Protocol of the intercomparison at La Sapienza University, Rome, Italy on September 1 to 4, 2003 with the travelling standard spectroradiometer B5503 from ECUV within the project QASUME

Report prepared by Julian Gröbner

Operator: Julian Gröbner

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer operated by the University of Rome La Sapienza (ITR) and the travel standard B5503. The measurement site is located at Rome; Latitude 41.90 N, Longitude 12.51 E and altitude 60 m.a.s.l..
The horizon of the measurement site is free down to about 85° solar zenith angle (SZA) in all directions; Only in the east a building about 10 meter distant from the instruments shadows the ITR instrument at 7:00 UT (about 64 SZA) during the period of the intercomparison. B5503, within 2 meter from ITR, was free the whole time.

B5503 arrived at Rome in the afternoon of September 1, 2003. The spectroradiometer was installed on the roof of the University building at 1.5 m distance from the ITR instrument. The spectroradiometer in use at Rome is a Brewer MKIV single monochromator. The intercomparison between B5503 and the ITR spectroradiometer lasted three days, from the morning of September 1 to the evening of September 3.

B5503 was calibrated several times during the intercomparison period using a 100 W portable calibration system. Three 100 W lamps (T53061, T53062, and T53063) 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 less than 1% during the intercomparison period. No diurnal variations of the responsivity could be observed during the measurement period. The internal temperature of B5503 was 24.6±0.2 °C. The diffuser head was heated to a temperature of 30±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 400 nm, every 0.5 nm, and 3 seconds between each wavelength increment.

<u>September 1 (244):</u>

B5503 was installed on the measurement site at 14:10 UT and left to stabilize over night.

September 2 (245):

Synchronised measurements are available from 5:00 UT to 17:00 UT with some interruptions; due to problems with the photomultiplier, B5503 lost all measurements between 10:30 and 13:30 UT. Measurements were resumed at 14:00 UT. The measurement at 7:00 was discarded because ITR was in the shadow from a nearby building while B5503 was unobstructed.

Weather conditions were reasonable, with some low lying clouds and cirrus clouds in front of the sun in the morning which cleared in the afternoon.

B5503 calibrated at 6:11, 7:10, 8:40, 13:41, 13:50, 14:40, 15:40 UT, and from 17:00 to 18:00 UT.

September 3 (246):

Synchronised scans are available from 5:00 to 16:30 UT with some interruptions due to rain in the afternoon. In the morning low-lying clouds obscured the sun; dark heavy clouds moved in around 9:00 UT and heavy rain started at 13:13 UT and lasted until 14:50. Misses scans: 7:00 UT (ITR in shadow), 9:30 and 10:00 UT (ITR calibrates), 13:00 to 14:30, and 16:00 to 17:00 UT (rain).

Lamp measurements from B5503 at 5:41, 6:40, 7:08, 11:10 UT.

September 4 (247):

Synchronised scans are available from 5:00 to 17:00 UT. Missed scans: 7:00 UT (ITR in shadow), 14:30 to 15:30 UT (Power failure affects ITR). Weather conditions were very good, no clouds for the whole day.

Lamp measurements from B5503 at 6:40, 9:11, 12:40, and 16:40 UT.

The directional response of ITR was measured in the late evening of this day.

Results:

53 synchronised simultaneous spectra from B5503 and ITR are available from the measurement period. The wavelength shifts of the submitted solar spectra of the ITR spectroradiometer retrieved through the SHICRivm analysis were between ±50 pm and stable to 20 pm over the whole measurement period.

ITR submitted a revised data set after the end of the campaign to account for changes in the calibration of the instrument (+5.1% relative to the original measurements). The following discussion applies to the revised data set.

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

- Global solar irradiances measured by ITR were between 7% lower to 3% higher than those measured by B5503 for wavelengths between 305 and 325 nm and SZA below 75°. At higher SZA, irradiances measured at wavelengths at 305 nm are too high due to stray light of the monochromator.
- The spectral ratios between ITR and B5503 are slightly decreasing with wavelength, from 1.00 at 300 nm to 0.94 at 325 nm.

- Neglecting the measurements disturbed by stray light (early morning and late afternoon), the diurnal variability of the ratios showed a decreasing trend of about 3 to 4% during the day on all three days.

Conclusion:

ITR measures global solar irradiance on average 2 to 3% lower than B5503 for wavelengths above 305 nm. Lower wavelengths have a stray light problem which manifests itself at SZA angles above 75°. The variability between the two spectroradiometers was around 3 to 4% during the measurement period.

The directional response measurement of ITR implies an under-estimation of the solar global irradiance of about 8% which was not taken into account.

Comments from the local operator:

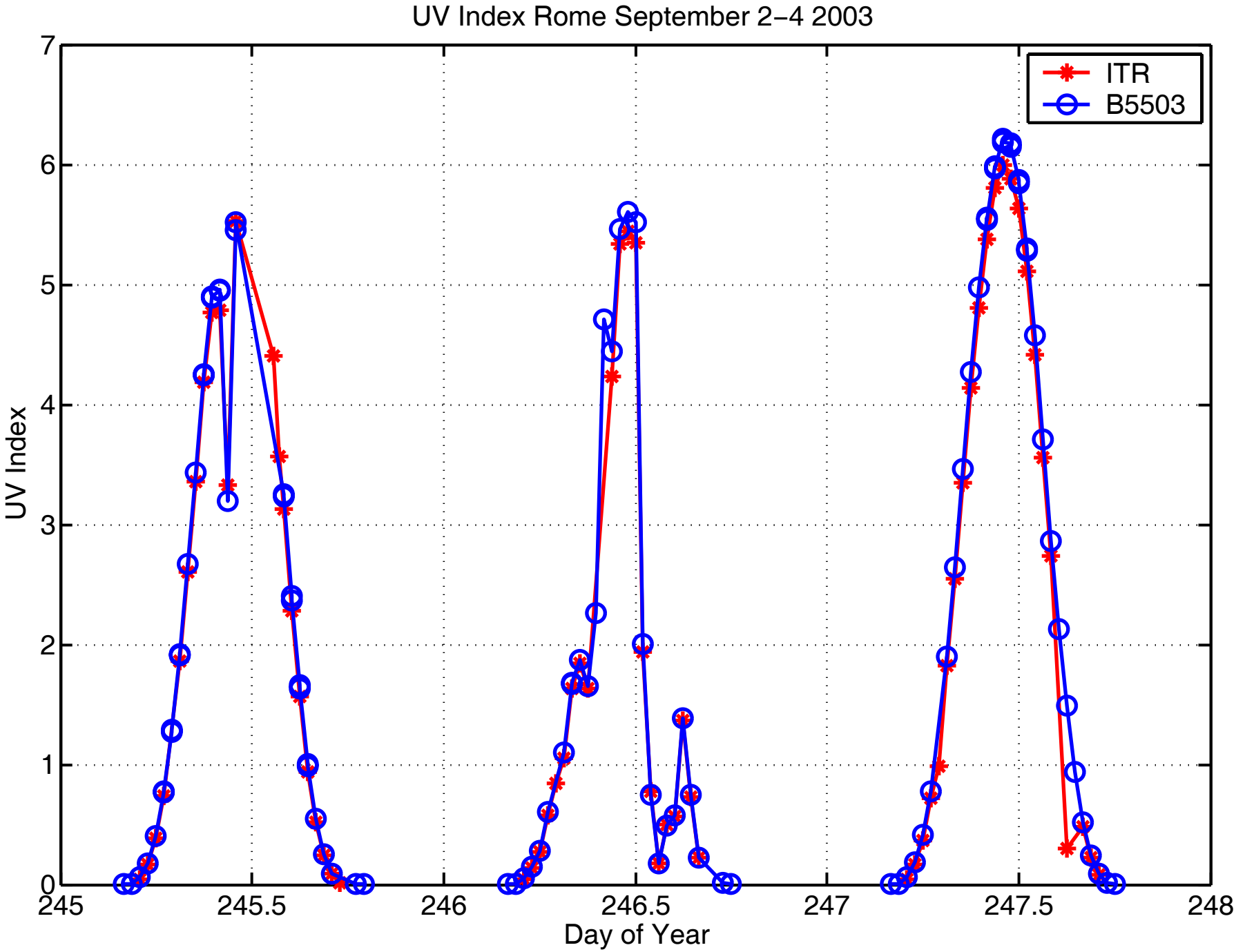
Brewer MKIV 067 is a single monochromator spectrophotometer. UV spectral scans range from 290 to 325 nm at 0.5 nm steps with Full Width Half Maximum (FWHM) of 0.63 nm. Each scan lasts approximately 8 minutes. The spectrophotometer has been working from January 1st 1992 in Rome (41.9°N, 12.5°E, 60 m a.s.l.). The site is located at University “La Sapienza” in the city centre.

