THE BIG MELT IN GREENLAND DURING SUMMER 2012 DETECTED BY MWR ABOARD SAC-D/AQUARIUS

ID: C21B-0572

S. Masuelli[1], M.F. Labanda[1], M. Marenchino[1], M. Jacob[1]

[1] Comisión Nacional de Actividades Espaciales (CONAE), Argentina

ABSTRACT

An unusually strong melting occurred in mid-July on Greenland was reported by NASA. In this work we present the capability of the MWR (MicroWave Radiometer) sensor on board of SAC-D/Aquarius satellite to monitor this kind of phenomena.

INTRODUCTION

The National Space Agency of Argentina (CONAE, Comisión Nacional de Actividades Espaciales) developed the SAC-D/Aquarius science mission (launched in June 2011), together with the National Aeronautics and Space Administration of the USA (NASA). The main Argentinean sensor aboard the SAC-D is the MWR (Micro Wave Radiometer). This instrument is a three channel push-broom microwave radiometer with 8 antenna beams per channel and two different incident angles (52° and 58°), that provides a measurement swath of approximately 380 km. These channels provide 36.5 GHz dual horizontal and vertical polarized and 23.8 GHz horizontal polarized radiance measurements in an overlapping swath with the L-band Aquarius radiometer/scatterometer. The main objective of this instrument is to retrieve sea geophysical variables such as columnar water vapor, wind speed, sea ice concentration and rain detection.

On an average summer, about half of Greenland's surface ice melts, but during the summer of 2012 about 90 percent of the ice sheet thawed in mid-July, as was observed first by NASA Satellites. This kind of comprehensive surface melting is the biggest since satellites started monitoring the Arctic in 1979. However, some researchers believe that it might happen about every 150 years or so in Greenland, which would make this event unusual but not unprecedented (NASA, 2012).

Snow cover and snow water equivalent (SWE) were estimated by passive microwave sensors for more than 30 years (Foster et al 2008). Usually, algorithms exploit the strong response of the difference between 37 and 19 GHz V-pol bands to SWE for dry snow conditions, but the presence of liquid water within the snowpack alters strongly the microwave emission, given erroneous estimations (Walker and Goodison, 1993). Thus, the last operational algorithm for AMSR-E adds other microwave bands (23 and 89 GHz) in a more complex estimation method (Tedesco, 2012). Therefore, it is possible to use the algorithm with the MWR bands, but it remains the problem of bad classification for wet condition. For this reason, we try to determine areas having dry and deep snow and areas where snow melting or freezing is probably occurring.

METHODOLOGY

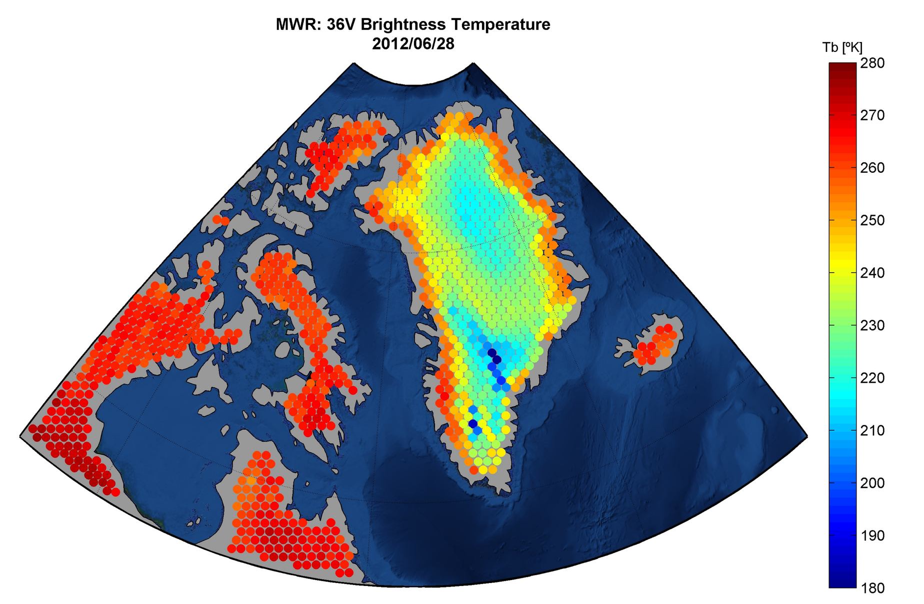
The swath of MWR is almost 400 km, so it is not enough to produce a complete daily image even for high latitudes. Thus, to obtain a global image it is necessary to combine passes of several days. As the re-visit of SAC-D is one week, the best way is combining a week of data to avoid spurious effects due to changes in the sequence of data acquisition. Hence, we produce daily products using a temporal window of a week of data, centered in the middle of it. The pixels of these images are the nodes of a geodetic grid of 60 km of distance between them (Randal et al 2002). On each pixel and for each band, we calculate the mean and the standard deviation.

