Evaluation of the Cyprus Erythemal Irradiance (UVI) Forecasting System Using One Year of Ground-Based, CAMS, and Satellite Ozone Data

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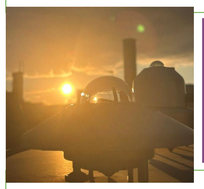
INTRODUCTION



Cyprus is characterized by some of the highest ultraviolet (UV) radiation levels in Europe, presenting a persistent challenge to public health. Despite these high levels of exposure, which are directly linked to increased incidences of skin cancers, ocular damage, and immune system suppression, the island has historically lacked a dedicated, high-resolution national UV Index (UVI) forecasting system. Furthermore, significant portions of the population do not consistently adhere to appropriate sun-protective measures. To address this critical gap and support both atmospheric research and solar energy applications, we developed the Cyprus Erythemal Forecasting System (CERYFOS). This platform provides the first localized, hourly UVI forecasts for Cyprus at a 0.1˚x 0.1˚resolution, aiming to serve as both a reliable scientific tool and an essential public health educational resource.

CERYFOS SYSTEM ARCHITECTURE

Radiative Engine: libRadtran simulations explicitly accounting for aerosol-radiation and ozone-radiation interactions. All-Sky Processing: High-resolution (2x2km) Cloud Modification Factors (CMFs) derived from the WRF Model. Key Inputs: Forecasted aerosol properties from CAMS, total ozone column (TOC) from TEMIS, and high-resolution elevation data from NOAA, cloudiness from WRF.

METHODOLOGY

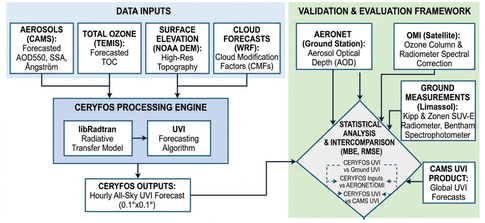
Aerosol Validation: Forecasted aerosol optical properties from CAMS were cross-verified against ground-based AERONET (Cimel Sun Photometer) measurements at 340 nm to assess input uncertainty.

Ozone Assessment: TEMIS ozone forecasts were compared with OMI Satellite overpass data to determine their impact on UVI performance and to correct radiometer spectral misalignment.

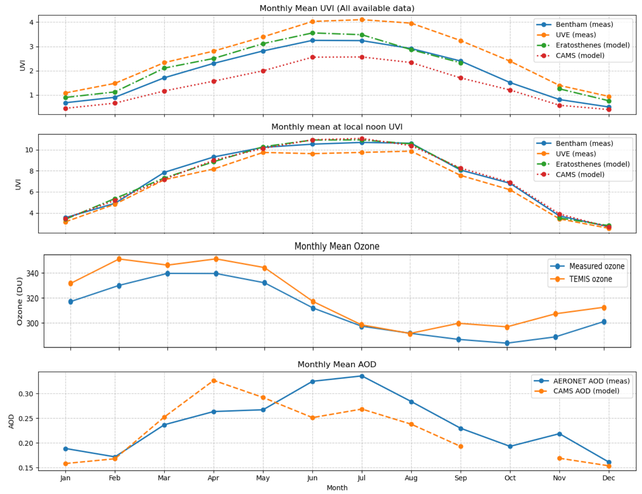
Ground-Based UVI Reference: Forecasts were evaluated against traceable, high-quality measurements from a Kipp & Zonen SUV-E radiometer and a Bentham DMc150 spectrophotometer.

Sky Conditions: All-sky camera (EKO ASI-16) observations were utilized to isolate clear-sky periods, allowing for a focused analysis of aerosol and ozone interactions versus cloud-affected performance.

Benchmarking: CERYFOS outputs were directly compared with global CAMS UVI products to quantify the added value of localized high-resolution modeling.



