Branch Validation wth ORCA2

The branch validation has been performed in both forced and coupled modes based on the ORCA2_ICE_PISCES reference configuration, for 20 simulation days.

1) In forced mode NEMO receives wave fields from external files and the tests include checks on the Stokes Drift and Stokes-Coriolis term.

2) In coupled mode an online coupling between NEMO and WW3 (version 6.07) by means of OASIS-MCT3 (version 4) has been set-up and used to test all the wave-current processes implemented. WW3 is forced by the same wind as ORCA2 simulation and runs in a regular grid of 1 degree resolution. Time steps for NEMO and WW3 (global timestep) are set to 3600 seconds and waves fields are transferred to NEMO each hour.

   Results are congruent with the expectation. They show differences principally in the strongest waves areas. The Breivik 2016 implementation improved the vertical profile of the Stokes drift, especially the strong shear in the first meters. The wind stress changed up to 20%, if waves intake is taken into account. The quasi-eulerian currents in the open ocean are only weakly affected by the Stokes-Coriolis (SC), the vortex-force (VF) and the Bernouilli head (BHD). The modification of the vertical mixing induced by waves generates small changes in the turbulent kinetic energy and the vertical eddy viscosity and diffusivity. Nevertheless, a longer simulation is required to evaluate the effect of wave coupling on the mixed layer depth. The 1 year Mediterranean sea simulation, which is part of next year's activity plan, will allow to analyse the effect of wave breaking and Langmuir mixing on the MLD. In this simulation, we could not verify the Charnock coupling because of the atmospheric forcing source and the bulk formulae used which are not the one of ECMWF.

In the following, we present the ORCA2 results for a 12 hours mean. In this period, winds of 25 m/s are observed in the North Pacific region and generate waves up to 8 meters (figure 1).

