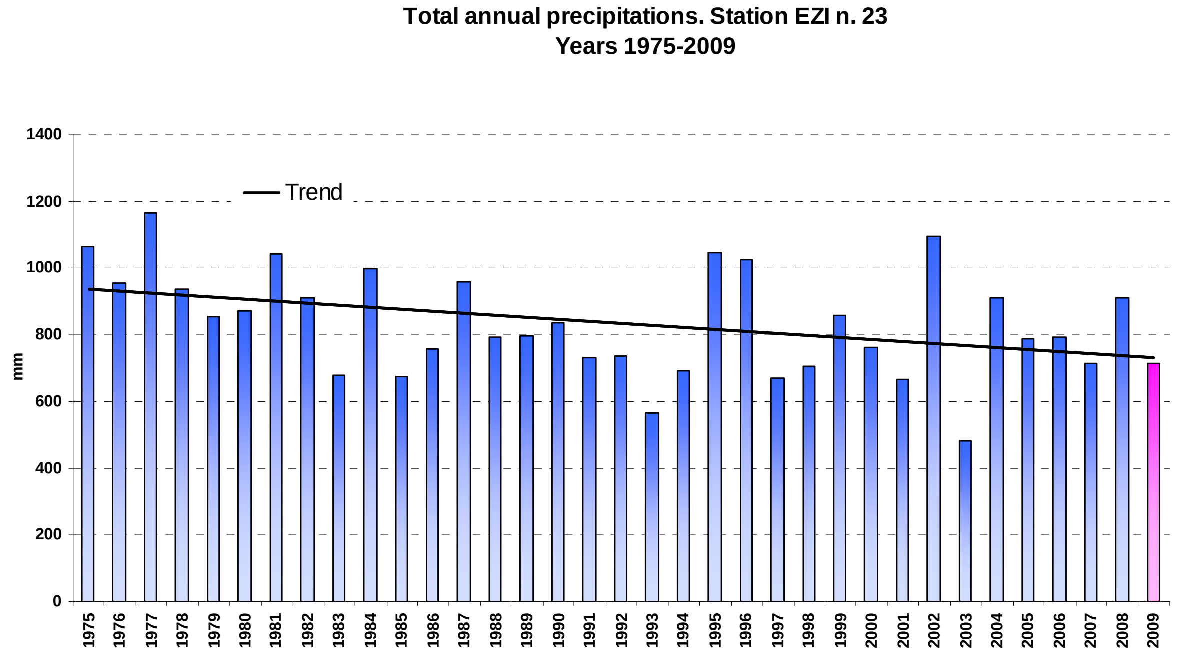
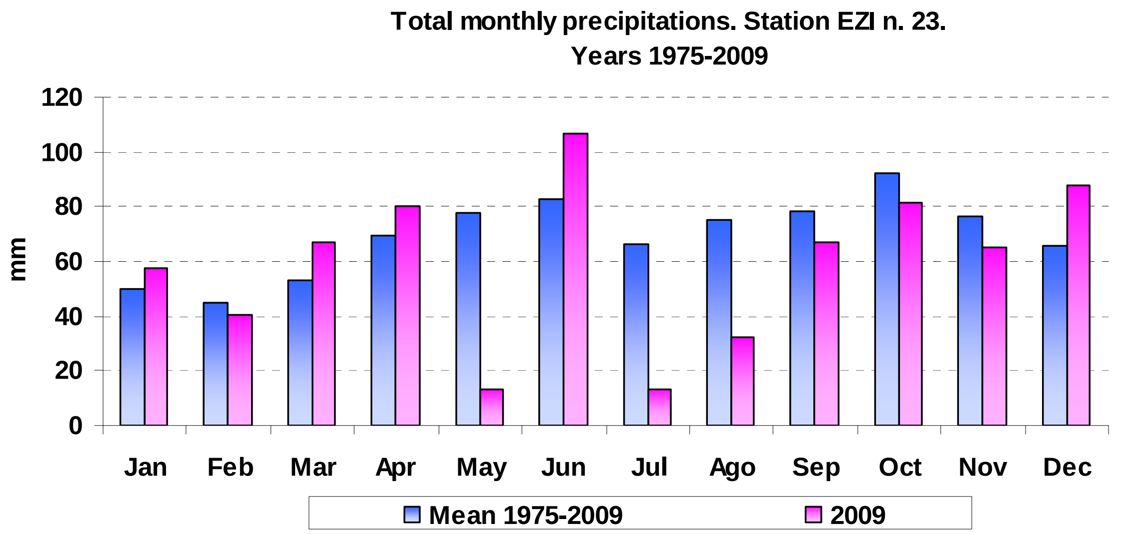


Fig 20.Total monthly precipitations at Stat. EZI n. 23. Period 1973-2009 (elaboration by EZI).



1.2.3 Overview of temporal trends and seasonal variability for pollutant concentrations

Pollutants data analysis has been performed following two mainly objectives: to describe air pollutant concentrations variability among seasons, along hours of the day and along multi-year periods and to bear out variability inside the study area due to different levels of exposure to different emission sources.

Sulphur dioxide

Data analysis for SO_2 concentrations has been performed on the following db:
As concerns ARPAV stations, hourly concentrations for:

- 3 years period (2007-2009) for the urban background stations of Parco Bissuola and Sacca Fisola (the first station situated in the mainland part of the city of Venice and the second

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

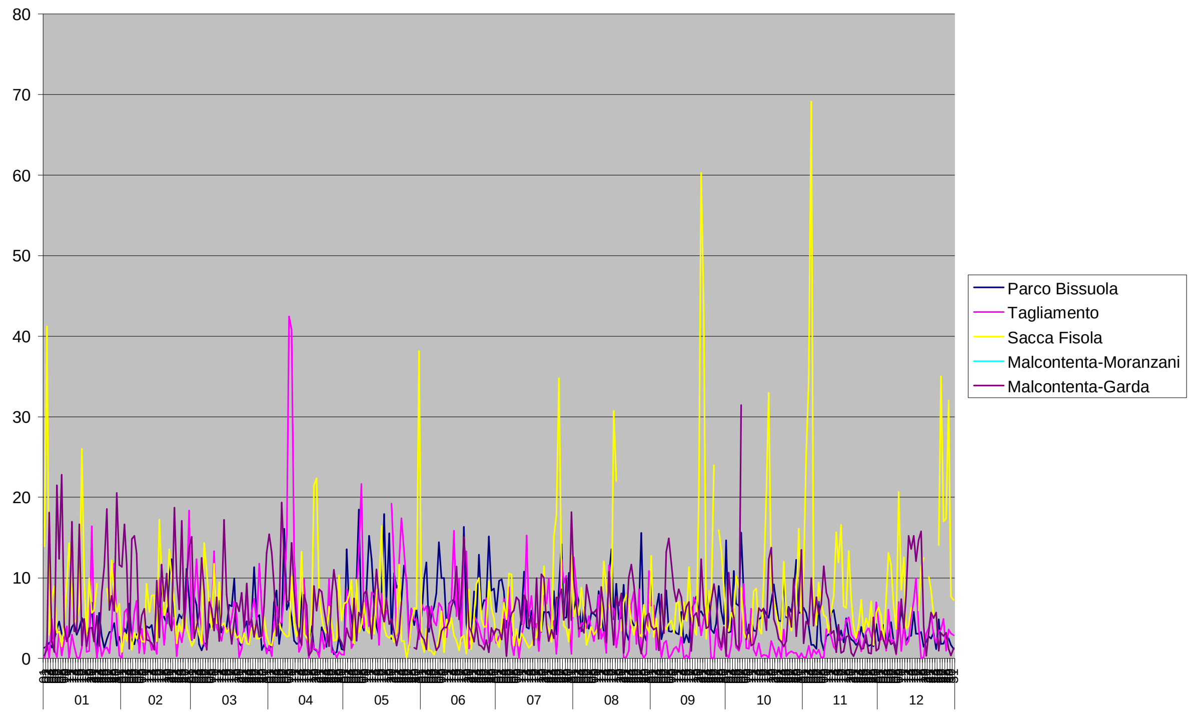
one in the historical city just in front of Giudecca's Channel and the terminal for cruise-liners, ferries and yachts);

- 2 years period for the industrial suburban Malcontenta-Moranzani station (2007-2008) and the urban traffic Tagliamento station (2008-2009).
- 1 year (2009) for the industrial suburban Malcontenta-Garda station.

As concerns the 13 industrial EZI stations, daily concentrations for year 2009.

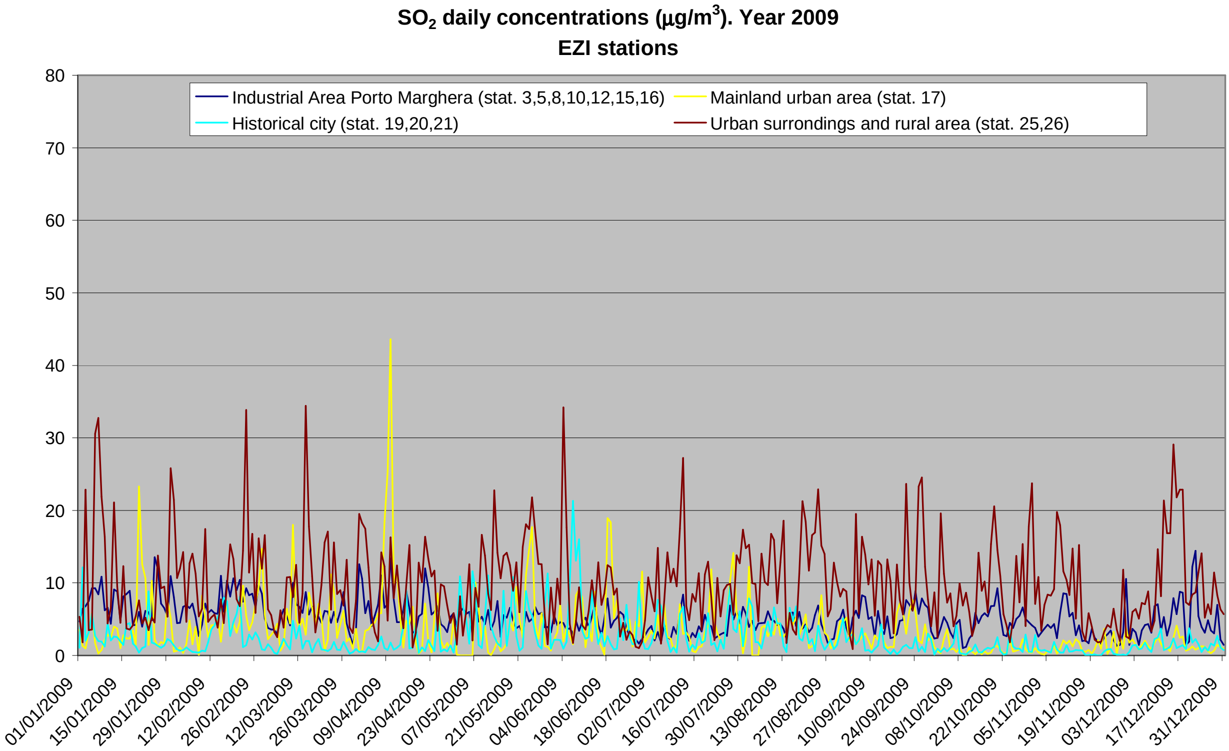
In Fig 21 and Fig 22 SO_2 daily mean concentrations during year 2009 are shown for ARPAV stations and EZI stations respectively. Data for the 13 EZI stations are aggregated according to their position (Industrial Area of Porto Marghera, Mainland urban area, Historical city, Urban surroundings and rural area) and average concentrations for the four groups are reported.

Fig 21. SO2 daily mean concentrations (µg/m3). Year 2009.
ARPAV Air Quality Stations.



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

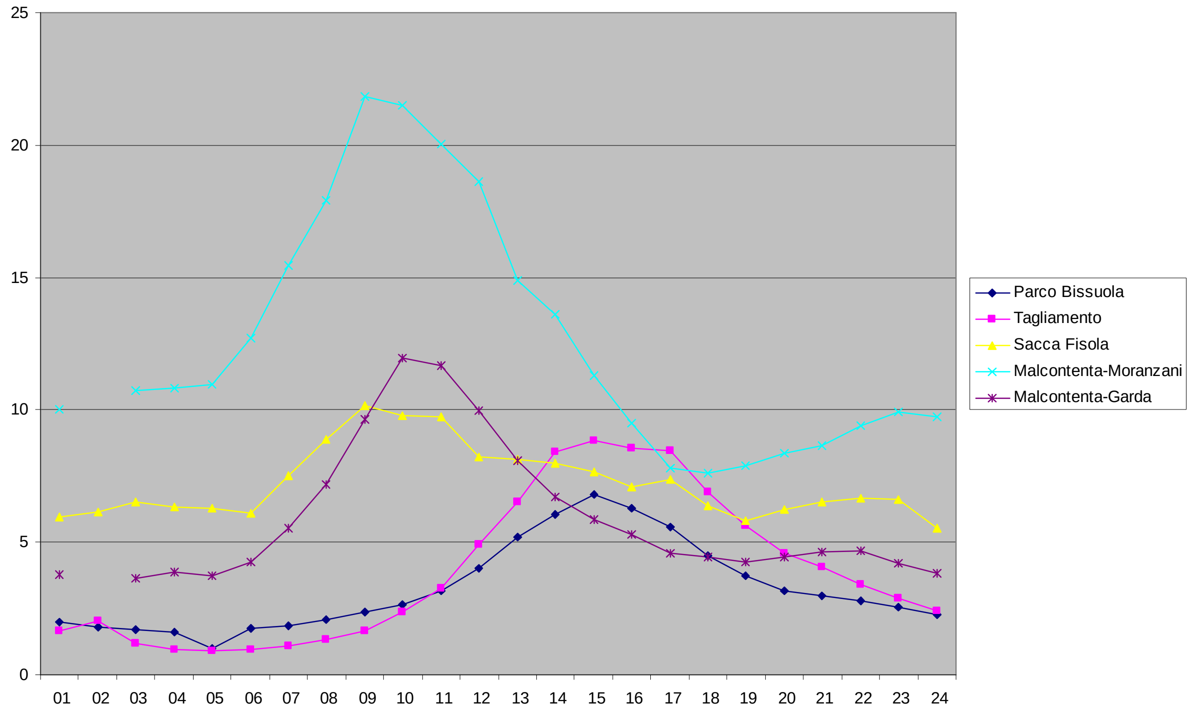
Fig 22. SO_2 daily mean concentrations (μg/m^3). Year 2009.
EZI Stations (data provided by EZI).



Even if the highest daily concentrations reported in the two graphs are those of Sacca Fisola, the absolute maximum (70 μg/m^3) is recorded at Stat. n. 8 Enel Fusina, close to the coal thermal power plant and the urban waste incinerator.
High concentrations in Sacca Fisola are interesting for their possible relation with the transit of the ships along the Giudecca's Channel as well the parking phase of the big cruise-vessels in the maritime harbor of Santa Marta. This hypothesis is going to be confirmed or reject by APICE apportionment studies.
It is also important to understand the relatively high concentrations (especially hourly values) recorded at the background station of Parco Bissuola. As the peaks are more frequent in summer time and spring time, they can't be addressed to domestic heating (moreover because in Venice, according to the special legislation for the safety of the monumental heritage, almost the whole city is feed by methane).
Hourly concentrations display different behavior in the different ARPAV stations, as can be observed on the following graph (Fig 23) of multi-annual averages stratified by hours of the day.

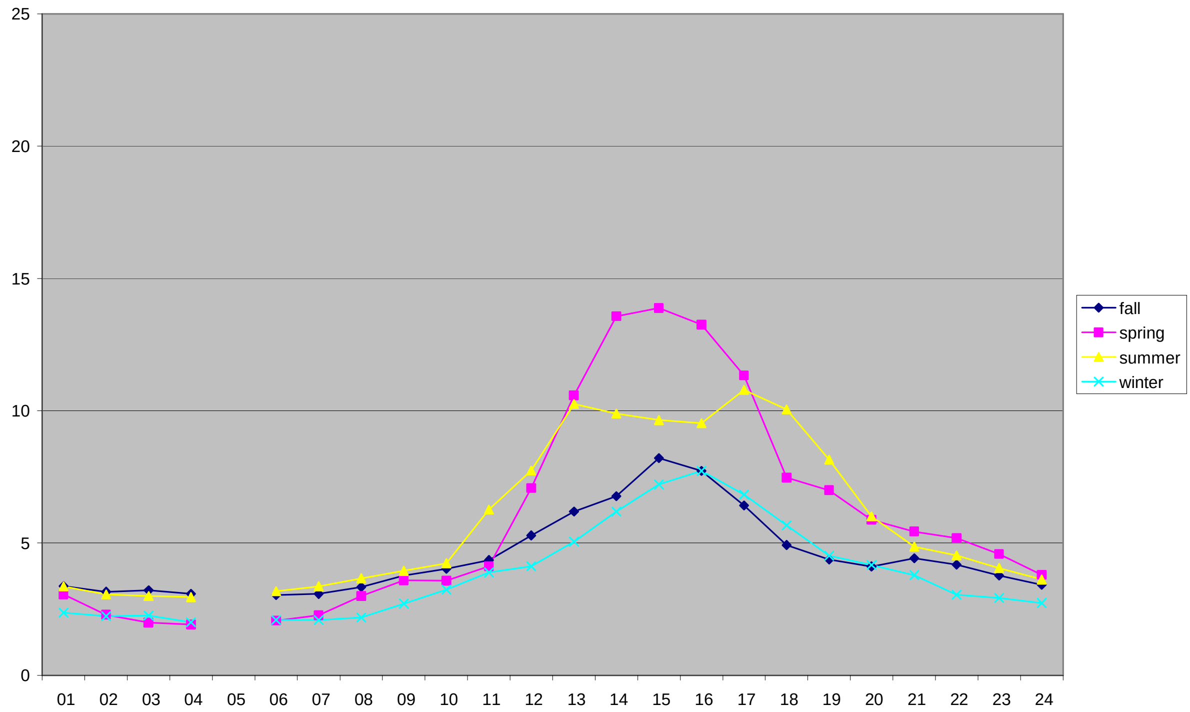
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 23. SO_2 concentrations (µg/m^3) for years 2007-2009, stratified by hours of the day. ARPAV Stations.



On the following graphs (from Fig 24 to Fig 26) data analysis is focus on year 2009 and the mean concentrations are stratified by hours of the day as well seasons.

Fig 24. SO2 concentrations (µg/m3), stratified by hours of the day and seasons. Parco Bissuola Year 2009.



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 25. SO_2 concentrations (µg/m^3), stratified by hours of the day and seasons. Sacca Fisola Year 2009

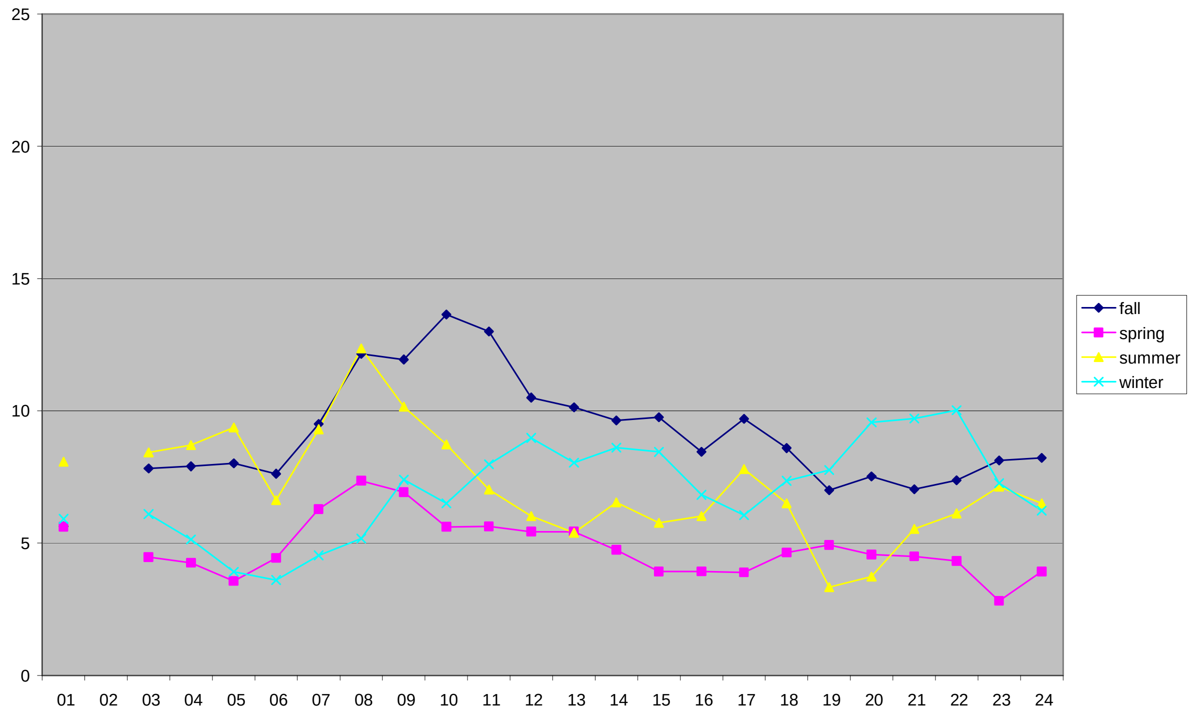
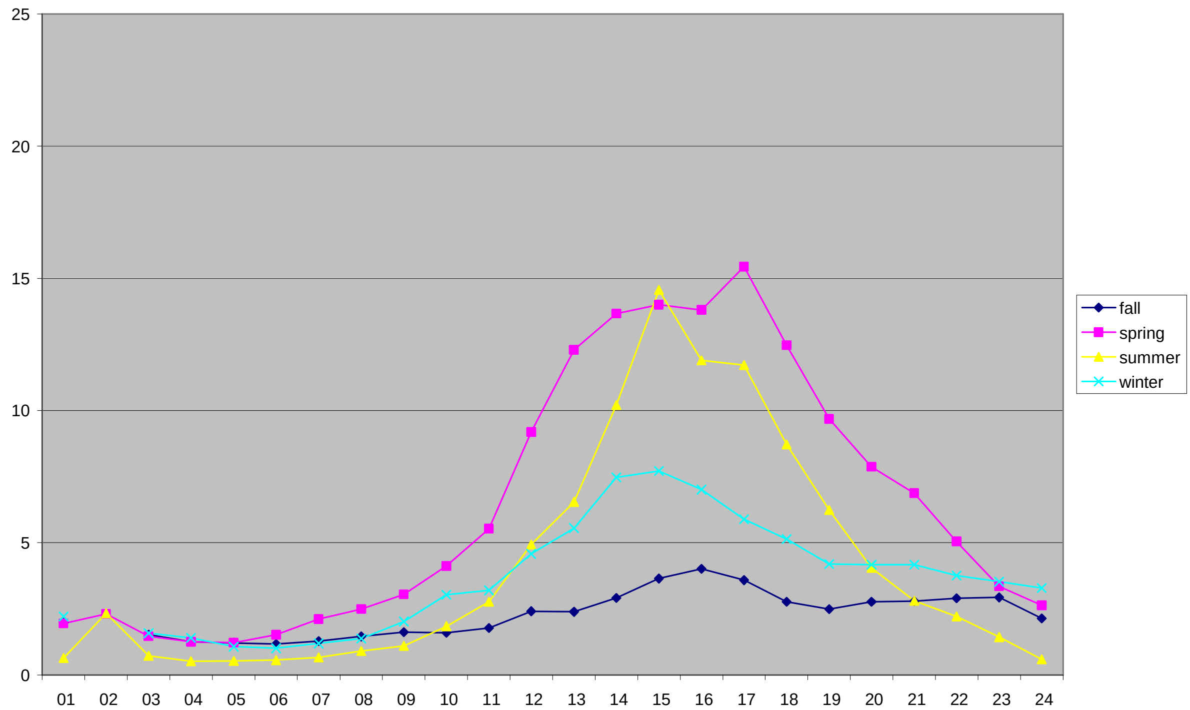


