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Vertical velocities in the Northwestern Mediterranean Sea: combining *in situ* and modeling approach

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The study of oceanic vertical velocities arises increasing interest in the oceanographic community. The general interest in the determination of vertical velocities is rooted in their key role for global oceanic balance and their impact on the vertical transfer of nutrients, heat and carbon despite their generally low magnitude of *O*(1-100 m day^{-1}). With the pressing global warming issues linked to the disturbance of the carbon cycle by anthropogenic activities, estimating vertical velocities becomes an essential information for a better representation of biogeochemical budgets, especially in coastal areas. Considering the challenges in directly measuring vertical velocities, numerous studies have been conducted in highly energetic regions, with estimation of large vertical motions. Instead, in this study, we have estimated vertical velocities based on a method suitable for low-intensity regions, where we expected a magnitude of few mm s^{-1} up to cm s^{-1}.

We have developed a new method for direct *in situ* measurement of vertical velocities using data from different Acoustic Doppler Current Profilers (conventional four-beam vs new generation Sentinel-V five-beam ADCPs) following different sampling techniques (lowered vs free falling). We collected data during the FUMSECK cruise in May 2019 in the Ligurian Sea (Northwestern Mediterranean Sea). Our analyses provided profiles of vertical velocities of the order of mm s^{-1}, as expected, with standard deviations of a few mm s^{-1}. While the fifth beam of the Sentinel-V showed a better accuracy than conventional ADCPs, the free-fall technique provided more accurate measurements compared to the lowered technique.

In parallel to this *in situ* analysis, we use the three-hourly fields of the SYMPHONIE circulation model that we implemented over the FUMSECK area during the period of the measurement campaign, using a grid of 1 km horizontal resolution and 60 hybrid "z-sigma" vertical levels. Combining *in situ* and numerical data in this study allows us to have a synoptic vision of the temporal evolution of vertical velocities.

Some of these measurements were gathered along the density front of the Northern Current known to be active in terms of vertical dynamics. The Northern Current flows along the coast; measuring vertical velocities in its region represents a new way to approach nearshore oceanic

processes. Moreover, this new information should also represent a key point for the future improvement of altimetry near the coast, especially in the context of the launch of new generation SWOT altimetry.

Finally, this innovative study paves the way to measure vertical velocities directly *in situ*, by coupling the free-fall technique with a five-beam ADCP. Consequently, we plan to apply these findings in areas characterized by either low or intense vertical dynamics to improve both the observational and modeling components of oceanic processes.