

Protocol of the intercomparison at LKO, Arosa, Switzerland on
March 20 to 31, 2006 with the travelling standard
spectroradiometer B5503 from PMOD/WRC
within the project QASUME

Report prepared by Gregor Hülsen

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The purpose of the visit was the comparison of global solar irradiance measurements between the three spectroradiometers operated by the Lichtklimatische Observatorium (LKO), MeteoSchweiz and the travel standard B5503. The measurement site is located at Arosa; Latitude 46.78 N, Longitude 9.68 E and altitude 1846 m.a.s.l..

The horizon of the measurement site is free down to about 75° solar zenith angle (SZA). For this reason, only measurements between 7:00 UT and 16:00 UT have been analysed. After 16:00 UT shadows of poles and hatches moved over the instruments at the time of the measurements.

B5503 arrived at LKO in the noon of March 20, 2006. The spectroradiometer was installed in line to the three LKO instruments with the entrance optic of B5503 within 2 m of the nearest LKO (Br #156). The spectroradiometers in use at LKO is one Brewer double monochromator (Br #156) and two Brewer single monochromators (Br #040 and #072). The intercomparison between B5503 and the LKO spectroradiometers lasted eight days, from forenoon of March 20 to forenoon of March 24 and from morning March 29 to noon March 31.

B5503 was calibrated several times during the intercomparison period using a portable calibration system. Two lamps (T68522 and T68523) were used to obtain an absolute spectral calibration traceable to the primary reference held at PMOD/WRC, which is traceable to PTB. The daily mean responsivity of the instrument based on these calibrations varied by less than 1 % during the intercomparison period. The internal temperature of B5503 was 19.9 ± 0.5 °C. The diffuser head was heated to a temperature of 25.3 ± 0.9 °C.

The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the SHICRivm analysis were between ± 50 pm in the spectral range 290 to 400 nm.

Protocol:

The measurement protocol was to measure one solar irradiance spectrum every 30 minutes from 290 to 400 nm, every 0.5 nm, and 3 seconds between each wavelength increment.

March 20 (79):

B5503 was installed on the measurement site at 10:20 UT. Synchronized measurements are available from 13:00 UT when the internal temperature of B5503 reached its nominal temperature. Last scan was at 16:00 UT. Weather conditions were a mix of sun and clouds.

B5503 was calibrated at 16:31 to 16:31 UT and at 16:44 to 16:57 UT after sunset.

March 21 (80):

Synchronized measurements are available from 6:00 to 16:30 UT. Weather conditions were a mix of sun and clouds with snowfall in the afternoon. The scans from 15:00 till 16:30 UT were perturbed by snowfall.

B5503 was calibrated at 6:11, and 11:11 UT between the scans. Thus, no scans were lost.

March 22 (81):

Synchronized scans are available from 6:00 to 16:30 UT. The weather conditions were a mix of sun and clouds without snowfall.

B5503 was calibrated at 6:11, 11:11 and 16:11 UT.

March 23 (82):

Synchronized scans are available from 6:00 to 16:30 UT. The weather conditions were a mix of sun and clouds with snowfall from morning till noon. The scans from 8:30 till 14:00 UT were perturbed by snowfall.

B5503 was calibrated at 6:11, 6:41, 16:41 and 17:04 UT.

The shadow of a pole and stairs covers Br #072 and Br #156 at 16:02 UT. The shadow of the Dobson-hutch reaches the Br #040 at 16:16 UT.

March 24 (83):

Synchronized scans are available from 6:00 to 8:00 UT. The weather conditions were a mix of sun and clouds with snowfall starting at 8:00 UT. The 8:00 UT scan was thus perturbed by snowfall. Stopped the scans after the 8:00 UT scan.

B5503 was calibrated at 6:11 UT.

March 29 (88):

Synchronized scans are available from 5:30 to 17:00 UT. The weather conditions were a mix of sun and clouds with little snowfall around noon. Thus the scans from 10:30 till 12:00 UT are perturbed by minor snowfall. A partial sun eclipse happened to be between 9:37 till 11:39 UT with a maximum of 34 % coverage at 10:38 UT.

B5503 was calibrated at 6:11, 6:41 and 13:11 UT.

March 30 (89):

Synchronized scans are available from 5:30 to 17:00 UT. The weather conditions were a mix of sun and clouds with little snowfall in the evening. The scans 15:30, 16:30 and 17:00 UT are perturbed by minor snowfall. Missing scans of Br #072 between 8:30 till 11:00 UT.

B5503 was calibrated at 10:11 UT.

March 31 (90):

Synchronized scans are available from 5:30 to 12:00 UT. The weather conditions were a mix of sun and clouds. The scan at 10:30 UT is missing because of calibration. End of the campaign after the 12:00 UT scan.

B5503 was calibrated at 10:11 and 10:29 UT.

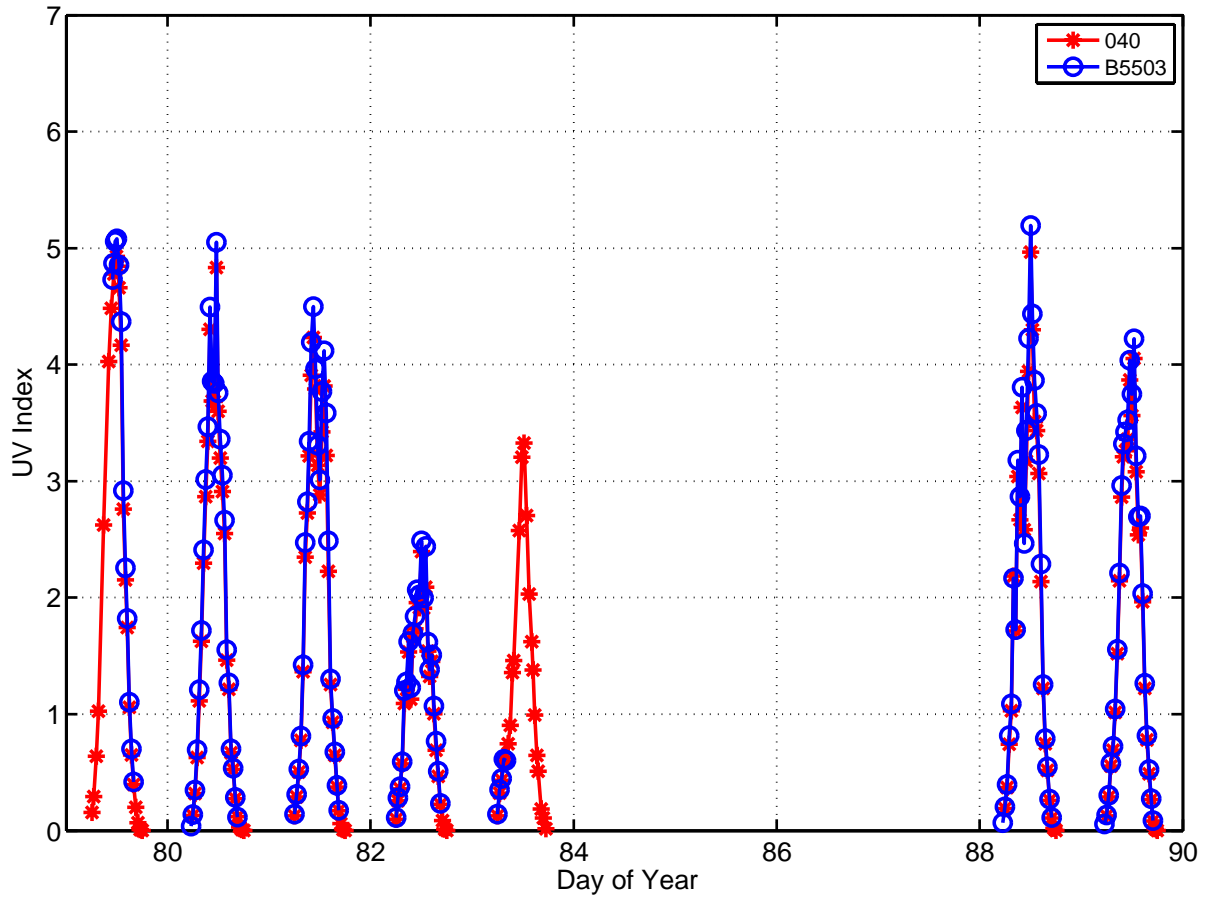
Results:

In total 116, 119 and 114 synchronized simultaneous spectra from B5503 and LKO (Brewer #040, #072 and #156) are available from the measurement period. Due to nearby obstructions by trees, poles and hutches which might affect the instruments differently only measurements between 7:00 and 16:00 UT have been analysed (SZA smaller than 75°).

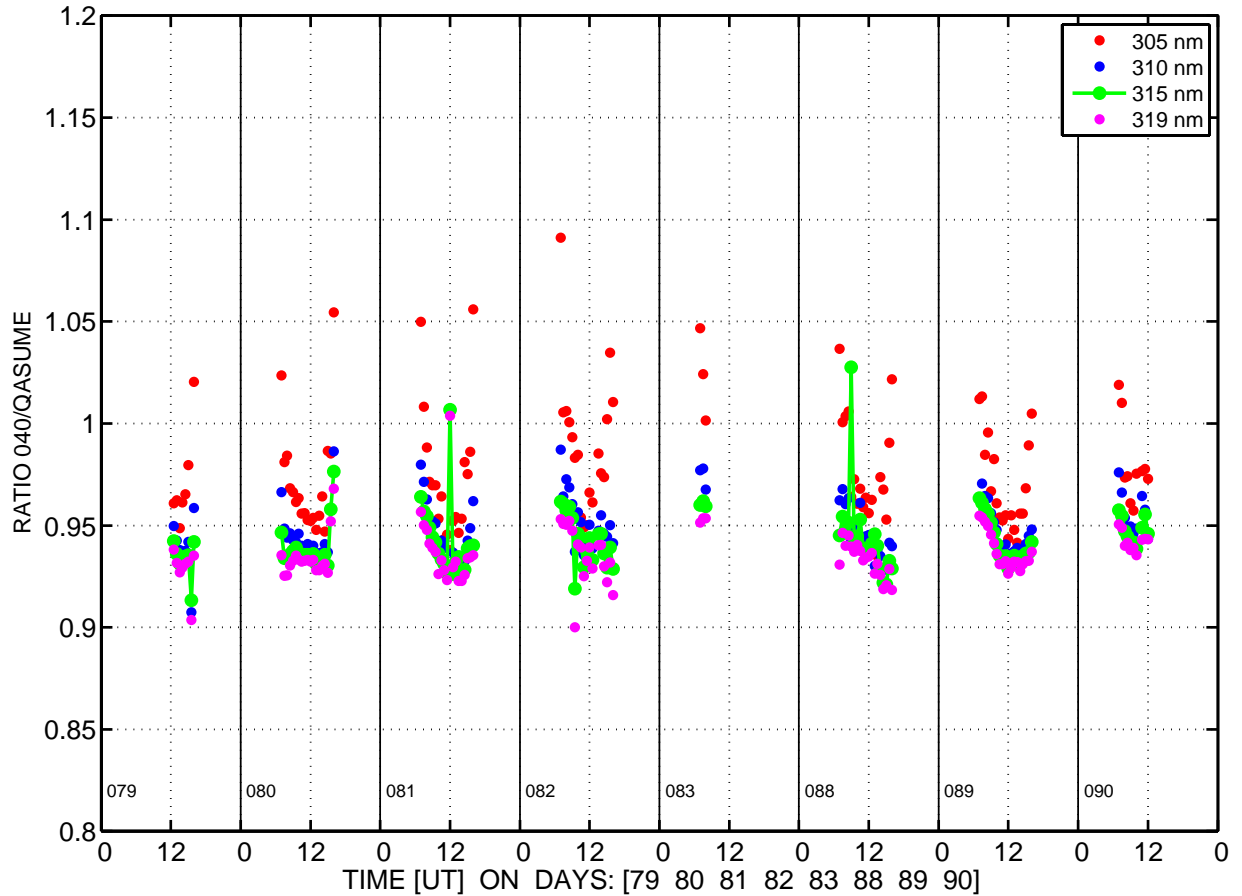
Remarks:

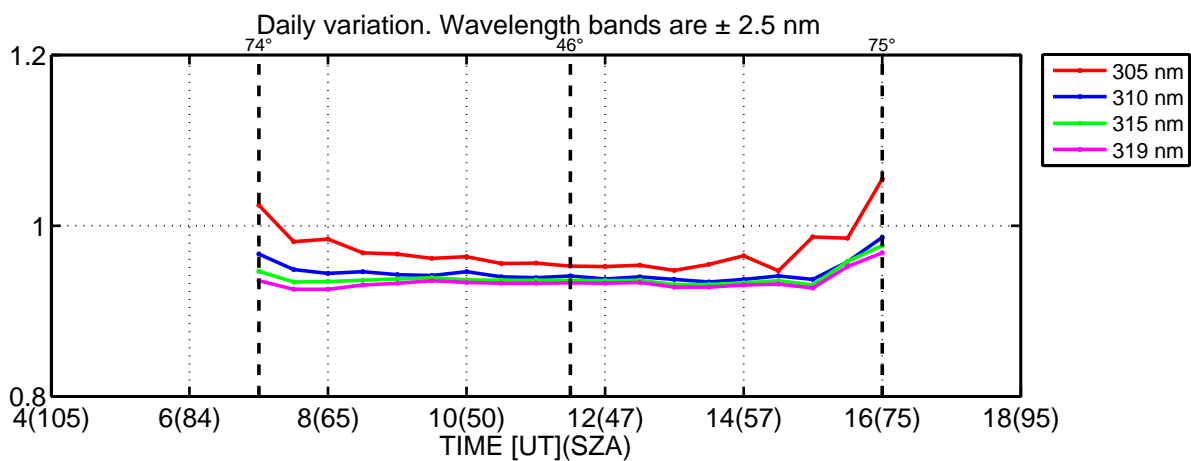
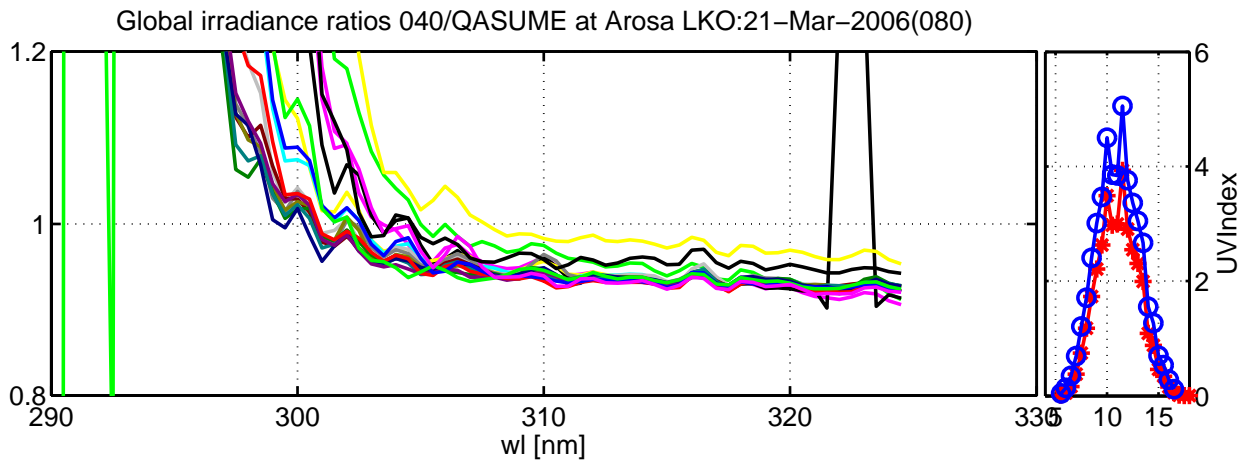
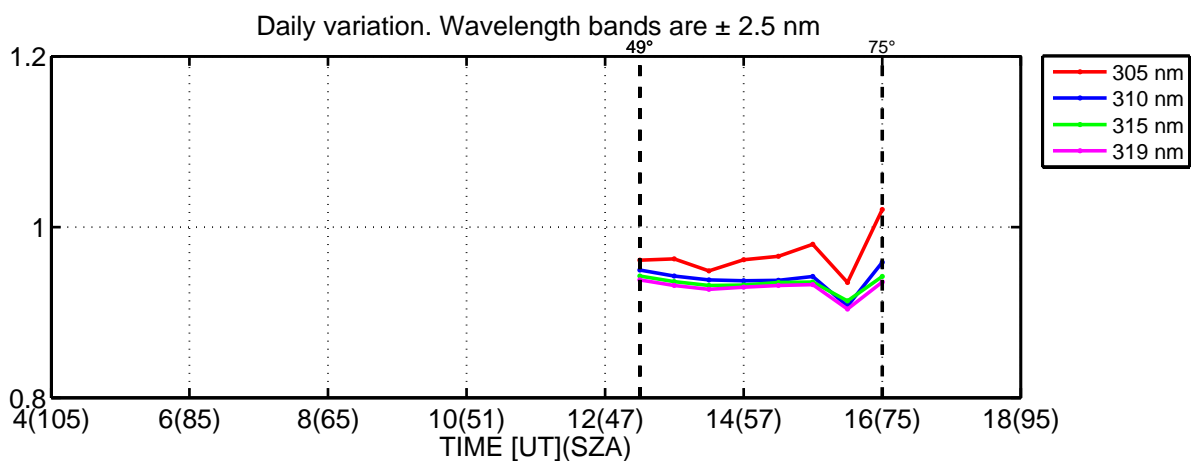
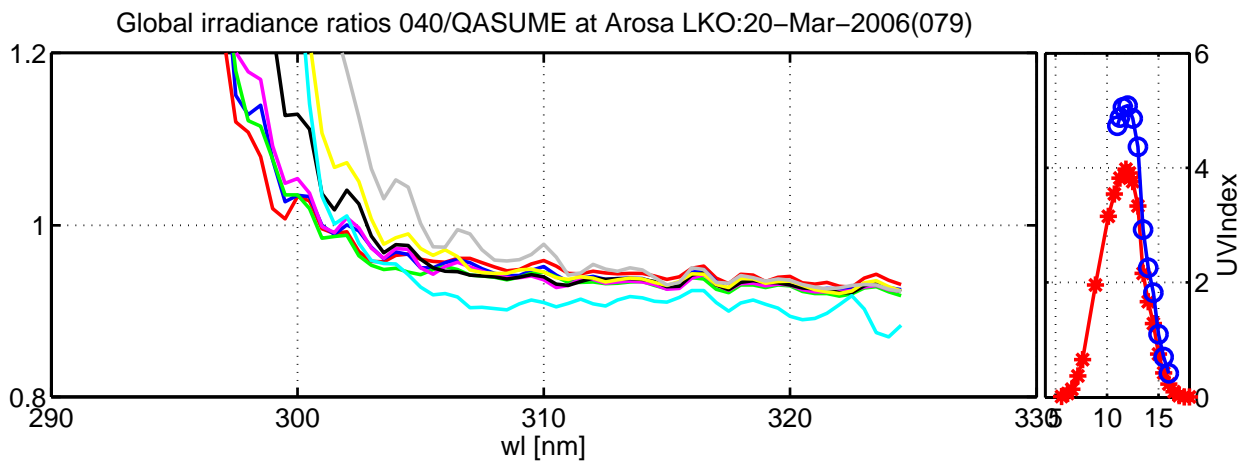
1. The raw data of the Brewers #040, #072 and #156 were converted to absolute units using the standard GWBasic software 'RD_UX3'. The responsivity file *UVR20205* is based on a calibration performed by IOS in 2005.
2. The single Brewers #040 and #072 show enhanced signals due to straylight below approx. 305 nm.
3. For all solar scans the wavelength shift of the Br #040, #072 and #156 are below ± 50 , ± 20 and ± 50 pm, respectively.
4. During the intercomparison period several spikes could be observed in the data.
 - Br #040: day 80 at 8:00 UT, day 81 at 12:00 UT and day 88 at 9:00 UT.
 - Br #072: day 81 at 16:00 UT.
 - Br #156: day 81 at 15:00 UT, day 82 at 15:30 UT and day 88 at 7:00 UT.
5. To avoid uncertainties due to nonlinearity, it is suggested to select the appropriate neutral density filter used during the UV-scans.
6. The increased variability of the Brewer #156 above 350 nm is due to loss of synchronisation. This is especially visible during rapidly changing weather conditions.

