Snow variation modes in the Northern Hemisphere related to the Arctic and Antarctic Oscillations

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The atmosphere lacks the mechanisms to generate predictable variations beyond synoptic time scales (Lorenz 1963), so for climate prediction, it is very important to study patterns of variation in atmospheric forcings. El Nino as a variation mode of the tropical ocean water has become an important factor in prediction that significantly influences the atmosphere (Kim et al. 2012). Snow over land is another important lower boundary forcing source and another form of water that directly and persistently influences the atmosphere and soil on multi-time scales. Thus, snow has also been investigated during recent decades as another potential source of predictability. It is still unclear whether a stable snow–atmosphere coupled mode exists in the extratropics, like the sea-atmosphere coupled ENSO mode in the tropics. Our study analyzes the major modes of winter snow over the Northern Hemisphere, quantitatively evaluates the stability of coupling relationships between the snow modes and the winter atmospheric Arctic Oscillation (AO), the Antarctic Oscillation (AAO) and the Siberian High over the period 1872–2010, and discusses their possible relationships for different seasons.
Results show that the first mode of the winter snow cover fraction and the winter AO together constitute a stable snow–atmosphere coupled mode, the SNAO. The coupled mode is stronger during recent decades than before. The snow anomaly over Europe is one key factor of the SNAO mode due to the high stability there, and the polar vortex anomaly in the atmosphere is its other key factor. The continuity of signals in the SNAO between autumn and winter is weaker than that between winter and spring. The second winter snow mode is generally stably correlated with the winter AAO and was more stable before the 1970s. The AAO signal with boreal snow has a strong continuity in seasonal transition. Generally, through these coupled modes, snow and atmosphere can interact in the same season or between different seasons: autumn snow can influence the winter atmosphere; the winter atmosphere can influence spring snow.

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