Protocol of the intercomparison at Jokioinen Observatory, Finnish Meteorological Institute, May, 25-30, 2003 with the travelling standard spectroradiometer B5503 from ECUV within the project QASUME

Report prepared by Julian Gröbner

Operators: Julian Gröbner, Josef Schreder, Stelios Kazadzis

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer operated by FMI (FIJ) and the travel standard B5503. The measurement site is located at Jokioinen; Latitude 60.81 N, Longitude 23.50 E and altitude 104 m.a.s.l..
The horizon of the measurement site is free down to about 85° solar zenith angle (SZA) in all directions.

B5503 arrived at Jokioinen in the afternoon of May 25, 2003. The spectroradiometer was installed on the solar radiation measurement platform at about 4 meters from the ground. The spectroradiometer in use at Jokioinen is a Brewer #107 double monochromator. The intercomparison between B5503 and the spectroradiometer from FMI lasted five days, from the morning of May 26 to the evening of May 29.
Three NILU-UV filter radiometers were installed on the measurement platform and acquired solar irradiance data during the whole measurement period.

B5503 was calibrated several times during the intercomparison period using a 100 W portable calibration system. Four 100 W lamps (T53063, T38986, T57825, T57824) were used to obtain an absolute spectral calibration traceable to the primary reference held at ECUV, which is traceable to PTB. The daily mean responsivity of the instrument based on these calibrations varied by 2.5% during the intercomparison period. These variations were taken into account on a daily basis. Observed diurnal variations of the responsivity were 3% on May 26 and 1% on May 28. The responsivity of B5503 was stable on May 29. No lamp calibrations were made on May 27. The diurnal responsivity variation of May 26 and May 28 were taken into account. The internal temperature of B5503 was 25.4±0.2 °C. The diffuser head was heated to a temperature of 28±8°C.
The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the SHICRivm analysis were between ± 50pm in the spectral range 310 to 400 nm.

Protocol:
The measurement protocol was to measure one solar irradiance spectrum every 30 minutes from 290 to 365 nm, every 0.5 nm, and 3 seconds between each wavelength increment.

May 25 (145):

Arrival and setup of the instrument in the late afternoon. The instrument was turned on and temperature stabilised since 9 UT prior to arriving at Jokioinen. After installation on the measurement platform the instrument was calibrated using lamps T57825, T53063, T57824 and T38986 from 16:00 to 17:30 UT. Then B5503 was left to stabilise over night.

May 26 (146):

Synchronised scans started at 2:00 UT with clear sky and few scattered clouds on the horizon. Clouds start moving in front of the sun at 6:00 UT. Clear skys again from 8:18 till 11:20 UT. Rain (thunderstorm) starts at 11:25. B5503 misses 12:00 and 12:30 scans. Mix of sun and clouds from 13:00 till 15:00 when rain starts again.

At 16:00 UT, prepare for HUT/STUK portable calibrator calibration on the measurement platform. B5503 measures the calibrator at 17:00 (3 scans), followed by FIJ. The second FIJ scan is interrupted due to heavy rain. Nevertheless the measurements were successful (see graphic).

100 W measurements from B5503 at 2:35, 3:35, 7:00, 10:00, and 17:40 UT.

May 27 (147):

Start synchronised scans at 2:30 UT. Overcast till 6:30. Then sky nearly clear (few scattered clouds) for the rest of the day. 16:00 scan perturbed by heavy cloud. No 100W lamp calibrations performed on B5503 during this day.

May 28 (148):

Start synchronised scans at 2:30 UT. Some clouds in front of the sun until 5:00 UT followed by clear skies with no clouds from 5:30 UT onwards. 100 W calibrations at 6:35, 11:05, and 13:05 UT.

May 29 (149):

Start synchronised scans at 2:30 UT. Clear skies until 7:00 UT when clouds start moving in front of the sun. Thin cirrus clouds in front of the sun until 12:00 UT. B5503 misses the scans at 12:30, 13:00, and 13:30 due to the final 100W calibration. Synchronised start again at 14:00 UT; Low lying clouds in front of the sun for the rest of the day. 100 W calibrations at 6:35, 8:05, 10:38, 11:35, and 12:00-14:00 UT.

May 30 (150):

FIJ is moved into the darkroom to measure its directional response using the portable cosine device.

Results:

118 synchronised simultaneous spectra from B5503 and FIJ are available from the measurement period. The time reference used by FIJ and B5503 differed by less than 2 seconds. The wavelength shifts of the submitted solar spectra of the FIJ spectroradiometer retrieved through the SHICRivm analysis were constant to within 20 pm. The absolute wavelength shift (relative to the extraterrestrial spectrum used by SHICRivm) decreased from +50 pm at 320 nm to 0 pm at 350 nm.

The irradiance scale of FIJ is 1% higher than the one of B5503 based on the results from the STUK/HUT calibrator results measured on May 27. The laboratory measurements of 2002 at ECUV gave a difference of +2% which is in good agreement with this new measurements.

A revised data set has been submitted by the FIJ operator after the end of the campaign in response to some variations seen in the intercomparison with B5503. As stated by the local operator, the changes between the original and revised data set are below 1.5% (see comments from the local operator).

The intercomparison of the global irradiance measured by the two instruments can be summarized as follows:

- Global irradiances measured by FIJ were between 4% lower to 6% higher than those measured by B5503 on the 4 days. For wavelengths longer than 305 nm, measurements from FIJ show a variability relative to B5503 of less than 5% for all days. The average difference during the measurement period is +1.5%.
- Measurement ratios between FIJ and B5503 increase from 300 to 310 nm from 0.95 to 1.03 and decrease again to 1.0 from 310 nm to 360 nm.
- At high SZA (>85°) measurements start deviating for wavelengths shorter than 305 nm while at mid day measurements agree down-to 300 nm.
- The diurnal variation of the measurements ratios of FIJ relative to B5503 on May 27 (147) of about 5% are unexplained as is the sharp decrease in the ratio FIJ to B5503 between 4:30 and 5:00 UT. Unfortunately, no 100 W lamp calibrations of B5503 were performed on this day so these variations remain unexplained. The diurnal variation of 3% seen on May 29 was not observed in the 100 W lamp calibrations performed on B5503 during the day and remain unexplained.
- The decrease of FIJ relative to B5503 on the afternoon of May 28 is larger at longer wavelengths and might be a remaining feature of the cosine correction applied to this instrument.

