

## Protocol of the intercomparison at FMI, Sodankylä, Finland on June 8 to 13, 2014 with the travelling reference spectroradiometer QASUME from PMOD/WRC

Report prepared by Luca Egli

Operator: Luca Egli

The purpose of the visit was the comparison of global solar irradiance measurements between the two Brewer spectrophotometer, FIS and FIA (Brewer #214) operated by the Finnish Meteorological Institute (FMI) and the travel reference spectroradiometer QASUME. The measurement site is located at Sodankylä; Latitude 67.37 N, Longitude 26.63 E and altitude 179 m.a.s.l. The horizon of the measurement site is free down to at least 75° solar zenith angle (SZA). Measurements between 1:00 UT and 23:00 UT have been analysed.

QASUME was installed on the measurement platform of FMI-Sodankylä in the early afternoon of June 8, 2014. The spectroradiometer was installed next between the Brewer spectrophotometer "FIS" and "FIA" with the entrance optic of QASUME within 2 m to the other instruments. The Brewer Spectrometer FIS is a single monochromator (Brewer MkII #037) and the FIA Brewer spectroradiometer is a double monochromator (Brewer MkIII #214). The intercomparison between QASUME and the spectroradiometers lasted four days (one rainy day laboratory measurements for FIA), from early morning of June 9<sup>th</sup> to midnight of June 12<sup>th</sup>.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T685240, T68522 and T68523) 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 0.5 % during the intercomparison period. The internal temperature of QASUME was  $23.7 \pm 0.1$  °C and the diffuser head was heated to a temperature of 28 °C. Note that the internal data recording of the diffusor had failed during the intercomparison, however the temperature was monitored regularly with an external device, indicating that the temperature was stable at 28°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 0.5 nm, and 3.0 seconds between each wavelength increment. Qasume recorded the spectra in 30 min intervals with 0.25 nm increments, the FMI spectroradiometer also every 30 min with 0.5 nm increments from 290 to 325 nm for FIS, respectively 290 to 363 nm for FIA.

DOY	Date	DAY	Weather	Comment (times are in UT)
159	08. Jun	Sunday	Overcast, rain	Installed at 11:30 no calibration due to rain
160	09. Jun	Monday	Overcast in the morning temporarily visible sun in the afternoon	4:30 calibration (T685240) 15:30 calibration (T68522)
161	10. Jun	Tuesday	Overcast	7:30 calibration (T685240) 18:00 calibration (T685240)
162	11. Jun	Wednesday	Overcast	12:00 calibration (T685240)
163	12. Jun	Thursday	Overcast some rain	8:30 calibration (T685240) 9:00 calibration (T68523) 10:00 Brewer FIA in laboratory
164	13. Jun	Friday	Overcast mainly rainy	no calibration due to rain  End of Campaign: 12:15

**Results:**

In total 167 (FIS) / 142 (FIA) synchronised simultaneous spectra from QASUME and FIS/FIA are available from the measurement period. Measurements between 1:00 and 23:00 UT have been analysed (SZA smaller than 90°).

**Remarks:****I. FIS:**

1. The ratios between FIS and QASUME have on average an offset of +5% for wavelengths longer than 305 nm, in analogy to the 2 previous campaigns.
2. Below 305 nm, the measurements of FIS detect too high irradiance due to internal stray light of the single monochromator.
3. The diurnal variation of the FIS to QASUME ratio is less than 2 %. However, due to overcast weather conditions a cosine error could not be detected.
4. The wavelength shifts are stable to better than  $\pm 25$  pm and the average of the wavelength shifts is spectrally almost constant at about 25 pm.

**II. FIA:**

1. The ratios between FIA and QASUME have on average an offset of -6% for wavelengths longer than 300 nm. As small spectral dependency can be observed (-5% at 300 nm to -7% at 360 nm). A stabilization of the averaged bias of ~5% was detected after the cleaning of the micrometer screws on DOY 162 (9:30 UTC).
2. Remarkably in DOY 161 and in particular in DOY 162 the ratios revealed a continuous reduction of FIA irradiance measurements above 350 nm. After cleaning all micrometer screws on DOY 162 (9:30 UT), the malfunction and irradiance reduction disappeared. For the certificate only valid spectra in the spectral range below 350 nm were used.
3. The diurnal variation of the FIA to QASUME ratio is less than 3 % (in particular after cleaning the micrometer screws). However, due to overcast weather conditions a cosine error could not be detected.
4. An angular response function is measured by the operator on behalf on the local operator. The analysis will be provided by the local operator.
5. For all solar scans the wavelength shifts of the FIA are below  $\pm 50$  pm. Note that the malfunction of the micrometer screws could not be detected by a wavelength shift using SHICRivm analysis
6. The wavelength shifts are stable to better than  $\pm 30$  pm and the average of the wavelength shifts is between 50 pm and -2 pm, at respectively short (300 nm) and long wavelengths (355 nm).

