MAMM Level-1, Single-Look-Complex Image Product Validation

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1.0 Introduction

The Modified Antarctic Mapping Mission commenced in September 2000 and concluded in November 2000. The region of Antarctica from 80^{o} S to the coast was imaged with Fine 1, Standard 6, Standard 2, Standard 1 and Extended Low beams. The area was during three repeat cycles and for each repeat cycle nearly complete ascending and descending coverage was acquired.

Signal data were downlinked to the McMurdo Ground Station in real time and, more often, were stored on the satellite for downlinks to the Alaska SAR Facility, Prince Albert Satellite Station, and Gatineau Satellite Station. All of the signal data were transferred to ASF for processing to Level 1 (L1) Single Look Complex (SLC) data in CEOS format. The ASF-provided L1 data were also calibrated and can be used to compute the backscatter coefficient. As noted, the original L1 data need slight adjustments to account for differences between the doppler bandwidth (900 Hz) used to process the calibration target data and the doppler bandwidth (PRF – 100 Hz) used to process the MAMM data. These effects contribute less than 1 dB bias to the backscatter coefficients estimated from the L1 data.

This report describes various tests devised to validate the L1 products. Tests include: geolocation accuracy; radiometric accuracy; and tests of the processing algorithm such as verifying that the data are single look.

2.0 Geometric Accuracy

2.1 Tie Point Comparisons

The geometric accuracy of the SLC products was tested by orthorectifying a data swath using only the ephemeris information supplied with the data. We selected a test site on an island just south of the Drygalski Ice Tongue (Figure 1). We chose a coastal area to minimize uncertainties introducted by our digital elevation model. We observed about a 250 m offset between the MAMM 25 meter product with the AMM-1 25 meter. This is consistent with the expected accuracy of the CSA supplied restituted ephemeris. Though not strictly related to SLC product validation, we note that MAMM data are being block adjustment using control points selected from the AMM-1 mosaic. This decision is based on our requirement for many more MAMM ground control points (because of the shape of the blocks and because we do not image South Pole Station on each orbit as was done with AMM-1). We also reviewed this decision with the Antarctic Mapping Planning Group who concurred. An example of the registration between final MAMM orthorectified imagery and AMM-1 imagery is shown in figure 2. The registration is accurate to better than 75 m or about 3 pixels.

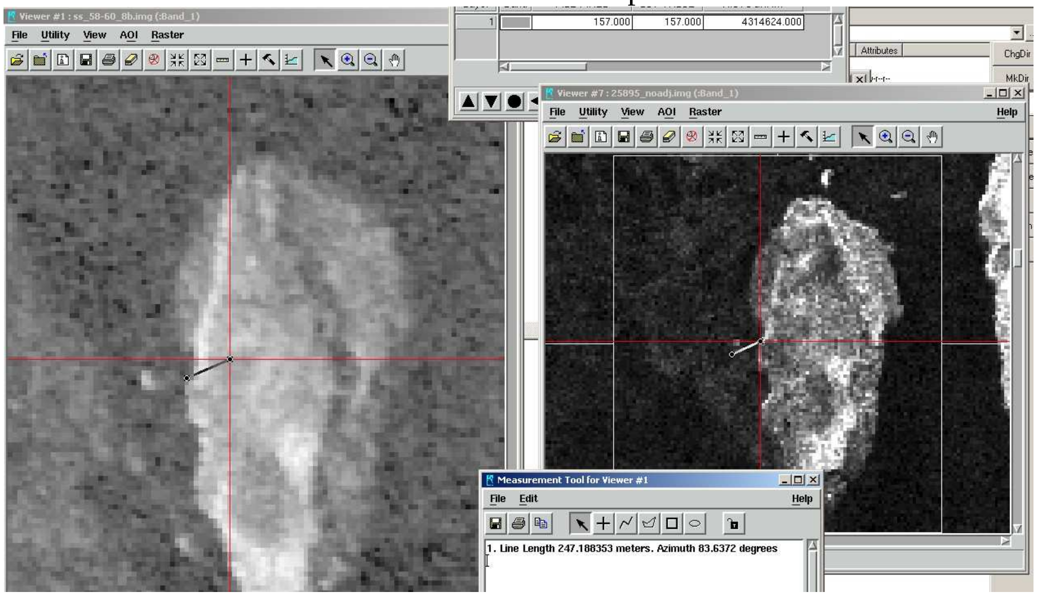


Figure 1. Comparison between the location of a feature identified in the MAMM data (right) and AMM-1 data (left). We observe about a 250 m difference when the MAMM data are orthorectified using solely the ephemeris data.