Comparison with the measurements of July 2002 at Jokioinen:

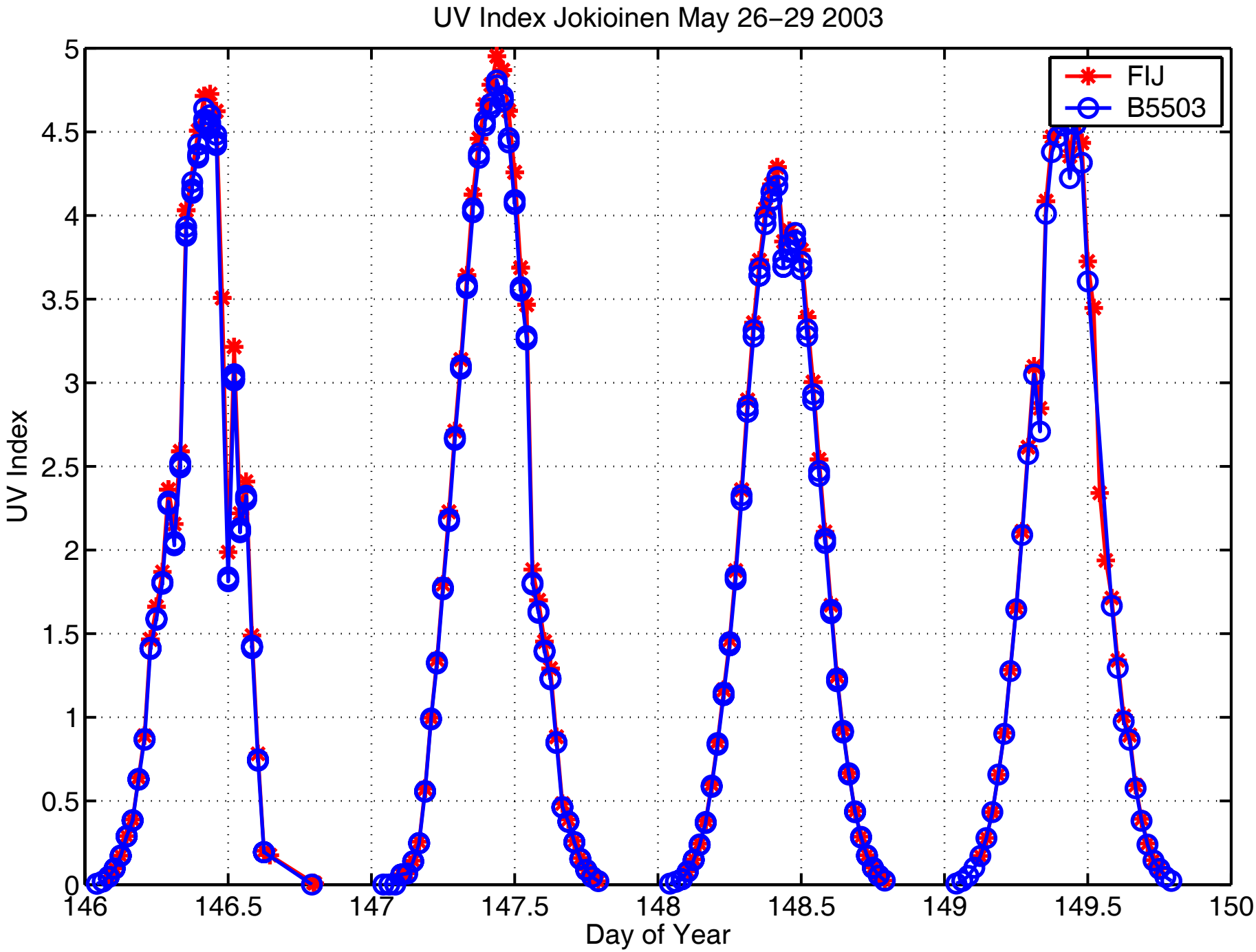
- The average offset between FIJ and B5503 during the 2003 campaign (+1.5%) is very similar to the one seen in 2002 (+2%) and is within the observed variability (5%).

