

Protocol of the solar UV intercomparison at INTA, El Arenosillo, Spain from May 30 to June 7, 2017 with the travelling reference spectroradiometer QASUME from PMOD/WRC

Report prepared by Julian Gröbner

Operator: Julian Gröbner (QASUME)

The purpose of the visit was the comparison of spectral global solar irradiance measurements between the 14 spectrophotometers participating at the 12th Regional Brewer Calibration Center – Europe (RBCC-E) Campaign and the travel reference spectroradiometer QASUME. The measurement site is located at El Arenosillo; Latitude 37.10 N, Longitude 6.73 W and altitude 50 m a.s.l.

The horizon of the measurement site is free down to at least 85° solar zenith angle (SZA). Measurements between 6:00 UT and 19:00 UT have been analysed.

QASUME arrived at INTA in the morning of May 29, 2017. The spectroradiometer was installed in line to the Brewer spectrophotometers with the entrance optic of QASUME between 2 and 20 m away from the other instruments. The measurement campaign lasted nine days, from morning of May 30 to the afternoon of June 7; the core comparison days were June 4-7.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Two lamps (T61252, T68523) were used to obtain an absolute spectral irradiance calibration traceable to the primary reference held at PMOD/WRC, 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 wavelength shifts relative to an extraterrestrial spectrum as retrieved from the matSHIC analysis were between ± 50 nm in the spectral range 290 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. The official UV days were scheduled from 4 to 7 June.

DOY	Date	Weather	Comment (time in UT)
155	4-Jun	Clear sky, cirrus	Calibrated at 10:32 using T68523
156	5-Jun	Clear Sky	Calibrated at 6:44 using T68523 Calibrated at 15:02 using T68523
157	6-Jun	Clear sky, cirrus	Calibrated:12:02 using T68523
158	07-Jun	Clear Sky	Calibrated at 1426 using

Results:

Up to 92 synchronised simultaneous spectra from QASUME and the Brewer spectrophotometers are available from the measurement period. Measurements between 6:00 and 19:00 UT have been analysed (SZA smaller than 90°) using matSHIC. An angular response correction was applied to the solar UV spectra of the Brewer spectrophotometers using the methodology developed by FMI (Lakkala, K., Arola, A., Gröbner, J., León-Luis, S. F., Redondas, A., Kazadzis, S., Karppinen, T., Karhu, J. M., Egli, L., Heikkilä, A., Koskela, T., Serrano, A., and Vilaplana, J. M.: Performance of the FMI cosine error correction method for the Brewer spectral UV measurements, *Atmos. Meas. Tech.*, 11, 5167-5180, <https://doi.org/10.5194/amt-11-5167-2018>, 2018.). The absolute calibration was obtained by a common transfer standard traceable to PMOD/WRC and performed during the campaign using a portable calibration equipment.

The average ratios to QASUME are shown in Figure 1 below.

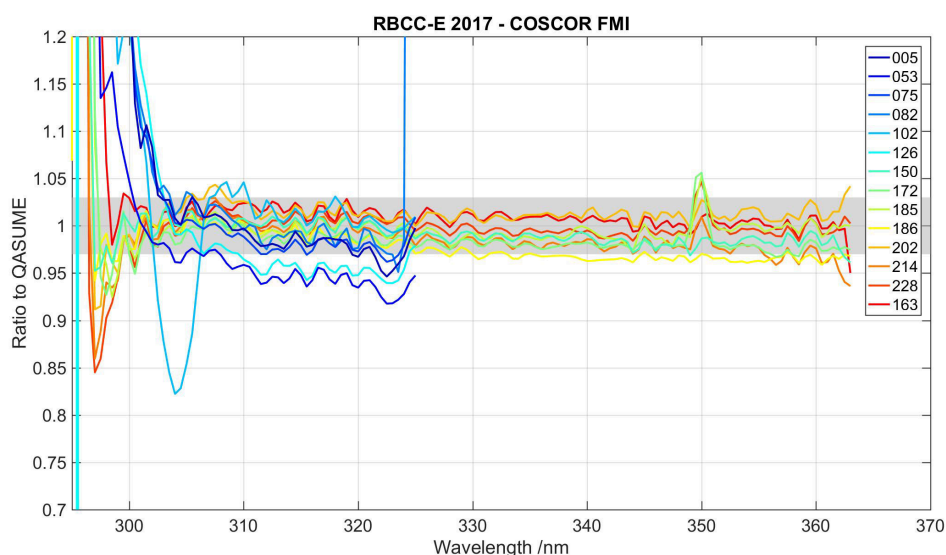


Figure 1 Average ratios from 14 Brewer spectrophotometers to QASUME for the period 4 to 7 June 2017.

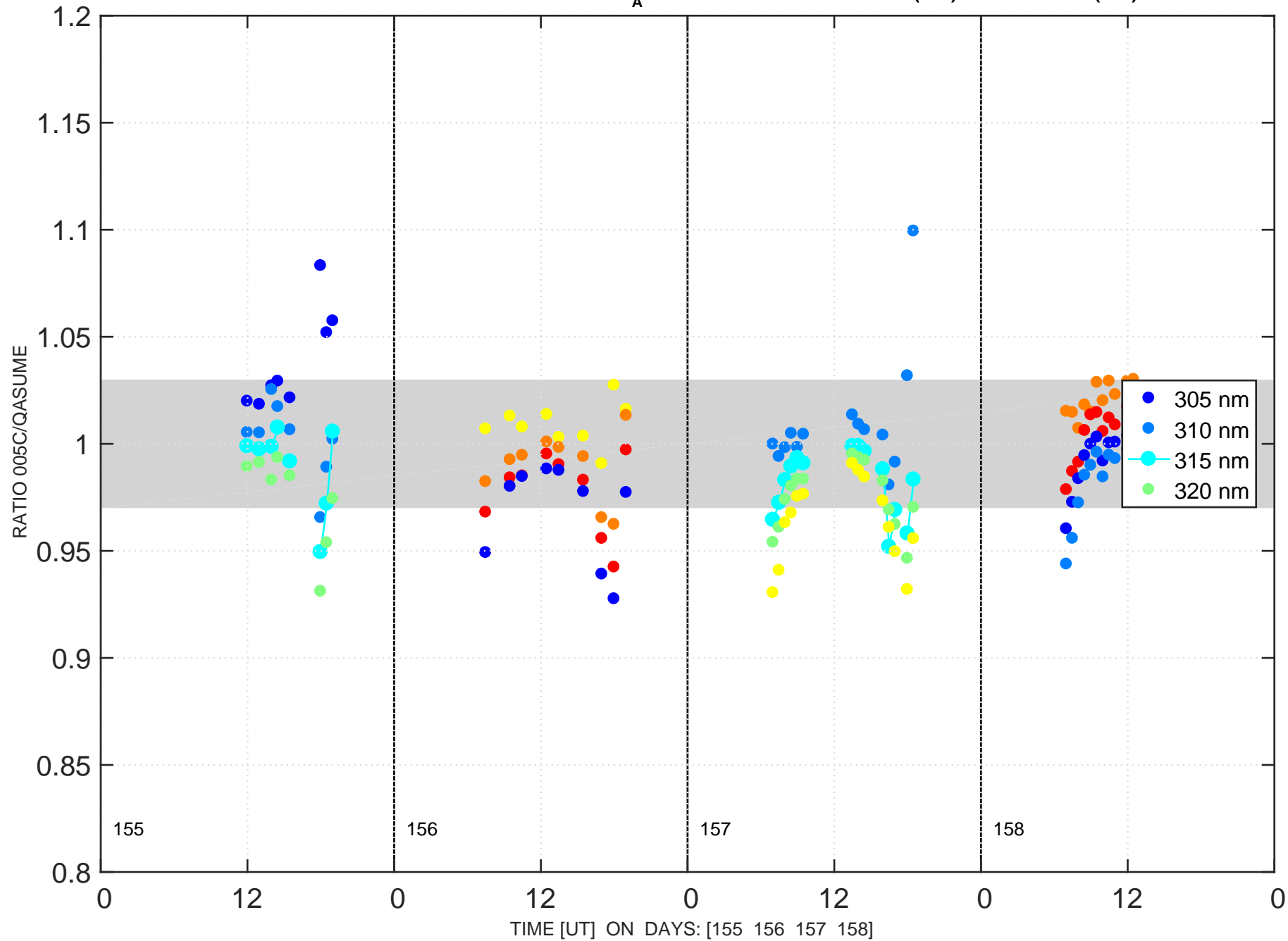
Conclusion:

- The angular response correction applied to the solar UV spectra has considerably improved the comparison to QASUME. Remaining uncertainties are the stray-light for single monochromator brewers and the temperature dependence which was only applied to Brewer #163 (ISQ).

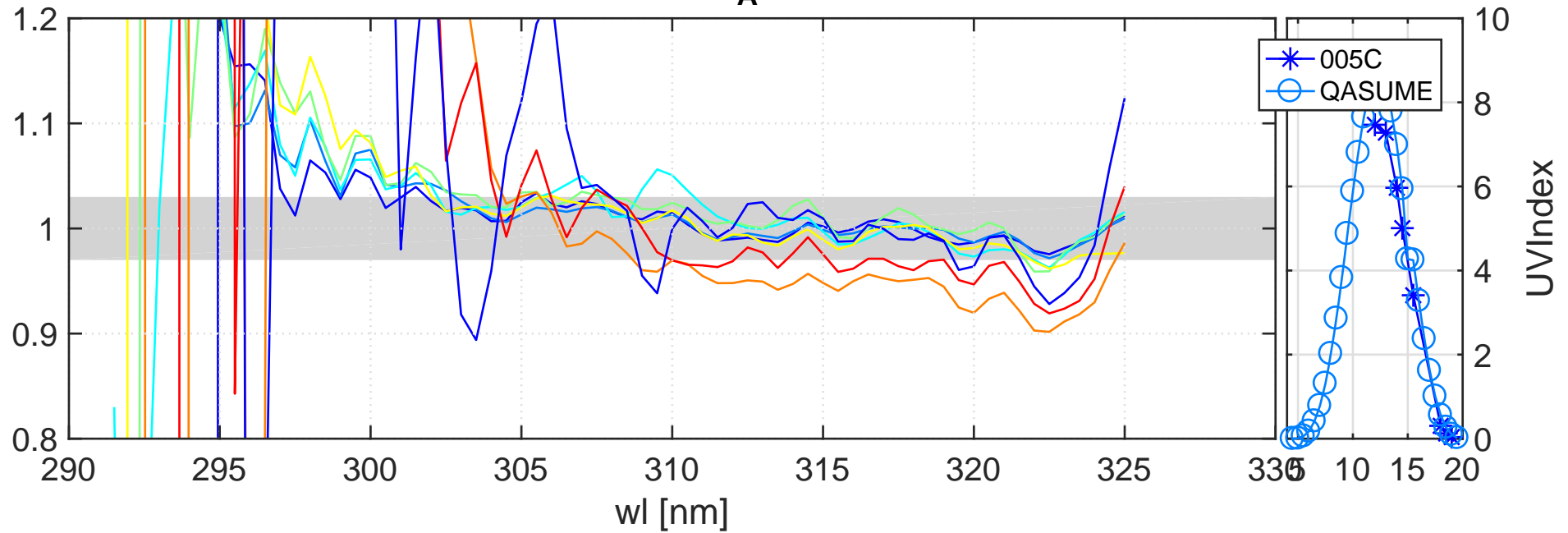
Appendix

Detailed results for all Brewer spectrophotometers with respect to the reference spectroradiometer QASUME

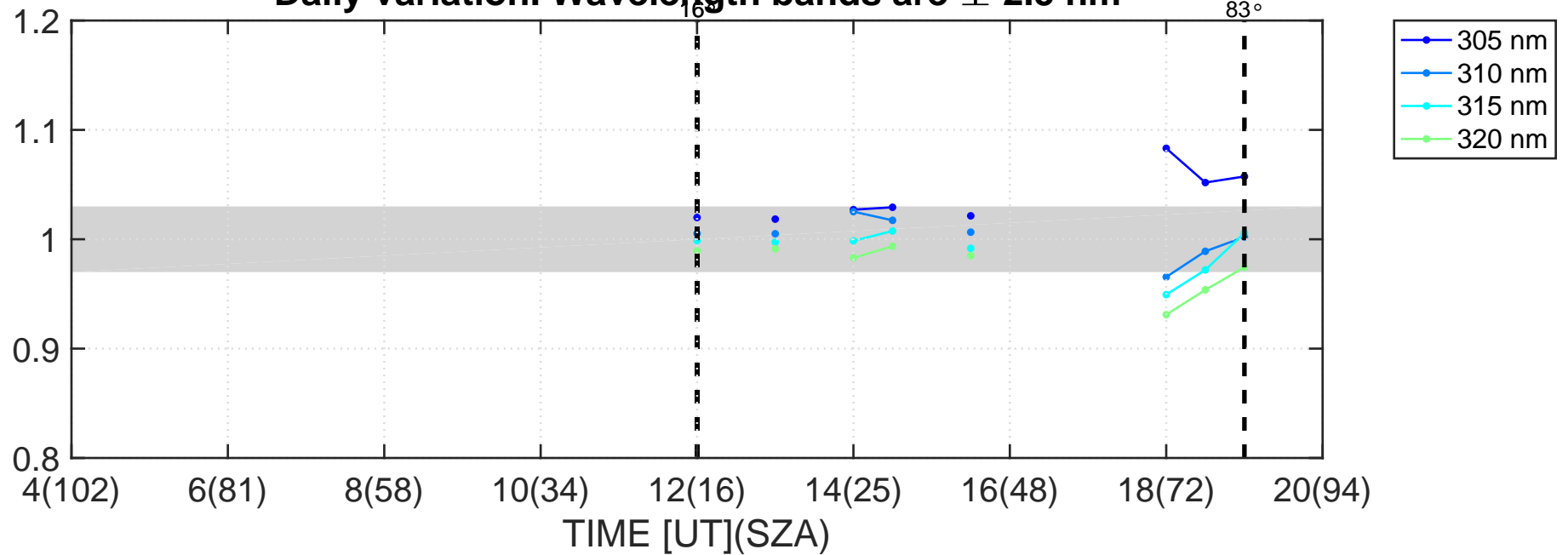
Global irradiance ratios 005C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



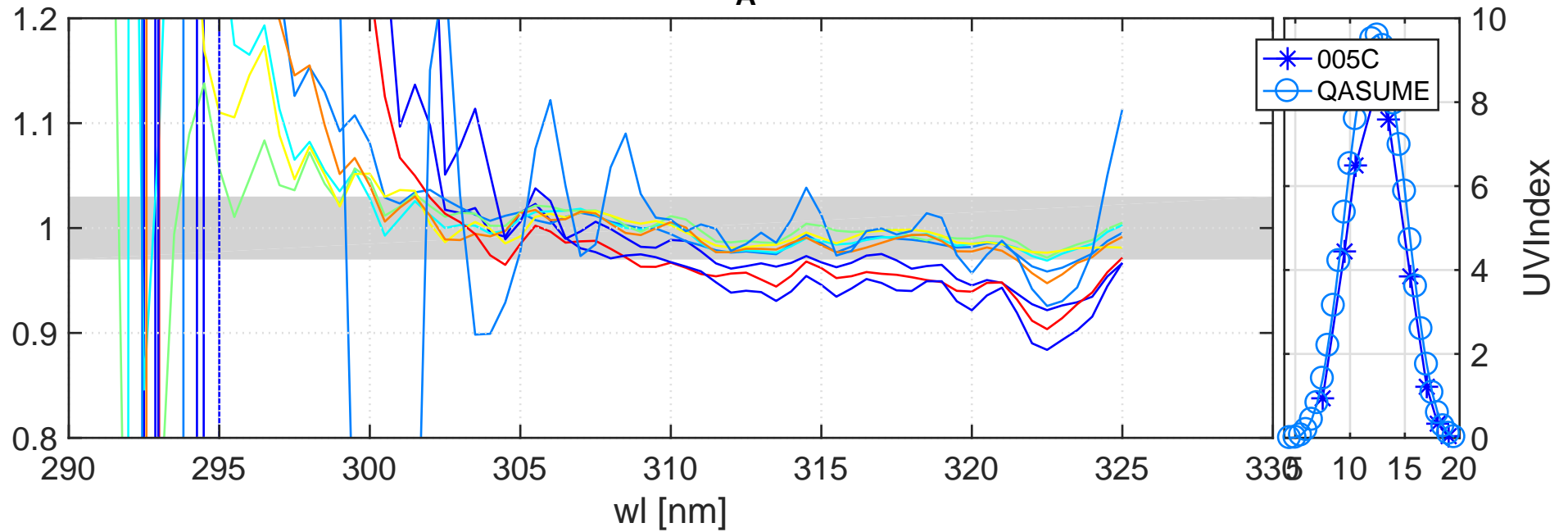
Global irradiance ratios 005C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



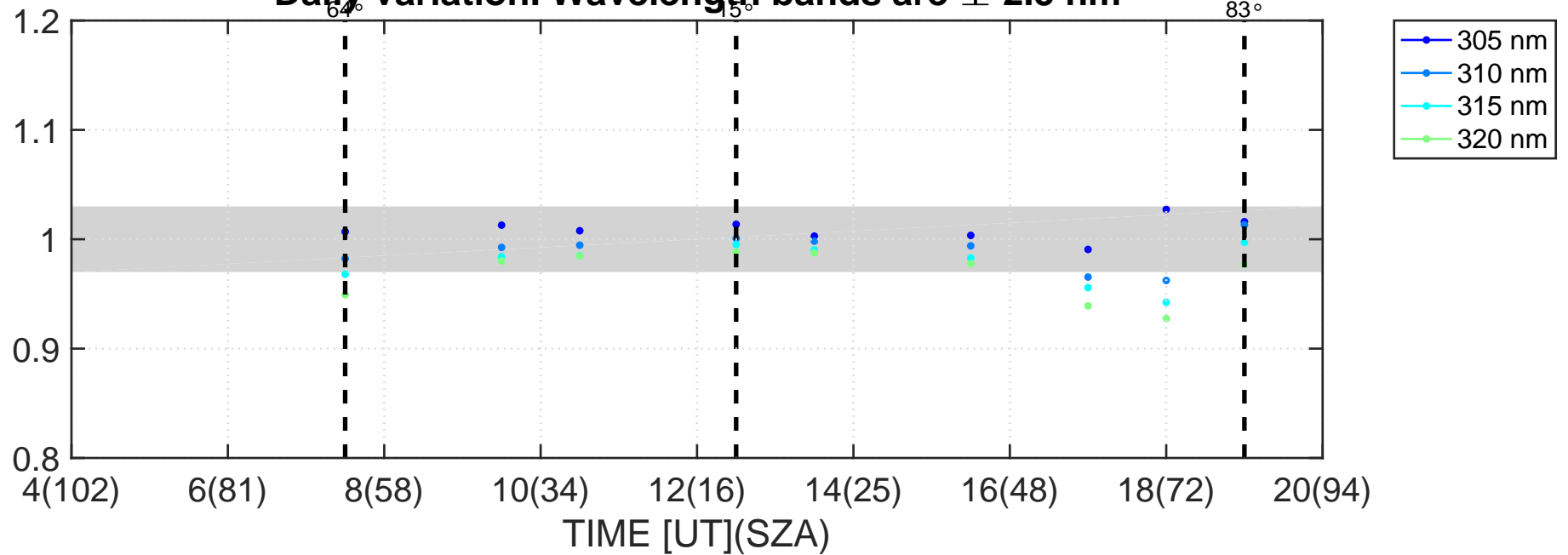
Daily variation. Wavelength bands are ± 2.5 nm



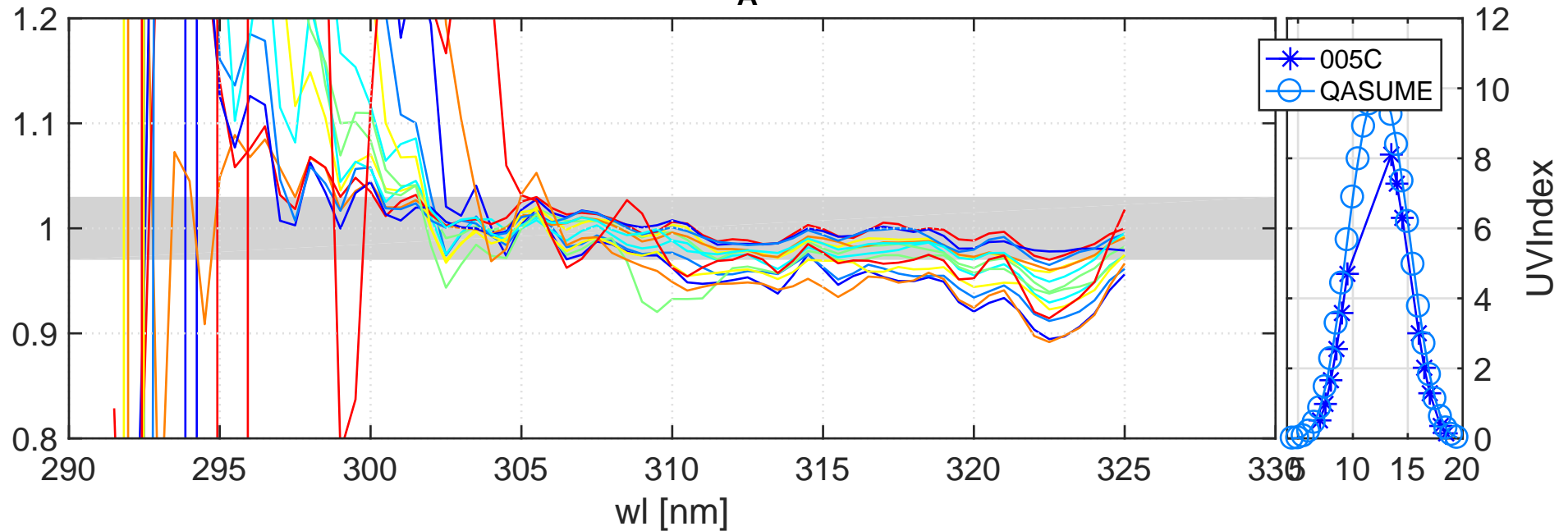
Global irradiance ratios 005C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



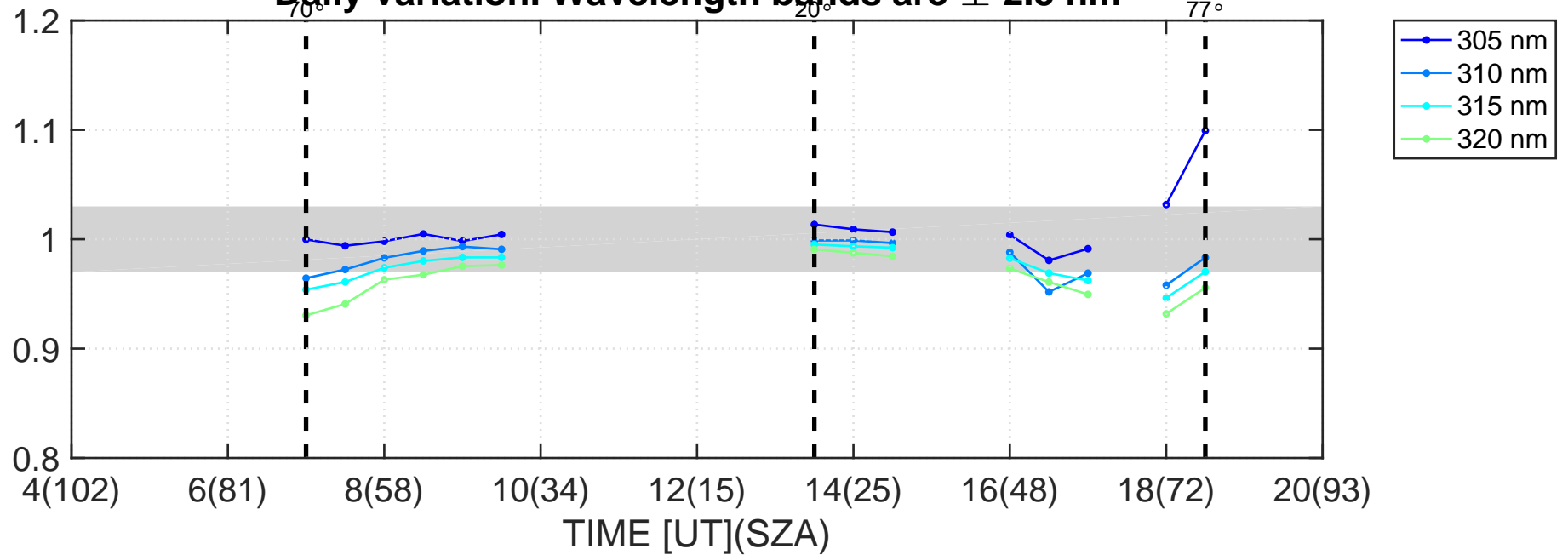
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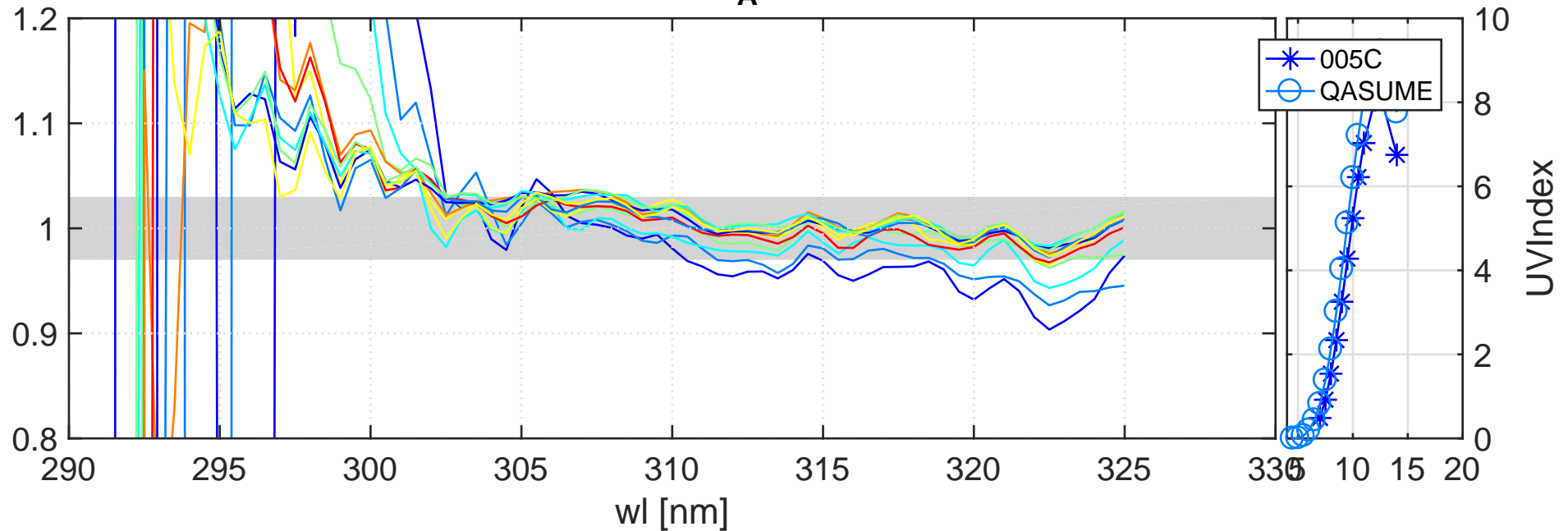
Global irradiance ratios 005C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



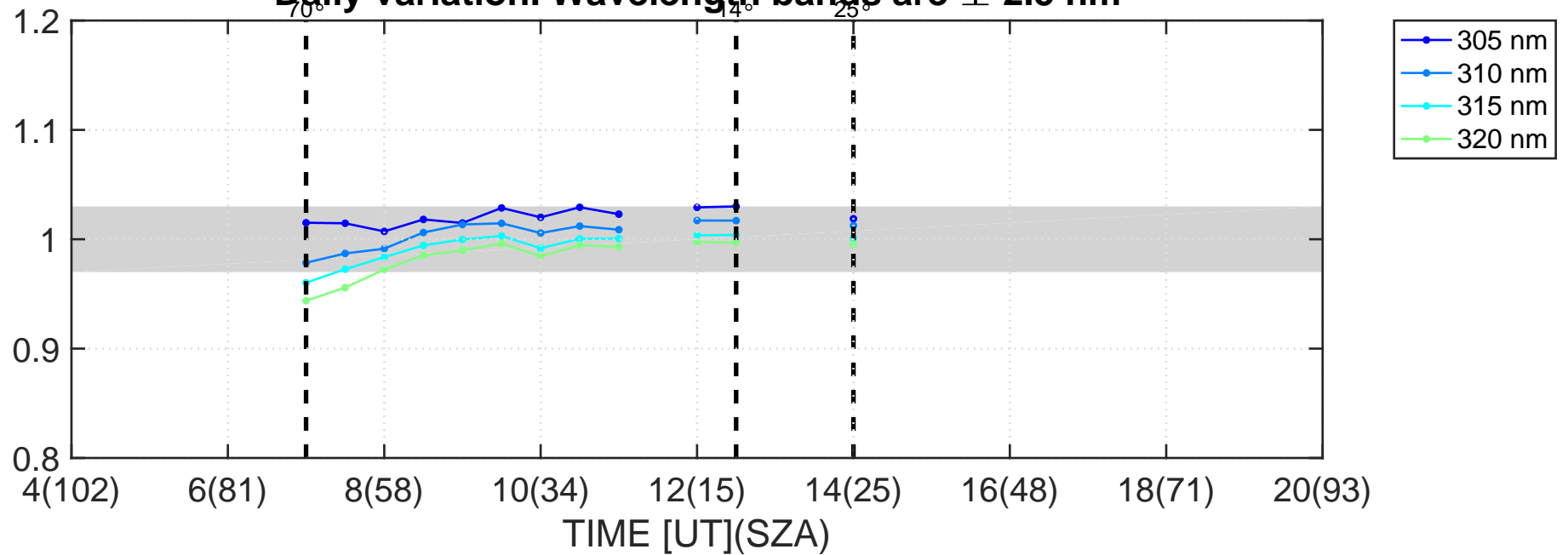
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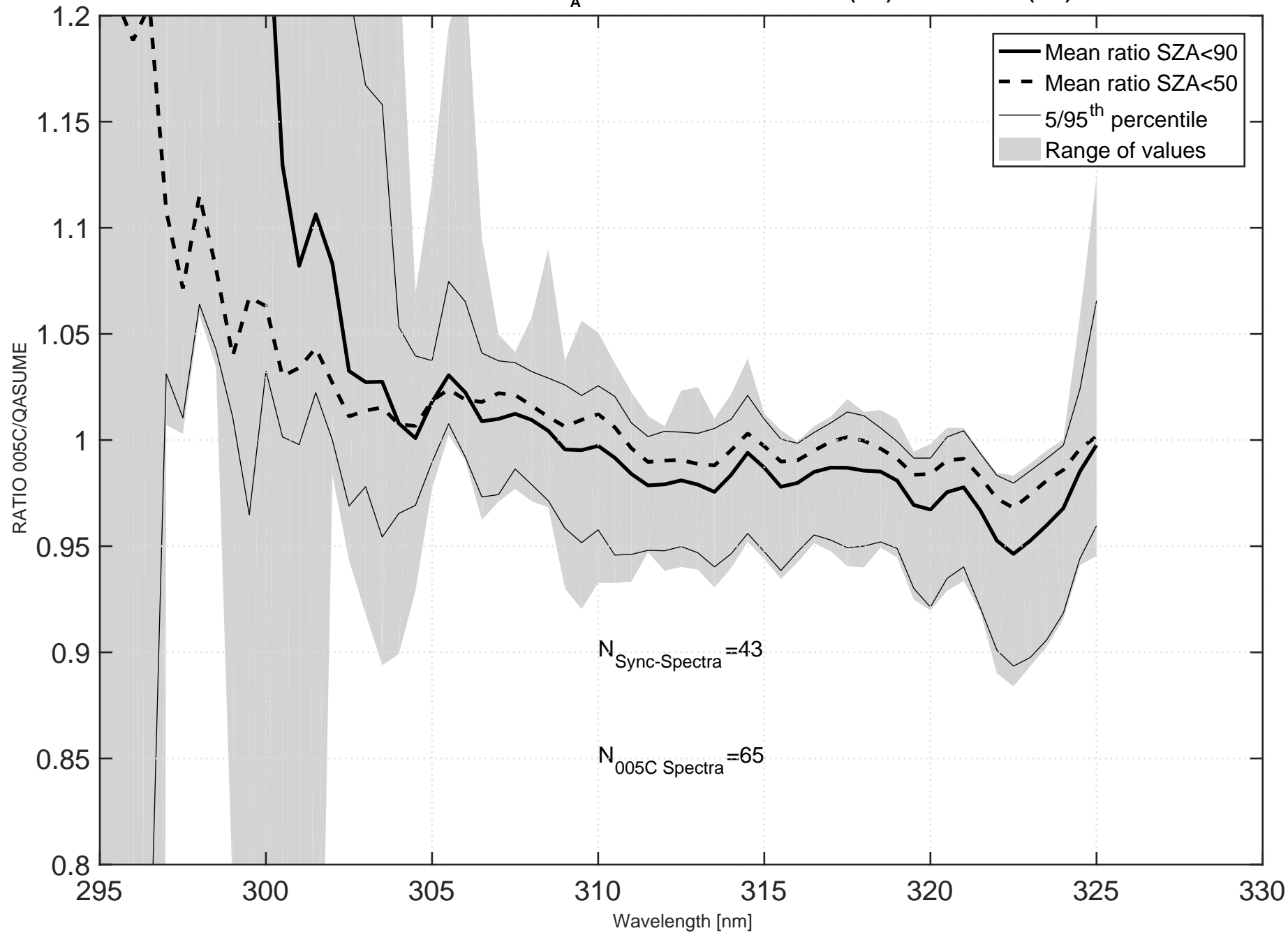
Global irradiance ratios 005C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



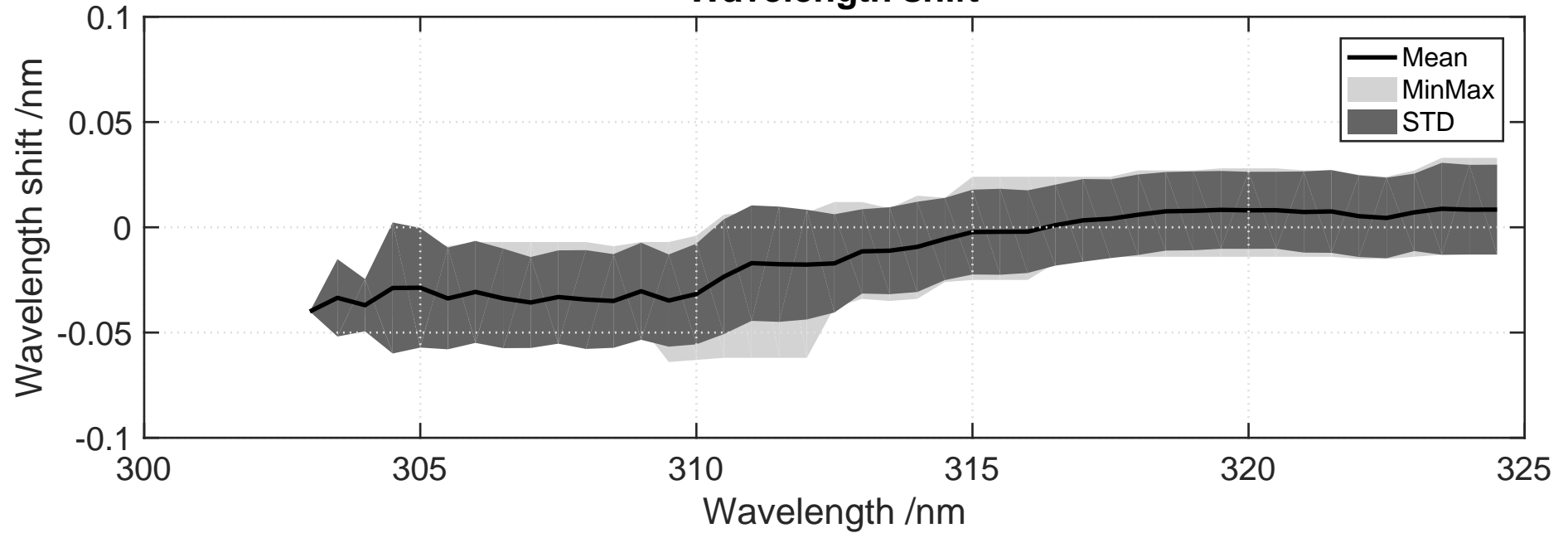
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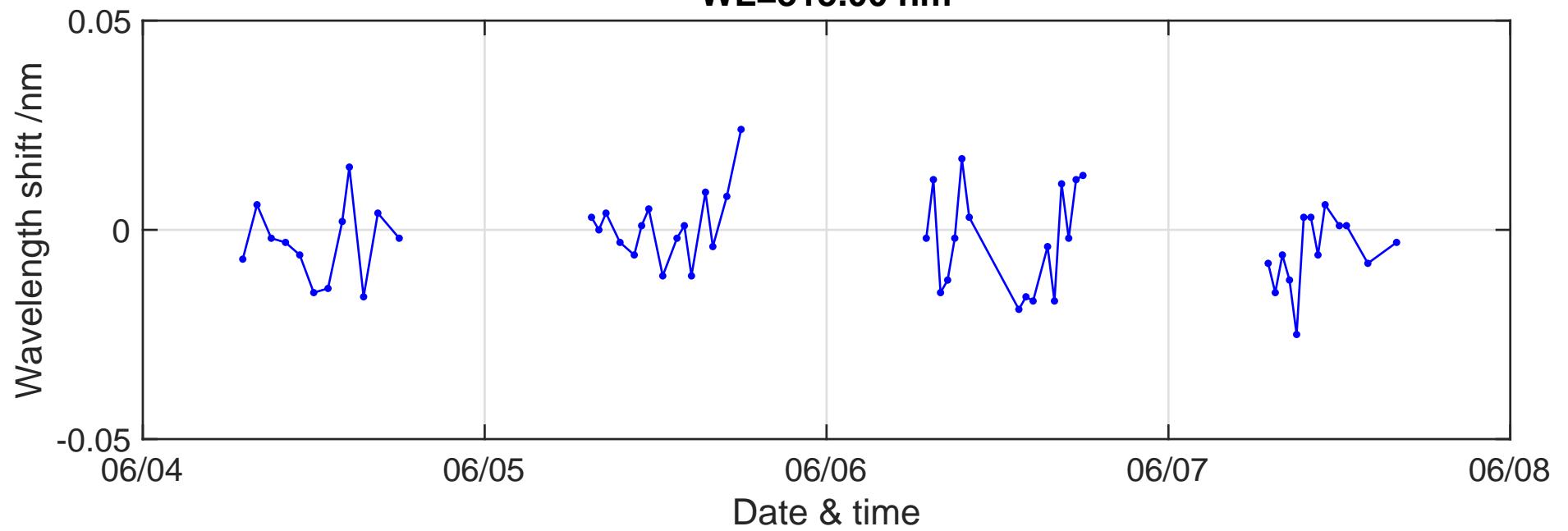
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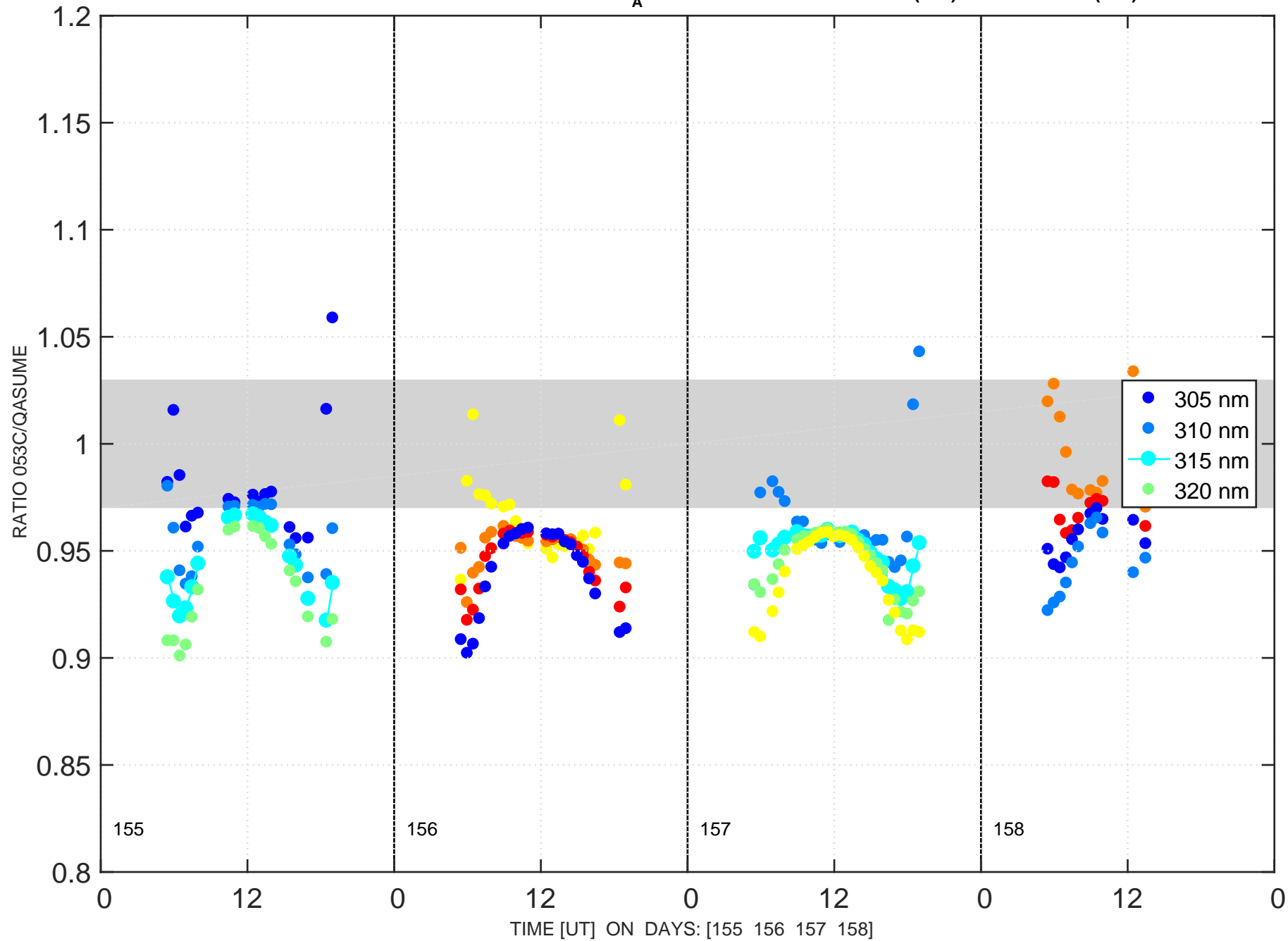
Wavelength shift



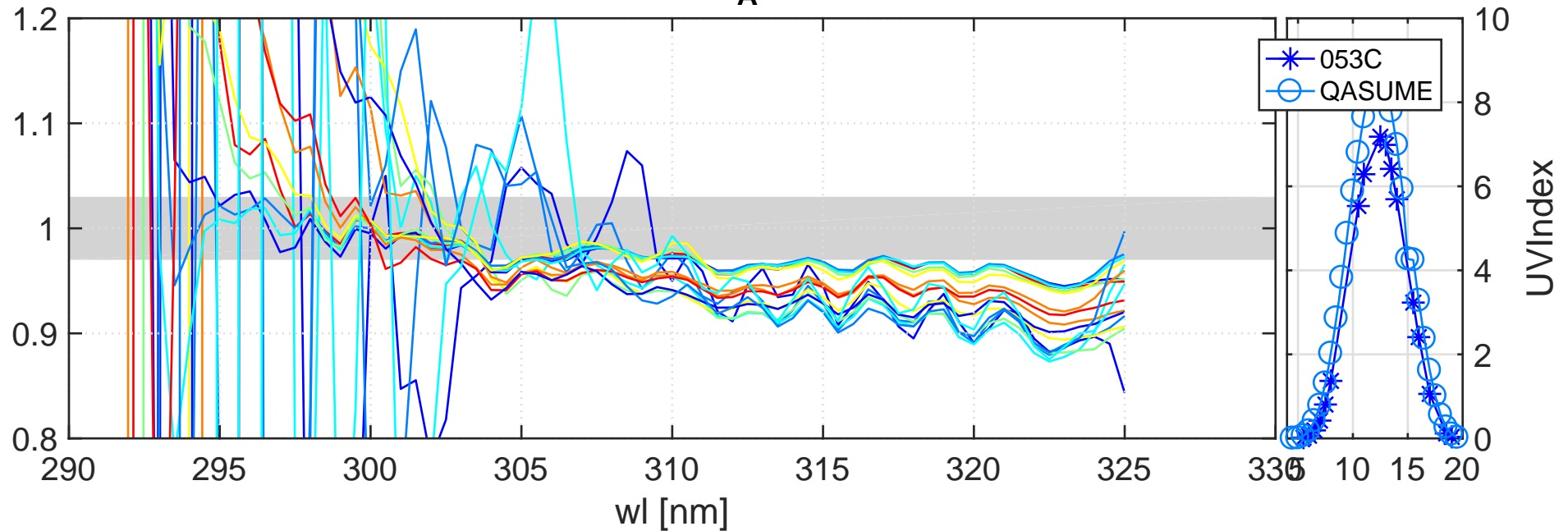
WL=315.00 nm



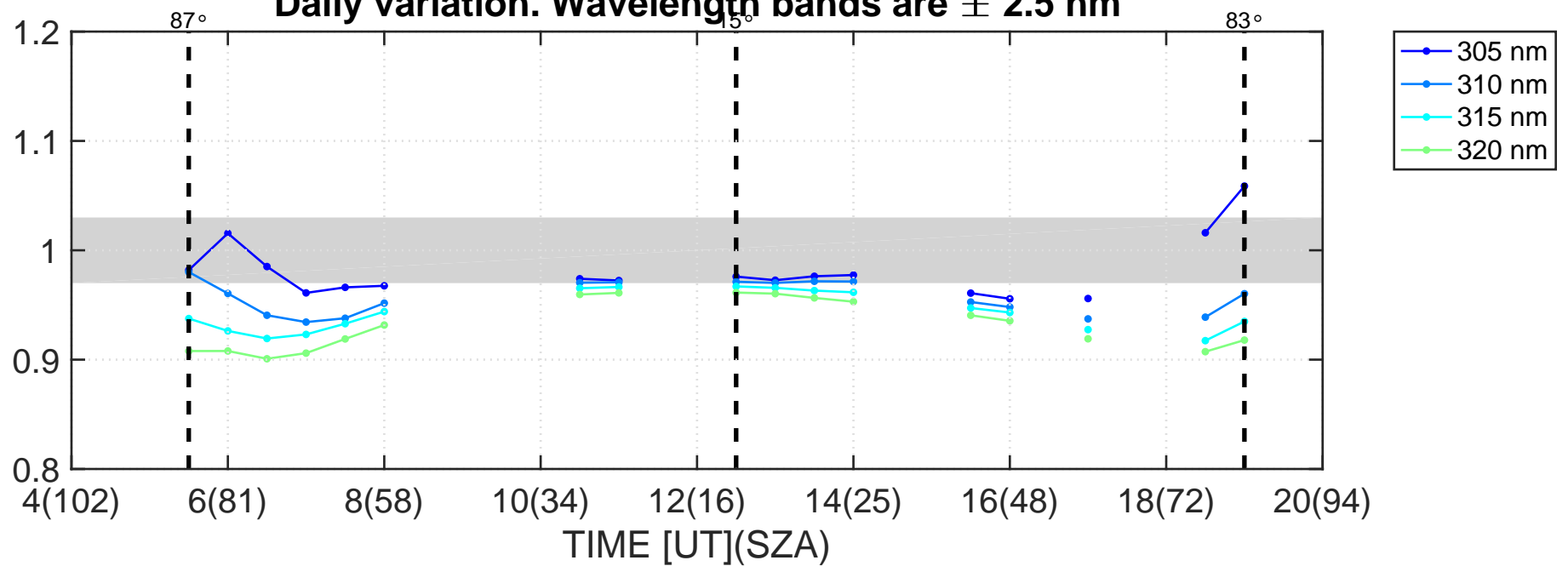
Global irradiance ratios 053C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



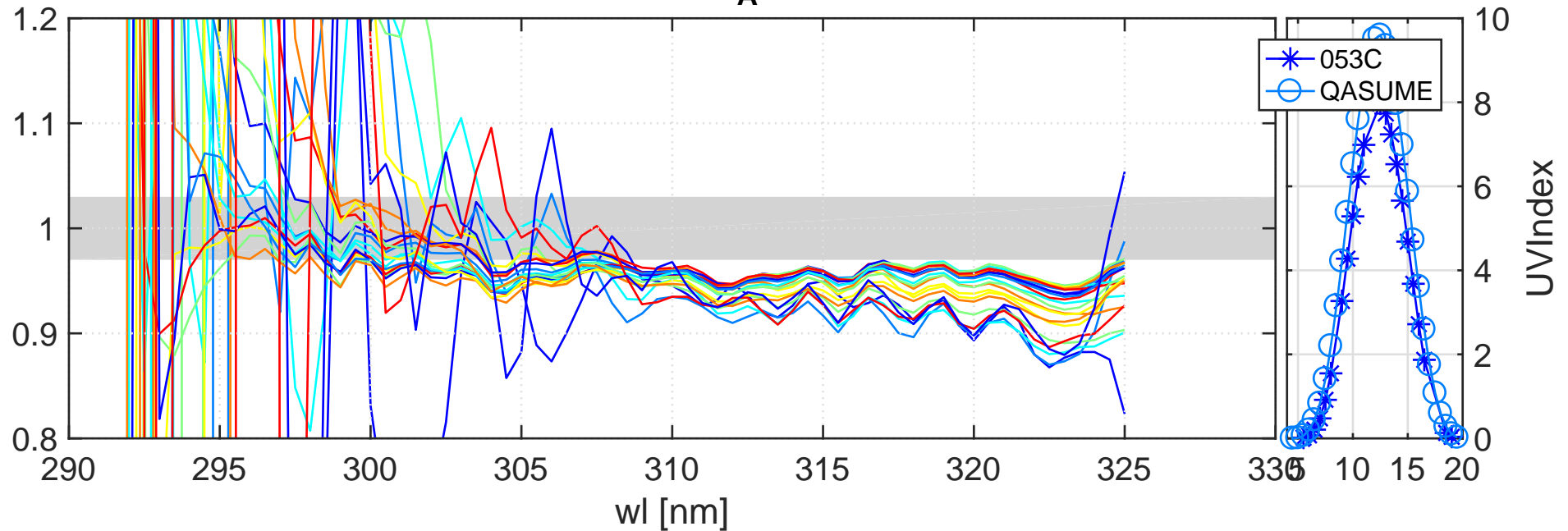
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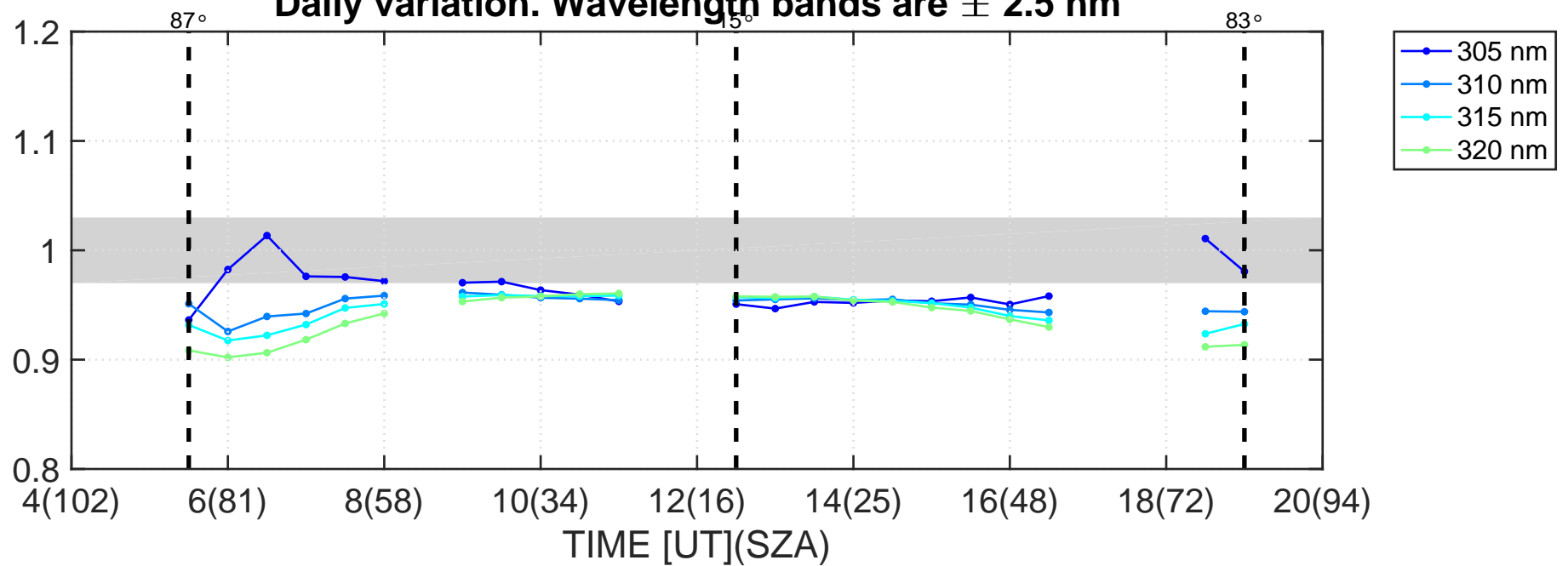
Daily variation. Wavelength bands are ± 2.5 nm



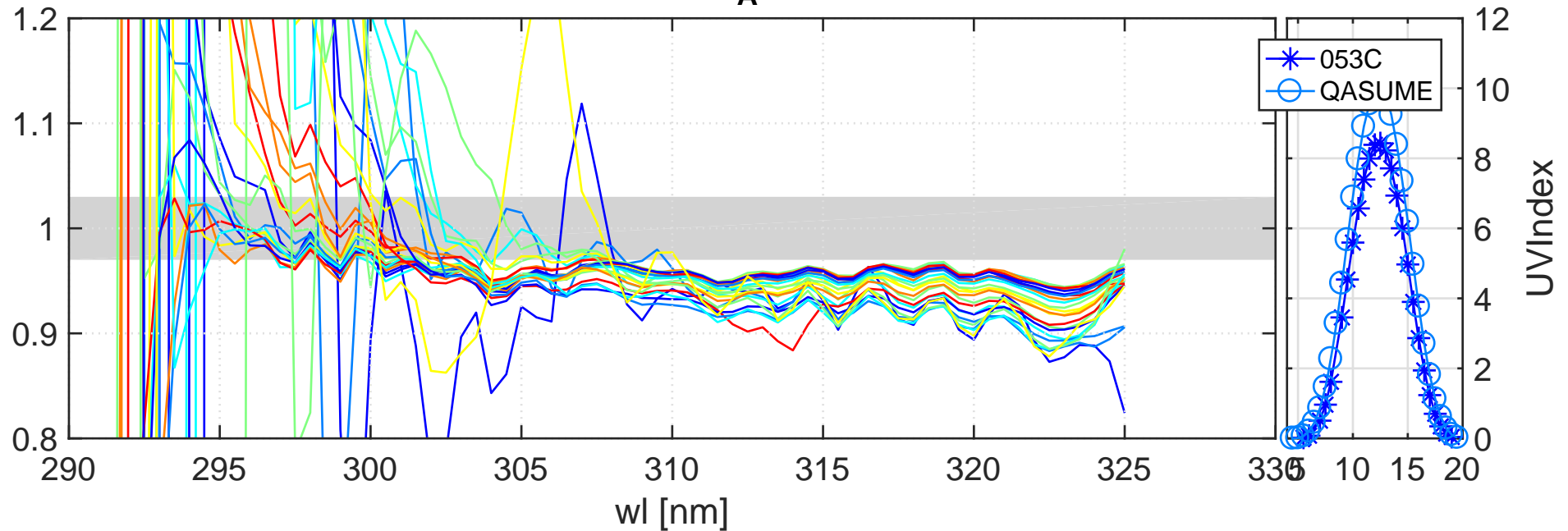
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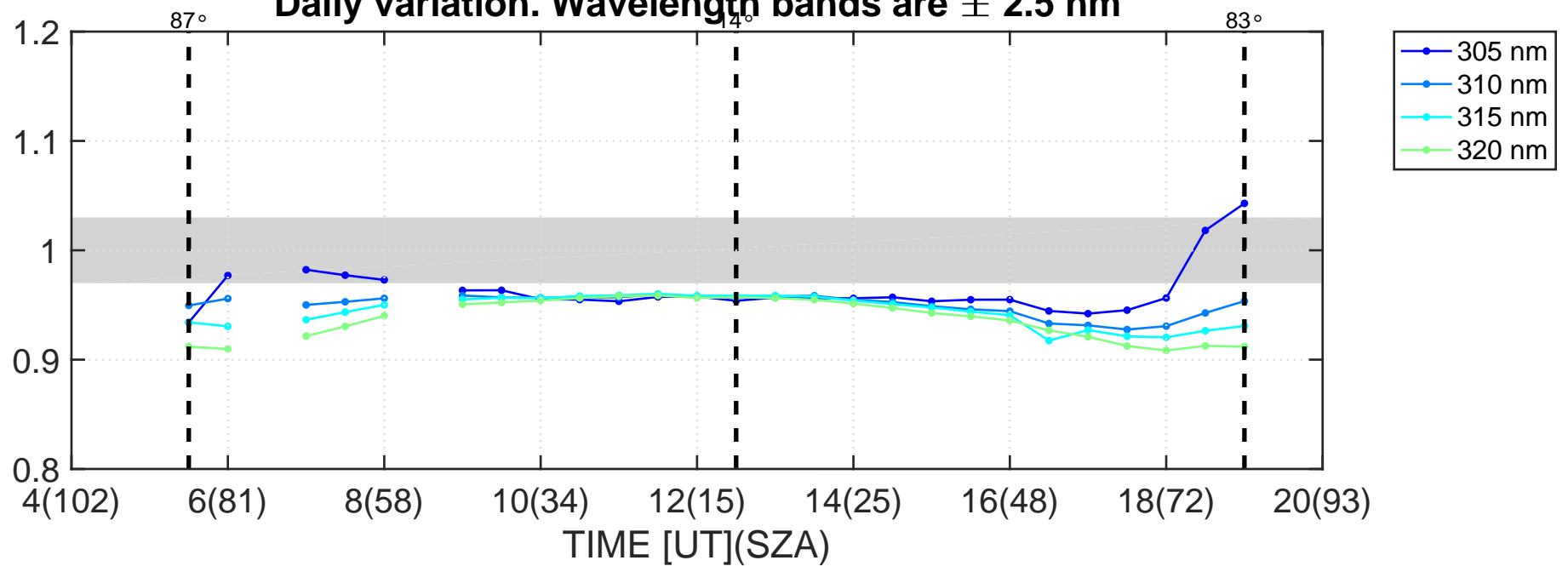
Daily variation. Wavelength bands are ± 2.5 nm



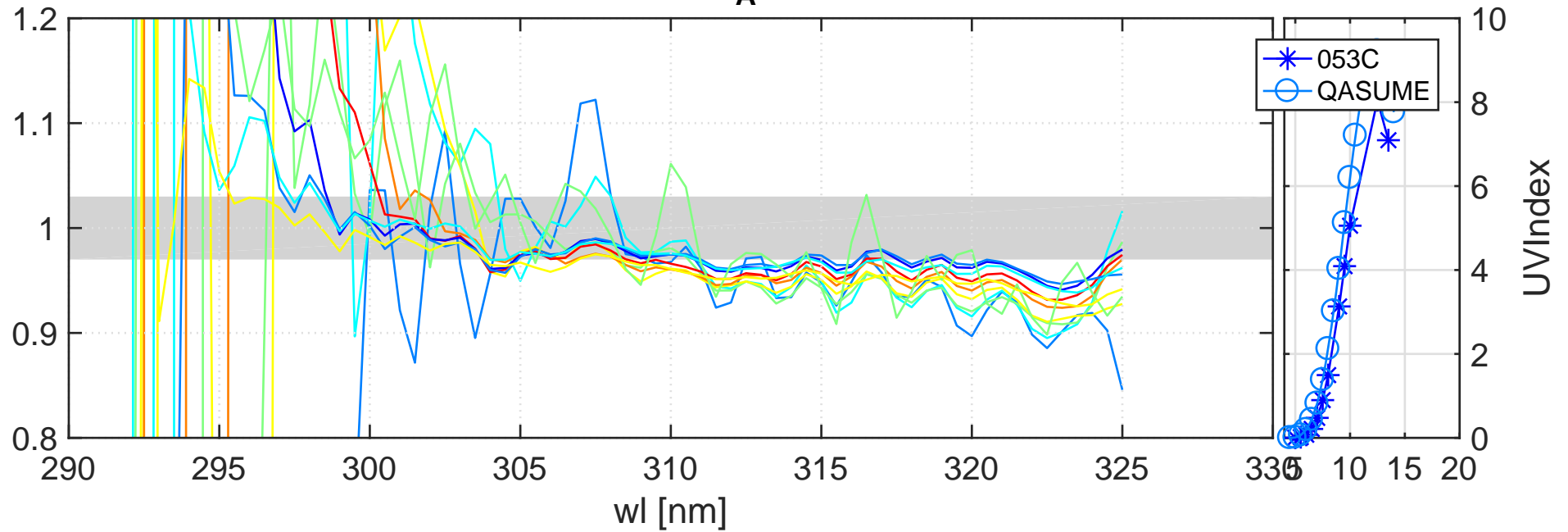
Global irradiance ratios 053C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



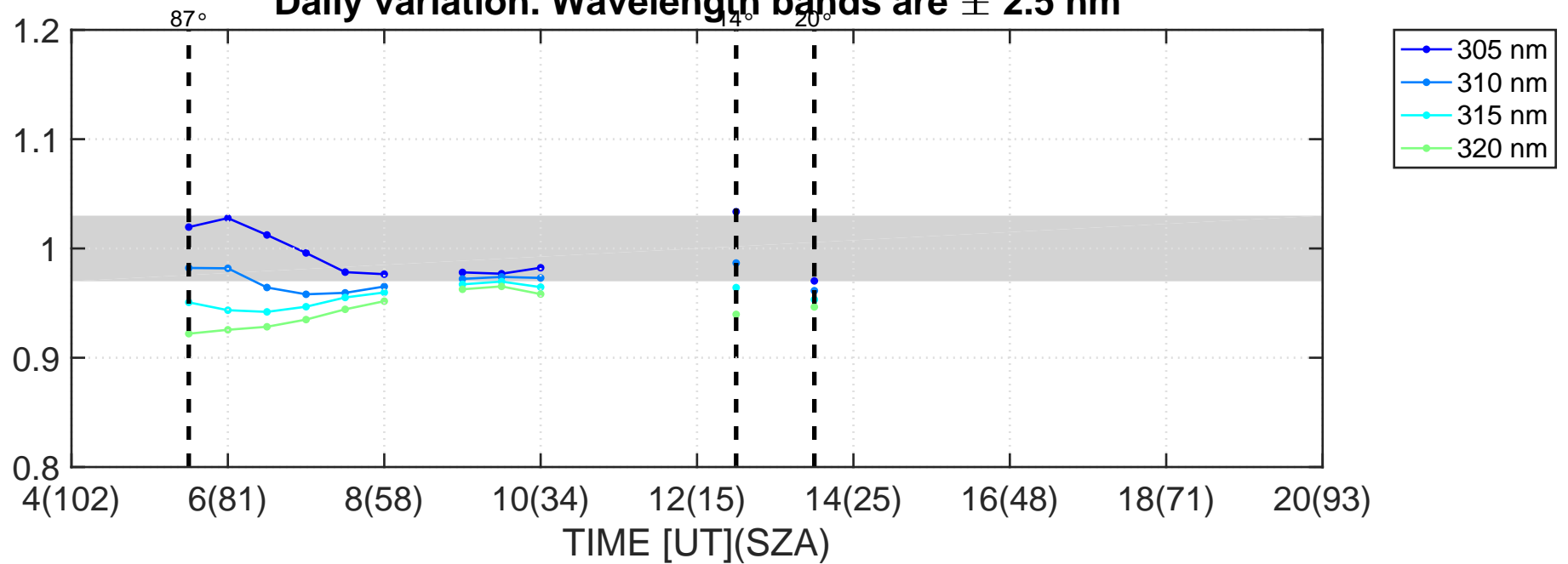
Daily variation. Wavelength bands are ± 2.5 nm



