THE CHARACTERISTICS OF THUNDERSTORM FREQUENCY VARIATION AND THEIR POSSIBLE RELATION WITH THE ADJUSTMENT OF CROP DISTRIBUTION IN THE LEIZHOU PENINSULA

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Abstract: In order to research possible influences of the adjustment of plant distribution on the development frequency of thunderstorms over the Leizhou Peninsula, mathematic statistic methods, including correlation analyses, 11 kinds of fitting models and all-variable regression methods, were used for analyses and research. The results show that the average trend of the number of annual thunderstorm days is descending obviously, and there are thunderstorms in all seasons, in which warm post-midday thunderstorms have taken up the most part, and high frequency is found from May to September, and the starting and ending dates of thunderstorms have a great annual discrepancy. The vegetation structure has been improved along with the reduction of rice fields and the area increment of sugarcane and fruits planting, which results in the decrease of the number of thunderstorm days; the change in the characteristics of winter spare fields, which is caused by the planting of vegetables, limits the formation of thunderstorms in early winter and late spring. Meanwhile, the area adjustment of peanut planting has little influence on the variation of thunderstorm days. The adjustment of principal crop distribution, such as rice, sugarcane, fruits and vegetables, may have obvious influence on the formation of thunderstorms, and sugarcane has the largest effect, followed in turn by rice, vegetables and fruits, and the adjustment of crop distribution has little influence on the starting and ending dates of thunderstorms.

Key words: atmospheric physics; thunderstorm frequency variation; mathematic statistic methods; adjustment of crop distribution

CLC number: P446

Received date: 2008-03-18; revised date: 2009-03-26

Foundation item: Natural Science Foundation of China (40537034)

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1 INTRODUCTION

Thunderstorm is a kind of widespread local convective weather with thunder strike and lightning. The findings by Zhang et al. showed that the southeast and south of China have more lightning in daily spatial distribution\textsuperscript{[1]}. Li et al. analyzed the climatic characteristics\textsuperscript{[2]}, and pointed out that most thunderstorms occur mainly in summer and secondly in spring and autumn while few thunderstorms take place in winter. Landform is the main causal factor of thunderstorms in Northwest China. Xu et al. investigated the climatic characteristics of thunderstorms in the southern China\textsuperscript{[3]}. Using the data recorded by a lightning locating system\textsuperscript{[4]}, Zeng et al. concluded with the behavioral patterns of lightning activities in recent years in Suzhou, and analyzed the characteristics and possible causes of lightning hazards on the basis of lightning hazards examples from 1999 to 2003. Yi et al. explored the temporal and spatial characteristics and the climatological variation of thunderstorms and lightnings over the past 50 years in Guangdong\textsuperscript{[5]}. Chen et al. researched the basic climatic characteristics of thunderstorm day anomalies of Guangzhou Metropolis and discussed its relationship with SST over offshore waters\textsuperscript{[6]}. Lightning storm mostly happen in the formation and mature stages of cumulonimbus (Cb)\textsuperscript{[7]}, whereas the formation of cumulonimbus asks for not only instable atmospheric stratification, but also
triggering factors, including kinetic and thermal lifts \[8\]. Feng et al. discussed the lightning characteristics in Shandong\[9\], and considered that the spatial distribution of lightning is closely related to the topography and the nature of the underlying surface. Mao et al. indicated that thunderstorms in Guangdong are mainly caused by favorable thermal and dynamic conditions \[10\], and the temperature of the underlying surface is the critical factor for the triggering of convection and the formation of the Cb cloud. For the vegetated surface, the temperature directly related with convective activities is the one at the canopy layer, which is determined by radiative and turbulent exchanges, and related to vegetation species, branch density, growth period, height, color, shape, canopy transmissivity and reflectivity, etc. The canopy temperature varies with different crops, dissimilar growing period of the same crop, and diverse planting methods \[11-14\]. Qian also revealed that spatial variation of land surface temperature is correlated with vegetation fraction \[15\]. Accordingly, variations of underlying-surface vegetation lead to temperature change, and then may influence the formation and evolution of thermal thunderstorms.

The Leizhou Peninsula, being famous for lightning, is located in a low-latitude region with abundant heat and vapor. There arise intense Cb clouds very easily, and thunderstorm activity is very frequent. The peninsula is one of the three well-known lightning areas in China, and lightning-induced hazards happen from time to time, involving human and animal injuries or deaths, forest fires, traffic vehicle and equipment damages, etc. Therefore, it is very instructive for local disaster prevention and mitigation to investigate the variation characteristics of thunderstorms over the peninsula. In addition, the primary crop distribution has been adjusted continuously for many years, leading to obvious transformation of the land surface. Hence, a question arises, i.e., does the variation affect the formation and evolution of thunderstorms?

