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Evaluation of 20th century climate model simulations of heavy precipitation over North America

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There is considerable evidence in the scientific literature that heavy precipitation events have increased during the period of instrumental records and that this may have been associated with human-induced greenhouse warming. In order to faithfully characterize future changes in extreme precipitation due to greenhouse warming and diagnose the mechanisms for such changes, the reliability of climate model simulations of precipitation must be better understood. Here, daily precipitation from 20th century simulations from the Coupled Model Intercomparison Project Phase III (CMIP3) is compared with observations from the NOAA Climate Prediction Center over North America for the period 1979-1999. Additionally, the model simulated large scale atmospheric circulation and thermodynamic patterns associated with extreme precipitation events are compared with North American Regional Reanalysis data. We found that mean and heavy precipitation from the models is generally smaller than observed in the southeastern United States and does not follow observed topographically forced precipitation patterns along the Pacific coast. Additionally, precipitation frequency distributions reveal that climate models generally produce precipitation events lighter than 15 mm/day too frequently and events heavier than 15 mm/day too infrequently. The biases in the models are likely due to the coarse spatial resolutions, which impede the models' ability to produce realistic precipitation in regions where precipitation is convective and/or orographically forced, as well as prevent the simulation of very heavy precipitation. Simulated precipitation is more realistic in the northeastern portion of North America, perhaps due to flatter terrain and more synoptically forced precipitation. The CMIP3 climate models also do a good job capturing the seasonal cycle of heavy precipitation over most parts of North America, with the exception of Mexico. A composite analysis of various atmospheric quantities during extreme precipitation events reveals that the climate models produce fairly realistic spatial patterns of the atmospheric circulation and thermodynamic properties associated with extreme precipitation events. The positive results of the composite analysis suggest that the CMIP3 models can be reliably used to diagnose the physical mechanisms for projected future extreme precipitation changes.