

**Map3D**  
Forecasting Air Quality



**Map3D**  
"Mesoscale Air Pollution 3D  
modeling"

<http://map3d.epfl.ch>

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## Regional Air Pollution Processes

COMPLEX

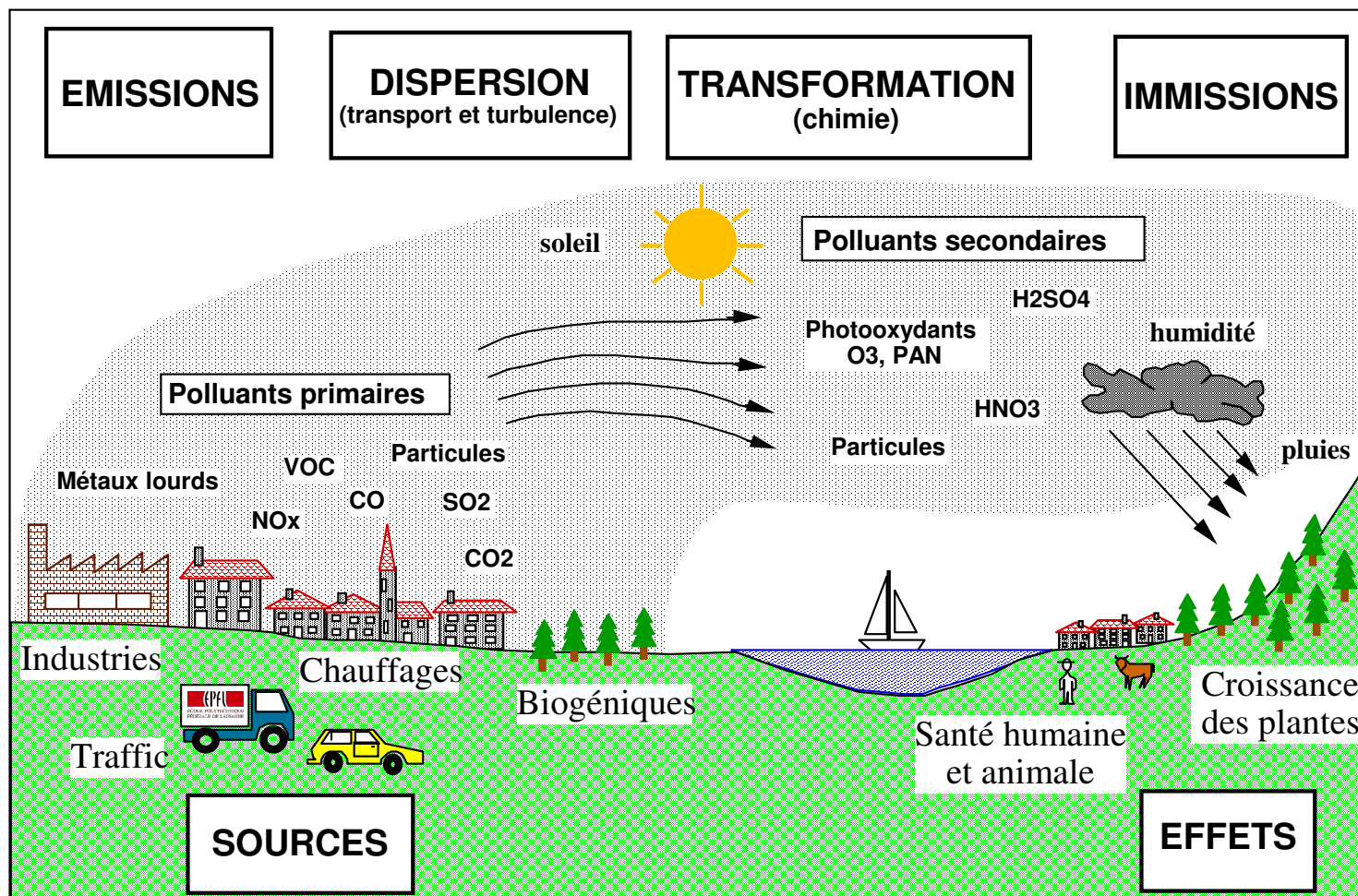
TRANSPORT

CHEMISTRY

OZONE

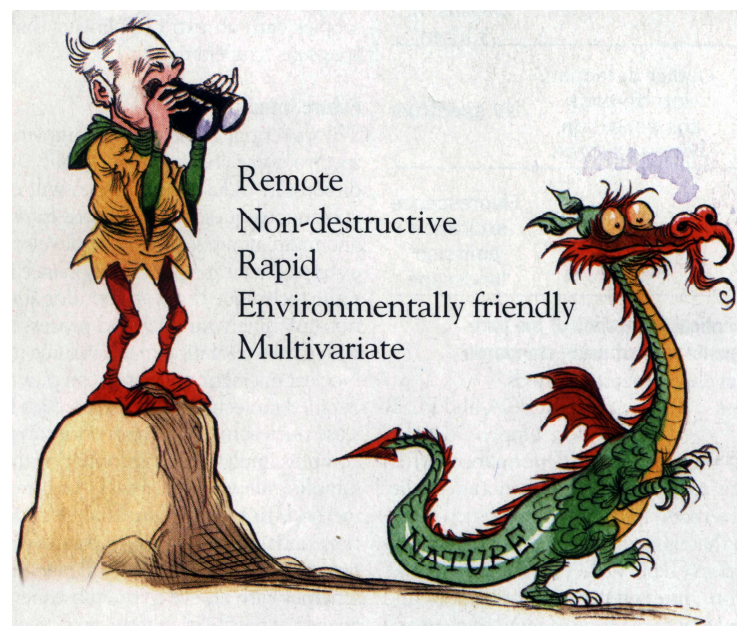
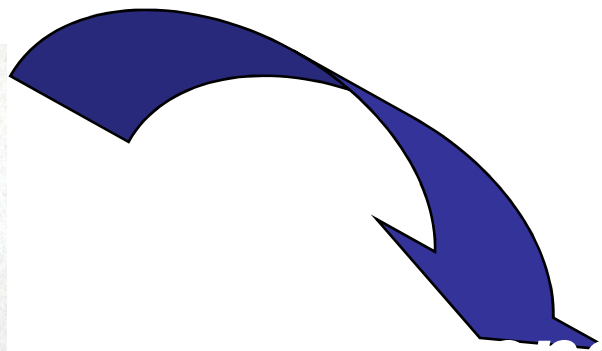
METEO

