Protocol of the intercomparison at the Meteorological Institute in Lisbon, Portugal, on July 19 to 22, 2004 with the travelling standard spectroradiometer B5503 from ECUV within the project QASUME

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The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer (IML) operated by the Meteorological Institute of Portugal and the travel standard B5503. The measurement site is located on the roof of a building in downtown Lisbon; Latitude 38.78 N, Longitude 9.13 W and altitude 113 m.a.s.l.. Several obstructions limit the horizon of the instruments; to about 85° SZA in the East (morning); 60° in the ENE direction; 75° due to a building in the WNW direction; an antenna plate in the same direction (5 m distance from the instruments) is a possible reflection light source mostly in the morning.

B5503 arrived at Lisbon in the evening of July 18, 2004. The spectroradiometer was installed beside the IML instrument with the entrance optic of B5503 about 2 m from IML. The spectroradiometer in use at Lisbon is a Brewer single monochromator #47. The intercomparison between B5503 and IML lasted four days, from the morning of July 19 to the afternoon of July 22.

B5503 was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T57824, T57825 and T61251) were used to obtain an absolute spectral calibration traceable to the primary reference held at ECUV, which is traceable to PTB. The responsivity of the instrument based on these calibrations varied by less than 1% during the intercomparison period. The internal temperature of B5503 was 28.4±0.2°C. The diffuser head was regulated to a temperature of 30±7°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. The upper wavelength limit of the IML spectroradiometer was 325 nm.

<u>July 18 (200):</u>

B5503 was installed on the measurement site at 18:30 UT and left to stabilize over night.

July 19 (201):

Synchronised measurements are available from 11:30 UT to 19:30 UT. Weather conditions were a mix of sun and clouds with cumulus and some cirrus.

B5503 calibrated at 9:20 UT, 10:06 UT, and 10:30 UT.

July 20 (202):

Synchronised scans are available from 5:30 to 18:30 UT. Weather conditions were clear skies without clouds.

B5503 calibrated at 18:12 UT.

July 21 (203):

Synchronised scans are available from 6:00 UT to 18:30 UT. Weather conditions were partly overcast (cumulus and cirrus) in the morning and clear skies without clouds in the afternoon (after 13:30 UT).

B5503 calibrated at 18:10 UT.

July 22 (204):

Synchronised scans are available from 6:00 UT to 13:00 UT. Weather conditions were clear skies without clouds until 10:00 UT, then about 5 octa cirrus cloud cover.

Results:

86 synchronised simultaneous spectra from B5503 and IML are available from the measurement period. The average wavelength shift relative to the extraterrestrial spectrum used by the SHICRivm software was between –60 to –20 pm and stable to within 20 pm.

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

- Global solar irradiances measured by IML were 35% to 10% higher than those measured by B5503 for wavelengths between 305 and 325 nm respectively.
- The spectral ratios between IML and B5503 decrease linearly from 1.25 at 305 nm to 1.15 at 325 nm. Below 305 nm the ratios increase with increasing SZA, which is probably due to stray light within the single monochromator. The ratios at 305 nm are affected at SZA higher than about 65°.
- 2 spectral ratios during the measurement period show “spikes” at specific wavelengths. These “spikes” could be traced to the IML instrument: July 20, 10:00 UT scan at 311.5 nm and July 21, 15:00 UT scan at 312.5 nm.
- The ratios IML to B5503 show a decrease of about 10% during each measurement day, which seems independent of wavelength.

Conclusion:

The global solar irradiance spectra measured by the IML spectroradiometer are on average between 13 to 25% higher than those measured by B5503 between 305 and 325 nm. Below 305 nm the measurements by IML are affected by internal stray light which is

dependent on the SZA. Diurnal variations of the order of 10% are seen on all measurement days.

Comments from the local operator:

- On the protocol description I suggest to define better what is a "synchronised scan". It refers to the central time of the scan or to the individual wavelength measurement time or other ? Anyway, how much should be the difference between the two times (IML and B5503) to be considered synchronised ?

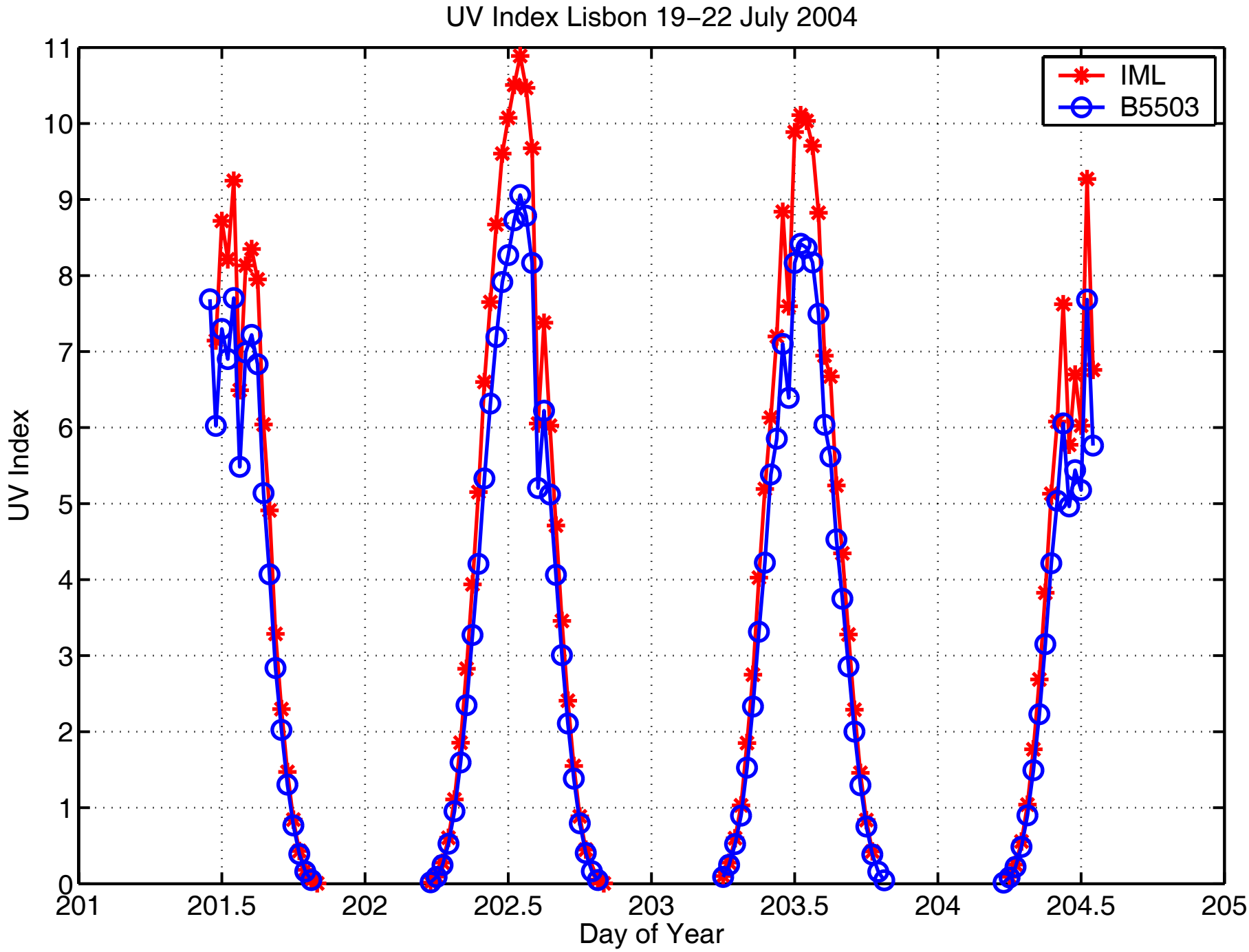
Response (J. Gröbner): *A synchronised scan is defined on page one (Protocol); Both instruments start exactly on the full and half hour at 290 nm and increment the wavelength by 0.5 nm every 3 seconds, until reaching the maximum common wavelength (i.e. 325 nm in your case). It is the responsibility of the local operator to ensure that the time used by the local spectroradiometer is exact (in UT). In your case, I have records in my logbook by Stelios Kazadzis that the time of your instrument was set (and checked). Therefore I expect the time differences between the two instruments to be below 2 seconds at each wavelength.*

