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Dynamical downscaling of a GCM simulation over the lower Mississippi River Valley

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The Weather Research and Forecasting (WRF) model was used as the regional climate model (RCM) to downscale global climate simulations over the Lower Mississippi River Valley (LMRV). WRF Version 3.2.1 was used to downscale the IPCC AR4 simulations from the NASA GISS-ER GCM. A set of two 11-year periods of was used: 1990-2000 (20C3M scenario) and 2050-2060 (selected from the SRESA2 forcing scenario). The options included: Kain-Fritsch cumulus parameterization; the WRF single-moment 5-class microphysics; Rapid Radiative Transfer Model (RRTM) for longwave atmospheric radiation; the Goddard scheme for shortwave radiation; the Yonsei University parameterization for the atmospheric boundary layer; and the Noah land surface model with a 2-m deep soil layer. The RCM was configured as three nested domains with two-way coupling between the nests with grid spacing of 45-, 15-, and 5 km. The vertical levels were represented by 41 sigma-pressure levels. The pre-processing of the GCM fields includes the modification of original atmospheric and land surface variables, their spatial interpolation from the native 4 deg ◊5 deg GCM grid to 1 deg x 1 deg latitude-longitude grid, temporal interpolation, level/time subseting and units conversions. Missing values of air temperature, relative humidity, and wind components at low isobaric levels (1000 hPa, 925 hPa, and 850 hPa) were filled from above using a special approach. Each of 11-years downscaling simulations were performed on a month-long basis. Every month-long simulation was started from initial conditions retrieved from the GISS model data. To keep the WRF-based solution close to the GCM large-scale fields, a simple nudging approach was adopted above 700 hPa for the following model variables: air temperature, geopotential, water vapor mixing ratio, and wind components. The sea surface temperature (SST) was represented by the skin temperature field available from the GCM. During January, the GCM produces a marked cold bias of about 3 K in the northern part of the domain. In April, the surface air temperature is consistently warmer in the RCM simulations when compared with the corresponding NARR data over the 5 km domain. The warmest overland temperatures are observed over the LMRV (having lower vegetation fraction in comparison with adjacent areas and therefore the higher surface temperature). The spatial distribution of this warm bias indicates that it could be associated with a different specification of green vegetation fraction in the WRF-based RCM. During July, the LMRV is clearly observed as a region of elevated surface air temperature both in RCM and NARR. A better agreement between the NARR and RCM simulations over the LMRV is due to fine spatial resolution (5 km grid spacing) used in the RCM. In general, the RCM-downscaled simulations show a closer agreement with the NARR data as compared with the output from the GISS model, except for spring and the northern part of the 5 km domain. Typically, the GISS model shows lower values of surface temperature having negative monthly mean bias of 2-3 K, when compared to temperatures from the NARR data and from RCM simulations. In winter, the RCM simulation of total precipitation is in better agreement with NARR data with more spatial details. Total winter precipitation in GCM is lower by 2-3 mm/day over the central and southern parts. During spring the RCM overestimates the rainfall mounts even though the GCM precipitation is underestimated. During summer, both RCM and the GCM show overestimation of precipitation over the land. There is a distinct minimum of precipitation amount observed in NARR data over the northern part of the domain Contrary to the NARR data, both the RCM and GCM produce an excessive increase in precipitation amount from April to August. This increase of precipitation is mostly noticeable in RCM simulations and associated with precipitation estimated from a parameterization of cumulus convection.