

## Protocol of the intercomparison at AEMET, Madrid, Spain on August 31 to September 4, 2013 with the travelling reference spectroradiometer QASUME from PMOD/WRC

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The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer AEM and Brewer spectrophotometer operated by AEMET Madrid and the travel reference spectroradiometer QASUME. The measurement site is located at Madrid; Latitude 40.45 N, Longitude 3.72 W and altitude 680 m.a.s.l.

The horizon of the measurement site is free down to at least 85° solar zenith angle (SZA). Measurements between 6:00 UT and 18:30 UT have been analysed.

QASUME was installed on the measurement platform of AEMET-Madrid in the afternoon of August 31, 2013. The spectroradiometer was installed next to the AEM spectroradiometer and Brewer spectrophotometer with the entrance optic of QASUME within 2 m to the other instrument. The spectroradiometer in use at AEMET is a Bentham DTM300 double monochromator system. The input optics is from CMS Schreder. The Brewer Spectrometer is a double monochromator MkIII with the ID 186. No comparison was carried out to the second Brewer #070. The intercomparison between QASUME and the AEMET spectroradiometers lasted four days, from morning of September 1<sup>st</sup> to the afternoon of September 4.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T68522, T68523 and T61251) were used to obtain an absolute spectral irradiance 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 diurnal drift of the responsivity of around 2% was compensated with lamp calibrations. The internal temperature of QASUME was  $25.4 \pm 0.2$  °C and the diffuser head was heated to a temperature of  $33.3 \pm 2.0$  °C.

The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the SHICRivm analysis were between  $\pm 50$  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 0.25 nm, and 1.5 seconds between each wavelength increment.

DOY	Date	DAY	Weather	Comment (times are in UT)
243	31-Aug	Saturday	Clear sky with few Cirrus	Installed at 11:15 14:40 calibration T68522 and T68523
244	01-Sep	Sunday	Clear sky with few Cirrus	9:13+14:13 calibration (T68522)
245	02-Sep	Monday	Clear sky with few Cirrus	9:14+15:16 calibration (T68522) 19:00: Setting up 1000W calibration on the roof of AEMet 19:20 Calibrations using F386 20:17 Calibration using T61251 20:47 Calibration using T68522 20:50 AeMet calibration with F386
246	03-Sep	Tuesday	Clear sky	8:44+15:43 calibration (T68522)
247	04-Sep	Wednesday	Clear sky with few Cirrus	7:44+1Xxx calibration (T68522)
				End of Campaign: 15:00

**Results:**

In total 86 synchronised simultaneous spectra from QASUME and AEM are available from the measurement period. Measurements between 6:00 and 18:30 UT have been analysed (SZA smaller than 90°).

**Remarks:****I. AEM:**

1. In July 2013 a new input optic (J1002-52, CMS Schreder) was mounted to the AEM spectroradiometer.
2. Standard Lamp calibrations:
  - a. The AEM spectroradiometer was calibrated by the AEM 250 W transfer standard KS055, KS071 and KS072 using the CMS calibrator KS-J1011 (Seri. No. 1148) several times during the intercomparison.
  - b. Monday night, 2<sup>nd</sup> September, the AEM system was calibrated using a 1000 W FEL lamp F386 (Gigahertz). This calibration was performed outdoor on the roof of AEMET. This measurement was verified using QASUME reference spectroradiometer.
  - c. The difference of the FEL and the KS-Lamp calibrations are around 3% - still within the uncertainty stated in the CMS certificates.
  - d. The final dataset of AEMET is based on the F386 FEL calibration.
3. The ratios between AEM and QASUME have on average an offset of -1 %.
4. The diurnal variation of the AEM to QASUME ratio is less than 2 %. The ratios AEM to QASUME show a dip in the morning and in the evening. The reason is unknown.
5. For all solar scans the wavelength shifts of the AEM show a shift of +100 pm.

**I. Brewer #186:**

1. Brewer #186 was calibrated relative to QASUME in July 2013 at El Arinosillo during the 8<sup>th</sup> RBCC-E. The Brewer was re-installed at AEMET Madrid in July.
2. The ratios between the AEM and QASUME is identical to the calibration carried out at the RBCC-E:
  - a. The average offset is -2 %
  - b. The diurnal variation of the #186 to QASUME ratio is around 4 %.
3. For all solar scans the wavelength shifts of the Brewer #186 show a shift of less than 50pm.

**Recommendation:**

The irradiance scale based on the F386 FEL transfer standard should be transferred to the CMS KS transfer standards and to the two uncalibrated

FEL lamps (F407 and F409) of AEMET. The measurement schedule could look like the following:

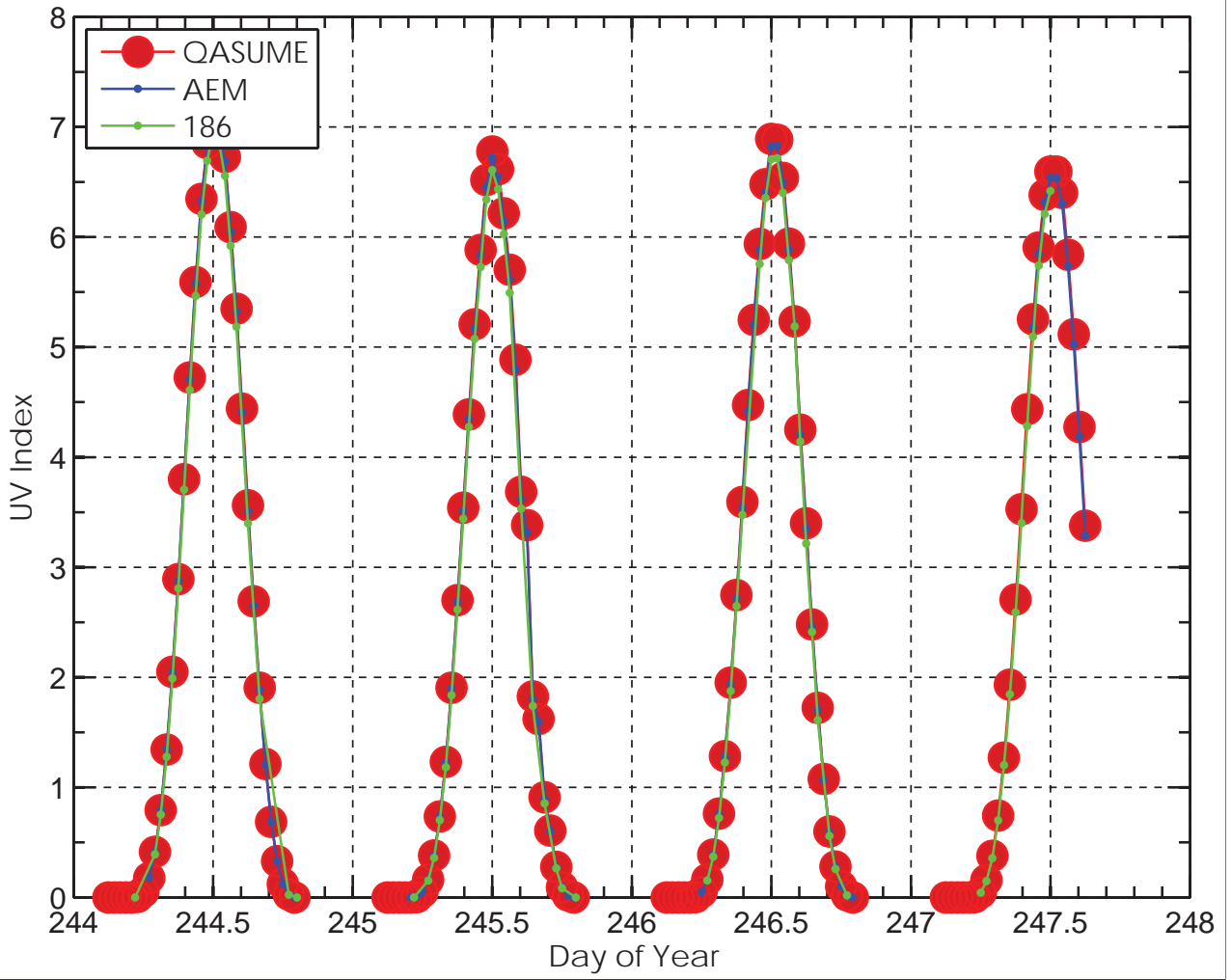
F407 – F386 – F409 – F407 – KS055 – KS071 – KS072 – F407

Between the KS lamp measurements the increase of the temperature of the input optic should be minimized. This can be achieved by removing the head during the lamp warm up time: 5-10 min warm up, mounting of the head, 2 min settling time followed by the actual measurement.

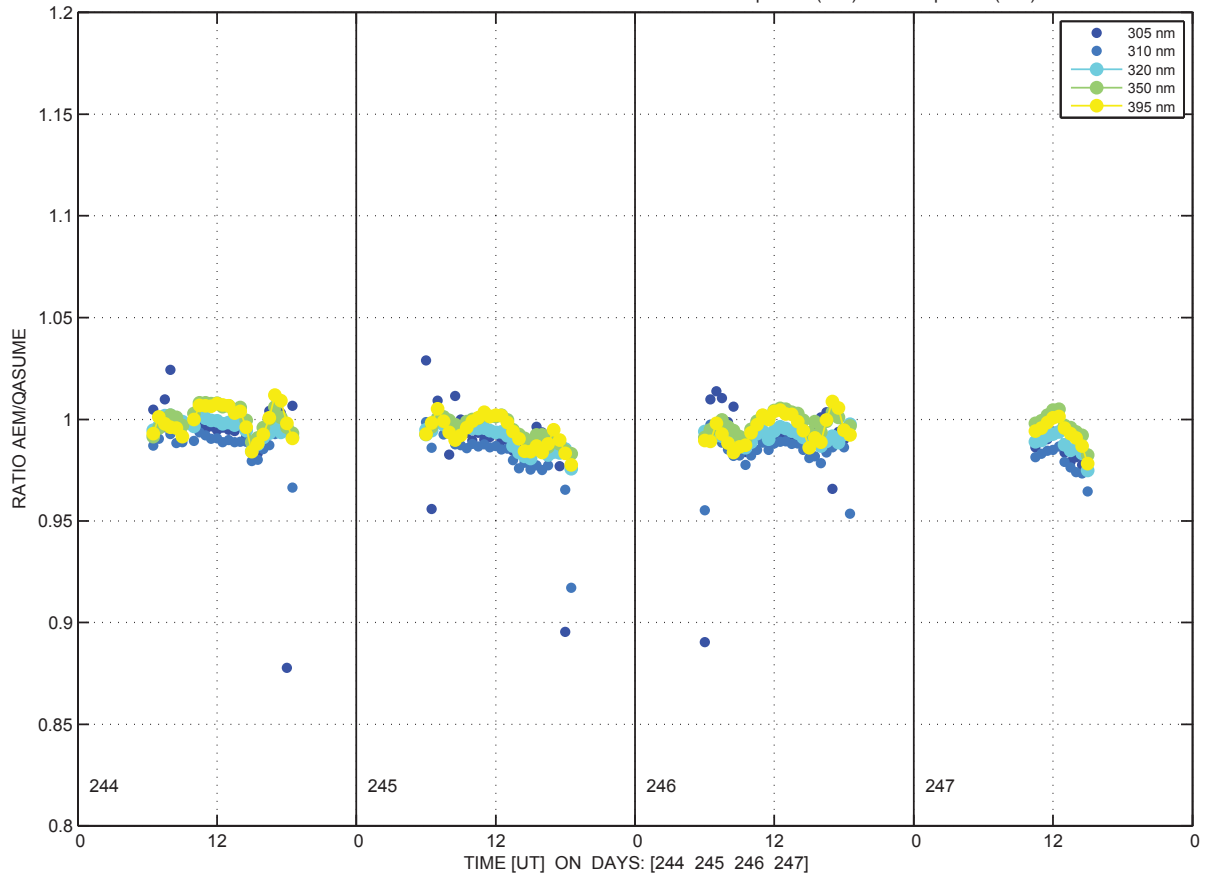
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Maria Postigo

