DROUGHT MONITORING FOR ASIA-PACIFIC AREA USING THE CLOUD PARAMETERS METHOD BASED ON FY-2 DATA

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ABSTRACT:

In this paper, our recent research mainly focuses on the application of the drought monitoring using the cloud parameters method for the drought monitoring of China. In order to apply this method for an expanding range, we analyzed the total monitoring accuracy to prove that this method is highly adaptable at large temporal and spatial scales. Due to the high precision of the monitoring result in the circumjacent area in China, we applied this model to even larger spatial scale for drought monitoring of the Asia-Pacific Area. The ultimate objective of this research is to monitor the drought of the experimental area using the cloud parameters method based on the FY-2C/D data, and then to analyze the monitoring result of July 2007 for FY-2C and February 2008 for FY-2D. The experimental results show that this drought model performs well with good stability and high precision for the drought monitoring in the Asia-Pacific Area at the large temporal and spatial scales.

1. INTRODUCTION

1.1 The Original Drought Monitoring Model

Generally speaking, Drought would last for a long period, and gradually lead to a wide rang of serious disaster. Therefore, it is of great significance to develop a drought monitoring model to monitor the distribution and intenseness of drought timely, which is crucial for drought warning and resisting effectively. Drought monitoring model based on cloud parameters is developed to improve traditional methods, as well as further utilize the RS data (Liangming Liu, 1994).

The cloud parameters method mainly contains three cloud indexes: Continuous Cloud-Free Days (CCFD), Cloud Days Ratio (CDR) and Continuous Cloud Days (CCD). With the three cloud indexes calculated, relationship between these indexes and drought condition could be generalized as functions, which are finally combined to show the Remote Sensing Drought Risk Index (RDRI) as the following formula (Debao Tan, 2004; Liangming Liu, 2004):

$$RDRI = \frac{F_1 \cdot W_1 + F_2 \cdot W_2 + F_3 \cdot W_3}{F_1 + F_2 + F_3} \quad (1)$$

Where W_1, W_2, W_3 are the infection functions

F_1, F_2, F_3 are the weights

The three infection functions were simulated by the process of generating cloud indexes based on RS data.

1.2 The Spatial and Temporal Modification Function

As the temporal and spatial changes contribute to the diversity of drought conditions, it is necessary to perform naturalization for these infection functions, which develops a improved drought monitoring model based on cloud index. Solar zenith angle, length of daytime, distance between earth and sun, which are affected by the movement of the earth, and in turn, affect the solar radiance received by the land surface resulting in the seasonal changes in our world. Thus, requirements for cloud indexes to get the uniform drought condition vary within the range of different time and locations. With temporal and spatial modification applied, three basic infection functions could be revised (Liangming Liu, 2008).

Based on the analysis for the same area at different seasons, the same cloud indexes might indicates different conditions of drought grade index, due to different solar zenith angles, received solar radiance and intensity of transpiration. Therefore, temporal changes will result in different RDRI even with the same cloud indexes, which makes it required to modify the cloud indexes per month as a basic unit according to the temporal condition and its gradually accumulated effect on drought condition, which is called temporal modification (Liangming Liu, 2008).

There is no doubt that solar radiance received by earth surface in different locations is varied due to different solar zenith angles and distances between the sun and the earth, which will definitely lead to different soil moisture and RDRI. Thus traditional drought monitoring model is not always applicable without the modification for spatial change. Even if the temporal change was considered to be the same, the spatial change will also affect the contribution made by cloud indexes for drought condition, so quantitative method is also applied to analysis and modifies the infection functions. Such as on the other hand, low latitude indicates higher possibility of drought, while the change with longitude shows very little. Therefore latitude is the main independent variable.

1.3 Soil Moisture

Soil moisture is one of the most important variables to the disciplines of agriculture, hydrology, meteorology and ecology. It plays an important role on the water and energy exchanges at the land surface/atmosphere interface. Drought refers to the soil moisture shortage phenomenon that the unevenness of the moisture revenue and expenditure. Thus, the soil moisture is used to evaluate accuracy in this paper. Furthermore, the drought of the Asia-Pacific is monitored using the cloud parameters method based on FY-2C/D data. Meanwhile, we compare the predicted result and real data.

