



# **Atmo AURA air quality network**

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*Overview of the context*

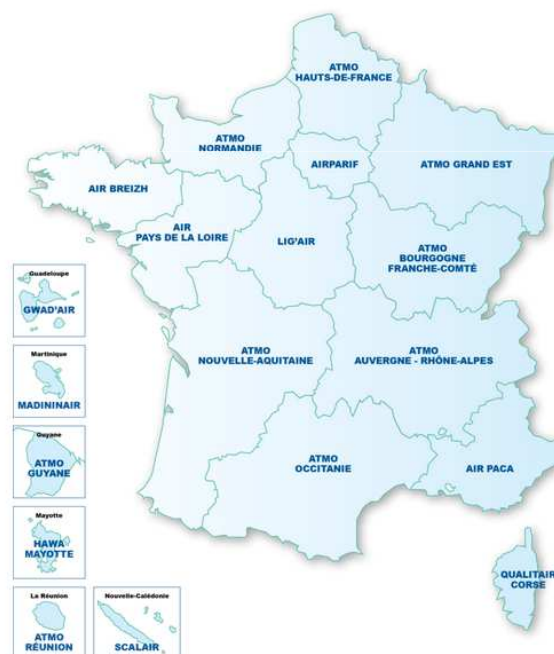
# ATMO Auvergne-Rhône-Alpes

## French Air quality Network

French Network = Associations  
approved by the Ministry of  
Ecology for monitoring air quality



(1 network in each Region)



## Tools for Air Quality Observatory



# Monitoring Network

~ 100 permanent stations in Auvergne-Rhône-Alpes



With different  
typologies



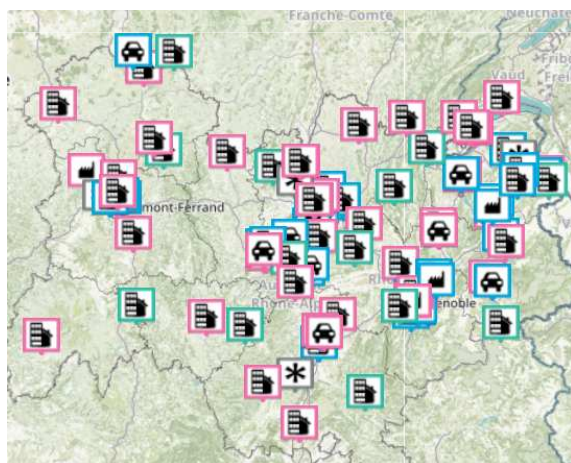
Urban background



Peri-urban background



Traffic



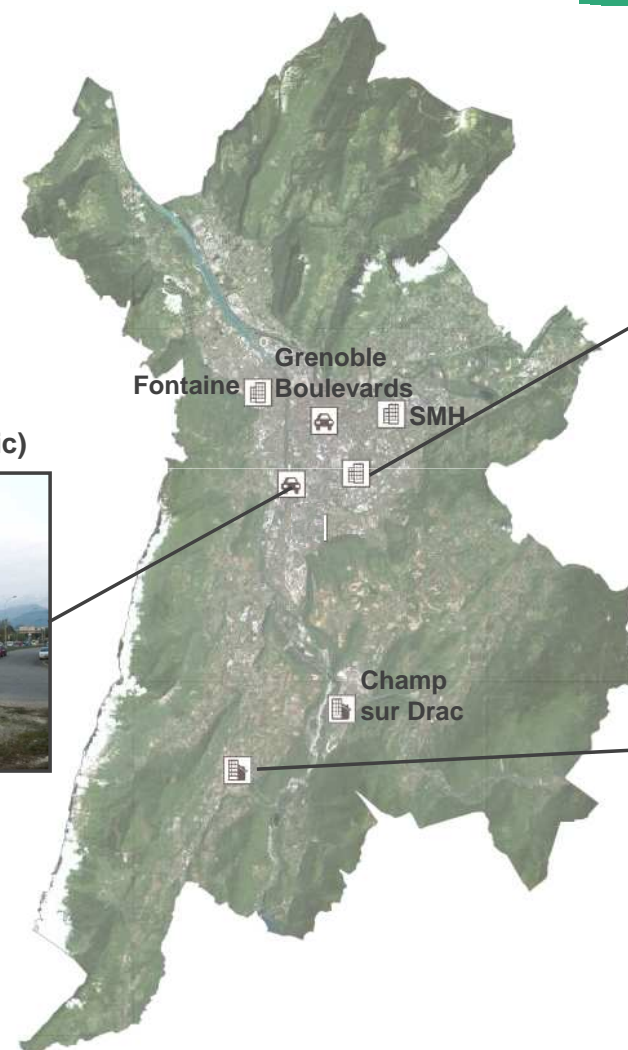
Grenoble le rondou (Traffic)



