

Protocol of the intercomparison at the ENEA Observatory,
Lampedusa, Italy, April, 19-21 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 ENEA (LMP) and B5503 within the project QASUME. The measurement site is located at Lampedusa Island; Latitude 35.52 N, Longitude 12.63 E and altitude 40 m.a.s.l.. The horizon of the measurement site is free in all directions.

B5503 arrived at Lampedusa in the morning of April 19, 2003. The spectroradiometer was installed on the solar radiation measurement platform of the observatory at about 5 meter from the ground. The spectroradiometer in use at Lampedusa is a Brewer #123 double monochromator. The intercomparison between B5503 and the local spectroradiometer lasted two and a half days, from the afternoon of April 19 to the evening of April 21.

B5503 was calibrated several times during the intercomparison period using a portable calibration system. Two lamps were used to obtain an absolute spectral calibration traceable to the primary reference held at ECUV which is traceable to PTB: T53061 (100 W) and T61251 (250 W). The responsivity of the instrument based on these calibrations varied by less than 0.5% during the intercomparison. The internal temperature of B5503 was 24.4°C and varied by less than 0.4 °C. The diffuser head was heated to a temperature of about 25±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 400 nm, every 0.5 nm, and 3 seconds between each wavelength increment.

April 19 (110):

Arrival and setup of the instrument in the morning. After the instrument stabilised, measurements were initiated at 12:00 UT. Weather conditions until 15:30 UT were clear skies, and wind up to 7 m/s. At 15:40 clouds move in. Rain starts at 17:15 UT and lasts till the evening.

Calibration at 13:41 with T53061.

April 20 (111):

Synchronised measurements are available from 5:00 to 17:30 UT. B5503 missed the 9:30 UT scan due to calibration. Weather conditions from 5:00

till 11:30 are a mix of sun and fast moving low lying clouds. Clear skies from 12:00 till 17:30 UT.

Calibration from 9:12 to 9:45 UT: T53061 and T61251.

April 21 (112):

Synchronised measurements are available from 4:30 to 17:30 UT. Weather conditions were a mix of sun and fast moving low lying clouds until 11:30 UT. Clear skies from 12:00 UT till evening.

Results:

64 synchronised scans are available from the measurement period.

The wavelength shifts of the submitted solar spectra of the LMP spectroradiometer retrieved through the SHICRivm analysis were stable to within 20 pm. The absolute wavelength shift relative to the extraterrestrial spectrum used by the SHICRivm software varied spectrally between -30 and -80 pm (see attached graphic).

LMP submitted a revised data set after the end of the campaign. The difference between the original and revised data set is up to +10% and is due to the implementation of a cosine correction and a linearity correction (see comments of the local operator on the next page).

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

- Global irradiances measured by LMP were between 1% lower to 10% higher than those measured by B5503 on the five days.
- Diurnal variations with an amplitude of 6% can be observed in the afternoons of April 20 and 21, and on the morning of April 22 when the sky was clear of clouds. The amplitude is larger at longer wavelengths, which might be related to the directional response of the instrument which deviates from the nominal cosine weighed response.
- The average ratio between LMP and B5503 is spectrally flat between 308 and 365 nm at 1.05. Below 308 nm the ratio rises to 1.09. Selected spectra (clear sky cases) are spectrally flat down to 300 nm for SZA below 70°.
- The directional response of LMP was measured during the night of April 21 in all four planes (see attached graphs). The average integrated cosine error over the four planes (diffuse cosine error) is 0.90. The diffuse cosine error in the principal plane (0°) is 0.91.

Conclusion:

LMP measures global solar irradiance on average 4 to 5% higher than B5503. The diurnal variability of the ratio LMP to B5503 is of the order of 6%.

Comments from the local operator:

Brewer #123 is operational at Lampedusa since 1998. It is calibrated on site regularly with 1000 W NIST traceable FEL lamps by means of a field calibrator, whose characteristics are described by Early et al. (1998). The lamps are referred to the NIST scale and provided by the Central UV Calibration Facility at Boulder (NOAA).

During the QASUME campaign, the Brewer was calibrated on days 109 and 113. The Brewer responsivities on these two days differed by less than 1%.