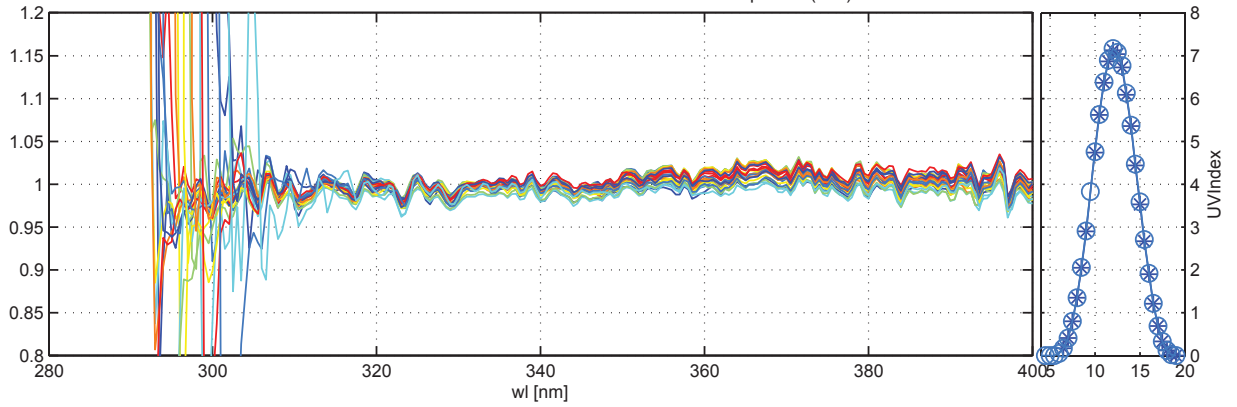
UV Index Madrid, September 2013



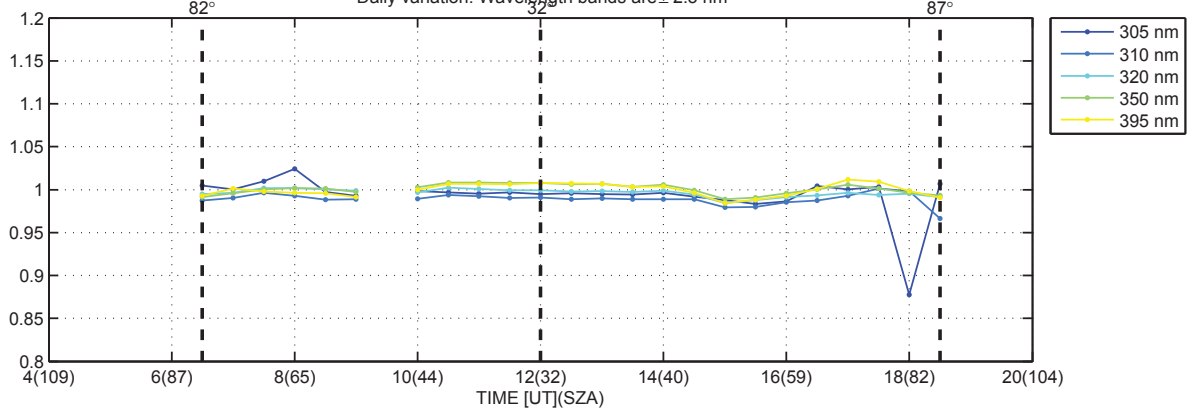
Global irradiance ratios AEM/QASUME at Madrid-shicrivm:01-Sep-2013(244) to 04-Sep-2013(247)



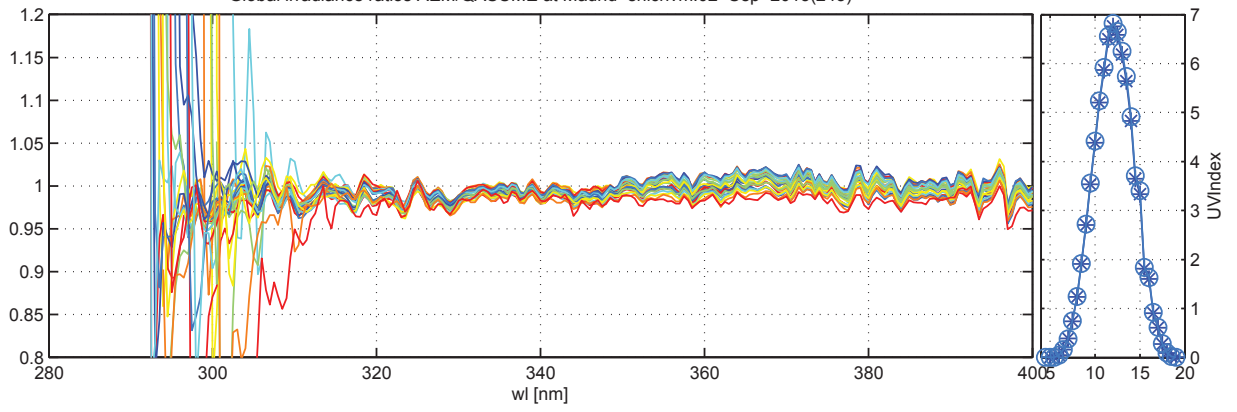
Global irradiance ratios AEM/QASUME at Madrid-shicrivm:01-Sep-2013(244)



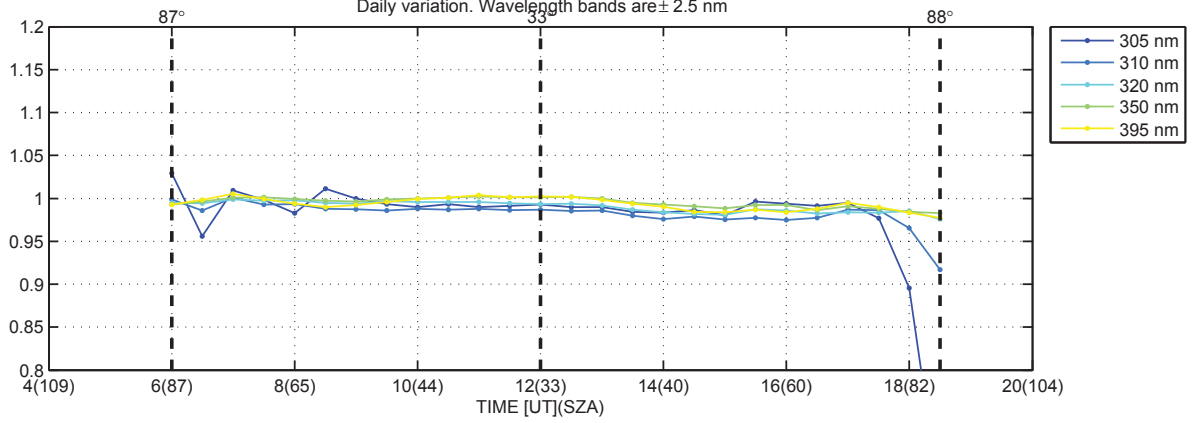
Daily variation. Wavelength bands are  $\pm 2.5$  nm



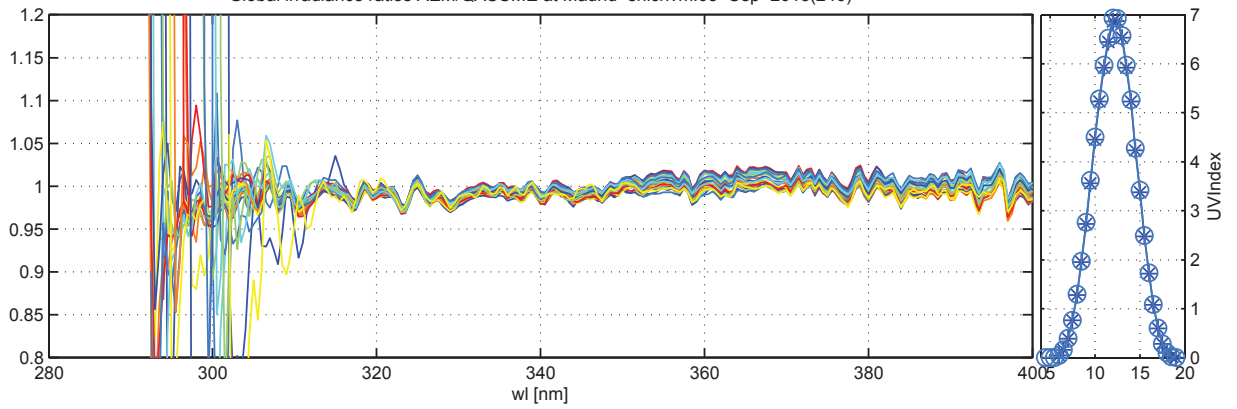
Global irradiance ratios AEM/QASUME at Madrid-shicrivm:02-Sep-2013(245)



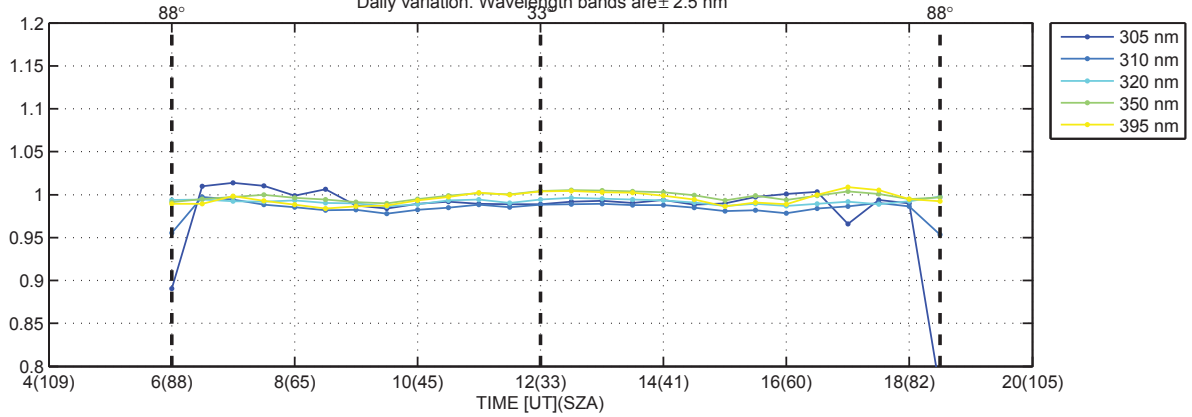
Daily variation. Wavelength bands are  $\pm 2.5$  nm



