UV radiation weighted with action spectra: erythemal, previtamin D3,

against total ozone and solar zenith angle

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Introduction

UV radiation plays a meaningful role in many processes in the biosphere and has an important influence on human health. Most vitamin D for the human requirement comes from exposure to sunlight. The knowledge of UV biologically effective (UVBE) radiation and its distribution is very important for live on Earth.

Within this framework we will present the variations of UV radiation, weighted with previtamin D3 (CIE, 2006) action spectrum, in comparison with erythemal (CIE, 1987) as functions of total ozone and solar zenith angle. For the calculations the UV radiation transfer model libRadtran v.1.1 is used.

Moreover, the variations of UVBE over Poland from the period 1999-2001, for summer will be presented. To calculate the UV radiation the UV reconstruction model formulated by A. Curylo in the frame of COST Action 726 "Long-term changes and climatology of UV radiation over Europe" is used.

Action spectra:

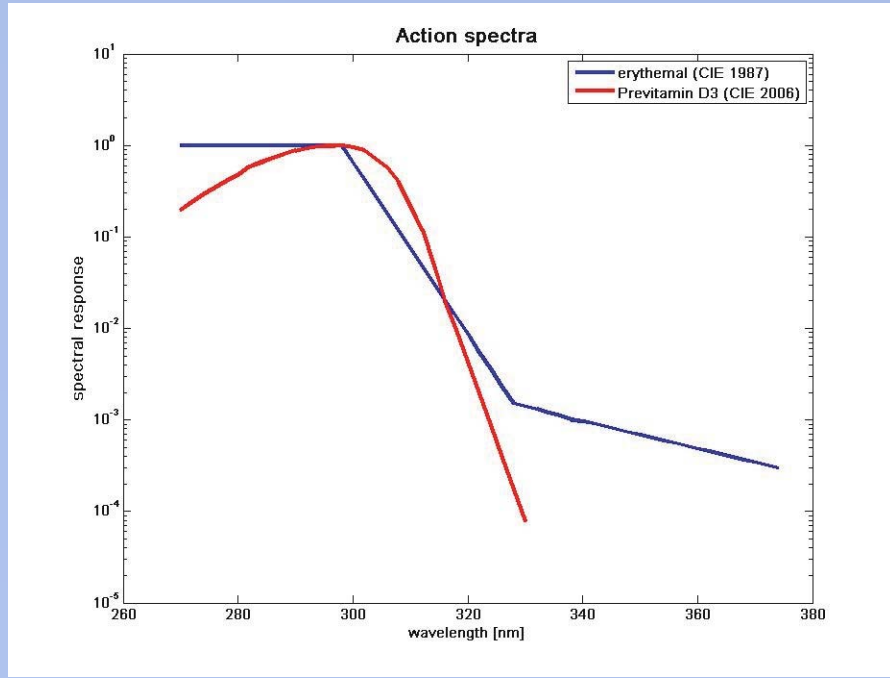
An action spectra describes the spectral effectiveness of a photobiological or photochemical process.

- **Erythemal - CIE, 1987**

Erythemal response function.

- **Previtamin D3 - CIE, 2006**

Action spectrum for the production previtamin D3 in human skin, normalized to 1 at 298 nm.



LibRadtran v.1.1 - UV radiation transfer model parameters:

- clear sky
- standard aerosols
- atmospheric profiles: Midlatitude summer
- albedo: 0.03
- altitude: 0 m
- day of year: 80
- radiative transfer equation solver: SDISORT
- extraterrestrial spectrum: atlas plus modtran

The UV reconstruction model input data:

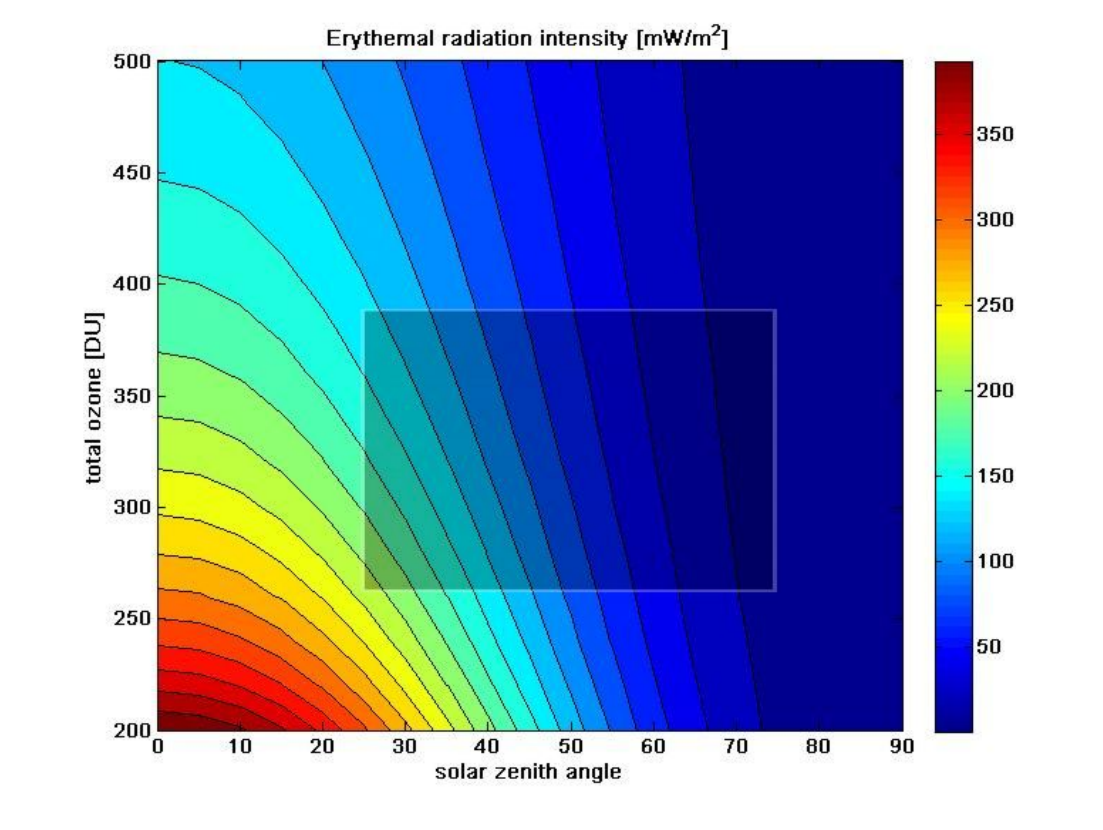
- measured global radiation
- reconstructed total ozone
- aerosols information from EDUCE

The comparison of the European UV reconstruction models under the COST Action 726 shows that the model formulated by A. Curylo has very good compatibility with measured data.

Results

Erythemal radiation

Erythemal radiation [mW/m^2] as a function of solar zenith angle and total ozone.



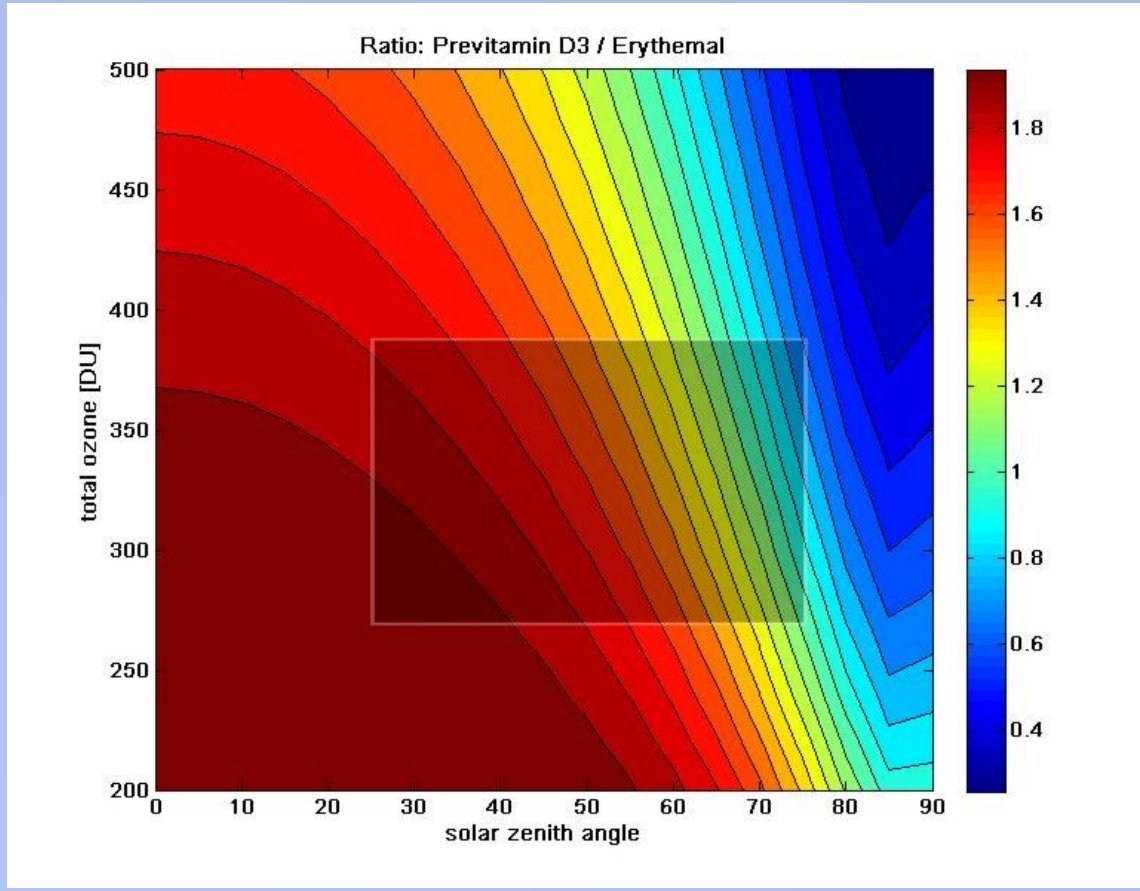
This frame shows the ranges of solar zenith angle and total ozone for Poland.