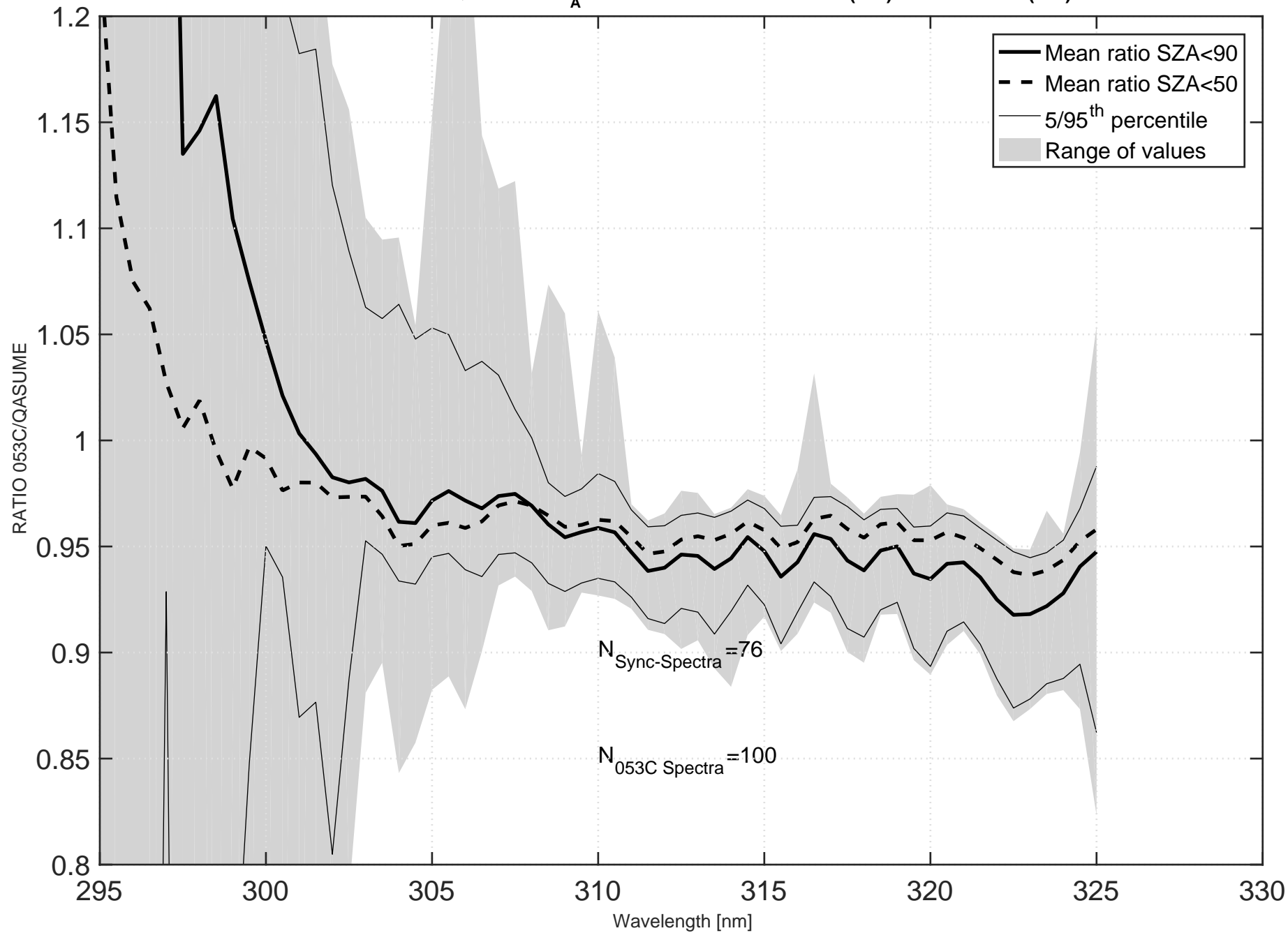
Global irradiance ratios 053C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)

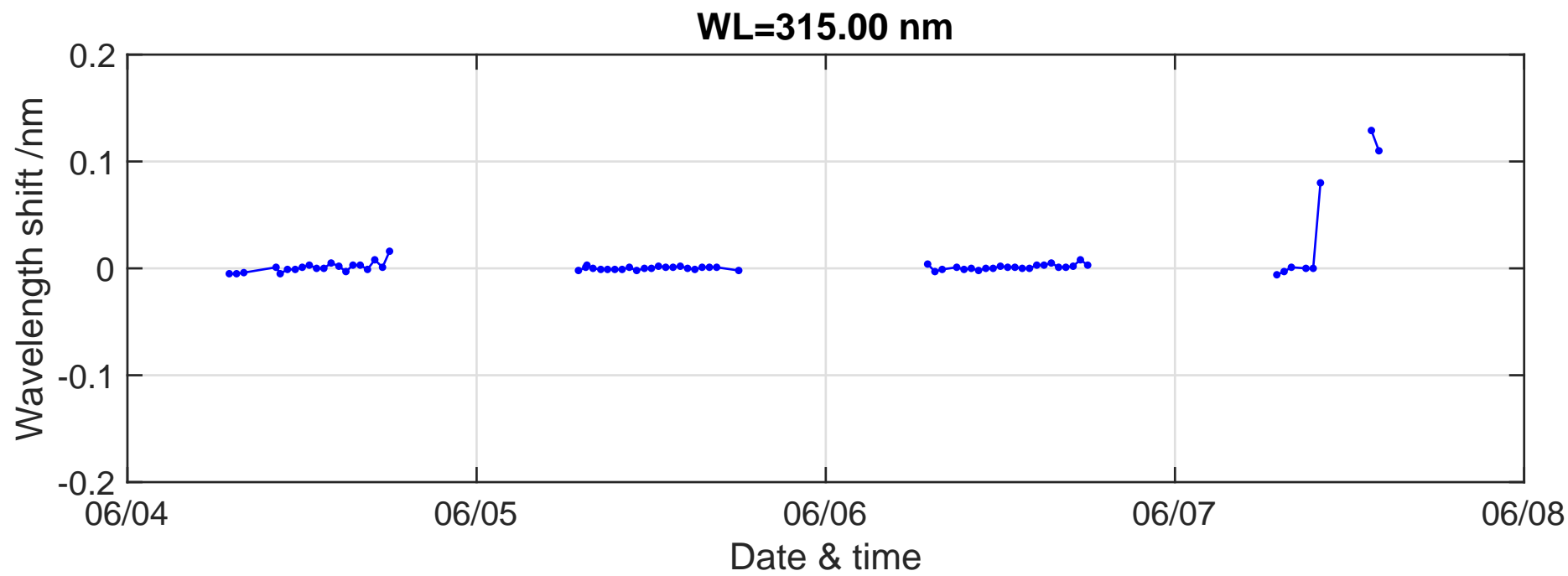
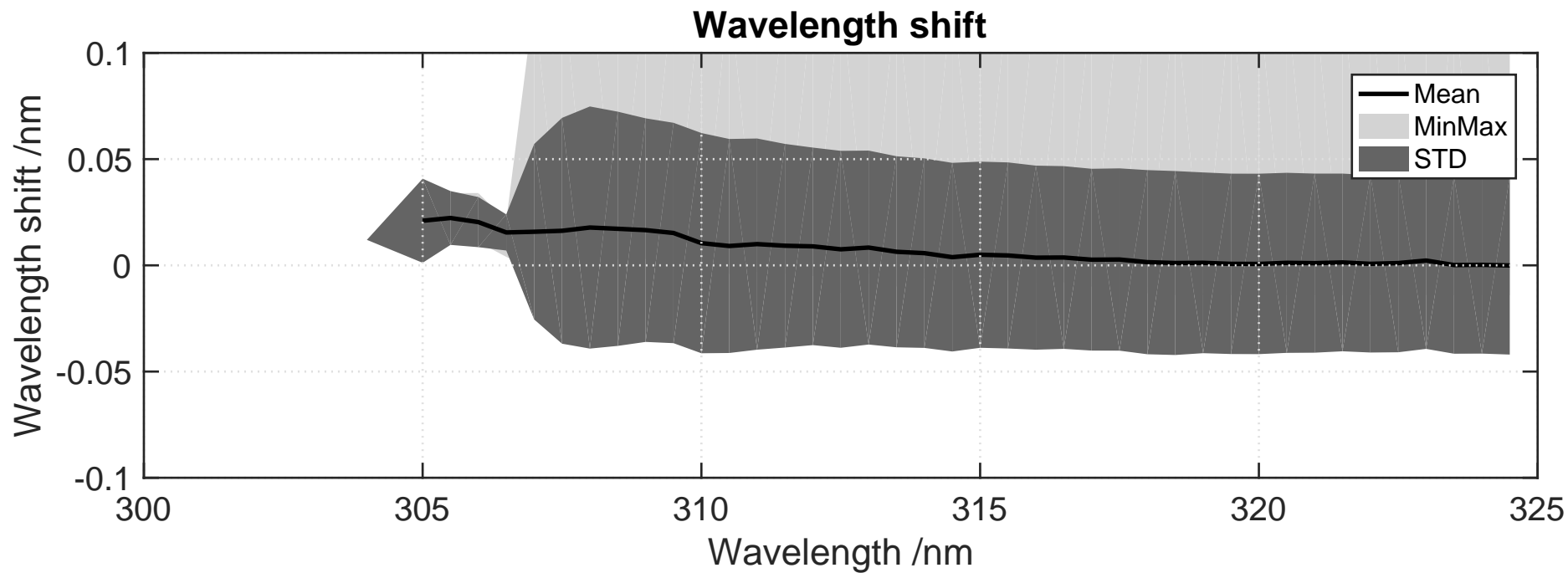


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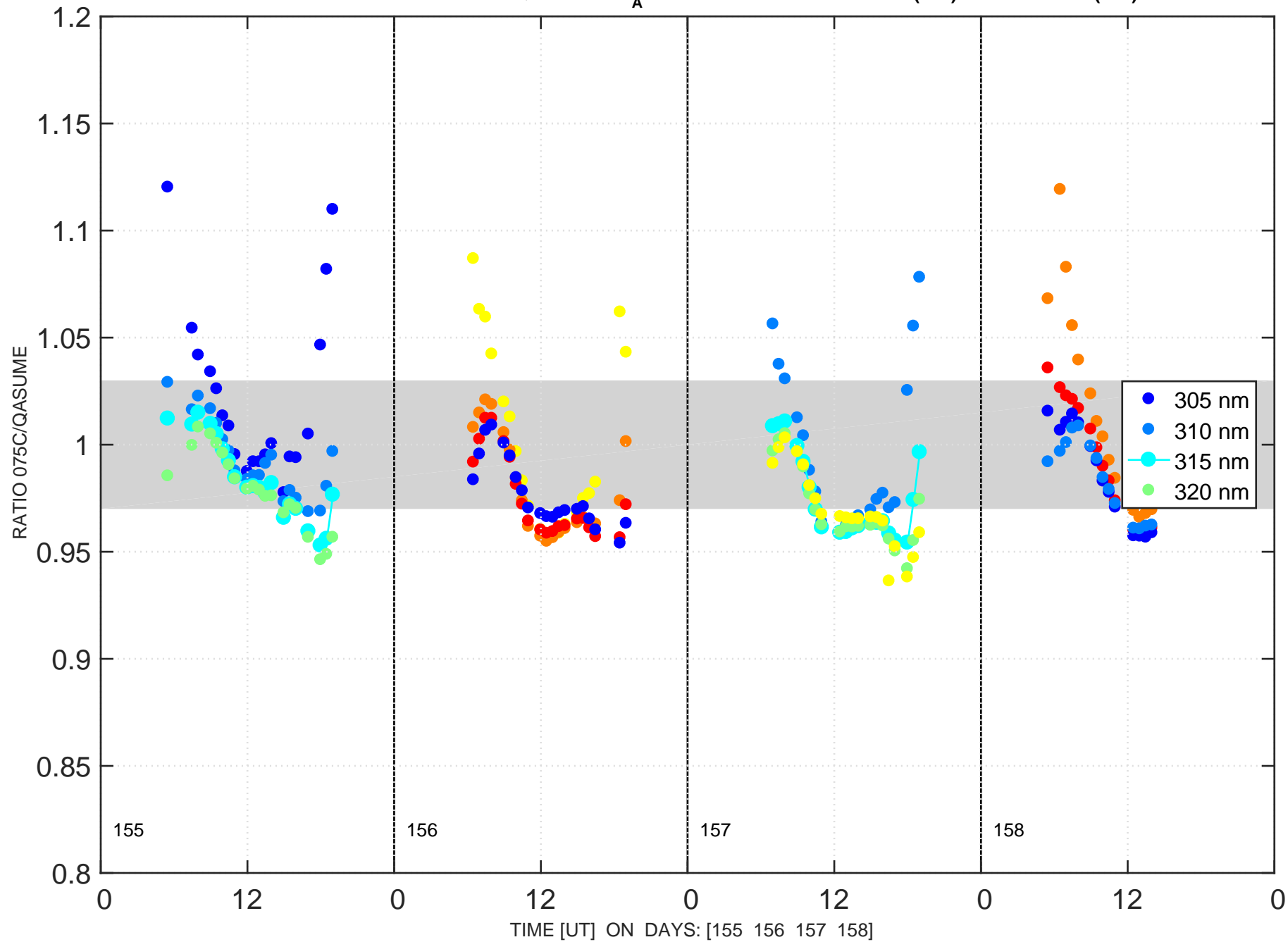


Mean ratio 053C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)

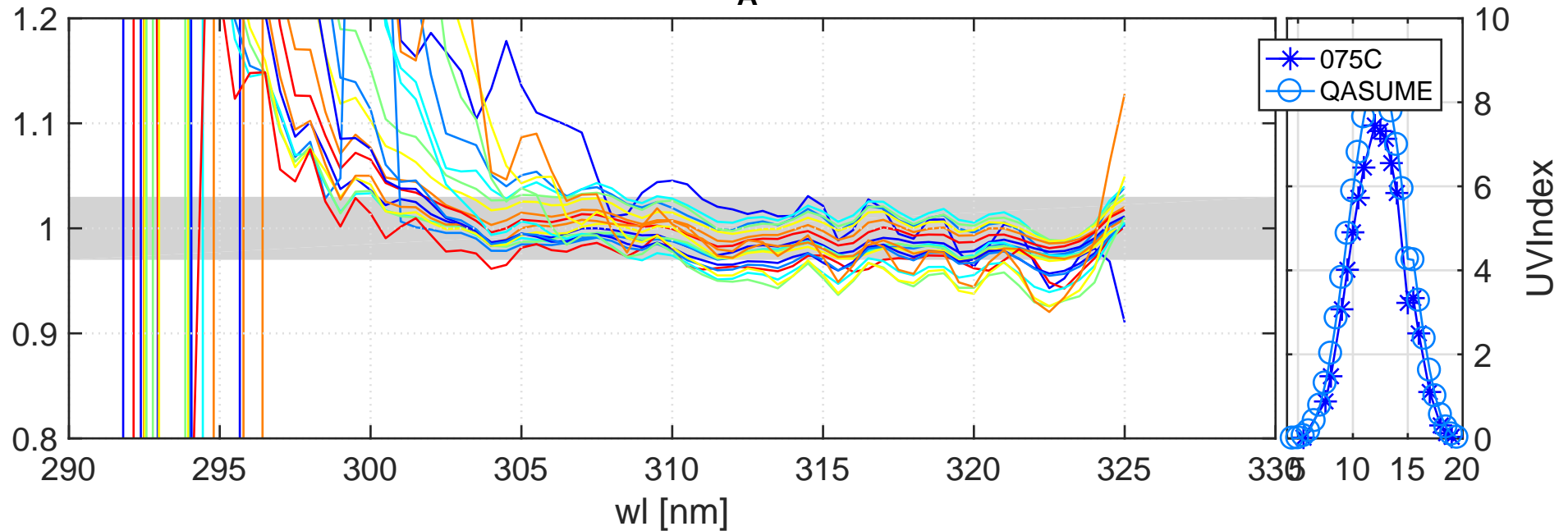




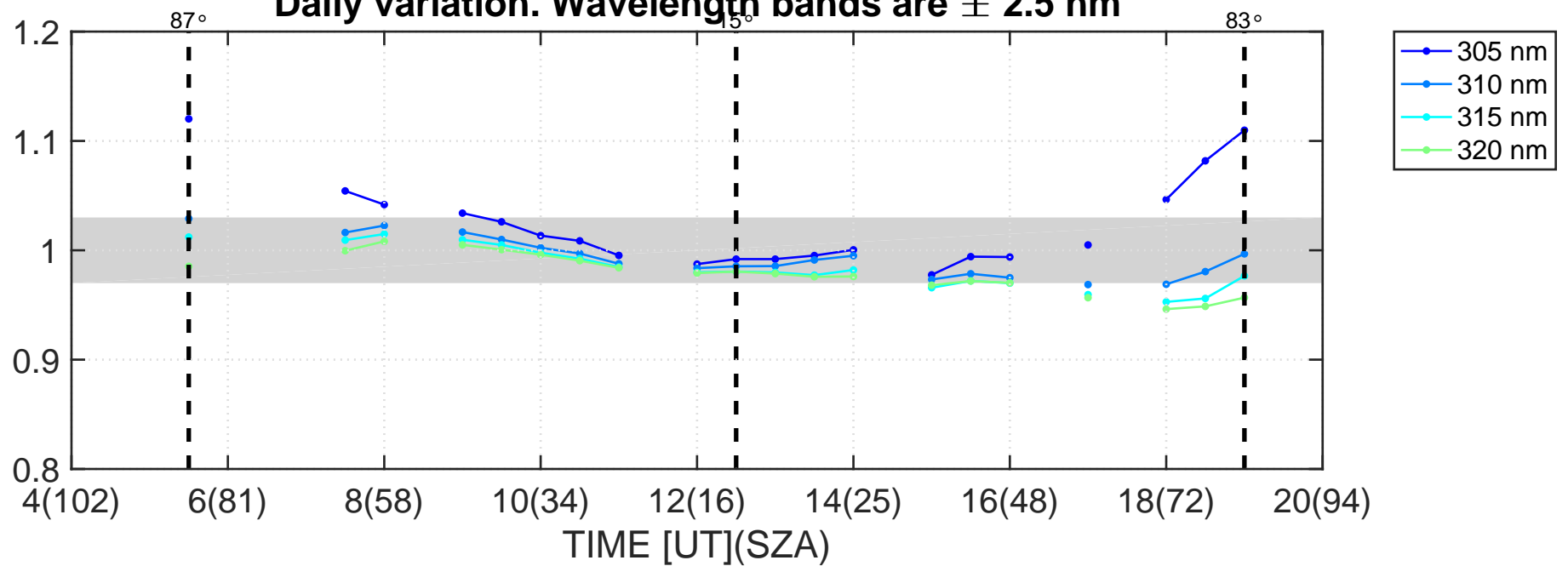
Global irradiance ratios 075C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



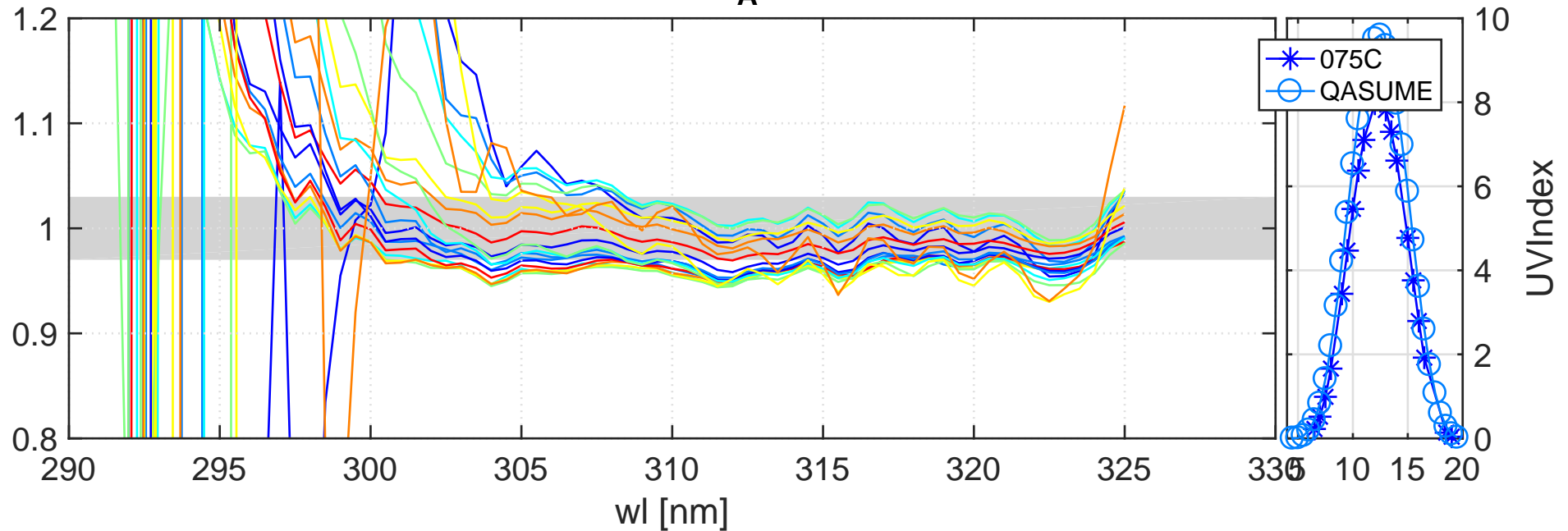
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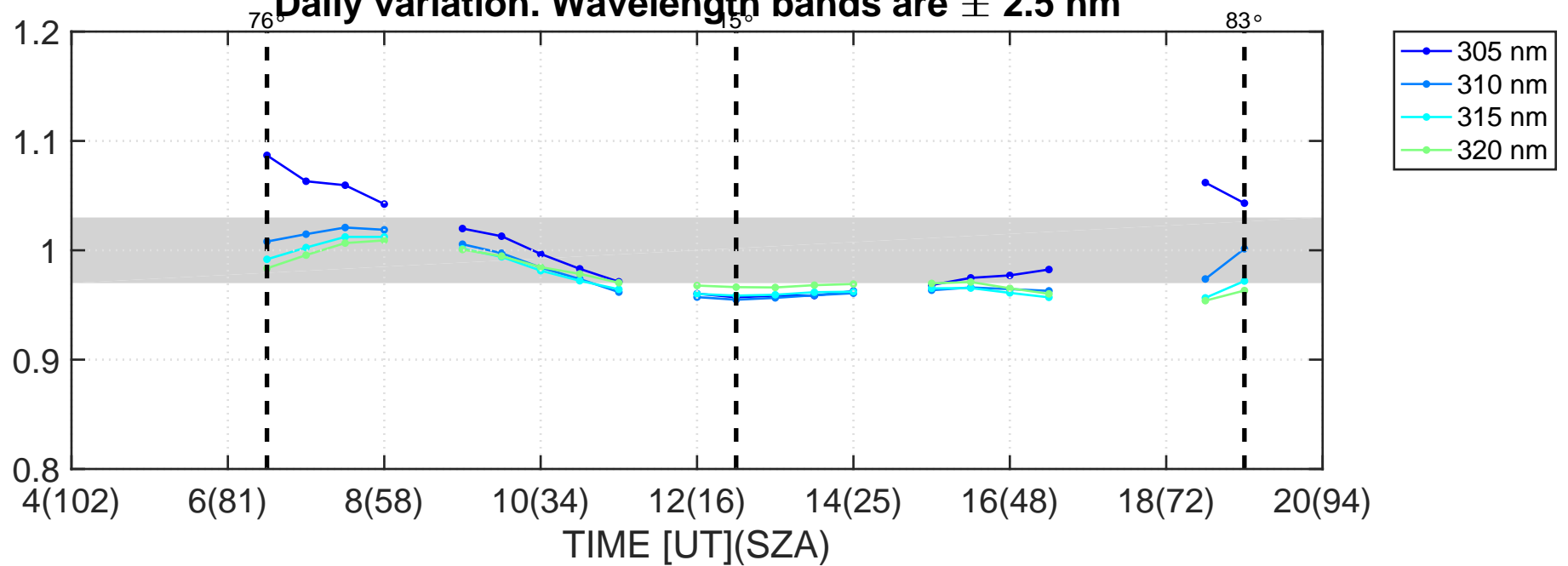
Daily variation. Wavelength bands are ± 2.5 nm



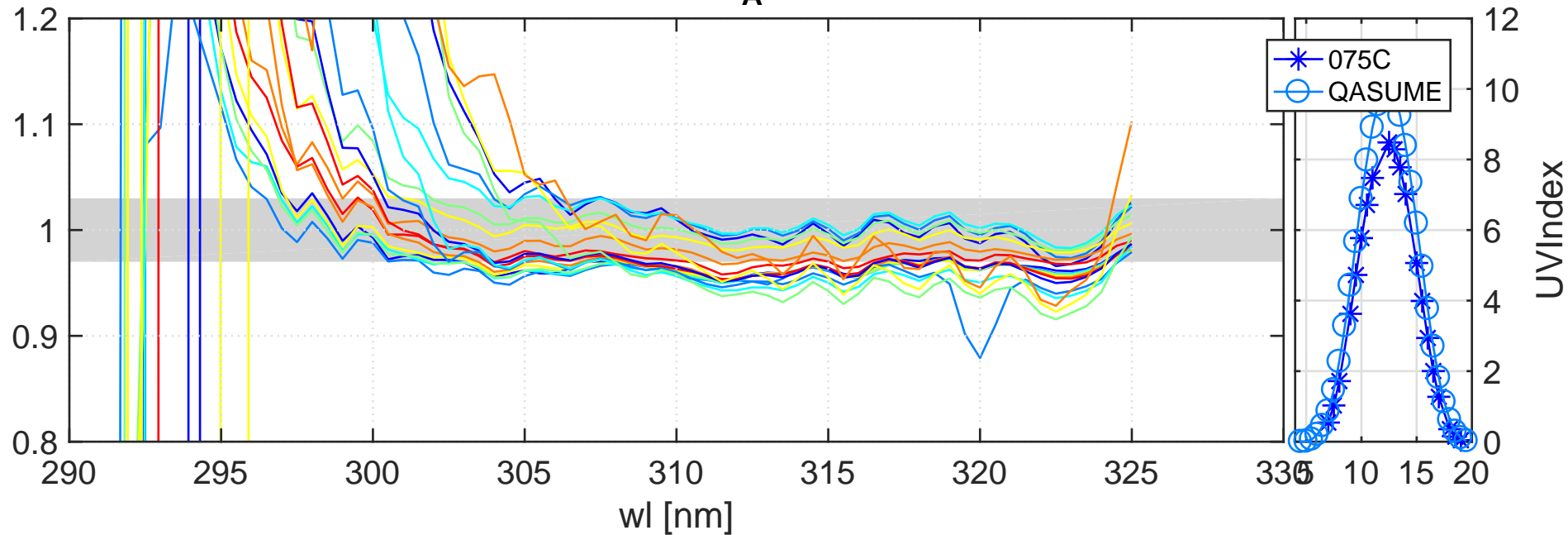
Global irradiance ratios 075C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



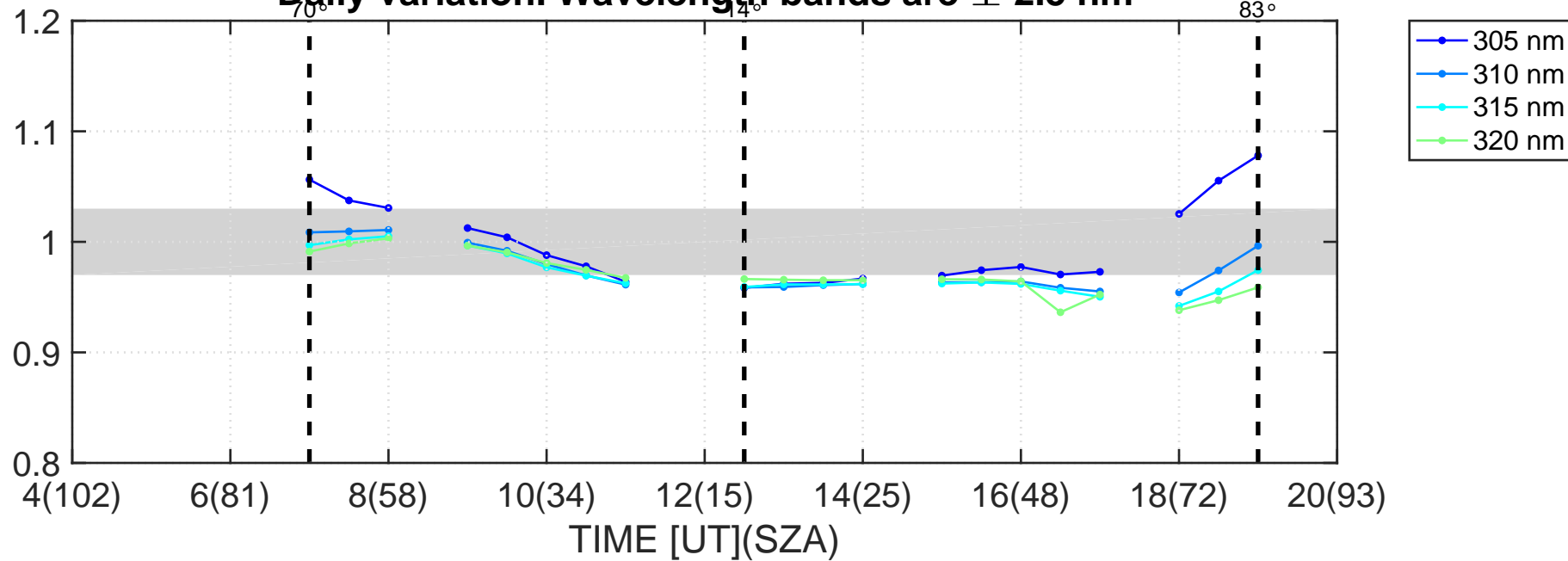
Daily variation. Wavelength bands are ± 2.5 nm



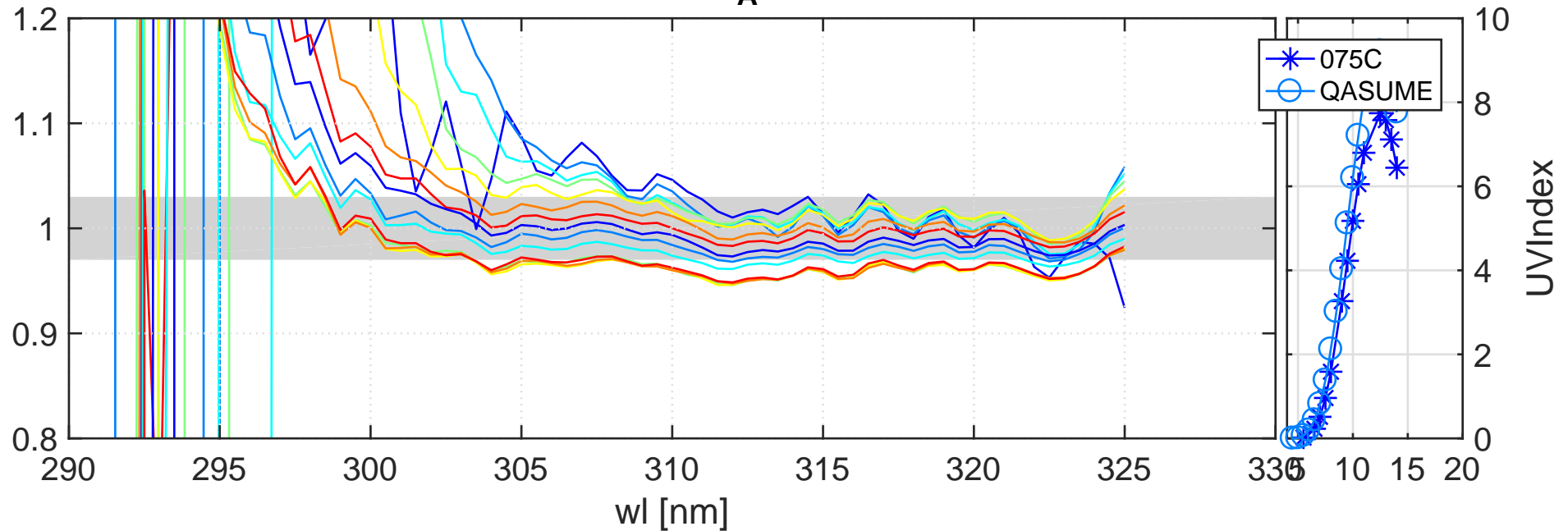
Global irradiance ratios 075C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



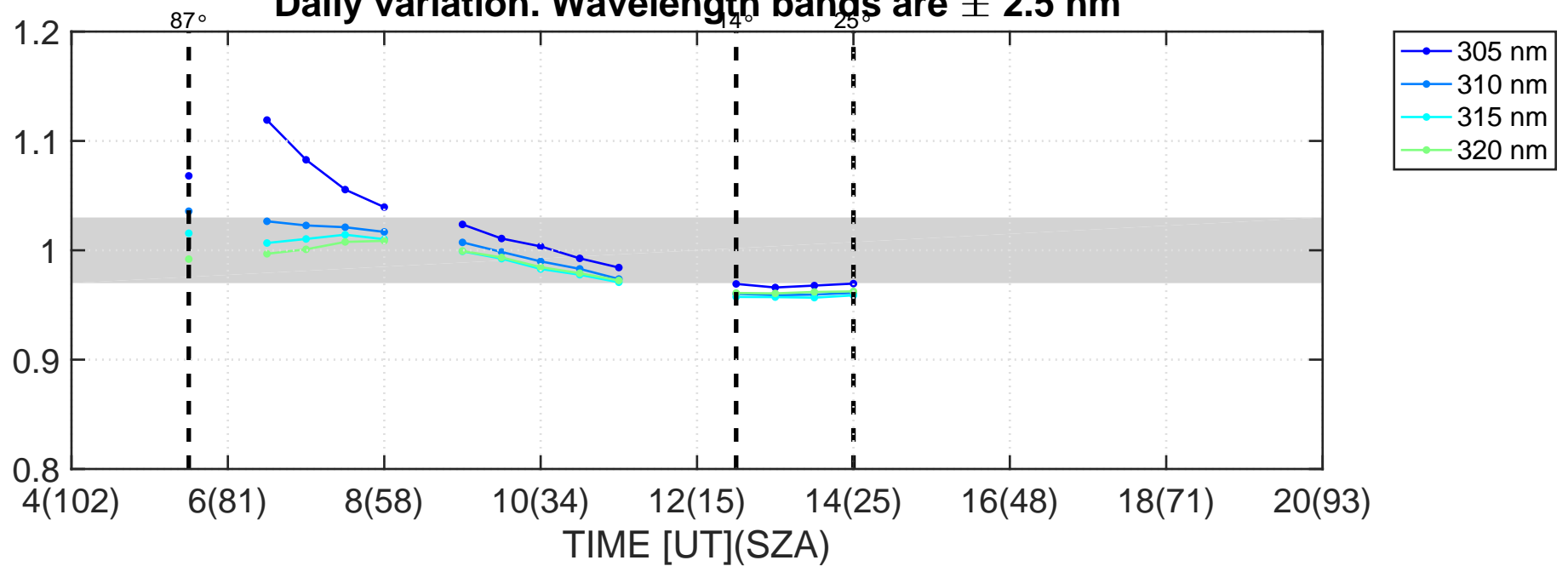
Daily variation. Wavelength bands are ± 2.5 nm



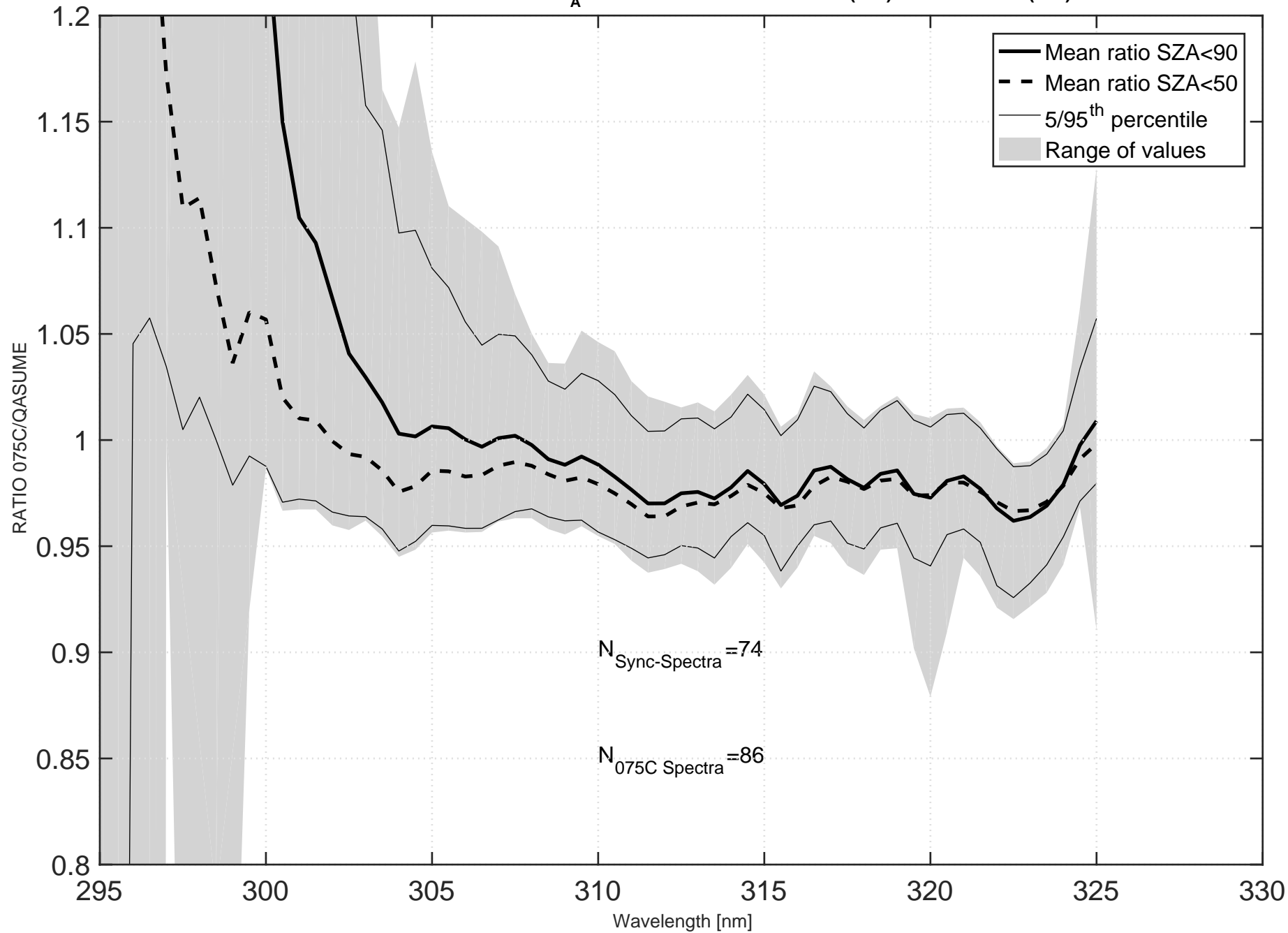
Global irradiance ratios 075C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



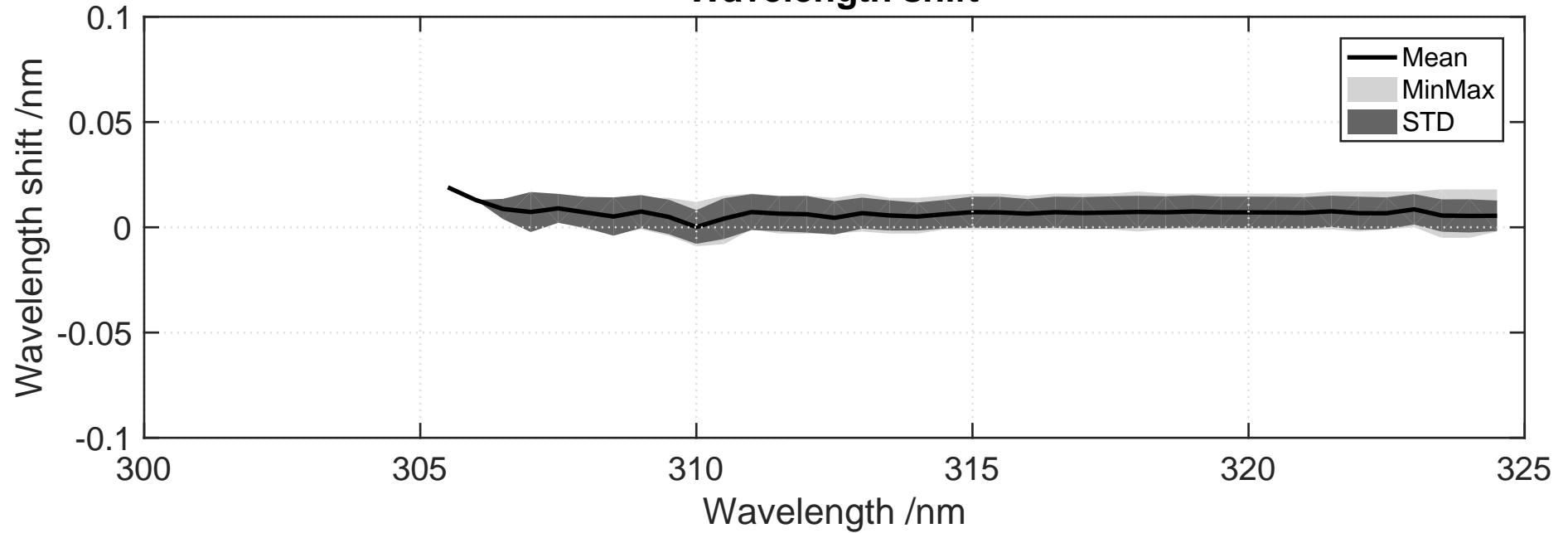
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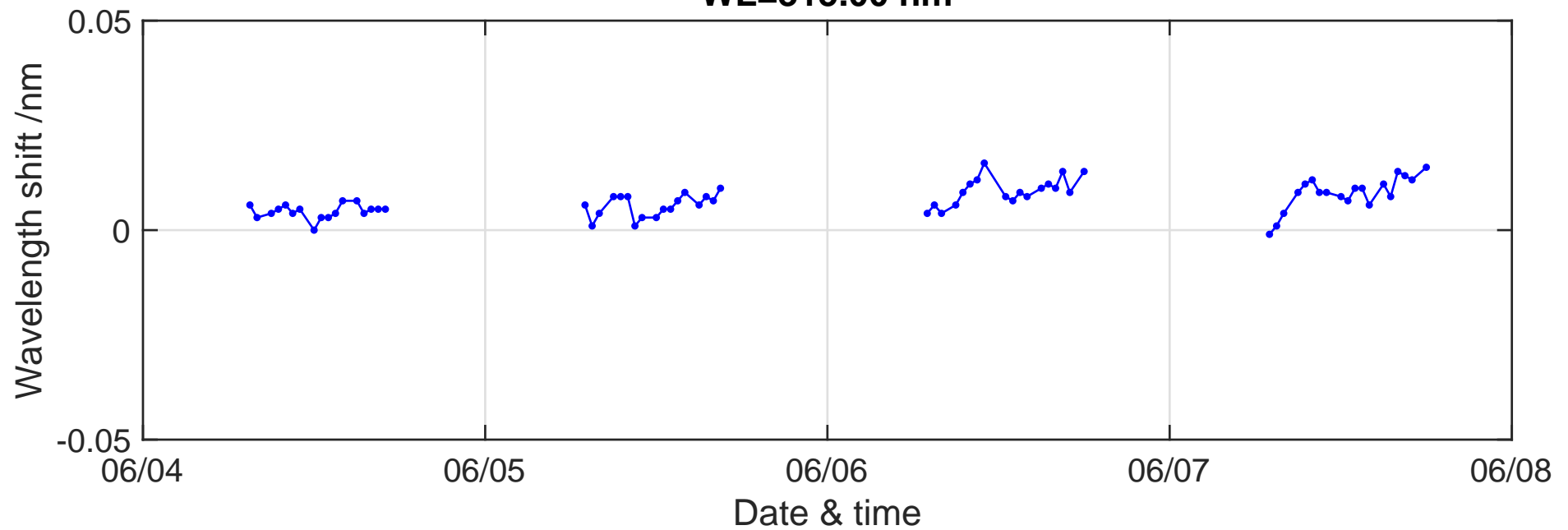
Mean ratio 075C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



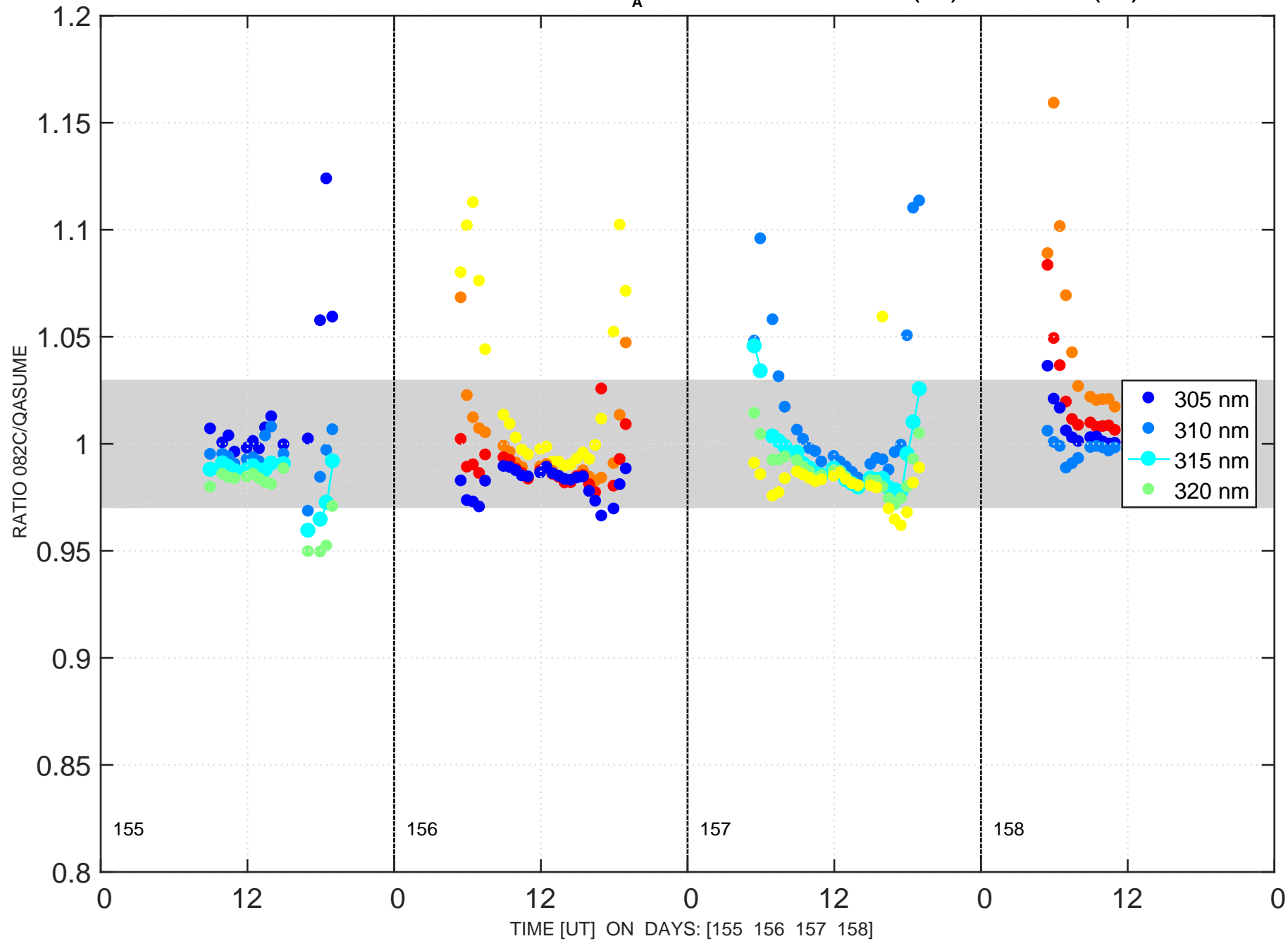
Wavelength shift



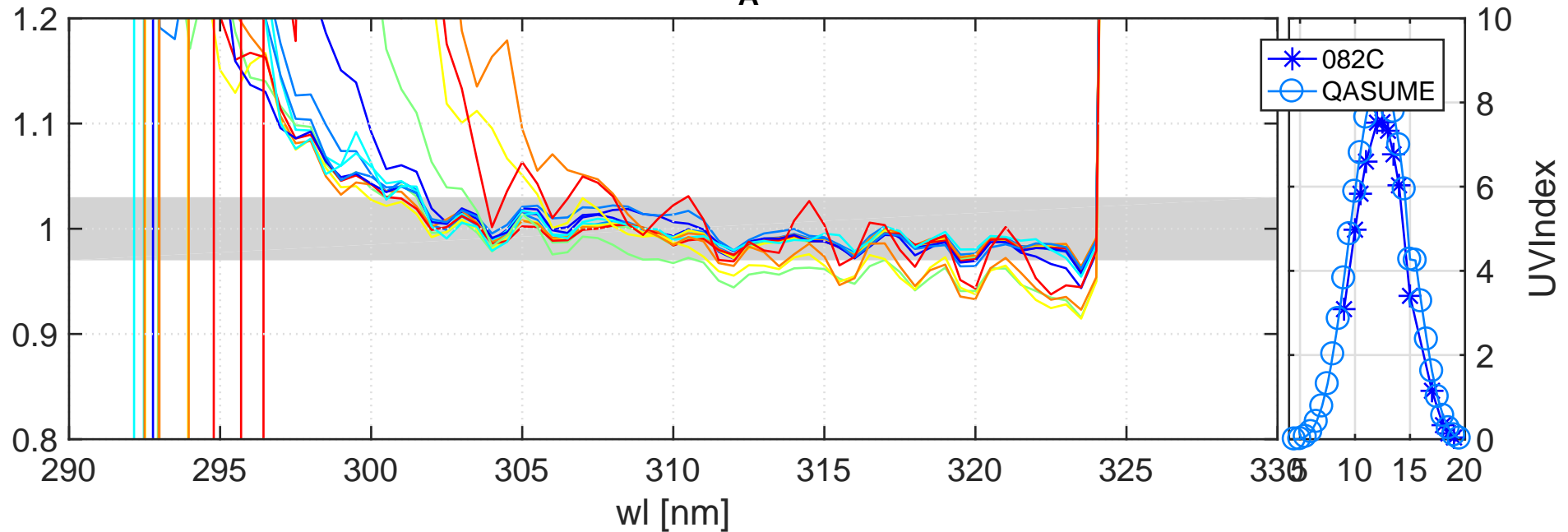
WL=315.00 nm



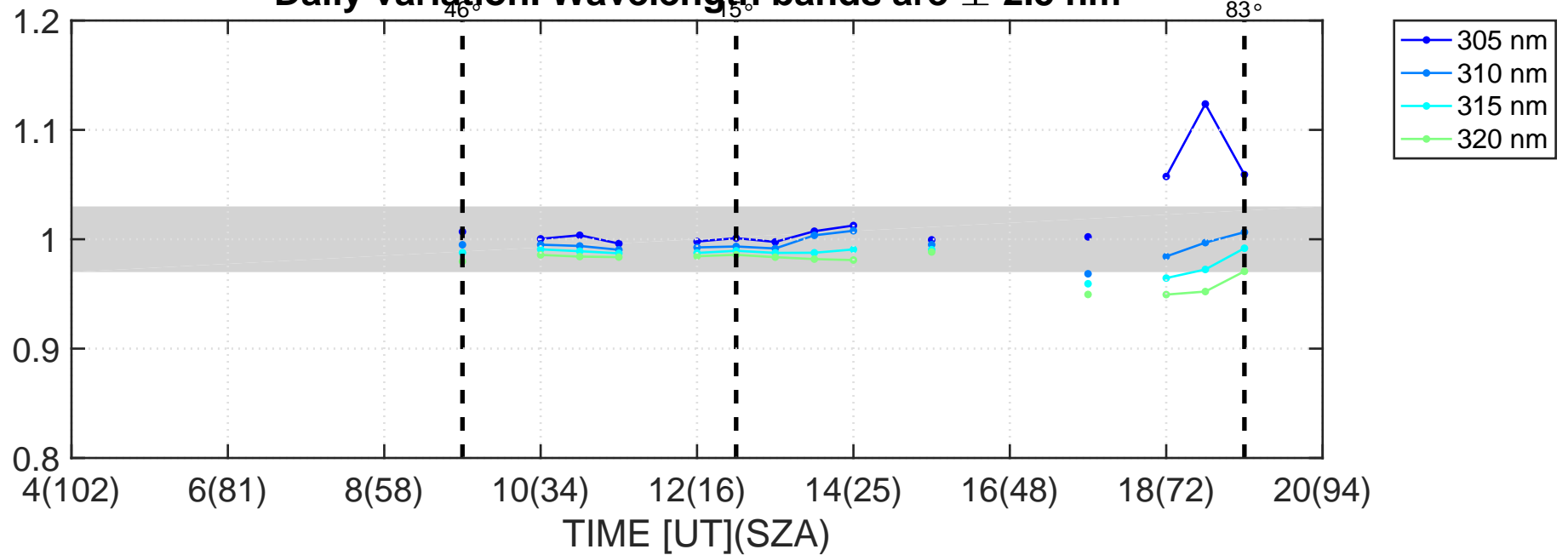
Global irradiance ratios 082C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



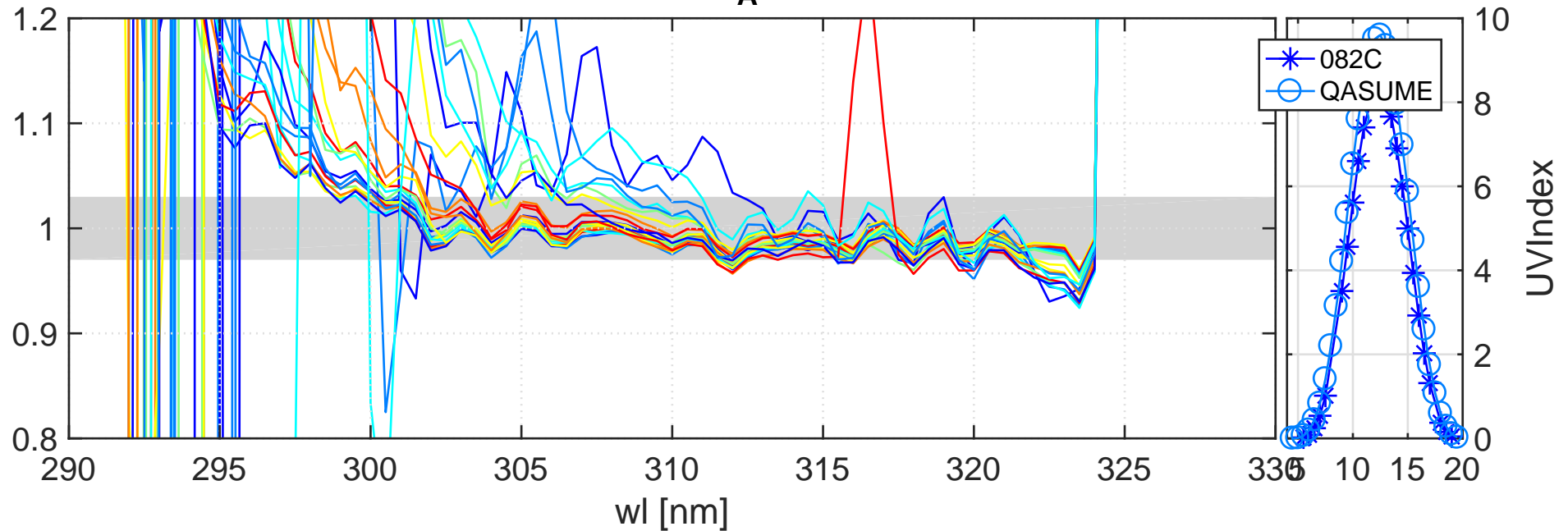
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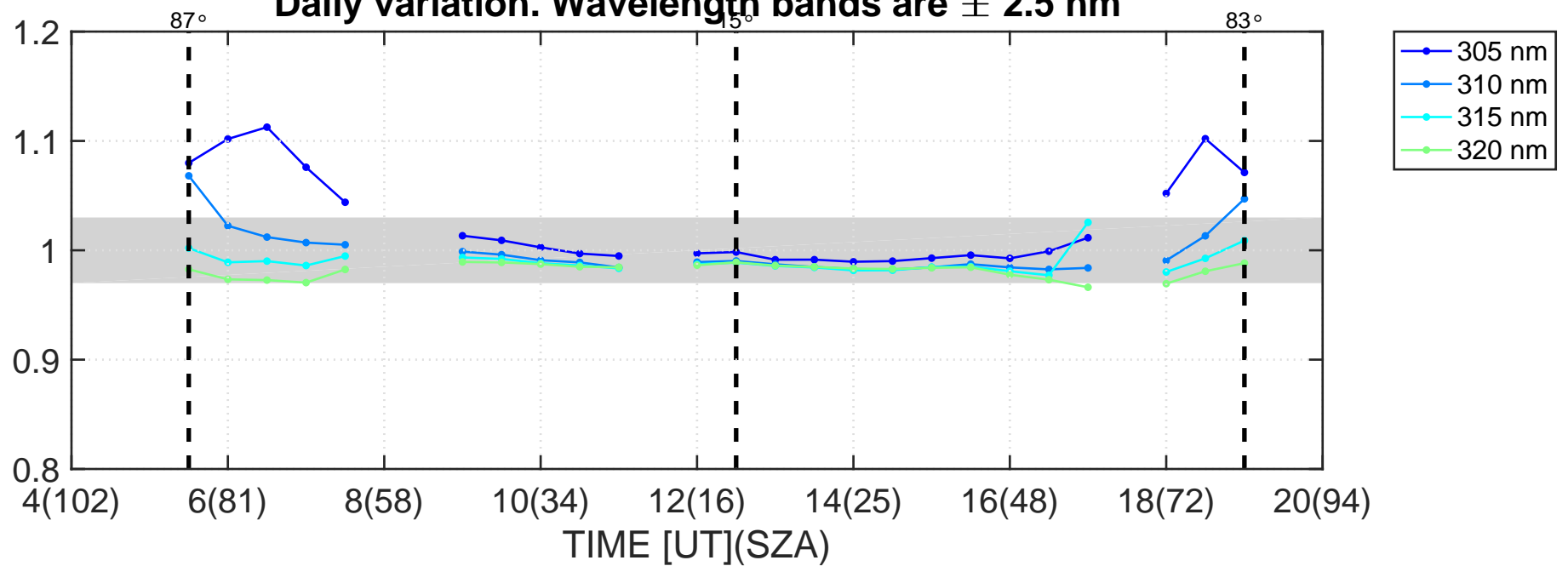
Daily variation. Wavelength bands are ± 2.5 nm



