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

final meeting, 18 March 2008, Darmstadt
Components of assimilation system

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

• uncertainty in emissions:
  \[ \text{emis}(t) := \text{emis}(t) \times (1 + g(t)) \]
• noise process \( g(t) \):
  • normal distribution, standard deviation \( \sigma = 40\% \):
    \[ g(t) \sim N(0, \sigma^2) \]
  • time correlation \( \tau = 3 \) days:
    \[ \langle g(t) \, g(t+dt) \rangle = \exp\left( -|dt|/\tau \right) \]
  • bounded to \([-1,1]\)
model uncertainty (2)

- default in this project: 4 uncertain emissions: NOx, SOx, NH3, PM2.5+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