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Comprehensive Methodology for the Evaluation of High-Resolution WRF Multi-Physics Precipitation Simulations for Small, Topographically Complex Domains

Ioannis Sofokleous[1], Adriana Bruggeman[1], Silas Michaelides[2], Panos Hadjinicolaou[2], George Zittis[2], and Corrado Camera[3]
[1]The Cyprus Institute, Energy, Environment and Water Research Center, NICOSIA, Cyprus (i.sofokleous@cyi.ac.cy)
[2]The Cyprus Institute, Climate & Atmosphere Research Centre (CARE-C), NICOSIA, Cyprus
[3]University of Milan, Dipartimento di Scienze della Terra A. Desio , MILAN, Italy

A stepwise evaluation method and a comprehensive scoring approach are proposed and applied to select a model setup and physics parameterizations of the Weather Research and Forecasting (WRF) model for high-resolution precipitation simulations. The ERA5 reanalysis data were dynamically downscaled to 1-km resolution for the topographically complex domain of the eastern Mediterranean island of Cyprus. The performance of the simulations was examined for three domain configurations, two model initialization frequencies and 18 combinations of atmospheric physics parameterizations (members). Two continuous scores, i.e., Bias and Mean Absolute Error (MAE) and two categorical scores, i.e., the Pierce Skill Score (PSS) and a new Extreme Event Score (EES) were used for the evaluation. The EES combines hits and frequency bias and it was compared with other commonly used verification scores. A composite scaled score (CSS) was used to identify the five best performing members.

The EES was shown to be a complete evaluator of the simulation of extremes. The least errors in mean daily and monthly precipitation amounts and daily extremes were found for the domain configuration with the largest extent and three nested domains. A 5-day initialization frequency did not improve precipitation, relative to 30-day continuous simulations. The use of multiple and comprehensive evaluation measures for the assessment of WRF performance allowed a more complete evaluation of the different properties of simulated precipitation, such as daily and monthly volumes and daily extremes, for different dynamical downscaling options and model configurations. The scores obtained for the selected five members for a three-month simulation period ranged for BIAS from zero to -25%, for MAE around 2 mm, for PSS from 0.25 to 0.52 and for EES from 0.19 to 0.26. The CSS ranged from 0.56 to 0.83 for the same members. The proposed stepwise approach can be applied to select an efficient set of WRF multi-physics configurations that accounts for these properties of precipitation and that can be used as input for hydrologic applications.