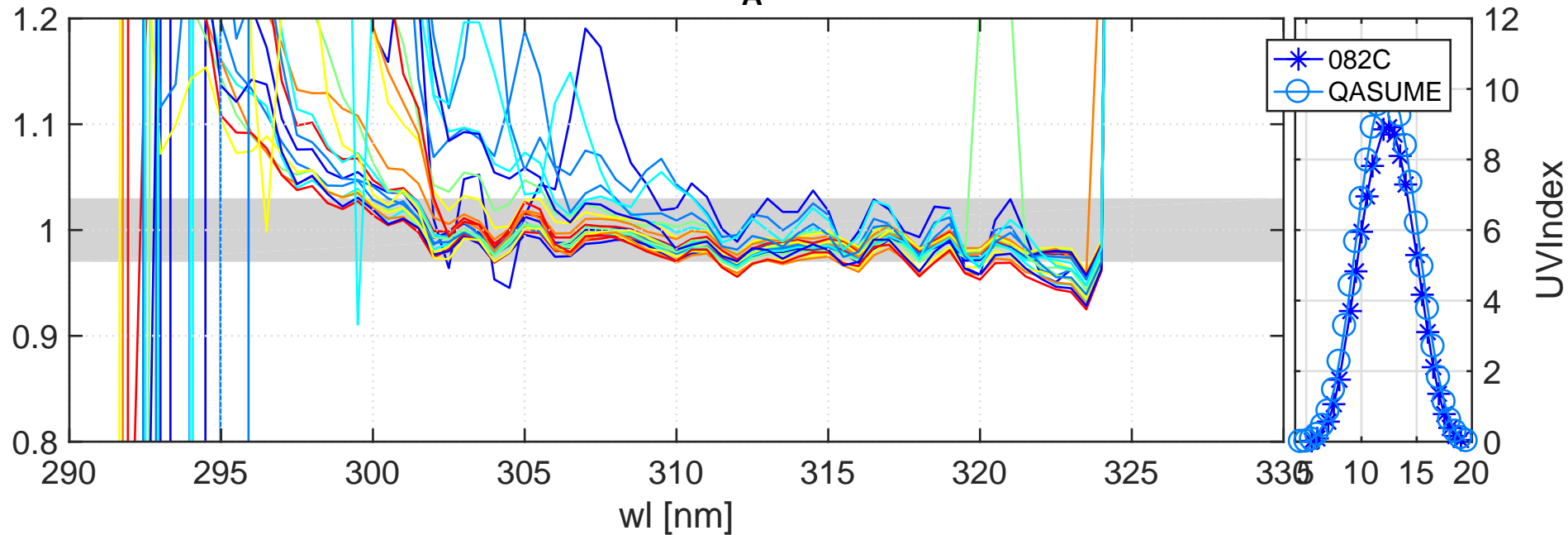
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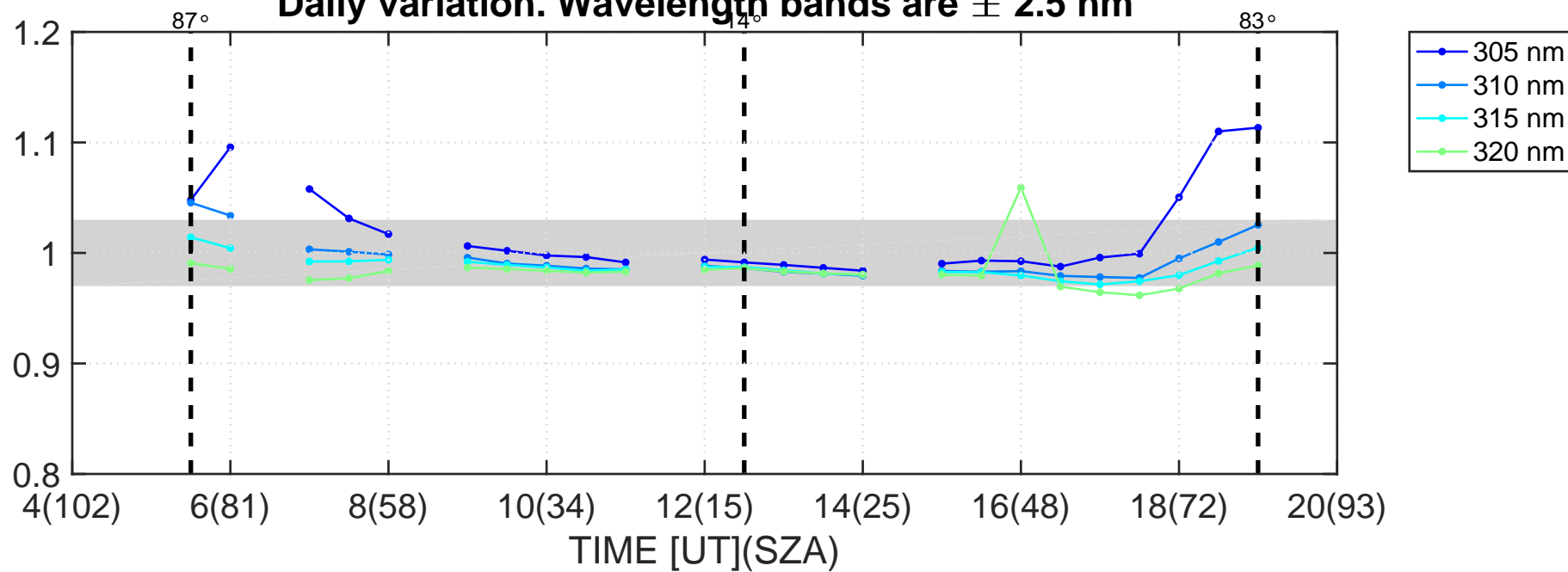
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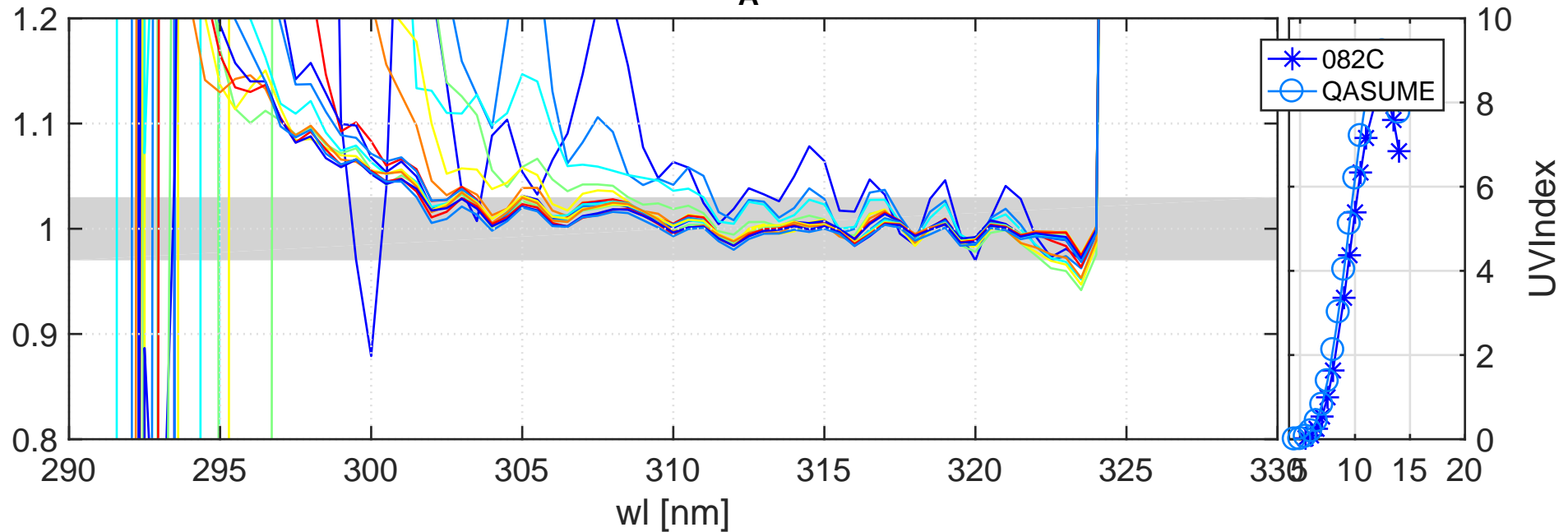
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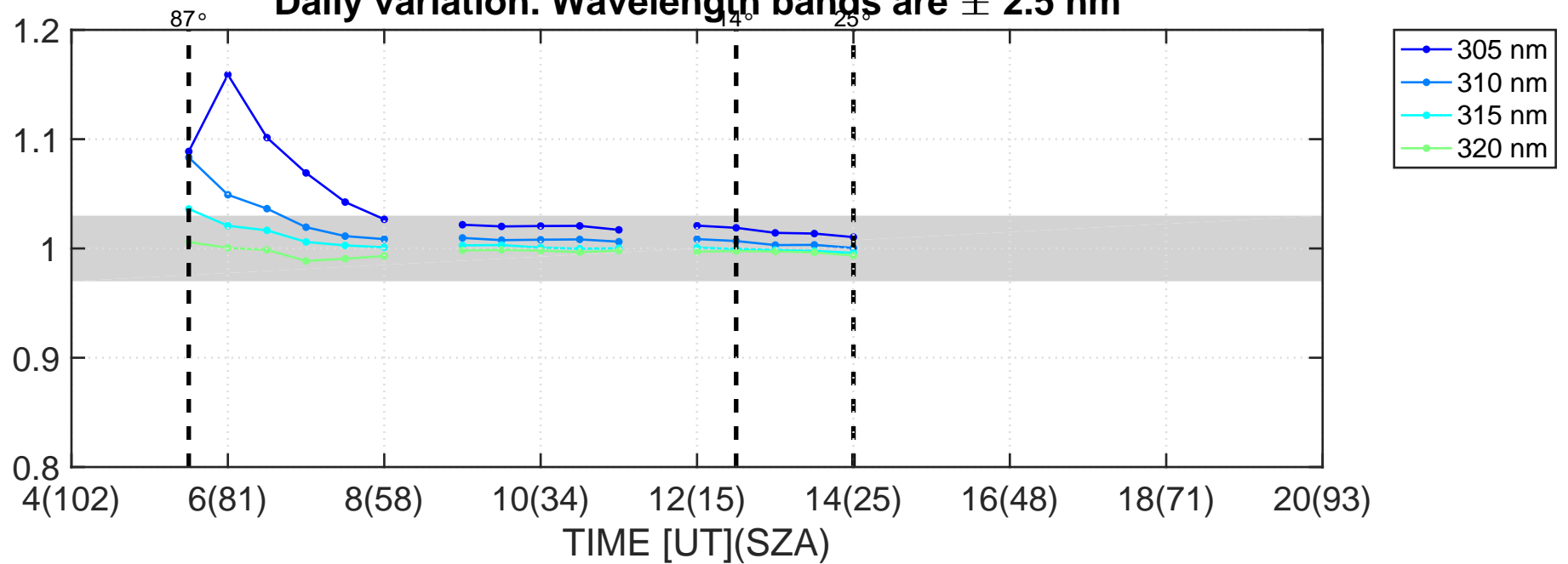
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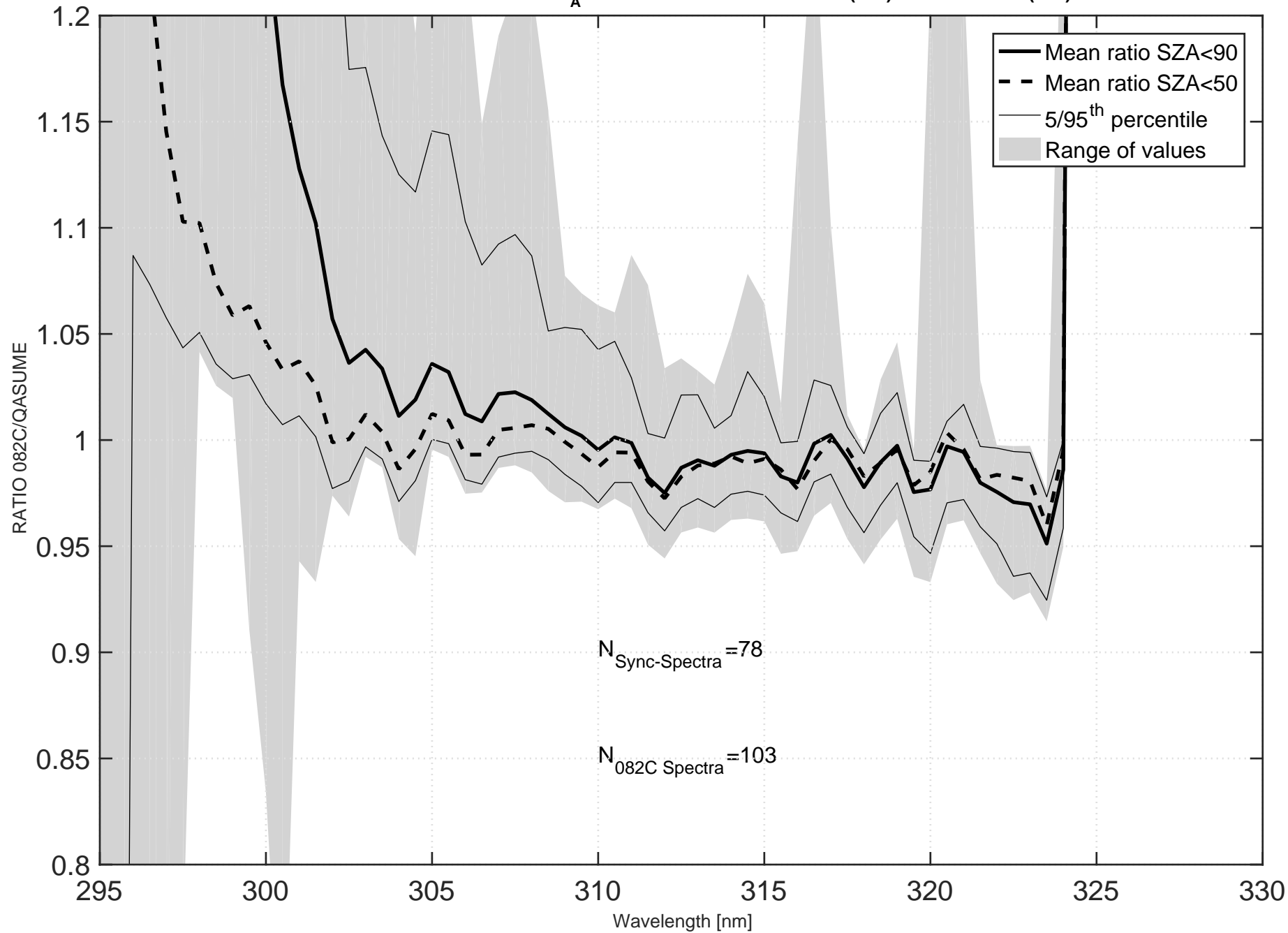
Global irradiance ratios 082C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



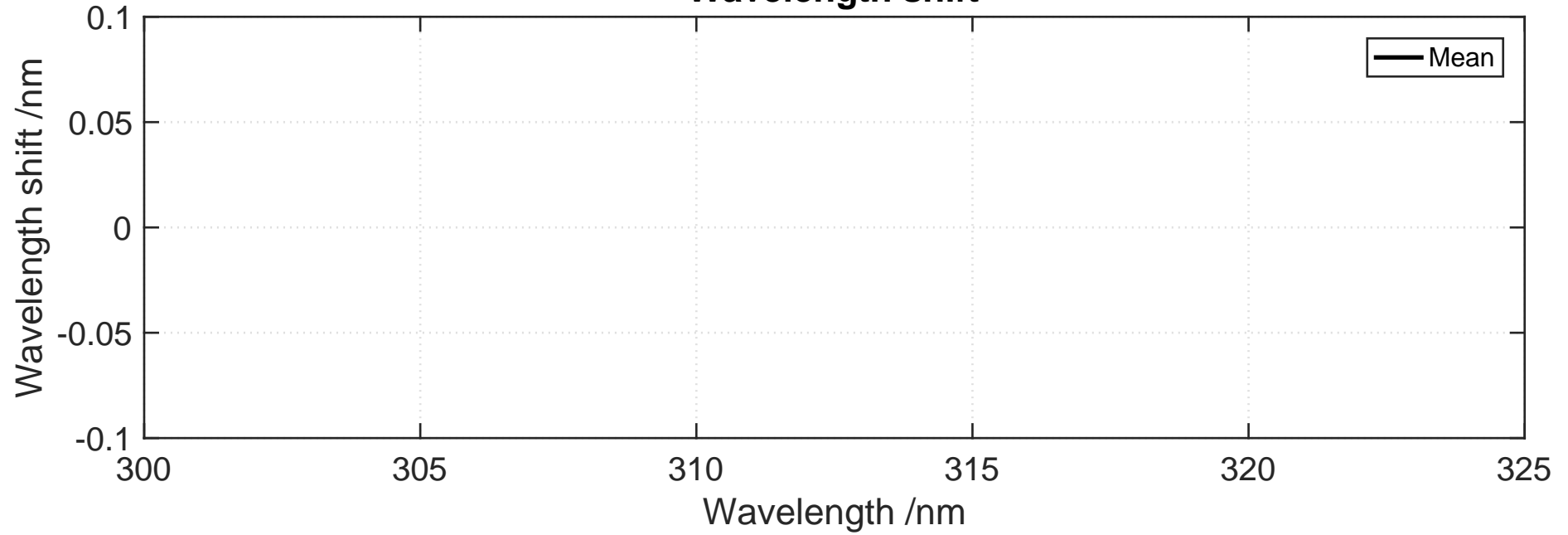
Daily variation. Wavelength bands are ± 2.5 nm



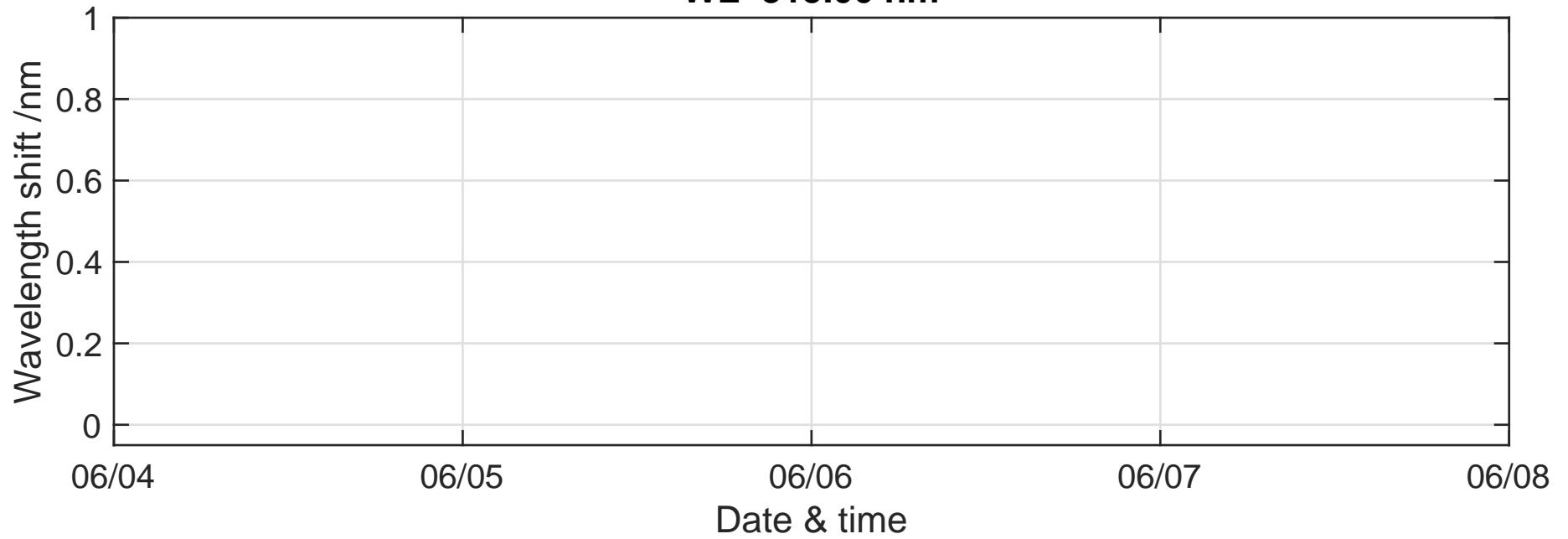
Mean ratio 082C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



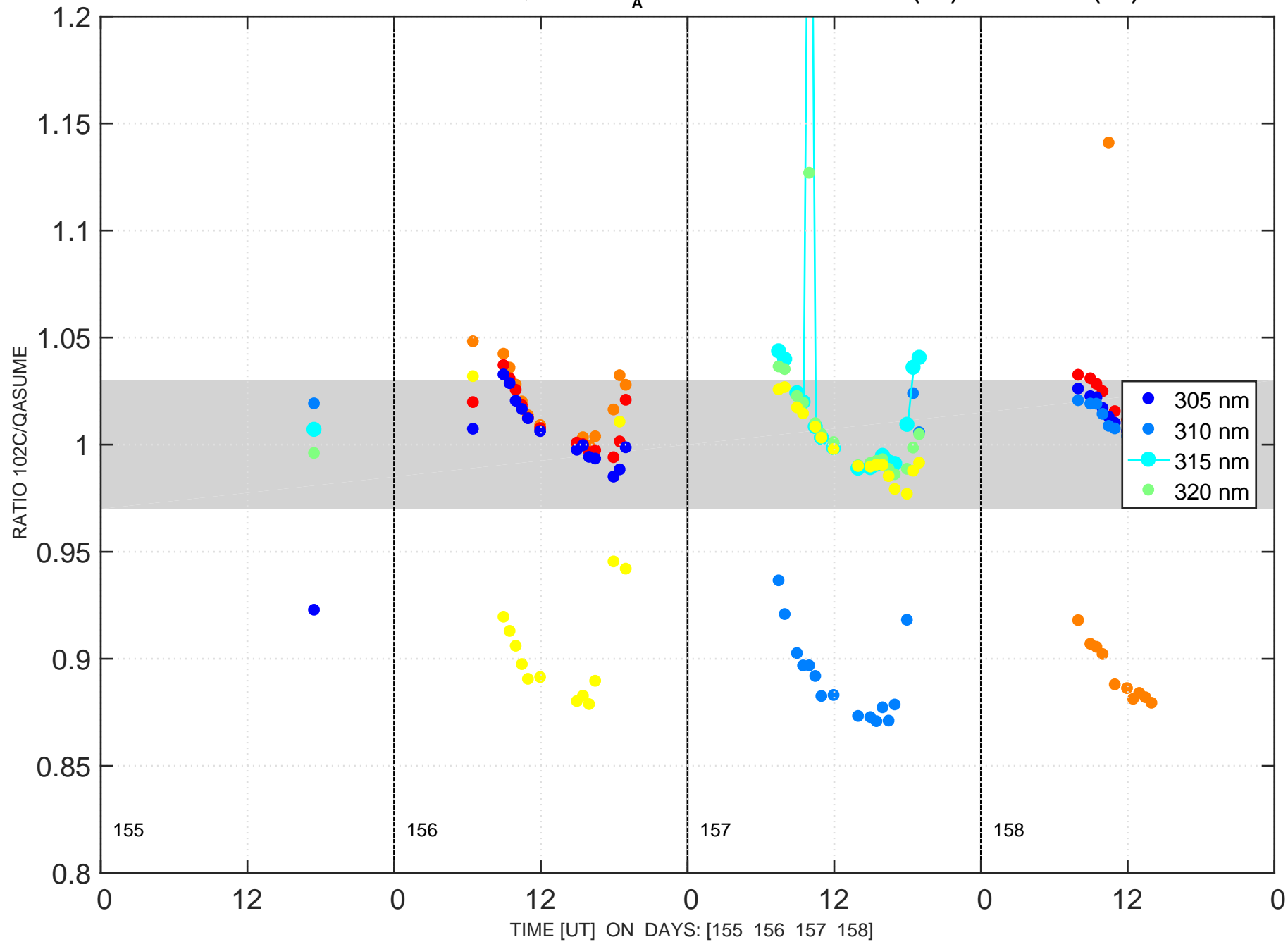
Wavelength shift



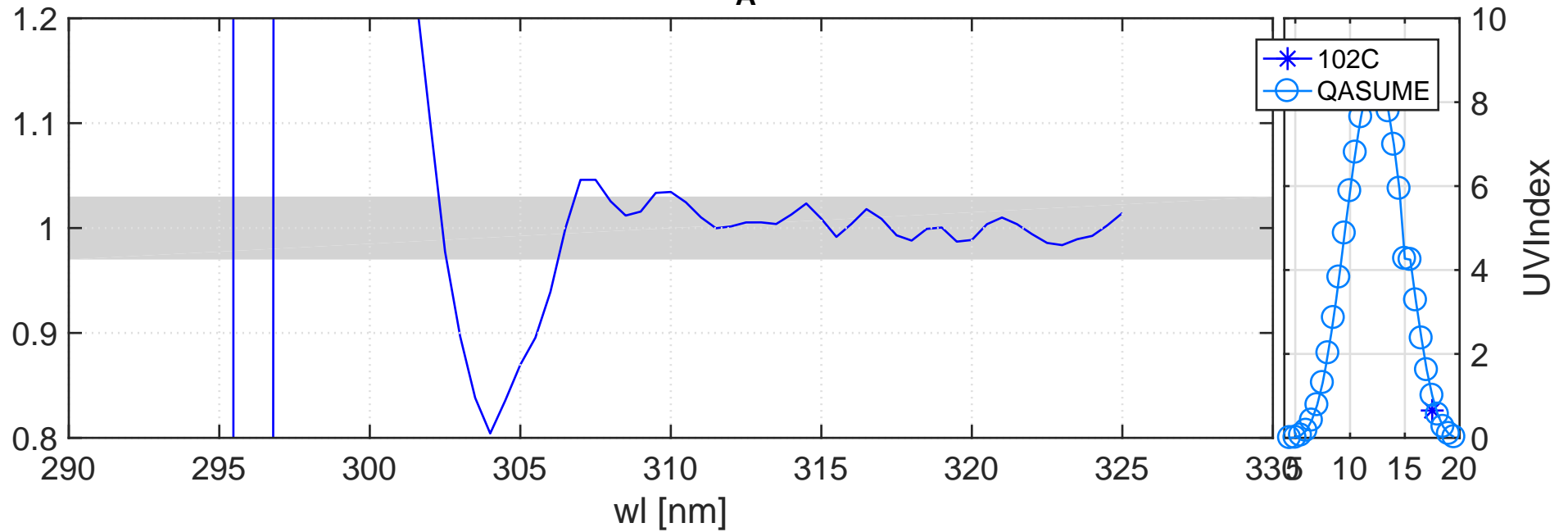
WL=315.00 nm



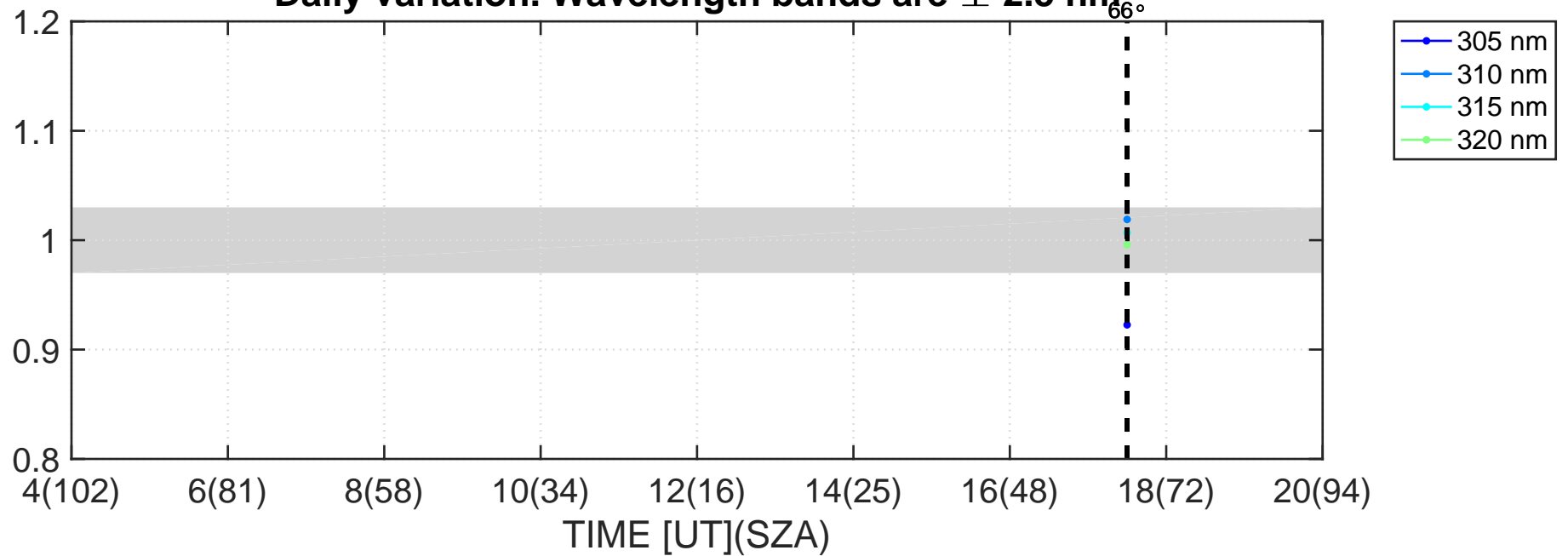
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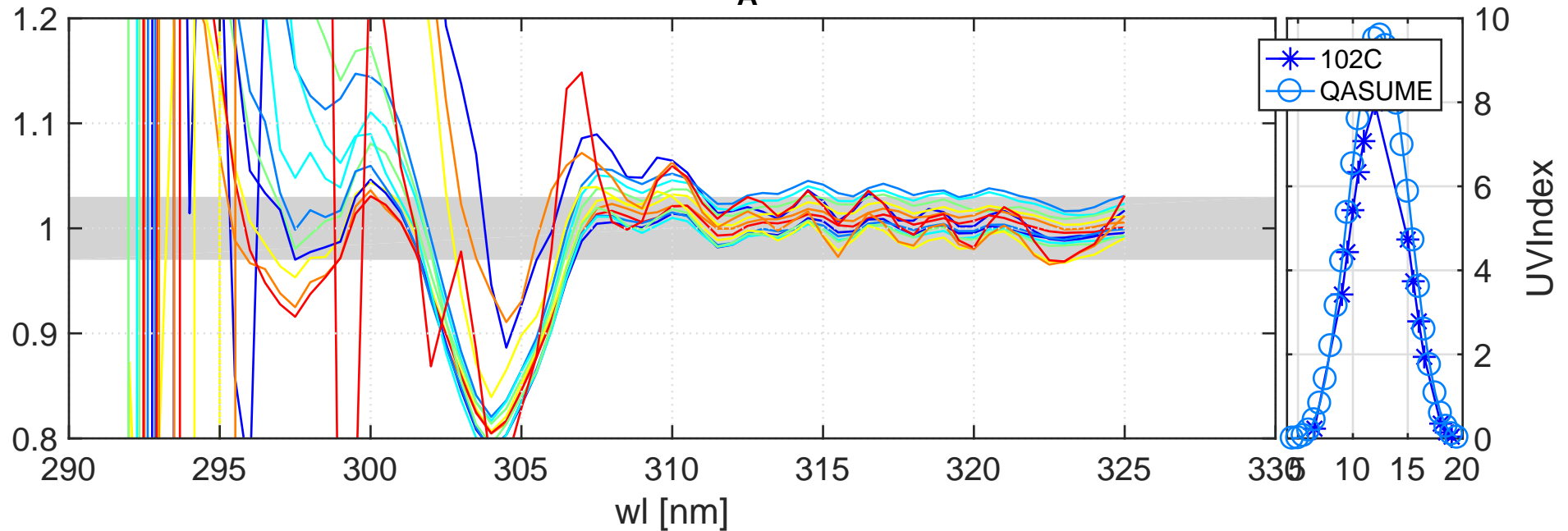
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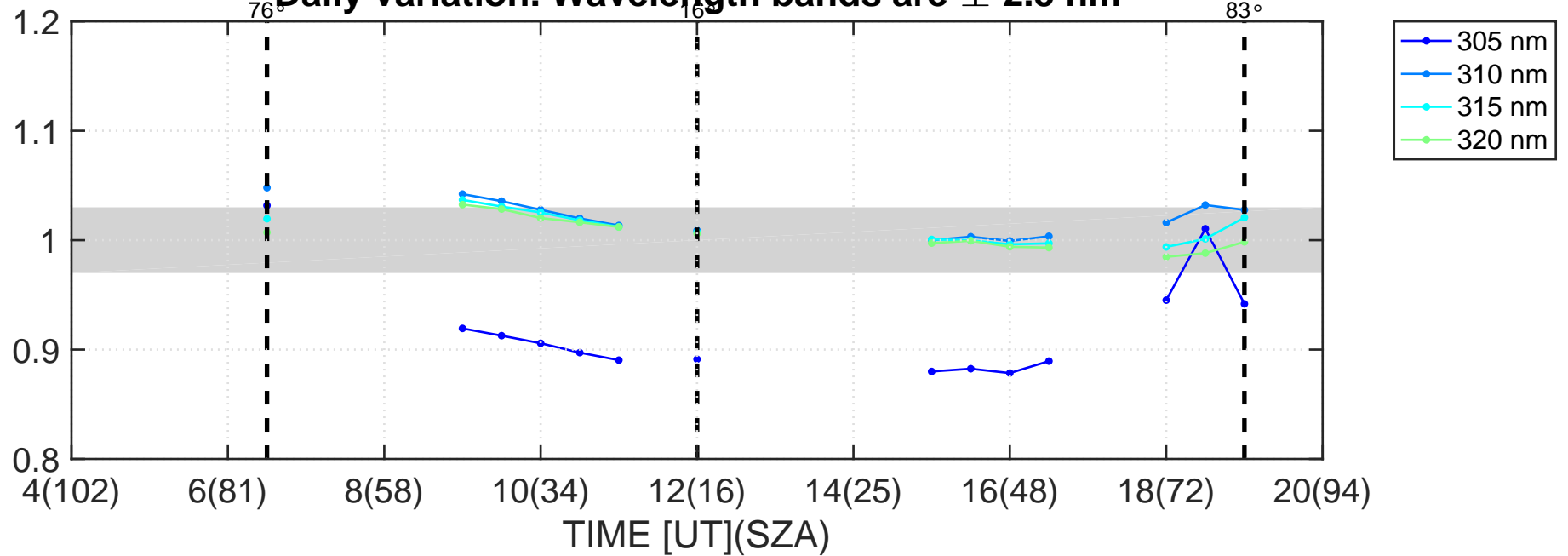
Daily variation. Wavelength bands are ± 2.5 nm



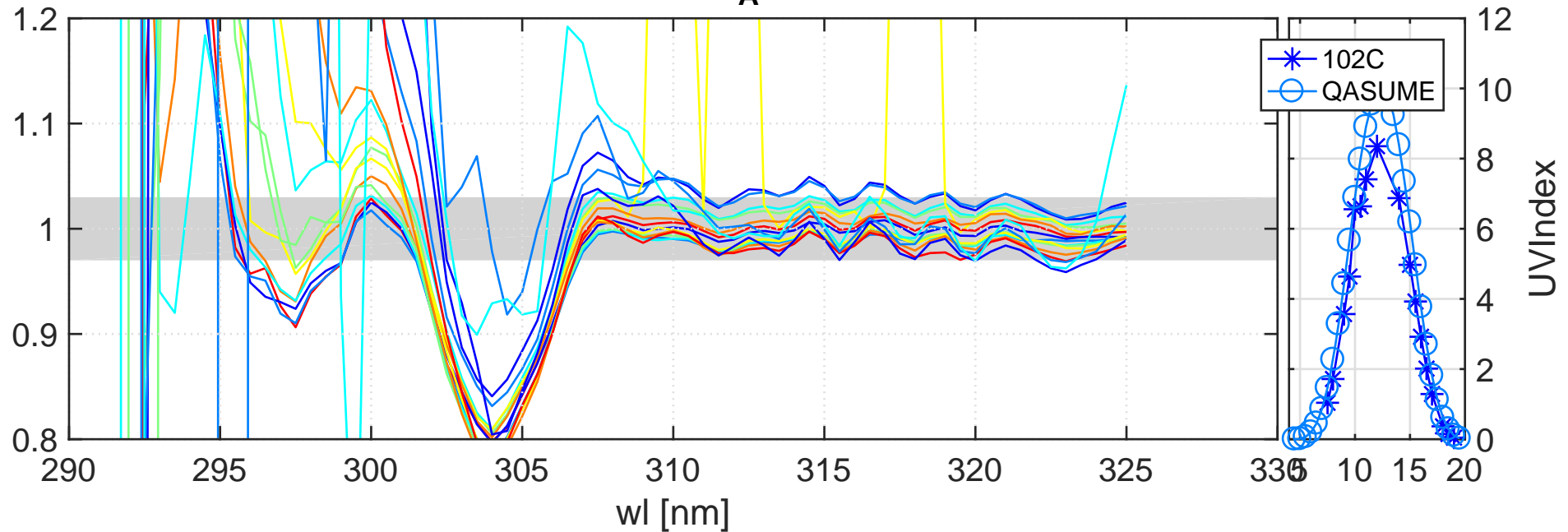
Global irradiance ratios 102C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



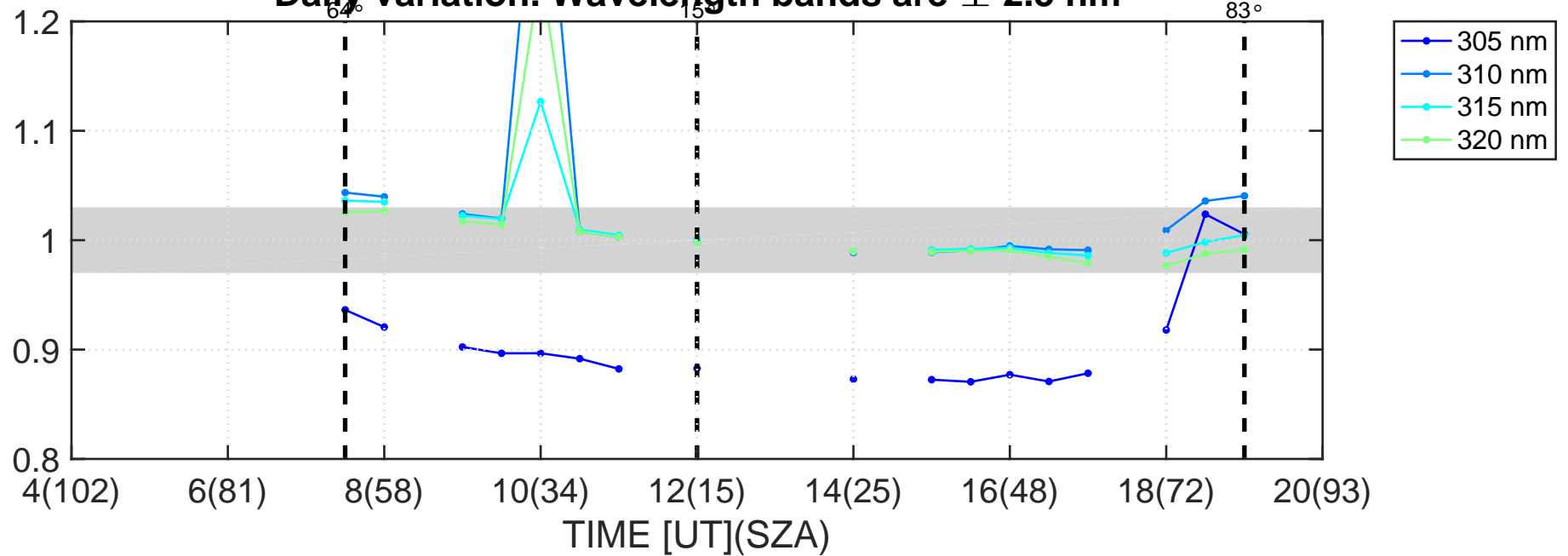
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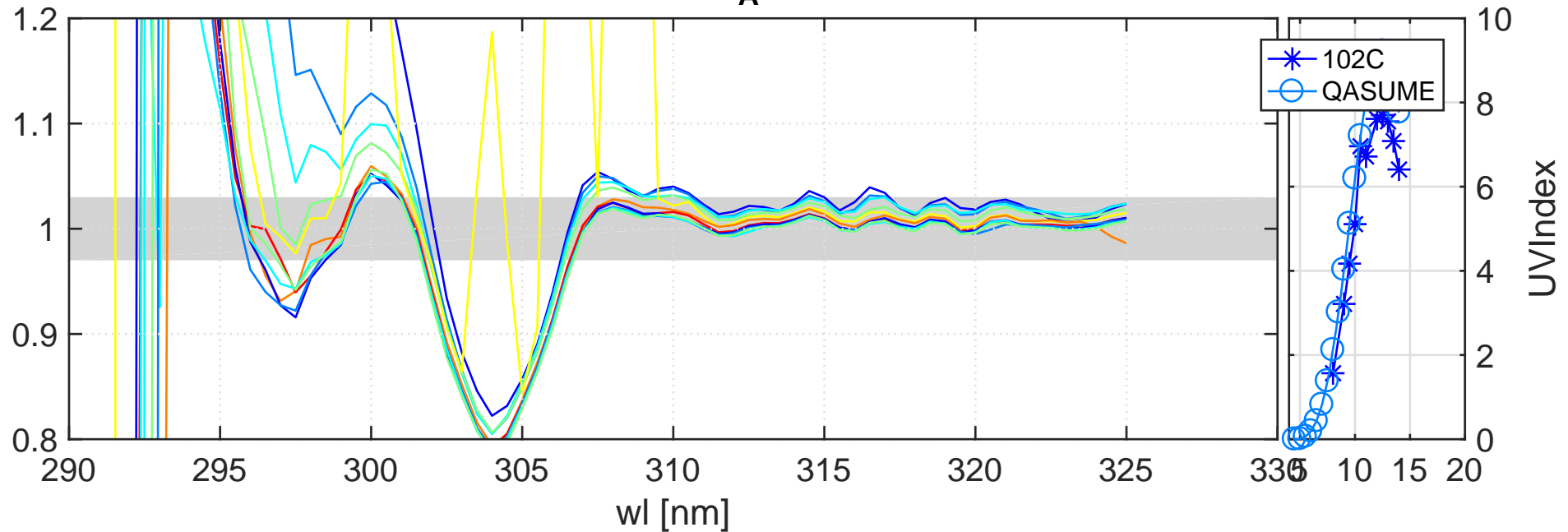
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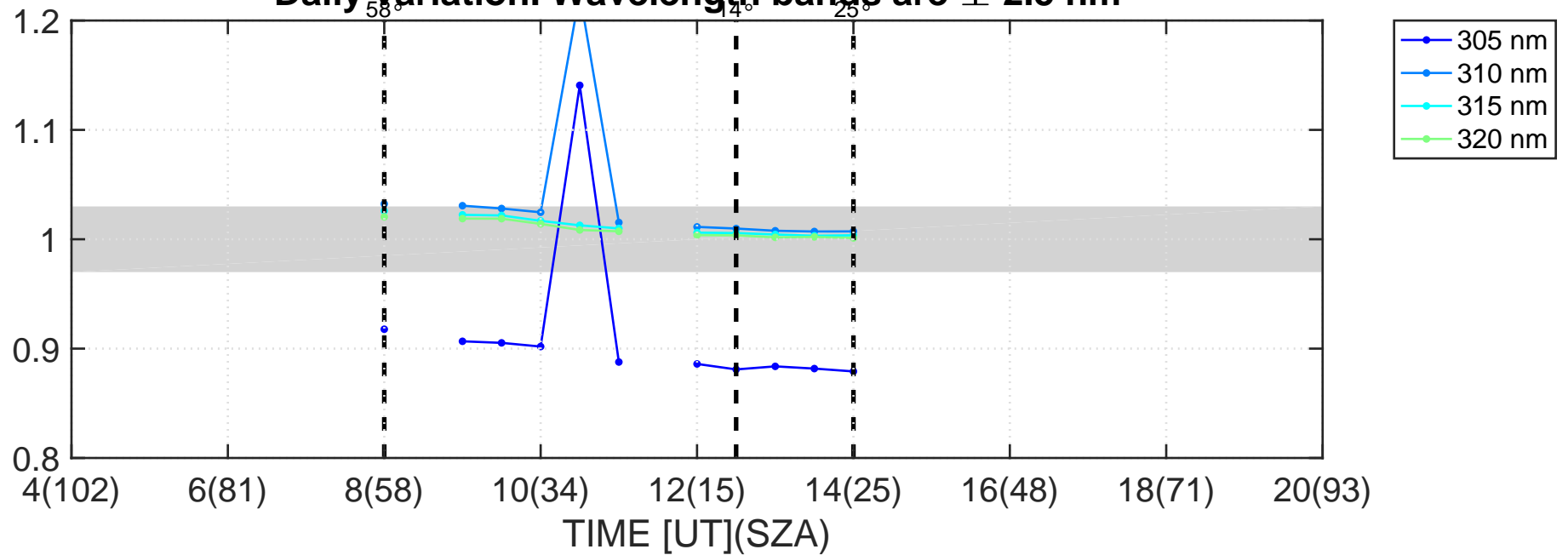
Daily variation. Wavelength bands are ± 2.5 nm



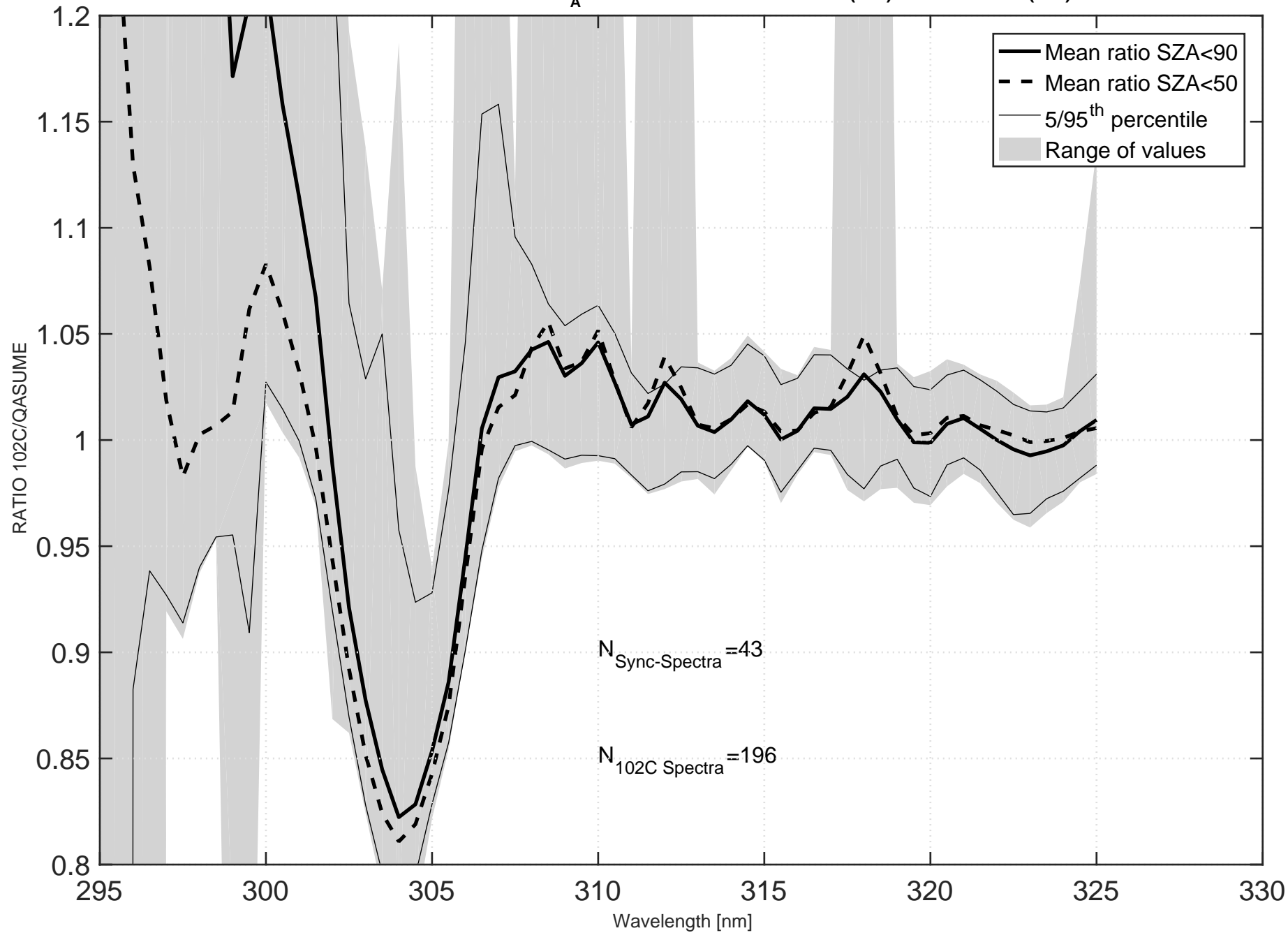
Global irradiance ratios 102C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



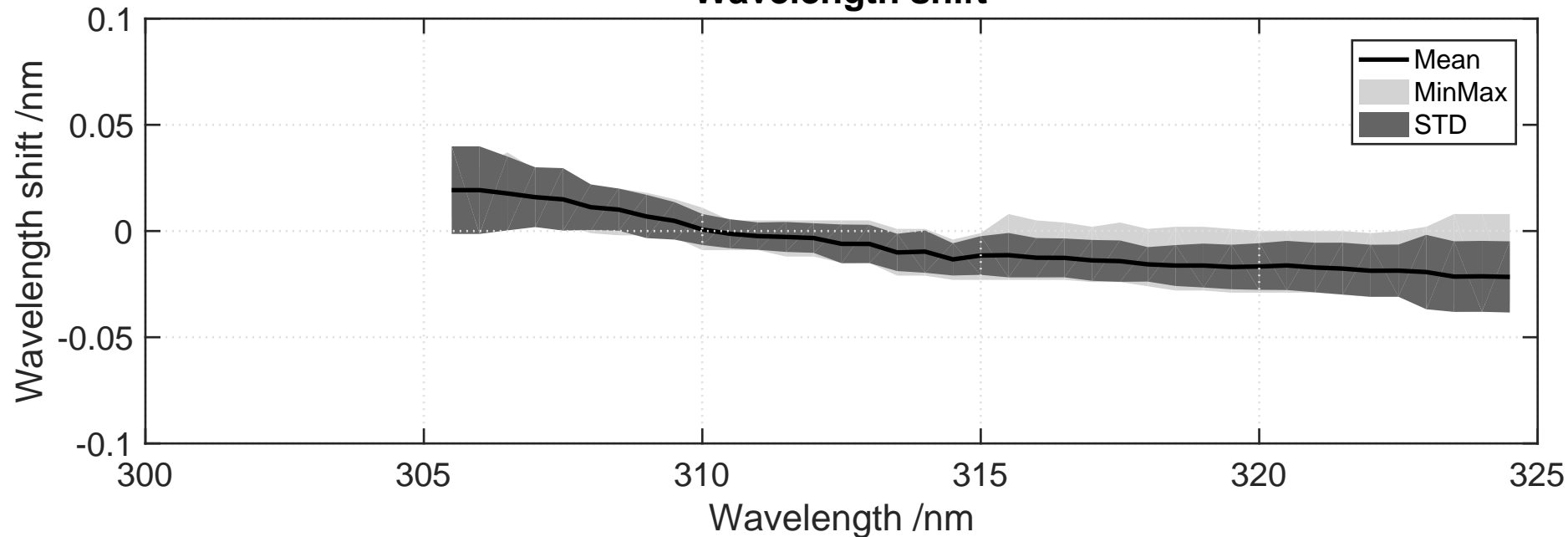
Daily variation. Wavelength bands are ± 2.5 nm



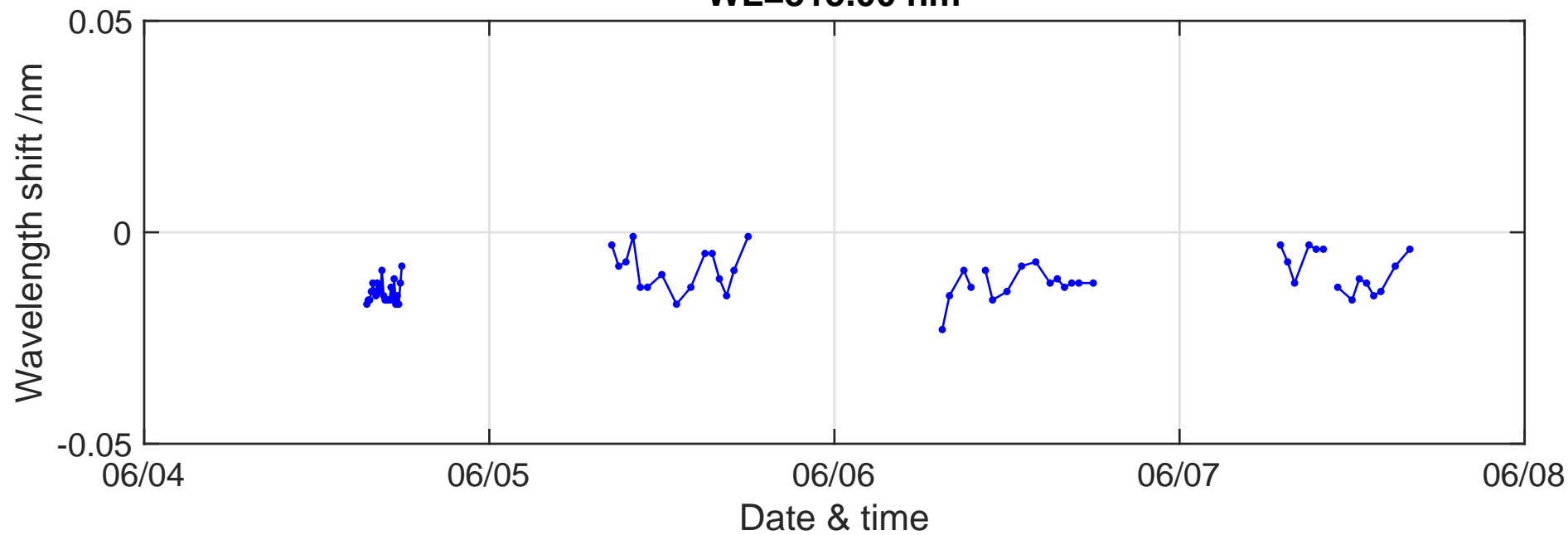
Mean ratio 102C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



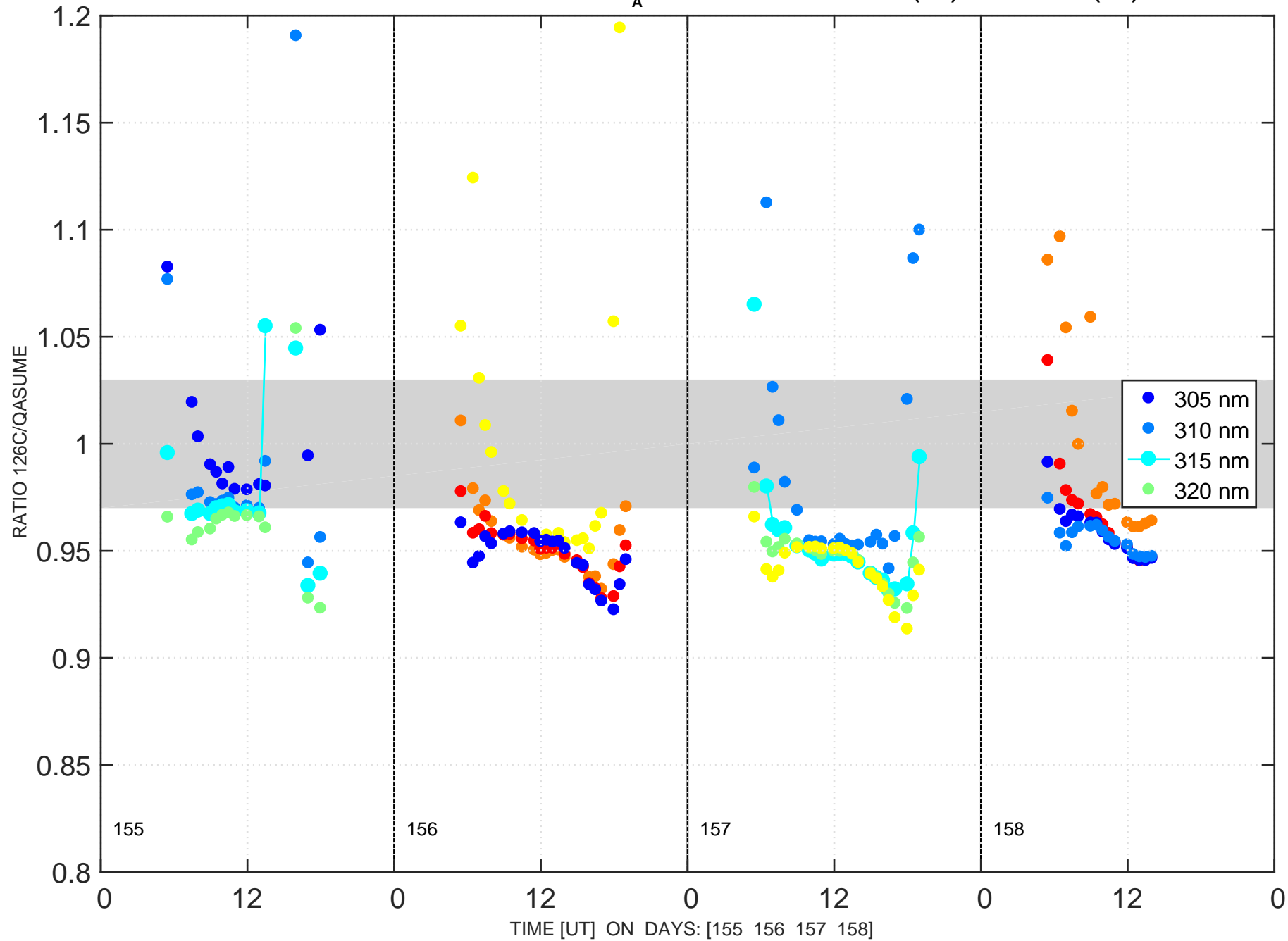
Wavelength shift



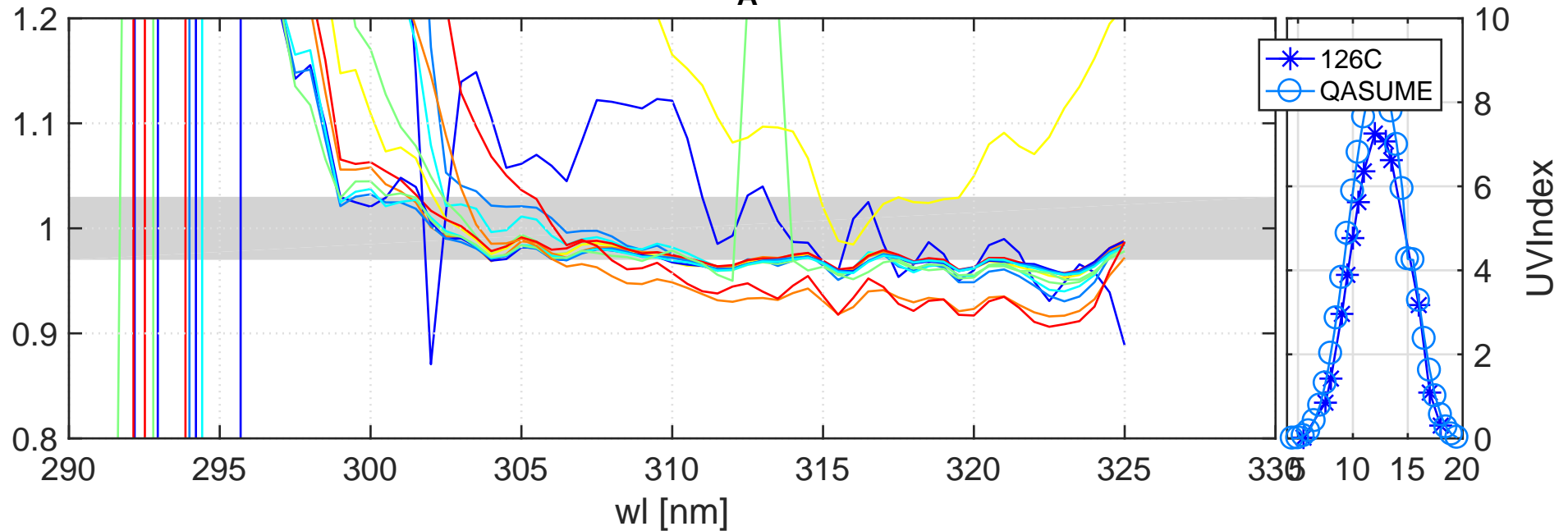
WL=315.00 nm



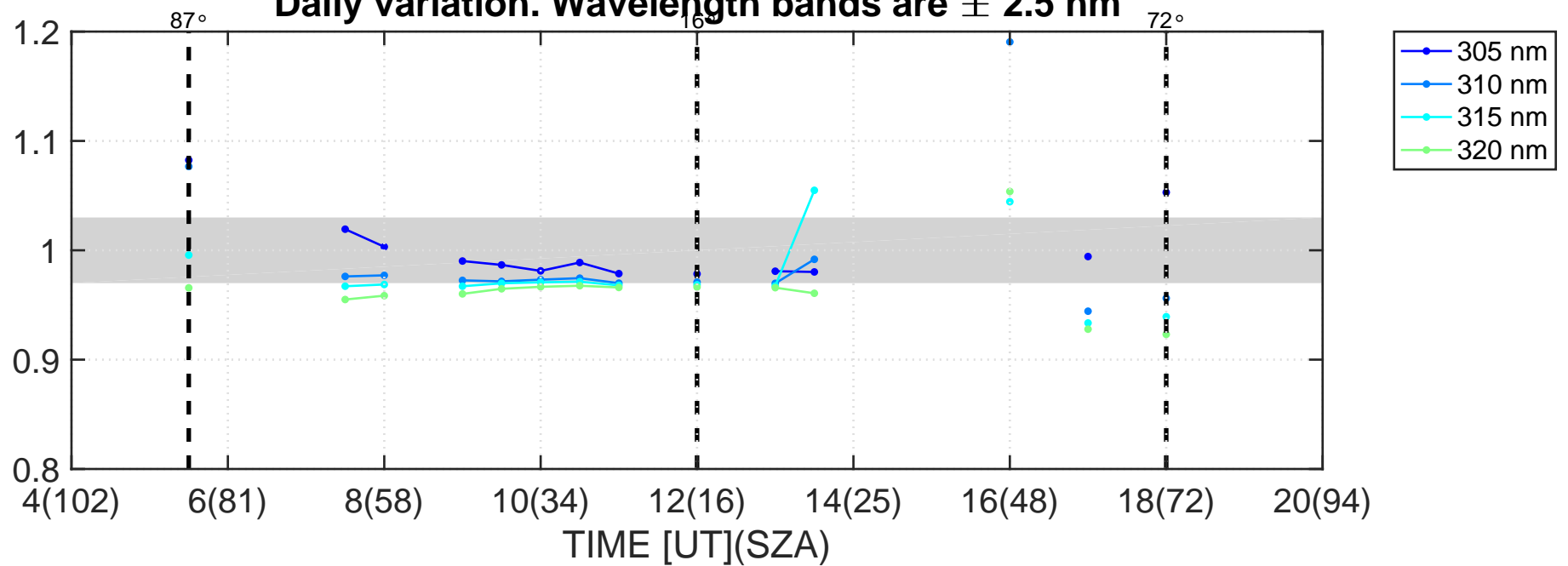
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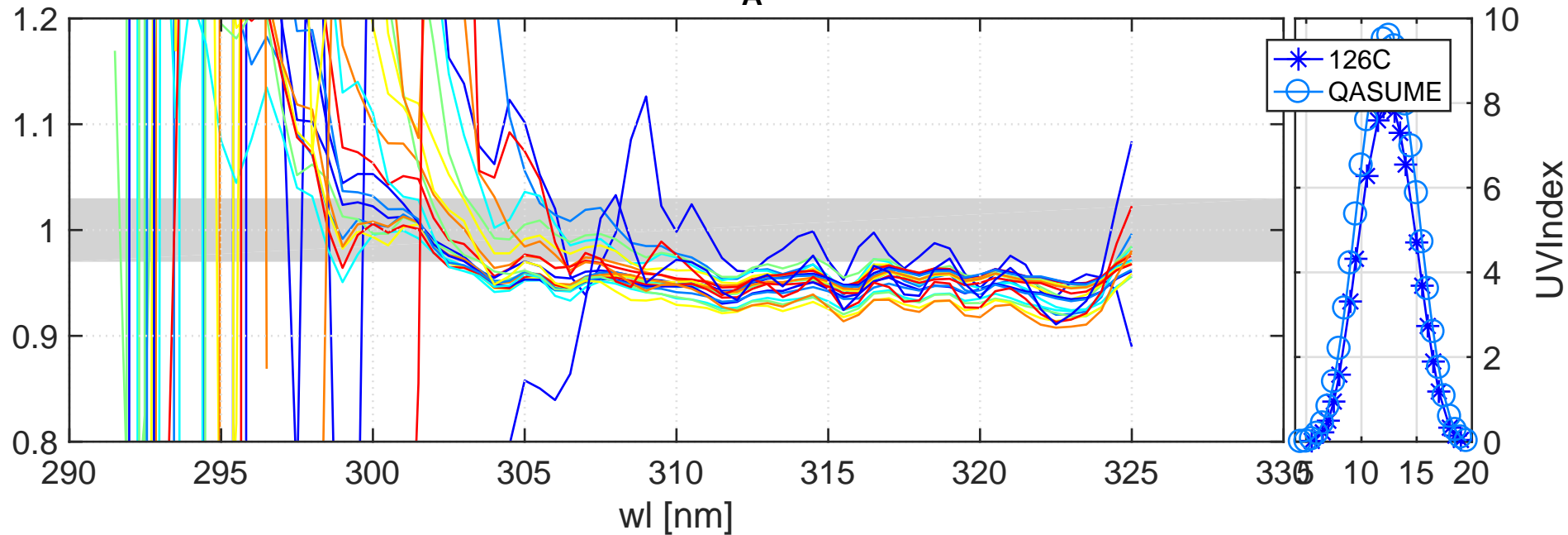
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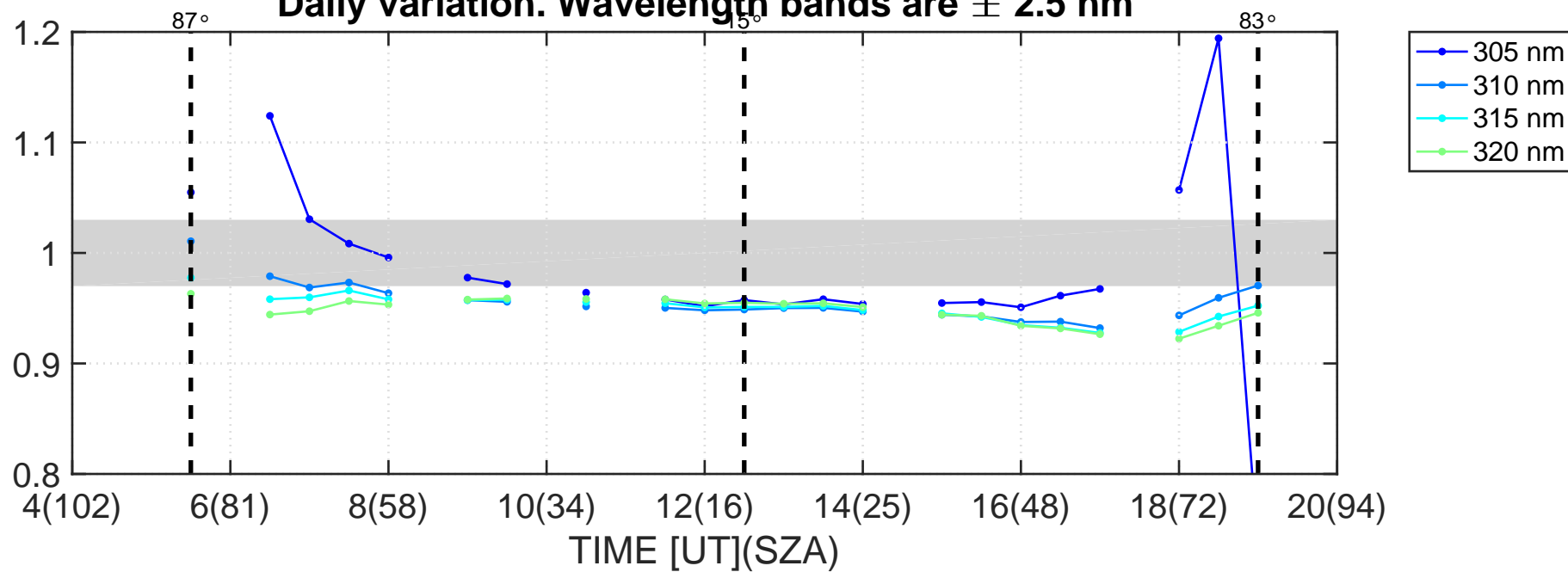
Daily variation. Wavelength bands are ± 2.5 nm



