APPLICAIONTS OF SMALL SATELLITE CONSTELLATION FOR ENVIRONMENT AND DISASTER MONITORING AND FORCASTING (SSCEDMF) IN DISASTER MONITORNG AND ASSESSMENT

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ABSTRACT:

SSCEDMF is a new generation of in-building remote sensing constellation. Just as the name, the new constellation was especially designed for the environment and disaster monitoring and forecasting. And the constellation is also shortly named as HJ. The satellites of SSCEDMF started to launch continuously since 2008. Being the first part of the constellation, HJ-1 A and B were launched on September 6th, 2008, which were launched by the same rocket. By now, all the two satellites work well, and high-quality remote sensing data are acquired and transmitted to the ground steadily. There are three kinds of optical remote-sensing sensors on board, multi-spectral imager (CCD), infrared imager (IRS) and hyper-spectral imager (HSI). The swath of CCD could be about 700km, and the revisit-period of the constellation could be less than 48 hours. So, the constellation, with wide-swath and short revisit-period character, is more suitable for the disaster emergency applications. And, the different kinds of space-borne instruments also provide a new steady and multi-spectral remote sensing data for the disaster monitoring and assessment in China.
Since the satellites launched, HJ-1 A/B had been widely used for the monitoring and assessment of the disaster, such as blizzard. Based on a series of HJ-1 A/B applications in the past months, the wide-swath CCD has been turned out to be more suitable for the wide-region disaster monitoring and assessment, such as blizzard. IRS data work well for the hot-spot detection and forest fires assessment, and it is also applicable for the snow detection and drought risk monitoring.
In this paper, the characteristics and working-condition of constellation and instruments would be introduced in brief firstly. In the second part, based on the study on the application capability evaluation and the technological route, the HJ-1 A/B data were applied for the disaster monitoring and assessment of the blizzard in Tibet. Finally, the application capability of HJ-1 A/B is evaluated. And a technical application method, for blizzard monitoring, risk forecasting and disaster assessment, are established, which would contribute to expand the application benefit of the satellite constellation.

1. INTRODUCTOIN

The Small Satellite Constellation for Environment and Disaster Monitoring and Forecasting (SSCEDMF) is a new generation of in-building remote sensing constellation. Just as the name, the new constellation was especially designed for the environment and disaster monitoring and forecasting. And the constellation is also shortly named as HJ.

The satellites of SSCEDMF started to launch continuously since 2008. Being the first part of the constellation, HJ-1 A and B were launched on September 6th, 2008, which were launched by the same rocket. By now, all the two satellites work well, and high-quality remote sensing data are acquired and transmitted to the ground steadily. HJ-1 C will be launched in 2009 on schedule. By then, the first stage of the constellation will be completed, and the revisit-time of the constellation will reach less than 48 hours.

There were three kinds of optical remote-sensing sensors on board by HJ-1 A/B, multi-spectral imager (CCD), hyper-spectral imager (HSI) and infrared imager (IRS).
Both of HJ-1 A and B carried CCD system on board, and each CCD contains two CCD cameras. The swath of each CCD is about 360km, and the swath of the combined cameras is about 700km. The CCD provides four bands optical remote sensing data, with 30m resolution.

HSI provides 115 observation bands, from 0.45μm to 0.95μm, and the resolution of the hyper-spectral remote sensing data is about 100m, with 50km swath. HSI is the only sway payload on HJ-1 A/B. The sway range reaches to $\pm 30°$.

IRS, carried on HJ-1 B, provides four infrared bands, from 0.75μm to 12.5μm. The three lower bands provide 150m resolution observation, and the highest band takes 300m resolution observation. All of the four bands cover 720km swath.

In the near future, HJ-1 C, one SAR satellites, will be launched. And the SAR provides S band microwave remote sensing data, with different mode. The higher resolution (4~6m) can be acquired by single-look, and 15~25m SAR data will be acquired by multi-look. SCAN mode provides wide swath (95~105km), and Strip Mode provides narrow swath (35~40km).

Using the payloads on HJ-1 A and B, the multi-source dataset, which contains the synchronized CCD, HSI and IRS remote sensing data, can be acquired. And such dataset could be applied for the disaster monitoring and assessment.

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This paper will focus on the disaster monitoring and assessment applications for the blizzard in Tibet with CCD and IRS.

