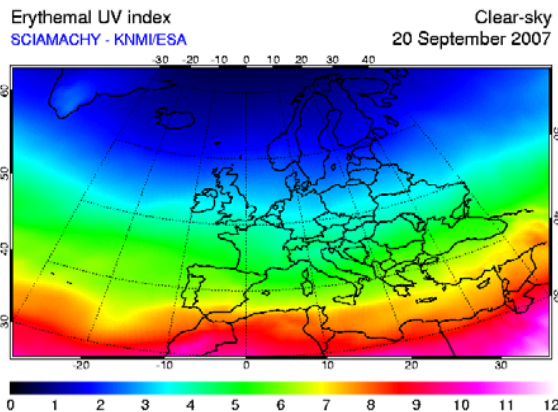




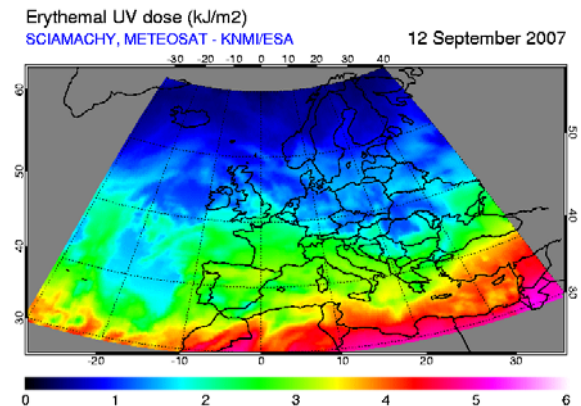
# Surface UV radiation products from TEMIS

<http://www.temis.nl>



Michiel van Weele, Ronald van der A  
KNMI, De Bilt, The Netherlands

Jos van Geffen,  
BIRA-IASB, Brussels, Belgium



# Overview



- About TEMIS
- Clear-sky UV index: worldwide forecasting and monitoring
- UV daily doses: Semi-operational monitoring over Europe
- TEMIS users and their requirements
- Evaluation methods for spaceborne UV products
- Summary



# Tropospheric Emission Monitoring Internet Service '[www.temis.nl](http://www.temis.nl)'



- Data service within the Data User Program of the European Space Agency (ESA)
- Operational data delivery a few hours after (satellite) observation
- Forecast capabilities via 4d-var data assimilation of near-real time satellite data  
=> demonstrator of SCIAMACHY total ozone assimilation at ECMWF
- On-line multi-year data archives, regularly updated by reanalysis

Current application areas using multiple satellite instruments (OMI, SCIAMACHY, GOME):

- Protocol monitoring (various O<sub>3</sub> products)
- Air pollution monitoring (tropospheric NO<sub>2</sub>, aerosol index, etc)
- UV radiation monitoring (UV index; UV daily dose)

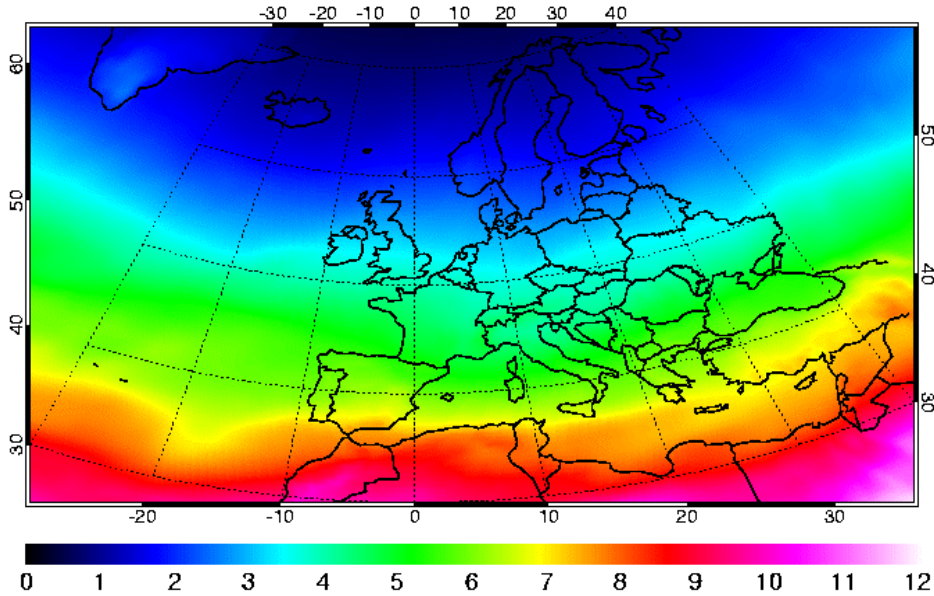


# TEMIS Clear-sky UV Index



Erythemal UV index  
SCIAMACHY - KNMI/ESA

Clear-sky  
20 September 2007



Clear-sky UV index forecasts

Up to 8-days ahead

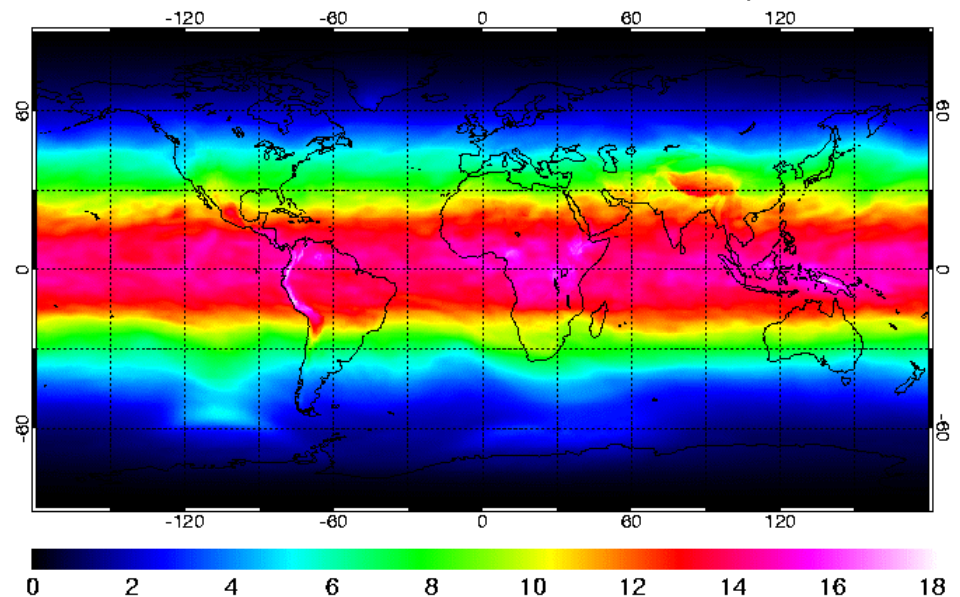
Using ECMWF analysis and forecast fields

