

Protocol of the intercomparison at FMI, Sodankylä, Finland on June 3 to 8, 2018 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 two Brewer spectrophotometer, FIS and FIA operated by the Finnish Meteorological Institute (FMI) and the travel reference spectroradiometer QASUME. In addition, the spectroradiometer TOB from the Tartu Observatory (Tallin) joined the campaign. 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 80° 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 late afternoon of June 3, 2018. 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 Spectroradiometer TOB is a Bentham DM150 with a D6_ENV entrance optic. The intercomparison between QASUME and the spectroradiometers lasted five days, from early morning of June 4th to the evening of June 8th.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T61573 and T68522) 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 $\pm 0.5\%$ during the intercomparison period. The internal temperature of QASUME was $25.63 \pm 0.07^\circ\text{C}$ and the diffuser head was heated to a temperature of $28.65 \pm 0.63^\circ\text{C}$.

The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the matshic 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 3.0 seconds between each wavelength increment. Qasume and TOB 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)
154	03. Jun	Sunday	Overcast, rain	Installed at 18:00
155	04. Jun	Monday	Overcast, rain	15:45 calibration (T68522)
156	05. Jun	Tuesday	Mostly overcast, some rain	13:46 calibration (T68522)
157	06. Jun	Wednesday	Mostly overcast, rain drops and snowflakes	
158	07. Jun	Thursday	Mostly overcast some rain	8:30 calibration (T68522) 9:00 calibration (T16573)
159	08. Jun	Friday	Mostly overcast	8:30 calibration (T68522)
				End of Campaign: 17:15

Results:

In total 140 (FIS), 146 (FIA) and 90 (TOB) synchronised simultaneous spectra from QASUME and FIS/FIA/TOB are available from the measurement period. Measurements between 2:00 and 22:00 UT have been analysed (SZA smaller than 90°).

Remarks:

FMI delivered two datasets for the FIS and three for the FIA Brewer. They differed by the way of processing the data. They were labelled as follows:

FIS: FMI standard processing (Lakkala et al. 2008, Mäkelä et al. 2017, Lakkala et al. 2018).

FIS1: same as FIS, but temperature correction changed to Fountoulakis et al. (2017).

FIA: FMI standard processing without temperature correction (Lakkala et al. 2005, Lakkala et al. 2018).

FIA1: same as FIA but including temperature correction from Fountoulakis et al. 2017.

FIA2: same as FIA1, but the cosine correction method was slightly modified".

The dataset used for the calibration report are FIS and FIA1.

I. FIS:

1. The ratios between FIS and QASUME have on average an offset of +1% for wavelengths longer than 310 nm.
2. Below 310 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 the diurnal dependence of the cosine correction could not be studied.
4. The wavelength shifts are stable to better than ± 25 pm and the average of the wavelength shifts is spectrally almost constant at about 20 pm.

II. FIA:

1. The ratios between FIA and QASUME have on average an offset of +2 % for wavelengths longer than 305 nm. A small spectral dependency can be observed (5 % at 305 nm to 1 % at 360 nm).
5. The diurnal variation of the FIA to QASUME ratio is less than 2 %. However, due to overcast weather conditions the diurnal dependence of the cosine correction could not be studied.
2. The wavelength shifts are stable to better than ± 25 pm and the average of the wavelength shifts is spectrally almost constant at about -20 pm.

III. TOB:

1. The data of TOB were processed using a slit function derived from a Mercury lamp spectrum. Due to the large slit width of 2.27 nm the slit function was calculated using the 366 nm peak. The normalisation to a nominal 1 nm triangle slit function results in noise free comparison between TOB and QASUME in this wavelength range, but a high variability for lower wavelength.
2. The ratios between TOB and QASUME have on average an offset of -2 % for wavelengths longer than 305 nm.
3. The diurnal variation of the TOB to QASUME ratio is around 5 %. As the overcast weather conditions hide a possible cosine error, the reason for the variability is unknown.
4. The wavelength shifts are stable within ± 50 pm and the average of the wavelength shifts around -700 pm with a spectrally dependency (-800 pm at 320 nm to -600 pm at 390 nm).

Summary:

To investigate the performance and data processing algorithm of the FMI Brewers in depth, measurements under cloud free conditions are needed in addition the overcast conditions. The ratio of the FIS Brewer to the reference differs now by +2 % - in contrast to the +5 % seen all previous intercomparisons.

The comparison result of the TOB instrument suffers first from the bad slit function derived several months after the campaign. A slit function measurement using a HeCd Laser is recommended. The reason for diurnal variability could not be found because of the overcast sky situation.

FMI Operator: Kaisa Lakkala

TOB Operator: Margit Aun and Ilmar Ansko

Comments by the local operator:

FMI: The cosine correction of FIS and FIA are 11% and 9%, correspondingly, when sky radiation distribution is "all diffuse". During the campaign, even if there were not clear sky days, the cosine correction varied between 7% and 11%, depending on wavelengths, cloud optical depth and SZA for FIA. This variation was due to the detected changes in cloud optical depth due to changing cloud conditions during the scans.

References:

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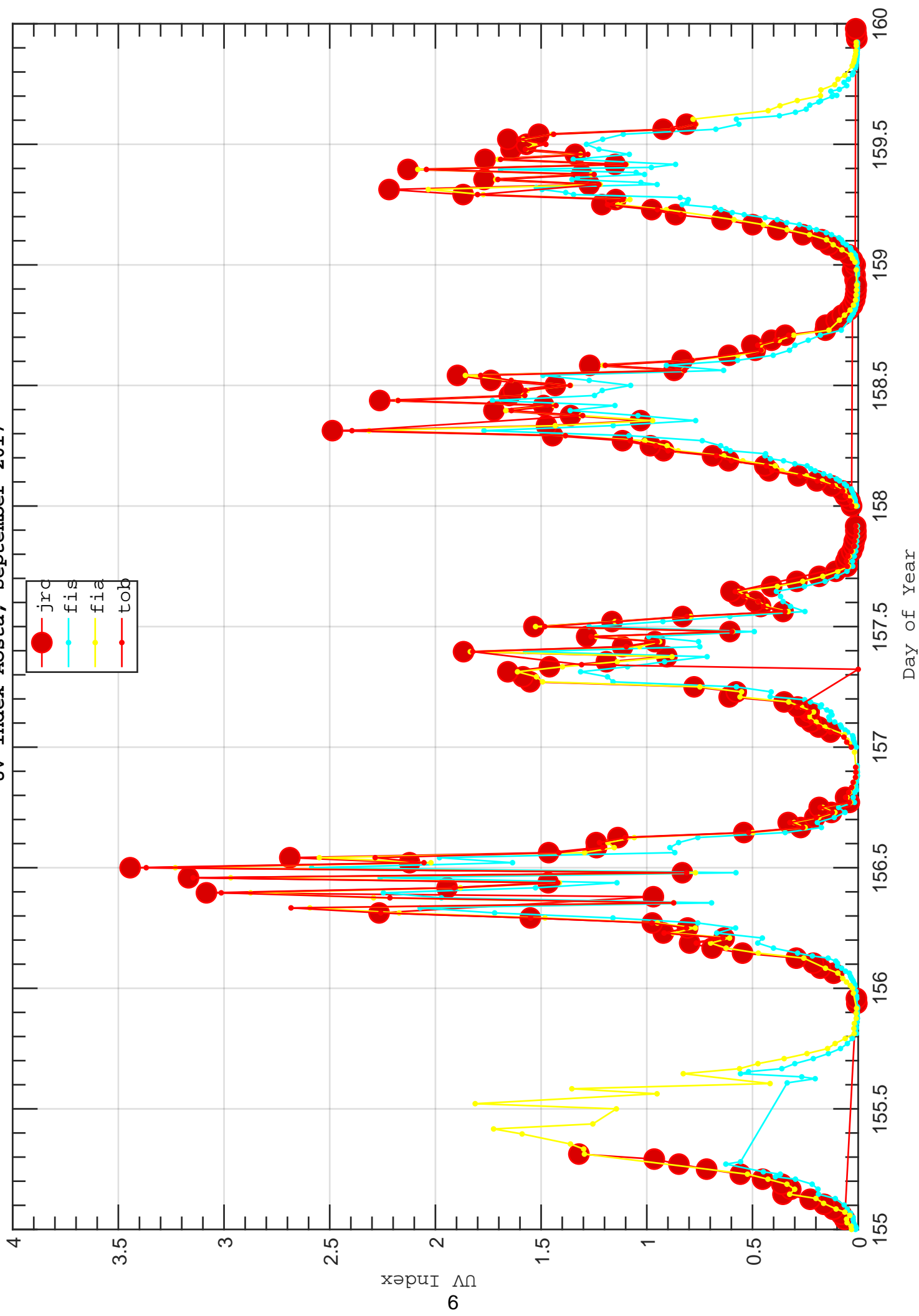
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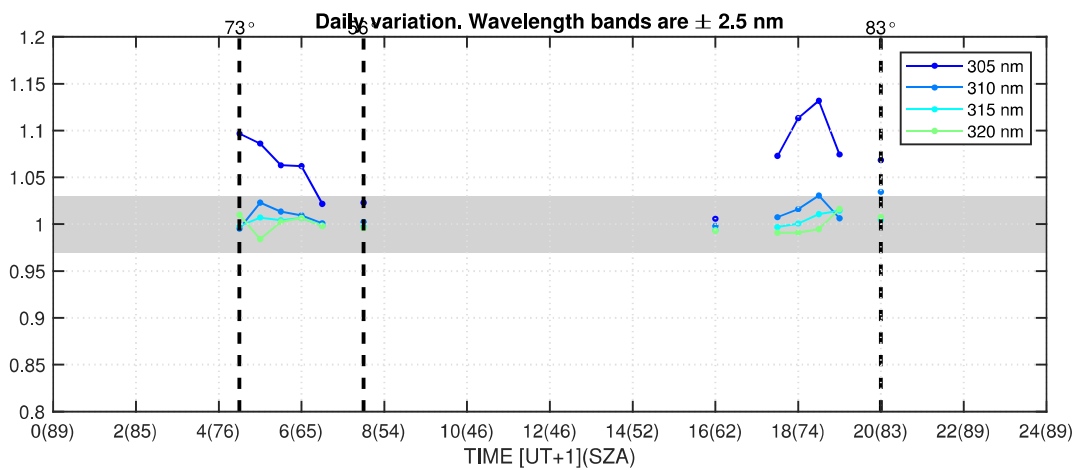
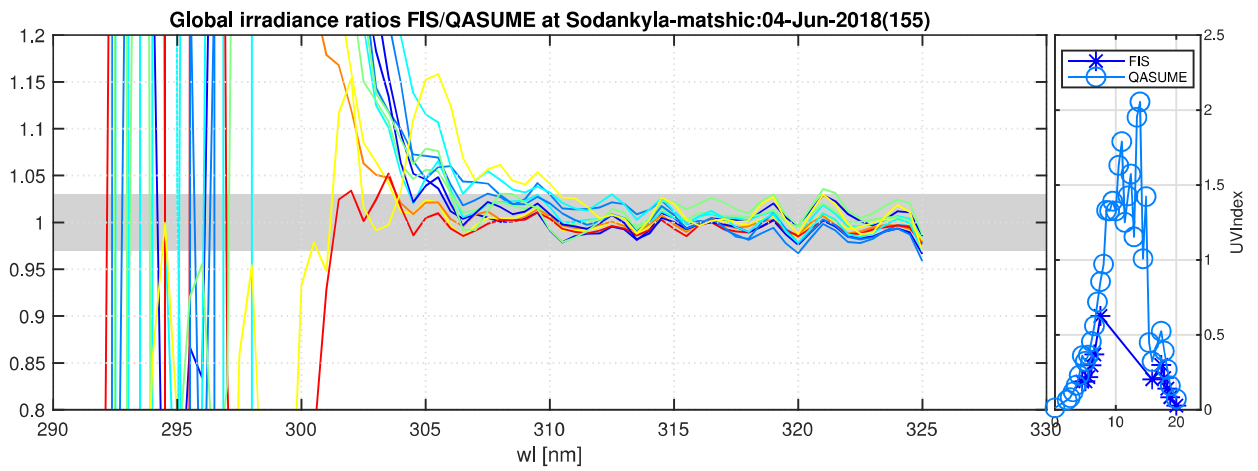
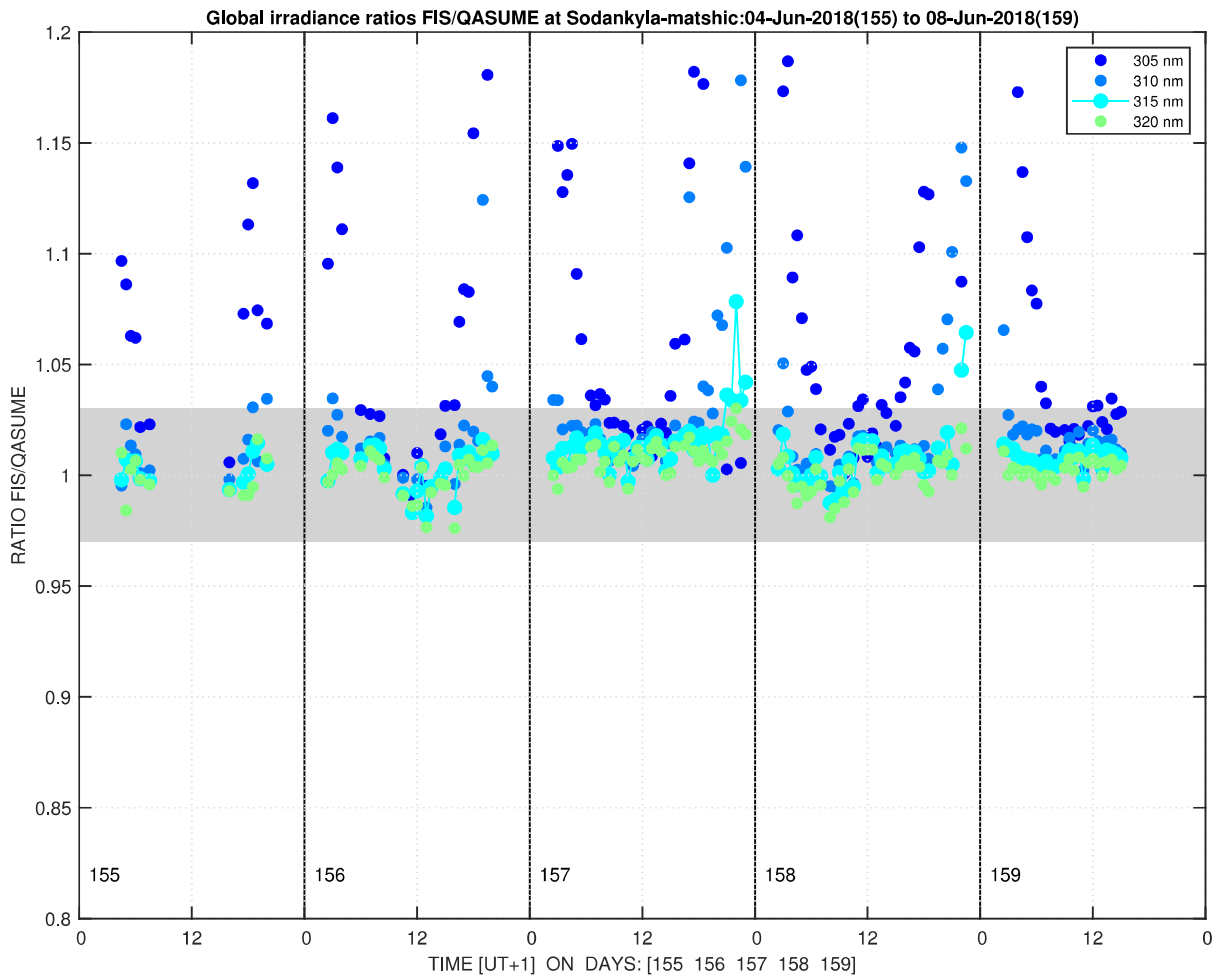
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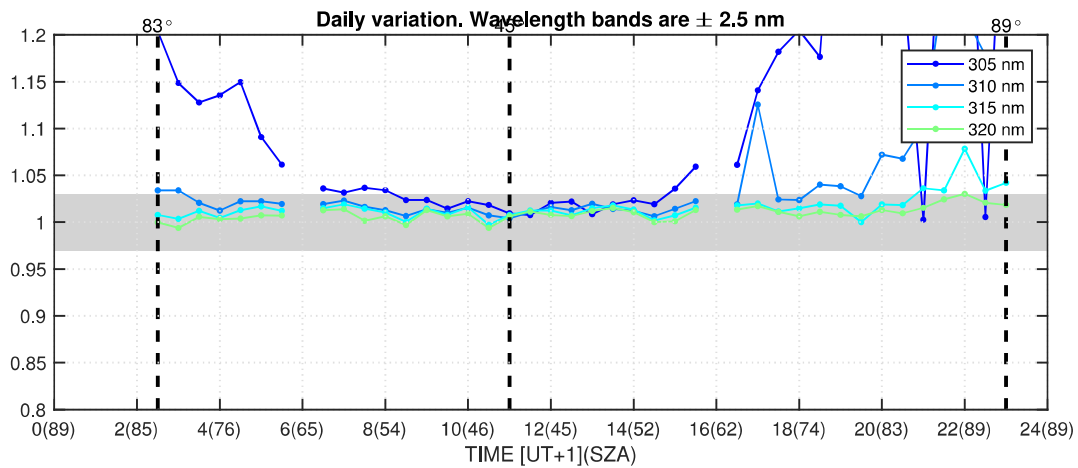
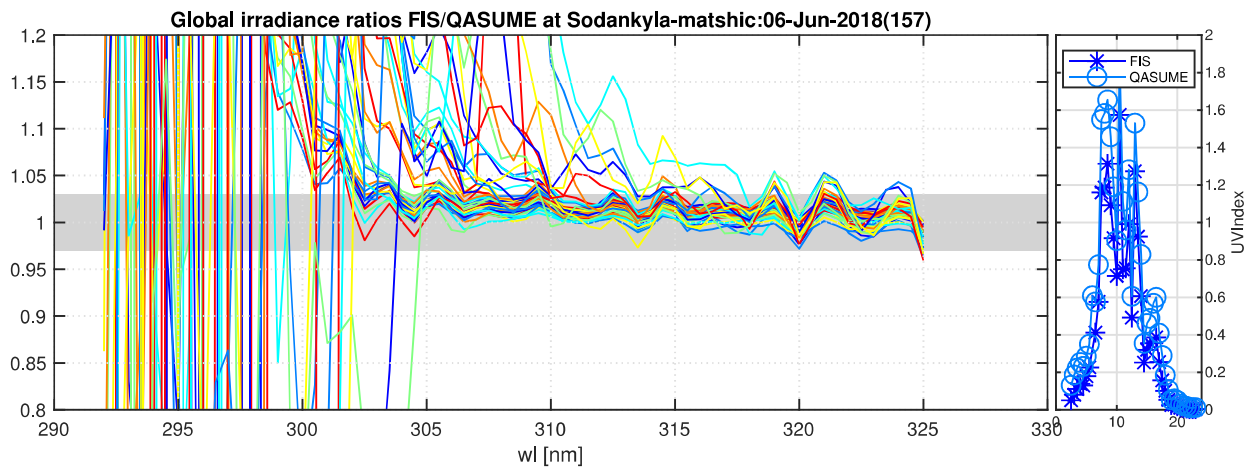
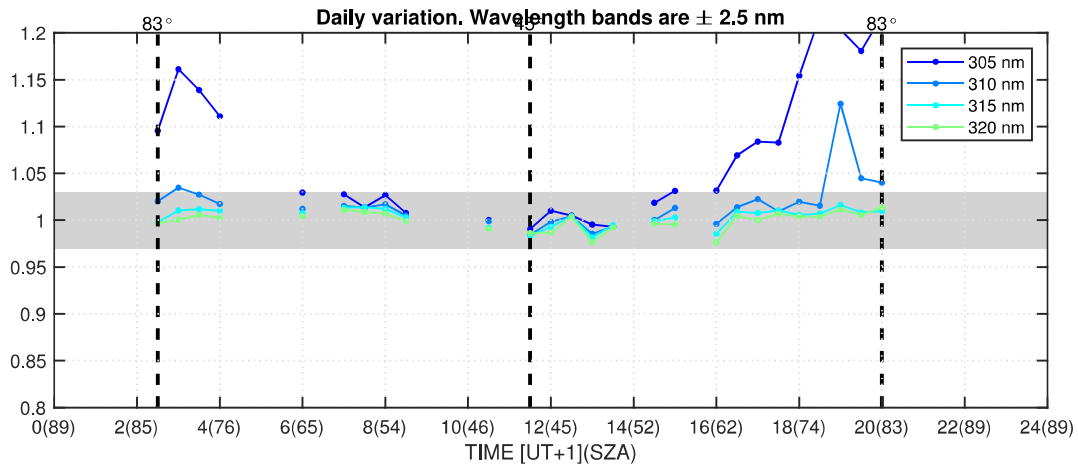
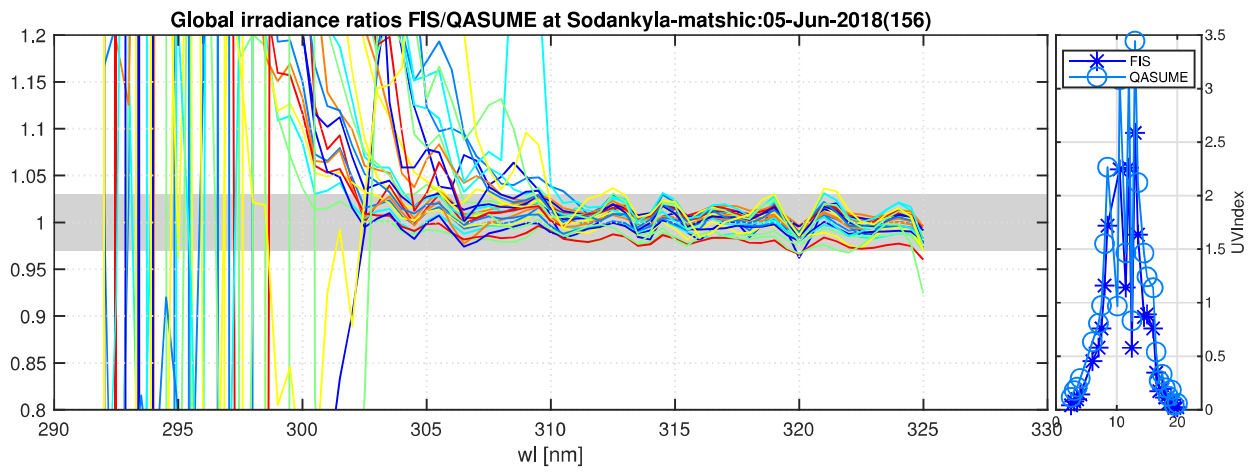
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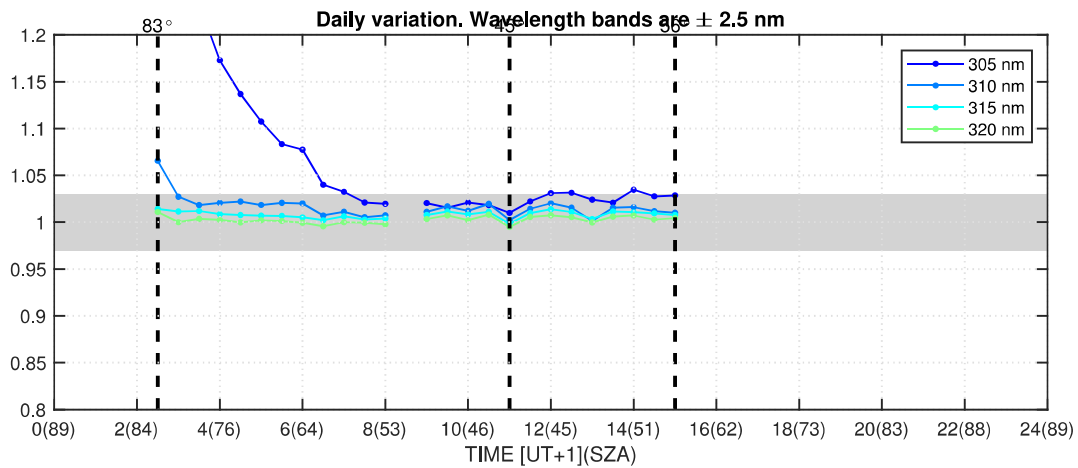
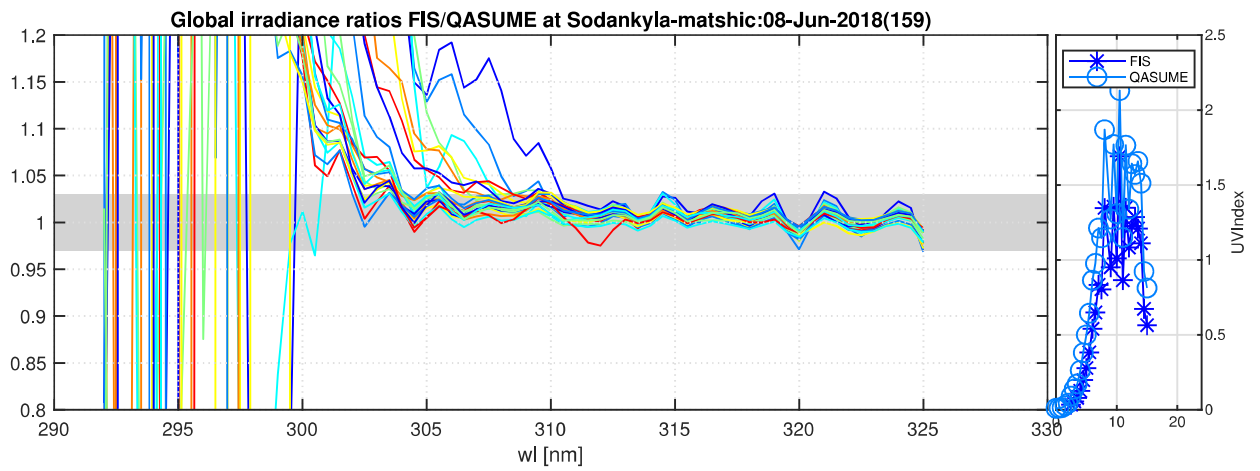
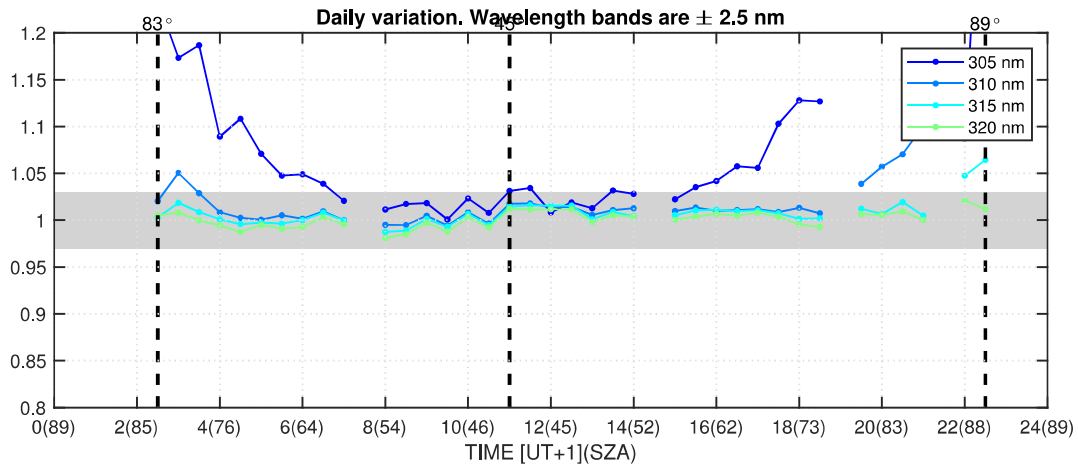
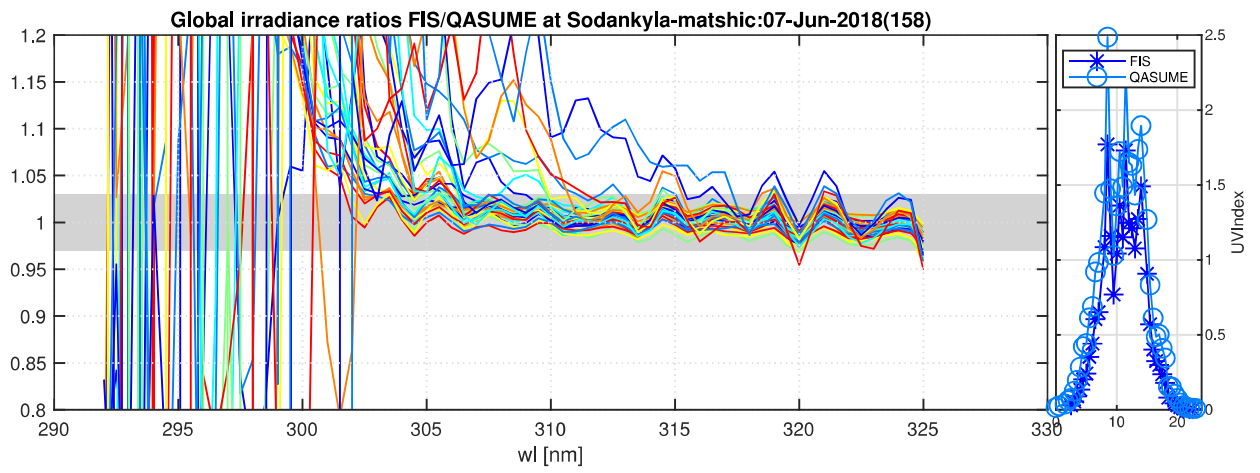
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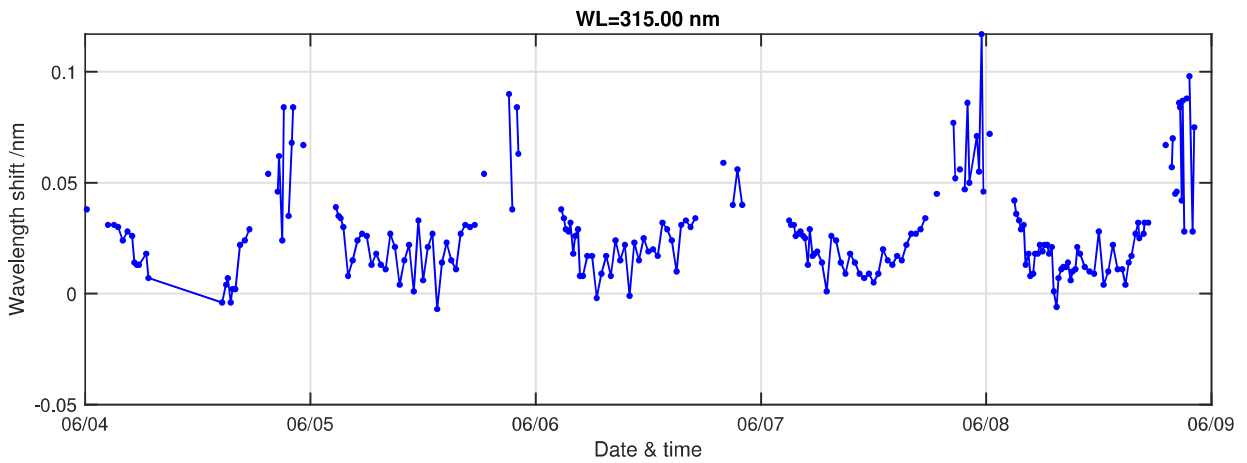
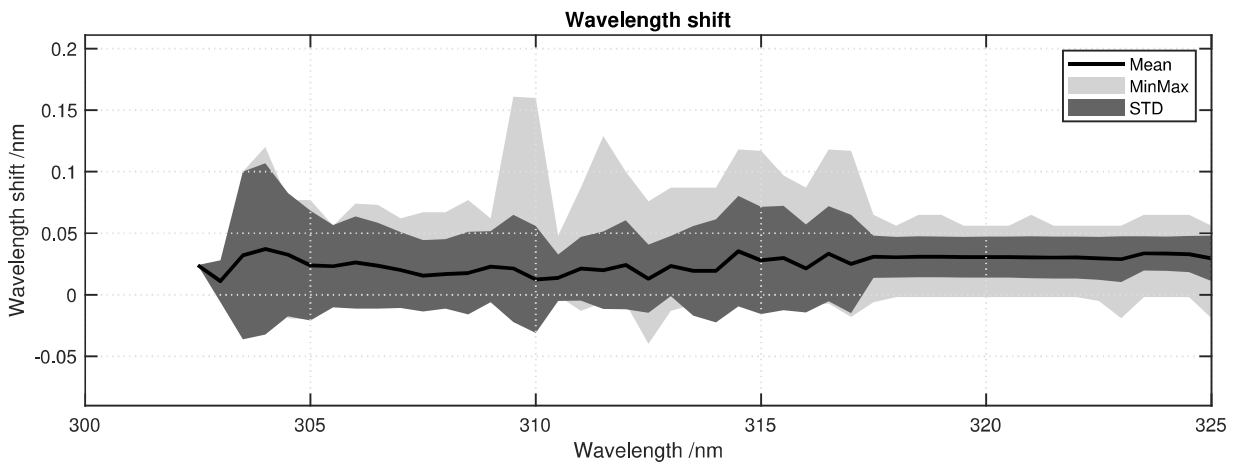
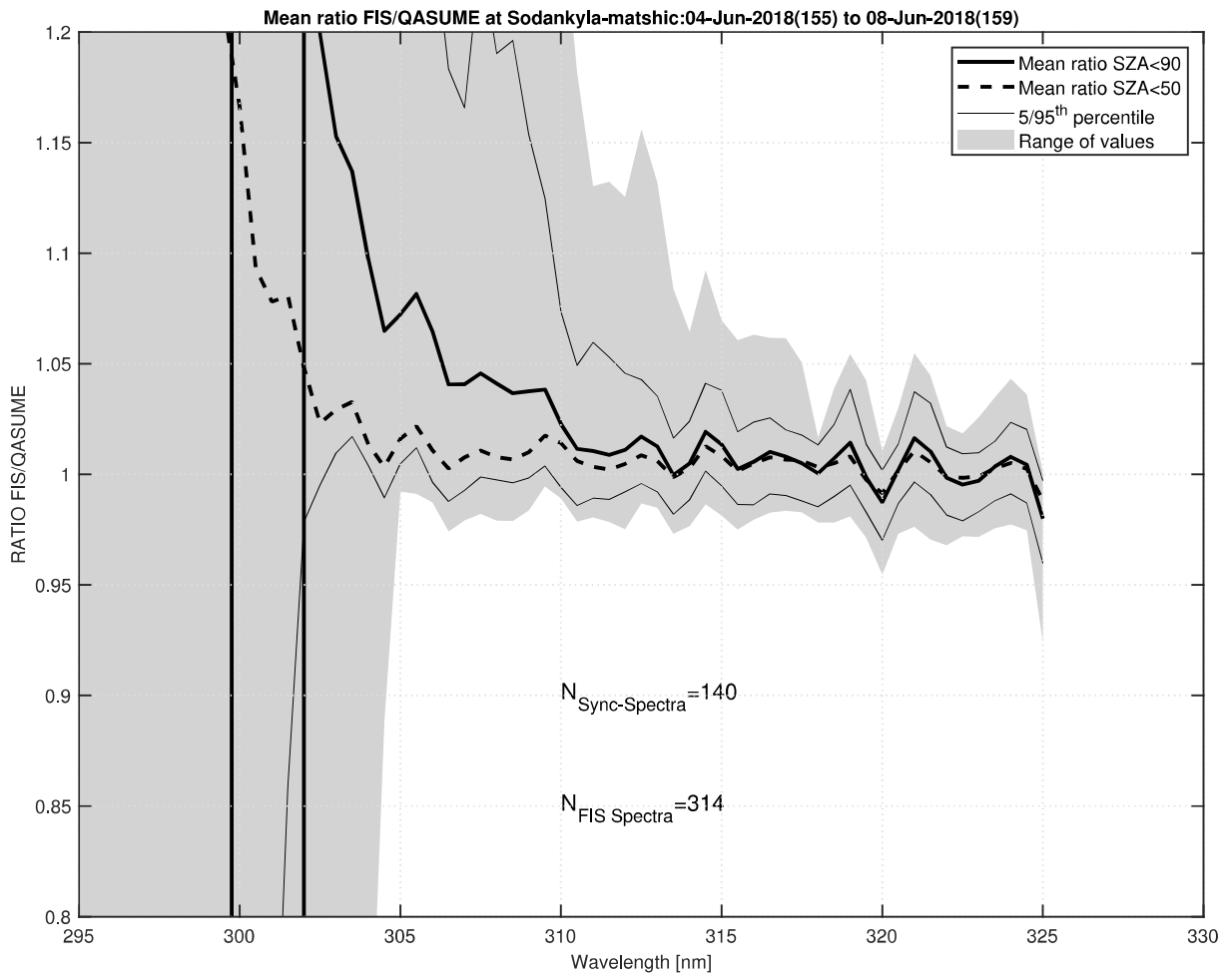
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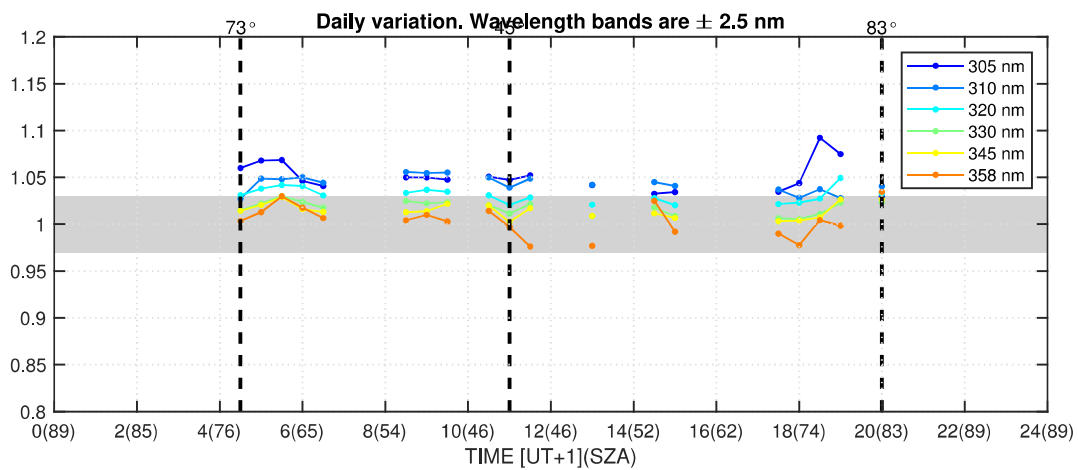
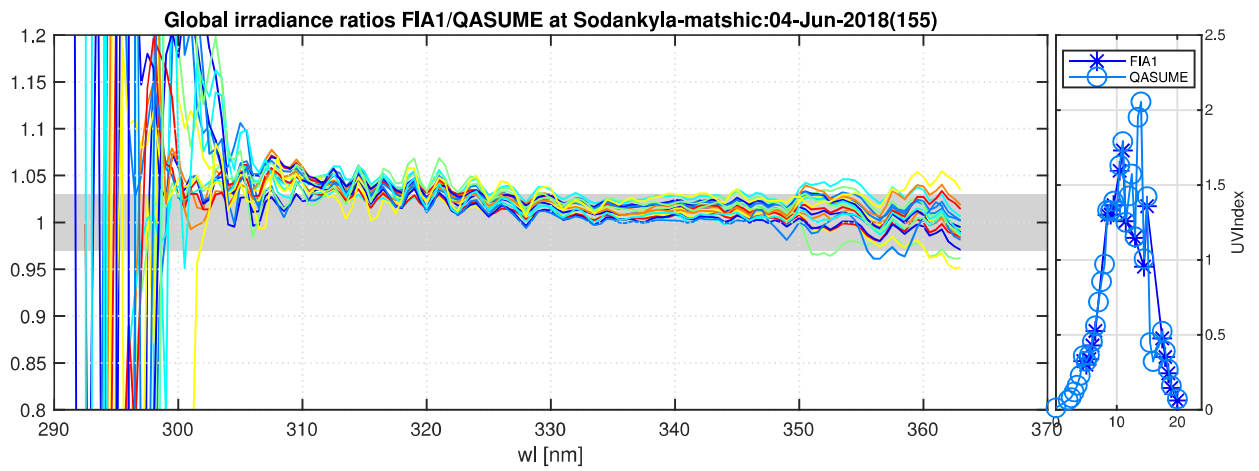
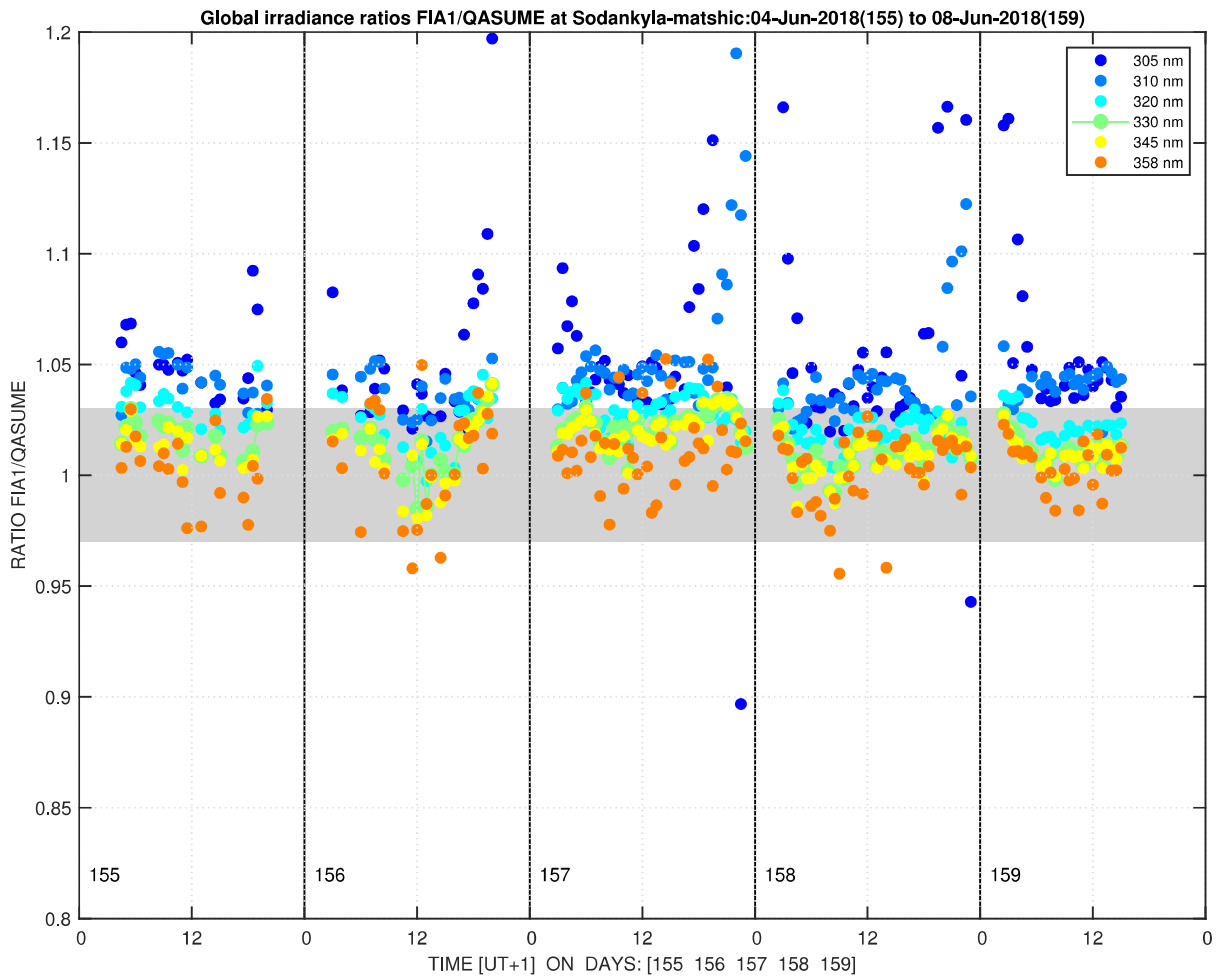


