The Use of
NRT Altimeter Wind and Wave Products at ECMWF

Saleh Abdalla, Peter Janssen
and Jean-Raymond Bidlot

ECMWF, Reading, UK

ECMWF

Outline

● Use of NRT Altimeter Products at ECMWF.

● Operational Altimeter Data Reception at ECMWF.

● Quality of NRT Significant Wave Height (SWH).

● Impact of NRT Altimeter SWH Assimilation.

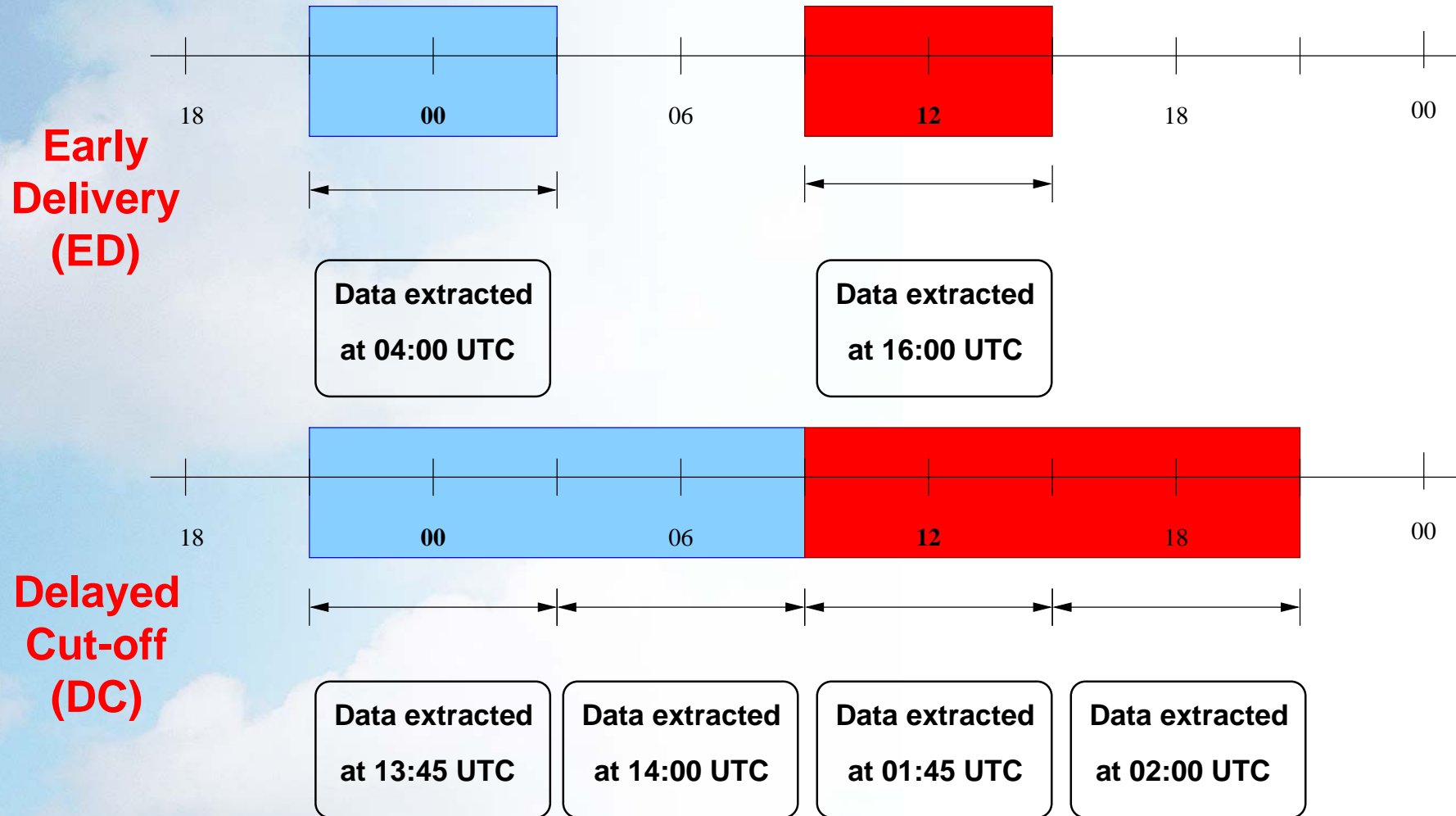● Quality of Surface Wind Speed.

● Conclusions

ECMWF

Use of Altimeter Products at ECMWF

● Only **NRT** Products (within few hours) are used.

● **Data assimilation:** To correct the model analysis (i.e. initial conditions) in order to improve the model forecast:
- *Significant Wave Height.*
 (- Sea Surface Height).

● **Model verification:** To assess the model performance and changes:
- *Significant Wave Height;*
- *Surface wind speed; and*
- *Atmospheric Water Vapour Content.*

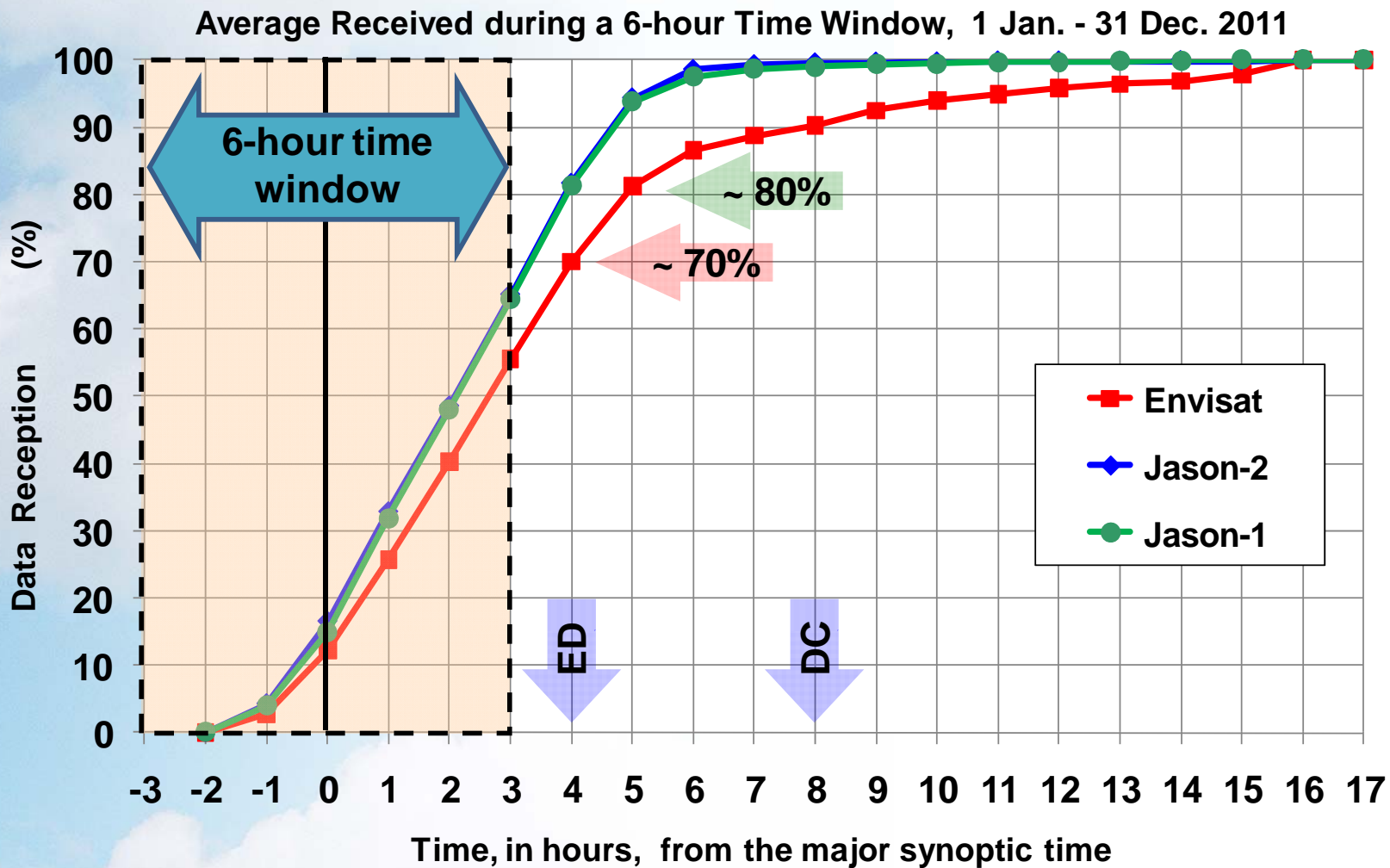**ECMWF**

Latency of Wind & Wave Observations

- NRT data (should be received within few hours).

- Data reception delay with respect to the major synoptic time at the centre of each 6-hour time window.

- Two cut-off times after the end of the 6-hour window:
  - Early Delivery (ED): 1 hour.
  - Delay Cut-off (DC): 5 hours for 06 and 18 windows,
                        and ~11 hours for 00 and 12 windows.

- From 01 January to 31 December 2011.

