Environment, Health and Safety

TNO | Knowledge for business

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Estimating Regional Background Concentrations using Data Assimilation

To assess the influence of the combined urban emissions in a city one needs to know the regional background.
Current practices to use measurements or modelling have disadvantages:

- *Using observations:*
  How to account for influence by City-emissions: double counting
- *Using modelling:*
  Limited model-performance

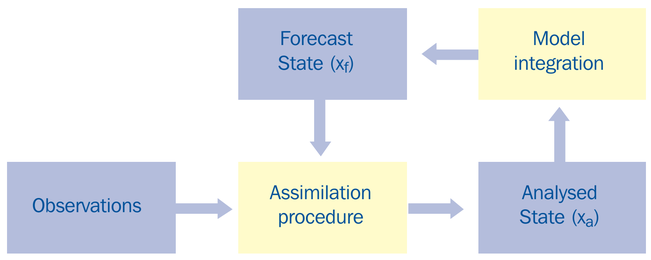
In this work we combine modelling and measurements to arrive at an optimal estimate of the regional background concentrations.

Objective

To derive consistent air quality fields over Europe on an hour-by-hour/daily averaged basis by a combination of modelling and observations

Data assimilation

Data assimilation is the technique whereby observational data are combined with model output to produce an optimal estimate of the evolving state of the system.
In practise, data assimilation defines a new "analyzed" atmospheric state by making a weighted average of the observed and modelled state in an intelligent and statistically sound way. The weights are determined by the associated uncertainties in the model and measurements.
Observations of Ozone and PM10 are assimilated into the LOTOS-EUROS air quality model using an ensemble kalman filter.

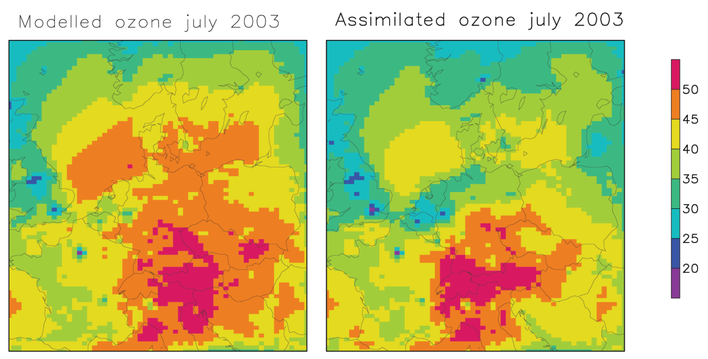


Schematic representation of the data assimilation procedure

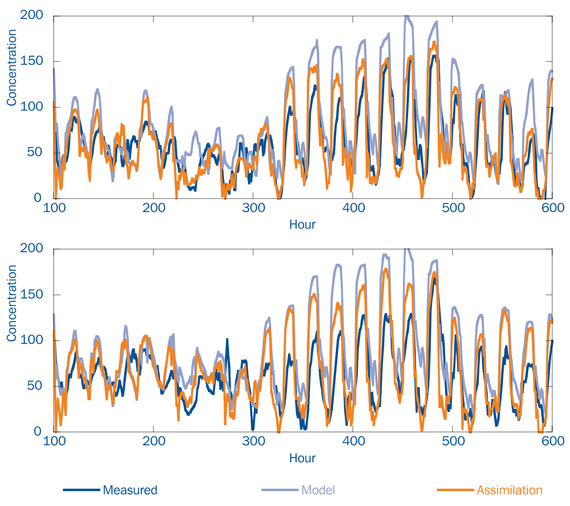
With an ensemble kalman filter the model uncertainties are determined by the range of modelled states of the ensemble members. We generated an ensemble of 15 members by adding noise to the emissions of NOx, SOx, VOC, NH_3 and particles and the deposition rates for Ozone, NOx and/or particles.

For ozone we assimilated the ozone observations from the EMEP network. The data from the AIRBASE network were used for validation. In case of PM10, we assimilated the data from the AIRBASE network, the only source for a large number of observational data.

