Calibration and validation of **wave models** using **Hs, sigma0** and **iceberg** data from altimeters

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This work is funded under NOPP (ONR grant N00014-10-1-0383)
And ERC Young investigator award « IOWAGA » (240009)

Integrated Ocean Waves for Geophysical and other Applications

IOWAGA is mostly funded by FP7-ERC

Ifremer

A few words on numerical wave modelling …

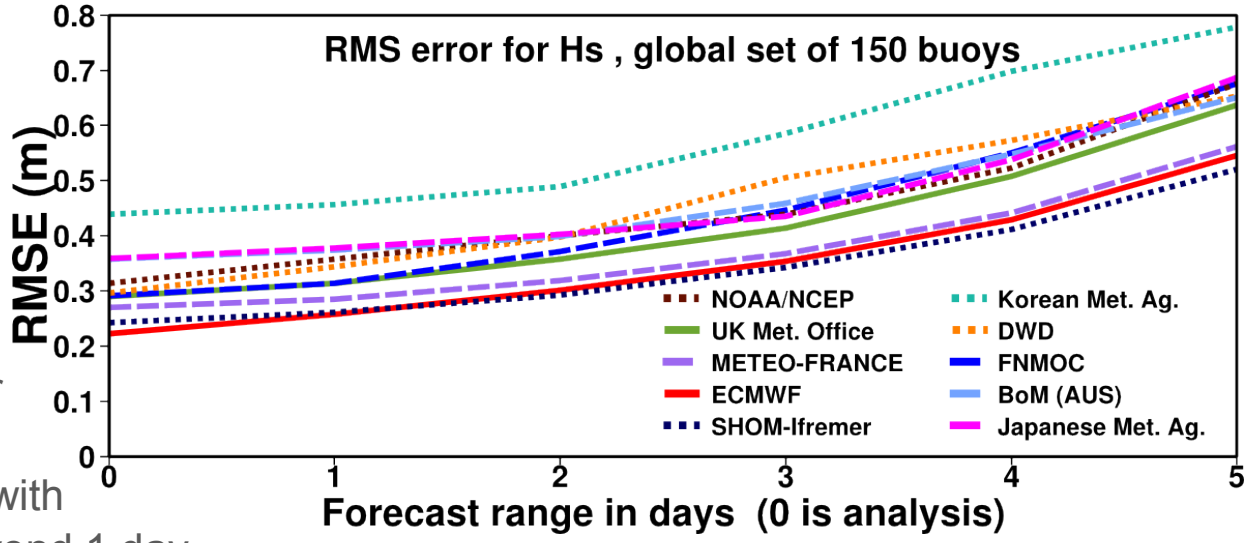
Wave models predict the **statistical properties** of the sea surface via the directional wave spectrum. From this we derive the **significant wave height** (Hs) and many other parameters (mean square slope, velocities, spectrum of infragravity waves …) that can also be of used for **remote sensing**.

Efforts today, in the IOWAGA project and elsewhere, focus on :

- improving models
- extending their capabilities:

-wave breaking statistics …

Example of improvement:
- new parameterizations (Ardhuin et al. JPO 2010) without data assimilation at SHOM-Ifremer & METEO-FRANCE lead to better results that old parameterizations with D.A. at ECMWF , for forecasts beyond 1 day



JCOMM wave model verification. Picture adapted from J.-R. Bidlot
See JCOMM web site for more

NB: All three models use the same winds (but different resolutions)
Differences with others are mostly due to driving winds...

