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Separating the role of aerosol and meteorological factors in modulating marine boundary layer cloud characteristics in the Indian Ocean

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Aerosol-cloud interaction is the largest source of uncertainty in quantifying the anthropogenic climate forcing (Boucher et al., 2013). Climate models have large discrepancy in cloud characteristics and resulting feedback (Lauer and Hamilton, 2013). Variability of cloud macrophysical and microphysical properties is influenced by both meteorology and aerosols. For this study cloud and aerosol parameters for fifteen years (Mar 2000 – Feb 2015) from Moderate Resolution Imaging Spectroradiometer (MODIS) and Modern-Era Retrospective analysis for Research and Applications Version 2 (MERRA-2) reanalysis products are analyzed. Changes in cloud top pressure (CTP) and cloud fraction (fc) in view of changing aerosol optical depth (tau) are examined as follows.

(dlnfc/dlntau) * (dlnCTP/dlnfc) = dlnCTP/dlntau + Residuals

(dlnfc/dlntau) depicts the aerosol indirect effect. A positive change in fc implies increase in cloud lifetime in polluted condition; however the same may occur due to favorable meteorological conditions. The term (dlnCTP/dlntau) represents the aerosol mediated change in CTP or in other words the aerosol invigoration process. The change in CTP w.r.t. change in fc (dlnCTP/dlnfc) depends on the meteorological condition and therefore, if the changes in CTP and fc can be explained only in terms of , the ‘residual’ term in the equation should be zero. A non-zero ‘residual’ term implies role of meteorology with a larger value indicating larger role of meteorology. The fc is found to be most sensitive to change in during the monsoon season. In both AS and BOB, the slope is larger for the monsoon season relative to winter and post monsoon, as the meteorological forcing is larger in monsoon. In all seasons, it is more sensitive over the AS compared to BOB and SIO. On the other hand, the slope of CTP-fc are more or less similar across the region and season. The slopes of CTP- tau are smaller in the monsoon season compared to the winter and post monsoon suggesting larger role of aerosols in the winter season in modulating cloud evolution. Further the results from MODIS datasets are also compared with MERRA-2 reanalysis datasets with speciation in aerosol types majorly anthropogenic, sea salt and dust.

Keywords: Aerosol-cloud interaction, aerosol indirect effect.