From the city to the street: modeling at a finer grain … yes but how? (air quality modeling)

Fabien Brocheton – NUMTECH
& INRIA Innovation Lab with CLIME

Content

- NUMTECH
- Evolution of needs about urban air quality and tools used in the past
- and Now ?

NUMTECH

- Age : 16 years of expertise
- Activity : Atmospheric modelling (air-quality, meteorology, …)
- Location : Clermont-Fd (Head), PACA and Ile de France (Campus Ter@tec)
- Size : 18 people
- Cluster : SYSTEM@TIC, SAFE, CEREALES VALLEES
- Turn-over : ~ 1,3 M€
- R&D Partnership : INRIA, LISA, LAMP, LSCE, …

Meteorology

- Consulting (EIA, …)
- Expertise and Training
- Conception and distribution of applications
- Data provider

Air-quality

Context of urban air-quality

- Historical request:
  - Annual statistics according to regulatory thresholds
  - Survey of specific sites

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

Context of urban air-quality

- Fifteen years ago, new request:
  - High detailed cartography of concentrations
  - General assessment of sources contribution to air-quality
  - Environmental impact assessment study of new construction
  - ….

But we were face to

- Complex phenomenology of urban scale
  - Flow and dispersion around complex geometry: buildings, trees, exchange between streets, …
  - Urban meteorological processes (thermal effect, ….)
  - Various sources of air pollution
  - Etc.
- And operational limitations
  - Engineering needs to simulate some scenarios in an “acceptable” cpu time
  - On simple server
  - Whereas Thousands buildings and streets, moving vehicles and potential receptors must be taken into account

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

Urban air-quality models

Natural,
Residential,
Tertiary
… sources

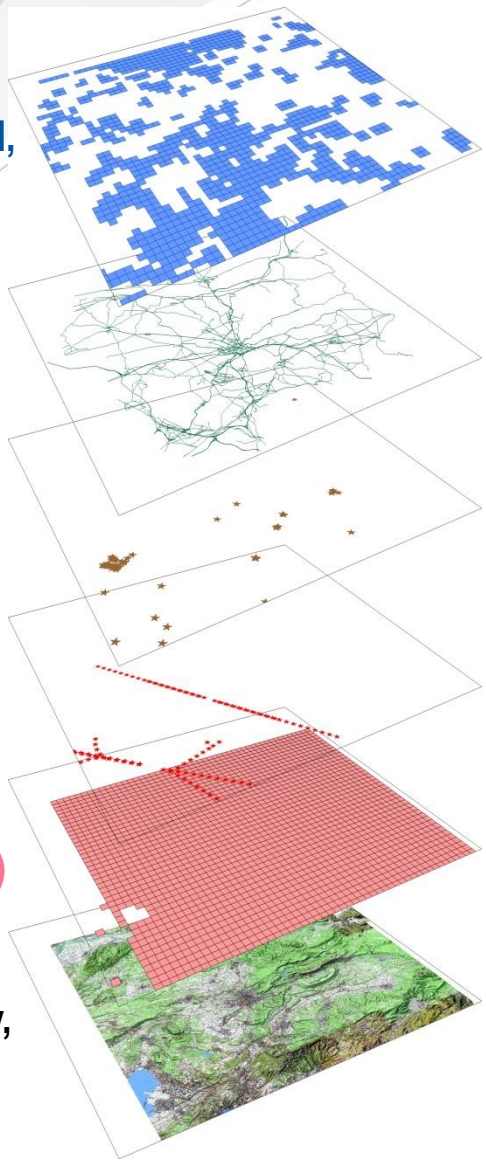
Roads

Industry

Airplane,
Ships, …

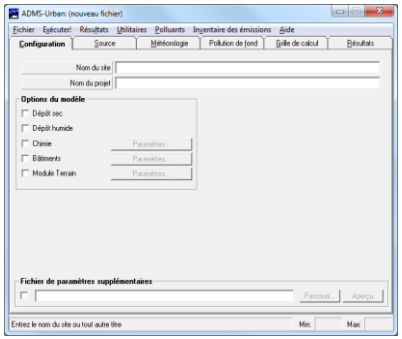
Cadastre
(sum + others)