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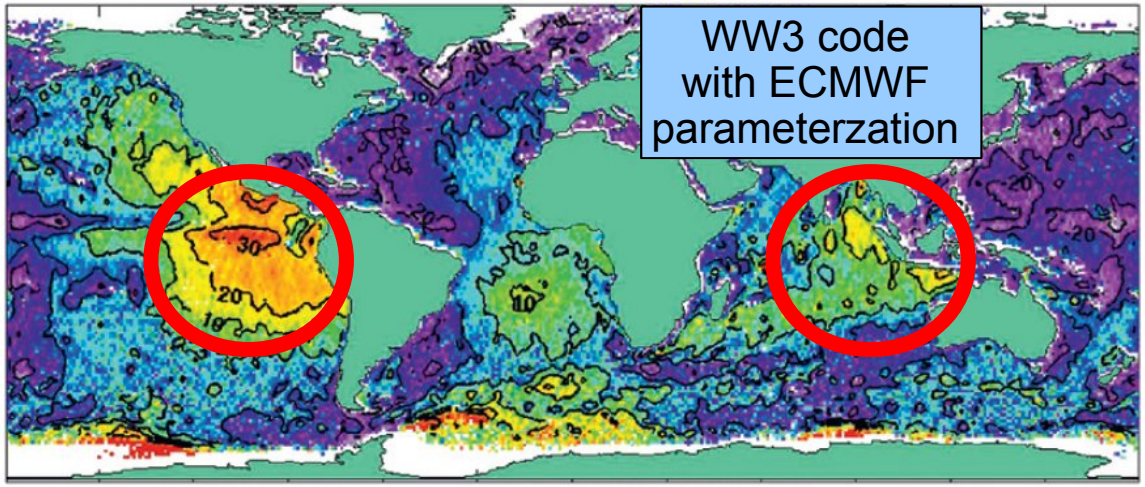
The global view: Swells, storms and ice cubes

1. Global wave model errors

a. swells

Thus, wave models are getting better every year … thanks to altimeters and SARs:

Model bias for Hs in meters, as compared to altimeters for 2007 (GFO, JASON, Envisat)



ECMWF operational parameterization (2005-2009) used in the WAVEWATCH III model.
This is a **FREE RUN** (no D.A.)
Resolution is 0.5 degree

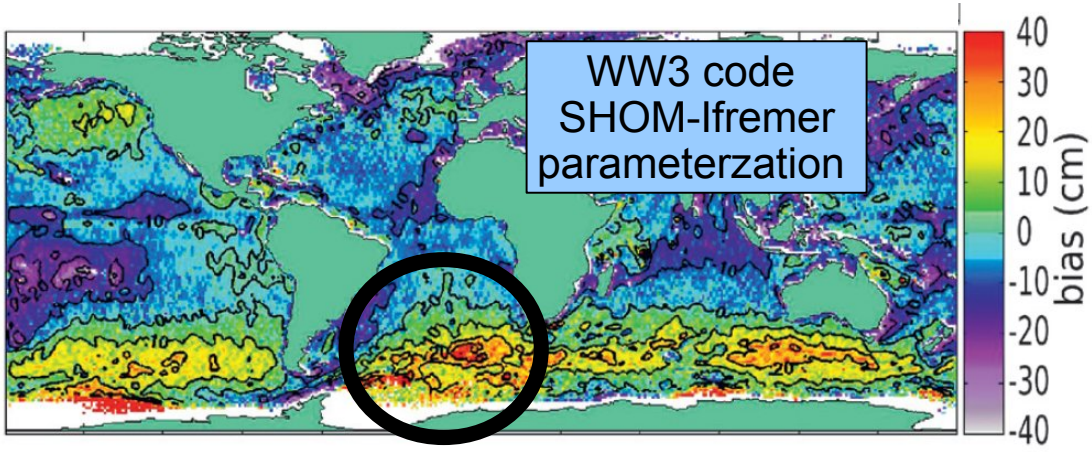
(figure 9 in Ardhuin et al. JPO 2010, Copyright Am. Met. Soc).

Tolman (2000) had already shown that the « ECMWF » parameterization **do not dissipate swells** properly: swell energy piles up un the tropics (red circles). In operational runs, this is corrected by D.A. at every cycle.