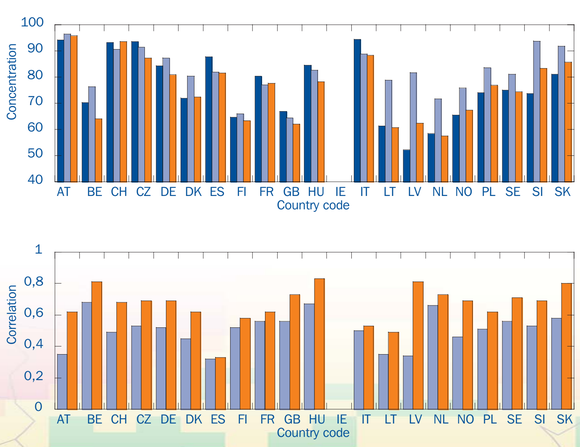
Ozone results



Modelled and assimilated ozone fields (ppb) for July, 2003



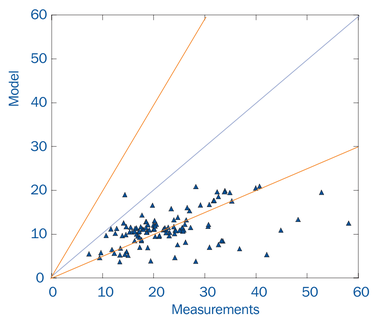
Time series of ozone (μg/m³) for the Dutch stations Vredepeel (used in the assimilation) and Westmaas (validation station). An episode with an overestimation was selected to illustrate the influence of the assimilation



Comparison of annual average ozone concentrations (μg/m³) against measurements (a) and the correlation between model / assimilation and observations. All stations grouped per country

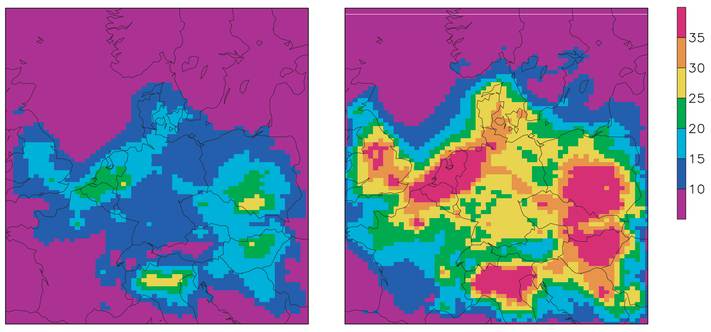
PM10 results

Current status of PM10 modelling is that the models underestimate the observed concentrations severely due to missing knowledge on processes and emissions to incorporate all components in the models.

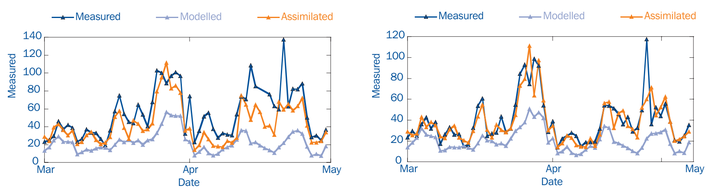


Comparison between measured and modelled PM10 concentrations (μg/m³) in Europe

LOTOS-EUROS also shows this underestimation.
Hence, for PM10 a bias correction has been applied of a factor of 2.



Modelled and assimilated PM10 fields (μg/m³) for March-April, 2003



Time series of measured, modelled and assimilated PM10 (μg/m³) at Vredepeel (left) and Kolummerwaard (right), the Netherlands. Both stations are assimilation stations

Conclusions

- A system that is able to assimilate observations of O_3, PM and in principal also NO_2 from the EMEP and AIRBASE networks is operational.
- The validation of the results shows that the assimilated fields are in better agreement with independent observations compared to the stand alone model.
- The produced air quality fields for O_3 and PM10 are available for use as Background Concentrations by City Users.

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