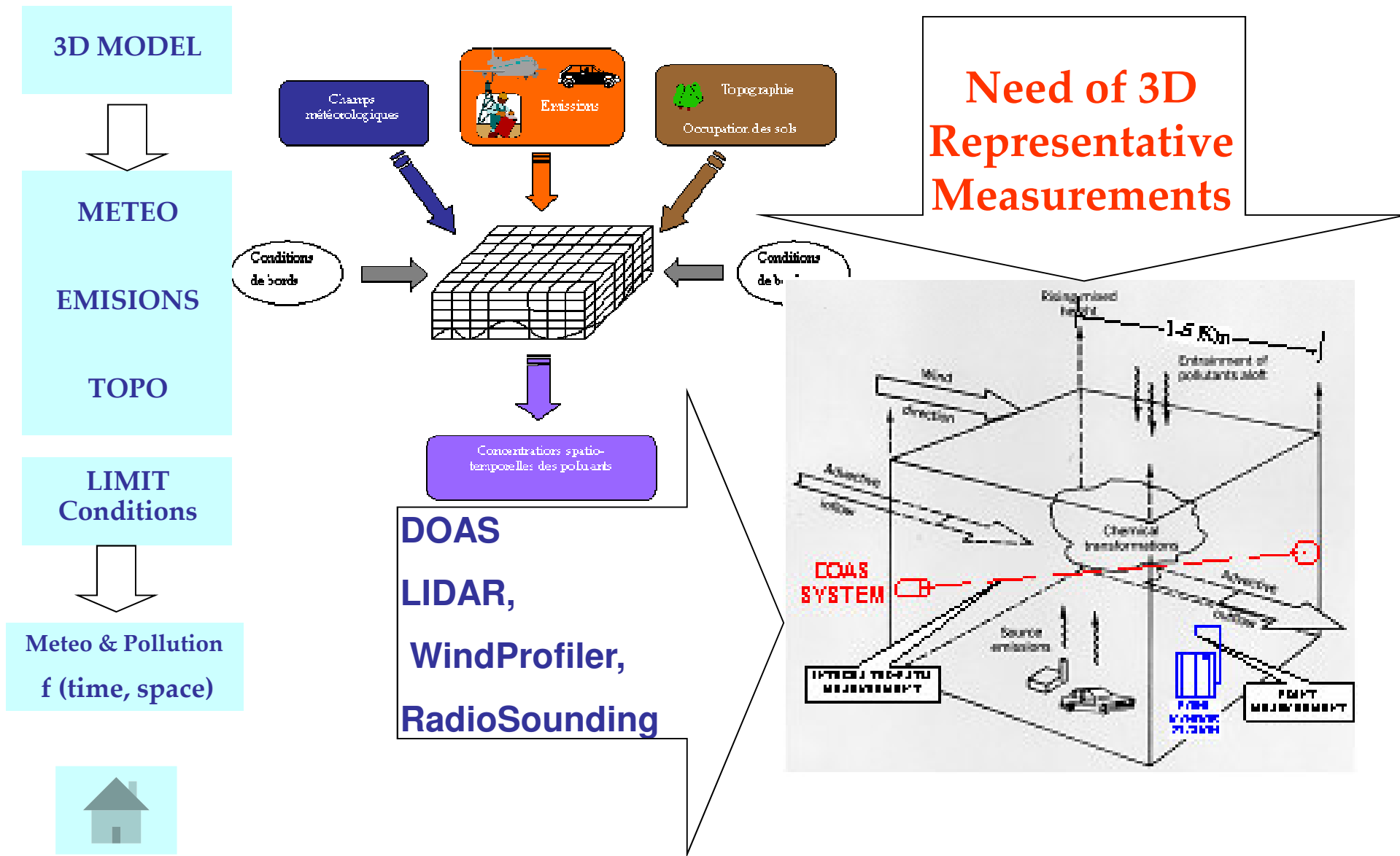
EFFECTS





*Classical  
Analytical Techniques*



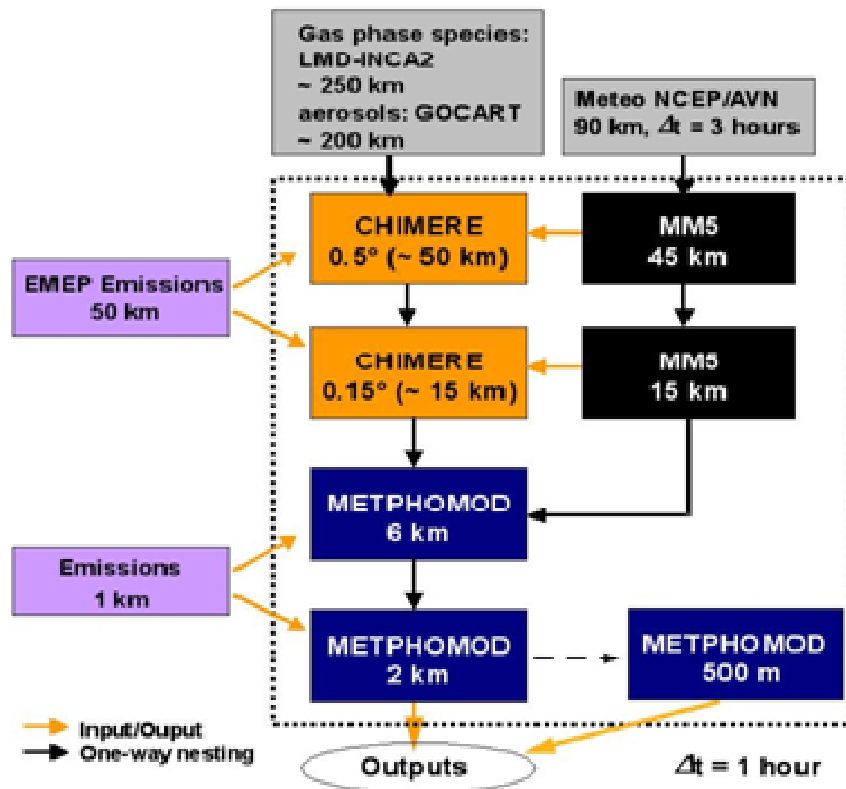


# Outline

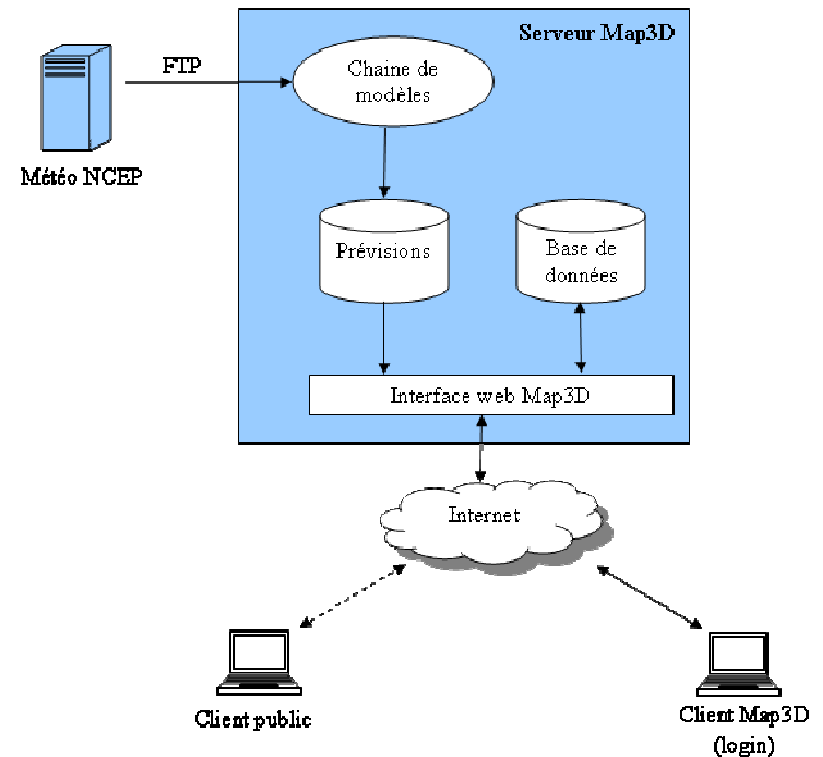
- Experience of air quality studies and Innogrants awards
- Description of the modelling chain
- **MAP3D** outputs and web interface
- Model results validation for the period of August 2008 - February 2009 for  $O_3$ ,  $O_x$  and  $PM_{10}$
- Discussion and perspectives

# Technical solution

## Model Chain Set up



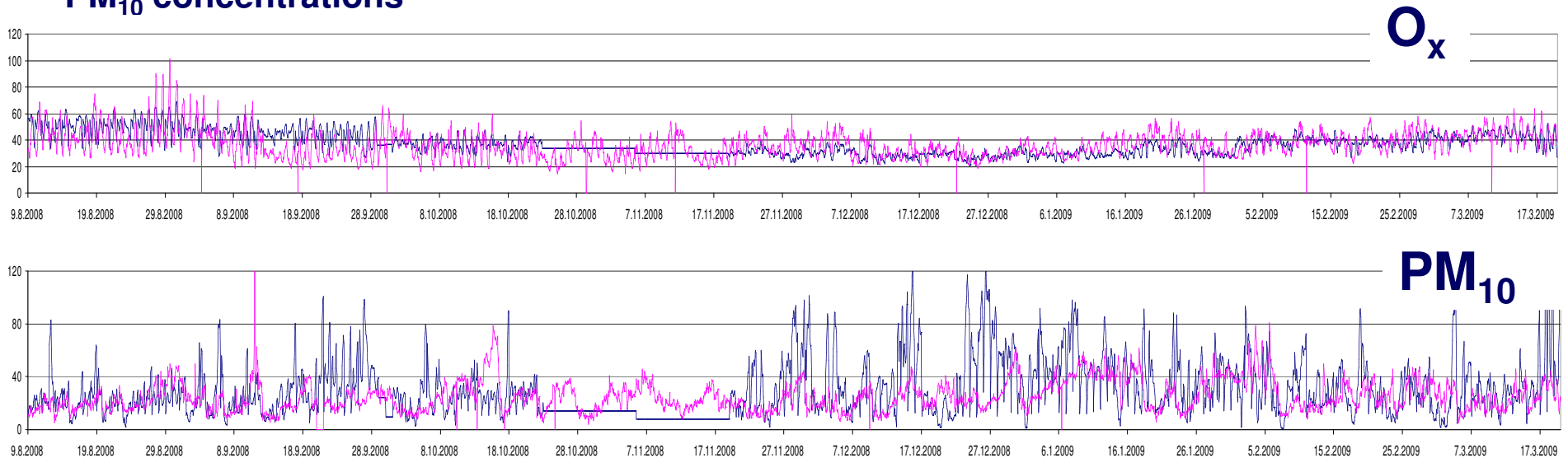
## Computer Architecture



Map3D server :  
 Dell PowerEdge 2950 with Intel Quad-Core  
 Xeon 2,33GHz/2x4MB

# Model results validation for the period of August 2008 - February 2009

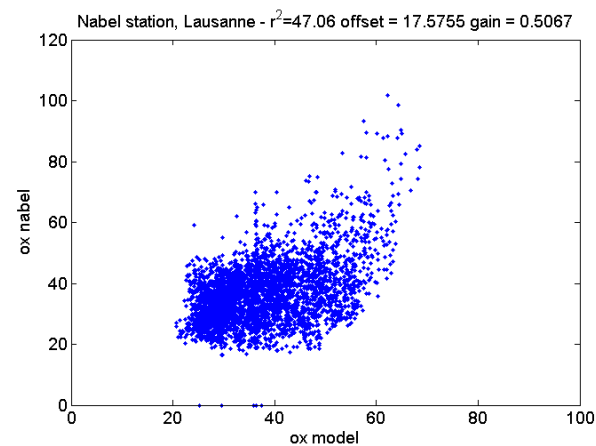
Validation of the calculations for Switzerland with the Lausanne Nabel measurements urban stations for the period of August 2008 - February 2009 for  $O_x = (O_3 + NO_2)$  and  $PM_{10}$  concentrations



$$O_x \text{ Nabel} = f(O_x \text{ model})$$

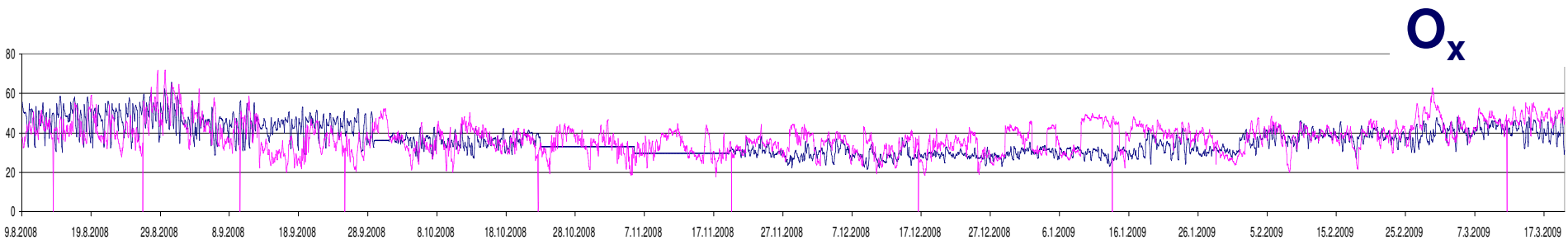
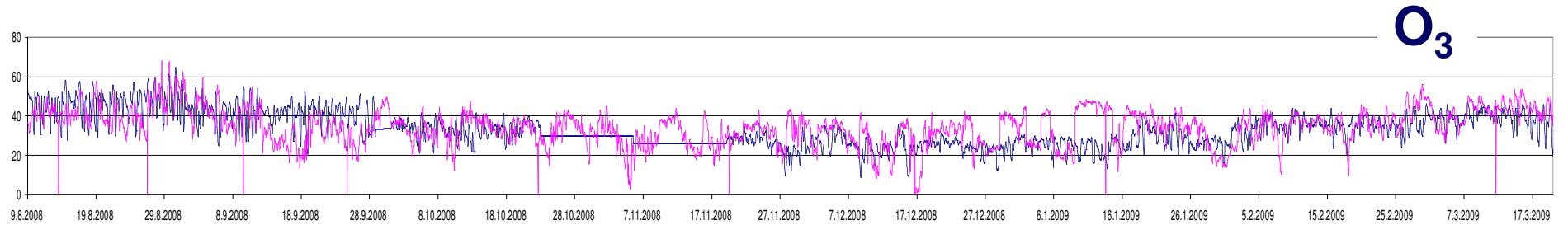


