

***Interactive comment on* “Typical distribution of the solar erythemal UV radiation over Slovakia” by A. Pribullová and M. Chmelík**

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Response to referee 2

1. Relations between total ozone measured at Poprad-Gánovce (PPG) and at nearby surrounding stations were investigated in study of Chmelík (2000). Differences between the total ozone measured at PPG and at surrounding stations were calculated from the period 1994 - 1999. Standard deviation of total ozone monthly average measured at PPG and at Budapest (250 km southward from PPG), Belsk (300 km northward from PPG), Hradec Králové (350 km north-westward from PPG) were of 2.7%, 2.4% and 1.6% (2.0% for total ozone measured by the Dobson spectrometer at Hradec Králové), respectively. The coefficients of determination between monthly total ozone measured at PPG and at surrounding stations ranged between 0.97 and 0.99. Differences between monthly total ozone corresponded to coordinates of PPG and sur-

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Interactive Discussion

Discussion Paper



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Comment

rounding stations were determined in the period 1979 - 1994 from the TOMS satellite measurements. Standard deviation of the satellite monthly total ozone at PPG and at surrounding stations ranged from 1.2% to 1.5%. The correlation between the average monthly total ozone determined from satellite measurements (TOMS) at PPG and at surrounding stations performing total ozone measurements was very tight - the coefficient of determination was of 0.99. Larger differences were found between daily average values of total ozone. Comparison between the TOMS satellite 1979 - 1994 data corresponded to PPG and to Belsk, Budapest and Hradec Králové coordinates showed that standard deviation of PPG daily total ozone from Belsk, Budapest and Hradec Králové daily values decreased to 4.9%, 3.9% and 5.5%, respectively. The coefficient of determination ranged from 0.92 to 0.95. The latest comparison between daily total ozone at PPG and at Hradec Králové (period 1994 - 2004) confirmed close correlation between daily total ozone at both observatories ; annual coefficient of determination ranged between 0.87 and 0.93, average difference was of 4.2%. The largest differences were detected during the first 3 months of year (4.9%). Both, daily values and monthly climatology of the PPG total ozone were used in the publication. The daily total ozone measurements were utilized for calculation of the daily cmfUV at every station with total solar radiation measurements. Utilization of the PPG total ozone for stations bulked in the High Tatra's area is reliable. Reliability of the PPG daily total ozone application at remote stations Bratislava (250 km southwestward from PPG) and Hurbanovo (200 km southward from PPG) can lead to introduction of errors in the model. The range of errors is probably close to differences between daily total ozone measured at PPG and at surrounding stations Budapest and Hradec Králové (4 - 5%). The distance between PPG and the most remote points at model domain is around 300 km. An error arising from usage of uniform monthly total ozone for whole investigated territory can be comparable with the differences between PPG monthly mean total ozone and total ozone measured at Budapest or Hradec Králové. For monthly total ozone, the error is less than 3%. PPG 1995 - 2004 total ozone was used in the publication.

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2. Clear-sky erythemal UV radiation (EUV) daily doses for the map presentation were calculated for altitude 500 m a.s.l. by the radiative transfer model TUV. Typical vertical gradient of the EUV irradiance was estimated from local study of differences between EUV irradiance measured by UV biometers at two locations in the High Tatra's mountains - foot-hill observatory Stará Lesná (810 m a.s.l.), and slope observatory Skalnaté Pleso (1778 m a.s.l.). The change of the EUV irradiance was studied with respect to snow presence at both stations by cloudless condition. Vertical gradient of the EUV irradiance of 15.2%/1000 m and 16.7%/1000 m was determined for situations with no snow and continuous snow cover at both stations, respectively. Increase of the EUV irradiance of 23.1%/1000 m was found for situation with continuous snow at Skalnaté Pleso and no snow at Stará Lesná. Homogeneous distribution of aerosol in layer of the air between the lowest and the highest positions of investigated area with equal vertical gradient of erythemal UV radiation (15%/1000 m) was assumed in presented publication. Radiative transfer model TUV simulation of the erythemal UV radiation vertical change was utilized to estimate error arising from this assumption. Modeling was performed using Elterman's (1968) vertical profile of continental aerosol, the aerosol optical depth at 340 nm $AOD_{340} = 0.4$ at altitude of Poprad-Gánovce, Angstrom's parameters $a = 1.3$ and $b = 1.0$, average total ozone at Poprad-Gánovce of 325 DU, U.S. standard atmosphere and no-snow surface albedo 0.03. Daily doses of the EUV radiation were calculated for coordinates and altitudes of Lomnický štít, Skalnaté Pleso, Poprad-Gánovce and place with coordinates of Poprad-Gánovce and with altitude of 100 m a.s.l. The modeled vertical increase of clear-sky EUV radiation daily dose between Poprad-Gánovce and level at altitude 100 m a.s.l., between Poprad-Gánovce and Skalnaté Pleso and between Skalnaté Pleso and Lomnický štít was 13.3% / 1000 m (range in annual course - max 14.0%, min 12.7%), 14.7%/ 1000 m (range in annual course - max 15.4%, min 13.7%), and 7%/1000 m (range in annual course - max 7.5%, min 6.5%), respectively. An average modeled vertical gradient between levels with altitudes 100 m and 2635 m a.s.l. was of 11.5%/1000 m. Error arising from assumption of fixed vertical gradient of the EUV radiation probably causes overestimation

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of the clear-sky erythemal UV radiation daily doses at the highest mountain peak positions. Confrontation of model results with measurements of erythemal UV radiation at higher mountain positions than Skalnaté Pleso could clarify how the Eltermann's (1968) aerosol vertical distribution fits real condition in the Tatra's mountains. AOD340 of 0.4 used in the TUV model was derived from average annual value of AOD320 calculated by the Langley method from the Brewer spectrophotometer 'direct Sun' measurements at Poprad-Gánovce in time period 1993 – 2002 (Pribullová, 2002).