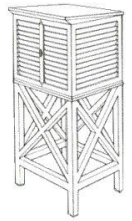
Topography,
land-use



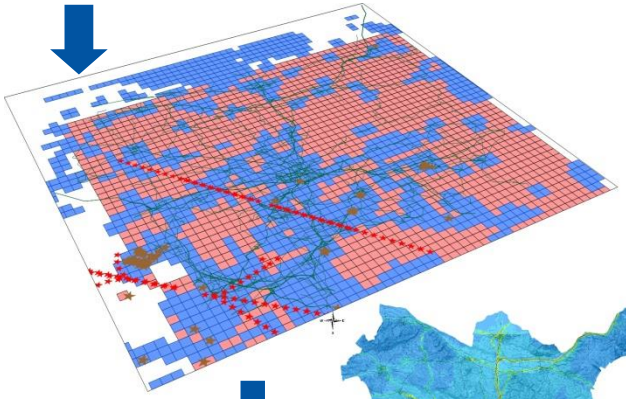
Urban buildings

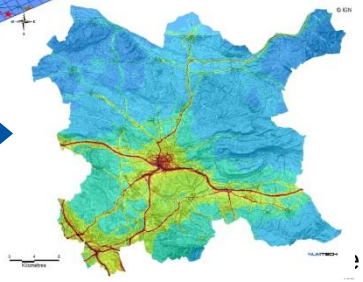
Background pollution





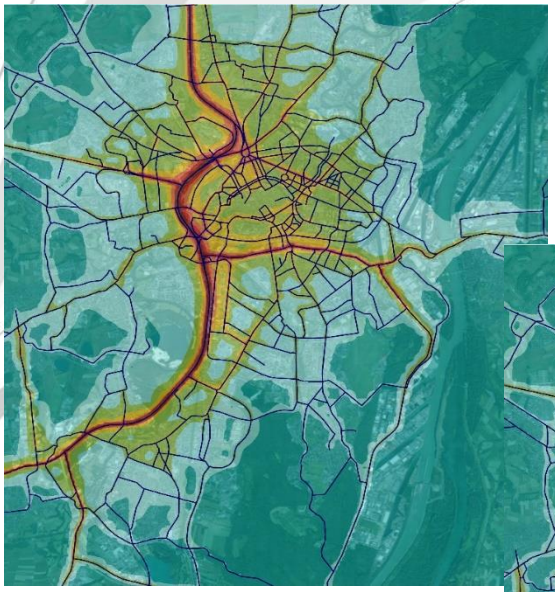
Meteorological data



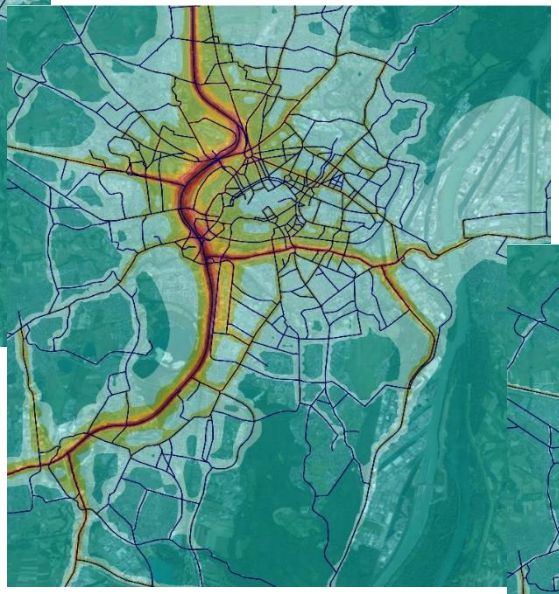


Urban air-quality models

