Protocol of the intercomparison at RIVM, Bilthoven, the Netherlands on June 17 to 19, 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 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 morning of June 17, 2004. 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 monochromator. The intercomparison between B5503 and the NLR spectroradiometer lasted three days, from the afternoon of June 17 to the afternoon of June 19.

B5503 was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T38986, T57824, and T61251) were used to obtain an absolute spectral calibration traceable to the primary reference held at ECUV, which is traceable to PTB. The daily mean responsivity of the instrument based on these calibrations varied by less than 1% during the intercomparison period. The internal temperature of B5503 was 24.5±0.1 °C. The diffuser head was heated to a temperature of 25.5±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 450 nm, every 0.5 nm, and 4 seconds between each wavelength increment.

<u>June 17 (169):</u>

B5503 was installed on the measurement site at 8:00 UT. Synchronised measurements are available from 10:00 UT when the internal temperature of B5503 reached its nominal temperature. Weather conditions were a mix of sun and clouds with some occasional rain-showers. Missed scans due to rain are at 12:00, 12:30, and 13:00 UT.

B5503 calibrated at 12:50 to 13:05 UT and at 16:15 UT while raining.

June 18 (170):

Synchronised measurements are available from 5:00 UT to 18:00 UT. Weather conditions were a mix of sun and clouds with occasional rain-showers. Missed scans due to rain were at 12:00, 12:30, and 13:00 UT.

B5503 calibrated at 9:17, and 16:16 UT. The 9:00 and 16:00 UT scans were aborted at 400 nm so no scans were lost.

June 19 (171):

Synchronised scans are available from 5:00 to 16:30 UT. The weather conditions were a mix of sun and clouds with occasional rain-showers. The 8:00 UT scan was perturbed by slight rain with the sun still shining. Missed scans due to rain at 9:00, 10:00, and 10:30 UT. End of the campaign after the 16:30 UT scan.

B5503 calibrated at 16:50 till 17:30 UT.

Results:

66 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 5:30 and 18:00 UT have been analysed (SZA smaller than 75°).

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 2% lower to 6% higher than those measured by B5503 for wavelengths between 300 and 450 nm.
- The spectral ratios between NLR and B5503 show no spectral variation over the wavelength range 310 to 450 nm. At 305 nm the measurements of NLR increase by about 4% above 60° SZA.
- The average difference between NLR and B5503 is less than 1% over the wavelength range 310 to 450 nm. Between 310 and 300 nm, NLR measures up to 3% more than B5503.

Conclusion:

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

The difference between the instruments during this site visit relative to the previous one in 2003 is less than 1% for most of the wavelength range. Between 380 and 420 nm the difference is up to 2%.

Comments from the local operators:

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" Comparing the intercomparison 2004 with 2003 it was concluded that the difference between the instruments during these site visits is less than 1% for most of the wavelength range."

The following information is to be noted :

- In 2003 the result was biased by the temperature dependence of the NLR measuring head. During the first three days (no clouds and ambient temperature above 30 °C) the measuring head heated up to about 45 °C. The last two days the weather changed into overcast conditions, rain and lower ambient temperatures. The temperature of the measuring head during these last two days was stable at 25 °C. The first three days the NLR/JRC ratio is roughly between 0.97 – 1.01 with a diurnal pattern which follows the temperature of the measuring head. The last two days the NLR/JRC ratio is roughly between 1.00 and 1.03. The temperature dependence of the measuring head sensitivity was determined experimentally to be about -0.08% per degree Celsius. So when heated up to 45 °C, the NLR irradiance is about 2% lower, explaining at least partly the difference found during the campaign.
- In 2004 weather conditions did not lead to heating up of the measuring head.
- In 2003 the absolute irradiance calibration of the NLR spectroradiometer was based on the DXW S794 lamp from Optronics with a NIST traceability. This " S794 irradiance scale " is about +2% compared to the ECUV scale.
- In 2004 the absolute irradiance calibration of the NLR spectroradiometer was based on the FEL F365 lamp from Gigahertz calibrated by PTB. The irradiance scale of the F365 is about -2% compared with the S794 and therefore equal to the ECUV scale.

Summarized :
Based on the difference between the JRC and NLR irradiance scale in 2003 the mean ratio NLR/JRC is expected to be about 1.02. However, due to the temperature dependence of the measuring head(-2%), it is lowered to about 1.00. Since the NLR irradiance scale changed(-2%) from 2003 to 2004 and there were no temperature effects in 2004 the mean ratio NLR/JRC in the 2004 campaign was expected and found to be 1.00.

It is now under investigation :
how to correct for the temperature dependence of the measuring head
how to correct for the change of the irradiance scale in the long term datasets

" Between 310 and 300 nm NLR measures up to 3% more than B5503."
This is mainly explained by the dark count correction method of the NLR instrument. In the NLR instrument is implemented that a constant dark count rate value is subtracted from the measured count rate during sun light measurements. In fact this dark count rate does vary a bit. In this case the subtracted dark count rate is lower than the real value during the campaign. In the new NLB instrument the dark count rate is measured before each spectrum and used for subtraction.

During this measurement campaign also the other RIVM spectroradiometer (NLB) was measuring following the same measurement protocol. The instrument is located at about 150 m from the JRC-NLR location on top of a building and has an almost free horizon (see figure 1).

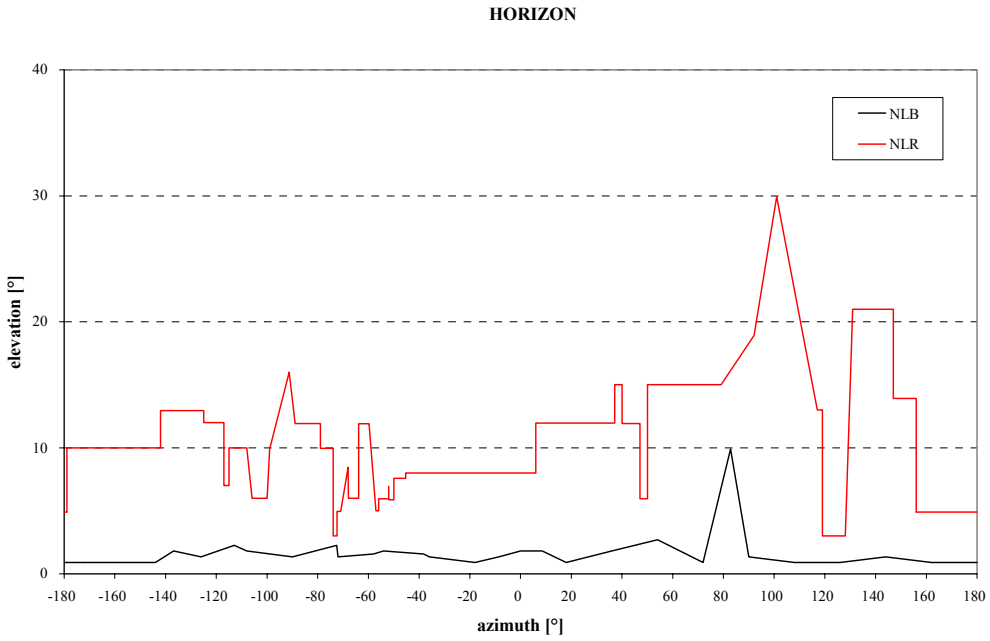


Figure 1 Horizon of NLR and NLB instrument.

The NLB instrument is operational since 2002 and is the instrument used for monitoring at the RIVM location. The NLR instrument will move to another location. In the years 2002, 2003, 2004 for most of the time both instruments were running simultaneously, providing a long term intercomparison of the instruments. We would like to add in this comment the NLB/NLR ratio during this campaign, see Figure 2.

Due to the variable cloudiness during the campaign and the distance between both instruments the NLB/LR-ratios show a lot of scatter (at least ±5%, between the 5th and 95th percentile). On average the NLB/NLR ratio is about 1.02. NLB being a little higher might be due to the free horizon as NLR has a more obstructed one.

To illustrate that a large part of the scatter is caused by the variable cloudiness Figure 3 shows a similar plot for a clear sky day (8 August 2004). The main ratio NLB/NLR is still about 1.02 and the scatter is only ±1.5% above 310 nm.

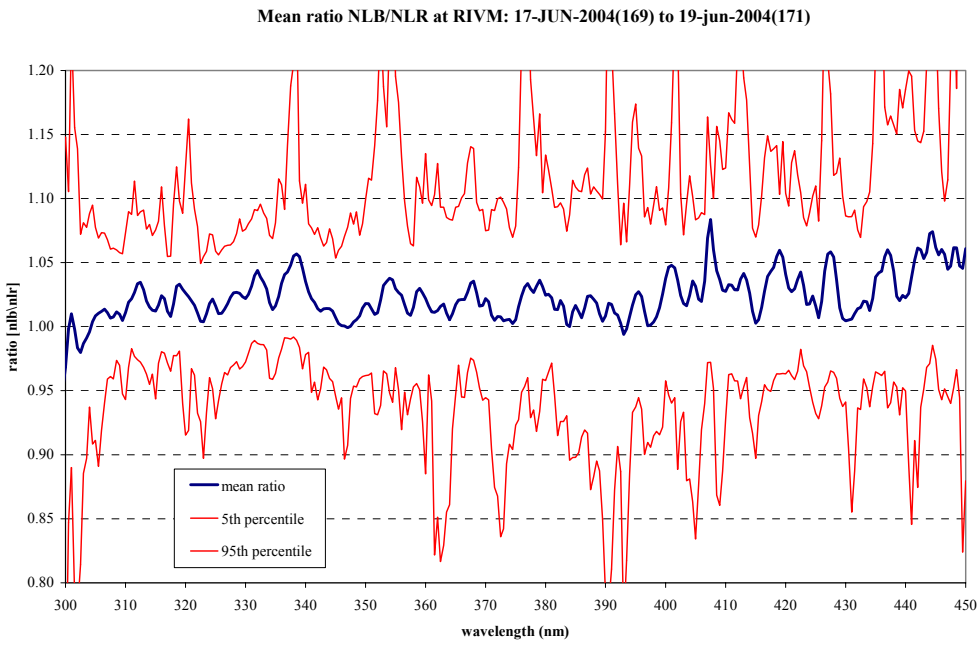


Figure 2 NLB/NLR ratio during 2004 campaign

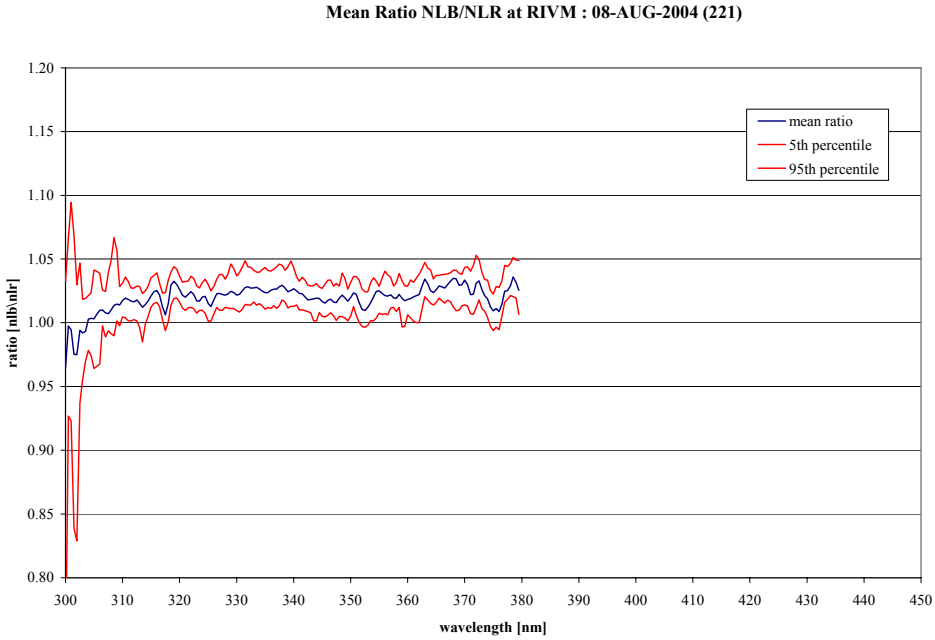
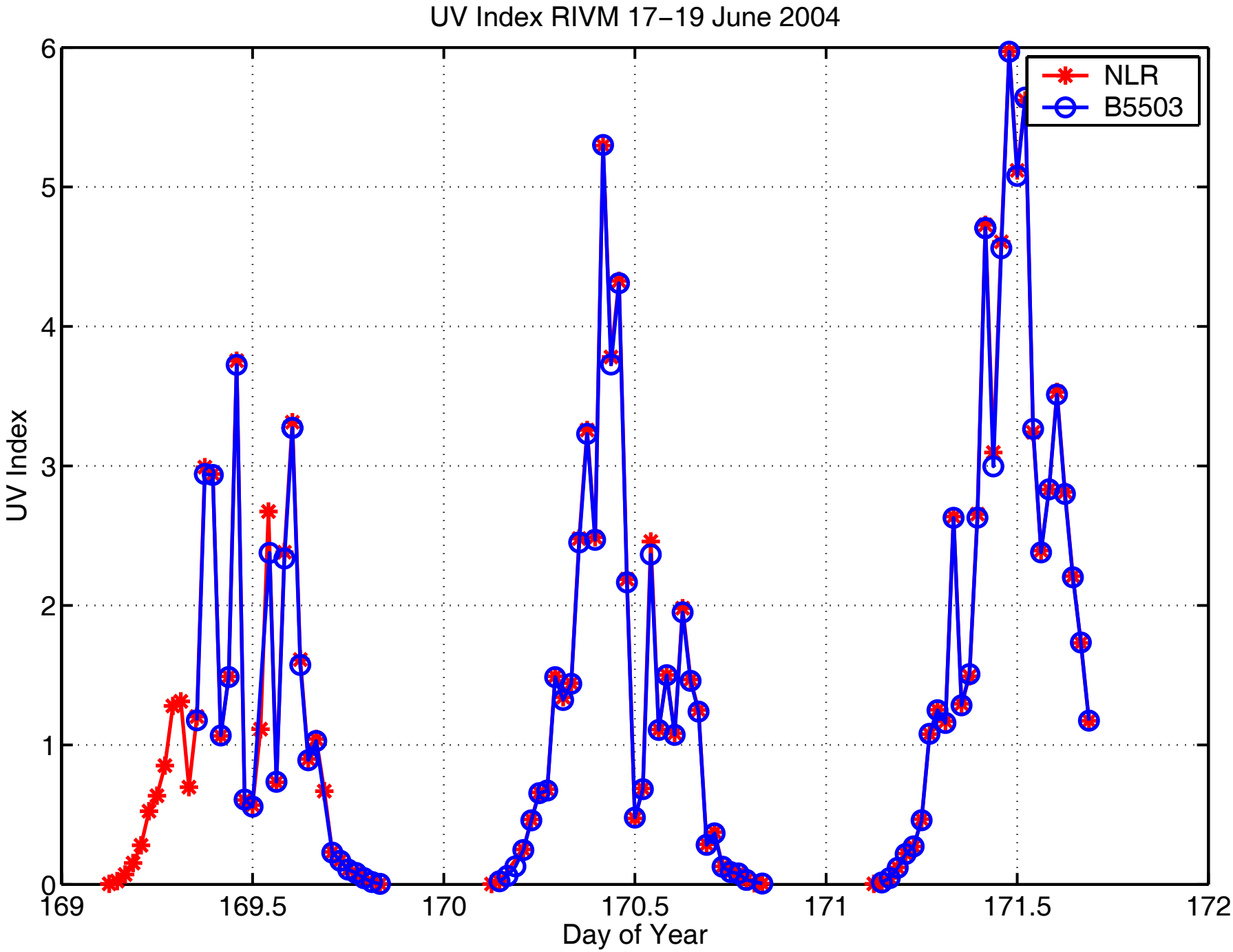
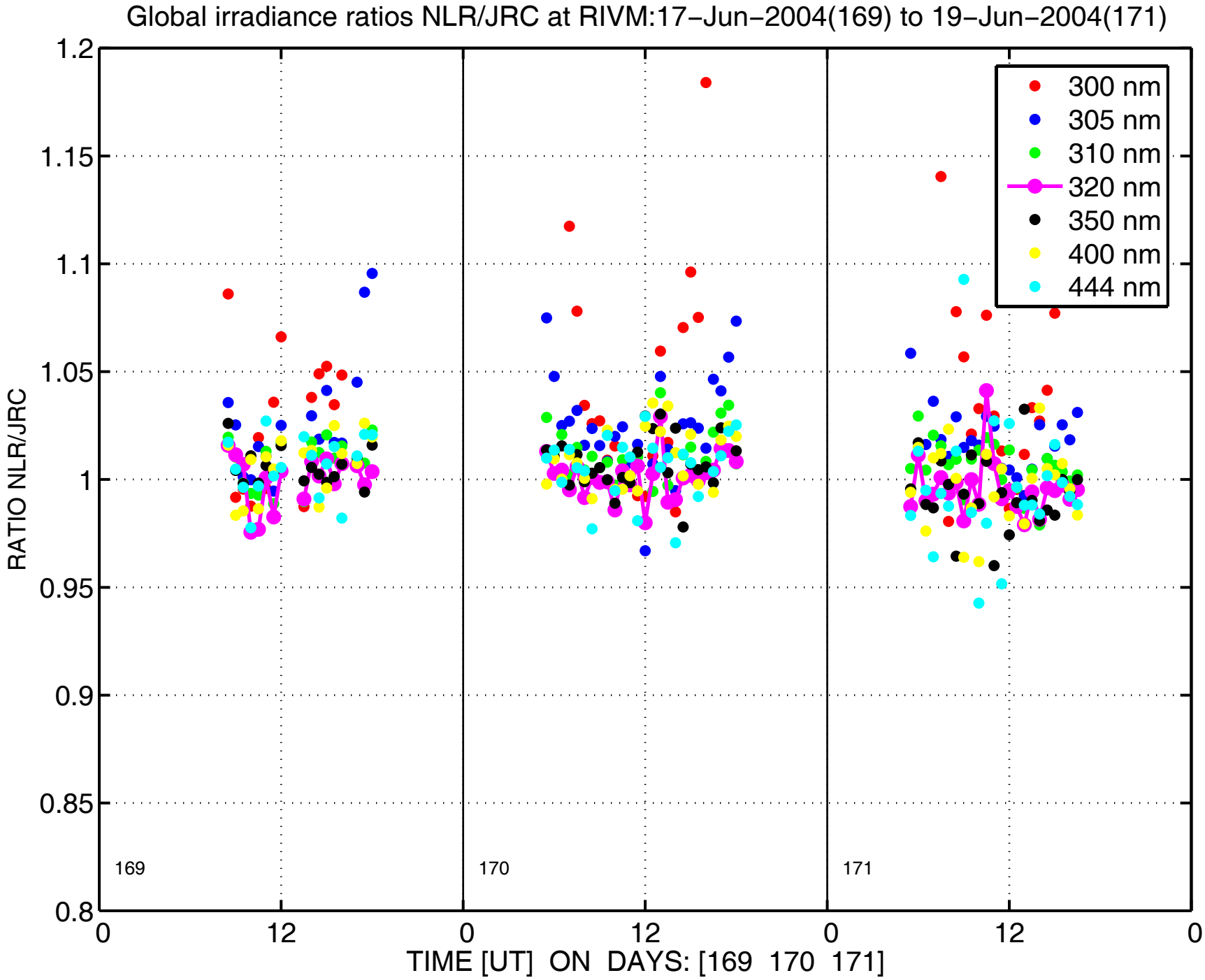
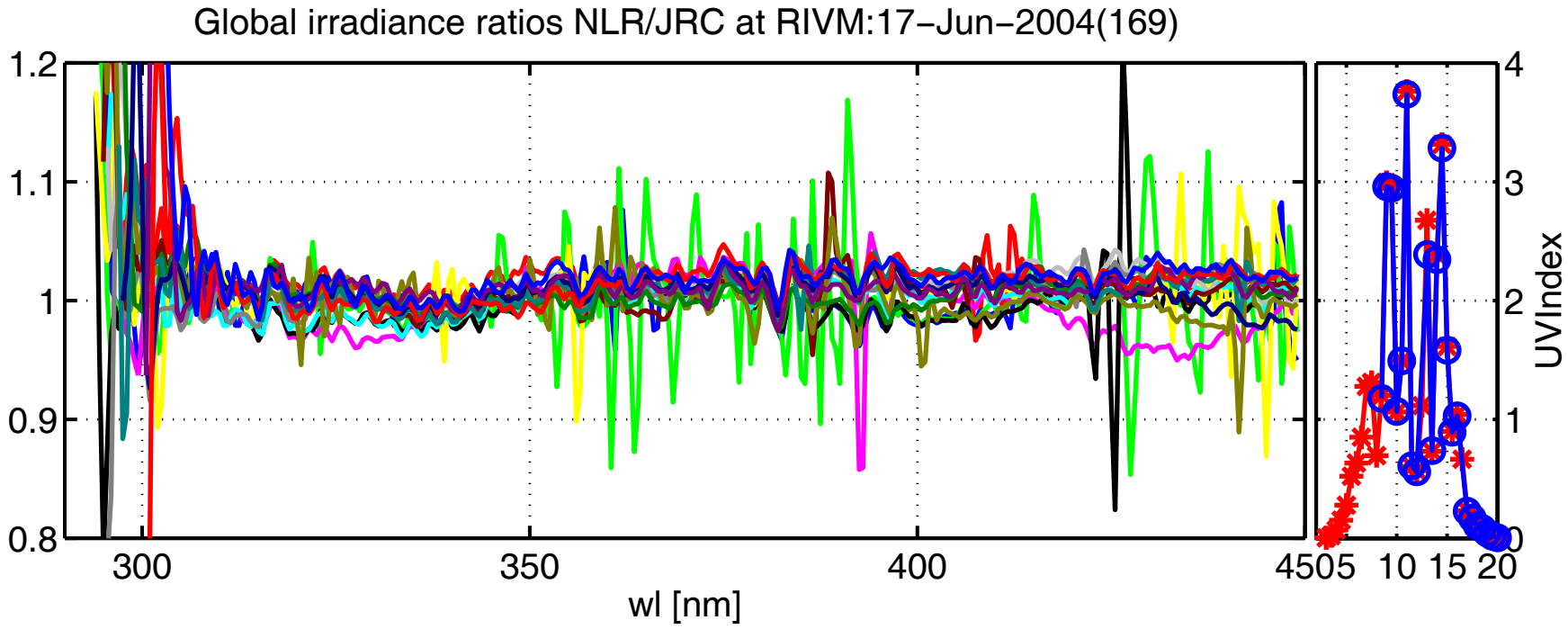
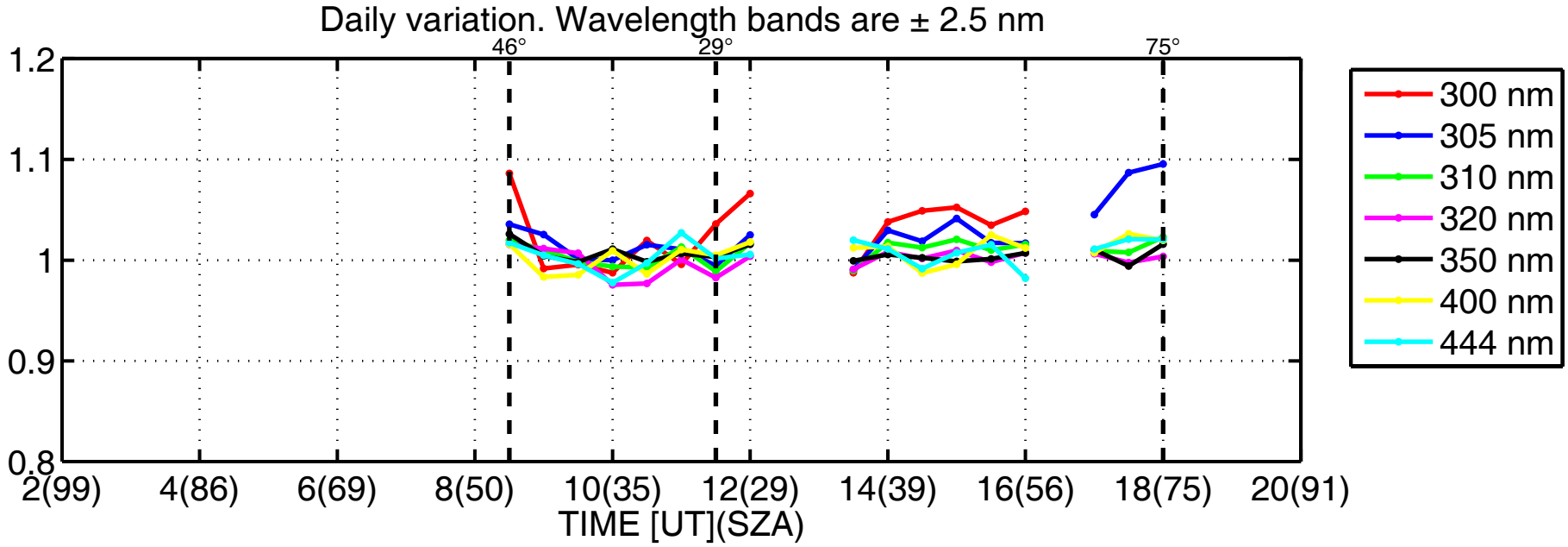


Figure 3 NLB/NLR ratio 08 August 2004


UV Index RIVM 17–19 June 2004
NLR
B5503
UV Index
Day of Year
0
1
2
3
4
5
6
169
169.5
170
170.5
171
171.5
172


Global irradiance ratios NLR/JRC at RIVM:17–Jun–2004(169) to 19–Jun–2004(171)
RATIO NLR/JRC
TIME [UT] ON DAYS: [169 170 171]
300 nm
305 nm
310 nm
320 nm
350 nm
400 nm
444 nm
169
170
171
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
12
0
12
0
12
0
04–Nov–2004 08:42:45





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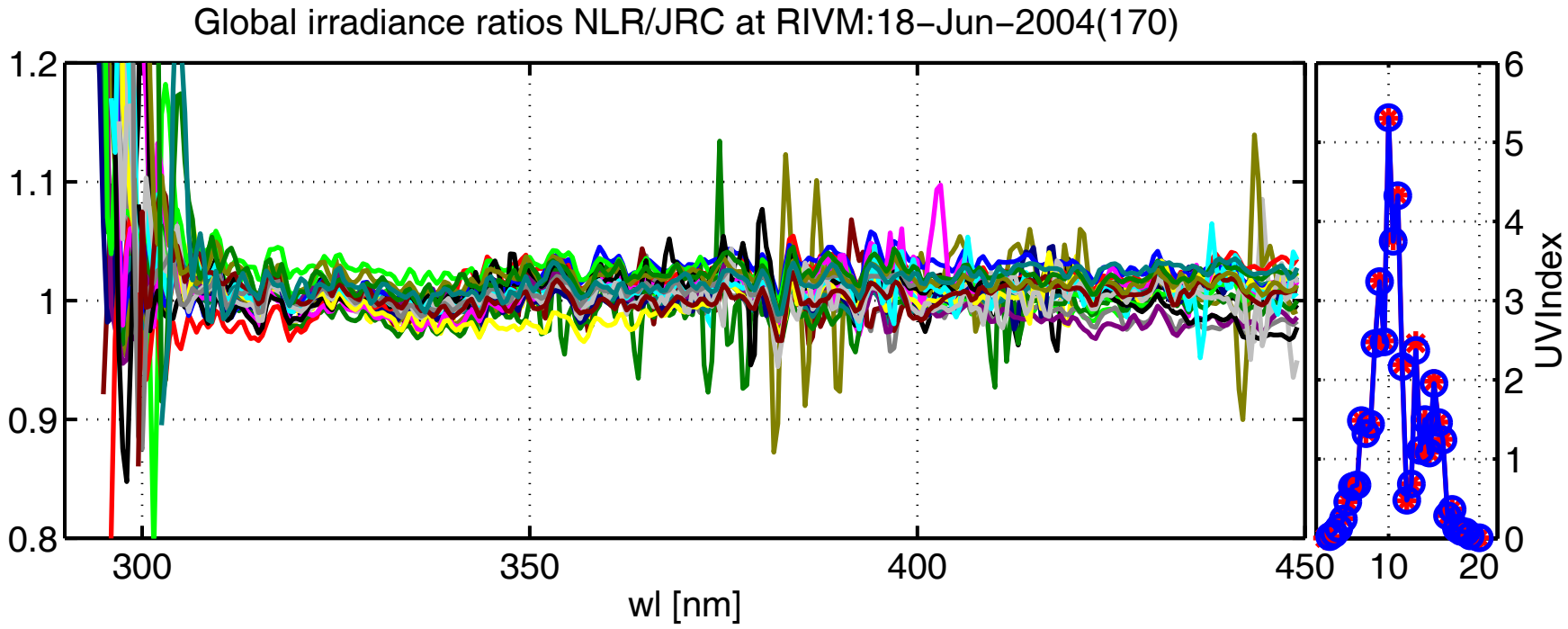

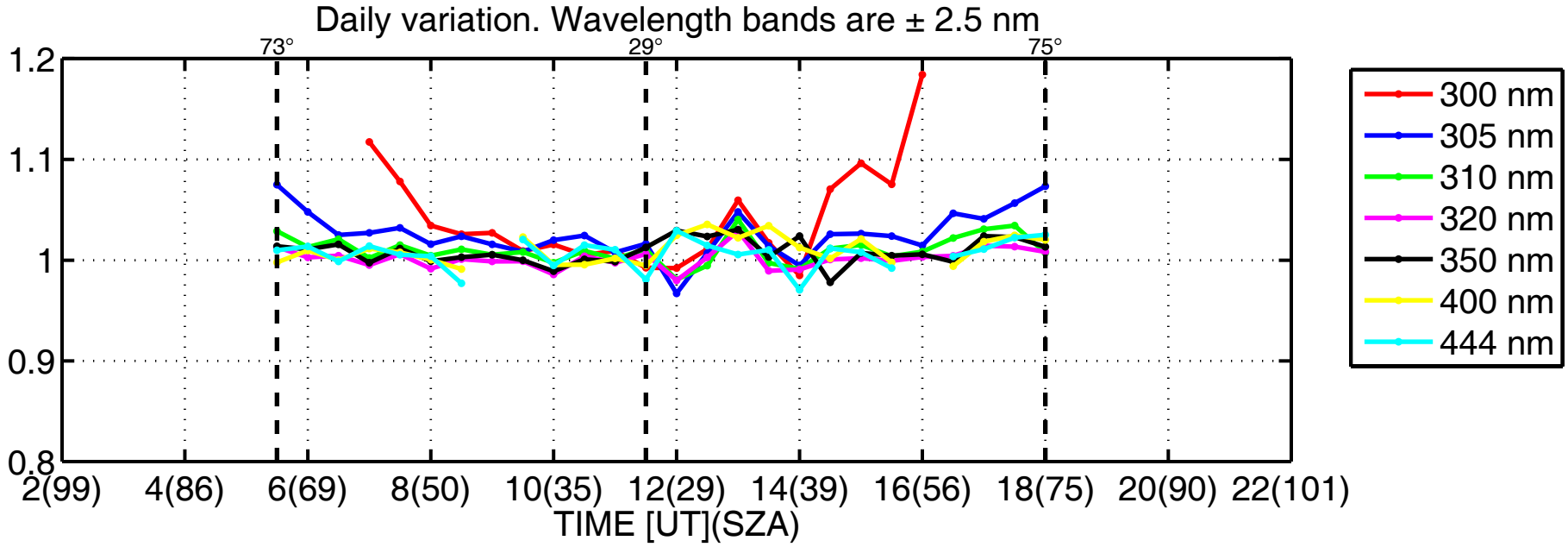

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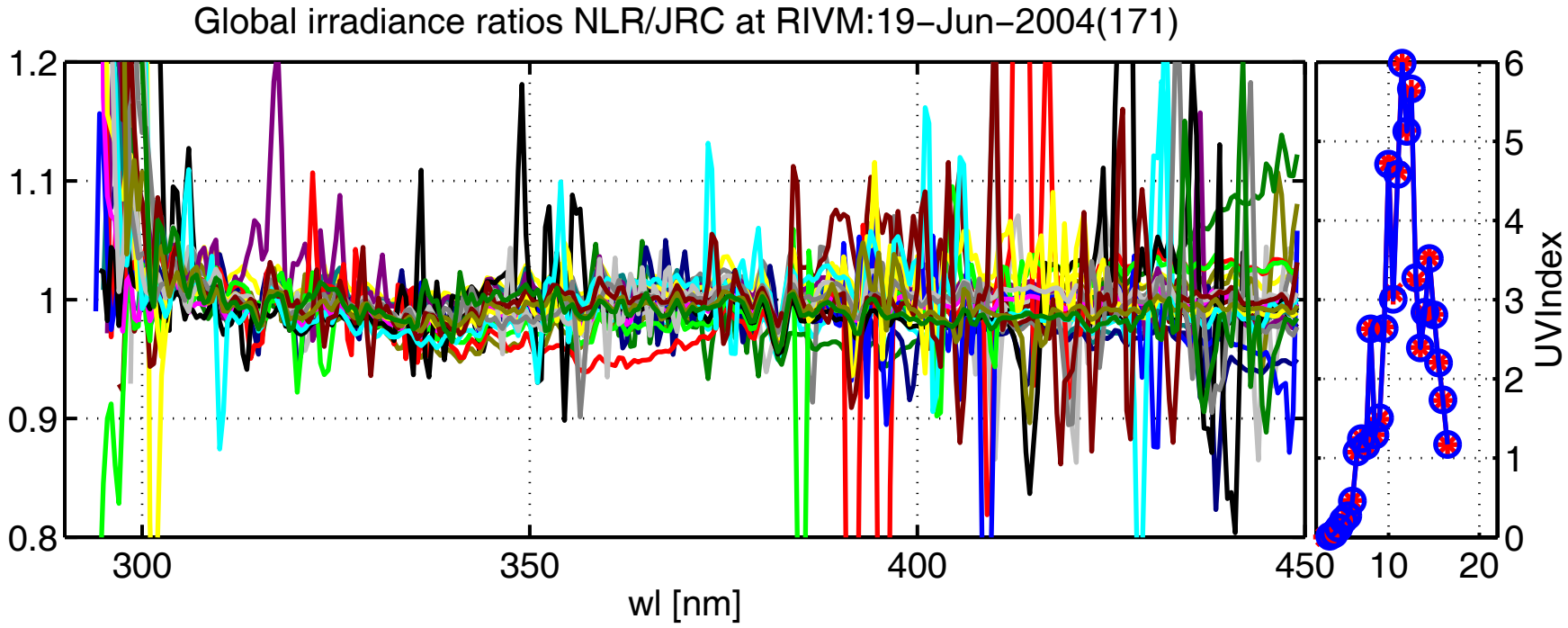