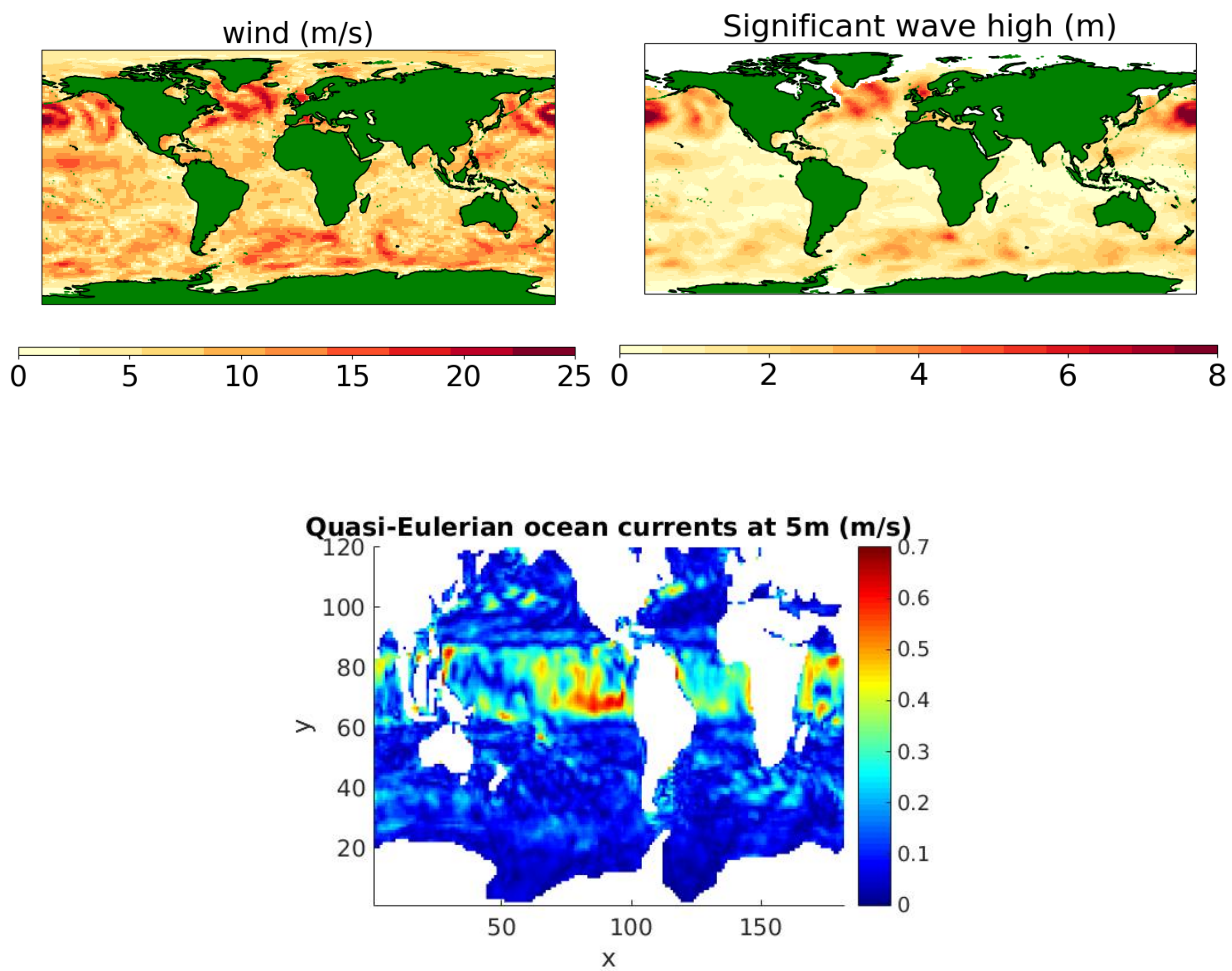

Figure 1: wind speed in m/s (left) , significant wave high in m (right), currents magnitude at 5m depth for the uncoupled run in m/s (down).

Figure 2, shows vertical Stokes drift profiles calculated from the basic Stokes drift calculation in NEMO, from the Breivik 2016 new implementation and from the wave spectrum calculated by WW3, for one point in the North Pacific. The Stokes drift profile using the Breivik 2016 implementation is closer to the one calculated with the entire wave spectrum. Differences are due to the low vertical resolution used here in the ORCA2 simulation. The implementation is able to represent a larger shear in the first meters of the ocean, as expected.

The Breivik 2016 implementation gives a Stokes drift at 5m depth up to 0.1m/s, in the North Pacific area, in response to the storm. The Stokes drift calculated with Brevik 2016 is up to 0.5 cm/s larger in comparison to the basic implementation (figure 2).

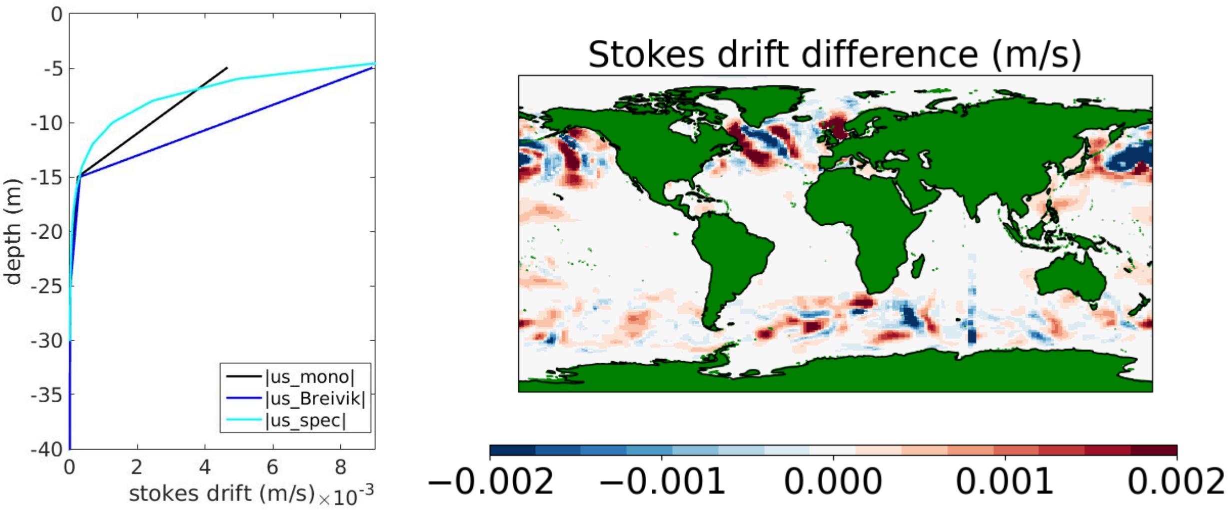

Figure 2: Left: vertical profile of the Stokes drift calculated with the old implementation (dark), with Breivik 2016 (dark blue), and from the WW3 wave spectrum(light blue). Right: 5m depth Stokes drift difference between the old and Breivik 2016 implementation (m/s)

This difference is quite small because of the large Stokes drift shear in the first meter and the low vertical resolution in this simulation. The Stokes-Coriolis, Vortex force and Bernouilli head have only a weak impact on the 5m-depth currents (figure 3).

