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# Urban compaction vs city sprawl : impact of road traffic on air quality in the greater Paris

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# Context – Energy consumption

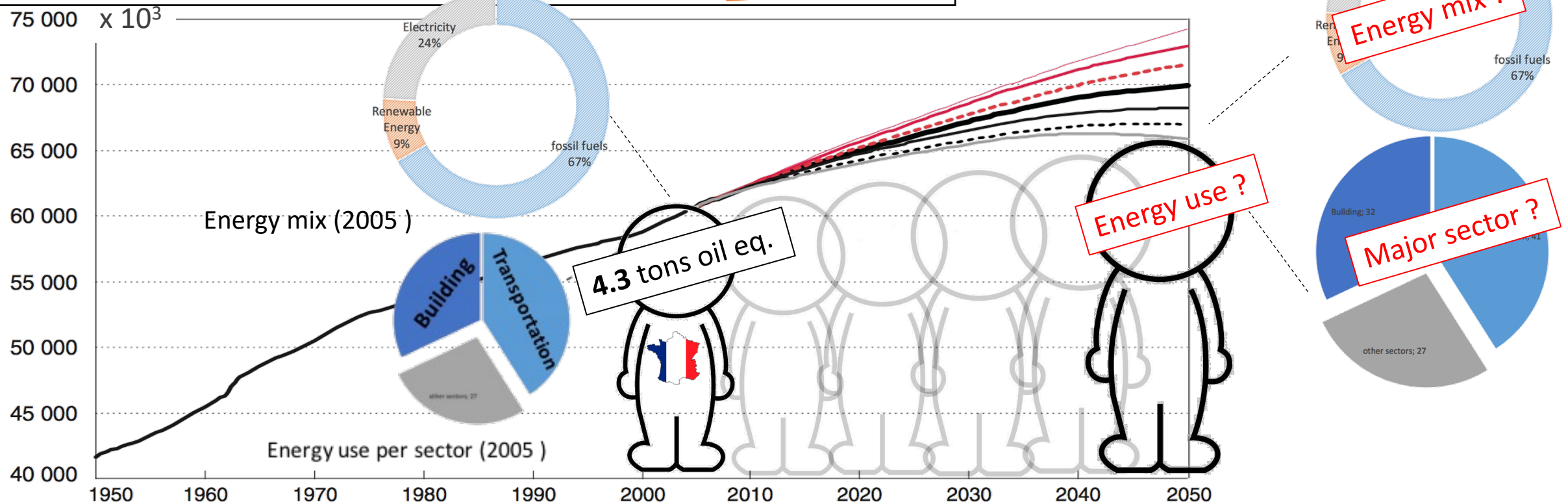
## Energy transition

- Global priority
- Environmental policies to reduce GHG and air pollutant emissions
- Limitations of abatement technologies (Internal combustion engine)

## Energy use in the future ?

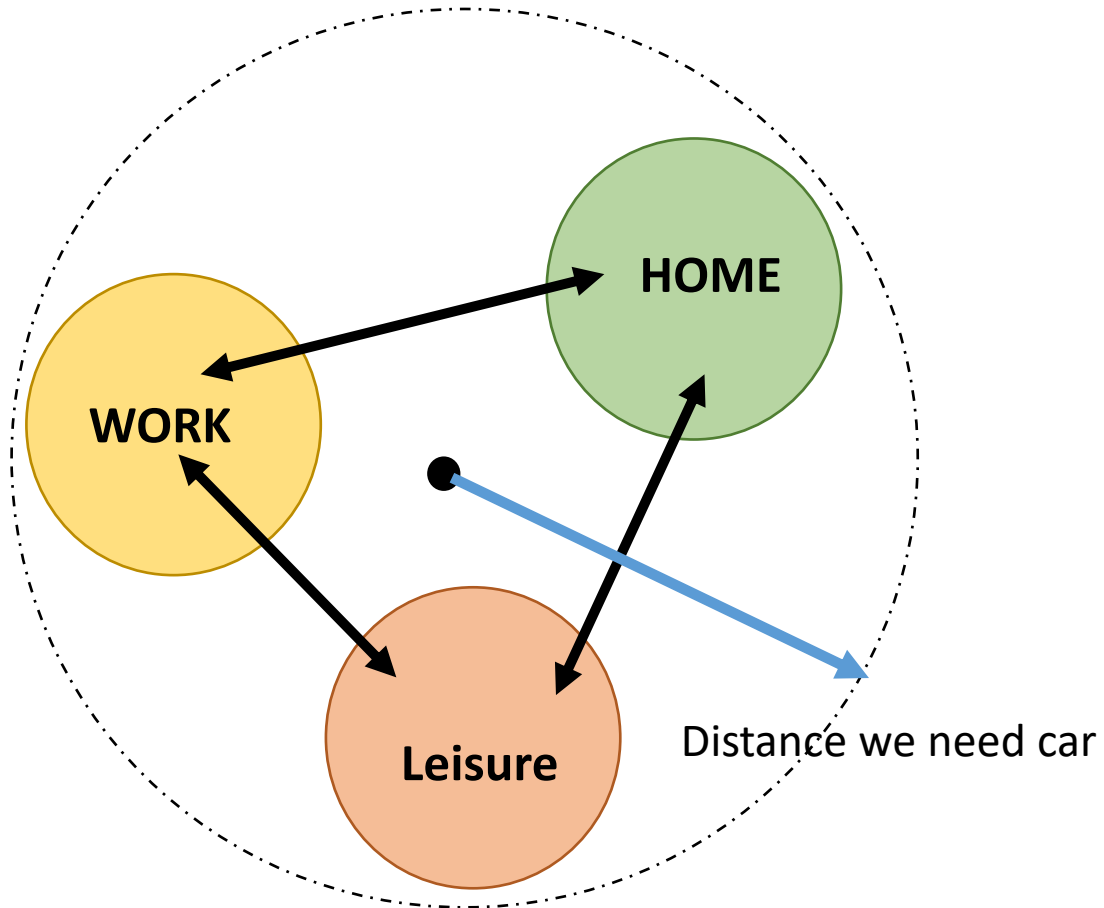
### New reflexions on reducing energy use (Urban planning)

Concept of the compact city



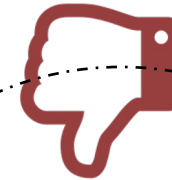
# Compact city

- ❑ High density urban settlement
- ❑ Proximity and mixity of services
- ❑ Reducing commuting distances



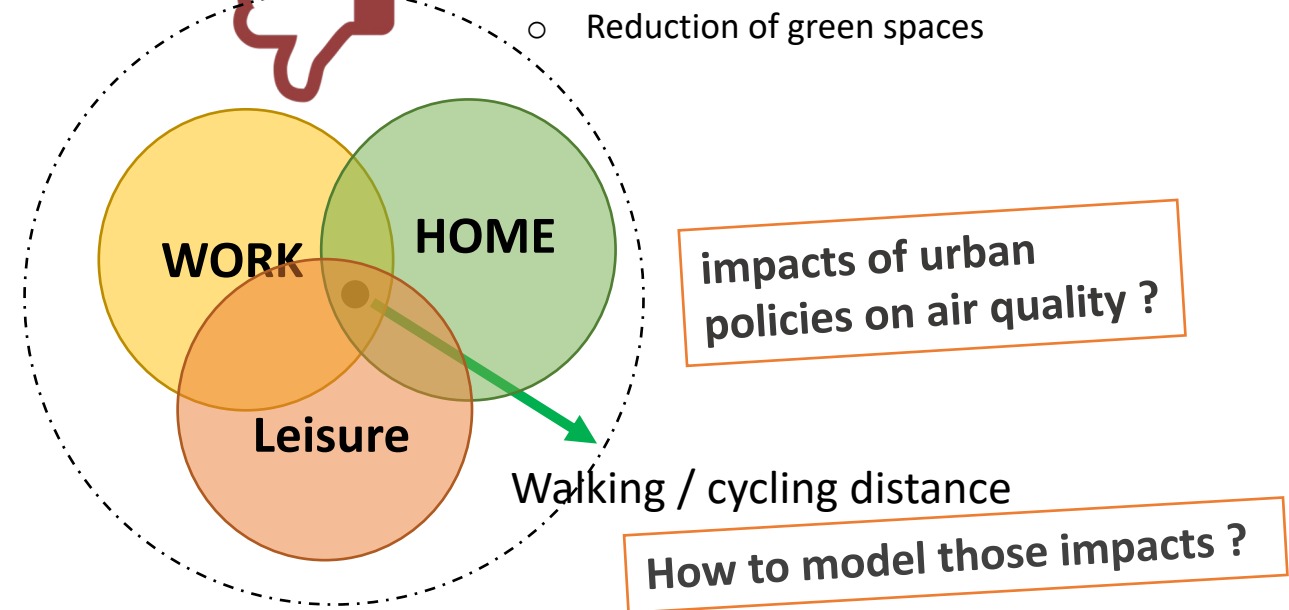
## Reduction of energy use/ GHG /air pollutant

- Organizing energy networks (heating, services)
- ↘ travel by car ↗ walking / cycling



