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Implementation and validation of a 3D wave-induced current model from the surf zone to the inner-shelf

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We implement the new set of equations of Bennis et al. (2011) which use the glm2z-RANS theory (Ardhuin et al., 2008) to take into account the impact of waves into the 3D circulation model SYMPHONIE (Marsaleix et al., 2008, 2009). These adiabatic equations are completed by additional parameterizations of wave breaking, bottom friction and wave-enhanced vertical mixing, making the forcing valid from the surf zone through to the open ocean. The wave forcing is performed by WAVEWATCH III® (Tolman 2008; Ardhuin et al., 2010) for the realistic cases and SWAN (Booij et al., 1999) for the academic cases.
Firstly, the model is tested in two academic cases. In the first case, it is compared with other models for a plane beach test case, previously tested by Haas and Warner (2009) and Uchiyama et al. (2010). Then, a comparison is made with the laboratory measurements of Haller et al. (2002) of a barred beach with channels. Results fit with previous simulations performed by other models or with available observational data: the littoral drift and the vertical profiles of current or in the second case, the rip current are well reproduced.
Finally, a realistic case of a winter storm over a coast of the Gulf of Lion (NW of the Mediterranean Sea) for which currents are available at different depths as well as an accurate bathymetric database of the 0–10m depth range, is simulated. A grid nesting approach is used to account for the different forcing acting at the different spatial scales. We use at the smaller scale a grid with a variable resolution. The model is successful to reproduce the powerful northward littoral drift in the 0–15m depth zone. More precisely, two distinct cases are identified: when waves have a normal angle of incidence with the coast, they are responsible for complex circulation cells and rip currents in the surf zone, and when they travel obliquely, they generate a northward littoral drift. These features are more complicated than in the test cases, due to the complex bathymetry and the consideration of wind and non-stationary processes. In the inner shelf, wave impacts are less visible since wind and regional circulation seem to be the predominant forcing. Besides, a discrepancy between model and observations is noted at that scale, possibly linked to an underestimation of the wind stress.
Lastly, this three-dimensional method allows a good representation of vertical current profiles and permits to calculate the shear stress associated with wave and current. Future work will focus on the combination with a sediment transport model.

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