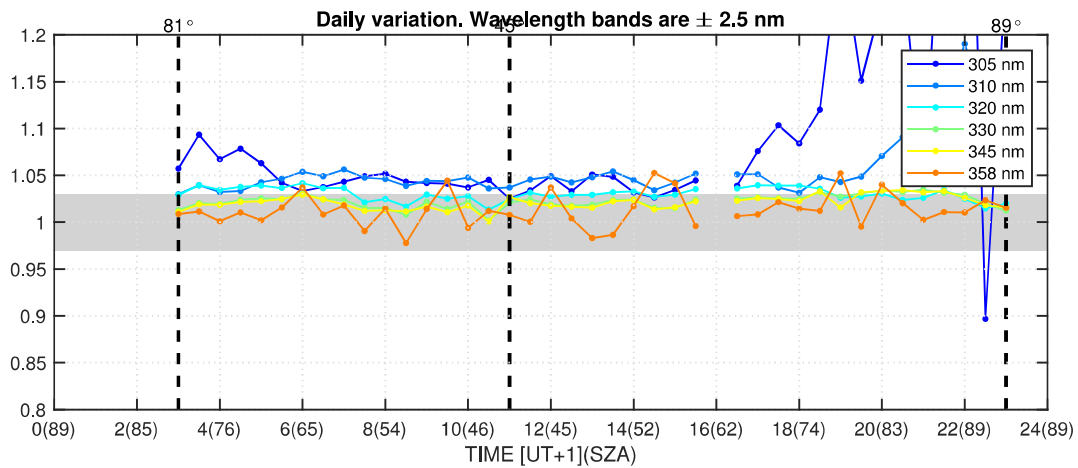
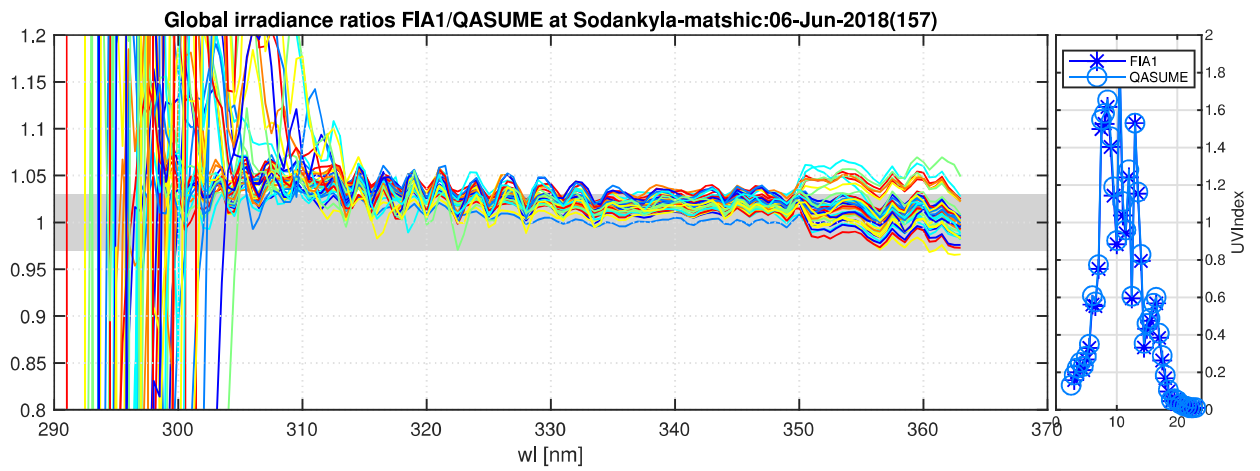
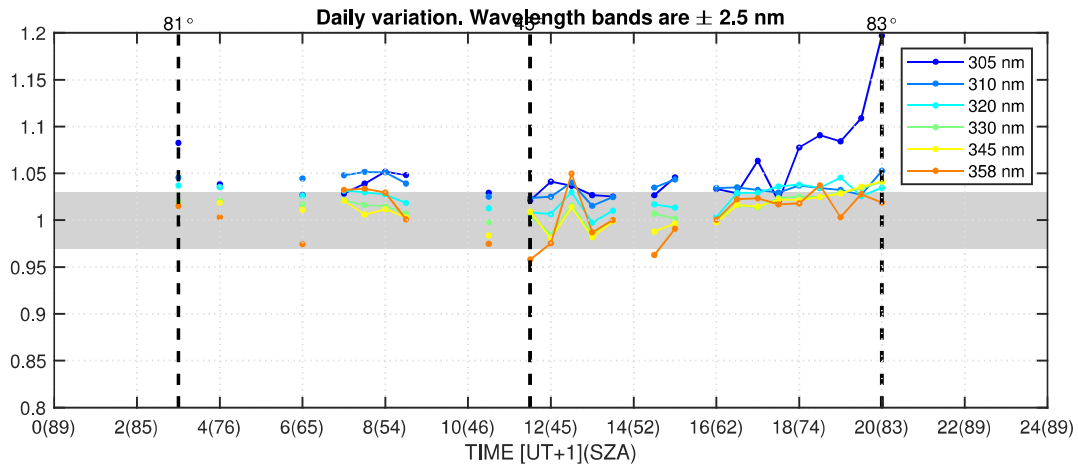
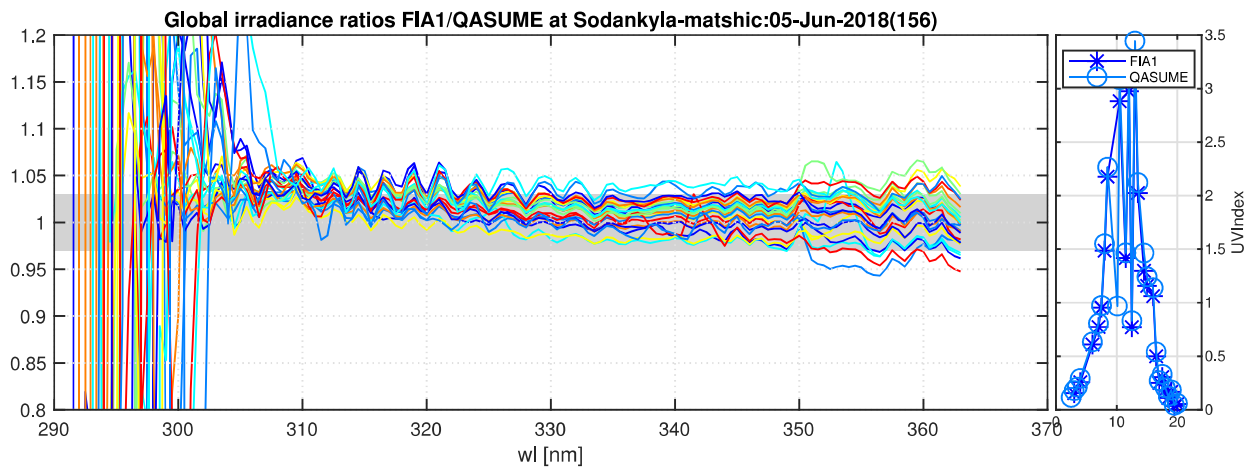


