Protocol of the intercomparison at RIVM-Bilthoven, The Netherlands 10 – 14 June 2002 with the travelling reference spectrometer 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 spectrometer operated by the Laboratory of Radiation Research, National Institute of Public Health and the Environment (RIVM) and the reference travelling spectroradiometer (B5503) operated by the European reference centre for ultraviolet radiation measurements (ECUV) located at the Joint Research Centre (JRC) of the European Commission. B5503 is a commercial double monochromator spectroradiometer (DM-150) from Bentham, UK optimized for measurements of global solar ultraviolet irradiance. The radiation is sampled with an input optic connected to the entrance slit of the spectroradiometer through a 4 m long optical quartz fiber. The integrated directional response of the input optic deviates less than 2% from the desired cosine response. It uses gratings with 2400 lines/mm with entrance and exit slits to obtain a spectral resolution of about 0.8 nm. The instrument can be operated in the wavelength range 250 to 500 nm. The whole system is temperature stabilized.

The visit at RIVM follows the previous intercomparison at the home site of B5503 at the JRC, Ispra, Italy. The measurement site is located on the roof of a container roughly 4 meters above ground. Latitude is 52.120 and longitude 5.195E, altitude 4 m.a.s.l. The horizon of the measurement site is free down to 75 deg to the south. Higher obstructions are located in the NorthWest.

B5503 left the home site of JRC and arrived at RIVM in the evening of June 10, 2002. The instrument was installed on the roof of a container 1.5 m away from the spectrometer operated by RIVM and left to stabilize over night.
The intercomparison between B5503 and the spectrometer from RIVM lasted four days from noon June 11 to noon June 14.

B5503 was calibrated at the beginning and end of the intercomparison period using a 100W portable calibration system. Three 100W lamps were used to obtain an absolute spectral calibration traceable to the primary reference (F330) held at ECUV and traceable to PTB. The first calibration on June, 11 was held from 17:30 to 19:30 UT, and the second on June, 13 from 20 to 22 UT. The sensitivity of the instrument decreased by 1% between the two calibrations (see appended graph). For the purpose of the intercomparison, the mean sensitivity of the two calibrations has been used for the data analysis.
The internal temperature of B5503 was 27.1±0.1 °C during the whole period. No information is available on possible temperature gradients within the instrument. The wavelength shifts relative to an extraterrestrial spectrum as retrieved from the SHICRivm analysis were between ±50pm in the spectral range 310 to 450 nm (see appended graphs).

Protocol:
Measurements started at noon of June 11. Synchronous global irradiance measurements were performed every 30 min in the range 290 to 450 nm with an increment of 0.5 nm every 4 sec. Measurements on this day were performed under cloudy conditions without rain.
Measurements on June 12 are quality controlled from 4 UT to 19:00 UT. Sunrise was at 03:21 UT and sunset was at 19:57 UT. The minimum solar zenith angle was 29 deg. Measurements from 4:00 UT till 12:30 UT were performed under rainy conditions. At 12:50 both domes were dried and cleaned and measurements afterwards were performed under cloudy-overcast conditions with partly sunshine. At 19:30 RIVM measured the laser line from a HeCd laser at 325 nm. The laser beam was attenuated by a set of filters, which were put between the laser and the diffuser. The peak of the HeCd line was measured with a total attenuation of nd=1.8 from the filters and the side-wings of this line with a total attenuation of nd=1.

On June, 13 the day was characterized by rain from 4:30 UT to 7:30 UT and drizzle till 12:30 UT. At 14:00 UT both domes were cleaned and dried. Afterwards the sky was partly cloudy to overcast without rain. At 19:00 a second calibration took place at the site.

On June 14, measurements were carried out under overcast conditions in the morning and broken cloud conditions in the afternoon and evening. Measurements were controlled from 04:00 UT to 18:30 UT.

All data starting from 04:00 UT were quality controlled by the operators.

Results:
The global solar irradiance spectra from RIVM were run through the SHICRivm routine and were submitted that way to the operators. Only measurements from non rainy periods have been analysed.

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

- The mean global irradiance measured by the spectrometer from RIVM is about 4-6% higher than B5503 at all wavelengths.
- The variability during the whole measuring period between the two spectrometers has an amplitude of 2% for the measurements without any systematic diurnal variation.

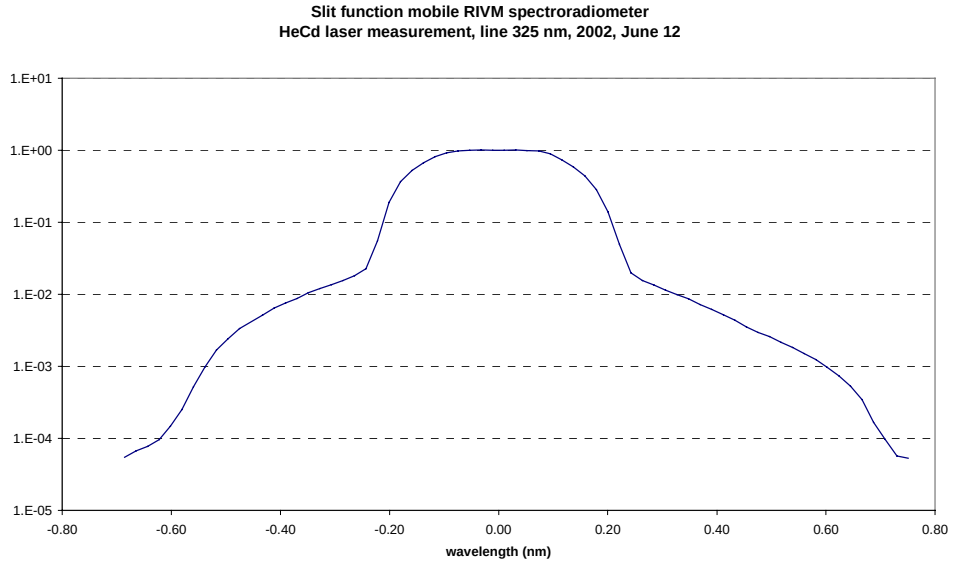
Comments from the site operator:

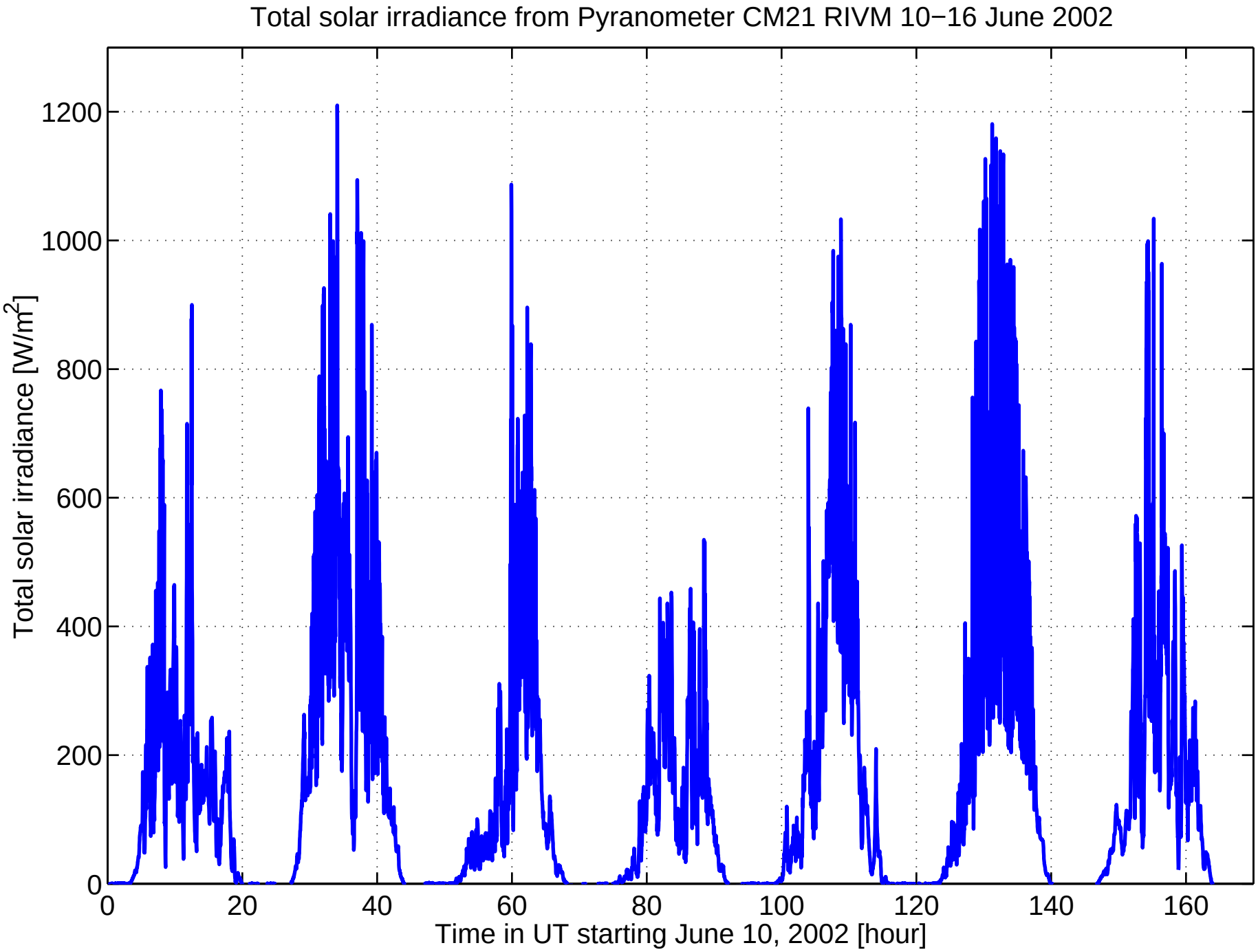
Description spectroradiometer :
The spectroradiometer from RIVM is a XY50 double monochromator from Dilor, France. The slits are set to give about 0.32 nm FWHM, gratings with 2400 lines/mm are used. The output signal of the monochromator is measured with an end window photomultiplier. Photon counting is used. The entrance optics consists of a flat teflon diffuser. It is connected with a 1.5m long quartz fiber connected to the entrance slit. The spectroradiometer is build in a container, the temperature in the instrument room is 20 ± 2 ° C.

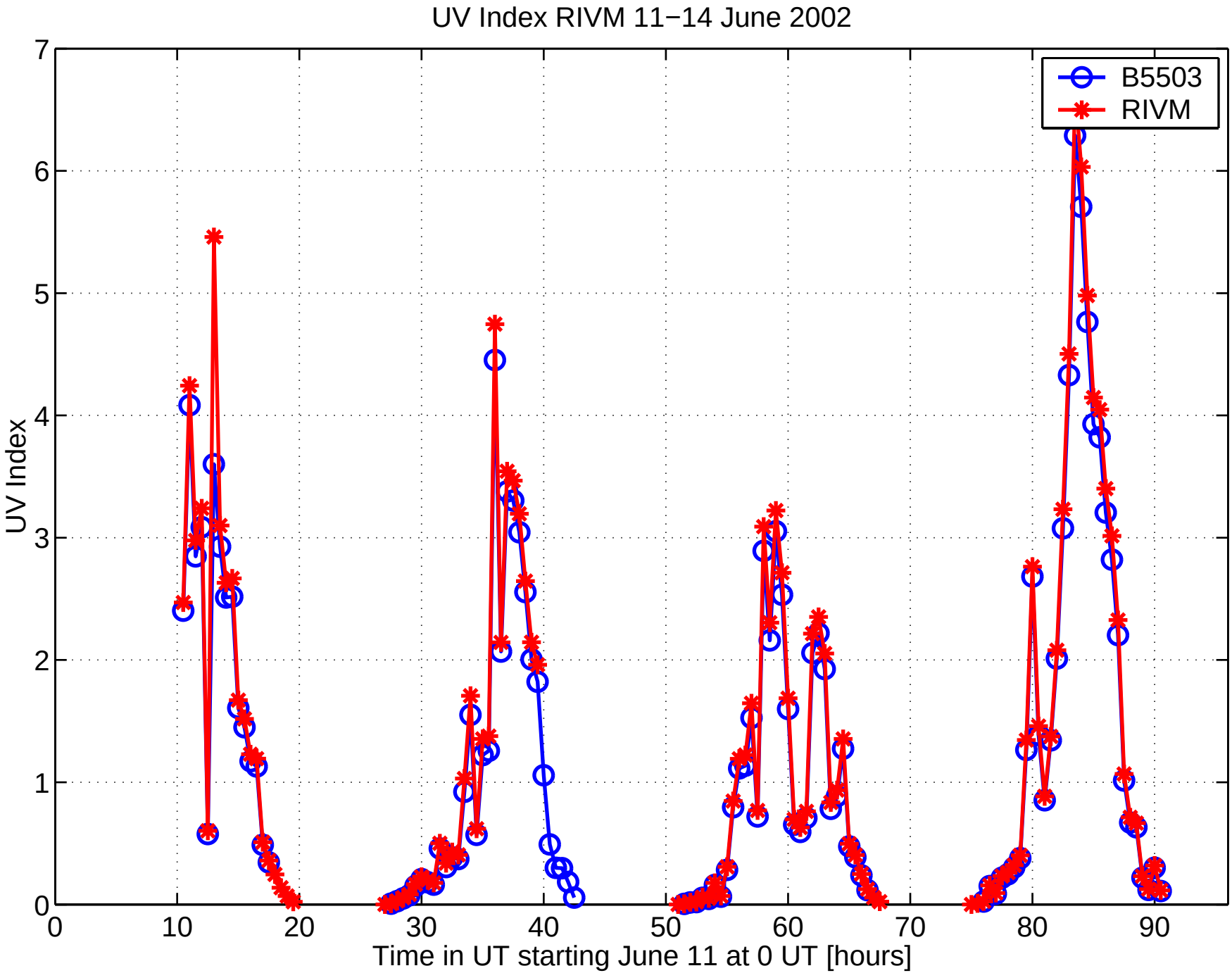
Calibration of the spectroradiometer :
May 11, during the measurement campaign in Ispra the spectroradiometer was calibrated with a 1000W (DXW-S794) lamp from Optronics Laboratories Inc. On the same day and on the last day of the campaign, May 16th, a 200W lamp in a housing was measured. Just before the campaign in Bilthoven, June 10, the 200W lamp was measured also. The lamp measurements agreed within ±1% in the wavelength range 280 – 450 nm. Therefore the spectroradiometer was assumed to be stable since Ispra and it was decided to use the 1000W lamp calibration from June 11.