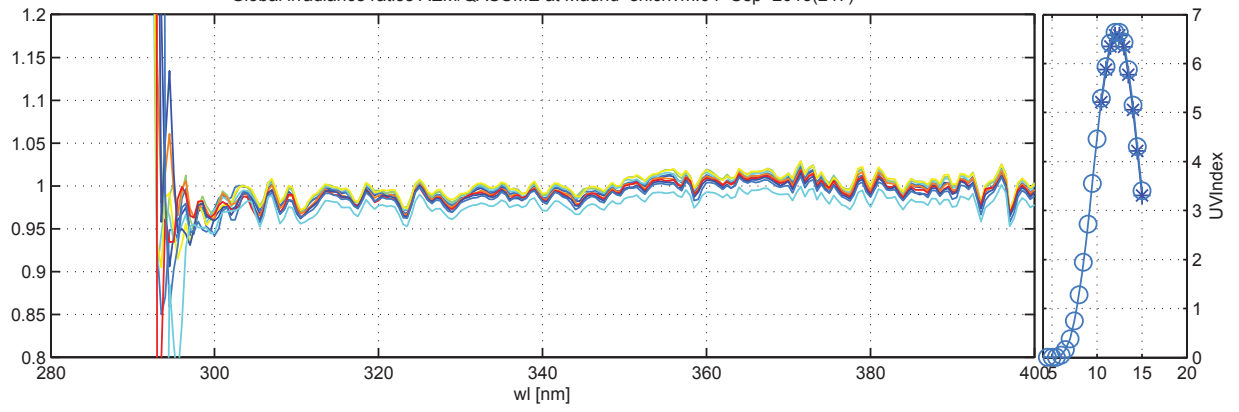
Global irradiance ratios AEM/QASUME at Madrid-shicrivm:03-Sep-2013(246)



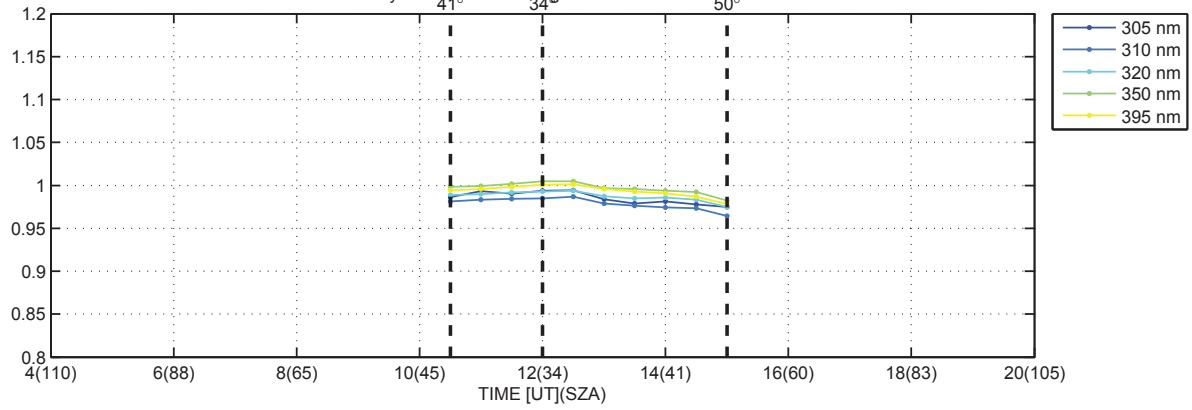
Daily variation. Wavelength bands are  $\pm 2.5$  nm



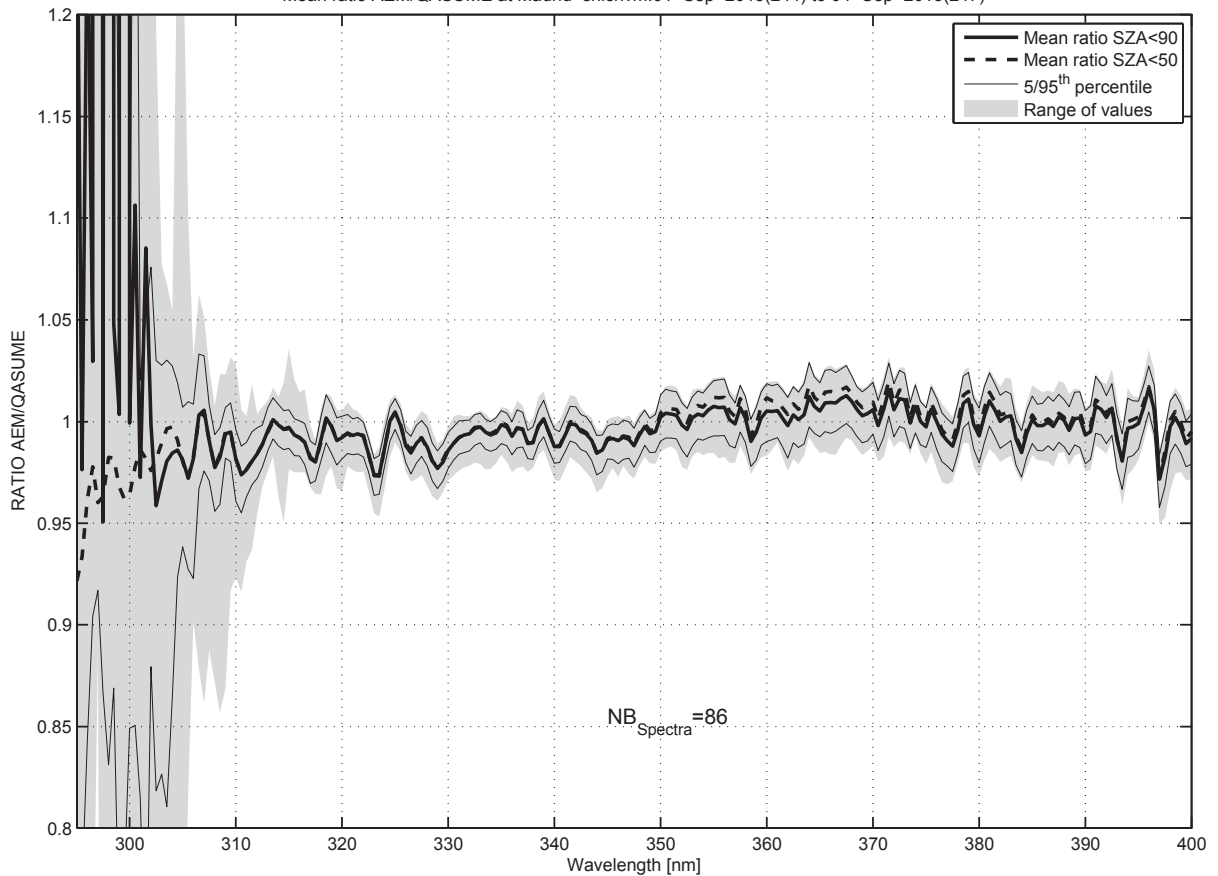
Global irradiance ratios AEM/QASUME at Madrid-shicrivm:04-Sep-2013(247)



Daily variation. Wavelength bands are  $\pm 2.5$  nm.

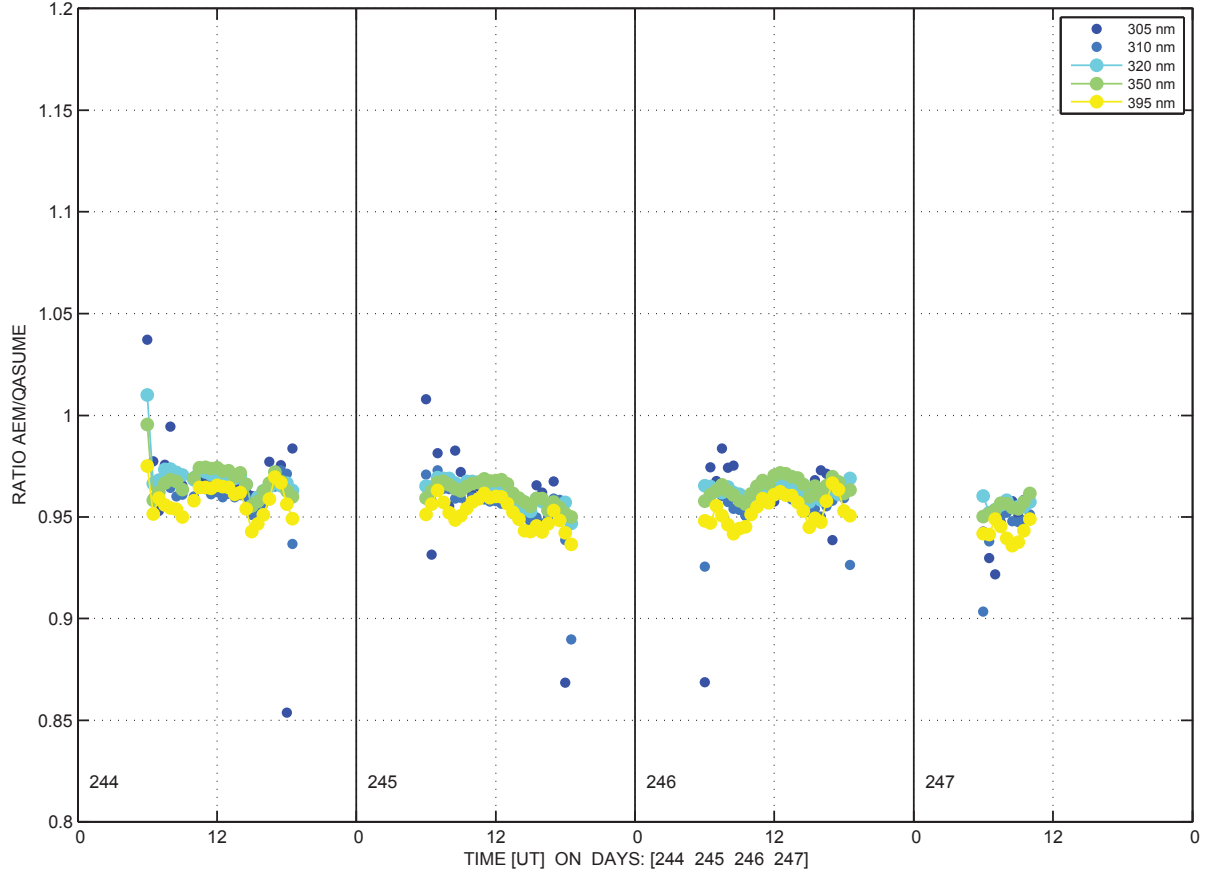


Mean ratio AEM/QASUME at Madrid-shicrivm:01-Sep-2013(244) to 04-Sep-2013(247)

