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Interactive comment on "Aerosol Optical Depth retrievals at the Izaña Atmospheric Observatory from 1941 to 2013 by using artificial neural networks" by R. D. García et al.

Anonymous Referee #2 (RC, C3224-C3226, 2015):

This paper presents the reconstruction of the 73 year time series of the aerosol optical depth (AOD) at 500nm at the Izaña Atmospheric Observatory (IZO) located in Tenerife (Canary Islands, Spain). They reconstructed AOD records cover the period 1941 to2001 using artificial neural networks (ANNs). This record was validated against more recent measures of radiation. The authors conclude that "... the reconstructed AOD time series captures well the AOD variations and dust-laden Saharan air mass outbreaks at short-term and long-term time scales and, thus, it is suitable to be used inclimate analysis."This paper addresses an important issue, the changes in dust transport over long time periods and how these changes might be linked to climate. The paper is well organized and clearly written.

The general approach used in this paper seems reasonable. However I cannot properly comment on the appropriate use (or misuse) of ANN in this study. Nonetheless the testing of the results against direct measures of AOD seems to yield reasonable results.

The main product of this effort is encapsulated in Figure 6 - in particular 6c: Time series of the ANN AOD monthly medians in July in the period 1941–2009. This figure suggests that there were great changes in column dust concentration over there cord. Four periods are particularly interesting because of the high values of monthly median ANN AOD: a) 1941 to about 1950; b) 1968 to 1971; c) 1971 to 1976; d)1981 to about 1990. This record should be assessed in terms of changes of dust emission and transport from North Africa. There is considerable evidence that dust emissions are linked to rainfall, among other factors. Thus one could ask how this record relates to rainfall records in Africa. Unfortunately the only long term record sare for the Sahel region. See for example the Sahel Precipitation Index (SPI) from the Univ. of Washington Joint Institute for the Study of the Atmosphere and Ocean. (http://www.jisao.washington.edu/data_sets/sahel/)

Drought began abruptly in the late 1960 with one intense period in the early 1970. These second period in the 1980s was particularly strong and long lasting with devastating consequences for the population. Since the late 19980s rainfall has

increased and drought has ameliorated although rainfall is still less than the long term means.

The high values observed in Figure 6 during periods c) and d) are consistent with the SPI index. Also the peak values of ANN AOD during c) and d) are consistent with the general knowledge of dust transport variability to the tropical Atlantic. But if these two periods are consistent with links to rainfall, then it is difficult to explain the causes of period a) and b). Indeed the years between about 1950 to the late 1960s were quite "wet". In Figure 6, the 1950s were characterized by some of the lowest ANN AOD values in the record. But in 1967 AOD increases sharply to the high AOD in the record and remains high until 1971.

The high values during period a) are also puzzling. They are comparable to those seen during the peak of the drought in the 1980s. Yet the SPI was mostly average or above during that period. One might argue that WW2 was going on during the early part of this period. I recall reading reports that increased dust was observed in the Caribbean after intense tank battle in North Africa. This would only explain the first couple years, but one might argue that the soils were destabilized for some time after the battlesended.

In conclusion, the paper presents some interesting technique that could provide new data that is of importance to climate studies, in particular the variability of dust with climate. But as the paper stands, it really does not address that possible relationship or our general expectations. It could be that our expectations are wrong in which case they would be very wrong indeed. Also it could be argued that this paper is about "measurement techniques" which fits the general nature of the journal. My own cursory observations in this regard raises some puzzling questions which would seem to question the validity of the technique. I would not expect the authors to fully explain these contradictions, but they should at least address them to some degree. What short comings in their procedure might lead to such a finding? Are there any direct meteorological observations at IZO that could support the increased occurrence of increased dust events during the wet phases in Africa?. What would Figure 6c look like with a plot of ANN AOD with visibility alone and coupled with wind sector partitioning? With observations of suspended dust? Etc.

Authors:* *We appreciate the comments and suggestions of the Referee.

The purposes of this technical paper are to firstly present the tools and methodology needed to reconstruct the long-term AOD time series at Izaña Observatory and, secondly, to validate it with independent AOD measurements and historical meteorological observations. The results obtained by the comprehensive validation study done allow us to conclude that the reconstructed AOD time series captures well the AOD variations and dust-laden Saharan air mass outbreaks at short-term and long-term time scales.

