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Mixed-layer instability and submesoscale eddy formation in the Gulf of Taranto

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In this study, the submesoscale motions associated with a large-scale anticyclonic gyre in the central Gulf of Taranto were examined using realistic submesoscale-permitting simulations. We used realistic flow field initial conditions and multiple nesting techniques to perform realistic simulations in areas with submesoscale variability. The hierarchy of nested models highlighted one-way consecutive horizontal grid nesting from a parent grid with a resolution of $\Delta x \sim 6000$ m, and with child grids at $\Delta x \sim$2000m, $\Delta x \sim$700m, and $\Delta x \sim$200m.

The flow field showed a large-scale anticyclonic rim current with intensified jets and additional structural complexity (e.g. elongated filaments and small-scale cyclonic vortices) emerging in higher resolution nests. To generate submesoscale eddies, a 200-m resolution was required. A submesoscale cyclonic vortex with a diameter of 4 km was found in the northwest region of the central anticyclonic gyre. The submesoscale eddy generation mechanism was probably due to small-scale baroclinic instability (also called 'mixed-layer instabilities') in the rim of a large-scale anticyclonic gyre where both the density front sharpening and vorticity threads or filaments are produced. The development of MLIs produced larger vertical velocities and rapid restratification by slumping the horizontal density gradient.

The submesoscale eddy was confirmed by observational data from the area. We directly compared our high resolution geostrophic current with the observational evidence and the comparison results in a major validation of our model output. Thus, we can say that for the first time we have a proof that the model reproduces a realistic submesoscale vortex, similar in shape and location to the observed one.