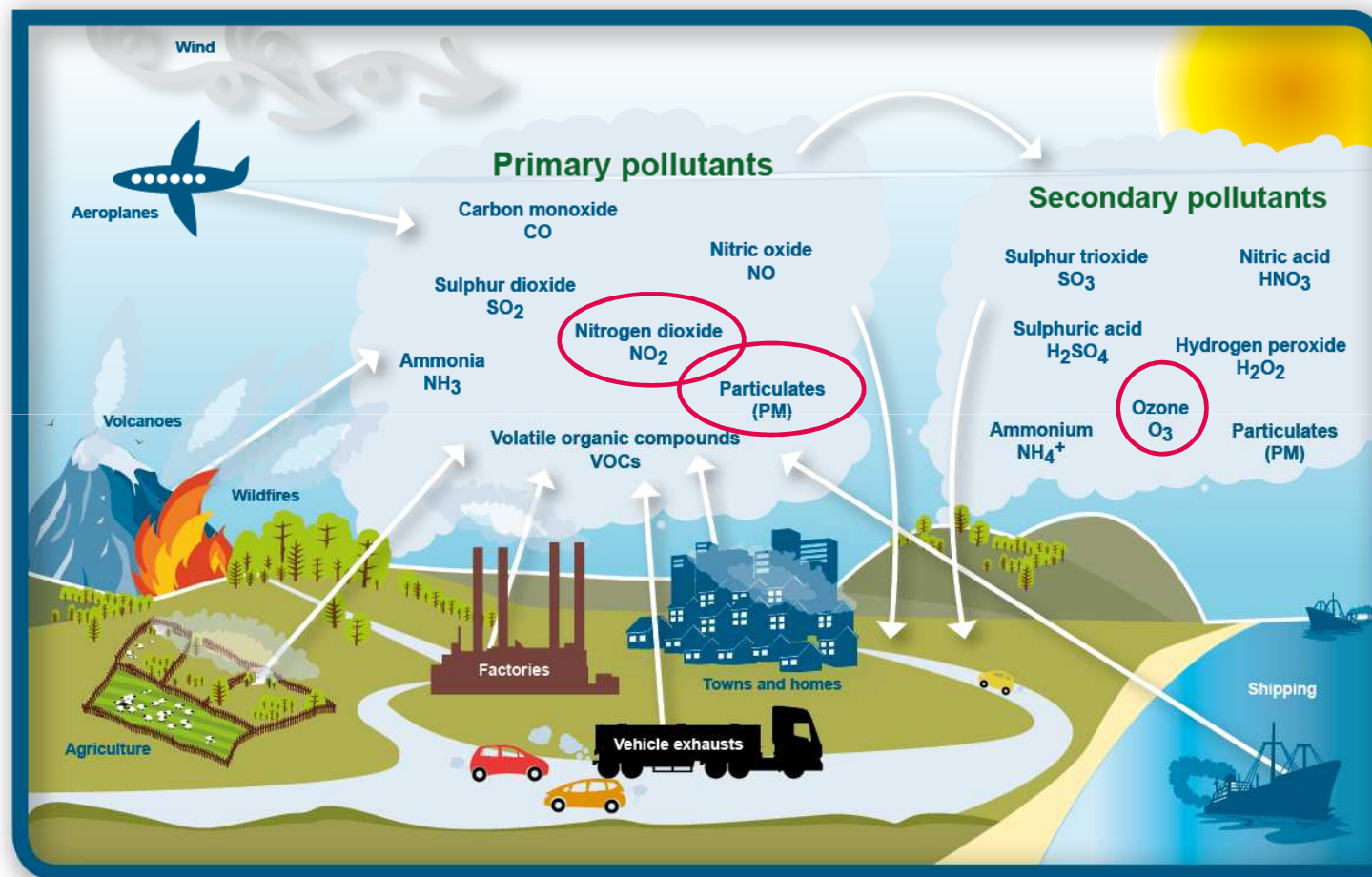
Grenoble les Frênes (Urban)