## Reinforcing potential exposure to degraded air quality

- Increase in street canyon / traffic congestion
- Reduction of green spaces



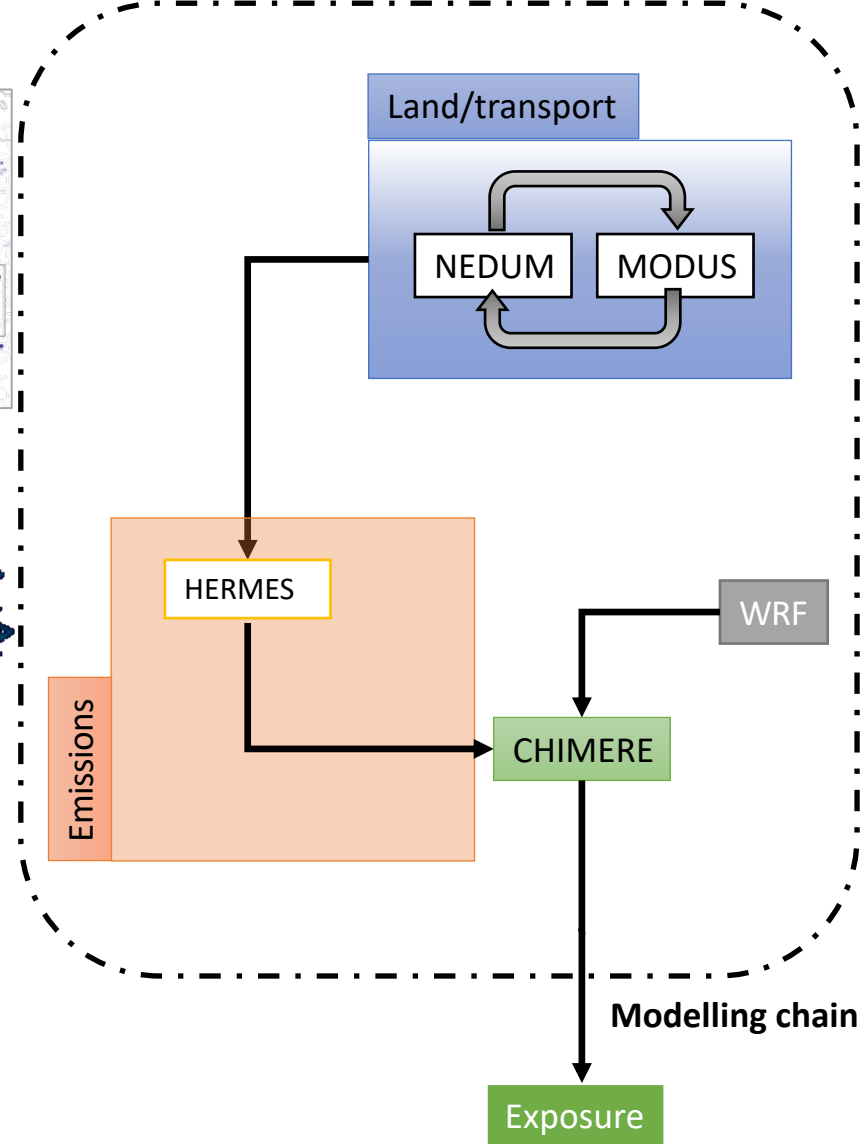
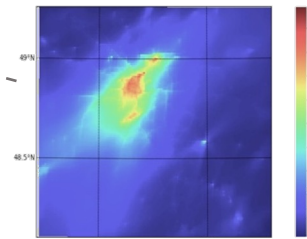
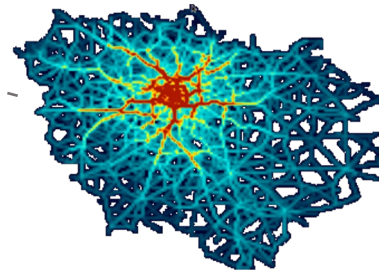
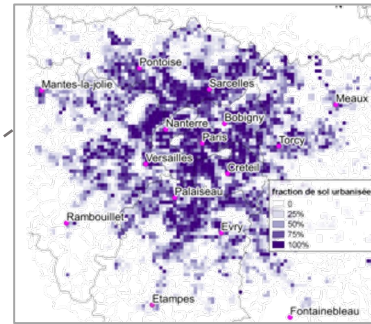
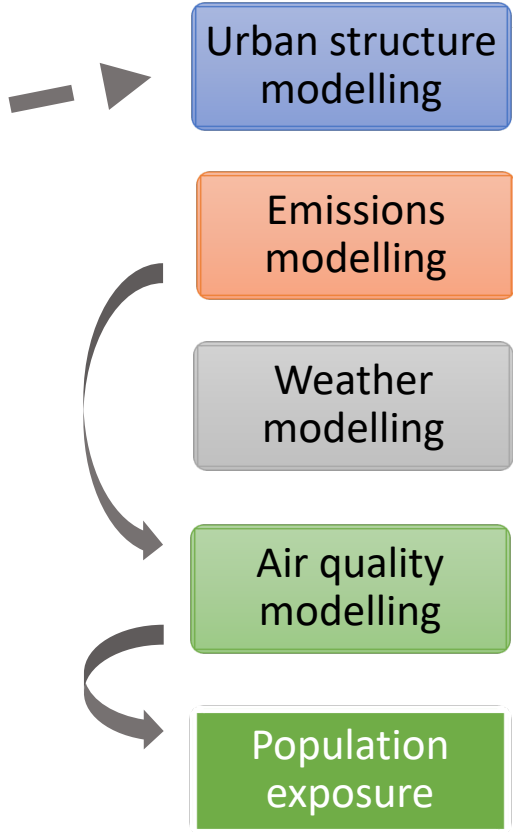
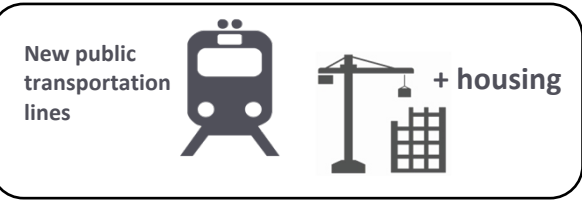
impacts of urban policies on air quality ?

How to model those impacts ?

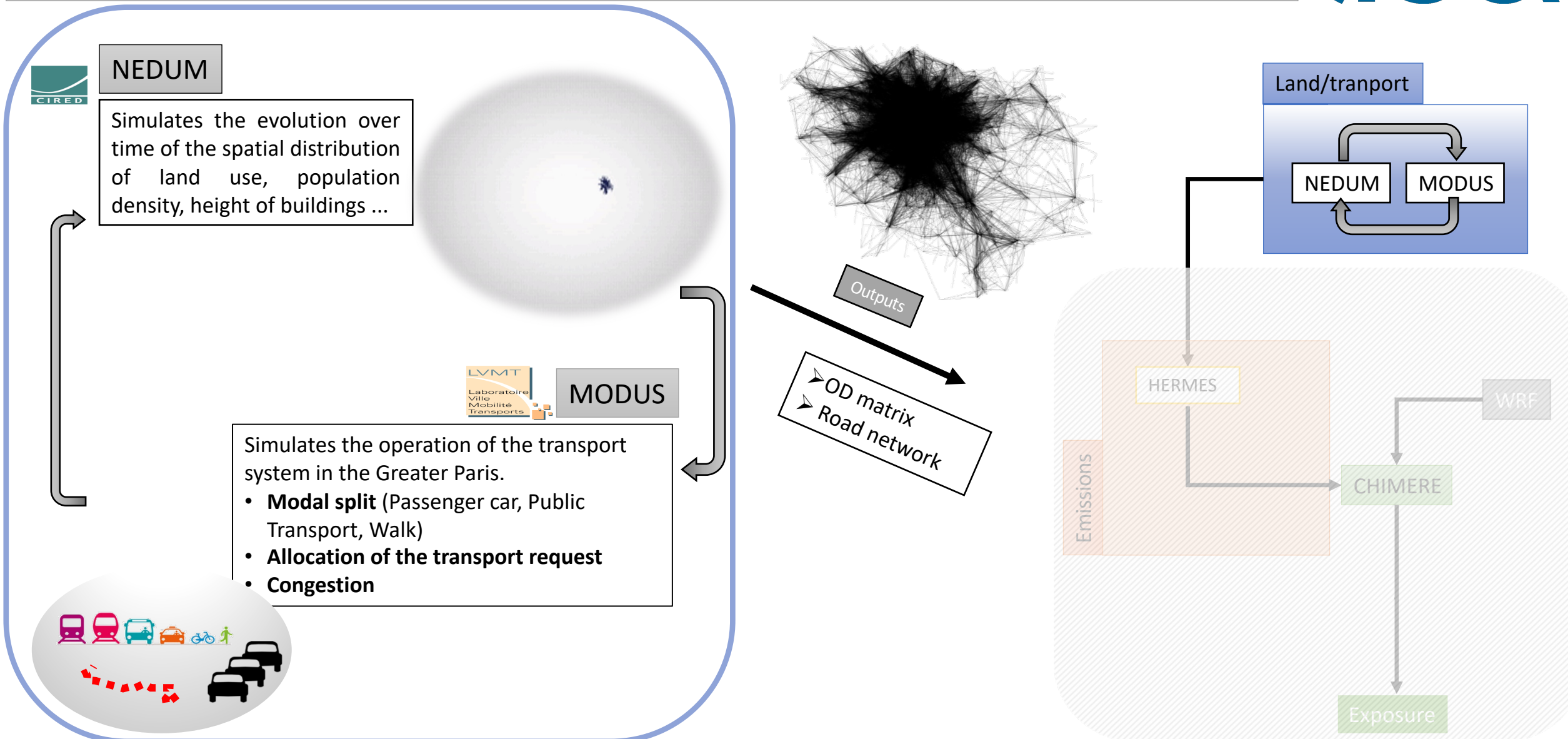
# Integrated modeling of the analysis of impacts of urban policies on air quality

- Diagnosis of future scenarios**
- Academics (Compact, sprawl cities)
  - Territorial planning schemes
- Taking into account the major determinants of the city**
- Economic / Energy / Housing / Transport / Health