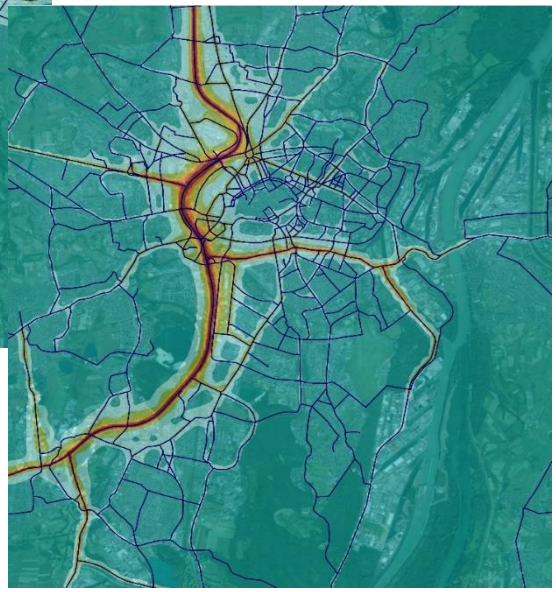
« Simplified modelling but requesting to taken into account all sources »



Explicit modelling of all sources as much as possible and regular cadastre



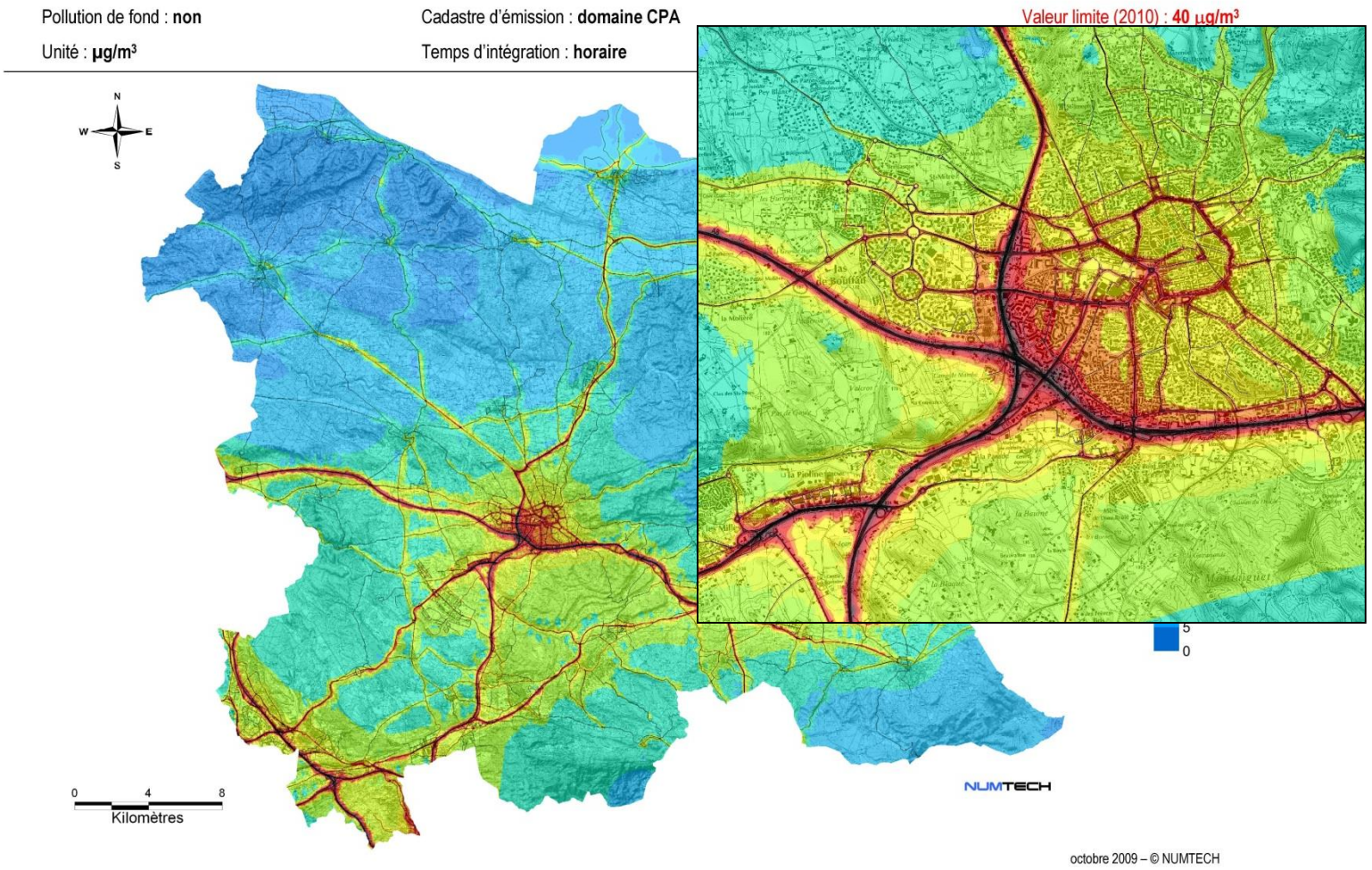
Explicit modelling of only main road sources and regular cadastre (1km)



