# COMBINING SAR AND DISP IMAGERY TO INVESTIGATE THE STRUCTURAL AND GLACIOLOGICAL SETTING OF THE TRANSANTARCTIC MOUNTAINS

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## ABSTRACT

We present a comparison between regional scale satellite imagery of the Transantarctic Mountains (TAM), Antarctica. Our reference data set is the 1997 RADARSAT SAR mosaic. The 25 m pixel, 5.3 GHz SAR data were geocoded and terrain corrected using ground control points and a high-resolution digital elevation model. The 1963 declassified intelligence satellite photographs (DISP) were registered with respect to the SAR mosaic. We present a difference map of the DISP and SAR imagery to demonstrate how optical and microwave satellite imagery can be used in combination to enhance information about the structural and glaciological environment of the TAM. The difference map filters out the visual confusion in the SAR imagery caused by backscatter, shadow, and pixel stretching, while retaining the proxy indications of basal topography related to crustal structure. Such information is useful for extrapolating and correlating local and regional lineament trends in order to determine large-scale movements along regional structures and for a better understanding of the kinematic evolution of the TAM.

## INTRODUCTION

The Transantarctic Mountains extend over 3,500 km across the Antarctic Continent and reach elevations over 4,000 m. They mark the physiographic boundary between East and West Antarctica, holding back the East Antarctic Ice Sheet, which carves through the mountains as giant outlet glaciers draining into the Ross Ice Shelf (Fig. 1). The TAM are best described as an intracontinental rift shoulder comprising linear to curvilinear fault blocks cut by transverse faults. Outlet glaciers are believed to delineate these transverse faults. Since glaciers flow in the direction of least resistance they often follow fault and fracture zones through preferential erosion of fractured and weakened rock making them particularly suitable for mapping from remotely sensed imagery. The large linear to curvilinear fault blocks and transverse faults visible in the satellite imagery are often referred to as lineaments.

## OBJECTIVE

Our objective is to demonstrate how optical and microwave satellite imagery can be used in combination to enhance information about the structural and glaciological environment of the TAM.

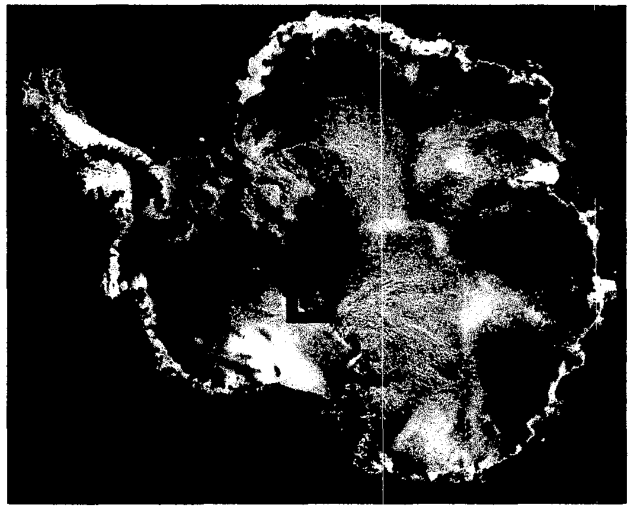

Figure 1. Location map for the Transantarctic Mountain study area as depicted on the RADARSAT SAR mosaic of Antarctica. The mountains strike roughly from the study area toward the lower center right.

## DATASETS

For this study we have chosen an area approximately 24,000 square km positioned at 85 degrees south and 172 degrees west in the vicinity of the Shackleton Glacier (Fig. 1 and 2b)

The SAR mosaic comprises over 4,000 RADARSAT images. Each 16-bit image covers 100x100 km at a ground resolution of 25 meters (Fig. 1). The image data were combined with a newly created digital elevation model and ERIM supplied ground control points to produce geometrically correct, orthorectified image products [1]. The orthorectified images were radiometrically balanced and mosaicked together. All processing was done in a Vexcel Corporation processing system. The data were then resampled to 100 meter resolution for this study. Operating in the microwave part of the spectrum, SAR penetrates snow and ice to detect shallow subsurface features, accentuates surface topography, and is unaffected by clouds or darkness [2].

The 1963 DISP ARGON frames cover 500x500 km. The frames were scanned at 7-microns then orthorectified and terrain corrected with the newly created digital elevation model and registered with respect to the SAR mosaic. The geolocation error was calculated at approximately 140 meters.