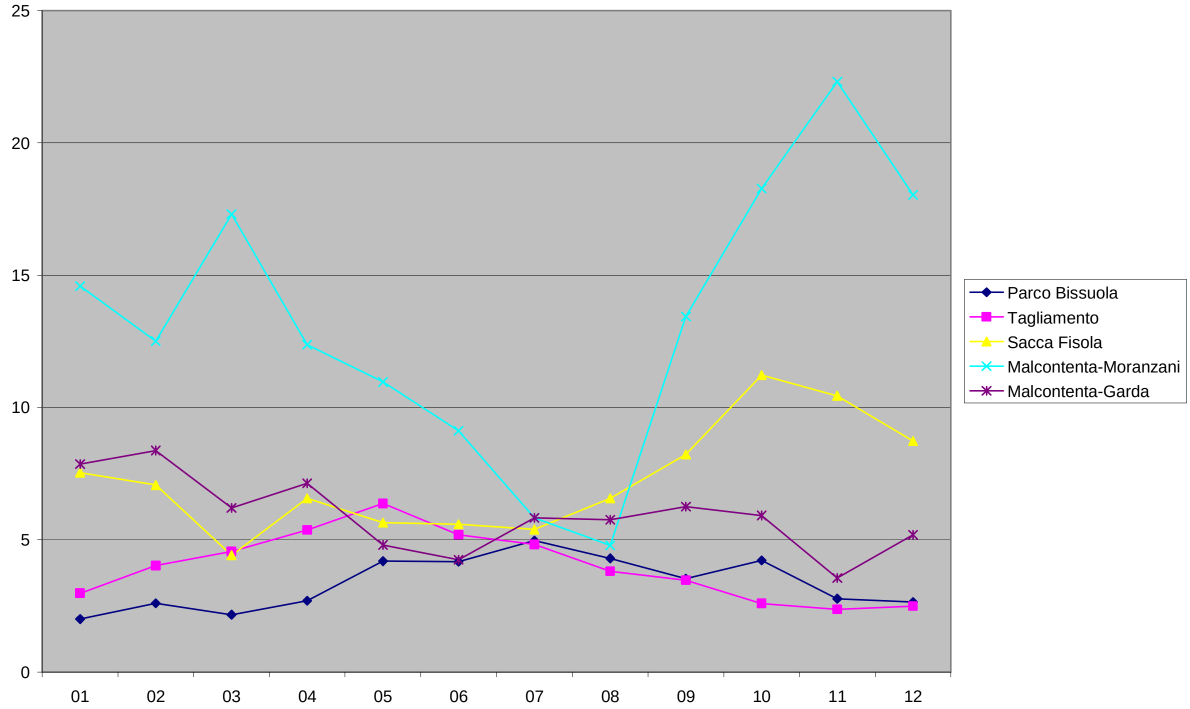
Fig 26. SO_2 concentrations (µg/m^3), stratified by hours of the day and seasons Tagliamento Year 2009.



In Fig 27, SO_2 concentrations for the period 2007-2009 at the different ARPAV stations are stratified by months of the year.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

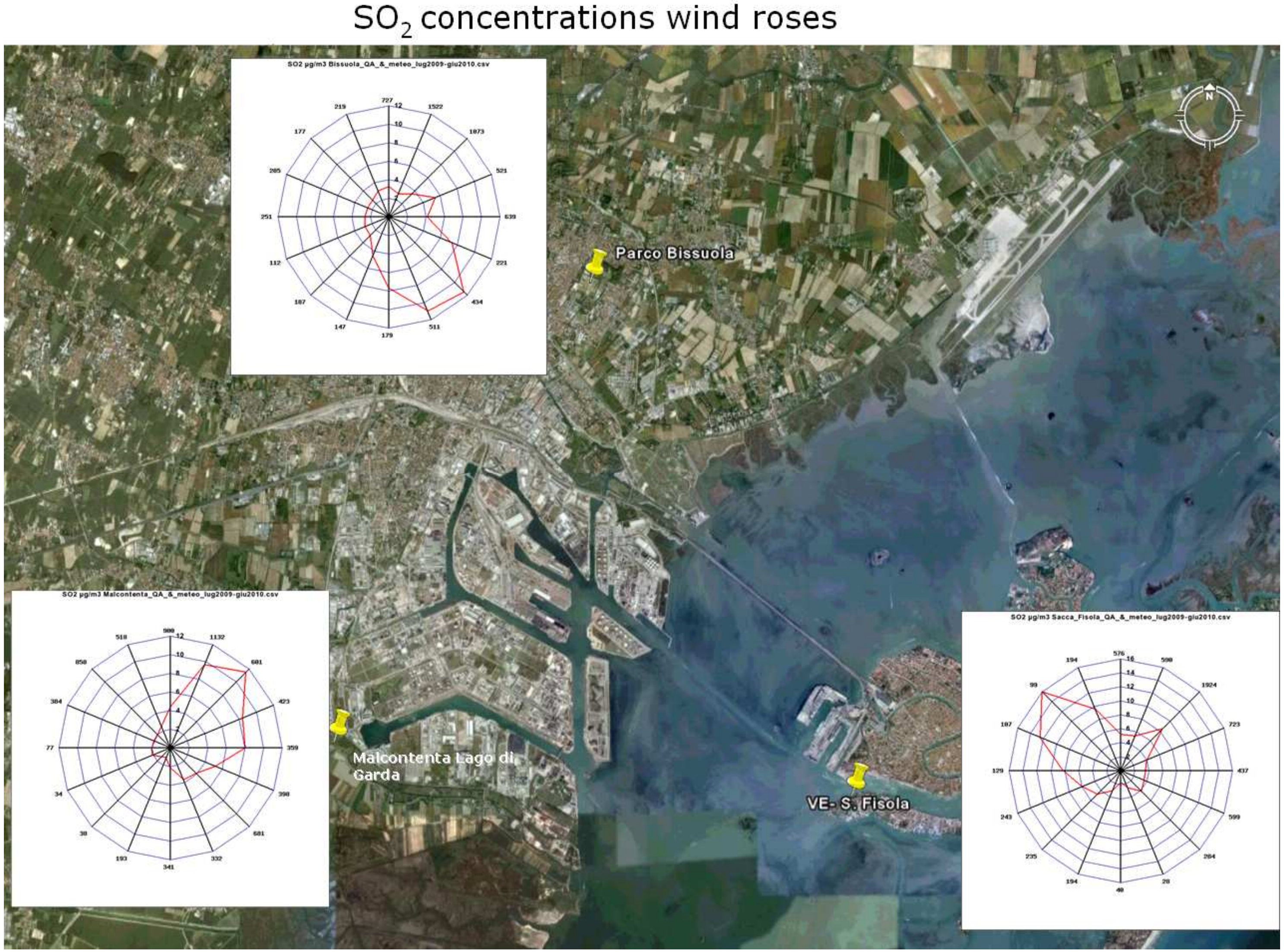
Fig 27. SO_2 concentrations (µg/m^3) for years 2007-2009, stratified by months of a year. ARPAV Stations.



The last elaboration reported on SO_2 concentrations are the 3 wind roses in Fig 28, overlapped on the map of the study area. In the x axis of the radar diagram there's indicated the average concentrations, while on the various vertexes of the radar plot the number of data recorded for winds blowing from those sectors.
Concentrations wind roses have been elaborated on one year hourly concentrations, starting from the 1st of July 2009 and ending to the 30th of June 2010, at the stations of Parco Bissuola, Malcontenta-Lago di Garda e Sacca Fisola. The choice of this period, half on 2009 and half on 2010, has been made to have a correspondent one year data for PM10 concentrations recorded at Parco Bissuola where automatic measurements with 2-hour resolution have started from the 25th June 2009.
SO_2 wind roses clearly bears out different sectors from which wind blows during peak concentrations at the 3 stations. In the case of Parco Bissuola, an evident SE-ESE origin can be observed, for Malcontenta a NE origin, whereas for Sacca Fisola a NW origin. The 3 stations, thus, seem to triangle to a common origin that could be the harbor areas (the maritime harbor and the industrial one in the inner lagoon), but also the north industrial area of Porto Marghera where are situated some of the major plants emitting SO_2.
The concentration wind roses for the other pollutants are totally different (see from Fig 29 to Fig 31)

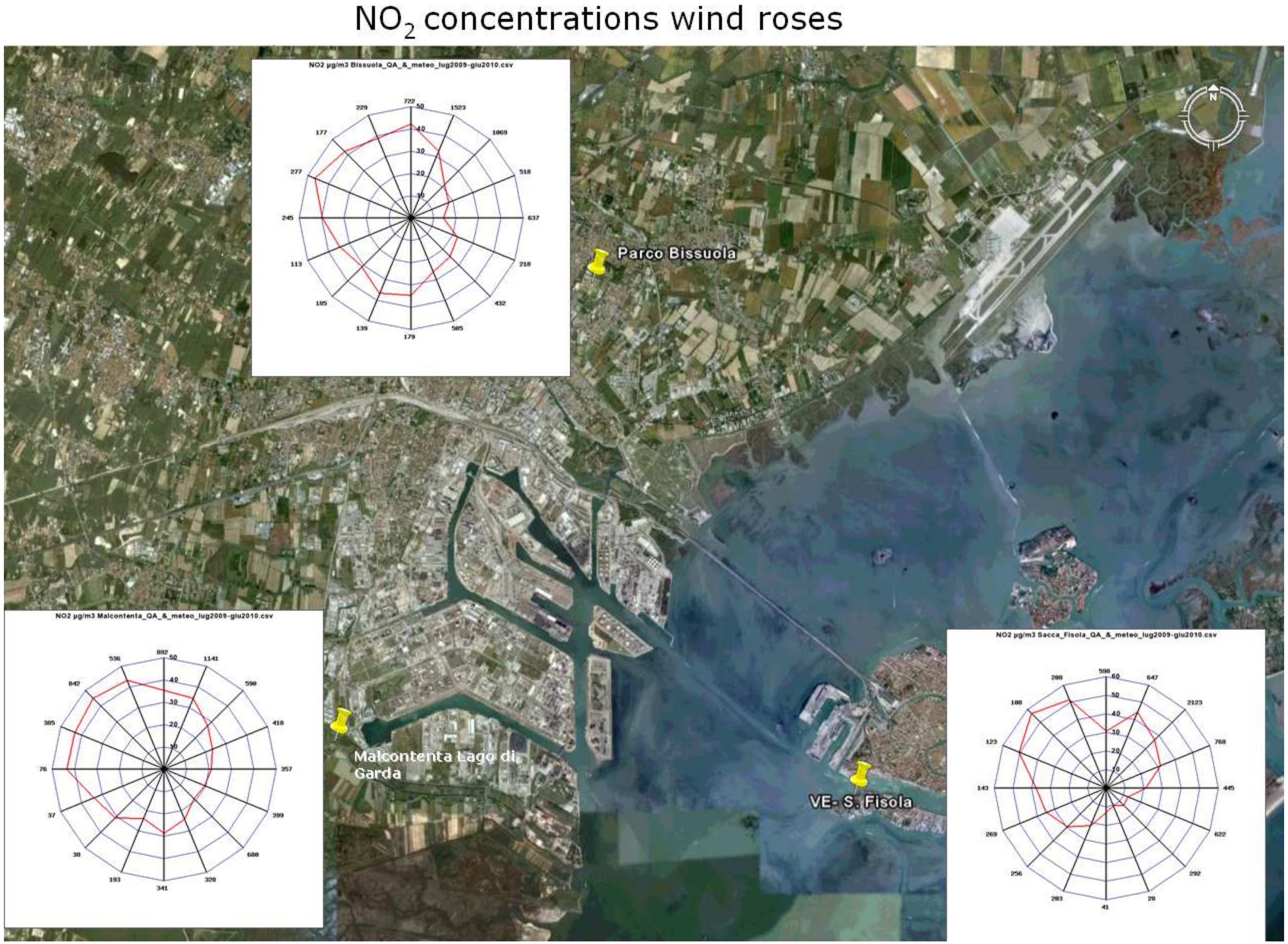
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 28 Wind roses for concentrations SO2 recorded at Parco Bissuola, Malcontenta-Moranzani and Sacca Fisola for the period 1st july 2009-30th June 2010.



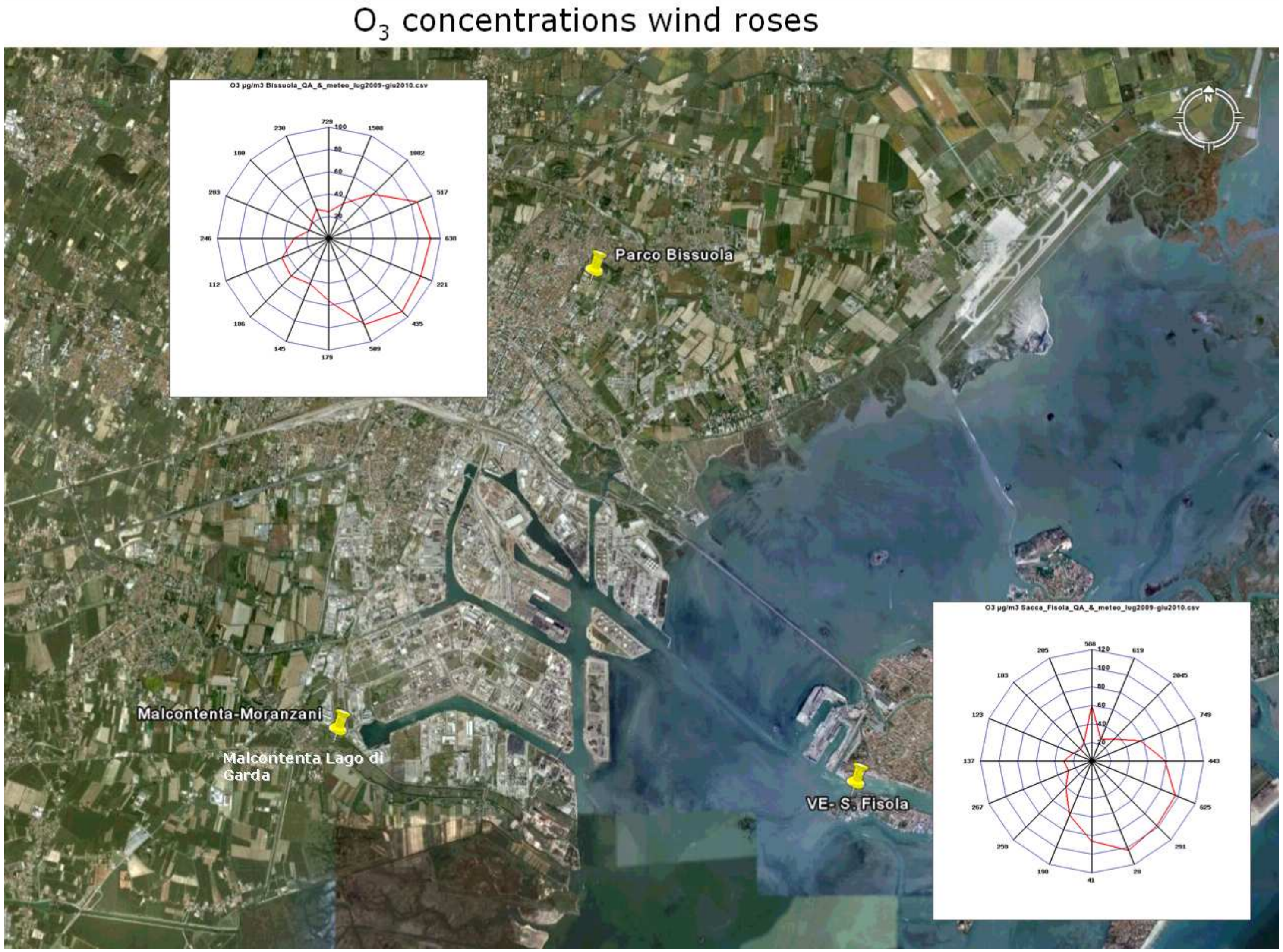
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 29. Wind roses for concentrations NO_2 recorded at Parco Bissuola, Malcontenta-Moranzani and Sacca Fisola for the period 1st july 2009-30th June 2010



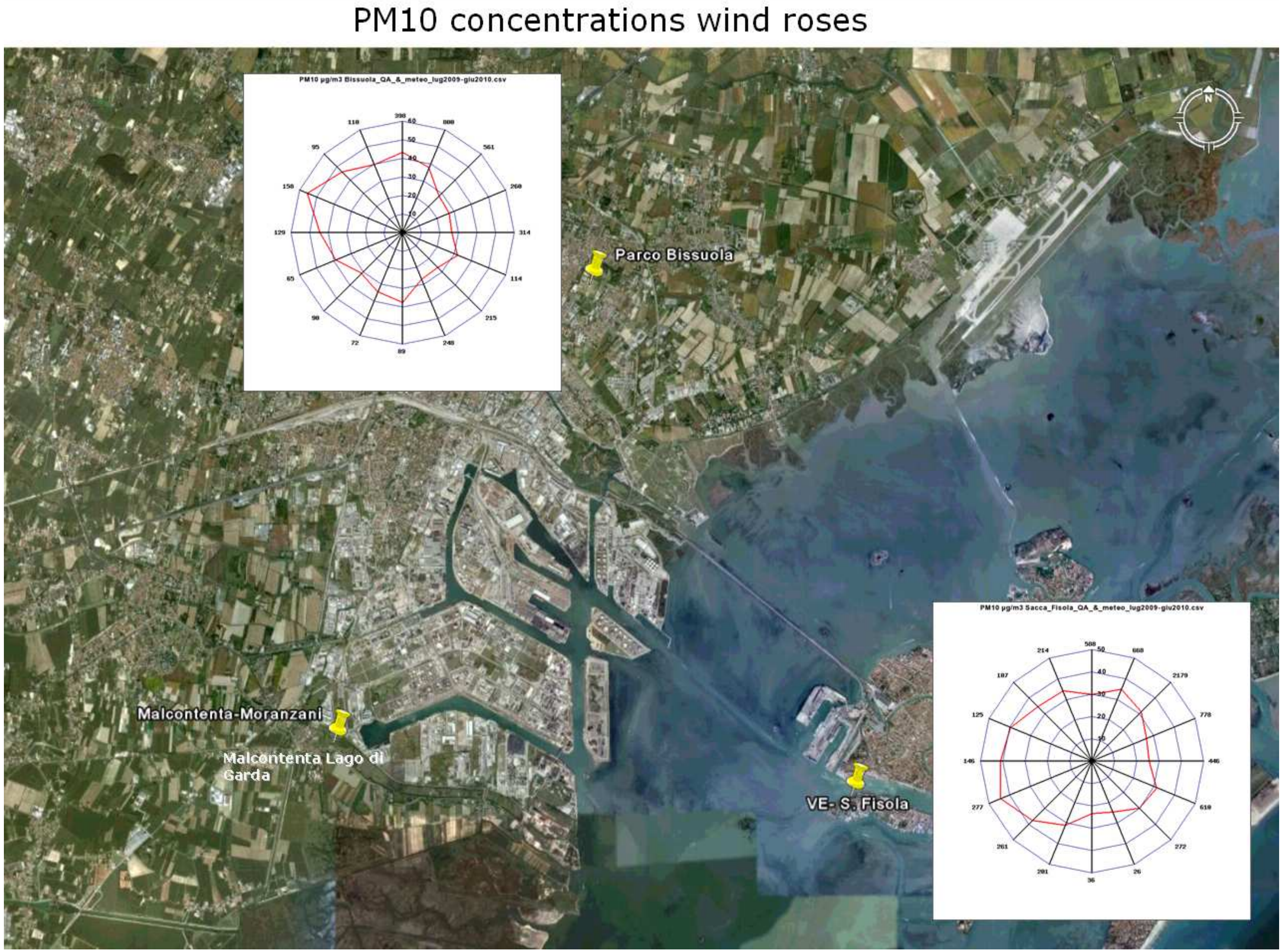
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 30. Wind roses for concentrations O_3 recorded at Parco Bissuola and Sacca Fisolafor the period 1st july 2009-30th June 2010



