



Urban planning and Urban air-quality modelling

NUMTECH – Fabien Brocheton

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- NUMTECH
- Context of urban air-quality
- Urban'Air
- The future : urban planning and HPC

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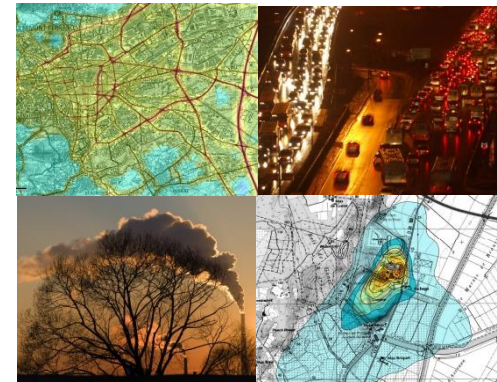
- **Age** : 13 years of expertise
- **Activity** : Atmospheric modelling (air-quality, meteorology, ...)
- **Localisation** : Clermont-Fd (siège), PACA and Ile de France (Campus Ter@tec)
- **Size** : 18 people
- **Cluster** : SYSTEM@TIC, Mer PACA et RISQUES
- **Turn-over 2012** : ~ 1,4 M€
- **Share-holder** : SETH Group

Meteorology



- Consulting (EIA, ...)
- Conception and distribution of application
- Data provider
- Expertise and Training

Air-quality



Context of urban air-quality

□ Historical request :

- Annual statistics according to EU regulatory thresholds
- Survey of specific sites
- General cartography of concentrations



⇒ **Measurement alone (permanent or temporary) were sufficient to give answer**

□ From 5/10 years ago :

- High detailed cartography of concentrations
- General assessment of sources contribution to air-quality
- Environmental impact assessment study of new construction

⇒ **measurement alone was no more sufficient**

Context of urban air-quality

But we were face to

❑ Complex phenomenology of urban scale

- Flow and dispersion around complex geometry: buildings, trees, moving vehicles, ...
- Urban meteorological processes
- Chemical reactions
- Various sources of air pollution
- Etc.

❑ And operational limitations

- Thousands buildings and streets
- Thousands moving vehicles
- Thousands potential receptors
- Engineering needs to simulate some scenarios in an “acceptable” cpu time
- and must be used on simple server

⇒ **Specific simplified Urban air-quality models have been developed are used by environmental agencies , engineering companies,**

Context of urban air-quality

Surface /
Volume

Roads

Industry

Airplane

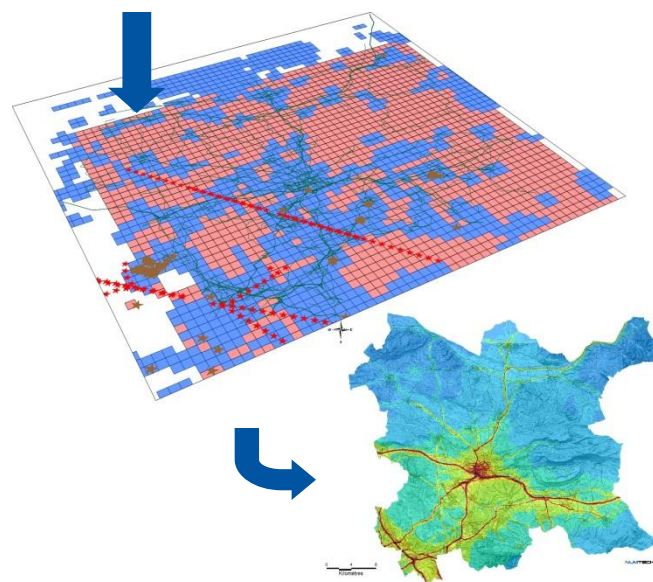
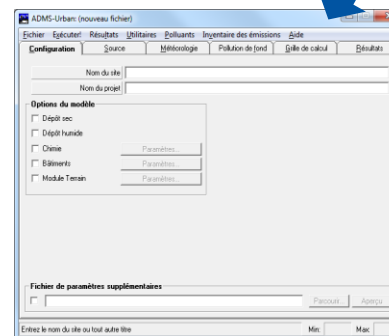
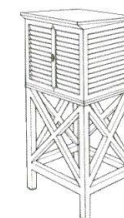
Cadastre