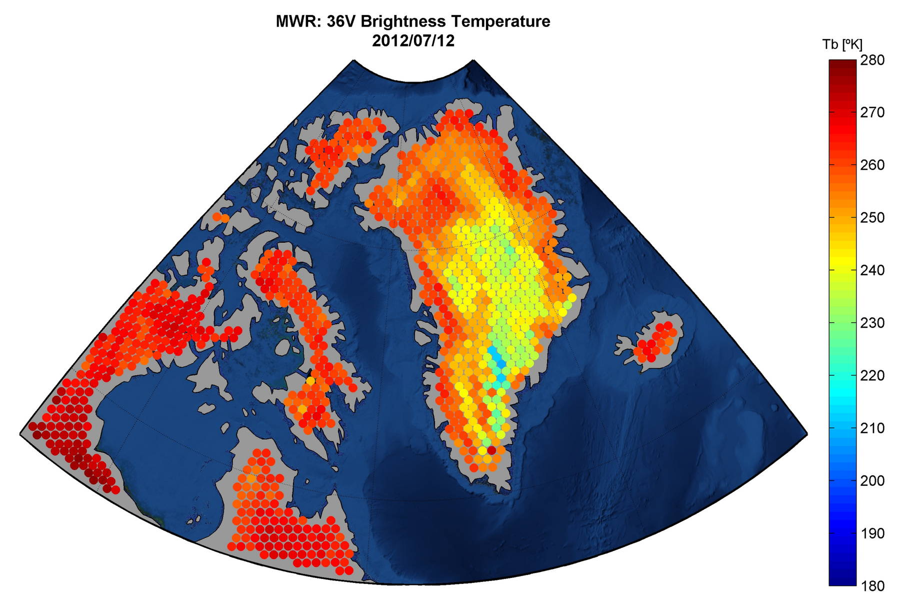
Our purpose is to detect deep changes in the surface properties and the natural scale of changes for MWR is a week. Therefore, we can use the mean of the data without taken into consideration any time dependance. Heterogenity or variability of data for each pixel can be assumed that is due to changes in the surface emissivity, inside the temporal window itself. Then, we can consider the standard deviation as an indicator of changes in the pixel for this time period.

First, to explore the inner capability of MWR data to separate between different land covers, we ran a fuzzy k-means classification method for several weekly products obtained. The analisys of these classifications shows that the best number of categories is 3, because it classifies reasonable dry and deep snow without commission errors all the seasons. Finally, using standard deviations we defined a coefficient of weekly amplitude variation (WAV) which is analogous to the diurnal amplitude variation or DAV (Foster et al 2008).

RESULTS

The following figures show the brightness temperature corresponding to 36.5 V-pol channel for two different dates: before and during the big melt of the Greenland snow pack.

