

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

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

**By:** *Saleh Abdalla*

**Date:** *11 February 2004*

## **Overview:**

On average, about 48 SAR wave mode spectra arrived at ECMWF every 6 hours of which 22.1% have been rejected. The data coverage has been significantly reduced to around 10% of the usual data reception following the failure of the ERS-2 tape recorders. As can be seen in Figure 1, there was no time windows with missing data (apart from significant reduction of data at few time windows).

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: -0.049 m

ERS-2 northern hemisphere: -0.052 m

ERS-2 tropics: -0.029 m

ERS-2 southern hemisphere: *missing*



Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England

Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703

Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: [abdalla@ecmwf.int](mailto:abdalla@ecmwf.int)

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

## Remarks:

- The SAR worked normally this month.
- 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.

## 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:

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



Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England

Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703

Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

$F$  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:

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

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

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

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

3. The mean wave propagation direction defined as:

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

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:

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



# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

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 January 2004.

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

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

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

Figure 5: Comparison of ECMWF wave height results with ERS-2 SAR wave height data for January 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 January 2004 (global).

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

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

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

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

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

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

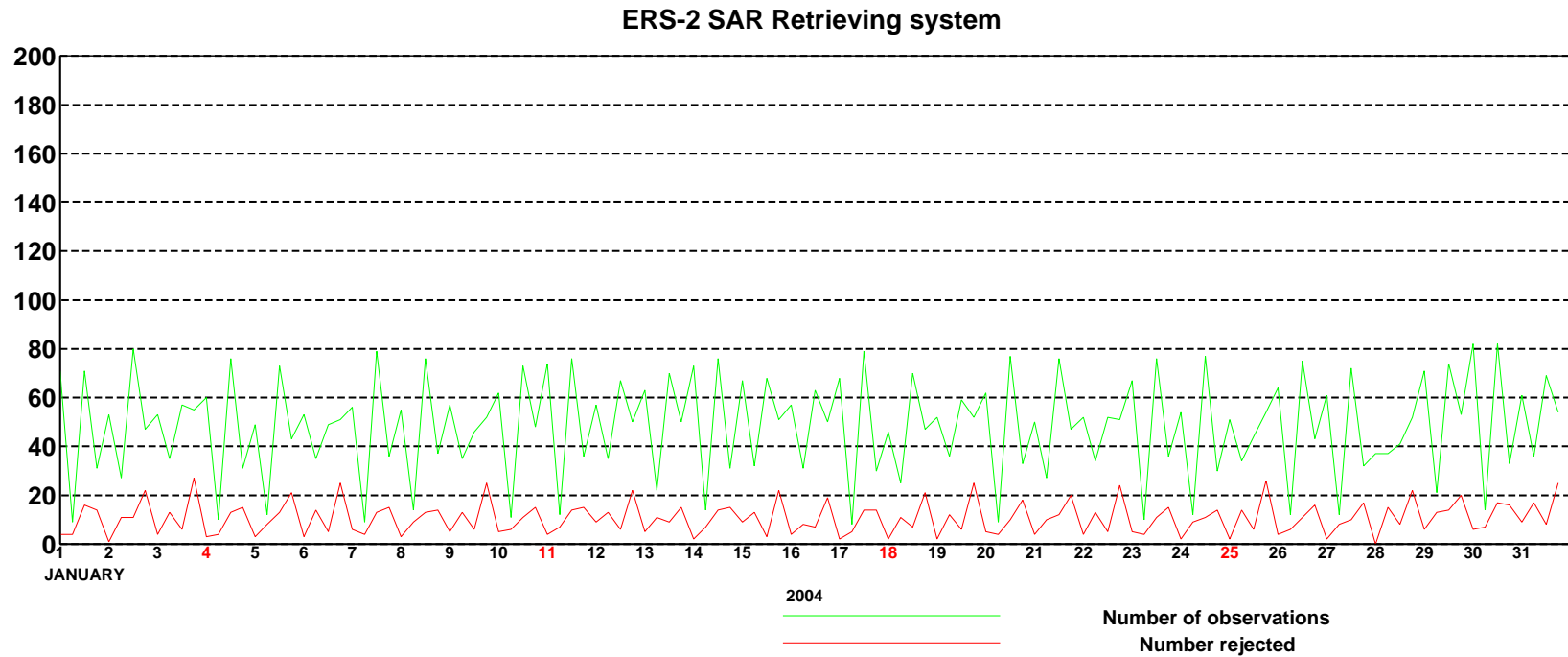


Figure 1: Time series of data reception for ERS-2 SAR wave mode spectra for January 2004

# ECMWF Report on ERS-2 SAR for January 2004

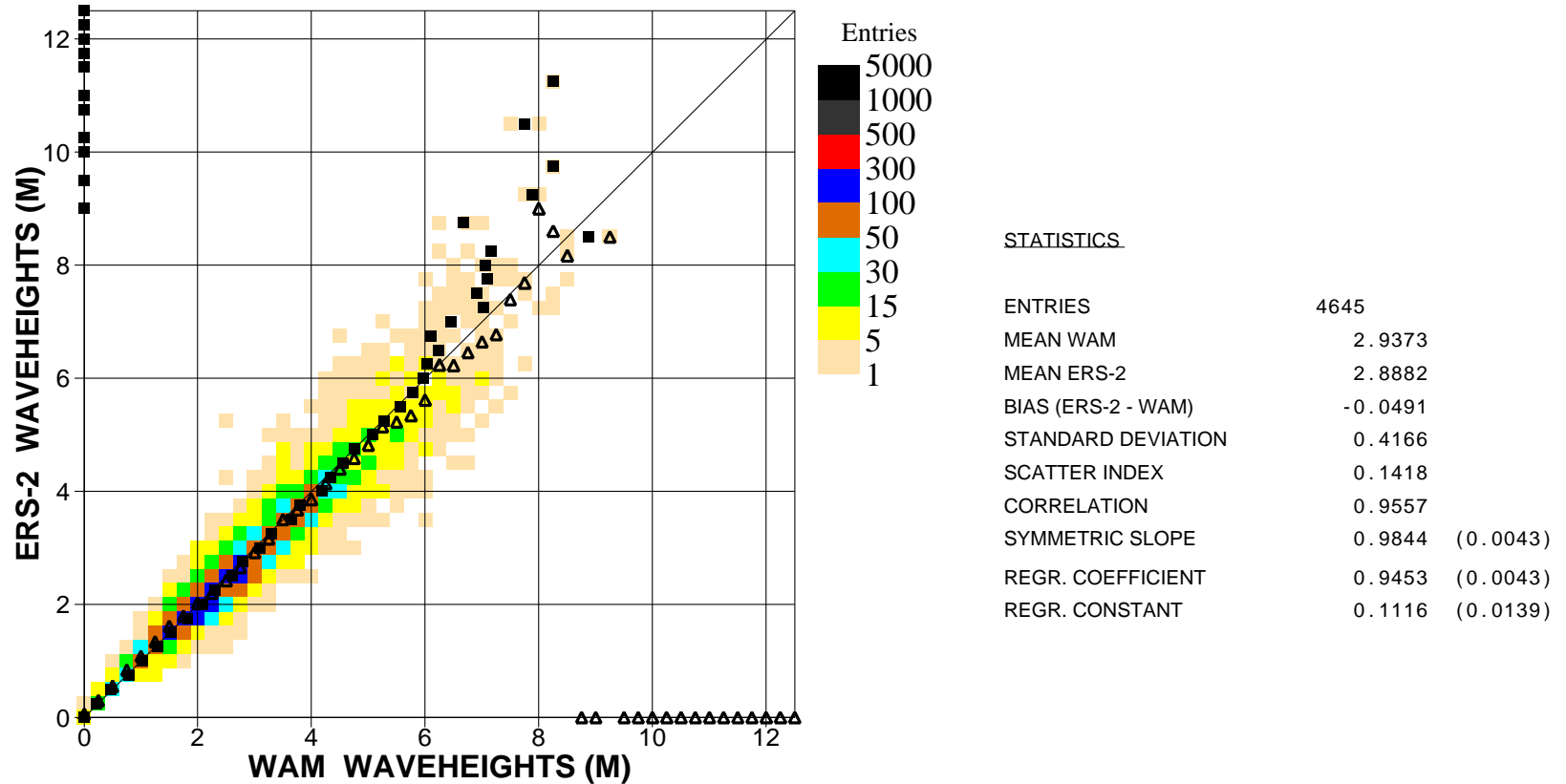


Figure 2: Comparison of ECMWF wave height results with ERS2 SAR wave height data for January 2004 (global)

Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
 Shinfield Park, Reading, Berkshire RG2 9AX, England  
 Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
 Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ECMWF Report on ERS-2 SAR for January 2004

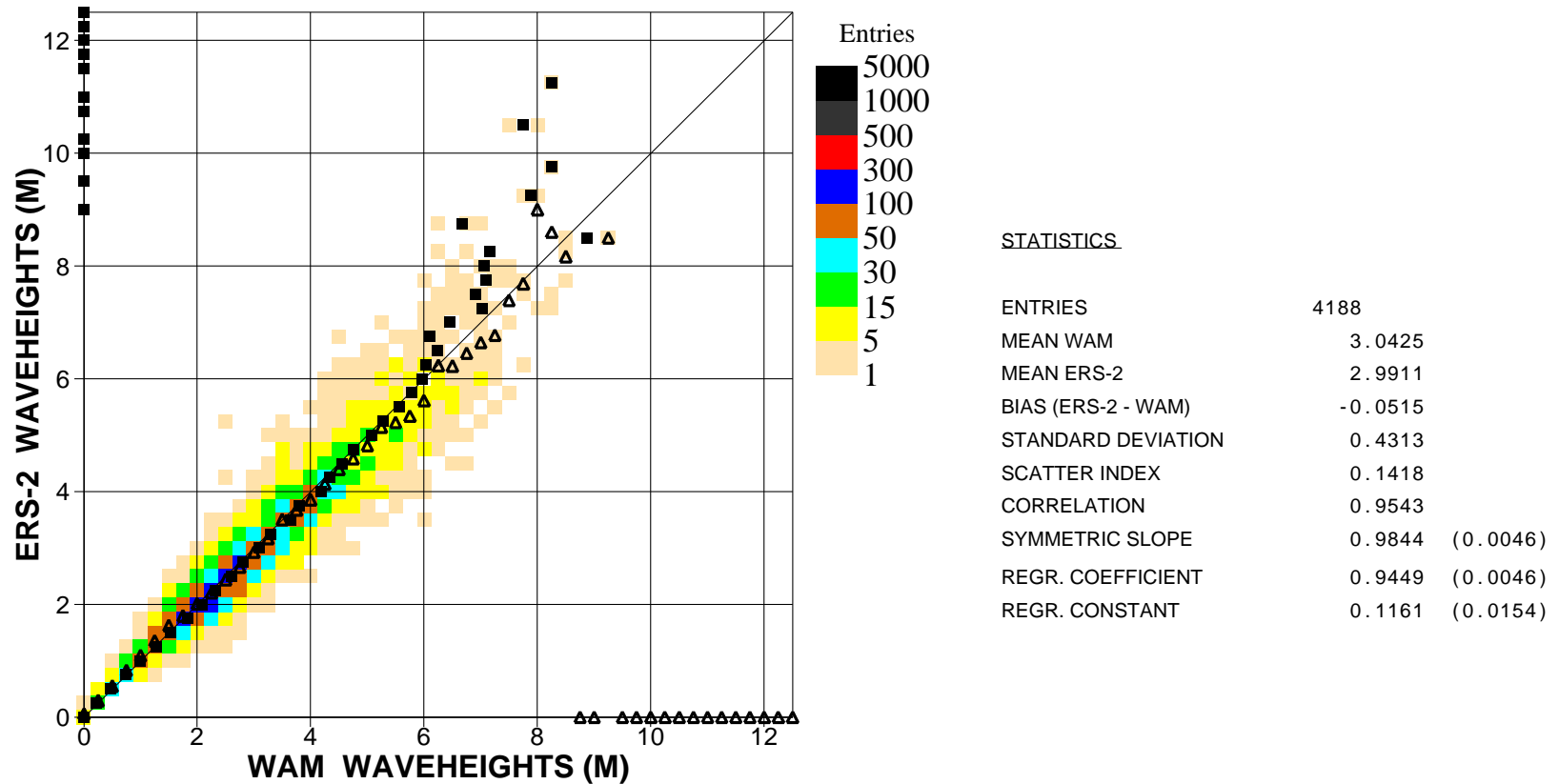


Figure 3: Comparison of ECMWF wave height results with ERS2 SAR wave height data for January 2004 (n.hem.)

Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
 Shinfield Park, Reading, Berkshire RG2 9AX, England  
 Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
 Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