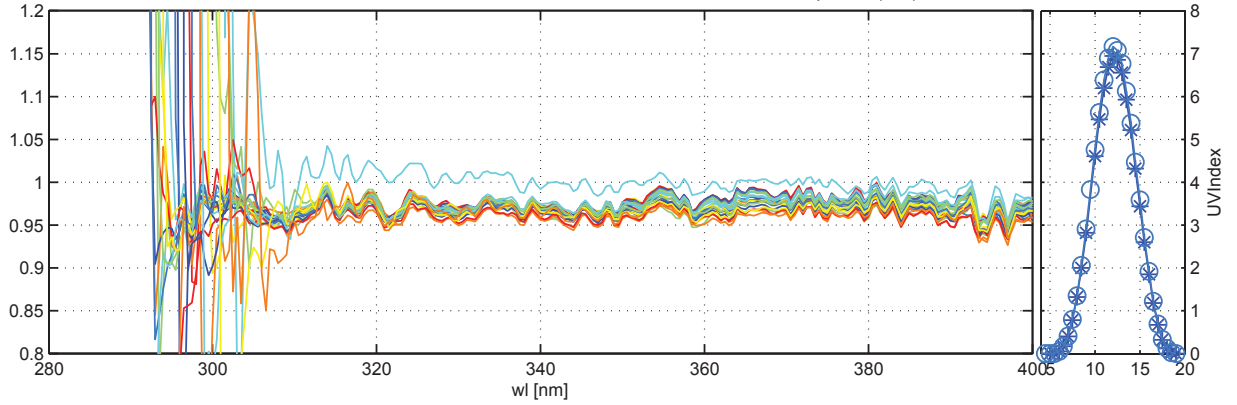




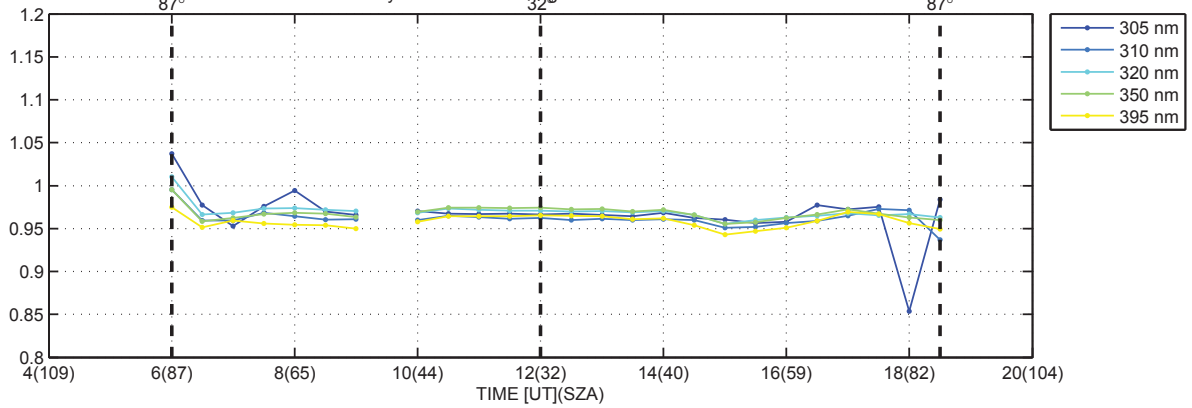
Global irradiance ratios AEM/QASUME at Madrid - KS072 based -shicrivm:01-Sep-2013(244) to 04-Sep-2013(247)

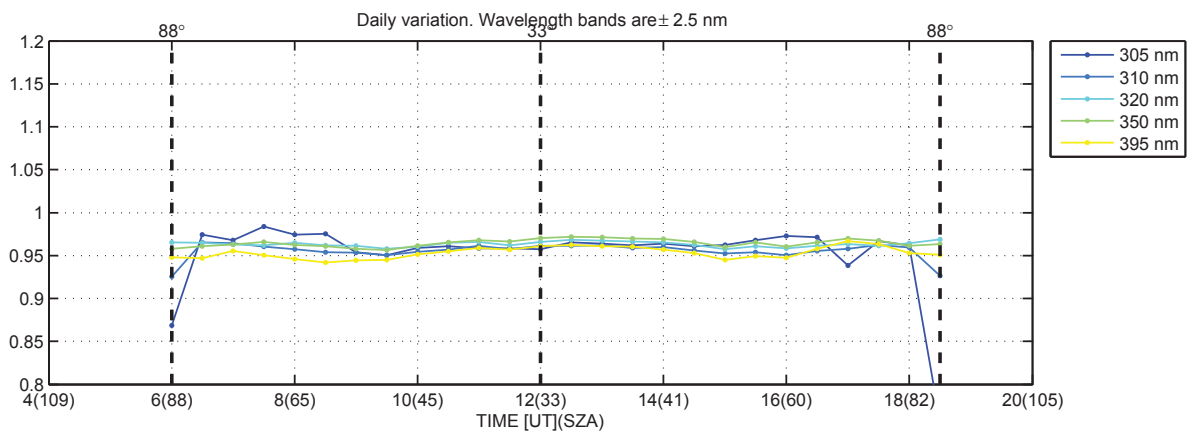
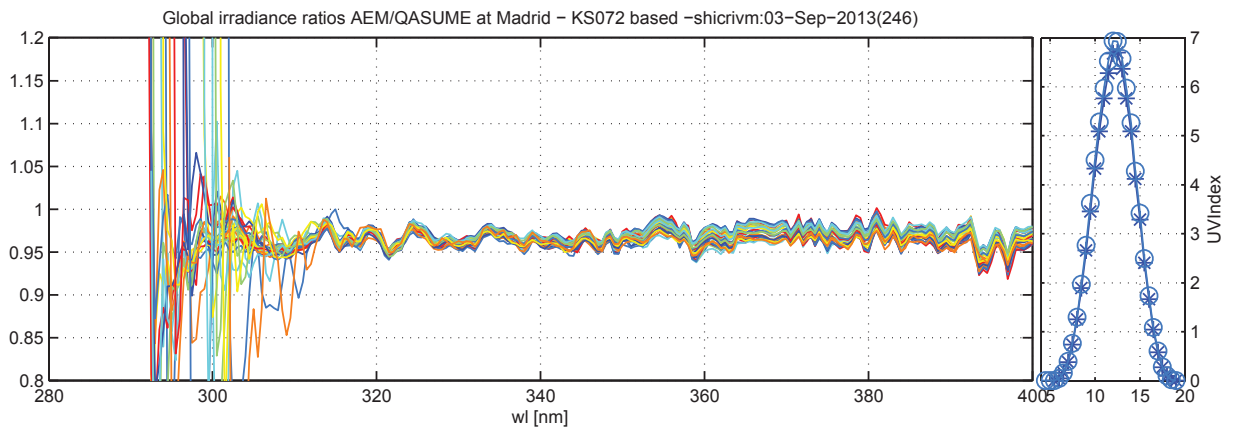
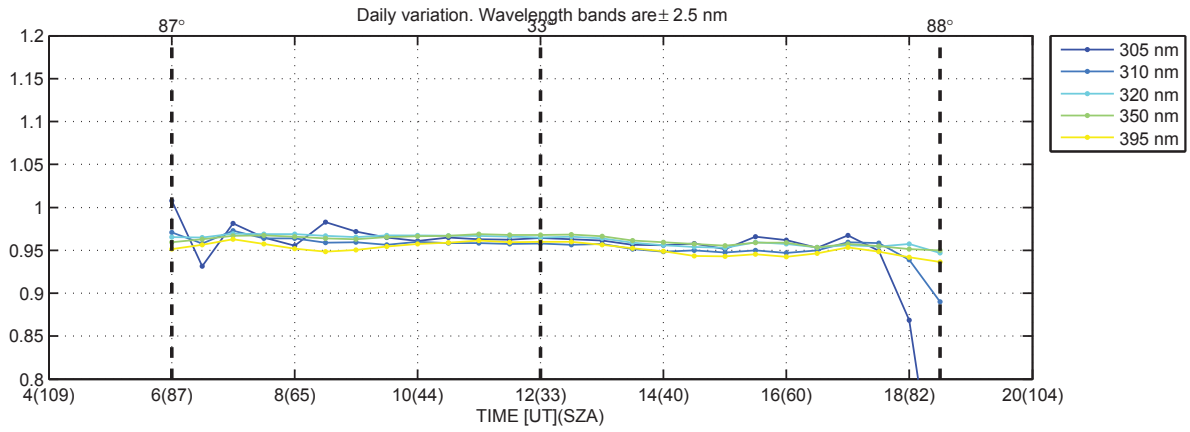
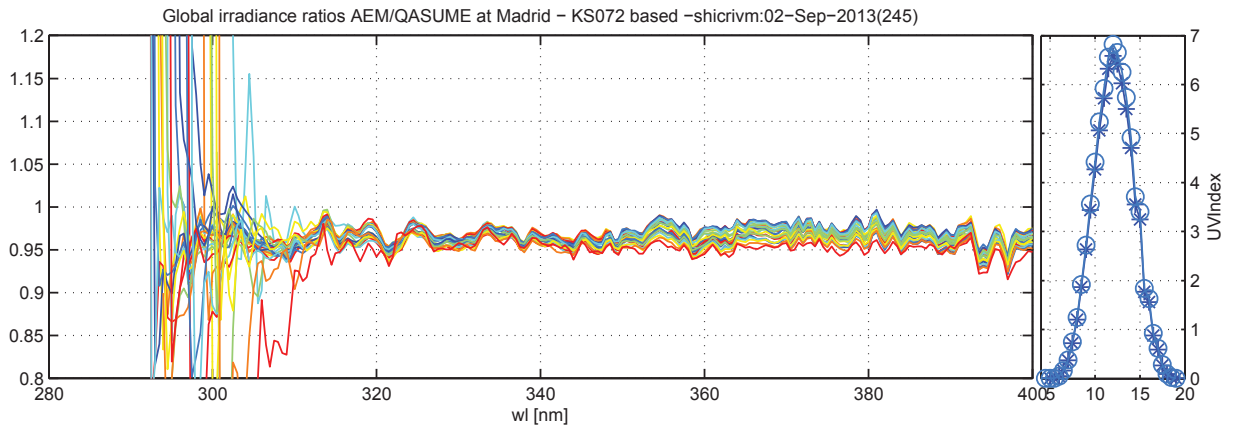


