SYSTEMATIC ANALYSIS OF METEOROLOGICAL CONDITIONS CAUSING SEVERE URBAN AIR POLLUTION EPISODES IN THE CENTRAL PO VALLEY

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Objectives

- Identification of meteorological conditions that cause severe urban air pollution episodes
- Identification of key meteorological variables that can be used to describe and forecast episodes
- Support the improvement of urban meteorological and air quality forecast

Aknowledgenents

The work has been supported by:

- the European Commission for the EU 5FP project FUMAPEX
- COST 715 Action

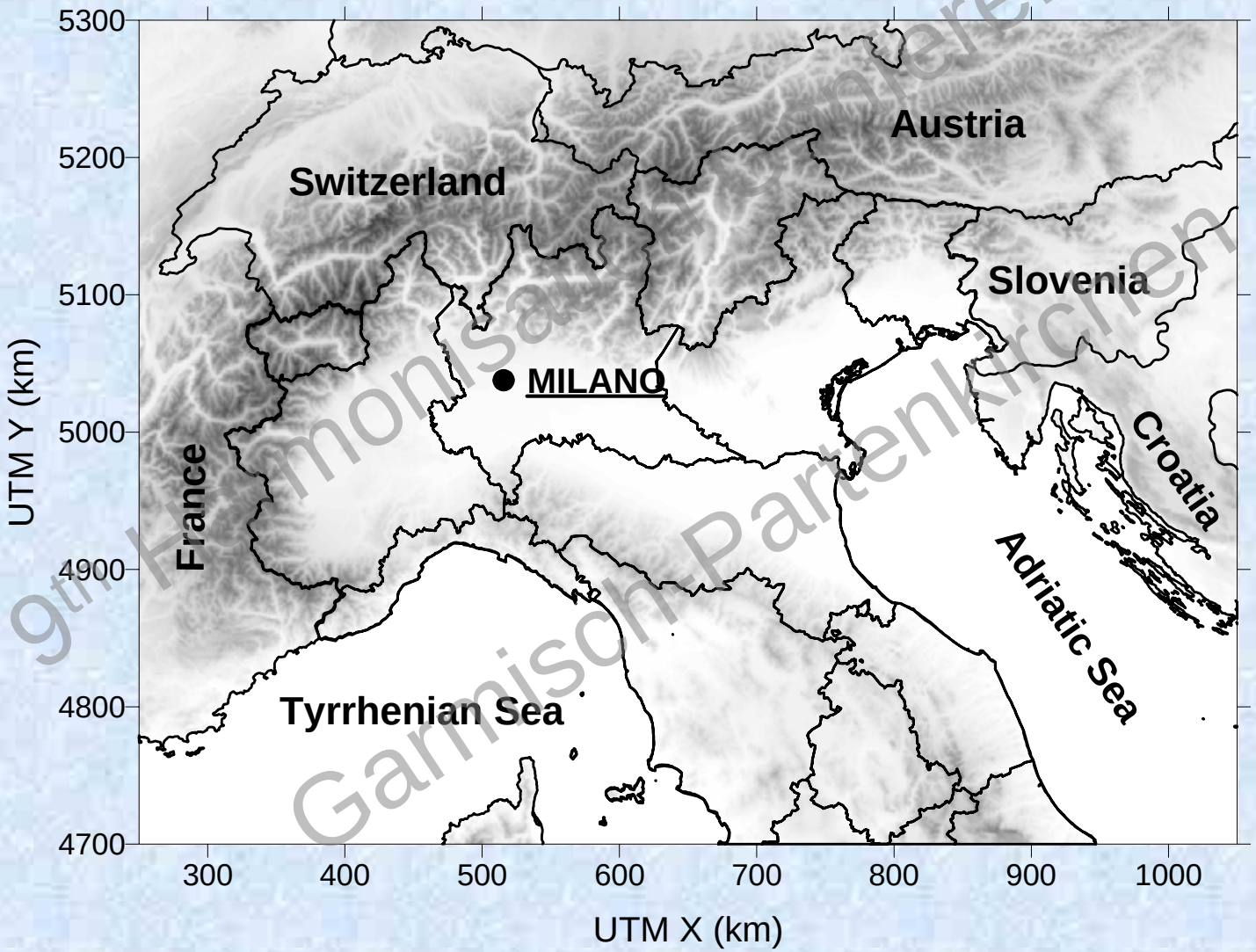
The work has been possible thanks to:

- ARPA Lombardia and Regione Lombardia for providing air quality and meteorological data.