2. ACCURACY ASSESSMENT

2.1 The Theory of Accuracy Assessment

Spatial accuracy assessment includes state-of-the-science methods, techniques and real-world solutions designed to validate spatial data, to satisfy quality assurance objectives, and to ensure cost-effective project implementation and completion. There are many sources of both conservative and optimistic bias in accuracy assessment, most of which are impossible to avoid. There are at least three significant sources of conservative bias: errors in reference data, positional errors, and minimum mapping unit of reference grid (Dave Verbyla). There are also at least three significant sources of optimistic bias: utilization of training data for accuracy assessment, restriction of reference data sampling to homogeneous areas, and sampling of reference data not independent of training data. The magnitude and direction of bias in estimation accuracy depend on the methods and reference data sampling.

We usually assume that our “ground truth” data are perfect. However, if there are any errors in our reference data (such as mistakes in recording or processing the reference data, etc.), some of our correct pixels may be incorrectly considered as mistakes. Meanwhile, because images are always rectified to a certain tolerance of positional error, we can not be absolutely sure of the location of any given pixel.

2.2 Accuracy Assessment of the Drought Monitoring

In this study, the monitoring accuracy is evaluated through two aspects: accuracy of spatial scale and accuracy of temporal scale. In this original drought monitoring model, we only take the spatial and temporal into account besides the three basic cloud parameters. So we can validate the stability and adaptability of this model if the incorrect monitoring result is proved to be random in the temporal and spatial scales, in other words, the incorrect result is not regular with the change of the spatial and temporal.

2.2.1 Spatial Accuracy Assessment: The spatial accuracy assessment mainly evaluates the spatial distribution of the monitoring accuracy. The process mostly includes three steps. Firstly, the traditional accuracy assessment method which is comparing the calculated drought index to the ground survey data is used. In this step, the drought index and the ground data are unified to the same data type by the classification criterion of meteorological drought. Then, we evaluate the accuracy based on the position of each ground data by the traditional accuracy assessment method and get the accuracy map for each drought monitoring period. The figure1 is the positional distribution and quantity of the ground data, where each point responds to the ground data and each colour grade shows the different quantity of the ground data for that point. The distribution of the East China is zoomed in to the right figure in order to understand the meaning of the distribution map easily.

Secondly, it is necessary to collect all the accuracy maps in order to produce e the total accuracy distribution maps. That is to say, the percents of the absolutely correct accuracy and the usable accuracy for each point are calculated. From these maps, we could easily distinguish the bad and well result of drought monitoring and contrastively analyze the influence factors for the different regions.

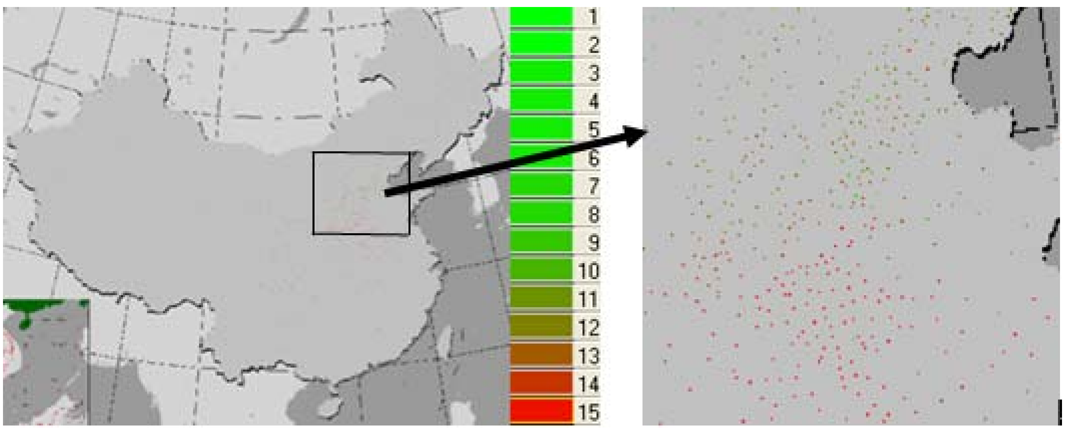
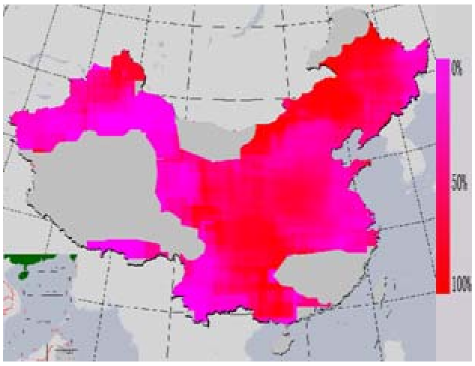
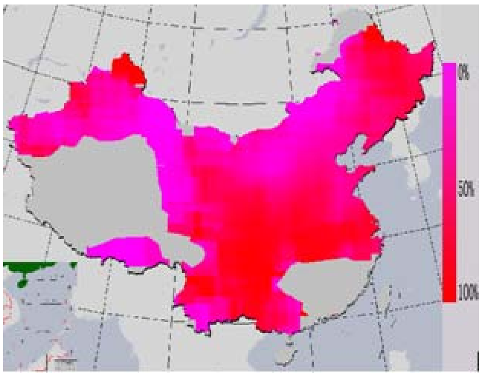


