Aspects of modelling UV radiation

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Modelling UV radiation

means solving the Radiative Transfer Equation for all layers of the atmosphere,

taking into account spectral extinction (optical depth), single scattering albedo and scattering function of all relevant atmospheric and surface parameters and illumination by extraterrestrial Sun

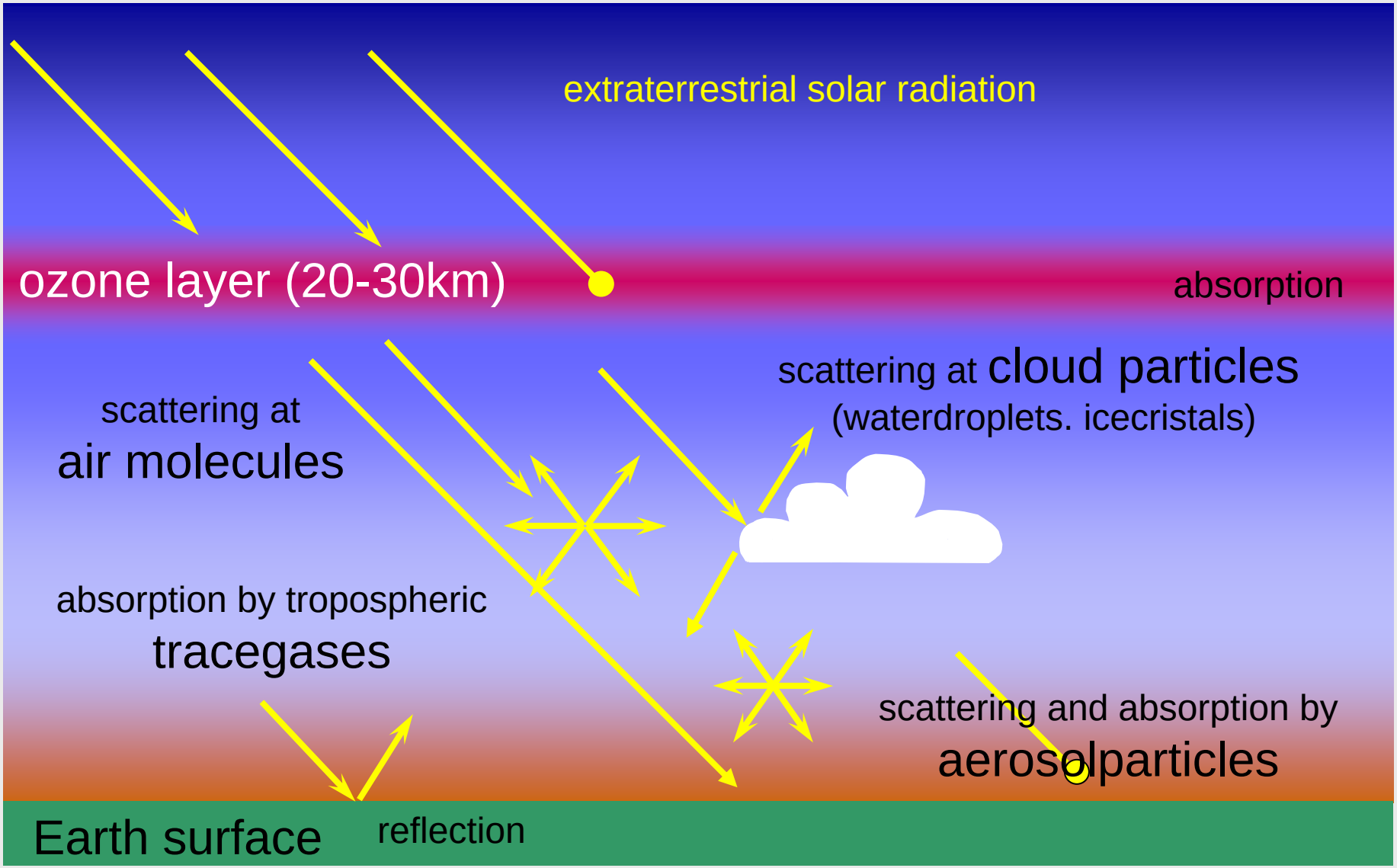
resulting in the spectral radiation field

$$\mu \frac{dI(\tau,\mu,\varphi)}{d\tau} = I(\tau,\mu,\varphi) - \frac{\omega_0}{4\pi} \int_{4\pi} I(\tau,\mu',\varphi')\, P(\mu,\varphi;\mu',\varphi')\, d(\mu',\varphi')$$

extinction — multiple scattering

$$- \frac{\omega_0}{4\pi} \pi F_0\, P(\mu,\varphi;\mu_0,\varphi_0)\, e^{\frac{-\tau}{\mu_0}}$$

scattering


extraterrestrial solar radiation
ozone layer (20-30km)
absorption
scattering at cloud particles
(waterdroplets. icecristals)
scattering at
air molecules
absorption by tropospheric
tracegases
scattering and absorption by
aerosolparticles
Earth surface
reflection

