The Copernicus Marine Service wave Reanalysis : WAVERYS

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Outline

1 Motivation

2 Description of WAVERYS

3 Validation results (WAVERYS vs ERA5)

4 Relevance related to applications

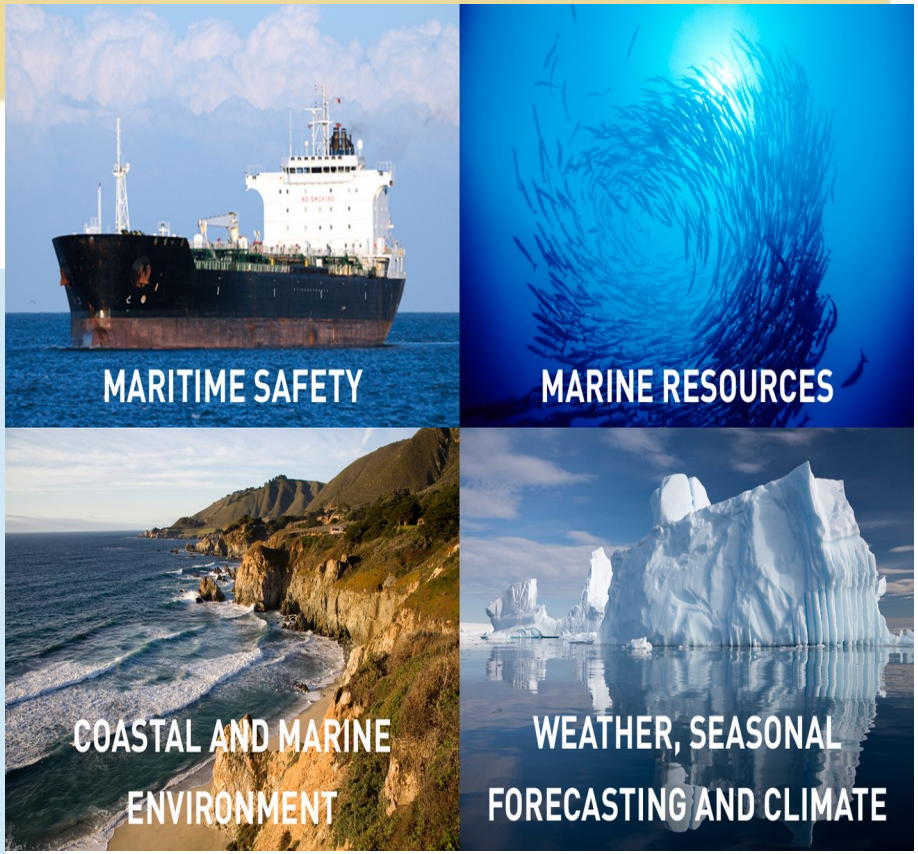
5 Conclusions

MOTIVATION

- WAVERYS has the ambition to provide the best wave products for world wide users implementing wave climate studies, Coastal applications,...etc

- The best boundary conditions for nesting CMEMS regional wave reanalysis (IBI, MED, Artic,...etc)

- Need of outstanding sea state accuracy for relevant users applications (coastal environment, seasonal variability, O/A coupling, SSB estimate,...)



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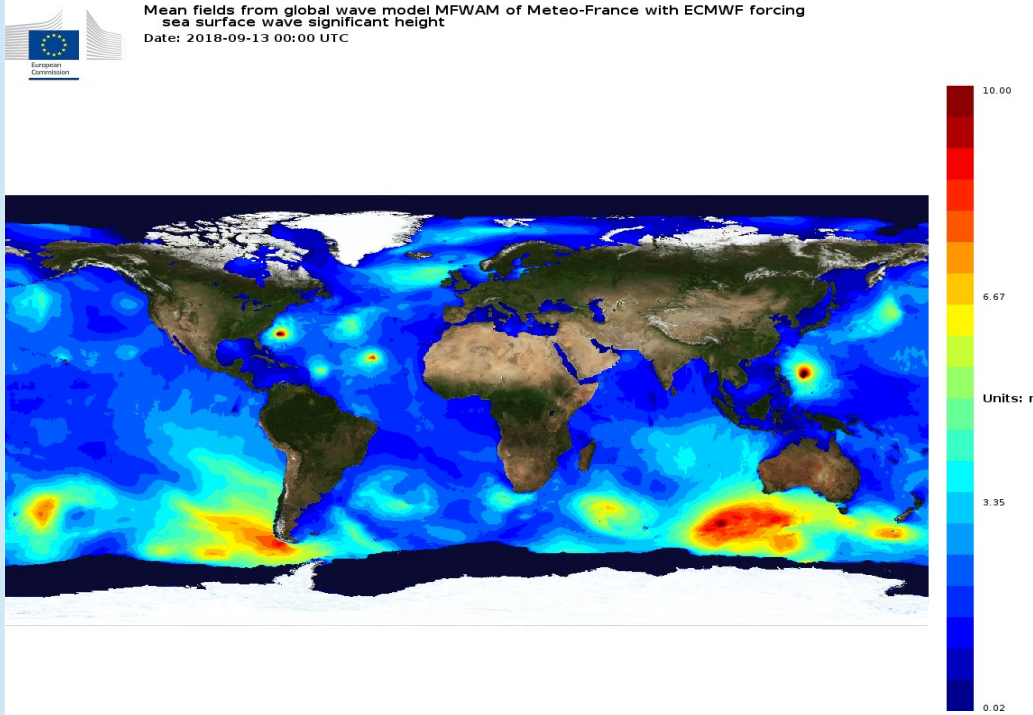
CMEMS global wave reanalysis 1993-2018

- Global grid of 20 km (Etopo2 bathymetry)
- Upgraded wave physics for better surface stress (MFWAM 2018)
- 3-hourly wind forcing ERA5
- 3-hourly assimilation step of altimeters and SAR wave spectra from Sentinel-1
- 3-hourly surface currents forcing from CMEMS ocean reanalysis GLORYS
- 3-hourly output of wave parameters (including partitionning wind-wave and swell partitions) : 20 parameters CMEMS catalogue



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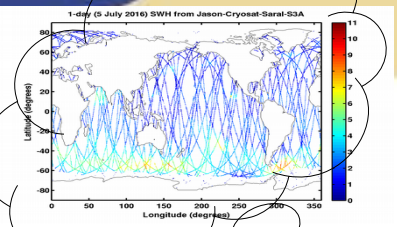
Relevance of forcing components and assimilation in WAVERYS (1993-2018)



ERA5 atmospheric forcing (winds and sea ice fraction)

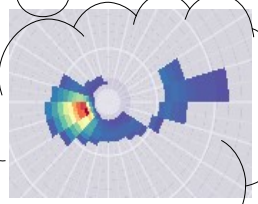
Altimeters SWH (ESA/IFREMER Globwave Data base)