Daily assimilation of SCIAMACHY total ozone columns within a few hours after observation followed by UV processing

Daily extension of the archives

Erythemal UV index  
SCIAMACHY - KNMI/ESA

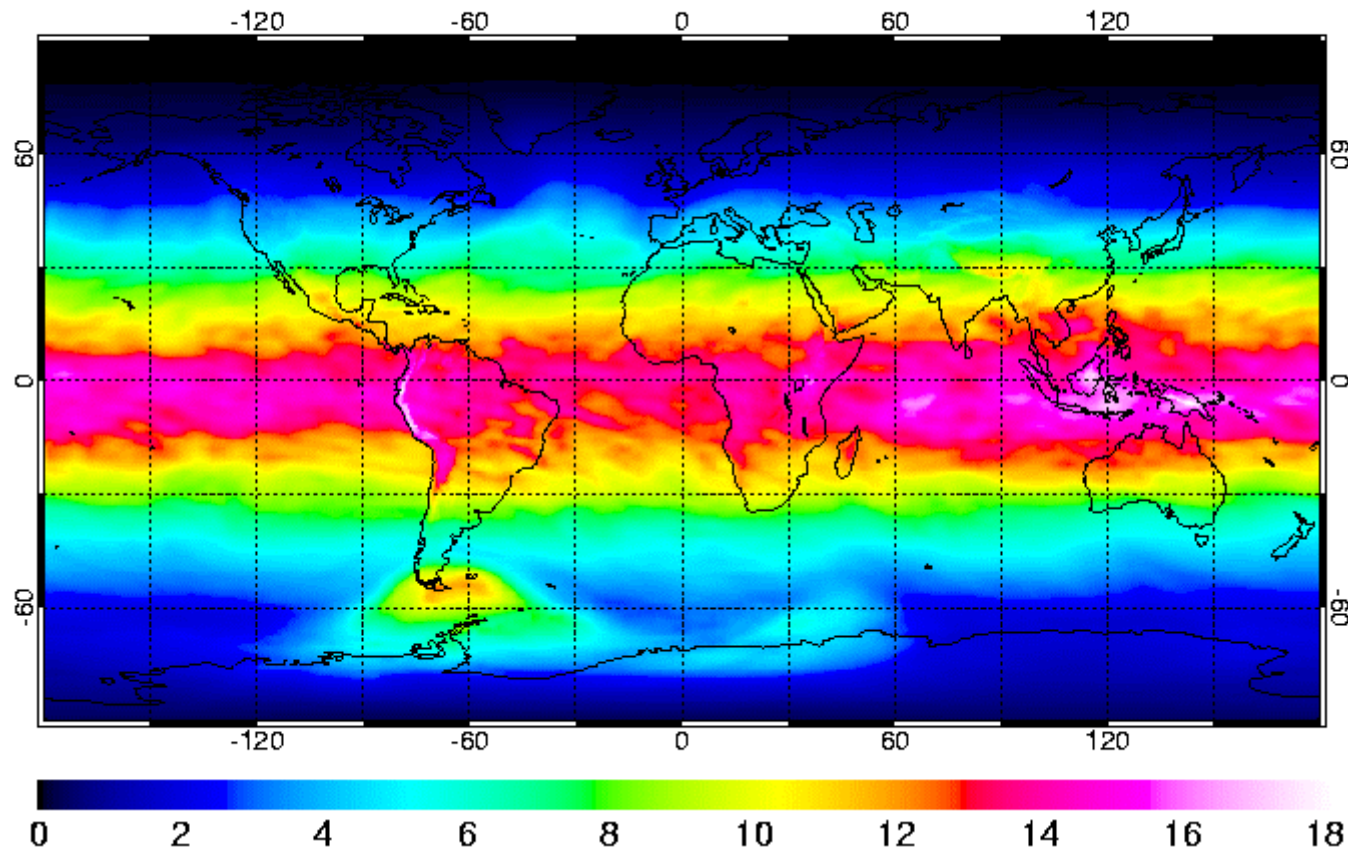
Clear-sky  
20 September 2007



# Forecasts of extreme events

Clear-sky UV index  
GOME - KNMI/ESA

local noon  
12 October 2000

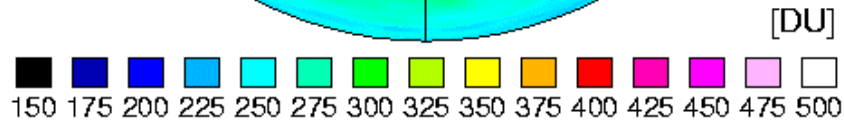
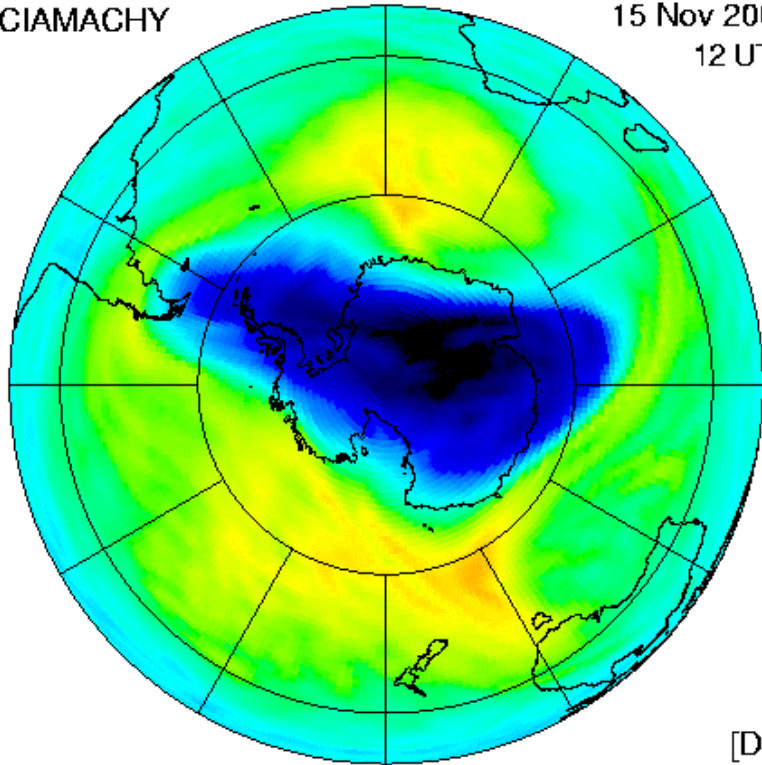


