An operational system for air quality **monitoring** and **forecasting** over Europe

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This platform is proposed by the **PREV 'AIR consortium** - **http://www.prevair.org**

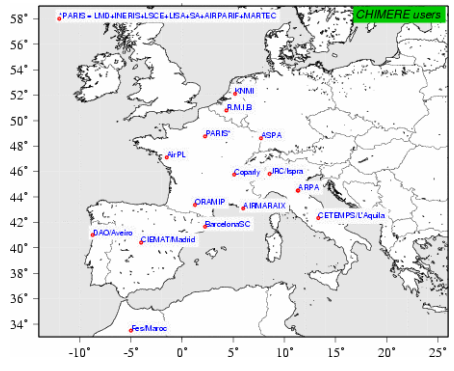
Questions about PREV 'AIR? Please send an e-mail to frederik.meleux@ineris.fr

Principles of the PREV'AIR system : www.prevair.org (i)

- An operational system that has become a part of the French air quality monitoring strategy .
- A new approach, borne by numerical tools, to reinforce the air quality management network, with new products :
  - Forecasts: since 2003, public information procedures and emergency measures are based not only on measurements but also on forecasts. This is one of the decision of the "Air Plan" adopted by the national authorities after the August heat wave
    - Regulatory pollutants: O3, NO2 and PM
    - Global / European / French scales
    - 3 days ahead ➔ Prevention of exposure
  - Monitoring: not all regions are fully covered by fixed measurement stations
    - Measurements and model results are combined to provide « analyses » : the most relevant
    - Air pollution maps describing air pollution patterns on a hourly or daily basis

Principles of the PREV'AIR system : www.prevair.org (ii)

- Daily broadcast of information through Internet: ***http://www.prevair.org***
- A user- oriented system which to reach different kinds of products
  - Free access, open scope: forecast maps / observations / analyses
  - Restricted access, registered users: numerical model data
- More then 50 users among which local and regional air quality monitoring agencies, research laboratories, private companies

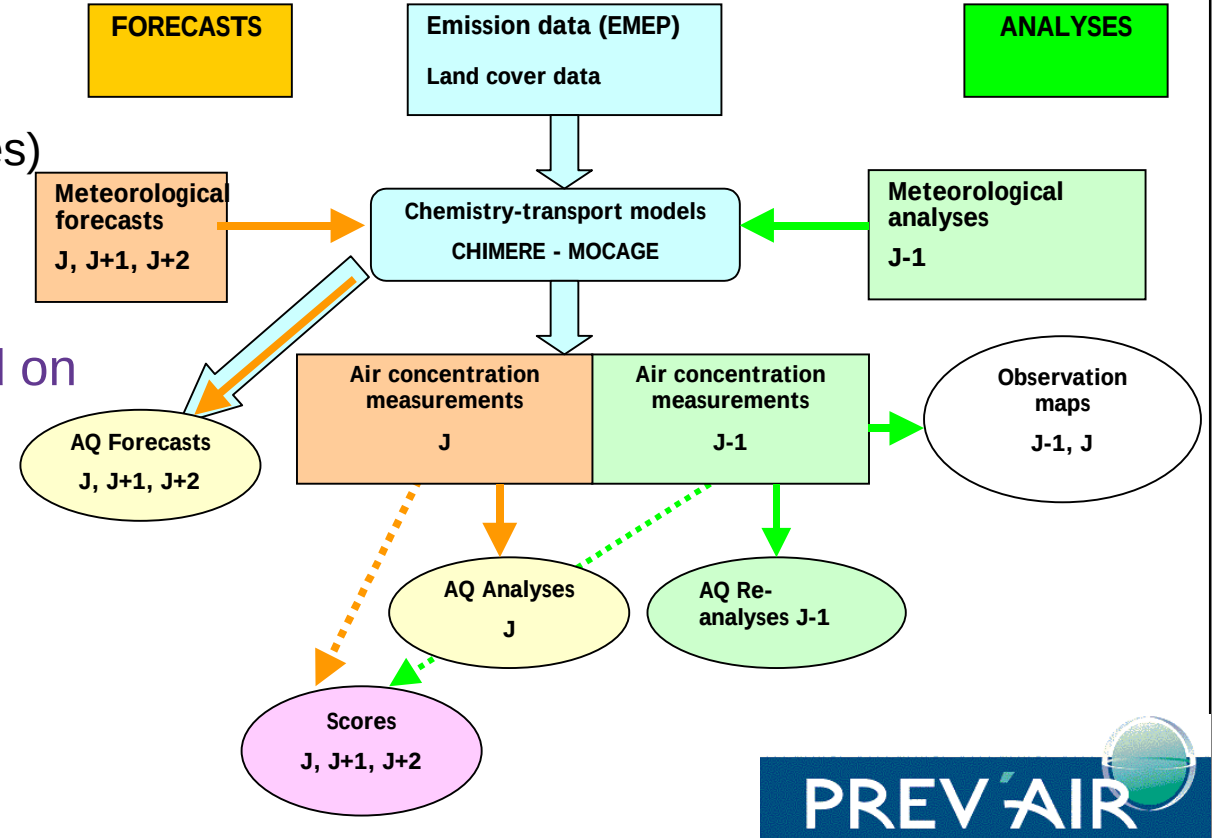


- Daily information about the model performances is also available to build users' confidence
- Fully operational running conditions in summer with 24h/24h turns to guarantee the data availability on the user accounts each morning at 8:00 a.m.
- In case of persistent (more than 2 days) and large scale (more than 2 administrative regions) ozone episodes, PREV'AIR maps are sent to TV media for informing general public

Tools and partners within PREV'AIR

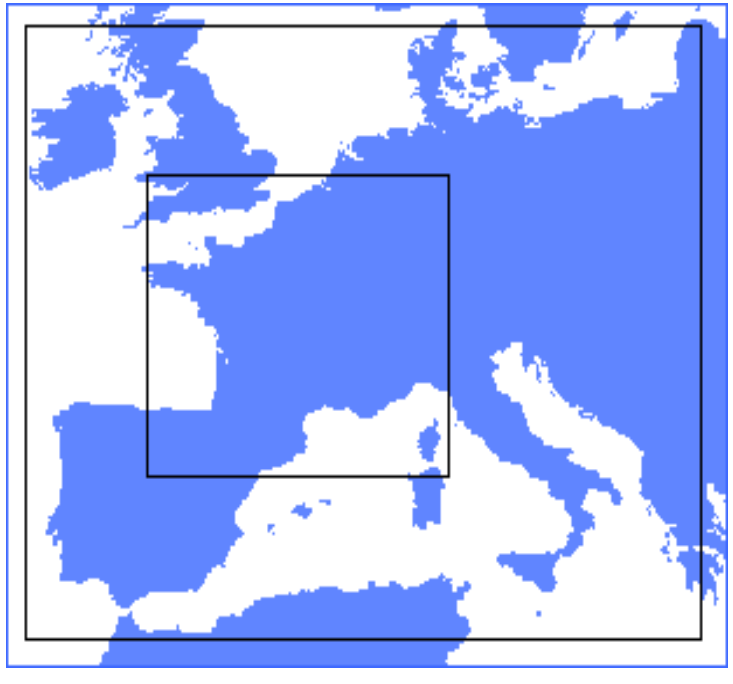
- 3D CTM
- Input data
- Outputs
  - Maps and numerical data
  - Forecasts / analyses
  - Accuracy of the forecasts (scores)

