A modeling platform for the air quality predictability study

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HONORÉ Cécile[1], Laurent MENUT[2], Bertrand BESSAGNET[1], Frédérik MELEUX[1], Laurence ROUIL[1], Robert VAUTARD[3], Matthias BEEKMANN[4], Nathalie POISSON[5], Vincent-Henri PEUCH[6]

[1] INERIS, , National Institute for Industrial Environment and Risks, 60550 Verneuil en Halatte, France ; [2] LMD/IPSL, Ecole Polytechnique, Palaiseau, France ; [3] LMD/LSCE, CEA, Gif sur Yvette, France [4] LISA, Université Paris 7, Paris 12, CNRS, UMR7583, Créteil, France ; [5] ADEME, Paris, France ; [6] CNRM Meteo-France, Toulouse, France ;

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1. Introduction

The PREV'AIR system is one among the few systems for air pollution forecasting currently running in Europe. Since 2003, the PREV'AIR forecasting system delivers **daily air quality forecast over western Europe**. It results from an agreement between local networks, ministries, industrial consortium and research laboratories called the PREV'AIR consortium (composed of the National Institute for Industrial Environment and Risks (INERIS), the National Research Center (CNRS), the Agency for the Environment and Energy Management (ADEME) and Météo France).
The core of the PREV'AIR system are **numerical air quality simulation models, meteorological forecast data and near-real time air quality observations**. Each day, PREV'AIR delivers forecast maps up to three days in advance for ozone, NO_2, $PM_{2.5}$ and PM_{10}. Different spatial scales are considered : from global to European and France. For the latter one, corresponding to the highest resolution, maps of daily peak and averaged forecast concentrations are issued. These numerical air quality forecast data are thus delivered to air quality monitoring networks asking for this service. In addition, the available ozone observation data are used to correct the ozone peak simulated by the PREV'AIR system for the day before and to built realistic 'analysis' maps.
All the PREV'AIR data are freely available through the Internet (http ://www.prevair.org/en/) , including :

- Observation maps in near real time
- Analysis for the day before and the current day
- Tests of model performances
- Annual budgets

2. The observation network used : BASTER

Observation data carried out in France by the Official Air Quality Monitoring Associations (AASQA) are transmitted as a whole to ADEME, in charge of the national database. The BASTER data base gathers in near real time these measurements and a direct link is set up towards the air quality models used in the PREV'AIR system. Additional data are directly send to the PREV'AIR system by ARPA-Emilia Romagna and ARPA-Piemonte in Italy.

3. The models used

3D Chemistry Transport Models...	...Driven by meteorological forecasts
CHIMERE	AVN/NCEP global data
MOCAGE	MM5 higher resolution forecasts ARPEGE, ALADIN

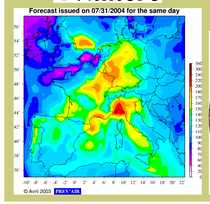
Other input data are required

- ▷ Emissions inventory (EMEP)
- ▷ Gas and aerosols boundary conditions for CHIMERE are provided by MOZART
- ▷ Land-use (GLCF data base)

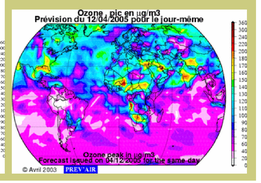
All details about CHIMERE are available at http ://euler.lmd.polytechnique.fr/chimere.

Examples of ozone forecast

Chimere



MOCAGE

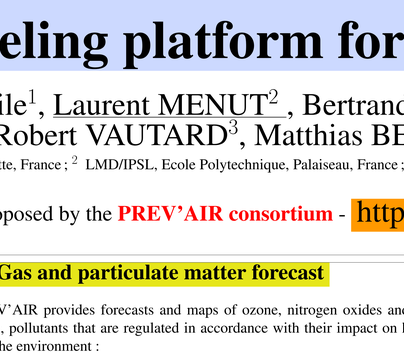


4. Gas and particulate matter forecast

PREV'AIR provides forecasts and maps of ozone, nitrogen oxides and particles, pollutants that are regulated in accordance with their impact on health and the environment :

- **Forecasts**
  Maps that represent average concentrations and maximum daily figures of each of these pollutants are drawn up every morning for the same day, the following day and the day after at various spatial scales.
- **Observation maps in France**
  A national map is published everyday reporting the measurements performed in France by the Official Air Quality Monitoring Associations (AASQA). This map is updated every hour.
- **"Analyzed" ozone maps**
  Ozone simulations in Europe and France are subsequently readjusted assimilating observation data available from the monitoring air quality network. Therefore, a map is published everyday in the early afternoon, derived from a simulation corrected with the ozone levels observed in the late morning. This map is then updated once again at the end of the afternoon (more frequently in the case of a pollution event) in order to include the maximum number of observations and thus improve the reliability of the pollution maps.

