Study Review and Primary Construct for Fast Estimation System of Snow Disaster in Tibet by Remote Sensing

Li Caixing1, Liu Yuanming4
Institute of Atmospheric Environmental Science in Tibet Plateau
No.1 Lin kuo Bei Rd, Lhasa City, 850000，Tibet，China
cxli21@ne.rsgs.ac.cn

Xi Xiaohuan2, Jiang Xiaoguang 3
China Remote Sensing Satellite Ground Station, Chinese Academy of Sciences
. No.45 Bei San Huan Xi Rd, 100086, Beijing, China
xhxi@ne.rsgs.ac.cn, xgjiang@ne.rsgs.ac.cn

Abstract: Based on related literatures from home and abroad, this paper reviews the present status of monitoring snow disaster, snow depth in Tibetan Plateau and snow disaster-causing mechanism by using satellite remote sensing, and accordingly presents deficiencies of the previous research. The feasibility and necessity of establishment a fast estimating system of snow disaster by remote sensing in Tibet is fully analyzed. With a view of the current development of remote sensing and GIS, especially the development of civil society and economy of Tibetan autonomous region, a primary design for the system contents and technical methods is provided.

Key words: Snow disaster; Remote sensing; Disaster situation assessment; Theory of disaster system

1. Introducton

Nowadays, satellites in orbit have capacity of all weather and 24-hour continuous surveying and monitoring all over Tibetan regions, as well as with the ability of multi-spatial resolution (from 0.61m to 1000m) and multi-spectral resolution (e.g. EOS MODIS with 36 bands and EO-1 with 220 bands).Tibetan Remote Sensing Center has begun to receive, process and archive NOAA series data from the end of 1980s, and in the year of 2001, it introduced EOS/MODIS multi-satellite remote sensing data acquiring and processing system. The center has been taking on the commitments to monitor snow disaster and forest fires by remote sensing satellites for many years and gained abundant experiences on disasters prevention and mitigation using RS and GIS technology. It tests that satellite remote sensing datum can provide objective information about snow dynamic covering and snow disaster situation in large scale, especially in Tibetan areas with bad weather and lack of weather information, satellite remote sensing data will be a very important way to analyze snow disaster. With the further development of the application of remote sensing and computer technology, remote sensing data has gradually been an indispensable tool to monitor snow. Thus, to establish a fast estimation system for snow disaster using multi-source remote sensing data in Tibetan pasturing areas will be stringent and feasible.

2. Study Status at Home and Abroad

1) Reviews of Monitoring Snow Disaster by Satellite Remote Sensing

TIROS21 Satellite monitored snow in eastern Canada in 1960s for the first time. Since then, with the high spatial resolution satellite to be launched, e.g. COES satellites and Landsat series, the capacity of monitoring snow by remote sensing has been further developed. And since 1980's [1], meteorology department and related research institutes carried out much more studies on snow spatial-time distribution feature using satellite remote sensing data and weather station datum, and they found the geographic distribution, seasonal variability of snow and its variety among years in plateau and mountain areas. Based on snow and snow disasters, they plotted the climate districts[2]. With the application of NOAA weather satellite in China, many scientific researchers were engaged in monitoring and analyzing snow, spectral characteristics of cloud and snow included. However, how to discriminate cloud and snow using NOAA data has been a highlighted issue for home and abroad researchers for a long time. Kidder Q, et al found that the difference of middle-infrared wavelength between cloud and snow is also showed in AVHRR Channel3[3-4]. Accordingly, snow information can be extracted and its covered area can be calculated[5－6]。Liu Yj et al analyzed snow covering characteristics and dynamic rules in western China and offset the deficiencies of monitoring snow in routine weather stations[7－8]。Li Zhen et al demonstrated an established a database containing a large amount ground truth of snow covered area for snow mapping algorithm development and validation by using the high spectral resolution, and then showed its application example in the validation of MODIS snow mapping algorithm and the development of ASTER snow mapping algorithm. Gao Feng et al monitored snow extent, snow depth and snow water equivalent by using remote sensing monitoring and though which derived to establish climatic mode and estimate snow disaster[16-17].

