Protocol of the intercomparison at RIVM, Bilthoven, the Netherlands on July 14 to 18, 2003 with the travelling standard spectroradiometer B5503 from ECUV within the project QASUME

Report prepared by Julian Gröbner and Stelios Kazadzis

Operators: Stelios Kazadzis , Vasilis Amoiridis

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer operated by the Laboratory of Radiation Research, National Institute of Public Health and the Environment (RIVM) (NLR) and the travel standard B5503. The measurement site is located at Bilthoven; Latitude 52.12 N, Longitude 5.19 E and altitude 4 m.a.s.l..
The horizon of the measurement site is free down to about 70° solar zenith angle (SZA) in all directions. For this reason, only measurements between 6:00 UT and 16:30 UT have been analysed.

B5503 arrived at RIVM in the afternoon of July 13, 2003. The spectroradiometer was installed beside the NLR instrument with the entrance optic of B5503 within 1 m of the NLR one. The spectroradiometer in use at RIVM is a DILOR double mono-chromator. The intercomparison between B5503 and the NLR spectroradiometer lasted four days, from the morning of July 14 to noon of July 18.

B5503 was calibrated several times during the intercomparison period using a 100 W portable calibration system. Three 100 W lamps (T53062, T53063, and T57825) were used to obtain an absolute spectral calibration traceable to the primary reference held at ECUV, which is traceable to PTB. The 100 W lamps were compared to the primary standard at ECUV after the campaign and recalibrated. The measurements reported here have been re-analysed using these new lamp certificates; the effect of this recalibration on the measurements at RIVM is an overall 1% decrease of the B5503 solar measurements.
The daily mean responsivity of the instrument based on these calibrations varied by 3% during the intercomparison period. These variations were taken into account on a daily basis. Observed diurnal variations of the responsivity were 3% on July 14, 15, and 16 and were taken into account in the analysis. The internal temperature of B5503 was 27.9±0.3 °C. The diffuser head was heated to a temperature of 30±10°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 450 nm, every 0.5 nm, and 4 seconds between each wavelength increment.

July 13 (194):

B5503 was installed on the measurement site at 15:00 UT and left to stabilize over night.

July 14 (195):

Synchronised measurements are available from 6:00 UT to 16:30 UT. Weather conditions were very good without any clouds for the whole day.

B5503 calibrated from 7:50 to 9:20 UT, 12:47, 15:10, 17:48, and 18:17 UT.

July 15 (196):

Synchronised scans are available from 6:00 to 16:30 UT. The weather condi-tions during the day were similar to the day before; no clouds during the measurement period.

Lamp measurements from B5503 at 5:18, 5:48, 8:20, 11:17, 14:18, 17:48, and 18:20 UT.

July 16 (197):

Synchronised scans are available from 6:00 to 16:30 UT. The weather condi-tions during the day were similar to the day before; no clouds during the measurement period. After 17:00 the sky becomes fully overcast.

Lamp measurements from B5503 at 5:18, 5:48, 8:46, 11:17, 13:49, and 16:48 UT.

July 17 (198):

Synchronised scans are available from 6:00 to 13:30 UT with several interruptions due to rainy conditions. The weather conditions during the day were fully overcast with rain interrupting the measurements.

Lamp measurements from B5503 at 6:17, 6:47, 13:48, 18:15, and 18:47 UT.

July 18 (199):

Synchronised scans are available from 6:00 to 12:00 UT. The weather condi-tions during the day were overcast with no sunshine for most of the measurement period.

Lamp measurements from B5503 at 5:48, 6:15, and from 12:30 to 13:40 UT.

Results:

78 synchronised simultaneous spectra from B5503 and NLR are available from the measurement period. Due to nearby obstructions by trees which might affect the instruments differently only measurements between 6 and 17:30 UT have been analysed (SZA smaller than 70°).

The solar spectra of the NLR spectroradiometer were processed by the SHICRivm algorithm before being submitted and show therefore no wavelength shifts.

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

- Global solar irradiances measured by NLR were between 4% lower to 4% higher than those measured by B5503 for wavelengths between 300 and 450 nm.
- The spectral ratios between NLR and B5503 are remarkably constant over the whole measurement period and show a spectral variation of 2% amplitude over the wavelength range 305 to 450 nm. Below 305 nm the measurements of NLR increase slightly by 1 or 2 % above approximately 50° SZA.
- A diurnal variability of 3% amplitude is visible on the first three days with a minimum around local noon.

Conclusion:

NLR measures global solar irradiance on average 1% lower than B5503. The variability between the two spectroradiometers is less than 5% during the whole measurement period.

During the previous visit of B5503 to RIVM, NLR measured solar irradiances about 6% higher than B5503. The difference between this site visit and the previous one could not be explained so far.

Comments from the local operator:

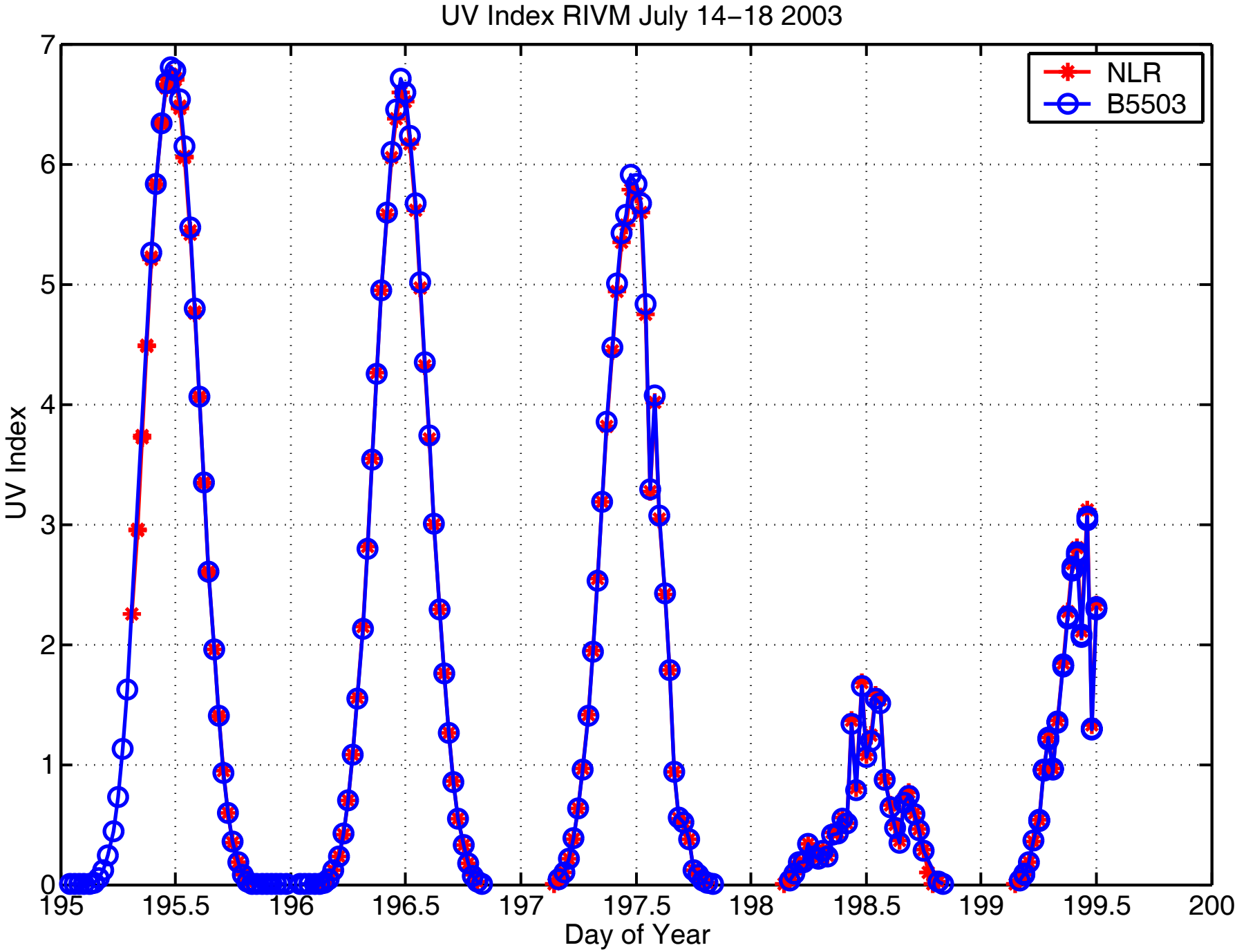
- Since the comparison we did a check of our DXW/S794 1000 W lamp by comparing it to two other 1000W lamps, the same way we did in 2002 before the QASUME campaigns. Furthermore we use a 200W lamp to check the stability of the instrument. Based on these lamp measurement results, our nlr instrument did not change more than ±2%.
- It seems there is a difference in ratio for "sunny" and "non sunny" days. During the 2003 campaign the ratios for the last two days are about 2% higher. Also in the period (2001) that we were using the Schreder head in our nla-instrument (no cosine correction) and a flat diffuser for the nlr-instrument (cosine correction applied) we observed the same phenomenon. Bear in mind that during the campaigns in 2002 the weather was not so good, maybe this effect plays a role.
- The nlr-instrument 2003 has a higher sensitivity than in 2002, and might also need a dead time correction. However it is much smaller than for the nla instrument. It might be a small part of the "sunny"-"non sunny" difference, in the wavelength above 340 nm. It can not be a strong effect, because in that case it should be strongly wavelength dependent, and we see no such dependence in the data.
- Can there be any effect of the change of the Schreder head of the JRC-instrument between 2002 and 2003? Although the azimuth is now better, the cosine is probably slightly worse, so a small cosine correction might be required.

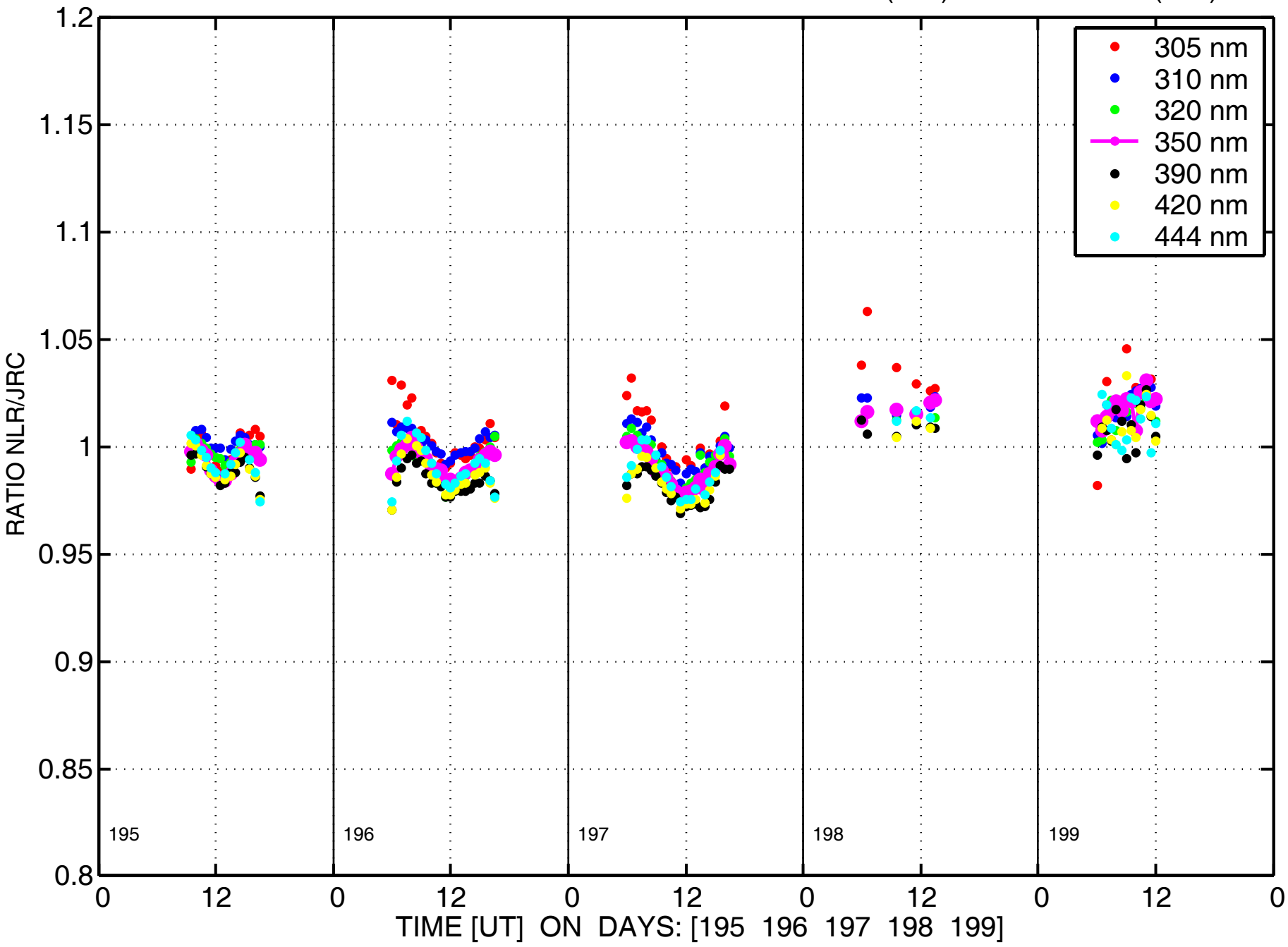
Answer (J. Gröbner): The integrated cosine error of the Schreder head in use in 2003 is between 0.99 and 1.01 at 320 and 500 nm respectively.