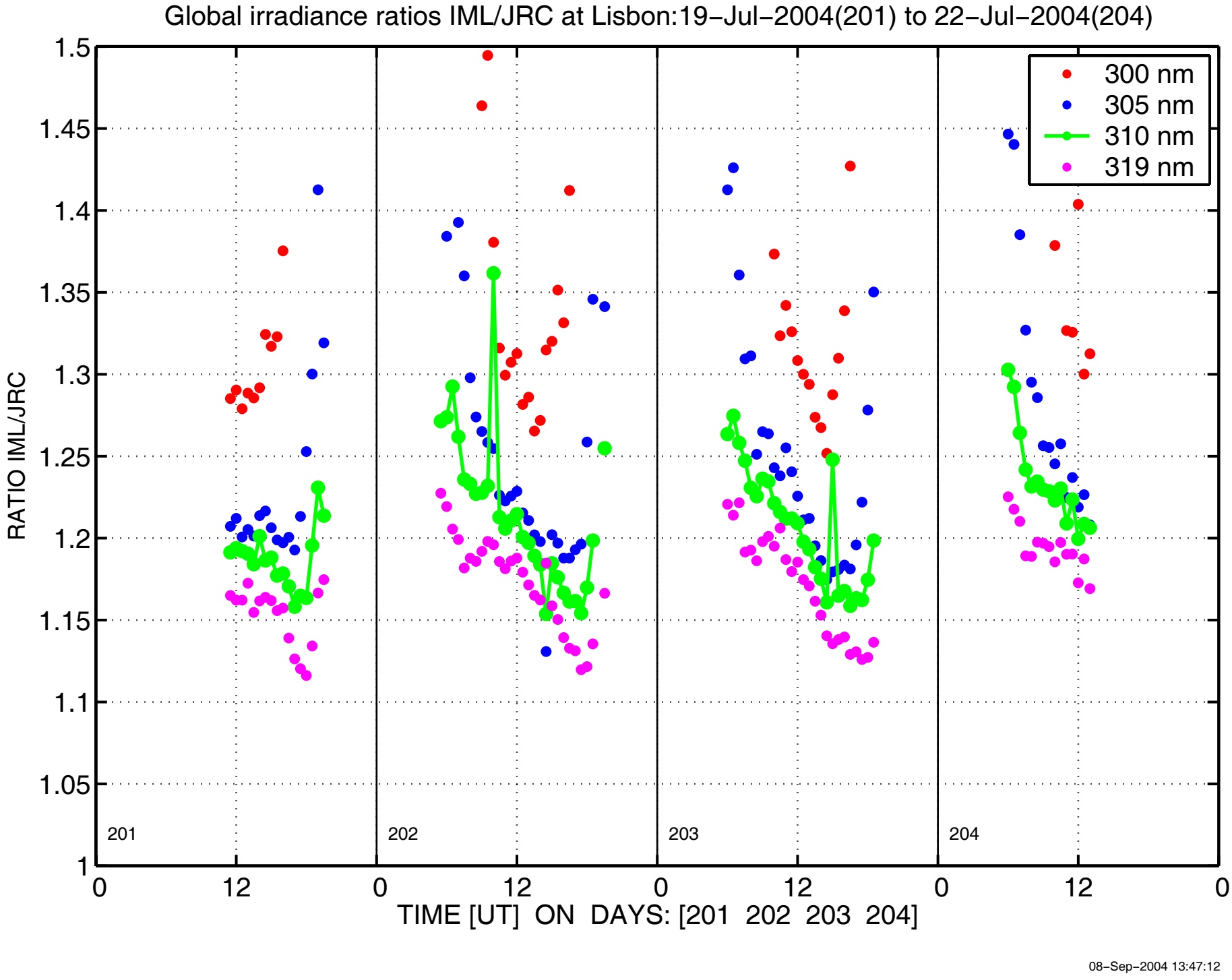
- On the results section It is referred that ratios decreases with ZA, but I think there is also a strong dependence with azimuth angle that can be seen better at higher wavelengths. Is there also a cosine response error ?