Using SAR data, swell dissipation was measured and parameterized (Ardhuin, Chapron, Collard GRL 2009).

New model performs better everywhere in terms of RMS error... but funny bias in the **South Atlantic** (black circle)

What's up down there?

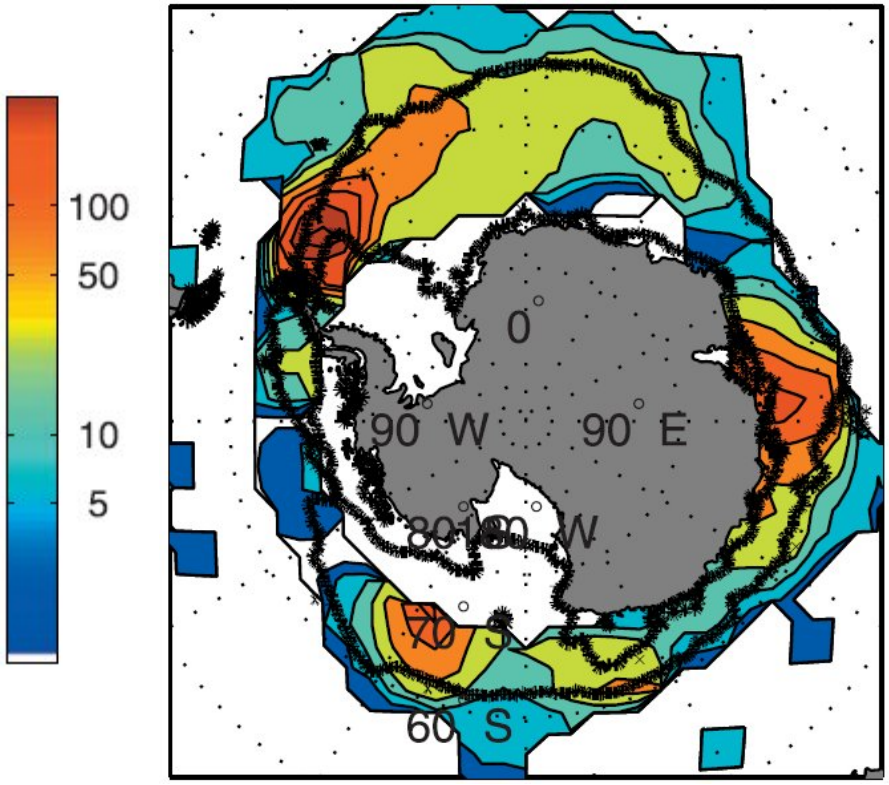


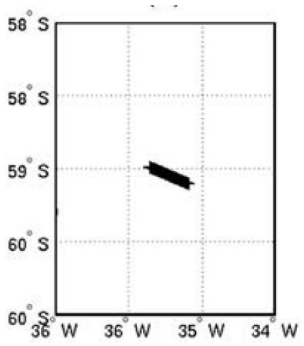
1. Global wave model errors

b. Icebergs

At the same time, Tournadre et al. (JGR 2008) found a trick to detect « small » icebergs

Number of icebergs per 200 x 200 km tile of the ocean, for January-March 2004 *(Taken from Tournadre et al. 2008).*





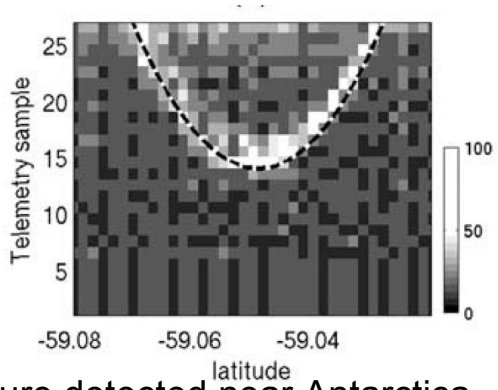


Figure 2. Iceberg signature detected near Antarctica on Jason cycle 143 pass 49, 25 November 2005. (a) Geographical location of Ku band waveforms for telemetry samples 1 to 30 (thermal noise). (b) The dashed line represents the best fit for a 8.5-m-high iceberg located at the satellite nadir.

