Study of Ocean-Tropical Cyclone interactions with multisensor observations

ABSTRACT

Moving tropical cyclones (TCs) are extreme atmospheric phenomena that powerfully impact the ocean. Indeed, TCs are intense sources of surface stress and stress curl generating a variety of responses : surface waves, internal currents and turbulence in the upper layer that causes vertical mixing and enhances thermocline erosion often leading to large sea surface temperature (SST) changes. There is also a measurable barotropic response with an associated trough in sea surface height (SSH). Taking advantages of multi-sensor observations, this study aims to help infer the TC intensity and life-cycle evolution. The method is based on simplified analytical models describing asymmetrical sea states, SST and SSH anomalies. First, a new parametric wind stress model can then be derived. Our approach underlines the better capacity of an outer radius forced model to reproduce the global wind forcing profile, compared to previous Rmax-based parametric models. Secondly, a work based on an altimetry dataset and a simplified analytical wave model gives an interesting way to validate wind profile. In the meantime, it will be useful for collecting necessary sea state and SSH parameters.

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Parametric wind

Chavas is a merged profile of 2 solutions based on absolute angular momentum:
-inner ascending (ER11), with key term Ck/Cd
-outer descending (E04), key term $\frac{f \times r0}{Wcool/_{Cd}}$

Wave Model

Kudry&al wave model is a fetch and duration limited model (based on Hasselman growth wave equation) leading to self-similar laws including inverse wave age.

Database

Satellite:
-Ascat-A (KNMI)
-SMOS (LOPS)
-AMSR2 (SOlab)
-Sentinel 1-A (ESA-LOPS)
-Altimeter base: ERS-2, Envisat, Jason-1, Jason-2, Cryosat2, Saral

Model:
-Forecast ECMWF
-Reanalysis CFSR
-Blended wind
-Analysis HWind

1. Outer size structure

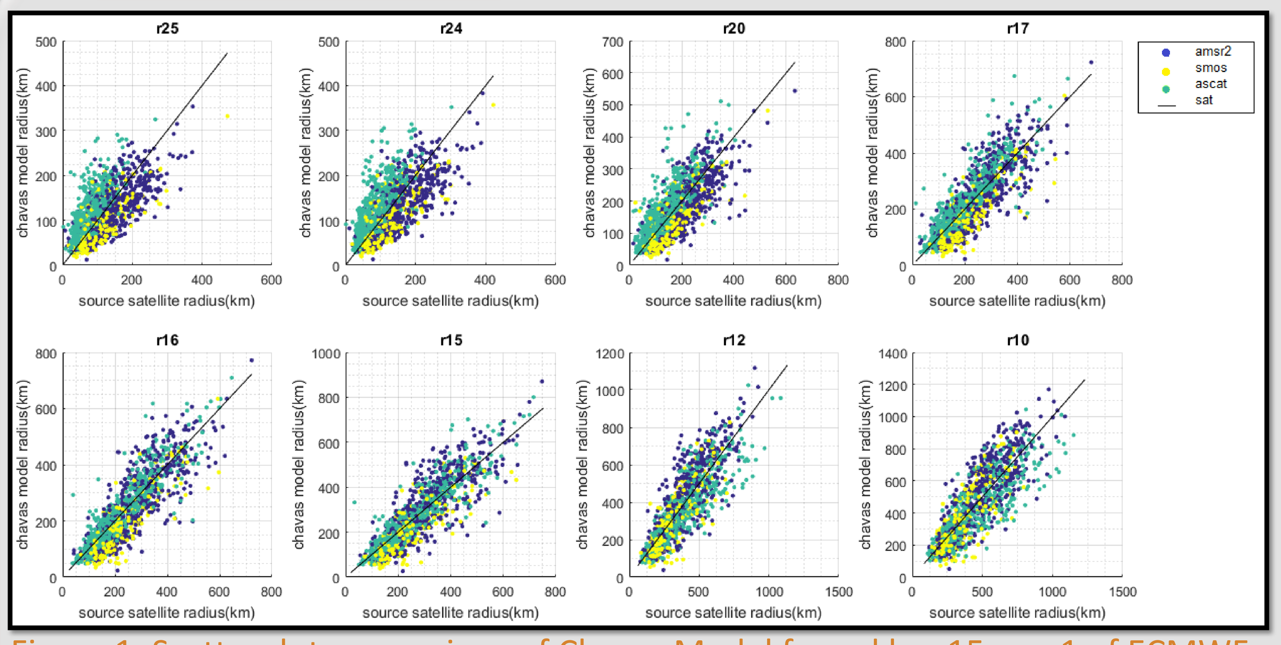
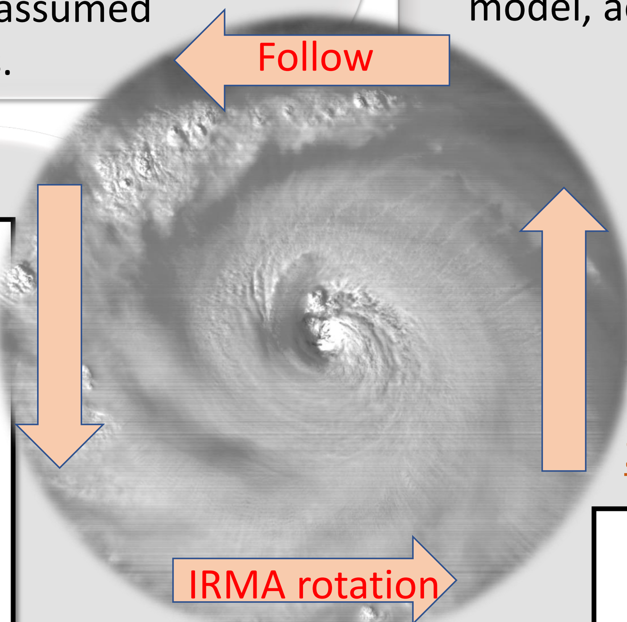