# Monitoring of extreme ozone hole excursions



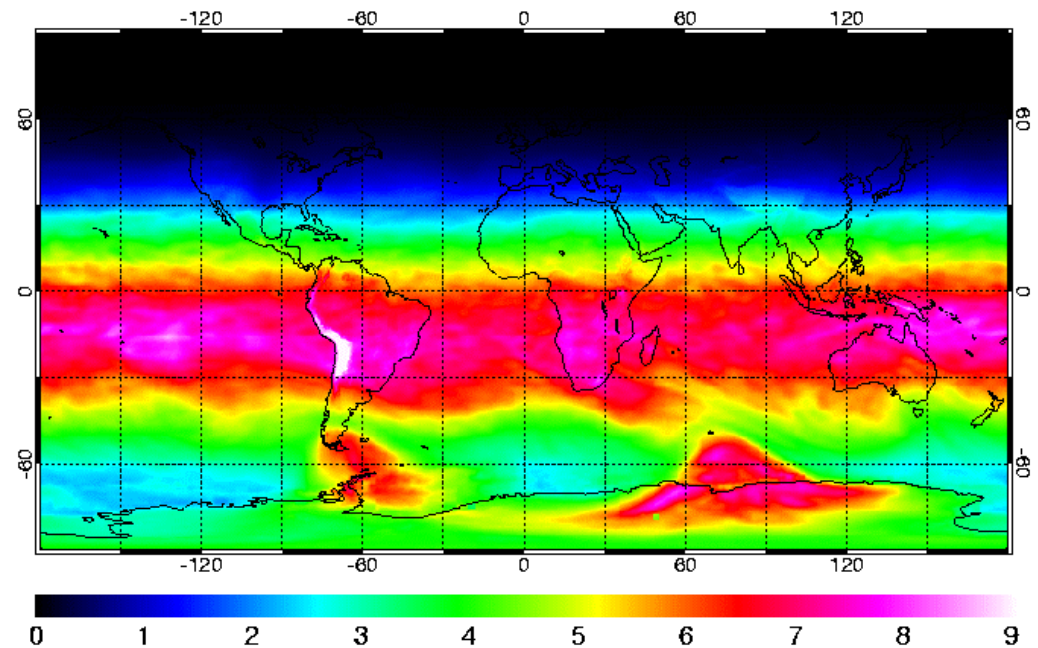
KNMI / ESA  
SCIAMACHY

Assimilated total ozone  
15 Nov 2006  
12 UTC

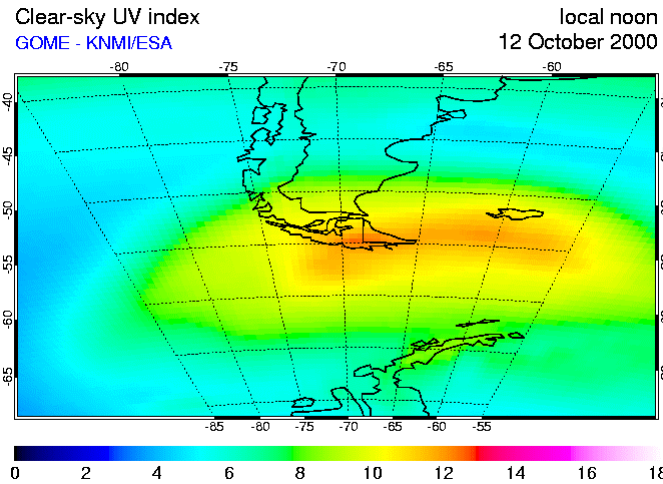
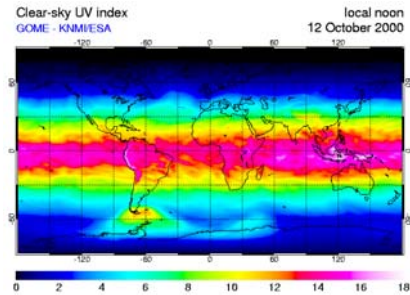
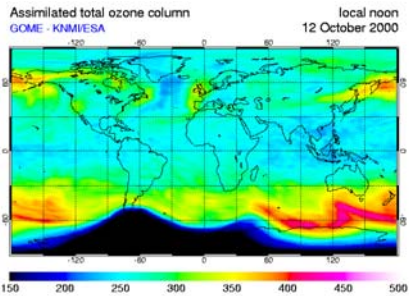