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 31 Wind roses for concentrations PM10 recorded at Parco Bissuolaand Sacca Fisola for the period 1st july 2009-30th June 2010



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

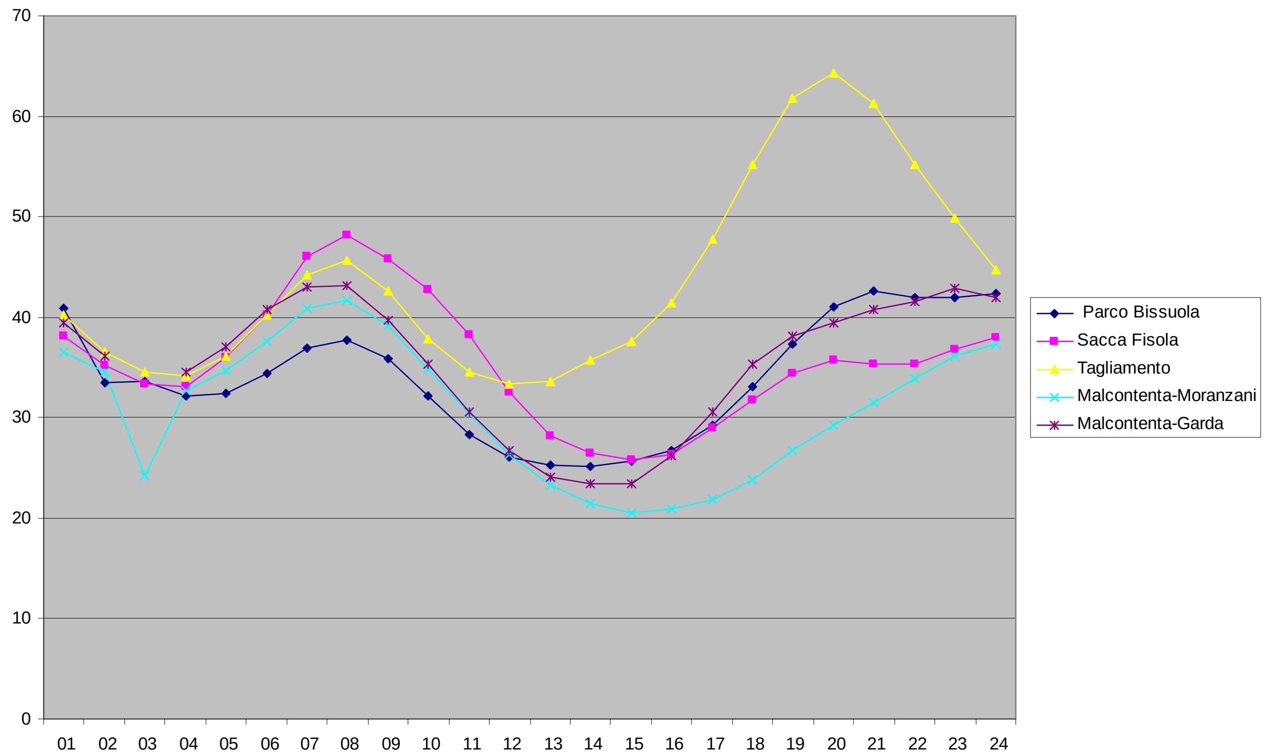
Nitrogen dioxide NO2

Data analysis for NO_2 concentrations has been performed on hourly concentrations at ARPAV stations for:

- 3 years period (2007-2009) for the urban background stations of Parco Bissuola and Sacca Fisola;
- 2 years period for the industrial suburban Malcontenta-Moranzani station (2007-2008) and the urban traffic Tagliamento station (2008-2009).
- 1 year (2009) for the industrial suburban Malcontenta-Garda station.

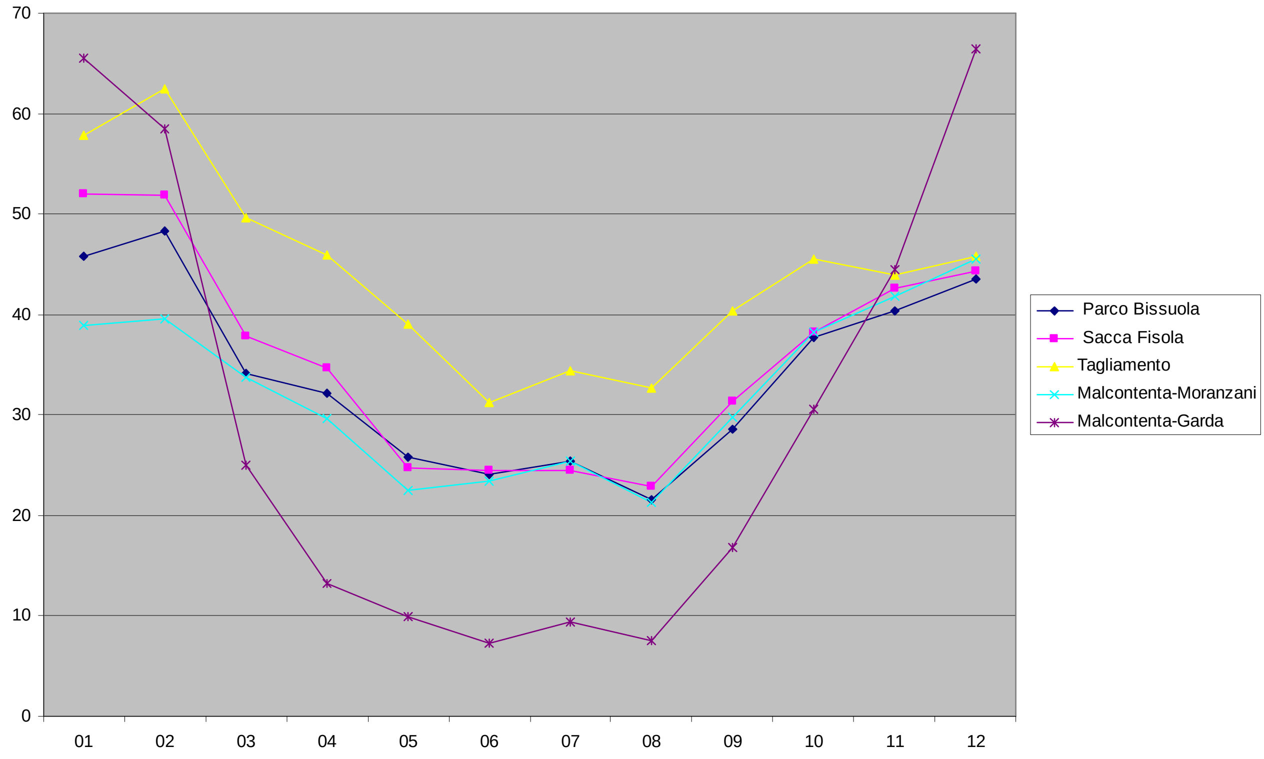
In the following graph (Fig 32) multi-annual averages stratified by hours of the day are displayed for ARPAV stations.

Fig 32. NO_2 concentrations (µg/m³) for years 2007-2009, stratified by hours of the day. ARPAV Stations.



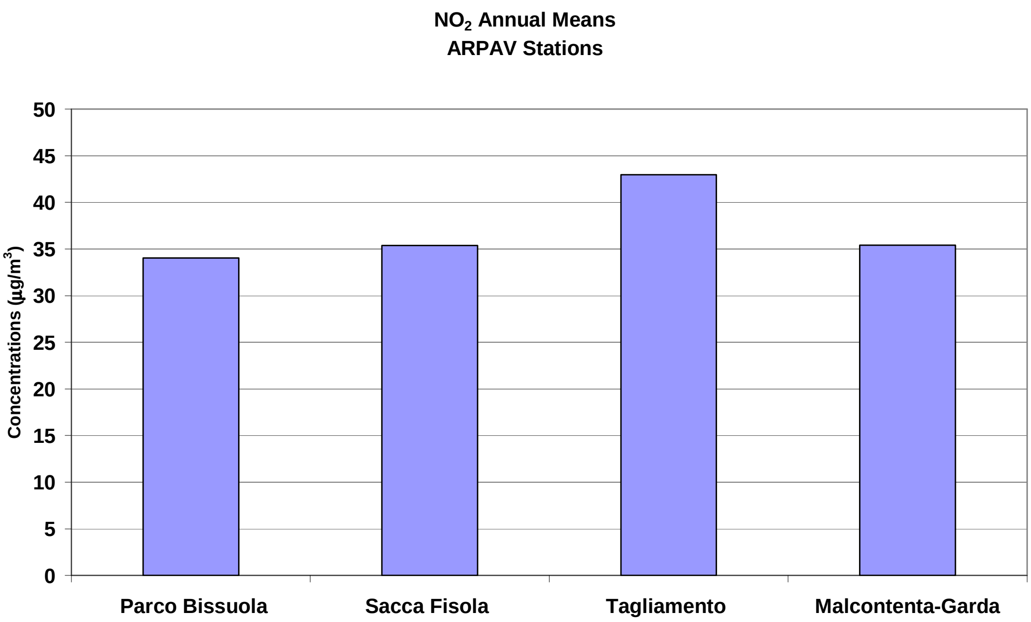
Differently from SO_2 concentrations, hourly concentrations of NO_2 have a similar pattern with a peak in the morning and a peak in the evening in all the stations, regardless of the typology of the station. The evening peak is maximum for the traffic urban Tagliamento station.
In the following graph (Fig 33) multi-annual averages stratified by months are display for ARPAV stations. Typical pattern with maximum concentrations during cold months is evident for all the station and particularly for the industrial suburban station of Malcontenta-Garda.

Fig 33 NO_2 concentrations (µg/m³) for years 2007-2009, stratified by month of the year. ARPAV Stations.



The last graph (Fig 34) proposed for NO_2 is the annual mean concentrations at ARPAV Stations for year 2009.

Fig 34. NO2 annual mean concentrations (µg/m³) at ARPAV Stations.



Ozone

Data analysis for O_3 concentrations has been performed on the following db:

- hourly concentrations during a 3 years period (2007-2009) for the urban background stations of Parco Bissuola and Sacca Fisola.

Fig 35. O_3 concentrations ($\mu g/m^3$) for years 2007-2009, stratified by hours of the day. ARPAV Stations.

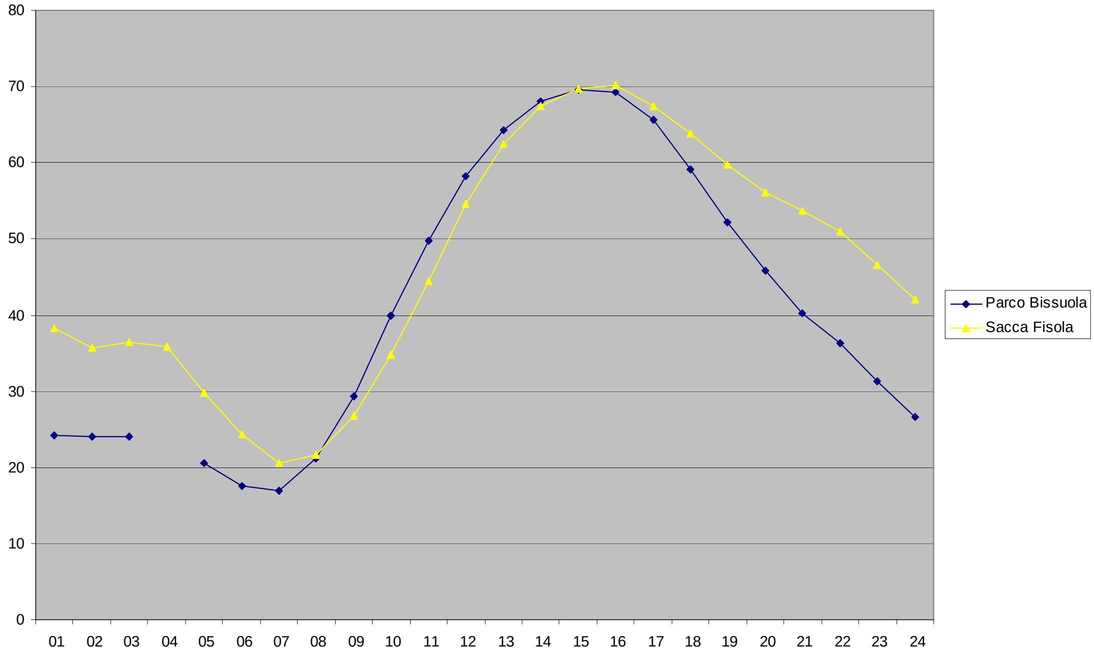
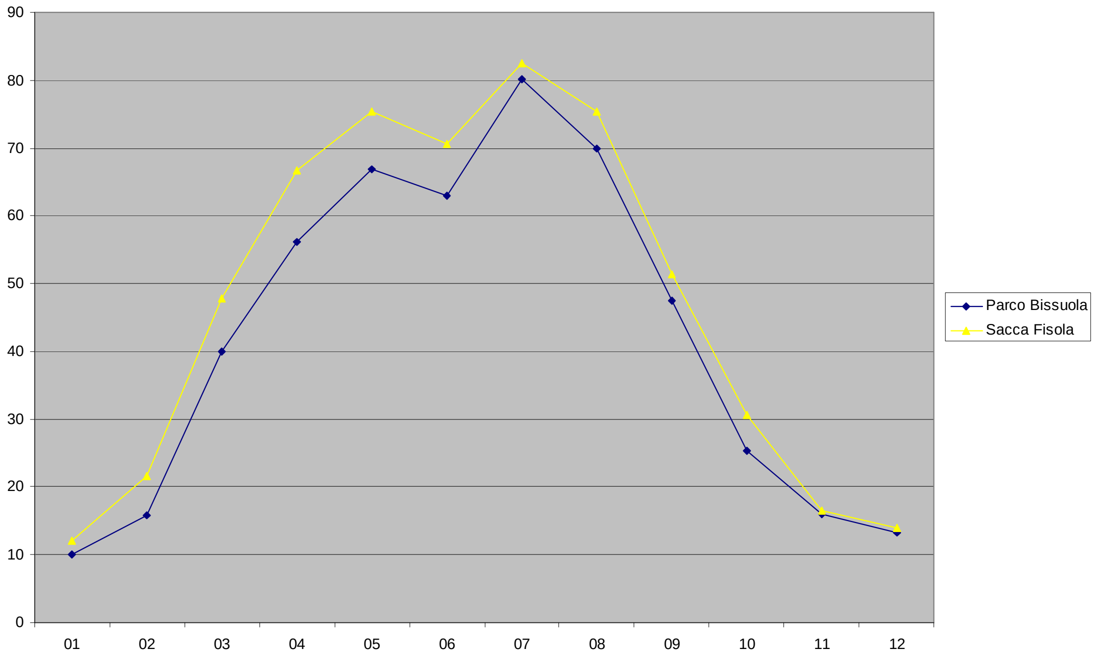


Fig 36 O_3 concentrations ($\mu g/m^3$) for years 2007-2009, stratified by month of the year. ARPAV Stations.



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

In the following table (Tab 5) comparison to O_3 limit values and long term objectives are shown for the two ARPAV stations.

Tab 5. Comparison with limit values and long term objectives for O_3 at ARPAV stations.

			Parco Bissuola		Sacca Fisola	
Directive 2008/50/EC for ozone	Averaging period	Value	N. events	N. days	N. events	N. days
Information threshold	1 hour	180 µg/m^3	2	1	0	0
Alert threshold	1 hour	240 µg/m^3	0	0	0	0
Protection of human health	Maximum daily eight-hour mean within a calendar year	120 µg/m^3	36	36	36	36
Protection of vegetation	May to July	6000 µg/m^3 h for AOT40	21714		21124	

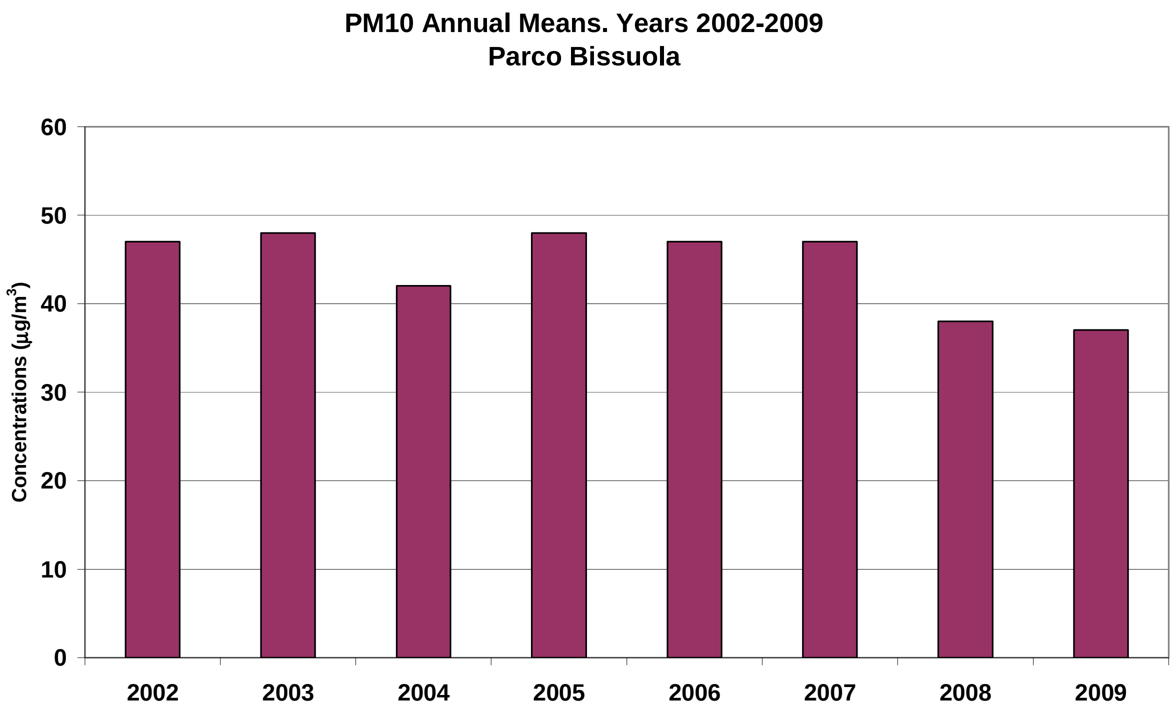
PM10

Data analysis for PM10 concentrations has been performed on daily concentrations over:

- 3 years period (2007-2009) for the urban background stations of Parco Bissuola and Sacca Fisola (the first station situated in the mainland part of the city of Venice and the second one in the historical city just in front of Giudecca's Channel and the terminal for cruise-liners, ferries and yachts);
- 2 years period (2008-2009) for the urban traffic Tagliamento station;
- 2 and a half years period (2007-mid 2009) for the urban traffic Cironvallazione station.

In the following graphs the PM10 annual mean concentrations (Fig 37) and the number of exceedances of the daily limit value of 50 µg/m^3 recorded at Parco Bissuola are reported in the years 2002-2007.

Fig 37 PM10 annual concentrations at Parco Bissuola. Years 2002-2007



Multi-annual averages stratified by months and day of the week are display for ARPAV stations in Fig 39 and Fig 40.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 38. Number of exceedances of PM10 daily limit value at Parco Bissuola. Years 2005-2009.

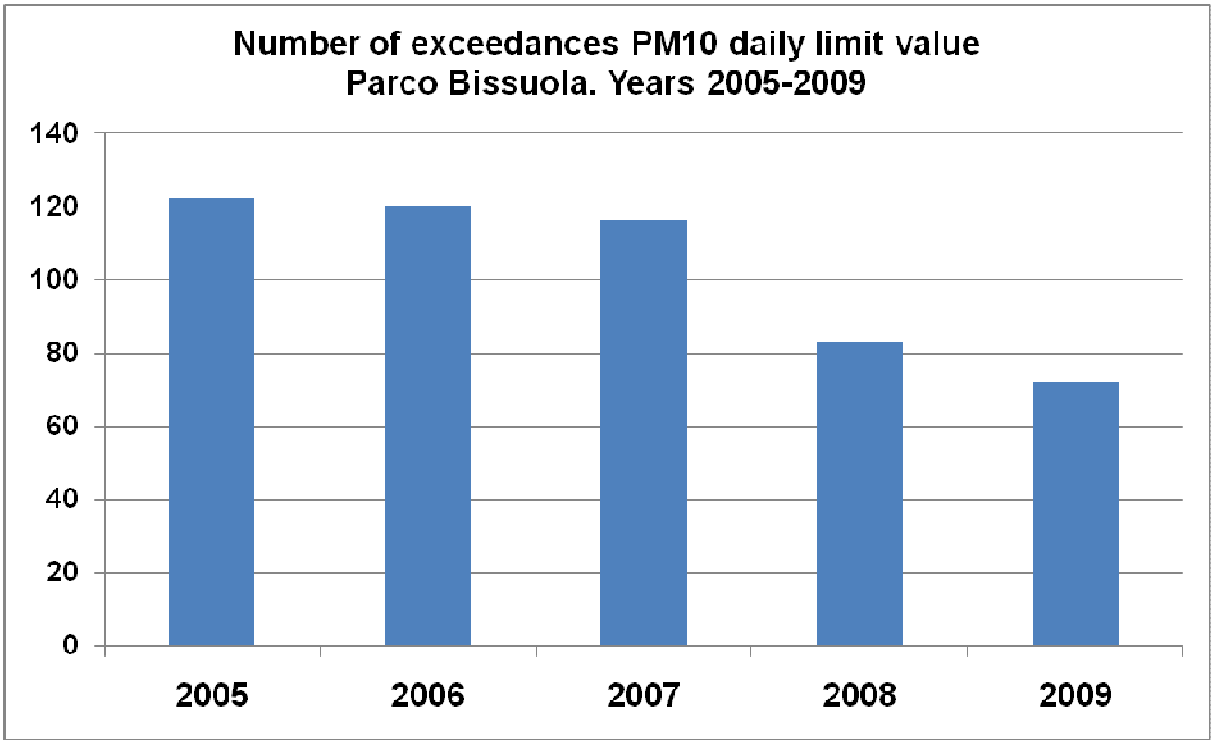


Fig 39. PM10 monthly means (µg/m3). Years 2007-2009. ARPAV Air Quality Stations.