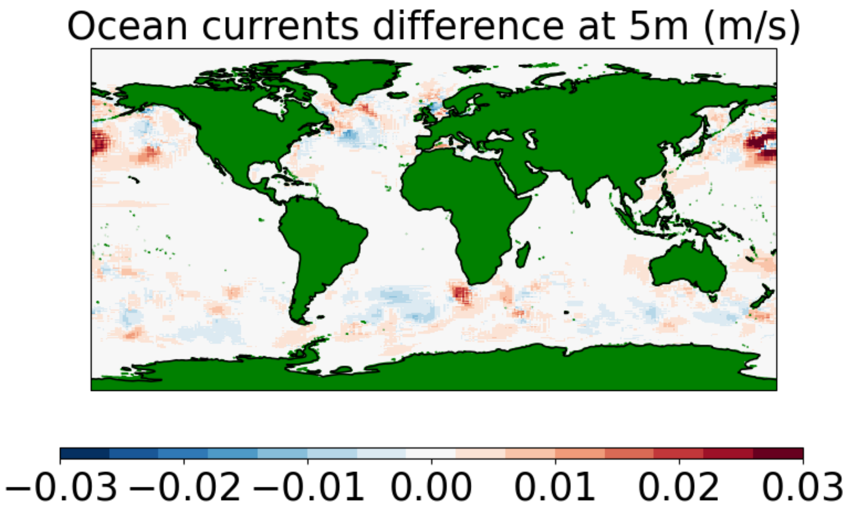

Figure 3: Difference between the quasi-eulerian currents affected by the SC,VF and BHD and the one without wave influences (m/s). The difference is calculated at 5m depth (the first layer of ORCA2)

The wave intake correction leads to an absolute difference up to 0.6 N/m2 (figure 4). The wind stress magnitude is not affected at low wind speed. In case of fast wind speed a variation of about 20% in the wind stress can be observed. Nevertheless these variations are very punctual in time and space.

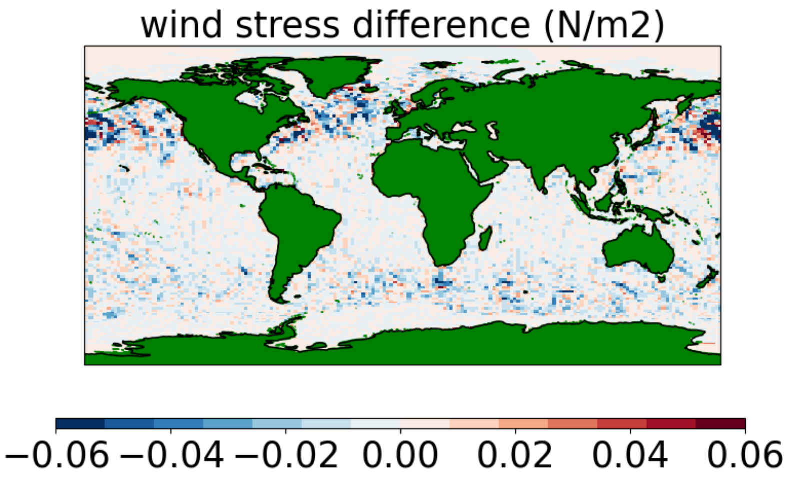

Figure 4: Wind stress difference between a simulation with and without wave intake (N/m2)

The modification of the vertical mixing scheme to account for waves does not have a strong impact on this simulation due to the short simulation time. Nevertheless, results showed small differences between the vertical eddy viscosity at 10m for the uncoupled simulation, the coupled simulation with Dirichlet surface boundary condition for the TKE, and the coupled simulation with Neumann surface boundary condition for the TKE (figure 5).