Erythemal UV dose (kJ/m<sup>2</sup>)  
SCIAMACHY - KNMI/ESA

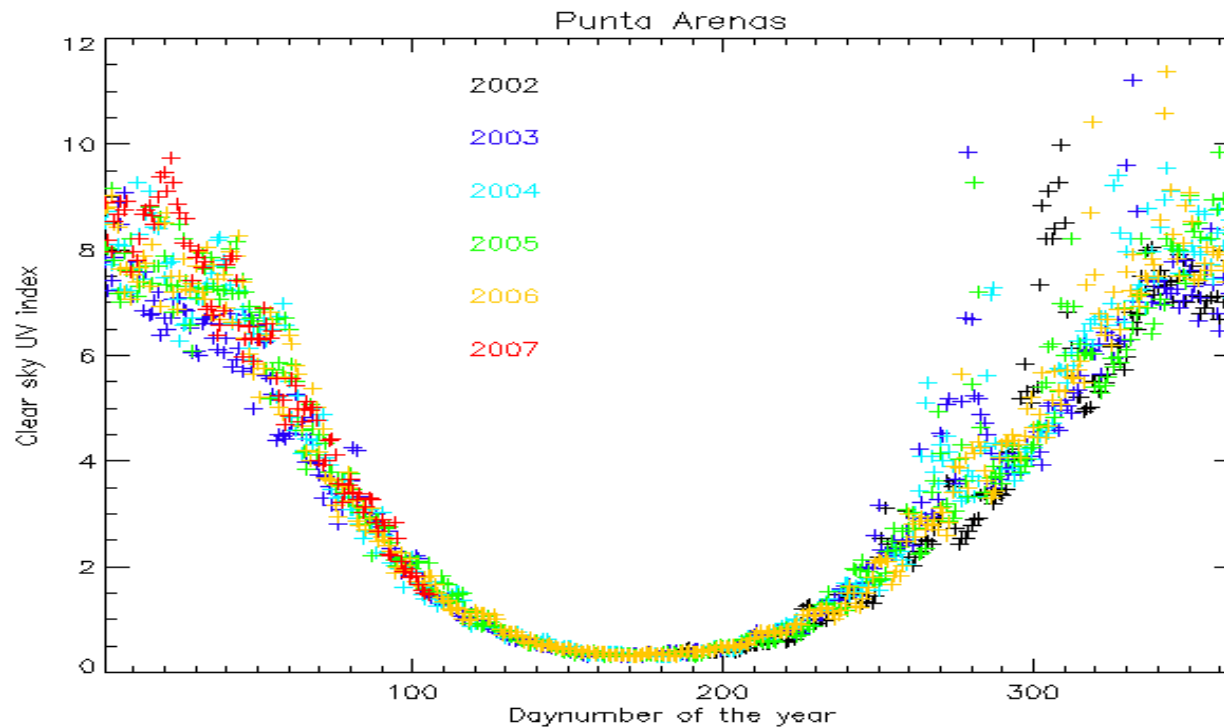
Clear-sky  
15 November 2006



# Monitoring of extreme ozone hole excursions



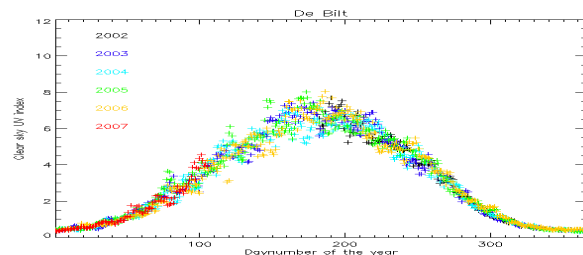
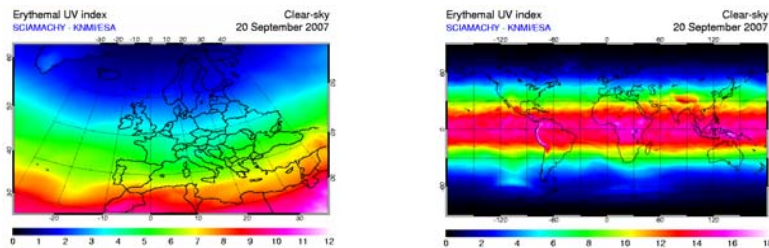
Ushuaia 12.4 (138 DU)  
Punta Arenas 10.7 (156 DU)



# TEMIS Clear-sky UV Index



- UV forecasts 'at your location' for next 8 days
- UV index maps (World/Europe) for next 8 days
- Gridded (1.0 x 1.5 deg) data in hdf-format
- Daily updated time series since 1995 of the UV index for >100 (UV-) sites worldwide
- UV Index archive based on the GOME + SCIAMACHY ozone records assimilated using analysis fields from ECMWF



## UV station data based on SCIAMACHY



### Station UV data

The following table lists the places in alphabetic order.

Some further notes regarding the data file are given [below the table](#).

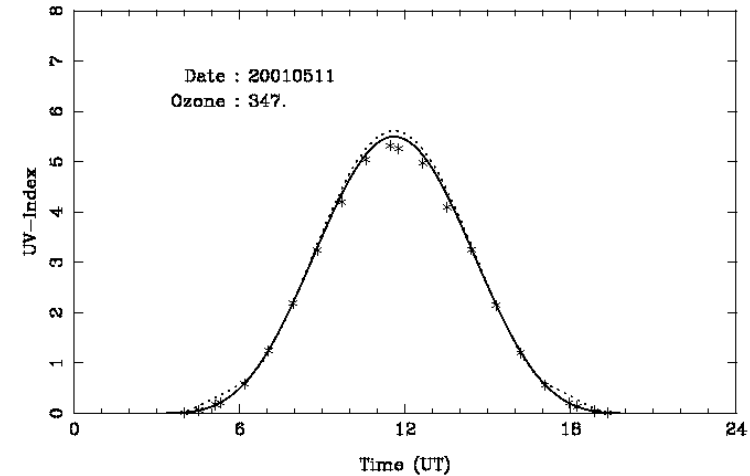
| <i>station/place name</i>                               | <i>longitude</i> | <i>latitude</i> | <i>download the ascii file<br/>time series data file</i>       |
|---------------------------------------------------------|------------------|-----------------|----------------------------------------------------------------|
| Locations inside Meteosat MSG-N range [30-70N; 30W-40E] |                  |                 |                                                                |
| <a href="#">Andoya, Norway</a>                          | 16.00            | 69.30           | <a href="#">uv Andoya Norway ENS M8.dat</a>                    |
| <a href="#">Angra do Heroismo, Azores Portugal</a>      | -27.22           | 38.66           | <a href="#">uv Angra do Heroismo Azores Portugal ENS M8.da</a> |
| <a href="#">Belsk, Poland</a>                           | 20.78            | 51.83           | <a href="#">uv Belsk Poland ENS M8.dat</a>                     |
| <a href="#">Bilthoven, Netherlands</a>                  | 5.20             | 52.12           | <a href="#">uv Bilthoven Netherlands ENS M8.dat</a>            |
| <a href="#">Briancon, France</a>                        | 6.65             | 44.90           | <a href="#">uv Briancon France ENS M8.dat</a>                  |
| <a href="#">Camborne, GreatBritain</a>                  | -5.30            | 50.20           | <a href="#">uv Camborne GreatBritain ENS M8.dat</a>            |
| <a href="#">DeBilt, Netherlands</a>                     | 5.18             | 52.10           | <a href="#">uv DeBilt Netherlands ENS M8.dat</a>               |
| <a href="#">Funchal, Madeira Portugal</a>               | -16.89           | 32.64           | <a href="#">uv Funchal Madeira Portugal ENS M8.dat</a>         |
| <a href="#">Garmisch, Germany</a>                       | 11.07            | 47.48           | <a href="#">uv Garmisch Germany ENS M8.dat</a>                 |
| <a href="#">Hohenpeissenberg, Germany</a>               | 11.02            | 47.80           | <a href="#">uv Hohenpeissenberg Germany ENS M8.dat</a>         |
| <a href="#">HradecKralove, CzechRepublic</a>            | 15.83            | 50.19           | <a href="#">uv HradecKralove CzechRepublic ENS M8.dat</a>      |

# TEMIS Clear-sky UV Index

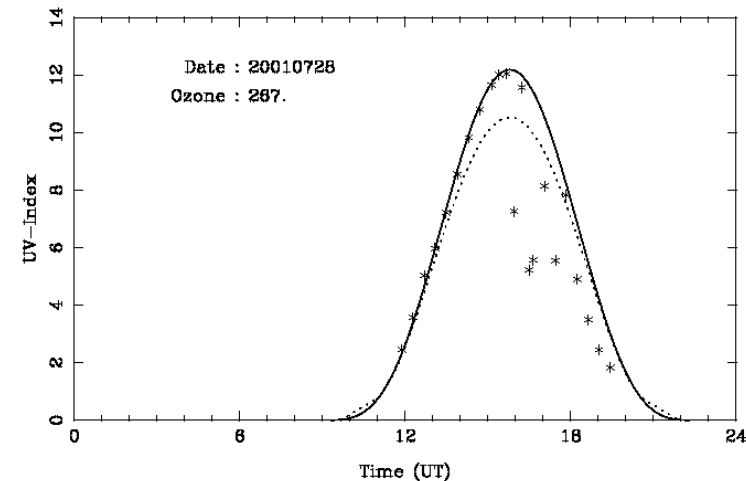


## Key elements TEMIS UV Index

- Based on an empirical parameterisation as function of total ozone column and solar zenith angle following Allaart et al. (Meteorol. Appl., 2005)
- Implicit aerosol conditions  
AOD(@ 368nm) = 0.3; SSA = 0.9  
derived from RT model analysis
- Very fast (re-)processing:  
No radiative transfer; no look-up tables
- Applied modification factors are delivered together with the data product in the hdf files
- Applicable year-round from polar to tropical latitudes



