Cryosat-2 Wind & Wave Products: Preparation for Sentinel-3

Saleh Abdalla[1], Salvatore Dinardo[2], Jérôme Benveniste[3], Peter Janssen[1]

[1]European Centre for Medium-Range Weather Forecasts (ECMWF), UK. [2]Serco/ESRIN, Italy. [3]European Space Agency/ESRIN, Italy.

Introduction

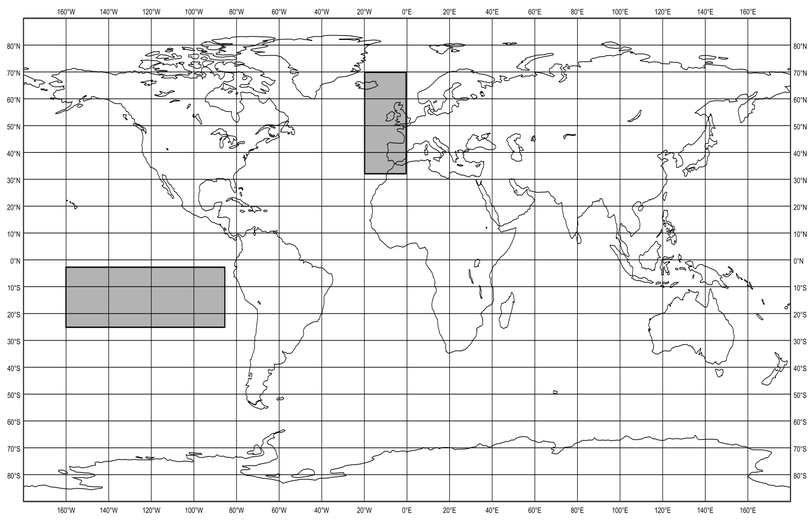
The altimeter significant wave height (SWH) and the surface wind speed measurements are of considerable importance for weather prediction either for assimilation or verification. In order maintain the usage of this source of information, Sentinel-3 radar altimeter (SRAL) wind and wave products will be used. Although SRAL is capable of operating in both conventional altimetry and in SAR mode, the decision was made to operate almost exclusively in Synthetic Aperture Radar (SAR) mode. As a preparation for Sentinel-3, SAR wind and wave data from CryoSat-2 (the first ever, and currently the only operating, mission with this capability) are verified.

The CryoSat-2 Fast Delivery LRM Ocean Level 2 (FDM) data over the vast majority of the ocean in conventional altimetry mode were verified and proved to be of high quality. The FDM SWH data have been assimilated operationally in the ECMWF ocean wave model since 11 May 2015.

Cryosat-2 SAR-Mode radar altimeter data based on SAMOSA ocean model from SAR Versatile Altimetric Toolkit for Ocean Research & Exploitation (SARvatore) are used here. The data cover two geographic boxes: one in the northeast Atlantic Ocean extending from 32°N to 70°N and from 20°W to the prime meridian (0°) and the other in eastern Pacific extending from 2.5°S to 25.5°S and from 160°W to 85°W (see the opposite map). The period extends from 6 September 2010 to 30 June 2014 for the Atlantic box and from 7 May 2012 to 30 June 2014..

Only 1-Hz Significant wave height and surface wind speed is considered here. The comparison is done at scales of about 70 km. Therefore, characteristics of finer scales are not part of this study.

Validation is done against ECMWF model (first-guess for waves & analysis for wind) and in-situ measurements. Results presented here are preliminary.



Significant Wave Height

CryoSat-2 SAR Mode significant wave height (SWH) compares quite well with the model and the in-situ measurements. It is as good as other conventional altimetry products (e.g. Jason-2; not shown). However, CryoSat-2 SAR SWH is about 5% higher than the model and about 3.5% higher than the in-situ measurements (and Jason-2, not shown) in the Atlantic box. Although, CryoSat-2 SWH in the Pacific box is almost unbiased compared to the model, it has a tendency to overestimate higher SWH.