- **Post-processing tools,** based on NRT observation data
  - Skill scores
  - Analyses
  - MOS forecasts



Model set-up in PREV'AIR (1) : CHIMERE

- Domains — Over Europe — Over France
  - Horizontal resolution: 0.5°x 0.5° — 0.15° x 0.1°
  - Vertical resolution: 8 levels from surface pressure up to 500 hPa
- Meteorological forecast data
  - **AVN / NCEP** for initialisation and boundary conditions
  - **MM5** higher resolution forecasts (36km, 18km)
- Boundary conditions
  - **LMDzINCA** and **GOCART** climatologies
- Chemical scheme
  - **MELCHIOR** reduced (~45 species, ~120 reactions)
- Emission data
  - **EMEP** regridded (greater quantity over urban areas)
- Aerosol module
  - Dust, PPM, nitrates, sulfates, ammonium, SOA, water content
  - **25 reactions** (aqueous and heterogeneous phase)



➔ *Open-source code:* ***http://euler.lmd.polytechnique.fr/chimere***

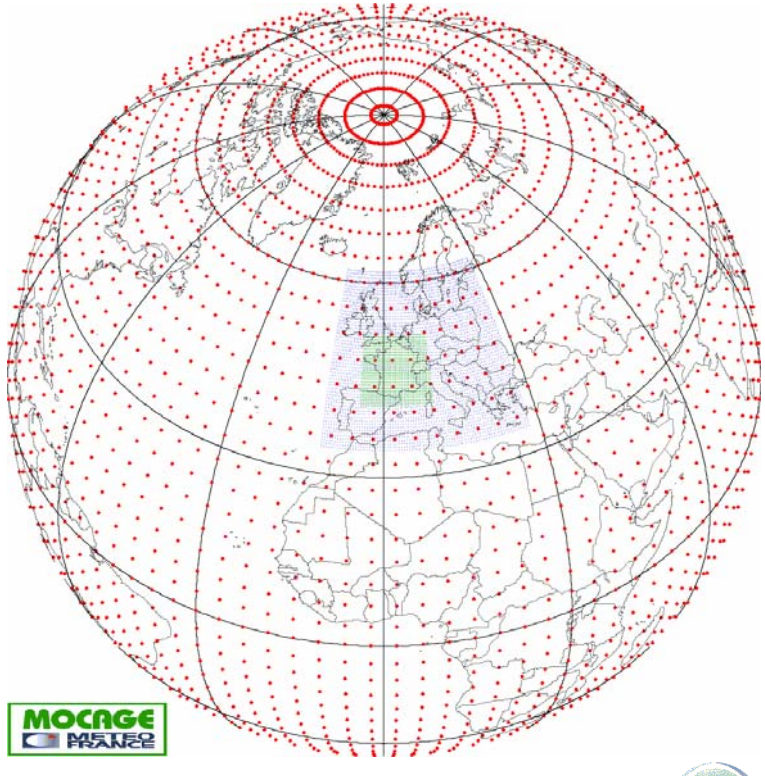
Model set-up in PREV'AIR (2) : MOCAGE

- Domains

	Global Model	Over Europe	Over France
Horizontal resolution:	2°x 2°	0.5° x 0.5°	0.1° x 0.1°
Vertical resolution:	47 levels from surface pressure up to 5hPa		

- Meteorological forecast data
  - **ARPEGE** and **ALADIN**
- Chemical scheme
  - **RACMOBUS** (118 species, 381 reactions)
- Emissions
  - **GEIA** and **EDGAR** / **EMEP** regridded
- No aerosol module

