Evaluation of the performance of WRF model in extreme precipitation estimation concerning the changing model configuration and the spatial and temporal variations

Eren Duzenli1, Heves Pilatin2, Ismail Yuçel1, Berina M. Kilicarslan1, and M. Tugrul Yilmaz1
1Middle East Technical University, Graduate School of Natural and Applied Sciences, Department of Civil Engineering, Ankara, Turkey (eren.duzenli@metu.edu.tr)
2Middle East Technical University, Graduate School of Natural and Applied Sciences, Earth System Science, Ankara, Turkey

Global numerical weather prediction models (NWP) such as the European Centre for Medium-Range Weather Forecasts (ECMWF) and Global Forecast System (GFS) generate atmospheric data for the entire world. However, these models provide the data at large spatiotemporal resolutions because of computational limitations. Weather Research and Forecasting (WRF) Model is one of the models, which is capable of dynamically downscaling the NWP models’ output. In this study, all combinations of 4 microphysics and 3 cumulus parametrization schemes, 2 planetary boundary layers (PBL), 2 initial and lateral boundary conditions and 2 horizontal grid spacing (i.e., an ensemble consisting of 96 different scenarios) are simulated to measure the sensitivity of WRF-derived precipitation against different model configurations. The sensitivity analyses are performed for 4 separate events. These events are selected among the extreme precipitation events in the Mediterranean (MED) and eastern Black Sea (EBLS) regions. For each region, a summer and an autumn event are chosen. Here, the fundamental aim is to determine the spatiotemporal differences in WRF input parameters that yield better outcomes. A total of 72 hours simulations are started 24 hours before the event day to avoid spin-up time error. The model is adjusted to produce hourly precipitation outputs. The relative performance of scenarios is measured using Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method considering 5 categorical validation indices and 4 pairwise statistics calculated between the model estimations and the ground-based precipitation observations. According to the TOPSIS results, microphysics scheme, initial and lateral boundary condition, and horizontal grid spacing are substantially influential on WRF precipitation estimates, while cumulus parameterization has a comparatively low effect. The choice of PBL scheme is essential for the summer events, but the results of the autumn events are independent of PBL selection. WRF products are better for the events of the EBLS basin when ERA5 is used as the initial and lateral boundary condition. On the contrary, GFS is superior in the MED region. In terms of spatial resolution, 9 km horizontal grid spacing is commonly preferable for all the events rather than 3 km. Besides, the model underestimates the area-averaged precipitation amounts except for the MED-autumn incident. Still, the model is successful at catching the peak hours of all events. Moreover, the precipitation detection ability of WRF is better for the autumn months. The probability of detection index is
higher than 0.5 at 35% of MED stations and 68% of EBLS stations for the autumn events. The local and convective summer events are investigated considering the event centers. Albeit relatively low relationships are defined for the MED-summer event, a statistically significant correlation is obtained between the central station of the EBLS-summer event and the closest grid for the predictions of 52 scenarios (i.e., 54% of the ensemble).