Reconstruction and Analysis of the 1964–2013 Erythemal UV Radiation Time Series from Hradec Králové, Czech Republic

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Introduction

The monitoring of ultraviolet (UV) radiation is very important because UV radiation has harmful effects on human health, such as skin cancer, eye diseases or immune system weakening. Since the 1980s, increased levels of UV radiation were observed due to the depletion of ozone layer (Farman et al., 1985). Although the long-term changes of UV radiation intensity occur in a longer time frame, recorded data are only available for a short interval of time (often 1 to 2 decades), it is therefore important to reconstruct UV radiation doses based on other measured parameters such as global radiation.

The aim of this study was to reconstruct and analyze the erythemal ultraviolet (UV) radiation time series from Hradec Králové, Czech Republic, in the period 1964–2013. The period is long enough to allow the study of long-term processes, such as the effects of ozone and cloud cover variations.

Fig. 1. The localization of Hradec Králové, Czech Republic.

Study Site

The Solar and Ozone Observatory Hradec Králové (50.180° N, 15.833° E) is located in the Czech Republic, as shown in Fig. 1, in the altitude of 285 m. The Solar and Ozone observatory was founded in 1951 and its main aim is studying solar radiation and the ozonosphere (VANÍČEK, 2001). The instruments for solar radiation and ozone measurement are placed on the roof of the building (Fig. 2) and, except from instrument changes, there are no known sources of recorded data inhomogenities. There are no local pollution sources that may affect the measurements.

Fig. 2. The Solar and Ozone Observatory Hradec Králové. The red arrow marks the position of instruments for monitoring solar radiation.

