

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



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## Introduction:

- Solar Ultraviolet (UV) radiation plays a key role in many chemical and biological processes, and affects significantly human health.
- Excessive UV exposure may lead to adverse health effects, including sunburns, skin cancer, and cataracts, whereas moderate exposure is beneficial, e.g., by supporting vitamin D production and promoting mental well-being, among other benefits.
- Solar UV radiation interacts with various atmospheric components before reaching the Earth's surface.
- Understanding these interactions is thus essential for accurately assessing UV exposure using modeled UV irradiance.

## Aim / Methodology:

The purpose of this study is to evaluate satellite- and reanalysis-based retrievals of the effective UV dose for the production of vitamin D (**VID UV**) in the human skin using ground-based measurements over Athens and Thessaloniki, Greece.

### 1) VID UV Datasets:

- VID UV climatology derived using a similar methodology with Fragkos et al., (2024), (CAMS optical properties – AOD, SSA, AE; total ozone from OMI; CMSAF-based CMF, libRadtran v.2.0.6 simulations)
- VID UV climatology from TEMIS
- VID UV from Brewer spectroradiometers #001 & #086 (Athens & Thessaloniki respectively)

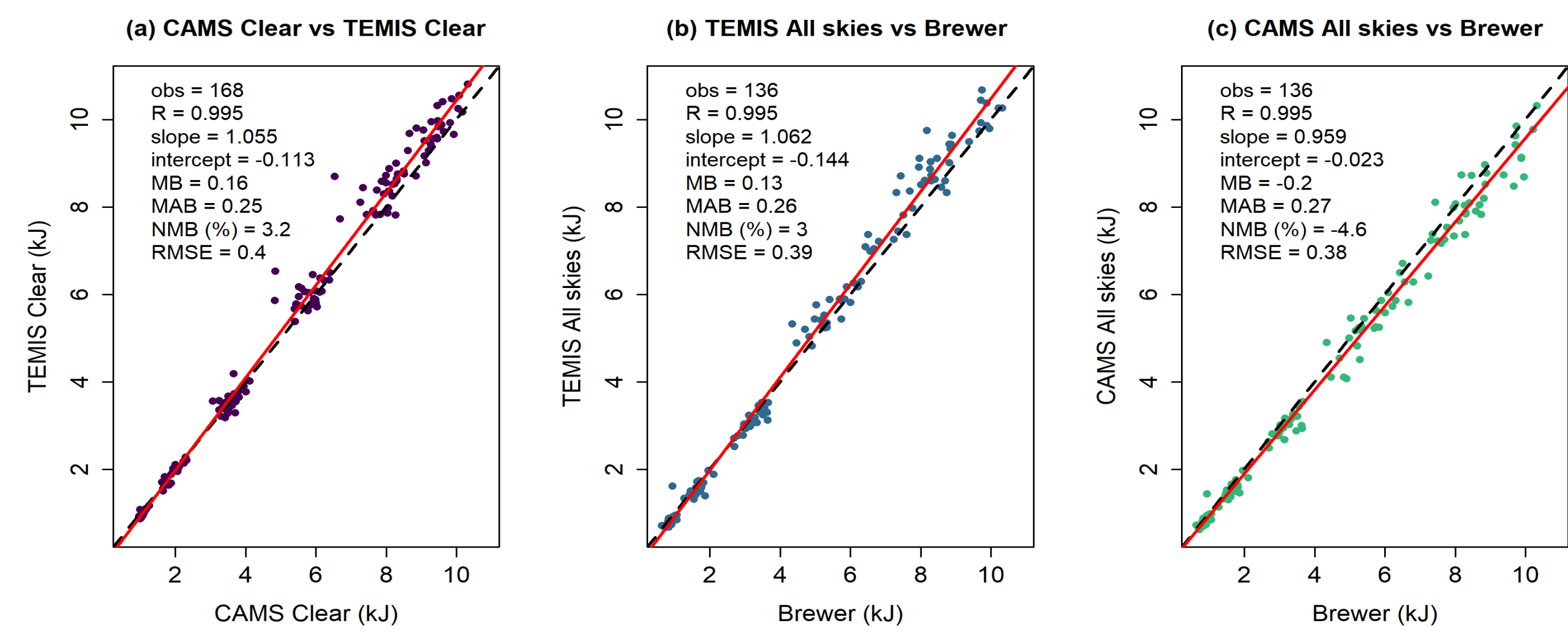
### 2) AOD Datasets:

- AERONET level 2 AOD at 440 nm
- CAMS AOD at 550 nm extrapolated to 440 nm using the 550 – 675 nm AE from CAMS

