Protocol of the intercomparison at UMIST Manchester, UK June, 28- July, 2 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 UMIST and B5503. The visit at UMIST 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 building 40 meters above ground. Latitude is 53.474 N and Longitude 2.234 W, altitude about 100 m.a.s.l. The horizon of the measurement site is free down to about 80 deg SZA. Higher obstructions are located in the South-West.

B5503 arrived at UMIST in the morning of June 28, 2002. The instrument was installed on the roof of the UMIST 1.5 m away from the spectrometer operated by UMIST. The intercomparison between B5503 and the spectrometer from UMIST lasted four days, from noon of June 28 to the morning of July 1.

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 28 was held from 19:30 to 21:00 UT, and the second on July 1 from 04:30 to 06:00 UT. The stability of the instrument during the intercomparison is ± 0.5%, based on the 100W calibration data (see appended graph).
The internal temperature of B5503 was 27.25 ± 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 500 nm (see appended graphs).

Protocol:
Measurements started at noon of June 28 at 14:30 UT. Synchronous global irradiance measurements were performed every 30 min in the range 290 to 500 nm with an increment of 0.5 nm every 3 sec. The last synchronous scan was started at 19:00 UT (78^o solar zenith angle). The conditions were cloudy without rain. B5503 was calibrated from 19:30 to 21:00 UT.

Measurements on June 29 are quality controlled from 4 UT to 20:30 UT. Sunrise was at 03:46 UT and sunset was at 20:38 UT. The minimum solar zenith angle was 30 deg. Measurements were performed under cloudy-overcast conditions with partly sunshine. Due to timing problems, measurements of B5503 between 9:30 and 12:00 UT were unsynchronised by about 40 seconds and therefore removed from the analysis.

June 30 was characterized by cloudy-overcast conditions with partly sunshine till 15:00. At 15:00 light rain started and further measurements were removed from the analysis.

On July 1 the calibration of the B5503 took place from 04:30 to 06:00 UT. Synchronized measurements continued from 06:30 to 10:30 UT. Afterwards a 100W lamp was measured (T53061) using the calibrator of B5503. This was jointly decided as a measure to identify differences in the absolute irradiance measured by the instruments the previous days.

On July 2, the UMIST instrument measured the laserline 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.

Results:
The wavelength shifts of the UMIST spectrometer retrieved through the SHICRivm analysis were stable during the measurement period. The magnitude of the wavelength shifts changed from 0 pm at 310nm to –300 pm at 500 nm.

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

- Global irradiances measured by UMIST were between 15 and 30% higher than those measured by B5503. The differences increased progressively throughout the measurement period.
- A diurnal variation of 8 to 10% was observed on June 28 and 29.
- The spectral shape of the global irradiance ratios between UMIST and B5503 are spectrally flat to within 5% between 310 and 500 nm. At shorter wavelengths the variability between the two instruments is higher, especially in the morning and evening of June 29, and in the morning of June 30.
- The measurement of the 100 W lamp inside the calibrator of B5503 by UMIST was 25% higher than measured by B5503, which is in agreement with the solar measurements seen during the previous days.

Comments from the site operator:

The UMIST instrument is the one used in Ispra in May – nothing had been changed, in part to see whether we observed the same behaviour at UMIST as we did at Ispra (increasing sensitivity and diurnal pattern of variation cf. the JRC instrument).

The spectroradiometer is a Bentham DTM300, and had been to Bentham for a service and replacement grating just before the Ispra intercomparison. The input optic is a Schreder cosine diffuser connected to the entrance port by a quartz fibre bundle 2m in length. The outer quartz dome on the diffuser was changed immediately before the JRC Ispra intercomparison as the original was scratched. The slit function has a FWHM of 0.6 nm, as measured on both a Hg line and the JRC cadmium laser. The instrument is in a temperature-stabilised box at 25^0C. The box contains the entire instrument (spectroradiometer and electronics), with the temperature probe controlling the temperature being strapped to the PMT. The box is new. It is longer and thinner than the original and so the components of the instrument are arranged differently – this is the only other thing that was changed just prior to the Ispra intercomparison.

Background:

At several intercomparisons in the past this instrument has proved to be very stable with no significant zenith angle related aspects of performance. In Ispra it showed both a steady drift and a diurnal response (the latter being exactly the same as that of the Innsbruck instrument). The following changes had recently been made to the instrument:

1. One new grating, plus a general service and correction of the filter wheel mechanism that kept sticking – all performed by Bentham Instruments.
2. New temperature stabilised box (same temperature and control, different layout).
3. New quartz dome on the Schreder diffuser.

At Ispra, the first calibration check (Julian's lab) showed a 2% change after transport, verified on several UMIST lamps, 1000W and 200W. Thereafter calibrations were performed on the roof with the 200W lamp. After 2 days there had been a 9% increase in sensitivity, followed by 7% and then 4% at further 2 day intervals. The initial change was at first attributed to a drying out of the diffuser as a brand new silica capsule was put in the head as it was mounted on the roof, as the existing one was a pale blue. It was assumed there was some moisture in the head (non observed) that was slowing being removed to give the increase in sensitivity. However, the sensitivity continued to increase at a decreasing rate throughout the campaign…..not sure moisture was (entirely) the reason.

Nobody I have spoken to feels that either the new grating or new quartz diffuser (actually a spare from Innsbruck that had been in use for solar work before) could explain an increasing sensitivity.

The UMIST calibration lamps (traceable to NIST) were compared to the JRC lamps at Ispra and showed a difference of about 4%, consistent with expectation. Cross-checking

with several lamps shows that the lamps themselves have not changed between the Ispra campaign and now (July 22nd, after many more tests in UMIST lab.).

Many tests were made during the Ispra campaign to try and determine the cause of the UMIST/Innsbruck diurnal variations. Instrument temperature, diffuser temperature, diffuser position (ie azimuth effect) and instrument position on roof. No solution found.

After the Ispra campaign:
Instrument returned to UMIST, stabilized and 200W lamp measured every day for a week. The sensitivity increased by about 7% over this period.

During this time the HV was also monitored leaving the supply and entering the PMT. It was very stable (although the front panel meter bears no relation to the supply – it should read supply/10).

Contacted Bentham – they had no ideas.

Pre-JRC arrival:

The UMIST Bentham was calibrated in the laboratory and the 200W transfer lamp also checked against the 1000W standard. The instrument was transported to the Pariser building roof. It was then very wet and stormy for a week and no roof-top calibration or tests were possible until the day the JRC van arrived. A measurement was made of the 200W lamp and showed a change of 3% since the lab. calibration. A new calibration file was generated for use during the campaign.

A new silica capsule was placed in the diffuser as the existing one was looking pale after all the rain (though not pink, or even white).

UMIST- JRC intercomparison:
Measurements were made over the following 2.5 days (grey and damp), followed by a UMIST measurement of the UMIST 200W calibration lamp, the JRC calibration unit, and finally, on the last day, the cadmium laser (on the roof).

Results:

Very reproducible behaviour between Ispra and UMIST! However, at UMIST there is an additional 25% difference in absolute calibrations, consistent on both the sky and the JRC calibration unit. Aaaaarrrrgh.

The diurnal variation was still evident (as it was also in Innsbruck), so the suspicions about the static effects on the JRC roof are not upheld as a reason for this effect.

The drift (increasing sensitivity) of about 7% over 2 days is similar to that observed in Ispra, and may indicate some moisture in the diffuser since in both cases the silica capsule was changed prior to the start of the measurements. This would indicate that first

the diffuser is not properly sealed, second that truly dry air is critical to the throughput of the diffuser, and also that the drying process is very slow (the silica capsule only has a small hole open to the inside of the (comparatively large) diffuser. Since the silica capsule was showing some fading (ie some moisture uptake) before it was changed , but was still “blue”, it is not a reliable indicator of moisture problems in the diffuser.

Post-intercomparison:

The UMIST instrument was moved to the lab. for further diagnostic tests. Nothing was disturbed ie the diffuser was not opened for inspection and the instrument remained in its new, thin temperature box.
Measurements were then made every day (except weekends) for 9 days using 1 x 200W lamps on the cosine diffuser and 2 x 200W lamps on the actinic head (same monochromator, different input port, fibre and input optic). All showed the same trend ie a continuing increase (6-7%) in sensitivity over a period of 9 days.