Mathematical procedure with high accuracy

	calculation time [s]
-- 1- dim, spectral, multiple scattering models	$10^{0} – 10^{+1}$
-- cloud – algorithmus (CMF)	10^{-3}
-- 3-dim, spectral, multiple scattering models	$10^{+3} – 10^{+4}$

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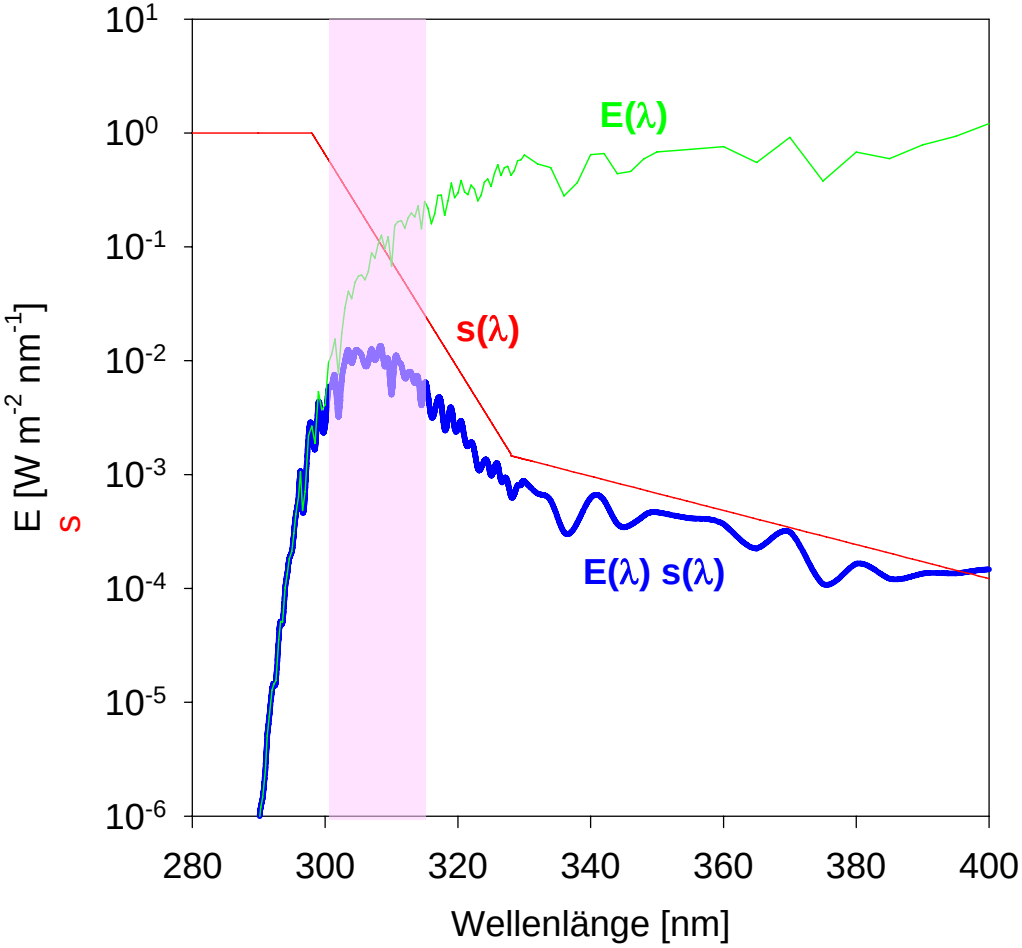
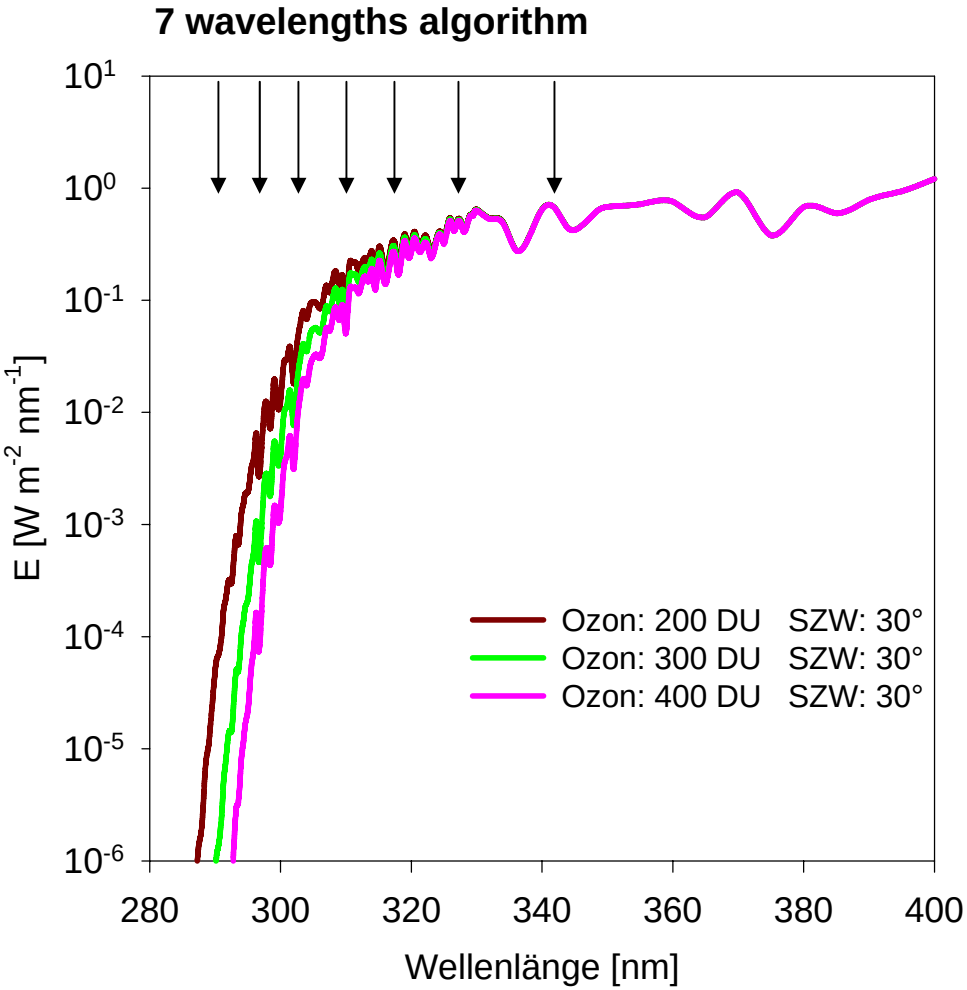
Modelling spectral, for consideration of biological weighting functions