## Urban policies



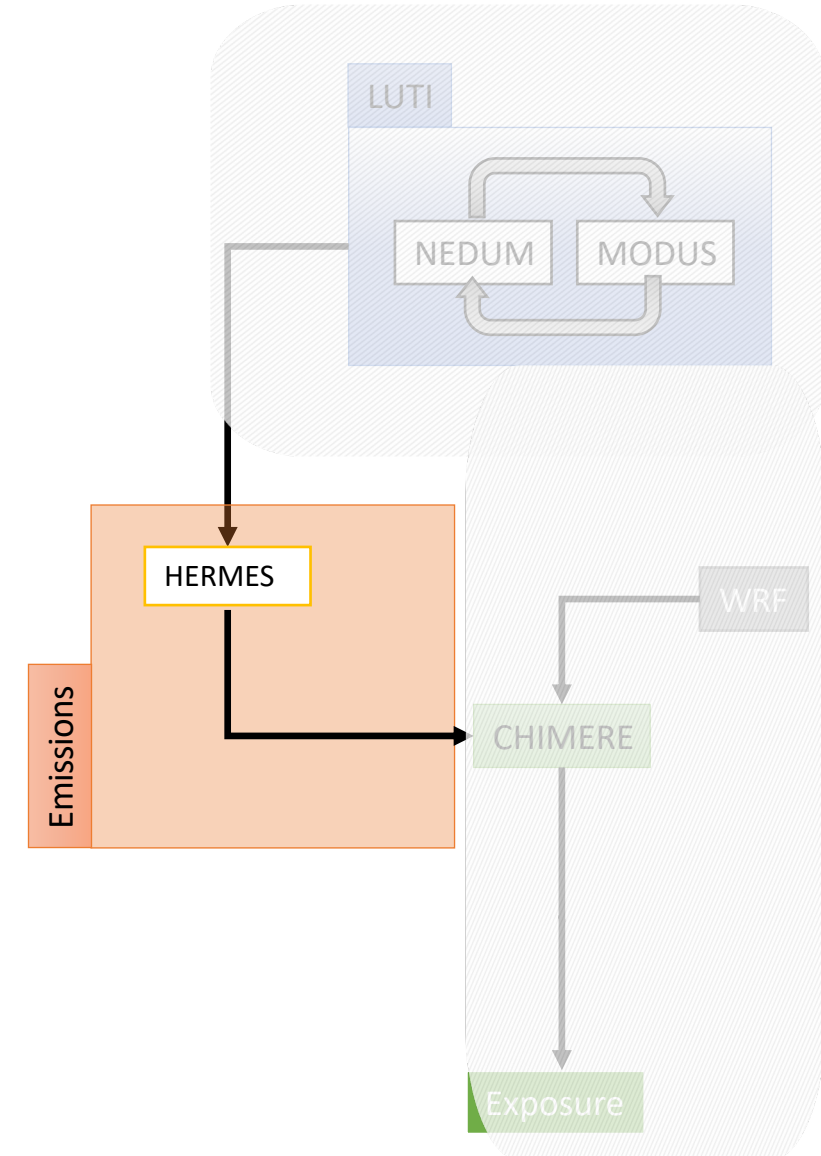
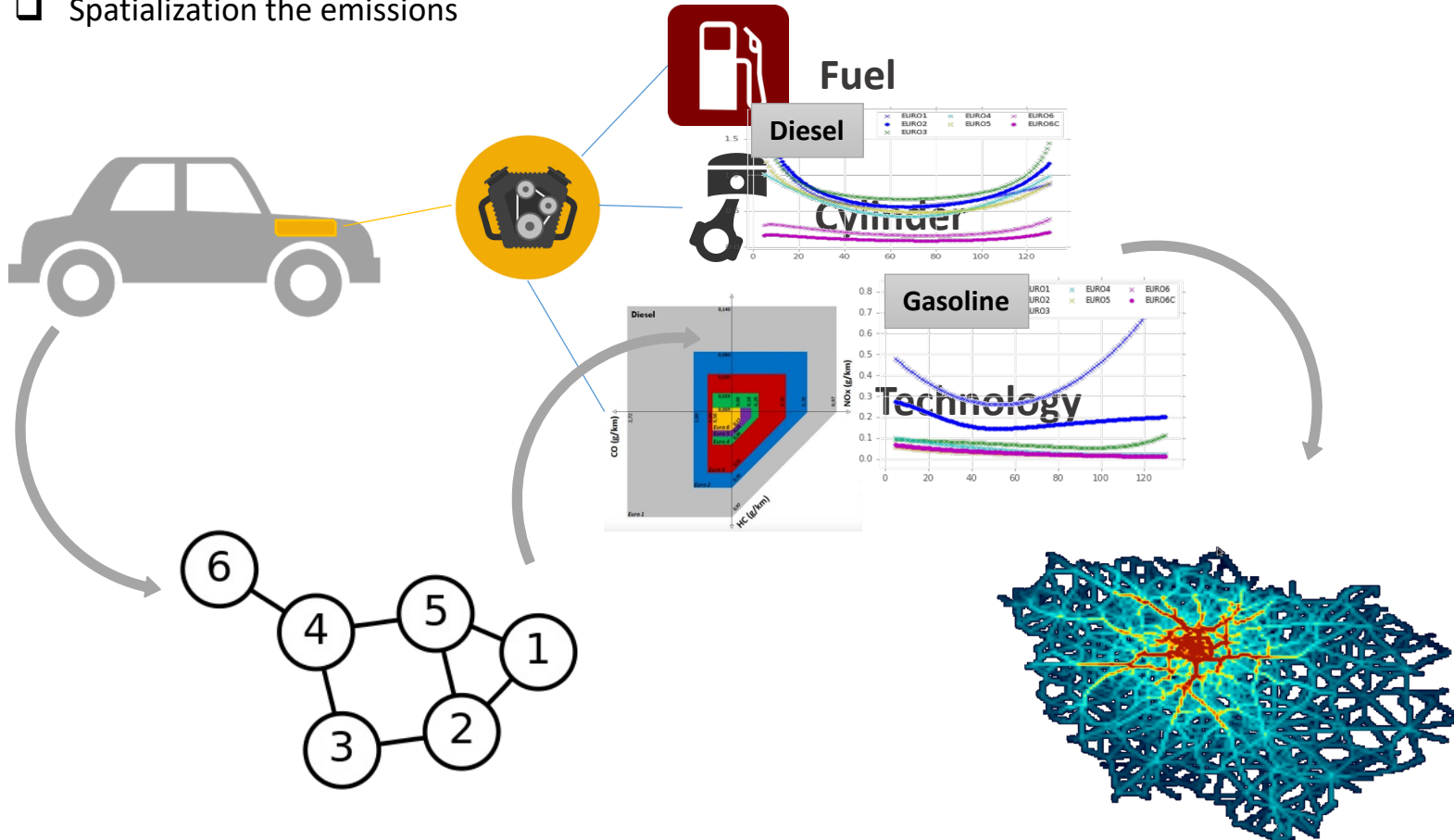
# The modeling chain : LandUse transport interaction model



# The modeling chain : HERMES

## Spatial modeling of individualized travel emissions

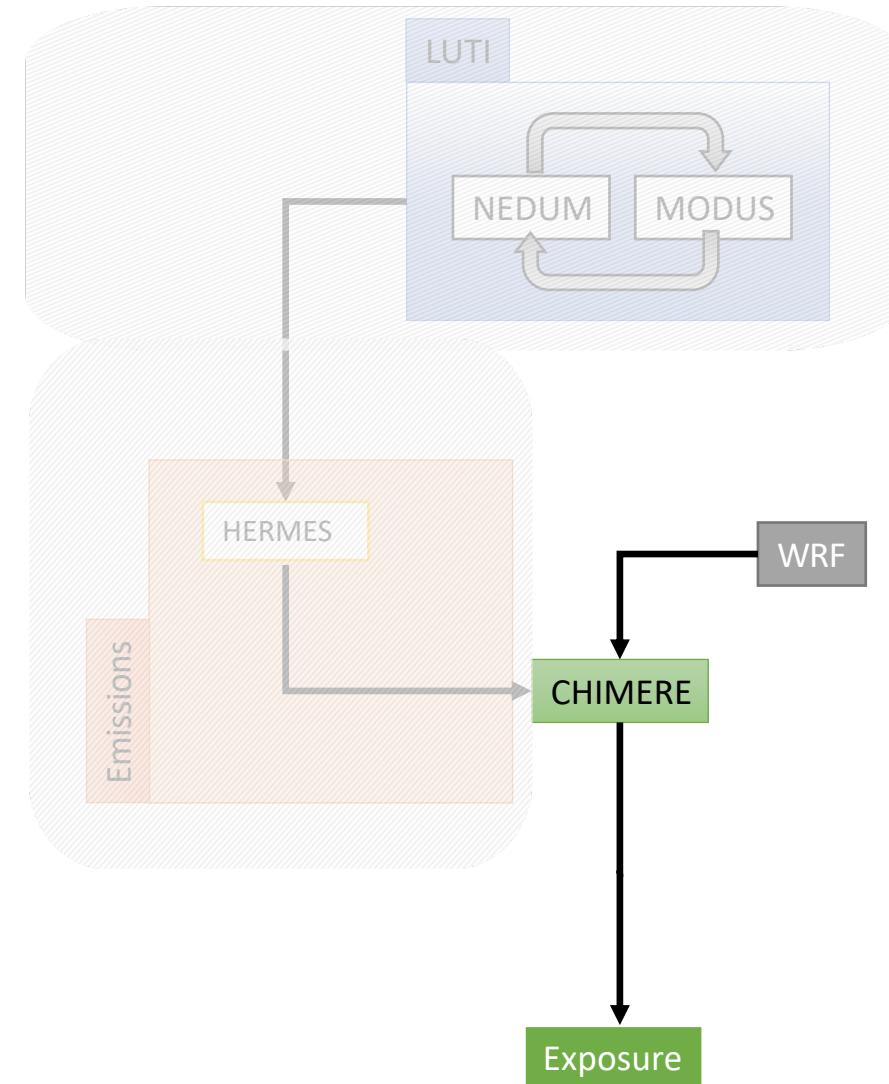
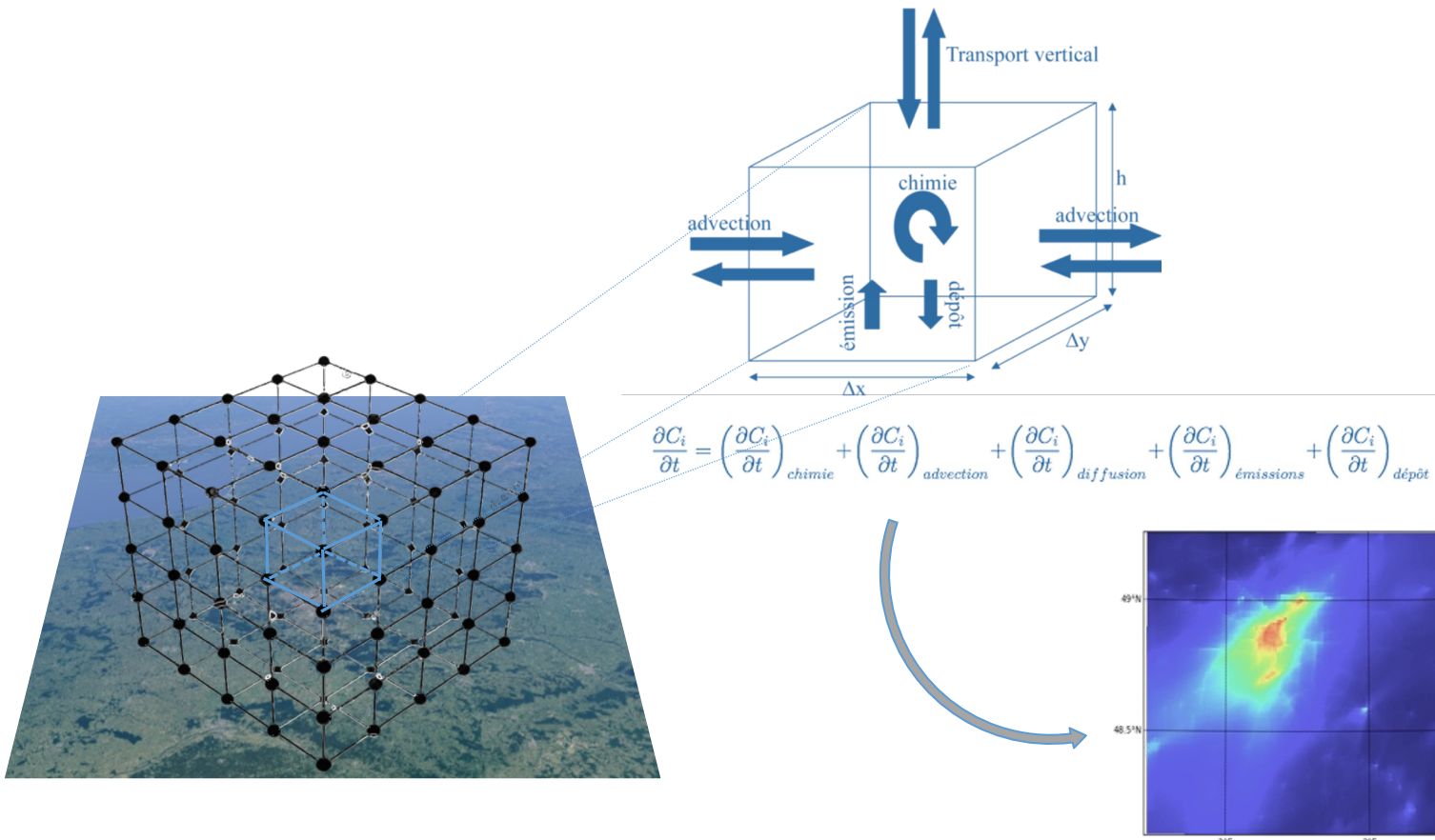
- ❑ Generation of car fleet
- ❑ Generation of the path (Dijkstra algorithm of shortest path – Graph theory)
- ❑ Calculate hot and cold start emissions NO<sub>x</sub>, NMVOC, CO, PM (COPERT methodology)
- ❑ Spatialization the emissions