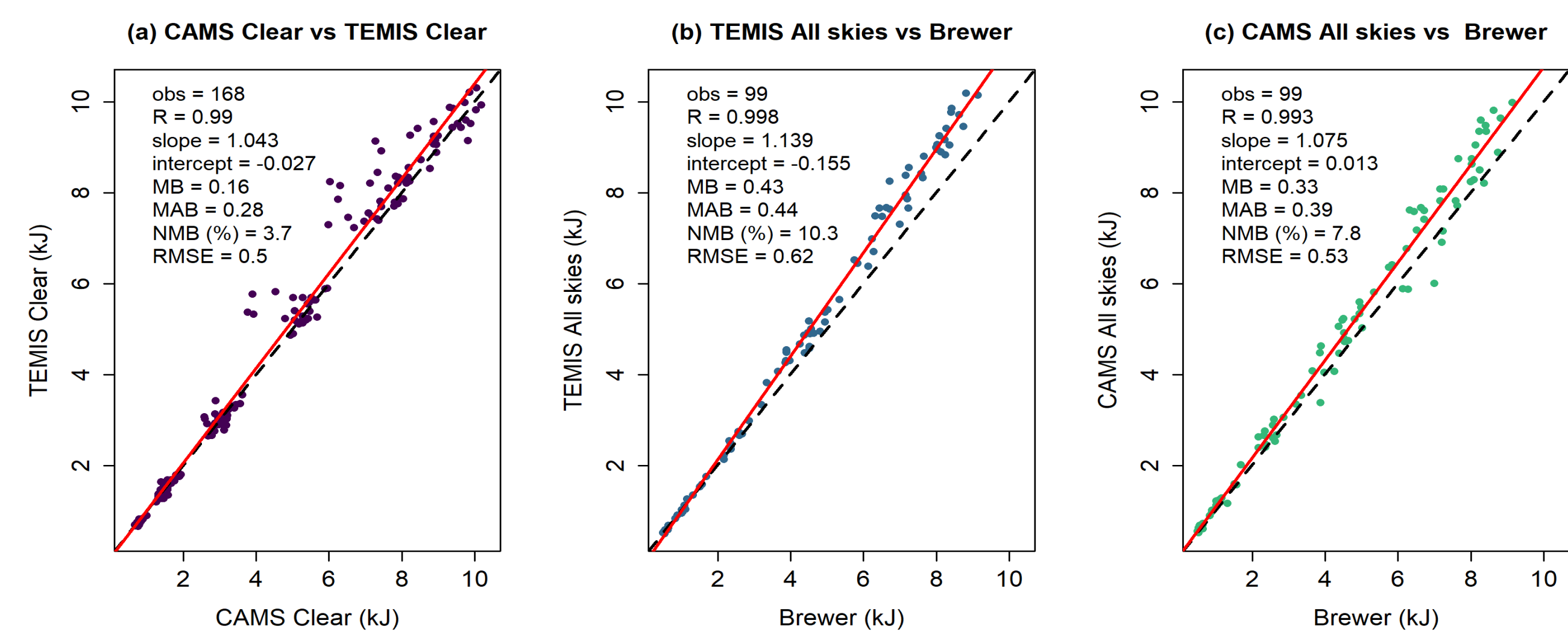
## Studied period:

The evaluation has been performed for the period 2008 - 2021.

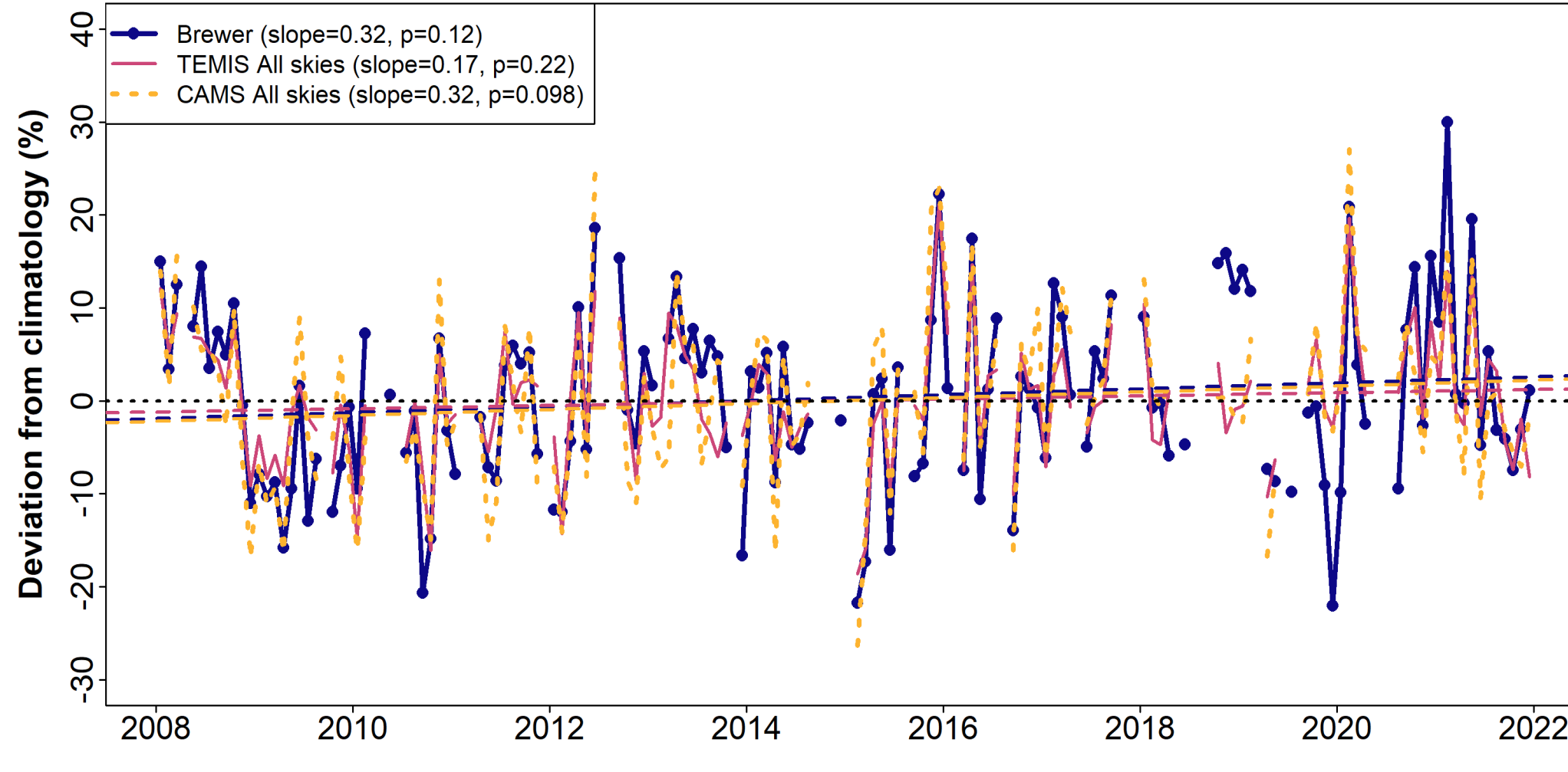
Comparison of VID UV datasets in Athens (2008 – 2021)