Figure 1: Scatterplot comparison of Chavas Model forced by r15 m.s-1 of ECMWF with satellite observations.

This dataset of 600 snapshots comes from smosstorm project, covering 2010-2015 cases of Ascat-A, SMOS and AMSR2.

The model seems to perform well for the outer radius profile, with global correlation of **R=85%** and a weak normalised bias less than **2%** .

The shown results are obtained by forcing the model with the **r15 m.s-1**, which is assumed to bring a better transition between the high wind structure and the outer regions.



0.Multiplatform Satellite TC comparison

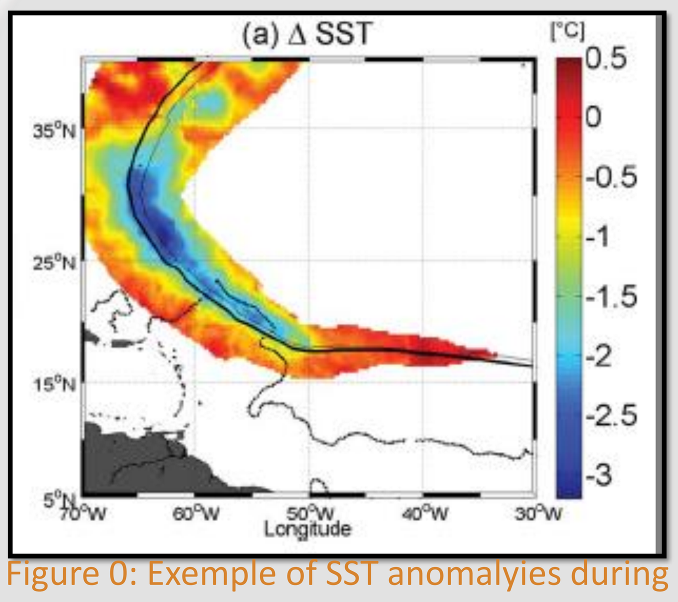


Figure 0: Exemple of SST anomalies during IGOR 2010

The upper ocean response to TC events deeply relies on the good parametrization of its wind forcing. The radius profile informs on the size and intensity of the phenomenon, whereas the storm motion and the azimuthal distribution bring the 2D aspects, which are important terms to describe the time coupling and the 2D asymetries ocean answer (SST, SSH,…). Our method consists to generalize an outer radius forced model (Chavas2015) into a 2D wind field.