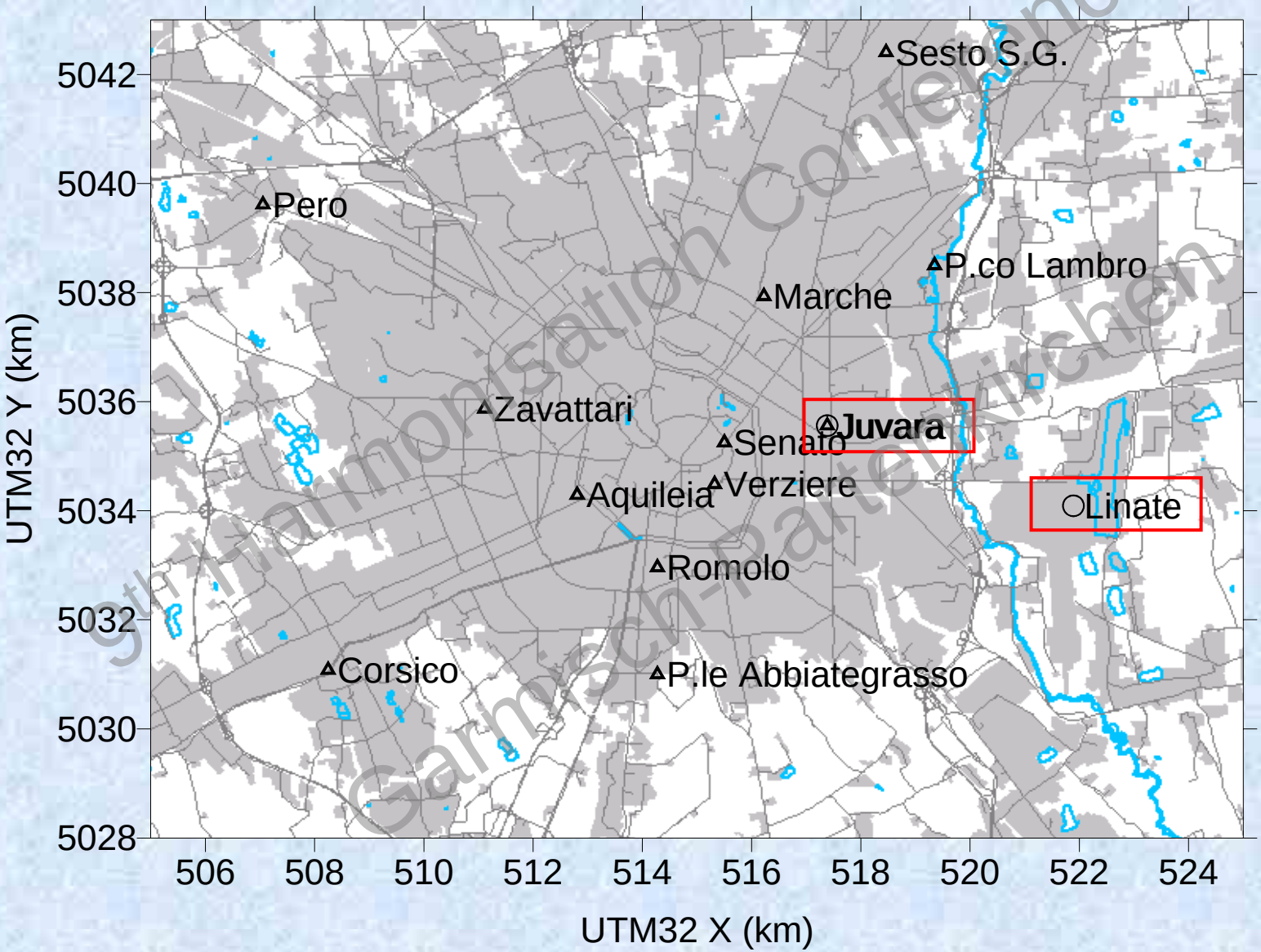
Outline

- Analysis of NO_2 and PM_{10} yearly maximum concentrations and exceedances statistics
- Definition of severe winter episodes during the last six years (1998-2003)
- Analysis of synoptic and local meteorological conditions
- Classification of the meteorological circulation
- Identification of episodes common features
- Conclusions

Geographic Location



Milan AQ Network



Milan City NO_2 Hourly Average Exceedancees

	1998	1999	2000	2001	2002	2003
Mi-Marche	65	33	24	22	46	26
MI-Juvara	137	50	26	10	51	28
Mi-Zavattari	77	86	20	10	35	48
Mi-Verziere	93	40	24	7	12	11
Mi-Aquileia	70	37			7	
Mi-Romolo	29	31	1	0	10	22
Mi-ParcoLambro	43	32	15	6	50	2
Mi-Senato	93	36	26	13	24	3
Mi-PzaAbbiategrasso	8	24	0	4	29	4
Mi-Messina	89	50	27	30	57	20

* Green cells indicate non attainment of EU air quality standards for NO_2

Number of days recording NO_2 Hourly Averages Exceeding 200 $\mu g/m^3$

	1998	1999	2000	2001	2002	2003
Mi-Marche	21	13	8	9	10	8
MI-Juvara	28	11	9	4	10	9
Mi-Zavattari	23	23	9	5	9	11
Mi-Verziere	21	12	7	4	4	3
Mi-Aquileia	19	10			3	
Mi-Romolo	12	9	1	0	4	8
Mi-ParcoLambro	14	13	8	3	11	2
Mi-Senato	18	9	9	7	7	2
Mi-PzaAbbiategrasso	4	8	0	2	8	1
Mi-Messina	13	16	10	12	12	8

Milan Province PM_{10} Daily Average Exceedancees

	1998	1999	2000	2001	2002	2003
Mi-Juvara	109	105	102	103	126	113
Mi-Zavattari	117	126	107	106		
Mi-Verziere				38	115	113
Limito	68	92	84	82	101	91
Meda	110	124	95	103	111	116
Vimercate	98	106	91	87	95	84
Magenta	85	86	87	90	104	117

Milan Province PM_{10} Daily Average Exceedancees of 100 µg/m³

	1998	1999	2000	2001	2002	2003
Mi-Juvara	13	18	16	16	19	12
Mi-Zavattari	16	23	21	14		
Mi-Verziere				9	18	6
Limito	7	14	15	4	14	11
Meda	21	32	19	11	15	12
Vimercate	14	17	13	12	10	6
Magenta	6	10	12	5	15	12

NO_2 and PM10 Winter Episodes

Episodes with NO2 exceeding of 200 ug/m3

1998	1999	2000	2001	2002	2003
30-31/01/1998	*21-27/01/1999*	*3-6/01/2000*	*2/02/2001*	*5-21/01/2002*	*15/01/2003*
4-16/02/1998	*3-4/02/1999*	*10-11/01/2000*	*16/02/2001*	*26/01/2002*	*20/01/2003*
20-21/02/1998	*17/02/1999*	*31/01/2000*	*12/10/2001*	*5/02/2002*	*24/01/2003*
25-26/02/1998	*15/03/1999*	*27/11-01/12/2000*	*30/11/2001*	*8/02/2002*	*21-22/02/2003*
28-30/03/1998	*10-12/10/1999*	*18-19/12/2000*	*05/12/2001*	*20/02/2002*	*24-28/02/2003*
14-20/12/1998	*24/11-3/12/1999*		*10/12/2001*	*12/03/2002*	*10-11/03/2003*
			19-21/12/2001		*24-27/03/2003*
					17-21/09/2003
					09/12/2003
					20/12/2003

