

Protocol of the intercomparison at AEMET, Madrid, Spain on July
14 to 18, 2011 with the travelling reference spectroradiometer
QASUME from PMOD/WRC

Report prepared by Gregor Hülsen

Operator: Gregor Hülsen

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer AEM 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 5:00 UT and 19:00 UT have been analysed.

QASUME was installed on the measurement platform of AEMET-Madrid in the afternoon of July 14, 2011. The spectroradiometer was installed next to the AEM spectroradiometer with the entrance optic of QASUME within 2 m to the other instrument. The spectroradiometer in use at AEMET is a Bentham DM300 double monochromator system with custom made input selector to select between three input optics: An input optic for global irradiance measurements (Bentham D6-ENVIRO), an integrating sphere to measure diffuse irradiance and a direct irradiance optic. The intercomparison between QASUME and the AEM spectroradiometer lasted four days, from morning of July 15 to the afternoon of July 18.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Two lamps (T68522, T68523 and T61253) 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 internal temperature of QASUME was 25.9 ± 0.1 °C and the diffuser head was heated to a temperature of 29.9 ± 2.7 °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 20 minutes from 290 to 400 nm, every 0.25 nm, and 1.5 seconds between each wavelength increment.

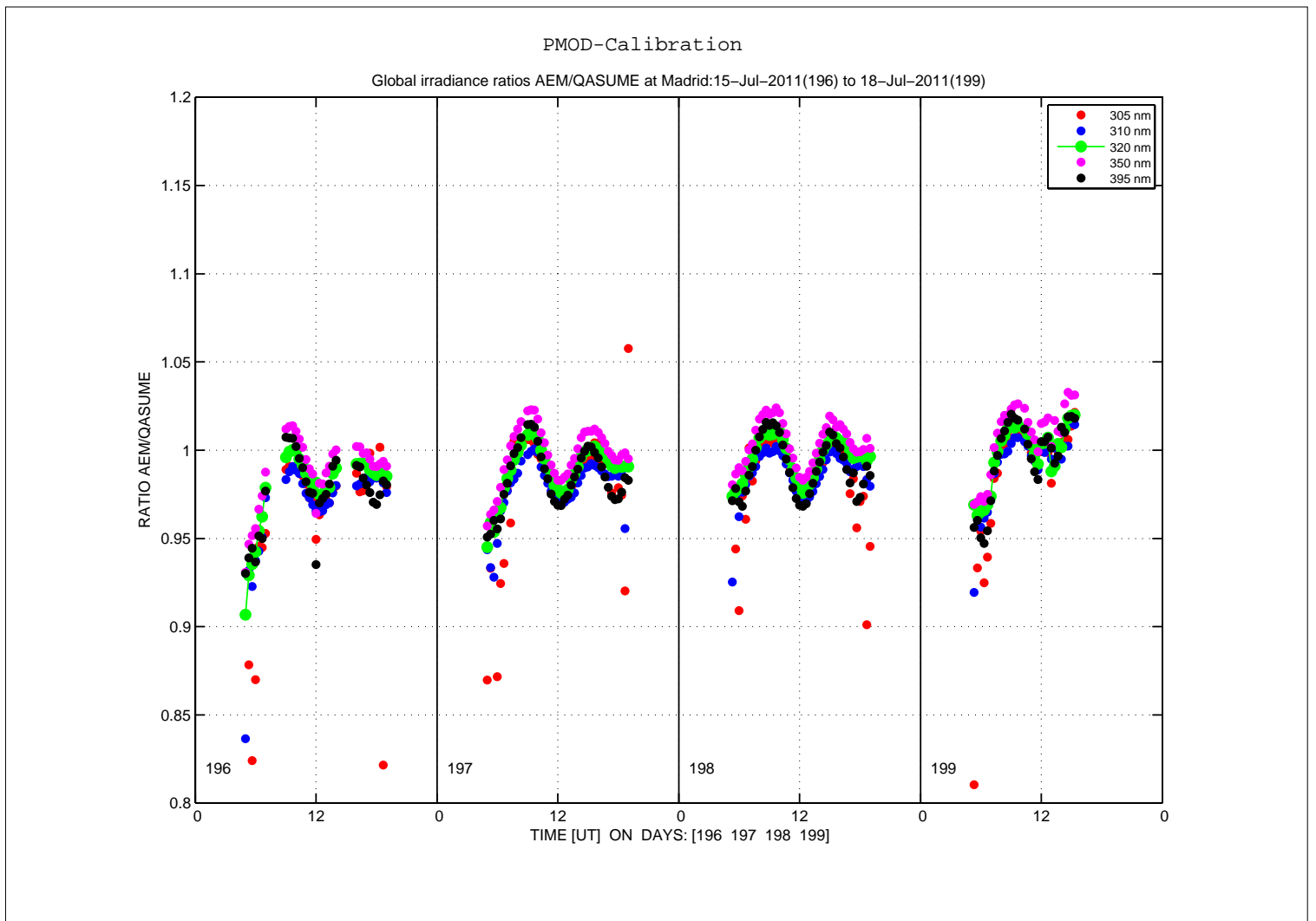
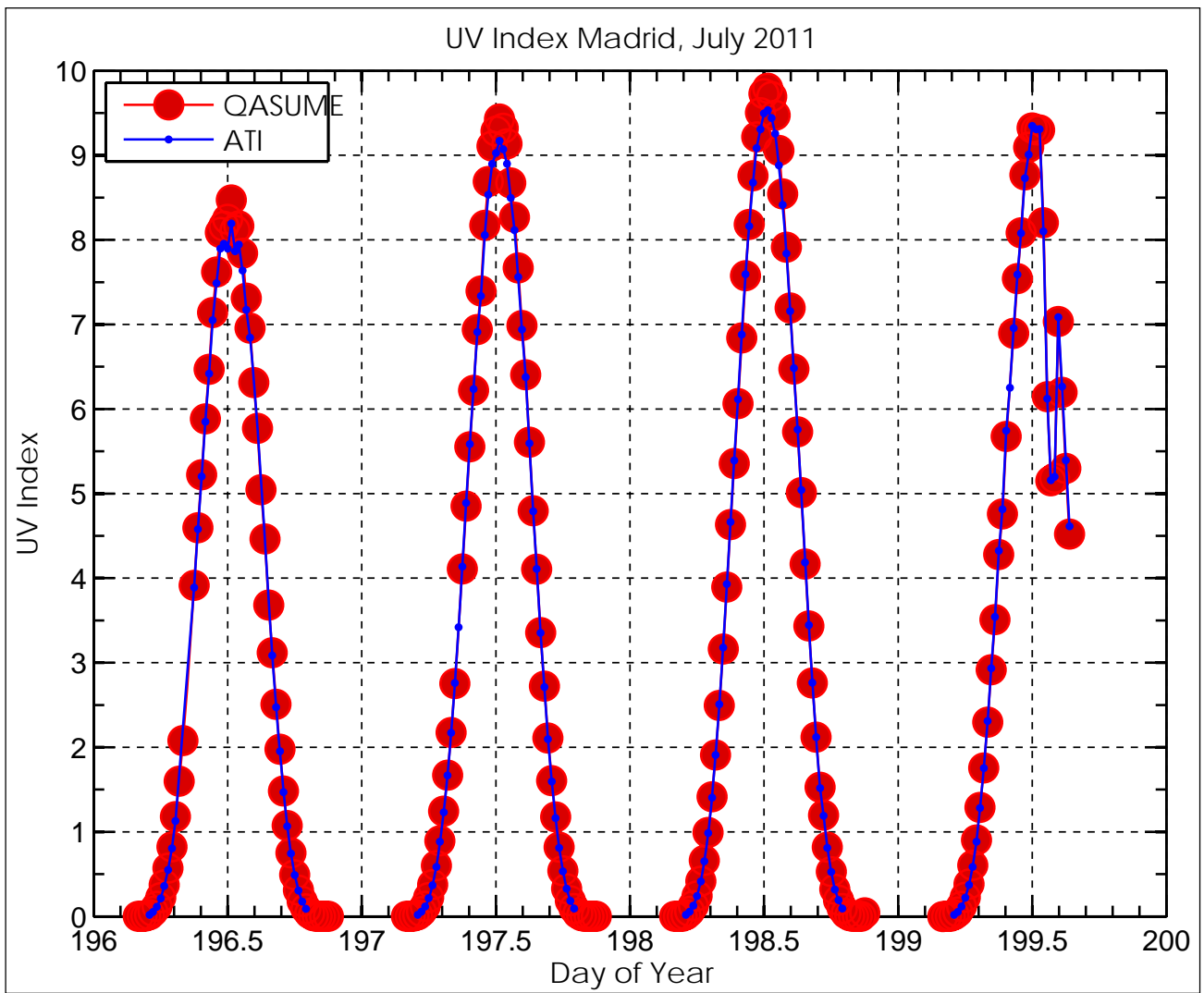
DOY	Date	DAY	Weather	Comment (times are in UT)
195	14-Jul	Thursday	Sun & Clouds	Installed at 16:00
196	15-Jul	Friday	Mostly clear sky	8:13 and 8:27 - calibration using T68523 and T68522 12:00-14:30 Overheading of the Qasume cooling system 14:22 AEM calibration using T68522
197	16-Jul	Saturday	Mostly clear sky	8:52 calibration using T68523 7:30 Test of AEM lamp setup
198	17-Jul	Sunday	Mostly clear sky	8:52 turn AEM Head by 180deg 9:32 turn AEM Head back to 0deg 14:56 turn AEM Head by 180deg 15:32 turn AEM Head back to 0deg 19:30 ARF measurement of AEM 22:10 ARF meas. Finished
199	18-Jul	Monday	Mostly clear sky	9:46 and 10:02 calibration using T68523 and T61253 11:55 turn AEM Head by 180deg 12:55 turn AEM Head back to 0deg End of Campaign: 15:00