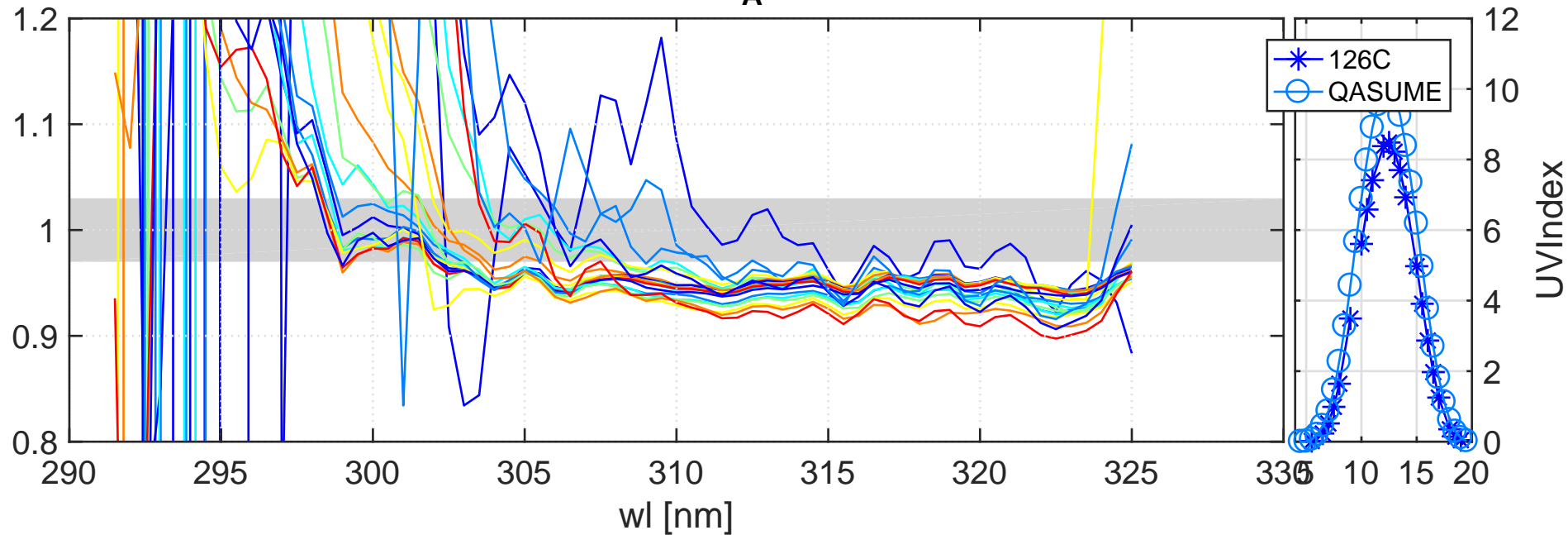
Global irradiance ratios 126C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



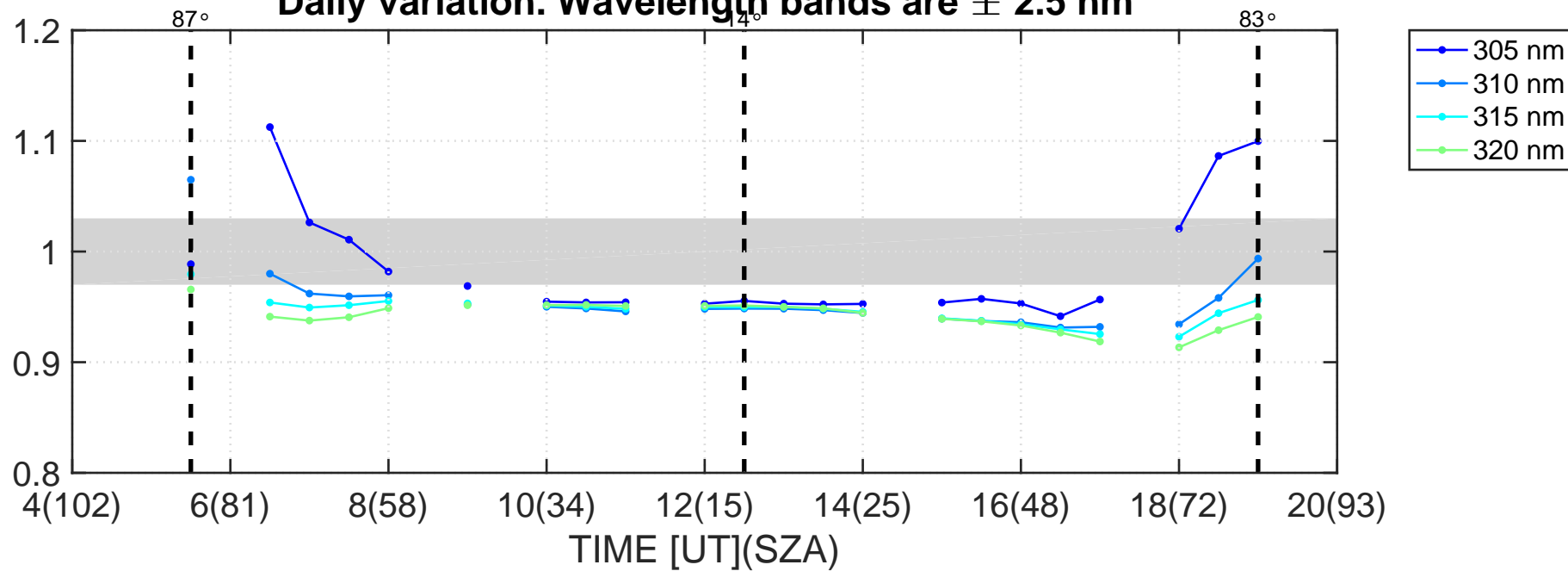
Daily variation. Wavelength bands are ± 2.5 nm



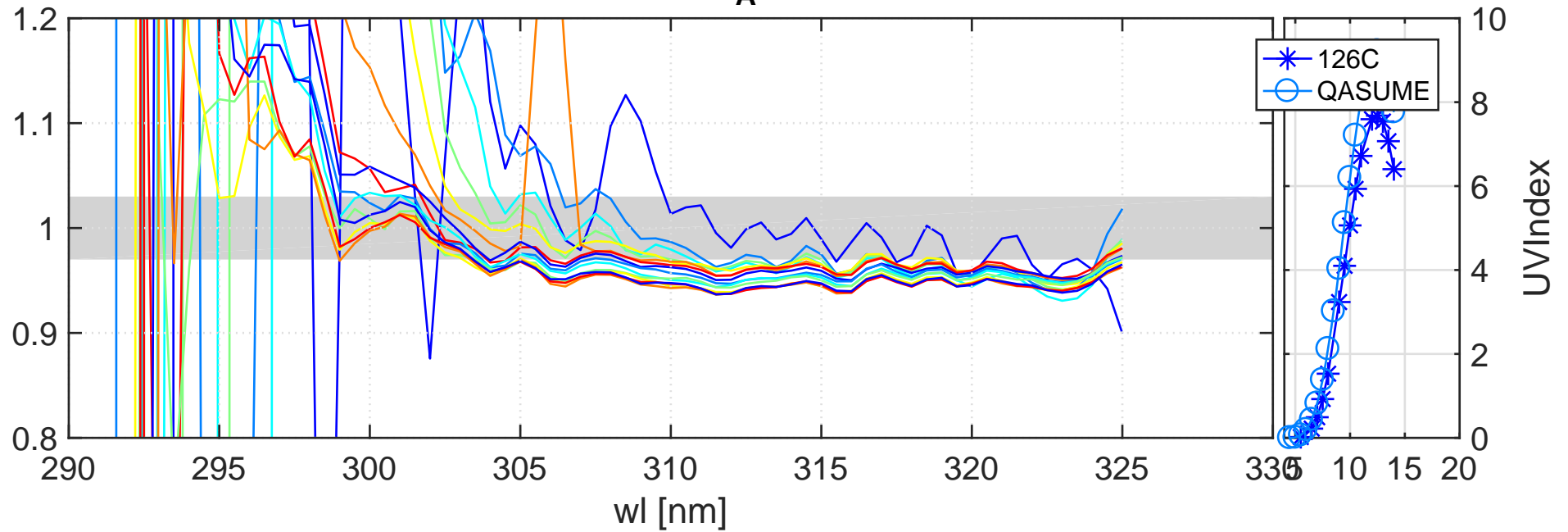
Global irradiance ratios 126C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



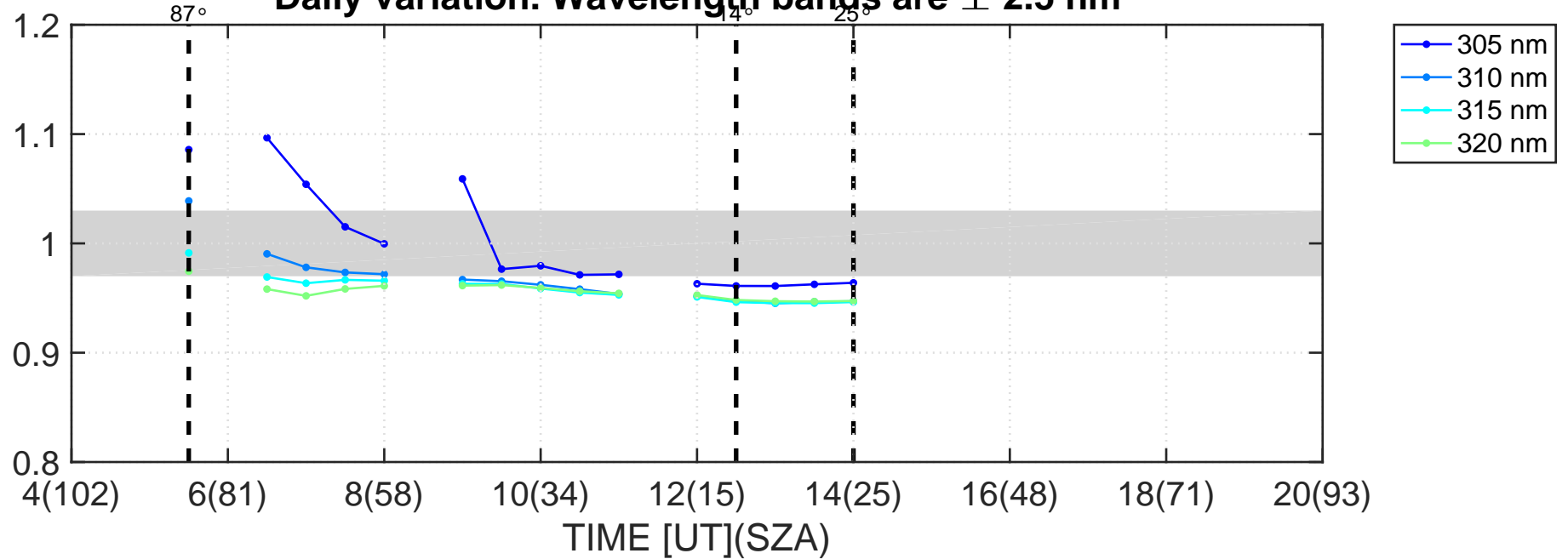
Daily variation. Wavelength bands are ± 2.5 nm



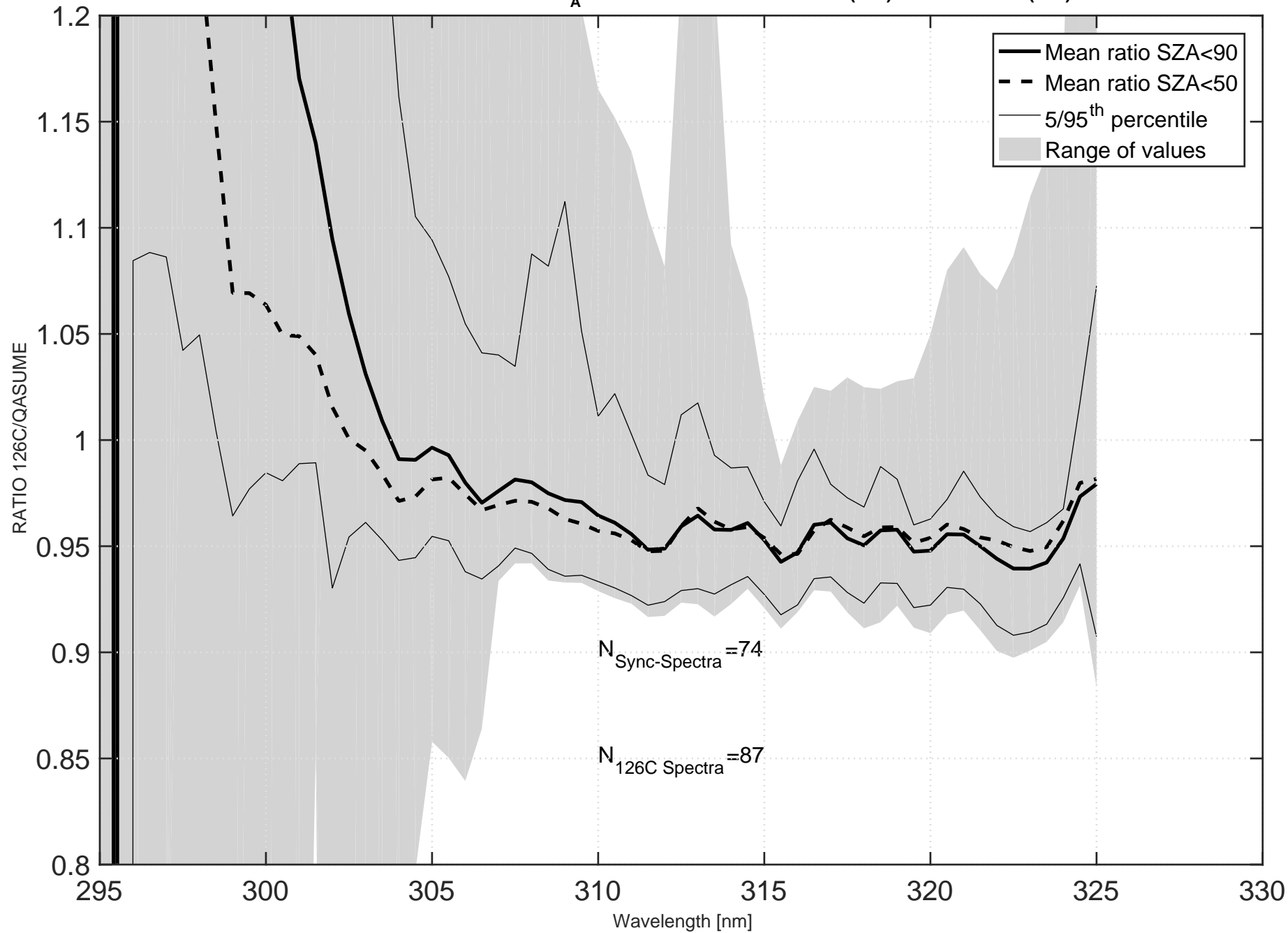
Global irradiance ratios 126C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



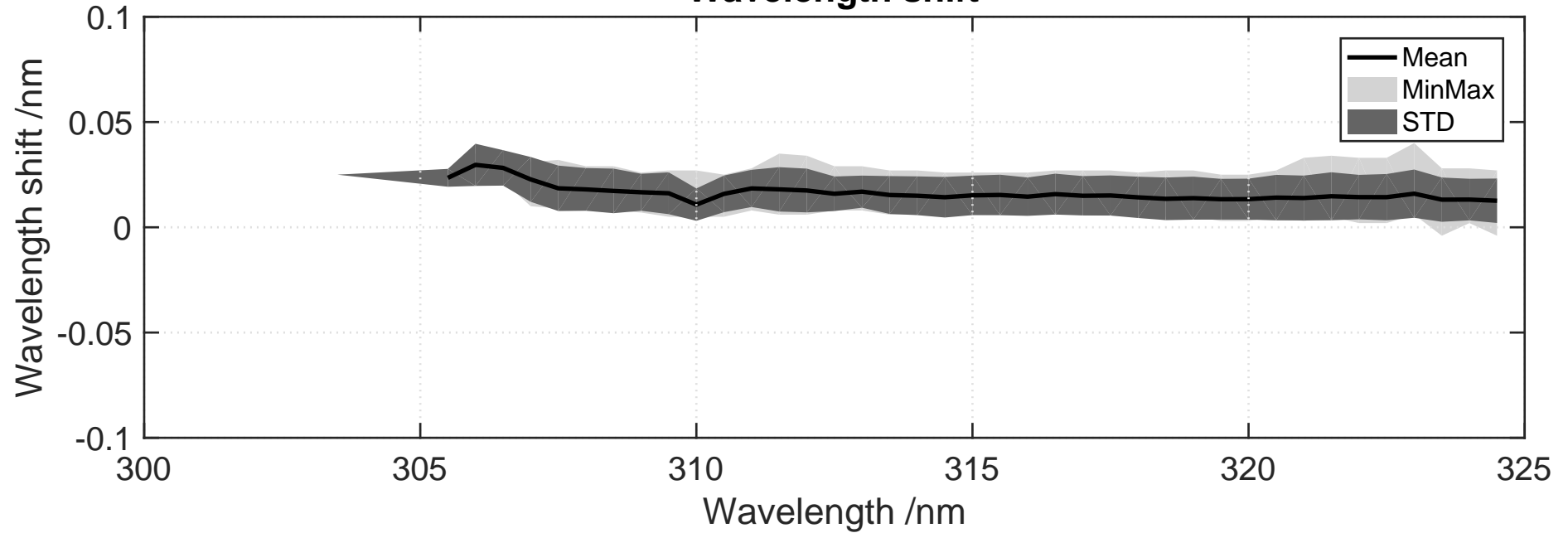
Daily variation. Wavelength bands are ± 2.5 nm



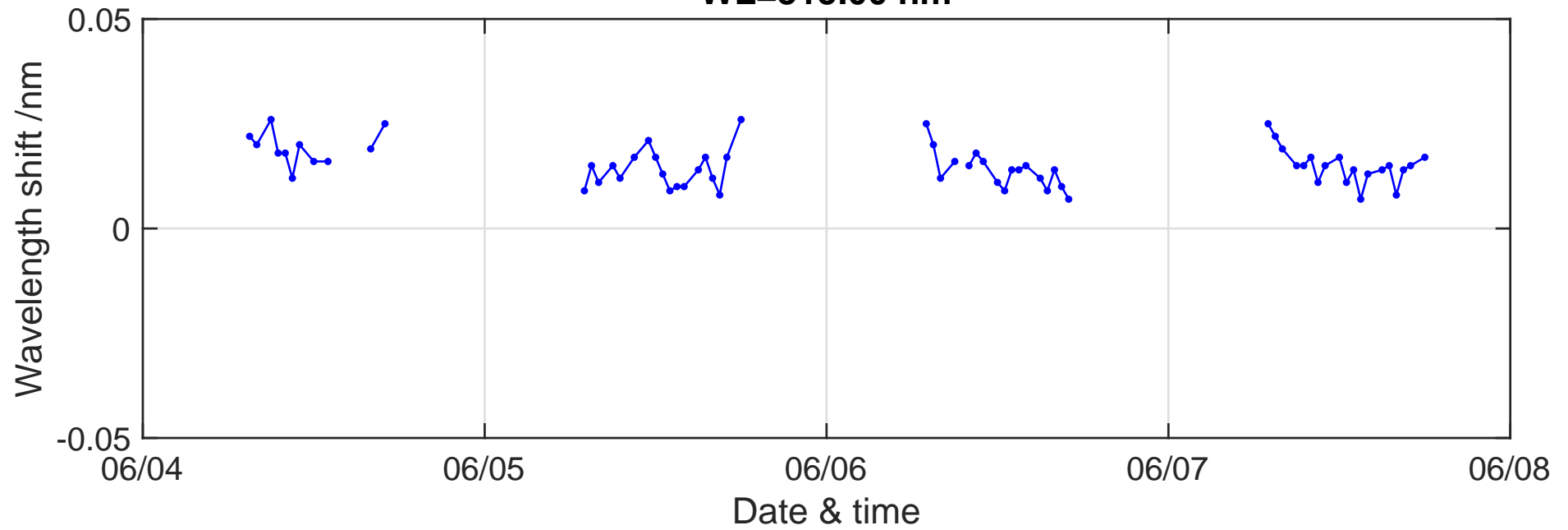
Mean ratio 126C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



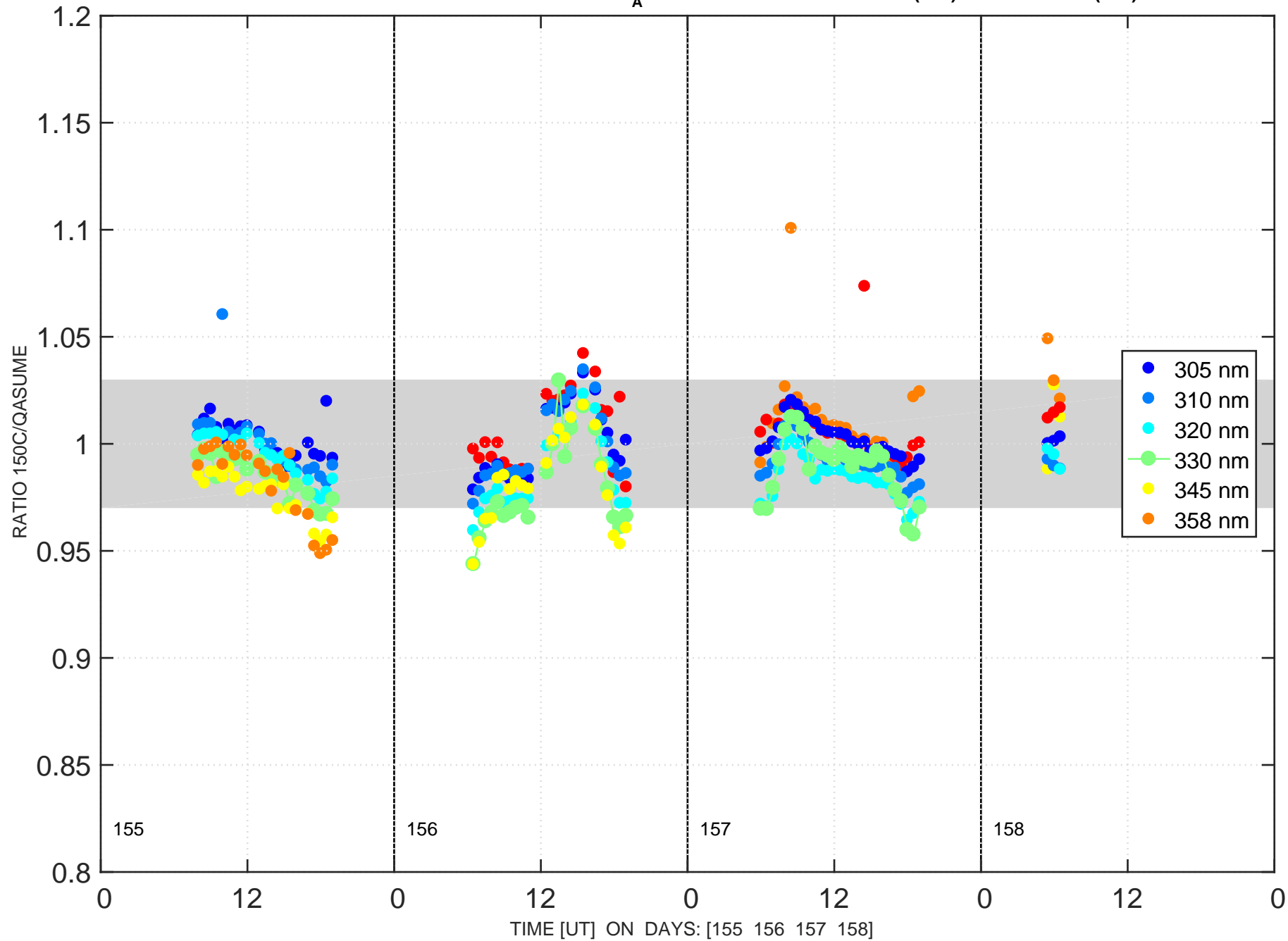
Wavelength shift



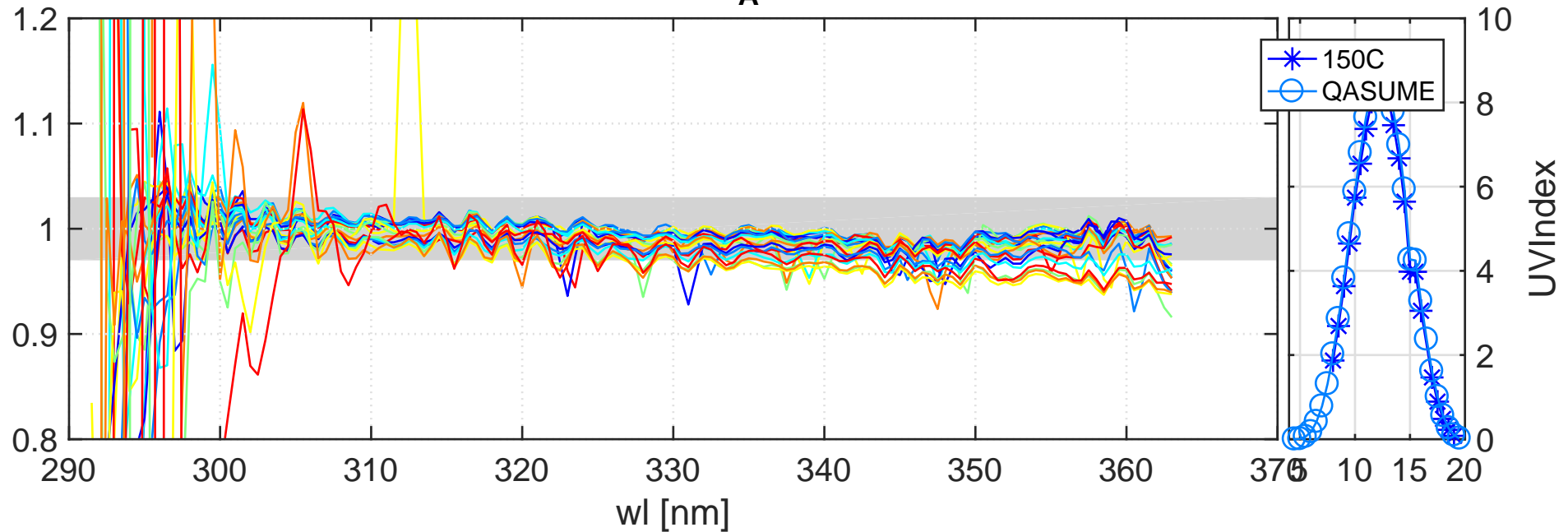
WL=315.00 nm



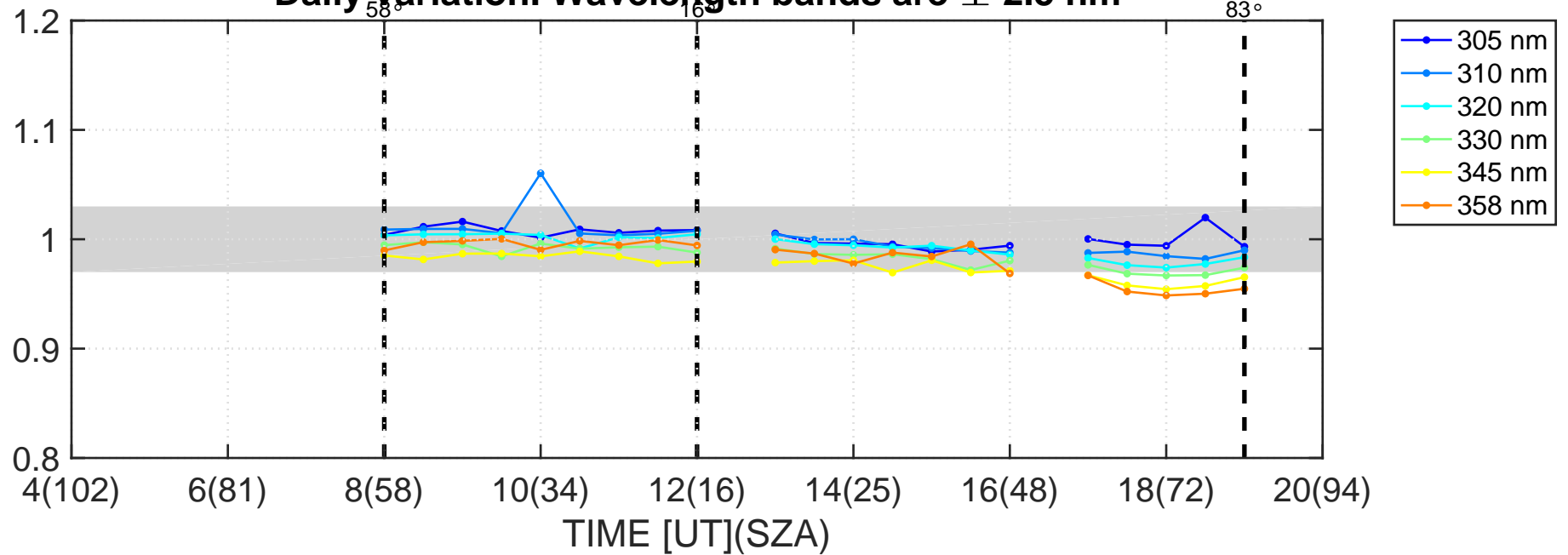
Global irradiance ratios 150C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



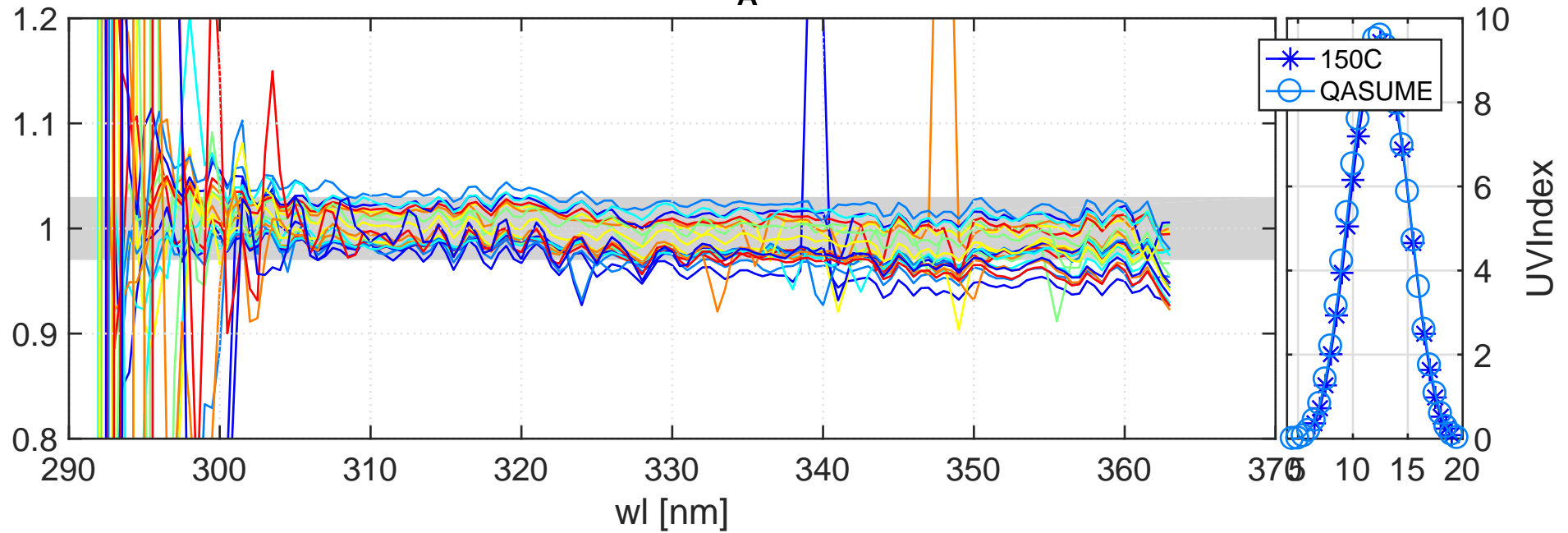
Global irradiance ratios 150C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



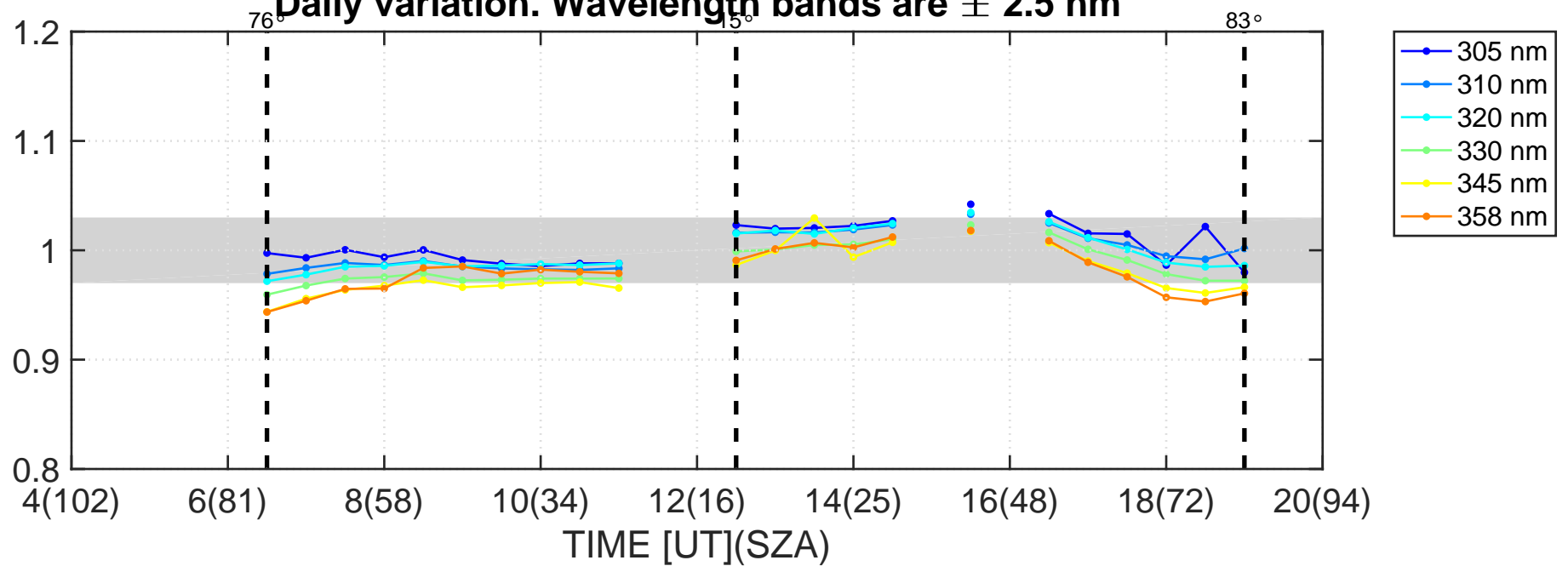
Daily variation. Wavelength bands are ± 2.5 nm



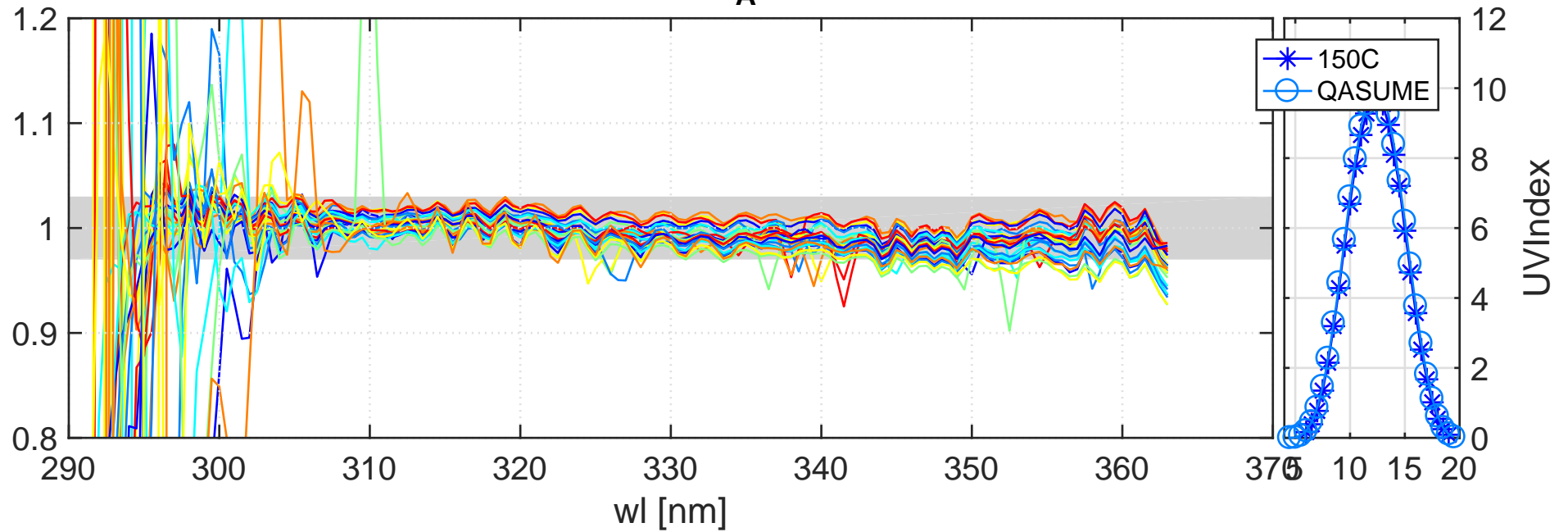
Global irradiance ratios 150C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



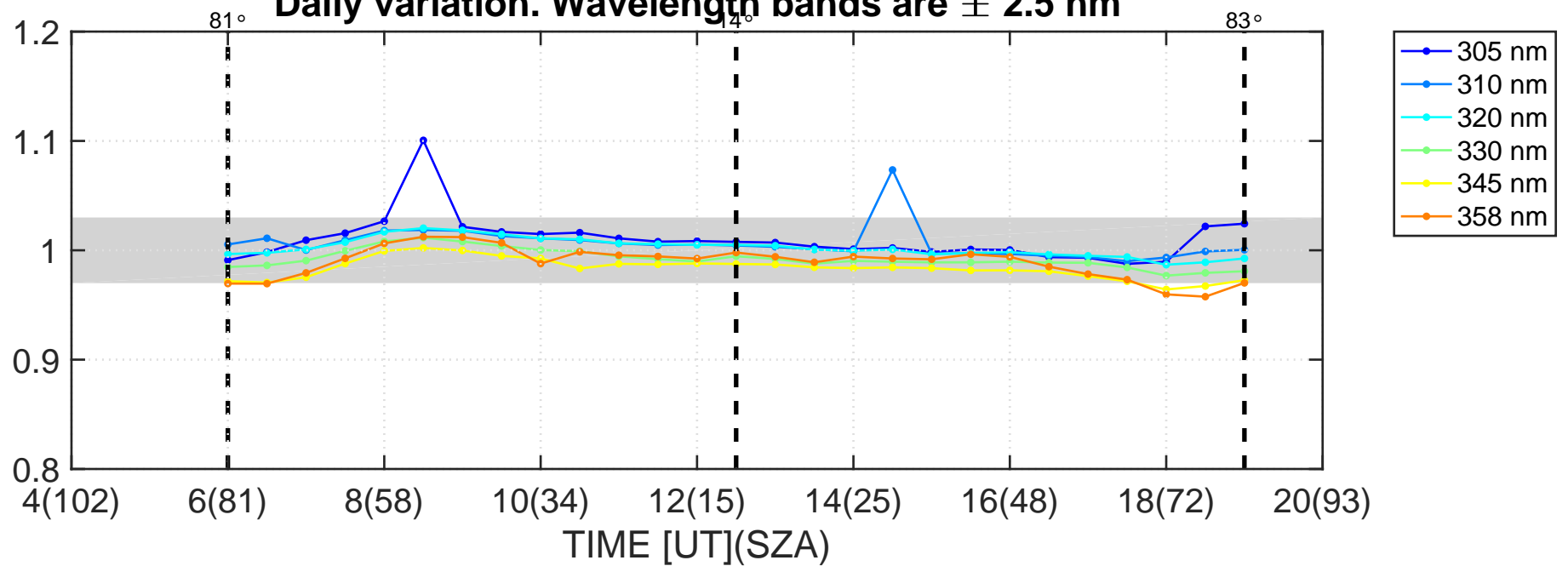
Daily variation. Wavelength bands are ± 2.5 nm



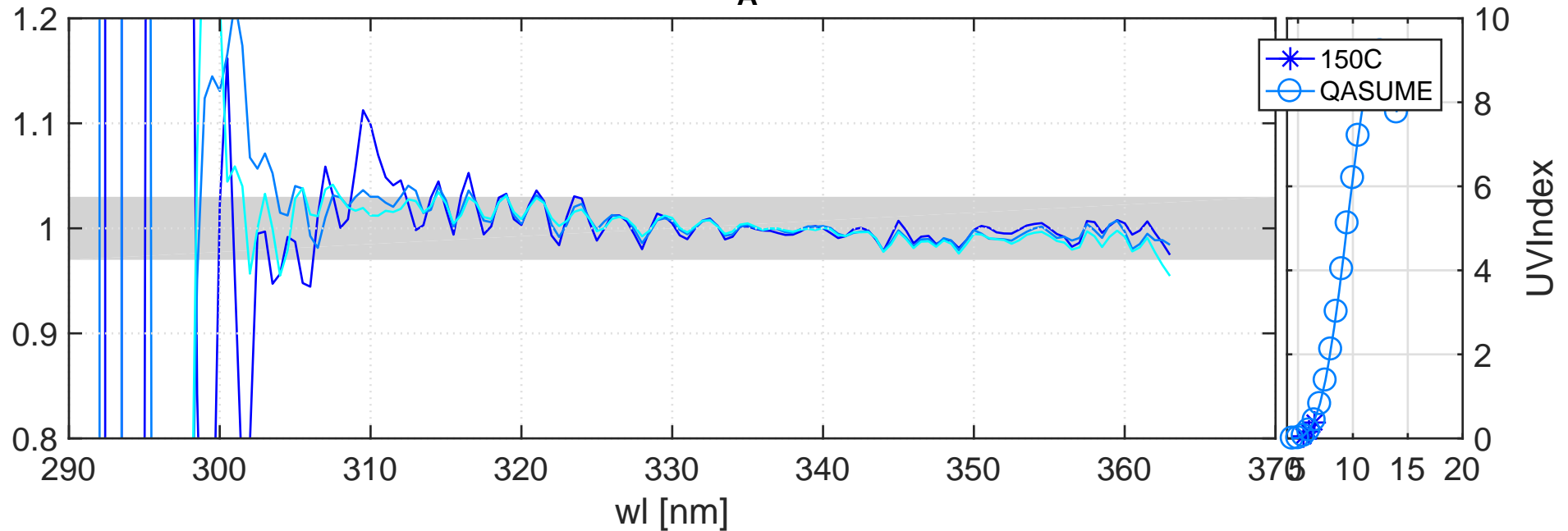
Global irradiance ratios 150C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



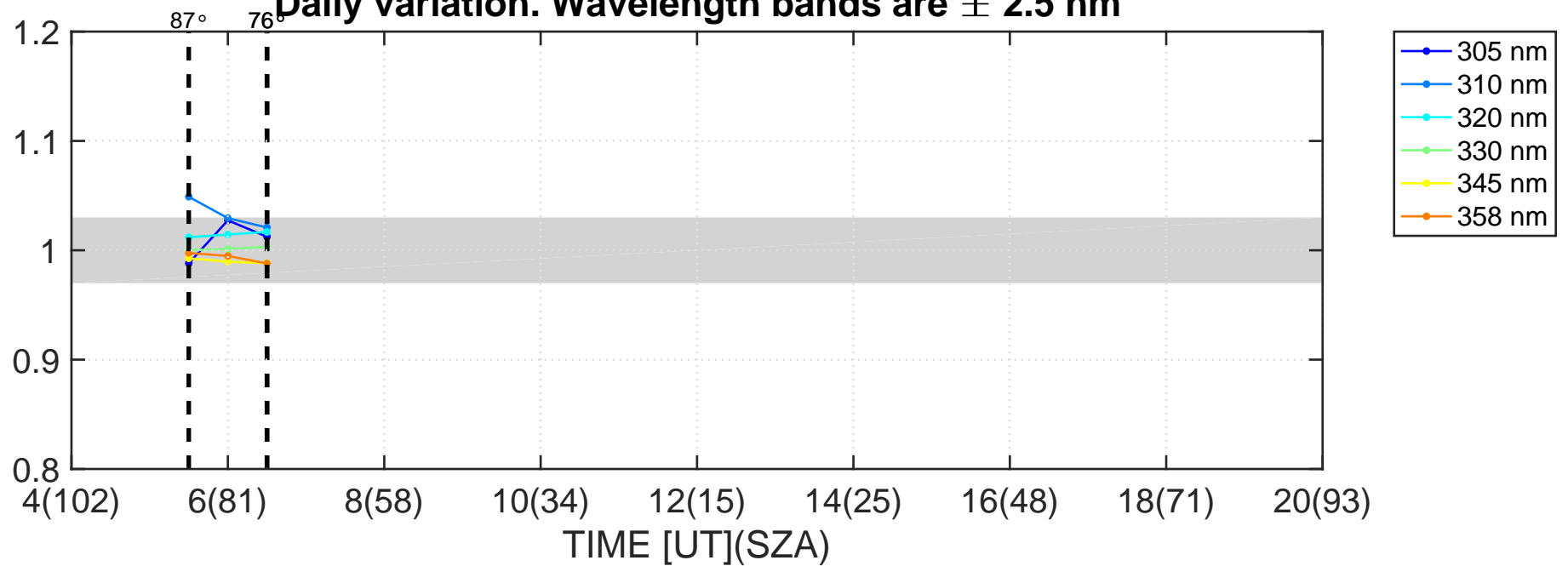
Daily variation. Wavelength bands are ± 2.5 nm



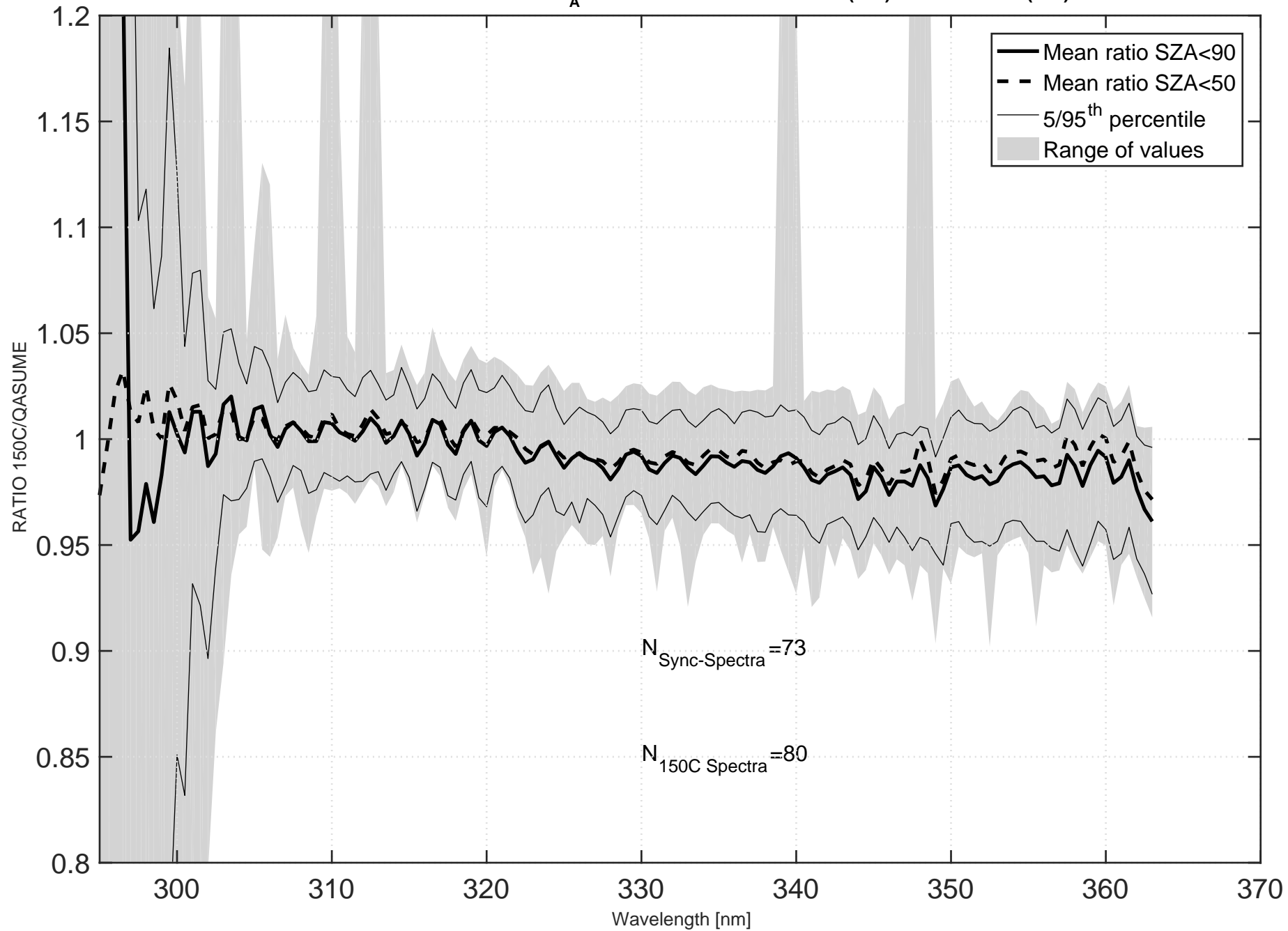
Global irradiance ratios 150C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



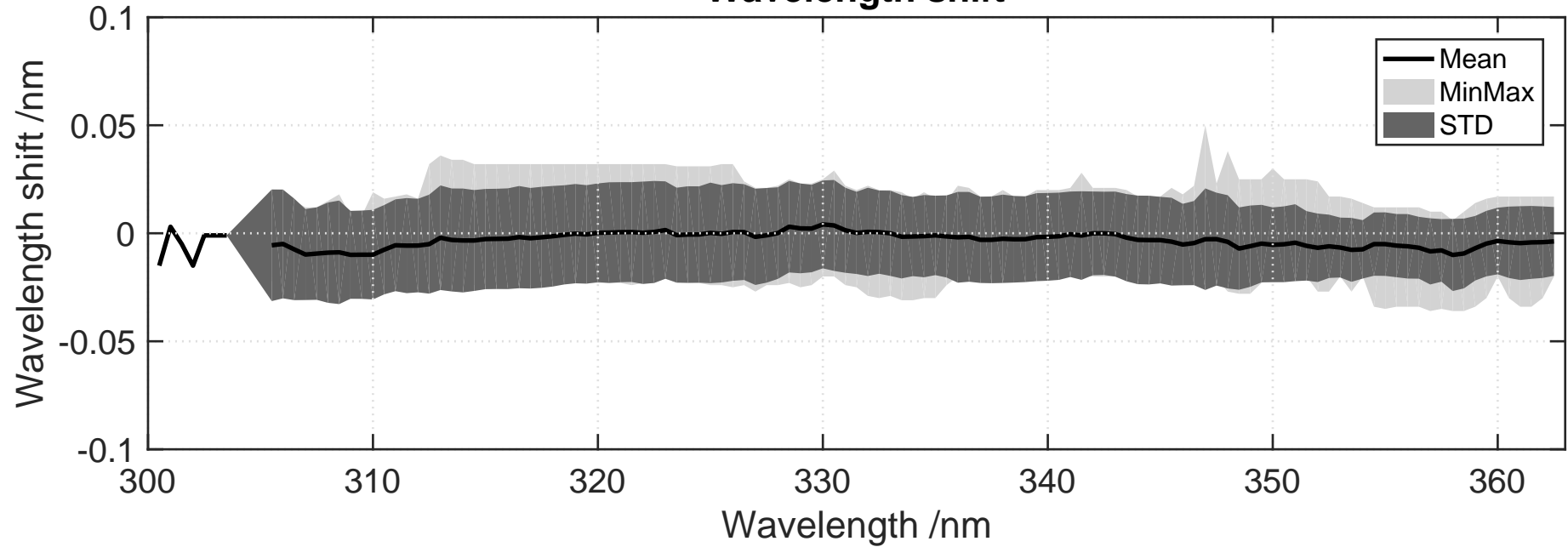
Daily variation. Wavelength bands are ± 2.5 nm



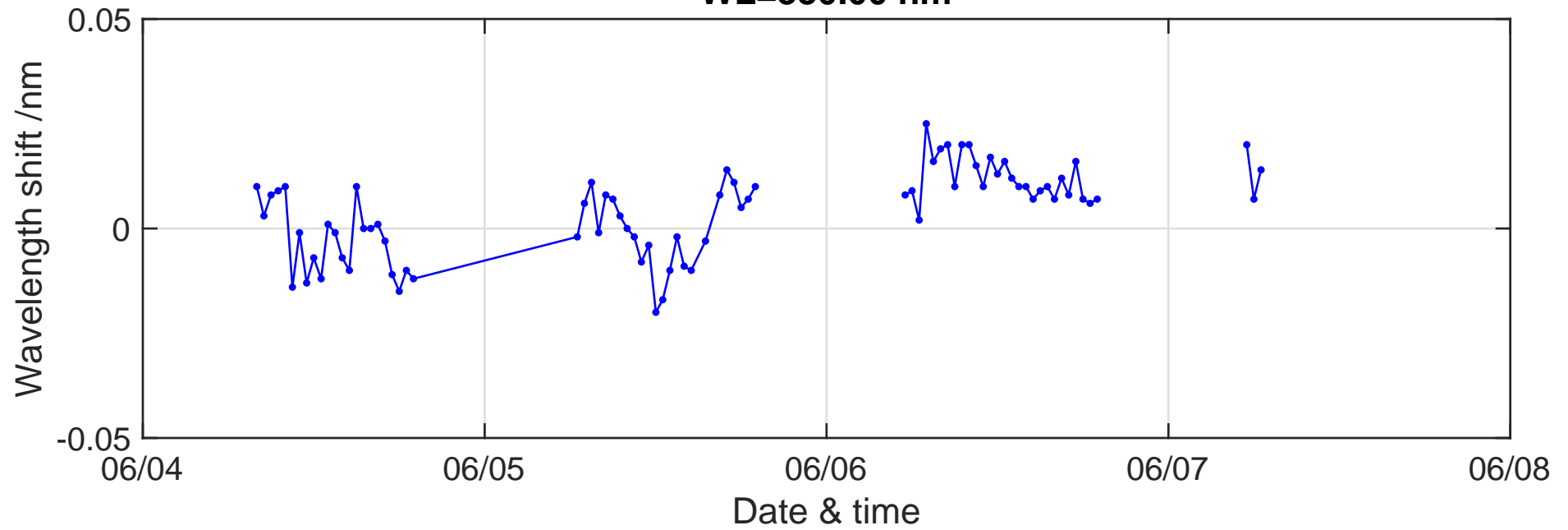
Mean ratio 150C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



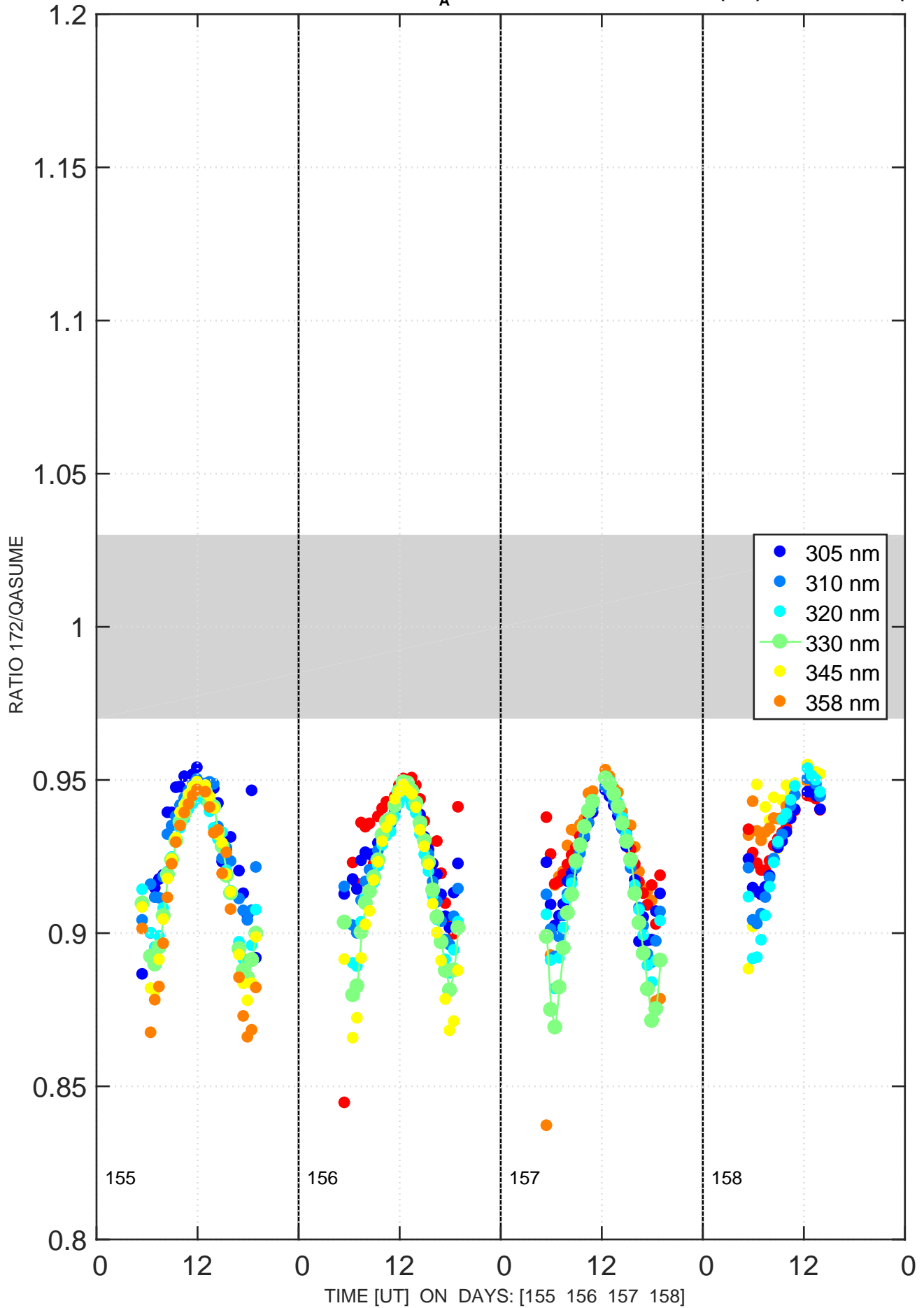
Wavelength shift



WL=330.00 nm

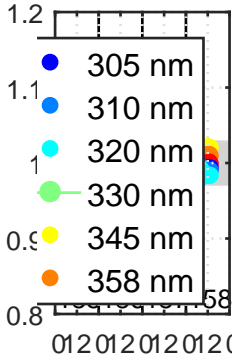


Global irradiance ratios 172/QASUME at E_Arenosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



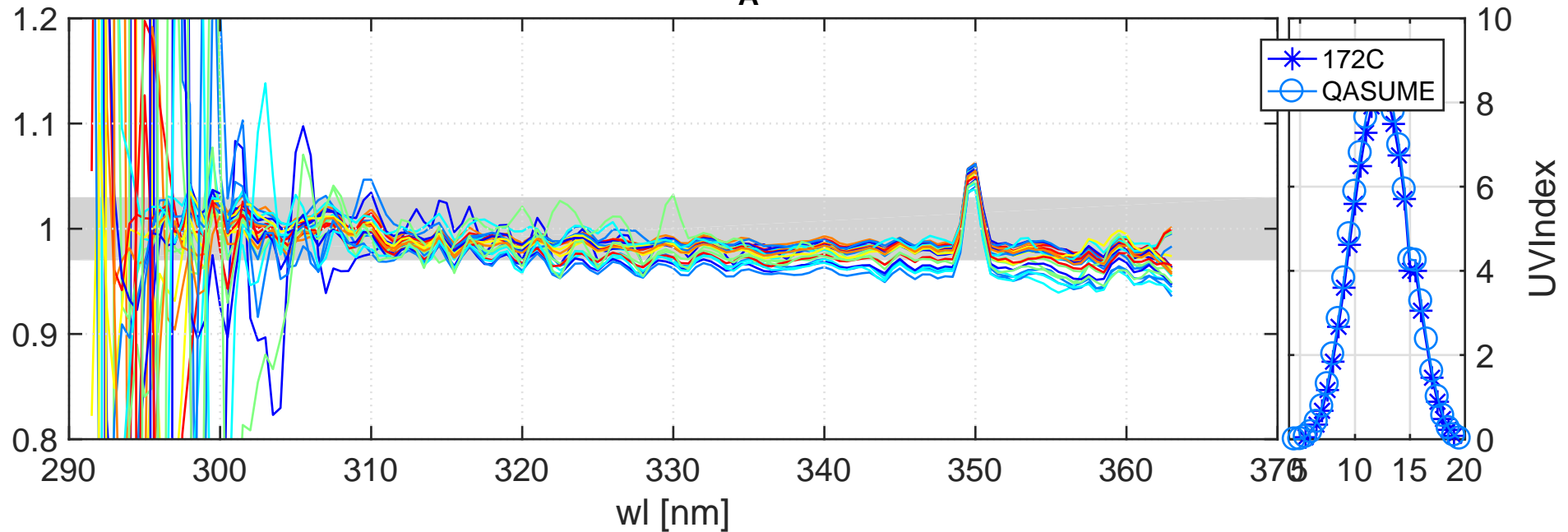
t EI renosillo-matshic:04-Jun-2017(155) to

A

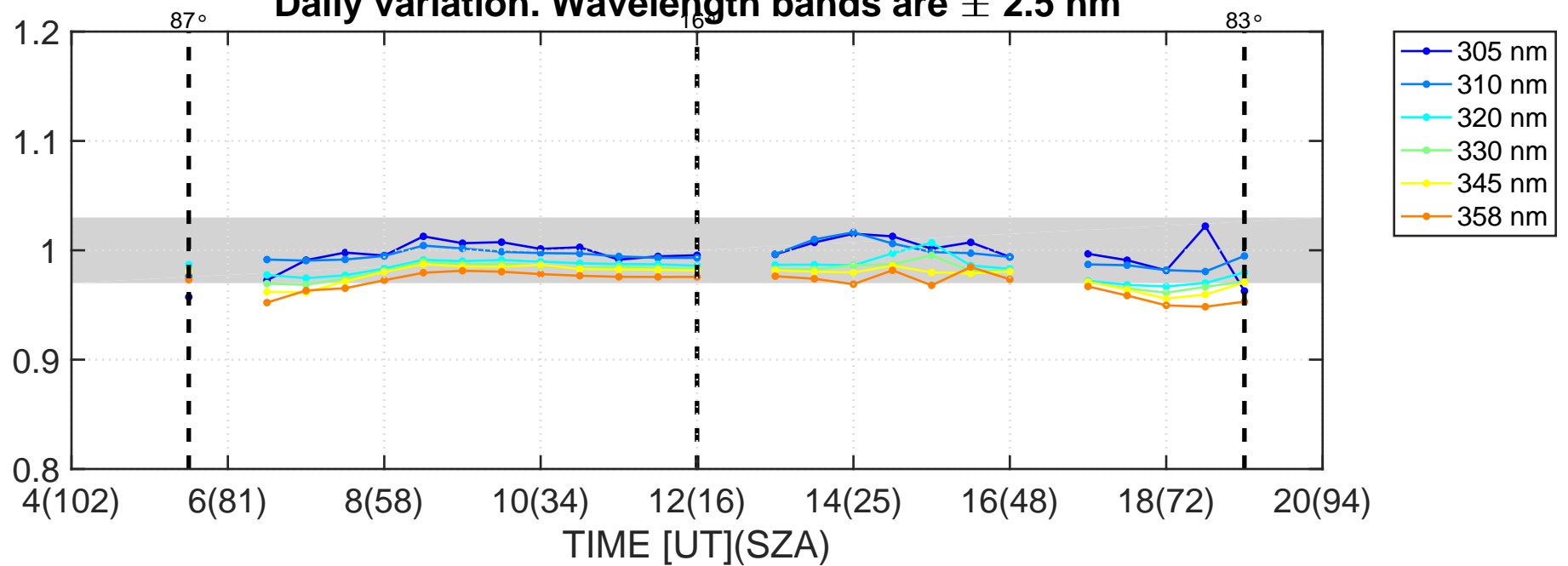


ON DAYS: [155 156 157 158]