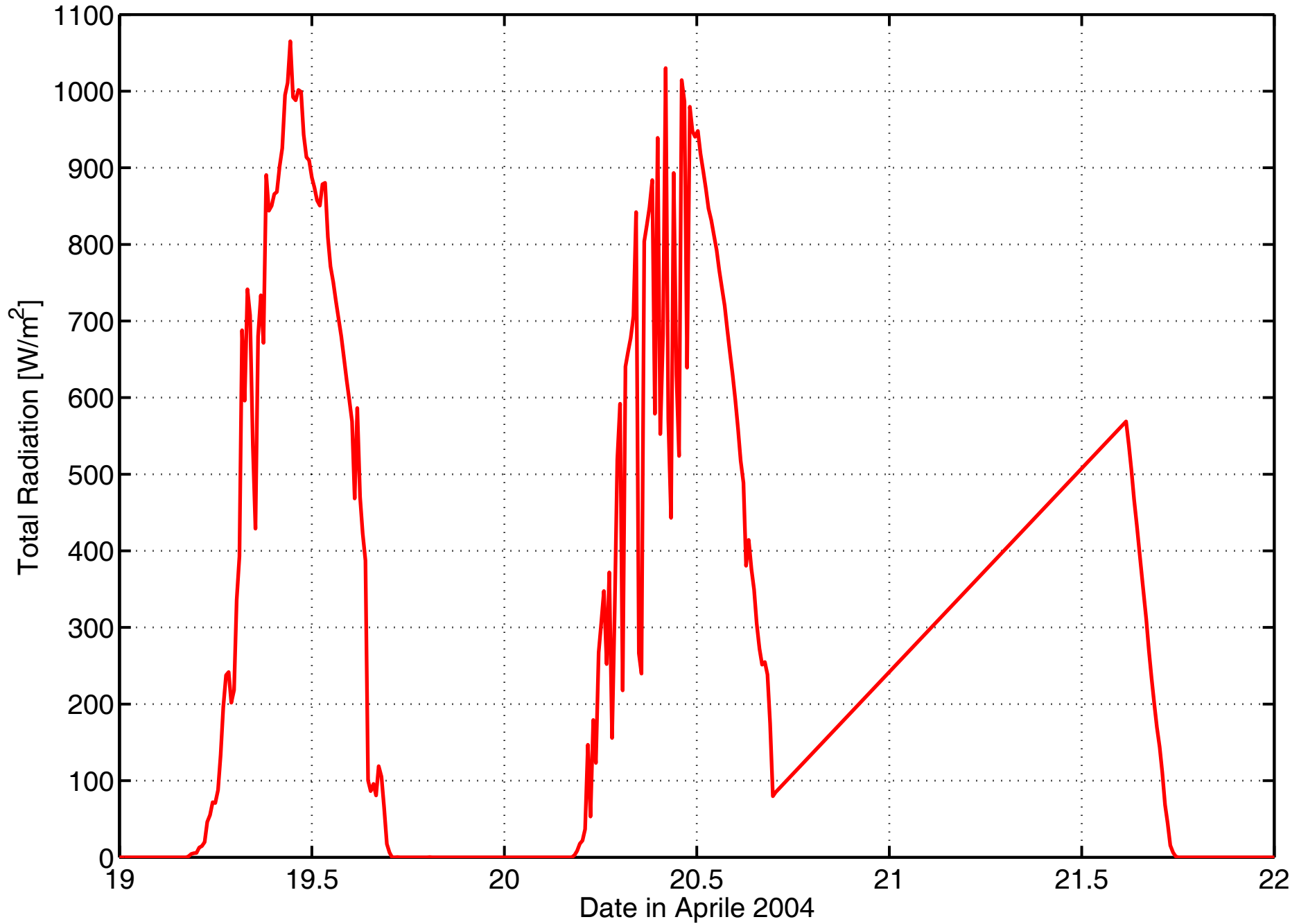
A revised version of the Brewer data was submitted after the intercomparison. Two main changes were implemented: a modification of the value of the PMT dead time, that needed to be updated; the implementation of a correction for the non ideal cosine response of the Brewer entrance optics. The correction uses the cosine response measured during QASUME, and model estimates of the diffuse-to-direct radiation ratio. The model calculations were performed with the aerosol Elterman (1968) distribution with an optical depth of 0.37 at 340 nm (0.25 at 550 nm); this value is somewhat higher than that measured at Lampedusa during the QASUME intercomparison (about 0.2 at 500 nm). Some unaccounted effect may be due to the influence of the wavelength dependence of the optical depth on the cosine correction (through a modification of the diffuse-to-direct ratio), which may differ significantly from what expected by Elterman.

References:

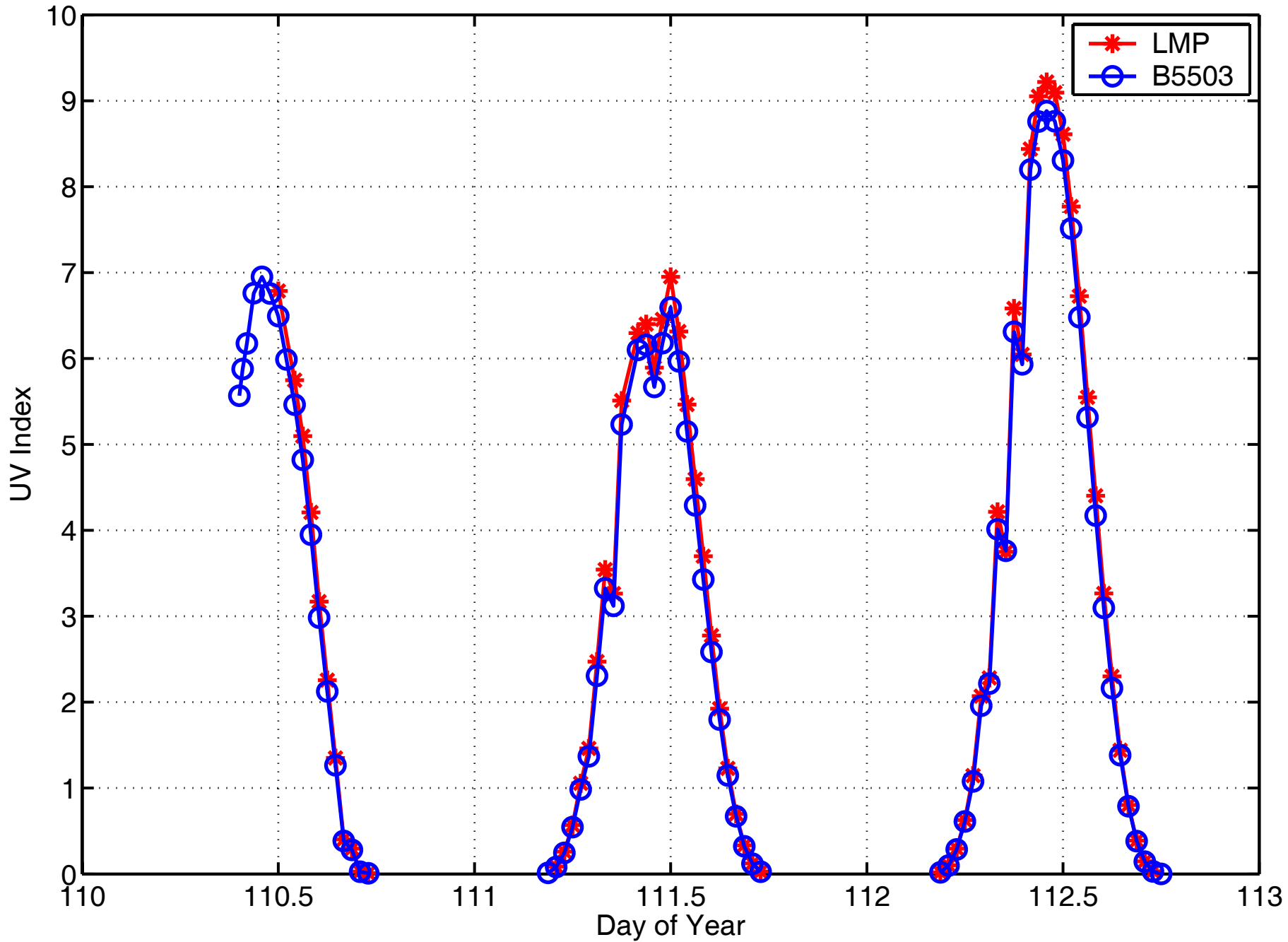
Early, E. E., E. A. Thompson, and P. Disterhoft, Field calibration unit for ultraviolet spectroradiometers, *Appl. Opt.*, 37, 6664-6670, 1998.