The whole Bentham monochromator was then removed from the new, thin box and replaced in the old, wide box. This was the first time anything had been disconnected or opened since before the JRC instrument arrived at UMIST. During the change the monochromator was inspected as were the innards of the electronics bin.
In the amplifier 3 chips could be pressed further into their holders (on the ADC). They were properly seated and the cover replaced. In the old box this bin sits horizontally on the top of the monochromator. In the new box it is upended and stands on its side.

A 200W lamp was measured on both the actinic and cosine heads and the instrument left over the weekend. The change after the weekend was < 1%. Further measurements on the next 2 days confirmed that the instrument now appeared stable.

Also concern about instability in the computer/software – on occasion it seemed to lose settings (rare but worrying). After the first weekend with the old temperature box the PC was also changed.

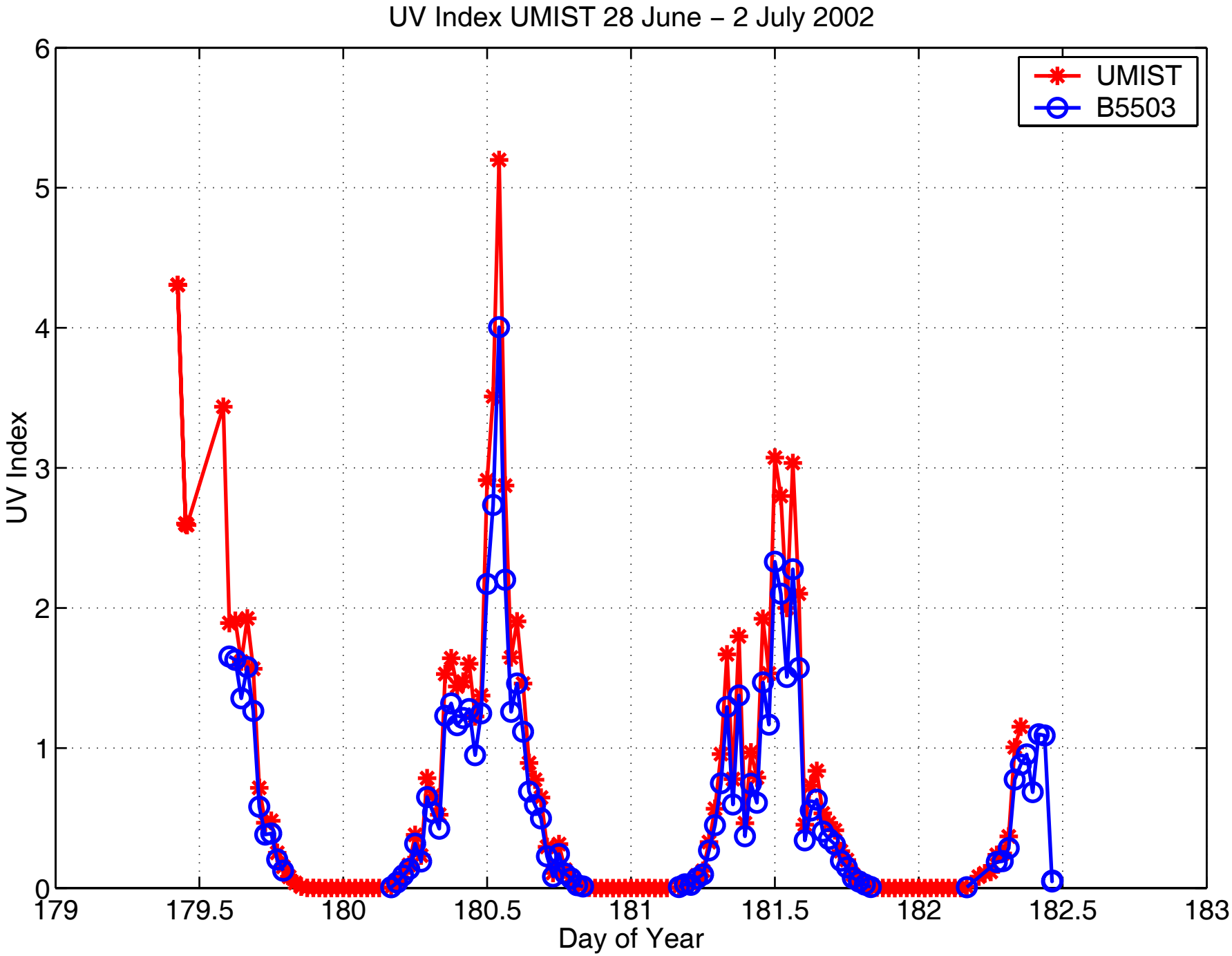
Current situation:

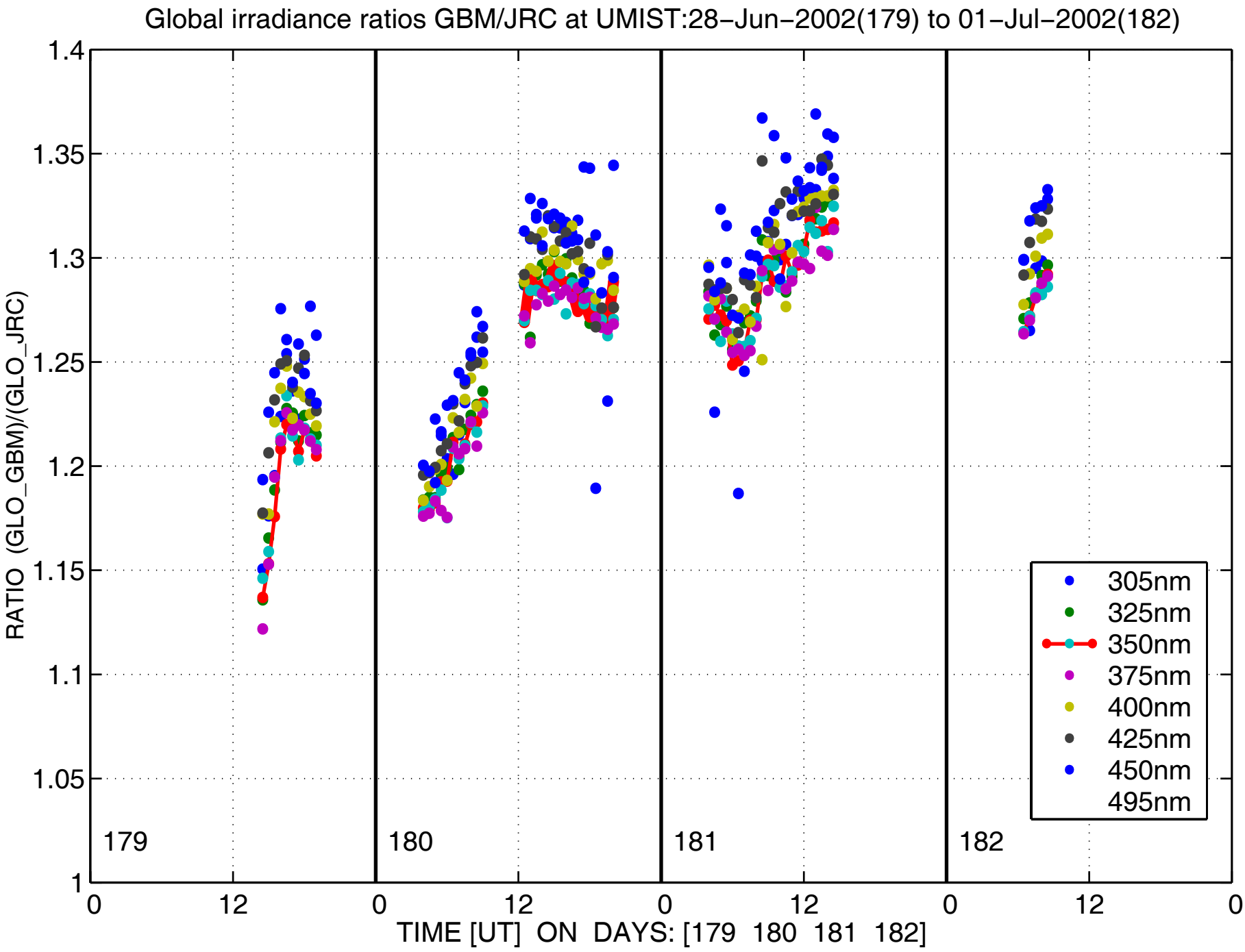
1. Stability appears to have improved either because of some undetermined problem in the new temperature box OR due to ill-seated chips (NB the amplifier has not been opened for years).
We cannot resubmit data to remove the drift caused by this, we can only hope it has gone, and try to find out whether there is a problem with the new box.