Results:

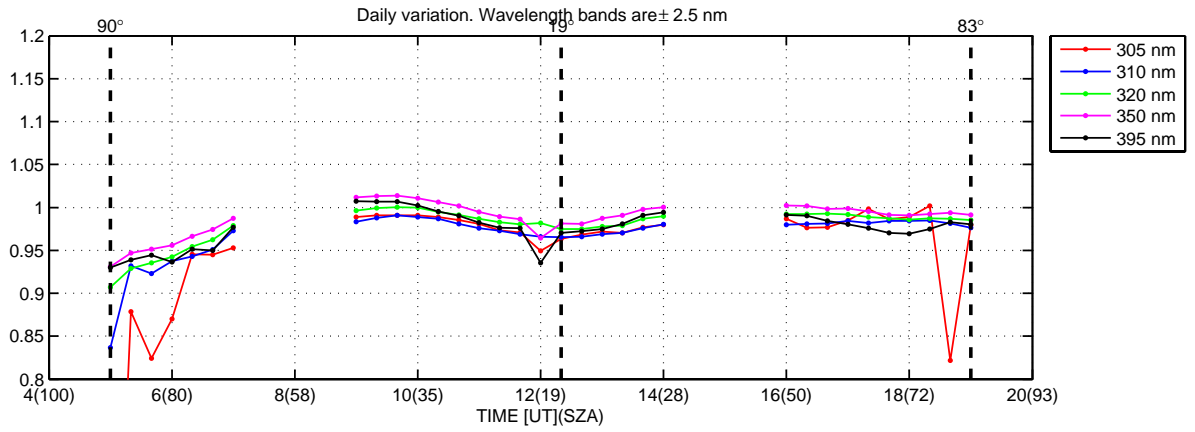
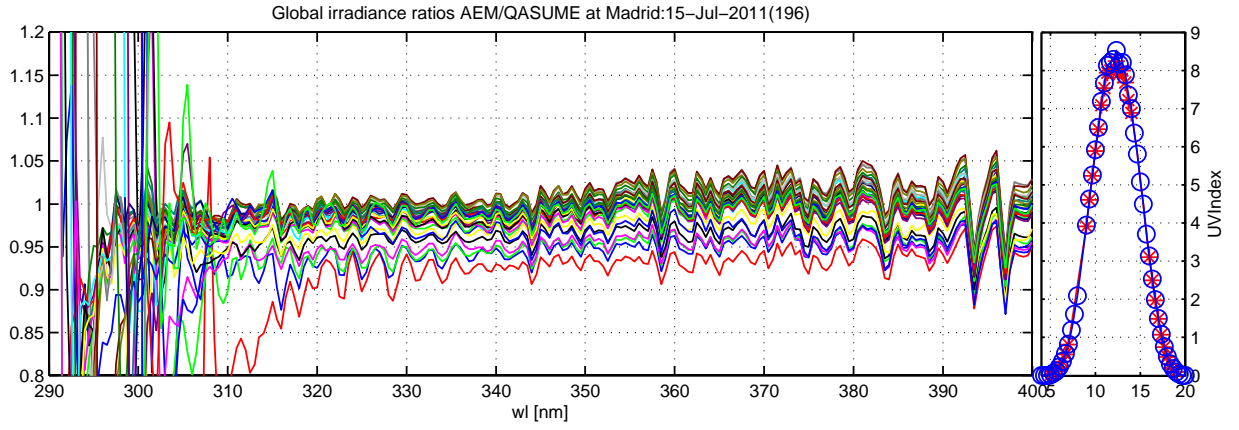
In total 147 synchronised simultaneous spectra from QASUME and ATI are available from the measurement period. Measurements between 5:00 and 19:00 UT have been analysed (SZA smaller than 90°).

Remarks:

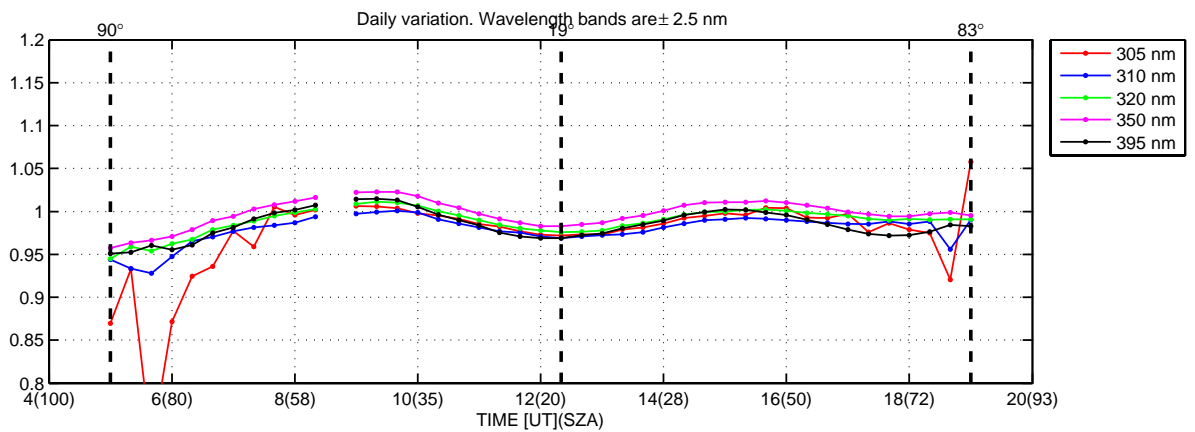
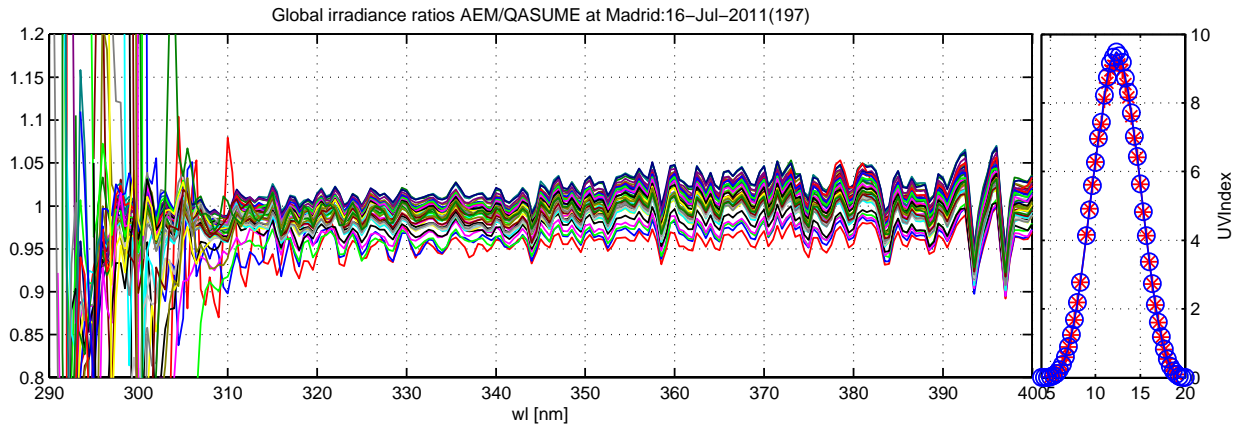
1. One week prior of the intercomparison the Bentham input optic D6-ENVIRO (SN. 12545) 'broke', i.e. the Teflon Diffuser moved out of the case into the dom (see picture). It was decided to change the input optic by on older D6-ENVIRO (SN. 11738). This older device was replaced in 2009 because of dirt inside the quartz dom (see picture, last page).
2. The AEM spectroradiometer was calibrated by the AEM Lamp 93512 (Bentham) prior to the intercomparison and using the PMOD/WRC lamp T68522 on 15th July 2011. Therefore, two datasets could be compared to the reference data from QASUME: Dataset1 (PMOD calibration) and Dataset 2 (AEMET calibration).
3. The ratios between the AEM Dataset 1 and QASUME have on average an offset of +1 % (see figures on page 4-7). The ratios of Dataset 2 and QASUME have on average an offset of +10 % (see figures on page 8-10). Between the two datasets from AEMET an average difference above 10% was found - with a strong spectral dependence (see figure on page 11).
4. The diurnal variation of the AEM to QASUME ratio is around 5 % on clear sky days (both Datasets). The variability is probably dominated by these effects:
 - a. Azimuth error: The input optic of AEM is tilted towards North. This could be verified by turning the AEM diffuser head by 180 deg before the 12:00 UT scan of DOY 199 (18th July) and back before the 13:00 UT scan (see figure on page 7, bottom).
 - b. Responsivity change: The responsivity of the photomultiplier changes after illumination. This was tested after the campaign by a measurement at 6:49 (before sunrise) and at 10:49 – resulting in a 3 % responsivity increase (see figure on page 15).
5. After sunset of DOY 198 (17th July) the angular response function of the input optic was measured (see picture). The results, shown on page 12-14, visualize first the good cosine response of the input optic. However the asymmetry of the scan from 0-North to 180-South show the misalignment of the head resulting in the azimuth error discussed in paragraph 4a.
6. The slit function used as input for the ShicRIVM algorithm was derived for a Mercury lamp measurement on the 4th July 2011.
7. For all solar scans the wavelength shifts of the AEM show a shift of +300 pm (see figure on page 11).