Wave/currents interactions Surface currents forcing GLORYSV1.2

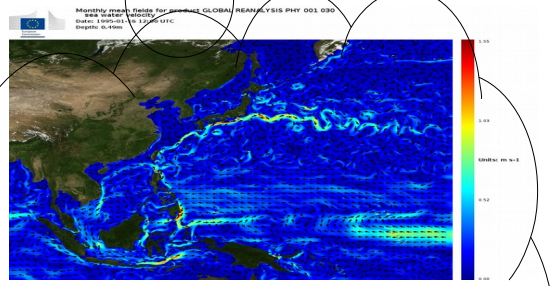
WAVERYS

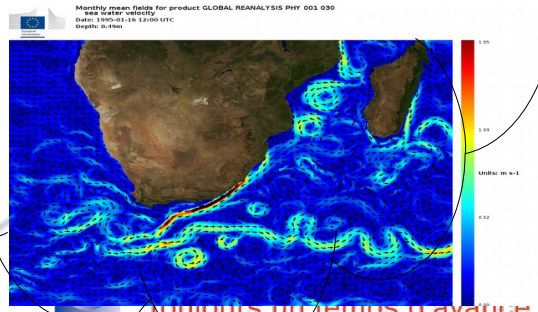
Assimilation

SAR wave spectra from Sentinel-1



Expect the best Wave products





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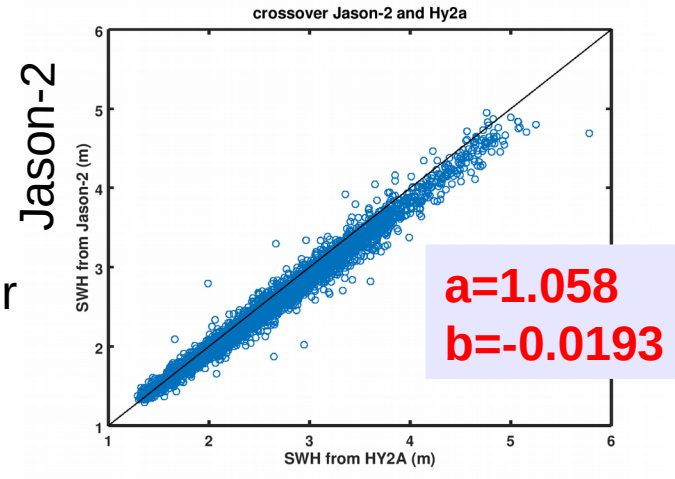
Methodology of validation

➔ **Comparison with HY2A :**

- Validation with SWH from HY2A has been performed for the period 2012-2018. GDR L2 products have been provided by CNES processing (AVISO+).

- HY2A has been calibrated with Jason-2 as a reference mission. Regression relation is used to correct SWH from HY2A (Y=a*X+b)

- Colocation with model grid points (~50 km)



HY2A

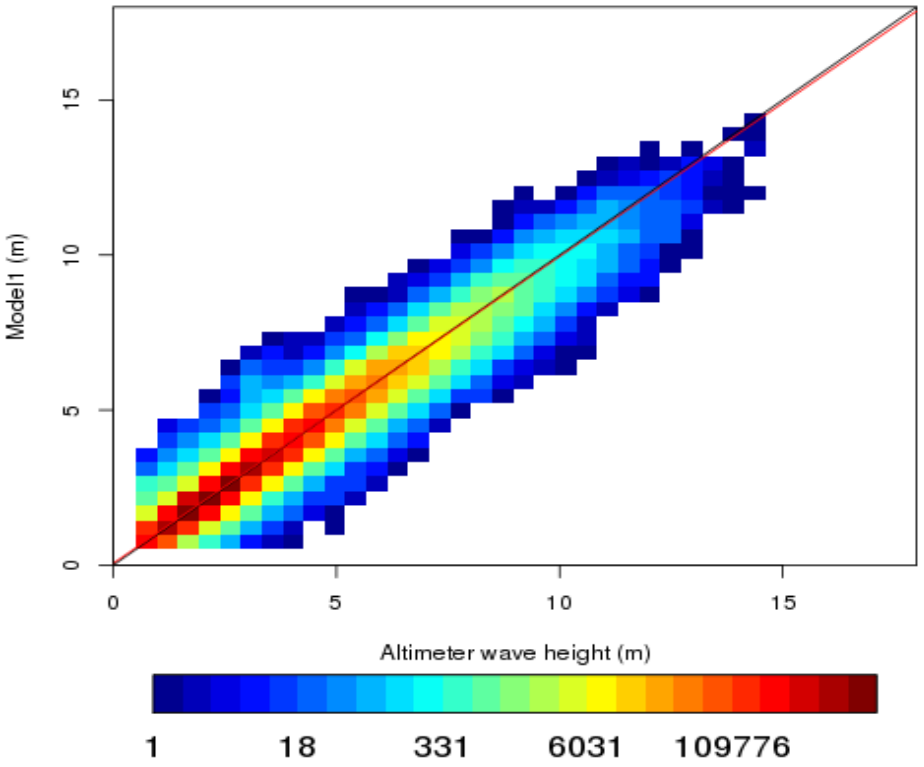
➔ **Comparison with buoys** :

data provided by CMEMS In-situ Thematic Assembly Center (TAC) for the whole period of WAVERYS

