Protocol of the intercomparison at the Norwegian University of Science and Technology in Trondheim (NTNU), June 6 to 9, 2003 with the travelling standard spectroradiometer B5503 from ECUV within the project QASUME

Report prepared by Julian Gröbner and Stelios Kazadzis

Operators: Stelios Kazadzis , Josef Schreder

The purpose of the visit was the comparison of global solar irradiance measurements between the spectroradiometer operated by NTNU (NTN) and the travel standard B5503. The measurement site is located at Trondheim; Latitude 63.41 N, Longitude 10.41 E and altitude 50 m.a.s.l..
The horizon of the measurement site is free down to about 85° solar zenith angle (SZA) in all directions.

B5503 arrived at Trondheim in the morning of June 5, 2003. The spectroradiometer was installed on the roof at 1.5 m distance from the NTN instrument. The spectroradiometer in use at Trondheim is a Bentham DM-150 double monochromator. The intercomparison between B5503 and the spectroradiometer from NTNU lasted four days, from the morning of June 6 to noon of June 9.

B5503 was calibrated several times during the intercomparison period using a 100 W portable calibration system. Three 100 W lamps (T38986, T57825, T57824) 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 3% during the intercomparison period. These variations were taken into account on a daily basis. Observed diurnal variations of the responsivity were 4% on June 6 and less than 2% on the remaining days. These diurnal variations of the responsivity were not taken into account. The internal temperature of B5503 was 25.4±0.2 °C. The diffuser head was heated to a temperature of 26±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 450 nm, every 0.5 nm, and 3 seconds between each wavelength increment.

<u>June 6 (157):</u>

NTN started synchronised scans at 12:30 UT. Synchronised measurements are available until 18:30 UT. Weather conditions during the day were a mix of sun and clouds with fast moving clouds in front of the solar disk.

Lamp measurements from B5503 at 6:13, 6:43, 8:40, 10:49, and from 18:40 to 20:30 UT.

June 7 (158):

Synchronised measurements are available from 6:30 to 18:30 UT. There was rain before 6:30 and during the 11:30 scan. The rest of the day was characterised by a complete cloud cover from 6:30 to 11:00 UT and a mix of sun and clouds in the afternoon.

Lamp measurements from B5503 from 18:40 to 20:00 UT.

June 8 (159):

Synchronised scans are available from 4:30 to 18:30 UT. Light rain was present before 4:15 UT and during the 6:30 and 10:30 UT scans. The rest of the day was characterized by complete cloud cover in the morning followed by a mix of sun and clouds for the rest of the day.

Lamp measurements from B5503 at 11:18, 11:47, and from 18:30 to 20:00 UT.

June 9 (160):

Synchronised scans are available from 5:00 to 11:00 UT. Rain was present during the 8:30 and 10:00 UT scans. The remaining measurement period was completely overcast.

Lamp measurements from B5503 from 11:10 to 12:30 UT.

Results:

75 synchronised simultaneous spectra from B5503 and NTN are available from the measurement period. The wavelength shifts of the submitted solar spectra of the NTN spectroradiometer retrieved through the SHICRivm analysis were constant to within 30 pm during the measurement period. The spectral dependence of the wavelength shifts showed a decrease from +0.1 nm at 310 nm to –0.1 nm at 440 nm.

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

- Global solar irradiances measured by NTN were between 9% lower to 4% higher than those measured by B5503 for wavelengths between 300 and 450 nm.
- The spectral ratios between NTN and B5503 are spectrally flat between 300 and 400 nm. At longer wavelengths the spectral ratios show some variability of about 2-3% (slightly increasing relative to B5503).
- A diurnal variability with amplitude -3%, +10%, +11%, and +4% was observed on June 6 to 9 respectively. The variation seen in the lamp measurements of B5503 could account for part of the diurnal variability of June 6 (2%) but for 1% or less on the other days.

Conclusion:

NTN measures global solar irradiance on average 2% lower than B5503. The variability between the two spectroradiometers seems to be independent of wavelength and was around 10% on the two days with the

most measurements and about 5% on the two half days; on three of the four days this variability occurred mainly during the morning. This variability is not correlated with the solar zenith angle (SZA) but measurements of June 8 do show a diurnal pattern of the ratios NTN to B5503, which might imply a sensitivity to ambient temperature.