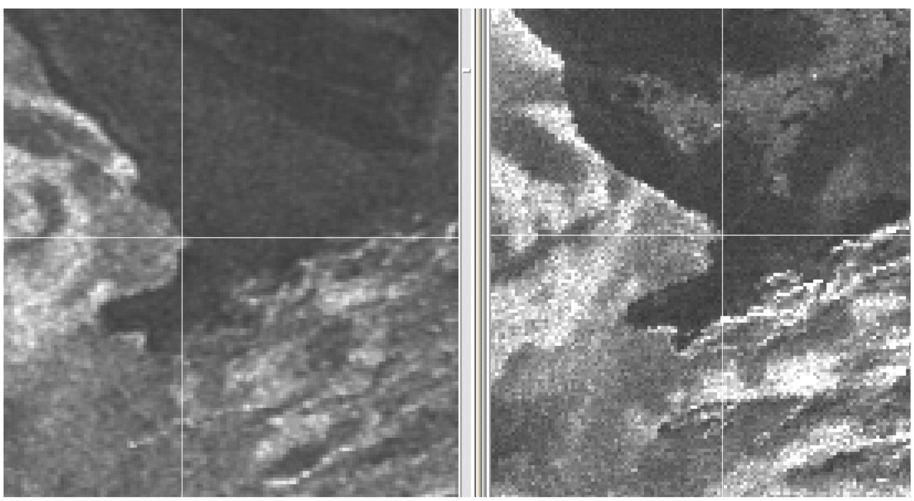


Figure 2. AMM-1 version 2 file (left) and MAMM 25 block overview (right). Cross hairs are linked between images.

2.2 Coastline Comparison

3.0 Radiometric Accuracy and Looks

We compute backscatter coefficients from the ASF L1 MAMM data by compiling histograms of relatively homogeneous targets. We compute the number of looks by taking the ration of standard deviation and mean of pixel amplitude. The value is compared to predict values given by relationships found in Ulaby Moore and Fung.

We compare AMM-1 and MAMM mean values of backscatter coefficient. We attempt to assess difference by examining expected biases related to beam geometry.

3.1 Clark Glacier – Bright Target Test Site, MAMM Fine 1 Beam

We compared backscatter coefficients for F1 beam data measured during AMM-1 and MAMM for a bright target on Clark Glacier near the Drygalski Ice Tongue. The location is shown in figure 1. The glacier surface is bright because ice lenses form during brief episodes of summer melt. Based on in situ observations of the percolation zone (Jezek, and others, 1995) we expect the backscatter coefficient to vary less than 2-3 dB with incidence angle between 20 and 50 degrees.

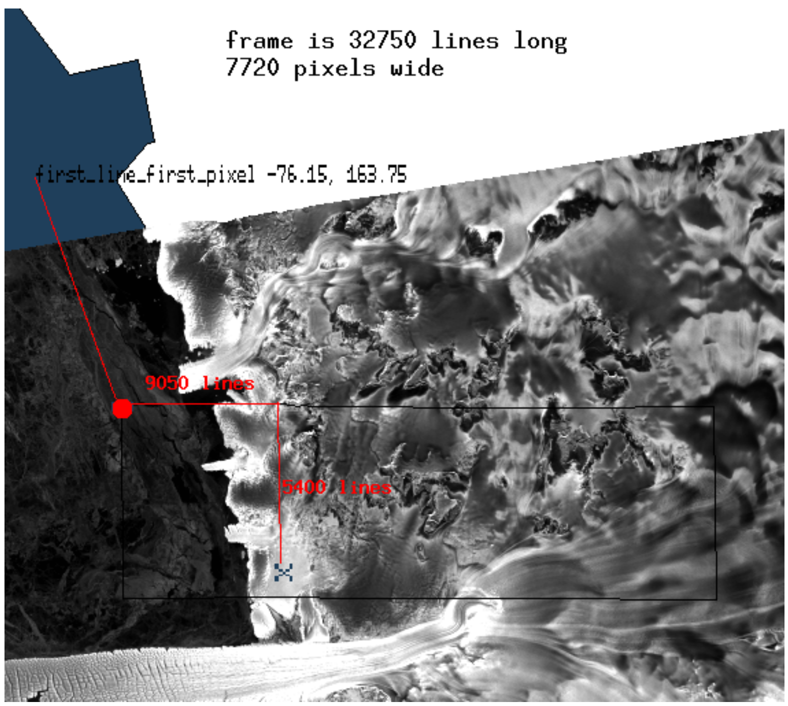


Figure 1. Bright target test site on Clark Glacier which is south of the Drygalski Ice Tongue (bottom of the image).

