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Analysis of the effect of plum rain on Yangtze River Delta

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Abstract. Every year, from June to July, there will be two or three weeks of continuous precipitation at Yangtze River Region. This precipitation is called Plum Rain. This paper is mainly about the Plum rain front, and its effect on the Yangtze River Delta. While the Yangtze River Delta is a large area, and considering that the data has to be easy to access, this paper specifics the topic to the most representable region-Shanghai. This paper is divided into 4 parts, the first part is the introduction, including the naming and formation of the plum rain. The second part is mainly about several types of anomalous plum rain and how they occurred. The third part analyzes the effects of the plum rain on the Yangtze River Delta region, and how to prevent these effects. The fourth part is conclusion. This paper believes that the prediction and alarming of anomalous plum rain should be focused on, and the prediction can let the government to advance layout, and decrease the economic loss when anomalous plum rain strikes.

Keywords: Plum Rain, Yangtze River Delta, Plum Rain Anomaly.

1. Introduction

Plum rain is a precipitation event happening at Yangtze-Huaihe River basin annually June to July, with a long period of rainfall, usually as long as 30 days. As this precipitation coincided with the ripe of plum, this kind of weather event is given the name as plum rain. Also, due to the long rainfall, the humidity of the air is also very high, causing items placed at home to become moldy very easily. So, the precipitation was also given the name moldy rain, as moldy and plum have the same pronunciation in Chinese as Mei [1].

Talking about the formation of the rain, a concept has to be introduced, a front. When the forces of the cold and warm air masses are equal, or the cold air weakens southward and is blocked by the terrain, making the interface between the cold and warm air masses static, a Stationary front will be formed. Sometimes the front moves slowly or oscillates back and forth between cold and warm air masses.

At the end of May, as the subsolar point is moving north, the wind on top of Yangtze River Delta region is exchanging controls, from the north west cold wind to South east monsoon. The cold and warm air is converging in the south of the Yangtze River, forming a long and narrow rain belt with north-south swing, and the rain is sometimes strong and sometimes weak. This front is the major cause of the plum rain season.

The plum rain is a rainy season with a long rainy period and relatively concentrated rainfall in early summer, which is also a unique phenomenon of the East Asian Atmospheric circulation during the seasonal transition at the turn of spring and summer. During this period, the cold air force in the north is shrinking, while the warm and humid air in the south is increasing. The cold and warm air is

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converging in the south of the Yangtze River, forming a rain belt that runs thousands of meters across East Asia and the Western Pacific region. This rain belt advances and retreats together with the monsoon.

On the Surface weather analysis, it is shown as a Stationary front slightly in the northeast southwest direction, always accompanied by a narrow and long precipitation area, swinging back and forth in the Yangtze-Huaihe River basin and southwest Japan.

Plum Rain is a major feature of the southeast monsoon climate, and its formation is directly related to the northward movement of the subtropical high monsoon. In general, Plum Rain starts on June 15th and ends around July 10th, lasting for nearly a month. However, with the increase of meteorological data, some years have atmospheric circulation and weather climate similar to the Plum Rain as early as May and as late as August, often causing floods in the Yangtze River region. People refer to the continuous rainy season from mid to late May to early June as early plum rain or welcome mold rain, the continuous rainy season from mid to late June to early July as typical plum rain, and the continuous rainy season from mid to late July to early August as late plum rain or midsummer continuous rainy season [2].

The purpose of this paper is a brief introduction of all kinds of plum rain anomalies, and the ways to prevent the effect of plum rain. Plum rain anomaly may cause economic losses, it is important for people to know how to predict, and make measures to prevent losses.