# The modeling chain : CHIMERE

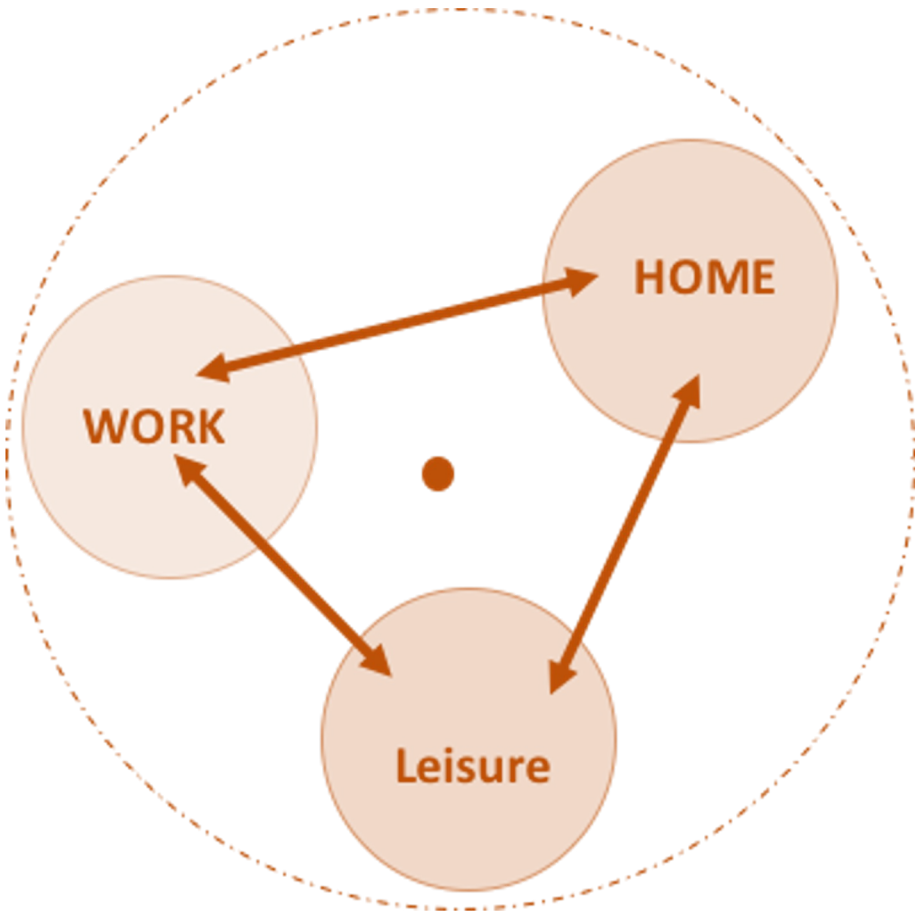
Eulerian off-line chemistry-transport model (CTM) chimere

- Calculate at each timestep  $\Delta C$  in each box
- Forecasting and analysis of air quality
- Driven by weather outputs WRF

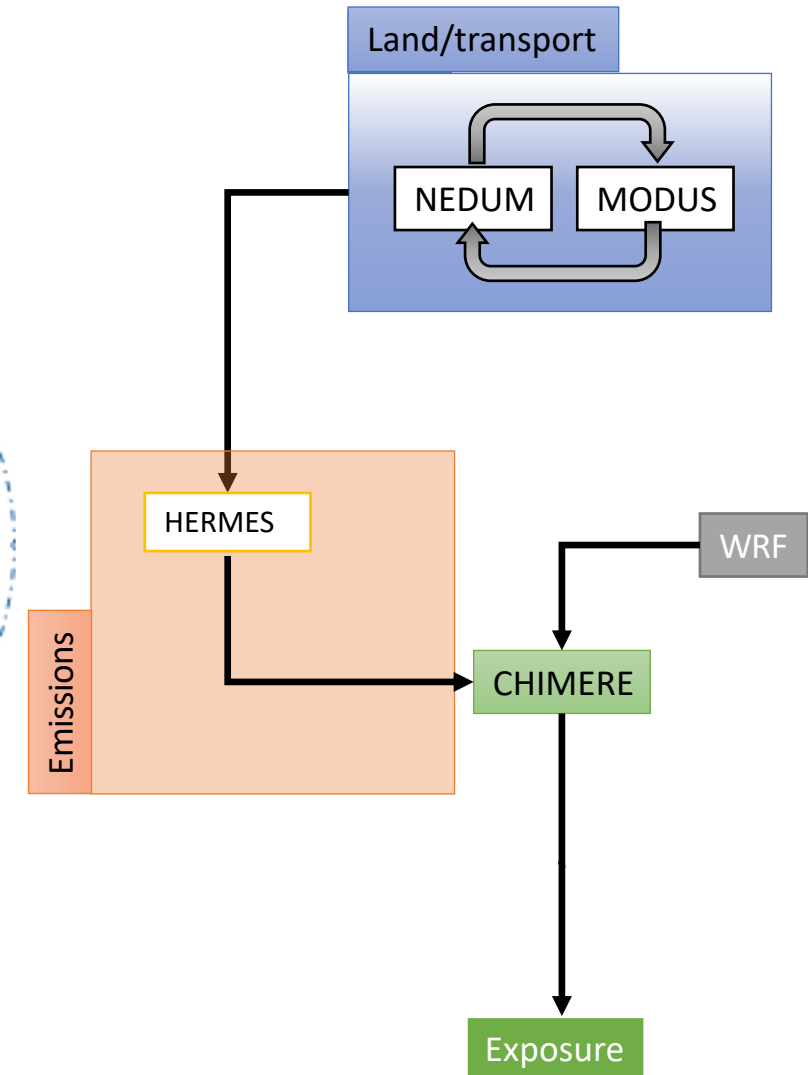
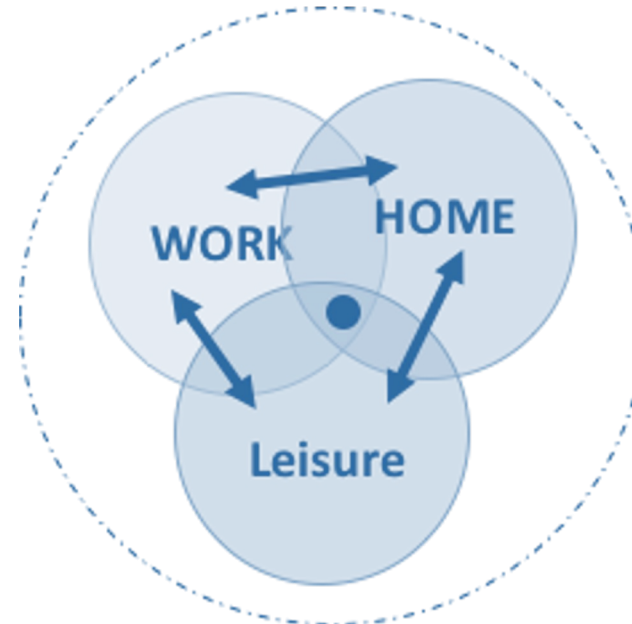


# Scenarios

## SPRAWL



## COMPACT





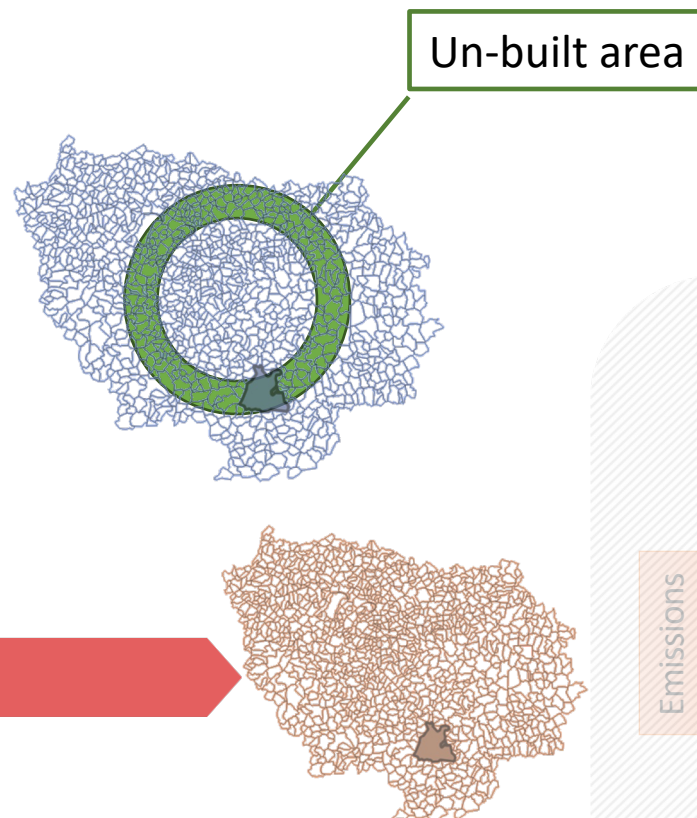
# Generation of land use scenarios

## Study on past urbanization

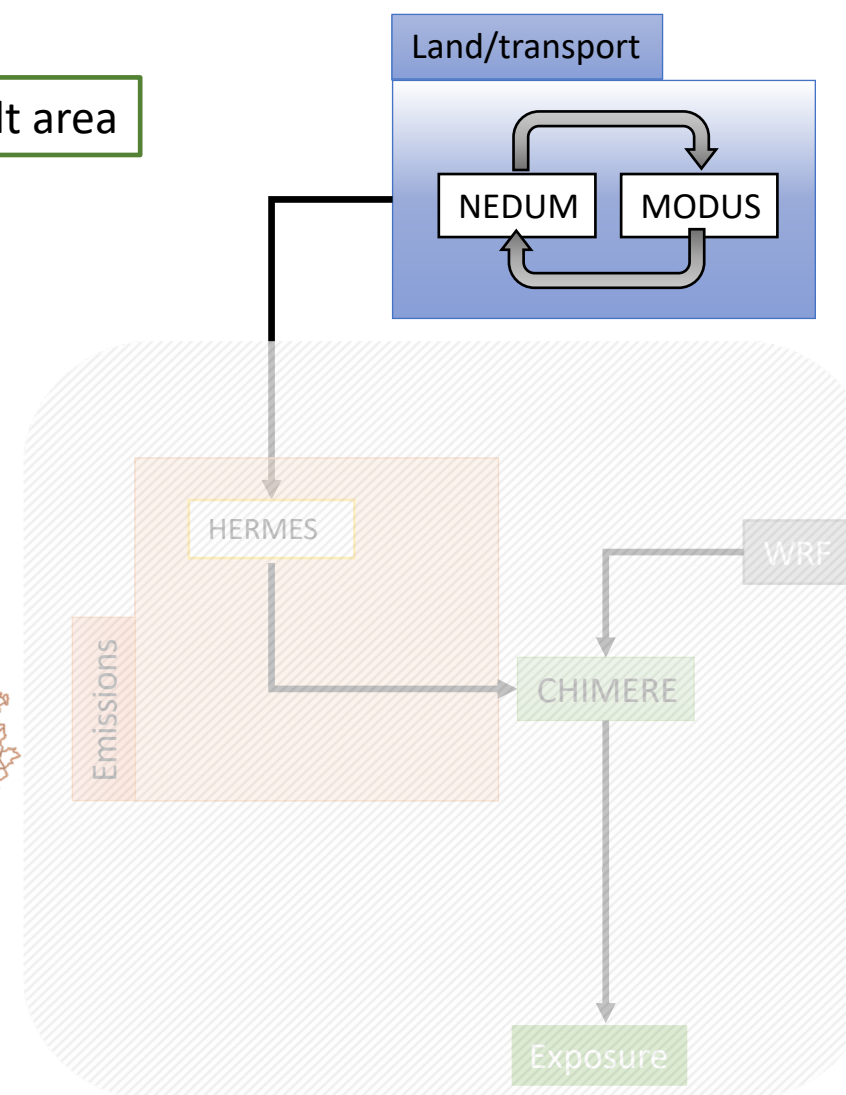
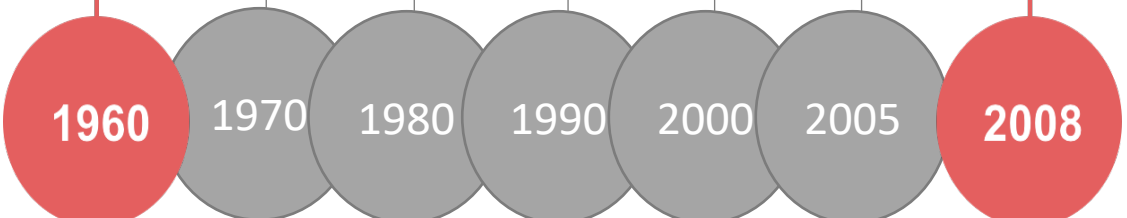
Reference situation in 1960 (On data census)

