8.4 AN INTERDECADAL MODE OF NORTHERN HEMISPHERE STORM TRACK VARIATIONS

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EXTENDED ABSTRACT

Gridded atmospheric analyses produced by the NCEP/NCAR reanalysis project have been analyzed to examine inter-annual variations of the northern hemisphere winter storm tracks. High pass filtered 300 hPa meridional velocity variance, filtered using a 24-hour difference filter, is used to highlight the storm tracks (results using a broader, 2-8 days band-pass filter are very similar). An EOF analysis is performed on fifty one winters of data, taken from December-January-February (DJF) of 1948/49 to 1998/99.

The leading EOF of interannual storm track variations account for 29% of the total variance. The spatial pattern for this EOF is plotted in Fig. 1, and the principal component (PC) corresponding to this EOF is plotted in Fig.2. The pattern shown in Fig. 1 corresponds to a simultaneous strengthening/weakening of both the Pacific and Atlantic storm tracks. The correlation between the two storm tracks has been verified by performing EOF analyses separately on the Pacific (120E to 100W) and Atlantic (90W to 50E) sectors respectively. The leading EOFs for the two analyses resemble the spatial pattern in the respective sector plotted in Fig. 1, and the principal components corresponding to these two EOFs (not shown) display a statistically significant correlation of 0.47.

The principal component shown in Fig. 2 clearly shows marked inter-decadal variability, with the storm tracks being much stronger in the 1980's and 1990's, and much weaker during the 1960's, with a transition occurring during the early 1970's. This inter-decadal variability is highlighted in Fig. 3, which shows the decadal mean of the storm tracks for 1962/63-1971/72 (Fig. 3a), when the storm tracks were weakest, and the mean for the period 1985/86 to 1994/95, when the storm tracks were strongest (Fig. 3b). Their differences are shown in Fig. 3c. Shaded areas in Fig. 3c denote areas over which the difference is greater than 40% of the mean. We can see that over large regions over the Pacific and Atlantic storm tracks, the storm tracks were much stronger during 85/86-94/95 compared to 62/63-71/72.

The relationship between the storm track variations and the seasonal mean flow is examined by regressing the PC shown in Fig. 2 with seasonal mean 300 hPa zonal wind, 500 hPa geopotential height, mean sea level pressure, as well as other mean flow fields. The regressions with 300 hPa U and 500 hPa z (not shown) basically show a slight northward shift in both the Pacific and Atlantic jets associated with the intensification of the storm tracks. The mean flow changes can be shown to be strongly tied to the storm track changes, as the time series formed by projecting the regression maps for either the 300 hPa U or 500 hPa z back onto the interannual U or z data both correlate very well with the storm track PC (correlations equal 0.8 for both cases).

We have also investigated the relationship between the storm track variability and other "modes" of low-frequency variability, including the Arctic Oscillation (AO, Thompson and Wallace, 2000), as well as the ENSO-like interdecadal variability (Zhang et al. 1997). The results suggest that while part of the storm track variations could be related to the AO as well as the ENSO-like interdecadal variability, when storm track variations linearly dependent on these two modes are taken out, substantial inter-decadal variations still remain, suggesting that a large part of the storm track variability is unrelated to these other modes of variability. For more details, please see Chang and Fu (2001).

The results discussed in this paper are based on gridded analyses produced by the NCEP/NCAR reanalysis project. The objective analysis scheme used in the reanalysis is designed to minimize r.m.s. errors in the analyses, such that on average, analysis errors are expected to be smaller than observational errors, at least over regions where ample amount of observations are available. However, it can be shown that the variances generated by the objective analysis scheme can be seriously affected by model errors and biases, as well as biases introduced by changes in the observation network, such that analyzed variances are not necessarily better than observed variances. Hence in a companion paper (P6.2: Storm track variations as seen in radiosonde observations and reanalysis data), we will compare storm track variations computed directly from radiosonde observations to those in the reanalysis data to verify whether the large interdecadal storm track variation is real or not.

REFERENCES

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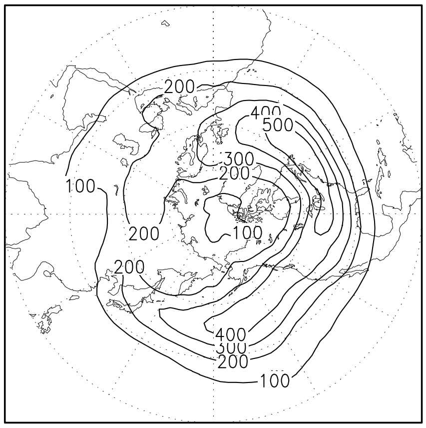
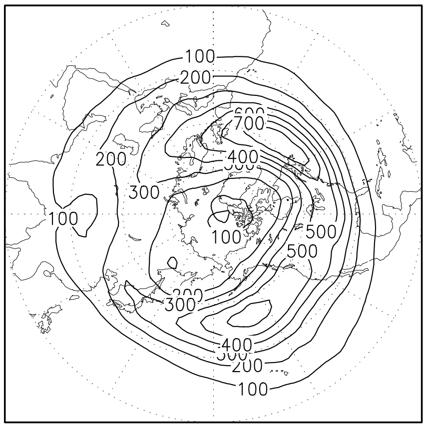
Fig. 3a) v300 1df 63-72



3b) v300 1df 86-95



3c) 86-95 minus 63-72

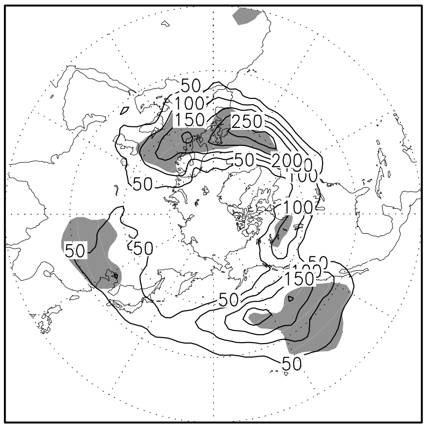


Fig. 1) EOF1, v3001df

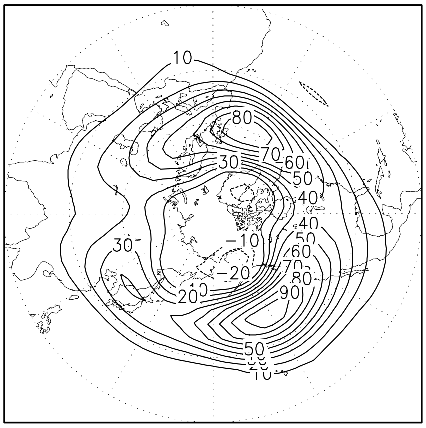


Fig. 2) PC1, v3001df