Air quality forecasts in Milan: the AIR Sentinel project

Giorgio Corani, Stefano Barazzetta

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AGENZIA MILANESE MOBILITÀ AMBIENTE

Outline

- Overview of the aims of the project
- The current stage of the project
- The current modelling framework
- Ongoing research efforts

Introduction

- Milan experienced over the last years strong reductions of pollutants such as SO2, NOx, CO, TSP
- However, a major concern for air quality is constituted by PM10. About 100 exceedings of the 50 $\mu g/m^3$ limit value are observed yearly (State of the Environment Report, AMA 2003)
- An air quality forecast system may be useful
  - to the Municipal Authorities, which can plan in advance the management of heavy pollution episodes
  - to the citizens, which can avoid exposure to unhealthy air, or prepare for incoming traffic blockages

The Air Sentinel project

- It will deliver air quality forecasts up to 48 hours in advance for many pollutants in Milan
- The project involves expertises from different areas such as environmental modelling, time series forecasting, micrometeorology
- A wide set of data is collected from different sources such as:
  - Air quality monitoring network
  - Radiosondes (Linate airport)
  - Meteorological forecasts
  - Sodar

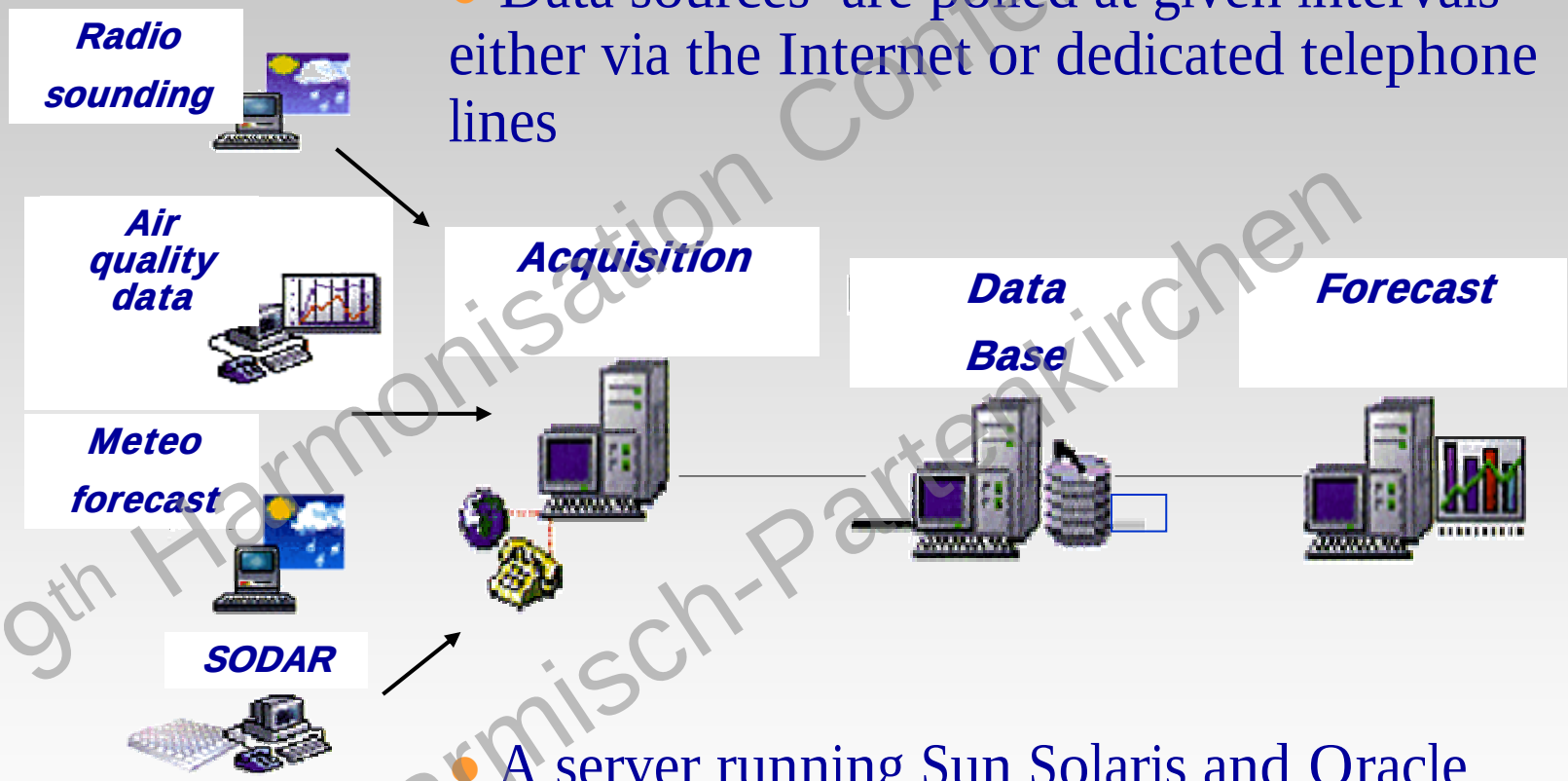
The Sodar

- A Sodar has been installed in the very center of the city in order to track the vertical profiles of wind components

- Although sodar data are currently not included in the predictor because of the time series shortness, it will constitute a precious source of data in the near future

The data acquisition system

- Data sources are polled at given intervals either via the Internet or dedicated telephone lines



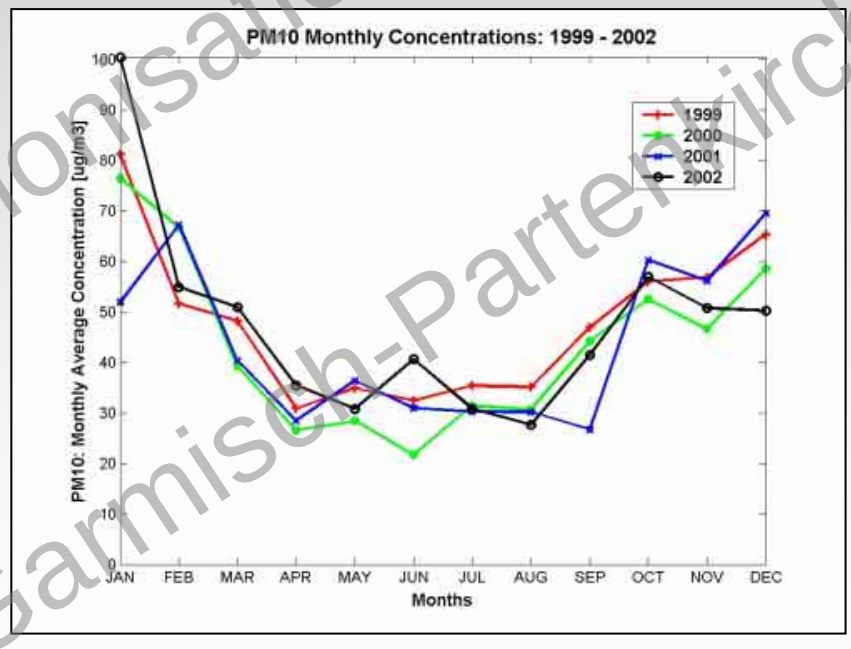
- A server running Sun Solaris and Oracle hosts the database of the project

The current modelling framework

- The developed models are aimed at predict PM10 concentrations on the two different Milan measuring stations
- The models run at 9 a.m. making available the prediction for the current day.
- They return both a numerical prediction and an associated distribution probability in order to manage the prediction uncertainty.

