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Future changes in winter storm activity in a high-resolution AGCM

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Future changes in the Northern Hemisphere wintertime storm activity by global warming is investigated using atmospheric general circulation models with the horizontal grid size of 20km and 60km. As the present-day climate experiment (1979-2003), the observed sea surface temperature (SST) and sea-ice concentration are given as the lower boundary conditions. As the future climate experiment (2075-2099), the warming in the SST for the CMIP3 multi-model ensemble mean is added to the observed SST. Three members of initial value ensemble simulations with the 60km model are used to support the statistical significance of the changes appearing in the 20km model.

Cyclone trackings are conducted in the simulation results, and the frequency of the cyclones and its spatial distribution in the Northern winter in the present-day experiment agree with those found in the reanalysis data. The frequency decreases significantly in the future climate experiment, associated with the decrease of baroclinicity in the lower troposphere. The frequency of the heavy storms, which have sea level pressure (SLP) lower than 980hPa, however, shows significant increase. Synoptic-scale bandpass-filtered variability (so called storm track activity) also increases especially in the upper troposphere, and in the downstream of the storm track region in the lower troposphere. These are very similar to the results obtained from CMIP3 models themselves, as shown by previous studies.

The growth rate of the storms, defined as the temporal SLP change along each cyclone track, increases on the polar side of the storm track region and slightly decreases on the equatorial side. This spatial pattern of the change is found to be similar to the pattern of the change in the upper-troposphere baroclinicity, especially in the North Pacific region. This suggests that the increase of the upper-troposphere baroclinicity affects the cyclone growth, resulting in the increase of heavy storms. Although a large part of the change in the baroclinicity is attributed to the change in the temperature gradient, associated with the northward shift of the jet, the decrease in the static stability also contributes to the change around the western North Pacific.