An empirical relationship to estimate mineral dust concentration from visibility observations

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Northern Africa is the largest source of emission of mineral dust into the atmosphere. Mineral dust has a significant effect on human health and a strong interaction with the climate system. The main impact of mineral dust on the economy is related to visibility reduction, especially affecting air and ground transportation. It is necessary to characterize and quantify the mineral dust over the source regions to better understand the dust cycle and to assess its impacts.

Near dust source regions, there is a huge lack of PM10 (particulate matter with diameter less than 10 micrometers) measurements. Moreover, satellite remote sensing techniques have significant limitations over highly reflective surfaces, such as deserts, and therefore, provide limited performance over dust source regions. Due to all these limitations, given that meteorological stations provide a good spatial distribution and temporal resolution near dust source regions, we use visibility observations provided by meteorological stations as an alternative tool to characterize and quantify the concentration of mineral dust in Northern Africa.

The first goal is to derive an empirical relationship between PM10 concentration and horizontal visibility at Izaña Observatory (IZO, 28.30ºN, 16.49ºW, 2367 m a.s.l., under free troposphere conditions). The second goal is to assess whether this empirical relationship can be used to derive PM10 concentrations under desert conditions in North Africa.

In the first part of this work, summer data from the period 2005-2010 measured at IZO were used to determine the empirical relationship between PM10 concentration and visibility. The analysis was restricted to the summer months at IZO, because Saharan dust intrusions over IZO mainly occur during this season.

In an attempt to avoid fog or rain events, we excluded from calculations observations with relative humidity higher than 75% or any reported precipitation. Additionally, we used aerosol optical depth and Ångström exponent (α) from a collocated AERONET station to avoid events with dominant marine or anthropogenic aerosol, according to *Basart et al (2009)*.

A good empirical relationship to estimate PM10 at IZO from visibility data was found. Preliminary tests indicate that, in comparison with other equations found in the literature *D'Almeida (1986)* and *Shao et al (2003)* for visibility and PM10 and *Ben Mohamed et al (1992)* for total suspended particles and visibility, our empirical relation improves the quality of the fit.

In the second part of this work, in order to evaluate the performance of the derived empirical relationship in Northern Africa, the equation was tested for Sahelian stations reporting PM10 data: Baninzoumbou in Niger, Cinzana in Mali and M'Bour in Senegal, from the AMMA (African Monsoon Multidisciplinary Analysis) network, described by *Marticorena et al (2010)*.

Our resulting empirical relationship reproduces quite well the PM10 observations recorded at AMMA sites. It may be concluded that the empirical relationship found at IZO can be used as a new approach for estimating PM10 from horizontal visibility measurements from meteorological stations in Northern Africa.

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