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Weather pattern variability produces dust variability in the North American Great Plains

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Recently, several studies have investigated the relationship between the occurrence of dust in the North American Great Plains and factors such as precipitation, soil moisture, and vegetation. A complementary approach is to identify the specific weather patterns associated with dust occurrence. Doing so provides an alternative method by which one might forecast dust outbreaks, or understand the sources of observed dust variability.

In this study we make use of a previously published atmospheric classification (Evans, et al. 2017) that defined a set of weather states for the southern Great Plains to identify the specific weather patterns most responsible for dust in various parts of the central US. The classification defined 21 distinct weather states that included various stages of both warm and cold frontal passages, cold northerlies, anticyclones, and a variety of summertime patterns not associated with mid-latitude cyclones. We use the time series of weather state as a basis for compositing Suomi-VIIRS daily aerosol observations at 1^{o} resolution from 2012 - 2020, focusing on the aerosol retrievals classified as dust. By comparing states with warm fronts in different locations, we can see that warm fronts enhance both the intensity and frequency of atmospheric dust in the northern Great Plains, but that the strength of this effect is dependent on how far north the warm front has advanced. In contrast, cold fronts produce some limited atmospheric dust at their southern extents, but less dust through most of the Great Plains. The summertime patterns all feature deep convection, and show enhanced dust along the western edge of the plains, likely due to thunderstorms generated in the lee of the Rockies. Classification analysis also allows for the calculation of the fraction of observed dust due to each weather pattern. Comparing the annual occurrence of particular weather patterns with the annual occurrence of dust, we can learn that one particular summer pattern explains over 60% of the interannual variance of dust in the northwestern Great Plains, while the occurrence of particularly northward warm fronts can explain over 80% of the dust variance in Wisconsin and Minnesota.