**Sprawl** city - Expansion of Paris with no specific constraint (LUTI)

**Compact** city - Expansion of Paris with a green-belt (LUTI)



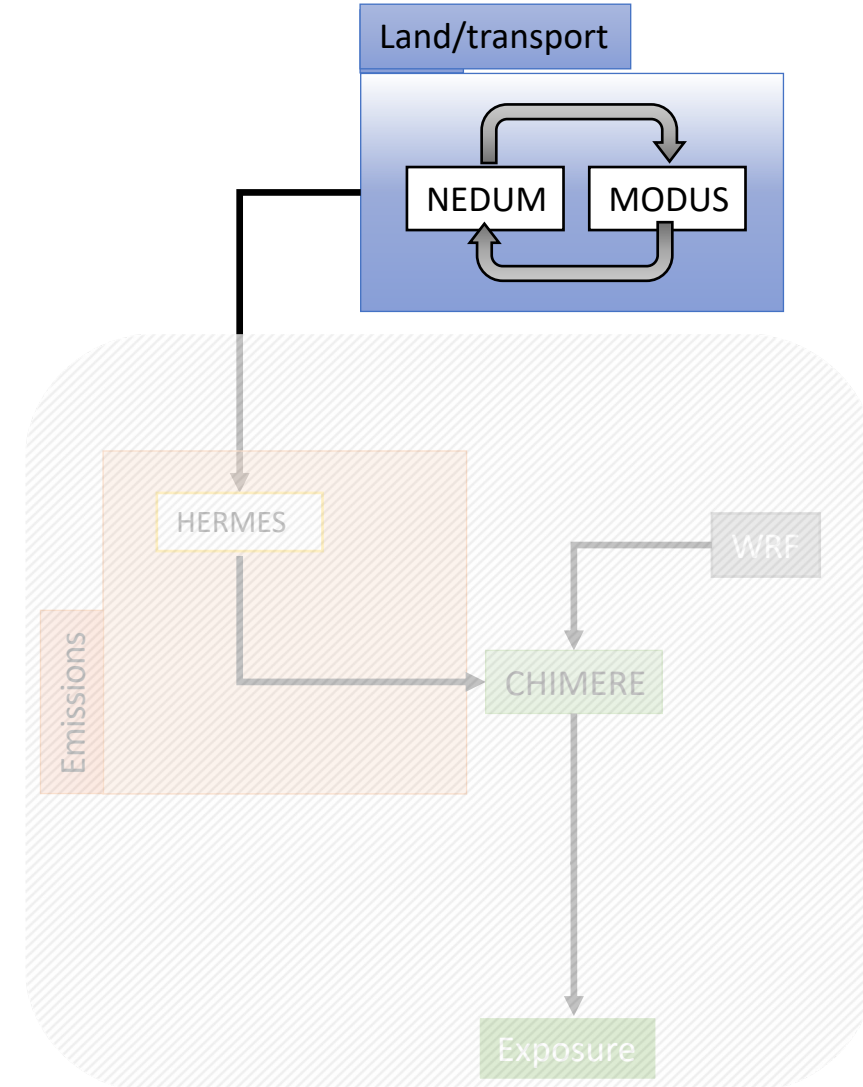
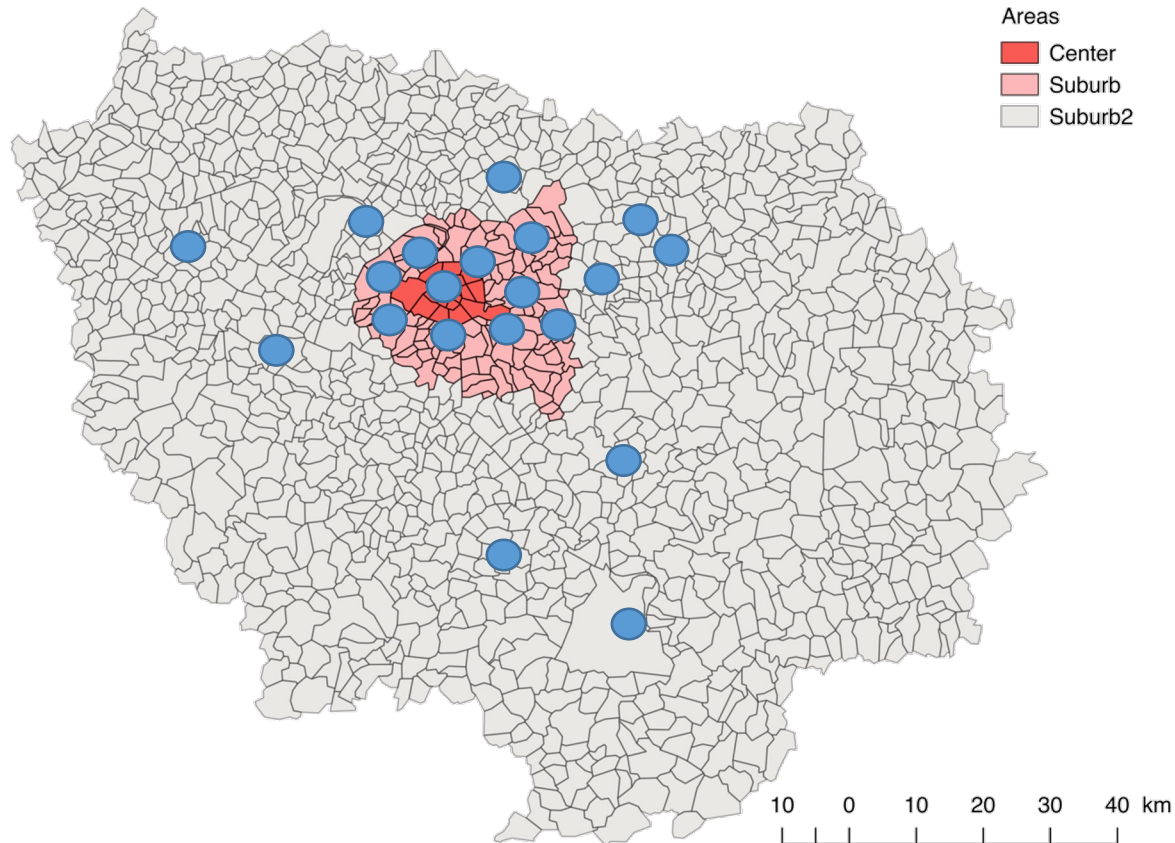
No constraints – scenario\_SPRAWL



# Scenarios parametrization

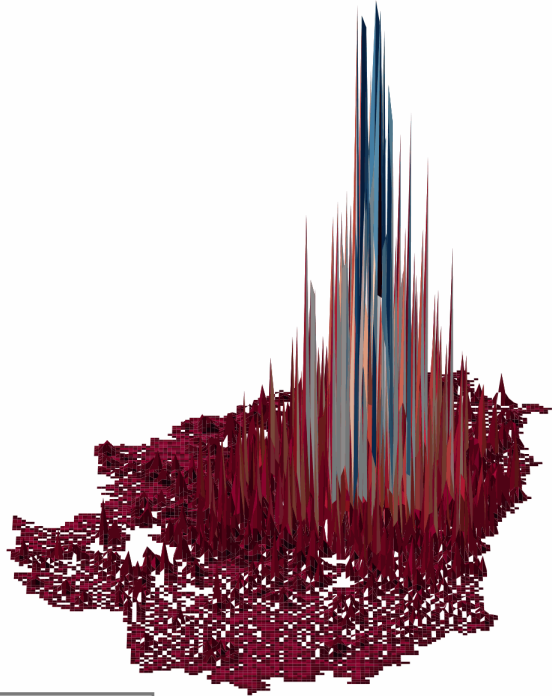
## Parameters fixed in time

- job centers location of 2008 ●
- Single average income per individual
- Transportation network of 2008
- No modal split

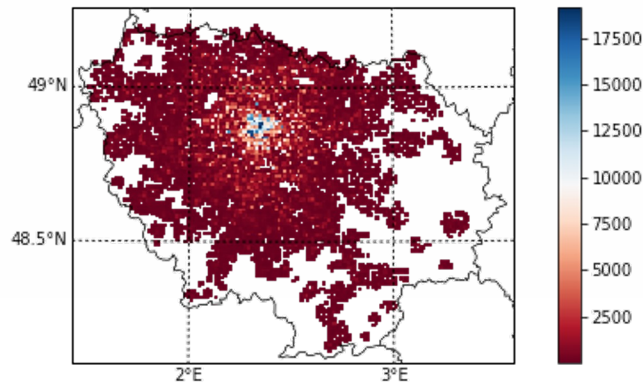


# Scenarios - Land-use transport outputs

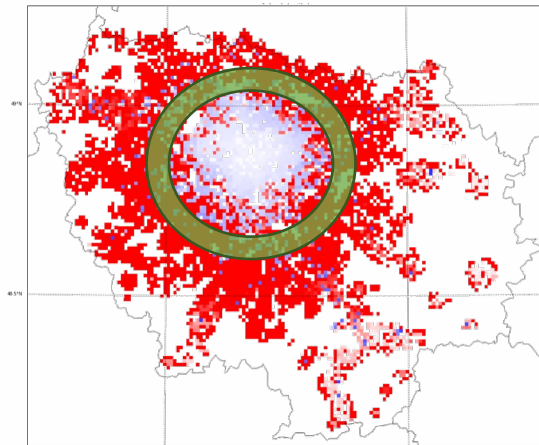
## households density



Scenario\_SPRAWL

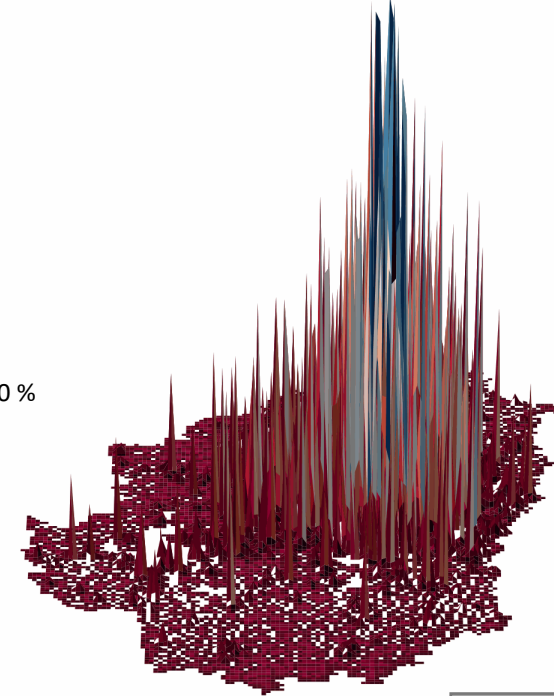
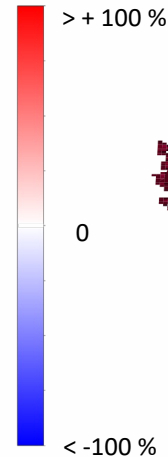