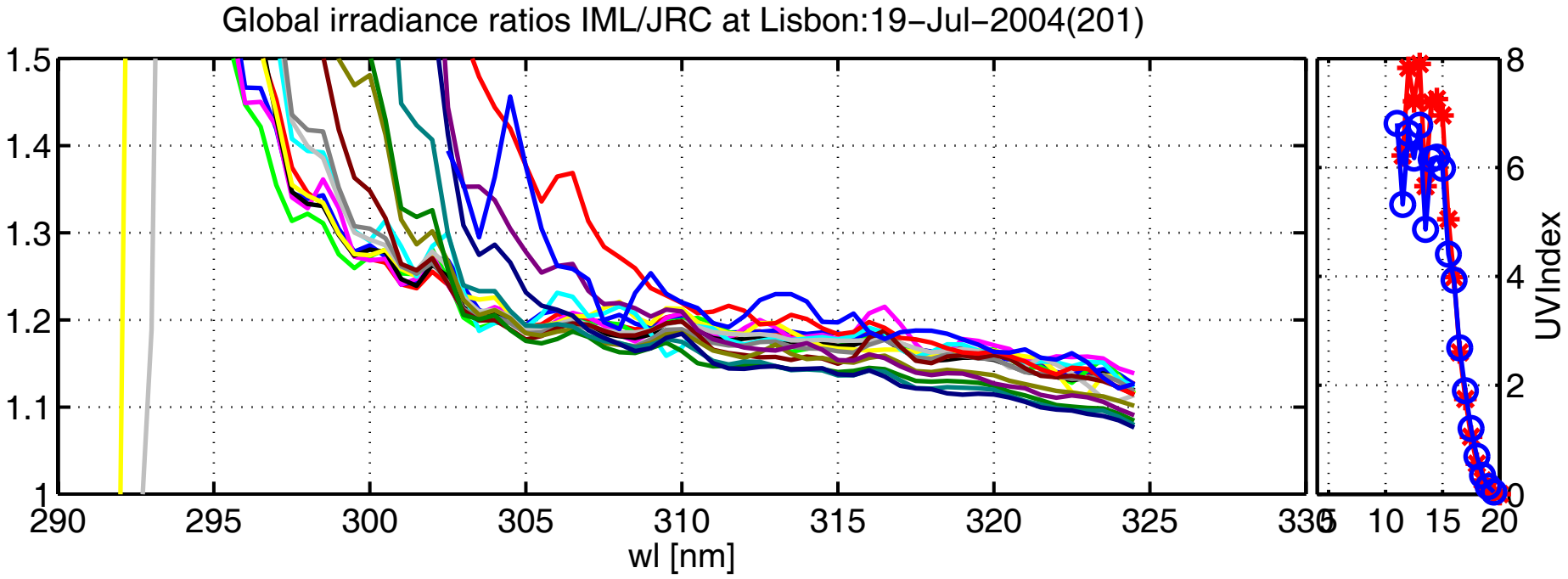
Response (J. Gröbner): *The decrease is referred mainly to the short wavelengths at and below 305 nm, which are affected by internal stray light of the monochromator. The diurnal variation seen on all days is mentioned in the report; the reasons for that behavior is left to explain to the local operator who should know his instrument better than the QASUME operators. One possibility could be the temperature of the spectroradiometer, since most Brewer spectrophotometers have a decreasing sensitivity with increasing temperature. If your instrument does not apply a cosine correction to the meaqsured irradiances, then it is likely that it has a cosine error, which would manifest itself as an offset as well as a diurnal variation in the ratios.*

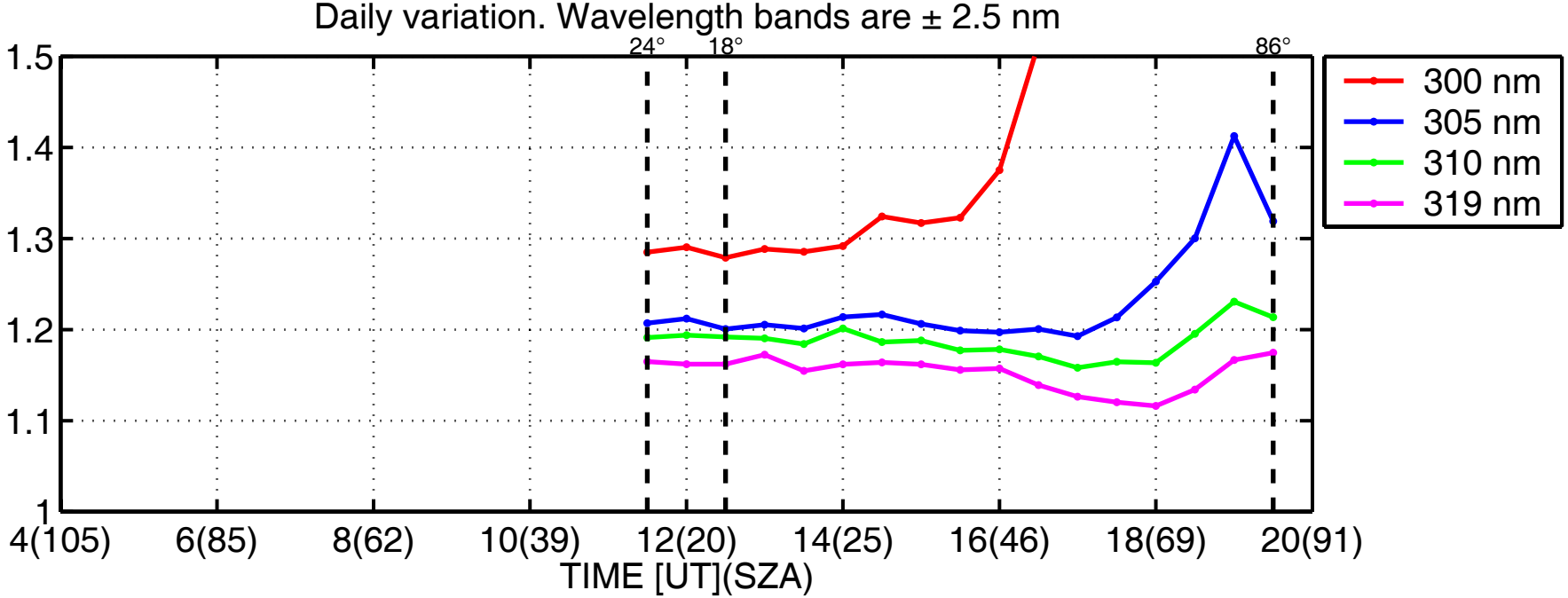
- Regarding the Ratio spikes, is the B5503 to low or IML too high ? Because this is not evident from the UV index graphs, I think that spectral irradiance data should also be plotted for the control wavelengths.