Episodes with PM10 Daily Averages > 100 ug/m3

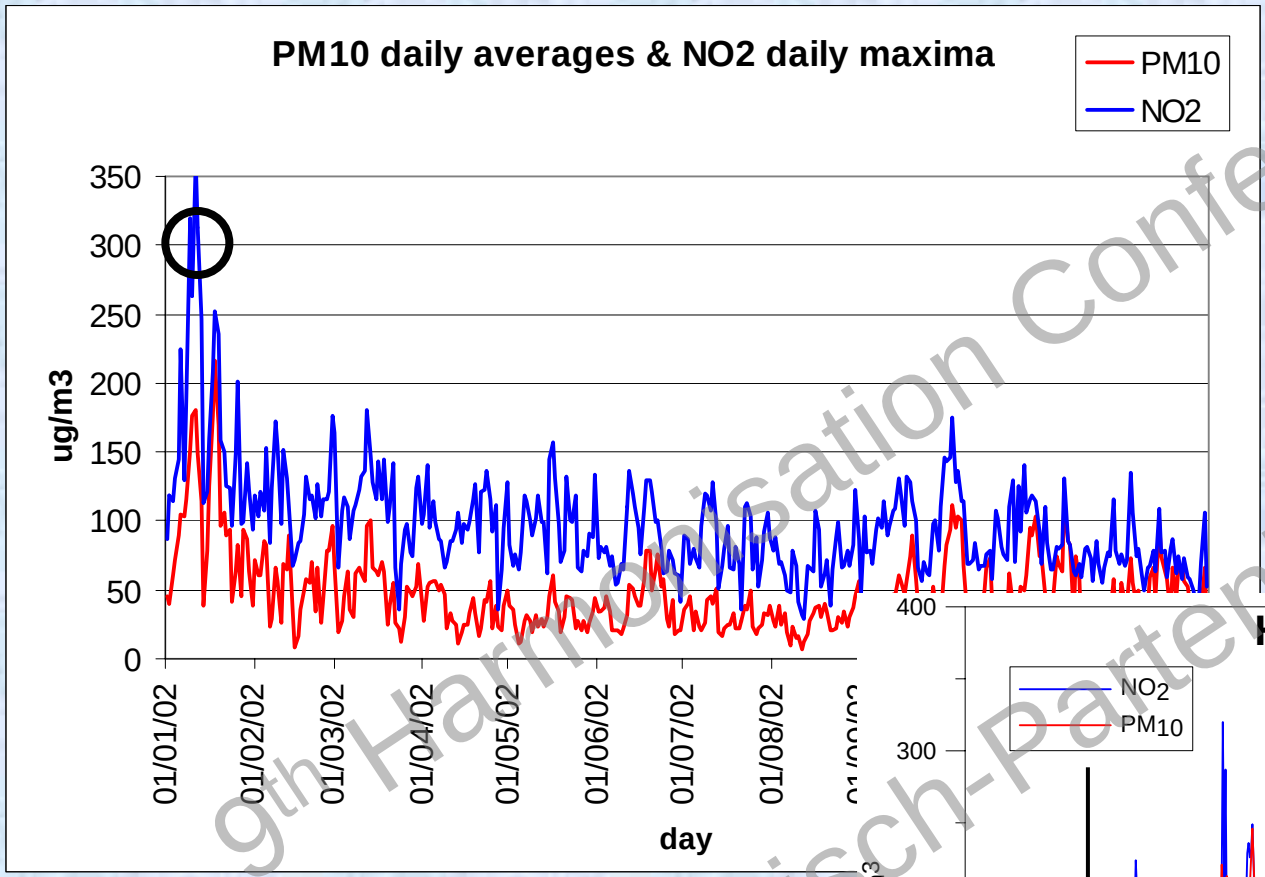
1998	1999	2000	2001	2002	2003
20-25/02/1998	*7/01/1999*	*1-11/01/2000*	*1/01/2001*	*5-19/01/2002*	*14-18/01/2003*
11-18/12/1998	*16-26/01/1999*	*14/01/2000*	*6-7/02/2001*	*28/01/2002*	*11/02/2003*
24-25/12/1998	*3-4/02/1999*	*28/01-02/02/2000*	*13-17/02/2001*	*4/02/2002*	*20-22/02/2003*
30/12/1998	*2/03/1999*	*25-29/02/2000*	*20/02/2001*	*3-6/10/2002*	*24-25/02/2003*
	12-15/03/1999	*27/11-02/12/2000*	*18-19/10/2001*	*1/11/2002*	*28/02-01/03/2003*
	24/11-05/12/1999	*18/12/2000*	*5/11/2001*	*11/11/2002*	*9/12/2003*
	7-8/12/1999		*29-30/11/2001*	*14/12/2002*	*12-13/12/2003*
			3-5/12/2001		*20/12/2003*
			12/12/2001		
			18-22/12/2001		

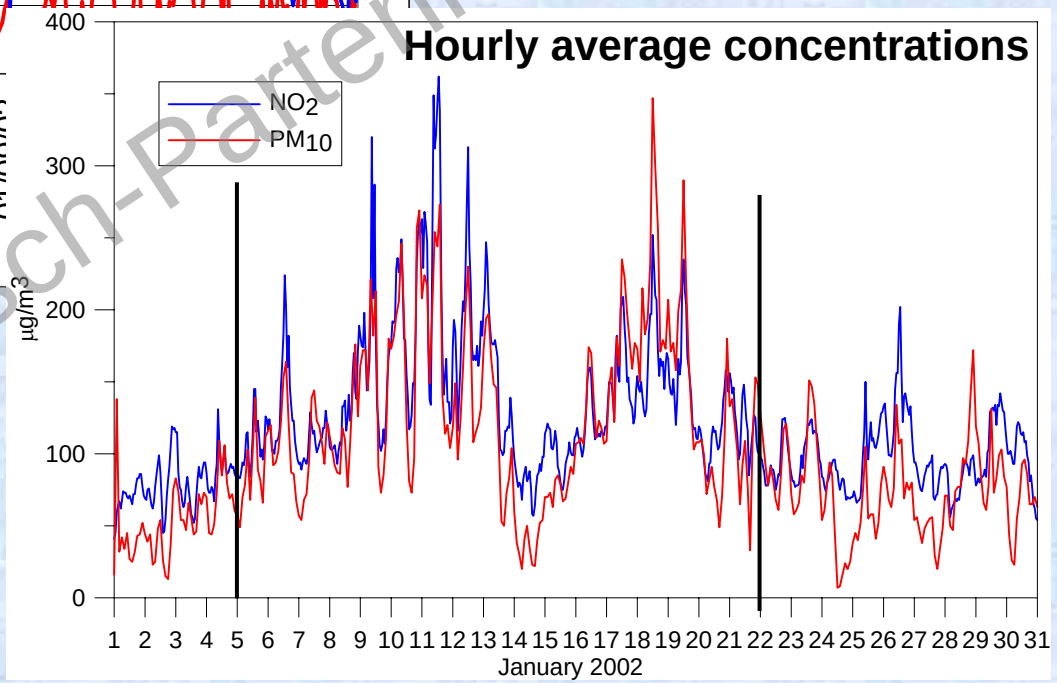
NO_2 and PM10 Severe Winter Episodes

Year	Episode	NO_2 Exceedances	Total Yearly Exceedancees
1998	11-20/12/1998	65	137
1999	24/11-5/12/1999	30	50
2000	27/11-02/12/2000	19	26
2001	18-22/12/2001	6	10
2002	5-21/01/2002	50	51
2003	20/02-01/03/2003	17	28

