Basic data assimilation methods:
application to the European scale

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Summary

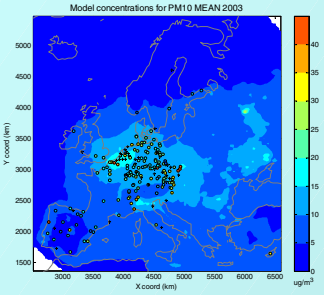
This case study examines the use of basic data assimilation methods and how they can improve the spatial assessment of air quality on the European scale. In previous studies Horálek et al. (2005) produced interpolated maps of PM_{10} based on annual statistics for Europe by combining the unified EMEP model with observations. As part of this case study the assimilation methodology has been further developed to make use of Bayesian statistics to combine observational and model fields and to calculate the annual mean and number of exceedance days based on the daily mean statistics, rather than annual values. This poster looks at the differences that occur when applying the assimilation method to annual or daily mean statistics. The maps represent the rural background concentrations of PM_{10} averaged over a 25 x 25 km grid.

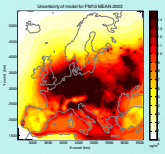
Assimilation methodology

The assimilation method used here combines a linearly fitted model regression field with an interpolated observational field using kriging. The two fields are combined based on minimisation of the variance using Bayesian theory. Uncertainty of the regression model is estimated from the normalised root mean square error (NRMSE). The uncertainty field is then made by multiplying the model field with the NRMSE. The uncertainty of the observational field is determined from the kriged variance field used in the kriging interpolation. Uncertainty is also assessed using the cross validated RMSE. Observational data has been retrieved from the AirBase and EMEP databases.

Annual mean for PM_{10} 2003

Model

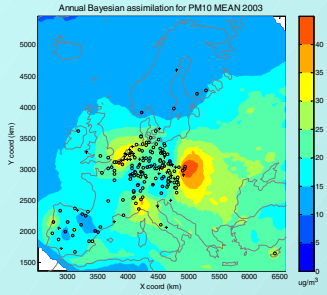


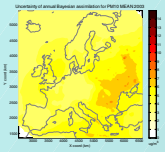


Uncertainty field showing the NRMSE of the model, compared to the 150 available stations, multiplied by the model field. RMSE = 14.4 ug/m^3

Original model field as calculated using the unified EMEP model for the year 2003. Also shown are the observations with availability > 75%, circles. Crosses indicate stations also used in the daily statistics but with total availability < 75%

Assimilation: annual statistics

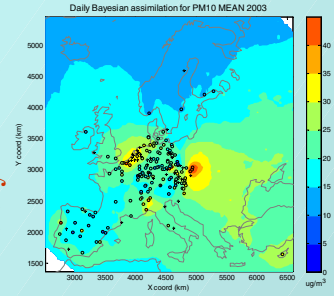


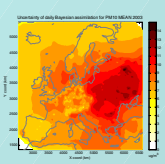


Uncertainty field of the annual assimilation. Cross validated RMSE = 6.9 ug/m^3

The assimilated map is created by the weighted combination of linear model regression with kriged interpolation fields. The weighting, according to Bayesian theory, minimises the uncertainty in the final map. Annual mean values have been used

Assimilation: daily statistics

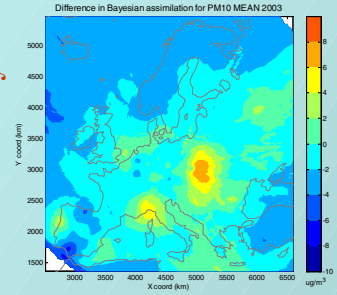


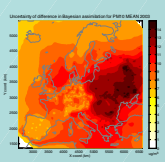


Uncertainty for the assimilation using daily mean values. The uncertainty is based on the sum of the daily uncertainty. Cross validated RMSE = 7.0 ug/m^3

The assimilated map is created using assimilation on a daily basis, rather than annual.