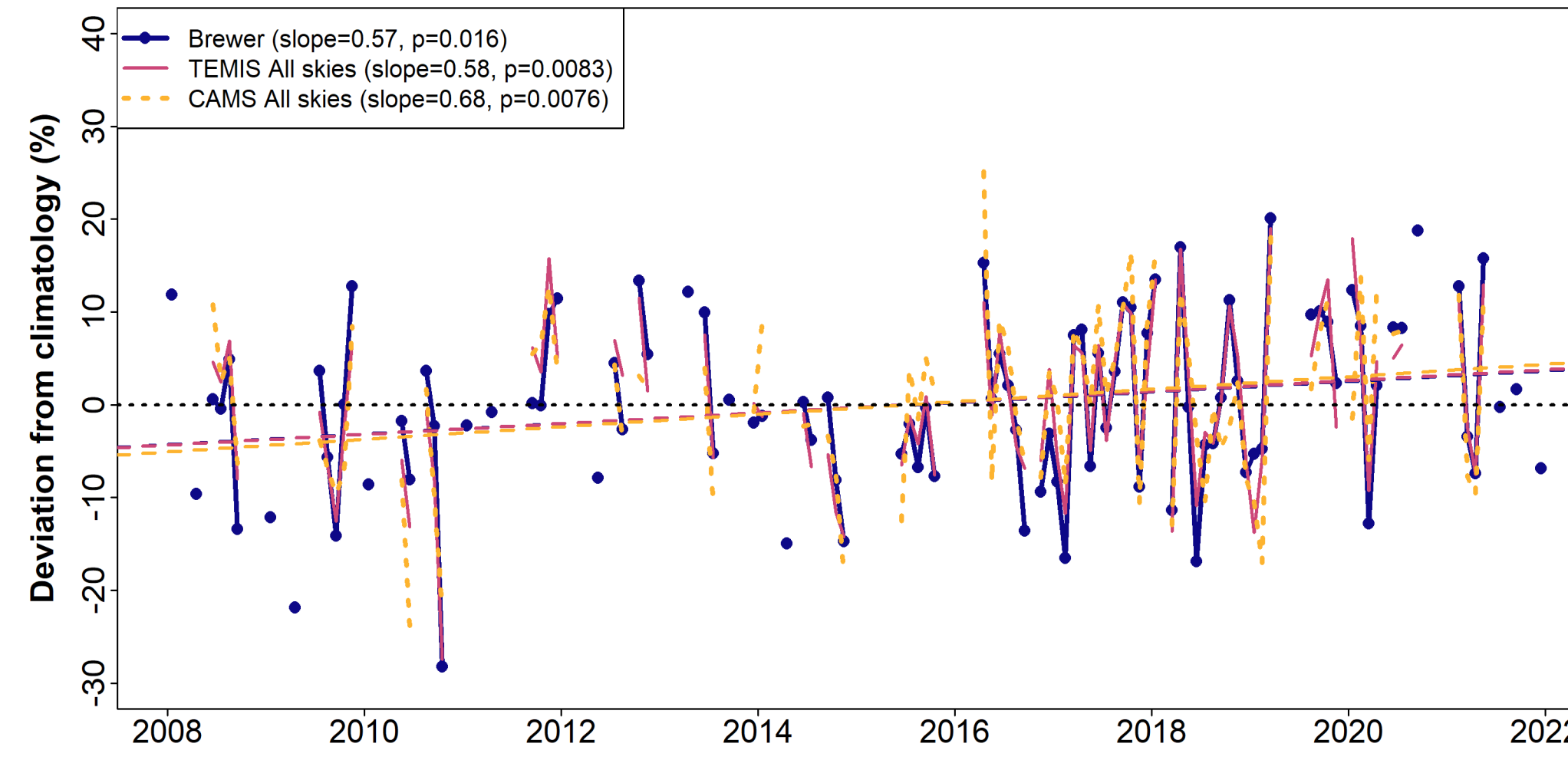
Comparison of VID UV datasets in Thessaloniki (2008 – 2021)