ECMWF

ECMWF System Configuration

Early Delivery (ED)

18   **00**   06   **12**   18   00

Data extracted at 04:00 UTC

Data extracted at 16:00 UTC

Delayed Cut-off (DC)

18   **00**   06   **12**   18   00

Data extracted at 13:45 UTC

Data extracted at 14:00 UTC

Data extracted at 01:45 UTC

Data extracted at 02:00 UTC

ECMWF

Monitoring of NRT Altimetry Data – Reception

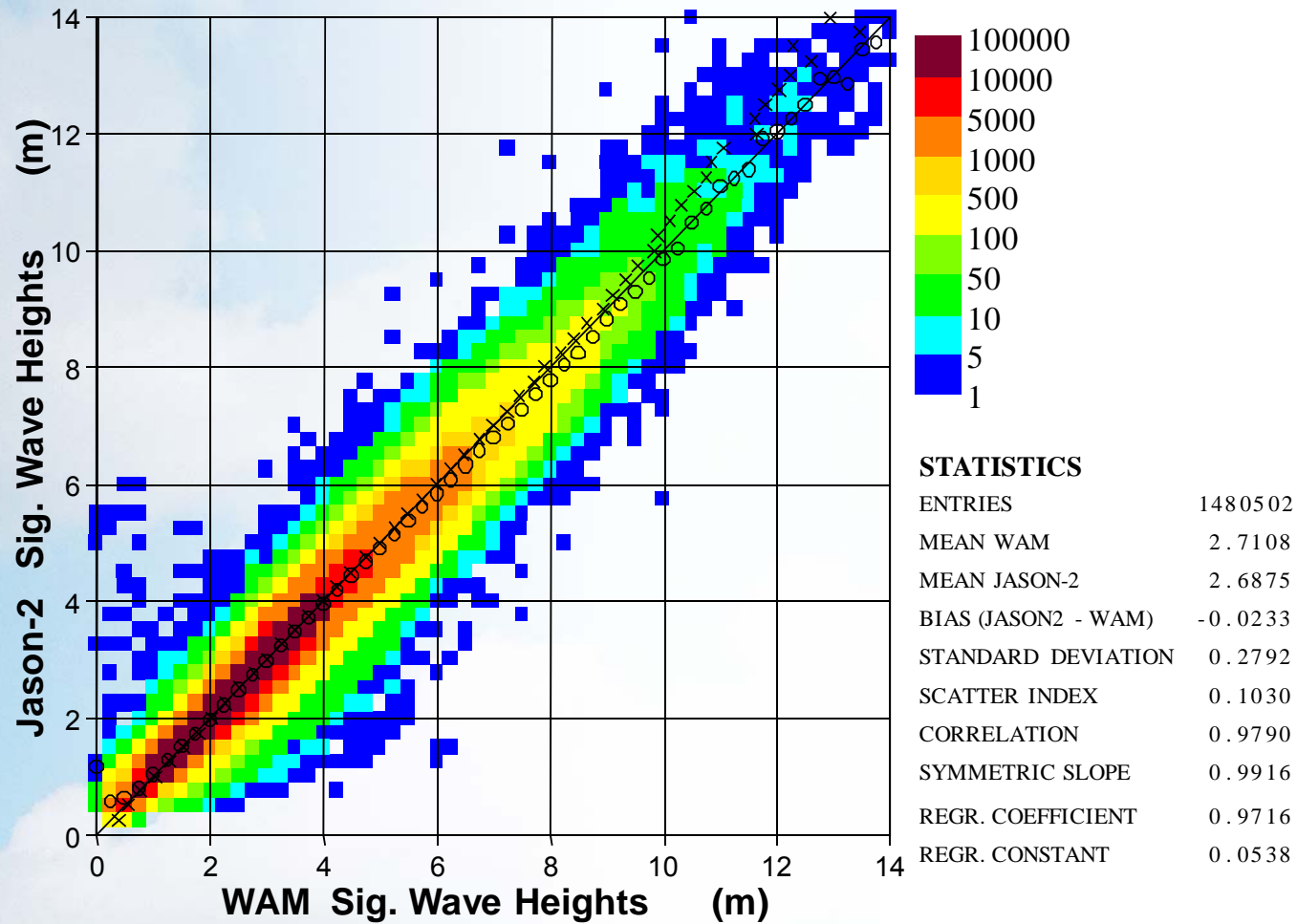Average Received during a 6-hour Time Window, 1 Jan. - 31 Dec. 2011

NRT Altimeter data reception at ECMWF

Quality of Altimeter NRT (Jason-1 OSDR and Jason-2 OGDR and Envisat FDMAR) SWH

- Against: - ECMWF wave model first-guess

                    - GTS in-situ wave measurements

- Envisat SWH is almost unbiased after 1 Feb. 2010.

  Jason-1 SWH is slightly high (by about 4%).

  Jason-2 SWH is almost unbiased.

- Envisat SWH is very good (except for slight

  degradation at low values after 1 Feb. 2010).

  Jason-1 SWH product is very good.

  Jason-2 SWH is even better.

ECMWF

Jason-2 SWH Comparison against ECMWF Wave Model - 2011

STATISTICS

|	
ENTRIES	1480502
MEAN WAM	2.7108
MEAN JASON-2	2.6875
BIAS (JASON2 - WAM)	-0.0233
STANDARD DEVIATION	0.2792
SCATTER INDEX	0.1030
CORRELATION	0.9790
SYMMETRIC SLOPE	0.9916
REGR. COEFFICIENT	0.9716
REGR. CONSTANT	0.0538

ECMWF

Global comparison between Altimeter and ECMWF wave model (WAM) first-guess SWH values (From 02 February 2010 to 01 February 2011)
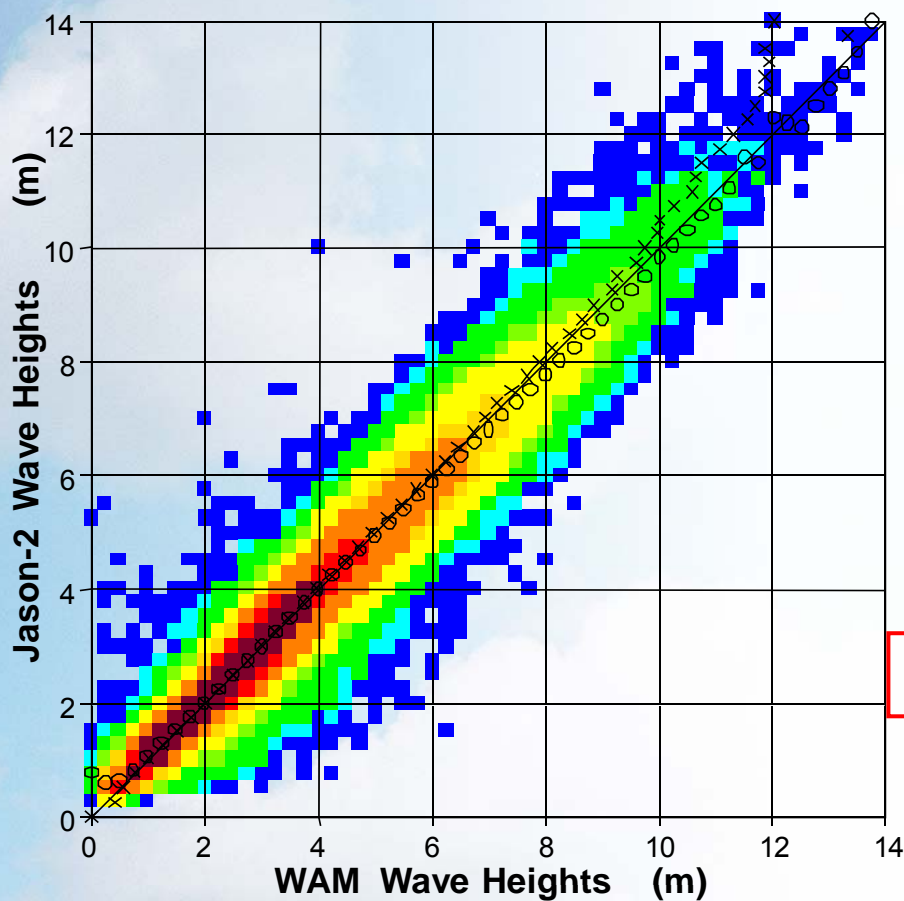
STATISTICS	Jason-2	Envisat	Jason-1
ENTRIES	142 5055	1 125908	138 2997
MEAN WAM	2 .7073	2. 6014	2. 6939
MEAN JASON2	2 .7041	2. 5851	2. 8078
BIAS (JASON2 - WAM)	- 0 .0032	- 0 . 0163	0 . 1140
STANDARD DEVIATION	0 .2826	0 . 2733	0 . 3232
SCATTER INDEX	0 .1044	0 . 1051	0 . 1200
CORRELATION	0 .9791	0 . 9786	0 . 9738
SYMMETRIC SLOPE	0 .9983	1. 0026	1. 0397
REGR. COEFFICIENT	0 .9753	1. 0163	1. 0025
REGR. CONSTANT	0 .0637	- 0 . 0587	0 . 1072

