Short wavelength cut-offs and maximum spectral irradiance wavelengths comparison of the spectra for erythema and pre-vitamin D_3 synthesis

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Introduction

- **Minimisation of UV exposures necessary to reduce the risks of skin cancer and sun-related eye disorders**

- **Beneficially, UVB exposures required to initiate the first stage of the synthesis of pre-vitamin D_3**

- **Requires optimisation of the solar UV exposures to humans**

- **Requires understanding of the complex interactions between the factors influencing the solar UV**

Aims

The aims of this research were

- **To compare the short wavelength cut-offs (λ_c) and**

- **the wavelengths of the maximum spectral irradiances (λ_{Max})**

- **for the spectral UV for the initiation of the formation of pre-vitamin D_3 (UVD_3) and for the erythemal UV (UV_{Ery})**

Spectral Solar UV

- **Integrated automated cloud and spectral UV measurement system employed**

- **UV spectroradiometer enclosed in a weather proof container:**
  - **double monochromator**
  - **280 to 400 nm in 0.5 nm increments every 5 min**

- **Located on an unshaded roof at University of Southern Queensland, Toowoomba, Australia**


Input optics
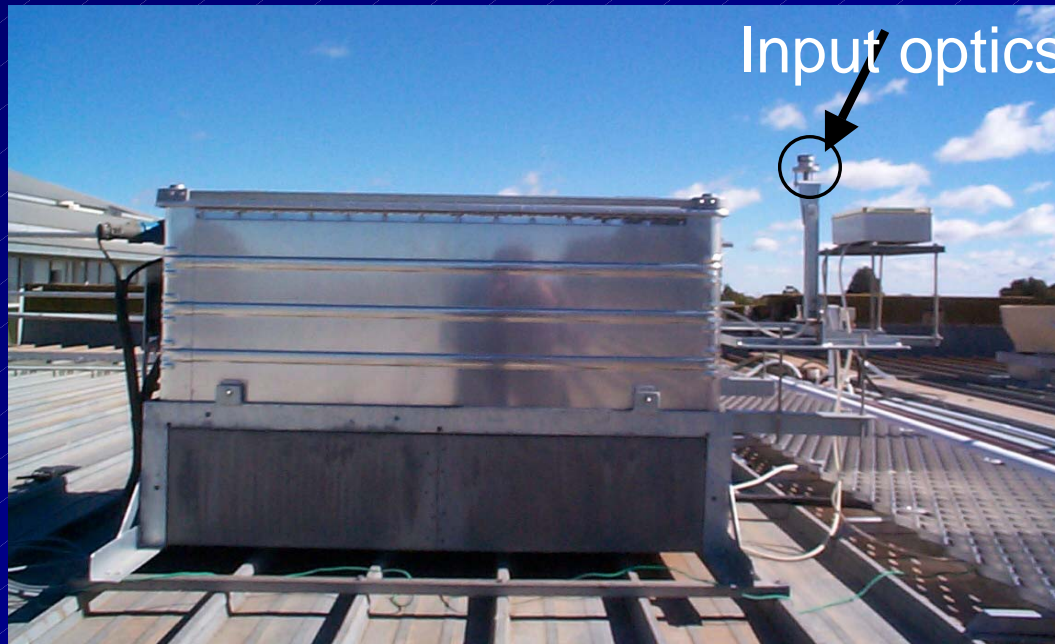
Cloud Cover

- **Total sky imager installed on a building roof**

- **Weatherproof installation with battery backup**

- **Every 5 min images acquired & processed to calculate fractional cloud cover**

Spectral UVD$_3$

- **Employed spectral UV data at 5 min intervals in first six months of 2003**

- **Example solar UV spectrum for solar zenith angle of 7.5°**

- **Action spectrum for the photolysis of 7-dehydrocholesterol (7-DHC) in skin to pre-vitamin D$_3$ (Webb, 1993)**

- **Weighting the UV spectrum with the action spectrum gives the spectral UVD$_3$**
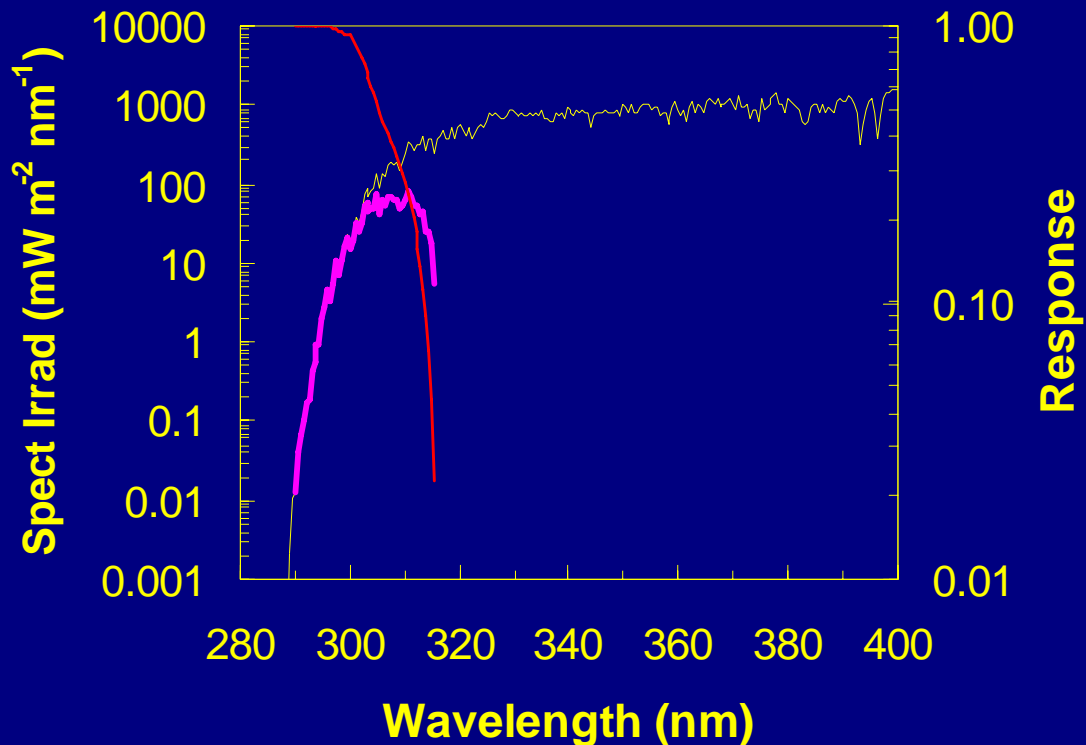
Spectral UVD$_3$

