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Using artificial neural networks to retrieve the aerosol type from multi-spectral lidar data

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Aerosols can influence the microphysical and macrophysical properties of clouds and hence impact the energy balance, precipitation and the hydrological cycle. They have different scattering and absorption properties depending on their origin, therefore measured optical properties can be used to retrieve their physical properties, as well as to estimate their chemical composition. Due to the measurement limitations (spectral, uncertainties, range) and high variability of the aerosol properties with environmental conditions (including mixing during transport), the identification of the aerosol type from lidar data is still not solved. However, ground, airborne and space-based lidars provide more and more observations to be exploited. Since 2000, EARLINET collected more than 20,000 aerosol vertical profiles under various meteorological conditions, concerning local or long-range transport of aerosols in the free troposphere.
This paper describes the basic algorithm for aerosol typing from optical data using the benefits of artificial neural networks. A relevant database was built to provide sufficient training cases for the neural network, consisting of synthetic and measured aerosol properties. Synthetic aerosols were simulated starting from the microphysical properties of basic components, internally mixed in various proportions. The algorithm combines the GADS database (Global Aerosol DataSet) to OPAC model (Optical Properties of Aerosol and Clouds) and T-Matrix code in order to compute, in an iterative way, the intensive optical properties of each aerosol type. Both pure and mixed aerosol types were considered, as well as their particular non-sphericity and hygroscopicity. Real aerosol cases were picked up from the ESA-CALIPSO database, as well as EARLINET datasets. Specific selection criteria were applied to identify cases with accurate optical data and validated sources. Cross-check of the synthetic versus measured aerosol intensive parameters was performed in order to ensure the homogeneity and consistency of the inputs considered for the neural network. Pure aerosol types are not sufficiently represented by the observations, as well as the mixtures of marine and volcanic, therefore only synthetic properties can be used for those.
A Multilayer Perceptron neural network with three hidden layers was built and trained to retrieve the aerosol type based on 3a+2b+1d lidar data. Five pure aerosol types and eight mixtures were considered. About 70% of the total number of cases was used to train the network, 20% for the internal auto-testing and adjustments, and 10% for blind testing. Supervised training was applied until more than 90% of the synthetic cases, respectively more than 80% of the measurement cases were correctly identified.
Preliminary results are presented, underlining the advantages and disadvantages of the neural network algorithm compared to other methods.

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