SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2019……………………………………………………….……
Project Title:	Improvement of the barotropic tide in the 1/12° global ocean NEMO model …………………….……
Computer Project Account:	spfrmore……………………………………………….……
Principal Investigator(s):	Yves Morel, Benoît Tranchant, Loren Carrere ……………………………………………………………….……
Affiliation:	LEGOS/CNRS and CLS…………………………….……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	……………………………………………………….…… ……………………………………………………….……
Start date of the project:	January 2019…………………………………………….……
Expected end date:	December 2020……………………………………….……

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			6200000	6826811
Data storage capacity	(Gbytes)			2450	1400

Summary of project objectives (10 lines max)

The main project objective is the implementation of a new barotropic tide solution in the global 1/12° NEMO ocean model in order to ensure an accurate barotropic tide without disrupting the eddying general circulation. To do so, different solutions have to be tested. The first, classical, one is to modify/improve the tide dynamics in the model (bathymetry, bottom friction, tide loading and tide dissipation via internal tide generation). The second solution is through assimilation of data coming from the "state of the art" tide model FES2014. Providing an accurate global barotropic tide atlas is an essential step before doing realistic simulation of baroclinic tides. The NEMO model (Nucleus for European Modelling of the Ocean (https://www.nemo-ocean.eu) is a platform for ocean modelling developed by a European consortium. This project will use the global configuration at 1/12° named MFC-GLO used in CMEMS that explicitly solve the barotropic tides from an astronomical tide potential.

Summary of problems encountered (10 lines max)

As mentioned above, our project is based on the global configuration at 1/12° named MFC-GLO used in CMEMS and it is a time-consuming configuration especially since we explicitly solve the barotropic tides at a high resolution. For this study, our time step was 180" whereas 300-360" is used in most of the case with ORCA12.

Many tests/simulation have been done in order to check the validity of the parametrization of the Internal Wave drag.

Summary of plans for the continuation of the project (10 lines max)

- A new Initial condition have been used, it comes from of a long simulation (20 years) of a ORCA12.
- A specific parametrization of the internal tide generation has been done. It consists of adding a parameterization of the Internal Wave Drag. It is based on the study of Jaynes and St-Laurent (2001) and already used in a NEMO ORCA12 version developed by Kodaira et al. (2016).

List of publications/reports from the project with complete references

- Evolution and optimization of NEMO code used in CMEMS-MFC-GLO: global barotropic tide simulations - Quarterly report – Q1, February 2019, CLS-ENV-RP-19-0050
- Evolution and optimization of NEMO code used in CMEMS-MFC-GLO: global barotropic tide simulations - Quarterly report – Q2 May 2019, CLS-ENV-NT-19-0177.
- Evolution and optimization of NEMO code used in CMEMS-MFC-GLO: global barotropic tide simulations - Quarterly report – Q3, July 2019, CLS-ENV-RP-19-0306
- Evolution and optimization of NEMO code used in CMEMS-MFC-GLO: global barotropic tidesimulations documentation on tide validation diagnostics, –TIDE-REP-02: CLS-ENV-RP-19-0302.
- Evolution and optimization of NEMO code used in CMEMS-MFC-GLO: global barotropic tide simulations - Quarterly report – Q4, February 2020, CLS-ENV-RP-20-0060
- Evolution and optimization of NEMO code used in CMEMS-MFC-GLO: global barotropic tide simulations - Quarterly report – Q5, May 2020, CLS-ENV-RP-20-0203

Summary of results

- A specific parameterization of the internal tide generation has been done. It consists of adding a parameterization of the Internal Wave Drag. It is based on the study of Jaynes and St-Laurent (2001) and already used in a NEMO ORCA12 version developed by Kodaira et al. (2016; see equation (5)).
- The bottom roughness h' used in this parameterization has been estimated following Gille et al. (2000): (i) we high-pass filtered the GEBCO bathymetry, (ii) we squared this filtered bathymetry and (iii) applied a low-pass filter to obtain a roughness h'.
- Different tests have been done in order to define the best parameterization h', see **Figure 1**