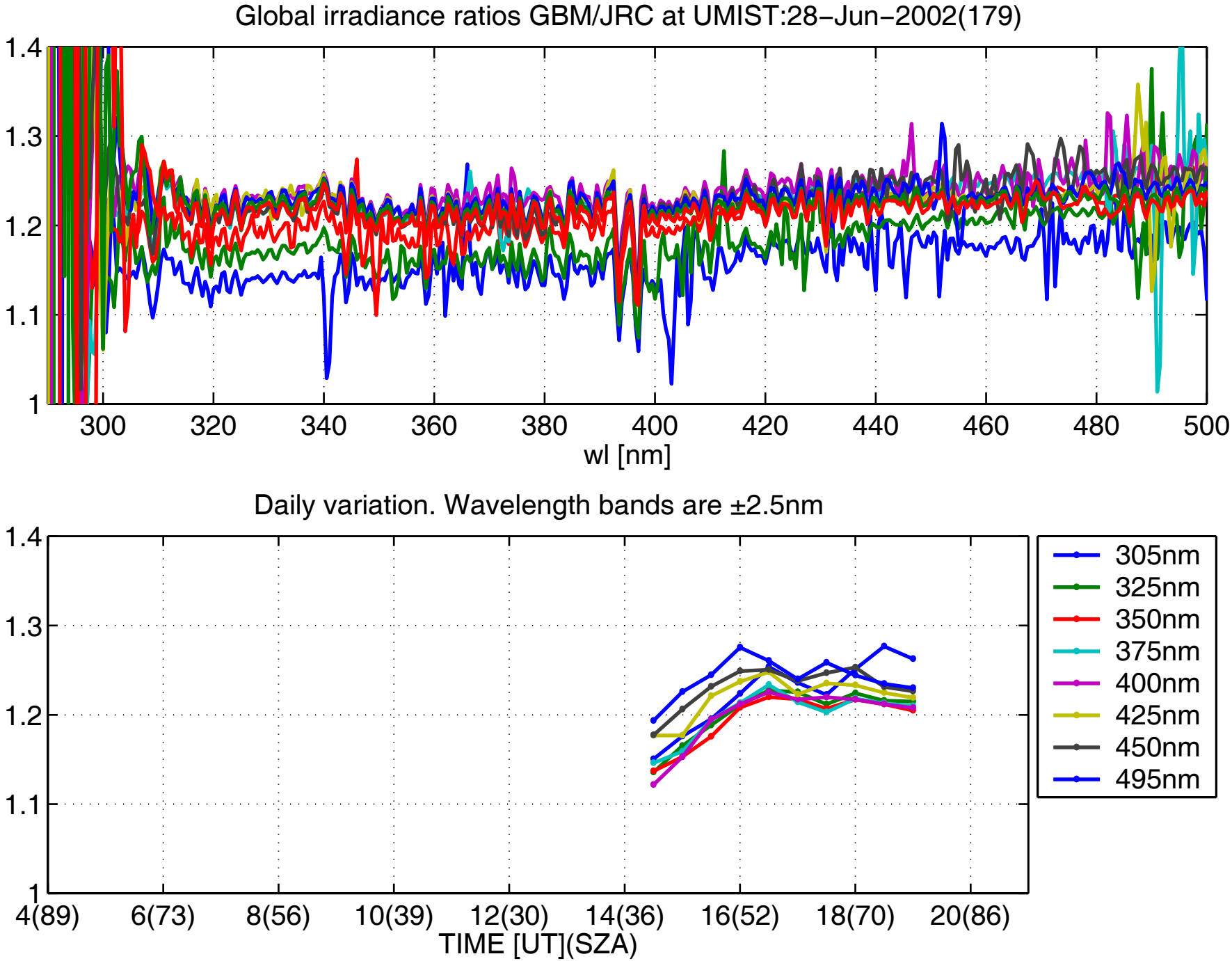
2. In the case of the 25% absolute calibration difference observed at UMIST, we suspect that it reverts to a mix-up / faulty calculation / PC problem in defining the calibration file used on the roof BUT we cannot prove this. Certainly the 200W lamp used in Ispra and UMIST has been thoroughly checked against several other standards (many times) in the past months and is stable and the known 4% from the JRC standard. The drift in sensitivity was a different issue observed on top of the 25% absolute discrepancy. Since

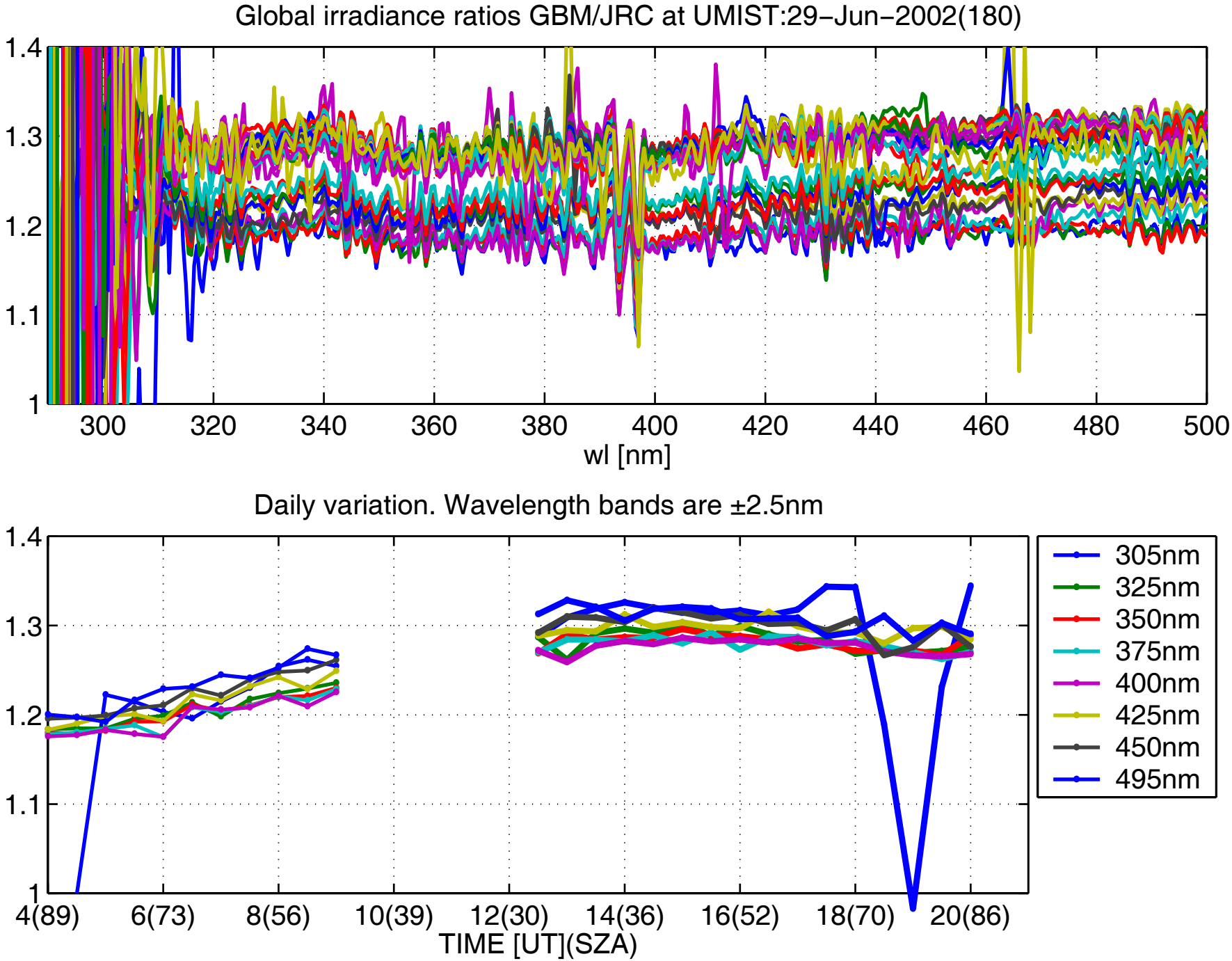
we cannot provide concrete proof that the error is in the software/humanware we will not revise the data at this point. If we find a solution in the next month we will let you know!

