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On the North American summer monsoons

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Summer rainfall in the southwestern United States has been studied in a framework of the "southwest U.S. summer monsoon." Yet, it remains debatable if that region is a monsoon region because, except for rainfall, there has been insufficient information about that region's seasonal circulation change and low-level wind reversal. This uncertainty undermines the effort in understanding and predicting the southwest U.S. summer rainfall. To clear this uncertainty and to further provide a systematic evaluation and a paradigm of summer monsoons in the North America, this study used the recently available high spatial resolution North America Regional Reanalysis data and examined various circulation features in North America, including the divergence circulations associated with seasonal changes in thermal contrasts of the Rocky Mountain Plateau and Mexican Plateau and their environments. In addition, various methods were used to quantify the monsoon regions and to identify the monsoon influence regions. Major results show distinct west Mexico summer monsoons in the west slope of the Sierra Madre Occidental and the Gulf of California, the northeast Mexican monsoon in the east slope of the Mexican Plateau, and the U.S. Great Plains summer monsoon. The Mexican monsoons onset in July and end in September, and the Great Plains monsoon starts in May and end in July. A reason for the onset difference is provided. Further analyses of wind and precipitation indicate that the U.S. Southwest is a heavily influenced region by the two different Mexican monsoons, and interactions and subtle imbalance between the influences of those monsoons could have attributed to the rather low predictability of the summer rainfall in the Southwest. Because the Mexican monsoons start on dates when the Great Plains monsoon nearly ends, influence or connection of summer rainfall anomalies in the U.S. Southwest with those

in the Great Plains is questioned. In addition, from evaluation of the circulations, a plausible connection of summer rainfall anomalies in those two regions, as observed by some previous studies, is suggested to be through the southerly and southeasterly flows from the Gulf of Mexico, which influence both the northeast Mexican monsoon (thus, the rainfall in the U.S. Southwest) and the U.S. Great Plains monsoon and rainfall. Some specifics of the relationships and their temporal variations are provided. Results of this study complement our knowledge of North American summer monsoons and can be used for further improvements of summer rainfall predictions in various regions of the North America.