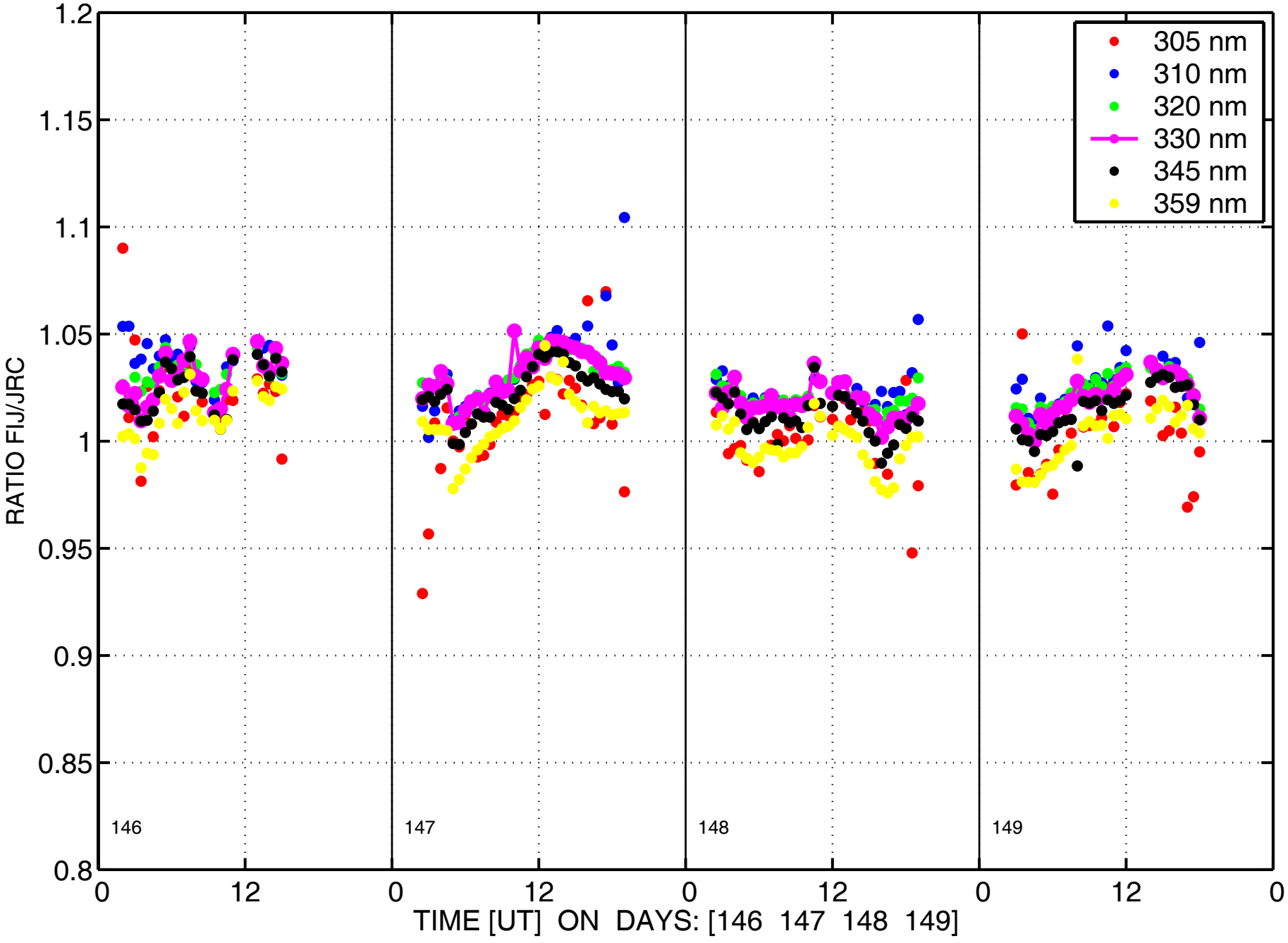
Conclusion:

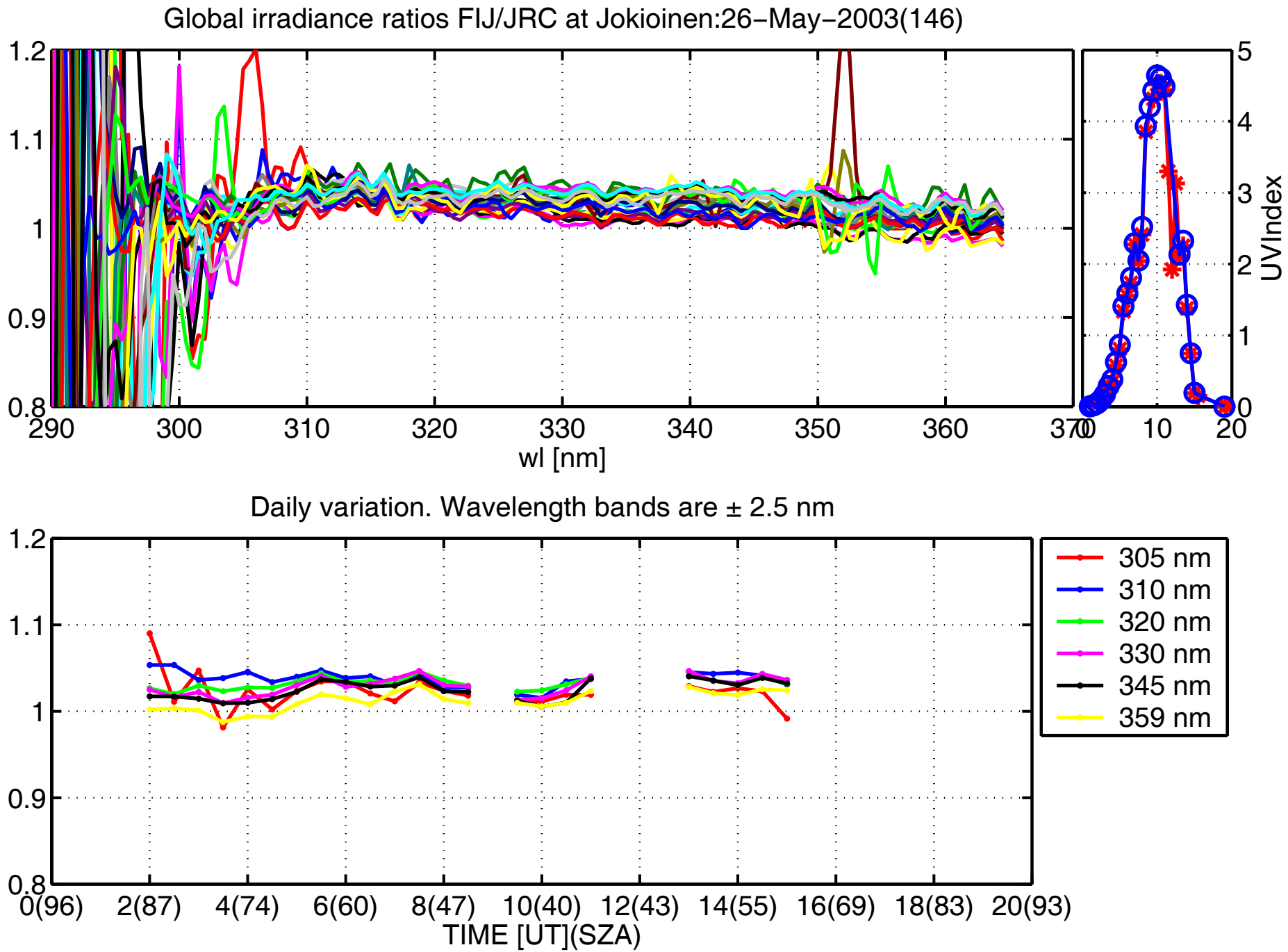
- The measurements of B5503 and FIJ show a high degree of consistency between 2002 and 2003. The irradiance scales used by FIJ and B5503 differ by about 2%. On average, the same difference is also seen during the solar measurements.
- The remaining unexplained features are diurnal variations of up to 5% on some days (not all) in 2002 and 2003.
- The mean spectral ratio of FIJ to B5503 shows a 2 to 3% decrease between 310 and 365 nm from 1.03 to 1.0, which was also seen in 2002. The mean spectral ratio increases by 8% between 300 and 310 nm from 0.95 to 1.03.