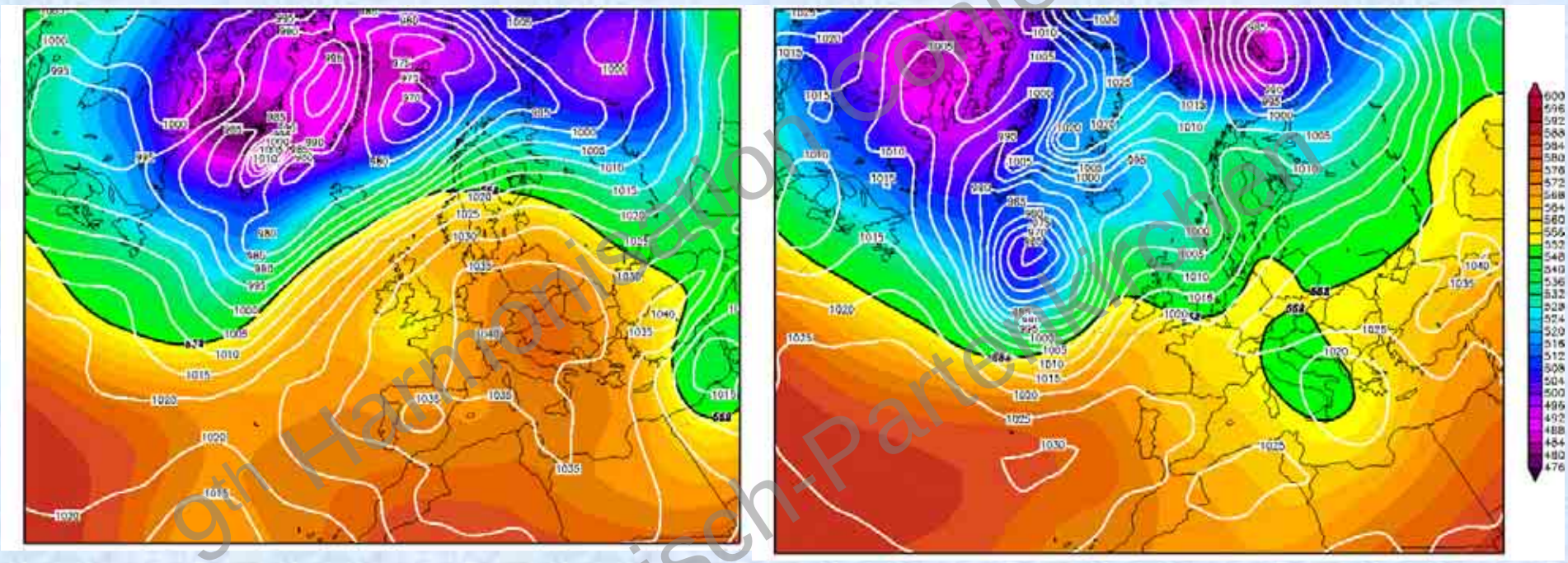
* The number of observed exceedancees refer to NO_2 hourly averages measured in Milan-Juvara station

05-21 January 2002 - Concentrations





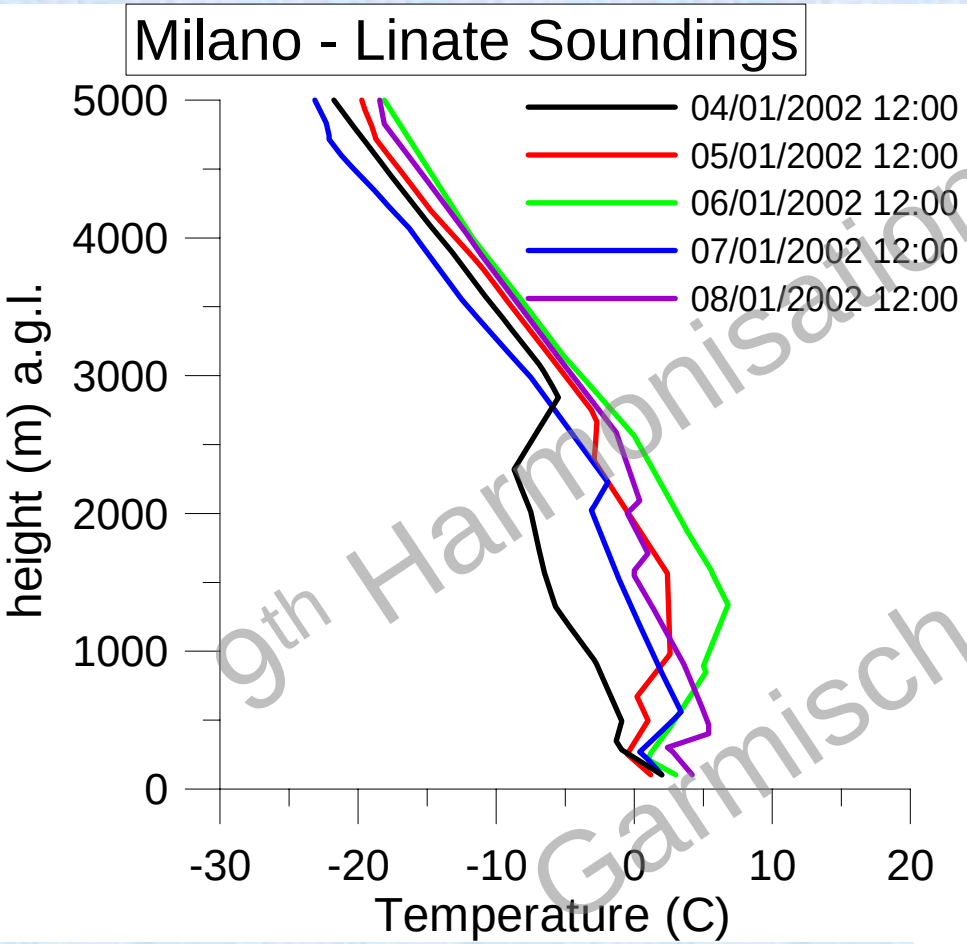
05-21 January 2002 – Synoptic Conditions

