AREAL ANALYSIS OF INCREASED DAILY UV-B VALUES IN THE CZECH REPUBLIC IN JULY 2005

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ABSTRACT: Submitted study deals with assessment of enhanced daily values of UV-B radiation (280-320nm) in July 2005 in the Czech Republic as a consequence of low amount of stratospheric ozone in this period. The 30th July of 2005 was chosen as a representative day for case study, because the amount of total ozone dropped 12.5% below the long-term mean at Hradec Králové observatory. The statistical model for estimating daily values of UV-B radiation (developed at Institute of Agrosystems and Bioclimatology at Mendel University of Agriculture and Forestry in Brno) was used for 88 stations from the Czech Republic. This model requires (as an input data) values of daily sum of Global radiation (R_G), daily sum of extraterrestrial radiation (R_A), amount of total ozone and altitude. Firstly, daily sums of UV-B for each station based on measured total ozone content were derived. Subsequently these values were compared with results of model which corresponds to average amount of total ozone content. The UV-B increment during 30th July 2005 (as effect of stratospheric ozone decrease) reached 323.6 $J \cdot m^{-2} \cdot day^{-1}$ at the average in the Czech Republic. For detailed assessing of UV-B increase the spatial analysis with using of Geographical Information System (ArcInfo GIS software) was conducted.
Keywords: UV-B radiation, global radiation, stratospheric ozone, statistical model.

INRODUCTION

Although ultraviolet-B (UV-B) radiation (320-280 nm) comprises only a small portion of solar spectrum, it has disproportionately large effects on living organisms (HEISLER et al., 2003). Many investigations have demonstrated, how the UV-B affects various components of natural and man-controlled ecosystems as well as humans (e.g. PAUL and GWYNN-JONES, 2003; CALDWELL et al., 2003; FLINT et al., 2003; DIFFEY, 1998). Its amount reaching the earth's surface is increasing as a result of the stratospheric ozone depletion (e.g. WMO, 2003; JANOUCH, 1994). So, the information about Solar UV-B radiation at the earth's surface is very important number of users not least for agriculture meteorologists.

The main aim of submitted study was to assess UV-B radiation increase in the Czech Republic during the episode of attenuation of ozone layer above Northern hemisphere (from 28th to 30th July 2005) as a consequence of inflow of tropical air mass (see Figure 1) (http://www.chmi.cz/meteo/ozon/redukceO3.html, 2006). For this purpose the statistical model for estimating daily values of UV-B radiation (developed at Institute of Agrosystems and Bioclimatology at Mendel University of Agriculture and Forestry in Brno) was used. This model requires (as an input data) values of daily sum of Global radiation (R_G), daily sum of extraterrestrial radiation (R_A), amount of total ozone content and altitude of corresponding stations. Firstly, daily sums of UV-B for 88 Czech station based on measured total ozone content were derived. Subsequently these values were compared with output of model which corresponded to average amount of total ozone content. Result of this comparison was determined as UV-B increment (or difference) and its spatial variability was analysed with using of Geographical Information System (GIS).

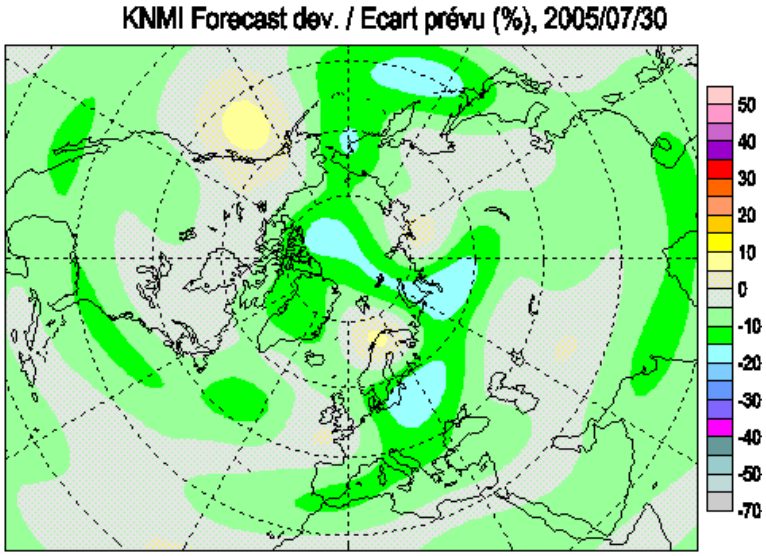

Figure 1: Forecast of total ozone content deviation (in %) for Northern hemisphere during 30th July 2005 (http://www.chmi.cz/meteo/ozon/redukceO3.html; 2006).