Explicit modelling of only main road sources

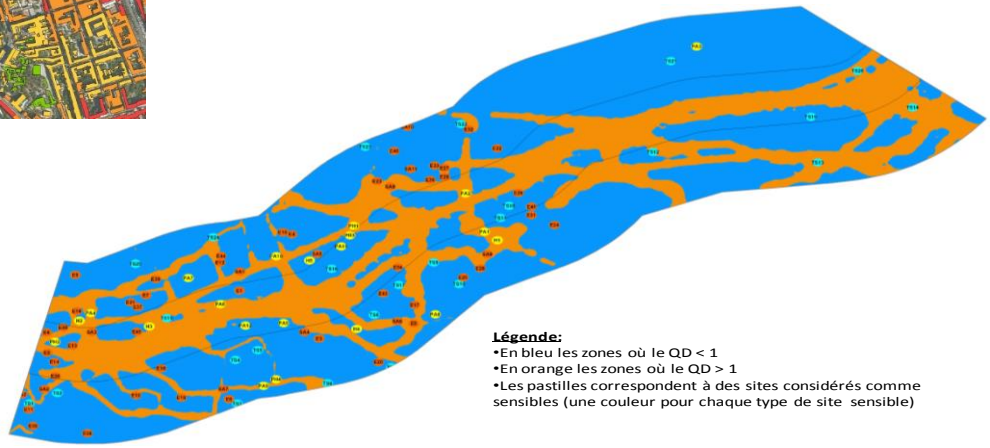
Urban air-quality models

Mean annual concentration of NO_2



Urban air-quality models

Population exposure
and
health impact assesment



Légende:
- En bleu les zones où le QD < 1
- En orange les zones où le QD > 1
- Les pastilles correspondent à des sites considérés comme sensibles (une couleur pour chaque type de site sensible)

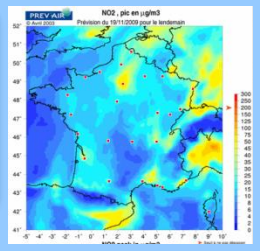
Few years ago, “real-time” needs appear:

- Prediction and operational control
  - Near Real-time survey of pollution
  - Forecast of air-quality for the next days with emission scenario measures (reduce speed, …)
- Active communication to the public

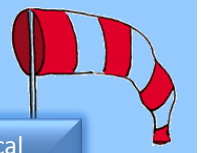
⇒ **Development of operational systems**

Urban'Air (developed by NUMTECH)

