

■ ECMWF Report on ERS-2 SAR for September 2004 ■

Title: Report on ERS-2 SAR wave height data.

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Overview:

On average, about 44 SAR wave mode spectra arrived at ECMWF every 6 hours of which 5.3% have been rejected (the data coverage has been reduced to around 12% of the nominal data reception following the failure of the ERS-2 tape recorders in June 2003). As can be seen in Figure 1, there were two time windows with missing data which are: 00:00 and 06:00 UTC on the 24th. of the month. There were few other time windows with significant reduction of data reception as well.

The quality of the received data, which are now limited to the **North Atlantic and the western coast of North America**, is as good as usual.

Wave Height Comparison (bias):

ERS-2 global: 0.070 m

ERS-2 northern hemisphere: 0.071 m

ERS-2 tropics: 0.061 m

ERS-2 southern hemisphere: *missing*



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Remarks:

- The SAR worked normally this month.
- The high wave height bias values in the tropics during several days (especially between 28 and 30 September) as can be seen in Figure 6 can be attributed to the hurricanes which were active during this month. ECMWF atmospheric model with its current resolution and numerics can not resolve such low scale features accurately and therefore the model wind speeds in the hurricanes are not predicted correctly. Being driven by the model wind speed fields, the model wave heights are affected as a result. Keeping in mind the current limited coverage of ERS-2 which resulted in less than 20 altimeter-model collocations each day in the tropics, the impact of any model prediction problem in those limited collection would be significant.
- According to ESA (EOHelp message of 4 July 2003), the recording capabilities of ERS-2 are declared permanently unavailable following the failure of the ERS-2 tape recorder on 22 June 2003. The ERS-2 tape recorders were used to record the ERS-2 Low Rate mission globally for a period of 8 years of continuous acquisition. The global coverage is, therefore, discontinued. The ERS-2 Low Rate mission will be continued within the visibility of ESA ground stations over Europe, North Atlantic, the Arctic and western North America. ESA has the intention to extend the coverage of the Real Time Low Rate acquisition over the North Atlantic in the near future.
- ERS-2 SAR data and ENVISAT RA-2 Ku-band significant wave heights are assimilated in the ECMWF wave model.
- The ECMWF atmospheric and wave models were changed to CY28R3 on the 28th. of September 2004. The relevant change was in the model set-up to allow the proper propagation of the wave analyses information at time windows 06:00 and 18:00 to model to next time windows.



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Definitions:

Four new integrated parameters are used to compare the SAR and the model spectra. These parameters are:

1. The mean wave period based on the ‘-1th.’ moment (m_{-1}) defined as:

$$T_{-1} = m_{-1} / m_0$$

where m_0 and m_{-1} are the zeroth and the ‘-1th.’ moments of the wave spectrum with the n -th. moment, in general, is defined as:

$$m_n = \int d\theta \int df \cdot f^n \cdot F(f, \theta)$$

F is the wave spectrum in frequency, f , - direction space. The comparison between ECMWF model and SAR mean wave periods for the whole month is given in Figure 7.

2. The wave directional spread defined as:

$$\sigma = \sqrt{2[1 - r_1(f)]}$$

$$r_1(f) = \int df \int d\theta \cdot F(f, \theta) \cdot \cos[\theta - \varphi(f)]$$

$$\varphi(f) = \text{atan} \left\{ \left[\int d\theta \cdot F(f, \theta) \cdot \sin(\theta) \right] / \left[\int d\theta \cdot F(f, \theta) \cdot \cos(\theta) \right] \right\}$$

The comparison between ECMWF model and SAR wave directional spread values for the whole month is given in Figure 8.



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3. The mean wave propagation direction defined as:

$$\phi = \text{atan} \left\{ \left[\int df \int d\theta \cdot F(f, \theta) \cdot \sin(\theta) \right] / \left[\int df \int d\theta \cdot F(f, \theta) \cdot \cos(\theta) \right] \right\}$$

The comparison between ECMWF model and SAR mean wave propagation directions for the whole month is given in Figure 9.

4. The spectral peakedness parameter of Goda (Q_p) defined as:

$$Q_p = 2m_0^{-2} \int d\theta \int df \cdot f \cdot F^2(f, \theta)$$

The comparison between ECMWF model and SAR spectral peakedness (or roughly, spectral narrowness) values for the whole month is given in Figure 10.

Figure captions:

Figure 1: Time series of data reception for ERS-2 Altimeter data for September 2004.

Figure 2: Comparison of ECMWF wave height results with ERS-2 SAR wave height data for September 2004 (global).

Figure 3: Comparison of ECMWF wave height results with ERS-2 SAR wave height data for September 2004 (northern hemisphere)

Figure 4: Comparison of ECMWF wave height results with ERS-2 SAR wave height data for September 2004 (tropics)

Figure 5: Comparison of ECMWF wave height results with ERS-2 SAR wave height data for September 2004 (southern hemisphere)

Figure 6: ERS-2 SAR wave heights: Timeseries of bias (ERS-2 - model) and scatter index (SI).

Figure 7: Comparison of ECMWF mean wave periods with ERS-2 SAR mean wave periods for September 2004 (global).

Figure 8: Comparison of ECMWF wave directional spread with that of ERS-2 SAR for September 2004 (global).



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Figure 9: Comparison of ECMWF mean wave directions with those of ERS-2 SAR for September 2004 (global).

Figure 10: Comparison of ECMWF wave peakedness factor with that of ERS-2 SAR for September 2004 (global).

Figure 11: ERS-2 SAR wave heights: Timeseries of daily bias (ERS-2 - model) for the past year.

Figure 12: ERS-2 SAR wave heights: Timeseries of daily root mean square difference (RMSE) for the past year.

Figure 13: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for September 2004 (global).

Figure 14: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for September 2004 (n. hem.).

Figure 15: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for September 2004 (tropics).



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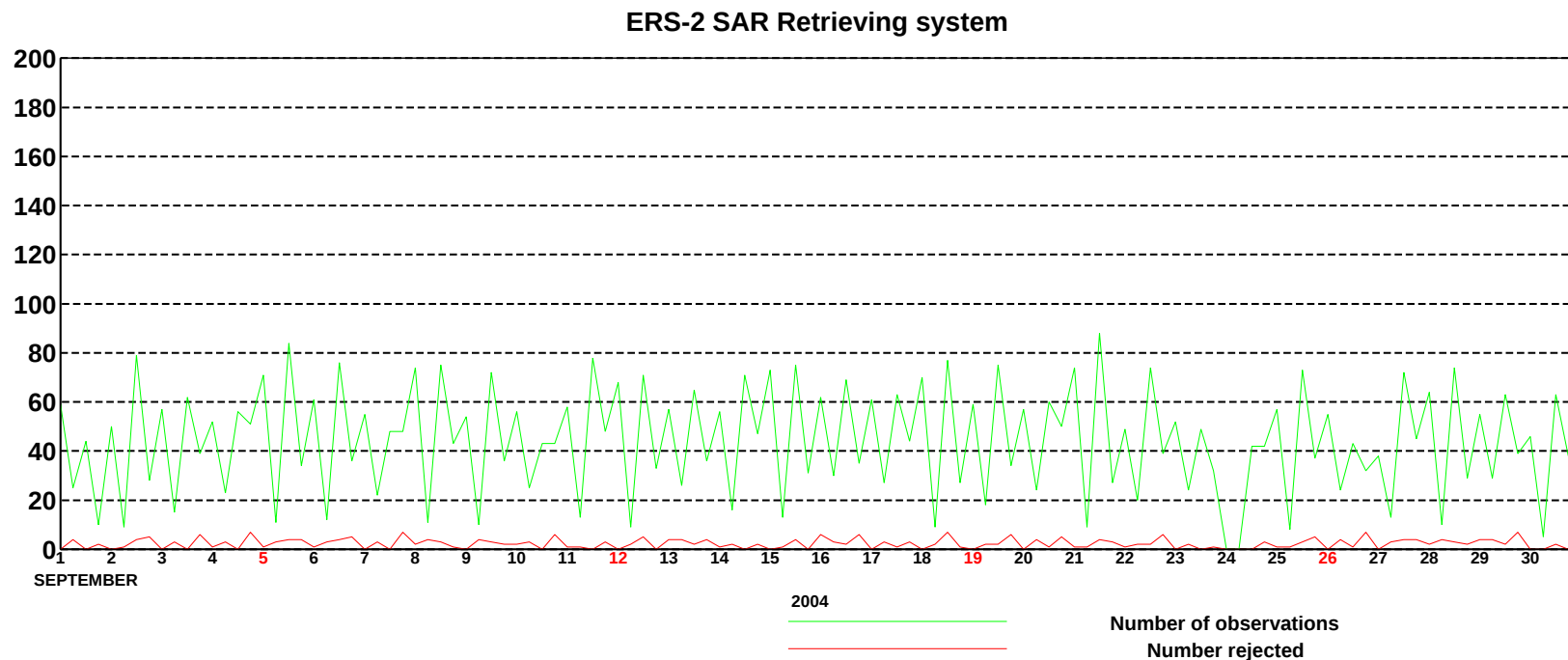