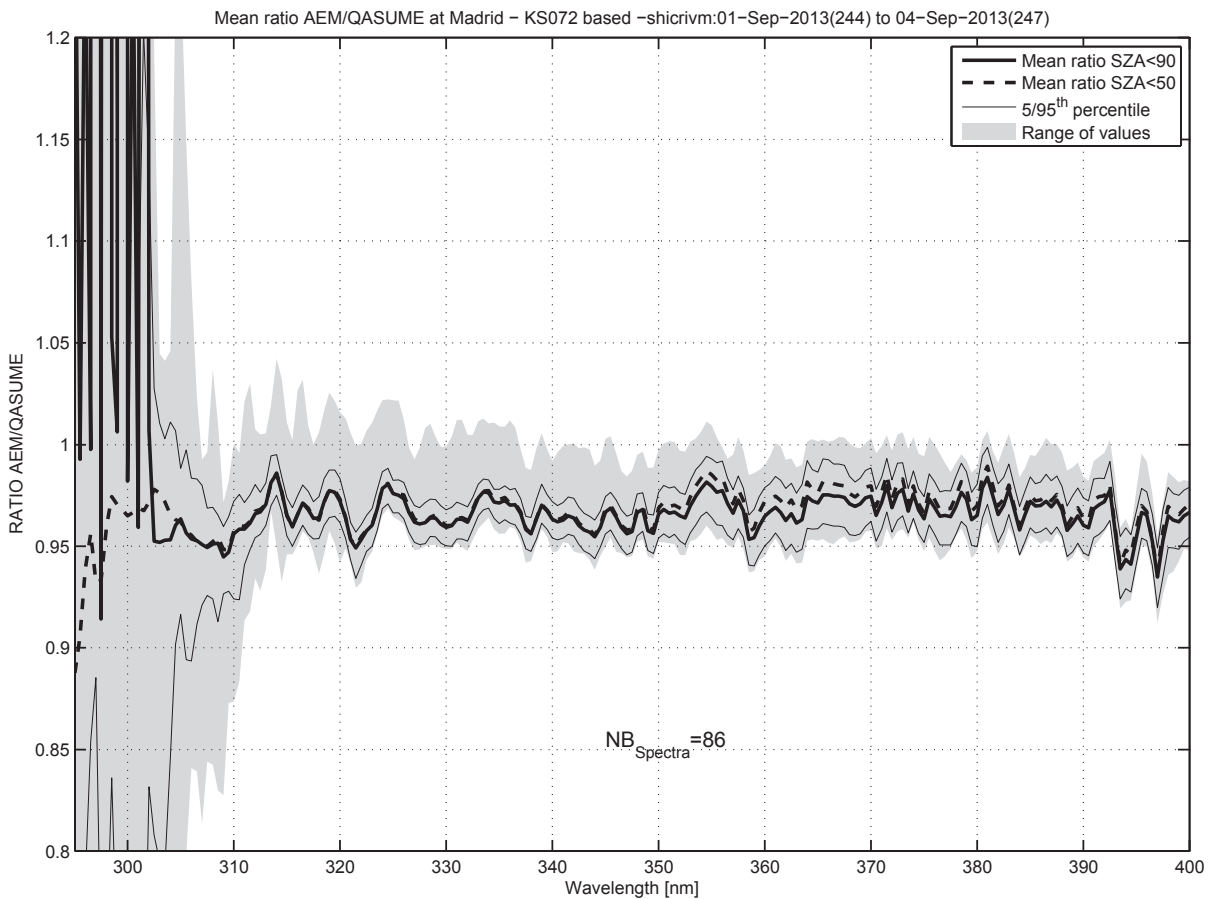
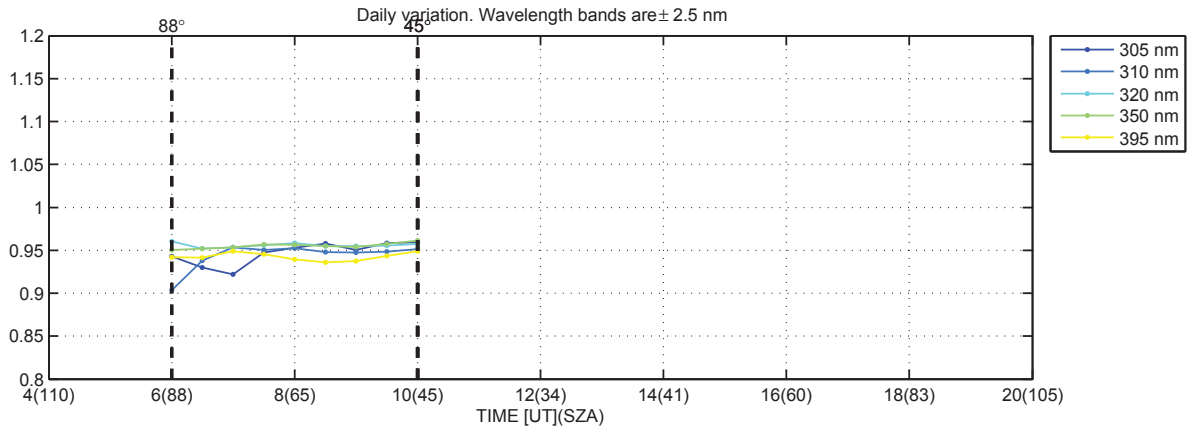
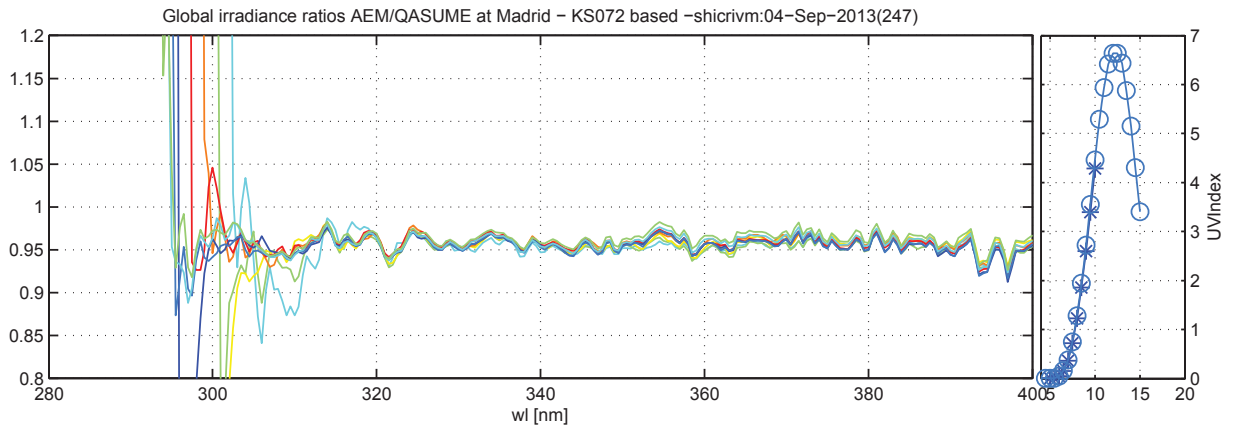
Global irradiance ratios AEM/QASUME at Madrid - KS072 based -shicrivm:01-Sep-2013(244)



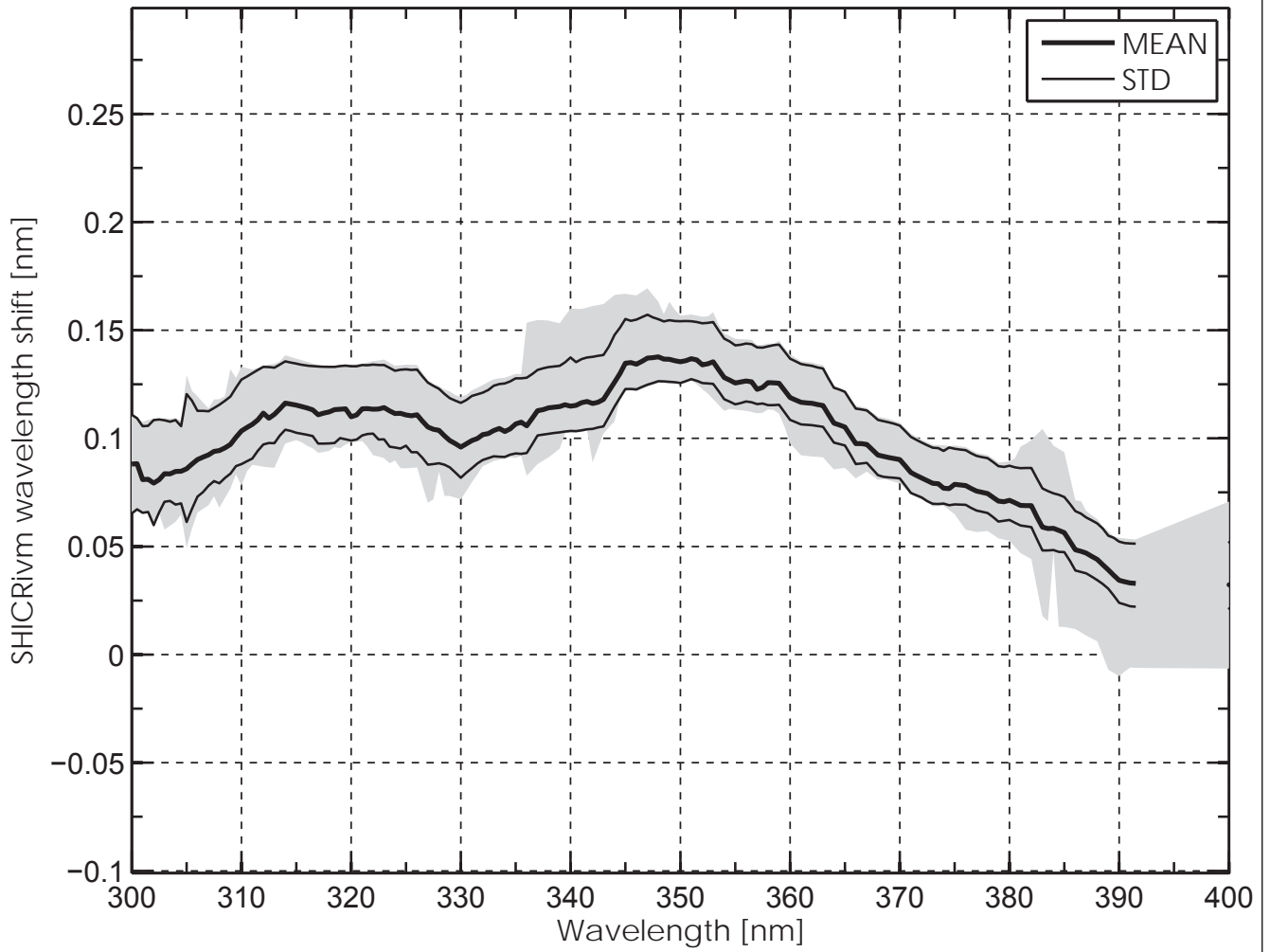
Daily variation. Wavelength bands are  $\pm 2.5$  nm