National / Regional air-quality modelling



Air-quality measurement network

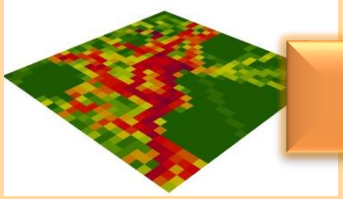


Meteorological observations and forecast

Dynamic data available every hours

Dynamic and modeling data

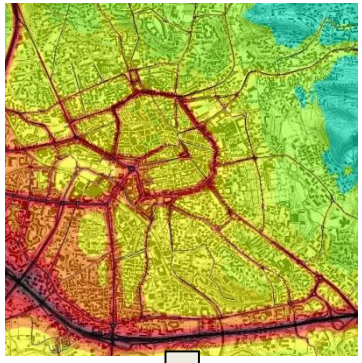
Urban topography and buildings configuration



Detailed emission inventory

Atmospheric urban air dispersion modeling

Assimilation of air quality observations

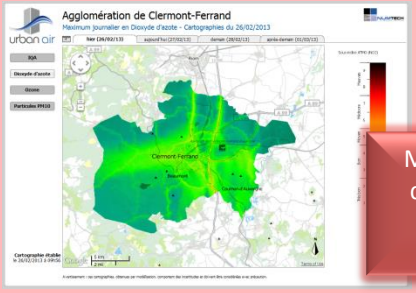


Data storage

Evaluation tool of score performances

Temporal geo-referenced database

Web services Applications



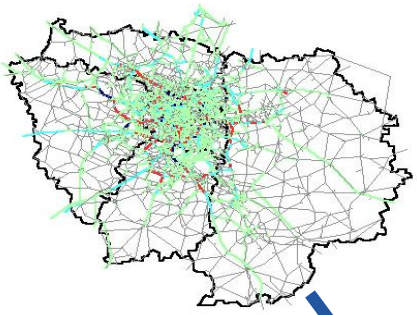
Mapping of air-quality at high resolution, Report, ….

Additional services on internet and smart-phones

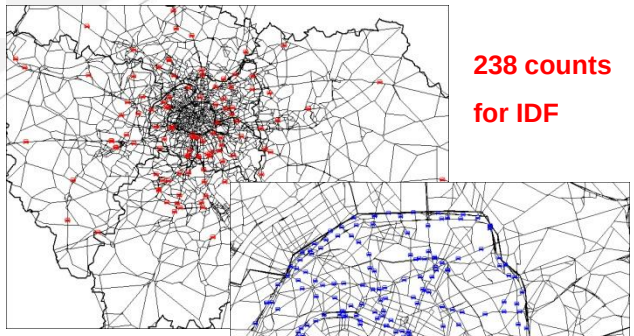
Votre'Air project

- Realtime traffic emission calculation coupled to realtime airquality modelling

• **Reference allocated traffic**
for specific hours/days



• **Traffic counts**



238 counts for IDF

421 counts for Paris

Traffic Model (iterations)

Allocated traffic data

for 10000 km of roads every hour

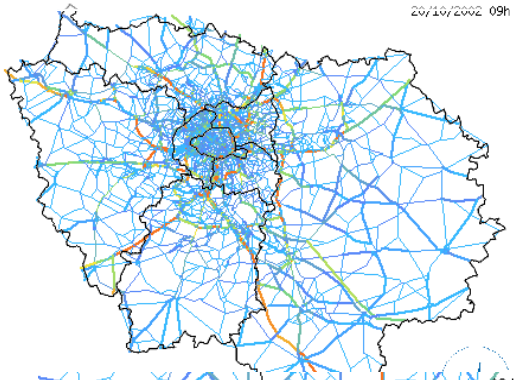
- # of vehicles, average speed
- Cold start %
- Hourly description
- Meteorology

Emissions factors (Copert IV)

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

Traffic emissions

every hour



Agglomération de Lille

Indice de la Qualité de l'Air du 06/11/2013

05/11/2013 | 06/11/2013 | 07/11/2013 | 08/11/2013

Très bon (1-2) | Bon (3-4) | Moyen(5) | Médiocre (6-7) | Mauvais (8 et +)

- Indice de la Qualité de l'Air
- Ozone
- Particules PM10
- Dioxyde d'azote

Prévision établie le 07/11/2013 à 14h08
Prochaine mise à jour : 27/11/2013 13h

Zone survolée

Conception : NUMTECH Cartographies réalisées avec le soutien du Conseil Régional du Nord-Pas-de-Calais

