Protocol of the intercomparison at the BOKU Observatory, Großenzersdorf, Austria, May, 10-13 2004 with the travelling standard spectroradiometer B5503 from ECUV within the project QASUME

Report prepared by Julian Gröbner and Josef Schreder

Operator: Josef Schreder

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer operated by the Universität für Bodenkultur (BOKU) (ATW) and B5503 within the project QASUME. The measurement site is located at Großenzersdorf; Latitude 48.20 N, Longitude 16.559 E and altitude 156 m.a.s.l..
The horizon of the measurement site is mostly free in all directions.

B5503 arrived at Großenzersdorf at noon of May 10, 2004. The spectroradiometer was installed on the BOKU measurement container at about 2 meters from the ground. The spectroradiometer in use at BOKU is a Bentham 150 double monochromator. The intercomparison between B5503 and the local spectroradiometer lasted two and a half days, from the morning of May 11 to 10:30 UT of May 13.

B5503 was calibrated several times during the intercomparison period using a portable calibration system. Three lamps were used to obtain an absolute spectral calibration traceable to the primary reference held at ECUV which is traceable to PTB: T53062 (100 W), T53063 (100 W) and T61252 (250 W). The internal temperature of the instrument was 24.2+-0.4 degC. The diffuser head was heated and the internal humidity was less than 10%. The diffuser temperature on May 11 was below 19degC until 10:00 UT and rose to 28 degC at 12:00 UT before settling at a nominal temperature of 22 degC. Based on a temperature study of the diffuser, it is expected that the measurements of B5503 before 10:00 UT are too low by about 2%. This effect has not been taken into account in thw following data analysis. On May 12 and May 13 the diffuser temperature was between 22 and 28 degC which should affect measurements less than 0.5%.

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 (see appended graphs).

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>May 10 (131):</u>

Arrival and setup of the instrument at 12:00 UT. The instrument was left to stabilise until the next morning.

May 11 (132):
Synchronised measurements are available from 4:30 to 17:30 UT. B5503 missed the 10:00 UT and 10:30 UT scan due to calibration. Weather conditions from 5:00 till 09:30 are fully overcast. Partly broken skies from 11:00 till 17:30 UT.
B5503 was calibrated from 9:45 to 10:45 UT and from 17:45 to 18:45 UT.

May 12 (133):
Synchronised measurements are available from 5:00 to 7:00 UT, from 10:30 to 11:00 UT, and from 12:30 to 13:30 UT. Weather conditions were clear skies up to 10:30 UT, later a mix of sun and fast moving low lying clouds.
B5503 missed several measurements due to a photomultiplier problem. B5503 was unsynchronised during the 11:30 and 12:00 UT scans.
B5503 was calibrated from 10:45 to 11:00 UT.

May 13 (134):
Synchronised measurements are available from 4:30 to 9:00 UT. Weather conditions were cloudy skies. Rain started at 9:30 UT.
B5503 was calibrated from 05:13 to 05:30 UT and from 5:43 to 6:00 UT.

Results:
45 synchronised scans are available from the measurement period.
The wavelength shifts of the submitted solar spectra of the BOKU spectroradiometer retrieved through the SHICRivm analysis were stable to within 10 pm during the three-day measurement period. The absolute wavelength shift relative to the extraterrestrial spectrum used by the SHICRivm software varied between –60 pm at 310 nm to –200 pm at 350 nm. The wavelength shifts were stable at –200 pm between 350 and 400 nm.

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

- Global irradiances measured by ATW were between 0% and 8% higher than those measured by B5503 on the three days for wavelengths above 310 nm. Below 310 nm ATW measures systematically more than B5503, reaching +15% around 300 nm. These deviations seem to be also correlated to SZA, with larger deviations at high SZA.
- Diurnal variations between the two instruments are below 2% at wavelengths above 310 nm while at 305 nm the diurnal variability is around 12%.
- A systematic wavelength structure is observed between 310 and 370 nm, with amplitude of about 6% and a periodicity of about 20 nm.
- ATW measures solar spectra with wavelength misalignments of –0.05 to –0.2 nm in the wavelength range 310 to 390 nm.

Conclusion:
ATW measures global solar irradiance on average 4 to 5% higher than B5503. Between 300 and 310 nm ATW measures up to 20% more than

B5503. A systematic wavelength structure is observed which is partly explained by an erroneous calibration of ATW prior to the campaign (see attached operator comment).

Comments from the local operator:

The spectroradiometer of the BOKU (ATW) is a DM 150 double monochromator, 2400 lines/mm from Bentham, UK. Continuous measurements of spectral UV irradiance are performed in Großenzersdorf since 1998. The slits are set to give about 0.68 nm FWHM. The entrance optic of this measuring system consists of a quartz dome and a shaped cosine diffuser (Schreder, Austria) which is connected to the monochromator entrance with an optical fibre. The integral cosine error of the input optic is less than 2 % at 320, 400 and 500 nm. The temperature sensitivity of the global input optic was not investigated, since this optic was installed just before QASUME. Investigations of Blumtaler and Schreder of the temperature sensitivity of the global input optic from April 2004 show, that maximal change on the response of about -2 % occurs at 320 nm between 27 °C and 44 °C. The spectroradiometer is placed in a temperature controlled box at 19±0.5°C.

Results of the campaign:

The spectroradiometer ATW was calibrated with an Osram Sylvania FEL1000 Watt lamp at the measuring place at the beginning and the third day of the intercomparison period. The difference between these two calibrations was less than 1.5 %. The temperature of the DM150 (ATW) was stable within ±0.5°C during the intercomparison.

Global irradiances measured by ATW were higher than those measured with B5503. Investigations after the intercomparison showed that an error occurred evaluating the response file UVRES1272004. Fig. 1 shows the UVRES1272004 used during the intercomparison and the corrected UVRES1272004, and in Fig. 2, the ratio of both data with respect to the wavelength is visible. Fig. 2 exhibits a systematic wavelength structure of the ratio (periodicity 20 nm), which has been similarly found comparing the global irradiance measured by ATW and B5503.

After the intercomparison, the used Osram Sylvania FEL1000 Watt lamp was compared to another standard F290 1000W [NIST]. In Fig. 3, the ratios of irradiances measured with these two lamps are presented and differences of approximately 4 % are visible.

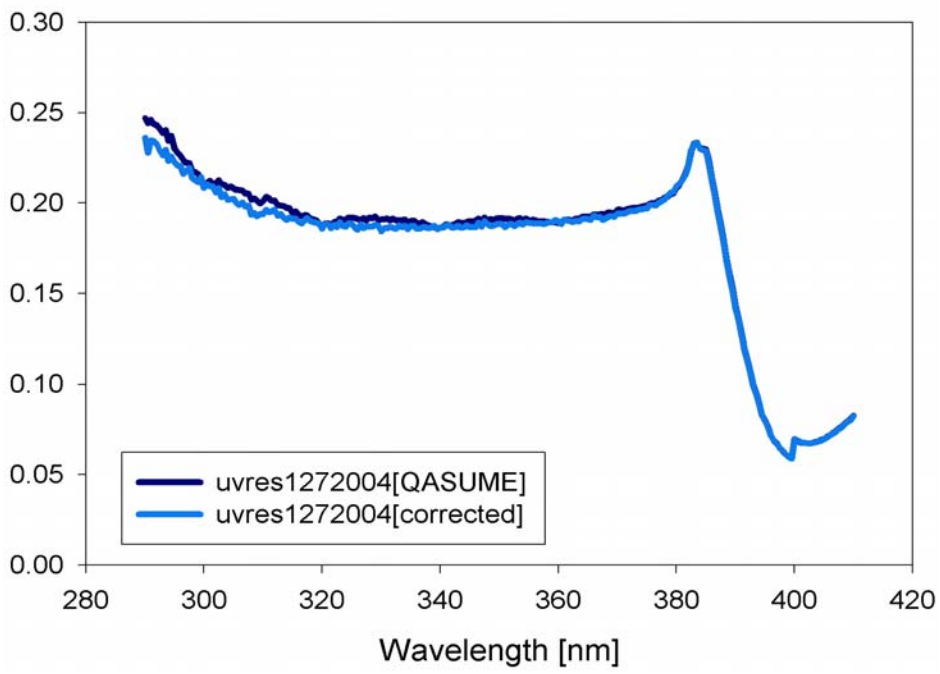


Fig. 1: *Dark blue - UVRES1272004 used in QUASUME, light blue - corrected UVRES1272004*

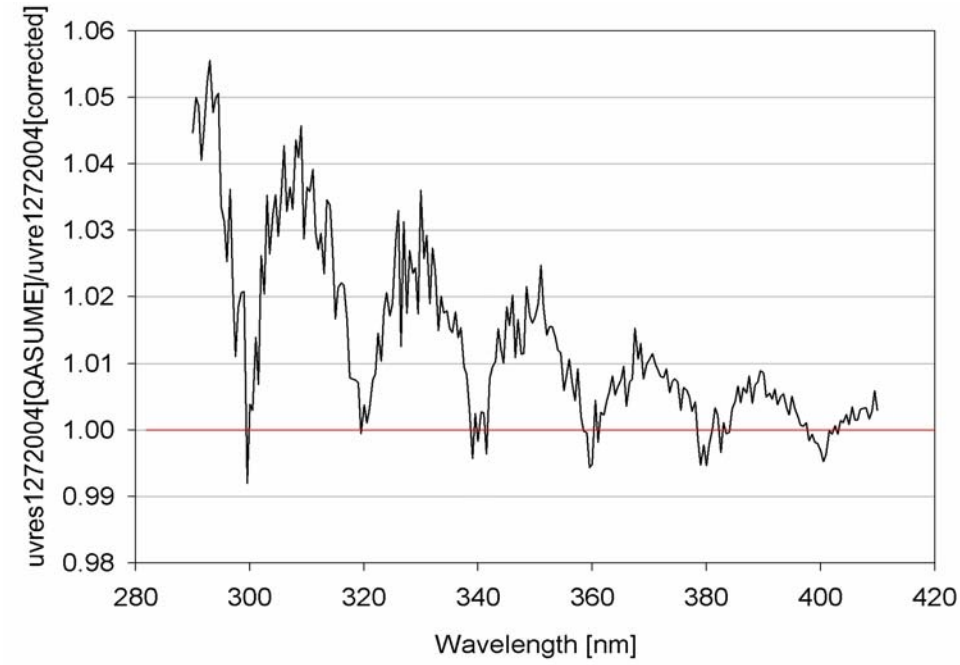


Fig. 2: *Ratio of UVRES1272004 used in QUASUME and corrected values*

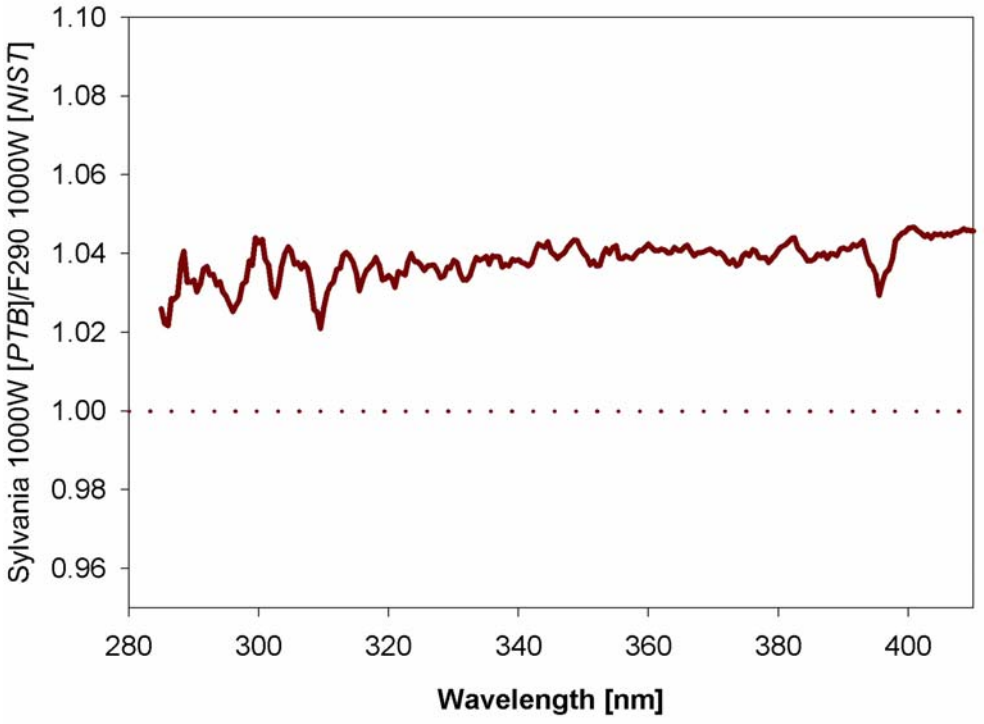
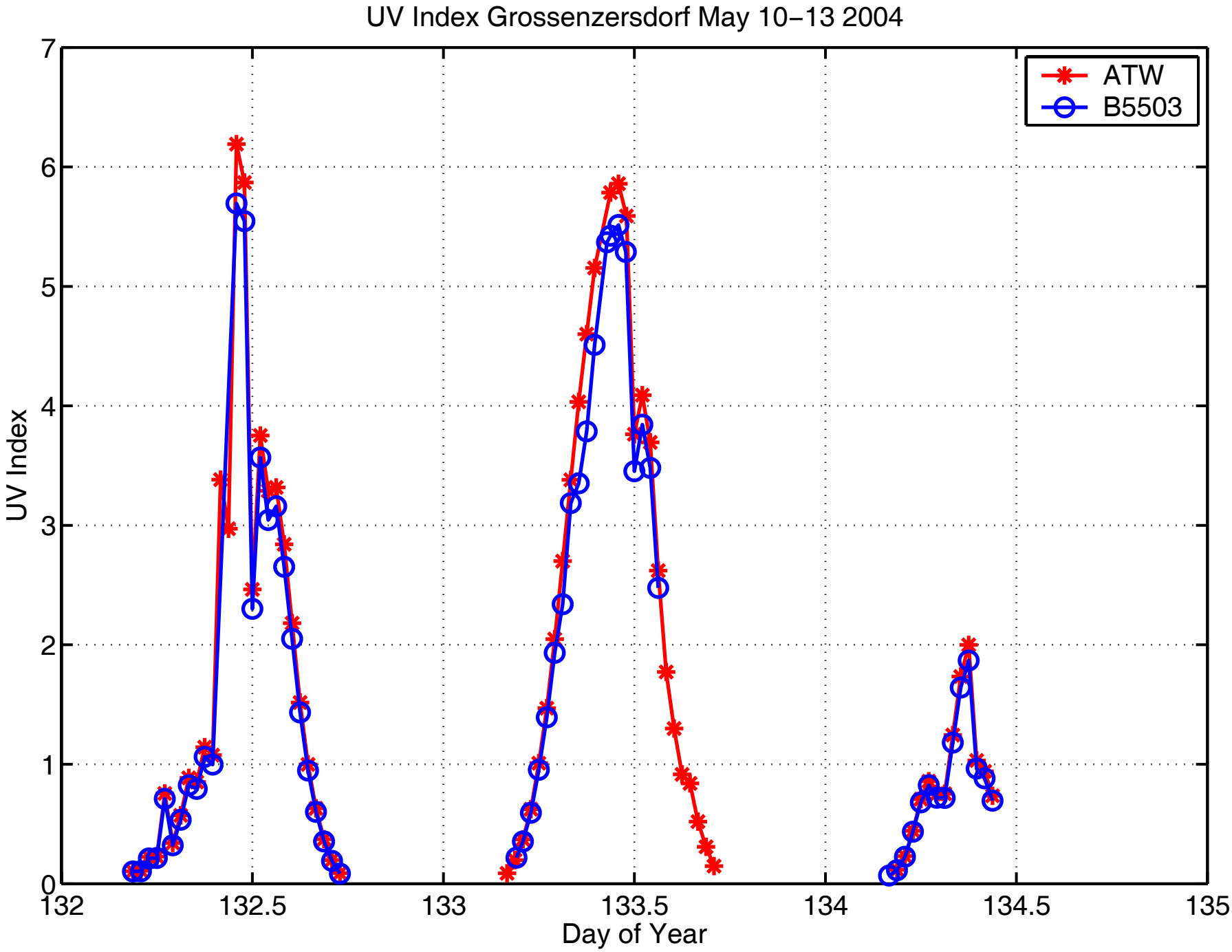
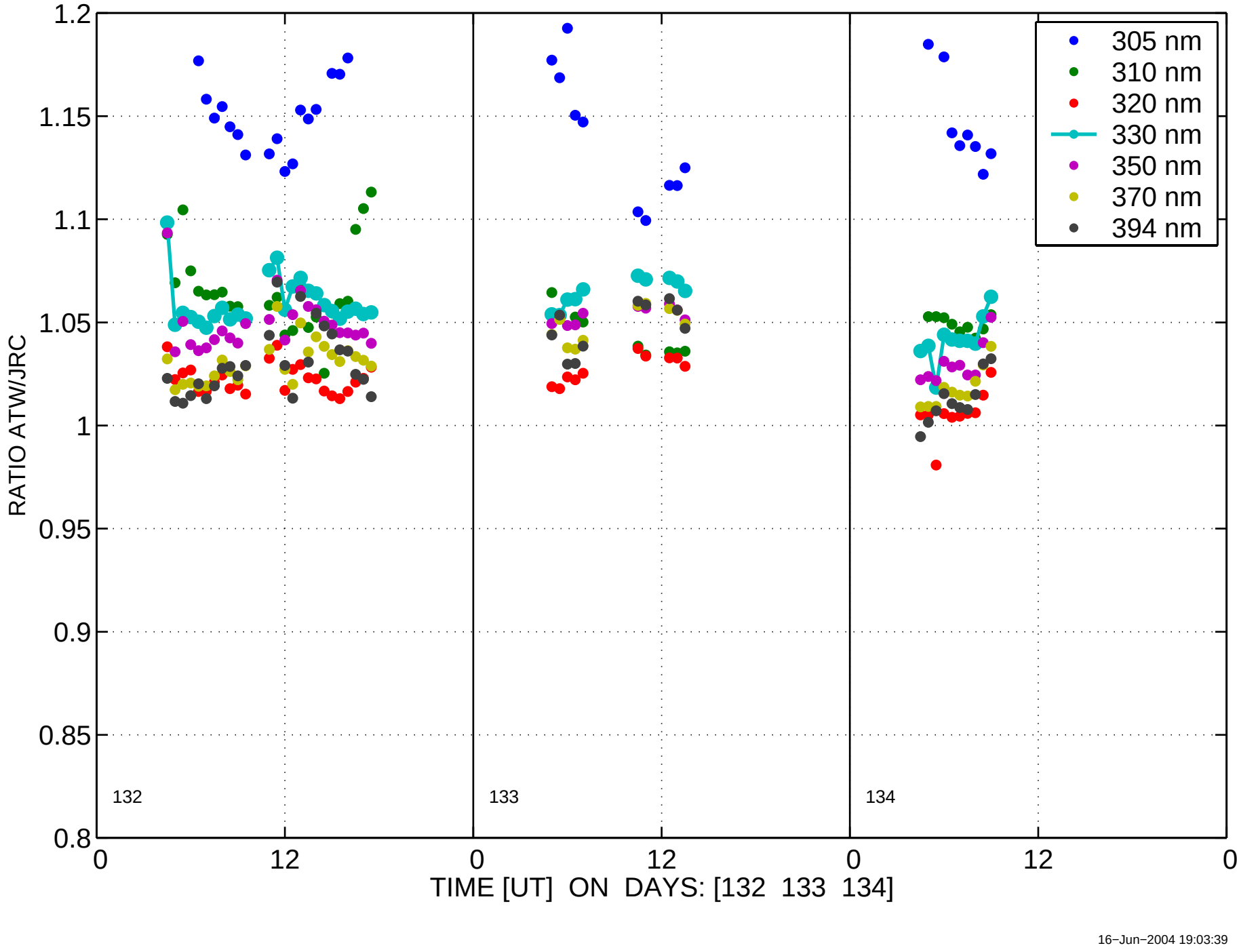
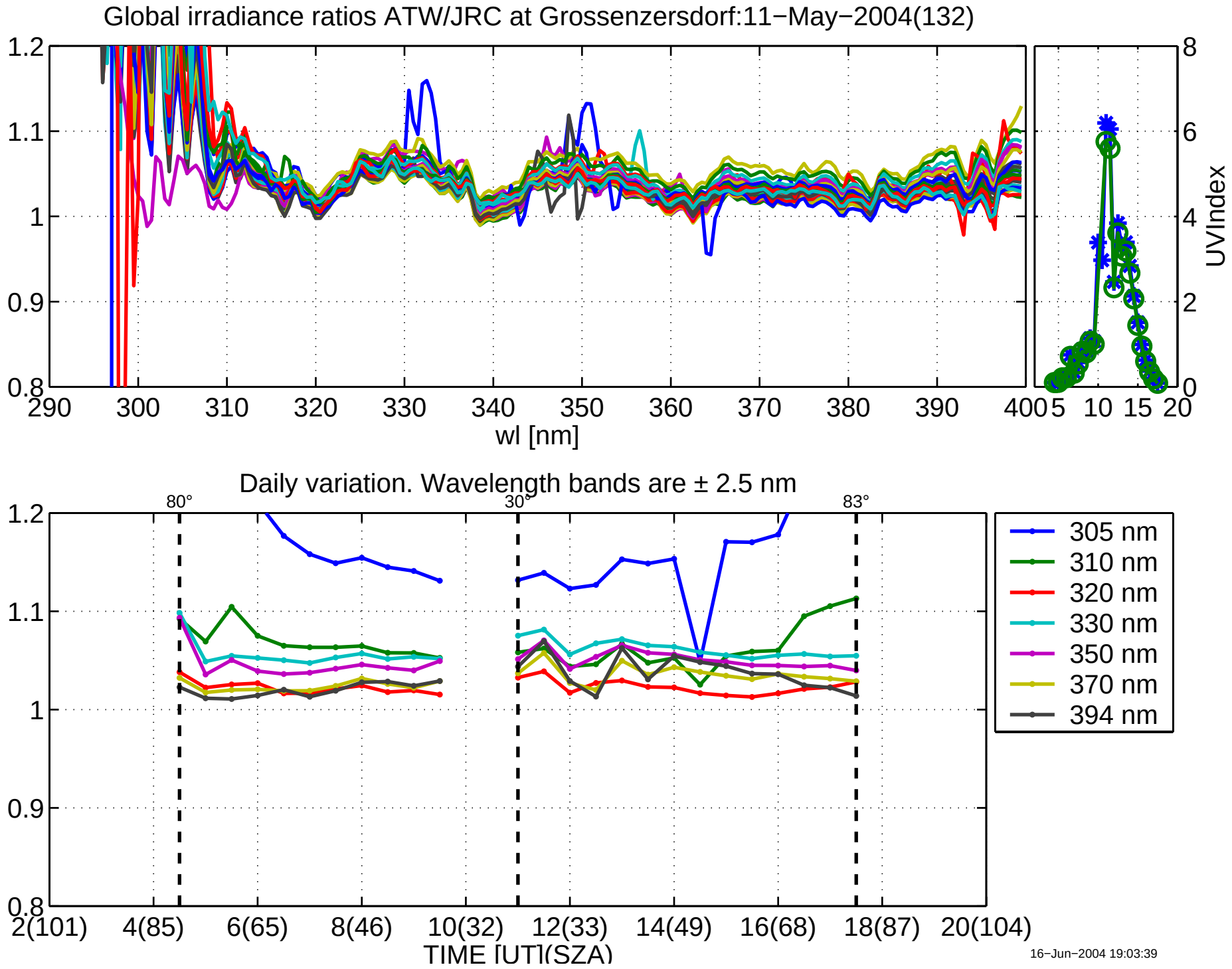
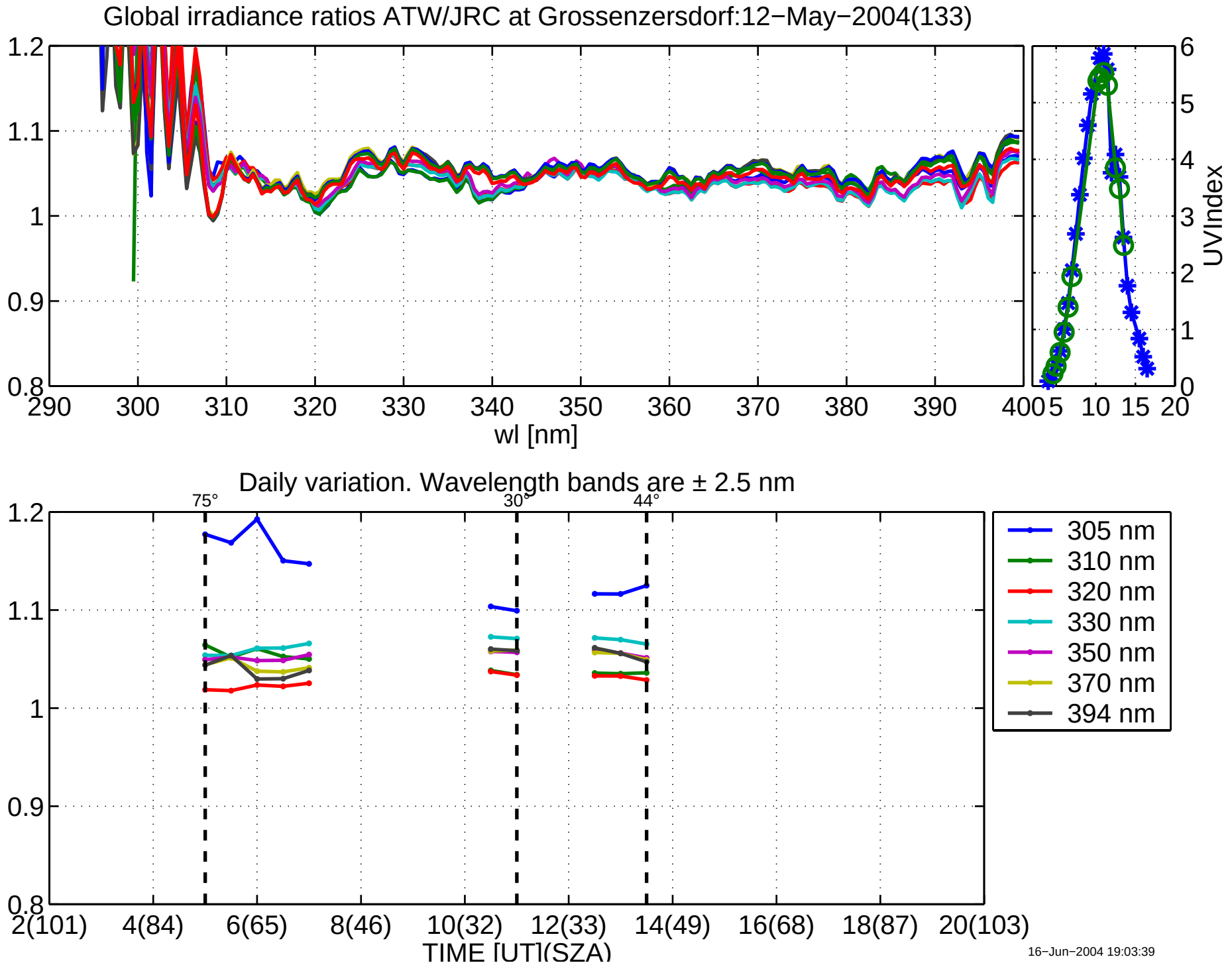


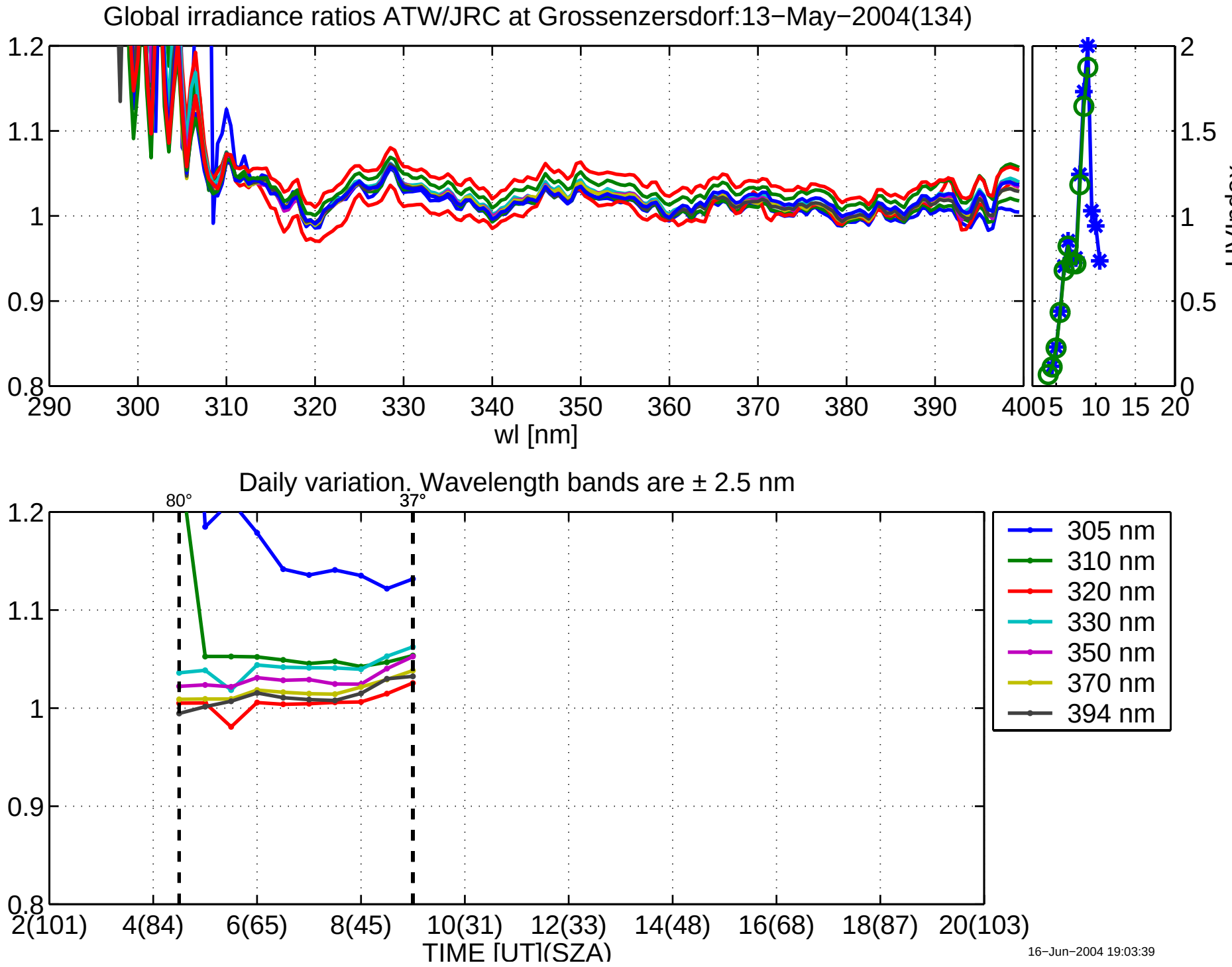
Fig. 3*: Ratios of irradiance of the calibration lamp Sylvania 1000W [PTB] which was used in the intercomparison to the calibration lamp F290 1000W [NIST]*

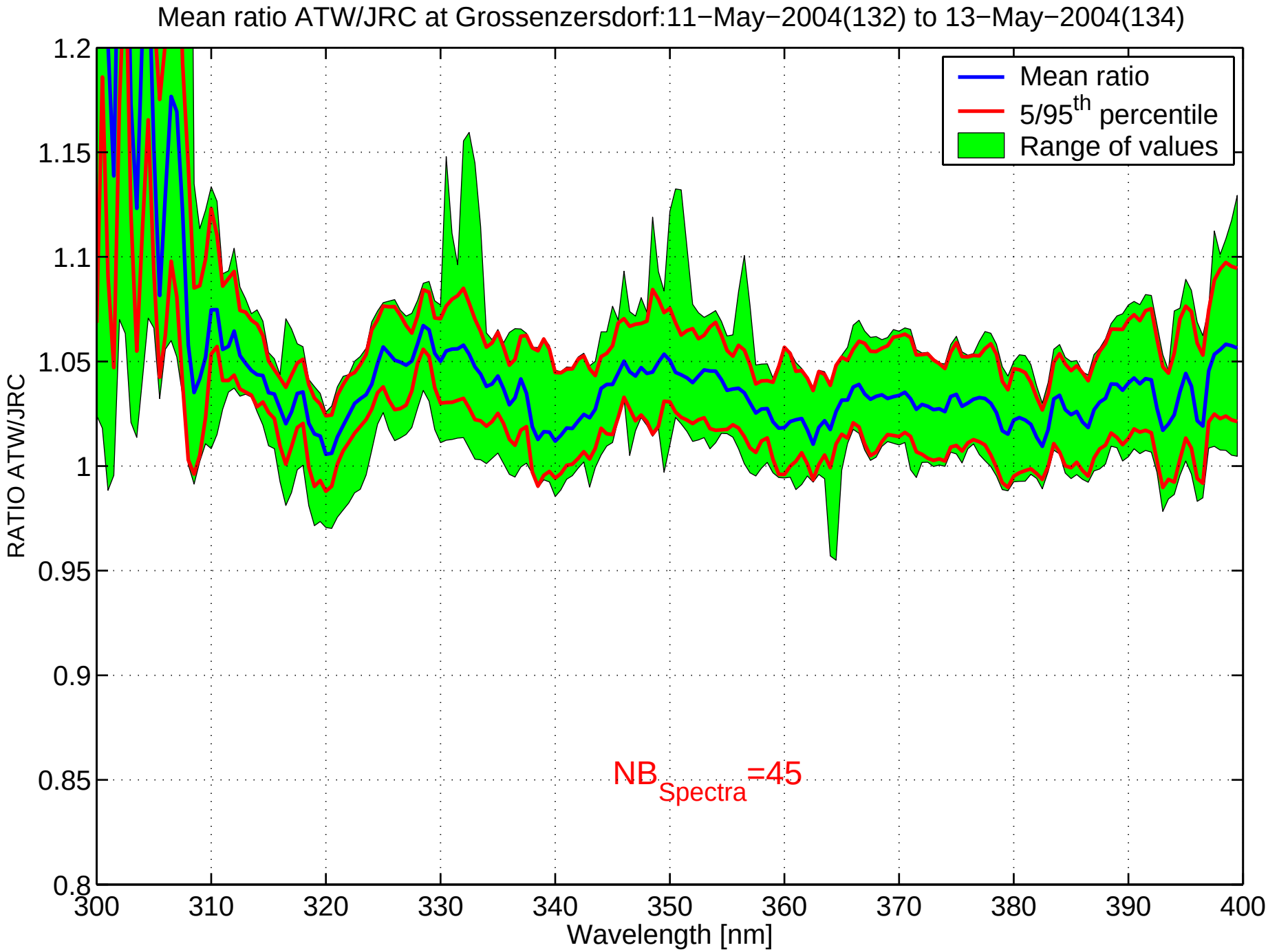

UV Index Grossenzersdorf May 10−13 2004
ATW
B5503
UV Index
Day of Year
0
1
2
3
4
5
6
7
132
132.5
133
133.5
134
134.5
135