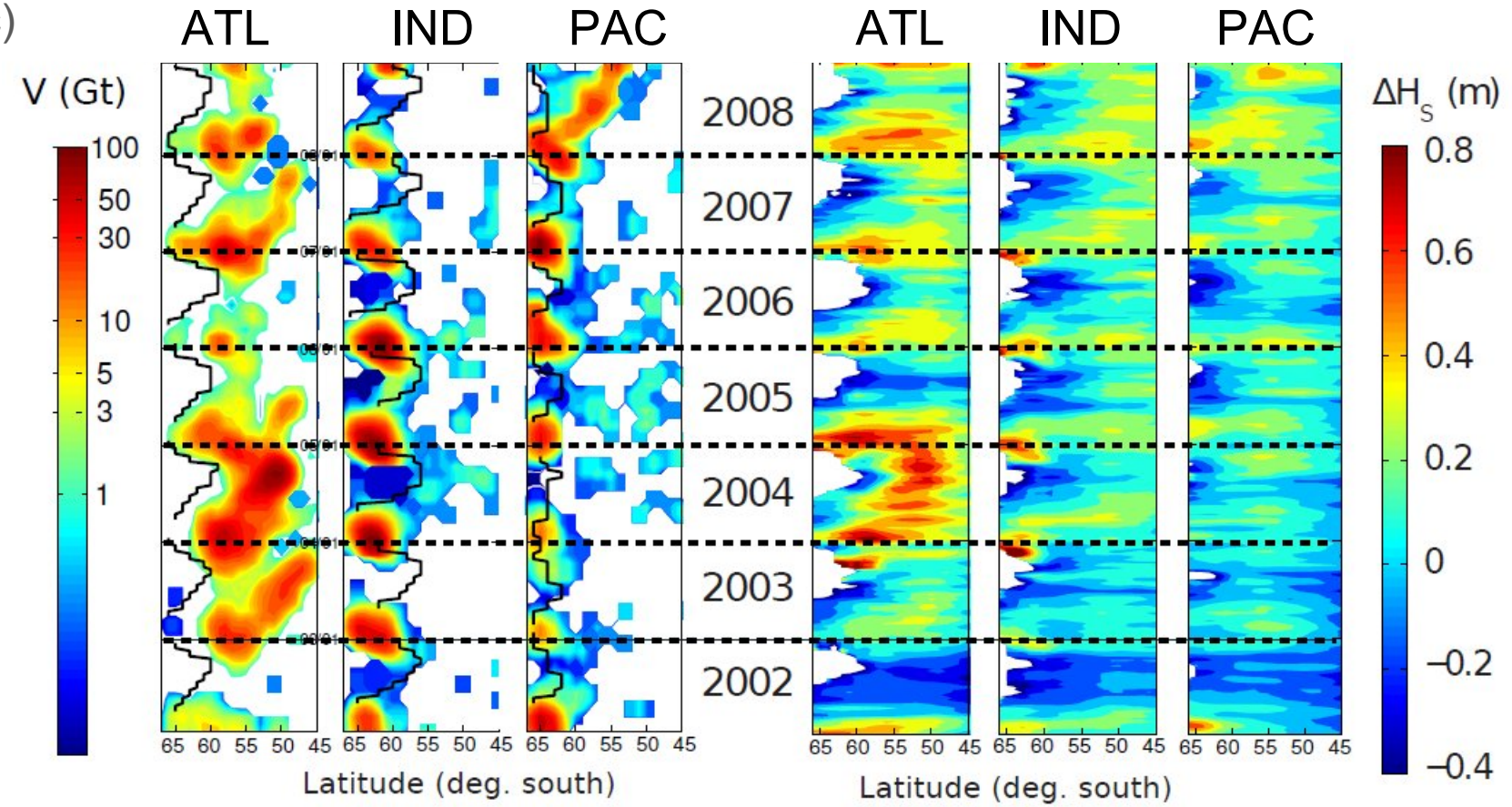
… and the iceberg distribution map looks like the error map of new wave model …

is this a coincidence ?