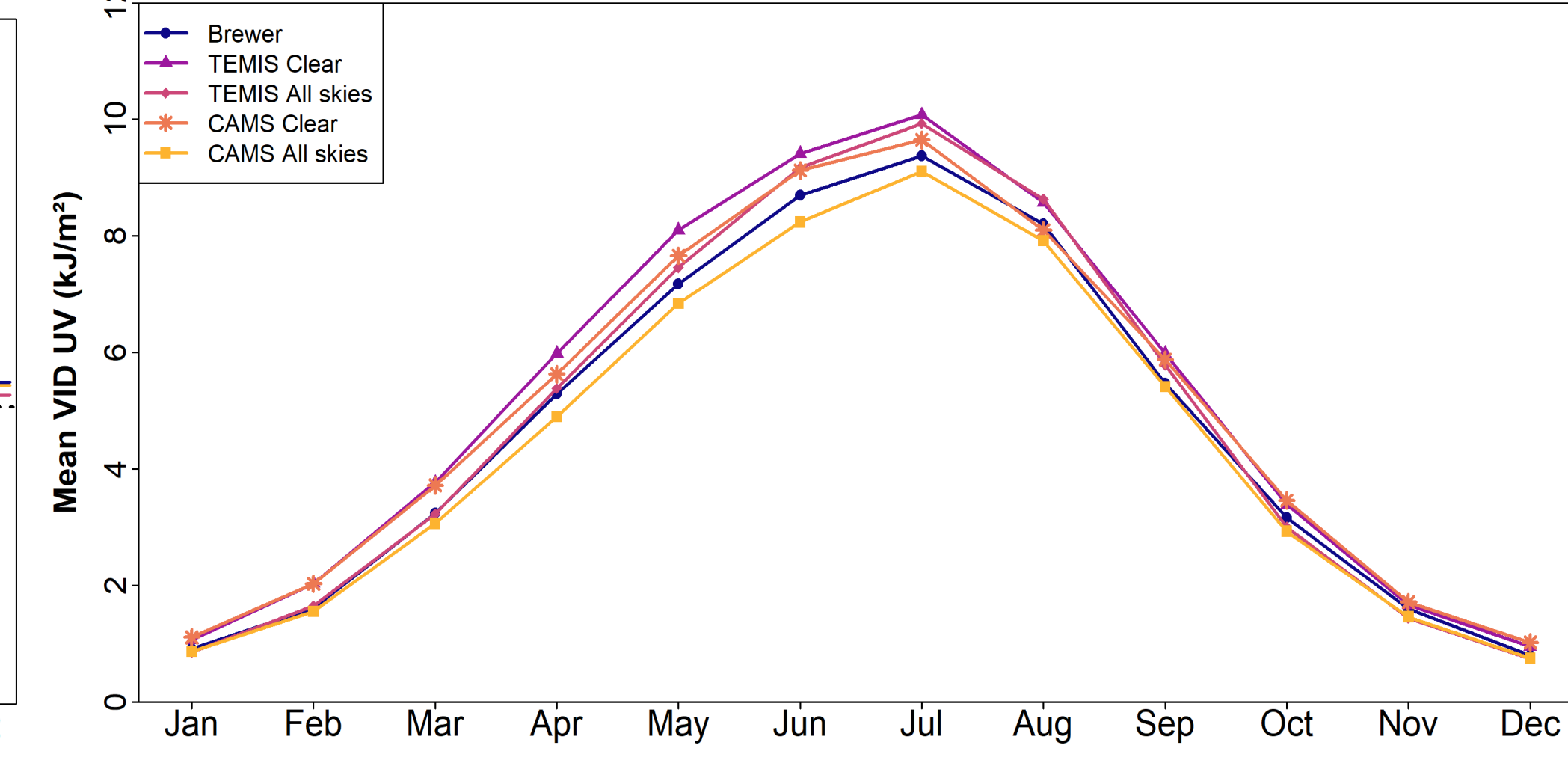
VID UV trend 2008–2021 in Athens: TEMIS vs CAMS vs Brewer



