



CNRS (UMR N° 8568) - ENPC
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Impacts of urban spatial structure on air quality *an integrated modeling approach*

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Work in progress !

C.I.R.E.D.

JARDIN TROPICAL

45 BIS AVENUE DE LA BELLE GABRIELLE

94736 NOGENT-SUR-MARNE CEDEX - FRANCE

Urban form and environment

- **Urban forms matter for greenhouse gas emissions**
 - Transport, housing, ...
- **Urban forms matter for climate-change vulnerability**
 - Urban heat island
 - Urbanization in flooding prone areas...
- **Urban forms matter for many other policy objectives, e.g., related to social and spatial inequalities, competitiveness...**
- **Wat can we say about the link with pollution issues?**
 - Air pollution levels remain a concern in many parts of Europe
 - Transportation is a major contributor to NO_x (55%) and fine PM (30 %) emissions. It also generates very close proximity to emissions.

Research question

- **What are the impacts of the form of urban growth on air quality ?**
- **A confrontation of several mechanisms**
 1. In a compact urban form, pollutant emissions can be **lower** than in a sprawled city (*higher public transport/non-motorized travel modal share*)
 2. In a compact urban form, pollutant emissions can be **higher** than in a sprawled city (*increased congestion*)
 3. In a compact urban form, everybody leaves closer to emission sources...

Project goals

■ Several works have investigated into this issue

- E.g. Borrego et al. 2006, De Ridder et al. 2008, Martins 2012, Schindler et Caruso 2014...
- The result of the confrontation of the 2 mechanisms depends on the **type of pollutant**, and on the **city**
- Also depends on the type of vehicles → technological change can have an important impact

■ Many questions still need to be addressed

- What result for the case of Paris?
- To what extent can mitigation policies (e.g. vehicle efficiency increases, electric vehicles...) influence this issue?
- To what extent can adaptation policies (e.g. city greening) influence this issue?
- Are there thresholds? Non-linear relationships ?
- Is there an optimal density/urban form when considering both CO2 emissions and air pollution?
- Is the link between urban shape and air quality significant enough to play a role in the public debate?
- ...

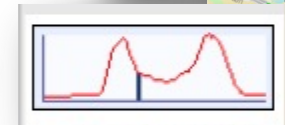
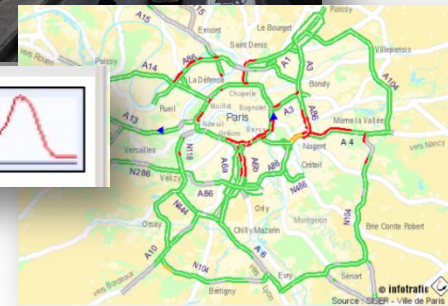
Proposed approach: Integrated city modelling

MODUS / GREEN models

Model for modal allocation and traffic simulation

Construction of traffic flows

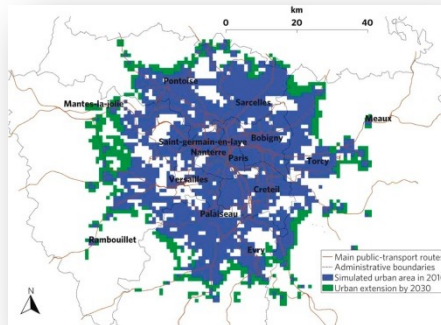
Calculating associated emissions



Emissions linked with road traffic

City structure & urban fabric

NEDUM 2D : Socio-economic model /
interaction transport–landuse
Rearrangement of urban space
Transport costs
Rent cost



Urban consequences of policy choices
→ Location of new employment centers and residential areas
→ New landuse

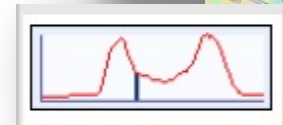
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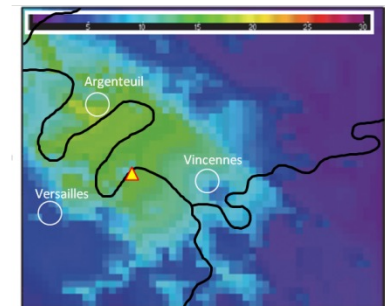
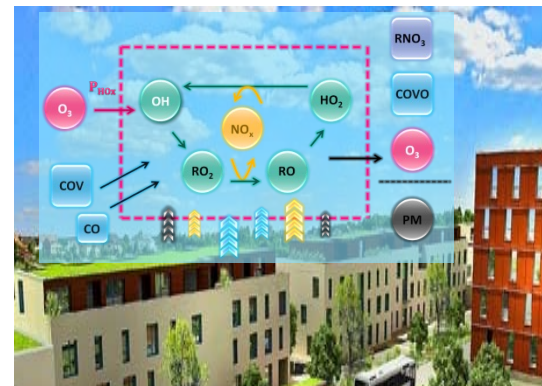