**Recommendation:**

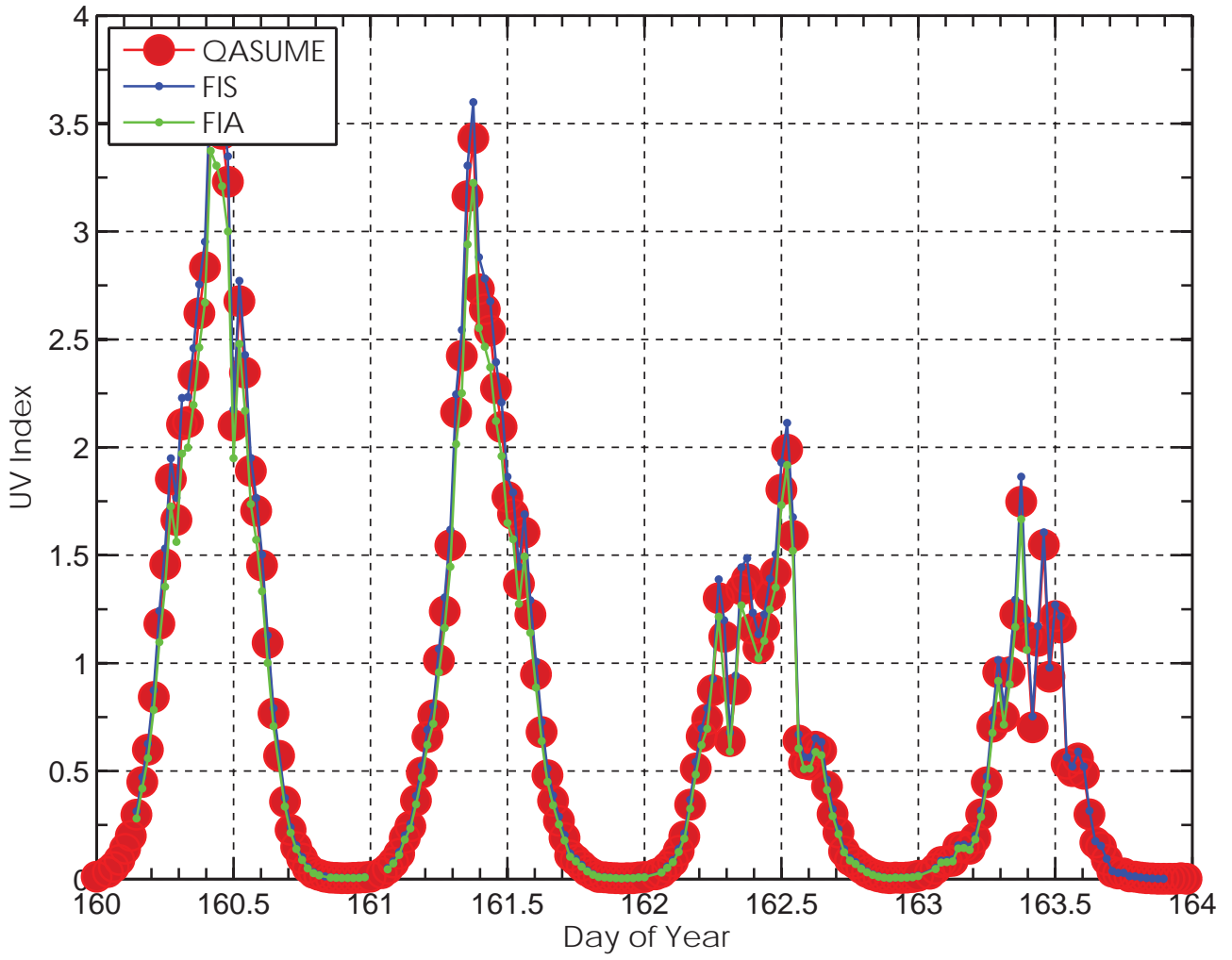
In order to avoid biased measurements above 350 nm, the micrometer screws should be cleaned on a regular schedule (monthly). Since the wavelength adjustment is not affected by the malfunction, most likely the lower micro meter screw is the origin of the biases measurements. The correct function of the micrometer alignment should be monitored.

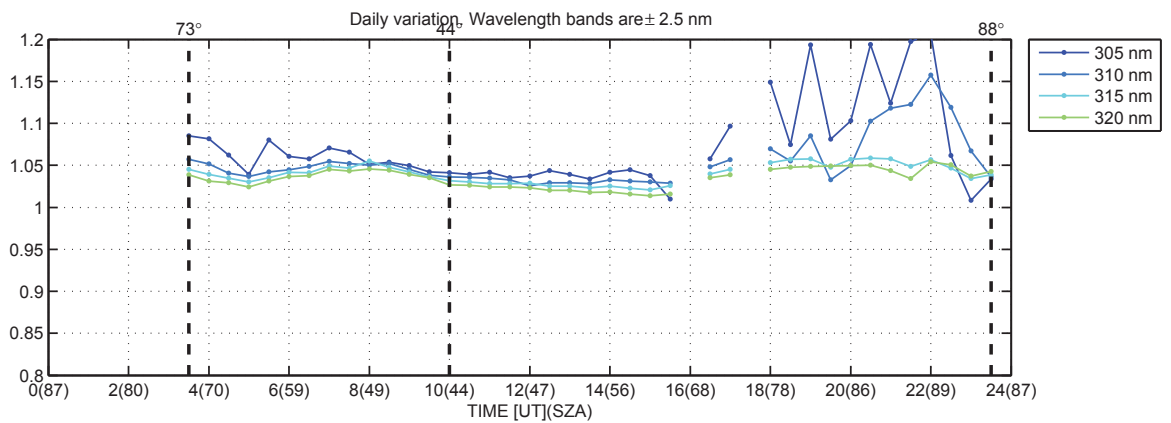
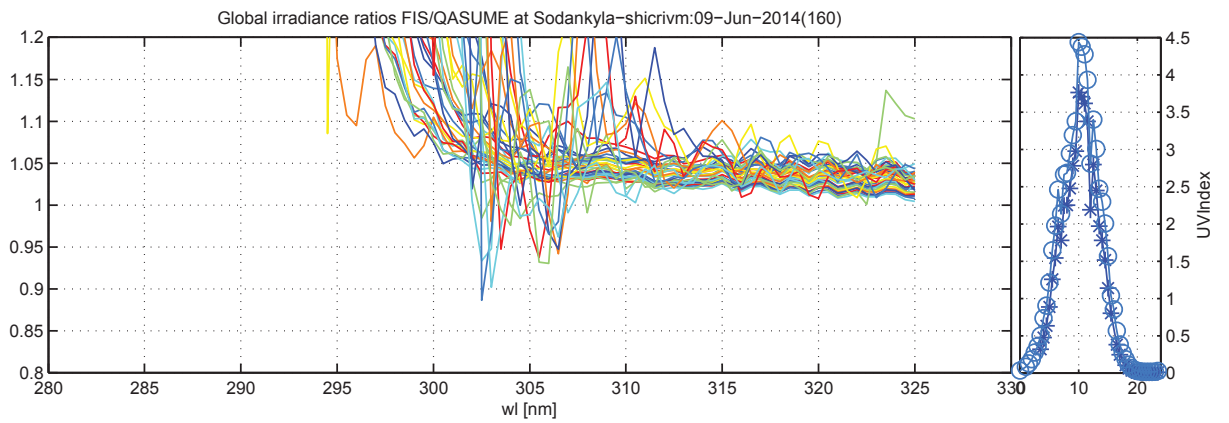
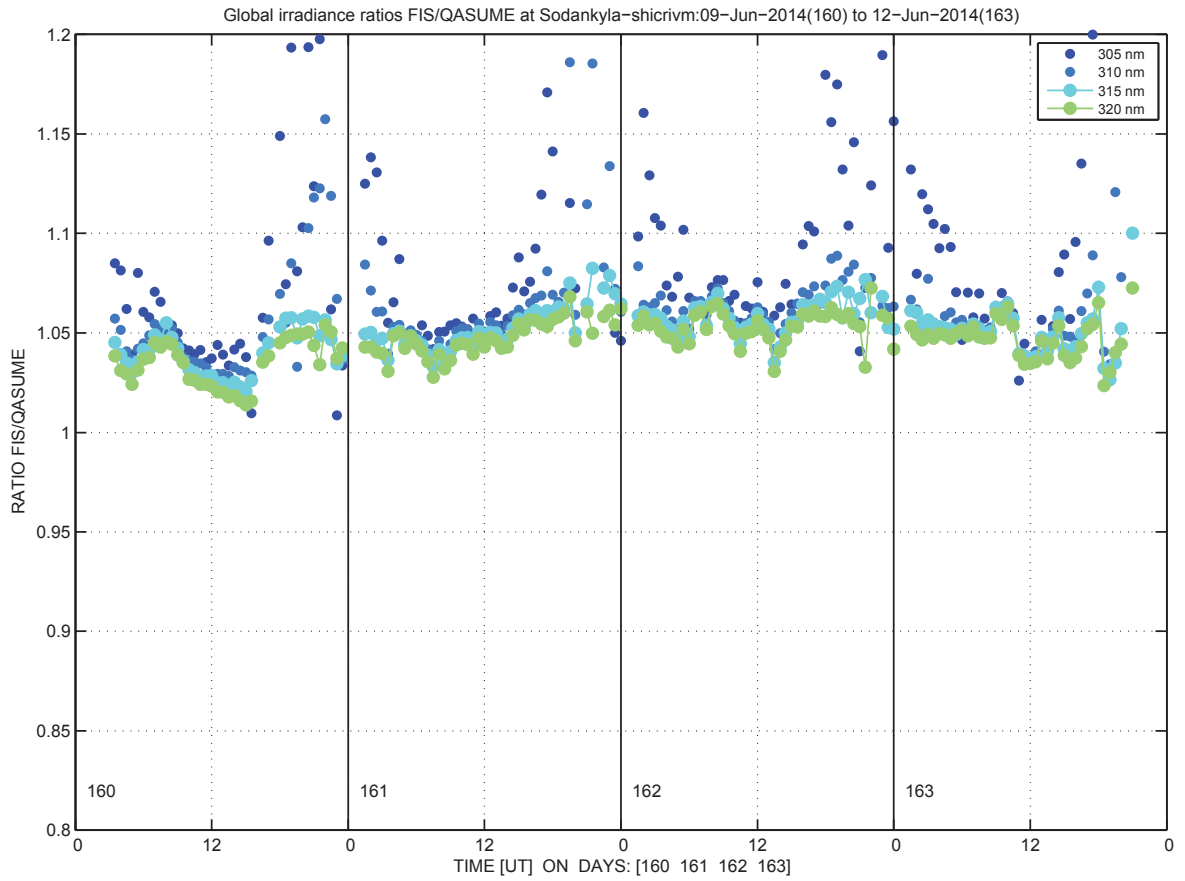
**FMI Operator:** Kaisa Lakkala