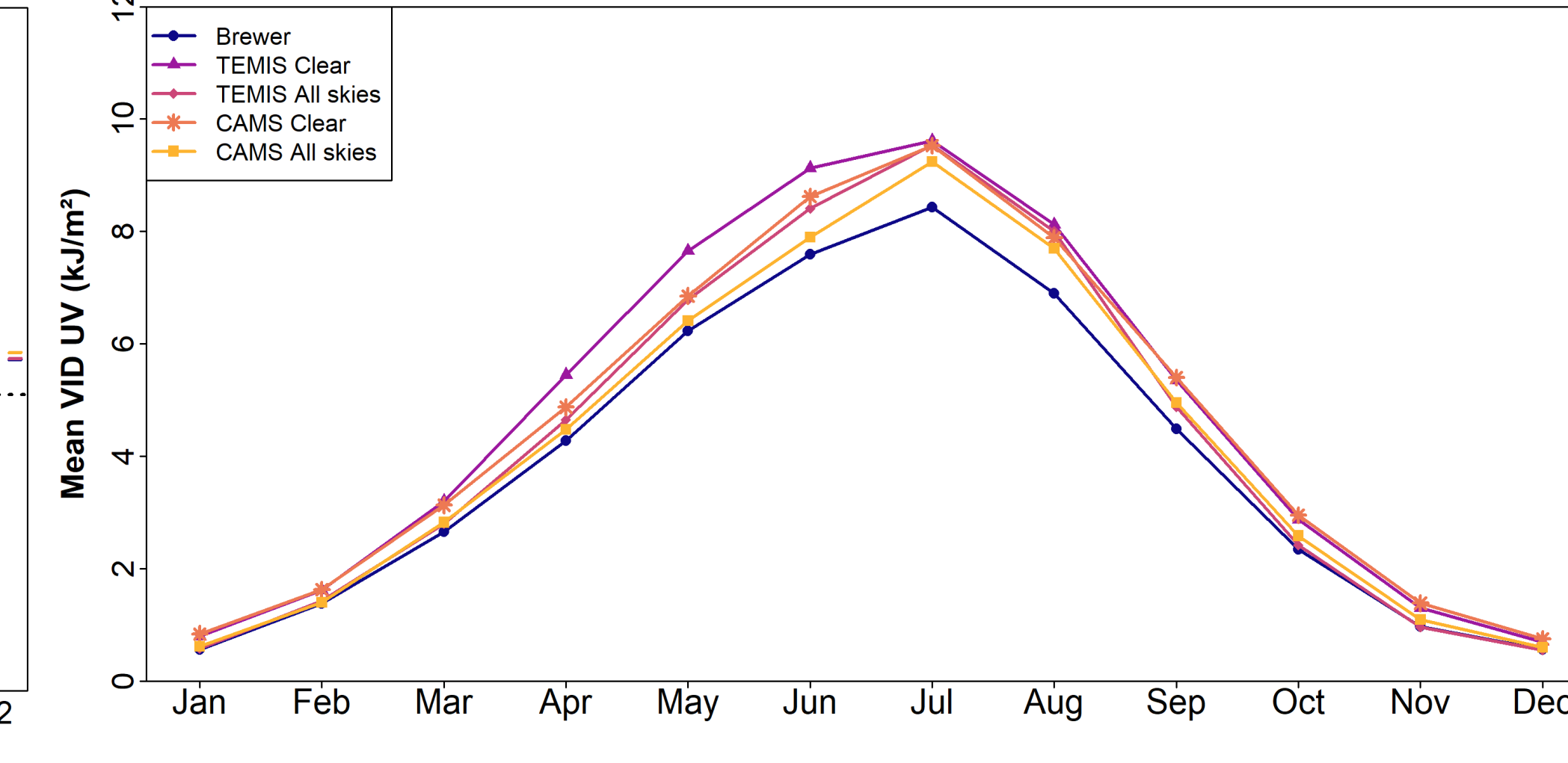
VID UV trend 2008–2021 in Thessaloniki: TEMIS vs CAMS vs Brewer