Figure 1: Time series of data reception for ERS-2 SAR wave mode spectra for September 2004

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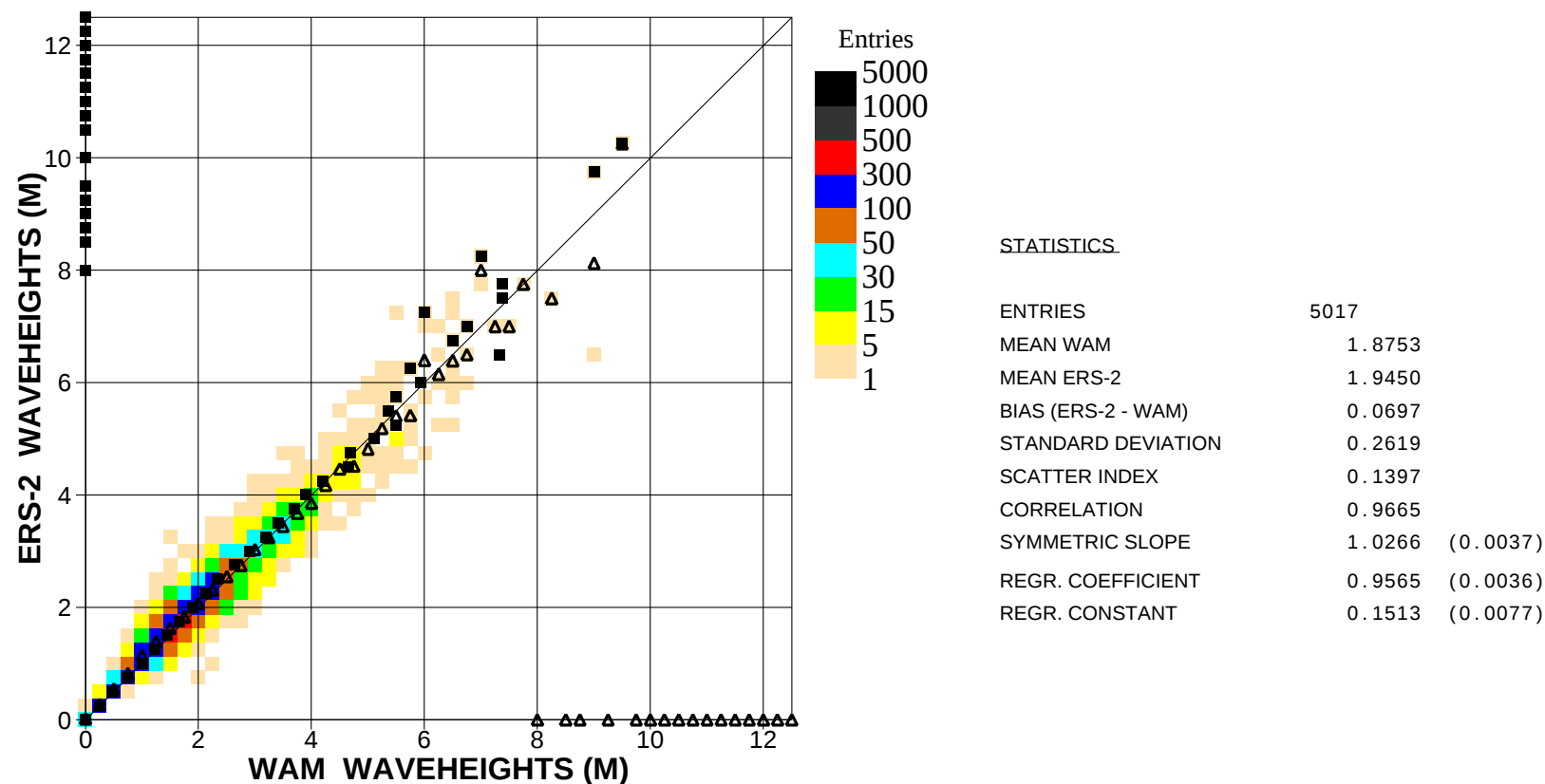


Figure 2: Comparison of ECMWF wave height results with ERS2 SAR wave height data for September 2004 (global)

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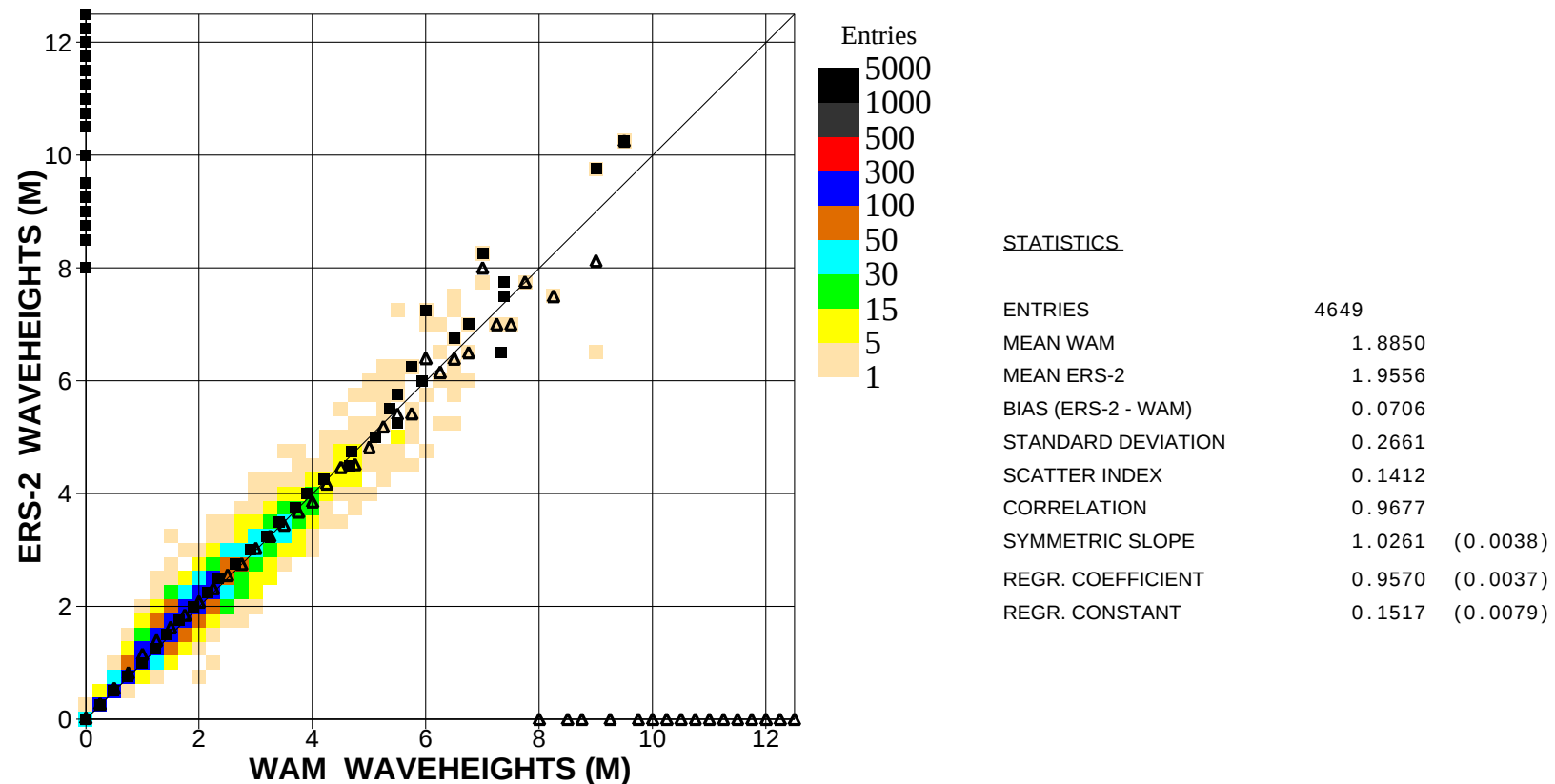


Figure 3: Comparison of ECMWF wave height results with ERS2 SAR wave height data for September 2004 (n.hem.)

