Protocol of the intercomparison at the Belgian Institute for Space Aeronomy (IASB) in Brussels, September 6-8 2004 with the travelling standard spectroradiometer B5503 from ECUV within the project QASUME

Report prepared by Josef Schreder and Julian Gröbner

Operator: Josef Schreder

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer operated by IASB (BRU) and the travel standard B5503 within the project QASUME. The measurement site is located at Brussels; Latitude 50.796 N, Longitude 4.357 E and altitude 120 m.a.s.l.
The horizon of the IASB measurement site is nearly free in direction from W to N to S. In the direction S to SW trees obscure the horizon by up to about 15°. The local environment is urban.

The Royal Meteorological Institute (RMI) participated with two Brewer spectrophotometers to this intercomparison, the single monochromator Brewer#016 (KMI), and the double monochromator Brewer #178 (RMI). The instruments RMI and KMI were distant by 100 m from B5503 which might induce some uncertainties into the comparison of the instruments.
The horizon of the RMI site is obscured in direction N to NW by 2 satellite antennas, up to 40°.

B5503 arrived at Brussels in the afternoon of September 3, 2004. The spectroradiometer was installed in a temperature stabilized room below the measurement platform of IASB. The intercomparison between B5503 and RMI and KMI lasted 2 1/2 days, from noon of September 6 to the evening of September 8.

B5503 was calibrated several times during the intercomparison period using a portable calibration system. Two lamps were used to obtain an absolute spectral calibration traceable to the primary reference held at ECUV which is traceable to PTB: T57825 (100 W) and T61251 (250 W). The responsivity of the instrument based on these calibrations varied by less than 0.5% during the intercomparison. The internal temperature of B5503 was 27.1°C and varied by less than 0.4 °C. The diffuser head was heated to a temperature of about 25±3°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.

September 3 (247):

Arrival and setup of B5503 in the afternoon. It is left (turned on) until September 6.

September 6 (250):

Hardware failure of the temperature stabilisation of B5503 resulted in an internal temperature of 41°C during the previous two days. The problem was fixed in the morning, and temperature stabilisation is resumed at 10:00 UT.

Synchronised measurements are available from 12:00 to 18:00 UT. Weather conditions were cloudless sky during the whole day.

September 7(251):

Synchronised measurements are available from 4:00 to 18:00 UT. Weather conditions were fog in the morning until 8:30 UT, then a mix of sun and clouds until about 13:30 UT, then cirrus.

B5503 calibrated at 12:46 UT and 13:14 UT (no scans lost).

September 8 (252):

Synchronised measurements are available from 4:00 to 15:00 UT.

Weather conditions from beginning are cloudless sky in the morning with increasing cirrus clouds during the day.

B5503 calibrated at 13:12 UT and 13:45 UT (no scans lost).

Results:

52 synchronised scans are available from RMI and KMI (In the following discussion scans obviously disturbed by clouds were not taken into account).

The wavelength shifts of the submitted solar spectra of the KMI spectroradiometer retrieved through the SHICRivm analysis were stable to within 20 pm. The absolute wavelength shift relative to the extraterrestrial spectrum used by the SHICRivm software was -10 pm (see graph).

The wavelength shifts of the submitted solar spectra of the RMI spectroradiometer retrieved through the SHICRivm analysis were stable to within 20 pm. The absolute wavelength shift relative to the extraterrestrial spectrum used by the SHICRivm software varied spectrally between –40 pm to +40 pm (±0.04 nm) (see graph).

The intercomparison of the global irradiance measured by RMI and KMI relative to B5503 can be summarized as follows:

1) RMI
   - Global irradiances measured by RMI were on average between 1% higher to 9% lower than those measured by B5503.
   - A diurnal variation is observed on September 7 (251) and 8 (252); at 305 nm it is about 2% to 4%, while at 357 nm it is 5% (252, morning) and 8% (251, afternoon). This feature could be in part due to differences in the directional responses of RMI and B5503, since RMI does not apply a cosine correction to the measured data.

2) KMI
   - Global irradiances measured by KMI were on average between 0 to 10% lower than those measured by B5503.
   - The spectral ratios increase at shorter wavelengths which is due to stray light in the single monochromator Brewer (this feature has been observed with all single Brewer spectrophotometers). Based on this data set, reliable measurements down to 305 nm are possible for SZA smaller 70°.
   - A diurnal variation of the ratios is observed which is dependent on wavelength. This might be partly due to stray-light (discussed before) and also to differences in the directional responses of KMI and B5503, since KMI does not apply a cosine correction to the measured data.

Conclusion:

3) RMI

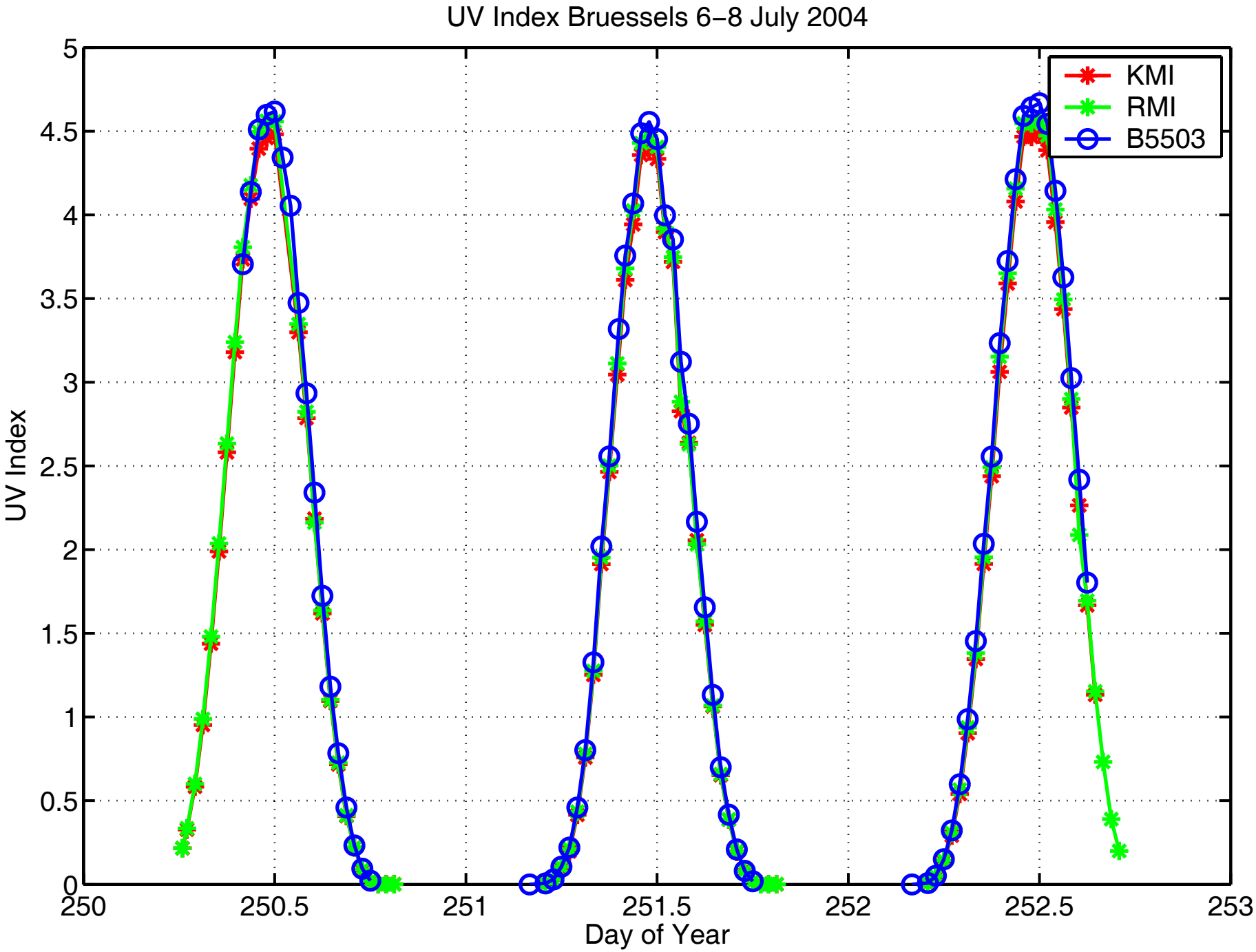
   The global solar irradiance spectra measured by the RMI spectroradiometer are on average 0 to 8% lower than those measured by B5503. Diurnal variations of about 3-4% are seen at 310 nm, and about 10% at 357 nm.

