Occurrence of Meso-Scale Disturbances and Seasonal and Spatial Variation of CAPE in the South Asia

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Abstract

Meso-scale disturbances occur frequently in the northeastern Indian subcontinent, and cause devastative damages in this region every year. These meso-scale disturbances mainly occur in the pre-monsoon season (from March to May). However, differences in an atmospheric environment between the pre-monsoon season and the other season (monsoon and dry season) are not clarified. In this study, seasonal and spatial variation of CAPE (Convective Available Potential Energy) is examined in the South Asia as the index of the thermal instability. The thermal instability is very important for the initiation of meso-scale disturbances. In the center of Bangladesh, CAPE is high in the pre-monsoon season and highest on May (>2400J/kg), and lower in the monsoon and dry season.

Keyword: CAPE, Meso-scale disturbance, Northeastern Indian subcontinent

1. Introduction

Meso-scale disturbances, for example, tornadoes and hail storm, frequently occur in the northeastern Indian subcontinent (the northeastern part of India and Bangladesh) in the pre-monsoon season (from March to May), and cause much loss of life, house and crop ever year. In 2004, the tornado occurred in Maymensingh division in Bangladesh on 14 April and caused the deaths of about 70 people. Two launches were capsized by high gust during a thunderstorm in the Meghna River in Bangladesh on 23 May 2004. These meso-scale disturbances are locally called as “Nor’wester” in the northeastern Indian subcontinent, which is derived from thunderstorm coming from the north-west direction.

In this study, the seasonal and spatial distribution of CAPE (Convective Available Potential Energy) is examined in the South Asia. CAPE is the index for evaluation of the thermal instability of the atmosphere. The thermal instability of the atmosphere is very important for the initiation of convective clouds causing meso-scale disturbances. Through the analysis of CAPE, it is attempted to reveal quantitative estimation that meso-scale disturbances frequently occur in the pre-monsoon season and in the northeastern Indian subcontinent.

2. The general features of meso-scale disturbances in the northeastern Indian subcontinent

Meso-scale disturbances including tornado is one of the most remarkable meteorological phenomena in the northeastern Indian subcontinent. Peterson and Dewan (2002) show that about 60% of “Nor’westers” occur in April and May in Bangladesh (Fig.1.1). According to tornadoes, their climatology has been studied by many researchers. Fig.1.2 shows the spatial distribution of tornadoes in the world (Fujita (1973)). In the South Asia, the place of tornado occurrence concentrates only over the northern and northeastern area of the Indian subcontinent. Fig.1.3 shows monthly frequency of tornado in India from 1839 to 1999 (Goldar et al. (2001)). About 70% of tornadoes

occur in the pre-monsoon season (from March to May). Fig.1.4 shows monthly frequency of tornado from 1961 to 2000, and about 80% of tornadoes occurs from March to May and the largest figure is in April. Fig.1.5 indicates the distribution of the places of tornado occurrence in Bangladesh for same duration as Fig.1.4. Tornadoes seem to occur in the center of Bangladesh.

3. Data and CAPE analysis

The ECMWF 40 years reanalysis data (ERA-40) were used for the calculation of CAPE. These data sets could be downloaded freely from the following web site:http://data.ecmwf.i-nt/data/d/era40_daily/.

Fig.2.1 shows seasonal variation of daily CAPE at longitude 90 ° E and latitude 22.5 ° N (around the center of Bangladesh) in 2001. The ECMWF data sets are archived for 00UTC, 06UTC, 12UTC and 18UTC per day. CAPE was calculated four times in a day and the daily CAPE was made of the average of these four values. Daily CAPE is increasing from late February, highest on early May in the year, decreasing gradually in the monsoon season. In the dry season (from December to February), daily CAPE is very low (around 0 (J/kg)).

Fig.2.2 shows spatial distribution of monthly CAPE in the South Asia in (a) January (dry season), (b) May (pre-monsoon season) and (c) July (monsoon season) respectively. Monthly CAPE is the monthly average of daily CAPE's. In January, CAPE is very low over the South Asia. In May, relatively higher CAPE region (>2400 (J/kg)) is recognized around Bangladesh and in the northern and southern area of India. In July, monthly CAPE is lower than on May in the northeastern India and Bangladesh, and continues relatively high in the northern India with a similar pattern on May.

These results show that the thermal instability is quantitatively highest on May (pre-monsoon season) in a year in Bangladesh and the northeastern India. Bangladesh and the northeastern India is one of the highest regions of the thermal instability in the South Asia. This indicates that meso-scale disturbances frequently tend to occur in Bangladesh and the Northeastern Indian in the pre-monsoon season.