UV Index Arosa LKO, 20–31 March 2006

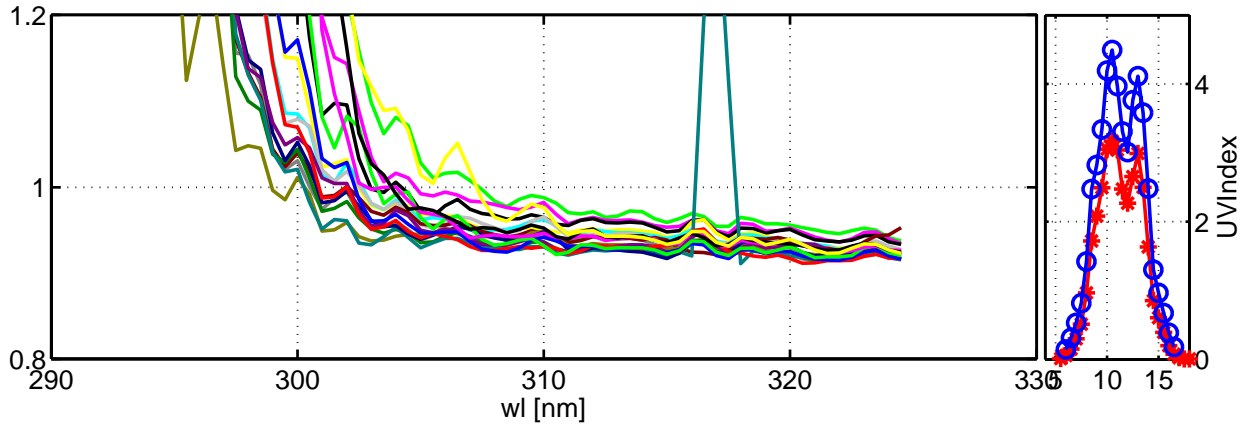


Global irradiance ratios 040/QASUME at Arosa LKO:20–Mar–2006(079) to 31–Mar–2006(090)

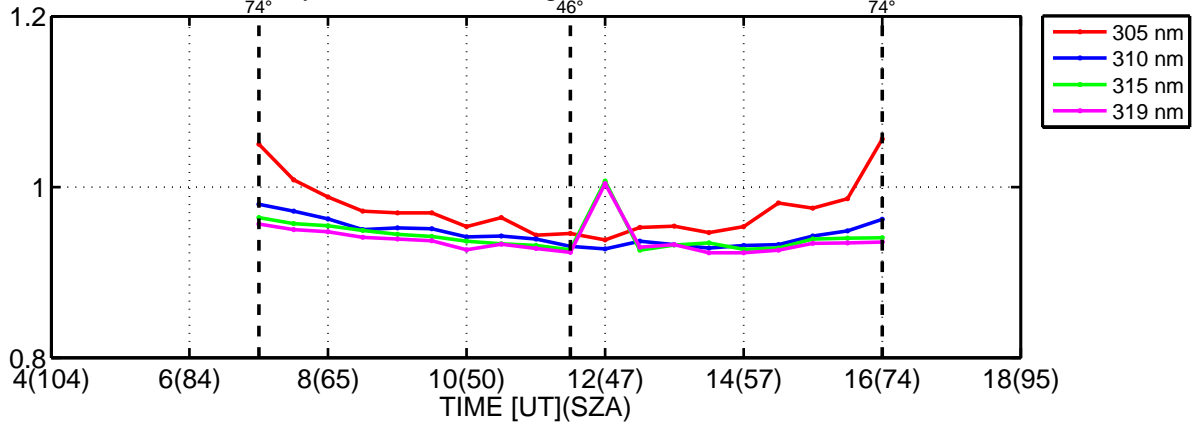




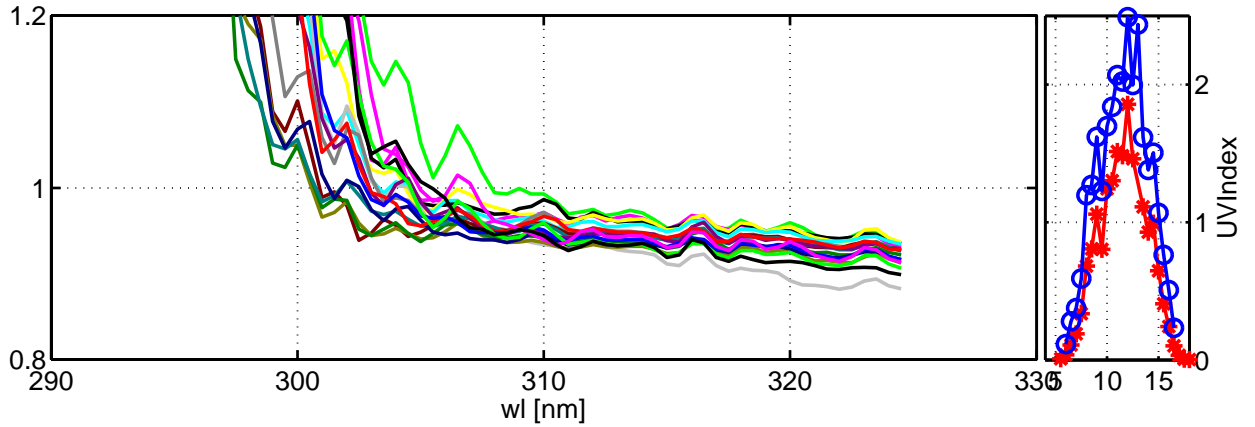
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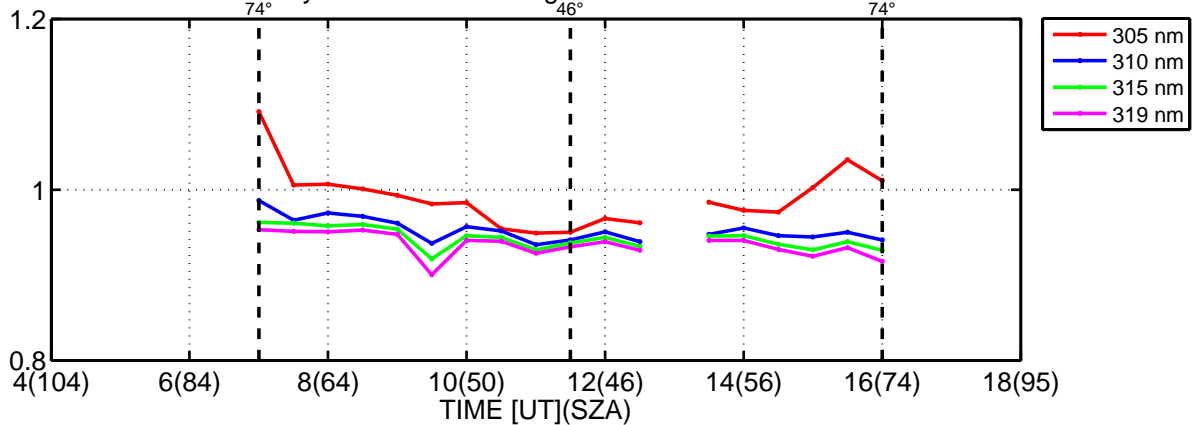
Daily variation. Wavelength bands are ± 2.5 nm



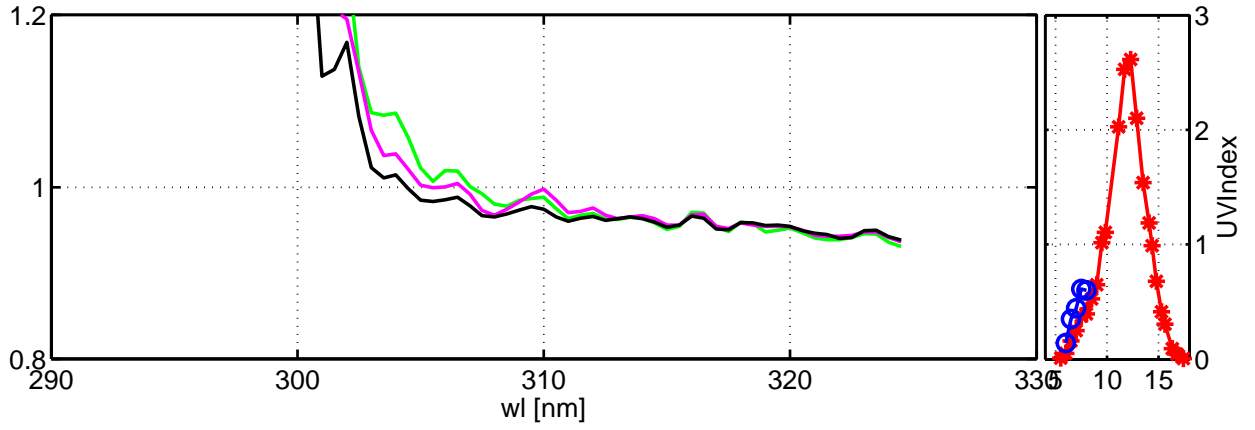
Global irradiance ratios 040/QASUME at Arosa LKO:23-Mar-2006(082)



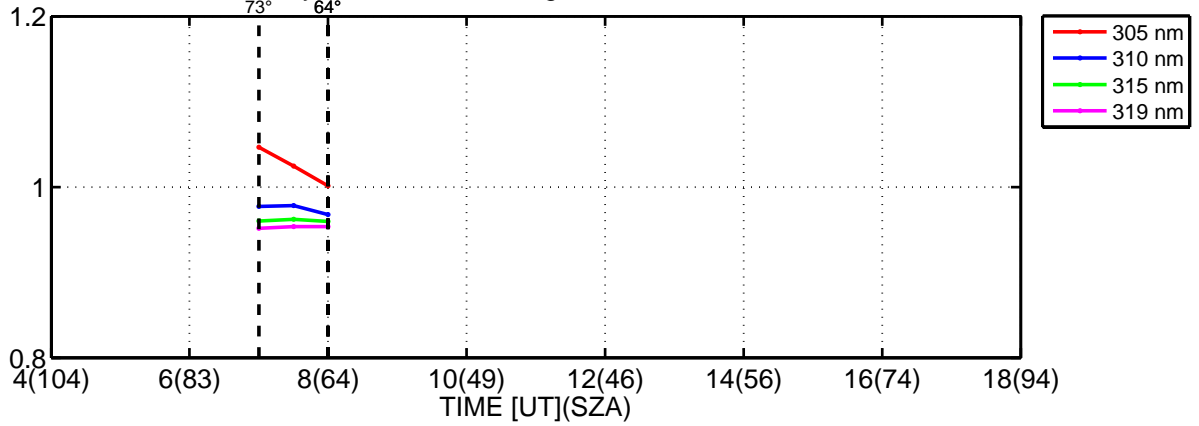
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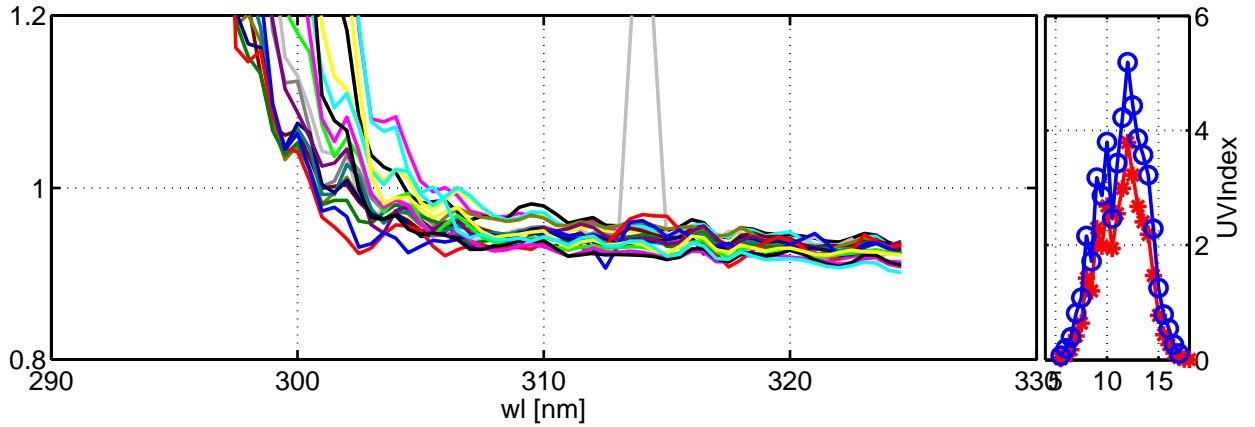
Global irradiance ratios 040/QASUME at Arosa LKO:24-Mar-2006(083)



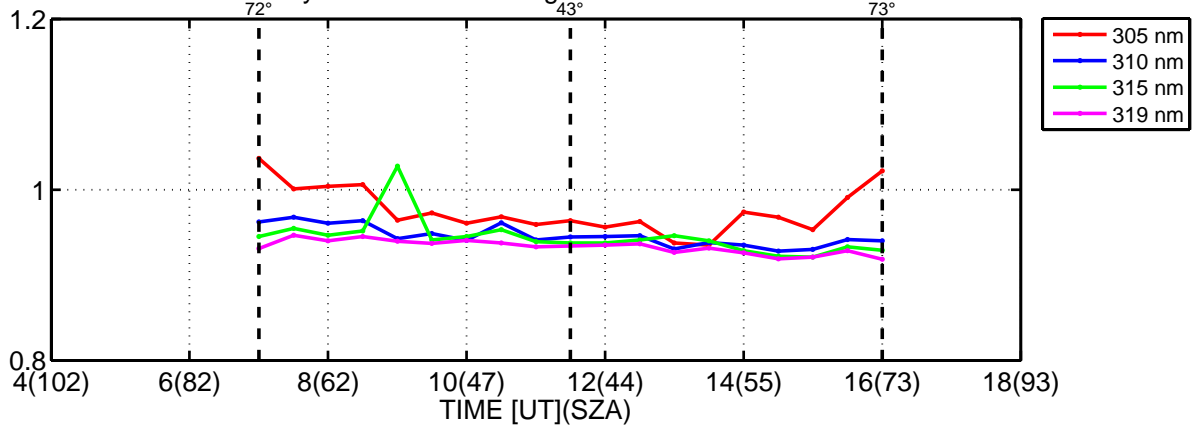
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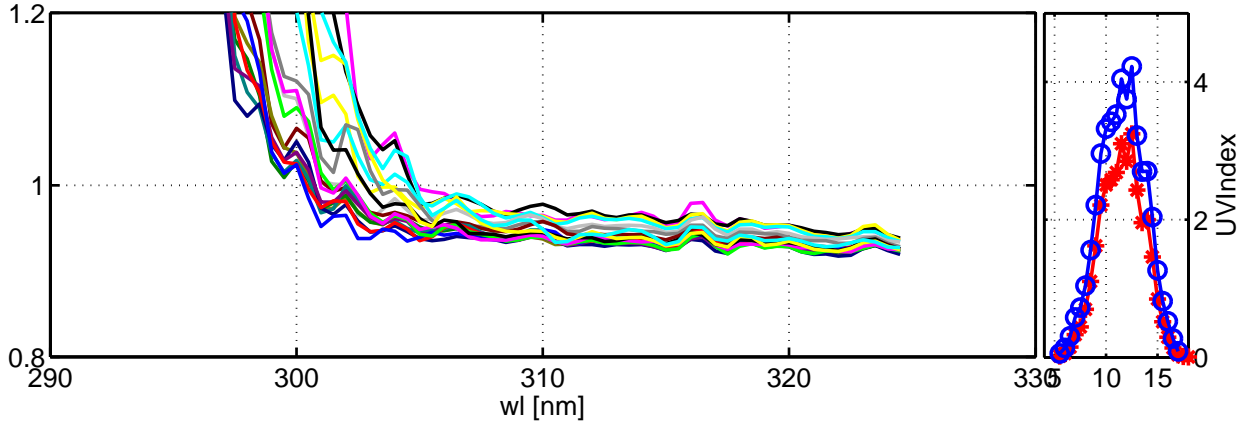
Global irradiance ratios 040/QASUME at Arosa LKO:29-Mar-2006(088)



