Aerosol and Cloud Influence on global surface UV irradiance retrieved from satellite sensors

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S. Kazadzis; Institute of Environmental Research and sustainable Development, National Observatory of Athens, Greece (kazadzis@noa.gr)

Ultraviolet (UV) solar radiation has a broad range of effects concerning life on Earth. It influences not only human beings, but also plants and animals. Furthermore, it causes degradation of materials and functions as a driver of atmospheric chemistry. In order to study the UV related effects and their implications thoroughly; accurate information is needed on UV radiation intensities over the globe. The main overall scientific goal of this project is to search for improvements in estimating surface UV from satellite measurements and thus to decrease the uncertainty related to the globally available surface UV data, which is of importance and interest for a wide discipline of UV related studies.

Since the network of ground-based UV measurements will inevitably remain sparse, satellite-based UV methods are needed to better document the geospatial distribution of the surface UV irradiance. Although the development of the algorithms to estimate the surface UV from satellite measurements has been on-going since the early 1990s, these algorithms still struggle with the same sources of uncertainty as ten years ago, namely the representation of aerosols and clouds in UV. Any possible improvements in the accuracy of the current global UV monitoring by satellite data would therefore be valuable for many purposes, e.g. for UV impact studies, estimates of long-term UV changes, scenarios of future ozone recovery and climatology. Moreover, there are additional products that would have importance, such as the actinic flux, critical input for UV driven photochemistry, that are not operationally available and only little has been done so far in order to assess the feasibility to derive them using satellite measurements. In all these aspects, the quality of satellite based UV measurements is of critical importance.

The main overall scientific goal of this project is to search for improvements in estimating surface UV from satellite measurements and thus to decrease the uncertainty related to the globally available surface UV data, which is of importance and interest for a wide discipline of UV related studies. The specific goals of the project are:

- *To evaluate the improvement of the satellite-based surface UV irradiance estimates that are achievable with the synergistic use of satellite aerosol and cloud related data*
- *To assess the improvement of the satellite-based UV estimates that is achievable with the use of aerosol climatology.*
- *To evaluate the effect of different factors affecting long term time series of solar UV irradiance.*
- *To propose algorithms in order to calculate and evaluate photolysis frequencies of O_1D and NO_2 in a global scale using satellite products.*

Ground based measurements from various spectroradiometric UV networks have been used together with satellite based atmospheric retrievals, in order to:

- Validate the current state of the art of satellite based UV irradiance calculations.

We have explored the possibility to use radiative transfer codes using satellite inputs of cloud and aerosol related optical properties in order to calculate the ground based UV irradiance. The results

have shown quite good agreement with the ground based UV spectroradiometric measurements. Their deviations were analysed and depend on spatial, temporal differences as long as on the use of specific aerosol and cloud parameters and not only optical depth. Satellite post processing algorithms for UV calculations have been assessed and results of this study showed that aerosol absorption accuracy and high measurement frequency, as long as the use of ancillary data as cloud indicators could be introduced. In addition, the effect of the wavelength dependence of the satellite inputs on the above calculations have been assessed, concluding that conversion of various optical atmospheric properties to the UV wavelengths is not an easy task but an important step for UV irradiance calculations. Accurate measurements of aerosol absorption in the UV wavelength region is still an open issue and while different approaches have been introduced to the literature, only few stations worldwide could provide such information with limited uncertainty.

- Build a climatology and analyse the UVB and UVA variability in different parts of the planet based on the variability of ozone, aerosol load and properties, cloud fraction and cloud properties.

In order to achieve this various atmospheric parameters have been used from ground based or satellite based sensors. The study examined the UV variability over selected sites based by the availability of UV spectroradiometric datasets (longer than 15 years). The analysis of UV variability was conducted in combination to total ozone, aerosol optical depth and cloud variability. The results suggest that last 20 year period over Canada, Europe and Japan can be divided into three sub-periods of scientific merit: The first period is the period perturbed by the Pinatubo volcanic eruption for which it is shown that excess volcanic aerosol might have enhanced by an additional 6% the “conventional” (+18%) amplification factor of UVB at ground level. The second period is characterized by a UVB increase caused by the synergy of ozone decline and tropospheric aerosol decline (brightening effect). The third period, which refers to the last 4-5 years, might provide for the first time significant statistical evidence indicating the slowdown of the upward trends observed before, over the sites studied where UVB sites seem to have passed maximum UVB exposure levels since about 2006.

Various aerosol climatology and related databases have been used lately for assessing their effect on incoming solar irradiance. Within this project we have investigated the effect of the aerosol variability with height and also their type on solar irradiance. Elevated dust aerosol loads over the greater Mediterranean area have an impact on the vertical distribution of the solar irradiance, though can affect directly the tropospheric chemistry related atmospheric reactions and the air quality of affected areas.

Within this project we have developed an algorithm that converts satellite based solar UV irradiance to photolysis frequencies of NO_2 and O^1D. Using two long term series data sets of NO_2 and O^1D photolysis frequencies (Finokalia, Greece and Mace Head, Ireland) we have validate this method and point out the major sources of uncertainties. Such radiation parameters are very rare to find them worldwide despite the fact that they play an important role in atmospheric photochemistry. A use of globally available satellite data with the help of our algorithm could provide the available data in order to be used on related studies.

Results of this project have been indirectly guide scientists of the host institute to propose and succeed in various ongoing projects related with: Global aerosol properties mapping, wavelength dependency of vertical aerosol properties from satellite missions and studies investigating the effect of aerosol loads to air quality of Athens, Greece area through the modification of the solar radiation field.