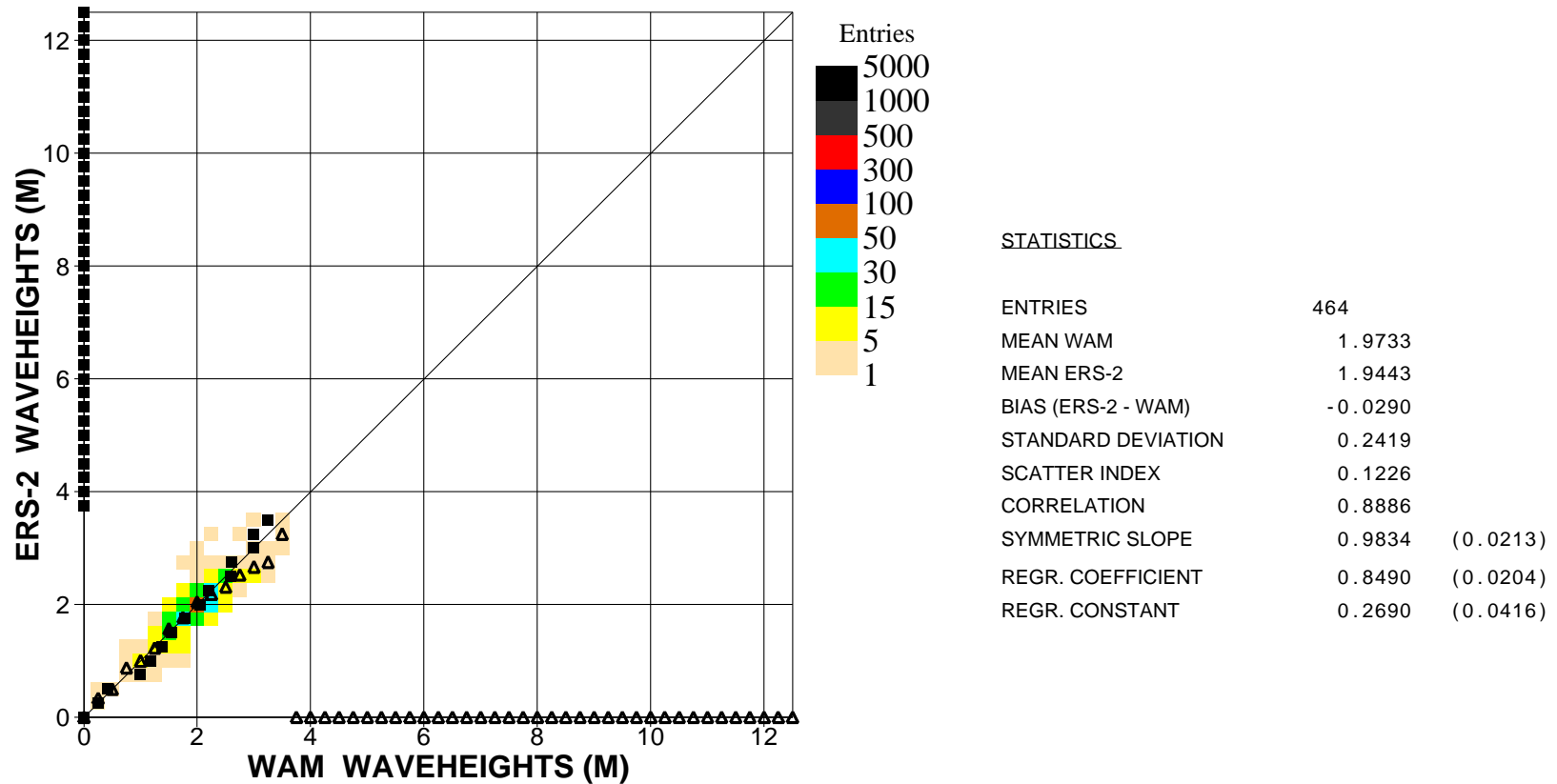


Figure 4: Comparison of ECMWF wave height results with ERS2 SAR wave height data for January 2004 (tropics)

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
 Shinfield Park, Reading, Berkshire RG2 9AX, England  
 Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
 Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int



# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

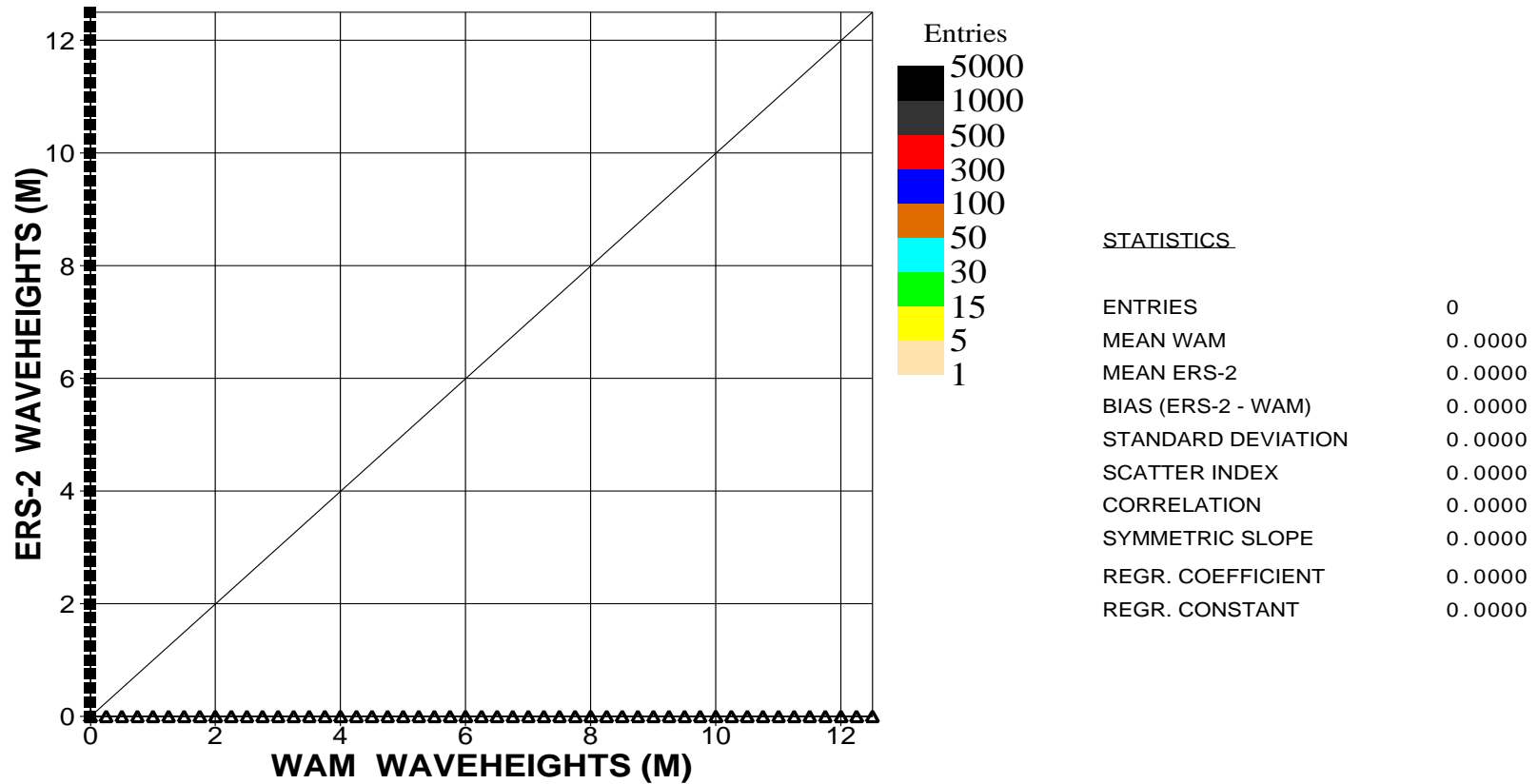


Figure 5: Comparison of ECMWF wave height results with ERS2 SAR wave height data for January 2004 (s.hem.)

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ECMWF Report on ERS-2 SAR for January 2004