Elterman, L., UV, visible, and IR attenuation for altitudes to 50 km, AFCRL-68-0153, 1968.

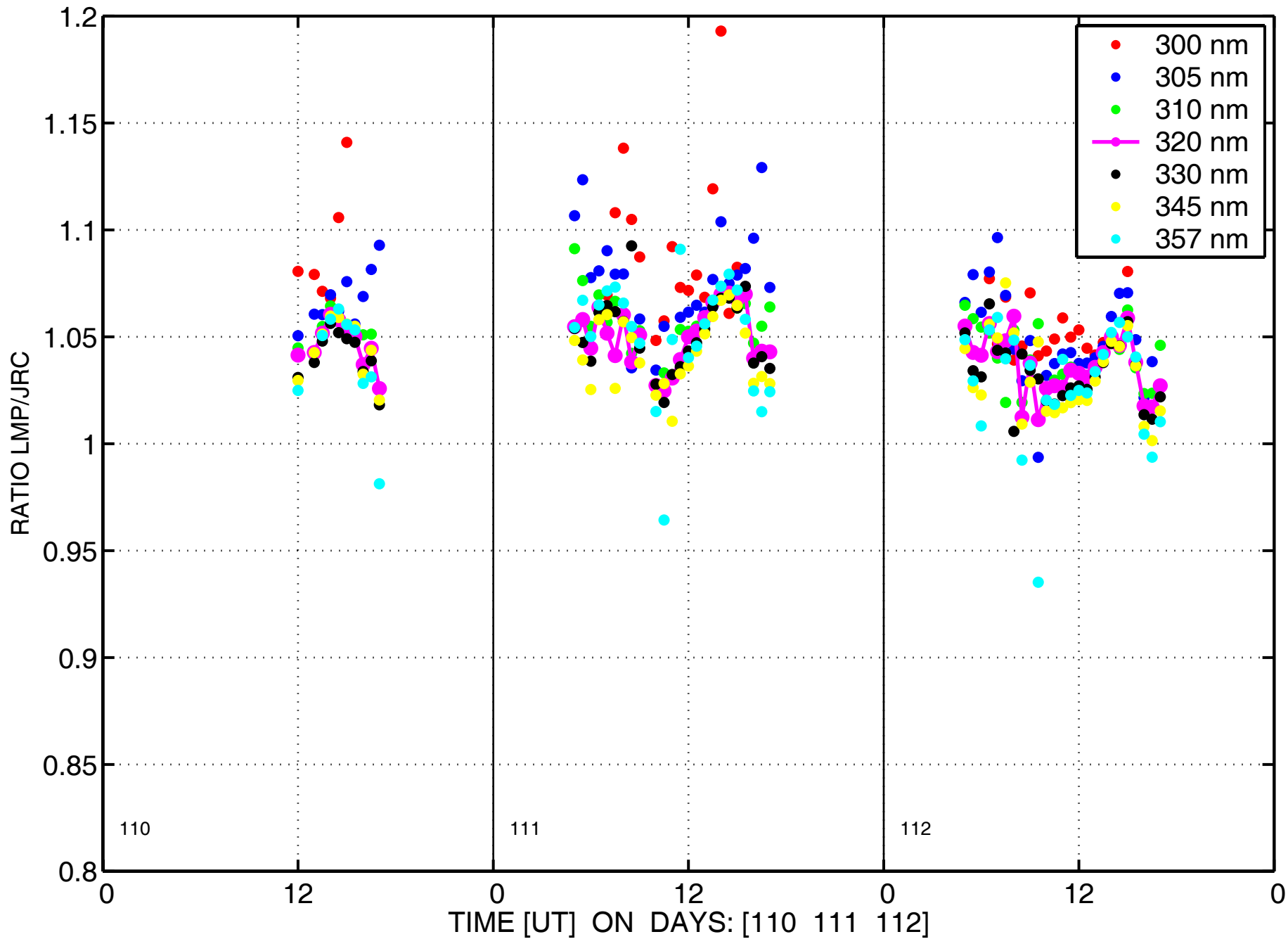
Total Radiation Lampedusa April 19 21 2004