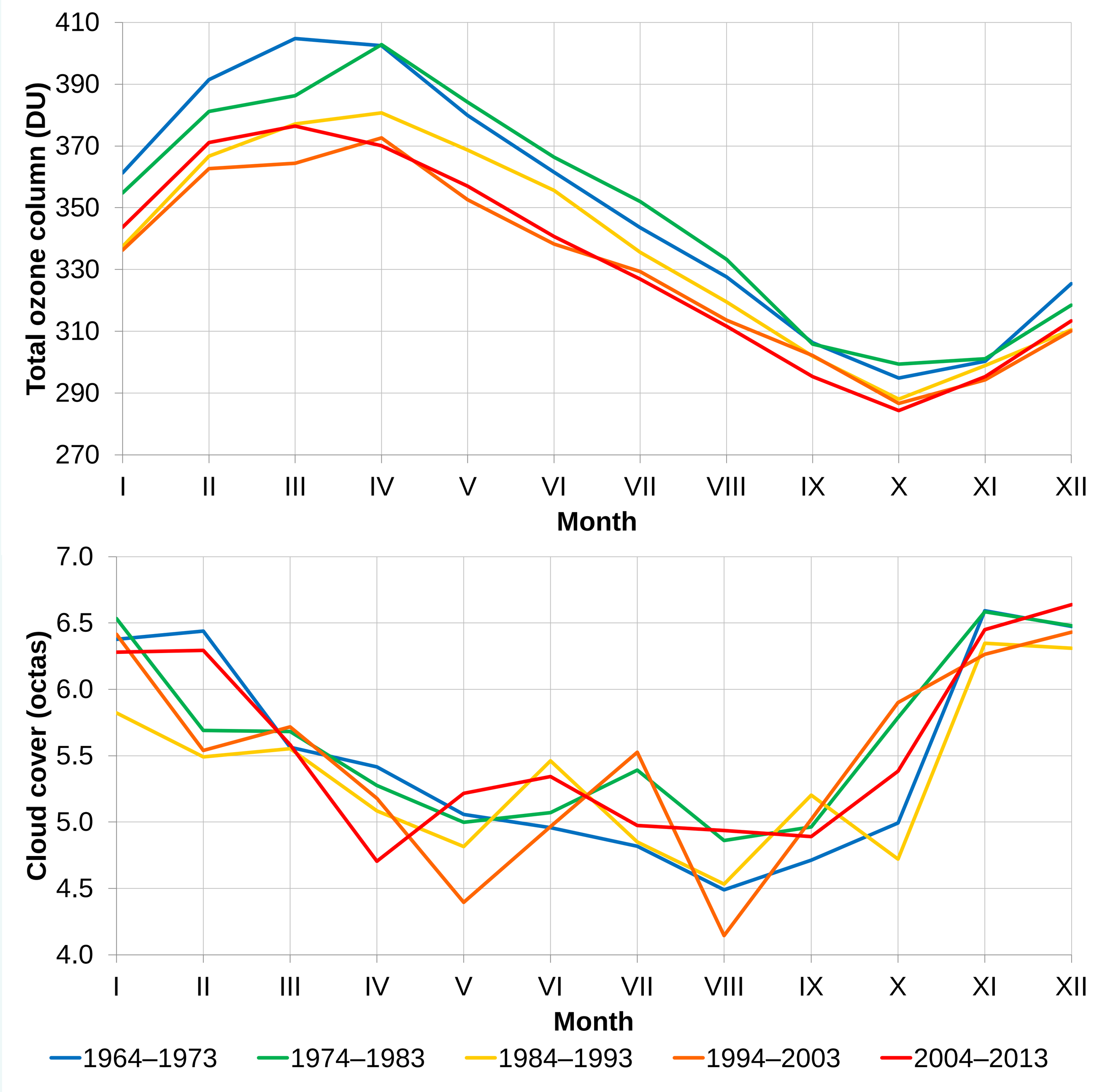

Fig. 4. The mean yearly variation of total ozone column and cloud cover in the five studied decades. The decrease of total ozone column was significant in all months except from XI but there were no long-term trends observed in cloud cover.

Data and Methods

The time series of erythemal UV radiation (1964–2013) was reconstructed using the libRadtran radiative transfer model (MAYER et al., 2015) and empirical relationships (multiple non-linear regression) based on the data measured at the Solar and Ozone Observatory (erythemal UV radiation, global radiation, total ozone column, albedo, AOD 320 nm) and the data from other sources (AOD 550 nm from MODIS, total water vapor column from Era-40 and Era-Interim). The analysis of the reconstructed time series consisted of three main steps:

1. Assessment of monthly, annual and decadal variation and trends
2. The influence of total ozone column and cloud cover on the erythemal UV radiation daily doses (partial correlation, the implementation of libRadtran)
3. Analysis of days with high erythemal UV irradiance (highest 10% of days for each month)