Results

Previtamin D3

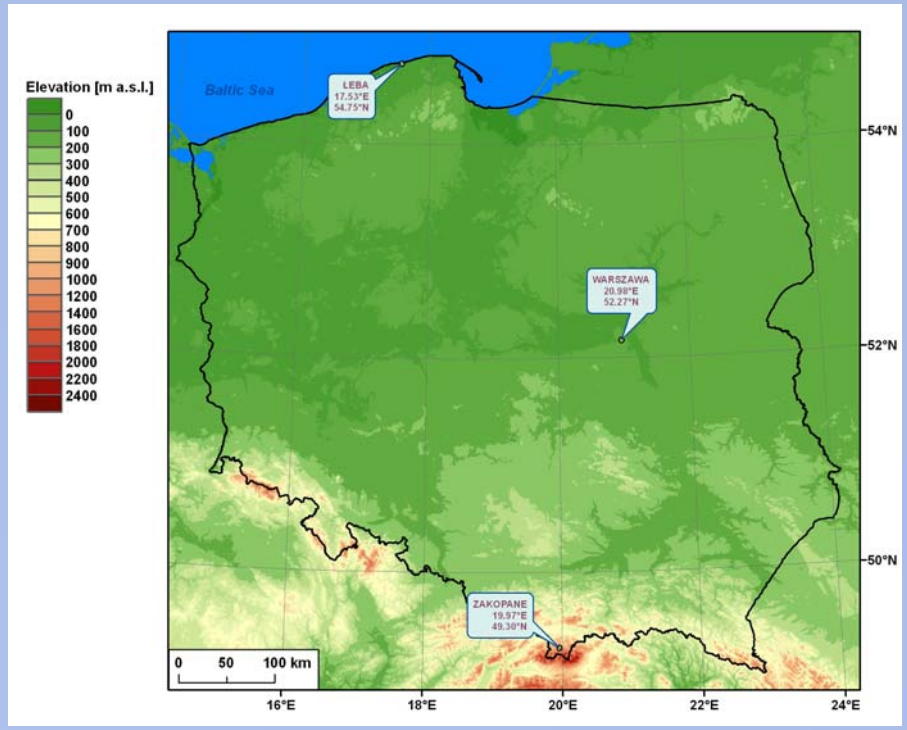
The ratio of UV radiation weighted with Previtamin D3 action spectrum to erythemal radiation as a function of solar zenith angle and total ozone.

- **Ratio between 2.0 to 0.2**
- **Higher values of UV radiation weighted with Previtamin D3 action spectrum than the erythemal radiation at the lower solar zenith angle**
- **Lower values of UV radiation weighted with Previtamin D3 action spectrum than the erythemal radiation in the polar regions**
- **Bigger variation as function of solar zenith angle than as function of total ozone**
- **In Poland during the winter, the Previtamin D3 weighted UV radiation is lower than the erythemal**



UVBE radiation over Poland

The reconstructed UVBE radiation has been calculated for 3 stations: Leba (54.75° N, 17.53° E), Warsaw (52.27° N, 20,98° E), Zakopane (49.30° N, 19.97° E) for the period 1999-2001, for the months May, June, July, August, September.