© ECMWF, 2011

Jason-2 and ENVISAT Ku-band SWH St. Dev. Diff. as functions of SWH

Ocean Surface Topography Science Team Meeting, Venice, Italy, 27-28 Sep. 2012
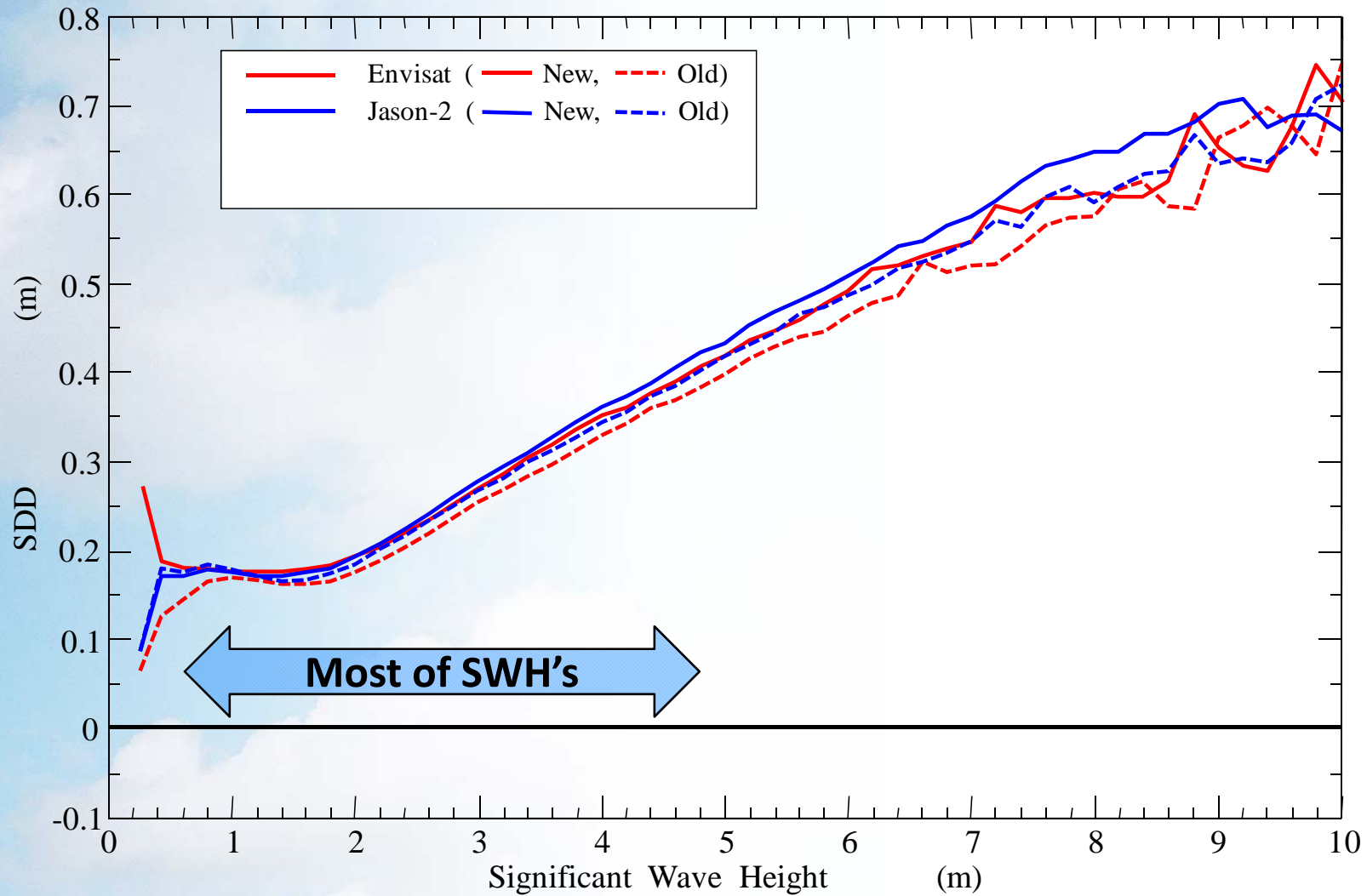
Impact of the Assimilation of Altimeter Significant Wave Height

● NRT Altimeter SWH products have been assimilated operationally at ECMWF since:

- ~~22 October 2003~~ . . . ~~for ENVISAT FDMAR~~;
- *1 February 2006* . . . *for Jason-1 OSDR*;
- 10 March 2009 . . . for Jason-2 OGDR.

| Envisat	Jason-1 Envisat	Jason-2 Envisat	Jason-1 Jason-2 Envisat	Jason-2 Envisat	Jason-2
22 Oct. 2003	1 Feb. 2006	10 Mar. 2009	8 Jun. 2009	1 Apr. 2010	7 Apr. 2012

© ECMWF, 2012

ECMWF
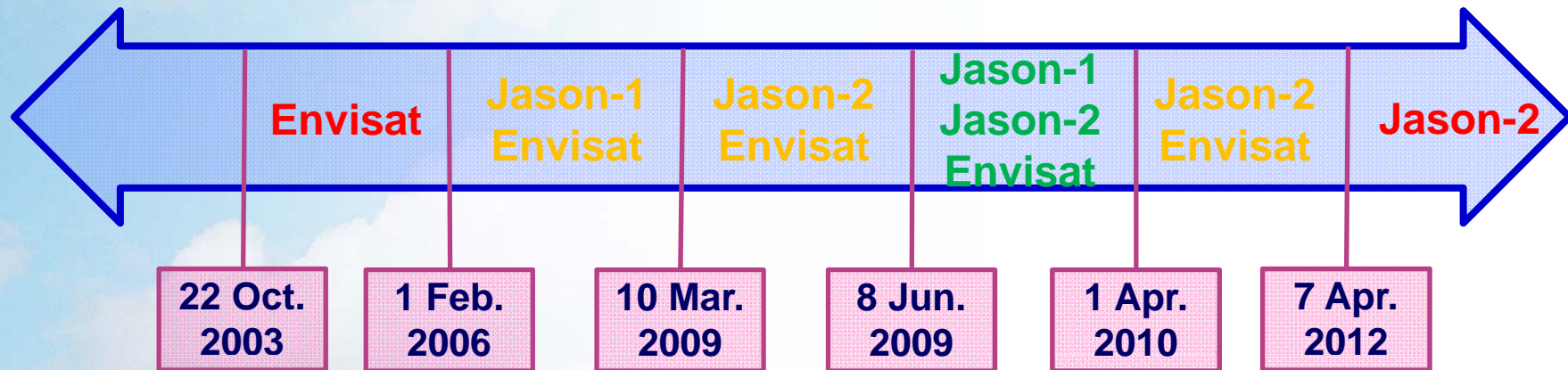
Impact of the Assimilation of Altimeter Significant Wave Height *(Cont'd)*

- The impact is positive.

- Jason-1 assimilation was paused when:
  - was in tandem with Jason-2 after 10 Mar. 2009; &
  - after 1 Apr. 2010, but will be resumed soon.

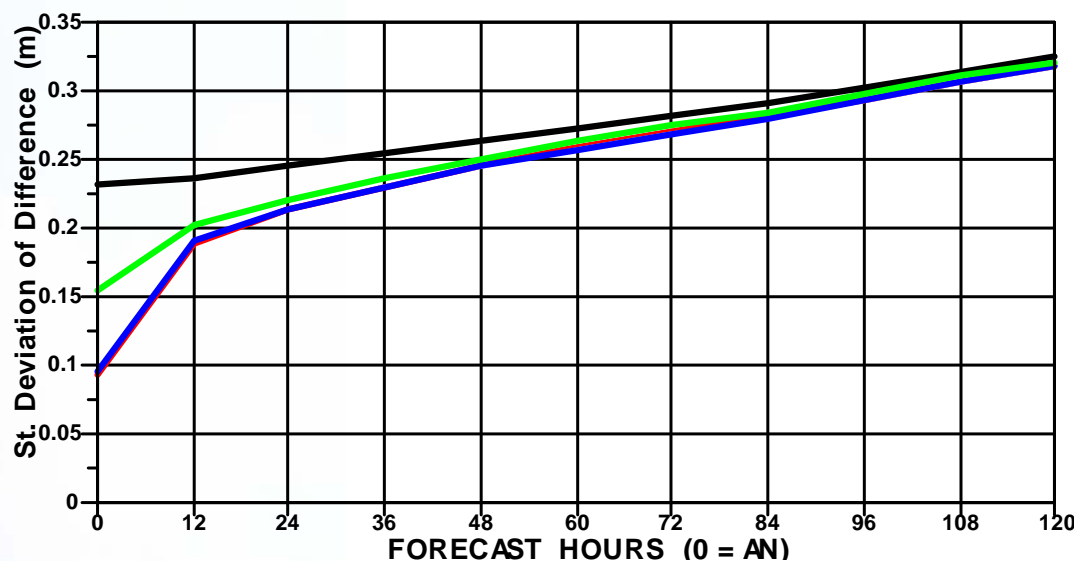- Communication loss with ENVISAT in April 2012.

ECMWF

Impact of Jason-2 SWH assimilation on the model SWH forecast errors in the Tropics