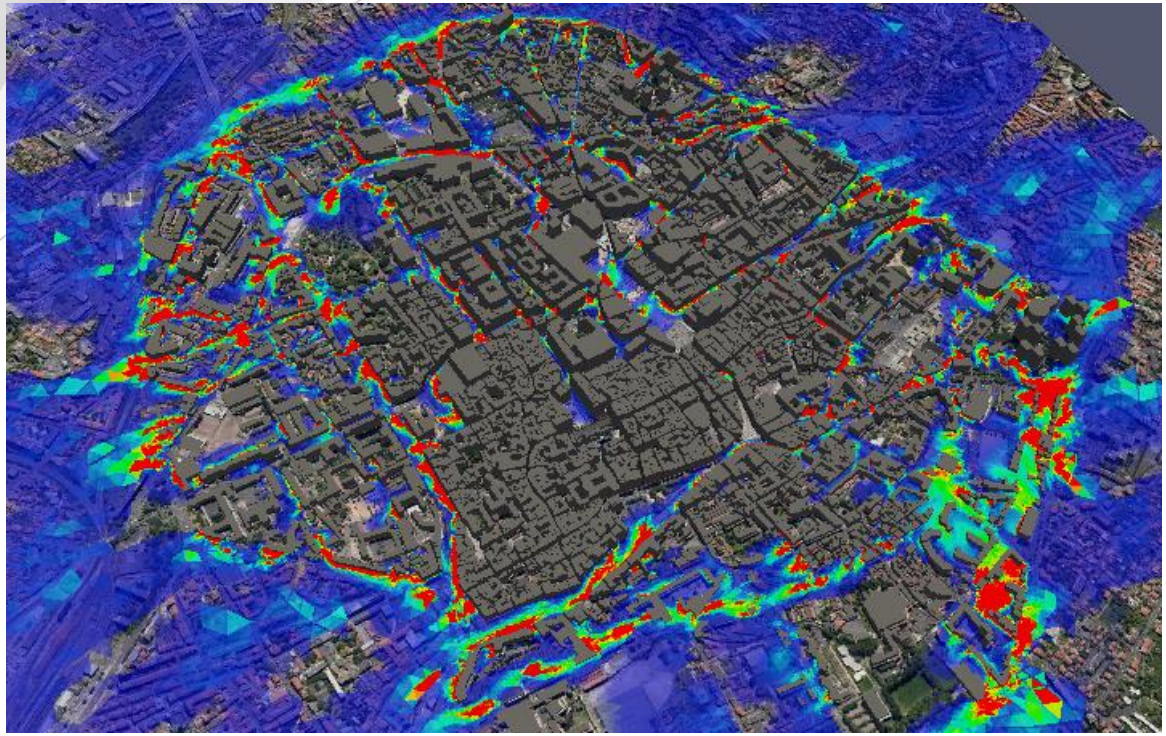
And now ?

- More and more detailed information are available:
  - Urban topography (buildings, streets, trees, …)
  - Emission data (road traffic data, …)
  - Open data (or not ..., but available)

- New requests/applications:
  - Uncertainties quantifications
  - Individual exposure / health industry
  - Online coupling with urban planning systems
  - Real-time decision applications (alternative mobility paths, …)