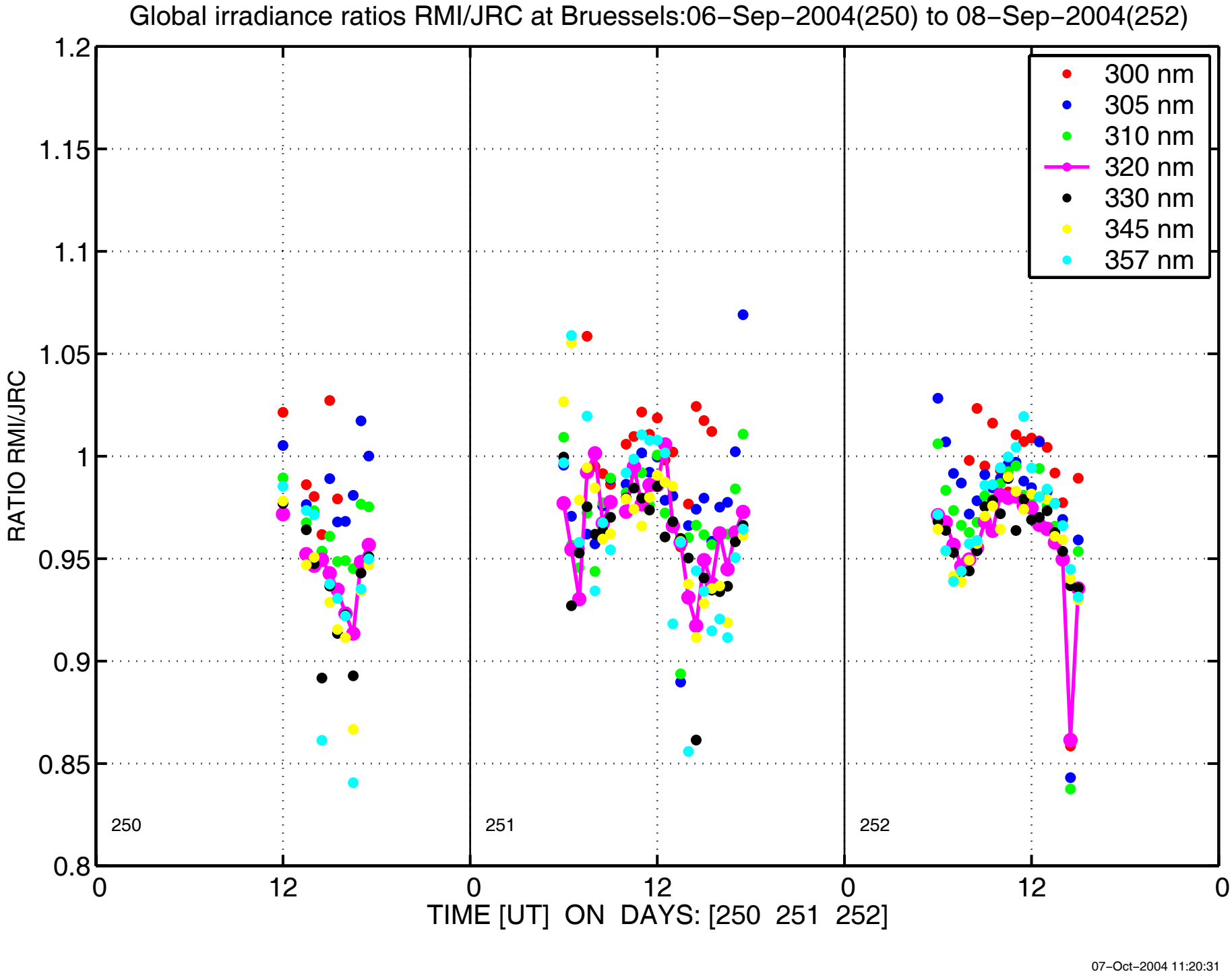
4) KMI

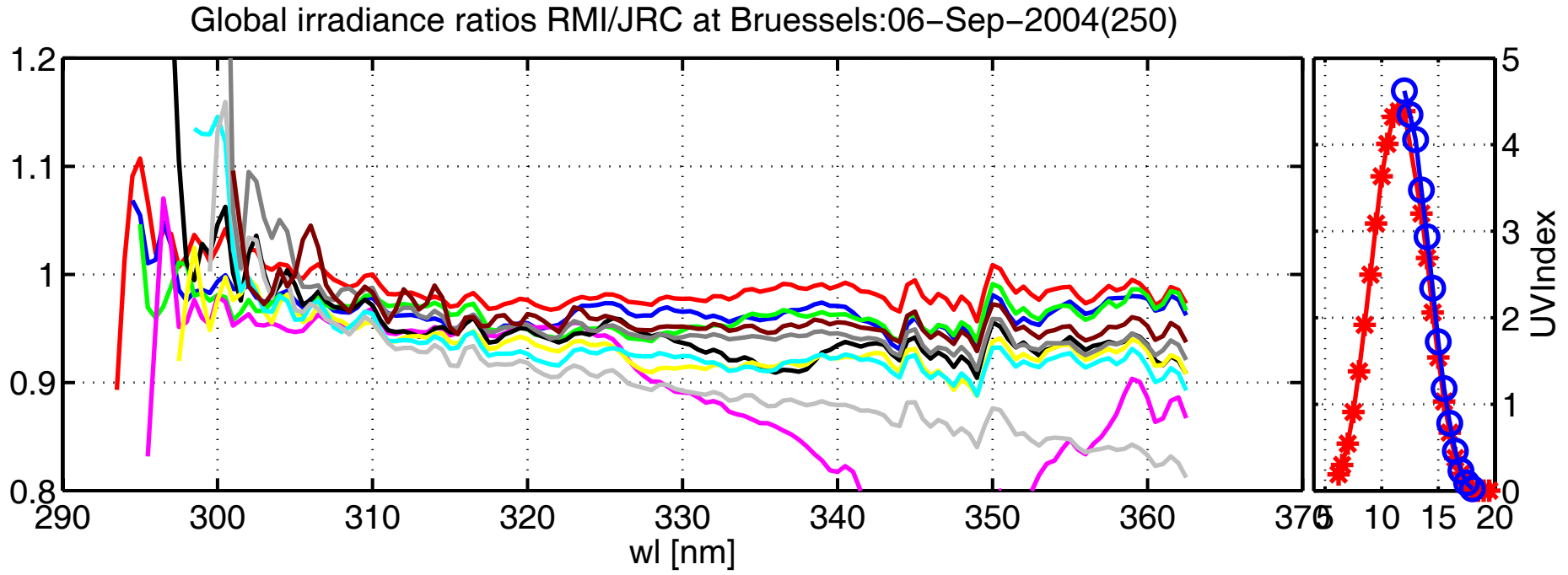
   The global solar irradiance spectra measured by the KMI spectroradiometer are on average 5% lower than those measured by B5503 between 305 and 325 nm. Below 305 nm the measurements by KMI are affected by internal stray light which is dependent on the SZA. Diurnal variations of the order of 5% are observed during the measurement period.