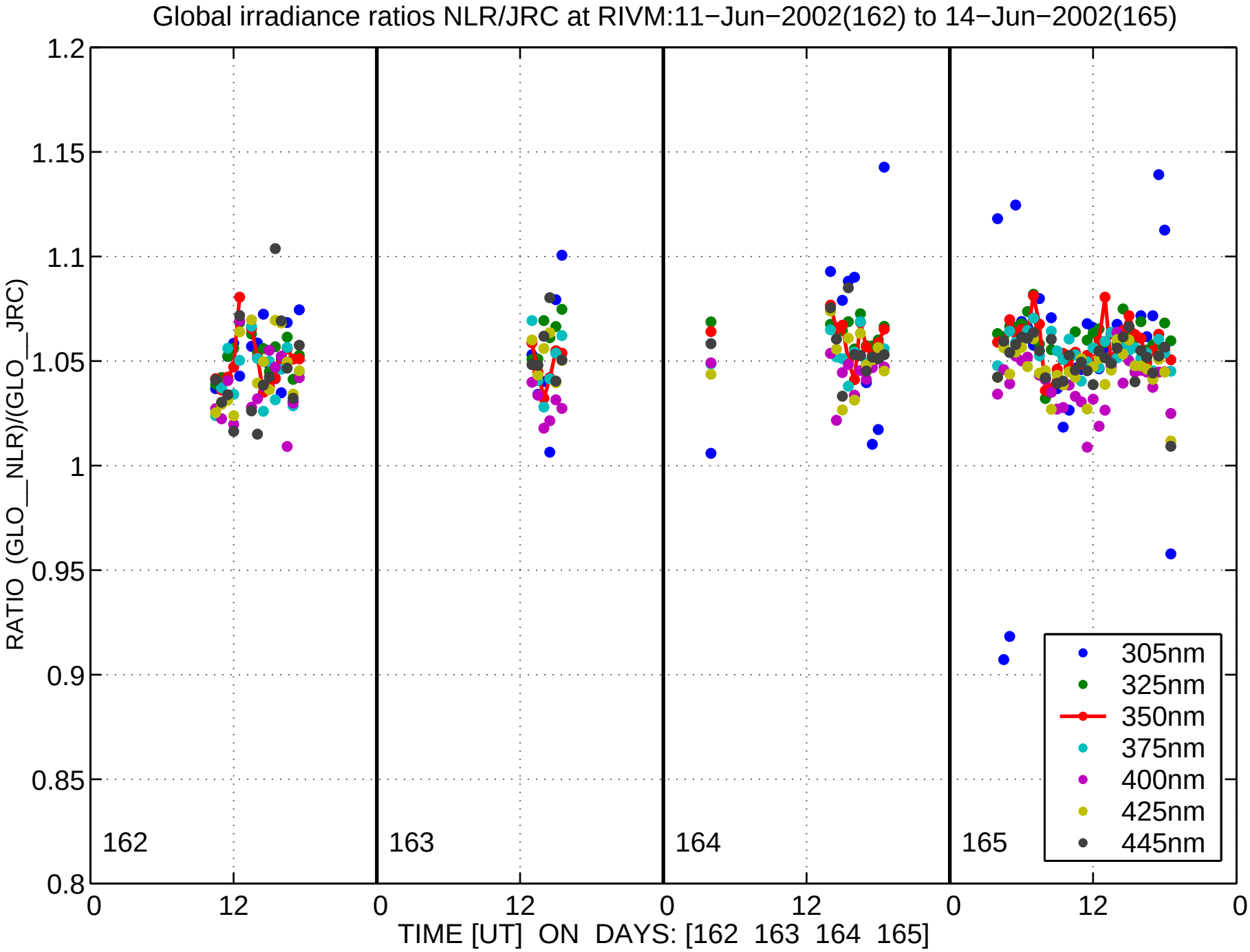
Shift correction and cosine correction of data :
RIVM applied shift correction using the Shicrivm software before submitting the data, as well as a cosine correction [1] to correct for the non-ideal cosine response of the flat diffuser. The shift correction is about +0.01 nm at 290 nm going upto about +0.12 nm at 450 nm. The cosine correction during overcast conditions is about 1.08 with almost no spectral dependency. For instance around noon on day 165 during broken cloud conditions, the correction factor ranges from about 1.074 at 300 nm to 1.06 at 450 nm.

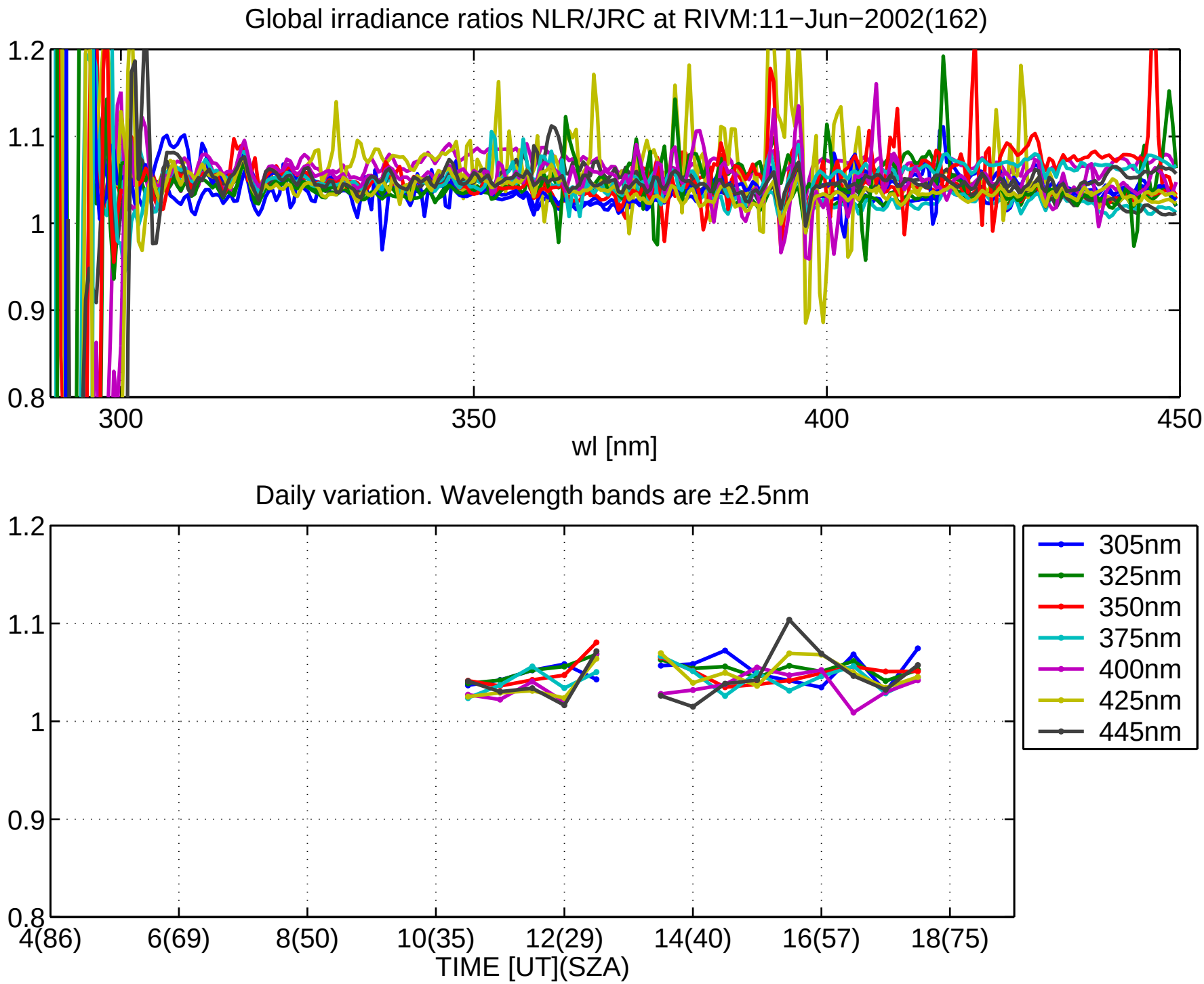
Result of HeCd laser line measurement :
The slit function of the spectroradiometer was determined on the 12th of June. The peak of the HeCd line was measured with a total attenuation of nd = 1.8 from the filters and the side wings of this line with a total attenuation of nd = 1.3. The result is given in the graph below. The slit function has a flat top, due to some misalignment of the fiber with respect to the entrance slit of the monochromator. The FWHM is 0.30 nm.