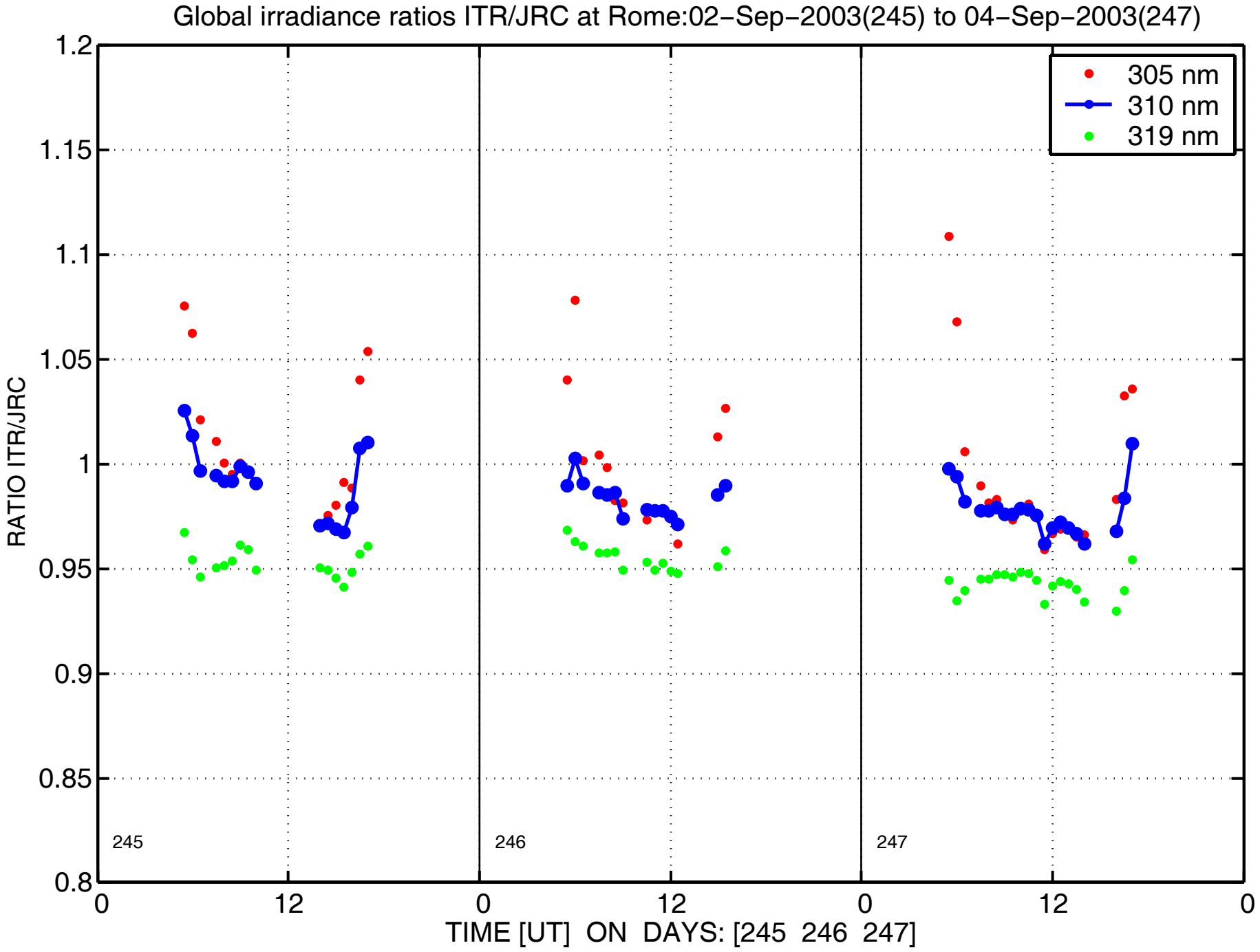
The responsivity file, used to process data and convert photocounts to physical irradiance was uvr32800.067. This file was obtained by the absolute field calibrations, carried out by external agencies with their own equipment, (in 2000 and 2002 by the International Ozone Service Inc.(IOS). A set of four 50W quartz tungsten halogen lamps, supplied by Kipp and Zonen instrument manufacturer, is periodically used for in situ calibration to check the internal stability (UL test).