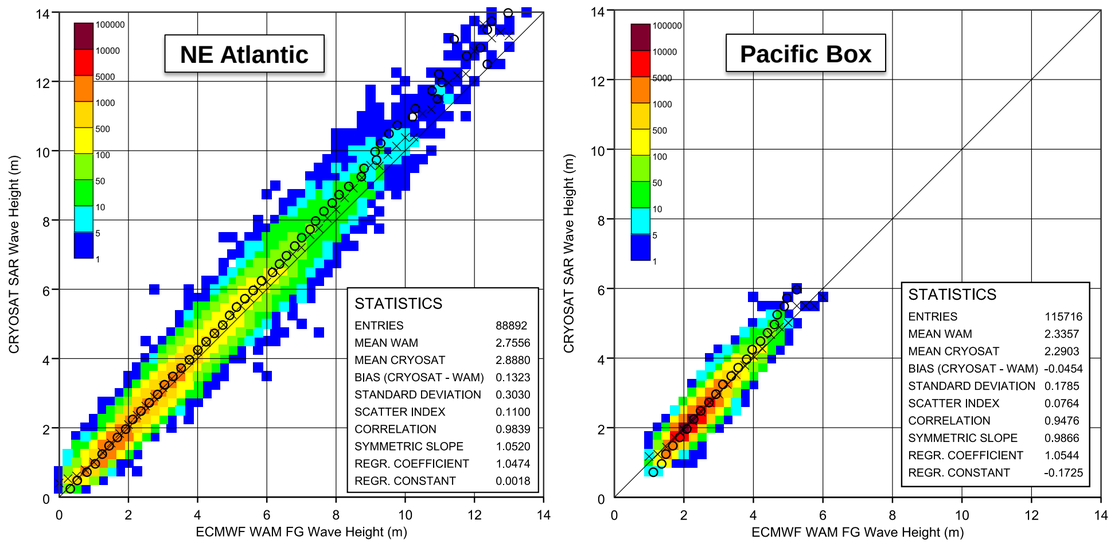


Fig. 1: Comparison between CryoSat-2 SAR and ECMWF model first-guess (FG) SWH values during the period from 6 September 2010 to 30 June 2014 in the NE Atlantic (left) and Pacific (right) boxes. The number of collocations in each 0.25 m x 0.25 m 2-D bin is color-coded as in the legend. The “x” symbols are the means of the bins for given x-axis values (model) while the “o” symbols are the means for given y-axis values (CryoSat).