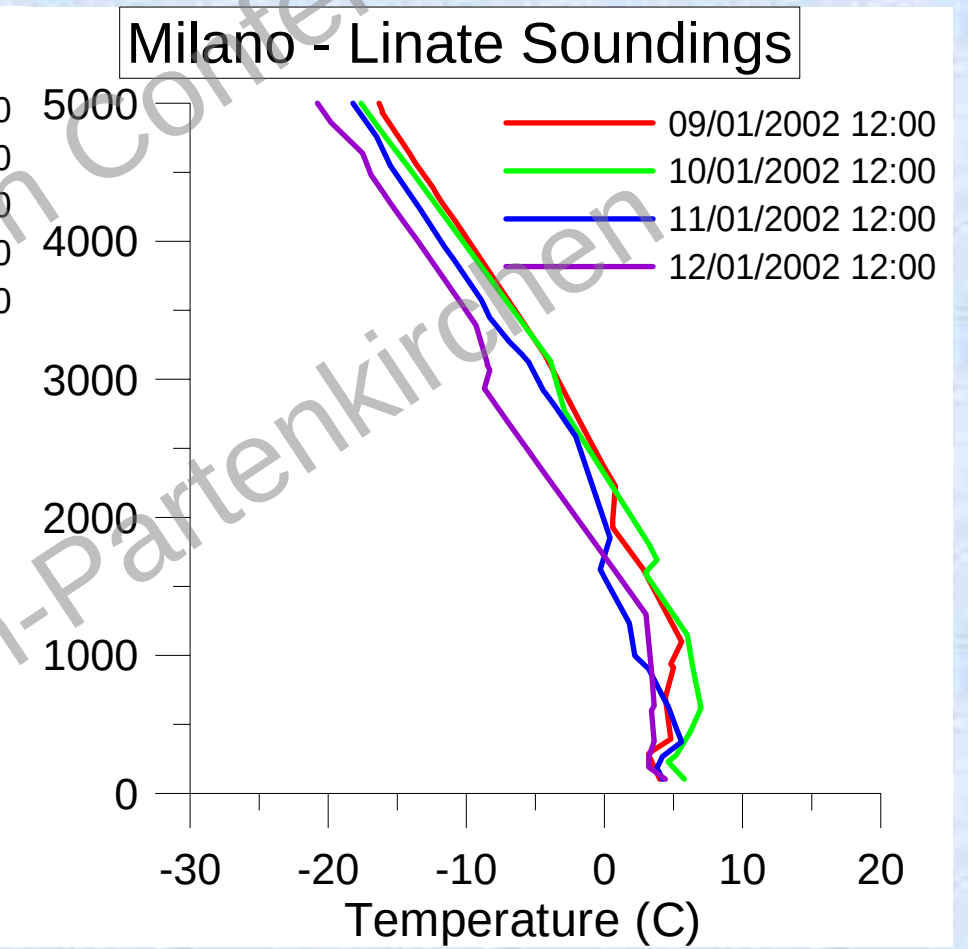


10/01/2002 00:00

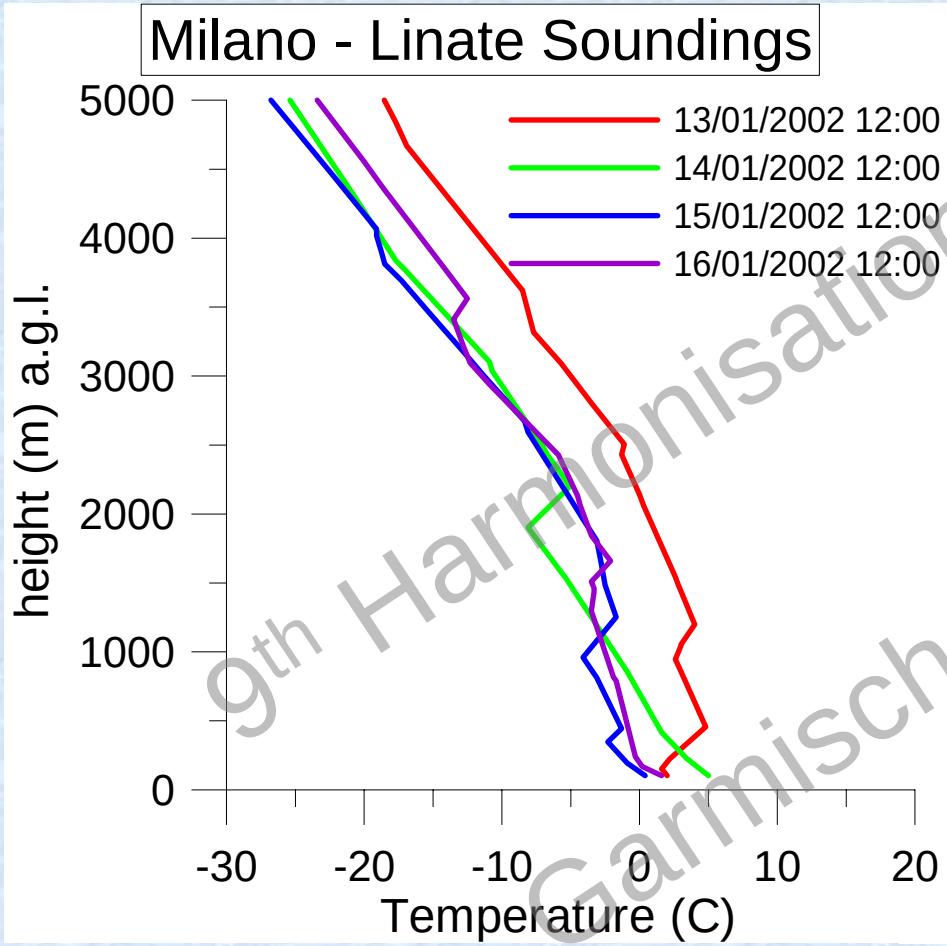
18/01/2002 00:00

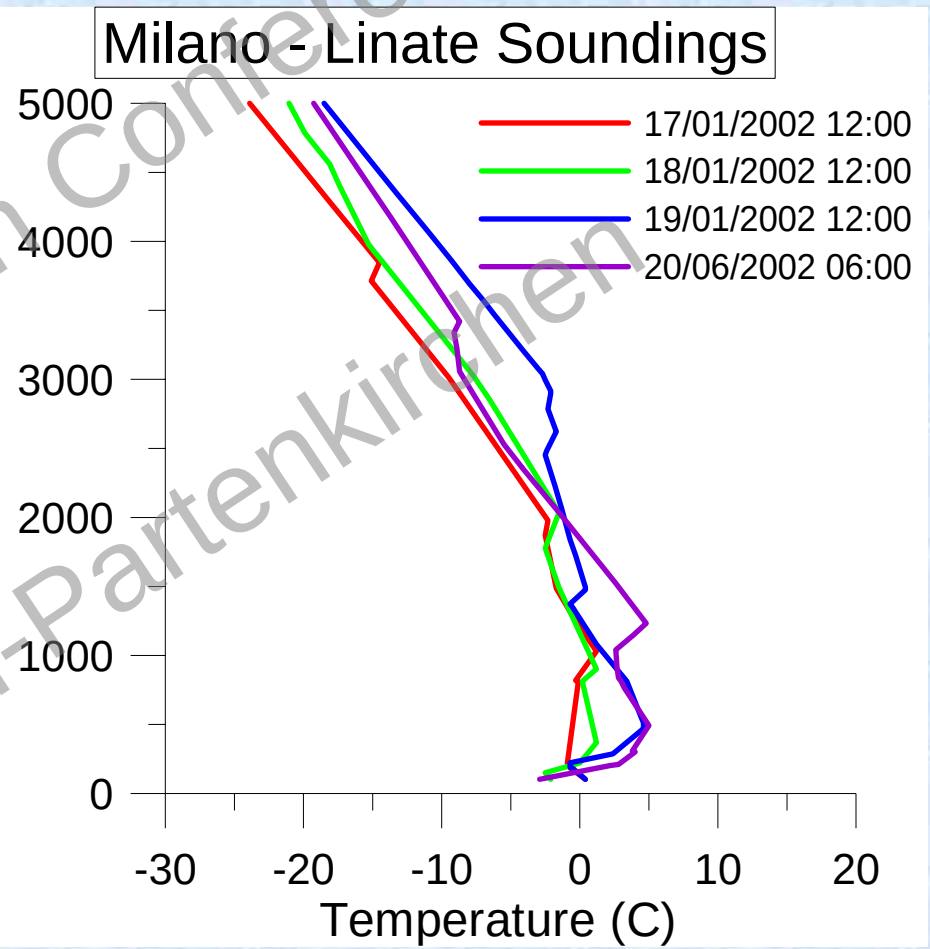
05-21 January 2002 –Temperature Profiles (1)