- **Compare to UV spectrum for SZA of 77.2º**
- **Short wavelength cut-off, λ_{CD3} defined as wavelength at which irradiance was 0.1% of the maximum**
- **λ_c and λ_{Max} for the spectral UVD$_3$ shift to longer λ for higher SZA**
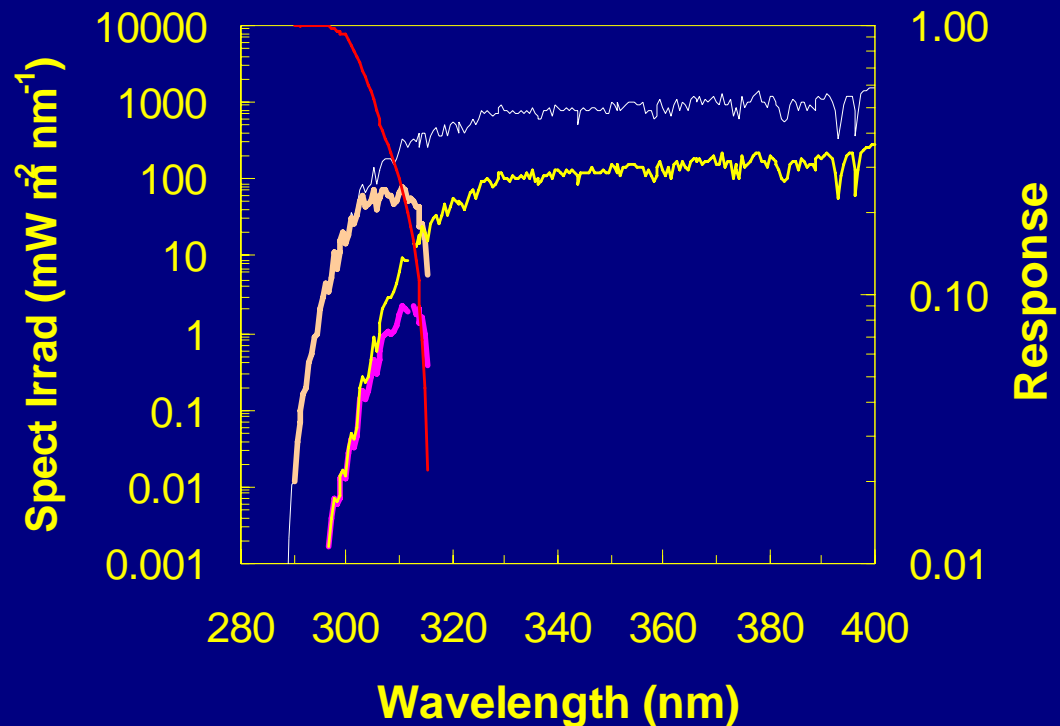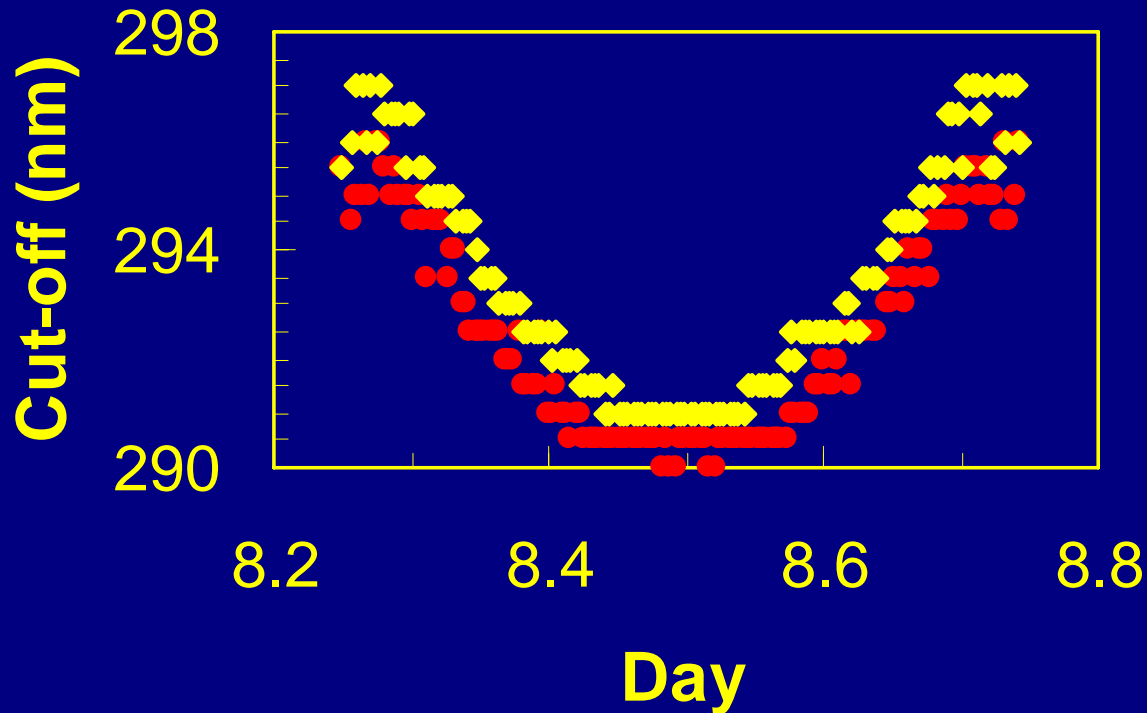
Spectral UVD$_3$

