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Impact of the atmospheric-hydrological fully coupled approach in a high-resolution medium-range forecasts: a case study in the Mediterranean

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Mediterranean coastal areas are prone to hydrometeorological extremes. Their complex orography often enhances the severity of high impact events and, at the same time, makes forecasts more challenging, particularly in the medium range. Nevertheless, global operational forecasts significantly improved their accuracy in the last decades, while several novelties in mesoscale modelling are emerging, such as the atmospheric-hydrological fully coupled approach, which explicitly describes the complex interactions between the Planetary Boundary Layer (PBL) and land surface including terrestrial lateral water transport. Overall, several clues open new perspectives to define new standards in medium-range forecast performances in the Mediterranean basin.

This study investigates the skills of the Advanced Research WRF (ARW) mesoscale model both one-way and two-way coupled with the hydrological extension WRF-Hydro in providing a medium-range (7 days) forecast of a severe event hitting the Calabrian peninsula (southern Italy) in November 2019. Such event was simulated in a classical ensemble approach, using the European Center for Medium-Range Weather Forecasting (ECMWF) ensemble product (Ensemble Prediction System – EPS), which consists of 50 members providing the initial and boundary conditions to the mesoscale model. WRF model was applied in two one-way nested domains with 10 km and 2 km horizontal resolutions, encompassing most of the Mediterranean basin. WRF-Hydro was applied in the innermost domain, with NOAH-MP as Land Surface Model. Surface and subsurface routing was performed adopting 200 m as horizontal resolution.

Results highlighted that the fully coupled approach increased soil moisture and latent heat flux from land in an increasing way in the days preceding the event. Such an increase partially affected the lower PBL layers. However, when shoreward moisture transport from surrounding sea rapidly increased becoming the dominant process, only a weak signature of moisture contribution from land to the atmosphere could be detected, resulting in only slightly higher precipitation forecast and slightly increased hydrological response. Overall, the proof-of-concept carried out in this study highlighted a remarkable performance of the medium-range ensemble forecasts, suggesting a profitable use of the fully coupled approach in the selected study area for forecasting purposes in circumstances in which soil moisture dynamics and exchanges with the atmosphere are of

particular interest.