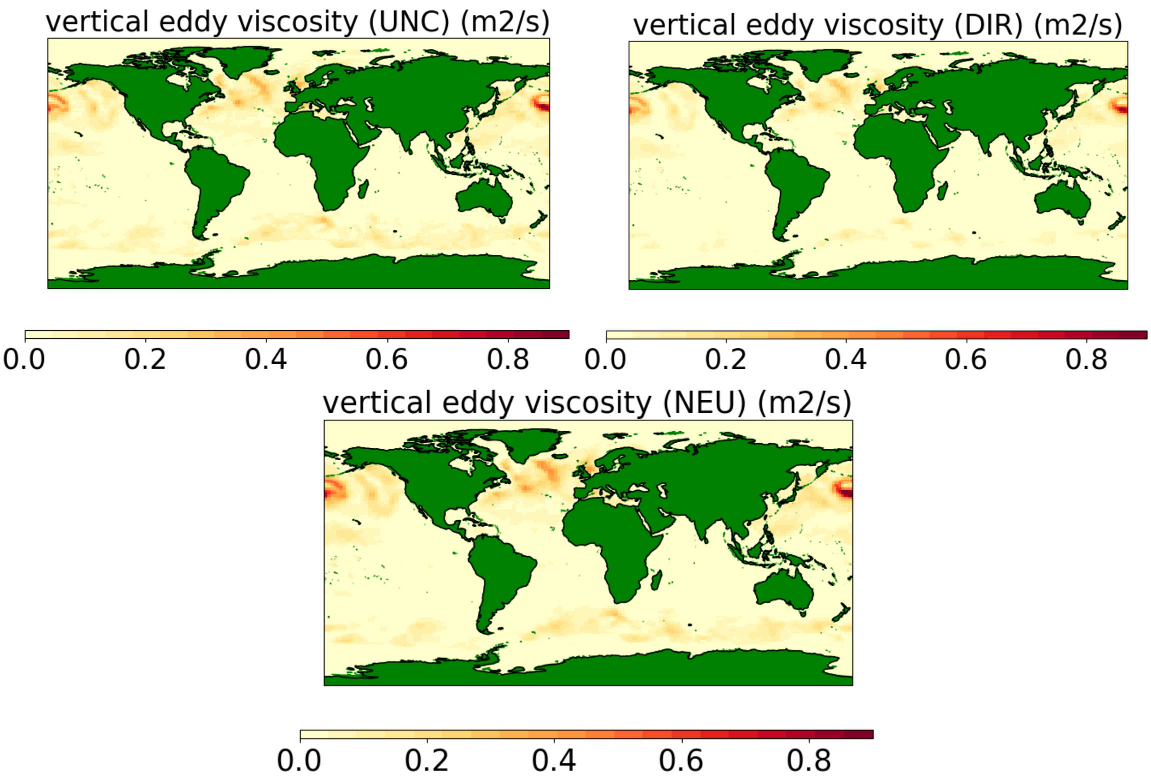

Figure 5: Vertical eddy viscosity (m2/s) for the UNCOUPLED run (UNC), COUPLED run with Dirichlet SBC for TKE (DIR) and COUPLED run with Neumann SBC (NEU)

(i) A literature review has been carried out in order to evaluate a possible test-case. Most of the references deal with spectral waves approaching a plane beach with an oblique angle of incidence (Haas et al., 2009; Uchiyama et al., 2010; Michaud et al., 2012; Kumar et al., 2012) and on adiabatic test cases for 3D wave-current models (Ardhuin et al., 2008; Bennis and Ardhuin, 2011; Bennis et al., 2011). It was decided to select an adiabatic case which consists of the validation of the Generalized Lagrangian Mean implementation for the wave-current interaction. The initial set-up of the test case has been done and the final implementation and code checks are ongoing.

The adiabatic test case consists of a steady monochromatic wave shoaling from 4 to 6 m depth on a slope without bottom friction (figure 6). A symmetric bottom sloping is used to allow for periodic boundary conditions in the x-direction. Open boundary conditions are defined in y-directions. The characteristics of the monochromatic waves are a significant wave height of 1.02 m, a wave period of 5.24s and a wave direction propagation in the x-direction. Wave breaking and wave induced mixing are not taken into account. The horizontal resolution is 10 meters in x-direction and 50m in y-direction. The NEMO configuration has a high vertical resolution using 60 levels.

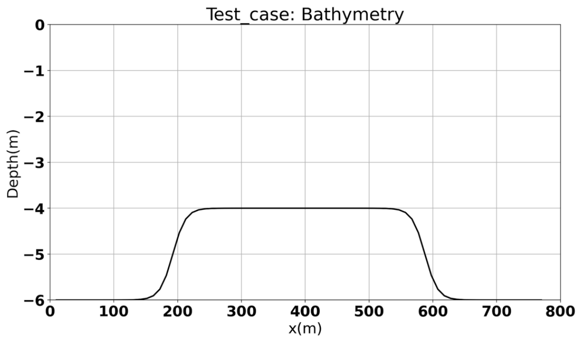

Figure 6: Slice of the bathymetry for the test case.

CMCC has attended the Realistic Configuration Meeting (videoconf in October 2020) presenting the plan for the Mediterranean Sea coupled configuration set up and experiments to be held during the 3rd year of the project.