- **Comparison of spectral UV$_{D3}$ and UV$_{Ery}$**
- **In this case SZA = 13.8°**
- **The peak of the spectral UV$_{D3}$ shifts to a longer wavelength compared to that for UV$_{Ery}$**
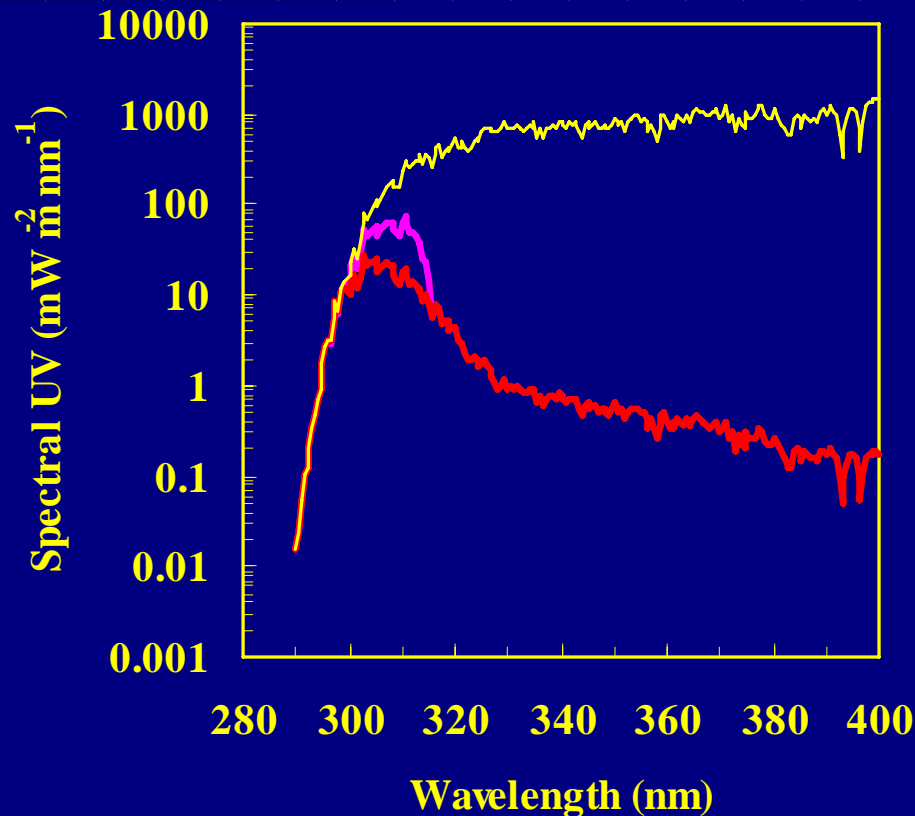
Cut-off Wavelengths over a day

- **Variation over a typical summer's day on 8 Jan**
- **The λ_c for the UV_{D3} are shifted to longer λ by an average of 1 nm compared to λ_c for the UV_{Ery}**

● **Erythemal UV** ◆ **Pre-vitamin D3 UV**

UVD$_3$ Cut-off Wavelength

- **12,493 data points over first 6 months of 2003**
- **Variation of the λ_{CD3} for the spectral UVD$_3$ for all the SZA and the atmospheric conditions**
- **λ_{CD3} ranges from 290 to 300 nm**
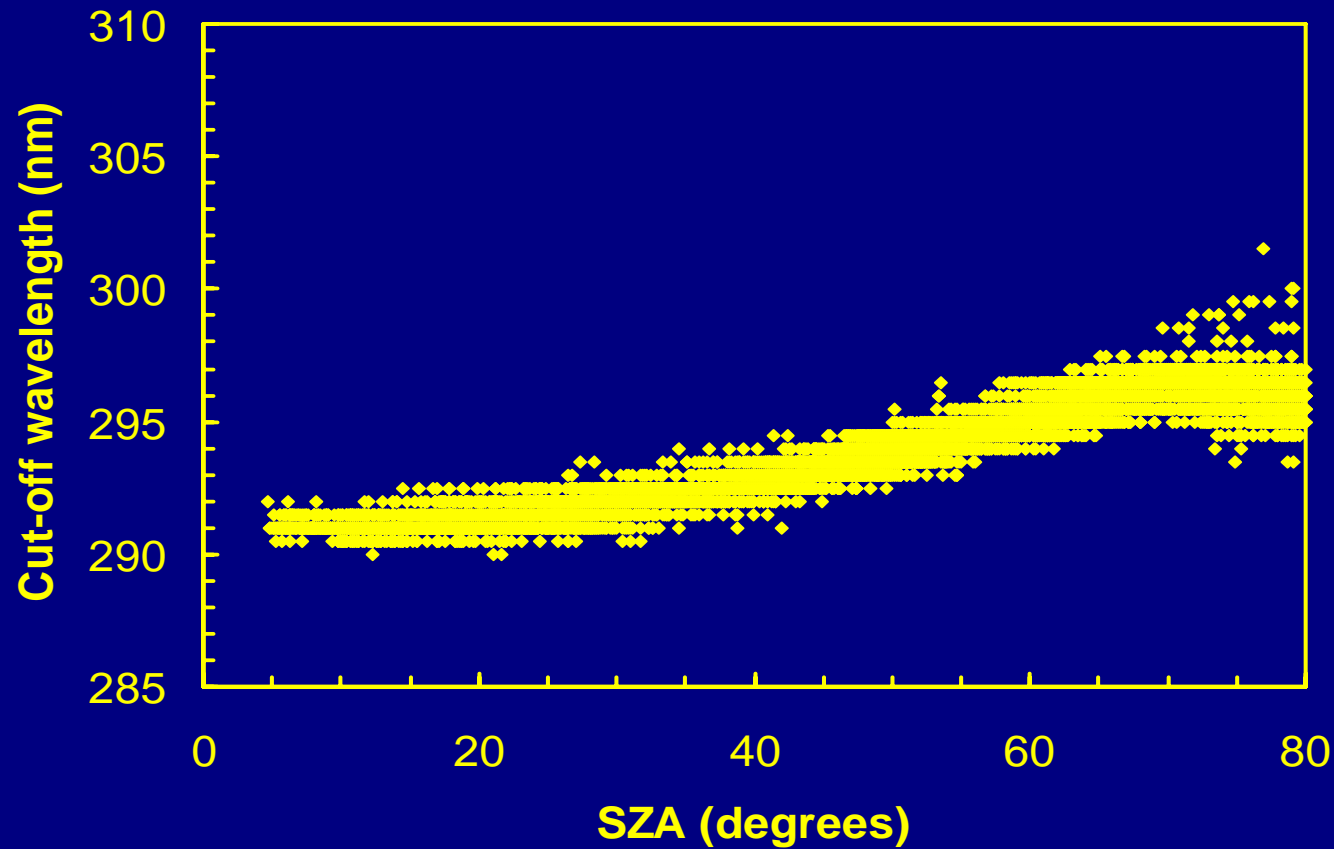
UVD$_3$ Cut-off Wavelength

