Temporal and Spatial Characteristics of Climate Dryness in Eastern Qinghai Province

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Abstract. Agrometeorological drought is the most important meteorological disaster that restricts the development of agricultural areas in the east of Qinghai Province. It is very important to evaluate the climate dryness by studying its temporal and spatial characteristics. Based on the long-term meteorological data of 12 meteorological stations, the temporal and spatial distribution of precipitation and dryness in the study area was analyzed. The dryness degree of each year varied greatly, ranging from 1.5 to 3.1, showing a trend of increasing with time. The dryness of the study area was relatively small in the three months of July, August and September, and larger in the period from November to March. The intensity of drought in the middle of the study area is higher than that in other areas, while the duration of drought in the south is longer. The drought tendency rate of the 12 weather stations was -30.962/10a. The results help to provide reference for spring wheat planting to cope with spring drought.

Keywords: Eastern Qinghai province; Agricultural area; Precipitation; Climate dryness.

1. Introduction

The agricultural production area in the east of Qinghai province is located in the south of Qilian, which is greatly affected by agricultural drought. This area is the transition zone from the Loess Plateau to the Qinghai Tibet Plateau, and is the main grain production area of Qinghai Province. The total area is 35000 square kilometers, and the cultivated area accounts for 70% of the whole province. Frequent droughts will affect the agricultural production in this area, and further restrict the development of Qinghai Province [1-3].

The eastern agricultural area of Qinghai Province has the saying of "nine droughts in ten years". Water resources are in short supply all the year round, and there are serious soil erosion phenomena. Local residents have prominent contradictions in production, domestic water and other aspects. From 1950 to 1994, the affected area reached 124000 hectares. Among them, 65000 hectares suffered from drought, accounting for more than half of the total area. As a drought stricken area, most of the agricultural areas are between 250-450mm, and the annual evaporation can reach several times of the precipitation. In addition, the precipitation in this area is mainly concentrated between June and September, and the frequency of drought is as high as 50% - 65% in spring.
The paper object is analyzing firstly the situation of climate drought in the eastern agricultural area of Qinghai Province. Then, the characteristics of the occurrence of meteorological drought in this area will be summarized. Finally the understanding of the causes and influencing factors of drought, and the early warning and response to the drought climate in this area will be given.

2. Methods

2.1. Data Sources
The meteorological data are collected from 12 meteorological stations in the eastern agricultural area of Qinghai Province. The meteorological stations are Xining County, Minhe County, Datong County, Jianzha County, guide County, Leshan County, Huzhu County, Hualong County, Menyuan County, Xunhua County, Huangyuan county and Huangzhong County. The year is from 1961 to 2006. Meteorological elements include precipitation, relative humidity, average temperature, altitude, sunshine hours, average wind speed, etc.

2.2. Dryness Degree Calculation
The dryness degree \( k \) takes the general form

\[
k = \frac{ET_0}{P}
\]

Where \( ET_0 \) is the reference crop water demand (mm) [4], which is usually calculated from observed weather data. \( P \) is the precipitation (mm).

3. Results and Discussion

3.1. Seasonal Variation of Dryness
In order to analyze the variation of dryness in the study area, the monthly values of dryness at each point were calculated by using the monthly values of crop demand and precipitation at 12 meteorological stations. The greater the dryness index is, the higher the climate dryness is, and vice versa. There are obvious seasonal changes in the dryness of the study area (Table 1). The dryness of the study area is relatively small in the three months of July, August and September, and larger in the period from November to March.

| Station       | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Xining        | 17.6| 19.3| 10.5| 4.7 | 2.6 | 2.2 | 1.6 | 1.5 | 1.4 | 2.4 | 9.0 | 16.9|
| Ledu          | 30.8| 28.4| 13.7| 6.4 | 3.1 | 2.8 | 1.9 | 1.6 | 1.7 | 3.0 | 14.0| 32.8|
| Menyuan       | 10.8| 8.0 | 3.5 | 2.4 | 1.5 | 1.3 | 1.0 | 0.9 | 0.9 | 1.7 | 5.5 | 15.5|
| Guide         | 92.0| 81.8| 37.7| 11.0| 4.0 | 3.4 | 2.0 | 2.2 | 2.5 | 4.5 | 33.9| 93.9|
| Datong        | 9.9 | 9.2 | 4.6 | 2.9 | 1.7 | 1.4 | 1.1 | 1.0 | 0.9 | 1.6 | 5.2 | 10.4|
| Xunhua        | 113.5| 95.0| 41.7| 12.0| 4.2 | 3.6 | 2.1 | 2.3 | 2.7 | 5.1 | 42.7| 114.5|
| Huzhu         | 7.6 | 5.9 | 4.1 | 2.7 | 1.8 | 1.4 | 1.0 | 0.9 | 0.8 | 1.4 | 3.7 | 8.7 |
| Huangzhong    | 7.6 | 6.3 | 4.8 | 2.8 | 1.6 | 1.5 | 1.1 | 1.0 | 0.9 | 1.5 | 3.9 | 8.5 |
| Huangyuan     | 24.6| 19.9| 9.9 | 4.6 | 2.2 | 1.7 | 1.3 | 1.1 | 1.2 | 2.0 | 5.4 | 19.3|
| Jianzha       | 63.7| 44.7| 17.5| 6.2 | 2.9 | 2.6 | 1.7 | 1.7 | 1.7 | 3.1 | 20.1| 68.3|
| Hualong       | 11.5| 8.3 | 5.1 | 3.3 | 1.9 | 1.7 | 1.2 | 1.1 | 1.1 | 1.8 | 5.7 | 5.4 |
| Minhe         | 16.6| 14.6| 7.9 | 5.4 | 2.8 | 3.1 | 2.0 | 1.4 | 1.6 | 2.4 | 9.1 | 20.4|