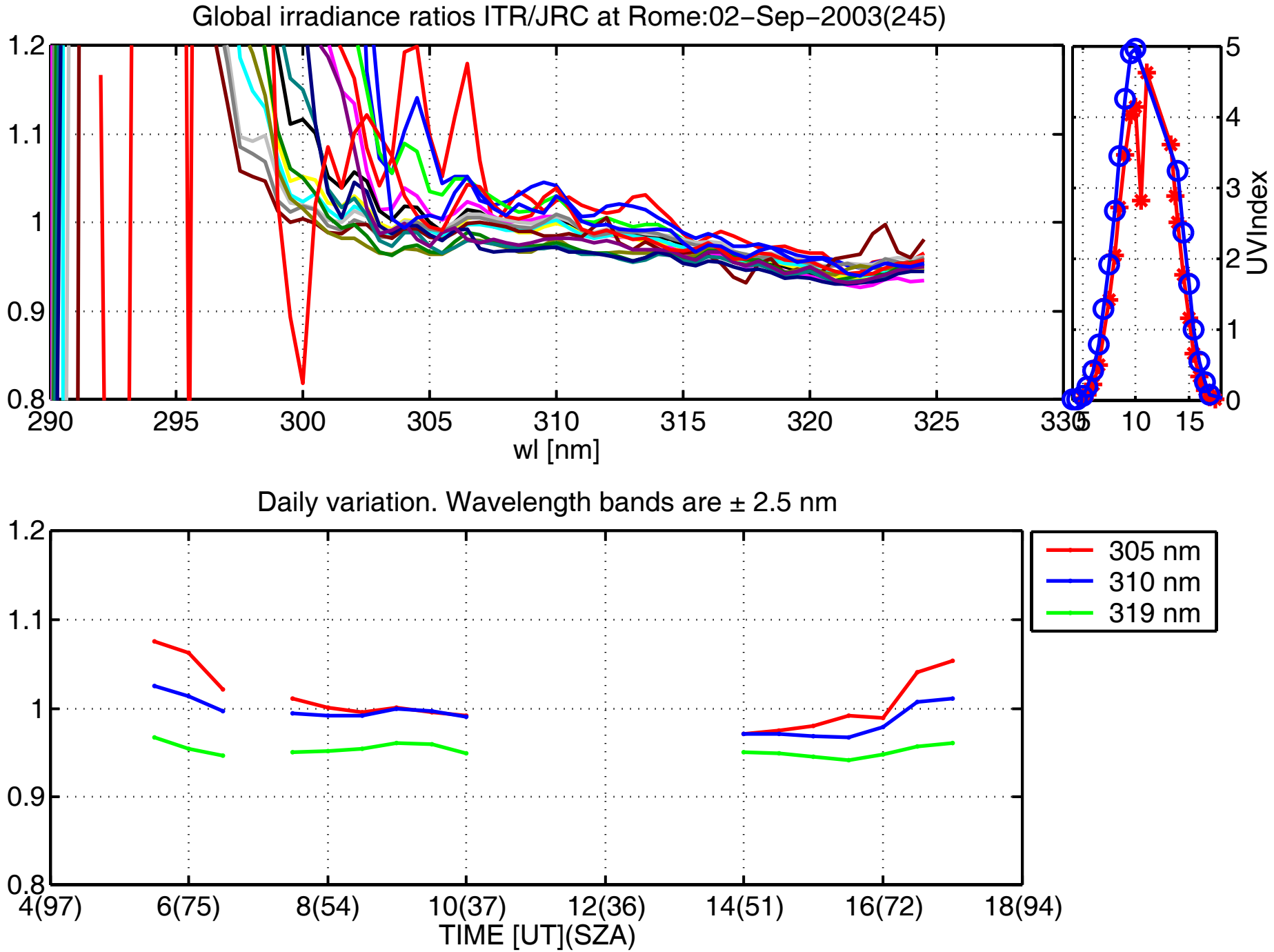
The UV data submitted were temperature corrected.

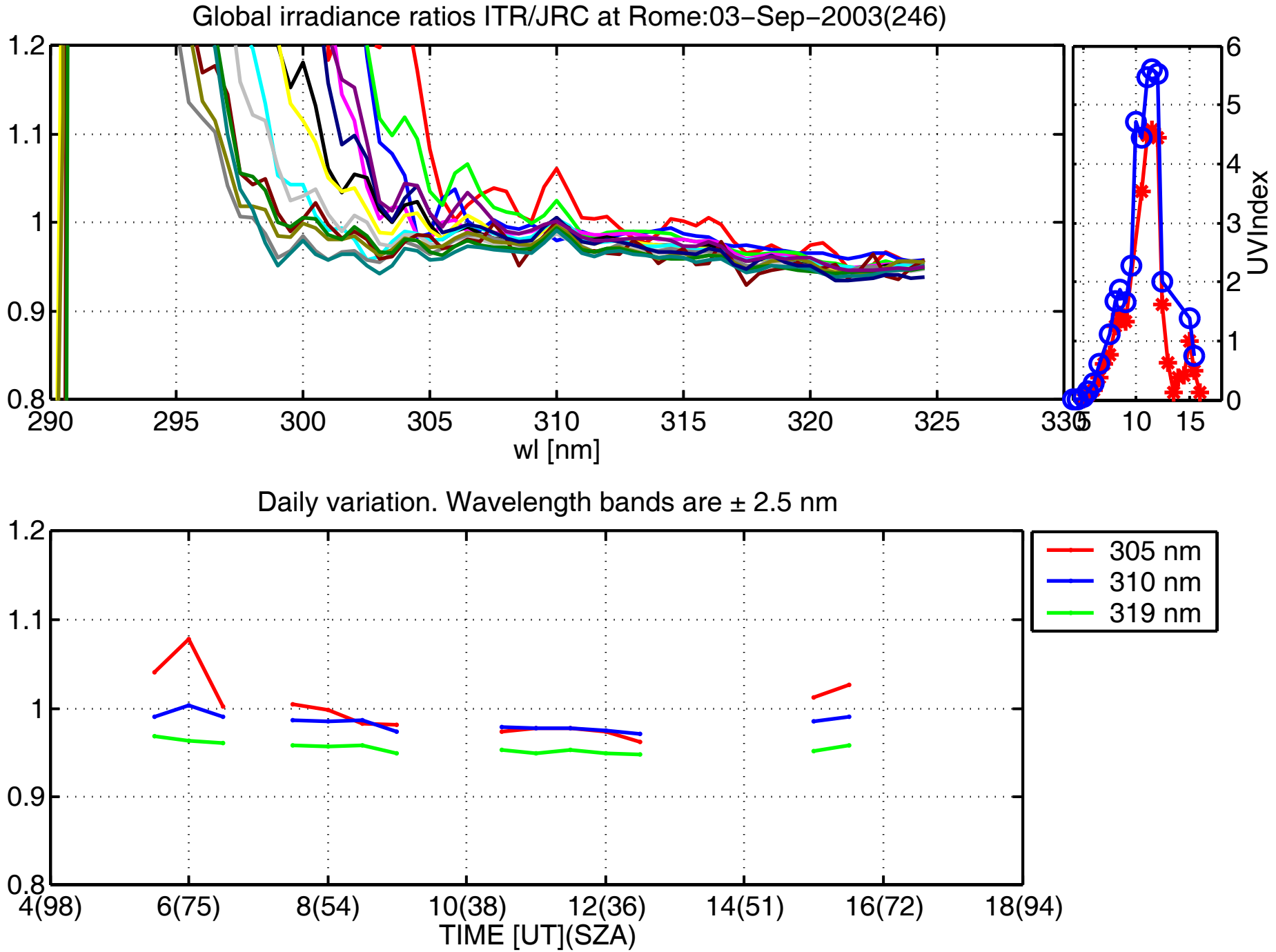
After the end of the campaign, a revised data set was submitted. To process that data a UV irradiance response was computed by the 50W calibrated lamps. No cosine correction was carried out on UV data.