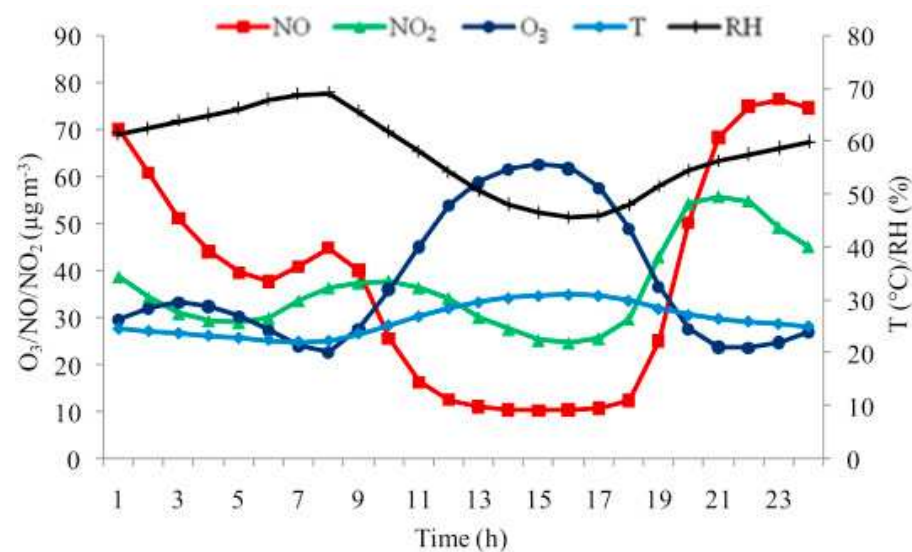
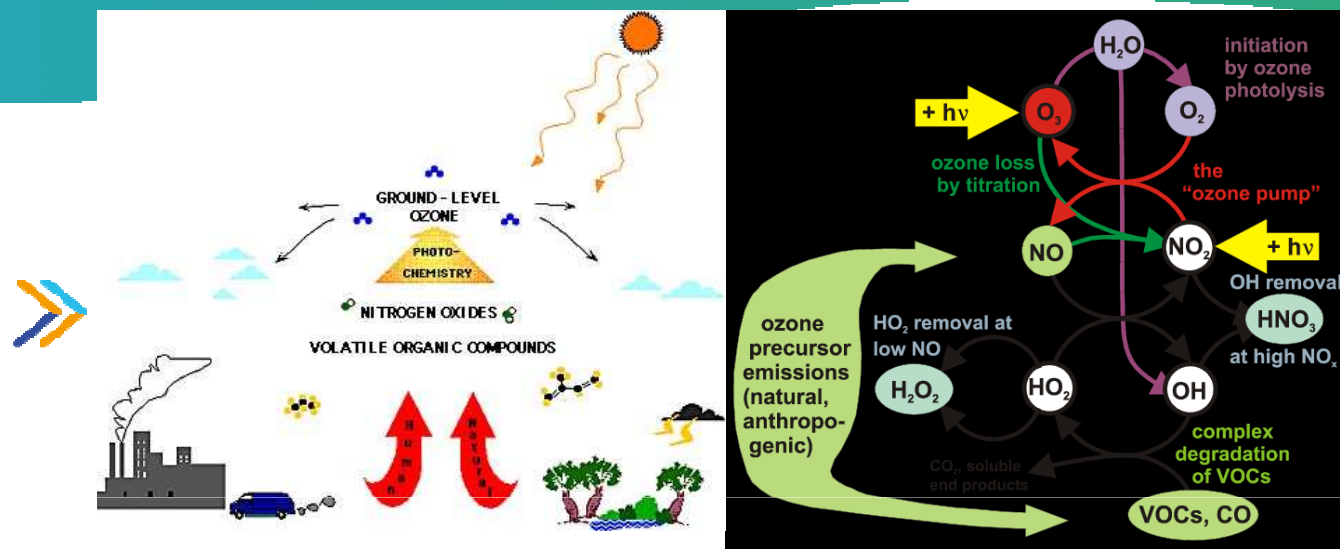
Grenoble périurbaine sud – Vif  
(Peri-urban)



