Korteweg-deVriès limitations for the interpretation of SAR images in the Strait of Gibraltar: impact of different stratifications on ISW surface signature.

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Internal Solitary Waves (ISW) are particularly large amplitude internal waves which may propagate in the ocean over tens of kilometres while preserving their shape via a balance between non-linearity and non-hydrostatics effects. These waves may have wide impacts on the ocean dynamics (mixing or inducing vertical currents) and on human activities (fisheries, underwater acoustic or offshore activities).

ISW can be detected on satellite scenes. For instance, they may induce surface currents and thus enhance or damp the capillary waves at the sea surface which signed on the Synthetic Aperture Radar (SAR) scenes. On SAR images, ISW appear as successions of bright and dark bands over a grey background. From these images, the amplitude of the ISW and the depth of the pycnocline may be inferred using the Korteweg-DeVries (KdV) theoretical framework. Several SAR images interpretation methods have been developed based on curve fitting or Peak-to-Peak methods (Zheng et al., 2001) or parametric autoregressive techniques (Le Caillec, 2006). The KdV theory relies on the weakly nonlinear approximation and a Two-Layers Ocean Model (TLOM).

In Gibraltar Strait, the tidal dynamic leads to strong periodic currents. The exchanges between the Mediterranean sea and the Atlantic ocean occurred according a two layer scheme that maintains large density gradient located at the interface between Atlantic and Mediterranean Waters. At some tidal outflow, an internal hydraulic jump is formed above Camarinal sill, when the tidal outflow slackens, it is released and leads to the formation of eastward propagating internal solitary waves. The site is thus considered as an ISW “hot-spot”. Part of the energy carried by these waves propagates eastward into the Alborean Sea, although the stratification may differ from the TLOM.

If the stratification differs from TLOM, a given surface signature of ISW could match to several configurations of the pycnocline geometry and ISW amplitude, depending on the associated stratification.
In order to assess the impact of the stratification on the surface signature of the ISW, we implemented an idealized 2DV (one vertical and one longitudinal directions) configuration with the Coastal and Regional Ocean modelling COmmunity model (CROCO) using its non-Boussinesq (pseudo compressible) capability. The bathymetry and the density profile are inspired from oceanic observations. The tidal forcing is simplified to a pure monochromatic M2 tide.

First, simulations are initialized with a two-layer density profile and different pycnocline depths. Then, we added continuous stratification in each of the two (surface/bottom) layers. We tested also several tidal regimes in order to represent the various strengths between the neap and spring tide. SAR images interpretation techniques are then tested in each configurations. Pycnocline depths and ISW amplitudes computed from SAR methods are then compared with the ones initially simulated by the CROCO model.