We extracted an SLC image chip (3000x3000 pixels) from the MAMM acquisition (orbit 25252) and converted the data to floating point intensity values. We used the Vexcel utility named readCeosSLC to extract the data (this means that there will be less than 1 dB error introducted because the backscatter values reported here do not have correction for along track doppler centroid drift or compesations for differences between the doppler bandwidth used for ASF calibration targets and the doppler bandwidth used to process this scene). The intensity image is shown in figure 2.

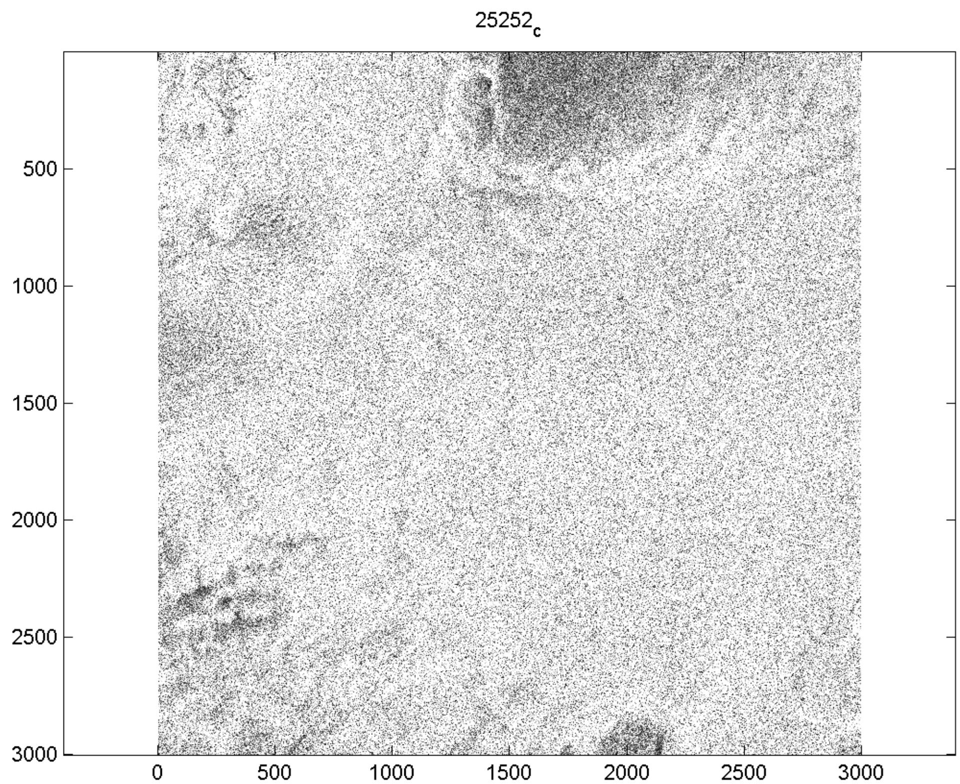


Figure 2. MAMM data used for estimating backscatter for a bright surface.

The image is generally homogeneous save for the top which seems to be the start of a highland. In any case the backscatter coefficient was calculated for the entire image. The histogram of backscatter coefficient is shown in figure 3 (which may be slightly biased because of the dark area at the top of the scene). The backscatter coefficient is about –8.2 dB and the ratio of the standard deviation of the amplitude to the mean of the amplitude is about 0.56, consistent with one-look data.