Lausanne Nabel urban station



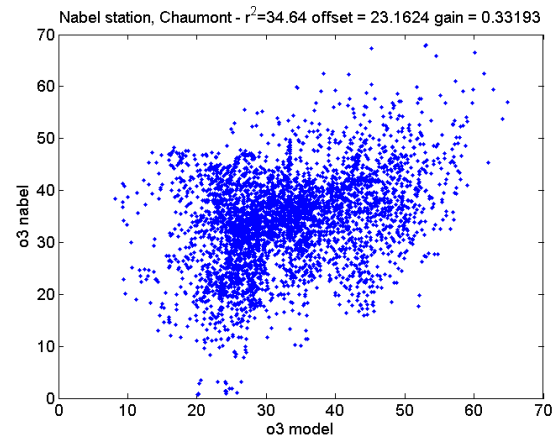
# Model results validation

Validation of the calculations for Switzerland with the Chaumont Nabel rural measurements stations for the period of August 2008 - February 2009 for  $O_3$  and  $O_x = (O_3 + NO_2)$  concentrations



$$O_3\text{Nabel} = f(O_3\text{model})$$

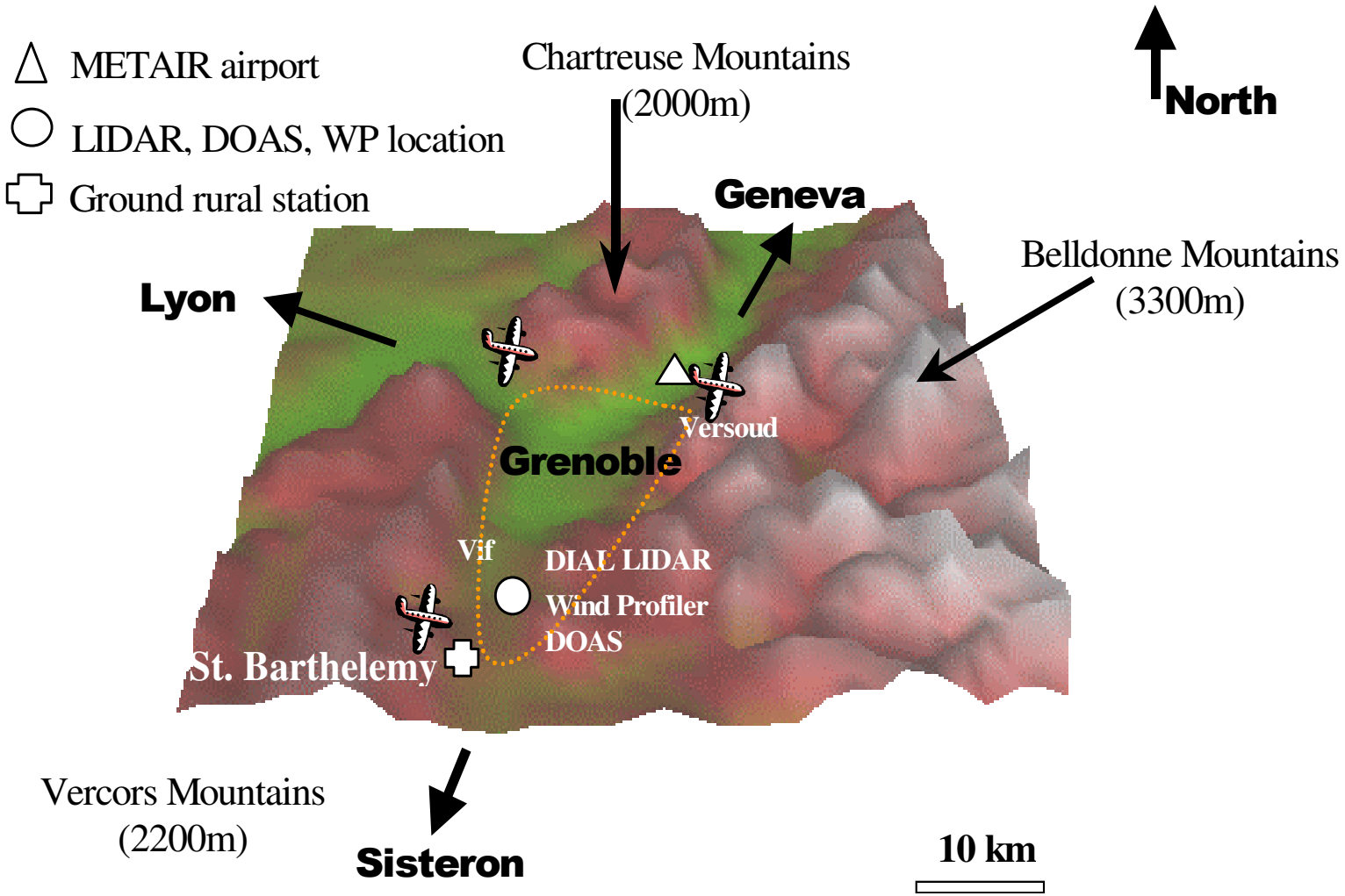
Chaumont Nabel  
rural station







- Complex Topography
- 3 D Monitoring
- 3 D Modeling
- Inter Validation
- Complex Chemistry



