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Impact of aerosols on marine cloud microphysics over the Indian Ocean using satellite data.

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Aerosol-cloud interaction is the one of the least understood and largest sources of uncertainty in quantifying climate forcing. Despite progress, the problem remains unresolved because of the buffering effect of meteorology and therefore it is suggested to separate the meteorological forcing from aerosol forcing focusing on different cloud types (Stevens and Feingold 2009). However, most of the previous studies on aerosol-cloud interaction over the Indian Ocean (including INDOEX) are limited to either one particular season or short period. We examine relationships between aerosol and cloud parameters using MODIS data sets for 15 years (2000-2015) period over Indian Ocean. We separated the meteorological forcing from aerosol forcing. In both the Arabian Sea (AS) and Bay of Bengal (BOB), the meteorological forcing is largest in the monsoon. In all the four seasons, cloud microphysical properties are more sensitive to aerosol optical depth (AOD) over the AS compared to BOB. Further analysis reveals presence of semi-direct effect in the winter season. Influence of aerosols on liquid water path (LWP) – cloud effective radius (R_{eff}) relation is quantified. Cloud albedo (R_c) dependency on LWP and R_{eff} is examined in view of changing aerosol load. Cloud drop growth is facilitated in presence of high moisture content. This is evident from the fact that R_{eff} is found to broadly increase with an increase in LWP in every season over Arabian Sea as well as over Bay of Bengal. It is also noted that R_{eff} is larger across a wide range of LWP in 'clean' condition (AOD $<$ 0.2) and it decreases in the 'moderately polluted' condition (0.2 $<$ AOD $<$ 0.4) and decreases further in the 'highly polluted' condition and (AOD $>$ 0.4). This clearly demonstrate that in more polluted conditions, growth of cloud drops are restricted. This is the evidence of classic aerosol indirect effect. However, we notice a saturation in the decrease in Reff with an increase in AOD beyond 0.4. The results provide robust observational evidence of aerosol-cloud interaction in the Indian Ocean region that can be helpful in evaluating the climate model performance in representing such complex interaction.

Keywords: Aerosol-cloud interaction, semi-direct effect, aerosol indirect effect.