# Pollutants and sources

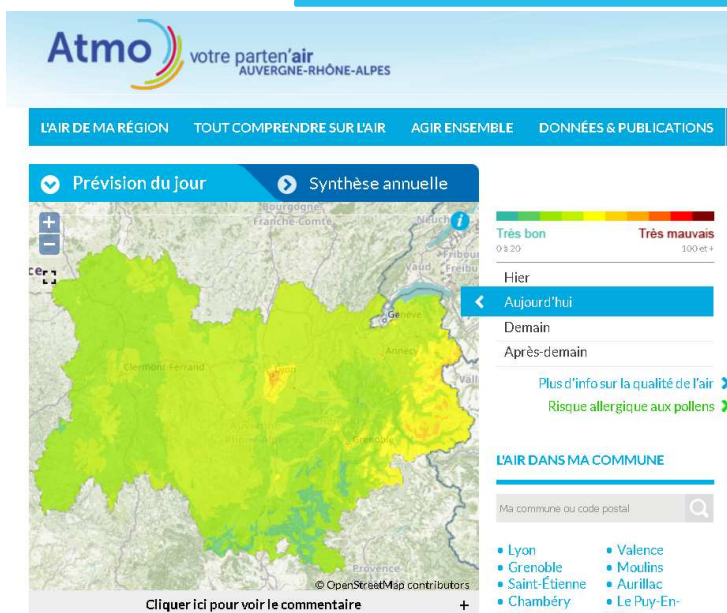


# Pollutants and interactions in the atmosphere



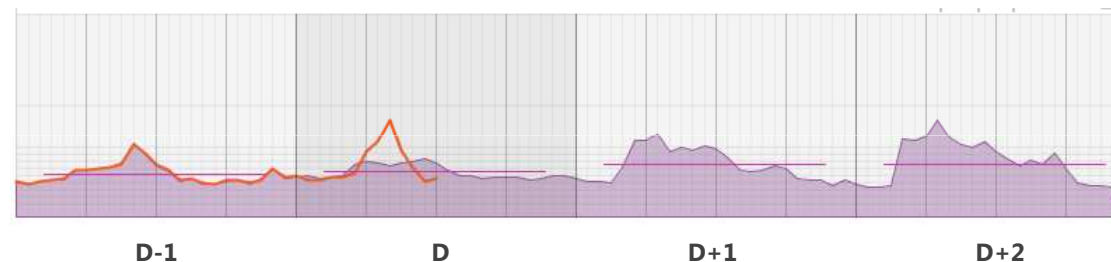


# ATMO Auvergne-Rhone-Alpes Mission : Forecasting the pollution at each point of the region



Forecast for today (D)  
For D+1  
For D+2

Challenge objective :  
**Best Forecast** at each **fixed station**  
for 4 pollutants hourly concentrations :  
NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, Ozone





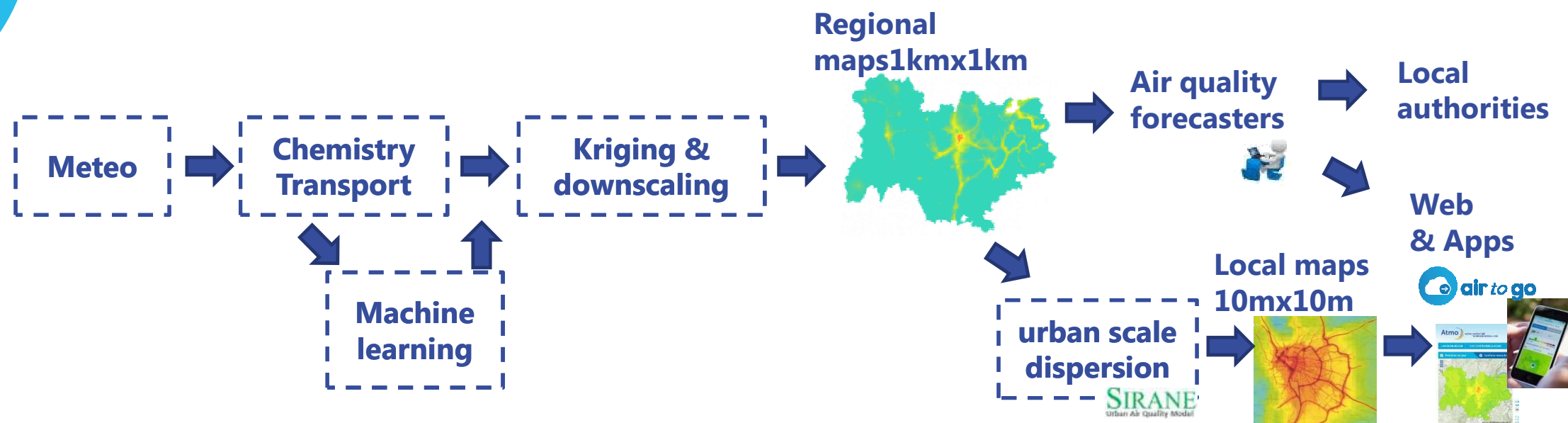
## **Atmo AURA air quality forecast platform**

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- *Overview of the different steps & timing*

# Daily forecast

## D-1, D, D+1, D+2



Constraints : regional forecast 1km :

- Available at 9h loc
- Each day : ➔ 2 « runs » :
  - ✓ « Rescue » (14h00 UTC)
  - ✓ « Main » (1h45 UTC)



# Meso scale meteorology forecast

**Model :** 

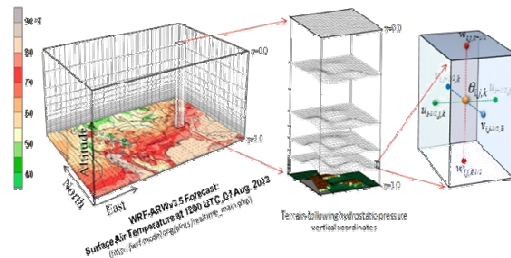
National Center for Atmospheric Research, NOAA

<https://www.mmm.ucar.edu/weather-research-and-forecasting-model>

3D non hydrostatic

→ Advection, diffusion/turbulence

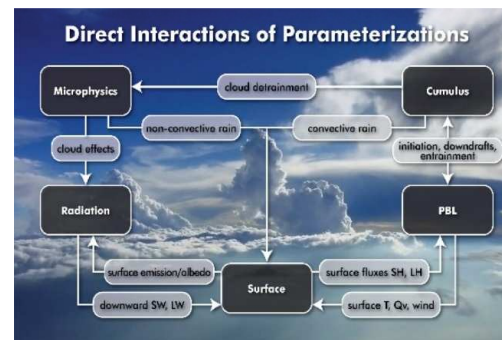
→ Physic (radiation, surface layer, PBL, microphysics)



3 nested domains :

- « Europe » :  $\Delta x = 27$  km, grid : 82x82
- « France » :  $\Delta x = 9$  km, grid : 112x112
- « AuRA » :  $\Delta x = 3$  km, grid : 178x133