Emissions linked with road traffic



CHIMERE model : air quality / concentration fields

Chimere

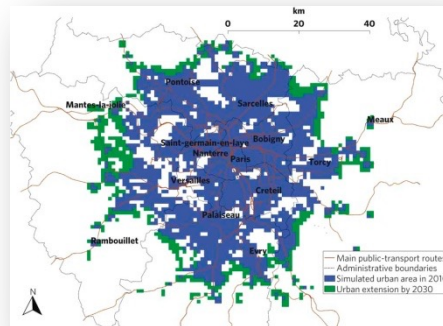


City structure & urban fabric

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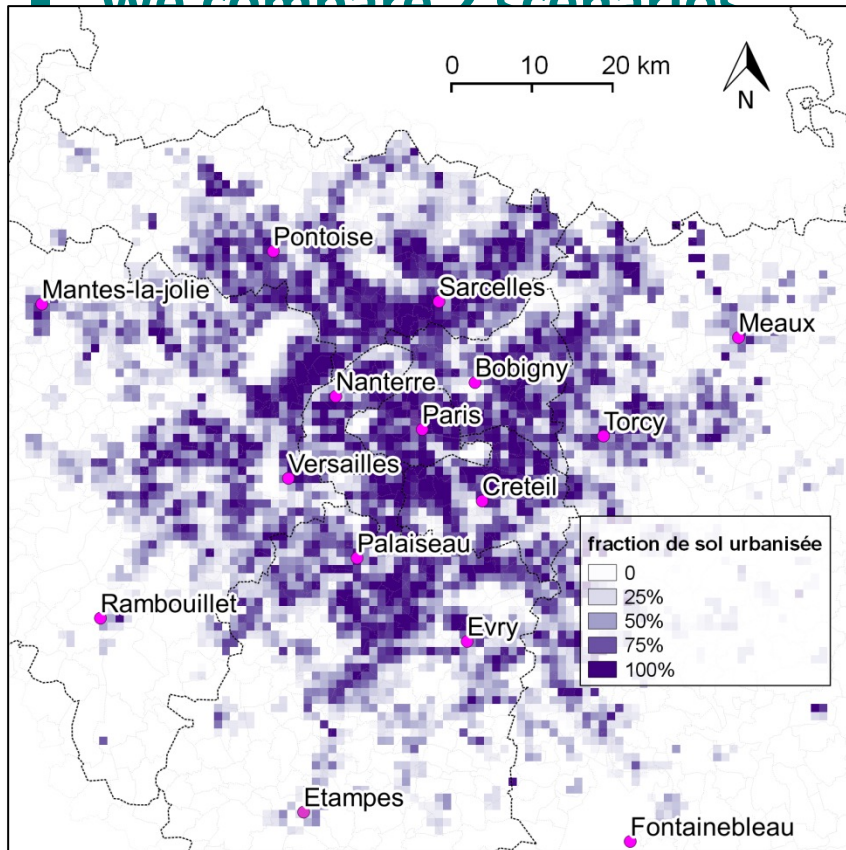
First results (work in progress)

