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A physically-based approach for deriving aerosol optical depth from sunshine duration measurements in cloud-free conditions

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The accurate knowledge of the historical evolution of aerosol optical depth (AOD) has become of a great interest to the scientific community in order to tackle questions related to the reduction of the largest uncertainty in the projections of climate change or the role played by atmospheric aerosols in the dimming/brightening phenomenon occurring since the mid-20th century. A physically-based approach has been developed for deriving AOD from long time–series of sunshine duration (SD) measurements. In addition to the daily SD measurements, the approach uses daily total column water vapor and ozone from the global ECMWF re-analysis over the period 1900–2010 and the established seasonal variability of burning threshold as inputs.

The study is carried out over ten stations in Europe from the European Climate Assessment & Dataset (ECA&D) providing SD and cloud cover measurements collocated with AErosol RObotic NETwork (AERONET) stations providing AOD measurements. The approach exhibits a similar or better performance than two earlier developed and published state-of-the-art methods when compared to AERONET AOD serving as reference. The reconstructed AOD from this new approach shows a comprehensive seasonal variability and it improves the detection of the signal induced by aerosol events such as volcanic eruptions. In addition, the decadal variations of atmospheric aerosols and associated increase and decrease of AOD over the periods 1960–1984 and 1985–2010, respectively, are in good agreement with the dimming/brightening phenomenon.