Response (J. Gröbner): *By dividing subsequent spectra of the same instrument, it is possible to say that the spikes are due to the IML instrument, as stated in the report. (these plots are added to the report).*

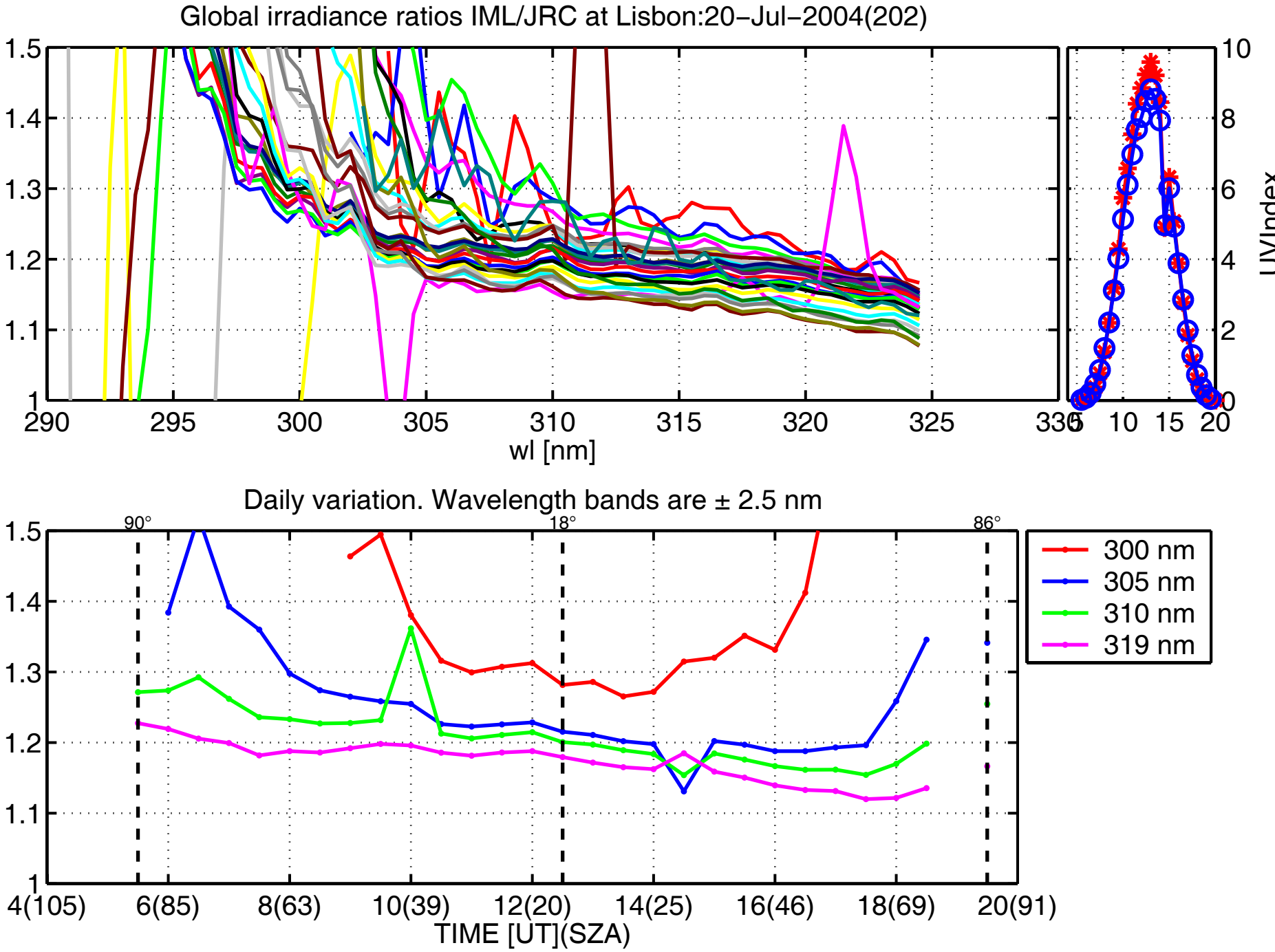

UV Index Lisbon 19–22 July 2004
IML
B5503
UV Index
Day of Year
0
1
2
3
4
5
6
7
8
9
10
11
201
201.5
202
202.5
203
203.5
204
204.5
205

