An Introduction to Some Historical Governmental Weather Records of China

Pao K. Wang and De'er Zhang[1]

Department of Meteorology
University of Wisconsin
Madison, WI 53706

Abstract

Some historical weather records of China in the governmental archives are discussed. The records in the pre-Qing period (before 1636) are briefly summarized and their use for the reconstruction of past climate is assessed. The more-elaborate weather records of the Qing dynasty, the *Clear and Rain Records* and the *Inches of Rain and Snow*, are examined in more detail.

1. Introduction

The recent issue of climatic change and its potential impact on society stirs interest not only among climate researchers but also stirs the interest of the general public and national-policy makers. It is now of some urgency to understand how and why the climate changes. In order to achieve this it is important to collect the past-climate data and study their evolution. Climate data can be broadly divided into two categories, namely, historical data and environmental data. Historical data are recorded by human beings, while the environmental data are inferred from natural climatic indicators (such as tree rings, pollen assemblage in lake sediments, radioactive isotopes in ice cores, etc.). When available, the historical records often provide more-direct and clearer climate information and in most cases, better time resolution than the environmental data. It is the purpose of this paper to discuss some historical climate data of China. Specifically, we want to give a more-detailed account of two historical climate records contained in governmental archives in the last imperial dynasty of China, the Qing Dynasty (1636–1910). In addition, in view of the fact that the Chinese historical climate records are not well known among most climate researchers, it is perhaps useful to give a brief summary of the historical climate records in the pre-Qing period (i.e., before 1636). This is done in the following section. The more-detailed account of the two Qing weather records is given after that.

2. Weather records before the Qing Dynasty

Due to its long and continuous history, China possesses a huge wealth of historical documents. Although many of these documents were destroyed or lost in unstable political situations, the number that have survived is staggering. In this huge pile, many documents contain information about weather and climate at the time. The earliest known written weather records that survive are those inscribed on the so-called "oracle bones" of the Shang Dynasty (circa 18th to 12th century, B.C.). These are weather records engraved by knife on ox bones or turtle shells by Shang diviners. These diviners occasionally made weather forecasts for the Shang kings based on how the bones or shells cracked when scorched by fire (see Chou, 1976). They later also inscribed the actual weather on the same piece of bone or shell for verification purposes thus forming eyewitness records of the weather at that time.These records have been analyzed by Wittfogel (1940) and Hu (1944) who both showed that the climate of Northern China during the Shang period was warmer and more humid than that of the present. Unfortunately these records do not form a complete series. First of all, they were not intended to be daily weather records. In addition, the incomplete excavation and the consumption of the bones by patients who used them as medicine (Chou, 1976) also contributed to the disappearance of the records. People in the succeeding Zhou Dynasty (1111–246 B.C.) were not deeply interested in this kind of divination and therefore did not leave behind extensive oracle-bone records. They kept, however, records about unusual weather and climate (e.g., extreme cold and heat, floods, droughts, etc.) and the general descriptions of some phenological phenomena (e.g., the blossoming dates of certain flowers, lake or river freezing dates, the arrival dates of swallows, etc.). These records can be used for indirect inference of the general climatic conditions. Some of these records were described by Wang (1979, 1980).

The Qin Dynasty succeeded Zhou but lasted only 40 years (246–206 B.C.). Due to the relatively short time span and political instability no significant number of documents was produced. In addition, some of the previous records were probably destroyed by an incidence of burning books ordered by Emperor Qin Shihuang in 213 B.C.

The Qin Dynasty was succeeded by the Han Dynasty (206 B.C.–220 A.D.). In this period, standard formats for various records, including weather and climate, were established. The format set up by Ban Gu (or Pan Ku, 32–92 A.D.) was followed by most authors of official histories of China thereafter. In these histories, the entries of weather and climate are usually contained in Wu-Xing-Zhi (*Records of Five Elements*) or Zai-Yi-Zhi (*Records of Disasters and Portents*), but are also found occasionally in other chapters. There are reprints of these official histories, called *Twenty-Five Histories*, that are commercially available.