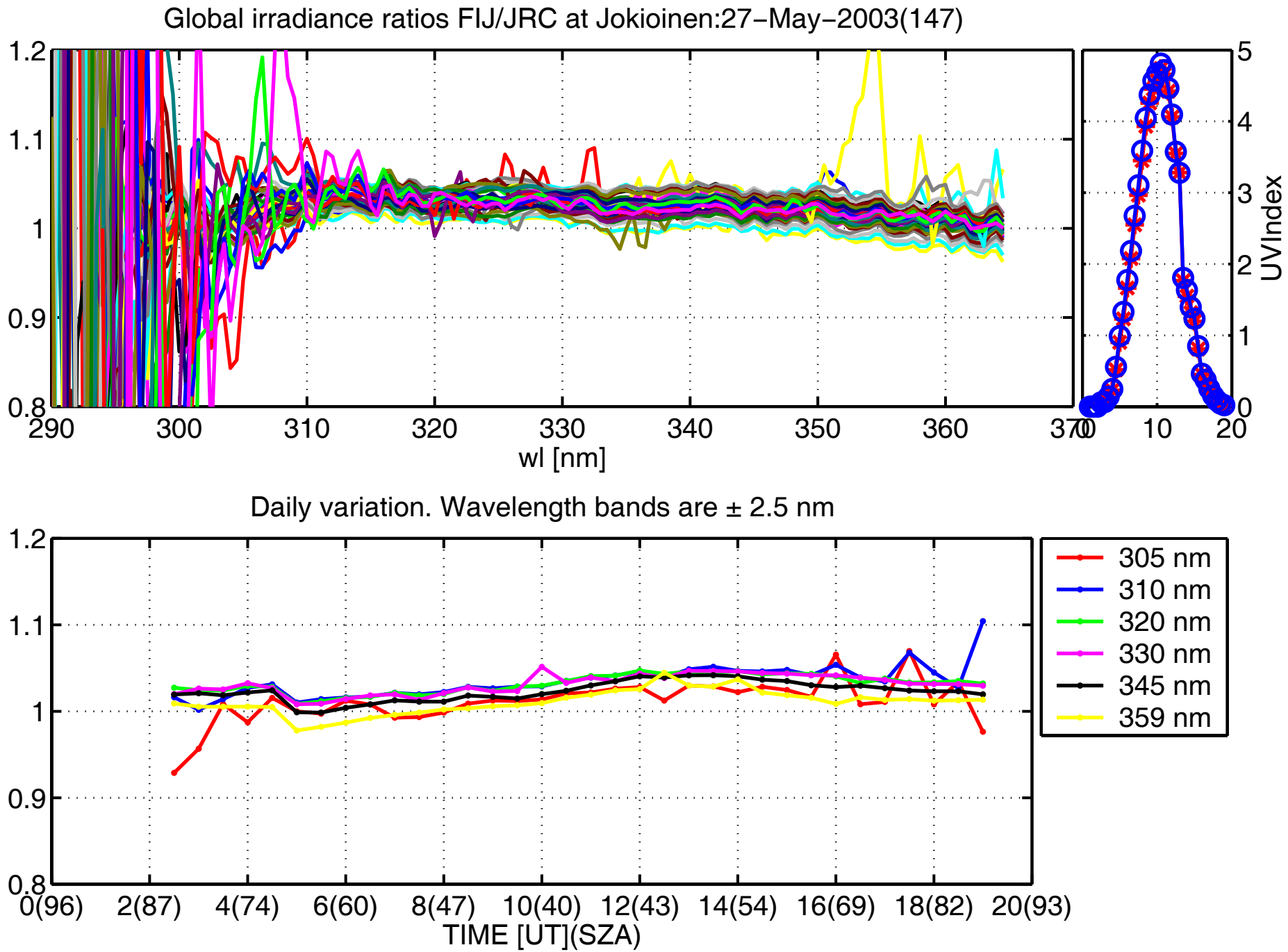
Comments from the local operator:

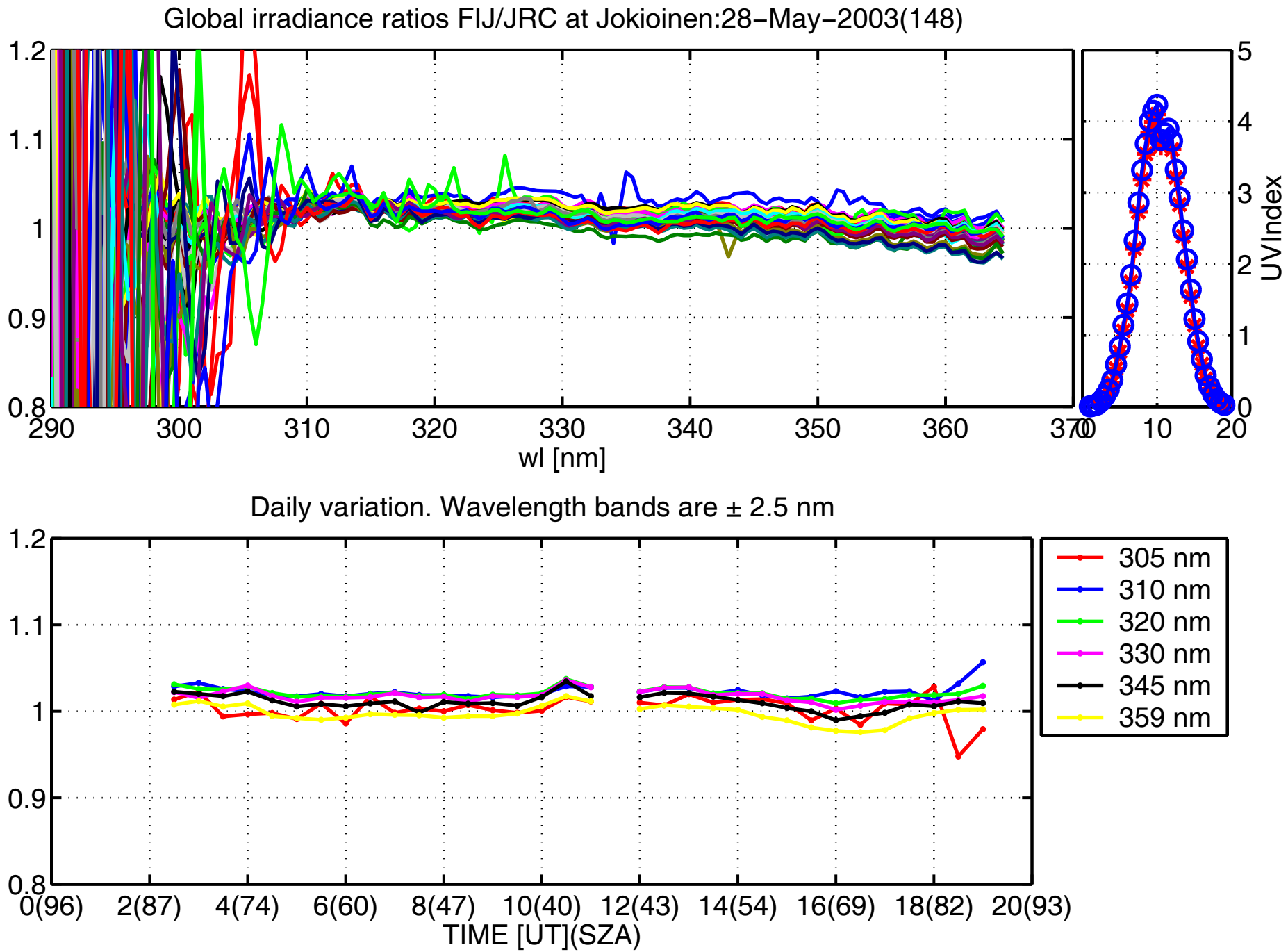
As we realised in the valuable discussions during the campaign the cosine correction algorithm was a little too simple when the SZA changed considerably during the course of the scan. This is now corrected, and the revised irradiances show a change of up to 1.5% in UV-A at SZA 70 to 75 degrees. The change is down in the mornings and upwards in the afternoons, most visible on day 148/03. No other changes in the data were introduced. The new cosine characterisation was not yet applied because the results have not yet been discussed sufficiently.

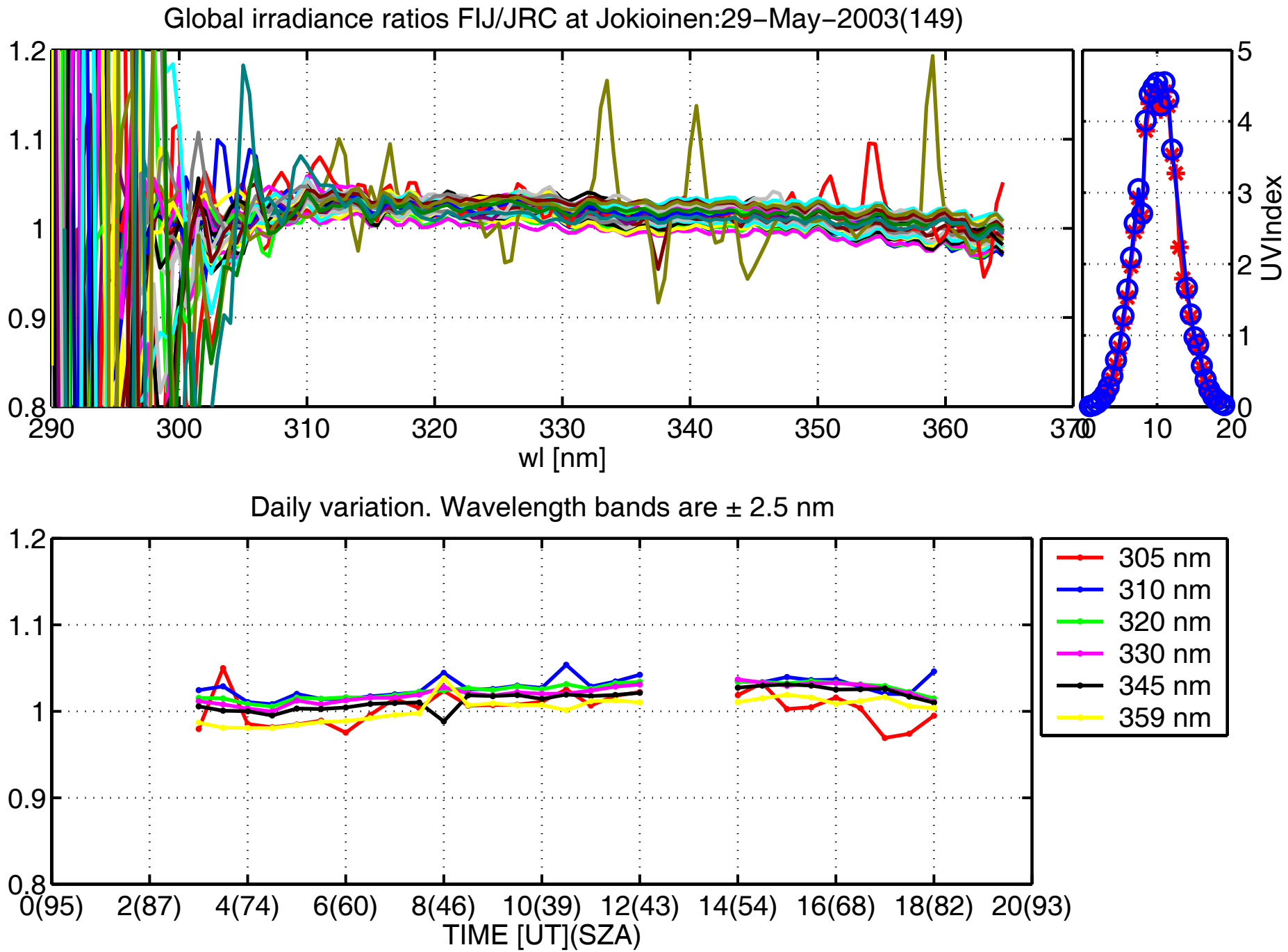

UV Index Jokioinen May 26–29 2003
FIJ
B5503
UV Index
Day of Year
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
146
146.5
147
147.5
148
148.5
149
149.5
150