- **Cloud free cases (<2% cloud)**

- **2,460 cloud free cases**

- **λ_{CD3} ranges from 290.5 to 298.5 nm**

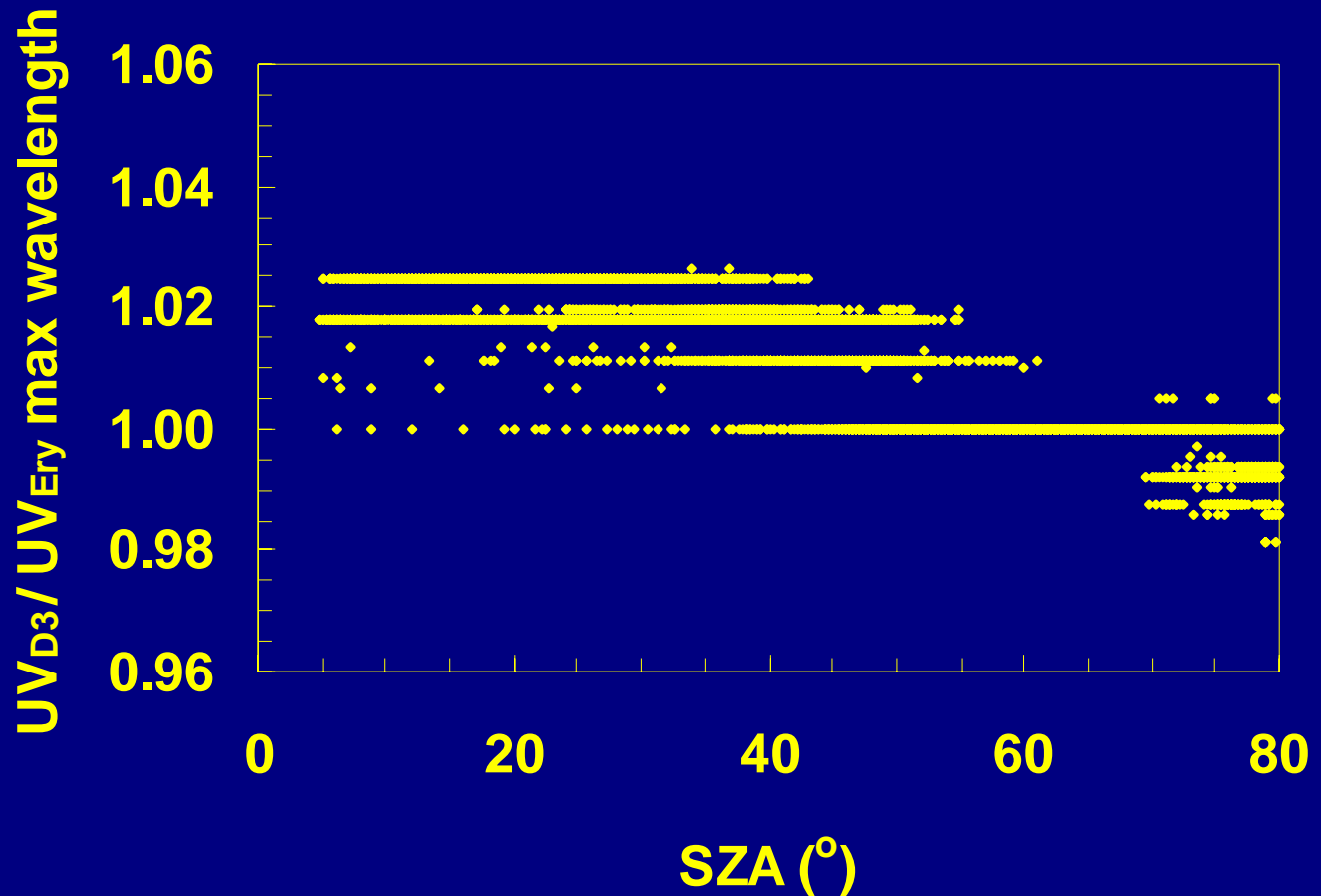- **Spread of data is less, but general variation with SZA is similar**
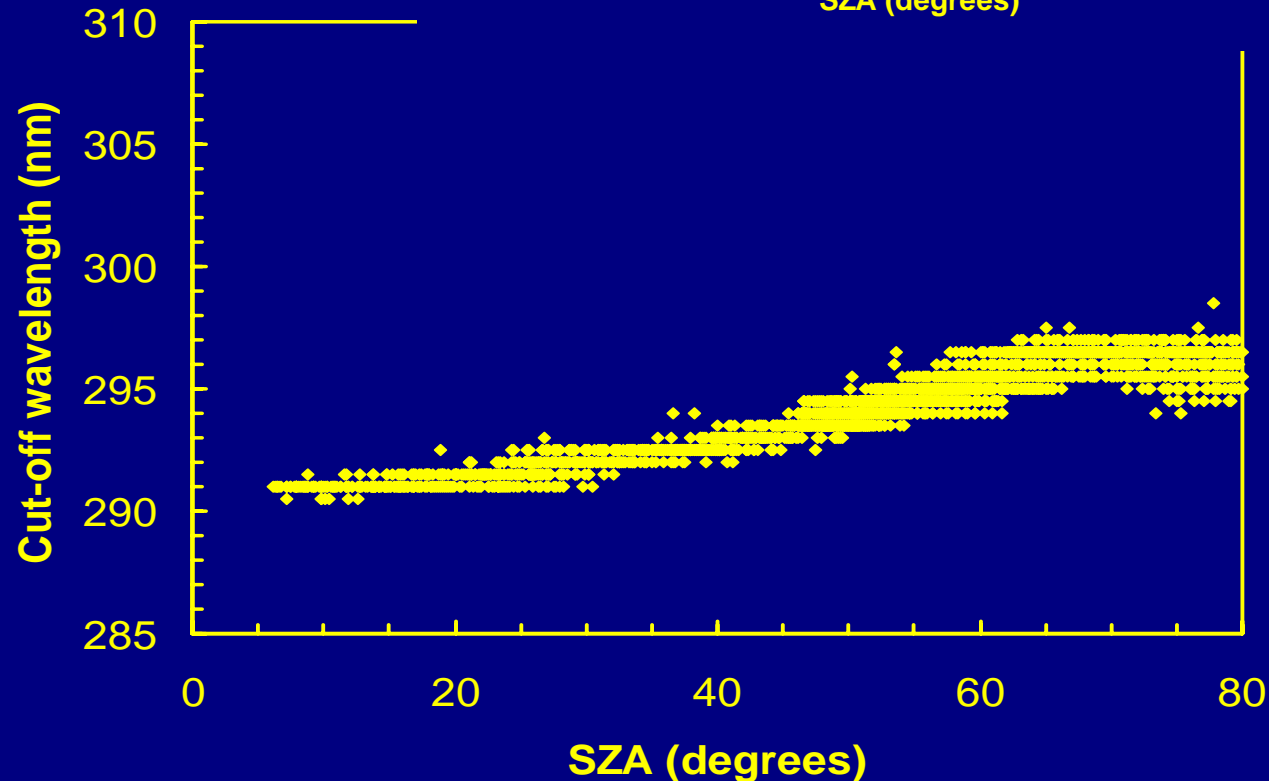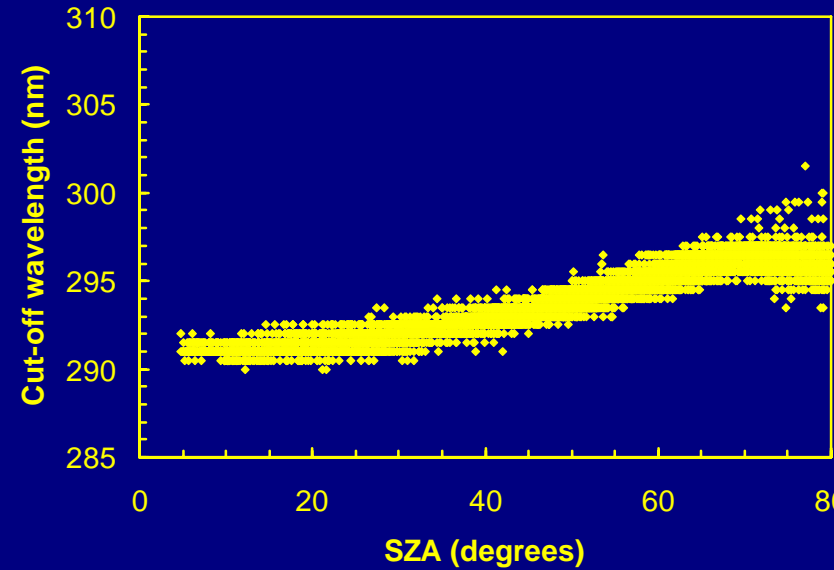
Ratios

