Ocean Surface Topography-Science Team (OSTST), annual meeting, 7-11 November 2023, Porto Rico

On the estimate of maximum wave height from CFOSAT mission : thanks to SUMOS campaign

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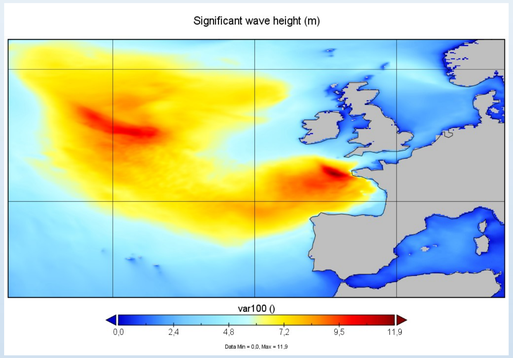
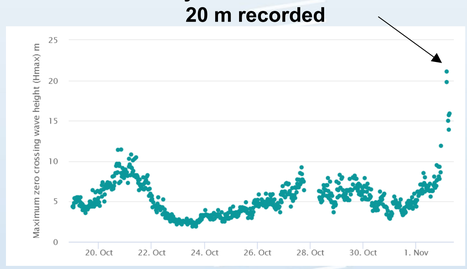
MOTIVATION:

- **Forecasting dangerous seas is a very challenging task for operational wave centers. This request is needed from operational users such as ship navigation, local authorities for wave submersion warning and leisure applications.**
- **This work aims firstly to improve the estimate of maximum wave height (Hmax) from the model MFWAM, and secondly to set dangerous seas indicators based on satellite wave observations such as the one provided by the instrument SWIM of CFOSAT**
- **Rogue waves is defined as the ratio of Significant wave height (SWH) and Hmax, that exceeds 2. This work uses machine learning methods in order to provide Hmax along track altimeters missions**

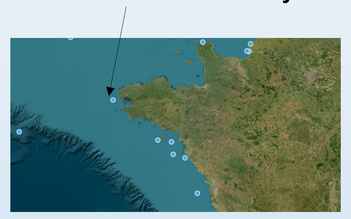
Maximum wave height (HMAX) during storm CIARAN 2 November 2023 at 0:00 UTC



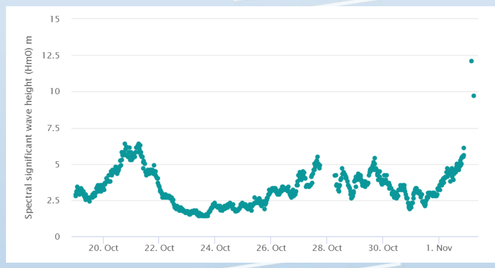
Hmax at buoy Pierres Noires more than 20 m recorded



Location of Pierres noires buoy at French coast Brittany

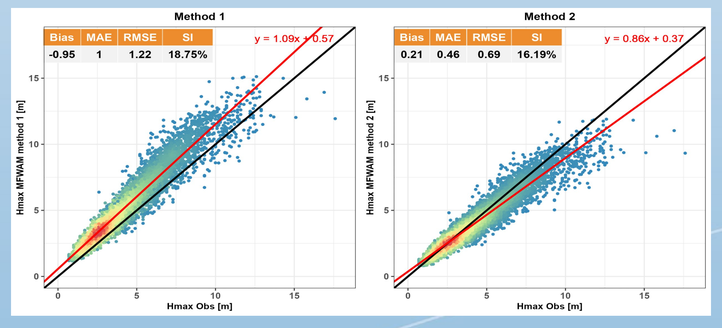


Significant wave height at buoy Pierres Noires more than 12 m recorded

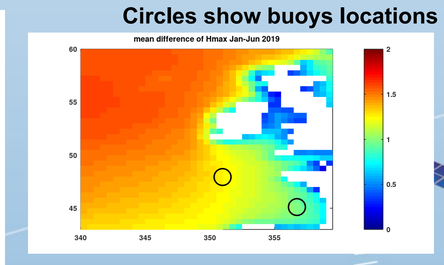


Uncertainties on computation of Hmax
Comparison of Hmax from MFWAM-Global at Brittany and Biscay buoys in North-East Atlantic : Jan-Jun 2019

Two computations : method-1 (Janssen) and method-2 (Latemar : Benetazzo et al.)