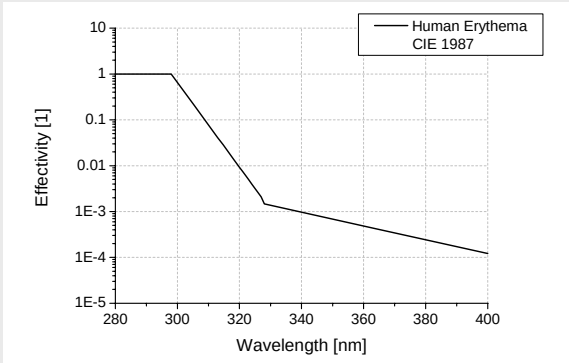


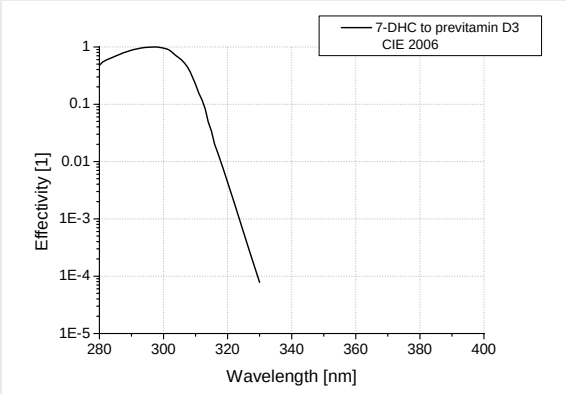
erythemal weighting,

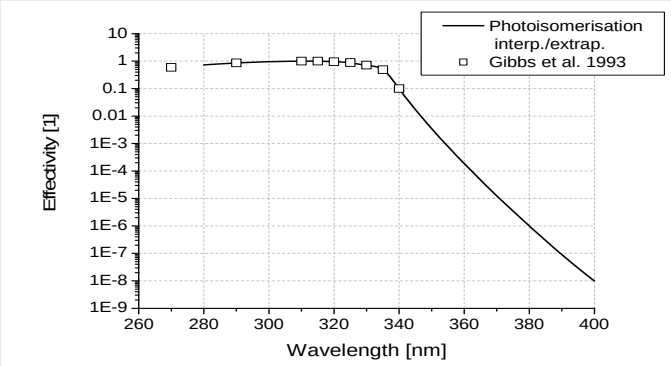
generally used for the COST 726 study

Modelling spectral, for consideration of biological weighting functions

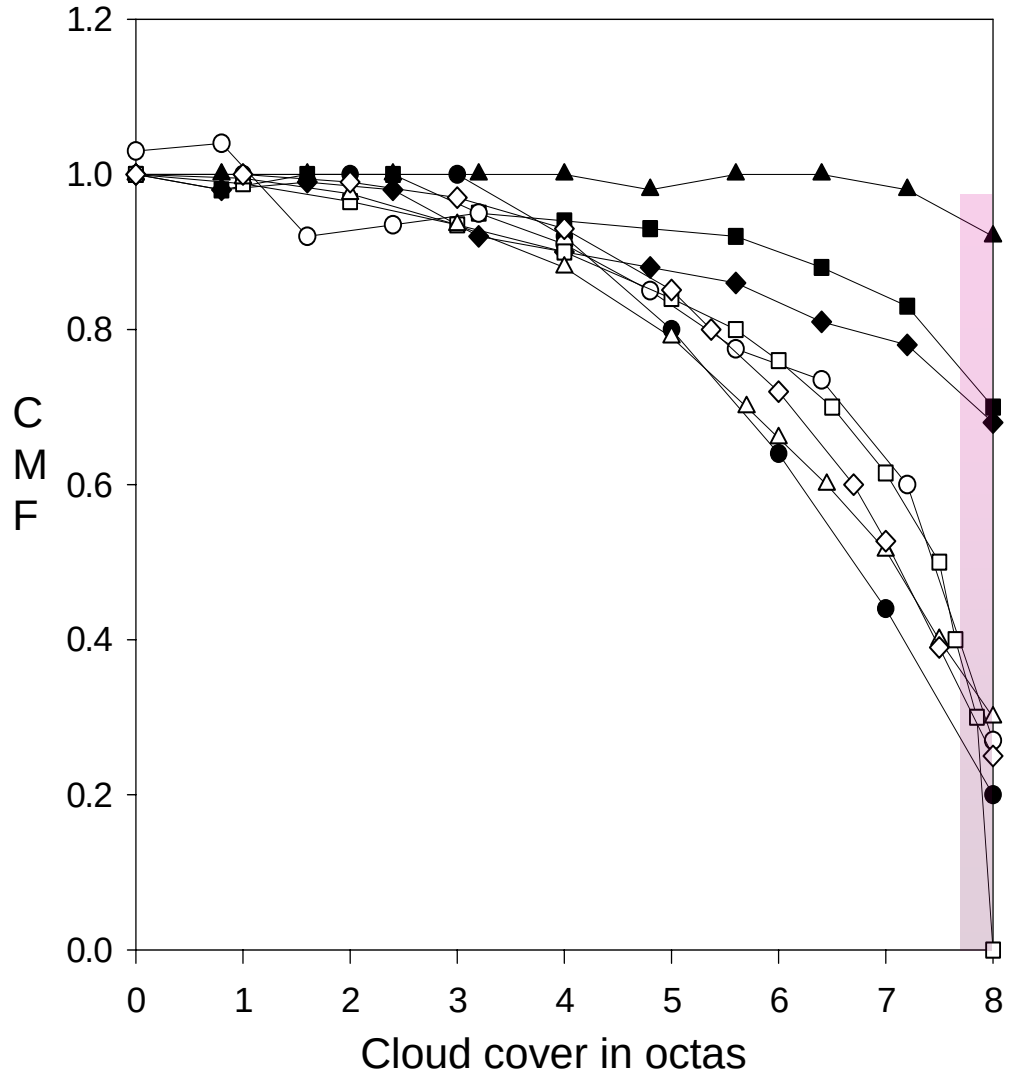








Effects of clouds (UVI reduction against clodfree conditions)