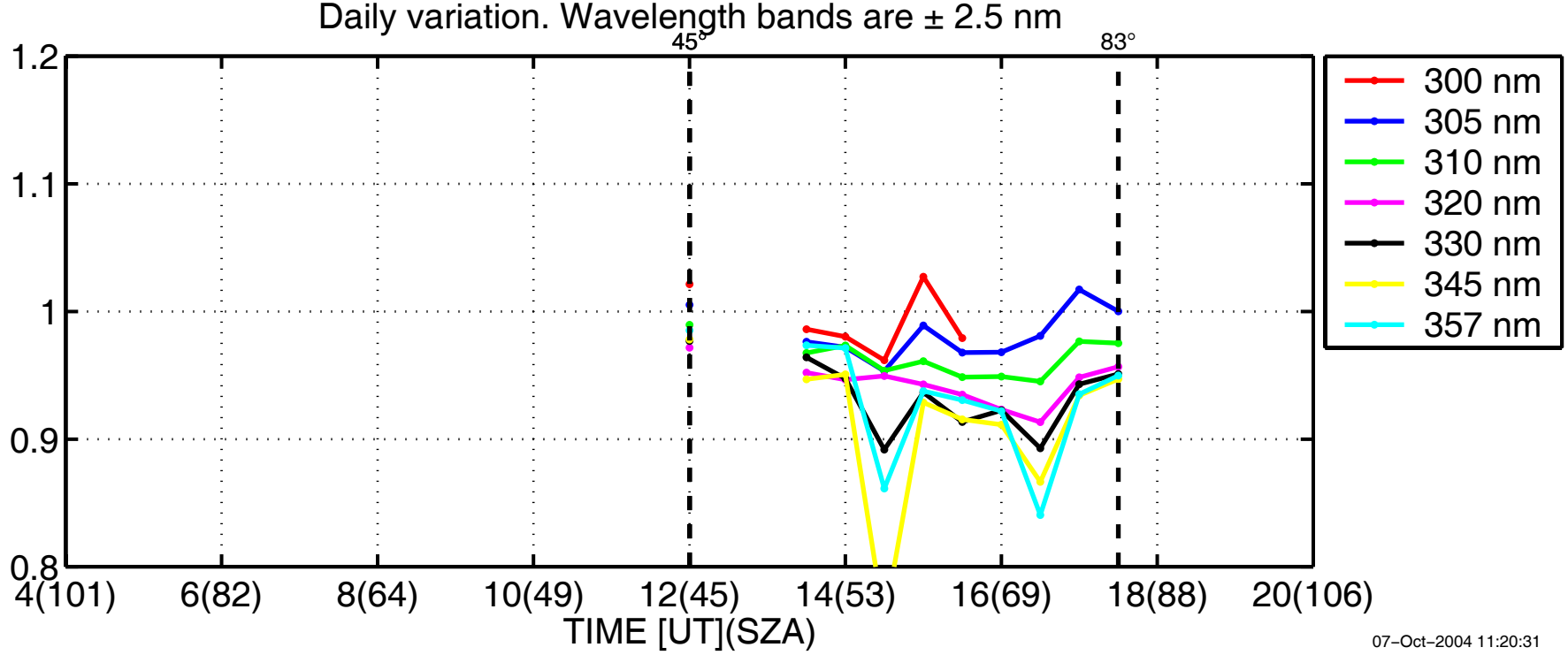
Comments from the local operator:

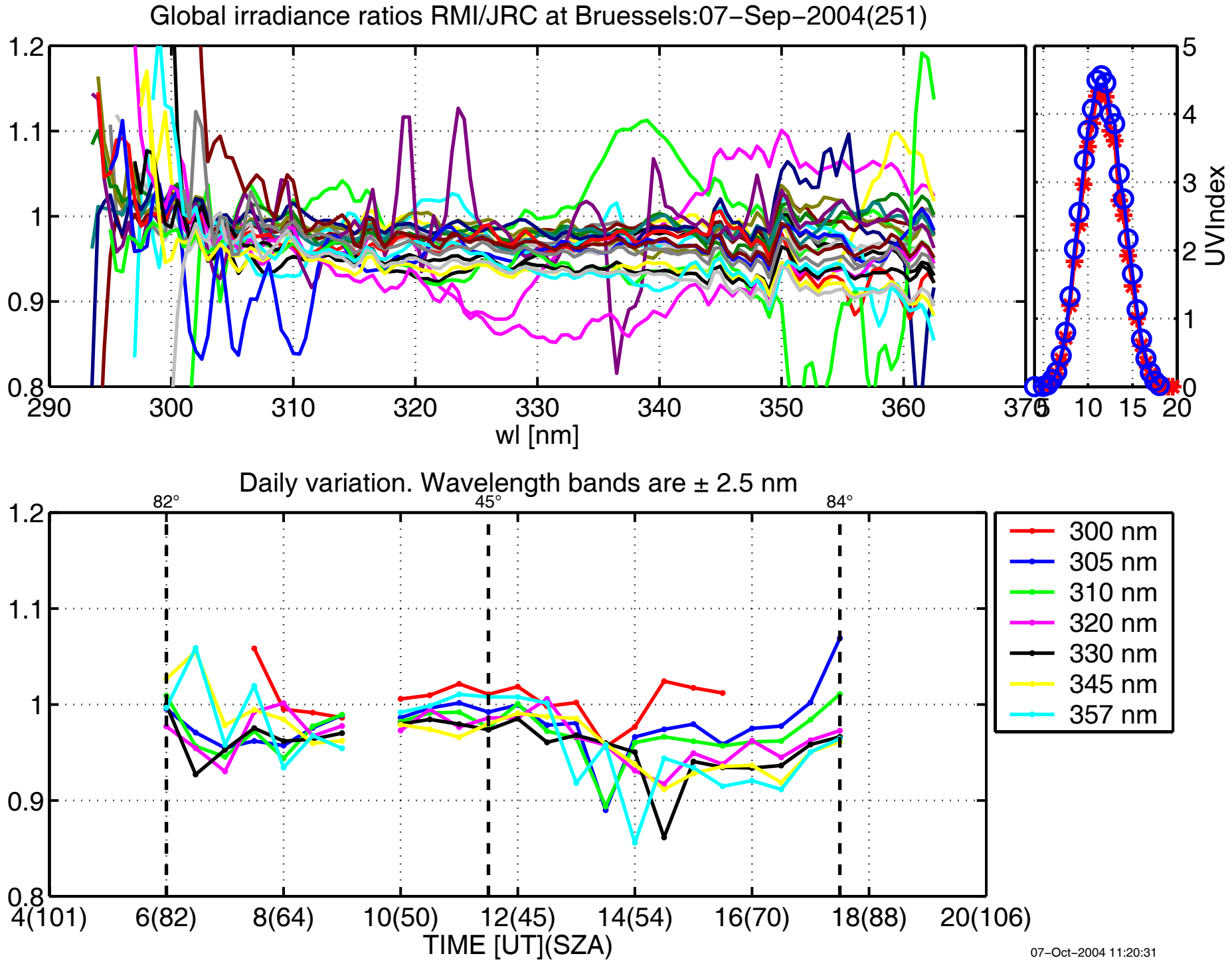
The lower solar irradiance measurements at RMI relative to the IASB site (distant by a few hundred meters) might be partly due to the horizon of the site which obstructs some of the global irradiance.