2) Snow Research Status in Tibet Plateau

Chen XF[10] et al. analyzed the relationship between precipitation forming into snow and the abnormity of average circumfluence from winter of 1995 to winter of 1996 in eastern areas of Tibetan Plateau, and the relationship of snow disaster and precipitation, climate vibration and its background in winter in Plateau areas. He figured out that snow disaster and precipitation was trending up from 1960s – 1970s to 1980s – 1990s. Dong AX（11）et al. studied the climatic feature of snow damage in the Qinghai-Xizang Plateau during the winter half years of 1967-1996 using singular spectrum analysis. He points out that general tendency of snow damage increases, especially in the late winter, this may respond to global warming. Its quasi-periods are main 2.03.1 and 5.47.5 years. Zhou LS[12] analyzed 26 weather stations in eastern pastoral areas of Qinghai-Xizang Plateau and found there have appeared 1 689 heavy snowstorm weather processes in the past 30 years. By means of statistic analysis, he concluded some preliminary time-spatial distribution characteristics of heavy snowstorm processes and snow disaster: Jiuzhi was the frequent center of heavy snowstorm processes and snow disaster, while Qingshuihe was the high value center of snow disaster and disaster-forming. The probability of disaster reached to 80.3% in the later winter，but only 14.3% in the spring. As a result, to make an impact on snow disaster is getting more and more serious because of the significant increment of heavy snowstorm processes and precipitation, particularly it becomes more frequent since 1990s. Li PJ（13）studied the time-spatial distribution feature of snow disaster in Tibetan Plateau using snow depth image obtained from SMMR passive microwave from NASA. He thought the spatial-time distribution of snow was mainly on mountains all around, particularly with much snow in east and a little while in hinterland. The decade change and annual change were evident. With the global warming the snow was increasing and the annual change of snow clearly increased, snow disaster was more serious. Dong WJ（14）pointed out the period and high frequency months of snow disaster. The snow disaster on the Qinghai-Xizang Plateau livestock farm is mainly to the south and east of the BaYankalashan mountains and has an increasing trend in recent 30 years. There is an obvious 5-6 year cycle and a weak 2-3 year cycle of the snow disaster. They found that there was high former winter snow disaster in 1970s and was high latter winter snow disaster in the period from the end of 1980s to 1990s, and studied further from the point of view of climatology. Wang XJ[19] collected and analyzed the biggest snow depth every ten days and put forward a standard for snow disaster in winter and spring, and then established a rating serial annual table for snow disaster.

3) Research Progress of Snow Disaster-causing Mechanism

Zhang DFet al [15] studied snow disaster-causing mechanism in northern China and thought the snow calamity is caused by both natural and mankind in the northern prairie of China. Despite of climate anomaly affected by Lanina as a direct reason, irrational human activities, such as overgrazing, undue land reclamation, excessive digging and water abusing, destroyed the eco-balance of grassland. The extensive management and low-grade infrastructure made grassland reduce ability of fighting natural calamities, which also degrade the resistance of disasters of the grassland ecosystem. The phase difference of publicly-owned grassland and privately owned livestock is the base reason of irrational human activities. The key reason was the conflict of public-owned grassland and private livestock which might cause farmer to use grass resource invasively. Based on the synthetic analysis, Li S[18] et al. used the method of the gray incidence analysis of gray system and chosen the average proportion of the loss caused by snow disaster in 1985 and 1995 as referring series, several factors including air temperature and average precipitation of 1985 and 1995, thickness of accumulated snow, days of accumulated snow, quantity of livestock, overloaded proportion of pastureland in cold season and amount of herbage stored for the winter as the factors of comparing series respectively and also calculated the degree of gray incidence. The results objectively reveal the relations between the loss of snow disaster and the factors and provide a scientific basis for the predication and prevention of snow disaster in Nagqu.

4) Deficiencies of the Present Study and Improvement

From the point of view of regional disaster system theory, the regional disaster system is a complicated and diverse earth surface system. It is also a composite environment, involving disaster-containing circumstance, disaster-causing factors and carrier-disaster. Its sub-systems act on one another which may result in disaster[22]. Generally speaking, the production of stockbreeding is carrier-disaster, massive snowfall and snow shaped at low temperature are disaster-causing factors. Local natural environment, civil society and economy form into carrier-disaster environment. The degree of disaster is determined by stability of disaster environment, peril of disaster-causing factor and frangibility of carrier-disaster body and their mutual reaction. The specific changes of each factor have different effects on disaster degree. Previous scholars explored mainly in disaster factors, such as snowfall and snow covered area, whereas carrier-disaster and latent disaster environment etc. are not to be considered in disaster situation estimation. Additionally, snow disaster monitoring by remote sensing mainly rely on weather satellite data, with the advantages of high time resolution and low price. However, its low spatial resolution can’t meet the demands of detailed disaster assessment. Based on this, we think it is necessary to use multi-source satellite remote sensing data, i.e., Landsat, SPOT with high resolution to establish carrier disaster database, while in key monitoring areas, it needs much higher resolution data, such as Quickbird.