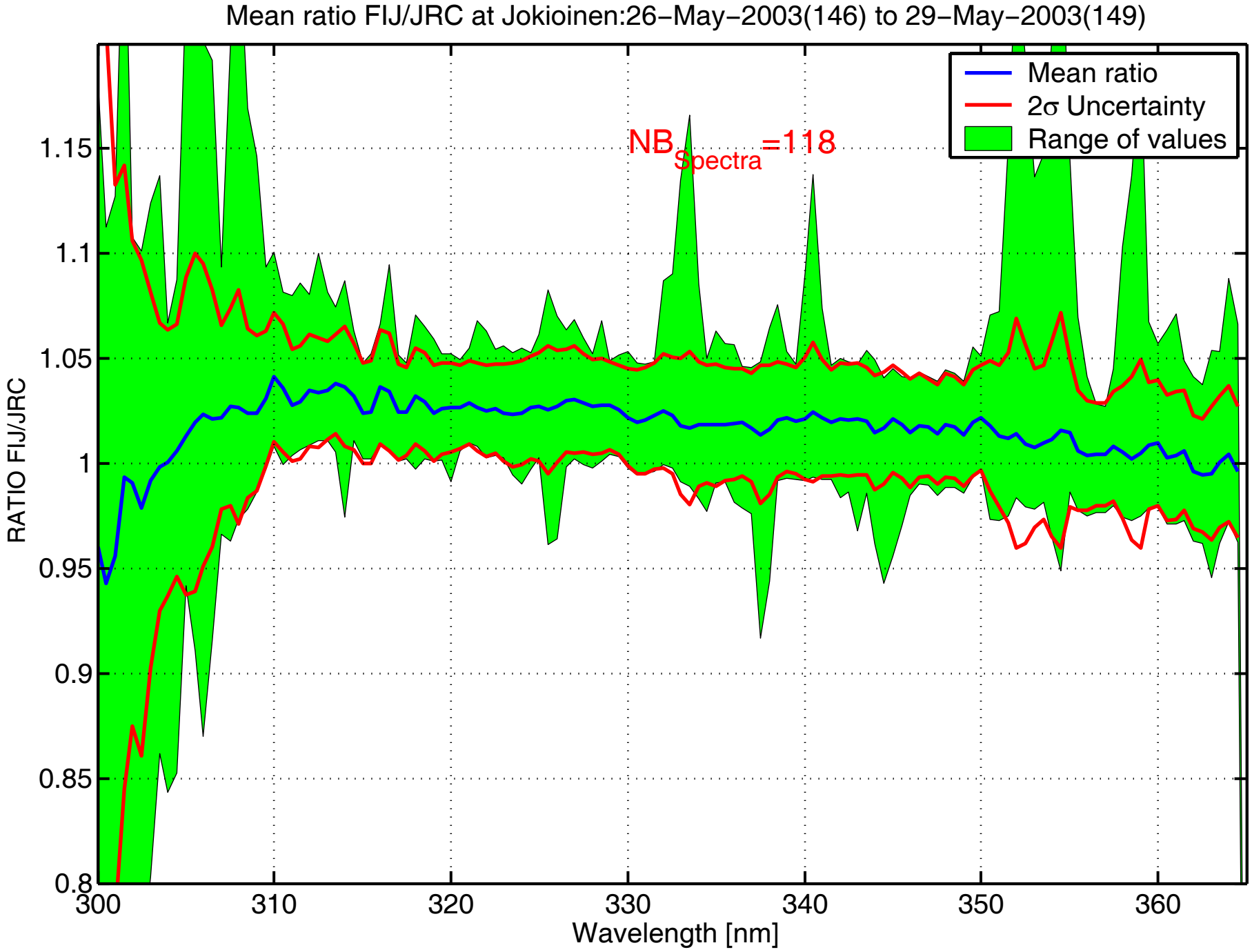

Global irradiance ratios FIJ/JRC at Jokioinen:26−May−2003(146) to 29−May−2003(149)
RATIO FIJ/JRC
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
305 nm
310 nm
320 nm
330 nm
345 nm
359 nm
146
147
148
149
0
12
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [146 147 148 149]
26−Jun−2003 14:57:38

