

TOPOGRAPHY AND LANDFORMS OF SUBANTARCTIC MACQUARIE ISLAND, AUSTRALIA, AS REVEALED BY AIRSAR IMAGERY

Ian J. Tapley¹ and Henk Brolsma²

¹ Cooperative Research Center for Landscape Environments and Mineral Exploration, CSIRO Exploration and Mining, Perth, Western Australia. Email: Ian.Tapley@csiro.au

² Australian Antarctic Division, Kingston, Tasmania 7050. Email: henk.brolsma@aad.gov.au

Macquarie Island is a World Heritage listed sub-antarctic island located in the Southern Ocean at latitude of 54° 30' south, longitude 158° 57' east. Part of the state of Tasmania, it is 1500 km southeast of the island of Tasmania and 1300 km north of the Antarctic continent. Macquarie Island, or "Macca" as it is generally referred to, is 34 km long and 5.5 km wide at its widest point. It has a total surface area of 128 sq. km, much of which is a central rolling plateau 250-400 m above sea level, bounded on all sides by steep cliffs, from the foot of which extends a coastal platform up to 800m wide.



Figure 1: Steep coastal slopes masked by low tussock grasses and occasional sandy beaches where king penguins colonize.

In 1998 Macquarie Island was inscribed on the World Heritage List, mainly for its unique geological features. The island is the exposed crest of the undersea Macquarie Ridge, raised to its present position where the Indo-Australian tectonic plate meets the Pacific plate. It is seismically active and the only place on earth where rocks from the earth's mantle (6km below the ocean floor) are being actively exposed above sea level. These unique exposures include excellent examples of pillow basalts and other extrusive volcanic rocks.

Macquarie Island is home to a large variety of wildlife including Elephant and Fur seals, Royal, King, Gentoo and Rockhopper penguins. There are no trees on the island although tussock grass and other plants cover the island. For over 50 years Australia has operated a research station at the northern end of the island. A wide variety of research by international groups is carried out on the island including biology, botany, auroral physics, plate tectonics and continental drift, meteorology and medical research.

Up until the acquisition of TOPSAR elevation data in 2000 little or no topographic information of Macquarie Island existed for management or scientific purposes. A 1972 map is inaccurate in many places as it was based on oblique aerial photography and little ground control. Due to the almost constant cloud cover on the island and the short windows of opportunity during resupply, aerial photography of the island has been largely unsuccessful. Available imagery from satellites such as SPOT have poor base:height ratio for the creation of an

accurate DEM. In fact only one relatively cloud-free scene of SPOT data has been acquired of the island during the entire SPOT campaign.

PacRim2 presented the Australian Antarctic Division with an opportunity to obtain a high resolution, digital elevation dataset and polarimetric multi-frequency radar data simultaneously with the AIRSAR instrument. Two flightlines of TOPSAR data from opposite directions were necessary to compensate for the loss of data caused by radar shadowing in vicinity of the steep coastal slopes. The data were successfully collected on 16th August 2000 when the island was masked by 60% cloud cover and the terrain by a cover of fresh snow (Figure 2).



Figure 2: An oblique aerial photo along the east coast of a snow-covered Macquarie Island taken from an altitude of 8000 m during the PacRim2 mission. Cloud has obscured part of the island view.

The DEM product supplied to AAD was a mosaic of the two passes with minimal areas of data loss. Although the absolute height accuracy of the DEM data was within 5 metres for each of 16 tie points, it was necessary to apply additional calibration using the Z values from 56 survey points whose height had been accurately measured using DGPS. A regression of the 56 TOPSAR DEM values and GPS points gave a R^2 value of 0.998516, SE of 3.890949, slope value of 0.99868 and intercept of 1.824971. These values were used to adjust the TOPSAR DEM and produce a contour image map with 5 m intervals and a range of 0 to 415 m (Figure 3).

