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Atmospheric and ocean preconditioning factors of dense shelf water cascading in the NW Mediterranean: insights from reanalyses

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The wide continental shelf of the Gulf of Lion in the NW Mediterranean is a region subject to pronounced atmospheric and oceanic interactions. Persistent cold northerly winds trigger progressive cooling of shelf waters, instigating a notable increase in seawater density. This dense water is forced to overflow by the slope, primarily channeled through the submarine canyons and especially through the southernmost Cap de Creus submarine canyon. Known as dense shelf water cascading, this intricate phenomenon exerts a pivotal influence not only on regional oceanographic dynamics but also on seafloor morphology and deep-sea living resources, warranting comprehensive investigation.

To understand the interannual variability of cascading events spanning recent decades, we use the Med MFC physical reanalysis dataset, which encompasses the Mediterranean Sea. This dataset has proven invaluable, exhibiting robust correlations with in-situ observations of dense shelf water cascading via moored instrumentation, thereby offering unprecedented insights into the spatiotemporal evolution of water properties and dynamics within the Gulf of Lion.

Our study quantifies the influence of the shelf water density modulation by the buoyancy fluxes in the air-sea interface. Leveraging data from atmospheric ERA5 and hydrological GloFAS reanalyses, we unveil a comprehensive understanding of the ocean-atmosphere interaction dynamics within this region. Specifically, we analyze the interannual variability in the buoyancy fluxes calculated from the main forcing agents impacting shelf water density: river freshwater input, wind speed, air-sea temperature contrast, absolute humidity, and precipitation.

Our analysis reveals a significant correlation between these fluxes and the East Atlantic pattern (EA), which is one of the main modes of climate variability in the atmosphere. This underscores the intricate interplay between oceanic processes and broader atmospheric dynamics, particularly over the Gulf of Lion. Our findings offer insights into the mechanisms governing dense shelf water cascading and natural variability, thus augmenting our understanding of regional climate dynamics and enhancing predictive capabilities, and help foresee its occurrence and evolution in the context of climate change.