Deducing correction factors for European anthropogenic emission inventories:

WHAT WE LEARN FROM OBSERVATIONS USING JOINT 4D-VAR DATA ASSIMILATION

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Motivation

Air quality models & air pollution mitigation strategies rely on the quality of emission data, which generally includes large uncertainties. In particular,

- anthropogenic emission inventories base on estimates using bottom-up/top-down approaches
- total national emission amounts are spatio-temporally distributed based on diverse proxy data (e.g. population density, traffic density, energy consumption etc.), which can be highly variable

To minimize these uncertainties and to assess the spatial distribution of anthropogenic emissions, a 4D-var reanalysis is performed under the following conditions:

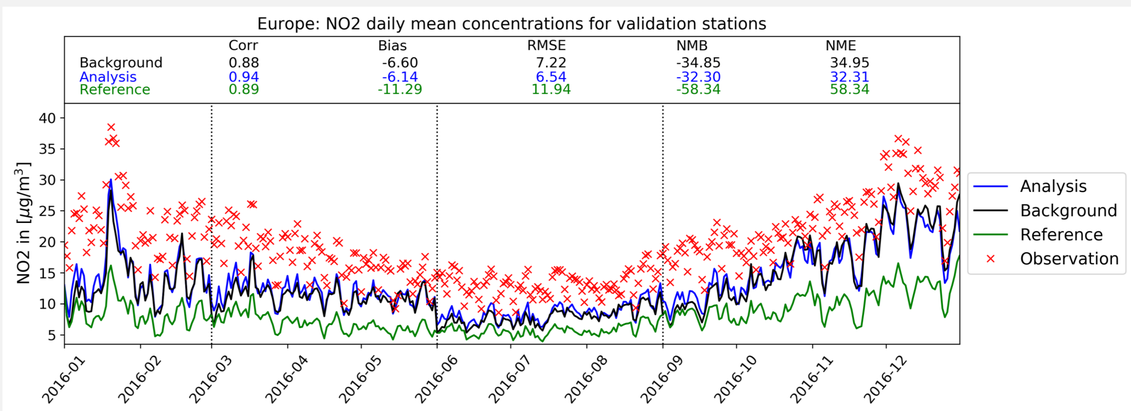
- full year reanalysis of air quality in Europe for 2016
- joint optimization of initial value & emission factors with EURAD-IM
- vertical & temporal emission profiles are assumed less uncertain
- CAMS emission data for Europe, UBA/GRETA emission data for Germany (gridded on the model resolution)

➡ Assessment of emission corrections for

- Europe (15 x 15 km^2)
- Germany (5 x 5 km^2)
- 3 German regions (1 x 1 km^2)

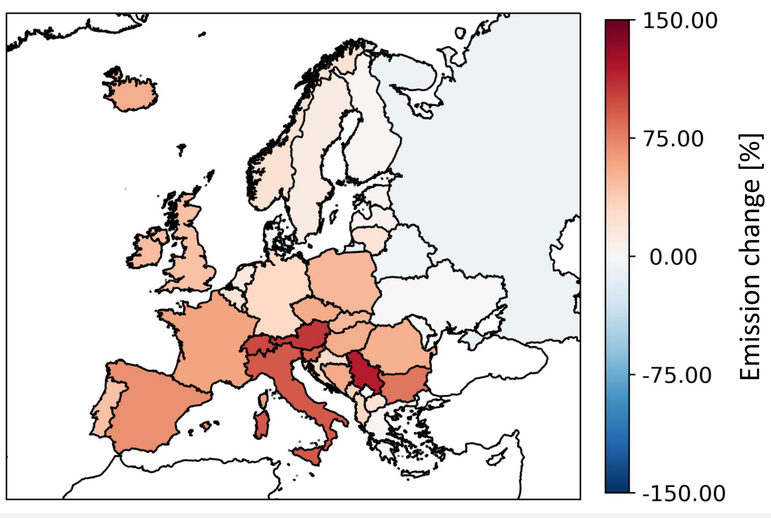
European emission corrections

The 2016 reanalysis using sequential 4d-var cycles with 24 h-windows allows for a substantial improvement of the representation of atmospheric pollutants in the EURAD-IM simulations.



- the enhancement of the background compared to the reference bases on emission corrections from the previous day
- the underestimation of NO2 concentrations is significantly reduced in the analysis
- EURAD-IM performance & results are comparable to other regional CTMs → frequent evaluation within regional CAMS