Number of households

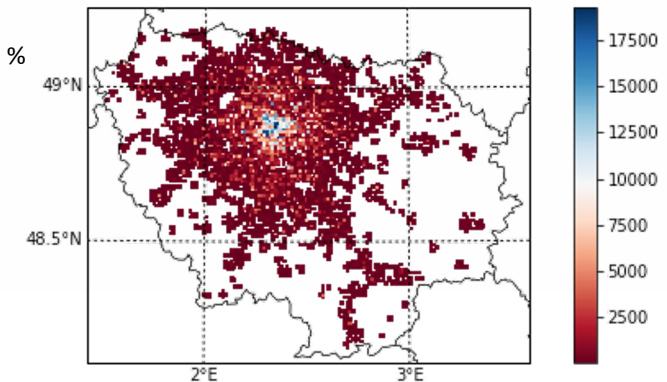


Absolute difference of households

**SPRAWL - COMPACT**



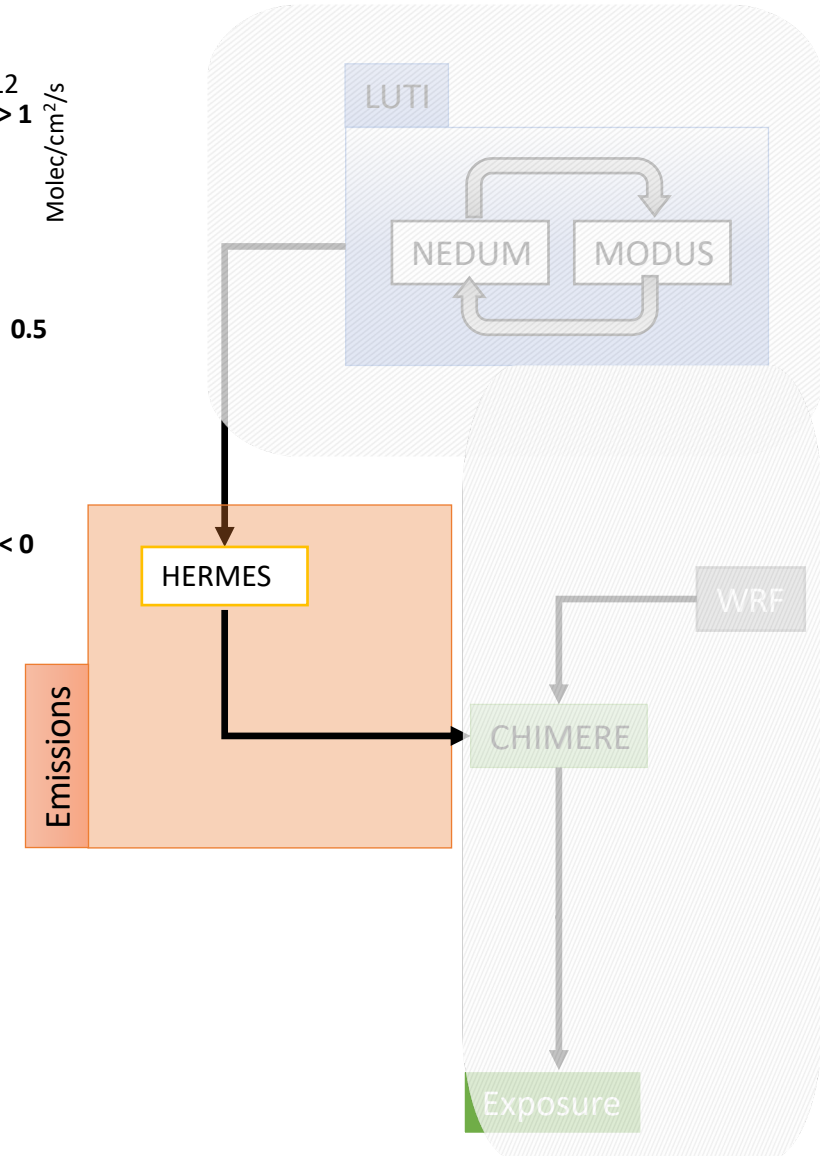
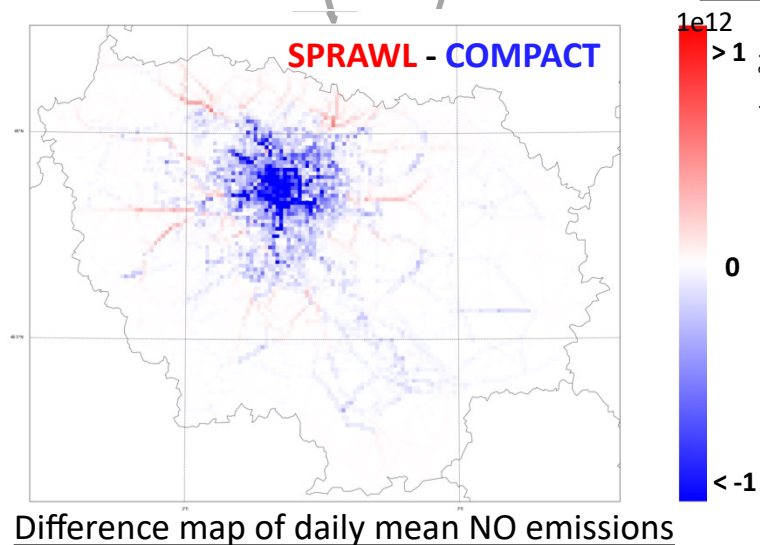
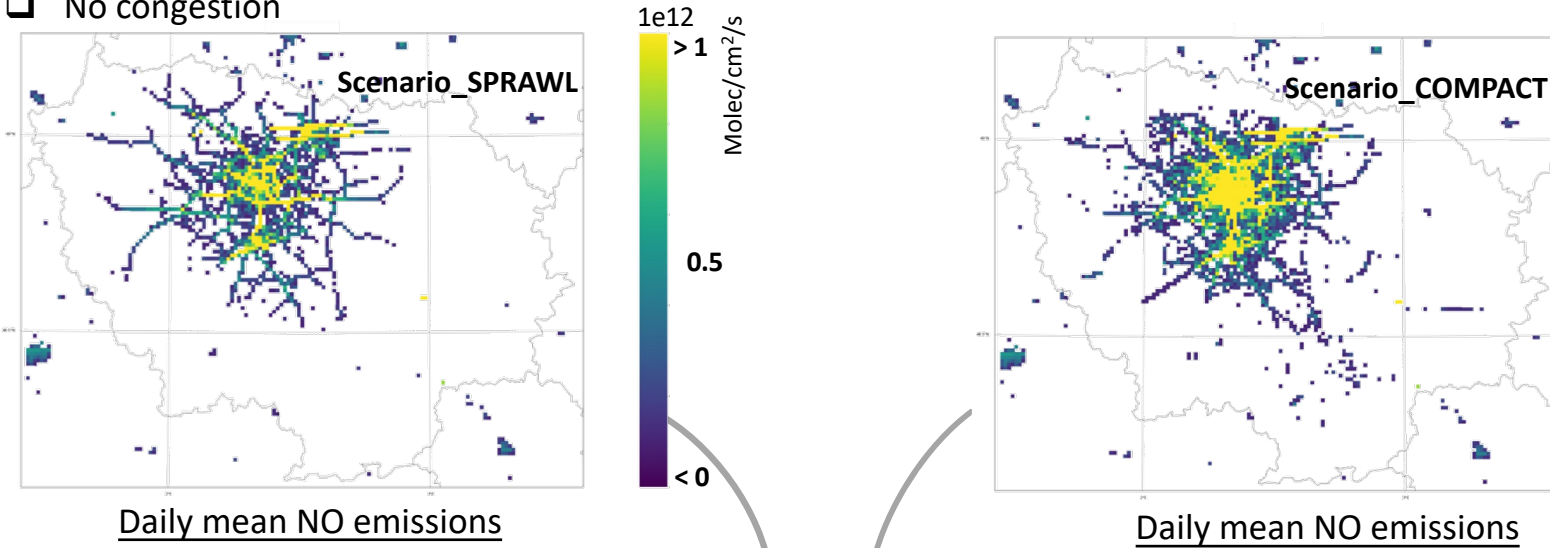
Scenario\_COMPACT



