WAVE HEIGHT MEASUREMENTS FROM ALTIMETERS: VALIDATION STATUS & APPLICATIONS

Ifremer

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From ERS-1 to Jason-2, twenty years of altimeter wave height measurements are available. For an easier access to these multi-altimeter data, a simplified homogeneous data base was developped. ftp://ftp.ifremer.fr/ifremer/cersat/products/swath/altimeters/waves

The goal is to gather, in the same format, significant wave height (SWH) and wind speed measurements from the various altimeters and space agencies in order to construct homogeneously validated and calibrated data sets. This work is also a contribution to the ESA GLOBWAVE project www.globwave.org

Validation and calibration of altimeter wave height measurements are regularly updated. Recent results are presented for in-flight altimeters Jason 1&2, ENVISAT and ERS-2 (though ERS-2 mission ended in July 2011).

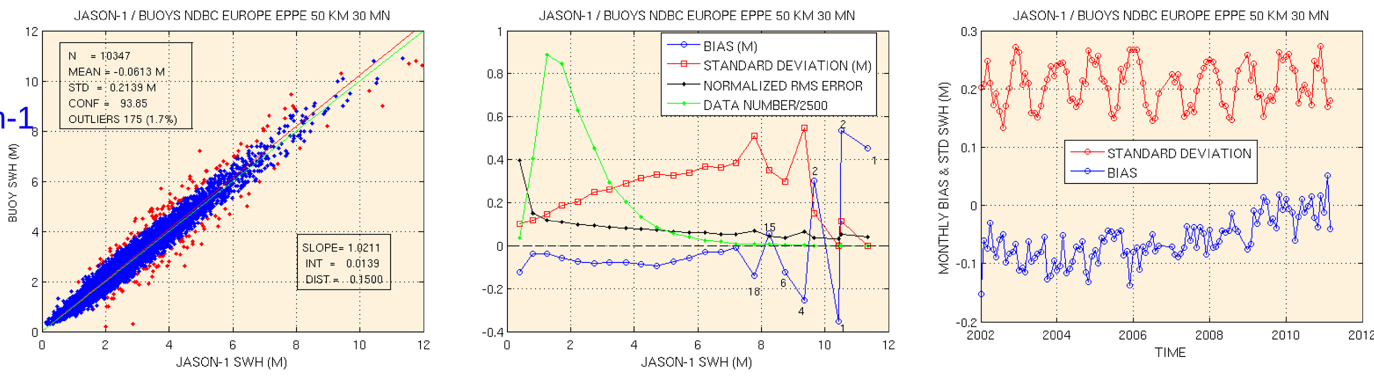
Main change concerns the calibration of the ENVISAT RA-2 new V2.1 processing implemented in January 2010: the wave height GDR exhibits a non-linear behavior at low wave height, relative to buoy and Jason-1 measurements.
A new correction is proposed.
The whole data base will be updated as soon as the V2.1 processing is completed.

Some applications of the merge altimeter SWH data base are presented in three different domains
- validation and improvment of wave modelling
- analysis of long term wave height anomalies
- observation of very high sea states in the North Atlantic Ocean in February 2011