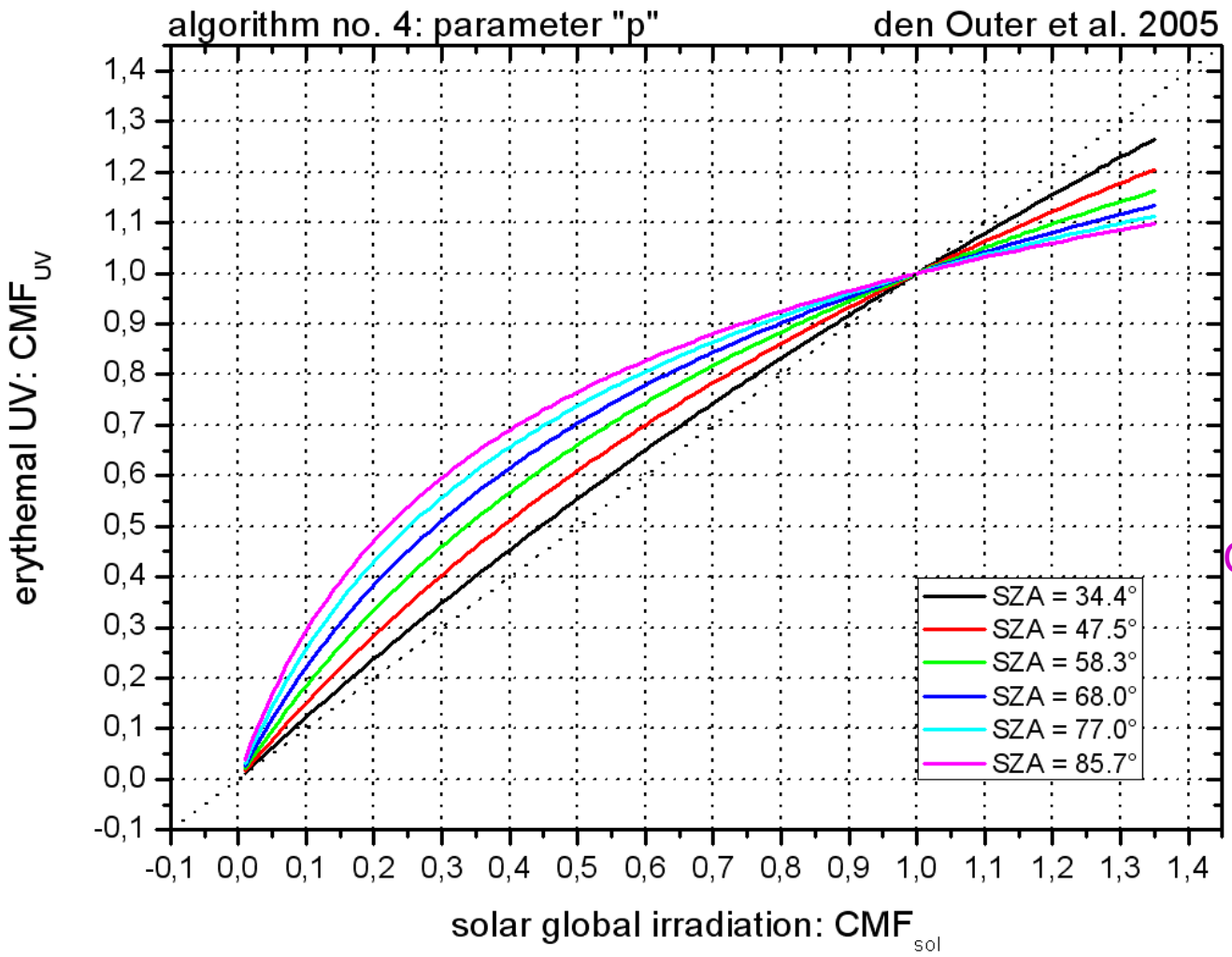


CMF =
Cloud modification factor =

$$\frac{\text{UVI cloudy sky}}{\text{UVI sky without clouds}}$$

Koepke et al.,2002,
Rec. Res. Devel. Photochem. Photobiol.
after different authors

CMF_{UV} as function of CMF_{solar}

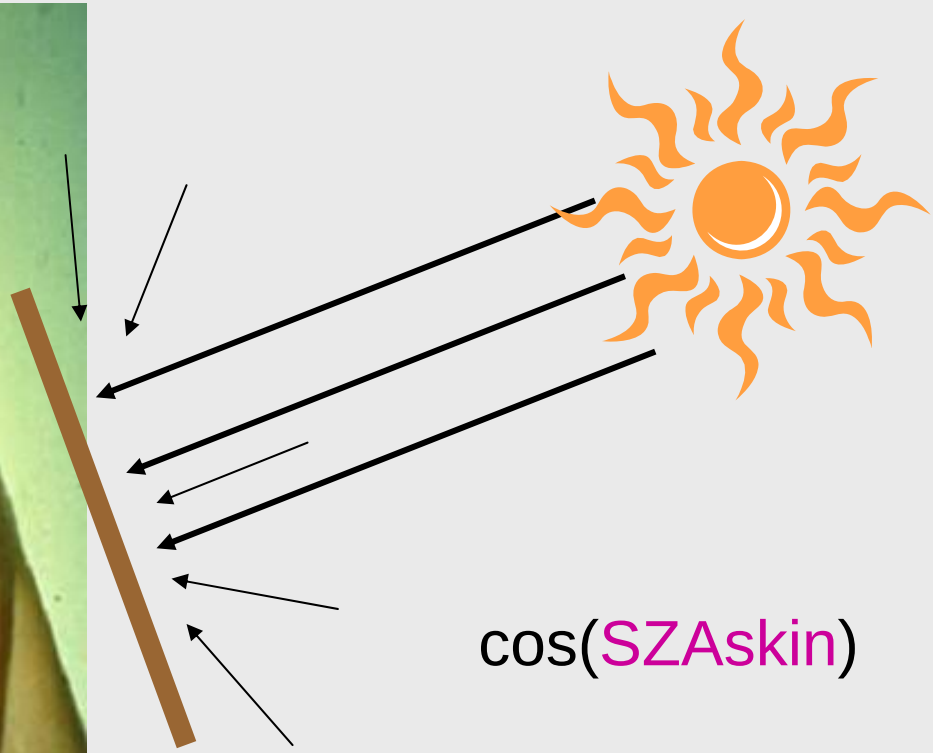


CMF =
Cloud modification factor

$$= \frac{\text{UV irrad cloudy sky}}{\text{UV irrad no clouds}}$$

den Outer et al.,2005,
J.Geophys.Res.

Human skin is **not** horizontal



cos(SZAskin)