For this purpose, a multiplatform satellite comparison was released to validate the model, according to the strenght of the different used devices:

1. **Combination of scatterometers and radiometers (Outer radius and size comparison).**
2. **SAR sentinel-1A comparison (Inner core and asymetries).**
3. **Altimetry dataset: (two goals) : - Sea states and SSH**
   - Validate the Wind gradient

This parametrization is a necessary step for our upper ocean response study.

2. High wind structure in Irma & José

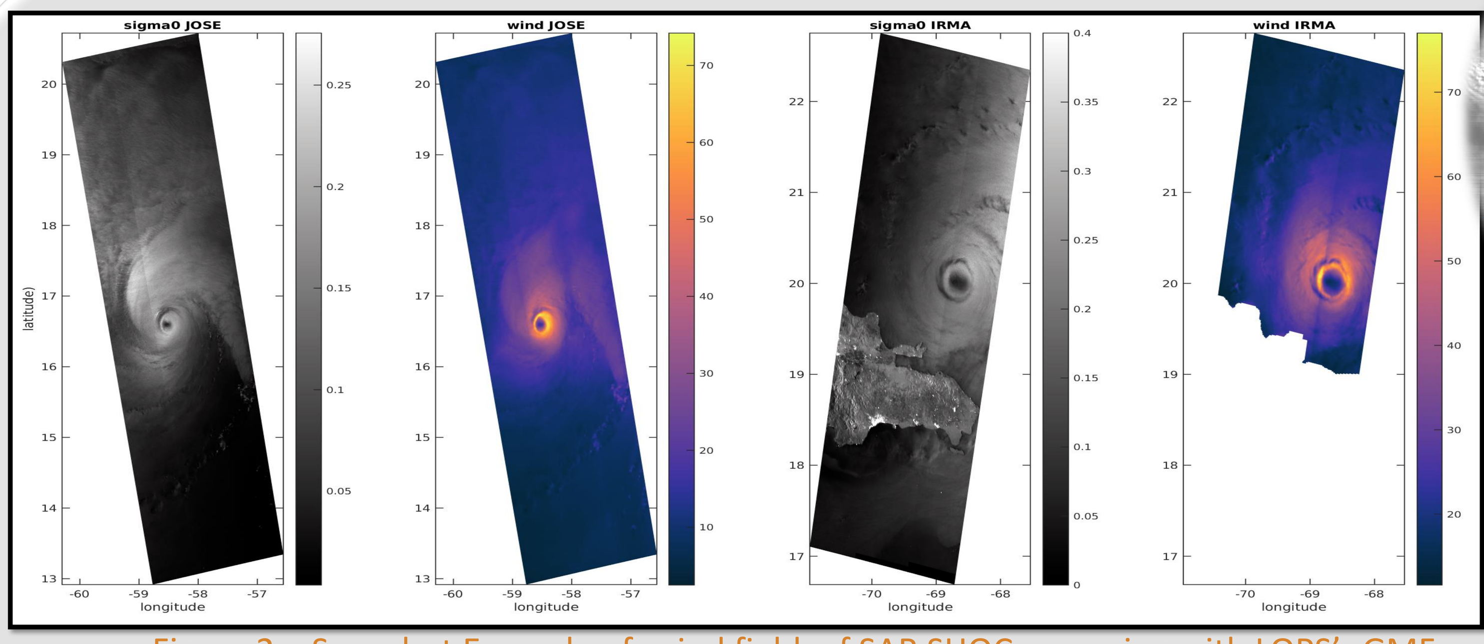


Figure 2a: Snapshot Exemple of wind field of SAR SHOC campaing with LOPS's GMF

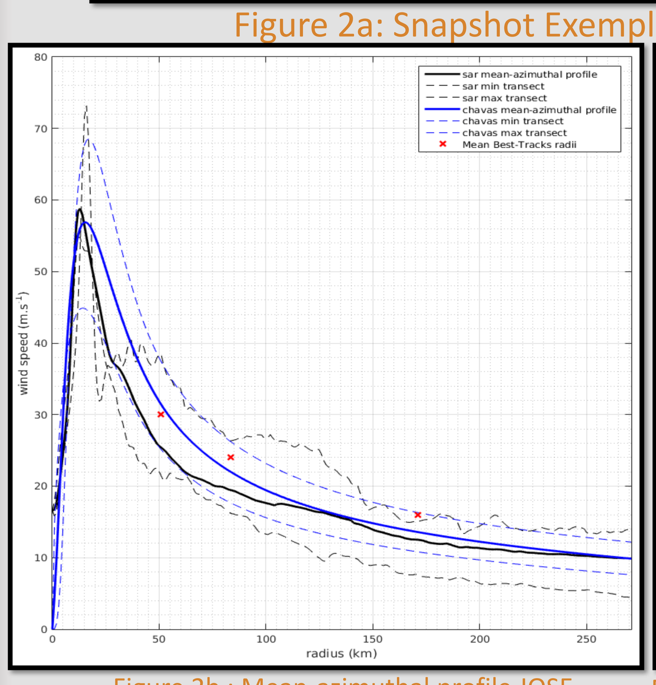


Figure 2b : Mean-azimuthal profile JOSE 08/09/2017-22h00 (cat 5)

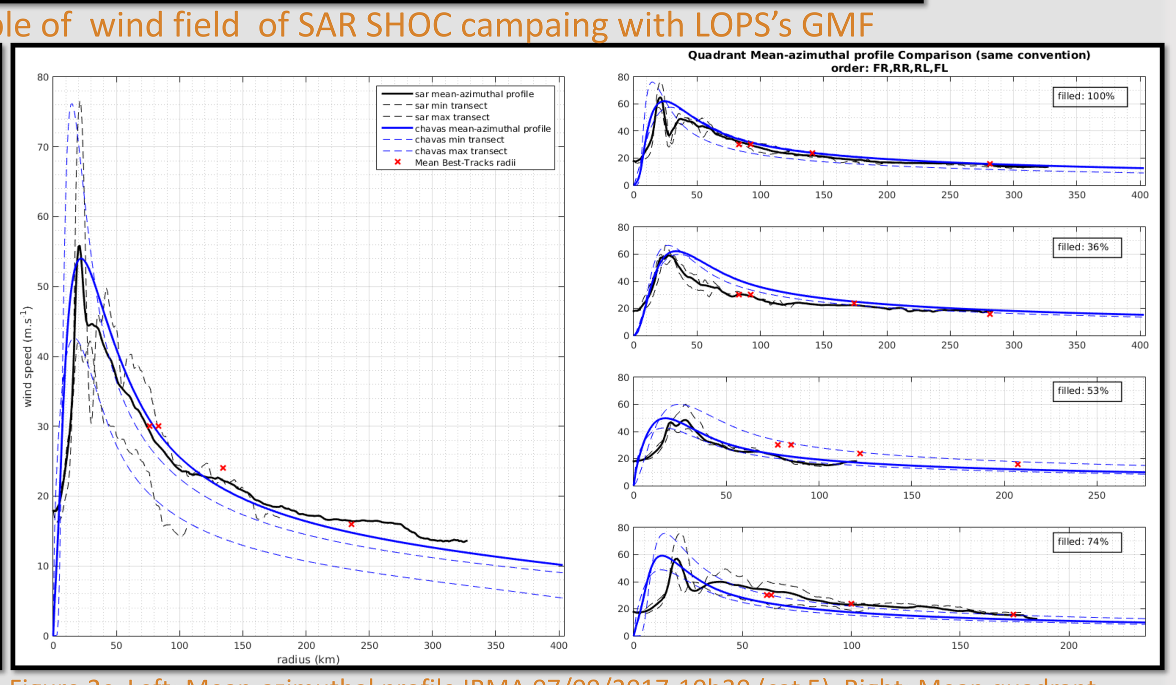


Figure 2c. Left: Mean-azimuthal profile IRMA 07/09/2017-10h30 (cat 5). Right: Mean quadrant profile.