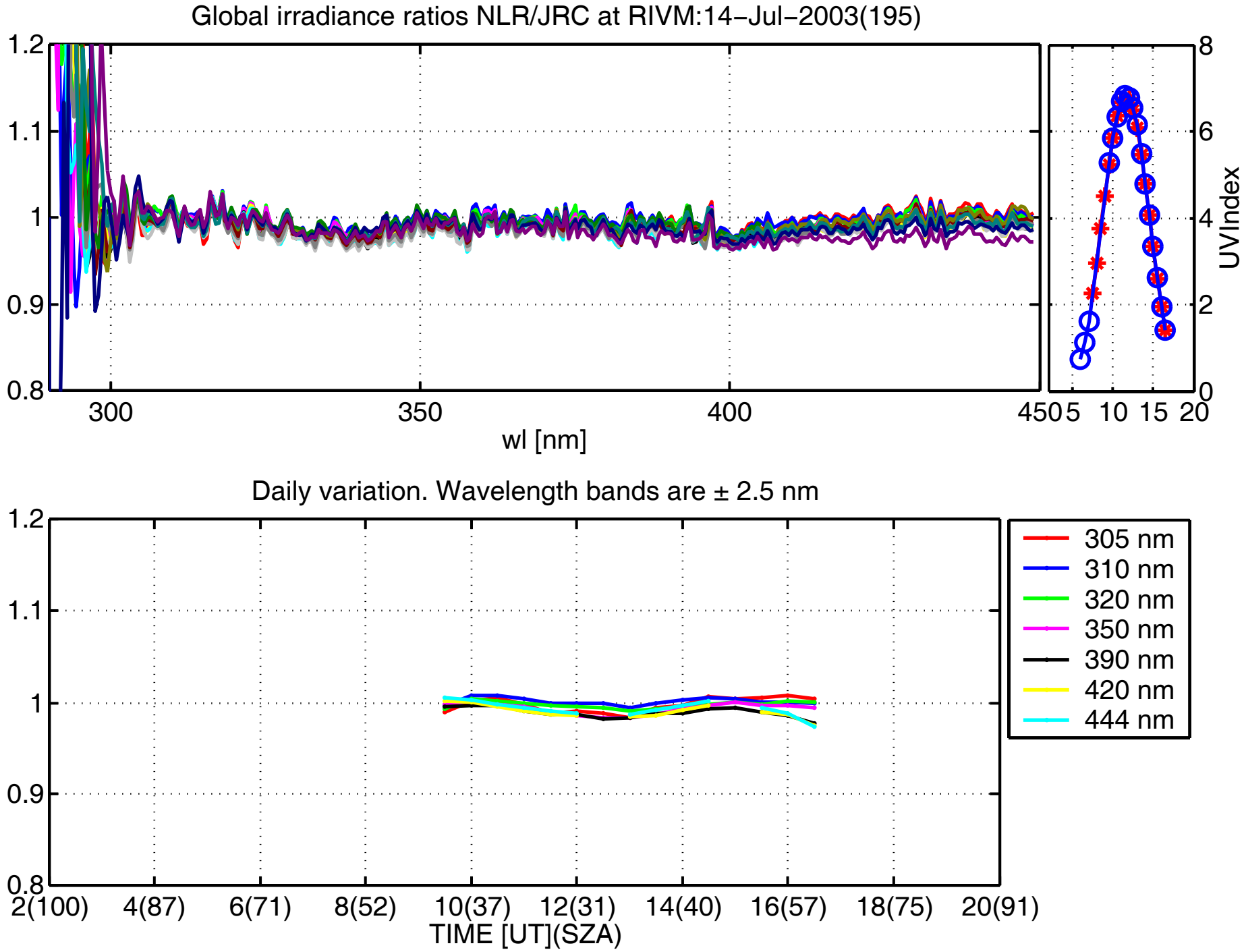
- Stelios mentioned the sensitivity change (about 3%) of the JRC instrument especially during the morning, which was monitored and corrected for in 2003. As this was not corrected for in 2002, this might have an effect for the 2002 campaigns, maybe depending on sunny/non sunny weather conditions.