Placzek 2003

Angle SCAnning RAdiometerfor UV irradiances on Tilted Surfaces

ASCARATIS at ski region on Zugspitz mountain

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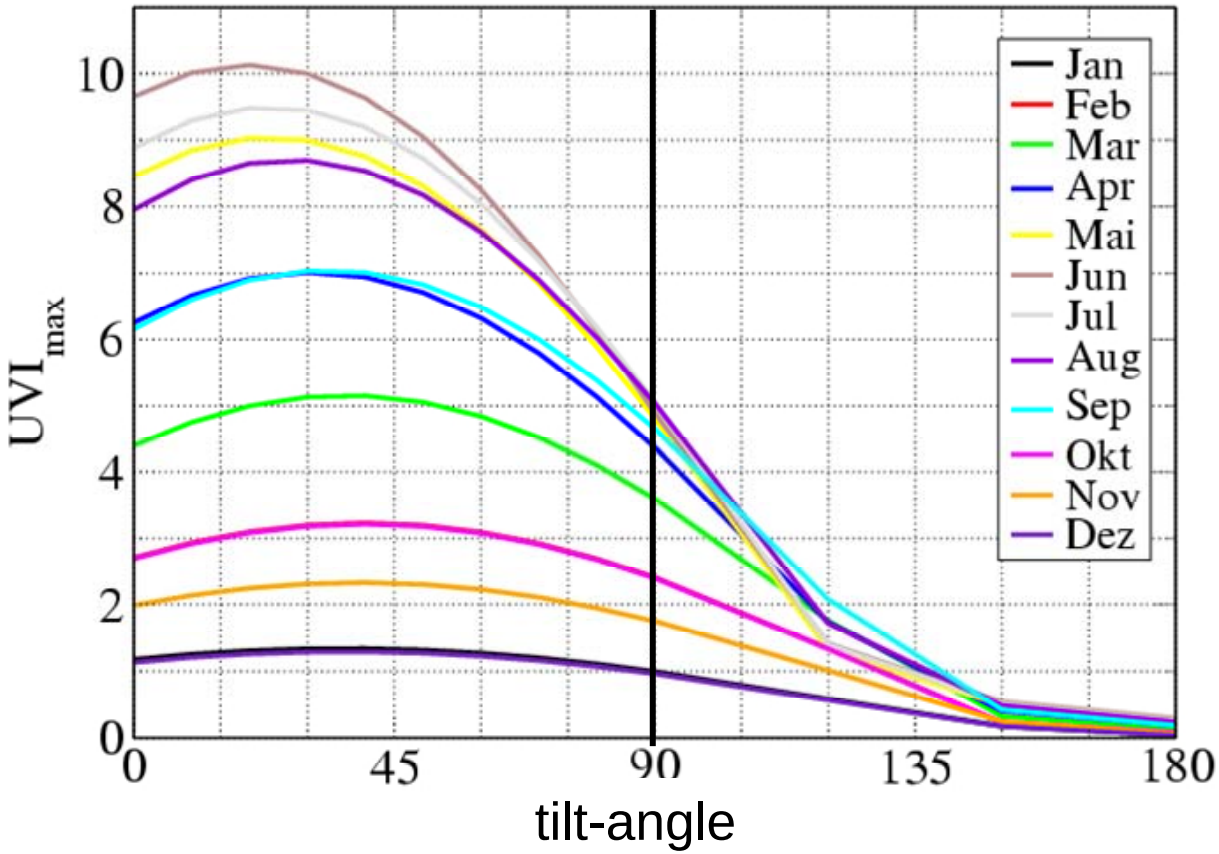
UVI on a surface tilted towards the Sun (azimuth receiver = azimuth Sun)



Munich,
clear atmosphere,
no obstruction of sun or sky,