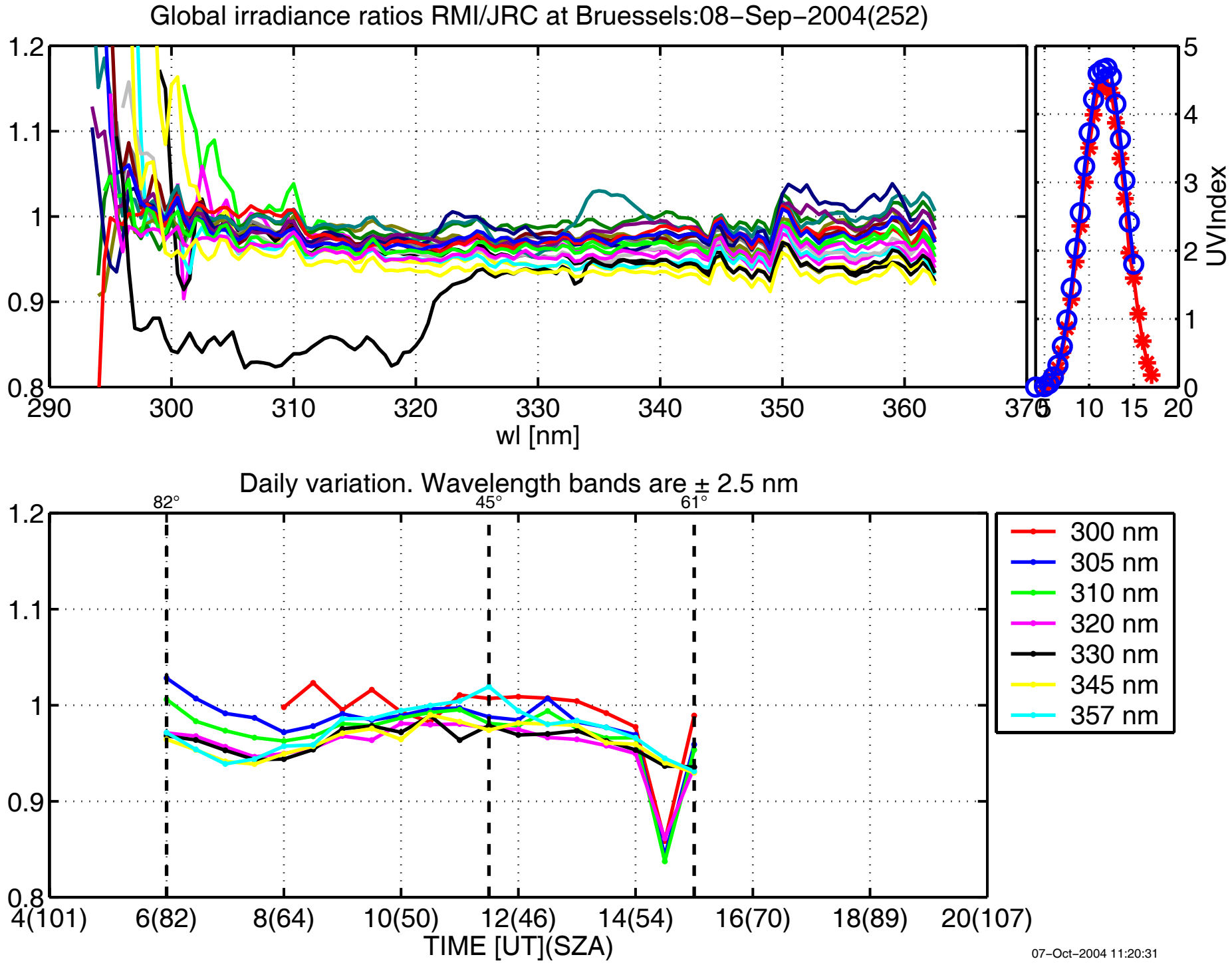

UV Index Bruessels 6−8 July 2004
KMI
RMI
B5503
UV Index
Day of Year
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
250
250.5
251
251.5
252
252.5
253

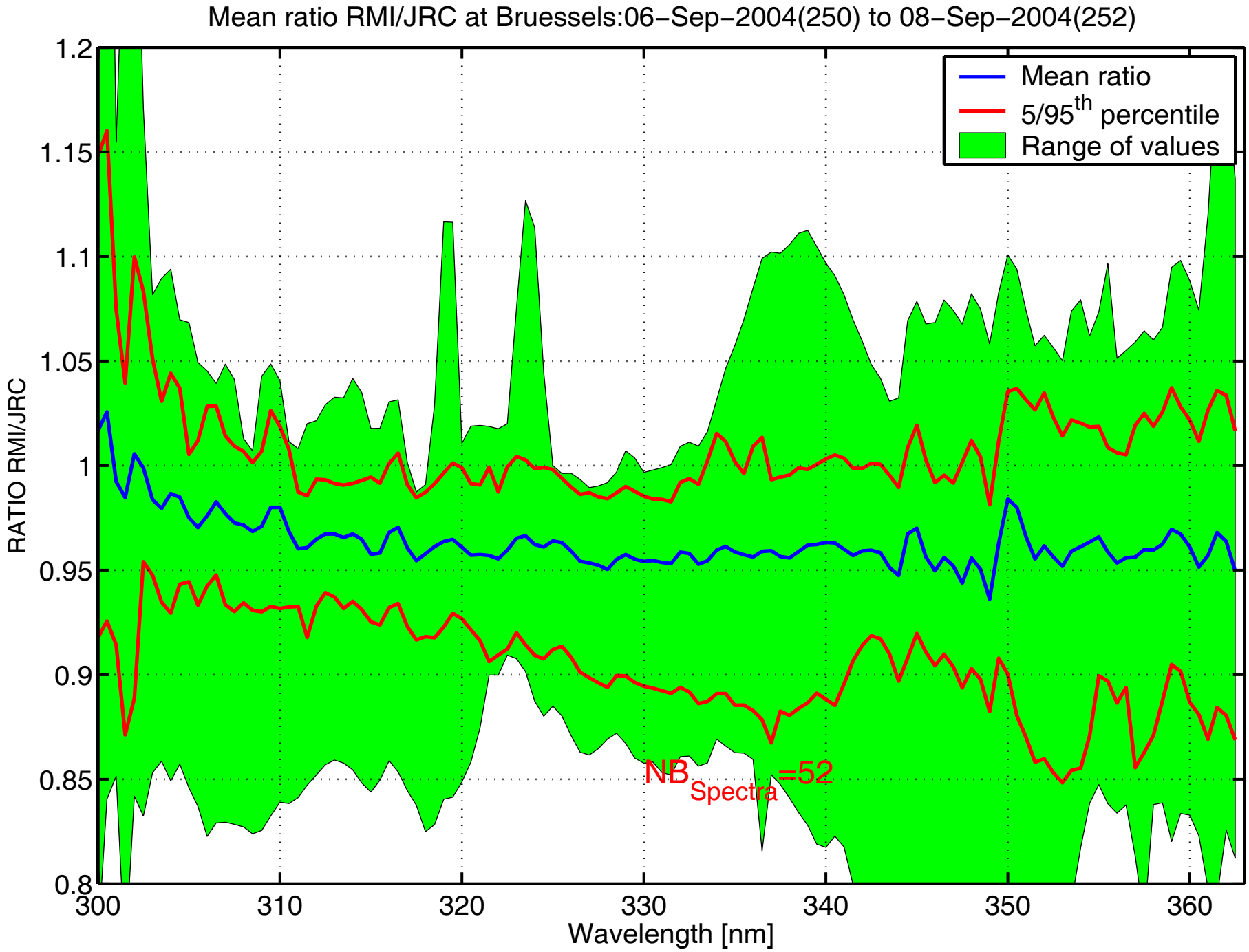

Global irradiance ratios RMI/JRC at Bruessels:06−Sep−2004(250) to 08−Sep−2004(252)
RATIO RMI/JRC
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300 nm
305 nm
310 nm
320 nm
330 nm
345 nm
357 nm
250
251
252
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [250 251 252]
07−Oct−2004 11:20:31