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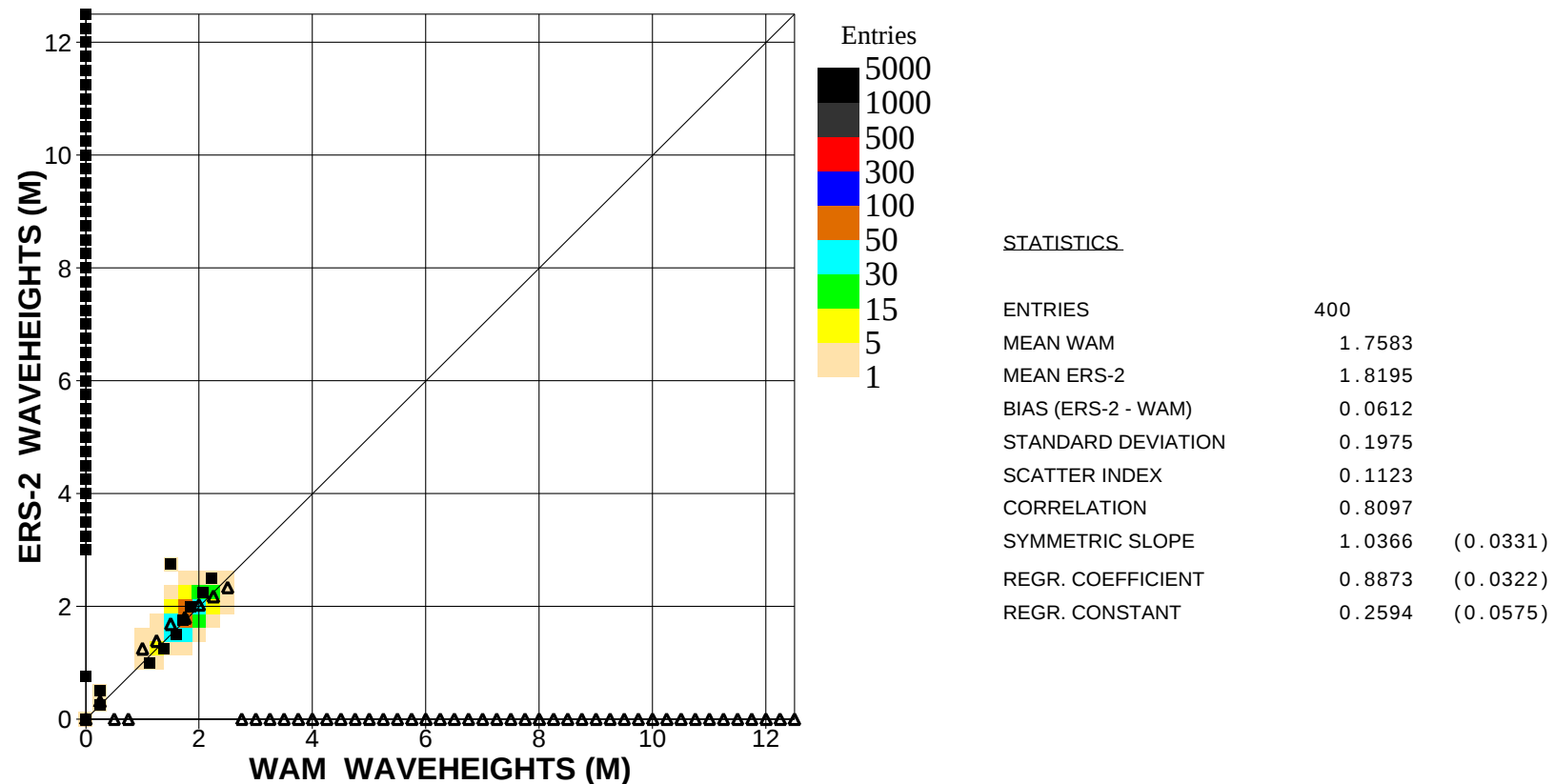


Figure 4: Comparison of ECMWF wave height results with ERS2 SAR wave height data for September 2004 (tropics)

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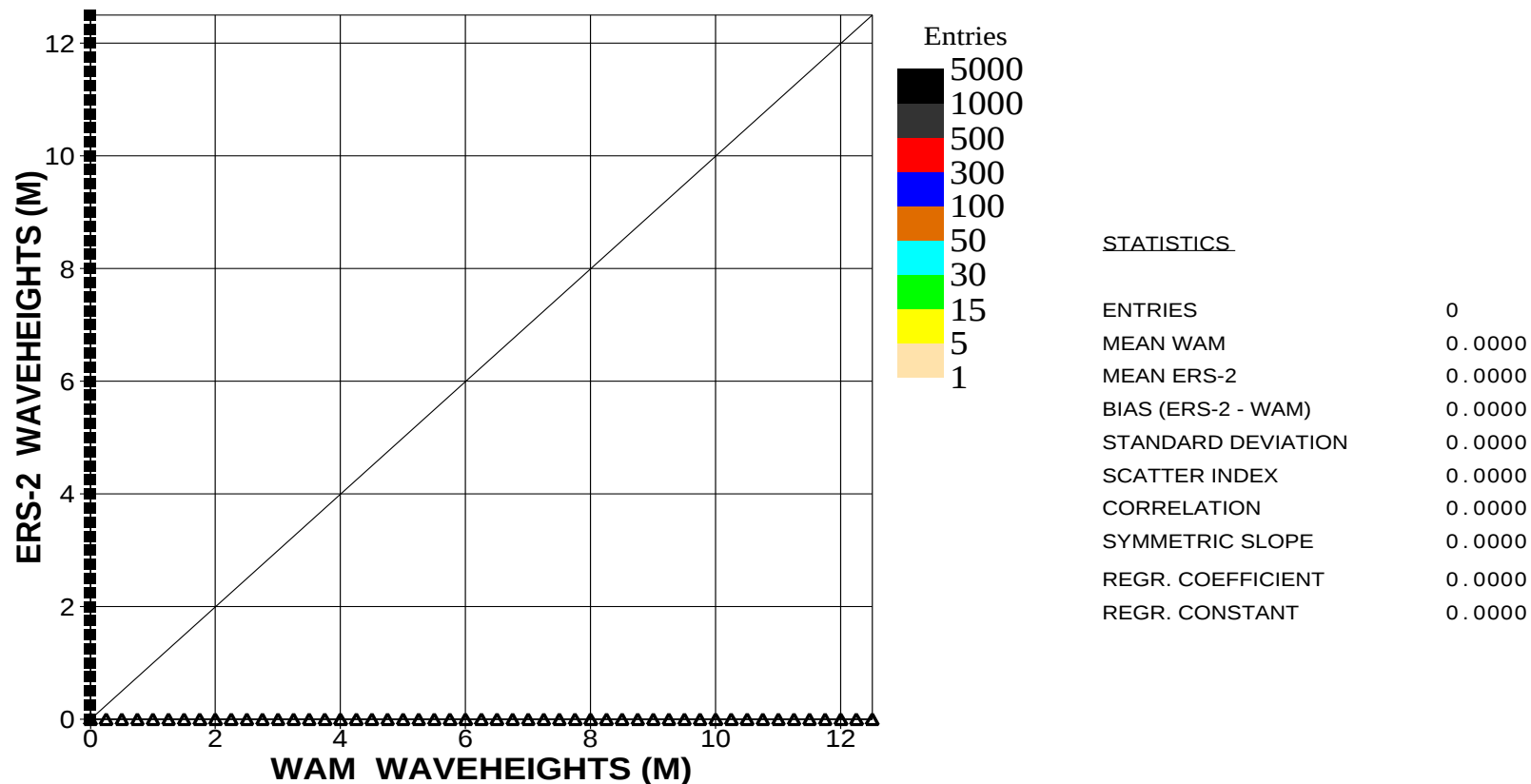


Figure 5: Comparison of ECMWF wave height results with ERS2 SAR wave height data for September 2004 (s.hem.)