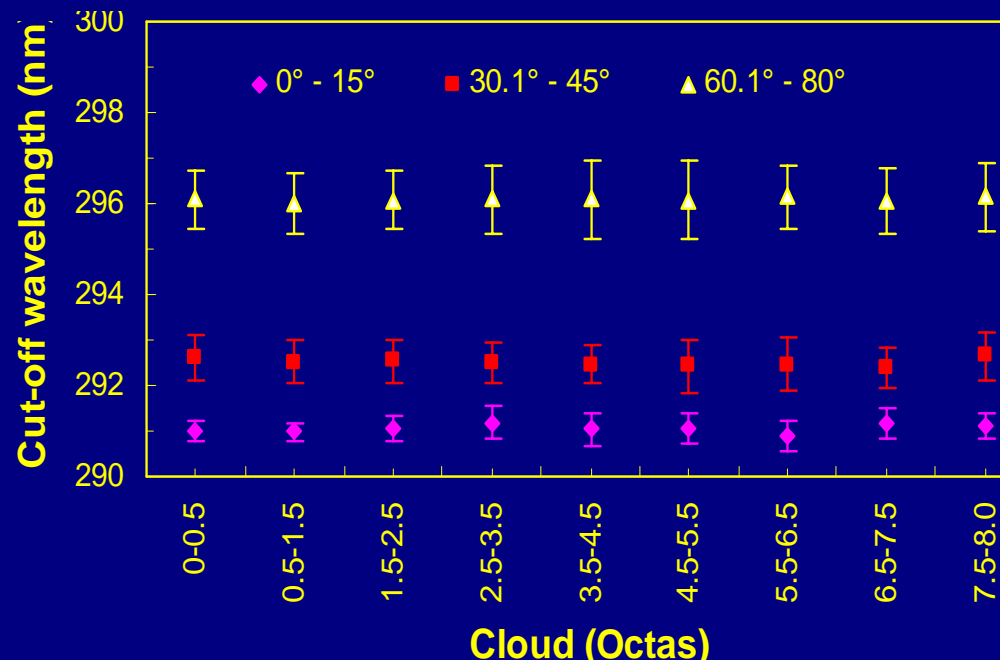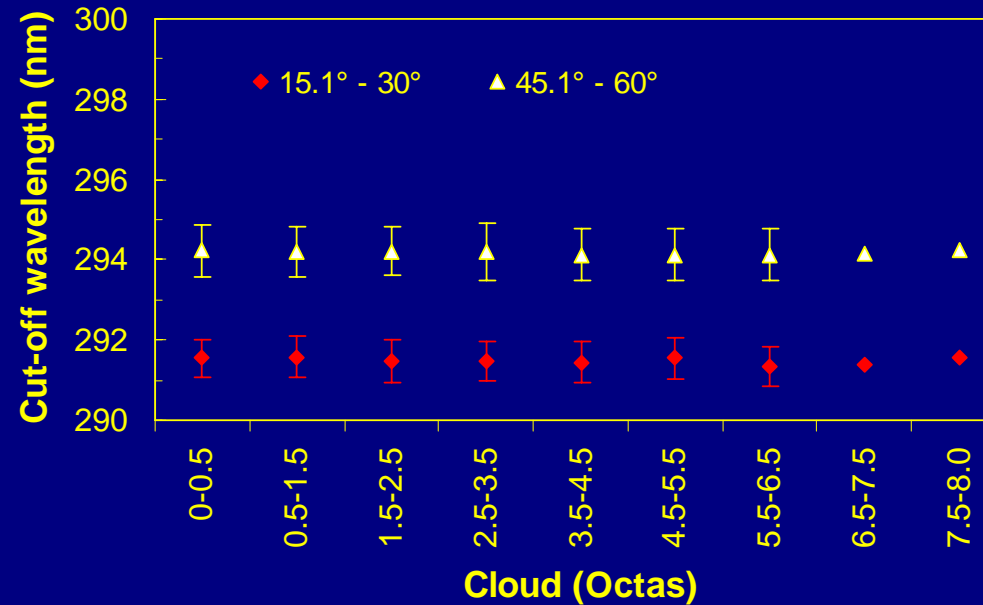- **Ratio of the λ_C for the UV_{D3} compared to those for the UV_{Ery}**
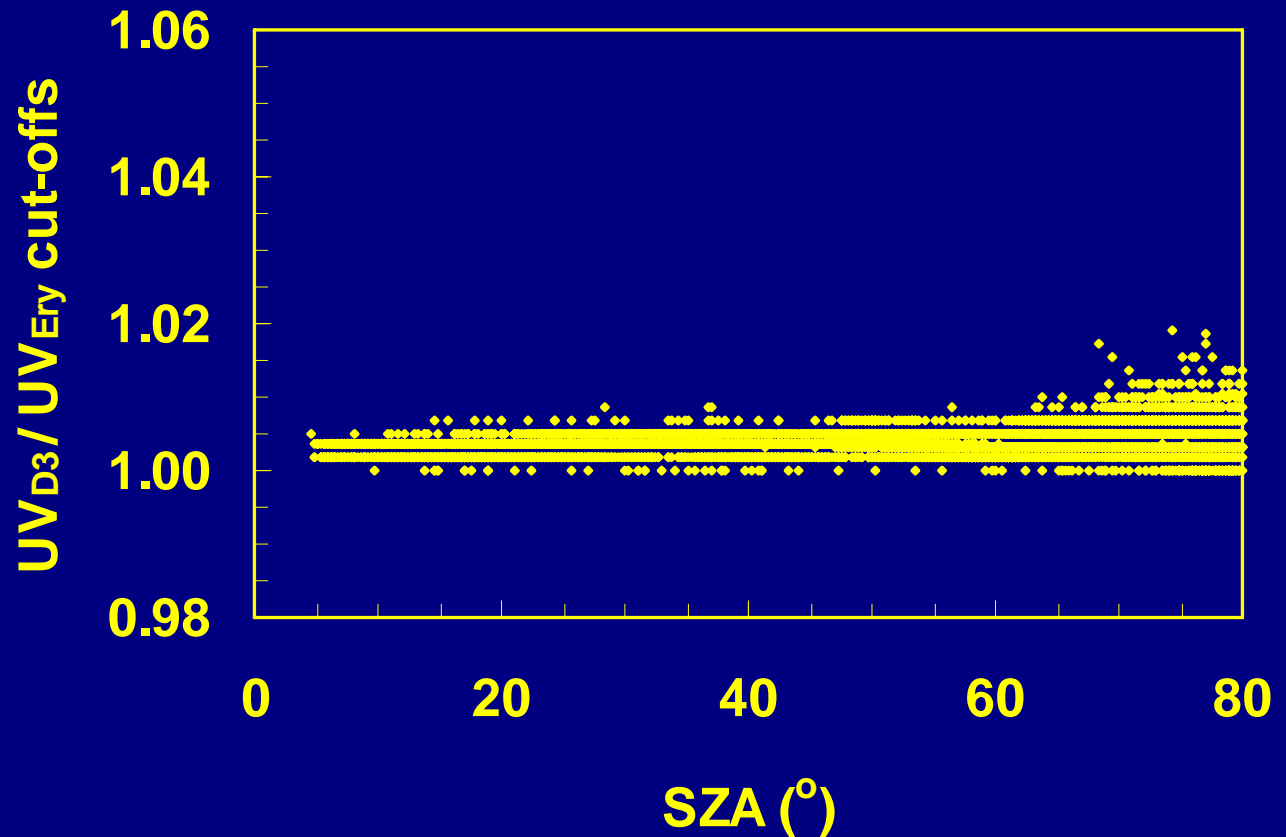
Ratios