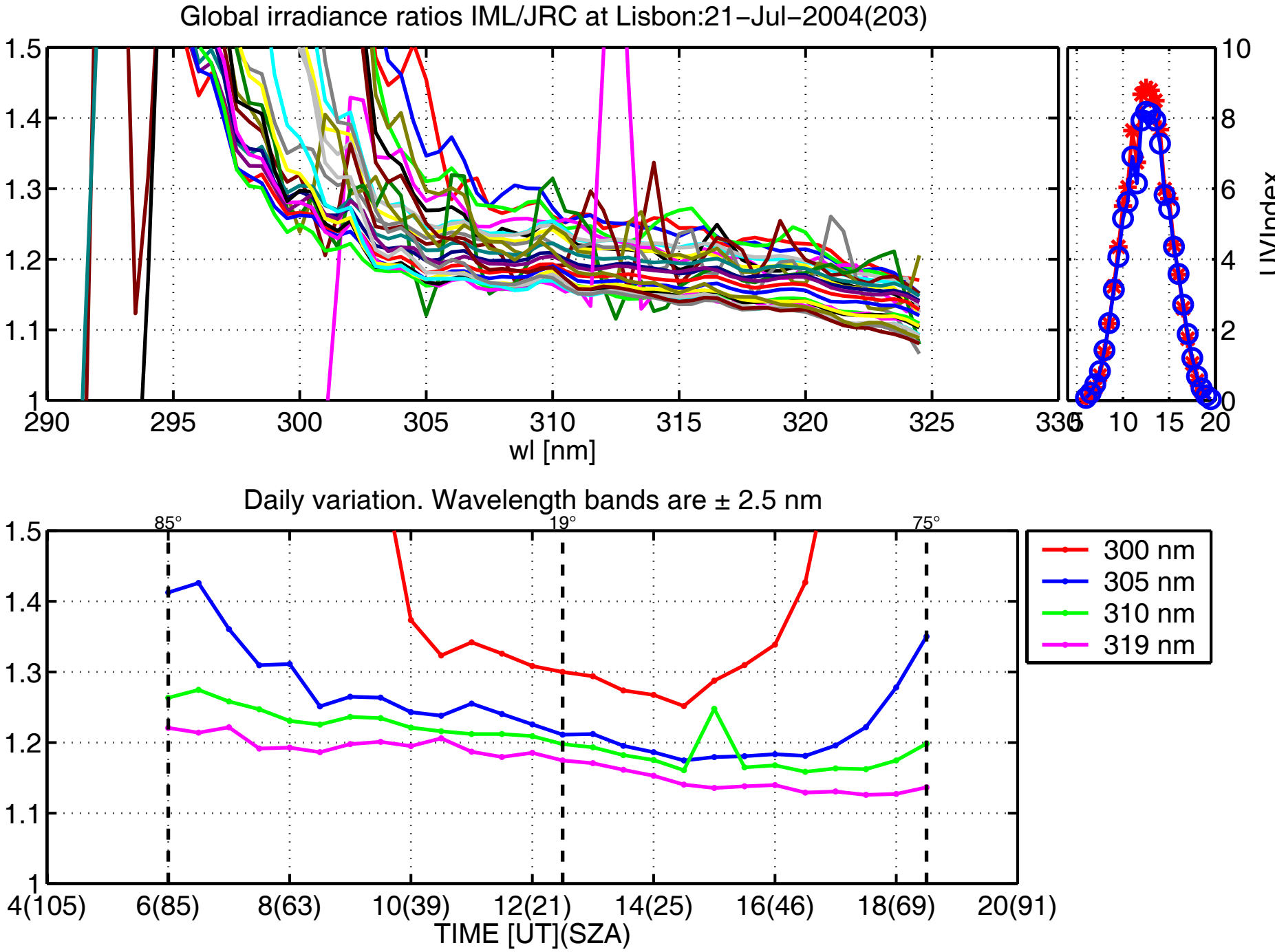

Global irradiance ratios IML/JRC at Lisbon:19–Jul–2004(201) to 22–Jul–2004(204)
RATIO IML/JRC
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
300 nm
305 nm
310 nm
319 nm
201
202
203
204
0
12
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [201 202 203 204]
08–Sep–2004 13:47:12