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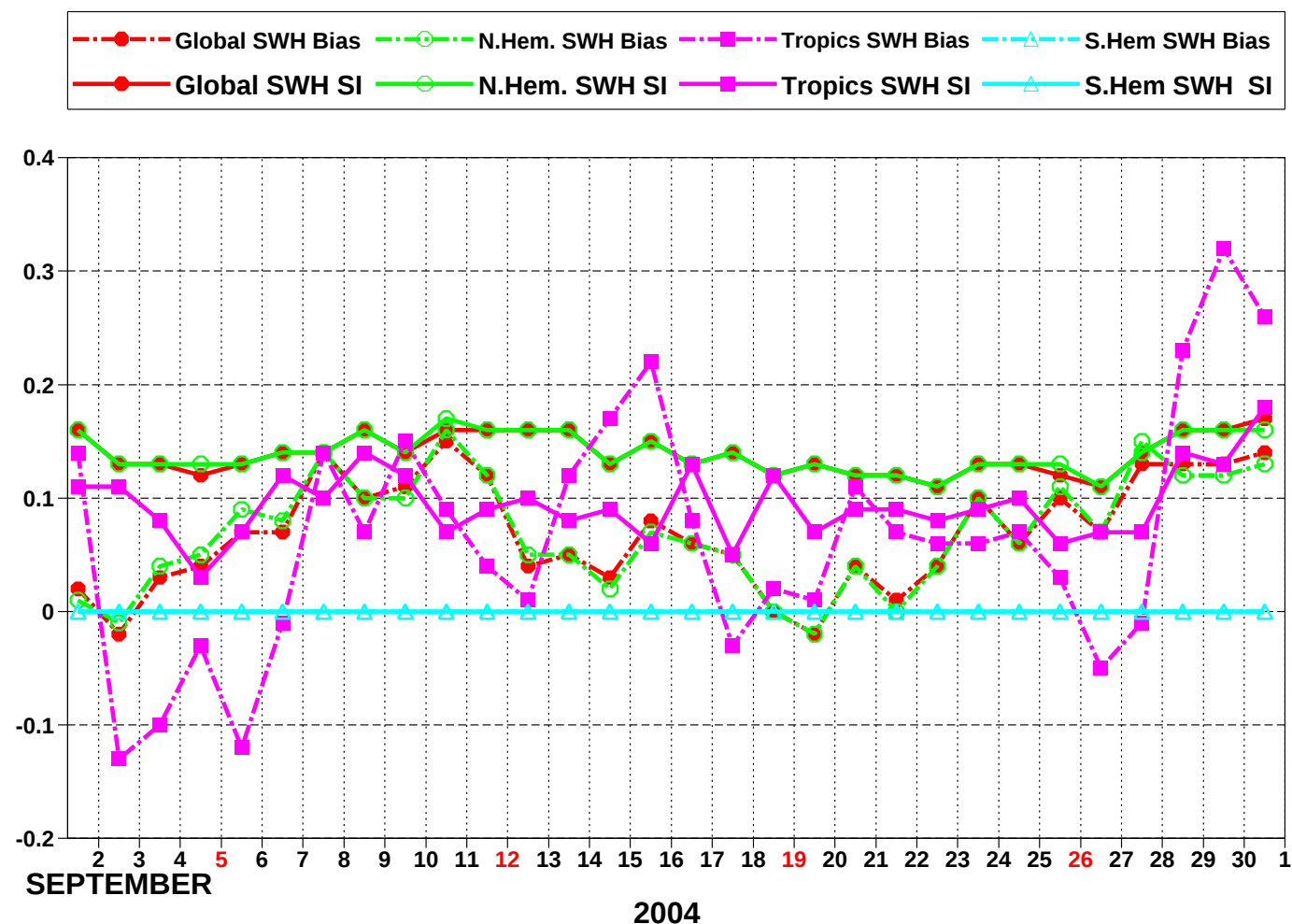


Figure 6: ERS-2 SAR wave heights: Timeseries of bias (ERS-2 - model) and scatter index (SI)

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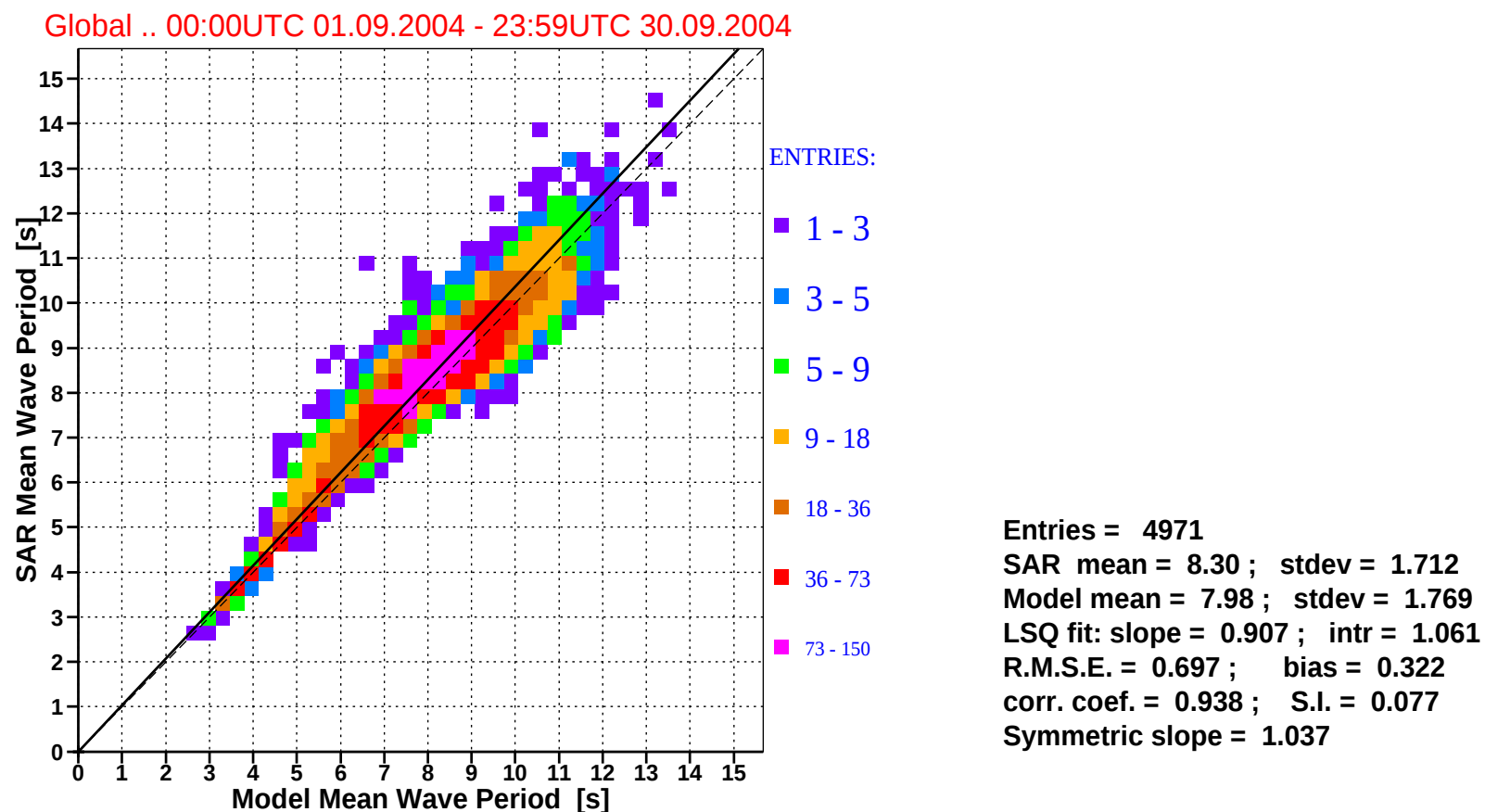


Figure 7: Comparison of ECMWF mean wave periods with ERS-2 SAR mean wave periods for september 2004 (global).