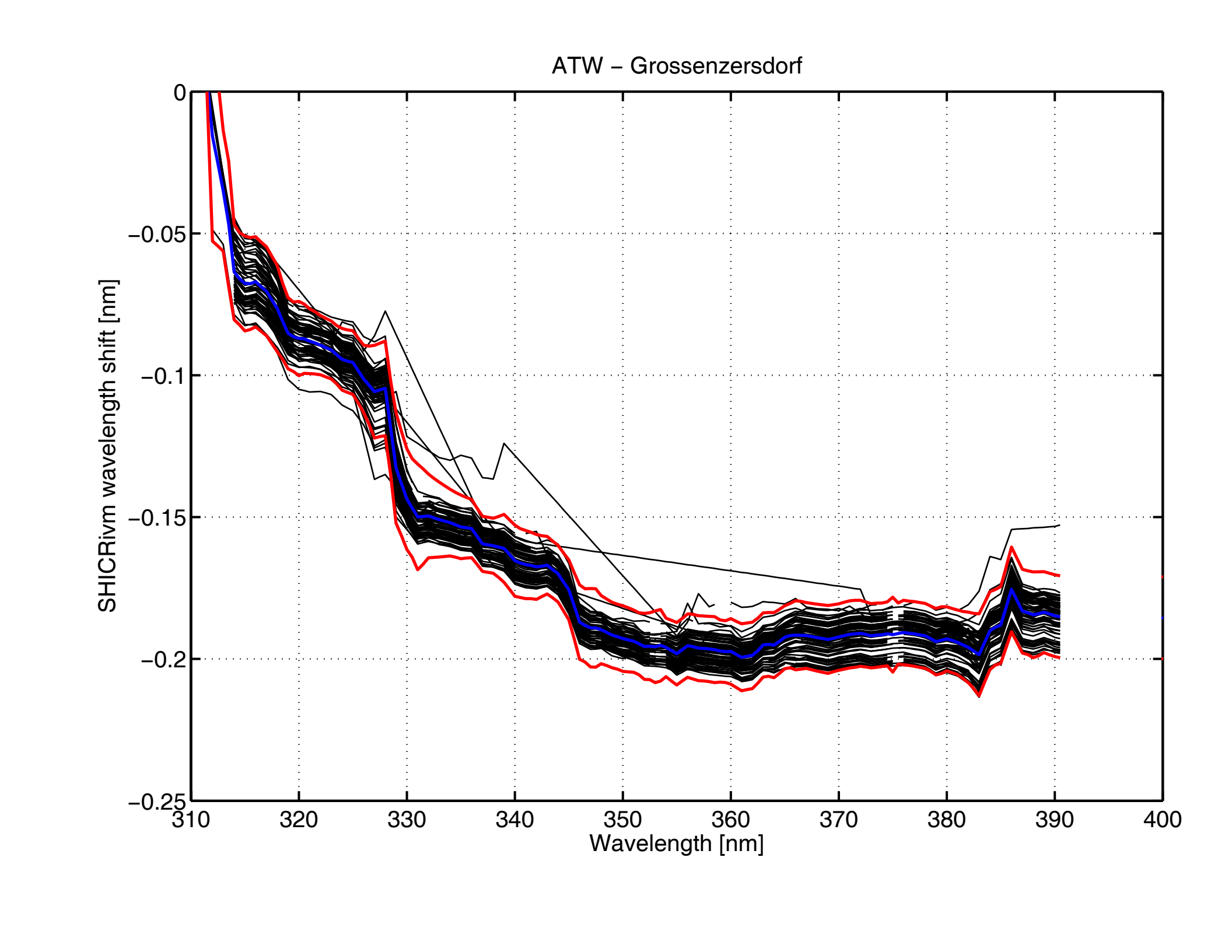

Global irradiance ratios ATW/JRC at Grossenzersdorf:11−May−2004(132) to 13−May−2004(134)
RATIO ATW/JRC
TIME [UT] ON DAYS: [132 133 134]
305 nm
310 nm
320 nm
330 nm
350 nm
370 nm
394 nm
132
133
134
16−Jun−2004 19:03:39


Global irradiance ratios ATW/JRC at Grossenzersdorf:11−May−2004(132)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
380
390
400
wl [nm]
8
6
4
2
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
80°
30°
83°
305 nm
310 nm
320 nm
330 nm
350 nm
370 nm
394 nm
2(101)
4(85)
6(65)
8(46)
10(32)
12(33)
14(49)
16(68)
18(87)
20(104)
TIME [UT](SZA)
16−Jun−2004 19:03:39


Global irradiance ratios ATW/JRC at Grossenzersdorf:12−May−2004(133)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
380
390
400
wl [nm]
6
5
4
3
2
1
0
5
10
15
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
75°
30°
44°
305 nm
310 nm
320 nm
330 nm
350 nm
370 nm
394 nm
2(101)
4(84)
6(65)
8(46)
10(32)
12(33)
14(49)
16(68)
18(87)
20(103)
TIME [UT](SZA)
16−Jun−2004 19:03:39


Global irradiance ratios ATW/JRC at Grossenzersdorf:13−May−2004(134)
1.2
1.1
1
0.9
0.8
290
300
310
320
330
340
350
360
370
380
390
400
wl [nm]
2
1.5
1
0.5
0
5
10
15
20
Daily variation, Wavelength bands are ± 2.5 nm
80°
37°
305 nm
310 nm
320 nm
330 nm
350 nm
370 nm
394 nm
2(101)
4(84)
6(65)
8(45)
10(31)
12(33)
14(48)
16(68)
18(87)
20(103)
TIME [UT](SZA)
16−Jun−2004 19:03:39


Mean ratio ATW/JRC at Grossenzersdorf:11−May−2004(132) to 13−May−2004(134)
Mean ratio
5/95th percentile
Range of values
RATIO ATW/JRC
Wavelength [nm]
NBSpectra=45
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
310
320
330
340
350
360
370
380
390
400


ATW – Grossenzersdorf
SHICRivm wavelength shift [nm]
Wavelength [nm]
0
−0.05
−0.1
−0.15
−0.2
−0.25
310
320
330
340
350
360
370
380
390
400


CCR ISPRA