Atmósfera 28(1), 63-70 (2015)

Winter frequency of western disturbances and precipitation indices over Himachal Pradesh, India: 1977-2007

NARESH KUMAR and B. P. YADAV
India Meteorological Department, Lodi Road, New Delhi-110003, India
Corresponding author: N. Kumar; e-mail: naresh.nhac@gmail.com

SHILPA GAHLOT
Indian Institute of Tecnology, Hauz Khas, New Delhi-110 016, India

MANMOHAN SINGH
Meteorological Centre, Bibra House, Cliffend Estate, Shimla, Himachal Predesh-171001, India

Received October 23, 2013; accepted November 3, 2014

RESUMEN

Los Himalayas desempeñan un papel importante en el clima y el tiempo meteorológico de la India, y controlan tanto las perturbaciones del oeste (PO) durante el invierno como el monzón del suroeste durante el verano. En los meses de invierno (diciembre a marzo), los vientos del oeste asociados con PO causan precipitaciones, en ocasiones asociadas a fuertes nevadas y extensas avalanchas sobre Himachal Pradesh. Por tal motivo, el presente estudio analiza la variabilidad temporal de la frecuencia de PO y de diversos índices de precipitación (como número de días húmedos y lluviosos, días con precipitación fuerte y muy fuerte, e intensidad de la precipitación de 1977 a 2007) en Himachal Pradesh durante el invierno. También se analizan las características sinópticas asociadas con PO intensas que provocaron fuertes precipitaciones sobre la región durante el periodo señalado. El análisis de datos revela una tendencia decreciente estadísticamente significativa (con un nivel de confianza > 95%) de las PO en la región de estudio. Debido a que la precipitación invernal en Himachal Pradesh ocurre sobre todo como resultado de las PO, tanto la precipitación total como los días con precipitación fuerte y muy fuerte han disminuido en la región. El análisis también muestra una disminución de alrededor de 25% en los días de precipitación fuerte y de 13% en la precipitación invernal total sobre Himachal Pradesh respecto de su media respectiva (de 1977 a 2007).

ABSTRACT

The Himalayas have an important role in Indian weather and climate, since they control the western disturbances (WDs) during winter and the southwest monsoon during summer. During the winter months (December to March), westerly winds associated with WDs cause precipitation, sometimes along with heavy snowfall, extensive avalanches, etc., over Himachal Pradesh. Therefore, this study examined the temporal variability in the winter months frequency of WDs and various precipitation indices like wet days, rainy days, rather heavy and heavy precipitation days, and precipitation intensity during 1977 to 2007 over Himachal Pradesh. The study also examined synoptic features associated with intense WDs that caused heavy precipitation over the region during the same period. Analysis of data reveals a statistically significant (confidence level > 95%) decreasing trend in the frequency of WDs over this region. Since winter precipitation in Himachal Pradesh mainly occurs due to WDs, total winter precipitation and frequency of rather heavy and heavy precipitation days have decreased over the region. The analysis also shows a decrease of about 25% in heavy precipitation days and of 13% in total winter precipitation from their respective mean (from 1977 to 2007) over Himachal Pradesh.

Keywords: Himachal Pradesh, precipitation, western disturbances.

1. Introduction

Winter precipitation plays an important role over the Western Himalayan Region (WHR), particularly in Himachal Pradesh, for various sectors like agriculture, water resources, horticulture, hydroelectric power generation and regional economy. Winter precipitation in the WHR occurs under the influence of extratropical systems known as western disturbances (WDs) (Dimri and Dash, 2012; Yadav *et al.*, 2012). These are the extratropical upper air troughs or cyclonic circulations (CCs) in midlatitude westerlies that move west to east across the Himalayan region (Das *et al.*, 2002; Das 2002; Lang and Barros, 2004; Puranik and Karekar, 2009). Under its influence, CCs sometimes develop south of the system at lower levels, in which case they are known as induced CCs. Some WDs produce well-distributed and large amounts of precipitation along with heavy snowfall/rainfall, landslides, cloudbursts etc. over the Himalayan region, while others pass across this area without causing precipitation (Malurkar, 1947). Hence, studies related to WDs and their associated weather are essential to the WHR.

There are many studies related to WDs and their associated weather over the WHR in literature. Pisharoty and Desai (1956) and Rao and Srinivasan (1969) studied the synoptic aspects of WDs and their associated weather over the WHR. They found that about 6-7 WDs per month move across the region. Singh and Kumar (1977) found that WDs intensified over the WHR in association with a pre-existing surface low over central Iran overtaken by a strong upper frontal layer. Rangachary and Bandyopadhyay (1987) and Hatwar *et al.* (2005) studied the synoptic features associated with extreme weather over the WHR. They found that widespread precipitation along with extensive avalanches over this region occur under the influence of WDs along with a high amount of moisture coming from the Arabian Sea, the Bay of Bengal or both. Das *et al.* (2002) studied the frequency of WDs in the premonsoon season, as well as its relation with monsoon rainfall and its advancement over northwest India. Their study found a significant decreasing trend in the frequency of WDs during May. Dimri (2005) studied the contrasting features associated with surplus and deficient precipitation years during the winter season to assess the wintertime synoptic weather system affecting the western Himalayas. He found higher heat flux convergence in excess years and higher flux of convergence of kinetic energy with higher dissipation of kinetic energy during surplus years. Dimri (2007) studied the meridional transport of heat, momentum, potential energy and moisture associated with WDs over the Himalayan region due to mean and eddy motion. He observed that significant meridional transport due to mean motion takes place in the upper troposphere at 300 hPa and 200 hPa. Raju *et al.* (2011) studied kinetic energy associated with intense WDs that caused widespread precipitation over northwest India, finding that this phenomenon occurred due to strong flux convergence and adiabatic production of kinetic energy.

There are also studies related to temporal and spatial variability in precipitation over the Himalayan region. Shrestha *et al.* (2000) studied precipitation across Nepal and found significant variability at annual and decadal time scales. Bhutiyani *et al.* (2008) have done trend analyses of discharge data from rivers in the northwest Himalayas, finding out that the number of high-magnitude flood events in this region have increased in the last three decades. Bhutiyani *et al.* (2010) also studied precipitation trends in the northwest Himalayas and did not found any trends in precipitation during the winter season or significant decreasing trends in precipitation during the monsoon season. Kumar and Jain (2010) studied the trends in seasonal annual rainfall and rainy days in the Kashmir Valley using data of five stations within this area. They found decreasing trends in monsoon and winter rainy days over all the stations and a decreasing trend in annual rainfall over three stations. However, there is hardly any study in literature related to frequency of WDs and variability of precipitation indices over the WHR with particular focus on Himachal Pradesh. Therefore, we have studied the frequency of winter WDs and several precipitation indices like total winter precipitation, wet days, rainy days, and rather heavy and heavy precipitation days by using daily precipitation data for the period 1977 to 2007 over Himachal Pradesh. We also examined the synoptic features associated with intense WDs that caused heavy precipitation ($\geq$ 64.5 mm) events over Himachal Pradesh during the same period.

2. Data and methodology

In the present study we used daily precipitation data of 15 rain gauge stations at Himachal Pradesh