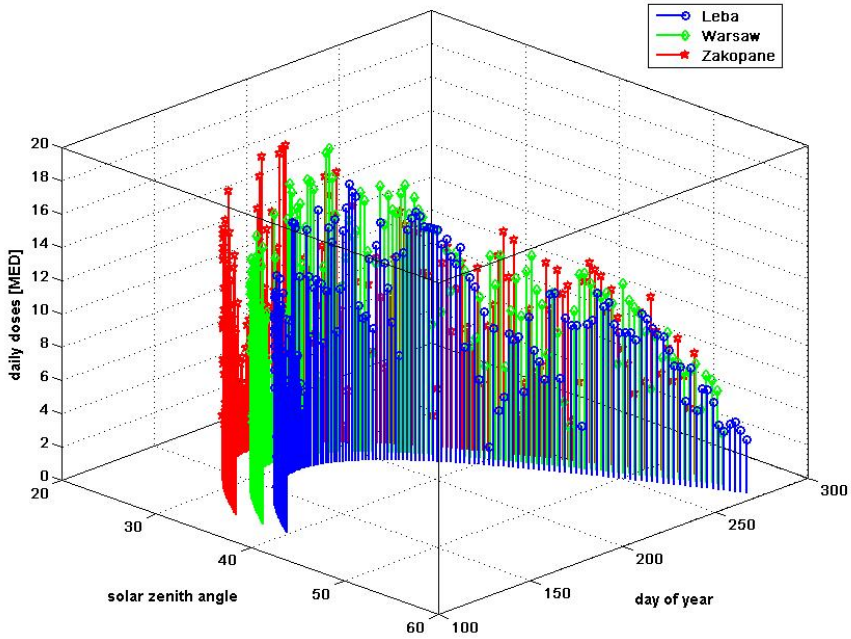


The daily doses of UVBE radiation in MED were calculated.

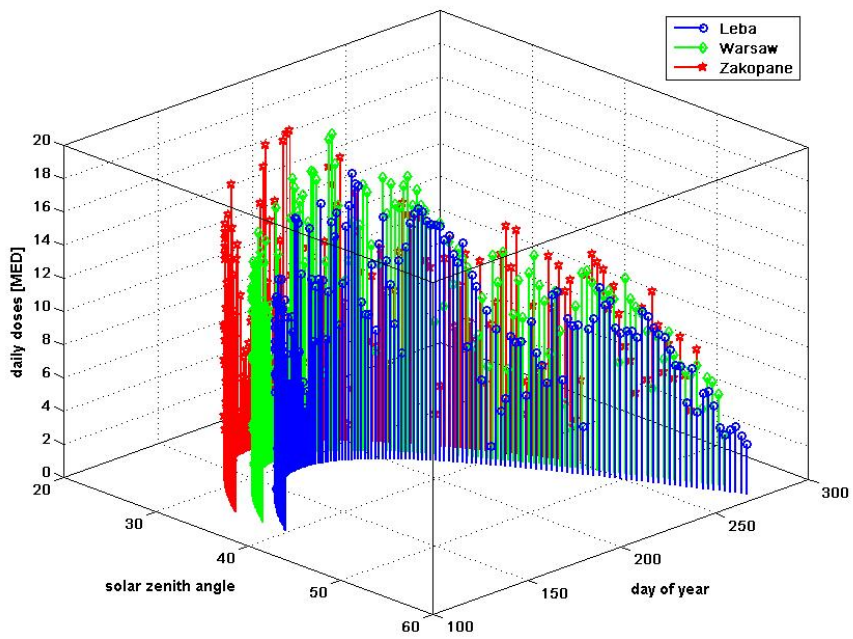
1 MED (Minimal Erythemal Dose) is defined as the effective UV dose that causes a perceptible reddening of previously unexposed human skin. 1 MED varies among the European population within the range of between 200 and 500 J/m2. In our work we have used 1 MED = 250 J/m2 - typical value for the II skin type according to DIN-5050.

Results

1999



Daily doses [MED] of erythemal radiation as function of solar zenith angle and day of year.