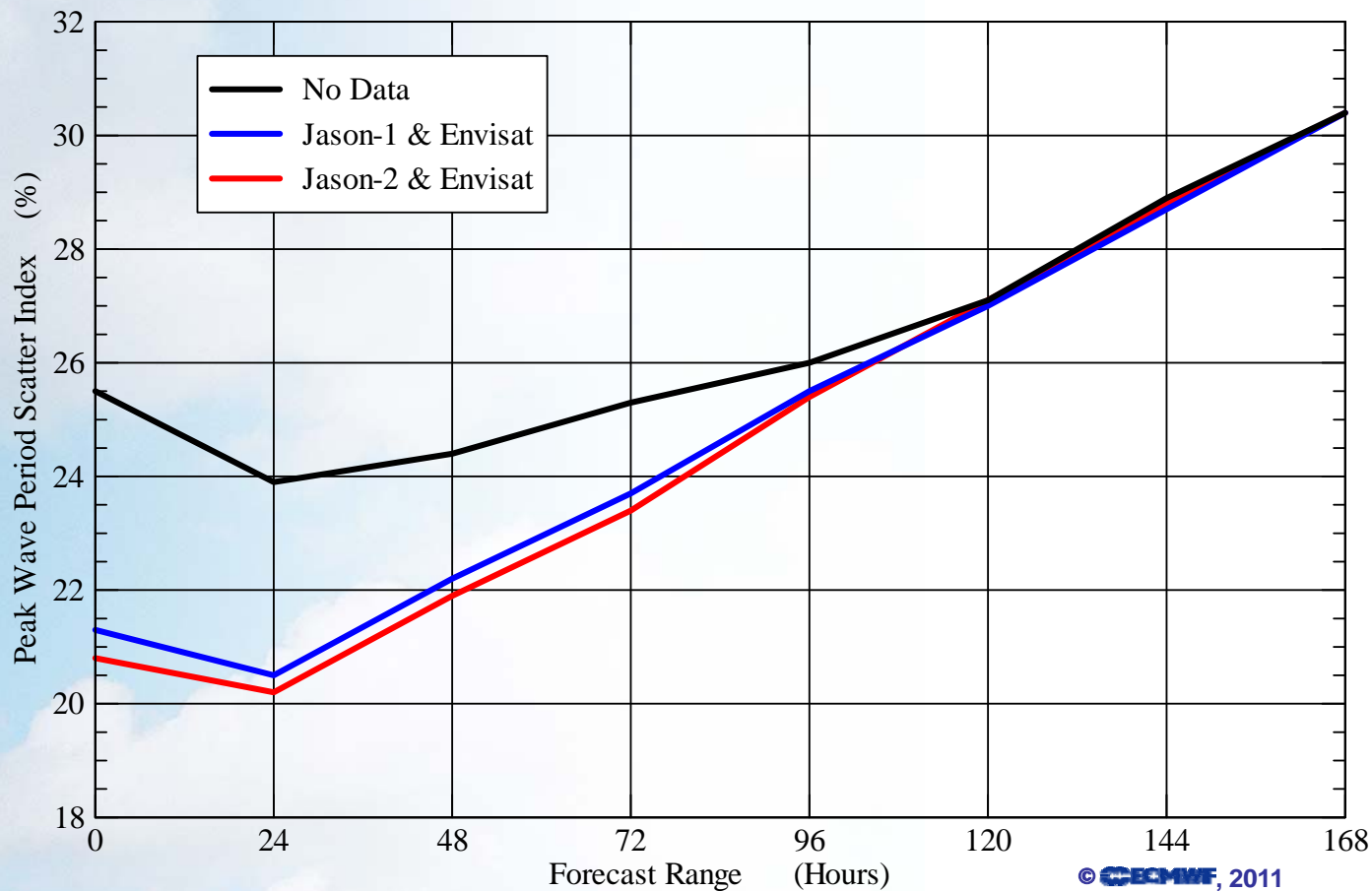Verified against Envisat & Jason-1

(From 01 August to 21 September 2008)

——	**No data assim.**
······	**Jason-2 alone**
——	**Jason-2 & Envisat**
– –	**Jason-1 & Envisat**
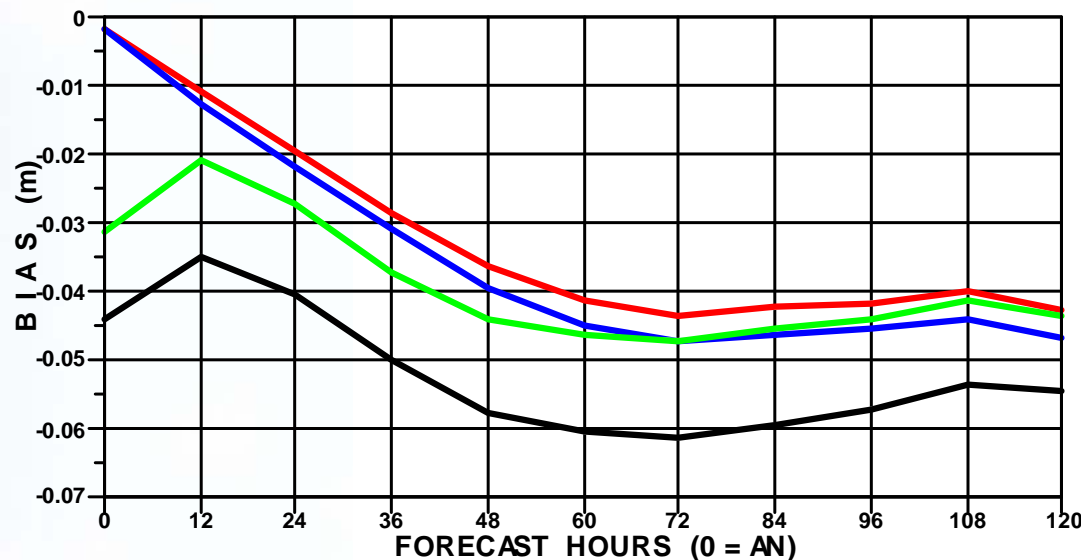
© ECMWF, 2011

Impact of Jason-1/2 SWH assimilation on the model peak wave period forecast errors
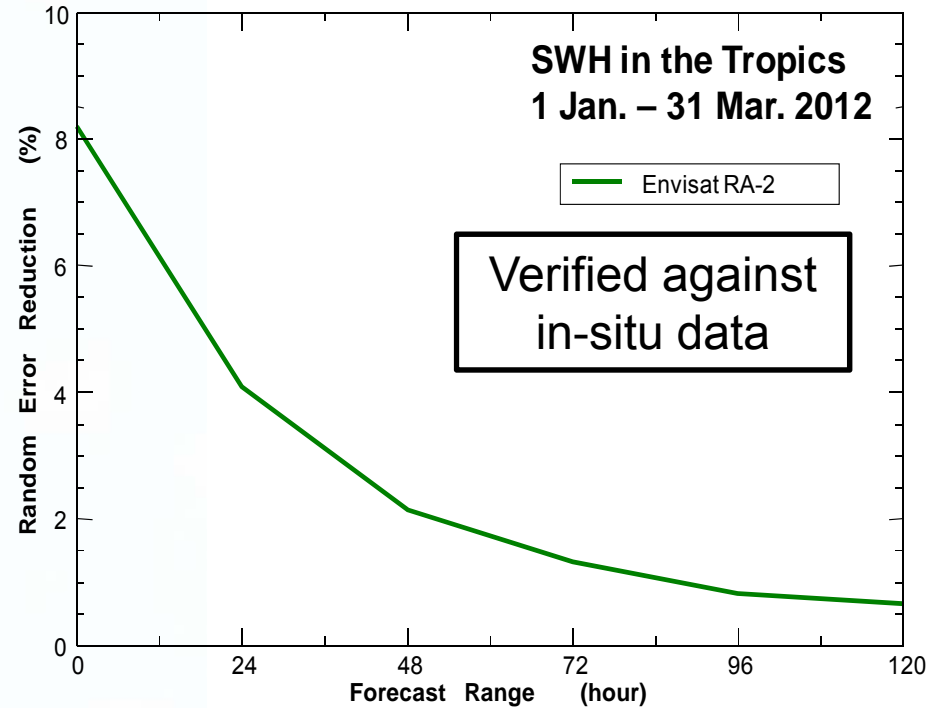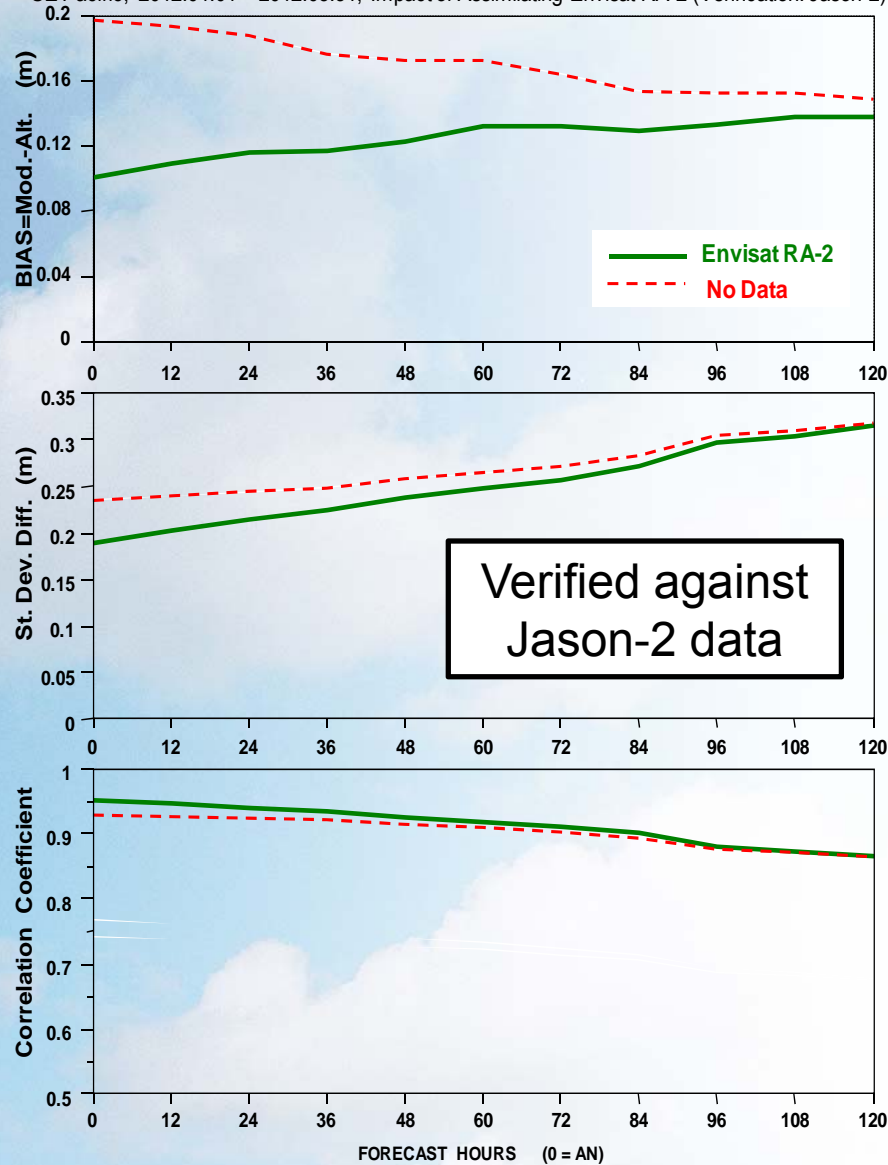
(At all buoys; From 01 Aug. to 21 Sep. 2008)

© ECMWF, 2012

© ECMWF, 2011

ECMWF

Impact of Alt. SWH assimilation – Model Forecast

SE Pacific, 2012.01.01 – 2012.03.31, Impact of Assimilating Envisat RA-2 (Verification: Jason-2)

SWH in the Tropics
1 Jan. – 31 Mar. 2012

— Envisat RA-2

Verified against
in-situ data

— Envisat RA-2
--- No Data

Verified against
Jason-2 data

ENVISAT RA-2 Assimilation

1 Jan. - 31 March 2012

Impact of Jason-2 SWH assimilation on the model 500 hPa Geopotential Height forecast errors in the Northern Hemisphere

