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Title:

Retrieval of Cloud Properties for the Copernicus Atmospheric Missions Sentinel-4 (S4) and TROPOMI / Sentinel-5 Precursor (S5P) using deep neural networks

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Abstract text:

Due to their fast computational performance and accuracy, neural networks are nowadays commonly used in the context of remote sensing. The issue of performance is especially important in the context of big data and near-real-time (NRT) operational processing. Classical retrieval algorithms typically use a radiative transfer model (RTM) as a forward model to solve the inverse problem of inferring the quantities of interest from the measured spectra. However, these RTMs are often computationally very expensive and therefore replacing them by a NN is desirable to increase performance. But the application of NNs is not straightforward and there are at least two main approaches:

1. NNs used as forward model, where a NN accurately approximates the radiative transfer model and can thus replace it in the inversion algorithm
2. NNs for solving the inverse problem, where a NN is trained to infer the atmospheric parameters from the measurement directly

The first approach is more straightforward to apply. However, the inversion algorithm still faces many challenges, as the spectral fitting problem is generally ill-posed. Therefore, local minima are possible and the results often depend on the selection of the a-priori values for the retrieval parameters.

For the second case, some of these issues can be avoided: no a-priori values are necessary, and as the training of the NN is performed globally, i.e. for many training samples at once, this approach is potentially less affected by local minima. However, due to the black-box nature of a NN, no indication about the quality of the results is available. In order to address this issue, novel methods like Bayesian neural networks (BNNs) or invertible neural networks (INNs) have been presented in recent years. This allows the characterization of the retrieved values by an estimate of uncertainty describing a range of values that are probable to produce the observed measurement.

We apply and evaluate both approaches for the retrieval of cloud properties and consider their potential as operational algorithms for current (Sentinel-5P) and future (Sentinel-4) Copernicus atmospheric composition missions.