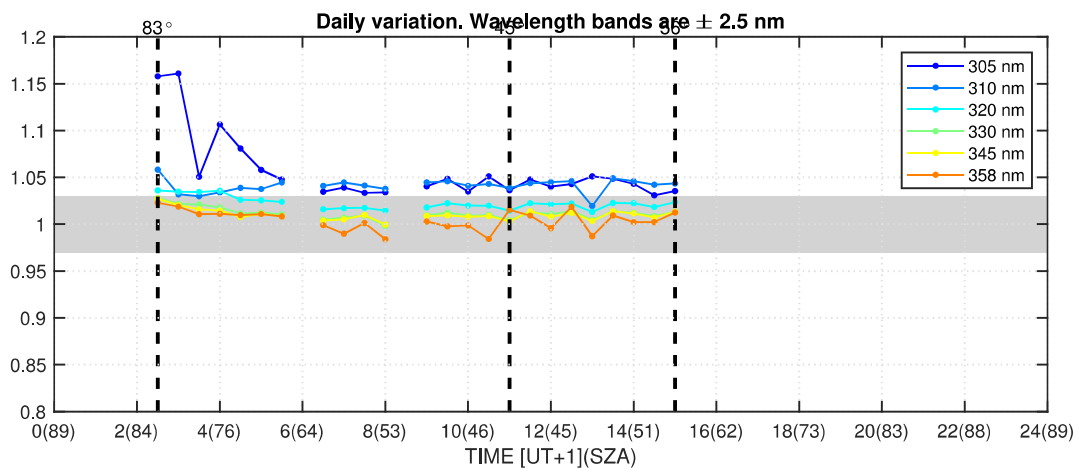
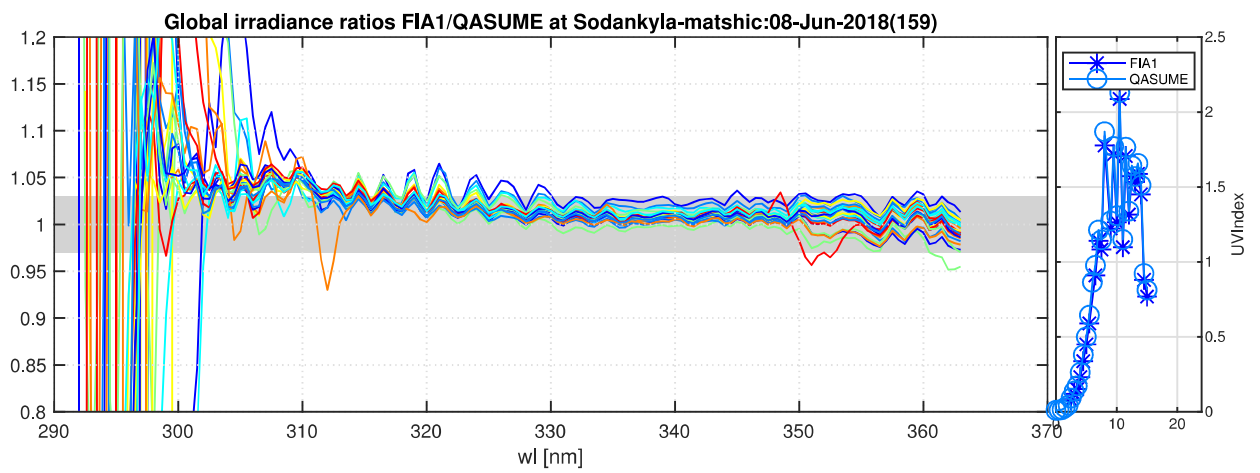
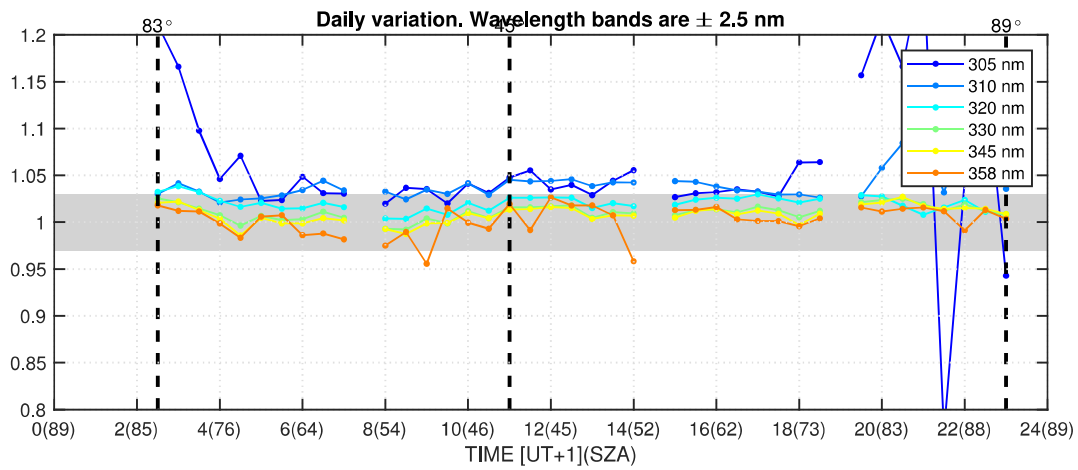
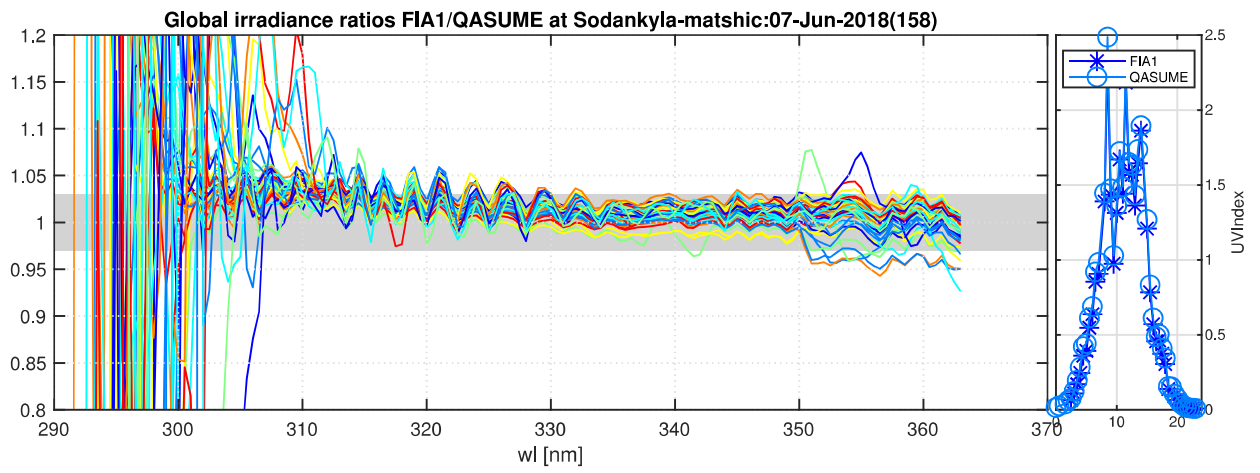