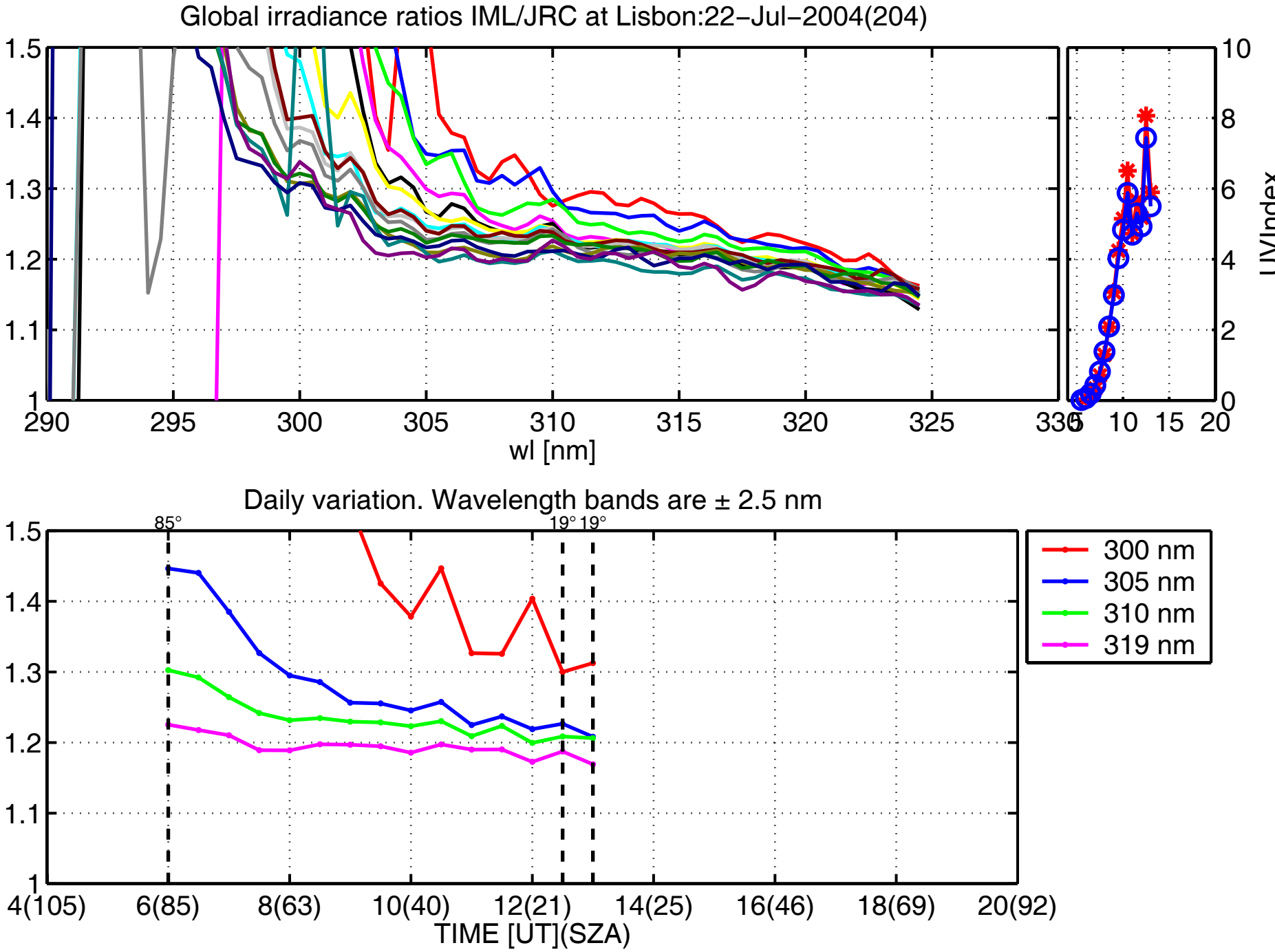


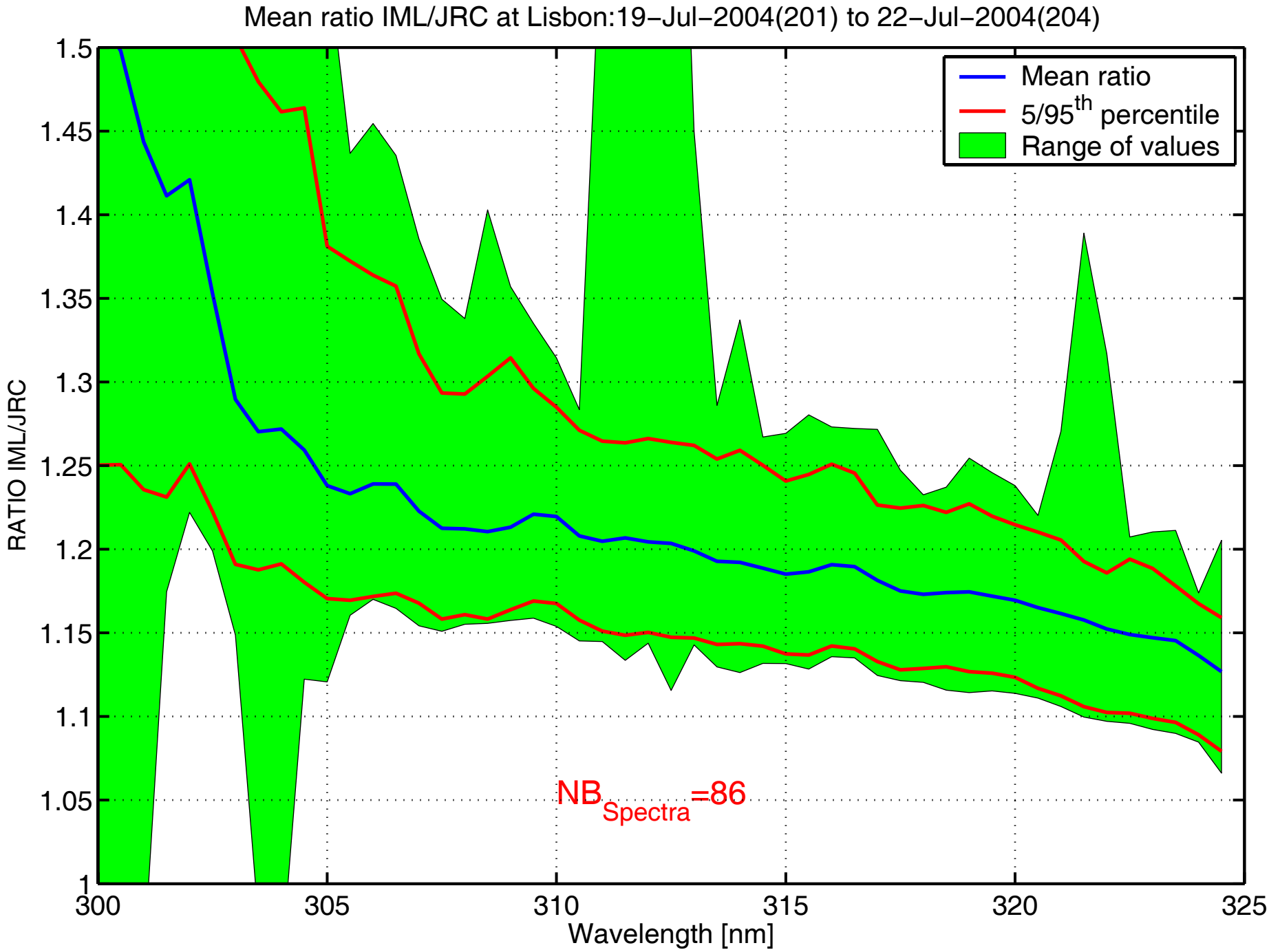


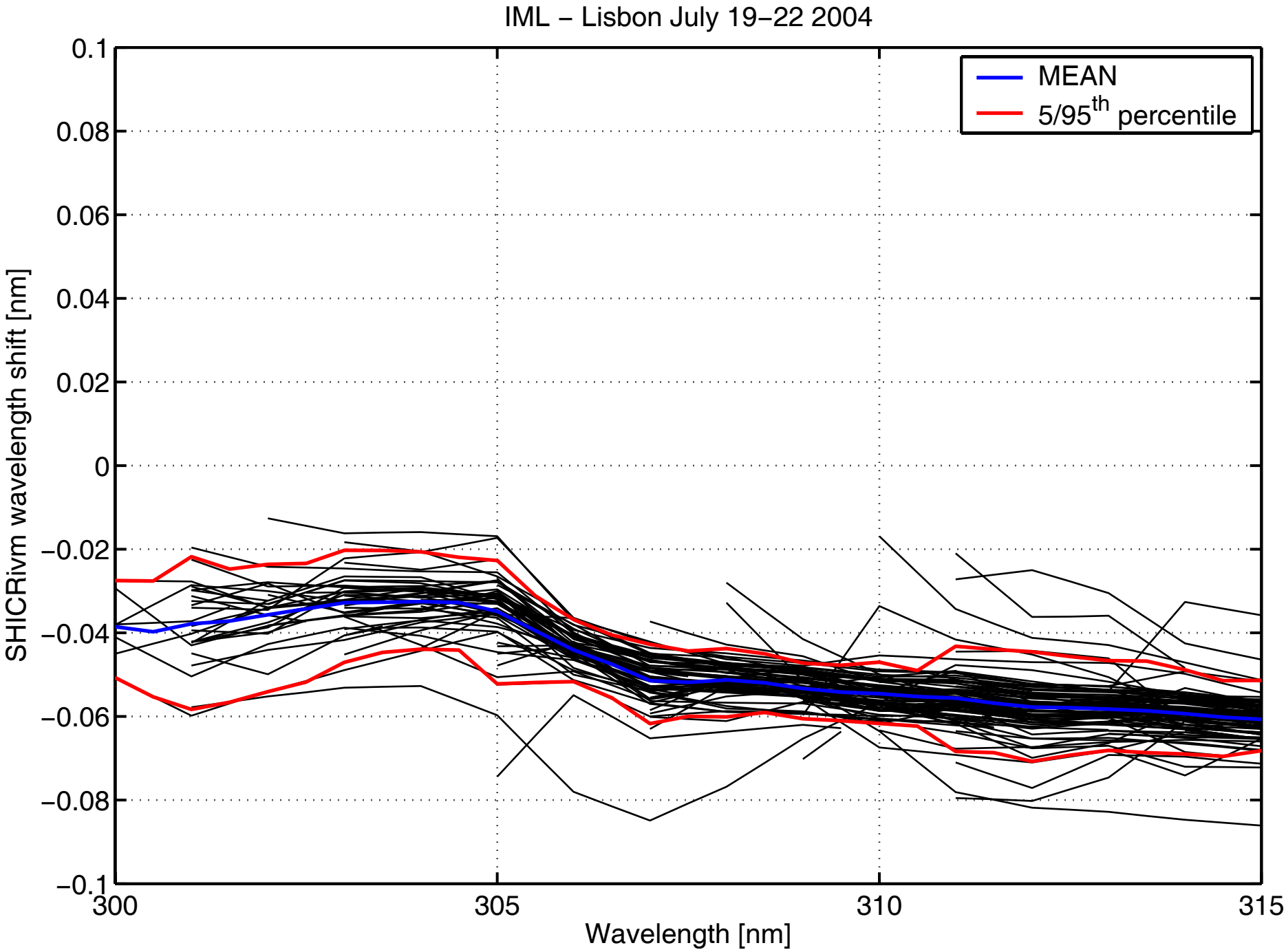
08−Sep−2004 13:47:12

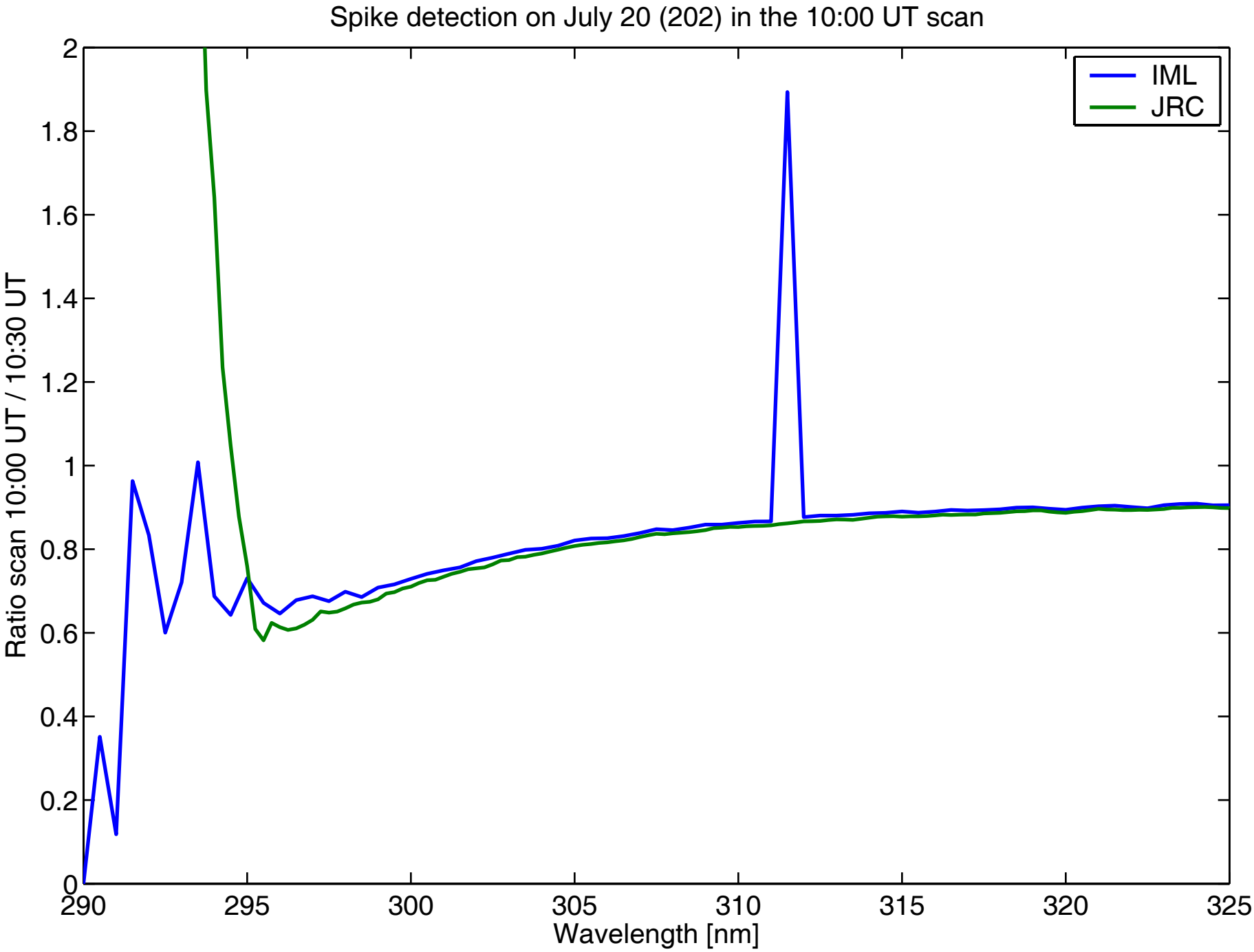

Global irradiance ratios IML/JRC at Lisbon:20−Jul−2004(202)
1.5
1.4
1.3
1.2
1.1
1
290
295
300
305
310
315
320
325
330
wl [nm]
10
8
6
4
2
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
90°
18°
86°
300 nm
305 nm
310 nm
319 nm
4(105)
6(85)
8(63)
10(39)
12(20)
14(25)
16(46)
18(69)
20(91)
TIME [UT](SZA)
08−Sep−2004 13:47:12

