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Application of Machine Learning for the operational Cloud Product of the Copernicus Satellite Sensors Sentinel-4 (S4) and TROPOMI / Sentinel-5 Precursor (S5P)

Fabian Romahn[1], Victor Molina Garcia[1], Athina Argyrouli[2], Ronny Lutz[1], and Diego Loyola[1]
[1]German Aerospace Center (DLR), Remote Sensing Technology Institute
[2]Technical University of Munich (TUM), Department of Civil, Geo and Environmental Engineering

The increasing amount of Earth observation data provided by the Copernicus Satellite Sensors, the already operational Sentinel-5 Precursor (S5P) and the upcoming Sentinel-4 (S4), that has to be processed within strict near real time (NRT) requirements demands the use of new approaches to cope with this challenge.

In order to solve the inverse problems that arise in atmospheric remote sensing, usually complex radiative transfer models (RTMs) are used. These are very accurate, however also computationally very expensive and therefore often not feasible in combination with the time requirements of operational products. With the recent significant breakthroughs in machine learning, easier application through better software and more powerful hardware, the methods of this field have become very interesting as a way to improve the classical remote sensing algorithms.

In this presentation we show a general approach in order to replace the RTM of an inversion algorithm with an artificial neural network (ANN) with sufficient accuracy while at the same time increasing the performance by several orders of magnitude. The several steps, sampling and scaling of the training data, the selection of the ANN architecture and the training itself, is explained in detail. This is then demonstrated at the example of the ROCINN (Retrieval of cloud information using neural networks) algorithm for the operational cloud product of S5P. It is then shown how this approach can also be easily applied to the upcoming S4 mission and how the current algorithm for S5P can be improved by replacing or adding new physical models (e.g. for ice-clouds) in the form of ANNs.

The procedure has been continuously developed and evaluated over time and the most important results, in terms of sampling, architecture selection, activation functions and training parameters, are presented.

Finally, the huge performance benefits of using an ANN instead of the original RTM also allow for improvements in the inversion algorithm. Several ideas regarding this, e.g. global optimization techniques, are also shown.