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The Community Earth System Model: Evaluation and CMIP5 simulations. Activities of the Climate Change Working Group

Gerald Meehl[†]; Warren Washington; Julie Arblaster; Aixue Hu; Haiyan Teng; Claudia Tebaldi; Warren Strand; James White
[†] NCAR, USA
Leading author: meehl@ucar.edu

Results are presented from experiments performed with the Community Climate System Model version 4 (CCSM4) for the Coupled Model Intercomparison Project phase 5 (CMIP5). These include multiple ensemble members of 20th century climate with anthropogenic and natural forcings as well as single forcing runs, sensitivity experiments with sulfate aerosol forcing, 21st century Representative Concentration Pathway (RCP) mitigation scenarios, and extensions for those scenarios beyond 2100 to 2300. Equilibrium climate sensitivity of CCSM4 is 3.20oC, and the transient climate response is 1.73oC. Compared to previous generation models, the former is higher by about 25% compared to CCSM3, and 50% higher compared to the Parallel Climate Model (PCM). The indirect effect of sulfate aerosols is not included, and this could contribute to a late-20th century climate simulation that is somewhat warmer in CCSM4 compared to observations. Sensitivity experiments are performed with CCSM4 to increase the negative radiative forcing from the direct effect of sulfate aerosols in the second half of the 20th century to better understand the factors that influence the time series of modeled globally averaged surface air temperatures compared to observations. Though the surface temperature trend in the late 20th century is reduced by increasing the sulfate aerosol concentrations, thus bringing the model closer to observations, the resulting over-sensitive response to volcanoes degrades the similarity of the time-evolving temperature time series compared to observations. This result highlights the complications involved with trying to compensate for a missing forcing by adjusting the magnitude of a somewhat different forcing. Global surface temperatures mostly stabilize by the end of the 21st century in RCP2.6, 4.5 and 6, decrease somewhat after 2100 in RCP2.6, and continue increasing out to 2300 in RCP8.5. The ocean meridional overturning circulation (MOC) in the Atlantic, which weakens during the 20th century in the model, recovers to near early 20th century values in RCP2.6, partially recovers in RCP4.5 and RCP6, and does not recover by 2100 in RCP8.5. Heat wave intensity is projected to increase almost everywhere in CCSM4 in a future warmer climate, with the magnitude of the increase proportional to the forcing. Precipitation intensity is also projected to increase, with dry days increasing in most subtropical areas. However, for areas of California and Nevada, dry days show mostly decreases. Thus, combined with increased precipitation intensity, there is little consistent change in annual mean precipitation in a future warmer climate in that region in CCSM4 compared to previous multi-model results that show mostly precipitation decreases. For future climate, there is almost no sea ice left in the Arctic in the high RCP8.5 scenario by 2100, but in the low RCP2.6 scenario there is substantial sea ice remaining in late summer at the end of the century, indicating that it does make a large difference to Arctic climate as to which path is followed with regards to future emissions.