- **We compare 2 scenarios**

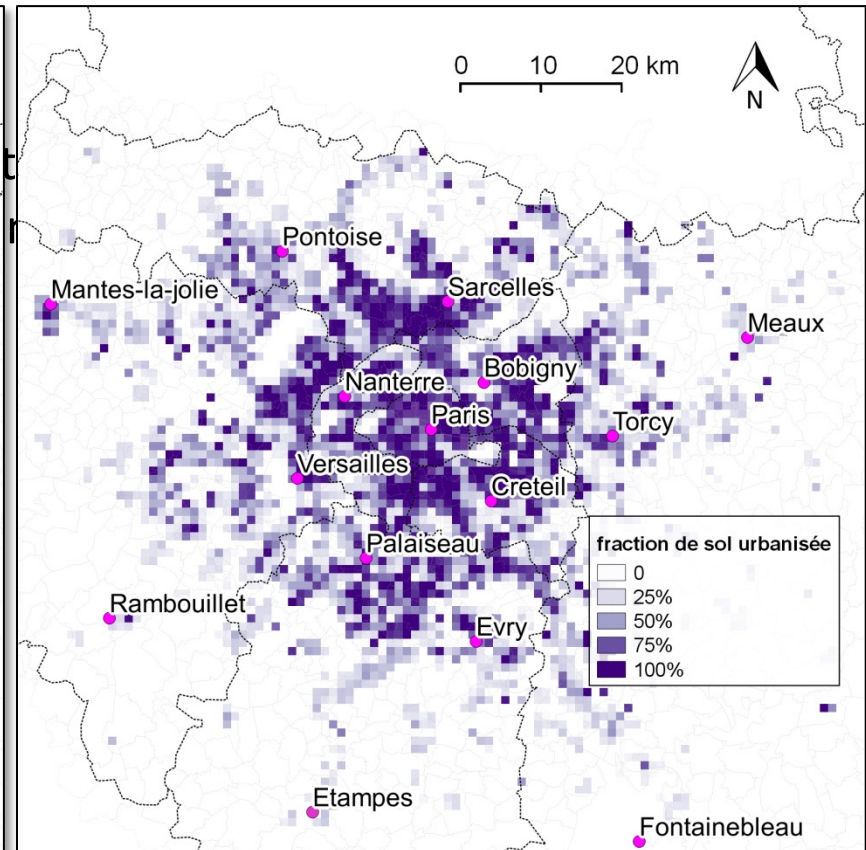
- Paris today (**reference** case)
- **Compact scenario:** Paris, as if strong land-use policies had been implemented since 1960 to promote a compact city development

First results (work in progress)