ozone: mean monthly minimum;
SZA: noon 15th month

Human environment (Munich, English Garden)

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Sun and shadow in human environment

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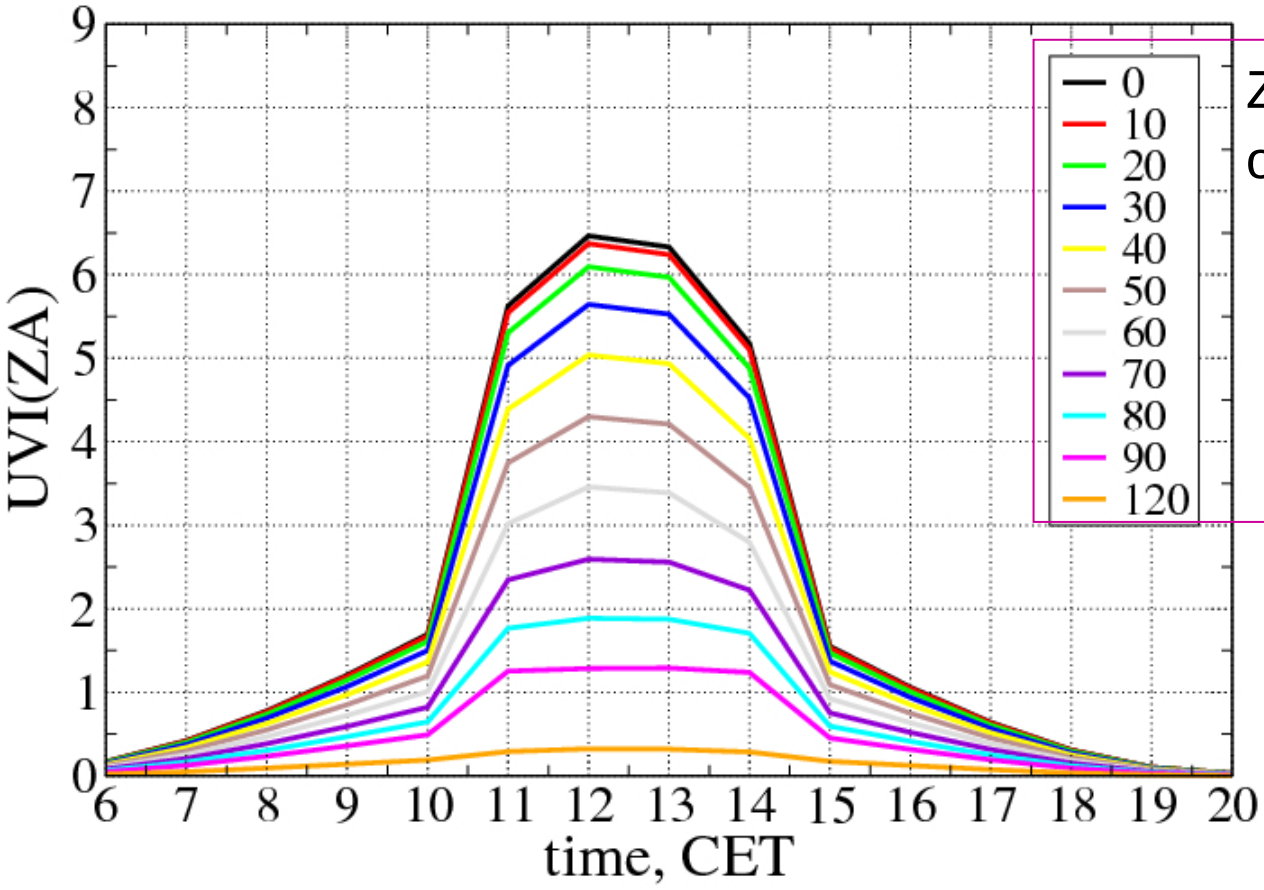
Diurnal variation of UVI on a surface tilted, but azimuth averaged