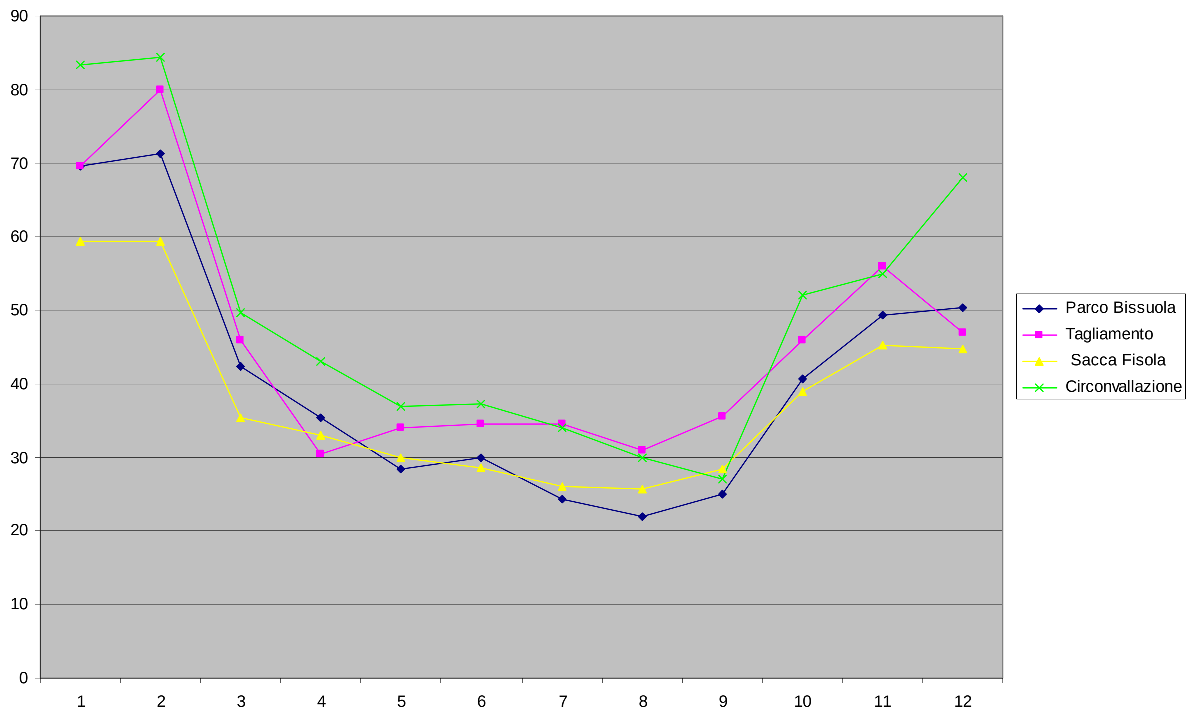
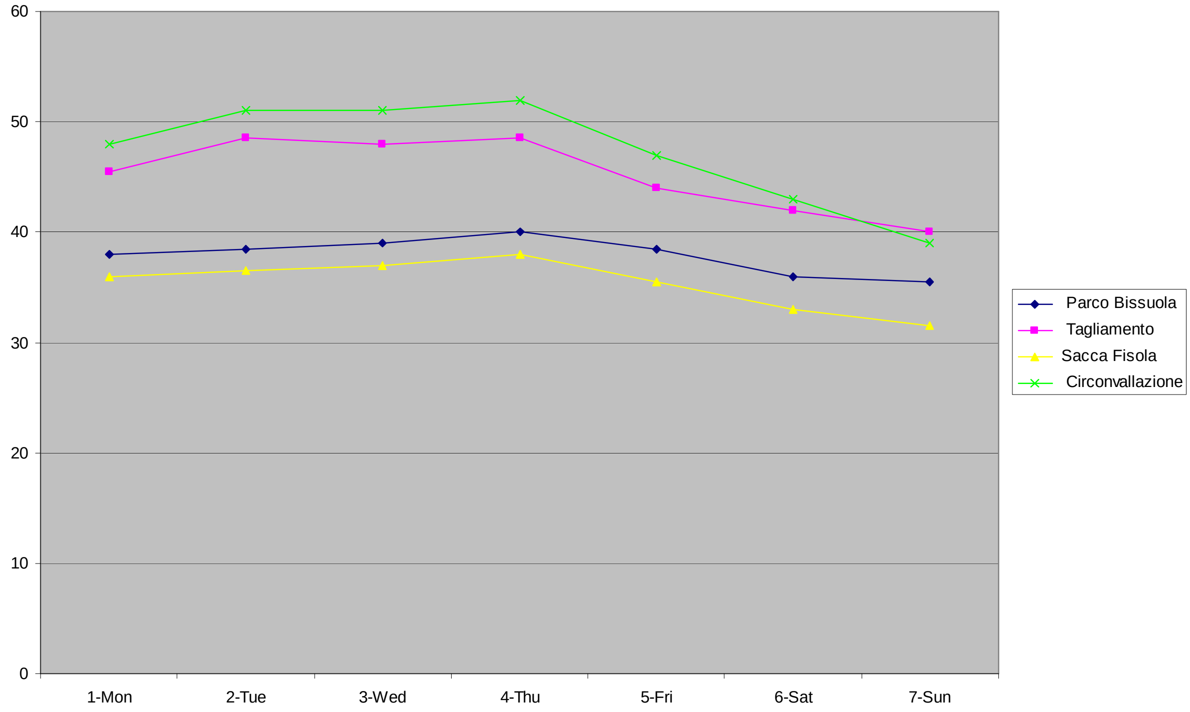
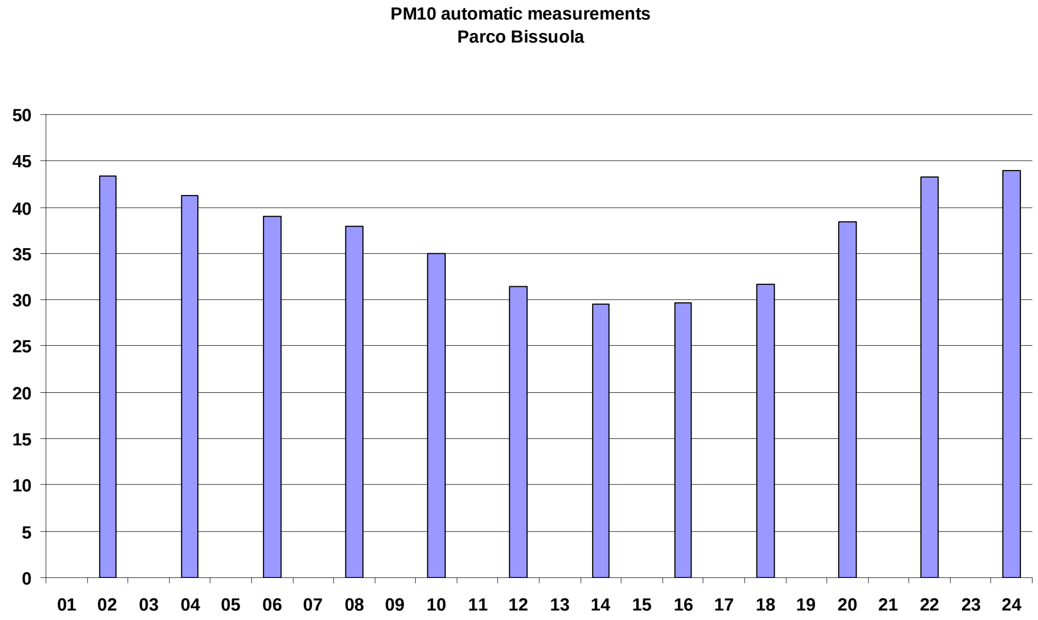


Fig 40. PM10 means (µg/m3) stratified by day of a week. Years 2008-2009. ARPAV Air Quality Stations.



For the urban background station of Parco Bissuola concentrations with two-hour time resolution from 1st July 2009 to 30th June 2009 have been analysed, too. Average concentrations stratified by hour of the day are shown in Fig 41.

Fig 41. PM10 means (µg/m3) stratified by hour of a day. Samplers with two-hour time resolution from 1st July 2009 to 30th June 2009. Parco Bissuola.



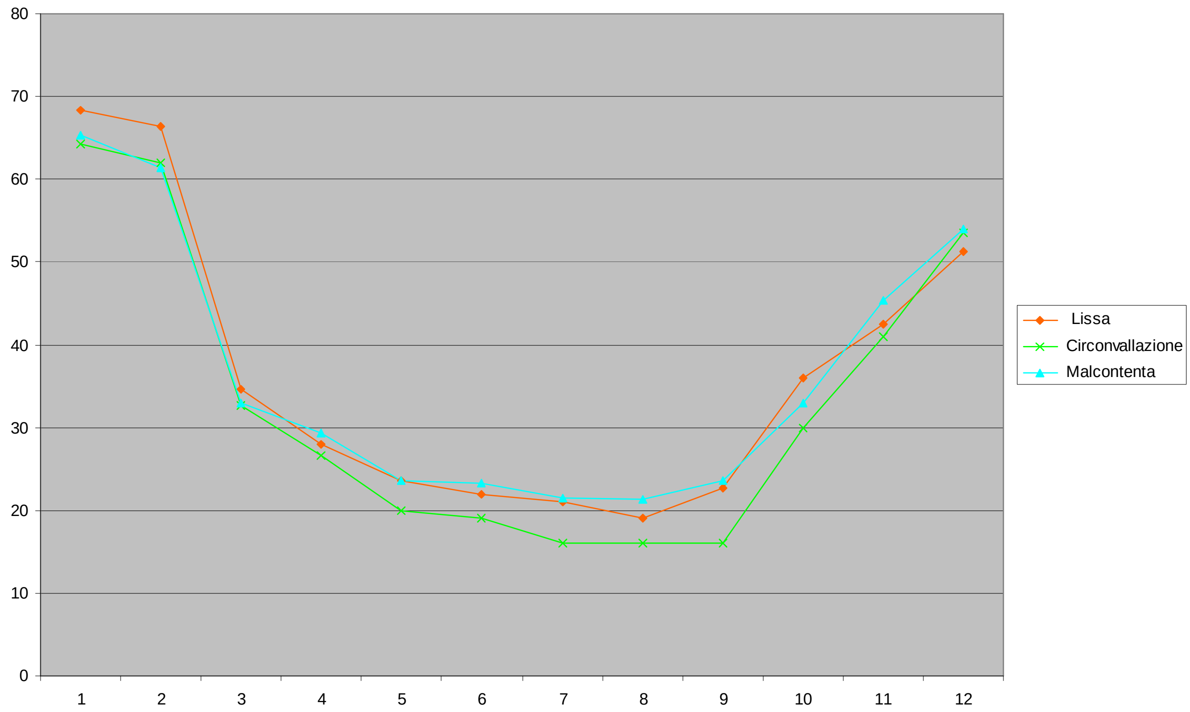
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

PM2.5

PM2.5 daily concentrations stratified by months of the year are shown in Fig 42. The analysis has been performed on daily concentrations over:

- 3 years period (2007-2009) for the urban background site in Via Lissa;
- 3 years period (2007-2009) for the suburban industrial site of Malcontenta, obtained considering records both from Malcontenta-Moranzani station and from the new Malcontenta-Garda station;
- 2 and a half years period (2007-mid 2009) for the urban traffic Cironvallazione station.

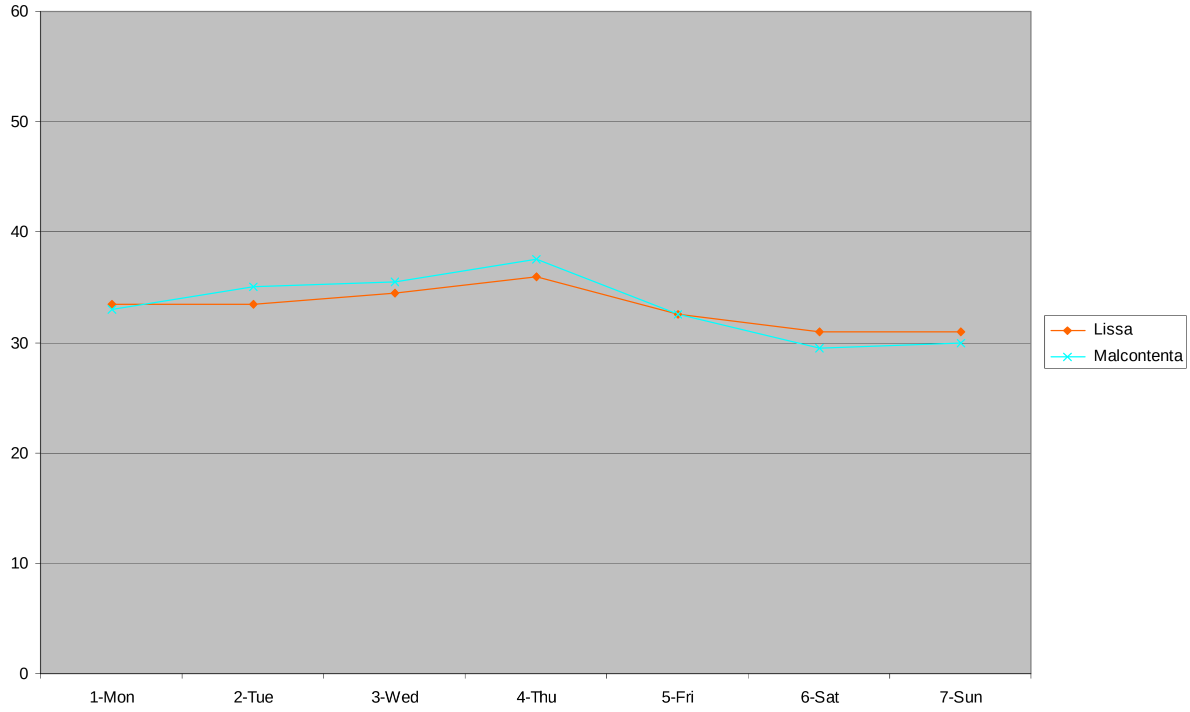
Fig 42. PM2.5 monthly means (μg/m^3). Years 2007-2009.
ARPAV Air Quality Stations.



PM2.5 daily concentrations stratified by day of the week are shown in Fig 43 and Fig 42. The analysis has been performed on daily concentrations recorded at sites of Lissa and Malcontenta in 2008 and 2009.

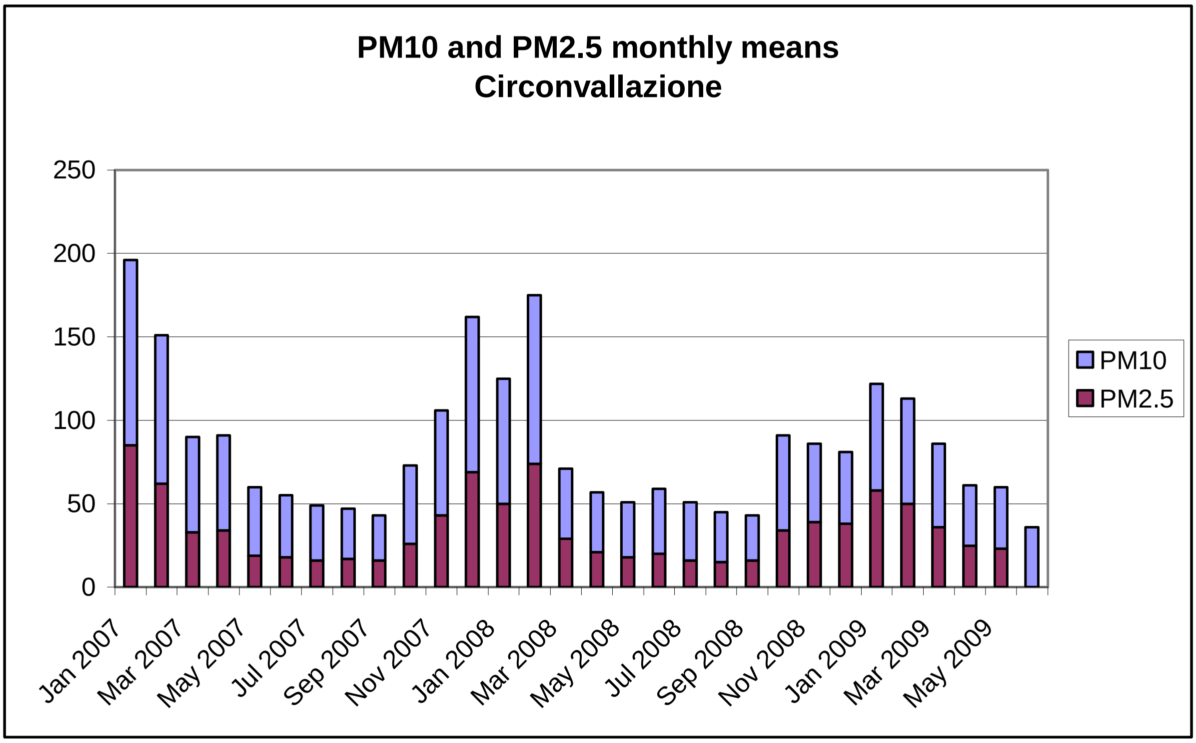
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 43. PM2.5 means (µg/m³) stratified by day of a week. Years 2008-2009. ARPAV Air Quality Stations.



The last graph presented for PM2.5 is Fig 44, where PM2.5 monthly mean concentrations are shown together with contemporary means of PM10 concentrations. Data comes from records at the urban traffic Circonvallazione station, that were ended in may 2009.

Fig 44. PM10 and PM2.5 monthly means (µg/m³). Years 2007-2009.



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

As, Cd, Hg, Ni, Pb

From Fig 45 to Fig 49, annual mean concentrations are reported for metals monitoring at the urban background station of Parco Bissuola and at the urban traffic station of Circonvallazione, years 2002-2009.

Fig 45. Annual concentrations of arsenic. Years 2002-2009.