2. Anomalous Plum Rain

2.1. Early Plum Rain

The basic reason for the early plum rain is that the north jump of the Western Pacific Subtropical High occurred early, which made the main rainfall belt in the eastern half of China suddenly move from the south of Nanling to the middle and lower reaches of the Yangtze River. For example, the plum rain in 1971 began on May 26, more than half a month earlier than the normal plum rain. The turning point of the year began in the tropics. Within ten days in late May, three typhoons occurred in the northwest Pacific tropical ocean. These typhoons occurred on the south side of the subtropical high and moved northwest. This activity, as if the subtropical high pressure had been pushed northward, caused the high pressure to rise northward. During this change, the upper westerly jet moved northward, and the Plum rain in the middle and lower reaches of the Yangtze River suddenly began. It should be noted that the early northbound jump of the subtropical high is not all caused by thermal typhoon activities, and other reasons can also cause its early northbound jump. As long as the subtropical high moves to the coastal stability of South China in advance, it will cause “early plum rain”.

2.2. Late Plum Rain

In some years, the south branch westerly jet is strong and stable in early summer. In June, in the middle of the troposphere, from the Yangtze River basin of China to the northwest Pacific Ocean south of Japan, there has been a strong westerly wind, which inhibits the northward elevation of the Northwest Pacific Subtropical High, making the rain belt in the middle and lower reaches of the Yangtze River unable to establish for a long time. In this way, the late arrival of plum rain is caused. For example, in 1982, the plum rain in the middle and lower reaches of the Yangtze River did not start until July 9, which was the case. Before June 20, the westerly jet stream was southerly, as was the subtropical high. Around 20 days ago, the Northwest Pacific subtropical high extended in the southeast coast of China’s ridge of high pressure once strengthened, the north carried to the South China coastal areas, the Yangtze River in the middle and lower reaches had three or five days of rainy weather. But the change is not a seasonal twist. The main body of the Northwest Pacific Subtropical high has not moved northward, especially the south branch westerly wind is still staying near 30 degrees north latitude. Under the influence of the westerly jet, a wave of cold air moved south, and the subtropical high soon retreated to the south. It was not until late in early July that the westerly jet over East Asia suddenly retreated to the north, making the Subtropical High jump significantly to the north over the eastern coast of China and Japan.

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2.3. Abundant Plum Rain

Table 1. Extra heavy and light plum rain through 1885~1998 [3].

	Year	Plum Rain Season							Plum Rain Intensity	
									Total Amount	Strength Index
		Early Plum Rain	Plum Rain		Enter Plum Date	Enter Plum Date	Period Length (d)	Length of days with heavy rainfall	/mm	
Heavy	1887	-	6.3~6.12	6.18~7.7	6 03	7 08	35	30	2 320	4.129
Plum	1896	-	5.26~7.3	7.9~7.29	5 26	7 30	65	60	3 508	6.48
Rain	1901	-	6.15~7.1	7.6~7.20	6 15	7 21	36	27	2 978	4.817
	1909	-	6.2~7.14	-	6 02	7 15	43	43	3 364	5.676
	1931	-	6.13~6.20	6.30~7.29	6 13	7 30	47	38	2 767	4.876
	1954	5.16~5.25	6.12~7.31	-	6 12	8 01	50	50	3 727	6.31
	1991	5.18~5.26	6.2~6.19	6.30~7.12	6 02	7 13	41	31	3 377	5.35
	1998	5.8~5.15	6.24~7.5	7.17~8.2	6 24	8 03	40	29	2 488	4.32

Among them, there are also some years of plum rain, which have greater variability and cause more serious harm and impact. From the perspective of the entire Meiyu region and the Meiyu period, the precipitation is mainly high or low. From Table 1, it can be seen that their annual intervals are irregular and have no obvious periodicity [3].

In combination with other characteristics of the plum rain, such as the length of the plum rain period, the range of the plum rain area and the strong rain area, the early and late entry and exit of the plum rain, the actual concentrated precipitation period (including the early plum rain), the intensity, concentration and discontinuity of the rainstorm process, and the serious natural disasters caused by it, the following eight years (7%) of the plum rain in the Yangtze Huaihe River are respectively designated as unusually rich and dry plum rain years [3].