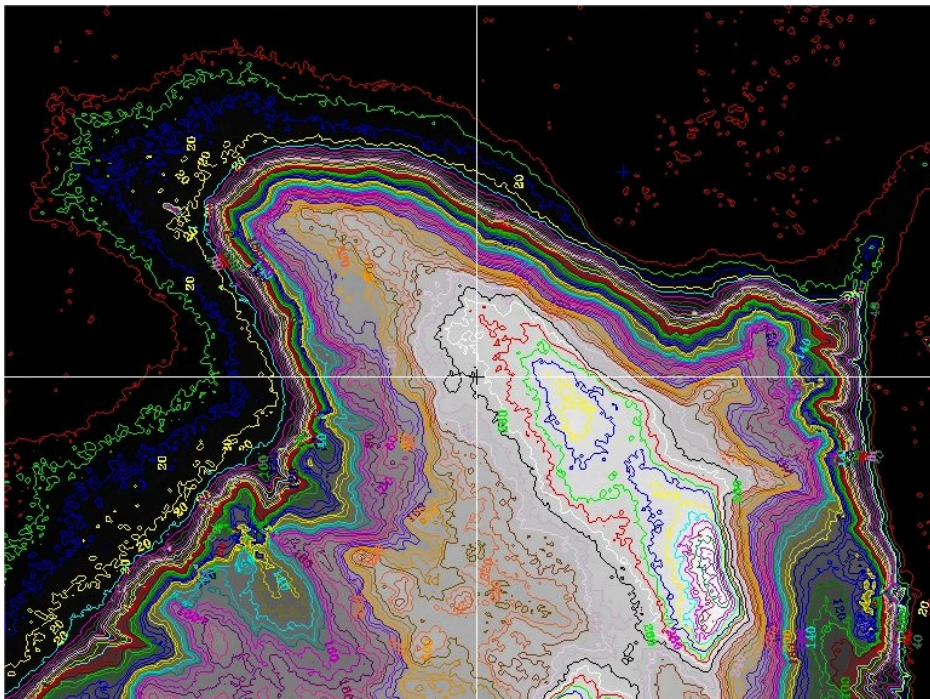


Figure 3: Five metre contours of the north end of Macquarie Island generated from the TOPSAR DEM dataset using ENVI software. The contour image-map was converted into a grid file suitable for use in an ArcInfo GIS.

The TOPSAR DEM will in the first instance be used to locate accurately within a GIS of the island, all scientific data collected to date. This includes the location of penguin colonies, restricted areas for management of endangered species, archaeological sites, vegetation distribution map and an accurate topographic base for the existing geological map and future geological expeditions. Management purposes include the location of walking tracks, hazardous areas to avoid, feasibility studies for alternative energy sources such as wind farms and an accurate location of Judge and Clerk and Bishop and Clerk Islands for navigational purposes

A further accuracy assessment of the TOPSAR data is to be conducted in March 2002 by comparison with DGPS measurements of height taken along two transects extending from the west to east coasts. If as expected the data are of suitable accuracy then there is a prospect of future coverage using radar interferometry to examine the impact of major earthquakes (6.2 or greater on the Richter scale) and their aftershocks that occur approximately once per year. Quantitative assessment of landslides along the steep coastal slopes and structural deformation of the island bedrock should be possible using a combination of differential interferometry, topographic modeling and analyses of the polarimetric data, an example image of which is shown in Figure 4.