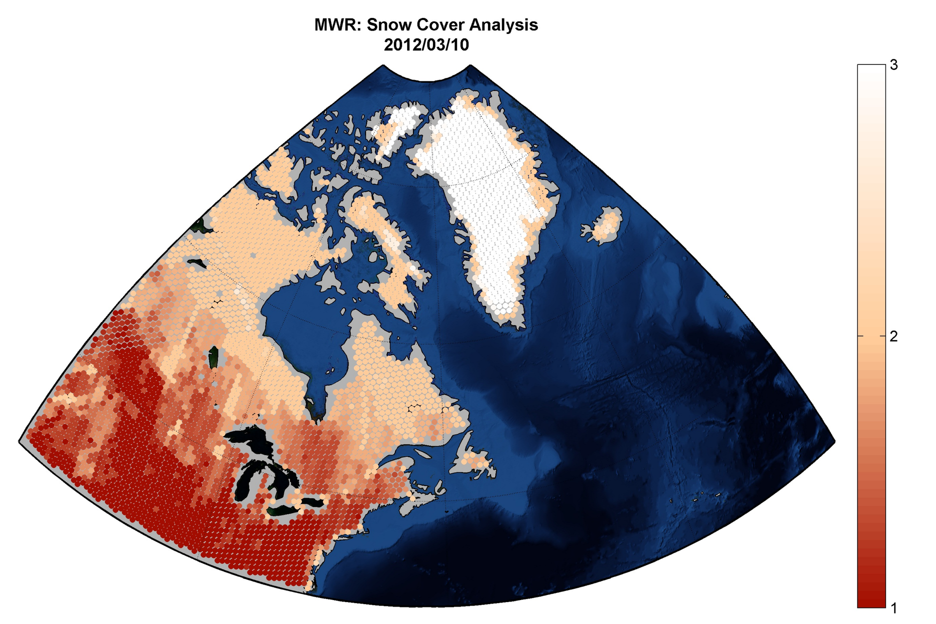




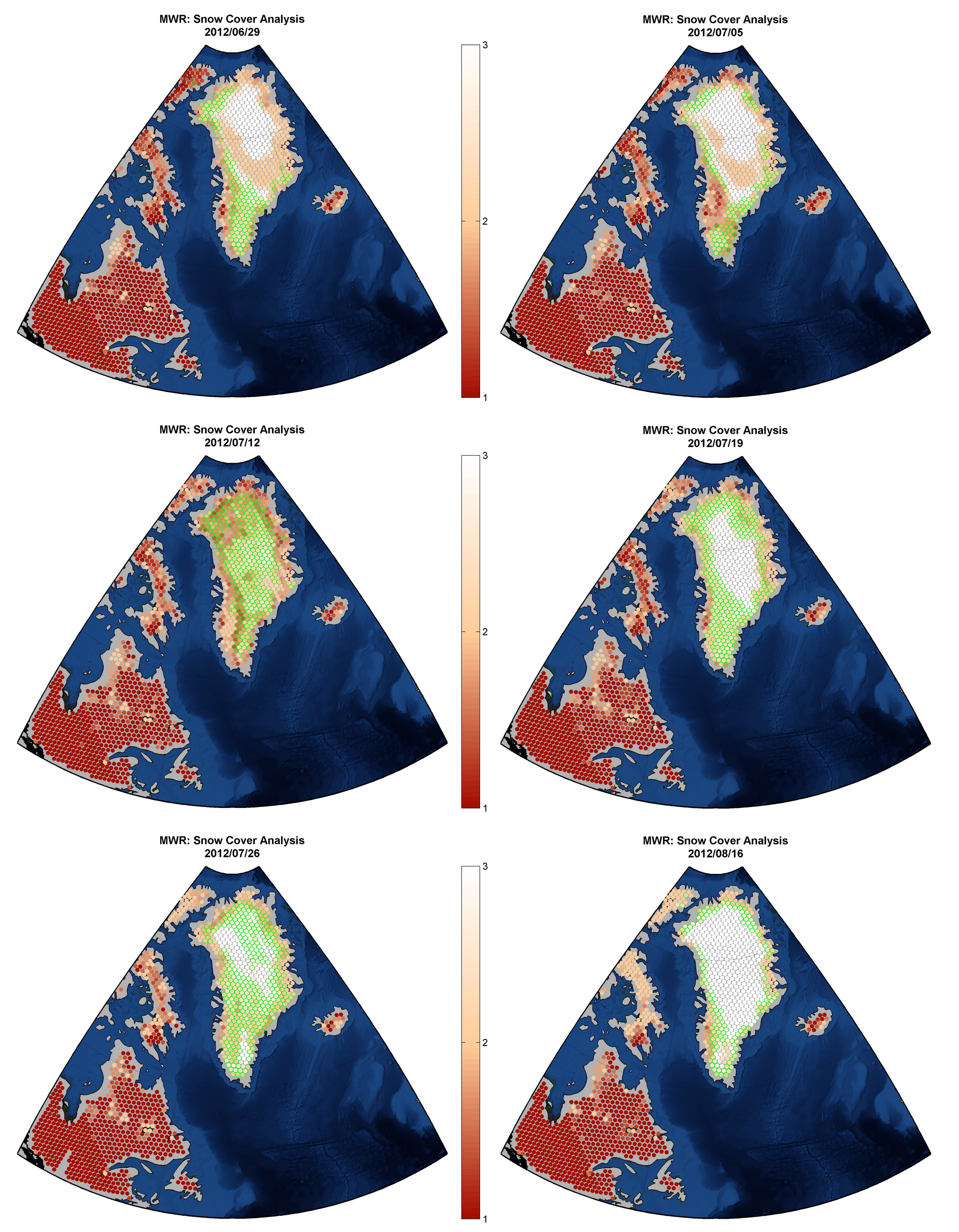
Comparing with the images published by NASA (Nasa, 2012), the pixels having brightness temperature below 240°K (yellow to blue) could be associated to dry and deep snow, and those having brightness temperature above 240°K (yellow to red) could be associated to free snow pixels or melting areas.