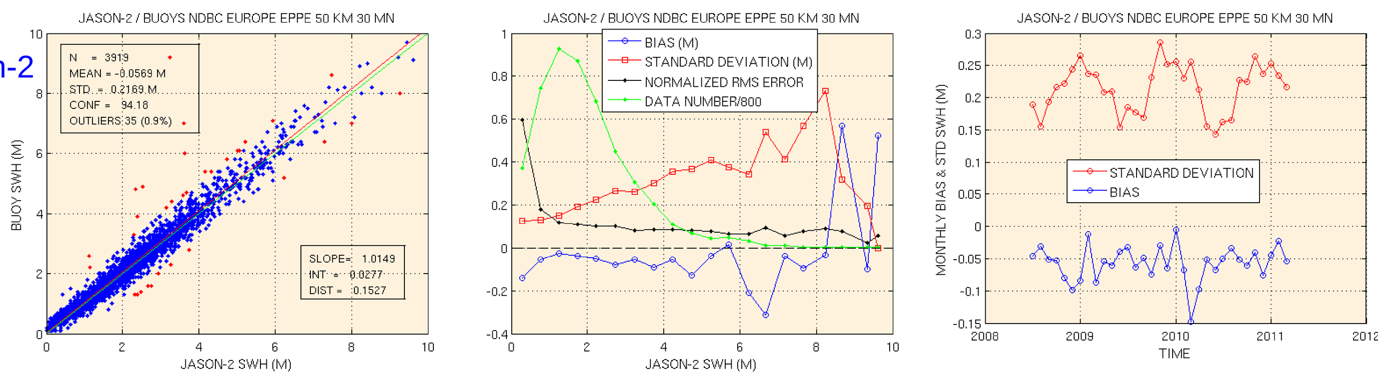
SWH UPDATED VALIDATIONS

buoy data comparisons, using classical collocation criteria : 30 min and 50 km maximum time space differences, 50 km along-track averaging

Jason-1

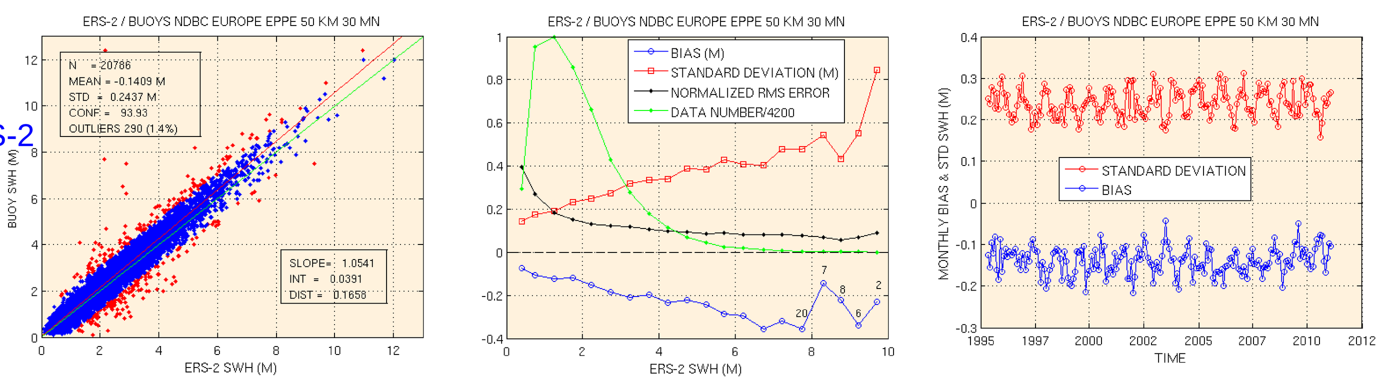


Jason-2



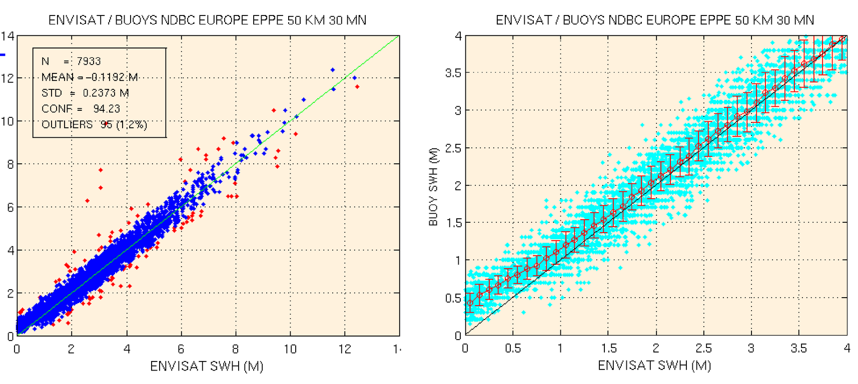
Jason-1&2 SWH are in good agreement with buoy SWH: 6 cm mean bias; 21 cm standard deviation
Slight trend of the monthly Jason-1 bias since year 2006. Seasonal modulation of the monthly std.

