Surface currents : Key parameter for ocean/waves coupled system of CMEMS

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Workshop of Doppler Oceanography from Sapce
From science to technology and applications,
10 October 2018, Brest

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OUTLINE

1- Motivation

2- currents in CMEMS-GLO wave system

3- coupling waves and ocean

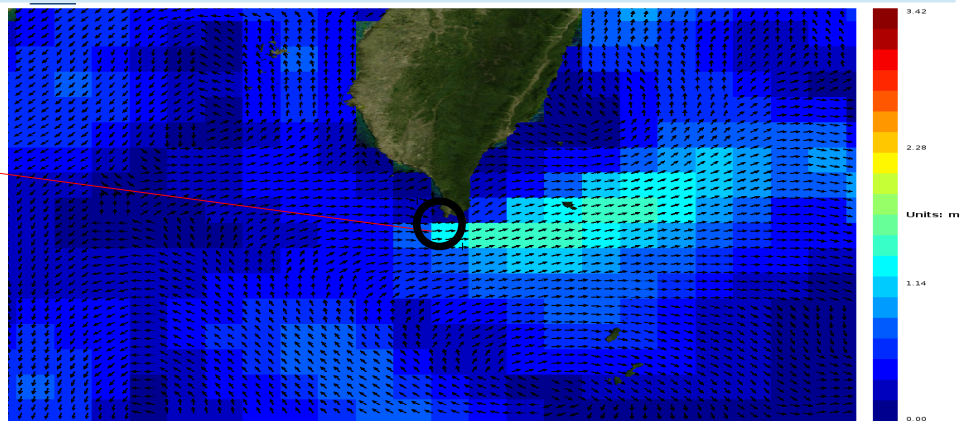
4- Tropical-Atlantic setting and preliminary results

5- Conclusions

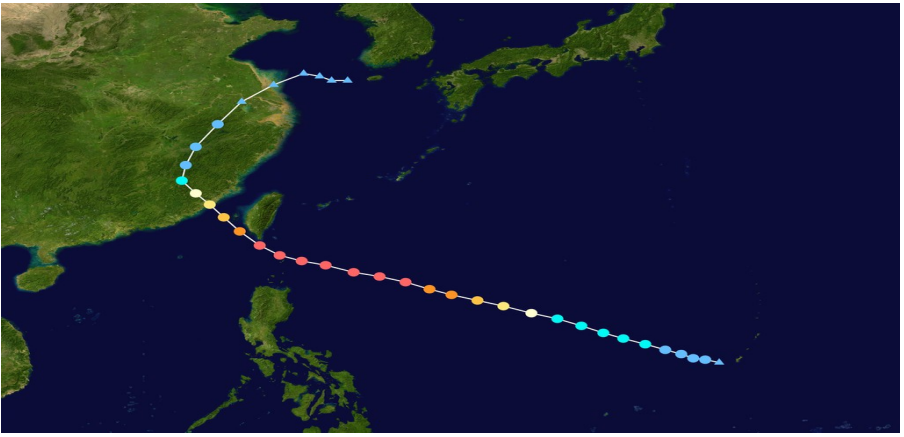
High waves during typhoon Meranti (Sep. 2016)

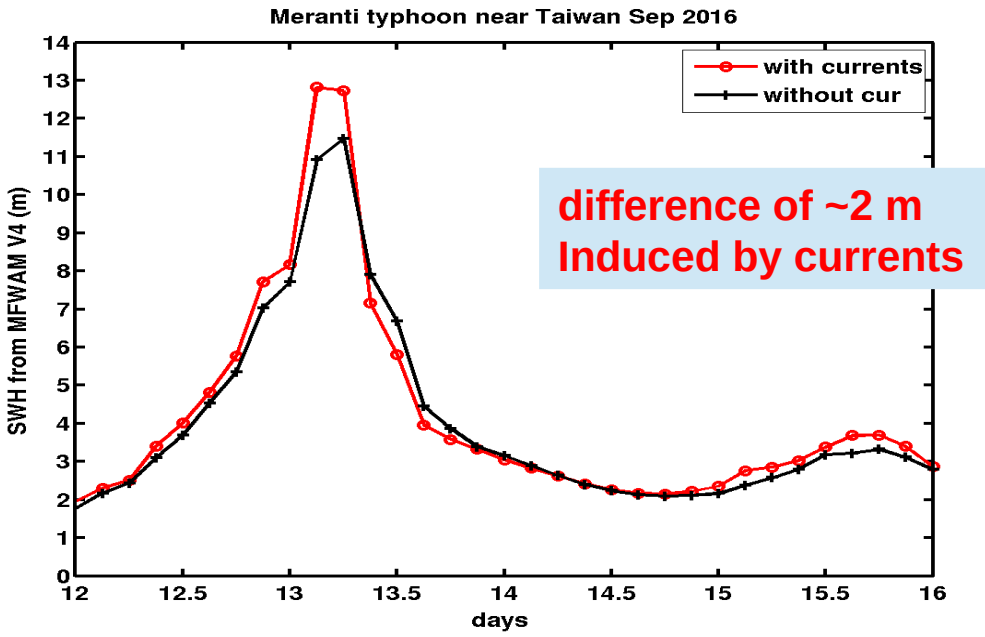
Strong currents (~2 m/s) in opposite direction of long swell and high tide conditions (almost 3 m)

18 meters of SWH recorded at Taiwanese buoy on 13 Sep. 2016 At 06:00 (Source from Jason YU)



Typhoon track



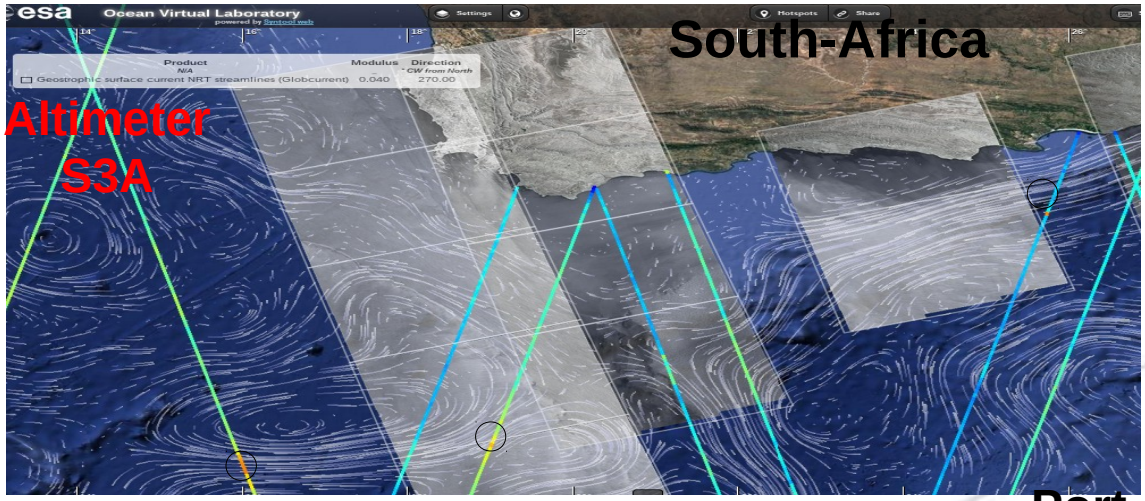


difference of ~2 m Induced by currents

Impact of currents on waves
CMEMS-V4 vs CMEMS-V3

MOTIVATION

- **Impact of surface currents forcing on wave forecasting : upgrade of CMEMS-GLO waves system**
- **Coupling waves with ocean : improvement and validation**
- **Preparation of the earth system : understanding how the waves and currents affects the ABL (numerical tropical atlantic study)**



Waves modulation Induced by currents observed by SAR In the Agulhas

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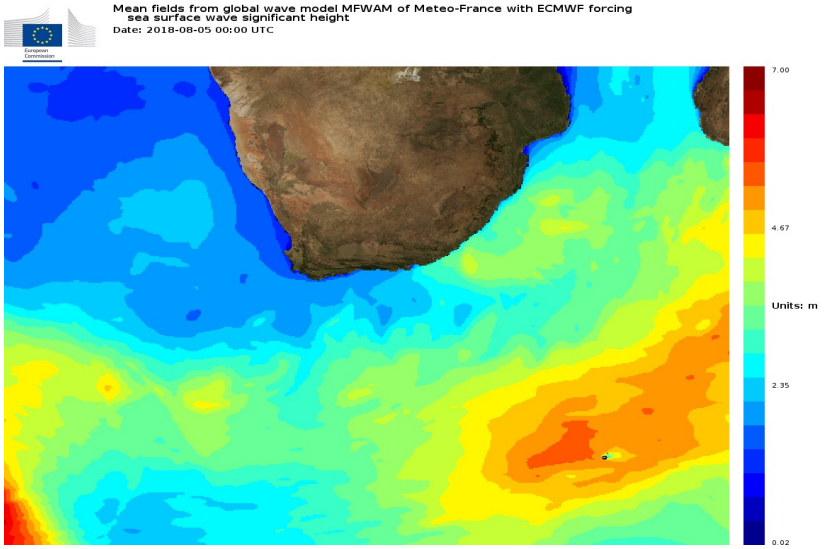
The current operational wave system MFWAM for CMEMS-GLO waves (marine.copernicus.eu)

- Global grid of 10 km 3-hourly atmospheric forcing from IFS-ECMWF.
- Improved wave physics for better surface stress for the coupling with ocean
- Daily surface currents forcing from CMEMS global ocean system
- 3-hourly assimilation of 5 altimeters in operations (Jason 2 & 3 Saral, Cryosat-2, Sentinel-3A)



