The 3D Structure of Atmospheric Blocking: Role of Moisture and Response to Climate Change

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Atmospheric blocking is a large-scale weather phenomenon that interrupts the prevailing eastward progression of pressure systems and can result in weather extremes in the midlatitudes. Due to their devastating consequences, understanding the changes of blocking in response to climate change has been of great interest in recent years. In this study, we investigate the 3D structure of blocking events in reanalysis and two large-ensemble, fully coupled GCM simulations: NCAR’s CESM1 Large-Ensemble Project (LENS) and GFDL-CM3 large-ensemble project. Here we compare the climatology of blocks in the models with reanalysis and show that the structure of the blocks is remarkably reproduced well in the GCMs, given that these models are known to have biases in reproducing the climatological Northern Hemisphere large-scale circulation. The results of our composite analysis indicate that the blocks exhibit an equivalent-barotropic structure in both summer and winter seasons over both oceans and continents in the northern hemisphere. However, blocking events are stronger in winters compared to summers. We also notice a significant latent heating associated with ascending airstream on the east side of blocks. This warming, which is stronger in winter especially over the ocean basins, leads to a westward shift in the temperature anomaly during blocking episodes. Furthermore, we study the response of the blocks to climate change (RCP8.5) and find that blocking events will be weakened in the summer of three different northern hemisphere regions. However, wintertime blocks’ responses to climate change are more complex than those in summers and depend on the regions and atmospheric pressure levels. Finally, we examined the response of surface temperature associated with blocking events. We have found that the surface temperature response associated with blocking events will be weaker over all the regions in the winter season. However, during summer, the temperature responses will be slightly stronger over Russia and partially over the two ocean basins. Our results suggest that summertime blocking events over Russia are going to be more impactful compared to those over the ocean basins.