AQUARIUS RADIOMETER AND SCATTEROMETER WEEKLY-POLAR-GRIDDED PRODUCTS TO MONITOR ICE SHEETS, SEA ICE, AND FROZEN SOIL

Ludovic Brucker, Emmanuel Dinnat, Lora Koenig

NASA GSFC, Cryospheric Sciences Laboratory, Greenbelt, MD, U.S.A.

1. INTRODUCTION

Space-based microwave sensors have been available for several decades, and with time more frequencies have been offered. Observations made at frequencies between 7 and 183 GHz were often used for monitoring cryospheric properties (e.g. sea ice concentration, snow accumulation, snow melt extent and duration). Since 2009, satellite observations are available at the low frequency of 1.4 GHz. Such observations are collected by the Soil Moisture and Ocean Salinity (SMOS) mission, and the Aquarius/SAC-D mission. Even though these missions have been designed for the monitoring of soil moisture and sea surface salinity, new applications are being developed to study the cryosphere. For instance, L-band observations can be used to monitor soil freeze/thaw (e.g. Rautiainen et al., 2012), and thin sea ice thickness (e.g. Kaleschke et al., 2010, Huntemann et al., 2013). Moreover, with the development of satellite missions comes the need for calibration and validation sites. These sites must have stable characteristics, such as the Antarctic Plateau (Drinkwater et al., 2004, Macelloni et al., 2013). Therefore, studying the cryosphere with 1.4 GHz observations is relevant for both science applications, and remote sensing applications.

This study presents Aquarius weekly-polar-gridded products of L-band brightness temperatures (TB) and normalized radar cross sections (NRCS). These products allow for an efficient use of the Aquarius data over the polar regions, and can be used to move forward our understanding of the L-band observations of ice sheet, sea ice, and frozen soil.

2. AQUARIUS

The Aquarius passive instruments consist of three radiometers providing TB at 1.413 GHz at vertical and horizontal polarizations. They operate in a push-broom alignment at the incidence angles of 28.7°, 37.8°, and 45.6°. The sensors footprint dimensions increase as the incidence angle increases (from 76 km x 94 km, to 97 km x 156 km). The accuracy and stability of Aquarius radiometric observations is remarkably good. Observations have shown stability within ±0.2 K over the ocean and celestial Sky over several months. Aquarius' active instrument consists of one scatterometer observing NRCS at 1.26 GHz at the same three incidence angle as the radiometer, and at four polarizations: VV, VH, HV, and HH. The largest coverage of the polar regions is obtained over seven day. Aquarius TB and NRCS observations are distributed by NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC), as along track products.

3. AQUARIUS WEEKLY-POLAR-GRIDDED PRODUCTS

To allow for an efficient use of the Aquarius data over the polar regions, and to move forward our understanding of the L-band observations of ice sheet, sea ice, permafrost, and polar oceans, weekly-polar-gridded products were developed. The gridded products were produced on the version 2.0 Equal-Area Scalable Earth (EASE) grid (Brodzik et al., 2012). Each grid cell is 36 km x 36 km. This grid and resolution were selected because they offer a fair compromise between Aquarius' high sampling along track (an observation every 10 km) and the distance between tracks, and they will be used by the forthcoming NASA's Soil Moisture Active/Passive mission. Gridded data were produced using all the valid Aquarius observations from the seven-day satellite cycle (i.e. observations deemed as RFI free, and recorded during nominal operation of the spacecraft).

For TB, each radiometer was treated independently to produce three weekly-gridded TB products corresponding to observations from the ascending orbit, the descending orbit, and both orbit types combined. The distinction per beam is necessary due to the different incidence angles, which lead to different reflection intensities at the interface created by dielectric constant changes (e.g. snow/air interface). For each seven-day cycle, all observations from a given radiometer whose footprint center was within a given 36-km grid cell were averaged together, and the standard deviation was calculated.

For NRCS, each beam and each orbit type was treated independently. The distinction for each beam is also needed due to the different incidence angles. The distinction between each orbit type is necessary because of the anisotropy of the ice covered surfaces.

4. RESULTS

An initial analysis of the Aquarius weekly-polar-gridded products was carried out over the Greenland and Antarctic ice sheet, sea ice in both hemispheres, and frozen soil in subarctic regions. For the ice sheet, we discuss the spatial patterns (Figure 1), and we also highlight the effect of the 2012 summer melt event at Summit, Greenland which created a sudden TB variation including a drop larger than 15 K and 20 K at vertical and horizontal polarization, respectively. After the melt/refreeze cycle, the TB level remained ~5 K lower than before the event, revealing the significant impact that a refrozen snow layer can have on the L-band TB, and thus on the monitoring of long-term snow accumulation.