Circles show buoys locations



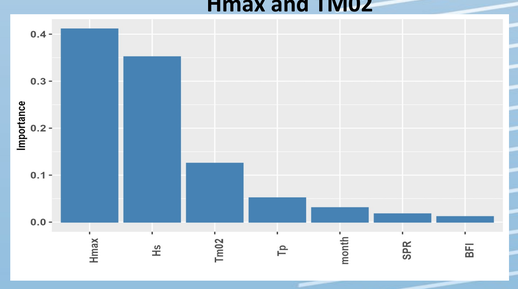
Mean difference Hmax (Janssen-Latemar)

For hmax <8 m Latemar method has a better estimate, while for Hmax > 8 m Latemar method is strongly underestimating the observations

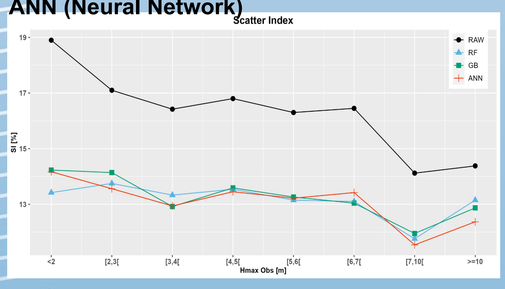
Calibration of Hmax from NRT by using Deep Learning scheme : Brittany, Biscay and Campbell island buoys

- **Input for the DNN training : Hmax, SWH, Tm02, Tp, month, Directional Spreading, BFI**
- **Deep Learning methods : ANN, Random Forest, Gradient Boosting**

Sensitivity to inputs : the most important SWH, Hmax and TM02

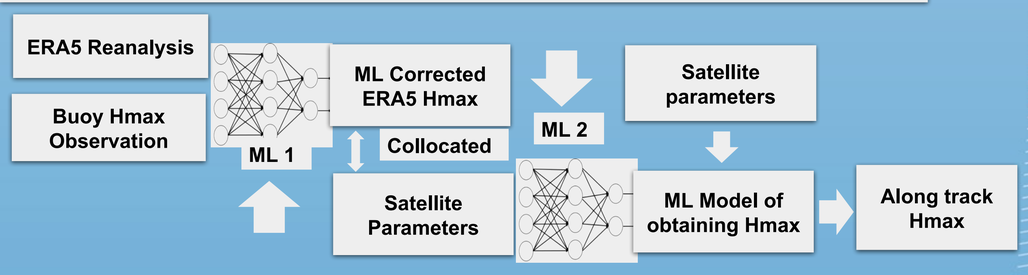


Significant improvement of SI for different range of Hmax and the best estimate is for ANN (Neural Network)



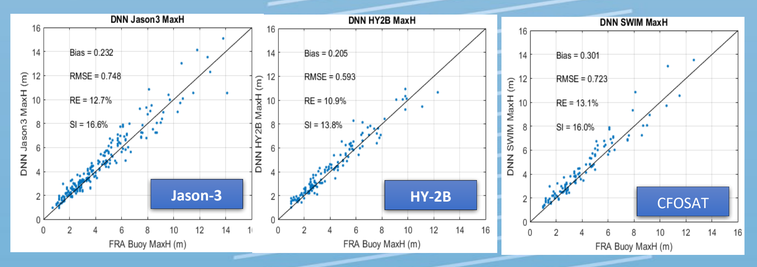
SI variation with Hmax range

Implementation of Hmax based on along track satellite altimeters through Machine Learning (ML)



- **The training dataset is in 2019-2020**
- **The assessment is performed done based on the data in 2021 and SUMOS data**