Topography, land-use



Monitoring stations

Meteorological
data



Context of urban air-quality

Mean annual concentration of NO₂

Pollution de fond : non

Cadastre d'émission : domaine CPA

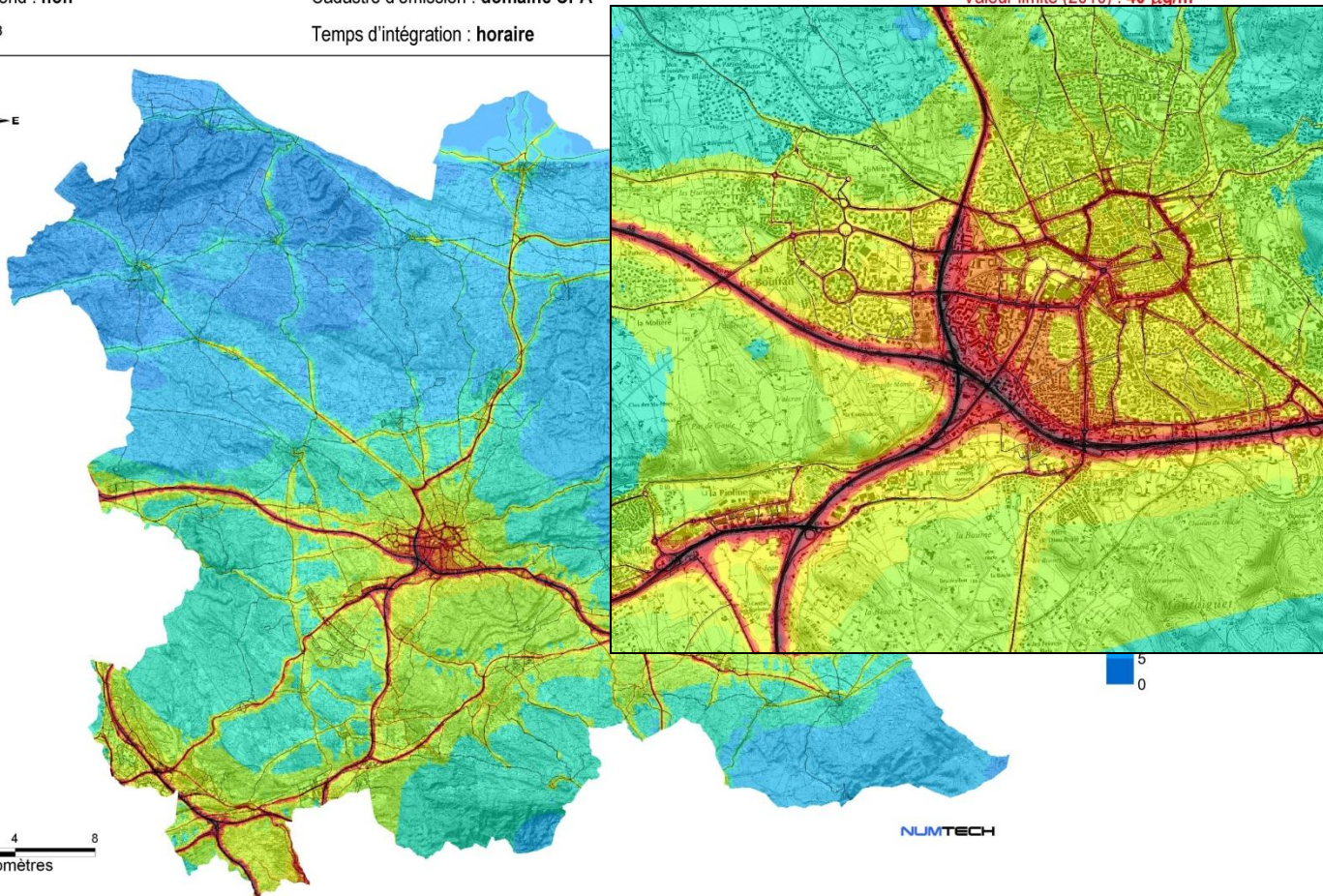
Unité : $\mu\text{g}/\text{m}^3$

Temps d'intégration : horaire

Valeur limite (2010) : $40 \mu\text{g}/\text{m}^3$



0 4 8
Kilomètres

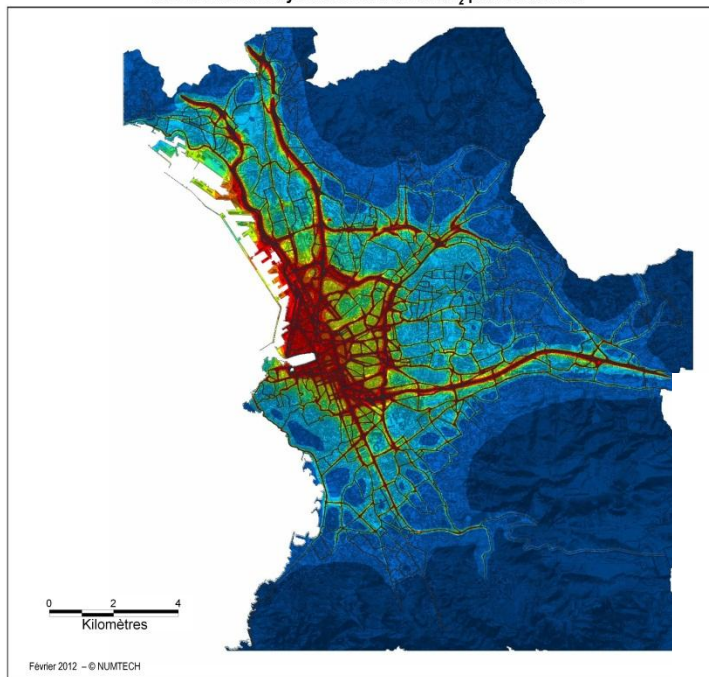


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octobre 2009 – © NUMTECH

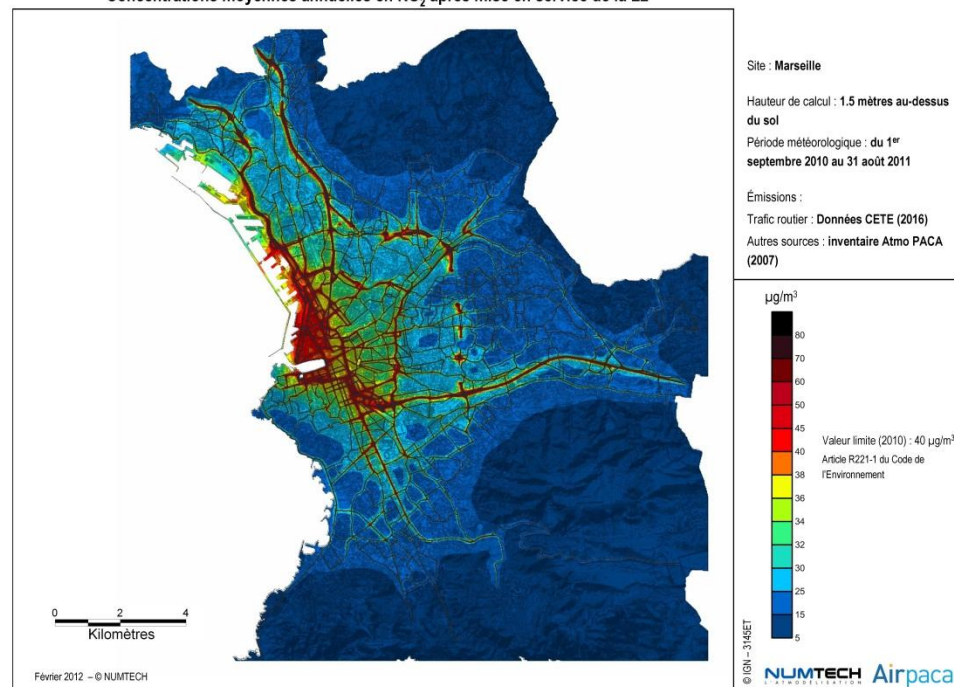
Context of urban air-quality

Concentrations moyennes annuelles en NO₂ pour l'état initial