Snapshot of SWH with features Induced by surface currents Forcing in the Agulhas (5 Aug. 2018)

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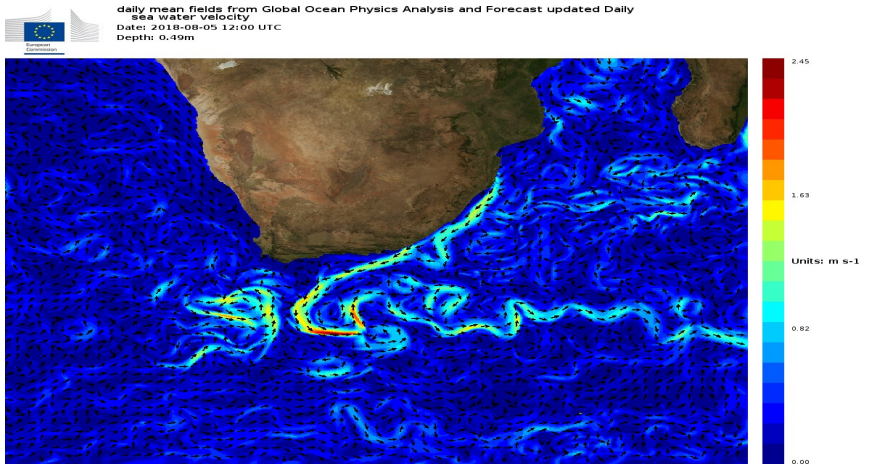
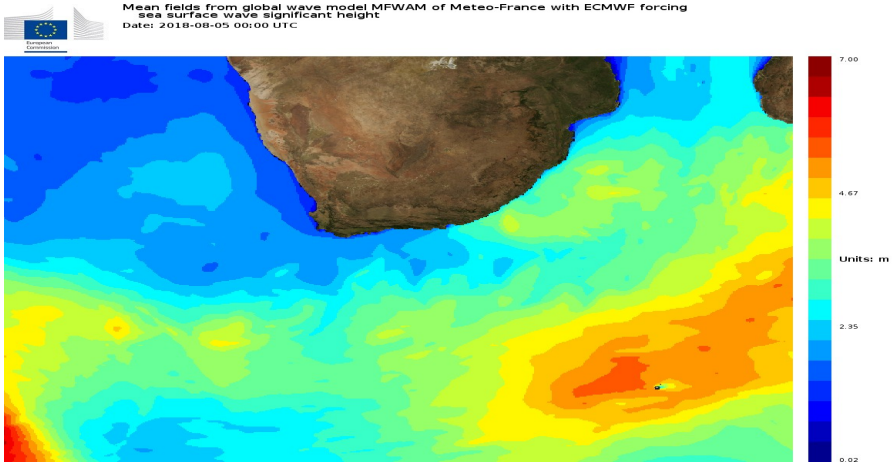
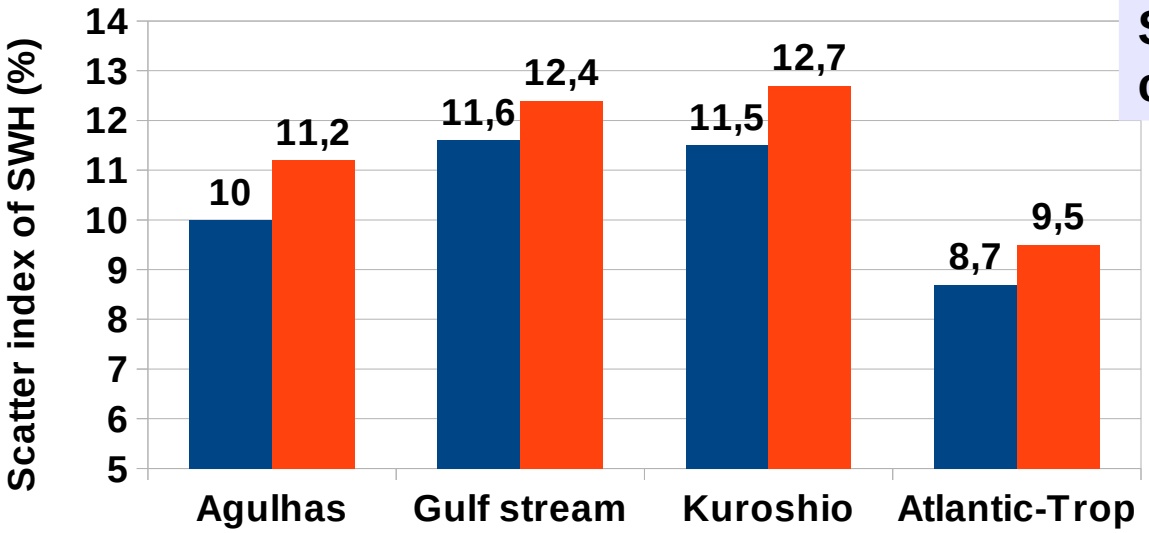
Impact of surface currents on CMEMS-GLO SWH
March 2017

Surface currents CMEMS-GLO-PHYS



SWH CMEMS-GLO-WAVES

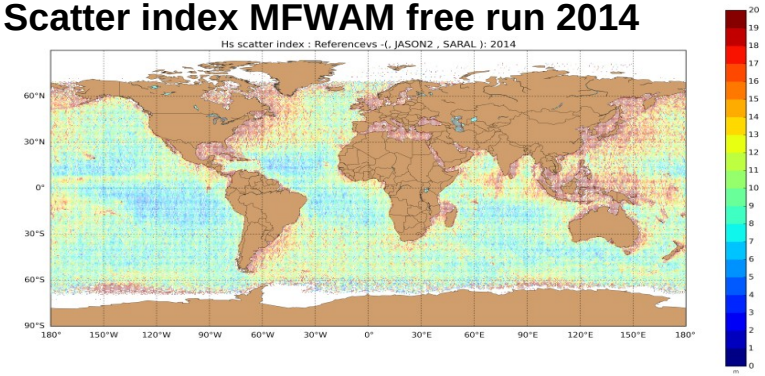




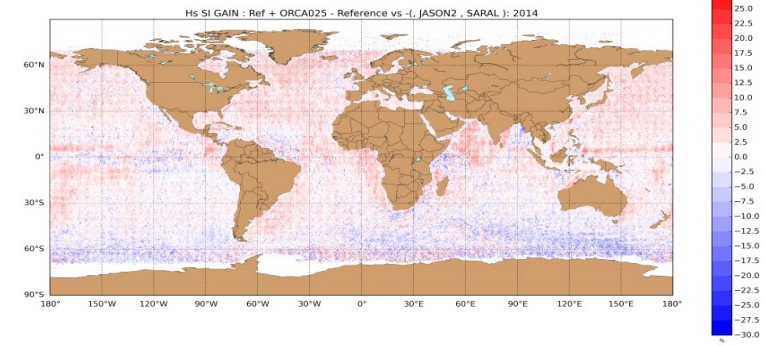
Significant impovement in strong currents ocean areas (up to 10%)

Validation of MFWAM forced by NEMO currents during 2014 (ORCA25 ou PSY3)