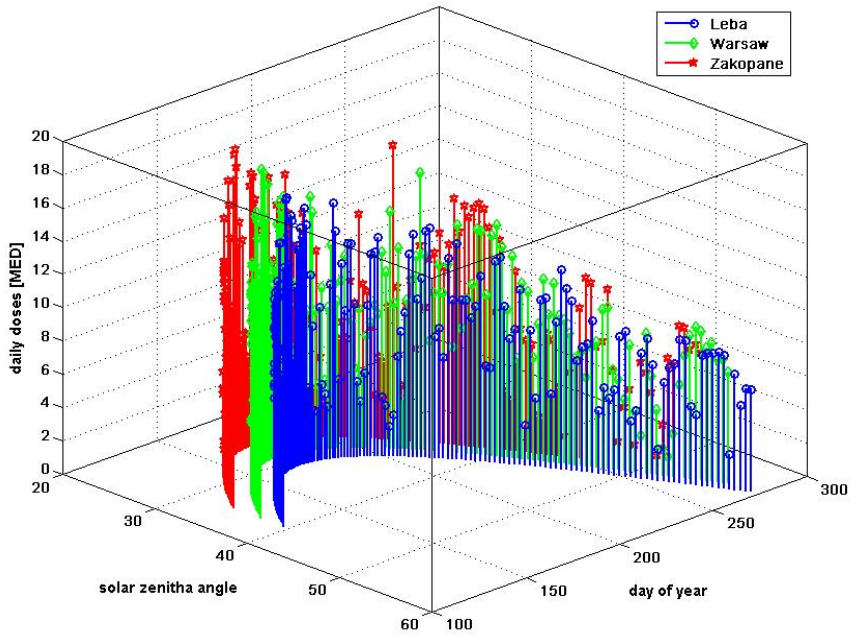


Daily doses [MED] of UV radiation weighted with Previtamin D3 action spectrum as function of solar zenith angle and day of year.

The solar UVBE radiation depends on solar zenith angle and physical parameters of the atmosphere, mainly the cloudiness. The highest values of UVBE radiation are observed in southern Poland.

Results

2000



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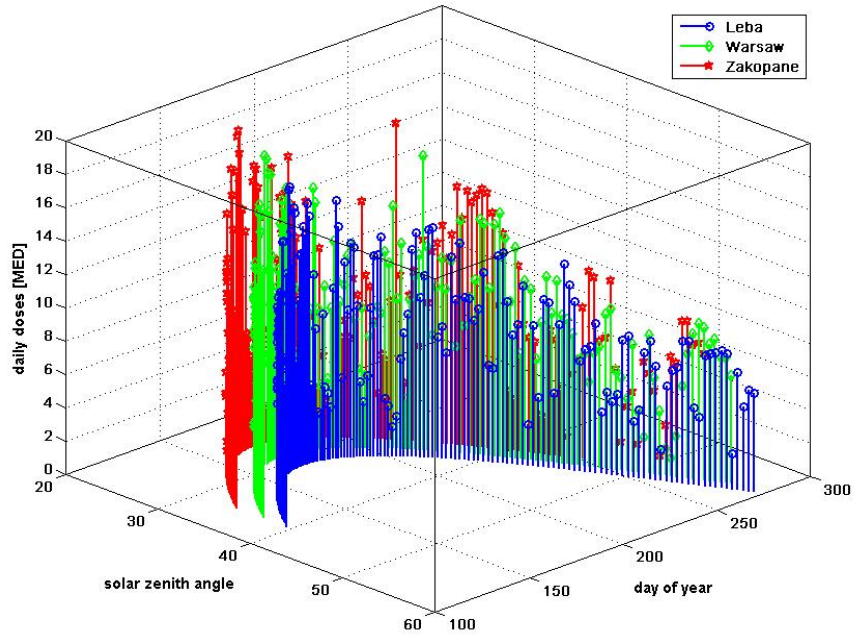

