

# PRELIMINARY STUDY ON THE FLOODING AND DROUGHT CALAMITY DURING PAST 1500 YEARS IN THE HAI'AN REGION, JIANGSU PROVINCE

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**ABSTRACT:** Collection and arrangement of the historical records of climatic changes and environment evolution, especially in the aspect of calamities, are made on the history documents of past 1500 years about Hai'an region, Jiangsu Province. There existed two obvious flooding-drought frequently-occurring periods: one was from 1550 AD to 1850 AD and another was 1000 AD to 1200 AD. The period of 1550 AD to 1850 AD is interrupted by two relatively arid and cold climatic periods: one was from 1630 AD to 1700 AD and another was 1750 AD to 1820 AD. The main characteristic of the calamity periods is that they occurred by turns, and sometimes, both drought and flooding occurred in the same year. The instability of the climatic changes in the Little Ice Age may be the main reason of the frequently-occurring flooding and drought in Hai'an region. Research results also show that the frequently-occurring periods of flooding and drought is in close relationship with the solar activity, and therefore, occurrence of the flooding and drought may be in relation with the intensity of the solar activity. This hypothesis may need further study in the future.

**KEY WORDS:** Hai'an region; flooding calamity; drought calamity; history document

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Global changes and its effect on development of human society receive notable attention from governments of countries and scientific circles in the world. In recent years, flooding and drought occurred to many countries, China included, caused immeasurable loss to agriculture, industry and even the whole national economy.

Much study has been made on the past climatic changes on different temporal stages from various angles (AN, 1999; ZHU *et al.*, 2000; ZHANG *et al.*, 2001a), concentrating on the information of the past climatic recorded in sediments, which plays an important role in our understanding of the past climatic evolution. China has a long history and a large amount of experiences have been made during human fighting natural calamities during past thousands of years. Historical documents about natural calamity and environmental changes are rich in content and of major importance, as a kind of historical heritage, receiving high

praise from international scientific circles. Study on climatic changes of short temporal-scale is made on analysis of these precious materials. ZHU Ke-zhen (1972) made a good study on climatic changes of past 5000 years in China through analysis of historical record about climatic changes and phenology, suggesting that there existed alternatively four cool periods and four warm periods during the past 5000 years in China. Humidity conditions of the same periods were studied by WANG Cun (1987). These research results are of major importance in theory and experience for the understanding of the past climatic evolution and forecasting of future climatic changes.

A large amount of materials about the local historical climatic changes were collected during the field investigation for environmental archaeology in Hai'an, Jiangsu Province. Preliminary study was made on evolution of the flooding and drought occurred to Hai'an regions during past 1500 years through analysis of these

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precious materials.

## 1 STUDY REGION

Hai'an region is located on the north-bank of the Changjiang(Yangtze) River, neighboring Huanghai Sea eastwards and characterized by the north sub-monsoon climate (Fig. 1).

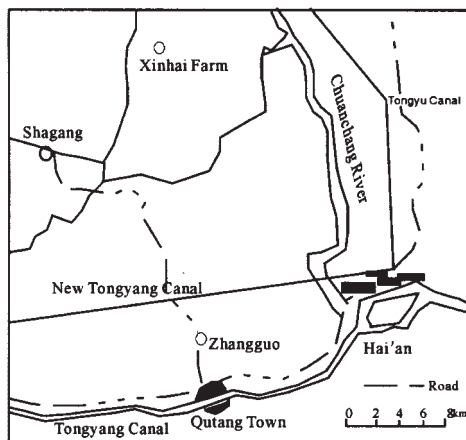


Fig. 1 Geographical location of Hai'an

Hai'an is warm climatically and with rich precipitation. The mean annual temperature from 1959 AD to 1990 AD is about  $14.5^{\circ}\text{C}$ , and the mean annual precipitation is 1060.5mm. The extreme high temperature is  $39.4^{\circ}\text{C}$  in 1959 AD, and the extreme low one is about  $-13.4^{\circ}\text{C}$  in 1955 AD. The main natural calamity occurred to Hai'an region including flooding, drought, hailstone and cyclone.