Validation  
Comparisons

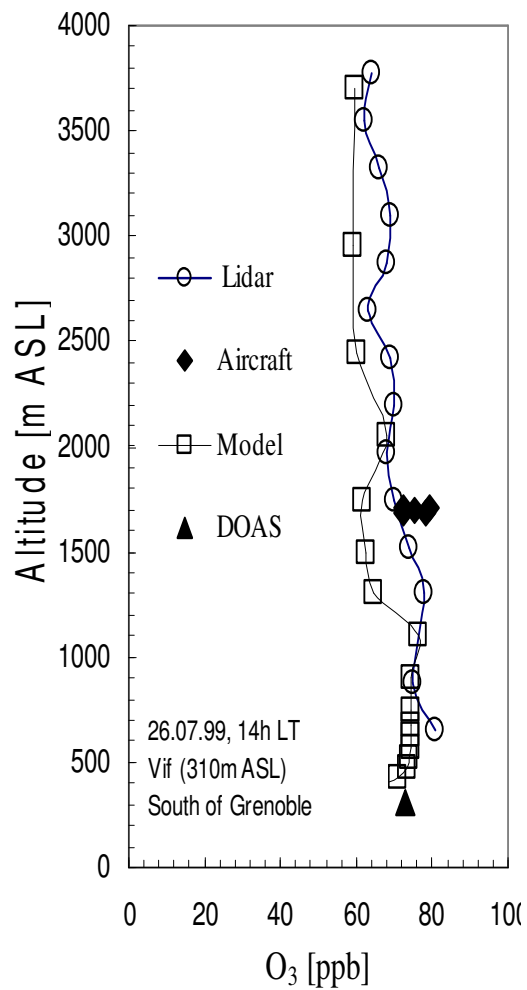
Complement  
WindProfiler

Complement  
DOAS

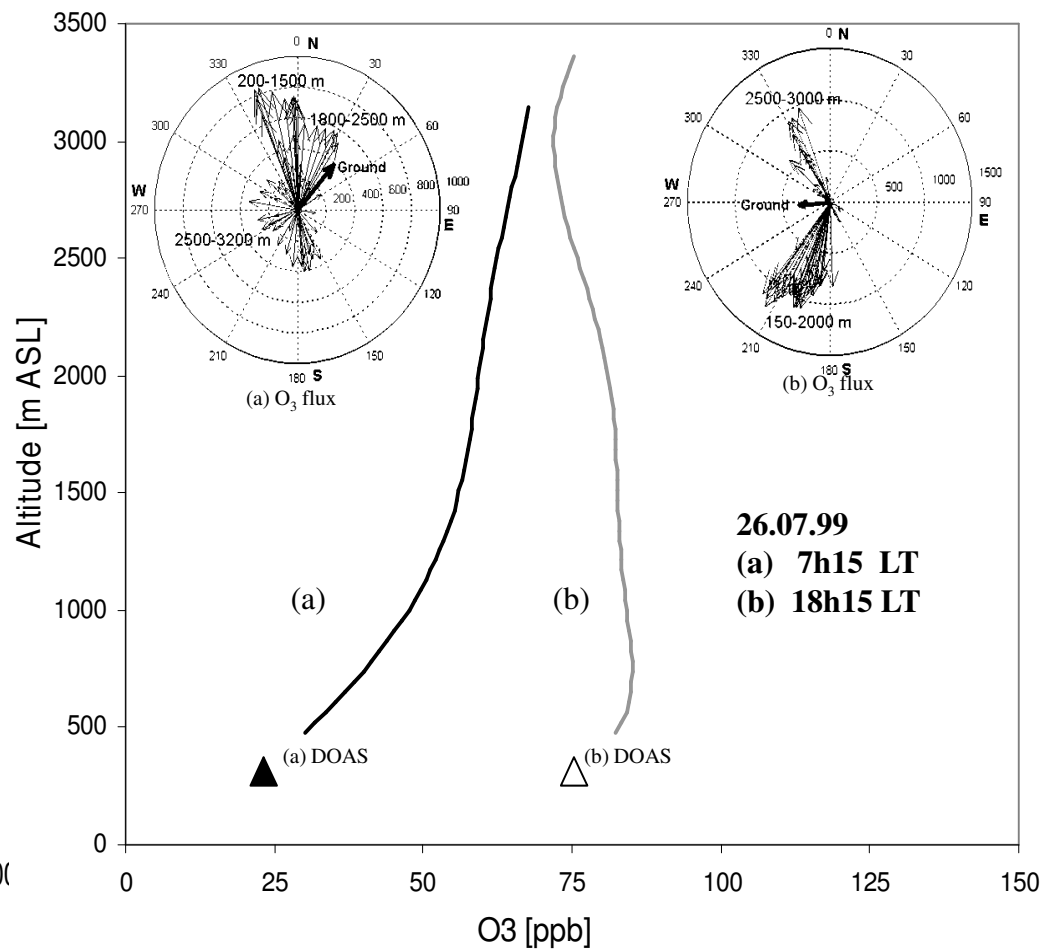
Complement  
AirCraft

Complement  
MODEL

## OZONE : Profiles

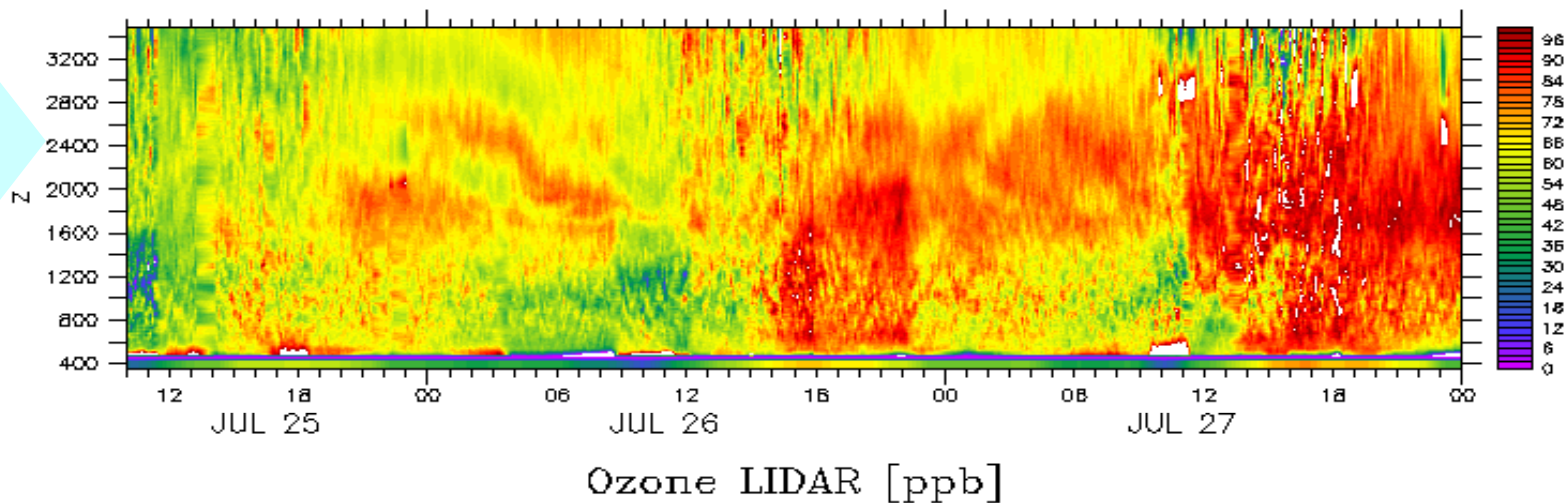


## Fluxes

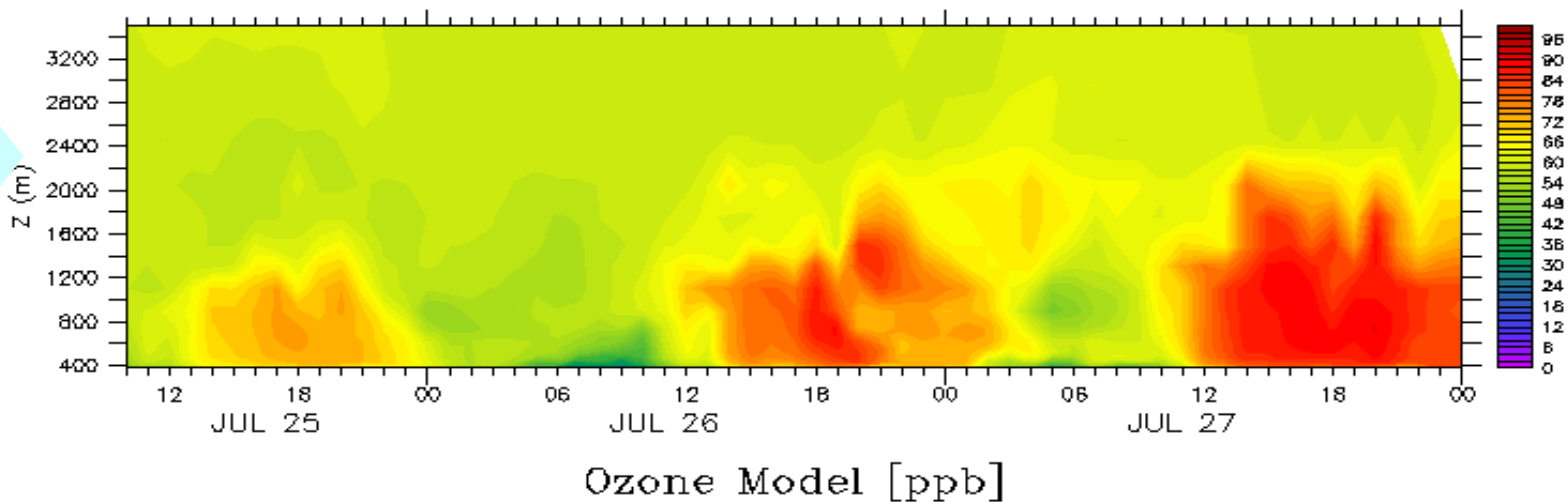


### 3D - OZONE: LIDAR & MODEL

**LIDAR**



**MODEL**



# Long experience of air quality studies in several European regions

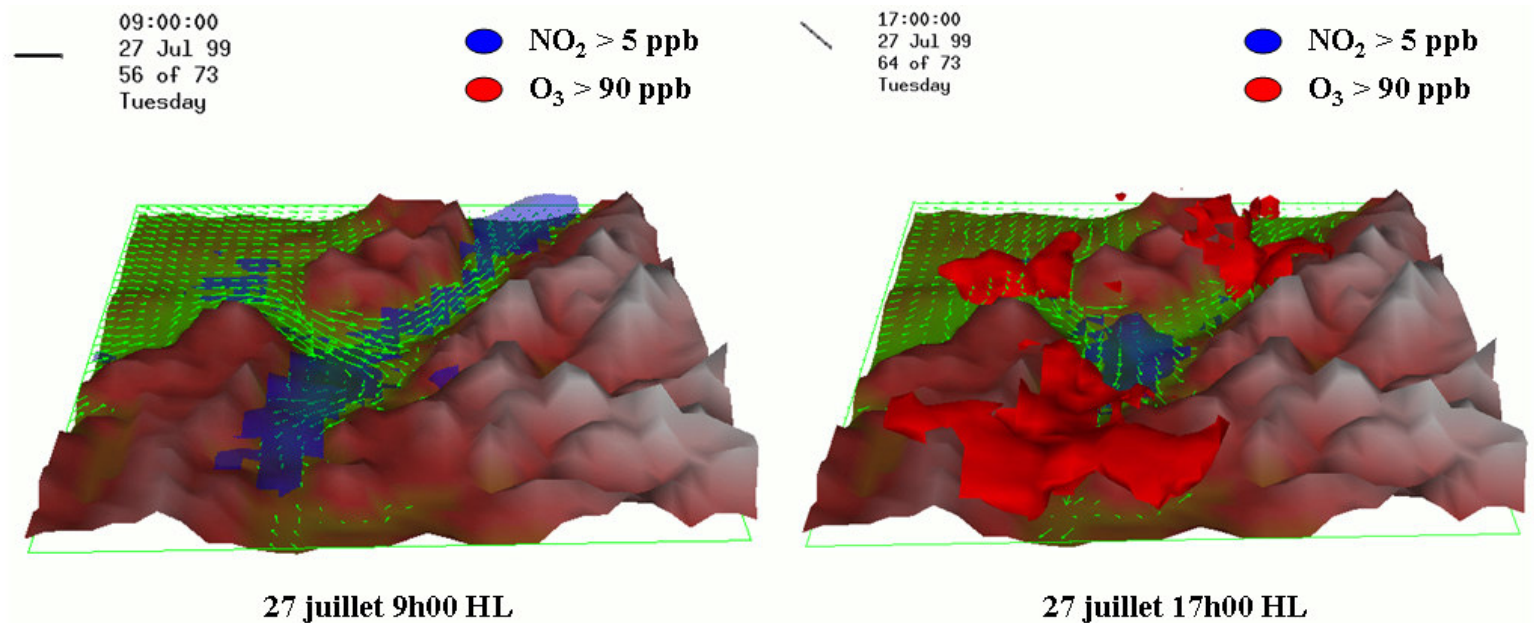
## Different case studies

- City of Grenoble in complex terrain
- Strasbourg area
- City of Geneva
- Greater Madrid area
- Greater Athens area

## Model development

- Metphomod
- Model chain
- Chemical mechanism RACM
- Chemeta
- Air pollution indicators

Grenoble Case  
3D simulations  
 $O_3$ ,  $NO_2$  and  
wind





ÉCOLE POLYTECHNIQUE  
FÉDÉRALE DE LAUSANNE

### Criteria for Supported projects

- They are not research, but development projects
- Technology based ideas with large potential and vision
- Inventions with growth-oriented business perspectives
- Ideas with unique potential for new markets and Swiss industry
- Team/individual's high motivation and excellence

### Innogrants Awards

- 45 projects were submitted in 2007;
- 16 went through a second phase assessment and 7 have been approved.
- the found by project support is 100'000.- CHF for one year.
- 7 projects have been backed in medical instrumentation, biotechnology, energy and environment, and internet technologies.