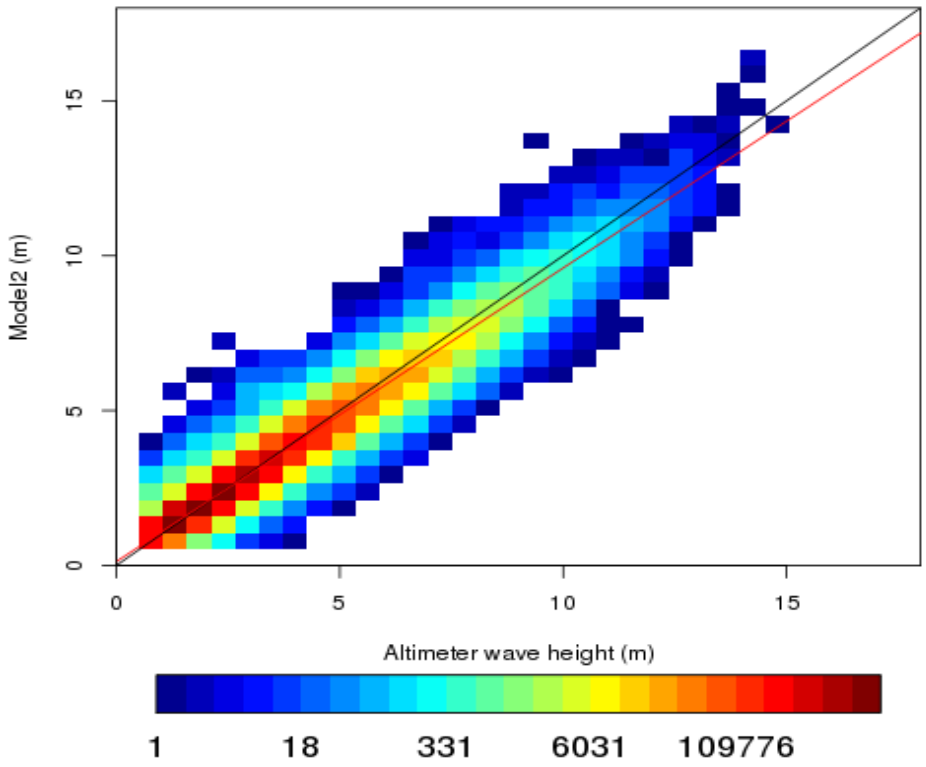
CMEMS in-situ TAC buoys

Scatter plots of SWH
WAVERYS vs ERA5

WAVERYS



ERA5



Bias =0.03
SI = 8,7%
RMSE = 8.8%
Slope = 0.99
Intercept = 0.10

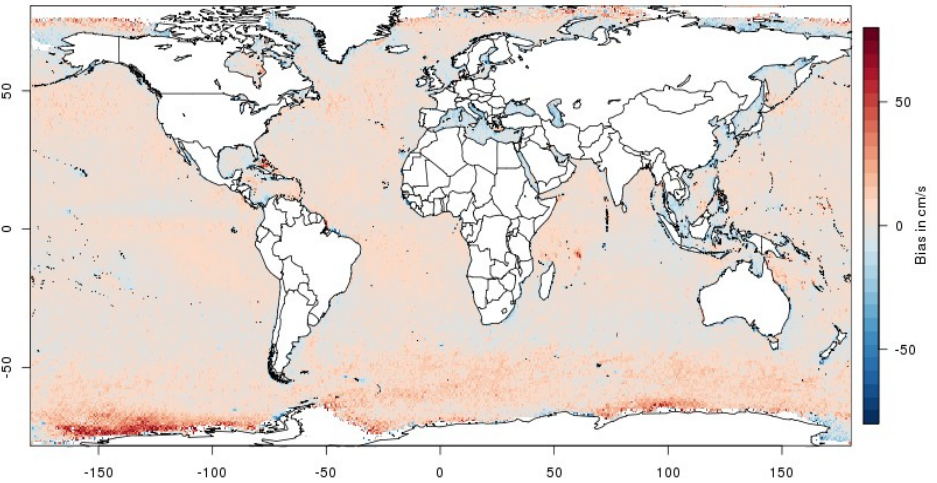
SI is better by ~10 % for waverys in comparison with ERA5