UV-index Paramaribo



Solid: Allaart et al., 2005  
dotted: W.R. Burrows et al, 1994

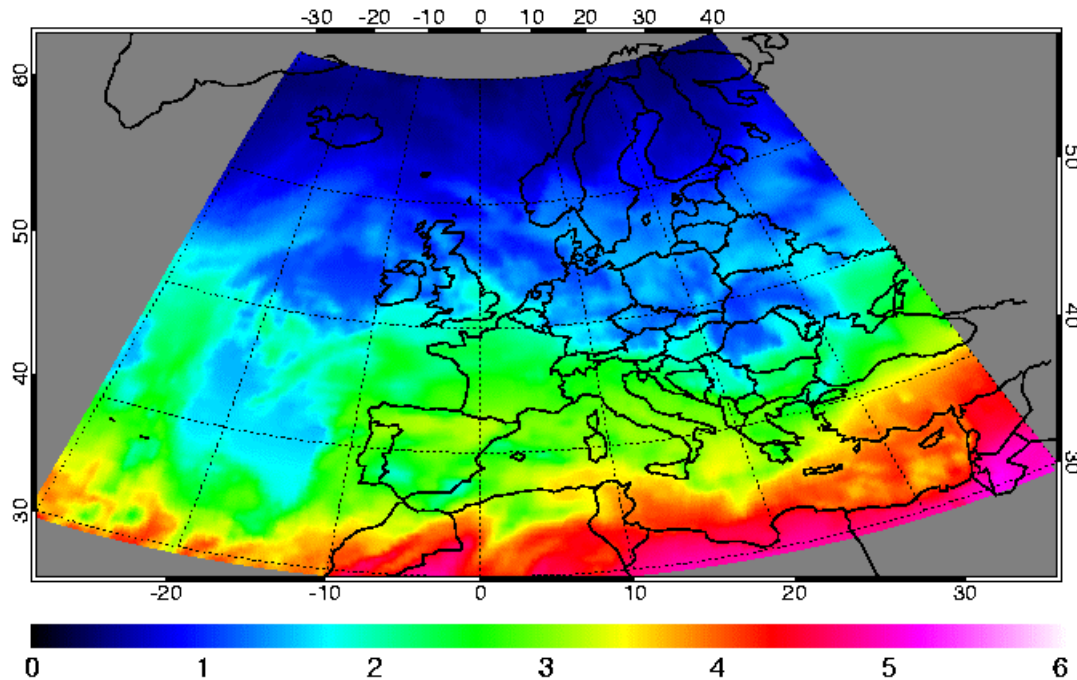
# TEMIS UV daily dose



Erythemal UV dose (kJ/m<sup>2</sup>)

SCIAMACHY, METEOSAT - KNMI/ESA

12 September 2007



## Key elements TEMIS UV dose

- Yesterday's UV dose is provided (maps, data, 'at your location')
- Based on ozone analysis field from the assimilation and half-hourly Meteosat cloud mask ('Nowcasting')
- Simple integration of the clear-sky UV Index over the day using daily-averaged assimilated ozone
- Relatively coarse spatial resolution (0.5 X 0.5 degrees) caused by the cloud modification procedure
- Archived time series at most UV measurement sites in Europe
- Inhomogeneous time series; data gap in 2003

| Instruments                | Time Coverage        |
|----------------------------|----------------------|
| SCIAMACHY + MSG Meteosat-9 | May 2007 – Yesterday |
| SCIAMACHY + MSG Meteosat-8 | Jul 2005 – May 2007  |
| SCIAMACHY + Meteosat-7     | Jan 2004 – Jun 2006  |
| GOME + Meteosat-7          | Aug 1998 – May 2003  |

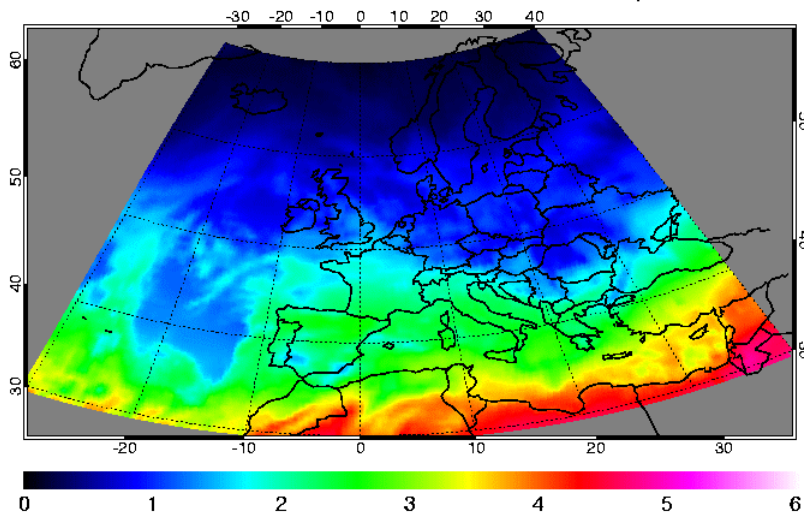
# TEMIS UV daily dose



Vitamin-D UV dose (kJ/m<sup>2</sup>)

SCIAMACHY, METEOSAT - KNMI/ESA

12 September 2007



Daily doses currently for three action spectra

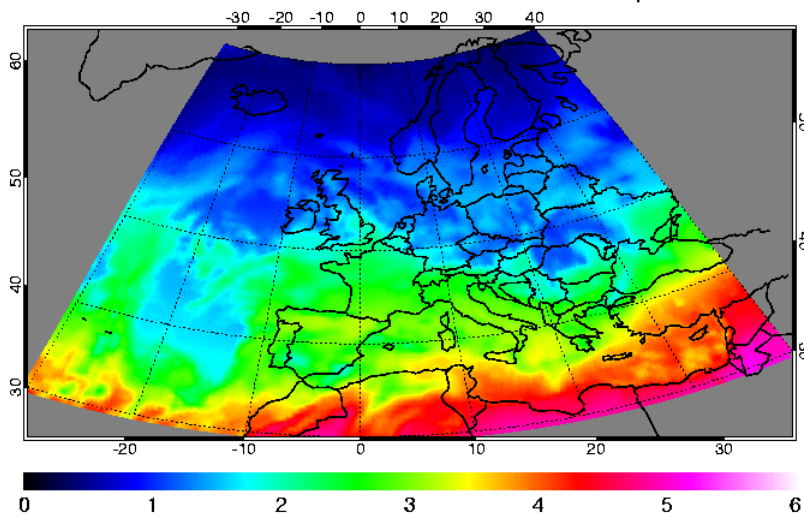
Erythema, Vitamin-D, and DNA-damage

- Approach identical to Erythemal UV dose
- though with different empirical parameterisations for the total ozone and solar zenith angle dependence
- The Vitamin-D daily dose, using the recent CIE recommended action spectrum, has not yet been validated.