Difference: annual - daily



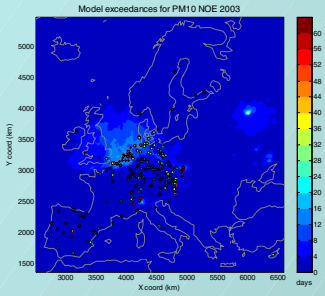


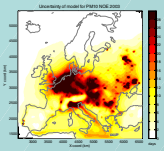
Uncertainty of the difference between the annual and daily assimilation fields.

The difference between the annual and daily mean assimilation fields. The annually based method gives slightly higher values in polluted regions. The difference is smaller than the uncertainty.

Number of exceedance (NOE) days for PM_{10} 2003

Model

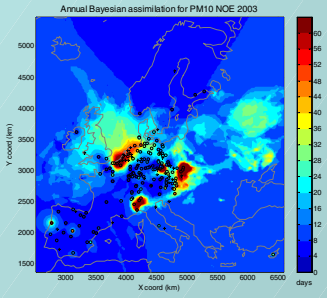


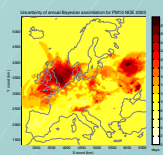


Uncertainty field showing the NRME of the model, compared to the 150 available stations, multiplied by the model exceedance field. RMSE = 32.6 days

Original model exceedance field as calculated using the unified EMEP model for the year 2003. Also shown are the observations for availability > 75%, circles. Crosses indicate stations also used in the daily statistics but with total availability < 75%

Assimilation: annual statistics

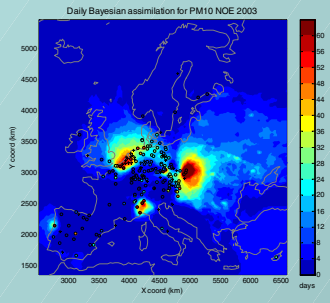


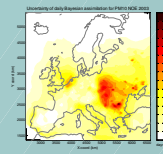


Uncertainty field of the annual assimilation. Cross validated RMSE = 20.3 days

The assimilated map is created by the weighted combination of linear model regression with kriged interpolation fields. The weighting, according to Bayesian theory, minimises the uncertainty in the final map. Annual mean values have been used.

Assimilation: daily statistics

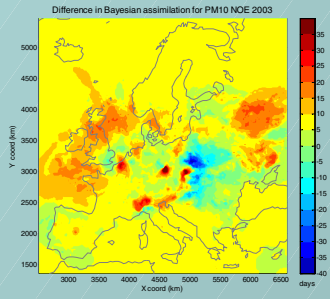


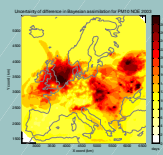


Uncertainty for the assimilation using daily exceedances. The uncertainty is based on the sum of the daily uncertainty. Cross validated RMSE = 23.4 days

The map is created by assimilating the daily mean concentrations. The number of exceedances are calculated based on these daily mapped exceedances, rather than by mapping the annual number of exceedances.

Difference: annual - daily





Uncertainty of the difference between the annual and daily assimilated exceedance fields.

The difference between the annual and daily assimilated exceedance fields. The difference is of the same order as the uncertainty but are in some areas significant.

Conclusion

- Basic data assimilation methods have been used to create maps of the annual mean PM_{10} and of the number of daily exceedances over the limit value for PM_{10} on the European scale. These methods significantly improve the spatial mapping for both these indicators.
- Comparison of the data assimilation method applied to annual or daily statistics indicates that:
  - There are only small differences between the annual and daily assimilation on mean concentrations of PM_{10} and these are less than their estimated uncertainty.
  - There are significant differences between the annual and daily assimilation of PM_{10} when calculating the number of exceedance days.
- It is recommended to use annual statistics when calculating annual means.
- It is recommended to use daily statistics when calculating daily exceedances.
- Both the cross validation RMSE and general uncertainty maps are useful in ascertaining the uncertainty of the assimilated field. The methodology for producing uncertainty maps requires further research.
- The inclusion of uncertainty maps is a very useful indicator of the uncertainty in the assessment maps and is highly recommended for any air quality mapping.

References: Horálek J., P. Kurfürst, B. Denby, P. de Smet, F. de Leeuw, M. Brabec, 2005. Interpolation and assimilation methods for European scale air quality assessment and mapping - Part II: Development and testing new methodologies. ETC/ACC Technical Paper 2005/8 .