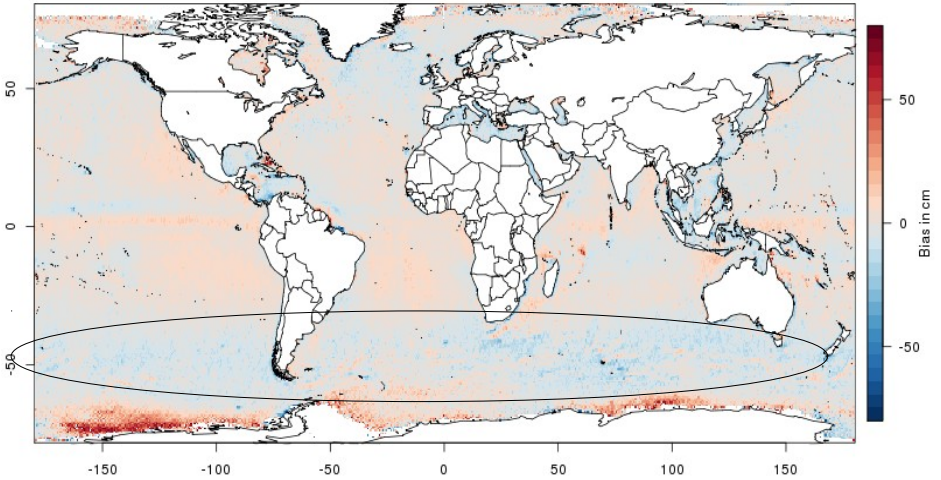
Validation with HY2A
2012-2018

Bias=-0.01
SI=9,6%
RMSE=9,6%
Slope=0.93
Intercept=0.17

WAVERYS vs ERA5 : performance
Validation with HY2A

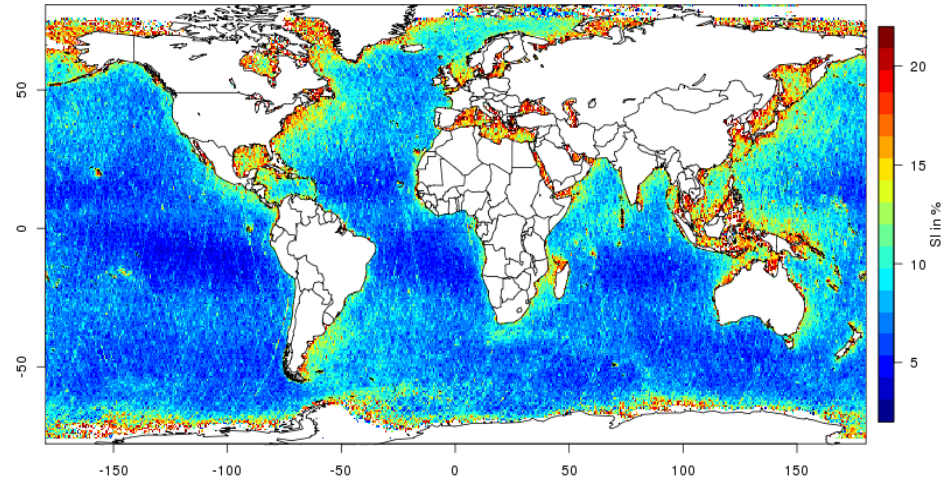
WAVERYS **Bias (max 60 cm)** **ERA5**

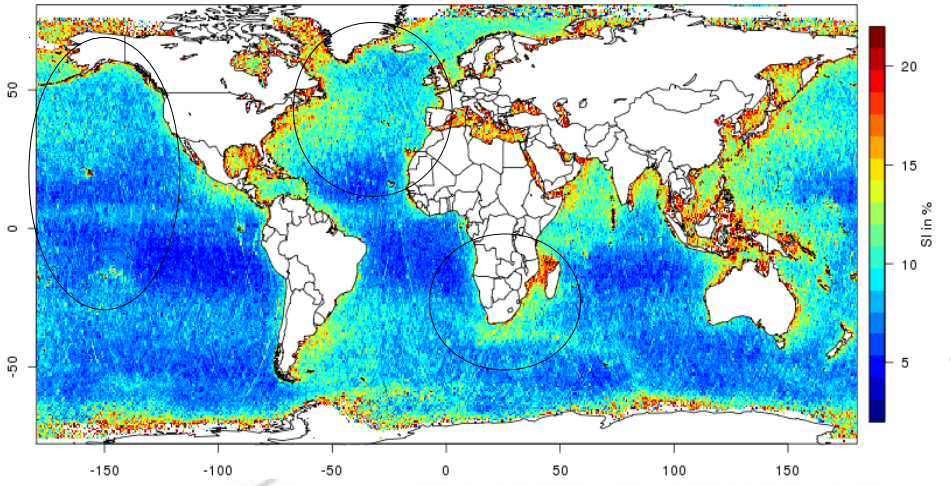




WAVERYS : significantly better in mid lats and tropics

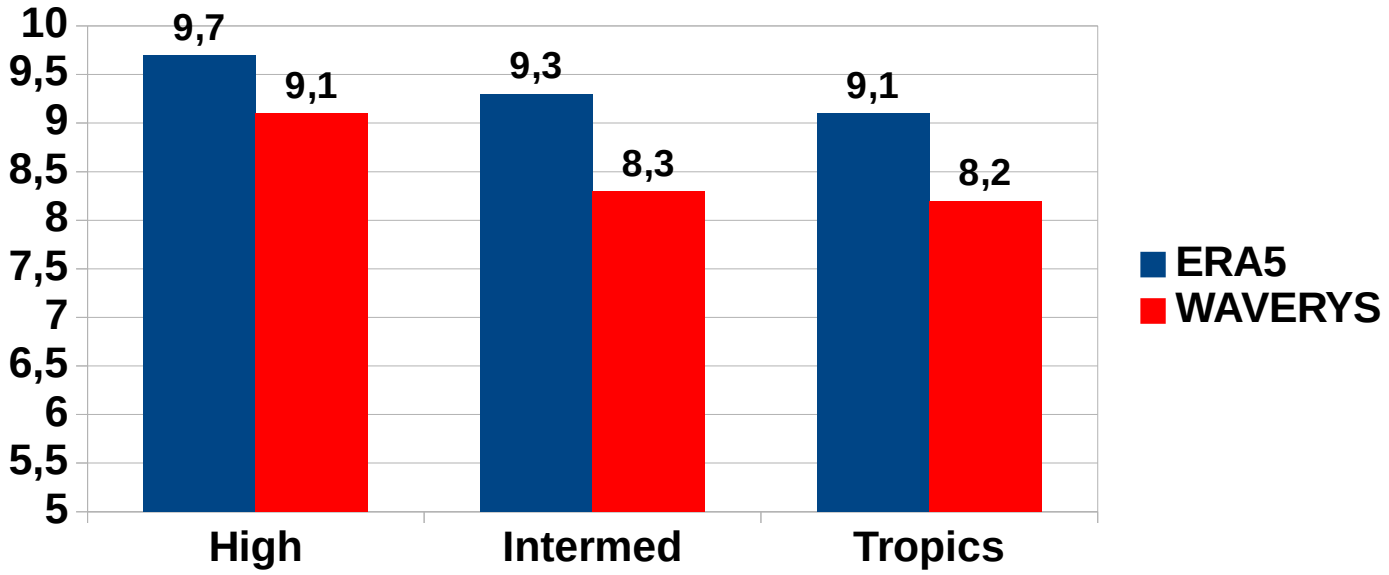
Scatter index maps in %





Performance of WAVERYS for SWH in different ocean basins

Scatter Index of SWH (%)



	High	Intermed	Tropics
Collected data :	2269161	4451612	3524874

WAVERYS induces a better SI of SWH in comparison with ERA5

High Lat $|\Phi| > 50°$
Intermediate lat $20° < |\Phi| < 50°$
Tropics $|\Phi| < 20°$

Validation with HY2A
Period 2013-2018

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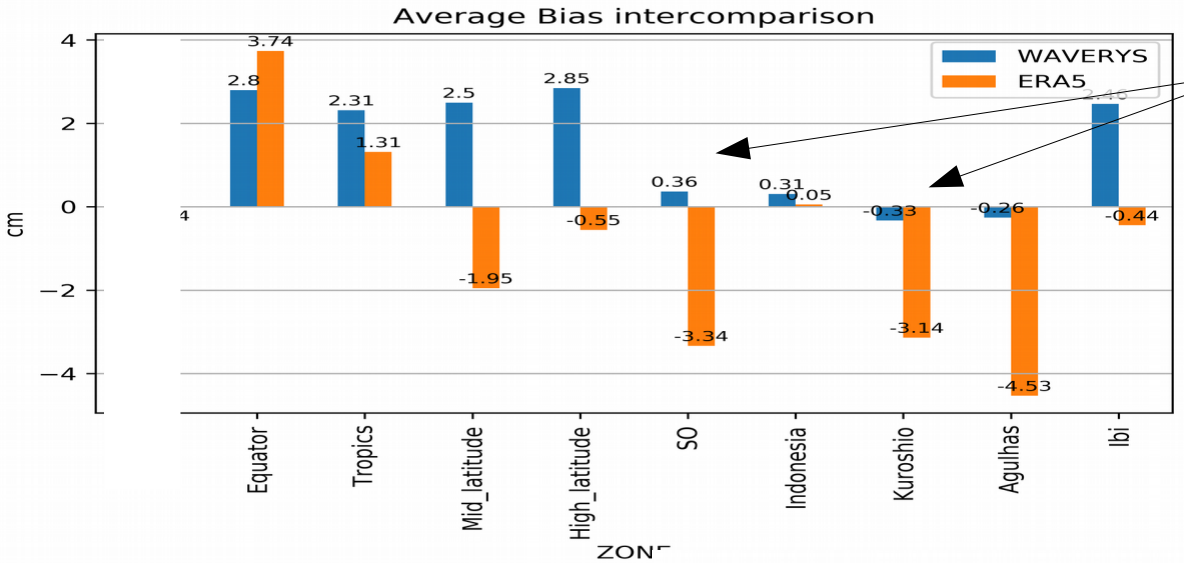
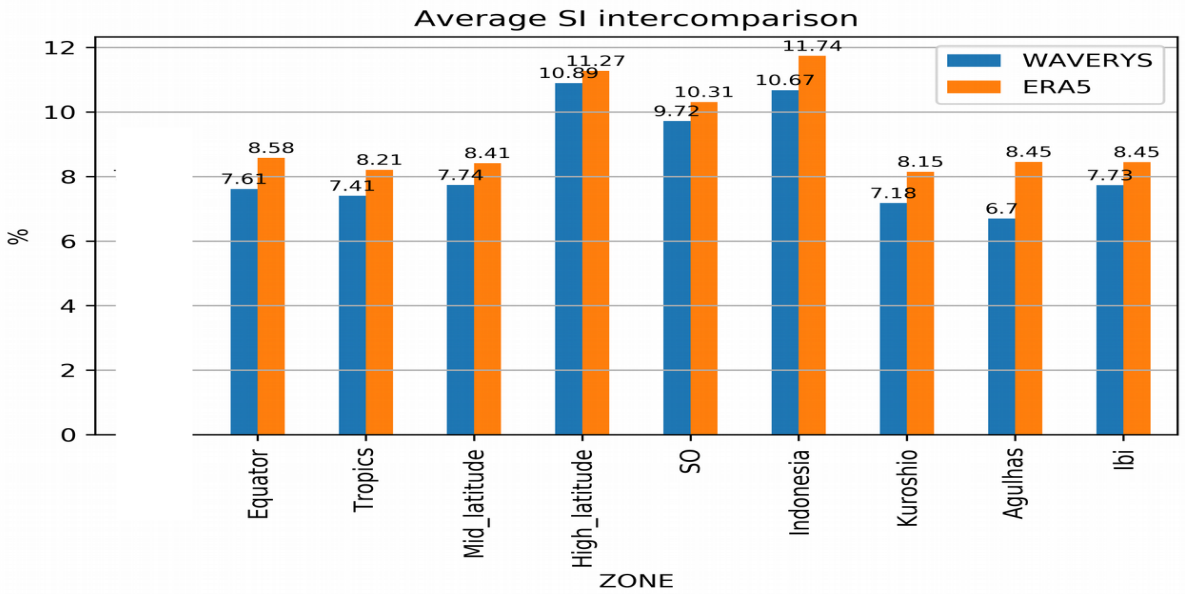
Performancefor SWH in several ocean regions : WAVERYS vs ERA5

BIAS (cm)



Bias is completely removed In Agulhas, Kuroshio, SO,..: Thanks to GLORYS currents forcing

Scatter index (%)