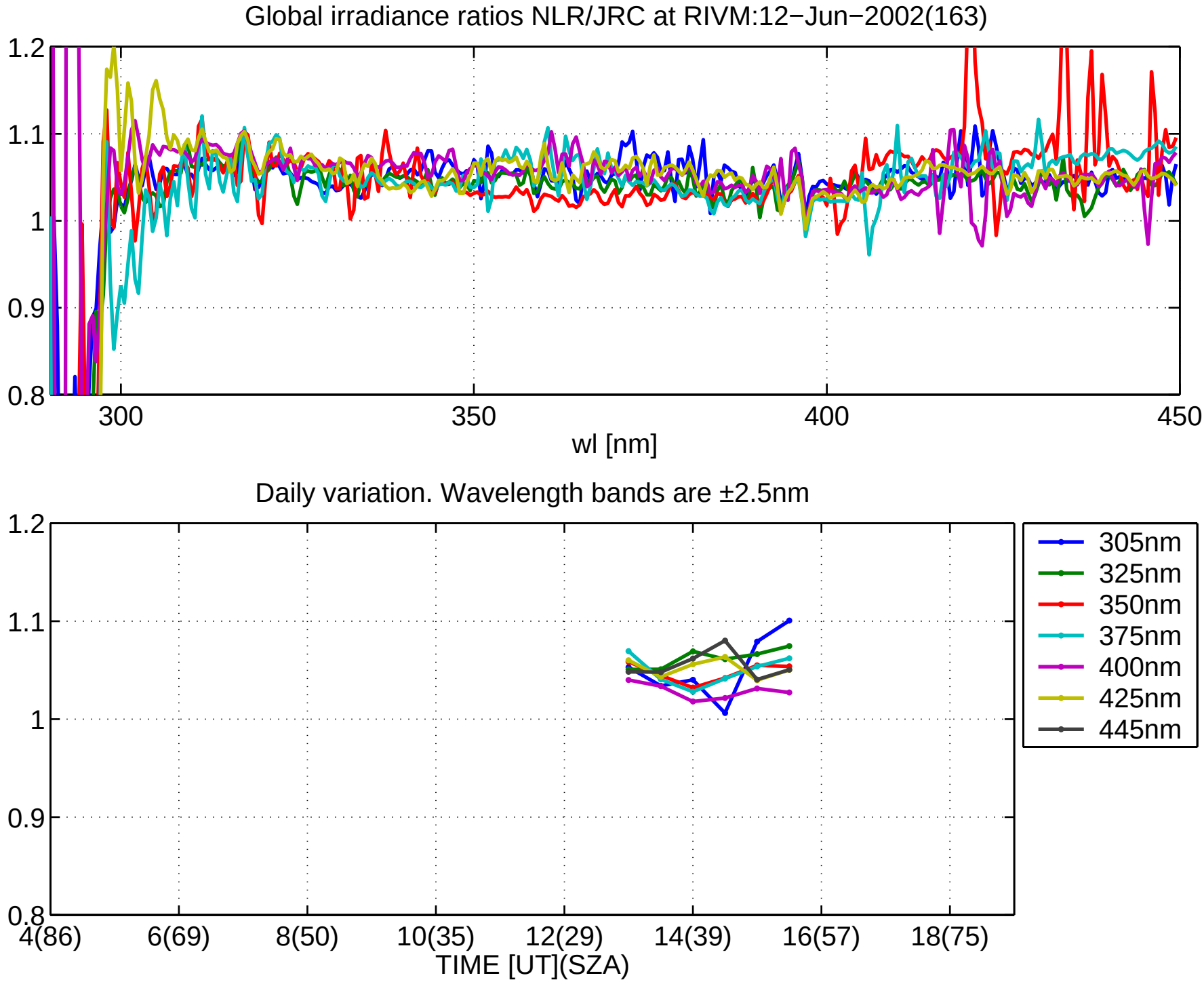

Slit function mobile RIVM spectroradiometer
HeCd laser measurement, line 325 nm, 2002, June 12
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
-0.80
-0.60
-0.40
-0.20
0.00
0.20
0.40
0.60
0.80
wavelength (nm)

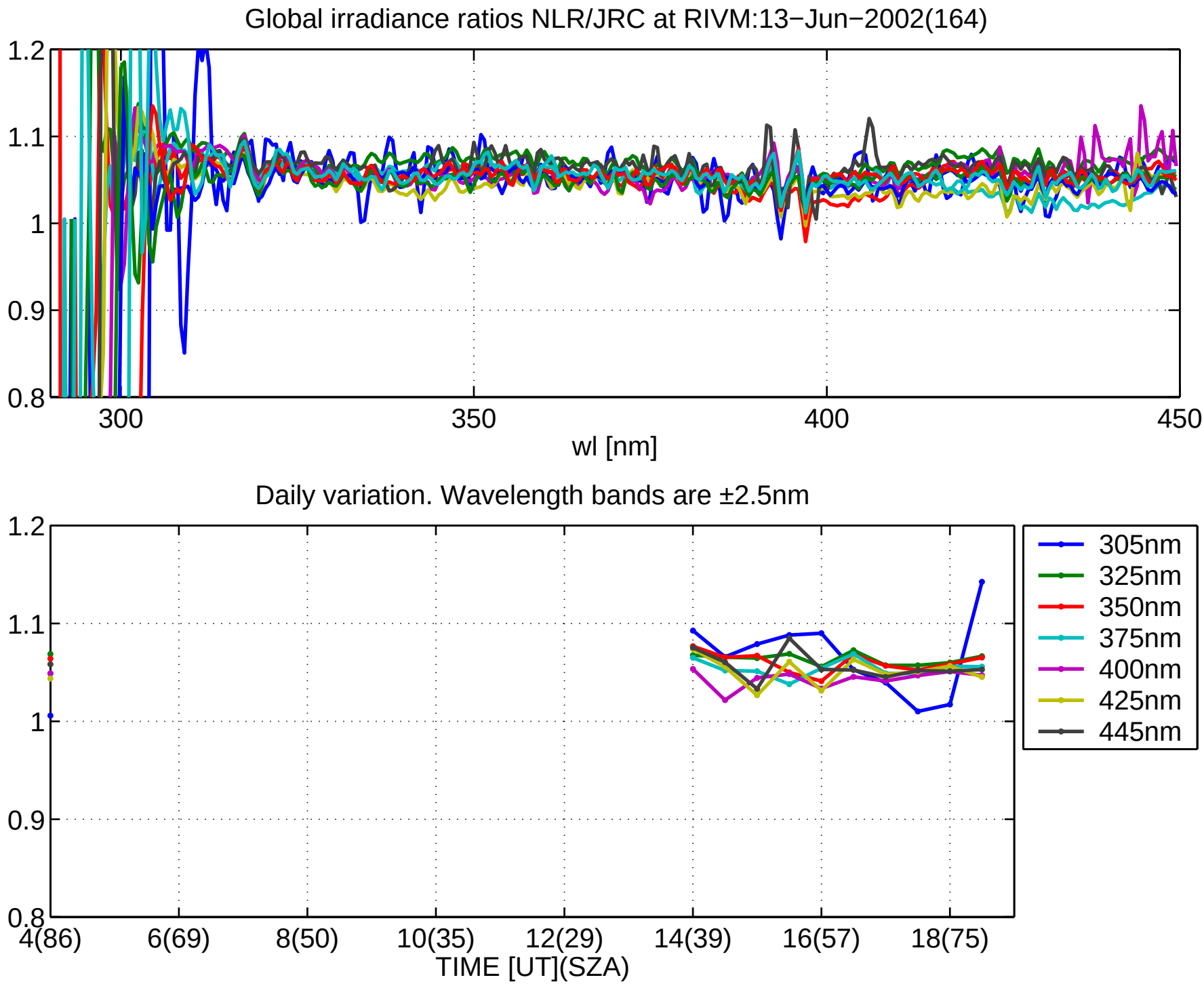

Total solar irradiance from Pyranometer CM21 RIVM 10−16 June 2002
Total solar irradiance [W/m2]
0
200
400
600
800
1000
1200
0
20
40
60
80
100
120
140
160
Time in UT starting June 10, 2002 [hour]