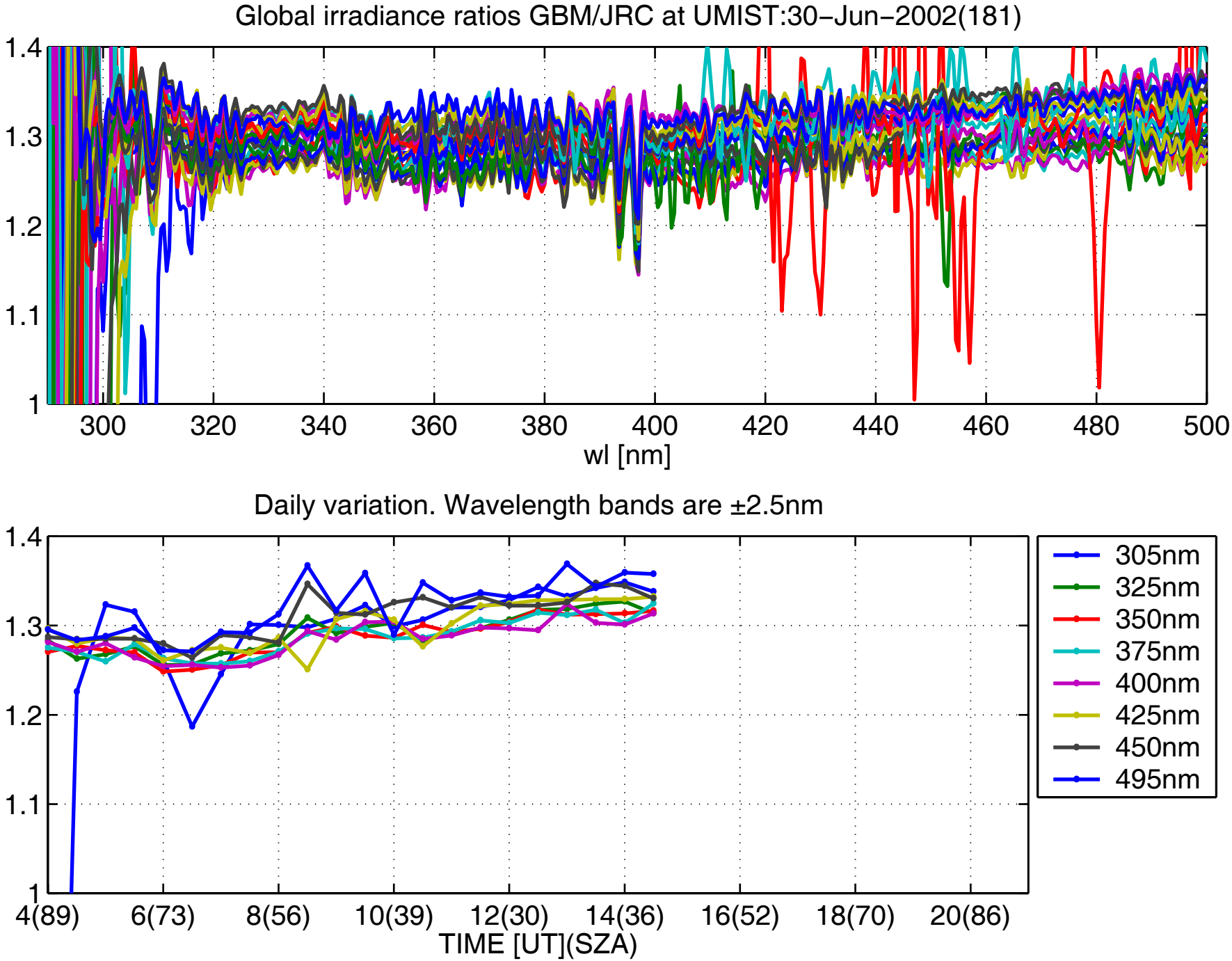
3. The diurnal variation remains unsolved but is not unique to us – we continue to search for a solution.

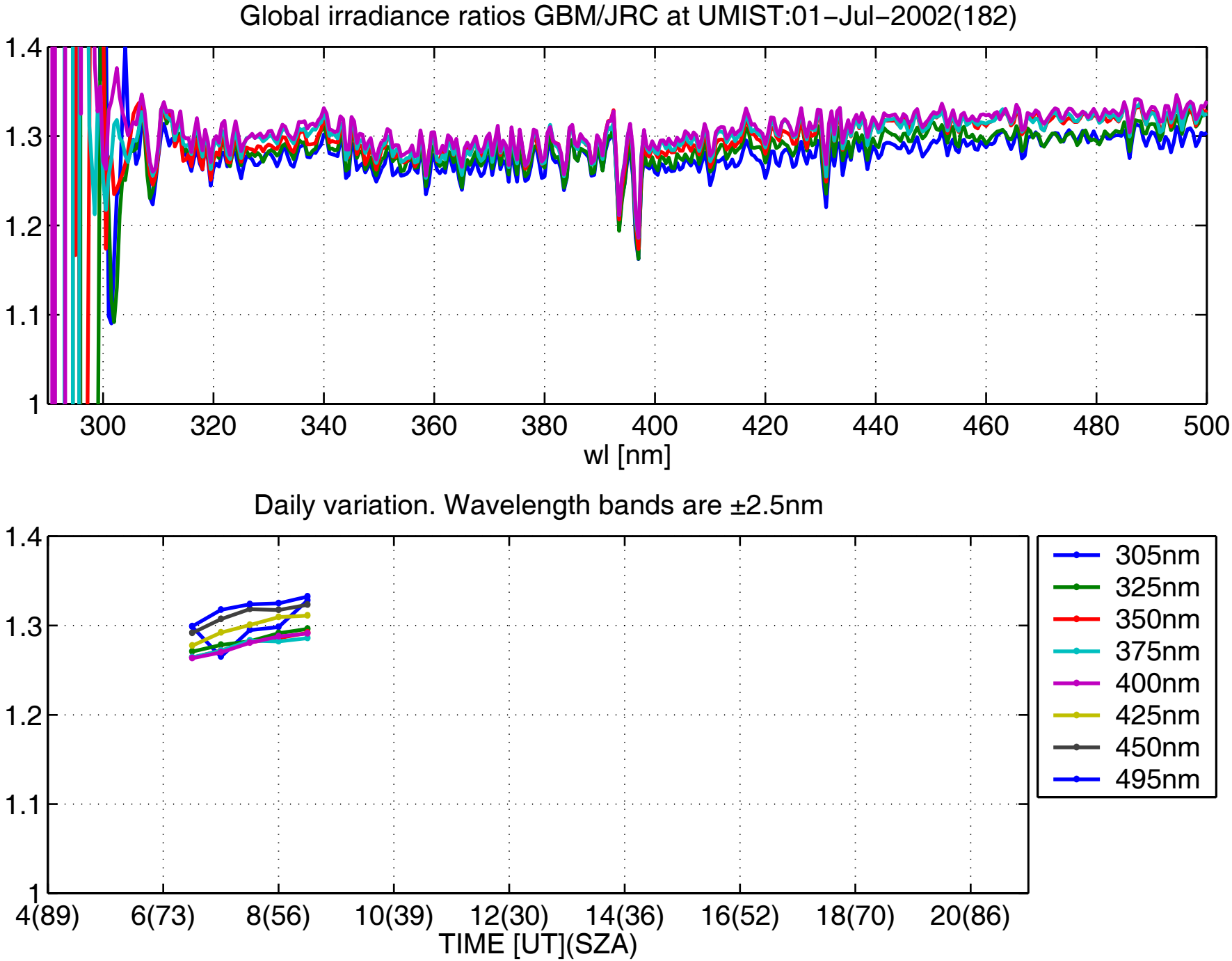

UV Index UMIST 28 June – 2 July 2002
UMIST
B5503
UV Index
Day of Year
0
1
2
3
4
5
6
179
179.5
180
180.5
181
181.5
182
182.5
183