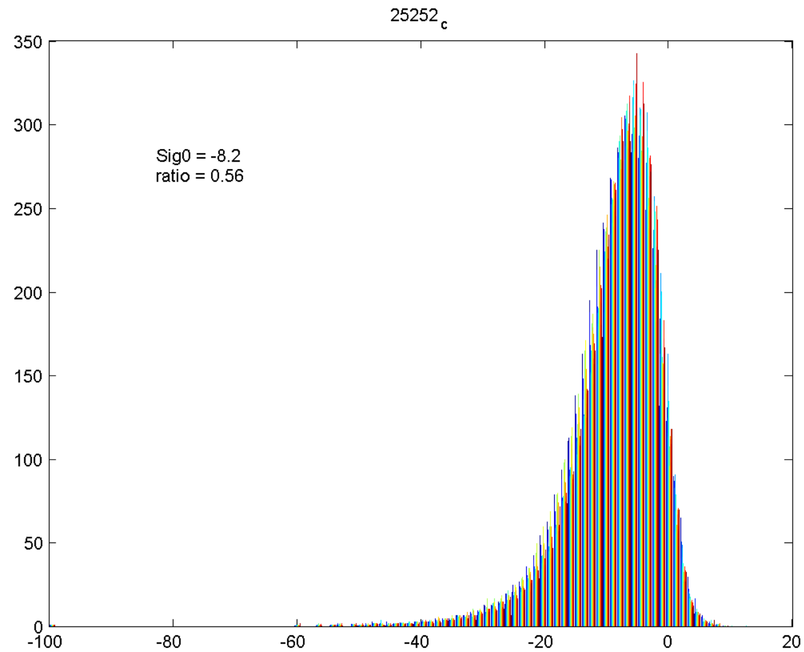


Figure 3. Backscatter coefficient histogram for MAMM orbit 25252

We also selected a portion of the AMM-1 for comparison. We used the AMM-1 tile product and getsig0 program to extract backscatter coefficients. The test area is shown in figure 4. The coverage is from Standard Beam 2.