We compare 2 scenarios



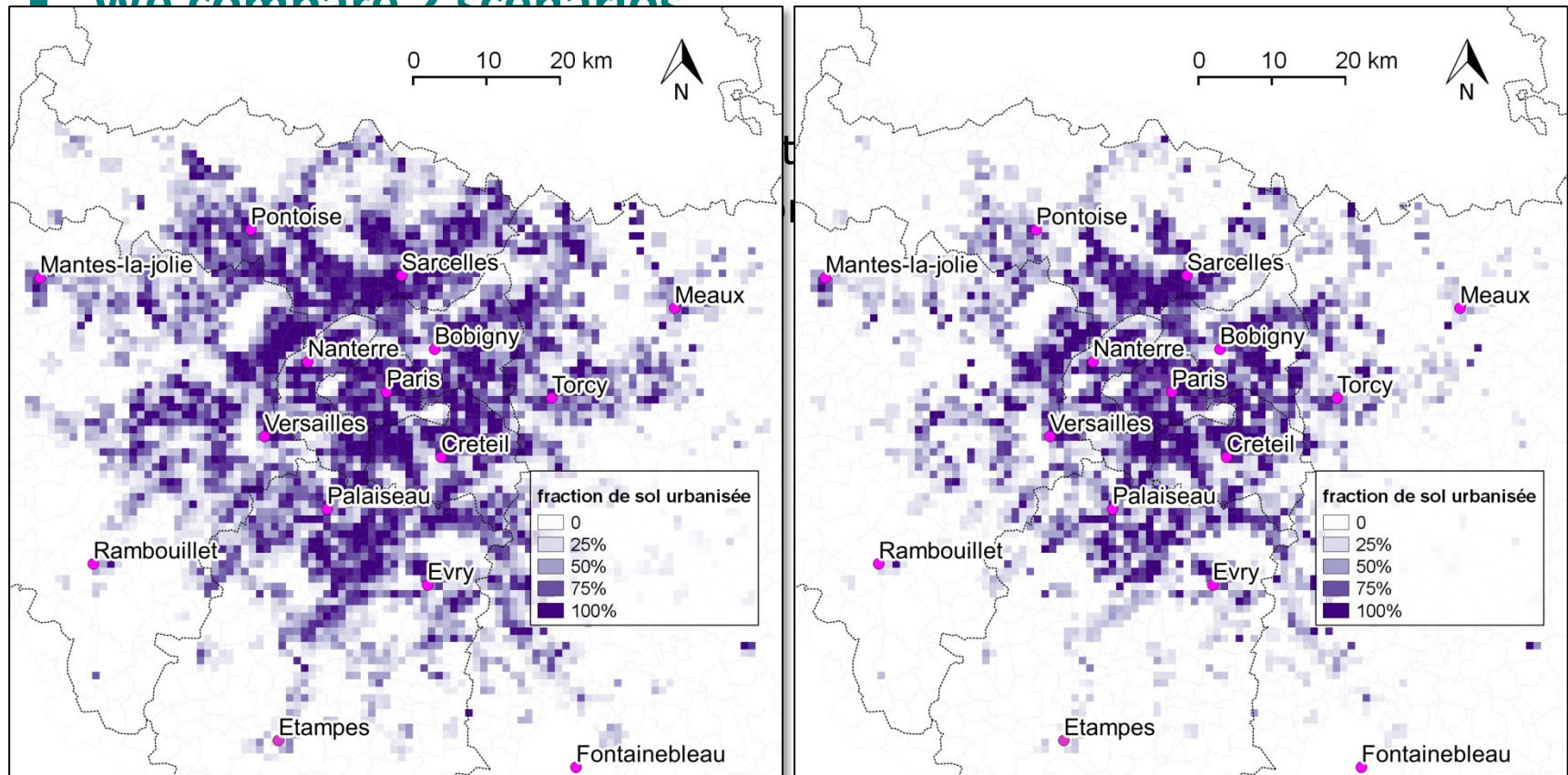
2008 : REFERENCE SCENARIO



**2008 : DENSIFYING ONLY
1960 EXISTING URBAN AREAS**

First results (work in progress)

We compare 2 scenarios



2008 : REAL SITUATION

**2008 : DENSIFYING ONLY
1960 EXISTING URBAN AREAS**

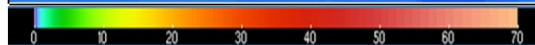
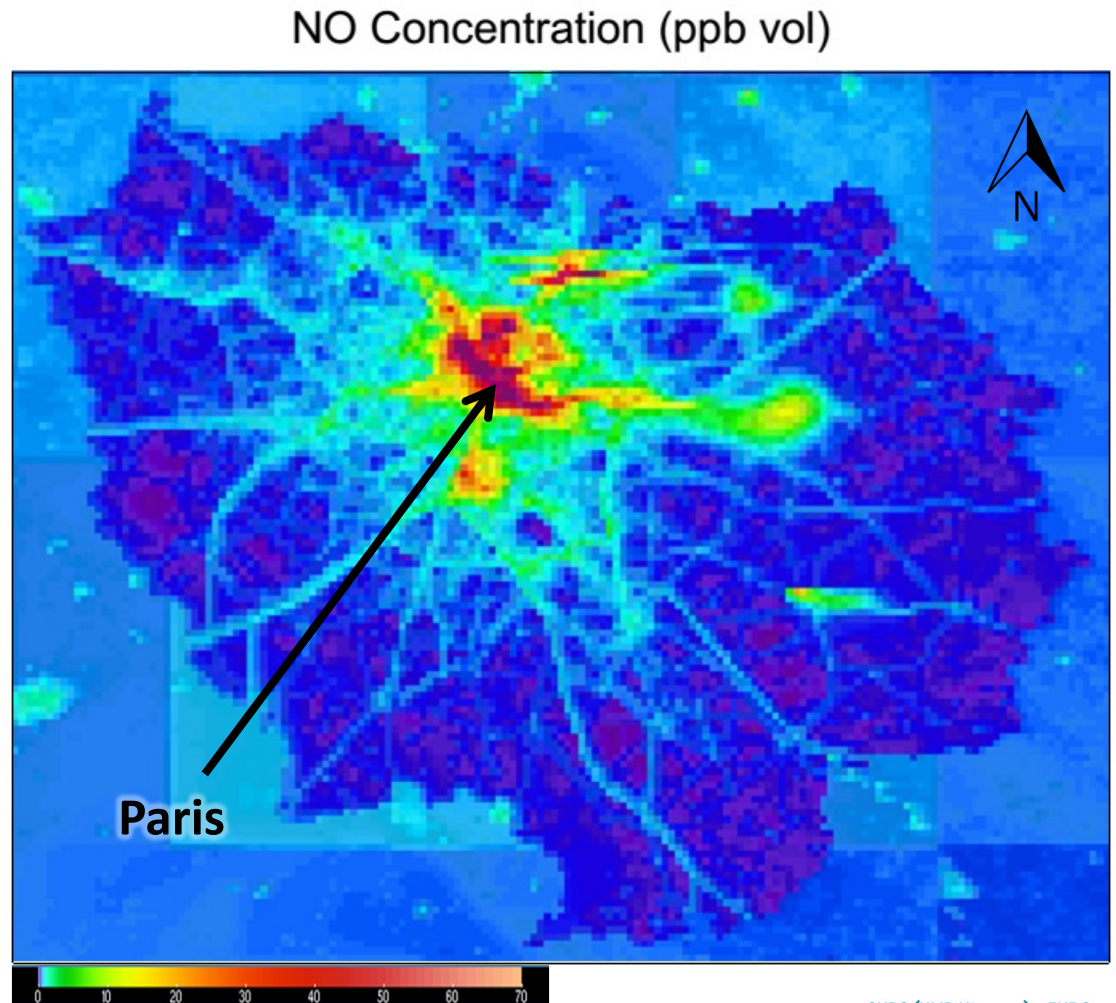
First results (work in progress)

