Assessing aerosol-related uncertainties in satellite-based retrievals of effective UV doses for the production of cutaneous vitamin D.

Theodora Stavraka[1,2,8], Ilias Fountoulakis[1,8], Konstantinos Eleftheratos[2,8], Panagiotis Nastos[2], Thomais Papazoi[1], Konstantinos Fragkos[3], Alkiviadis Bais[4], Katerina Garane[4], Andreas Kazantzidis[5], Alex Papayannis[6], Vassilis Amiridis[7] and Christos Zerefos[1,8,9,10]

[1] Research Centre for Atmospheric Physics and Climatology, Academy of Athens, Athens, Greece
[2] Laboratory of Climatology and Atmospheric Environment, Department of Geology and Geoenvironment, National and Kapodistrian University of Athens, Athens, Greece
[3] The Cyprus Institute, CARE-C, Nicosia, Cyprus
[4] Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece
[5] Laboratory of Atmospheric Physics, University of Patras, Rio, Greece
[6] Laser Remote Sensing Laboratory, Physics Department, National Technical University of Athens, Zografou, Greece
[7] Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, Athens, Greece
[8] Biomedical Research Foundation of the Academy of Athens, Athens, Greece
[9] Navarino Environmental Observatory (N.E.O.), Messenia, Greece
[10] Mariolopoulos-Kanaginis Foundation, Athens, Greece

First author e-mail: tstavraka@academyofathens.gr

Supplementary material:

Introduction/ Methodology / Results:

For this study, we used both ground-based and satellite-derived values of vitamin D–weighted UV radiation (VID UV). VID UV data from TEMIS [1] as well as from ground-based measurements from two Brewer spectroradiometers operating in Athens and Thessaloniki (#001 and #086 respectively), Greece have been used for the study. In addition, we used a climatology derived following a methodology similar to Fragkos et al. [2], based on CAMS optical properties (AOD, SSA, AE), total ozone from OMI, CMSAF-based cloud modification factors (CMF), and radiative transfer simulations with libRadtran (v.2.0.6). The measured or simulated spectral UV irradiance was weighted with the CIE (2006) effective spectrum for the production of vitamin D in the human skin [3,4].

Furthermore, we analyzed aerosol optical depth (AOD) using AERONET Level 2 data at 440 nm, and CAMS AOD at 550 nm, which was extrapolated to 440 nm using the 550–675 nm Ångström exponent (AE) from CAMS. The study period covers 2008–2021. The datasets were categorized into clear-sky conditions (“TEMIS Clear”, “CAMS Clear”), where cloud effects are not considered and all-sky conditions (“Brewer”, “TEMIS All skies”, “CAMS All skies”). The study focuses on Athens and Thessaloniki, the two largest cities in Greece.

Scatterplot results of VID UV are based on monthly averaged VID UV values. The different number of matched data pairs arise from limited availability of Brewer observation under both clear- and all-sky conditions.

For both cities, there is a very good agreement between the different VID UV datasets, particularly between CAMS Clear and TEMIS Clear, as well as between Brewer observations and the all-sky products (TEMIS and CAMS). CAMS Clear sky and TEMIS all sky values are generally higher than TEMIS Clear and Brewer observations, respectively. CAMS all-sky also overestimates VID UV relative to Brewer observations in Thessaloniki, whereas in Athens an opposite tendency is observed.

Trend analysis was performed using linear regression and indicates an overall increasing tendency in VID UV radiation at both cities. In Athens, the trends are between 0.07%/year and 0.32%/year depending on the dataset, but they are not statistically significant ($p > 0.05$), while in Thessaloniki, most of the datasets are statistically significant ($p < 0.05$) and trend varies from 0.01%/year and 0.68%/year depending on the dataset.

Finally, **the monthly climatology** shows that during autumn and winter, all datasets present similar values, while larger discrepancies are observed in summer. In Thessaloniki, all datasets tend to overestimate VID UV relative to the Brewer. In Athens all datasets overestimate VID UV relative to the Brewer except CAMS all-sky.

Regarding **the AOD analysis**, a statistically significant decreasing trend ($p < 0.05$) is observed over the study period for both stations, which seems to be the main driver of the VID UV trends. Both AOD time series (CAMS and AERONET) exhibit consistent temporal variability. Monthly mean AOD values are higher in Thessaloniki compared to Athens, while ground-based observations tend to underestimate satellite-derived values.

These results underline the significant role that aerosol variability can play in Mediterranean urban environments such as Athens and Thessaloniki in modulating UV radiation. Future work will focus on quantifying the contribution of different aerosol types, explaining inter-site differences, and assessing the evolution of these trends under future climate change scenarios.

References:

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