WAVERYSv2: a high-resolution global wave reanalysis covering the historical period from 1980 to nowadays

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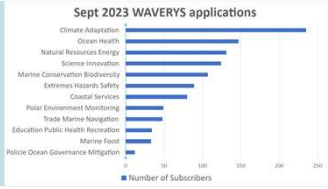
I - INTRODUCTION

As part of Copernicus Marine Service, WAVERYSv1 was the first global wave reanalysis to ever consider ocean currents and directional wave spectrum assimilation.
These features allow it to perform particularly well in areas dominated by strong currents or long swells (Law-Chune et al 2021 [1]). In 2022, WAVERYS was downloaded more than 632k times, which represents 56,5k Po of data. Despite not being a climate projection, WAVERYS is primarily used in climate change studies. Other fields of application include energy potential studies and the safeguarding of coastal ecosystems.

WAVERYSv2 is planned for Oct. 2024. This new reanalysis proposes an upgrade in spatial and directional resolution, as well as new reprocessed data for assimilation, such as altimeters and SAR/scatterometer spectra. WAVERYSv2 will also benefit from wave-ice interactions, as for instance under-ice wave dissipation, with daily ice thickness and ice cover provided by the future CMS 1/12° global ocean reanalysis.



II - V1 DESCRIPTION

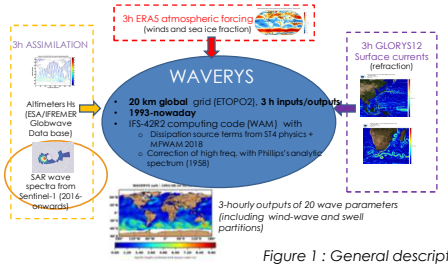


Figure 1 : General description of WAVERYSv1

V1 covers the 1993-nowadays period

Temporal extension are made each month with an Interim production (each month, month-3 series is produced)

Climatological months are also distributed

III – VALIDATION

V1 performs globally better than ERA5 wave

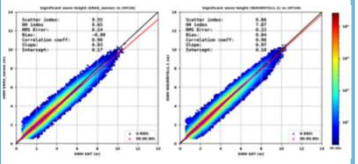
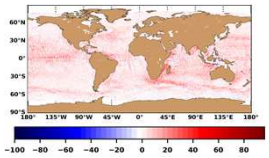


Figure 2 : Global SWH validation with HY2-a altimeter (2014-2018)

IV – IMPACT OF OCEAN CURRENTS

Ocean current improves results for large-scale current systems, but also in the open ocean



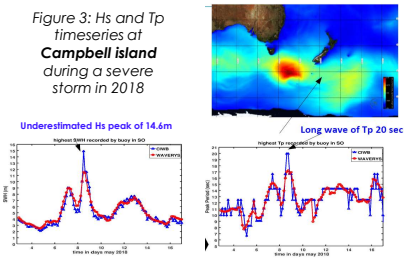
$$HH = \sqrt{\frac{\sum((Model(t) - Obs(t))^2}{\sum Model(t).Obs(t)}}$$

HH index: (Mentaschi et al. 2013 [2]). unbiased RMSE based metrics
HY2-A altimeter as Obs

Figure 2 : Mentaschi index improvement(%) for accounting oceanic currents (2014-2018)

V – EXTREME EVENTS

*Figure 3: Hs and Tp timeseries at **Campbell island** during a severe storm in 2018*



Extreme events are captured by WAVERYS with good timing, but are often underestimated. This is mainly due to insufficient resolution (wind forcing + model)

Long waves are introduced by wave spectra assimilation (Aouf et al 2021 [3])

But techniques exist to improve extreme events:

e.g. Fanti et al 2023 [4] → In-situ based calibration of extreme values for WAVERYS

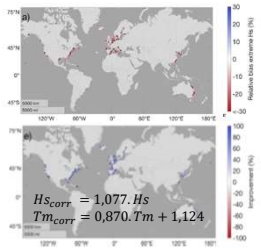


Figure 4: Original Hs extrema bias (up) and improvement (down) of corrected extreme values (> P95) with the calibration from 326 coastal buoys. Correction formulas are written

VI – WAVE ENERGY STUDIES

WAVERYS can be a useful tool in identifying the most attractive regions regions for renewable energy from waves

Farias de Freitas et al 2023 [5]

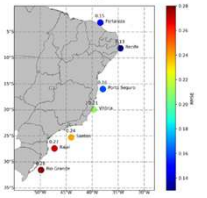


Figure 5:
Up: Hs validation of WAVERYS around the Brazilian coasts (Hs) ; validation of energy density at Fortaleza and Rio Grande.