DATA

The daily sums of R_G (in $MJ \cdot m^{-2} \cdot day^{-1}$) at 88 Czech stations were derived from sunshine duration with help of the Angström-Prescott method (PRESCOTT, 1940). Measurements of sunshine duration were done by Campbell-Stockes sunshine recorders (data were provided by CHMI). The daily values of R_A (in $MJ \cdot m^{-2} \cdot day^{-1}$) were calculated for all stations (ALLEN, 1998). The daily observed values of total ozone (measured by Brewer Spectrophotometer) for the Czech Republic (single value for all stations) were also provided by CHMI. Used long term average values of total ozone for relevant days corresponded to study of KALVOVÁ and DUBROVSKÝ (1995). The last input for statistical model is altitude of each station.

METHODOLOGY

For estimating of daily values of UV-B radiation for each of 88 Czech stations the statistical model was used. The model, which is described by equation (1), was derived from observed values of UV-B, R_G, daily amount of total ozone, altitude of stations and calculated values of R_A at eight Austrian stations during 2000 and 2002 and was verified for the Czech Republic with satisfactory results.

$$UVB_{est} = a + b \cdot R_G \cdot R_A + c \cdot R_G \cdot A + d \cdot O^2 - e \cdot R_G^2 + f \cdot R_G - g \cdot R_G \cdot O - h \cdot O - i \cdot A^2 + j \cdot R_A \cdot A - k \cdot R_A^2 + l \cdot R_A - m \cdot R_A \cdot O \quad (1),$$

where:
UVB_{est} is estimated daily value of UV-B radiation (in $J \cdot m^{-2} \cdot day^{-1}$)
R_G is daily value of global radiation (in $MJ \cdot m^{-2} \cdot day^{-1}$),
R_A is daily value of extraterrestrial radiation (in $MJ \cdot m^{-2} \cdot day^{-1}$),
O is amount of total ozone (D.U.),
A is altitude of station (m a.s.l.) and
a to *m* are coefficients of statistical model, which are defined in the Table 1.

Table 1: List of coefficients which are incorporated into statistical model.

Coefficient	*Value*	*Coefficient*	*Value*
A	311.6368	*h*	4.2594
B	4.3597	*i*	$1.256 \cdot 10^{-5}$
C	$1.245 \cdot 10^{-2}$	*j*	$1.631 \cdot 10^{-3}$
D	$9.19086 \cdot 10^{-3}$	*k*	0.6273
E	1.2436	*l*	47.0864
F	99.75	*m*	$7.7833 \cdot 10^{-2}$
G	0.316348		

Daily sums of UV-B radiation for 88 stations based on measured total ozone content were derived. These values were compared with daily UV-B values which were calculated by the same model but with the use of long-term mean of total ozone content on 30th of July. Results of this comparison were determined as UV-B increment (in $J \cdot m^{-2}$) for relevant day.

For spatial analysis of UV-B increment during 30th July 2005 for the Czech Republic ArcInfo GIS software was used. Values of UV-B increment from 88 Czech stations were interpolated by Cokriging's method (the altitude of grids was used as additional parameter) to show spatial distribution of UV-B radiation increase. After that the spatial distribution of UV-B increment was confronted with spatial variability of so-called "clearness index" (as ratio of R_G and R_A) for the same day. This index can describe conditions in the atmosphere (e.g. occurrence of clouds). Values of clearness index from 88 stations were interpolated by Kriging's method (without any other parameter).

RESULTS

Our results show that UV-B increment (as a consequence of total ozone attenuation) reached 236.0 $J \cdot m^{-2} \cdot day^{-1}$ during 28th July, 361.2 $J \cdot m^{-2} \cdot day^{-1}$ during 29th July and 323.6 $J \cdot m^{-2} \cdot day^{-1}$ during 30th July 2005 (at the average of 88 Czech stations). Overview of mean, minimal and maximal values of UV-B increments during separate days in conjunction with values of total ozone content is included into Table 2. The three-day increment (from 28th to 30th July 2005) reached 920.8 $J \cdot m^{-2}$ at the average of 88 stations incorporated to this study.

Figure 2 shows the spatial variability of UV-B increment (difference) during 30th July 2005, which is in good agreement with appearance of clouds depicted by spatial distribution of clearness index (see Figure 3). Spatial variability of clearness index corresponds to occurrence of cold front during this day.

Table 2: Overview of mean, minimal and maximal values of UV-B increments in conjunction with values (measured values, long term average and deviation from its average) of total ozone content.