ERS-2

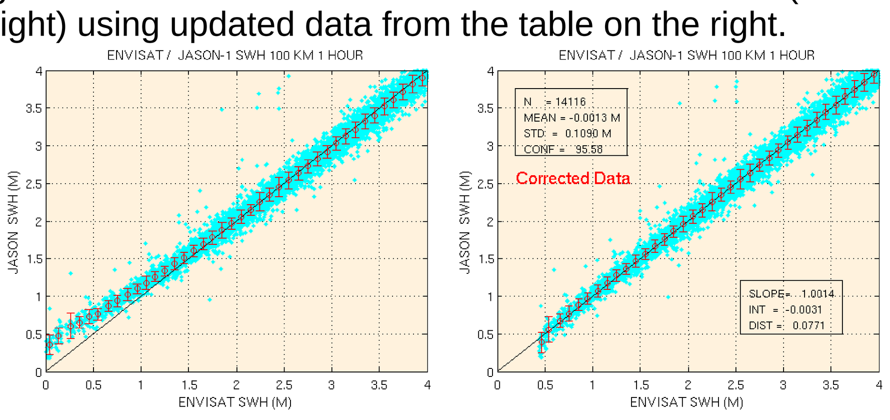


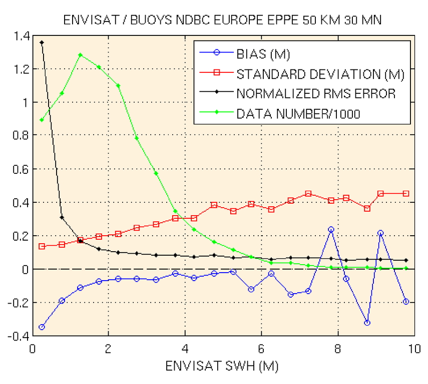
ERS-2 swh bias is larger: mean 14 cm; 24 cm standard deviation.The negative bias increases significantly with SWH. The monthly mean bias is very steady along the whole mission.

ENVISAT



Zoom on the 4 m SWH range shows the non-linearity of ENVISAT at low SWH (top right). This is confirmed on the ENVISAT Jason-1 comparison (bottom left). Agreement is good when both Envisat and Jason-2 are corrected (bottom right) using updated data from the table on the right.

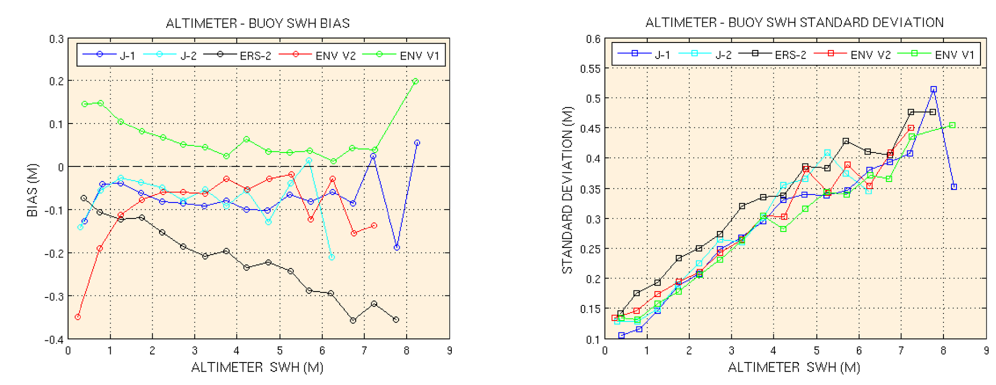




Altimeter GDR SWH updated corrections

SWH correction : $\sum A_i SWH^i$	A_0	A_1	A_2	A_3
JASON-1 updated GLOBWAVE	0.0139 0.0588	1.0211 1.0250		
JASON-2 updated GLOBWAVE	0.0277 -0.0420	1.0149 1.0410		
ERS-2 updated GLOBWAVE	0.0391 0.0006	1.0541 1.0642		
ENVISAT GLOBWAVE (V1) updated (V2) SWH >3.41 m updated (V2) SWH <3.41 m	-0.1935 0.0192 0.4358	1.0585 1.0095 0.5693	 0.1650	 -0.0210