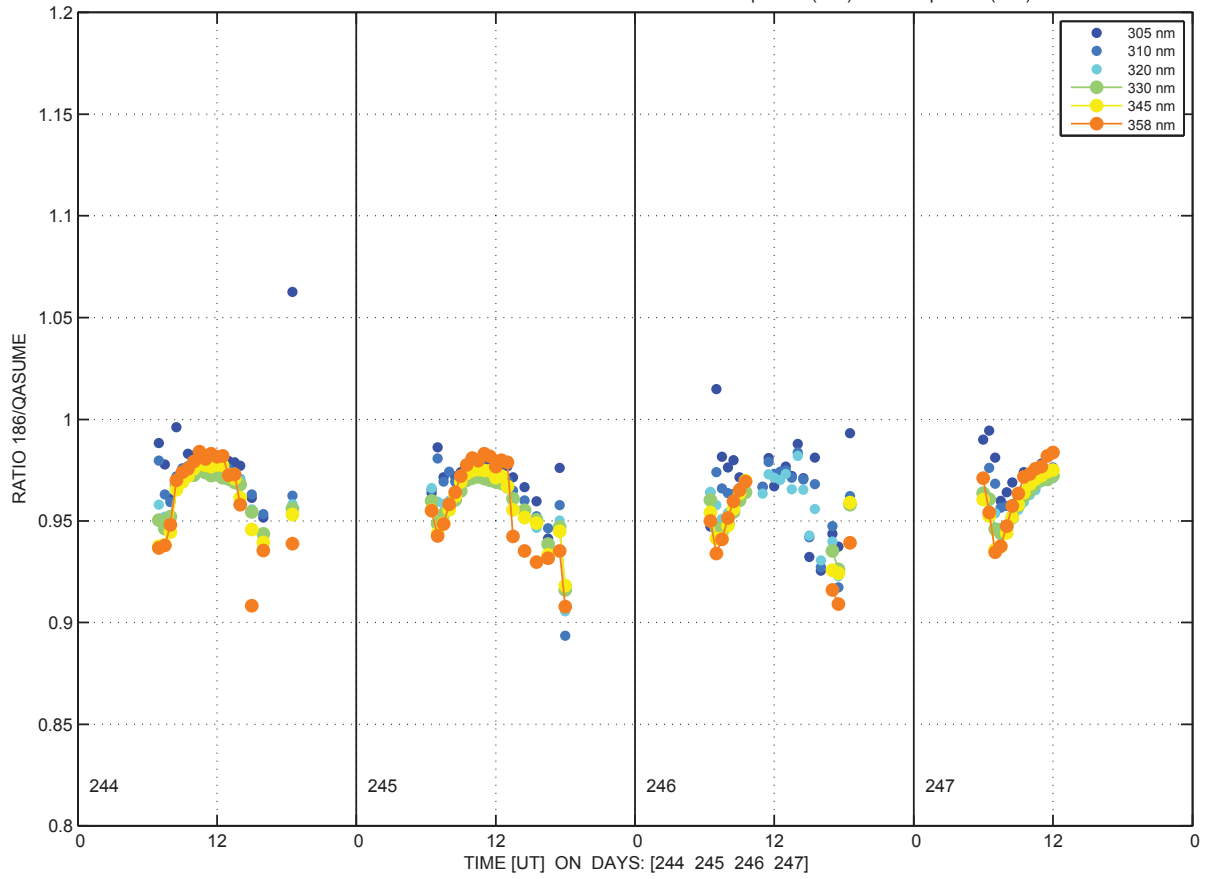




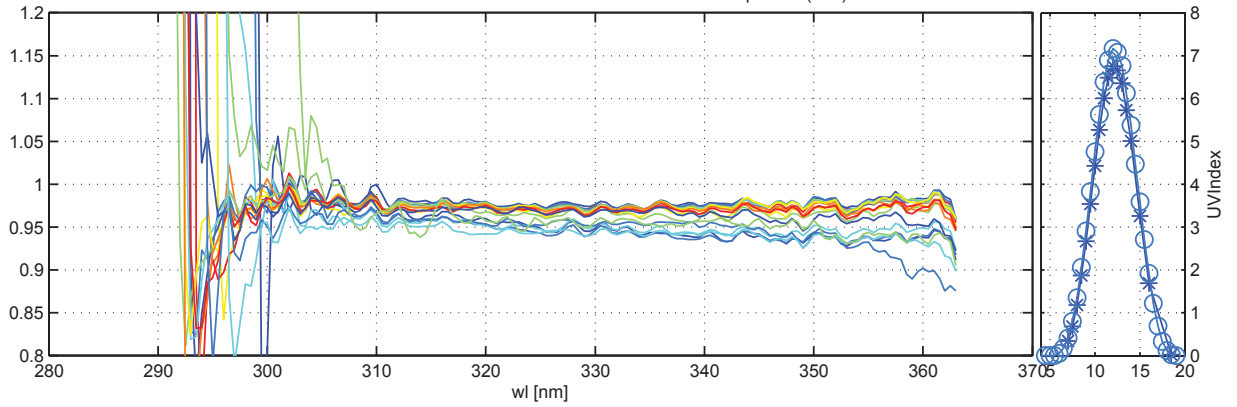
Madrid, AEM, September 2013



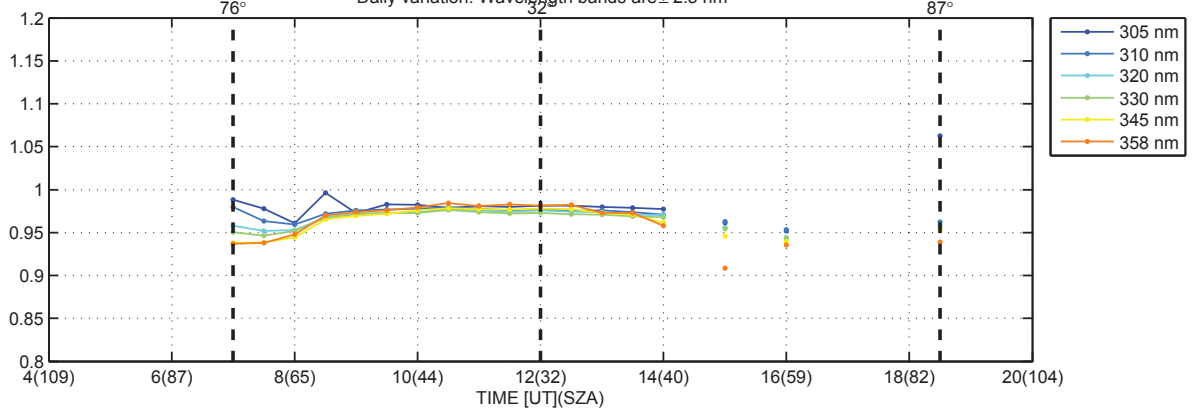
Global irradiance ratios 186/QASUME at Madrid-shicrivm:01-Sep-2013(244) to 04-Sep-2013(247)

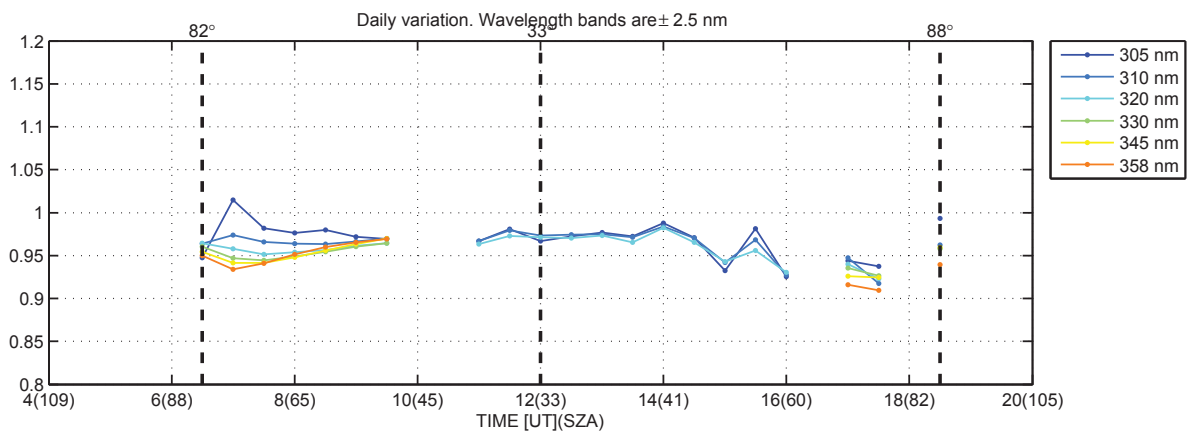
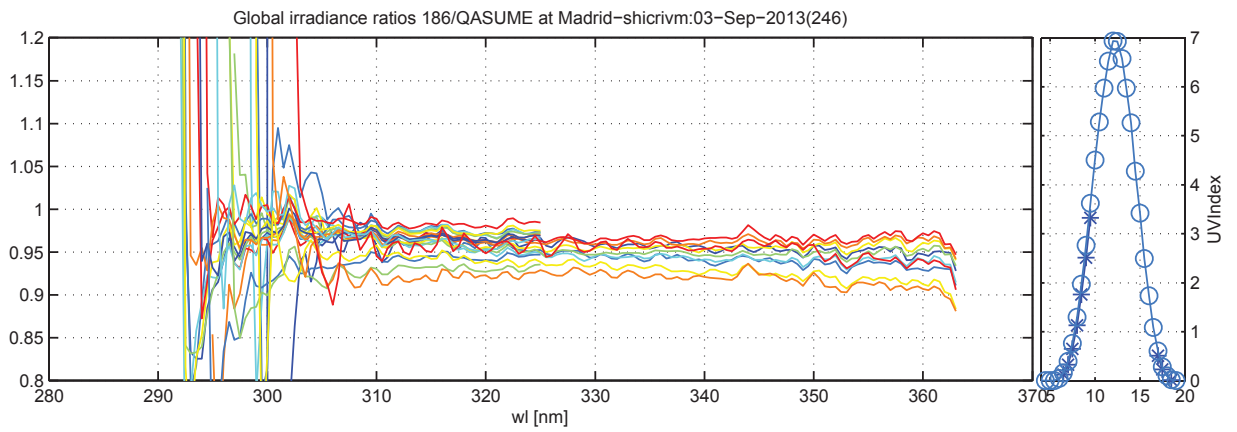
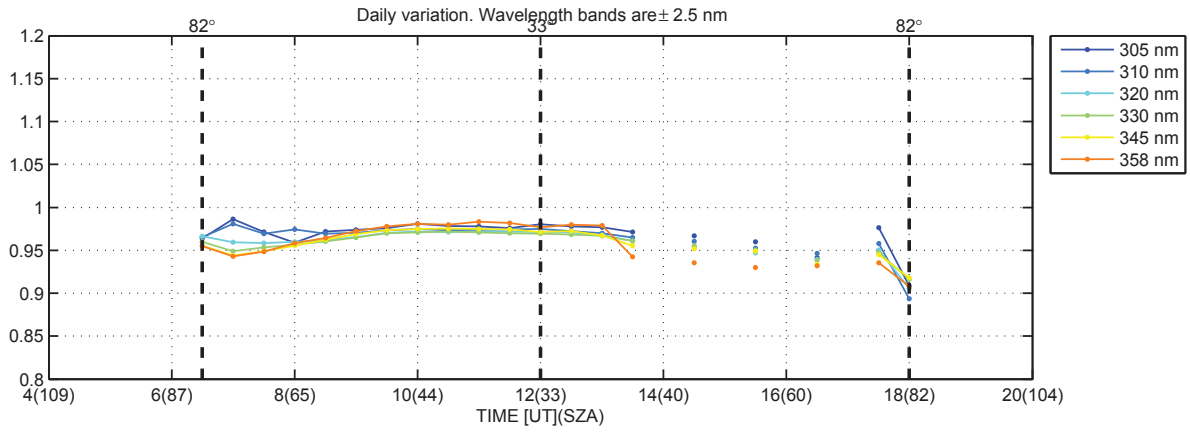
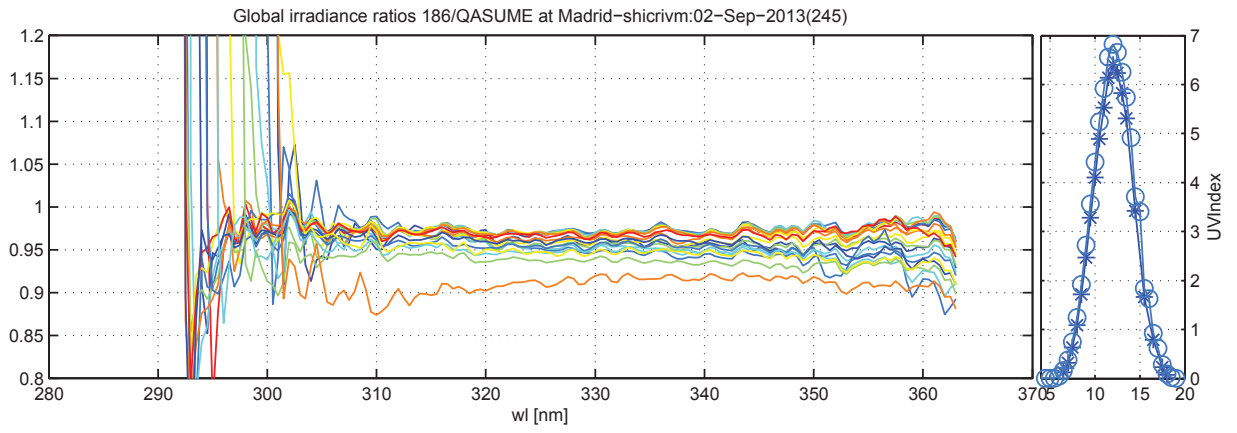