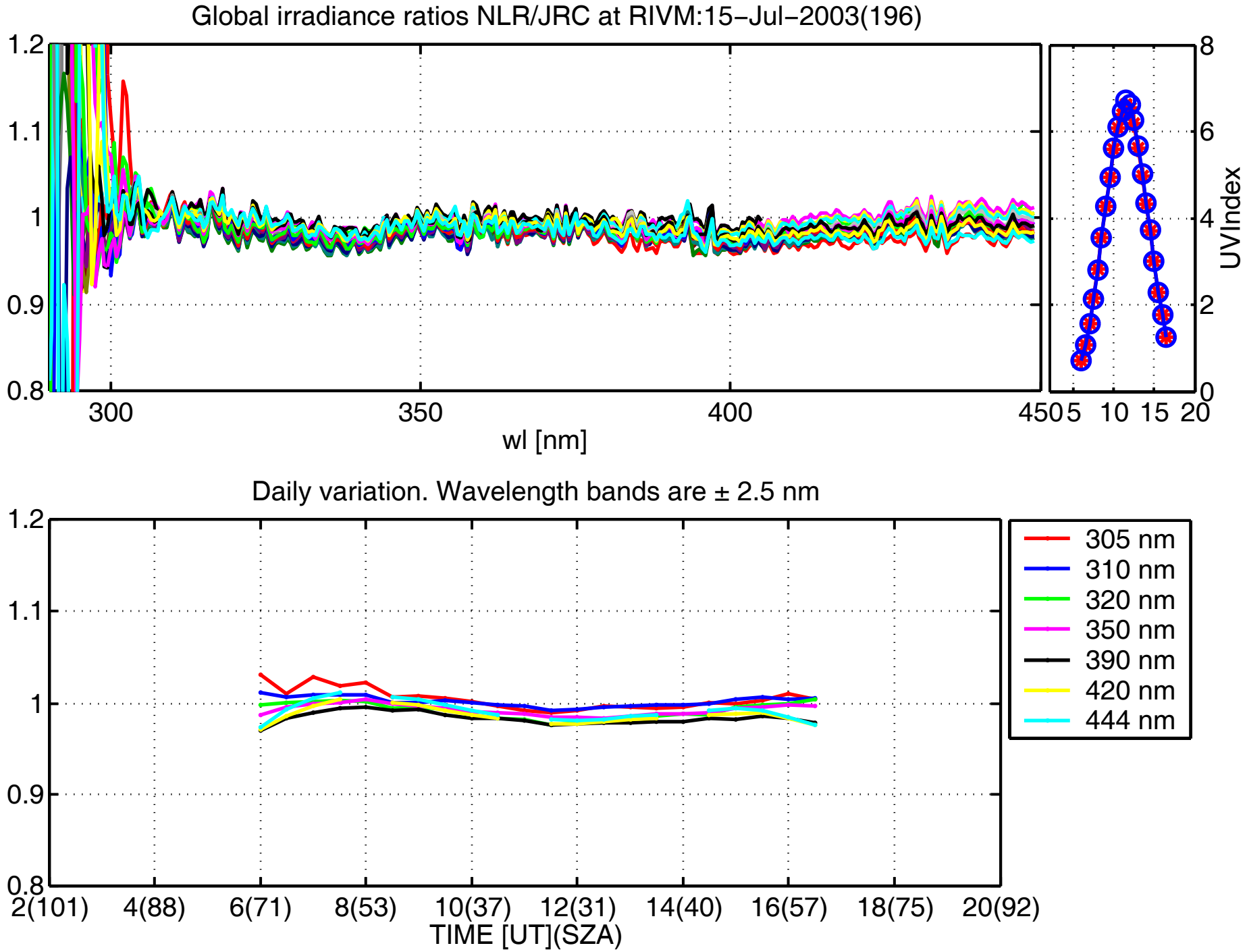
Answer (J. Gröbner): The calibrations in 2002 were done twice at the end of a measurement day. Measurements of 2003 have shown that a calibration done at the end of a day could underestimate solar UV measurements by 1 to 2%. Therefore the nlr/jrc ratios of 2002 might be 1.04 to 1.05 instead of 1.06.

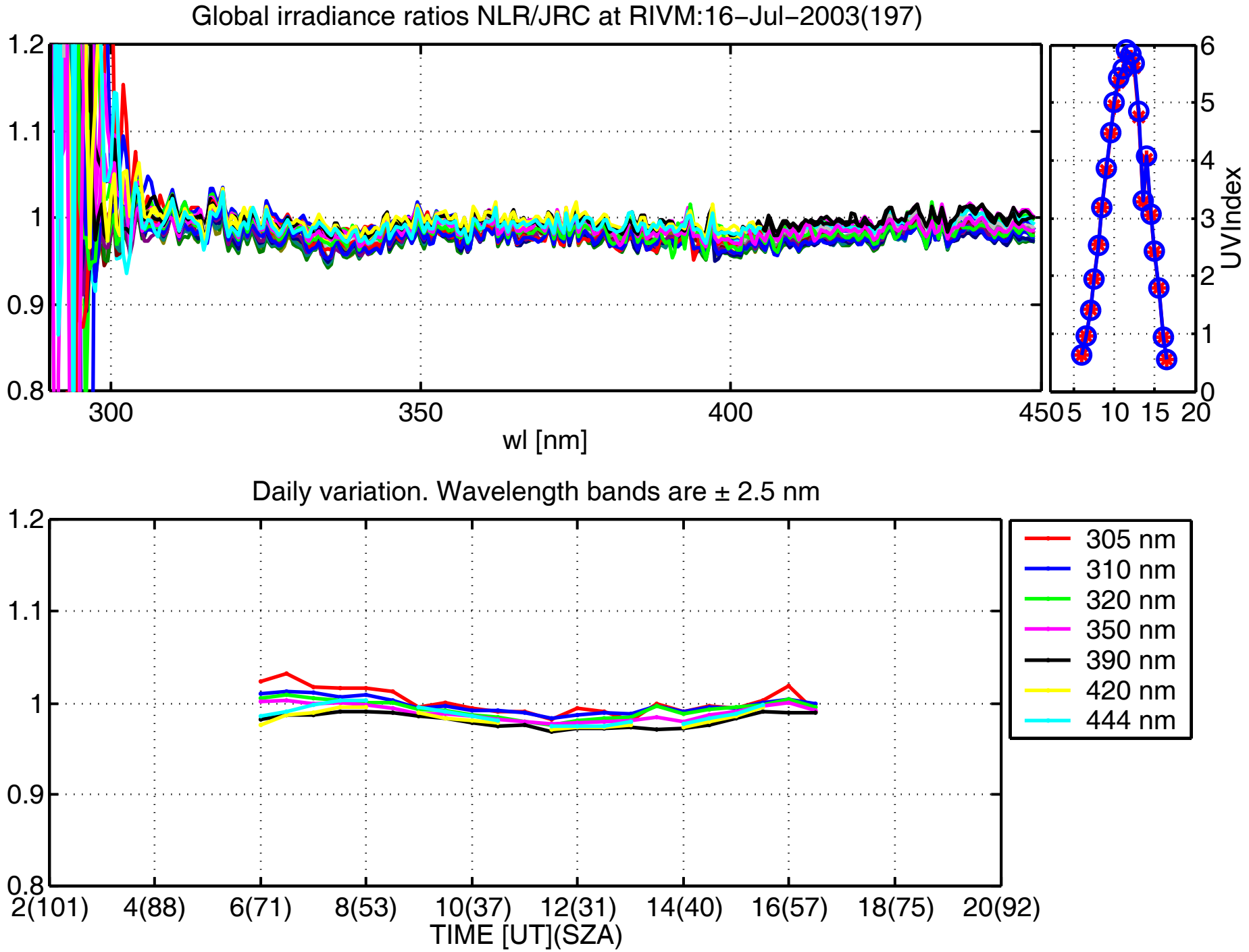
When looking closer to the plots we see that for the non sunny day (the last day) the comparison of the nlr/jrc-ratio (this year 1.02, last year 1.06) with previous year (almost all days non sunny) is within about ±2%.