- **We compare 2 scenarios**
 - Paris today (**reference** case)
 - **Compact scenario**: Paris, as if strong land-use policies had been implemented since 1960 to promote a compact city development
- **Apart from transport related emissions, all emissions are the same**
 - NB: we only simulate emissions due to commuting trips
 - We make here no difference between week days and weekend
- **Simulation for the weather of the first week of January 2009**

First results (work in progress)

- NO concentration in the reference scenario

7 a.m. at the end of a week corresponding to the first week of January 2009



Vincent Viguié

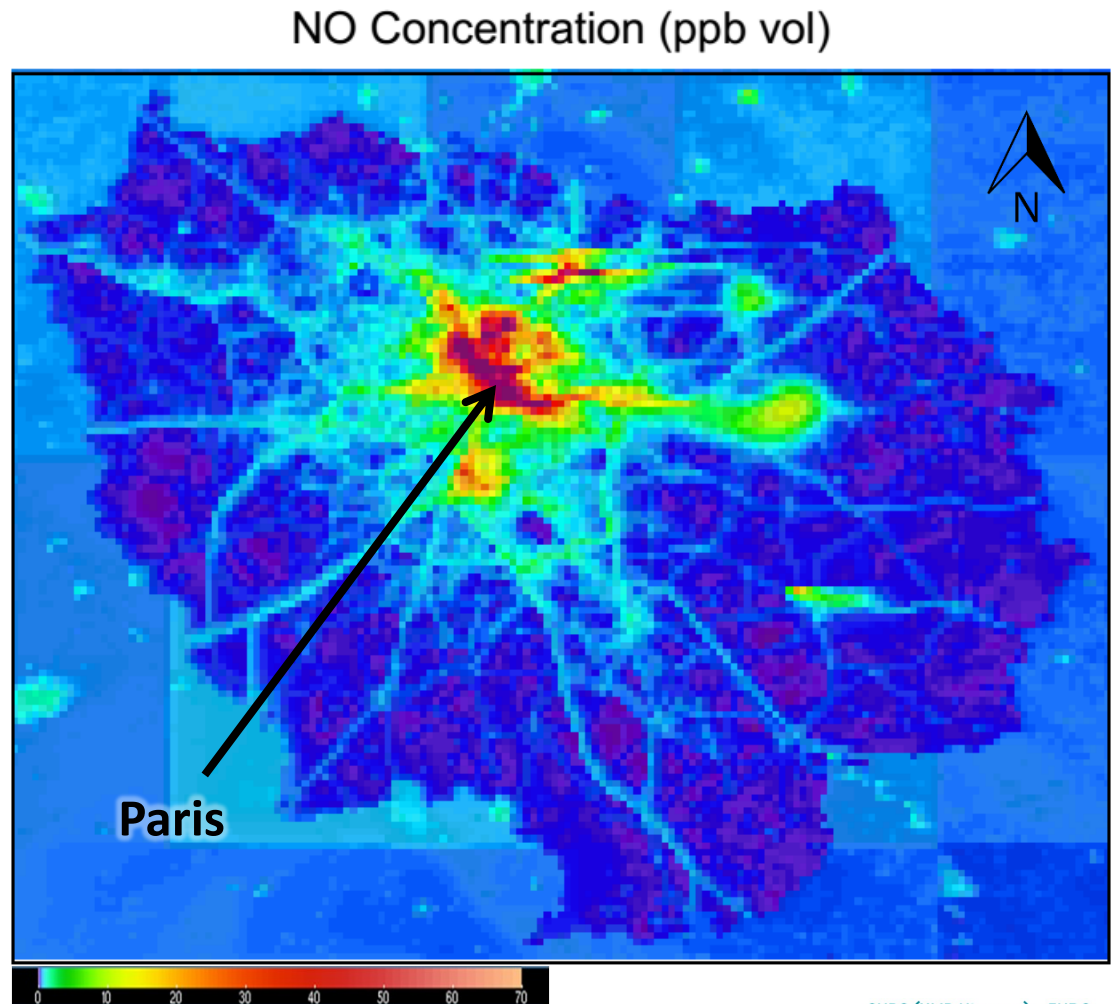
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First results (work in progress)