3. Importance and Necessity to Establish a Snow Disaster Fast Estimation System by Remote Sensing in Tibet

1) Snow Disaster - One of the Most Principal Impediment in Eeconomic Development in Plateau Pasturing Areas

Snow disaster is a kind of weather disaster. It causes by much snowfall in cold weather, snow in grass areas covering pasture too thick and lasting very long time which affects livestock routine breeding, resulting in hungry and becoming thin, even dead. This case happens frequently in Tibetan pasturing areas and threatens local residents and produces enormous loss to them. A heavy snow disaster happening in 1985 lasted for five months, covering over 500,000 square kilometers areas, near 80,000 people and 3,000,000 livestock suffering from the disaster. The heavy snow disaster happening in 1997 in north of Tibet aroused much concern internationally. According to study of Tibetan Weather Bureau, there was middle degree snow disaster happening from every 3-4 years and a heavy snow disaster every ten years. Especially, with the development of stockbreeding in Tibet, the loss caused by snow disaster is much more enormous which greatly affects stock farmer's life and stock production.

2) Disaster Situation Information Acquired in Time ---- the Basis to Make Relieving Plan during Government's Disaster Prevention and Fighting.

When there is a heavy snow disaster, how to forecast accurately during its sprout, how to relief quickly after disaster, settle down the refugee of disaster better and cure the wounded in time, and how to eliminate people's dread and properly lead them to participate in disaster prevention and fighting, all in all, how to response to disaster situation, protect human beings and their properties is the key problem relating to people's safety and social stabilization. The base is to estimate disaster situation accurately, fast and continuously, accordingly it is necessary to establish a practical and executable estimating method and a set of normative disaster situation publicizing way so as to let all rescuers be informed in detail.

3) Remote Sensing ----a Ideal Technical Method to Estimate Snow Disaster Situation Comprehensively in Tibet with Large Areas and a Few Observation Stations.

The area of Tibet is 120 square kilometers, while only 39 weather observation stations. However, in uncultured Nagqu and Ali region, there are fewer stations which doesn't meet the demand of monitoring by ordinary ways. Remote sensing technology can response disaster situation in real time, dynamically, impersonally and comprehensively, and comparing with ordinary observation, inquiry and interview, it is much more economical, efficient and impartial.

4) Critical Demand for Acquiring Disaster Information Quickly in Plateau Pasturing Areas with Low Carrier-disaster Capacity

The natural environment is bad with complicated climate, not enough oxygen and weak ecosystem. With low degree culture, people have not much scientific knowledge about disaster, their consciousness of disaster prevention and flight is not good. Together with uncultured economy, not convenient communication and lack of relieving materials, it need much more disaster information in order to dispatch materials rationally. The accuracy of estimating disaster in time reflects the level of government's scientific management which will advance Tibetan government's prestige in local areas and ambient countries, prosper borders and consolidate national defence.

4. Main Content and Technique Route of the Disaster Eestimation System

1) Main Content of the System

Based on fully investigation and study, it is proposed to use multi-source satellite remote sensing, image processing and analyzing and overlay processing, neighboring areas analysing and spatial statistic function to study the method of snow disaster fast estimation system in plateau. It is to program on the basis of GIS platform to establish a snow disaster fast estimation system for some typical test areas in Tibet. This system will abtain the primary disaster situation information within a few hour, provide disaster estimation information and related suggestion in one day and complete a detailed estimation report in one week. The main content of the system includs ：A model for extracting information of snow covering area, a model for snow covering time and a model for deduce snow depth by remote sensing, Index system of snow carrier-disaster body and disaster containing environment, compiling snow disaster risk map, disaster situation estimation system and criterion to issue disaster information etc. When achieving good effects in test areas, it will be spread out to all over the regions and other disasters to provide disaster information for all governments.

2) Research Method

The detailed technique route is listed as fig.1 in the following page.