The SHOC campaign of ESA provides us with 17 TC cases during 2016 & 2017 seasons. The **high resolution** and **the crosspolariaztion** of SAR sentinel 1A allow us to make a complete comparison of the profiles. All cases were compared as a mean azimuthal profile (2b & 2c left) and as mean-quadrant point view, in order to check the asymetry given by the model and the complete 2D wind field. The model performs well from the Rmax to the outer region for Tropical cyclone cases, as the Vmax asymetry is well represented (2c right). However Rmax position is in most cases underestimated (fig2d). Besides TS cases are suffering from larger errors. Further study will try to correct the Rmax region. These resuts underline the **capability** of the **new cross-polarized SAR algorithms** to give **unprecedented estimate of the high wind patterns ,in such powerful TCs.**

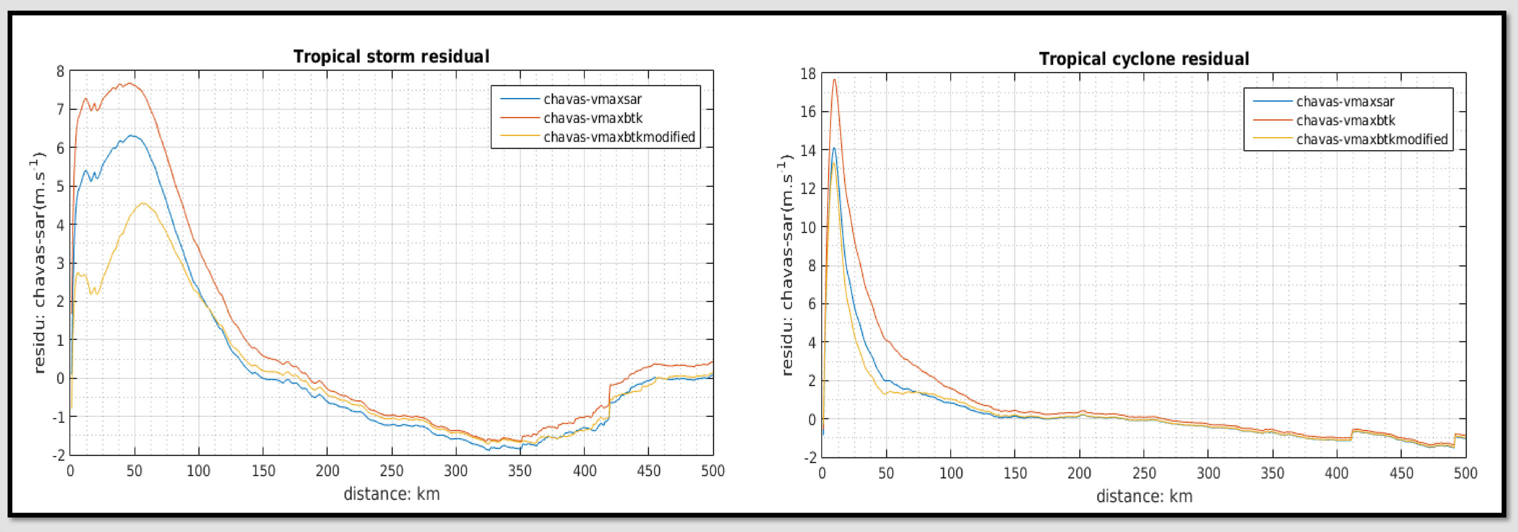


Figure 2d: General Residual, left: Tropical storms cases, right: Tropical Cyclone (Colours = different methods).