Satellite	Payload	Band	spectral region (μm)	Resolution (m)	Swath (km)	Sway
HJ-1A	CCD	1	0.43-0.52	30	Single camera 360 Combined camera 700	—
		2	0.52-0.60			
		3	0.63-0.69			
		4	0.76-0.90			
	HSI	115	0.45-0.95	100	50	±30°
HJ-1B	CCD	1	0.43-0.52	30	Single camera 360 Combined camera 700	—
		2	0.52-0.60			
		3	0.63-0.69			
		4	0.76-0.90			
	IRS	1	0.75-1.10	150	720	—
		2	1.55-1.75			
		3	3.50-3.90			
		4	10.5-12.5	300		
HJ-1 C	SAR	1	S-band	multi-look : 15～25 single-look : 4～6	SCAN Mode : 95～105 Strip Mode : 35～40	—

Table 1. Characters of the payloads on SSCEDMF.

Based on the applications with CCD and IRS, the application capability of HJ-1 is evaluated in detail. And a technical application method, for blizzard monitoring, risk forecasting and disaster assessment, are established, which would contribute to expanding the application benefit of the satellite constellation.

2. METHDOLOGY AND APPLICATION

2.1 Blizzard in Tibet

From 26 to 28 Oct., 2008, a wide blizzard occurred in Tibet, and the blizzard is the most deadly snow storm in the history of Tibet. The blizzard led the severe damage to the local residents. Till to November 1st, the disaster caused part of houses collapsed, and some traffic-line blocked. Some infrastructures for irrigation, electric-power, traffic and communications were also demolished. Linzhi, Naqu, Shannan and the other 16 counties were the heavy disaster area.

2.2 Methodology and Routine

In order to carry out the blizzard monitoring and assessment, the application routine, which is based on the HJ-1 IRS, AMSR-E remote sensing data, was established.

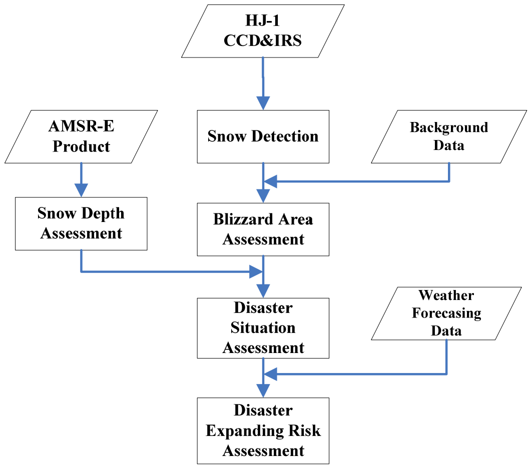

Figure 1. The routine of the application for the blizzard monitoring and assessment.

HJ-1 CCD and IRS data are used to detect the snow distribution, and blizzard area can be assessed by the GIS spatial analysis with the background data. Then, snow depth can be retrieved with the AMSR-E product, which provides global daily snow water equivalent data. Combining the snow distribution and the snow depth information, the disaster situation can be assessed by county. Further more, with the weather forecasting data, the blizzard expanding risk can be estimated.

2.3 Snow Area Detection

Researches and applications have shown the optical remote sensing potential for the snow detection, classification and assessment. Both snow and cloud behave higher reflection within optical and near-infrared range, so it is possible to distinguish snow and cloud from the land background in the remote sensing data. Based on the cloud detection with multi-optical data and texture analysis, the cloud area can be distinguished from the snow area. And the snow distribution can be assessment by spatial analysis.

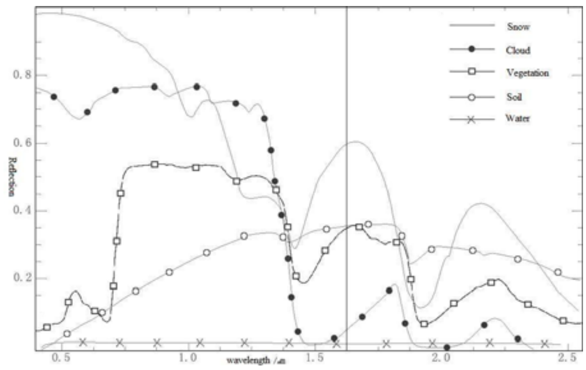

Figure 2. The characters of the reflection over different landuse.

