Clouds And Precipitation In General Circulation Model Extratropical Cyclones: An Analysis Based On Cyclone-Centered Metrics

James F. Booth
City College of the City University of New York, and NASA Goddard Institute of Space Studies

Catherine Naud
Columbia University in the City of New York, and NASA Goddard Institute of Space Studies

Jeyavinoth Jeyaratnam
City College of the City University of New York, and NASA Goddard Institute of Space Studies

Extratropical cyclones (ETCs) are responsible for the majority of midlatitude precipitation, and they also create an important amount of cloud cover. This study investigates ETC cloud and precipitation biases in GCMs. The model data used is from the CMIP5 archive and CMIP6-prototype model output generated for the NOAA Model Diagnostic Task Force. First, ETCs are tracked using a Lagrangian tracking algorithm. Then, cyclone-centered composites are generated for the models, and they are compared with reanalysis and satellite observations. The work presented will focus on two aspects of the storms: post cold-frontal clouds, which are known to contribute to a serious bias in the southern hemisphere radiation budget, and warm sector precipitation, which is the region of ETCs that typically generates the most precipitation. For the post cold-frontal cloud analysis, we also utilize a feature-tracking algorithm to identify the fronts. Then, an analysis of the post cold-frontal cloud properties finds that models and reanalysis have biases in the cloud content, and that horizontal resolution does not by itself lead to a bias reduction. Instead, it appears that the models boundary layer scheme implementations affect the results. Therefore, we present covariance results between the post cold-frontal cloud properties and low-level atmospheric stability, vertical velocity and surface turbulent heat fluxes, to help determine which of these physical mechanisms influence the cloud behavior. Next, the analysis of warm sector precipitation utilizes a previously published estimated cyclone rainfall metric based on the product of the cyclone-averaged precipitable water and surface wind speed. The work determines the regions and characteristic storm paths for which the models have more and less ETC precipitation biases, and links these with biases in model vertical velocities as well as issues related to modeled convective rainfall activity.