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# Radiative effects of clouds and water vapor on the monsoon

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Monsoons are summertime circulations shaping climates and societies across the tropics and subtropics. Here the radiative effects controlling the climatological monsoon and its response to climate change are investigated using idealized simulations. The influences of clouds, water vapor and $CO_2$ on the monsoon are decomposed using the radiation-locking technique. Seasonal cloud and water vapor radiative effects strongly modulate the climatological monsoon, reducing net monsoon precipitation by approximately half. Warming and moistening of the monsoon by seasonal longwave cloud and water vapor effects are counteracted by a strong shortwave cloud effect. The shortwave cloud effect expedites monsoon onset by approximately 10 days, whereas longwave cloud and water vapor effects delay onset. A simple theory for monsoon onset relates monsoon onset to the efficiency of surface cooling. In climate change simulations the water vapor feedback and $CO_2$ forcing have similar influences on the monsoon, warming the surface and moistening the region. In contrast, clouds have a negligible effect on surface temperature yet dominate the response of the monsoon circulation to climate change. The radiation-locking simulations and analyses advance understanding of how and why radiative processes influence the monsoon, and establish a new framework for interpreting monsoon--radiation coupling in observations, in state-of-the-art models and in different climate states. Moreover, sensitivities of the monsoon to the longwave cloud feedback are found to be similar over the seasonal cycle and under $CO_2$ forcing, suggesting a potential emergent constraint for monsoons in a changing climate.