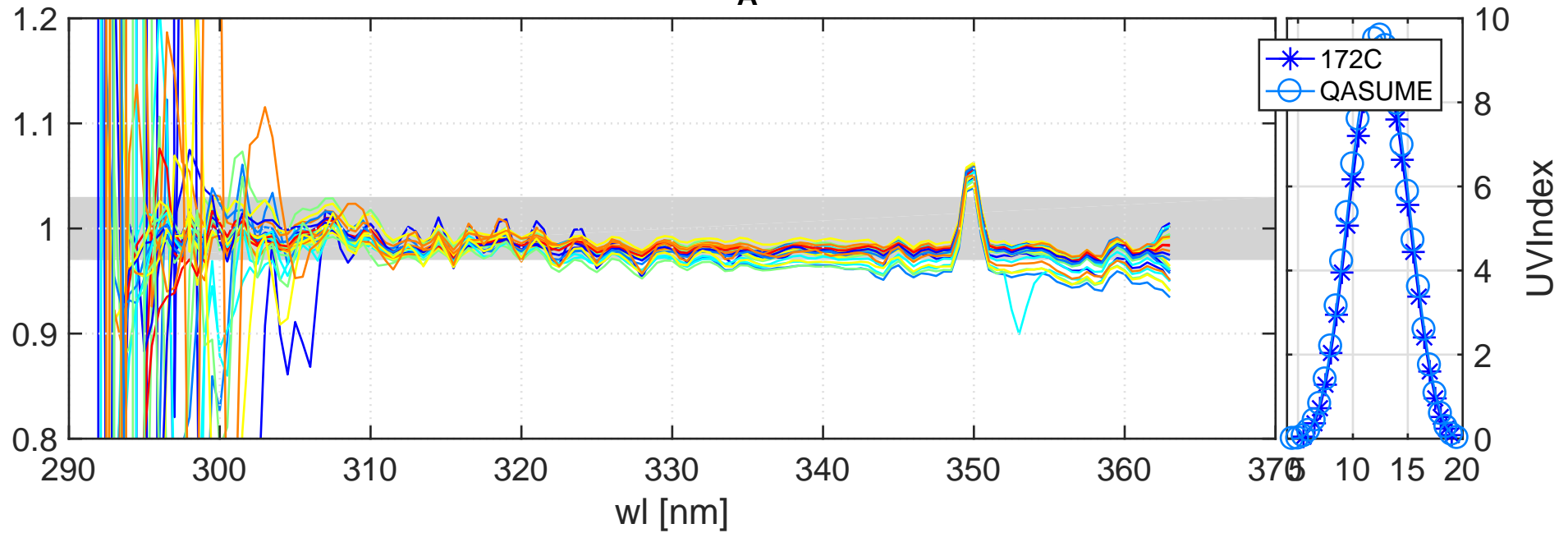
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



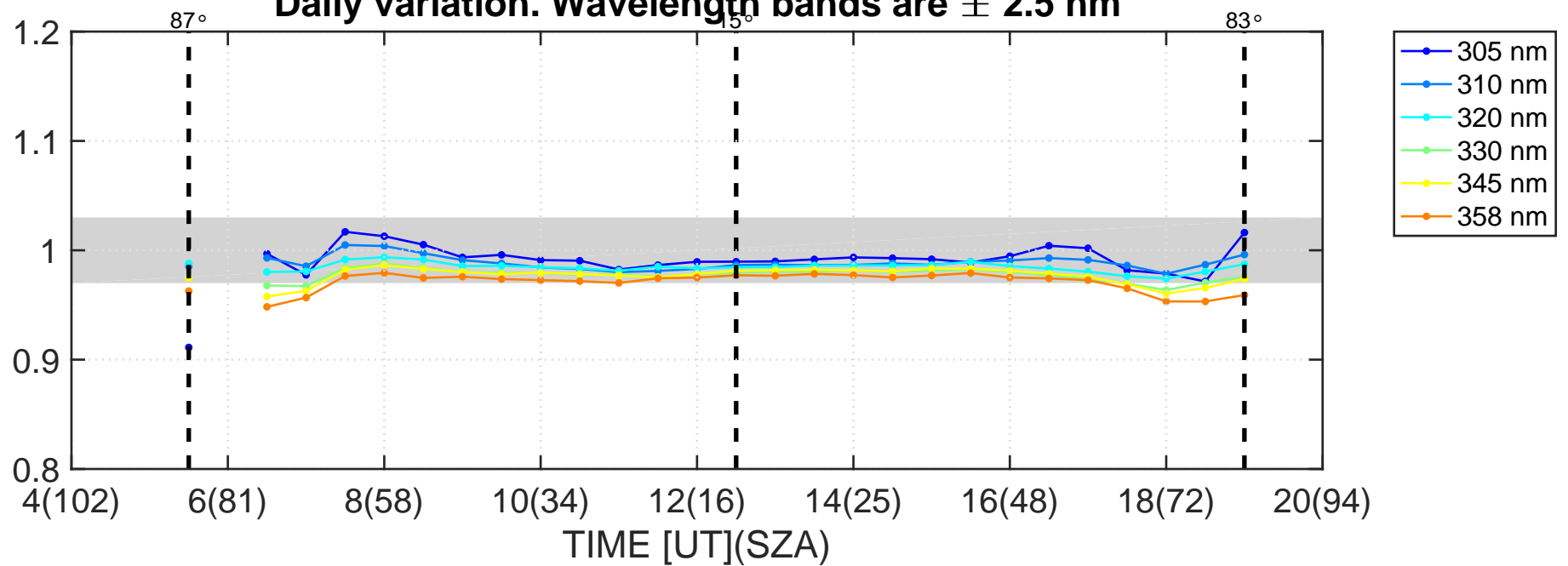
Daily variation. Wavelength bands are ± 2.5 nm



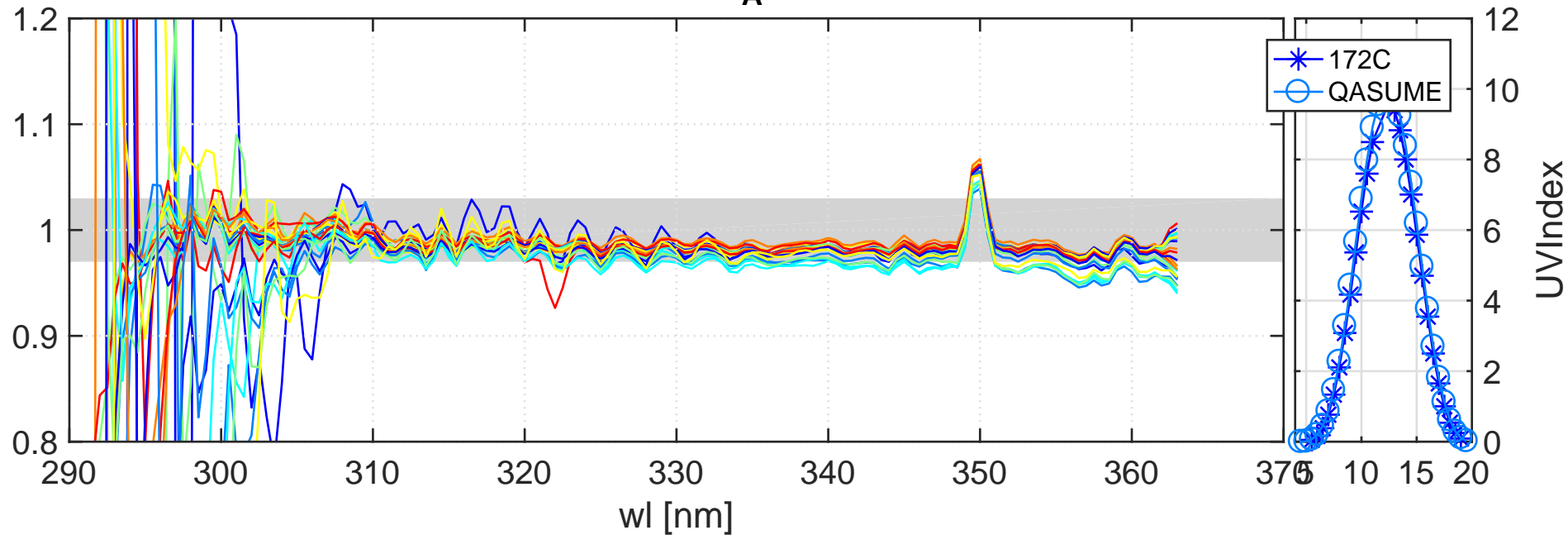
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



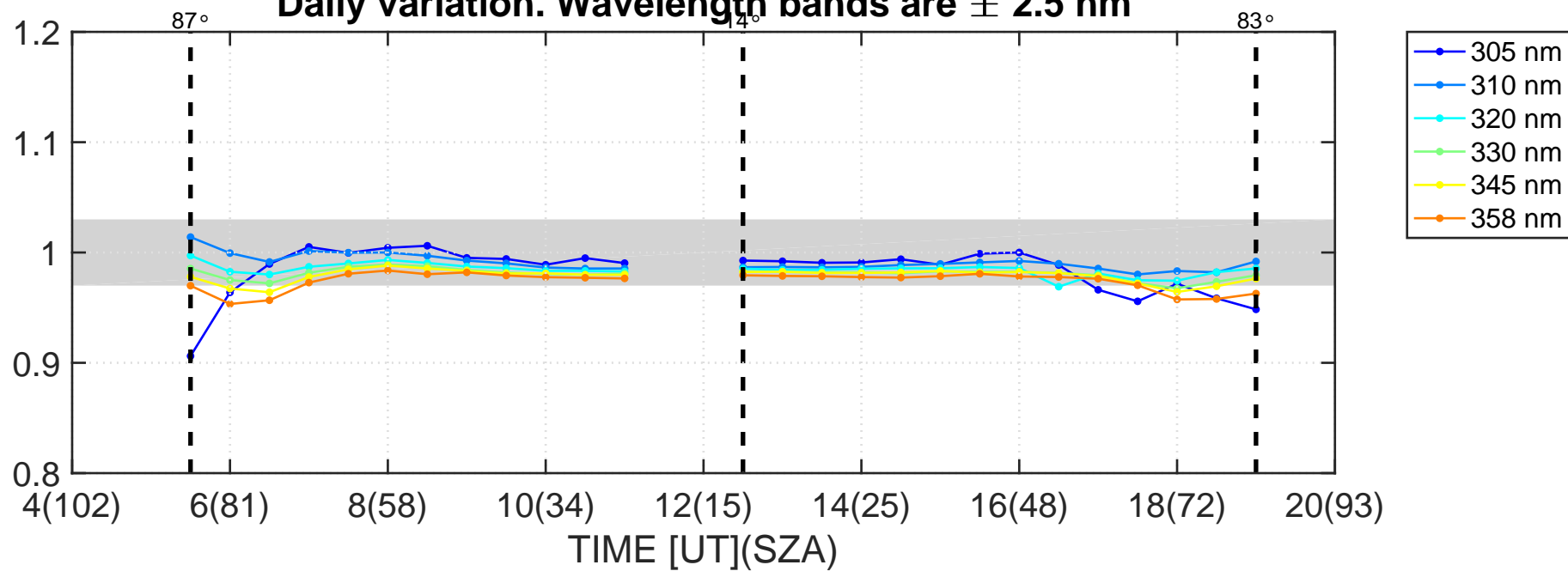
Daily variation. Wavelength bands are ± 2.5 nm



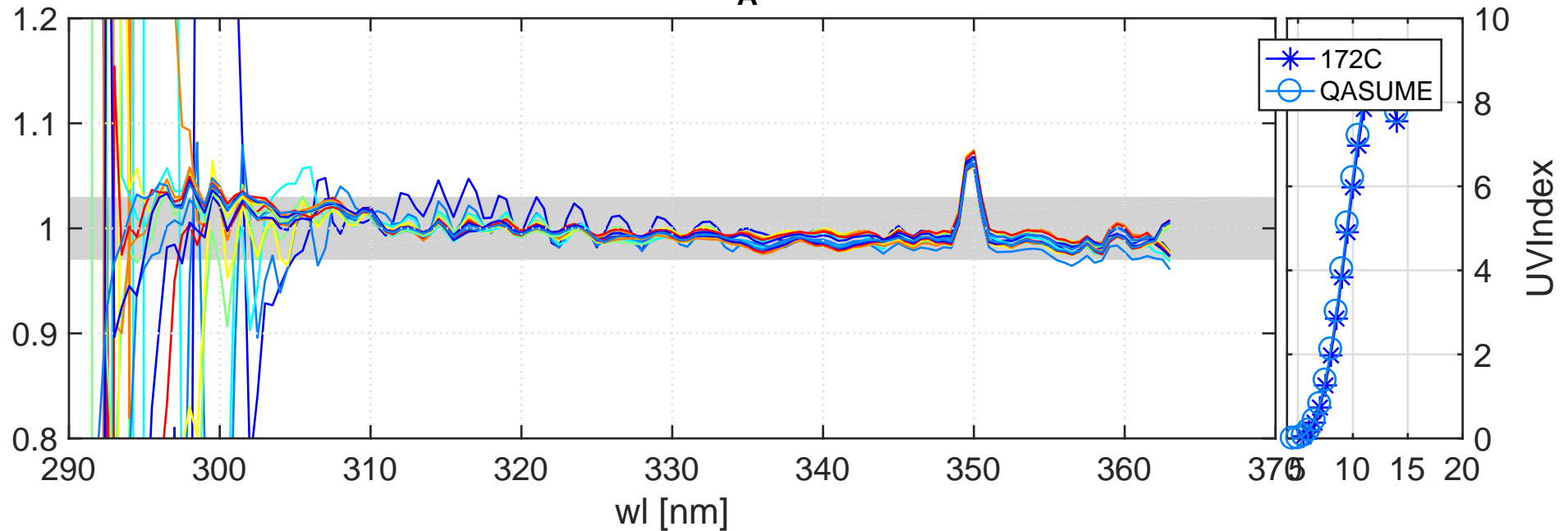
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



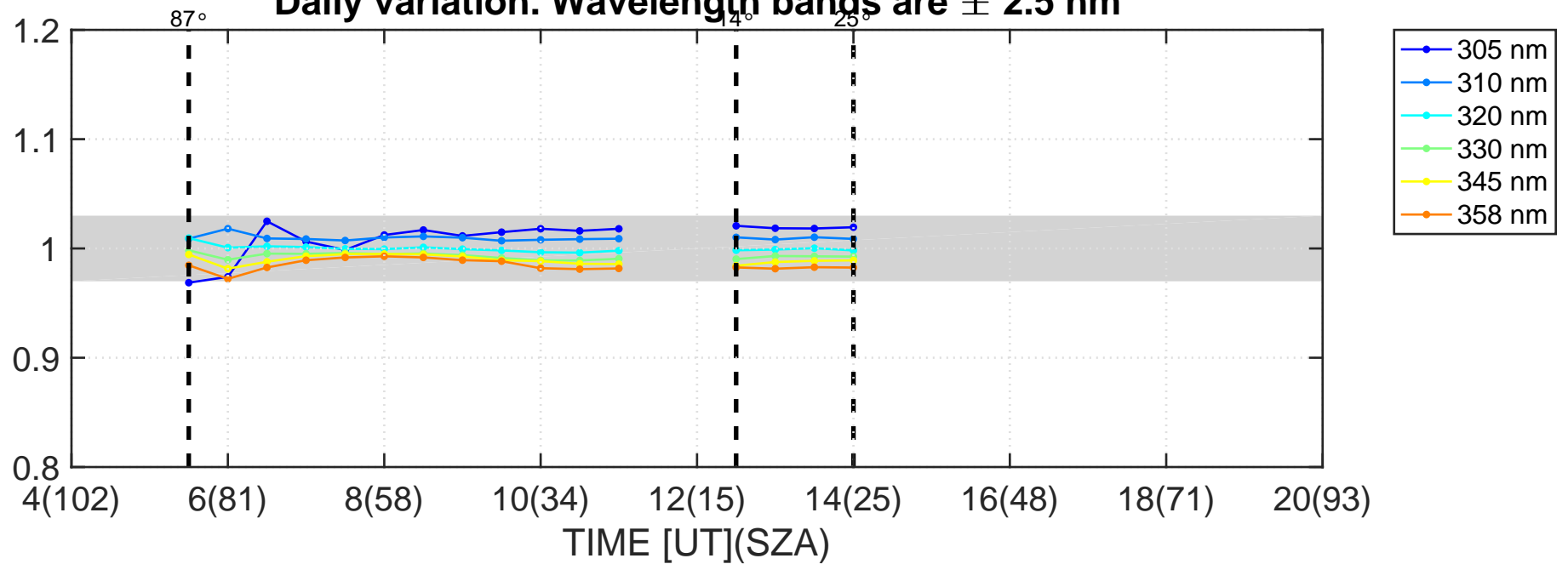
Daily variation. Wavelength bands are ± 2.5 nm



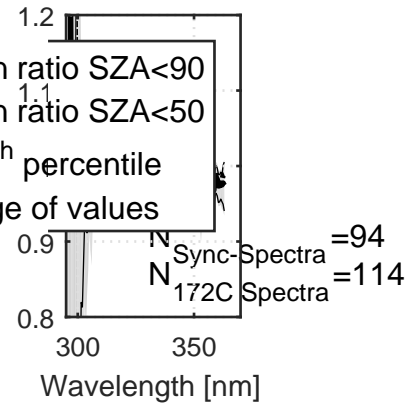
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



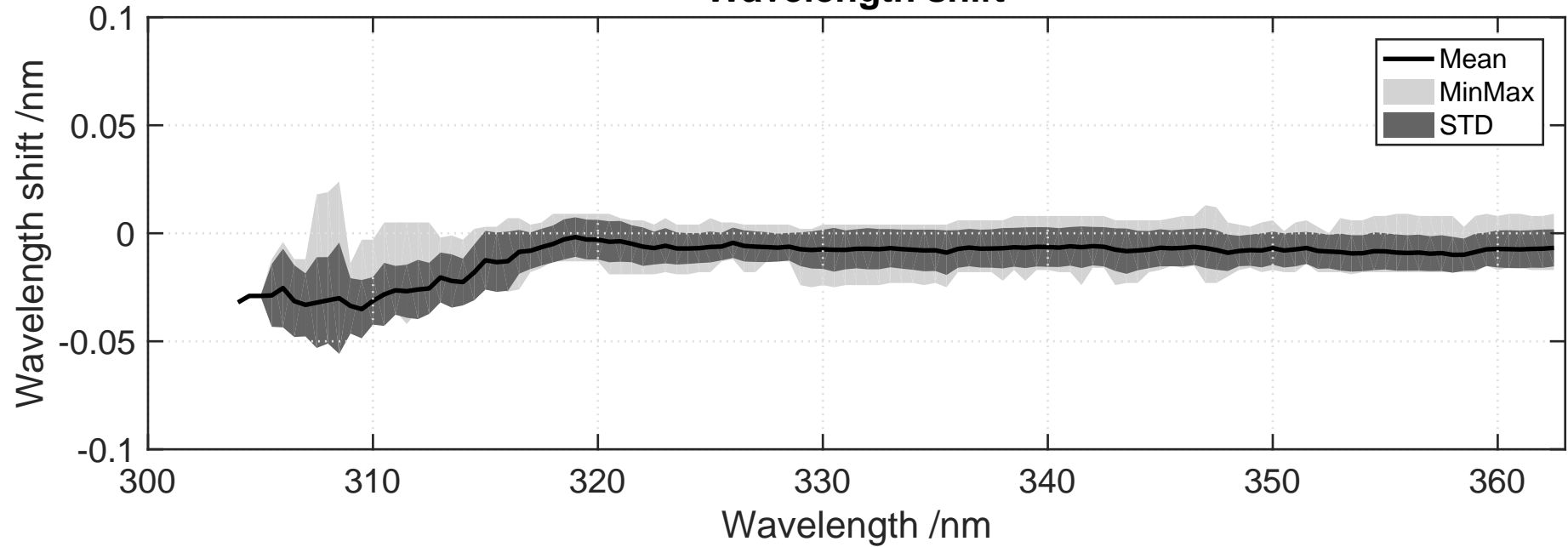
Daily variation. Wavelength bands are ± 2.5 nm



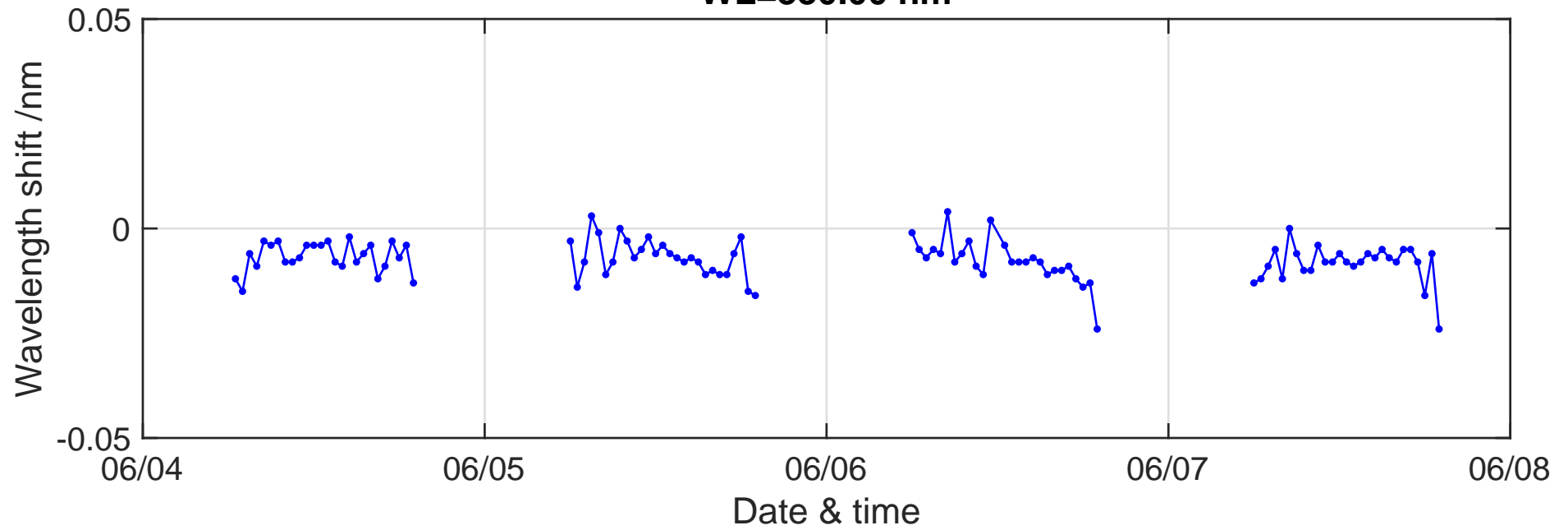
enosillo-matshic:04-Jun-2017(155) to 07-Jun



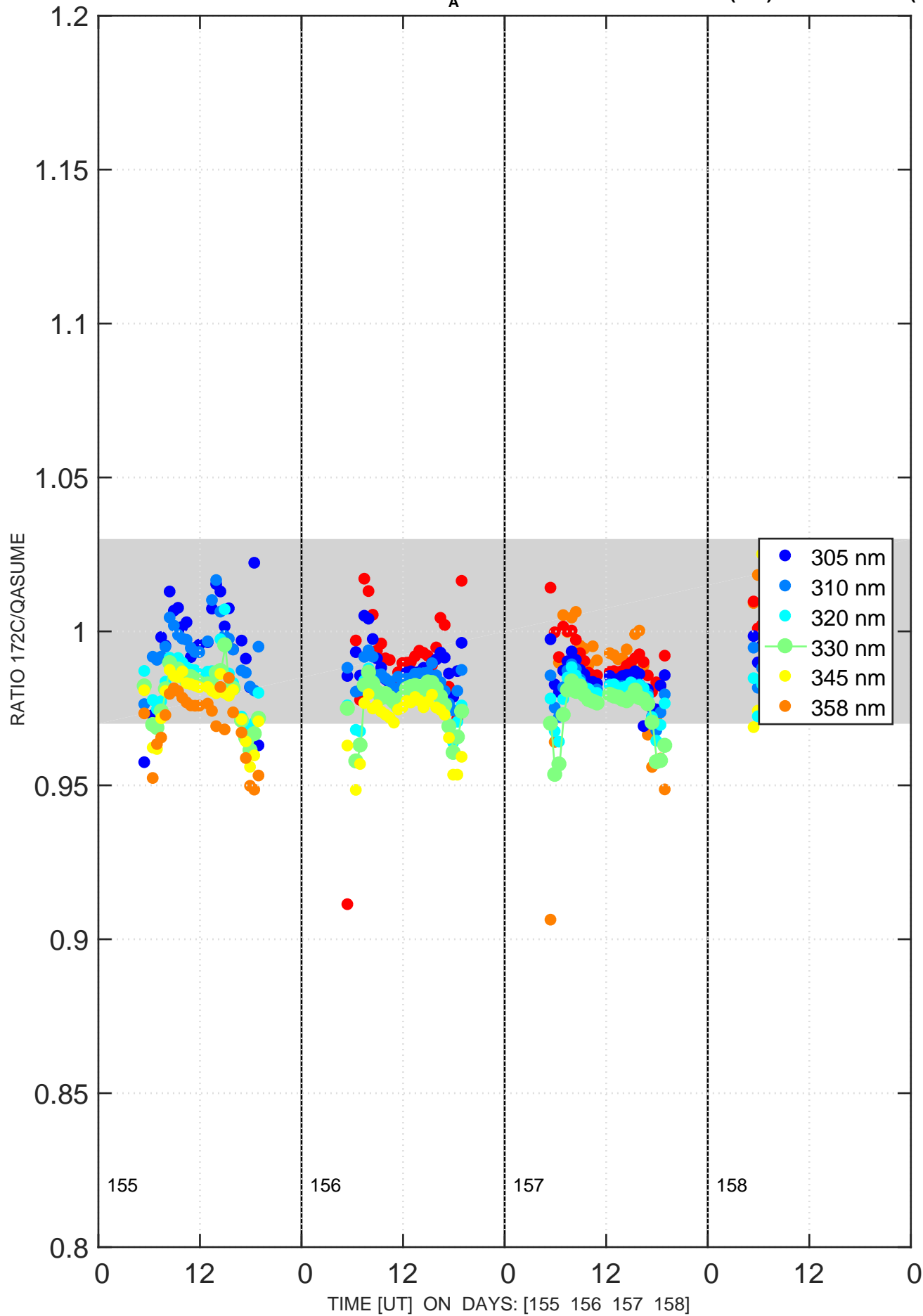
Wavelength shift



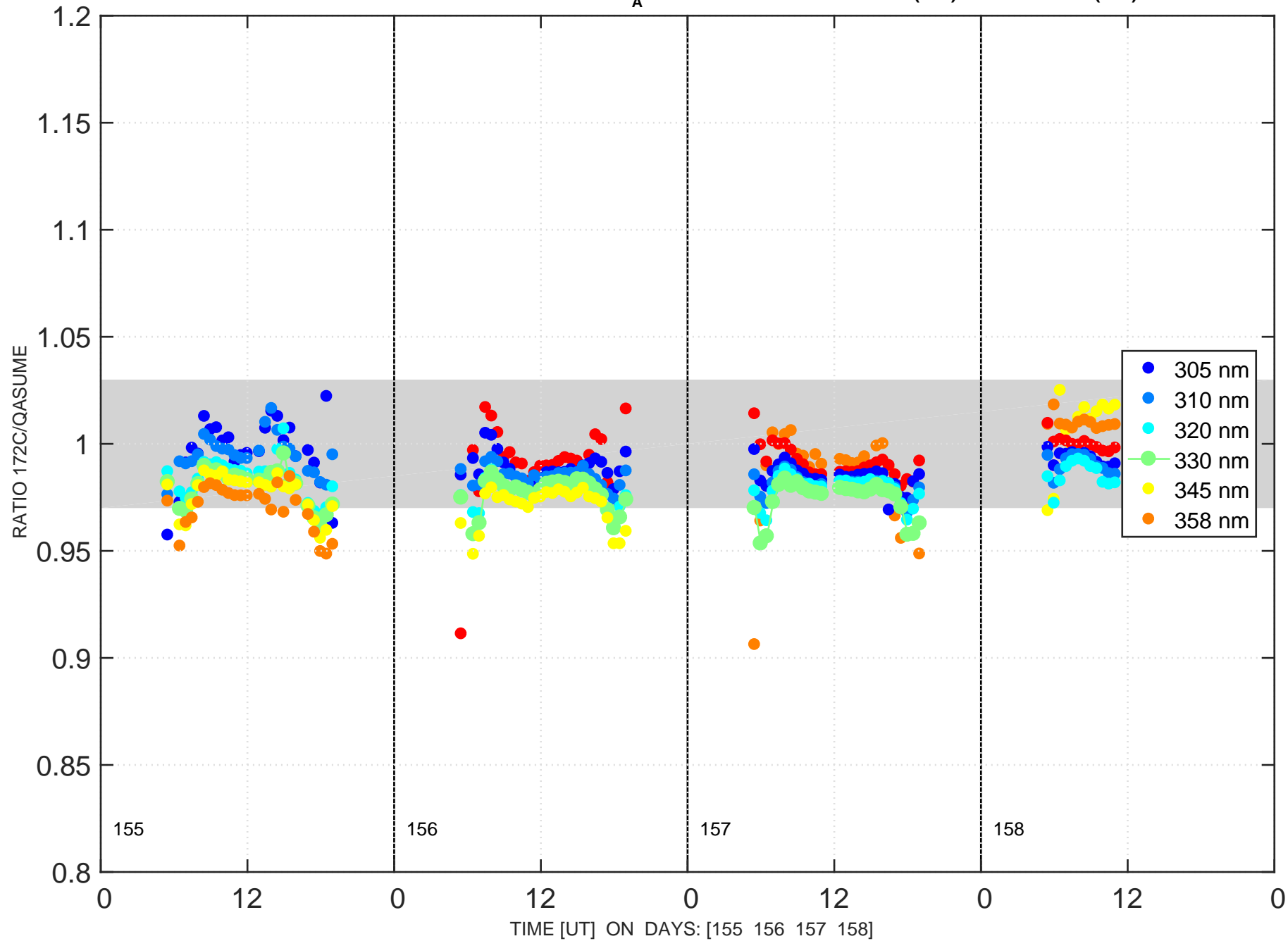
WL=330.00 nm



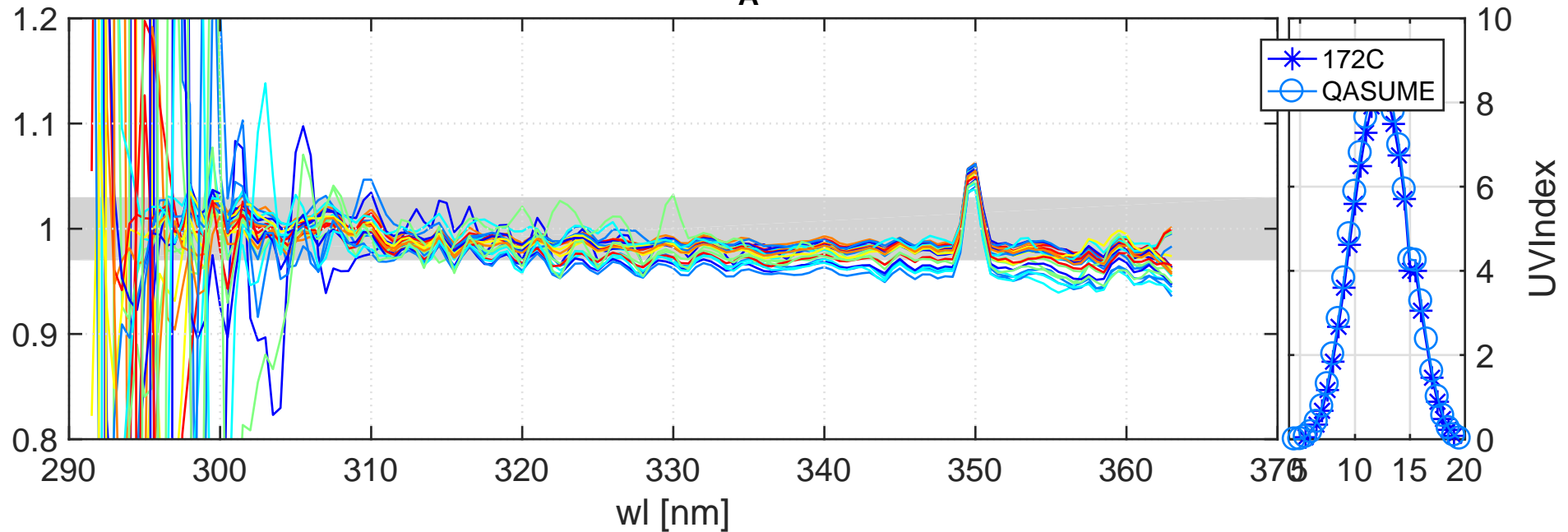
Global irradiance ratios 172C/QASUME at E_Arenosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



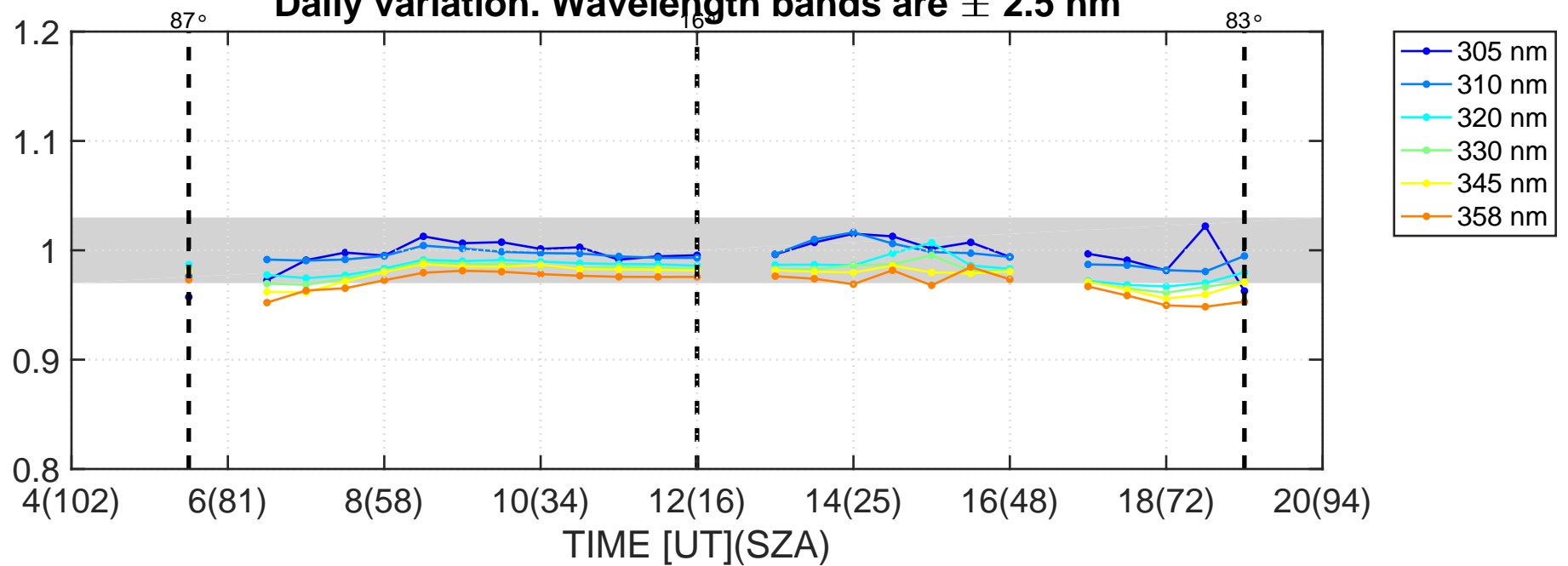
Global irradiance ratios 172C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



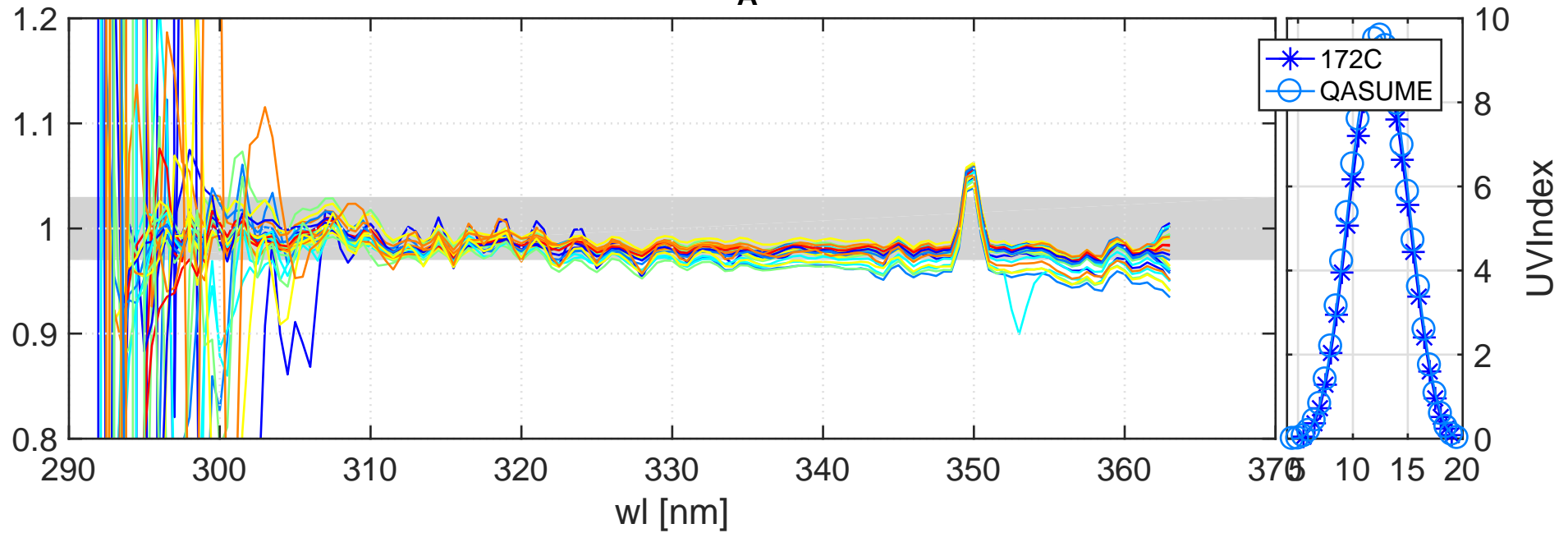
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



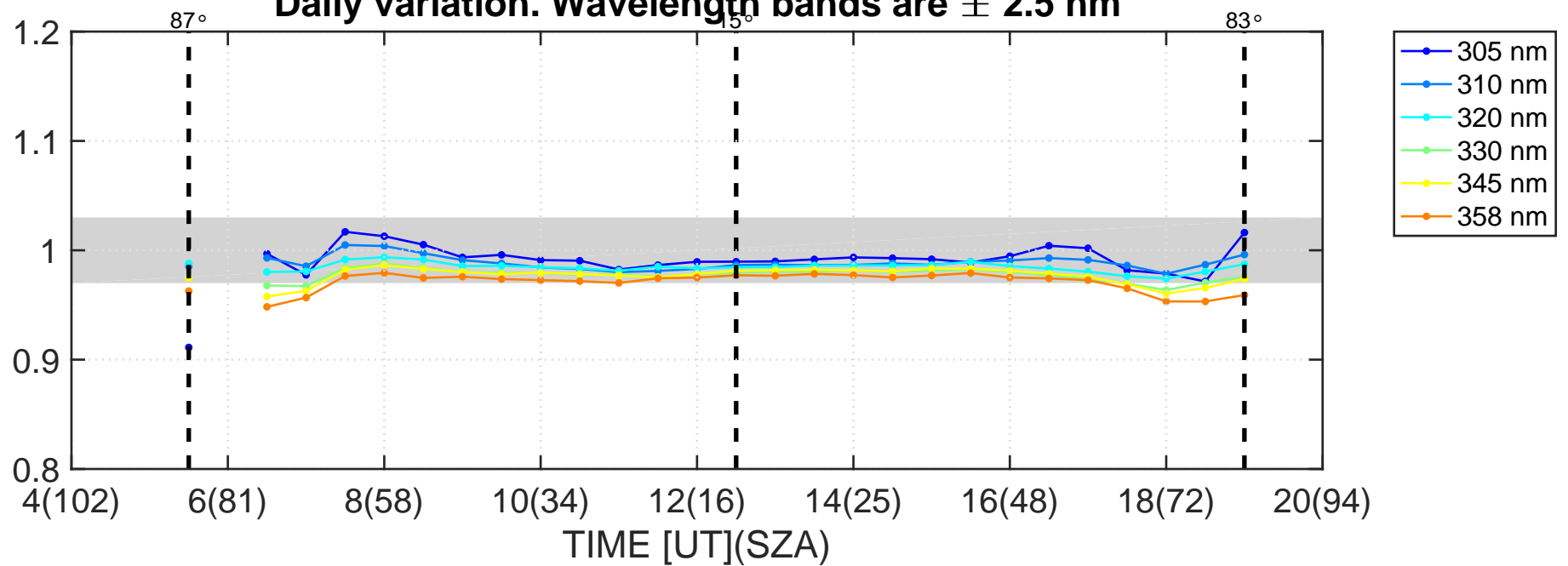
Daily variation. Wavelength bands are ± 2.5 nm



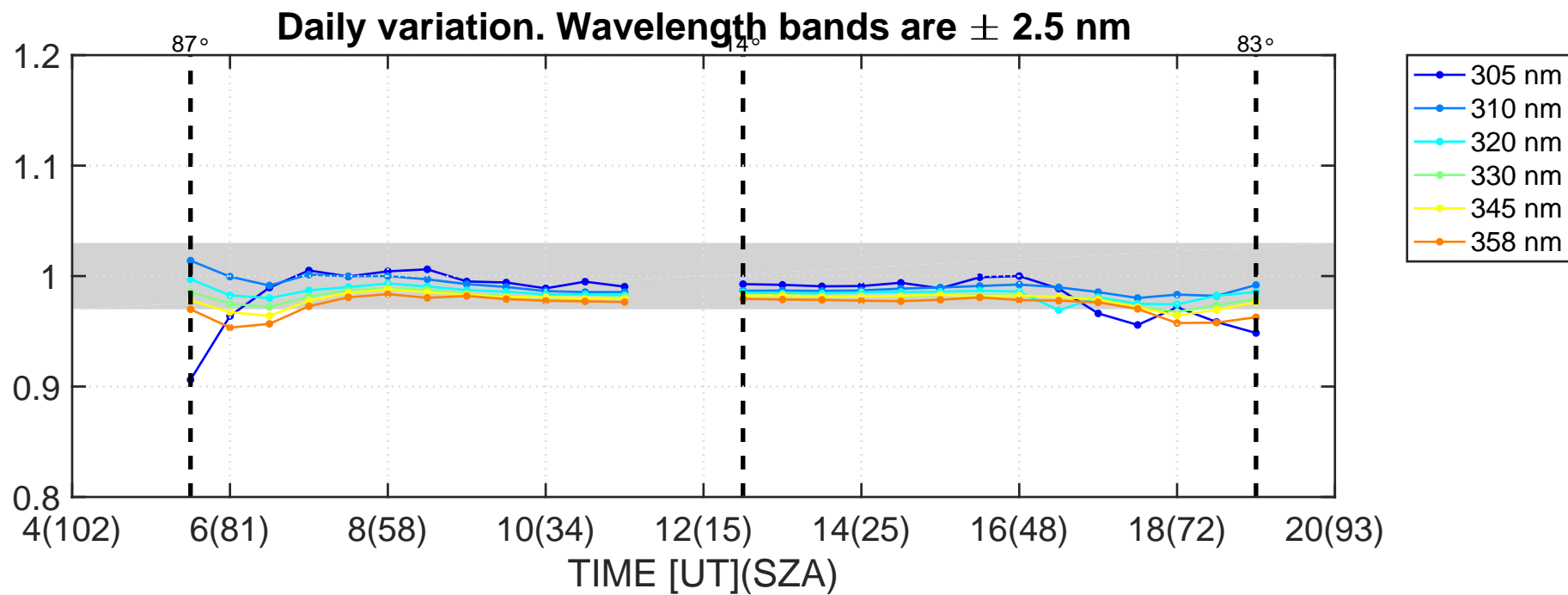
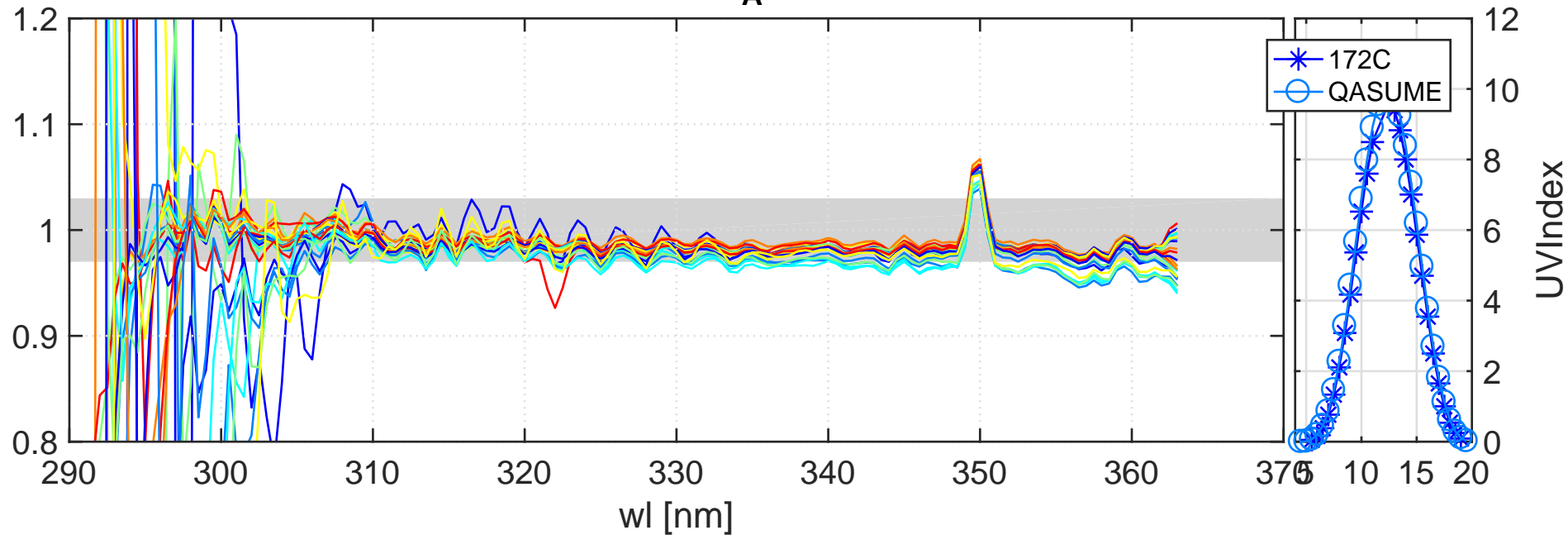
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



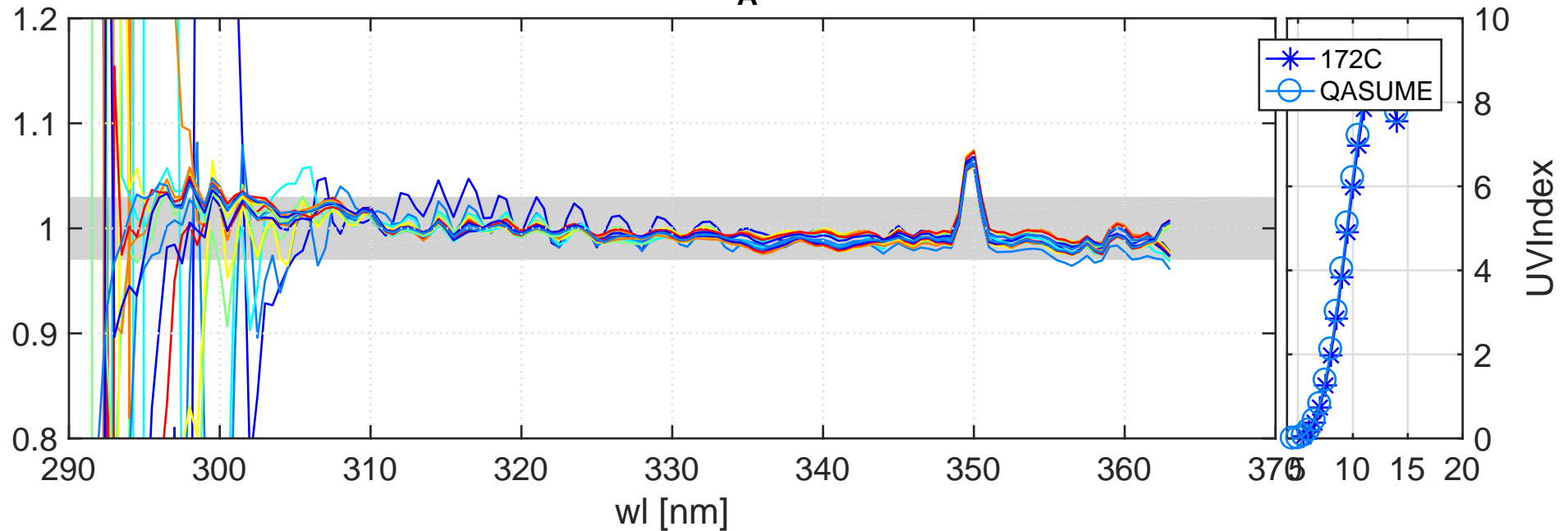
Daily variation. Wavelength bands are ± 2.5 nm



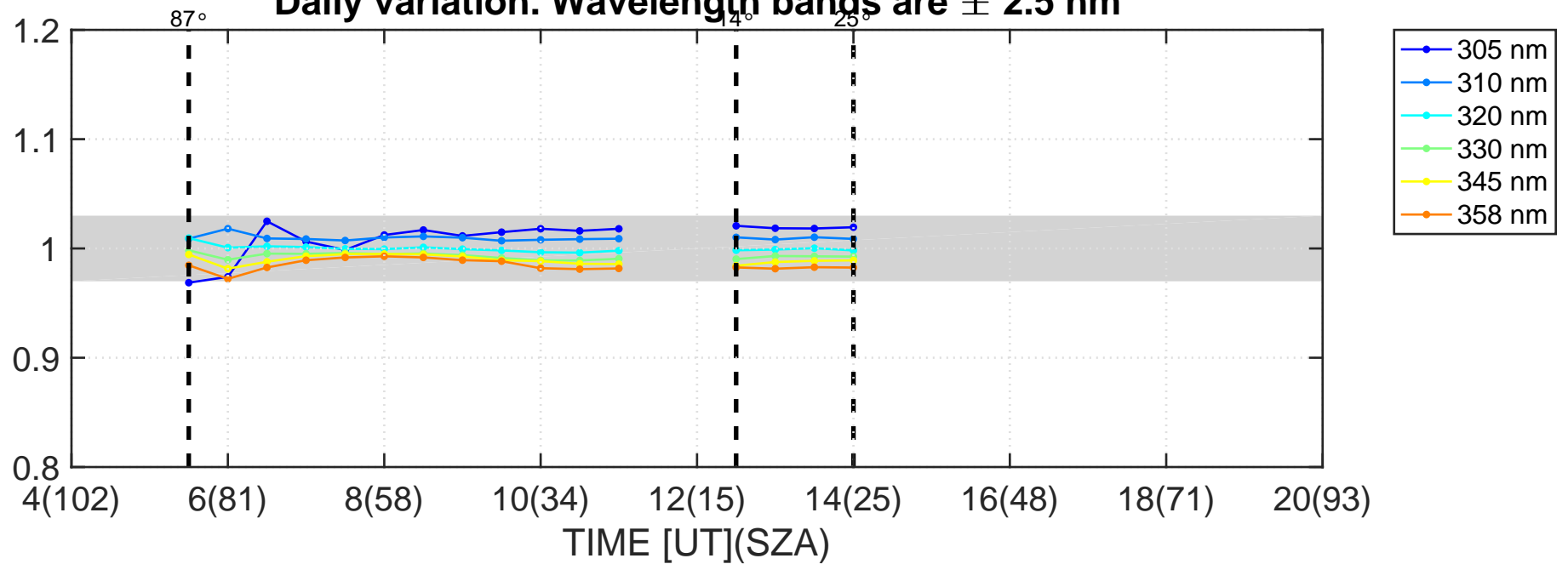
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



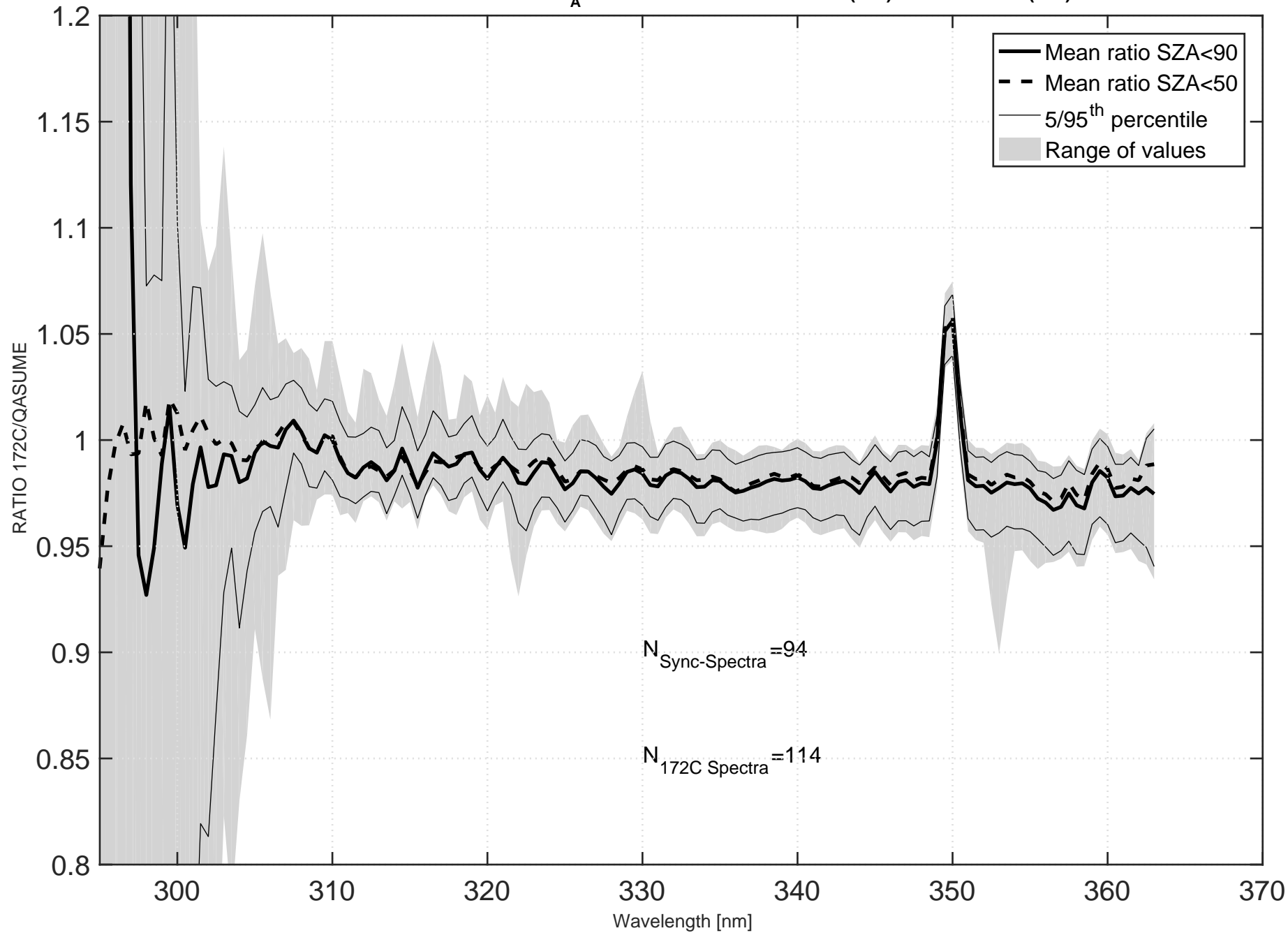
Global irradiance ratios 172C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



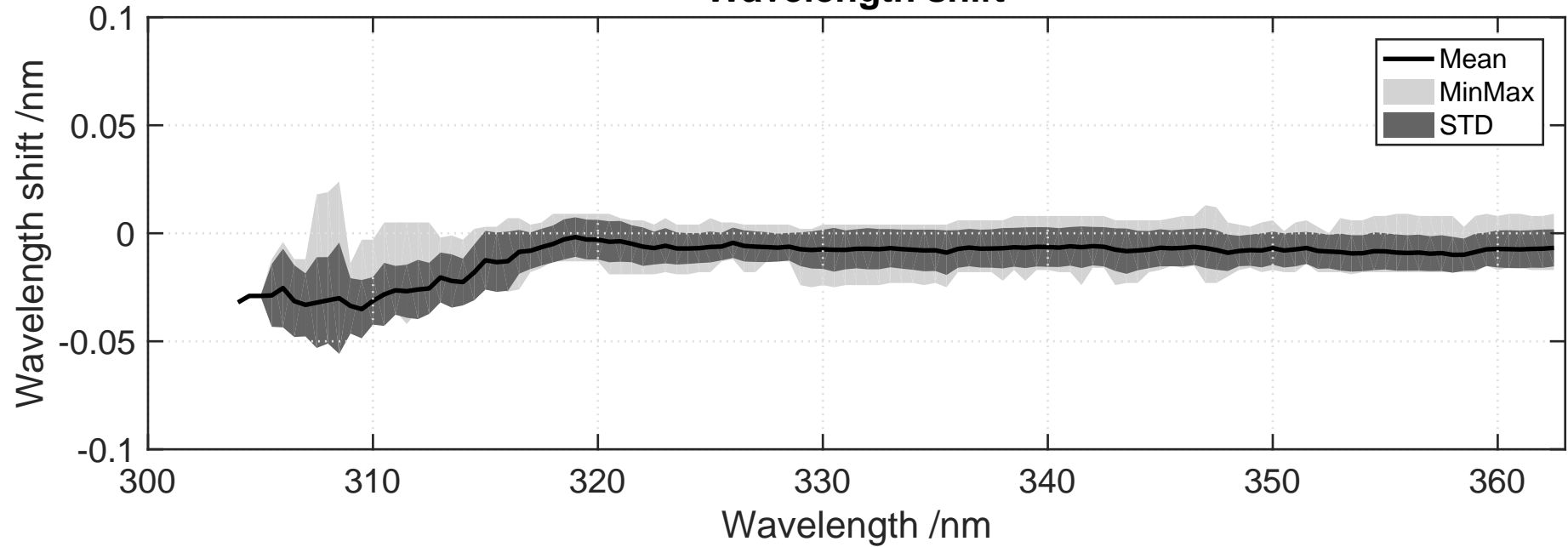
Daily variation. Wavelength bands are ± 2.5 nm



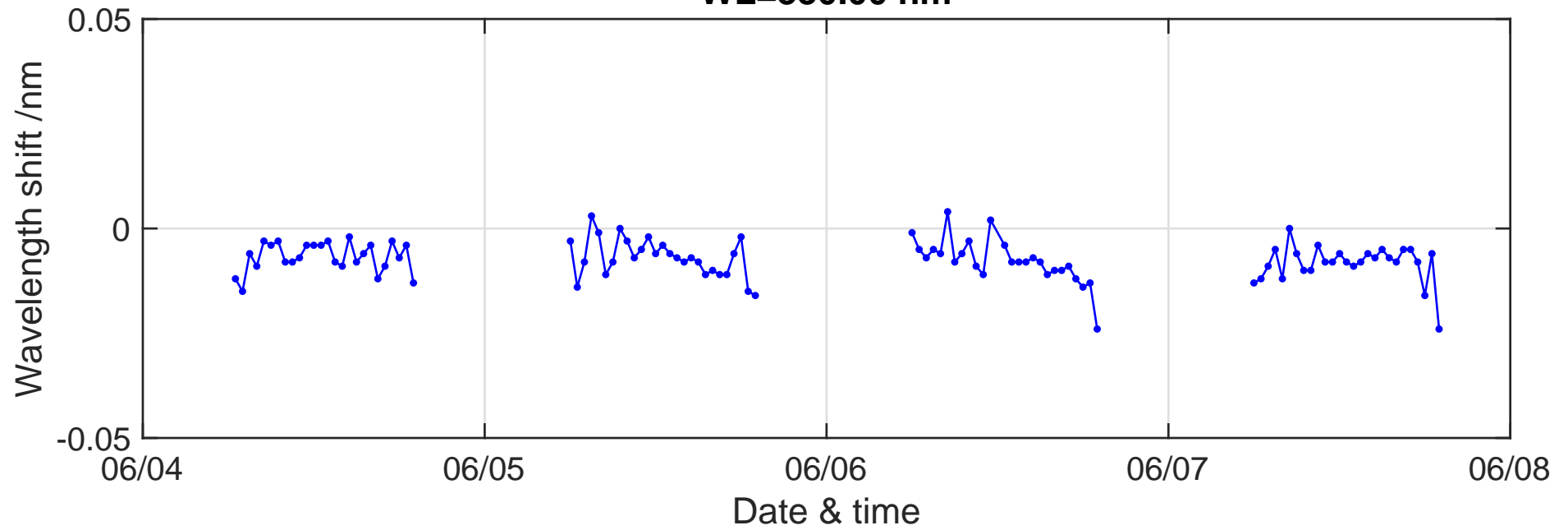
Mean ratio 172C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