The weather and climate records in the official histories were not continuous daily records, but were records of anomalous weather and climate conditions. Nevertheless, they can still be used to form a continuous series if it is assumed that the missing records represent normal conditions. For example, the records of extreme cold and warm years can become a continuous series

[1] Permanent Affiliation: Academy of Meteorological Science, State Meteorological Administration, Beijing, People's Republic of China.

records represent normal conditions. For example, the records of extreme cold and warm years can become a continuous series if those years without records are considered as normal years. We can assign a grade 0 to a normal year, 1 to a warm year, and -1 to a cold year. In this manner we can form a series of 1, 0, and -1. Of course, the validity of such a series depends on various tests. Wang (1980) used the winter thunderstorm records in the official histories to form a series from 2200 years of data. By comparing this series with the winter-temperature series of Chu (1973), he found that in a time scale of a few decades, the frequency of winter thunderstorms was negatively correlated with the air temperature with a correlation coefficient of about 0.67.

The entries of the official histories were based on the observational records of the imperial astronomers, who naturally paid more attention to what was observed at or near the capital of the empire—places away from the capital received relatively little attention. This fact is reflected in the uneven geographical distribution of the records in the official histories. Fortunately, local records can help in bridging the gaps. Starting in the Sung Dynasty (960–1279), the compilation of local records by province, prefecture, county, and city became a popular practice. According to some statistics, there exist more than 7000 volumes of such records (Zhu, 1958; cited in Hong and Chen, 1983), covering the period from about the mid-11th century to 1933. Unlike official histories, local records were usually written by private scholars. Because these scholars were not centrally trained as were the imperial astronomers, the uniformity of the local records is not as good as those of the official histories. Nevertheless, these records cover a much-wider area and provide much-higher data density than the official histories. They are thus also of great value to the reconstruction of the past climate of China. Flood and drought conditions in China in the period from 1471 to 1979 have recently been analyzed based on the compiled local records (Central Meteorological Bureau, 1983). The qualitative descriptions of flood and drought in these records were assessed and a numerical annual flood and drought grade was assigned. In this manner, a "moisture" series of each city was formed. The time resolution of the series is one year. It may be possible to "push" the resolution to one season.

All the historical records mentioned above are mainly bare-eye observations. This is not to say that prior to the modern time, there was no attempt to perform instrumental measurements. Although there seems to be no observations related to pressure and temperature, there were records showing the use of rain gauges, wind-measuring devices, and a prototype hygrometer. For example, a record in the chapter of Li-Yi-Zhi in the *History of Later Han Dynasty* (25–220 A.D., by Fan, circa 5th century) says that the local governments were required to report the amount of rainfall "from the beginning of spring to summer and to the beginning of fall." Presumably, these were the seasons most intimately related to agriculture. It is hard to imagine that such a systematic report could be prepared without the use of standardized rain gauges. Thus, it appears that as early as the time of Christ, there were systematic rainfall measurements in China. Unfortunately, no records on either the method of measurement or the amount of rainfall measured in the Later Han period have been found to this date. More-definite descriptions of rain-gauge measurements appeared later in a book, *Nine Chapters of Mathematics* (1247), written by a Sung mathematician, Qin Jiushao (1202–1261). Four mathematical techniques to determine the actual rainfall and snowfall from the measurements of some rain and snow gauges were described. Although there was no pictorial information about these gauges, it is possible to guess their actual shape from the calculations provided by Qin. Actual records of precipitation measurements in the Sung period have not been found.

Wind measurements were obtained with either a kind of weathercock or a wind flag. The weathercock appeared in China no later than 104 B.C.. The shape and basic components were almost the same as the one used later in the Occident. Apparently, the major use of this device was only to determine the wind's direction. The wind flag, on the other hand, could measure both the wind's direction and speed. It was basically a pole with feathers tied to the top. A clear description of the wind flag was given in a book written by Li Cunfeng (~602–671) (Hong and Chen, 1983). A later book by Li Zhi (circa 11th century) also mentioned the daily measurement of wind using the wind flag; however, no measurement records have been found.

Two other meteorological parameters that are known to have been measured in pre-Qing China are the humidity and ground temperature. The humidity measurement was mentioned in a West Han Dynasty book Huai-Nan-Zi (Liu, 120 B.C.). A passage in the book says that "by hanging feather and charcoal together one can know the dryness or wetness of the air . . . . . When it is dry, the charcoal is light. When it is wet, the charcoal is heavy." This instrument was evidently a prototype hygrometer.

The ground temperature was measured by an instrument called scale tubes (*Lu-guan* in Chinese). These tubes originally were made to provide standard pitches for tuning musical instruments. The structure and use of these tubes described in the aforementioned History of Later Han Dynasty were detailed by Shen Gua (1086) in his book Meng-Xi-Bi-Tan. Tubes of different length, representing different pitches, were buried underground. The portions above ground were of the same length for all tubes but the underground portions were different. Ashes of reed tissues, which were supposed to rise when the tubes were exposed to a proper ground temperature, were spread in the tubes. Since the ground's temperature varied with the depth during the year, the ashes would fly out of different tubes at different date, giving some idea of the depth at which a "particular" temperature (called *yang* gas in the book) occurred. Neither the humidity nor the ground temperature was known to have any surviving records.