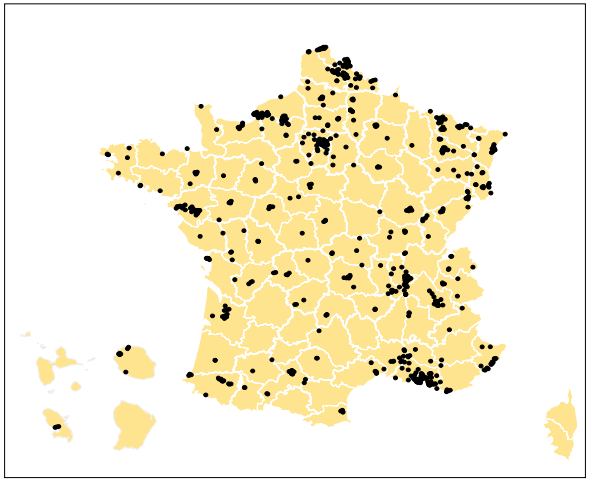
- Dust model



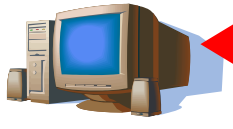
The BASTER Near Real-Time database

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

41 French AQ related organisms (AASQA)



680 monitoring stations



Local servers

hour

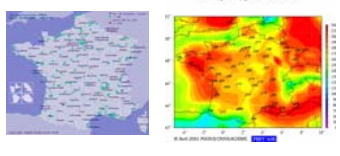
"real time" national database BASTER

O_3
NO_2
SO_2
PM10
PM2.5

ADEME

AASQA web sites

National web site



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LOCAL

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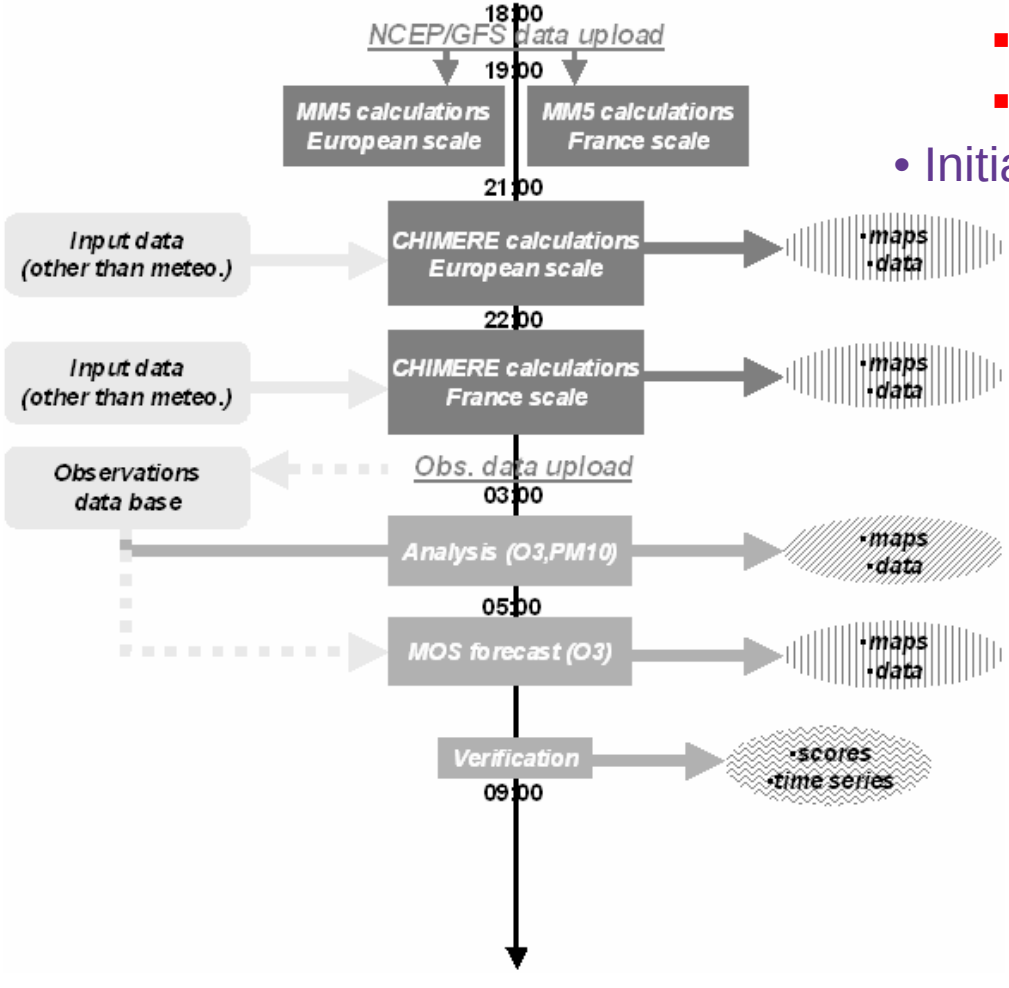
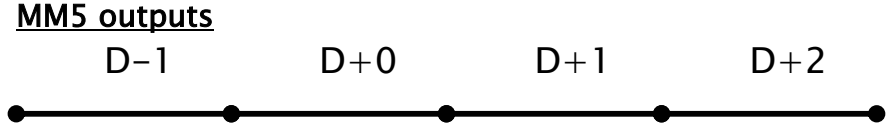
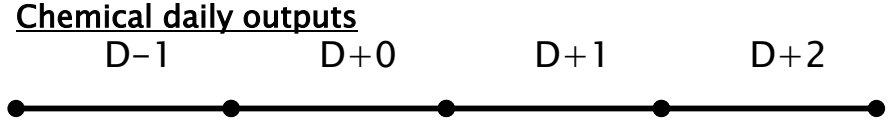
Cycle of operations



- Forecasts go from D-1, 00:00 to D+3, 00:00 UT
  - MM5: 80 ’
  - CHIMERE: 210 ’
- Initialization: last forecast, D+0, 00:00

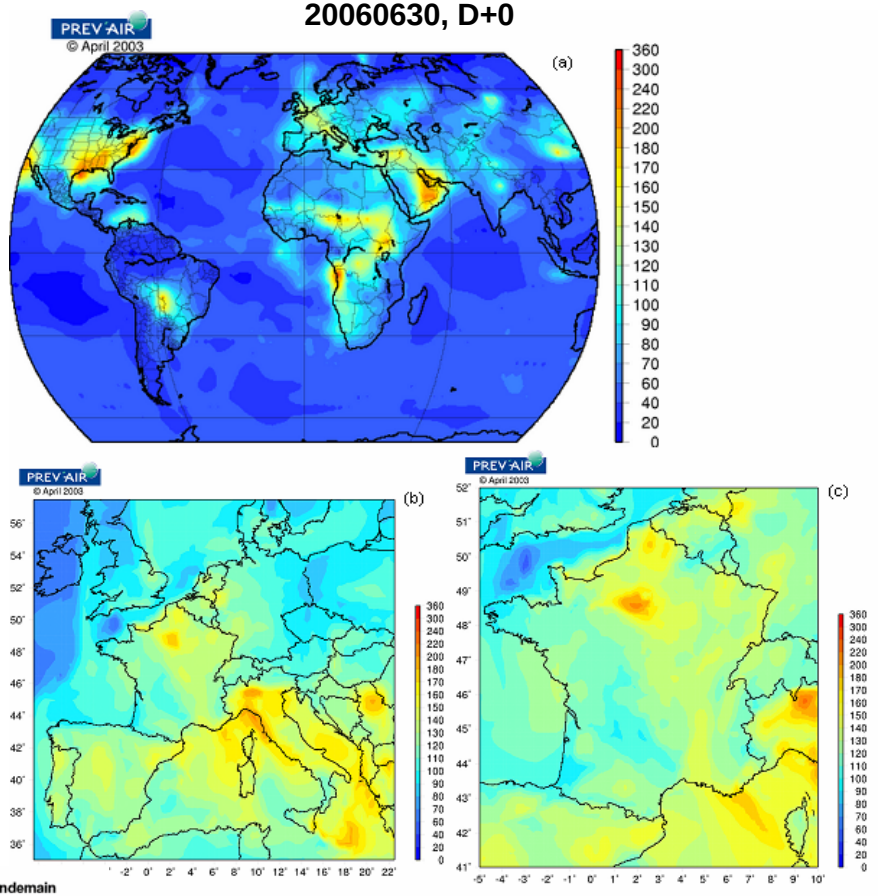




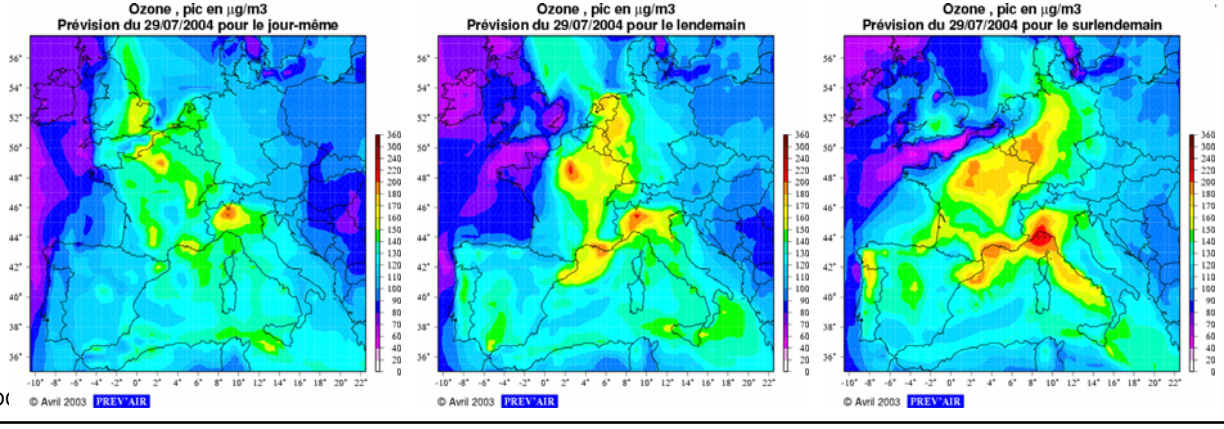
An example of forecast (ozone)