41 vertical levels ( $\sigma_P$ )



[http://www2.mmm.ucar.edu/wrf/users/tutorials/201202/Physics\\_Diagrams.pdf](http://www2.mmm.ucar.edu/wrf/users/tutorials/201202/Physics_Diagrams.pdf)



**Inputs :**

- Topography & land use (USGS)
- Global scale meteorology ( $0.5^\circ \times 0.5^\circ$ ) : GFS



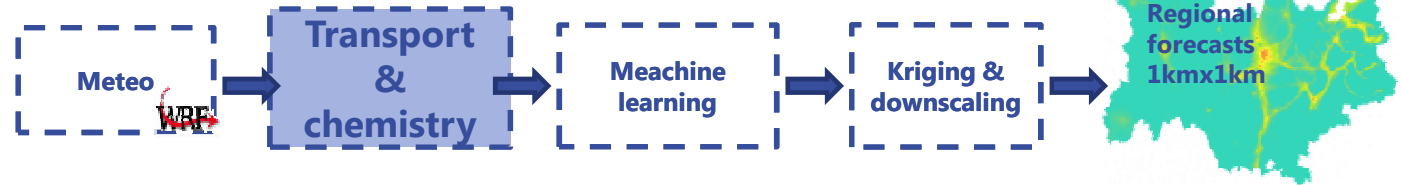
**Outputs :**

3D met fields, hourly (→ 97 h), netcdf

# Meso scale pollutant forecast

**Model :** 

Institut Pierre-Simon Laplace, INERIS, CNRS  
<http://www.lmd.polytechnique.fr/chimere/>



Eulerien « off-line »

Transport (vertical & horizontal advections, turbulent mixing)

Chemistry (anthropic & biogenic emissions, sea salt, particulates matters ...)

Primary & secondary aerosols

Deposition (dry & wet)

2 nested domains :

- « Europe » : 27 km
- « AuRA » : 3 km

8 vertical levels.

## Inputs :

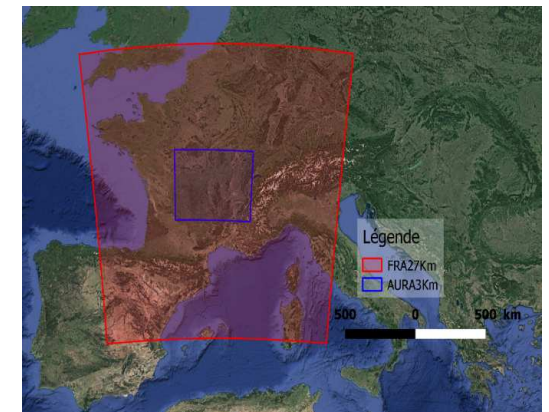
- Land cover : CLC
- Emissions : residential/traffic/industry/railway/airport...inventory  
Atmo AuRA + EMEP outside AuRA
- Meteo: WRF
- Global scale pollution : climato (LMDz/GOCART), upper domain