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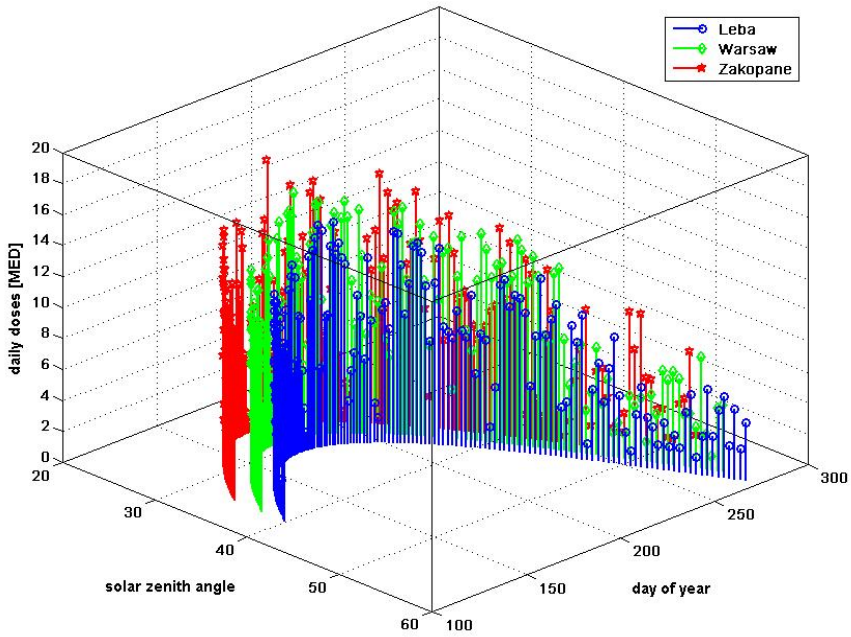
Results

2001



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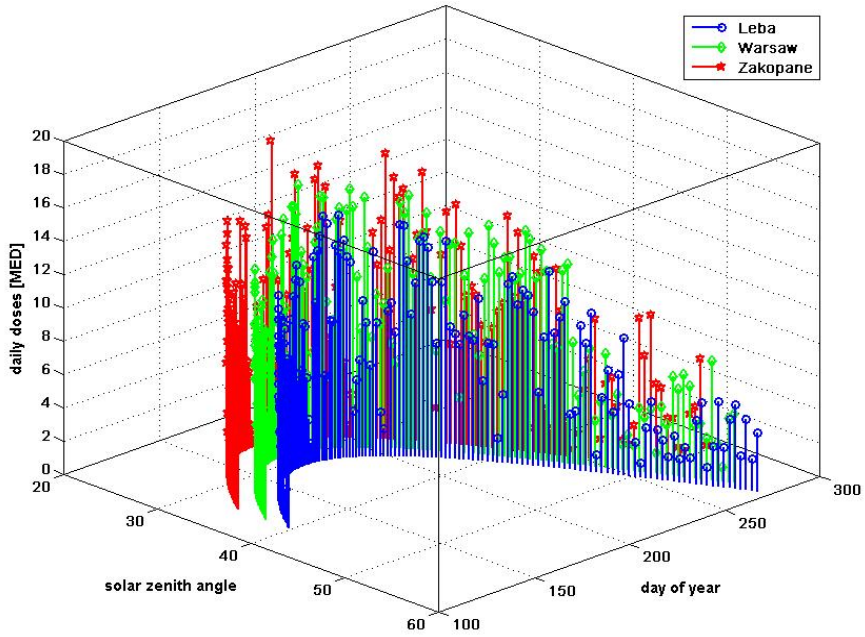

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Conclusion

Vitamin D

	maximum	*minimum*	*average*
1999			
Leba	17.26	1.10	9.05
Warsaw	18.74	1.79	10.32
Zakopane	19.08	0.94	9.17
2000			
Leba	17.11	1.76	8.65
Warsaw	18.57	1.06	9.78
Zakopane	19.36	0.70	9.20
2001			
Leba	14.64	0.82	7.31
Warsaw	16.03	0.84	8.84
Zakopane	18.07	0.38	7.96

Maximum, minimum and average daily doses [MED] of UV radiation weighted with Previtamin D3 action spectrum.

The oral daily dose of 1000 IU vitamin D is recommended to gain all possible health benefits of vitamin D. Achieving the equivalent of 1000 IU vitamin D would require exposure of ¼ skin area (hands, face and arms) to ¼ MED.

In Poland, from May to September, there is enough UV radiation to get vitamin D.

Thank You

References:

1. *A reference action spectrum for ultraviolet induced erythema in human skin, CIE, 1987.*
2. *Action spectrum for the production of Previtamin D3 in human skin, CIE, 2006.*
3. *The UV Advantage, M. F. Holick, ibook inc., New York, 2004*
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6. *Modelling solar UV radiation in the past: comparison of algorithm and input data, P. Koepke, H. De Backer, A. Bais, A. Curylo et al., Proceedings of SPIE, Stockholm, 2006*