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Understanding the changes of hydrological cycle in response to increasing greenhouse gases

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The global and local hydrological cycle is vital to human life and natural ecosystems. Its changes such as a consequence of climate change are expected to play a central role in governing a vast range of environmental impacts and in regulating climate stability and variability. In this study, the mechanisms responsible for the changes in the hydrological cycle are elucidated using sensitivity experiments carried out with an atmospheric general circulation model (GCM). The GCM is forced by doubling CO2, by increasing SST, or both. First, we focus on investigating and understanding the contrasted features of the hydrological changes over land and sea globally and their seasonal evolutions. Then we analyze regional details of hydrological changes caused by different forcings with a focus on Asian monsoon regions. Globally, the direct CO2 forcing weakens the global mean precipitation, accompanied by a decrease of precipitation over sea and an increase of precipitation (1.4%) over land associated with an increase in soil moisture (4.4%) and runoff (11%). By contrast, the increased SST leads to land breeze-like large scale circulation anomalies characterized by anomalous ascent over sea and anomalous decent over land, which in turn is associated with decreased precipitation (-0.6%), soil moisture (-2.5%) and runoff (-2.5%) over land and increased precipitation over sea. Regionally, both SST change and CO2 change lead to an increase in precipitation, soil moisture and runoff over the East Asian and Indian monsoon regions, implying that both forcings will lead to an increase of flooding risks locally. The direct response to the CO2 change has two components, one associated with purely radiative effects and the other associated with the reduction in stomatal conductance. Their separate effects on the global and regional changes of hydrological cycle will also be
discussed.