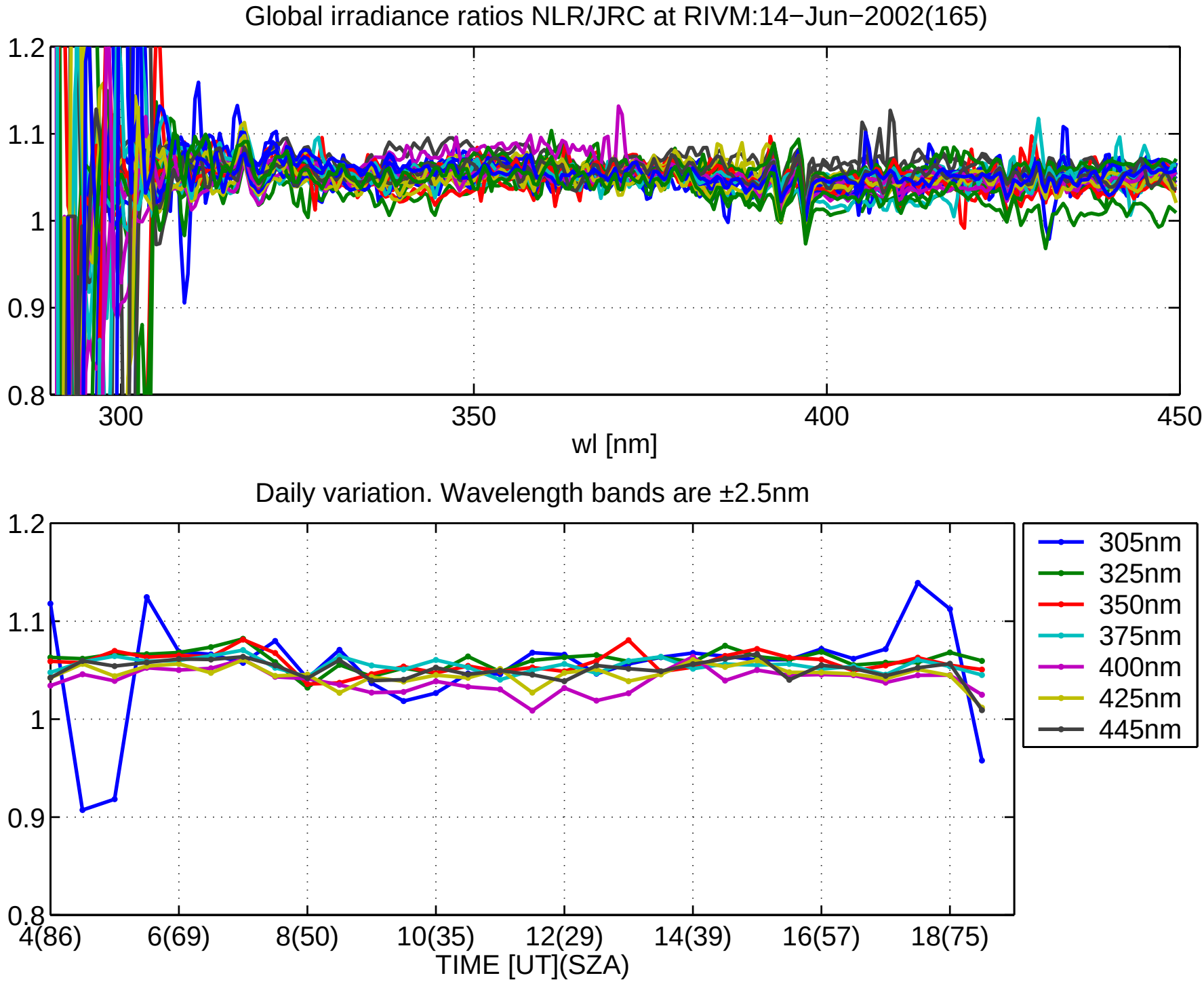

UV Index RIVM 11−14 June 2002
B5503
RIVM
UV Index
Time in UT starting June 11 at 0 UT [hours]
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80
90

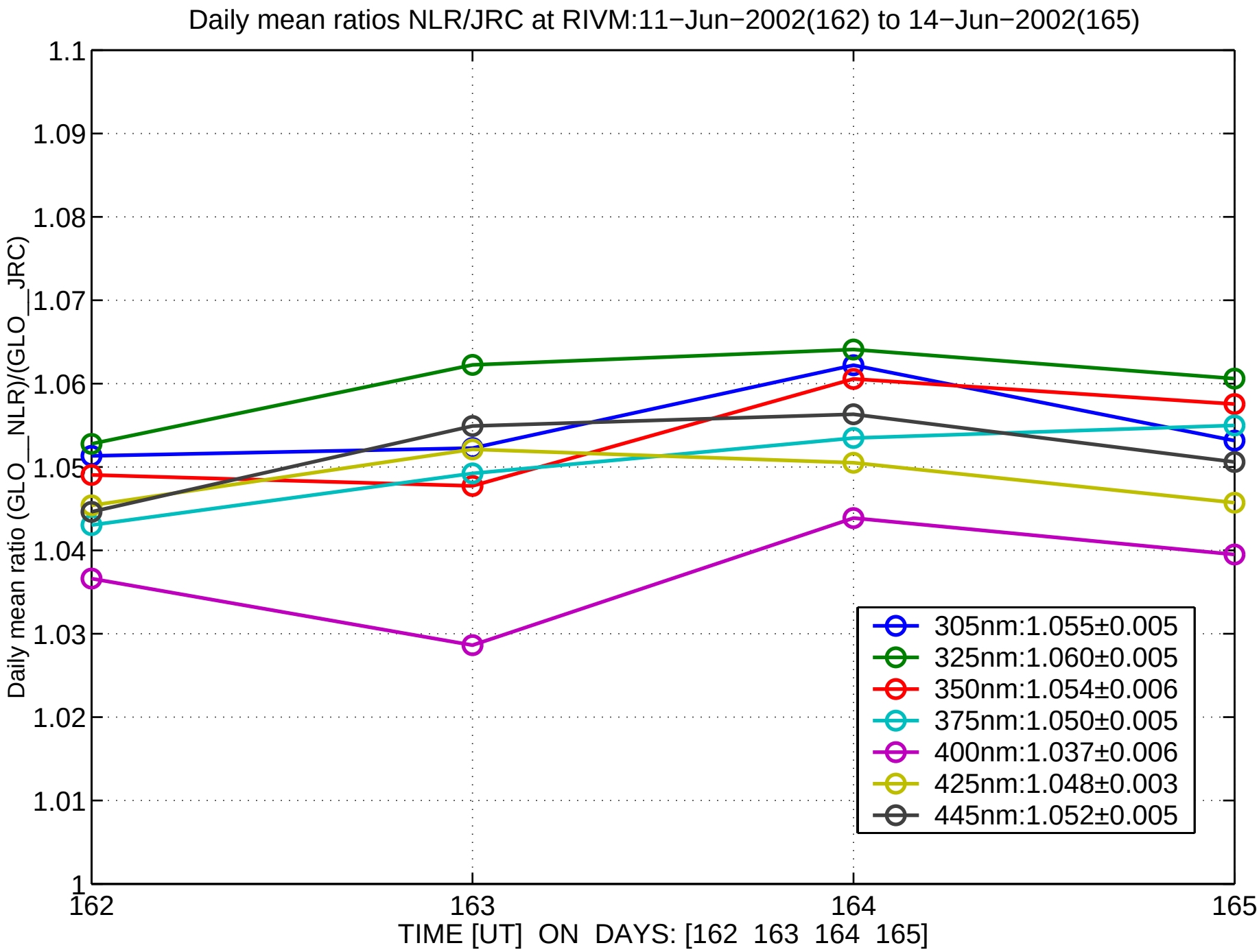

Global irradiance ratios NLR/JRC at RIVM:11−Jun−2002(162) to 14−Jun−2002(165)
RATIO (GLO__NLR)/(GLO__JRC)
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
12
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [162 163 164 165]
162
163
164
165
305nm
325nm
350nm
375nm
400nm
425nm
445nm