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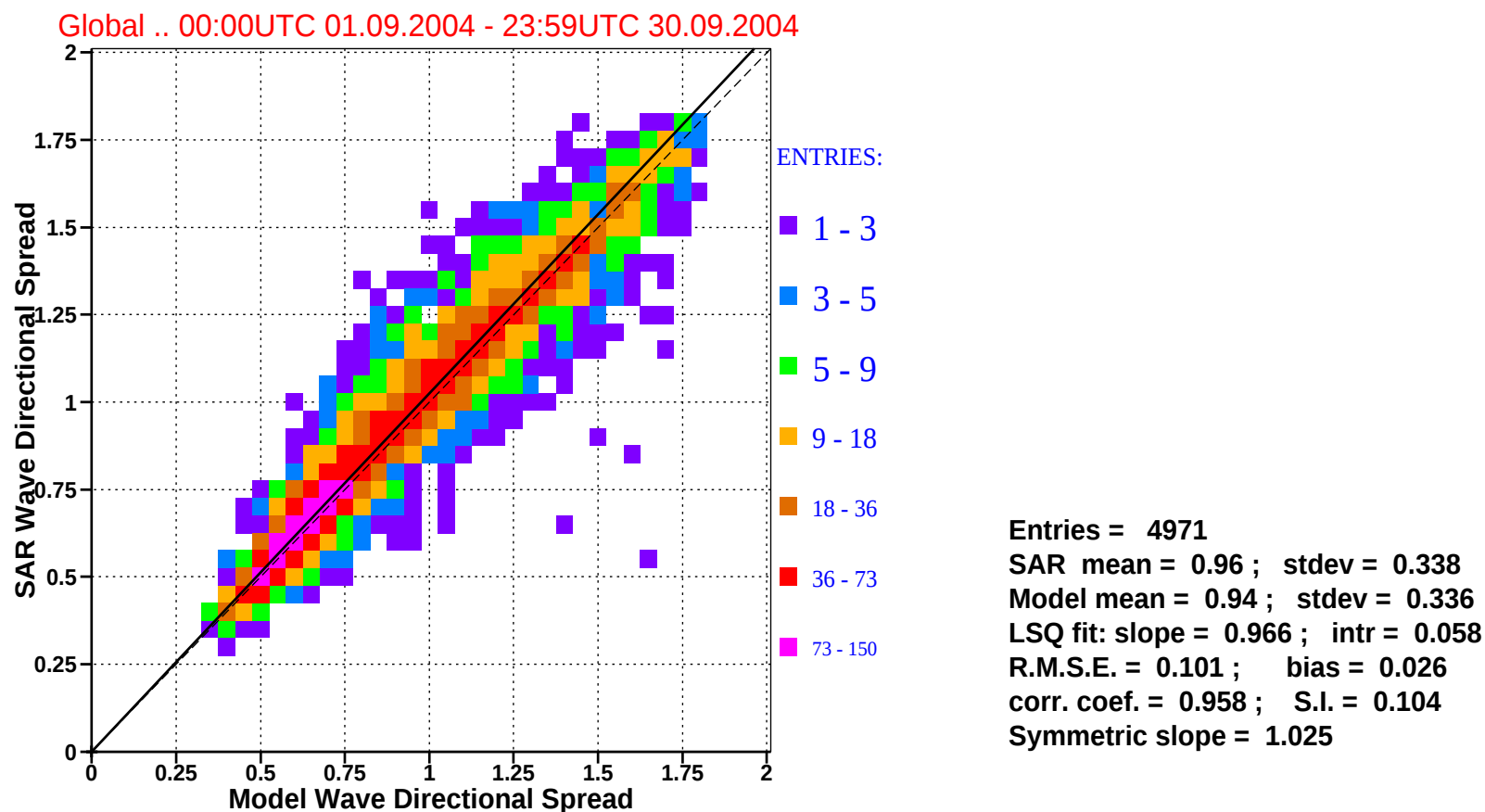


Figure 8: Comparison of ECMWF wave directional spread with that of ERS-2 SAR for september 2004 (global).

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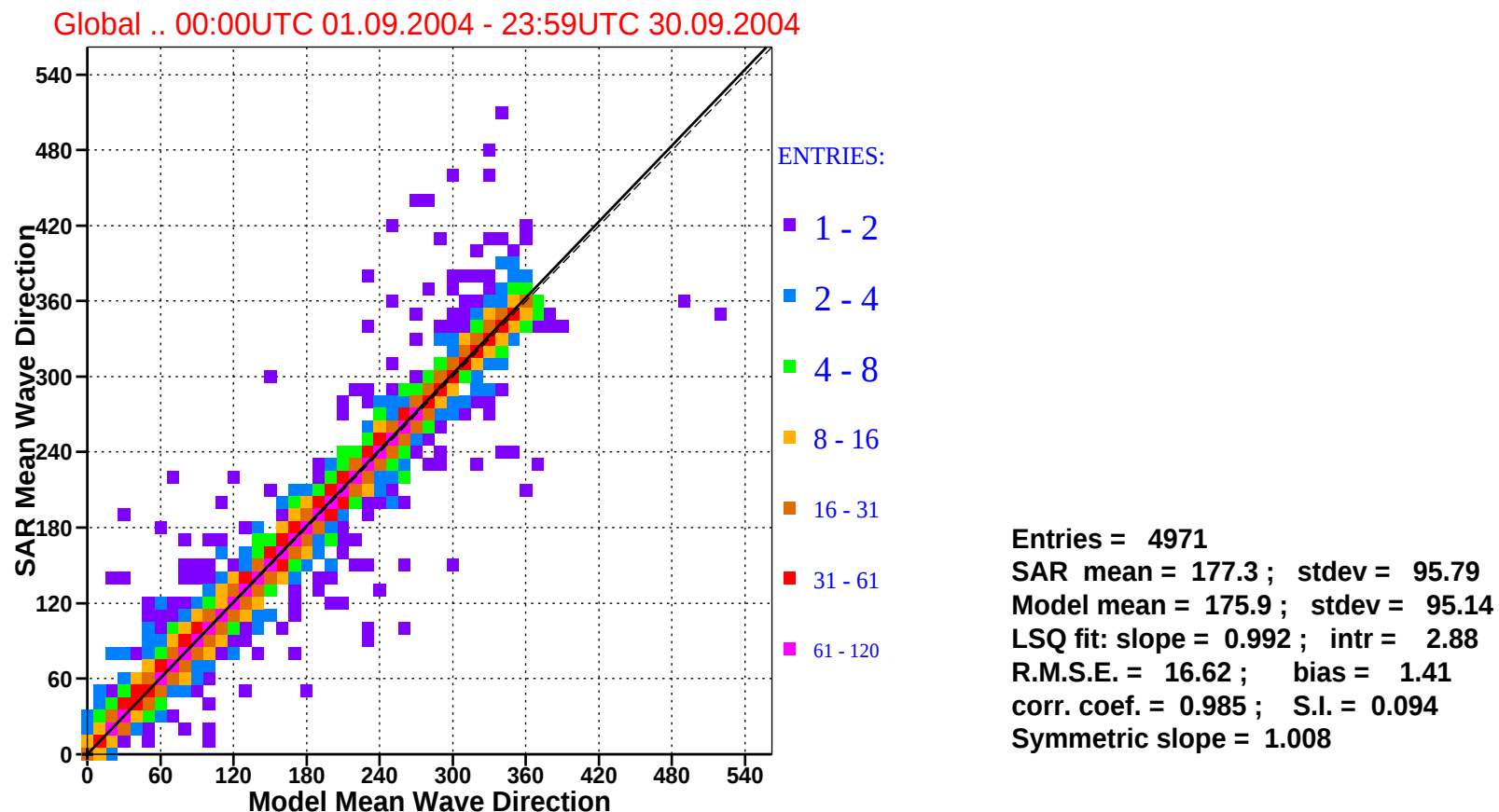


Figure 9: Comparison of ECMWF mean wave directions with that of ERS-2 SAR for september 2004 (global).