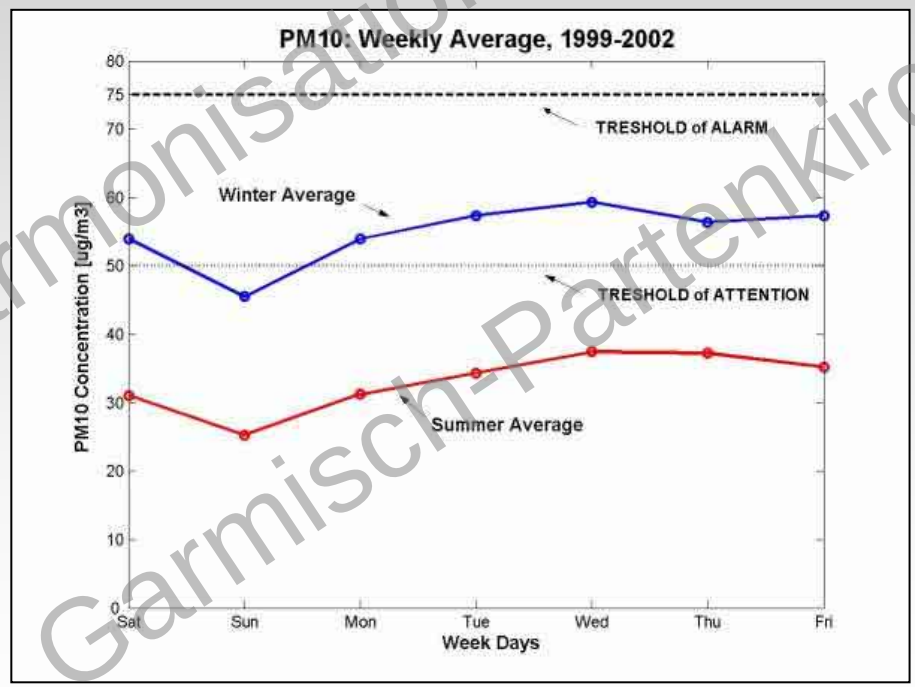
PM10 time series: yearly analysis

- No trends can be recognized on the yearly average: since the beginning of the monitoring (1998) PM10 is substantially stable
- The time series is periodic during the year because of changes in both meteorology and anthropic emissions



PM10 time series: weekly analysis

- PM10 time series underlies also typical *weekly* patterns, due to the cycles in anthropic activities
- PM10 daily average are in fact about 20% lower on Sunday than in the remaining days of the week



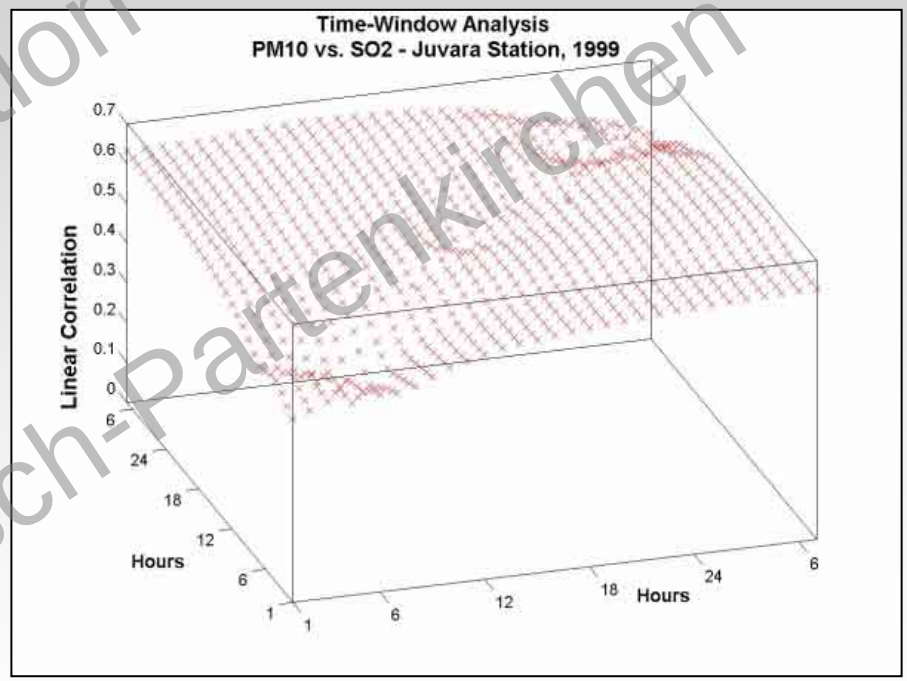
Input variables suitable for prediction

- **PAST PM10 (time series auto-correlation)**
- **EMISSIONS PROXIES**:
  - *NOx* (see traffic volumes)
  - *SO2* (see building heatings)
- **METEOROLOGICAL CONDITIONS:**
  - Wind
  - Temperature
  - Atmospheric pressure
  - Etc.

Input selection methodology

- The input variables of the model are chosen by means an exhaustive correlation analysis.

- Inputs variables are grouped to daily values from the hourly ones by using those time windows which maximizes the input/output correlation.