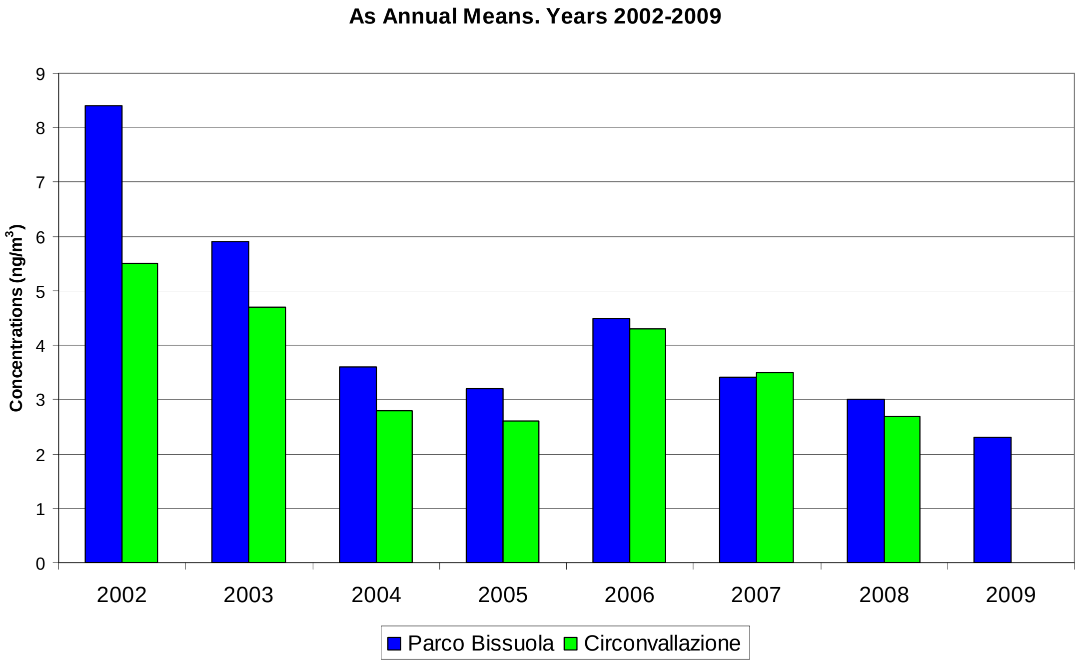
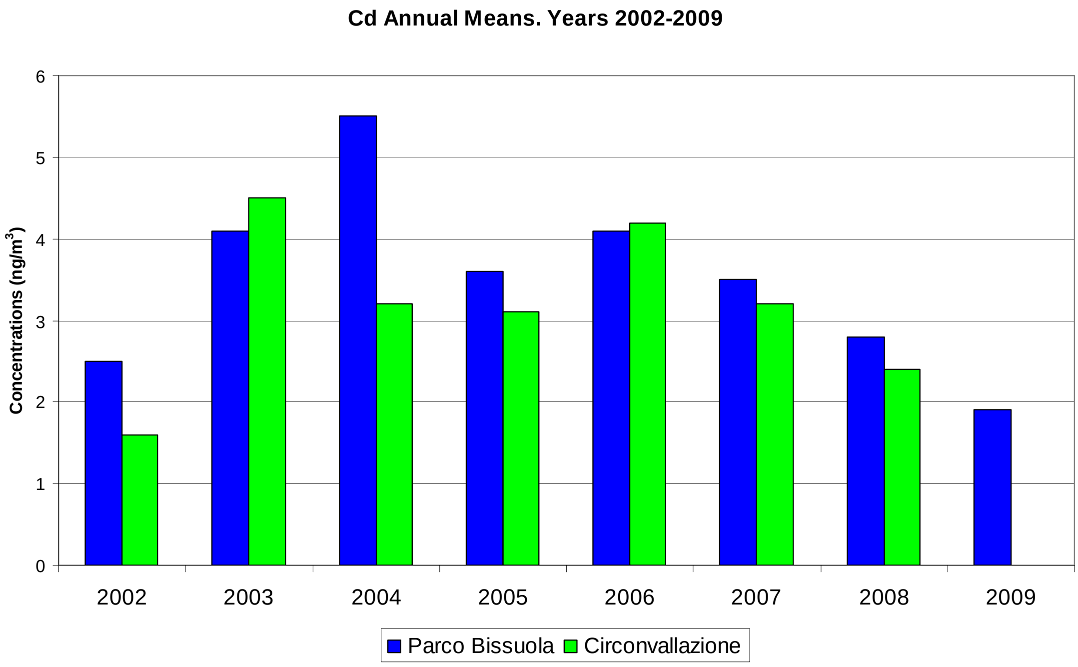


Fig 46. Annual concentrations of cadmium. Years 2002-2009



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 47. Annual concentrations of nikel. Years 2002-2009

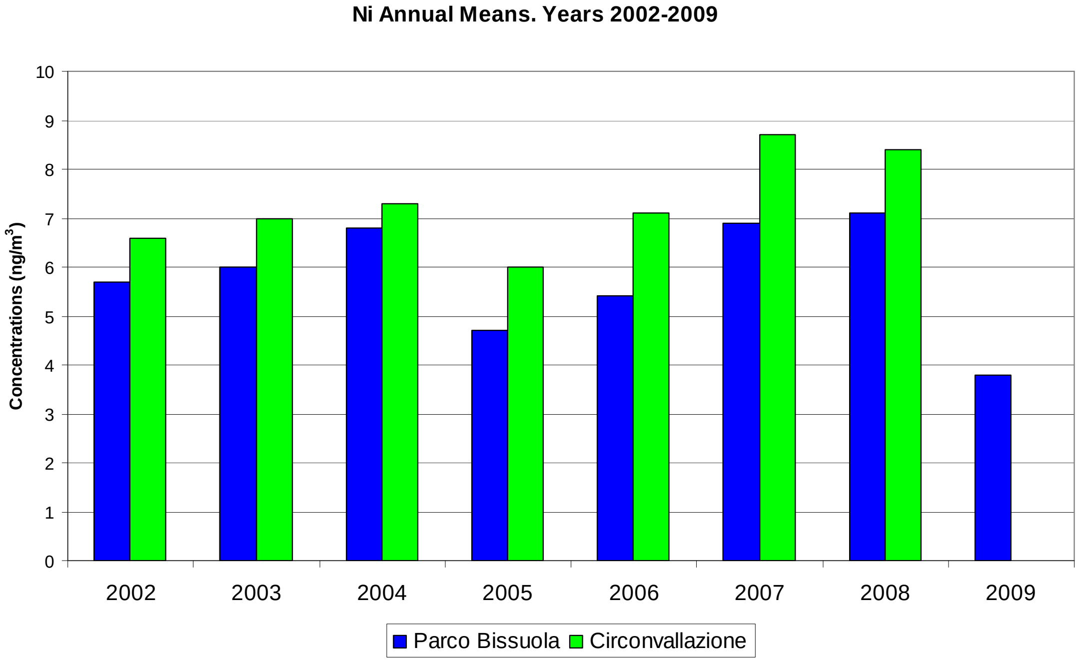
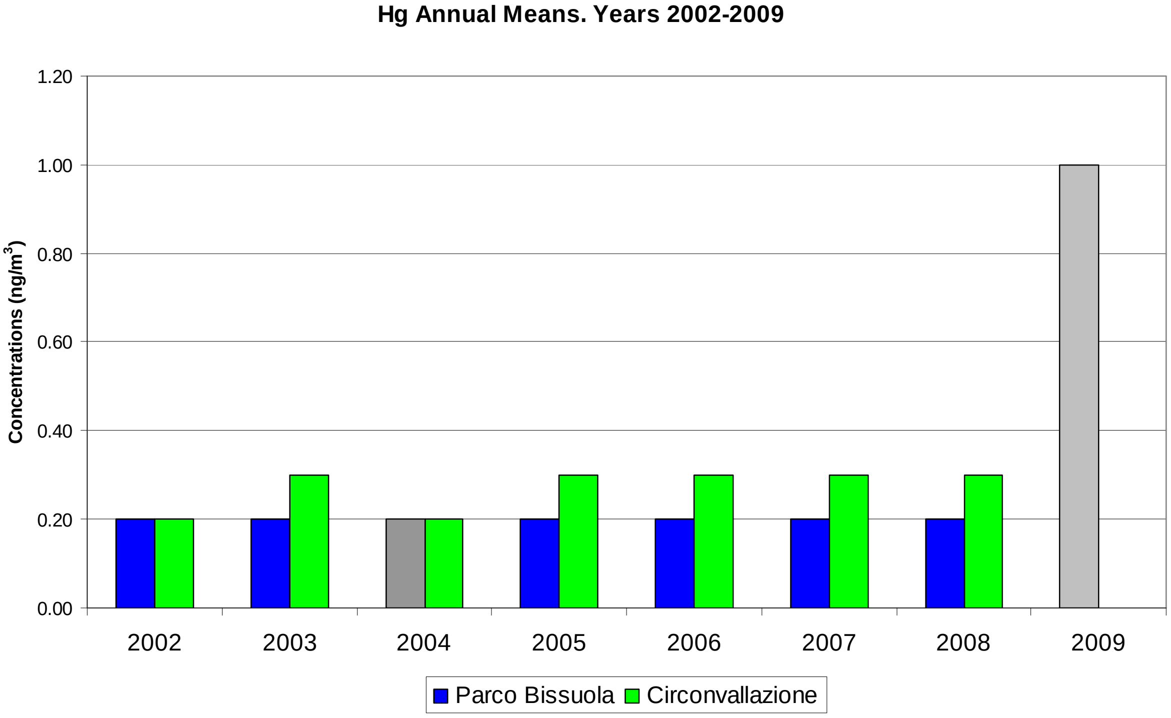
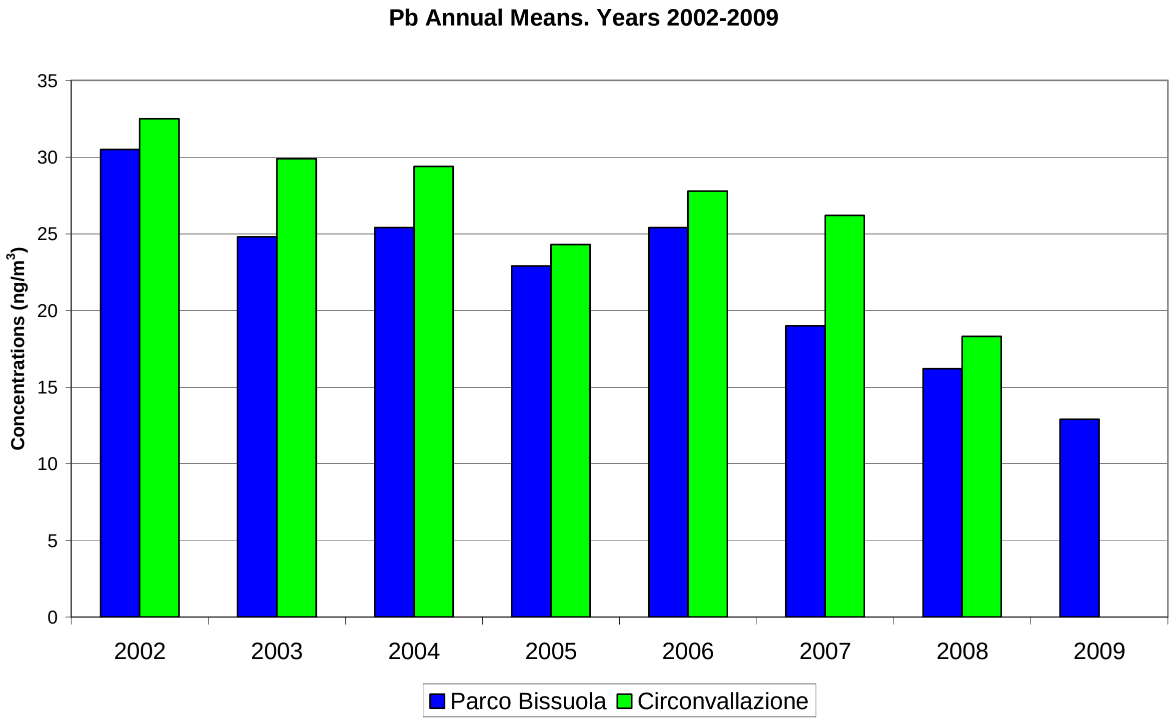


Fig 48. Annual concentrations of mercury. Years 2002-2009



In grey two measurements reported to the Detection Limit (LOD).

Fig 49.Annual concentration of lead. Years 2002-2009.



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

1.2 Former scientific projects and publications

1.2.1 Projects

The Regional Air Observatory (http://www.arpa.veneto.it/aria_new/htm/osservatorio_aria.asp?1) is the thematic body on Air Pollution in ARPAV, the Regional Environmental Protection Agency of Veneto. Founded in 1999 with the support of the European structural funds (European Regional Development Fund, Objective 2 - 1997-1999), the Observatory supports on technical ground both the ARPAV Provincial Departments and other Public Administrations.
In particular the Observatory fosters high air quality standards for the Veneto citizens and natural environment by seeking and furthering the understanding of the state of the air quality for supporting knowledge-based pollution reduction policies.
The Observatory is the Veneto Region contact with the National Environmental Protection Agency and the Italian Ministry of Environment on air quality management and control themes. It contributed to the drafting of National Guidelines for the implementation of air quality monitoring networks and carries out duties for the Regional Authority in terms of air quality data management, elaboration and reporting. The Observatory is the regional entity developing the Regional Emission Inventory for estimating emissions from all pollution sources in Veneto.
Regional Air Observatory is composed of four units and one laboratory:

- the Policy unit;
- the Modelling unit;
- the Operational Support unit;
- the Large Plants Emissions unit;
- the Quality Control laboratory.

The Policy Unit supports the Veneto Regional Authority in developing policies for the reduction of atmospheric pollution and it has been involved in the drafting of Regional plans for air quality protection according to the air quality Directive 2008/50/EC. Furthermore the unit provides technical support to public administrations responsible for planning the improvement and safeguard of air quality.
The Modelling Unit coordinates the data analysis and modelling efforts in ARPAV and it is consulted by the Regional Public Authorities when the decision making process involves projects that undergo to an Environmental Impact Assessment (EIA). More specifically the modelling unit manages a suite of modelling tools from dispersion models for impact assessment (CALPUFF, AERMODE, ISC3, CALINE, ADMS-Urban, SPRAY) to street emission modelling (COPERT) to Chemical Transport Models for pollution assessment and apportionment (CAMx, FARM). This unit also develops *ad hoc* algorithms and methodologies for air quality evaluations and assessment.
The Operational Support unit works on the development of the Veneto regional emissions inventory, by carrying out a bottom-up approach (the INEMAR Project) but also by distributing national emission data at regional level when detailed local activity data are not available.
The unit also works on reporting air quality/emissions indicators and gives support to the other units by processing road traffic data and environmental/geographic data by means of GIS techniques.
The Large Plants Emissions Unit is devoted to develop inside the Agency the enforcement of new European standards of emission measurements and the Quality Assurance issue in this field.
In the future the unit itself is supposed to carry out emission measurements at large industrial plants.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

The Quality Control laboratory implements the Quality Control programme on the air quality regional network analyzers. The Laboratory acts as the test bench for innovative air monitoring instrumentation and develops and tests standard methodologies and procedures for monitoring air quality pollutants. Its team members coordinate specific monitoring campaigns by means of mobile stations. It furthermore takes part to air quality intercomparisons.

Main Project activities ruled by Regional Air Observatory
"SIMAGE" (Environmental Monitoring System and Risk Management) for the creation of a monitoring and management system of air quality in case of industrial risk; funded by the Veneto Regional Council (Project "SIMAGE I Lotto", 2002-2005, http://www.arpa.veneto.it/aria_new/htm/qualita_progetti_simage.asp),
"IN.EM.AR" (INventory EMissions Air) for realization of the Veneto Region Emission Inventory (see http://www.arpa.veneto.it/aria_new/htm/progetti_aria.asp?2), funded by Veneto Region, 2006-2010.
"DOCUP Regional Project Optimization of the air quality monitoring network in the Veneto Region (2000-2006)" for the implementation of the regional air quality network performance, funded by the European Regional Development Fund, "Veneto Region Single Programming Document for objective 2 – 2000/2006", axis 4, measure 4.3, (see http://www.arpa.veneto.it/aria_new/htm/qualita_progetti_docup2.asp)
"Passante di Mestre" a regional project based on monitoring, control and modelling evaluation of atmospheric pollution due to the construction of a new highway (Passante di Mestre) in the Venetian hinterland (see http://www.arpa.veneto.it/aria_new/htm/p_mestre.asp)

"PM SOURCE APPORTIONMENT ANALYSIS IN THE VENETIAN AREA", ARPAV 2006.
The study (Pillon *et al*., 2008) was carried out by ARPAV in 2006 to evaluate the contributions of different sources to PM10 levels in the Venetian area through measurements and chemical speciation (Biancotto et al., 2007) as well as an air quality photochemical modelling system (Pillon *et at*., 2007).
A multi-scenario approach was applied on a CALMET-CAMx System (Benassi *et al*., 2007; Dalan *et al*. 2005) to investigate fine particular matter (PM10) source apportionment in the urban area of Venice and its mainland.
CALMET model (Scire *et al*., 2000) was used to produce the meteorological fields, while CAMx model (ENVIRON International Corporation, 2004 v 4.03) was used to simulate the dispersion of primary and secondary aerosols. The 200x168 km^2 domain covered most of the Veneto region on a 4 km resolution mesh, while a 1 km nested grid encompassed three of the largest urban agglomerations of the Veneto Region: Treviso, Padova and Venice.
CAMx was set-up to run with Carbon-Bond IV with extension for aerosol modelling, distinguishing between two particulate sizes: coarse (PM2.5-PM10) and fine (<PM2.5); the PiG submodel was activated for main stacks (power plants principally).
The initial and boundary conditions, on 0.5° resolu tion, was provided by of Prev'air Service of INERIS (http://www.lmd.polytechnique.fr/chimere/) as CHIMERE model outputs.
The atmospheric emissions of an integrated Bottom-Up and Top-Down inventory (Gnocchi *et al*., 2005; Gnocchi *et al*. 2006) were distributed according to the land use classification, while the main stack emissions were modelled using a Lagrangian approach (the CAMx plume-in grid tool).
The nested grid was used to better represent the land-use variations (used for the attribution of rural and urban emissions) and the most important traffic roads of the domain. The transport emissions in the nested domain were calculated using the COPERT III methodology based on a bottom-up approach of traffic flows. In the remaining part of the

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

domain, transport emissions were computed by breaking down the national inventory following the CORINAIR methodology.
The modelling system was run on a period when data on PM10 chemical speciation were available, i.e. from February to March 2006 (Biancotto et al, 2007) and the concentration fields of PM10 and its organic and inorganic components were computed and compared with daily measurements taken in 4 sites, with different exposure characteristic: a kerbside site, near a traffic light of a congested road; a urban site in Mestre, the mainland part of the city of Venice; a rural site, about 50 km from Venice and an a site near Porto Marghera, the industrial site in the mainland part of the city of Venice about 5 km south of the urban site.
The scenario runs allowed to estimate the relative importance of emission sources inside the nested area to PM10 concentrations and the source apportionment of the locally produced PM10, at least for the primary and the secondary inorganic PM10 components, for which the modelling system showed an acceptable confidence level.
The results showed in the nested grid a local contribution to the PM10 levels from a minimum value of 30% to a maximum of 50%. The source apportionment analysis depended on the location of the site and the emission sector; for example road transport had a maximum weight of 48% in the urban-exposed site and a minimum value of 14% in the industrial site, while industrial plants had a maximum of 44% in the industrial site and a minimum of 13% in the rural background one.

“EULERIAN MODELLING APPLICATION FOR A HIGHWAY AIR QUALITY IMPACT ASSESSMENT”, ARPAV, 2006-2009.
An eulerian modelling application was carried out by ARPAV, in collaboration with ARIA-net, to assess the impact on Air Quality by a new highway bypassing Mestre, open to traffic at the beginning of 2009 (Elvini et al. 2010).
This atmospheric modelling system was based on FARM model (Flexible Air quality Regional Model, Silibello et al., 2008; Gariazzo et al., 2007) that was applied with the SAPRC-90 (Carter, 1990) chemical mechanism and the aero3 modal aerosol scheme implemented in CMAQ framework (Binkowski, 1999; Binkowski and Roselle, 2003). Time varying boundary conditions for all modelled species on the regional domain were derived from the corresponding three-dimensional fields coming from PREV'AIR system based on CHIMERE chemistry-transport model (http://prevair.ineris.fr/en/modele.php).
The diagnostic model SWIFT/MINERVE (Desiato et al., 1998) was fed by 20 meteorological surface stations (ARPAV-CMT), 1 off shore station (Municipality of Venice), 3 radio-sounding stations (Raob) and 1 SODAR (EZI). The same meteorological fields were used to drive the dispersion module for both the base case and the future.
The meteorological fields together with land cover information (e.g. roughness length) and chemical species characteristics (gas reactivity), were then used by interface module GAP/SURFPRO (Finardi et al., 2008; FUMAPEX, 2006) to produce dry deposition velocities and turbulent diffusivity fields needed by FARM.
The modelling system has been applied on a 60 x 50 km^2 domain with a 1-km horizontal resolution, including, besides the Mestre-Venice urban system, also the larger Padua – Treviso – Venice urban area, involved in the road network reorganization.
The simulations were applied for a whole year (2005).
The emissions coming from diffuse sources over the considered domain were derived from the national emission inventory for the year 2000 (APAT, 2004) that was projected to the simulated year using national trends differentiated for each pollutant and activity. A more detailed approach were adopted to estimate emissions coming from major industrial facilities and traffic over the investigated area. The former were estimated on the basis of an exhaustive inventory that included major facilities present in the area: thermal power plants, refineries, cement factories, chemical plants and glass factories (Gnocchi et al., 2005). TREFIC model (Nanni and Radice, 2004), implementing COPERT III methodology

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

(Ntziachristos and Samaras, 2000) and including IIASA emission factors for the treatment of PM (IIASA, 2001), was used to estimate road transport emissions starting from a detailed db of flows and velocities for different kind of vehicles (motorcycles, cars, light and heavy duty vehicles, trucks and buses), coming from a traffic assignment model applied on a road network, made up of more than 6000 links, that covers a large part of the investigated area (Venice and adjacent provinces).
Model performance was evaluated by comparing the monitoring stations data available for the year 2005 (7 stations for NO_2 and 5 stations for PM10 inside the model domain) and the model results for the base case.
The model presented a generalized light tendency to underestimate the measured values, however the uncertainty was well between the value of ±30% for NO_2 and ±50% for PM10, as EU legislation requires for model estimates.
As regards
In the base scenario, NO_2 recorded the highest concentrations along the Mestre ring road. High concentrations, exceeding the annual limit value, were calculated along the Padua ring road and at the Venice airport as well. About the difference between the future and the base scenarios, the increase in concentration values along the new highway is stronger than the decrease along the Mestre ring road.
For PM10 highest concentrations, exceeding the annual limit value, are calculated at South of Padua and in the urban area of Mestre. Also for PM10 the difference between the future and the base scenarios records a stronger increase along the new highway than the decrease along the Mestre ring road.

MODELLING OF ORGANIC AND INORGANIC MICROPOLLUTANTS ON THE LAGOON OF VENICE, funded by the Veneto Regional Council (Project “SIMAGE I Lotto”, 2002-2005).
The Veneto Region Council financed the SIMAGE project with the aim of protecting the atmospheric environment of the Venice lagoon. The purpose of the project was to estimate the importance of atmospheric transport and deposition of inorganic and organic pollutants within the Lagoon borders.
A CALMET-CALPUFF modelling system was applied, to assess the pollution and deposition levels of Heavy Metals (HMs), Dioxins and Furans (PCDD/Fs) and Polycyclic Aromatic Hydrocarbons (PAHs) in the Venice lagoon (550 km^2) and its drainage basin (2038 km^2).
The modelling system included a Bottom-Up emission inventory (Gnocchi et al., 2005), where the most significant point sources belonging to the industrial SNAP sectors 1, 3, 4, 6 and 9 had been collected for the whole Venice Lagoon Drainage Basin (VLDB). In addition, emissions from road transport were calculated with a self-made code which integrated COPERT III methodology (Ntziachristos and Samaras, 2000) with PM IIASA emission factors (IIASA, 2001), obtaining micropollutant emissions from the vehicular flows on the sub-regional road graph.
The diagnostic meteorological model CALMET (Scire et al., 2000) was applied to produce the meteorological input fields to CALPUFF (Scire et al., 2001). CALMET blended together data coming from 32 surface stations (9 of which synoptic stations), 1 off-shore station and 3 radio-sounding stations. The 200 km x168 km CALMET domain covered most of the Veneto region on a 4 km resolution mesh, while CALPUFF had a 2 km nested grid in a 80 x 88 km^2 domain which covered all the VLDB.
CALPUFF was run for one year with the tri-dimensional meteorological output of CALMET. Both annual mean concentrations and deposition fluxes were so obtained.
The ratio between atmospheric annual loads (total deposition) inside the VLDB and annual emissions of the whole domain laid between 2% and 7%. For the loads inside the lagoon of Venice this ratio layid between 0.4% and 3%. Dry deposition was about 30% of the wet one (with some variability inside the domain and among pollutants) for road transport emissions,

whereas for industrial ones dry deposition was only 1% of wet one. Such different patterns are clearly due to the different high of release for stack and road emissions.
The comparison with contemporary bulk deposition measurements indicated a underestimation of the daily deposition fluxes.