1. Global wave model errors

b. Icebergs

Look at the full JASON record... the similarity is really striking: a large concentration of icebergs allways lead to a high bias in the wave model (see 2004 in the Atlantic, 2008 in the Pacific)



Volume of icebers **wave model bias for Hs / altimeter**

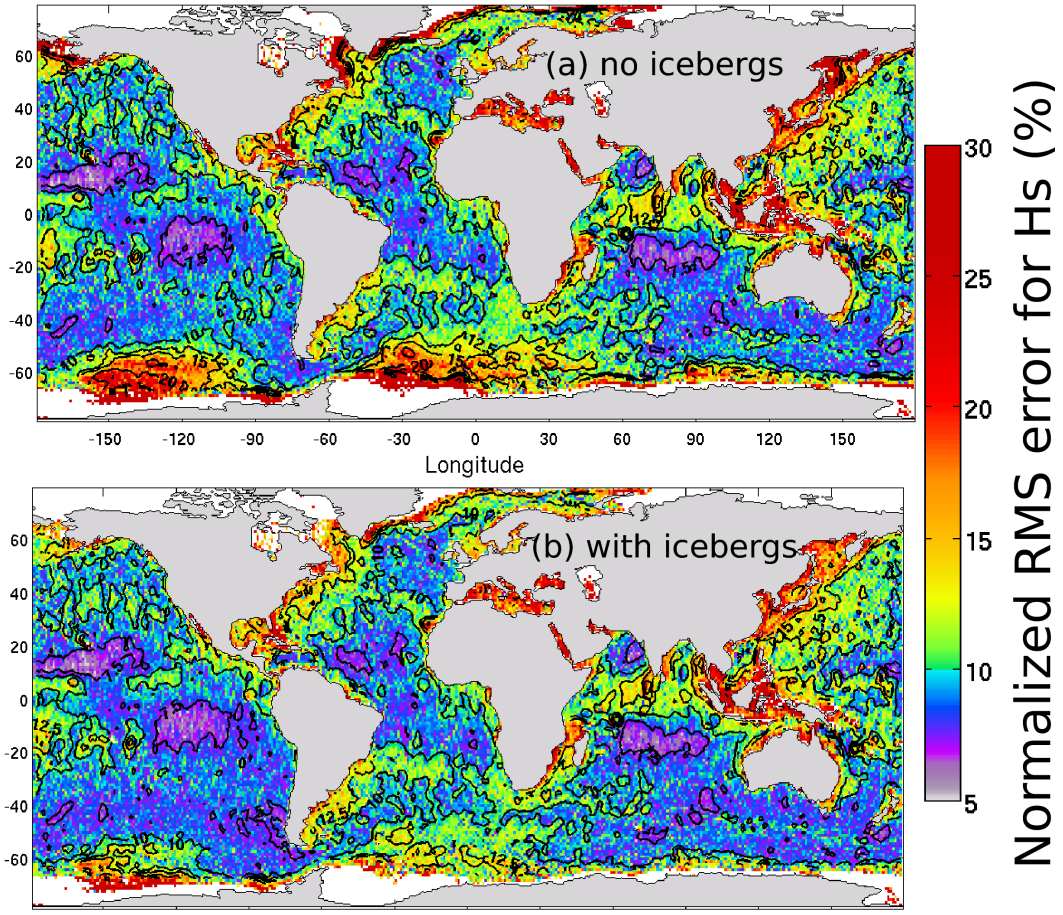
(figure from Tournadre et al., in revision with GRL).