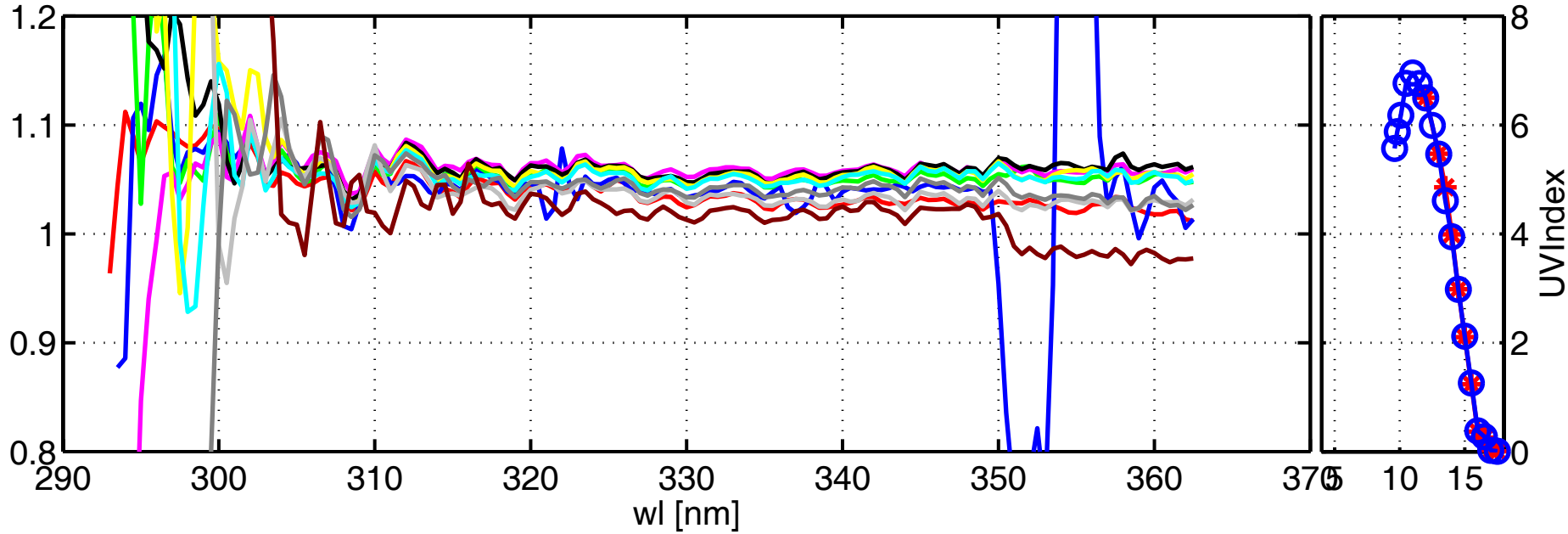
UV Index Lampedusa April 19–21 2004



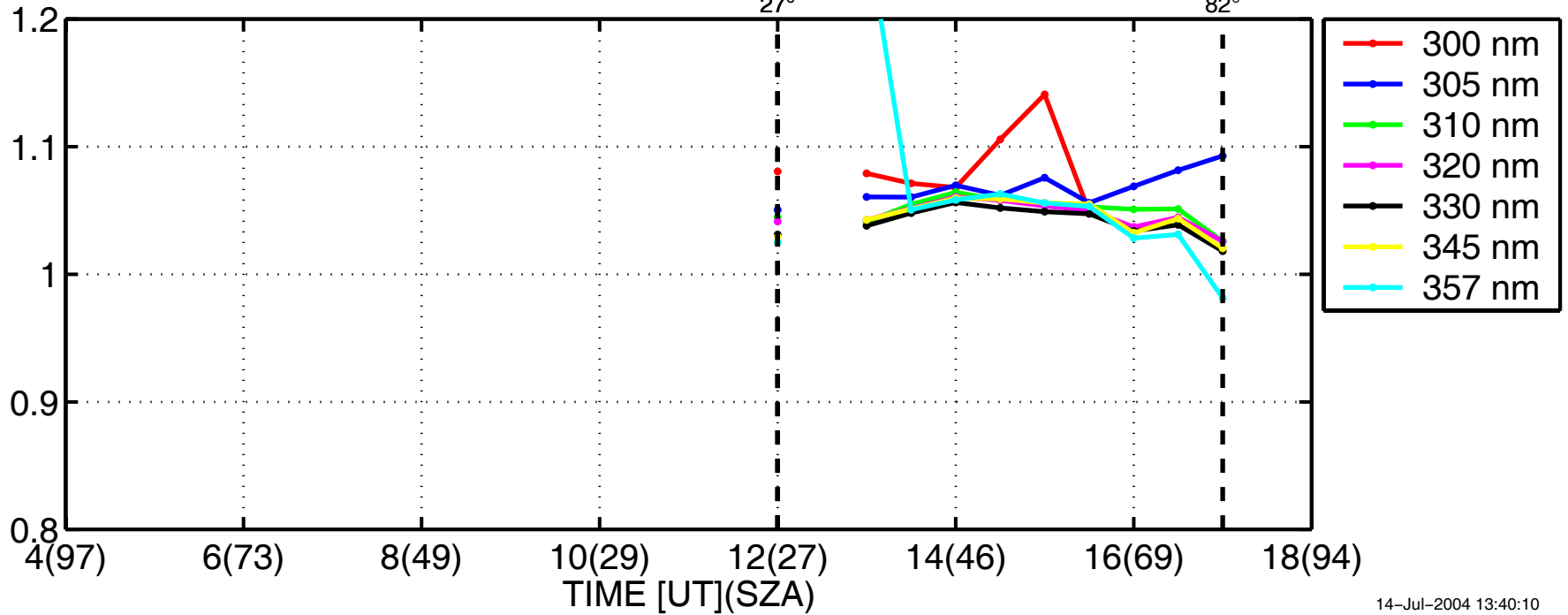
Global irradiance ratios LMP/JRC at Lampedusa:19-Apr-2004(110) to 21-Apr-2004(112)