Erythemal UV dose (kJ/m<sup>2</sup>)

SCIAMACHY, METEOSAT - KNMI/ESA

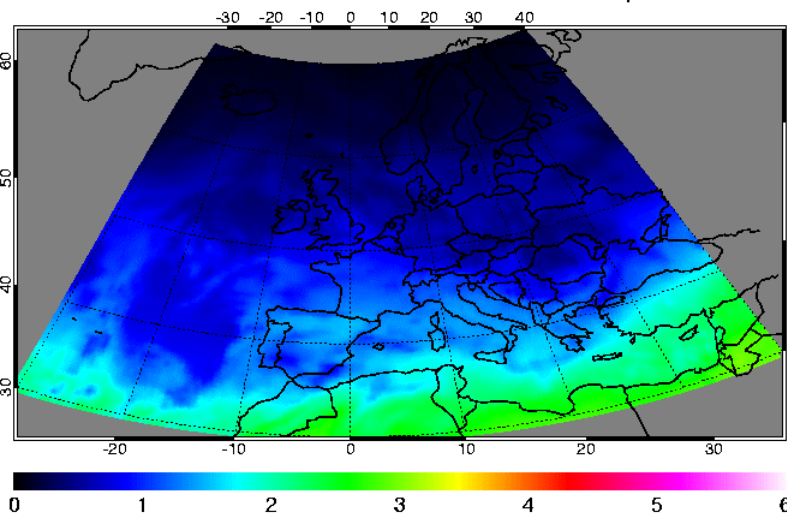
12 September 2007



DNA-damage UV dose (kJ/m<sup>2</sup>)

SCIAMACHY, METEOSAT - KNMI/ESA

12 September 2007



# TEMIS cloud modification factor



- Calculate cloud cover fractions from the 0/1 cloud mask on a grid of 0.5 x 0.5 degrees
- Apply an empirical cloud correction factor as a function of cloud cover fraction:

One year (1997) of ground-based spectra fitted linearly with Meteosat-7 cloud cover fractions

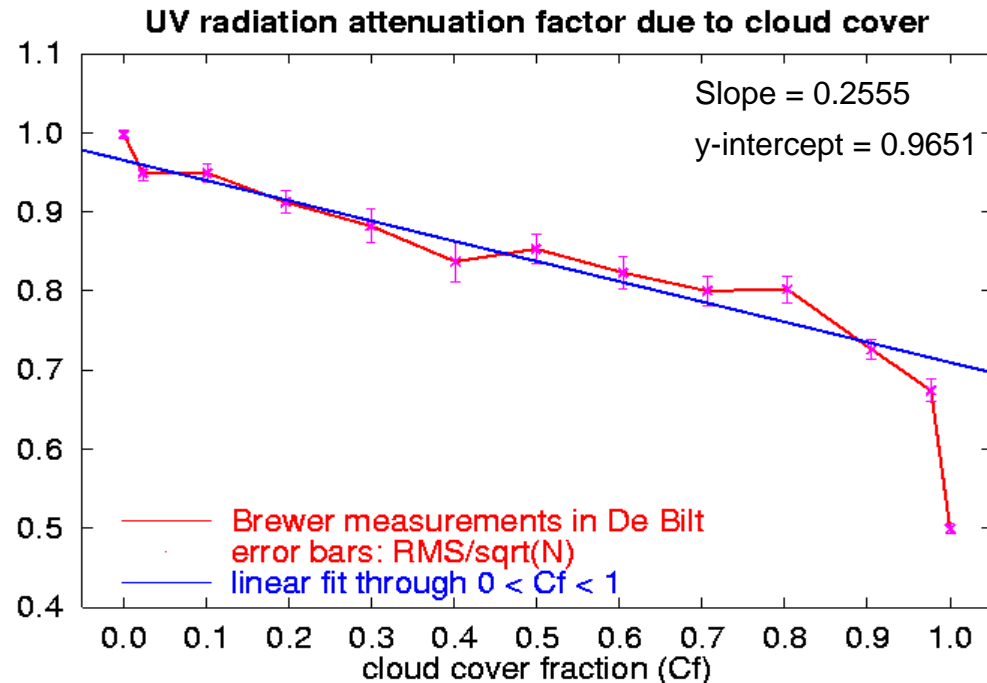
CMF = 1

for fractions < 0.02 (“cloud free“)

CMF = 0.5

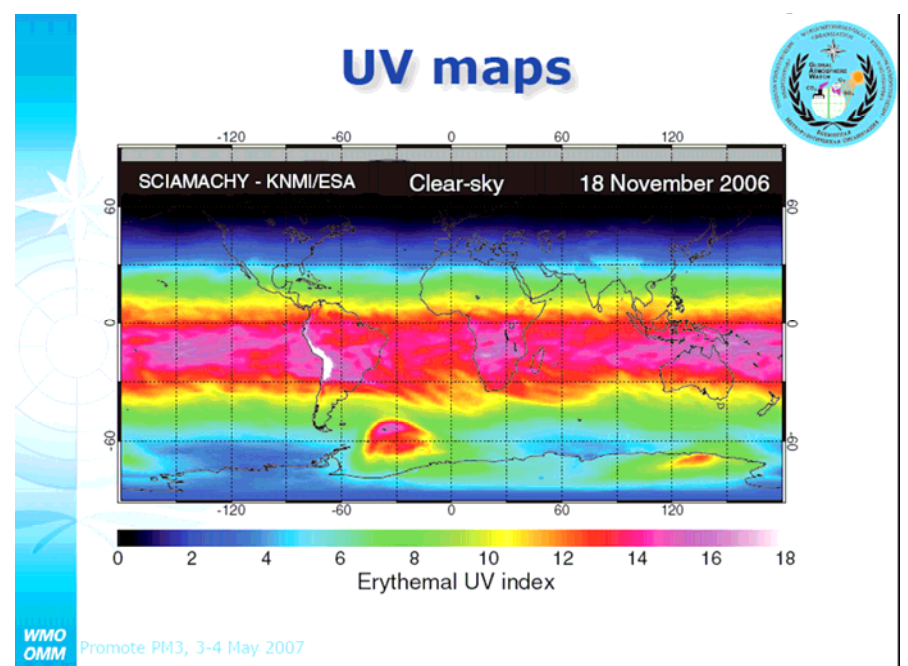
for fractions > 0.98 (“overcast“)

