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First experiences in measuring, modeling and forecasting the vitamin D effective UV radiation

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There has been a growing interest in the connection of vitamin D and solar ultraviolet-B (UVB) radiation because numerous studies have shown that there is an anti-correlation between the vitamin D level various diseases especially cancers. Additionally there is the well known anti-correlation with osteoporosis and its progress, a disease that affects approximately in 30% of all post-menopausal women.

Information about the actual effectiveness of solar UVB radiation in initiating vitamin D production could therefore a very helpful tool for health care. Such information should base on well estimated parameters either measured or modeled. Therefore, we investigated the possibilities in measuring, modeling and forecasting the vitamin D effective radiation. Measurements were made with two different broadband devices. One is a hand-held radiometer (Model 6.4, Solartech Inc., USA) which was designed as a personal dosimeter and the other is a device which is in use world wide to measure the erythemally effective UV radiation (Model 501, SolarLight Inc., USA). A conversion matrix in dependence of solar height and total ozone content (TOC) is necessary to correct the differences between the spectral sensitivity of the devices and the action spectrum of vitamin D photosynthesis. The conversion factors show an increasing importance with decreasing solar height and increasing TOC.

Further on we introduce a world wide forecast of the vitamin D effective UV radiation for clear skies together with its validation. The core procedure is a fast spectral model which delivers spectral irradiance between 297nm and 400nm. Irradiance is weighted by the action spectrum of vitamin D photosynthesis, integrated over the UV range and

integrated from sun rise to sun set to gain the daily dose. Input parameters for the forecast are date and time, geographical position and altitude, TOC, less aerosols and neglected albedo.

The validation of model calculations and forecast can be done by comparisons to measurements of broadband meter. The application of conversion factors depending on solar height and TOC delivers satisfactory agreement. We have converted the broadband meter readings from our measuring station in Vienna (48.26˚N, 16.43˚E, 153m a.s.l.) made from January 2003 to December 2005. The validation was done for the daily dose for all sky conditions. The hit rate for the model is 42% and for the forecast 38%. As hit we count deviations less than ± 0.125 Wh/m2. This value corresponds to approximately 2 MED for skin type 2. Overestimation results mainly through cloudiness which is not an input parameter for the model and the forecast. The forecast is free available under: www.vu-wien.ac.at/uv/uv_online.htm

A conversion factor is necessary to transform the physically calculated unit to the biologically relevant quantity of vitamin D production like the International Unit (IU) (1 IU = 40 μg). The conversion has to take into account several parameters: orientation of the receiver, duration of exposure, size of exposed surface (body size, age related changes of the body shape and gender), transmission through the skin (skin type, facultative tan and possible applied sun protection tool), the efficiency of photosynthesis and vitamin D3 formation (depends on age and skin temperature), effectiveness in converting vitamin D to its active form Calcitriol in the liver, the kidneys and other organs (personal conditions, gender and age). Especially the later points of the conversion build the main challenge in the future to give radiation quantities a biological meaning.