The cause that CAPE increases in pre-monsoon season in the northeastern India and Bangladesh could be considered as follows: In the pre-monsoon season, the southwesterly wind becomes predominant in the lower troposphere over northeastern India and Bangladesh. However, the westerly cold flow (subtropical jet) is still prominent in the upper troposphere (Hirosawa (1996)). So, the lapse rate of temperature between the lower and the upper troposphere is large. On the other hand, the heating of the Tibetan plateau causes relative higher temperature region in the upper troposphere in the monsoon season and the lapse rate of temperature is small. Moreover the strong southwesterly inflow transports moisture in the lower troposphere from the pre-monsoon season to monsoon season (The Bay of Bengal is on the south side of this region). The thermal instability is higher in the pre-monsoon season over the northeastern India and Bangladesh.

4. Summary

Seasonal and spatial distribution of CAPE is examined in the South Asia using ECMWF 40 years data. The relatively higher CAPE region is just over the northeastern India and Bangladesh. CAPE is highest on May around the center of Bangladesh. These quantitative facts indicate that meso-scale disturbances frequently occur in the pre-monsoon season and especially in the northeastern India and Bangladesh.

Reference

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Goldar, R.N., Banerjee, S.K. and Debnath, G.C., 2001: Tornado in India and neighborhood and its predictability, India. Met. Dept., pre-published scientific report, No.2

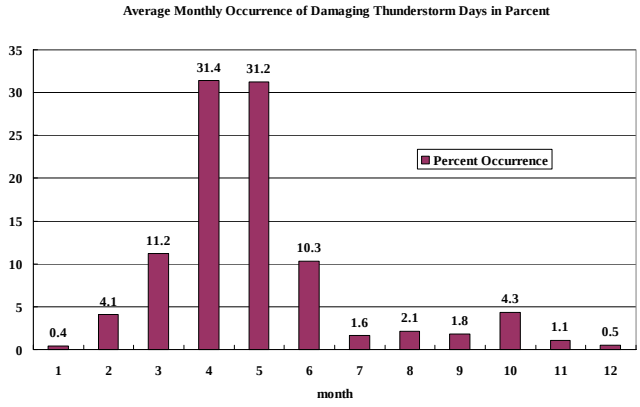


Fig.1.1 Monthly frequency of Nor'westers in Bangladesh (Peterson et al. (2002))

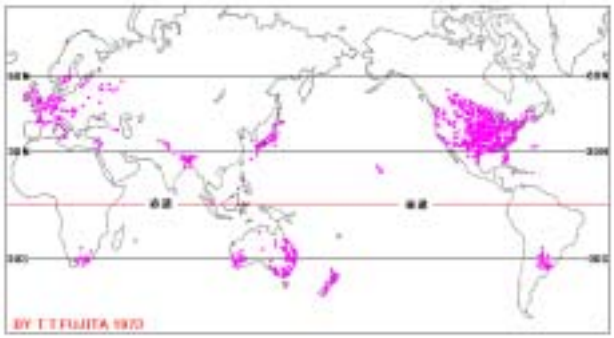


Fig.1.2 The spatial distribution of tornado in the world (Fujita (1973))

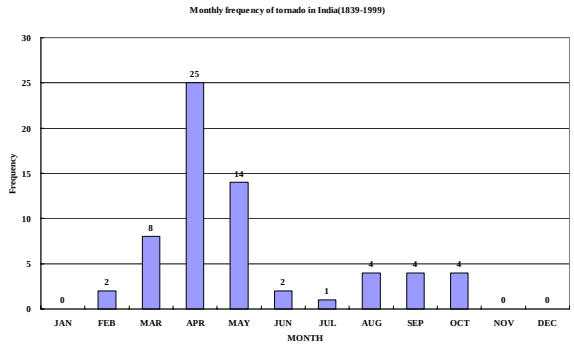


Fig.1.3 Monthly frequency of tornado in India from 1839 to 1999)

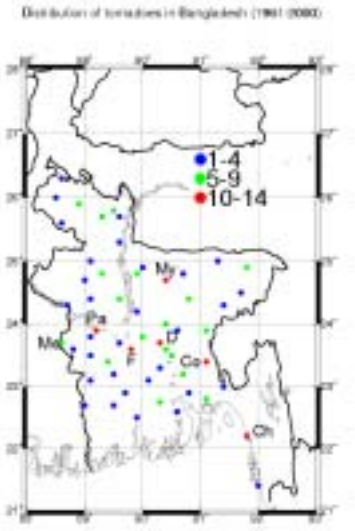


Fig.1.4 The distribution of tornado in Bangladesh from 1961 to 2000. (The dot indicates the number of tornado for each division).