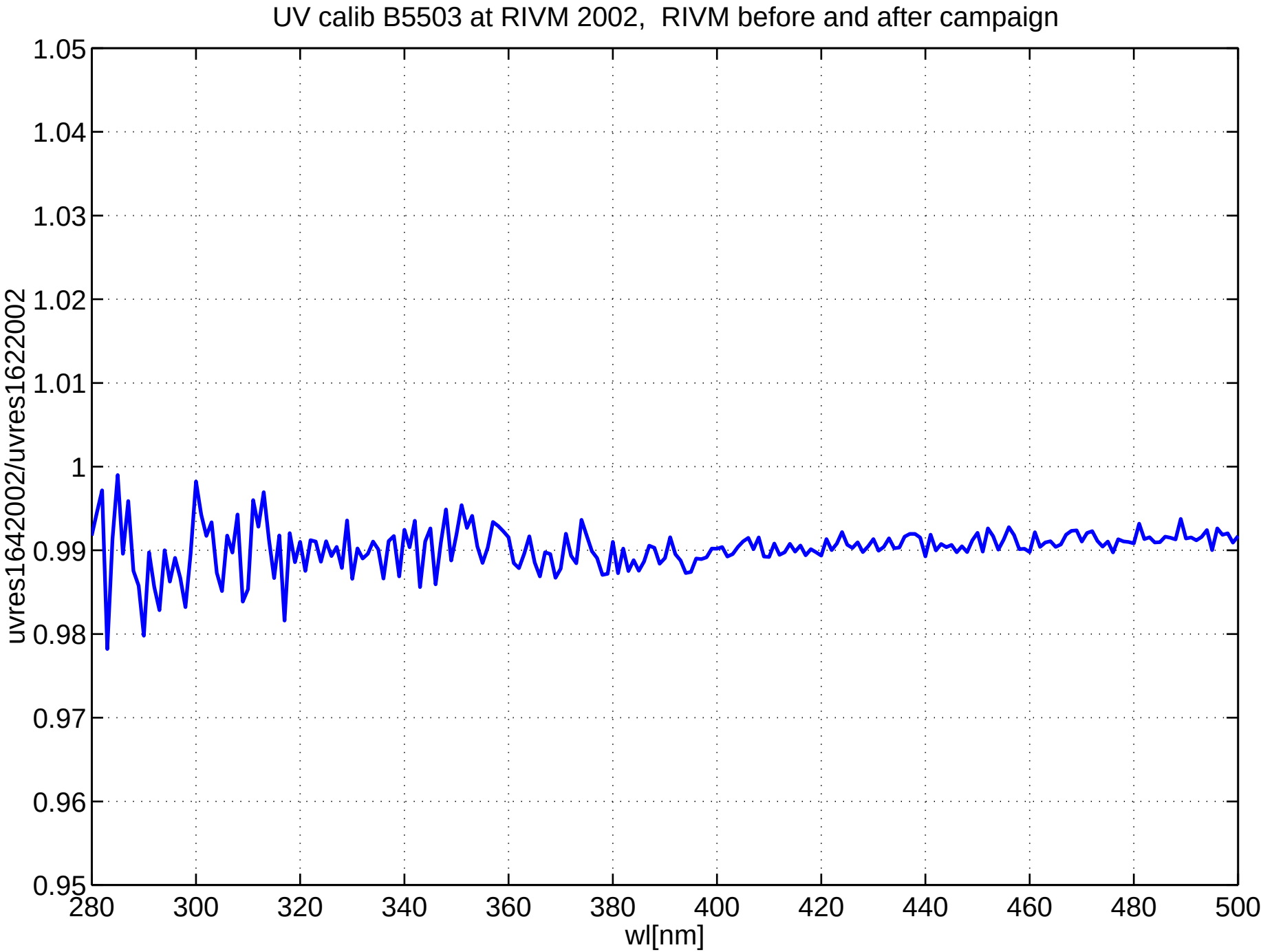

Global irradiance ratios NLR/JRC at RIVM:11−Jun−2002(162)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.2
1.1
1
0.9
0.8
4(86)
6(69)
8(50)
10(35)
12(29)
14(40)
16(57)
18(75)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
445nm

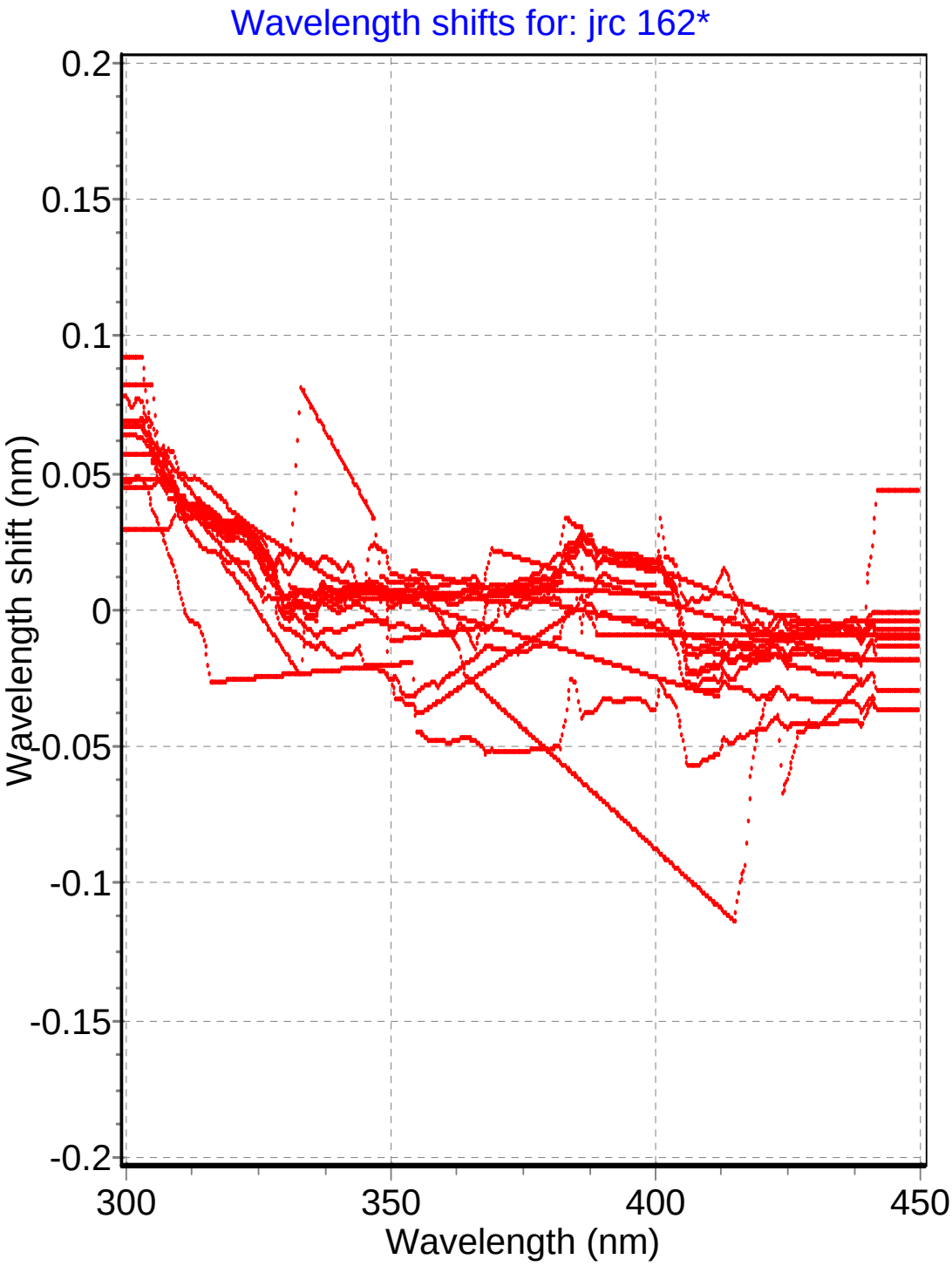

Global irradiance ratios NLR/JRC at RIVM:12−Jun−2002(163)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.2
1.1
1
0.9
0.8
4(86)
6(69)
8(50)
10(35)
12(29)
14(39)
16(57)
18(75)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
445nm

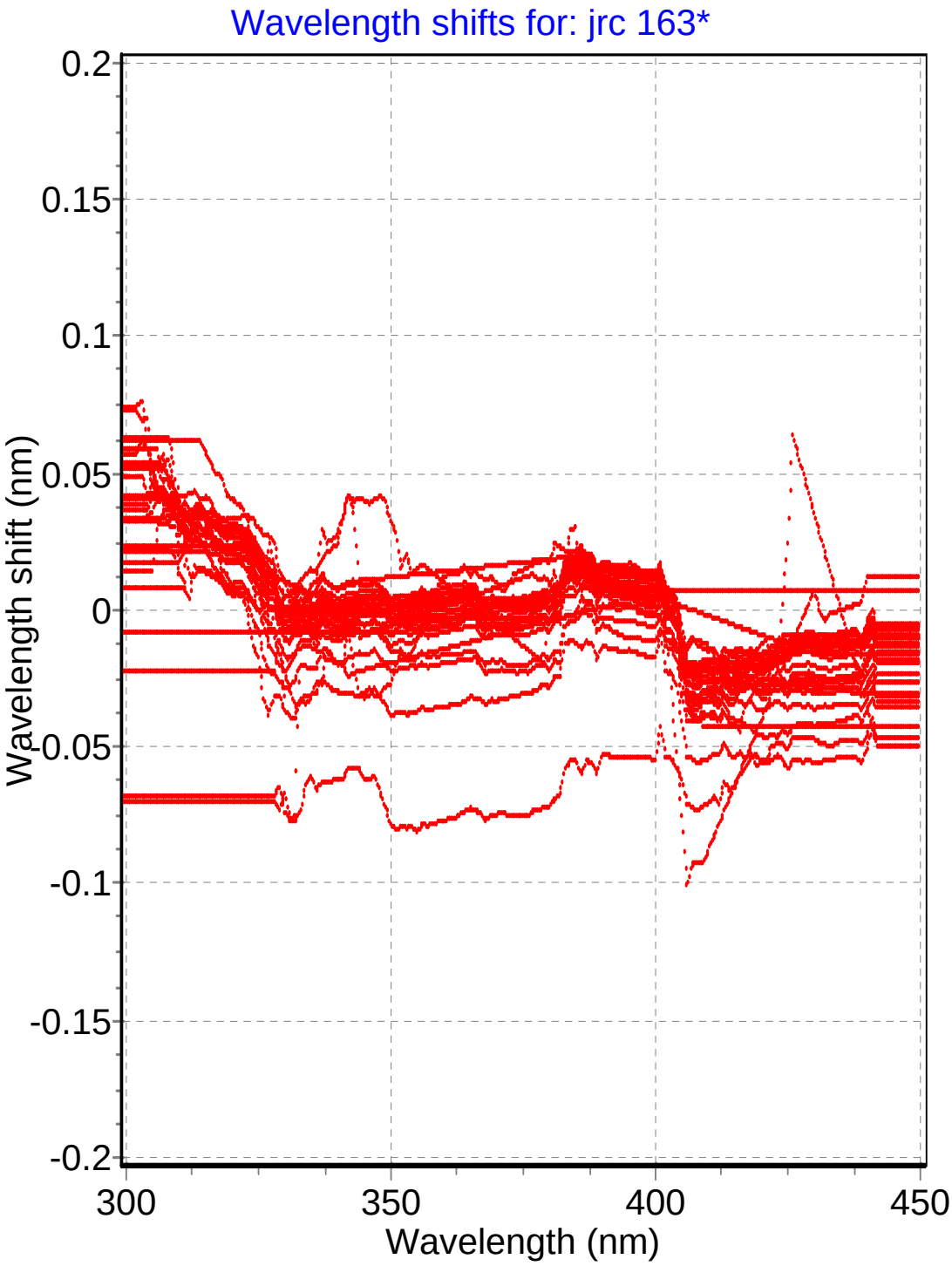

Global irradiance ratios NLR/JRC at RIVM:13−Jun−2002(164)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.2
1.1
1
0.9
0.8
4(86)
6(69)
8(50)
10(35)
12(29)
14(39)
16(57)
18(75)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
445nm

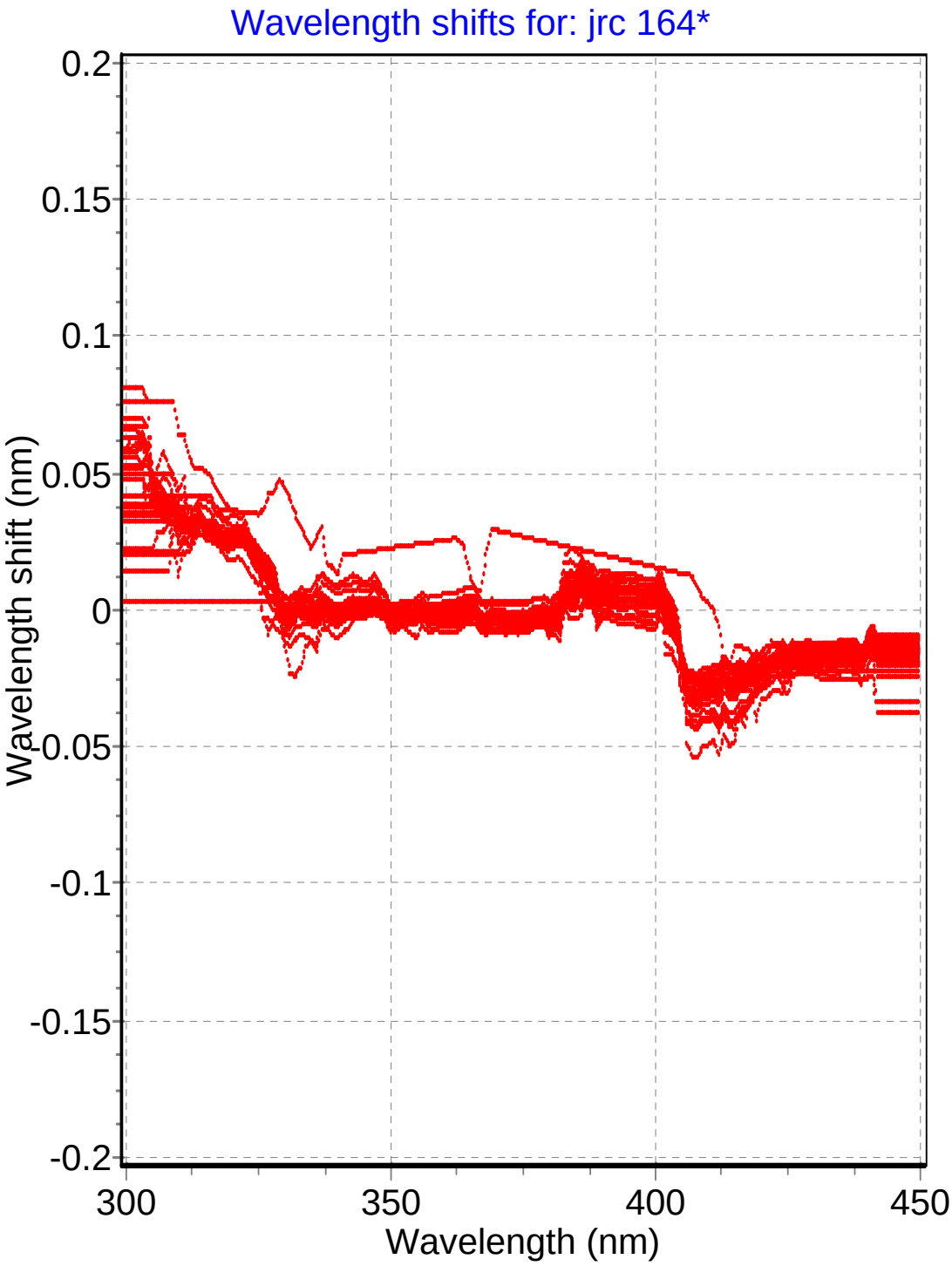

Global irradiance ratios NLR/JRC at RIVM:14−Jun−2002(165)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.2
1.1
1
0.9
0.8
4(86)
6(69)
8(50)
10(35)
12(29)
14(39)
16(57)
18(75)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
445nm