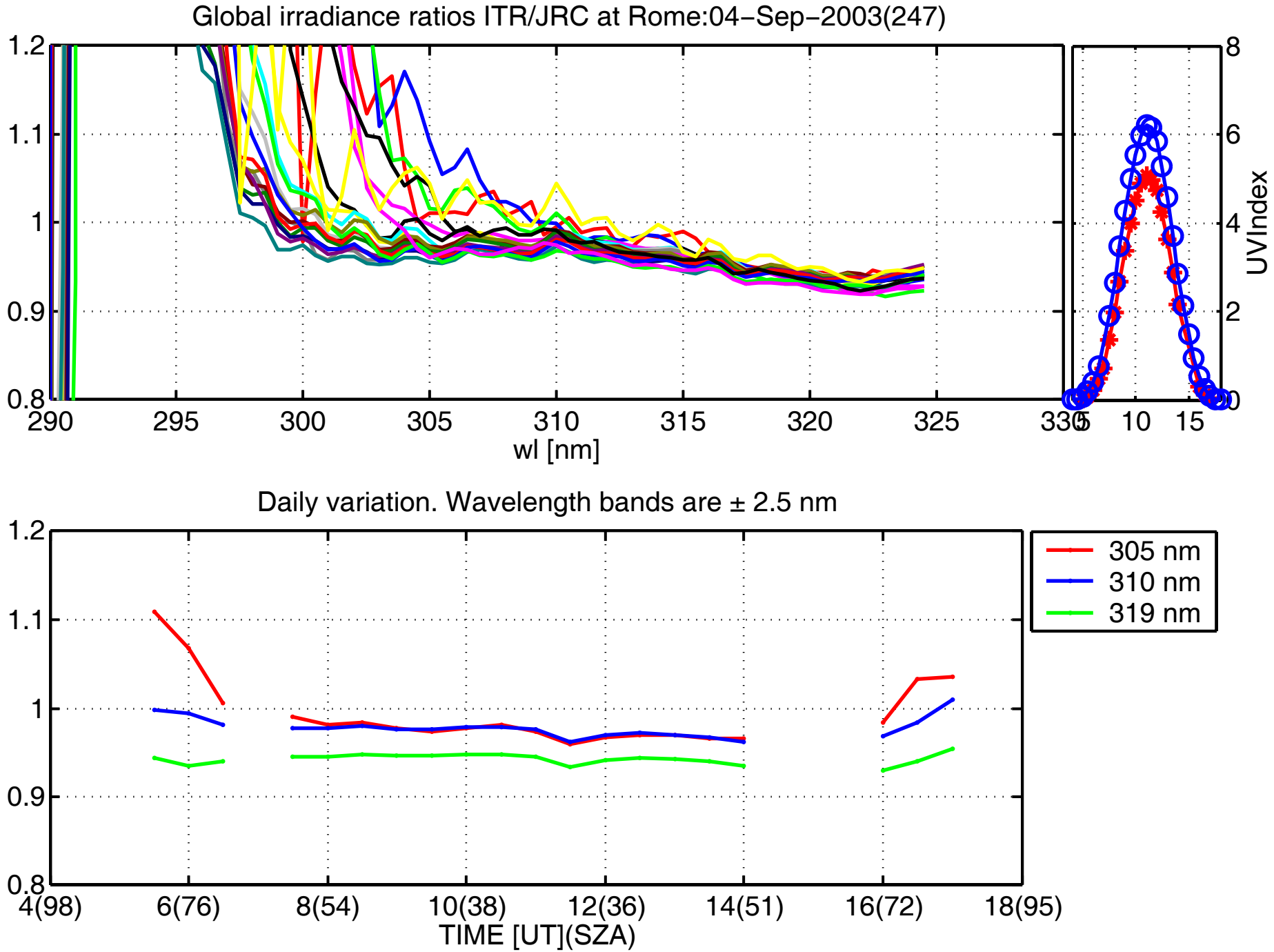
During the QASUME’s visit the full angular response was estimated and a corrections of 8% on UV data is advisable.

