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Synergy POLDER-CALIOP for the study of aerosol-above-cloud properties and their radiative impacts off the coast of Angola

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Aerosols impact the Earth's radiative budget and clouds and the effects of above cloud aerosols are particularly associated with high uncertainties (IPCC 2013). Therefore, it is prerequisite to improve the understanding of these situations for a better characterisation of the aerosol effects in climate models.
The objective is to study the impact of aerosols on the cloud properties and their radiative forcing. The presence of a semi-permanent stratocumulus cloud deck seasonally covered by large loads of biomass-burning aerosols transported from the African continent, makes the Southeast Atlantic region the perfect candidate to study the impact of above cloud absorbing aerosols. We consider the method based on the passive polarisation measurements provided by the POLDER instrument, the operational method developed for the space borne lidar CALIOP, and the CALIOP-based depolarisation ratio method (DRM). By analysing the consistency between the aerosol above clouds (AAC) retrievals from these passive and active satellite measurements, we find good agreement between DRM and POLDER AOT retrievals when the microphysics of the aerosols is well defined (such as biomass-burning aerosols) and when the aerosol layer is detached from the cloud. These results give confidence in our ability to measure the properties of AAC over the South Atlantic region.
We focus on a sample area located off the coast of Angola for a period where the loading of biomass-burning aerosols covers a wide range. We generate a database containing aerosol and cloud properties retrieved with POLDER (including the absorption of AAC) and collocated ERA-Interim meteorological profiles along the CALIOP track, which provides the vertical profiles of clouds and aerosols. This synergy is used in radiative transfer calculations in the visible and thermal infrared domains. We analyse the covariation between aerosol loading, cloud properties and meteorology, in case of high and low amounts of absorbing AACs. We find that aerosols warm significantly the layer where they reside. They come together with larger amounts of water vapor, which has an effect on the longwave cooling of the cloud top. These two cumulated effects could impact cloud processes, preserving the humidity of the cloud layer and inhibiting its vertical development. Our results show that under large loads of AACs, clouds become optically thicker, with an increase in liquid water path of 20 g.m-2 and their cloud top altitudes are lower by 100 m. These results do not contradict a semi-direct effect of above cloud aerosols; however, we are still cautious in attributing the observed effects on clouds to aerosols. The study of different time periods and other sample areas may improve the understanding of these results. Flux measurements in the visible and infrared domains, along with aerosol and water vapor properties recently acquired during the airborne campaign AEROCLO-sA in Namibia can also be used to validate our flux estimations realised at different levels in the atmosphere.