“THE LAGOON INFLUENCE ON THE ATMOSPHERIC DISPERSION IN VENICE”, ARPAV, 2005.
The presence of the lagoon coastline and the nearby Porto Marghera industrial area calls for the possibility of fumigation effects and affects the dispersion of pollutants toward the Venice Island and Mestre city. Sea-land effect were tested (Dalan et al., 2005) using a CALMET-CALPUFF model system under different scenarios;
Gaussian models are commonly used for Environmental Impact Assessment (EIA), most of which ignore the sea-land discontinuity considering a homogeneous dispersion characteristic over the whole domain. The purpose of the study was to address a future guideline for EIA in the Venetian lagoon area with its peculiar characteristics of both an open sea and a wetland area.
The lagoon effect on the dispersion in the atmosphere was evaluated by comparing the degree of dispersion of a dummy pollutant from an hypothetic stack using two different types of land-use as input to the CALMET model, both in the lagoon area and Adriatic Sea, namely: open sea and wetland The simulations using the two land-use as inputs were compared on different scenarios where a single stack of five possible stack heights (from 40 to 200 meters) was placed at different distances from the coastline (from 0 to 8 Km).
Findings indicated that a gradient of mixing height exists in a 2 to 15 km strip of land facing the lagoon. The interaction between the stack plume and the mixing height depends both on the stack height and its distance from the shoreline.

1.2.2 Other Relevant Publications

Benassi A., F. Dalan, A. Gnocchi, G. Maffeis, G. Malvasi, F. Liguori, D. Pernigotti, S. Pillon, M. Sansone, L. Susanetti, 2007. The Veneto region modelling system for air quality assessment, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, 2 -5 July 2007.
Dalan F., Benassi A., Maffeis G., Pillon S., 2005. The lagoon influence on the atmospheric dispersion in Venice. 5th Conference on Urban Air Quality, Valencia, Spain, 2005.
Dalan F., Pillon S., Maffeis G., Liguori F., Benassi A., 2005. Validation and source apportionment analyses of CAMx model over the Veneto Region and Venice Lagoon, 10th International Conference on "Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes" Sissi, Crete, October 17-20, 2005.
Deserti M., Bande S., Angelino E., Pession G., Dalan F., Minguzzi E., Stortini M., Bonafè G., De Maria R., Fossati G., Peroni E., Costa M.P., Liguori F., Pillon S., 2007. *Rapporto Tecnico sulla applicazione di modellistica al bacino padano adriatico,* Rapporto Tecnico CTN-ACE.
Gnocchi A., G. Malvasi, G. Maffeis, K. Lorenzet, L. Susanetti and A. Benassi, 2006: Stima delle emissioni in atmosfera nella laguna di Venezia secondo un approccio integrato Top-Down e Bottom-Up, Ingegneria Ambientale 7/8, 359-368.
Gnocchi, A., G. Maffeis, G. Malvasi, L. Susanetti, K. Lorenzet and A. Benassi, 2005. An integrated top-down and bottom-up approach to estimate atmospheric emissions in the Venice Lagoon, 1st International Conference on Harbours & Air Quality, Genoa (Italy), 15 - 17 June.
Latella Aurelio, A. Benassi, E. Baraldo, A. De Bortoli, P. Tieppo, 2006. Rural bonfires and the urban area: relevance of an announced pollution episode. Advanced Atmospheric Aerosol Symposium (AAAS), Chemical Engineering Transaction, vol. 10, 387-394, 2006.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi and G. Paolucci, 2008. Particle-bound organics in the urban and suburban area of Padua. European Aerosol Conference (EAC2008), Thessaloniki, Greece, August 24-29, 2008.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi and G. Paolucci, 2008.. DTD-GC-MS di filtri PM10 non precondizionati. 3° Congresso Nazionale sul Partico lato Atmosferico PM2008, Società Italiana di

Aerosol, Società Chimica Italiana, Università degli Studi di Bari, Comune di Bari, Bari, Italy, October 6-8, 2008.
Latella Aurelio, L. Cobelli, A. Miliazza, 2008. Thermal desorption of organics from PM filters using the Gerstel TDU. Anatune Autumn Conference "Automation in the Chromatography Laboratory" , London (Hatfield Heath Nr Bishop's Stortford Hertfordshire), October 1-2, 2008.
Latella Aurelio, M. Cavallazzi, G. Cobelli, A. De Bortoli, P. Tieppo, 2006. DTD-GC-MS Analysis of ambient air particulate matter during bonfires lighting. 29th International Symposium on Capillary Chromatography, Riva del Garda (TN), Italy, 29 Maggio - 2 Giugno, 2006.
Latella Aurelio, M. Cavallazzi, A. Benassi, A. De Bortoli, P. Tieppo, 2006. Caratterizzazione DTD-GC-qMS di polveri sottili durante un tradizionale evento di combustione antropogenica. 2° Convegno Nazionale sul Particolato Atmosferico PM2006, Firenze, 10-15 Settembre, 2006.
Latella Aurelio, G. Marson, A. Benassi,2007. Venice under siege by biomass burning. European Geosciences Union General Assembly 2007, Vienna, Austria, April, 15-20, 2007. Geophysical Research Abstracts, Vol. 9, 08675, 2007.
Latella Aurelio and A. Benassi, 2007. Annual semicontinuous monitoring of surface PAH(s) in the Venice mainland. 2007 European Aerosol Conference (EAC2007), Salzburg, Austria, September 9-14, 2007.
Latella Aurelio, L. Sperni, E. Rampado and A. Benassi, 2007. Speciation of semivolatile organics in the Veneto’s bonfires aerosol. 2007 European Aerosol Conference (EAC2007), Salzburg, Austria, September 9-14, 2007.
Latella Aurelio, A. De Bortoli, G. Marson, E. Baraldo, P. Tieppo and A. Benassi, 2007. Exceptional urban air pollution episode from biomass burning. 2007 European Aerosol Conference (EAC2007), Salzburg, Austria, September 9-14, 2007.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi and G. Paolucci, 2007. Screening of PAH(s) in PM10 samples collected on untreated glass fibre filters.2007 European Aerosol Conference (EAC2007), Salzburg, Austria, September 9-14, 2007.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi and G. Paolucci, 2008. Advanced routine PMx characterization: contradiction or feasibility of an almost careless technique. 32nd International Symposium on Capillary Chromatography, Riva del Garda (TN), Italy, 25-30 Maggio, 2008.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi, G. Paolucci, 2008. Advanced routine PMx characterization: contradiction or feasibility of an almost careless technique. XI Congresso Nazionale di Chimica dell’Ambiente e dei Beni Culturali: Dalla conoscenza alle strategie di intervento. Porto San Rocco, Muggia (Trieste), Italy, 16-20 Giugno, 2008.
Latella Aurelio and A. Benassi, 2008. Kerbside aerosol monitoring in downtown Padua. 1. Trace gases, SPAH and meteorological implications. 2008 European Aerosol Conference (EAC2008), Thessaloniki, Greece, August 24-29, 2008.
Latella Aurelio and A. Benassi , 2008. Kerbside aerosol monitoring in downtown Padua. 2. Ozone precursors and PAH(s). 2008 European Aerosol Conference (EAC2008), Thessaloniki, Greece, August 24-29, 2008.
Latella Aurelio, A. Benassi, 2008. Aerosol monitoring a bordo strada nel centro storico di Padova. 1. Trace gas, SPAH e implicazioni meteorologiche. 3° C ongresso Nazionale sul Particolato Atmosferico PM2008, Società Italiana di Aerosol, Società Chimica Italiana, Università degli Studi di Bari, Comune di Bari, Bari, Italy, 6-8 Ottobre, 2008.
Latella Aurelio, A. Benassi, 2008. Aerosol monitoring a bordo strada nel centro storico di Padova. 2. Misura semicontinua di particolato con sensori. 3° Congresso Nazionale sul Particolato Atmosferico PM2008, Società Italiana di Aerosol, Società Chimica Italiana, Università degli Studi di Bari, Comune di Bari, Bari, Italy, 6-8 Ottobre, 2008.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi, G. Paolucci, 2008. Analisi quantitativa di SVOC su PMx mediante DTD-GC-MS. 3° Congresso Nazionale sul Particolato Atmosferico PM2008, Società Italiana di Aerosol, Società Chimica Italiana, Università degli Studi di Bari, Comune di Bari, Bari, Italy, 6-8 Ottobre, 2008.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi, G. Paolucci, 2010. Aerosol a Padova centro: 1. Misura giornaliera e semicontinua di IPA su PMx. 4° Congresso Nazionale sul Particolato Atmosferico PM2010, Società Italiana di Aerosol, Società Chimica Italiana, Università degli Studi di Venezia, Comune di Venezia, Venezia, Italy, 18-20 Maggio, 2010.
Latella Aurelio, L. Sperni, L. Cobelli, A. Benassi, G. Paolucci, 2010. Aerosol a Padova centro: 2. Ozono precursori in aria, opani ed altri organici semivolatili su PM2.5. 4° Congresso Nazionale sul

Particolato Atmosferico PM2010, Società Italiana di Aerosol, Società Chimica Italiana, Università degli Studi di Venezia, Comune di Venezia, Venezia, Italy, 18-20 Maggio, 2010.
Latella Aurelio, K. Lorenzet, G. Rizzi, A. Benassi, 2010. Aerosol a Padova centro: 3. Monitoraggio veloce del particolato con sensori ottici e ionizzanti. 4° Congresso Nazionale sul Particolato Atmosferico PM2010, Società Italiana di Aerosol, Società Chimica Italiana, Università degli Studi di Venezia, Comune di Venezia, Venezia, Italy, 18-20 Maggio, 2010.
Liguori F., S. Pillon, F. Dalan, A. Benassi, 2007. A model application for the estimation of the traffic policy restriction effectiveness, 6th International Conference on Urban Air Quality Cyprus, 27-29 March 2007.
Maffeis G., Pillon S., Dalan F., Liguori F., Benassi A., 2005. *Validation, sensitivity and source apportionment analyses of CAMx model over the Veneto Region and Venice Lagoon*. Book of Abstracts "1st International Conference on Harbours & Air Quality", 15-17 June 2005, Genova, p. 217-224.
Pillon S., F. Liguori, L. Susanetti, F. Dalan, G. Maffeis, G. Malvasi, 2009. MODELLING OF ORGANIC AND INORGANIC MICROPOLLUTANTS ON THE LAGOON OF VENICE. 7th INTERNATIONAL CONFERENCE ON AIR QUALITY – SCIENCE AND APPLICATION24-27 MARCH 2009. ISTANBUL.

2. Modeling activities

2.1 Model used and main characteristics

The modelling system used up until recently by ARPAV-Air Observatory for air quality assessment over the whole Veneto Region was composed by an integrated Bottom-Up and Top-Down emission inventory (Gnocchi et al. 2005), the diagnostic meteorological model CALMET (Scire et al., 2000) and the Chemical Transport Model CAMx (Environ, 2004). The domain covered most of the Veneto region on a 50x42 horizontal mesh with 4x4 km^2 resolution.
The ARPAV modelling system for air quality was validated with measurements using one year of model simulation (Benassi *et al.*, 2007). Considering the current scientific knowledge in pollution modelling, a satisfying level of correlation between model and measurements for all pollutants had been reached. Furthermore the model estimated a reasonable magnitude of the deposition field for sulphates and nitrates .
Yet, some challenges were open to drive future improvements with respect to O_3 summer peak underestimation, tendency to overestimate the NO_2 at night-time and PM10 underestimation (Benassi *et al.*, 2007).
General improvements of model chain is regarding: inventory completeness (particularly for PM), implementation of a prognostic meteorological model and temporal profiles for emission sources.
As regards the **Emission Inventory**, the national Top-Down emission inventory, disaggregated at province level in space and at activity level of SNAP'97 nomenclature (APAT, 2004), was further disaggregated to the municipality level (Gnocchi et al., 2005 and Gnocchi et al., 2006) carefully choosing proxy variables tailored for each sector. Emissions were then distributed over a regular grid based on the land-use, i.e. residential combustion was distributed over urban areas. Furthermore emissions were chemically disaggregated and temporally modulated considering local data from each emission sector (Maffeis et al., 2004). The major point sources for emissions belonging to industrial SNAP sectors (1, 3, 4, 6 and 9) were collected in a Bottom-Up inventory.
This mixed Top-Down and Bottom-Up inventory is now substitute by the INEMAR, the Regional Inventory that ARPAV-Air Observatory is in charge of filling and managing (see next paragraph).
CALMET model, used to produce the **meteorological** input **fields**, blended together data coming from 32 surface stations (9 synoptic and the remaining operated by ARPAV-CMT), 1 off shore station (operated by Venice Municipality) and 3 radio-sounding stations (raob stations) and provided the chemical model CAMx with the hourly temperature field, the

horizontal wind, and the vertical diffusivity (following CALGRID method, Yamartino et al., 1989) at every grid cell. Furthermore, pressure and water vapour content were directly computed by interpolation of radio-soundings data while an ad-hoc processor interpolated synoptic cloud data and produces three-dimensional cloud input fields. The meteorological processor had been tuned to best represent the meteorological fields in the domain of interest [Sansone et al., 2005 and Pernigotti et al., 2005). Vertically CALMET was initialised with 10 levels from the surface to 3000m height.
The diagnostic meteorological model CALMET is going to be substitute or at least put side by side by the non-hydrostatic meteorological model LAMI, the Italian version of the Lokal Modell (Steppeler, 2003), which is operational at ARPA-SIM.
ARPA SIM, as member of the European research consortium COSMO (http://www.cosmo-model.org/), provides two runs a day of LAMI. In the operational configuration, LAMI runs on a domain covering Italy and the central Mediterranean (1900 x 1600 km). The horizontal grid uses Arakawa C-grid and spherical rotated coordinates, with a mesh size of 0.0625° (~7km,).
In the vertical, terrain-following hybrid sigma coordinates are used, with 35 layers covering most of the atmosphere: there are 10 levels in the the lowest 1500m, and model top is set at 30 hPa. LAMI uses mean orography derived from GTOPO30 data set (30''x30'') of USGS, prevailing soil type from DSM data set (5'x5') of FAO, land-fraction, veg cover, root depth and leaf area index from CORINE data set of ETC/LC (250m), roughness length from GTOPO30 and CORINE. DWD's operational global model GME (icosahedral-hexagonal grid with a mesh size of ~60km) provides boundary conditons and initial conditions for surface parameters; initial conditions for non-surface variables are calcultaed through a continuos assimilation cycle (Jongen S. and G.Bonafè, 2006).
CAMx (Environ, 2004, v. 4.03) was set-up to run with chemical mechanism n° 4, specifically Carbon-Bond IV with extension for aerosol modelling, distinguishing among only two particulate sizes, coarse (PM2.5-PM10) and fine (<PM2.5); the PiG submodel was activated for main stacks (power plants principally).
Model outputs obtained by latter versions of CAMx and using also the specific model for PM source apportionment (PSAT Tool) are going to be published in the framework of the new Regional Air Quality Plan.
Boundary and **initial condition** are given by CHIMERE output from Prev'air system (http://prevair.ineris.fr) with 0.5° of resolution (roughly a 30x50 Km2 mesh). Initial conditions consistes of a single 3D field of the species modelled by CAMx while the top condition for each chemical specie was constant both in space and time.
Ozone column level, atmospheric turbidity are downloaded from the NASA web and ftp sites. A 5-dimensional table of photolysis rates is obtained from the TUV model for each of the six photochemical reactions included in CAMx chemical mechanism.
In the framework of APICE it is foreseen to apply the new LAMI-CALMET-CAMx modelling chain, using INEMAR output as emissions on the domain covering Veneto Region (grid size 4 km). A nested grid (1 km resolution at least) covering the study area is foreseen as well.

2.2 Emission Inventories

The emission inventory adopted by ARPAV-Air Observatory is INEMAR, acronym which stands for the Italian name INventario EMissioni in ARia (Air Emissions Inventory).
INEMAR was originally founded by Lombardy Region in the late nineties within the framework of the Regional Air Quality Management Plan (PRQA) and then, in 2006, adopted by Veneto Region together with Piemonte, Emilia Romagna, Friuli Venezia Giulia, and Puglia Regions. Regions have put in charge of the db management, that comprehends the local data collection and the running of the calculation algorithms, their respective Environmental Protection Agencies.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

The INEMAR system considers emissions of different sources (point, area, biogenic, road transport), and organizes all information needed for their estimation: activity indicators, emission factors, other statistical data necessary on spatial and temporal distribution of emissions (Caserini, 2002).
For the activities' classification the SNAP 97 Nomenclature (E.E.A., 2000), used for the CORINAIR (CooRdination InformationAIR) project, promoted by the European Union, is adopted together with IPCC classifications.
Estimates are based on data measured by industrial plans, on emission factors and methodologies proposed by EMEP-Corinair. COPERT IV methodology is adopted for road transport emissions. The IPCC methodology is adopted for landfill emissions estimate, with some variations and adaptations to the Italian context.
The SNAP97 system is set up according to three levels:
the upper level - 11 source categories which features grouping of sources as commonly performed;
the intermediate level - 75 source subcategories embodying technological and social-economic criteria;
the lower level - 416 source activities, aiming at an exhaustive enumeration of sources and sinks to spot homogeneous sections in generating emissions.
INEMAR's resolution is at municipality level (513 Municipalities in Veneto).
The atmospheric pollutants taken into consideration in INEMAR are

- sulfur oxides (**SOx**);
- nitrogen oxides (**NOx**);
- non-methane volatile organic compounds (**NMVOC**);
- methane (**CH_4**);
- carbon monoxide (**CO**);
- carbon dioxide (**CO_2**).
- ammonia (**NH_3**);
- nitrous oxide (**N_2O**);
- total suspended particulate matter (**TSP**);
- particulate matter with diameter below 10 μm (**PM10**);
- particulate matter with diameter below 2.5 μm (**PM2.5**).

Elaborations are still in progress in order to assess emissions of micro-pollutants (**metals, organic chloride compounds, PAH**). For these pollutants, in fact, there are generally few measurements available only for few activities such as waste incineration and cement industry.
Some pollutants, such as non-methane organic volatile compounds (**NMVOC**), are very wide classes of pollutants, that can contain very diverse compounds (i.e. hydrocarbons or benzene). Emission estimates for these pollutants are more affected by a high range of uncertainty, as census and estimate methodologies followed the ones used for the other pollutants (indicator and total emission factor), remanding then to disaggregation to a single NMVOC component.
As concerns **particulate matter**, PM10 and PM2.5 are estimated on the basis of source specific granulometric distributions of TSP .
The first release for INEMAR Veneto is available for **reference year 2005**. The db results are going to be publishing by ARPAV in Internet initially as a public review.
Update to year 2007 is ongoing.
In the Venetian area INEMAR gathers emissions from about 35 industrial plants, treated as point emissions. Most of them are industrial plants of the Porto Marghera area (main activities are: coke-derived production, petrochemical production, refineries, aluminum and semi-finished material production, shipyards, chemistry, fertilizer production, urban and industrial waste treatment, coastal oil storage, and energy production).

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

INEMAR takes into account **harbor emissions** derived by a bottom up estimation conducted by ARPAV-DAP VE in 2007 (ARPAV, 2007. A cura di Rosa *et al.*) , and related to year 2005. Data on ship movements during the whole year 2005 were supplied by Venice Port Authority, as well as the classification of every single ship on a restricted number of typologies. This classification has allowed to apply the MEET methodology (Trozzi and Vaccaro, 1998) for ship emissions quantification starting from a restrict number emissions factors and the different operational phases such as landing and standing phases (EC, 2002).
INEMAR considers emissions generated by the airport of Venice, too. Also this estimation derives by a study conducted by ARPAV-DAP VE in 2007 (ARPAV, 2007. A cura di Rosa *et al.*) and related to year 2005.

2.3 Lack and specific needs

APICE is expected to clarify not only the relative weight of different sources on the study area but also the effectiveness of realistic scenarios.
In order to achieve this goal it is necessary to have a sufficiently detailed emission inventory on those activities that will be involved on scenario that are going to be evaluated.
Thus it is foreseen the necessity of a close examination to some activities both relative to the harbor and to the industrial emissions.
As regards emission inventory, the INEMAR database doesn't consider **sea salt emissions**, nor **wind blown dust.**
As regards the eulerian modeling chain, the inclusion of a **Prognostic Meteorological Model** (LAMI or WRF) is considered a major issue.
Boundary and **Initially Conditions** for scenario run maybe projected on a distant future could be a issue to be resolved too.

3. Source apportionment activities

3.1 Species measured

The characterization of the semivolatile organic compounds (SVOC) in the atmospheric particulate matter will be performed by Direct Thermal Desorption GC-MS (DTD-GC-MS), a technique proposed in aerosol research studies (Hays, et al., 2004, Chow et al. 2007, Lavrich et al. 2007), and routine analysis (Schnelle-Kreis, et al. 2007) for screening, compliance verification and source receptor modelling (Schnelle-Kreis, et al. 2007).
As part of the characterization of SVOC bound to atmospheric PM10 samples collected at the harbour and remote locations (Venice mainland) analysis will performed on a small punch from the 47 mm diameter filters without any sample preparation. Samples collected on glass fibre strip used by the automated bihourly PM10 analysers of the air quality survey network are also compatible with the technique.
A quantitative comparison of the port influenced and remote site samples will be possible (Figure 1) on the basis of the expected aerosol compounds from urban daily activities (PAH(s), n-alkanes, steranes and hopanes, see Tab 6).