Analysed national mean emission corrections

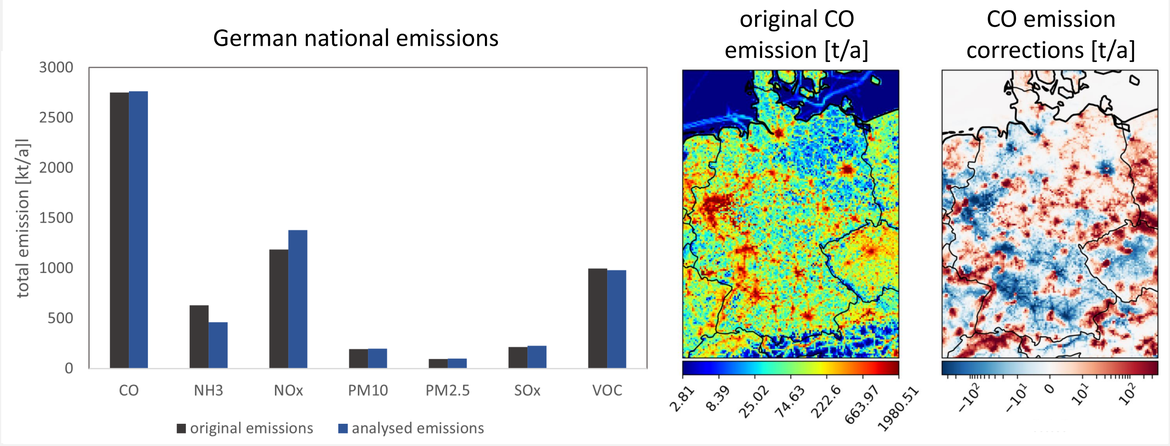


The reanalysis shows

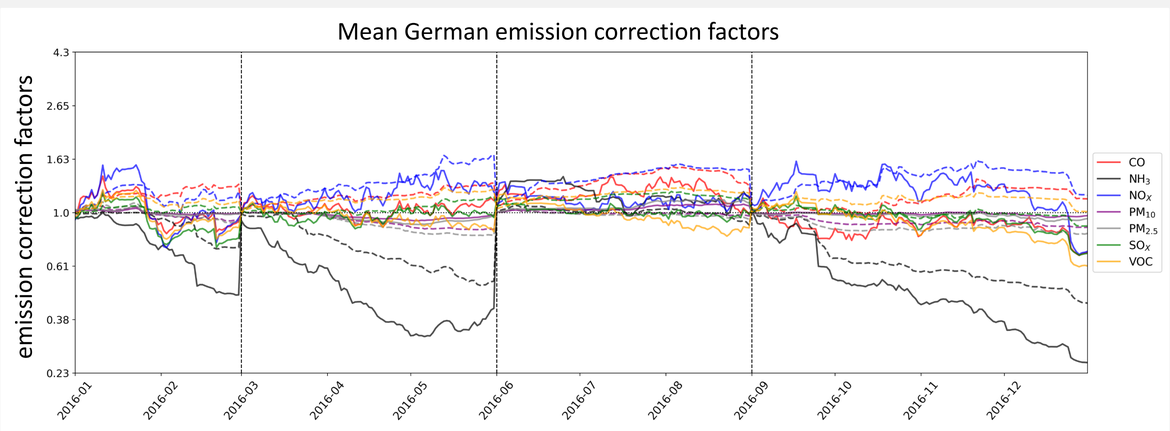
- stronger corrections in the South & East of Europe
- influence of observational network configuration
- ability to correct non-observed species

High resolution emission corrections

National emissions are analysed with respect to the national sum, horizontal distribution and the temporal evolution of national mean emission correction factors.



- total national emission amount remains similar but horizontal distribution is changed in the analysis
- emission corrections are horizontally very heterogeneous & reflect regional characteristics (e.g. road network, highly populated areas)



- NO_x & NH_3 correction factors follow a clear trend throughout 2016
- emission corrections are dependent on meteorological conditions

Polluter specific emission corrections

A new approach has been developed to derive emission correction factors resolving individual polluter groups (GNFR sectors).

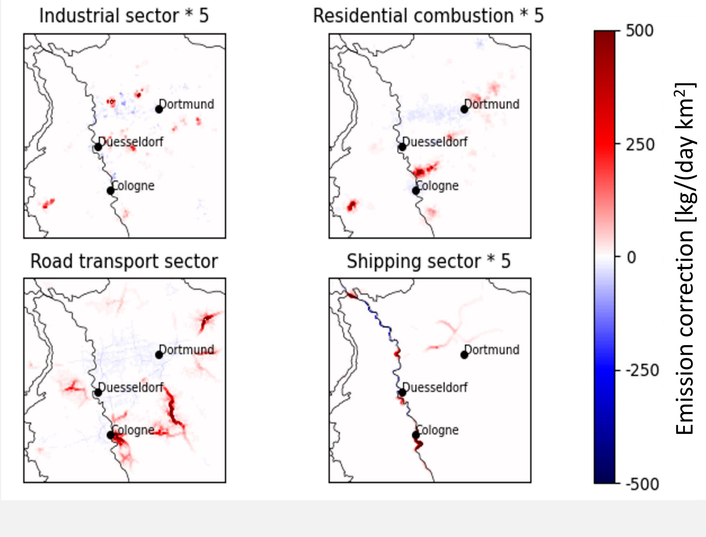
Assumptions:

- temporal emission profiles are dependent on polluter group
- full correlation of different species within one polluter group
- road transport: stretching of gradient information along road system

Extended cost function:

$$J(x,u_1,u_2,\ldots,u_M)=\frac{1}{2}x^T B^{-1}x+\frac{1}{2}\sum_{i=1}^{M}u_i^T K_i^{-1}u_i + \frac{1}{2}\sum_{j=1}^{N}\left(y_j-H(x_j)\right)^T R^{-1}\left(y_j-H(x_j)\right)$$

Correction of NO_x emissions in different sectors



The analysis of emission correction factors in NRW on 19-03-2016 reveals emission corrections that are:

- highly resolved & locally heterogeneous
- Able to separate between different polluter groups at the same location
- realistic corrections
- comparable to species resolved emission correction factors

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