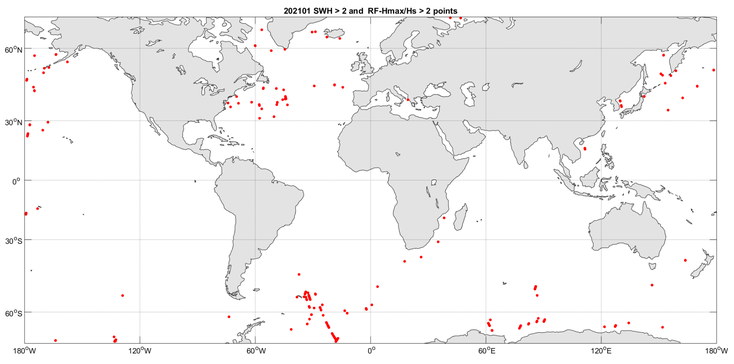
Satellite MaxH Assessment Against French Buoys



	ERA5	Jason-3	CFOSAT	HY-2B
Bias (m)	0.765	0.232	0.301	0.205
RMSE (m)	1.095	0.748	0.723	0.593
Relative Error (%)	20.6	12.7	13.1	10.9
Scatter Index (%)	18.6	16.6	16.0	13.8

Good estimate of Hmax from Jason-3, CFOSAT and HY2B. This also shows better estimate of Hmax than ERA5.

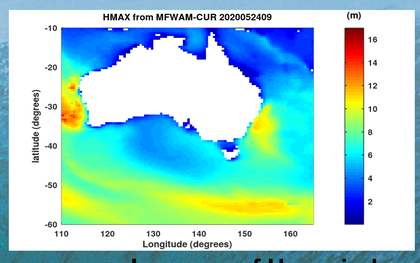
Ratio of Hmax/SWH >2 from along track SWIM/CFOSAT : January 2021



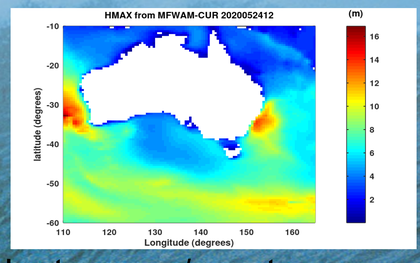
Red dots show the occurrence of rogue waves

The case of APL England (24 May 2020 at 6-9h (UTC) : occurrence induced by strong current cell (white stream line)

24 May 2020 at 09:00 UTC

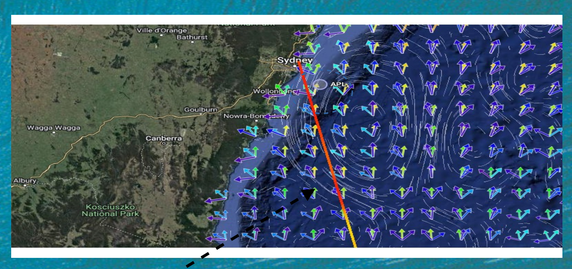


24 May 2020 at 12:00 UTC



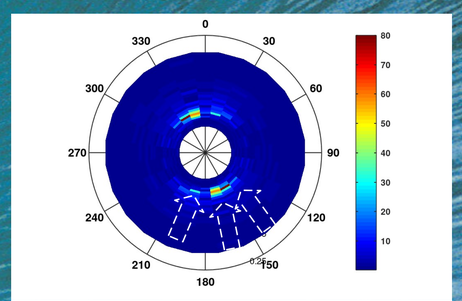
Increase of Hmax induced by strong wave/current Interaction in the event location

Wind-wave 8.6 sec, 1st swell:9.5sec 2nd swell 12.6 sec



CFOSAT track at 9:25 UTC

SWIM wave spectrum nearby the event



40 km from the location R=0.6 & BFI2D=0.13

Key messages

- **Improved estimate of Hmax from the model MFWAM has been impemented by using Deep Learning method based on buoys data**
- **Successful estimate of Hmax from along track SWIM : very promising for forecasting rogue waves from multi-missions of altimeters.**
- **Evaluation of rogue waves indicators in ship accident event is needed in order to provide such parameter to operational users. Successful analysis for APL England ship container accident in Australian eas Coast (off-shore Sydney).**