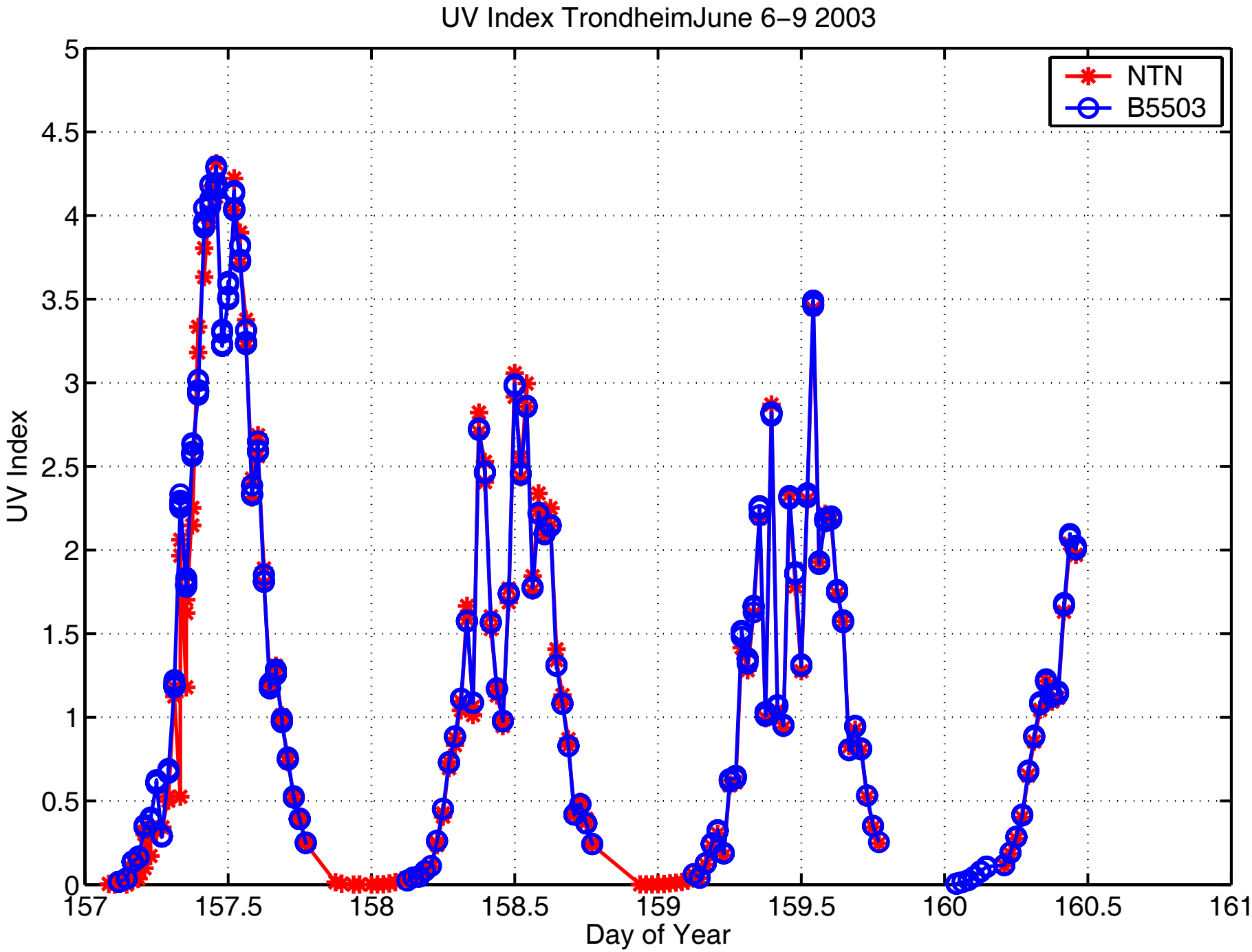
Comments from the local operator:

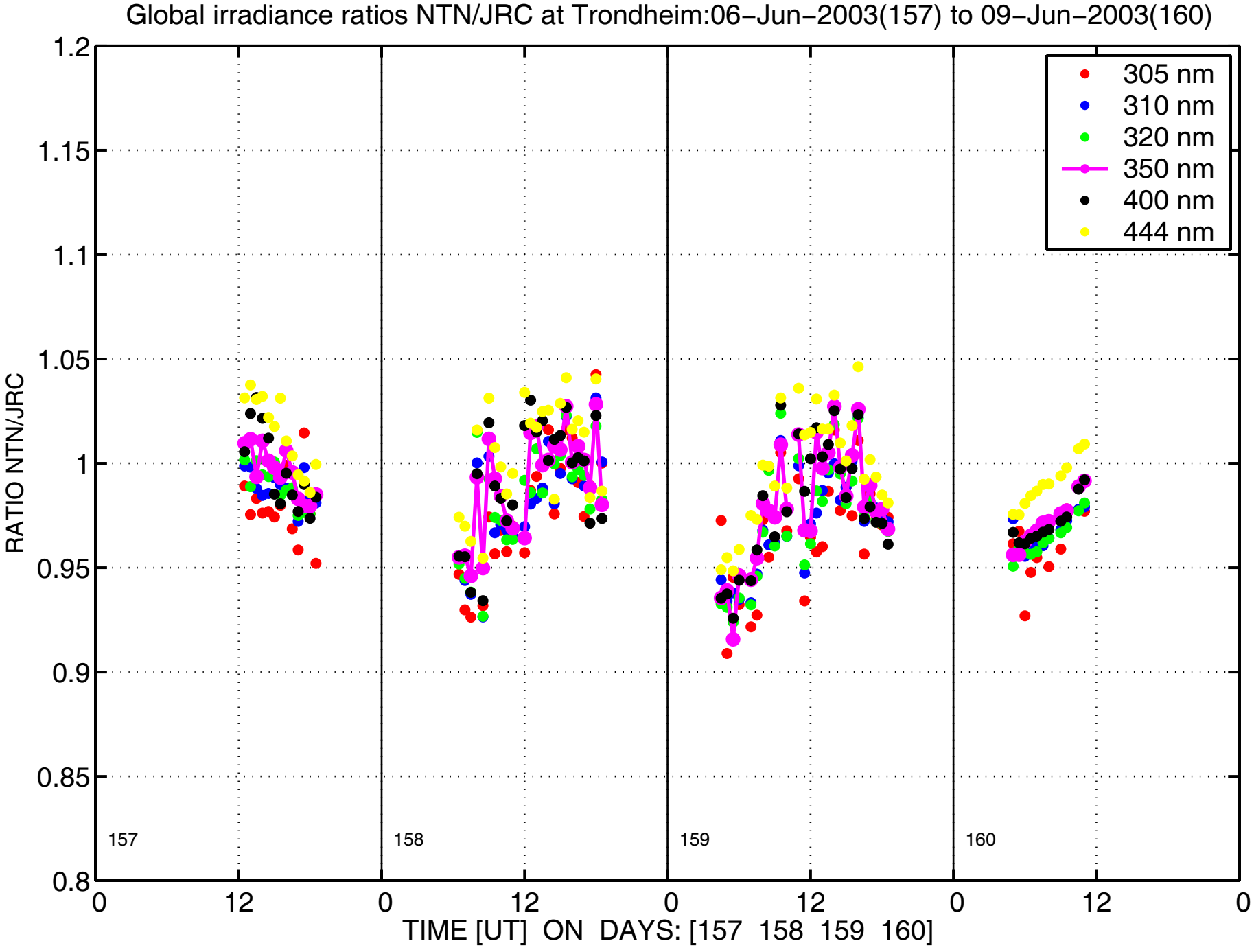
The 4% deviation between the two instruments from scan to scan is probably not a synchronization problem. The deviation keeps constant through the whole spectrum. We are working on the problem, but we think it is a hardware problem with our instrument, related to the filter wheel position which might not be optimal at each spectrum. We saw the same problems during the INSPECTRO campaign (September-October 2002). The "filter wheel positioning" problem might be related to humidity in the box. We have seen such a drop in the dark room as well when the instrument has been moved from the roof directly to the darkroom. After a while the problems disappear and we are not able to reproduce the 4% jump in the darkroom.

