COMPARATIVE INFLUENCE OF SNOW AND SST VARIABILITY ON EXTRATROPICAL CLIMATE IN NORTHERN WINTER

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The influence of snow on atmospheric seasonal mean variability in extratropical latitudes in boreal winter was studied. The motivation for this analysis was to understand the characteristics of low-frequency atmospheric variability associated with the interannual variations of underlying snow cover and the remote tropical sea surface temperatures (SSTs). The influence was assessed from four sets of atmospheric general circulation model (GCM) simulations where snow amount was either prescribed to a climatology or was allowed to evolve during the model integration, and the SSTs were either set to a climatology or to the observed monthly means. First, composite responses of surface air temperature and atmospheric height to tropical SST forcing during ENSO events were contrasted between the pair of experiments in which snow was either prescribed or evolving. Then, the influence of snow variability was further contrasted with that of the interannual variability in SSTs.

A systematic influence of snow variability on the atmospheric seasonal mean variability was found. For the GCM simulations where the interannual variability in snow amount was allowed, the interannual variability of surface air temperature was found to be larger. The influence of snow variability, however, was confined to the lower troposphere, and little change in the interannual variability of upper tropospheric circulation, for example, 200-hPa heights, occurred. This bottom-up vertical structure of the influence of snow on the atmospheric variability was in contrast to the top-down influence of tropical SST variability on the extratropical flow. The cause for the enhancement of atmospheric variability in the lower troposphere was argued to be related to the dependence of surface albedo on snow depth amount. The interaction between the atmospheric variability and the underlying snow could be viewed as a positive feedback process whereby surface temperature anomalies amplify even further.

The study emphasized the importance of the parameterization of surface albedo over snow-covered surface for seasonal climate prediction. The relationship between albedo and snow depth also has implications for the estimates of climate sensitivity and regional climate changes induced by increasing greenhouse gases.