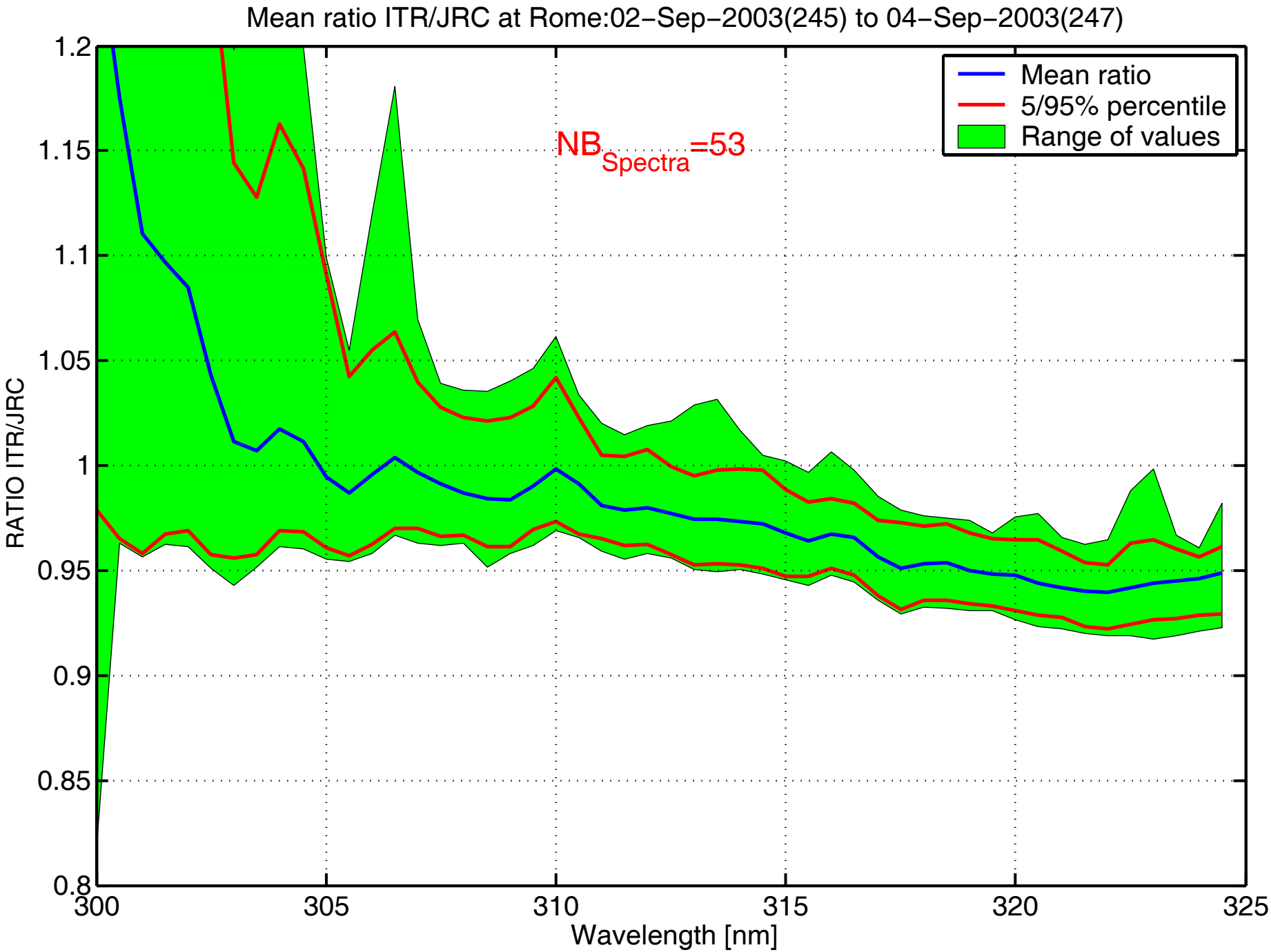

UV Index Rome September 2–4 2003
ITR
B5503
UV Index
Day of Year
0
1
2
3
4
5
6
7
245
245.5
246
246.5
247
247.5
248

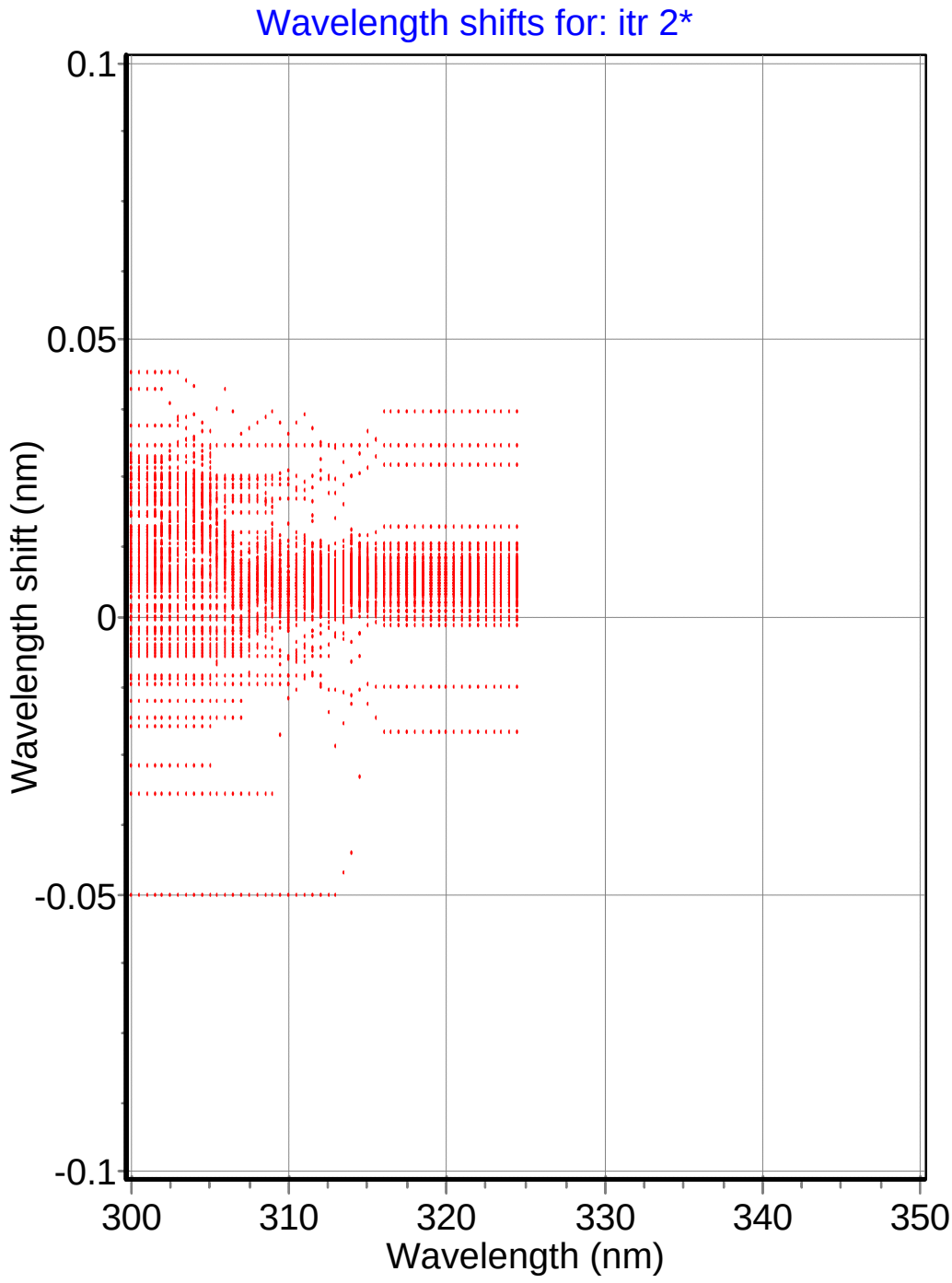

Global irradiance ratios ITR/JRC at Rome:02−Sep−2003(245) to 04−Sep−2003(247)
305 nm
310 nm
319 nm
RATIO ITR/JRC
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
245
246
247
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [245 246 247]
11−Nov−2003 12:12:06