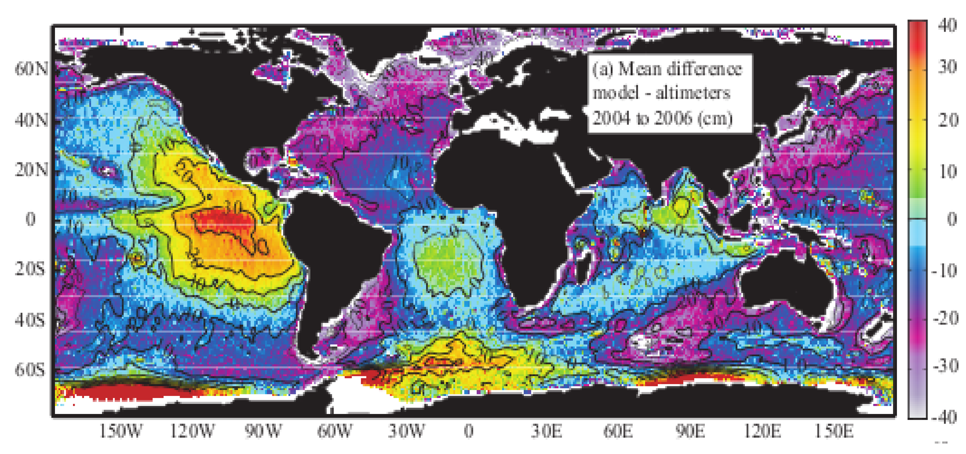
Summary comparison of altimeter / buoy swh biases and difference std



Note the opposite swh biases of ENVISAT version V1 and V2

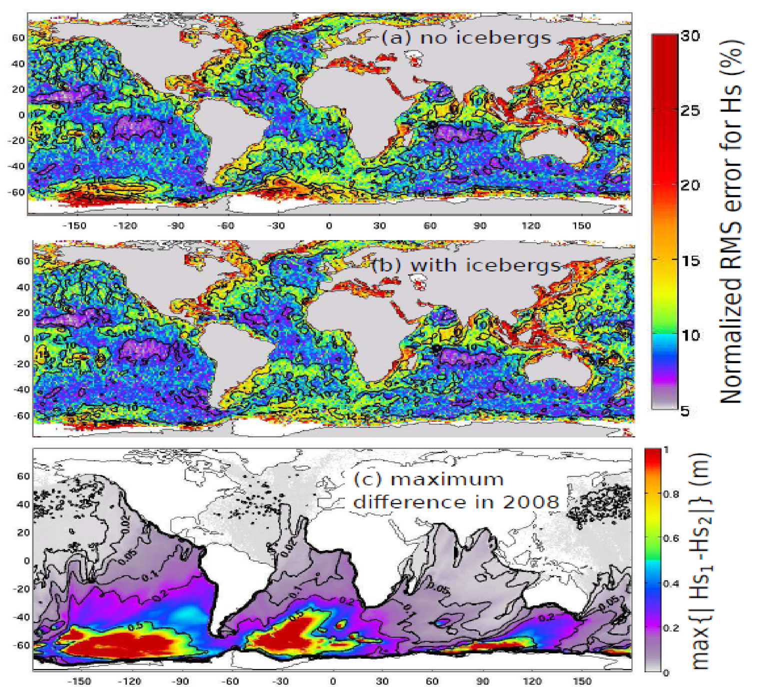
TWO EXAMPLES OF APPLICATIONS OF MERGED ALTIMETER SWH DATA TO WAVE MODELLING VALIDATION AND IMPROVMENT

IMPROVMENT OF THE SWELL ATTENUATION TERM



Map of SWH mean bias between WaveWatch-III (ECMWF parameterization, Bidlot et al. 2005) and JASON-1, ENVISAT and GFO altimeters, over 3 years, 2004-2006 (Rascle et al. 2008).
The large and systematic over-estimation of SWH in the eastern equatorial Pacific Ocean, up to 40 cm, revealed a default in the long swell attenuation modelling. A new term was estimated to correct for that, using SAR data (Ardhuin et al. 2010) .
Note also the over-estimation of SWH in the southern part of the oceans, mainly due to the effect of icebergs (see on the rigtht figures)

MODELLING THE IMPACT OF ICEBERGS ON SWH



Analysis of altimeter waveforms enables to detect small-size icebergs and to estimate their distribution (Tournadre et al. 2008, *see also the poster in this session*).

A significant correlation was then observed between the iceberg distributions and the bias between modelled swh and altimeter measurements, revealing the attenuation of waves in the presence of icebergs.

A wave iceberg attenuation modelling term was introduced in WaveWatch-III (Ardhuin et al. 2011).

The two upper maps above show the improvment of the normalized rms error between model and altimeters in southern oceans when modelling the iceberg impact.