Map3D was the only project to be selected in environment and finally win an Innogrant awards of 100'000.- CHF

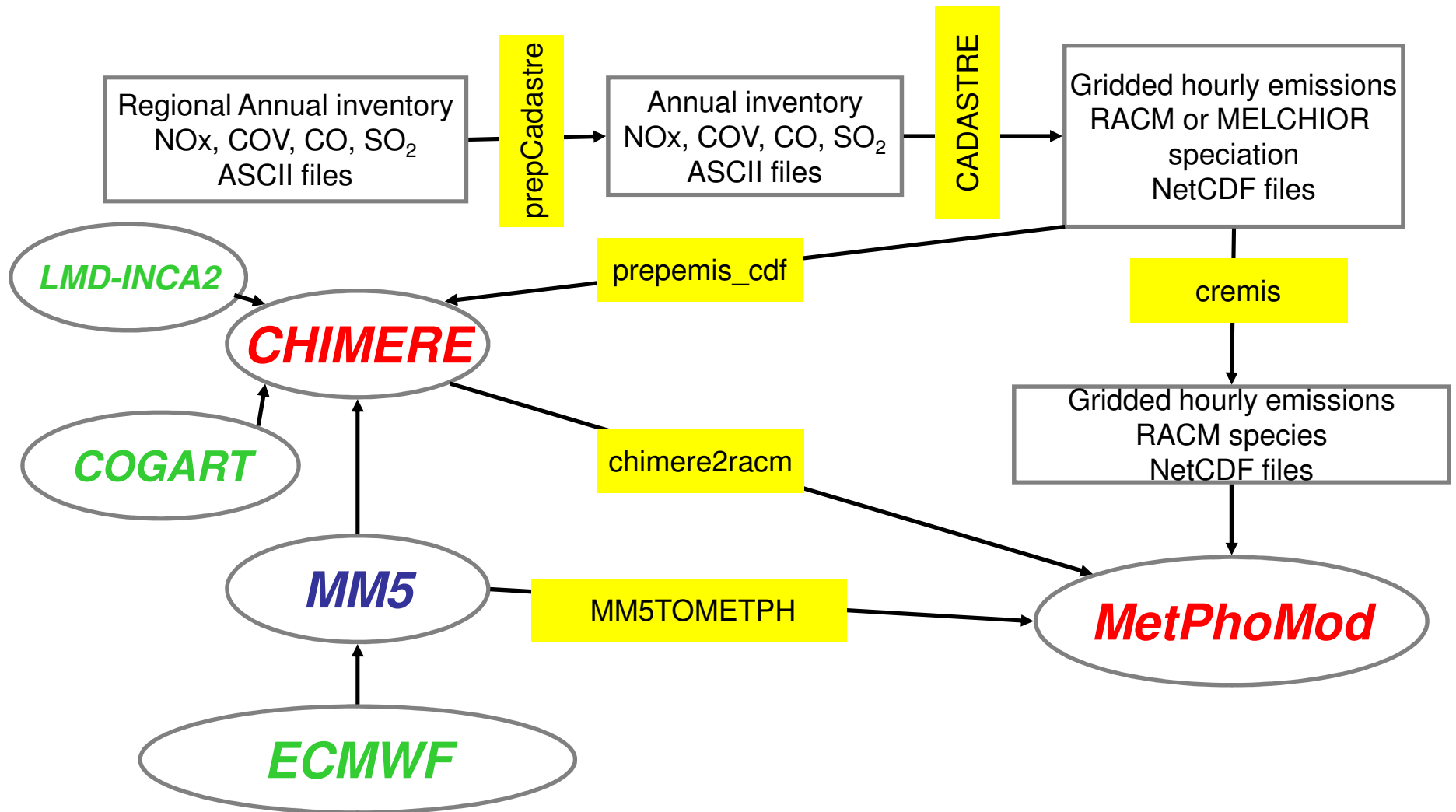
Laboratory: EPFL/ENAC/EFLUM

Project leader: Dr. Olivier Couach

## Our use of CHIMERE

- CHIMERE is used at boundaries of our model MetPhoMod
- Since CHIMERE has never been validated in very complex terrain our use of the model is limited to regional scales:
  - Continental for calculate background concentration in the Alps
  - Regional to account for main cities (Lyon, Geneva, Marseille, Torino) contributing to regional ozone

# Technical schematic of the chain



# Use of CHIMERE to constraint a fine scale model : MetPhoMod

- Problems and questions:

- How evaluate the quality of forcing by MM5 and CHIMERE ?
- Model have different horizontal meshes  
Lambert, dx = 6 km/ Lambert 2 Etendu, dx = 2 km
- Model have different vertical descriptions  
8 hybrid sigma levels/ 24 cartesian levels
- Models have different chemical mechanisms  
MELCHIOR/ RACM

- Solutions:

- Perform comparison with 3D and ground data
- Perform horizontal interpolation
- Perform vertical interpolation
- Using only common species to both mechanisms



## Our use of CHIMERE

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  - Regional to account for main cities (Lyon, Geneva, Marseille, Torino) contributing to regional ozone

# Correspondance between MELCHIOR and RACM

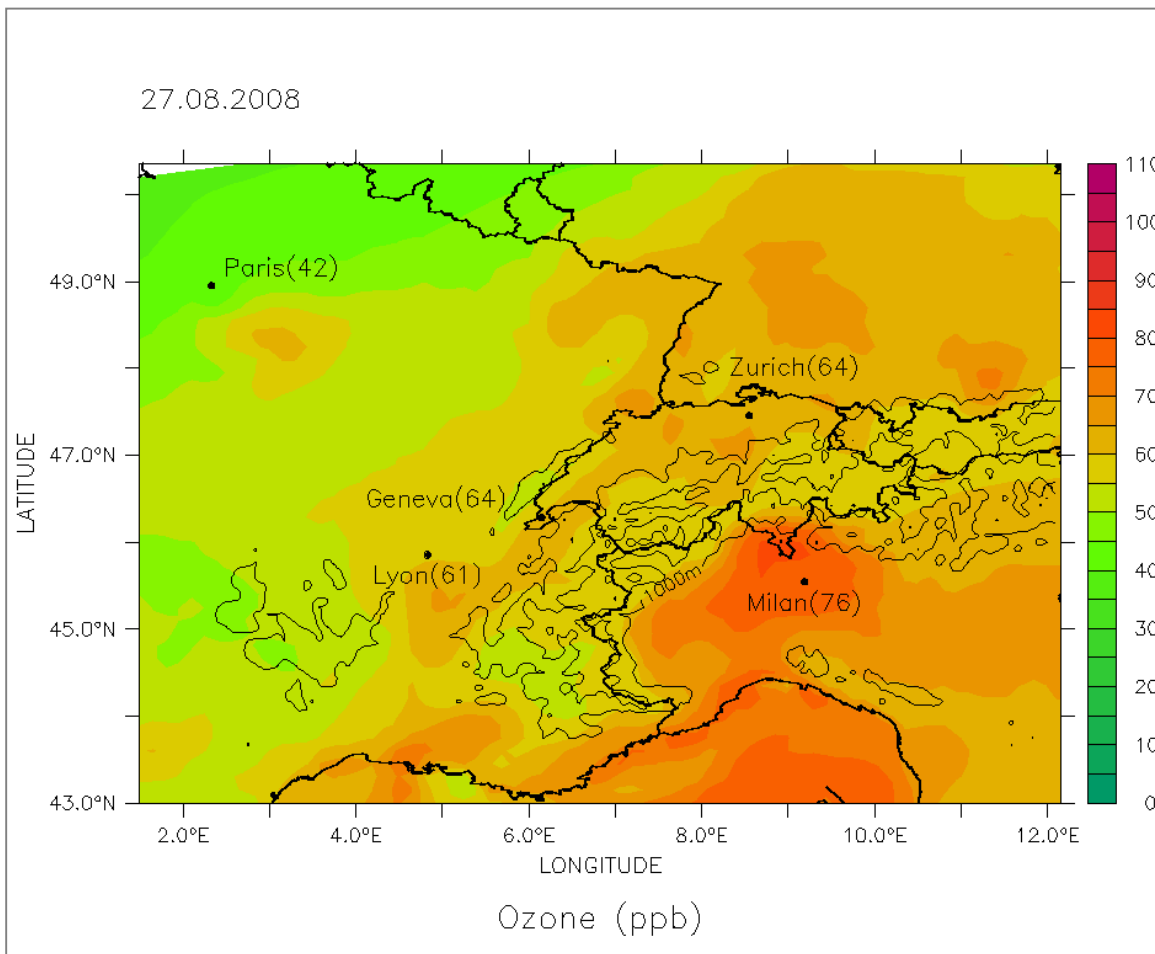
Nom MELCHIOR	Description MELCHIOR	Nom RACM	Description RACM
O <sub>3</sub>	ozone	O <sub>3</sub>	ozone
NO <sub>2</sub>	nitrogen dioxide	NO <sub>2</sub>	nitrogen dioxide
NO	nitric oxide	NO	nitric oxide
PAN	peroxyacetyl nitrate	PAN	peroxyacetyl nitrate ans higher saturated PANs
HNO <sub>3</sub>	nitric acid	HNO <sub>3</sub>	nitric acid
SO <sub>2</sub>	sulfur dioxide	SO <sub>2</sub>	sulfur dioxide
CO	carbon monoxide	CO	carbon monoxide
CH <sub>4</sub>	methane	CH <sub>4</sub>	methane
C <sub>2</sub> H <sub>6</sub>	ethane	ETH	ethane
NC <sub>4</sub> H <sub>10</sub>	n-butane	HC5	alkanes, alcohols, esters and alkynes with HO rate between $3.4 \cdot 10^{-12}$ and $6.8 \cdot 10^{-12}$ cm <sup>3</sup> s <sup>-1</sup>
C <sub>2</sub> H <sub>4</sub>	ethene	ETE	ethene
C <sub>3</sub> H <sub>6</sub>	propene	OLT	terminal alkenes
OXYL	o-xylene	TOL	toluene and less reactive aromatics
C <sub>5</sub> H <sub>8</sub>	isoprene	ISO	isoprene
APINEN	$\alpha$ -pinene	API	$\alpha$ -pinene and other cyclic terpenes with one double bonds
HCHO	formaldehyde	HCHO	formaldehyde
CH <sub>3</sub> CHO	acetaldehyde	ALD	acetaldehyde and higher aldehydes
GLYOX	glyoxal	GLY	glyoxal
MGLYOX	methyl glyoxal	MGLY	methylglyoxal and other $\alpha$ -carbonyl aldehydes
CH <sub>3</sub> COE	methyl ethyl ketone	KET	ketones