Predictor identification

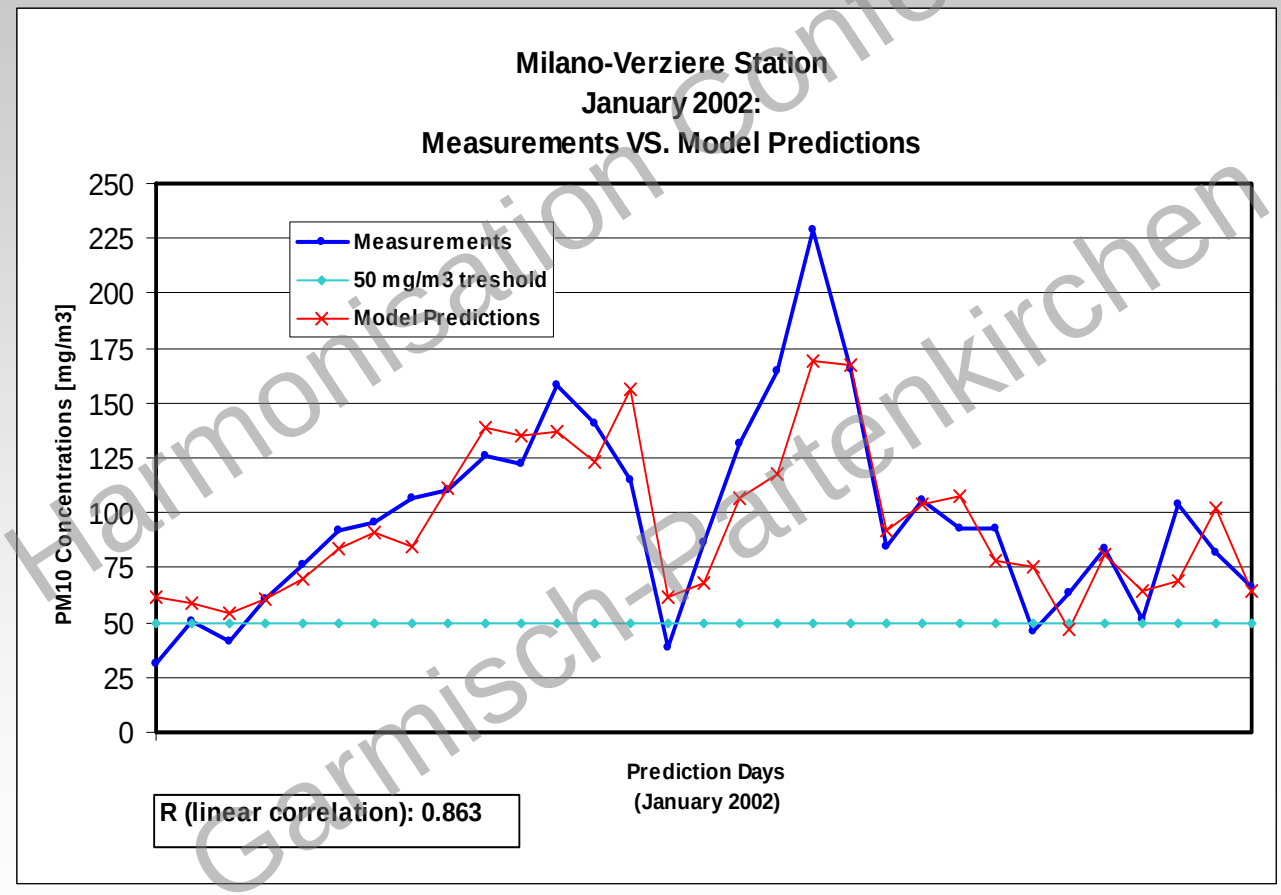
- The model is a simple linear regressors

$$PM10(t) = aPM10(t-1) + bSO2(t-1) + c\,Pressure(t-1) + d\,Temperature(t-1)$$

  - a, b, c, d are parameters to be estimated during the training
  - (t) is the current day and (t-1) refers to yesterday
  - each input is averaged on a specific optimal time window
- Model performances are then assessed by means of k-fold cross validation
- The correlation level for instance varies between 0.8 and 0.9 depending on the period of the year