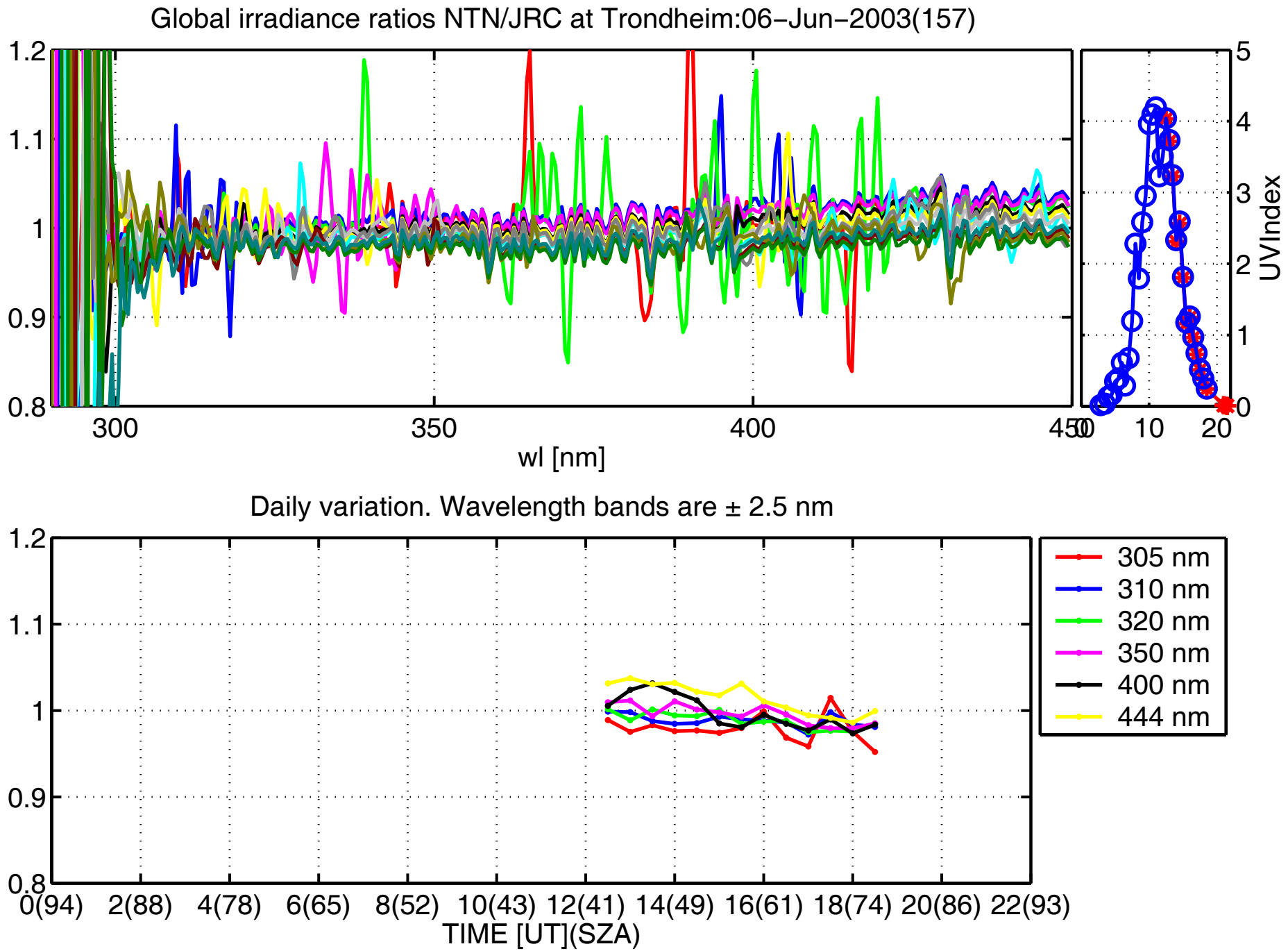
There was some heavy rain during the nights both between June 6 and 7, and June 8. At the moment I also think that the upward drift that we have seen before noon on both June 7 and 8 might be due to humidity in the instrument. We do not heat the global head. We are working on this as well to improve the system.

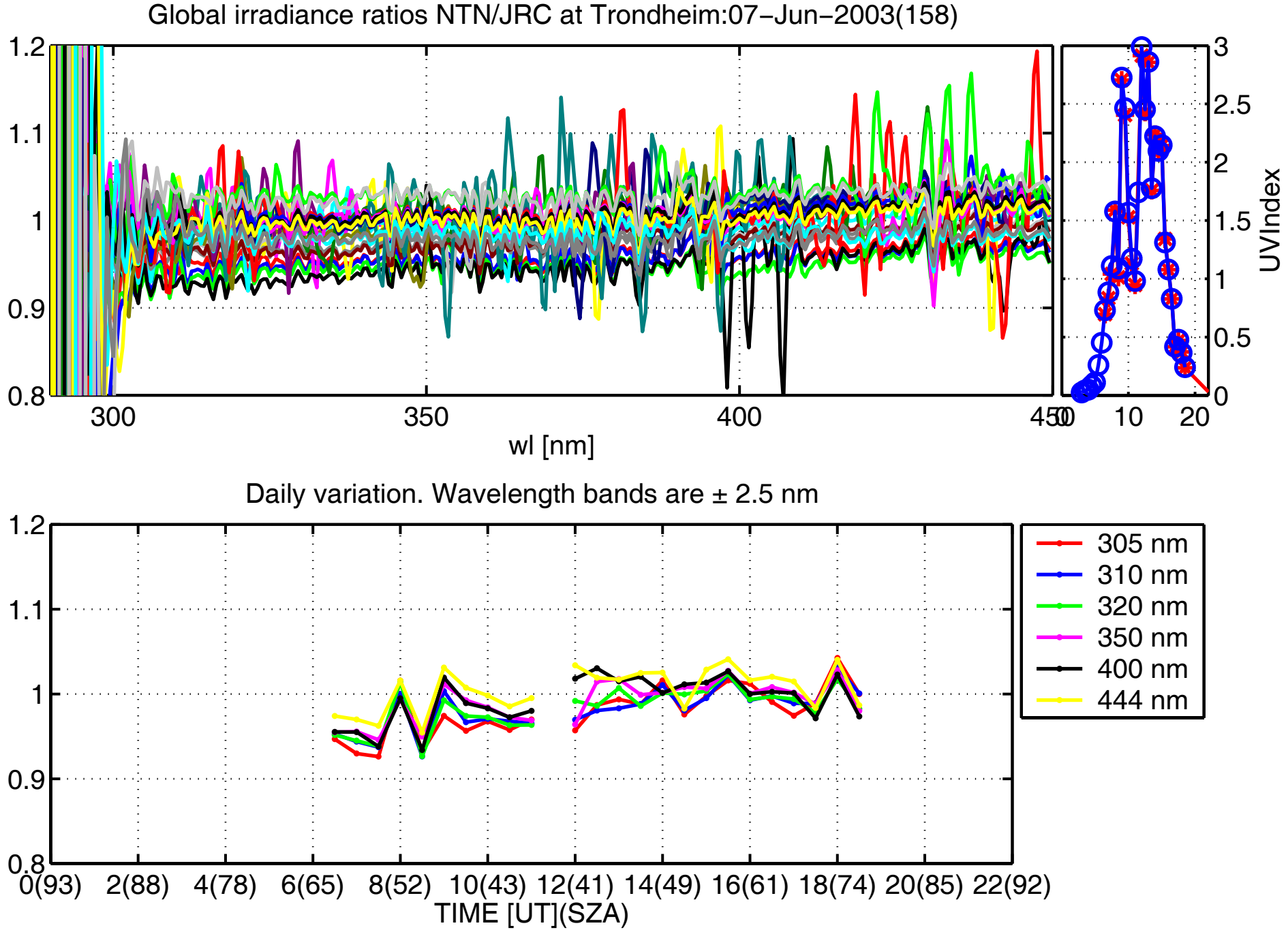
This intercomparison was a very good example on hardware problems (what ever they are) which are very difficult to find using only lamp calibrations, (travelling lamps or small lamps in the laboratory). The fact that this 4% might be due to humidity using the instrument outside at all weather conditions (although the environ box itself is always inside in a temperature stabilized room might) is something we hardly could have found with lamp measurements. Only an intercomparison could have shown this problem properly.

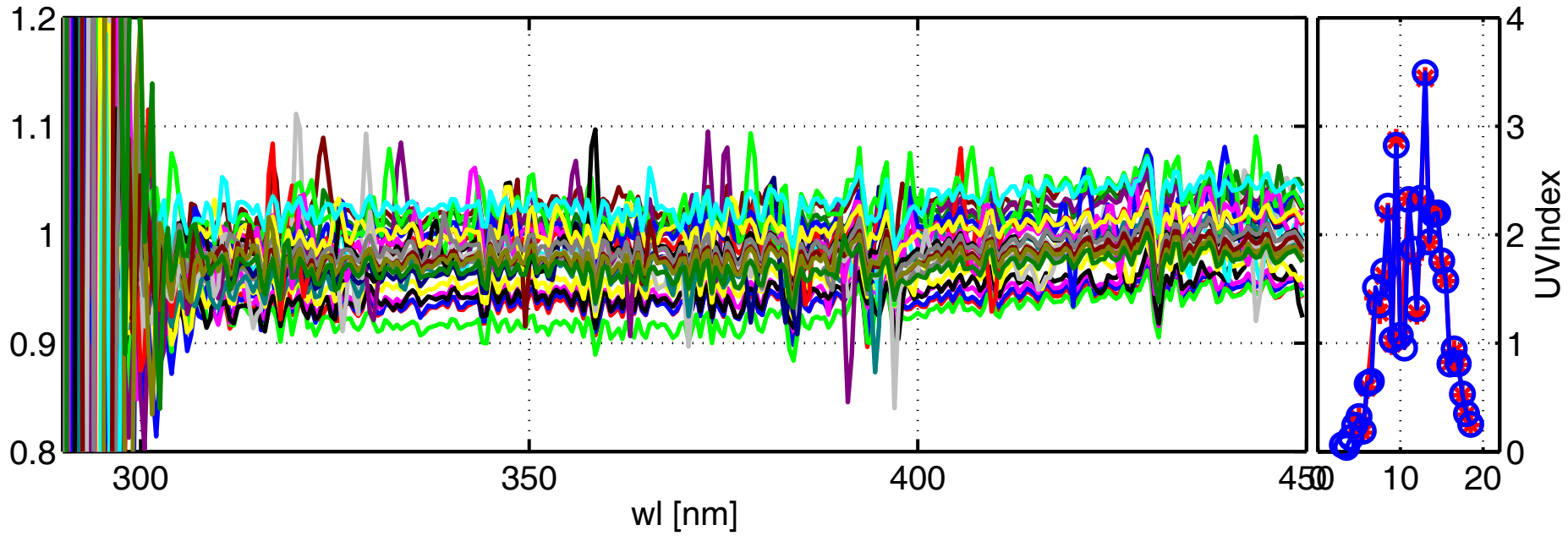
I am very happy that the travelling standard from ECUV could visit our station so we were able to see these problems.

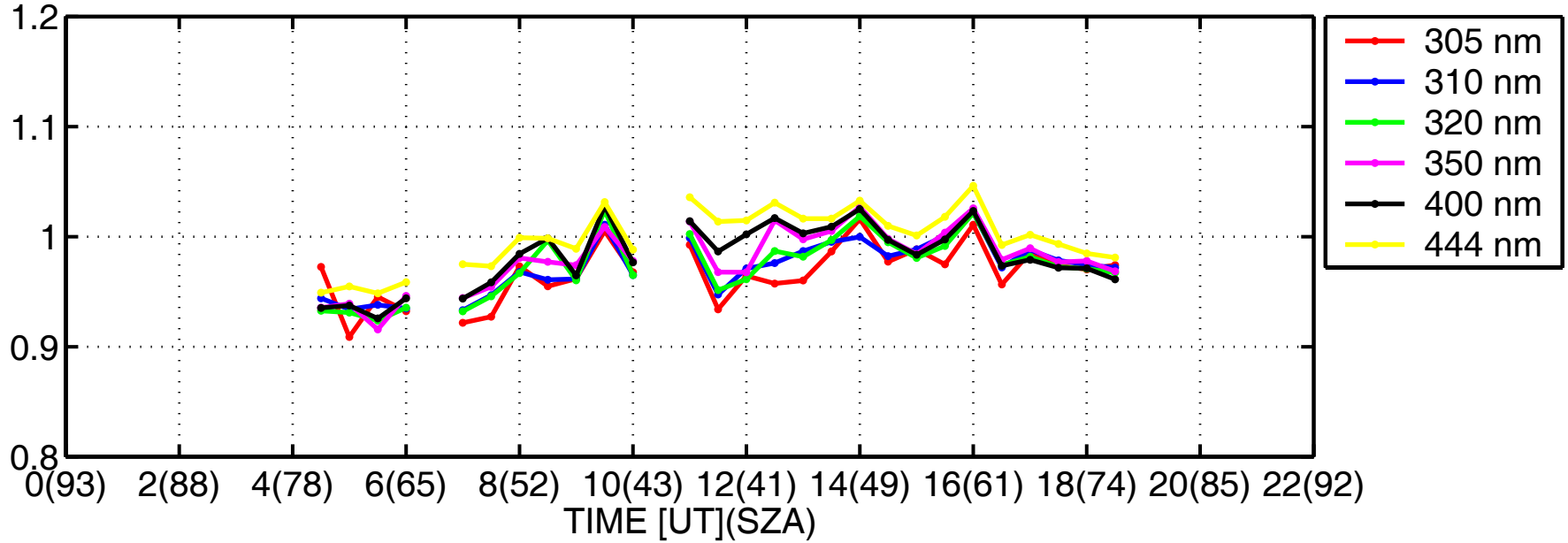

UV Index TrondheimJune 6–9 2003
NTN
B5503
UV Index
Day of Year
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
157
157.5
158
158.5
159
159.5
160
160.5
161


Global irradiance ratios NTN/JRC at Trondheim:06–Jun–2003(157) to 09–Jun–2003(160)
RATIO NTN/JRC
TIME [UT] ON DAYS: [157 158 159 160]
305 nm
310 nm
320 nm
350 nm
400 nm
444 nm
157
158
159
160
29–Jul–2003 11:35:34

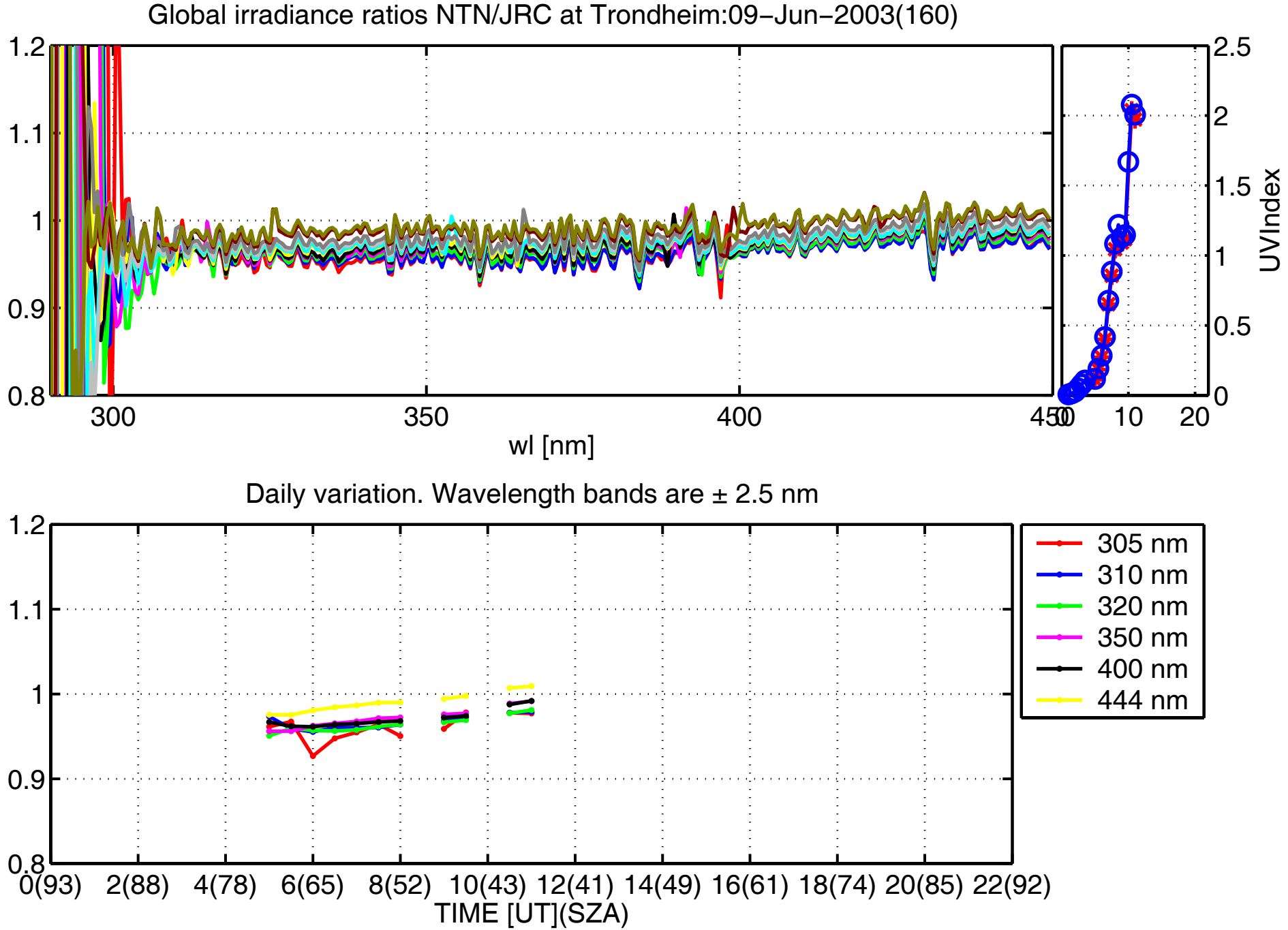

Global irradiance ratios NTN/JRC at Trondheim:06–Jun–2003(157)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
5
4
3
2
1
0
10
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
0(94)
2(88)
4(78)
6(65)
8(52)
10(43)
12(41)
14(49)
16(61)
18(74)
20(86)
22(93)
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
400 nm
444 nm
29–Jul–2003 11:35:34

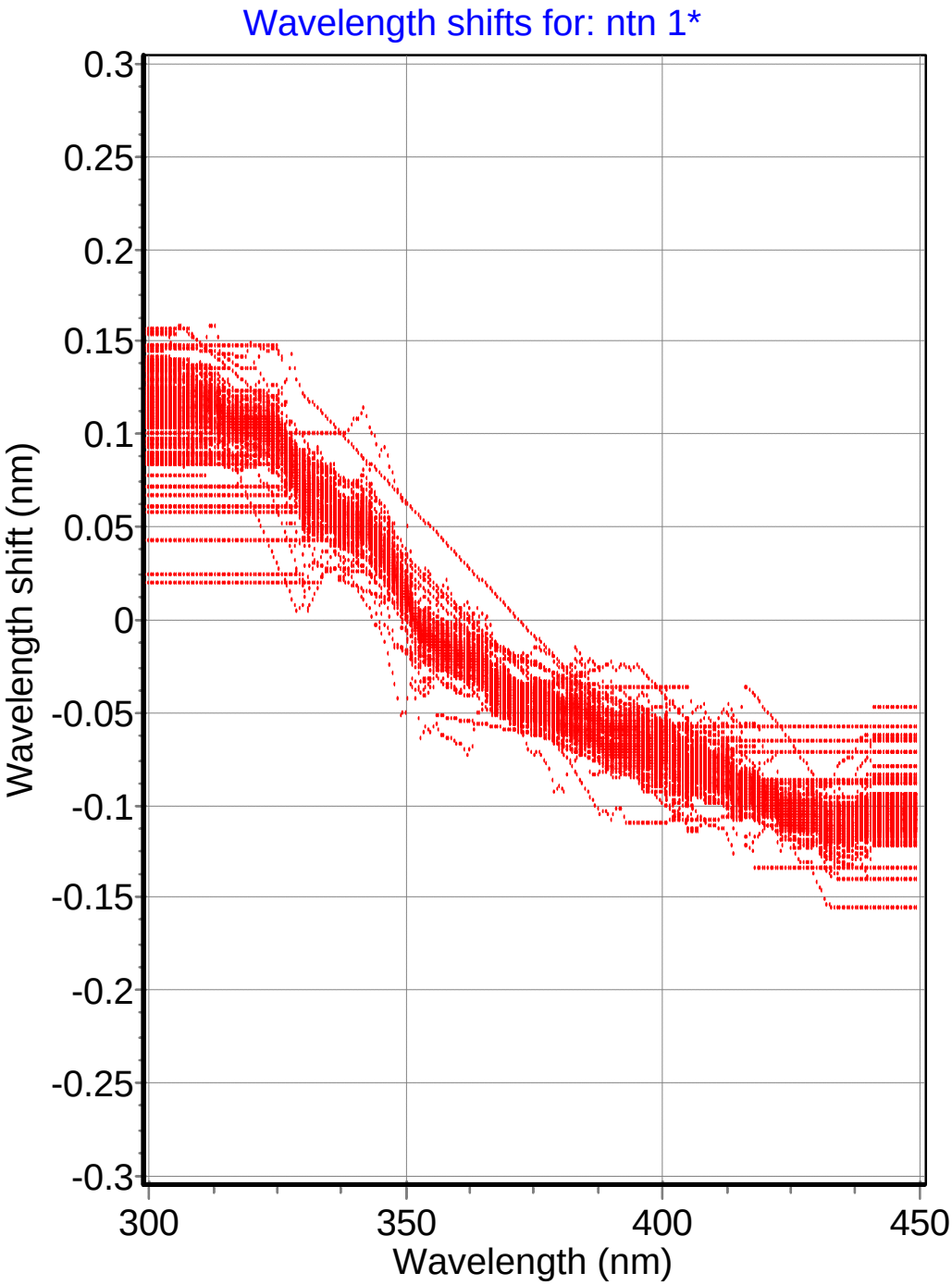

Global irradiance ratios NTN/JRC at Trondheim:07−Jun−2003(158)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
3
2.5
2
1.5
1
0.5
0
0
10
20
UVIndex
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
0(93)
2(88)
4(78)
6(65)
8(52)
10(43)
12(41)
14(49)
16(61)
18(74)
20(85)
22(92)
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
400 nm
444 nm
29−Jul−2003 11:35:34