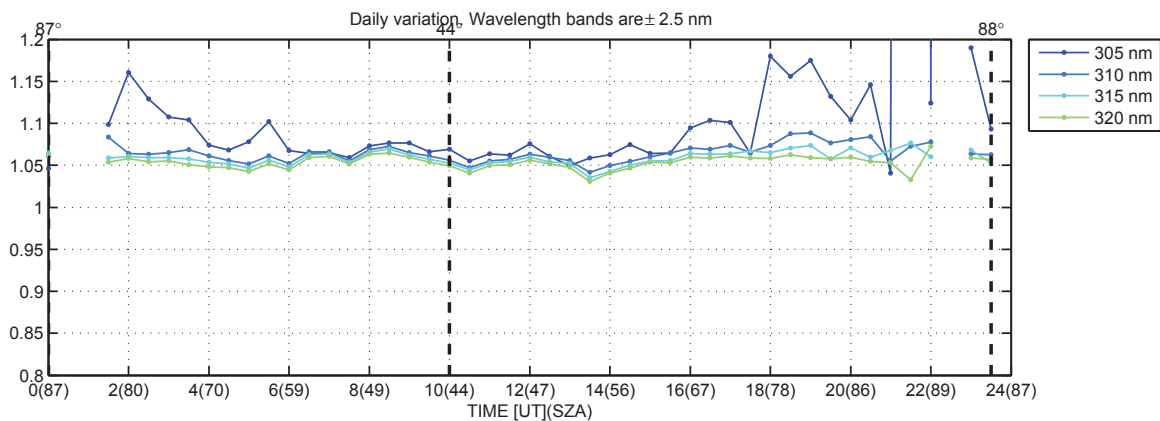
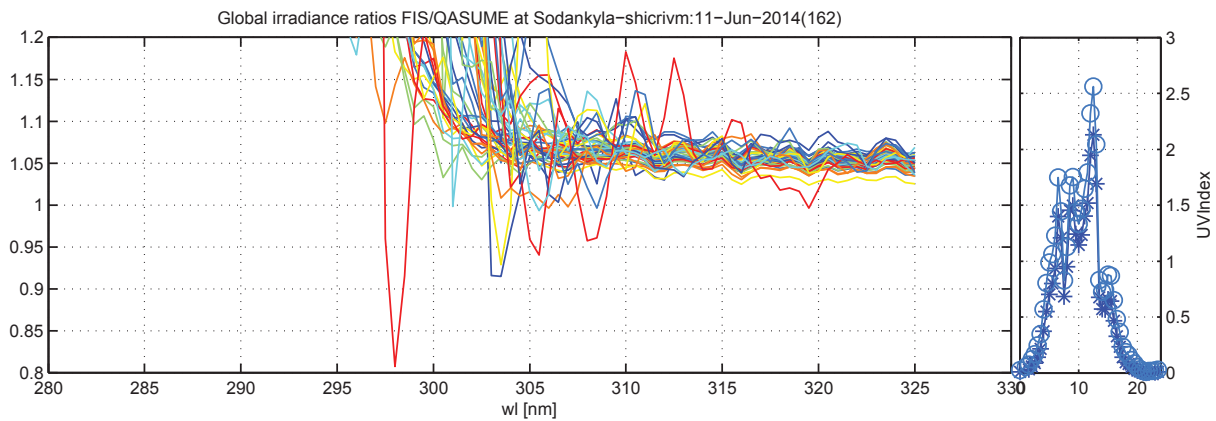
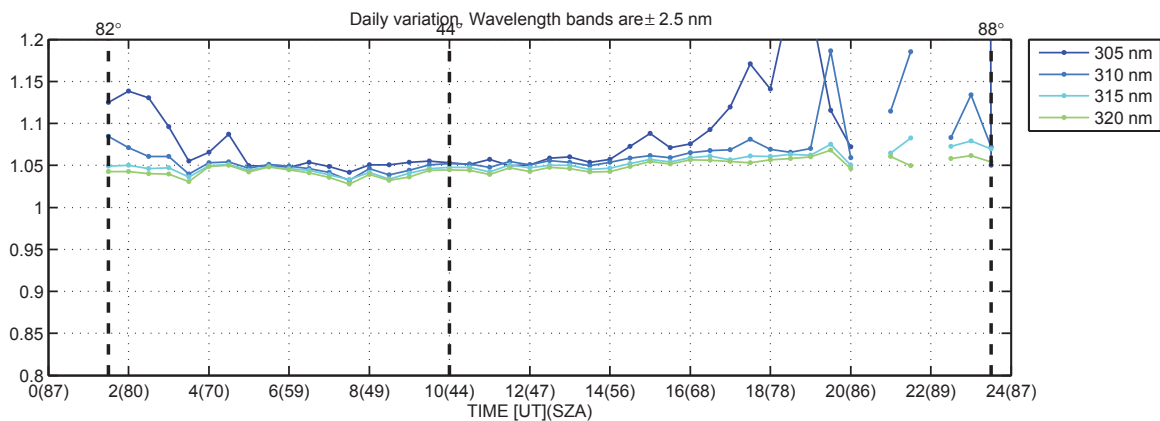
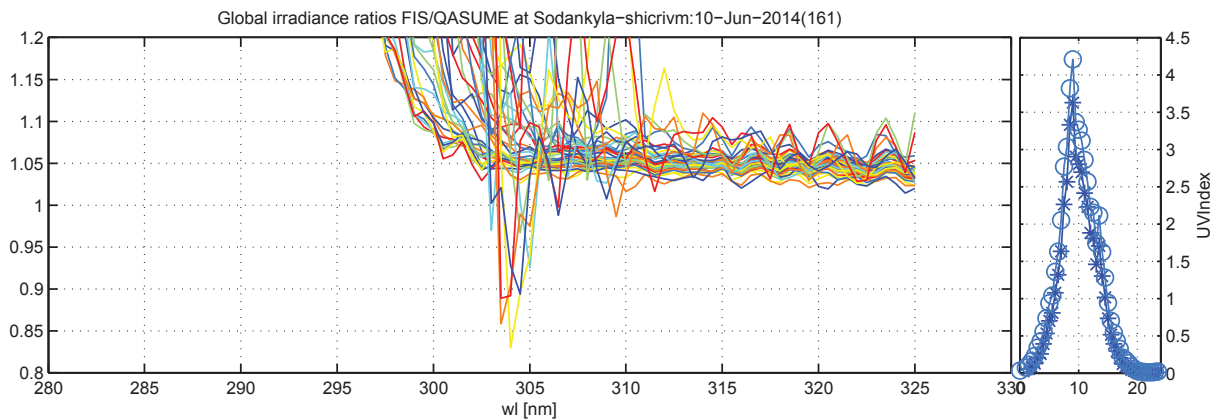
**Comments by the local operator:**