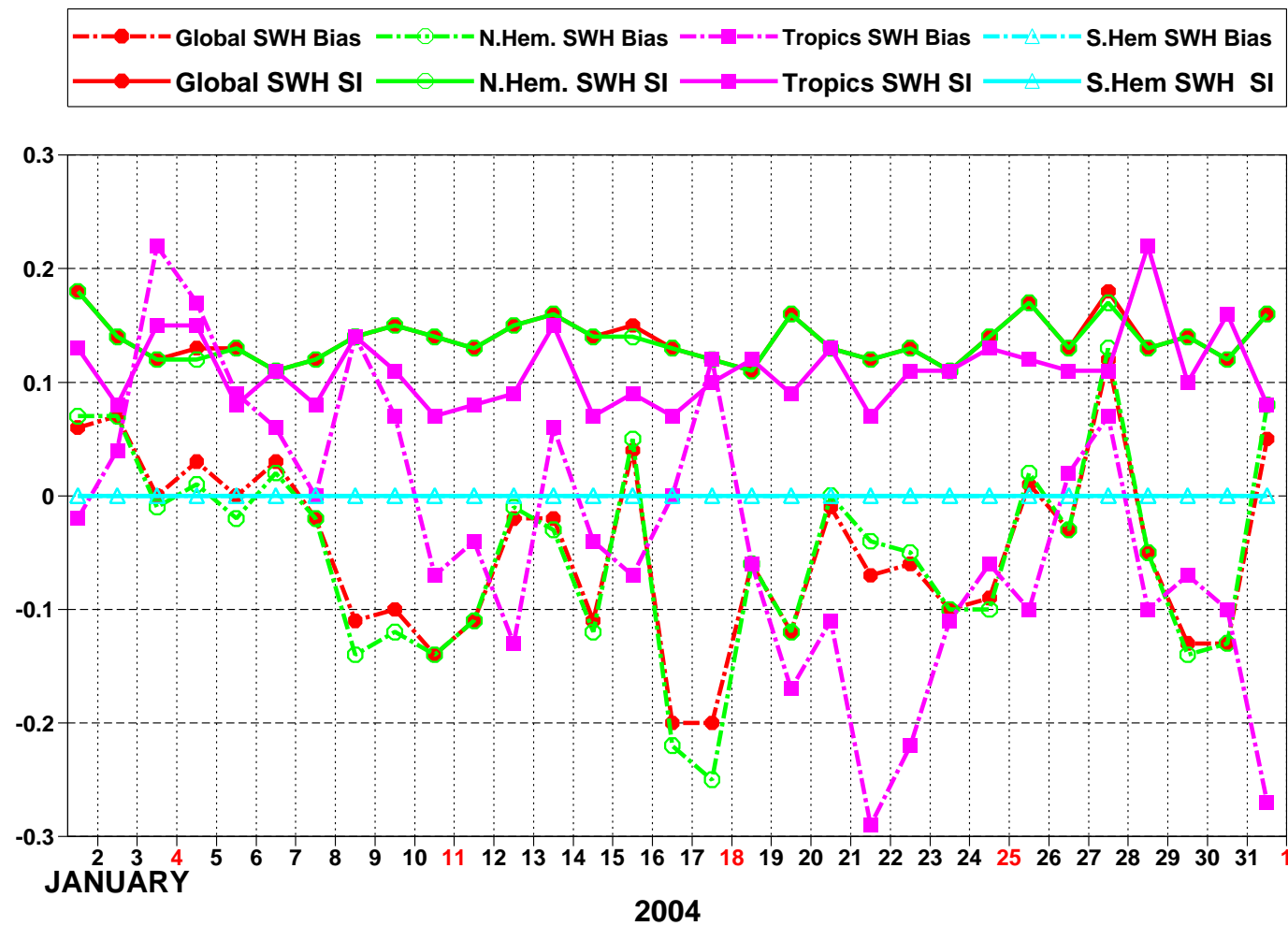


Figure 6: ERS-2 SAR wave heights: Timeseries of bias (ERS-2 - model) and scatter index (SI)

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

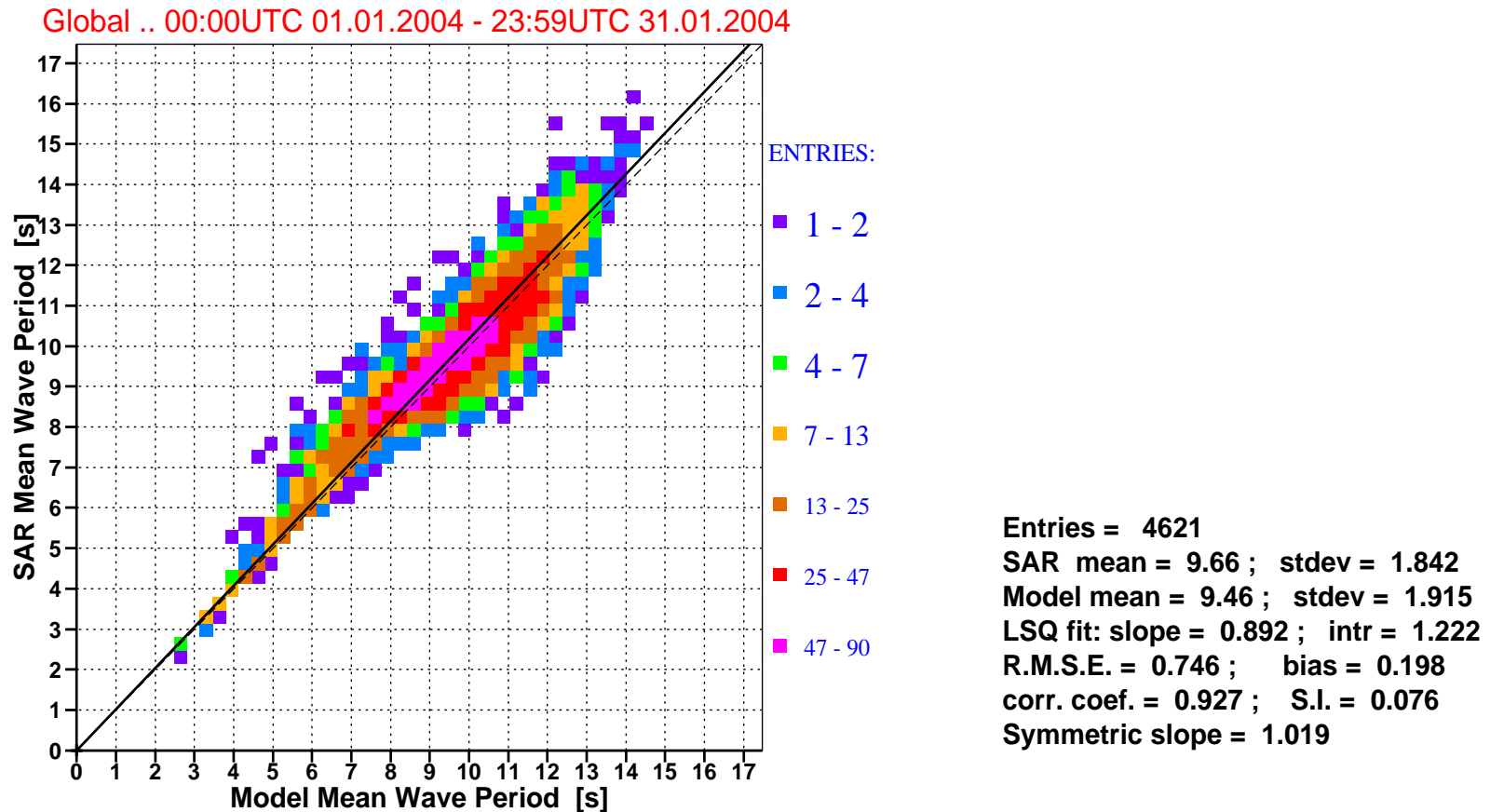


Figure 7: Comparison of ECMWF mean wave periods with ERS-2 SAR mean wave periods for January 2004 (global).

