Mapping of UV values:

DWD’s method

- conceptual design of radiation transfer calculation
- required input and discussion of downscaling
- simplified derivation of climatological means

Conceptual Design of Radiation Transfer Calculation

$$UV_i(d,t) = buv_i(sza_i(d,t), toc_i(d,t))$$

$$\times F\_aod\_ssa_i(aod_i(d,t), ssa_i(d,t), sza_i(d,t))$$

$$\times F\_ae_i(alt_i, aod_i(d,t), ssa_i(d,t), sza_i(d,t))$$

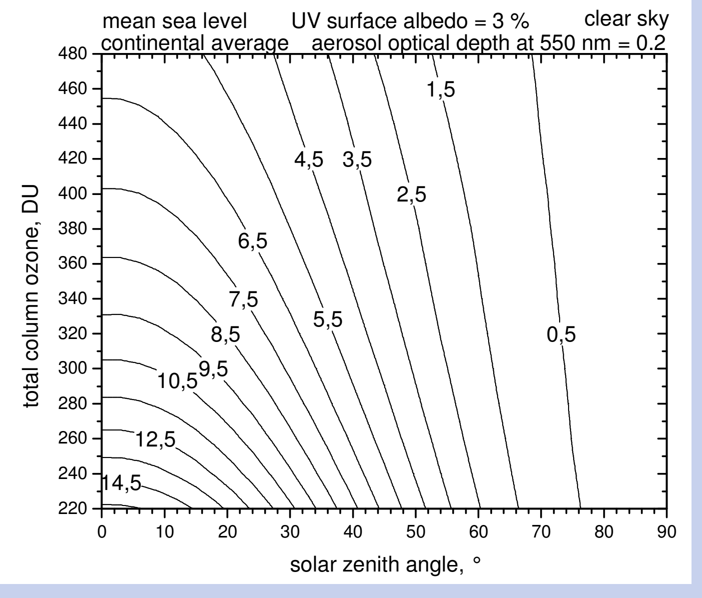
$$\times F\_alb_i(alb_i(d,t), alt_i, aod_i(d,t), ssa_i(d,t), sza_i(d,t))$$

$$\times CMF_i(glob_i(d,t), sza_i(d,t))$$

Indices: i= geographic location, d= date, t= time of day

Standardised Radiation Transfer based on STARneuro

$$buv_i\left(sza_i(d,t), toc_i(d,t)\right)$$



Lookup tables dependent on

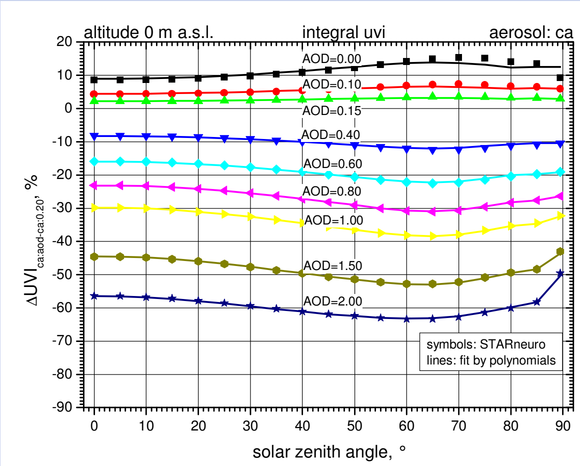
- solar zenith angle (SZA)
- total ozone content (toc)
- month
- latitude (10 zonal belts)

Standardisation:

- mean sea level
- clear sky
- UV surface albedo = 3 %
- aerosol type: continental average
- aerosol optical depth (550 nm)= 0.20