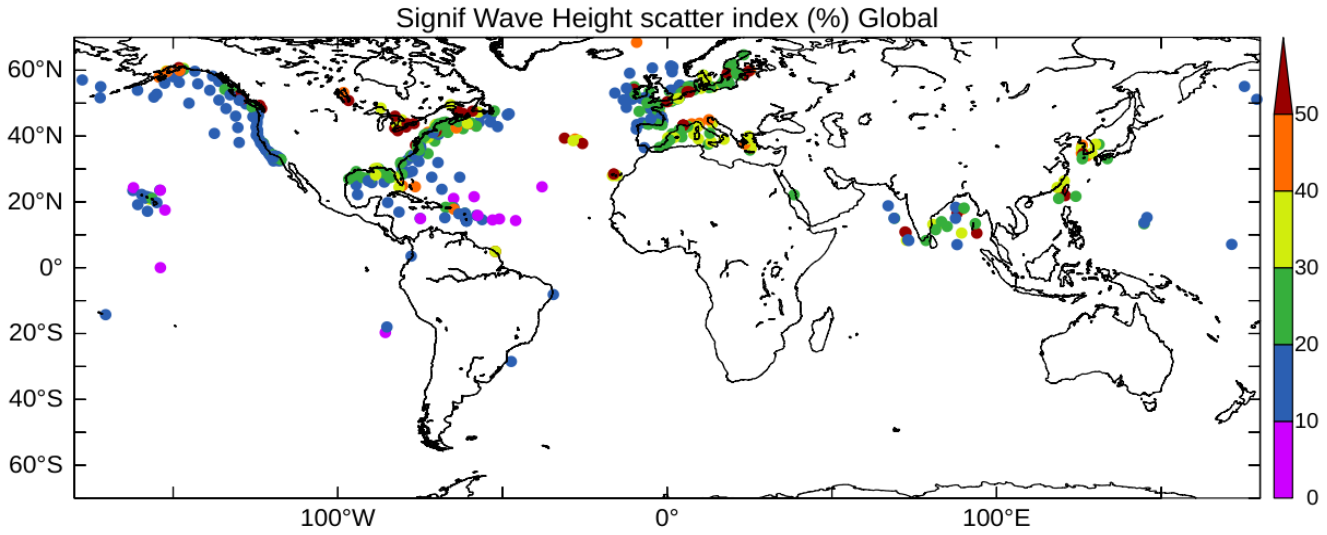


Equator
Tropics
Mid lats
High lats
Southern ocean
Indonesia
Agulhas
IBI (N-E Atlantic)

Validation of HY2A 2012-2018

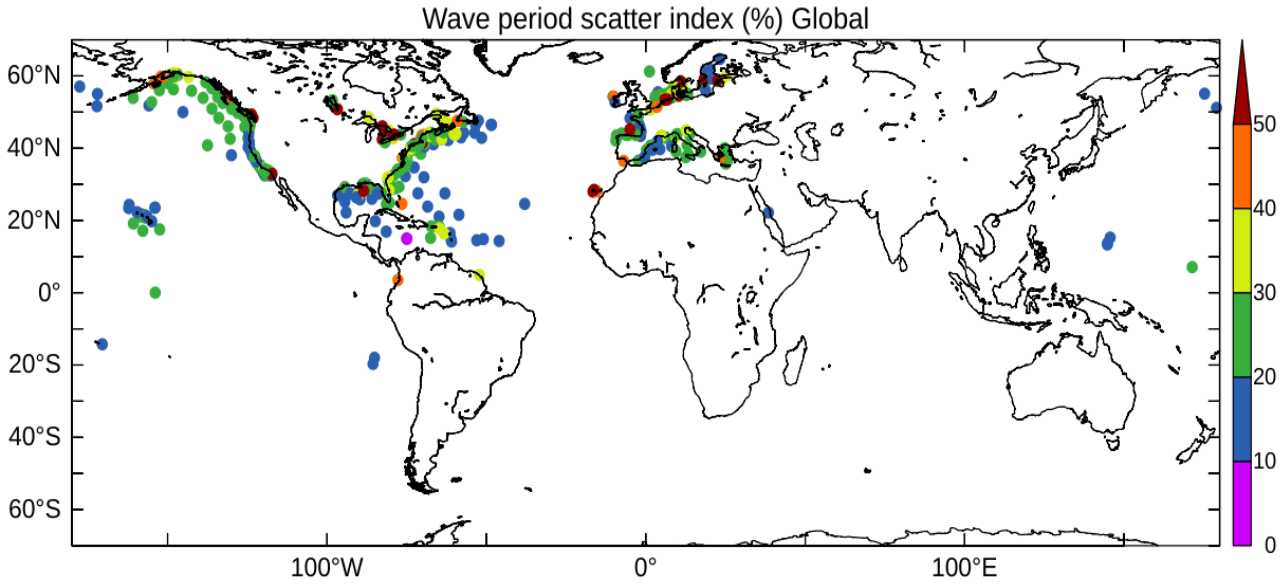
Comparison with available buoys during 1993-2018
Scatter index maps

SWH



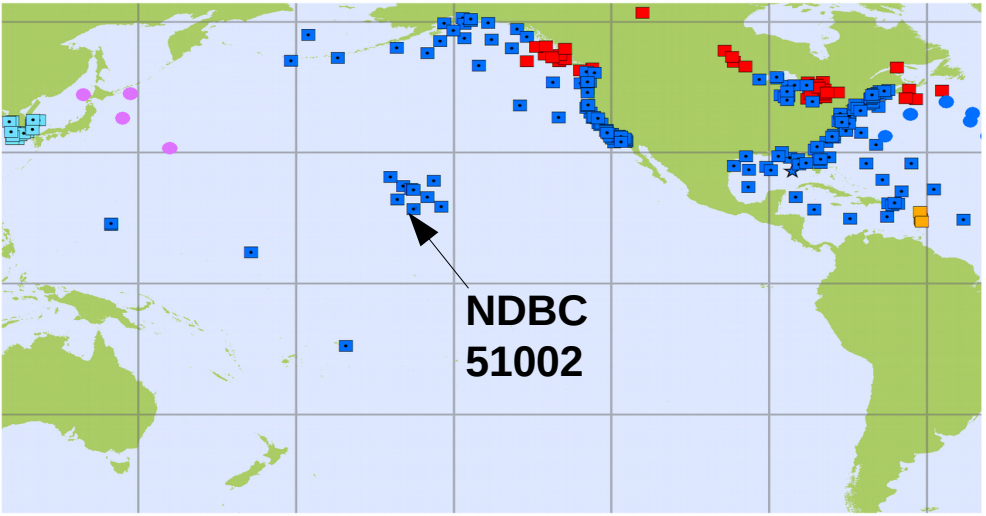
Overall good SI for SWH ~10-15 %, and increases to 20% in coastal areas