There were two devices constructed by Huang Luzhuan who lived near the end of Ming Dynasty (1368–1644) (Hong and Chen, 1983) that were supposed to measure the temperature and humidity. Unfortunately, not many details regarding the structure of the instruments or the methods of measurement survive.

3. Weather records in the Qing Dynasty

During the Qing Dynasty, meteorological observations increased considerably. The first few emperors of Qing, especially Kangxi (reigned 1661–1722) seemed to possess a great deal of scientific curiosity. In addition to traditional observations, these emperors were also interested in Western techniques. New techniques and instruments were brought into China largely by Jesuit missionaries. The earliest person to do

so was the Belgian Jesuit Ferdinandus Verbiest (1623–1688) who introduced the thermometer and hygrometer into China. However, there was no record indicating that he ever made any meteorological measurement using these instruments. The first person known to make modern instrumental measurements in China was the French Jesuit Pater Gaubil who started his work in Beijing in 1743. However, apart from the rather-fragmentary temperature records published by Mahlmann (1843, see Zhu, 1936), no records from Gaubil survived. Another Jesuit, Amiot, also made observations of temperature, pressure, cloudiness, precipitation, and wind direction in Beijing from 1755 to 1760. Most of the observations in Beijing after Amiot were carried out by Russians, especially Russian missionaries. Their observational records have been published by Zhu (1936). Apart from Beijing, there were also weather stations established in other places, such as the Zi-Ka-Wei Observatory in Shanghai, which was set up by French missionaries in 1872, and the five stations in Taiwan that were set up by the British in 1885.

Although the observations mentioned above were made with instruments, they covered only a few cities and were sporadic. During the period these instrumental observations were being made, the traditional method of reporting the weather to the emperor continued. This method provided records that cover a much larger area, and a longer and more-continuous period. Although these records are somewhat qualitative, they can be converted into more-quantitative series. We will describe two such traditional records of the Qing Dynasty in detail.

The first kind of records, and perhaps also the most detailed, is the *Clear and Rain Records* (*Qing-yu-lu* in Chinese, *Qing* means clear, *yu* rain, and *lu* records). These are the weather records reported to the emperor. In Beijing, the national capital, the observation and the recording were the duty of the imperial astronomer's office. In other locations, they were done by local officials. The observations, made on a daily basis, were compiled, carefully written, and submitted to the emperor on a monthly basis. Occasionally reports were made bimonthly. There were normally one or two months of delay before the reports were finally submitted. Thus, for example, the report of June weather might be submitted in August.

An entry in the report typically includes the year, month, day, and the weather conditions. The weather conditions include sky conditions (overcast, clear, fog, or rain), wind directions (N, S, E, W, NE, SE, NW, SW), precipitation types (rain, snow, light rain, light snow, heavy rain, heavy snow, thunderstorm, etc.), and duration (the starting hour and ending hour). The precipitation duration was reported using the traditional time system in China, that is, a day is divided into 12 intervals, called 12 *shichen*. One *shichen* is equal to two hours. The time resolution of the report is therefore two hours.

Figure 1 shows a page of the *Clear and Rain Records* of Suzhou in 1724. Except at the beginning or the end of the day, the hours in the translation (Fig. 1) correspond to the middle point of the two hour period. At the end of the day, the hour indicated is the ending point (which is always 11 p.m.). It is quite obvious from the above records that this was a rather wet period, especially the three consecutive rainy days from the 5th to the 7th. The starting of the 5th month in the Chinese lunar calendar usually occurs sometime in June of the Gregorian calendar. From the middle of June to early July is the so-called *meiyu* (plum rain) season of the middle and lower reaches of Yangtze River. It is characterized by a stable east-west–oriented rainband stretching across central China. Suzhou is on this rainband. The records show that in the middle of the 18th century, the weather of Suzhou in June was similar to the present situation. In addition to the information in rain, the wind direction and its change would indicate where the meiyu front was and how it had moved.

In the example translated, there was one raining period per rainy day. Sometimes there were days with two raining periods, such as:

21st. Rain stopped at 4 am. Cloudy. SW wind. Thunder, lightning, and rain started at 6 pm and stopped at 8 pm. Cloudy in the night.