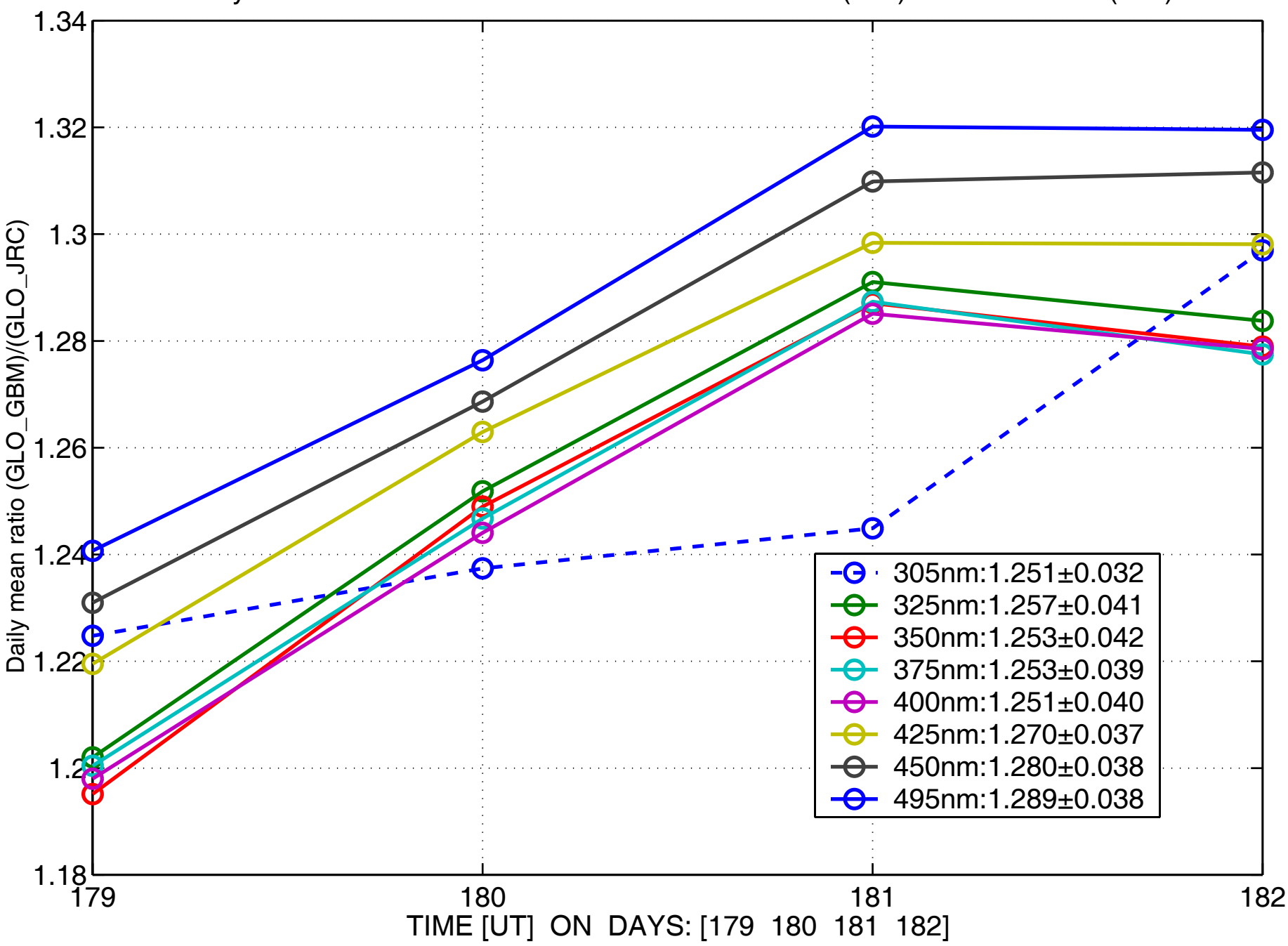

Global irradiance ratios GBM/JRC at UMIST:28−Jun−2002(179) to 01−Jul−2002(182)
RATIO (GLO_GBM)/(GLO_JRC)
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
0
12
0
12
0
12
0
12
0
TIME [UT] ON DAYS: [179 180 181 182]
179
180
181
182
305nm
325nm
350nm
375nm
400nm
425nm
450nm
495nm

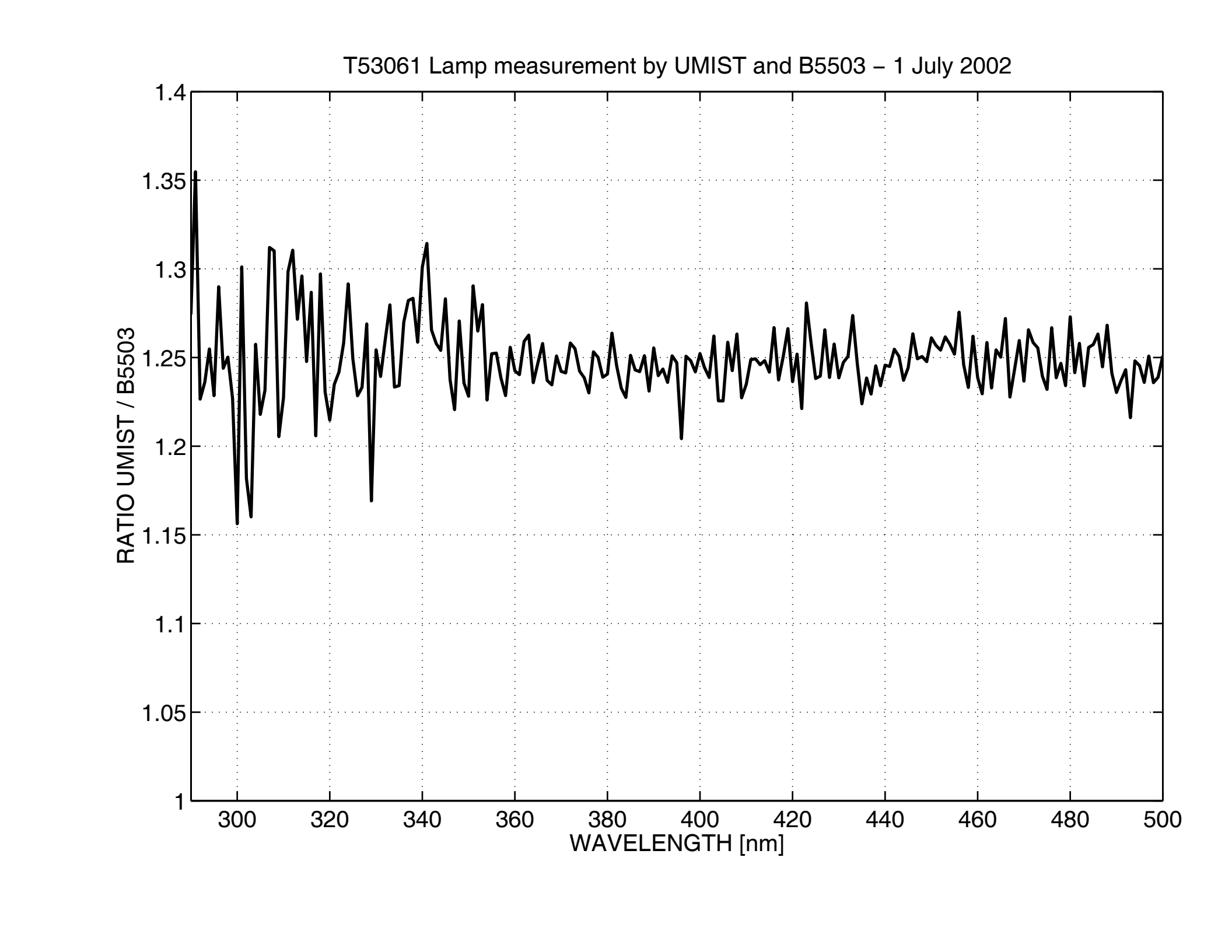

Global irradiance ratios GBM/JRC at UMIST:28−Jun−2002(179)
1.4
1.3
1.2
1.1
1
300
320
340
360
380
400
420
440
460
480
500
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.4
1.3
1.2
1.1
1
4(89)
6(73)
8(56)
10(39)
12(30)
14(36)
16(52)
18(70)
20(86)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
450nm
495nm