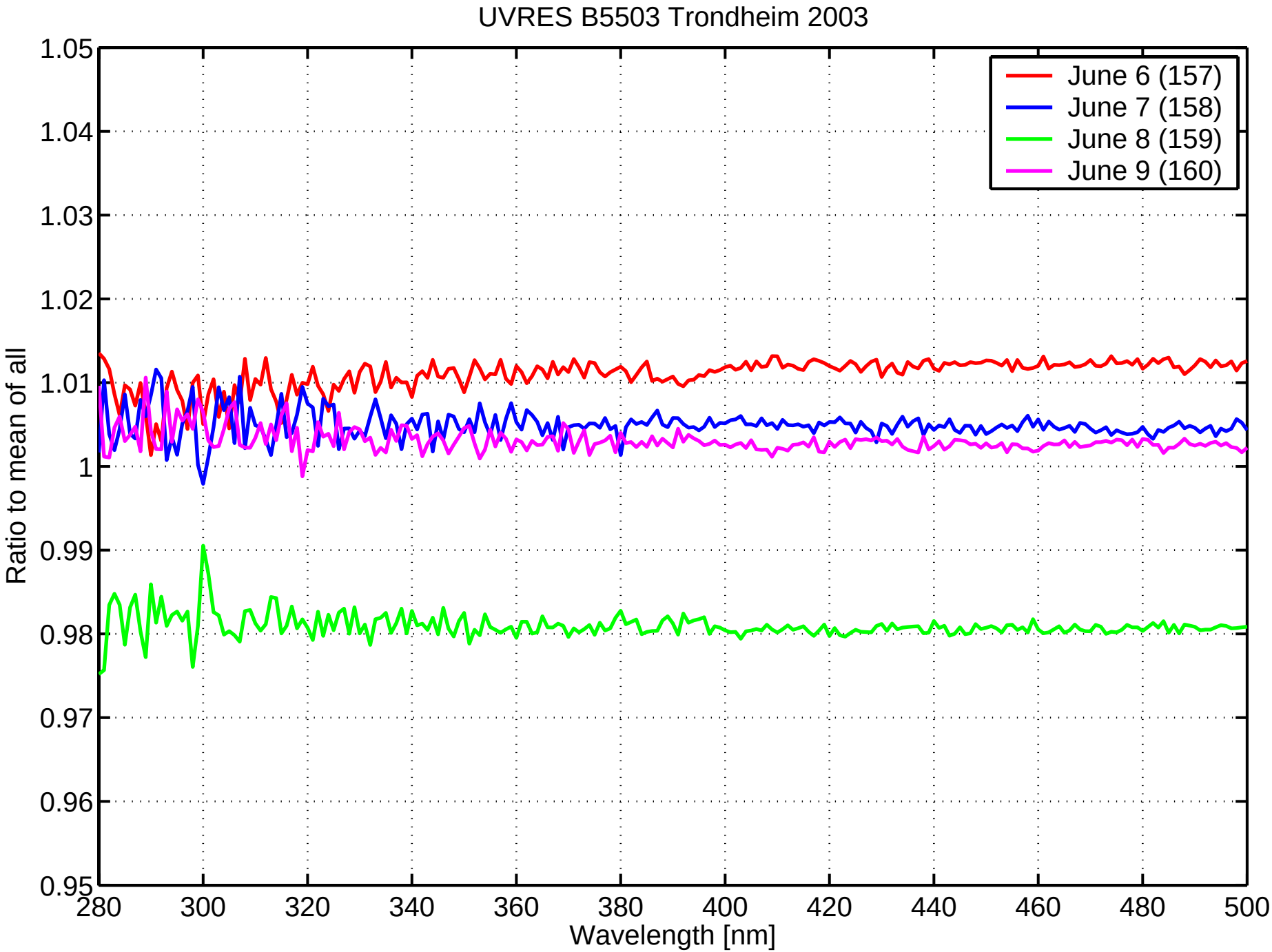


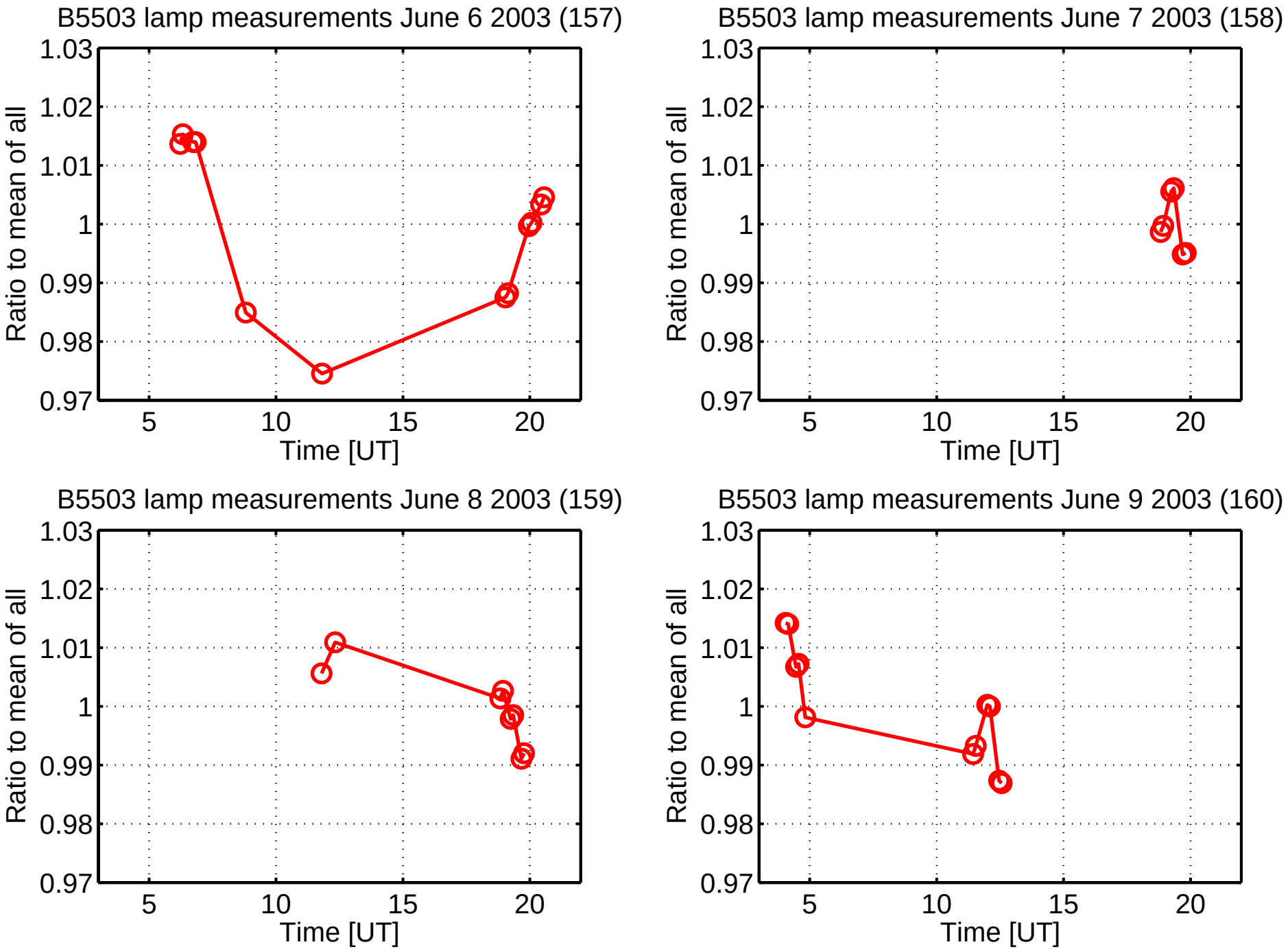


29–Jul–2003 11:35:34


Global irradiance ratios NTN/JRC at Trondheim:09–Jun–2003(160)
1.2
1.1
1
0.9
0.8
300
350
400
450
wl [nm]
2.5
2
1.5
1
0.5
0
UVIndex
0
10
20
Daily variation. Wavelength bands are ± 2.5 nm
1.2
1.1
1
0.9
0.8
0(93)
2(88)
4(78)
6(65)
8(52)
10(43)
12(41)
14(49)
16(61)
18(74)
20(85)
22(92)
TIME [UT](SZA)
305 nm
310 nm
320 nm
350 nm
400 nm
444 nm
29–Jul–2003 11:35:34


Wavelength shifts for: ntn 1*
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
Wavelength shift (nm)
300
350
400
450
Wavelength (nm)


UVRES B5503 Trondheim 2003
June 6 (157)
June 7 (158)
June 8 (159)
June 9 (160)
Ratio to mean of all
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
420
440
460
480
500


B5503 lamp measurements June 6 2003 (157)
B5503 lamp measurements June 7 2003 (158)
B5503 lamp measurements June 8 2003 (159)
B5503 lamp measurements June 9 2003 (160)
Ratio to mean of all
Time [UT]
1.03
1.02
1.01
1
0.99
0.98
0.97
5
10
15
20