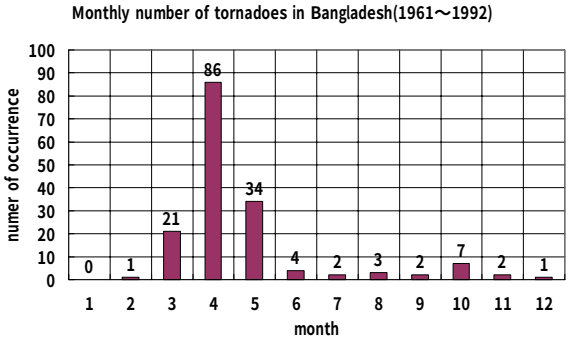


Fig.1.5 Monthly number of tornadoes in Bangladesh from 1961 to 2000

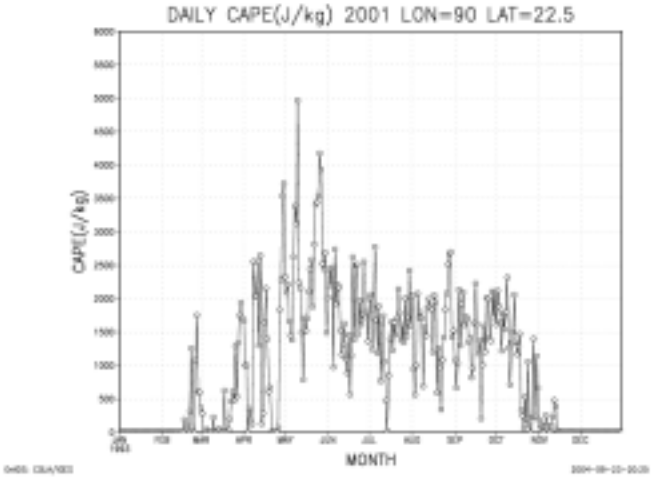
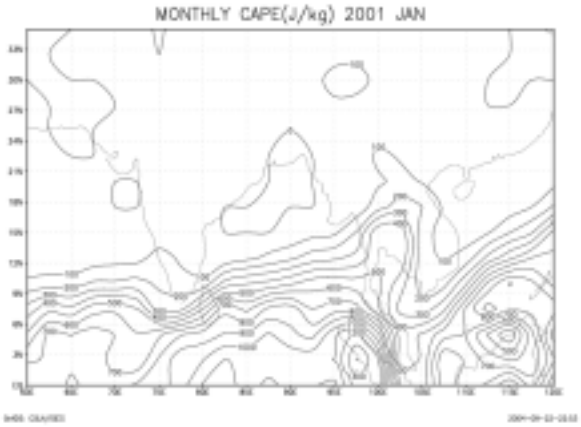
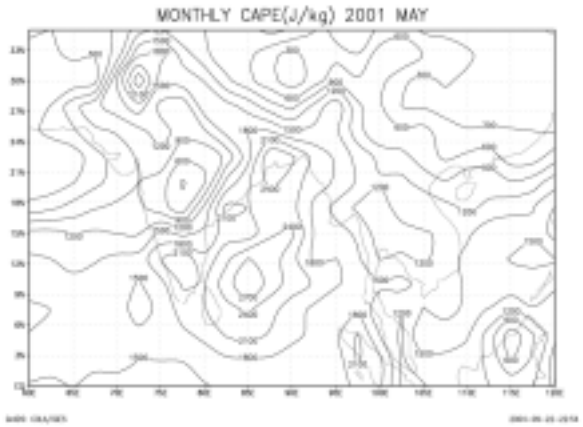


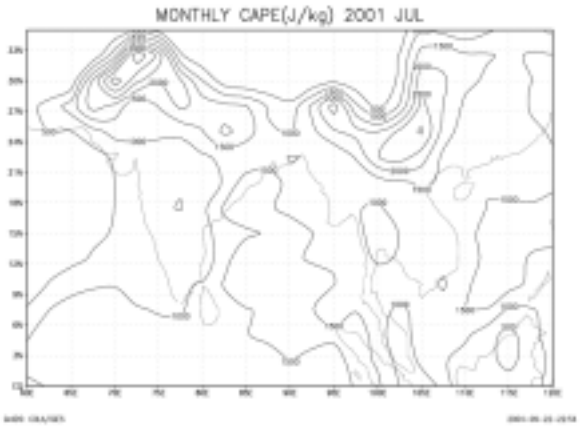
Fig.2.1 Daily CAPE at longitude 90 ° E and latitude 22.5 ° (around the center of Bangladesh) in 2001.



(a) January



(b) May



(c) July

Fig.2.2 The distribution of Monthly CAPE in 2001 in the South Asia.