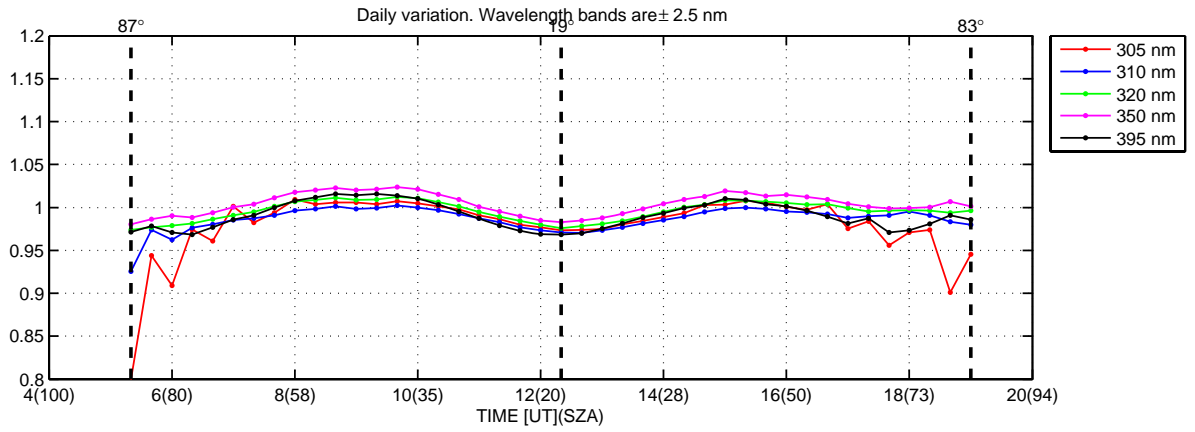
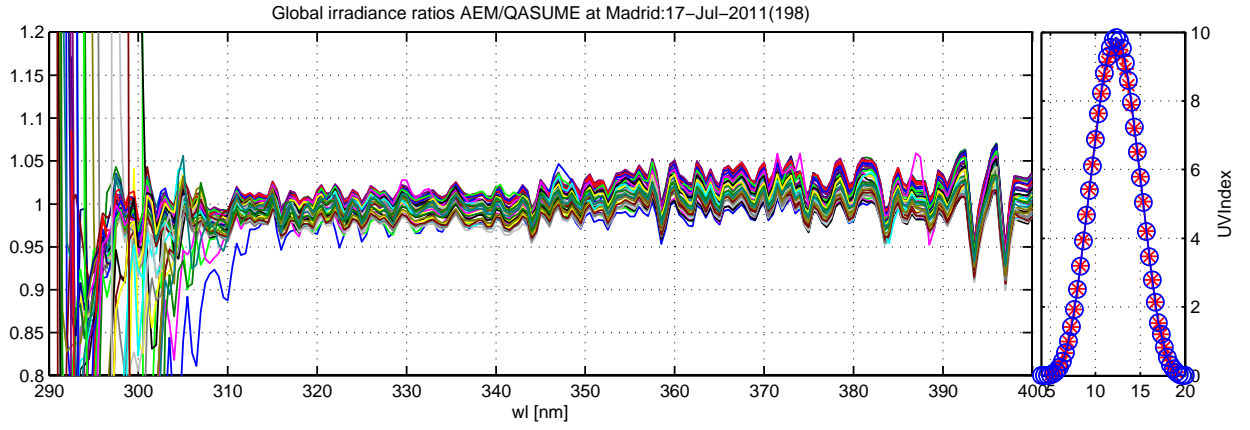
PMOD-Calibration



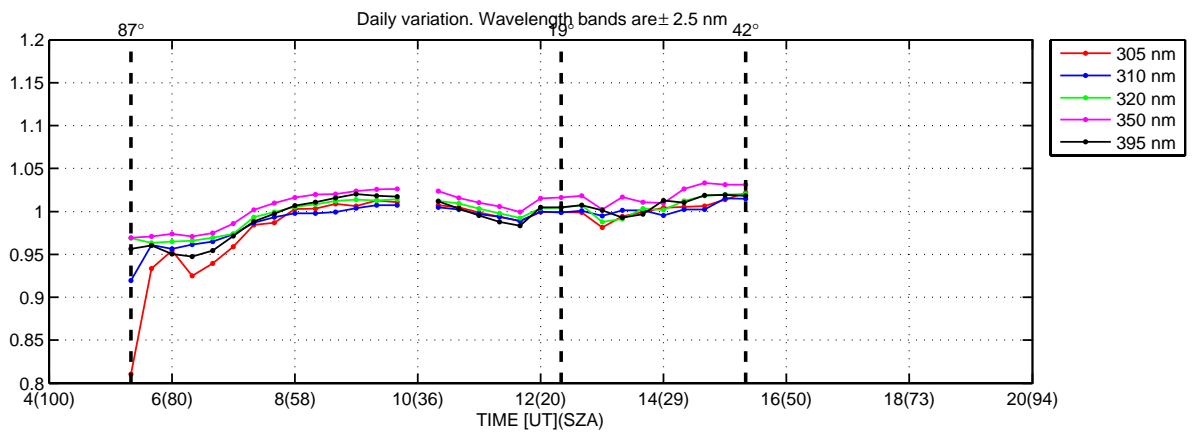
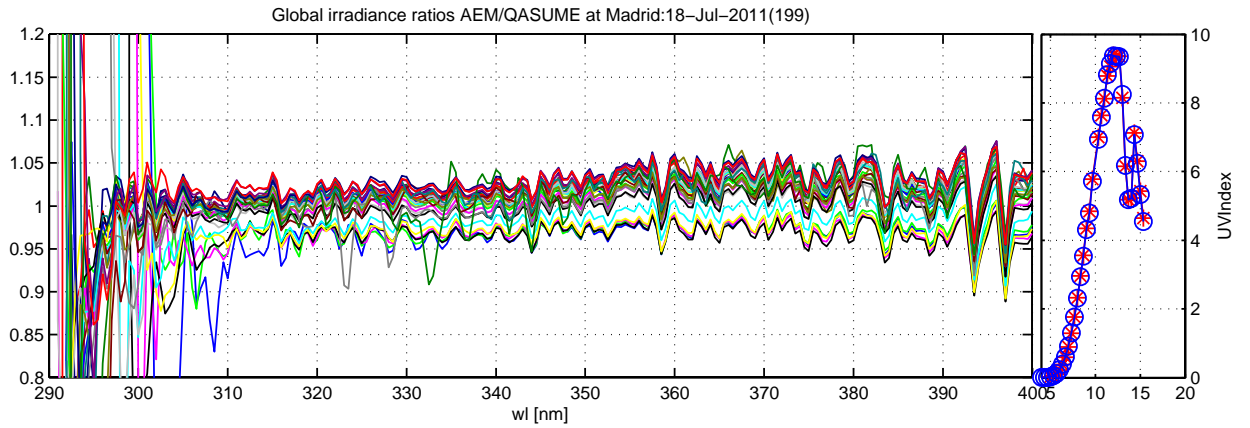
PMOD-Calibration