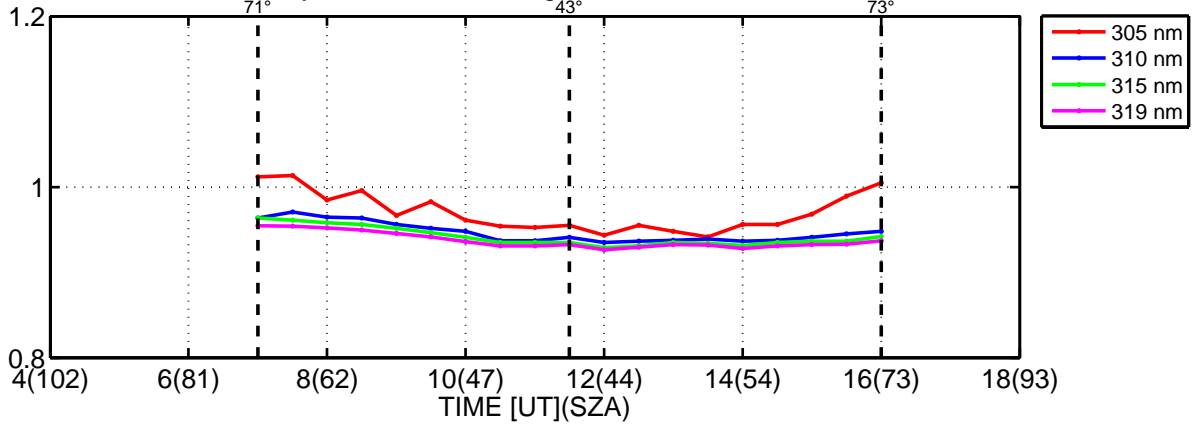
Daily variation. Wavelength bands are ± 2.5 nm



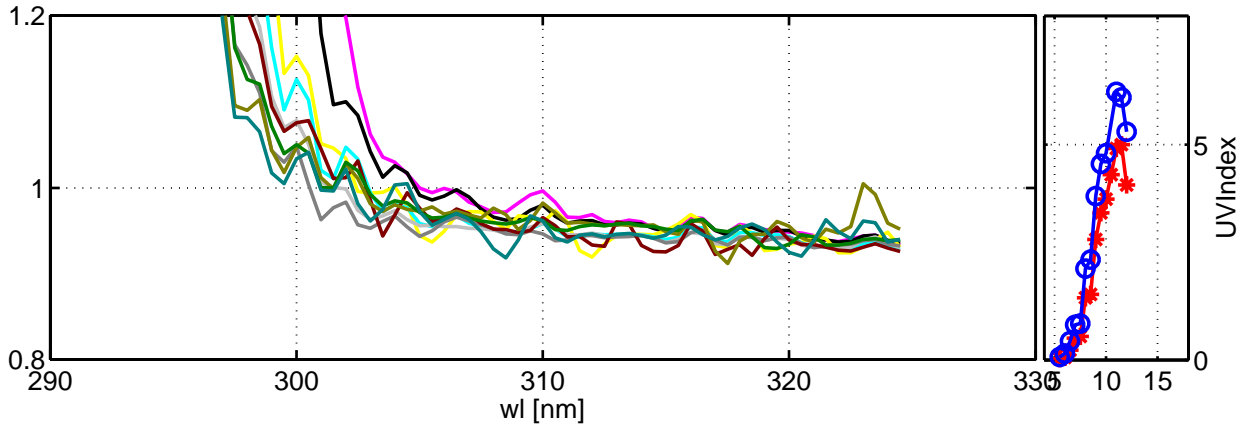
Global irradiance ratios 040/QASUME at Arosa LKO:30-Mar-2006(089)



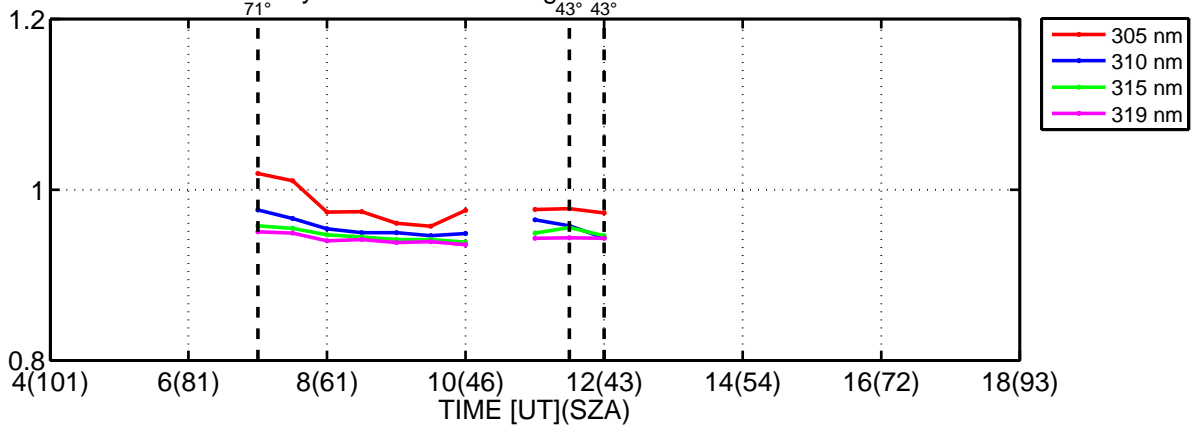
Daily variation. Wavelength bands are ± 2.5 nm

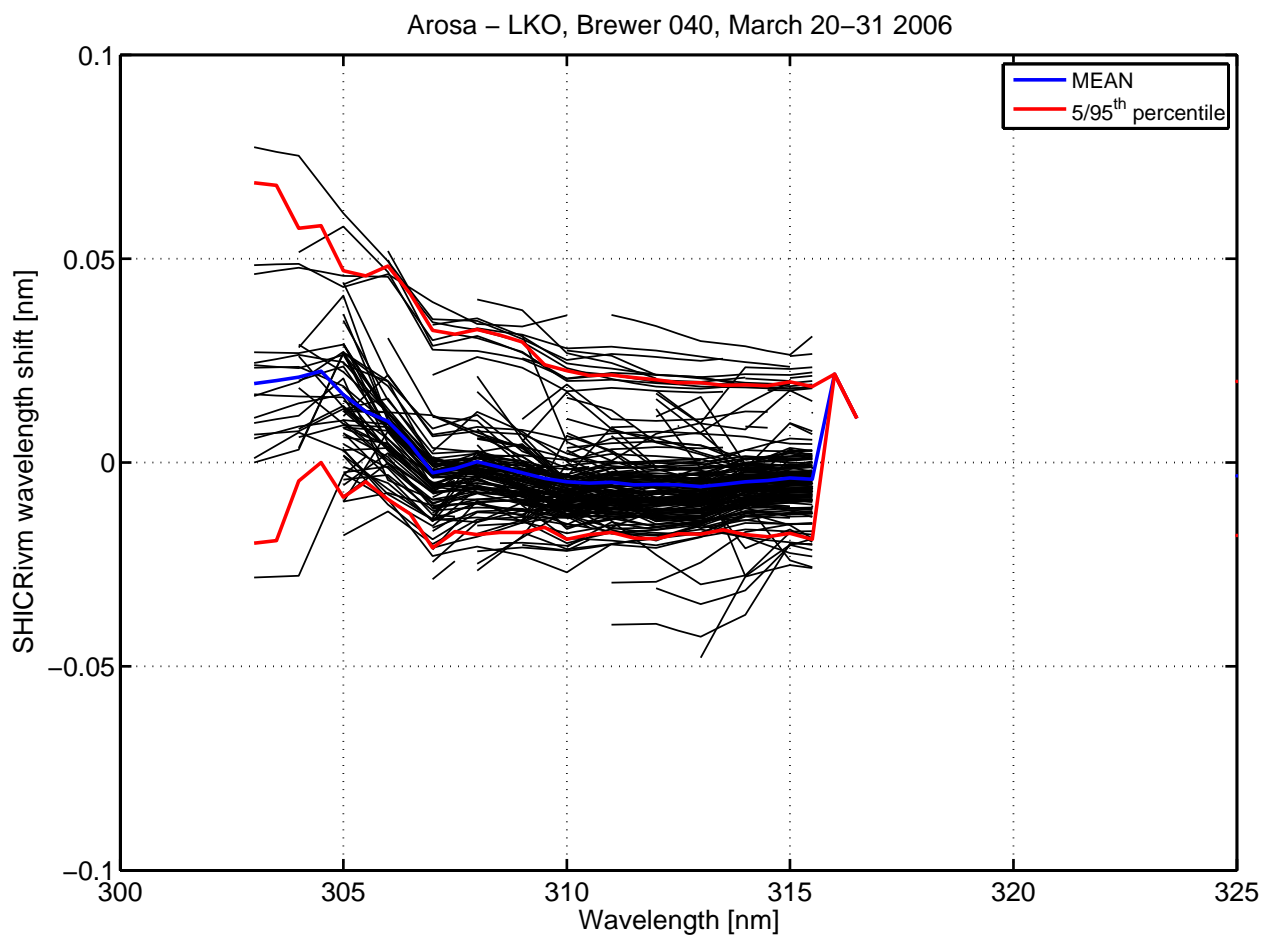
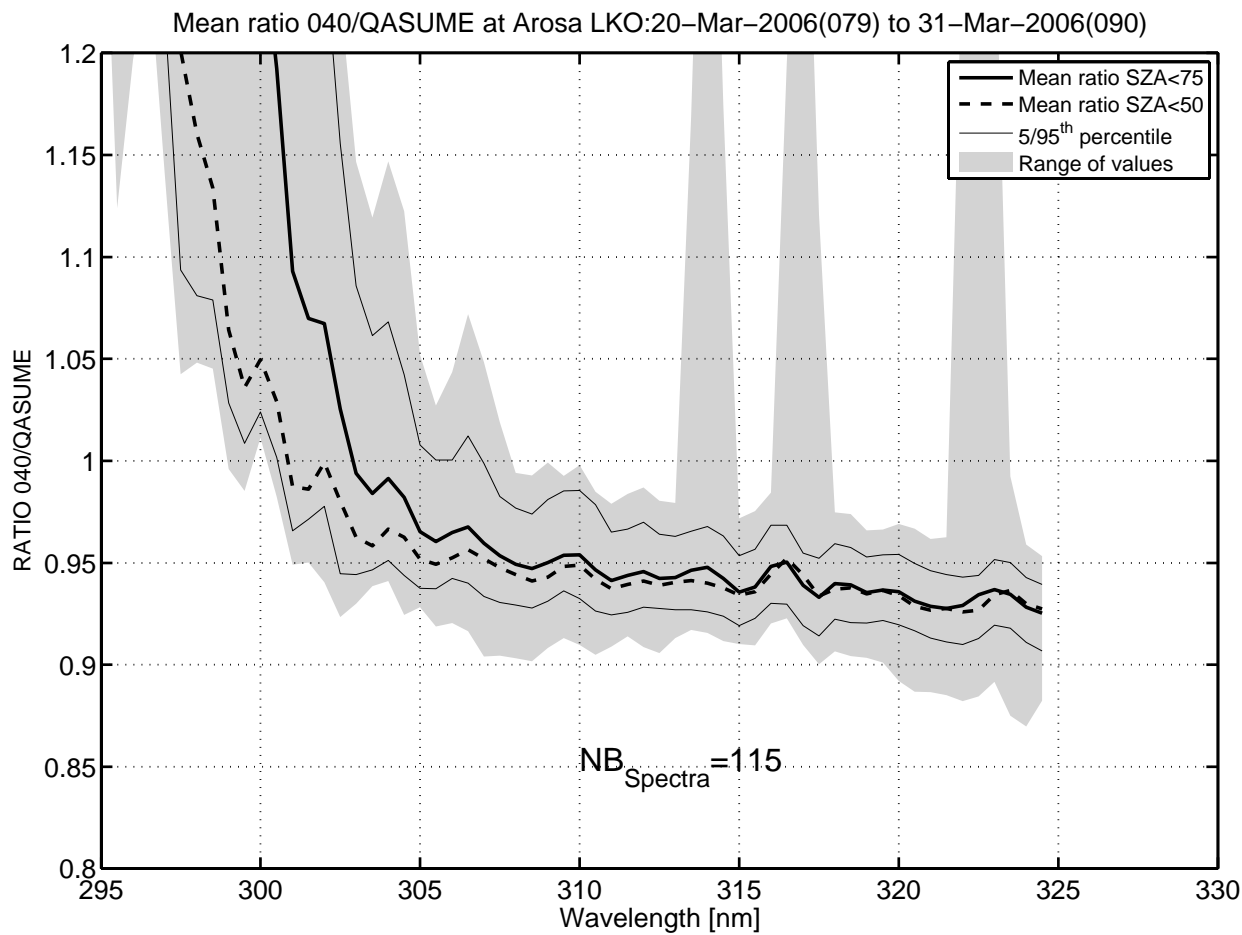


Global irradiance ratios 040/QASUME at Arosa LKO:31-Mar-2006(090)

