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Interactive comment on "Spatio-temporal Patterns of High Mountain Asia's Snowmelt Season Identified with an Automated Snowmelt Detection Algorithm, 1987–2016" *by* Taylor Smith et al.

Anonymous Referee #2

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General Comments

Passive microwave satellite data have been used for snowmelt onset detection on nearly all components of the cryosphere (e.g. ice sheets, sea ice, lake ice, and seasonal snow cover) mainly at the northern middle to high latitudes and Antarctica, where there is permanent or relatively stable snow accumulation each winter. It has also been used to classify daily freeze/thaw state dynamics for global vegetated land cover regions without distinguishing individual elements of the landscape (e.g. soil, vegetation, snow). The current study detects snowmelt onset/end dates and snowmelt season in Tibetan Plateau and its surrounding mountain ranges, and analyzes trends

in snowmelt timing during the 1987-2016 period. Snowmelt onset detection is based on the crossed-polarized gradient ratio (XPGR) algorithm developed in previous studies, and the end of snowmelt is determined by time series of Tb37v and snow water equivalent (SWE) calculated using the Chang et al. (1987) algorithm. It is a useful extension to previous studies. However, there are several caveats in the method used for snowmelt onset/end detection in this study as described below.

Specific Comments

First of all, there are no in situ observations used for either thresholds calibration or results validation. I wonder how the authors know the selected thresholds are associated with the actual snowmelt onset/end? Although a manual control dataset was generated and used for results evaluation, the control dataset was produced subjectively from the interpretation of the satellite data only.

The annual peak value of XPGR was used to identify snowmelt onset, which appears to correspond to dates of annual maximum SWE and very low Tb37v (Fig.3). Fig.3 shows that the brightness temperatures at 37GHz are <= 225K on the detected snowmelt onset dates for three out of the four winters. From my experience, the snowpack is unlikely to be melting under such low brightness temperatures. The magnitude of Tb37v was used as a condition for snowmelt detection in some previous studies, but it was always >= 248K.

The XPGR algorithm was developed and used for melt detection on the Greenland ice sheet. Several studies have shown that the XPGR technique detects less melt extent and duration than other algorithms (e.g. Ascraft and Long, 2006; Fettweis et al., 2006). Ascraft and Long (2006) compared six different melt detection methods using either active or passive microwave satellite data over the Greenland ice sheet for the year 2000, including the XPGR method. They found that compared to other methods, XPGR detected significant less melt extent and duration on Greenland (see Table 2 from their paper). Therefore in my opinion the XPGR method is not suitable for snowmelt detection, especially without proper calibration/validation.

"To determine the end of the snowmelt season, we choose either the date of the yearly maximum Tb37V value, which corresponds to the thinnest snowpack or to a 'bare earth' signal, or the first date where 4 out of 5 days have been within 2 cm of the yearly SWE minimum." SWE calculated using the Chang et al. (1987) algorithm was used for snowmelt end detection in this study. However, the Chang et al. (1987) algorithm was found to overestimate SWE or snow depth in western China (Chang and others, 1992; Che et al., 2008). SWE retrieval from passive microwave data is based on volume scattering of the microwave signals by snow, thus SWE can't be estimated accurately when the snowpack is wet. Most SWE retrieval algorithms are only applied to data from the morning orbit to mitigate the impact of wet snow. The snowpack is likely to be wet and shallow near the end of snowmelt, which would lead to erroneous SWE retrievals from the passive microwave data. Wang et al. (2013) showed that it was a challenge to discriminate wet snow from snow-free land using satellite data alone.

The estimated mean snowmelt periods in the current study are nearly 150 days for large areas of Tibetan Plateau during the 1987-2016 period (Fig.4), while Ke et al. (2016) showed that the annual mean snow cover days were 120 days during the 1981/82 – 2009/10 period based on observations from weather stations (see their Fig.3). This suggests that the detected snowmelt end dates in the current study are likely too late (Fig.5).

On account of the above, I recommend rejection of the paper.

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