Monthly climatology 2008–2021: TEMIS vs CAMS vs Brewer in Athens

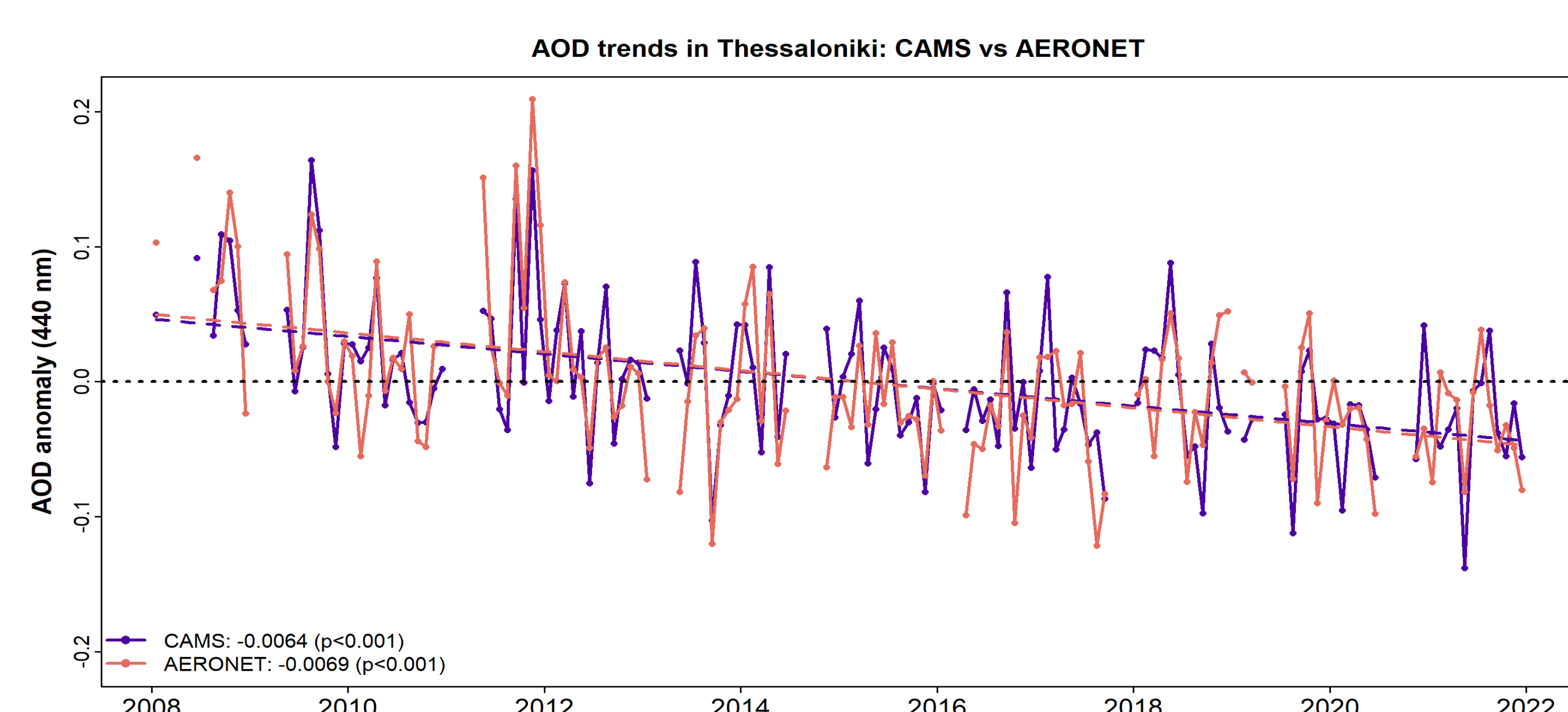
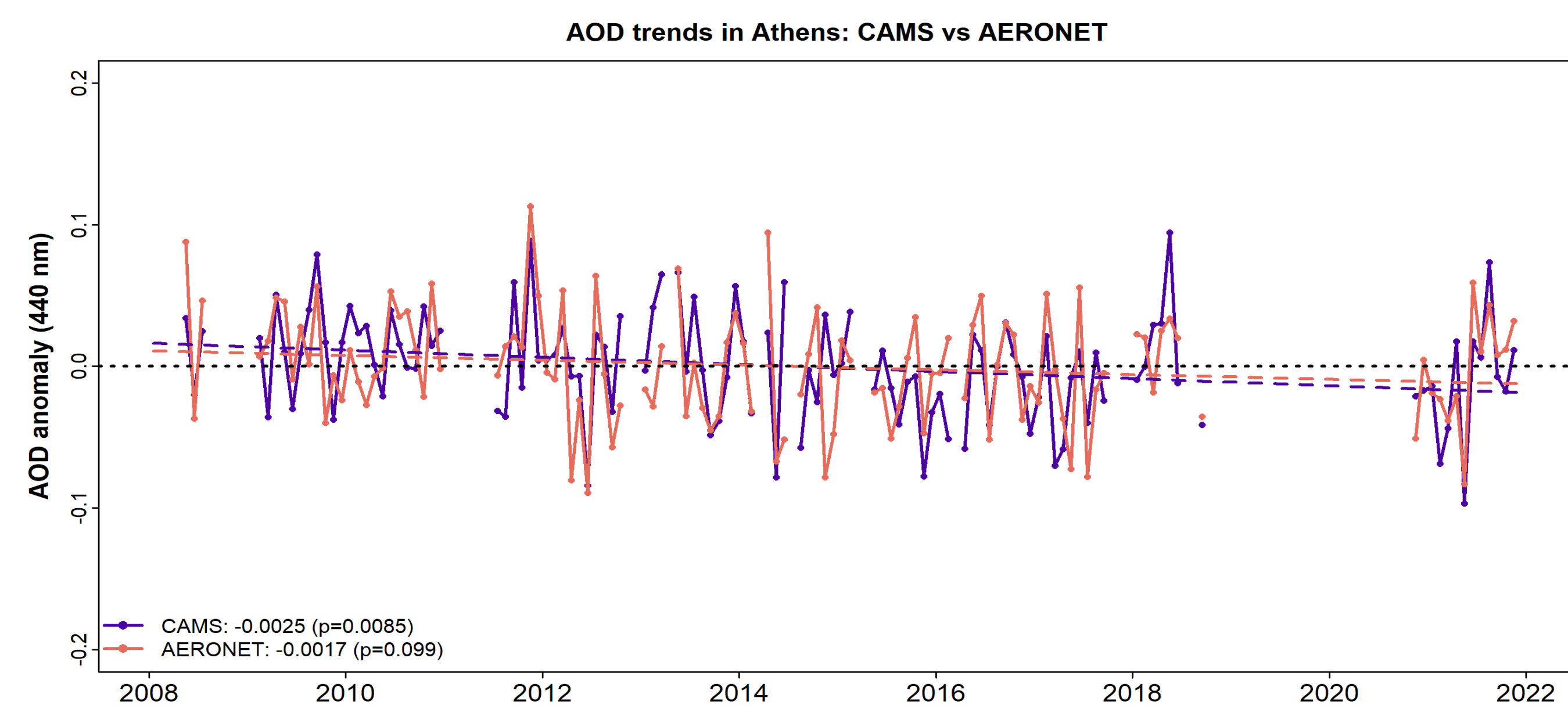