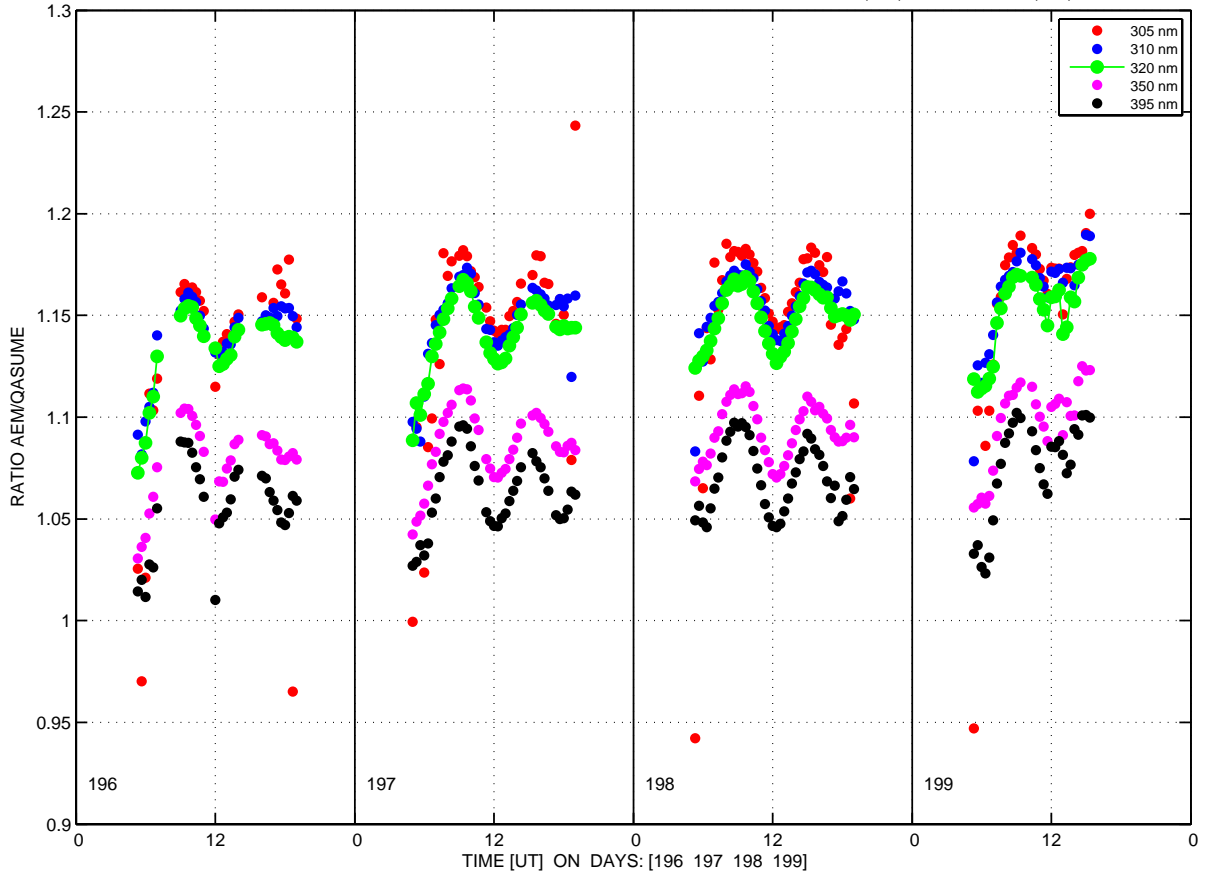
PMOD-Calibration



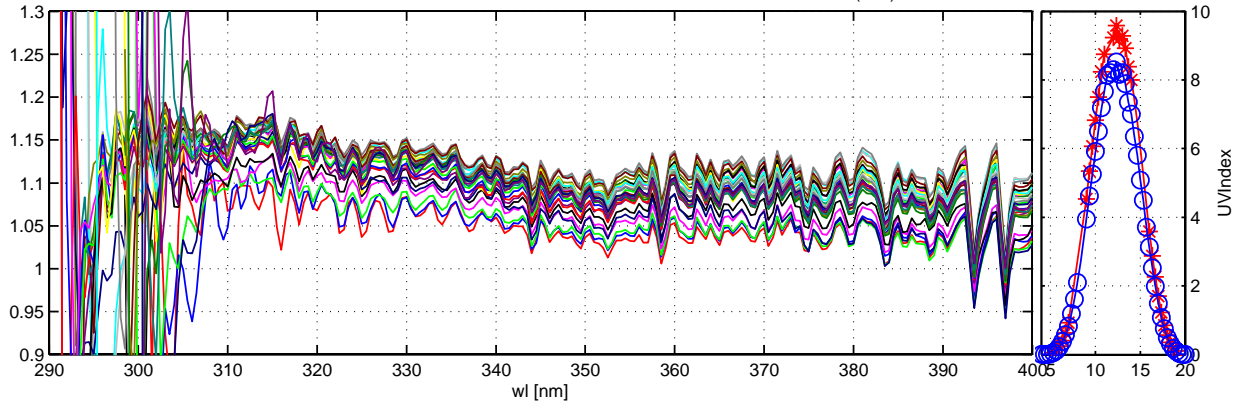
PMOD-Calibration



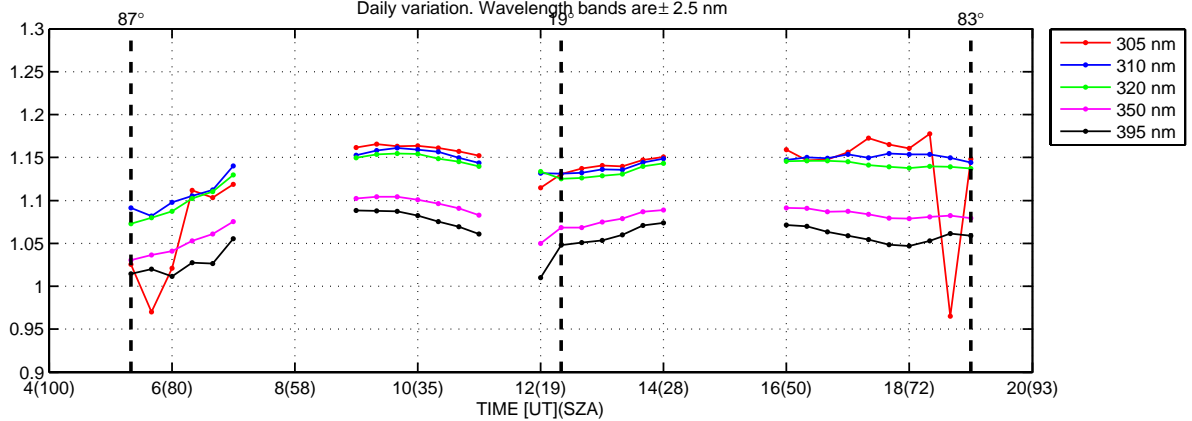
Global irradiance ratios AEM/QASUME at Madrid – AEMET Calibration:15-Jul-2011(196) to 18-Jul-2011(199)



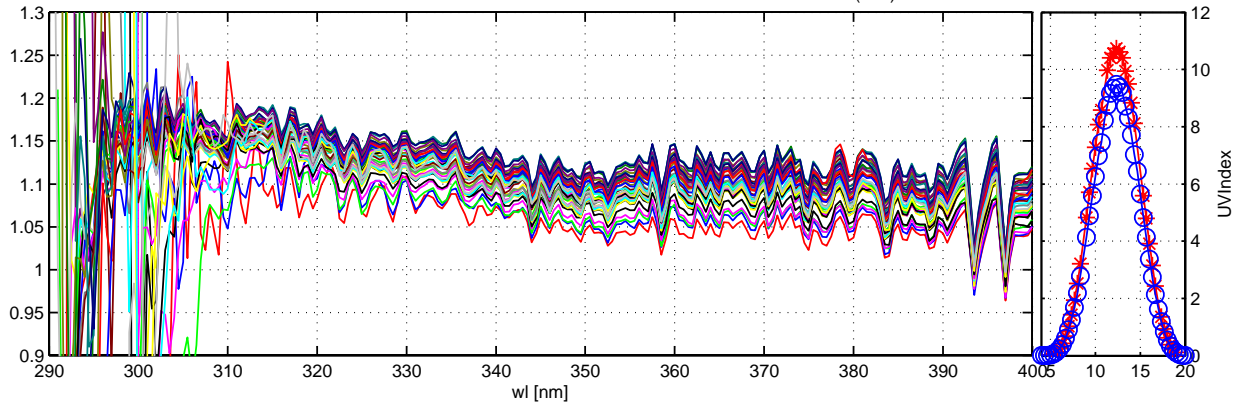
Global irradiance ratios AEM/QASUME at Madrid – AEMET Calibration:15-Jul-2011(196)



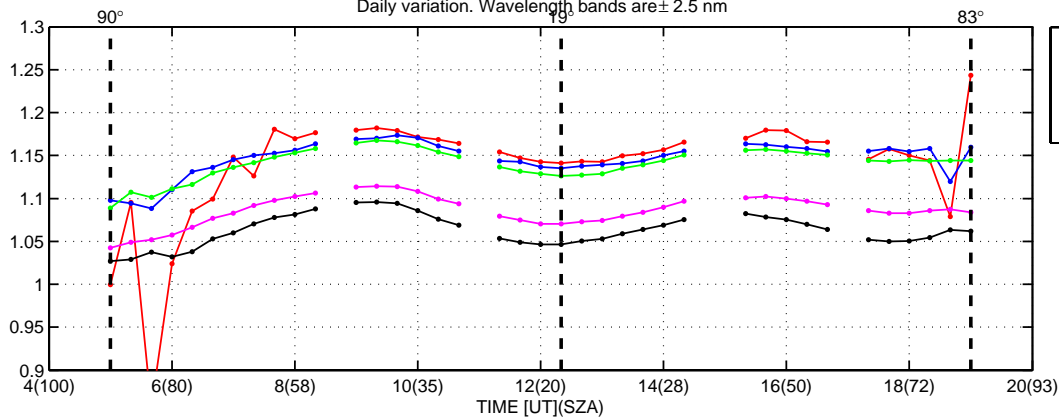
Daily variation. Wavelength bands are ± 2.5 nm



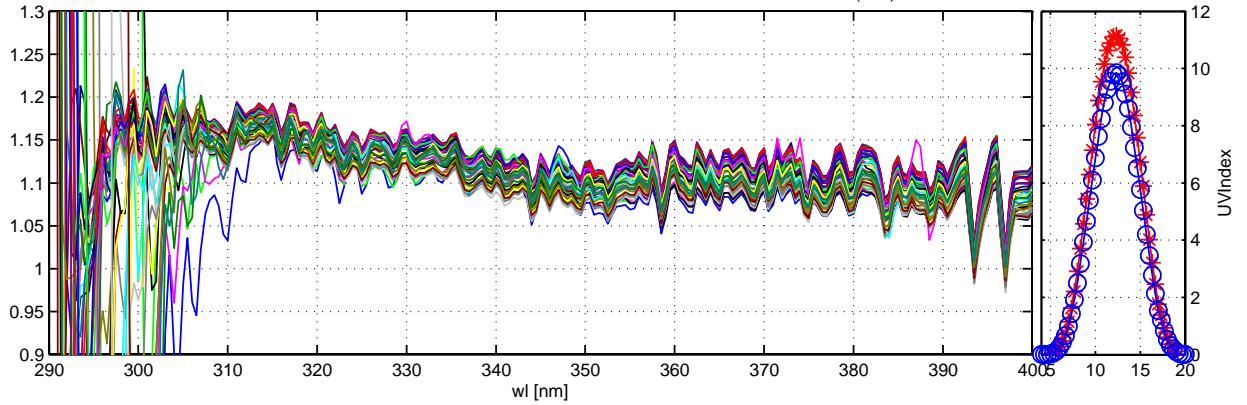
Global irradiance ratios AEM/QASUME at Madrid – AEMET Calibration:16-Jul-2011(197)