3. The effect of appropriate time step selection for model calculation of the EUV radiation daily doses was estimated using radiative transfer model TUV. Daily doses of the EUV radiation were calculated for Poprad-Gánovce coordinates, typical aerosol conditions (see point 2), no-snow surface, total ozone of 325 DU and two days - July 21 and December 21. The start of calculation was at 02.00 UTC. The daily doses calculated on July 21 with time steps of 10 min, 30 min, 1 h, 2h, 3h and 4 h were 4686 J.m^{-2} , 4685 J.m^{-2} , 4685 J.m^{-2} , 4685 J.m^{-2} , 4685 J.m^{-2} (4684 J.m^{-2}), and 4682 J.m^{-2} (4689 J.m^{-2}), respectively. Values in brackets relate to start of calculation at 01.00 UTC. The daily doses calculated on December 21 with time steps of 10 min, 30 min, 1 h, 2h were 222.7 J.m^{-2} , 222.7 J.m^{-2} , 222.7 J.m^{-2} , 223.2 J.m^{-2} , respectively. Model calculation showed that change of time step from 10 min to 2h did not cause substantial change of the EUV radiation daily dose under clear-sky. Using of longer time step could save the time needed for calculations.

4. The maps presented in text (Figs. 2-3) were created for the first day of month assuming average total ozone calculated from time period ± 15 days around this day, probability of snow occurrence and the cmfUV were calculated also from this time interval. Authors agree with referee that examples of maps for 15-th day of every month could be more compatible with monthly climatology of the cmfUV and snow line presented in sections 3.1 and 3.2. Maps in atlas of the EUV radiation were calculated for 15-th day of every month and maps in Figs. 2-3 will be replaced to those ones corresponded to day 15-th of every month.

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5. The formula (1) represents statistical dependence of the cmfUV daily values on the cloud modification of total solar radiation cmfG and solar zenith angle SZA. The cmfUV was calculated using this model at all places where measurement of total solar radiation was available (9 places). Monthly averages of the modeled daily cmfUV (cmfUVM) were calculated. Interpolation methods could be used to depict typical spatial distribution of the monthly cmfUVM at any grid point of investigated domain. The next possibility is to find out the cmfUVM distribution model. As the stations with total solar radiation measurements were distributed irregularly (stations were concentrated in the High Tatra's area), spatial interpolation methods did not provide reasonable maps of the monthly cmfUVM. It was the reason why there was an effort to model the dependence of the cmfUVM (modeled locally) on altitude. The dependence of the cmfUVM on altitude was expressed by 2nd degree polynomial function. It is clear from Tab. 2 that correlation between the measured and modeled data is not close for February, March, October and November when the vertical profile of the cmfUVM has been changed from winter mode to summer regime and vice versa. The cmfUVM is the lowest at Štrbské Pleso in October and November (the cmfUVM is significantly lower at Štrbské Pleso in comparison with Skalnaté Pleso from September to April what can relate to leeward position of Štrbské pleso in the High Tatra's mountains). The cmfUVM oscillates around fixed value in March and February when nearly the same cmfUVM were found at the highest and at the lowest positions of the stations vertical profile (the RMS error of the model was higher than standard deviation from average in March). Vertical change of the cmfUVM can not be expressed by simple increasing or decreasing function in these months. Interpolation between the cmfUVM modeled at different altitudes could be more reliable approach, but there are specific local conditions at some stations in modeled vertical profile – Štrbské Pleso (cloudy place at leeward side of the High Tatra's mountains) and Skalnaté Pleso (effects of shadowing and strong convection cloud formation manifest there in summer) and it is questionable if interpolated vertical profile of the cmfUVM is representative for the whole territory. The derived dependence of the cmfUVM on altitude reflects local character of cloudiness

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regime, it probably cannot be applied generally in any mountain condition and it can be used for altitude range of investigated places only. To model the cmfUVM distribution with high resolution, more stations with total solar radiation measurements regularly covering the modeled territory are needed. The modeled dependence of the cmfUVM on altitude was used for every month map construction and it can be expressed by following formula:

$$\text{cmfUVM} = f(h, M) \quad (2),$$

where the cmfUVM is monthly mean value of the cmfUV, h is the altitude, m is number of month and f is 2nd degree polynomial function with regression parameters determined for every month separately. Formula (2) will be added in the paper.

6. The aim of the Fig. 4 was not validation of the modeled daily dose of the EUV irradiance, but just comparison of the modeled data with measured ones. 2002 – 2004 period for comparison was used because EUV irradiance data were available from all stations from this period. The abbreviations to grey columns will be added.

References

Chmelík, M., 2000, Determination of the Long Term Total Ozone Average over Poprad-Gánovce station. In: Proceedings of the Quadrennial Ozone Symposium – Sapporo 2000, NASDA, Sapporo, 339-340.

Eltermann, L., 1968, UV, visible and IR attenuation for altitudes to 50 km, AFCRL, 68-74.

Pribullová, A., 2002, Spectral UV aerosol optical thickness determined from the Poprad-Gánovce Brewer spectrophotometer observations. Contributions to Geophysics and Geodesy, 32/3, 291-307.

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