At present we do not have adequate information on who made the observation and how it was done. We do know, however, who compiled and submitted the reports. For example, at the end of the Suzhou 5th Month report, there was an addendum which reads:

Qianglong 7th Year, 7th Month, 29th Day, Suzhou Silk Superintendent Tula submitted a report on the weather and rice prices of the 5th Month. No imperial rescription. Filed according to the routine and recorded.

It is seen from this paragraph that there was a two month delay in the report submission. In Beijing we had inspected the original handwritten report in the National First Historical Archives and did not see the rice price list attached to this report. It was probably listed on a separate sheet of paper. The person who submitted this report was obviously not a meteorologist but a local official in charge of the imperial silk production. The observation must have been done by others specialized in weather watch. Unfortunately, there is no information at present to indicate who they were or how they were trained.[2]

FIG. 1. The *Clear and Rain Records* of Suzhou of May 1742. The translation, from left to right, reads as follows: *Suzhou Clear and Rain Records* 5th Month—1st. Clear. SE wind. Cloudy in the night. 2nd. Cloudy. SE wind. Light rain started at noon. Still raining at 11 pm. 3rd. Rain stopped at 2 am. Clear. SE wind. Clear in the night. 4th. Clear. NE wind. Clear in the night. 5th. Cloudy. SE wind. Light rain started at noon. Still raining at 11 pm. 6th. Rain. NE wind. Still raining at 11 pm. 7th. Rain. NE wind. Rain stopped at 11 pm. 8th. Cloudy. NE wind. Light rain started at 10 am and stopped at 11 pm. 9th. Cloudy. NW wind. Cloudy in the night. 10th. Cloudy. NW wind. Light rain started at 8 pm and stopped at 2 pm. Cloudy in the night. 11th. Clear. NW wind. Light rain started at 4 pm and stopped in a short while. Clear in the night.

[2] The year indicated is 1724.

At present we do not know how many cities and counties submitted monthly weather reports to the emperor at the time. So far reports from 41 places have been found but most are very fragmentary and discontinuous. Only reports from Beijing, Nanjing (called Jiangning at the time), Suzhou, and Hangzhou are relatively continuous. Their beginning and ending years are: Beijing (1724–1903), Nanjing (1723–1798), Suzhou (1736–1806), and Hangzhou (1723–1773).

Unlike the other three cities, the Beijing reports contain no wind information. The precipitation reports had been compiled and converted into a quantitative precipitation series (Central Meteorological Bureau, 1975). The conversion of Beijing's precipitation series was facilitated by the fact that there was an overlapping period from 1841 to 1903 in which both the traditional records and instrumental observations are available. Thus the traditional records can be calibrated by the instrumental records. A stepwise regression method was applied to calculate the regression coefficients. The regression equations were then applied to pre-1841 records to calculate the equivalent precipitation.[3]

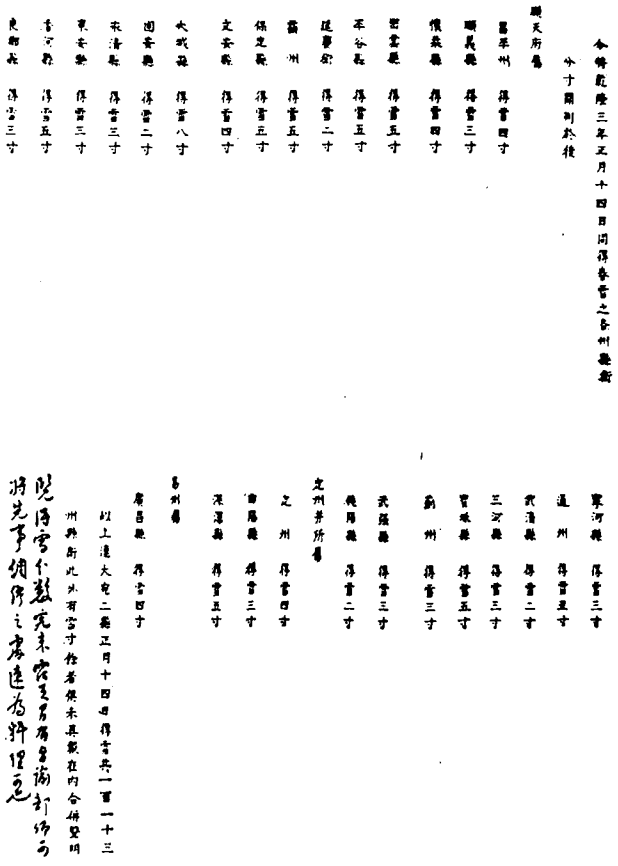

FIG. 2. An example of the *Inches of Rain and Snow*. It reads (from right to left in the upper panel): The inches of spring snowfall in the affected zhous, xians, and weis on the First Month, 14th Day of Qianlong 3rd Year are listed as follows:

Suntian Prefecture and subordinate units:	
Changpin Zhou	4 inches of snow
Shunyi Xian	3 inches of snow
Hairou xian	4 inches of snow
.....	.....