Number of households

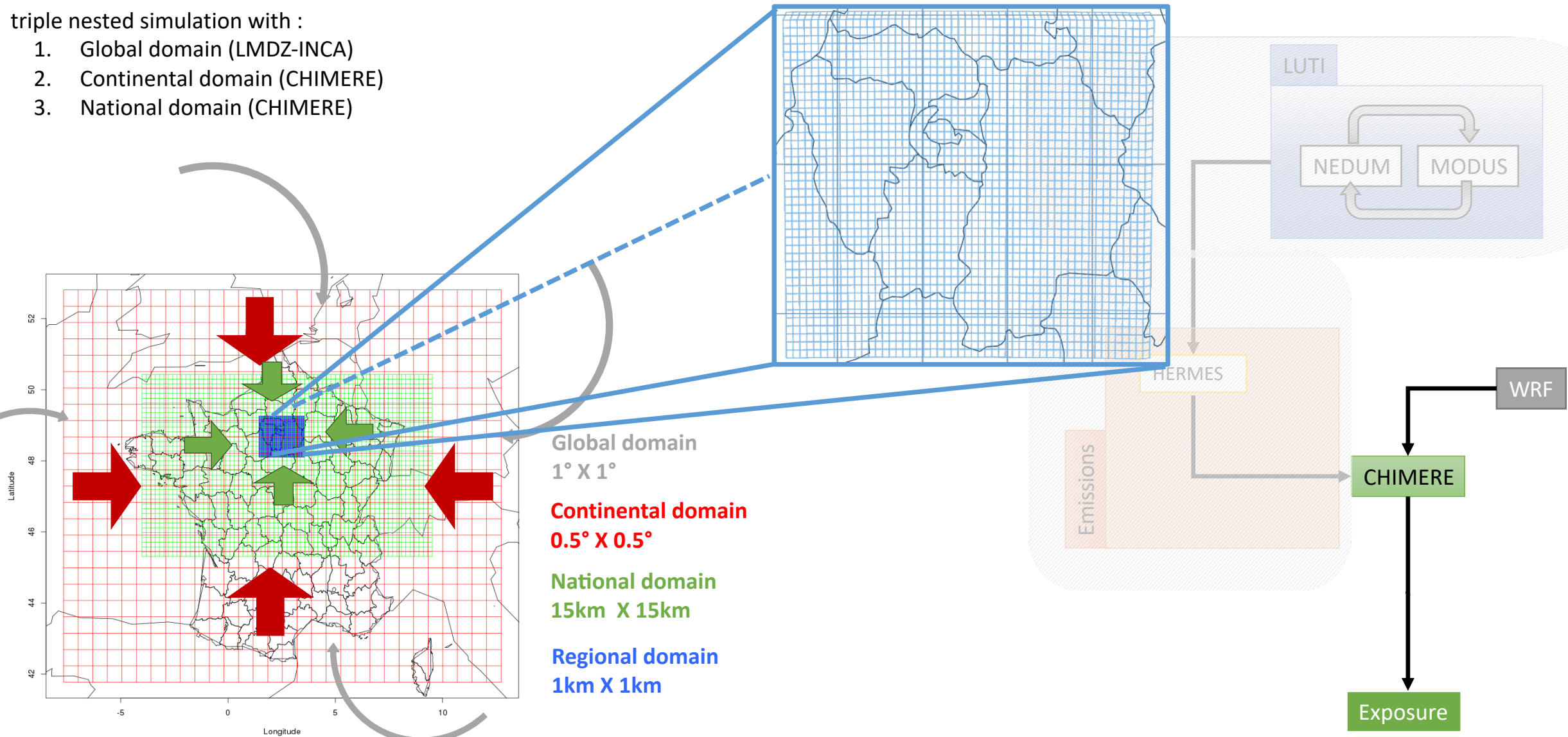
# Scenarios - Road emissions outputs

- Car fleet of 2008 (Census data)
- No congestion

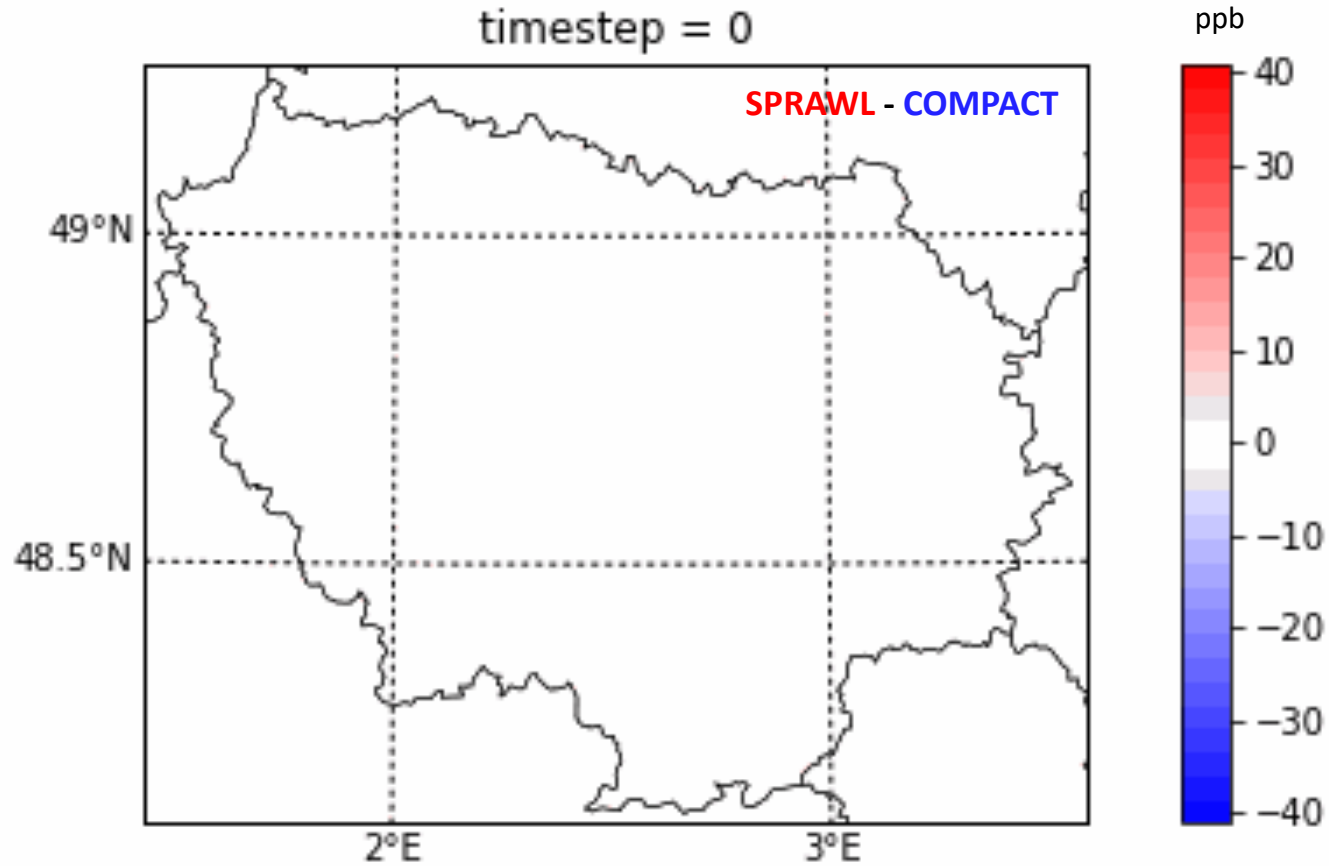


# Scenarios – CTM simulations

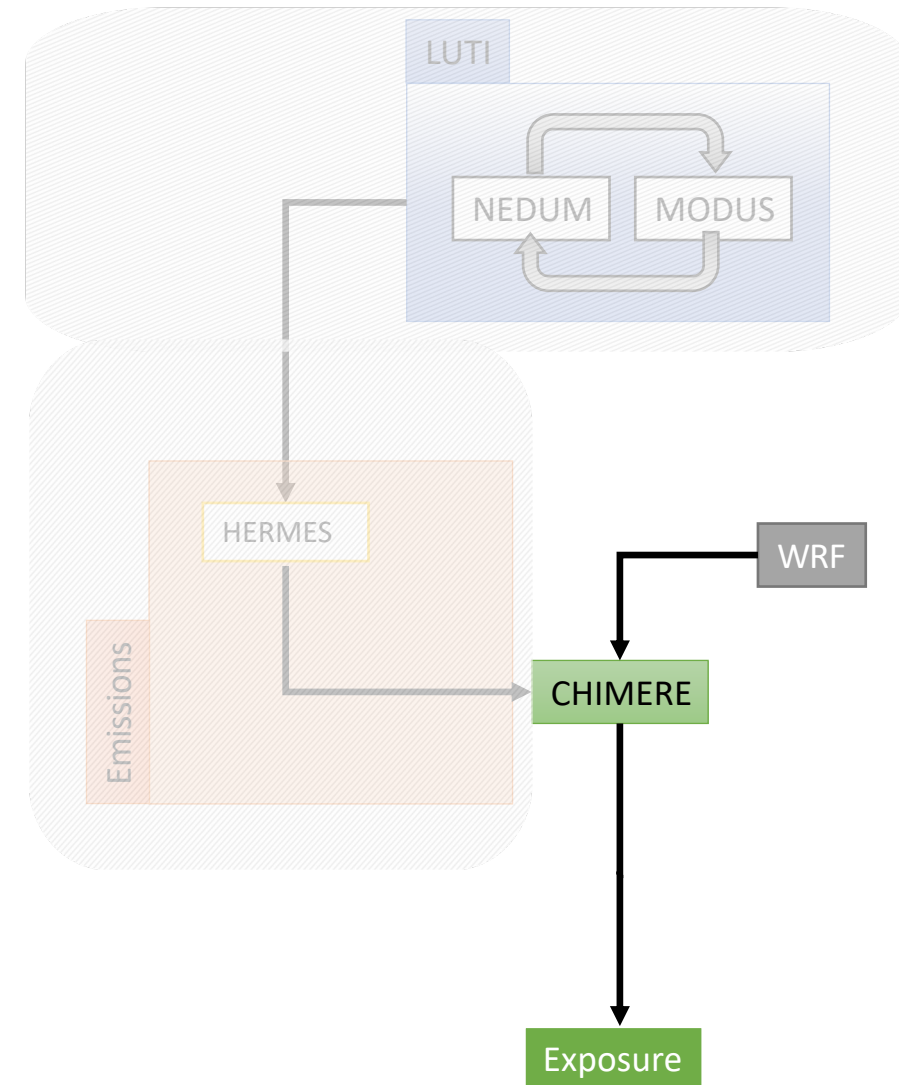
- ☐ triple nested simulation with :
  1. Global domain (LMDZ-INCA)
  2. Continental domain (CHIMERE)
  3. National domain (CHIMERE)



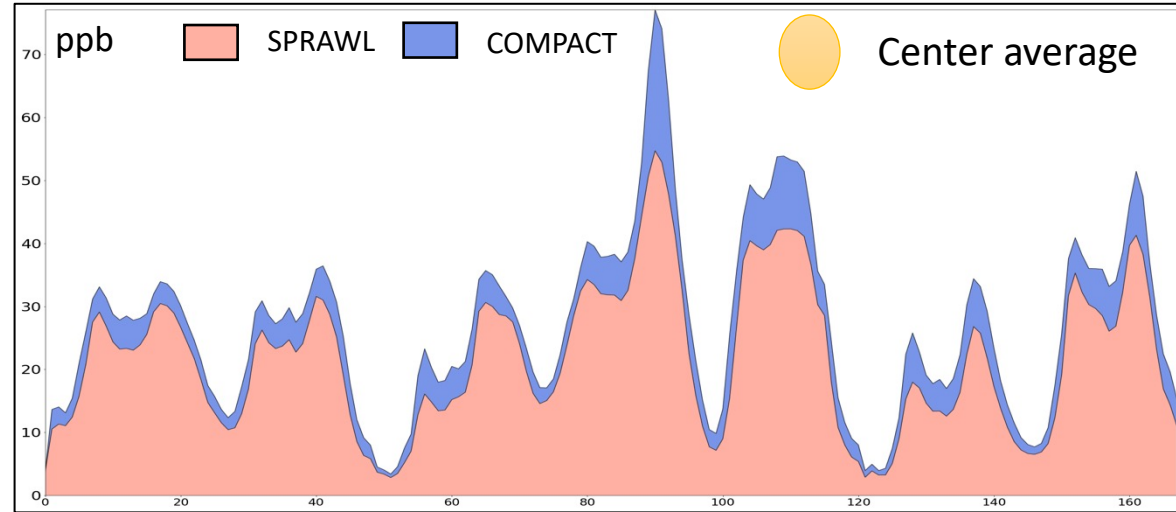
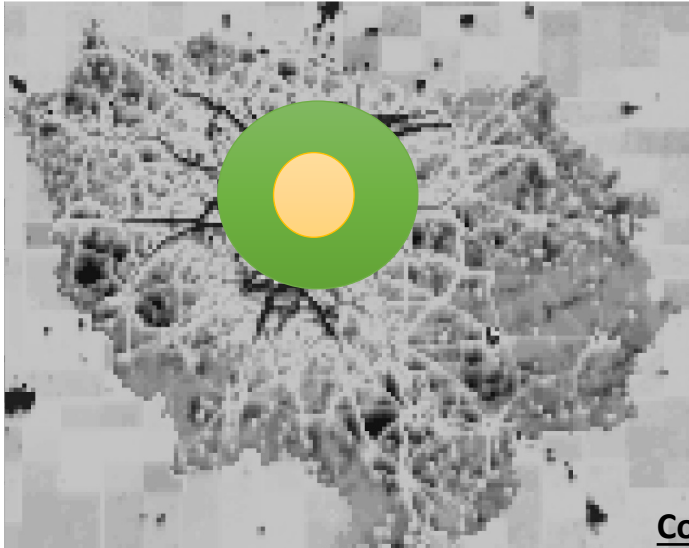
# Scenarios – CTM outputs