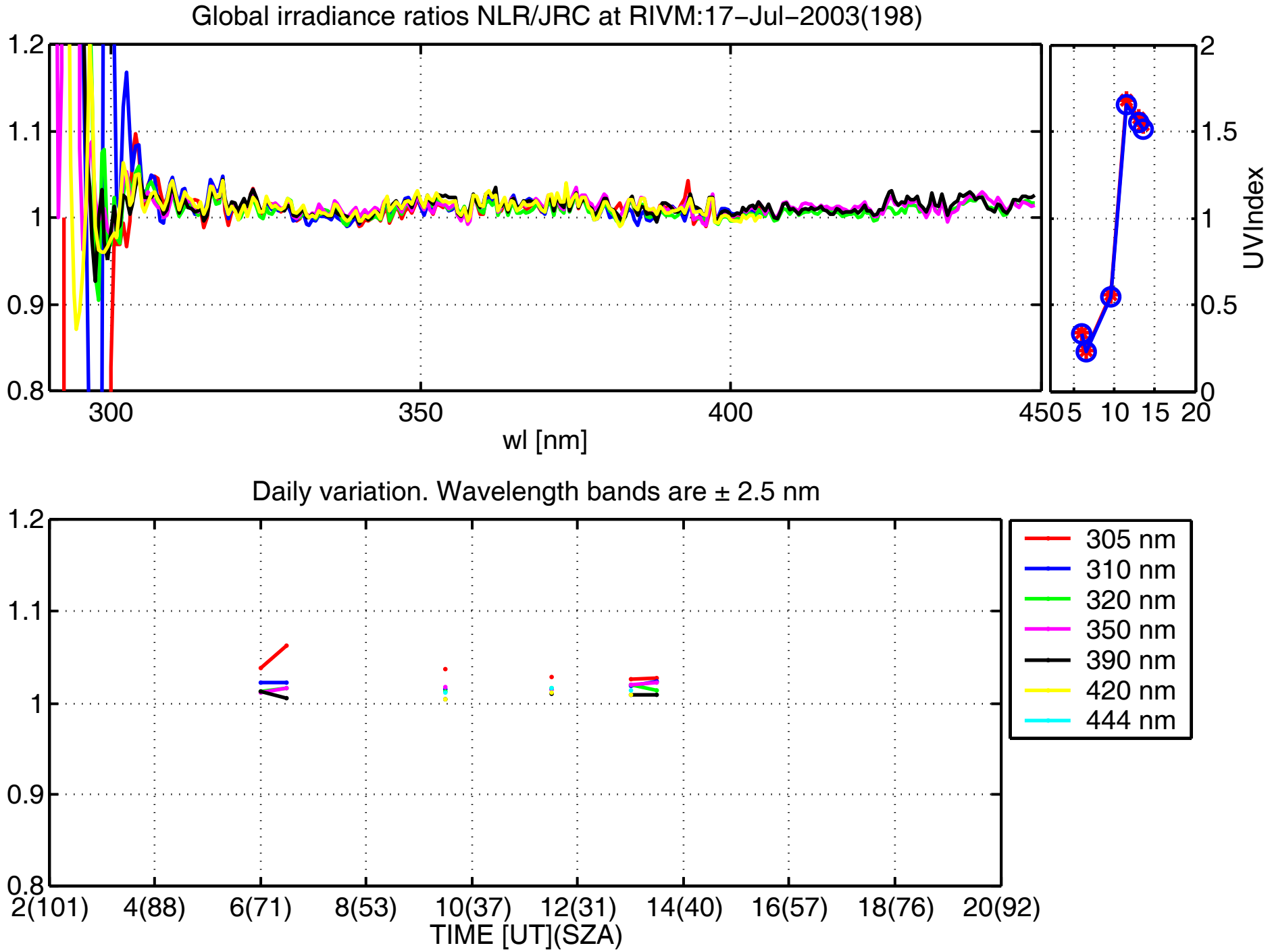

UV Index RIVM July 14–18 2003
NLR
B5503
UV Index
Day of Year
0
1
2
3
4
5
6
7
195
195.5
196
196.5
197
197.5
198
198.5
199
199.5
200