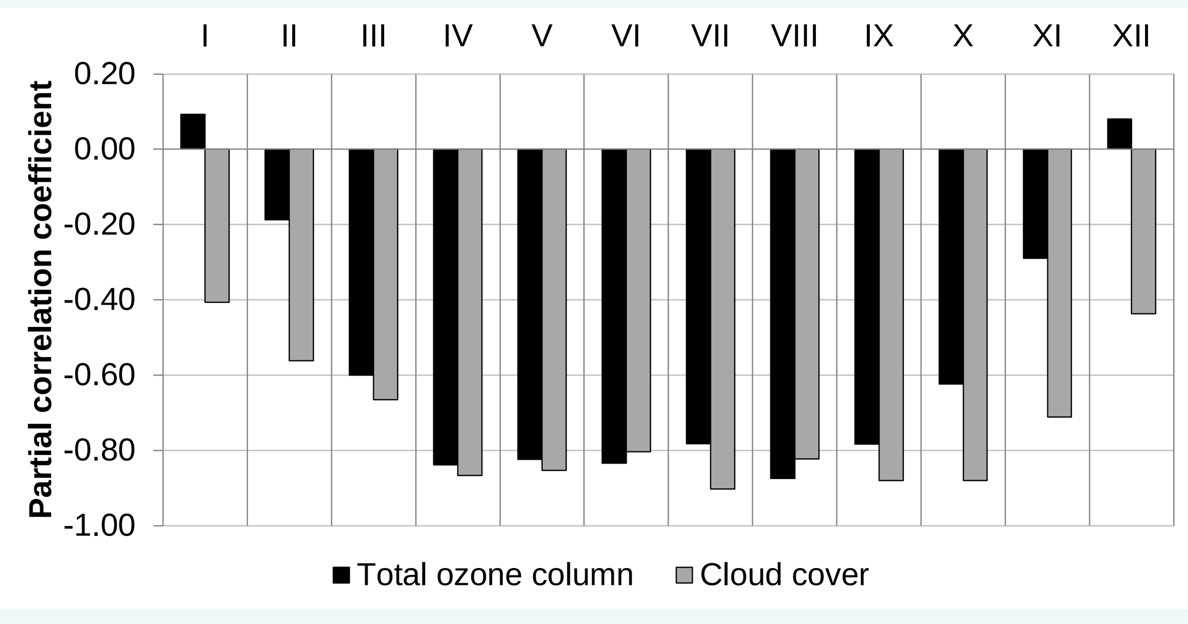

Fig. 5. Seasonal variation of partial correlation coefficient of mean erythemal UV radiation daily doses for total ozone column and cloud cover, respectively.

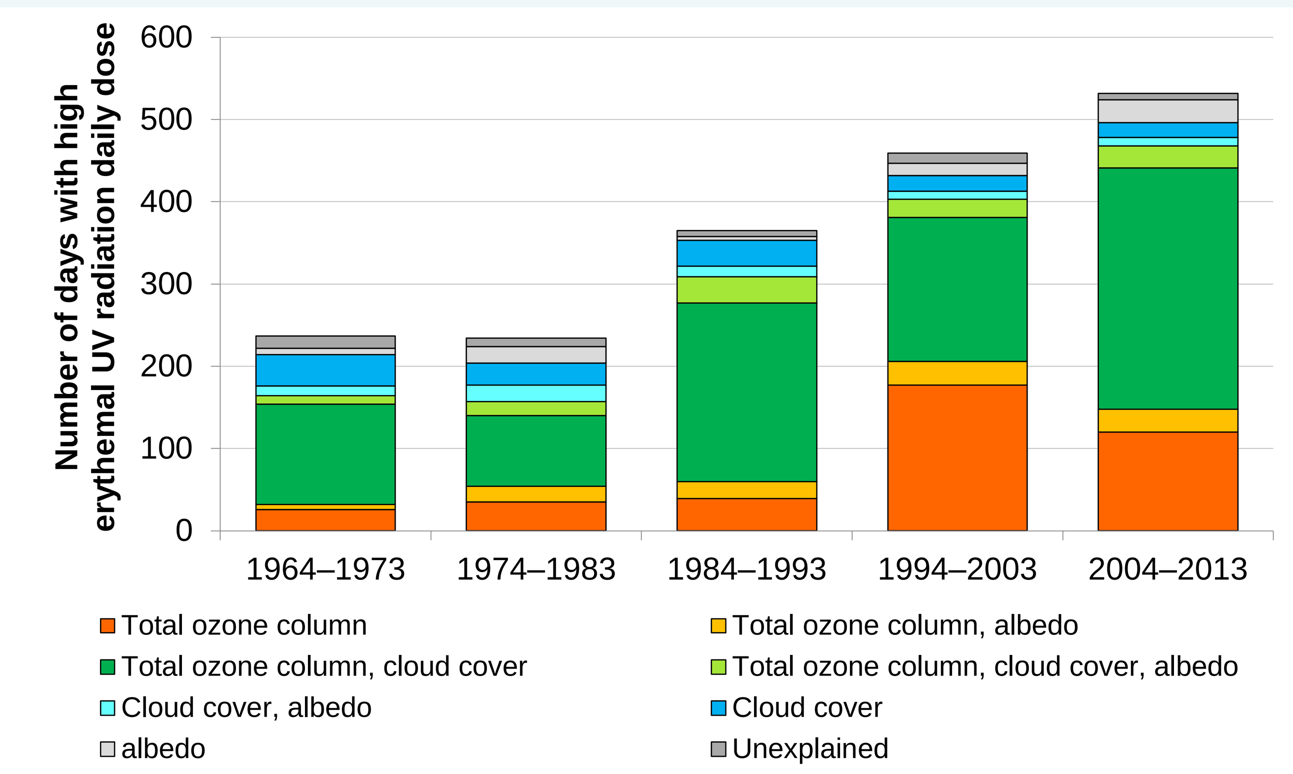

Fig. 7. Number of days with high erythemal UV irradiance in the five studied decades explained by various factors.