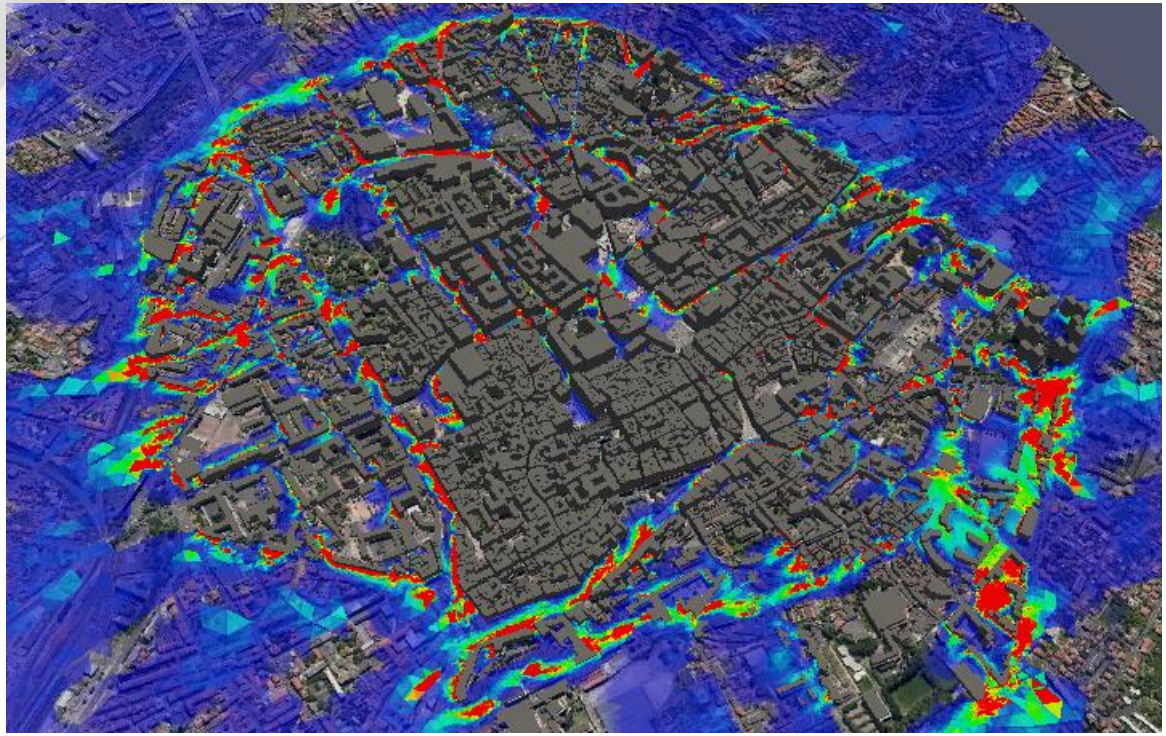
And now ?

- Need = obtain this map in few seconds in a robust way …



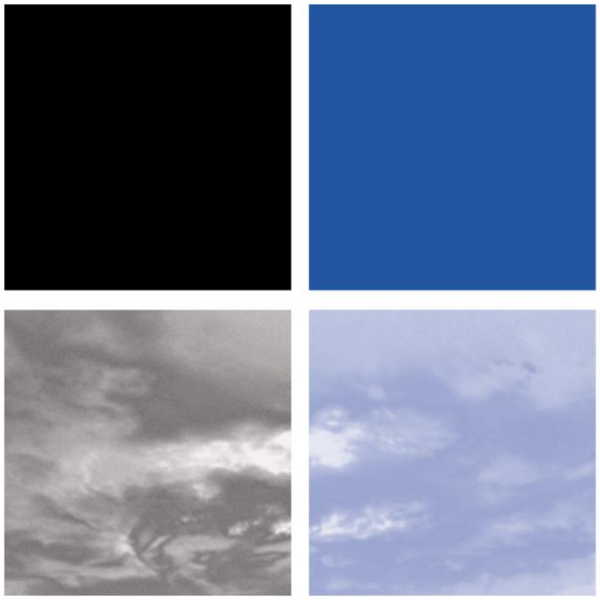
And now ?

- Need = obtain this map in few seconds in a robust way …



- To do that, new “tools” to combine:
  - CFD models (but CPU time consuming), and simplified models yet useful
  - Dense air-quality monitoring network (low&mid-cost sensors, fixed or mobile, …)
  - Numericals methods (ensemble aggregation, assimilation, emulation, ….)
  - Easy access to HPC services and Cloud

NUMTECH



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L'ATMODÉLISATION

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