(w.r.t. operational analysis, 1 August – 30 September 2008)

NH - Z 500
61 Cases
(1 Aug. - 30 Sep. 2008)

Jason-2 & Envisat
Jason-1 & Envisat

Anomaly Correlation (%)

Forecast Day

Ocean Surface Topography Science Team Meeting, Venice, Italy, 27-28 Sep. 2012
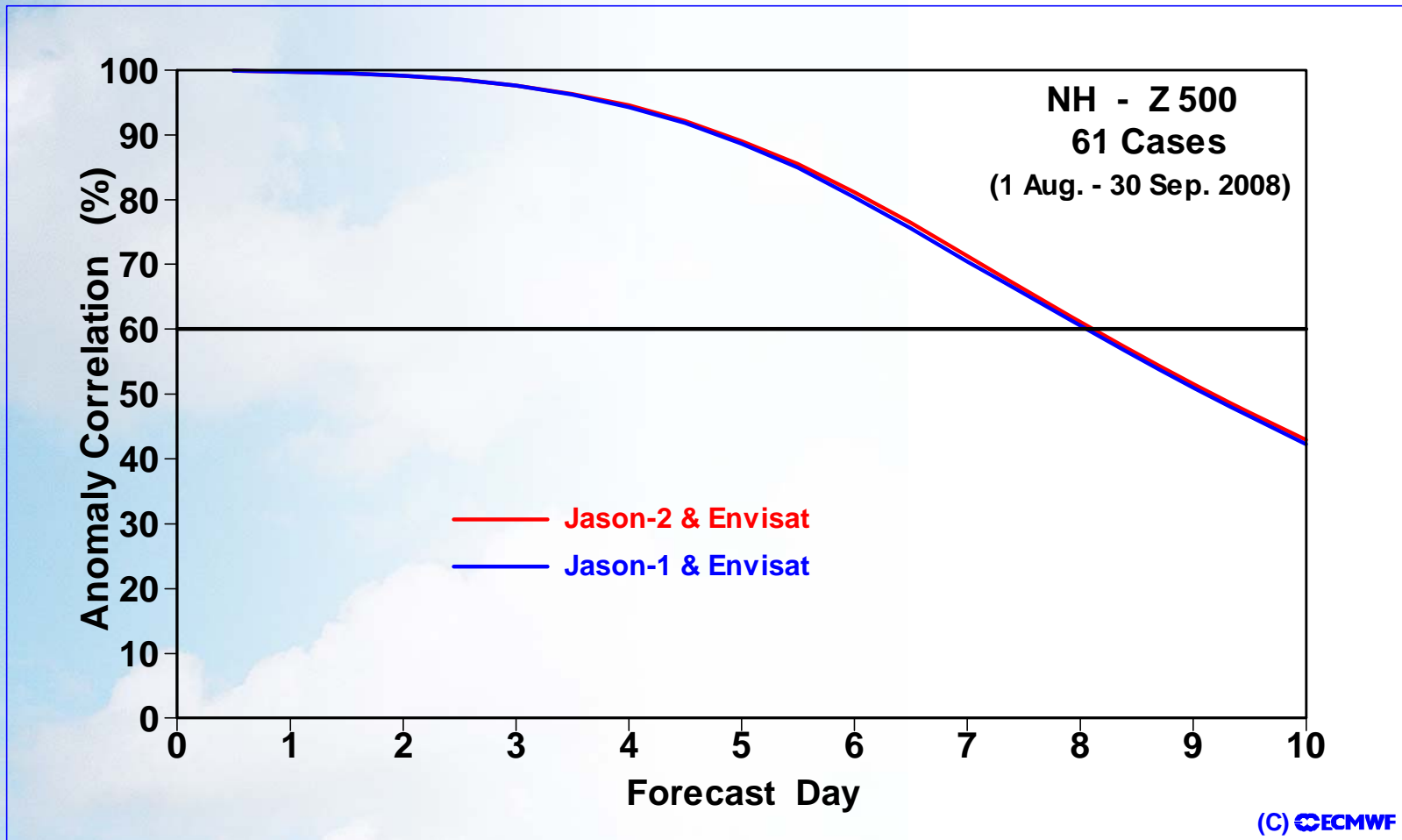
(C) ECMWF

ECMWF

Impact of the Assimilation Data from 3 Altimeters versus 2

- Use of data from Jason-2 and ENVISAT compared to adding Jason-1 to them.

- The use of data from 3 Altimeters:
  - ➔ **Positive** impact;
  - ➔ **More Resilient** data stream.

ECMWF

Impact of Jason-1 SWH assimilation on top of Jason-2 + ENVISAT

## (At all buoys; From 10 Feb. to 18 May 2009)

(Number of collocations)	SWH (38174)		Mean W. Period, T_z (28986)		Peak W. Period , T_p (23288)	
	Bias (cm)	SI (%)	Bias (s)	SI (%)	Bias (s)	SI (%)
Jason-1 + (Jason-2 + ENVISAT)	- 3.5	14.7	- 0.168	10.8	0.080	15.6
Jason-2 + ENVISAT	- 3.7	15.1	- 0.172	10.9	0.082	15.7

ECMWF

Quality of NRT Altimeter Surface Wind Speed and Backscatter Products

● Consistency and stability of backscatter.

● Verify wind speed against:

  - ECMWF model analysis

  - GTS in-situ wind measurements

● Used for model diagnostics and model-change verification.

ECMWF

Altimeter Backscatter Monthly Global Mean

- Rather stable with few issues:
  - slight drop in all altimeters towards the end of 2009.
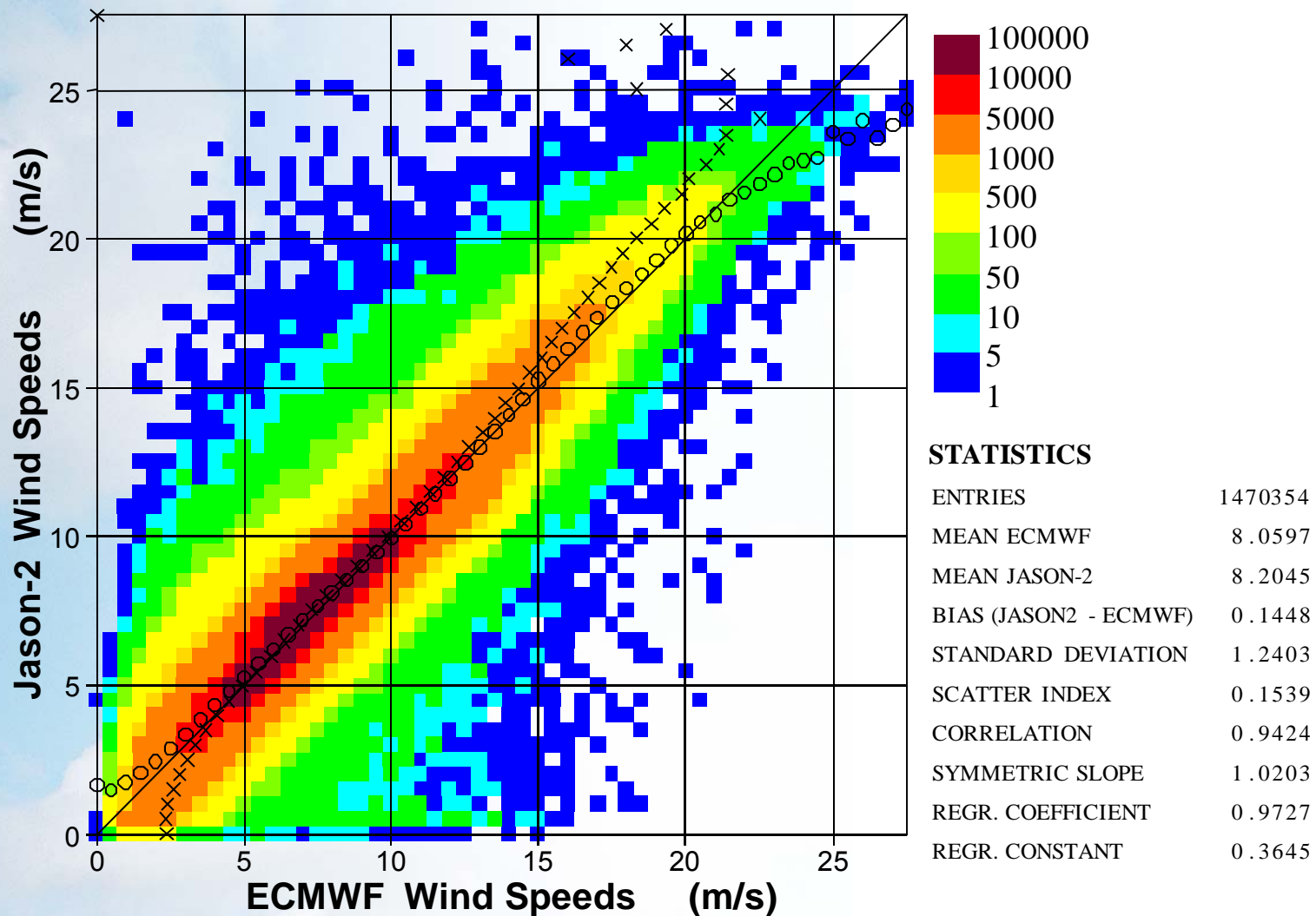 - reduction trend in Jason-1 backscatter.
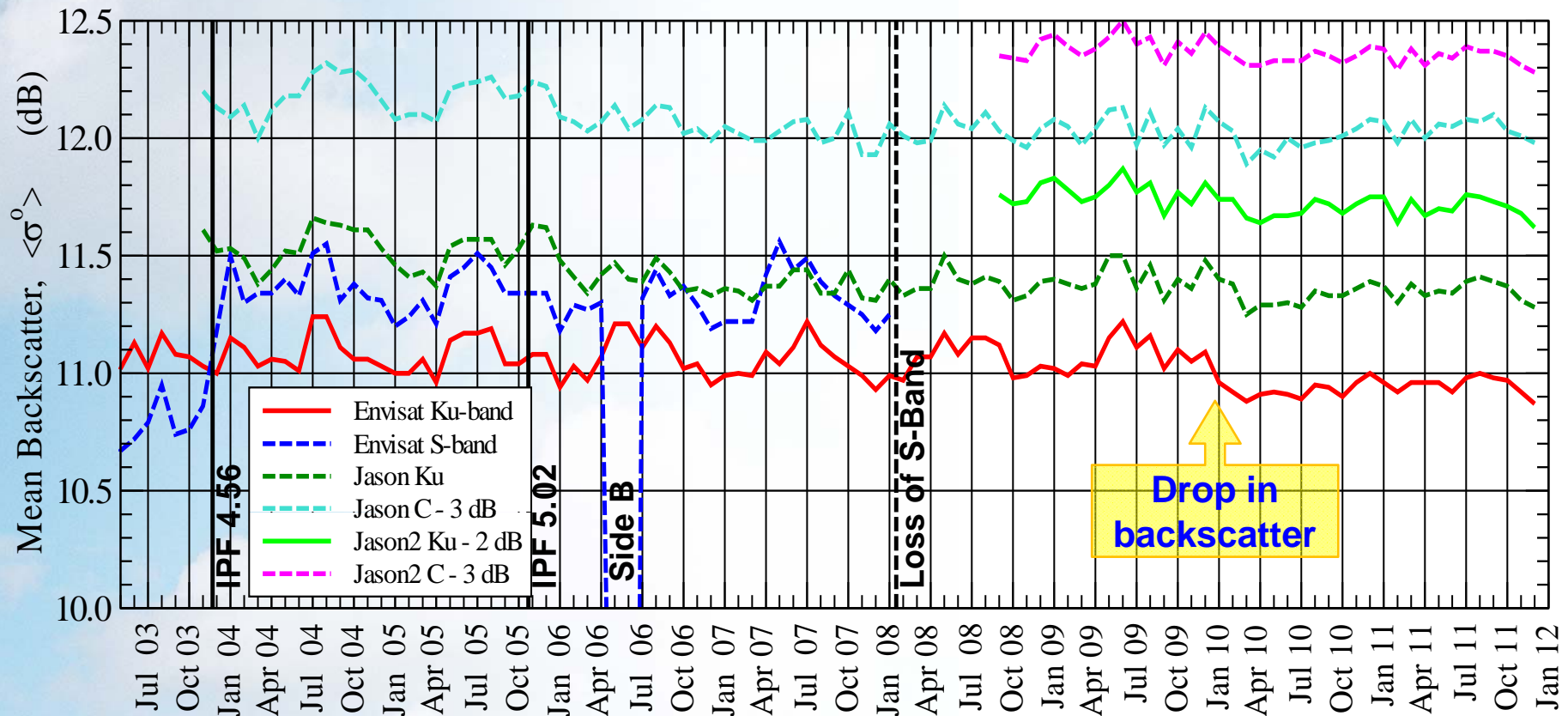
ECMWF