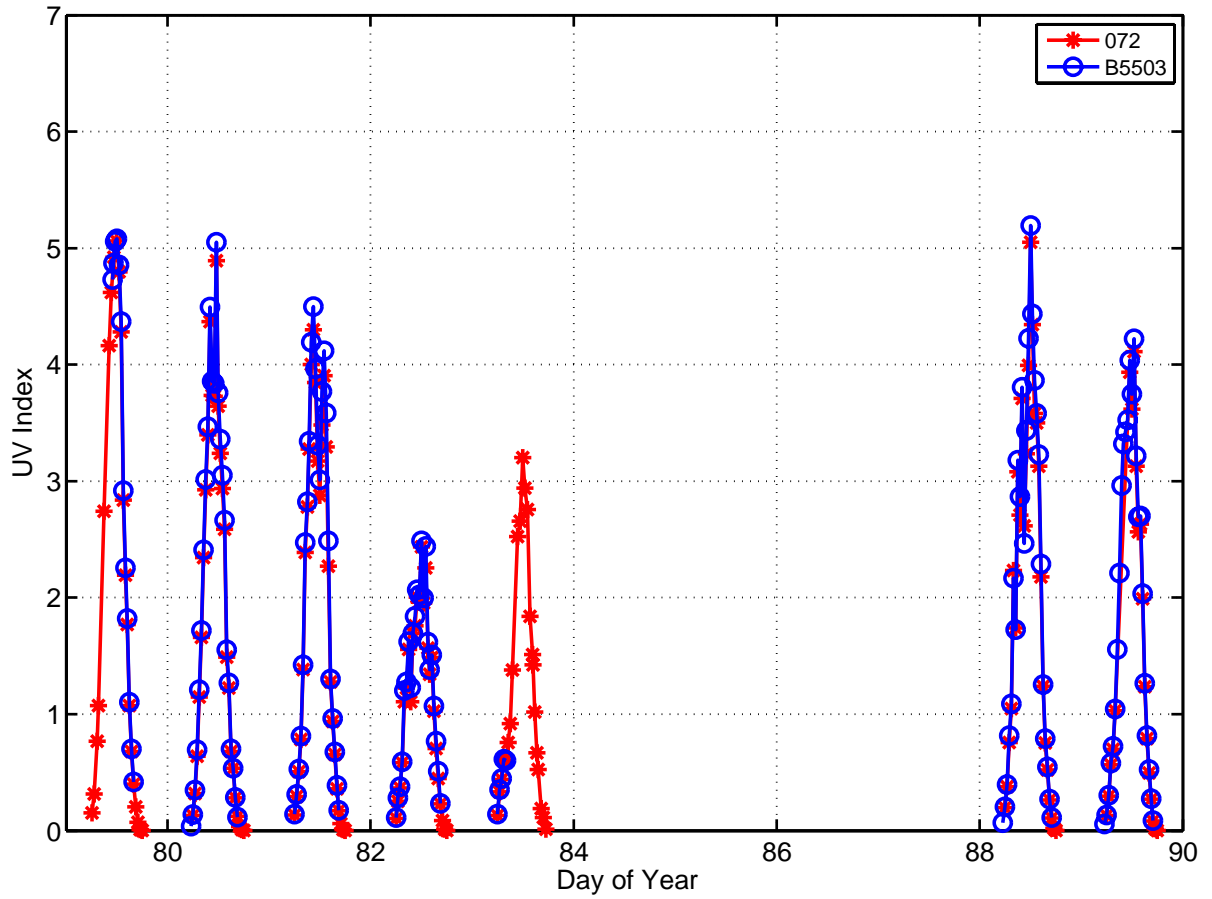


Daily variation. Wavelength bands are ± 2.5 nm

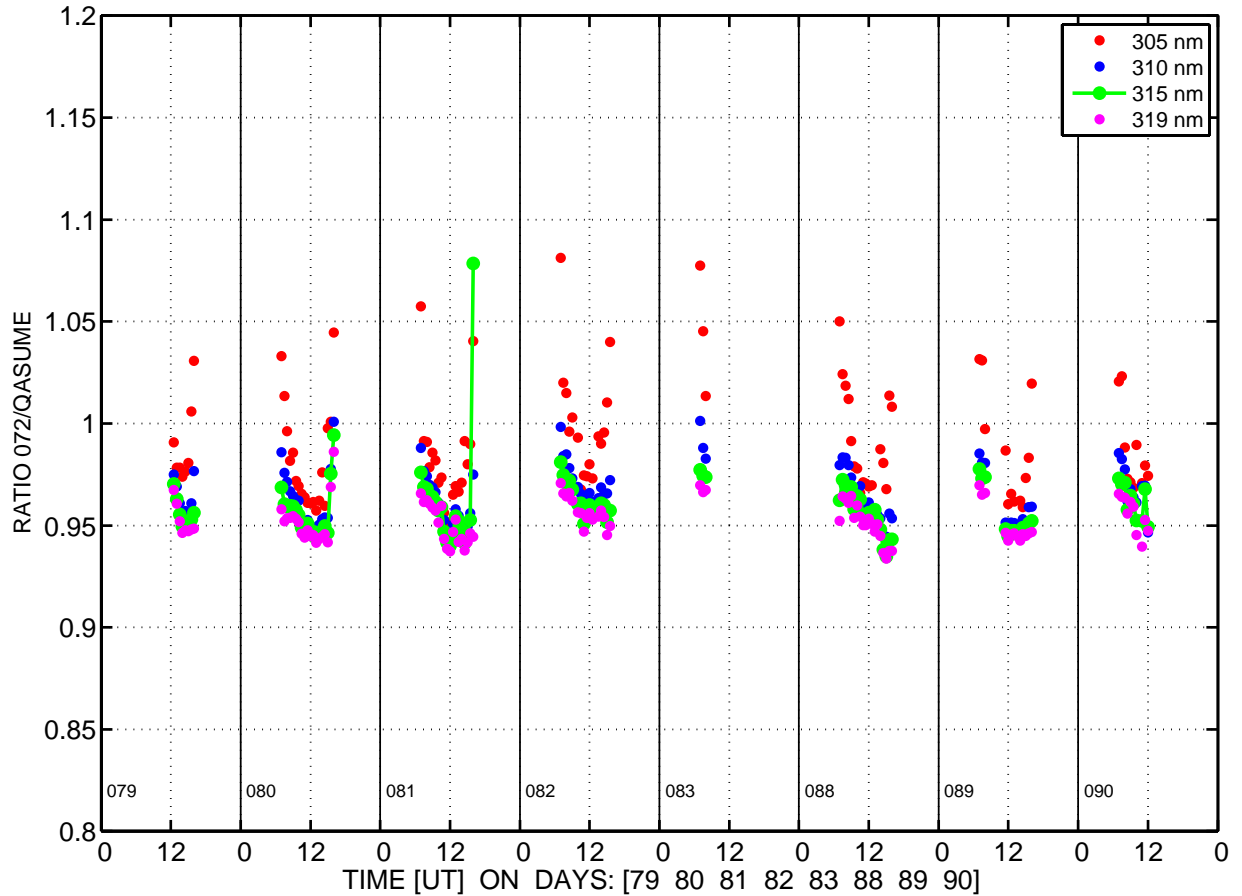




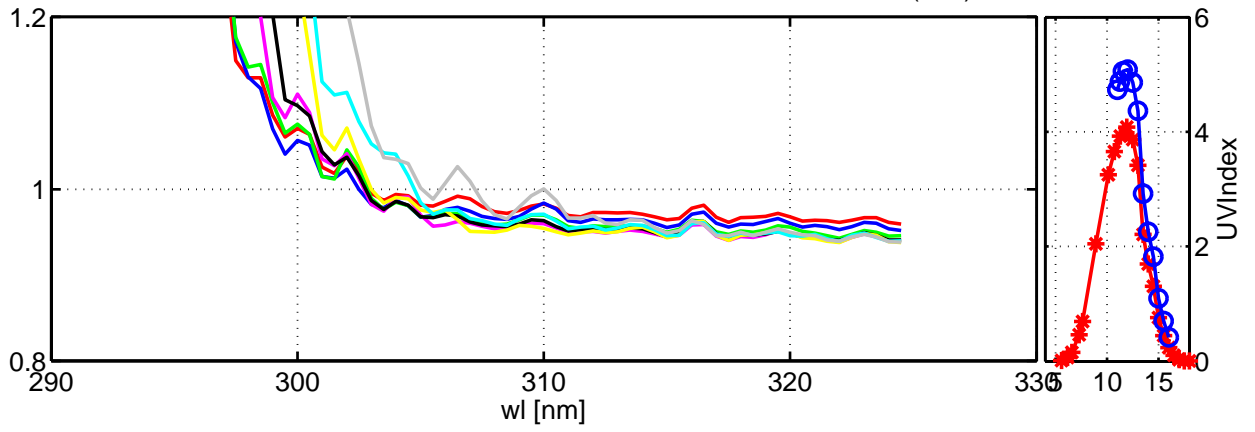
UV Index Arosa LKO, 20–31 March 2006



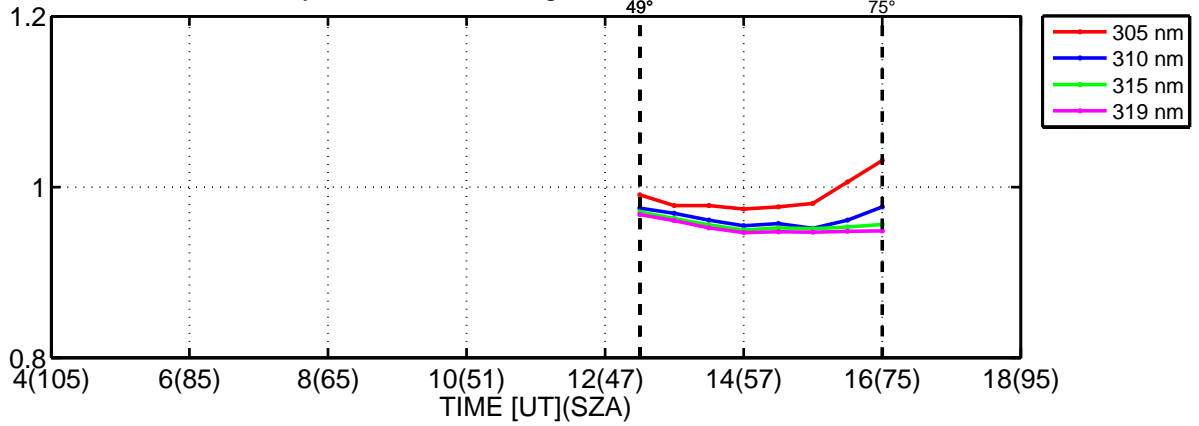
Global irradiance ratios 072/QASUME at Arosa LKO:20-Mar-2006(079) to 31-Mar-2006(090)



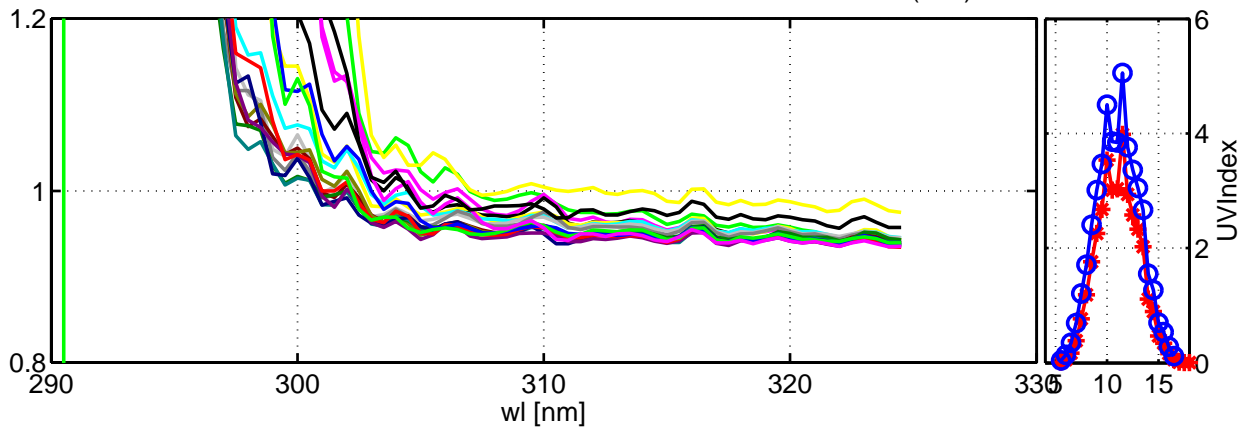
Global irradiance ratios 072/QASUME at Arosa LKO:20-Mar-2006(079)



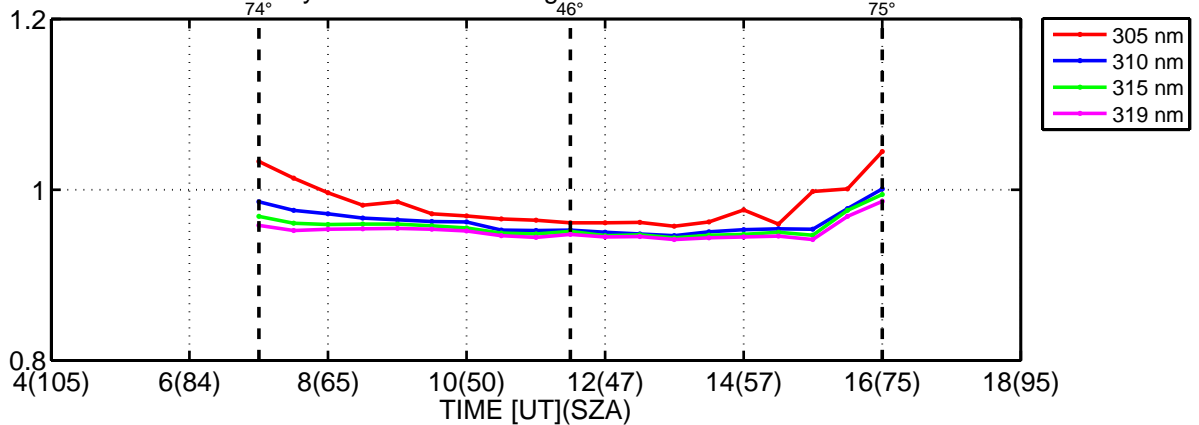
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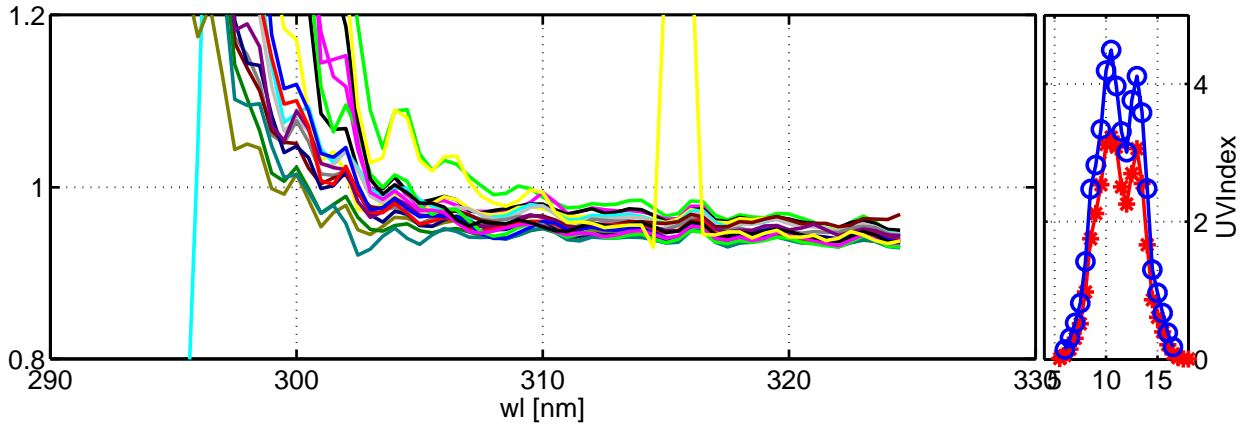
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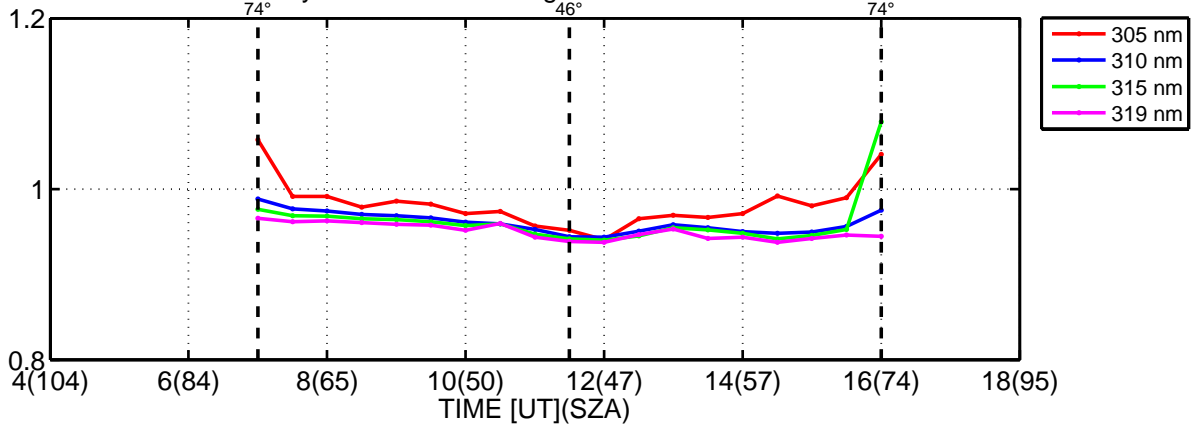
Daily variation. Wavelength bands are ± 2.5 nm



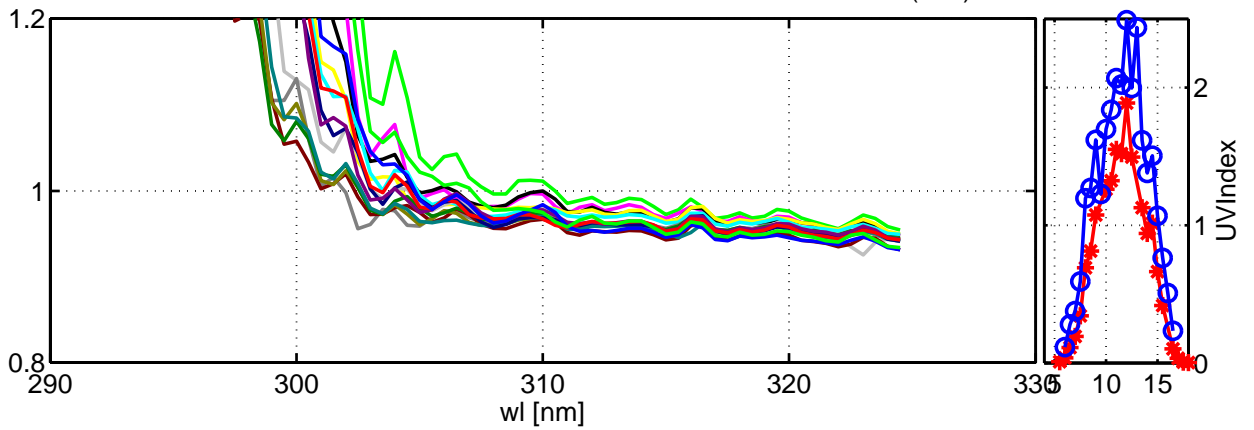
Global irradiance ratios 072/QASUME at Arosa LKO:22-Mar-2006(081)