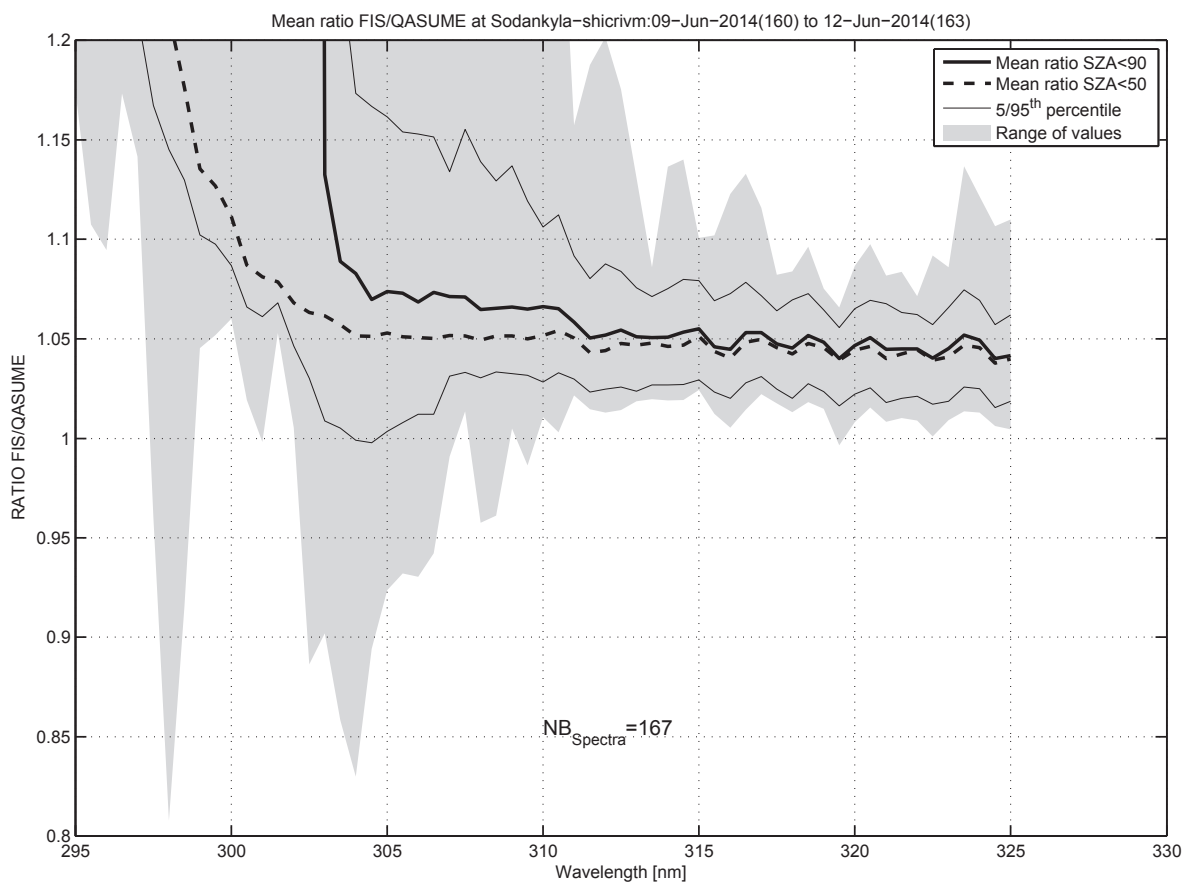
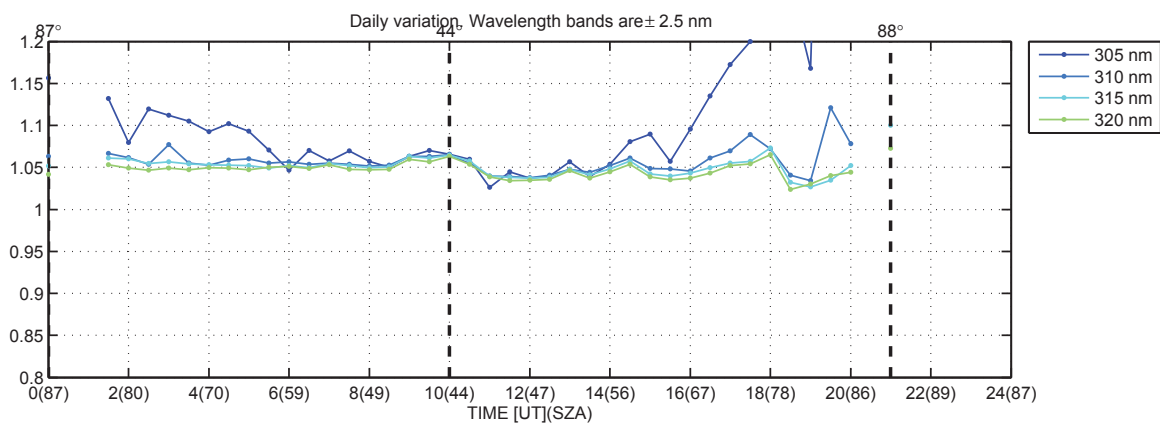
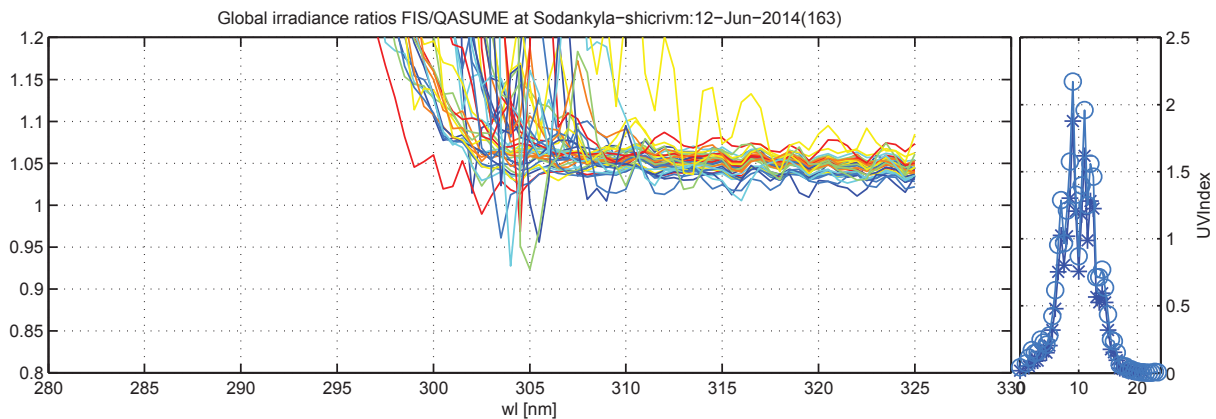
There are no major comments on the graphs and the content of the report.

