Geophysical Research Abstracts
Vol. 20, EGU2018-16939, 2018
EGU General Assembly 2018

Aerosol layer height from OMI and neural network – Evaluation and possibility of a 13-year time series?

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Sunlight scattering and absorption by aerosols perturb the atmospheric radiation. This brings both scientific and technical challenges to the research community. Aerosols are an important player in the climate system (Boucher et al., IPCC report, Chapter 5: Clouds and aerosols, 2015), and also affect satellite measurements of reflected sunlight. Because long-time series of OMI trace gas observations are so crucial for analysing the air pollution trends between urban and regional scales, the uncertainties due to aerosols must be reduced. While, overall, the horizontal distribution of aerosol optical thickness (AOT) can be relatively well described, uncertainties in aerosol layer height (ALH) significantly contribute to the overall uncertainty. In the absence of clouds, ALH remains the most important error source on the observations of trace gases in the troposphere (e.g. NO_2, HCHO, SO_2) from UV-Vis air quality space-borne sensors over areas dominated by high AOT (i.e. > 0.5), and absorbing particles (Krotkov et al., 2008; Boersma et al., 2011; Barkley et al., 2012; Hewson et al., 2015; Castellanos et al., 2015; Chimot et al., 2016). Because atmospheric models still have large uncertainties on the vertical distribution of aerosols the use of passive satellite measurements with global coverage, such as OMI, becomes advantageous.

We have developed a unique Multilayer Perceptron Neural Network (NN) algorithm (i.e. machine learning) to retrieve ALH from the OMI 477 nm O_2-O_2 visible absorption band and over cloud-free scenes (Chimot et al., 2017a). This band has high sensitivity to strong aerosol loading and has fewer challenges than other bands (e.g. O_2-A). This retrieval approach strongly benefits from a synergy with MODIS as prior AOT information is needed.

We will present the evaluation of the OMI ALH performances over cloud-free scenes. A 3-year time series (2005- 2007) over the urban and large industrialized area of north-east China shows accuracy in the range of 260-800 m for scenes with AOT (550 nm) > 0.5 (Chimot et al., 2017a). In addition, comparisons with CALIOP aerosol observations demonstrate a high correlation of the spatial distributions (Chimot et al., 2017b). Furthermore, analyses of biomass burning episodes over South America and Russia suggest the strong potential of UV-visible passive satellite sensors to probe thick smoke layer height (Chimot et al., 2017b). Improvement of these retrievals can be obtained by reducing uncertainties on the assumed aerosol type and surface albedo. Preliminary yearly global maps of OMI aerosol layer height will be shown. Finally, we will discuss how this first development may support the correction of aerosol radiation effect on the retrieved OMI tropospheric NO_2 product, a key element of fossil-fuel emissions.

This work illustrates the possibility, in the future, to derive a long-time series aerosol layer height with global coverage and to analyse the aerosol radiative effects, over cloud-free scenes, from current and next-generation UV-visible satellites: e.g. OMI, TROPOMI on-board Sentinel-5-Precurosr, Sentinel-4, Sentinel-5. Moreover, the proposed machine learning technique is a promising asset for facing the challenge of big satellite data.