- Available at D+0, 00:00 LT
- Daily peak and averaged concentration maps
  - D+0, D+1, D+2
- Pollutants: O3, NO2, particulate matter

20060630, D+0



20040729, D+0, D+1, D+2



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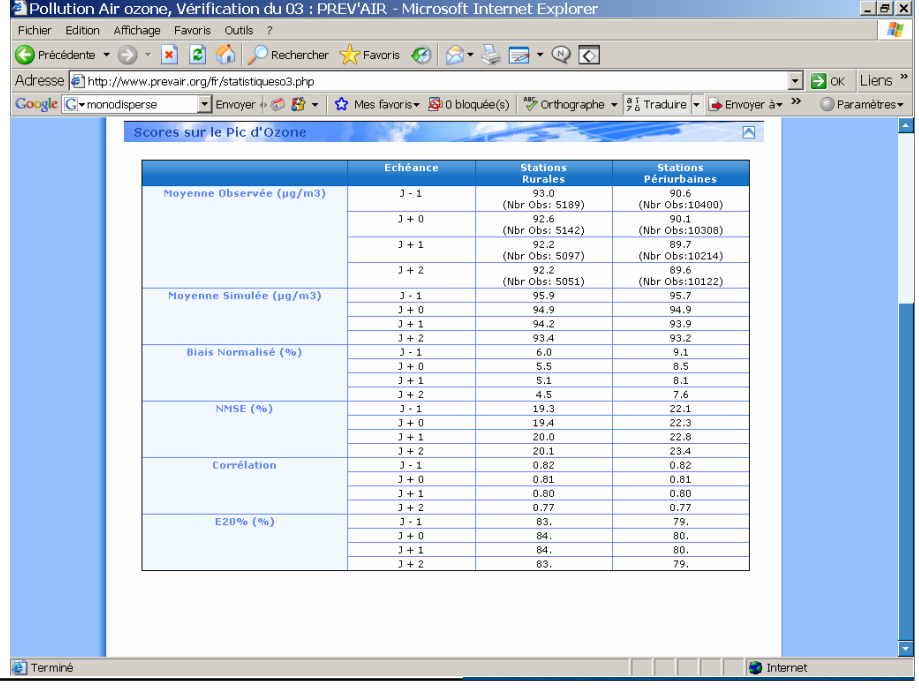
Accuracy of the forecasts

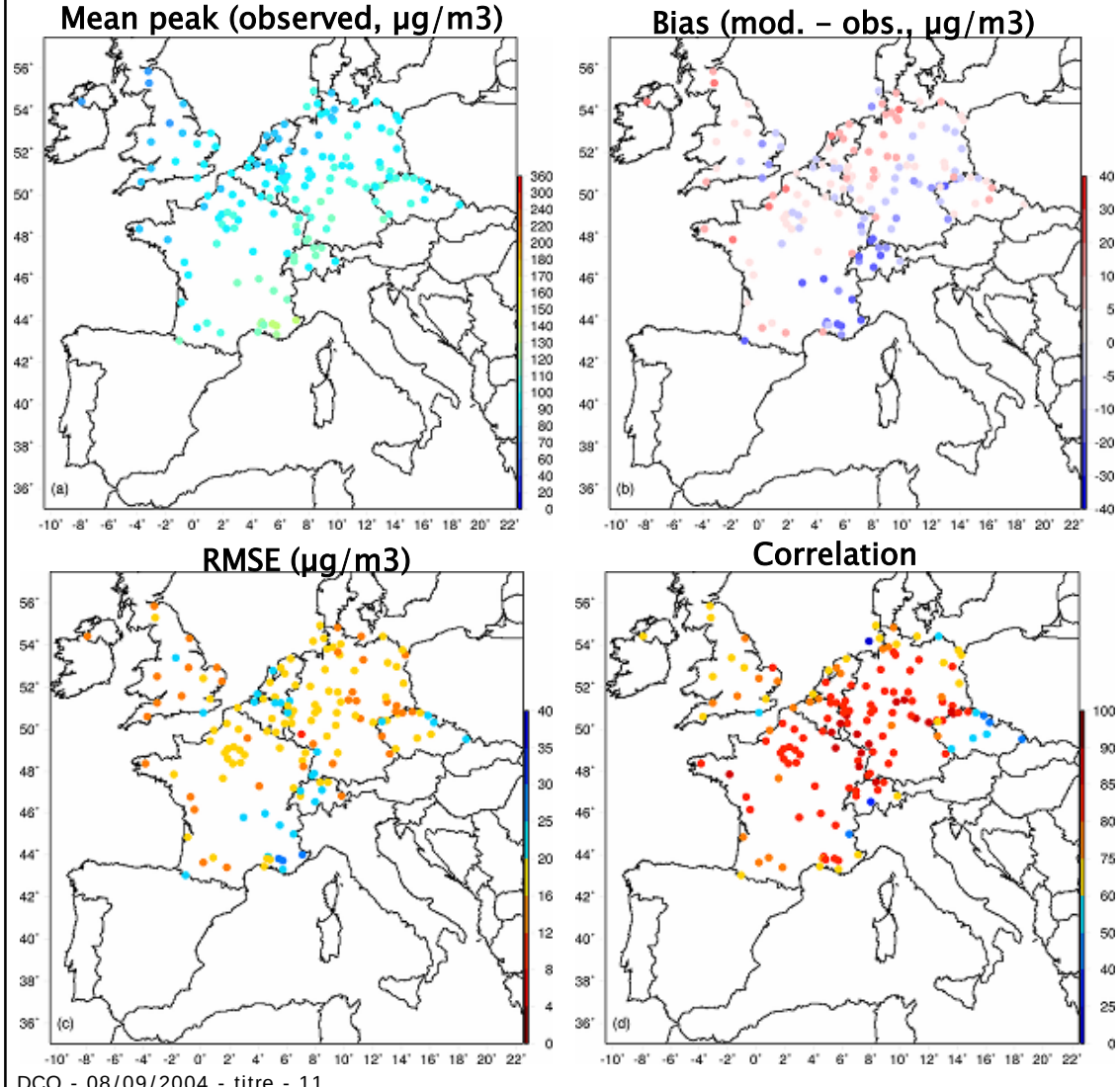
- Usual indicators
  - Bias, RMSE, correlation, sigma ratio
  - Histograms of errors
  - Contingency tables
  - Time series
- Against NRT observations (BASTER) on measurement sites:
  - Rural, suburban, urban
  - All sites but a few (anomalies reported)
- Outputs
  - Skill score tables and maps
  - Contingency tables
  - Time series
  - Scatterplots

- Difficulties:
  - Average concentrations against ponctual data
  - Topography effect
  - Representativeness of the measurement sites?