**20 species**  
from CHIMERE  
are related to  
RACM species

Table : correspondance between MELCHIOR and RACM species

# Map3D outputs and web interface

## Ozone concentration [ppb] with 15 km resolution for Switzerland



Access to the forecast results and to a personalized web interface via login

- three days weather and air pollution forecast: Hourly concentrations for ozone, PM10, PM2.5 and NO<sub>2</sub>. Other chemical compounds such as NO, NO<sub>x</sub>, SO<sub>2</sub> or CO can be added to the output.
- access to a database containing all these species. The concentration values can be extracted in text, netCDF or ESRI format
- validation of the data by comparison to values from measurement stations
- indicator values helping to estimate whether NO<sub>x</sub> or VOC emissions must be lowered in order to reduce the ozone concentrations

# Ozone simulation and forecast

# PM10 simulation and forecast

Map3D login >

Pollution Indicateurs Météo Extraction A propos

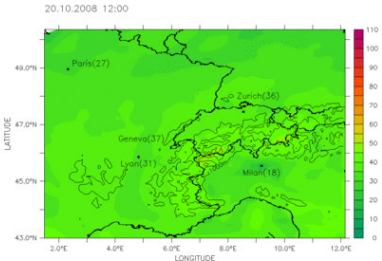
## Alpes

Prévisions du 13 novembre 2008

Région: Alpes Date: 13.11.2008 Espèce chimique: Ozone Normes: Europe

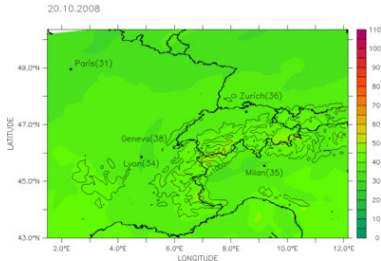
### Heure

12:00



Ozone (ppb)

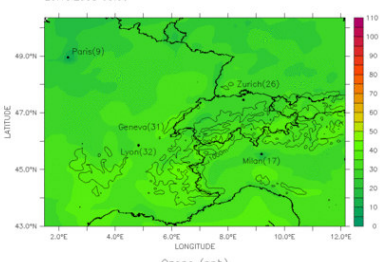
### Maximum journalier



Ozone (ppb)

### Animation journalière

03:00



Ozone (ppb)

### Moyennes horaires

	Journalier (13.11)			Sur 3 jours (13.11-15.11)			
	min	max	heure	min	max	jour	heure
Ozone [ppb]	0	47	14h	0	47	14.11	4h
NO <sub>2</sub> [ppb]	0	<b>52</b>	20h	0	<b>52</b>	13.11	20h

### Moyennes journalières

	Journalier (13.11)		Sur 3 jours (13.11-15.11)		
	min	max	min	max	jour
PM10 [ $\mu\text{g}/\text{m}^3$ ]	2	<b>117</b>	1	<b>117</b>	13.11
PM2.5 [ $\mu\text{g}/\text{m}^3$ ]	1	40	1	46	15.11
NO <sub>2</sub> [ppb]	1	31	0	31	13.11

- le maximum journalier est calculé pour chaque maille.
- les isocontours de la topographie sont représentés tous les 1'000 m (ASL).

Map3D login >

Pollution Indicateurs Météo Extraction A propos

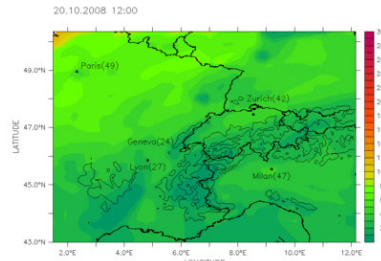
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Région: Alpes Date: 13.11.2008 Espèce chimique: PM10 Normes: Europe

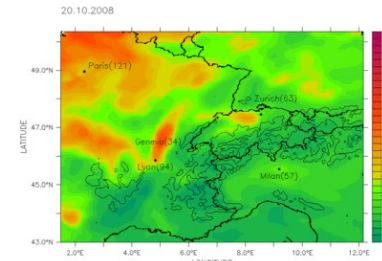
### Heure

12:00



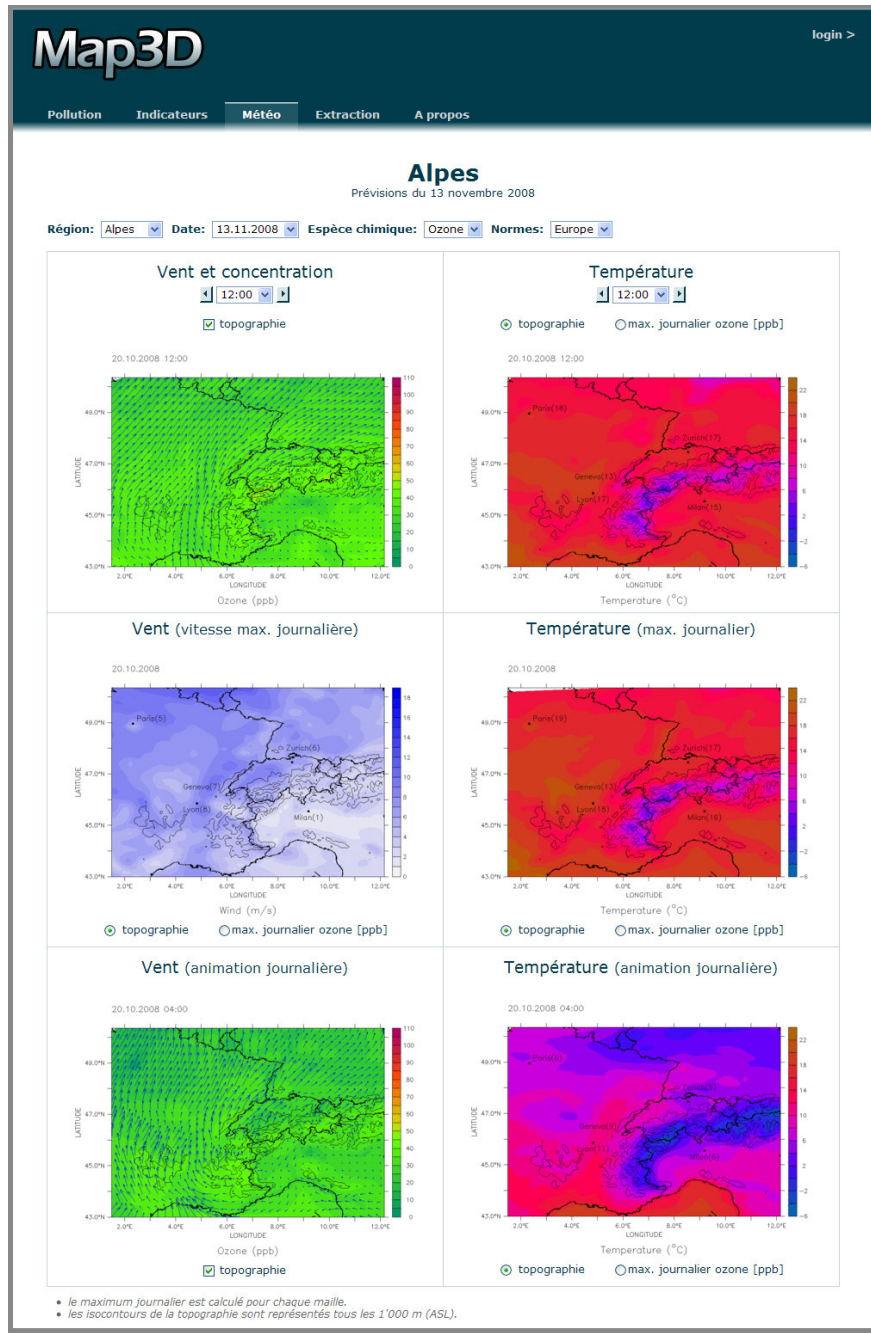
PM10 ( $\mu\text{g}/\text{m}^3$ )

### Maximum journalier

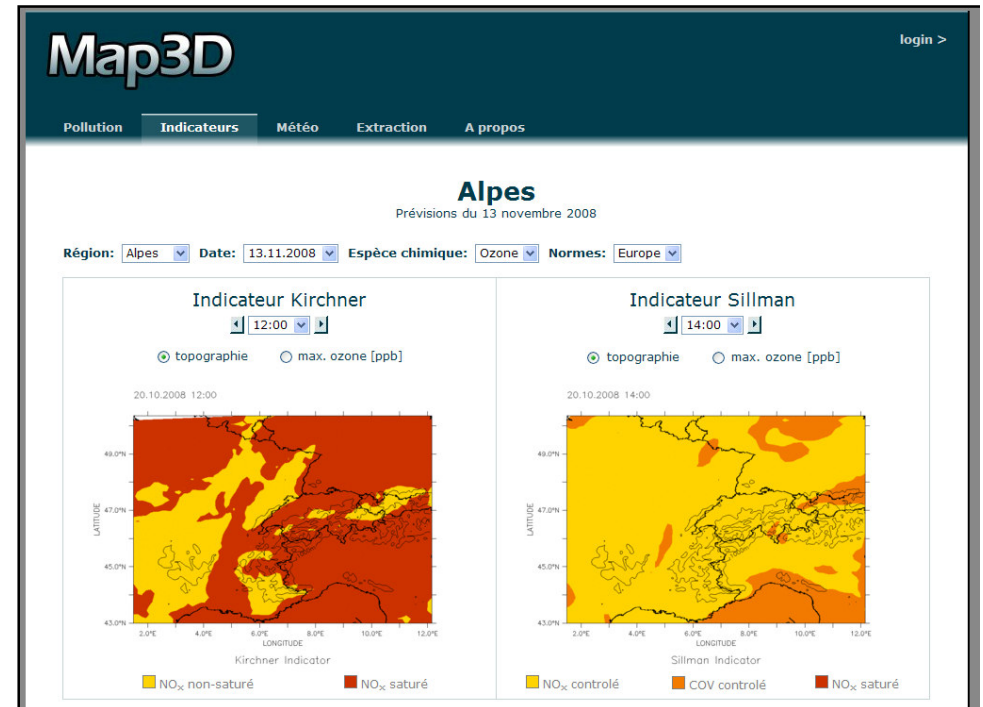


PM10 ( $\mu\text{g}/\text{m}^3$ )