2.4 Snow Depth Estimation

Researches show that the passive microwave remote sensing data is sensitive to the snow coverage. By land-surface parameter retrieval, the snow water equivalent (SWE) can be estimated from the passive microwave radiometer data. AMSR-E is aboard on Aqua, which was launched in 2002. AMSR-E provides 6 frequencies and dual-polarization observation data daily. And the high altitude zone can be observer twice everyday.

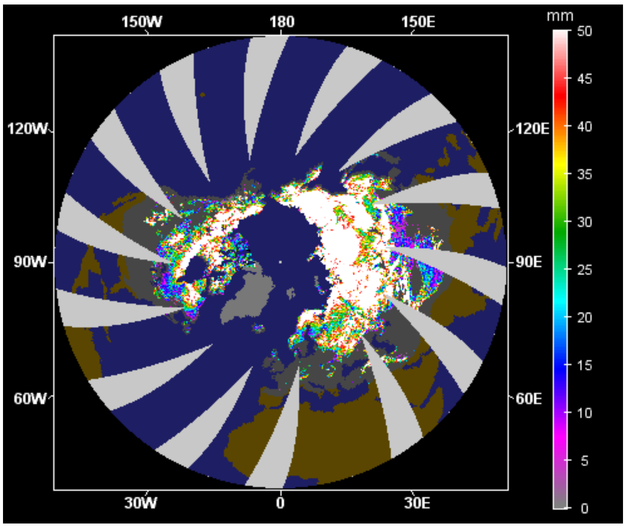

Figure 3. Snow water equivalent retrieved from the passive microwave radiometer of AMSR-E.

Past researches have established the experimental model to describe the relationship between snow water equivalent and snow depth. With the experimental models, snow depth (SD) can be estimated from the SWE.
SD=SWE/snow density

$$SD = \frac{SWE}{snow\_density}$$

Usually, for the heavy and dry snow, the snow density can be taken as 0.3g/cm^3.

Combining with the snow distribution and the snow depth, the snow depth distribution and assessment during the blizzard in Tibet is achieved. Figure 3 shows the east part of Tibet and the south part of Qinghai were covered by the blizzard. The heavy disaster area, in Cuona and Milin, were covered by over 40cm snow. In Naqu, Shannan and Linzhi, the covered snow was less, about 10cm to 15cm.

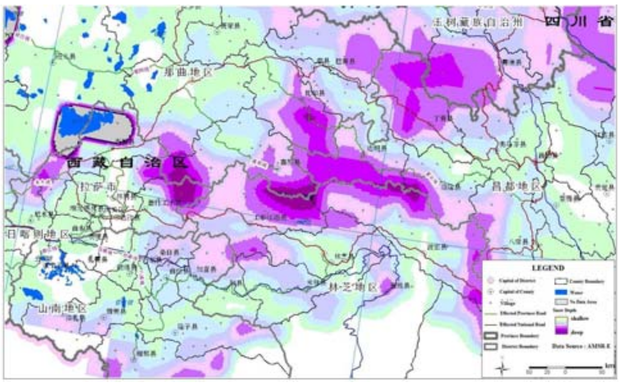

Figure 4. Snow depth assessment for the blizzard.

2.5 Disaster Assessment

In order to assessment the disaster in Tibet, a comprehensive disaster index was established, by taking snow depth, stockbreeding affection, residents outgoing and disaster relief difficulty. The disaster assessment can be divided as 3 levels.

Level	Damage Description
Heavy	• Over 30cm snow depth • Livestock can not find food • Residents can not go out, the traffic line has been blocked • Hard to relief • Heavy damaged
Middle	• Over 15cm snow depth • Livestock almost can not find food • Hard to transport relief goods • Heavy damaged
Light	• Over 10cm snow depth • Hard for livestock to find food • Possible for being short of food • Partly damaged

Table 2. The description of the comprehensive disaster index.

Based on the comprehensive disaster index and the topography and geomorphology analysis, the disaster level was assessed by county.