UV Index Sodankyla, June 2014



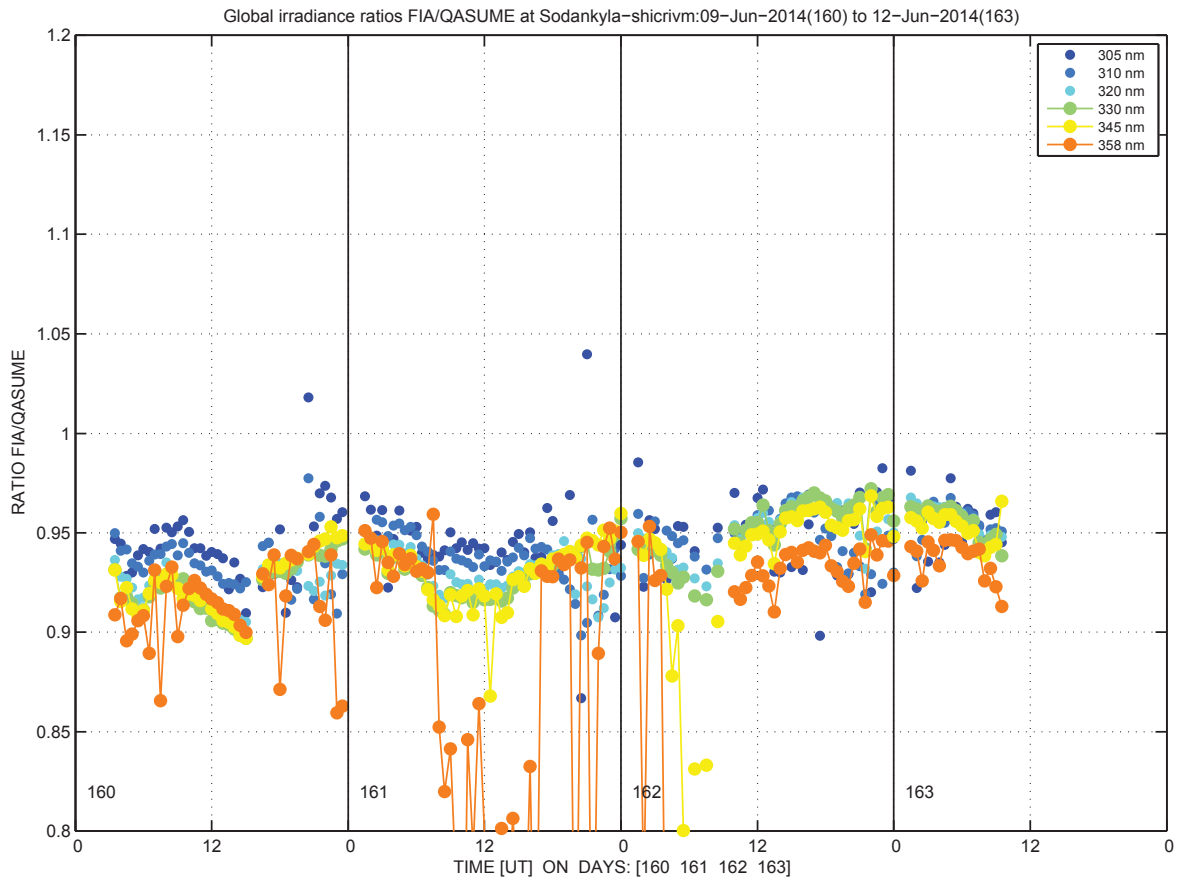
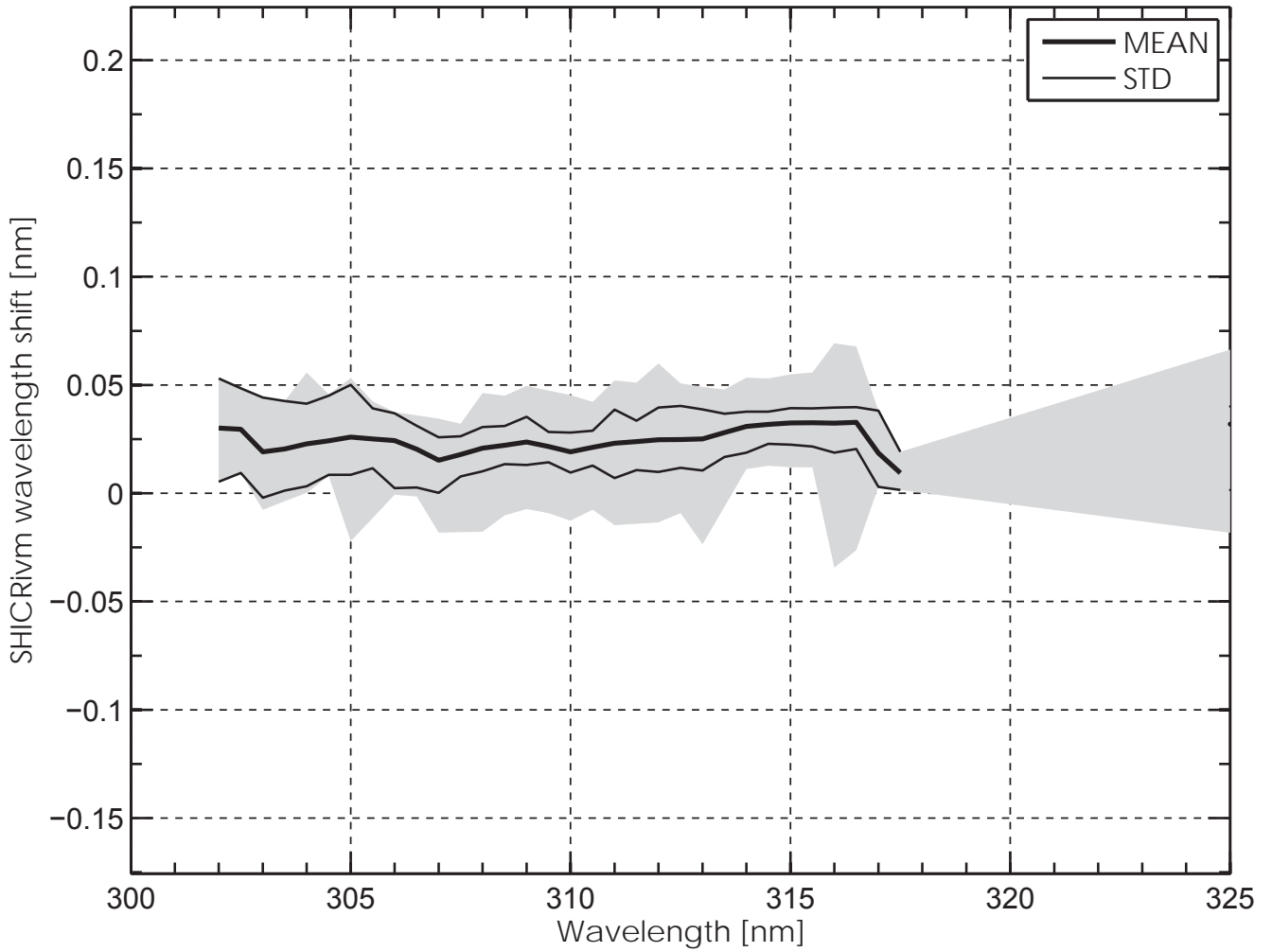