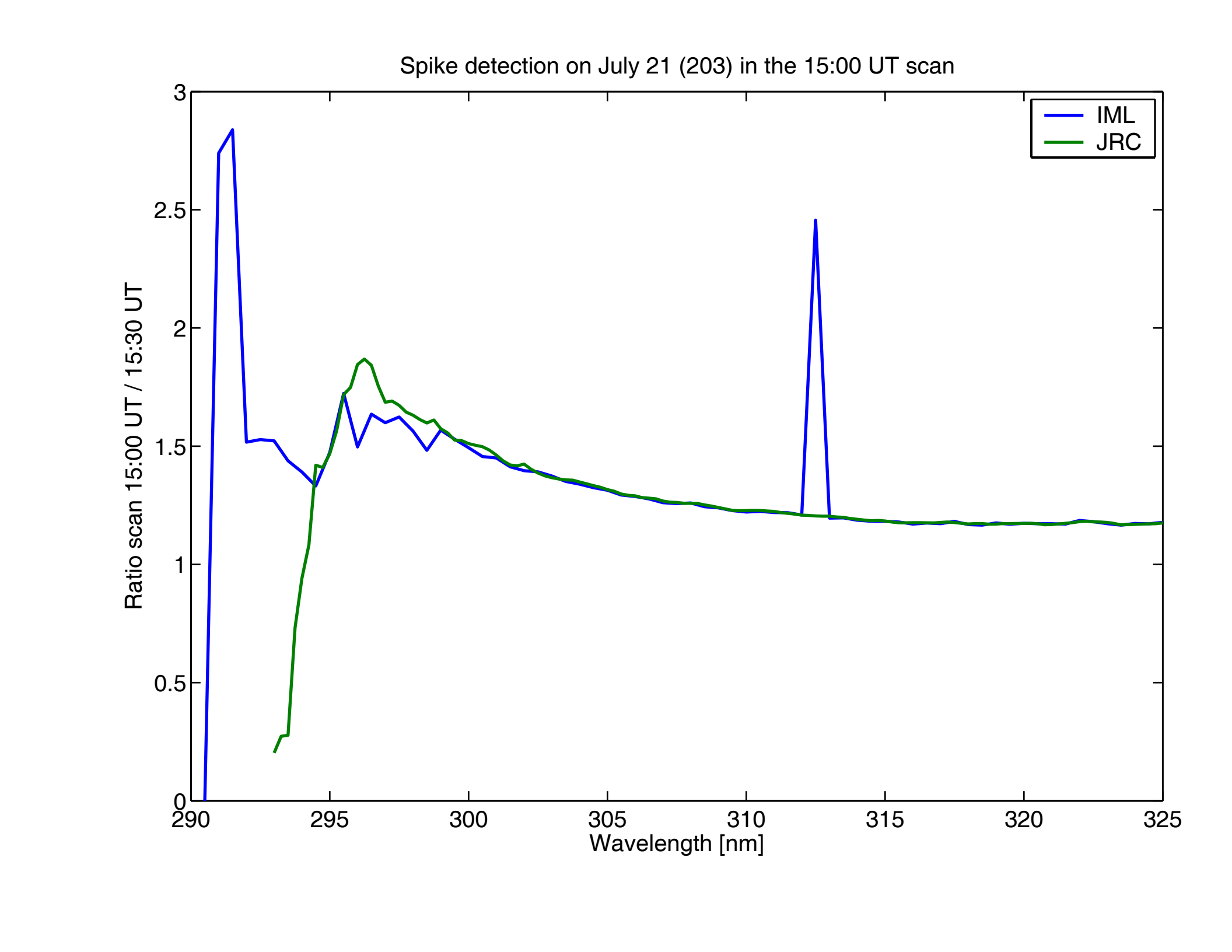

Global irradiance ratios IML/JRC at Lisbon:21−Jul−2004(203)
1.5
1.4
1.3
1.2
1.1
1
290
295
300
305
310
315
320
325
330
wl [nm]
10
8
6
4
2
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
85°
19°
75°
300 nm
305 nm
310 nm
319 nm
4(105)
6(85)
8(63)
10(39)
12(21)
14(25)
16(46)
18(69)
20(91)
TIME [UT](SZA)
08−Sep−2004 13:47:12

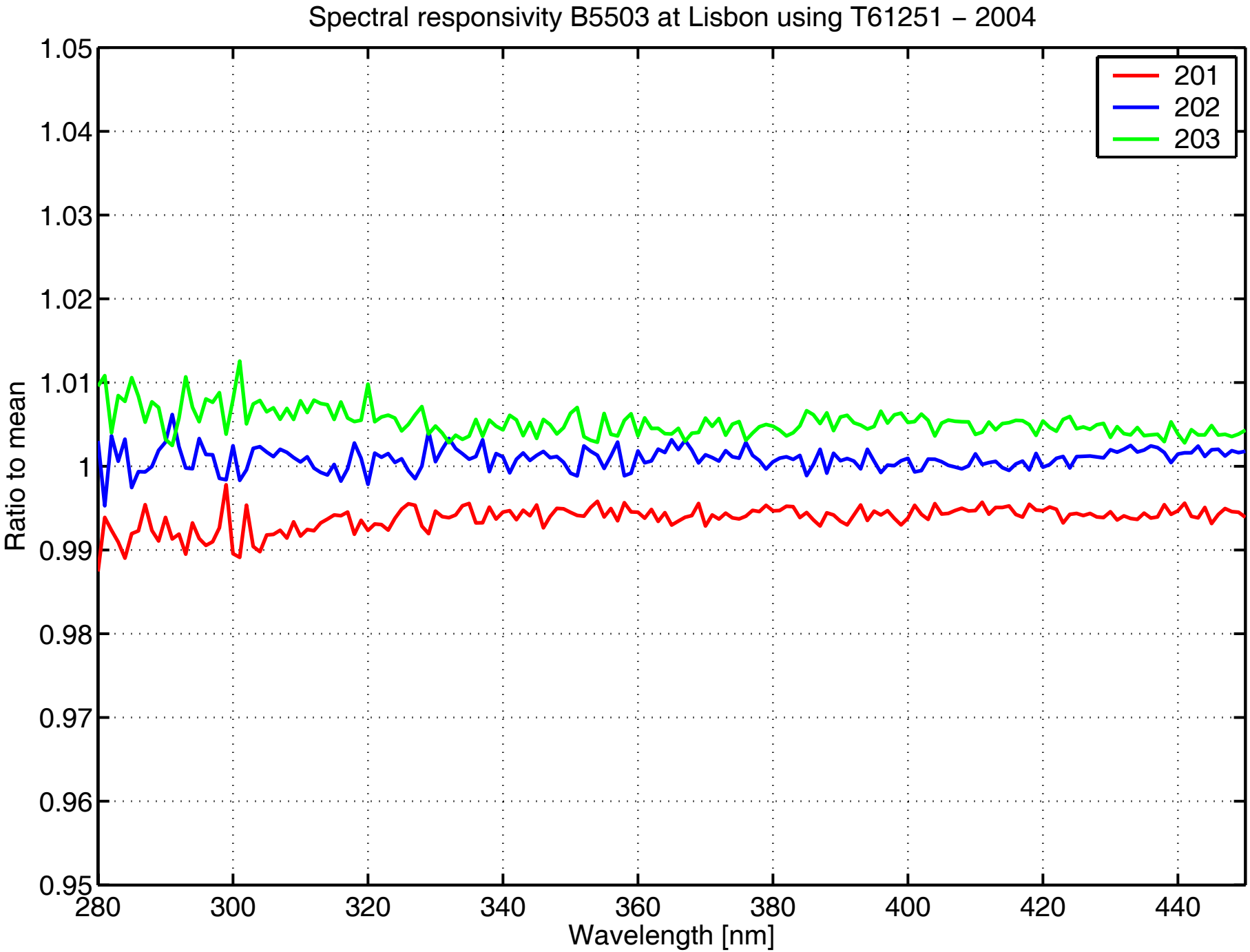

Global irradiance ratios IML/JRC at Lisbon:22–Jul–2004(204)
1.5
1.4
1.3
1.2
1.1
1
290
295
300
305
310
315
320
325
330
wl [nm]
10
8
6
4
2
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
85°
19°
19°
300 nm
305 nm
310 nm
319 nm
4(105)
6(85)
8(63)
10(40)
12(21)
14(25)
16(46)
18(69)
20(92)
TIME [UT](SZA)
08–Sep–2004 13:47:12


Mean ratio IML/JRC at Lisbon:19−Jul−2004(201) to 22−Jul−2004(204)
Mean ratio
5/95th percentile
Range of values
RATIO IML/JRC
Wavelength [nm]
NBSpectra=86
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
300
305
310
315
320
325


IML – Lisbon July 19–22 2004
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]
0.1
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
−0.1
300
305
310
315


Spike detection on July 20 (202) in the 10:00 UT scan
IML
JRC
Ratio scan 10:00 UT / 10:30 UT
Wavelength [nm]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
290
295
300
305
310
315
320
325


Spike detection on July 21 (203) in the 15:00 UT scan
IML
JRC
Ratio scan 15:00 UT / 15:30 UT
Wavelength [nm]
0
0.5
1
1.5
2
2.5
3
290
295
300
305
310
315
320
325


Spectral responsivity B5503 at Lisbon using T61251 – 2004
Ratio to mean
Wavelength [nm]
201
202
203
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
280
300
320
340
360
380
400
420
440