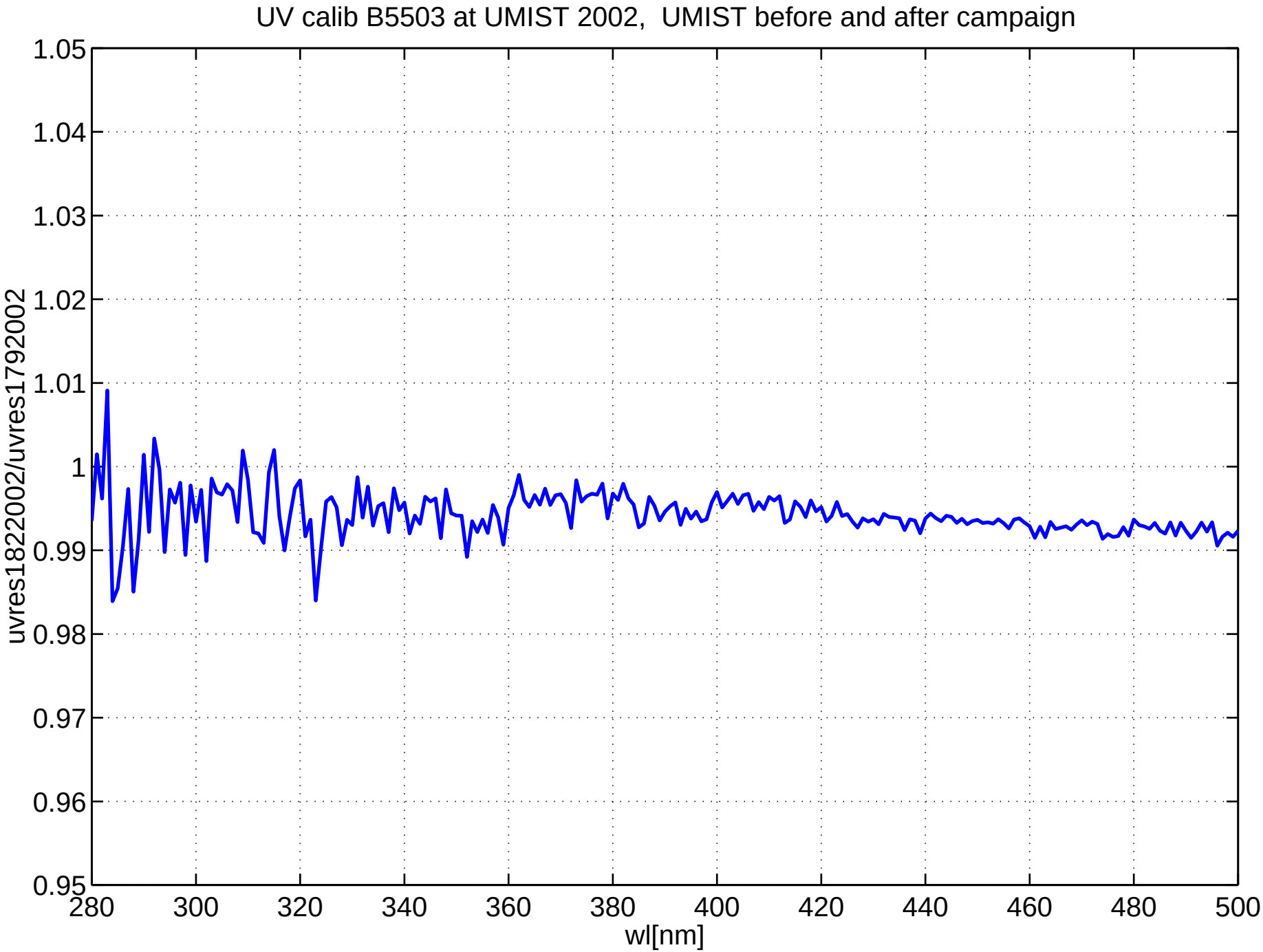

Global irradiance ratios GBM/JRC at UMIST:29−Jun−2002(180)
1.4
1.3
1.2
1.1
1
300
320
340
360
380
400
420
440
460
480
500
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.4
1.3
1.2
1.1
1
4(89)
6(73)
8(56)
10(39)
12(30)
14(36)
16(52)
18(70)
20(86)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
450nm
495nm

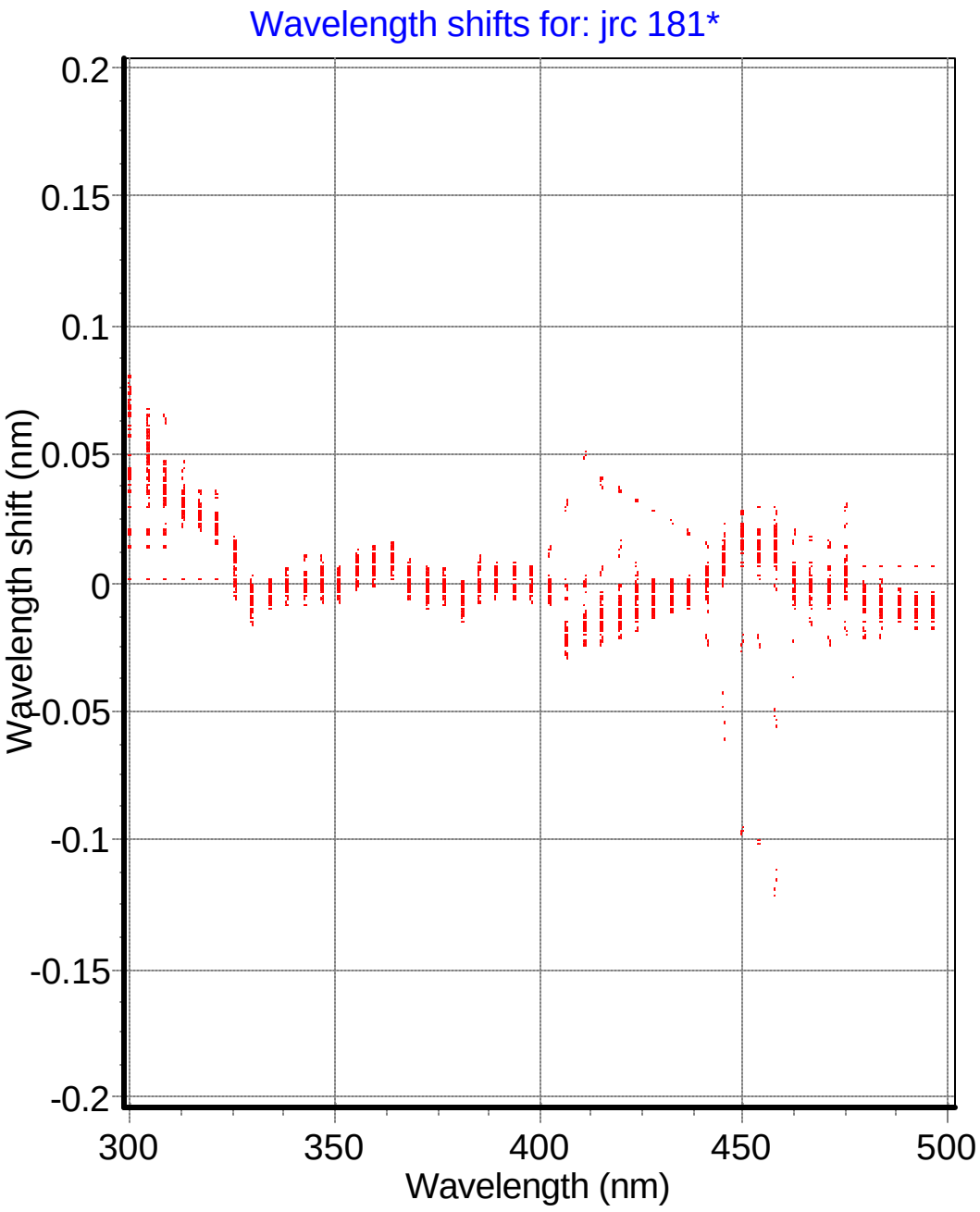

Global irradiance ratios GBM/JRC at UMIST:30−Jun−2002(181)
1.4
1.3
1.2
1.1
1
300
320
340
360
380
400
420
440
460
480
500
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.4
1.3
1.2
1.1
1
4(89)
6(73)
8(56)
10(39)
12(30)
14(36)
16(52)
18(70)
20(86)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
450nm
495nm