The system will forecast and give a warning about the heavy upcoming snow disaster, dynamically monitor its spreading during disaster and provide the best relief scheme, and estimate disaster situation in order to offer service for rebuild and insurance after disaster, which will serve government, civil administration, agro-stock raising and other related departments. And the system will also provide operational service for Tibetan government. The content and method of service will be improved with the experience to be gathered. Meanwhile, it will be extended to other disaster, such as drought, land slide and man-made disasters etc. Therefore, to carry out related studies earlier and establish a snow disaster fast estimation system will be a very important and urgent issue for remote sensing researchers in Tibet.

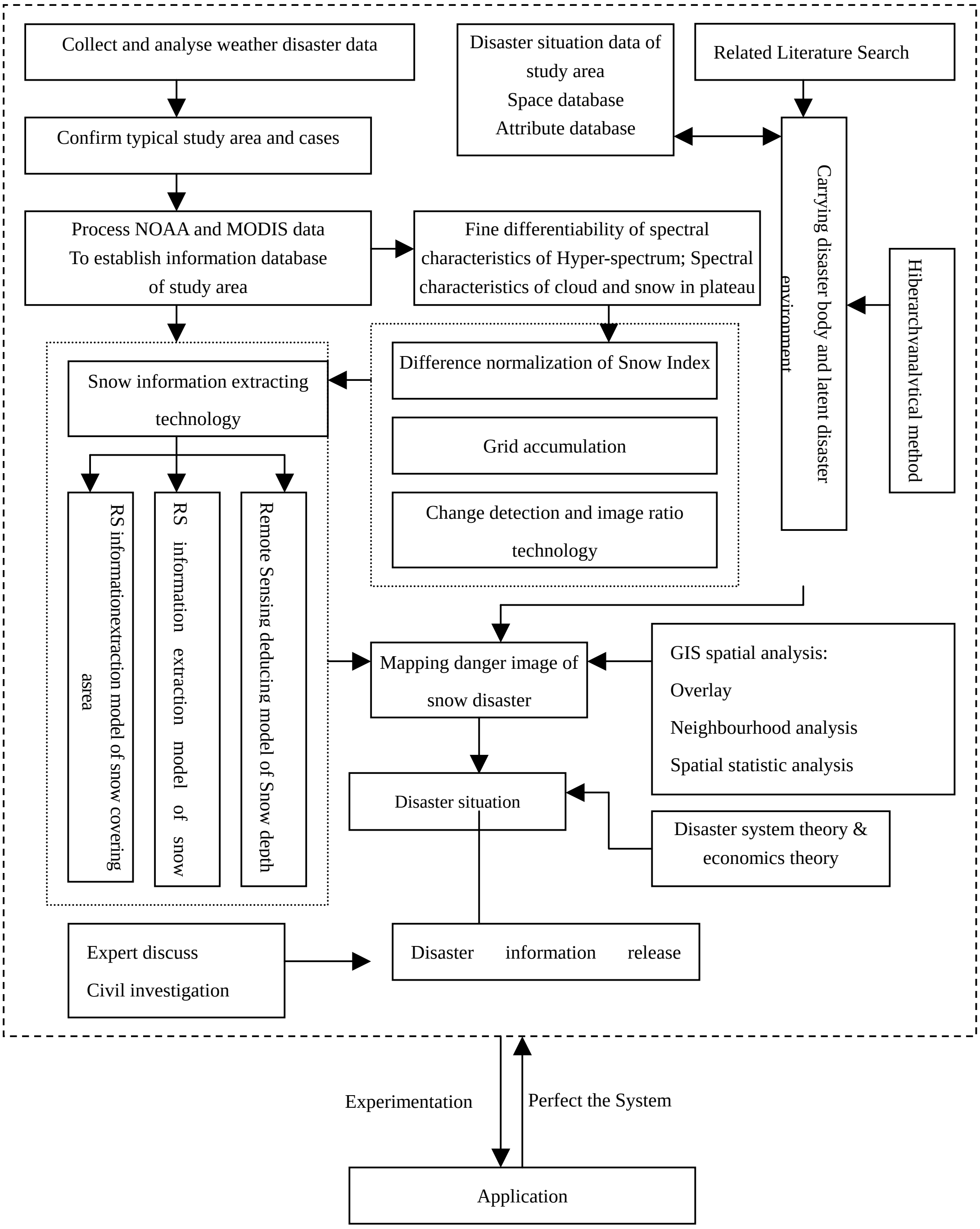

Fig.1 Flow chart of technique route

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