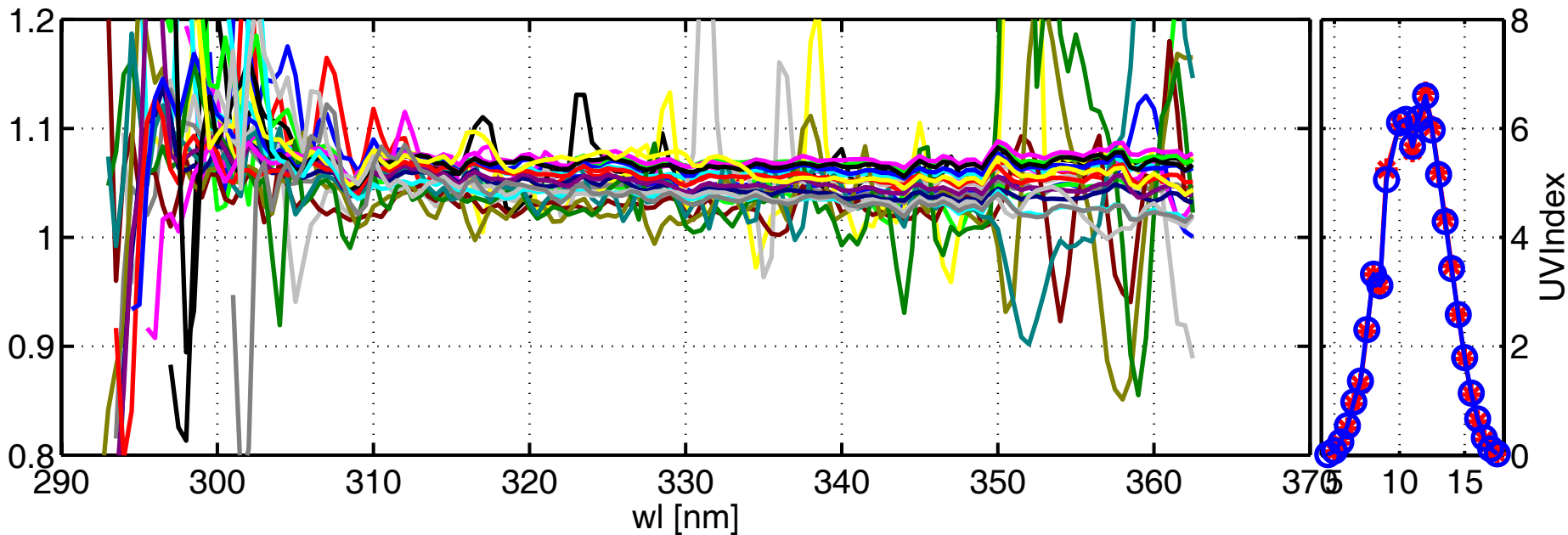
Global irradiance ratios LMP/JRC at Lampedusa:19-Apr-2004(110)



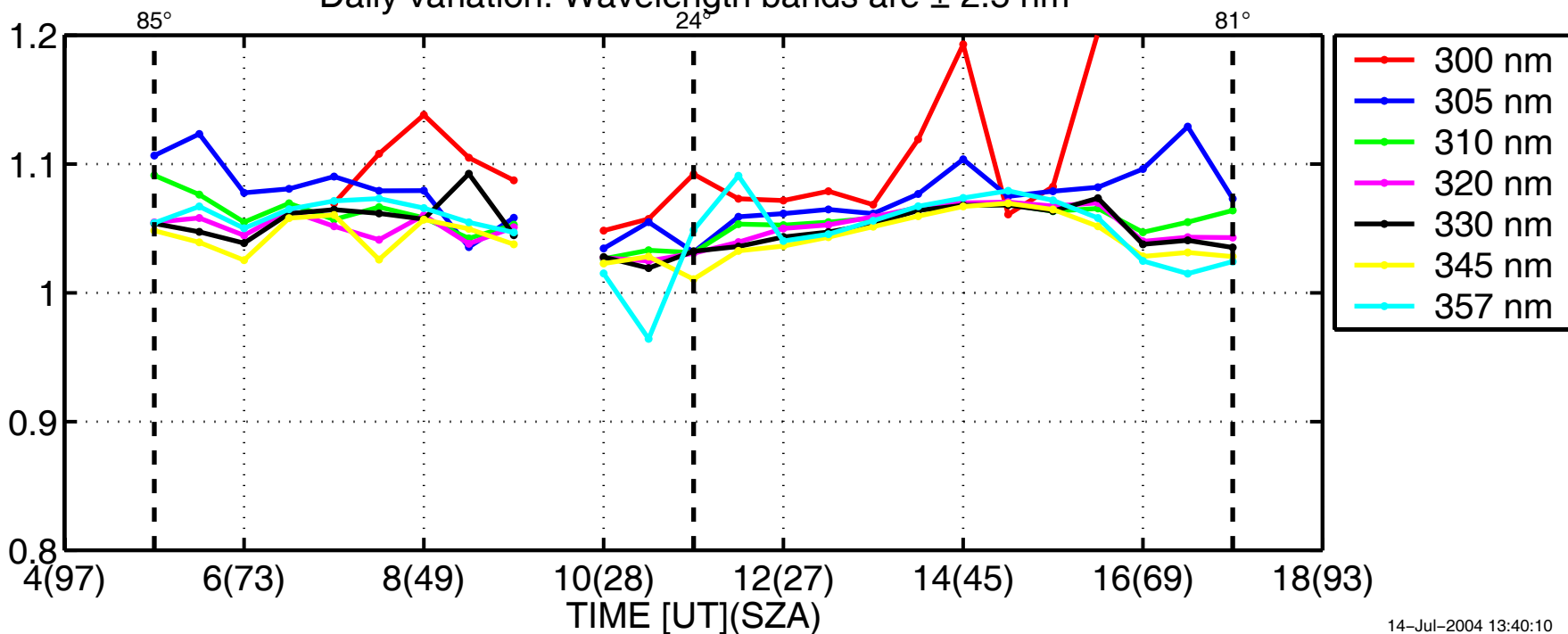
Daily variation. Wavelength bands are ± 2.5 nm



