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High-Resolution Dynamic Downscaling to Assess the Impacts of Climate Variability and Change

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Climate variability was examined through high-resolution (1-km grid spacing) dynamic downscaling conducted using the Weather Research and Forecasting (WRF) model, with initial and boundary conditions from the Global Forecast Model (GFS) reanalysis (GFS/WRF) and the High Resolution Atmospheric Model (HiRAM) historical simulations (HiRAM/WRF). The analysis was conducted over the eastern Mediterranean, with a focus on the country of Lebanon, which is characterized by a complex topography that magnifies the effect of orographic precipitation. Two simulation years were selected to capture the natural variability of the system, with 2003 selected as a typical wet year and 2010 as a typical dry year. The WRF simulations were conducted using three nested spatial domains with 9, 3 and 1 km resolution and no spin-up period was included. The HiRAM simulations followed the CORDEX protocol, and were conducted for the historical (1975-2006) and future (2005-2050) periods using both RCP 4.5 and RCP 8.5 emission scenarios. For the HiRAM/WRF model setup, a one month spin-up period was adopted to allow WRF to dynamically develop its own synoptic features. One-way nesting was adopted in all WRF simulations.
In this work, particular emphasis is placed on the impact of model setup and resolution on the quality of the results. Comparisons with observed temperature and precipitation time series (point-wise and spatially-averaged) suggest that the GFS/WRF captures the hydrometeorological dynamics over the simulated domain reasonably well. The statistics of the HiRAM/WRF outputs, which we must underline, represent a different realization of climate variability than GFS since the latter includes data assimilation, were then compared to mean decadal observations. These comparisons were designed to validate the ability of the WRF/HiRAM coupled approach to produce results within the observed climate variability range for the decade, with the aim of using WRF/HIRAM to assess the impact of future climate change under both the RCP4.5 and RCP8.5 scenarios.