There are totally 113 zhous, xians, and weis as listed above plus the two xians of Dayuan which received snowfall. In addition, places which received only slightly more than one inch of snow are not listed.

The *zhou* in the translation is an administrative unit somewhat larger than a county. A *xian* is about the same as a county. A *wei* is about the size of a city but was related to a military base. For example, the second largest city of northern China, Tainjin, used to be a *wei* in Qing Dynasty.

The second kind of weather records is called the *Inches of Rain and Snow* (*Yu-xue-feng-cun* in Chinese, *Yu*-rain, *xue*-snow, *feng*-1/10 of a *cun*, and *cun*-a chinese length unit approximately equal to an inch). These records contain strictly the information of precipitation. An example, shown in Fig. 2, is the record of snow on 4 March 1738 in the Suntian Prefecture area.

It is obvious that the above list is a snowfall report. We do not know exactly how the depth of the snow was measured. In the *Nine Chapters of Mathematics* mentioned previously, there were two methods of measuring snowfall. One was the direct measurement of the snow thickness above ground. The other was the measurement of snow depth in a snow gauge. The former is likely the one mentioned in the translation above.

The reports of rainfall are different. The number of inches of rainfall reported refer to the depth of soil swept through by rainwater. For this reason, the inches of rainfall were often called the "underground inches." One example of the rainfall reports is shown in Fig. 3.

The report shown in Fig. 3 is from 1725. Obviously, the depth of soil moistened by rain depends not only on the amount of rainfall but also on the properties of soil which are not necessarily uniform. Therefore the numbers given in these reports can only be taken as a relative indicator of the rainfall. In addition, the reports sometimes simply said "adequate rain" without giving the actual depth. In comparison, the depth in the snow reports is a better representation of the actual precipitation.

Despite these shortfalls, these reports should still be useful in the reconstruction of past precipitation. We can at least obtain a series of the number of rainy days from these reports, then use this series to reconstruct the rainfall because the correlation between the two are fairly good in East China. In addition, the existing reports of the *Inches of Rain and Snow* cover a larger area than the surviving *Clear and Rain Records*.

The *Clear and Rain Records* and the *Inches of Rain and Snow* are direct meteorological records. There are also other governmental documents which are indirectly related to weather and climate. One example is the food price reports. In these reports, the reasons for the price fluctuations were often stated, and many were related to climatic factors such as excessive rain, drought, or inadequate snow in the previous winter, etc. The time resolution of these climate records were much coarser than the above two reports, usually containing only general seasonal conditions. Nevertheless, they may serve as a separate

[3] For the other three cities, unfortunately, no such overlapping period exists. The conversion of these records is therefore more difficult than the case of Beijing. In order to solve this problem, we recently developed a precipitation characterization method that can be used as the basis of the conversion of these records. Using this method, we were able to convert the summer (May to August) records of these three cities into quantitative precipitation series. We will report the details of this work elsewhere in the near future. These precipitation series will give a good indication of the humidity fluctuation in the lower reaches of Yangtze River in the 18th century. In addition, since the precipitation pattern there is closely associated with the pressure systems such as the West Pacific High and South Asian High, these series can also reflect the past behavior of these systems.

check for the constructed meteorological series. An example of the grain price reports in 1726 is shown in Fig. 4.

The passage in Fig. 4 contains information about the above-normal precipitation in the fall of 1725 and the spring of 1726. Despite their qualitativeness, they can at least serve as confirmatory evidence.

4. Conclusion

All of the records mentioned in the previous section are contained in governmental documents. If sorted and analyzed carefully, they can be used for the reconstruction of the past climate series. We have completed the reconstruction of the summer precipitation series of Suzhou, Hangzhou, and Nanjing in the 18th century based on the *Clear and Rain Records*. They will be reported elsewhere in the near future.

In addition to the governmental documents and the previously mentioned local records, there are numerous private diaries that also contain daily weather records. They also cover a very large area. The description of these diaries, however, is beyond the scope of this paper.

