Prospective modelling, what we have and... what we dream of! AirMonTech workshop

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des Systèmes Atmosphériques

The "Air 2030 project"

One prospective study

A contribution to the assessement of an ambitious energy scenario proposed by ADEME for the time horizon of 2030.

focused on air quality issues...

keep in mind GHG emissions.

Two set of measures (first phase)	
Road traffic hybrid electric vehicles and electric vehicles (PC, LDV, HDV and 2W) vehicles sharing	Biomass combustion public power district heating residential, commercial and institutional manufacturing industry

The "Air 2030 project"



Nantes

oit.

inhabitants	280 000
density	4 350 / km ²
inhabitants	580 000
density	1 100 / km ²





Paris

2 234 000
21 200 / km ²
10 413 000
3 700 / km ²



Strasbourg

city inhabitants density *urban area* inhabitants density

270 000 3 500 / km²

440 000 2000 / km²

The "Air 2030 project"



Nantes - Pays de Loire





Paris - Île de France





Strasbourg - Alsace



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" "France" Pays de Loire Île de France Alsace Nantes Paris Strasbourg

 $\sim 60\,km{\times}60\,km$

- $\sim 15\,km{ imes}15\,km$
- \sim 5 kmimes5 km
 - \sim 3 km \times 3 km
 - $\sim 3\,km{ imes}3\,km$
 - $\sim 1\,\text{km}{ imes}1\,\text{km}$
 - $\sim 1\,\text{km}{ imes}1\,\text{km}$
 - $\sim 1\,\text{km}{ imes}1\,\text{km}$

Data provided to the CTM

- Meteorology from WRF model simulations (NCEP)
- Boundary conditions from global models LMDzT-INCA or MOZART4
- Base emissions from EMEP and "local" inventories

Impact of the emissions reduction measures

Base emissions Pays de Loire





Alsace



Road Traffic







NMVOC	-6%
$PM_{2.5}$	-12%
NOx	-44%

NMVOC	-13%
$PM_{2.5}$	-24%
NOx	-39%

NMVOC	-4%
$PM_{2.5}$	-8%
NOx	-41%

Impact of the emissions reduction measures

Base emissions Pays de Loire





Alsace



Biomass combustion







NMVOC	-9%
PM _{2.5}	-22%
NOx	+2%

NMVOC	-9%
PM _{2.5}	-28%
NOx	-0.2%

NMVOC	-28%
PM _{2.5}	-55%
NOx	-1.5%

NO_2 hourly concentrations (µg.m⁻³) Pays de Loire Distribution of hourly concentrations of NO2 reference 2010 road trafic 2030 Mean $7.5 \rightarrow 4.6$ Maximum .5 $75 \rightarrow 34$ Area concerned (in %) Île de France Distribution of hourly concentrations of NO-120 reference 2010 road trafic 2030 Mean 108 $29 \rightarrow 21$ Maximum $106 \rightarrow 90$ 0 0 Area concerned (in %)

$PM_{2.5}$ daily concentrations (µg.m⁻³)











Air quality - Biomass combustion - winter period (30 days)

NO₂ hourly concentrations (μ g.m⁻³)

Pays de Loire Mean $7.5 \rightarrow 7.3$ Maximum $75 \rightarrow 73$









$PM_{2.5}$ daily concentrations (µg.m⁻³)







What about uncertainties?

Source of uncertainties

- the input data of the model (meteorological fields, emissions sources, ...)
- the model formulation
 - badly known processes
 - subgrid parameterizations
- · the numerical schemes/configurations chosen
- in the framework of prospective studies a specific attention could be given to the uncertainties in the emissions reduction.

How an ensemble modelling approach can help?

replace the deterministic approach $c = \mathbb{M}(p)$

with a stochastic point of view $\hat{c} = \hat{\mathbb{M}}(\hat{p})$ where $\hat{c} \sim \mathcal{N}(\bar{c}, \Sigma)$

The covariance matrice of \hat{c} , Σ (the a priori uncertainties) can be approximate by the variance of a well chosen model ensemble.

Observations to assess and/or calibrate an ensemble

Example taken from Garaud, D., and V. Mallet (2011), Automatic calibration of an ensemble for uncertainty estimation and probabilistic forecast: Application to air quality, J. Geophys. Res., 116, D19304, doi:10.1029/2011JD015780.

The rank histogram

Each observation is given a rank which is the number of members that simulate a concentration lower than the observation. The rank histogram displays, for each rank, the number of observations with that rank. An ensemble properly estimates the uncertainty if the rank histogram is almost flat.



Example of application for an impact study

Example taken from Damien Garaud PhD Thesis [2011], Estimation des incertitudes et prévision des risques en qualité de l'air, Université Paris-Est

Case study: a coal power plant near from Paris

An ensemble of 14 members after calibration (!!! for the current situation !!!) for NO₂ hourly concentrations



Thanks for your attention.