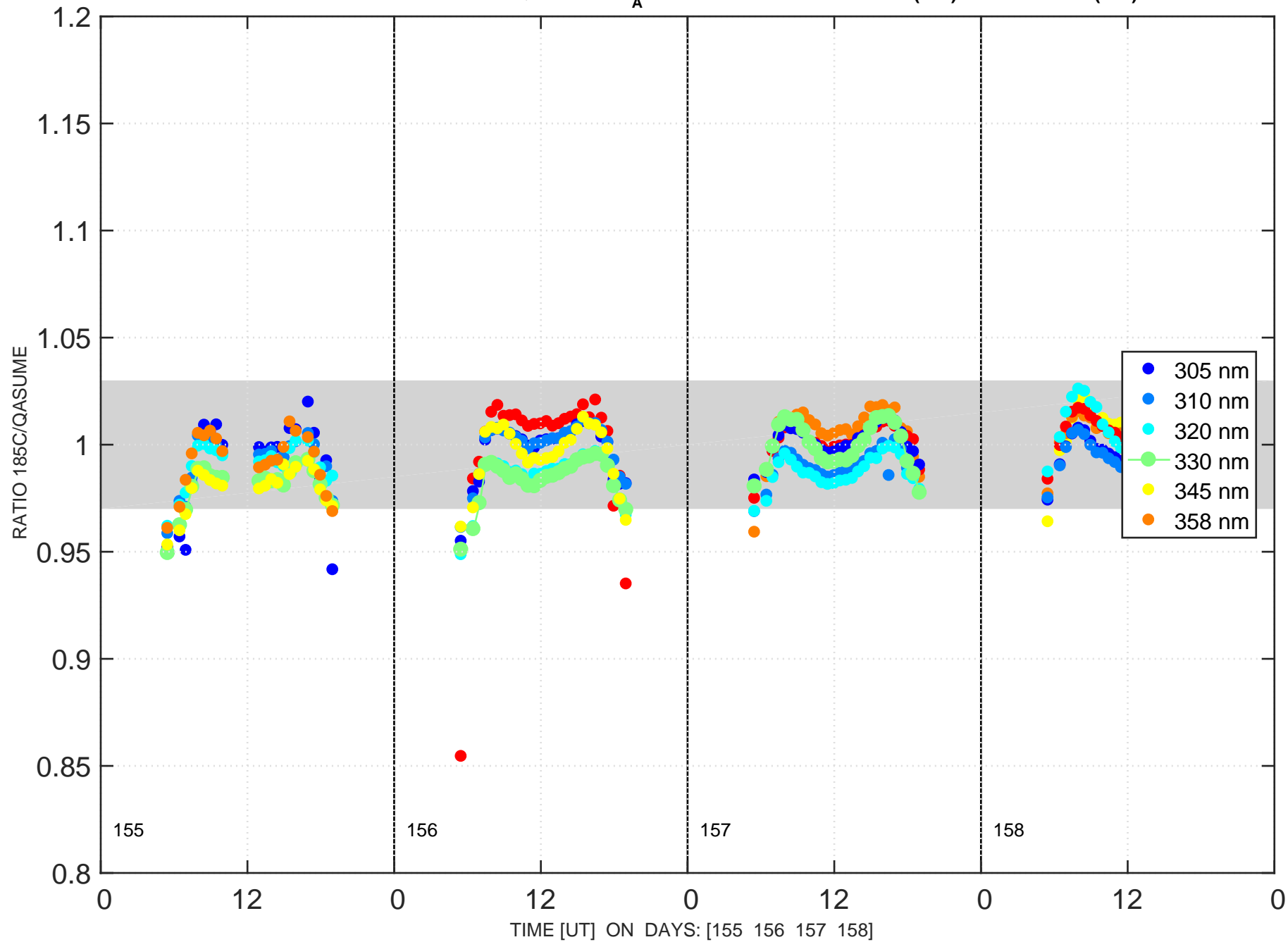
Wavelength shift



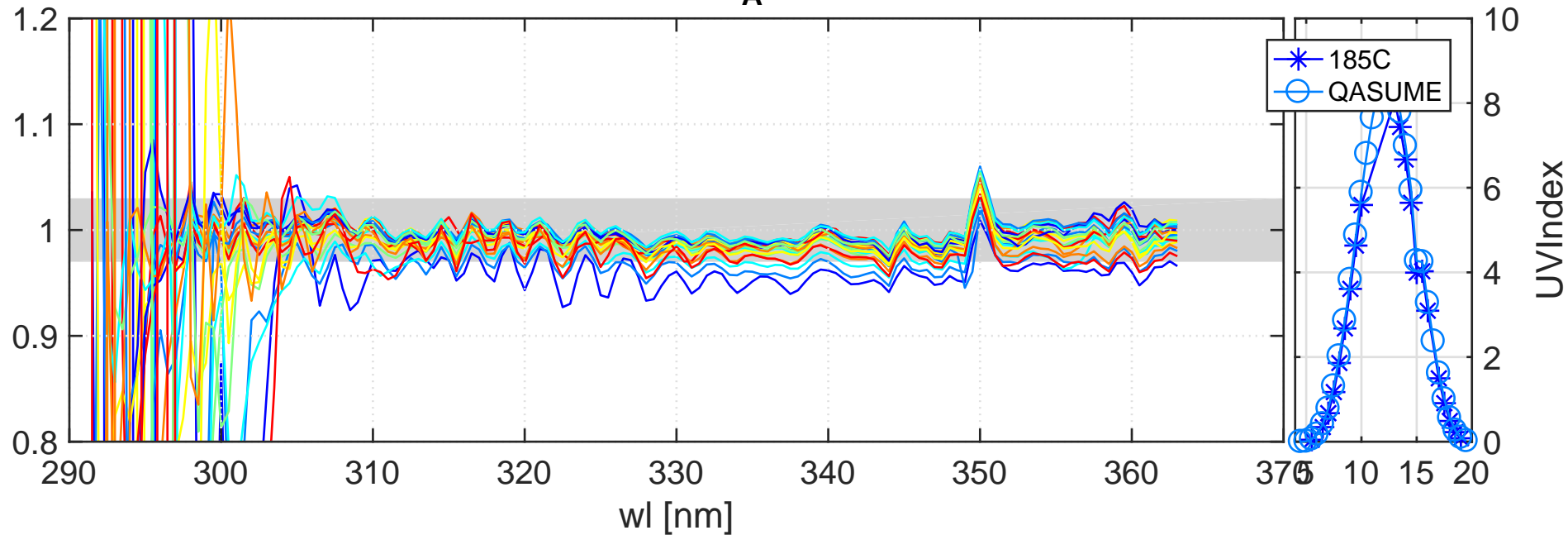
WL=330.00 nm



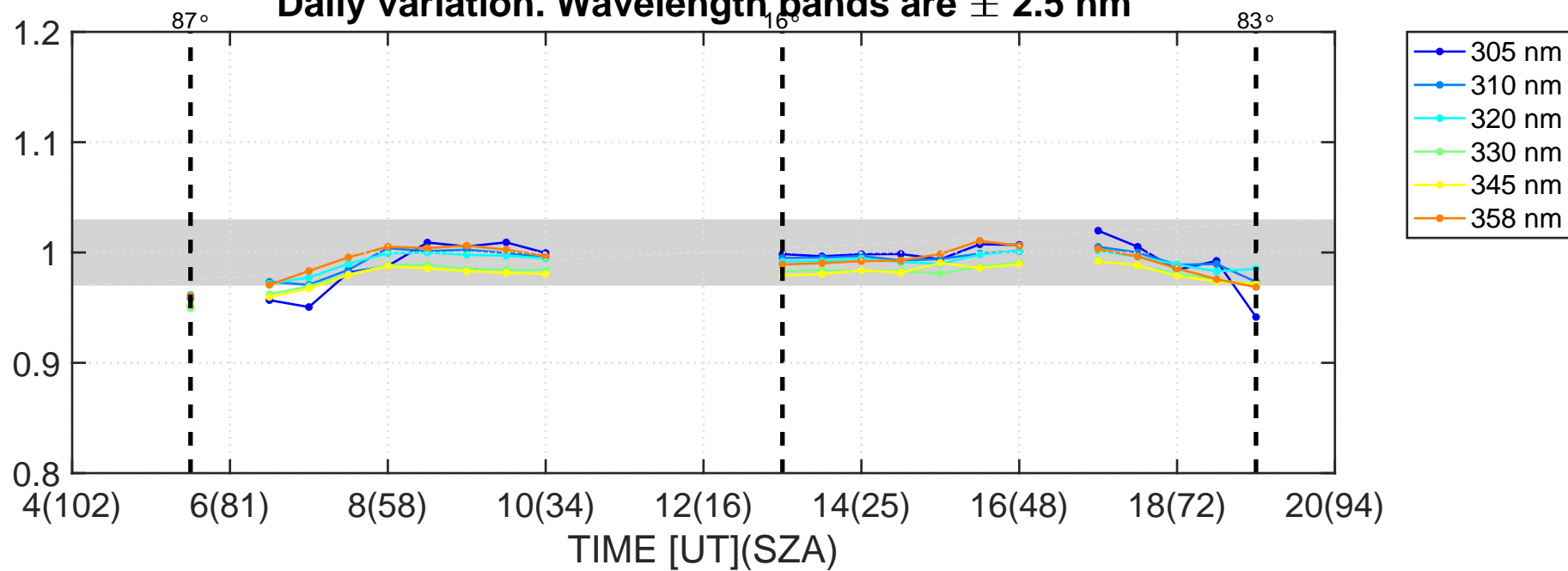
Global irradiance ratios 185C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



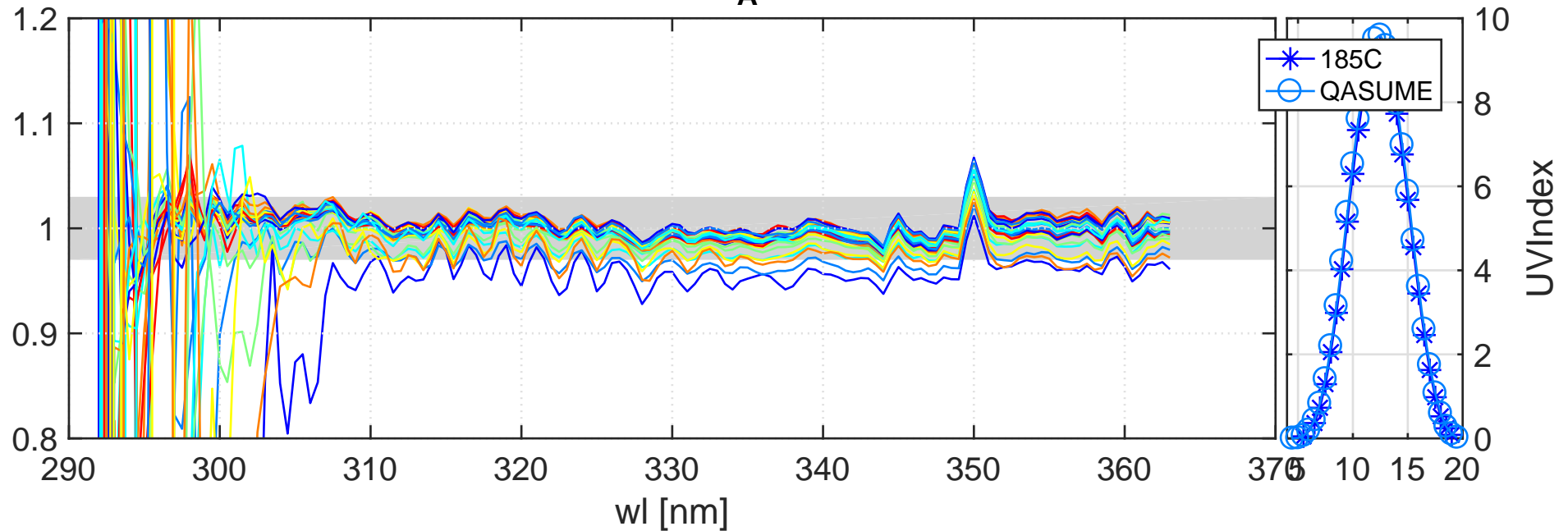
Global irradiance ratios 185C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



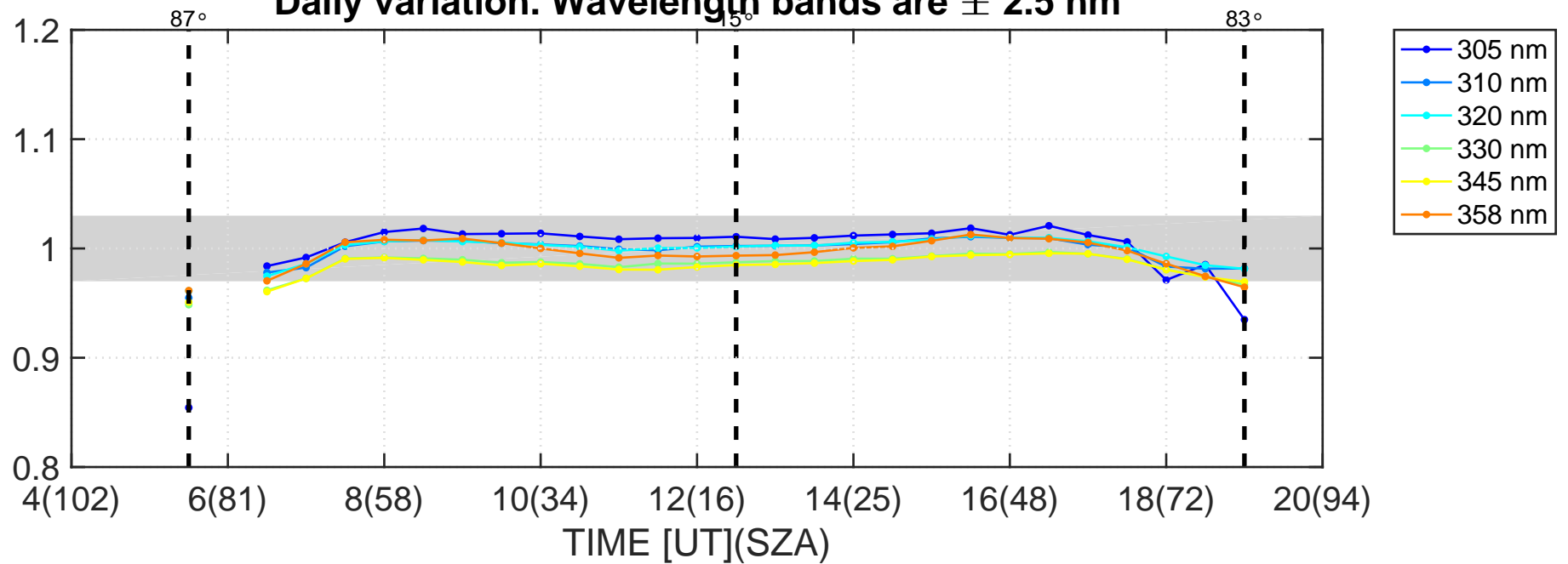
Daily variation. Wavelength bands are ± 2.5 nm



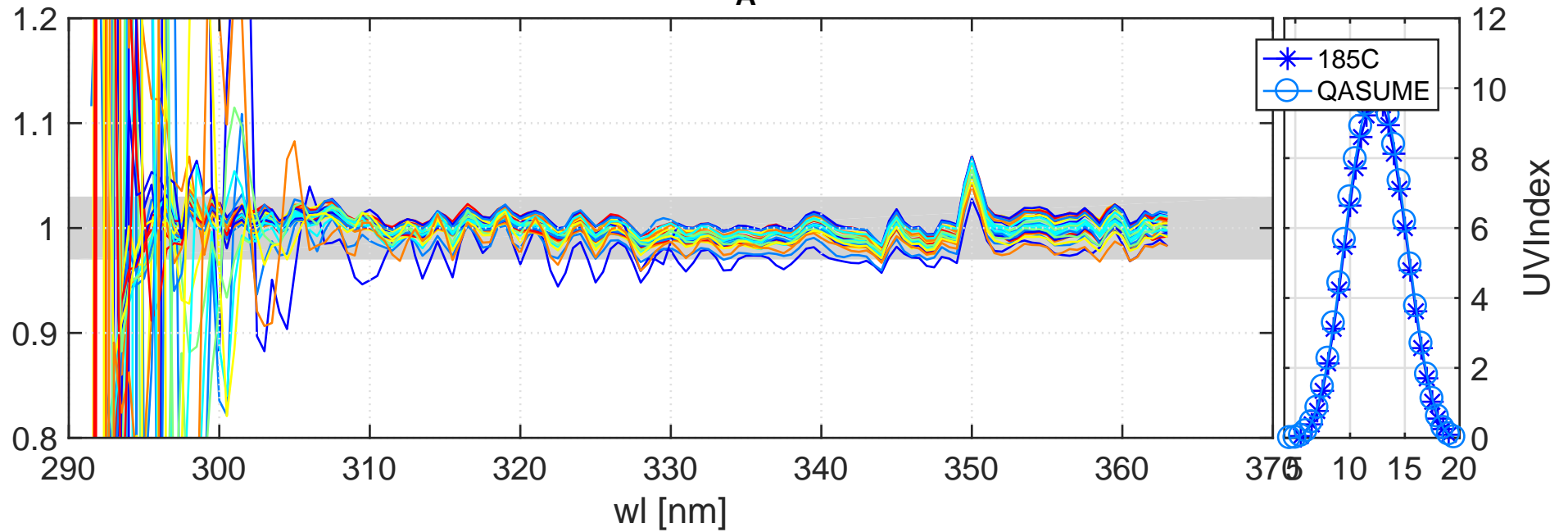
Global irradiance ratios 185C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



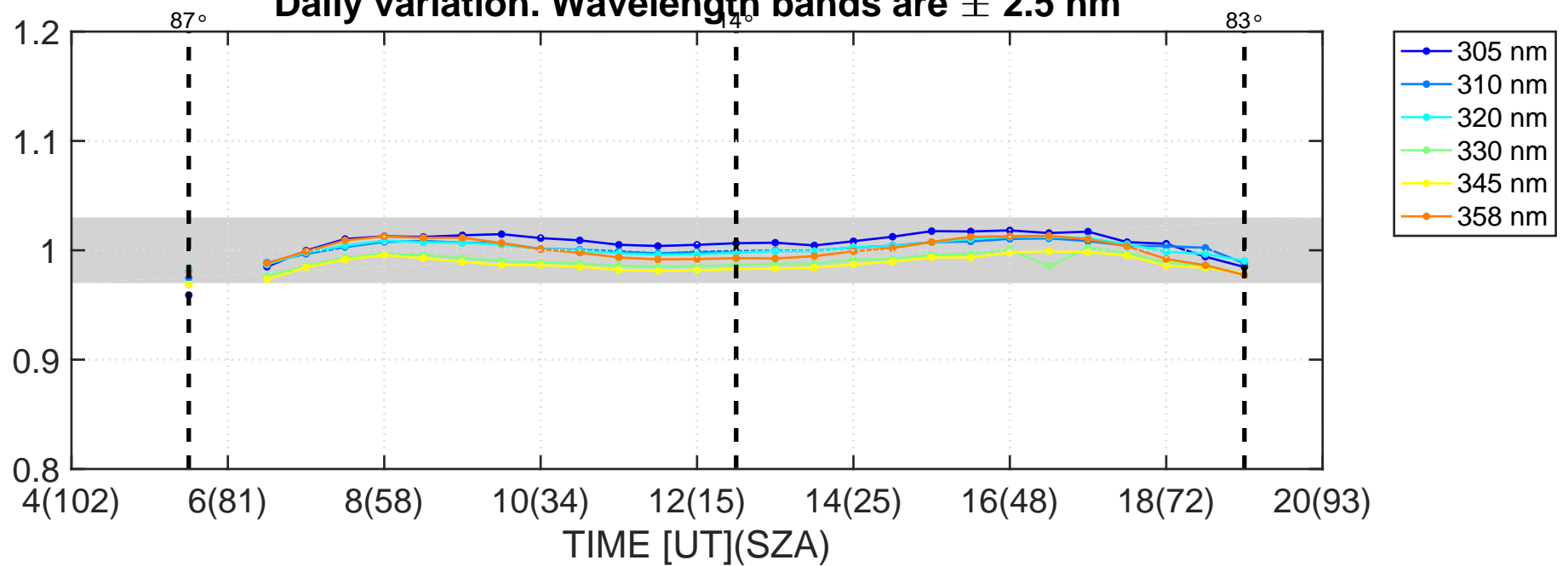
Daily variation. Wavelength bands are ± 2.5 nm



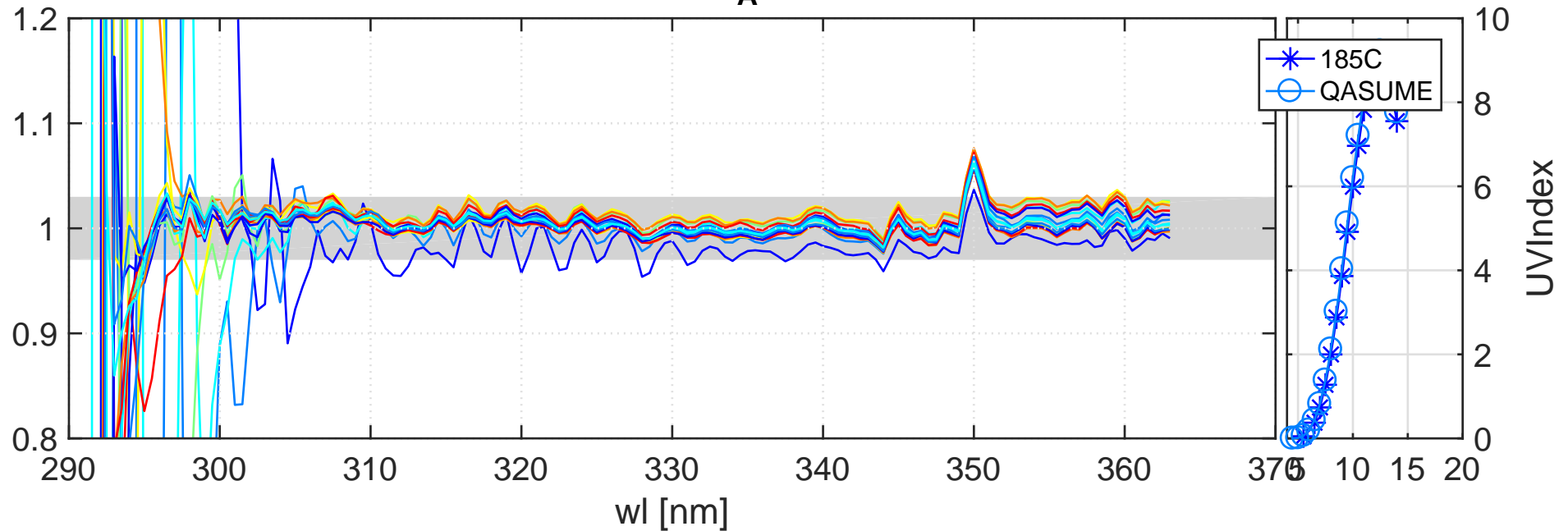
Global irradiance ratios 185C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



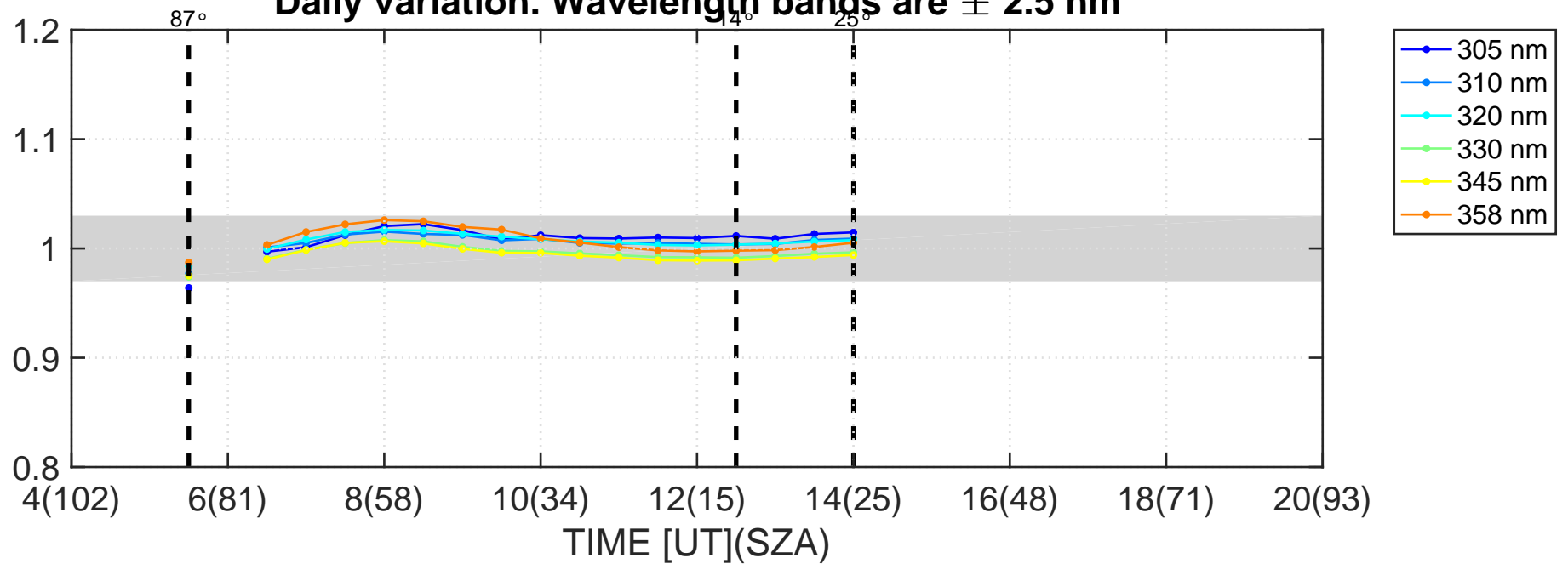
Daily variation. Wavelength bands are ± 2.5 nm



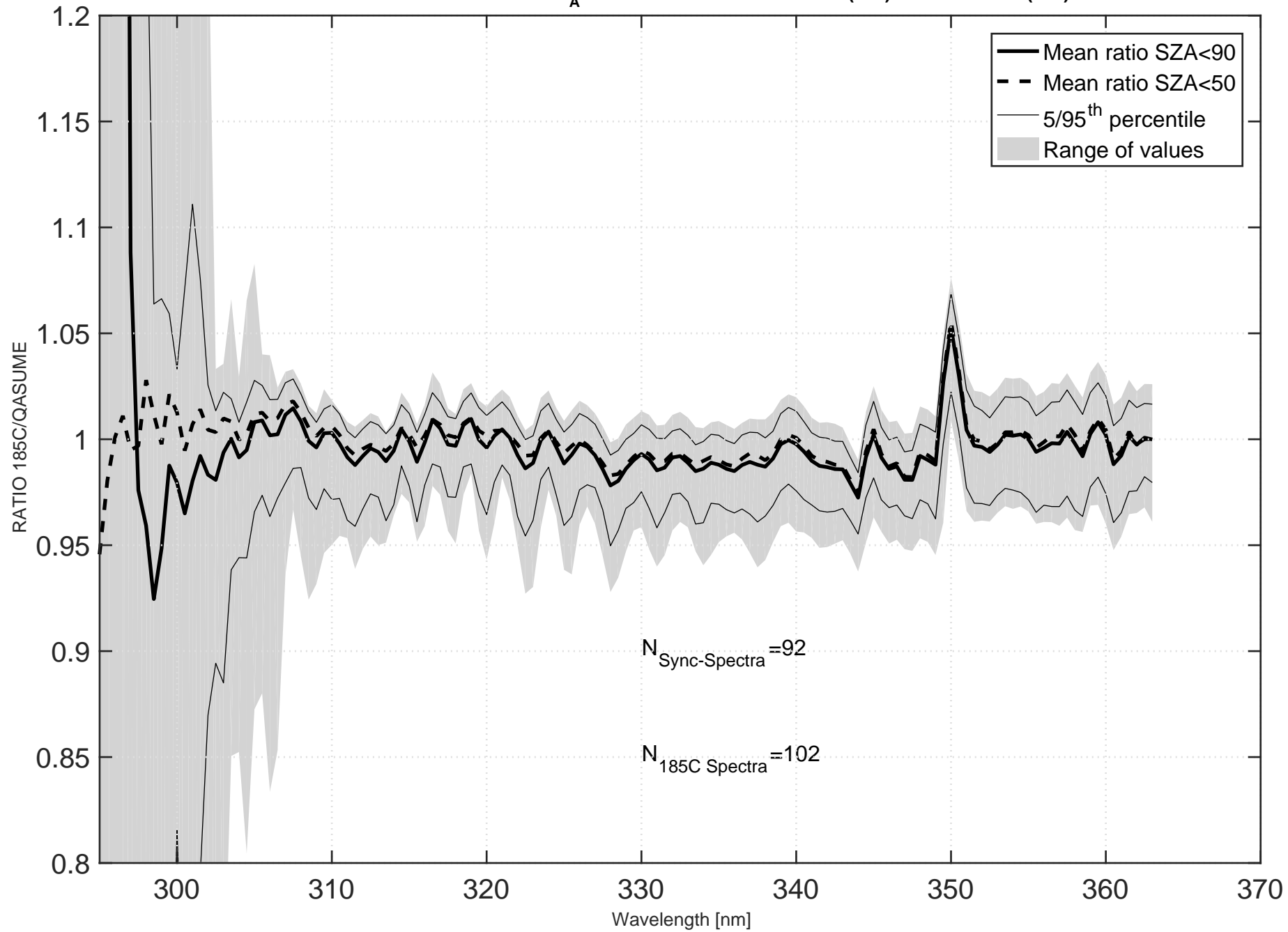
Global irradiance ratios 185C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)

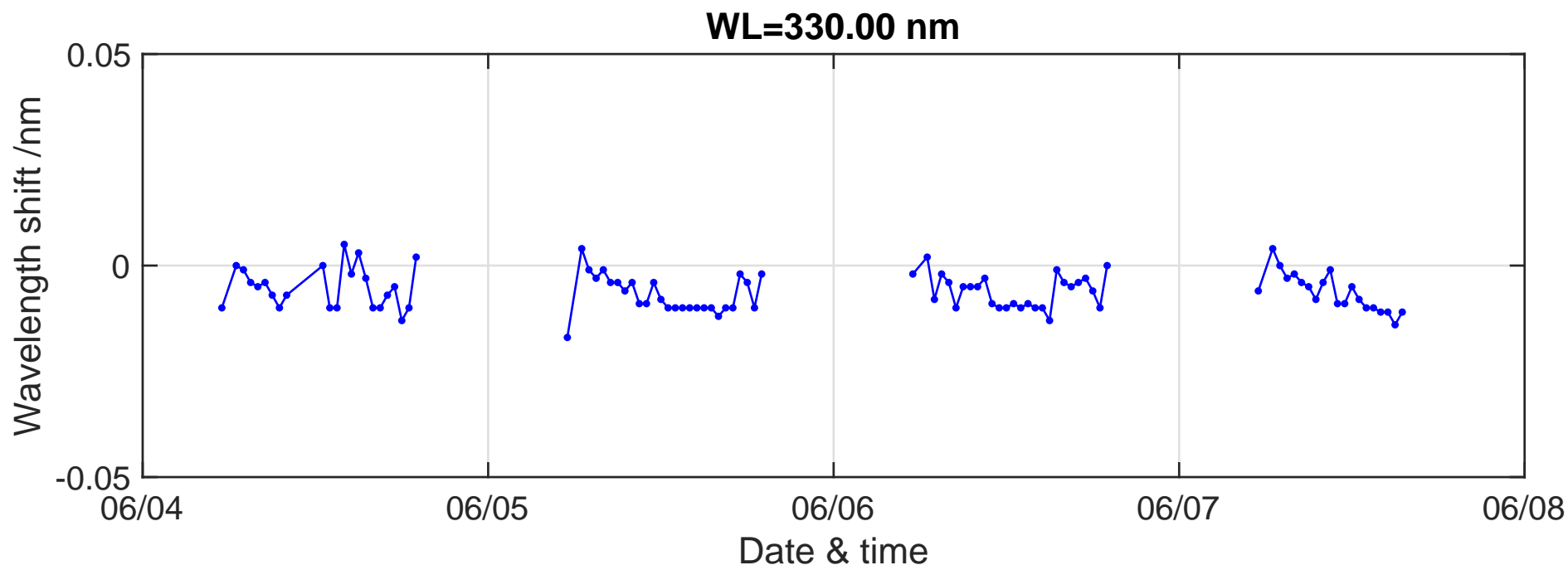
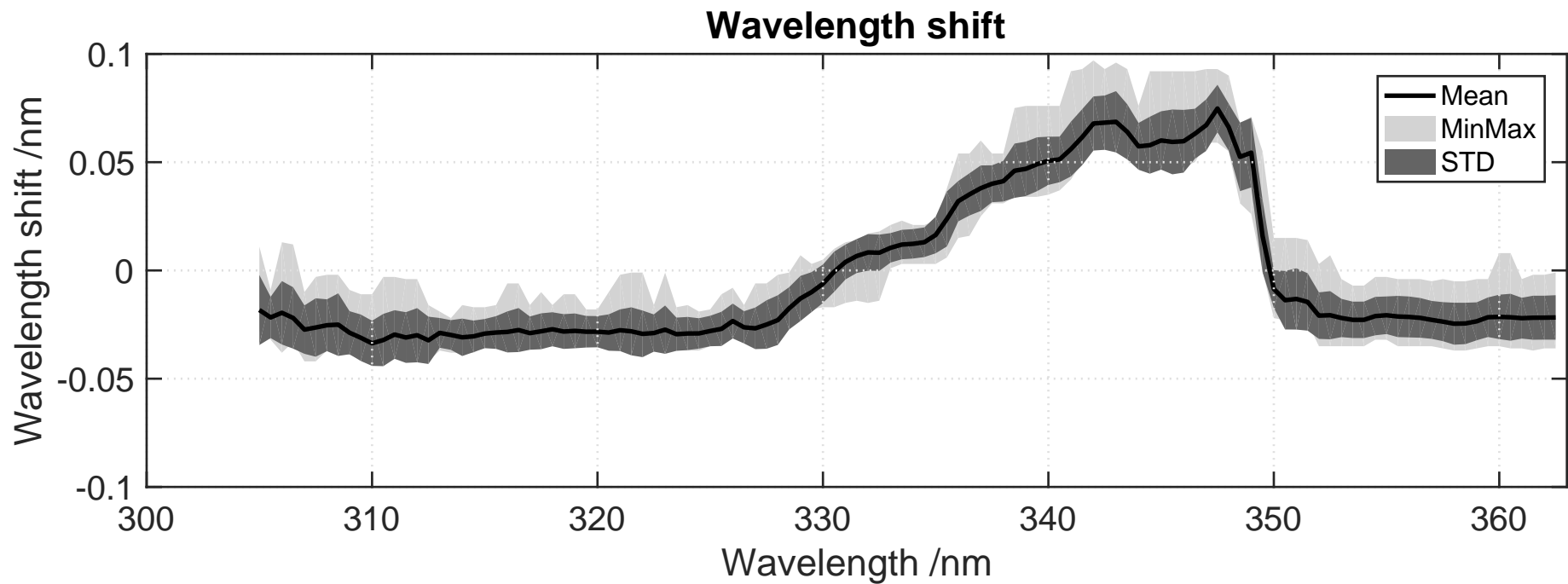


Daily variation. Wavelength bands are ± 2.5 nm

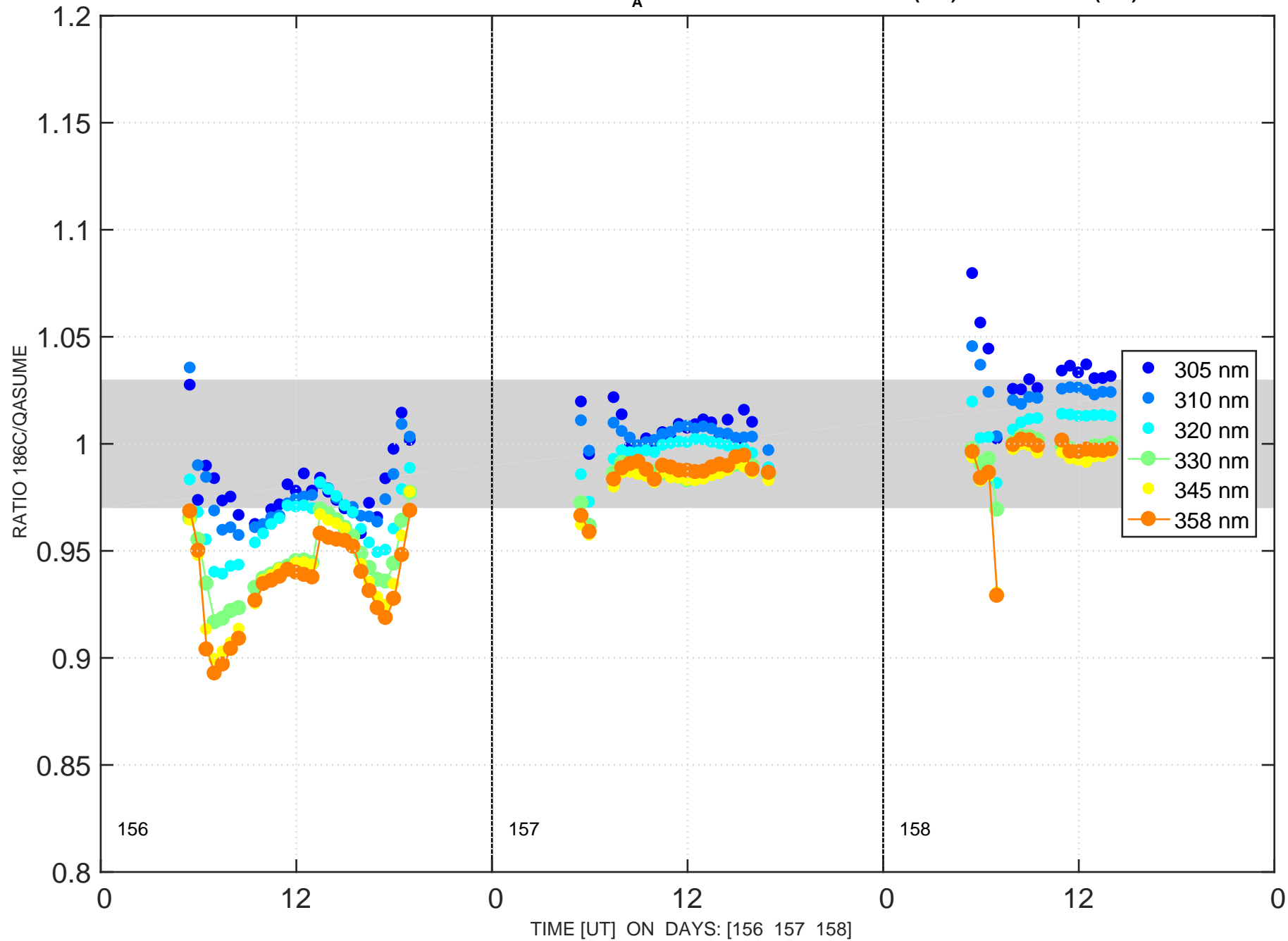


Mean ratio 185C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)

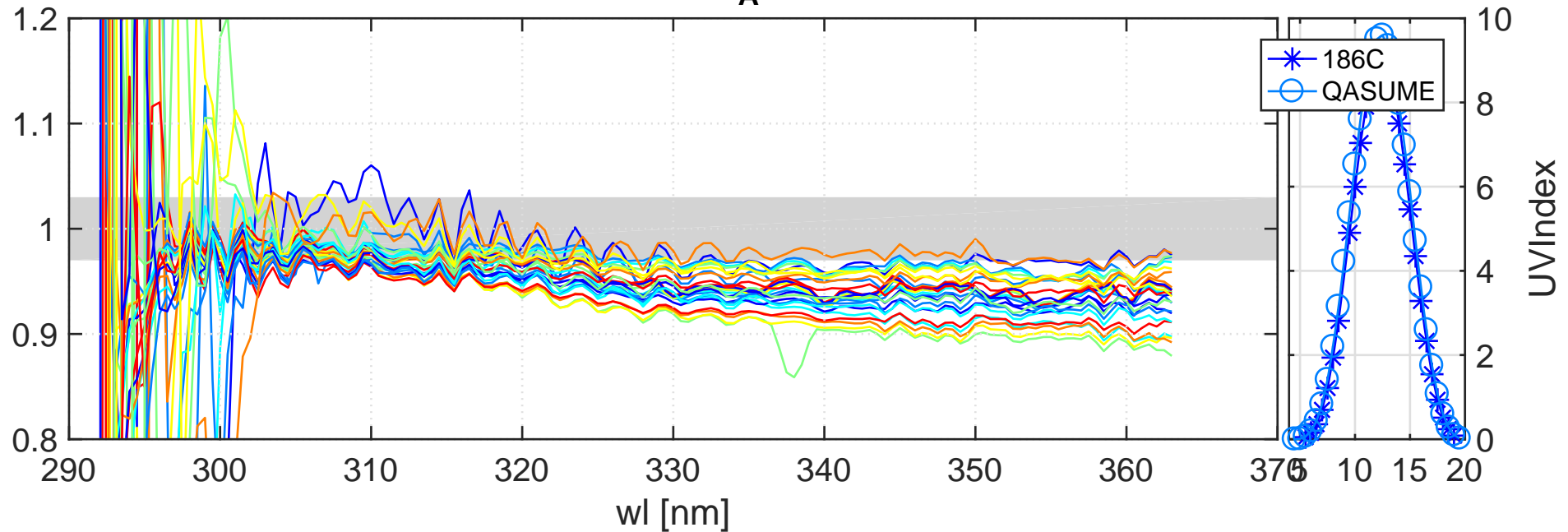




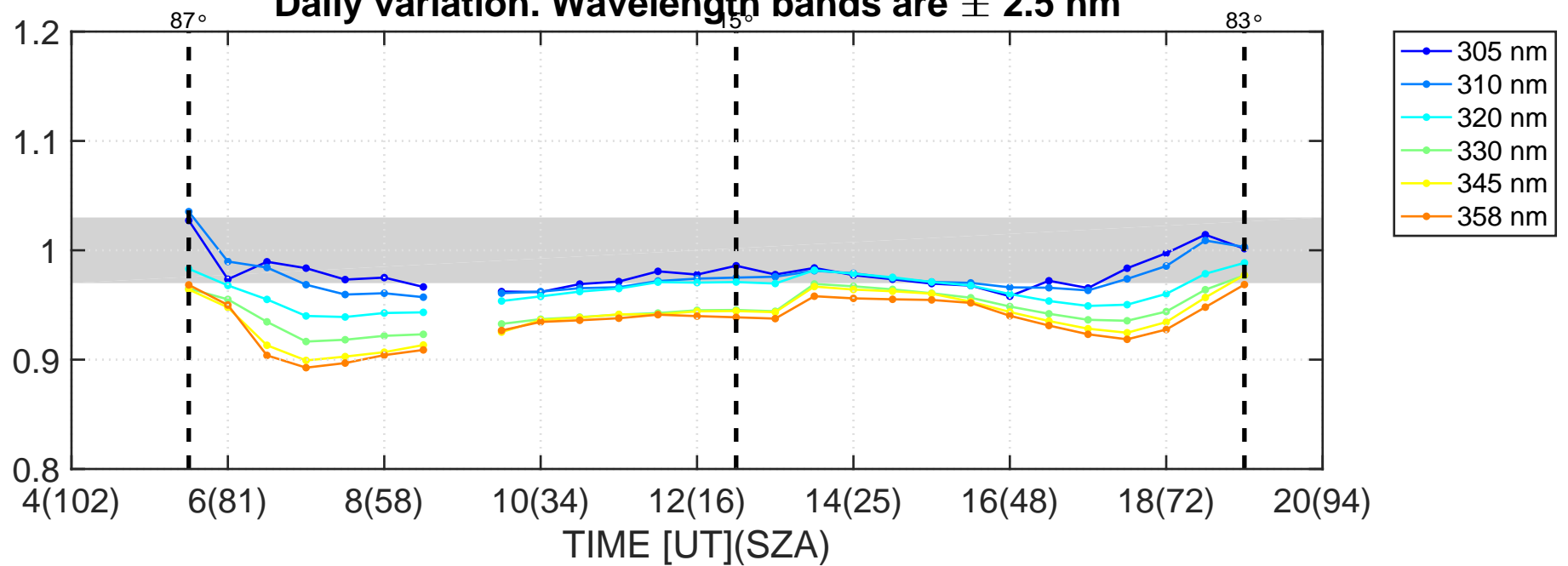
Global irradiance ratios 186C/QASUME at E|renosillo-matshic:05-Jun-2017(156) to 07-Jun-2017(158)



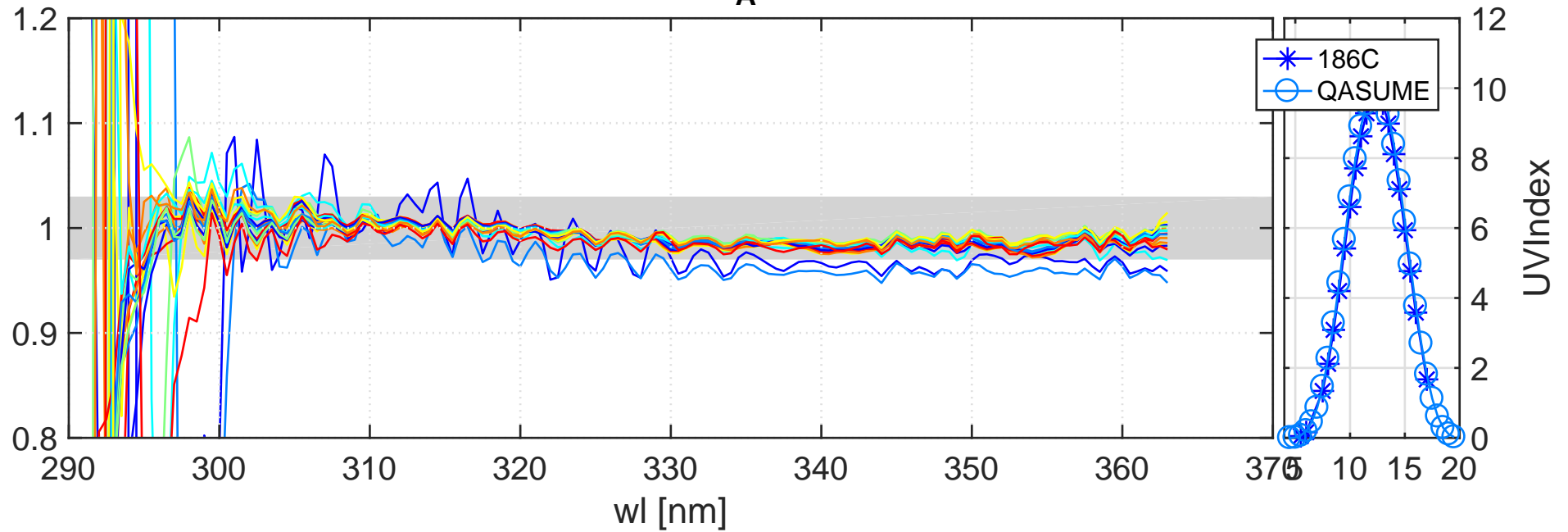
Global irradiance ratios 186C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



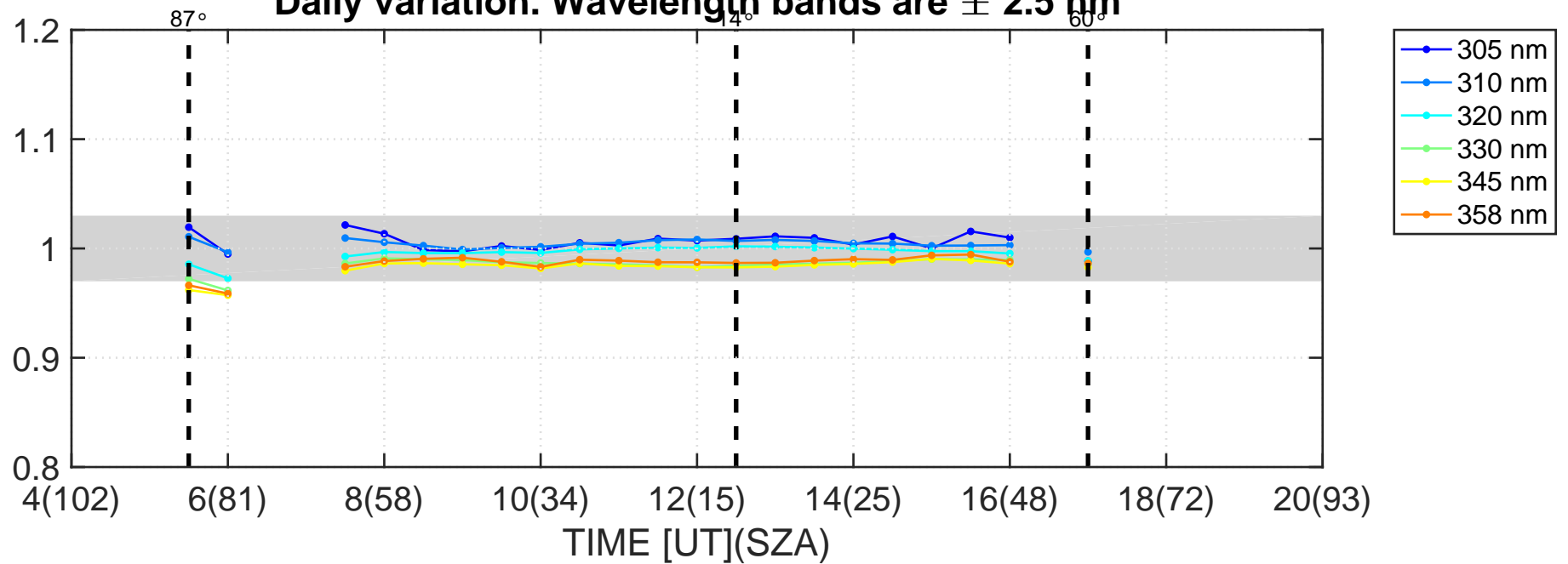
Daily variation. Wavelength bands are ± 2.5 nm



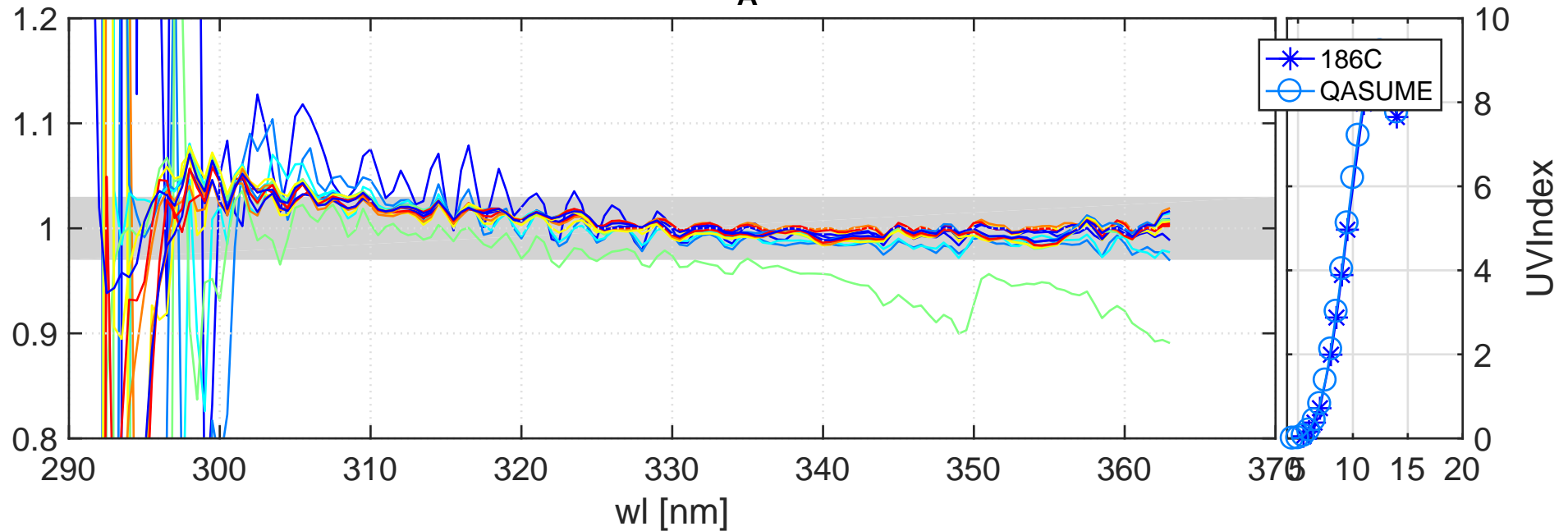
Global irradiance ratios 186C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



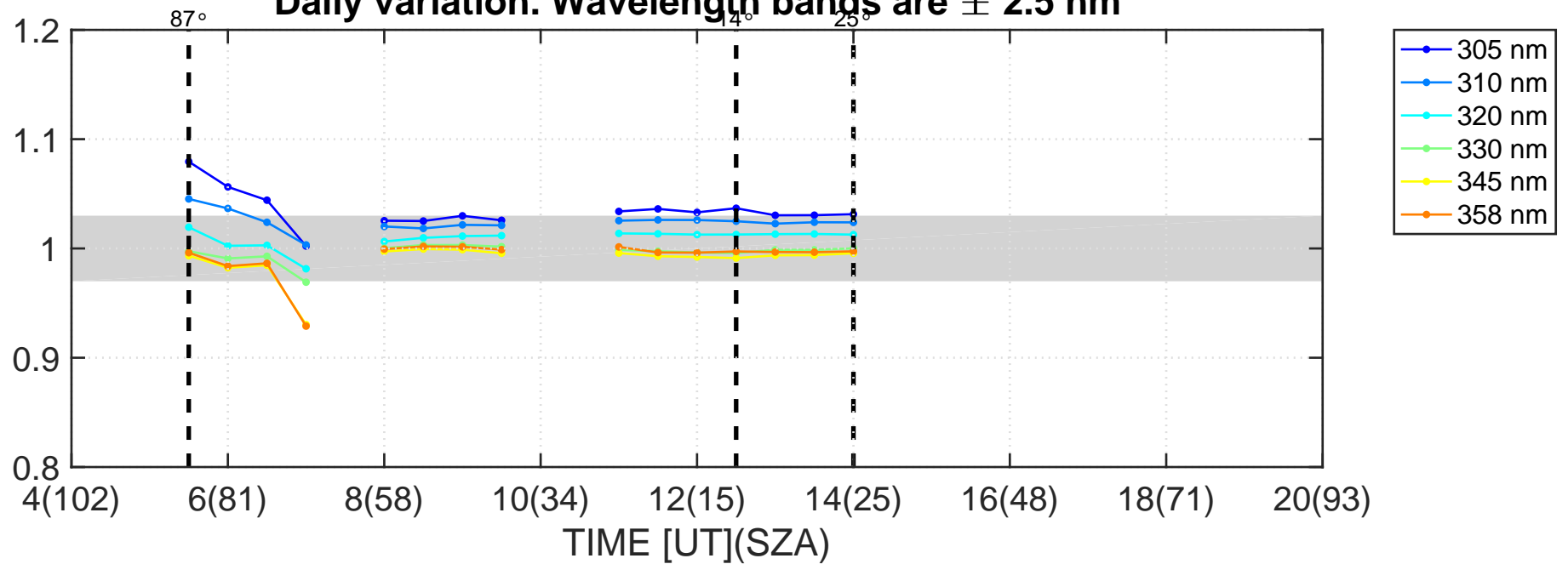
Daily variation. Wavelength bands are ± 2.5 nm



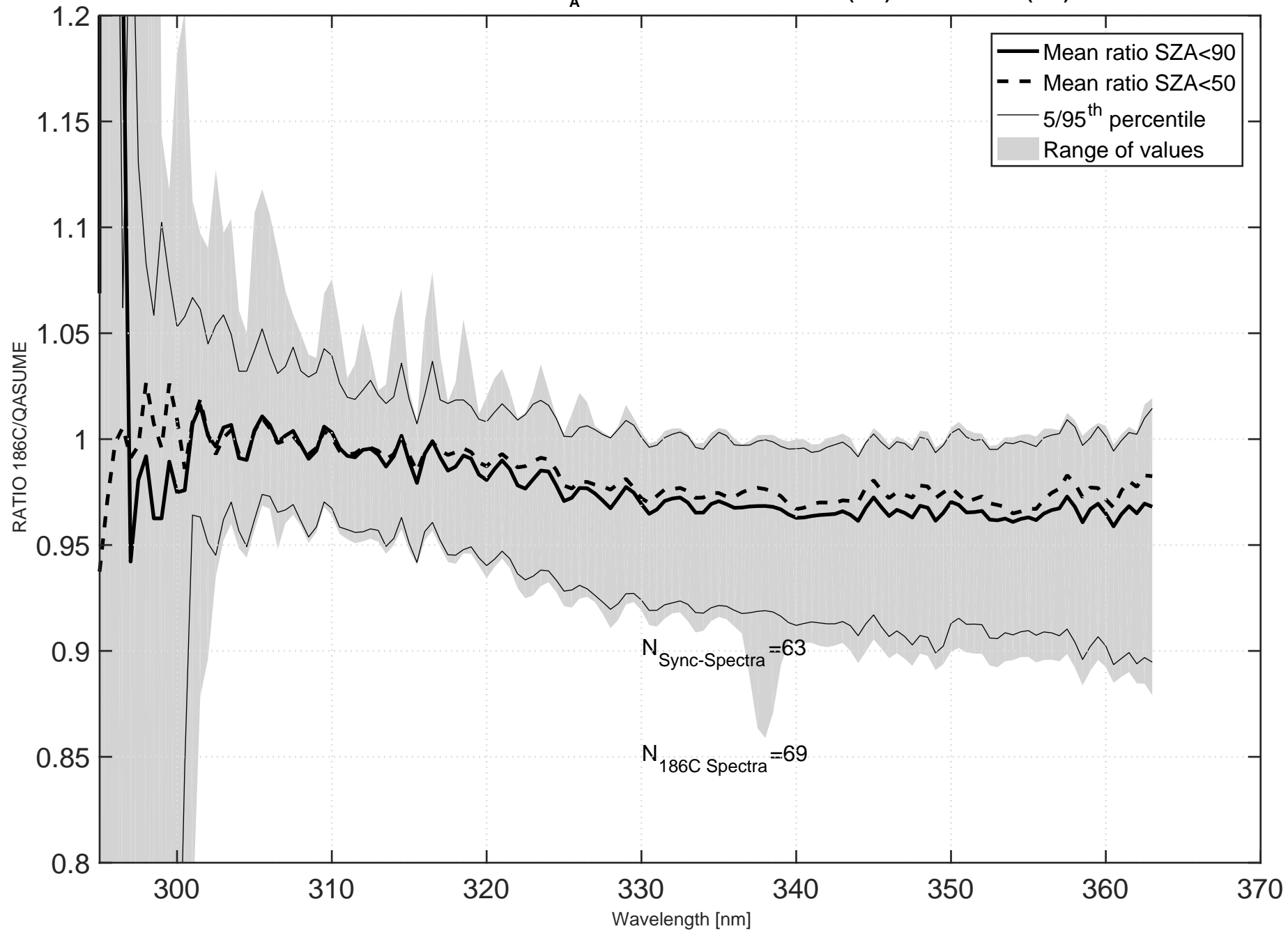
Global irradiance ratios 186C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



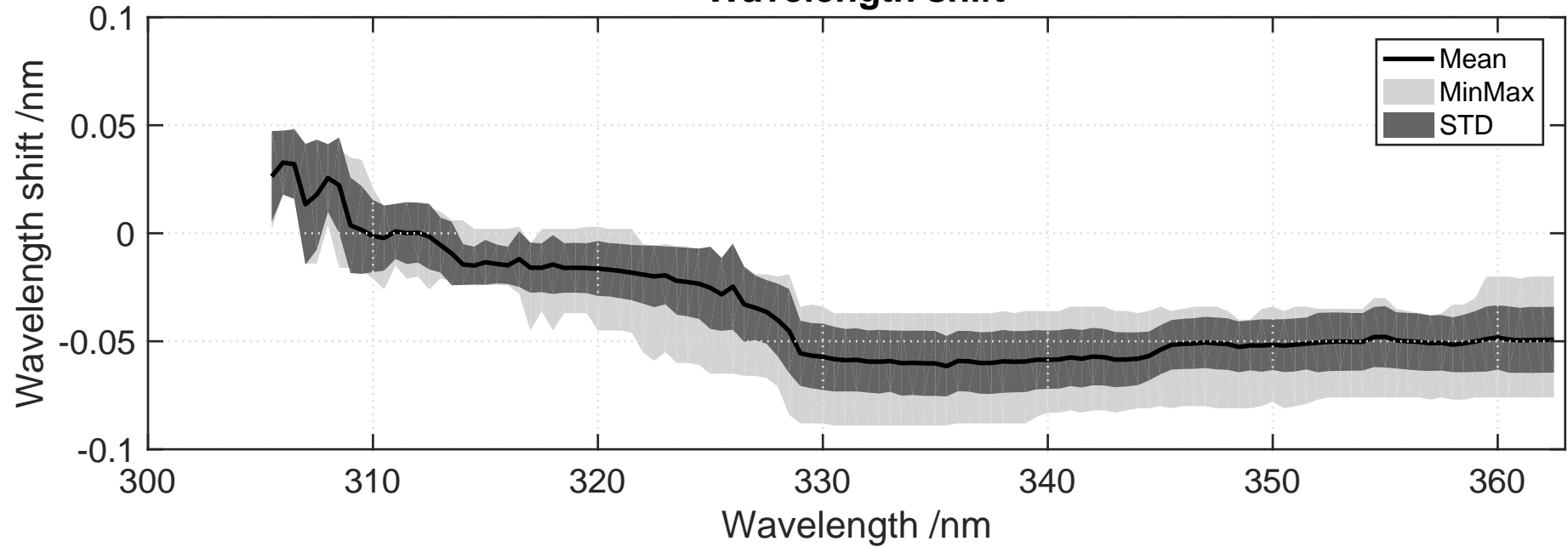
Daily variation. Wavelength bands are ± 2.5 nm



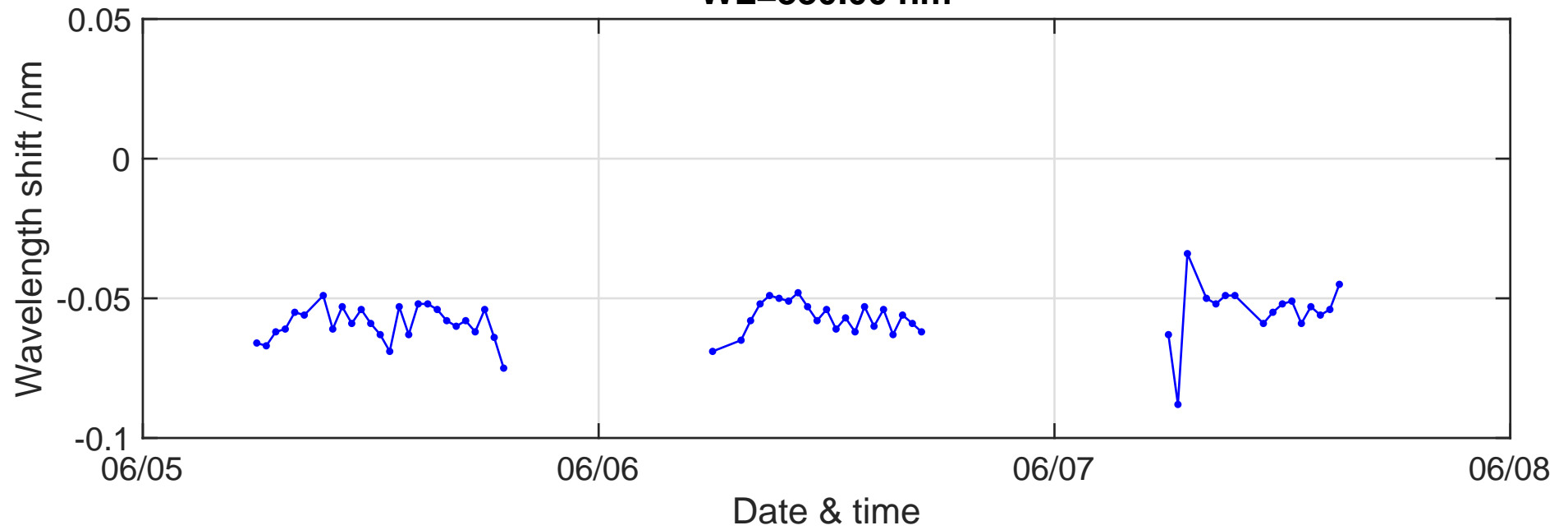
Mean ratio 186C/QASUME at E_A renosillo-matshic:05-Jun-2017(156) to 07-Jun-2017(158)



