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Development of a data-driven method to retrieve XCO2 using an artificial neural network in preparation for the European Copernicus CO2 Monitoring Mission CO2M

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Abstract

CO2 is the most important anthropogenic greenhouse gas and one of the main drivers of climate change. Monitoring its atmospheric concentration from space can help to detect and quantify anthropogenic emissions, supporting the mitigation efforts urgently needed to fulfill the Paris Agreement. Additionally, it can help to better understand the processes of the carbon cycle and thus allow better climate projections. These are key objectives of the European Copernicus CO2 Monitoring Mission CO2M, scheduled for launch in 2026, for which three retrieval algorithms are currently being developed and implemented in the EUMETSAT ground segment. One of these retrieval algorithms is the fast atmospheric trace gas retrieval FOCAL developed at the University of Bremen. Conventional retrieval techniques such as FOCAL are based on radiative transfer calculations. Despite shortcuts and approximations, the vast amount of satellite data makes them computationally expensive, often requiring many thousands of CPU cores. Although conventional retrievals use physical methods, they typically require data-driven methods to correct for biases, e.g., due to inaccuracies of the radiative transfer computations or unknown instrumental effects, in order to meet the demanding accuracy and precision requirements. Machine learning methods have the potential to combine both steps into a single data-driven retrieval algorithm, reducing the computational cost by several orders of magnitude.

In preparation for the implementation of FOCAL in the EUMETSAT ground segment, we use the radiative transfer model SCIATRAN to simulate two years of (sub-sampled) realistic radiances of three instruments on board CO2M: the main instrument CO2I (CO2 imager), MAP (multi angle polarimeter), and CLIM (cloud imager).

In addition to FOCAL-related activities, we use this data set to train artificial neural networks (ANNs) to retrieve XCO2 (the column-average dry-air mole fraction of atmospheric CO2), which is the topic of this presentation. We will analyze and compare the performance of different input vector settings, e.g., with and without MAP data and will discuss potential advantages or disadvantages of our ANN approach.