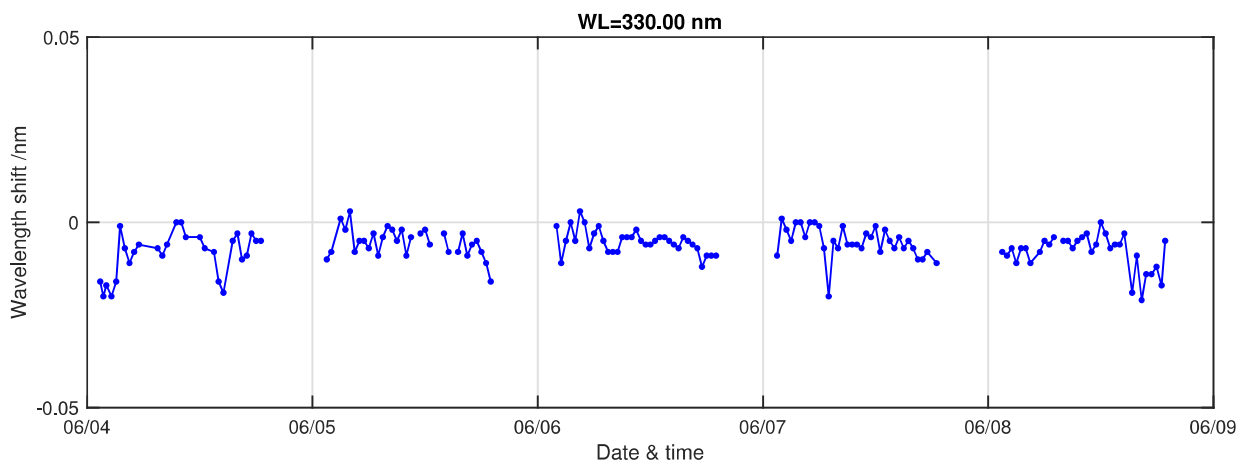
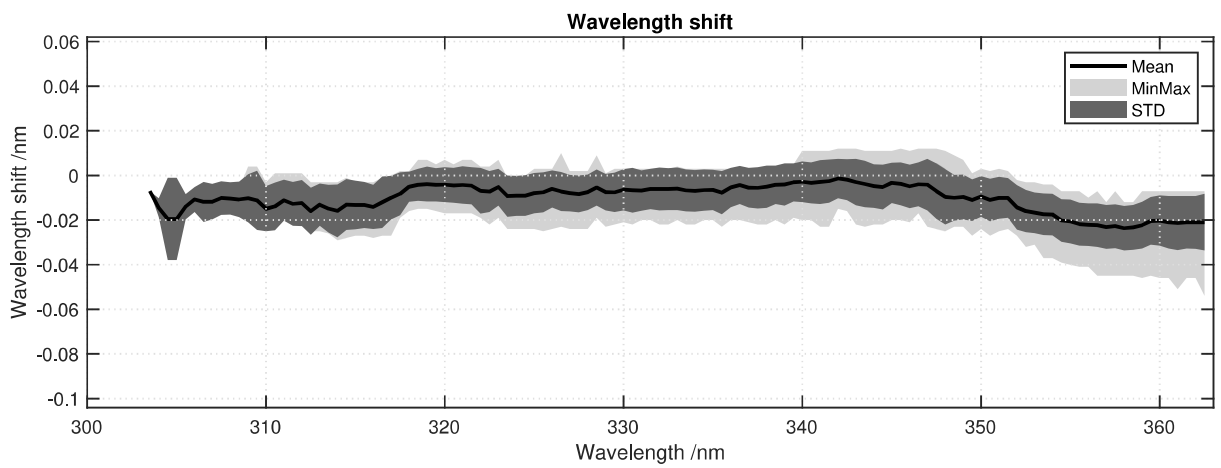
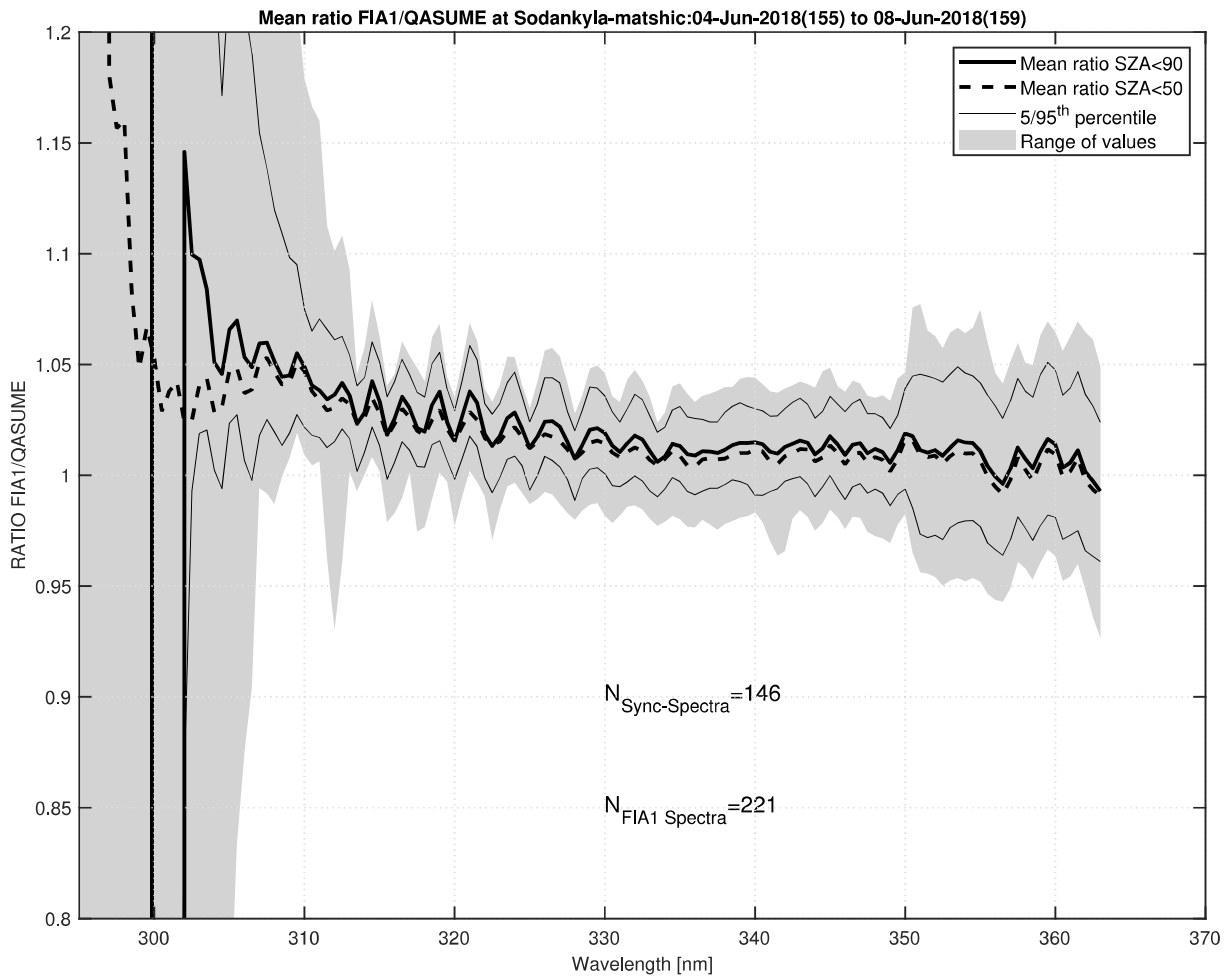