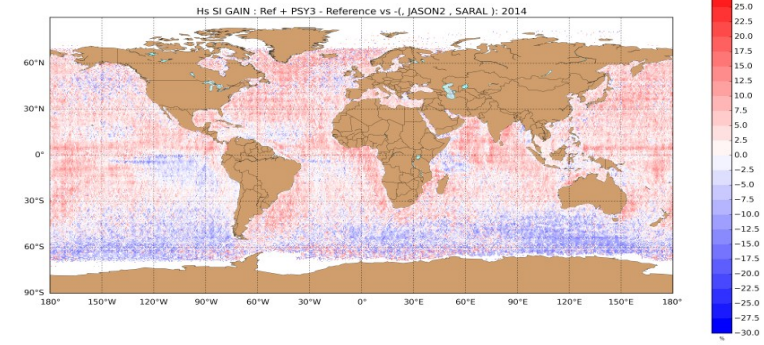
Scatter index MFWAM free run 2014



Improvement of SI (%) : MFWAM + ORCA025



improvement of SI (%) : MFWAM + PSY3

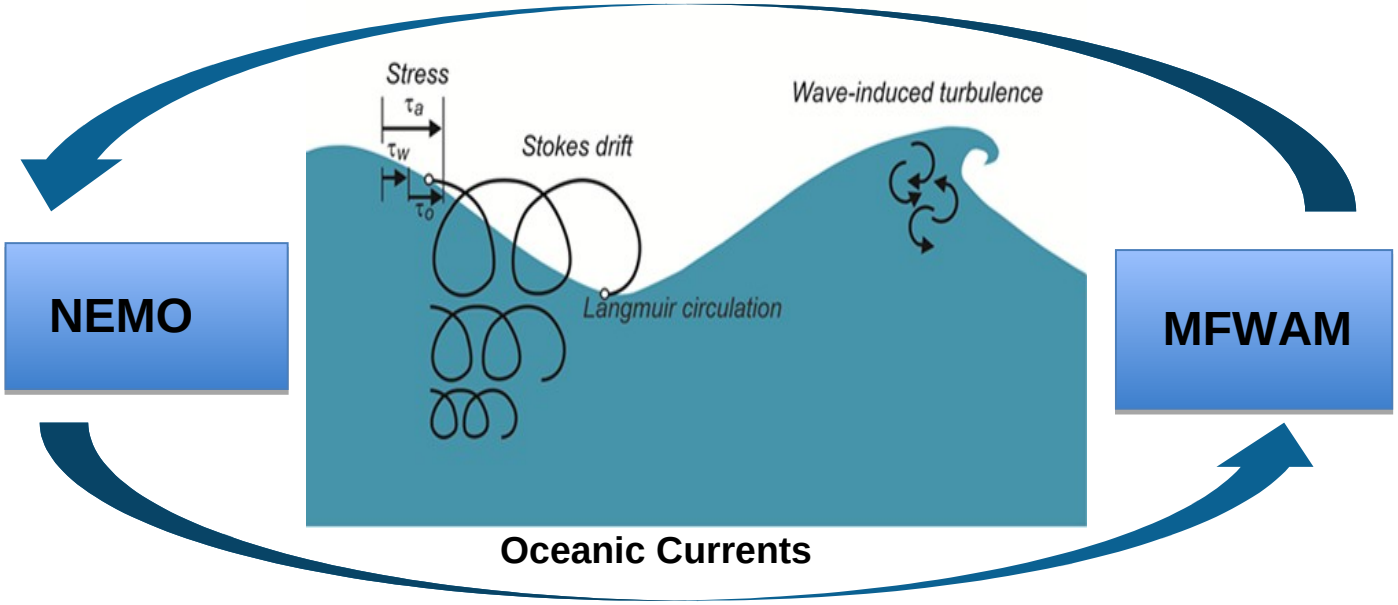


Run of MFWAM with ECMWF winds and 3-hourly surface currents from NEMO-ORCA25 (free run) and 1.4° PSY3 from Mercator ocean

ZONE	Improvement of scatter index	
	ORCA25	PSY3
Global	+ 2.88 %	+4.33%
Atlantic	+ 6.27 %	+10.15 %
Pacific	+ 4.47%	+8.45%
IBI	+ 5.56 %	+ 7.51 %
Mediterranean	+ 4.46 %	+8.21 %
Indian Tropics	+4.47 %	+9.57%
Benguela	+ 7.38 %	+ 10.33 %
Californian upwelling	+2.34 %	+5.32 %
Gulf Stream	+8.70 %	+ 13.68 %
Kuroshio	+8.63 %	+14.51 %

3-years global Ocean/waves coupling 2014-2016

Coupling NEMO ocean model and the wave model MFWAM)



- **Momentum flux modified by the waves (from the model MFWAM)**
- **Stokes-Coriolis forcing**
- **Wave breaking inducing turbulence in the ocean mixed layer**

MFWAM-0.2° (ECMWF wind forcing)
NEMO-PSY4 -0.2°
6-hourly wave forcing

(Law-Chune 2018 Ocean Dynamics)

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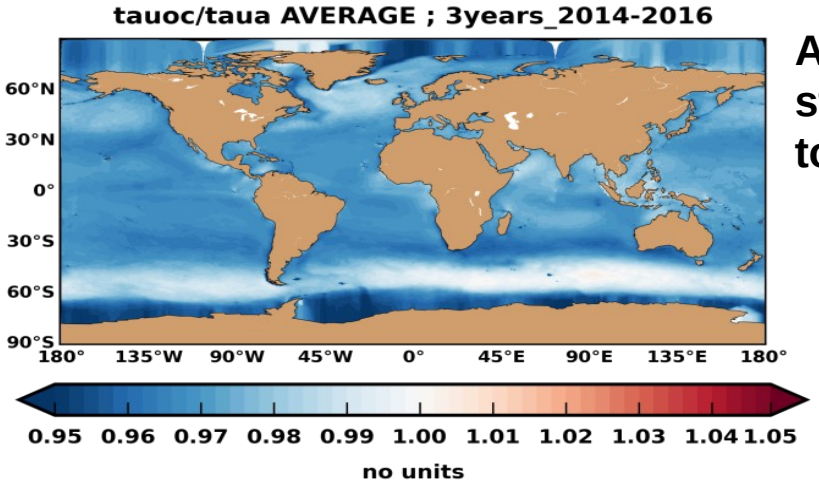
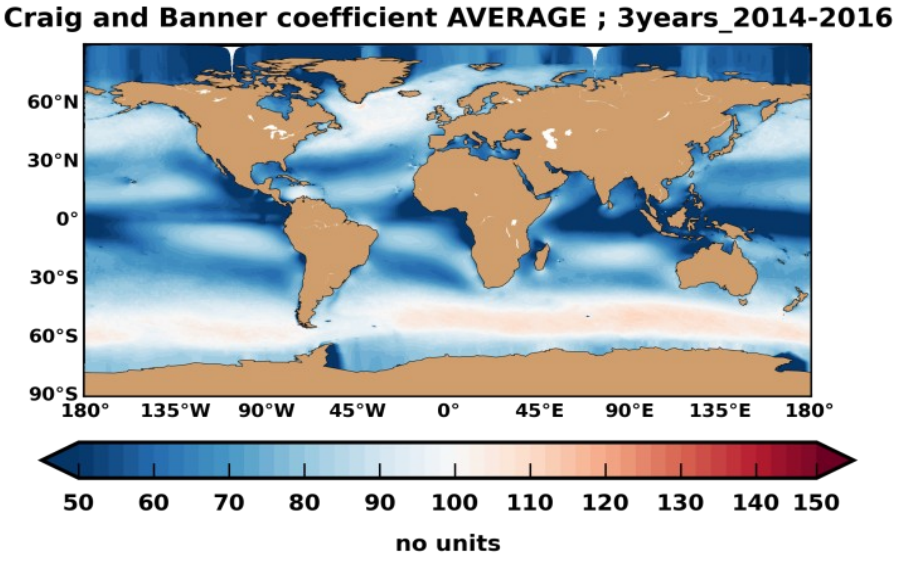
3-years ocean/waves coupling with MFWAM and NEMO-PSY4 2014-2016

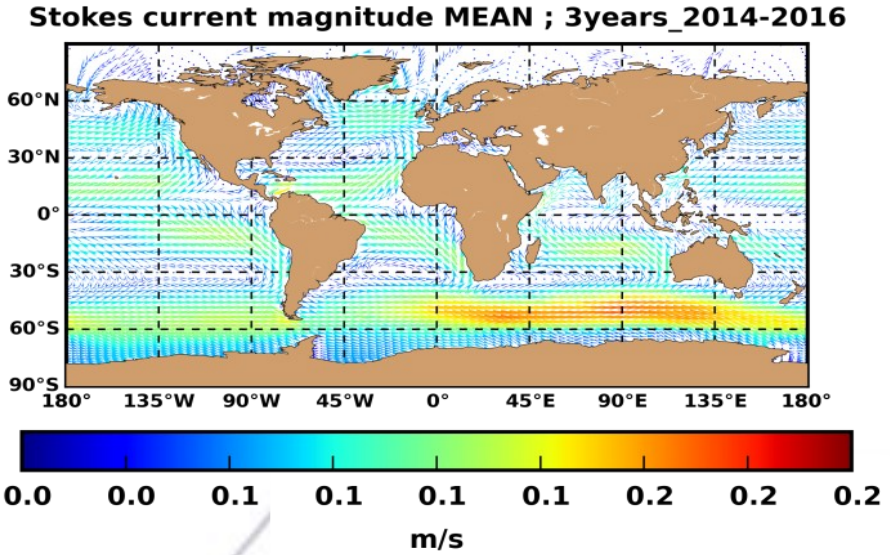


Average of ratio total stress and stress released to oceans

High CB coefficient
Induced enhanced ocean mixed layer

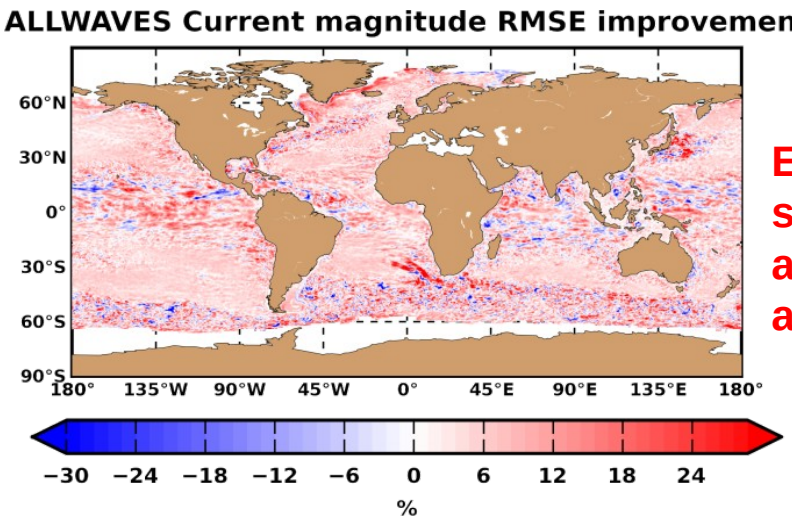


Average of Stokes forcing



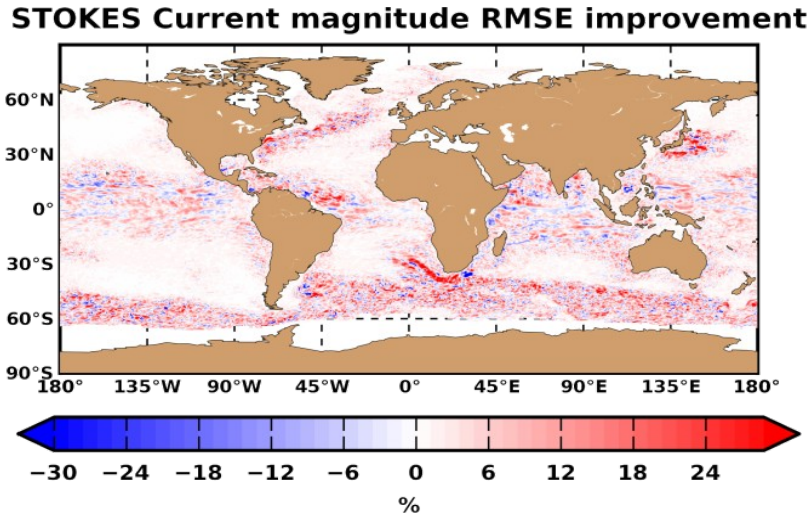
Validation with L4 surface currents from altimetry (CMEMS) Improvement skill (2014-2016)