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

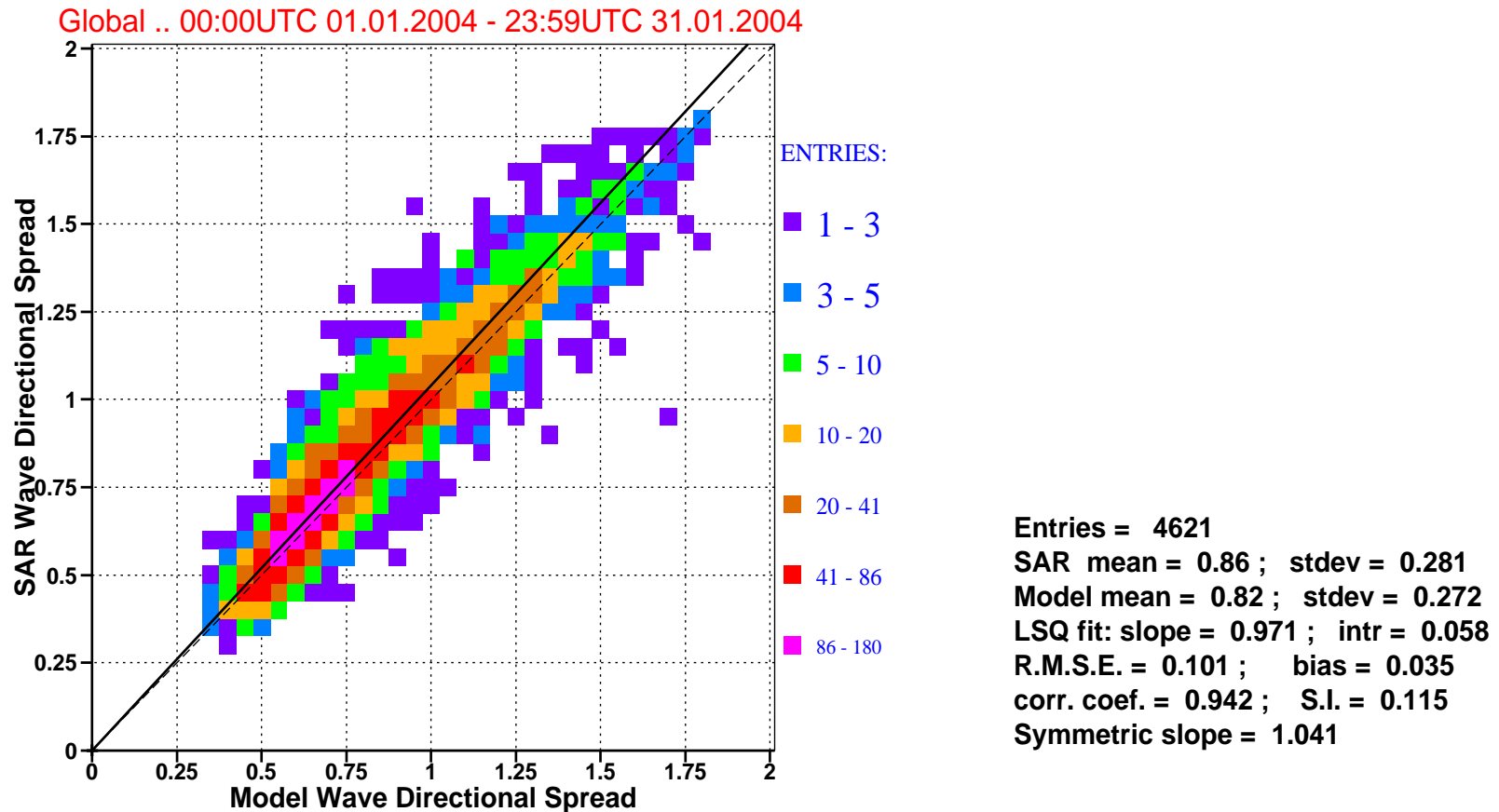


Figure 8: Comparison of ECMWF wave directional spread with that of ERS-2 SAR for January 2004 (global).

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

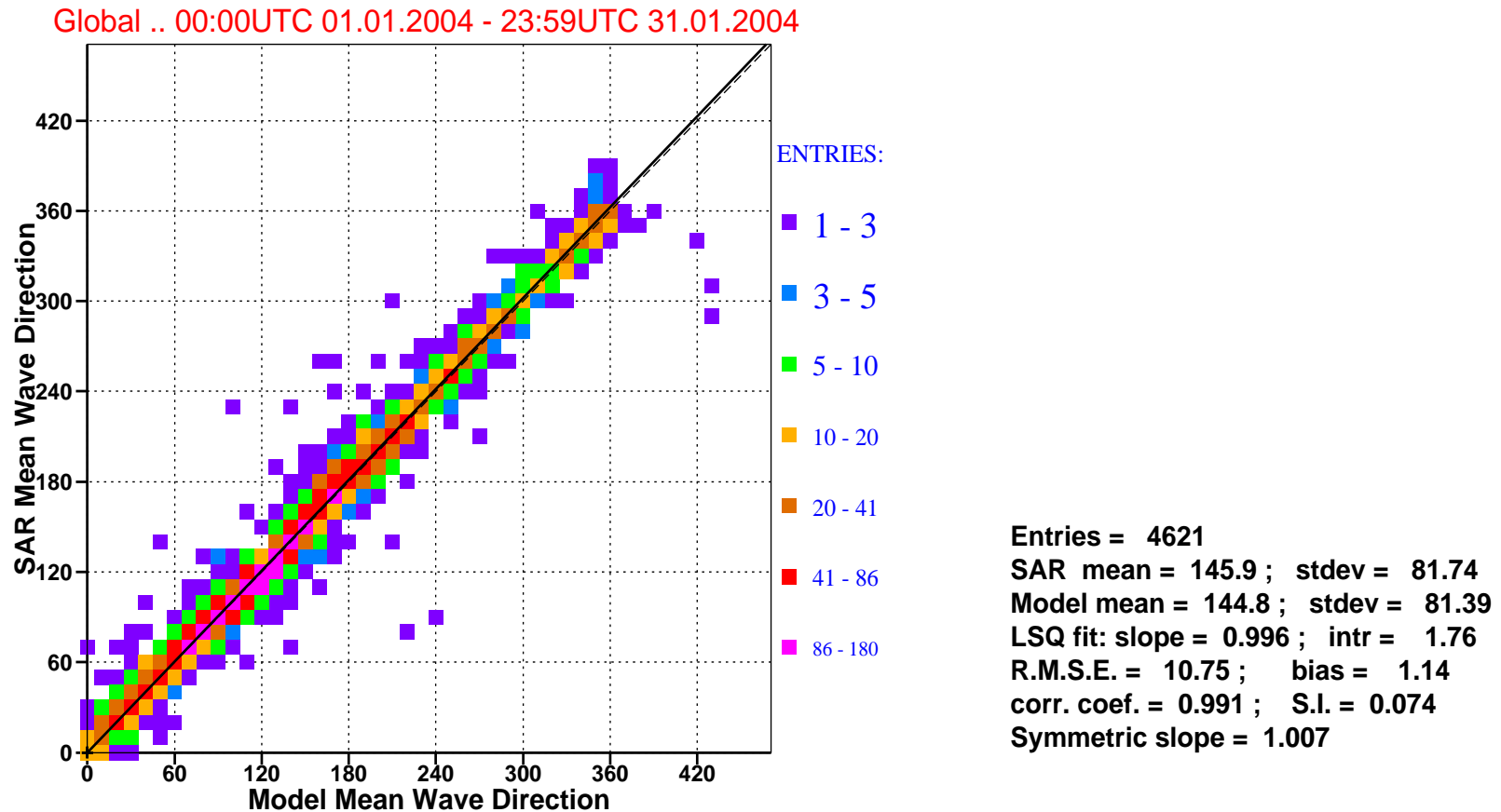


Figure 9: Comparison of ECMWF mean wave directions with that of ERS-2 SAR for January 2004 (global).

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
 Shinfield Park, Reading, Berkshire RG2 9AX, England  
 Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
 Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