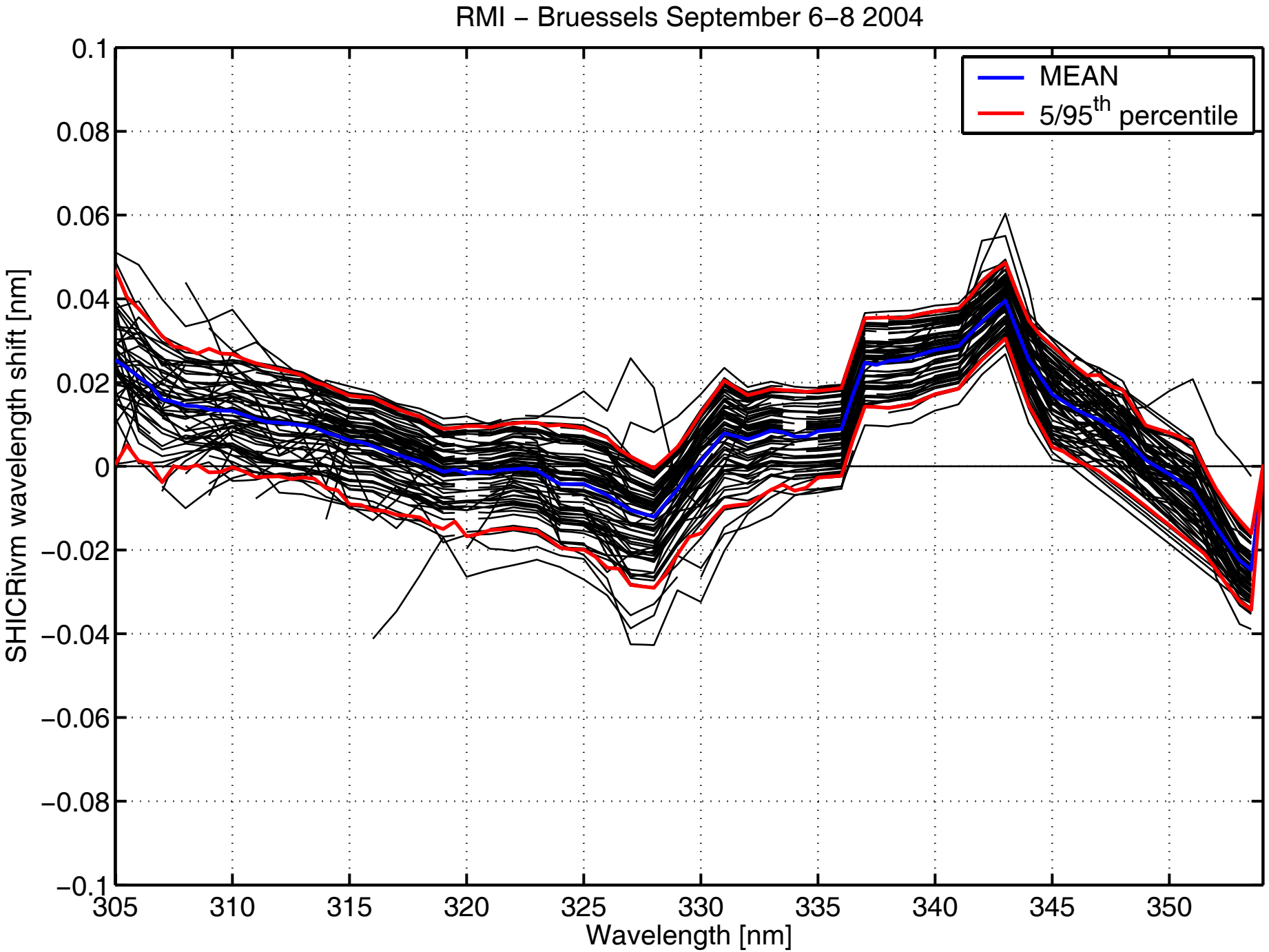

Global irradiance ratios RMI/JRC at Bruessels:06−Sep−2004(250)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
wl [nm]
5
10
15
20
UVIndex
0
1
2
3
4
5

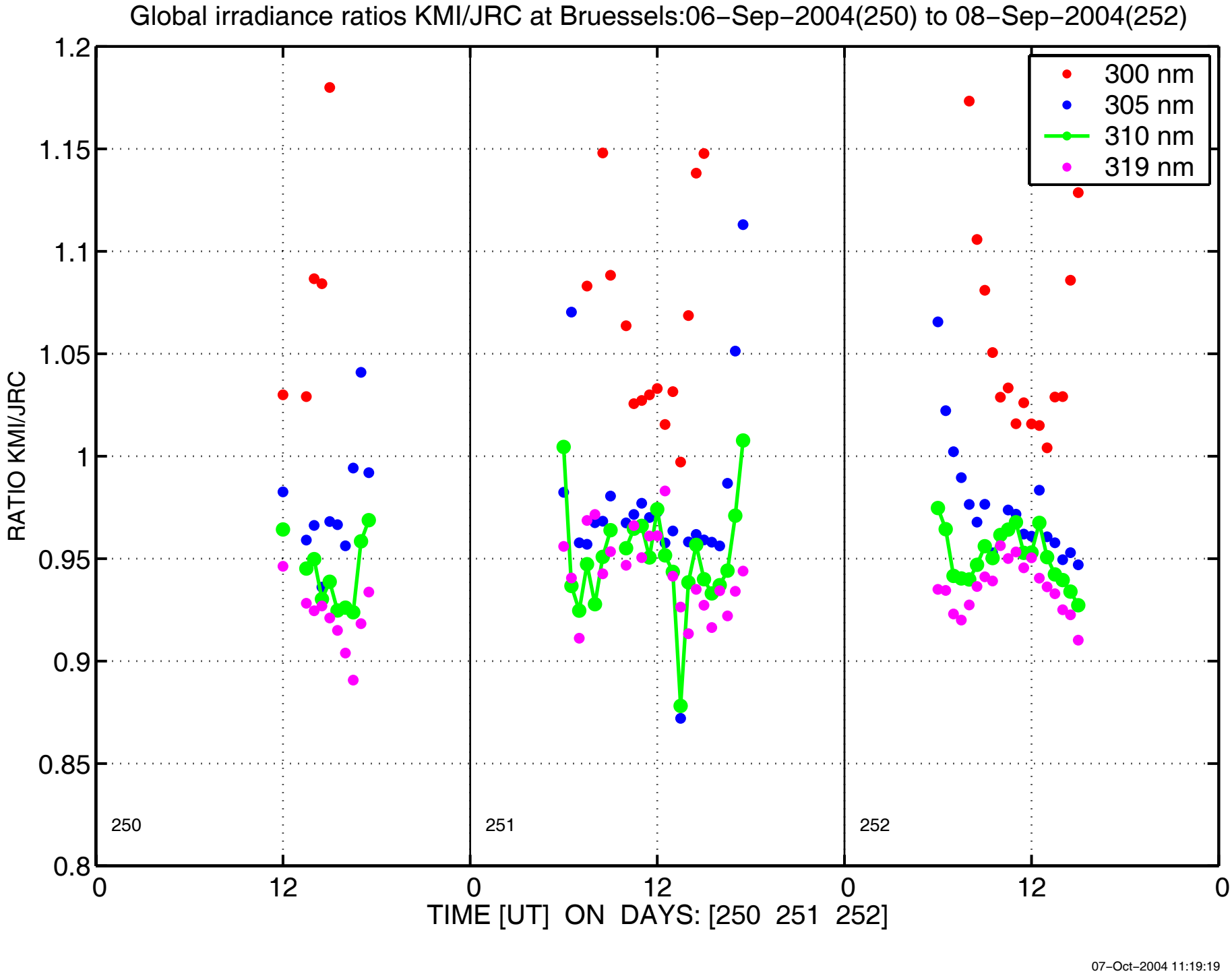

Daily variation. Wavelength bands are ± 2.5 nm
45°
83°
1.2
1.1
1
0.9
0.8
4(101)
6(82)
8(64)
10(49)
12(45)
14(53)
16(69)
18(88)
20(106)
TIME [UT](SZA)
300 nm
305 nm
310 nm
320 nm
330 nm
345 nm
357 nm
07−Oct−2004 11:20:31