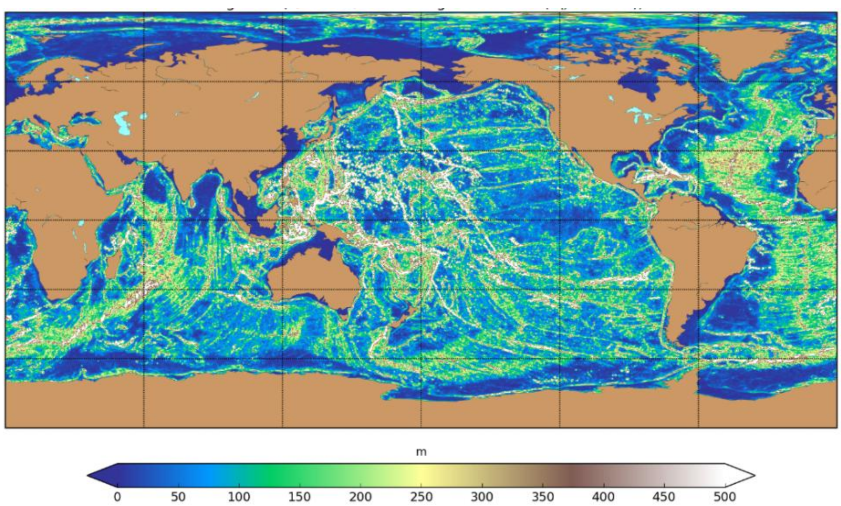
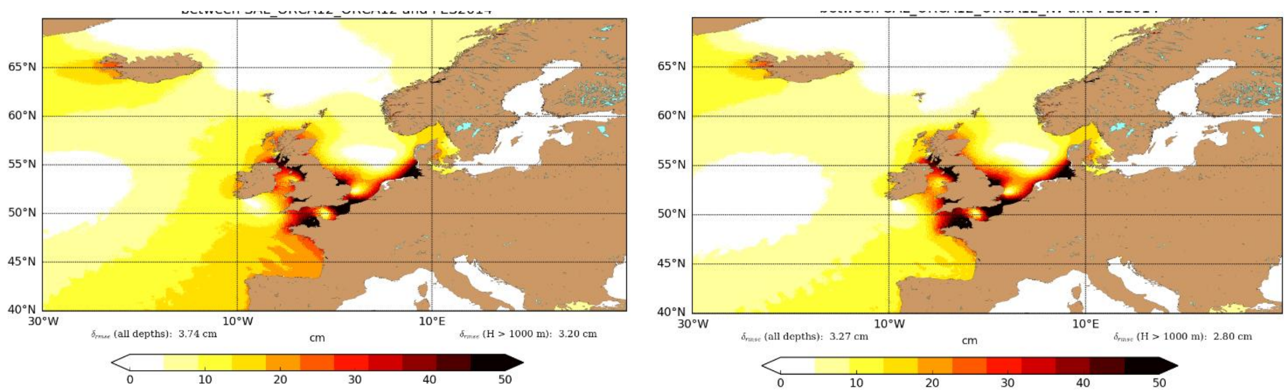


Figure 1: Roughness obtained with a gaussian filer (σ=√3) and the GEBCO bathymetry.

- The results, i.e. RMS differences between model and FES2014[1] and model and TPX/J1/J2 altimeter cross over compared with those found without the parameterization are quite equivalent for M2 and K1 over the global domain, and results are slightly better for K1 than for M2. However, more significant differences can be found in the Bay of Biscay, see Figure 2 and Table 1 , where the gain is up to 12.5% for M2 and 5% for K1.



1FES2014 is the last version of the FES (Finite Element Solution) tide model released in 2016.
FES2014 also benefits from data assimilation, taking advantage of higher accuracy datasets thanks to longer altimeter time series and better altimeter standards. Tidal heights from FES2014 are used operationally to correct altimetry measurements from tidal component.

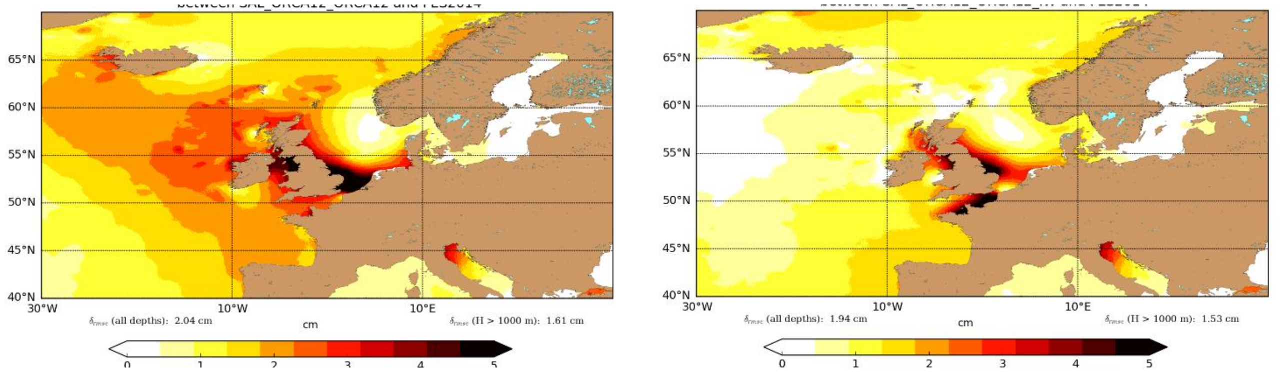


Figure 2: Surface tidal elevation complex differences (cm)) between FES2014 and a simulation without (left) and with the internal wave drag parameterization (right), (top) M2 and (bottom) K1 over the Bay of Biscay domain.

Experiment	**M2 (cm)**		**K1 (cm)**	
	FES2014 Global/BoB	TPX/J1/J2 global	FES2014 Global/BoB	TPX/J1/J2 Global
Without the internal wave drag	5.50/3.74	5.69	1.84/2.04	2.03
With the internal wave drag	**5.92/3.27**	5.96	**1.81/1.94**	1.93

Table 1: List of different ORCA12 experiments and their associated mean RMSE of M2 and K1 surface tidal elevation complex differences between FES2014 and TPX/J1/J2 cross over and model (cm) over the global domain. RMSE have been calculated for all depths, for global and Bay of Biscay (BoB) vs FES2014. Numbers in red refer to the best results.

References

Gille, S. T., M. M. Yale, and D. T. Sandwell, 2000: Global correlation of mesoscale ocean variability with seafloor roughness from satellite altimetry, Geophys. Res. Lett., 27, 1251-1254

Jayne, S, R., and L, C. St. Laurent (2001), Parameterizing tidal dissipation over rough topography, Geophys. Res; Lett., 28 (5), 811-814, doi:10.1029/2000GL012044.

Kodaira,T., K, R. Thompson and N., P. Bernier (2016), Prediction of M2 tidal surface currents by a global baroclinic ocean model and evaluation using observed drifter trajectories, J. Geophys. Res., Oceans, 121, 6159-6183, doi:10.1002/2015JC011549.