3. Altimetry: Wind and Hs profile

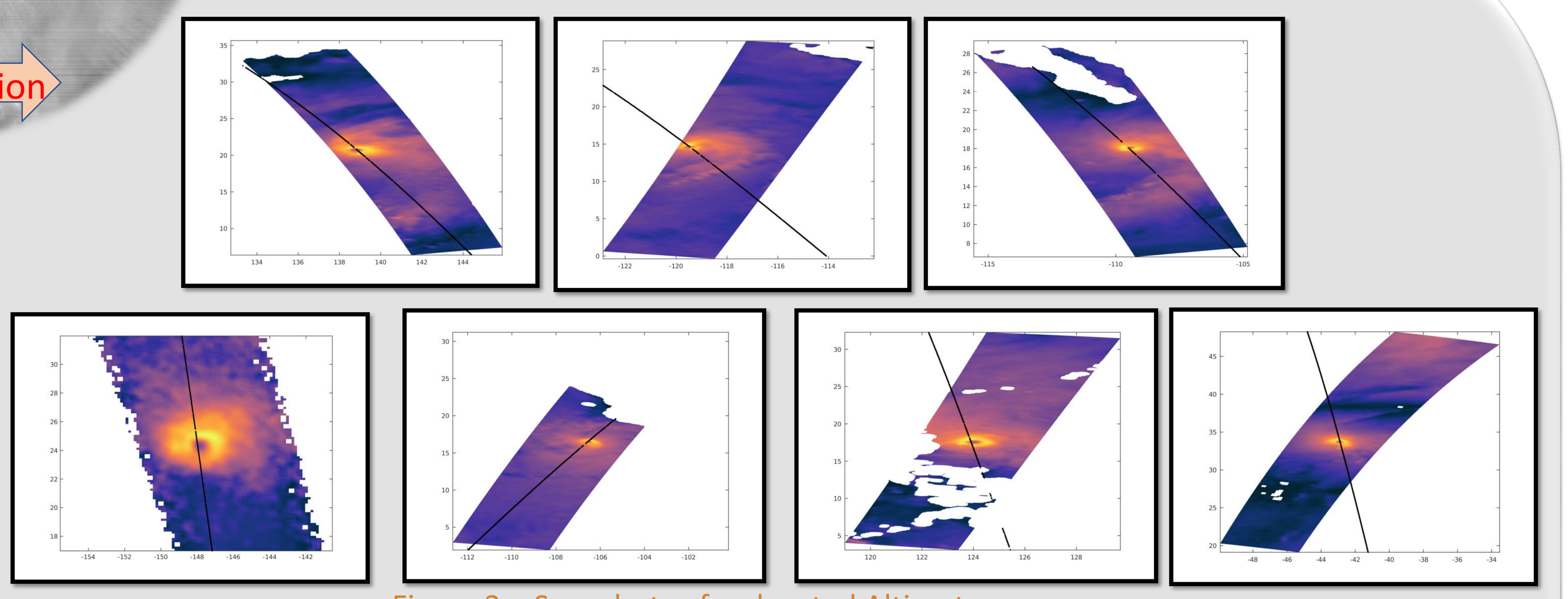


Figure 3a: Snapshots of colocated Altimetry cases

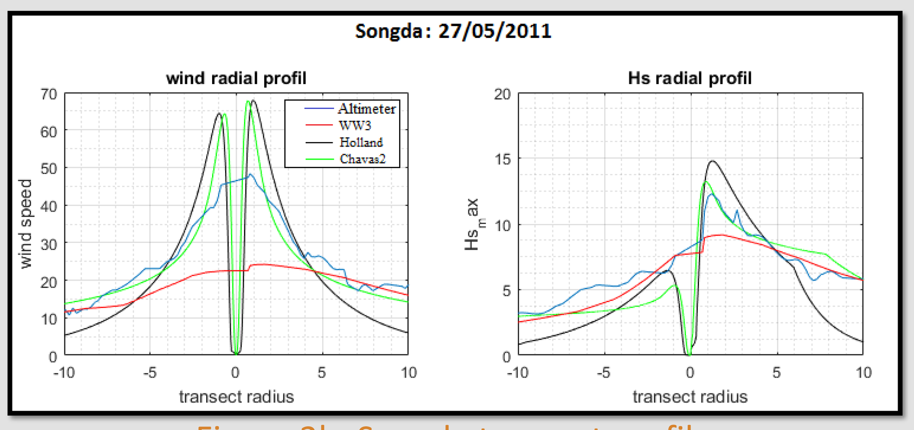


Figure 3b: Songda transect profile

From the different colocated cases (fig3a), we extract the transects of TC wind field and put them as the forcing in the Kudry& al model. This model gives us an estimation of Hs profile along the transect, under some conditions (Only transect from Front-right to Rear left , according to storm motion). For all cases we make comparisons of wind and Hs transects between model and altimetry dataset. This approach has two main interests:

- Validate wind model with altimetry wind profile, but also with Hs one which relies strongly on sustained wind (id wind gradient).
- Estimation of sea state information along the main observed asymetries axis.