All coupling activated



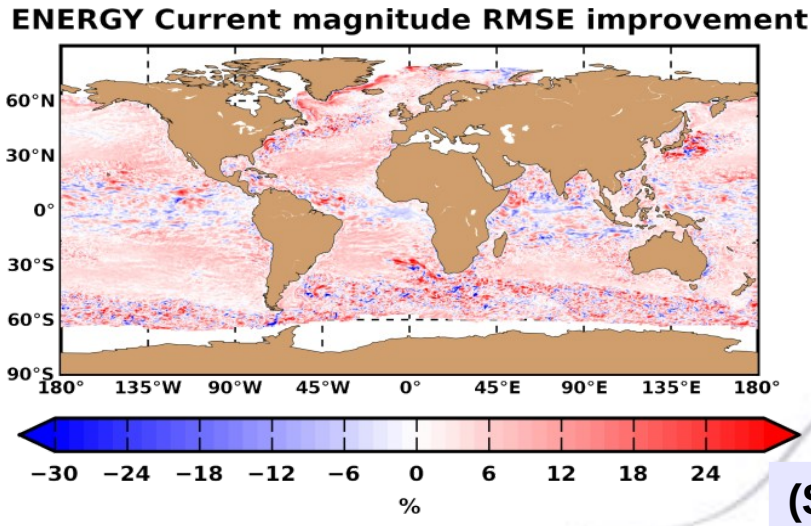
Enhanced skill when all processes activated

Only Stokes activated



Wave breaking activated

Contribution of different coupling processes



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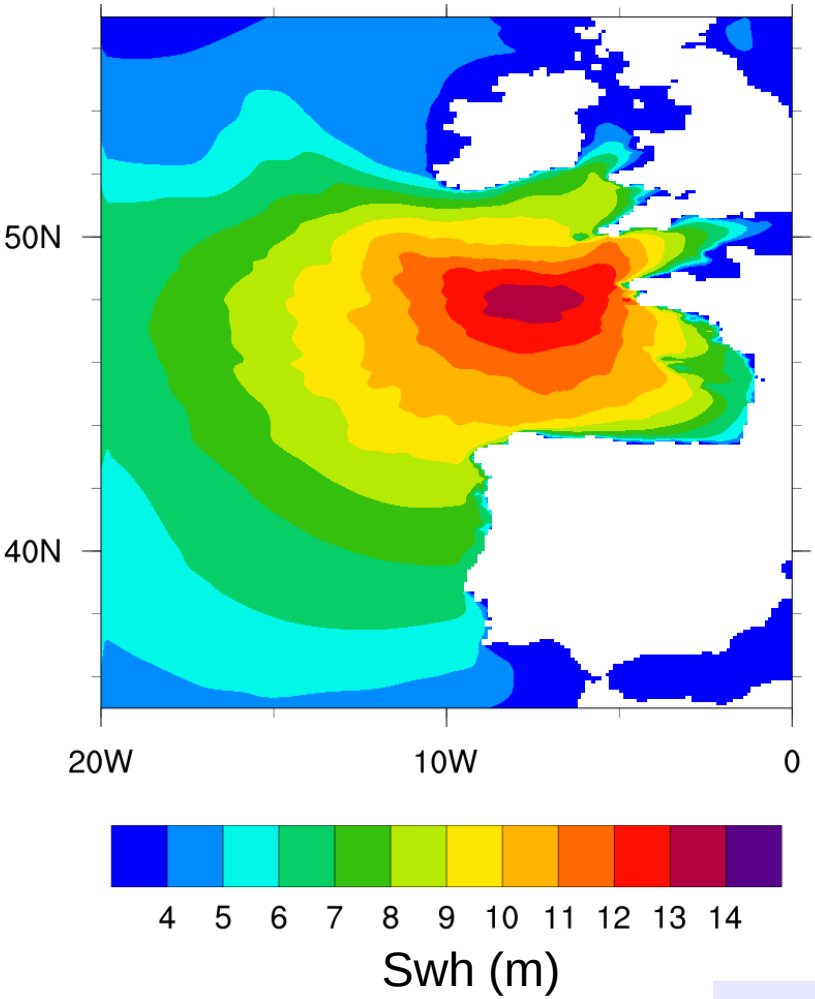
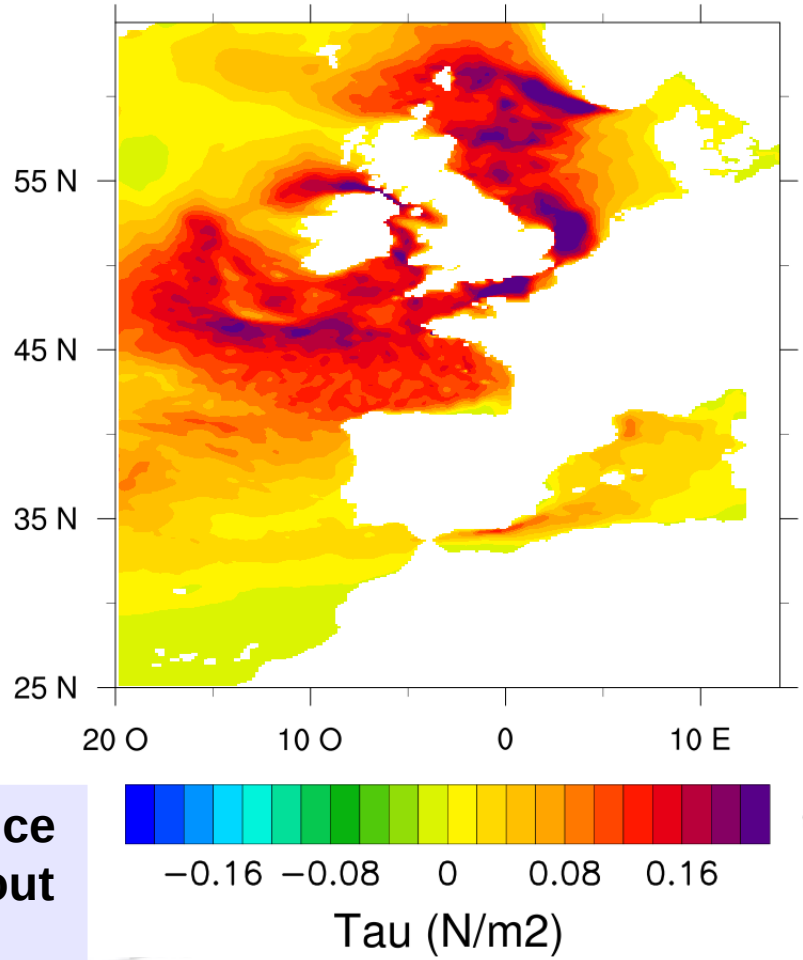
(See paper of Law-CHune 2018)

Ocean/waves coupling during storm Petra on CMEMS-IBI (5 February 2014)

More than 14 m of SWH near brittany

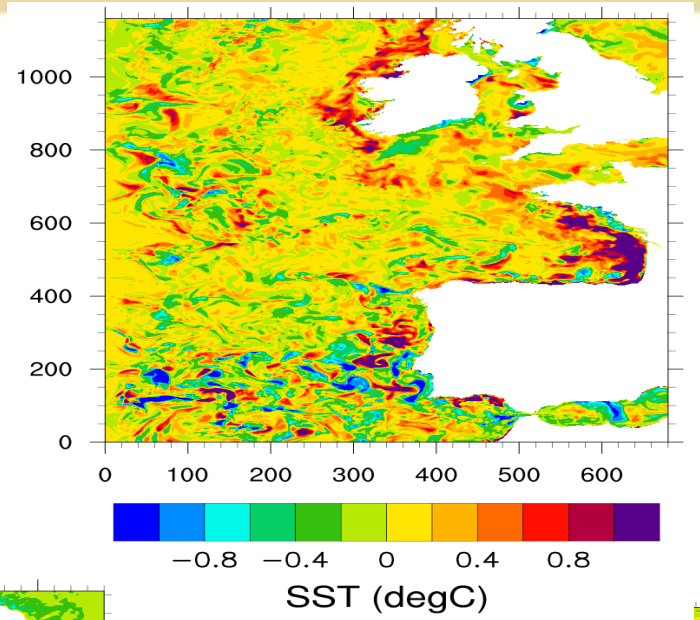


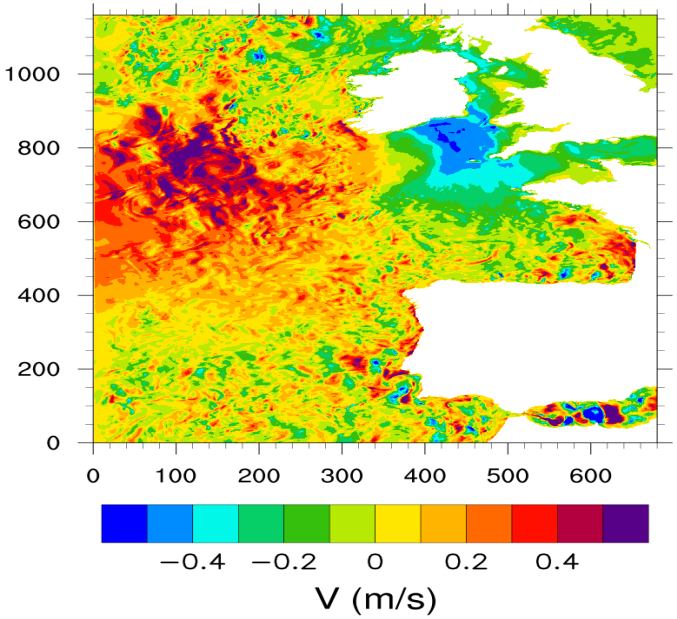
MFWAM-IBI 10km grid size
NEMO-IBI 1/36° grid size
1-year (2014) run with three coupling processes