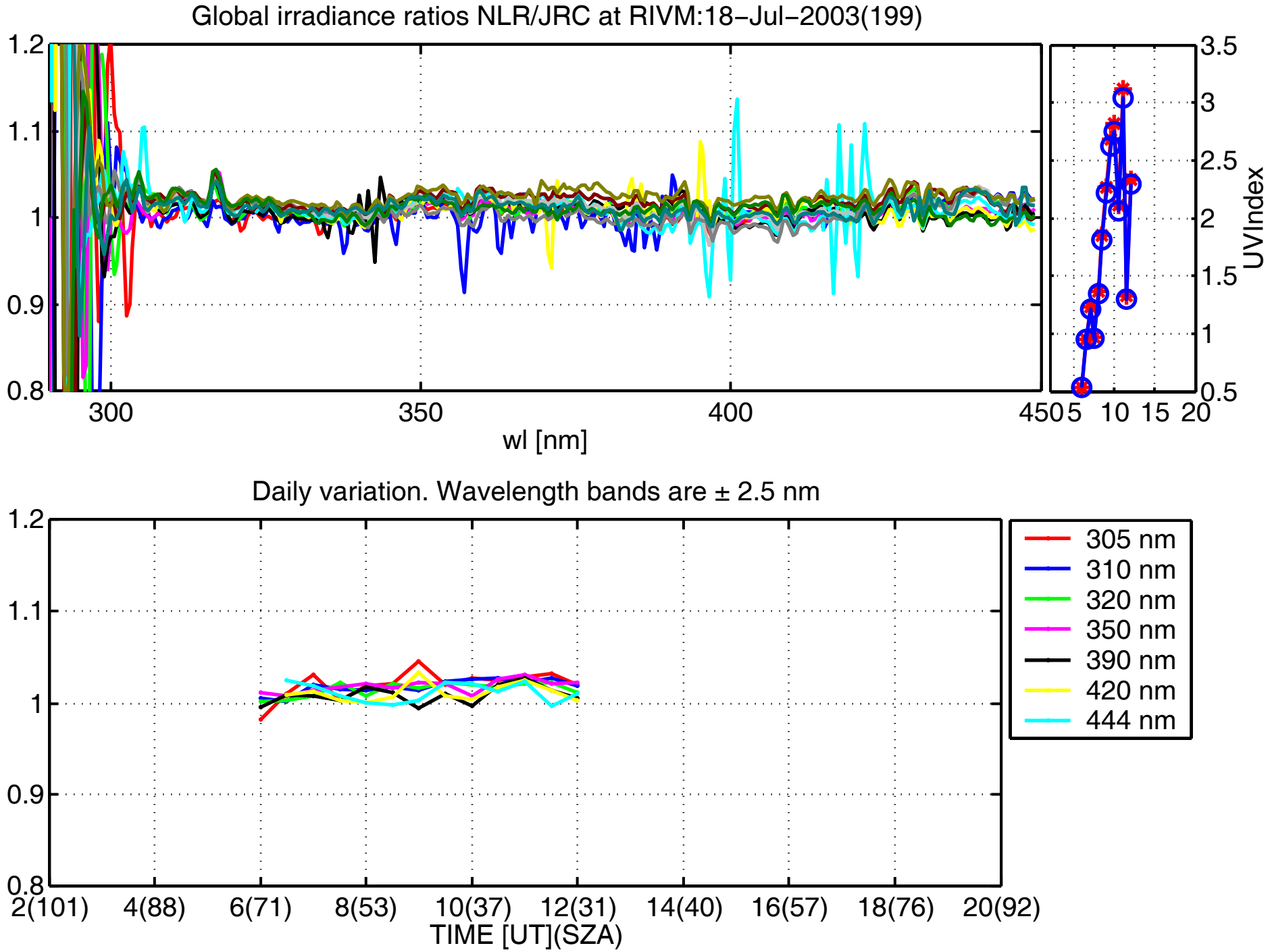

Global irradiance ratios NLR/JRC at RIVM:14–Jul–2003(195) to 18–Jul–2003(199)
RATIO NLR/JRC
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
305 nm
310 nm
320 nm
350 nm
390 nm
420 nm
444 nm
195
196
197
198
199
0
12
0
12
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [195 196 197 198 199]
30–Sep–2003 10:53:49

