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A coupled atmosphere-ocean-wave modeling approach for a Tropical Like Cyclone in the Mediterranean Sea

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In November 6-8, 2011, in the Balearic islands an extra-tropical depression developed into a Tropical-Like Cyclone (TLC) characterized by a deep-warm core, leading to a mean sea level pressure minimum of about 991 hPa, 10 m wind speeds higher than 28 m/s around the eye, and very intense rainfall, especially in the Gulf of Lion. To explore in detail the effect of the sea surface temperature on the Medicane evolution, we employed the coupled modeling system COAWST, which consists of the ROMS model for the hydrodynamic part, the WRF model for the meteorological part, and the SWAN for the surface wave modeling. All model run over 5 km domain (same domain for ROMS and SWAN). COAWST was used with different configurations: in Stand Alone (SA) mode (that is, with only the atmospheric part), in atmosphere-ocean coupled mode (AO), and in a fully coupled version including also surface waves (AOW). Several sensitivity simulations performed with the SA approach were undertaken to simulate the TLC evolution. Especially in the later stage of the lifetime, when the cyclone was weaker, the predictability appears limited. Sensitivity simulations have considered the effect of the cumulus scheme (using an explicit scheme the Medicane does not develop and remains an extra-tropical depression) and the PBL scheme (using MYJ or MYNN resulting "Medicane" are extremely similar, although the roughness appears rather different among the two experiments). Comparing the three runs, the effects of different simulations on the Medicane tracks are significant only in the later stage of the cyclone lifetime.
In the overall modeled basin, wind intensity is higher in the SA case w.r.t. both coupled runs. When compared to case AO, winds are about 1 m/s larger, even though the spatial distribution is very similar (possibly because of the lower SST produced by case AO). Case AOW produces less intense winds then SA and AO case in the areas where the wave is most developed (differences are about 2-4 m/s), while they are more intense in the neighborhood of the eye of the cyclone.
Moreover, the inclusion of the wave model (AOW) has implications in the water column, by changing the depth of the ocean mixed layer along the track of the Medicane, so that eventually the SST in AOW run is colder than in AO. The date chosen for the run initialization appears important: an earlier initial condition allows to properly simulate the evolution of the cyclone from the cyclogenesis and to include the effect of the air-sea interaction through the coupled models.