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Using ISCCP weather states to decompose cloud radiative effects

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The presentation will examine the shortwave (SW) and longwave (LW) cloud radiative effect CRE (aka "cloud radiative forcing") at the top-of-the-atmosphere and surface of ISCCP weather states (aka "cloud regimes") in three distinct geographical zones, one tropical and two mid-latitude. Our goal is to understand and quantify the contribution of the different cloud regimes to the planetary radiation budget. In the tropics we find that the three most convectively active states are the ones with largest SW, LW and net TOA CRE contributions to the overall daytime tropical CRE budget. They account for 59%, 71% and 55% of the total CRE, respectively. The boundary layer–dominated weather states account for only 34% of the total SW CRE and 41% of the total net CRE, so to focus only on them in cloud feedback studies may be imprudent. We also find that in both the northern and southern midlatitude zones only two weather states, the first and third most convectively active with large amounts of nimbostratus-type clouds, contribute $\sim$40% to both the SW and net TOA CRE budgets, highlighting the fact that cloud regimes associated with frontal systems are not only important for weather (precipitation) but also for climate (radiation budget). While all cloud regimes in all geographical zones have a slightly larger SFC than TOA SW CRE, implying cooling of the surface and slight warming of the atmosphere, their LW radiative effects are more subtle: in the tropics the weather states with plentiful high clouds warm the atmosphere while those with copious amounts of low clouds cool the atmosphere. In both midlatitude zones only the weather states with peak cloud fractions at levels above 440 mbar warm the atmosphere while all the rest cool it. These results make the connection of the contrasting CRE effects to the atmospheric dynamics more explicit – "storms" tend to warm the atmosphere whereas fair weather clouds cool it, suggesting a positive feedback of clouds on weather systems. The breakdown of CRE by cloud regime are however not entirely similar between the two midlatitude zones. Despite the existence of an additional state in the northern midlatitudes, only four weather states have net daytime CREs with absolute values above 100 Wm$-$2 compared to six in the south. This reminds us that the environment where clouds occur also has a crucial role in determining their radiative effects. All the above make evident that reproducing grand averages of current CRE by climate models in only part of the challenge. If existing cloud regimes and shifts in their distributions and frequency of occurrence in a changed climate are not properly simulated, the radiative role of clouds will not be adequately predicted.