EGU22-11043
https://doi.org/10.5194/egusphere-egu22-11043
EGU General Assembly 2022

Framework for the deployment of DNNs in remote sensing inversion algorithms applied to Copernicus Sentinel-4 (S4) and TROPOMI/Sentinel-5 Precursor (S5P)

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In remote sensing, the quantities of interest (e.g. the composition of the atmosphere) are usually not directly observable but can only be inferred indirectly via the measured spectra. To solve these inverse problems, retrieval algorithms are applied that usually depend on complex physical models, so-called radiative transfer models (RTMs). RTMs are very accurate, however also computationally very expensive and therefore often not feasible in combination with the strict time requirements of operational processing of satellite measurements. With the advances in machine learning, the methods of this field, especially deep neural networks (DNN), have become very promising for accelerating and improving the classical remote sensing retrieval algorithms. However, their application is not straightforward but instead quite challenging as there are many aspects to consider and parameters to optimize in order to achieve satisfying results.

In this presentation we show a general framework for replacing the RTM, used in an inversion algorithm, with a DNN that offers sufficient accuracy while at the same time increases the processing performance by several orders of magnitude. The different steps, sampling and generation of the training data, the selection of the DNN hyperparameters, the training and finally the integration of the DNN into an operational environment are explained in detail. We will also focus on optimizing the efficiency of each step: optimizing the generation of training samples through smart sampling techniques, accelerating the training data generation through parallelization and other optimizations of the RTM, application of tools for the DNN hyperparameter optimization as well as the use of automation tools (source code generation) and appropriate interfaces for the efficient integration in operational processing systems.

This procedure has been continuously developed throughout the last years and as a use case, it will be shown how it has been applied in the operational retrieval of cloud properties for the Copernicus satellite sensors Sentinel-4 (S4) and TROPOMI/Sentinel-5 Precursor (S5P).