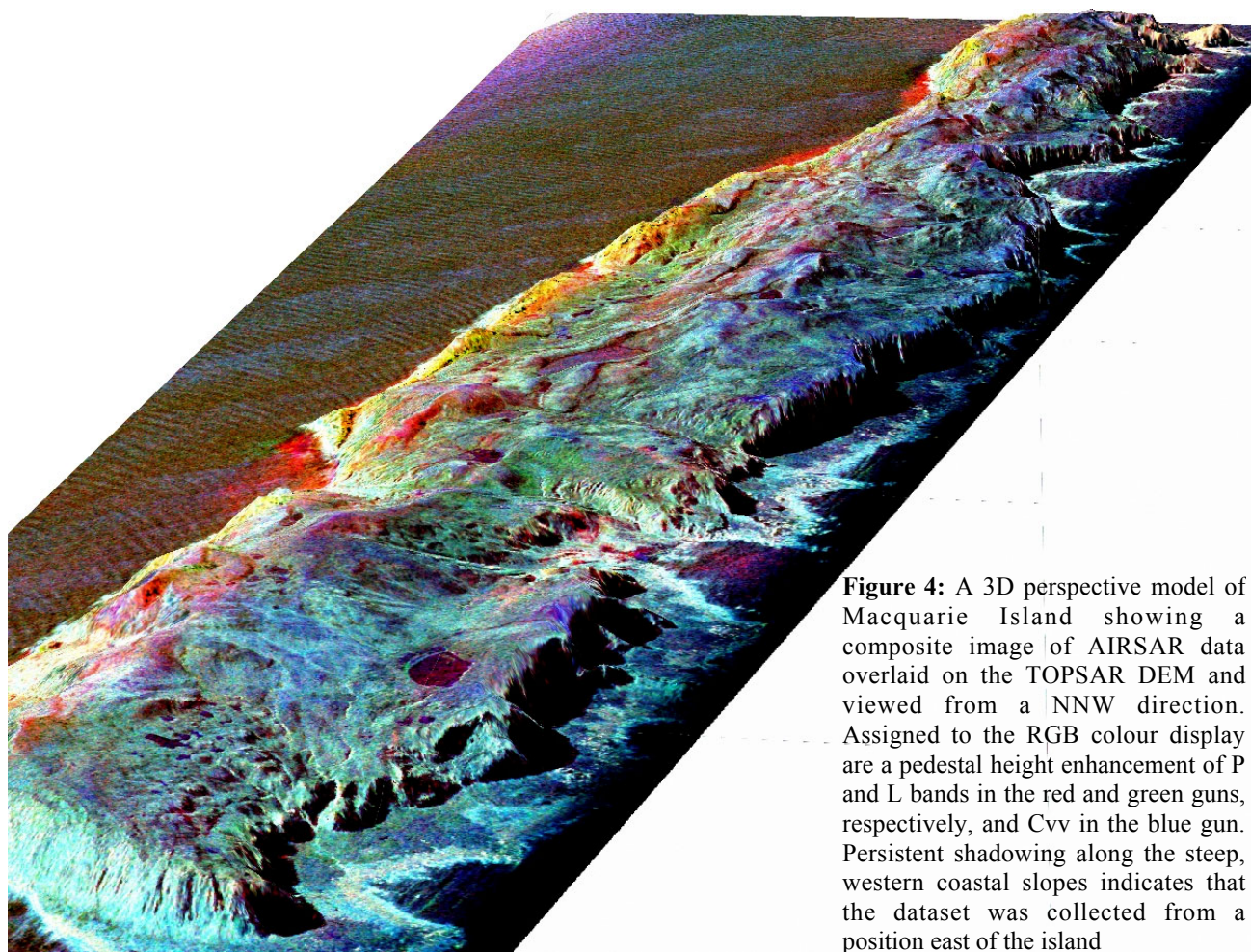


Figure 4: A 3D perspective model of Macquarie Island showing a composite image of AIRSAR data overlaid on the TOPSAR DEM and viewed from a NNW direction. Assigned to the RGB colour display are a pedestal height enhancement of P and L bands in the red and green guns, respectively, and Cvv in the blue gun. Persistent shadowing along the steep, western coastal slopes indicates that the dataset was collected from a position east of the island

Enhancements of POLSAR data are revealing an extraordinary amount of land-surface and geological information relevant to shaping of the island surface by extensive faulting, wave action and active processes today including freeze/thawing, wind and rain. Overlaying these enhancements on the TOPSAR DEM enables this active landscape to be analyzed in three dimensions. The level of detail indicates that the L- and P-band signals, and most likely those of C band, are penetrating the snow cover and being backscattered by the underlying surface of rock, lag gravels and vegetation. Drainage patterns, dammed lakes, levels of incision, fault structures, raised beach deposits and terraces can all be recognized in the AIRSAR data.