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Uncertainty quantification in satellite retrieval of aerosol - model selection and imperfect forward modelling

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We study Bayesian uncertainty quantification in satellite retrieval of atmospheric aerosol. The retrieval procedure replaces computationally intensive forward model calculations by pre-calculated aerosol microphysical model look-up tables (LUTs). Several LUTs are used to find the best match to the satellite measurements. In this study we are retrieving the aerosol optical depth (AOD), but, in addition, when selecting the most appropriate aerosol microphysical models, we obtain information on the possible aerosol types.

We utilize statistical analysis based on Bayesian inference that inherently quantifies the retrieval uncertainty. Especially, we examine difficulty in the model selection, which reflects the retrieval uncertainty as well. This source of uncertainty is almost always neglected in retrieval uncertainty analyses. To account this uncertainty, we apply Bayesian model averaging method that combines statistically the most appropriate aerosol microphysical models. In addition, we consider a source of uncertainty that originates from imperfect forward modelling. The systematic differences between simulated aerosol microphysical models and the real physical system are taken into account when seeking for the best match solution. We used Gaussian process to estimate this model error and applied it with real satellite data.

The motivation for our study is to obtain more realistic uncertainty estimates and to promote proper uncertainty quantification in satellite retrievals. We demonstrate this uncertainty quantification scheme using OMI/Aura data and consider its possibilities for the new TROPOMI/S5P instrument.

Reference: Kauppi, A., Kolmonen, P., Laine, M., and Tamminen, J.: Aerosol-type retrieval and uncertainty quantification from OMI data, Atmos. Meas. Tech., 10, 4079-4098, https://doi.org/10.5194/amt-10-4079-2017, 2017.