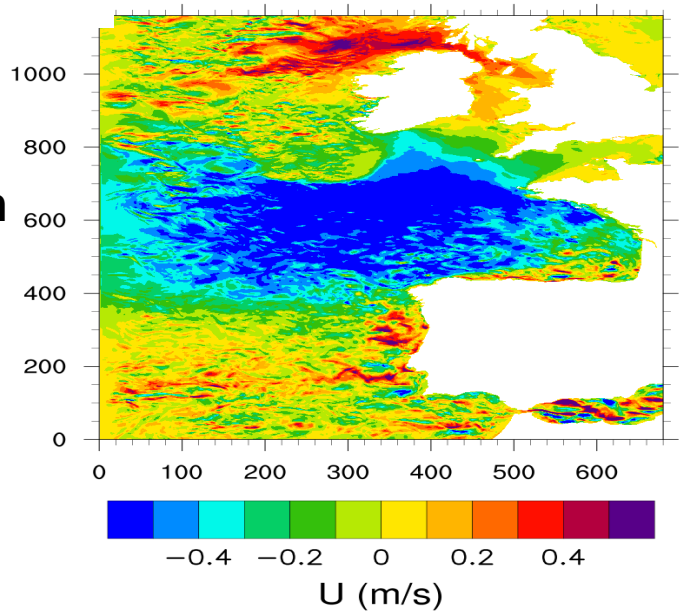
Stress difference With and without coupling