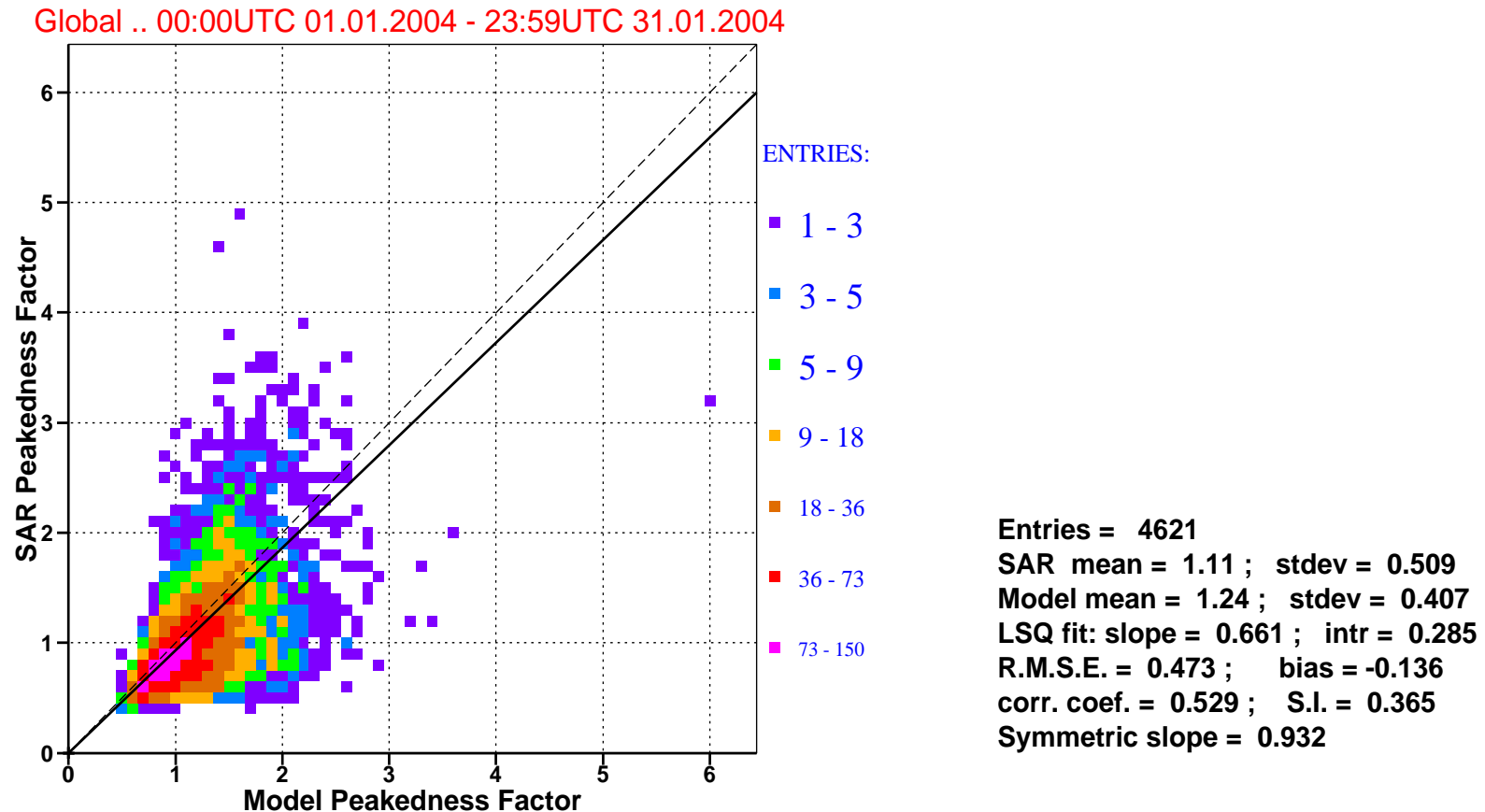


Figure 10: : Comparison of ECMWF wave peakedness factor with that of ERS-2 SAR for january 2004 (global).

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

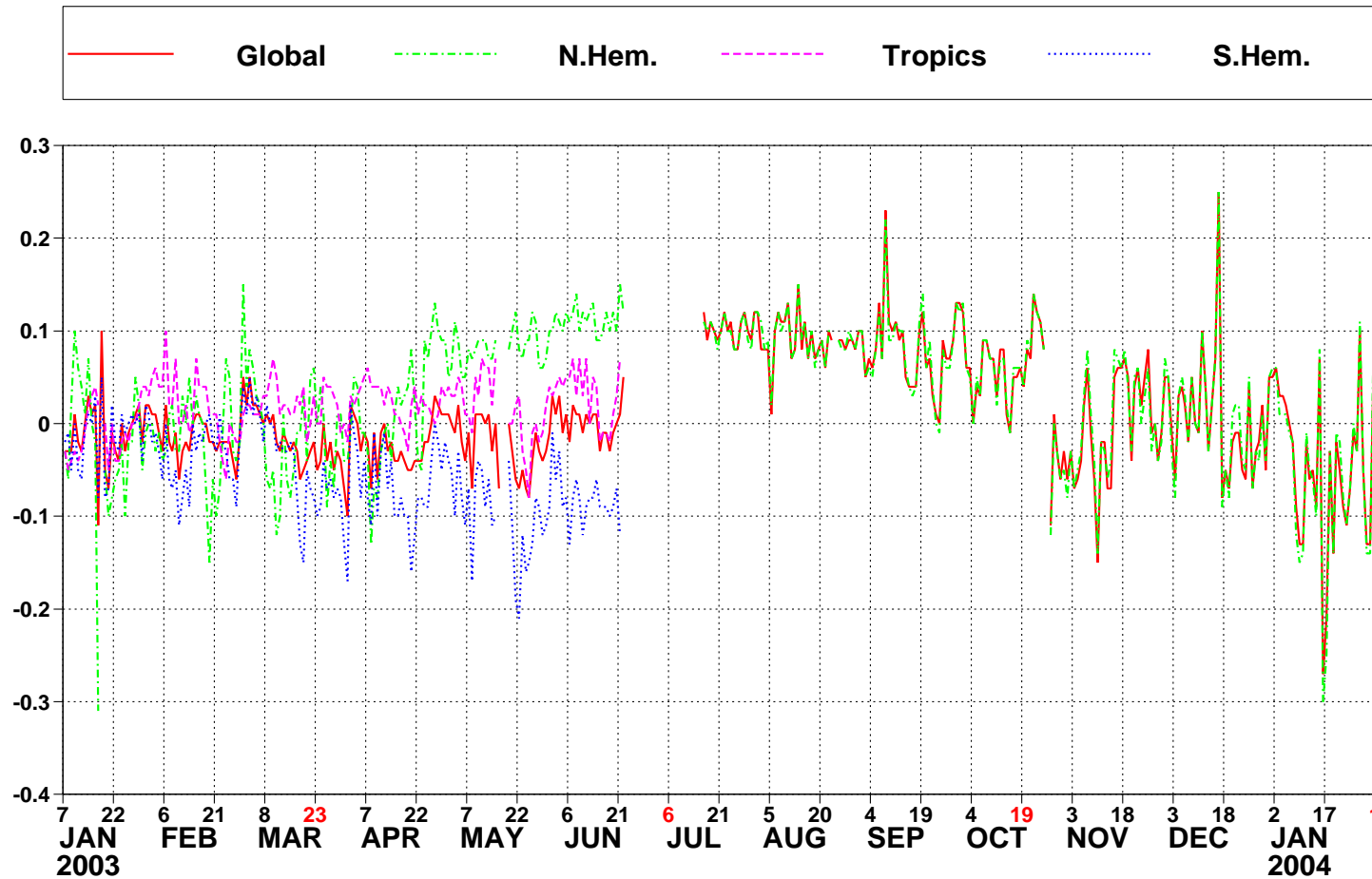


Figure 11: ERS-2 SAR wave heights: Timeseries of daily bias (ERS-2 - model) for the past year.