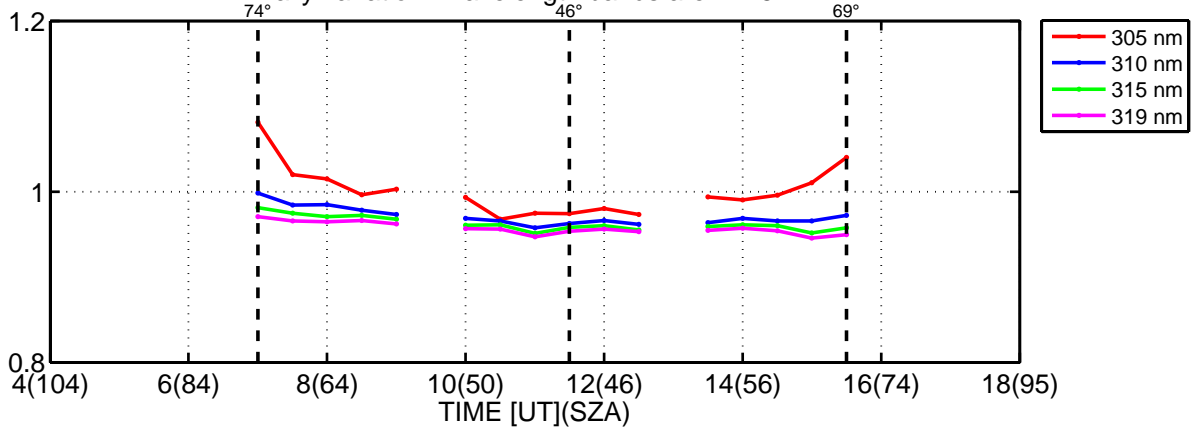
Daily variation. Wavelength bands are ± 2.5 nm



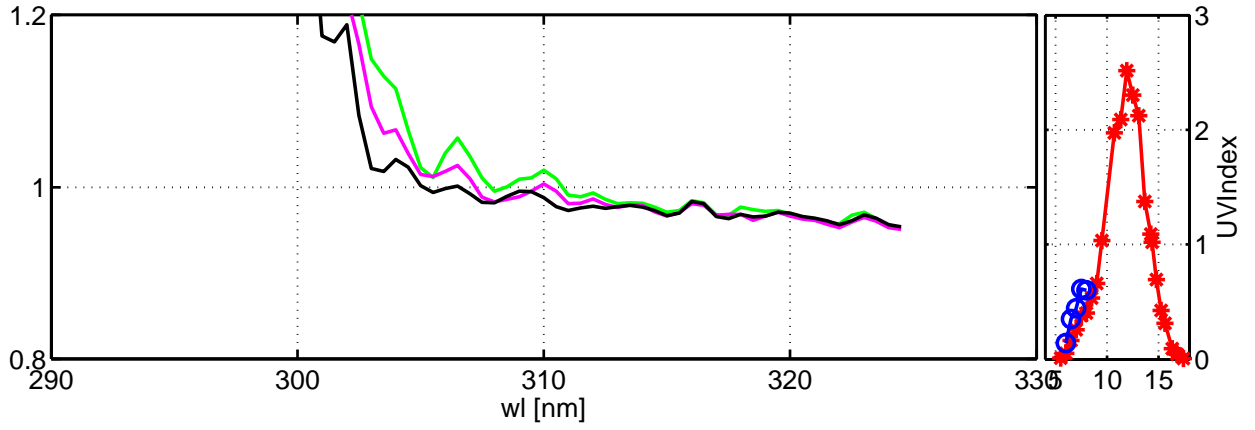
Global irradiance ratios 072/QASUME at Arosa LKO:23-Mar-2006(082)



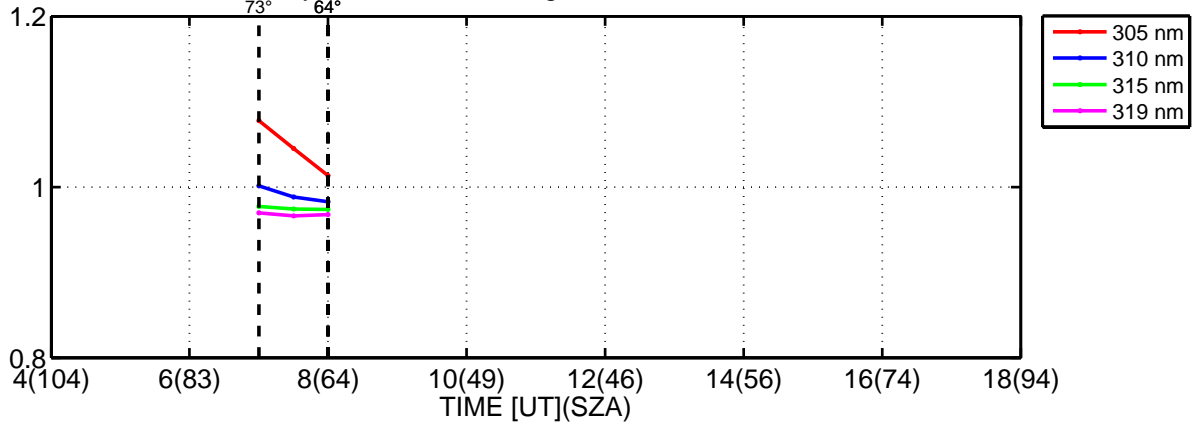
Daily variation. Wavelength bands are ± 2.5 nm



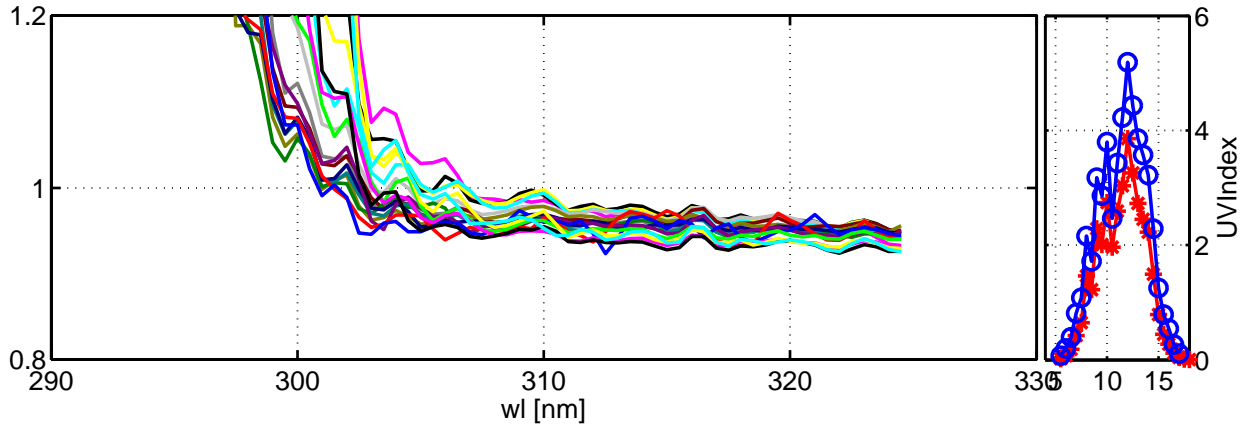
Global irradiance ratios 072/QASUME at Arosa LKO:24-Mar-2006(083)



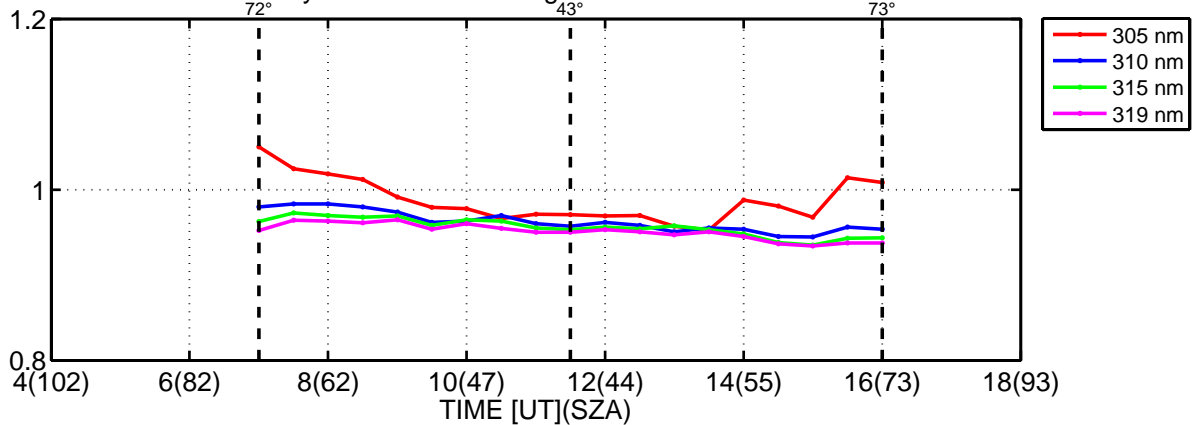
Daily variation. Wavelength bands are ± 2.5 nm



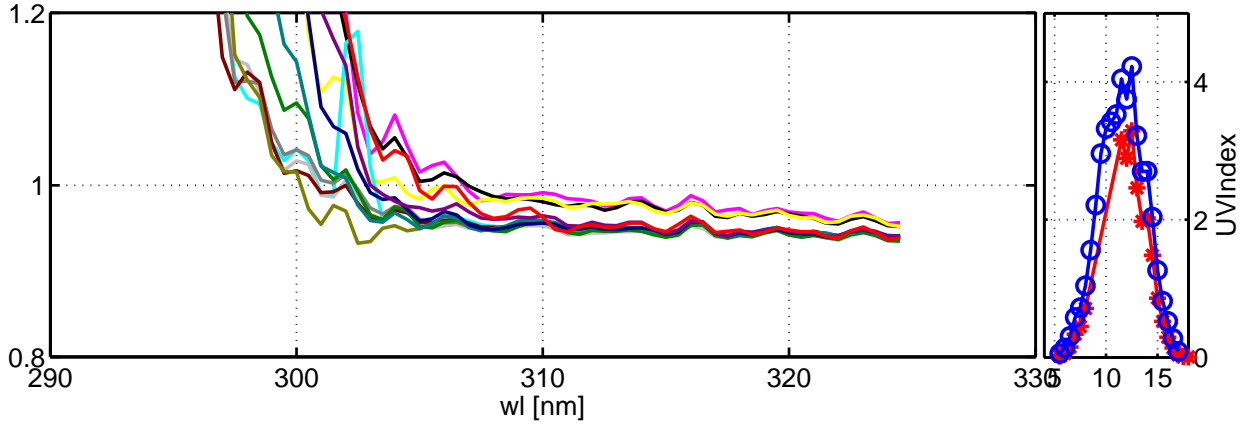
Global irradiance ratios 072/QASUME at Arosa LKO:29-Mar-2006(088)



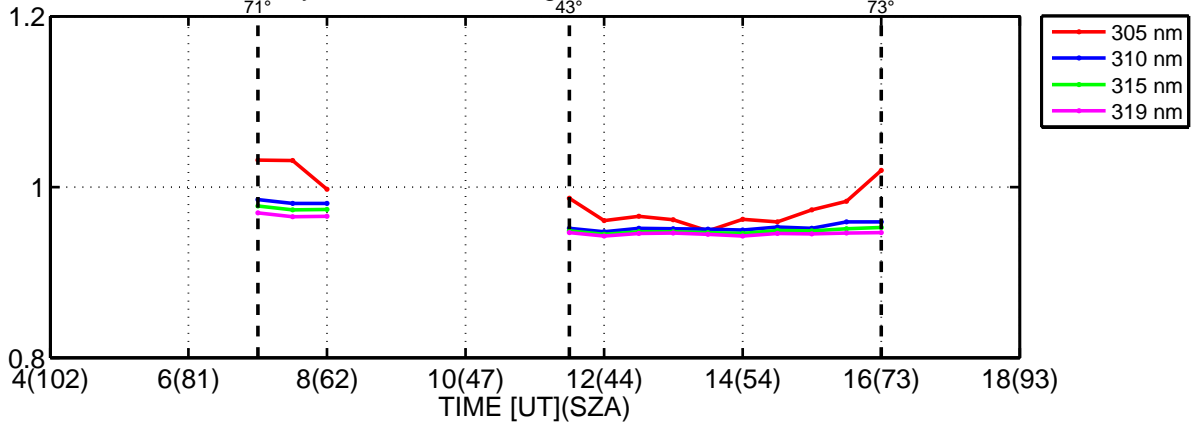
Daily variation. Wavelength bands are ± 2.5 nm



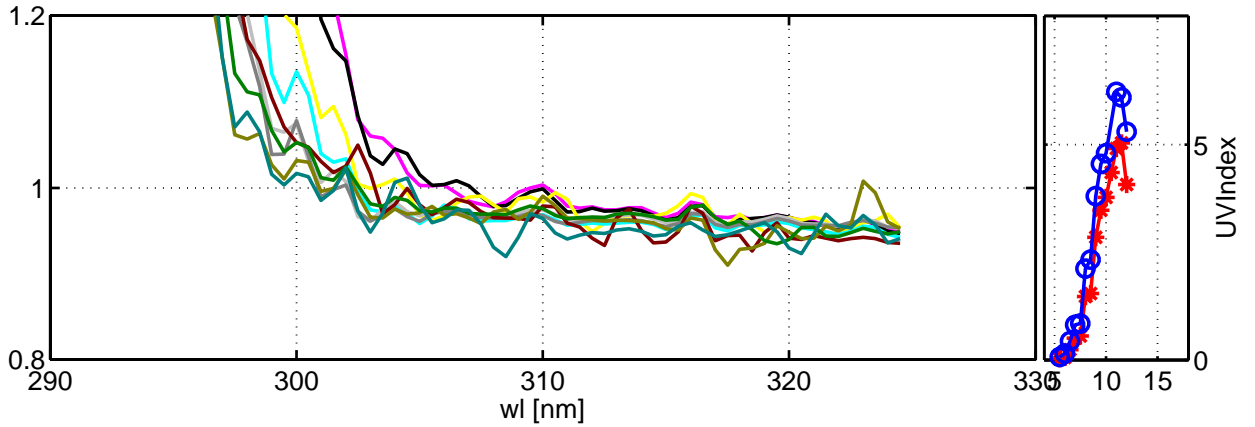
Global irradiance ratios 072/QASUME at Arosa LKO:30-Mar-2006(089)



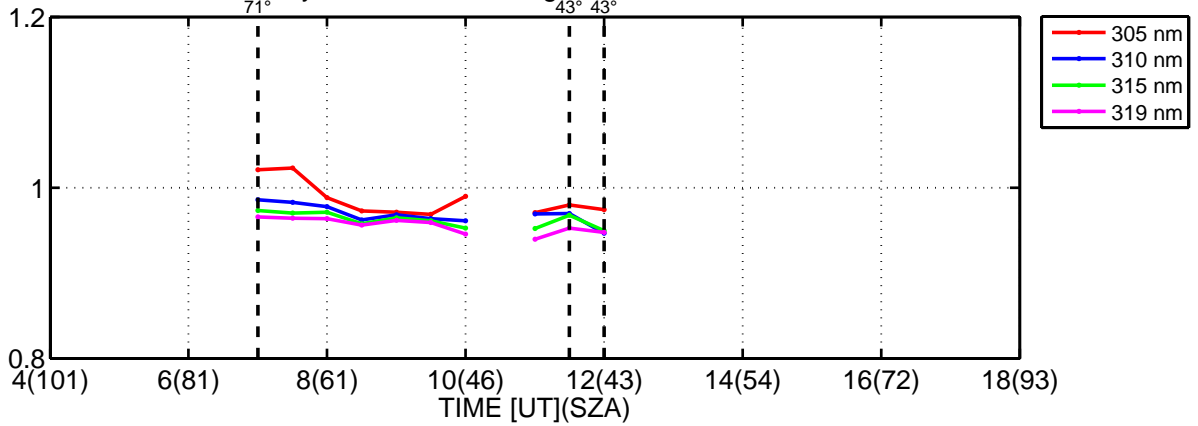
Daily variation. Wavelength bands are ± 2.5 nm