Aerosol Optical Depth at 550 nm and Single Scattering Albedo

aerosol: continental average

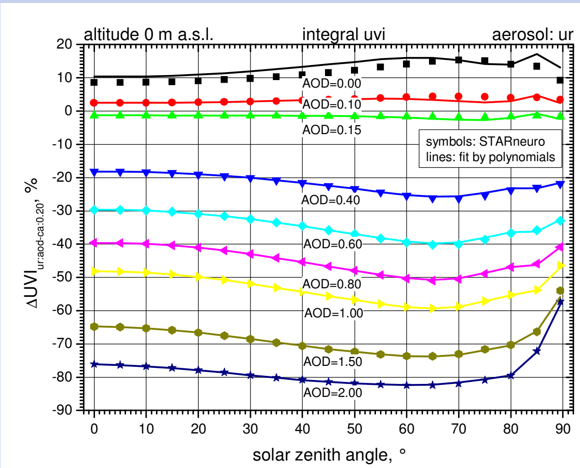


$$F\_aod\_ssa_i\left(aod_i(d,t), ssa_i(d,t), sza_i(d,t)\right)$$

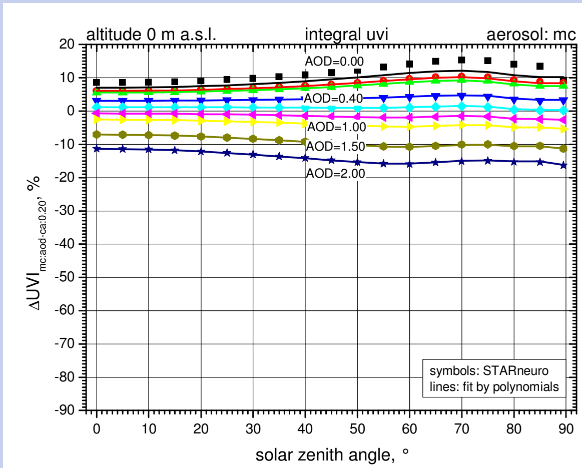
Standardisation:

- mean sea level
- clear sky
- UV surface albedo = 3 %

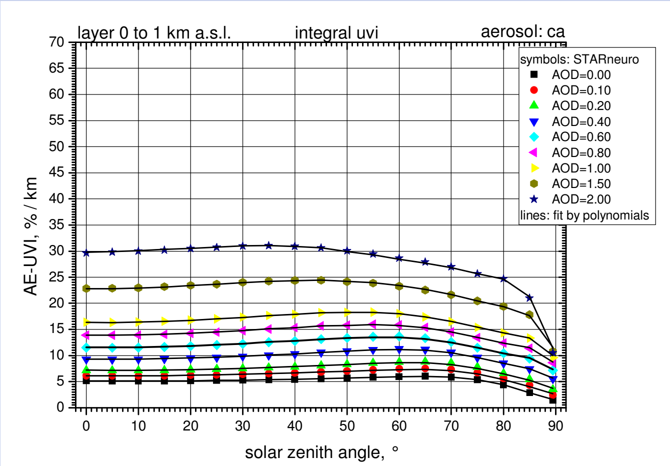
aerosol: urban



aerosol: maritime clear



aerosol: continental average



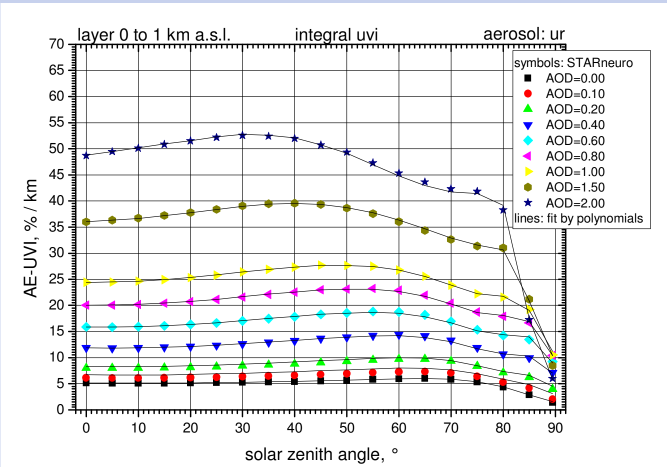
Altitude Effects

$$F\_ae_i\left(alt_i, aod_i(d,t), ssa_i(d,t), sza_i(d,t)\right)$$

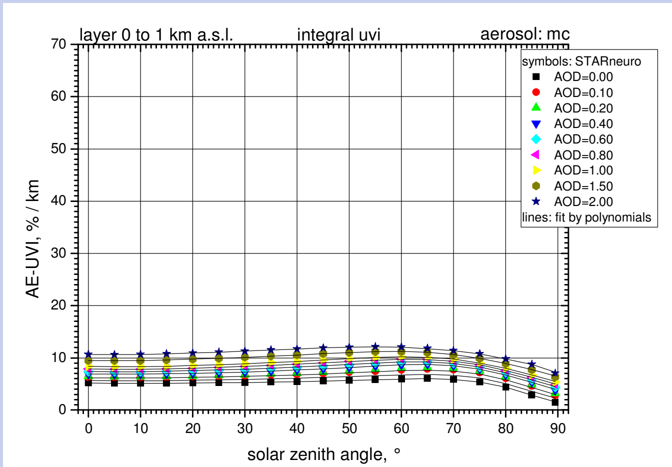
Standardisation:

- clear sky
- UV surface albedo = 3 %

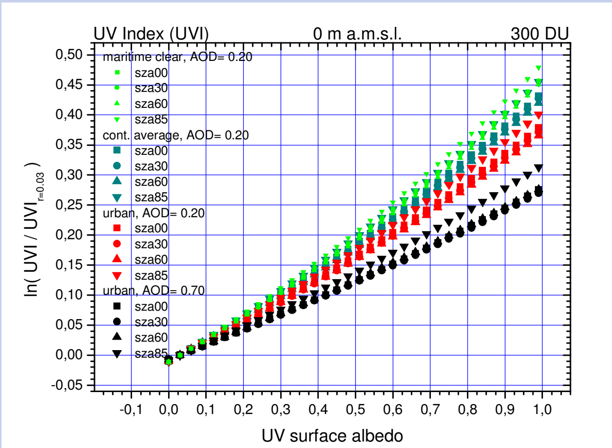
aerosol: urban



aerosol: maritime clear



albedo dependency



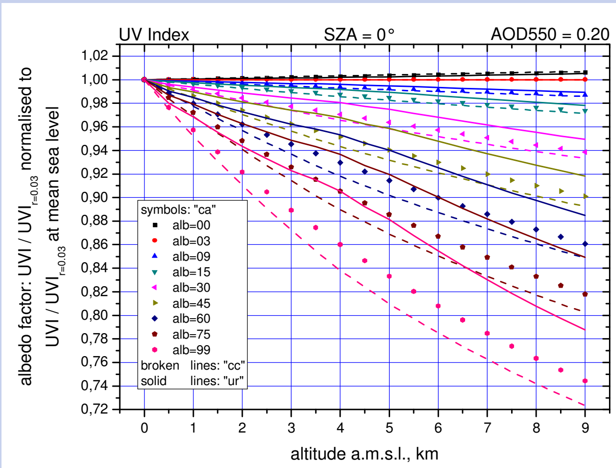
Dependency on UV Surface Albedo

$$F\_alb_i\left(alb_i(d,t), alt_i, aod_i(d,t), ssa_i(d,t), sza_i(d,t)\right)$$

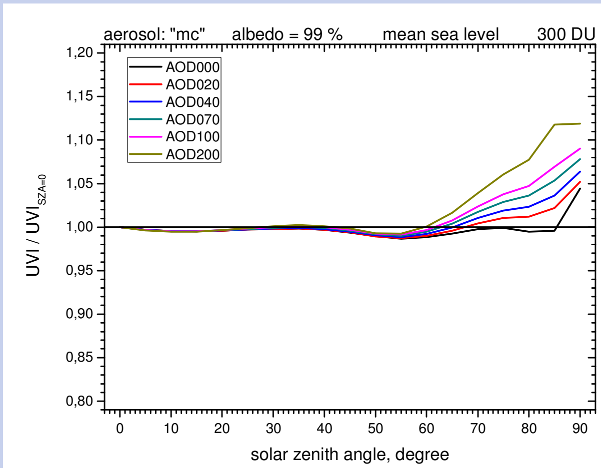
Standardisation:

- clear sky

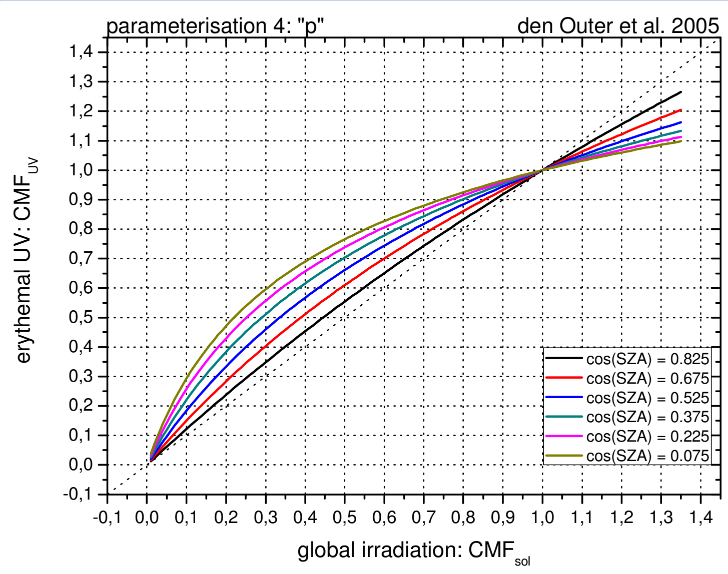
altitude dependency



SZA: aerosol "mc"



Cloud Modification Factor

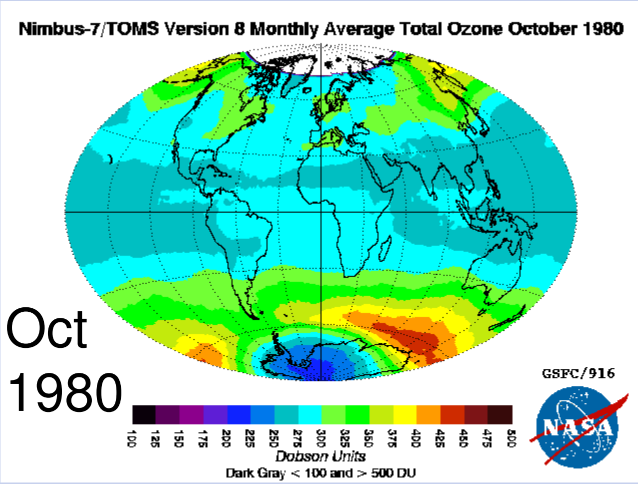


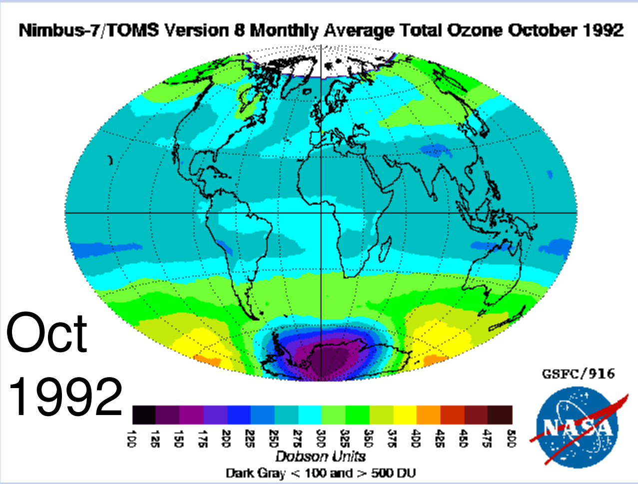
$$CMF_i\left(glob_i(d,t), sza_i(d,t)\right)$$

Standardisation:

- none

Gridded Total Column Ozone





Available:

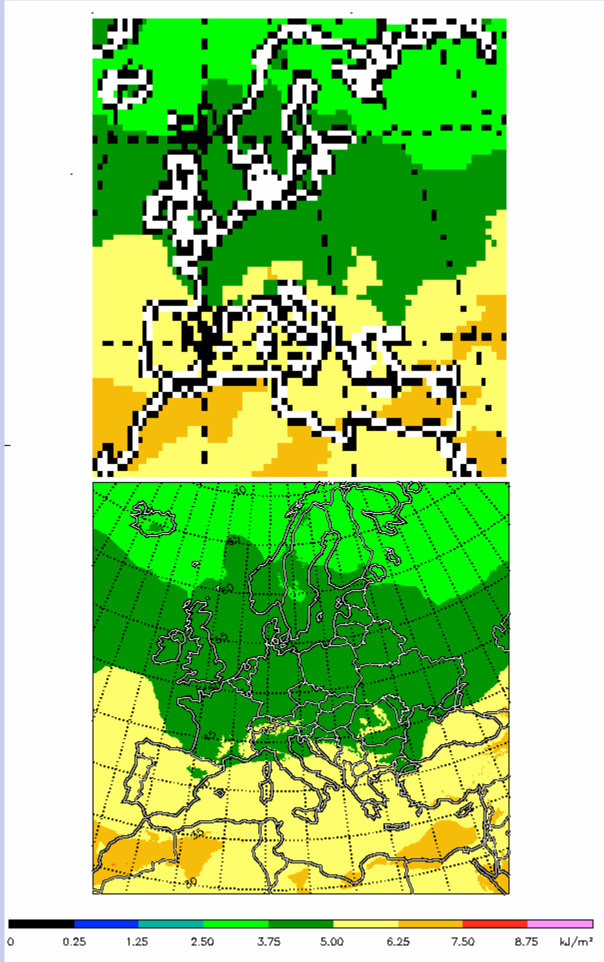
- 1950 – 1978 modelled by J. Krzyscin
- 1979 – 2006 measured by satellites

Spatial resolution:

- ~ 1 degree in latitude and longitude
- downscaling by interpolation

Temporal resolution:

- 1 day

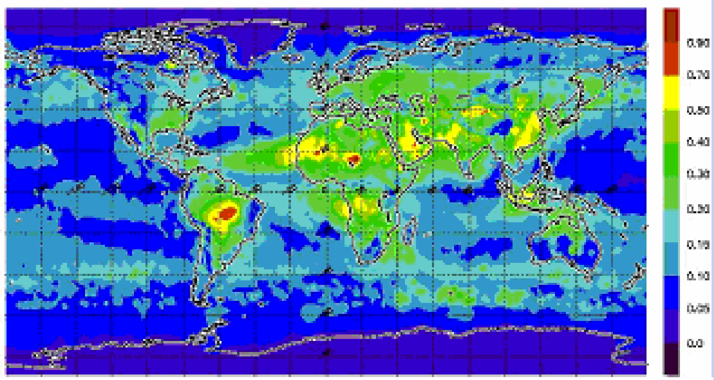


Daily UV_{ery} dose clear sky 06 Jul 2005

Orography

- The applied orography essentially influences the appearance of a map.
- methods are additionally required for downscaling information from a coarse grid to that of a higher resolution.

Gridded Aerosol Optical Depth



MODIS AOD550 + TOMS:
Average Sep 2000 - 2004

Available:

- 2000 – … : MODIS climatology
- 1979 – 2005 TOMS Aerosol Index ?
- GOCART modelled ?
- Visibility or further data sources ?

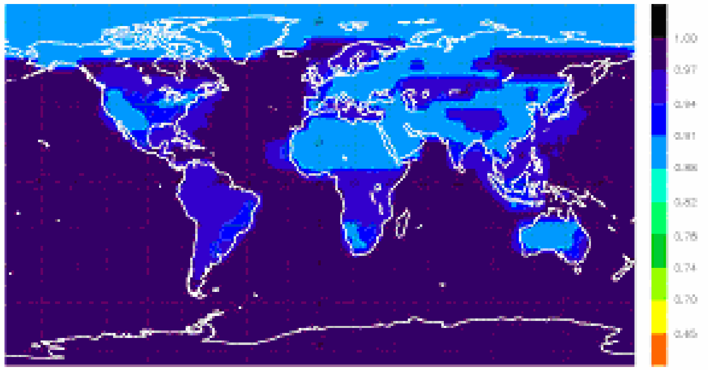
Spatial resolution:

- climatology: ~ 1 degree
- downscaling by interpolation

Temporal resolution:

- climatology: 1 month
- Aerosol Index: 1 day

Gridded Single Scattering Albedo



GADS: Single scattering albedo 300 nm, winter

Available:

- Global Aerosol Data Set (Koepke et al. 1997)
- further sources ?