# Meteorological fields simulation and forecast



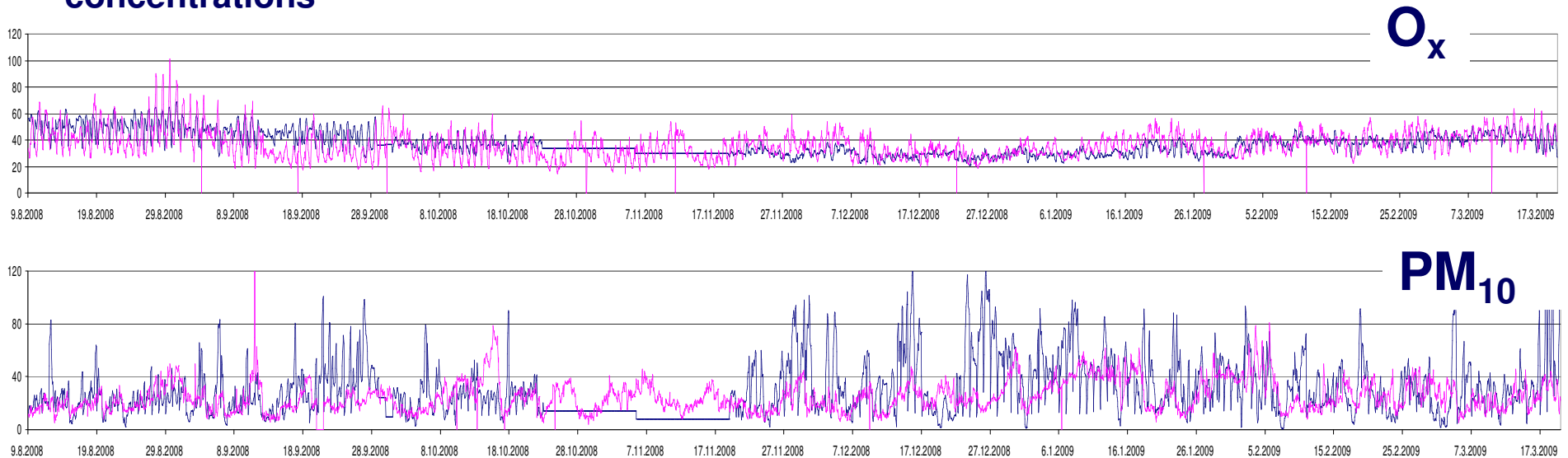
## Ozone regimes : Kirchner and Sillman Indicators



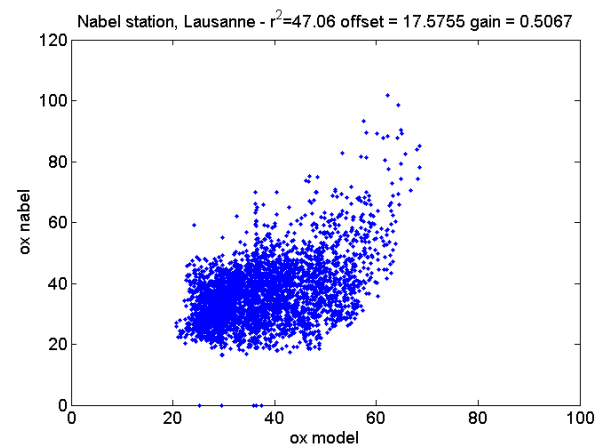
<http://map3d.epfl.ch>

# Model results validation for the period of August 2008 - February 2009

Validation of the calculations for Switzerland with the Lausanne Nabel measurements stations for the period of August 2008 - February 2009 for  $O_3$ ,  $O_x = (O_3 + NO_2)$  and  $PM_{10}$  concentrations

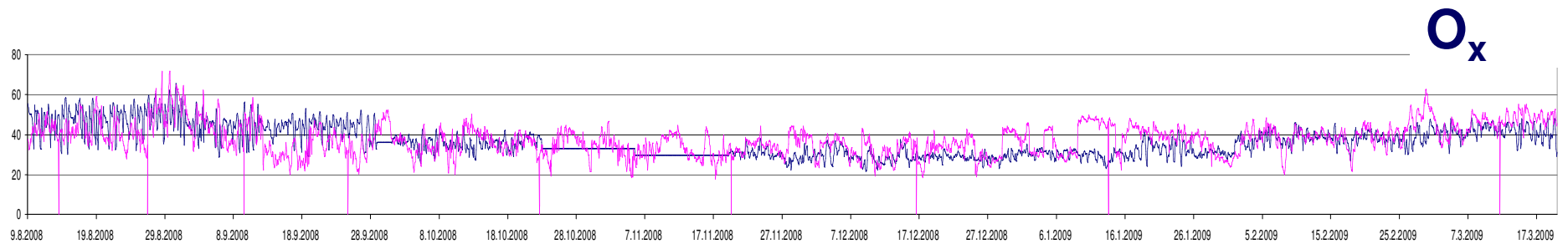
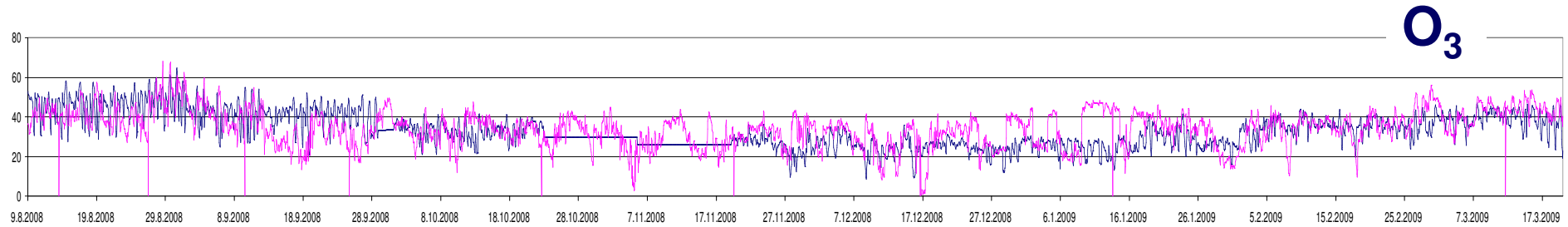


**Lausanne Nabel  
urban station**

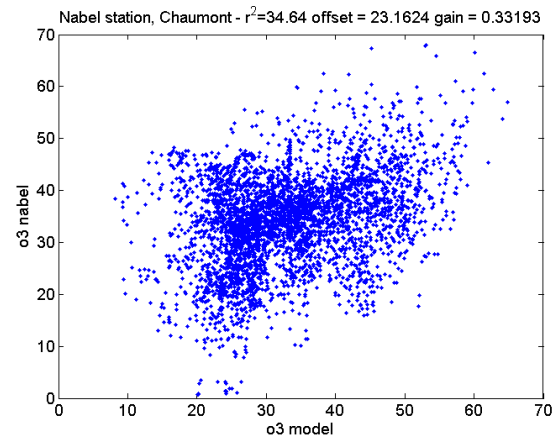


# Model results validation

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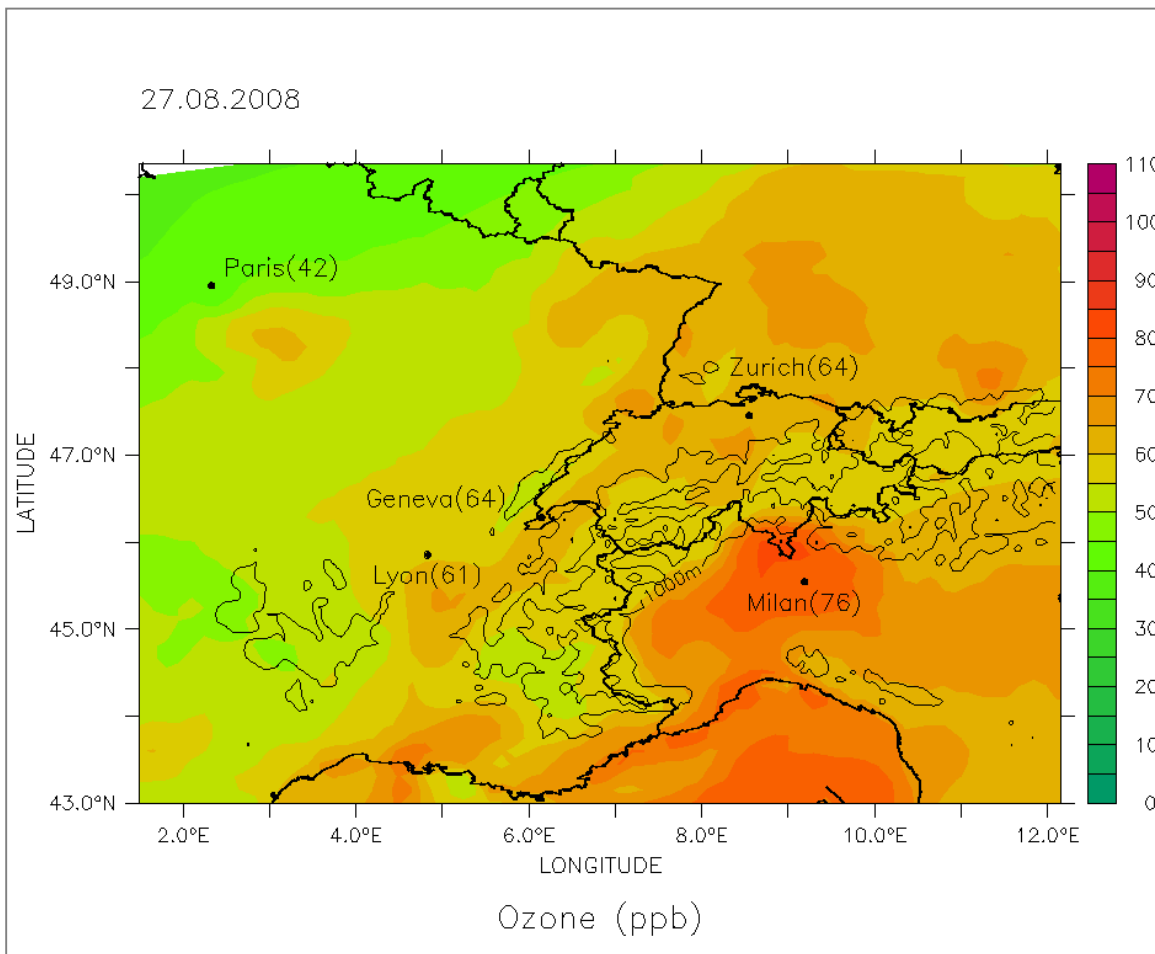