District	Disaster Situation		
	Heavy	Middle	Light
lhasa	Mozhugongka County	Dangxiong County Nimu County	Qushui County, Duilongdeqing County
Changdu	Leiwuqi County, Basu County	Changdu County, Dingqing County, Chaya County, Luolong County, Bianba County	Jiangda County, Gongjue County
Shannan	Luozha County, Longzi County, Cuona County	Naidong County, Sangri County, Qusong County, Cuomei County, Jiacha County	Qiongjie County, Langkazi County
Naqu	Naqu County, Jiali County	Biru County, Nierong County, Suo County, Baqing County	Anduo County, Bange County
Linzhi	Gongbudajiang County, Milin County, Bomi County	Linzhi County, Lang County	
Yushu (Qinghai)		Yushu County, Rangqian County	

Table 3. The disaster situation assessment by county.

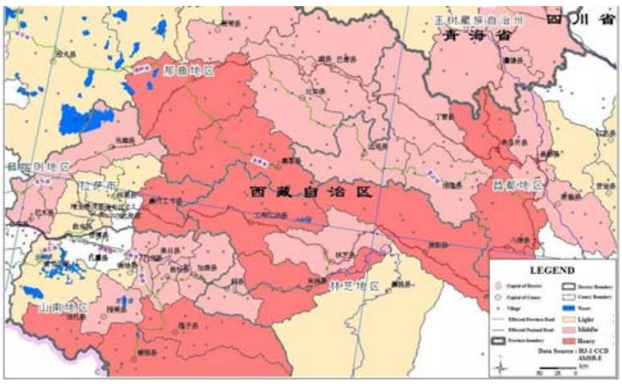

Figure 5. Disaster level assessment for the blizzard.

2.6 Blizzard Risk Forcasting

Based on the weather forecasting for the next 24 and 48 hours, and overlapping the disaster assessment with the land use by the GIS spatial analysis, blizzard expanding risk can be achieved. The disaster expanding risk, where the disaster situation is going to be stable or worse, is estimated by county.

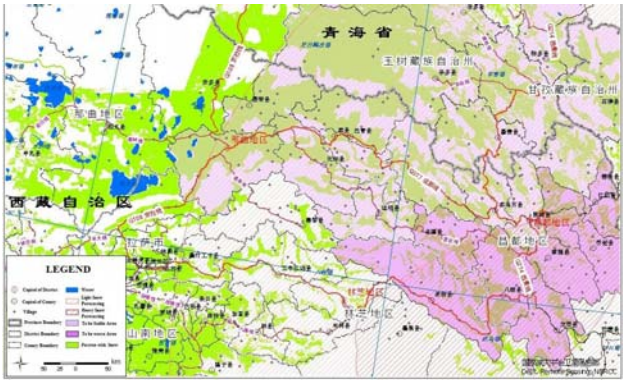

Figure 6. Disaster level assessment for the blizzard.

District	Disaster Expanding Risk	
	To be stable	To be worse
Changdu	Changdu County, Leiwuqi County, Dingqing County, Bianba County	Dajiang County, Gongjue County, Chaya County, Basu County, Zuogong County, Luolong County
Linzhi		Bomi County
Ganzi (Sichuan)	Shiqu County	
Yushu (Qinghai)	Yushu County, Zaduo County, Chengduo County, Zhiduo County, Nangqian County	

Table 4. The disaster expanding risk assessment by county.

3. CONCLUSIONS

It has been focused for a long time to put remote sensing technology into the operational disaster monitoring and assessment applications.

This paper, taking the blizzard monitoring and assessment as example, established an application routine. In the application routine, the optical data of HJ-1 A/B is used for the snow detection and distribution assessment. Combining with the other multi-source remote sensing data, the snow structure parameters, such as snow water equivalent and depth, can be retrieved. Based on the background data, the disaster situation can be estimated by the GIS spatial analysis. And the disaster situation is assessed by county, which is fit to the disaster management in practice. Further more, the disaster expanding risk also can be forecasting. Such application routine is designed to meet the national disaster management needs in deed, and also can be used with the other remote sensing and GIS data. It is much more practical for the disaster monitoring, assessment and risk forecasting.

In this study, HJ-1 A/B was also evaluated by applying for the blizzard monitoring. The application shows that the IRS data are accurate and sensitive to the cloud and snow detection. Combining with HJ-1 CCD and the other remote sensing, HJ-1 A/B data have the potential not only for the blizzard monitoring and assessment, but also for the other disasters. In the future, more application study would be carried out to validate, in a wide field, the application potential of HJ-1.

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