Geophysical Research Abstracts
Vol. 18, EGU2016-10843, 2016
EGU General Assembly 2016

Wetting and greening Tibetan Plateau in early summer since the late 1970s due to advanced Asian summer monsoon onset

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Known as the “the world water tower”, the Tibetan Plateau (TP) is the origin of the ten largest rivers in Asia, breeding more than 1.4 billion people, and exerts substantial influences on water resources, agriculture, and ecosystems in downstream countries. This region is one of the most susceptible areas around the world to changing climate due to the high elevation. Observed evidence have shown significant climate changes over the TP, including surface air warming and moistening, glaciers shrinking, winds stilling, solar dimming, and atmospheric heat source weakening. However, as an essential part of the hydrological cycle, precipitation changes on the TP remain an ambiguous picture. Changes in precipitation vary largely with different seasons, time periods and climate zones considered. This study shows a robust increase in precipitation amount over the TP in May, when the rainy season starts, over the period 1979-2014 (31% relative to the climatology). The wetting trend is spatially consistent over the south-eastern TP, to which both precipitation frequency and intensity contribute. Circulation trends show that the wetting TP in May is resulted from the advanced onset of Asian summer monsoon, which onsets 1$\sim$2 pentads earlier since 1979. It intensified water vapor transport from the Bay of Bengal (BOB) to south of the TP in May and local anomalous convection. This relationship is further validated by the significant correlation coefficient (0.47) between the onset dates of Asian summer monsoon (particularly the BOB summer monsoon, 0.68) and precipitation over the south-eastern TP in May. The wetting TP in May has further exerted profound impacts on the hydrological cycle and ecosystem, such as moistening the soil and animating vegetation activities throughout early summer. Both decadal variations of soil moisture (from May to June) and Normalized Difference Vegetation Index (NDVI) (from May to July) coincide well with that of precipitation over the south-eastern TP, significant at 99% confidence level by Mann-Kendall test. This implies that the increasing precipitation in May is favoring a greening TP throughout early summer, benefitting a more favorable ecological environment in the semi-humid region there.