Acknowledgments. This work is supported by the Climate Dynamics Program of the National Science Foundation Grant ATM-8511905.

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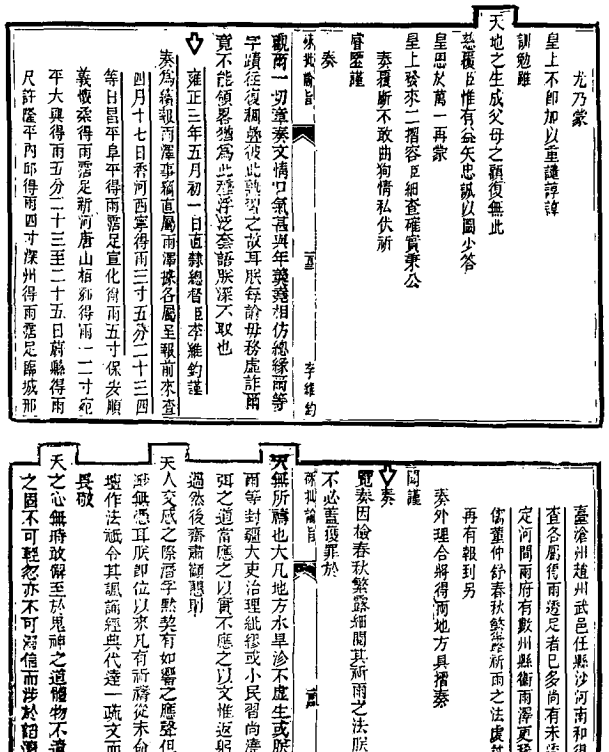

FIG. 3. Rainfall report by Zhili Governor Li Weijun in 1725. The columns with lines on the right hand side are translated here. It reads: Yongzheng 3rd Year, 5th Month, 1st Day, Zhili Governor Your Servant Li Weijun respectfully reports the rainfall situation in my governing districts. According to the reports of my subordinates, Xianghe and Xining received 3.5 inches of rain on the 17th Day, 4th Month. On the 23rd and 24th, Changping and Fuping received adequate rain while Xuanhua received 5 inches . . . Many districts also received adequate rainfall although some were not quite adequate. However, several zhous, xians, and weis belonging to Baoding and Hejian Prefectures received little rainfall.

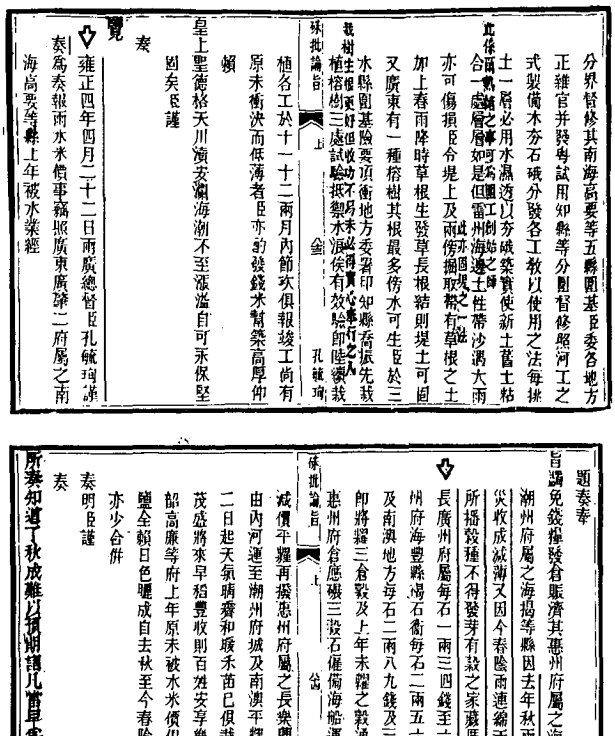

FIG. 4. Grain price report by Liangguang Governor Kong Yuxun in 1726. The columns with lines on the right hand side are translated here. It reads: On April 22, Yongzheng 4th year, Liangguan Governor Your Servant Kong Yuxun respectfully reports . . . Last year the rainfall in fall was somewhat above normal. Although no calamity was caused, the crop yield was reduced. In addition, it rained for a long time and was cold this spring. The crop seeds did not germinate. Those with crop stock hid their crops away from the market. The price of rice went up steeply. In Guangzhou Prefecture, each dan (133 1/3 lbs) costs from 1.3 or 1.4 to 1.5 or 1.6 ounces (of silver) . . . .

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