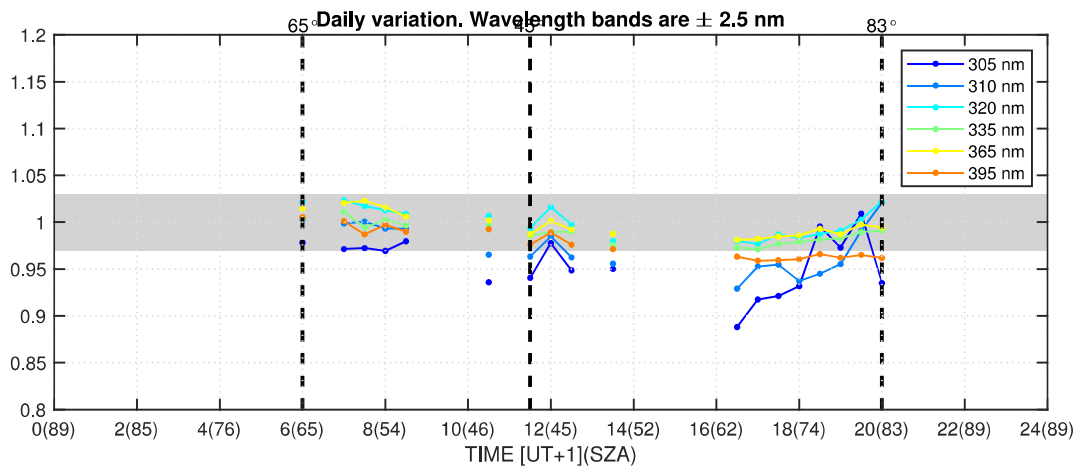
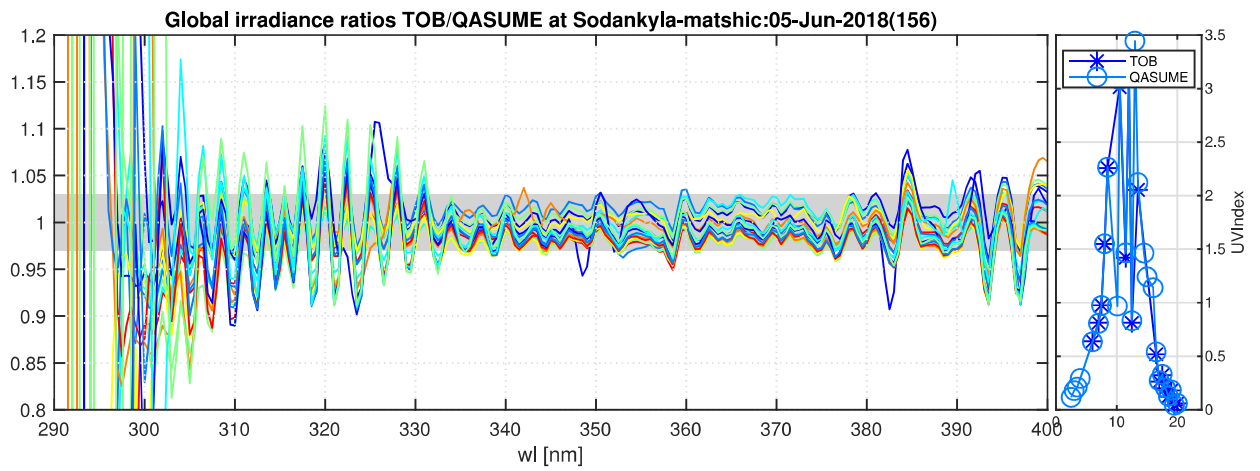
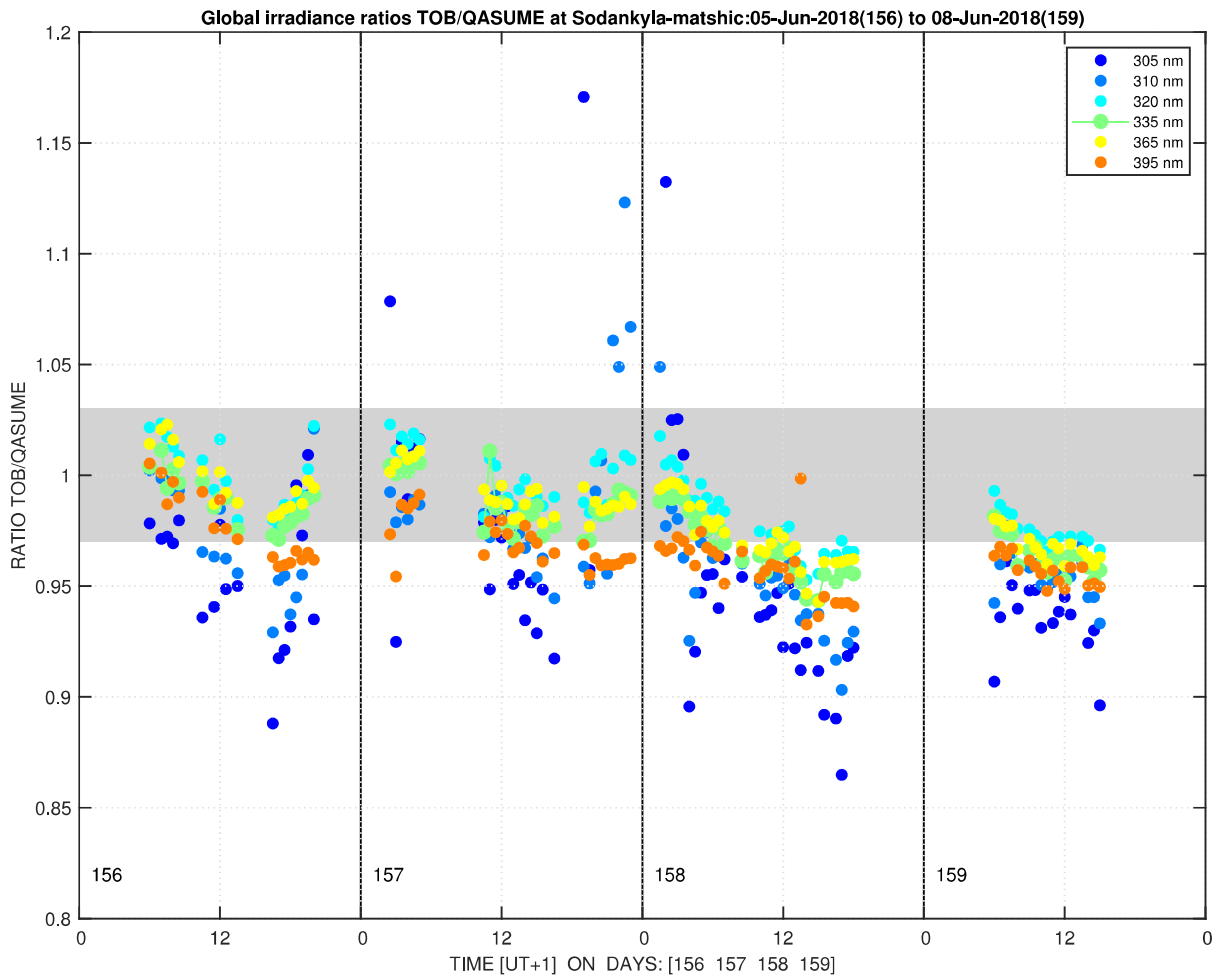