Impact of ocean/waves on 5 February 2014 (3:00 UTC) during storm Petra

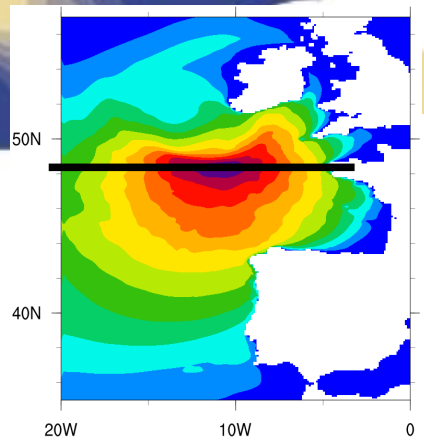




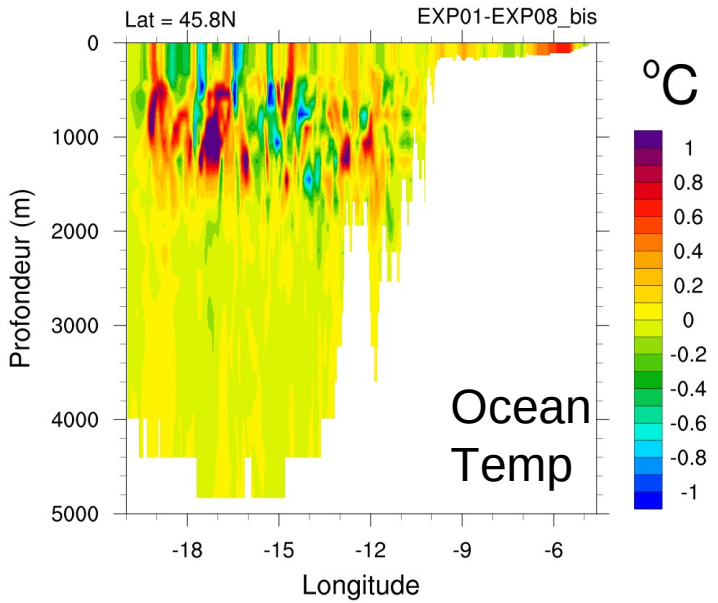
Strong impact on storm location

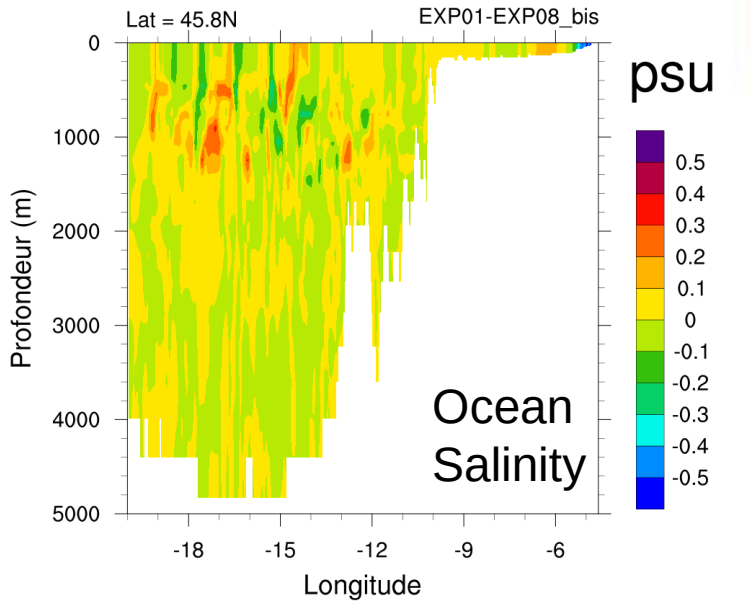


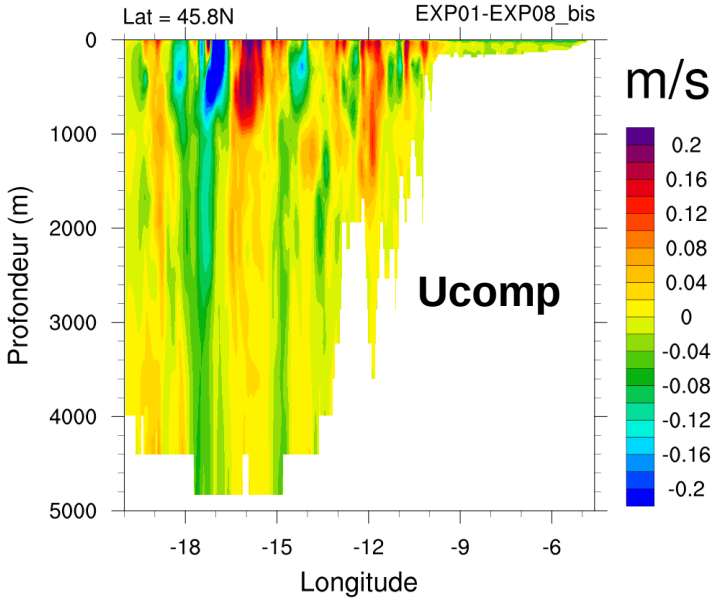
Profiles on 5 February 2014 storm Petra

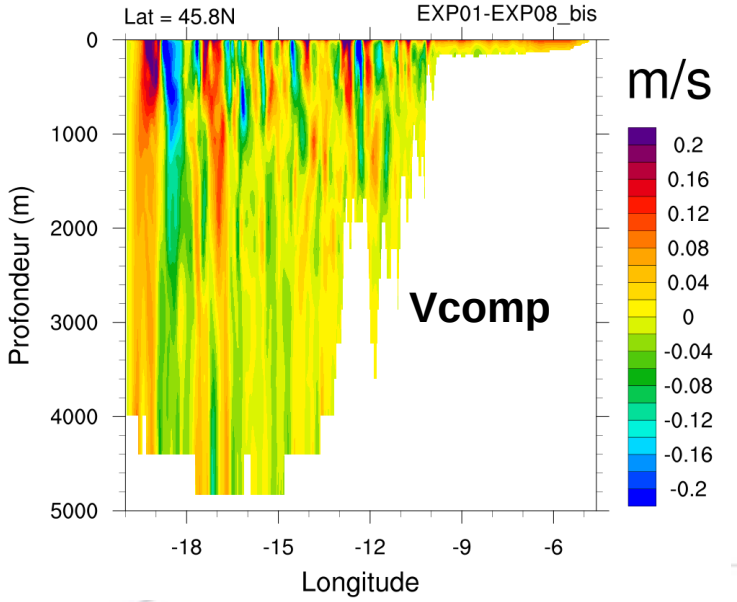


Difference between Control and Waves coupled experiments





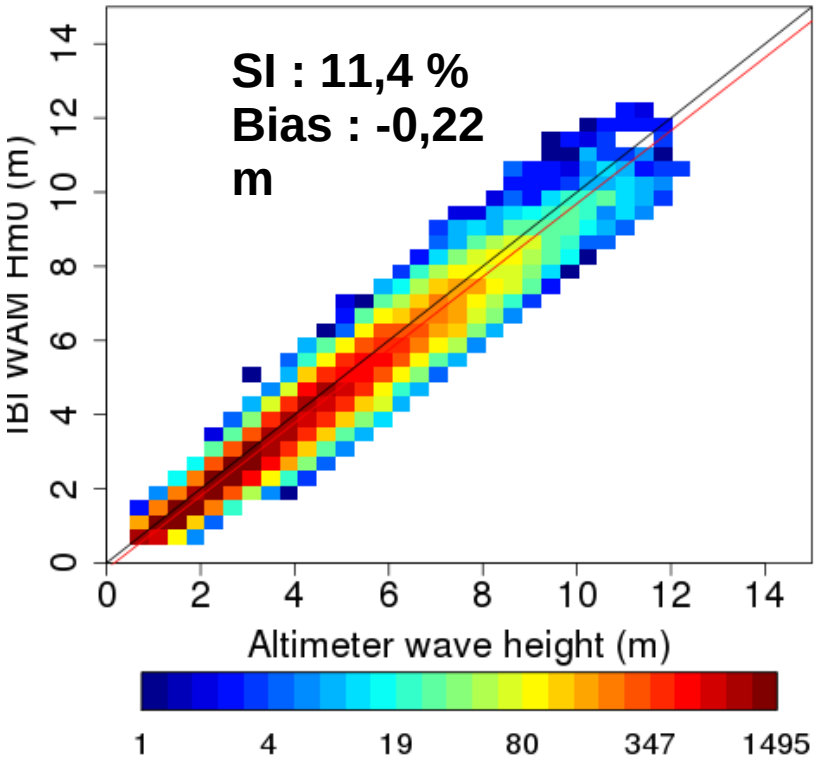




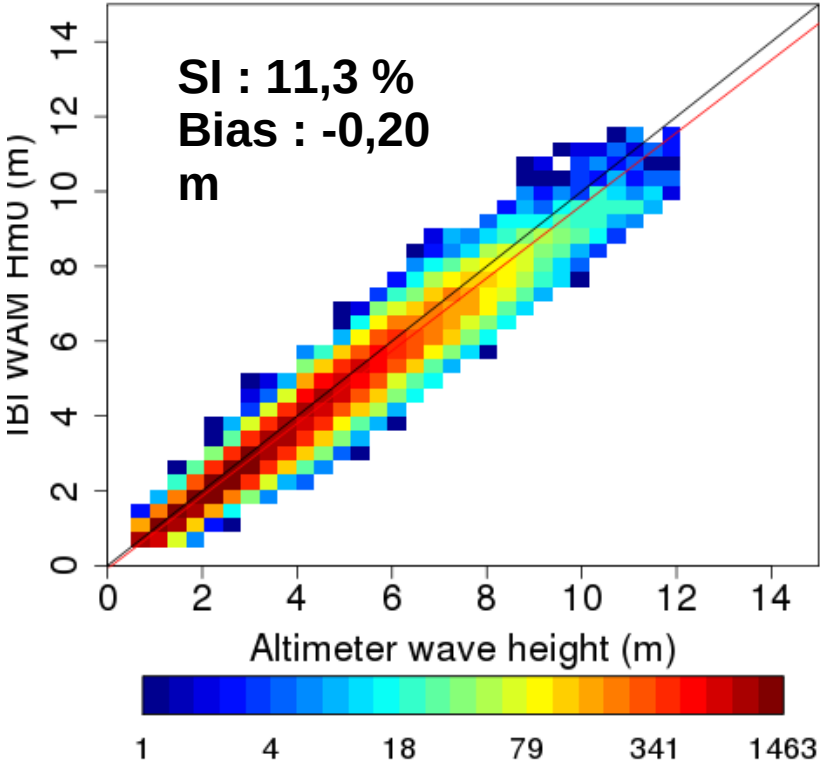
Significant impact of waves on surface currentsl until 1500 m

Surface currents impact on waves
Validation with altimeters

No currents



With currents from coupling

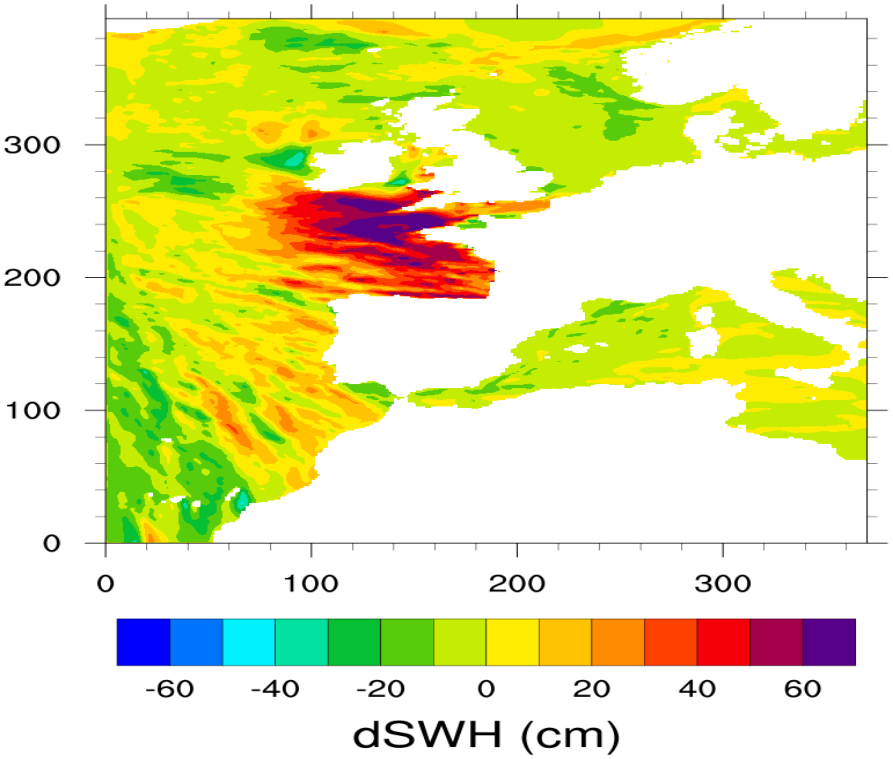


Surface currents from coupled NEMO-IBI improves slightly scatter Index and bias of SWH

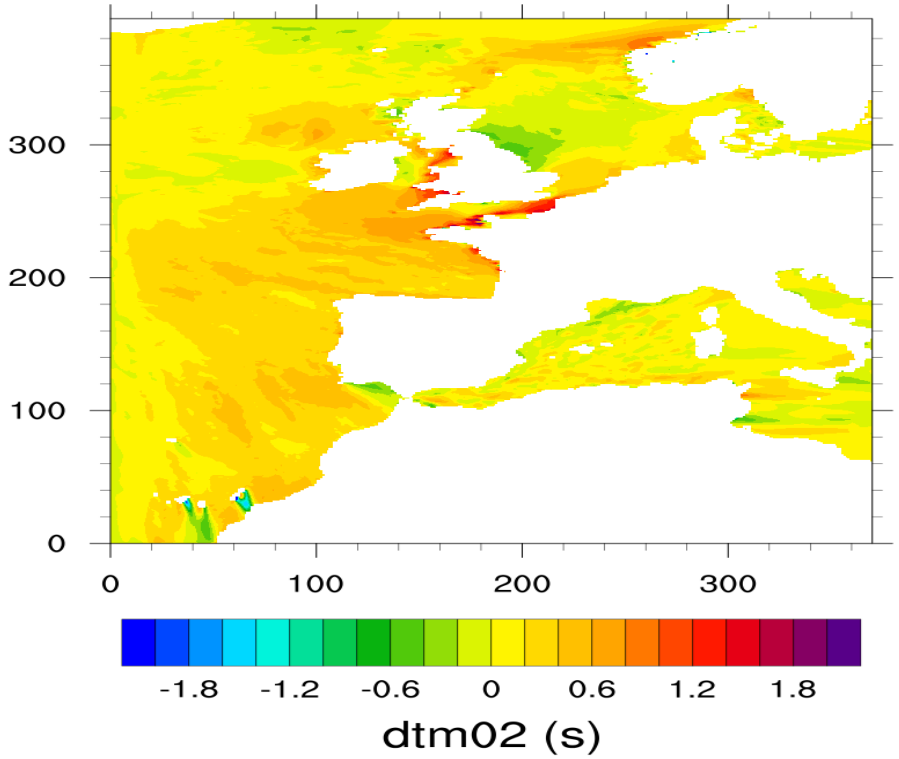
Validation with Jason-2 and Saral wave data

Impact of currents forcing on waves during storm Petra on 5 February 2014 12UTC

Significant wave height



Mean period Tm02



Difference on mean parameters from run of MFWAM-IBI without and with surface currents from coupled NEMO