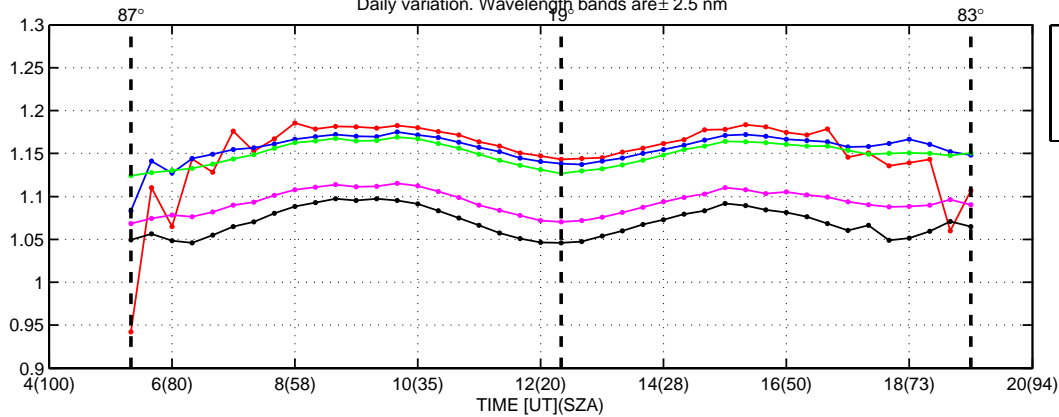
Daily variation. Wavelength bands are ± 2.5 nm



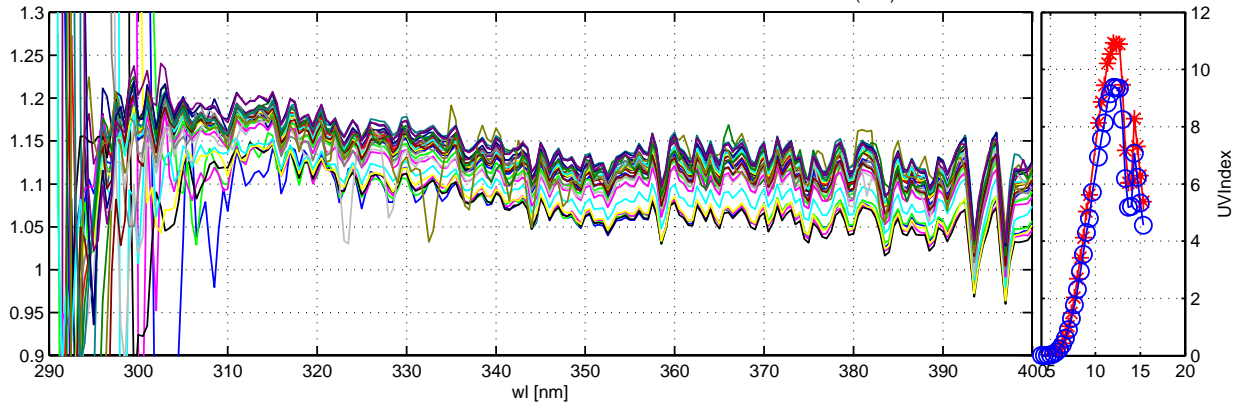
Global irradiance ratios AEM/QASUME at Madrid – AEMET Calibration:17-Jul-2011(198)



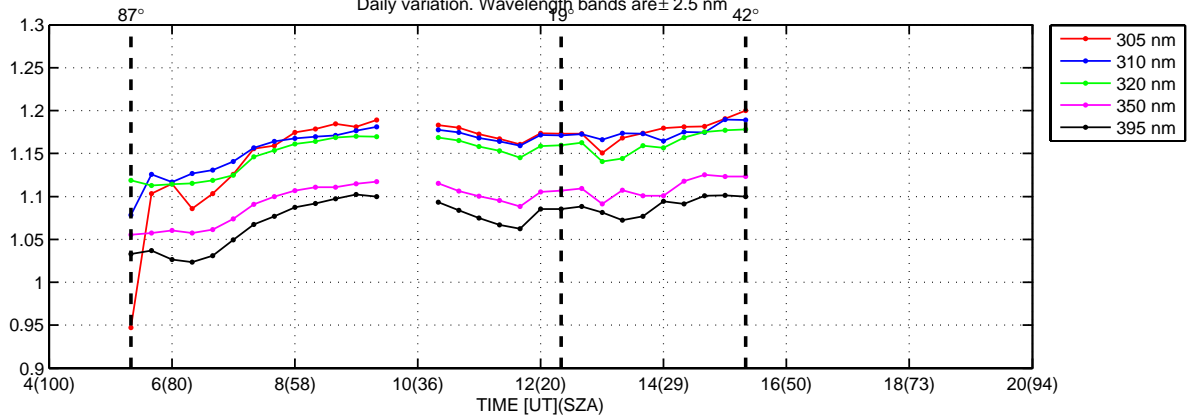
Daily variation. Wavelength bands are ± 2.5 nm



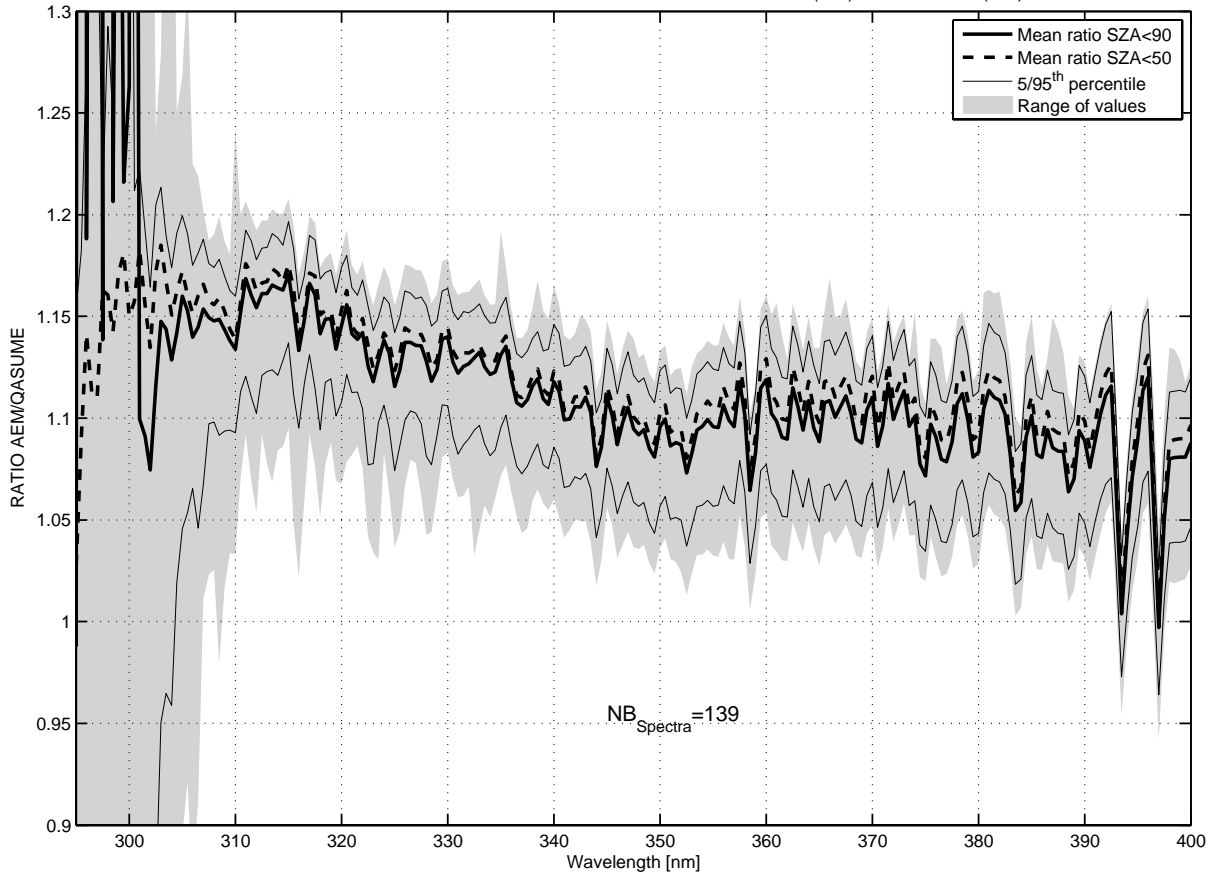
Global irradiance ratios AEM/QASUME at Madrid – AEMET Calibration:18-Jul-2011(199)