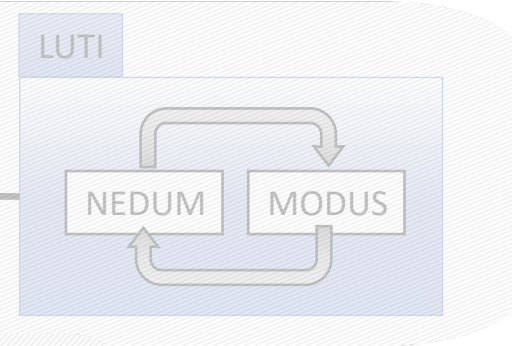
NO2 difference concentration



# Scenarios – CTM outputs time series

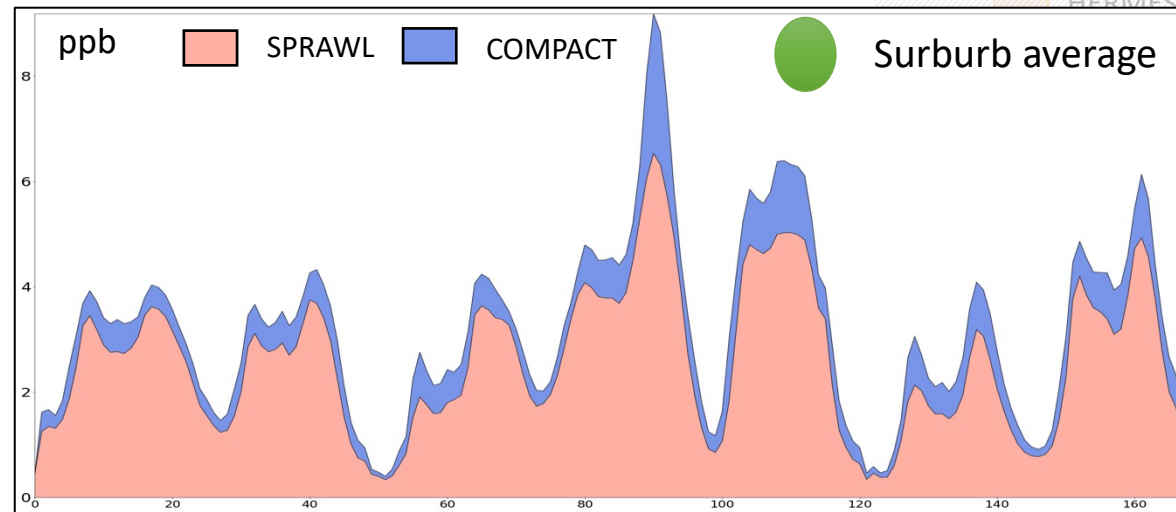


**Concentration of NO2 during a week (January 2009 - Average of all meshes in the center area)**

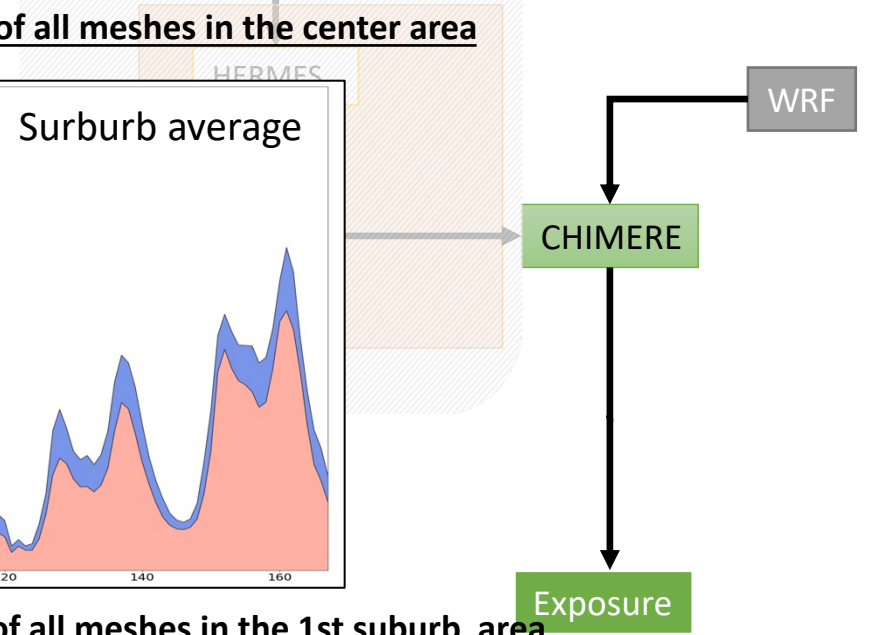


- Center zone
- Suburb zone

*concentration appears higher, in average, in the compact scenario (With the previous hypothesis)*



**Concentration of NO2 during a week (January 2009) - Average of all meshes in the 1st suburb area**



## Conclusion

- Operational modeling chain
- Sensibilité en terme de qualité de l'air
- In the center of the city, pollutants concentration appears higher, in average, in the compact scenario
- Simplified modeling of the city – Need to model modal split /households location

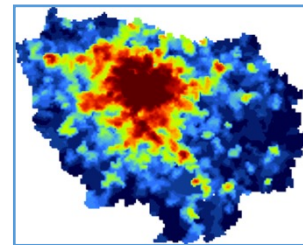
## Ongoing

### HERMES implementations

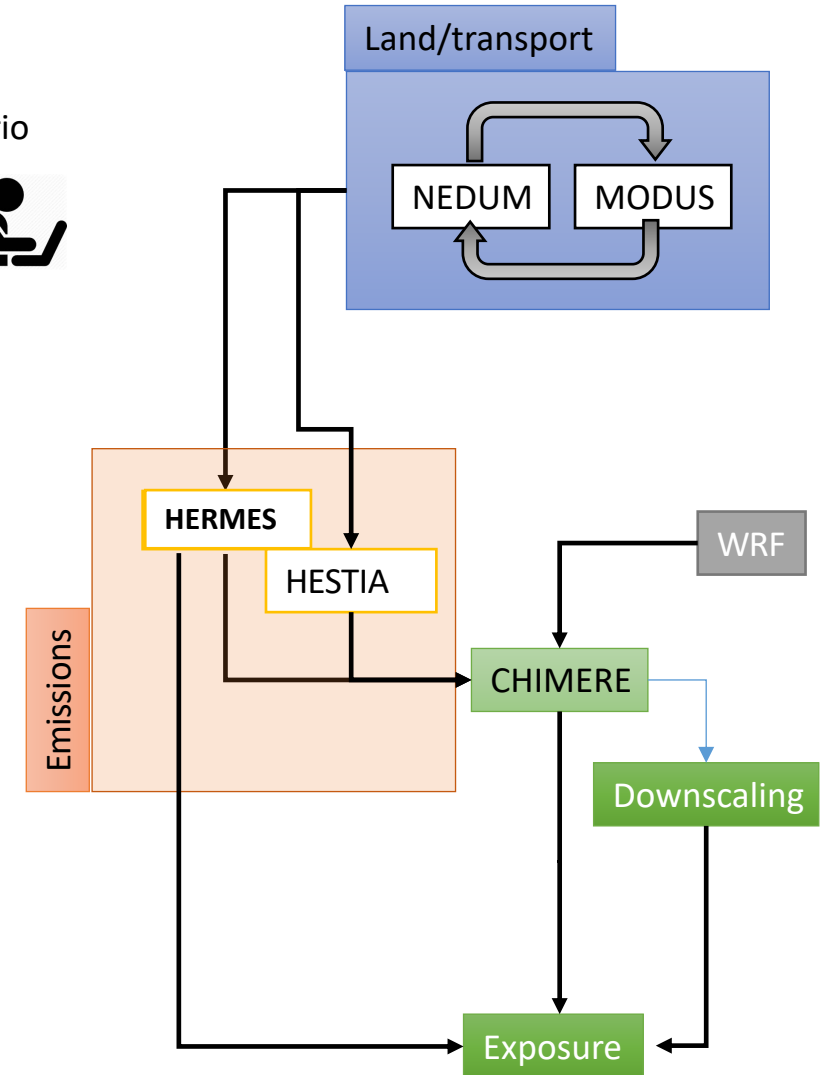
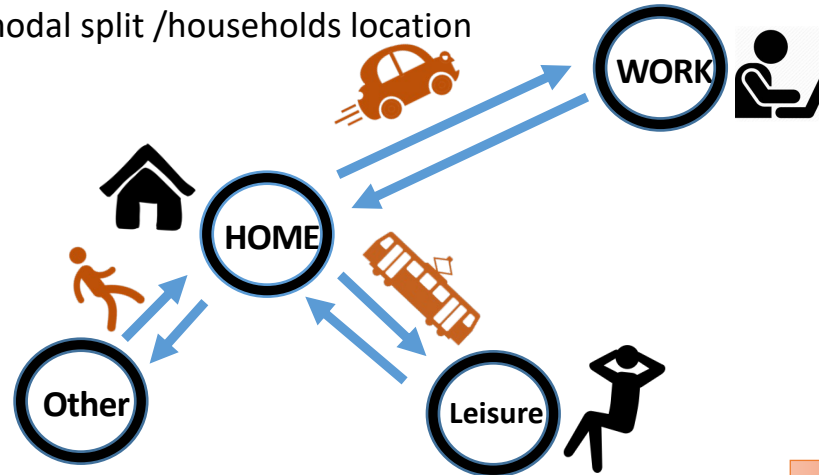
- Generation of a synthetic population
- Generation of population time schedule
- Taking account of the modal split

### HESTIA

- Modeling commercial and residential combustion emissions
  - Generation of spatialize energy consumption
  - Distribution of energy type (fossil fuel, electricity ...)
  - Modeling emissions



Energy consumption per m<sup>2</sup>



## Individual exposure

- Time geography exposure (Work in progress...)