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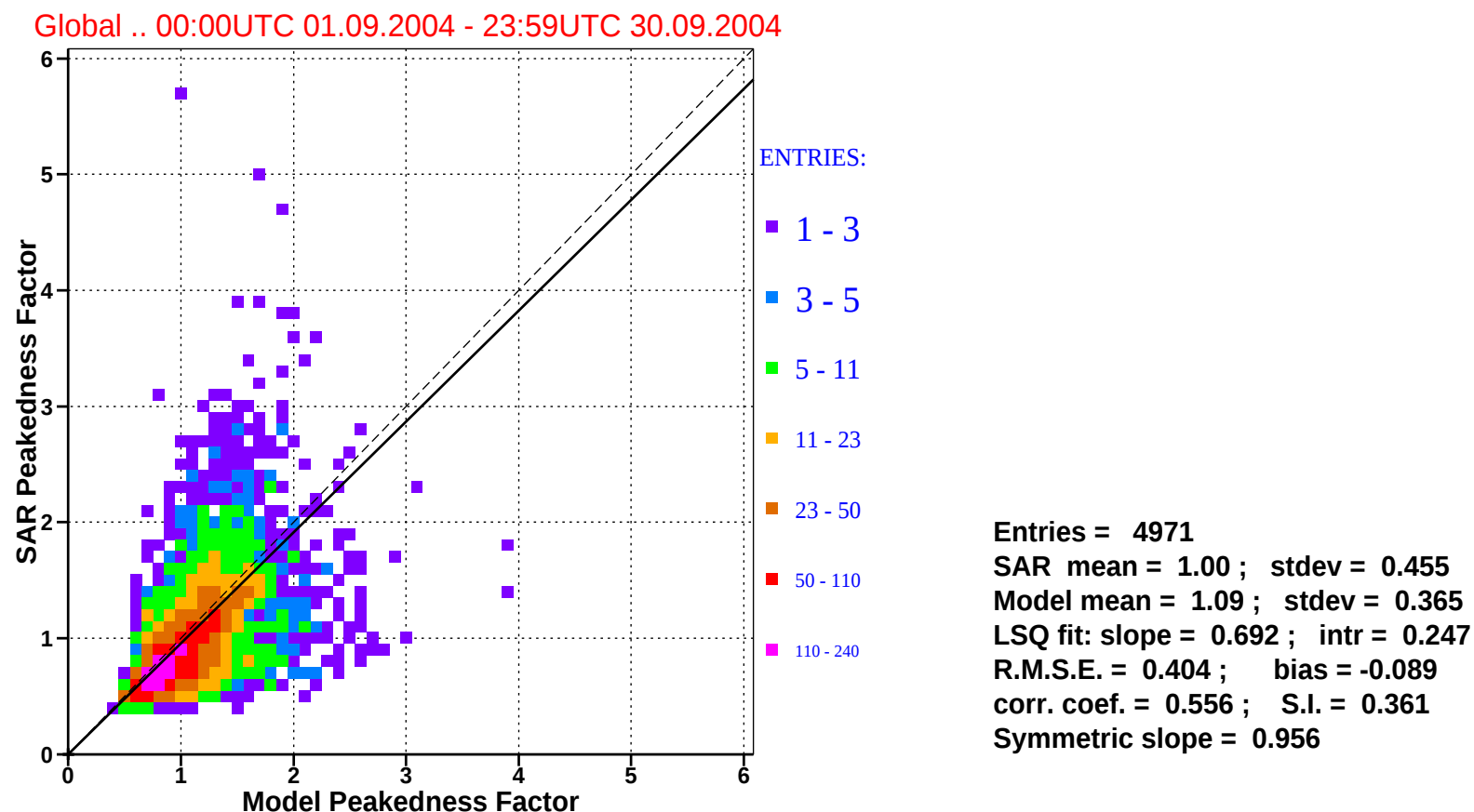


Figure 10: : Comparison of ECMWF wave peakedness factor with that of ERS-2 SAR for september 2004 (global).



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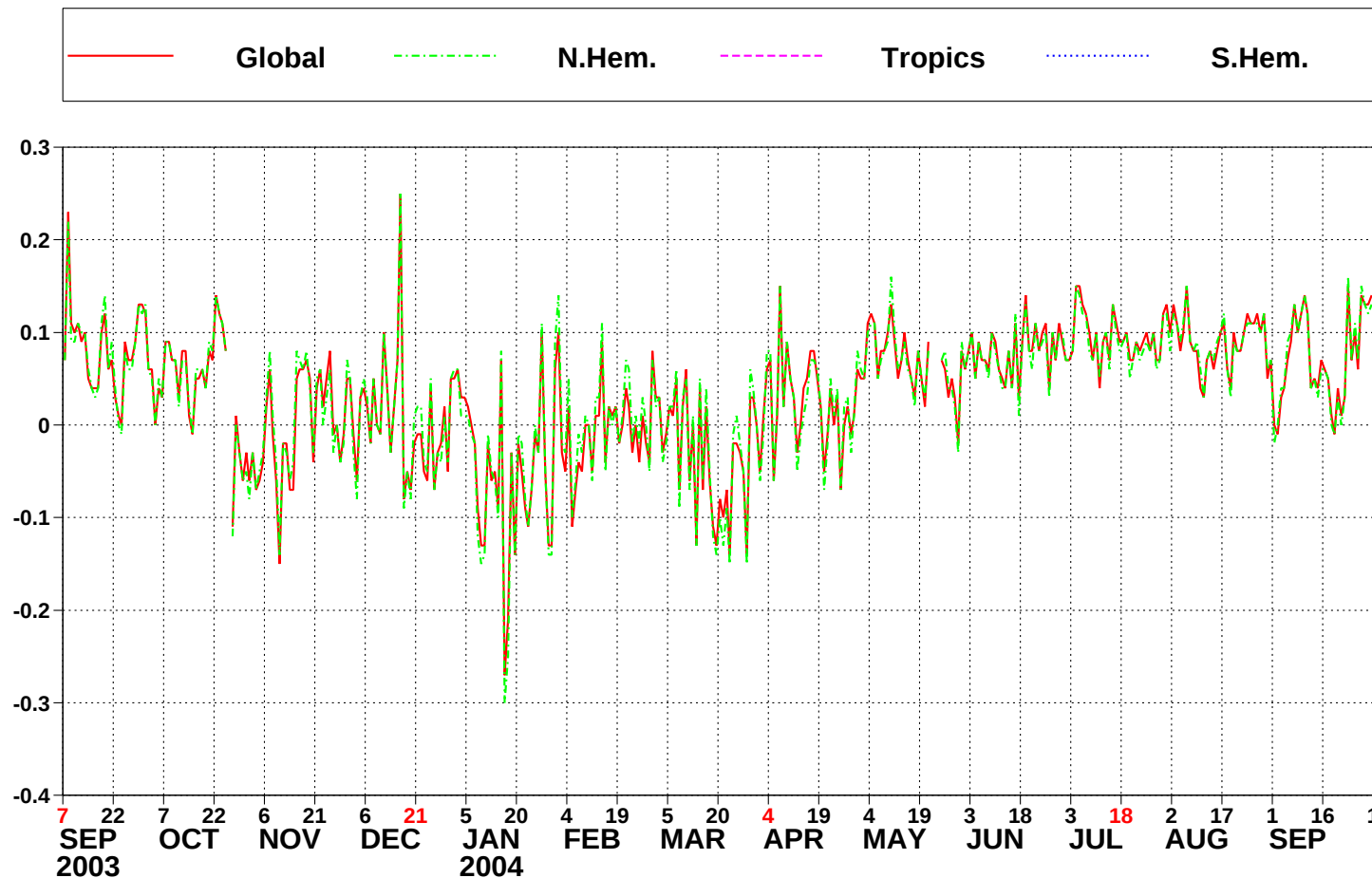


Figure 11: ERS-2 SAR wave heights: Timeseries of daily bias (ERS-2 - model) for the past year.



