Abstract

In this study a lagged Maximum Covariance Analysis (MCA) of the wintertime storm-track and sea surface temperature (SST) anomalies derived from the reanalysis datasets shows significant seasonal and long-term relationships between storm tracks and SST variations in the North Pacific. At seasonal time scales, it is found that the midlatitude cold (warm) SST anomalies in the preceding fall, which are expected to change the tropospheric baroclinicity, can significantly enhance (reduce) the storm-track activities aloft in early winter. The storm-track response pattern, however, is in sharp contrast to the forcing pattern, with cold (warm) SST anomalies in the western-central North Pacific corresponding to a counterclockwise (poleward) shift and intensification of storm tracks. At interannual time scales, it is found that the wintertime SST and storm-track anomalies are mutually reinforced up to 3 years, which is characterized by PDO-like SST anomalies with warming in the western-central domain coupled with basin-scale positive storm-track anomalies extending along 50°N.

Method

In this study, storm tracks are defined as the band-pass-filtered (2-8 days) 300-mb meridional wind velocity variance. Monthly anomalies of all field quantities are obtained by subtracting the climatological monthly means and removing the linear trend. Much of the ENSO influence is also removed by seasonally varying regression onto the first two principal component of the tropical Pacific SSTAs. The MCA as a function of time lag is performed to investigate the relationship between storm tracks and SST in the North Pacific. The statistical significance of the MCA modes is assessed on the squared covariance (SC) and squared covariance fraction (SCF) using the Monte Carlo test, in which MCA is repeated 100 times using the original SSTAs with storm-track time series randomly scrambled.

Seasonal coupling between storm tracks and SST

The SCs of the first MCA mode exhibit a strong seasonal dependence and an asymmetry of the lead-lag. Throughout the cold season, the SCs are strong when storm tracks lead SST, indicating a predominant forcing by storm tracks. However, there are significant SCs when SST leads storm tracks in November and December by 2 and 3 months, indicating a potential influence of SSTAs in fall on storm tracks in early winter. Here we mainly focused on December to explore the influence of SST on storm tracks.

Storm-track forcing on SST

In early winter, a southward movement and intensification of storm tracks can induce cold SSTAs in the western and central North Pacific and warm SSTAs along the western coast of North America (Fig. 2c,d). The warm SSTAs are found to be primarily determined by the surface heat flux forcing, whereas the cold SSTAs are attributed to both the anomalous heat flux and Ekman cold advection (Fig. 4).

Interannual coupling between storm tracks and SST

As shown in Fig. 5, the leading EOF of the DJF-mean storm-track anomalies characterizes the decadal variations in the intensity of wintertime storm tracks. This decadal variability of storm tracks is found to be highly associated with the North Pacific decadal mode which is linearly independent of ENSO.

Summary

- At seasonal time scales, SSTAs in the preceding fall can significantly influence storm tracks in early winter presumably by affecting the tropospheric baroclinicity. This storm-track response pattern, however, is in sharp contrast with the storm-track forcing pattern in early winter.
- Decadal variability of winter (DJF-mean) storm-track intensity is found to be highly associated with the North Pacific decadal mode linearly independent of ENSO. The lagged MCA results further suggest that such identified coupling is active and significant at interannual time scales (up to 3 years), indicative of a positive feedback between the wintertime SSTAs and storm-track anomalies.