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

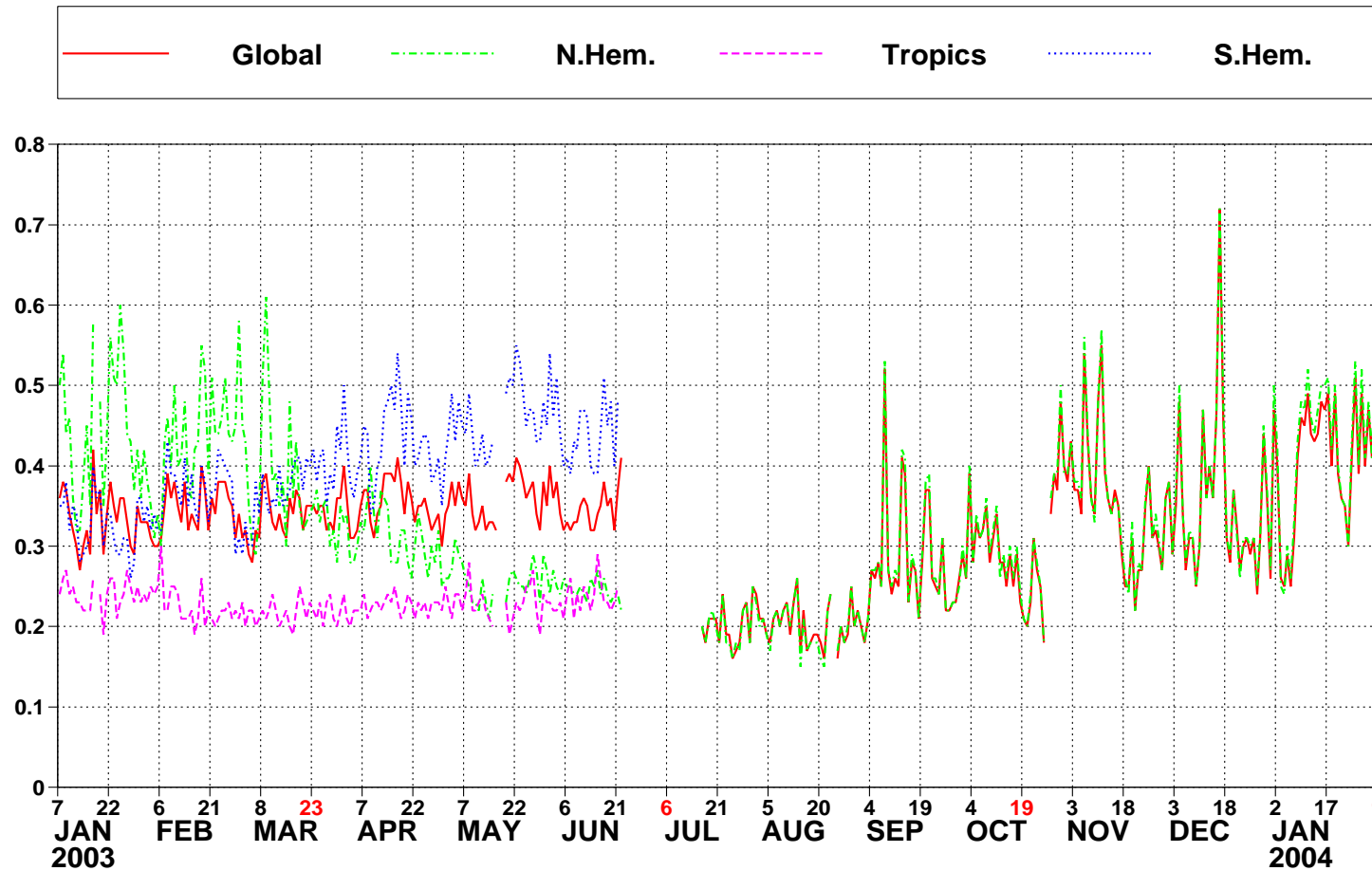


Figure 12: ERS-2 SAR wave heights: Timeseries of daily root mean square difference (RMSE) for the past year.

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int



# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

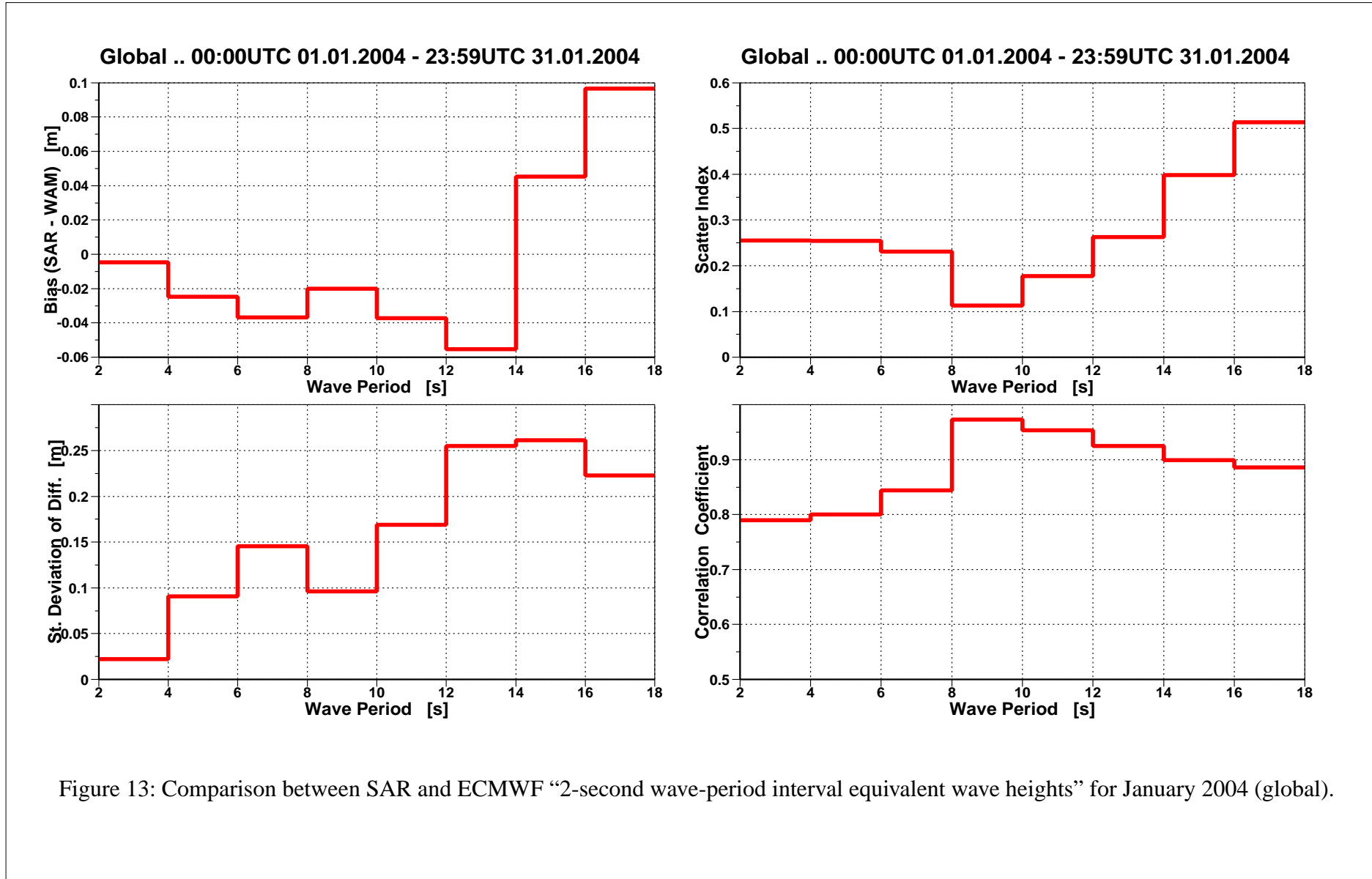


Figure 13: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for January 2004 (global).