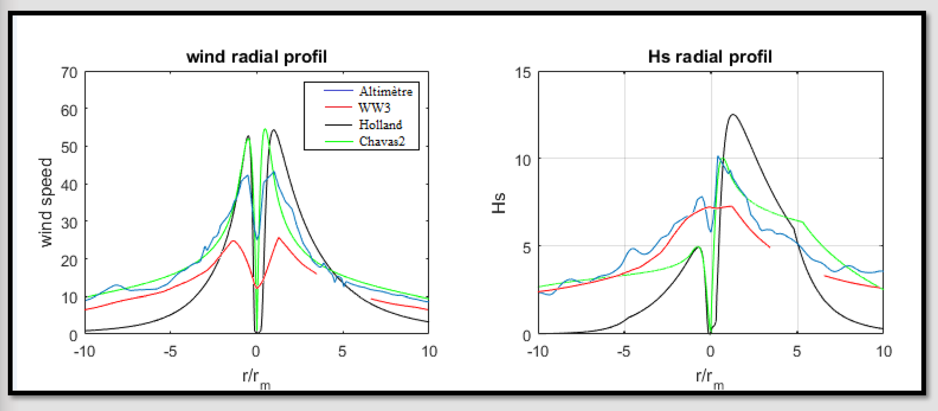


Figure 3c: Kilo transect profile

The last plot enhances the capacity of the Analytical waves model to estimate the Hs of the main quadrants. However some errors are shown for the rear left quadrant for slow TC motion, duration limited conditions are not as well verified.

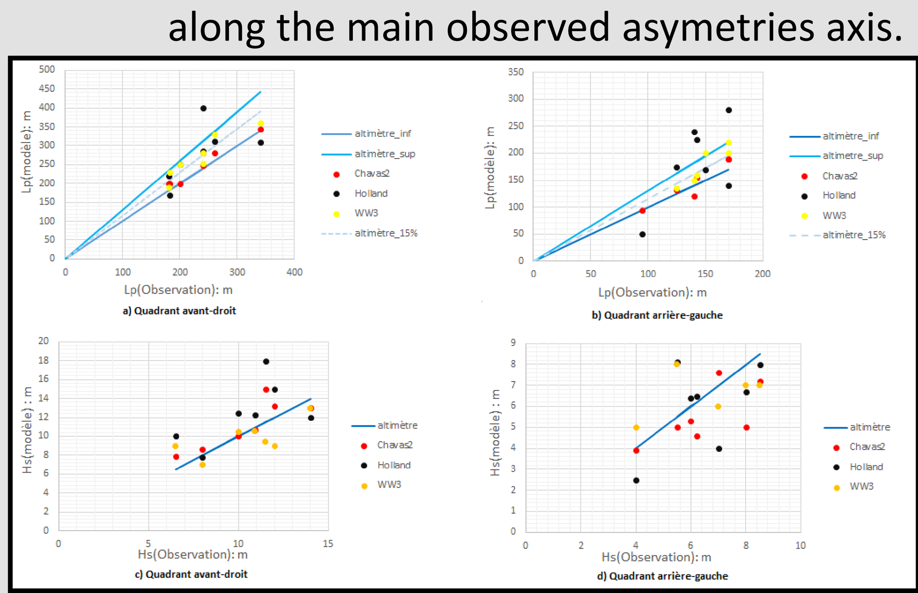


Figure 3d: Hs and Lp scatterplot

Reference & Acknowledgement

« Acknowledgement are made to data providers which logos appear down »

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Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment
RSHU
ECMWF European Centre for Medium Range Weather Forecasts
esa
AVISO+ Satellite Altimetry Data
LOPS
NOAA
cnes
oceandatalab making sense of the deep blue sea
NCEP National Centers for Environmental Prediction