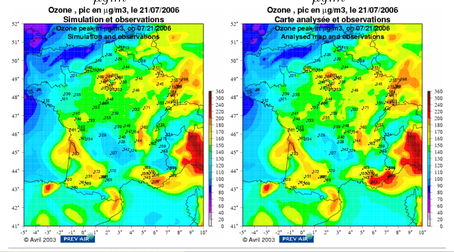
PM2.5 and PM10 are daily calculated over western Europe. An example is presented here for PM_{10} forecast with CHIMERE.



5. Ozone data assimilation in PREV'AIR

In PREV'AIR a Model Output Statistics (MOS) forecast is issued in addition to the raw forecast for ozone daily peak concentrations predicted over France. MOS relies on a training procedure : observations over past periods and simultaneous forecasts are required. Training seasons and implementation of the statistical adaptation must be coherent, deficiencies of the air quality forecasting models being a priori dependent on the season. MOS was applied during the 2006 summer season using three training periods : Summers 2003, 2004 and 2006. In PREV'AIR, the forecast error is regressed, at each monitoring site, from predicted 2m temperature issued from MM5 forecast, and the predicted ozone concentration itself. A different set of multiple regression coefficients is calculated for each site and each forecast lead time. Then MOS daily maxima are calculated. The MOS forecast issued for each monitoring station is then interpolated through the whole modeling domain by the same kriging method used for the analyses : kriging of the "innovations", taking as innovations the differences between the MOS forecasts and the raw model forecasts. In practice, the implementation of the statistical adaptation in PREV'AIR is based on 101 stations, including 39 rural, 27 suburban and 32 urban.
Data assimilation is done every day using an Optimal Interpolation method on O_3 surface fields. For each simulation, correction factors are estimated, leading to the **analyzed map**.

O_3 simulation — O_3 with Data Assimilation



6. Maps availability

Since the information is published daily on the Internet and filed in a database, the **PREV'AIR system is opened to all persons and organisations** that would like to, personally or professionally, be informed on the continent-wide evolution and trends of pollutant behaviour in the short and medium term.

- **PREV'AIR numerical data**
  - ▷ Extraction over user-defined domains
  - ▷ Available through the Internet for AQ related institutions (user accounts)
- **Applications**
  - ▷ 3D data : Boundary Conditions for Air Quality simulations at a local scale
  - ▷ 2D data : for Air Quality monitoring and forecast (interpolation, statistical modelling)
- Feed-back from PREV'AIR users

7. Statistics

For each summer and winter, scores are estimated. They showed the accuracy of the models used and their capability to forecast pollution events. (J-1) is the day before but without data assimilation. (J+0), (J+1) and (J+2) are forecast done at (J+0) during the night.
Summer 2006 Scores CHIMERE France (CF) versus CHIMERE + Optimal Interpolation (CFOI), for ozone [O3] in $\mu g/m^3$

D-1 :						
Site	Model	Obs	Norm.Bias	NMSE	Coor.	NumberObs
CF rural	106.1	106.6	2.9	20.7	0.84	6767
CFOI rural	109.5	106.6	5.6	20.6	0.87	6767
CF suburban	105.3	103.8	5.3	22.8	0.85	13384
CFOI suburban	106.9	103.8	6.4	22.8	0.86	13384
CF urban	104.8	101.5	7.1	25.1	0.83	25573
CFOI urban	106.5	101.5	8.5	24.7	0.85	25573
D+0 :						
Site	Model	Obs	Norm.Bias	NMSE	Coor.	NumberObs
CF rural	105.8	107.9	1.3	20.3	0.82	6458
CFOI rural	109.7	107.9	4.6	20.5	0.85	6458
CF suburban	105.0	105.0	3.5	21.6	0.84	12775
CFOI suburban	107.2	105.0	5.3	22.1	0.85	12775
CF urban	104.6	102.7	5.5	24.1	0.82	24401
CFOI urban	106.9	102.7	7.7	24.3	0.83	24401

The CHIMERE scores indicate :

- For ozone, the model slightly understimates the peaks values
- The bias increases with the forecast day (logically, also including the meteorological uncertainty)
- The correlation decreases but slowly (from 0.82 to 0.73) highlighting the robustness of the model
- The bias is larger over rural than urban sites due to the natural diffusivity of ozone plumes, the problems of transport modelling etc.