=> Overcast clouds are not discriminated; the optical thickness is implicitly assumed (~ 16)



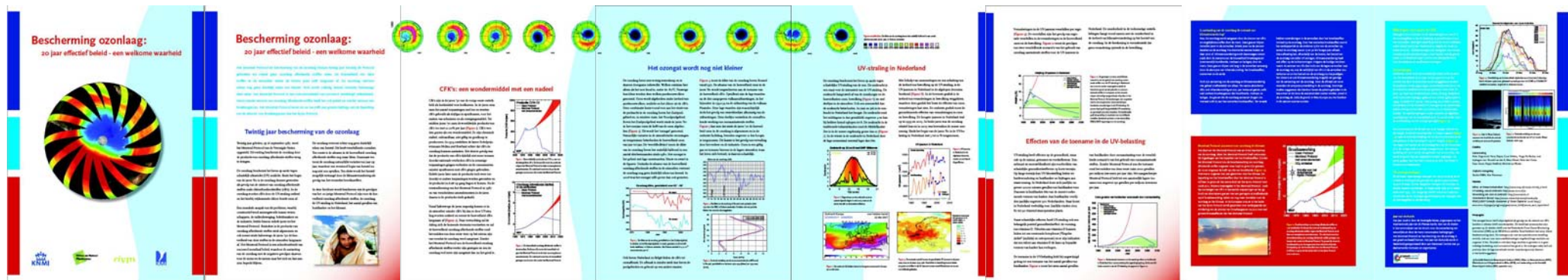
# TEMIS UV applications

- Daily forecast for the Netherlands
- Daily downloads by few 10s of users worldwide, often for further dissemination
- Several hundreds of web links
- Regular direct contacts / questions
- R&D Cosmetic industries
- Regular checked by UV scientists / biologists / agricultural scientists / etc



WMO, Antarctic ozone bulletins

Ozone and UV information leaflet (in Dutch) for 20-year celebration of the Montreal protocol



# TEMIS users and their requirements



TEMIS UV products user requirements (our current interpretation of ...):

## **TEMIS UV index**

- \* Worldwide forecasts of the clear-sky UV index (a few days is ok)
- \* Long-term homogeneous time series at any location

## **TEMIS UV daily dose**

- \* Monthly climatologies of daily dose with high spatial resolution
- \* Idem for cloud-free daily dose as maximum possible values
- \* Long-term homogeneous time series at any location
- \* Action spectra: erythema, flat UVA, flat UVB(, user-determined)

## Other user requirements....



- Each value of a UV product with an uncertainty estimate

### + Answers to following questions:

- What are the relevant factors controlling the UV product?
- What is the contribution of each of the factors to the overall uncertainties?
- Other trade-offs between uncertainty, and spatial- or temporal resolution?
- How does this product compare to similar available products?
- How do you rate the level of scientific understanding for the product?
- I want to tailor the product for local use (topography, aerosol, etc).
  - Can you provide the algorithm? (open source; 'user control')
- ...

=> Detailed product evaluations are required!

# Evaluation methods for spaceborne UV products

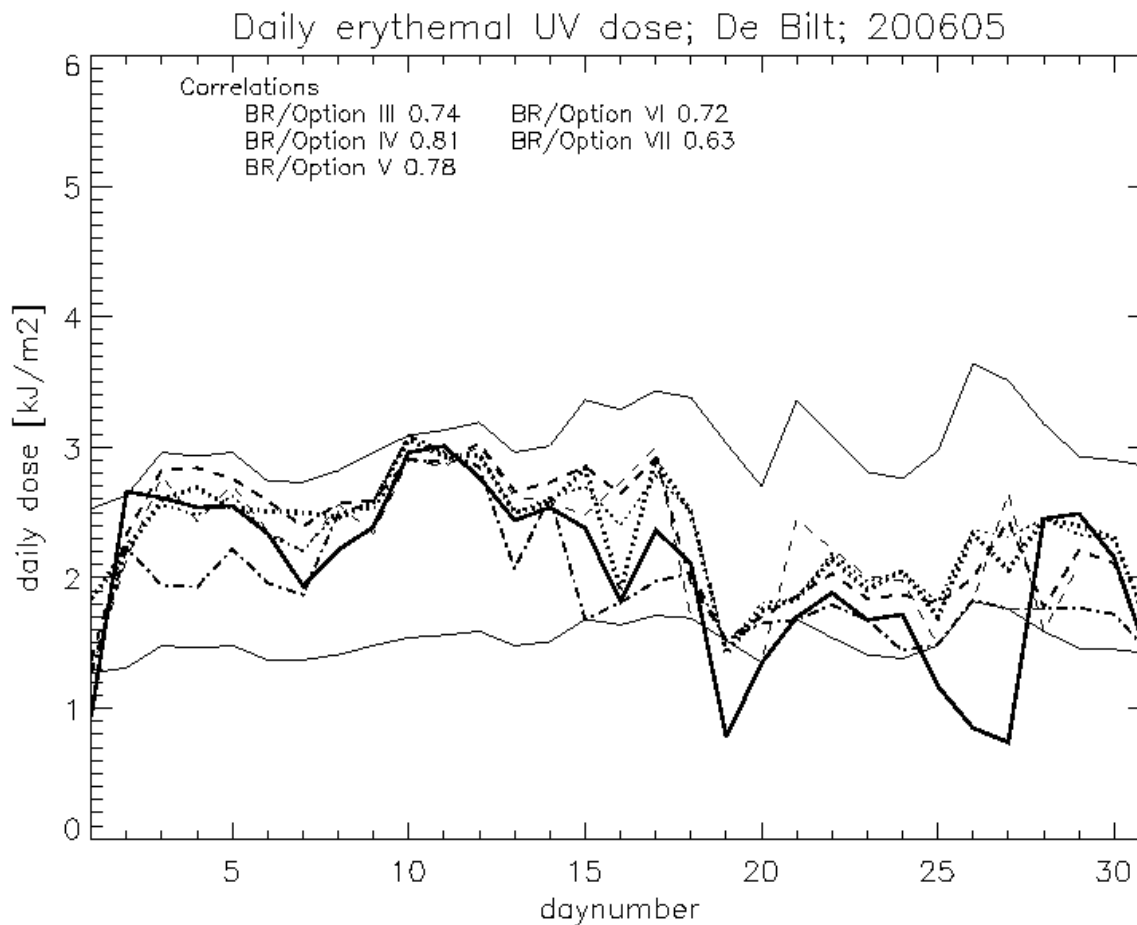


- Validate the UV product with surface UV observations
- Duplicate the UV product with similar though independent input data sources to better estimate the uncertainty of the input data
- Evaluate the UV product against other spaceborne UV products and describe differences
- Examine uncertainty, also in input parameters, in relation to spatial and temporal resolution of the UV product