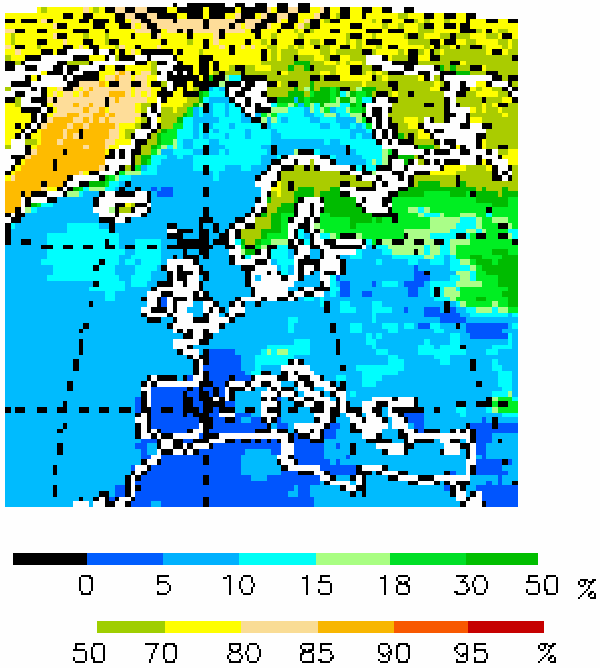
Spatial resolution:

- GADS: 5 degrees in latitude and longitude
- downscaling by interpolation ?
- nesting for specials regions, e.g. Alps ?

Temporal resolution:

- GADS: semi-annual

Gridded UV surface Albedo



March: minimum albedo

Available:

- FMI MTW UV albedo climatology based on TOMS reflectivity (Tanskanen 2004)
- NASA TOMS minimum reflectivity
- ERA40 snow heights and algorithm "Regional Albedo (Schwander et al. 1999)"

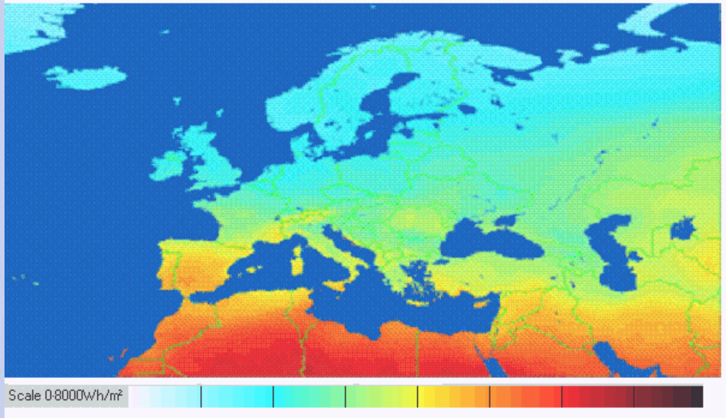
Spatial resolution:

- 1 degree in latitude and longitude
- downscaling by ERA40 snow heights ?
- nesting for specials regions, e.g. Alps ?

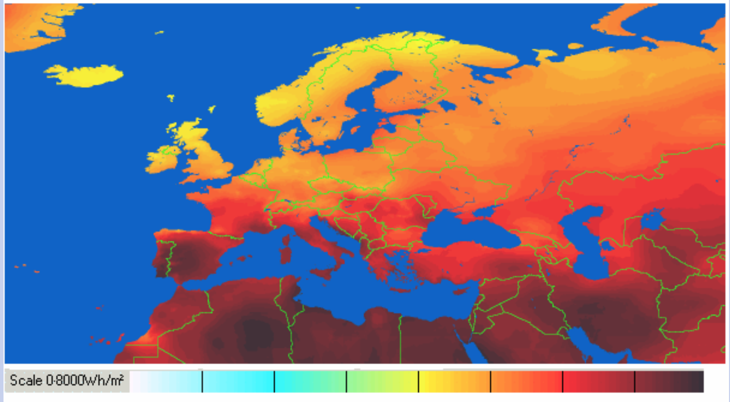
Temporal resolution:

- daily climatology based on TOMS 1979 - 92

ESRA: Map of daily irradiation for March



ESRA: Map of daily irradiation for July



Gridded Solar Global Irradiation

Available from reanalyses:

- 1957 – 2002: ERA40
- 1950 – 2002: NCEP

Spatial resolution:

- ERA40: 125 km in latitude and longitude
- downscaling by ESRA monthly means ?
- further information ?

