

'The added value of satellite observations of aerosol optical depth for operational air quality forecasts'

final meeting, 18 March 2008, Darmstadt

Data assimilation

TNO | Knowledge for business

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Components of assimilation system

- Ensemble Kalman Filter
 - LOTOS-EUROS model
 - model uncertainty
 - ensemble states
 - analysis of observations
- forecast system

Model uncertainty

- uncertainty in emissions:

$$\text{emis}(t) := \text{emis}(t) * (1 + g(t)) \uparrow$$

- noise process $g(t)$:

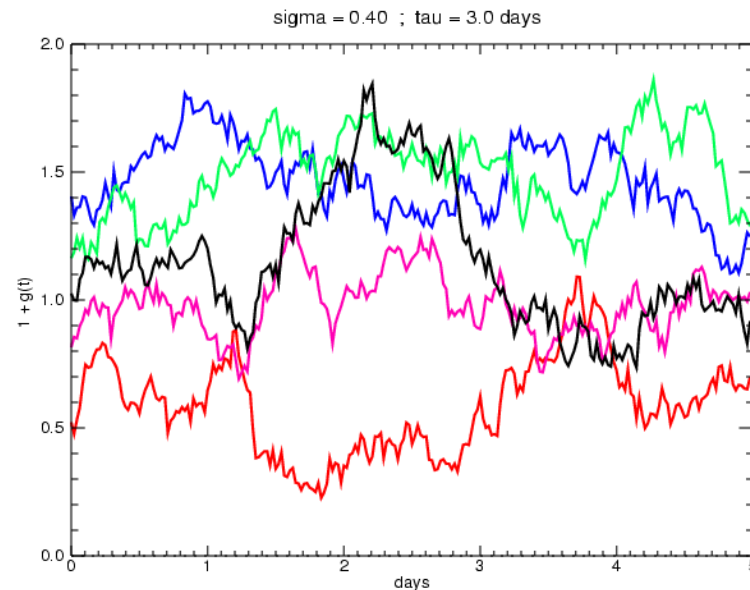
- normal distribution, standard deviation $\sigma=40\%$:

$$g(t) \sim N(0, \sigma^2) \uparrow$$

- time correlation $\tau=3$ days :

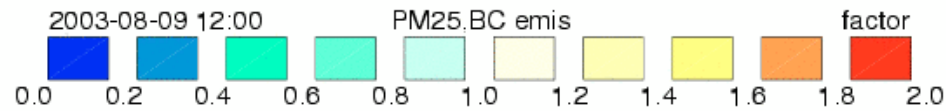
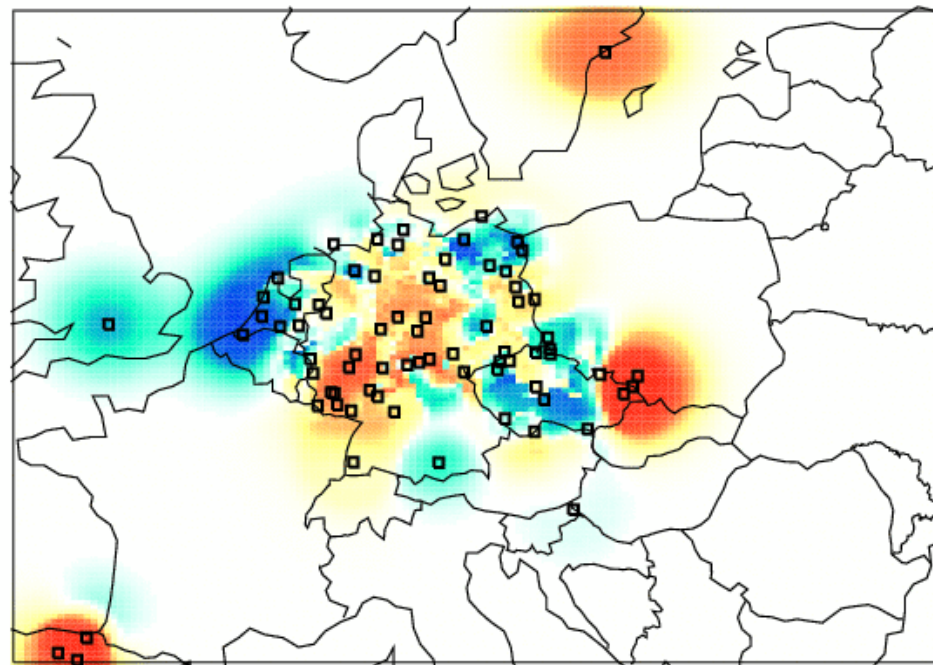
$$\langle g(t) g(t+dt) \rangle = \exp(-|dt|/\tau) \uparrow$$