Altimeter Backscatter Drop in Late 2009

- ENSVISAT Ku-Band backscatter drop ~ 0.15 dB
- Jason-1 Ku-Band backscatter drop ~ 0.08 dB
- Jason-2 Ku-Band backscatter drop ~ 0.08 dB
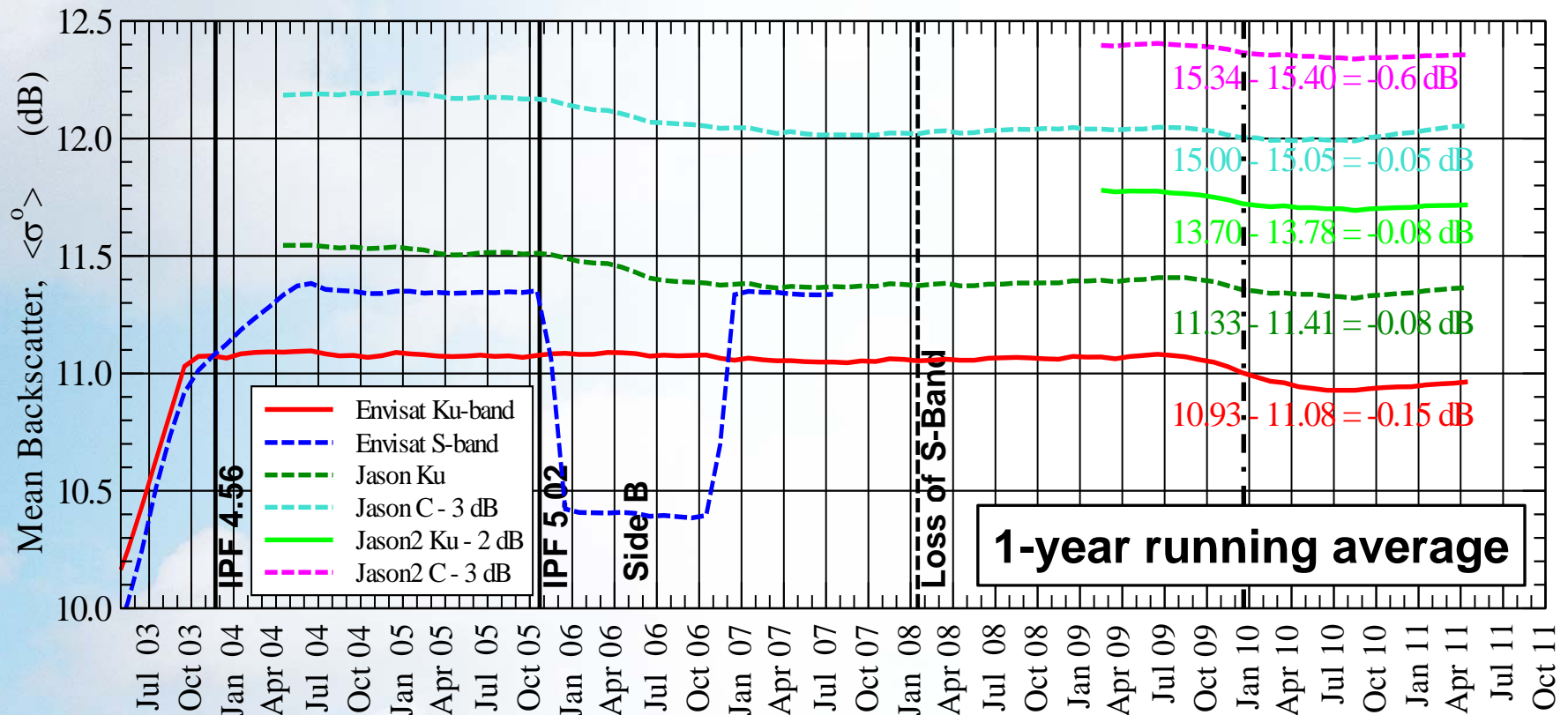
Jason-2 Wind Speed Comparison against ECMWF IFS Model - 2011

STATISTICS

ENTRIES	1470354
MEAN ECMWF	8.0597
MEAN JASON-2	8.2045
BIAS (JASON2 - ECMWF)	0.1448
STANDARD DEVIATION	1.2403
SCATTER INDEX	0.1539
CORRELATION	0.9424
SYMMETRIC SLOPE	1.0203
REGR. COEFFICIENT	0.9727
REGR. CONSTANT	0.3645