Figure.1 the positional distribution and quantity of the ground data

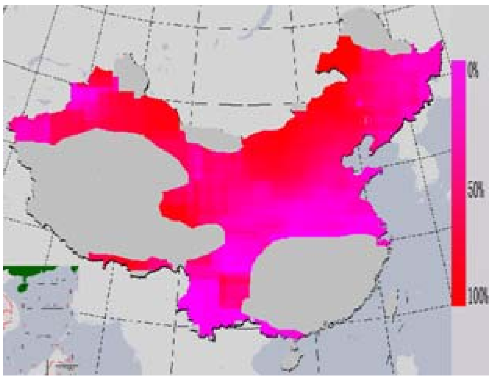
For the last step, the total accuracy distribution map for the study area is obtained easily and quickly by the method of the remote sensing imagines processing. Figure2 reflects the distribution of the correct accuracy, the usable accuracy and the incorrect accuracy, where the red represents the high percent of the correct results and the magenta represents the relatively low percent in the correct accuracy map (figure2 (a)) and the unable accuracy map (figure2 (b)). From the correct accuracy map, in the west of the Northeast China and part of the South China, the accuracy reaches to the maximum, about 65%. Meanwhile, the part of the Northwest China and the East China, the accuracy reaches to the minimum, about 6%. Accordingly, in the same regions, the maximum and the minimum increase to about 35% and 94% respectively. In the incorrect accuracy map (figure2(c)), the red represents the high percent of incorrect results and the magenta represents the low percent, the maximum and minimum are respectively 40% and 6% in the part of the North China and the Central China. Then, by analyzing the spatial distribute of the accuracy, we could easily find out the mostly effective factors of the incorrect monitoring points.



(a) The correct accuracy map



(b) The usable accuracy map



(c) The incorrect accuracy map

Figure.2 The accuracy maps

2.2.2 Temporal Accuracy Assessment: The temporal accuracy assessment mainly analyzes the accuracy from September 2005 to November 2006. The following table demonstrates the accuracy for users:

time\accuracy	correct	usable	acceptable
09/05	23.49	65.48	90.94
10/05	24.69	59.55	85.94
11/05	34.27	71.81	94.18
12/05	29.09	66.46	91.41
01/06	50.88	90.27	97.35
02/06	46.79	89.64	98.57
03/06	36.74	78.79	93.94
04/06	35.49	79.33	92.41
05/06	34.01	77.10	91.92
06/06	36.84	77.05	90.23
07/06	35.47	75.34	89.45
08/06	33.00	76.76	90.65
09/06	28.13	79.81	95.15
10/06	30.76	78.18	92.68
11/06	39.50	80.52	93.18

Table 1. Table of temporal accuracy

From the table of temporal accuracy, the acceptable accuracies are more than 90%, and the usable accuracies are about 75% excepted some on the low side months, such as September and October 2005 and some on the high side months, January and February 2006. The average level of correct accuracies is about 30% with 5% fluctuation, excepting the maximum accuracy, 50.88%, in January 2006.

