On the decadal scale correlation between African Dust and Sahel rainfall: the role of Saharan heat Low-forced winds

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To cite this version:
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By mass, aeolian dust is the most pervasive aerosol in the atmosphere. The presence of suspended dust affects the local energy balance through direct and indirect effects, modifies the hydrological cycle via radiative forcing and modification of cloud microphysical properties, and is a vehicle for the long-range transport of nutrients to global oceans and terrestrial land surfaces. North Africa is the world’s largest dust source; accounting for more than 55% of the global dust emissions. Long-term in-situ observations at and coral reef proxy and satellite have shown that dust emission from North Africa peaked during the mid-1980s and has followed a downward trend through at least the late 2000s. Studies have found dust cover over the Atlantic is anticorrelated with previous-year Sahelian precipitation. However, there are several aspects of such a theory that are not consistent. For example, satellite imagery suggests that the vast majority of dust-emitting regions lie to the north of the vegetated region of the Sahel. Here we reconcile this contradiction by showing that both Saharan surface wind fields over the major regional dust-emitting regions, and the northward propagation of the monsoon flow and thus Sahel rainfall, are forced by the thermodynamic state of a meteorological feature termed the Saharan Heat Low.

Data and Methods

The Saharan heat low (SHL)
The SHL is defined as the atmospheric thickness between the 700 hPa and 925 hPa levels, using geopotential height from ERA Interim reanalysis.

Precipitation
The Version 2 Global Precipitation Climatology Project (GPCP).

Dust aerosol optical depth
Retrieved from satellite radiation measurements from the Advanced Very High Resolution Radiometer (AVHRR).

Dust emission rates
Derived from Spinning Enhanced Visible and Infrared Imager infrared dust index images.

Winds
ERA Interim reanalysis

Results

Climatology (A) and anomaly (B) of precipitation and winds

Histogram count of 10m wind speed

Conclusion
We show that interannual variability in Sahelian rainfall, and surface wind speeds over the Saharan, are the result of changes in lower tropospheric air temperatures over the SHL. As the SHL warms an anomalous tropospheric circulation develops that reduces windspeeds over the Sahara and displaces the monsoonal rainfall northward, thus simultaneously increasing Sahelian rainfall and reducing dust emission from the major dust “hot-spots” in the Sahara.

Publications