Monthly climatology 2008–2021: TEMIS vs CAMS vs Brewer in Thessaloniki

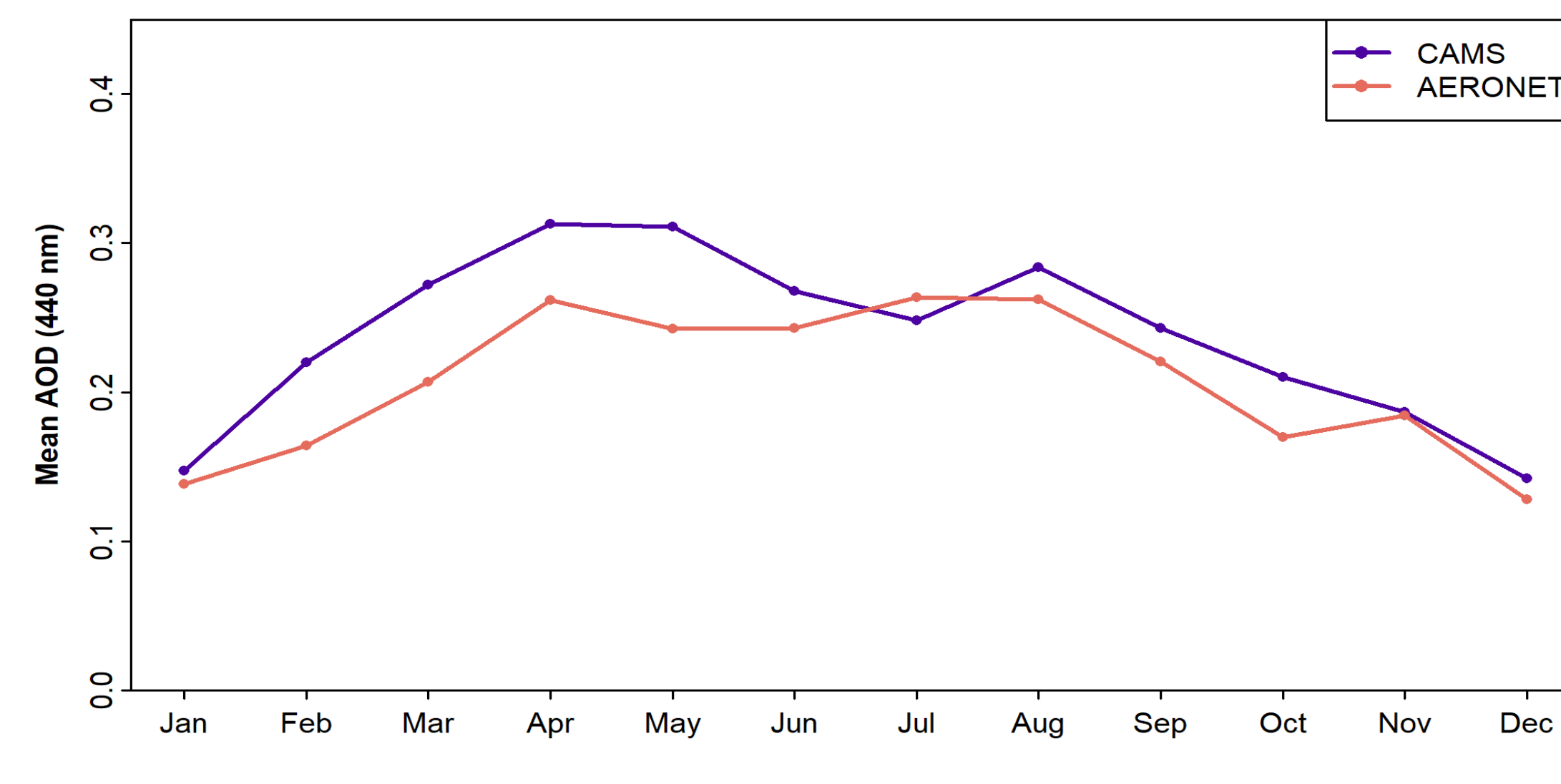


| VID UV RESULTS -ATHENS |                      |       |       |                        |       |
|------------------------|----------------------|-------|-------|------------------------|-------|
|                        | All – sky conditions |       |       | Clear – sky conditions |       |
|                        | Brewer               | TEMIS | CAMS  | TEMIS                  | CAMS  |
| Slope (% change/year)  | 0.32                 | 0.17  | 0.32  | 0.07                   | 0.26  |
| Standard error         | 0.2                  | 0.14  | 0.19  | 0.09                   | 0.11  |
| p-value                | 0.116                | 0.224 | 0.098 | 0.4                    | 0.018 |