(Moving person) Street canyon, orientation North - South



Zenith Angle of the receiver

Summer, Munich, clear atmosphere, ozone 330 DU

Conclusion

Modelling of UV radiation

is necessary for conditions without measurements

>>> The method used for COST UV climatology

Modelling of UV radiation is possible for any biological UV-weighting

>>> UV climatology useful for more than erythemal weighted UV radiation

Uncertainty of modelled UV radiation results from availability and uncertainty of atmospheric conditions

>>> limiting factors of COST UV climatology

Effects of environmental conditions can be considered by measuring and by models

>>> Questions for possible future UV activities

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Thank you

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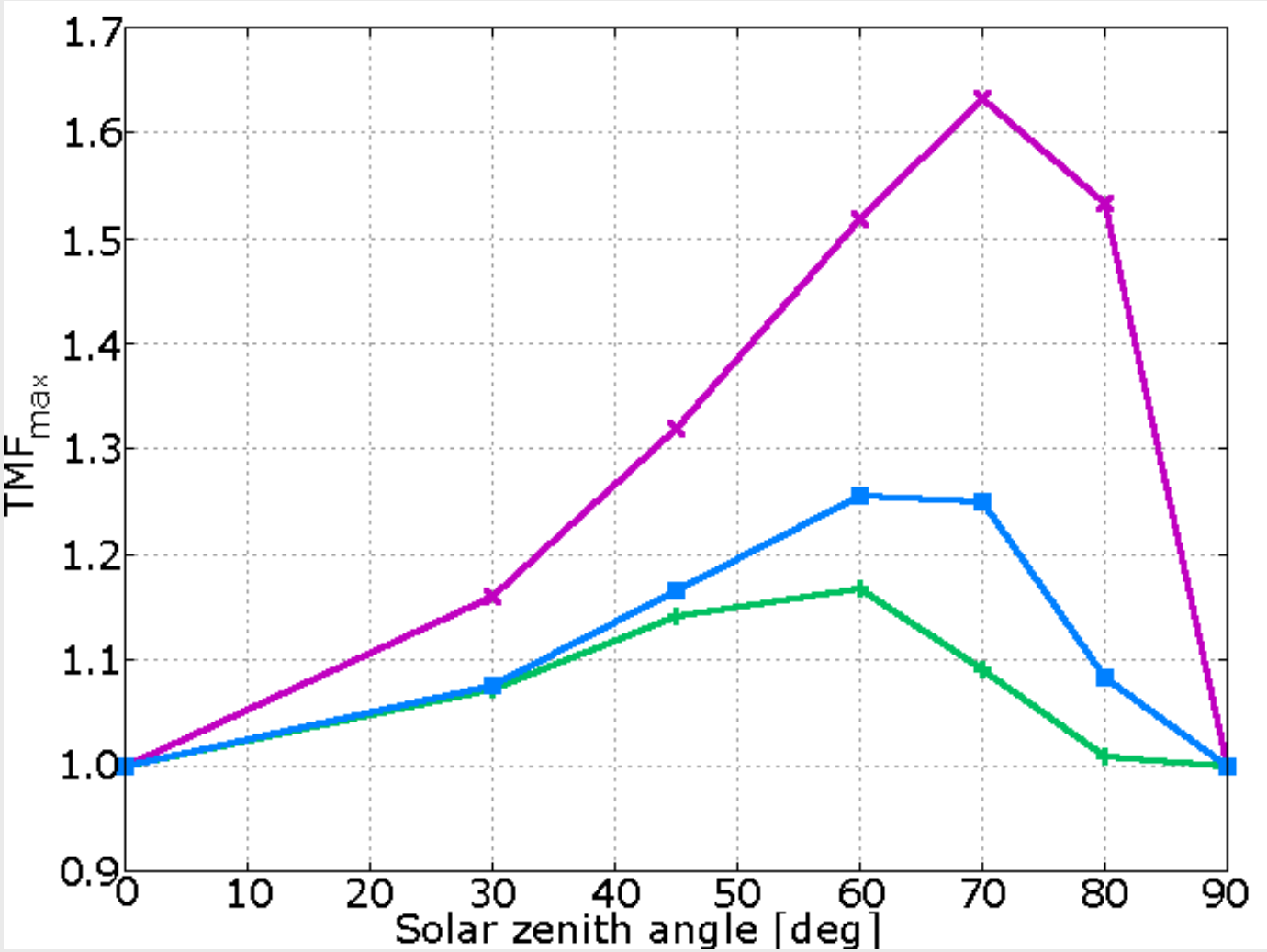
Tilt modification factors $TMF = UVI_{tilt} / UVI_{hor}$ (azimuth receiver = azimuth Sun)