This region is low-lying in geomorphology and belongs to the Changjiang Delta with an altitude of about 2–6.5m. This low-lying topography is susceptible to flooding, tropical cyclone and tide inundation.

## 2 MATERIALS AND METHODS

Data used in this paper are from county annuals of Taizhou, Dongtai, Rugao and Hai'an, and some records concerning natural calamity about this region are from *Natural Calamity and Human Catastrophe of China During History Periods* by CHEN Yong(1939). These data concerning drought, climatic changes and other natural calamity are collected and counted in detail. Another kind of data that interpret indirectly the climatic changes, including phenology, bumper and famine and pestilence of pests are also included. Some data with incomplete or no record of age are not col-

lected, in order to interpret the evolution principle of flooding and drought in Hai'an region in a more scientific way. Comparison is made between the flooding and drought occurrence of Hai'an region and those of other places in the world after these data are arranged and made into columns. Statistics are made in intervals of every 10 years from 283 AD to 1950 AD, to preliminarily study the drought and flooding principle and possible reason of this principle in Hai'an region since 1500 years.

## 3 RESULTS

### 3.1 Fundamental Features of Drought and Flooding

It can be seen from Fig. 2 that there was a peak value of occurrence frequency of flooding from 1550 AD to 1850 AD temporal interval(see the part C of Fig. 2). The frequency before this time interval, however, is very low. The extreme value occurred in the period from 1550 AD to 1650 AD with flooding occurring annually. The second relative peak value occurred in the period from 1000 AD to 1200 AD. The relative low value of occurring frequency occurred in other time intervals.

An obvious characteristics in the frequency of drought changing with time (see part B of Fig. 2) is that the temporal interval when flooding occurred frequently was also when the drought occurred frequently, that is, these two calamities, to some degree, occurred simultaneously. It can be seen from comparison between frequency-temporal figure of drought occurrence and that of flooding occurrence that large drought occurring period was usually followed by large flooding occurring period. In Fig. 2, these four shaded parts marked by c, d, e, f are the periods when flooding calamity occurred in high frequency, and at the same time, these four periods are just when the drought occurred in low frequency. There is an exception that two shaded parts marked by a and b are the periods when both frequently-occurring flooding periods and frequently-occurring drought periods occurred.

Relationship between drought occurring periods and flooding ones are very complex, for they usually occurred alternatively. Sometimes, flooding came before drought and sometimes, however, drought came before flooding. This phenomenon can be seen from historical record that "the 2nd year of Zhengtong era (1437 AD), flooding, and then drought"; "the 7th year of Chenghua era(1471 AD), drought in spring, rainy day in July, high tide stand, destroying salt

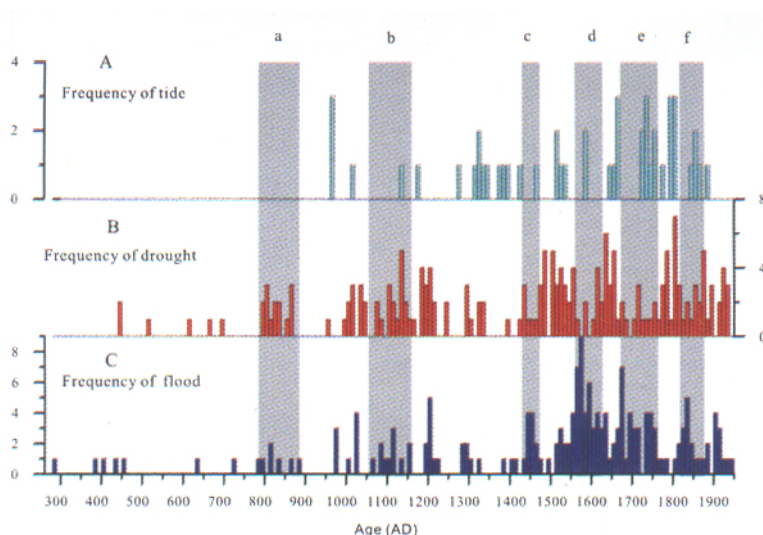


Fig. 2 Frequency of tide, drought, and flood calamity occurred to Hai'an region in the past 1500 years. Shaded zones show correlation between these three kinds of natural calamity. They are marked by a, b, c, d, e and f. The oxygen isotope content data and the climatic changes in China is taken from ZHU Ke-zhen (1972).