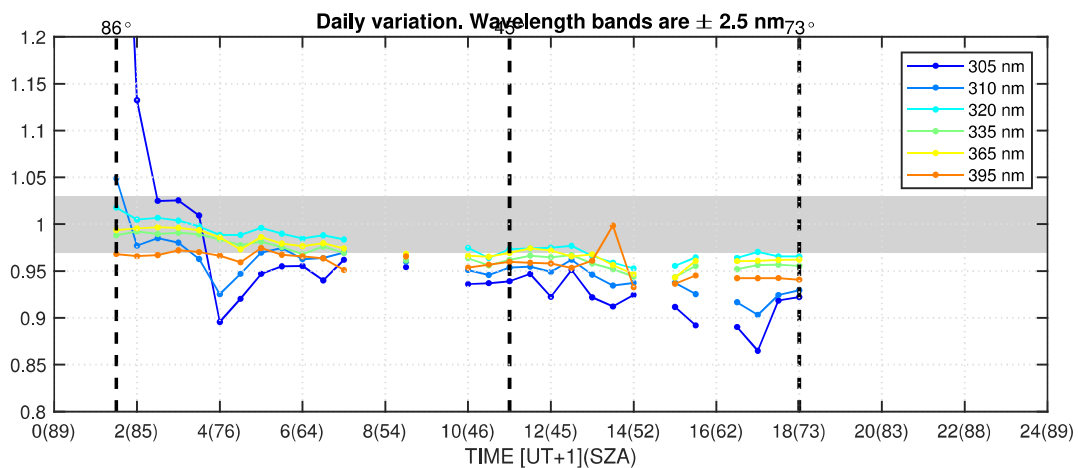
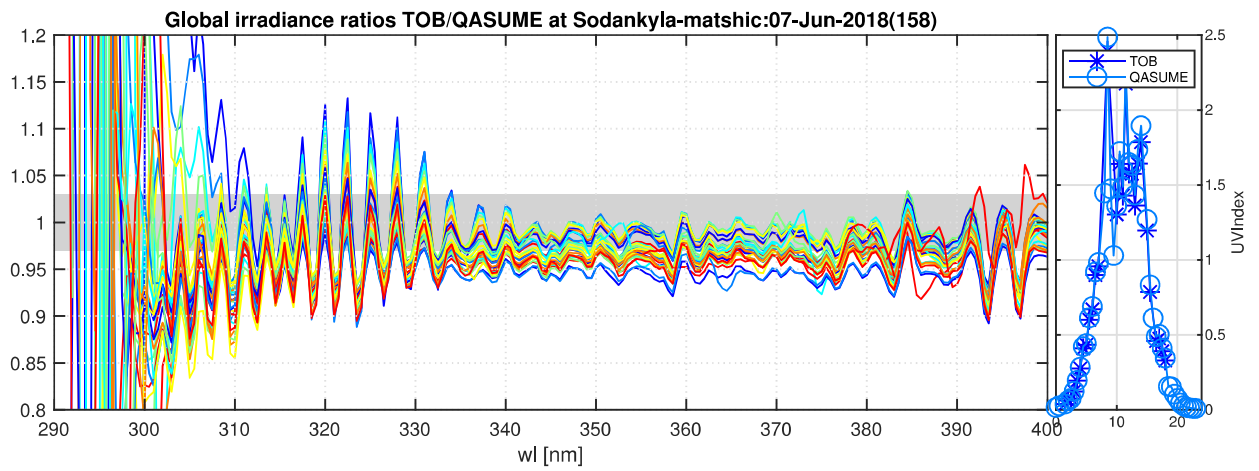
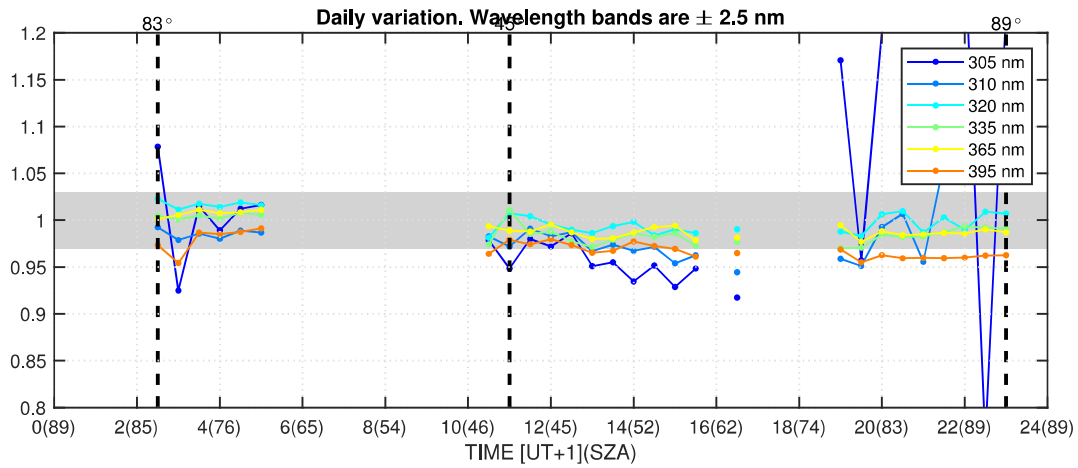
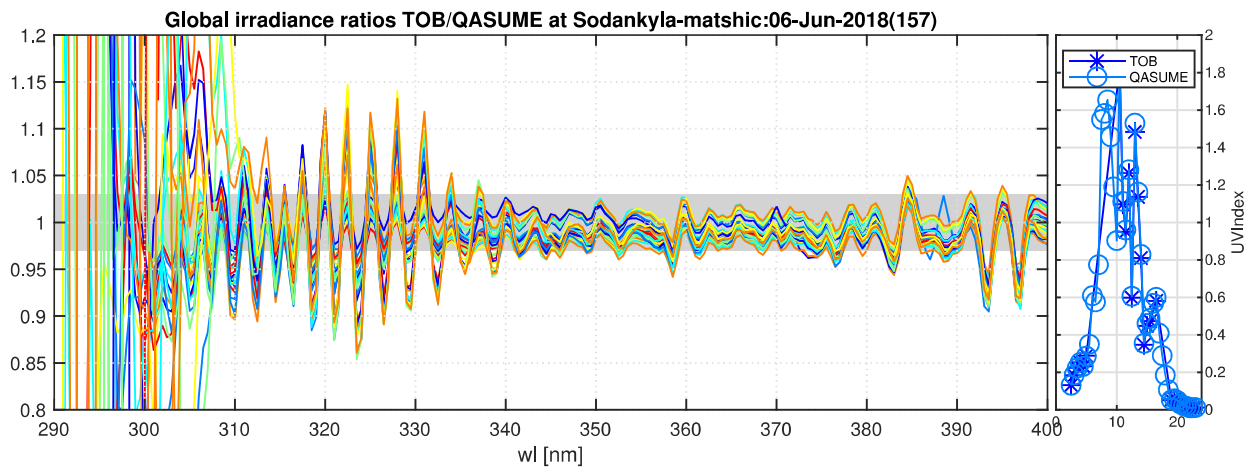


