ANALYZING RADAR BACKSCATTER OF LAND WITHIN THE TRMM FOOTPRINT USING HIGH RESOLUTION SAR

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1. INTRODUCTION

The Tropical Rainfall Measurement Mission Precipitation Radar (TRMM-PR) produces an estimate of the rain rate using the Surface Reference Technique (SRT) [1]. Essentially, this technique subtracts the measured surface backscatter through precipitation from an estimate of what the backscatter would be without precipitation to obtain the path attenuation. Over land, there are four schemes currently being used to determine the reference (non-precipitation) backscatter, or Normalized Radar Cross-Section (NRCS). The first uses a temporal reference which consists of monthly rain-free statistics calculated over a latitude-longitude grid of $1^\circ \times 1^\circ$. The statistics are then categorized by the 26 incidence angles used by the TRMM-PR. Two other methods use a spatial reference calculated from the NRCS of nearby non-rain cells (fields of view). One uses cells at the same incidence angle just prior to the rain cells and is referred to as the along-track spatial reference, while the other examines cross-track cells in a algorithm to handle different incidence angles and various conditions. A spatiotemporal global reference is the fourth technique. Given results from these schemes, the algorithm selects the one with the smallest variance which is typically one of the spatial reference techniques. While the SRT works reasonably well given the complex nature of NRCS over land, it has been shown that biases exist especially due to impact of surface water due to recent precipitation [2].

One of the contributing factors to the complexity of land NRCS is the spatial variability. At the current altitude, the TRMM-PR resolution cells on the surface are approximately 4.3 $\mathtt{km}^2$ at nadir and spacebourne scatterometers and altimeters typically have a lower resolution. In contrast, Synthetic Aperture Radar (SAR) has a very high resolution, typically on the order of tens of meters or less. Although SARs operate in lower frequency ranges (P to X band vs. Ku band) and incidence angles higher than the 18° for TRMM, they can be a powerful tool for analyzing surface backscatter characteristics. The research described here presents the results of this analysis using C-band SAR data over central Florida, USA.

2. APPROACH

Synthetic Aperture Radars were designed to study planetary surfaces at high resolution. Due to this resolution, different operating frequency and incidence angle, it is not reasonable to compare SAR data to TRMM directly. However, we can study the variability of the NRCS within the TRMM field of view and how that changes over time, especially during or after recent storm activity. From 08 January 2006 until 13 April 2008 the Canadian RadarSat-1 SAR acquired data over central Florida in two stripmap modes at approximately 27.5 and 37 degree incidence angles (modes ST2 and ST4 respectively). RadarSat-1 operates in HH polarization at C-band (5.3 GHz) with a repeat orbit of 24 days. With some gaps, this resulted in about 260 images from 9 frames containing more than 50% land. The ground resolution of single look imagery for the two beam modes is roughly 17.6 m cross-track by 5.3 m along-track for ST2 and 19.3 by 5.1 m for ST4.

A common coordinate system is required to determine the SAR pixels covered by a TRMM overpass, so the RadarSat-1 NRCS images were orthorectified at an equal angle latitude-longitude spacing of 1/2048 degrees - approximately 50 m in this region. This transformation also multilooks the data resulting in a decrease in speckle noise. TRMM has a completely different orbital pattern, and is not designed for precise repeat passes, so all TRMM-PR swaths that intersect a SAR frame within a day of acquisition were selected for analysis. The data was re-gridded to align with the SAR data using a linear interpolation scheme for σ^0 and the incidence angle, while the land/ocean/coast flag and the minimum echo flag used to indicate possible or definite rain used nearest neighbor interpolation. First and second order statistics were then calculated, grouping the TRMM-PR incidence angles into the original 25 bins where positive and negative angles are considered the same. Histograms were then generated to show the NRCS variability within TRMM-PR fields of view.

In addition to these two radar systems, three National Weather Service WSR-88D ground-based weather radars cover the region of interest. Since these radars collect data continuously, they can be used to determine precipitation occurring prior to and during the SAR and TRMM acquisitions. The Level-III precipitation accumulations can be used to indicate areas where surface water is likely to be present over land regions. The NRCS measured from RadarSat-1 and TRMM-PR at these times are then compared to data acquired when no recent rain activity was present. Thus, we explore the impact of precipitation on the observed NRCS.

3. CONCLUSION

The analysis and results presented from this work provide a more detailed look into the impact of precipitation on radar backscatter over land. The histograms show that in many cases, there is significant variability of the surface NRCS within the TRMM-PR field of view, which also provides more support of sub-footprint σ^0 estimation techniques [3]. This lays the groundwork for the development of algorithms to help reduce the bias in rain rate estimates from the TRMM-PR over land.

4. REFERENCES

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