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

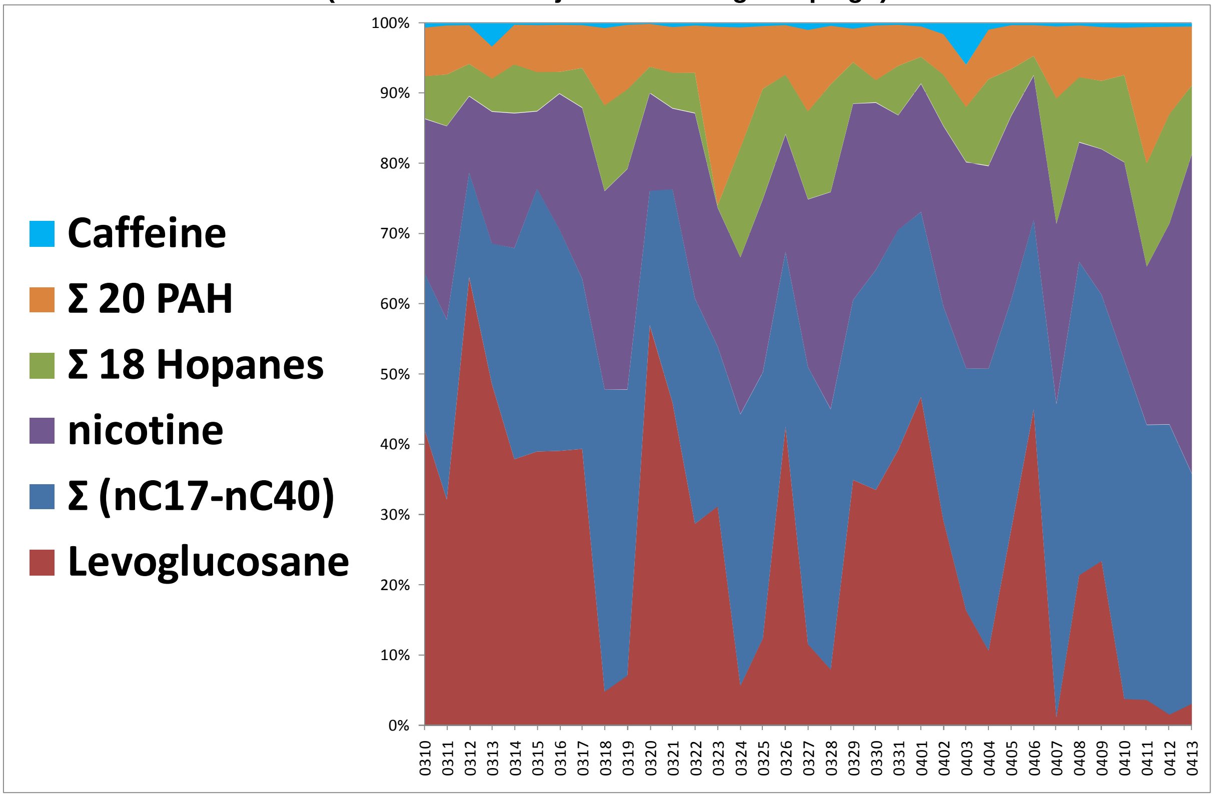
Tab 6. Non polar Semi Volatile Organic compounds quantified on PMx for receptor modelling in the Venice harbour area

Polycyclic Aromatic Hydrocarbons	Alkanes	Biomarkers
	All homologues from	
Naphthalene	n-C10	ααα (20S)-Cholestane
Acenaphthylene	to	αββ (20R)-Cholestane
Acenaphthene	n-C40	ααα (20R)-Cholestane
Fluorene	pristane	αββ (20R,24S)-24-Methylcholestane
Phenanthrene	phytane	17α(H)-22,29,30-Trisnorhopane
Anthracene		αββ (20R,24R)-24-Ethylcholestane
Fluoranthene		ααα (20R,24R)-24-Ethylcholestane
Pyrene		17α(H),21β(H)-30-Norhopane
Benz(a)anthracene		17α(H),21β(H)-Hopane
Chrysene		17β(H),21α(H)-Hopane
Benzo(b)fluoranthene		17α(H),21β(H)-(22S)-Homohopane
Benzo(k)fluoranthene		17α(H),21β(H)-(22R)-Homohopane
Benzo(a)pyrene		
Indeno(123-cd)pyrene		
Dibenz(a,h)anthracene		
Benzo(ghi)perylene		

According to Schnelle – Kreis (ES&T 2007) “Using positive matrix factorization (PMF) for the statistical investigation of the data set, five factors have been separated. These factors are dominated by the pattern of single sources or groups of similar sources: factor 1, lubricating oil; factor 2, emissions of unburned diesel and heating oil consumption; factor 3, wood combustion; factor 4, brown coal combustion; and factor 5, biogenic emissions and transport components.”. However these results have been obtained with the speciation of Polar Semi Volatile Organic Compounds that could be not performed by ARPAV analytical system. There will be however sufficient compounds and some markers to get results from the PMF in a similar way.
A qualitative screening, and relative intersamples comparison, of other less expected compounds from wood burning (levoglucosan) or alkaloids related to human habits and social behaviour like cigarette smoke and coffee will be also possible.
In Fig 50 is reported the daily relative composition on PM 2.5 of caffeine, nicotine, estimate of levoglucosan and the sum of speciated SVOC: 20 PAH, 18 hopanes, n-alkanes from nC17 to nC40. Some of the relevant decrease in the levoglucosane concentration is related to rainy days.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 50. Daily relative concentration of selected SVOC at Padua from March 3 to April 4 2008 (PARFUM Life Project monitoring campaign)



Other studies where molecular tracer species for wood smoke were found, reported the wood burning source as significantly contributing to the urban aerosol, especially in winter, in several European cities: Zurich, Duisburg, Prague, also at coastal sites like Amsterdam, Helsinki, Oporto, Copenhagen (Legrand et al., 2007, Saarikoski et al., 2008, Oliveira et al., 2007). ARPAV own findings for the city of Padua within the PARFUM project monitoring campaign, confirmed that, in addition to traffic in densely populated areas, incomplete biomass combustion with current heating appliances can be a major source of particulate pollution both at local and regional scales, then a substantial quote of air pollution in Europe during winter does not come from fossil fuel burning.
Results from the comparison of SVOC profile obtained during winter at Padua and at rural site (Monselice – Padua) on PMx samples with DTD-GC-MS, evidentiate differences in specific tracers like nicotine and caffeine and coronene more abundant at the urban kerbside and similar level of the odd number linear chain alkanes from wood burning as reported in Fig 51 and Fig 52. By the end of winter a substantial reduction in the presence of retene (wood burning proposed PAH tracer) was registered in the aerosol content (Fig 53)
A detailed speciation of SVOC in the PM10 at Venice mainland during the lighting of bonfires (on a regional scale) for the celebration of the eve of Epiphany. A detailed DTD-GC-MS analysis has been performed on bihourly PM10 samples. This high temporal resolution allows to follow the anthropogenic wood combustion event and closely follows the changes in the aerosol chemical properties as the wood burning source increase its contribution to the SVOC PM10 composition. Trend of PAH and n-alkanes and the Carbon Preference Index (CPI) along with the PM10 are reported in the following figures.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 51. Higher concentration of alkaloids and coronene in the PM10 at the urban kerbside of Padua compared to the rural site of Monselice. Quantitation obtained with DTD-GC-MS without sample preparation.

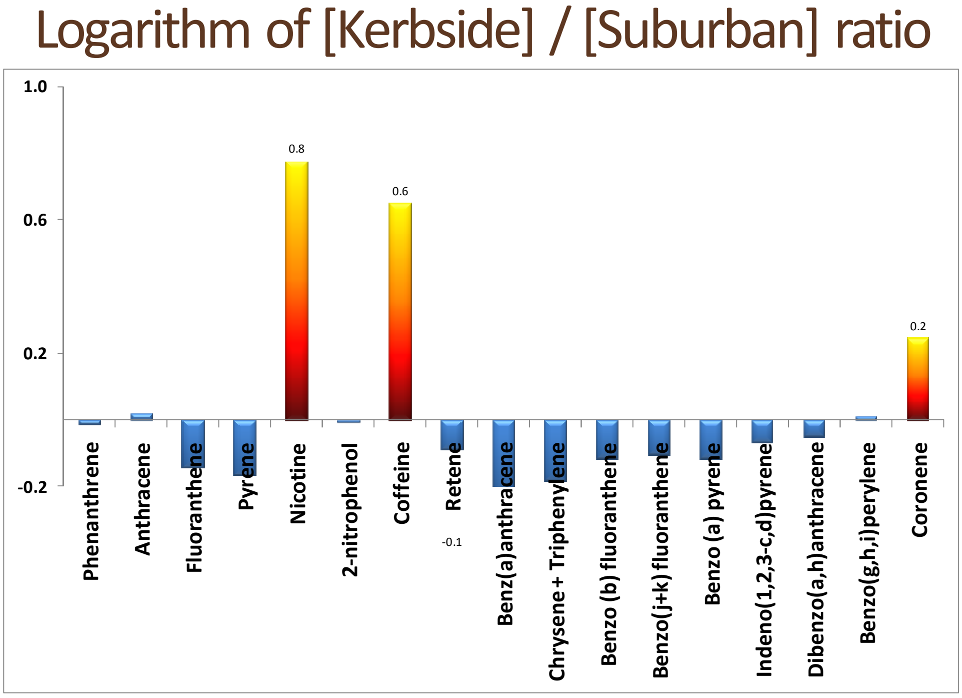
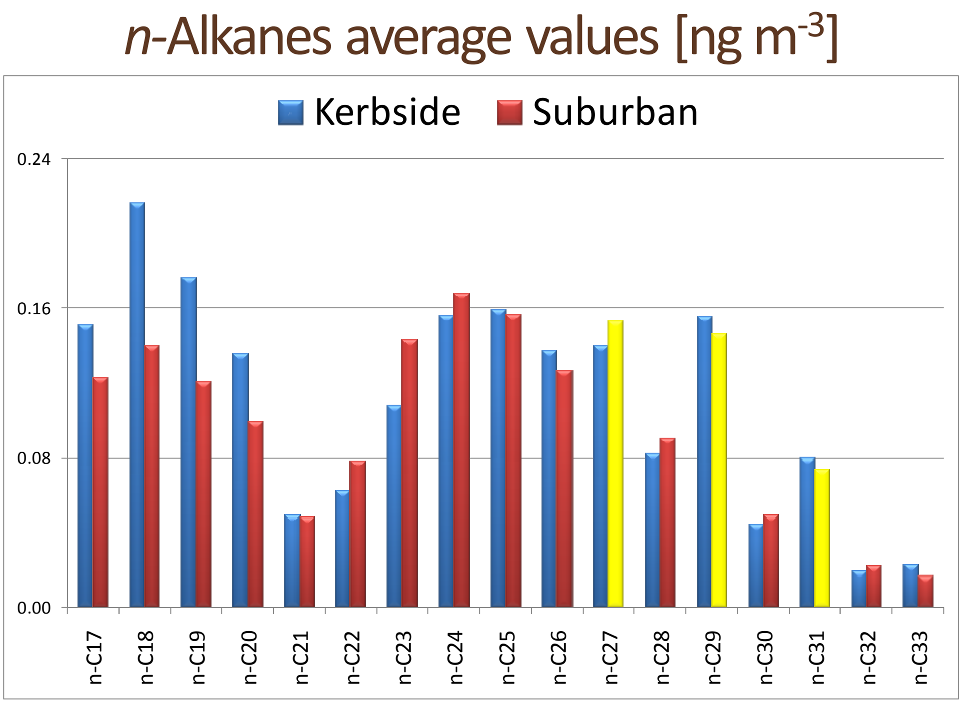


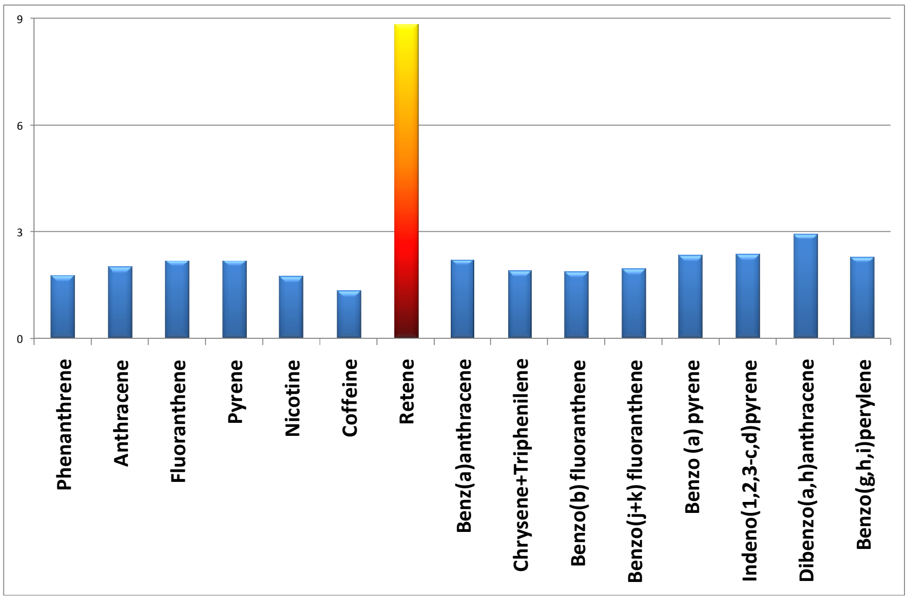
Fig 52. Higher concentration of alkaloids and coronene in the PM10 at the urban kerbside of Padua compared to the rural site of Monselice. Quantitation obtained with DTD-GC-MS without sample preparation.



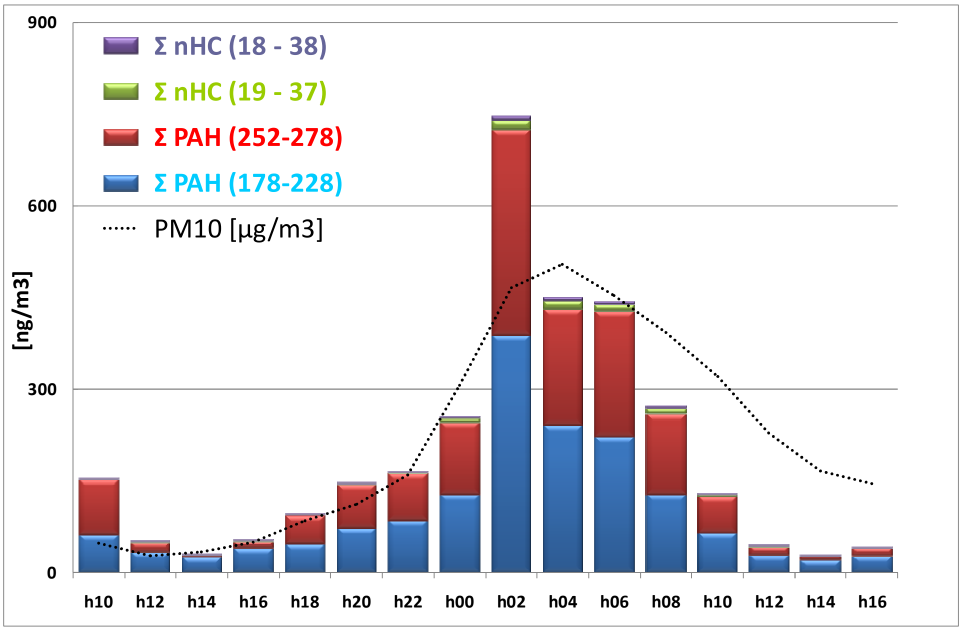
Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Fig 53. As spring approached and wood burning for heating discontinued, the urban aerosol concentration of retene (a proposed biomass burning tracer) dropped susbtantially compared to the other PAHs

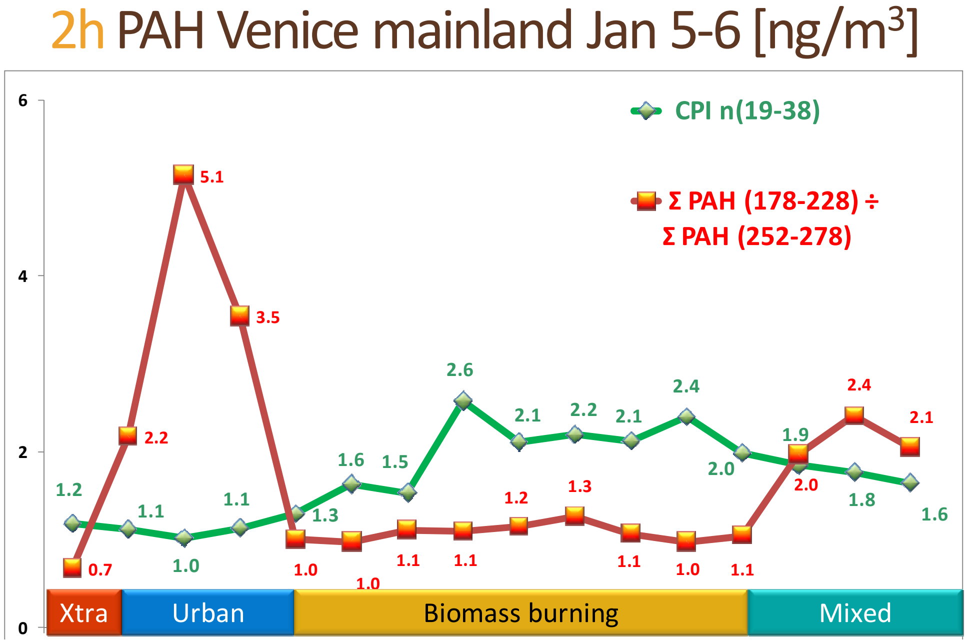
Kerbside: [late winter] / [early spring]



2h PAH Venice mainland Jan 5-6 [ng m^{-3}]



Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund



3.2 Source apportionment approaches and long observation period (LOP)

The air quality monitoring networks in the Venice area includes the mainland and the city. Several choices of background sites and harbour influenced spot can be assessed. An accurate evaluation of which site will be actually chosen is in progress. A rank of the possible combinations, with pros and cons of each, will lead to a number of 3 to 5 daily PMx samples. The aerosol's SVOC characterization will be available for at least a combination of one background and two sensitive spots, or a larger set of two background and three harbour influenced locations.
It's foreseen to carry out the Source Apportionment exercise by using Positive Matrix Factorization (PMF) model.
Even if other statistical models are also a possible choice, such as PCA or CMB, PMF model is considered a more suitable method because it doesn't need source profiles.
Given the peculiar mixed of emission sources not only in the surroundings of Venice (Porto Marghera), but even in its inner monumental city (such as the presence of a lot of artistic glass manufactories) difficulties in finding specific and trustworthy profiles could be onerous.

3.3 Lack and specific needs

APICE project is expected to clarify the major contributors to the PMx and SO_2 concentrations in the harbor area as well on the whole city.
Even if ARPAV-Air Observatory has a consolidated experience in air pollution monitoring, it doesn't have a personally experience in applying receptor models.
A collaboration in applying PMF or CMB algorithms by partners with long experience in this kind of modeling exercises is desirable.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

4. Normative frameworks and future scenario

4.1 Port Management and Development

4.2.1 4.1.1 Port Authority and other Institutions

The Venice Port Authority (VPA) is a public body by Law no. 84 of 28th January 1994. Its task is to guide, plan, co-ordinate, promote and monitor port operations. It is also in charge of maintaining common areas and the seabeds, overseeing the supply of services of general interest, managing the State Maritime Property and planning the development of the port.
In addition to the Port Authority, there are other institutions based in the Port of Venice. The Harbourmaster's Office monitors maritime navigation and ensures safety at sea, the Port and Airport Health Office (USMAF) checks the health and hygiene of transported goods and of the environment in which maritime activities are performed. The law enforcement agencies present in the port include the Finance Police (Guardia di Finanza) that monitors compliance to financial regulations and security in the port, the Immigration and Border Police is involved in operations associated to immigration and guards the State's borders. The Italian Customs Agency checks in- and out-bound cargo and passengers.

4.2.2 4.1.2 Stakeholders

_Venice Port Autority (PA);
_ Capitaneria di Porto (Harbour master);
_ Venice Water body (Magistrato alle Acque);
_ Venice Municipality (Comune di Venezia);
_ Province of Venice (Provincia di Venezia);
_ Veneto Region (Regione Veneto);
_ Port agents and operators (by Law 84/94, art. 16 comma a);
_ Companies that operate inside Port area, inscribed in Port Register. At 31st december 2009, 99 Companies are inscribed, according to PA Ordinance no 331, art. 3 (VPA 2009:100).

4.2.3 Port development (reference documents)

Venice Port Authority, Operating Plan 2008-2011, Strategic planning and development Office, Venice, 11th of September 2008.
Venice Port Authority, Operating Plan 2008-2011, first annual revision, Strategic planning and development Office, Venice, 3rd of February 2010.
Venice Port Authority, Annual Report 2009, Strategic planning and development Office, Venice 2009.

4.2.4 Strategic projects

A sizeable investment plan has been defined to enhance and boost the Port of Venice. The port's most ambitious projects for the Commercial area include the new container, Ro-Ro and off-shore terminals, while the tourist port's attractiveness will be augmented by new cruise ship terminals, and a large re-developed area with offices, leisure facilities, and a multi-storey car park. Between 2008 and 2011, EUR 870 M are being invested to develop the Port of Venice on both the cargo and the passengers side.