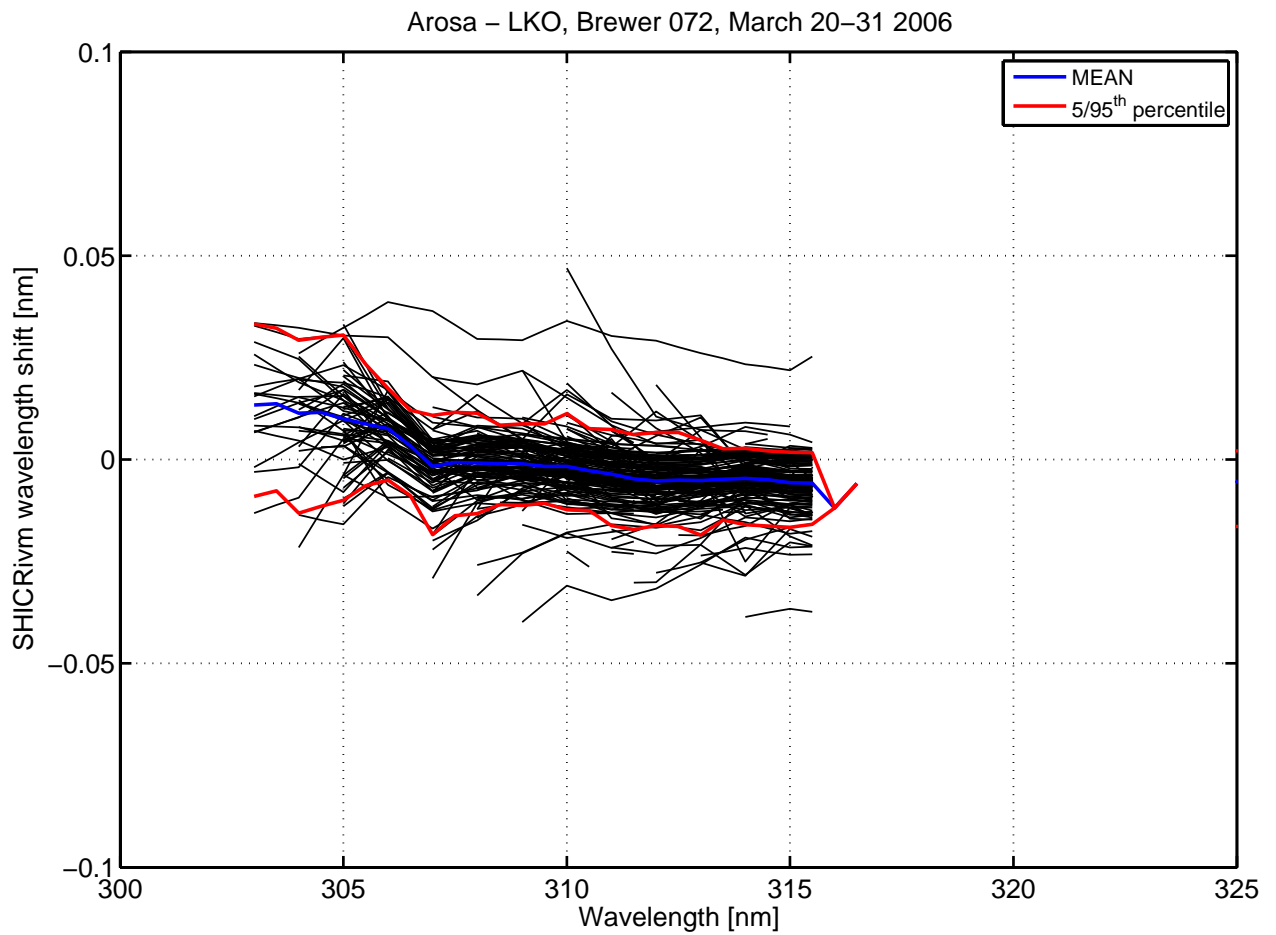
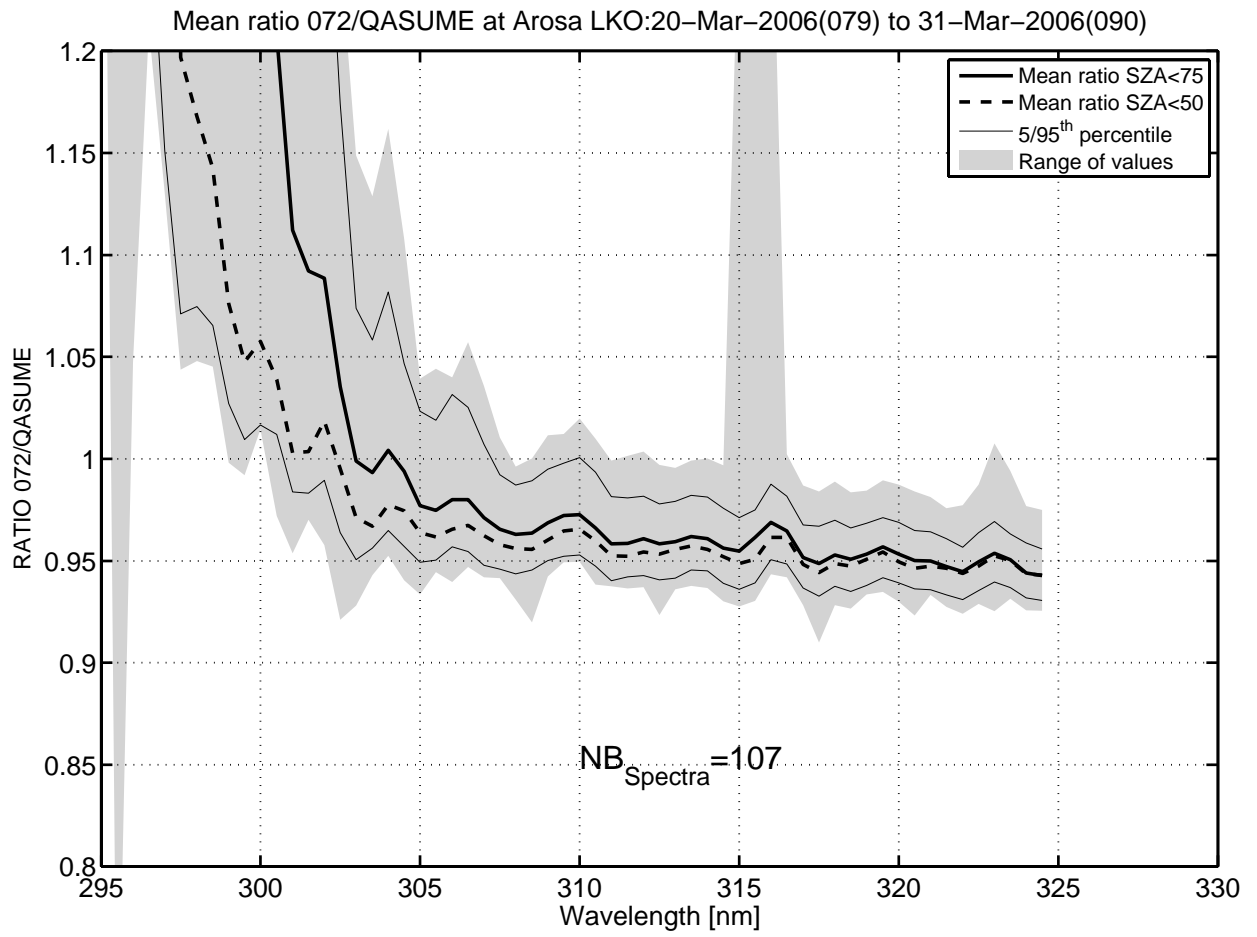


Global irradiance ratios 072/QASUME at Arosa LKO:31-Mar-2006(090)

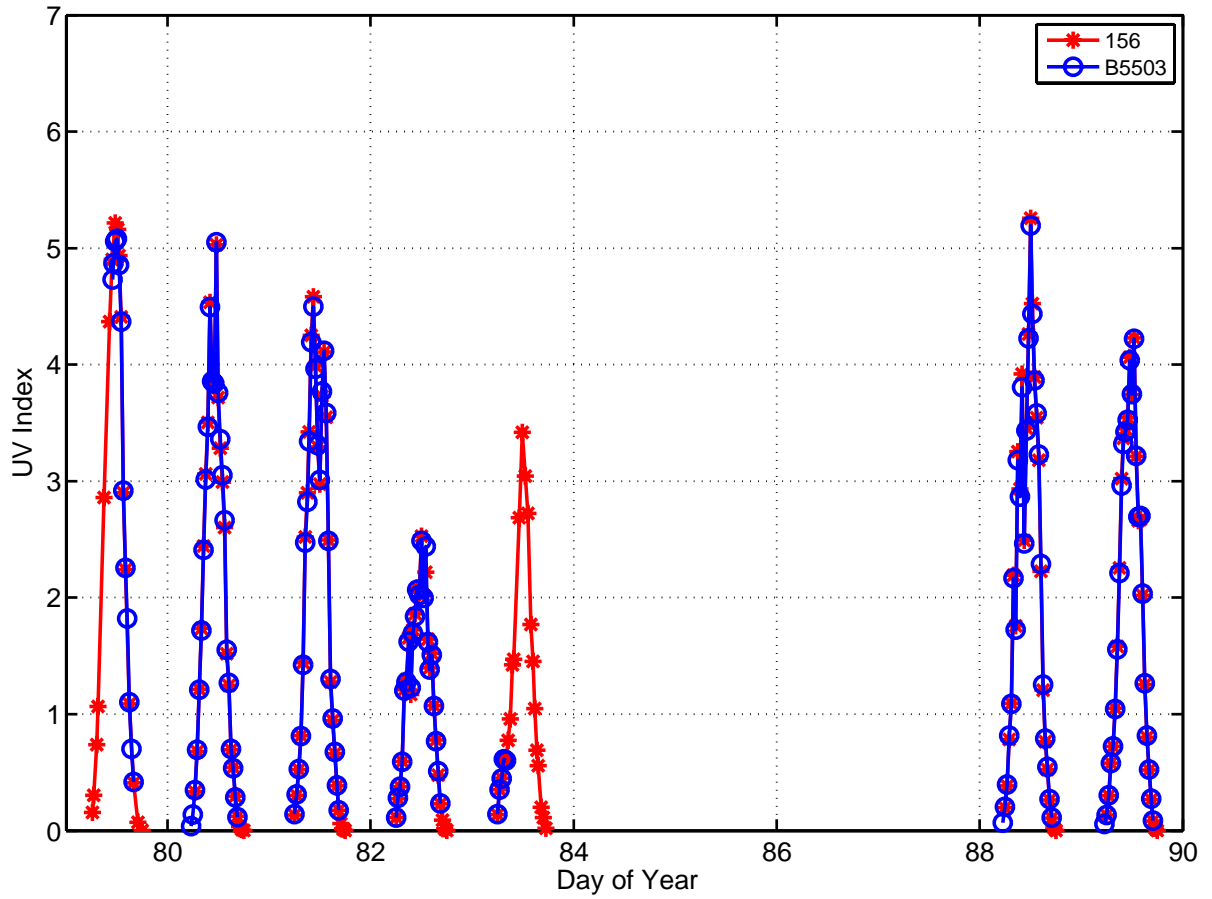


Daily variation. Wavelength bands are ± 2.5 nm

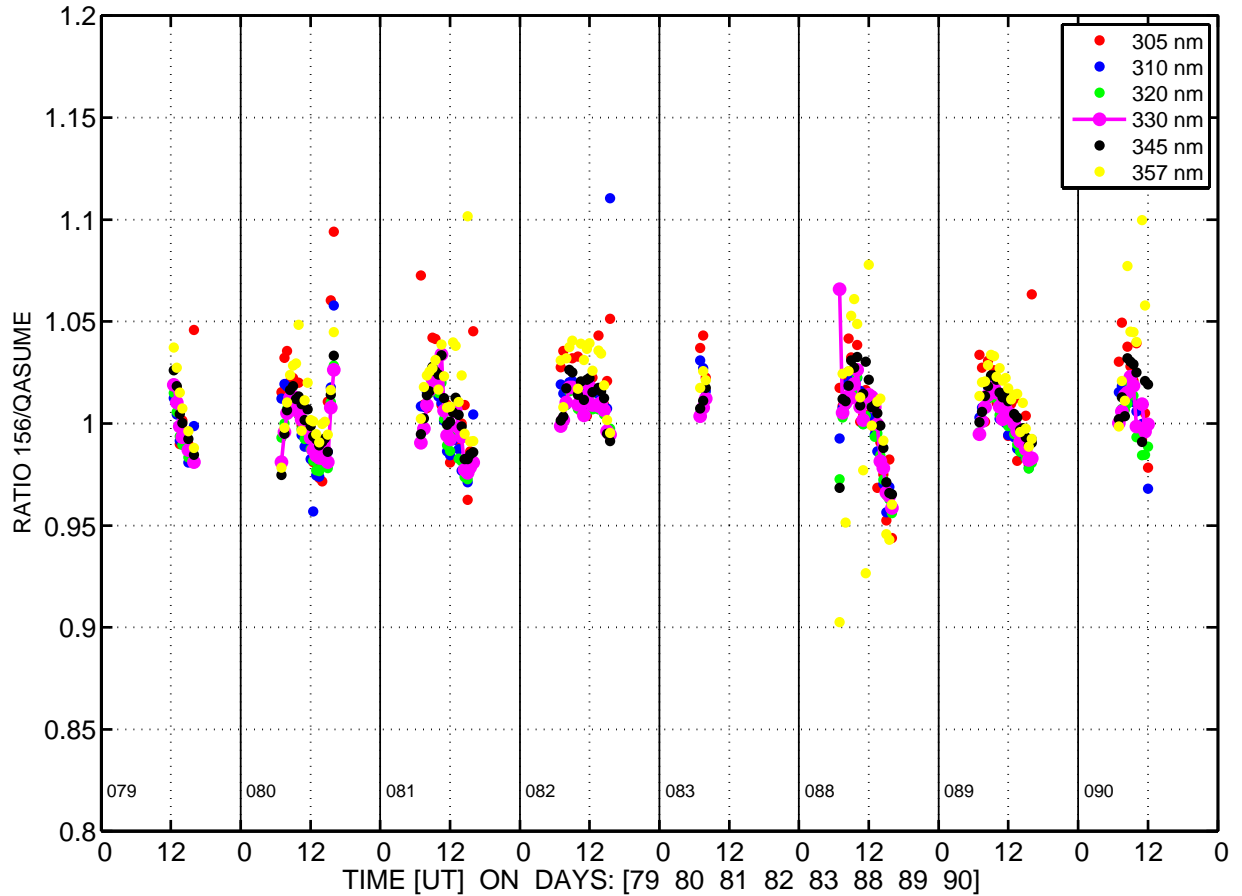




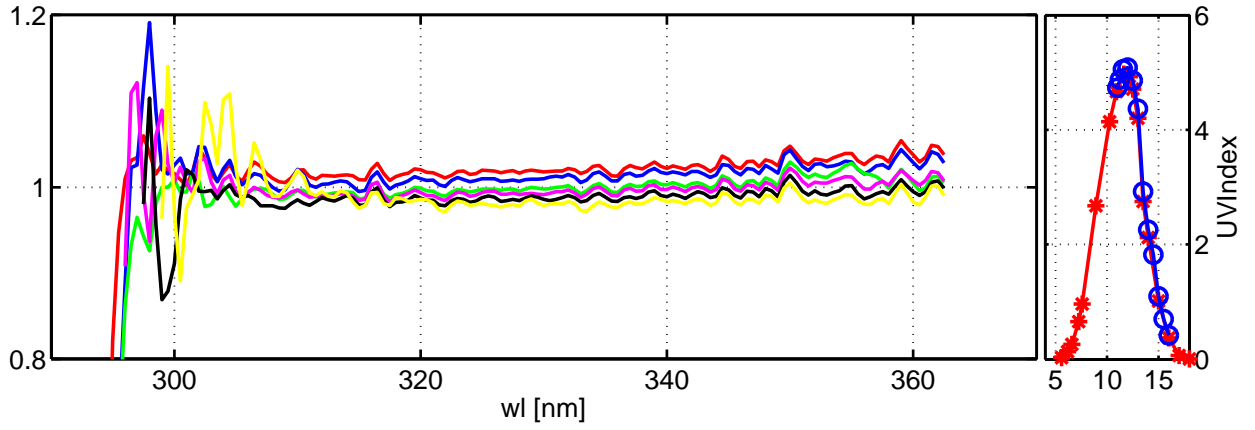
UV Index Arosa LKO, 20–31 March 2006



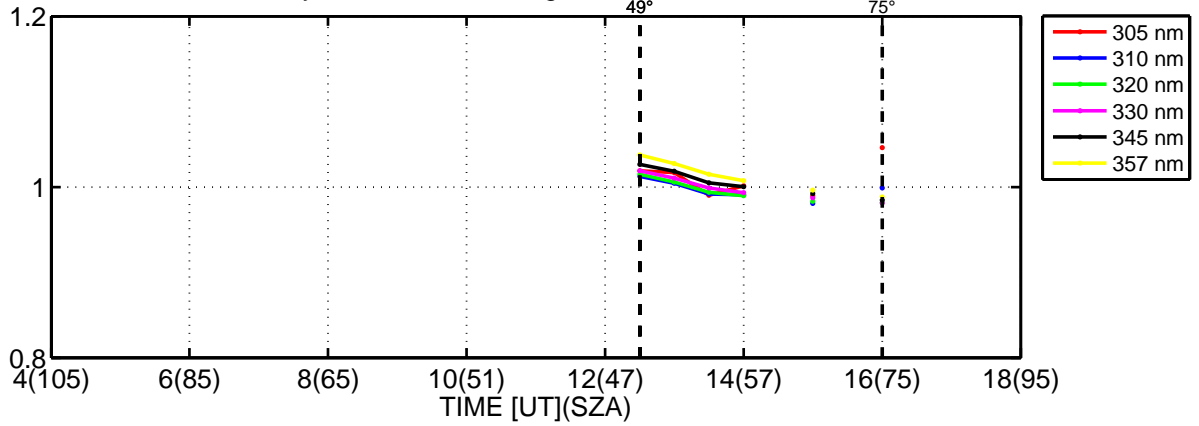
Global irradiance ratios 156/QASUME at Arosa LKO:20–Mar–2006(079) to 31–Mar–2006(090)



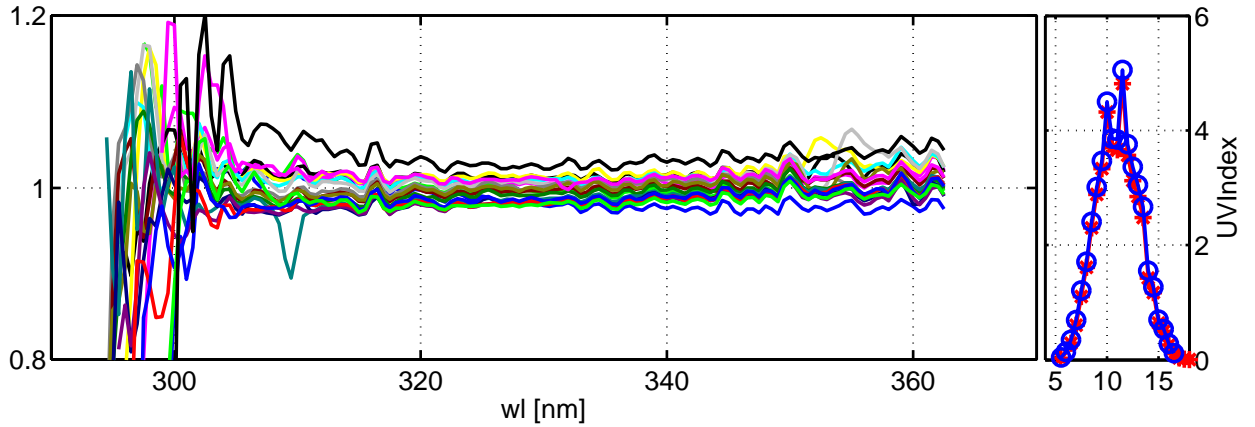
Global irradiance ratios 156/QASUME at Arosa LKO:20-Mar-2006(079)