Peak wave period

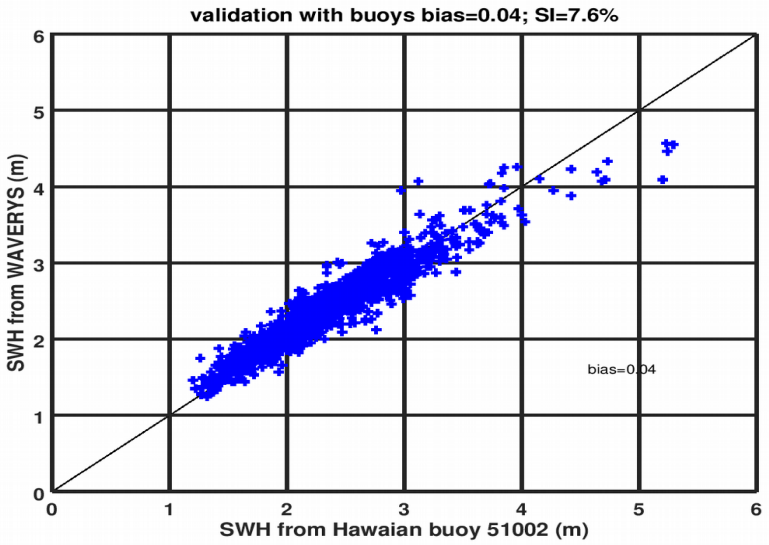


Good SI for Tp roughly 10-20%

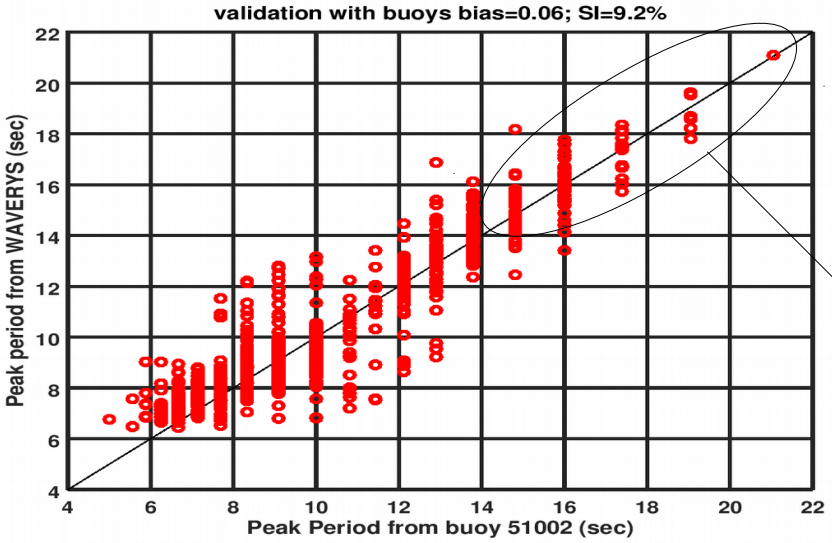
Comparison with Hawaii NDBC/NOAA buoy 51002
Year 2010



Sig. Wave Height



Peak wave period



SI for SWH and Tp is 7.5 %
And 9.7 %, respectively.

Good capturing of long swell dominant wave System (Tp>12 sec)

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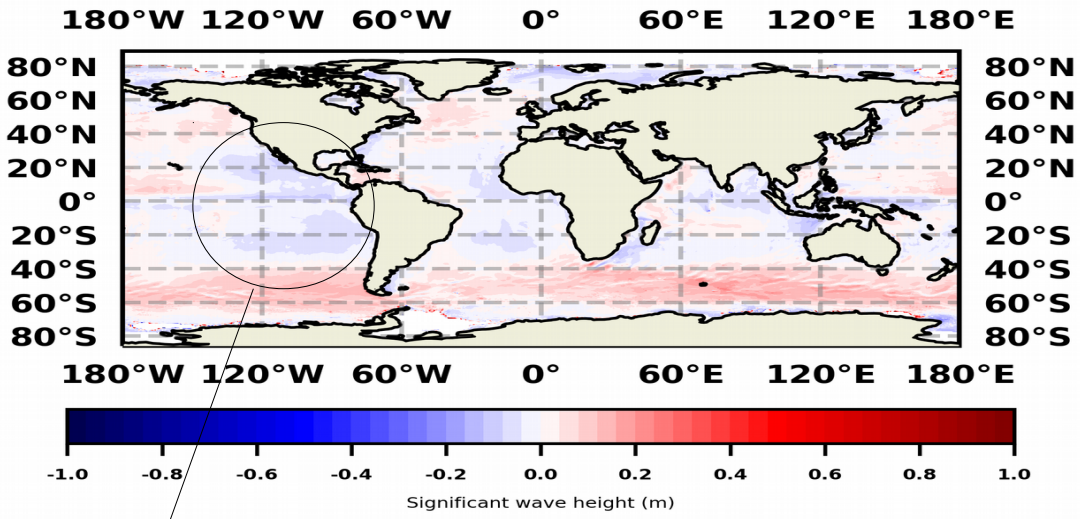
Highlights on strong waves/currents interactions WAVERYS vs ERA5 in 2010

SWH

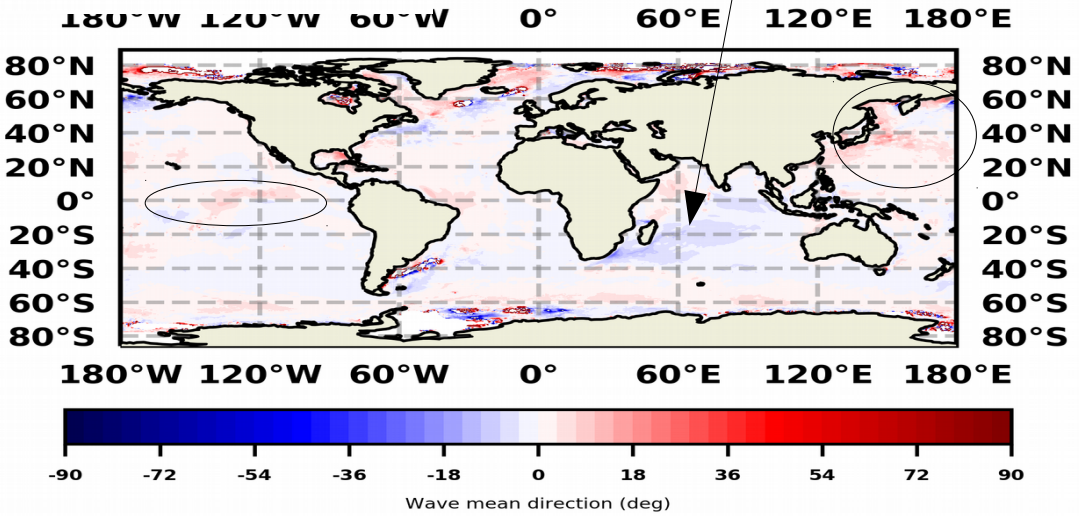


Difference of mean maps between WAVERYS and ERA5

Wave/currents interactions induces a significant impact on mean direction particularly on swell track