Impact study of a modification of road network

Concentrations moyennes annuelles en NO₂ après mise en service de la L2



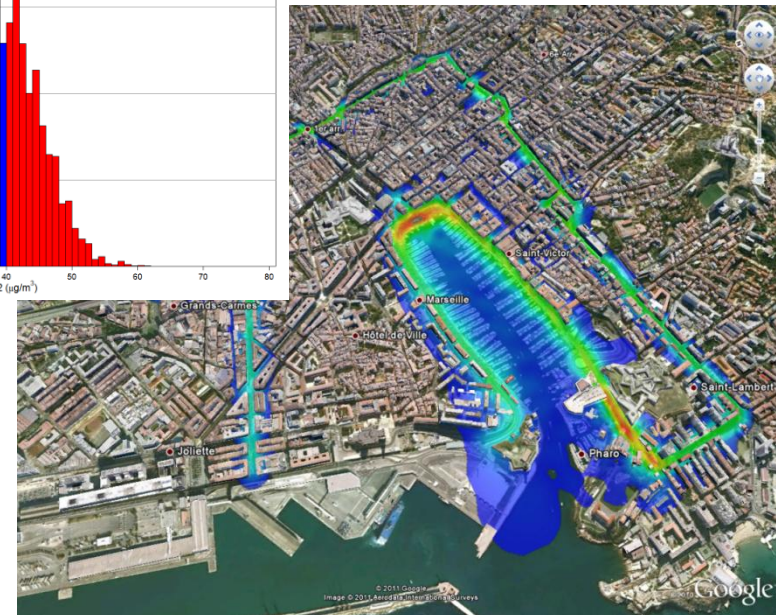
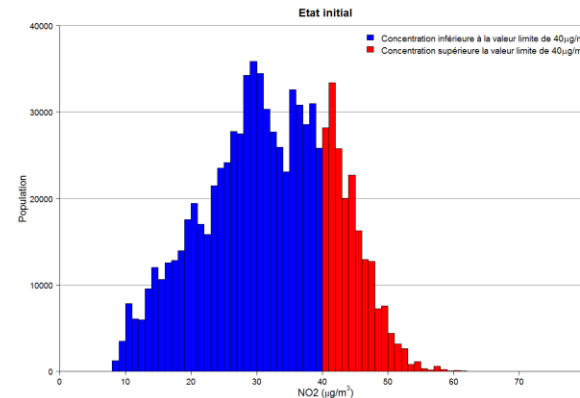
Context of urban air-quality

Moving few years ago to more and more specific needs

□ Urban air quality reporting

- European regulation are moving to general reporting to detailed reporting :
 - km² affected by thresholds (work on interpolation mapping)
 - Population exposure (work on transfer outdoor/indoor)
 - Assess impact of politic of emission reduction

