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Historical change of winter Tibetan Plateau snow cover and its controlling factors

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This study investigates the controlling factors of the interannual variability of Tibetan Plateau snow cover (TPSC) in winter. Since snow observation in Tibetan Plateau is limited in space and time, high-resolution multi-satellite data for TPSC were analyzed during 1982-2016. In addition, a large ensemble AGCM experiment from d4PDF (hereafter, HIST), driven by observed SST and anthropogenic forcings were analyzed during 1951-2010 to compare the contributions arising from internal variability and external forcings including the change in greenhouse gases (GHGs) concentration on TPSC variation. In this study TPSC fraction (hereafter, TPSCF) is defined as the percentage of the snow-covered area over the Tibetan Plateau. For both observation and HIST, high and low TPSCF years determined by the standardized January-March TPSCF were analyzed. The range of interannual TPSCF variation (i.e., TPSCF difference between high and low TPSCF years) is about 11% in both observation and the model, suggesting the AGCM well reproduced the TPSCF variability in the interannual timescale.

We found that high TPSCF is linked to a positive-AO-like pattern. The interannual variation of the observed AO index and TPSCF are significantly correlated. In d4PDF high TPSCF more likely appears with a higher (positive) AO index and vice versa. In high TPSCF years, the subtropical jet is strengthened, which significantly enhances zonal water vapor flux reaching the plateau supporting more precipitation. Another interesting result is a disagreement for ENSO's contribution to TPSC appears between observation and HIST. However, several members in HIST show a feature close to the observation, in which TPSCF anomalies are not sensitive to the El Niño/La Niña events. Thus, this weak linkage between ENSO and TPSCF is more likely due to the limited cases of observations rather than the model bias. Finally, by comparing HIST and non-warming experiments (NAT), we found historical global warming has decreased the snow-to-rain ratio over TP. Nonetheless, increased precipitation compensates for it. As a result, the impact of historical global warming on TPSCF could be considered negligibly weak.