Fifty Years of African Dust Studies in the Caribbean Basin: Linking Dust, Climate and Air Quality

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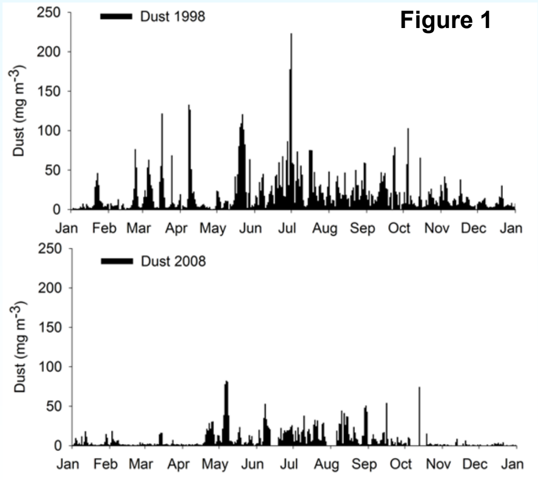
INTRODUCTION

Mineral dust has received increasing attention in climate assessments because it can affect climate through radiative and cloud processes and through ocean fertilization (by dust-iron) and, consequently, the carbon cycle [Fuzzi et l., 2015]. But the generation and transport of dust is itself a function of climate. Our aerosol studies show that the Caribbean Basin is greatly impacted by African dust. The 50 year record from Barbados [Prospero, 2014] shows a strong summertime maximum which has varied greatly over 50 years, most notably in the early 1970s and 1980s with the onset of drought in North Africa. Recent records from Cayenne show that during spring dust is carried to South America at rates comparable to those observed on Barbados in summer [Prospero et al., 2014]. In order to assess the impact of dust on the region we need a better understanding of the linkage of transport to the major climate drivers. To this end we require a integrated study of dust transport and deposition across the Caribbean Basin that can be interpreted in terms of processes over Africa and the tropical North Atlantic.

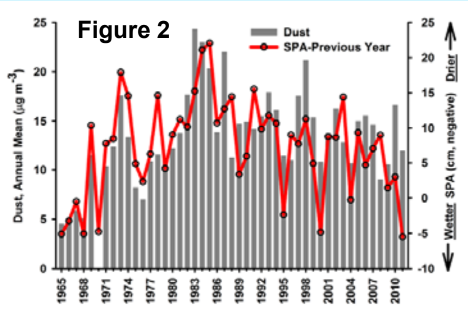
DUST VARIABILITY

At Barbados dust concentrations vary greatly on time scales ranging from days to decades. Fig. 1 shows daily dust concentrations from: 1998, a high dust year which happens to be a strong El Nino year; 2008 a low dust year. It is notable that the daily dust concentrations frequently exceed the World Health Organization 24-hr guideline for PM10 concentrations (i.e., particles under10 μm diameter), 50 μg m^{-3}.Thus in addition to our interests in the impact of dust on the physical environment, there is concern about human health.



DUST TRANSPORT AND AFRICAN CLIMATE

Fig. 2 shows Barbados annual mean dust concentrations from 1965 along with Sahel precipitation anomalies plotted as the arithmetic negative [Prospero, 2014]. Concentrations in the early-mid 1980s were several times greater than pre-drought. Transport has decreased since the 80s as rainfall increased in the Sahel but they remain higher than before the 1970s.



DUST LINKS TO LARGE-SCALE CLIMATE

While the Sahel is a major source, we know that other sources in the Sahara are of equal or greater importance. Thus the association with Sahel rainfall probably reflects associate changes in other parameters, especially wind speed [Ridley et al., 2014]. There have been many efforts to link dust transport to various climate metrics including the Atlantic Multidecadal Oscillation. This is complicated because these can be linked in a complex way [e.g., Evan et al., 2012] and in turn are affected by global-scale teleconnections.

CHARACTERIZING DUST-CLIMATE LINKAGES

In order to better understand these complex relationships we need to develop a program that more specifically links aerosol measurements to ocean properties in the tropical Atlantic and Caribbean. Of particular interest are dust and SST.

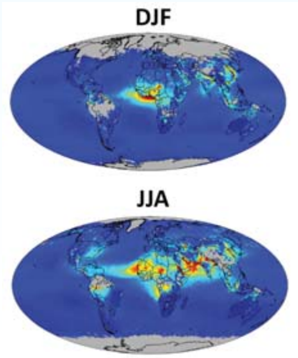
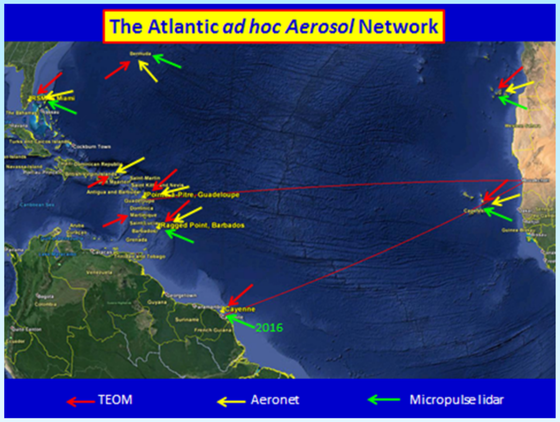


Fig 3: Satellite (SeaWiFS) aerosol optical depth shows the great seasonal change in sources and transport [Hsu et al., 2012]. Major sources are in the Sahel in winter and impact S. America. The Saharan sources impact the Caribbean and S. US in Summer.

THE ATLANTIC *ad hoc* AEROSOL NETWORK

To address these issues, we are establishing an *ad hoc* federated network of island and coastal stations (Fig. 4) that will measure a wide array of aerosol properties. These include high volume and real time (TEOM) aerosol samplers, multispectral optical depth (AERONET) and lidar aerosol vertical profiles [MPLNET] to 20km. These will be linked to satellite aerosol products and to global dust model products which will be available in real time on a web site. The models will provide dust (and other aerosol) forecasts that can be used to plan specific intensive field measurements (which could include deposition) and also to issue health alerts to the Caribbean Basin communities.



CONCLUSION

Dust plays a major role in climate forcing over the Atlantic and Caribbean. Because of the complex nature of the forcing, large-scale integrated measurements are required to test climate modes.

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