Valeur limite : 40 $\mu\text{g}/\text{m}^3$



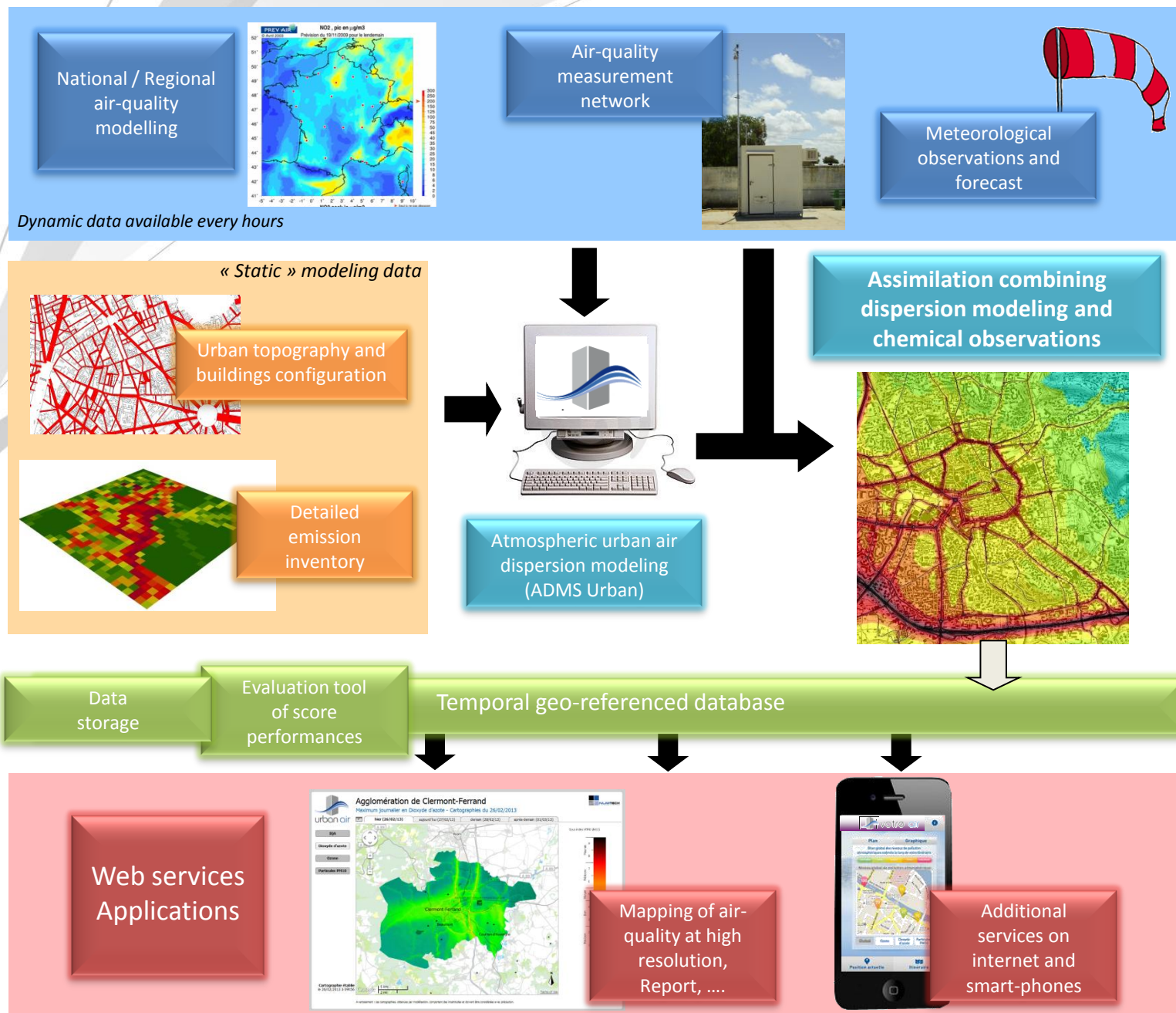
Context of urban air-quality

Moving few years ago to more and more specific needs

- Prediction and operational control
 - Near Real-time survey of pollution
 - Tomorrow forecast of air-quality

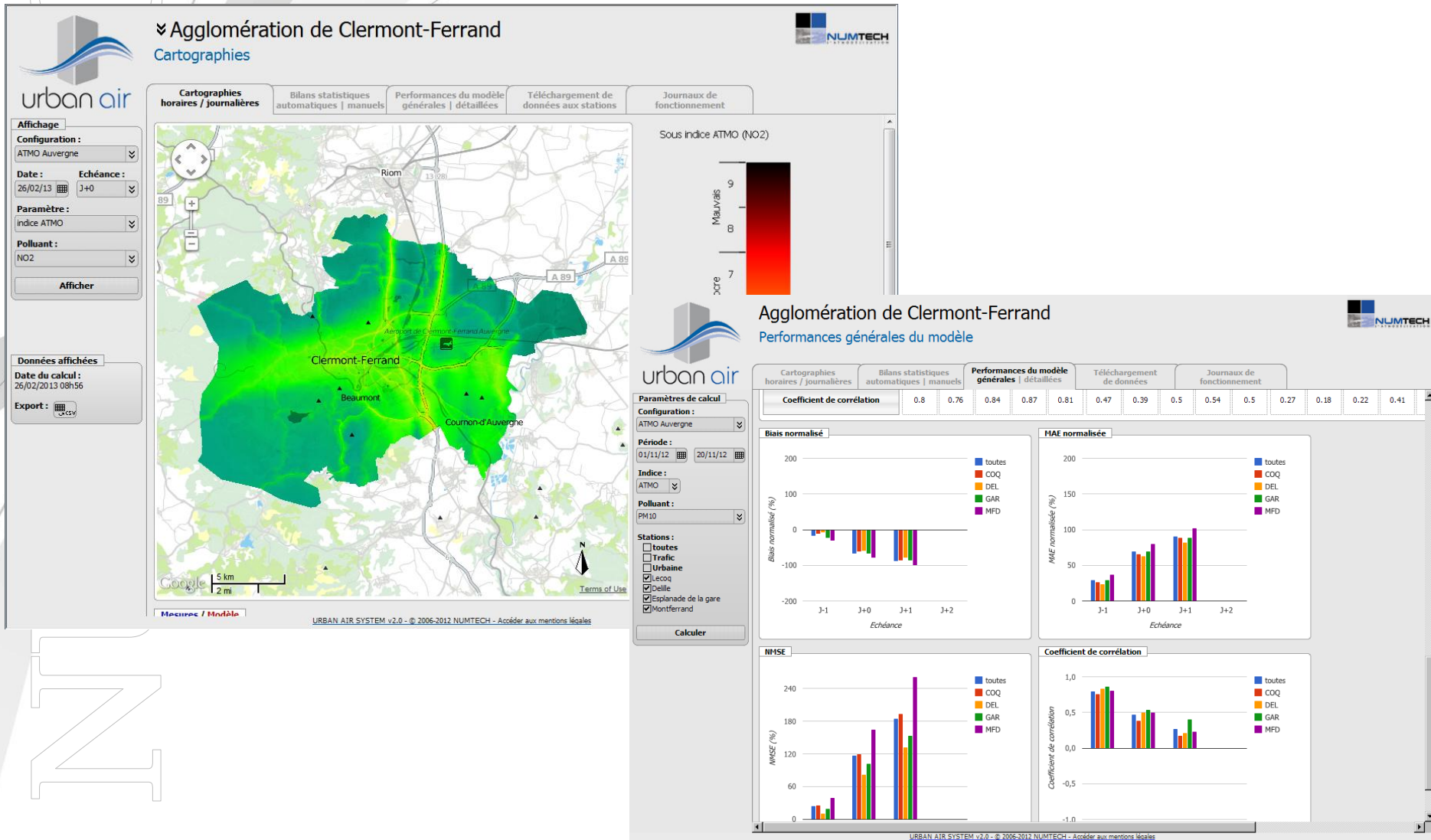


Urban'Air (developed by NUMTECH)



Urban'Air

- 10 cities in France (Strasbourg, Lille, Aix-en Provence, ...),
- 7 in preparation, Dubai, Casablanca, ...