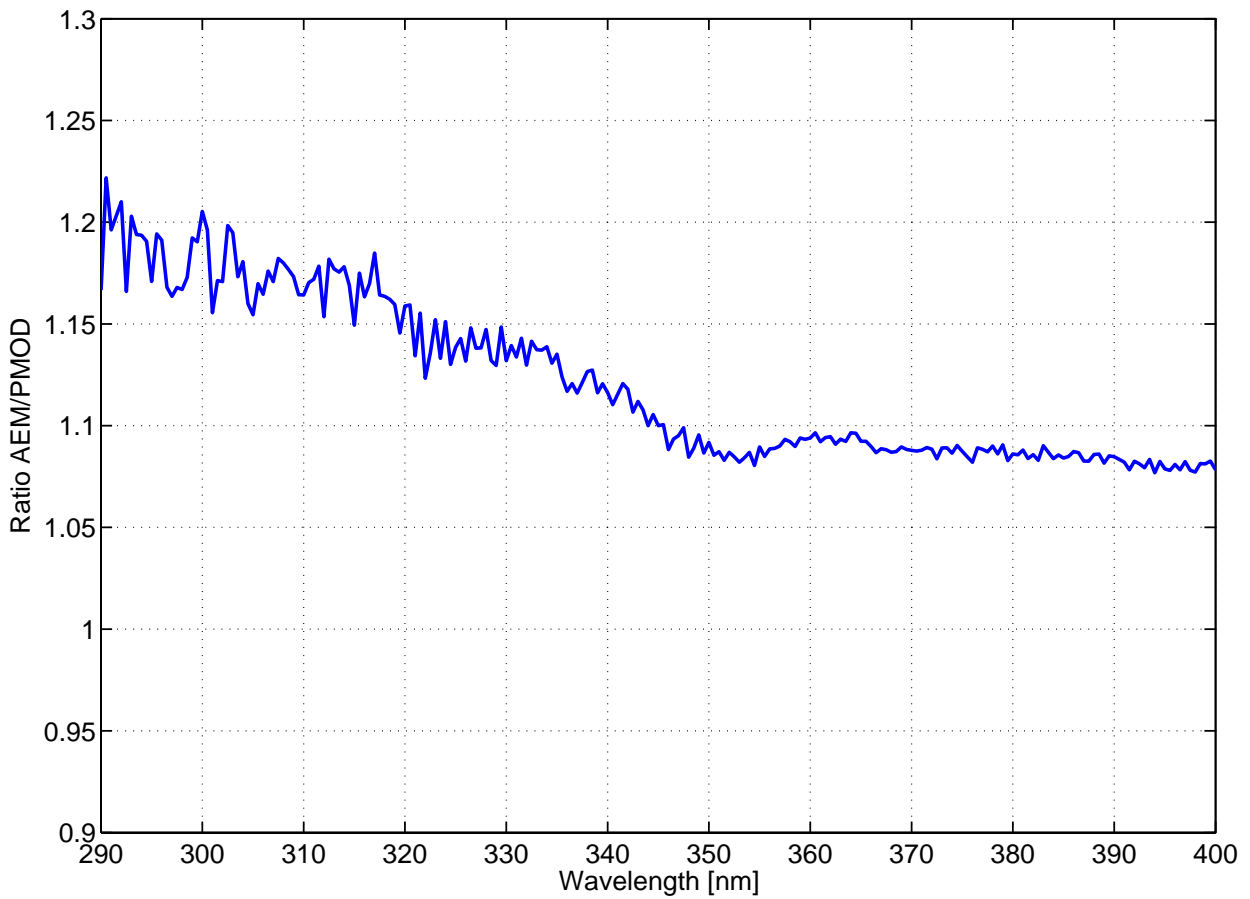
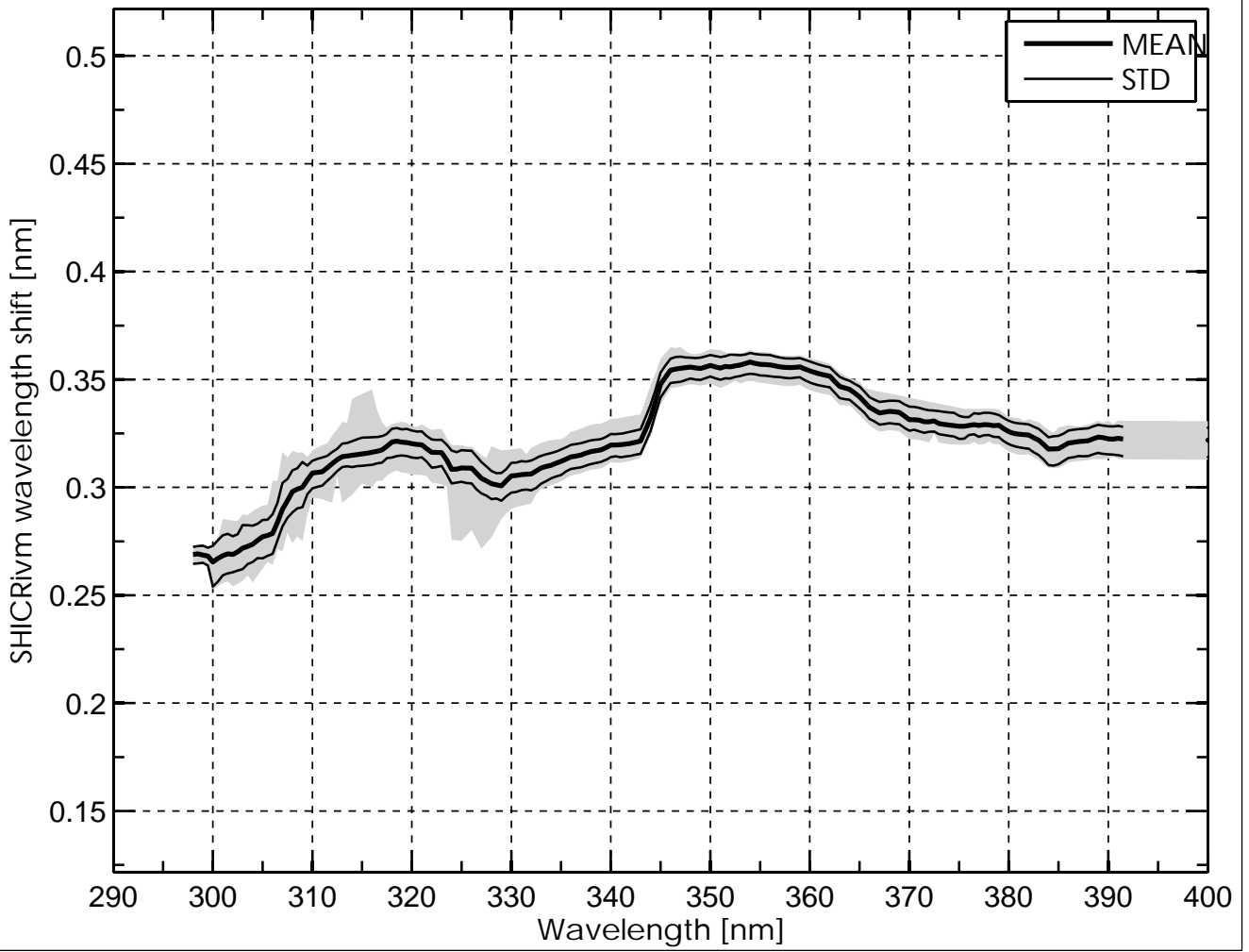
Daily variation. Wavelength bands are ± 2.5 nm



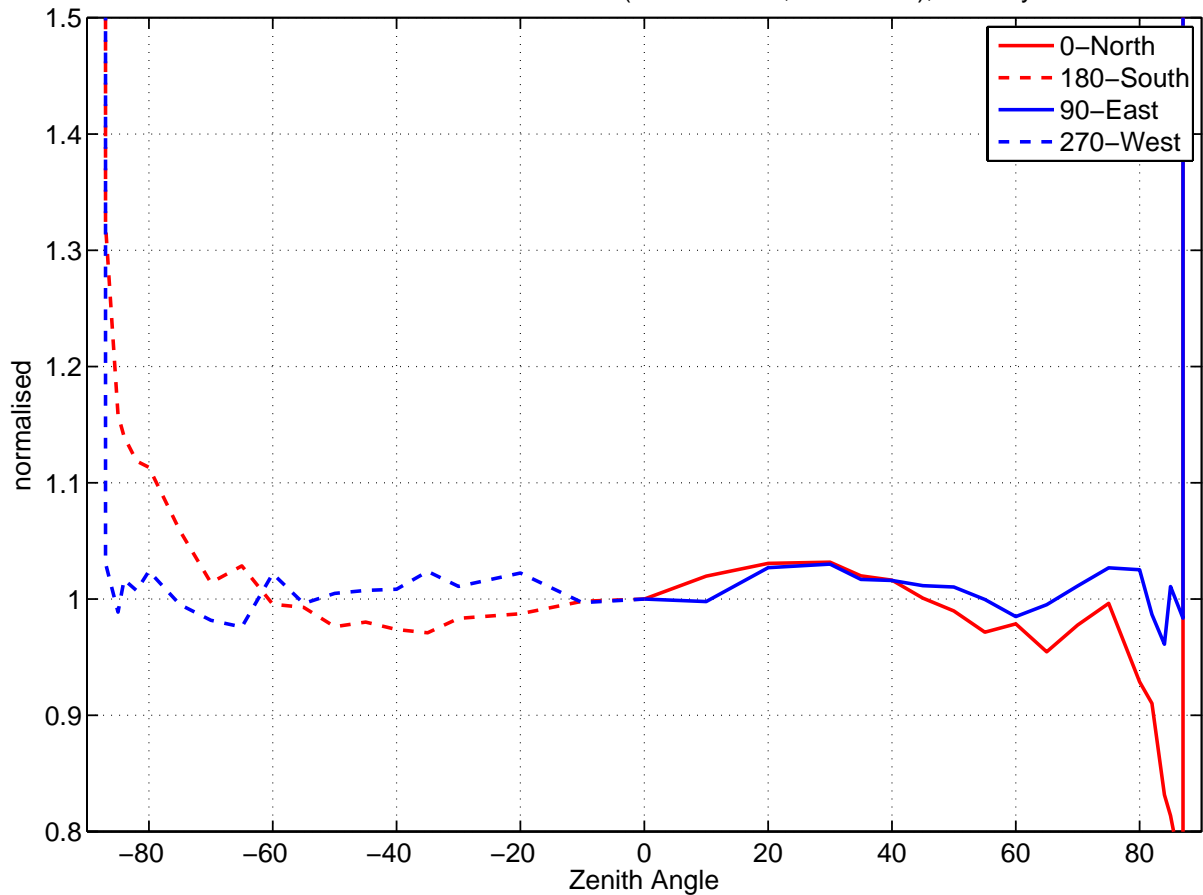
Mean ratio AEM/QASUME at Madrid – AEMET Calibration:15-Jul-2011(196) to 18-Jul-2011(199)