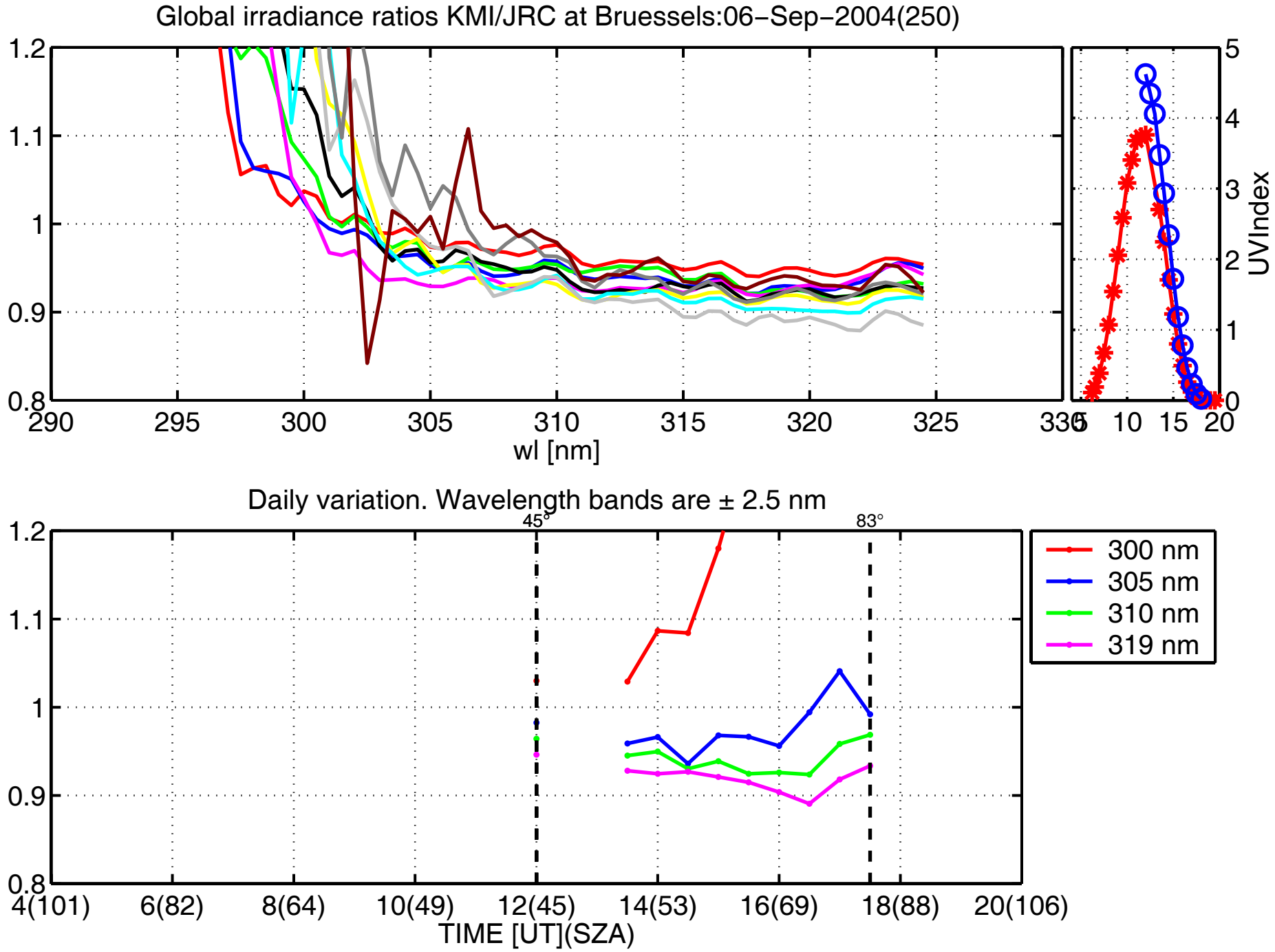

Global irradiance ratios RMI/JRC at Bruessels:07−Sep−2004(251)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
wl [nm]
5
4
3
2
1
0
UVIndex
5
10
15
20
Daily variation. Wavelength bands are ± 2.5 nm
82°
45°
84°
4(101)
6(82)
8(64)
10(50)
12(45)
14(54)
16(70)
18(88)
20(106)
TIME [UT](SZA)
300 nm
305 nm
310 nm
320 nm
330 nm
345 nm
357 nm
07−Oct−2004 11:20:31

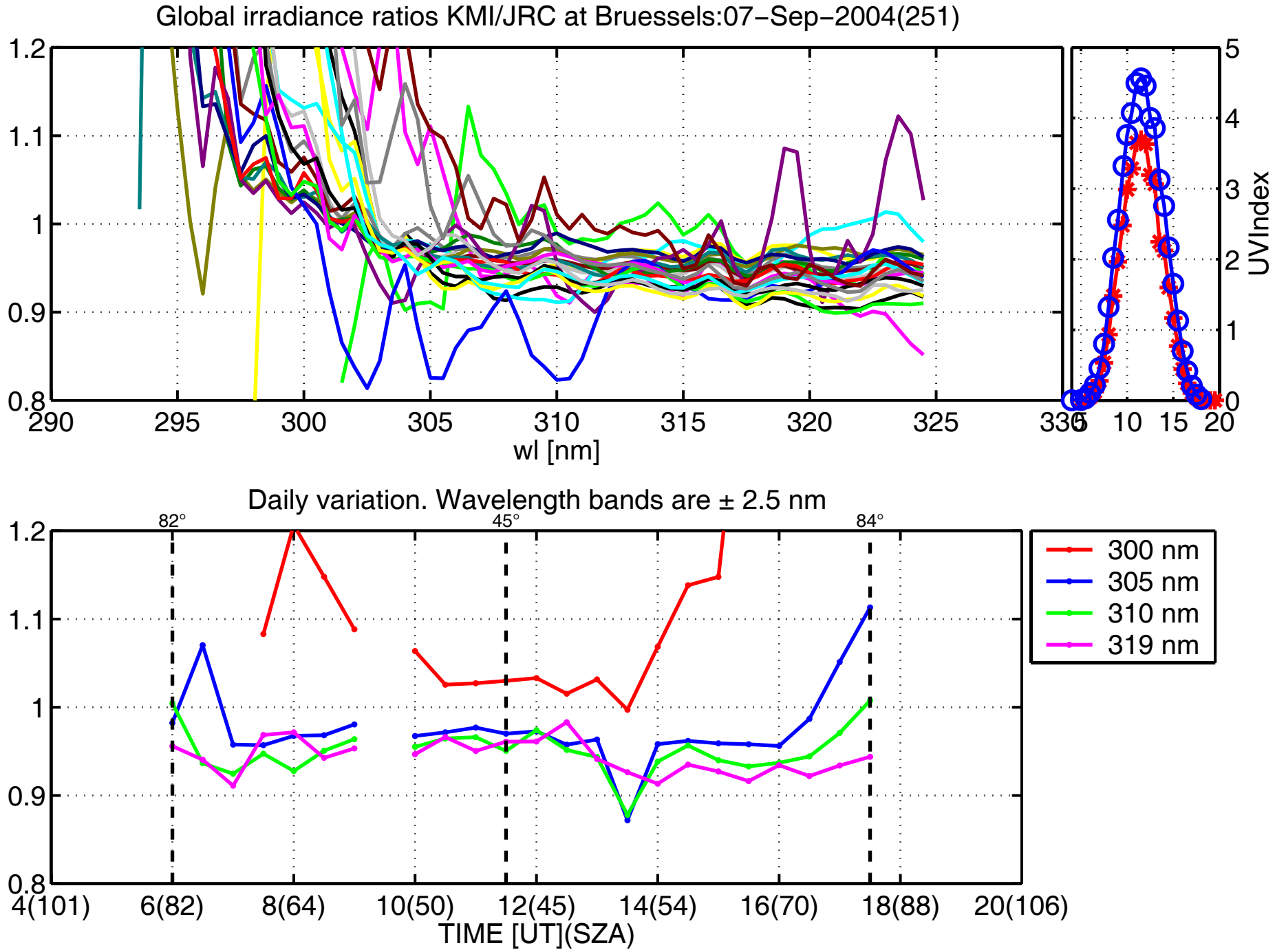

Global irradiance ratios RMI/JRC at Bruessels:08−Sep−2004(252)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
wl [nm]
5
4
3
2
1
0
UVIndex
5
10
15
20
Daily variation. Wavelength bands are ± 2.5 nm
82°
45°
61°
4(101)
6(82)
8(64)
10(50)
12(46)
14(54)
16(70)
18(89)
20(107)
TIME [UT](SZA)
300 nm
305 nm
310 nm
320 nm
330 nm
345 nm
357 nm
07−Oct−2004 11:20:31