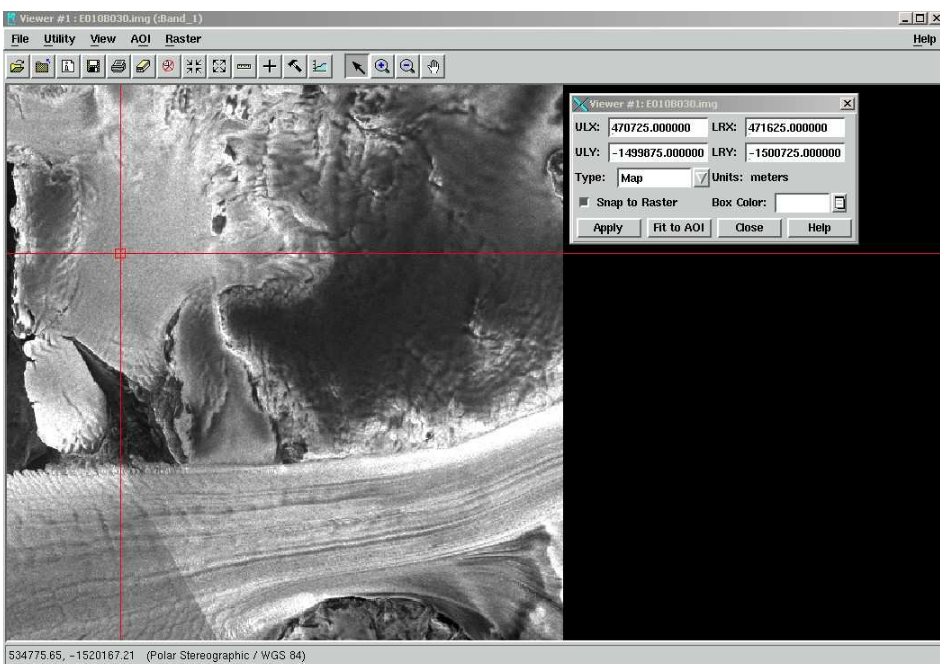


Figure 4. AMM-1 test area

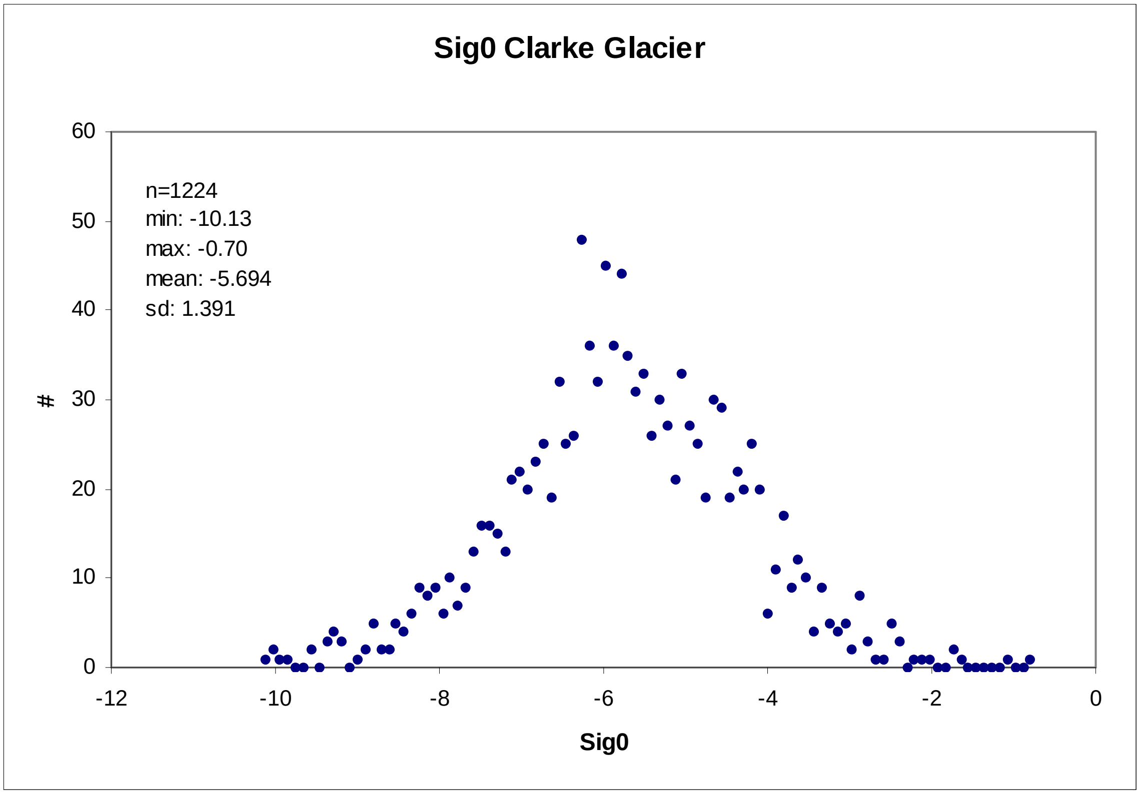


Figure 5. Backscatter coefficient of the AMM-1 test area.

The backscatter cofficient is about –5.7 dB. The difference between the MAMM amd AMM-1 data is about –2.5 dB. This is acceptable given the requirements of 2 dB absolute calibration uncertainty, the slight difference in test image area, and the different incident angle.

3.2 MAMM Dark Test Area

For our dark test area, we selected an area imaged during MAMM orbit 25237. The general area is shown in figure 6 and and enlargement is shown in figure 7. A portion of the MAMM SLC data were extracted for the test area and used to create the historgram shown in figure. The mean sigma nought is quite low, -22.9 dB.

Inspection of about 25 AMM data points yields an average sigma 0 of –13.5 dB. The difference between the AMM and MAMM data of 9.4 dB seems to be too large to be explained by changes in incidence angle. Results from Rack and Rott, suggest that we might expect a maximum difference of about -6 dB.