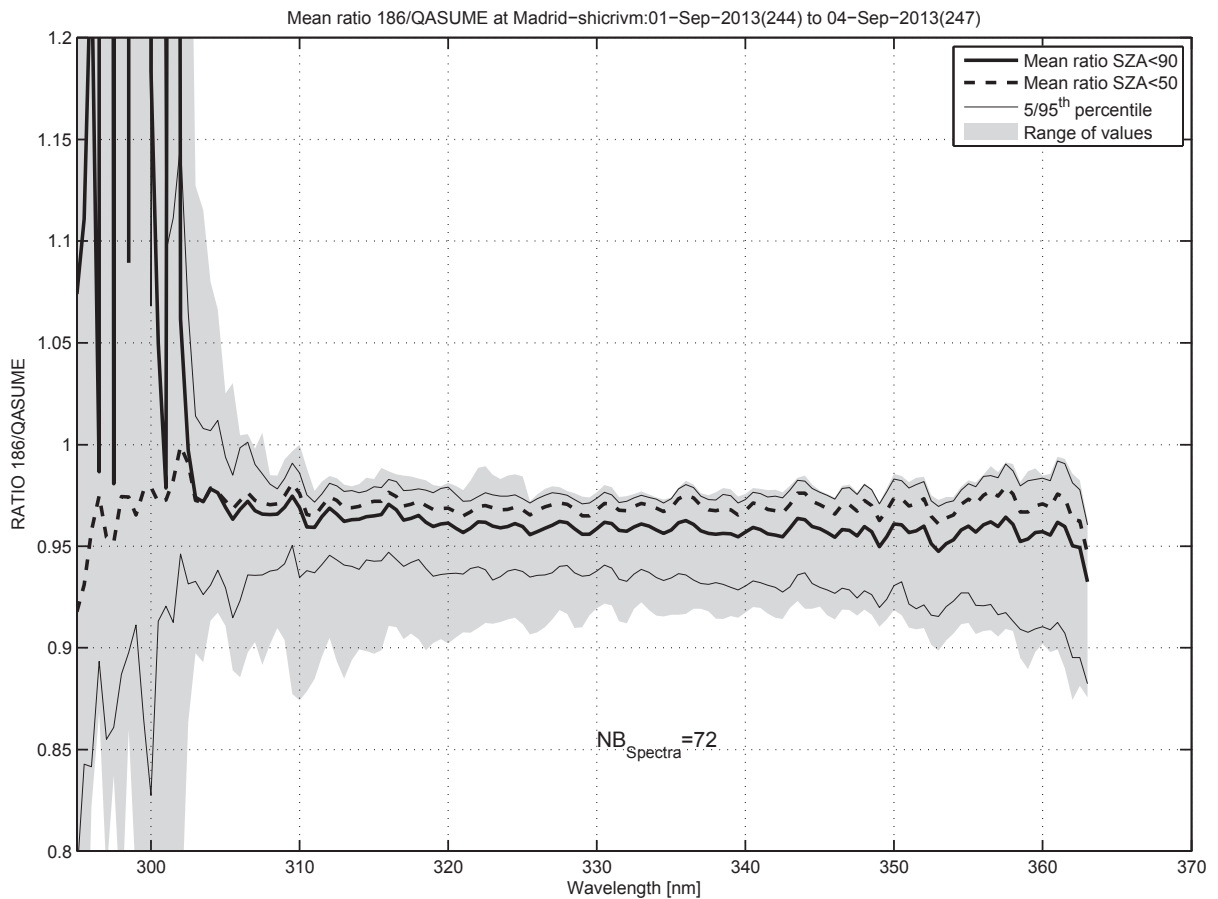
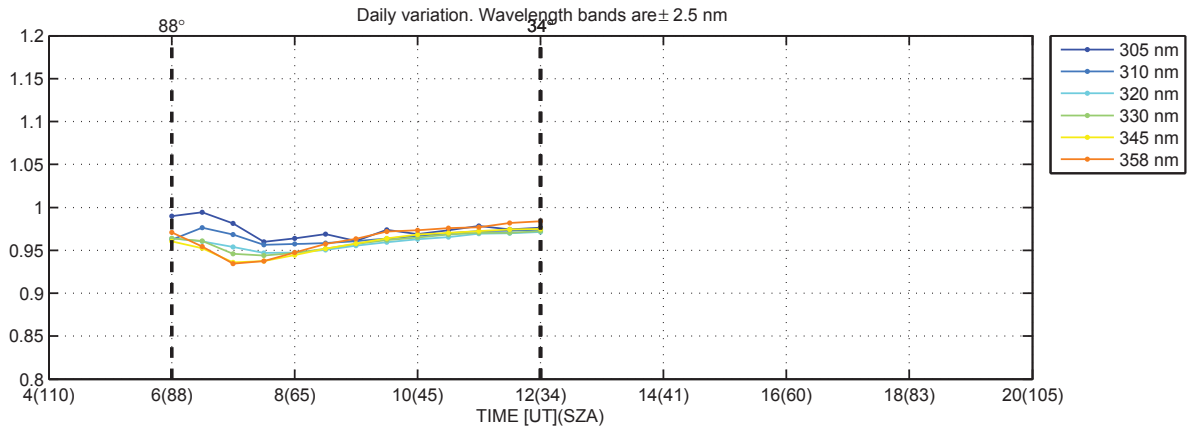
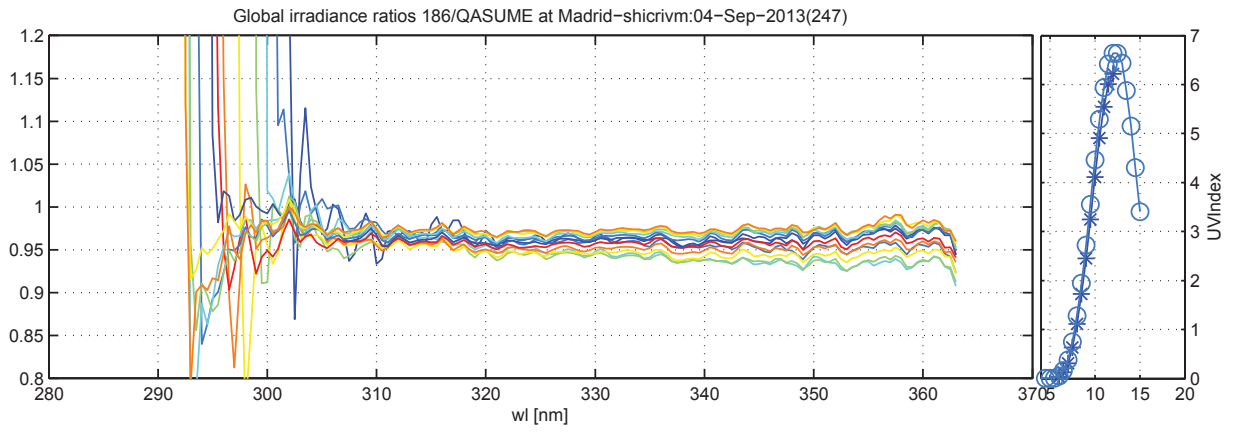
Global irradiance ratios 186/QASUME at Madrid-shicrivm:01-Sep-2013(244)



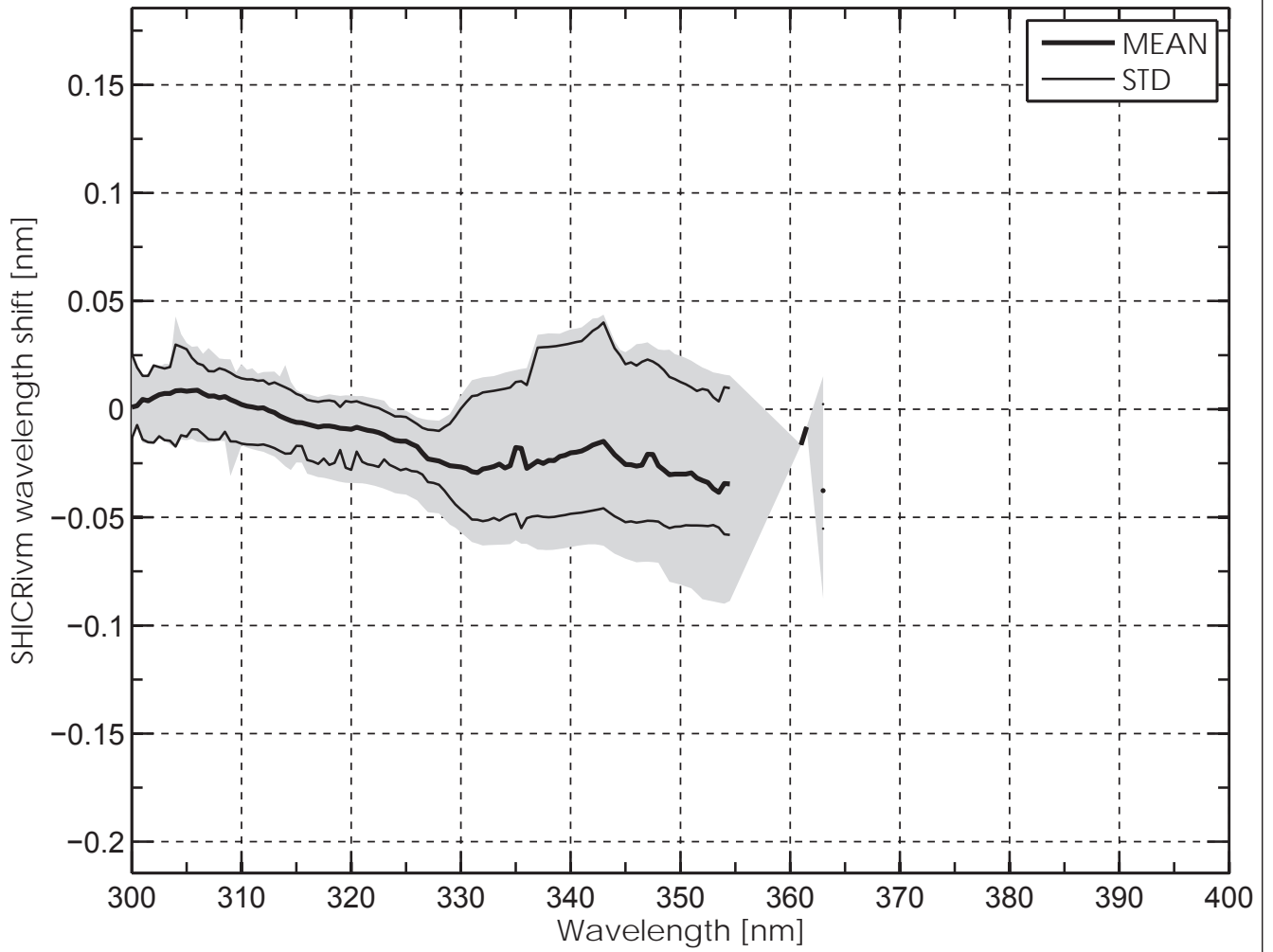
Daily variation. Wavelength bands are  $\pm 2.5$  nm