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

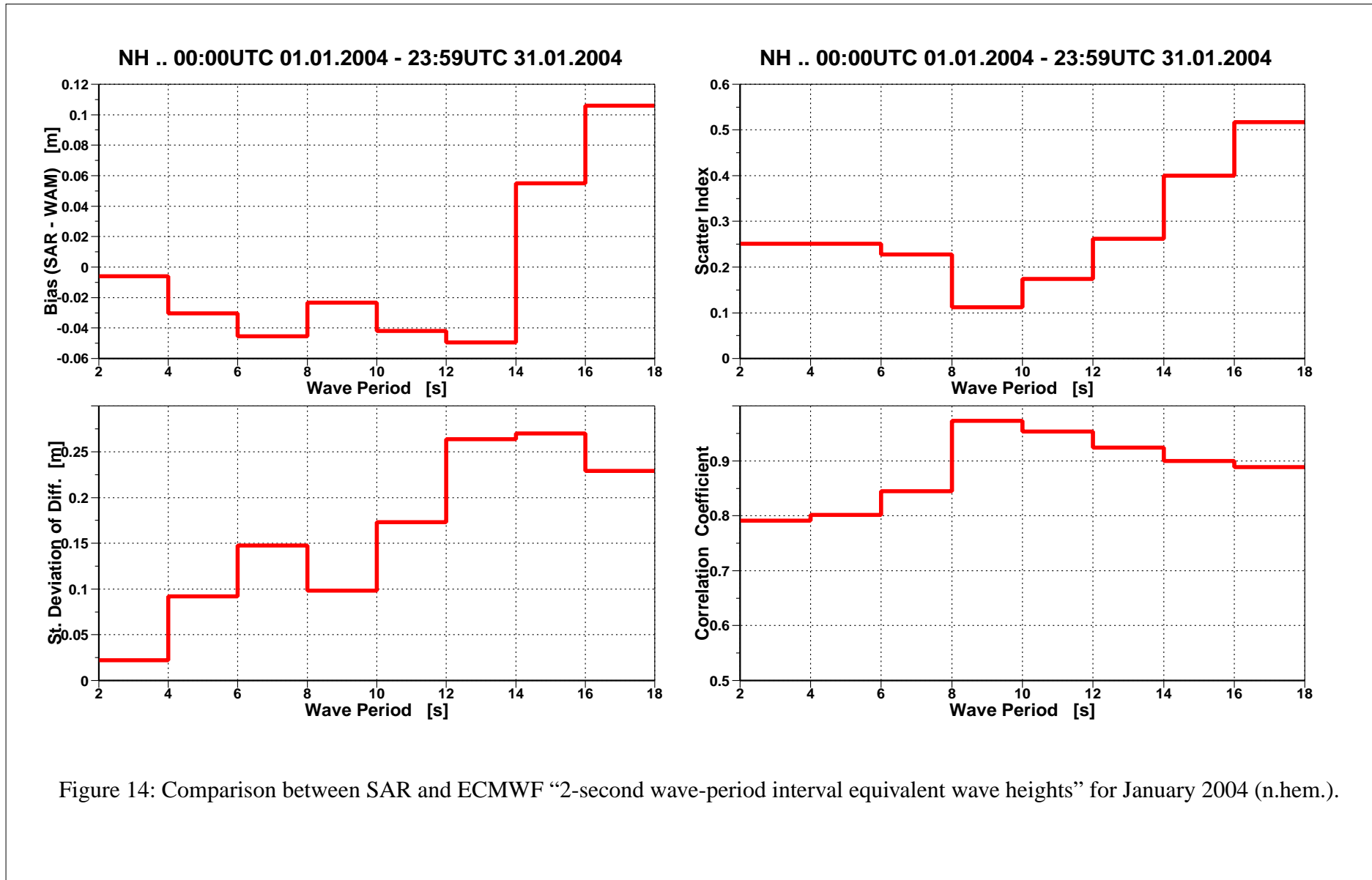


Figure 14: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for January 2004 (n.hem.).

■  
Saleh Abdalla

European Centre for Medium Range Weather Forecasts  
Shinfield Park, Reading, Berkshire RG2 9AX, England  
Telephone: U.K. (0118) 949 9703, International (+44 118) 949 9703  
Telex 984 7908 ECMWF G, Telefax (0118) 986 9450, e-mail: abdalla@ecmwf.int

# ■ ECMWF Report on ERS-2 SAR for January 2004 ■

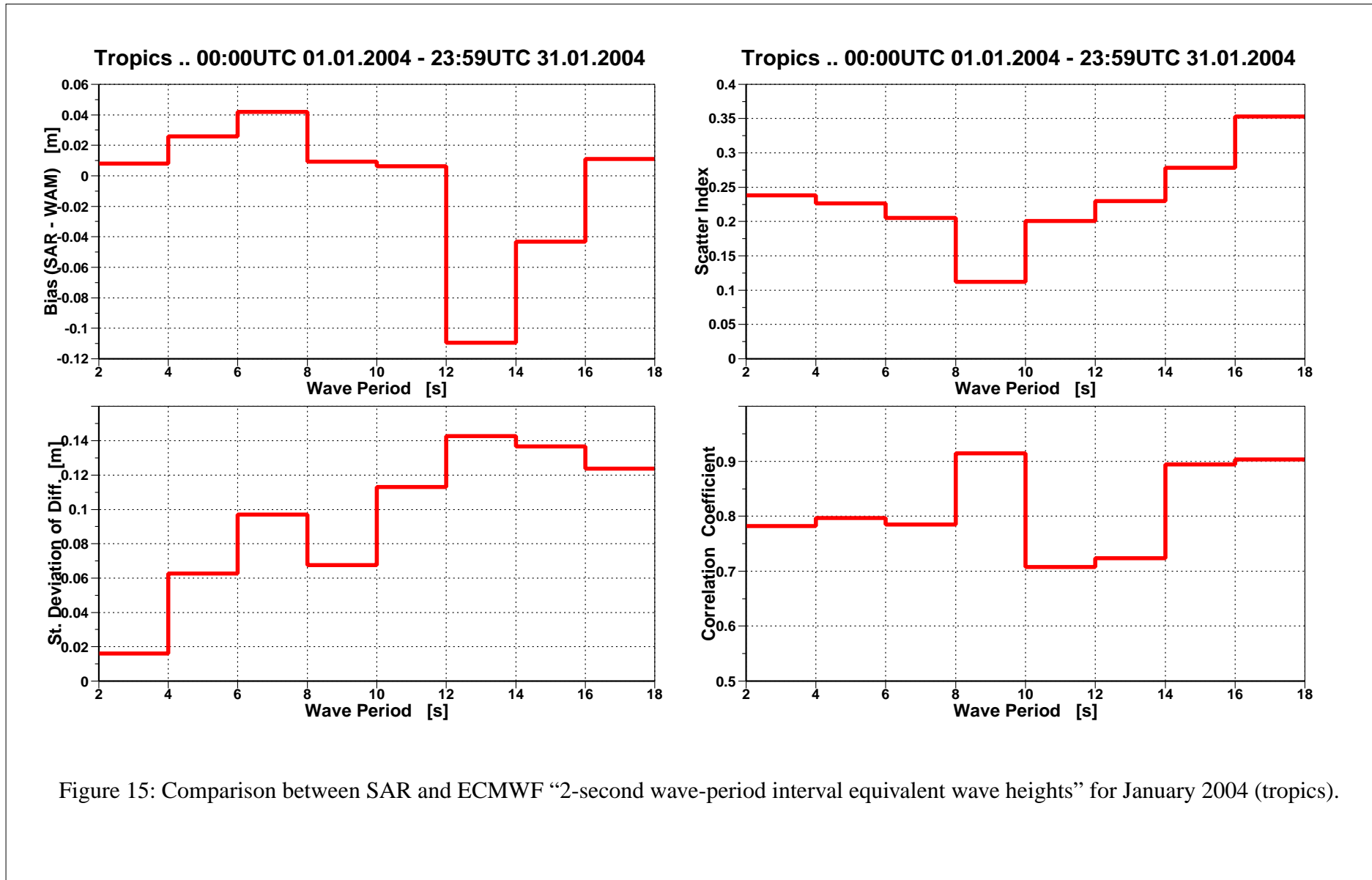


Figure 15: Comparison between SAR and ECMWF “2-second wave-period interval equivalent wave heights” for January 2004 (tropics).