	Echéance	Stations Rurales	Stations Périurbaines
Moyenne Observée (µg/m3)	J - 1	93.0 (Nbr Obs: 5189)	90.6 (Nbr Obs:10400)
	J + 0	92.6 (Nbr Obs: 5142)	90.1 (Nbr Obs:10308)
	J + 1	92.2 (Nbr Obs: 5097)	89.7 (Nbr Obs:10214)
	J + 2	92.2 (Nbr Obs: 5051)	89.6 (Nbr Obs:10122)
Moyenne Simulée (µg/m3)	J - 1	95.9	95.7
	J + 0	94.9	94.9
	J + 1	94.2	93.9
	J + 2	93.4	93.2
Biais Normalisé (%)	J - 1	6.0	9.1
	J + 0	5.5	8.5
	J + 1	5.1	8.1
	J + 2	4.5	7.6
NMSE (%)	J - 1	19.3	22.1
	J + 0	19.4	22.3
	J + 1	20.0	22.8
	J + 2	20.1	23.4
Corrélation	J - 1	0.82	0.82
	J + 0	0.81	0.81
	J + 1	0.80	0.80
	J + 2	0.77	0.77
E20% (%)	J - 1	83.	79.
	J + 0	84.	80.
	J + 1	84.	80.
	J + 2	83.	79.

Accuracy of the ozone forecasts (1)

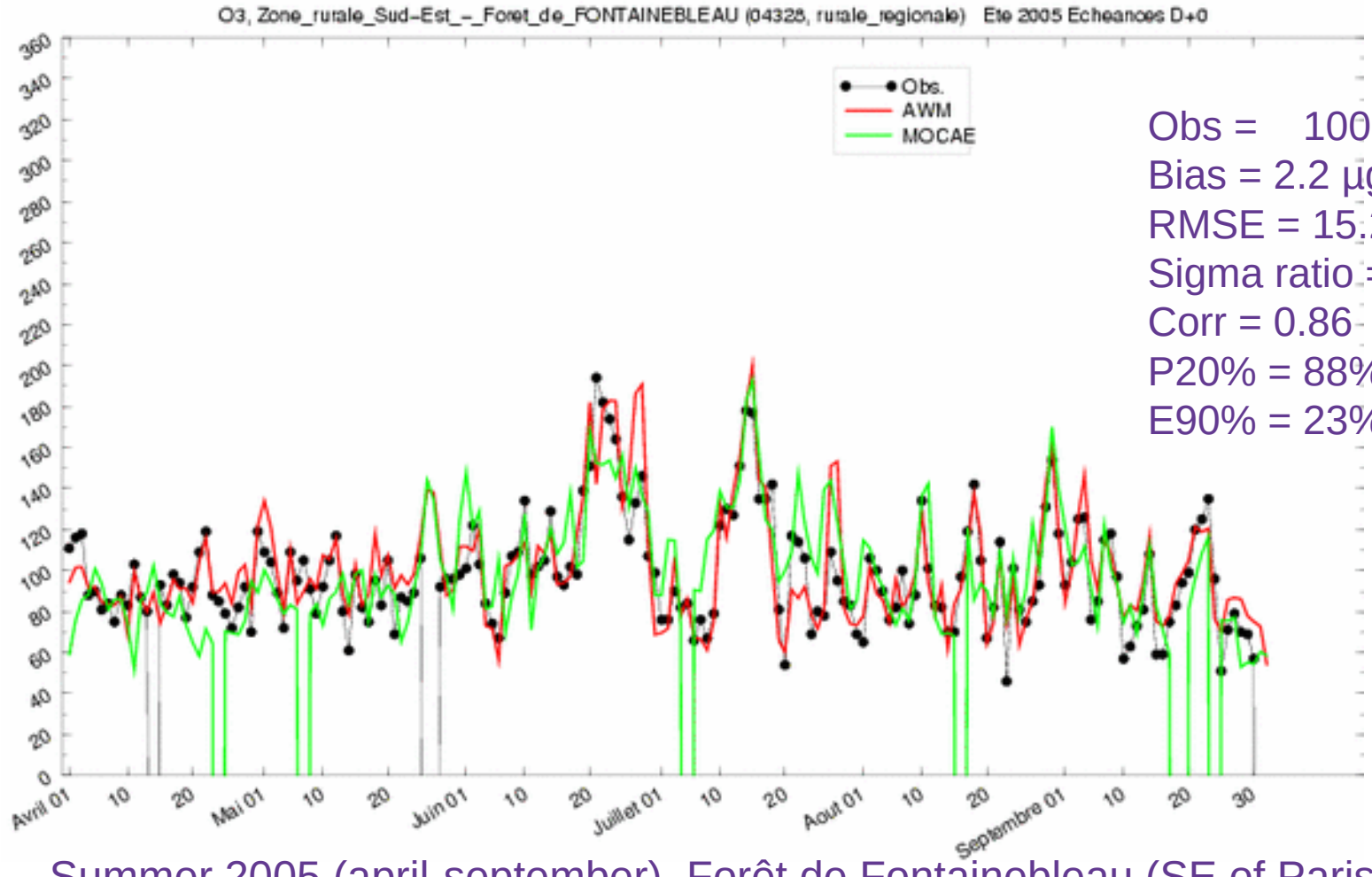


Springs / Summers 2004-2006

European scale (« AWM »)

	Lead time	RUR	SUB	URB
Mean obs.	-	100.1	102.0	99.3
Bias	D-1	1.7	3.6	5.6
	D+0	0.9	2.6	4.8
	D+1	0.0	1.6	4.1
	D+2	-0.4	1.2	3.7
RMSE	D-1	16.8	17.6	17.3
	D+0	17.3	18.2	17.7
	D+1	18.2	18.9	18.3
	D+2	19.4	20.1	19.4
Corr	D-1	0.83	0.83	0.84
	D+0	0.81	0.82	0.82
	D+1	0.79	0.80	0.81
	D+2	0.76	0.77	0.78