places, stores and rooms"; "the 34th year of Jiajing era, the Ming Dynasty(1555 AD), drought in spring, river dried up; downfall in summer, two banks of the river was inundated after one night of downfall, crops were also inundated"; "the 4th year of Chongzhen era, the Ming Dynasty(1631 AD), drought in summer, trunks were broken by strong wind; flooding in August, crops floating, famine", and other large amount of such records.

This region was also susceptible to storm and high tide stand, and some flooding calamities can be ascribed to storm and tide inundation. It cannot be seen from Fig. 2 that there was a certain relationship between tide inundation and flooding because statistics were made separately on flooding and high tide stands. It can also be seen from Fig. 2 that the temporal interval, when stormy tide occurred frequently, the flooding also occurred in large frequency. If combination is made between occurring frequency of flooding induced by stormy tide and that of flooding induced by large precipitation, this relationship will be more obvious. It should be mentioned that large occurring frequency of pestilence of pests occurred to the temporal intervals when drought occurred frequently. Such events documented are even more as follows "the 9th year of Xiantong era, drought and plague of locusts occurred"; "the 7th year of Jingtai era, the Ming Dynasty(1456 AD), drought and plague of locusts occurred"; "the 18th year of Hongzhi era, the Ming Dynasty(1505 AD), drought and plague of locusts occurred".

### 3.2 Flooding and Drought Calamity in Hai'an Region During Little Ice Age

Fig. 3 suggests that there was a close relation between flooding occurrence in Hai'an region and global changes. The temporal interval when the climatic changes were relatively stable was also the period when the flooding in the study region occurred in relatively low frequency. On the contrary, the temporal interval when the climatic changes were unstable was also the period when the flooding in the study region occurred in relatively high frequency, which was supported by the climatic record obtained from sedimentary section (ZHANG *et al.*, 2001b). It can be seen from Fig. 3 that the main period when flooding calamity occurred frequently was 1500 AD to 1900 AD, and which was also the period when the Little Ice Age occurred (HUANG, 2000; YANG *et al.*, 1995). Climatic change in Little Ice Age was very unstable, leading to frequently-occurring flooding. We can know from what mentioned above that the Little Ice Age was the period when flooding and drought occurred alternatively. Sometimes flooding and drought occurred in the same year, with the first half part of the year when drought occurred and the next half part of the year when flooding occurred and sometimes with frost and tsunami occurred during this process. These phenomena were also recorded in historical document: "the 11th year of Shunzhi era, the Qing Dynasty (1654 AD), tsunami, more than tens of thousands of persons were drown, with

drought in summer”; “the 29th year of Kangxi era, the Qing Dynasty(1690 AD), snowy in winter, cold”; “the 8th year of Qianlong era, the Qing Dynasty(1743 AD), flooding in summer, snowy in winter, and ice hung along the eaves in several inches”. These records indicated that the frequency of natural calamity occurring was high and the type of them was various. Fig. 3 indicates that there were two frequently-changing climatic periods in the past 1500 years, one was from 1000 AD to 1300 AD and another was from 1500 AD to 1900 AD. It can be seen from Fig. 3 that these two frequently-changing climatic periods are in good agreement with frequently-occurring periods flooding in Hai'an region, and at the same time, in these periods, flooding calamity and drought occurred alternatively, which was already discussed before. Periods when the climatic change was relatively stable were also the time when flooding and drought occurred in relatively low frequency. At the same time, these two changing curves of climatic changes show that these two periods were also the temporal interval of low temperature, and also, the

low-temperature periods and high-temperature periods appeared alternatively, which is also the reason why these two periods were the periods when flooding and drought calamity occurred frequently in study region.