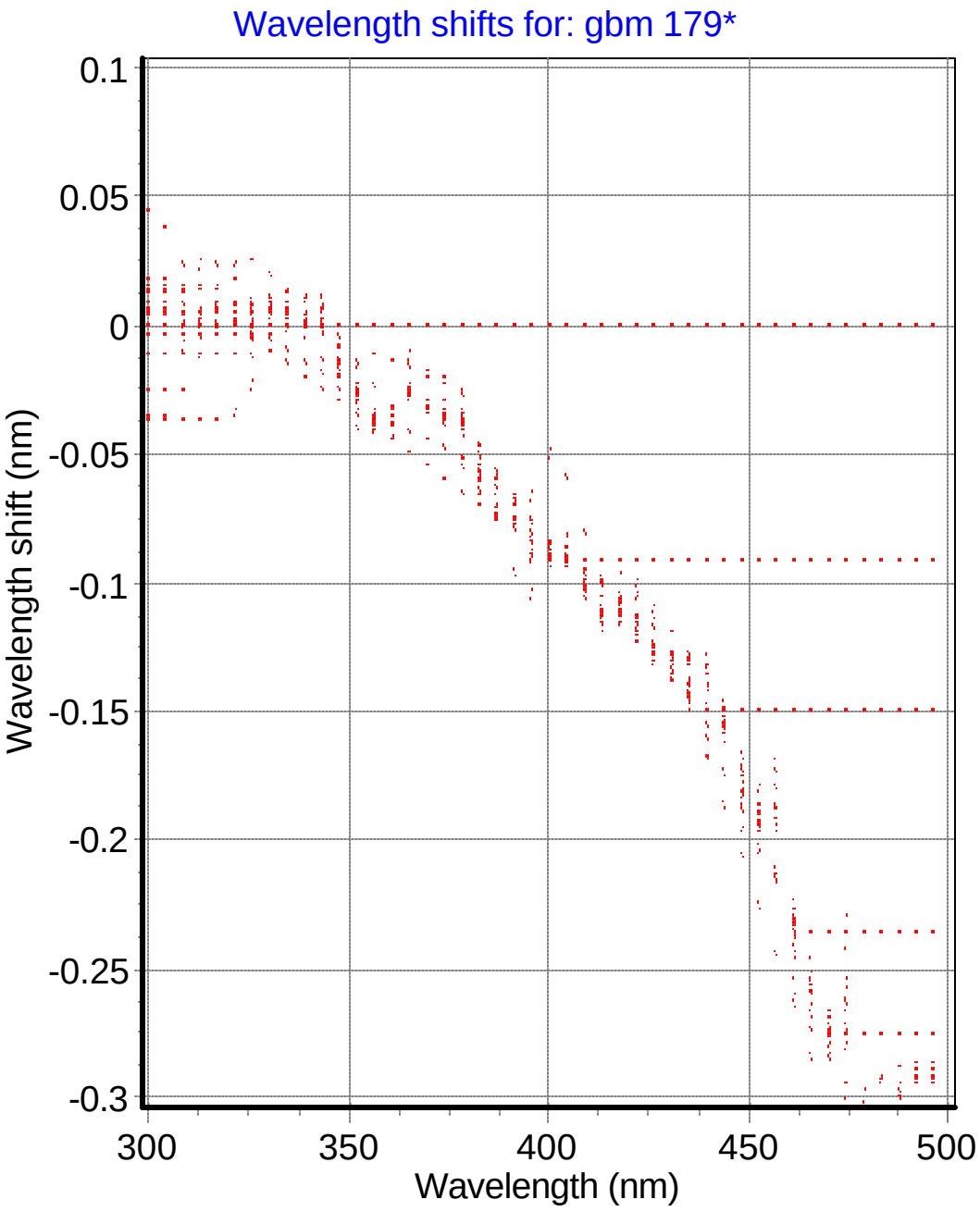

Global irradiance ratios GBM/JRC at UMIST:01−Jul−2002(182)
1.4
1.3
1.2
1.1
1
300
320
340
360
380
400
420
440
460
480
500
wl [nm]
Daily variation. Wavelength bands are ±2.5nm
1.4
1.3
1.2
1.1
1
4(89)
6(73)
8(56)
10(39)
12(30)
14(36)
16(52)
18(70)
20(86)
TIME [UT](SZA)
305nm
325nm
350nm
375nm
400nm
425nm
450nm
495nm

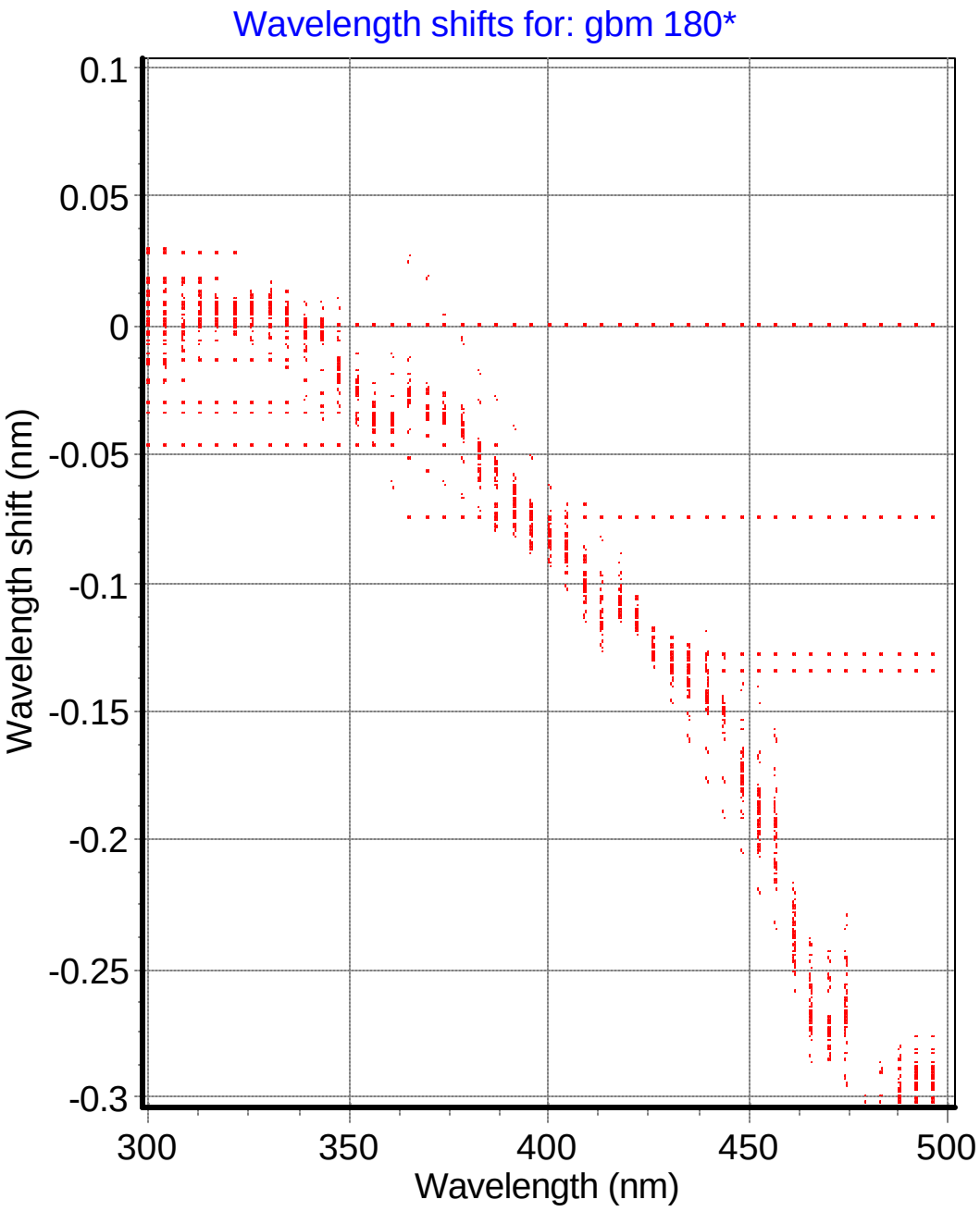

Daily mean ratios GBM/JRC at UMIST:28−Jun−2002(179) to 01−Jul−2002(182)
Daily mean ratio (GLO_GBM)/(GLO_JRC)
1.34
1.32
1.3
1.28
1.26
1.24
1.22
1.2
1.18
179
180
181
182
TIME [UT] ON DAYS: [179 180 181 182]
305nm:1.251±0.032
325nm:1.257±0.041
350nm:1.253±0.042
375nm:1.253±0.039
400nm:1.251±0.040
425nm:1.270±0.037
450nm:1.280±0.038
495nm:1.289±0.038