- bounded to $[-1,1]$



model uncertainty (2)

- default in this project: 4 uncertain emissions:
NO_x, SO_x, NH₃, PM_{2.5}+BC
- no spatial distribution in uncertainty ...
- ... but analysed locally around measurement locations



Filter state

- State vector composed of:
 - 3D concentration fields (LOTOS-EUROS)
 - 2D uncertainty fields
 - simulated PM2.5 ground measurements
 - simulated AOD satellite measurements
- Ensemble Kalman Filter with 12 ensemble members
 - each member requires 1 evaluation of LE
 - spread in ensemble represents uncertainty

Filter state (2)

- Correlations in ensemble represent correlations between concentrations, concentrations and measurements, measurements and uncertainties, ...
- local correlations ok
- 12 ensemble members is too low to represent spatial (de)correlation, unless correlations are spatially bounded

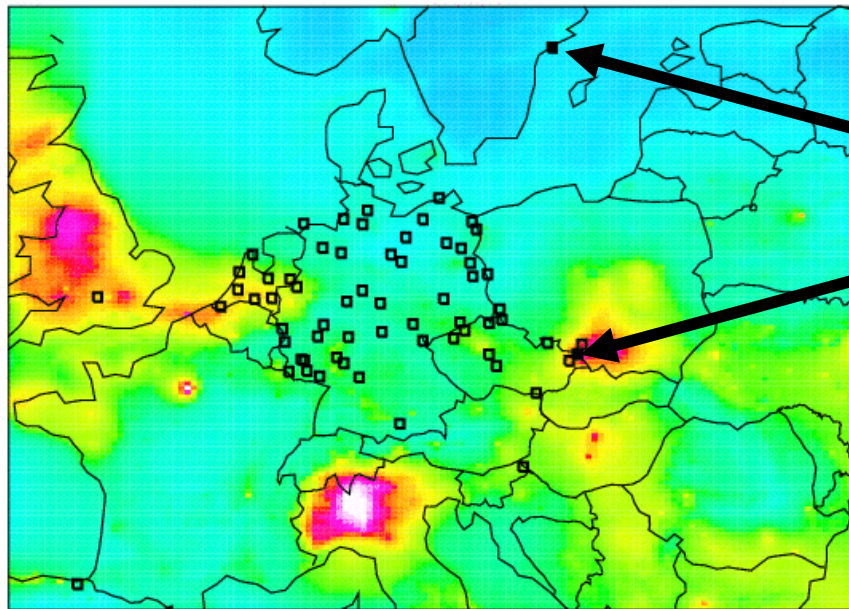
Analysis of observations

- Each measurement limits the spread of the ensemble ...
- ... but only in a limited area:
 - measurements in Scotland do not influence results in Albania
 - makes it feasible to analyze about 10^4 AOD measurements
- PM2.5 ground measurements: 0-300 km
- AOD measurements: single grid cell

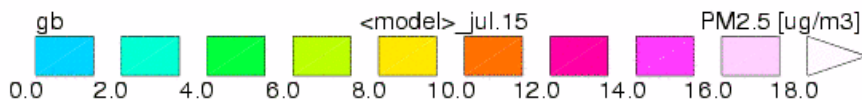
Analysis of observations (2)

screening of observations:

- do not assimilate an observation if square of observation-minus-forecast exceeds factor times expected variance
- Solves problems with extreme large concentrations in nature run at some sites