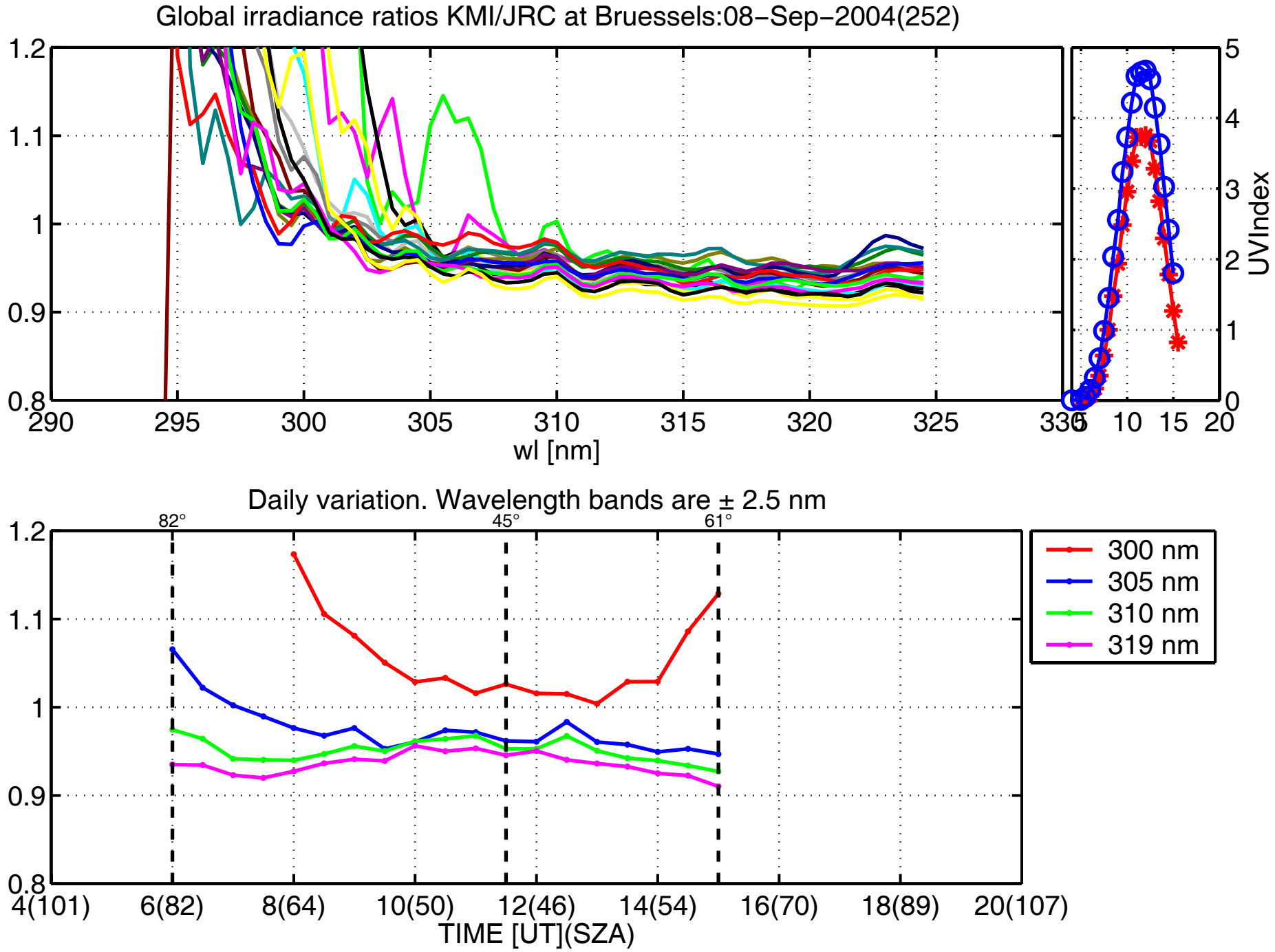

Mean ratio RMI/JRC at Bruessels:06−Sep−2004(250) to 08−Sep−2004(252)
Mean ratio
5/95th percentile
Range of values
RATIO RMI/JRC
Wavelength [nm]
NBSpectra=52
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360

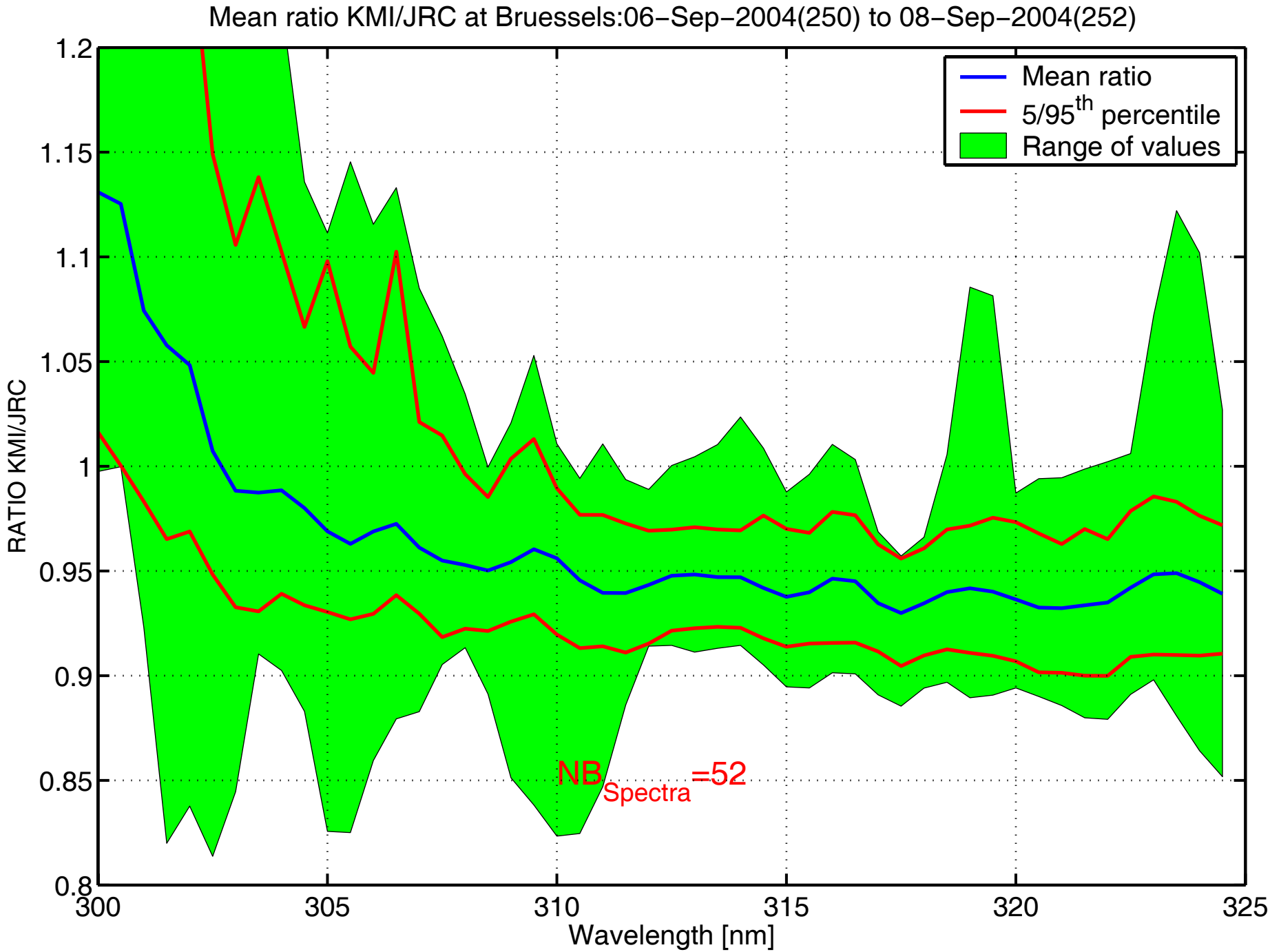

RMI – Bruessels September 6–8 2004
MEAN
5/95th percentile
SHICRivm wavelength shift [nm]
Wavelength [nm]
0.1
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
−0.1
305
310
315
320
325
330
335
340
345
350