2.3 Conclusion

Through the above analysis of the monitoring accuracy, some conclusions could be summarized as follows:

(1). In the spatial accuracy assessment, the Central China, the North China, the Northeast China and the Northwest China have highly accuracy according to the above figure. That is to say, this drought monitoring model is reasonably adapted to the study area. Considering the study area and the monitoring interval of time, this model shows satisfying results in the large temporal and spatial scales. However, we cannot obtain the accuracy of some parts of study area, such as Qinghai-Tibet Plateau, due to the insufficient ground data. In addition, the interval in monitoring drought is a period of a month in the paper, while the change of soil moisture is about certain day which cannot describe the whole interval, so this gap will effect the monitoring accuracy in some uncertainly degree..

From the figure2(a, b), it can be easily found out that the correct results distribute from the North China to South China equally in the spatial scale (the latitude orientation). Meanwhile, from the figure2(c), the incorrect results mainly focus on some areas, such as the north region of Inner Mongolia. Summarily, the correct results and the incorrect results are not regular with the change of the spatial. Thus, it is can be concluded that this drought monitoring model has a high stability in the spatial scale and can be practiced to other area with relatively high precision.

(2).From the above temporal accuracy table, the drought monitoring model based on the cloud parameters method can be practiced stability in the temporal scale. The bad accuracies only occur in the random months which are not disciplinary. So it can be certainly summarized that the time factor is applied in this drought monitoring model effectively.

Summarily, this model can be applied to monitor drought of larger spatial and temporal scales. Therefore, in order to increase the applicability of this model, we extend our study area to the Asia-Pacific Area. Because this monitoring model needs remote sensing data with high temporal resolution, the data of the Geostationary Meteorological Satellites FY-2C/D, which cover with the whole Asia-Pacific Area and whose temporal resolution is half an hour, are selected. Consequently, the next work is monitoring the drought of Asia-Pacific Area by this drought monitoring model and FY-2C/D data.

3. DROUGHT MONITORING FOR THE ASIA-PACIFIC AREA BY FY-2 DATA

3.1 Introduction of FY-2C/D

The meteorological satellite and satellite meteorology are new monitoring technology and discipline that gained rapid development and great success in the past decades. At present, the meteorological satellite plays the most important role in the earth-atmosphere monitoring system, whereas satellite meteorology is a very active field in the earth science. Since the 70s of 20 century, the history of China meteorological satellite development is introduced, with the focus on the launch, operation and basic specifications of orbit and geostationary meteorological satellites; the researches on the theory and data processing method of satellite remote sensing are reviewed.

The main technology characteristics of FY-2C satellite, which was the first one in the second batch of FY-2 geostationary meteorological satellite, such as construction and layout, control subsystem, 5 channel scanning radiometer, satellite-borne image forming, transponder of data transmitting and clouds image broadcasting, telemetry and control of engineering and service, the second separating, power bus regulation, composite structural member. C satellite had provided large a mount of image products, numerical products and man-machine interactive products since it began to operate, which played an important role in the monitoring of hard rain, typhoon, fire and sea ice. FY-2C can be used for continuous real-time observation on the variation of weather over China and her surrounding area, and plays an important in medium and long term weather forecast.

FY-2D launched successfully in December of 2006 ， which marks that two geostationary meteorological satellites locate west and east over China with wide image dissemination coverage. This compound observation is not only extremely significant to our country for weather forecast, hazard reduction, global climate change observation, but also provides meteorological service for East Asia, South Asia and even Australia and part of Africa.

