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High-Resolution Climatology of Compound Precipitation and Wind Extremes in the Mediterranean: Insights from Extratropical Cyclones

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Substantial human and socio-economic losses can result from combined extreme wind and rainfall events. The compound events of extreme precipitation and wind associated with extratropical cyclones (ECs) have been examined in European regions, particularly focusing on the Mediterranean due to their significant impact. We aim to analyze the climatology of EC-related extreme precipitation and wind gusts co-occurrence over the Mediterranean. We accomplished this by utilizing high-resolution data from dynamic downscaling with the Weather Research and Forecasting (WRF) regional model. The WRF model version 4.2 is forced by ERA-5 reanalysis data, with boundary conditions updated every 6 hours. We configured an output domain with a horizontal resolution of 20 km and 40 vertical sigma levels extending from the surface to 50 hPa. The simulation covered the period from 1985 to 2022. Given that combined extremes frequently coincide over the Mediterranean in the vicinity of North Atlantic (NATL) cyclones or Mediterranean cyclones (Raveh-Rubin and Wernli, 2015), we applied an EC tracking algorithm over both regions during the extended winter season from October to April.

Precipitation extremes are detected across timescales of 6 hours, 24 hours, and 48 hours, considering the sum of the variable, with wind gusts identified as the maximum within the shorter timescale. Following the methodology outlined by Owen et al. (2021), a co-occurrence is recorded when both precipitation accumulation and maximum wind gust exceed the 95th percentile threshold within the same period and gridpoint. Subsequently, we filtered the events to ensure they coincided within the spatial domain occupied by an EC. We delineated three distinct EC areas corresponding to the EC core region (within the cyclone radius), warm conveyor belt (WCB) regions, and an extensive area within the EC circulation. This analysis was facilitated by leveraging dynamic downscaling of high-resolution data, allowing for better capture of mesoscale structures. We used this classification to analyze insights into the seasonal occurrence, geographical distribution, and composite perspective of co-occurrence regarding EC centres during the most intense events. Following the approach of Owen et al. (2021), we established metrics for extremal dependency and temporal lag between extremes occurring in different structures of the lower pressure system, with a specific focus on those associated with the WCB. We categorized our findings into purely Mediterranean domain cyclones, those originating from the NATL, with a particular focus on the most intense occurrences.

Owen, L. E., Catto, J. L., Stephenson, D. B., & Dunstone, N. J. (2021). Compound precipitation and wind extremes over Europe and their relationship to extratropical cyclones. *Weather and Climate Extremes*, *33*, 100342. https://doi.org/10.1016/j.wace.2021.100342

Raveh□Rubin, S., & Wernli, H. (2015). Large□scale wind and precipitation extremes in the

Mediterranean: a climatological analysis for 1979–2012. *Quarterly Journal of the Royal Meteorological Society*, *141*(691), 2404-2417. https://doi.org/10.1002/qj.2531