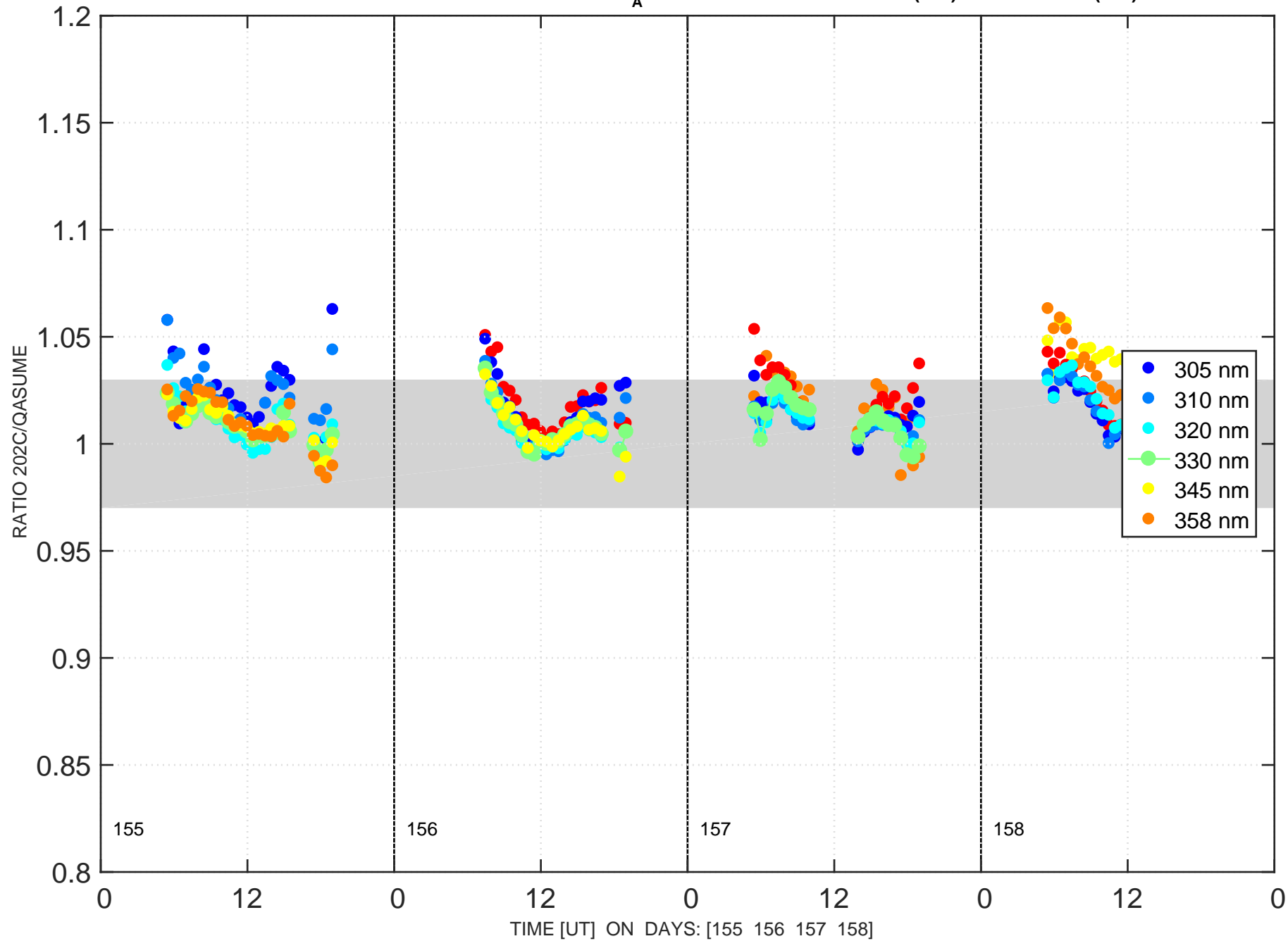
Wavelength shift



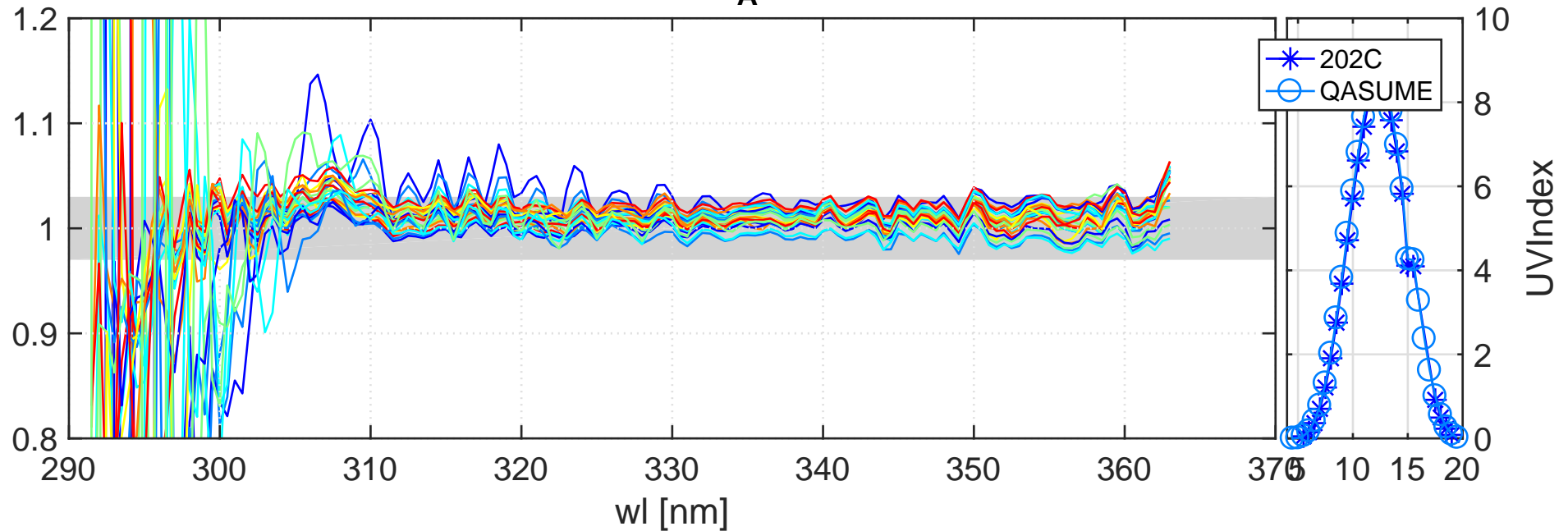
WL=330.00 nm



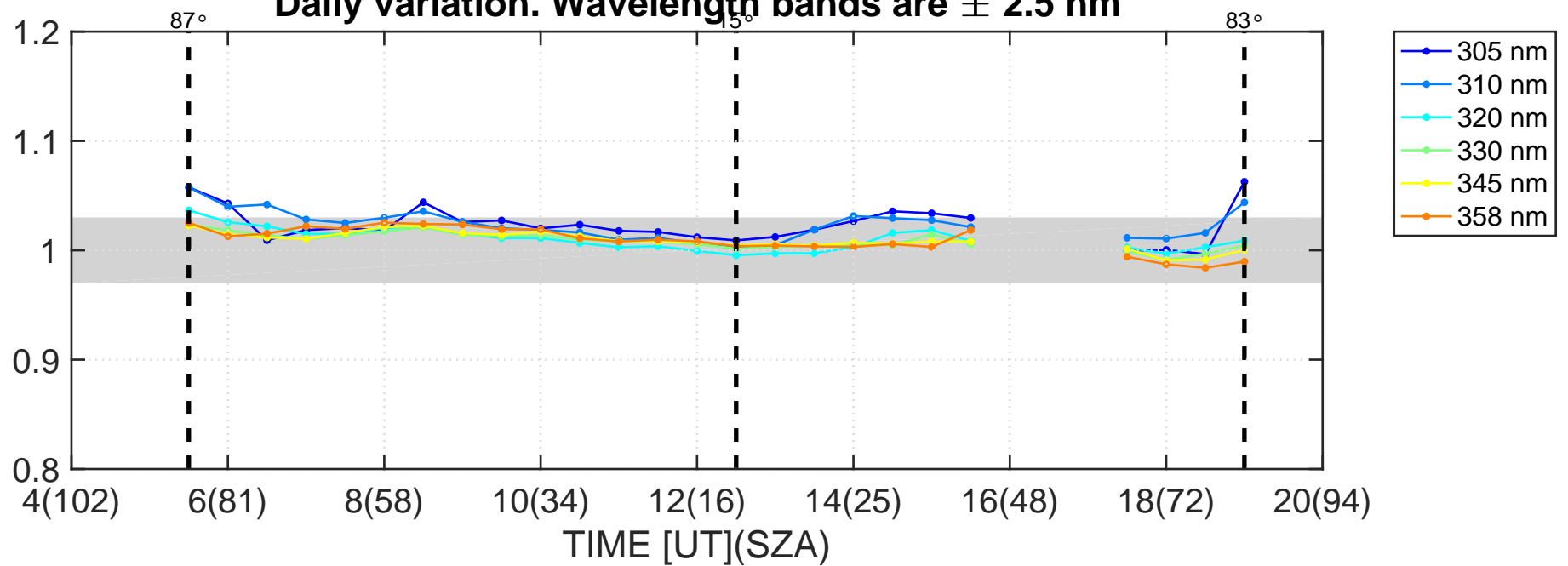
Global irradiance ratios 202C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



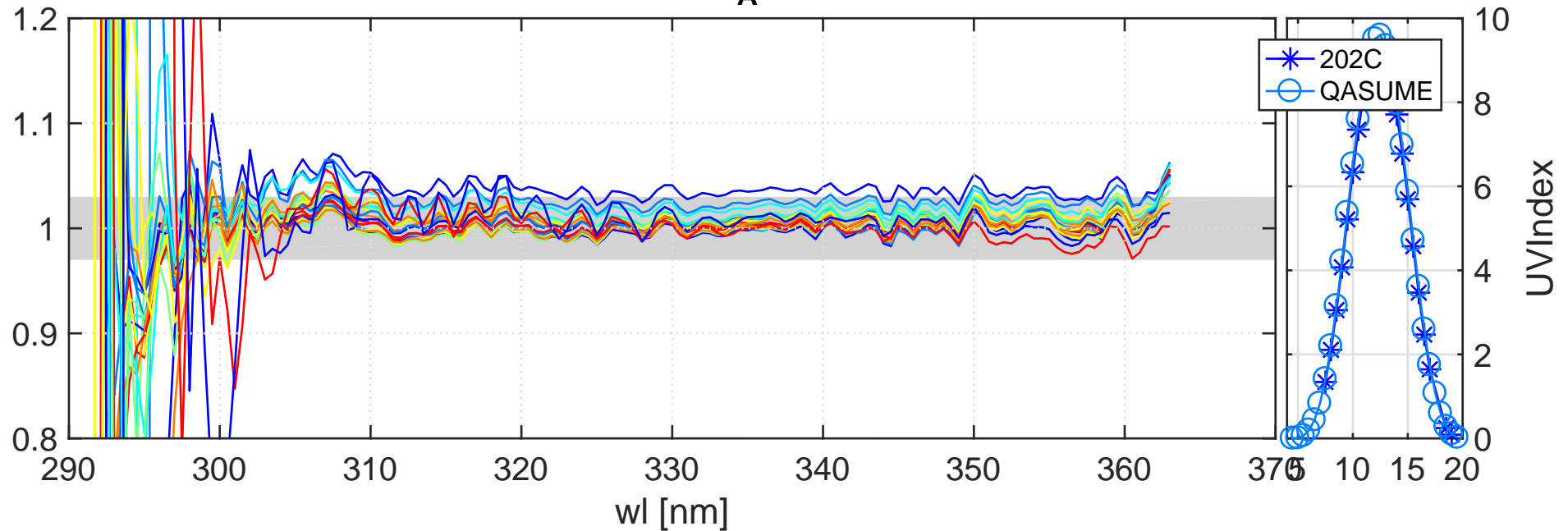
Global irradiance ratios 202C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



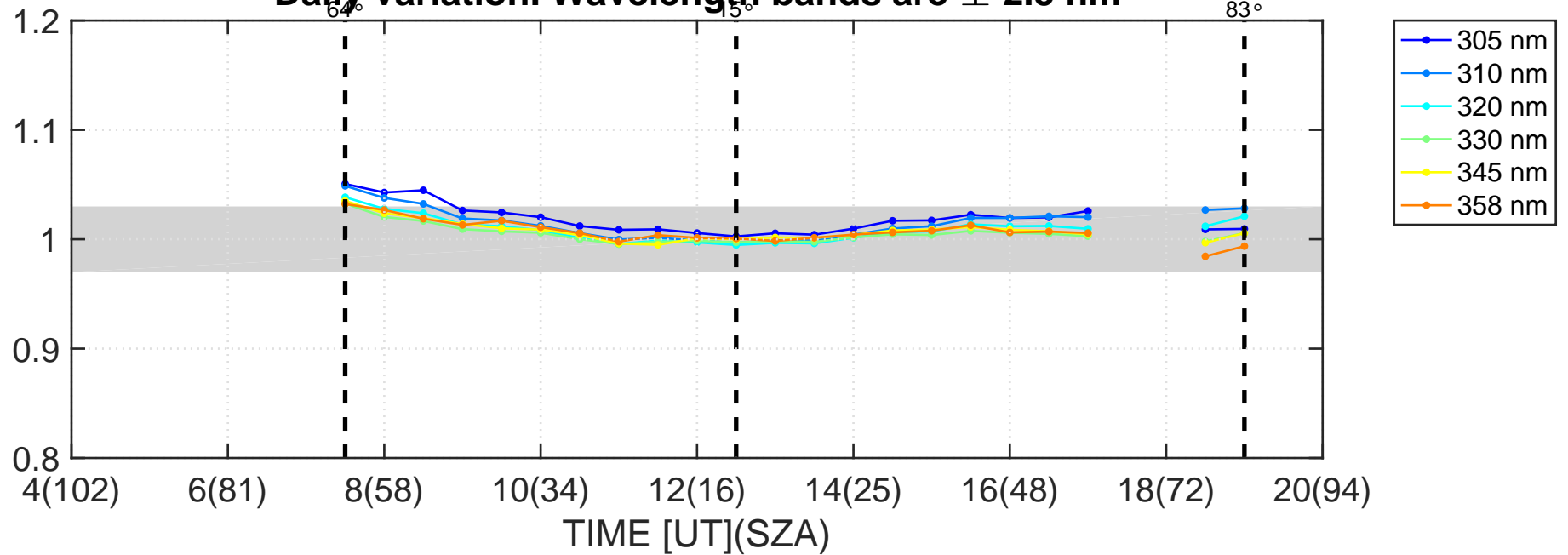
Daily variation. Wavelength bands are ± 2.5 nm



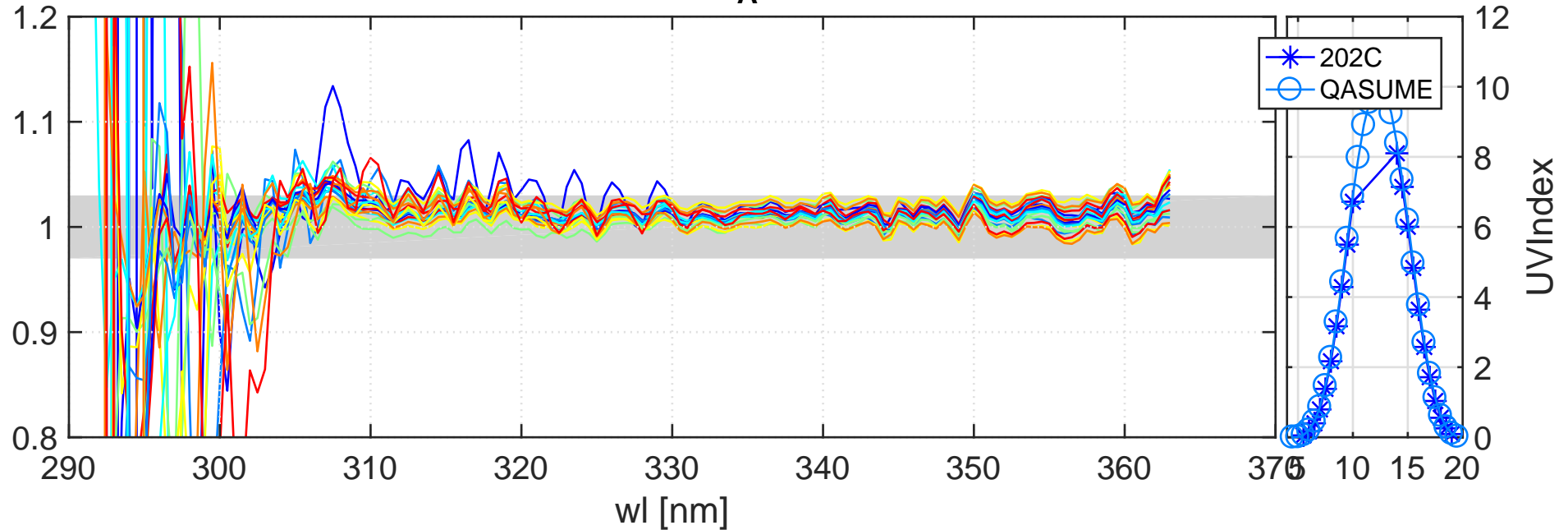
Global irradiance ratios 202C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



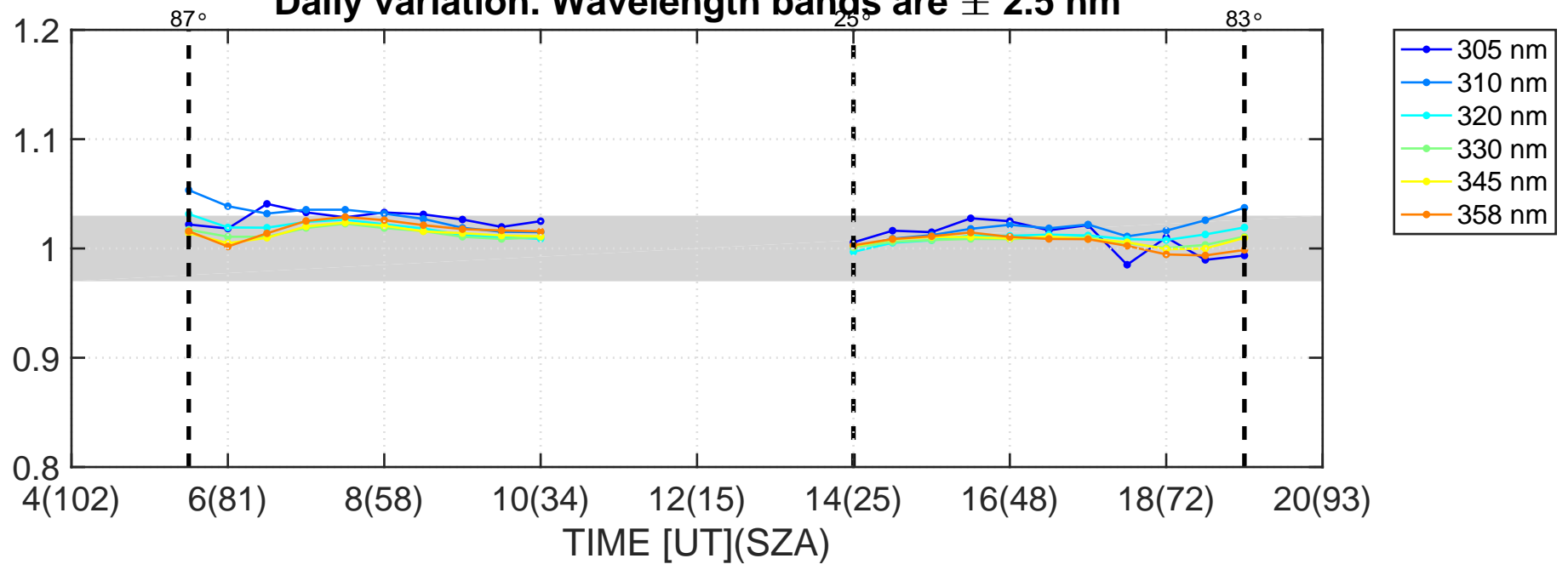
Daily variation. Wavelength bands are ± 2.5 nm



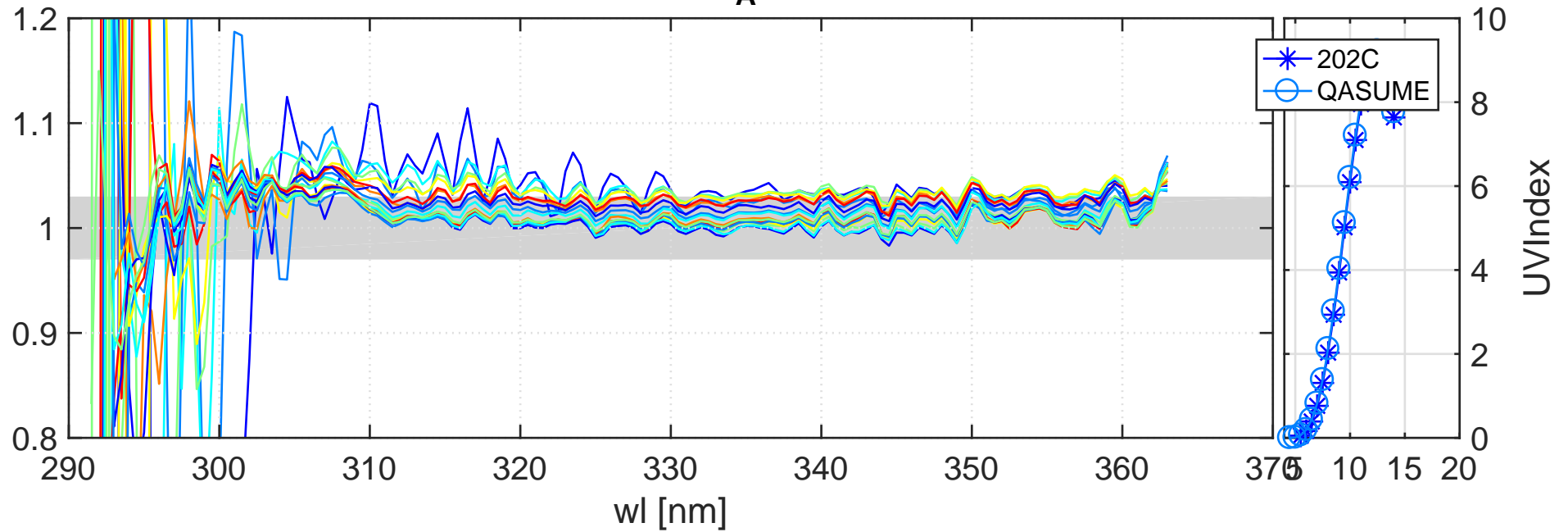
Global irradiance ratios 202C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



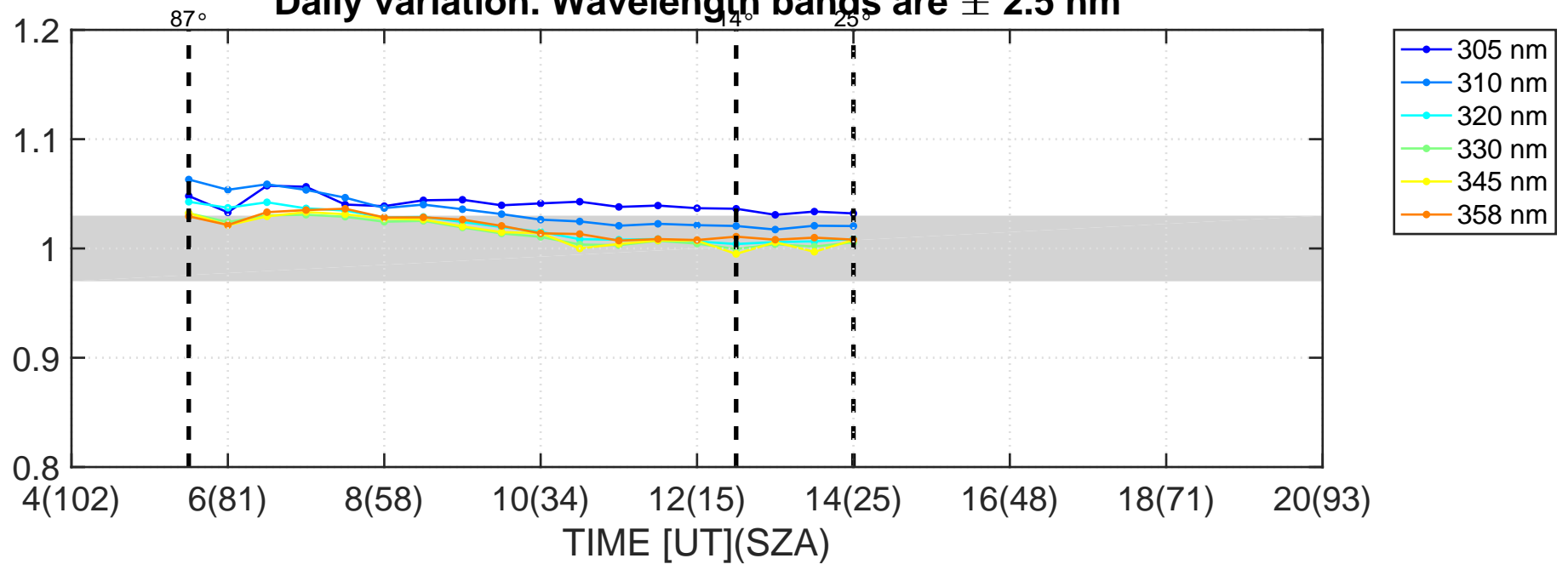
Daily variation. Wavelength bands are ± 2.5 nm



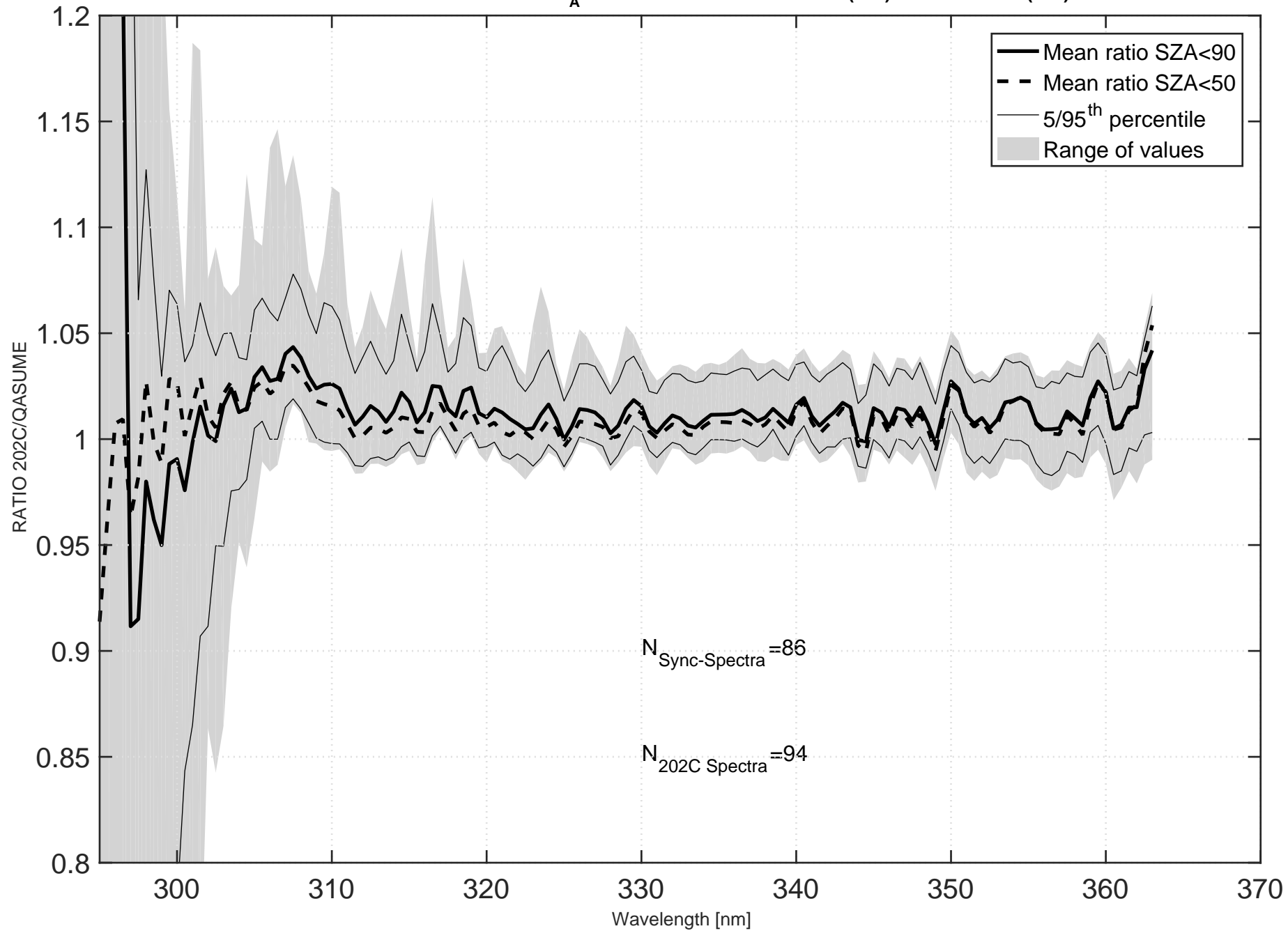
Global irradiance ratios 202C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



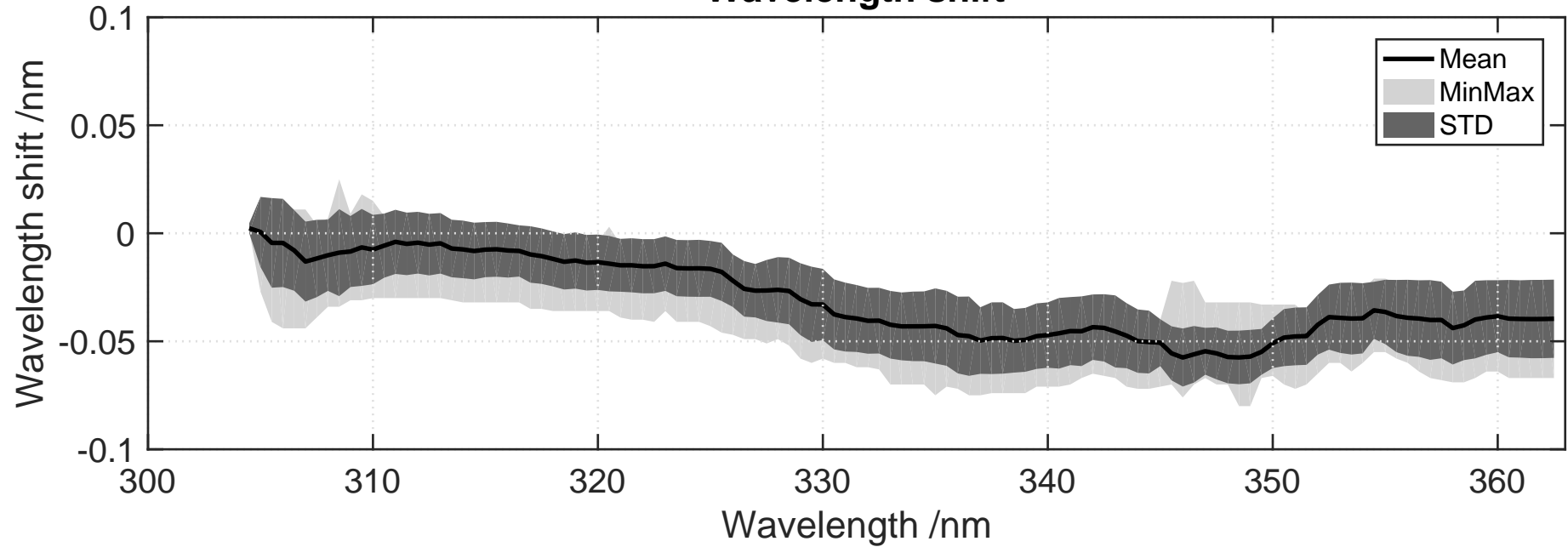
Daily variation. Wavelength bands are ± 2.5 nm



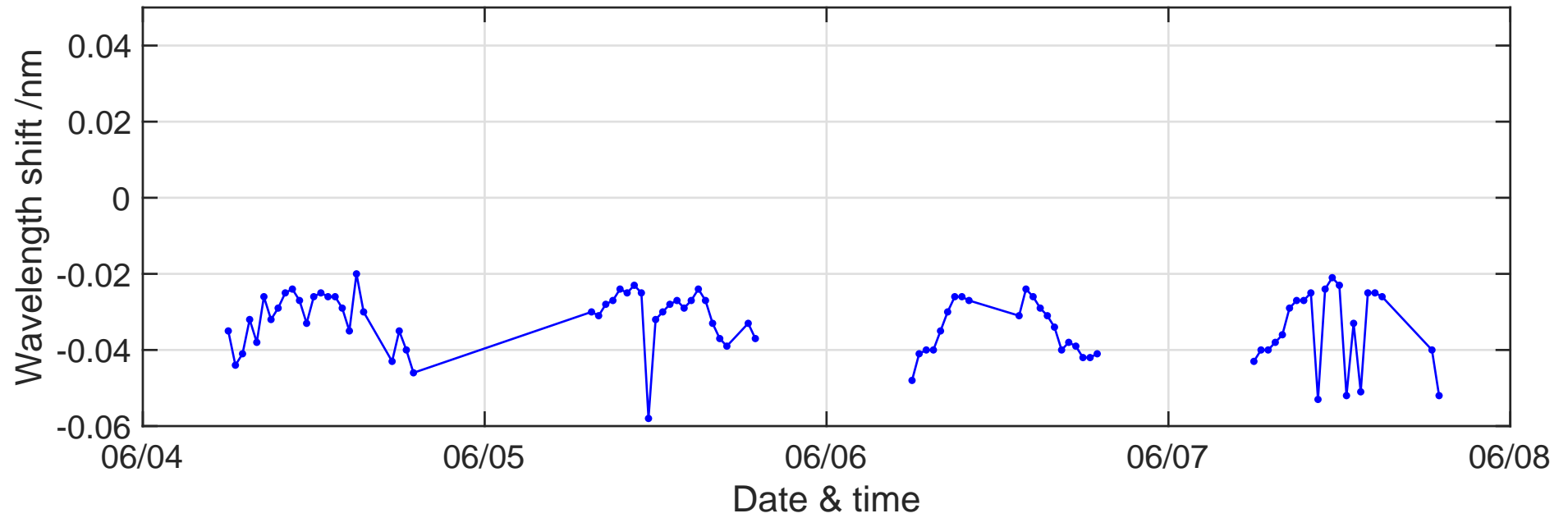
Mean ratio 202C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



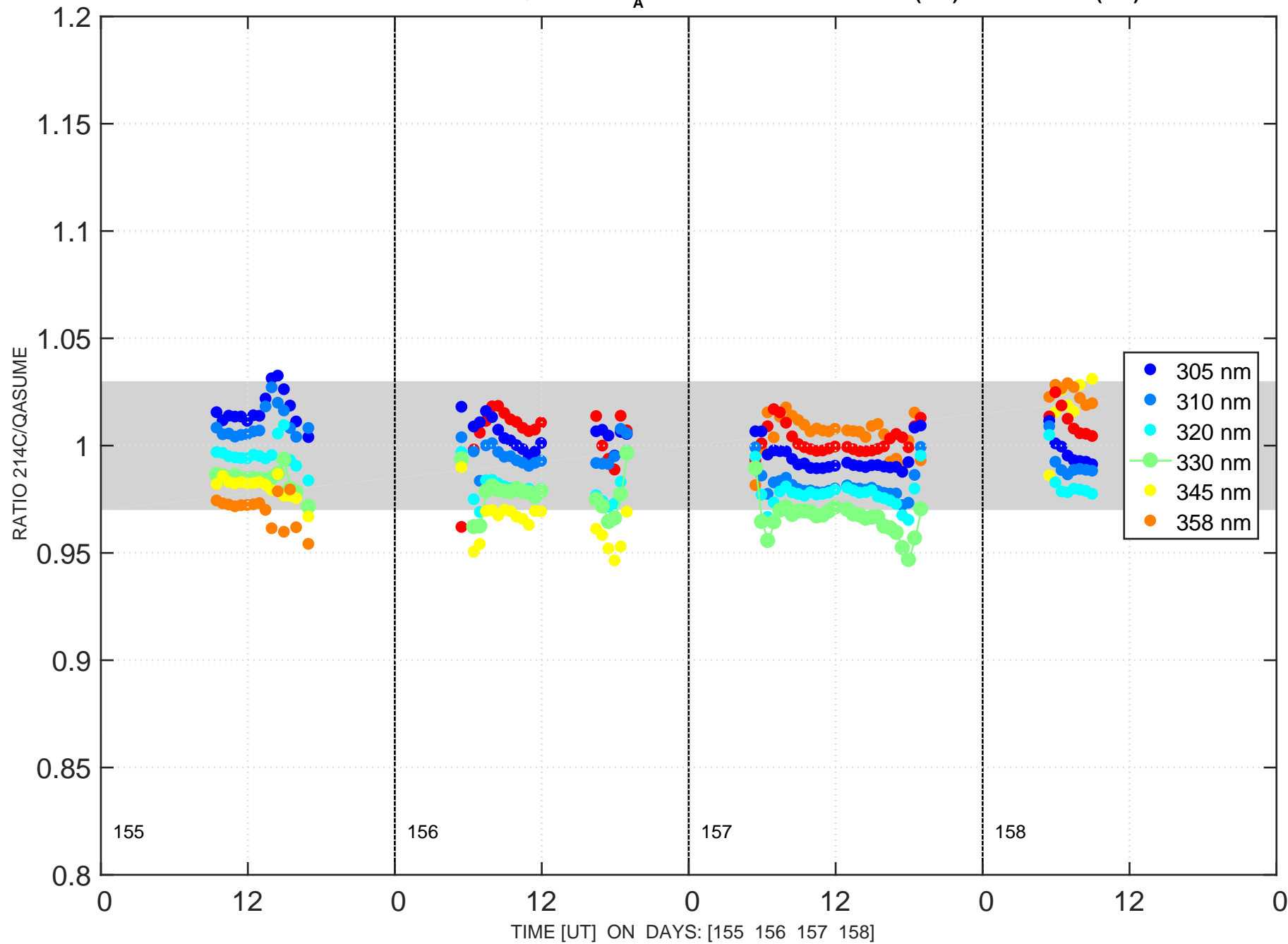
Wavelength shift



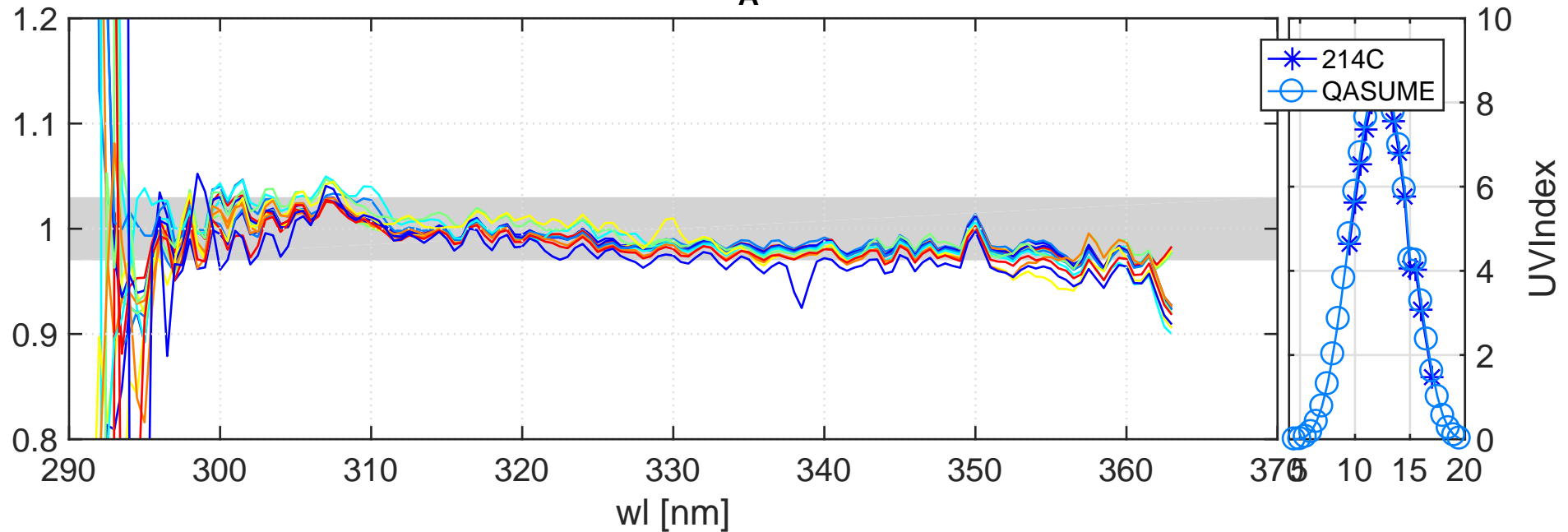
WL=330.00 nm



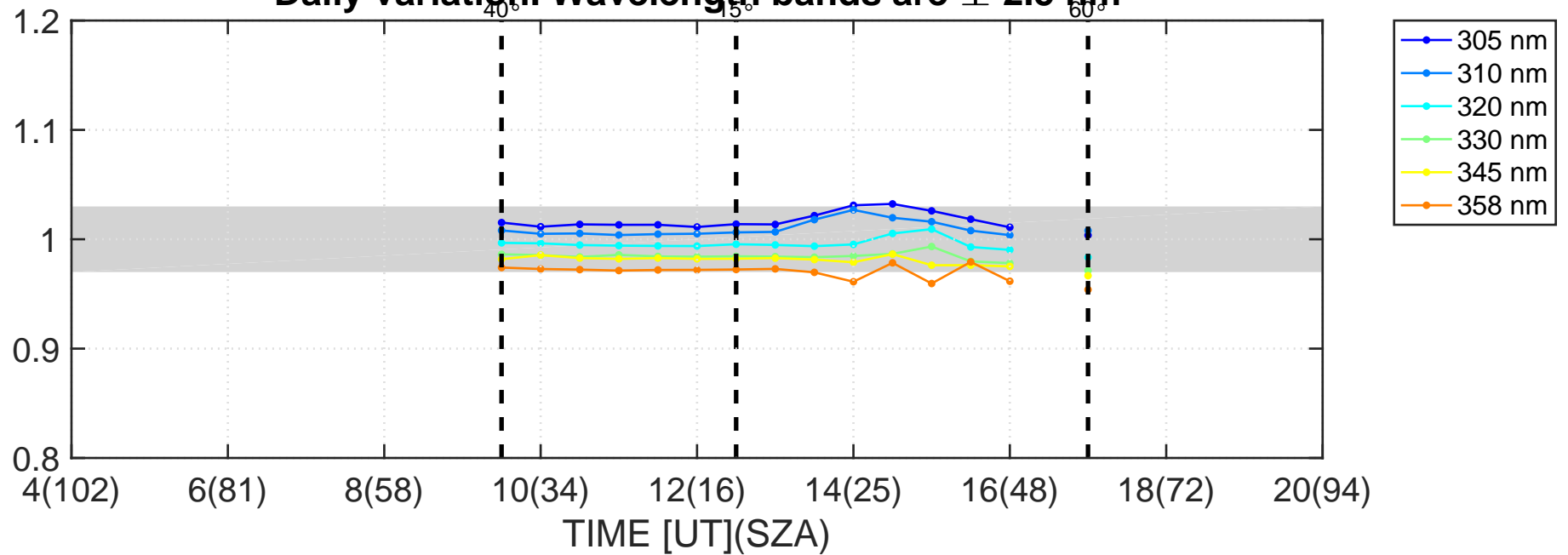
Global irradiance ratios 214C/QASUME at E|renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



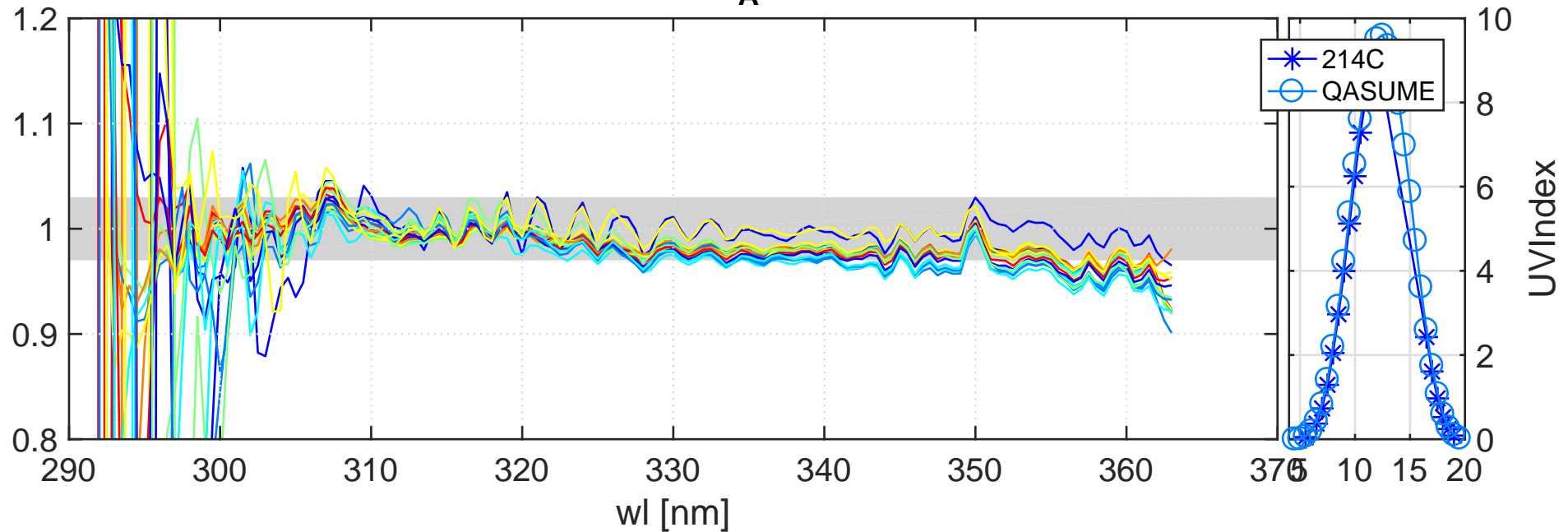
Global irradiance ratios 214C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



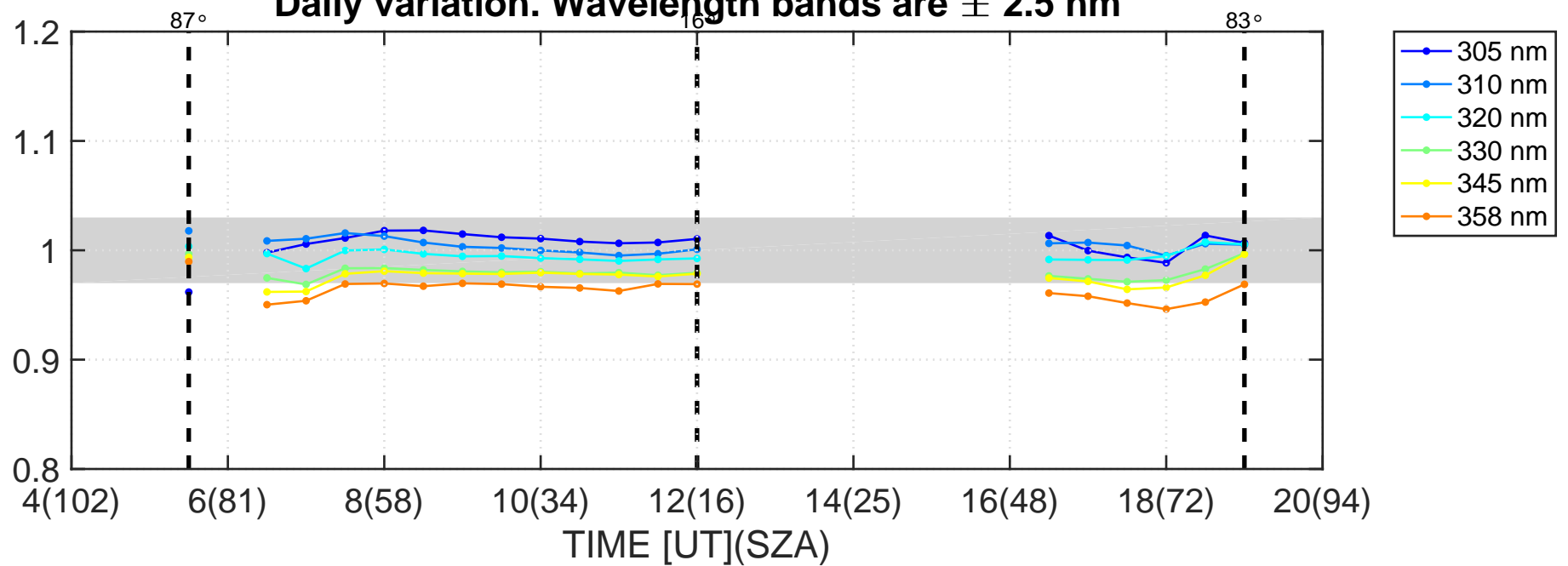
Daily variation. Wavelength bands are ± 2.5 nm



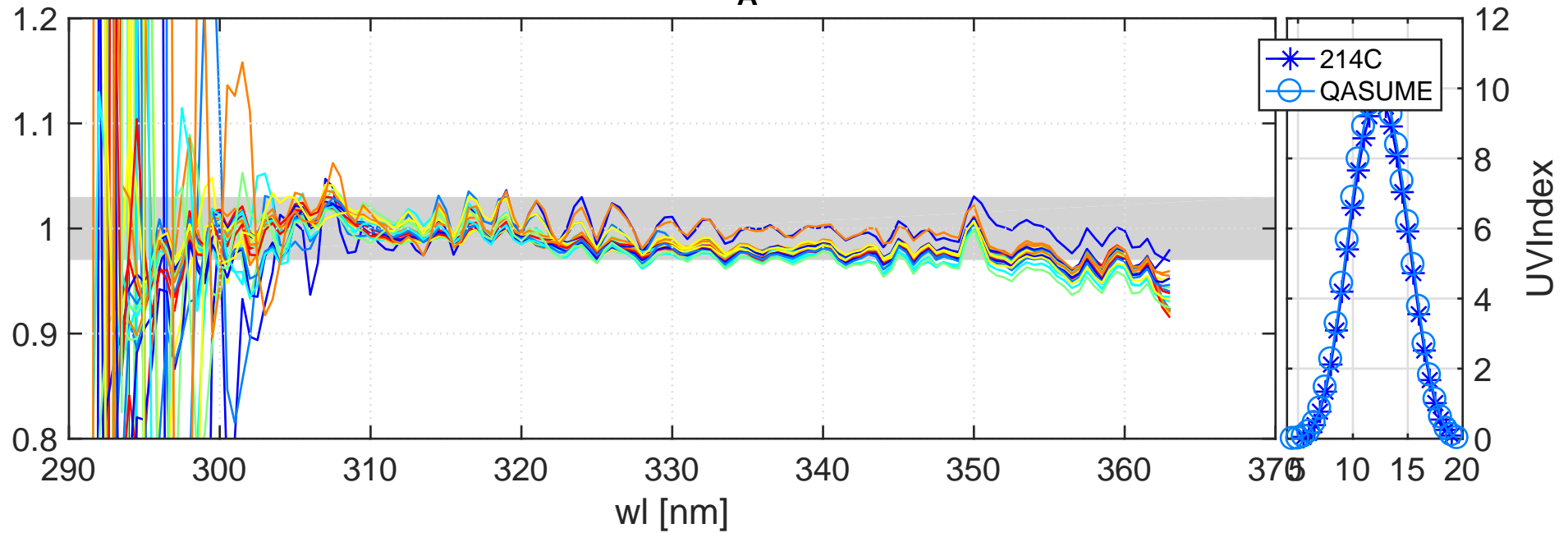
Global irradiance ratios 214C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



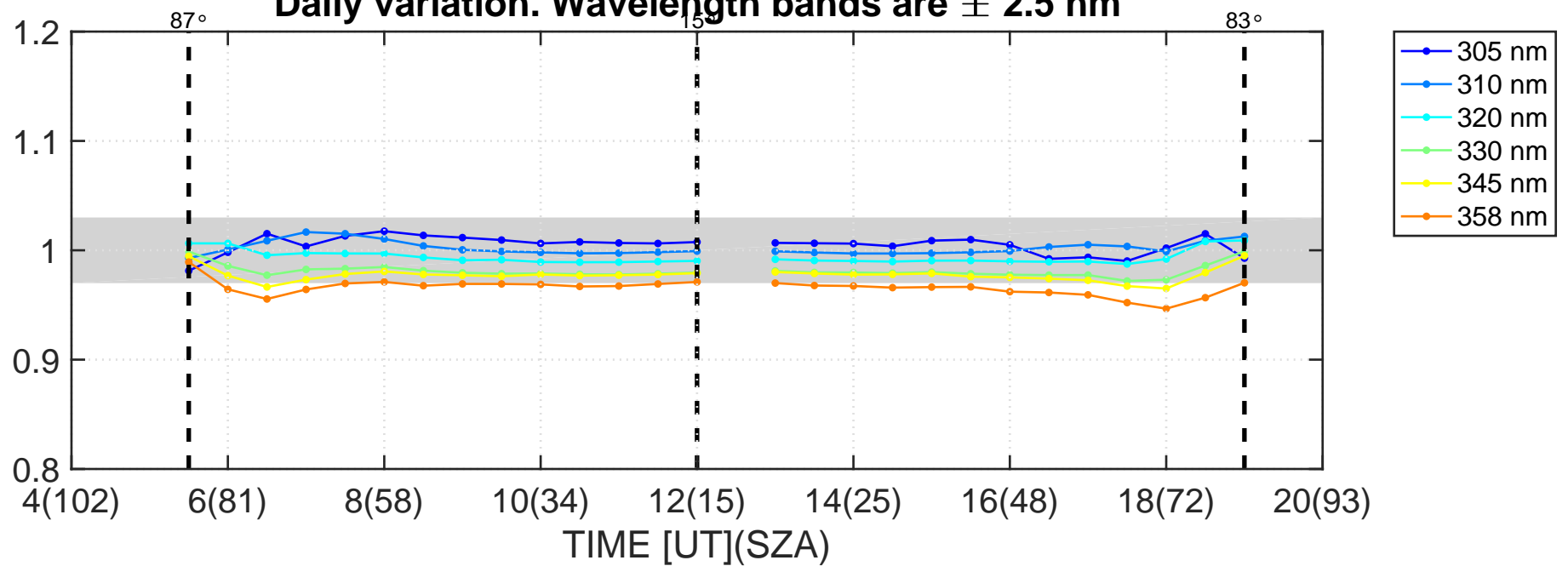
Daily variation. Wavelength bands are ± 2.5 nm



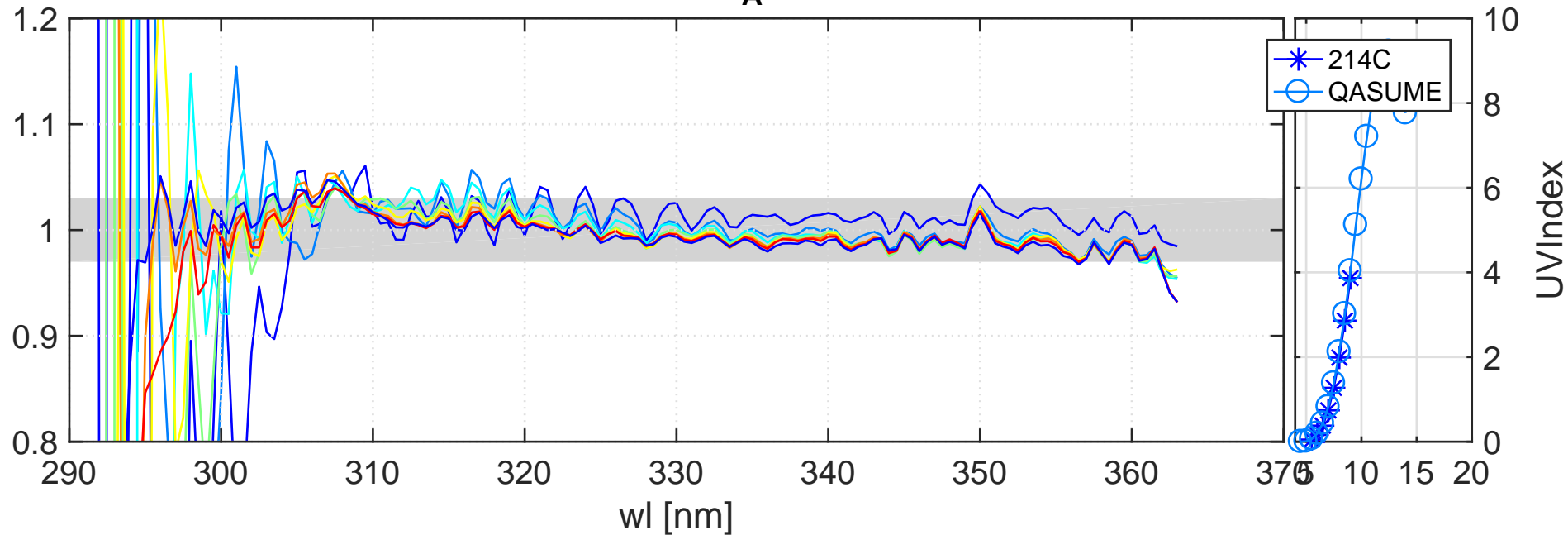
Global irradiance ratios 214C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



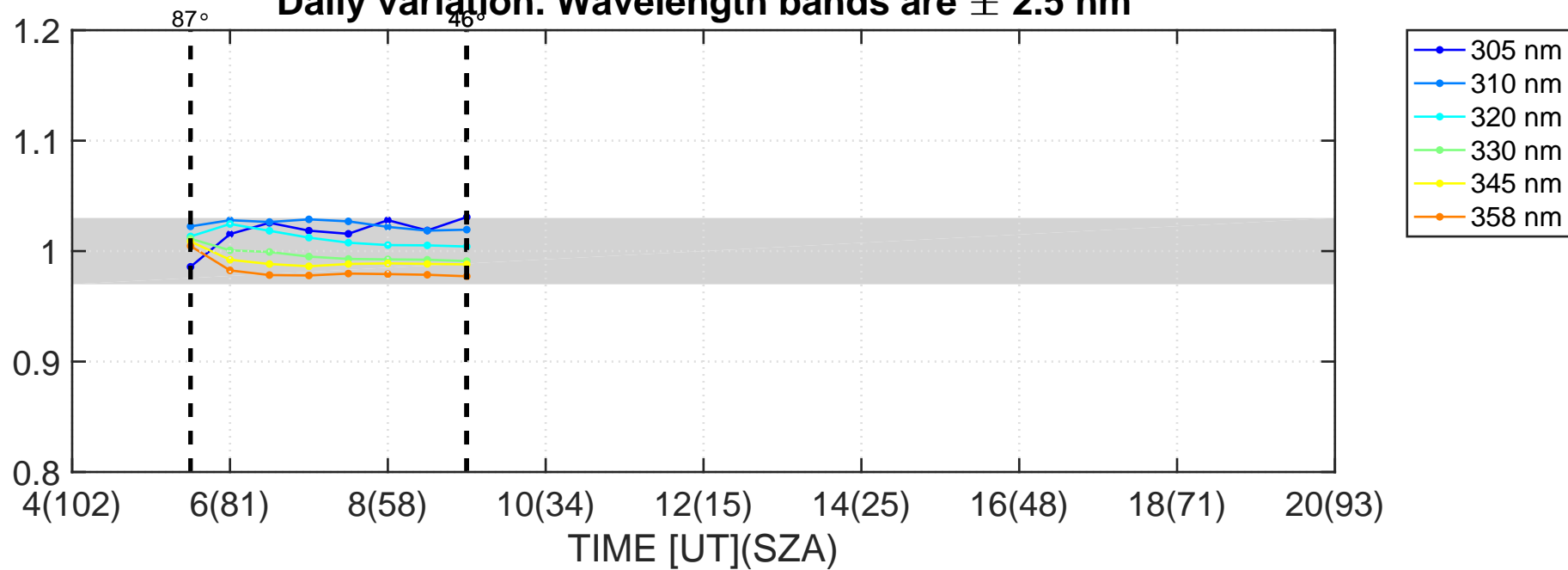
Daily variation. Wavelength bands are ± 2.5 nm



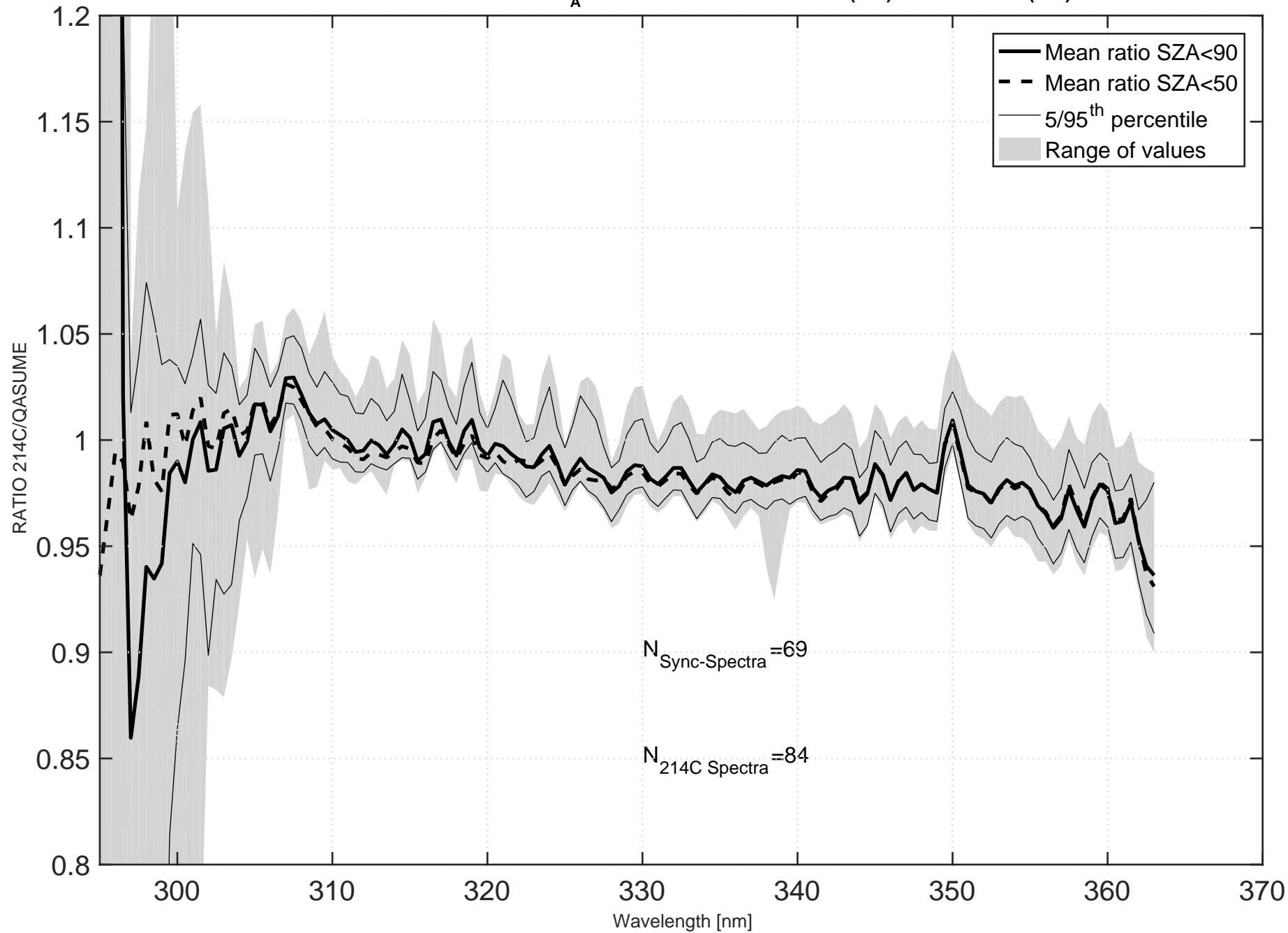
Global irradiance ratios 214C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



