Analysis and comparison of two models response to an emissions abatement scenario

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The “Air 2030 project”

A prospective study

A contribution to the assessment of an ambitious **energy scenario** proposed by the French Environment and Energy Management Agency (ADEME) for the time horizon of 2030.

focused on air quality issues...

keep in mind GHG emissions.

Air quality and environmental impact

The regulated air pollutants targeted in this study:

- **fine particles** \((\text{PM}_{2.5})\)
- **nitrogen dioxide** \((\text{NO}_2)\)
- **ozone** \((\text{O}_3)\)

but other species and deposition fluxes could be investigated.
The “Air 2030 project”

Nantes
- City inhabitants: 280,000
- Density: 4,350 / km²
- Urban area inhabitants: 580,000
- Density: 1,100 / km²

Paris
- City inhabitants: 2,234,000
- Density: 21,200 / km²
- Urban area inhabitants: 10,413,000
- Density: 3,700 / km²

Strasbourg
- City inhabitants: 270,000
- Density: 3,500 / km²
- Urban area inhabitants: 440,000
- Density: 2,000 / km²
Air quality simulation

Two “state-of-the-art” Chemistry Transport Model

POLYPHEMUS  http://cerea.enpc.fr/polyphemus/
Chimere  http://www.lmd.polytechnique.fr/chimere/

Spatial resolution

“Europe”  ~ 60 km × 60 km
“France”  ~ 15 km × 15 km
Pays de Loire  ~ 5 km × 5 km
Île de France  ~ 3 km × 3 km
Alsace  ~ 3 km × 3 km
Nantes  ~ 1 km × 1 km
Paris  ~ 1 km × 1 km
Strasbourg  ~ 1 km × 1 km

Data provided to the CTM

• Meteorology from WRF model simulations (NCEP)
• Boundary conditions from global models LMDzT-INCA or MOZART
Emission inventories

Continental and regional inventories

Provided by organisations in charge of air quality monitoring:

- “EMEP” - Europe with a 50 km × 50 km horizontal resolution.
- “Air Pays De Loire” - Pays de Loire with a 0.5 km × 0.5 km horizontal resolution.
- “Airparif” - Île de France with a 1 km × 1 km horizontal resolution.
- “Aspa” - Alsace with a 1 km × 1 km horizontal resolution.

Emissions projection for France

The emissions changes were assessed at national scale for SNAP sectors and/or sub-sectors by the Interprofessional Technical Centre for Studies on Air Pollution (CITEPA) in collaboration with ADEME.
Emission inventories

Nantes - Pays de Loire

Paris - Île de France

Strasbourg - Alsace
Example for the PM$_{2.5}$ concentrations

Average over the year of hourly concentrations ($\mu g\, m^{-3}$).
Example for the NO$_2$ concentrations

Mean over a winter period of hourly concentrations ($\mu$g m$^{-3}$).

Maximum over a winter period of hourly concentrations ($\mu$g m$^{-3}$).
Example of evaluation against “BDQA” observations

Comparison to daily observations ($\mu g \text{ m}^{-3}$) over 2009.

<table>
<thead>
<tr>
<th></th>
<th>Nº stations</th>
<th>Observation</th>
<th>Simulation</th>
<th>RMSE</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No stations</td>
<td>4</td>
<td>19.7</td>
<td>21.8</td>
<td>11.0</td>
<td>60.3%</td>
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</tbody>
</table>

Beyond 20 $\mu g \text{ m}^{-3}$ in Paris!

Comparison to hourly observations ($\mu g \text{ m}^{-3}$) over 2009.

<table>
<thead>
<tr>
<th></th>
<th>Nº stations</th>
<th>Observation</th>
<th>Simulation</th>
<th>RMSE</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
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<td>31.4</td>
<td>26.0</td>
<td>17.0</td>
<td>65.2%</td>
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Beyond 40 $\mu g \text{ m}^{-3}$ in Paris!
Impact of the ADEME energy scenario on the emissions

Base emissions

ADEME scenario

Pays de Loire
- NMVOC: -26%
- PM$_{2.5}$: -39%
- NOx: -69%

Île de France
- NMVOC: -32%
- PM$_{2.5}$: -55%
- NOx: -57%

Alsace
- NMVOC: -36%
- PM$_{2.5}$: -55%
- NOx: -68%
Simulated evolution of NO$_2$ concentrations (µg m$^{-3}$) over a winter period (15 January - 15 February).

Average $\Delta$ over the domain:
-6.9 µg m$^{-3}$

“Minimum” : -4.0 µg m$^{-3}$
“Maximum” : -20.8 µg m$^{-3}$

Average %$\Delta$ over the domain:
-49%

“Minimum” : -19%
“Maximum” : -57%
Impact of the ADEME energy scenario on the air quality: NO$_2$

**REFERENCE**

Maximum over a winter period of hourly concentrations ($\mu$g m$^{-3}$).

**ADEME SCENARIO**
Impact of the ADEME energy scenario on the air quality: PM$_{2.5}$

Simulated evolution of PM$_{2.5}$ concentrations over the year.

Average $\Delta$ over the domain: 
-3.6 $\mu$g m$^{-3}$

“Minimum”: -2.9 $\mu$g m$^{-3}$
“Maximum”: -9.3 $\mu$g m$^{-3}$

Average $\%\Delta$ over the domain: 
-24%

“Minimum”: -19%
“Maximum”: -38%
Comparison to the other regions: PM$_{2.5}$

**Pays de Loire**
Average $\Delta$ over the domain:
-2.4 $\mu$g m$^{-3}$
Contribution of natural source (sea-salt).

**Alsace**
Average $\Delta$ over the domain:
-3.5 $\mu$g m$^{-3}$
Contribution of other areas in the vicinity.
Comparison of the models response: PM$_{2.5}$

Simulated evolution of PM$_{2.5}$ concentrations ($\mu$g m$^{-3}$) over a winter period (15 January - 15 February).

$\sim 4 \ \mu$g m$^{-3} < |\Delta| < \sim 13 \ \mu$g m$^{-3}$  \quad  $\sim 3 \ \mu$g m$^{-3} < |\Delta| < \sim 8 \ \mu$g m$^{-3}$
Comparison of the models response: NO$_2$

Simulated evolution of NO$_2$ concentrations ($\mu$g m$^{-3}$) over a winter period (15 January - 15 February).

$\sim 4$ $\mu$g m$^{-3}$ < $|\Delta|$ < $\sim 21$ $\mu$g m$^{-3}$

$\sim 2$ $\mu$g m$^{-3}$ < $|\Delta|$ < $\sim 13$ $\mu$g m$^{-3}$
Next steps

Next month

- Extend the analysis to the urban domains.
  - Impact of the spatial resolution on the results?
- Extend the comparison with a “BAU” scenario.
  - “AME” scenario from the CITEPA.

Next year

- Health impact assessment.
- Environmental impact assessment.
Thanks for your attention.