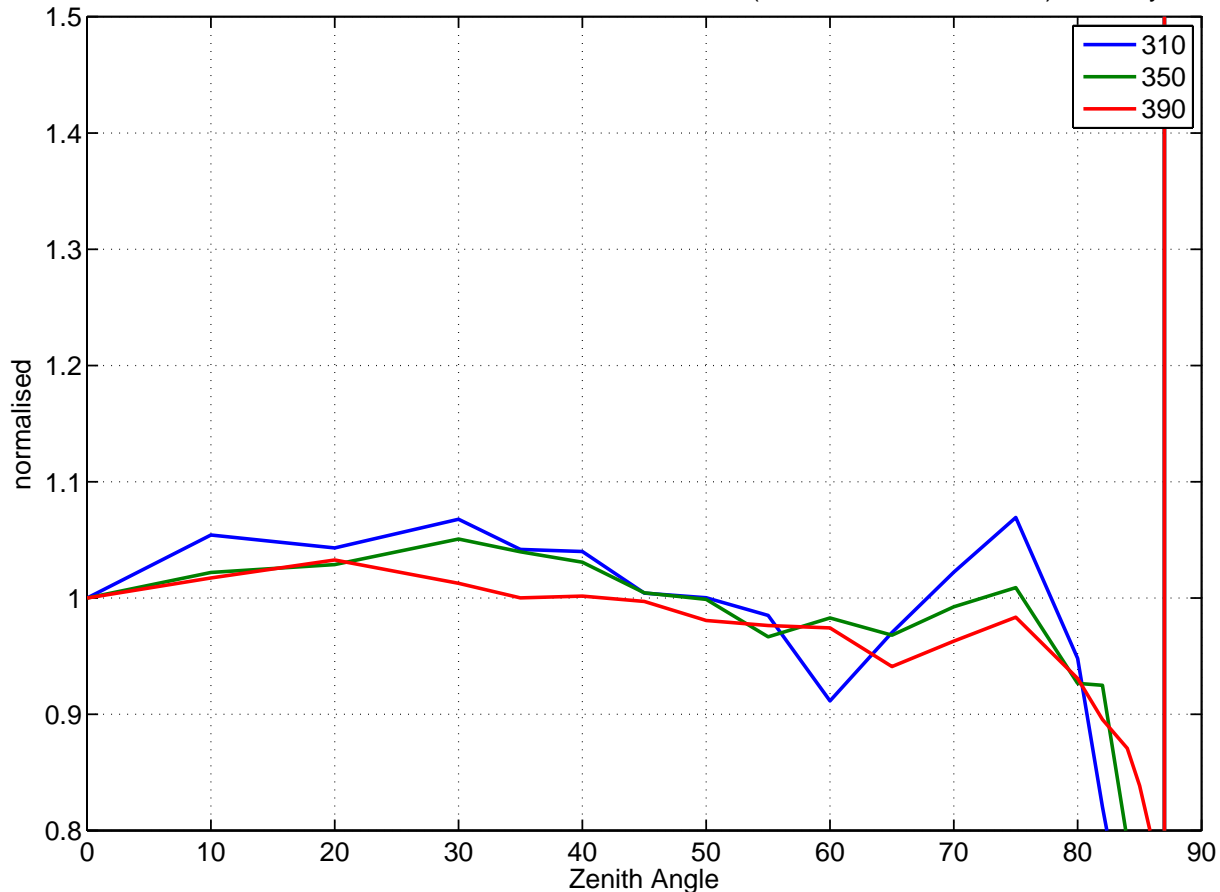
Madrid, AEM, July 2011



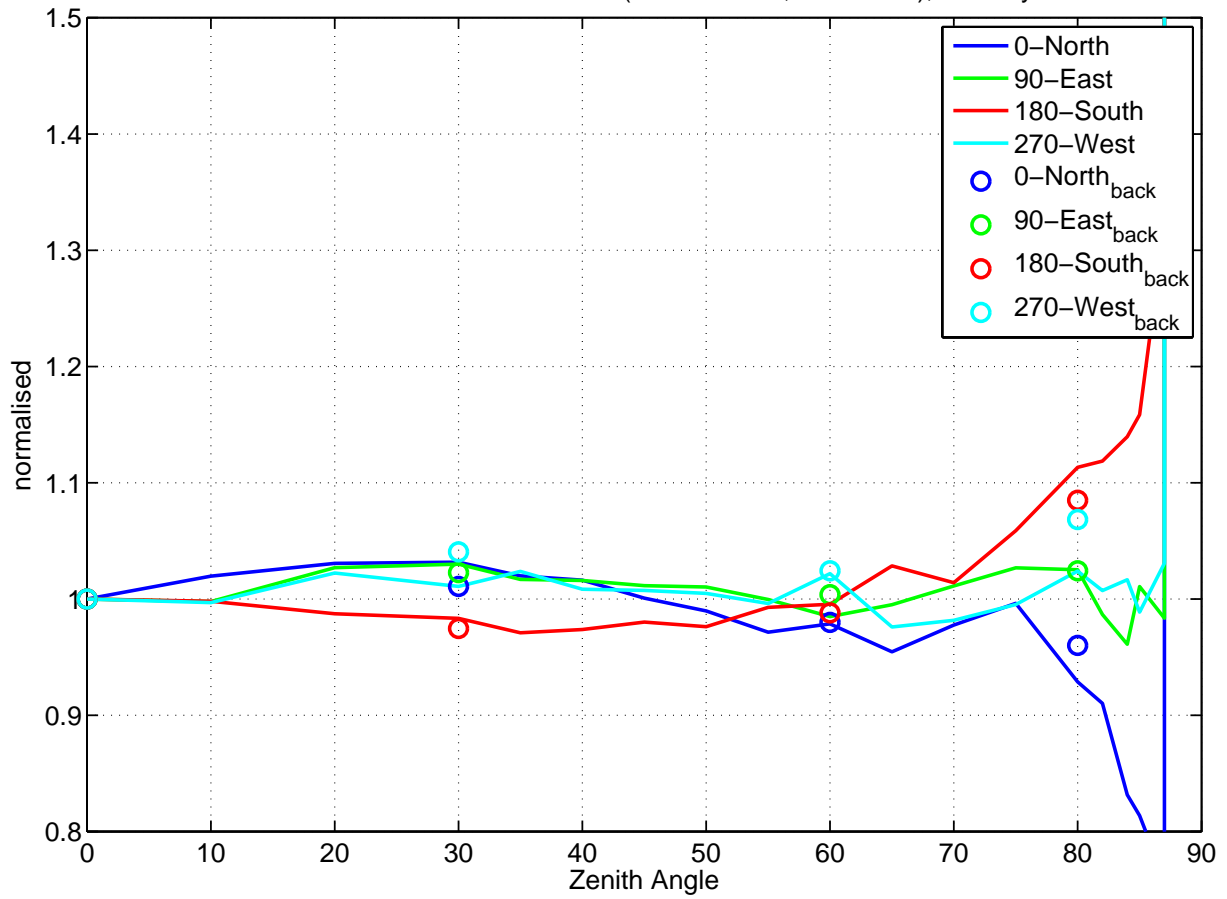
Cosine Error AEM-Bentham diffuser (D6-ENVIRO, SN 11738), 17-July-2011



