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A climatology of fine absorbing biomass burning, urban and industrial aerosols detected from satellites

Nikoleta Kalaitzi (1), Nikos Hatzianastassiou (1), Antonis Gkikas (2), Christos D. Papadimas (1), Omar Torres (3), Nikos Mihalopoulos (4,5)

(1) University of Ioannina, Laboratory of Meteorology, Department of Physics, Ioannina, Greece (nhatzian@cc.uoi.gr), (2) Earth Sciences Department, Barcelona Supercomputing Center, Barcelona, Catalonia, 08034, Spain, (3) National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC), Greenbelt , MD 20771, USA, (4) Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete, Greece, (5) Institute for Environmental Research and Sustainable Development (IERSD), NOA, Athens, Greece

Natural biomass burning (BB) along with anthropogenic urban and industrial aerosol particles, altogether labeled here as BU aerosols, contain black and brown carbon which both absorb strongly the solar radiation. Thus, BU aerosols warm significantly the atmosphere also causing adjustments to cloud properties, which traditionally are known as cloud indirect and semi-direct effects. Given the role of the effects of BU aerosols for contemporary and future climate change, and the uncertainty associated with BU, both ascertained by the latest IPCC reports, there is an urgent need for improving our knowledge on the spatial and temporal variability of BU aerosols all over the globe.

Over the last few decades, thanks to the rapid development of satellite observational techniques and retrieval algorithms it is now possible to detect BU aerosols based on satellite measurements. However, care must be taken in order to ensure the ability to distinguish BU from other aerosol types usually co-existing in the Earth's atmosphere. In the present study, an algorithm is presented, based on a synergy of different satellite measurements, aiming to identify and quantify BU aerosols over the entire globe and during multiple years. The objective is to build a satellite-based climatology of BU aerosols intended for use for various purposes. The produced regime, namely the spatial and temporal variability of BU aerosols, emphasizes the BU frequency of occurrence and their intensity, in terms of aerosol optical depth (AOD). The algorithm is using the following aerosol optical properties describing the size and atmospheric loading of BU aerosols: (i) spectral AOD, (ii) Ångström Exponent (AE), (iii) Fine Fraction (FF) and (iv) Aerosol Index (AI). The relevant data are taken from Collection 006 MODIS-Aqua, except for AI which is taken from OMI-Aura. The identification of BU aerosols by the algorithm is based on a specific thresholding technique, with AI$\geq$1.5, AE$\geq$1.2 and FF$\geq$0.6 threshold values. The study spans the 11-year period 2005-2015, which enables to examine the inter-annual variability and possible changes of BU aerosols. Emphasis is given on specific world areas known to be sources of BU emissions. An effort is also made to separate with the algorithm the BB from BU aerosols, aiming to create a satellite database of biomass burning aerosols. The results of the algorithm, as to BB aerosols and the ability to separate them, are evaluated through comparisons against the global satellite databases of MODIS active fire counts as well as AIRS carbon monoxide (CO), which is a key indicator of presence of biomass burning activities.

The algorithm estimates frequencies of occurrence of BU aerosols reaching up to 10 days/year and AOD values up to 1.5 or even larger. The results indicate the existence of seasonal cycles of biomass burning in south and central Africa as well as in South America (Amazonia), with highest BU frequencies during June-September, December-February and August-October, respectively, whereas they successfully reproduce features like the export of African BB aerosols into the Atlantic Ocean.