3.2. Spatial Distribution of Dryness
The dryness in the southeast and northwest of the study area first increased and then decreased. Compared with the north, the south is obviously dry, such as Xunhua and Minhe county in the southwest. Huzhu county is located in the northeast, the dryness is obviously lower than the north. On the whole, the annual average value of dryness in the study area is 2.4, with a range of 1.4-4.2. The reason for this
phenomenon can be explained as that the study area is located to the east of the sun moon mountain, and is affected by both altitude and latitude. The precipitation, solar radiation, temperature and other factors in the horizontal and vertical directions will be greatly affected, and then there will be some differences. Combined with two indicators of dryness and precipitation [4] (shixinghe, 2015), the study area can be divided into four regions (Table 2).

### 3.3. Interannual Variation of Dryness and Drought Events

In the past 46 years, the dryness of the study area has changed greatly, ranging from 1.5 to 3.1. The coefficient of variation can reach 18.15, and the average value is 2.30. From 1961 to 1971, the dryness of the study area fluctuated obviously. From 60 to 70 years, the fluctuation range of dryness is relatively small. From 1982 to 2006, the dryness was in the range of 1.7-3.1. The average value is 2.2.

The number, duration and maximum duration of drought events at each station are listed in the Table 3. Among the 12 meteorological stations, 95 droughts occurred in Huangyuan and Hualong stations in 46 years. The number of droughts in Huzhu station is the least, and 78 times. In terms of spatial distribution, the areas with frequent droughts are concentrated in the middle of the study area. In terms of the duration of a single drought, Xining station has the longest drought duration, reaching 455 days. The shortest lasting drought occurred in Huzhu station, only 202 days. The longest duration of drought in Xining, Huangzhong and Minhe is more than 400 days, all of which are located in the middle of the study area. Compared with other regions, the duration of drought in the central region is significantly longer.

From the cumulative situation of the comprehensive meteorological index, the value of Minhe station is the smallest, reaching -700.2. Huzhu station is the largest, reaching -187.9. Among the 12 meteorological stations, the cumulative value of comprehensive meteorological index of Xining, Ledu, Huangyuan and Minhe is less than -500. The smaller the value is, the stronger the drought degree is. The areas with the strongest drought degree are all concentrated in the middle of the study area, so it can be considered that the drought degree in the middle of the study area is relatively strong.

### Table 2. Division of arid climate in the study area.

| Dryness degree               | Areas                                     |
|-----------------------------|-------------------------------------------|
| Semi humid and drought      | Huzhu, Datong, Menyuan, Huangzhong        |
| Semi-arid                   | Xining, Huangyuan, Hualong                |
| Semi-arid and drought prone | Minhe, Jianzha, Ledu                      |
| Drought                     | Guidu, Xunhua                             |

### Table 3. Occurrence of drought events in the study area.

| Station       | Number | Maximum duration (d) | Accumulated dryness index |
|---------------|--------|----------------------|---------------------------|
| Xining        | 87     | 455                  | -506.9                    |
| Ledu          | 90     | 318                  | -593.1                    |
| Menyuan       | 80     | 335                  | -411.2                    |
| Guide         | 92     | 304                  | -464.8                    |
| Datong        | 81     | 263                  | -409.4                    |
| Xunhua        | 88     | 311                  | -397.3                    |
| Huzhu         | 78     | 202                  | -187.9                    |
| Huangzhong    | 89     | 434                  | -402.9                    |
| Huayuan       | 95     | 365                  | -562.4                    |
| Jianzha       | 92     | 311                  | -383.3                    |
| Hualong       | 95     | 244                  | -340.2                    |
| Minhe         | 90     | 431                  | -700.2                    |

The drought intensity of 46 years in the study area is increasing. The tendency rate of the 12 weather stations was -30.962/10a. The largest regional integrated meteorological drought index reached -589.5, which appeared in 1966. The minimum was -3869.9, which appeared in 1965. The comprehensive drought index of 17 years in the study area is between -2000 and -3000. The 46 years are divided into
three stages, i.e. 1961-1975, 1976-1990 and 1991-2006. The cumulative average values of the comprehensive meteorological drought index are -2094.3, -2304.6 and -2259.3, respectively.

4. Conclusions

In view of the spatial distribution of dryness, Hualong and Huangyuan have the most frequent droughts. Xining has the longest drought duration, while Huzhu county has the least drought frequency and the shortest drought duration. Compared with the northeast region, the central region of the study area is more prone to spring drought events. The southern part of the study area is more prone to autumn drought events, and the duration of drought is longer.

The spring drought in the study area is variable in different years. The intensity and duration of spring drought increased gradually. In summer, the intensity of drought is relatively small, and the frequency of drought changes greatly. In winter, the intensity of drought in the study area is small, but the probability of high intensity drought events is increasing year by year.

Climate dryness is one kind of objective drought index to describe the temporal and spatial characteristics of in eastern Qinghai Province. Considering crop species, growth and development period and soil moisture can further improve the accuracy of indicators. The results can provide basis for local government, agricultural production, planting structure adjustment and water conservancy project planning.

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