Date	*O_3*			*UV-B increment (in $J \cdot m^{-2} \cdot day^{-1}$)*		
	Measured (D.U.)	*Average (D.U.)*	*Deviation (%)*	*Ø*	*max.*	*min.*
28th July 2005	308.7	333.7	-7.5	236.0	255.2	203.1
29th July 2005	299.8	333.2	-11.5	361.2	385.3	282.4
30th July 2005	291.1	332.7	-12.5	323.6	390.6	214.1

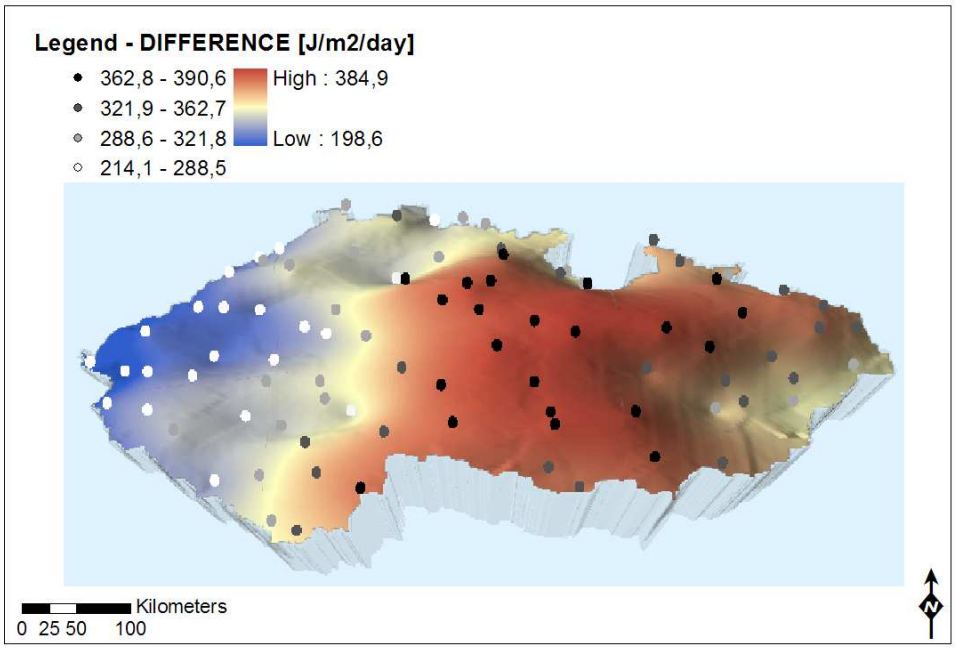

Figure 2: Spatial distribution of increment (difference) in daily UV-B radiation sums (in $J \cdot m^{-2} \cdot day^{-1}$) during 30th July 2005 as a consequence of 12,5% reduction of total ozone in the atmosphere.

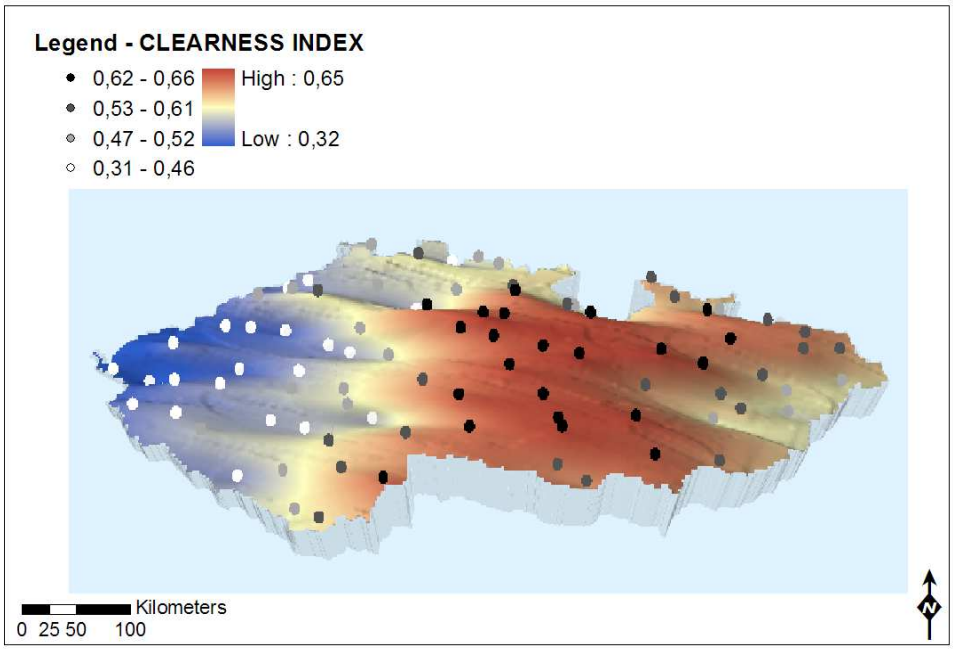

Figure 3: Spatial variability of so-called "Clearness index" (i.e. rate of R_G to R_A) which shows occurrence of clouds during 30th July 2005.

CONCLUSION

The main aim of the study was to analyze the episode of increased UV-B radiation during July 2005 with help of newly derived statistical model. Results showed that UV-B radiation increased by 306.9 $J \cdot m^{-2} \cdot day^{-1}$ on the average at 88 stations between 28th and 30th July 2005 as a result of total ozone decrease. Study also shows impact of total ozone content and appearance of clouds on UV-B radiation reaching the earth's surface. It may be concluded, that stratospheric ozone content is significant factor also when the sky overcast.

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