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Synergistic UV/Vis-Infrared ozone profile retrieval from METOP instruments

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With a growing number of spectral channels in multiple spectral regions and resolutions available from nowadays satellite sensors, questions about how to best combine their respective information content in a joint retrieval algorithm become more and more prominent. In this paper we study the synergies between the METOP instruments GOME-2, IASI and to a lesser degree AVHRR. To this end, we have constructed a joint retrieval scheme based on hierarchical neural networks.

In a first step, neural networks specialized on the UV/Vis and IR regions, and on different cloudiness regimes determined by AVHRR are trained on a historical data set comprising ozone sonde and limb sounder ozone profiles. The second step is to assemble these networks by means of a secondary mediator network that is separately trained to optimally combine the specialist networks into the final retrieval. In addition, the scatter associated with a stochastic method like randomly initialized neural networks is reduced by averaging over several retrievals using the same architecture. This new synergistic hierarchical retrieval scheme reduces the RMSE by up to 33% depending on altitude compared to a conventional retrieval architecture using all predicator in a single neural network.

When comparing the results to retrievals using the same training and methodology, but no IASI channels, the RMSE degrades by 5-10%, particularly in the troposphere. This is comparable to the theoretical effect radiative transfer based studies in the literature predict.
Leaving out IASI data is just one of many sensitivity studies performed during the development of NNORSY-METOP (Neural Network Ozone Retrieval System for METOP), the main results of which will also be presented. We also compare the outcome of our hybrid physical/heuristic feature selection scheme versus automatic feature selection using advanced machine learning techniques.

Multi-year global NNORSY-METOP retrievals are geophysically validated using a set of independent ground stations and lidars not present in the training data. We present an overview of the validation results, which will also shed some light on particularities of the method and the global distribution of retrieval errors.

NNORSY-METOP has been in operational use at EUMETSAT since 2010, and is currently further improved by exploiting the enormous gain in computation power recently achieved by adapting the machine learning software to run on graphics processors (GPUs).