The main reason for the special plum rain is that the “plum” is particularly late, such as the plum rain in 1954 did not end until the end of July and early August. In this year, there were many anomalies in the atmospheric motion characteristics of the entire northern hemisphere. From the perspective of Asia and the Northwest Pacific Ocean, there were mainly the following two aspects:

First, in June and July 1954, the position of the Northwest Pacific Subtropical High was much farther south than in normal years. Especially in July, the position of the ridge of the Subtropical High in the central troposphere along the East Asian coastal area is basically along the latitude of 18 degrees north, about 800 kilometers south of the annual average. It is rare for the average position of an entire month to deviate so much from the usual year. Originally, after the “Minor Heat”, the middle and lower reaches of the Yangtze River should be under the control of the subtropical high, the prevailing southeast monsoon, and the weather should be sunny and hot. However, due to this deviation, the warm and wet southwest monsoon replaced the southeast monsoon in the lower part of the troposphere in July of this year, which provided important conditions for the “Plum Rain Front” to stay in the Yangtze River basin.

Second, during June and July of the year, there was a strong high pressure that stayed over eastern Siberia for a long time. Like a big mountain, it “blocks” the passage of the upper westerlies and divides the jet into two branches. One branch passes north of it, the other propagates east from south of it, and the southern one is quite stable. It has already been mentioned that at the time of the “Exit Mei”, the jet stream moved to between 40-50 degrees north latitude, but the southern branch of the jet stream in July of that year still extended along the Yangtze-Huaihe River basin to the Japanese islands. There is constantly a trough of low pressure moving from west to east on this jet stream, and each time a trough passes, it merges with the southwest airflow northwest of the subtropical high, causing a heavy rain. Until the beginning of August, this “blocking” high pressure suddenly disappeared, the jet stream moved to the north, the subtropical high also jumped to the north, and the Plum Rain began to end. Although the above two characteristics are most typical in 1954, it is representative of the year of long plum rain.

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Most of the years in which the plum rains end in the second half of July have such characteristics. This is because after the "Minor heat", cold air usually does not hit the middle and lower reaches of the Yangtze River. Cold air can affect the middle and lower reaches of the Yangtze River only if there is a strong high pressure "blocking" over Siberia, causing the jet stream to split into two branches, with one passing south of the high pressure and much farther south than in normal years. Similarly, by that time, the rain belt can stay in the Yangtze River basin only in years when the Northwest Pacific subtropical high is significantly south. Once this high pressure intensifies and controls the middle and lower reaches of the Yangtze River, then it will be a scorching summer.

2.4. "Short plum" and "empty plum"

"Short plum" and "empty plum" are usually the result of the activities of the subtropical high and the cold air in the north. When the cold air activity is frequent, the subtropical high is located very south, and the cold and warm air meet in the Nanling Mountains. When the subtropical high North jumps to the South China coast, usually the beginning of Plum Rain in the middle and lower reaches of the Yangtze River, the upper westerly jet jumps to the north again soon, and the cold air activity suddenly weakens. It soon allowed the subtropical high to jump northward again and control the Yangtze River basin. In this way, Plum Rain will be short or absent. However, in some years, the "empty plum" is the result of very abnormal atmospheric motion. Mainly, the Northwest Pacific subtropical high is particularly strong, and it moves north to control the middle and lower reaches of the Yangtze River much earlier than usual, and is very stable, staying in this area for a long time. In these "empty" years, there are often severe droughts.

In the past 60 years, there have been three years of abnormal air plums: 1934, 1958, and 1965. Their main characteristics are:

(1) During the Plum Rain flood season of these three years, there was no Plum Rain convergence zone and its accompanying large-scale, long-term, and strong precipitation in the Yangtze River Region, with only sporadic precipitation, thunderstorms, or typhoon. The total precipitation at the five representative stations was 90 mm, 150 mm, and 63 mm, respectively. Enter Plum Rain is relatively late, exiting during the day of entering Plum Rain season, Plum Rain Season, and the days of heavy rain fall are all less than 1 day, and the composite index of precipitation intensity during the Plum Rain period is 0.000. These three empty plum years have no early plum rain and a long period of low rain.