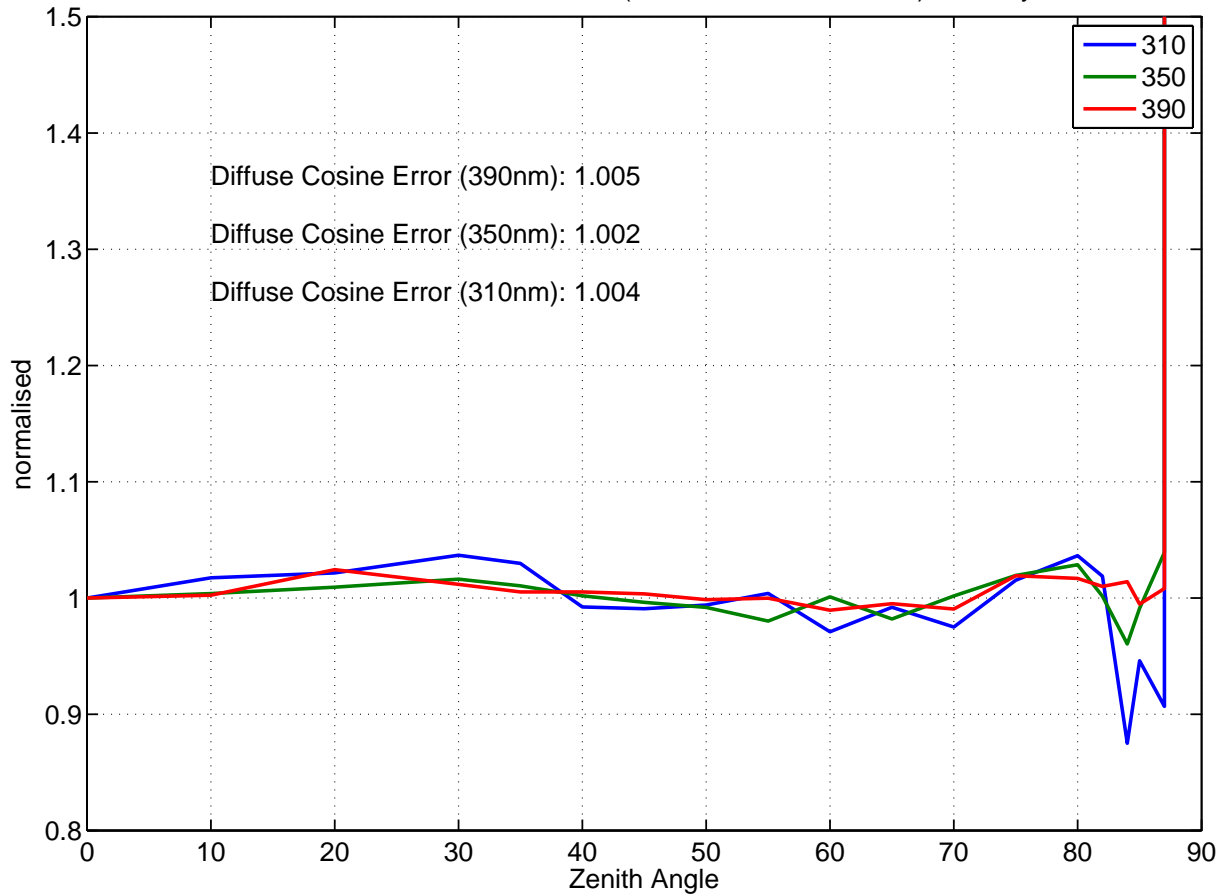
Cosine Error, Plane 0 - NORTH - AEM-Bentham diffuser (D6-ENVIRO, SN 11738), 17-July-2011



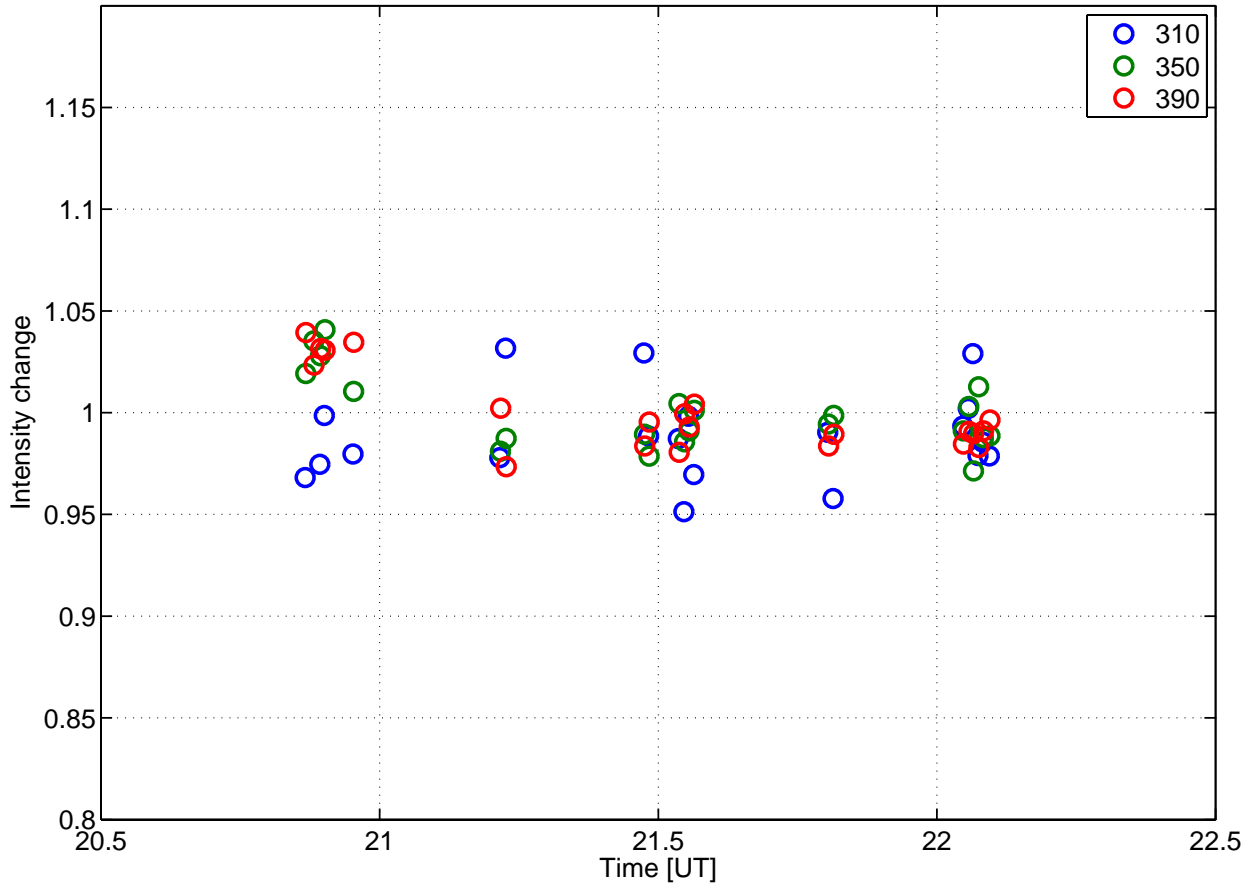
Cosine Error AEM-Bentham diffuser (D6-ENVIRO, SN 11738), 17-July-2011



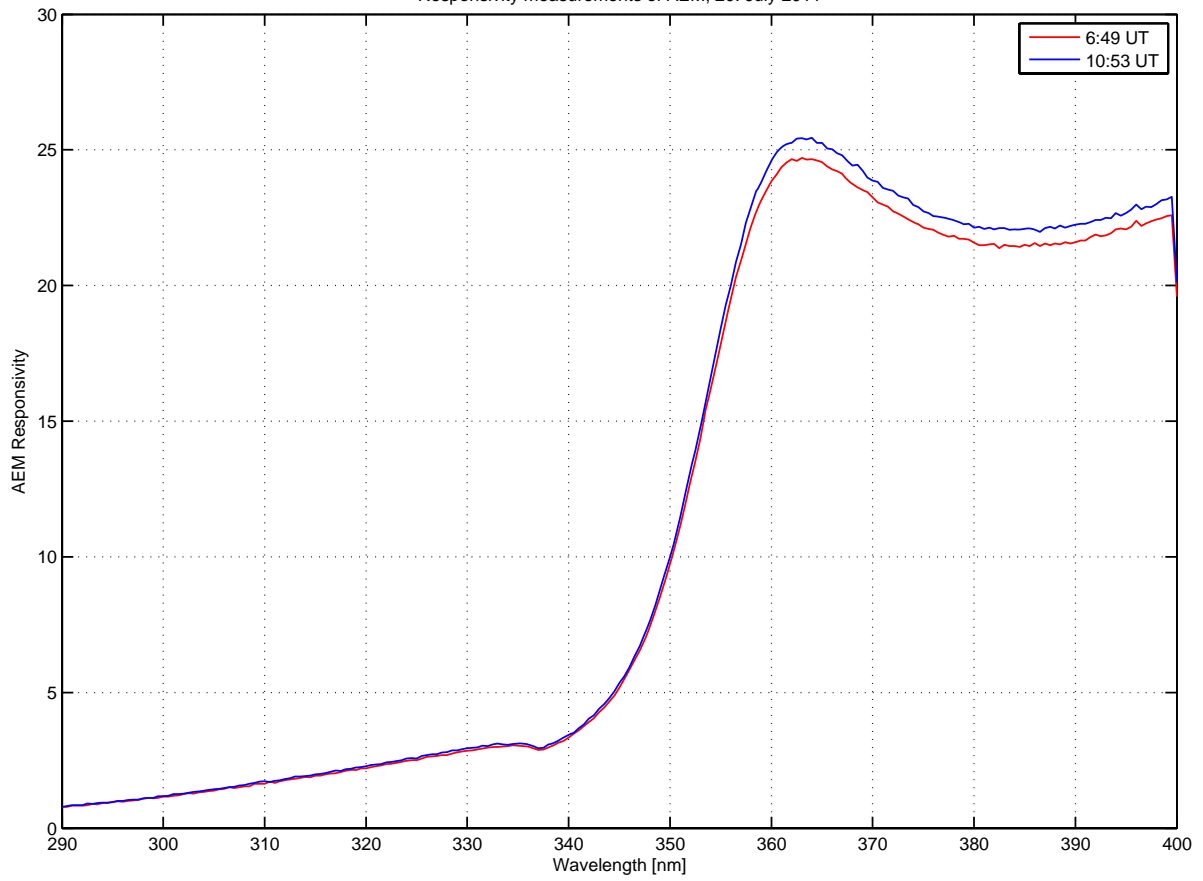
Cosine Error AEM-Bentham diffuser (D6-ENVIRO, SN 11738), 17-July-2011



Intensity at 0deg, AEM-Bentham diffuser (D6-ENVIRO, SN 11738), 17-July-2011



Responsivity measurements of AEM, 20. July 2011



Responsivity measurements of AEM, 20. July 2011

