EGU21-3260
https://doi.org/10.5194/egusphere-egu21-3260
EGU General Assembly 2021

Quantifying CO_2 emissions of power plants with the CO2M mission

Gerrit Kuhlmann[1], Stephan Henne[1], Yasjka Meijer[2], Lukas Emmenegger[1], and Dominik Brunner[1]
[1]Empa, Air Pollution / Environmental Technology, Dübendorf, Switzerland (gerrit.kuhlmann@empa.ch)
[2]European Space Agency (ESA), ESTEC, Noordwijk, The Netherlands

In this study, we analyse the capability of the Copernicus CO_2 monitoring (CO2M) satellite mission to quantify the CO_2 emissions of individual power plants, which is one of the prime goals of the mission. The study relies on synthetic CO_2 and NO_2 satellite observations over parts of the Czech Republic, Germany and Poland and quantifies the CO_2 and NO_x emissions of the 15 largest power plants in that region using a data-driven mass-balance approach.

The synthetic observations were generated for six CO2M satellites based on high-resolution simulations of the atmospheric transport model COSMO-GHG. To identify the emission plumes, we developed a plume detection algorithm that identifies the location, orientation and extent of multiple plumes from CO2M's NO_2 observations. Afterwards, a mass-balance approach was applied to individual plumes to estimate CO_2 and NO_x emissions by fitting Gaussian curves to the across-plume signals. Annual emissions were obtained by interpolating the temporally sparse individual estimates applying a low-order spline fit.

Individual CO_2 emissions were estimated with an accuracy <65% for a source strength >10 Mt CO_2 yr^{-1}, while NO_x emissions >10 kt NO_2 yr^{-1} were estimated with <56% accuracy. NO_2 observations were essential for detecting the plume and constraining the shape of the Gaussian curve. With three CO2M satellites, annual CO_2 emissions were estimated with an uncertainty <30% for source strengths larger than 10 Mt yr^{-1}, which includes an estimate of the uncertainty in the temporal variability of emissions. Annual NO_x emissions were estimated with an uncertainty <21%. Since NO_x emissions can be determined with better accuracy, estimating CO_2 emissions directly from the NO_x emissions by applying a representative CO_2:NO_x emission ratio seems appealing but this approach was found to suffer significantly from the high uncertainty in the CO_2:NO_x emission ratios determined from the same CO2M observations.

Our study shows that CO2M should be able to quantify the emissions of the 400 largest point sources globally with emissions larger than 10 Mt yr^{-1} that account for about 20 % of global anthropogenic CO_2 emissions. However, the mass-balance approach used here has relatively high uncertainties that are dominated by the uncertainties in the estimated CO_2 background and the wind speed in the plume, and uncertainties associated with the sparse temporal sampling of the varying emissions. Estimates could be significantly improved if these parameters can be better constrained, e.g., with atmospheric transport simulations and independent observations.