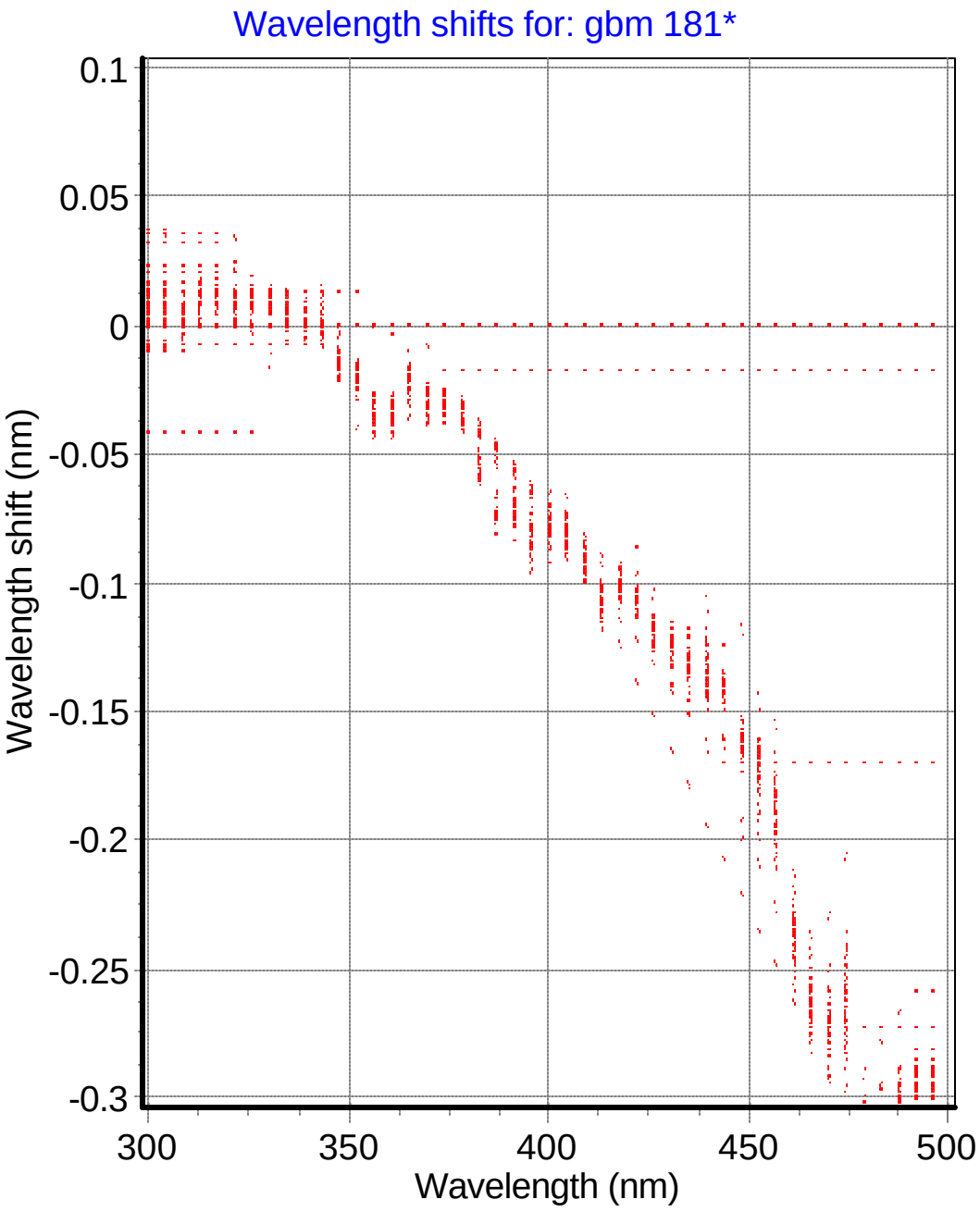

T53061 Lamp measurement by UMIST and B5503 – 1 July 2002
RATIO UMIST / B5503
WAVELENGTH [nm]
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
300
320
340
360
380
400
420
440
460
480
500

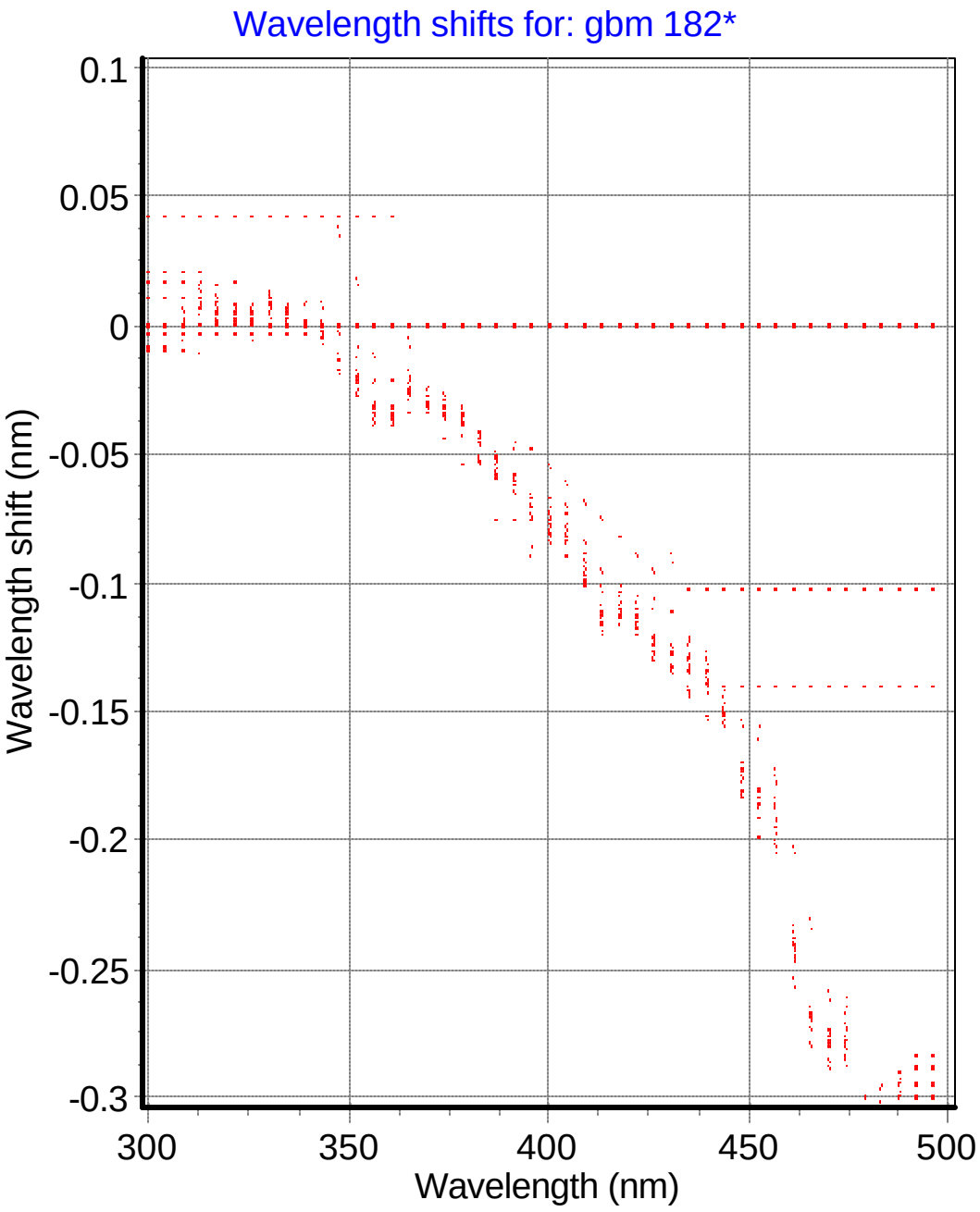

UV calib B5503 at UMIST 2002, UMIST before and after campaign
uvres1822002/uvres1792002
wl[nm]
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
280
300
320
340
360
380
400
420
440
460
480
500


Wavelength shifts for: jrc 181*
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Wavelength shift (nm)
300
350
400
450
500
Wavelength (nm)


Wavelength shifts for: gbm 179*
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
Wavelength shift (nm)
300
350
400
450
500
Wavelength (nm)


Wavelength shifts for: gbm 180*
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
Wavelength shift (nm)
300
350
400
450
500
Wavelength (nm)


Wavelength shifts for: gbm 181*
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
Wavelength shift (nm)
300
350
400
450
500
Wavelength (nm)


Wavelength shifts for: gbm 182*
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
Wavelength shift (nm)
300
350
400
450
500
Wavelength (nm)

The visible horizon at Brewer #107 (FIJ) at Jokioinen as recorded in summer 1994. Since then wood has been cut in the south and in the west, thus improving the horizon by a few degrees. Also the path of the Sun on days 1 to 180 is shown.