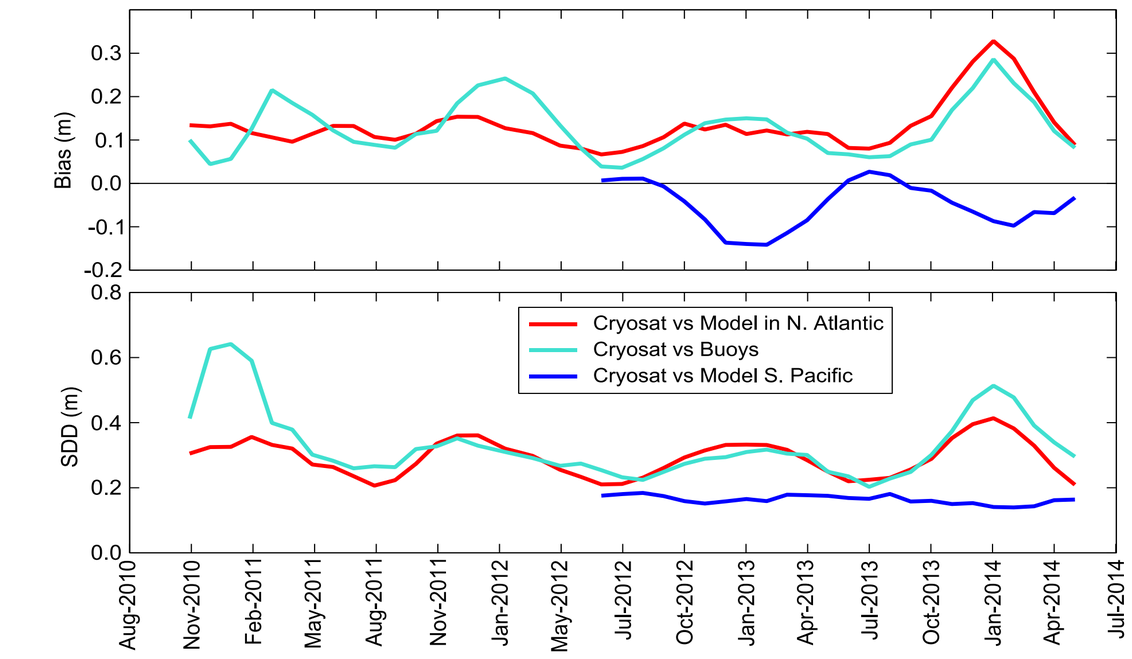


Fig. 2: Time series of monthly SWH bias defined as the altimeter - model (top) and the standard deviation of the difference, SDD, (bottom) between CryoSat-1 SAR and ECMWF model FG in the Atlantic and the Pacific boxes. Shown are 3-month running means.

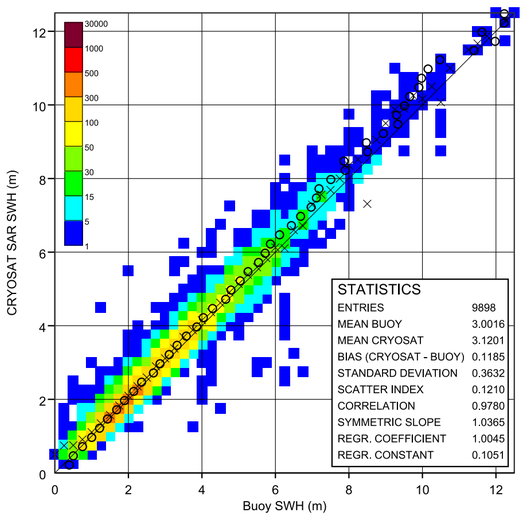


Fig. 3: Comparison between CryoSat-2 SAR and in-situ (buoy) SWH values in the Atlantic box during the period from 6 September 2010 to 30 June 2014. *(See Fig. 1 for the colour coding and the “x” and “o” symbols.)*

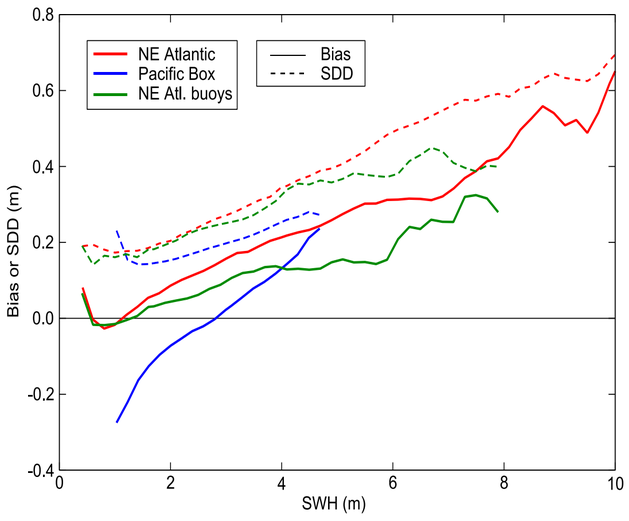


Fig. 4: Comparison between CryoSat-2 SAR SWH and model FG as well as in-situ (buoy) values at various SWH regimes during the period from 6 September 2010 to 30 June 2014. The buoy comparison is limited to the Atlantic box.

Surface Wind Speed

CryoSat-2 SAR Mode surface wind speed compares quite well with the model and the in-situ measurements. It is has negligible bias with respect to the model (~0.1 m/s) and slight bias compared to the in-situ data (~0.3 m/s) in the Atlantic box. CryoSat-2 wind speed is slightly higher than the model (~0.3 m/s) with few outliers in the Pacific box. It is as good as other conventional altimetry products (e.g. Jason-2; not shown), if not better at times.