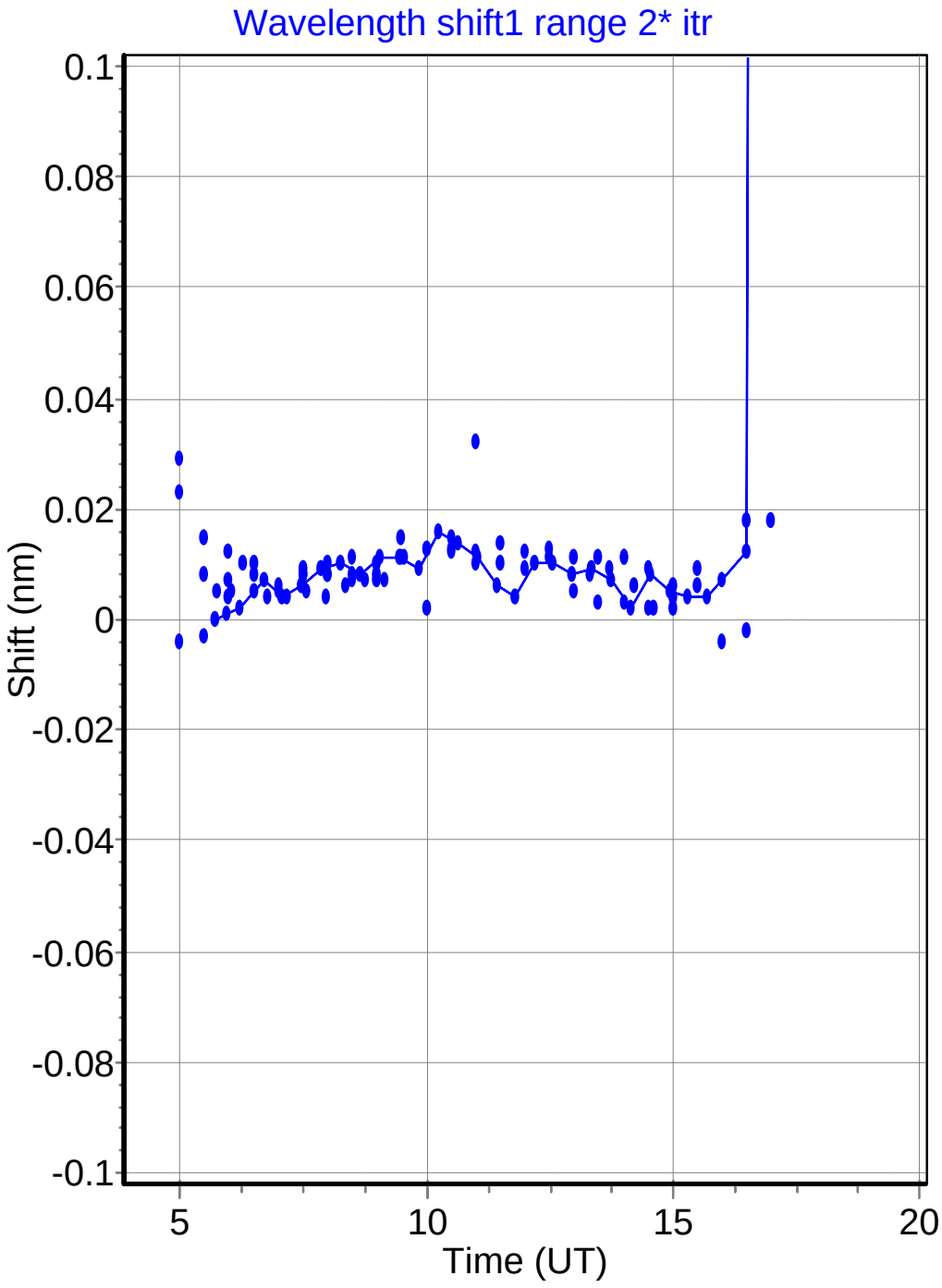

Global irradiance ratios ITR/JRC at Rome:02−Sep−2003(245)
1.2
1.1
1
0.9
0.8
290
295
300
305
310
315
320
325
330
wl [nm]
5
10
15
UVIndex
0
1
2
3
4
Daily variation. Wavelength bands are ± 2.5 nm
305 nm
310 nm
319 nm
4(97)
6(75)
8(54)
10(37)
12(36)
14(51)
16(72)
18(94)
TIME [UT](SZA)
11−Nov−2003 12:12:06

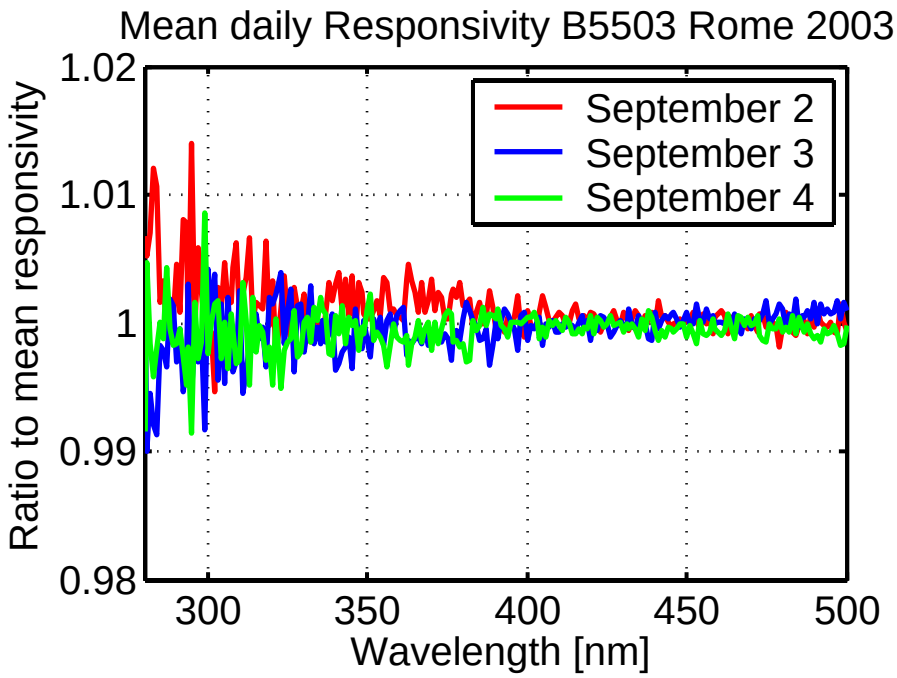

Global irradiance ratios ITR/JRC at Rome:03−Sep−2003(246)
1.2
1.1
1
0.9
0.8
290
295
300
305
310
315
320
325
330
wl [nm]
5
10
15
6
5
4
3
2
1
0
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
305 nm
310 nm
319 nm
4(98)
6(75)
8(54)
10(38)
12(36)
14(51)
16(72)
18(94)
TIME [UT](SZA)
11−Nov−2003 12:12:06

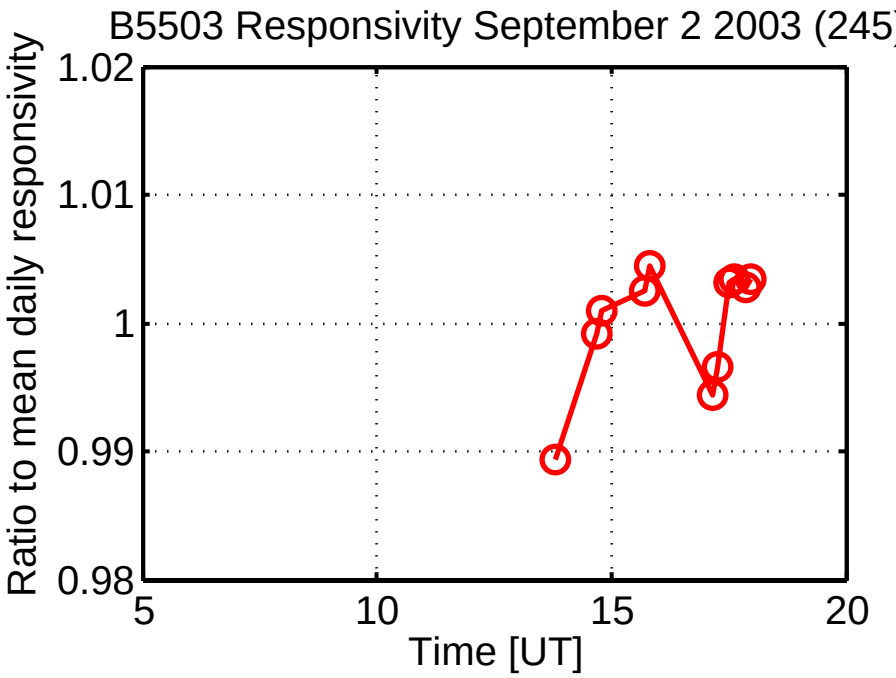

Global irradiance ratios ITR/JRC at Rome:04−Sep−2003(247)
1.2
1.1
1
0.9
0.8
290
295
300
305
310
315
320
325
330
wl [nm]
0
5
10
15
UVIndex
8
6
4
2
0
Daily variation. Wavelength bands are ± 2.5 nm
305 nm
310 nm
319 nm
4(98)
6(76)
8(54)
10(38)
12(36)
14(51)
16(72)
18(95)
TIME [UT](SZA)
11−Nov−2003 12:12:06