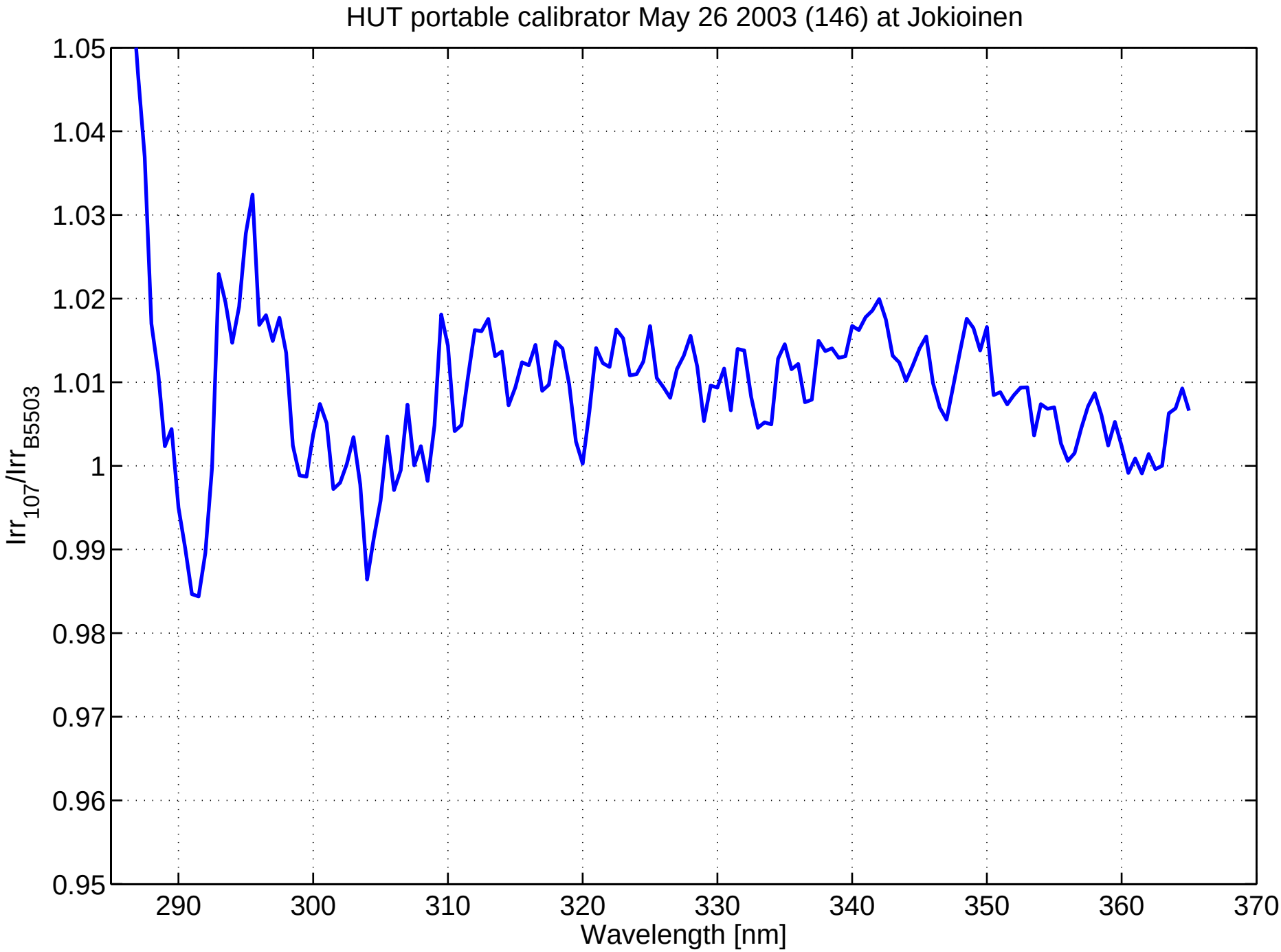

Global irradiance ratios FIJ/JRC at Jokioinen:26−May−2003(146)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
wl [nm]
0
10
20
5
4
3
2
1
0
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
0(96)
2(87)
4(74)
6(60)
8(47)
10(40)
12(43)
14(55)
16(69)
18(83)
20(93)
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
359 nm
26−Jun−2003 14:57:39

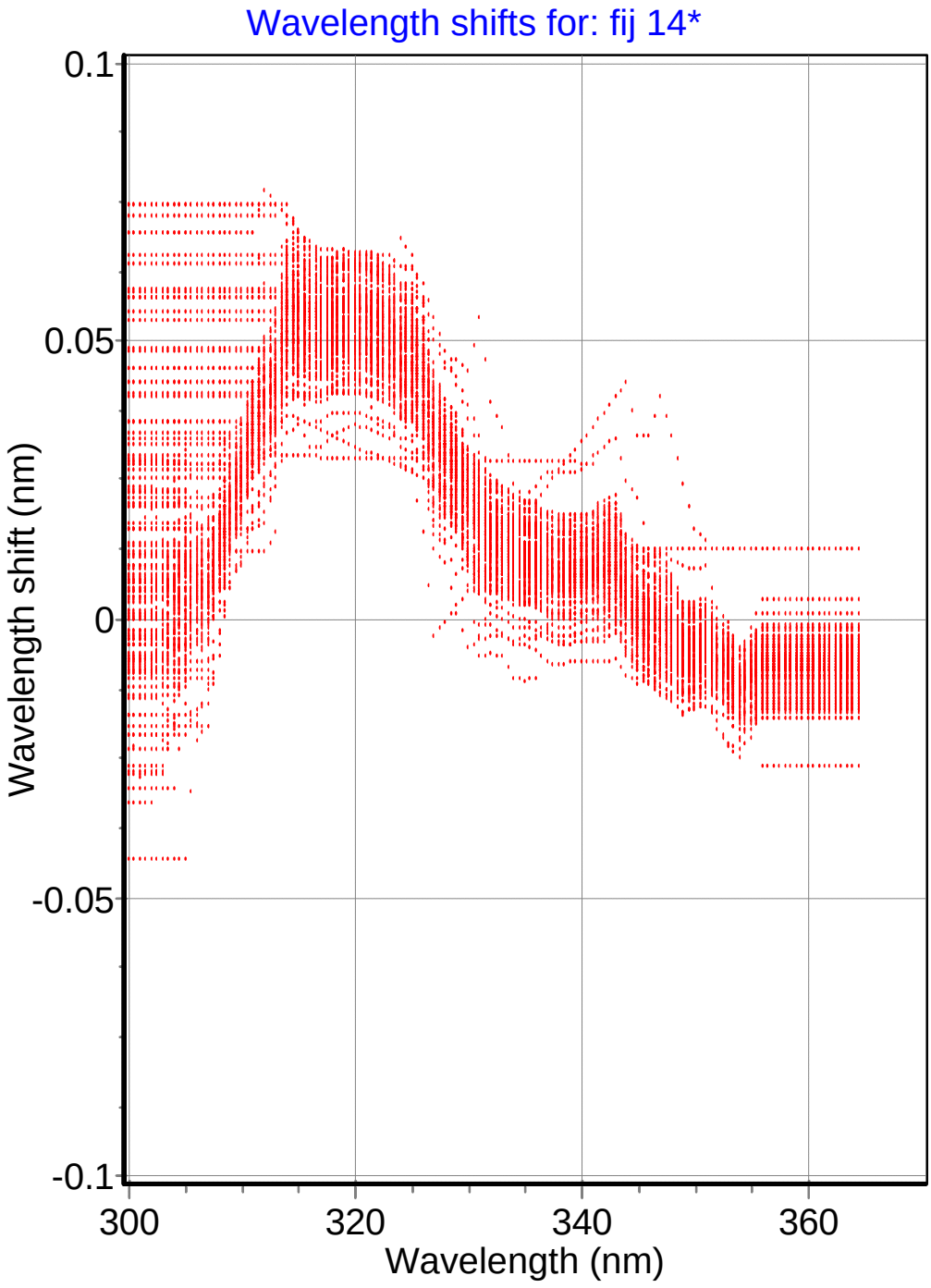

Global irradiance ratios FIJ/JRC at Jokioinen:27−May−2003(147)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
wl [nm]
0
10
20
5
4
3
2
1
0
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
0(96)
2(87)
4(74)
6(60)
8(47)
10(40)
12(43)
14(54)
16(69)
18(82)
20(93)
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
359 nm
26−Jun−2003 14:57:38