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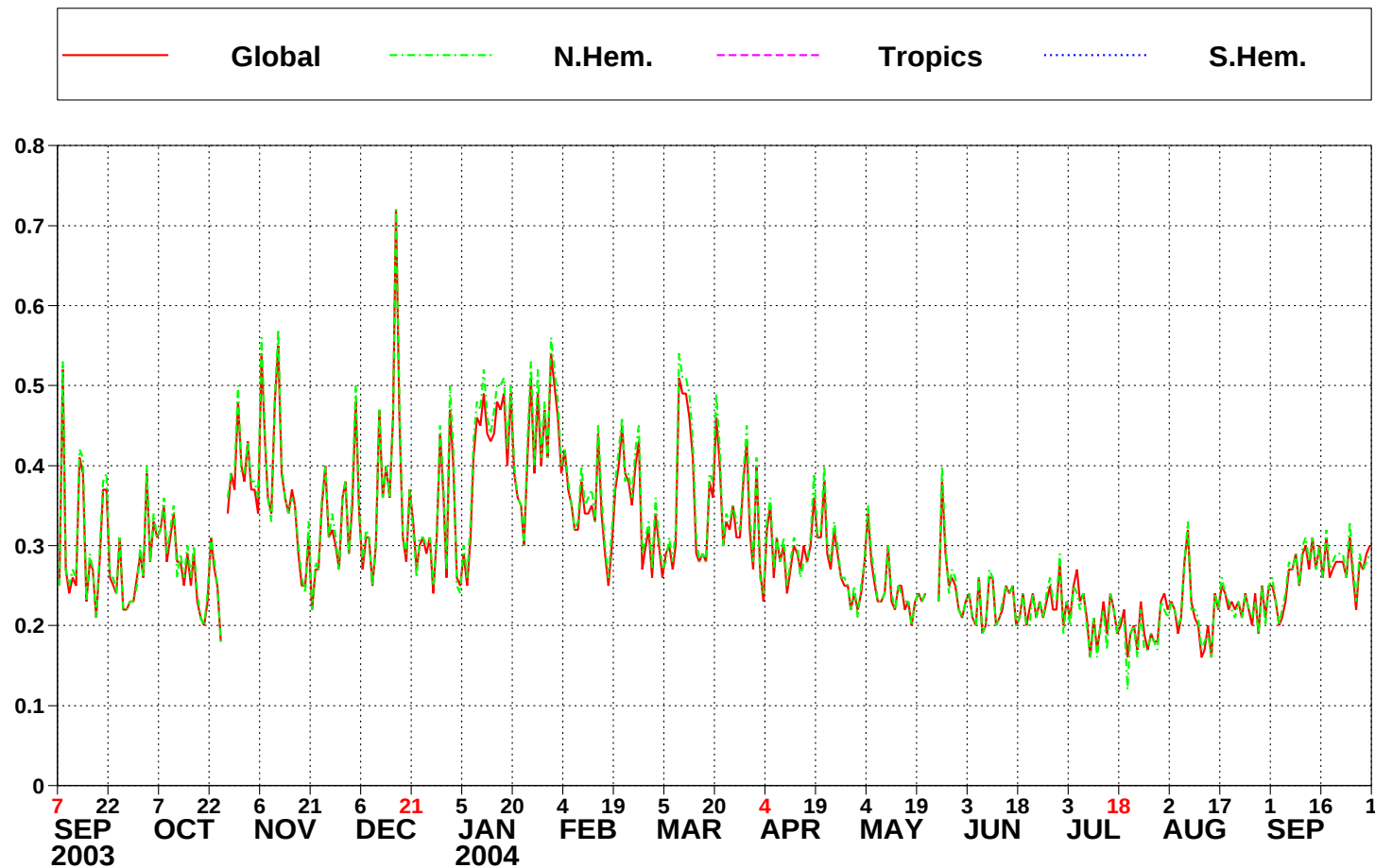


Figure 12: ERS-2 SAR wave heights: Timeseries of daily root mean square difference (RMSE) for the past year.



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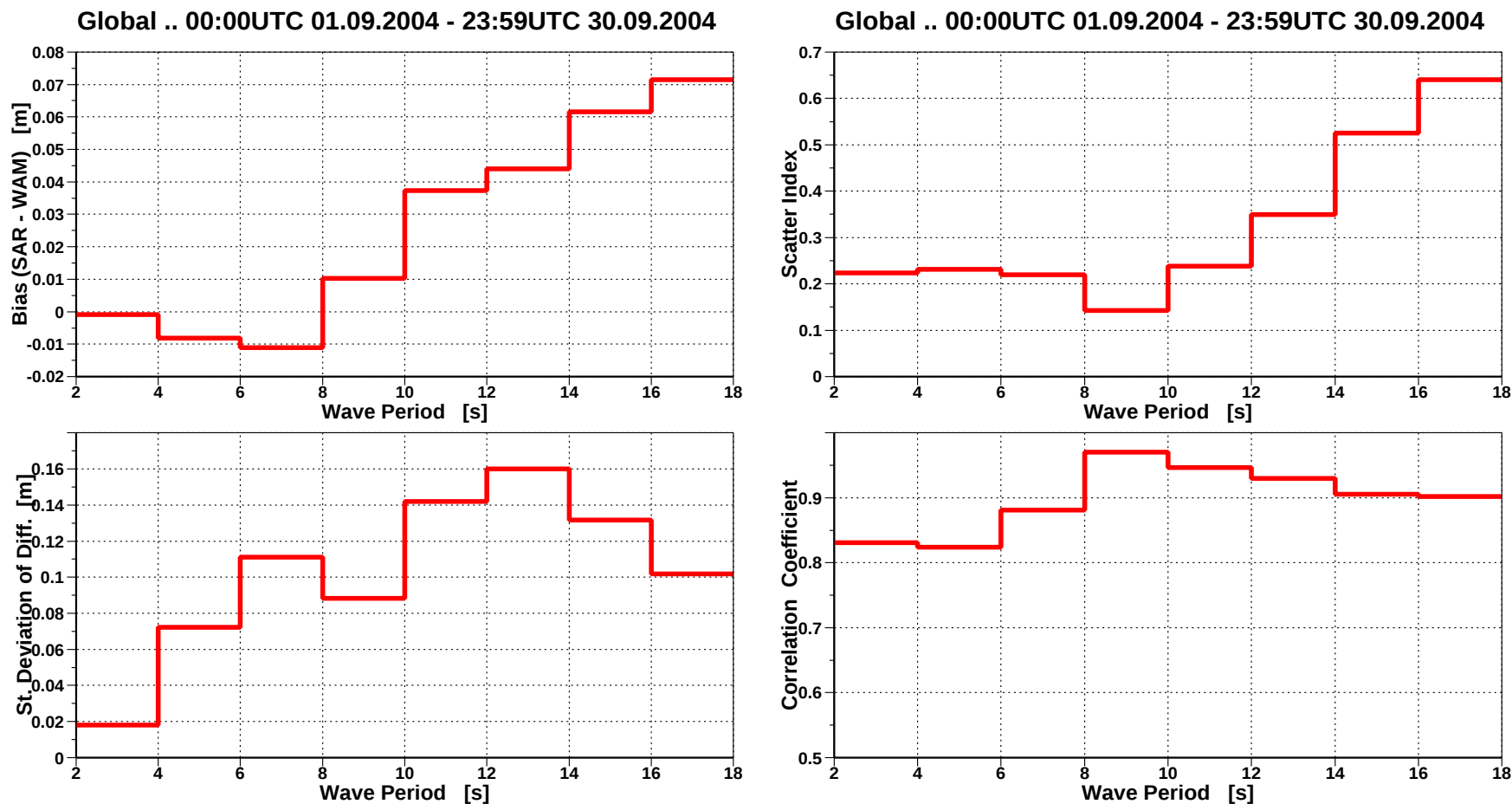


Figure 13: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for September 2004 (global).

