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Dynamics and drivers for dense shelf water formation, migration and cascading

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Dense Shelf Waters formation and their descent towards the deep ocean are generally accepted as one of the main factors driving large-scale thermohaline and biogeochemical fluxes from the continental shelf. With reference to a particularly intense event occurred in winter 2012 in the northern Adriatic Sea (namely Gulf of Venice), an epicontinental basin of the Mediterranean Sea, a set of high-resolution (1 km horizontal discretization) numerical experiments carried out by means of the COAWST (Coupled Ocean, Atmosphere Waves and Sediment Transport) modelling system allowed to explore the dynamics underlying such phenomena. The role of external factors (freshwater input, tides, and continental margin topography) was investigated as well as the mutual interactions involving atmosphere, waves and ocean circulation.

The so-called North Adriatic Dense Water (NAdDW) forms in the Gulf of Venice as a consequence of the cooling and salinization of the sub-basin induced by cold air jets blowing from northeast across the Eastern Alps and Balkans. Partially recirculating in a double-gyre structure, newly formed water masses progressively leave the formation region flowing southeastwards leant on the Italian shelf. Along its path, significant fractions of NAdDW are intercepted by mid-Adriatic pits and by the continental shelf break off the Apulian coast.

Whilst riverine freshwater input is crucial in preconditioning the NAdDW formation basin and controlling the intrusion of saltier waters from the south, atmosphere-wave-ocean dynamics drive the generation proper by governing air-sea heat and momentum exchanges and ocean circulation, with substantial effects on the modes of buoyancy extraction and on the extent of the water masses involved in this process.

The trajectory of the dense stream leaving the northernmost basin tends to a geostrophic equilibrium determined by water mass momentum and density, which in turn reflect the interplay of the factors acting on the generation phase. Along this path, fluxes are strongly modulated by tides, whose relative influence depends on water density and can instantaneously overwhelm that of the mean flow and of inertial oscillations.

As the NAdDW vein approaches the continental margin, seabed topography at different scales is the key factor governing the dense water descent. Large-scale morphology controls geostrophic trajectory and its possible oscillations, as well as the selective interception of water masses off the shelf break down the continental slope. Once the descent is triggered, it proceeds in response to subsequent perturbations of the dynamic equilibrium induced by seabed discontinuities and localised changes in slope and curvature. In this framework, integrating high-resolution bathymetric information within the modelling system allowed to identify descent pathways and role of different current regimes in the establishment of observed erosional and depositional bedform patches throughout the continental margin.

Overall, this study aims to disentangle the causal links and feedbacks in dense water dynamics as well as their sensitivity to different factors, with particular emphasis to the effect of coupled processes and their representation within the modelling framework.