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# Interpreting observed Arctic snow trends with large ensembles of climate simulations

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In response to increasing greenhouse gas concentrations, Northern Hemisphere snow cover extent is predicted to decrease while snowfall is predicted to decrease at midlatitudes but increase at high latitudes. Accurately forecasting both global and regional changes in the coming decades is predicated on the ability to properly simulate historical changes and the ability to separate forced signals from the large amount of natural variability.

In this context, we analyze Northern Hemisphere snow trends and trend variability as simulated by coupled and uncoupled configurations of a single comprehensive global climate model, the National Center for Atmospheric Research's Community Earth System Model (CESM). We compare two 40-member ensembles with one another and against observational data products over the historical period, 1981-2010. The model is able to reproduce the observed climatology and variability of snow cover extent and snow water equivalent (albeit the latter to a lesser degree of fidelity). Despite this success, in either ensemble internal climate noise generates widely different spatial patterns of snow trends in a given climate realization. These patterns are related in an intuitive way to the long-term temperature, precipitation and circulation trends of the given realization. For springtime snow cover, the mean trends of both ensembles have decreasing trends, consistent with observations but of weaker magnitude. In contrast the wintertime trends in snow cover are much stronger in the coupled model than the uncoupled model; such a large decrease in wintertime snow is not seen in the observations. We demonstrate that the difference in the wintertime trend magnitudes is ultimately related to differences in the pattern of sea surface temperature trends in the respective ensembles. The ensemble-mean of the coupled configuration has a shallow northern Pacific temperature gradient that leads to a strong decreasing snow signal over North America. However, a subset of realizations from this experiment shows better correlation with the historical SSTs, and correspondingly shows similar trends in snow cover and snow water equivalent to the ensemble mean of the uncoupled model. These results support the idea that historical SST patterns have played a large role in determining the amount of warming and snow cover trends over North America in the last thirty years.