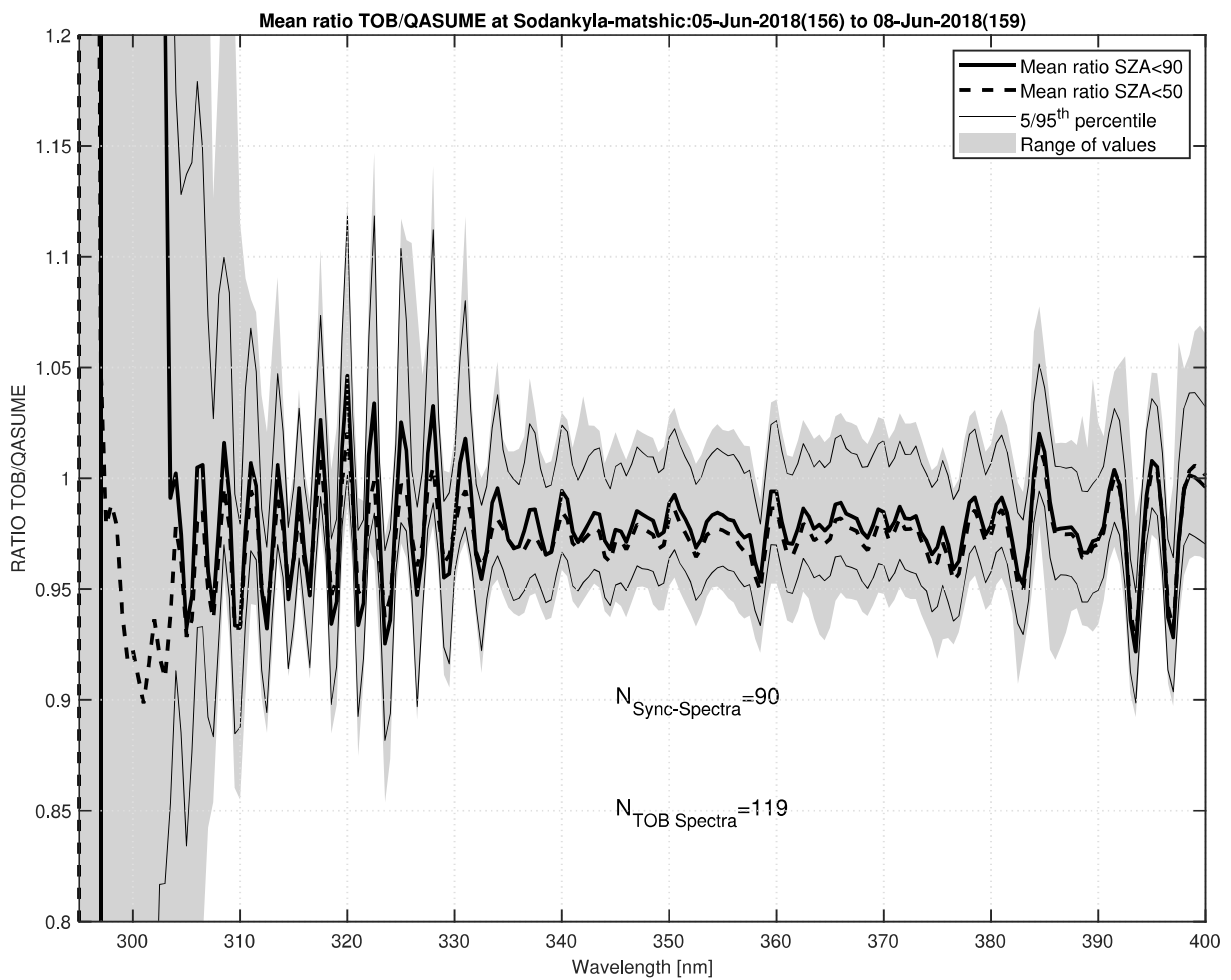
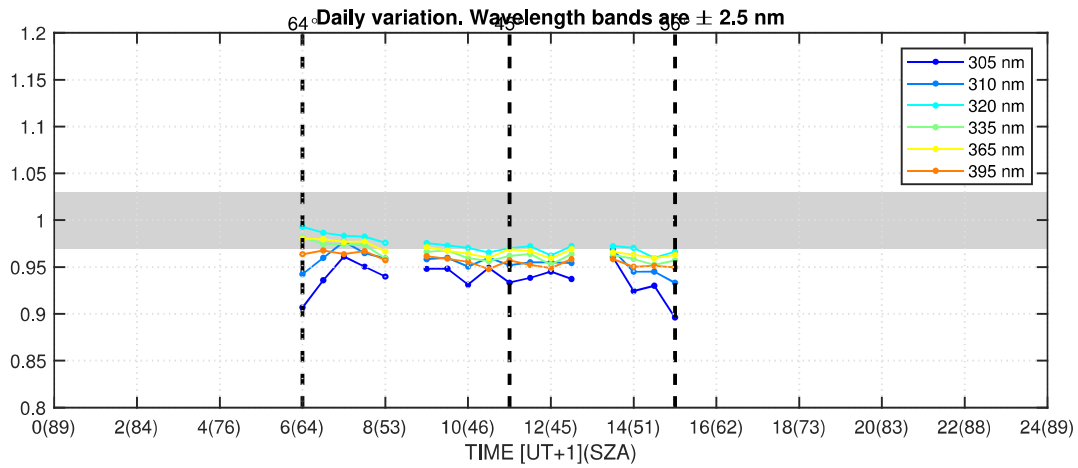
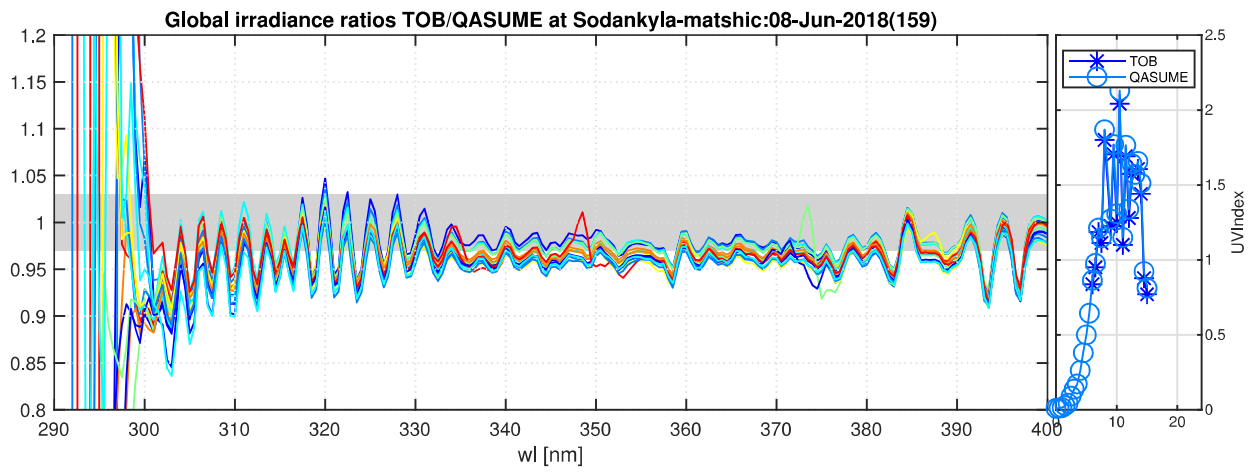


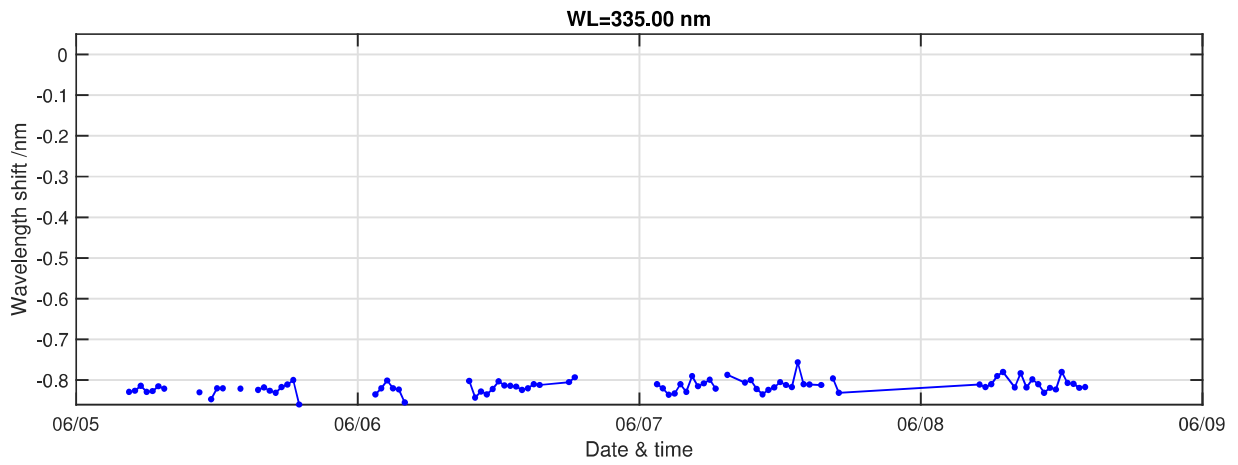
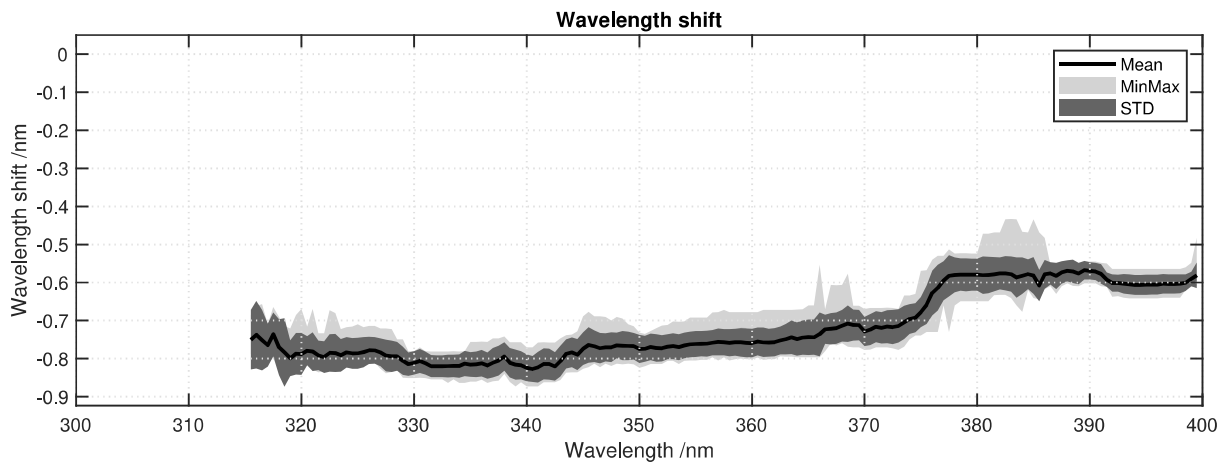












Qasume Responsivity Change, June 2018, Sodankyla (T16573, T68522)