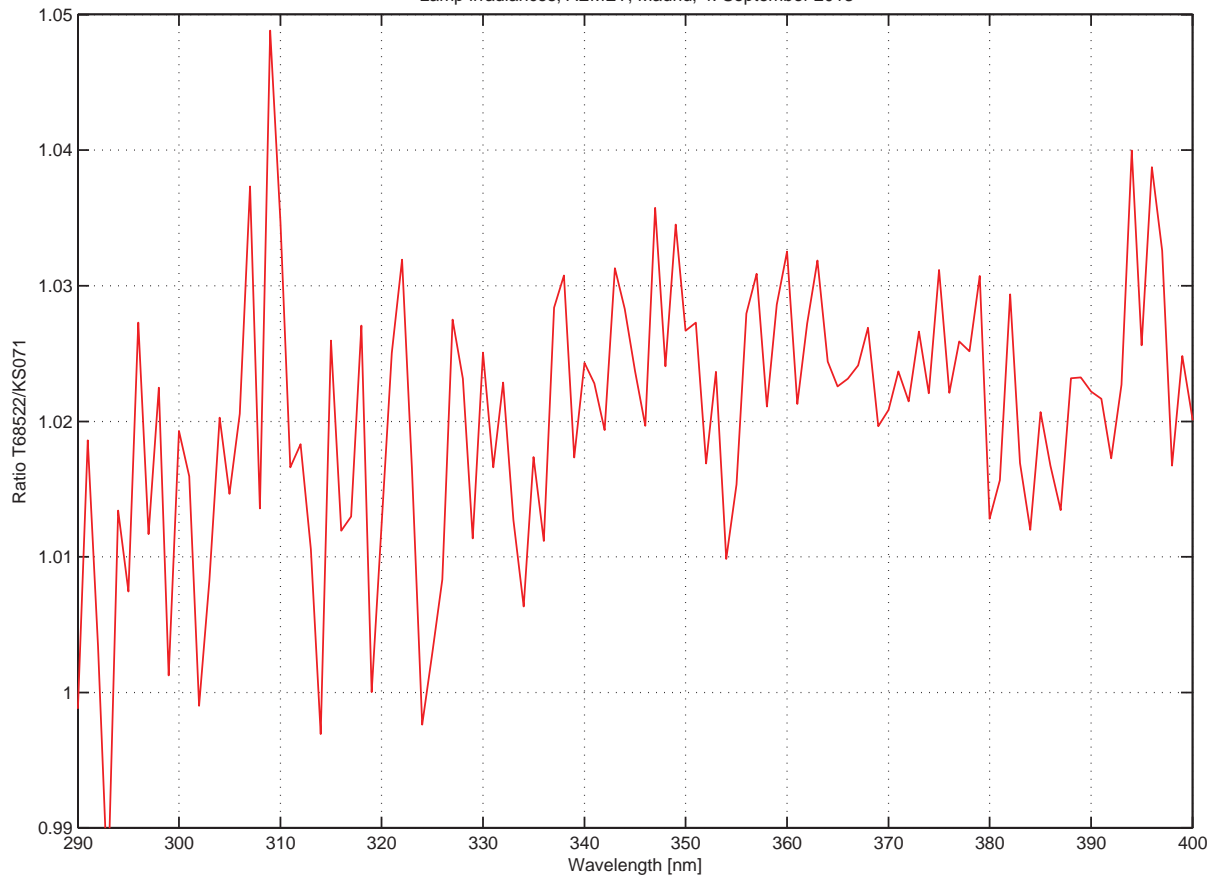


Madrid, 186, September 2013

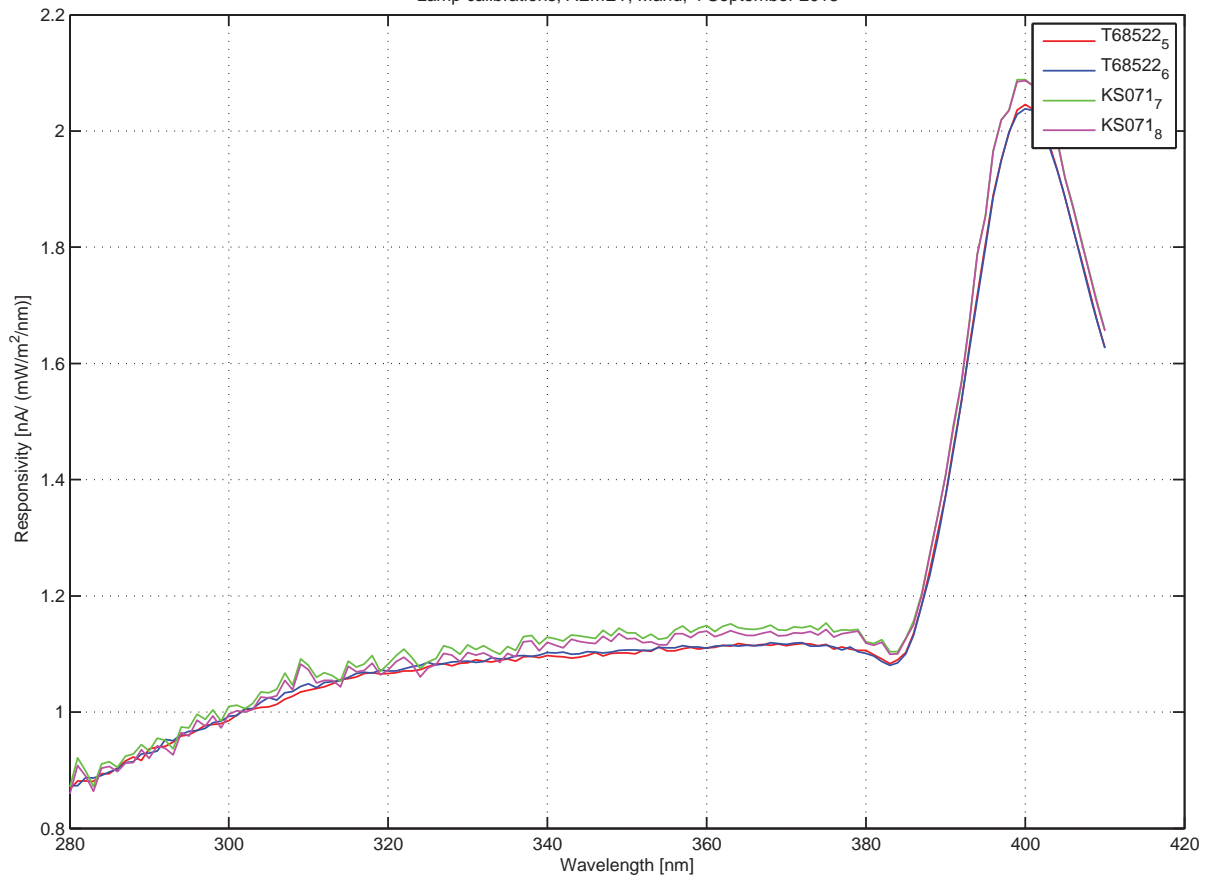




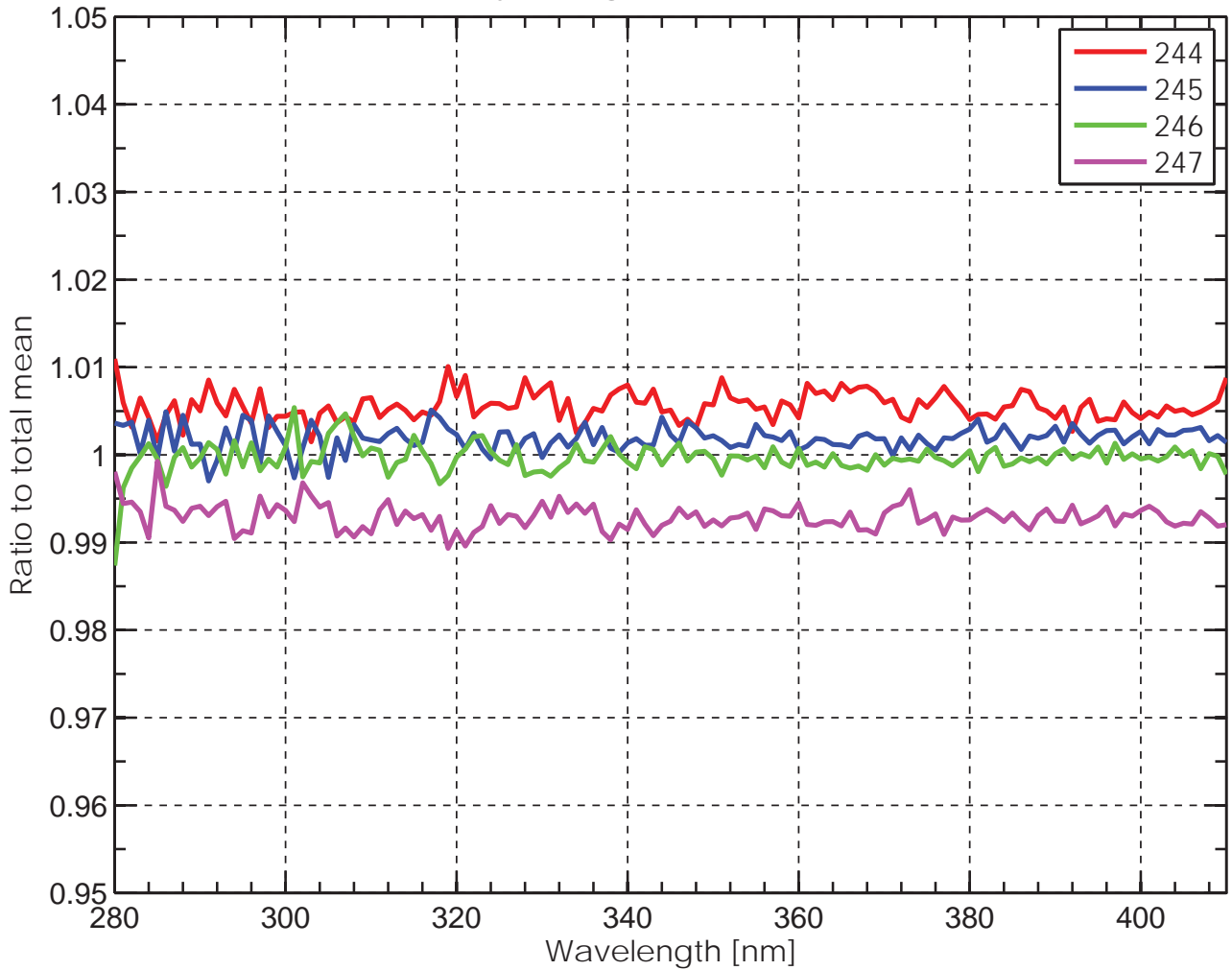
Lamp irradiances, AEMET, Madrid, 4. September 2013



Lamp calibrations, AEMET, Madrid, 4 September 2013



Qasume Responsivity Change, September 2013, Madrid (T68522)



Qasume Responsivity Change, 2nd September 2013, Madrid (T68522)