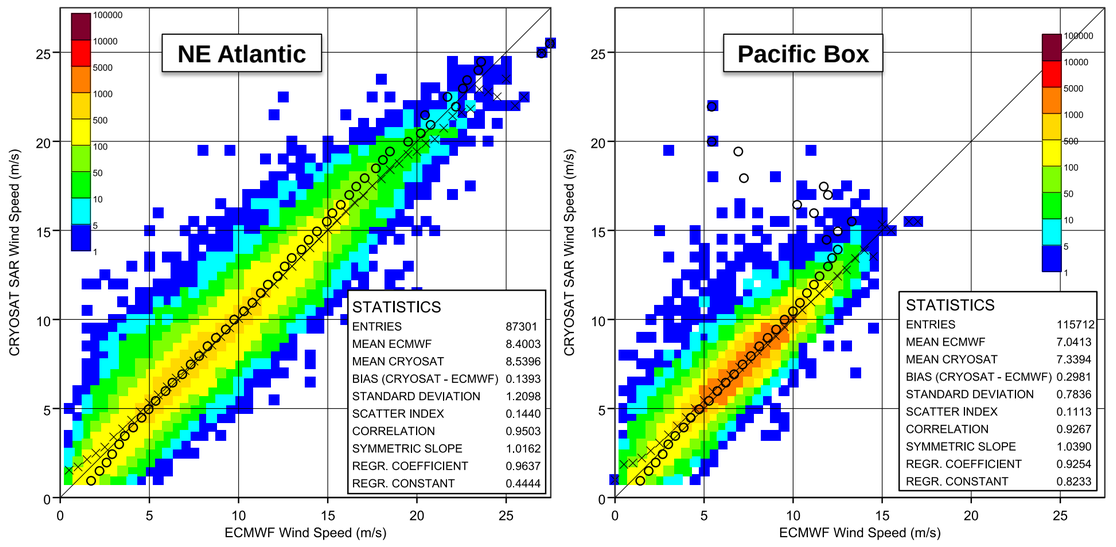


Fig. 5: Comparison between CryoSat-2 SAR and ECMWF model analysis (AN) surface wind speed values during the period from 6 September 2010 to 30 June 2014 in the Atlantic (left) and Pacific (right) boxes. The number of collocations in each 0.5 m/s x 0.5 m/s 2-D bin is color-coded as in the legend. *(See Fig. 1 for the “x” and “o” symbols.)*