1. Global wave model errors

b. Icebergs

Doing the maths, it is easy to realize that many small icebergs are acting as breakwaters in the middle of the ocean …

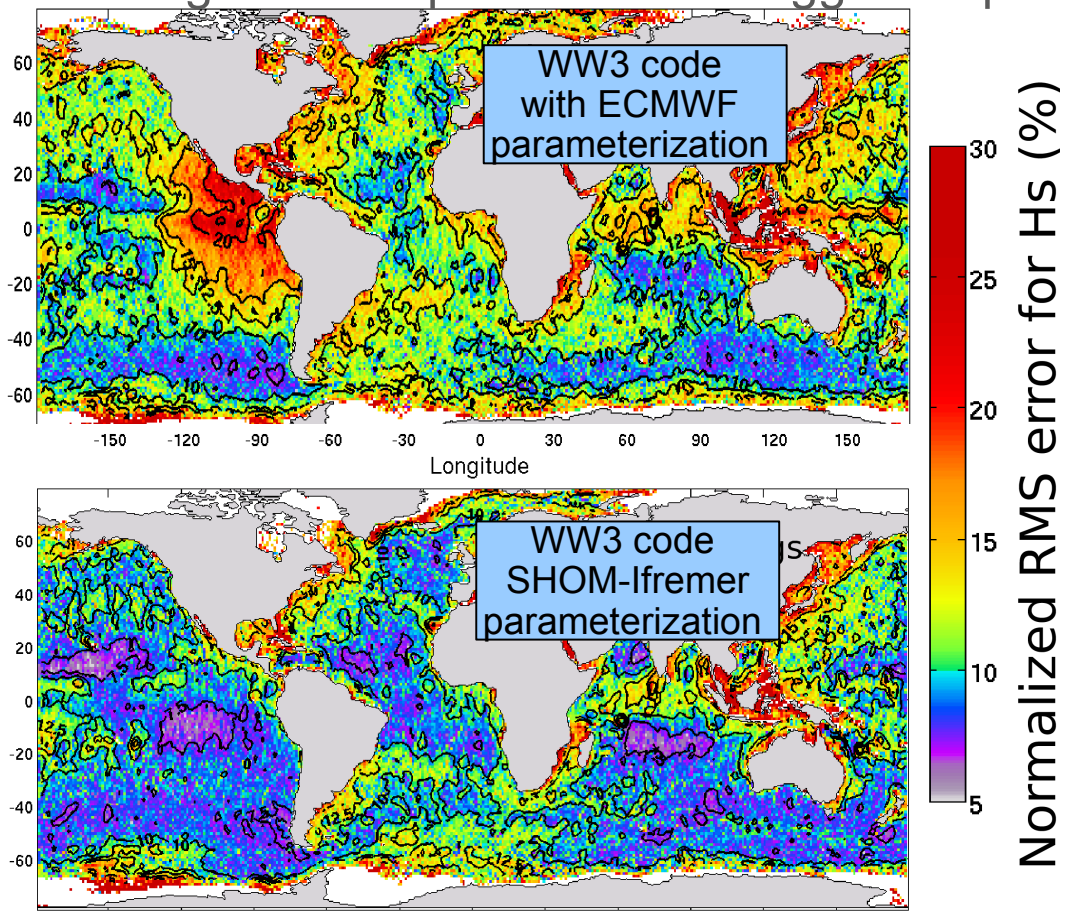
A simple parameterization of this blocking, with a bit of tuning … and here it is →



Model errors without and with icebergs, year 2008 (note the impact in the south Pacific, very particular for that year)
(figure from Tournadre et al., in revision with GRL).

A summary of recent progress

Icebergs important for Southern Ocean waves, but new parameterizations for wave breaking and dissipation are the biggest improvement



Global mean NRMSE with various parameterizations :

11.1 % (Ifremer-SHOM, with Icebergs)

12.7% (ECMWF 2005, with icebergs)

13.8% (ECMWF 1992, with icebergs)

Largest errors now:

- western boundary currents

- coastal areas (resolution + winds + ?)