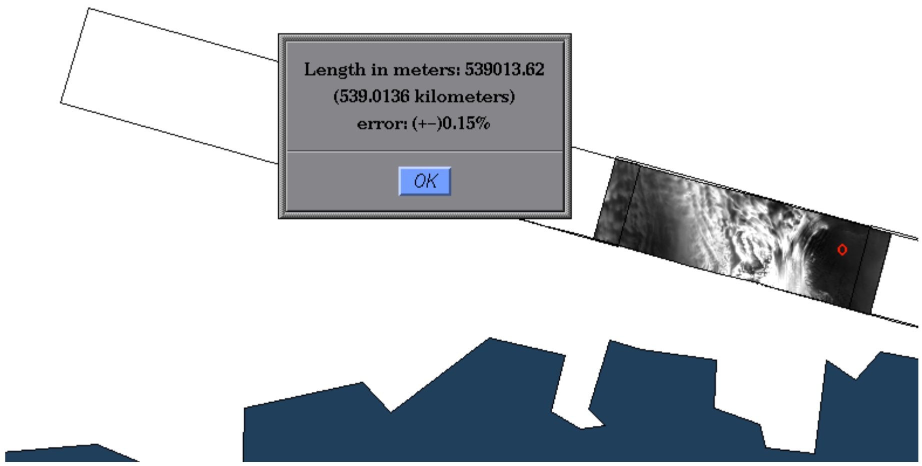


Figure . MAMM orbit 25237 intercepting the Wilkes Land Coast

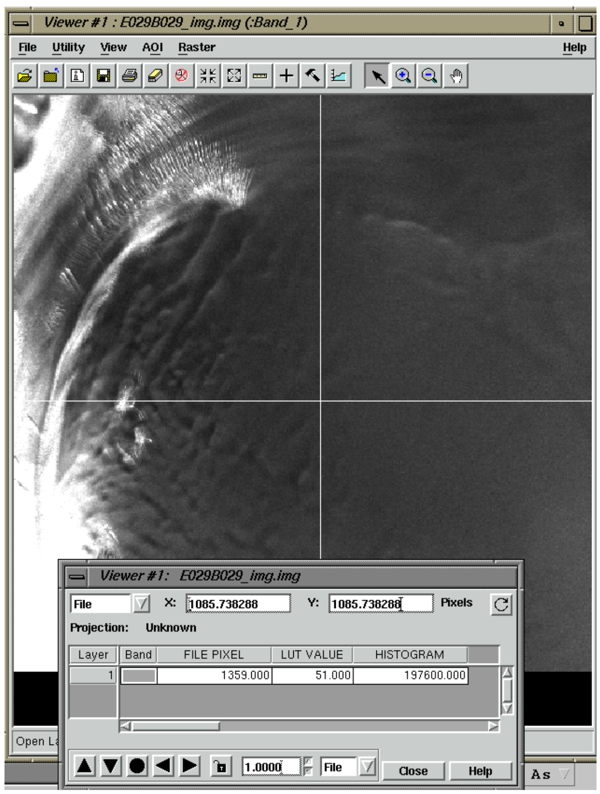
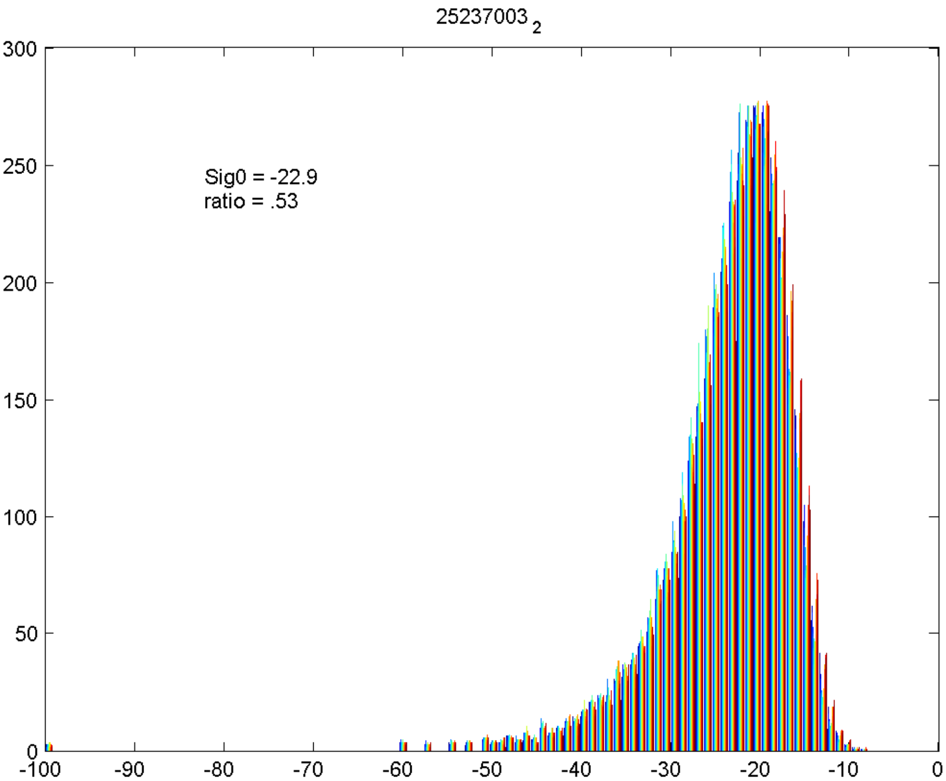


Figure Enlargement of dark test area on AMM-1 image mosaic.