- **Ratio of the λ_{Max} for the UV_{D3} compared to those for the UV_{Ery}**

- **$UV_{D3}/UV_{Ery} \geq 1$ for SZA up to $\sim 60^o$**

UVD$_3$ Cut-off Wavelength

- **Classified data into SZA ranges and cloud cover into octas**

- **No effect on the cut-off wavelength with cloud cover**

- **Data point is mean**

- **Error bars are ± 1SD**

Wavelength of Max Irradiance, λ_{MaxD3}

- λ_{MaxD3} remains relatively unchanged for the range of cloud cover and SZA

- Majority of values are 310.5 nm with an increase to 312.5 nm for larger SZA
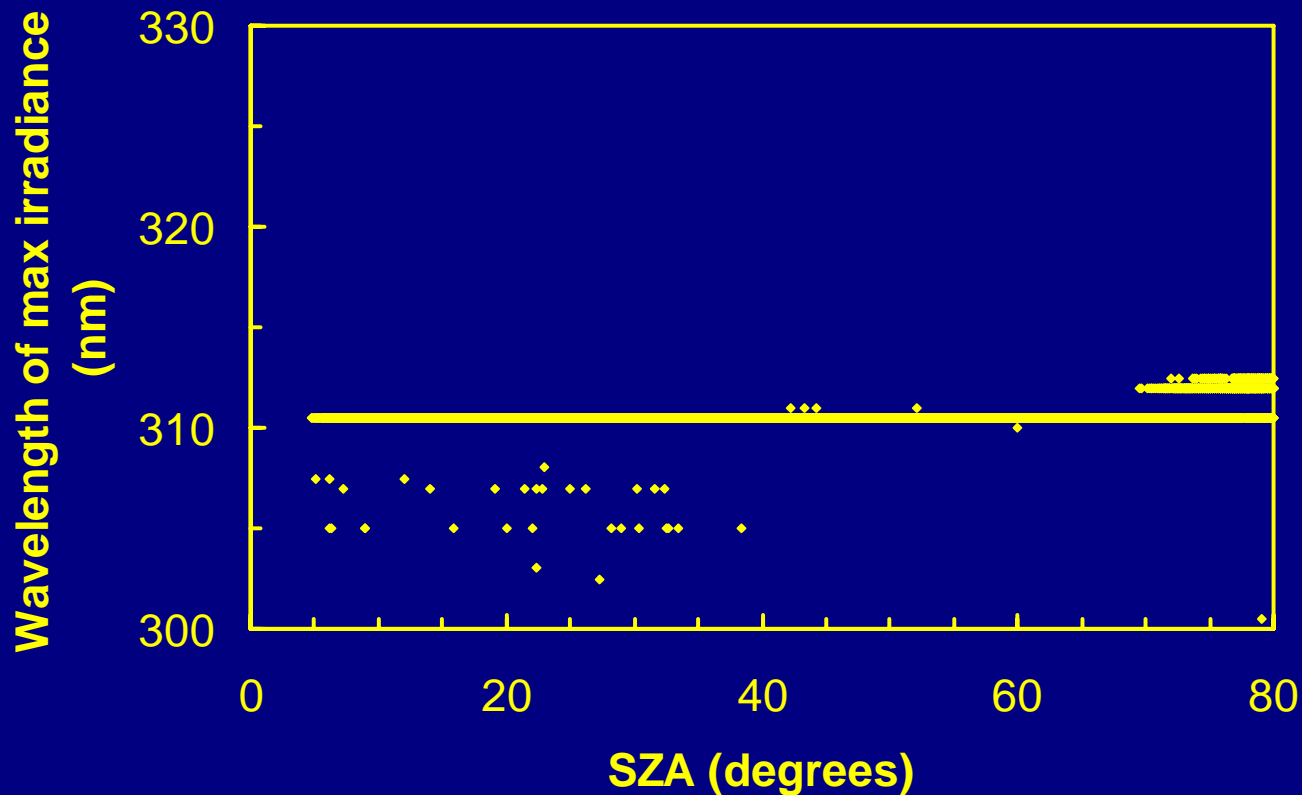
UVD$_3$ Irradiances

- **Effect of cloud considered on UVD$_3$ irradiances**

- **Data points are means of the irradiances in each SZA range for each octa category**

- **Error bars are ± 1 SD**

- **Minimal effect of cloud for 0-5.5 octa**

- **Cloud effect for 5.5-8.0 octa range**
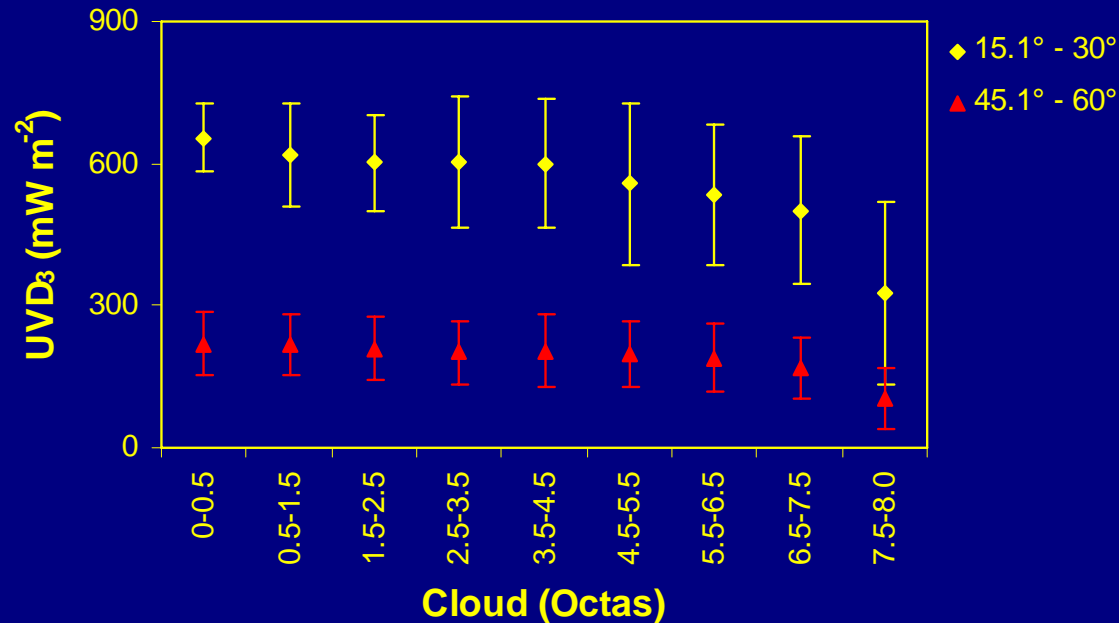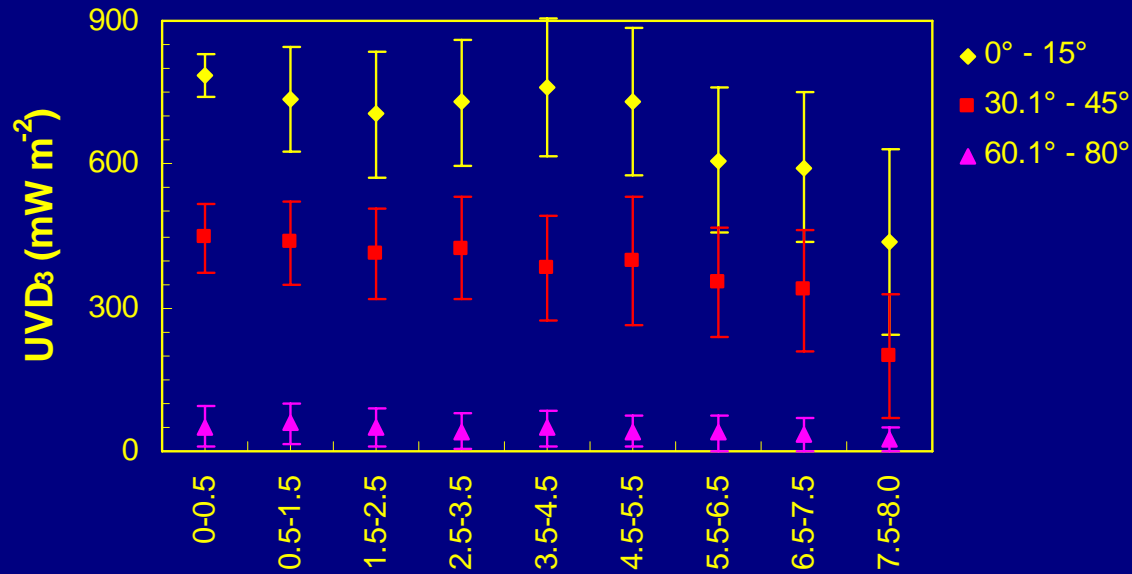
Dosimeters for Previtamin D$_3$