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Conclusions and perspectives: waves beyond wave heights and periods …

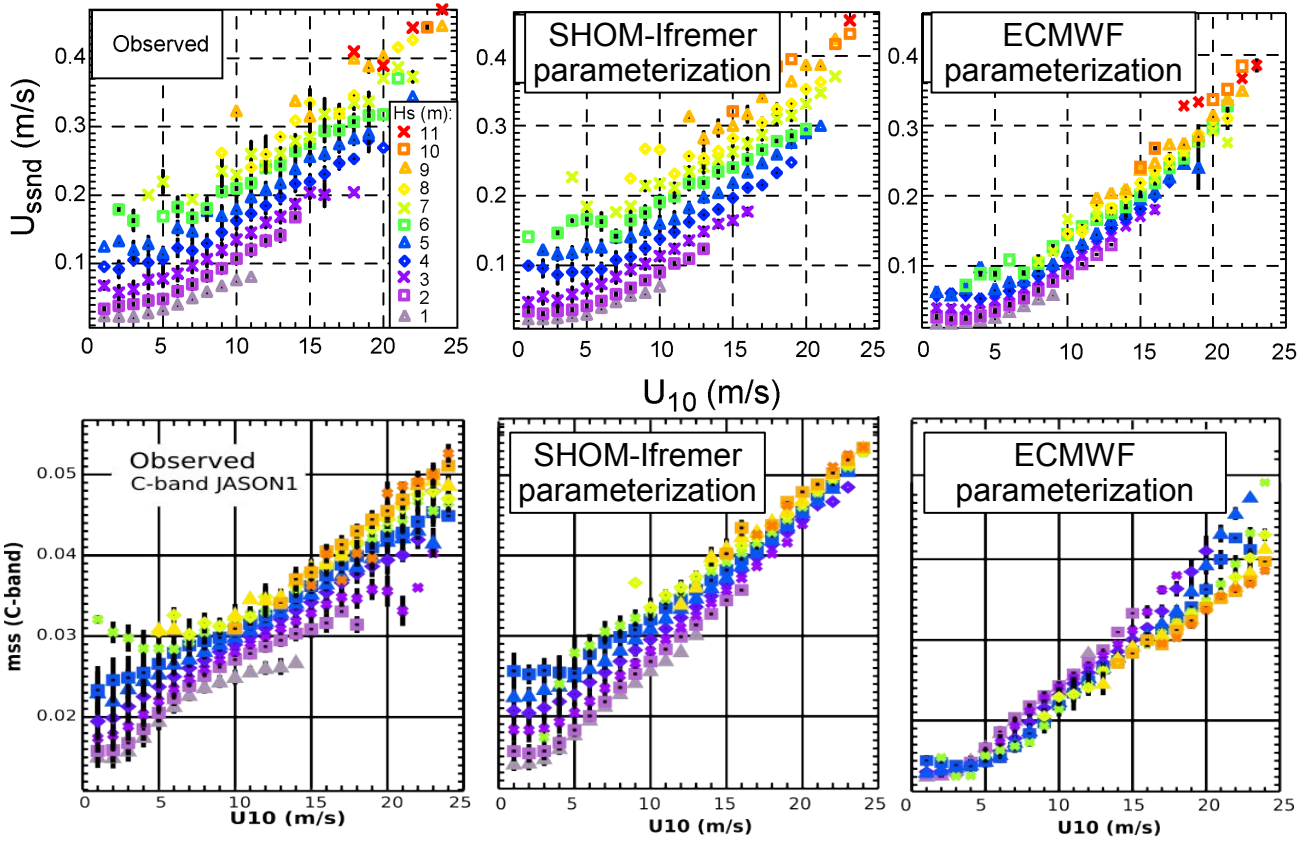
Wave spectra, surface slopes, SSB …

The better quality of models now allows the estimation of many parameters:

Third moment of frequency spectrum → Stokes drift (Ardhuin et al., JPO 2009)

Fourth moment → mean square slope (Ardhuin et al. JPO 2010)

All these can be used to derive better SSB corrections (Tran et al. 2010), estimate the long gravity wave spectrum (for SWOT …) ...