votre air

- Develop an operational tool to monitor air-quality and test it over Paris
- With real-time traffic emission calculations,
- Coupling observations and simulations for maps,
- And including test of communication tools for public

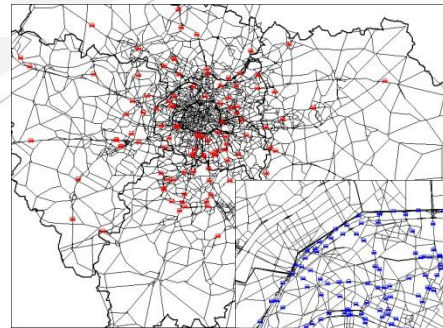
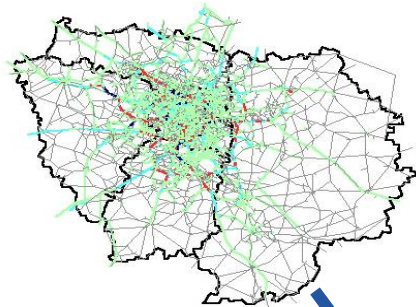


Urban'Air : Case of Paris

Realtime traffic emission calculation

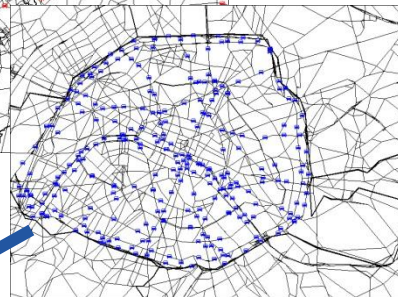
• Reference allocated traffic for specific hours/days

• Traffic counts



238 counts
for IDF

421 counts
for Paris



Traffic
Model
(iterations)



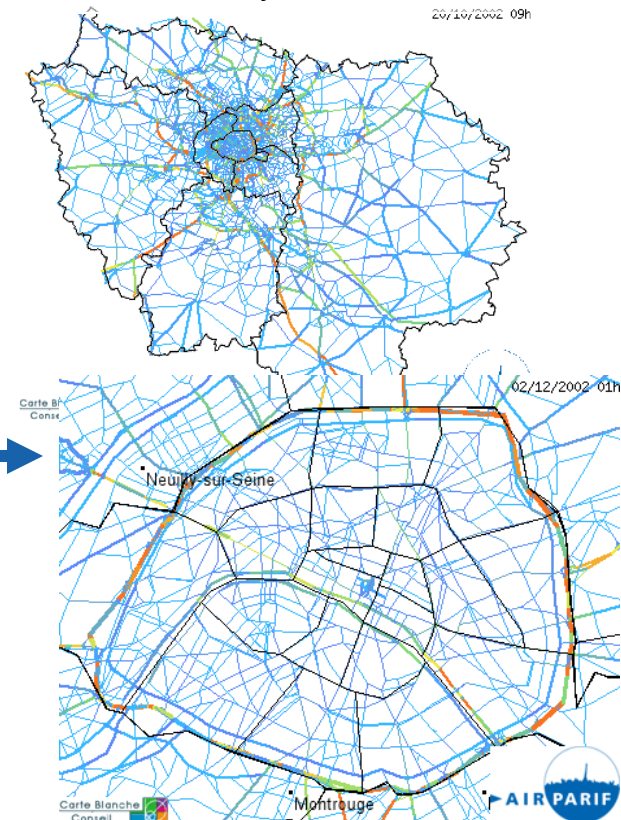
- # of vehicles, average speed
- Cold start %
- Hourly description
- Meteorology

Emissions factors
(Copert IV)

Running fleet based on
local and national data
(ADEME/INRETS)