To evaluate a UV product (by data provider and/or user) data files should include at least:

- UV Product + uncertainty estimate
- Each of the modification factors + uncertainty estimate per factor
- Geometry information (spatial/temporal resolution; domain; constant attributes)
- More general metadata (version control; data owner etc)

# Evaluation of the TEMIS CMF; May 2006



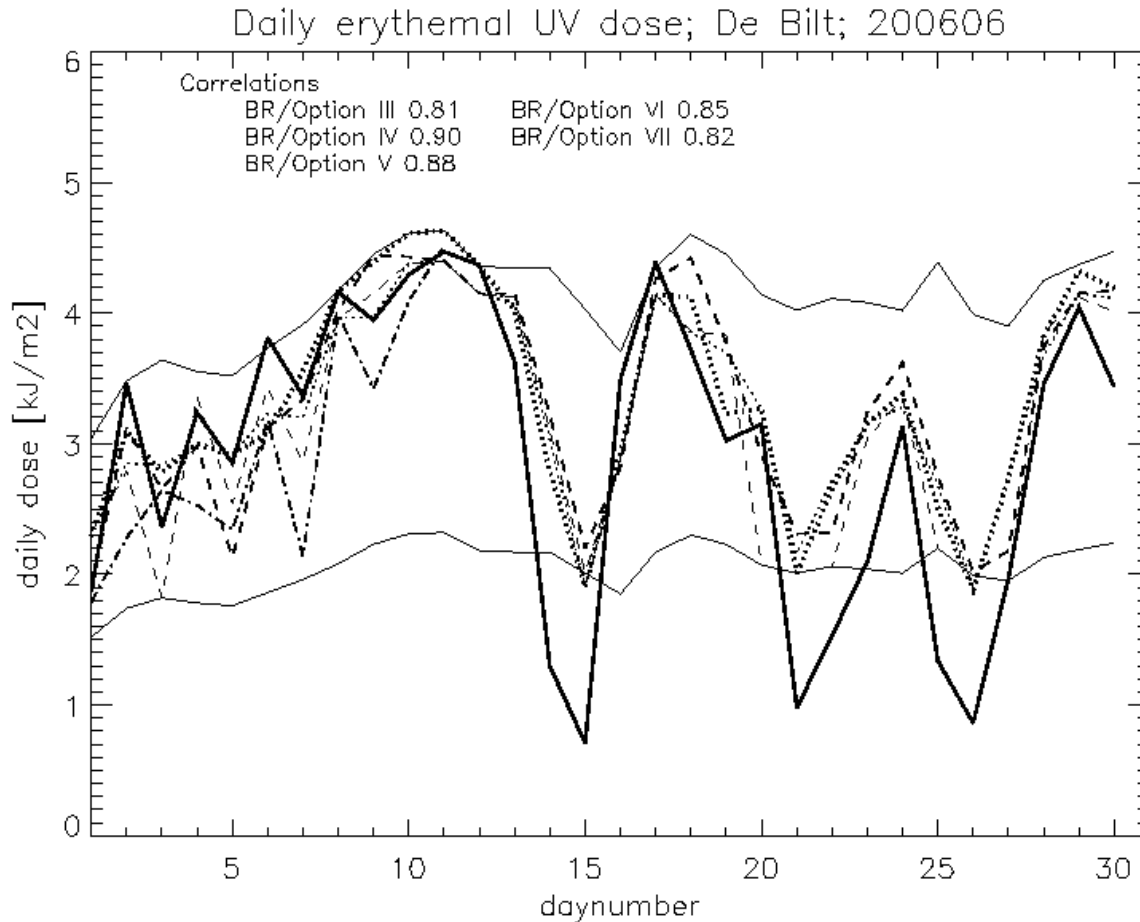
Solid line:  
Ground-based data (Brewer)

Dashed-dotted:  
Using Meteosat -7 cloud mask

Dotted:  
Using Meteosat-8 cloud mask

Thin dotted:  
Using Meteosat-8 CM-SAF  
daily-mean cloud optical thickness

# Evaluation of the TEMIS CMF; June 2006



Solid line:

Ground-based data (Brewer)

Dashed-dotted:

Using Meteosat -7 cloud mask

Dotted:

Using Meteosat-8 cloud mask

Thin dotted:

Using Meteosat-8 CM-SAF

daily-mean cloud optical thickness

# TEMIS UV monthly dose; De Bilt



| Monthly mean daily UV dose | Ground-based (Brewer, De Bilt) | Meteosat-8             | Meteosat-7             |
|----------------------------|--------------------------------|------------------------|------------------------|
|                            |                                | Overestimation / corr. | Overestimation / corr. |
| April 2006                 | 1.48 +/- 0.07                  | +1% / 0.76             | +1% / 0.83             |
| May 2006                   | 2.03 +/- 0.10                  | +13% / 0.74            | -3% / 0.72             |
| June 2006                  | 2.95 +/- 0.15                  | +12% / 0.81            | n/a                    |
| July 2006                  | 3.13 +/- 0.16                  | +19% / 0.80            | n/a                    |

- Cloud mask for Meteosat 8 typically yields higher monthly-mean daily UV dose than using cloud mask for Meteosat 7. e.g. in May 2006: +16%
- Differences between cloud masks of Meteosat 8 and 9 are smaller than between Meteosat 7 and 8.

Solution: 15 or 30-min cloud optical thickness per pixel from MSG / SEVIRI (though: then still no data before 2004)

# Summary



- TEMIS internet services are running for about a decade. Many, and different type of users find their way on TEMIS and use the data and maps
- **Clear-sky UV index forecasts** are issued every day
- **Clear-sky UV index monitoring** based on ozone analyses fields
  - => Currently homogeneous time series from Aug 1995 onward
  - => Longer UV index time series using assimilated TOMS/SBUV underway
- **UV daily dose monitoring** based on assimilated ozone and Meteosat cloud masks
  - => Currently homogeneous time series from Jul 2005 onward
  - => Large change in cloud modification from Meteosat-7 to Meteosat-8
  - => no UV dose climatologies yet
- Detailed evaluation of the UV products AND controlling factors is needed to satisfy users