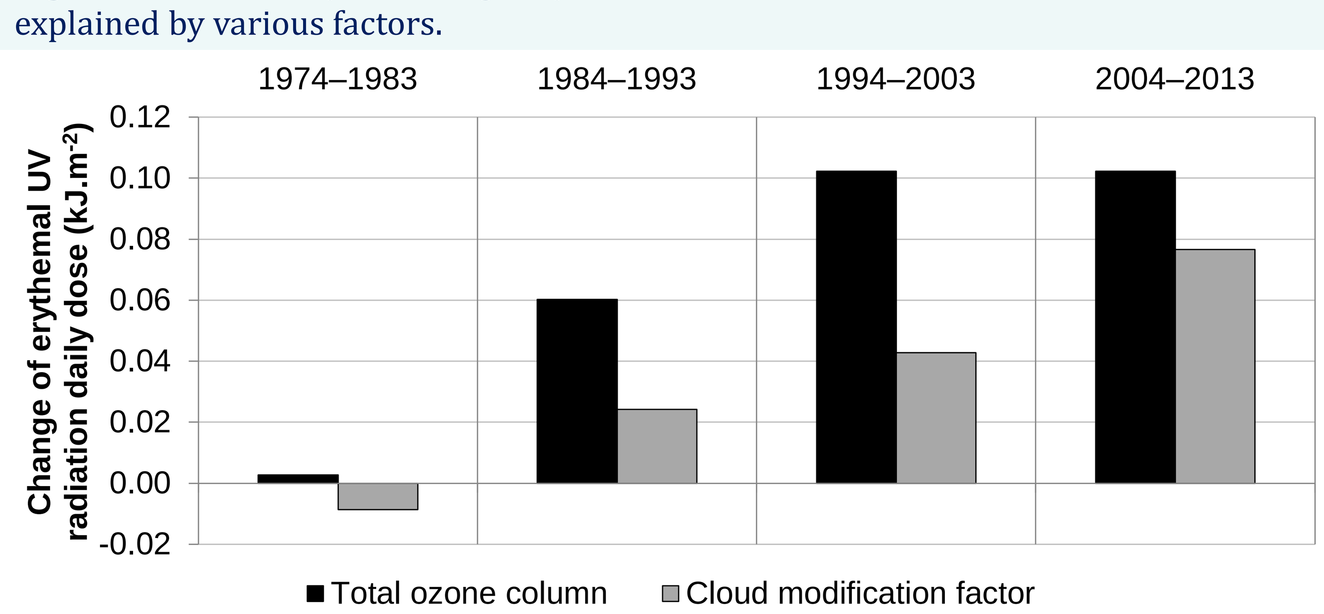

Fig. 6. The change of mean erythemal UV radiation daily dose in four decades in relation to the first decade mean, which can be explained by the changes in total ozone column and cloud modification factor (generally defined as the ratio between the irradiance under cloudy sky and the irradiance for cloud-free conditions).

