THE PRELIMINARY ANALYSIS OF SNOW MONITORING USING AMSR-E AND WINTER SNOW CAMPAIGN OVER *TIBET PLATEAN*, CHINA

Yubao Qiu[1), Huadong Guo[1), Jiancheng Shi[2), Shichang Kang[3), James R. Wang[4), Juha Lemmetyinen[5),
Lingmei Jiang[6)

1) Center for Earth Observation and Digital Earth, Chinese Academy of Sciences, Beijing 100190, China (e-mail ybqiu@ceode.ac.cn)
2) Institute for Computational Earth System Science, University of California, Santa Barbara, CA 93106-3060, USA
3) Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, 100085, China
4) NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
5) Finnish Meteorological Institute (FMI), Arctic Research Centre, Tähteläntie 62, FI-99600 Sodänkylä, Finland
6) School of Geography, Beijing Normal University, Beijing 100875, China

1. INTRODUCTION

Terrestrial snow cover has largest geographic extent in the northern hemisphere. Over the Tibet Plateau, snow cover is present only for a few months per year, except the mountain area. However, it highly influences the energy flux, atmosphere dynamics and surface water reservoirs. Recently, much effort has been put into developing region-specific retrieval algorithms for snow parameter retrieval from passive microwave measurements. Automatic station observations of snow cover are essential factors in the development of these retrieval algorithms, but they can not provide comprehensive information on the snow cover distribution. From the Fig1., the distribution of the meteorological stations in the Tibet Plateau can be seen to be very sparse, especially over the main part of the Plateau. Furthermore, many of them are near areas of human activity, and provide few measurements for a long time span with a very shallow snow depth values (see Fig.2 example for DanXung Station)[1]. Armstrong (2001) notices that the passive microwave remote sensing tend to underestimate the snow in the fall and early winter due to the weak signal of the thin snow with the 36.5GHz and 18.7GHz[2], while the situation is the opposite over Tibet Plateau. Matthew H. (2009) improved the accuracy of the snow measurement by considering the atmospheric influence to some extent [3].

In this work, we consider the shallow snow situation, and try to explain the discrepancy between the in situ time series measurement of snow (snow depth, SD/ snow water equivalent, SWE) and the values retrieved from passive microwave remote sensing with the traditional difference between the brightness temperature at 36.5GHz and 18.7GHz. Then, we analyse the ability of the higher frequencies in snow parameter retrieval over the Tibet Plateau (e.g. 89.0GHz of the Advanced Microwave Scanning Radiometer - Earth Observing System, AMSR-E) using the time series data comparison.

2. SNOW DEPTH AND SATELLITE DATA COMPARISON OVER TIBET AREA

2.1 Snow campaign dataset over NamCo station

We selected snow depth measurements at the NamCo station over 4700m in altitude, which is located beside the NamCo Lake and the Mt. Nyainqenttanglha (Fig.1). The Institute of Tibetan Plateau Research, Chinese Academy of Sciences, operates a station in the area. A snow campaign covering the whole winter offseason between 2006.10~2007.2 was conducted. SD records are acquired over three sites around the Namco station. Compared to the AMSR-E/Aqua satellite footprint, these sites are regarded as one site and represent the general situation of the whole area in this work, though this is a fairly inaccurate estimation for in mountainous areas. Some preliminary analyses are shown using the AMSR-E L2A brightness temperature and satellite snow products.

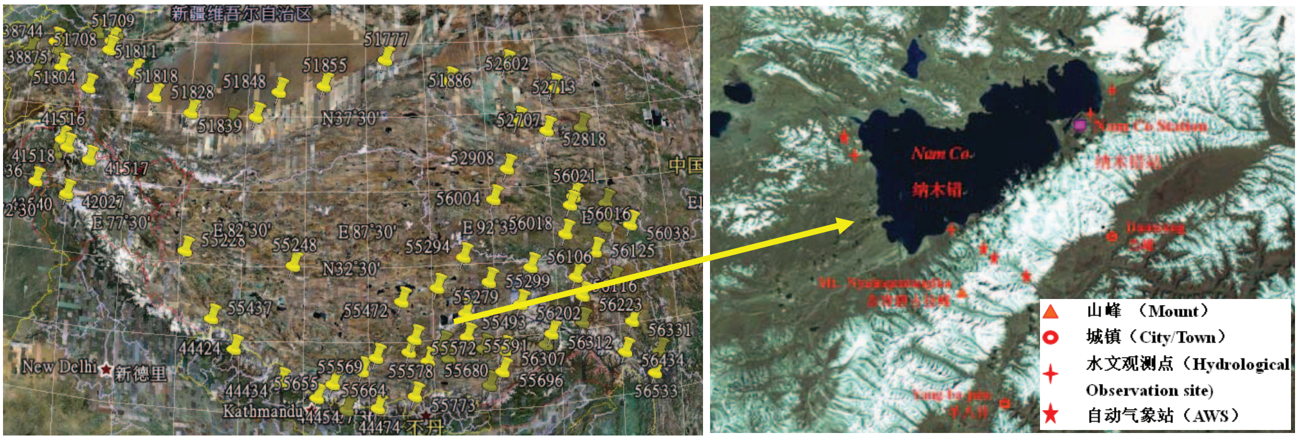

Fig.1 The distribution of the activated meteorological station over Tibet Plateau (from China Meteorological Data Sharing Server System) and the geographic location of the Namco station site ($30^0$46.44'N, $90^0$59.31'E).