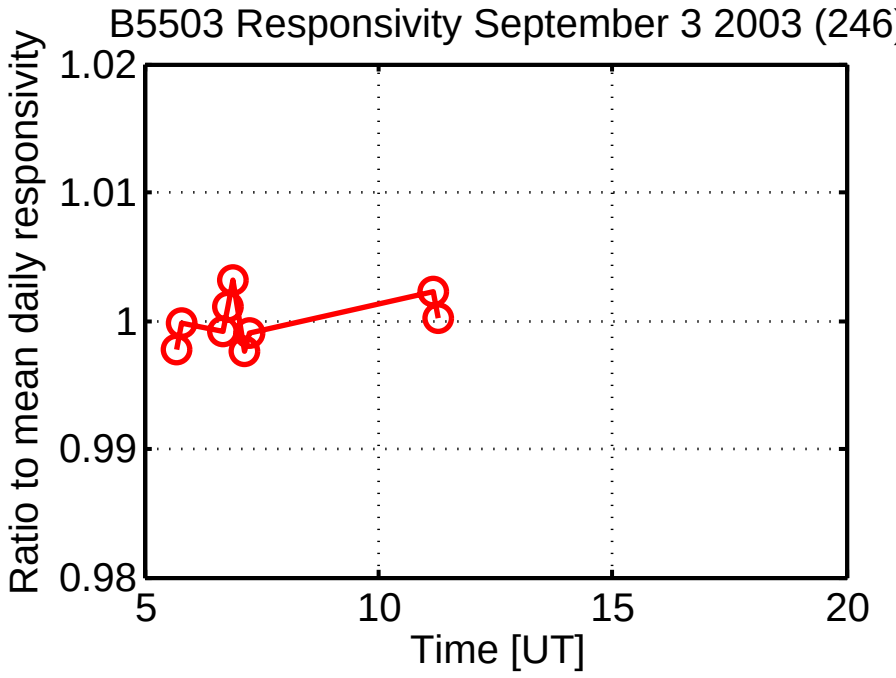

Mean ratio ITR/JRC at Rome:02−Sep−2003(245) to 04−Sep−2003(247)
Mean ratio
5/95% percentile
Range of values
NB Spectra =53
RATIO ITR/JRC
Wavelength [nm]
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
305
310
315
320
325

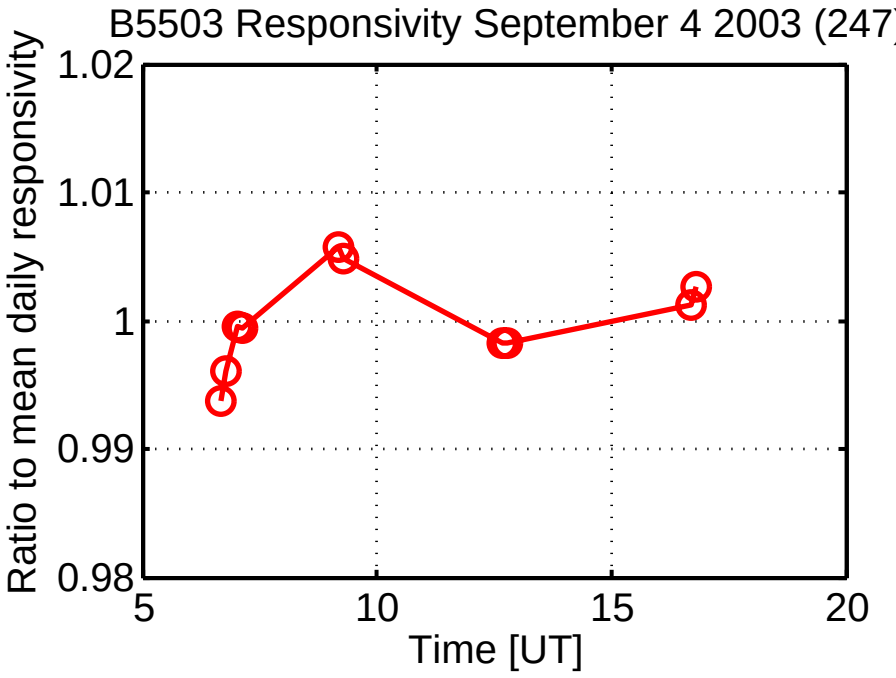

Wavelength shifts for: itr 2*
0.1
0.05
0
-0.05
-0.1
Wavelength shift (nm)
300
310
320
330
340
350
Wavelength (nm)

