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Understanding the long-term variability of African dust as recorded in surface concentrations and large-scale satellite observations

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Satellite observations are unique tools to investigate the high variability in space and time of African dust emissions and transport. Understanding the causes of this variability is of first importance in order to assess the impacts of atmospheric dust load on the climate system and environment. Currently, there is a lack of knowledge about the natural variability of dust emissions and transport as well as a lack of reliable estimates of the anthropogenic fraction of mineral dust.

Here we investigate the interannual variability of mineral dust over both north Africa and north tropical Atlantic using the most extensive long-term record of surface dust concentrations (SDC) at Barbados (daily measurements since 1966), along with the TOMS (Total Ozone Mapping Spectrometer)/METEOSAT VIS satellite Dust Optical Thickness (DOT) record covering the period 1979-2000. Despite their differences in spatial coverage, the two dust records are in good agreement over the 22 years of common operation, indicating that the Barbados measurements are representative of the year-to-year variability of dust export over the north tropical Atlantic during both winter and summer. The satellite DOT are used to assess the spatial and temporal characteristics of the impacts of climate factors, i.e., North Atlantic Oscillation (NAO) and Sahel drought on dust year-to-year evolution. The analysis shows a large regional impact of Sahel drought on dust emissions and transport both in winter and in summer. Additionally the influence of the NAO dominates the winter export and is more geographically limited to the eastern Atlantic north of 15˚N, and possibly some localized

source–regions (south Mauritania and Bodele depression).

Due to the strong influence of these natural climatic factors on the interannual variability of African dust loads, the question of a possible anthropogenic impact, due to human-induced desertification in the Sahel region, is more difficult to quantify and even to evidence. Here we search for such a human influence by removing the effects of both NAO and Sahel drought on the 35-years annual mean SDC measurements at Barbados and on the 22-years annual mean satellite DOT over both North Africa and tropical Atlantic. This approach shows a significant temporal trend that corresponds to an increase of 6 μg/m^3 (or a factor 2 considering a mean SDC value of 6 μg/m^3 in the late 1960's) in the 35 years Barbados dust record, and an increase of between 30 and 50% in the TOMS DOT over the north tropical Atlantic over the period 1979-2000. The TOMS DOT suggest that this intensification of dust export can be attributed to an intensification of dust emissions in a Sahel region centered on southern Mali affected by human-induced soil degradation.