We can observe the response of the surface of Greenland changing notably during this period while the surface of Canadian Islands suffer less changes.

The map below shows the result of applying the classification rules for the March 10, 2012:



Clearly, white pixels correspond to dry and deep snow while pale reddish pixels seem to be related with less deep snow areas. We have not got the certain relations between the categories obtained by the classification method and the actually different kind of surfaces because we have not got the in situ measurements to do a proper training.

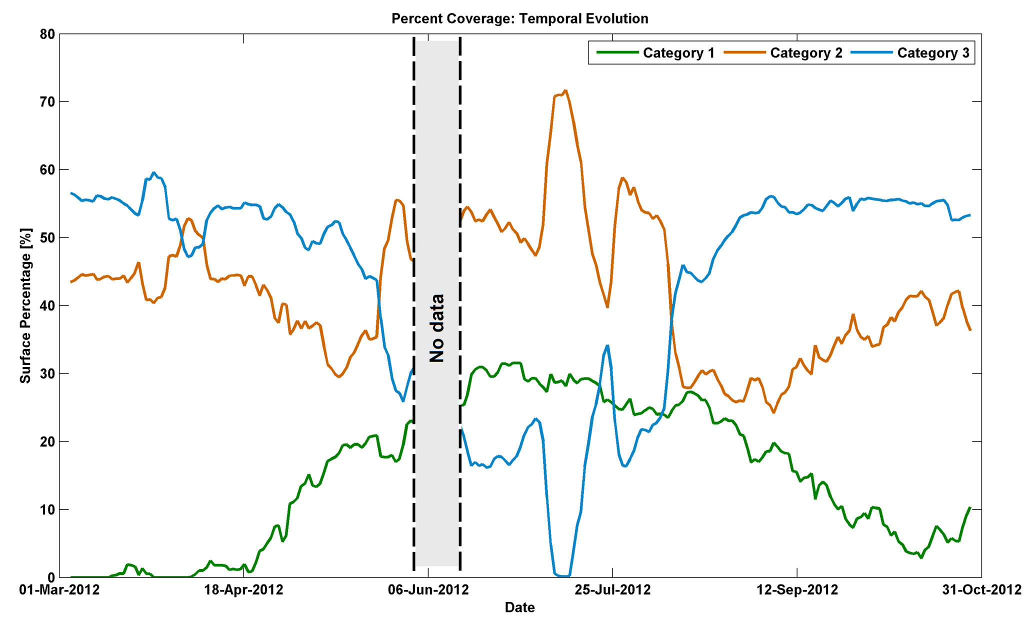


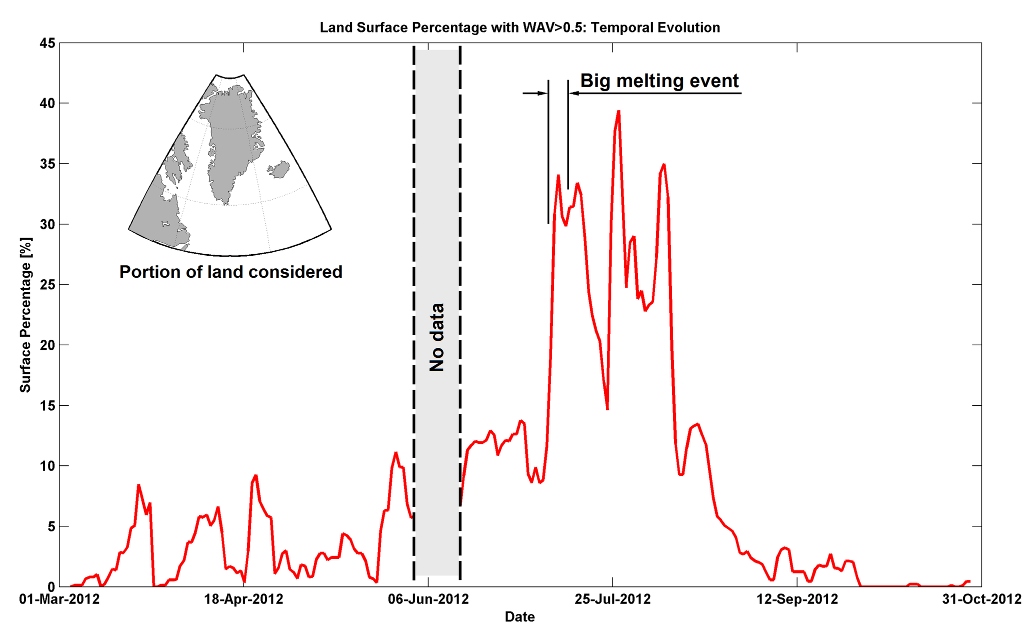
In the figures above we show a time sequence of weekly images, around the date of the strong melting event, that we applied the same classification rules applied in the figure above. Additionally, the border of the Greenlands pixels with great standard deviation were painted of green.

For all the figures, except to July 12, pixels with green borders are majorly located in the border between white and pale reddish regions. This fact shows that changes in the surface cover could be found in the interface between white and pale reddish regions.

The July 12 image shows a few white pixels and almost all the island has the border of the pixels in green. It is showing it is occurring strong changes in the surface cover that could be associated to an very extensive melting process. The increasing of the white pixels in the later images and the peak of pixels for category 2 and the corresponding deep fall for category 3, showed in the temporal evolution figure would confirm this melting process during about a 5 days.