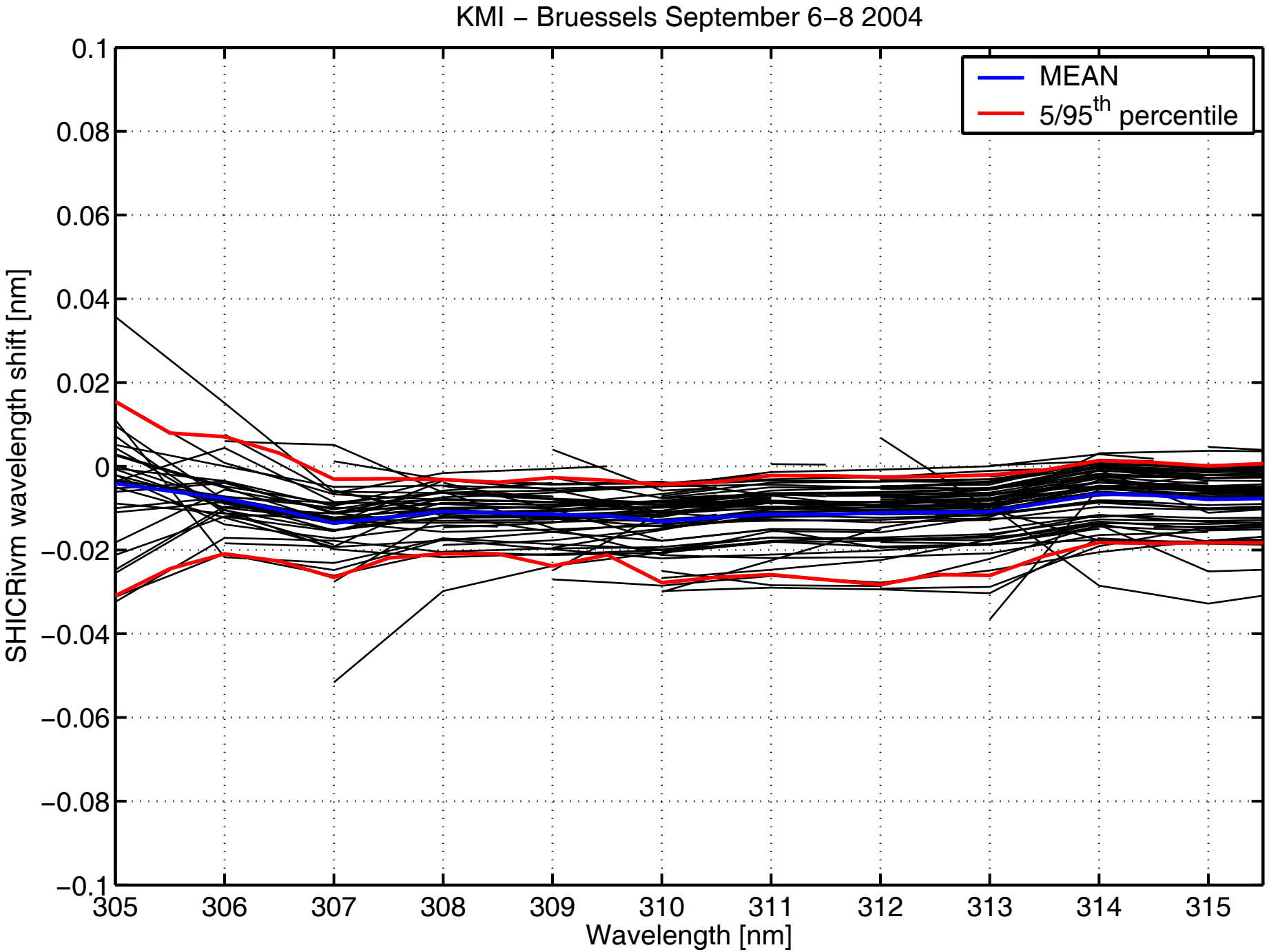

Global irradiance ratios KMI/JRC at Bruessels:06−Sep−2004(250) to 08−Sep−2004(252)
300 nm
305 nm
310 nm
319 nm
RATIO KMI/JRC
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
250
251
252
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [250 251 252]
07−Oct−2004 11:19:19

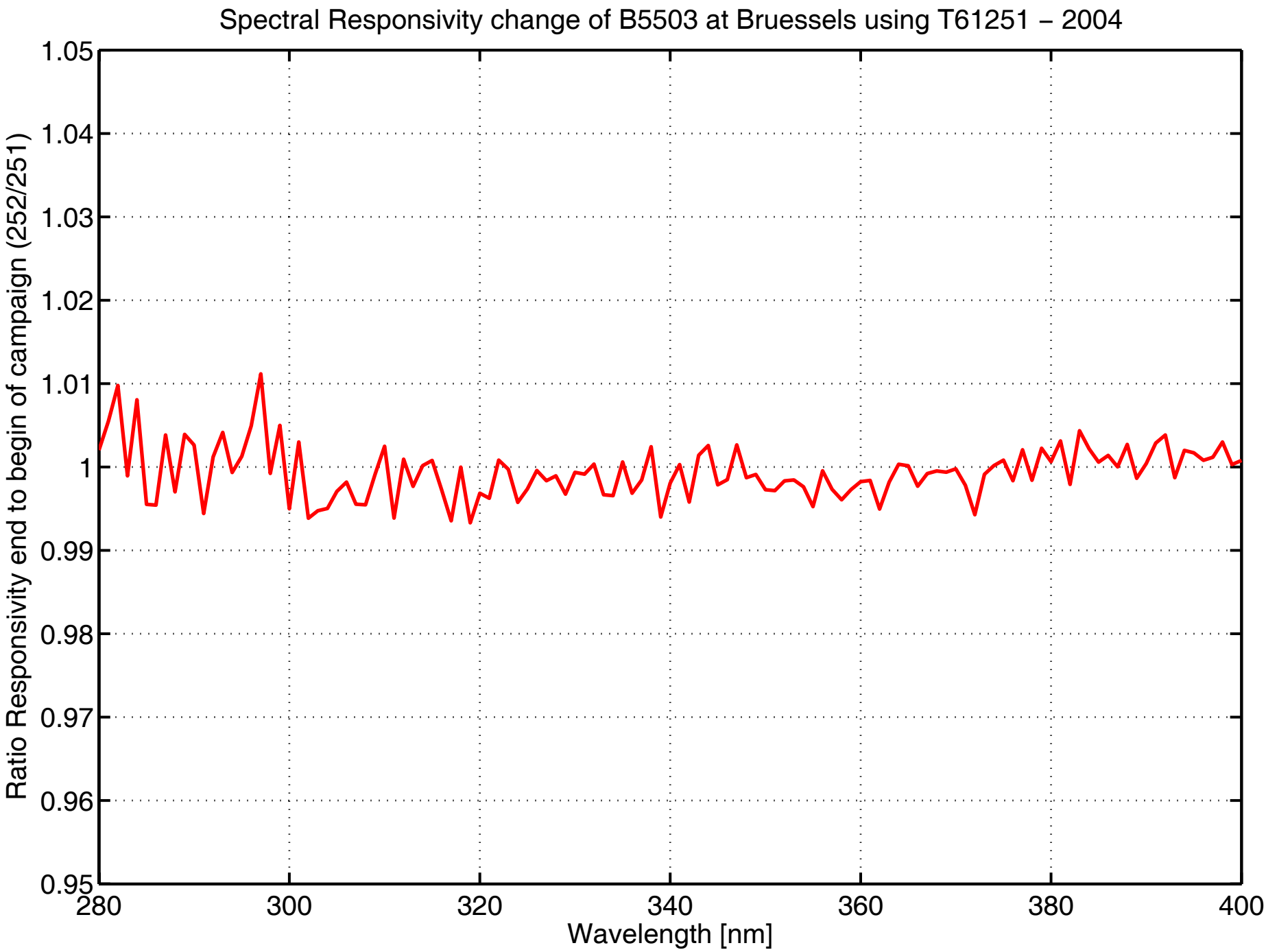

Global irradiance ratios KMI/JRC at Bruessels:06−Sep−2004(250)
1.2
1.1
1
0.9
0.8
290
295
300
305
310
315
320
325
330
wl [nm]
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
45°
83°
300 nm
305 nm
310 nm
319 nm
4(101)
6(82)
8(64)
10(49)
12(45)
14(53)
16(69)
18(88)
20(106)
TIME [UT](SZA)
07−Oct−2004 11:19:19


Global irradiance ratios KMI/JRC at Bruessels:07−Sep−2004(251)
1.2
1.1
1
0.9
0.8
290
295
300
305
310
315
320
325
330
wl [nm]
5
4
3
2
1
0
UVIndex
5
10
15
20
Daily variation. Wavelength bands are ± 2.5 nm
82°
45°
84°
300 nm
305 nm
310 nm
319 nm
4(101)
6(82)
8(64)
10(50)
12(45)
14(54)
16(70)
18(88)
20(106)
TIME [UT](SZA)
07−Oct−2004 11:19:19


Global irradiance ratios KMI/JRC at Bruessels:08−Sep−2004(252)
1.2
1.1
1
0.9
0.8
290
295
300
305
310
315
320
325
330
wl [nm]
5
4
3
2
1
0
UVIndex
5
10
15
20
Daily variation. Wavelength bands are ± 2.5 nm
82°
45°
61°
300 nm
305 nm
310 nm
319 nm
4(101)
6(82)
8(64)
10(50)
12(46)
14(54)
16(70)
18(89)
20(107)
TIME [UT](SZA)
07−Oct−2004 11:19:19


Mean ratio KMI/JRC at Bruessels:06−Sep−2004(250) to 08−Sep−2004(252)
Mean ratio
5/95th percentile
Range of values
RATIO KMI/JRC
Wavelength [nm]
NBSpectra=52
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
305
310
315
320
325


KMI – Bruessels September 6–8 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
305
306
307
308
309
310
311
312
313
314
315


Spectral Responsivity change of B5503 at Bruessels using T61251 – 2004
Ratio Responsivity end to begin of campaign (252/251)
Wavelength [nm]
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