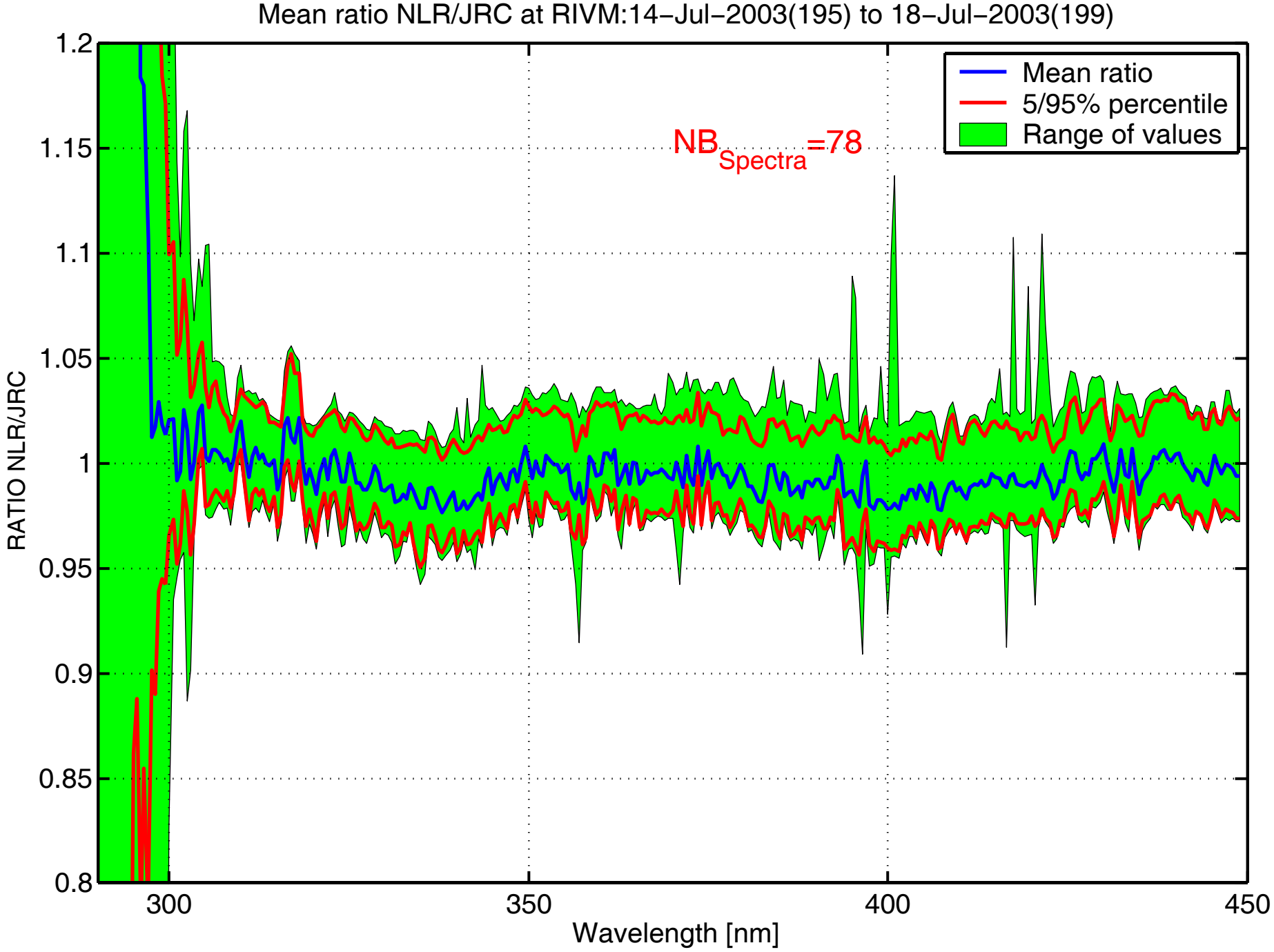

Global irradiance ratios NLR/JRC at RIVM:14−Jul−2003(195)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
8
6
4
2
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
2(100)
4(87)
6(71)
8(52)
10(37)
12(31)
14(40)
16(57)
18(75)
20(91)
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
390 nm
420 nm
444 nm
30−Sep−2003 10:53:49

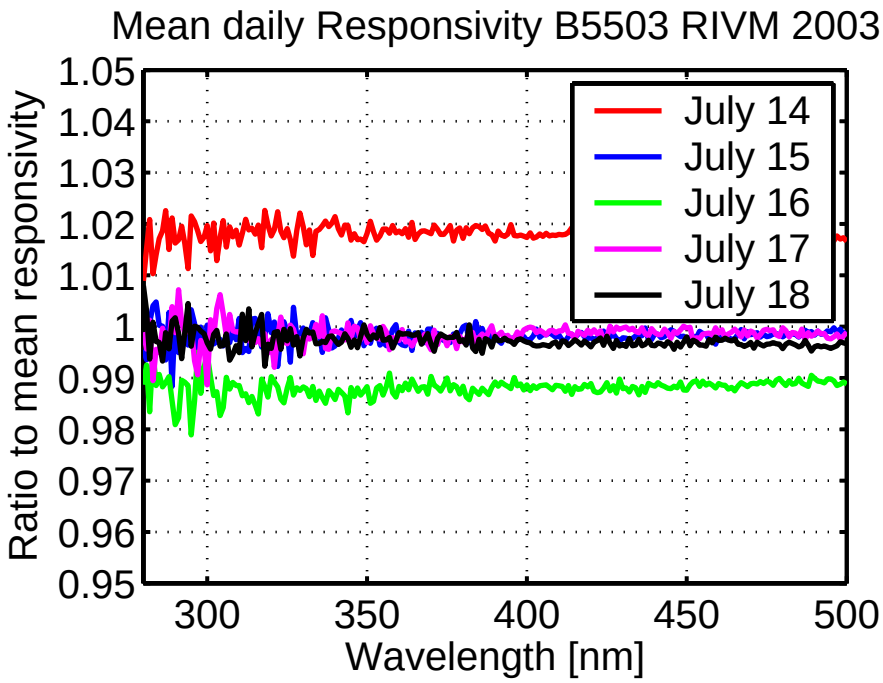

Global irradiance ratios NLR/JRC at RIVM:15−Jul−2003(196)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
8
6
4
2
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
2(101)
4(88)
6(71)
8(53)
10(37)
12(31)
14(40)
16(57)
18(75)
20(92)
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
390 nm
420 nm
444 nm
30−Sep−2003 10:53:49

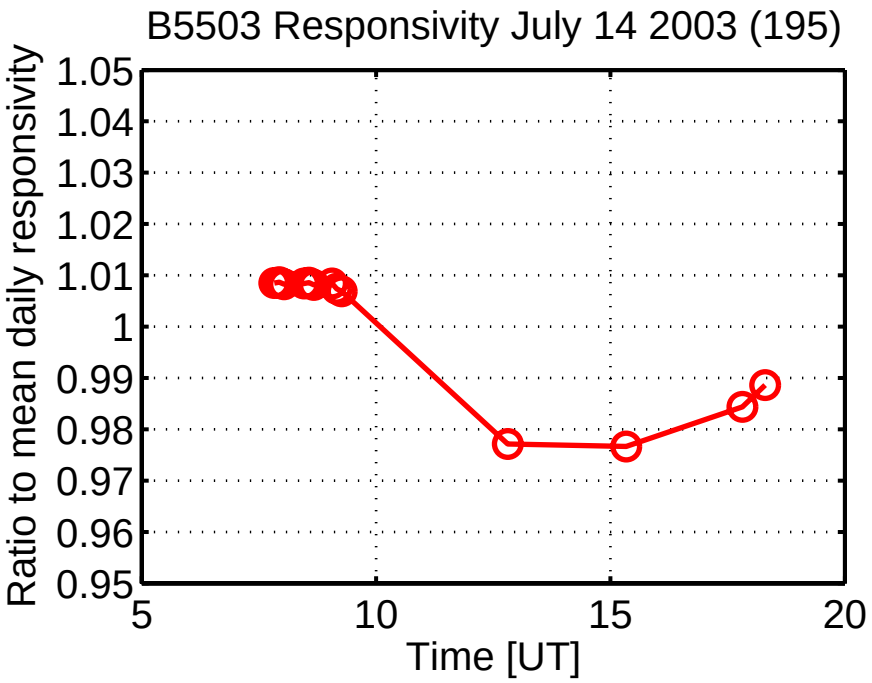

Global irradiance ratios NLR/JRC at RIVM:16−Jul−2003(197)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
5
10
15
20
UVIndex
6
5
4
3
2
1
0
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
2(101)
4(88)
6(71)
8(53)
10(37)
12(31)
14(40)
16(57)
18(75)
20(92)
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
390 nm
420 nm
444 nm
30−Sep−2003 10:53:49

