Summertime dust storms over the Arabian Peninsula and impacts on radiation and atmospheric circulation.

Diana Francis¹, Jean-Pierre Chaboureau², Narendra Nelli¹, Juan Cuesta³, and Noor Alshamsi⁴

¹Khalifa University, UAE, Abu Dhabi, United Arab Emirates (diana.francis@ku.ac.ae)
²Laboratoire d’Aérologie, Université de Toulouse, CNRS, UPS, Toulouse, France
³Laboratoire Interuniversitaire des systèmes atmosphériques (LISA), CNRS and Université Paris-Est Créteil, Université de Paris, Créteil, France.
⁴New York University Abu Dhabi, P.O. Box 129188, Abu Dhabi, United Arab Emirates

This study investigates the underlying atmospheric dynamics associated with intense dust storms in summer 2018 over the Arabian Peninsula (AP); a major dust source at global scale. It reports, for the first time, on the formation of cyclone over the Empty Quarter Desert as important mechanism for intense dust storms over this source region. The dust direct and semi-direct radiative forcings are observed, for the first time over this source region, using high-resolution in-situ and CERES-SYN satellite observational data. The three-dimensional structure and evolution of the dust storms are inferred from state-of-the-art satellite products such as SEVIRI, AERIASI and CALIPSO. The dynamics and thermodynamics of the boundary layer during this event are thoroughly analyzed using ERA5 reanalysis and ground based observations.

We found that a large dust storm by Shamal winds led up, through radiative forcing, to cyclone development over the Empty Quarter Desert, subsequent dust emissions, development of convective clouds and rain. The cyclogenesis over this region initiated a second intense dust storm which developed and impacted the AP for 3 consecutive days. The uplifted dust by the cyclone reached 5 km in altitude and altered the radiative budget at the surface, inducing both significant warming during night and cooling during day. The dust load uplifted by the cyclone was estimated by the mesoscale model Meso-NH to be in the order of 20 Tg, and the associated aerosol optical depth was higher than 3. The model simulates reasonably the radiative impact of the dust in the shortwave but highly underestimated its impact in the LW.

Our study stresses the importance of the dust radiative forcing in the longwave and that it should be accurately accounted for in models to properly represent the impact of dust on the Earth system especially near source areas. Missing the warming effect of dust aerosols would impact both the weather and air quality forecast, and the regional climate projections.

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