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GCM VALIDATION AND SELECTION ASSESSMENT

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EXECUTIVE SUMMARY

Understanding the Earth's climate system and its future projections requires the use of complex General Circulation Models (GCMs). However, the reliability of GCMs must be evaluated through validation and assessment studies performed against reference datasets. This report presents detailed validation and evaluation results of the latest GCMs over Türkiye within the Coupled Model Intercomparison Project 6 (CMIP6). At the conclusion of this process, the detailed information obtained about the strengths and weaknesses of CMIP6 GCMs is crucial for selecting the most appropriate models in regional downscaling studies.

The selection was made from the 31 available GCMs by evaluating the performance of the comprehensive assessment metric and extreme climate indices. The performance of GCMs in this report was evaluated in two stages. The first stage includes comparison between GCM-based temperature and precipitation datasets and the ERA5 reference dataset using monthly time series. In the second stage, the performance of climate models was assessed based on 12 extreme precipitation indices and 10 extreme temperature indices. The success of GCMs in simulating the extreme climate indices was measured using the ERA5-Land dataset, where the comparisons were made utilizing probability distributions rather than time series-based analyses. The aim of this two-stage performance evaluation is to assess the models' abilities to simulate both basic climate features and extreme climate events in a versatile manner.

Based on the results obtained from these evaluations, the selected CMIP6 climate models for dynamic downscaling and their performance rankings are HadGEM3-GC31-MM, HadGEM3-GC31-LL, EC-Earth3-Veg, MRI-ESM2-0, MPI-ESM1-2-HR, NorESM2-MM and CMCC-ESM2. The models were ranked based on precipitation, temperature and their respective indices. HadGEM3-GC31-MM and EC-Earth3-Veg perform equally well in all categories. MRI-ESM2-0 ranks well for temperature and precipitation, but lower for precipitation indices. MPI-ESM1-2-HR performs well in temperature but ranks lower in other categories. NorESM2-MM has good temperature rankings but lower precipitation rankings. CMCC-ESM2 has mixed performance. Although some models evaluated in the study showed better performance than those selected, their use was not possible due to limitations in data availability. Additionally, to ensure model independence and diversity within the model pool, multiple models from a single model family were not selected.

With the exception of HadGEM3-GC31-MM and HadGEM3-GC31-LL, all other models will be run for the reference and projection periods based on SSP2-4.5 and SSP5-8.5 emission scenarios. The HadGEM3-GC31-MM model could only be run for the reference and SSP5-8.5-based future periods due to the unavailability of the SSP2-4.5 scenario. This gap was addressed by running the HadGEM3-GC31-LL model for the reference and future periods based on SSP2-4.5. Therefore, these two models will not run concurrently; only one model from this model family will be available for each emission

scenario. This evaluation framework is critical for assessing the accuracy and reliability of climate models, forming the basis for data and model selections in climate change projections.