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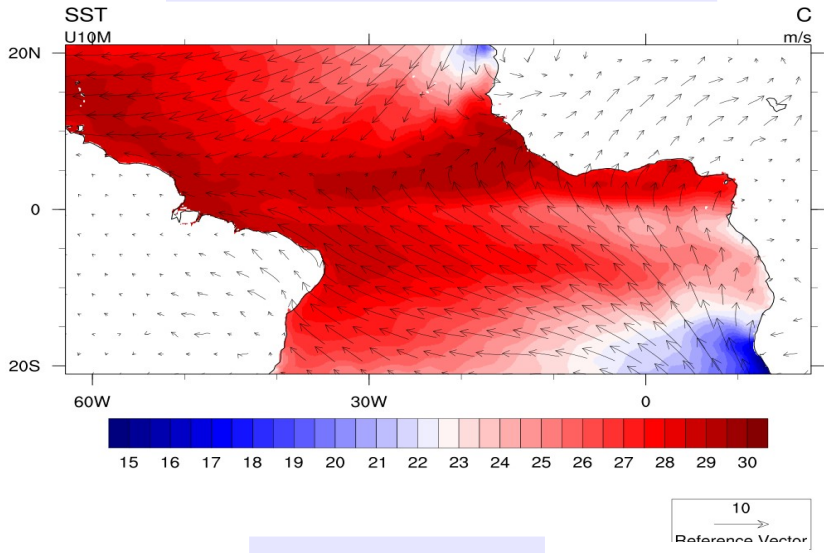
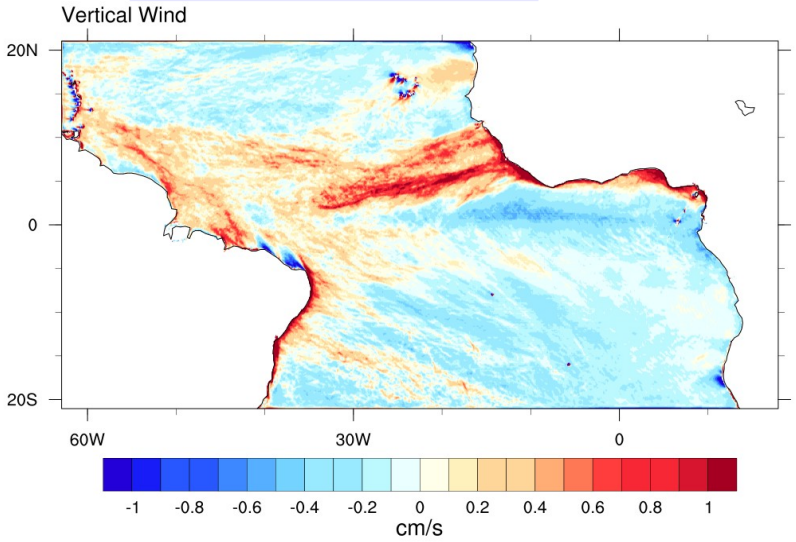
What processes control the wind in the Atm. boundary layer of the ITCZ (June 2010 SST anomaly)

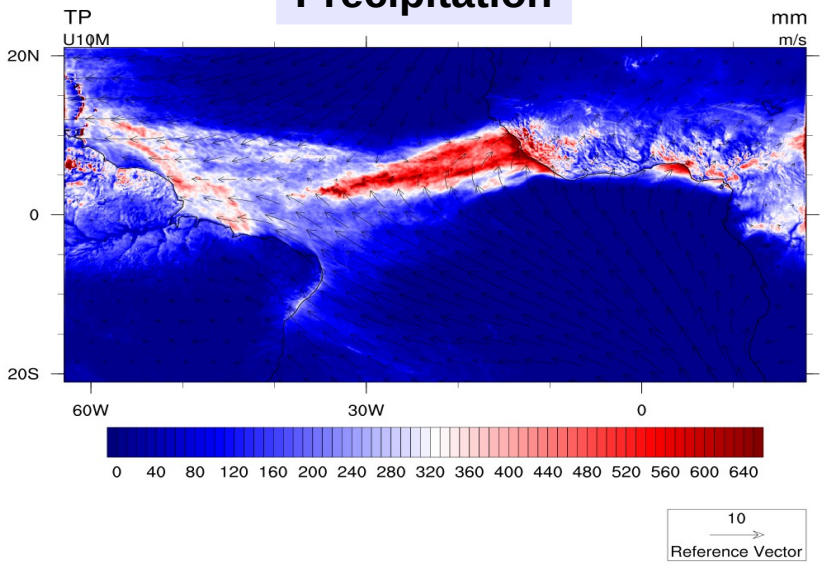
Sea Surface Temperature



wind convergence



Precipitation



Upward vertical velocity (*i.e.* horizontal wind convergence) and Precipitation are correlated with highest SSTs in the ITCZ

Subsidence close to the equator is induced by the cold tongue

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What processes control the wind in the boundary layer of the ITCZ

- Meso-NH :
Lafore et al. (1998) ; Lac et al. (2018)
Non hydrostatic anelastic model covering a wide range of scales
u, v,w, θ, 4 water phases as pronostic variables
Full physical package

- Numerical Configuration :
Domain Extension : 65W-19E 21S-21N
Δx=Δy=10 km with convection parametrized (900x480 points)
Δz from 10 m to 600 m with 70 verticals levels

1-month simulation from 1-30 June 2010, with hourly output !
Initial fields and lateral boundary conditions from ERAInterim

- Surface (SURFEX interface)
Interactive continent with prescribed vegetation
Default Ocean-atmosphere fluxes from ECUME3

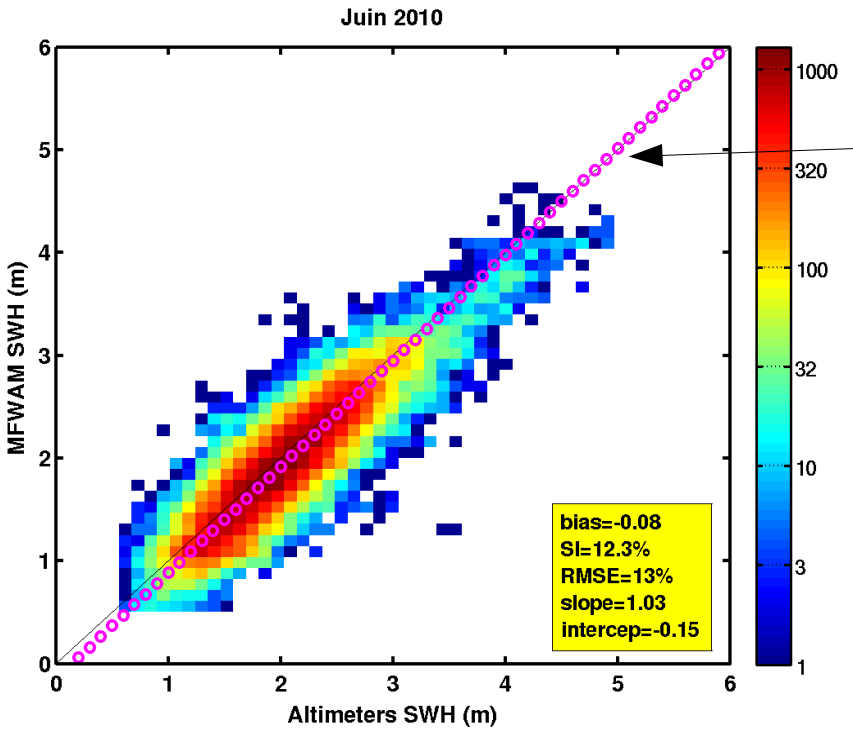
SST prescribed (ERA-I/6h)
SST from NEMO-Tropical-Atlantic

Stress forcing from Model MFWAM +currents

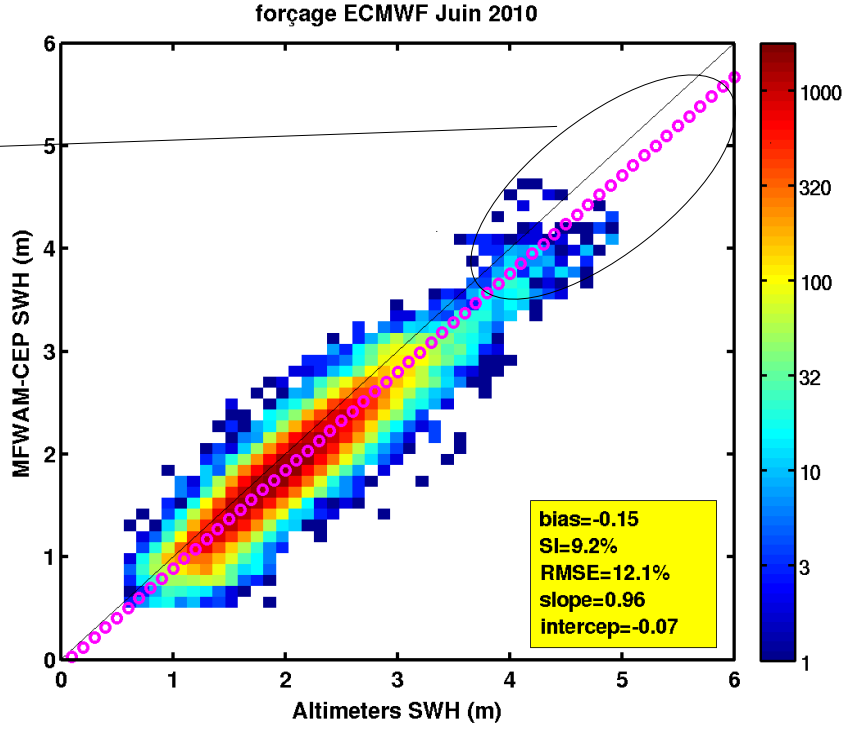
Wind forcing for MFWAM run
Validation with altimeters

