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Surface geochemistry controls 'hot-spots' of dust emission at Etosha Pan, Namibia

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Dust emissions from ephemeral playas are characterized by considerable spatiotemporal variability. It has proven extremely difficult to resolve the complex dynamics between climatic conditions and surface crust characteristics that control aeolian dust emissivity. In this study we used multitemporal satellite remote sensing and model reanalysis data to determine the climatic environments, surface sediment mineralogy, and hydrological context associated with the formation of ‘hot-spots’ of dust emission at Etosha Pan, Namibia. A twenty-year record (2000–2022) of dust source locations was established from MSG-SEVIRI and MODIS data, which enabled the identification of clusters of dust sources (‘hot-spots’). Using a time-series of Landsat 8-9 data we identified the surface mineralogical characteristics associated with the development of these ‘hot-spots’ of dust emission. These analyses were validated using reflectance spectroscopy and XRD analyses of sediment samples collected from the field. Linear spectral unmixing was applied to map the relative proportions of identified evaporite and clay mineral spectral endmembers from pixel spectra of Landsat image time-series. Results show that the development of emissive ‘hot-spot’ dust sources are associated with the formation of evaporite mineral crusts through the process of salt efflorescence initiated by wet season flooding events. Field experimentation using a portable wind tunnel combined with remote sensing analysis demonstrates that high winds in the dry season can break down this mineral crust exposing large quantities of fine and highly emissive sediments that are extremely susceptible to aeolian entrainment. Surface crust geochemistry, influenced by flooding history, therefore offers a first-order control on the development of ‘hot-spots’ of dust emission (Figure 1). The approach described here could be used at other ephemeral playas that are significant dust sources to elucidate hydrological and mineralogical controls on aeolian dust emission and to enhance regional-scale dust emissions modelling.

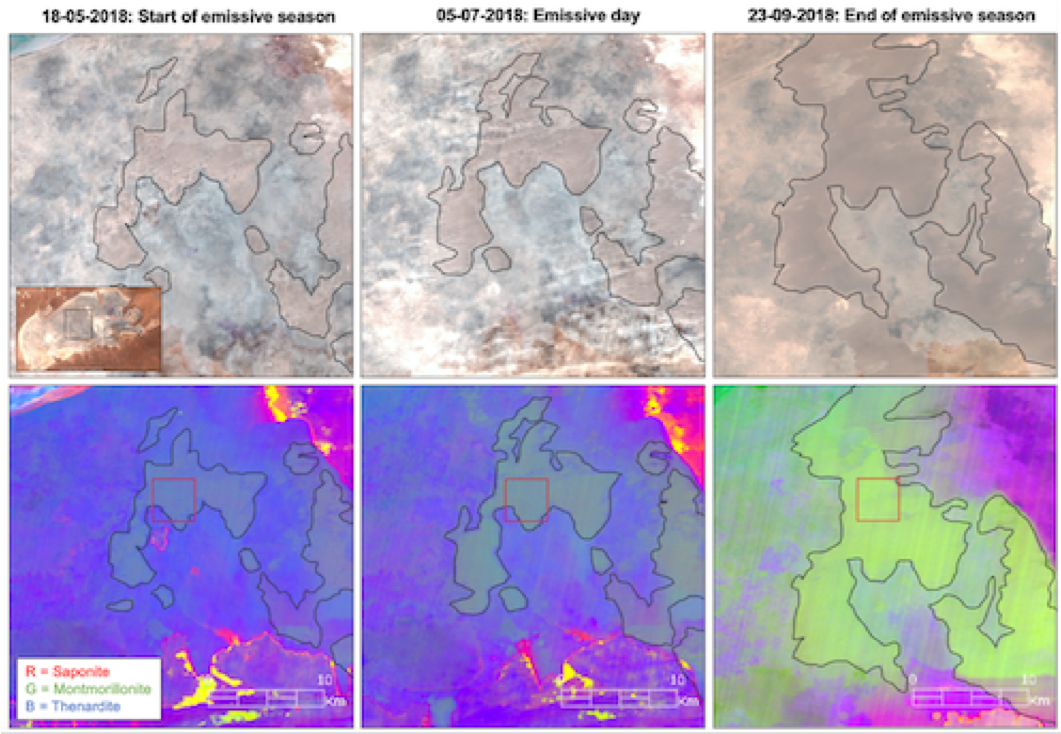

Figure 1. Landsat 8 OLI image time-series and linear spectral unmixing model outputs showing changes in crust mineralogy (abundance of saponite, montmorillonite, and thenardite) influenced by the flooding history of the surface and determining the location of emissive 'hot-spots' of dust emission (outlined) at Etosha Pan for the 2018 winter dust season (May to September).