Dynamics of Atmospheres and Oceans 63 (2013) 131–141

Contents lists available at SciVerse ScienceDirect

Dynamics of Atmospheres and Oceans

journal homepage: www.elsevier.com/locate/dynatmoce

Relationship between the frequency of tropical cyclones in Taiwan and the Pacific/North American pattern

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ARTICLE INFO

Article history:
Received 10 July 2012
Received in revised form 26 May 2013
Accepted 29 May 2013
Available online 20 June 2013

Keywords:
Tropical cyclone
Pacific/North American teleconnection pattern
East Asia
Taiwan

ABSTRACT

The frequency of tropical cyclones (TCs) in Taiwan during June to October (JJASO) is found to have a strong negative correlation with the Pacific/North American (PNA) pattern in the preceding April. In the negative PNA phase, the anomalous cyclonic and the anomalous anticyclonic circulations are intensified at low latitudes and mid-latitudes from East Asia to the North Atlantic, respectively, from April to JJASO. Particularly in East Asia, the anomalous southeasterly that converges between the anomalous anticyclone to the east of Japan and the anomalous cyclone to the east of Taiwan plays a decisive role in moving TCs not only to Taiwan, but also to the mid-latitude coastal regions of East Asia as a result of the steering flow. In addition, a southwestward extension of a western North Pacific (WNP) high during the positive PNA phase also contributed to a frequent movement of TCs to southern China without traveling north toward the midlatitude regions of East Asia. Due to the difference in the typical tracks of the TC in the WNP according to the PNA phase, the intensity of the TC in the negative PNA phase is stronger than that in the positive PNA phase.

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http://dx.doi.org/10.1016/j.dynatmoce.2013.05.003

1. Introduction

The Pacific/North American (PNA) teleconnection pattern is one of the most prominent modes of low-frequency variability in the Northern hemisphere (NH) extratropics (Wallace and Gutzler, 1981; Wallace, 2000). It tends to be most pronounced in the winter months. The PNA is associated with a Rossby wave pattern, with centers of action over the Pacific and over North America. It refers to the relative amplitudes of the ridge over western North America and the troughs over the central north Pacific and southern U.S. (Leathers et al., 1991a). That is, the positive PNA phase is characterized by an anomalous anticyclone in the subtropical western North Pacific (SWNP) and over the intermountain region of North America and by an anomalous cyclone in the North Pacific and over the southeastern U.S., and vice versa in the negative PNA phase.

The positive PNA phase is associated with above-average temperatures over western Canada and the extreme western United States, and below-average temperatures across the south-central and southeastern U.S. The PNA tends to have little impact on surface temperature variability over North America during summer. The associated precipitation anomalies include above-average totals in the Gulf of Alaska extending into the Pacific Northwestern United States, and below-average totals over the upper Midwestern United States (Leathers et al., 1991a,b; Leathers and Palecki, 1992; Coleman and Rogers, 1995; Isard, 1999; Renwick and Wallace, 1996).

Although the PNA pattern is a natural internal mode of climate variability, it is also strongly influenced by the El Niño/Southern Oscillation (ENSO) phenomenon. The positive phase of the PNA pattern tends to be associated with Pacific warm episodes (El Niño), and the negative phase tends to be associated with Pacific cold episodes (La Niña) (Trenberth et al., 1998; Straus and Shukla, 2002; Lin et al., 2005). The PNA phases are also associated with warm phases of Pacific Decadal Oscillation (PDO) and the reorganization of the PNA pattern toward a positive mode is strongest when the ENSO and PDO are in phase (Trouet and Taylor, 2009).

While many studies related to the PNA pattern have paid attention to its influences on regional temperature and precipitation in North America, fewer studies have focused on possible remote impacts of the PNA pattern on Indian monsoon and Asian climate. Peings et al. (2009) suggested a winter-to-spring PNA index as a reasonable basis for multiple linear regression scheme for the prediction of the Indian summer monsoon rainfall. Gong et al. (2007) found that the frequency of dust storms in northern China was positively associated with the PNA pattern on an interannual time scale during 1962–2002. Wang et al. (2000) explained how ENSO linked to the PNA affects the East Asian climate through the Pacific-East Asian teleconnection. Until now, however, there have been few studies on the relationship of the PNA pattern with the activity of tropical cyclones (TCs) in the western North Pacific (WNP).

Klotzbach and Gray (2004) used the PNA pattern as one of the potential predictors for 6–11-month predictions of seasonal hurricane activity in the Atlantic basin. Our study is based on the idea that a positive PNA phase in the preceding winter is usually related to a cold ENSO phase in the current summertime and that, eventually, a cold ENSO phase can enhance the activity of TCs in the Atlantic. Since ENSO linked to the PNA is a factor influencing TC activity over the WNP (Chan, 2000; Wang and Chan, 2002) and the TC variability between the North Atlantic and the North Pacific is related (Wang, 2010), it is interesting to examine whether the PNA pattern is related to the activity of TCs in the WNP. In particular, the present study attempts to identify a possible remote relationship between the PNA pattern in April and the frequency of TCs that affect Taiwan from June to October (JJASO) in the same year.

Section 2 describes the data and the methodology used. Section 3 investigates the relationship between the PNA index and the frequency of TCs that affect Taiwan, as well as the associated large-scale environments. The conclusion and summary appear in the final section.

2. Data and methodology

2.1. Data

Data on the frequency of TCs in the WNP from 1979 to 2011 (33 years) were obtained from the best track archives of the Regional Specialized Meteorological Center, Tokyo Typhoon Center. The data consist of the names of the TCs, their central positions (latitude and longitude), their minimum