Temporal resolution:

- ERA40 + NCEP: daily sum

Mean natural logarithm of UV_{ery} irradiation at time "t"

Averaging interval "m" of the days d1 to dn

$$\overline{\ln[UV_{i,m}(t)]} = \frac{1}{n}\sum_{d=d1}^{dn}\{\ln[buv_i(sza_i(d,t),toc_i(d,t))]\}$$

$$+\frac{1}{n}\sum_{d=d1}^{dn}\{\ln[F\_aod\_ssa_i(aod_i(d,t),ssa_i(d,t),sza_i(d,t))]\}$$

$$+\frac{1}{n}\sum_{d=d1}^{dn}\{\ln[F\_ae_i(alt_i,aod_i(d,t),ssa_i(d,t),sza_i(d,t))]\}$$

$$+\frac{1}{n}\sum_{d=d1}^{dn}\{\ln[F\_alb_i(alb_i(d,t),alt_i,aod_i(d,t),ssa_i(d,t),sza_i(d,t))]\}$$

$$+\frac{1}{n}\sum_{d=d1}^{dn}\{\ln[CMF_i(glob_i(d,t),sza_i(d,t))]\}$$

UV_{ery} irradiation at time “t” of the averaging interval “m”

$$\overline{\ln[UV_{i,m}(t)]} = \ln\left[buv_i\left(sza_{i,m}(\bar{d},t),\overline{toc_{i,m}}\right)\right] \pm std_{\ln(buv_i)}$$

$$+\ln\left[F\_aod\_ssa_i\left(\overline{aod_{i,m}},\overline{ssa_{i,m}},sza_{i,m}(\bar{d},t_n)\right)\right]$$

$$+\ln\left[F\_ae_i\left(alt_i,\overline{aod_{i,m}},\overline{ssa_{i,m}},sza_{i,m}(\bar{d},t_n)\right)\right]$$

$$+\overline{\ln[F\_alb_{i,m}]} \pm std_{\ln(F\_alb_{i,m})}$$

$$+\overline{\ln[CMF_{i,m}]} \pm std_{\ln(CMF_{i,m})}$$

Mean daily UV dose of the averaging interval “m”

$$\overline{H_{i,m}(\bar{d})} = \left\{ \sum_{t=0}^{23} \left[buv_i \left(sza_{i,m}(\bar{d},t), \overline{toc_{i,m}} \right) \right] \right\}$$

$$\times F\_aod\_ssa_i \left(\overline{aod_{i,m}}, \overline{ssa_{i,m}}, sza_{i,m}(\bar{d}, t_n) \right)$$

$$\times F\_ae_i \left(alt_i, \overline{aod_{i,m}}, \overline{ssa_{i,m}}, sza_{i,m}(\bar{d}, t_n) \right)$$

$$\times \overline{F\_alb_{i,m}}$$

$$\times \overline{CMF_{i,m}}$$

$$\times / \div \exp\left[std_{\ln(buv_i)} + std_{\ln(F\_alb_{i,m})} + std_{\ln(CMF_{i,m})} \right]$$

Summary and Conclusions

Advantages of the method:

• low computational costs due to lookup tables and polynomials to adjust to an actual environment

• allowing for different temporal and spatial scales to derive factors for adjustment

• flexible: allowing for different methods to derive a factor for adjustment

Required as must:

Daily:

• total column ozone

• global solar irradiation

• snow heights

Seasonal climatology and trend:

• aerosol optical depth

• single scattering albedo

Disadvantages:

• accuracy reduced relative to a complete calculation of the radiation transfer the end