1997 SAR Imagery　　　　1963 DISP Imagery

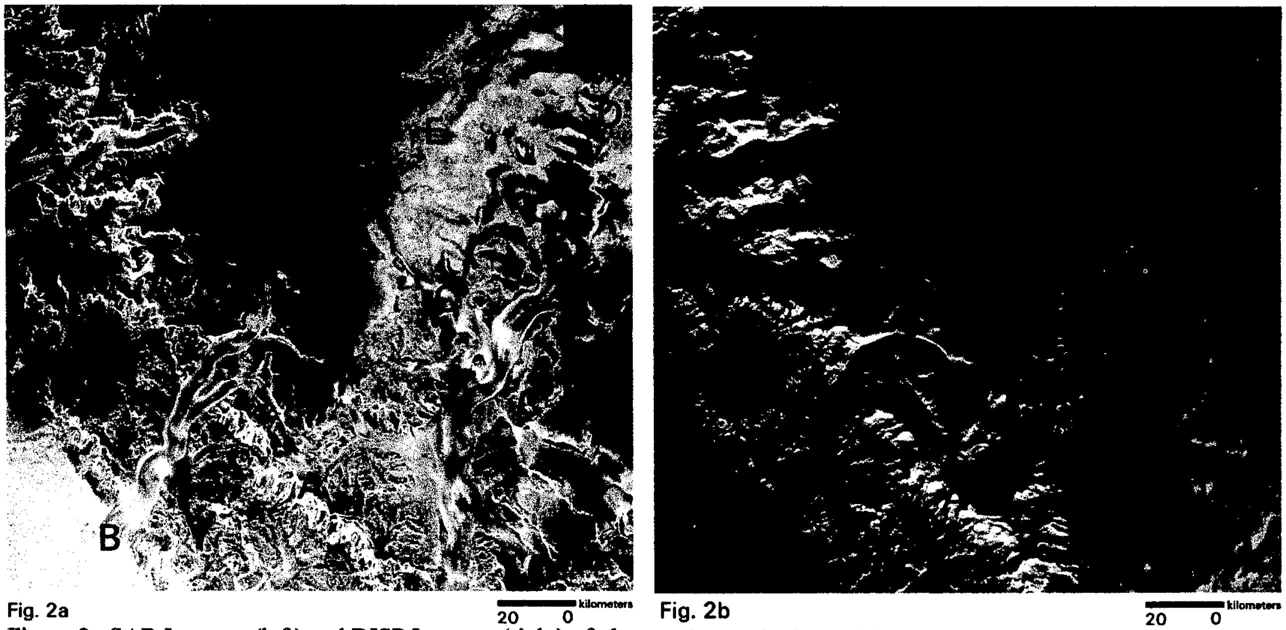


Fig. 2a　　Fig. 2b

Figure 2. SAR Imagery (left) and DISP Imagery (right) of the study area in the TAM.

Difference Map

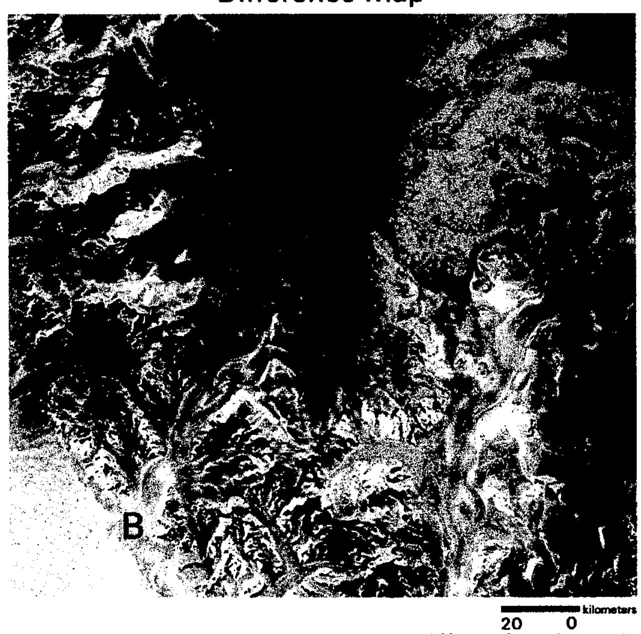


Figure 3. Resultant image map from differencing the SAR imagery and the DISP imagery.

