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Linking Cloud Variability with Surface Radiation Budget over the Continental United States Using NASA CERES Satellite Observations and CMIP6 Model Simulations

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The surface radiation budget is defined by the difference between the downward and upward components of shortwave and thermal infrared longwave radiation at the surface. The instability of the surface radiation budget plays a significant role in climate change and variability through the modulation of temperature, precipitation, atmospheric circulation, etc. Clouds are believed to be a key factor to regulate such energy imbalance at the surface, as they generally reflect shortwave radiation from the sun and emit infrared radiation. Specifically, we are going to focus on the continental United States and answer the following questions: How is the surface radiation budget varied with time and space in the observations? How do clouds impact variations of surface radiation budget? How do state-of-the-art global climate models capture these observed features? What can they tell us about future changes in the surface radiation budget?

To investigate these questions, the NASA Clouds and the Earth's Radiant Energy System (CERES) observations will be used, along with model simulations from Phase 6 of the Coupled Model Intercomparison Project (CMIP6). We will first focus on the surface radiation budget from CERES observations in the 21st century, and examine their seasonal cycles, spatial patterns, long-term trends, and interannual variations over the continental United States. More importantly, we are going to investigate how cloud variability, including cloud types, cloud amount and cloud water content, influences the surface radiation budget. Then the CMIP6 historical simulations will be compared with CERES observations over the same time period. In addition, the CMIP6 future scenario simulations will be used to investigate how the surface radiation budget changes from the middle and late 21st century to the early 21st century. Overall, this study will help us to better understand the cloud and radiation variations in the past, as well as build credibility in the hindcast and future projections of surface energy budget over the continental United States.