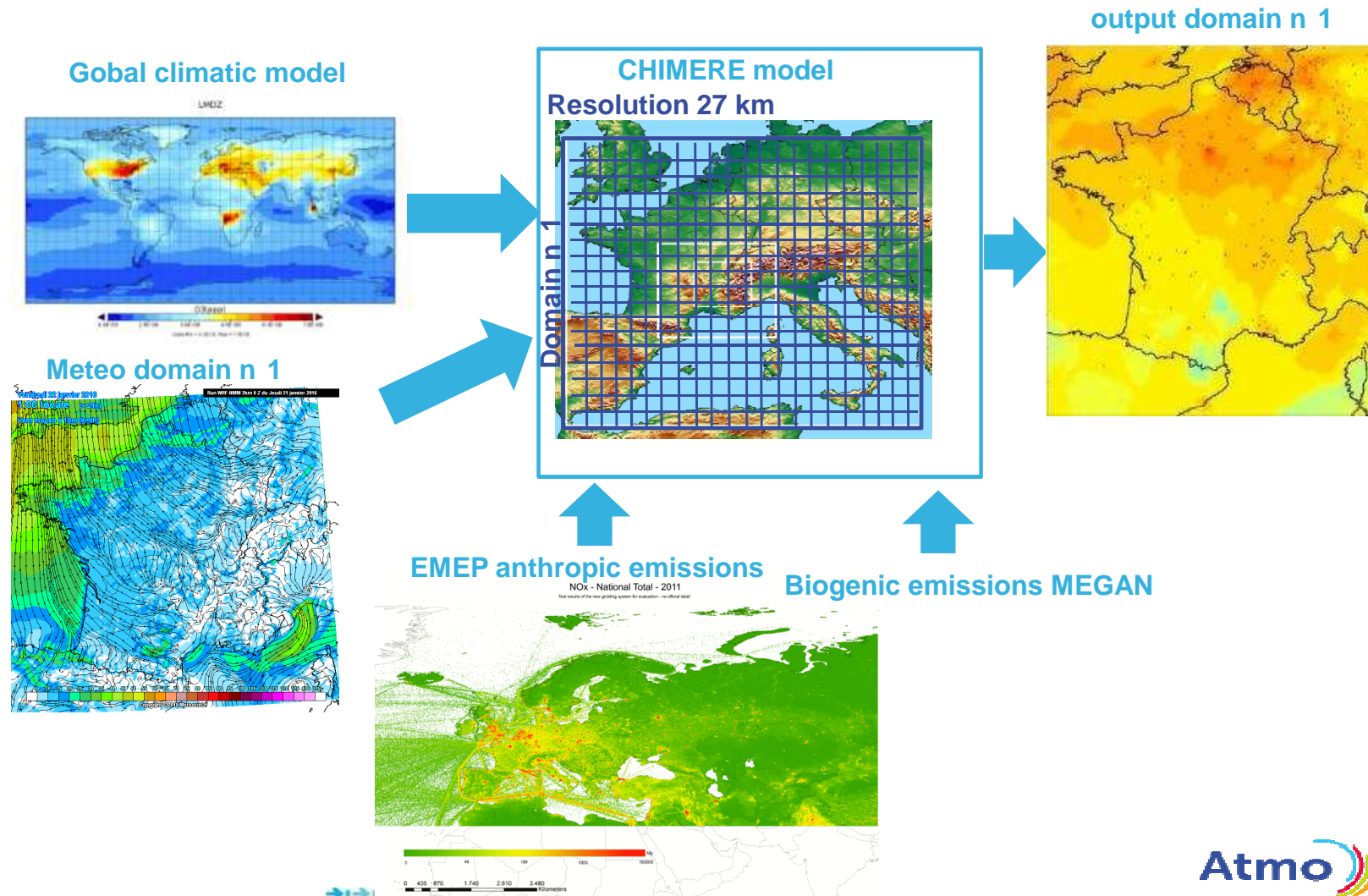
## Outputs :

Pollutants concentrations (NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, O<sub>3</sub>, NO, SO<sub>2</sub>...)

Hourly (97), netcdf



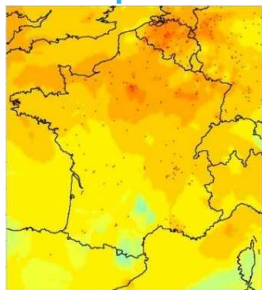
# Modelling approach : domain n 1



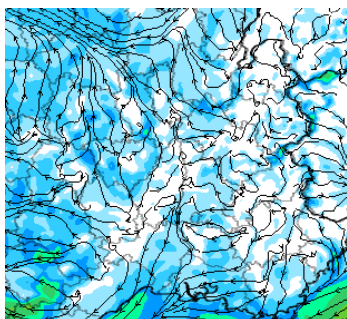


# Modelling approach : domain AuRA

CHIMERE Output domain n 1



Met. domain n 3



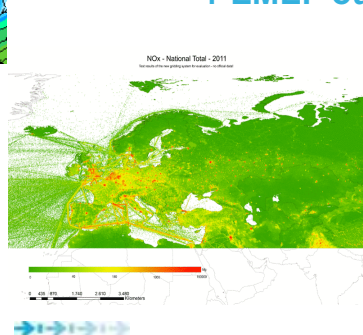
CHIMERE model



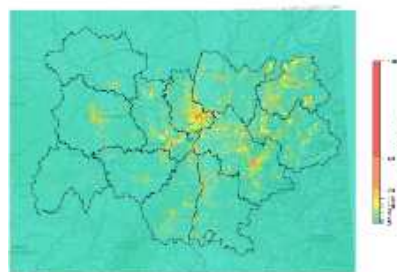
Output domain AuRA



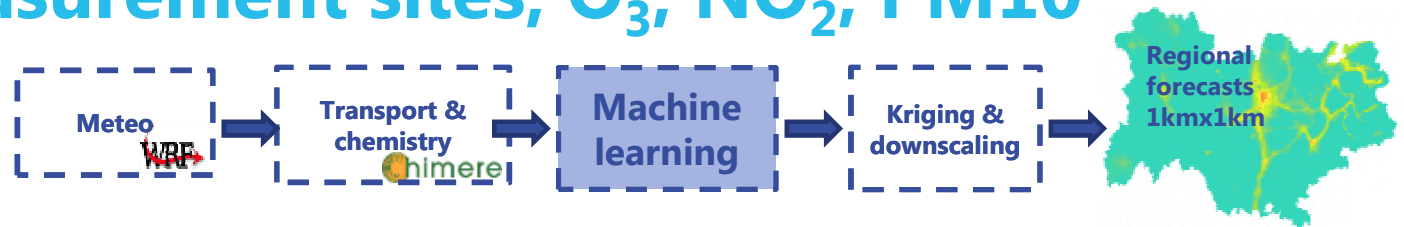
Anthropic emissions AuRA  
+ EMEP outside AuRA