**Chaumont Nabel  
rural station**



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# Ozone simulation and forecast

# PM10 simulation and forecast

Map3D login >

Pollution Indicateurs Météo Extraction A propos

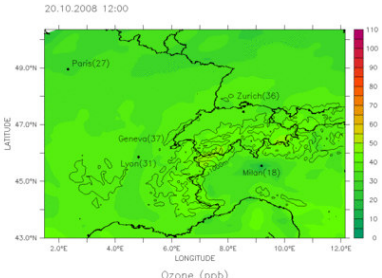
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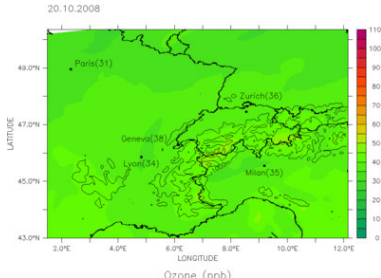
### Heure

12:00



Ozone (ppb)

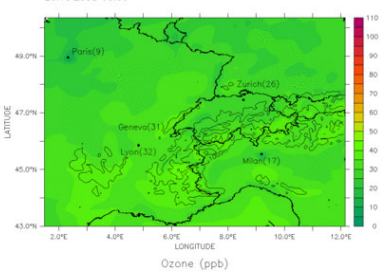
### Maximum journalier



Ozone (ppb)

### Animation journalière

03:00



Ozone (ppb)

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PM10 [µg/m <sup>3</sup> ]	2	117	1	117	13.11
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Map3D login >

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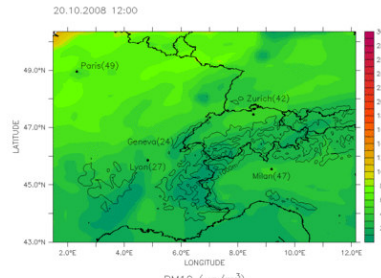
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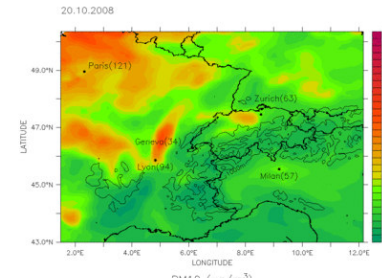
### Heure

12:00



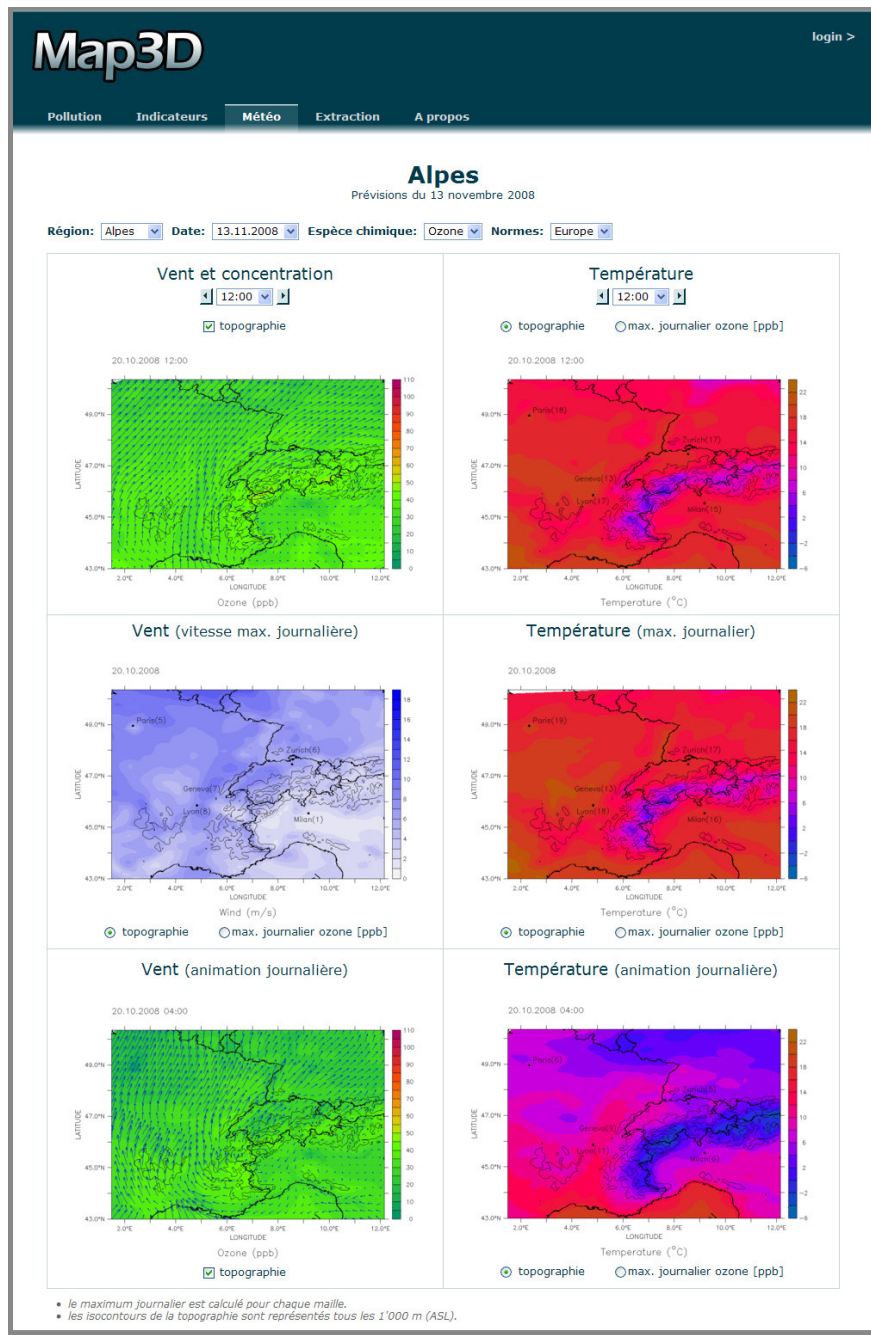
PM10 (µg/m<sup>3</sup>)

### Maximum journalier

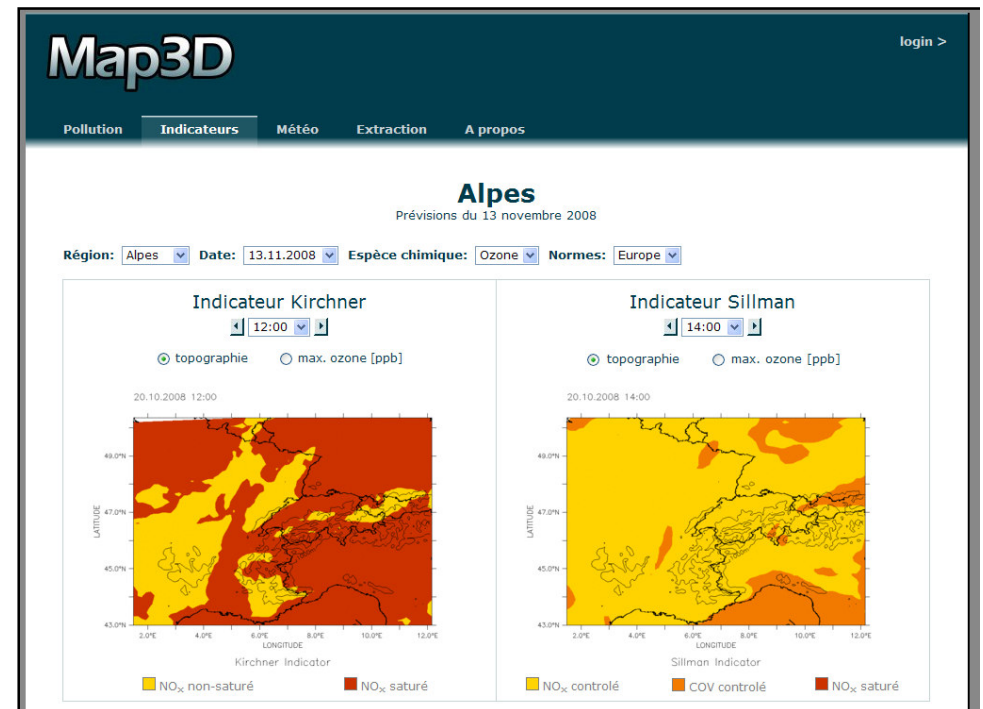


PM10 (µg/m<sup>3</sup>)

# Meteorological fields simulation and forecast



## Ozone regimes : Kirchner and Sillman Indicators



<http://map3d.epfl.ch>

# Conclusion & Perspectives

## **MAP3D**

the acronym for "Mesoscale Air Pollution 3D modeling" is today successfully developed after 1.5 year of work and is available for environmental administrations, urban air quality agencies, industries, and decision makers.

## **Strengths**

Strong expertise in atmospheric science and modeling software

- Daily forecast of meteorological fields and pollutant concentrations (gases and aerosols) at regional and urban scales and over complex and mountainous terrains
- Daily indicators calculation for localization of air mass ozone regimes control
- User friendly and customizable web-based interface
- Impact scenario studies (new projects, infrastructure measures or short-term abatement policies)

# Map3D - -----> RO

- Possibility of connecting the MAP3D results and forecasts to the Romanian measurement network data (air pollution and meteorological data) by developing an interface module (ftp access to the measurement data needed)
- Possibility to develop a module for geo-referencing the simulations results in order to relate the calculated concentrations for example to the population density calculating a map with ppb/habitants
- A data base will be built containing all the data of pollution episodes. This data base allows classifying the episodes and provides the data needed for running emission reduction scenarios.
- Daily 3D Output allows comparing the model results to O3 and aerosol lidars as well as to PBL measurement (cf. Atmos. Environ. Couach et al. 2004)

<http://map3d.epfl.ch>