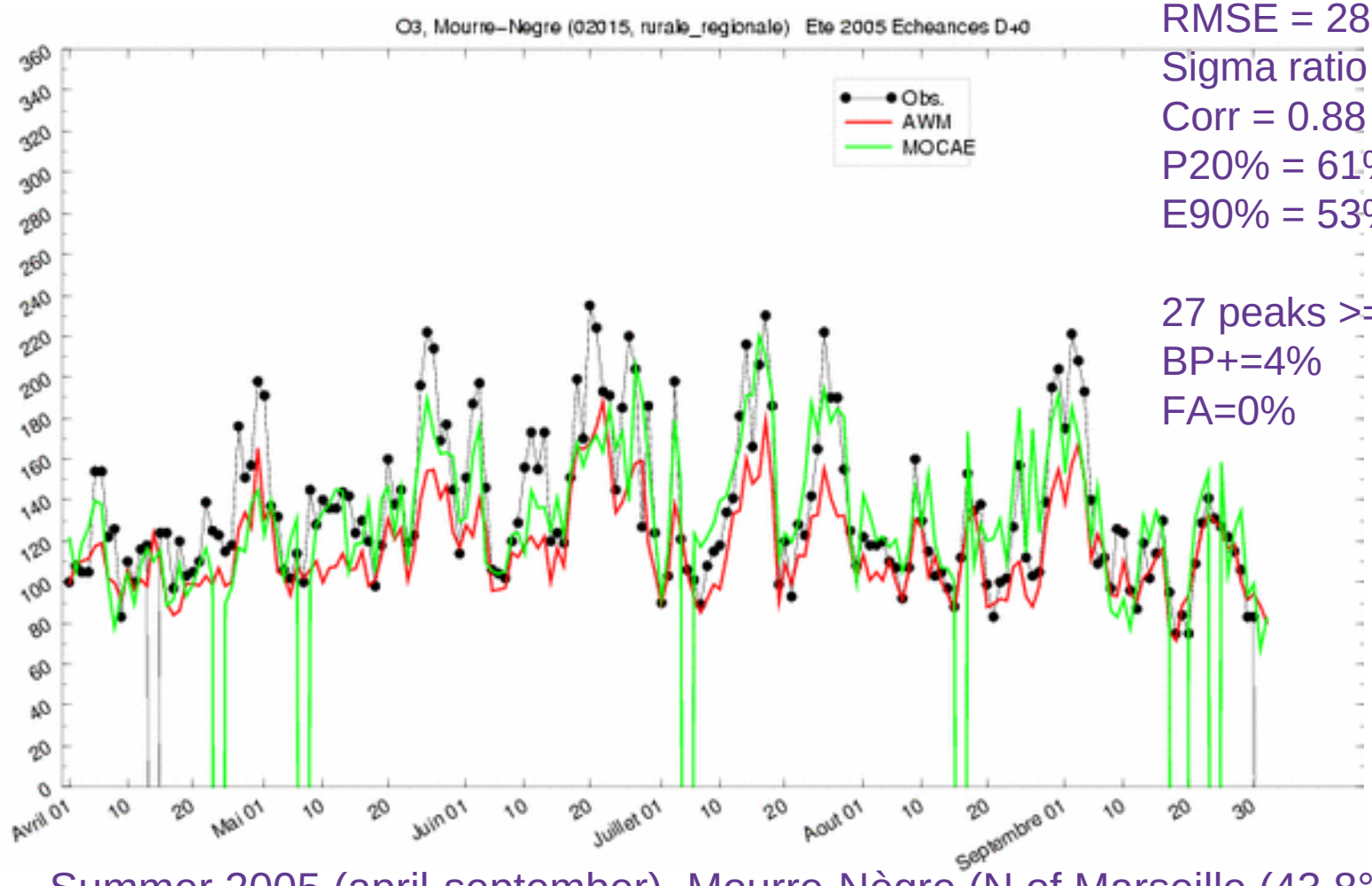
Accuracy of the ozone forecasts (2)



Obs = 100.6 µg/m3(145 obs)
Bias = 2.2 µg/m3
RMSE = 15.2 µg/m3
Sigma ratio = 1.07
Corr = 0.86
P20% = 88%
E90% = 23%

Summer 2005 (april-september), Forêt de Fontainebleau (SE of Paris)

Accuracy of the ozone forecasts (3)



Obs = 138.1 µg/m3 (146 obs)
Bias = -19.4 µg/m3
RMSE = 28.4 µg/m3
Sigma ratio = 0.61
Corr = 0.88
P20% = 61%
E90% = 53%

27 peaks >= 180µg/m3
BP+=4%
FA=0%

Summer 2005 (april-september), Mourre-Nègre (N of Marseille (43.8°,5.5°), 1100m)

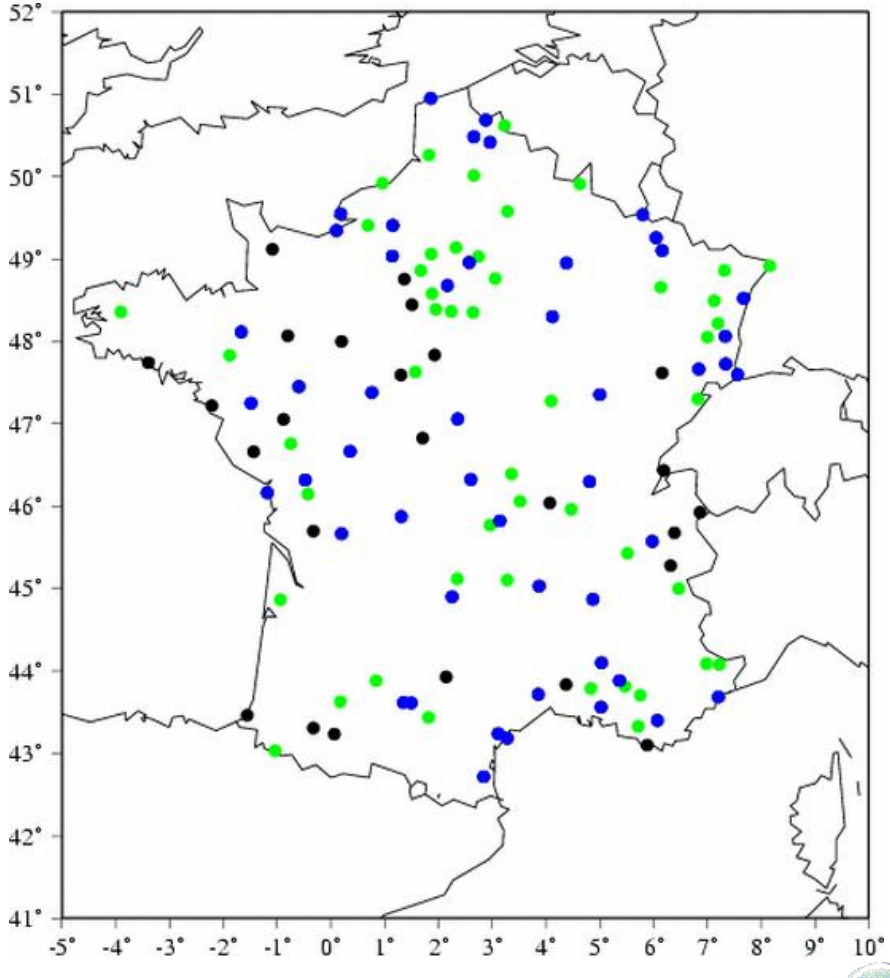
Analysis (e.g. ozone)

- Goal: have the best possible picture of air quality over France
- Idea: inject information in the system based on current observations

- An **error field** is assessed over a **selection of measurement stations**:
  - **[O3]error = [O3]*-[O3]**

- The **ozone correction field** is computed over the whole domain from these discrete errors (**kriging method**)

- The ozone **correction field** is added up to the simulated concentrations => **Analysis**