Biogenic emissions MEGAN



# Forecasting at measurement sites, O<sub>3</sub>, NO<sub>2</sub>, PM10



**Method : random forest , library(parallel)** 

Training period : 2013 → 2016

**Sites** : only for (peri) urban, rural typology

- NO<sub>2</sub>: 54 ,
- PM10 : 76,
- O<sub>3</sub> : 65,

**Outputs** : hourly concentrations at each site, RData

# Machine learning at measurement sites, O<sub>3</sub>, NO<sub>2</sub>, PM<sub>10</sub>



## Predictor D0 :

- Measured values : D-1 + D0 (mean [0 : 6] hTU)
- D-1 and D0 CHIMERE forecast
- Meteo D-1 et D0 forecast : temperature, precipitation, mixing height, wind components U and V, wind speed
- NO<sub>2</sub> : number of the weekday (1=monday et 7=sunday)

## Predictor D+1 :

- D0 random forests forecast
- D+1 CHIMERE forecast
- D+1 meteo forecast : temperature, precipitation, mixing height, wind components U and V, wind speed
- NO<sub>2</sub> : number of the weekday (1=monday et 7=sunday)

## Predictor D+2 :

- D+1 random forests forecast
- D+2 CHIMERE forecast
- D+2 meteo forecast : temperature, precipitation, mixing height, wind components U and V, wind speed
- NO<sub>2</sub> : number of the weekday (1=monday et 7=sunday)

## + adjustment factor by concentration range :

- PM<sub>10</sub> : <30 , 30-50 , >=50 µg.m<sup>-3</sup>
- O<sub>3</sub> : <50 , 50-160, >=160 µg.m<sup>-3</sup>
- NO<sub>2</sub> : <50, 50-100, >=100 µg.m<sup>-3</sup>



# Présentation générale des Forêts Aléatoires

## Données d'entrées

- Récupération de données brutes
- Modification de ces mêmes données → créer des prédicteurs / jour
- Création d'un **tableau** → **prédicteurs en colonnes** et **observations** (jours) **en lignes**

## Bootstrap

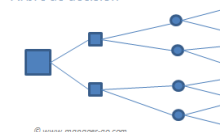
- **Tirage aléatoire avec remise** parmi les **observations** → sélectionner des lignes
- Création de **nouveaux sous échantillons** → formation des **nœuds racines**



## Algorithme de CART

- **Tirage aléatoire** d'un nombre de **prédicteurs** → sélectionner des colonnes
- **Découpage** d'un **nœud** en **2 sous parties** → **critère** de **minimisation** des **variances**
- Répète ces deux premiers points jusqu'à la création de **l'arbre maximal**

Arbre de décision



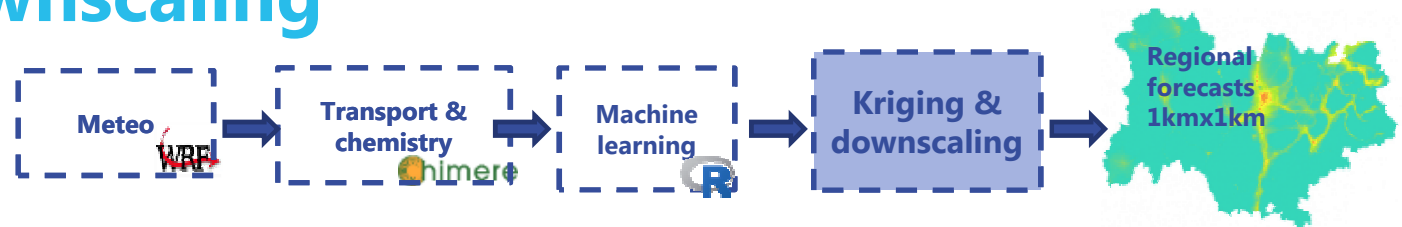
© www.manager-ga.com

## Données de sorties

- **Moyenne** les **prévisions** obtenues à l'aide des différents échantillons
- Prévisions de PM10 (moyenne jour)