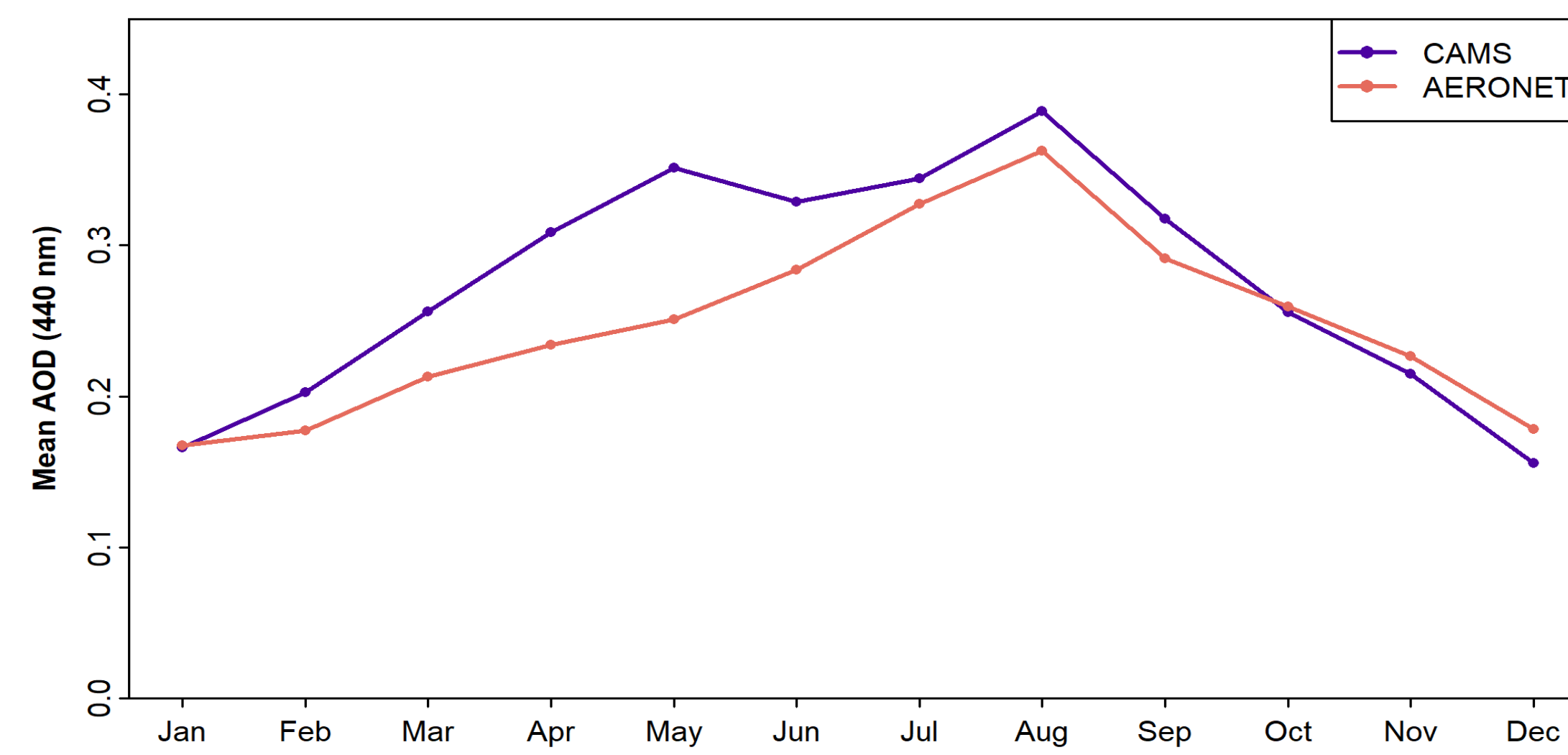
| VID UV RESULTS -THESSALONIKI |                      |       |       |                        |      |
|------------------------------|----------------------|-------|-------|------------------------|------|
|                              | All – sky conditions |       |       | Clear – sky conditions |      |
|                              | Brewer               | TEMIS | CAMS  | TEMIS                  | CAMS |
| Slope (% change/year)        | 0.57                 | 0.58  | 0.68  | 0.22                   | 0.01 |
| Standard error               | 0.23                 | 0.21  | 0.25  | 0.09                   | 0.15 |
| p-value                      | 0.016                | 0.008 | 0.008 | 0.018                  | 0.95 |



AOD monthly climatology in Athens: CAMS vs AERONET



AOD monthly climatology in Thessaloniki: CAMS vs AERONET



## Conclusions:

### 1) VID UV Datasets

- There is high consistency between CAMS and TEMIS VID UV datasets under clear-sky conditions at both sites.
- CAMS and TEMIS under all-sky conditions generally overestimate VID UV with respect to Brewer observations in Thessaloniki. For Athens, CAMS appears to underestimate and TEMIS to overestimate with respect to Brewer, particularly during spring and summer.
- At both stations, VID UV trends from Brewer, TEMIS, and CAMS, are consistent in magnitude and sign.
- In Thessaloniki, most trends (except for TEMIS under clear-sky conditions) are statistically significant ( $p < 0.05$ ). In Athens, trends are not statistically significant ( $p > 0.05$ ), although they indicate an increasing tendency.

### 2) AOD Datasets

- In Athens CAMS-derived AOD present high consistency with AERONET observations in terms of temporal variability (peaks and minima), and both datasets exhibit a decreasing trend over the study period.
- In Thessaloniki, peaks and minima are also consistent between the two datasets. The decreasing trend at this station is more pronounced compared to Athens.
- Regarding monthly climatology values, AERONET-derived data consistently exhibits lower values compared to CAMS across all months.
- Higher AOD levels are observed in Thessaloniki compared to Athens.

- Overall, combing the results of this study, a decrease in AOD is associated with an increase in surface UV irradiance, highlighting the dominant role of aerosol loading in modulating Vitamin D-weighted UV radiation at both study sites. This suggests that future changes in aerosol conditions should be considered when assessing UV radiation trends under climate change scenarios.

## References:

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