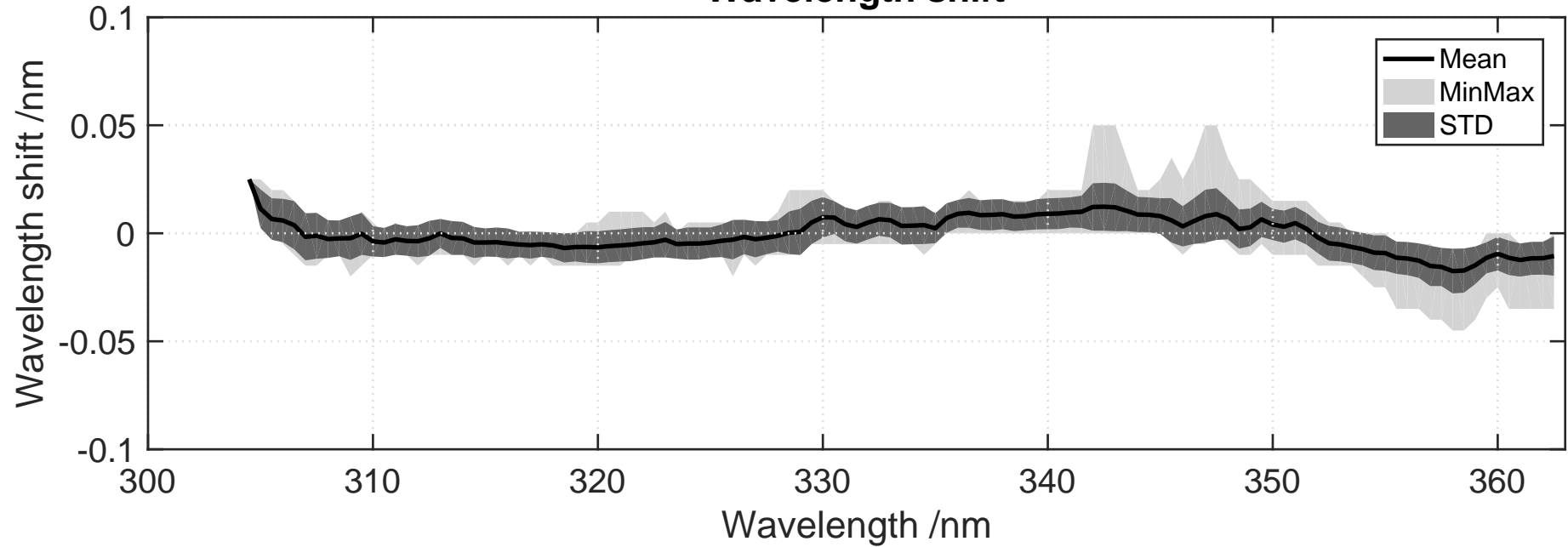
Daily variation. Wavelength bands are ± 2.5 nm



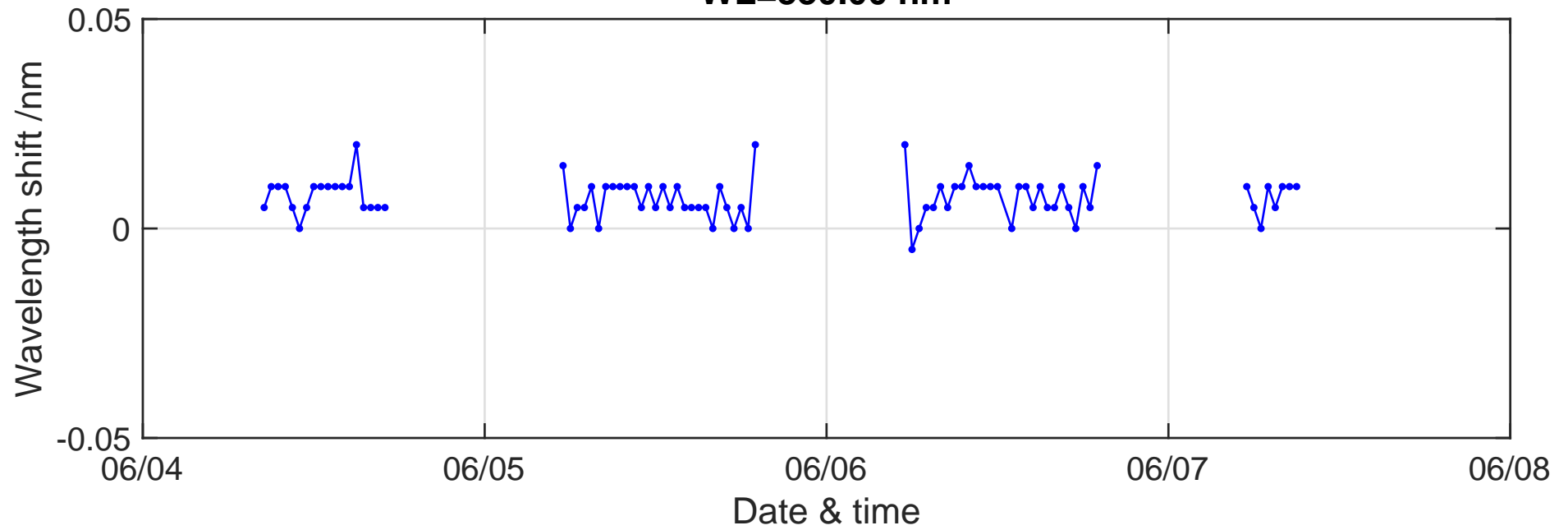
Mean ratio 214C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



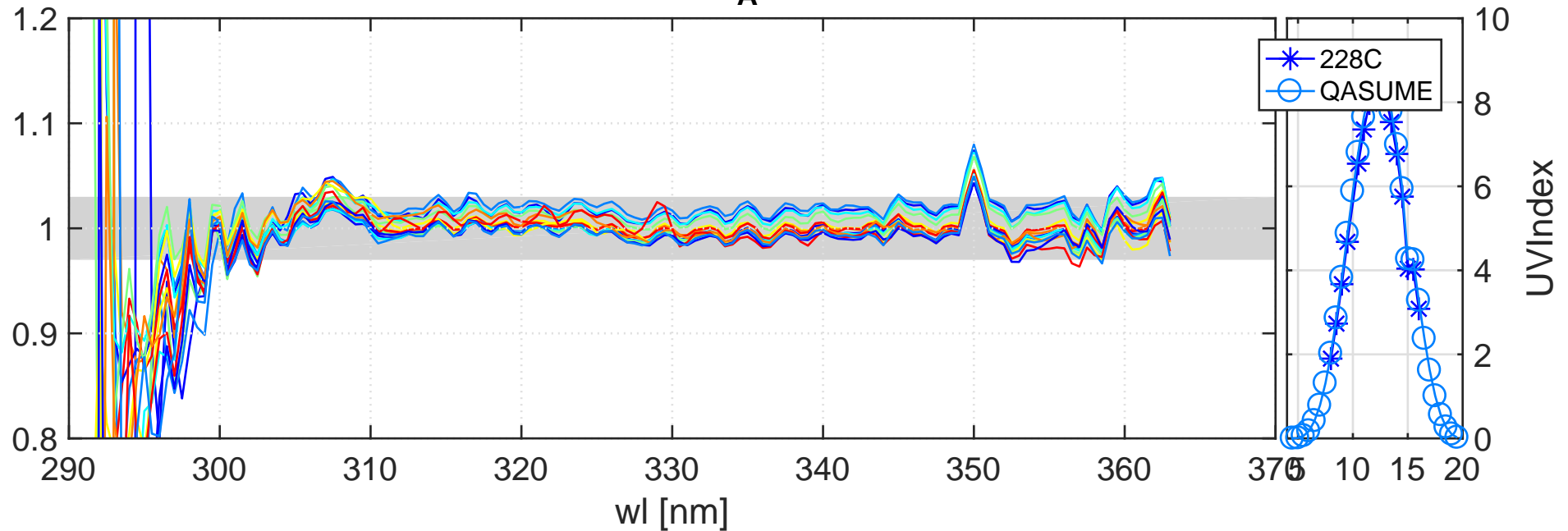
Wavelength shift



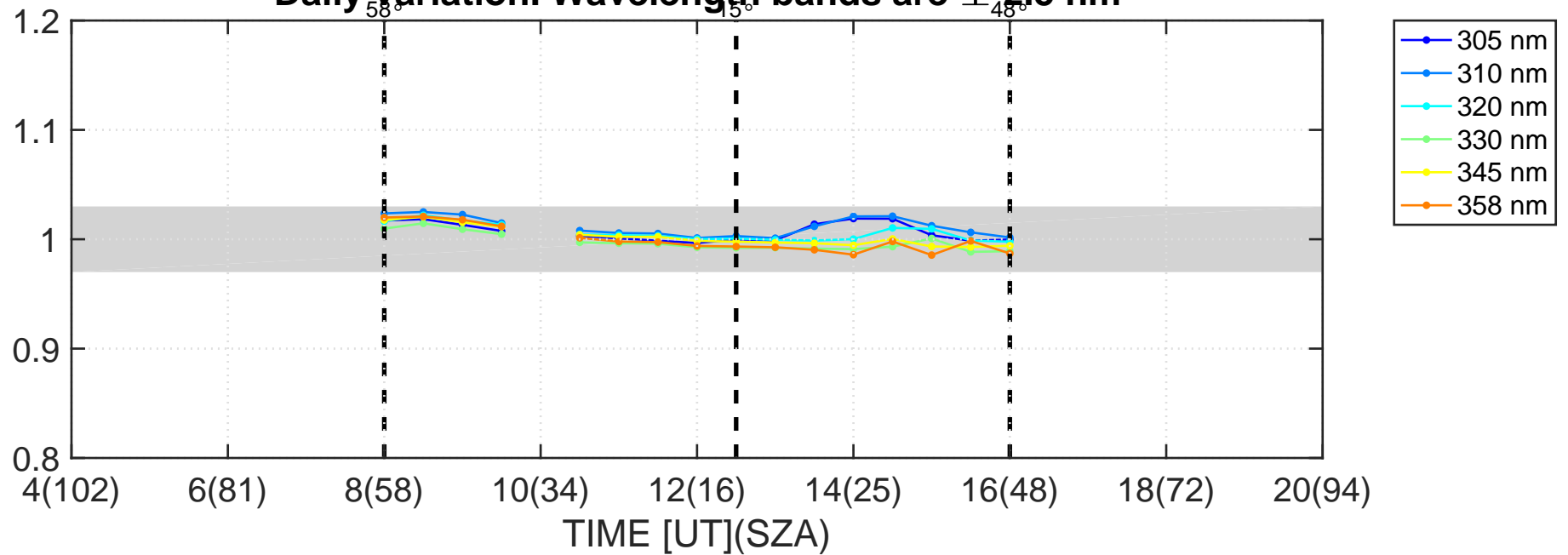
WL=330.00 nm



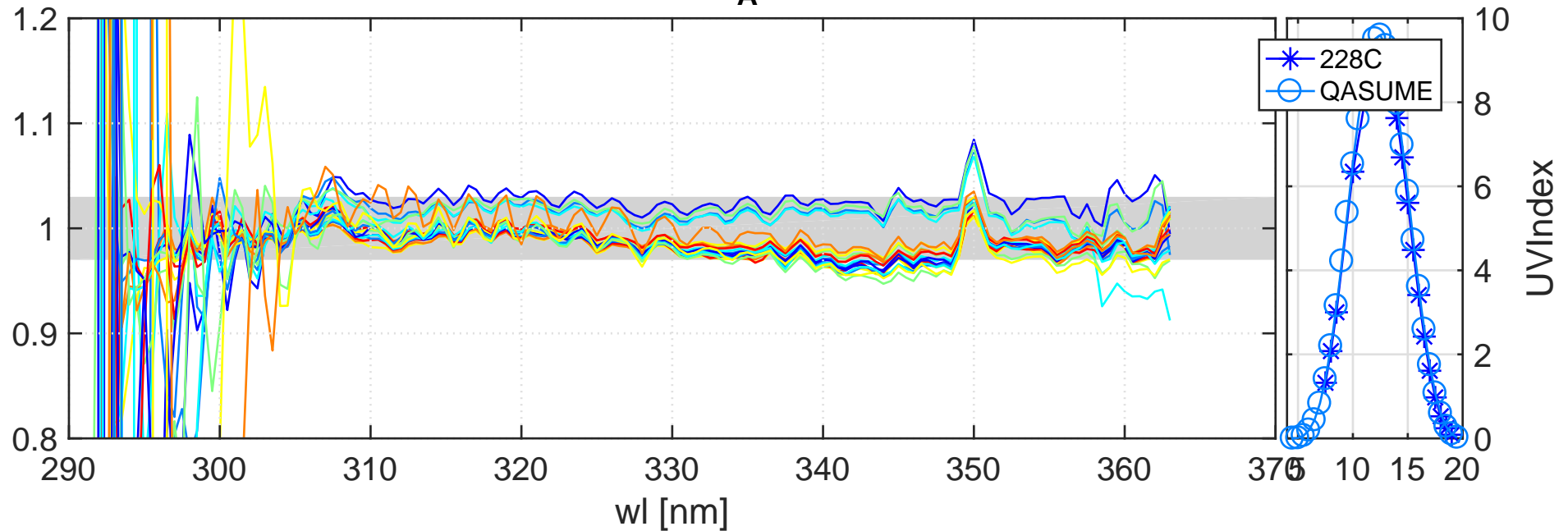
Global irradiance ratios 228C/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



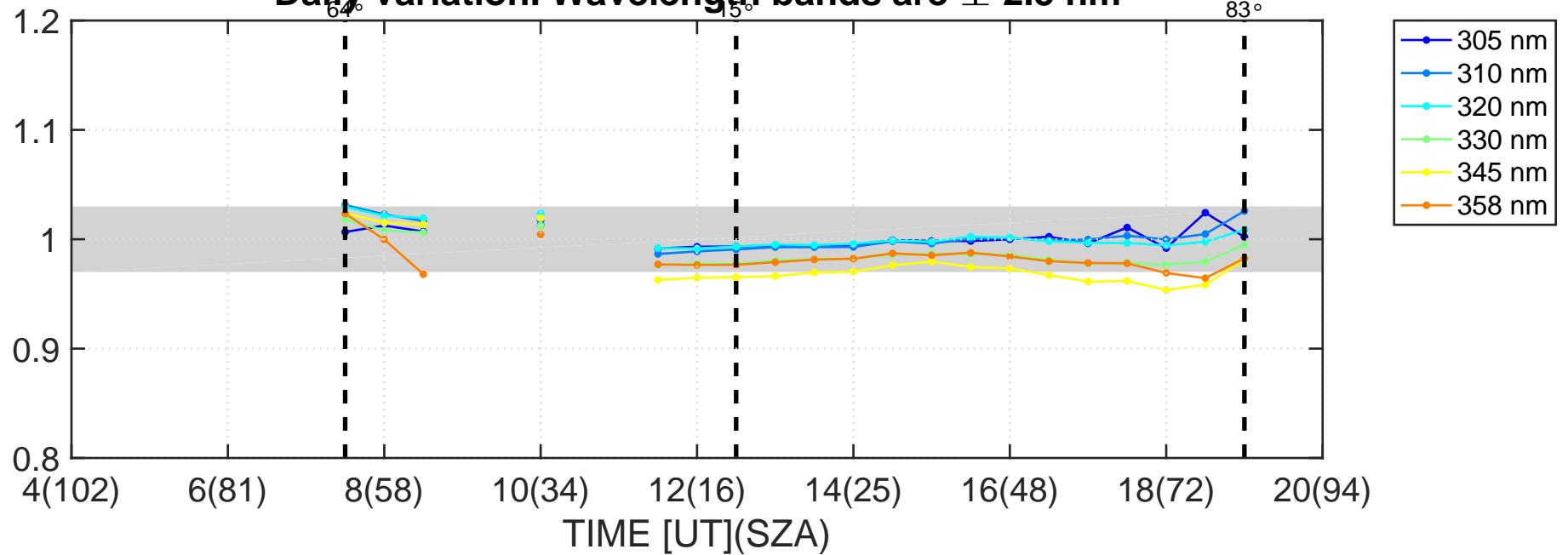
Daily variation. Wavelength bands are ± 2.5 nm



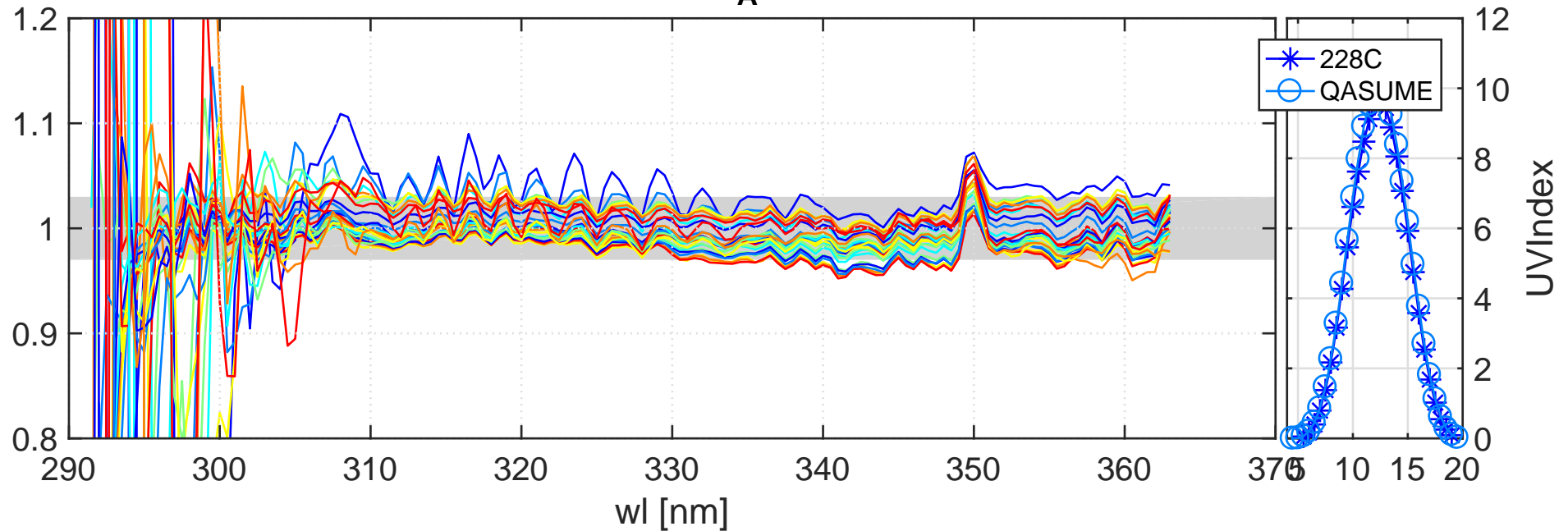
Global irradiance ratios 228C/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



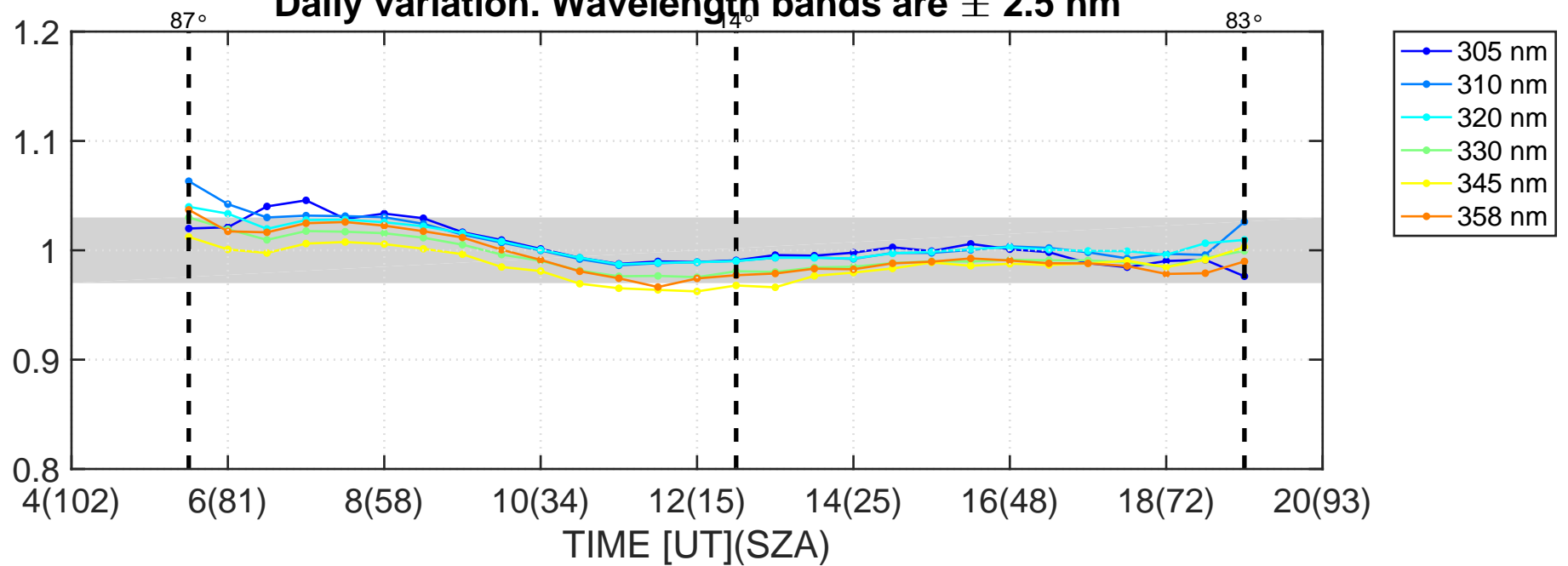
Daily variation. Wavelength bands are ± 2.5 nm



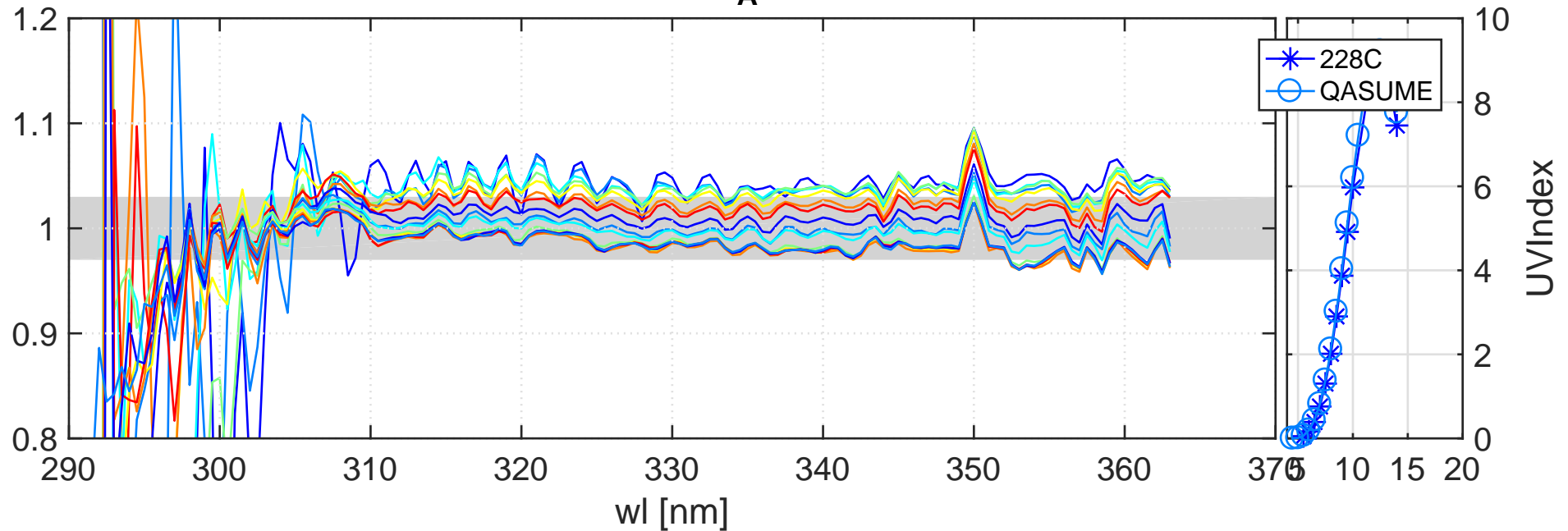
Global irradiance ratios 228C/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



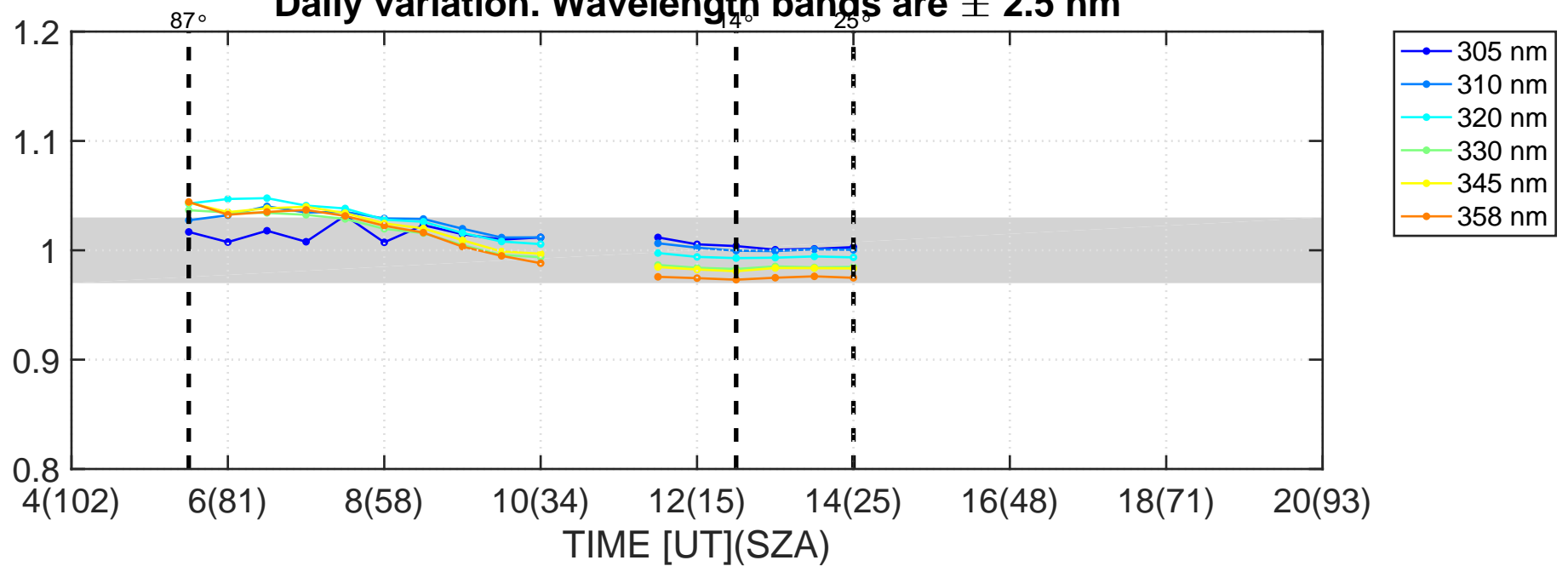
Daily variation. Wavelength bands are ± 2.5 nm



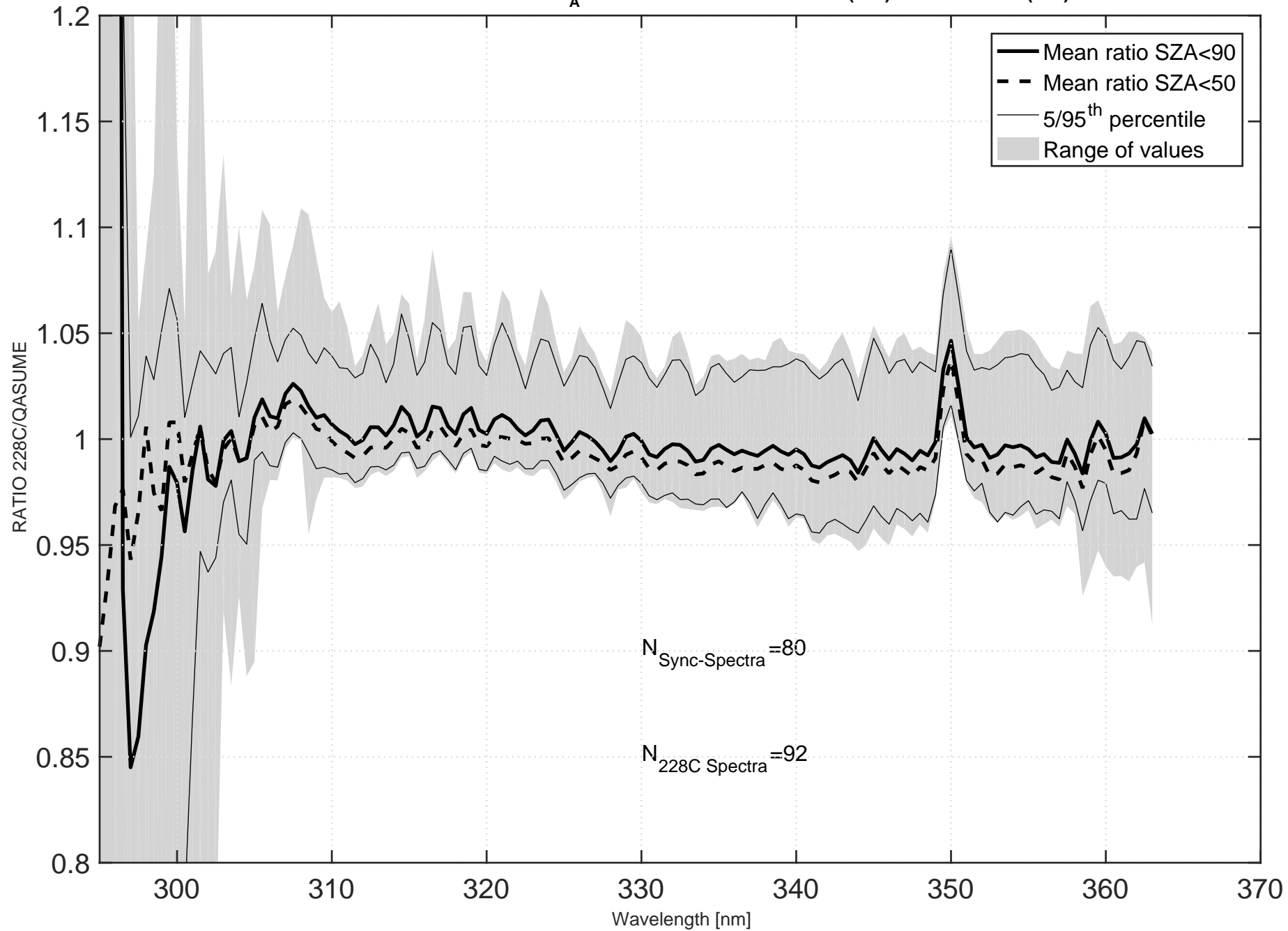
Global irradiance ratios 228C/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



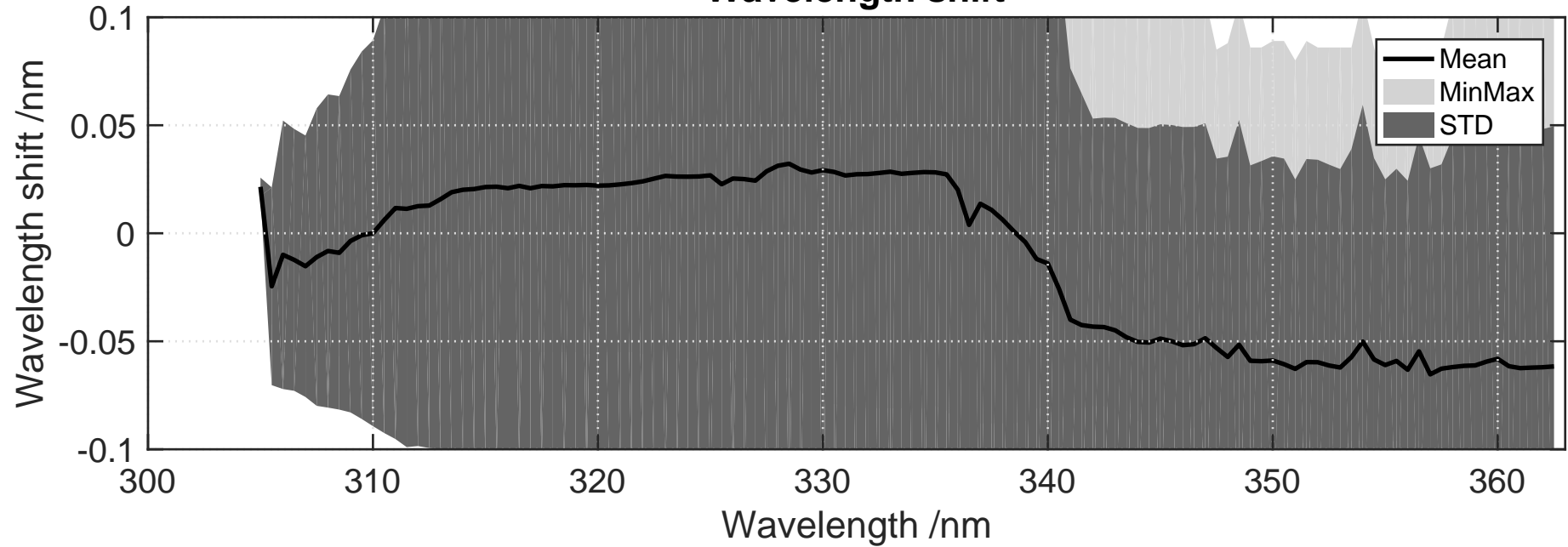
Daily variation. Wavelength bands are ± 2.5 nm



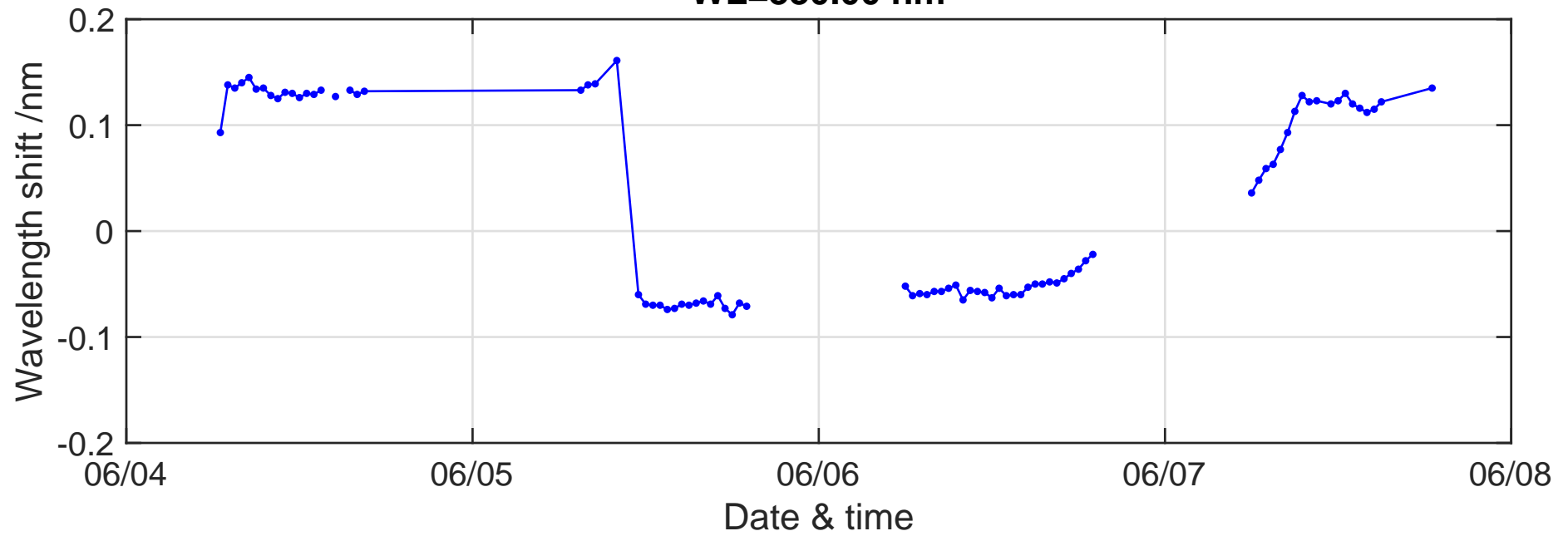
Mean ratio 228C/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



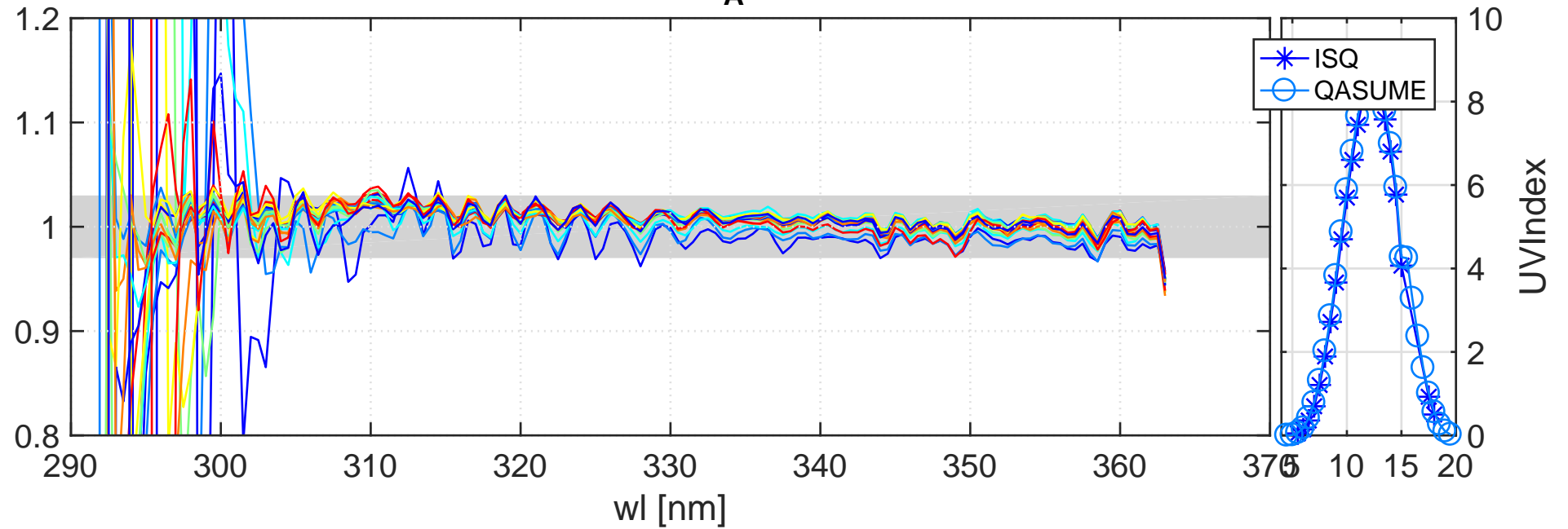
Wavelength shift



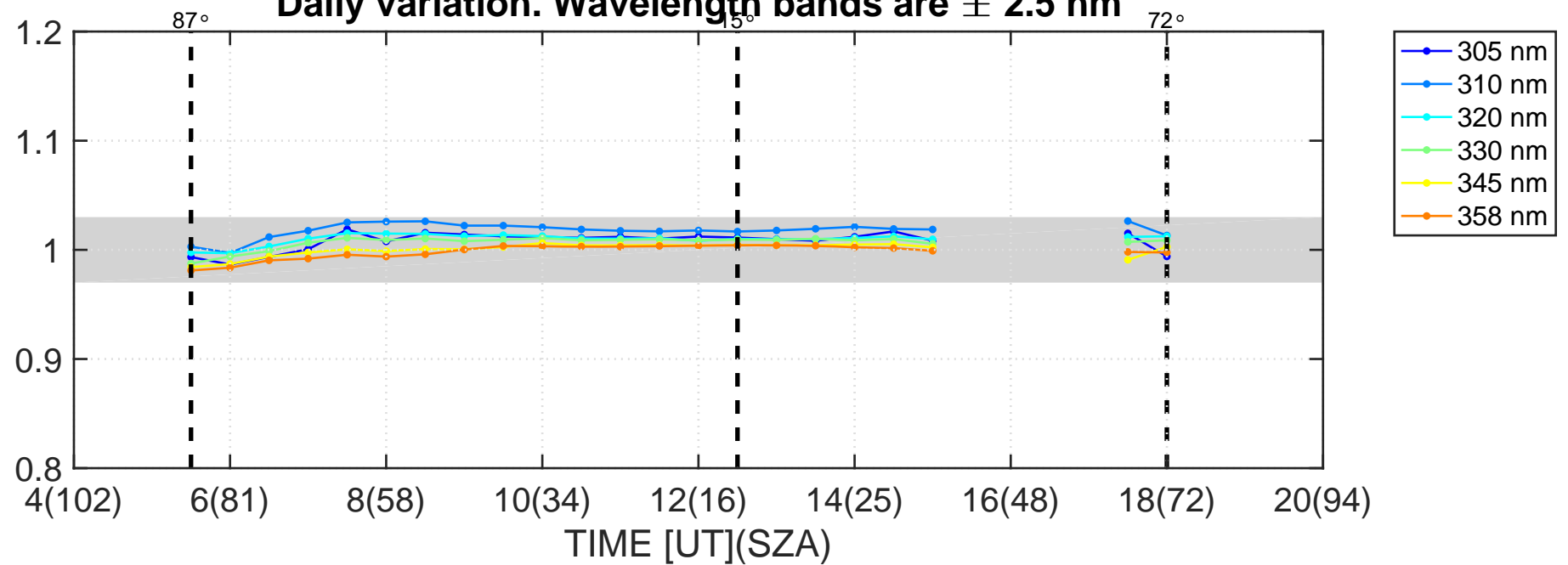
WL=330.00 nm



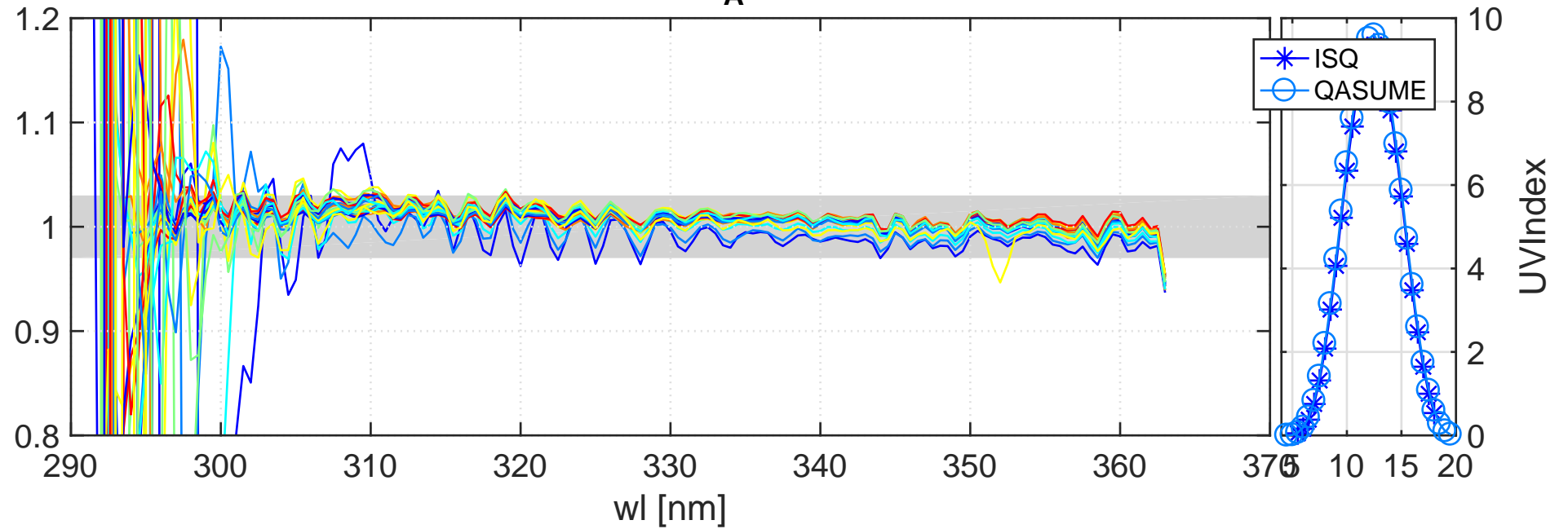
Global irradiance ratios ISQ/QASUME at El_A renosillo-matshic:04-Jun-2017(155)



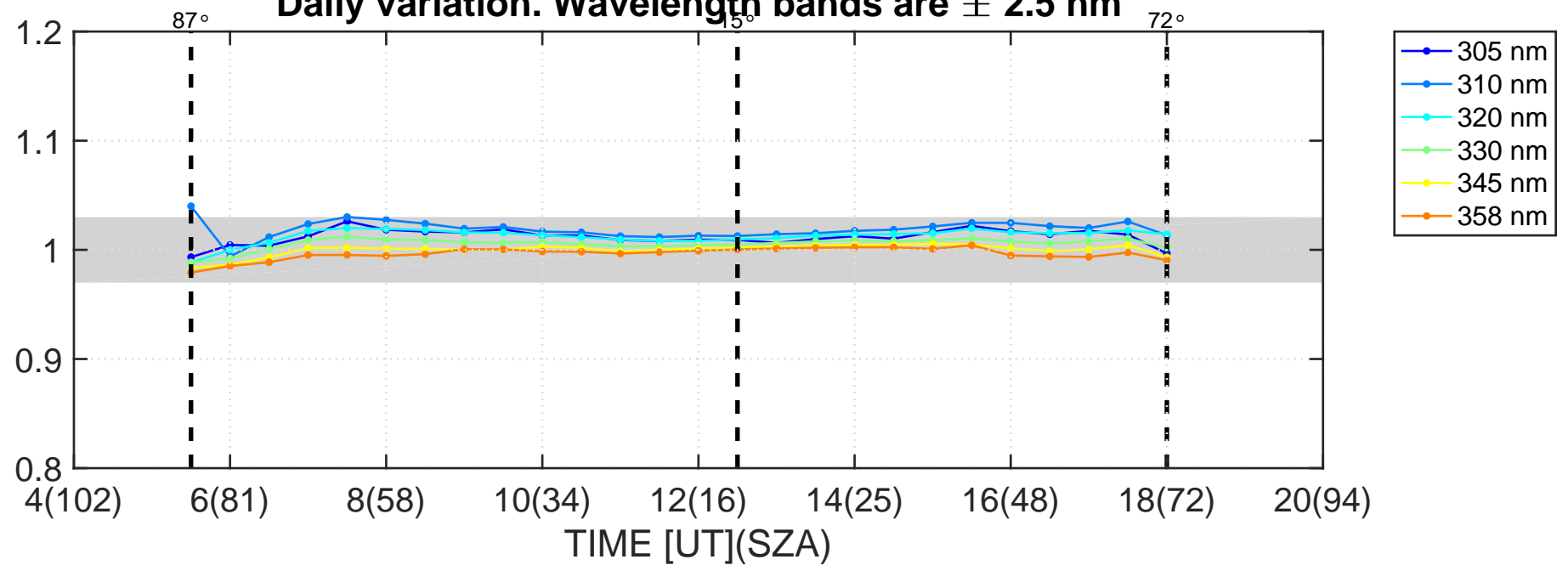
Daily variation. Wavelength bands are ± 2.5 nm



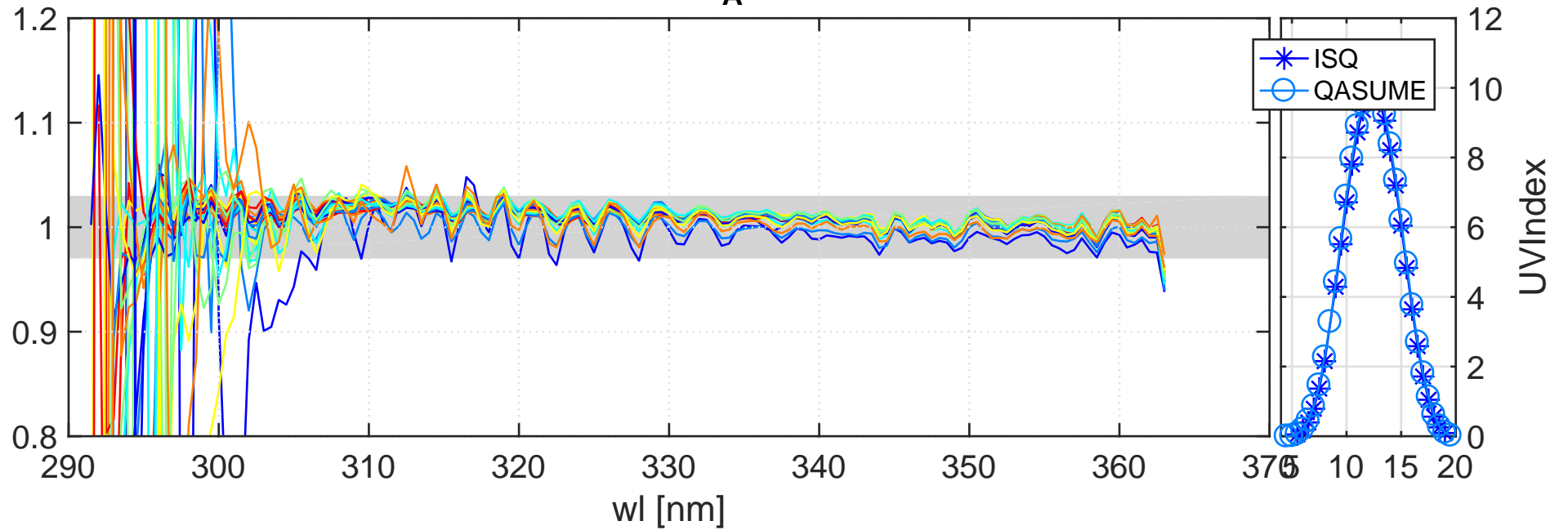
Global irradiance ratios ISQ/QASUME at El_A renosillo-matshic:05-Jun-2017(156)



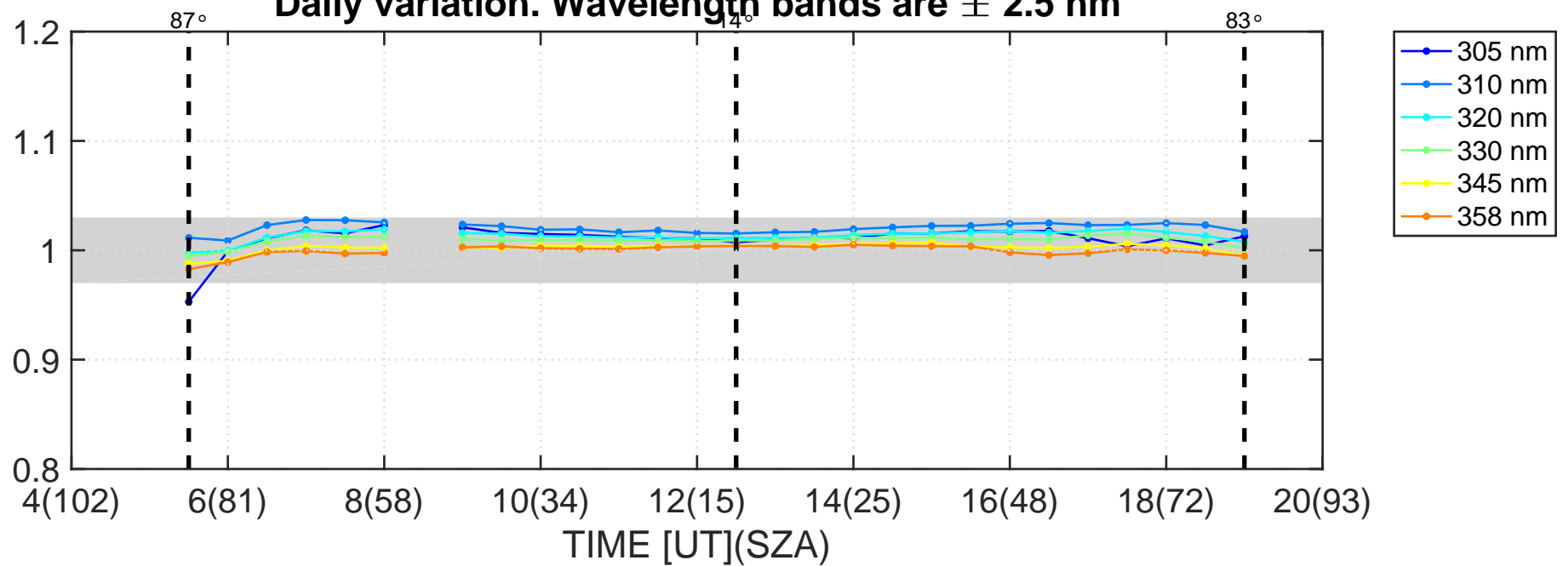
Daily variation. Wavelength bands are ± 2.5 nm



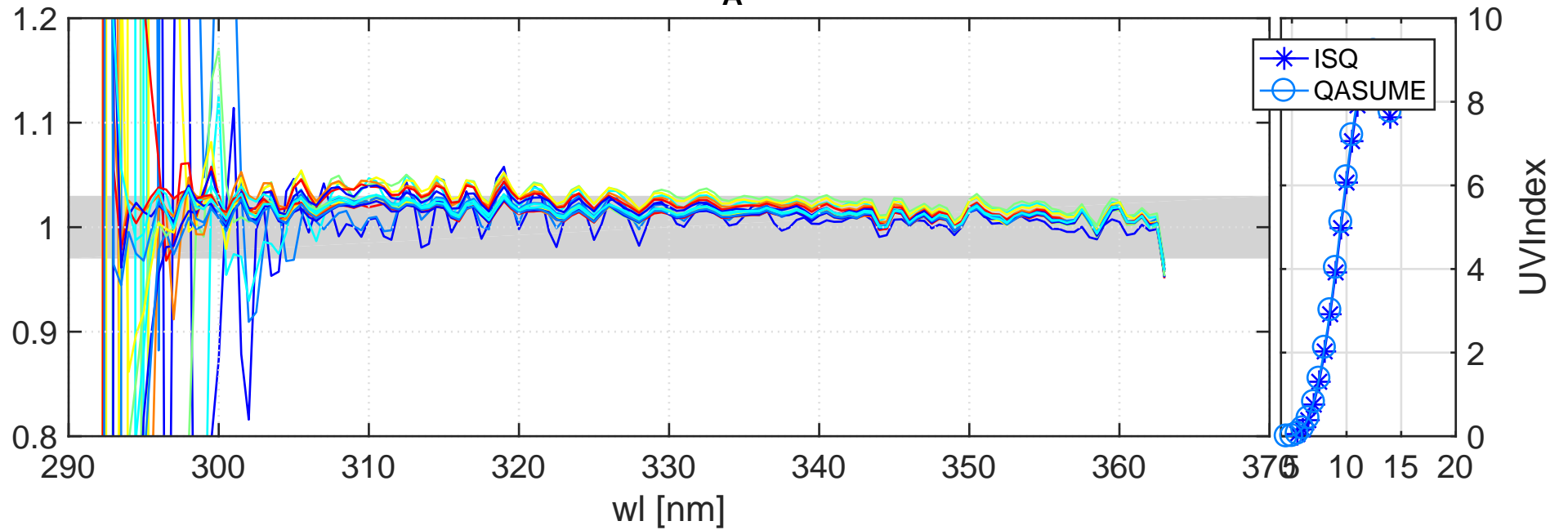
Global irradiance ratios ISQ/QASUME at El_A renosillo-matshic:06-Jun-2017(157)



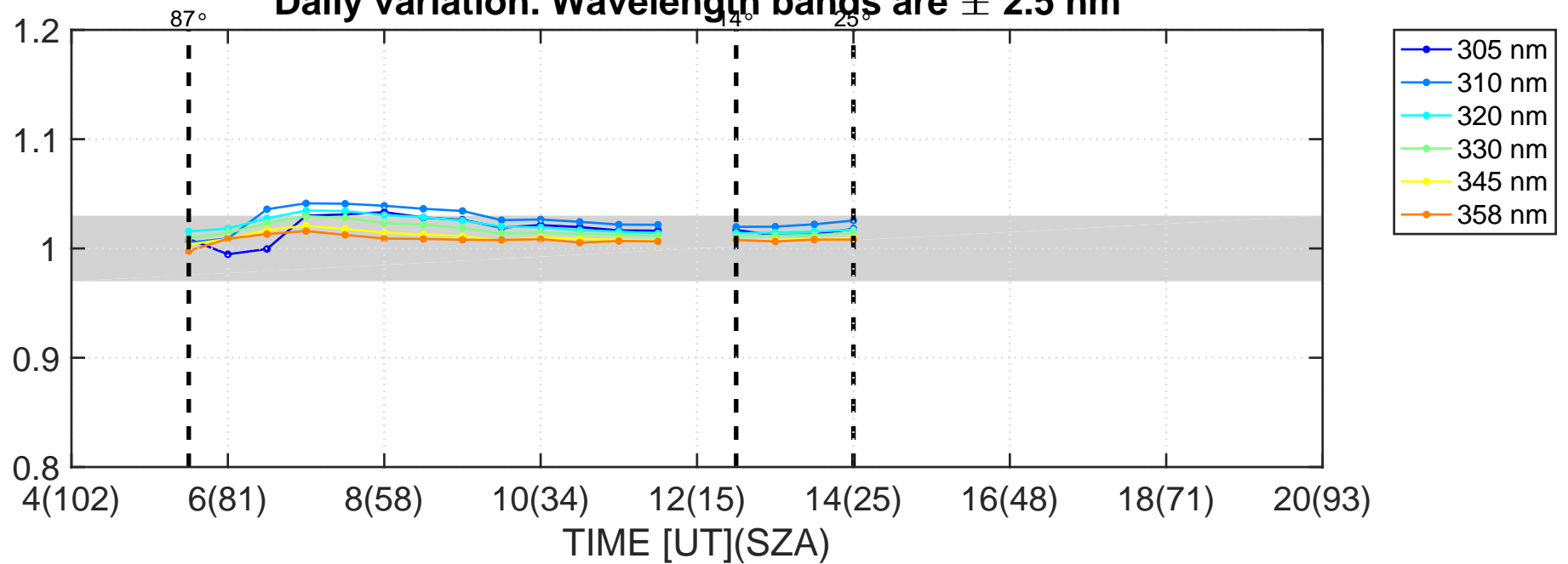
Daily variation. Wavelength bands are ± 2.5 nm



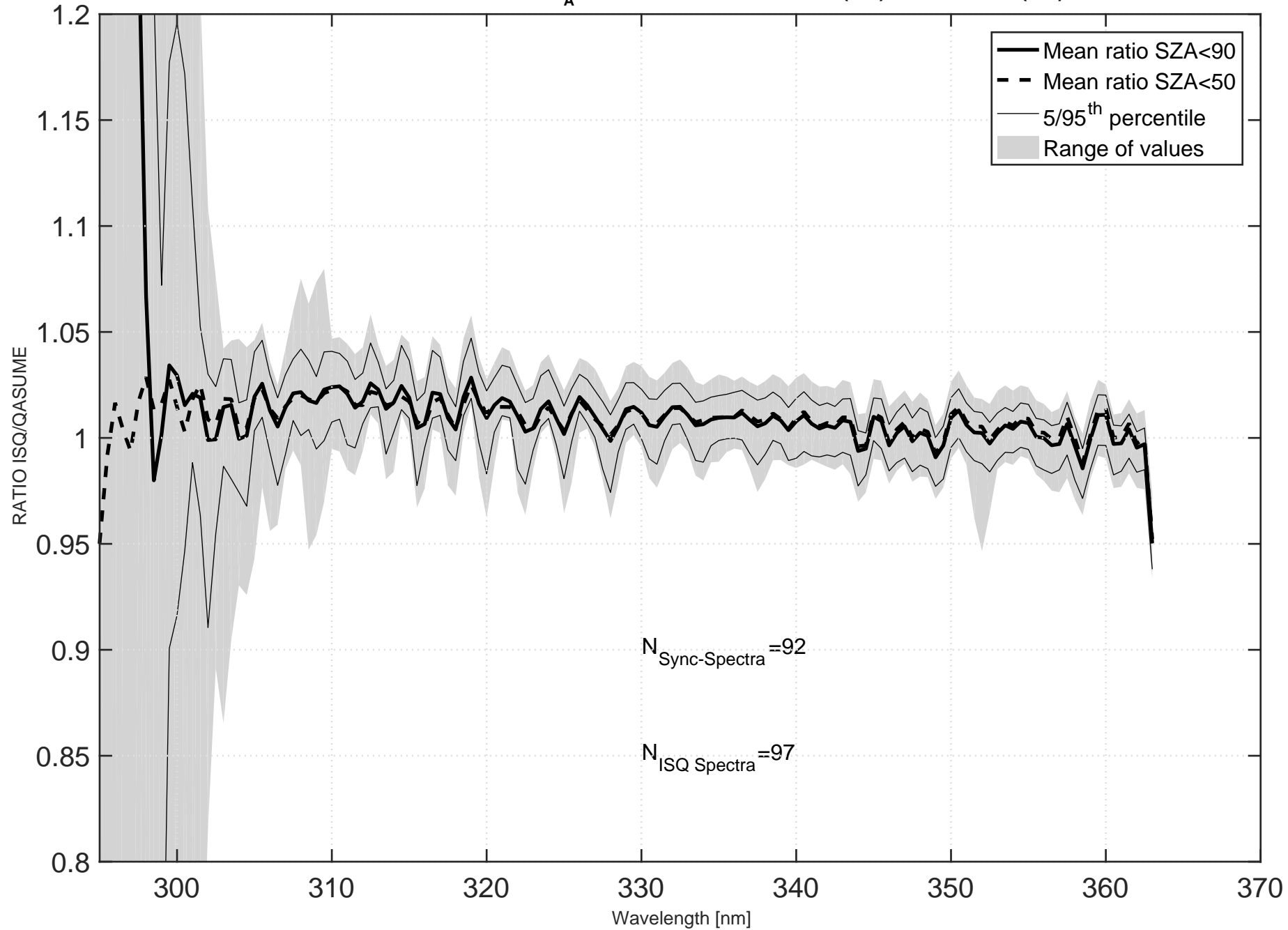
Global irradiance ratios ISQ/QASUME at El_A renosillo-matshic:07-Jun-2017(158)



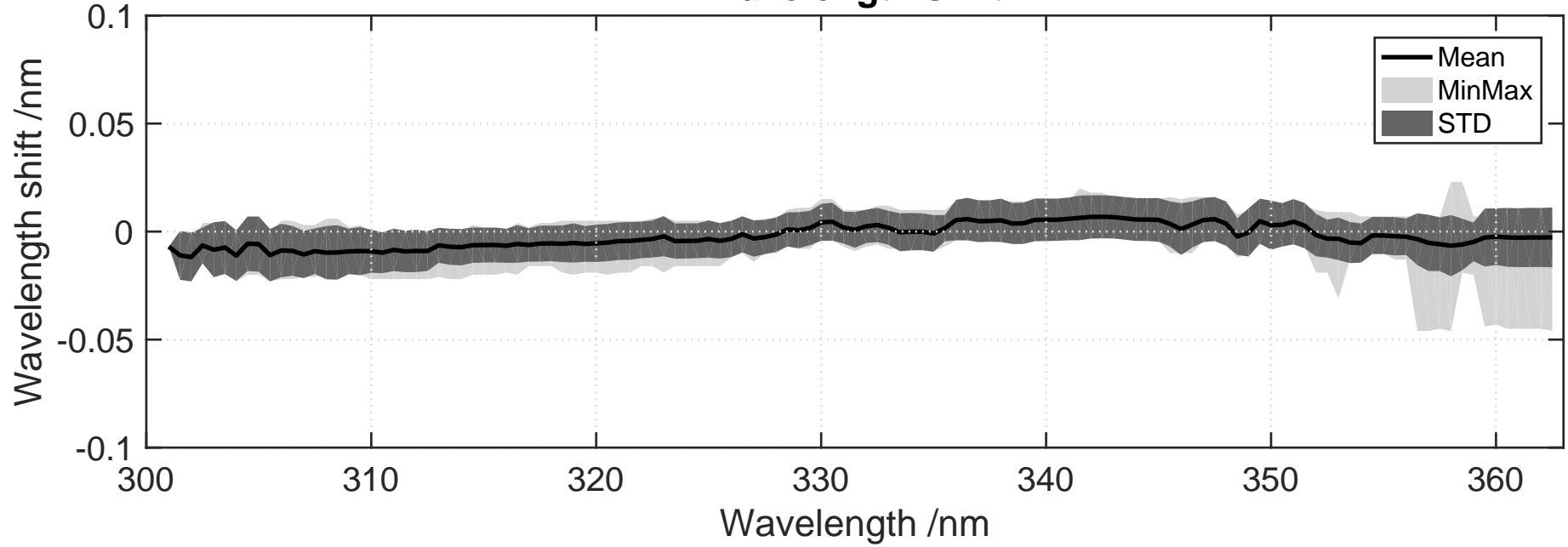
Daily variation. Wavelength bands are ± 2.5 nm



Mean ratio ISQ/QASUME at E_A renosillo-matshic:04-Jun-2017(155) to 07-Jun-2017(158)



Wavelength shift



WL=330.00 nm