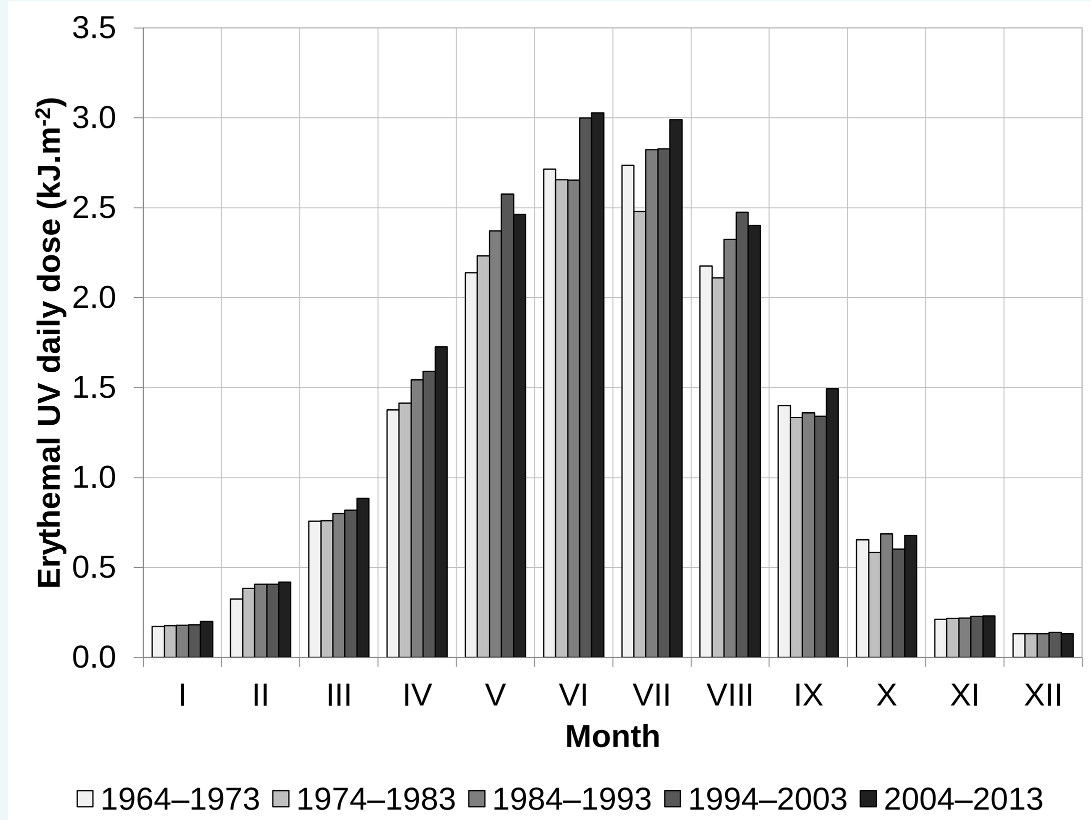

Fig. 3. The monthly means of erythemal UV radiation daily doses in the five studied decades.

Results and Summary

- Between 1964 and 2013, the erythemal UV radiation daily doses increased significantly (3.5% per 10 years), the increase was most significant in the 1980s and 1990s
- The increase of erythemal UV radiation daily doses was statistically significant in all months except from I, IX, X and XII (Fig. 3)
- Increase in total ozone or decrease in erythemal UV radiation daily doses after 1998 wasn't statistically significant
- The yearly mean erythemal UV radiation daily doses were affected mostly by total ozone column (its variation is shown in Fig. 4), monthly means were affected especially by cloudiness but in spring and summer also by total ozone column (Fig. 5)
- In comparison with the first decade, the relative increase of erythemal UV radiation daily doses was caused especially by total ozone column but in the last decade (2003–2013) the role of cloud modification factor increased (Fig. 6)
- The number of days with high erythemal UV irradiance increased significantly (8.1 days per 10 years), the increase was not significant only in autumn
- 82% of days with high erythemal UV irradiance were recorded in days with below-average total ozone column and 66% of days with high erythemal UV radiation daily dose were recorded in days with clear to partly cloudy skies
- The number of days with high erythemal UV radiation daily dose affected by low total ozone column and by the combination of low total ozone column and clear to partly cloudy skies and of low total ozone column and high erythemal UV albedo increased significantly throughout the period 1964–2013 (Fig. 7)

Acknowledgement

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References

FARMAN, J. C., GARDINER, B. G., SHANKLIN, J. D. 1985. Large losses of total ozone in Antarctica reveal seasonal ClOx/NOx interaction. Nature 315, 207–210.

MAYER, B., KYLLING, A., EMDE, C., BURAS, R., HAMANN, U., GASTEIGER, J., RICHTER, B. libRadtran user's guide. 2015, Accessible online: <http://www.libradtran.org/doc/libRadtran.pdf>.

VANÍČEK, K. 2001. Solar and Ozone Observatory Hradec Králové 1951–2001. Prague: Czech Hydrometeorological Institute. 38 p. ISBN 80-85813-83-1.