(2) Due to Empty Plum Rain, the precipitation of Yangtze River Region in June and July 1934 was negative 60% from normal. The monthly precipitation of Yueyang, Anqing, and Jiujiang along the Yangtze River in July was 0.28 mm and 5.2 mm [4], respectively. In 1958, the negative anomaly of monthly precipitation in the Yangtze River Region was generally negative 35% to 85%. The areas along the Yangtze River in the north and south of the Yangtze River were severely dry, and the negative anomaly of monthly precipitation was over 50%; In August of that year, except for short-term rainfall and waterlogging in coastal areas affected by typhoons, the drought in most areas continued until September of that year, which is usually rare. The total precipitation during the Meiyu period at the Five Representative Stations in 1965 was the least among the eight Empty Plum Rain Years, and the latest year was the Start of Plum Rain. Yangtze River Region was a large-scale heavy drought area from May to July, with monthly precipitation generally ranging from negative 35% to 85%, as shown in Figures 5a, 5b, and 5c [5].

2.5. Re-occurrence of plum rain

The emergence of "re-occurrence of plum rain" is mainly caused by the repeated seasonal transition process of atmospheric movement over East Asia from early summer to midsummer. Specifically, the main reason is that the upper westerly jet stream and the Western Pacific Subtropical High retreated to the south for a while after the second jump to the north, as if the two armies were facing each other. After the front had advanced, the position had not been consolidated, and they had to withdraw temporarily. In this case, the main rain belt in the east of China has moved from the Yellow-Huaihe River basin to the middle and lower reaches of the Yangtze River. After a period of time, the upper

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westerly jet stream and subtropical high really moved northward and stabilized, and the rain belt moved northward from then on, and the “re-occurrence” ended [6].

3. Impact of Plum Rain

There are three main types of meteorological disaster prevention during the Plum Rain period, namely flood prevention, moisture prevention, and disease prevention. In the Plum Rain period, rainstorm is the first, followed by continuous rain and high temperature and humidity.

3.1. Flood prevention

During the Plum Rain period, there will be rainstorm, heavy rain and other weather processes. Usually, a rainstorm appears when the Plum Rain season enters. When the precipitation intensity reaches the standard of once in four years, it is between 33mm and 54mm in other regions. Due to excessive concentration of precipitation in a short period of time, 32 roads in some areas of the urban area have accumulated water of 10-30 centimeters, and many residents have entered their homes with water. Some sections of Yan’an Road and the elevated inner ring road have also experienced short-term water accumulation.

According to the Shanghai Meteorological Disaster Ceremony, from June 7 to July 20, 1999, Shanghai ushered in a hundred years of strong plum rain raging, the plum rain period of 43 days, becoming one of the three major plum rain disaster years (1931, 1954, 1999) after Shanghai has meteorological records. The total rainfall during the Plum Rain period was 815 mm, which was the largest in history and more than four times that of the same period in the year. During the plum rain period, the number of heavy rain days exceeded the normal, 17 heavy rain days occurred in the city, of which 5 days reached heavy rain days, and there was a rare continuous heavy rain for 3 to5 days, forming a serious flood disaster. More than 1.27 million mu of farmland in the city was flooded for more than a week, of which 510,000 mu were affected and 162,000 people were affected. Of the 167,000 acres of watermelon and melon in the suburbs, 50,000 acres were nearly wiped out, and the rest were reduced by more than 80%. Of the 180,000 mu of vegetables, 60,000 mu failed to harvest, and the rest lost 6%-70%, resulting in a sharp rise in vegetable prices. The water flooded 47,000 urban residential households and 13,600 rural households in the suburbs. 698 houses collapsed, 1,760 were damaged, and 655 businesses were flooded. More than 2,000 mu of fish ponds were destroyed, and more than 600 pigs and 2,400 chickens drowned. More than 100 traffic lines in the city filled with water, only elevated highways on the car breakdown and traffic accidents increased by nearly 45% than usual, direct economic losses of 870 million yuan. The Shanghai branch of the People’s Insurance Company of China paid more than 70 million yuan to 5,135 residents and 1,069 enterprises affected by the disaster, becoming the largest “plum rain compensation” in Shanghai’s history [1].