A 10-year database (+ forecasts) is at www.tinyurl.com/yetsofy

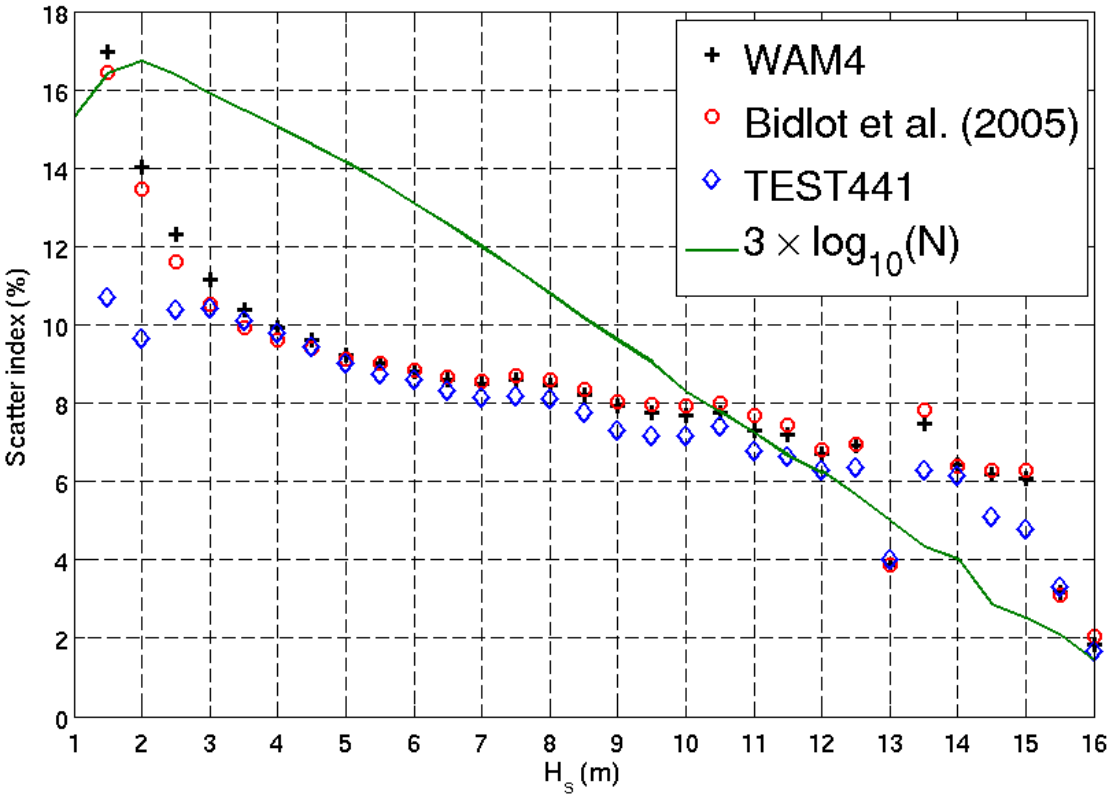
see also wwz.ifremer.fr/iowaga

Errors vs wave height

Largest errors are for small waves (swell).

Warning: TEST441 and Bidlot et al. (2005) have a ~10% negative bias for Hs > 10m

→ special correction for Meteo-France (TEST437).



NB: WAM4 = ECMWF 1992, Bidlot et al. (2005)=ECMWF 2005, TEST441 = SHOM-Ifremer