CFOSAT/SWIM's insight on small scales variations of significant wave height due to wave groups

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Context

Waves and Significant wave height :

To define a **« sea state »** (i.e. homogeneous waves conditions) we use:

- The **Significant wave Height (Hs)** ~ height estimated by an observer
- The repartition of the energy both in frequency and direction : **wave spectrum**

e.g. of 2 very different sea states :

Swell : Energy peak is narrow, waves are well defined

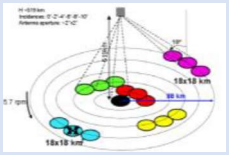
Wind sea : Energy peak is broad, waves are wind driven and « messy »

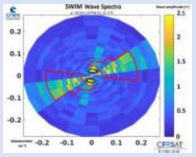
Classical altimeters:

- Get the evolution of **Hs** along the satellite nadir track.
- Some of the small scale variations of Hs measured are due to the waves variability itself.

CFOSAT / SWIM :

- Chinese-French Oceanic SATellite (launched 2018)
- Rotating antenna **=> Hs** (nadir) **+ wave spectra** (offnadir)



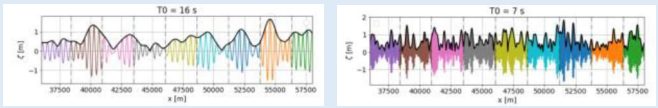


Left : SWIM illumination pattern, right : wave spectrum obtained with SWIM From CFOSAT /SWIM documentation (Hauser et al. 2018, cnes website)

Theory and method

Wave groups and Hs variations :

Wave groups modulate the sea surface and can affect the Hs detectability



Synthetic 1D signals for 2 given sea states : swell (left) and windsea (right). The colors represents altimeter windows where the Hs is calculated, the left configuration shows more variability between windows.

Wave envelope and wave spectra:

- Wave groups can be represented by the signal envelope
- $Envelope\ spec. = \propto wave\ spec. \otimes wave\ spec.$ *(Rice 1944, Nolte & Hsu 1972)*

CFOSAT / SWIM L2P product :

Hs (nadir)

- Std(Hs) over 77 km

⇒ **Observed std(hs)**

Wave Spectra (off nadir)

- Compute convolution ⇒ Envelope spectrum
- Integrate scales > footprint

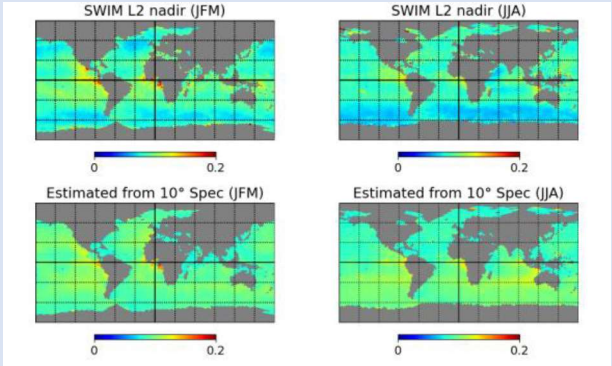
⇒ **Estimated Std(Hs)**

Comparison : part of std explained by wave groups

Which part of the variation is expected and geophysical ?

1st results and discussions

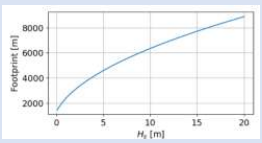
Results (2019 -> 2021) :



Comparison between std(Hs)/Hs measured – upper panels – and estimated from 1D spectra – lower panels. For January-February-March, left column and June-July-August , right column.

Limitations:

- 1D spectrum approximation ⇒ 2D is expected to also have impact
- Footprint size is currently not accounting for detection windows overlapping *(based on Chelton et al. 1989)*



Perspectives:

- Accounting for 2D and overlapping.
- Find zones of dominance of waves groups.
- Apply to other altimeters (e.g. ESA/CCI Seastate Database, *Dodet et al. 2020*) and gain information about the spectral width from the std(Hs).

More

- Danièle Hauser, Céline Tison et al., « CFOSAT: A new Chinese-French satellite for joint observations of ocean wind vector and directional spectra of ocean waves », Proceedings SPIE 9878, Remote Sensing of the Oceans and Inland Waters: Techniques, Applications, and Challenges, vol. 9878, avril 2016, p. 1-22 (DOI 10.1117/12.2225619
- RICE, Stephen O. Mathematical analysis of random noise. The Bell System Technical Journal, 1944, vol. 23, no 3, p. 282-332.
- NOLTE, K. G. et HSU, F. Statistics of Ocean Wave Groups, Paper 1688. In : Offshore Technology Conference, Houston, Texas. 1972.
- DODET, Guillaume, PIOLLE, Jean-François, QUILFEN, Yves, et al. The Sea State CCI dataset v1: towards a sea state climate data record based on satellite observations. Earth System Science Data, 2020, vol. 12, no 3, p. 1929-1951.