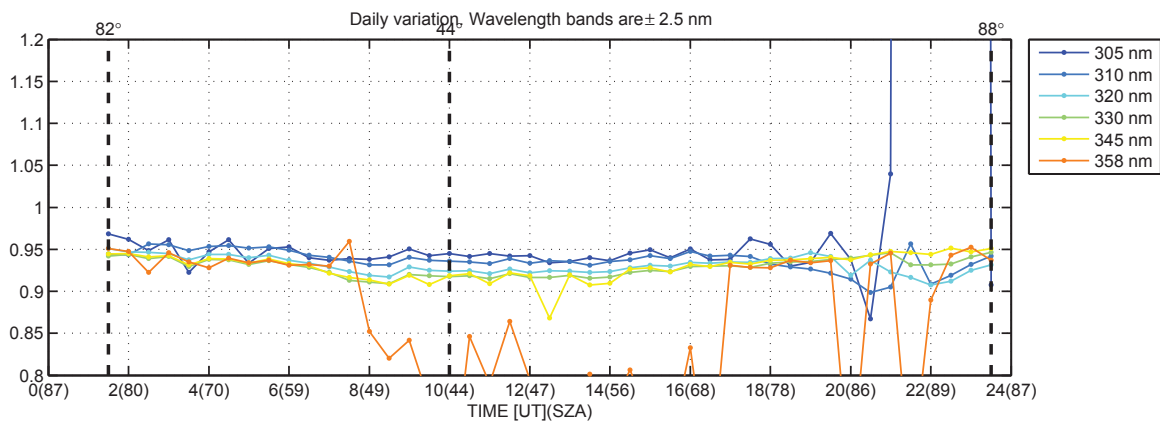
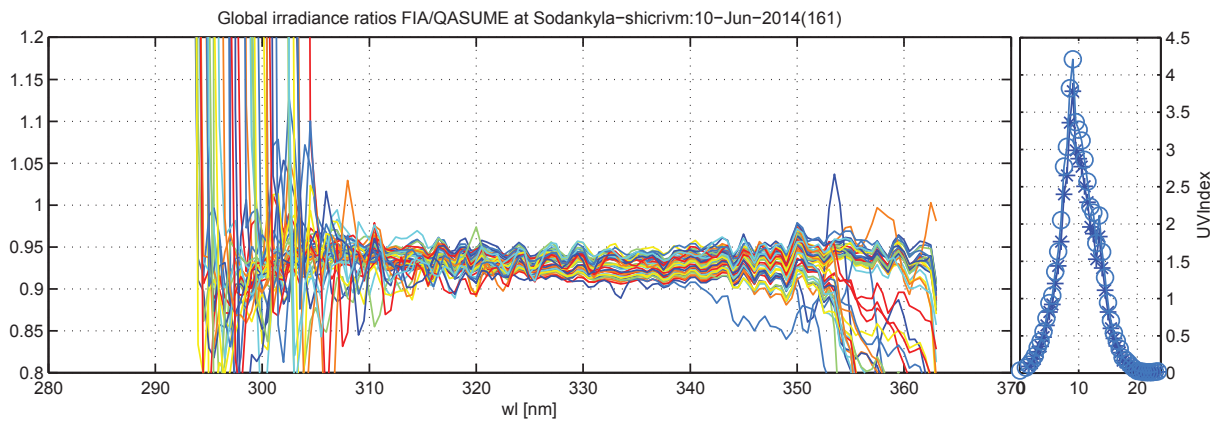
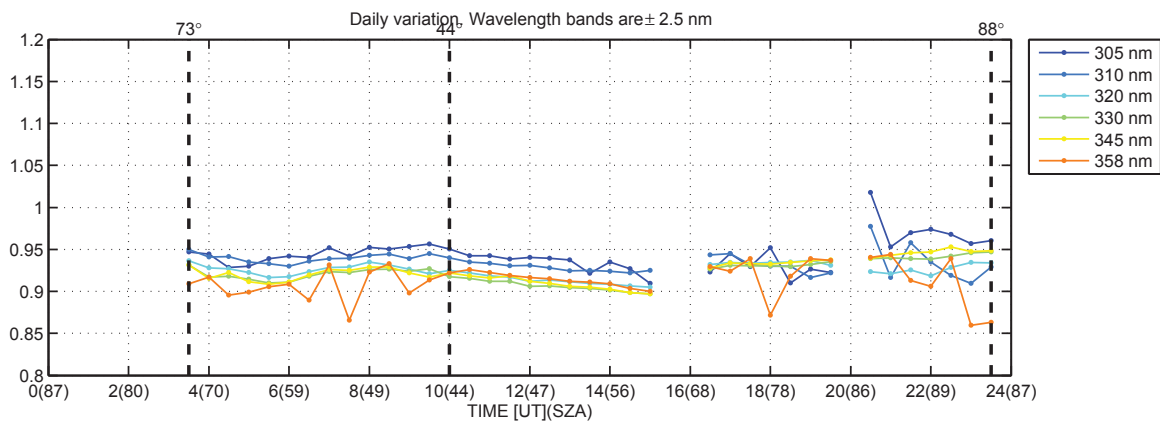
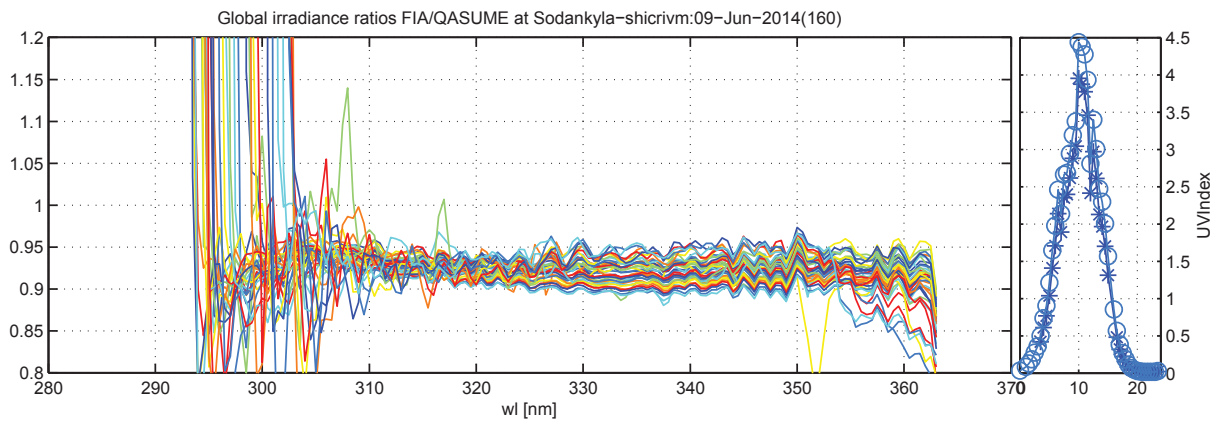


