Supporting air quality forecasting by modifying the emission fields through data assimilation

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Data-assimilation of concentration fields is known to have a limited impact on the forecast quality, in case there is a significant time lag in the acquisition of the observation data. This is due to the fact that at time scales of one day and longer, the emission fields have a much stronger impact on the forecast than the initial concentration fields. While it is obvious that emission fields modified for forecasting purposes are not necessarily more realistic than the original fields, as they may correct for model errors in other areas than emission, the use of such fields may result in improved forecast quality even years after the observations were made.

To obtain emission fields optimized for forecasting, we apply the Ensemble Kalman Filter (EnKF) by selecting emission correction fields for all modeled species as the state vector of the data-assimilation procedure. The chemical transport model SILAM is utilized as an effective observation operator, mapping the emission correction of the a priori emission fields into air quality observations. The assimilation procedure is performed iteratively, with smoothing of the fields between the iterative runs preventing over-fitting of the data. The a priori field can be a taken from an existing emission inventory or it can even be completely random. We show that such an approach can have a clear positive impact on the forecast quality, by utilizing air quality forecasts for China and aerosol optical depth forecasts for Northern Africa and Southern Europe as examples.

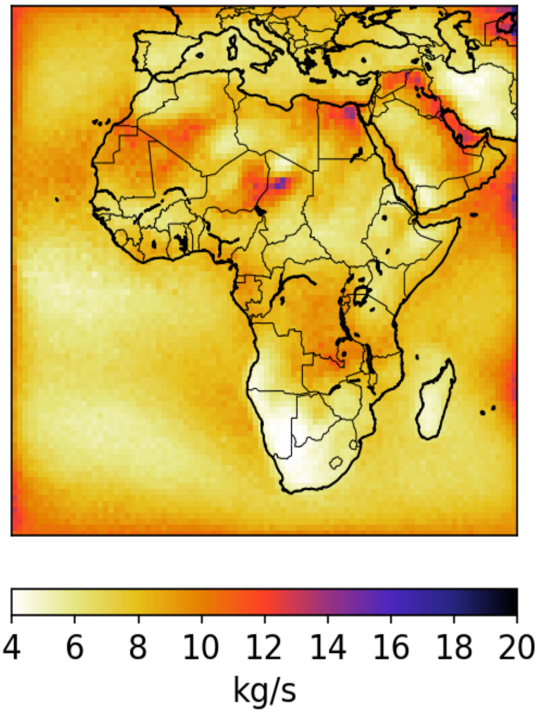

Figure: Annual average emission of a generic PM10 substance, obtained by assimilating 2012 MODIS AOD retrievals and starting from a random field. While the direct physical interpretation of such a field is ambiguous (especially as a zero boundary condition was applied), the dynamic version of the field still yielded a better comparison with 2017 AERONET AOD measurements than a forecast using standard emission inventories and emission models.