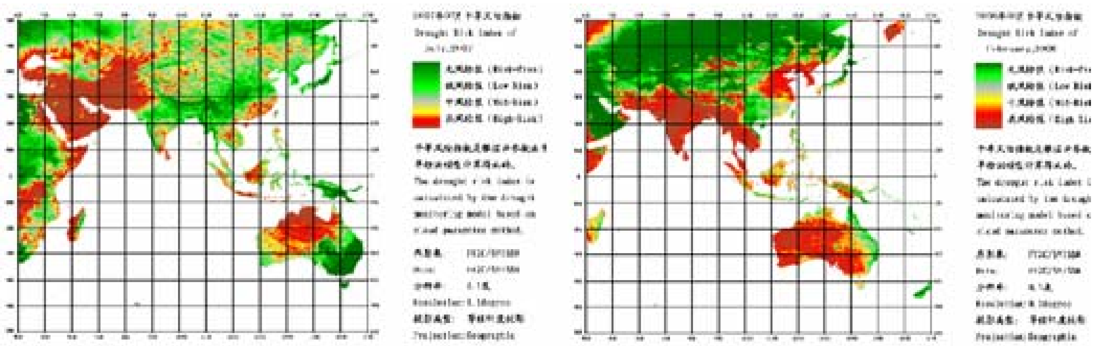
3.2 Introduction of the Study Area

The Asia area and the regions of the Pacific coast are defined to the Asia-Pacific Area, including 21 countries and regions, such as Australia, America, Canada, Japan, China, Taiwan, Hong Kong and so on. The major characteristic of this area is that there are many countries and regions and the gap of these countries' economic is relatively great.

The study area is land in the Asia-Pacific Area, which is located between about $N60^0$-$S60^0$ and $E25^0$-$E155^0$ for FY-2C and about $N60^0$-$S60^0$ and $E43^0$-$E173^0$ for FY-2D.

3.3 Monitor Drought for Asia-Pacific Area

Through the above analyses, it is thought that the cloud parameters method for the drought monitoring model can be used to monitor the drought of the Asia-Pacific Area based on the FY-2 satellites' data. FY-2C data of February 2008 and FY-2D data of July 2007 provided by National Satellite Meteorological Centre of China Meteorological Administration is involved in this study. However, we can not use the soil moisture deep to 20cm because it is difficult to obtain the soil moisture data of the other countries, except for China. Figure3 is the result of the drought monitoring for the Asia-Pacific Area.



a b

Figure.3 the result of drought monitoring
a for the result of FY-2D of July 2007, b for the result of FY-2C of February 2008

3.4 Analysis of the Result of Drought Monitoring

From the China satellite remote sensing information service network (21 Feb. 2008), the status of drought of July 2007 is that the major drought area are the west of the Northeast China, the northeast and centre of the Inner Mongolia, the northeast of the Northwest China and the part of the South China. Meanwhile, the drought of Australia covers the Northwest Area. All these situations can be reflected from our monitoring result figure3 (a), however, there is a little deviation between the real situation and our monitoring result. From the result figure, we can know that the northwest of the Asia-Pacific Area has serious drought disaster due to the desert and bare type of the land in Middle East regions.

In the same way, from the China satellite remote sensing information service network, the status of drought of February 2008 is that the regions including the west of the Northeast China, the southwest and centre of Inner Mongolia, the North China and the Northwest China are the coverage of drought area. Additionally, from the Australian National Meteorological Centre in the 3rd of March 2008, although some regions are divorced from the drought status, the mostly regions are enveloped in the shadow of drought all the same. According to the above result figure3 (b), it can be concluded that basically, our monitoring result is in accordance with the real situation. Nevertheless, some monitoring warps occur in some local areas. Thus, this drought monitoring model needs gradually improving in the future study.

4. CONCLUSIONS

In this study, we evaluate the accuracy of drought monitoring result for China from September 2005 to December 2006 firstly, and then we enlarge the monitoring area to the Asia-Pacific Area based on the accuracy analyses. That is to say, we monitor the drought situations of the Asia-Pacific Area of July 2007 and February 2008, and then we analyze the relationship between the monitoring result and the actual situation. Conclusions could be summarized as:

(1). Drought monitoring model using cloud parameters method performs very well in the drought monitoring for China at the large temporal and spatial scales;

(2). From the result of the drought for the Asia-Pacific, this drought monitoring model shows good stability and high precision based on the analysis of the real situation.

In addition, in some local areas the monitoring results divorced from the actual situations. Therefore, further research will be focused on local areas' drought monitoring in the precondition of the good stability at the large temporal and spatial scales.

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