Better swell dissipation in WAVERYS : thanks to ST4 physics

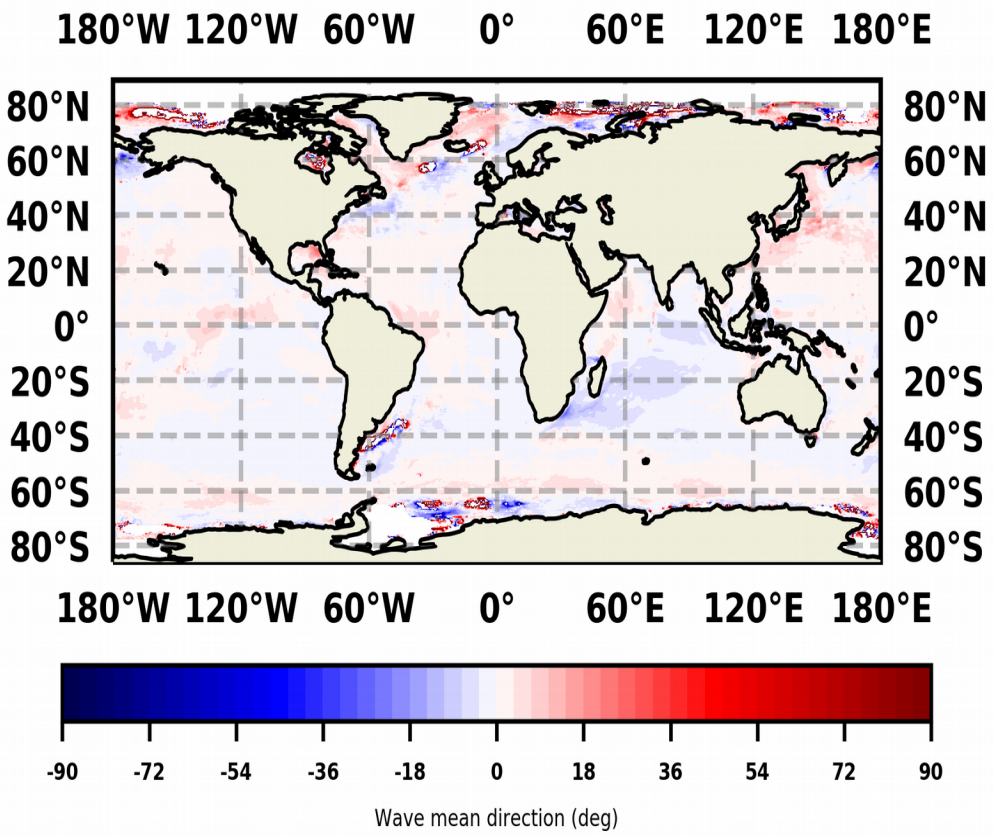
Mean direction

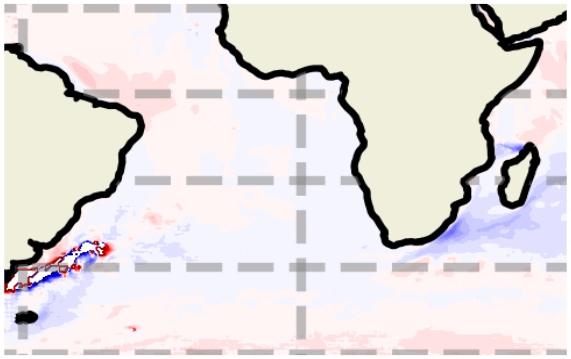


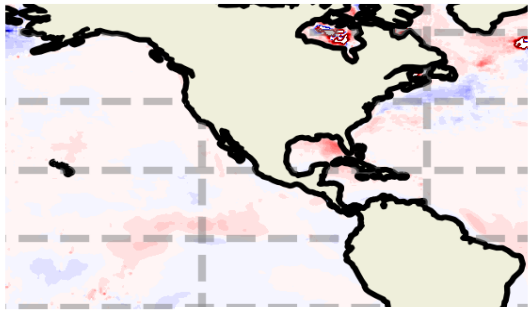
Year 2010

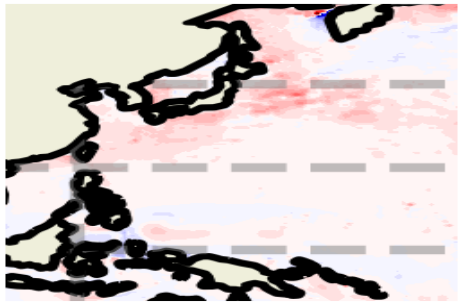
Consistent wave propagation in strong currents areas : Difference between WAVERYS and ERA5

Difference of mean wave direction







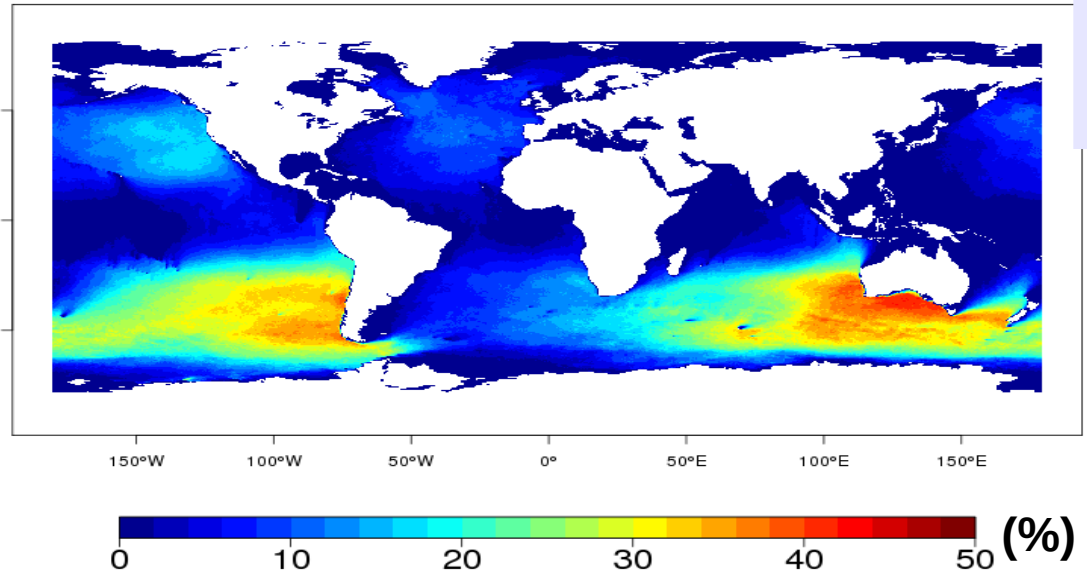


Strong deviation of mean wave direction induced by the GLORYS curents forcing

- Year 2010

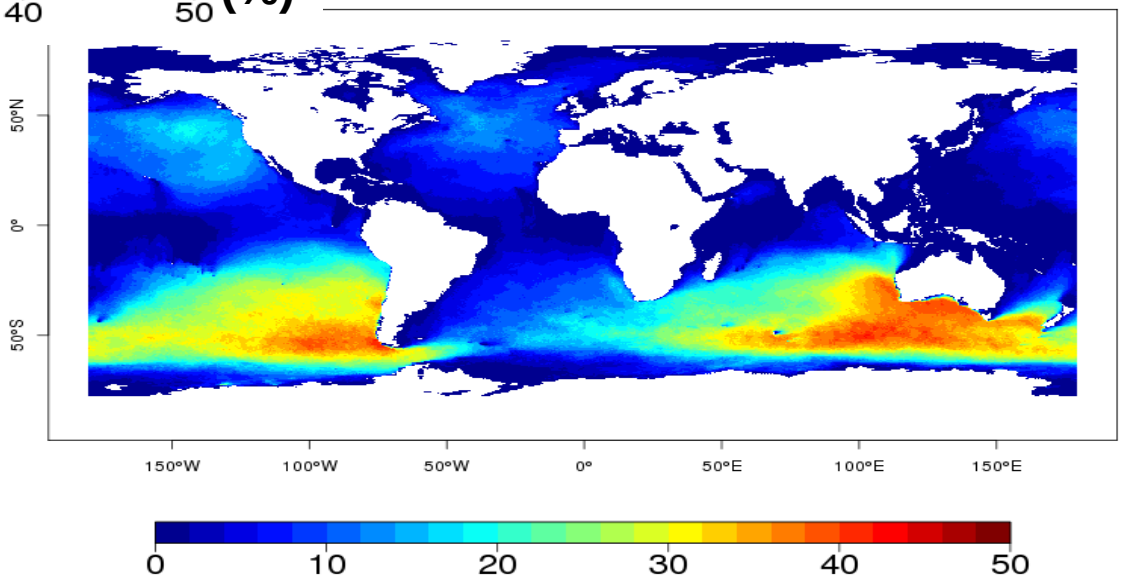
Primary swell climate regime during 2010: WAVERYS vs ERA5

WAVERYS



Probability of occurrence of primary swell with height and period greater than 2 m and 12 sec, respectively

ERA5

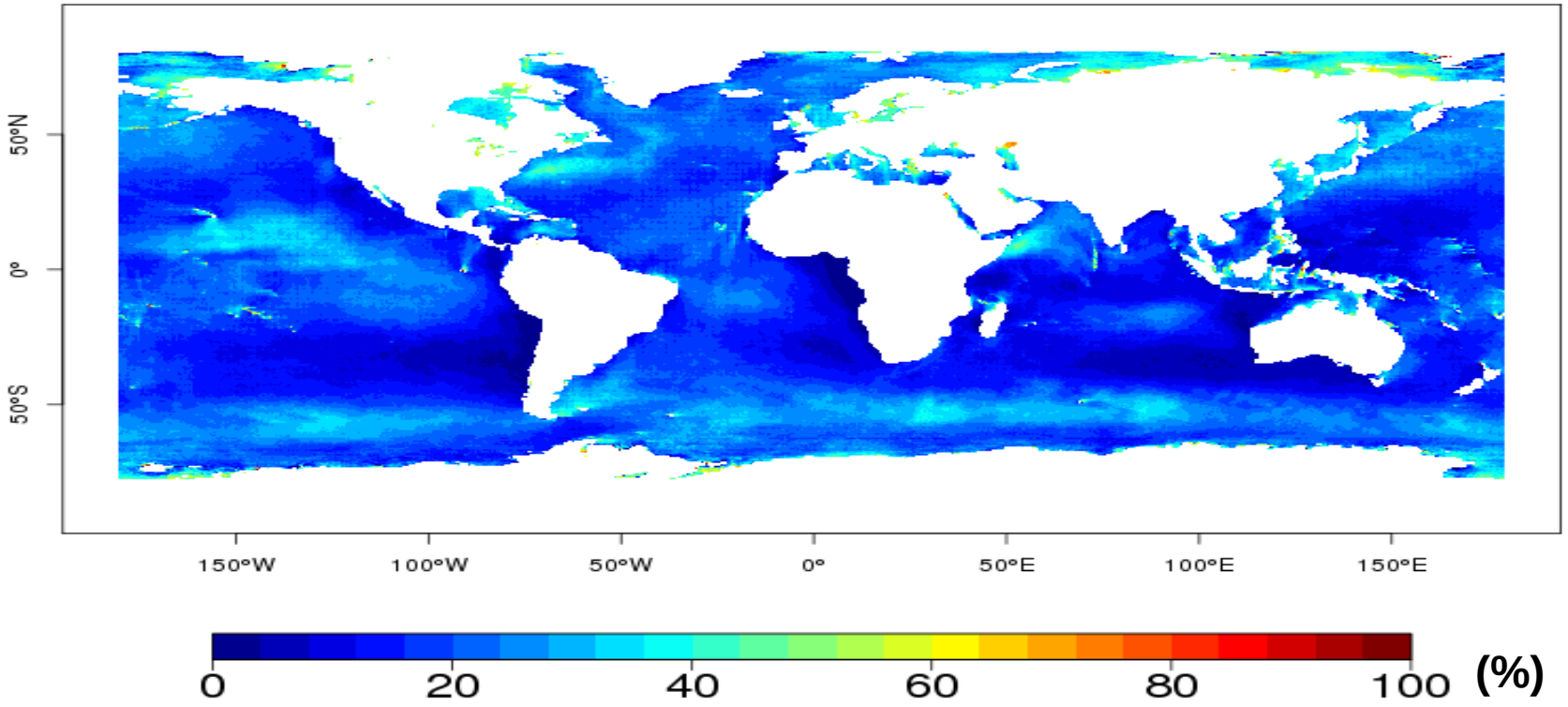


Finer estimate of swell regime with WAVERYS

ERA5 over-represented 1st swell In southern Australia

Primary swell climate regime during 2010: WAVERYS vs ERA5

Probability of occurrence when difference of Primary swell directions between WAVERYS and ERA5 exceeds 30 degrees



Occurence exceeds 30 % in strong surface currents regions

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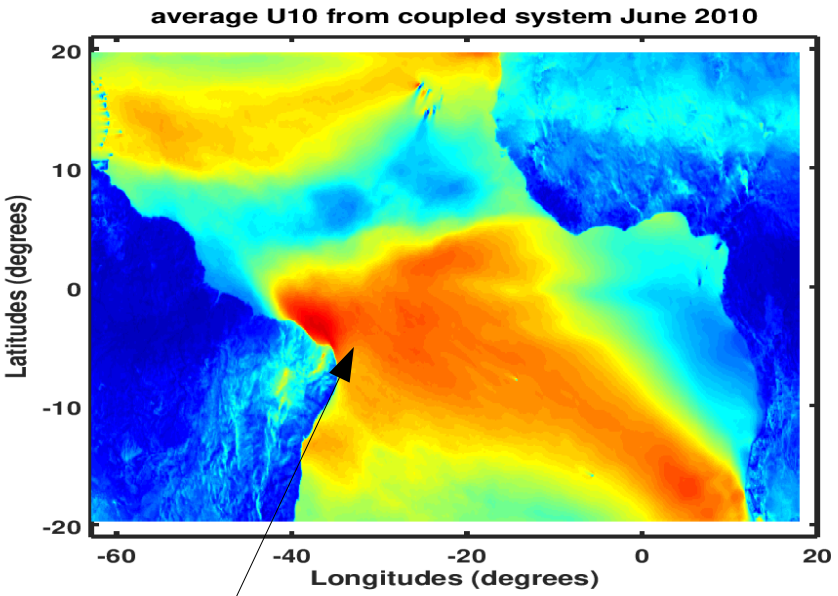
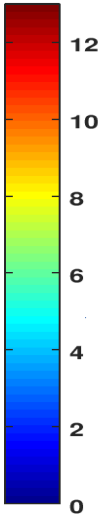
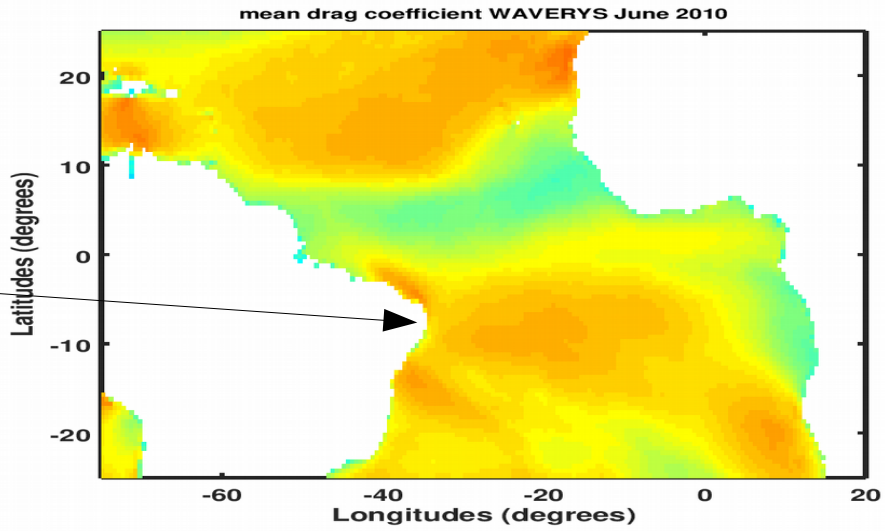
Relevance for ocean/wave coupling
Case of strongest SST anomaly (June 2010)





Wind speed (m/s) from coupled simulation of non-hydrostatic atmospheric model MESO-NH forced by SST from NEMO ocean model (Giordani et al. 2019)



Mean of drag coefficient (surface stress) from WAVERYS is highly consistent with winds From coupled simulation

Conclusions

- **Very good accuracy of WAVERYS integrated parameters (SWH, Peak period) : thanks to validation with HY2A and buoys.**
- **WAVERYS significantly better than ERA5**
- **Relevance of using currents forcing in WAVERYS : better sea state and swell propagation : good perspectives for users applications (wave climate, reprocessing of altimeters,….etc)**
- **WAVERYS wave products will be released in December 2019 : marine.copernicus.eu**
  (product name : *GLOBAL_REANALYSIS_WAV_001_032*)