Flooding occurred during 1550 AD to 1600 AD was in the highest frequency in the past 1500 years and this period was also one of the climatic transition from cold to warm. Climatic evolution in this period was characterized by instability. The occurring frequency of flood in 1640 AD to 1700 AD was lower than that in 1550 AD to 1600 AD, and this was also the period when it was the coldest period during Little Ice Age. The same phenomena were also occurred to the lower Changjiang Delta, including a flooding occurred in 1560 AD in grade of once every 400 years; and a flooding occurred in 1602 AD in grade of once every 2000 years. The flooding occurred in 1870 AD set up the historical record(ZHU *et al.*, 1998). Little Ice Age in other places of the world was also characterized by calamitous period.

Fig. 4 shows that frequently-occurring periods of

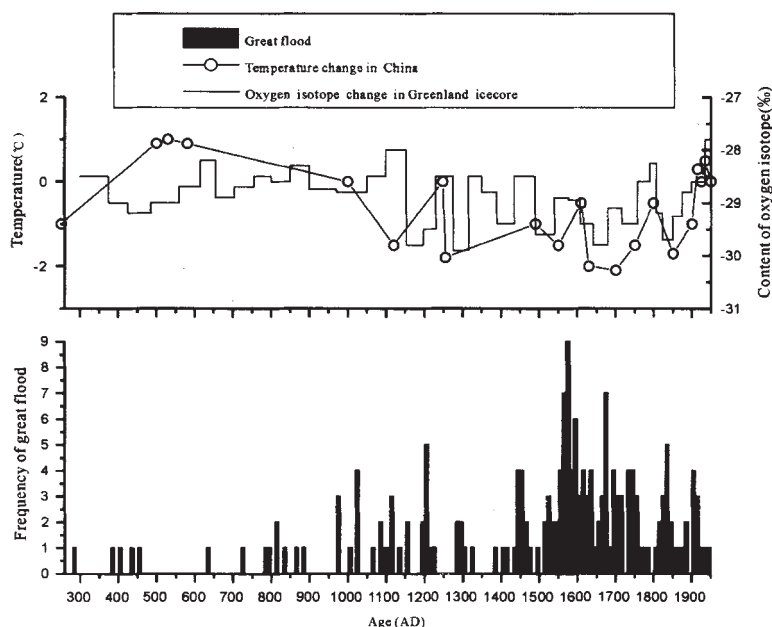


Fig. 3 The relationship between flooding frequency and the climate change in China and that reflected by the  $\delta^{18}\text{O}$  in the Greenland ice-sheet

flooding were in line with those in study regions, which corroborates again such a fact that Little Ice Age was characterized by calamitous period. Other places of China were also inundated with various calamities, for example, earthquake of 8 rank occurred to Guanzhong in 1556 AD, causing unimaginable damage and ruin (HUANG, 2000).

It can also be seen from Fig. 4 that in historical periods when amount of sunspot and aurora was larger were also the periods when flooding and drought occurred more frequently in the study region. We can draw a conclusion tentatively that the amount of sunspots and aurora may be in good relation with degree of occurrence frequency of flooding and drought in the study region. If