Bottom map shows maximum values of differences rising to almost 1 m, over large southern ocean areas.

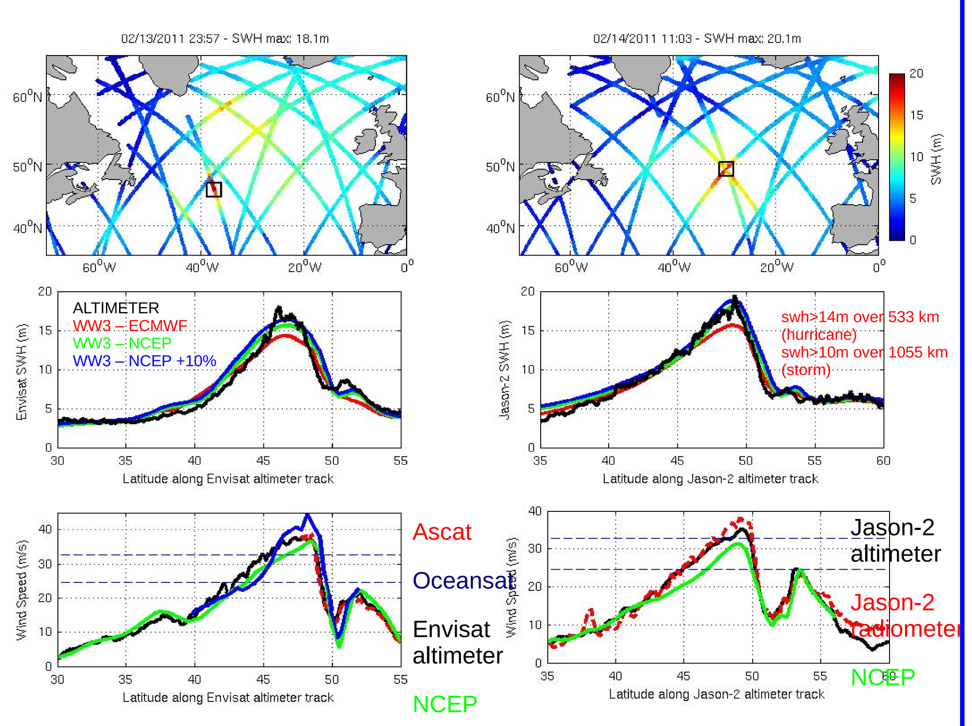
EXAMPLE OF APPLICATIONS OF MERGED ALTIMETER SWH DATA TO OBSERVATION OF PHENOMENAL SEA STATES IN NORTH ATLANTIC STORMS FEBRUARY 2011 (*see also Jenny Hanafin et al.poster, this session*)

Extreme sea states were observed over the North Atlantic Ocean in February 2011. During nine consecutive days (February 7 to 15) the along-track significant wave height measurements from available satellite altimeters (ERS-2, ENVISAT, Jason-1 and Jason-2) were larger than 12 meters over many wide areas included in a larger global region defined by 50°W-10°W in longitude and 40°N-60°N in latitude.

The maximum 1 Hz altimeter SWH was measured to 18.1 m by ENVISAT on 13 February (left), and to 20.1 m by Jason-2 on 14 February (right). This is the highest consistent altimeter swh ever measured. Such high altimeter SWH values have never been validated but along track consistency (i.e. no jump or anomaly) suggests a real feasibility. Note that the 1 Hz standard deviation of measurements was 1.5 m for the Jason-2 maximum SWH of 20.1 m.

