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A comparative study between the variability of spectral solar UV irradiance at Rome and Aosta, Italy: the role of total ozone, air quality and meteorological conditions

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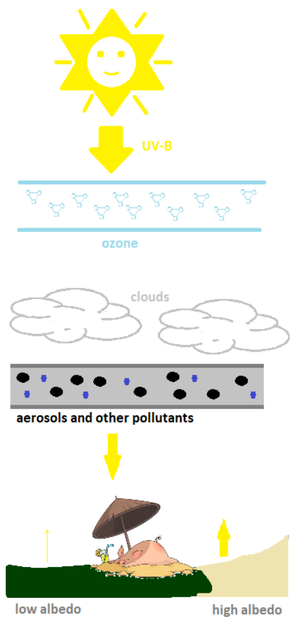
Introduction

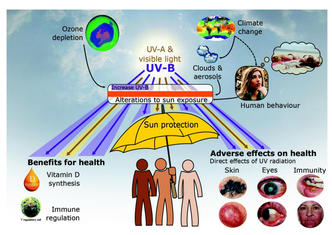
Solar UV radiation

Solar UV radiation reaching the Earth surface

Regulated by different atmospheric factors



Very significant biological effects



Adapted from Lucas et al. (2019)

UV and meteorological conditions

Large scale synoptic atmospheric circulation

- Total ozone
- Cloudiness
- Aerosols
- Surface albedo

→ UV radiation

Local atmospheric processes

Data and methodology

Solar UV-B irradiance in Rome and Aosta

In the present study we investigate the main drivers of the variability of the solar spectral global UV-B irradiance at two Italian sites located at quite different latitude, altitude and environmental context: Rome and Aosta, Italy.
There is also an effort to determine if the effect of the synoptic circulation or the local scale atmospheric phenomena are dominant on the short- and mid-term variability of the solar UV-B radiation.

Aosta-Saint Christophe
- north-western Alps(45.7°N, 7.4°E, 570 m a.s.l.)
- Mountainous site
- Significant effect from surface albedo
- Aerosols are not so important

Rome
- Central Italy (41.9°N, 12.5°E, 75 m a.s.l.).
- Urban site
- Significant effect from aerosols
- Surface albedo is not so important

Data

Monthly averages of the irradiance at 307.5 nm have been analyzed at Rome and Aosta, since the irradiance at this particular wavelength is strongly affected by ozone. Ancillary ground based and satellite data have been also analyzed.

Table 1: Analyzed parameters (2006-2016) and the corresponding data sources

Variable	Source
Spectral UV irradiance at 307.5 nm	Bentham double monochromator spectroradiometer (Aosta) MkIV Brewer spectrophometer (Rome)
Total ozone column	MkIV Brewer spectrophotometers at both stations (Siani et al., 2018)
Monthly total cloud cover	MERRA-2 reanalysis (Gelaro et al., 2017; https://giovanni.gsfc.nasa.gov/Giovanni)
Monthly AOD at 550 nm	MERRA-2 reanalysis (Gelaro et al., 2017; https://giovanni.gsfc.nasa.gov/Giovanni)
Surface albedo (Aosta)	MODIS, average over 5 km around the station (Diémoz et al., 2013)
Surface pressure	Measurements in Aosta (ARPA) and Fiumicino (https://rp5.ru/https://rp5.ru/)

Results

Short term variability

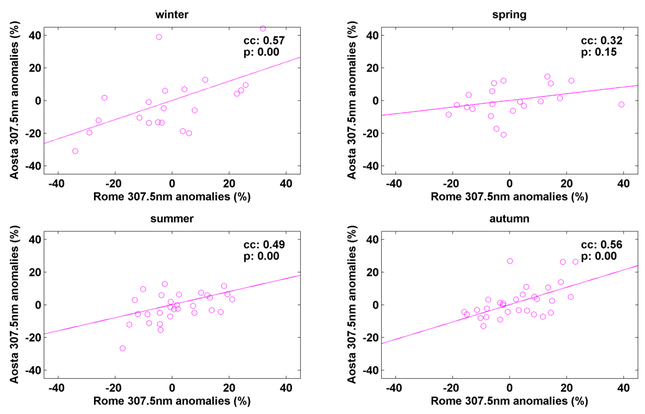


Figure 1: Scatter plot of the monthly anomalies for the 307.5 nm irradiance in Rome and Aosta for different seasons. The correlation coefficient (cc) and the corresponding p-value (p) are shown in the graph.

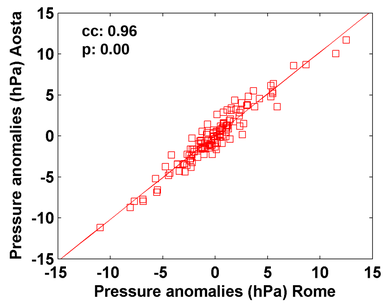


Figure 2: Scatter plot of the monthly anomalies for atmospheric pressure (for all twelve months of the year) in Rome and Aosta.
cc: correlation coefficient, p: p-value

Very strong correlation (0.96) between changes of atmospheric pressure over the two sites → Strong correlation between changes of total ozone (~0.7) and cloudiness (~0.7) ➔ Correlation between changes in UV-B

Mid-term trends (2006-2016)

The change (%)/year of the irradiance at 307.5 nm, total ozone, total cloud cover (TCC), aerosol optical depth and total snow cover were calculated assuming linear trends throughout the 11-year period

Figure 3: Change %/year of the irradiance at 307.5 nm. Shaded envelopes represent the standard uncertainty in the trends. Statistically significant results at the 95% confidence level are marked with x.

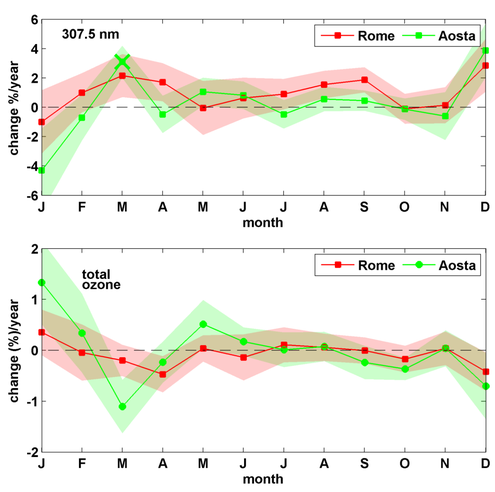


Figure 4: Same as in Figure 3 but for total ozone.

- Very **similar results for the two stations**
- UV-B changes are mainly driven by changes in **total ozone;**
- The role of **clouds** is also important;
- The effect of changes in **aerosols** and **surface albedo** are less significant.

Conclusions

- ***The similarity between the trends of the 307.5 irradiance in both sites indicates that the UV-B mid-term changes are possibly controlled by changes in the synoptic circulation which control the mid-term changes in cloudiness and total ozone.***
- ***Large changes of the levels of the 307.5 nm irradiance have been found in December, January and March*, which clearly follow the changes of total ozone** (the trend is statistically significant only at Aosta in March). The 11-year period of study is still too short to get definite conclusions.
- ***There is a strong correlation between the monthly anomalies of the 307.5 nm irradiance at Rome and Aosta*** which depicts the correlation between the corresponding total ozone and total cloud cover anomalies.

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