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Is a change in roughness length the cause of the recent decrease in Sahelian dust emission?

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The huge quantity of mineral dust emitted annually from North Africa makes this area crucial to the global dust cycle. Once in the atmosphere, dust aerosols have a significant impact on the global energy and carbon budgets and on air quality. Previous studies have documented changes in the dust output from North Africa on inter-annual to decadal time scales, but the exact reasons for this variability are still a matter of debate.

This work uses long-term observations from seven Sahelian surface stations with almost continuous records and frequent dust storms between 1984 and 2010 to explore the trends in mean wind, dust uplift potential (DUP) and dust emission frequency (DEF). DEF is inferred from the present weather codes (WW) of SYNOP reports. The synchronous measurement of wind allows an estimate of a local dust-uplift threshold velocity. DUP is a novel diagnostic that takes into account the non-linear relationship between wind-speed and dust uplift assuming a constant threshold velocity. ECMWF ERA-Interim 10m winds are also used for comparison.

There is little evidence in the station data that the increase in vegetation and soil moisture has significantly increased the threshold velocity for dust uplift, suggesting a dominant control by atmospheric processes. Averaged over the seven stations, there is a significant decreasing trend in mean wind over the study period for all seasons, and even more so for DUP and DEF, which are highly correlated. ERA-Interim mean wind, analysed over an area encompassing the seven stations, however, shows a much weaker downward trend, largely confined to the cooler half of the year. It is hypothesized that this cool-season signal is caused by a downward trend in the North Atlantic Oscillation, which is correlated to wind and dust activity on an inter-annual basis during this time of year. The remaining large discrepancies between ERA-Interim and the station observations are unexpected and are thought to be related to recent wetter conditions in the Sahel through the following mechanisms: (A) Changes in Bowen ratio due to higher soil moisture levels reduce atmospheric turbulence, which has a larger negative impact on local wind-speed measurements than on grid box vector winds. (B) Increases in vegetation lead to increased surface roughness, which is not accounted for by ECMWF. This effect might have been enhanced by population increase around the measurement sites.