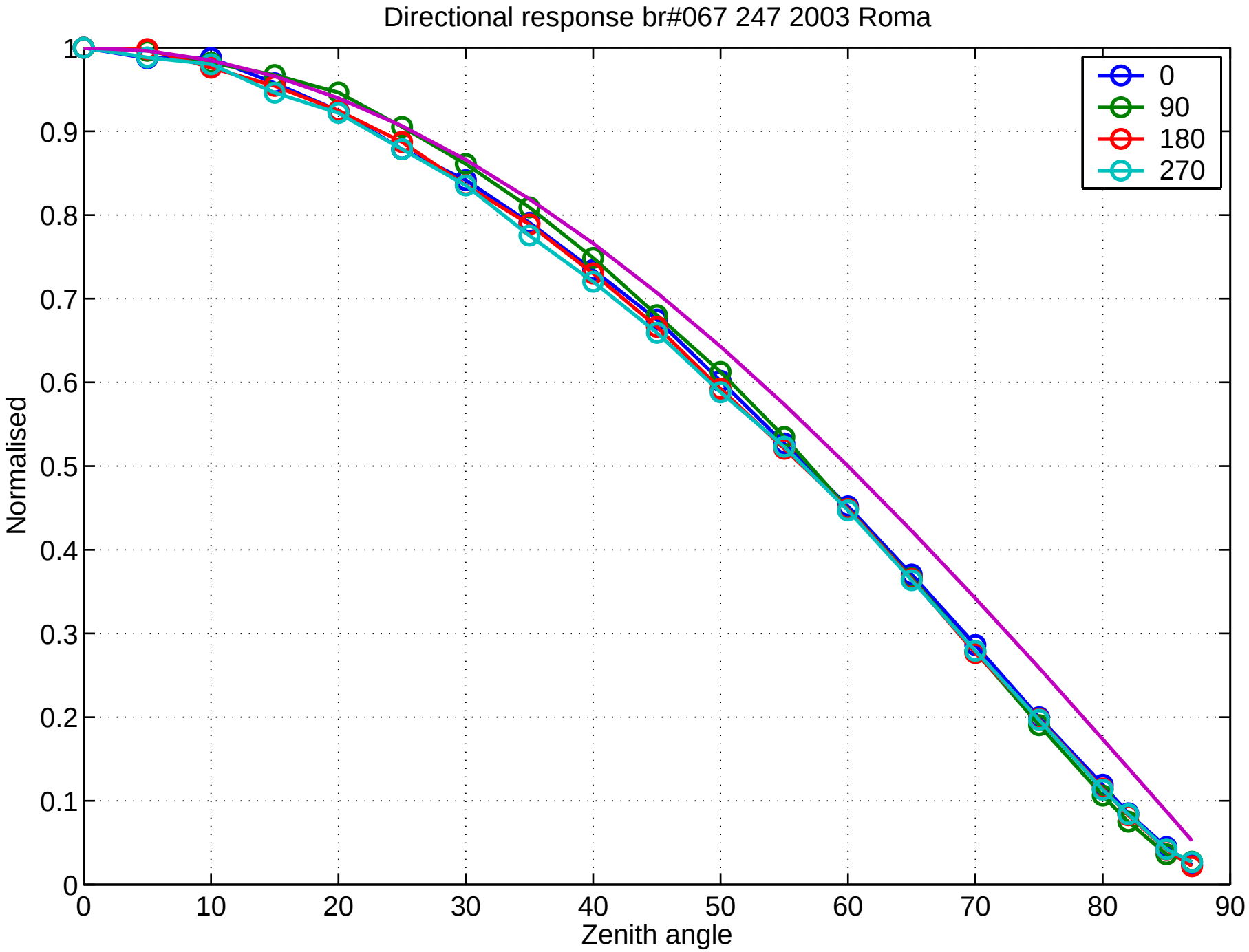

Wavelength shift1 range 2* itr
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
Shift (nm)
5
10
15
20
Time (UT)

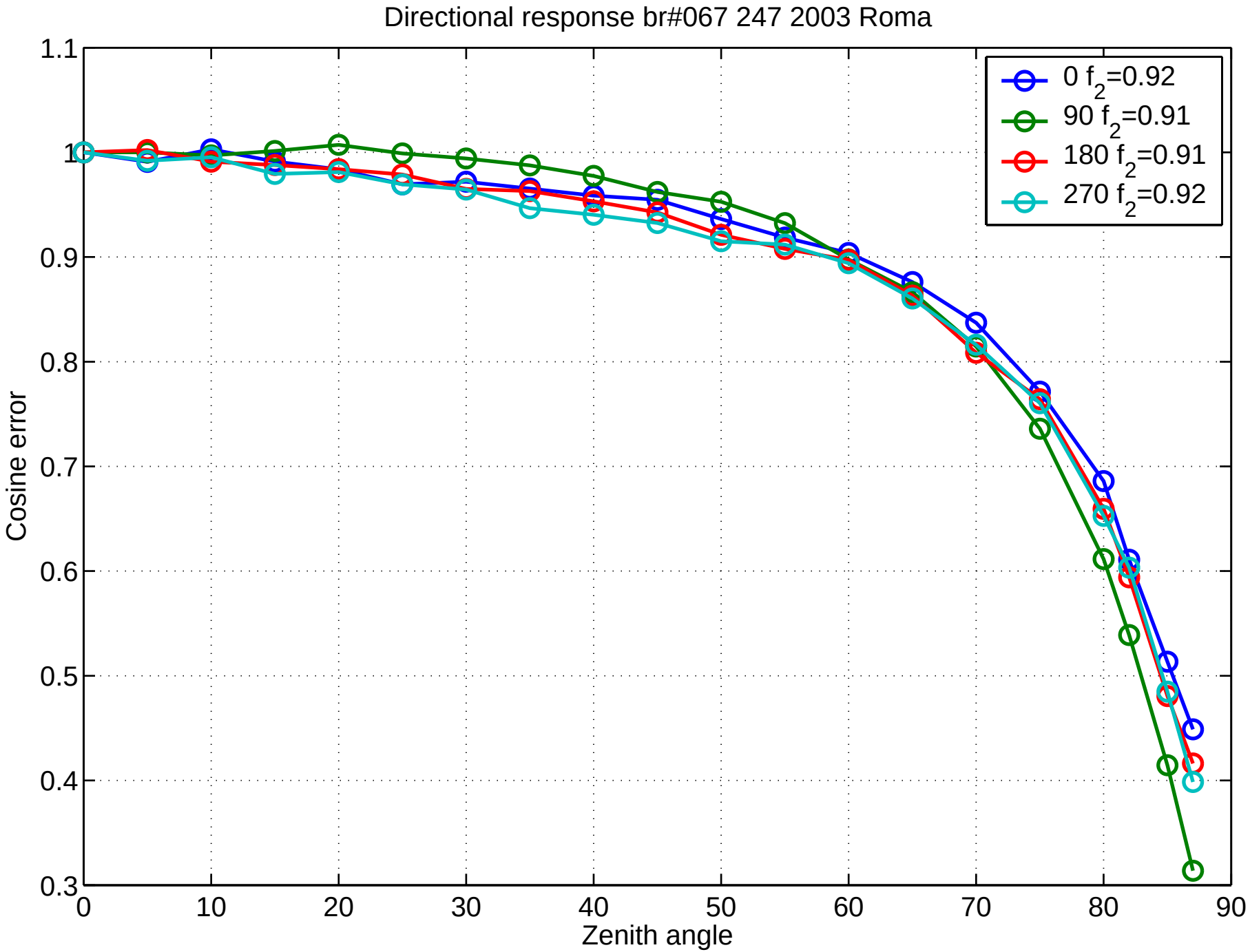

Mean daily Responsivity B5503 Rome 2003
Ratio to mean responsivity
Wavelength [nm]
September 2
September 3
September 4
1.02
1.01
1
0.99
0.98
300
350
400
450
500


B5503 Responsivity September 2 2003 (245)
Ratio to mean daily responsivity
Time [UT]
1.02
1.01
1
0.99
0.98
5
10
15
20


B5503 Responsivity September 3 2003 (246)
Ratio to mean daily responsivity
Time [UT]
1.02
1.01
1
0.99
0.98
5
10
15
20


B5503 Responsivity September 4 2003 (247)
Ratio to mean daily responsivity
Time [UT]
1.02
1.01
1
0.99
0.98
5
10
15
20


Directional response br#067 247 2003 Roma
Normalised
Zenith angle
0
90
180
270
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80
90


Directional response br#067 247 2003 Roma
Cosine error
Zenith angle
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
10
20
30
40
50
60
70
80
90
0 f2=0.92
90 f2=0.91
180 f2=0.91
270 f2=0.92