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Lightning Activities near the Red Sea: Effects of Aerosols Morphology and Local Meteorology

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Lightning activity is one of the global natural hazards that pose significant risks to human life and numerous aspects of society's technological infrastructure. Understanding the linkage between aerosols present in the atmosphere and lightning activity is important to further advance our knowledge of the global lightning activity cycle.

Saudi Arabia and Yemen host one of the world's largest desert areas namely the Empty Quarter (al-Rubea Al-Khali). Moreover, Saudi Arabia is one of the world's largest oil exporters with many water desalination, petrochemical, and cement industrial plants, while large cities in both Saudi Arabia and Yemen have large construction projects and vehicle emissions. This increases both natural and anthropogenic aerosol loading in both countries. Meanwhile, the inland regions close to the Red Sea are one of the 500 hottest lightning regions in the world. This work identifies a possible correlation between lightning activity and aerosol loading.

Using data of individual lightning strokes from the Global Lightning Detection Network (GLD360), in conjunction with remote sensing measurements of the aerosol optical depth (AOD) obtained at 500 nm from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument onboard the Terra and Aqua satellites during active lightning days, we examine the evolution of lightning activity in two geographically and topologically different regions over Saudi Arabia and Yemen. One region extends inland to the desert (R1) and the other is in the southwest mountainous region that is close to the Red Sea (R2). In both regions, results from thunder days only indicate that lightning is strongly and positively correlated with the AOD loading, up to AOD ~ 0.8, after which the trend flattens or reverses direction. Results suggest the two opposite effects that aerosols could indirectly have on lightning activity are at play. The mountainous region exhibits a much stronger linear relation compared to the inland region. Furthermore, both regions exhibit seasonal and asynchronous lightning activity and AOD loading. The year 2018 in R1 shows very high lightning activity, likely linked to the 2018 intense dust storms in the region.