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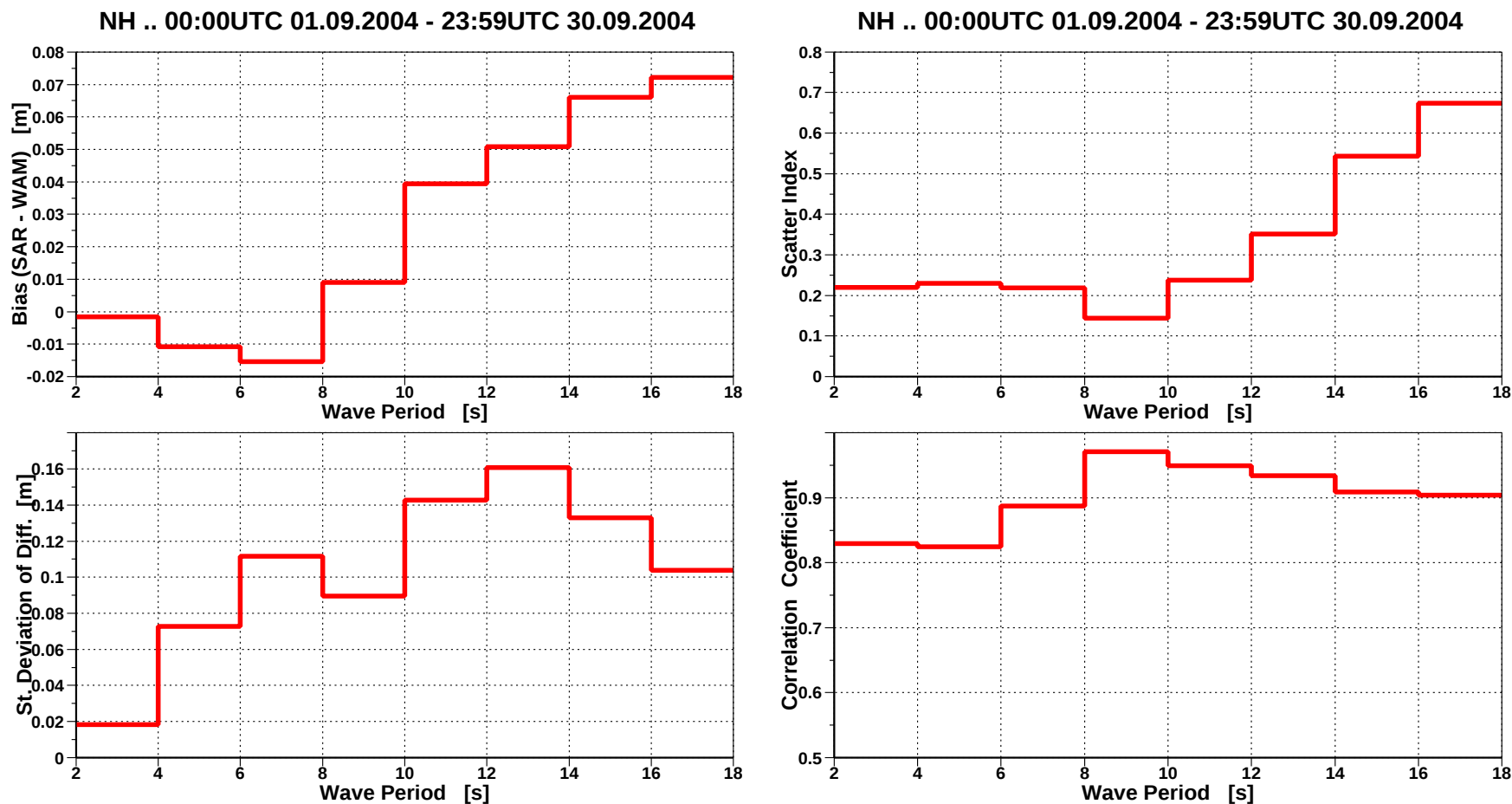


Figure 14: Comparison between SAR and ECMWF "2-second wave-period interval equivalent wave heights" for September 2004 (n.hem.).

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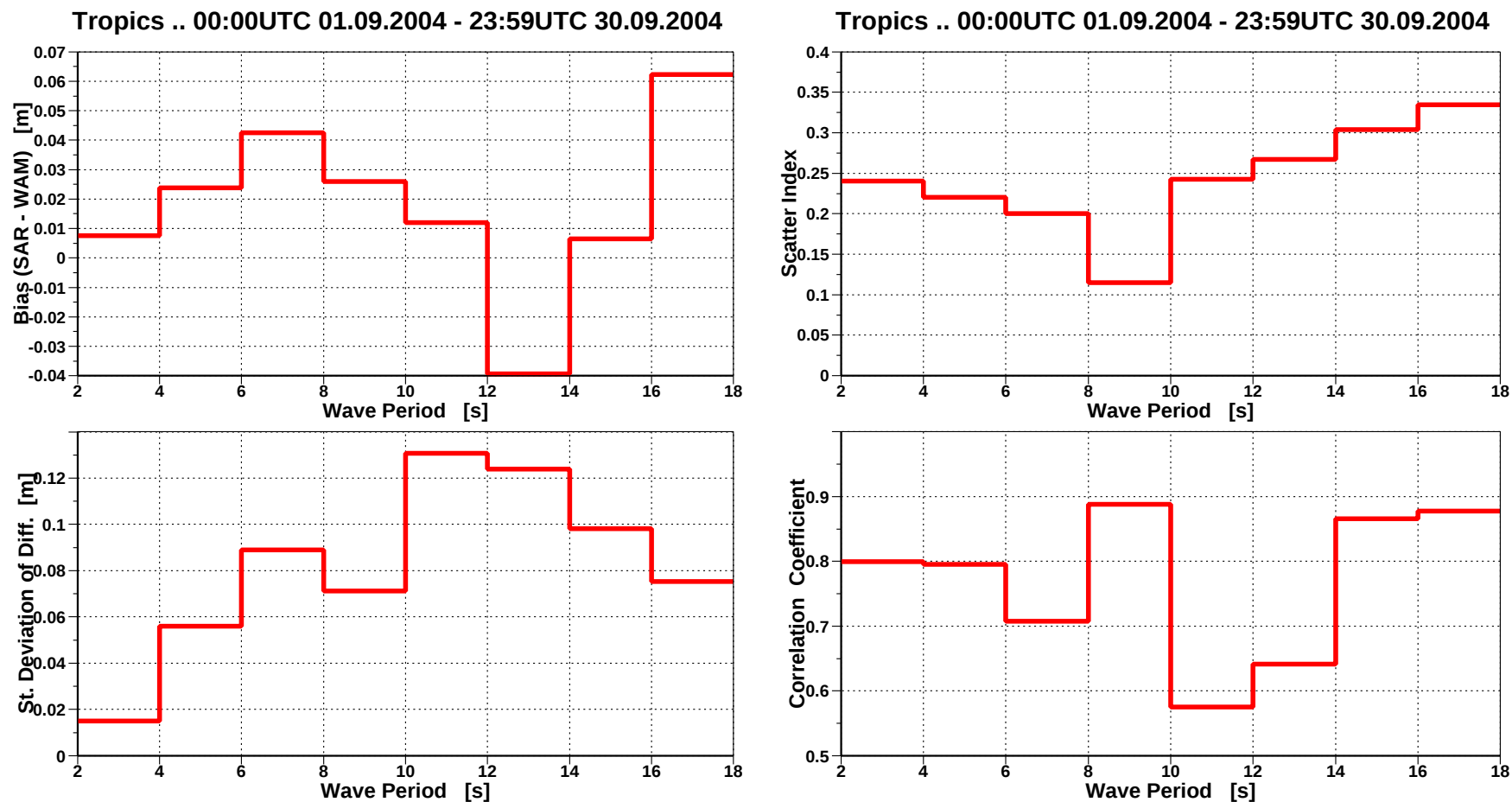


Figure 15: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for September 2004 (tropics).