Fig 2 (left) shows a time series of the measured in situ snow depth values. From 24/10/2006, snow depth increases from 23cm to about 45cm on 8/11/2006. after which the depth decreased to 17cm on 28/1/2007. In this time span, several snowfall events happened on 12/11/2006, 14/11/2006 and 16/1/2007, with 2 cm of new snow in the last case. A relatively large shift appeared on 14/12/2006 because of the change of the observation sites for the surface wind.

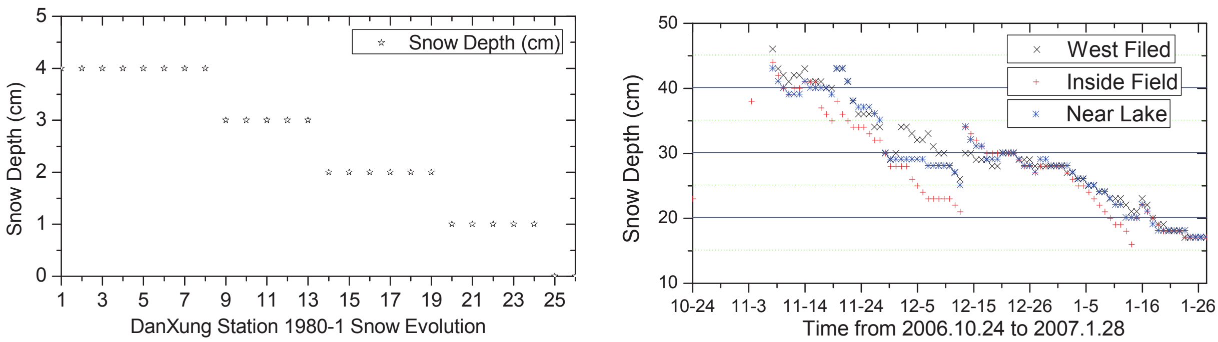

Fig. 2 The SDs from the Danxung station (No.55493) (left) and the SD (cm) field campaign near NamCo station (right)

2.2 AMSR-E L2A dataset over the NamCo test area

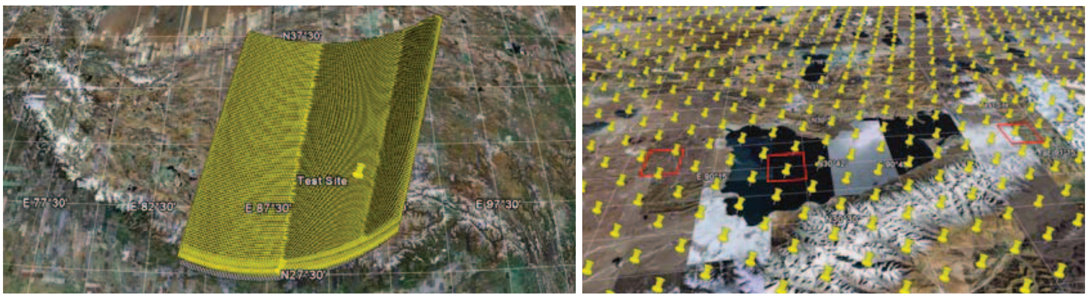

Fig 3 part of one swath L2A data from AMSR-E orbit (left) and the sample points (right) (red rectangles are prepared for the experiment in the pipe)

We selected the AMSR-E L2A brightness temperature over this area. The coverage area for one orbit is shown in Fig.3. We chose the 36.5GHz/89.0GHz and the 18.7GHz channels for the gradient algorithm. The sample resolutions are almost 10km for one sample, so we can select the sample value absolutely over land surface by eliminating the lake (or ice in winter) part. The time of the swath L2A dataset are consistent with the site filed measurement.