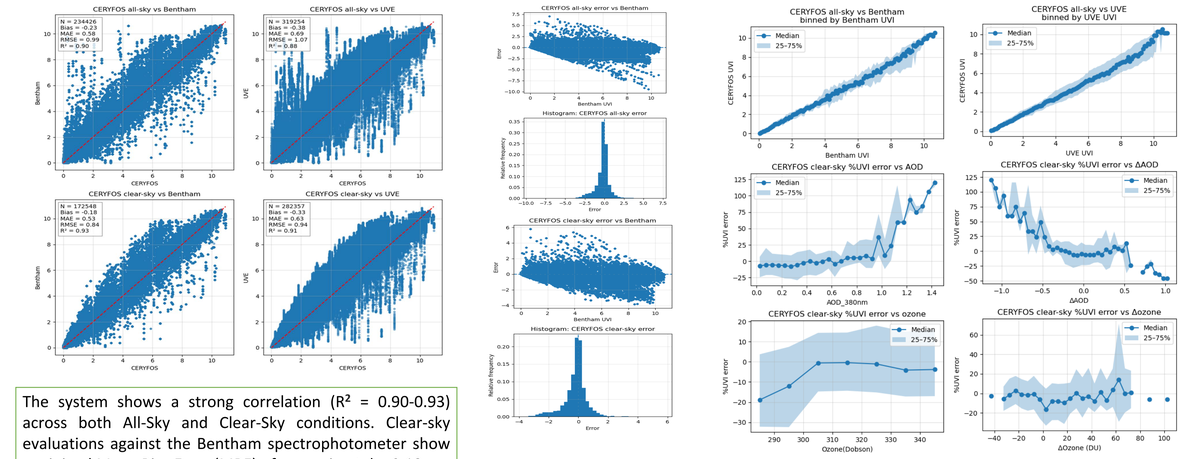
RESULTS & DISCUSSION



Evaluation of Model Inputs (Aerosols & Ozone)

- **Aerosol Optical Depth (AOD):** CAMS forecasts generally capture seasonal trends but frequently underestimate peak intensity during high-load dust events (e.g., June–July) compared to **AERONET** ground truth.
- **Total Ozone Column (TOC):** TEMIS ozone captures the same seasonal pattern as OMI but shows a consistent positive bias of about 5–15 DU.
- **Peak Intensity Accuracy:** At **local noon (**the period of highest health risk) the CERYFOS model (Eratosthenes) shows alignment with **Bentham** and UVE measurements, while the global CAMS model consistently underestimates peak UVI.

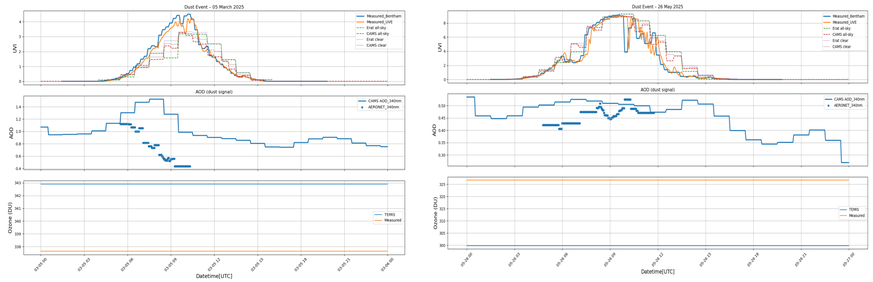
STATISTICAL PERFORMANCE - SENSITIVITY ANALYSIS & ERROR ATTRIBUTION



The system shows a strong correlation (R^2 = 0.90-0.93) across both All-Sky and Clear-Sky conditions. Clear-sky evaluations against the Bentham spectrophotometer show a minimal Mean Bias Error (MBE) of approximately -0.18.

UVI forecast error is highly sensitive to Aerosol Optical Depth (AOD). Percentage errors spike significantly when AOD exceeds 1.0. The model handles ozone-radiation interactions robustly, with error remaining flat across the measured ozone range (270–350 DU).

CASE STUDY: IMPACT OF EXTREME DUST EVENTS



Middle East Dust (05 March 2025): This event was characterized by high AOD values (>1.0) and a drop in UVI intensity. CERYFOS/Eratosthenes UVI successfully tracked the diurnal suppression of UV radiation, although minor discrepancies were observed during peak loading, linked to the temporal resolution of the CAMS aerosol forecasts.

Saharan Dust (26 May 2025): During this Saharan event, the system encountered highly variable dust concentrations. CERYFOS UVI demonstrated a dynamic response to these rapid fluctuations, aligning more closely with the Bentham ground truth than coarser global models.

Conclusion The evaluation of CERYFOS confirms that it provides a robust, high-resolution 0.1 x 0.1˚ forecasting service that captures the localized UVI dynamics of Cyprus with high statistical fidelity (R^2 > 0.90). By integrating WRF-derived cloud modification factors, the system effectively outperforms coarser global products, particularly in aligning with ground-truth measurements during peak solar intensity at local noon. However, sensitivity analysis and case studies of Middle Eastern (05 March) and Saharan (26 May) dust events reveal that the primary "bottleneck" for forecast accuracy remains the quality of external aerosol data. UVI errors scale sharply when AOD exceeds 1.0, reflecting the limitations of global CAMS aerosol forecasts during extreme events. While TEMIS ozone shows good agreement with measurements and contributes to stable radiative transfer performance, aerosol uncertainty remains the dominant source of error. Overall, this work highlights the importance of harmonized observations for improving national UV forecasting systems and supports the Harmonia initiative's objectives in advancing public health awareness and atmospheric research in the Eastern Mediterranean..

CONSORTIUM

AFFILIATED ENTITIES

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