Oceanic influence on Mediterranean cyclones: Insights from coupled ocean-wave-atmosphere simulations

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Understanding the complex interactions among ocean, wave, and atmosphere dynamics is essential for reliable forecasting and risk mitigation during marine extreme events. This study aims at investigating the oceanic influence on Mediterranean cyclones by employing ocean-wave-atmosphere coupling. Through a series of numerical experiments with varying coupling complexity, we simulated the evolution of the intense Mediterranean tropical-like cyclone (Medicane) Ianos in 2020, which caused severe damage in western Greece. Compared to an atmosphere-only simulation, the ocean-atmosphere coupled system reproduces the cyclone's SST cooling effect, reaching up to 3.7 °C, in agreement with satellite observations. This cooling effect leads to a reduction in cyclone intensity, as evidenced by the minimum Mean Sea Level Pressure (MSLP), 10-m wind speed, and surface enthalpy flux. Adding a wave model into the coupled system enhances the upper-ocean cooling by about 1.2 °C while causing competing effects on cyclone intensity—negative feedback via increased surface momentum flux and positive feedback via increased enthalpy flux. These results highlight the importance of ocean-wave-atmosphere feedback in predicting extreme events in the Mediterranean.