CONCEPTUAL OVERVIEW

Regional Climate Change Modeling – Atmospheric

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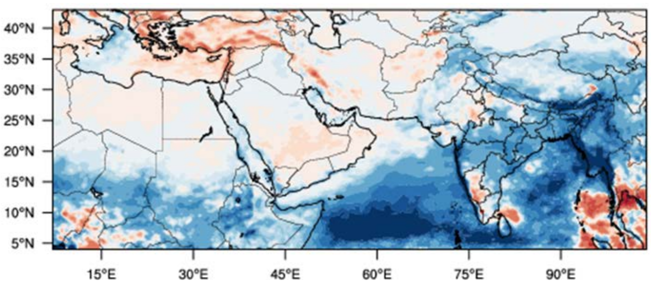

The goal of this Regional Climate Change Modeling study was to develop projections of regional climate for the Arabian Peninsula at fine spatial and temporal scale. Such a projection should reflect the large-scale features and temporal trends from Global Climate Model (GCM) simulations used in the development of the IPCC's 5th Assessment Report (AR5), but also the historical patterns of climate variables at the regional and local scale. To achieve this, a regional climate model (RCM) was deployed that dynamically downscaled the climate of the Arabian Peninsula using GCM data for lateral boundary conditions. Improved topographic representation across the domain reflects the taller topographic features of the region, which potentially increases and re-distributes precipitation due to enhanced lifting. The higher topography also provides a cooler environment for precipitation over places like the Al Hajar Mountains in Oman as compared to smoothed topography, which will not resolve warm season convection.

The results have been used in support of the other climate change impact, vulnerability and adaptation assessments in AGEDI's Local National, and Regional Climate Change Programme (LNRCCP). That is, the climate and hydrometeorological data from this study has been used to explore questions surrounding groundwater recharge and water demand questions as well as understand how potential impacts of climate change and variability on terrestrial ecosystems and human health related impacts of climate on the Arabian Peninsula. Moreover, the results can also be used to explore renewable energy prospects, especially solar and wind; as changes in

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wind-patterns, cloudiness, and how changes in aerosol concentrations due to industrial activity or dust from the vast Arabian Desert could impact these resources.

To quantify 21st century climate change over the UAE and Arabian Gulf region, the research team performed simulations using version 3.5.1 of the Weather Research and Forecasting (WRF) Model. WRF is a fully compressible conservative-form non-hydrostatic atmospheric model with demonstrated ability for resolving small-scale phenomena and clouds. WRF was employed to dynamically downscale climate fields from NCAR's comparatively coarse-scale gridded global climate model, the Community Climate System Model- Version 4 (CCSM4) which covers the global domain. The WRF simulations are comparatively fine-scale, covering the regional domain of the Arabian Peninsula, which is relevant for assessing climate change impacts at local-to-regional scales.

Figure 1. The Experimental Design (left) showing WRF run for a 30-year historical period and for RCP4.5 and RCP8.5 in the post-2050 period; The Spatial Domain (right) showing WRF runs for the contemporary and future periods for three domains using different model resolutions.

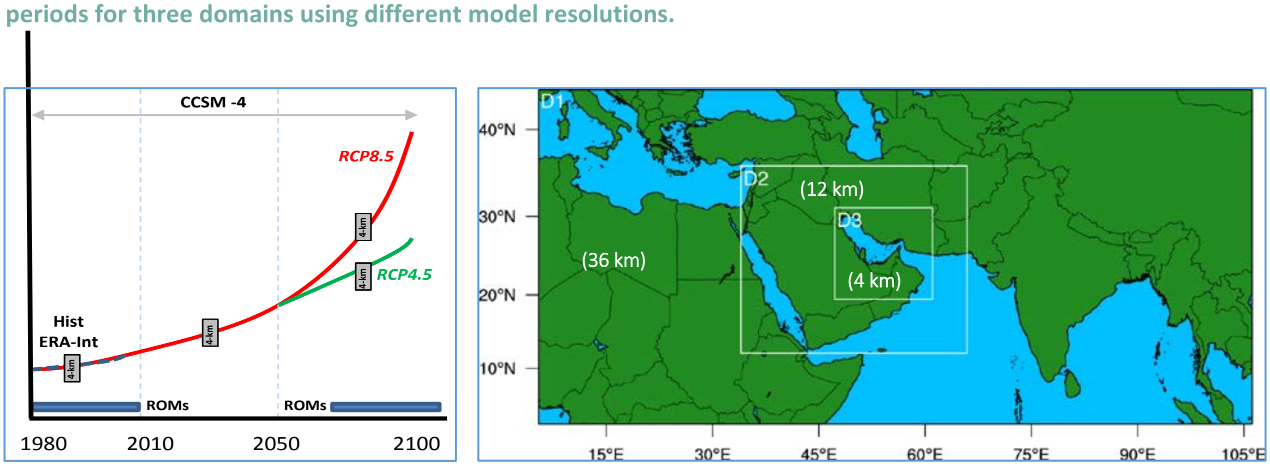

Figure 1 summarizes the temporal (left) and spatial (right) nature of the regional climate model experiments that were conducted. WRF benchmark simulations were performed over a historical period to provide a modeled estimate of the true state and dynamics of the atmosphere. The benchmark simulations in this study derive their initial and boundary conditions from the European Centre for Medium-Range Weather Forecasting (ECMWF) Interim Reanalysis (ERA-Interim; Dee et al. 2011;

available at http://onlinelibrary.wiley.com/doi/10.1002/qj.828/abstract). ERA-Interim is considered to be the most accurate atmospheric reanalysis available at the present time. The bias-corrected CCSM4 output was then used for the contemporary period (20-years at 12 and 36 km) and the RCP8.5 future period (20-year at 12 and 36 km); and for 2, 10-year periods at the

4km resolution. In summary, the following dynamic downscaling simulations were performed with WRF and are summarized in Figure 1:

1. A 30-year ERA-Interim driven WRF benchmark simulation for the historical period spanning 1981-2010 (36- and 12-km domains)
2. A 20-year bias-corrected-CCSM4-driven WRF climate simulation for the historical period spanning 1986-2005 (36- and 12-km domains, referred to as *20THC*). The 4-km domain was run for the 1990-1999 sub-period.
3. A 20-year bias-corrected-CCSM4-driven WRF climate simulation for the RCP4.5 period spanning 2060-2079 (36- and 12-km domains)
4. A 20-year bias-corrected-CCSM4-driven WRF climate simulation for the RCP8.5 period spanning 2060-2079 (36- and 12-km domains). The 4-km domain was turned on for the 2065-2074 sub-period.

Nearly 500,000 "core-hours" on the NCAR supercomputer were used for this analysis. The results show that the WRF simulations adequately captured the regional climate of the Arabian Peninsula for the 20th century period. Future climate results indicate generally wetter and warmer conditions in the region, with the CCSM4 projected trends similar to the ensemble average of all the GCMs used in the IPCC AR5 experiments (e.g. warm and wet). Most of the increased rainfall is associated with wetter conditions over the Arabian Peninsula that extends across a large portion of the UAE. A full discussion of the results as well as an interactive visualization of the outputs can be accessed at AGEDI's Climate Change Inspector website (http://www.ccr-group.org/#!agedi-climate-change-inspectors-bet/cnaej).

It should be noted that the data archive from this regional climate modeling experiment is quite large, roughly 110 Terra-Bytes.