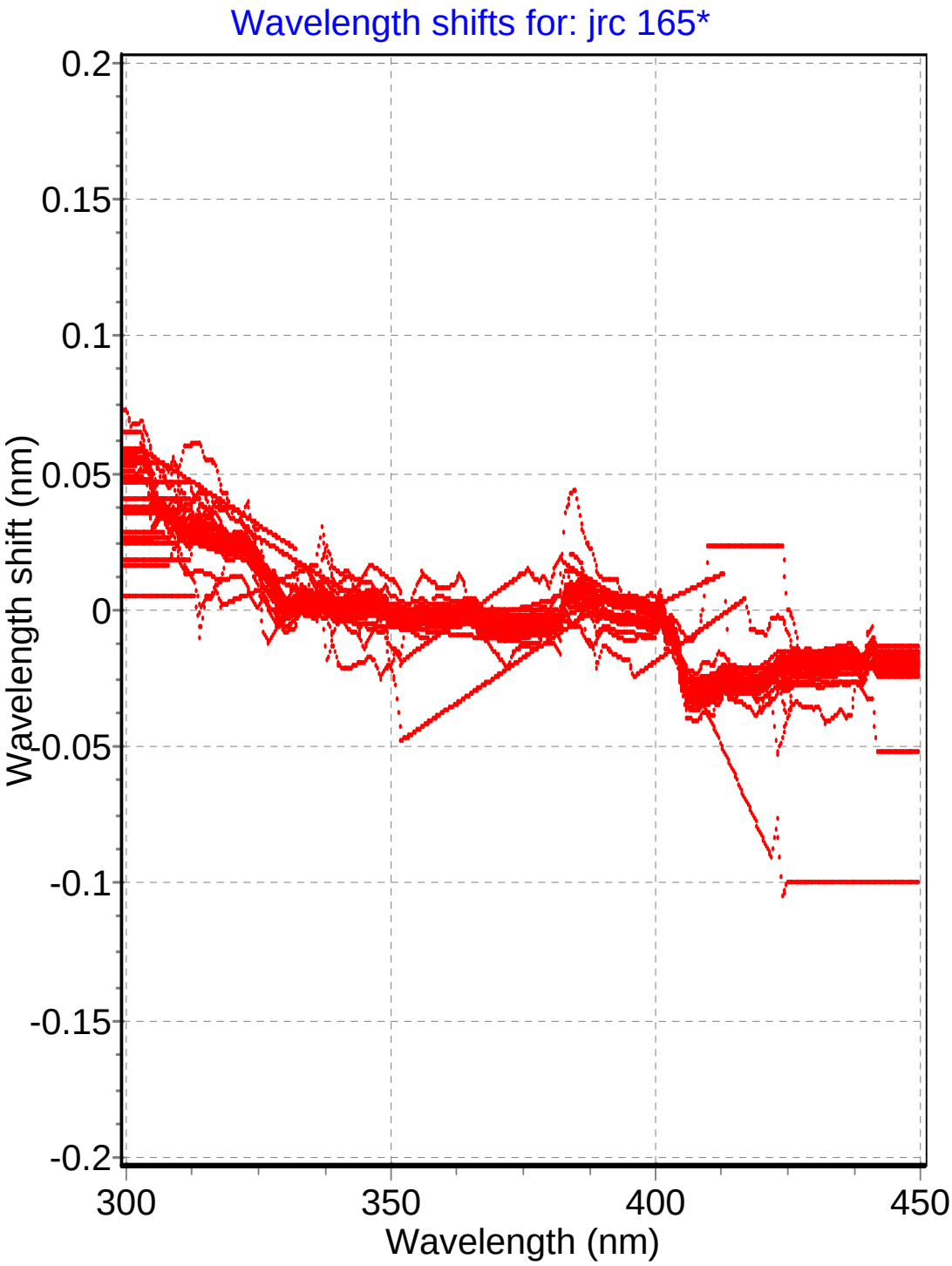

Daily mean ratios NLR/JRC at RIVM:11−Jun−2002(162) to 14−Jun−2002(165)
Daily mean ratio (GLO__NLR)/(GLO__JRC)
1.1
1.09
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1
162
163
164
165
TIME [UT] ON DAYS: [162 163 164 165]
305nm:1.055±0.005
325nm:1.060±0.005
350nm:1.054±0.006
375nm:1.050±0.005
400nm:1.037±0.006
425nm:1.048±0.003
445nm:1.052±0.005

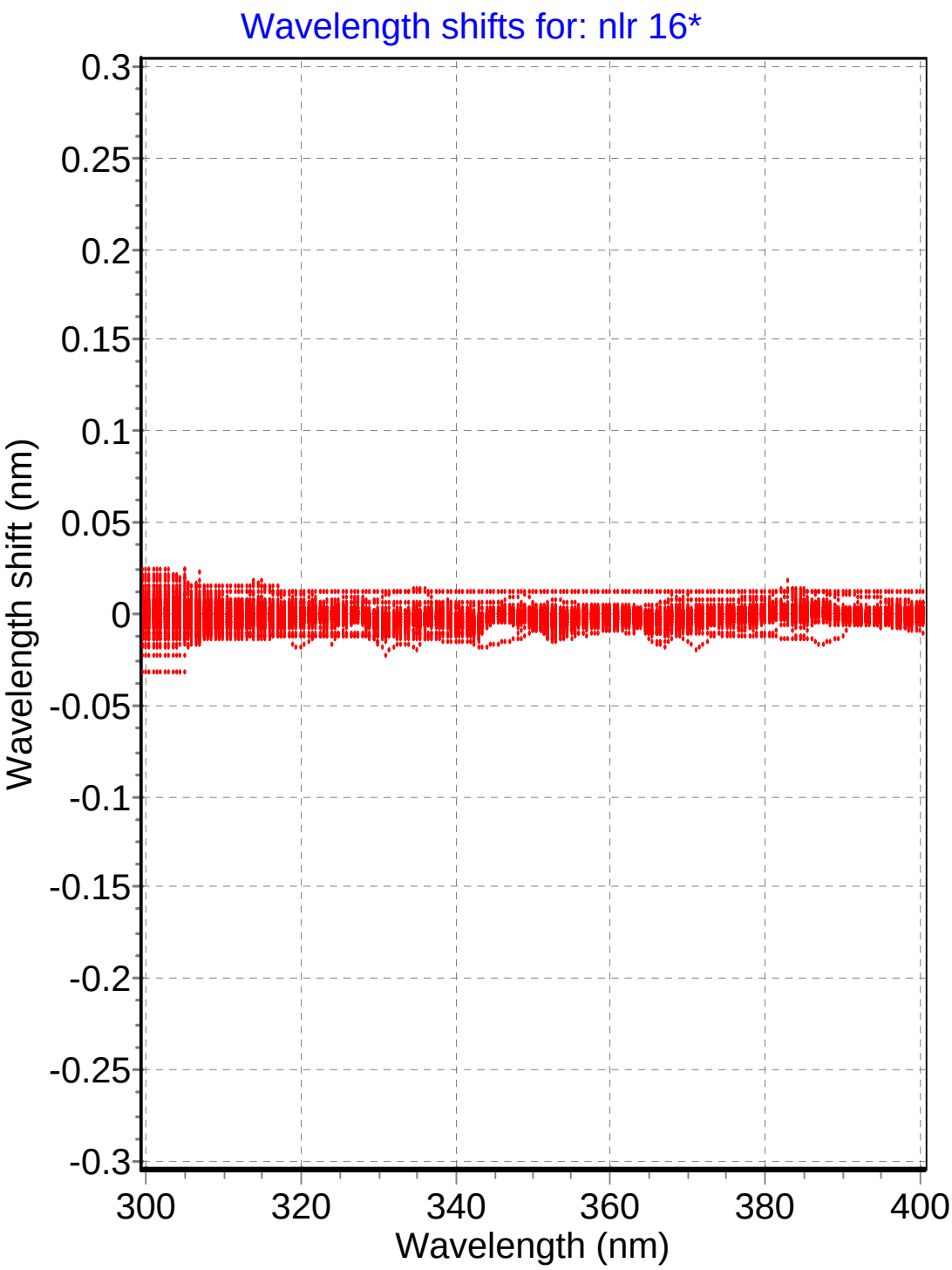

UV calib B5503 at RIVM 2002, RIVM before and after campaign
uvres1642002/uvres1622002
wl[nm]
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
280
300
320
340
360
380
400
420
440
460
480
500


Wavelength shifts for: jrc 162*
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Wavelength shift (nm)
300
350
400
450
Wavelength (nm)


Wavelength shifts for: jrc 163*
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Wavelength shift (nm)
300
350
400
450
Wavelength (nm)


Wavelength shifts for: jrc 164*
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Wavelength shift (nm)
300
350
400
450
Wavelength (nm)


Wavelength shifts for: jrc 165*
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Wavelength shift (nm)
300
350
400
450
Wavelength (nm)


Wavelength shifts for: nlr 16*
Wavelength shift (nm)
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
300
320
340
360
380
400
Wavelength (nm)

Skyline around RIVM UV mobile instrument