

Aerosol retrieval from POLDER observations using GRASP algorithm with machine-learning-based forward model

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Multi-angular polarimetric (MAP) observations from the POLDER sensor provide critical information for aerosol retrieval using the Generalized Retrieval of Atmosphere and Surface Properties (GRASP [1]) algorithm. Processing these complex observations traditionally relies on direct, online Radiative Transfer (RT) calculations. While GRASP utilizes an optimized physical "Fast" mode that is relatively fast and has successfully processed nine years of POLDER data in reasonable timing, RT calculations still consume over 95% of the forward model's processing time, acting as a bottleneck for Near-Real-Time applications. To further improve computational efficiency, a Neural Network (NN) forward model emulator was developed to replace the physical RT solver, as similar with [2]. The NN models were trained on a comprehensive synthetic dataset of approximately 200 million pixels, generated using a highly-accurate physical RT model to ensure strict physical accuracy. The study evaluated two primary network topologies: a "Single NN" that predicts all Stokes parameters simultaneously, and a "Dual NN" that decouples intensity from polarization components. Performance analysis on POLDER test data demonstrates substantial processing acceleration. The compact Single NN configuration achieved speeds up to 4.5 times faster over land and 3.3 times faster over ocean compared to the already efficient physical Fast mode. While the Single NN exhibited some accuracy limitations for complex parameters like Single Scattering Albedo (SSA) and chemical composition fractions, the Dual NN architecture successfully mitigated these issues. By decoupling the signals, the Dual NN recovered accuracy comparable to the complex physical models while remaining roughly twice as fast as the baseline physical mode.

References

- [1] Dubovik, O., D. Fuertes, P. Litvinov, A. Lopatin, et al., 2021: *A Comprehensive Description of Multi-Term LSM for Applying Multiple a Priori Constraints in Problems of Atmospheric Remote Sensing: GRASP Algorithm, Concept, and Applications*, *Frontiers in Remote Sensing*, 2, <https://doi.org/10.3389/frsen.2021.706851>.
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