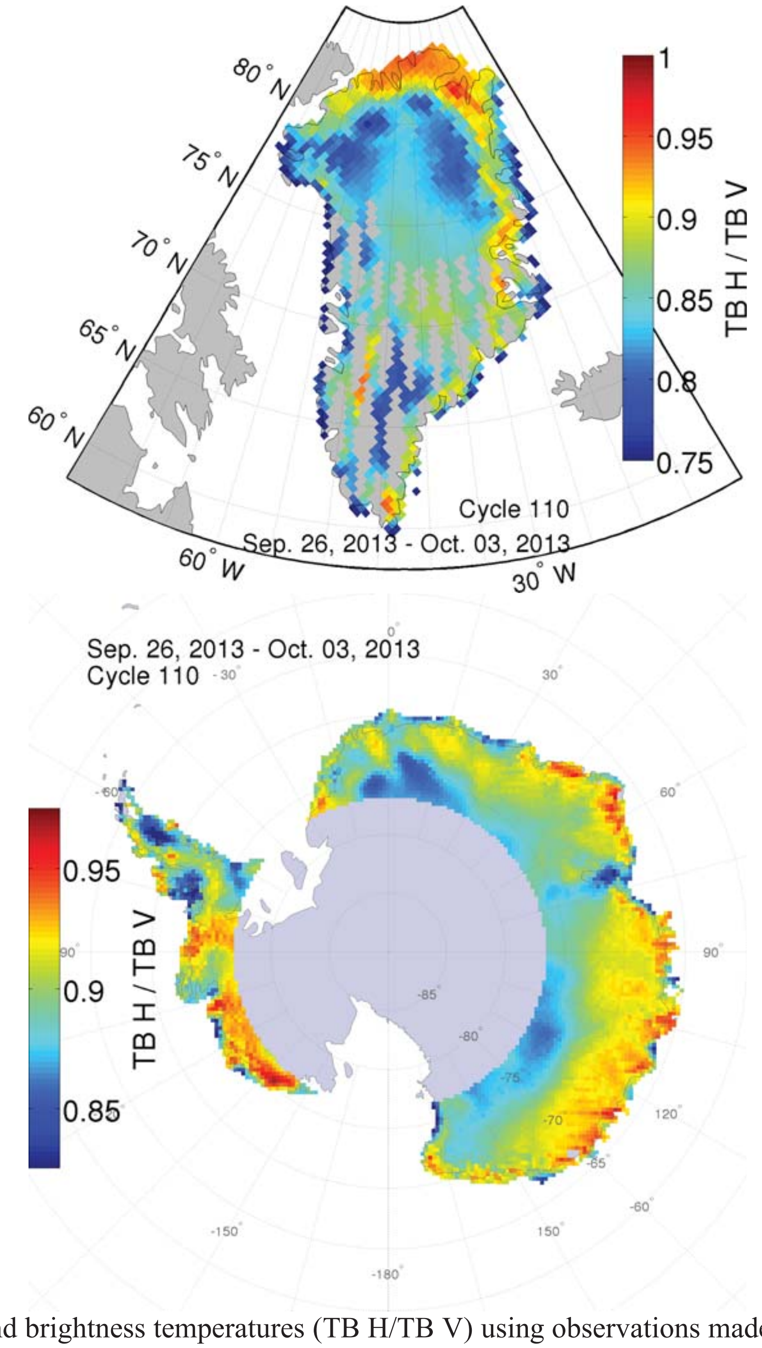

Figure 1. Ratio of L-band brightness temperatures (TB H/TB V) using observations made with an incidence angle of 45.6° over the Greenland (top) and Antarctic (bottom) ice sheets during the week Sept. 26 – Oct. 3, 2013.

Over sea ice, both TB and NRCS show strong seasonal cycles. TBs are the highest when snow on sea ice is melting, and decrease during the summer months when the sea ice cover is melting and more fractured, with wider leads exposing open water. NRCS has the lowest values (about -20 dB) when the sea ice cover is packed and snow covered. NRCS values increase in summer and reach their maximum (about -12 dB) in fall before snow accumulates.

A frozen soil has a distinct scatterometer signal at L band. To present the potential of the products for monitoring soil physical state, time series of TB and NRCS are presented at three locations (northern America, Asia, and Europe). At these locations, fall and spring transitions are easy to identify, especially in the scatterometer observations.

5. CONCLUSION

In addition to monitoring soil moisture and ocean salinity, low microwave frequency observations made by Aquarius can be used for studying the ice sheets, sea ice, and subarctic soils where frozen soil may exist. To that end, Aquarius weekly-polar-gridded products of L-band TB and NRCS were developed, and made available on the NASA Cryosphere Science Research Portal: http://neptune.gsfc.nasa.gov/csb/index.php?section=273. They cover the entire Aquarius mission period since its start in August 2011.

6. REFERENCES

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