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Cloud Detection from POLDER-3 Measurements using a Neural Network Approach

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Currently, aerosol properties from spaceborne Multi-Angle Polarimeter (MAP) instruments can only be retrieved in cloud-free areas, or for areas where an aerosol layer is located above a cloud. Therefore, it is important to be able to identify cloud-free pixels (cloud screening) for which an aerosol retrieval algorithm can provide meaningful output. The goal of this work is to develop a cloud screening procedure for aerosol retrievals from these instruments. First, we focus on the POLDER-3/PARASOL instrument (hereafter simply referred to as PARASOL) as it is the only MAP that has provided a multi-year data set. To avoid the choice of priory thresholds which define whether a pixel is cloud contaminated, our goal is to perform a retrieval of cloud fraction (CF) for each PARASOL pixel and use the retrieved cloud fraction to define one or more cloud masks (e.g. a strict and a loose one). Given that the MAP measurements are also affected by aerosol properties and surface reflection properties, a classical retrieval algorithm (based on radiative transfer calculations and analytical inversion) for the retrieval of CF would be very complex because it would need, in addition to CF, to include many fit parameters related to aerosol (e.g. amount, size, refractive index, layer height) and surface Bi-directional Reflection Distribution Matrix (BRDM) parameters. Apart from the fact that such a retrieval algorithm would require a prohibitive amount of computing power, it would also have the risk of not finding an optimal solution, e.g. by ending in a local minimum of the inversion cost function. The use of Neural Networks (NNs) is a promising way because of their computational efficiency and the possibility to define a reduced state vector (with just CF), while still taking into account the effect of aerosol and surface. This paper describes a neural network cloud detection scheme from PARASOL MAP measurements. The algorithm has been trained on synthetic multi-angle, multi-wavelength measurements of reflectance and polarization and has been applied to the processing of 1 year of PARASOL data. Comparisons of the retrieved cloud fraction with Moderate Resolution Imaging Spectroradiometer (MODIS) products show overall agreement in spatial and temporal patterns but the PARASOL-NN retrieves cloud fractions that are lower by about 10%. Comparisons with a PARASOL aerosol retrieval goodness-of-fit mask suggest that the NN cloud mask keeps more aerosol-data-available clear pixels with an acceptable ability to avoid invalid calculation on cloudy pixels. Additionally, the NN and MODIS cloud mask have been applied to the aerosol retrievals from PARASOL using the Remote Sensing of Trace Gas and Aerosol Products (RemoTAP) algorithm. Validation with AERONET shows that the NN cloud mask performs comparably with MODIS in screening residual cloud contamination in retrieved aerosol properties.

Keywords: neural network, aerosol, clouds

References

O. Dubovik, Zhengqiang Li, Michael I Mishchenko, Didier Tanré, Yana Karol, et al.. Polarimetric remote sensing of atmospheric aerosols: Instruments, methodologies, results, and perspectives. Journal of Quantitative Spectroscopy and Radiative Transfer, Elsevier, 2019, 224, pp.474 - 511. ⟨10.1016/j.jqsrt.2018.11.024⟩. ⟨hal-03009287⟩

Fu, G., Hasekamp, O., Rietjens, J., Smit, M., Di Noia, A., Cairns, B., Wasilewski, A., Diner, D., Seidel, F., Xu, F., Knobelspiesse, K., Gao, M., da Silva, A., Burton, S., Hostetler, C., Hair, J., and Ferrare, R.: Aerosol retrievals from different polarimeters during the ACEPOL campaign using a common retrieval algorithm, Atmos. Meas. Tech., 13, 553–573, https://doi.org/10.5194/amt-13-553-2020, 2020.

Zeng, S., Parol, F., Riedi, J., Cornet, C., & Thieuleux, F. (2011). Examination of POLDER/PARASOL and MODIS/Aqua Cloud Fractions and Properties Representativeness, Journal of Climate, 24(16), 4435-4450. Retrieved Jul 14, 2022, from https://journals.ametsoc.org/view/journals/clim/24/16/2011jcli3857.1.xml

di Noia, A., Hasekamp, O. P., van Diedenhoven, B., Zhang, Z. (2019). Retrieval of liquid water cloud properties

from POLDER-3 measurements using a neural network ensemble approach. Atmospheric Measurement Techniques 12(3), 1697–1716. https://doi.org/10.5194/amt-12-1697-2019