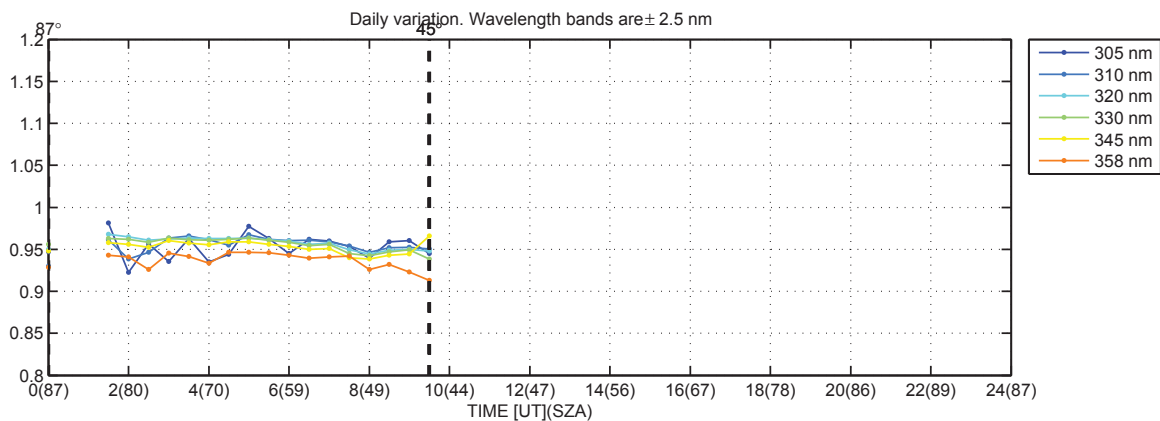
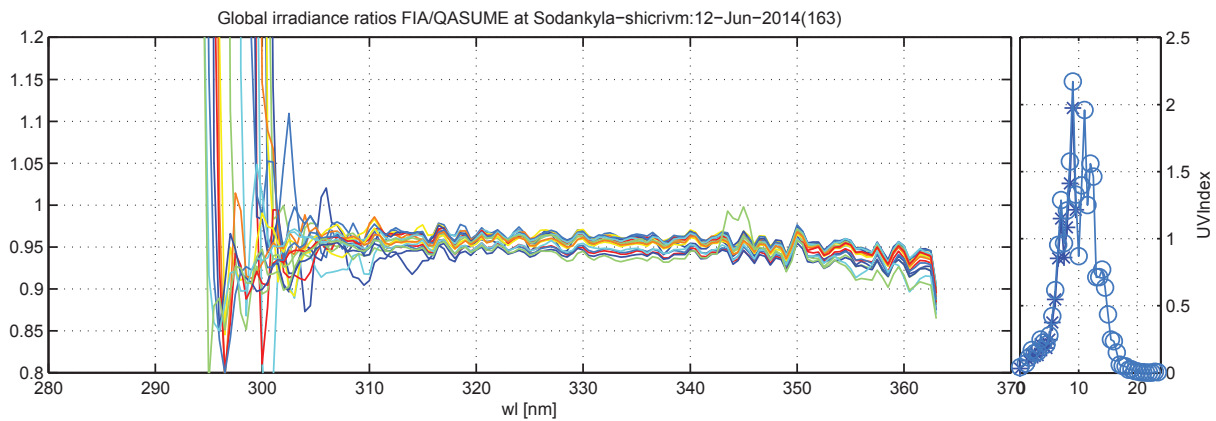
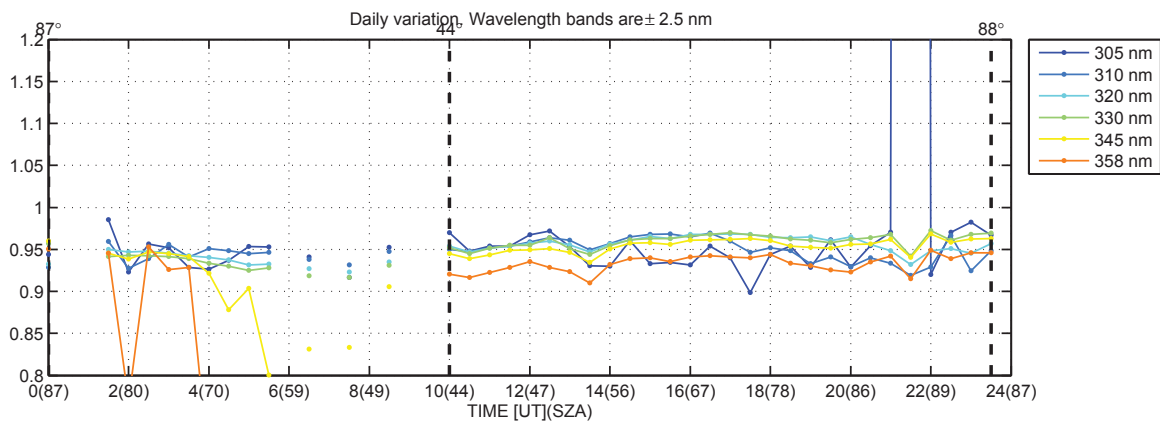
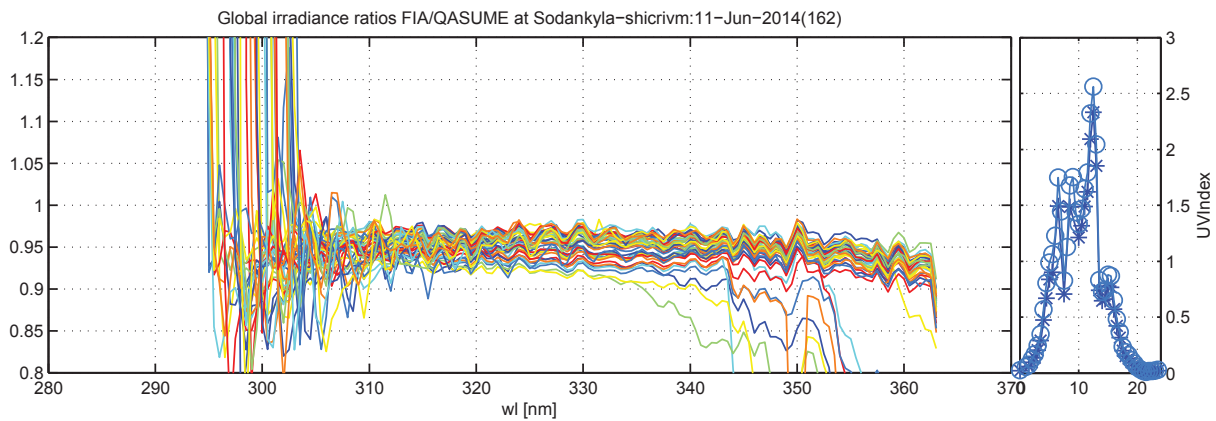