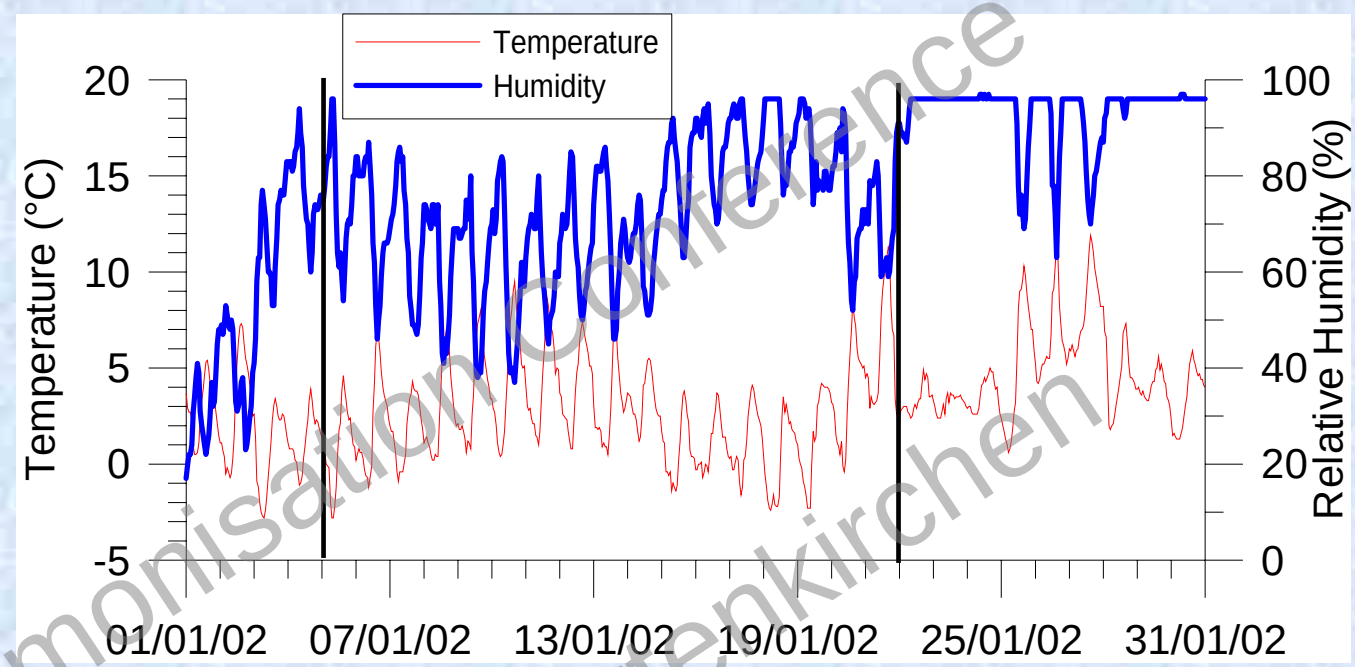


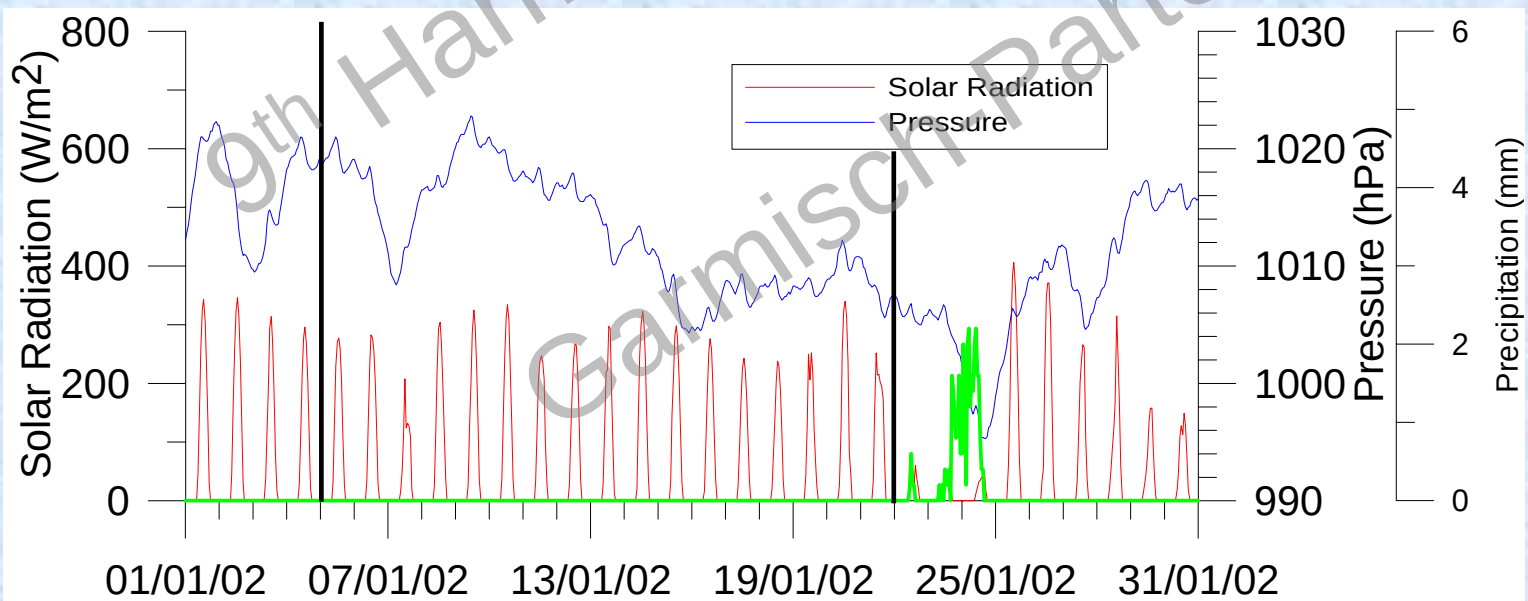
05-21 January 2002 –Temperature Profiles (2)