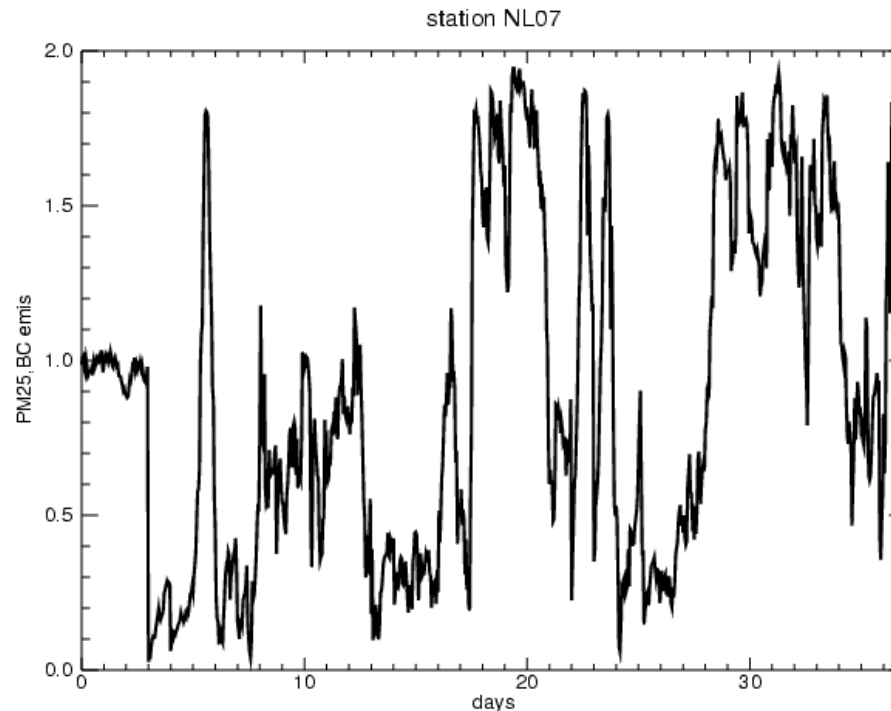


Sites with more than 10% rejected observations



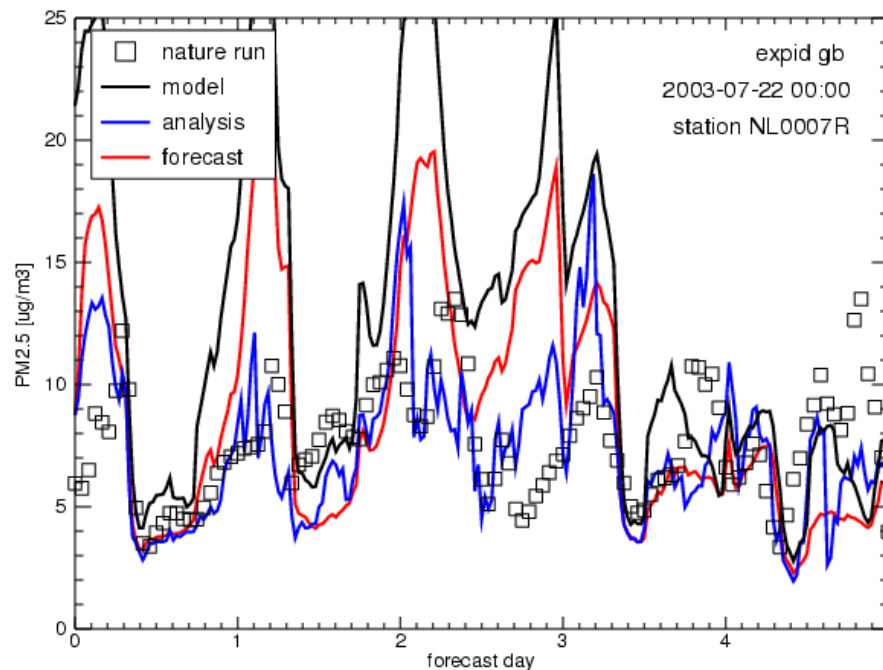
Forecast system

- Model run of 5 days started at 00:00
- Initial concentrations from analysis
- Options for emission factors:
 - fixed to latest analysis (implemented now)
 - fading to 1 (*not yet*)
 - diurnal cycle from previous analyses (*not yet*)



Forecasts (2)

- example of 5 days forecast at site NL07 for single forecast after analysis of ground observations



Run times etc

- Simulation periods of 36 days
- Linux cluster with 8 threads/node
(national computer facility)
- Assimilation runs on 1 node:
 - 2.5 days runtime for European area
 - 4.5 days for Paris area
- Forecast runs in parallel:
 - 4 hours runtime