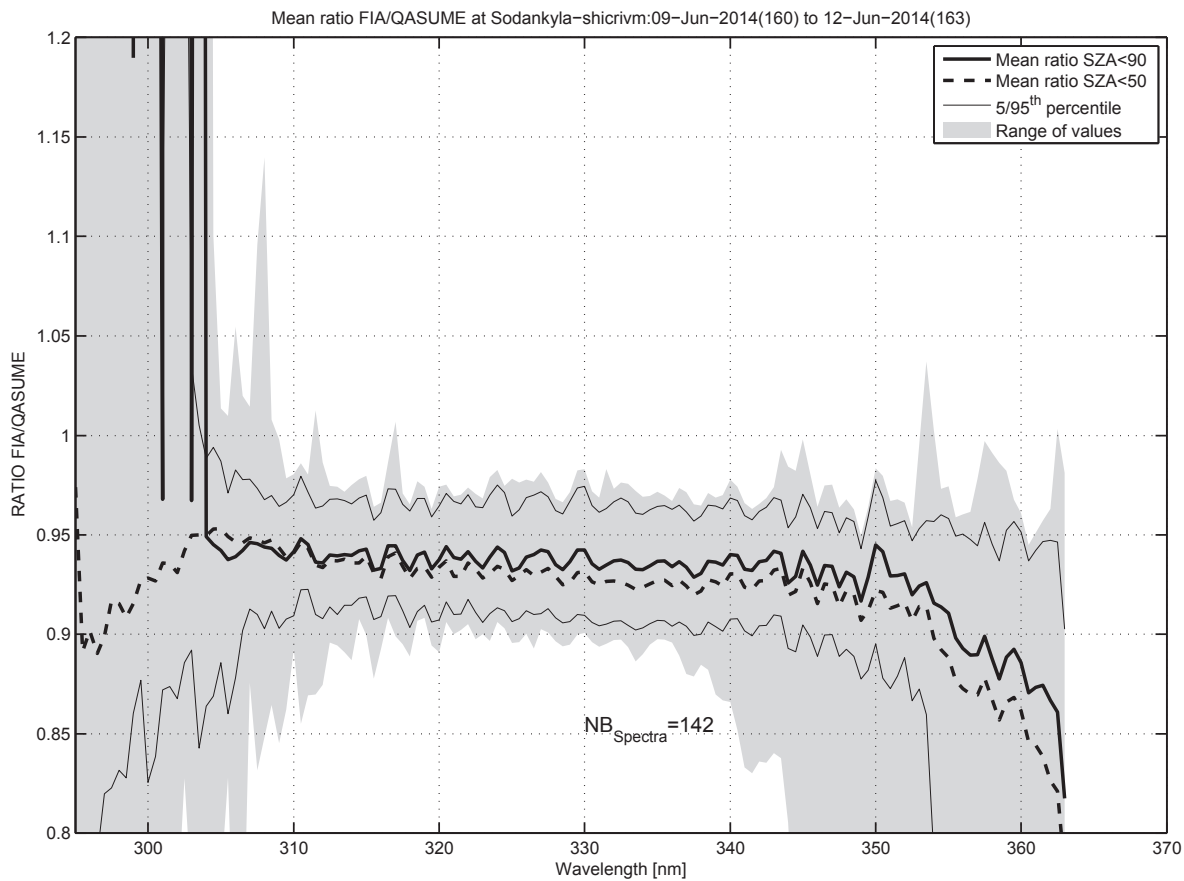


Sodankyla, FIS, June 2014









Sodankyla, FIA, June 2014