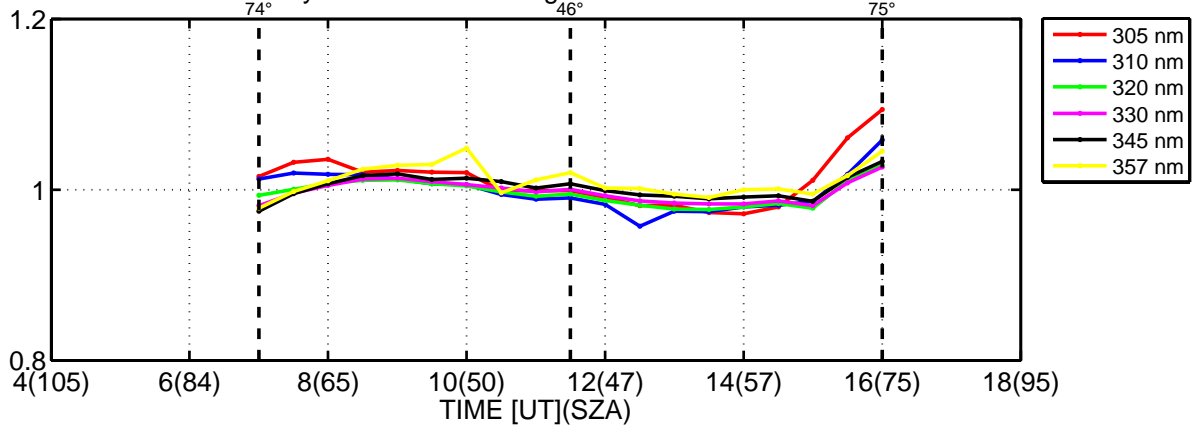
Daily variation. Wavelength bands are ± 2.5 nm



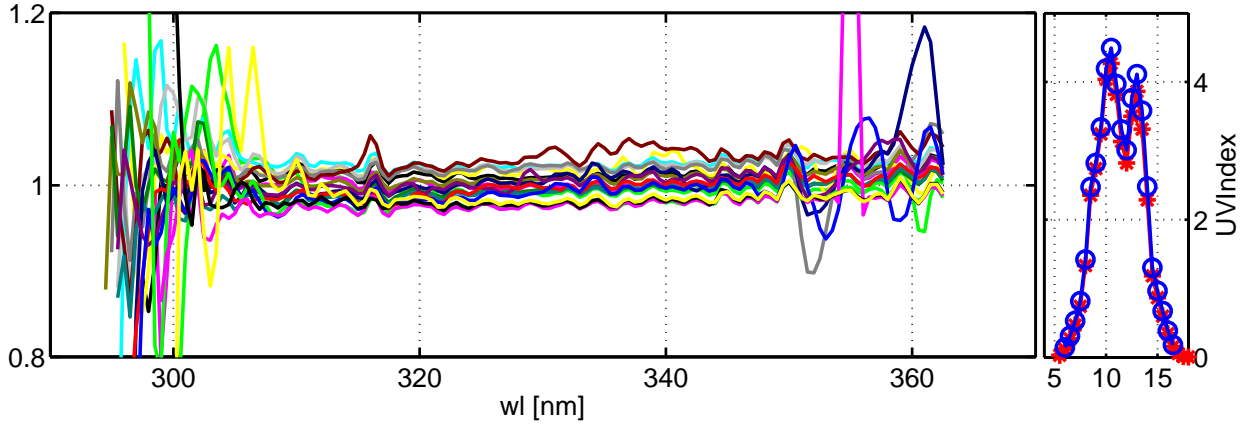
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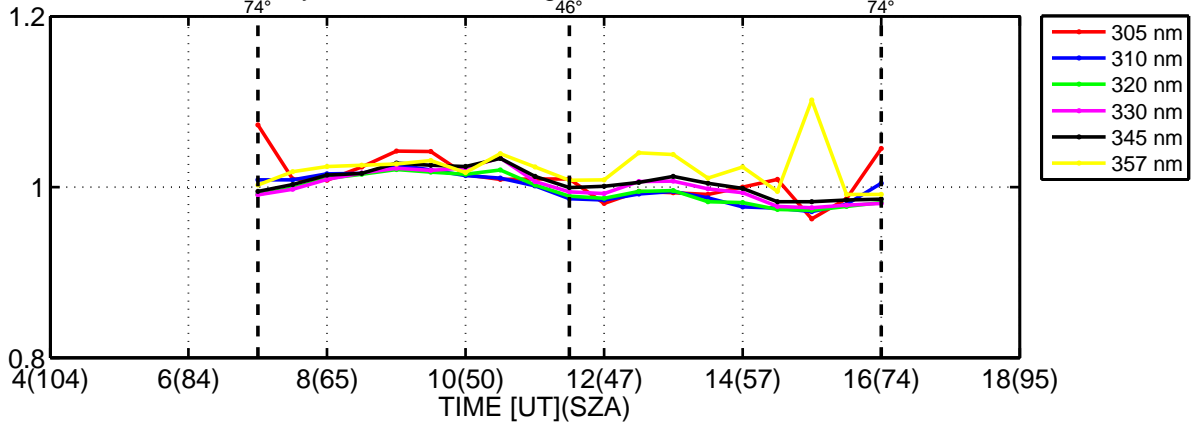
Daily variation. Wavelength bands are ± 2.5 nm



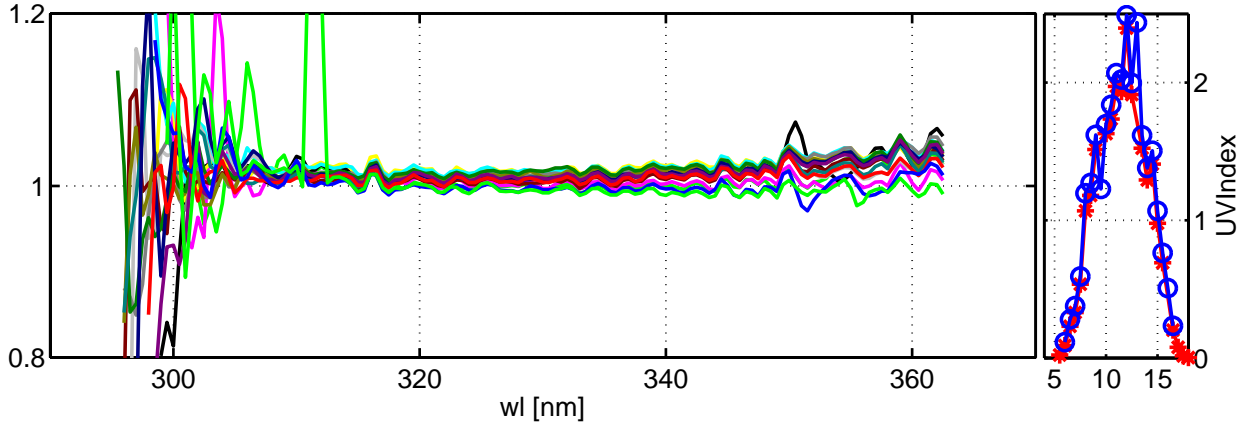
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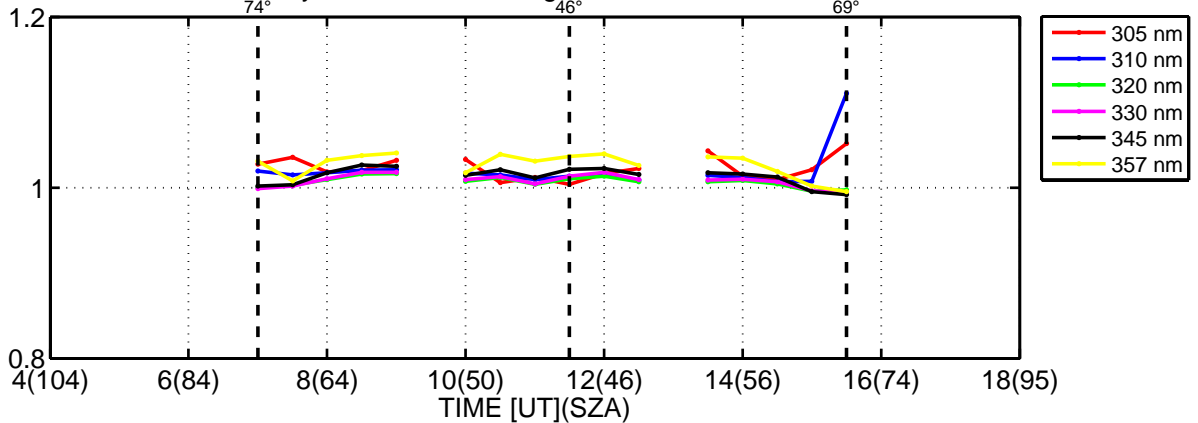
Daily variation. Wavelength bands are ± 2.5 nm



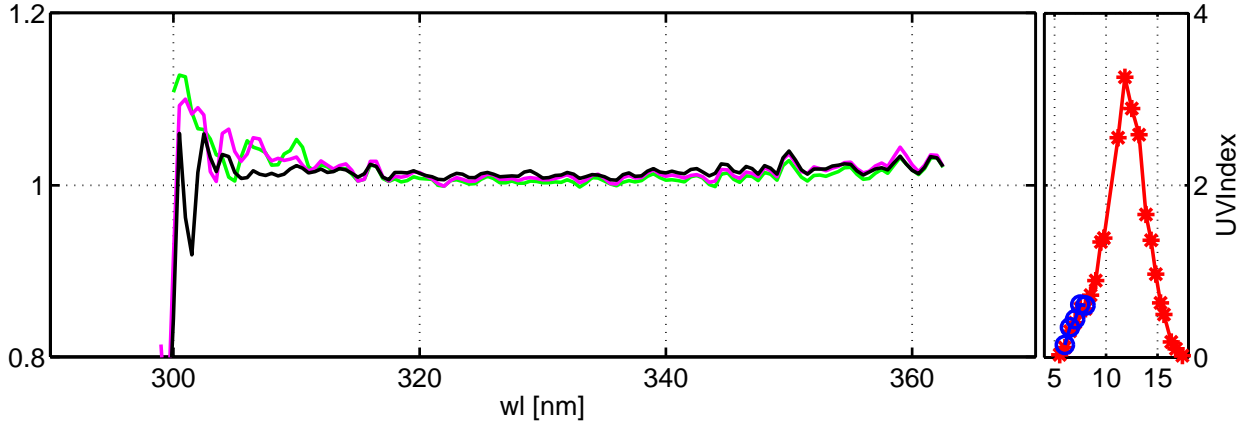
Global irradiance ratios 156/QASUME at Arosa LKO:23-Mar-2006(082)



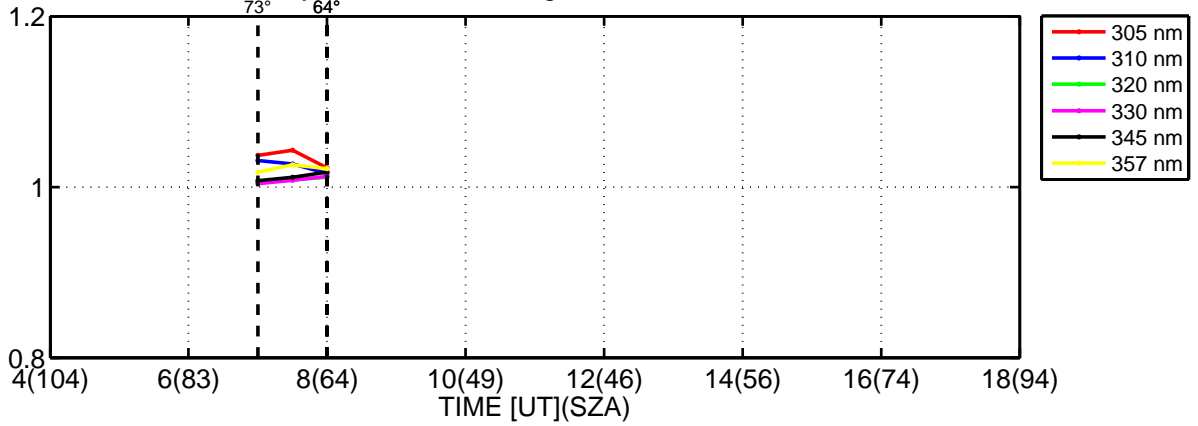
Daily variation. Wavelength bands are ± 2.5 nm



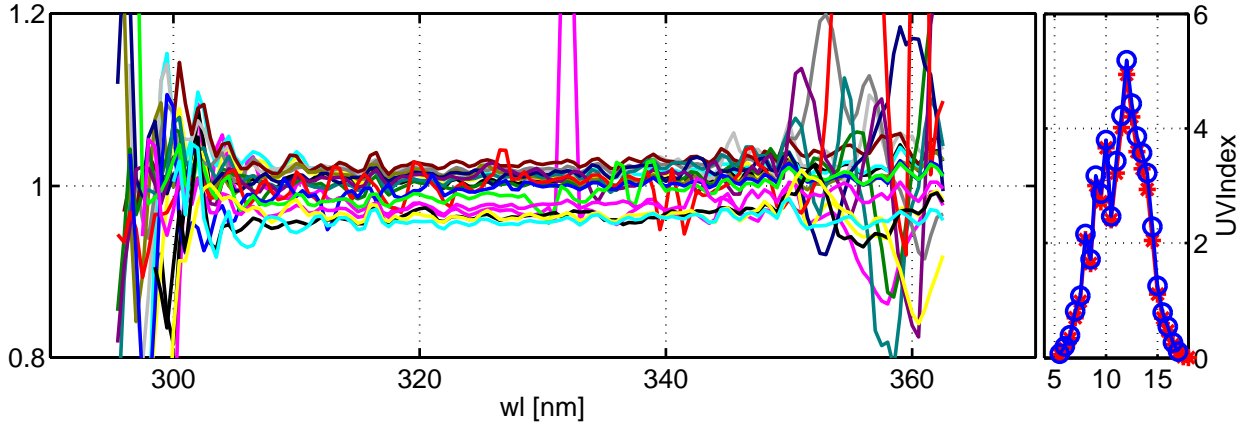
Global irradiance ratios 156/QASUME at Arosa LKO:24-Mar-2006(083)



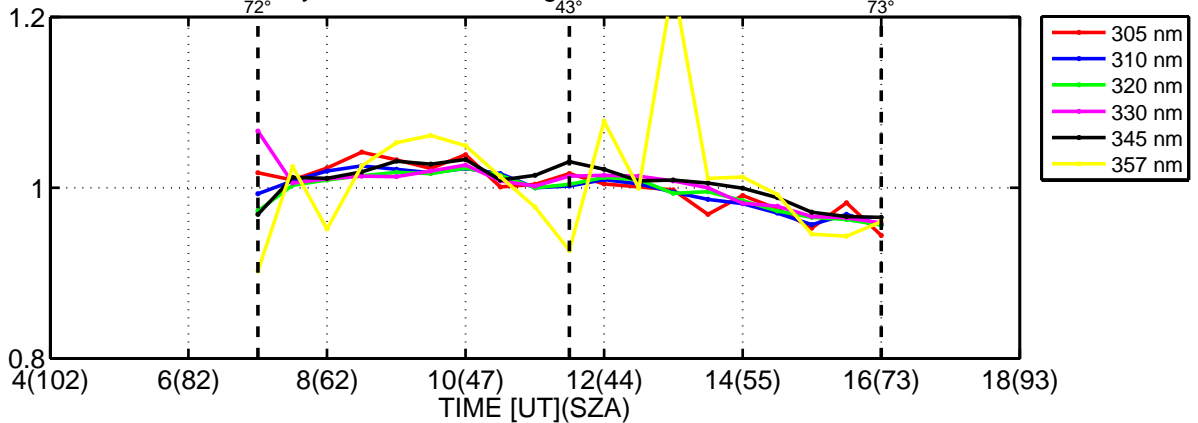
Daily variation. Wavelength bands are ± 2.5 nm



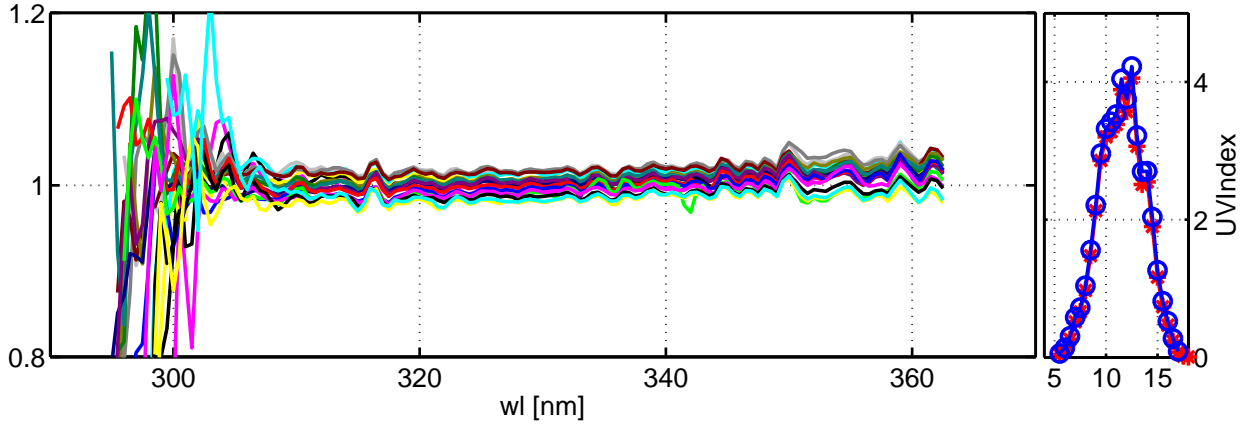
Global irradiance ratios 156/QASUME at Arosa LKO:29-Mar-2006(088)