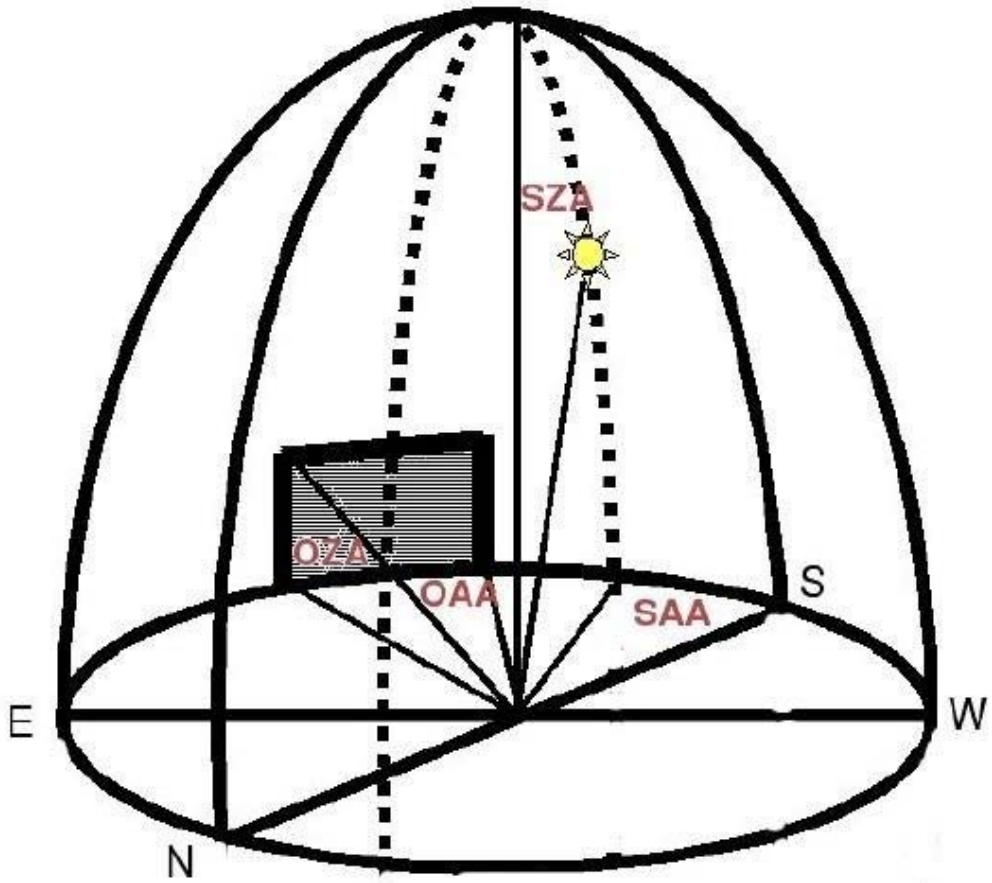
Skiing conditions:
Fresh snow, 3000 m ,
Clear atmosphere

Beach conditions:
Sand, 0 m,
Clear atmosphere

summer conditions:
meadow, 500 m ,
Average turbidity

Koepke a. Mech, 2006

UV irradiances on tilted surfaces: modelled



STAR
System of Transfer of Atmospheric Radiation
Koepke et al., 2004

Radoninc
Radiation on Inclined Surfaces
Mech a. Koepke, 2004, TheorApplClimatology 77, 151 -158

Skop
Sky Obstruction program
Hess a. Koepke, 2008, Atmosp. Chem. Phys. 8, 3583 - 3591