- **Action spectrum for the synthesis of pre-vitamin D$_3$ (Webb, 1993) can be approximated by the spectral response of polysulphone**

- **Use of this action spectrum allows calibration of polysulphone dosimeters to measure UVD$_3$**
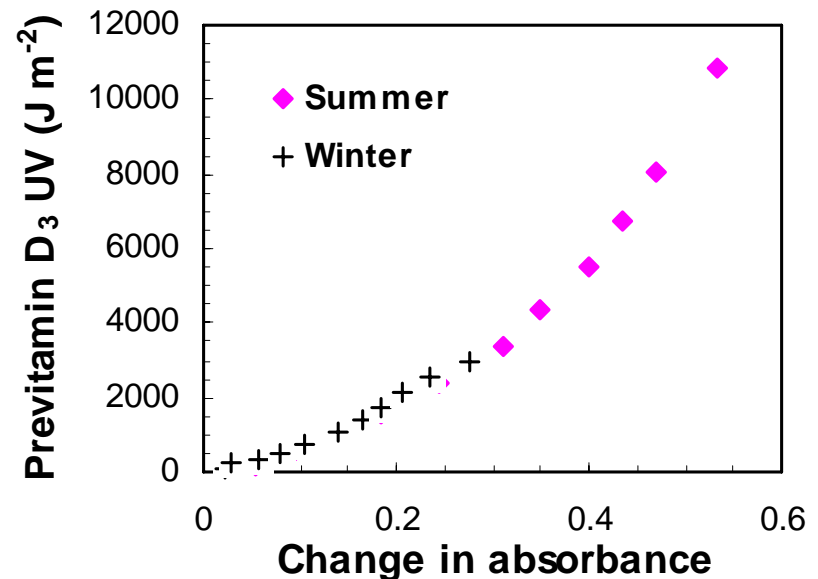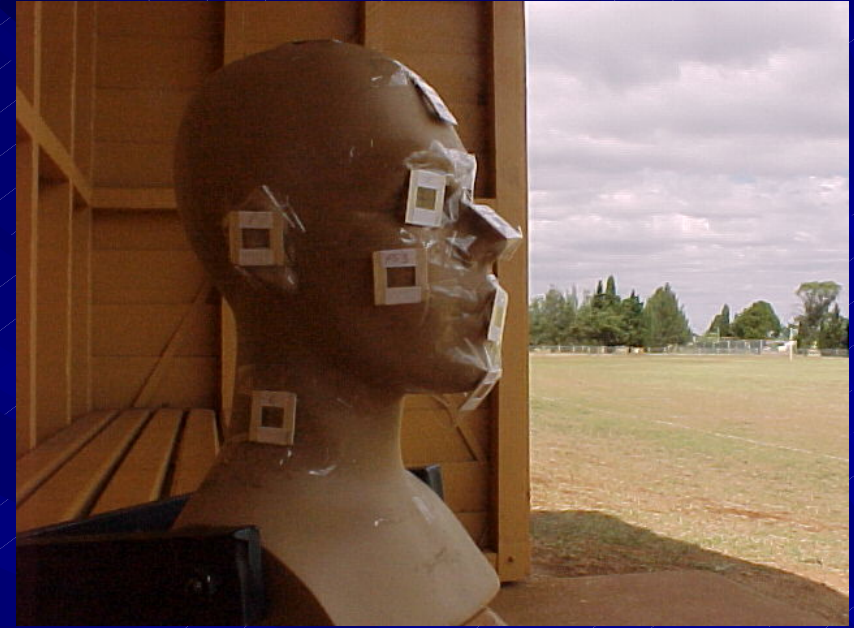
Conclusions

- λ_c and λ_{Max} of the UVD_3 and UV_{Ery} have been compared for the SZA range of 4.7° to 80°

- Averaged over 6 months, the λ_c for UVD_3 is higher by 0.9 nm than that for UV_{Ery}

- The λ_{Max} is higher for the UVD_3 compared to the UV_{Ery} for SZA less than ~60° and less than that for UV_{Ery} for higher SZA

- λ_c of the UVD_3 is not influenced by clouds

- λ_{Max} is relatively unchanged by cloud cover and SZA

- The magnitude of the UVD_3 is influenced only for more than 5.5 octa cloud

- Polysulphone dosimeters can be used to measure UVD_3 in different environments