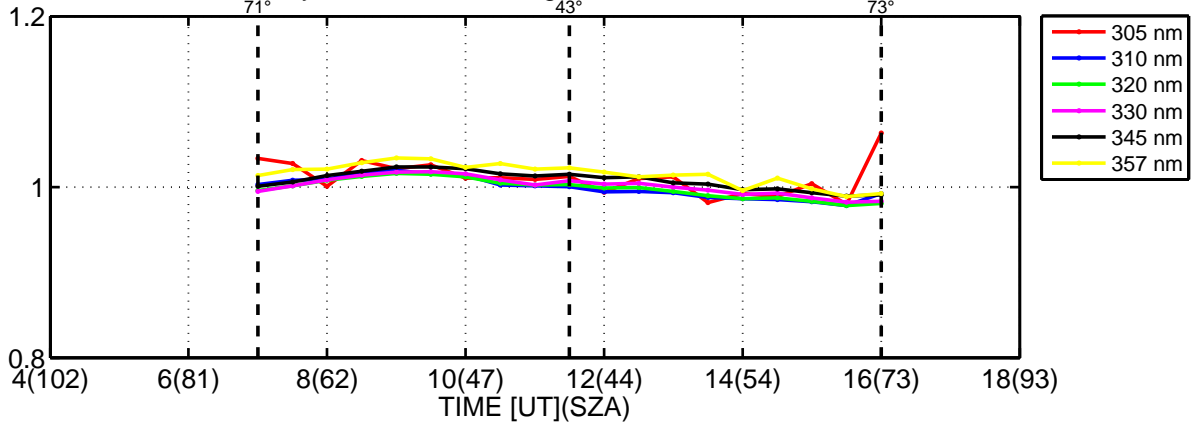
Daily variation. Wavelength bands are ± 2.5 nm



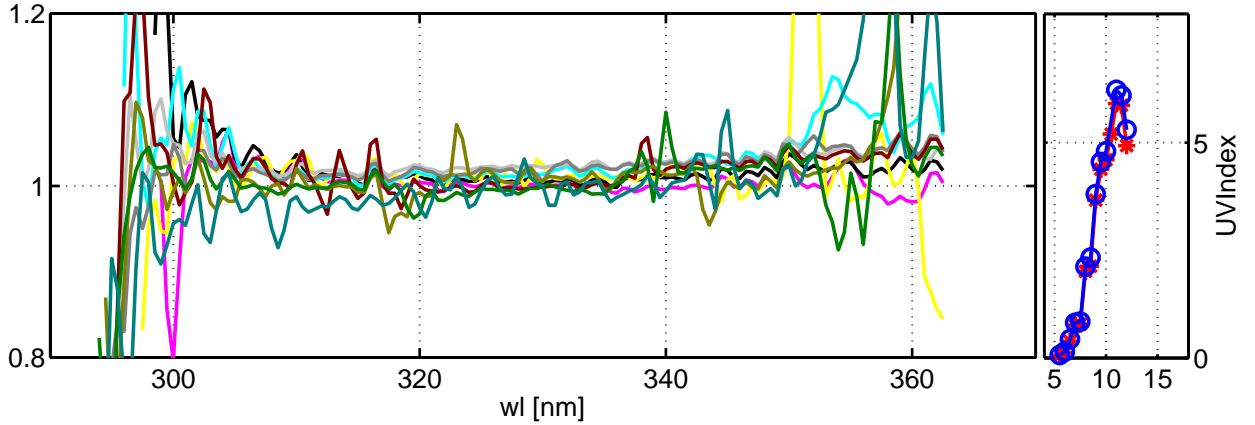
Global irradiance ratios 156/QASUME at Arosa LKO:30-Mar-2006(089)



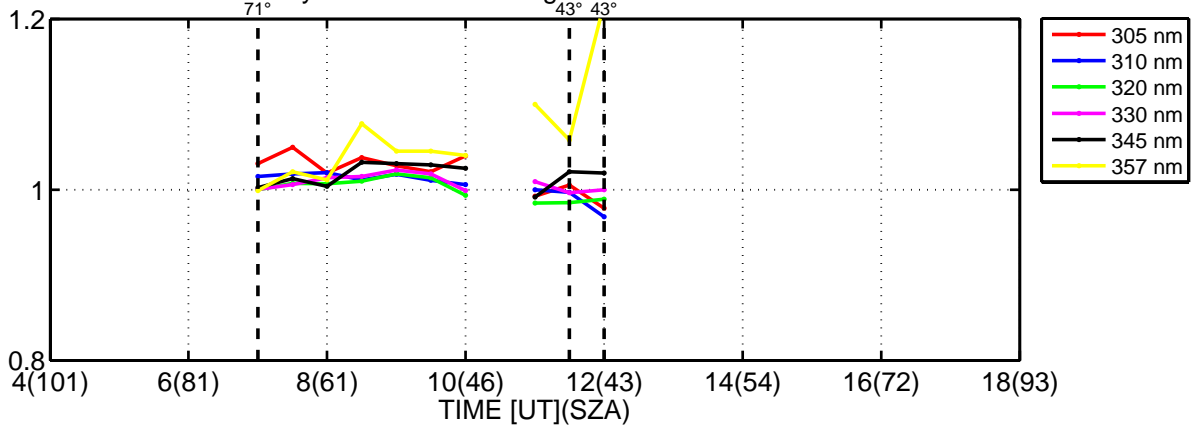
Daily variation. Wavelength bands are ± 2.5 nm

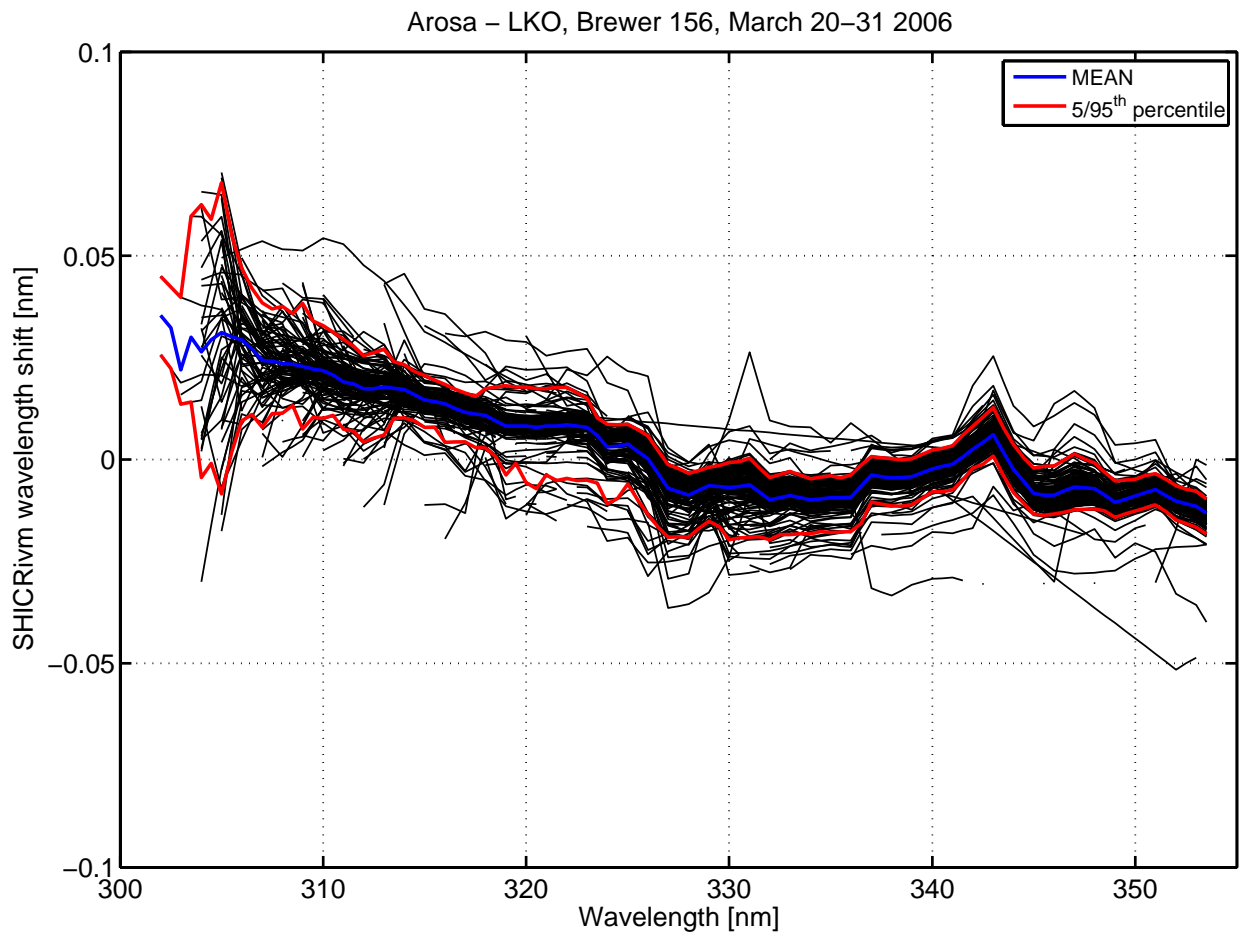
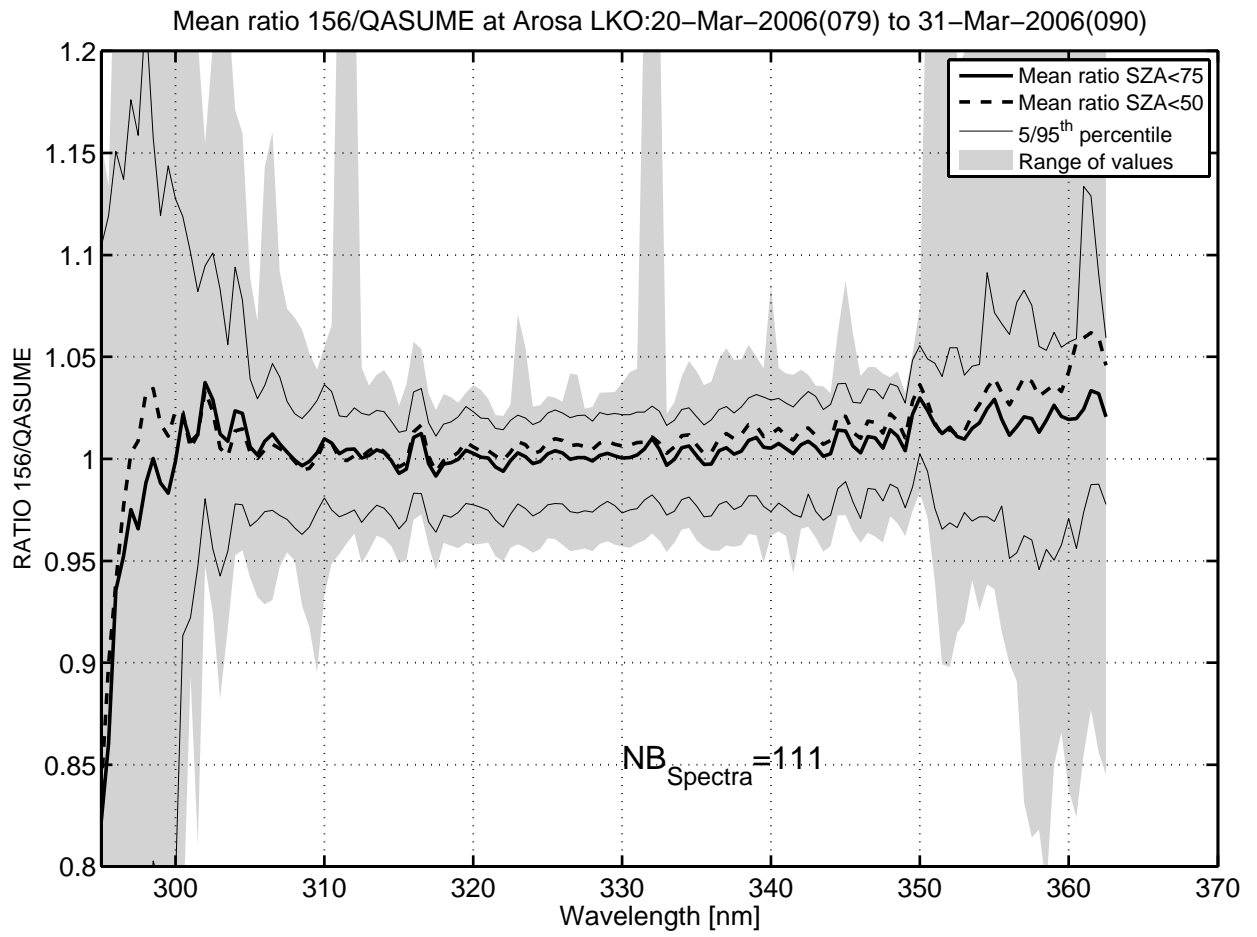


Global irradiance ratios 156/QASUME at Arosa LKO:31-Mar-2006(090)

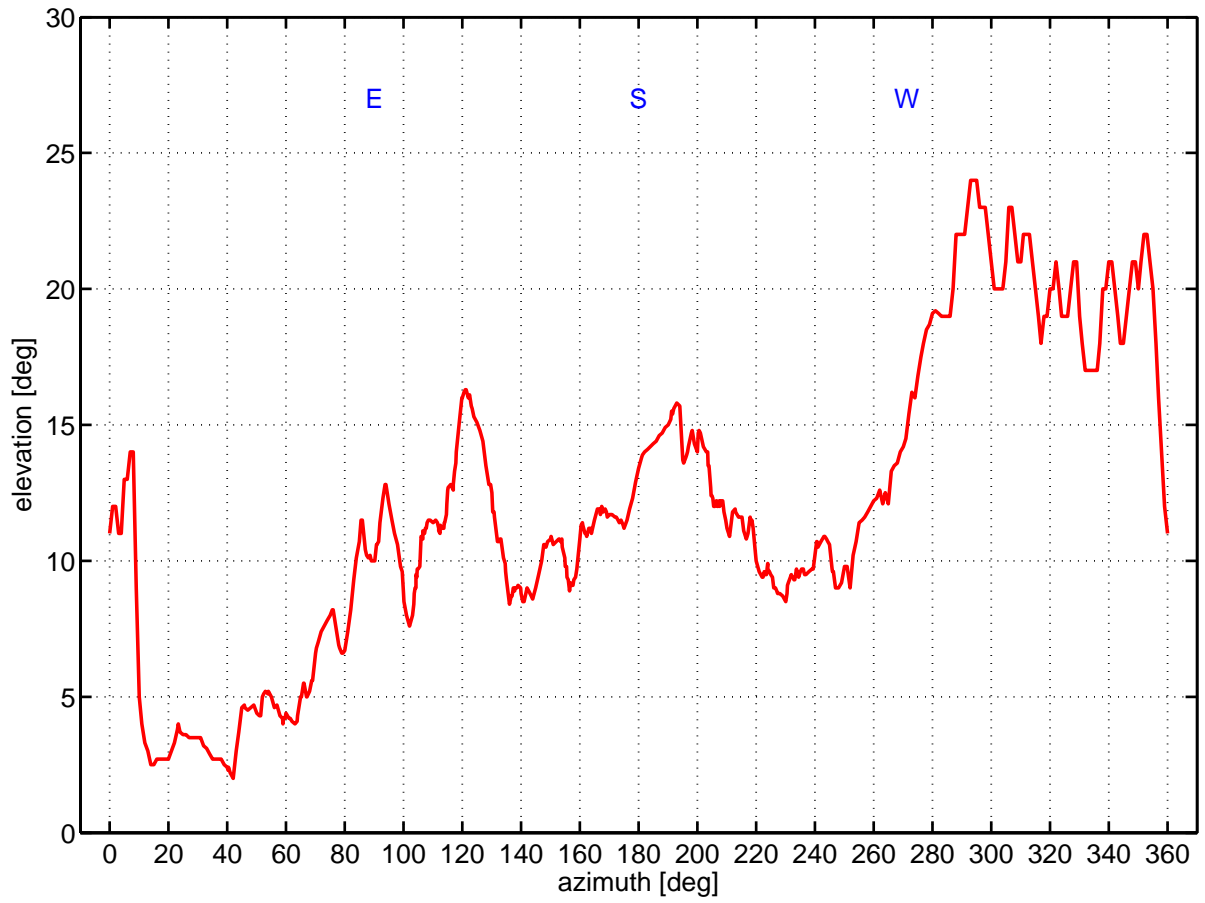


Daily variation. Wavelength bands are ± 2.5 nm





Horizon of Arosa LKO





Brewer 040

Brewer 072

Brewer 156

QASUME