This paper intends, firstly, to profoundly analyze the frequency variation of thunderstorms, and then to discuss the possible relations between the frequency variation and the land use change.

2 DATA AND METHODOLOGY

The data include meteorological observations in the Leizhou Peninsula from 1999 to 2003, planting areas of primary crops, as well as agricultural data.

Correlation analysis is made between the number of thunderstorm days and planting areas, based on statistical analysis of meteorological observations, and model fitting is studied for the data with significant correlations. Thereafter, regression analysis is carried out with all variables to set up a general regression equation. Then the possible effect of thunderstorms is estimated on primary crop, according to standardized regression coefficients.

3 VARIATIONS OF THUNDERSTORM FREQUENCY OVER THE LEIZHOU PENINSULA

Annually averaged number of days of thunderstorms ranges from 84 to 100 for each station over the peninsula. Figs.1-3 illustrate remarkable fluctuations and discrepancies of the number's interannual, intra-annual and diurnal variations, respectively. The monthly variation is mainly of unimodal type, and most thunderstorms happened...
during 02:00 – 08:00 p.m.

4 ANALYSIS OF POSSIBLE CORRELATION BETWEEN OCCURRENCE OF THUNDERSTORMS AND ADJUSTMENT OF CROP DISTRIBUTION

Fig. 4 shows the same tendency of interannual variations between rice areas and thunderstorm days. Planting areas of sugarcane, fruits and vegetables increased remarkably after the mid-1970s, which is opposite to the variation of thunderstorm days. The planting area of peanut has no significant interannual variation.

The standardized regression coefficients of rice, sugarcane, fruits and vegetables are 0.245, -0.28, -0.194, and -0.122, respectively. The starting and ending thunderstorms are primarily triggered by cold air synoptic systems in normal years.

For analyses of other aspects, refer to the Chinese edition of the journal.

Fig. 3 Daily changes in thunderstorms over the Leizhou Peninsula. The X- and Y-axes stand for time series (hour) and annual hourly average (hours/year), respectively.

Fig. 4 Variation tendencies of planting area of paddy (Units: 666.667 hectares) and thunderstorm days (day). The X- and Y-axes stand for the year and thunderstorm days (day/year) and planting area of paddy (Units: 666.667 hectares / year), respectively.
5 SUMMARY

(1) The variation tendency of annual thunderstorm days over the Leizhou Peninsula is as follows. It slightly increased from early 1960s to the mid-1970s but remarkably decreased from the mid-1970s. Thunderstorms happened in all seasons; the high frequency is found from May to September, during which they account for 85% of the yearly total. Most of the thunderstorm days appeared in August (July) in the middle and south (north) part of the peninsula. The early (late) starting month of thunderstorms is January (April), and the early (late) ending month is September (December), showing a great annual discrepancy.

(2) Synoptic situations that affect the thunderstorm are orographic uplift, kinetic lifting caused by convergent synoptic systems and thermal lifting induced by solar radiation heating, the last of which is a critical initiating factor. The afternoon thermal thunder shower is a kind of primary thunderstorm weather. The land surface temperature, especially for the afternoon, is a key meteorological factor to influence the thunderstorm.

(3) Most of the Leizhou Peninsula is covered by vegetation, making the canopy temperature a dominant contributor to the atmospheric temperature of the underlying surface. Canopy temperature is determined by vegetation species, branch density, growth period, canopy height, color, shape, transmissivity and reflectivity, etc.

(4) The primary crops, such as rice, sugarcane, fruits and vegetables, may have evident effects on thunderstorms. The planting area of rice is positively correlated with thunderstorm days, and the variation of planting area may affect the number of thunderstorm days, for instance, the decrease of rice areas may play a role in weakening thunderstorm weather. The planting areas of sugarcane and fruits have negative correlations with the number and thunderstorm days decreased with the increase of planting areas of sugarcane and fruits. Vegetable planting changed the vegetation features of the unplanted farmland in winter, which is negatively correlated with thunderstorms, and it goes against the formation of thunderstorms in early winter and later spring. As its adjustment has not changed vegetation feature obviously, peanut planting is not significantly correlated with thunderstorms. Sugarcane has the largest effect on thunderstorms, followed in turn by rice, vegetables and fruits. In a word, decreased planting areas of rice and increased planting areas of sugarcane, fruits, and vegetable may lead to reduced thunderstorm days over the Leizhou peninsula.

(5) The adjustment of crop distributions has little influence on and has no significant correlations with the starting and ending dates of thunderstorms.

REFERENCES: