

Interactive comment on “Modulation of Saharan dust export by the North African dipole” by S. Rodríguez et al.

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This work examines the interannual variability of African dust export in summer using a 25-year long concentration dataset from the Izana Observatory, satellite data (Aerosol Index) and atmospheric re-analysis data. The study defines an index, the North African Dipole Index (NAFDI), as the difference of the 700 hPa geopotential height anomalies averaged over central Morocco (30–32 °N, 5–7 °W) and Bamako (10–13 °N, 6–8 °W). The authors conclude that an increase in the so-called NAFDI results in higher wind speeds north of the Inter-Tropical Convergence Zone that enhances dust export over the subtropical North Atlantic, increases the coarse to fine dust ratio, and is associated with higher rainfall over tropical North Africa and the Sahel.

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The results are interesting and the long-term data set compiled and used by the authors is a great contribution to the dust community. The main outcome of the paper, in my opinion, is that it shows that the summer dust interannual variability at Izana (and more generally the subtropical Atlantic) is strongly controlled by easterly winds in Algeria and southern Morocco, and this suggests that there are no significant changes in the sources affecting the region over the last 25 years. The paper is well written and deserves to be published in ACP. I have several comments and suggestions that could help improving the content and the structure of the paper. The authors may address them before publication in ACP:

1) The use of the term “North African Dipole” is, in my opinion, slightly confusing. The term dipole (and index) in climate science is used to understand teleconnections (long distance connections between the climate of two places on the globe), and to understand climate variability in large regions of the globe. The use of the term North African Dipole can be confused with a leading mode of variability in North Africa, particularly if it is announced in the title of the paper. This does not seem to be the case, or at least it is not shown in the paper. Therefore, I suggest the term North African dipole is avoided, at least in the title, as it can be misleading. Basically, this term (a pressure difference), is a regional measure of the intensity of the geostrophic flow in August in subtropical North Africa. The larger the intensity of the flow, the larger is dust emission and transport towards Izana. I suggest a title that avoids any confusion in this sense.

2) There is a paper by Doherty and co-authors (Doherty, O. M., N. Riemer, and S. Hameed (2008), Saharan mineral dust transport into the Caribbean: Observed atmospheric controls and trends, *J. Geophys. Res.*, 113, D07211, doi:10.1029/2007JD009171.) not cited nor discussed in the paper. Their results highlight that subtropical dust export in summer is partly controlled by the longitudinal displacement of the Azores High. Their analysis suggests that the westward movement of the Azores High greatly impacts the circulation of the tropical North Atlantic, enhancing easterly flow across the western Sahara and increasing dust transport. There are

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many similarities between the 2 papers. I believe this paper should be properly cited and discussed in detail in section 4.4.

3) I have some questions about the interpretation of the “Dipole” in section 4.4:

Page 26703 line 2: “This suggests that NAFD may also influence Sahelian dust emissions and consequently dust impacts in the tropical North Atlantic”

It is not clear here how it can be derived that the NAFD may influence Sahelian dust emissions.

Line 3: “The low MDAF in the Sahel and in the tropical rain band during high NAFDI summers supports this (Fig. 2b2). The association of NAFDI with the monsoon rains (Fig. 4c) and the implications for dust emissions and scavenging, accounts for the negative correlation of NAFDI with the MDAF over the Sahel and tropical North Africa (Fig. 4b),”

Figure 2 shows larger MDAF for high NAFDI summers than for low NAFDI summers. Yet, there is a negative correlation in the Sahel (Figure 4b). Also a bit surprising is the negative correlation between the NAFDI and MDAF in the main source areas in Algeria (in contrast to the high MDAF for high NAFDI summers and the lower MDAF for low NAFDI summers in Figures 2B1 and 2B2). You may perform a t-test to compare the means for low and high NAFDI years (Figures 2B1 and 2B2). This will allow showing the regions where a larger MDAF mean during high NAFDI summers (compared to low NAFDI summers) is statistically significant. (the same applies to all other fields)

Line 12: “This modulation of dust export and monsoon rains by the NAFDI may account for the results obtained. . .”

This sentence implies that the NAFDI modulates monsoon rains and this is not shown. Correlation doesn’t mean causation.

Line 21: “This suggests that variability in MEI and in the NAFDI may be connected to global climate oscillations in the subtropics, e.g. intensity in the global trade winds belt,

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as also suggested by the correlation between NAFDI and the zonal component of trade winds (Fig. 4a)."

This sentence is difficult to understand. How the correlation of the NAFDI and the zonal component suggest that the NAFDI may be connected to global climate oscillations in the subtropics? More detail is needed to support this suggestion.

Line 3: "The increase in dust concentrations recorded in the tropical North Atlantic at Barbados [...] since the mid 1970s has been linked to Sahelian droughts (Prospero and Lamb, 2003). Have similar changes occurred at subtropical Saharan latitudes? To address this issue we assumed that the "dustT vs. NAFDI relationship found for the period 1987–2012 period" is also valid for preceding decades, and used regression equation shown in Fig. 3a for estimating summer dustT at Izaña using the NAFDI from 1950 to 2012. We estimate persistent high dust concentrations (68 to 10 120 μgm^{-3}) at Izaña's subtropical latitude (Fig. 1c) from the mid-1950s to mid-1960s and relatively low dust concentrations from mid-1970s to mid-1980s (16 to 81 μgm^{-3}) (Fig. 1c). This NAFDI-based record at Izaña is markedly different from that based on measurements in Barbados which showed low dust concentrations prior to the onset of Sahelian drought in the early 1970s and high concentrations since then (Prospero and 15 Lamb, 2003). This suggests that multidecadal changes in the NAFDI may have modulated the latitudinal transport pathways of North African dust across the Atlantic. This is supported by our overall results which show that high values of the NAFDI enhance dust transport at subtropical latitudes and rainfall in the Sahel"

How can we respond to the first question using the NAFDI? The trends in Barbados where linked to drought and not to the strength of the winds.

The last suggestion on the multidecadal changes in the NAFDI seems a bit speculative. In any case, the trends in the NAFDI can be explored using the reanalysis. Is there any trend?

The last sentence states that the NAFDI enhances rainfall in the Sahel. This causation

hasn't been shown.

It is not clear how you relate Barbados and Izana. Is the Barbados variability in August related to the NAFDI?

This paragraph and more generally section 4.4 needs more detail and discussion in the context of previous studies (including those related to summer dust variability in Barbados). In particular, the results may be compared with those obtained by Doherty and co-authors. Nothing is said in the paper about the Azores High displacement, which seems to be a central aspect partly explaining the enhanced easterlies resulting in high dust years.

4) The main text includes 5 figures and there is a rather long supplement with 8 figures. The detailed description of the measurements may be kept in the supplement, but the main manuscript could benefit of part of the remaining supplementary sections (and figures). The main manuscript is quite short (some of the discussions are perhaps too concise) and could benefit from some of the text included in the supplemental material in addition to further discussion and clarification. For example, Figure S8B including the time series of the wind and their correlation with dust at Izana may be in the main paper (I believe this is a main result of the paper: long term Izana dust variability in summer is controlled by winds – the emphasis of the paper on the so-called NAFDI partly obscures this clear result). Parts of Figure S7 repeat information that is already shown in Figure 2 of the main manuscript. These aspects may be addressed.

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