The next figure shows the percentage of area covered by each category during the period from March to October 2012.





In the figure above, the surface covered by unstable events (WAV>0.5) shows a possible correlation with melting/freezing events.

DISCUSSIONS

Even though the big ice melting over Greenland surface lasted around 5 days, we found a series of instability events during about 40 days as a part of the complete melting/freezing process.

The results show that MWR sensor has enough capability to detect melting processes for areas with deep snow. To do this accurately, it is necessary to have a set of in situ measurements.

References

- D. Randall, T. Ringler, R. Heikes, P. Jones and J. Baumgardner: Climate Modeling with Spherical Geodesic Grids. *Computing in Science and Engineering*, Vol. 4, Issue 5, pp 32-41 (2002).
- J. Foster, S. Nghiem, M. Tedesco, G. Riggs, D. Hall and J. Eylander: A Global Snowmelt Product using Visible, Passive Microwave and Scatterometer Satellite Data. *Inter. Arch. of the Photogrammetry, Rem. Sen. and Spatial Information Sciences*, Vol. XXXVII, Part B8, Beijing (2008).
- A. E. Walker and B. E. Goodison: Discrimination of a Wet Snow Cover using Passive Microwave Satellite Data. *Annals of Glaciology*, Vol. 17, pp 307-311 (1993).
- M. Tedesco: Algorithm Theoretical Basis Document - NASA AMSR-E SWE product . Draft v5.0. NASA (2012)
- *http://www.nasa.gov/topics/earth/features/greenland-melt.html*