MULTI-FREQUENCY INTERFEROMETRIC SYNTHETIC APERTURE RADAR (INSAR) DATA FOR CHARACTERISING THE TOPOGRAPHY AND LAND COVER IN AUSTRALIAN ANTARCTIC TERRITORY

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1. INTRODUCTION

This project investigated the use of multi-frequency (X- and L-band) Interferometric Synthetic Aperture Radar (InSAR) data for Digital Elevation Model (DEM) generation, coastline detection and land cover mapping over three islands in Australian Antarctic Territory. Accurate elevation data and land cover information is essential for topographic mapping, coastline monitoring, surface characterization and change detection [1, 2]. SAR Interferometry can be used to extract information about the height of the terrain using the phase of the signal [3]. SAR intensity data provides useful information on surface type and structure, and multi-temporal data can be acquired to assess change in remote and cloud-affected areas [4].

In this study, we acquired multi-temporal L-band ALOS PALSAR data (acquired between 2006 and 2009) and JERS-1 data (acquired between 1993 and 1994) over Macquarie, Heard and McDonald Islands. X-band TerraSAR-X data was acquired over Heard Island in 2009. Data from the NASA JPL Shuttle Radar Topographic Mission (SRTM) in 2000 was also available for all islands. Conventional InSAR processing was applied to generate DEMs for the three islands using X- and L-band SAR data. Topographic change was assessed through comparison of the best DEM for Macquarie Island with a DEM previously generated using NASA JPL TOPSAR data. Similarly, the best DEM for Heard Island was compared to a previous DEM generated using Radarsat-1 data. Differential InSAR (DInSAR) techniques were also applied to identify possible areas of land deformation.

The SAR data were processed to radar backscatter using standard equations. Segmentation and rule based classification were applied to the SAR data to map the dominant landforms and cover types. Validation data including Quickbird imagery, oblique aerial photographs and ground survey were provided by the Australian Antarctic Division (ADD). The coastline of each island was detected using filtering and thresholding techniques.

The derived DEMs and spatial map data will be made available to the AAD for inclusion in their topographic database and use in scientific investigations.

2. DATA PROCESSING AND RESULTS

2.1. InSAR DEM generation

Multi-temporal ALOS PALSAR data were acquired for Macquarie, Heard and McDonald Islands. Both Fine Beam Single (FBS; HH polarisation) and Fine Beam Dual (FBD; HH+HV polarisation) Single Look Complex (SLC) data were acquired at an incidence angle of 34.3°. Using 2-pass interferometry, DEMs were generated at 10 m and 20 m spatial resolution using the ALOS PALSAR FBS and FBD data respectively. An example of the interferogram generated for Heard Island is shown in Figure 1. The areas of high coherence are evident along the coast. Decorrelation was evident in some of the interferograms and presumably related to snow cover at the time of image acquisition. Layover and shadow effects were also limiting at high altitudes.

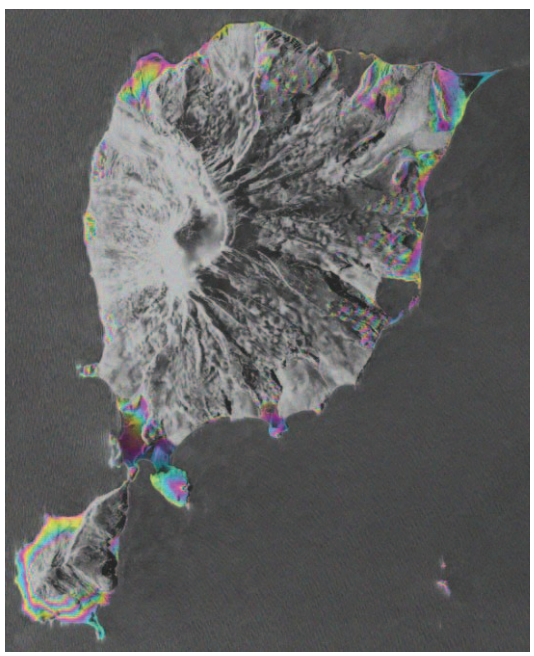

Figure 1. Two-pass interferogram in slant-range projection generated using ALOS PALSAR data for Heard Island: Pair IP1 (6 March 2007 and 6 June 2007), Bperp = -776.1 m and Btemp = 92 days.

DEMs were also generated for all islands using 3-arc second SRTM data retrieved from the NASA JPL website. The capacity to ease the phase unwrapping process and produce a higher quality DEM using the coarser resolution SRTM data as reference was evaluated. High resolution TerraSAR-X data was also acquired over Heard Island in 2009 and used to generate a DEM.

For comparison, previous DEMs generated using NASA JPL TOPSAR data (August, 2000) were available for Macquarie Island [5] and Radarsat-1 data (February/March, 2002) for Heard Island [6]. The DEM generated for McDonald Island was the first of its kind, and no previous DEM was available for comparison. Cross-sections were extracted from the DEMs and the difference in height information compared. DInSAR processing of the Heard Island data revealed an area of possible land deformation.

2.2. Terrain mapping and coastline detection

SAR data were converted to radar backscatter coefficient using standard radar equations and calibration coefficients specific to the sensor. The calibrated SAR data was then geo-referenced using available SPOT-3 and Quickbird data and ground survey points. Adaptive filtering was applied to minimize noise and image speckle prior to classification. Difference maps were computed that showed the change in brightness between image pairs, and related to changing surface and/or snow cover. Multi-frequency SAR backscatter data were segmented and classified to map the broad landscape units and land cover classes. GIS layers comprising the geology, land cover, settlements and coastline, and oblique aerial photographs and field survey data were available through the AAD to assist in interpreting the SAR data and derived classifications. The coastline of each island was detected by applying thresholds to differentiate between water, wave-cut platform and/or land, and used to generate vector polygons.

3. CONCLUDING REMARKS

Our initial results indicate that the ALOS PALSAR and TerraSAR-X data are suitable for DEM generation using conventional InSAR techniques in sub-Antarctic areas. The timing of image acquisition is critical however, to minimize the effects of temporal decorrelation and noise in the DEMs. The use of a reference DEM in the InSAR process appeared to improve the accuracy of the final DEM. Backscatter intensity data provided a valuable source of information on surface cover and condition. The integration of X- and L-band data improved the classification of land cover on Heard Island. The longer wavelength ALOS PALSAR data were well suited to coastline detection due to the high coherence and quality of the data.

The continuity of InSAR data collection over Antarctic regions seems ensured, with ongoing acquisition by ALOS PALSAR, ENVISAT and Radarsat-2. These data provide a valuable resource for DEM generation and terrain mapping in these largely inaccessible regions. Archive data can also be used to generate baseline terrain and elevation information against which to assess change; of particular relevance given the predicted impacts on ocean levels and snow/ice condition as a result of global warming.

4. REFERENCES

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