The Contribution of Clouds to Global Surface Temperature Variability on Monthly to Decadal Timescales

Cloud radiative effects (CREs) have well documented impacts on the mean climate, and have recently been found to play a key role in climate variability in the tropics. This thesis expands on previous work to probe the role of CREs in extratropical surface temperature variability. The impact of CREs in climate variability is isolated using the ‘cloud-locking’ method run on the Max Planck Earth System Model. This method involves comparing the output from two climate simulations: one in which clouds are coupled to the atmospheric circulation and another in which clouds are decoupled from the flow. Results show that coupling between CREs and the atmospheric circulation leads to widespread increases in extratropical surface temperature variability, particularly over the North Atlantic and North Pacific.

This work then explores on what timescales surface temperature variability is increased. In general, CREs play an increasingly large role in surface temperature variability at increasingly long timescales. Importantly, cloud-circulation coupling leads to enhanced decadal temperature variability of ~25-45% over most of the Northern Hemisphere oceans and ~10-15% over most of the land areas. Finally, using a simple expression for temperature variance in terms of the surface energy balance, the mechanisms driving these variability changes are identified. This variability enhancement derives from ‘reddening’ of surface temperature variability by cloud shortwave radiative effects. These results demonstrate the dominant effect that cloud-circulation coupling has on interannual and decadal temperature variability across much of the globe. This work has implications for the interpretation of observed decadal variability, and for the importance of cloud-circulation coupling in climate model simulations.
Topic: M.S. Defense: Chloe Boehm
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