ECMWF

Global comparison between Altimeter and ECMWF analysis wind speed values

(From 02 February 2010 to 01 February 2011)
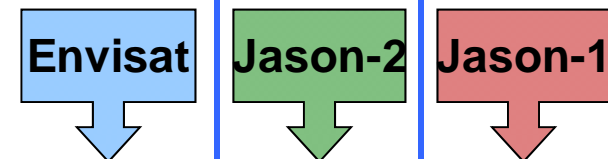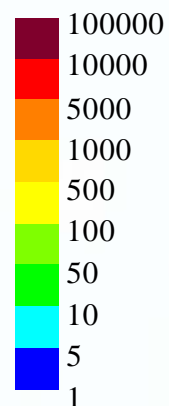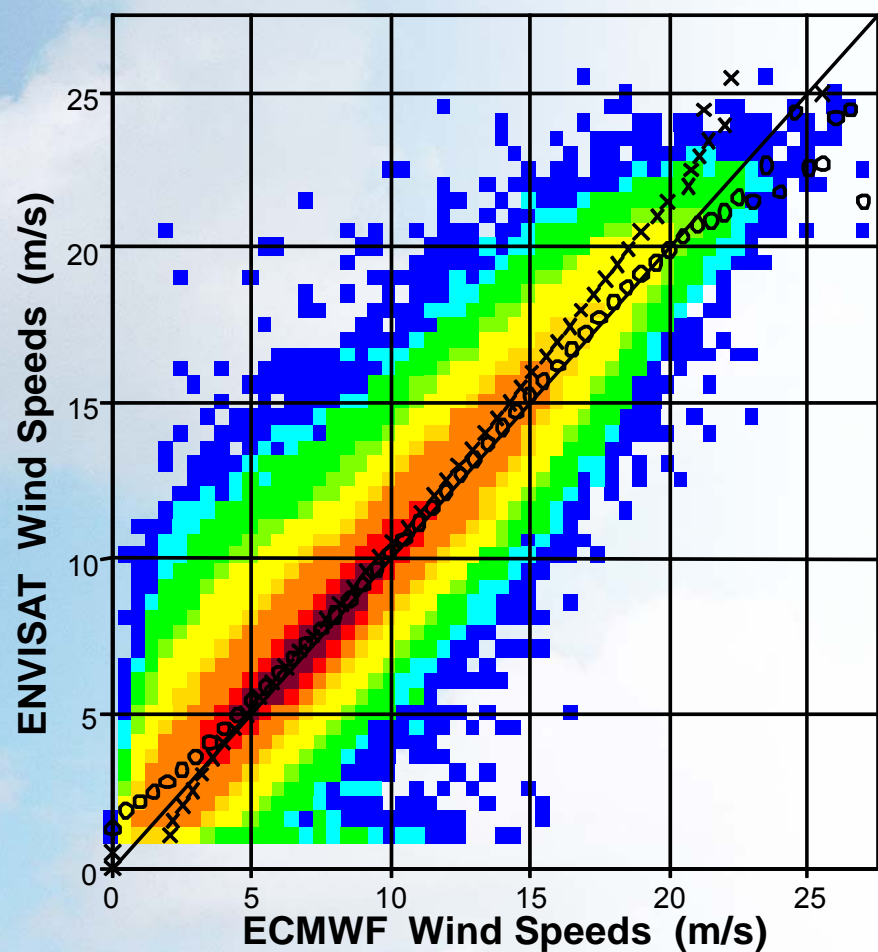
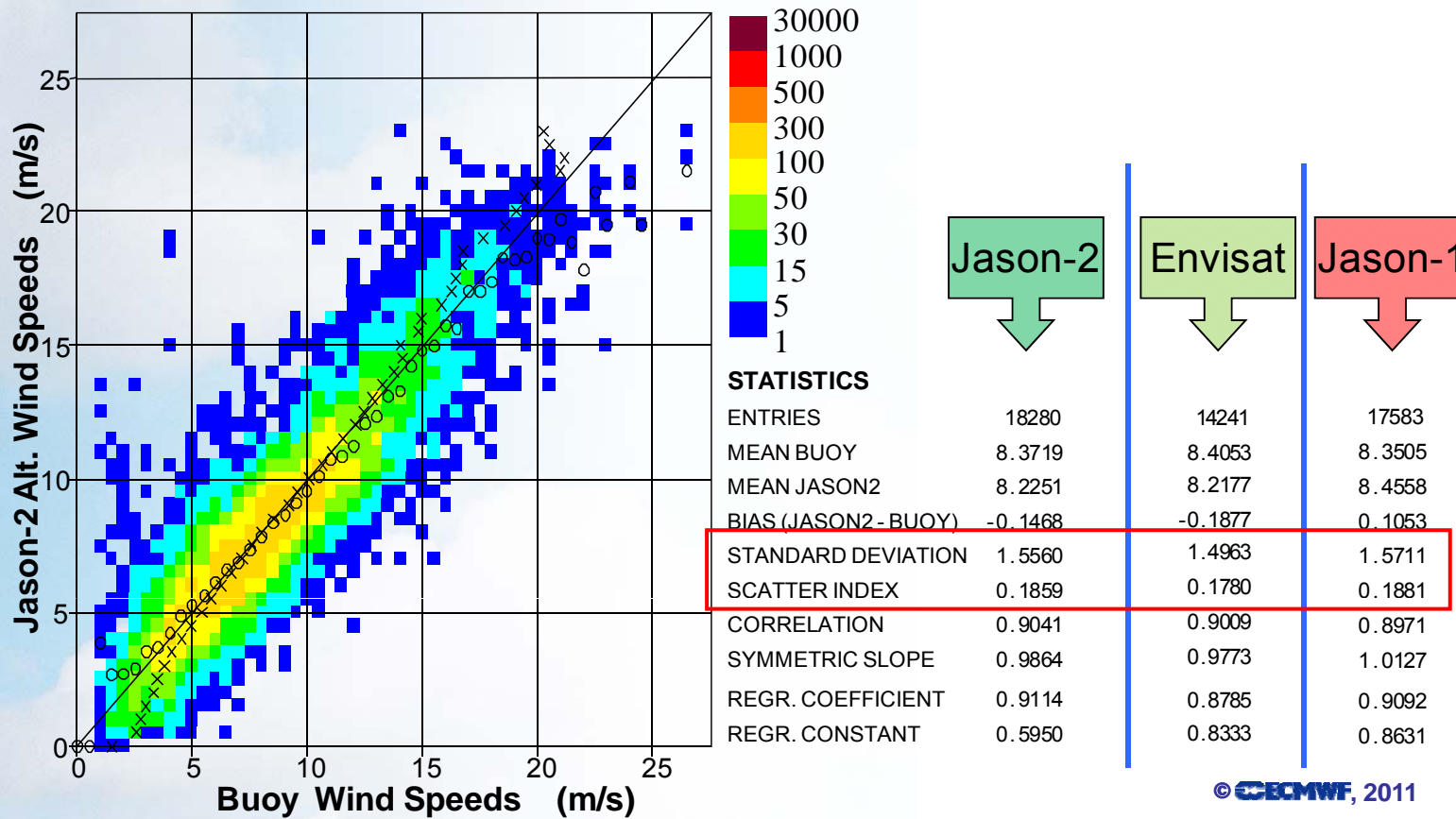| STATISTICS	Envisat	Jason-2	Jason-1
ENTRIES	1125908	1415821	1377085
MEAN ECMWF	7.8383	8.0747	8.0625
MEAN ENVISAT	8.1215	8.1891	8.4183
BIAS (ENVISAT - ECMWF)	0.2831	0.1143	0.3558
STANDARD DEVIATION	1.1275	1.2524	1.2596
SCATTER INDEX	0.1438	0.1551	0.1562
CORRELATION	0.9465	0.9418	0.9413
SYMMETRIC SLOPE	1.0333	1.0170	1.0438
REGR. COEFFICIENT	0.9639	0.9713	0.9808
REGR. CONSTANT	0.5663	0.3457	0.5103

ECMWF

Global comparison between altimeters and in-situ (buoy) surface wind speed values

(From 01 Sep. 2009 to 31 Aug. 2010)

| STATISTICS	Jason-2	Envisat	Jason-1
ENTRIES	18280	14241	17583
MEAN BUOY	8.3719	8.4053	8.3505
MEAN JASON2	8.2251	8.2177	8.4558
BIAS (JASON2 - BUOY)	-0.1468	-0.1877	0.1053
STANDARD DEVIATION	1.5560	1.4963	1.5711
SCATTER INDEX	0.1859	0.1780	0.1881
CORRELATION	0.9041	0.9009	0.8971
SYMMETRIC SLOPE	0.9864	0.9773	1.0127
REGR. COEFFICIENT	0.9114	0.8785	0.9092
REGR. CONSTANT	0.5950	0.8333	0.8631