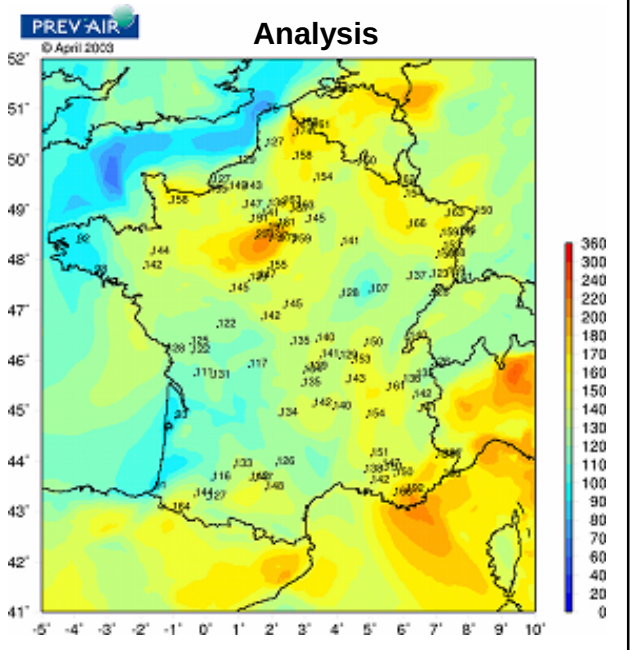


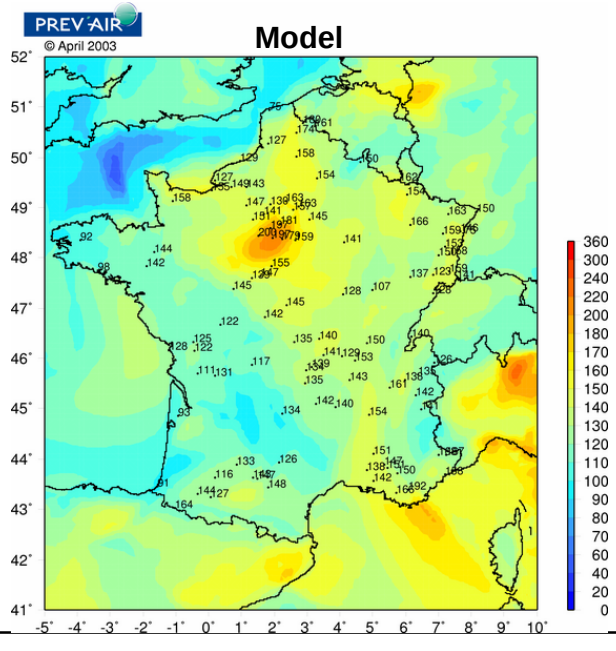
PREV ’AIR ozone analyses

- Deals with D-1 and D+0 ozone peaks
- Model:
  - AFM = France CTM

- Outputs:
  - Ozone peak concentration
  - Several times per day

June 30, 2006





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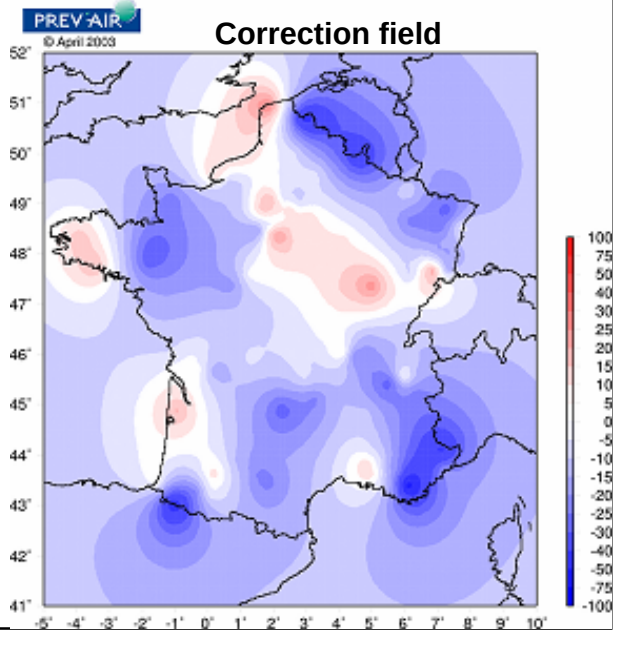


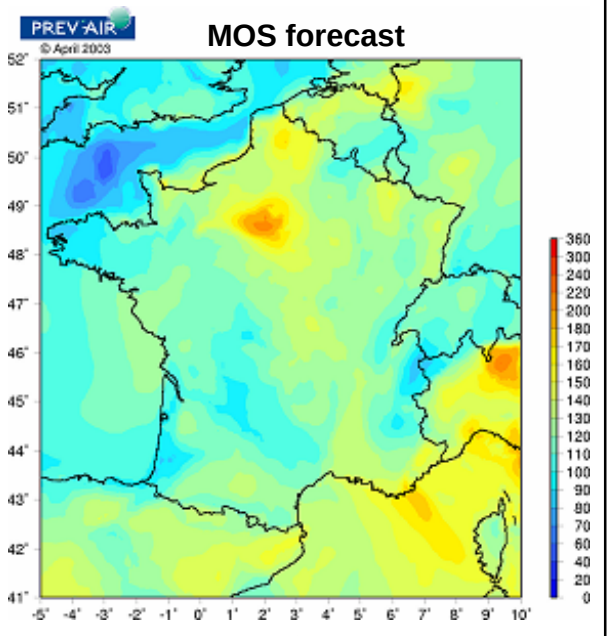
MOS forecasts (e.g. ozone)

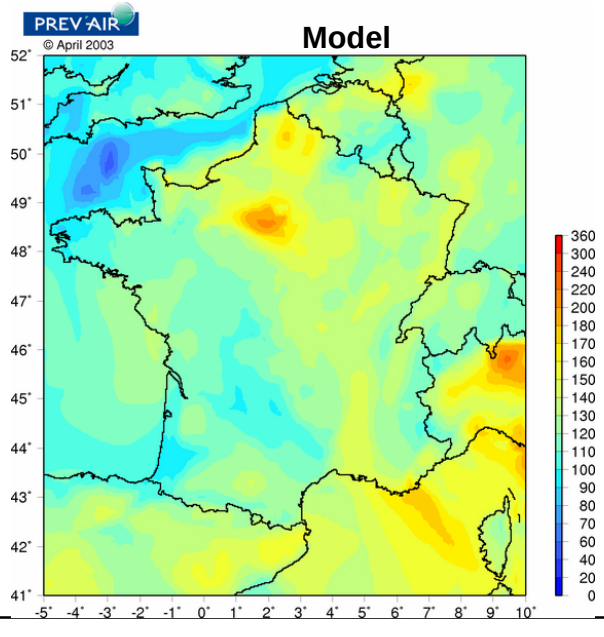
- Requires a **chemical climatological database** for past summers:
  - Ozone **error field** ([O3]error = [O3]sim -[O3]* over ~ 240 stations (rural and suburban) / Tsim / [O3]sim
- From past error fields, a linear regression is built for the ozone **error**:
  - [O3]error= αstation Tsim + βstation [O3]sim at each measurement site
- Given the ozone and temperature forecasts, ozone **errors** are assessed based on the regressions => **Pseudo observations**:
    - [O3]*=[O3]-[O3]error
- A **kriging method** is used to compute the ozone **correction field** over the whole domain from these discrete errors
- The ozone **correction field** is added up to the forecast => **MOS forecast**

PREV ’AIR ozone MOS forecasts

- Deals with D+0 to D+2 ozone peaks
- Model:
  - France CTM, Gaseous
- Outputs:
  - Ozone peak concentration
  - Available at D+0