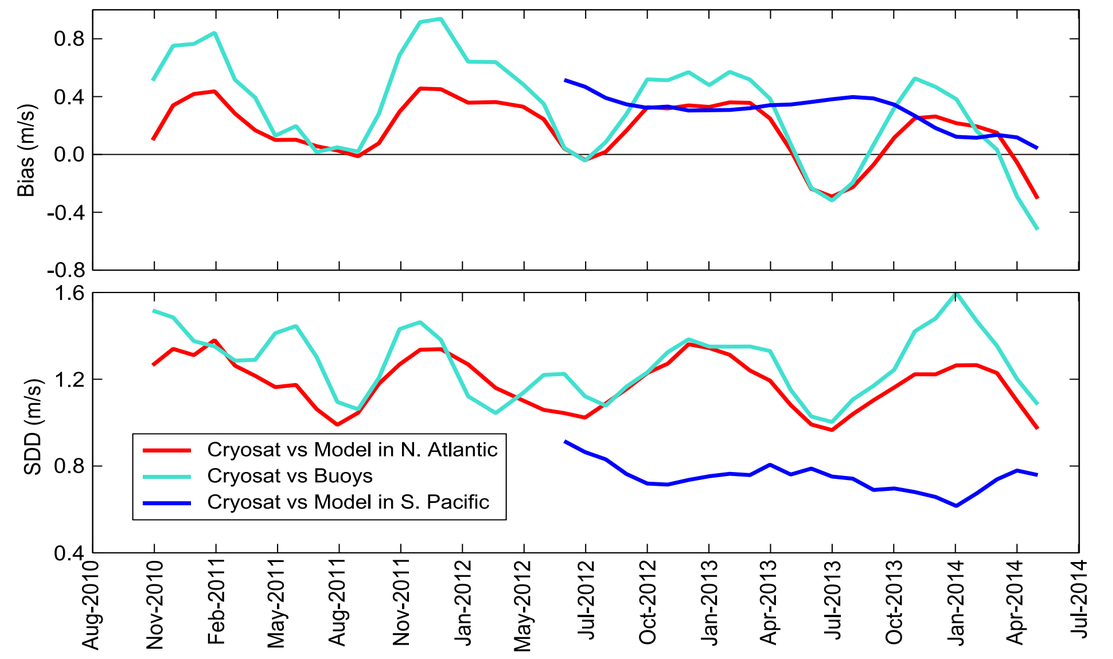


Fig. 6: Time series of monthly wind speed bias defined as the altimeter - model (top) and the standard deviation of the difference, SDD, (bottom) between CryoSat-1 SAR and ECMWF model AN in the Atlantic and Pacific boxes. Shown are 3-month running means.

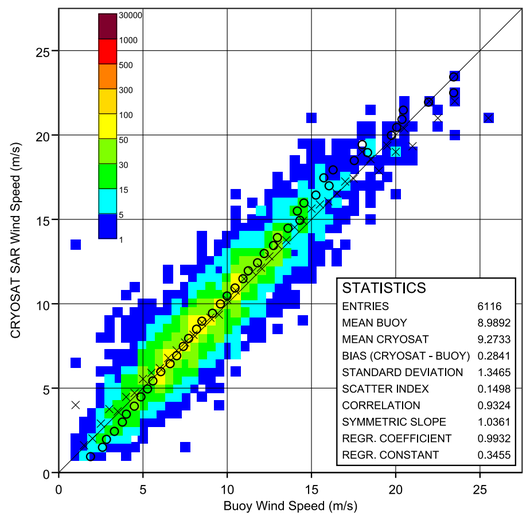


Fig. 7: Comparison between CryoSat-2 SAR and in-situ (buoy) wind speed values in the Atlantic box during the period from 6 September 2010 to 30 June 2014. *(See Fig. 4 for the colour coding and Fig. 1 for the “x” and “o” symbols.)*

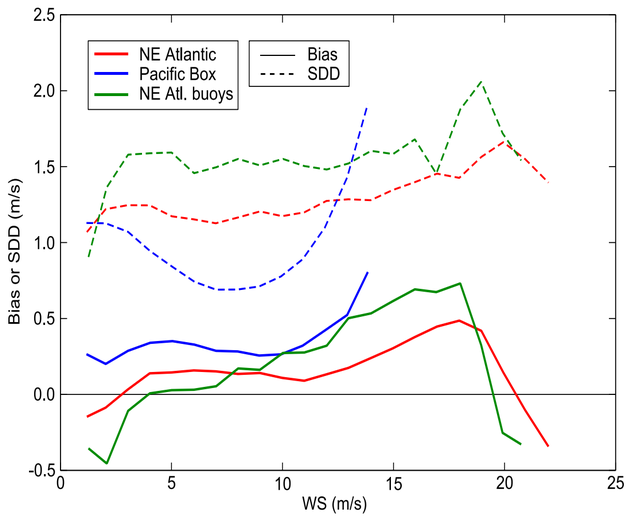


Fig. 8: Comparison between CryoSat-2 SAR wind speed and model FG as well as in-situ (buoy) values at various wind speed regimes during the period from 6 September 2010 to 30 June 2014. The buoy comparison is limited to the Atlantic box.

Concluding Remarks

- Preliminary results show that wind and wave products from the Cryosat-2 SAR mode are of good quality.
- Both products are similar to their counterparts from conventional altimeters (e.g. Jason-2).
- These results are based on scales in excess of 70 km. Finer scales were not investigated.

The help of Bruno Lucas (ESRIN) in obtaining the Cryosat-2 SAR-Mode altimeter products is highly appreciated.

For more info about SARvatore: Dinardo, S. (2015). “GPOD CryoSat-2 SARvatore Software Prototype User Manual”. Online at: https://wiki.services.eoportal.org/tiki-index.php?page=GPOD+CryoSat-2+SARvatore+Software+Prototype+User+Manual