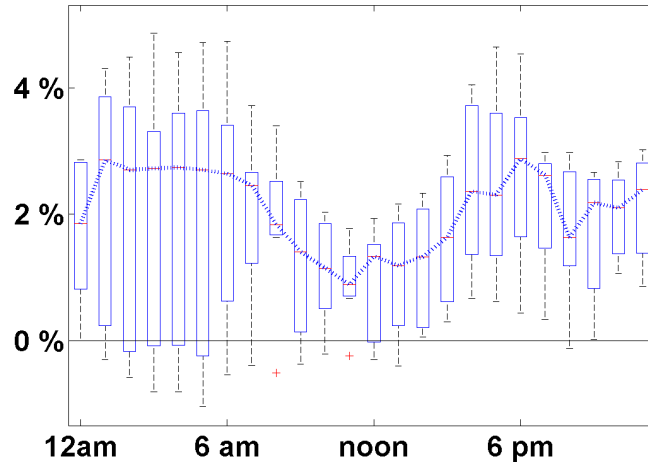
- NO concentration in the compact scenario

7 a.m. at the end of a week corresponding to the first week of January 2009

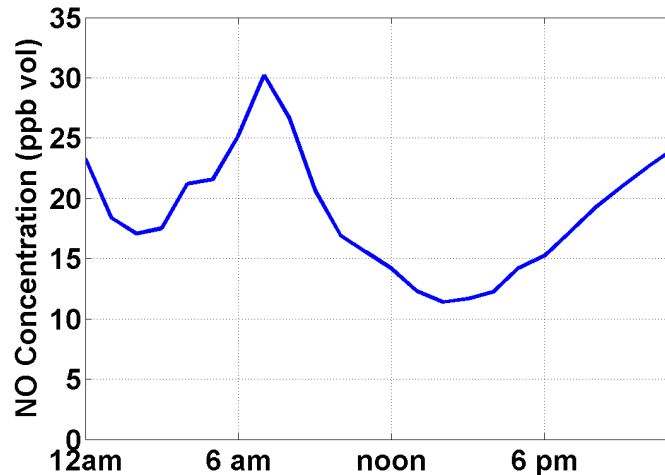


First results (work in progress)

Difference in NO concentrations between compact and reference scenarios



Evolution of average NO concentration over one day in the middle of Paris



- In the middle of the city, NO concentration appears higher, in average, in the compact scenario
- But the difference is very small...
- *Work in progress ! (issue with congestion ?...)*

CHIMERE TOOL : Chemistry Transport Model

Chimere

Internal modules for calculation

Chemical scheme /
Thermodynamics
Transport scheme
Solver

Meteorological
Parameters
(model)

Gridded
concentration fields
All calculated species



O₃ NO NO₂ PM₁₀ ...

Emissions
(database – emission
models)

Chemical fields
(large scale models)