The orthorectified images were filtered with an adaptive noise-removal filter and mosaicked using a radiometric balancing and blending function [3]. Processing was done in an ERDAS Imagine environment. The data were resampled to 100 meter resolution for this study. Acquired in the visible part of the spectrum, DISP only captures surface features, is dependent on cloud cover, and relies on the sun's elevation to accentuate surface topography.

To compute the difference map (Fig. 3) the two datasets were subsetted using exact map corner coordinates (Fig. 2a and Fig. 2b). The SAR imagery was then converted from 16 bit unsigned to 8-bit unsigned binary format to correspond with the DISP 8-bit unsigned imagery. The DN value of each pixel of the DISP was subtracted from the corresponding pixel in the SAR imagery using ERDAS Imagine software. The resultant difference map is in a floating point, binary format.

## DISCUSSION

### *Geology*

The TAM represent a long history of mountain building. Beginning with the Ross Orogen, an Andean style mountain chain formed from the subduction of oceanic crust under the paleo-Pacific margin of Gondwana [4]. By the Devonian the mountain chain had eroded to the low and gently undulating Kukri Erosion Surface. Presently these intrusive and metamorphic rocks are overlain by the Beacon Supergroup, a thick section of flat lying, gently tilted sedimentary rocks deposited in elongate basins from the Devonian to the Jurassic. Overlaying and intruding the Beacon Supergroup are rift-related igneous rocks of the Jurassic Ferrar group [5]. The stratigraphy in the general vicinity of the Shackleton Glacier characterizes a good sequence of the Beacon rocks [6].

The TAM are believed to represent a major rift flank uplift, comprised of fault blocks cut by transverse faults believed to lie beneath the many outlet glaciers that cut through the TAM and drain the East Antarctic Ice Sheet [4]. The clearest evidence for major faulting in the Shackleton area are faults blocks tilted between 3 and 19 degrees to the southwest, separated by faults downthrowing to the northeast and trending east to southeast [6].

*Comparison of optical and microwave datasets*

In the SAR imagery where the terrain is steep and rugged, backscattering appears chaotic and pixel stretching due to layover correction makes identification and interpretation of rock outcrops and associated features difficult. These same areas are well delineated in the DISP photographs (Fig. 2a, A and A' and Fig. 2b, A and A'). Although shadowing (black areas that mask features) is a characteristic of both SAR and DISP, it is more prominent in the DISP imagery (Fig. 2a, A' and Fib. 2b, A'). By differencing the two images we were able to reduce the visual confusion caused by backscattering and pixel stretching due to layover correction in the mountainous areas (Fig. 3, A). In addition, data masked by shadow in the DISP imagery are replaced with data from the SAR imagery (Fig. 3, A').

SAR imagery amplifies glacial flow lines and shear margins (Fig. 2a, B) as well as providing added information on glacier origin and drainage geometry. On the other hand, rock outcrops are much more discernable on the DISP imagery (Fig. 2b, C and C'). The advantage of the difference map is that it clearly shows the glacial features and bounding rock walls (Fig. 3, B) as well as rock outcrops (Fig. 3, C and C').

Sohn and others [7] showed that variations in grain size control backscatter patterns in SAR imagery and are associated with undulating surface topography. Noltimier and others [8] showed, by correlating SAR and aeromagnetic lineament trends, that SAR lineaments mark crustal structures. Although subtle variations in surface topography are visible on the DISP imagery, the SAR imagery reveal a more complex backscatter texture (Fig. 2a, D, D' and E and Fig. 2b, D, D' and E). Some of the complexity around E in Fig. 2a are likely due to climate driven variations in grain size and snow density. We suggest that Fig. 2a, D and D' are extensions of the exposed outcropping at C and C', thereby delineating basal topography.

Paulsen and Wilson [5] used DISP imagery to map morphotectonic lineaments believed to be related to fracture and fault zones. The correlation of local fault trends and regional structural lineaments can aid in the determination of large-scale movements along regional structures. The ability to extrapolate structural trends using the SAR imagery will aid kinematic evolution of the TAM. The difference map has the added benefit of highlighting detailed surface information, such as rock outcrops and glaciers, while revealing information on basal structure and melting events (Fig. 3).

## SUMMARY

Differencing optical and microwave satellite imagery provides an effective method to better map surface structural features by filtering out the visual confusion from backscatter, shadow, and pixel stretching in rugged and steep terrain while retaining the proxy indications of basal topography related to crustal structure. The extrapolation of structural trends and correlation of local fault zones will aid in the determination of large-scale movements related to the kinematic evolution of the TAM.

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