Allocated traffic data
for 10000 km of roads every hour

Traffic emissions
every hour



Urban'Air : Case of Paris

Assimilation of measurement

$$c^a = c^b + K (o - Hc^b)$$

$$\text{with } K = B H^T (H B H^T + R)^{-1}$$

c^a : analysis state vector

c^b : model state vector

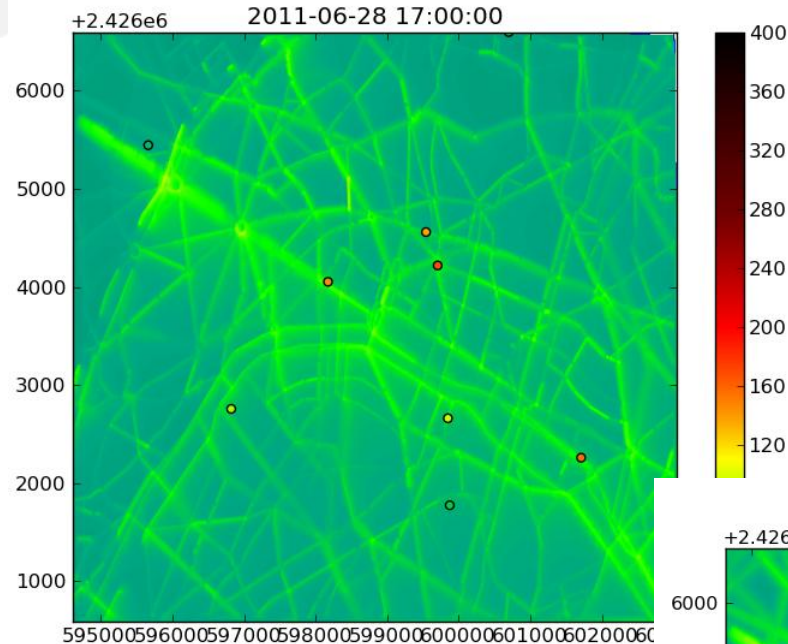
o : observation vector

K : gain matrix

H : observation operator

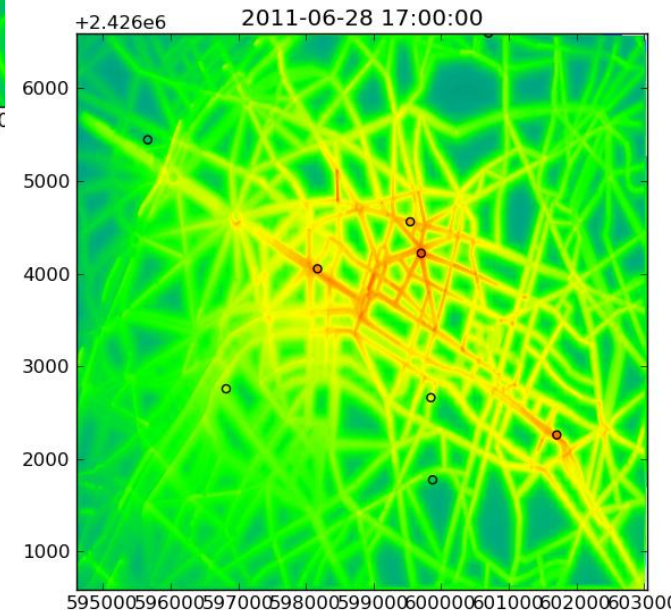
B : state error covariance matrix

R : observational error covariance matrix



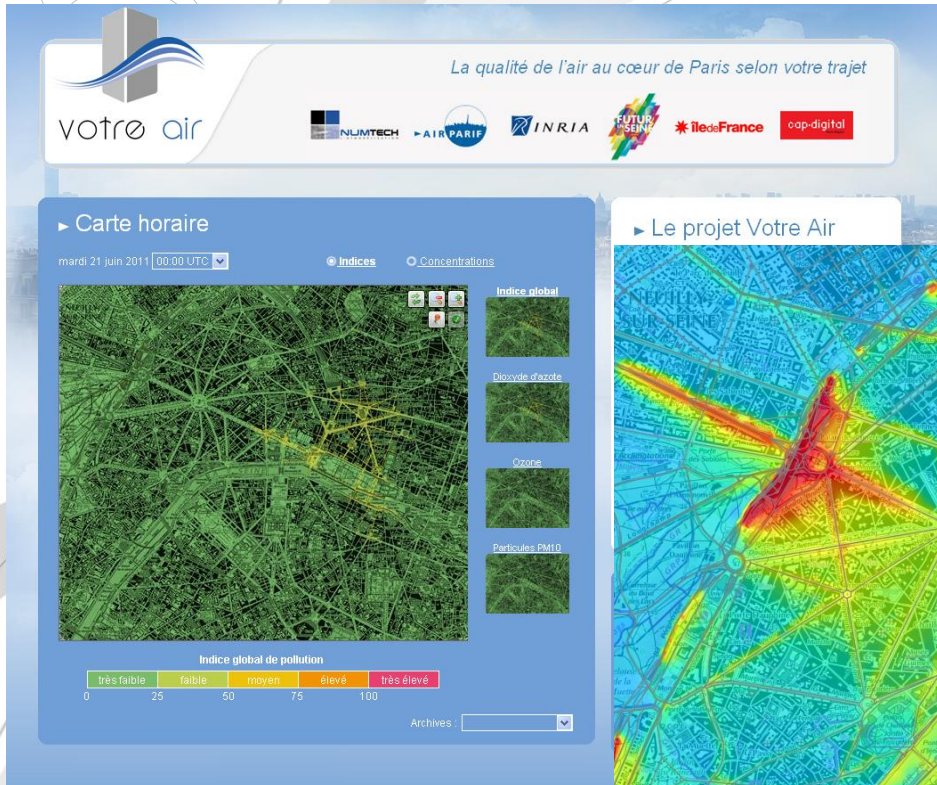
No assimilation

Assimilation

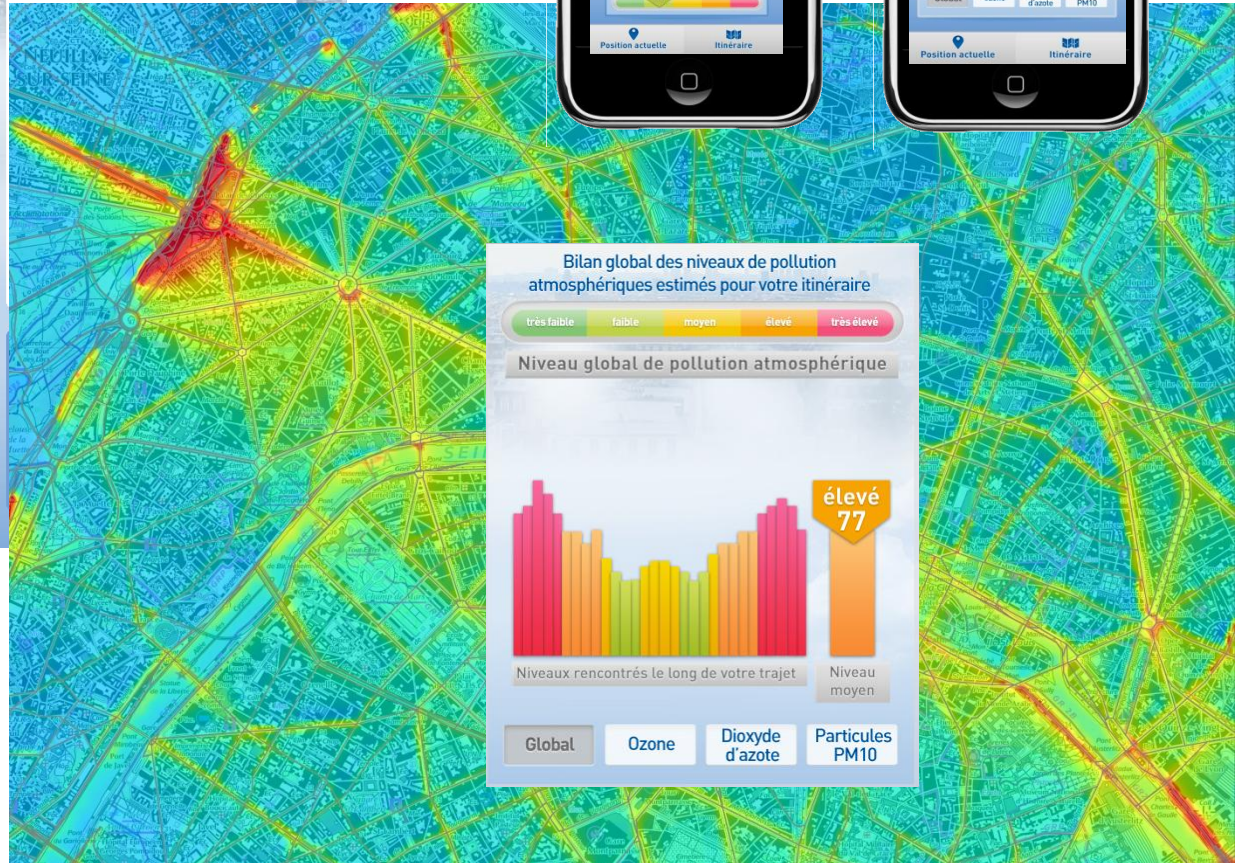


Urban'Air : Case of Paris

■ Communication

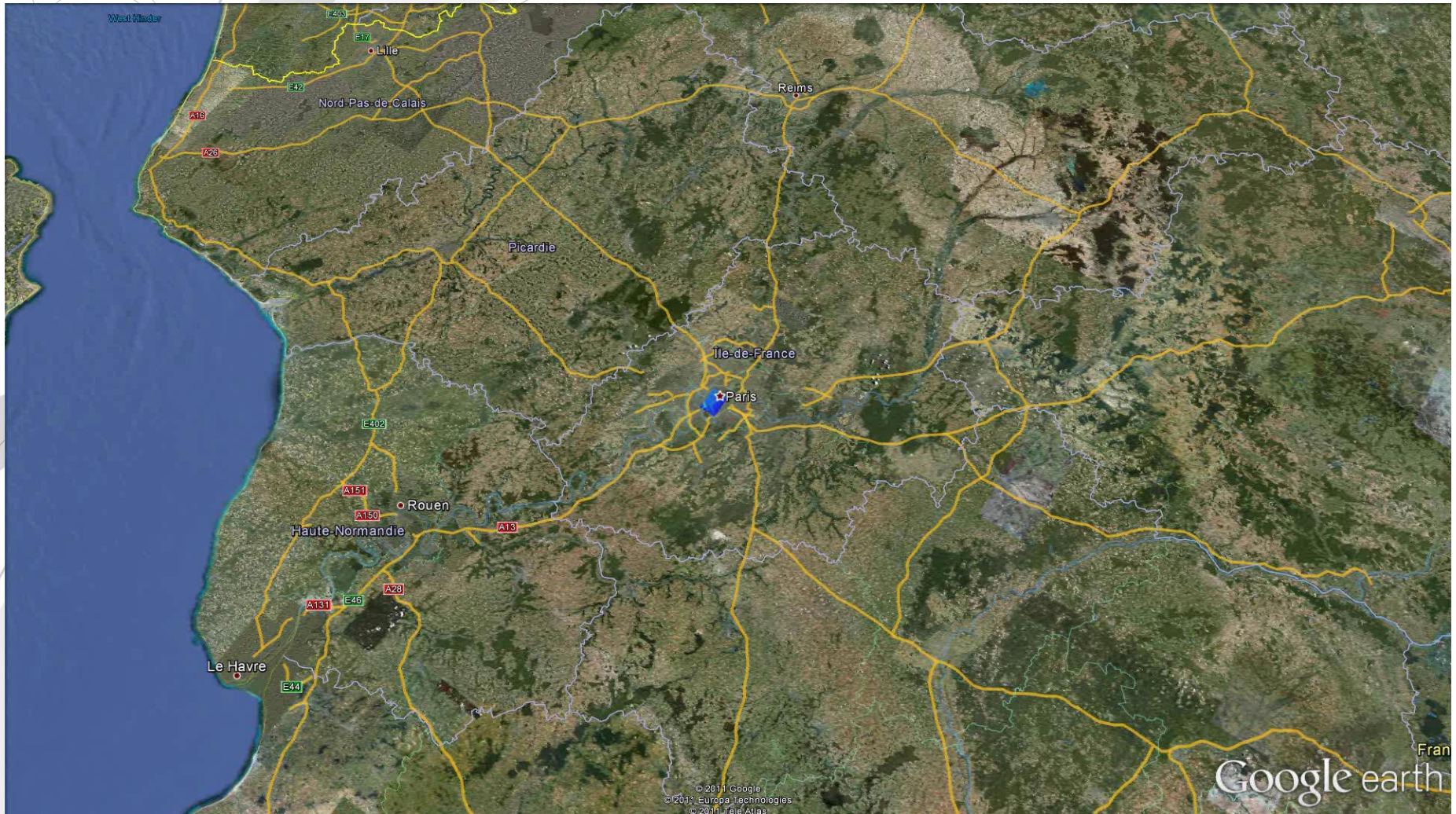


► Le projet Votre Air



<http://votreair.airparif.fr>

Urban'Air : Case of Paris



The future : urban planning and HPC

- Include more and more details on architecture, traffic data,

THE
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The future : urban planning and HPC



INTEGRATED

The future : urban planning and HPC

- Include more and more details on architecture, traffic data,
- Increasing demand on high resolution outputs

THE
CITY
GROWTH
TRENDS
AND
TRENDS

The future : urban planning and HPC



The future : urban planning and HPC



The future : urban planning and HPC

- ❑ Include more and more details on architecture, traffic data, ...
- ❑ Increasing demand on high resolution outputs
- ❑ Indoor air-quality



- Increase complexity in model
- or couple models of different complexity

- ❑ Increasing number of scenario to evaluate (urban equipment, traffic plan / LEZ, new legislation for vehicle or fuel, ...)
- ❑ Increasing robustness on outputs (uncertainties analysis, ensemble simulations, ...)



