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Abstract

Long-Term Changes in Aerosol Loading and Observed Impacts on Radiative Budget over the Middle-East †

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Abstract: Atmospheric aerosols play essential roles in regional energy balance, hydrological cycle, and air quality, thus greatly influencing the global climate and public health. Rapid economic expansion, industrialization, urbanization, and energy demand have significantly enhanced anthropogenic emissions over the Middle East (ME) that received the utmost scientific attention. Therefore, we present the temporal variability of atmospheric aerosols over the ME for a period of 15 years (2005–2019). Here, the long-term measurements from the Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua, Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP) onboard Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) and Clouds and the Earth's Radiant Energy System (CERES) on Aqua are analyzed in order to understand the spatio–temporal variability of aerosols and their impacts on radiation budget over the ME. On average, a significant increase in aerosol optical depth (AOD) trend is observed by ~0.01 per year over ME. The peak aerosol loading was observed in summer (March–September) followed by the winter (October–February). A similar trend was observed in the CALIOP-derived extinct aerosol coefficients over ME. In addition, MODIS retrievals are validated against the AErosol RObotic NETwork (AERONET)'s ground-based sun photometers. Overall, MODIS AOD showed good agreement against AERONET AOD, with ~70% of the retrievals falling within the expected error and high correlation coefficient ($R > 0.8$). Furthermore, the associated changes in clear-sky Shortwave (SW) radiative flux indicates the enhanced aerosol loading over ME further increases the surface cooling (~1.2 W m^{-2} per year) and atmospheric warming (~1.8 W m^{-2} per year). Overall, the results suggest that enhanced aerosol emissions have significantly impacted the regional energy budget over ME during 2005–2019. The assessment also demonstrates the potential of synergetic use of multi-platform measurements for climate system studies.

Keywords: aerosols; Middle East; MODIS; CALIPSO; extinction coefficients; radiation budget

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