Satellite-based observations of ground-level fine particulate matter and comparison to a regional air quality model

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Particulate matter and other air pollutants have become an increasing burden on the environment and human health. Especially in metropolitan and high-traffic areas, air quality is often remarkably reduced. For a better understanding of the air quality in specific areas, which is of great environment-political interest, data with high resolution in space and time is required. The combination of satellite observations and chemistry-transport-modelling has proven to give a good database for assessments and analyses of air pollution. In contrast to sample in-situ measurements, satellite observations provide area-wide coverage of measurements and thus the possibility for an almost gapless mapping of actual air pollutants. For a high temporal resolution, chemistry-transport-models are needed, which calculate concentrations of specific pollutants in continuous time steps. Satellite observations can thus be used to improve model performances.

There are no direct satellite-measurements of fine particulate matter (PM2.5) but ground-level concentrations of PM2.5 can be derived from optical parameters such as aerosol optical depth (AOD). A wide range of methods for the determination of PM2.5 concentrations from AOD measurements has been developed so far, but it is still a big challenge. In this study a semi-empirical approach based on the physical relationships between meteorological and optical parameters was applied to determine a first-guess of ground-level PM2.5 concentrations for the year 2018 and the larger Germany region. Therefor AOD observations of MODIS (Moderate Resolution Imaging Spectroradiometer) aboard the NASA Aqua satellite were used in a spatial resolution of 3km. First results showed an overestimation of ground-level aerosols and quiet low correlations with in-situ station measurements from the European Environmental Agency (EEA). To improve the results, correction factors were calculated using the coefficients of linear regression between satellite-based and in-situ measured particulate matter concentrations. Spatial and seasonal dependencies were taken into account with it. Correlations between satellite and in-situ measurements could be improved applying this method.

The MODIS 3km AOD product was found to be a good base for area-wide calculations of ground-level PM2.5 concentrations. First comparisons to the calculated PM2.5 concentrations from chemistry-transport-model POLYPHEMUS/DLR showed significant differences though. Satellite observations will now be used to improve the general model performance, first by helping to find and understand regional and temporal dependencies in the differences. As part of the German project S-VELD funded by the Federal Ministry of Transport and Digital Infrastructure BMVI, it will
help for example to adjust the derivation of particle emissions within the model.