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Impacts of surface gravity waves on a tidal front: a coupled model perspective

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In recent years much effort has been dedicated to understand and quantify the impacts of surface gravity waves on upper ocean currents and mixing, which have non-negligible physical and bio-geochemical consequences. Of particular interest are the impacts in coastal seas as these support essential industries.

The Iroise Sea provides an excellent natural laboratory to study wave-ocean (and atmosphere) interactions in strongly tidally forced conditions. Located in the North Atlantic, off the coast of Brittany, France, it is subject to long fetch waves and features an intense seasonal surface thermal front: the Ushant front which appears following the formation of a seasonal thermocline on the continental shelf and erodes at the end of autumn. The front is characterized by a strong temperature gradient at the ocean surface separating the homogeneous waters of moderate temperatures (<14°C) close to the coast and the stratified waters warm in surface (>16°C) offshore.

Here we will present results based on a set of realistic high horizontal resolution (500-1500 m) coupled and forced simulations. The numerical systems consists of a 3D coastal hydrodynamic circulation model (Model for Applications at Regional Scale, MARS3D), the 3rd generation wave model WAVEWATCHIII (WW3), and the non-hydrostatic mesoscale atmospheric model of the French research community (MesoNH) coupled with OASIS-MCT. The models were run for a period of low to moderate southwesterly winds as observed during the FroMVar (Front de Marée Variable) field campaign at the beginning of September 2011. Waves grow gradually over the 2 day period considered, propagating north east and east.

Contrasting a free ocean run with a coupled ocean-wave run, we show that waves move the Ushant front offshore and cool the stratified side by 1°C. Such a frontal displacement could be explained by increased mixing and/or increased (decreased) west(east)ward advection in the coupled run relative to the free run. Though counter intuitive given a northeastwards Stokes drift, analyze of the temperature budget reveals that the change in advection is the dominant factor contributing to the frontal shift. This change in advection results from wave induced changes to the quasi eulerian current. The latter is increased (decreased) in during ebb (flood) tide when the westward (eastward) current opposes (follows) the waves. These changes can be attributed to the impact of wave mixing on the tidally varying vertical structure of the quasi-eulerian current. Diagnosis of the horizontal momentum budget and analysis of partially coupled runs allow to further elucidate key processes at play.