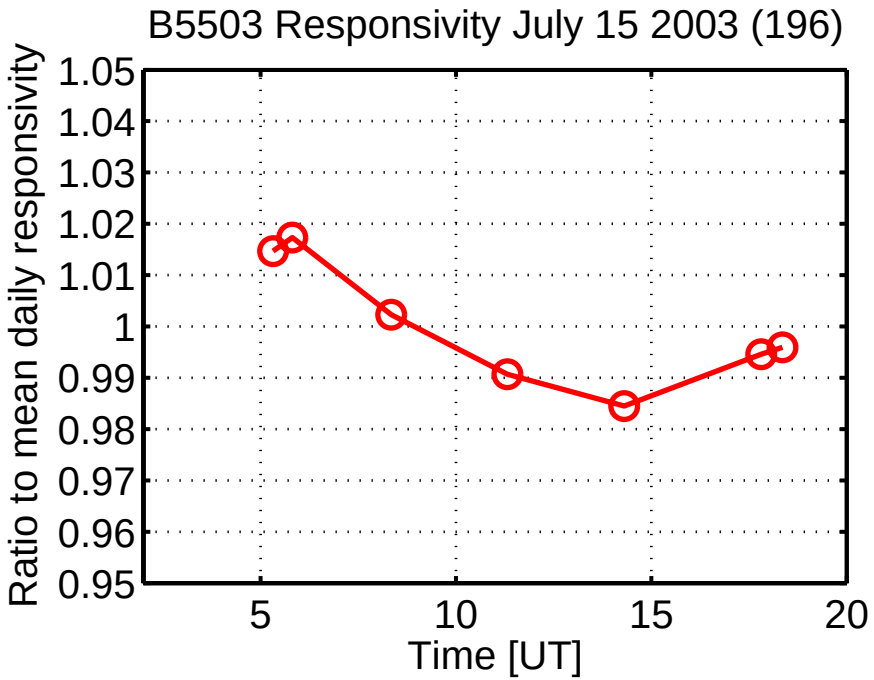

Global irradiance ratios NLR/JRC at RIVM:17–Jul–2003(198)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
2
1.5
1
0.5
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
2(101)
4(88)
6(71)
8(53)
10(37)
12(31)
14(40)
16(57)
18(76)
20(92)
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
390 nm
420 nm
444 nm
30–Sep–2003 10:53:49

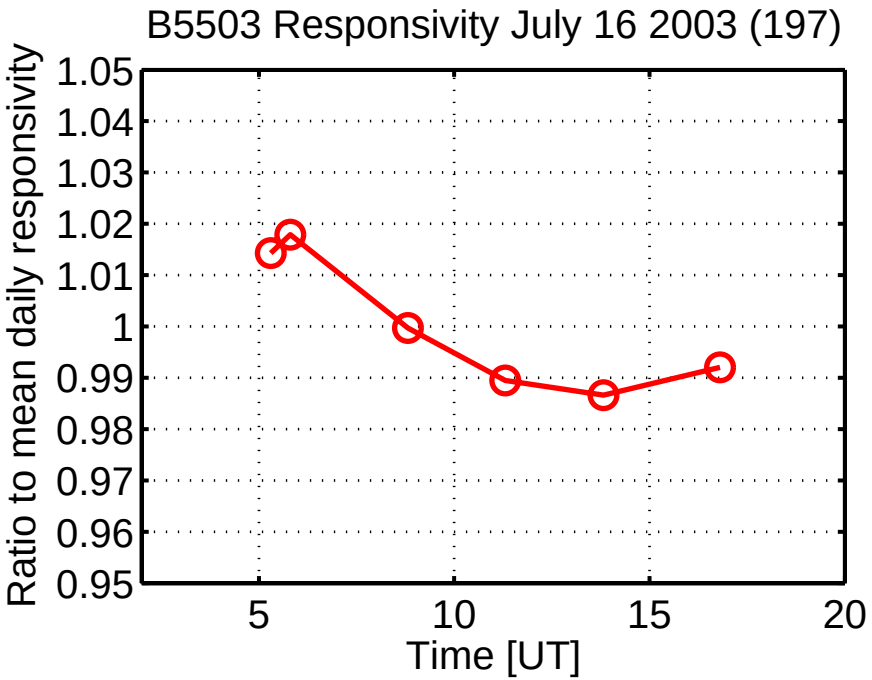

Global irradiance ratios NLR/JRC at RIVM:18−Jul−2003(199)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
3.5
3
2.5
2
1.5
1
0.5
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
305 nm
310 nm
320 nm
350 nm
390 nm
420 nm
444 nm
2(101)
4(88)
6(71)
8(53)
10(37)
12(31)
14(40)
16(57)
18(76)
20(92)
TIME [UT](SZA)
30−Sep−2003 10:53:49


Mean ratio NLR/JRC at RIVM:14–Jul–2003(195) to 18–Jul–2003(199)
Mean ratio
5/95% percentile
Range of values
NB Spectra =78
RATIO NLR/JRC
Wavelength [nm]
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
350
400
450


Mean daily Responsivity B5503 RIVM 2003
Ratio to mean responsivity
Wavelength [nm]
July 14
July 15
July 16
July 17
July 18


B5503 Responsivity July 14 2003 (195)
Ratio to mean daily responsivity
Time [UT]


B5503 Responsivity July 15 2003 (196)
Ratio to mean daily responsivity
Time [UT]


B5503 Responsivity July 16 2003 (197)
Ratio to mean daily responsivity
Time [UT]


rivm