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Observationally Constrained Estimates of Aerosol Indirect Radiative Forcing over Indian Ocean

Authors : Sofiya Rao, Sagnik Dey

Abstract : Aerosol-cloud-precipitation interaction continues to be one of the largest sources of uncertainty in quantifying the aerosol climate forcing. The uncertainty is increasing from global to regional scale. This problem remains unresolved due to the large discrepancy in the representation of cloud processes in the climate models. Most of the studies on aerosol-cloud-climate interaction and aerosol-cloud-precipitation over Indian Ocean (like INDOEX, CAIPEEX campaign etc.) are restricted to either particular to one season or particular to one region. Here we developed a theoretical framework to quantify aerosol indirect radiative forcing using Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol and cloud products of 15 years (2000-2015) period over the Indian Ocean. This framework relies on the observationally constrained estimate of the aerosol-induced change in cloud albedo. We partitioned the change in cloud albedo into the change in Liquid Water Path (LWP) and Effective Radius of Clouds (Reff) in response to an aerosol optical depth (AOD). Cloud albedo response to an increase in AOD is most sensitive in the range of LWP between 120-300 gm/m^2 for a range of Reff varying from 8-24 micrometer, which means aerosols are most sensitive to this range of LWP and Reff. Using this framework, aerosol forcing during a transition from indirect to semi-direct effect is also calculated. The outcome of this analysis shows best results over the Arabian Sea in comparison with the Bay of Bengal and the South Indian Ocean because of heterogeneity in aerosol spices over the Arabian Sea. Over the Arabian Sea during Winter Season the more absorbing aerosols are dominating, during Pre-monsoon dust (coarse mode aerosol particles) are more dominating. In winter and pre-monsoon majorly the aerosol forcing is more dominating while during monsoon and post-monsoon season meteorological forcing is more dominating. Over the South Indian Ocean, more or less same types of aerosol (Sea salt) are present. Over the Arabian Sea the Aerosol Indirect Radiative forcing are varying from -5 ± 4.5 W/m^2 for winter season while in other seasons it is reducing. The results provide observationally constrained estimates of aerosol indirect forcing in the Indian Ocean which can be helpful in evaluating the climate model performance in the context of such complex interactions.

Keywords : aerosol-cloud-precipitation interaction, aerosol-cloud-climate interaction, indirect radiative forcing, climate model
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