# Geostatistic & downscaling



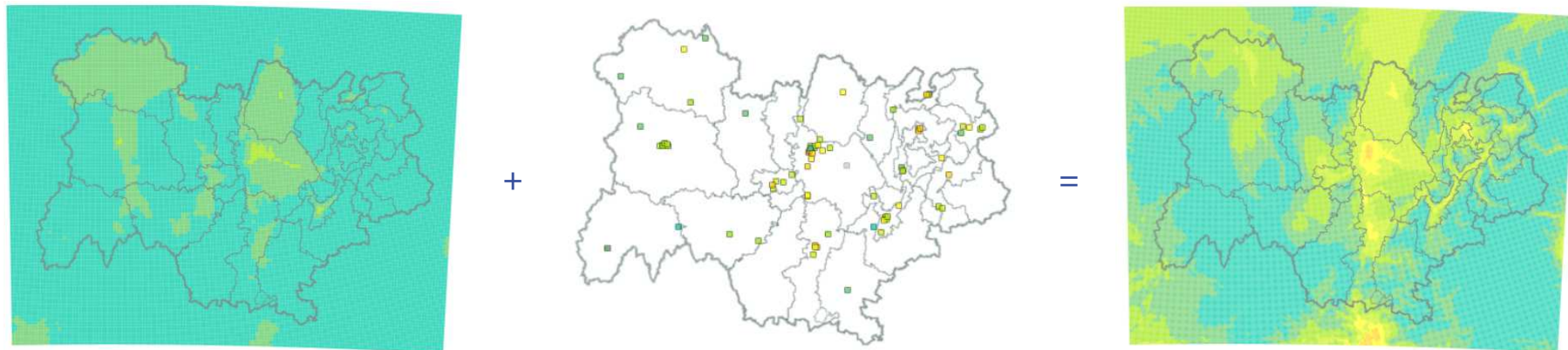
**Downscaling:**  $\Delta x \text{ 3km} \rightarrow \Delta x \text{ 1km}$

Method : bilinear interpolation 

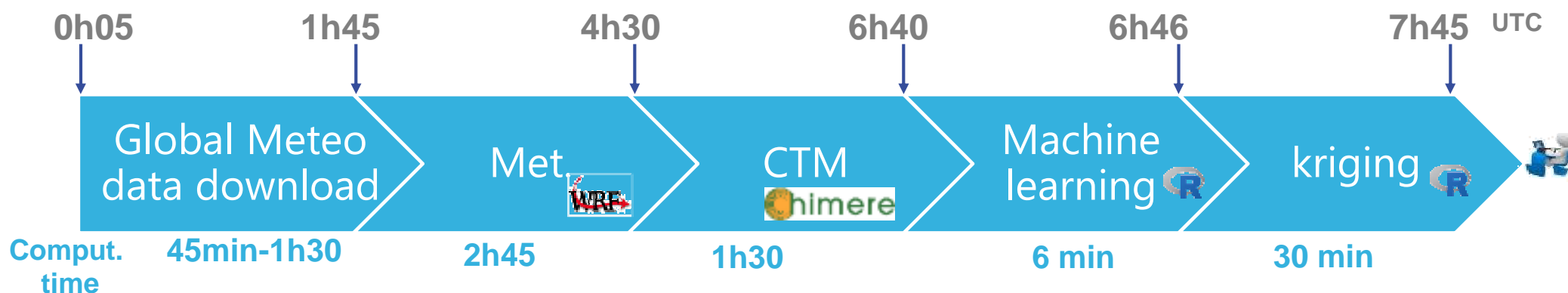
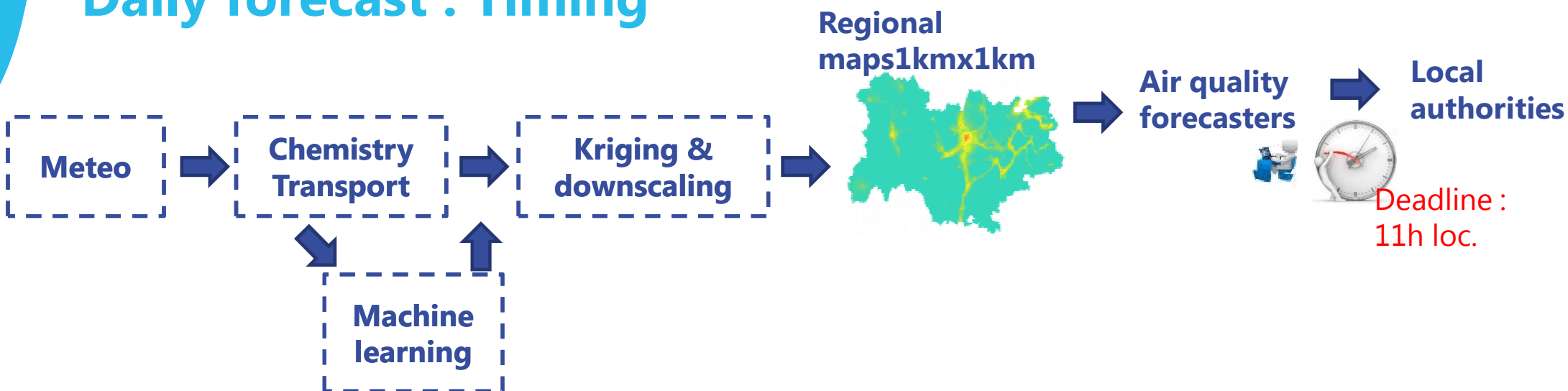
## Geostatistic

Method : kriging (Dr Krige 1951) + external drift : topography (1km) 

Principe : « Deux observations situées l'une près de l'autre devraient en moyenne se ressembler davantage que deux observations éloignées » (Maxime Beauchamp INERIS)



# Daily forecast : Timing



# Thanks for your attention

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18/10/2018

FTr.