© ECMWF, 2011

ECMWF

Time Series of Jason-1 Wind Speed Bias wrt ECMWF Model

Ocean Surface Topography Science Team Meeting, Venice, Italy, 27-28 Sep. 2012
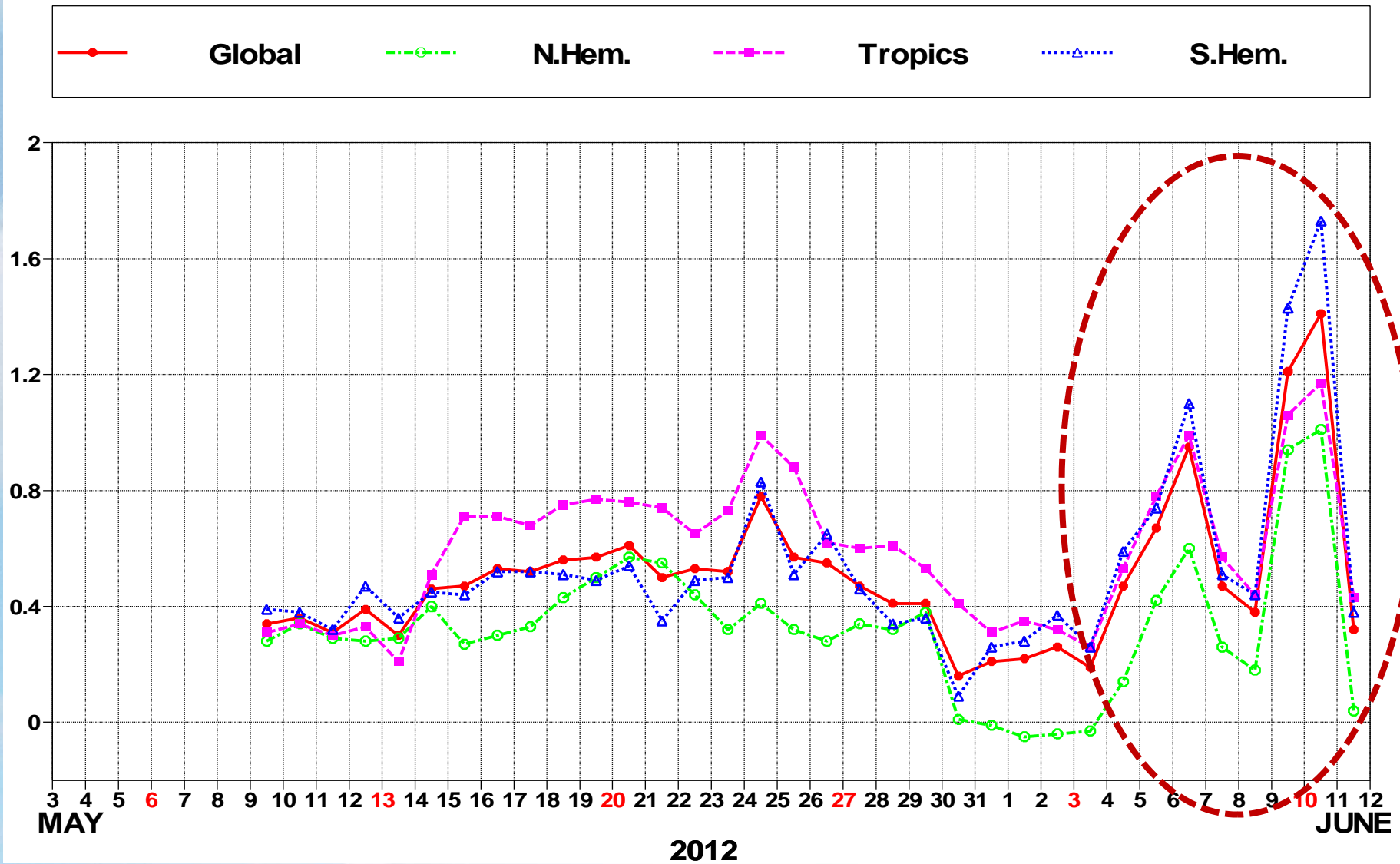
Global Comparison between Jason-1 and ECMWF Model Wind Speed for 1 Day (09 UTC 10 Jun – 09 UTC 11 Jun 2012)
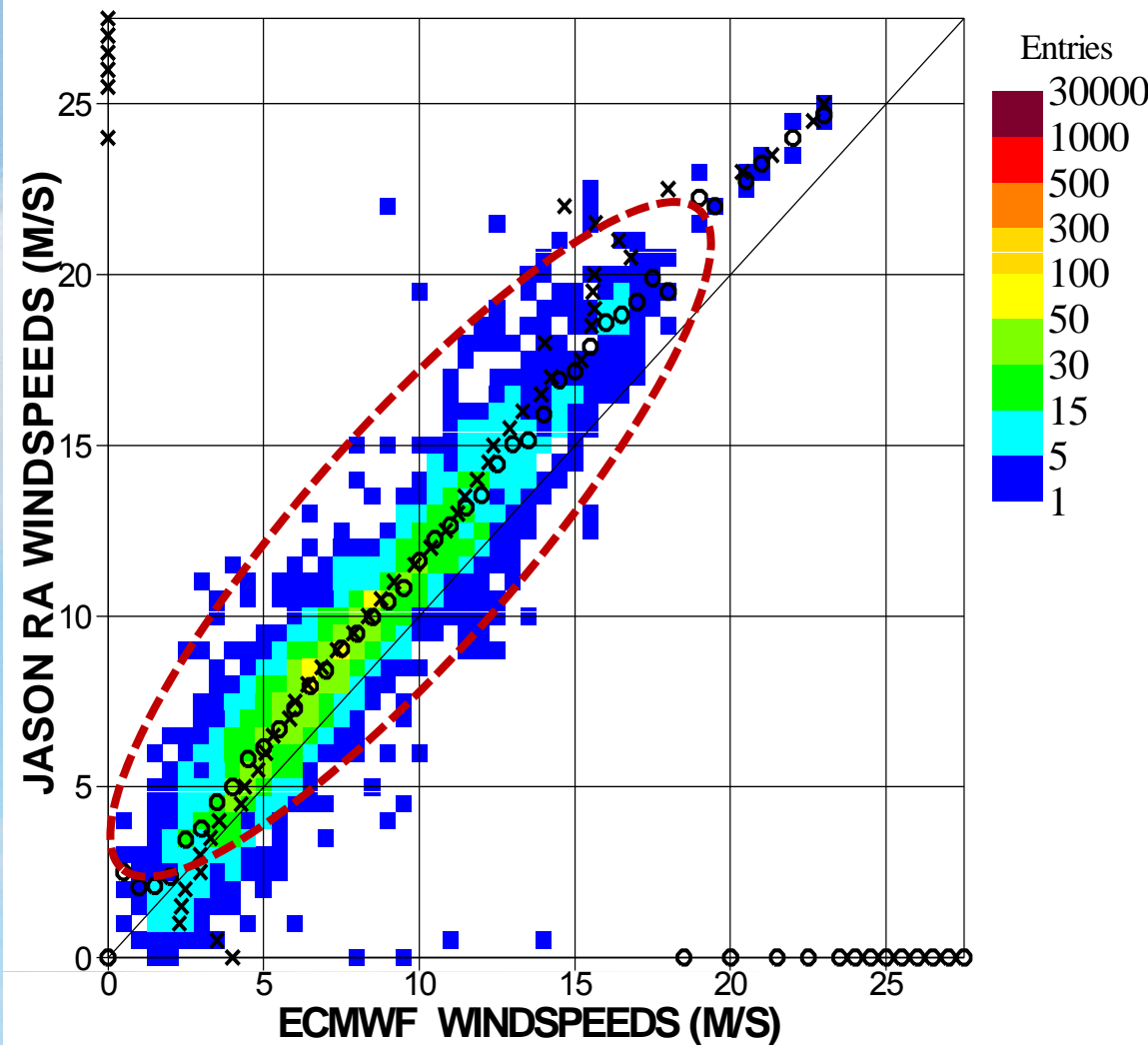
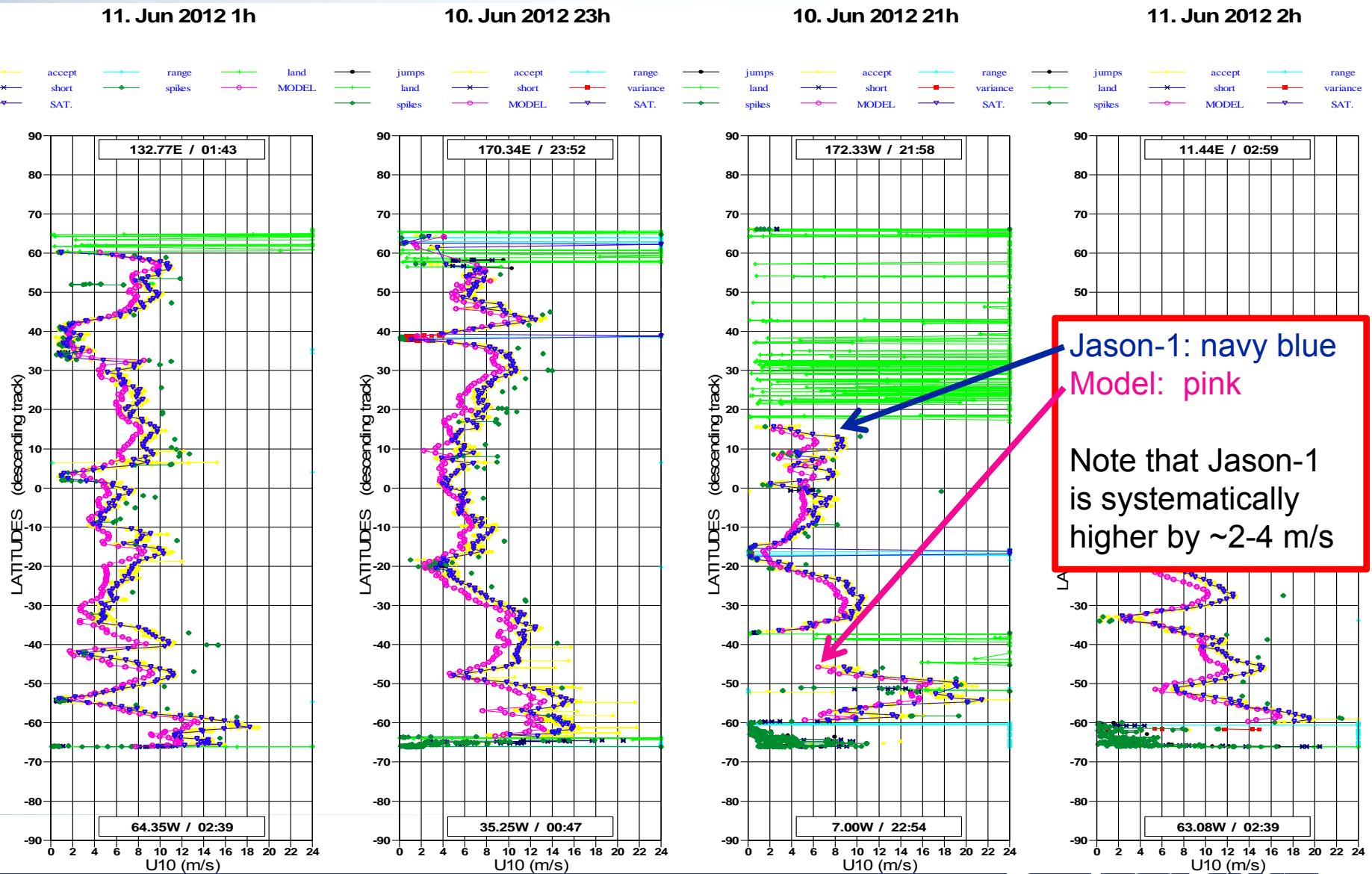**Typical daily scatter plot during the anomaly period. Note the high bias.**
(Std.Dev.Diff. and Scatter Index are nominal).

STATISTICS

ENTRIES	3988
MEAN ECMWF	7.6802
MEAN JASON	9.0866
BIAS (JASON - ECMWF)	1.4064
STANDARD DEVIATION	1.4347
SCATTER INDEX	0.1868
CORRELATION	0.9357
SYMMETRIC SLOPE	1.1807
REGR. COEFFICIENT	1.0934
REGR. CONSTANT	0.6891

ECMWF

Typical Along-Track Jason-1 and Model Wind Speed during the Anomaly Duration.

Jason-1: navy blue
Model: pink

Note that Jason-1 is systematically higher by ~2-4 m/s

Conclusions

- NRT Altimeter (~~ENVISAT FDMAR~~, Jason-1 OSDR and Jason-2 OGDR) wind and wave products are continuously monitored and verified at ECMWF.

- Significant wave height (SWH) products from the three altimeters are very good.

- Assimilation of NRT SWH ➔ positive impact on the model analysis and forecasts.

ECMWF

Conclusions *(Cont'd)*

● Assimilating SWH from 3 Altimeters (Jason-1, Jason-2 and ENVISAT):

   - shows improved positive impact; and

   - adds value to the availability of the data.

● SWH, wind speed and water vapour data products from Altimeters are invaluable for model verification and assessment.

© ECMWF, 2012

ECMWF