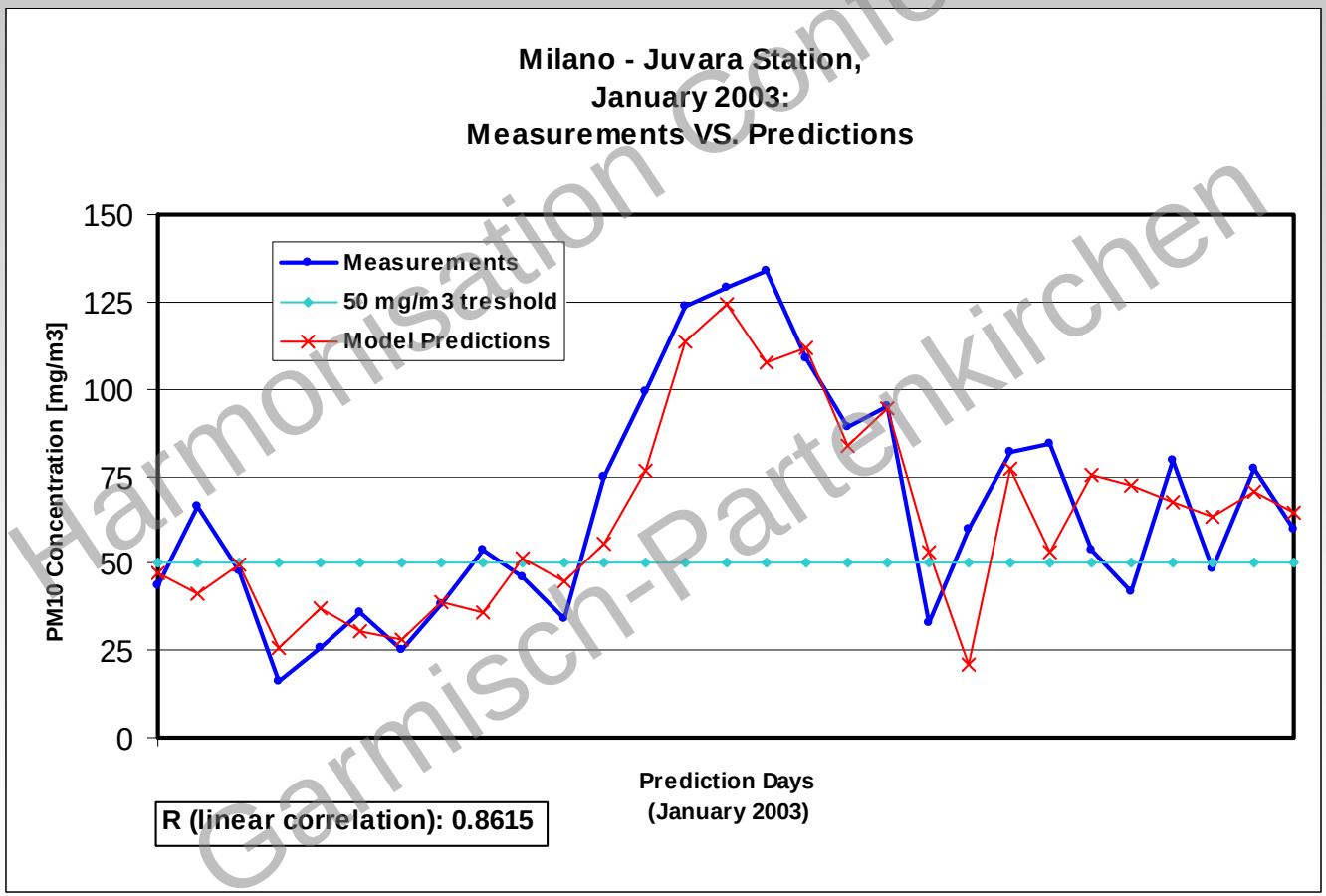
Model Validation (2002 sample)

- Milano –Verziere simulation: January 2002



Model validation (2003 sample)

- Milano–Juvara simulation: January 2003



Ongoing research efforts

- The predictors are currently being improved by:
  - Defining micro-meteorological indicators able to capture the main features of the dispersion phenomena, in order to increase of one day the prediction horizon.
  - Training neural networks architectures instead of linear predictors

Conclusions

- At the current stage, the Air Sentinel project provides:
  - a wide repository of meteorological and air quality data for Milan
  - an automated networking system which acquires the real time data
  - a modelling framework able to satisfactory compute PM10 predictions for the current day, with a correlation level between 0.8 and 0.9 depending on the period of the year
- Research efforts are currently undertaken to further improve the prediction accuracy and to extend the forecast horizon.