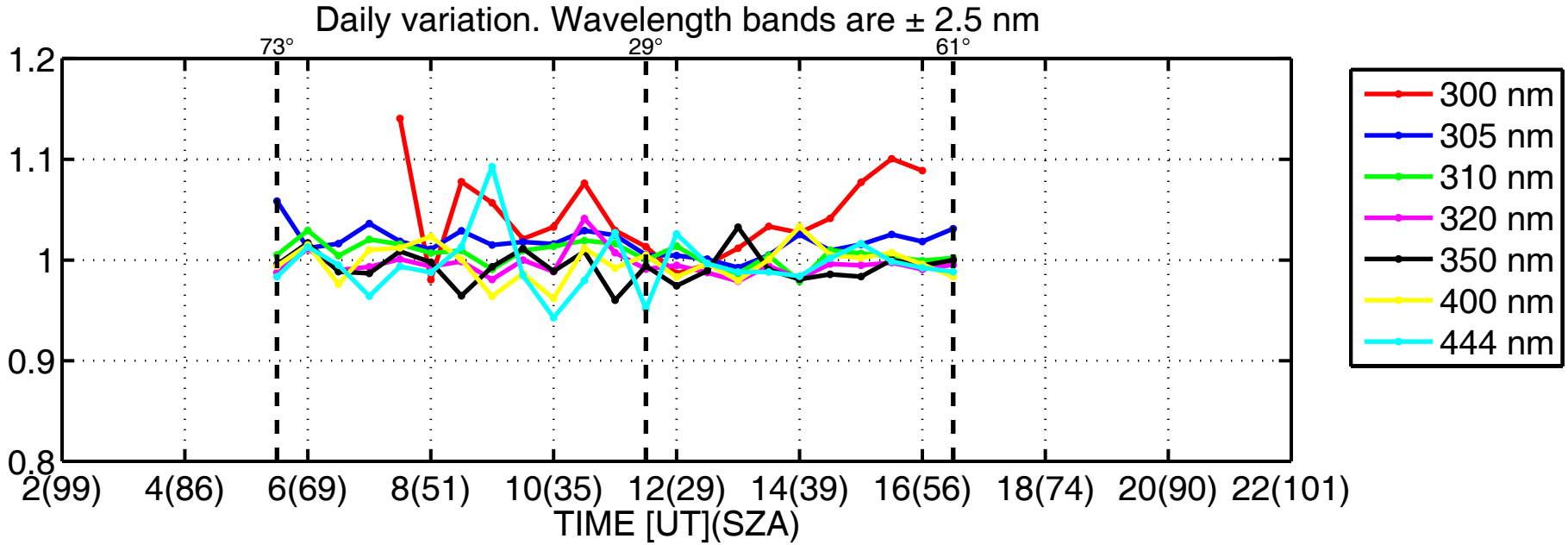

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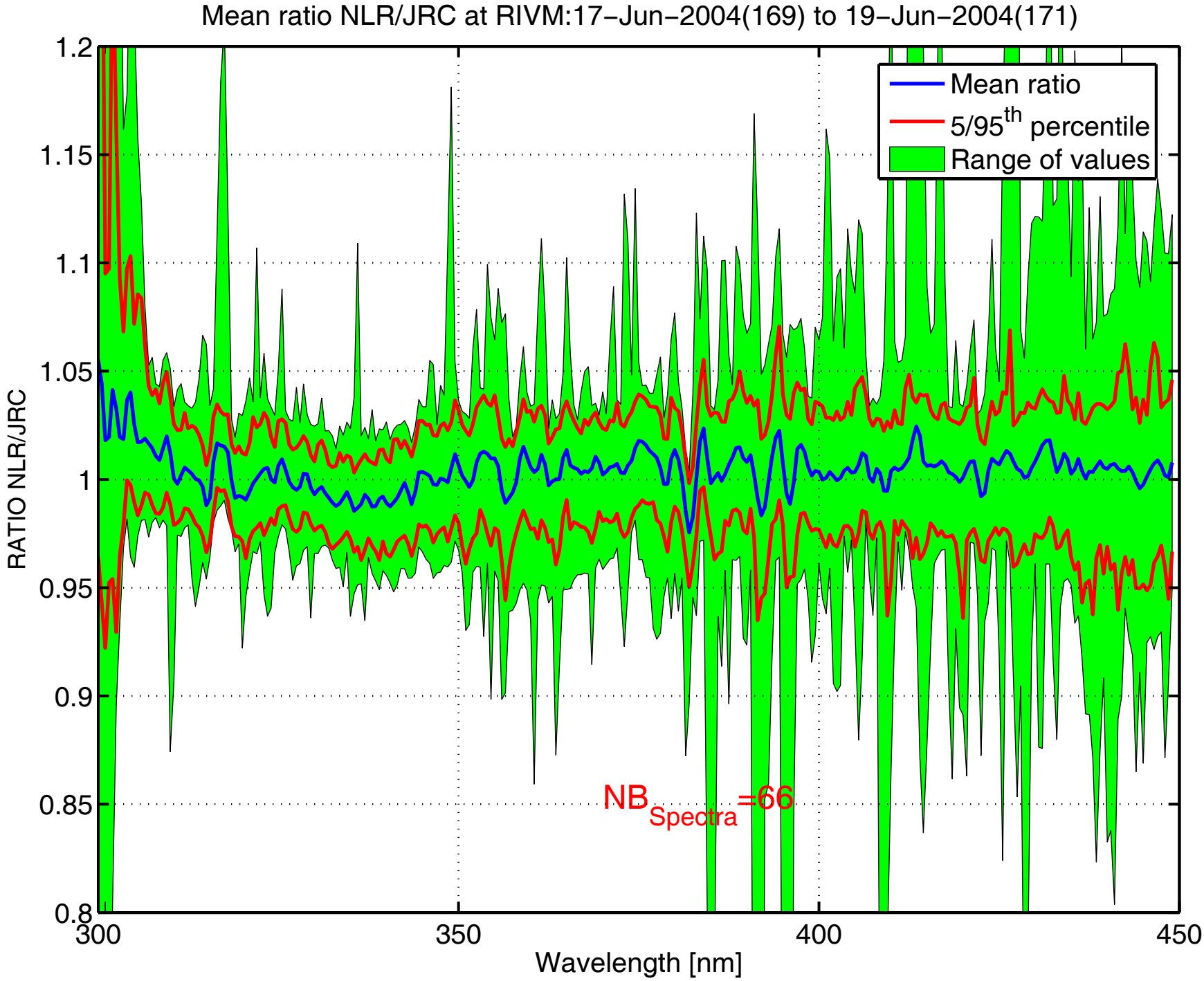
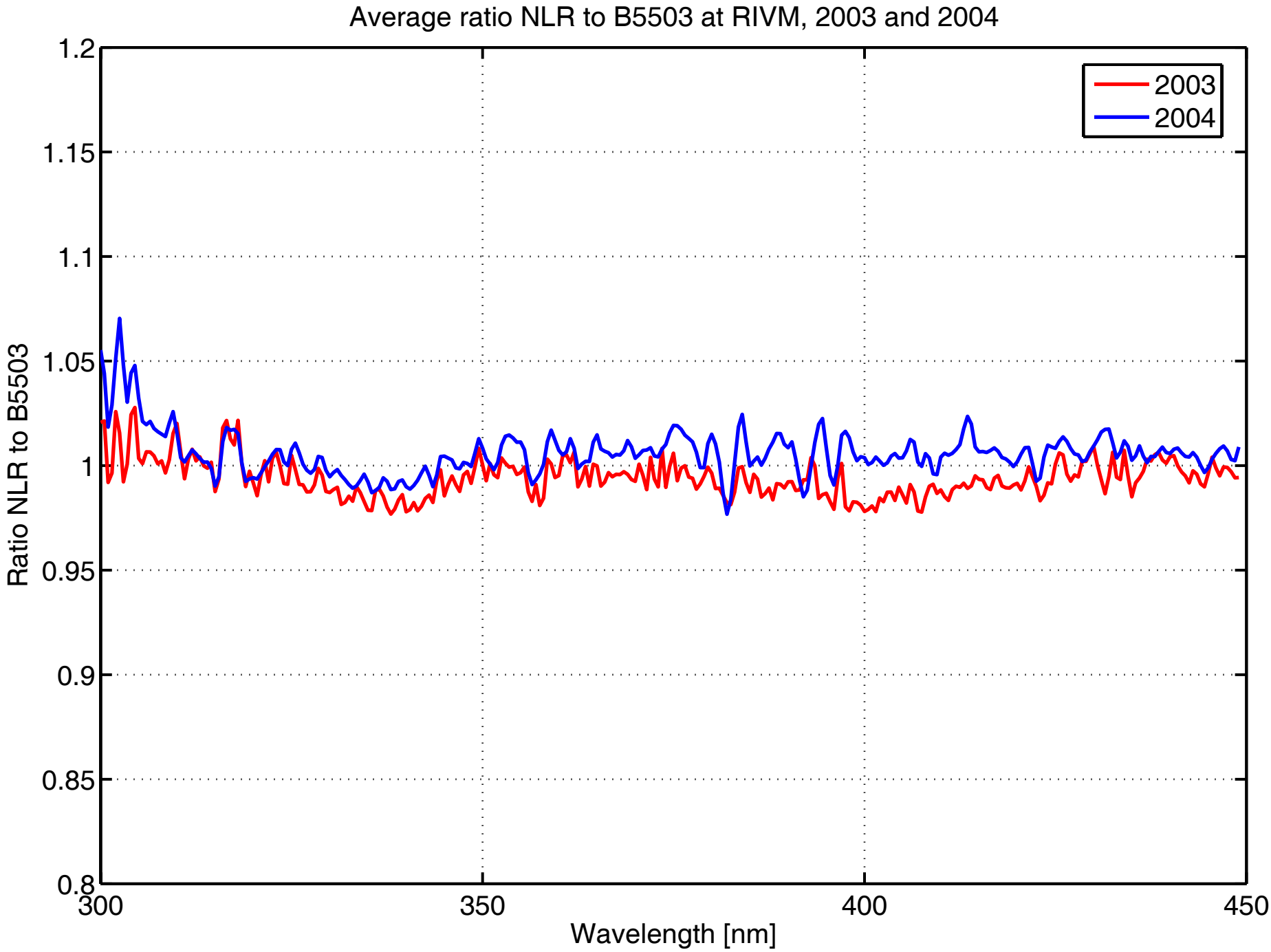
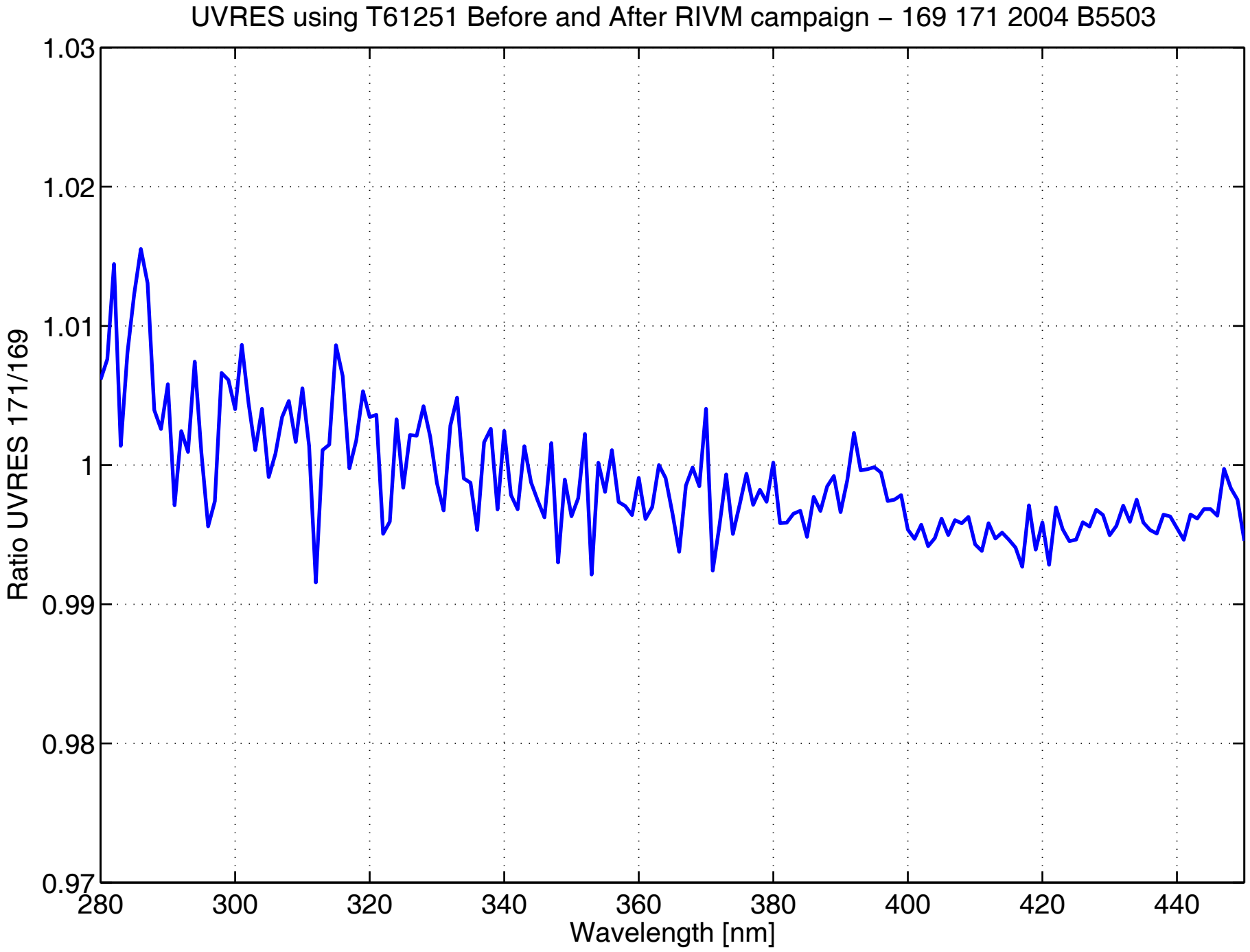

Mean ratio NLR/JRC at RIVM:17−Jun−2004(169) to 19−Jun−2004(171)
Mean ratio
5/95th percentile
Range of values
NBSpectra=66
RATIO NLR/JRC
Wavelength [nm]
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
350
400
450


Average ratio NLR to B5503 at RIVM, 2003 and 2004
2003
2004
Ratio NLR to B5503
Wavelength [nm]
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
300
350
400
450


UVRES using T61251 Before and After RIVM campaign – 169 171 2004 B5503
Ratio UVRES 171/169
Wavelength [nm]
1.03
1.02
1.01
1
0.99
0.98
0.97
280
300
320
340
360
380
400
420
440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