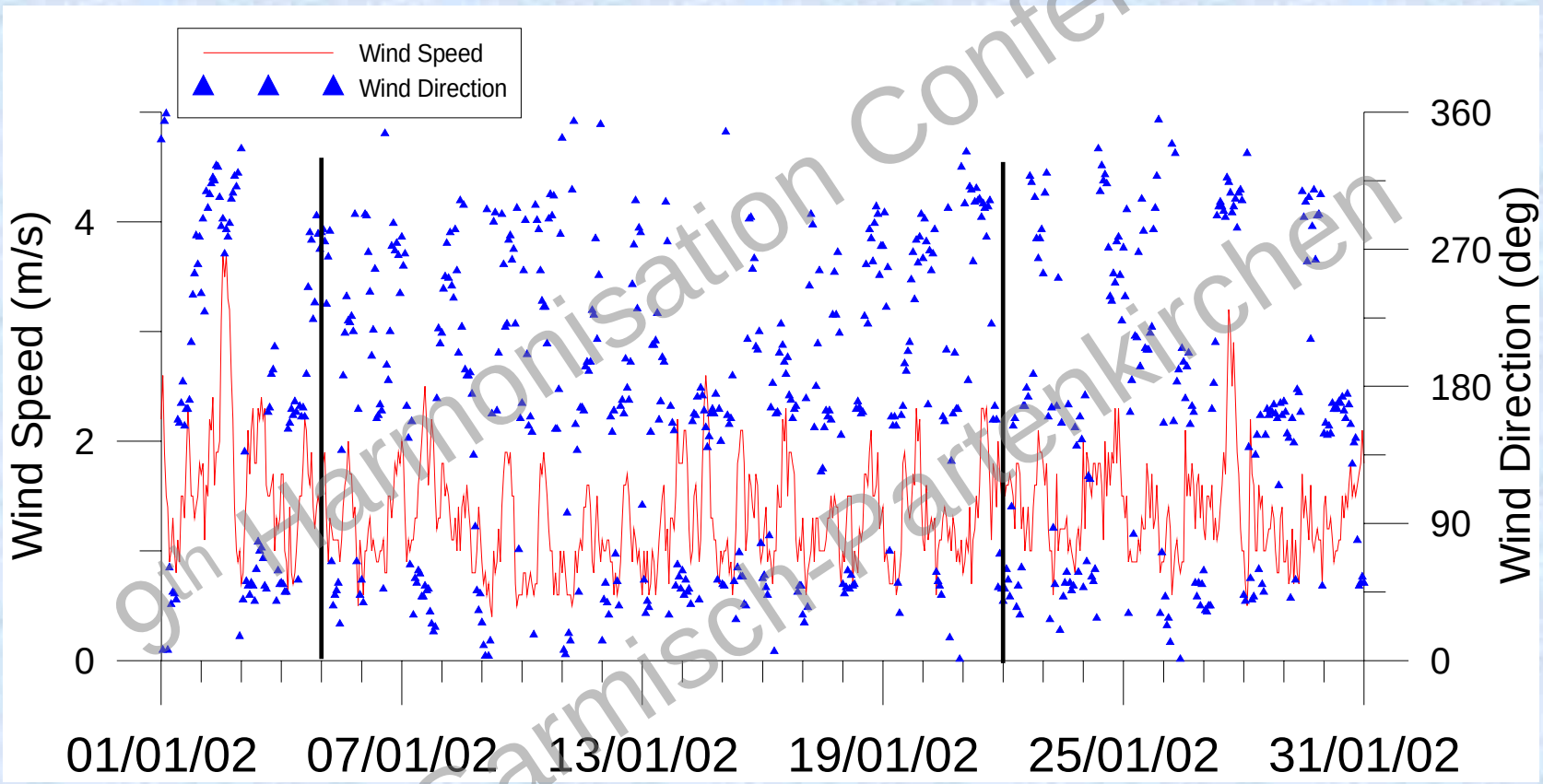


05-21 January 2002 – Local Meteorology (1)