3.3 MAMM Cycle 1,2,3 Comparison

We compared MAMM cycle 1, cycle 2 and cycle 3 data over the same test area (69.93S and 153.84E) to determine how much backscatter might be changing over the 24 day intervals. Information on the three cycles are given in table 1.

	Cycle 1 (25394)	Cycle 2 (25737)	Cycle 3 (26080)
Acquisition Date	9/15/2000	10/9/2000	11/2/2000
Processor Bandwidth	1000 Hz	1000 Hz	1225 Hz
Mean sigma 0	-16.3 db	-15.9 db	-16.96 db
Std/mean	0.54	0.54	0.54

We plotted SSMI brightness temperatures over the center of the test area. Notice that there is a general warming interrupted by abrupt brightness temperature increases. Fluctuations in snow temperature and hence in penetration depth may be responsible for some of the variability in backscatter coefficient. The magnitude of the abrupt increases (much less than the a black body temperature) suggests the surface is still frozen.

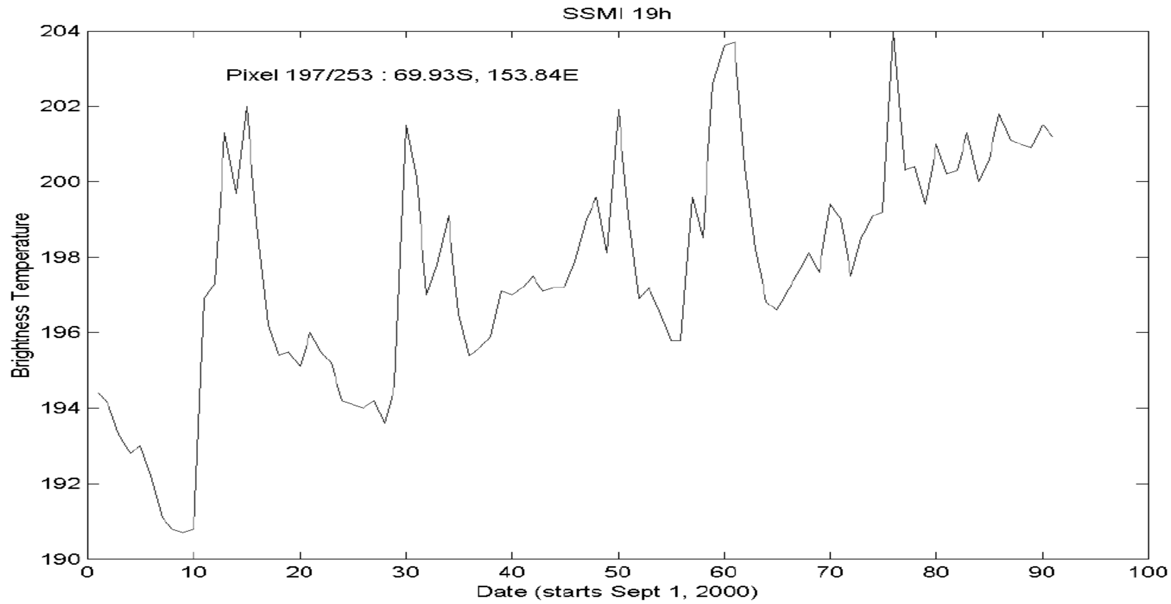


Figure . 19h passive microwave brightness temperature. Days 15, 39 and 63 correspond to the SAR observations during MAMM.

References:

Jezek, K., P. Gogineni, M. Shanableh, 1994. Radar measurements of melt zones on the Greenland Ice Sheet. Geoph. Res. Let., 21, 33-36.

Noltimeir, K.F., and K.C. Jezek, 1995. Variations in Radar Backscatter Across the Great Ice Sheets. BPRC Technical Report No. 95-04. Byrd Polar Research Center, The Ohio State University, Columbus, OH, 35 p.