3.2. Moist Prevention

Continuous rain causes a sharp increase in humidity in the air. In addition, as the weather warms, high temperatures and humidity make it difficult to store many items that are prone to moisture.

For example, when the wheat and rapeseed in the southern winter are harvested and stored in the warehouse, if there is continuous rain and no sunlight, the wheat and rapeseed cannot be fully dried and stored safely. Additionally, due to high external humidity, sprouting and mold can occur, and the harvest of this year is also “soaked”.

The harvest is not abundant. Due to high humidity, it also has adverse effects on industrial production. Water vapor saturation can easily create a rainy and hazy scene, posing a hidden danger to traffic safety. High temperature and humidity can also easily cause food spoilage. In daily life, a large number of winter heating items that have not been stored in a timely manner may become moldy due to the influence of moisture, which can cause harm to human health [2].

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3.3. Disease prevention

3.3.1. Hot and stuffy days, feeling down. The four seasons climate can directly affect emotions. During the rainy season, the high temperature and humidity in the plum blossom season can lead to a decrease in the body's heat dissipation function and an abnormality in the skin's ability to regulate body temperature. This can lead to depression, boredom, decreased memory, fatigue, and an increase in the incidence of accidents.

3.3.2. Unstable blood pressure, obstructed blood flow. In plum rain season, the pressure is unstable, which is also easy to lead to abnormal contraction of blood vessels, increasing the risk of heart and brain vascular disease such as myocardial infarction and stroke.

3.3.3. Frequent occurrence of respiratory disease. The weather is humid and hot, and people like to use air conditioning. However, once the air conditioner is turned on, although the human body feels comfortable, the stagnant air, mites, mold, etc. will induce many respiratory diseases, including colds, asthma, chronic bronchitis, etc.

3.3.4. Accelerated bacterial reproduction: Beware of digestive system issues. In summer, under the interaction of temperature and humidity, the frequency of moldy items is high, and bacteria reproduce particularly quickly in food. In daily life, a slight lack of attention to food hygiene and storage conditions may lead to food poisoning, and excessive or long-term consumption of moldy food may even pose significant health risks.

4. Conclusion

Plum rain is a large-scale and regular natural rainfall that begins to form every year when plums mature in the south. It is the longest, most concentrated, and most affected rainfall process in all four seasons of the year, and is the storage season for irrigation water in agricultural production. Plum rain is an important rainfall source for many rainy and humid crops, which is very beneficial for their growth and development. Plum Rain is an enhanced rainfall stage with sparse rainfall throughout the years in the Northern and Central Plains regions. It plays a significant role in the sowing and growth of crops in summer, autumn, and winter in these areas, and is a rare and important rainfall process in arid and water-deficient areas.

However, persistent overcast rain causes the groundwater level to be excessively high for a long time, affecting the normal development of crop roots. Long-term insufficient sunlight weakens plant photosynthesis, damaging the nutritional and reproductive growth of crops. The frequent occurrence of rainstorms will also cause mountain torrents, rivers to flood, water conservancy facilities damaged, bridges and railways to break, and floods will also directly endanger people's lives and property.

According to the previous paper, the author thinks that the prediction and alarm of anomalous plum rain should be focused on. The prediction can let the government advance layout, and decrease the economic loss when anomalous plum rain strikes.

There are still shortcomings of this paper, the methods of treating the effects of the plum rain should be improved, as other professionals could have better methods of solving these effects.

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