Validation with altimeters of MFWAM-Tropic (10 km)
June 2016

MESO-NH with SST of NEMO



Analysed IFS

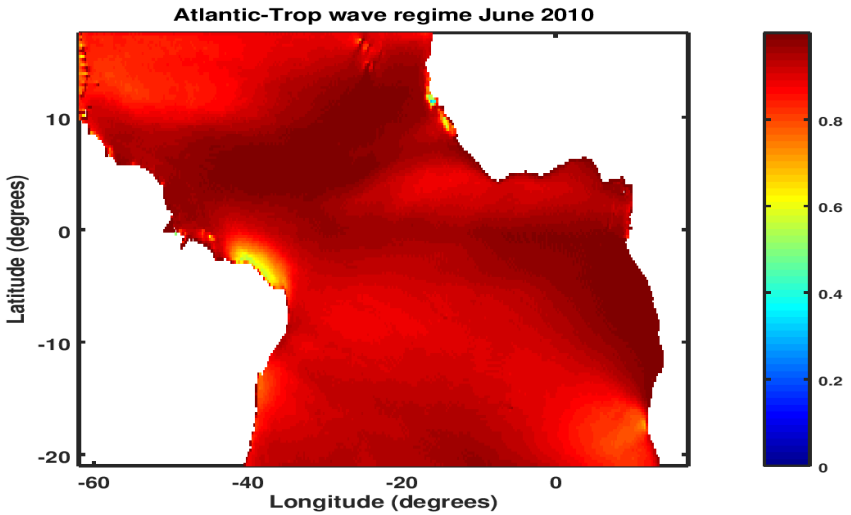


Validation with altimeters of 2 runs of MFWAM with different forcings :
analysed ECMWF, winds from MESO-NH with SST from NEMO
Good performance of run with MESO-NH winds with scatter index of 12,3 % and negative bias of 8 cm.

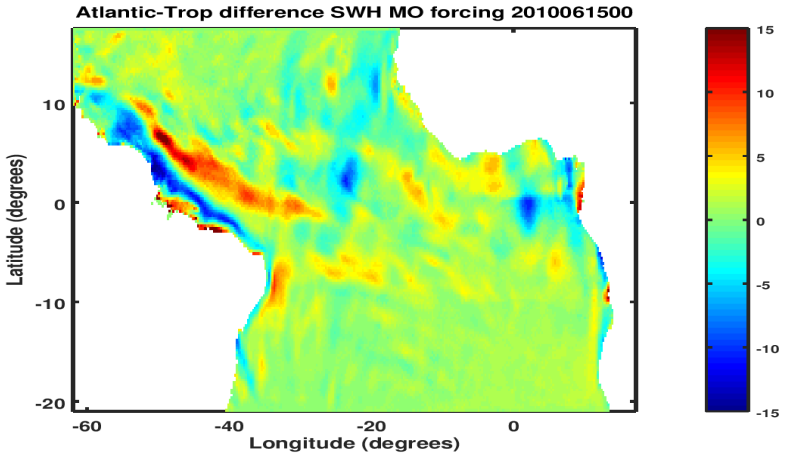
The run with analysed ECMWF winds shows better scatter index because of 4DVAR assimilation. However, the run with MESO-NH reduces the bias by 50 %

Impact of surface currents on the ABL

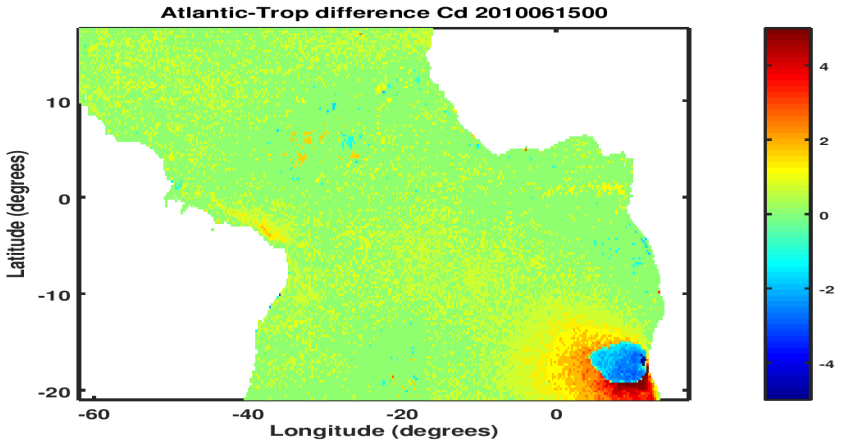
Wave regime (swell height/SWH)



Impact of currents forcing 15 June 2010 at 0:00 UTC



Evaluating the currents changing stress feedback to the ABL (forcing MESO-NH)



Impact of currents on sress (drag coef.) on 15 June 2010 at 0:00 UTC

Conclusions and perspectives

- **Upgrade of MFWAM for CMEMS is well skilled for accounting waves/ currents interaction.**

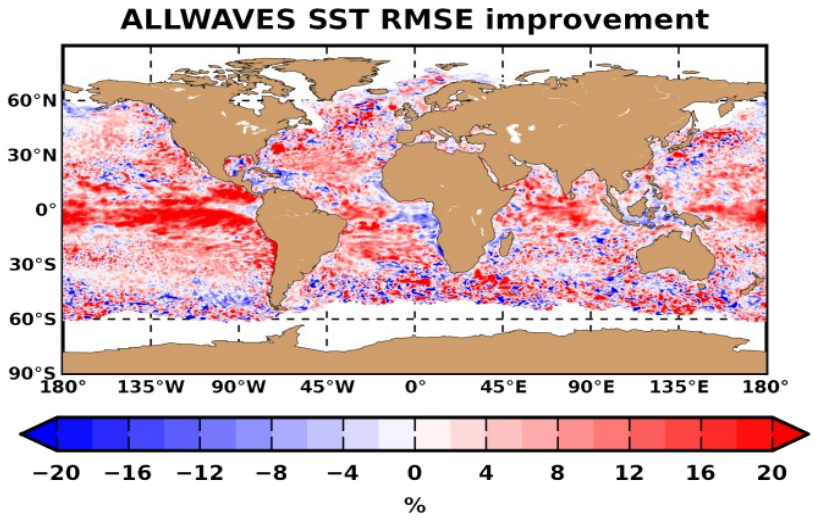
- **The ocean/waves coupling induced a an improvement on surface key parameters (global and IBI).**

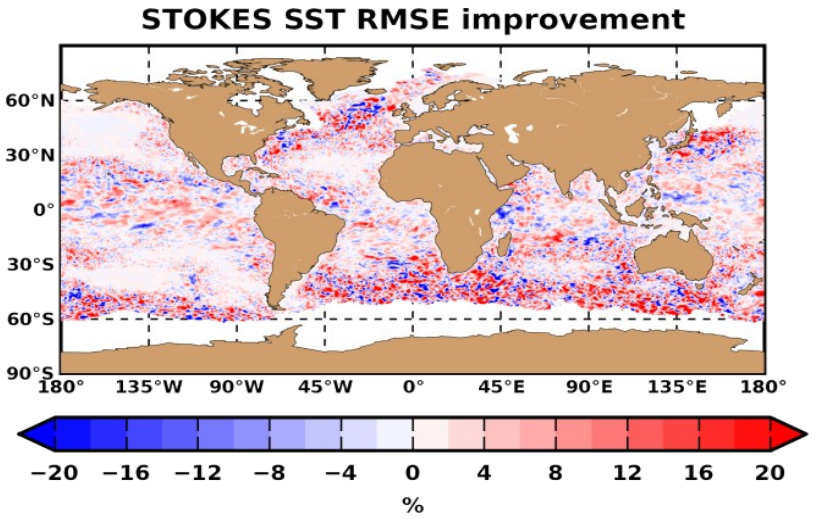
  --> Yes we need surface currents measurements from space to improve and validate the ocean/waves coupling

- **Works are on going for the impact of waves and currents on the atmospheric boundary layer**

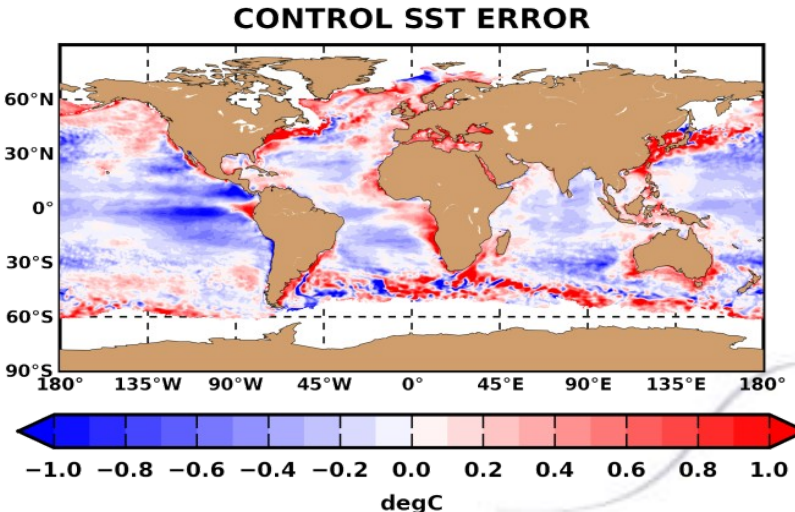
Validation of SST : OSTIA-Level-4

RMSE improvement skill





Average bias



Cooling induced by the waves coupling in blue

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