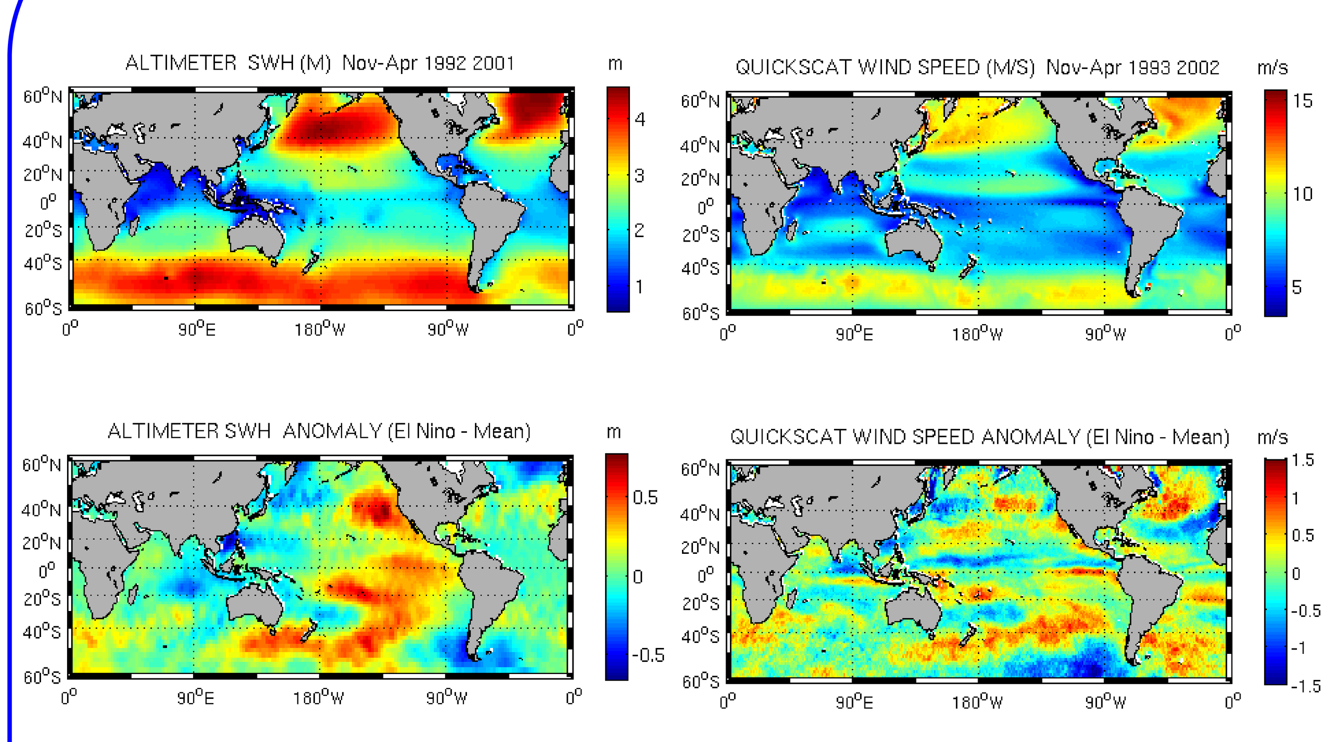
Along-track altimeter SWH are reported (black) on middle panels for ENVISAT and Jason-2, together with WaveWatch-III model output using ECMWF (red), NCEP (green), or 10% increased NCEP (blue) winds, indicating some difficulty in modelling such high sea states.

The two bottom panels present along-track interpolated wind speed from ASCAT, OCEANSAT, altimeter, radiometer and NCEP.



(Hanafin et al. in prep.)

EXAMPLE OF APPLICATIONS OF MERGED ALTIMETER SWH DATA: ANOMALIES OF SWH FIELDS DURING EL NINO 1997-1998



Calibrated and corrected SWH data of the various altimeters are used to estimate monthly SWH mean values on a global regular grid, 2°x2° resolution in latitude and longitude, collecting altimeter data within 300 km of each grid point. The spatial resolution of such a grid depends on the altimeter sampling (poor because of a narrow footprint), on the number of inflight altimeters, on their relative phasing, and on latitude. Nevertheless such maps are useful to analyse the large scale seastate variability over the oceans.

The figures illustrate the impact of the 1997-1998 El Nino event on SWH. On the left are reported the mean value of SWH for months of November to April, over years 1992 to 2001 (top, left) and the anomaly for the 1997-1998 year (bottom, left). During this El Nino event large patterns of SWH anomaly are observed. SWH decreases in Southern and Northern Atlantic, while strong enhancements of SWH are observed, particularly in the south of New Zealand, the Polynesian archipelago and the Eastern subtropical North Pacific. Such SWH increases over the Polynesian region have devastating effect because of fragile low island environment.

Almost similar wind patterns are revealed by the QuikScat data (right) in the Southern Pacific. The correlation between wind and wave patterns is lower in the Atlantic and in the Eastern subtropical North Pacific, which could be due to the relative level of wind sea and swell, according to the region.

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