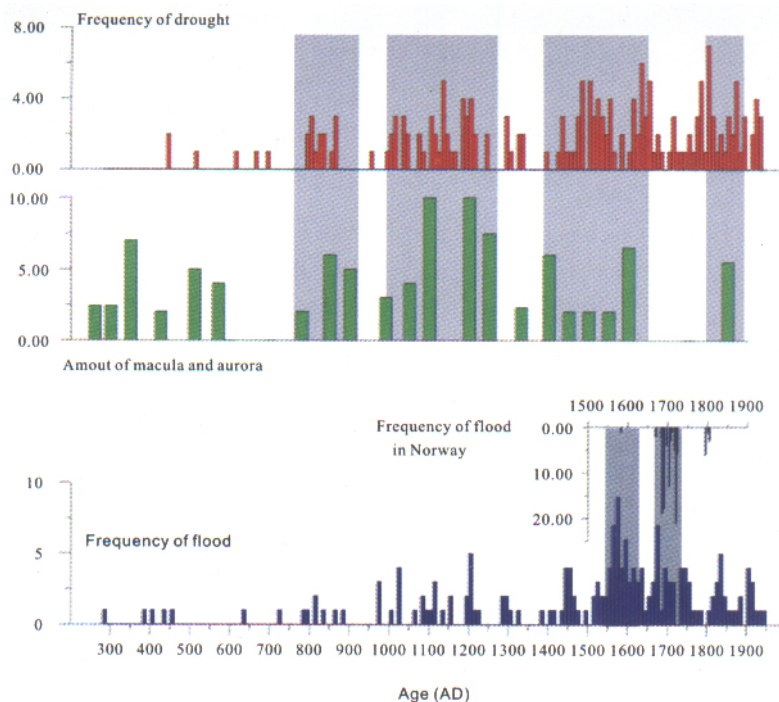


Fig. 4 Comparison of the flooding-drought period, amount of sunspots and aurora and the calamity occurred between studied area and other places of the world

so, the formation of Little Ice Age can be ascribed to the degree of solar activities. Some workers, however, don't support this hypothesis. They suggest that solar constant changes 1% or less 1%, but it is enough to lead changes of 2 – 3°C in temperature, and this still cannot interpret the influence of solar activities on the Quaternary climatic changes (HARVEY, 1997). YANG Huai-ren *et al.* (1995) indicated that ozone-layer changes caused by ultraviolet radiation may produce effect on climatic changes, but whether the intensity of solar activities or ozone-layer changes alone can not interpret the Quaternary climatic changes. Abruptness and periodicity of the Quaternary climatic changes can be interpreted by combination of these two factors and, taken together the inner factor of terrestrial globe system and astronomically alien factors (YANG *et al.*, 1995). Therefore, much study is necessary to understand the reason of climatic changes in the Quaternary and the Little Ice Age epoch, which is meaningful for depiction of future climatic changes.

#### 4 CONCLUSIONS

Some conclusions as follows can be drawn from analysis above:

(1) Instability of the climatic changes in the Little

Ice Age may be the reason of the high occurring frequency of the flood and drought in the study region.

It can be concluded from what mentioned above that occurrence of flooding and drought was closely related to instability of climatic changes in the Little Ice Age epoch, and so, to a certain degree, it was a result of instability of climatic changes in Little Ice Age. The occurrence characteristics of flooding and drought calamity in the study region were in good similarity to those occurred to other places of China and even places of the world, that is, flooding and drought calamity occurred alternatively and the greatest flooding was ready to occur. The frequency and intensity of flooding and drought was also unprecedented. Drought was usually accompanied by plague of locusts and which often intensified the degree of drought calamity.

(2) The low topography of the study region may intensify the degree of flooding and drought calamity.

East part of the study region is neighboring the Huanghai Sea, with low topography (with an altitude of about 2 – 6.5m above sea level). Such low-lying topography is susceptible to influence of flooding, tropical storm and tide inundation. This feature is similar to that of Taihu region (DANIEL, 1996). Sometimes only large rain will induce flooding because of low-lying topography and subsequent bad drainage. Low-lying topography



also induces inundation calamity with tide comes, which may serve as a reference for future flood prevention and anti-calamity in the study region.

(3) Linkage may occur between the intensity of the solar activities and frequency of the flood and drought calamities in the study region.

Research results above showed that frequently-occurring periods of flood and drought calamity in the study region were in good agreement with solar activities periods, and therefore, it may be concluded tentatively that occurrence of flooding and drought calamity in the study region may be in some relation with the amount of sunspots and aurora changing with time. If so, genesis of the Little Ice Age may be more easily understood. But there still exist divergence of opinion on this hypothesis, further study should be made on cause of formation of the Little Ice Age and the Quaternary climatic changes that was related closely to human activities, which may be meaningful in theology and experience.

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