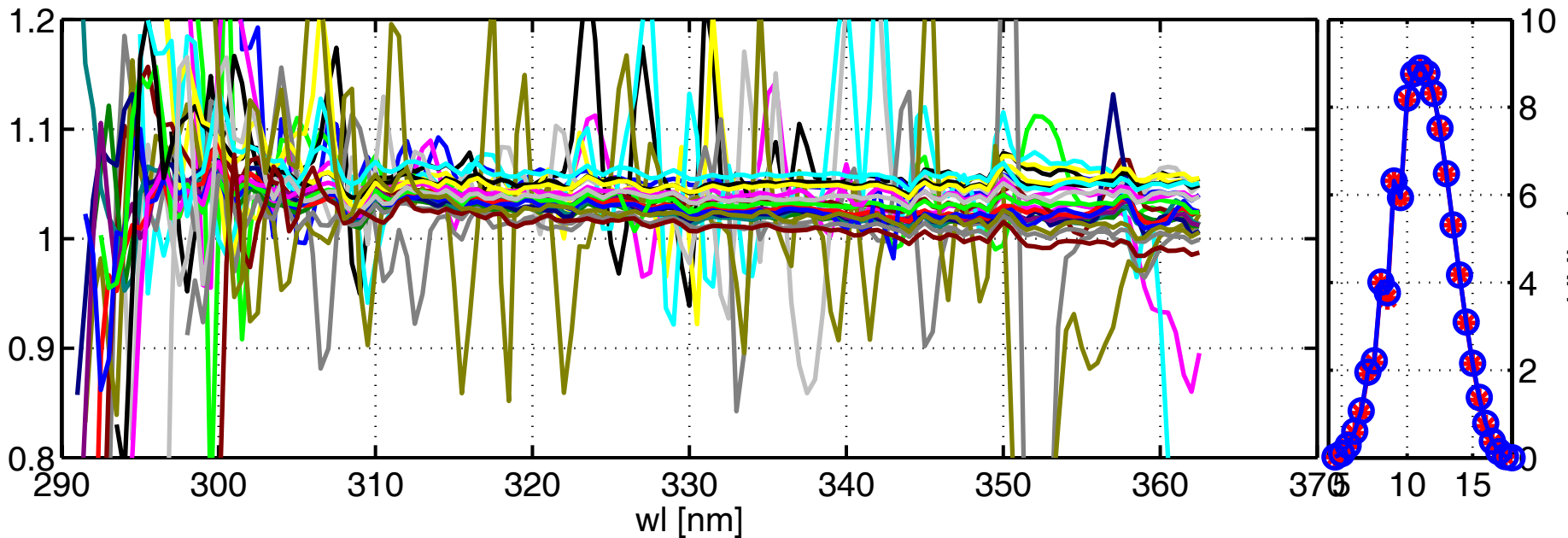
Global irradiance ratios LMP/JRC at Lampedusa:20-Apr-2004(111)



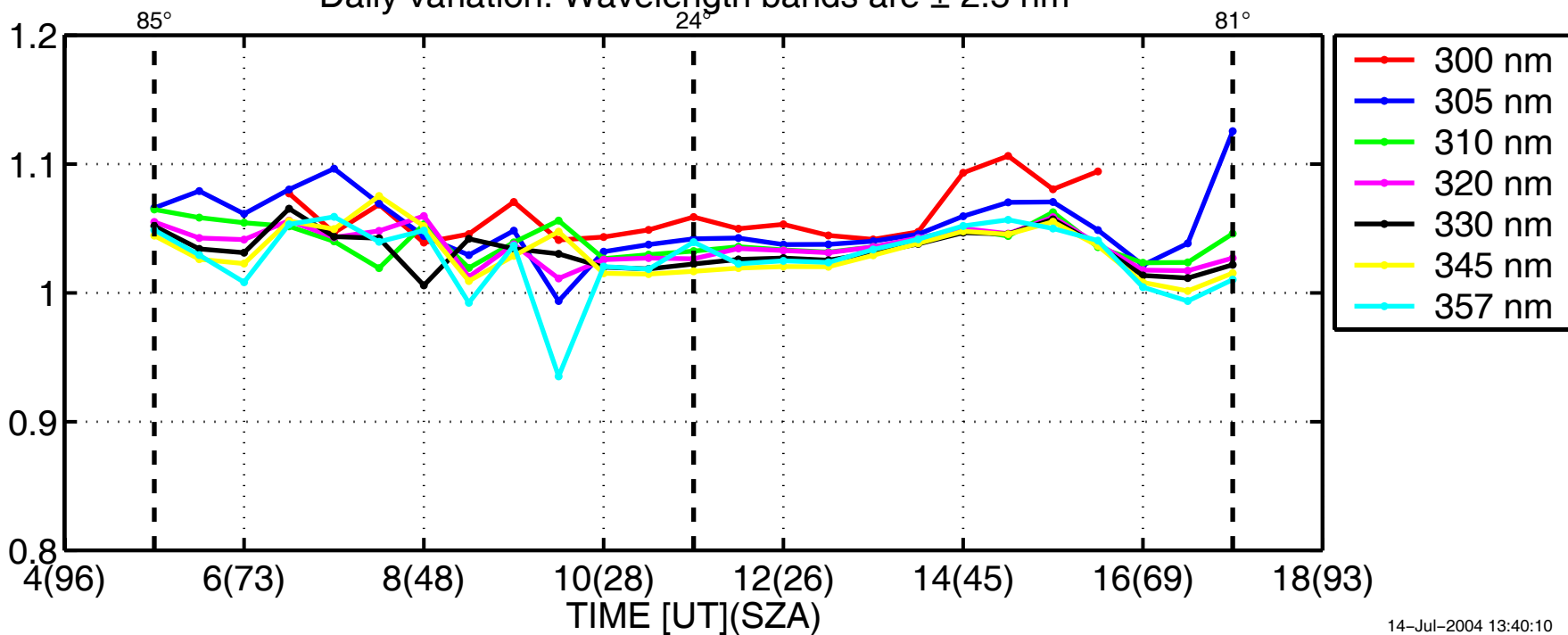
Daily variation. Wavelength bands are ± 2.5 nm



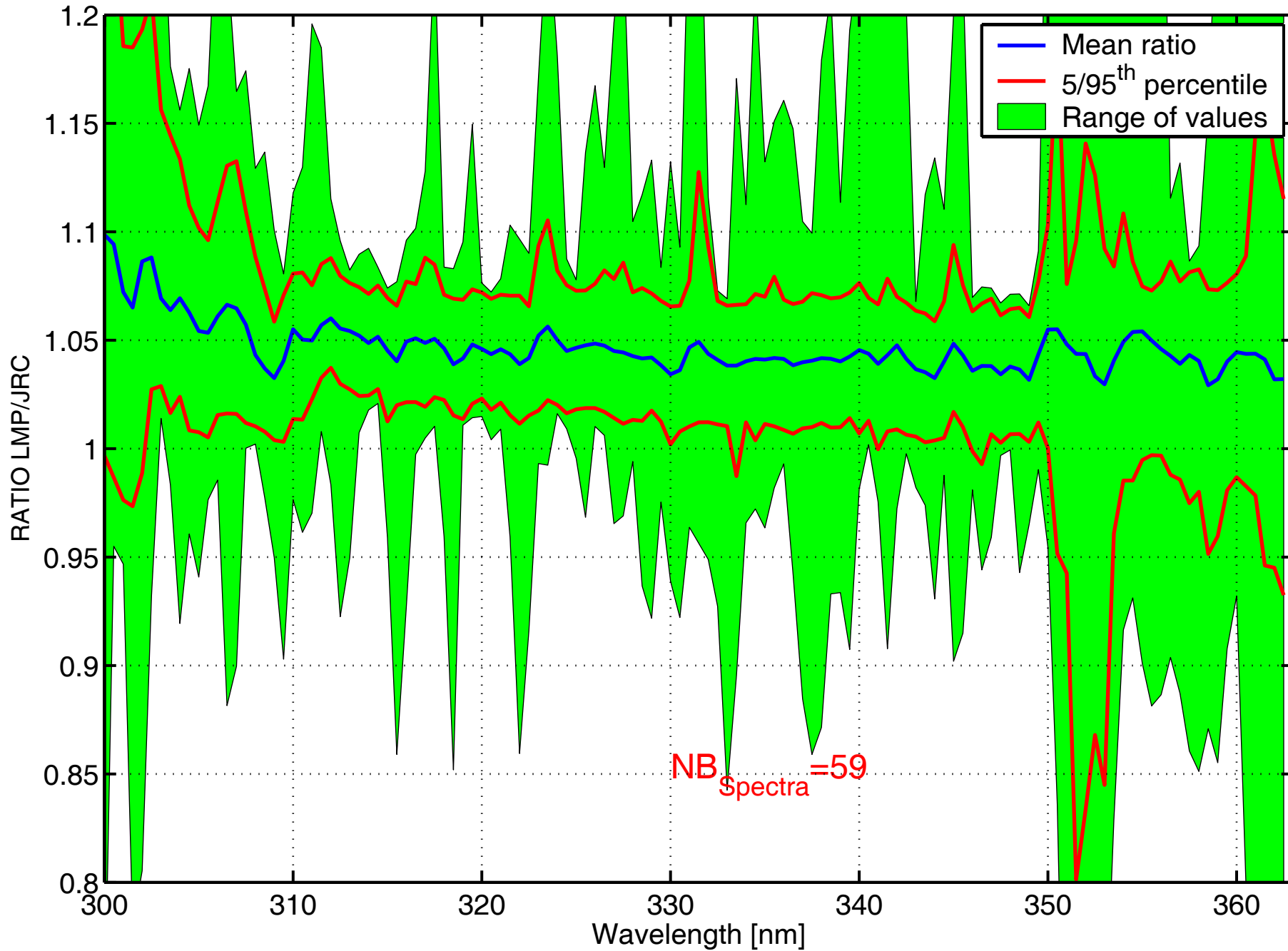
Global irradiance ratios LMP/JRC at Lampedusa:21-Apr-2004(112)



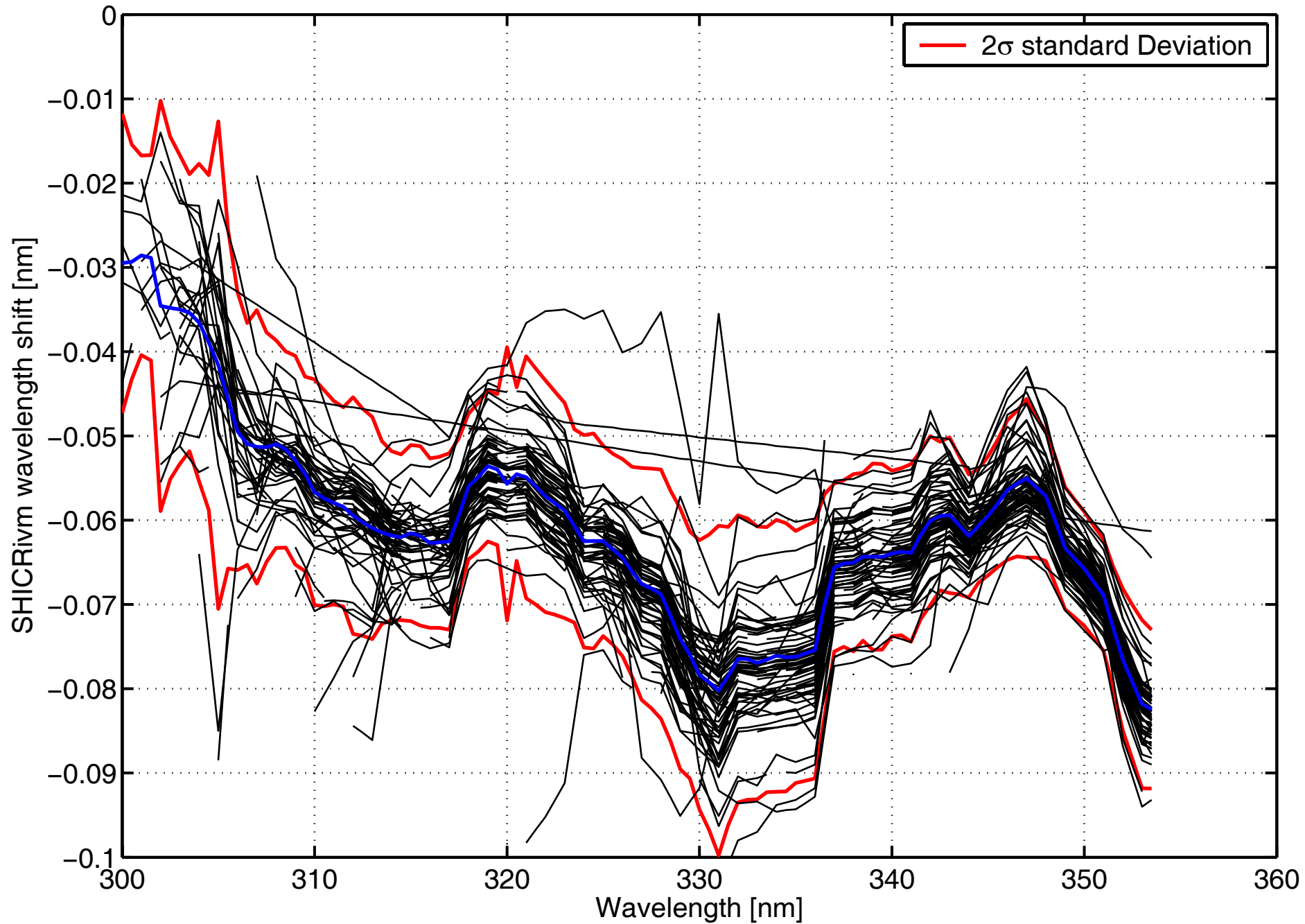
Daily variation. Wavelength bands are ± 2.5 nm



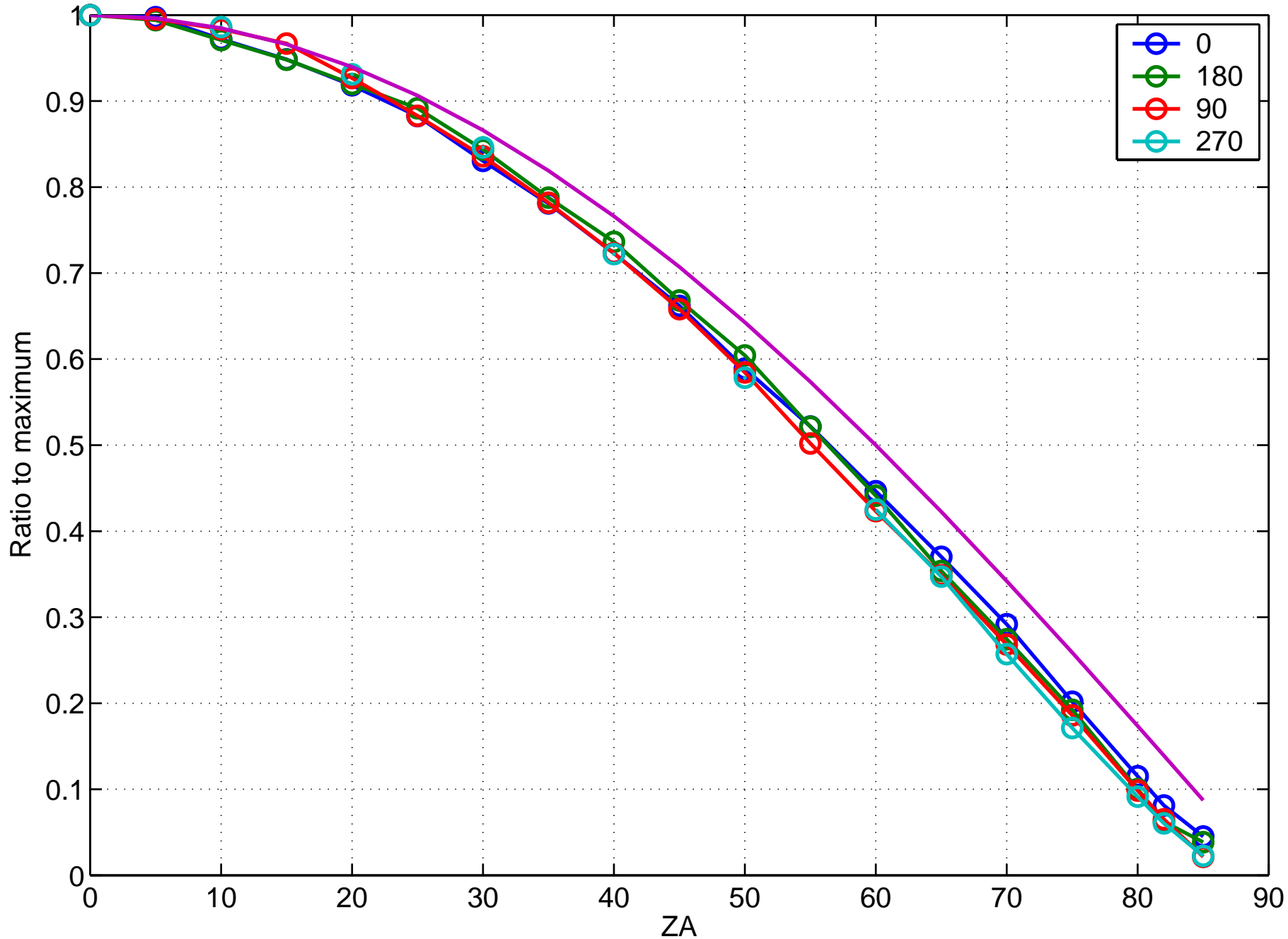
Mean ratio LMP/JRC at Lampedusa:19-Apr-2004(110) to 21-Apr-2004(112)



LMP - Lampedusa April 19-21 2004



Cosine response Br#123 Lampedusa 22/4/2004



Cosine error Br#123 Lampedusa 22/4/2004