Down: observed vs modelled wave energy density. CMEMS stands for WAVERYS

Table 4. Comparison of average energy density (E) W/m² at the study sites.

Location	Buoy	CMEMS
Fortaleza	497	352
Rio Grande	526	461

Courtesy of Valéria Mundaca-Moraga

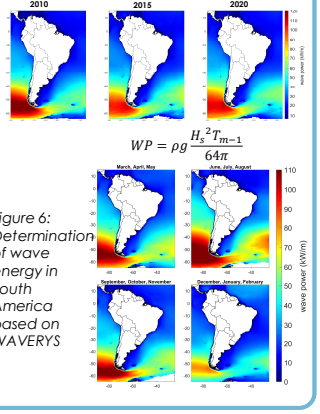


Figure 6: Determination of wave energy in South America based on WAVERYS

VI- WAVERYS V2 DEVELOPMENT

V2 is planned for release in Oct 2024, with features closer to the Copernicus near-real-time wave system

It will include recently reprocessed altimeter data from the WAVE-TAC, as well as Envisat SAR wave spectra over the 2010-2012 period. It will also cover a longer historical period, starting from 1980, making it more useful for users studying climate trends

	V1	V2
Resolution	Spatial : 1/5° Spectral : 30 freq, 24 dir	Spatial : **1/10°** Spectral : 30 freq, **36** dir
Period	1993-nowadays	**1980**-nowadays
Altimetry SWH assimilation	Cersat Ifremer (Globwave)	**CCI seastate (Copernicus wave-tac)**
Wave spectra assimilation	S1, CFOSAT	S1, CFOSAT, **ENVISAT**
Atmospheric forcing	ERA5 (ECMWF) wind and sea ice	ERA5 wind (ECMWF)
Ocean current forcing	GLORYS Copernicus (MOi)	GLORYS copernicus (MOi) + possibly **sea ice**
New variables		**Hmax , monthly climatology**

Table 1 : Differences between V1 and V2

Current tests focus on changing ERA5 surface forcing (1/5°, 1h for wind & ½°,daily for ice) for products with higher resolution or corrected from observation.

- **ERA5* (KNMI)** : 1/8°,1h → corrects ERA5 persistent bias from scatterometer observations
- **GLORYS ice (MOi)** : 1/10°, daily → having a more precise ice extension would benefit for the introduction of an ice interaction source term, e.g. *Yum et al 2022*

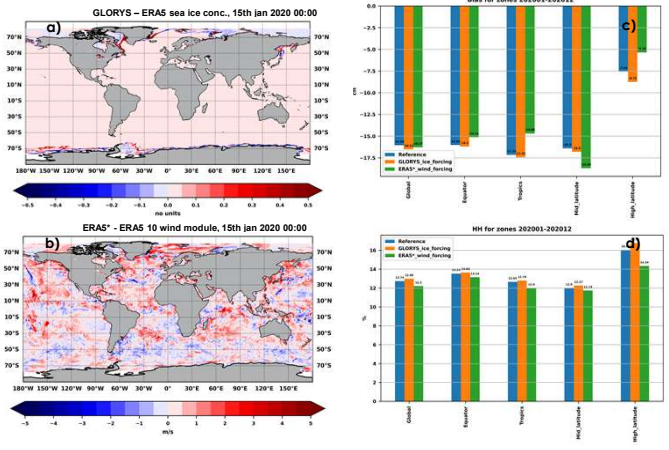


Figure 7:

Left: differences between ERA5 forcing and a) sea ice fraction from GLORYS and b)ERA5 10 m wind. Snapshots for 15/01/2020 at midnight*

Right : Average Bias (c) and HH index (d) according to latitude boxes, performed for sensitivity test on switching the surface forcing for ERA5 and GLORYS sea ice fraction. Reference simulation was runed with ERA5*

CONCLUSIONS AND PERSPECTIVES

The global wave reanalysis of Copernicus, namely WAVERYS, is widely used for a wide range of application. It will be updated with a new version (V2) in October 2024. This new release will improve spatial and directional resolution (1/10° and 36 directions), as well as adding new corrected data to the assimilation system. The period will also be extended from 1980 to the present day. Tests are underway to change the atmospheric forcing initially from ERA5 to higher resolution products. 1

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