June 30, 2006





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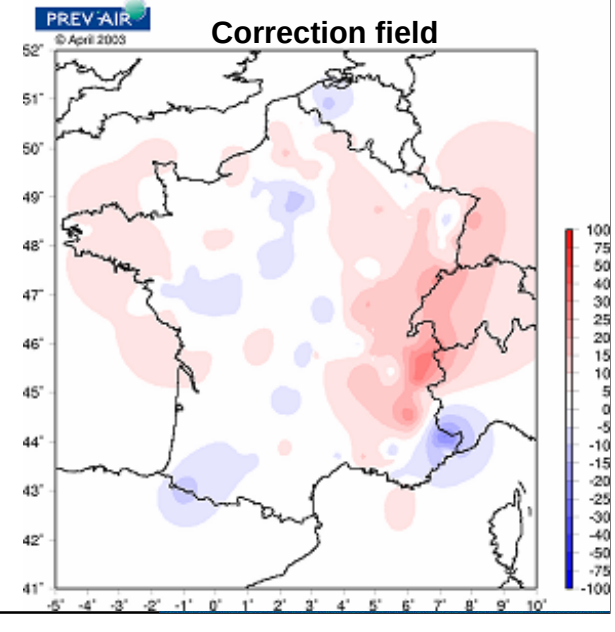
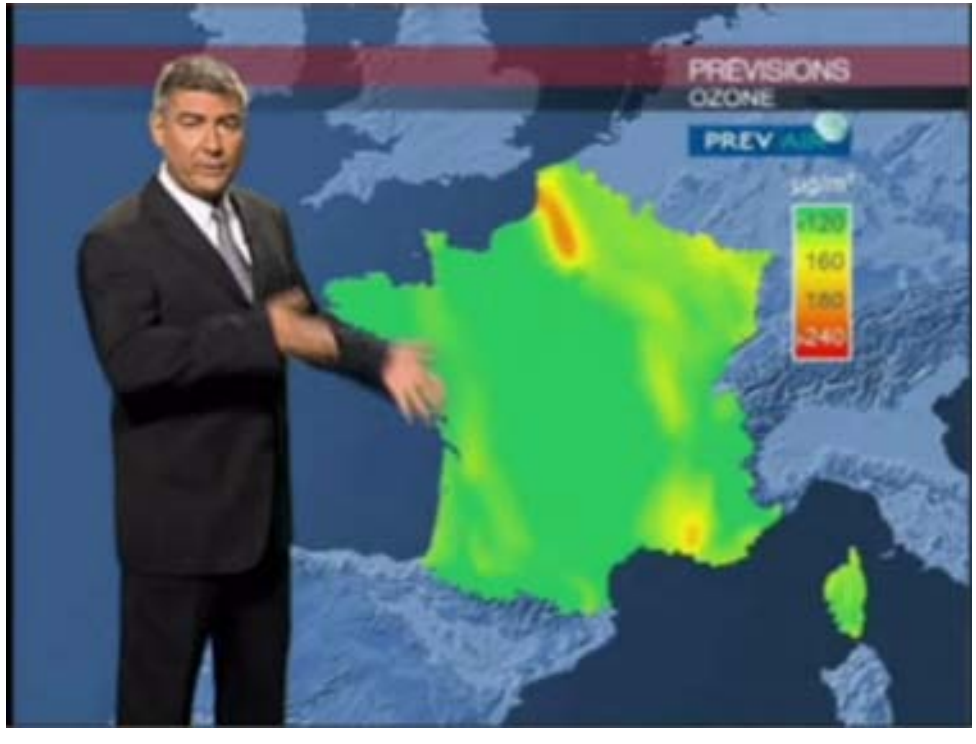


Ozone map on public television

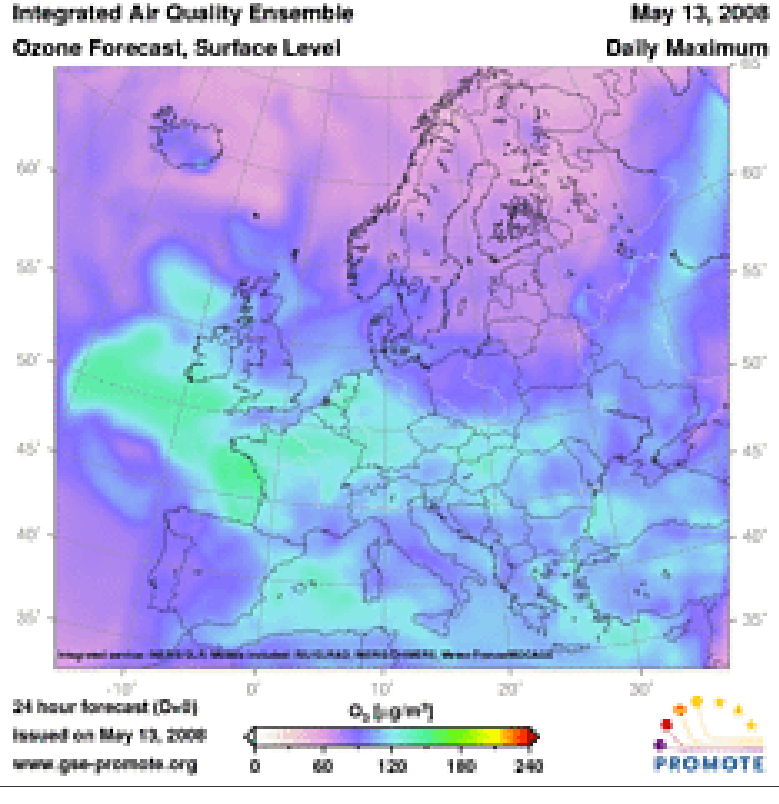
• In case of persistent (more than 2 days) and large scale (more than 2 administrative regions) ozone episodes, PREV'AIR maps are sent to TV media for informing general public



In 2007, 0 day
In 2006, 17 days
In 2005, 18 days

PREV ’AIR in the European context

- Contribution to the GEMS (FP6) and PROMOTE ESA GMES Service Element) projects that are supposed to prefigure the future GMES Atmospheric service
- Provision of CHIMERE and MOCAGE forecasts to build « ensemble » products : boundary conditions for local systems
- Provision of analysed maps for EEA (with NRT data)
- Contribution to the MACC proposal (FP7) : Considering its skills and experience, PREV ’AIR Consortium wishes to play a coordination role in the future GMES Atmospheric Service



Perspectives

- Take even more advantage of observations:
  - Analyzed concentrations integrated in the forecasting chain as initial concentrations
  - Longer term: Integration of 3D observations of pollutant concentrations (LIDAR, satellite measurements) by data assimilation procedures

- Ensemble forecasting:
  - Possible substantial improvement of AQ forecasting systems
  - Reliability of the forecasts: probabilistic response (e.g. probability of going beyond an air quality threshold in a given area)

- Emission inventory improvements :
  - Agricultural emissions (NH3, NOx)

PREV'AIR