2.3 The time series of the AMSR-E L2A brightness temperature gradient

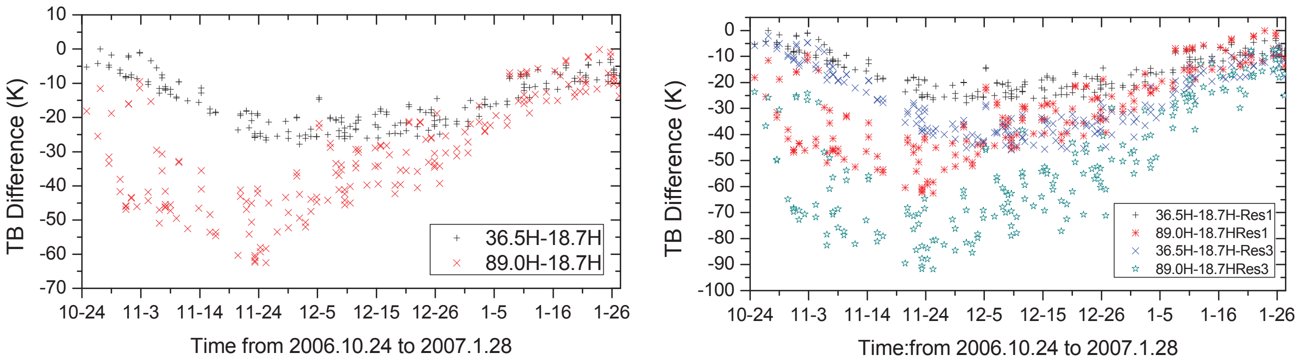

Fig. 4 The brightness temperature gradient between 36.5GHz/89.0GHz and 18.7GHz with different resolution correspondence to the snow measurement time

Compared to the Fig.2 (the right figure), the brightness temperature gradient (traditional algorithm prototype) shows a good relationship for the snow depth decreasing period (24/11/2006~26/1/2007) at 89.0GHz (named high frequency) gradient and 36.5GHz (named low frequency) gradient. For this period of time (snow depth are less than 30 cm), we can understand that the high frequency are more sensitivity to the snow evolution than that of the low frequency, and the right fig in Fig.4 indicates the high resolution (L2A.res3) resample is more sensitive to the snow evolution than that of low resolution (L2A.res1). Fig.5 (left figure) shows a sample, located beside (20km away from the field measurement site), that indicates the same trend as the previous Fig.4.

However, at the beginning of the measurement, the situation is more complicated. During the first 15days, the 89.0GHz shows a good sensitivity to the new snow. During the later succeeding 17days (7/11/2006~24/11/2006), the gradient becomes more and more large, but the snow depth decreases. This could be explained preliminary by the evolution of the snow grain size and density, which typically increases with time. A more physical explaination needs e.g. the model simulation work on the snow emission of snow grain size, snow depth and the snow density, in order to decide which part plays a dominant role [5].

2.4 Analysis of the AMSR-E daily snow water equivalent product

Another comparison (Fig.5, right figure) has been done by using the AMSR-E daily snow products, which are EASE-Grid with coarse resolution (25km), and the snow depths at Fig.2 (right figure). From these figures, we can find that the maximum estimated AMSR-E SWE(mm) (using 36.5GHz gradient) over NamCo station at the winter of 2006~2007 occurs around 26/12/2006, which are do not match the snow measurement, with a delay of almost one month.

Compared with the gradient figure, from Fig.4, we can find that the 36.5GHz gradient shows a relatively stable value from 1/12/2006~26/11/2006. The discrepancy between the SWE and TB gradients is probably due to mixed pixel effects especially beside the lake area over NamCo station. This requires a more extensive field dataset to acquire an explanation..

If we consider the typical snow density over Tibet area to be approximately 0.239g/cm^3, we get a maximum snow depth value of about about 75 cm from the AMSR-E observations This is quite large compared to the in situ measurements, an indication that the AMSR-E SWE value is overestimated[6].

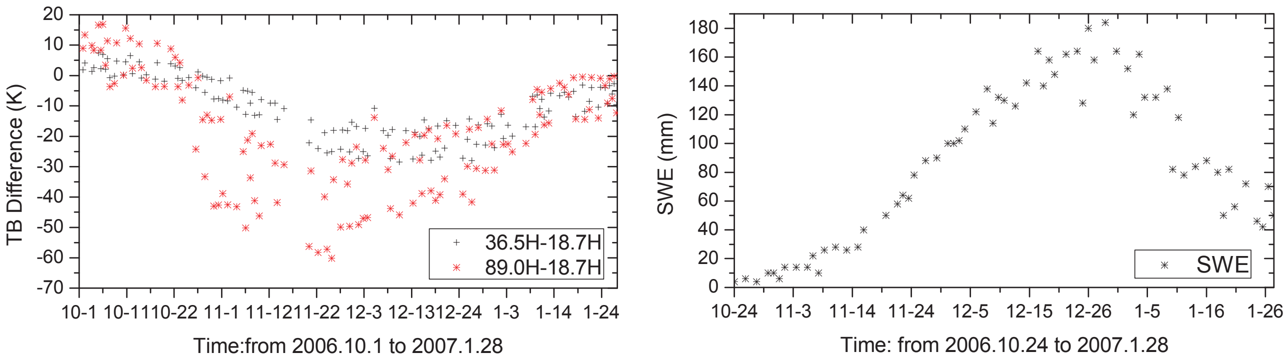

Fig.5 The AMSR-E SWE daily snow products (EASE-GRID) and the TB difference over the rectangle fig.3 (right)

RESULT AND FUTURE WORK

From what we have shown above, it can be argued that 1) the high frequency (89.0GHz) shows it's sensitive to the relative shallow snow pack, and this need the atmosphere effect elimination, 2) model simulation work is needed to explain the discrepancy of the snow evolution and brightness temperature gradient, 3) the SWE comparisons indicates the possible mixed pixel effect.

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