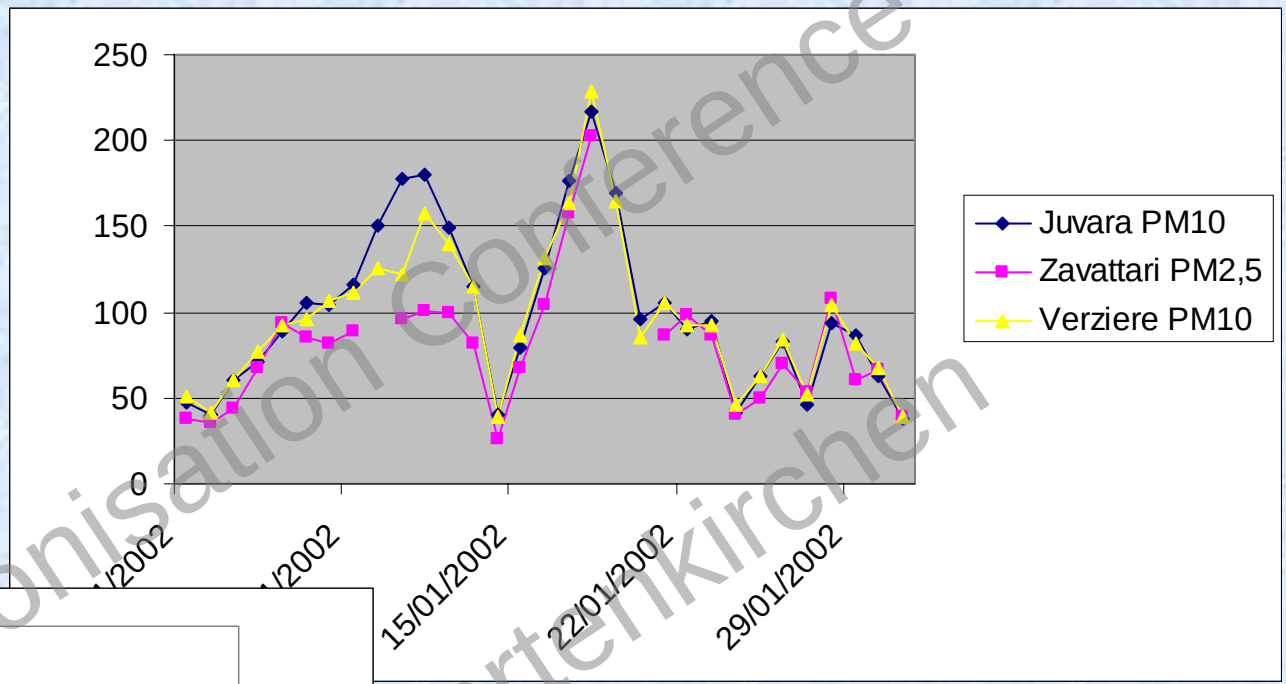


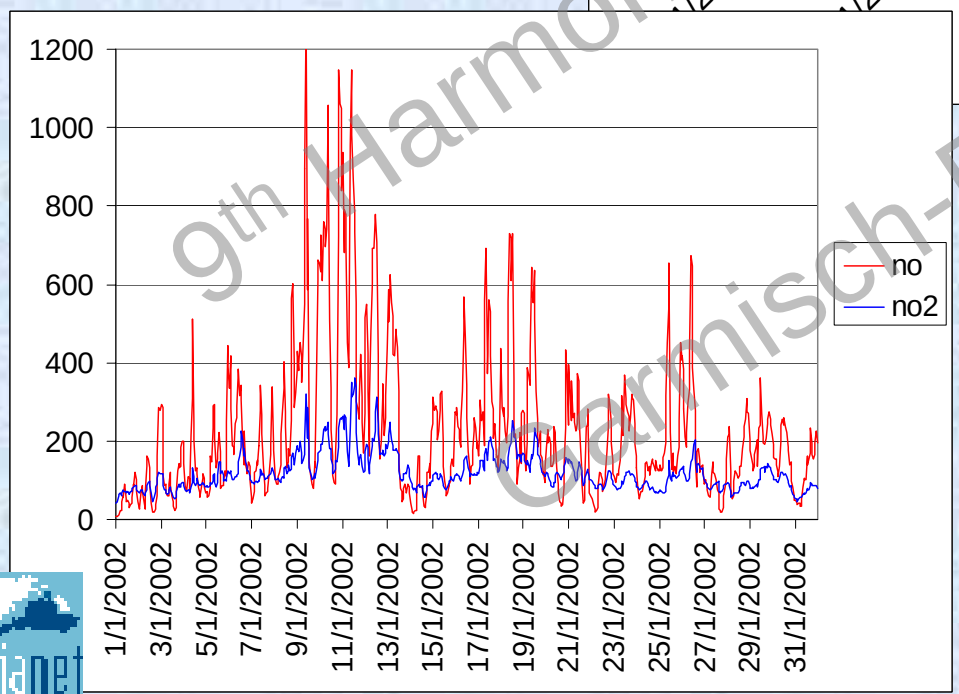


05-21 January 2002 – Local Meteorology (2)



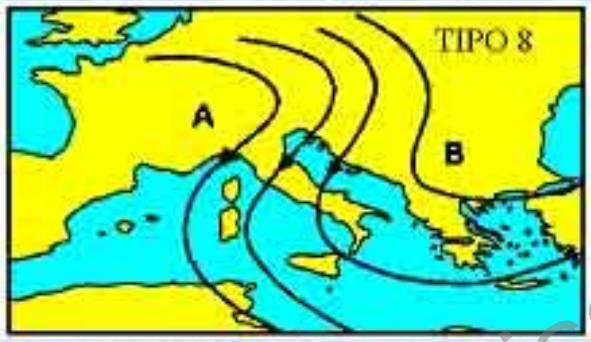
05-21 January 2002 – Concentrations (2)

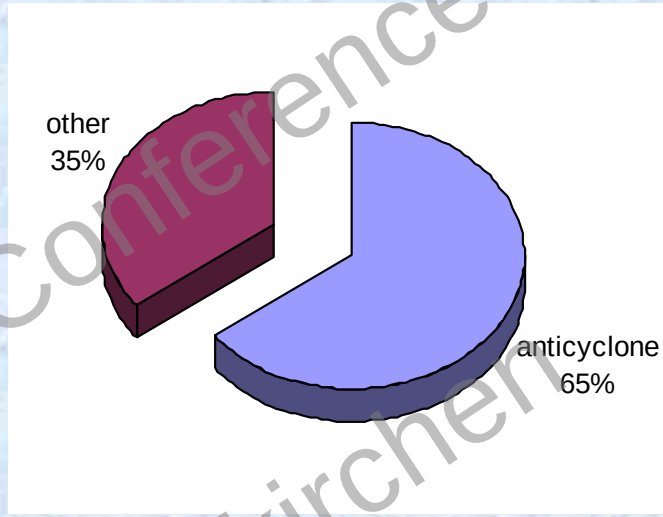




05-21 January 2002 – Synthesis

Prevailing weather type: **8**





Prevailing anticyclonic structures of African and Atlantic origin for the whole period.

Surface pressure decreases on January 8th-16th then constant. Dynamic due to the evolution of a small scale low pressure system inside the high pressure body.

Persistent stable (nearly-isothermal) vertical temperature profiles in the lower 2000 metres.

Severe episodes common features
Synoptic

All the studied episodes show the presence of an anticyclonic structure and the advection of warm air on the region of interest.

The advection of warm air in the mid troposphere (850-500 hPa) originates a stable thermal structure of the lower atmosphere.

During winter months cold air layers are present near the surface that favour the development of stable (isothermal or inversion) temperature profiles.

The weather types analysis shows a clear prevalence of anticyclonic types during the episodes.

Severe episodes common features
Local

Constant high pressure is the more frequent condition even if episodes have been observed with slowly varying surface pressure.

Surface temperature is not a cause of episode itself, even if “cold condition” are associated to the episodes that caused the highest concentrations.

Wind speed is not a key parameter to identify episodes in Milan due to the high frequency of weak winds and calms. Low wind speed is a necessary (no sufficient) condition.

Inversions or very stable (isothermal) vertical temperature profiles in the lower atmosphere (0-2000 metres) seem to be the key parameter to determine severe episodes.

Summary

- NO_2 & PM_{10} exceedances in Milan have been analysed
- 1-2 long lasting severe NO_2 and PM10 winter air pollution episodes per year occur in Milan urban area.
- Severe episodes record the largest part of NO_2 exceedances and PM_{10} highest concentrations
- The worst episodes have been thoroughly analysed by the meteorological point of view
- Common synoptic and local features have been identified

Conclusions

- Persistent Anticyclones with associated warm air advection in the mid-atmosphere are the main conditions causing winter air pollution episodes
- The temperature profile stability is the key parameter to identify the episodes
- The observed phenomena show common features, seem to be rather repetitive and predictable
- Reliable meteorological & air quality forecast can support the prevention of episodes and the respect of EU air quality standards

Future Work

- Verify if the studied episodes are present in Torino and with which behaviours

- Analysis of Summer Ozone episodes