Once this quality assessment is done and shown in this technical study, we totally agree with the Referee on the great potential of the reconstructed AOD time series for climate studies and, in particular, for assessing the inter-annual and decadal variability of dust with climate. Hence, at the present, we are working on a second manuscript where we analyze the air mass flow patterns driving the Saharan mineral dust exports over the subtropical North Atlantic since the 1940s and how the frequency and intensity of dust events have changed over time. These changes in meteorological patterns can also modulate changes in the activation dust sources in North Africa. To do so, we compare the ANN AOD time series with meteorological fields over the North Sahara (e.g. geopotential height or wind patterns at different pressure levels) and with different climatic indices, such as AMO (Atlantic Multidecadal Oscillation), SPI (Sahel Precipitation Index) or MEI (Multivariate ENSO Index). The apparent contradictions between our ANN AOD time series and the SPI, mentioned by the Referee, will be analyzed in deeper in this scientific paper, since many factors might be involved. For example, Prospero and Lamb (2011) found that there are periods in which the anti-correlation between dust concentrations and SPI is not consistent. This topic is also discussed in Rodriguez et al. (2015). Thereby, these authors doubt that SPI always module the annual variations in the concentrations of dust. Horizontal visibility is a not questionable observation as the sole cause of its reduction at the Izaña high mountain station in summertime is the presence of mineral dust from the Sahara, which is confirmed by the more concurrent higher frequency of air masses from the second quadrant, originated in Northern Africa. However, this scientific analysis is beyond the scope of this technical manuscript and will be addressed in the scientific paper mentioned before. We would like to take advantage of this opportunity to offer the Referee to participate in this study. We think his/her suggestions will significantly improve our analysis.

Regarding other direct meteorological observations at IZO that could support the increased occurrence of dust events during the wet phases in Africa, the unique records identifying Saharan dust events, available since 1941, are the number of days in which the meteorological observers reported presence of dust in suspension (05-06 SYNOP codes, WMO, 1998) and the wind records when the wind blows from the second quadrant (90°-180°). Usually both situations occur at the same time, allowing us to conclude that the origin of the dust outbreaks recorded at IZO is the Saharan desert. For that reason, these two independent meteorological records were used to validate the reconstructed ANN AOD time series at IZO. As shown in the manuscript, the agreement between those records and the estimated ANN AOD is rather good: Pearson coefficient (R) of 0.89 between the number of days with ANN AOD≥0.20 and the number of days with 05-06 SYNOP codes (see Figure 6a and 6b of manuscript), and R of 0.86 between the monthly ANN AOD time series and the monthly percentage of time the wind blows from the second quadrant at IZO (see Figure 6c of manuscript). Regarding Figure 6c, since the visibility has been used as input parameter in the ANNs, it is not suitable to be used in the validation of our ANN AOD time series. However, the figure below shows the representation recommended by the Referee, where we can see that there is a clear anti-correlation between ANN AOD and horizontal visibility (R -0.88), as expected. Also, we added the time series of the percentage of time the wind blows from the second quadrant (E-S; 90°-180°).

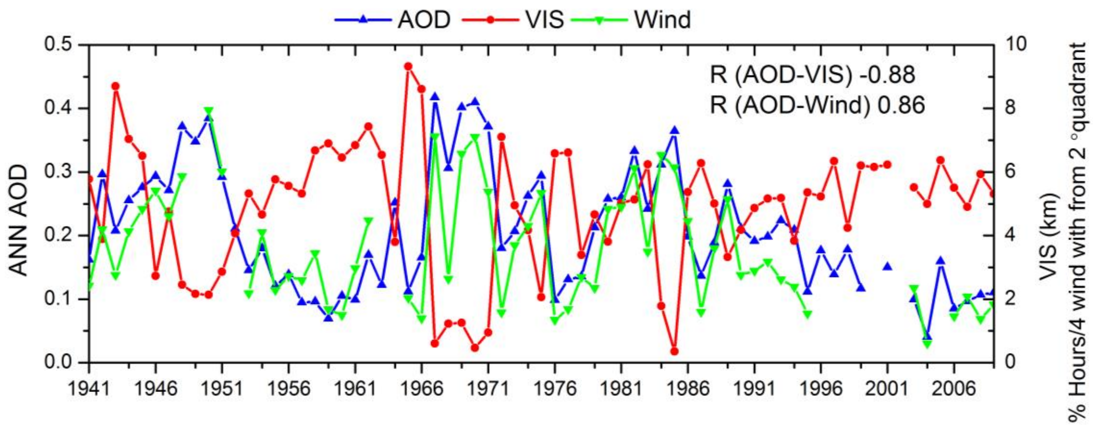

Figure 1. Time series of the ANN AOD monthly medians (blue line, left axis) at 500 nm, monthly medians of horizontal visibility in km (red line, right axis) and monthly percentage of time the wind blows form the second quadrant (E-S; 90°-180°) divided by 4 at IZO for July in the period 1941-2009 (green line, right axis). R indicates the Pearson coefficient.

References

Prospero, J.M., and Lamb, P.J.: African Droughts and Dust Transport to the Caribbean: Climate Change Implications, Science Vol 302, pp 1024-1027, 2014.

Rodríguez, S., Cuevas, E., Prospero, J. M., Alastuey, A., Querol, X., López-Solano, J., García, M. I., and Alonso-Pérez, S.: Modulation of Saharan dust export by the North African dipole, Atmos. Chem. Phys., 15, 7471-7486, doi:10.5194/acp-15-7471-2015, 2015.