Satellite and model perspectives of dust transport and deposition across tropical Atlantic Ocean and North Pacific Ocean in recent decades

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Large amounts of dust emitted from North Africa, Middle East, and Asia transport across the tropical Atlantic Ocean and North Pacific Ocean to reach the Americas, exerting far-reaching impacts on air quality, radiation balance, clouds and precipitation, and ecosystems. Significant fraction of dust is deposited into the ocean basins along the transport routes, which has important implications for ocean biogeochemical cycles and climate. Given their routine sampling over decadal time scales with extensive spatial coverage, satellites are a suitable platform to observe such large-scale phenomena and its variability at a range of time scales. Because of differences in dominant source regions, atmospheric circulations, as well as clouds and precipitation, the trans-Atlantic and trans-Pacific dust transport and deposition can differ in many aspects. In this study, we investigate similarities and differences between the trans-Atlantic and trans Pacific dust transport and deposition by analyzing the decade-long record of aerosol measurements from three distinctive satellite sensors, namely CALIOP, MODIS, and MISR. Specifically, we focus on the characteristics of dust optical depth (DOD) and its trend in recent decade, dust vertical profile, dust deposition rate, and dust loss frequency (LF), as well as how these dust characteristics are associated with atmospheric circulations, clouds and precipitation. Satellite remote sensing observations of aerosol optical depth (AOD) and particle size (e.g., the fine-mode fraction from MODIS) and shape (e.g., the depolarization ratio from CALIOP and the non-spherical fraction from MISR) properties are used to derive DOD. Although a daily snapshot of DOD from satellites does not provide information on dust deposition, an aggregation of these DOD snapshots over a timeframe of month or season yields a spatial distribution of DOD, in which the DOD gradient along the transport route indicates the amount of dust being deposited into surface ocean. The veering of dust plume by winds is accounted for in the estimate of dust deposition rate by calculating the divergence of zonal and meridional dust mass flux. The LF, defined as dust deposition rate normalized by the atmospheric dust loading, is derived to measures how efficient the dust is removed from the atmosphere. These observational characteristics of trans-Atlantic and trans-Pacific dust transport and deposition are also compared with model simulations to shed light on possible model deficiencies.

Keywords: Dust, Remote Sensing, Modeling, Deposition, Transport