- need to simulate 10s or 100s simulations



**Use of HPC
cluster is more
and more
required**

The future : urban planning and HPC

BUT also

- Need to couple urban model to architecture software / CAO-SIG / BIM/ application of urban management



The future : urban planning and HPC

BUT also

- ❑ Need to couple urban model to architecture software / system of urban management
- ❑ Need to provide very fast information / result

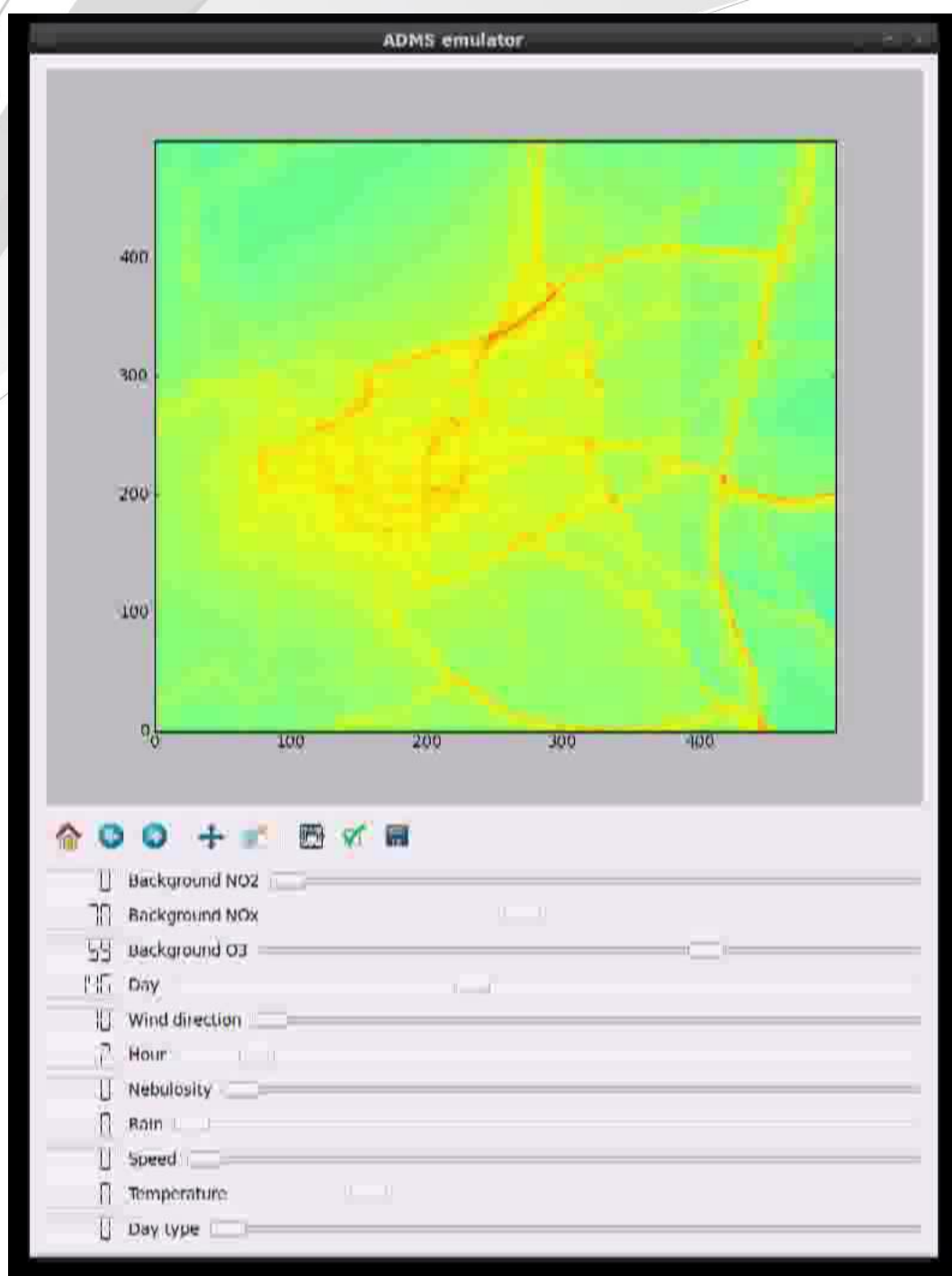


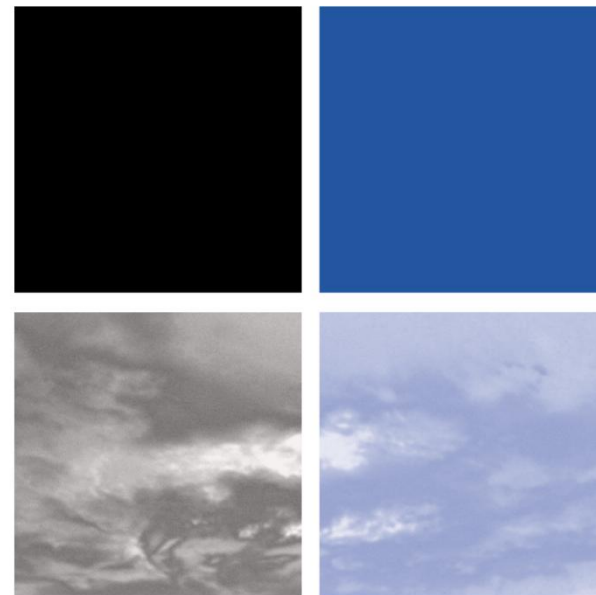
Reduction and emulation of model

Joint work with



in the framework of an Ilab





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