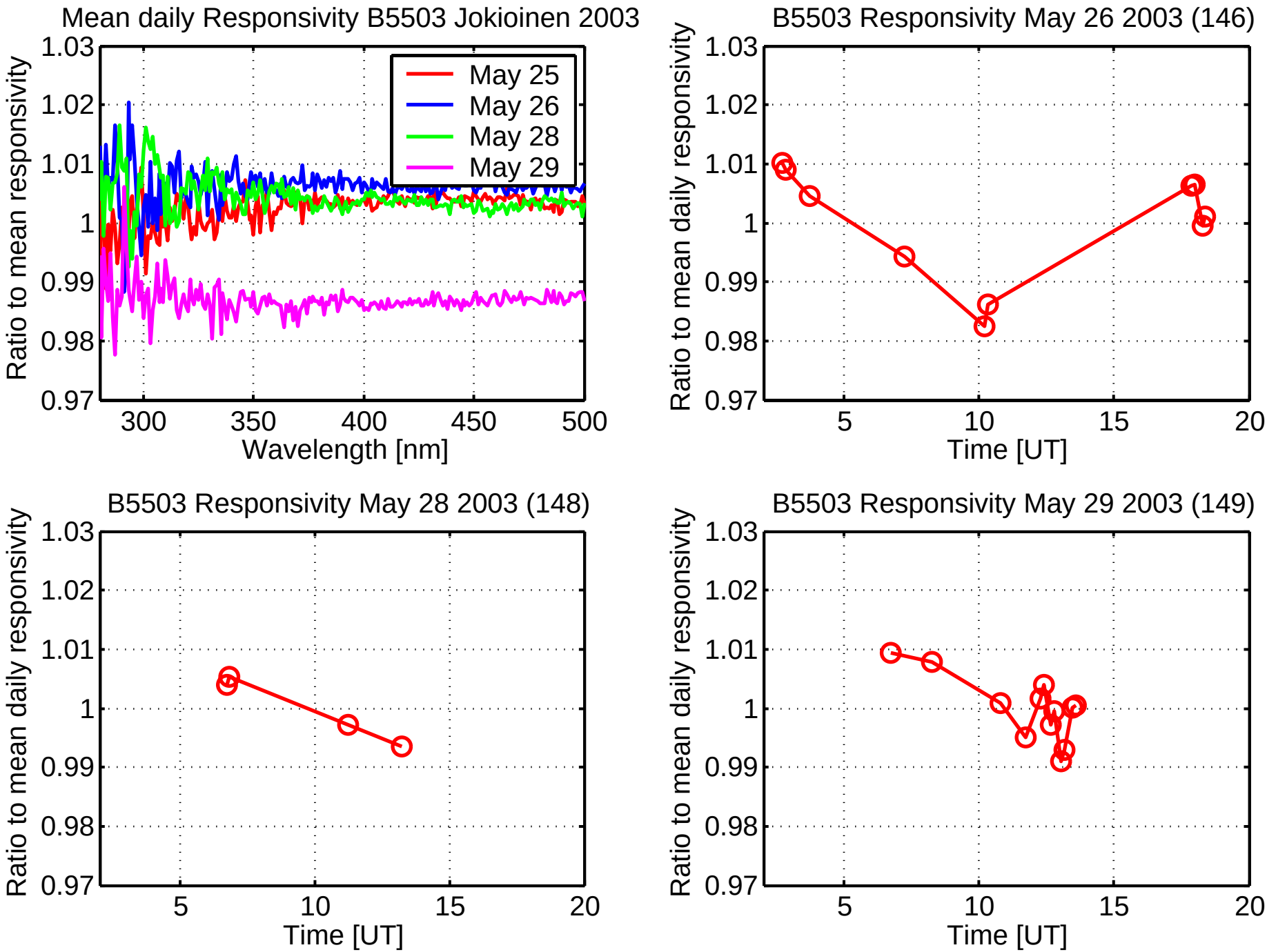

Global irradiance ratios FIJ/JRC at Jokioinen:28−May−2003(148)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
wl [nm]
5
4
3
2
1
0
UVIndex
0
10
20
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
0(96)
2(87)
4(74)
6(60)
8(47)
10(40)
12(43)
14(54)
16(69)
18(82)
20(93)
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
359 nm
26−Jun−2003 14:57:38


Global irradiance ratios FIJ/JRC at Jokioinen:29−May−2003(149)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
wl [nm]
5
4
3
2
1
0
0
10
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
0(95)
2(87)
4(74)
6(60)
8(46)
10(39)
12(43)
14(54)
16(68)
18(82)
20(93)
TIME [UT](SZA)
305 nm
310 nm
320 nm
330 nm
345 nm
359 nm
26−Jun−2003 14:57:38


Mean ratio FIJ/JRC at Jokioinen:26−May−2003(146) to 29−May−2003(149)
Mean ratio
2σ Uncertainty
Range of values
NB Spectra =118
RATIO FIJ/JRC
Wavelength [nm]
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360


HUT portable calibrator May 26 2003 (146) at Jokioinen
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
Irr107/IrrB5503
290
300
310
320
330
340
350
360
370
Wavelength [nm]


Wavelength shifts for: fij 14*
0.1
0.05
0
-0.05
-0.1
Wavelength shift (nm)
300
320
340
360
Wavelength (nm)


Mean daily Responsivity B5503 Jokioinen 2003
Ratio to mean responsivity
Wavelength [nm]
May 25
May 26
May 28
May 29
B5503 Responsivity May 26 2003 (146)
Ratio to mean daily responsivity
Time [UT]
B5503 Responsivity May 28 2003 (148)
Ratio to mean daily responsivity
Time [UT]
B5503 Responsivity May 29 2003 (149)
Ratio to mean daily responsivity
Time [UT]