The Commercial Port

The new container terminal and the annexed Distripark will be completed by 2012. With 1,500 metres of quayside and warehouses for 10,000 sqm., the terminal will have a handling capacity of 600,000/800,000 TEUs. A new terminal that is about to be implemented in Fusina

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

is an answer to the increase in RO-RO and RO-PAX traffic driven by the Motorways of the Seas (MoS) initiative. With the launch of new national and cross-Mediterranean lines the port will be able to cater for 400,000 calls yearly. To achieve its full potential, the access channels to the Port of Venice will be dredged to a depth of 12 m to enable access to larger ships. Future ultra large ships will be able to dock off-shore in the terminal that is planned to be erected off the Malamocco port mouth, where the seabed is over 20 m deep.

Passenger Port

Already a top cruise homeport in the Mediterranean, Venice is enhancing the range of services offered by the passenger terminal. A fourth terminal station is about to be completed and in the future a new interface area will be constructed between the port and the city. This area will rise on a vast piece of land that will be renovated to host management and welcoming facilities, a large piazza/garden, shops, a conference centre, a hotel and a large parking facility serving both Venetian residents and the Port. This area is already well connected to the centre of Venice through the dedicated monorail People Mover.

The Off-shore terminal

The off-shore terminal just off the Port of Venice will berth larger ships and will bring both economic and environmental benefits. The Port of Venice is planning an offshore platform at some 10 km off the Malamocco port mouth where the seabed has a natural depth of 20 m. The off-shore terminal will allow today's and tomorrow's ultra-large ships to call at the Port of Venice without having to dredge the existing lagoon channels. It will also be possible to distribute goods to the European and Italian markets exploiting the most convenient land port. The terminal is expected to become the central link between the existing logistics centres and the maritime traffic generated by global trade. The off-shore platform will mainly handle oil, bulk, and container traffic. The transport of petroleum will be managed through pipelines that will link the terminal to the coast. As a result oil-tankers will be kept out of the lagoon, as specified in the special law for Venice. The new terminal will be able to berth ships with deeper draughts and it will also help the logistics platform and terminals in Marghera to handle containers.

The new container terminal

The new container terminal is designed to serve Central and European Countries making business with the Far East. The new Distripark for goods processing operations will rise at the side of the terminal. The overall increase in container traffic in the Mediterranean is a major opportunity for the Port of Venice to increase its market share in this area. Today, the Port of Venice is the main port in the Adriatic for container traffic. To further enhance its position, the port will enhance its ability to receive container traffic by erecting a new terminal that will initially will host up to 650,000 TEUs yearly. The terminal will be erected in the site of a former industrial facility in Porto Marghera (formerly Syndial and Montefibre). The Distripark that will rise at the side of the container terminal will receive goods that will be unloaded from containers and processed before being sent on to final destination. Traffic volumes in the Port of Venice will increase thanks to the new container terminal that will also act as a catalyst to encourage the reconversion of Porto Marghera.
Some figures for the new container terminal:

* 650,000 TEUs/year;
* 1,500 m of quayside;
* 91 ha surface (32 ha for the Distripark);
* 100,000 sqm. of logistics warehouses.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

The new Venice container terminal will be fully integrated with the freight villages located in the Veneto Region and enable the Upper Adriatic port system to act as main gateway for goods exchanged between Central and Eastern Europe and the Far East.

New Motorways of the Seas terminal

The new Motorways of the Seas terminal will be completed by 2012 in Fusina and will have its own logistics platform and the ability to serve up to 1,000 ferries and 110 trains/year. The new Motorways of the Seas terminal will be constructed in Fusina at the junction between the southern industrial channel and the Malamocco-Marghera channel. It will be equipped with 2 marinas for a total of 4 quays to berth simultaneously up to 4 ships. It will serve rolling stock traffic, i.e. ferries transporting trucks or their trailers (Ro-Ro) and ferries carrying cars and passengers (Ro-Pax). In addition to the new port infrastructure, the project envisages the erection, in an area of 36 hectares, of a new logistics platform with links to rail and roadways, new buildings, warehouses, classification yards and parking lots. Initially, the new terminal will handle up to 850 ferries yearly. Once the railway connection has been completed, it is expected to handle up to 1,000 ferries and 110 trains a year. The project will be implemented using the project financing tool and will involve a group of Venetian businesses that have joined forces to establish the Venice New Port consortium that will manage the marina and the quayside for 40 years.

In addition to enhancing the port's rolling stock market, the new Fusina terminal will also benefit the city of Venice. All ferry ships that currently sail along the Giudecca Channel will enter the lagoon through the Malamocco port mouth: the total yearly reduction of traffic will be 500 less vehicles on the Ponte della Libertà and 400 less ferries in the Giudecca Channel. The project will recover a brownfield site and is part of the broader plan to reconvert and remediate the vast area of Porto Marghera.

A multi-functional facility

A new multi-functional facility will be erected between Venice and its port (near the Marittima station): it will include offices, shops, a hotel and a large car park to serve the port and Venice. The facility will serve as interchange to and from the city and the port and will include the People Mover's intermediate station, the monorail that links the island of Tronchetto to Piazzale Rome. The project will involve an area of some 40,000 sqm; works will cost EUR 63,235,000, wholly financed through own resources and private investors.

Main specifications:

* 135,000 cu.m. for car parks and associated services;
* 8,500 cu.m. for offices and law enforcement facilities;
* up to 50% of 50,000 cu.m.-25,000 cu.m. for hotel facilities and services;
* up to 40% of 50,000 cu.m.-20,000 cu.m. for offices;
* up to 10% of 50,000 cu.m.-5,000 cu.m. for shops;
* 2,400 car parks per garage.

The project is supervised by APV Investimenti, a company owned by the Venice Port Authority, and is currently in its final phase. Its implementation has been entrusted to a team led by Prof. Mauro Galantino.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

4.2 The Port of Venice and environmental policies

4.2.1 Green Port strategy

Environmental sustainability is one of the Venice Port Authority's main objectives, encouraging it to sponsor projects to cut the environmental impact of port operations on the city and the lagoon. This is particularly important for conserving the natural balance of this delicate city and its unique lagoon environment. Venice Port is part of the Association of North Adriatic Ports[1] (Associazione dei Porti del Nord Adriatico, NAPA), which aims at improving potentialities, quality and efficiency of North Adriatic Ports system and infrastructures. One of the main objectives concerns environmental protection and quality.
Activities undertaken under the "Green Port" initiative focus of four main areas: air, water, soil and the city of Venice. With respect to air pollution, in addition to air quality monitoring and assessment, the port has started up a number of projects aimed at cutting dangerous emissions and promoting the use of alternative energy.
The projects aimed at safeguarding the air in Venice and the port environment also include efforts to save energy and to cut CO_2 emissions, also using alternative energy sources. The projects are as follows:
_ cold ironing: as a result of the cold-ironing project, ships will be powered from the quayside. This means that when at berth, ships do not need to keep their engines running to generate power;
_ photovoltaic park: the photovoltaic park will be erected in the areas directly managed by the Port Authority in Marghera and the Marittima station. The project will be implemented starting from the Marittima and will generate 2.5 Mwp (i.e. the energy needed by 800 families);
_ LED illumination: Starting from the Marittima station, the Venice Port Authority will be the first port in Italy to install LED spotlights to achieve a 70% saving compared to traditional illumination systems;
_ power plant resorting to algae as biomass: The algal power plant project is indeed a technological challenge as it implements zero impact solutions that are a worldwide novelty;
_ assessment of ship emissions: the Port Authority has studied the extent to which transiting cruise ships impact the air quality in the city of Venice. State of the art methods and real-time measurements have provided broad understanding of the impact of ships on the air quality in the Port of Venice and have also enabled an assessment of impact reduction activities.

4.2.2 "Blue flag" environmental protection certification (2007)

Venice Blue Flag is a voluntary agreement aimed at reducing emissions and safeguarding the artistic and cultural integrity of Venice. Some Cruises adopted measures to reduce sulphurous anhydride (SOX) and nitrogen oxide (NOX) emissions, utilising diesel fuel with a sulphur content not exceeding 2.5% during transit and stop off in the Venice Lagoon. This led to the signing of the Venice Blue Flag, a partnership between Cruises and the institutions of Venice aimed at preserving the artistic beauty of Italy's canal city. The agreement gives place to the environmental protection certification call "Venice Blue Flag".

1 Founded in 2009 by Ports of Koper, Venice, Trieste and Ravenna.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Shipping Companies awarded with “Blue Flag 2007” were: Aida Cruise, Carnival Cruise Line, Costa Crociere, Cunard Line, Holland America Line, Ocean Village, P & O Cruises, P & O Cruises Australia, Princess Cruises, Seabourn Cruise Line, Pullmantur Cruises, Elegant Cruises and Tours, Crystal Cruises, Regent Seven Seas Cruises, SeaDream Yacht Club, Virtu Ferries, MSC Crociere, Anek Line, Iberojet Cruceros, Island Cruises, Louis Cruises Lines, Marina Cruises Company, Norwegian Cruise Line, Oceania Cruises, Orient Lines, ResidenSea, Saga Shipping, Silversea Cruises, Royal Caribbean International, Celebrity Cruises.

4.2.3 Studies and researches

Ca' Foscari University and CNR (- ISAC-CNR, IDPA-CNR), “Air pollution: survey on the influence of passenger maritime transportation on Venice air quality”, surveys in 2007, 2008 and 2009.
A. Miola, V. Paccagnan, I., Mannino, A. Massarutto, A. Perujo, M. Turvani, 2008, “External costs of Transportation Case study: maritime transport”, European Commission Joint Research Centre Institute for Environment and Sustainability, Luxembourg.
Ente Zona Porto Marghera (Industrial Area of Marghera Board) and Ca' Foscari University, study on sedentary particulate and thermic inversion, ongoing project.

4.2.4 Port Authority Ordinances

Ordinance No. 18 of 30/09/1996, Safety rules for "open loop" filling in of diesel machines by truck in the operational area.
Order No. 30 of 18/03/1997, Rules for the handling of bulk chemical origin of mineral.
Order No. 85 of 04/10/1999, Emergency Procedures for the Port of Venice.
Order No. 104, 29/08/2000, Safety for the “open loop” supply toof oil to the production machinery in the port operational areas by truck and on board ships by tanks.

4.2.5 Planning tools

Veneto Region, Regional Territorial Masterplan (Piano Territoriale Regionale di Coordinamento, P.T.R.C.), Report, Veneto Region Council, decree No. 372 of 17/02/2009.
Province of Venice, Provincial Territorial Masterplan (Piano Territoriale di Coordinamento Provinciale di Venezia, P.T.C.P.), Provincial Council, Decree No. 2008/104 of 05/12/2008.
Veneto Region, Regional Plan of Conservation and Restoration of the Atmosphere (Piano Regionale di Tutela e Risanamento dell'Atmosfera, P.R.T.R.A.), 2004.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

5. References

APAT Agency for Environmental Protection and Technical Services, 2004. La disaggregazione a livello provinciale dell'inventario nazionale delle emissioni – Rapporto Finale (in italian).
ARPA Veneto profiler data available in real time at http://www.arpa.veneto.it/bollettini/htm/profilatori.asp
ARPA Veneto, Dipartimento Provinciale di Venezia, 2008. rapporto annuale ARIA 2007 http://www.comune.venezia.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/29764
ARPA Veneto, Dipartimento Provinciale di Venezia, 2009. rapporto annuale ARIA 2008 http://www.comune.venezia.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/29764
ARPA Veneto, Dipartimento Provinciale di Venezia, 2010. rapporto annuale ARIA 2009 http://www.comune.venezia.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/29764
ARPAV, 2007. A cura di M. Rosa, S. Pistollato:, C. Zemello. Le emissioni aeroportuali. http://www.arpa.veneto.it/dapve/docs/Relazione_tecnica_emissioni_aeroportuali.pdf
ARPAV, 2007. A cura di M. Rosa, S. Pistollato:, C. Zemello. Le emissioni da attività portuale. http://www.arpa.veneto.it/dapve/docs/Relazione_tecnica_emissioni_portuali.pdf
Benassi A., F. Dalan, A. Gnocchi, G. Maffeis, G. Malvasi, F. Liguori, D. Pernigotti, S. Pillon, M. Sansone, L. Susanetti, 2007. The Veneto region modelling system for air quality assessment, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, 2 -5 July 2007.
Biancotto R., Piovesan M., Pistollato S., Rosa M., Zemello C., 2007. Studio pilota sulla caratterizzazione del PM10 in provincia di Venezia. Dicembre 2007. http://www.arpa.veneto.it/dapve/docs/Studio_pilota_PM10_VE_dic2007.pdf
Binkowski, F. S., 1999. The aerosol portion of Models-3 CMAQ. In Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. Part II: Chapters 9-18. D.W. Byun, and J.K.S. Ching (Eds.). EPA-600/R-99/030, National Exposure Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC, 10-1-10-16.
Binkowski, F.S., Roselle, S.J., 2003. Models-3 community multiscale air quality (CMAQ) model aerosol component 1. Model description. Journal of Geophysical Research, 108 (D6), 4183.
Carter, W.P.L, 1990. A detailed mechanism for the gas-phase atmospheric reactions of organic compounds.
Caserini S., A. Fraccaroli, A. M. Monguzzi, M. Moretti, A. Giudici, E. Angelino, G. Fossati, 2005. L'INVENTARIO DELLE EMISSIONI IN ATMOSFERA IN LOMBARDIA:STATO DELL'ARTE E PROSPETTIVE. IA Ingegneria Ambientale vol. XXXIV n. 5 maggio 2005
Caserini Stefano, Anna Fraccaroli, Anna Maria Monguzzi, Marco Moretti, Angelo Giudici, Giovanni Volpi, 2002. The INEMAR database: a tool for regional atmospheric emission inventory. Proc. IEMSS 2002, 1, 186-191, 2002.
Chow J.C., J.Z. Yu, J.G. Watson, S.S.H. Ho, T.L. Bohannan, M.D. Hays, K.K. Fung, J. Environ. Sci. Health-Part A 42 (2007) 1521
Dalan F., Pillon S., Maffeis G., Liguori F., Benassi A., 2005. Validation and source apportionment analyses of CAMx model over the Veneto Region and Venice Lagoon, 10th International Conference on "Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Sissi, Crete, October 17-20, 2005.
Desiato F., Finardi S., Brusasca G. and Morselli M.G, 1998. "TRANSALP 1989 Experimental Campaign - Part I: Simulation of 3-D Flow with Diagnostic Wind Field Models", Atmospheric Environment, 32, 7, 1141-1156, 1998.
E.E.A., European Environment Agency, 2000. EMEP/CORINAIR Atmospheric Emission Inventory Guidebook (Second edition), EEA, 2000.
Ente della Zona Industriale di Venezia, 2010. Rete di controllo della qualità dell'aria. Presentazione dei rilevamenti nell'anno civile 2009.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

ENVIRON International Corporation, 2004. Comprehensive Air Quality Model with extensions (CAMx), versione 4.03 ENVIRON International Corporation, USA (http://www.camx.com).
EU, 2008. Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.
European Commission, 2002. Quantification of emission from ships associated with ship movements between ports in the European Community. Final Report. Luglio 2002.
Ferraio Massimo Enrico, Andrea Massimo Rossa, Maria Sansone, and Antonio della Valle, 2010. HETEROGENEITY OF ACCUMULATION AND DISPERSION CONDITIONS FOR PM10 IN THE PO VALLEY. 13th Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 1-4 June 2010, Paris, France
Finardi, S., De Maria, R., D'Allura, A., Cascone, C., Calori, G., and Lollobrigida, F., 2008. A Deterministic Air Quality Forecasting System For Torino Urban Area, Italy. Environmental Modelling and Software, 23, 344-355
FUMAPEX, 2006. Integrated Systems for Forecasting Urban Meteorology, Air Pollution and Population Exposure: Final Project Scientific Report. In Baklanov, A. (Ed.). http://fumapex.dmi.dk.
Gariazzo C., Silibello C., Finardi S., Radice P., Piersanti A., Calori G., Cucinato A., Perrino C., Nussio F., Cagnoli M., Pelliccioni A., Gobbi G.P., Di Filippo P., 2007. A gas/aerosol air pollutants study over the urban area of Rome using a comprehensive chemical transport model. Atmospheric Environment, 41, 7286-7303.
Gnocchi A., G. Malvasi, G. Maffeis, K. Lorenzet, L. Susanetti and A. Benassi, 2006: Stima delle emissioni in atmosfera nella laguna di Venezia secondo un approccio integrato Top-Down e Bottom-Up, Ingegneria Ambientale 7/8, 359-368.
Gnocchi, A., G. Maffeis, G. Malvasi, L. Susanetti, K. Lorenzet and A. Benassi, 2005. An integrated top-down and bottom-up approach to estimate atmospheric emissions in the Venice Lagoon, 1st International Conference on Harbours & Air Quality, Genoa (Italy), 15 - 17 June.
Hays, M. D., Smith, N. D. & Dong, Y. J. (2004). J. Geophys. Res. Atmos. 109, D14504.
IIASA, 2001. RAINS-Europe http://www.iiasa.ac.at/~rains/home.html.
Jongen S. and G.Bonafè, 2006. LAMI verification for air quality forecast and assessment purposes: case studies, special measurement campaigns, long-term evaluation. ARPA-SIM Internal Report, February 2006.
Lavrich R.J., M.D. Hays (2007). Analytical Chemistry, 79, 3635-3645. Validation studies of Thermal Extraction-GC/MS applied to source emissions aerosols. 1. Semivolatile analyte - Nonvolatile matrix interactions.
Legrand, M., and Puxbaum H. (2007), J. Geophys. Res. 112, doi: 10.1029/2006JD008271.
Maffeis, G., E. Bossi, M. G. Longoni, P. Thunis, C. Cuvelier, 2004. *Lombardy emission inventory in City Delta framework*, PM Emission Inventories Scientific Workshop, Lago Maggiore (Italy), 18 October
Nanni, A. and Radice, P., 2004. Sensitivity analysis of three EF methodologies for PM10 in use with climatological dispersion modelling in urban Italian study cases. Proc. of 9th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 1–4 June 2004, Garmisch-Partenkirchen (Germany), Vol. 1, 309-314.
Ntziachristos, L. and Samaras Z., 2000. Computer programme to calculate emissions from road transport. Methodology and emission factors (Version 2.1). EEA Technical report No 49.
Oliveira C., Pio C., Alves C., Evtyugina M., Santos P., Goncalves V., Nunes T., Silvestre A. J.D., Palmgren F., Wahlin P. and Harrad S. (2007). Atmospheric Environment 41 (27); 5555-5570.
Pernigotti, D., M. Sansone and M. Ferrario, 2005. Validation of one-year LAMI model Re-Analysis on the Po-Valley, Northern Italy. Comparison to CALMET model output on the sub-area of Veneto Region. 10th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Crete 17-20 October.

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund

Pillon S., F. Dalan, G. Maffeis, F. Liguori, A. Benassi, 2007. Applicazione modello fotochimico CAMx: caso di studio PM10 nel periodo febbraio-marzo 2006 e analisi del contributo locale in area veneziana. Maggio 2007. http://www.arpa.veneto.it/dapve/docs/Applicazione_CAMx_PM10_relazione_ORAR.pdf

Pillon S., F. Liguori, L. Susanetti, F. Dalan, G. Maffeis, G. Malvasi, 2009. MODELLING OF ORGANIC AND INORGANIC MICROPOLLUTANTS ON THE LAGOON OF VENICE. 7th INTERNATIONAL CONFERENCE ON AIR QUALITY – SCIENCE AND APPLICATION24-27 MARCH 2009. ISTANBUL.

Pillon Silvia, Fabio Dalan, Francesca Liguori and Giuseppe Maffeis, 2008. *PM SOURCE APPORTIONMENT ANALYSIS IN THE VENETIAN AREA*. 12th Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Cavtat, Croatia, October 6-9, 2008.

Saarikoski S. K., Sillanpää M. K., Saarnio K. M., Hillamo R. E., Pennanen A. S. and Salonen R. O., Water, Air, & Soil Pollution, ISSN0049-6979 (Print) 1573-2932 (Online), DOI 10.1007/s11270-008-9623-1.

Sansone, M., D. Pernigotti and M. Ferrario, 2005. Application of CALMET model to the Veneto region, with particular attention to the shoreline, using offshore data for initialization. 1st International Conference on Harbours & Air Quality, Genova (Italy), 15 - 17 June.

Schnelle-Kreis, J.; Sklorz, M.; Orasche, J.; Stolzel, M.; Peters, A.; Zimmermann, R. (2007) Environ. Sci. Technol.; 41(11); 3821-3828.

Scire, J. S., F. R. Robe, M. E. Fernau and R. J. Yamartino, 2000. A user's guide for the CALMET Meteorological Model, Earth Tech, USA.

Silibello C., Calori G., Brusasca G., Giudici A., Angelino E., Fossati G., Peroni E., Buganza E., 2008. Modelling of PM10 Concentrations Over Milano Urban Area Using Two Aerosol Modules. Environmental Modelling and Software, 23, 333-343.

Steppeler J., G. Doms, U. Schättler, H. W. Bitzer, A. Gassmann, U. Damrath, G. Gregoric, 2003. *Meso-gamma scale forecasts using the nonhydrostatic model LM*. Meteorology and Atmospheric Physics, 82, 75-96.

Trozzi Carlo, Rita Vaccaro, TECHNE report MEET RF98, 1998. Methodologies for estimatine air pollutant emissions from ships.

Yamartino, R. J., J. S. Scire, S. R. Hanna, G. R. Carmichael and Y. S. Chang,1989. CALGRID: A Mesoscale Photochemical Grid Model Volume 1: Model Formulation Document, California Air Resource Board, USA

Projet cofinancé par le Fonds Européen de Développement Régional
Project co-financed by the European Regional Development Fund