The Applicability of Topographic Mapping in Antarctica with the Advanced Land Observing Satellite (ALOS)

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Summary Antarctica is not completely covered with topographic maps and the majority of the existing ones are small scale maps produced 20 or more years ago. Successfully launched on January 24, 2006, the Advanced Land Observing Satellite (ALOS) has three sensors. One in particular, the Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM) at 2.5-meter spatial resolution, has the potential of collecting stereo imagery for topographic mapping at scales up to 1:25,000 with little or no image identifiable ground control points because of an advanced attitude and orbit control subsystem supported by an on-board dual-frequency Global Positioning System (GPS). A crucial issue to the ALOS stereo mapping capability is the accuracy, scale, consistency, and speed achievable. To address this issue, ALOS data of the Ellsworth Mountain Range and other selected Antarctic regions are examined to assess the potential for topographic mapping.

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Introduction

The Advanced Land Observing Satellite (ALOS) was successfully launched by the Japanese Aerospace Exploration Agency (JAXA) on January 24, 2006 (*http://alos.jaxa.jp/index-e.html*). The ALOS was developed to contribute to the mapping sciences with emphasis on the development of global digital elevation models, precise regional land coverage observation, disaster monitoring, and natural resource surveying. ALOS has three imaging sensors: (1) PRISM with 2.5-m spatial resolution is comprised of fore (forward), nadir, and aft (backward), optical panchromatic systems dedicated to stereo imaging and topographic mapping (Figure 1). This "triplet" configuration is similar in design to MAPSAT (Colvocoresses, 1980). The nadir looking sensor aims at filling gaps originated from steep topography and can operate in either 70 km or 35 km swaths. The off-nadir looking sensors operate in 35-km swaths which is the limit of width for stereo imaging; (2) the Advanced Visible and Near Infrared Radiometer Type 2 (AVNIR-2) with 10-m spatial resolution collects land use and land coverage in four multispectral bands; and (3) the Phased Array L-band Synthetic Aperture Radar (PALSAR) with 10- to 100-m resolutions collects day-and-night and all-weather land observation. The PRISM data collected can be used for mapping on scales up to 1:25,000 without relying on control points on the ground. According to JAXA, this is possible because of an advanced attitude and orbit control subsystem based on an onboard dual-frequency GPS receiver, among other devices. It is predicted by JAXA that the positional accuracy of ALOS can be determined within one meter or better. An important determinant to performance capability is the level of accuracy, scale, consistency, and speed achievable with ALOS data. To determine these levels, PRISM and AVNIR-2 data of selected Antarctic scenes are put to the test to ascertain their potential for stereo mapping.

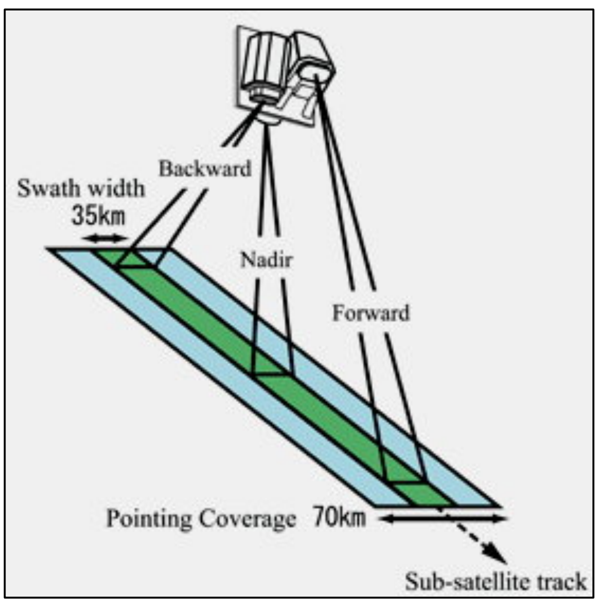

Figure 1. PRISM triplet panchromatic configuration.

This newly launched orbital sensor system may offer an effective way to generate 1:25,000 scale color orthoimage maps and revise existing topographic maps of Antarctica and generate larger scale versions . As a part of this study PRISM panchromatic images are merged with ANVIR_2 multispectral images to produce color orthoimages. This form of pan sharpening is done by remapping the PRISM high-resolution panchromatic image into the ANVIR_2 data range of principal component 1 (PC -1) and substituting it for the PC-1 then applying an inverse principal components transformation.

Antarctic Mapping

Conventional mapping is incapable of meeting user demands for up-to-date topographic information in Antarctica. Antarctica has many regions covered only by planimetri c maps based on conventional optical sensors in which cross-track stereoscopy was neither practical nor affordable. Up until recently satellite orbital systems were limited in meeting user demands because of low pixel resolution and the lack of geometric fidelity of stereo data collection. The declared capability of ALOS imagery with geometric quality suitable for map scales of up to 1:25,000 appears made-to-order for scientists in Antarctica (Figure 2). Because of the along-track stereoscopic viewing characteristic and continuous collection, PRISM allows the acquisition of overlapping imagery with a base-height ratio of .5 to 1.0, plus an expected vertical positional accuracy of 5-m. A complete PRISM derived digital elevation model (DEM) with a seamless horizontal and vertical database of Antarctica is both advantageous and desirable.

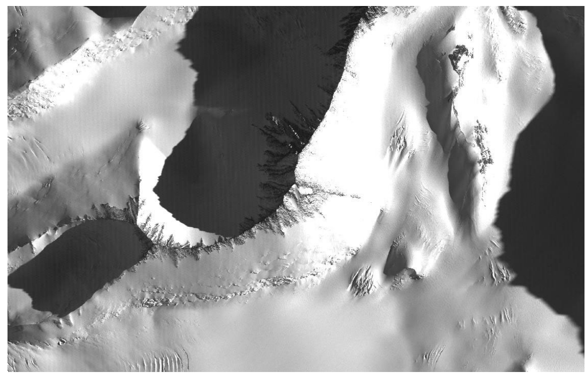

Figure 2. PRISM 1:25,000 coverage of Mount Slaughter in the Sentinel Range.

Positional Accuracy

How do stereo images from satellites compare with those of airborne camera systems? Stereo images from satellite sensor systems are not similar i n scope to aerial photography which renders them difficult to geometrically process and extract a DEM at a level of accuracy that mapping scientists usually expect from high-spatial resolution data. Vital to the issue of the ALOS stereo mapping capability is the determination of horizontal and vertical position al accuracy. To arrive at this determination, 15 PRISM and 8 AVNIR-2 scenes of the Ellsworth Mountain Range are acquired from the ALOS Data Node at the Alaska Satellite Facility (http://aadn.asf.alaska.edu) and applied in the positional accuracy evaluation (Figure 3). The evaluation includes finding image identifiable points in the geometrically corrected dataset provided by ALOS and comparing them with known ground geodetic control point coordinates. Preliminary findings of the horizontal positional accuracy show a statistical difference of +35.46 m (delta x) and -57.45 m (delta y) between the ground-surveyed reference points and the corresponding points in the ALOS PRISM imagery. These preliminary results appear not meet the National Mapping Accuracy Standard of less than 12 m at 1:24,000 and 1:25,000 scales (http://rockyweb.cr.usgs.gov/nmpstds/nmas.html). Achieving this demanding horizontal accuracy, as well as height accuracy, will require repositioning the PRISM stereo images to preci se image identifiable ground surveyed reference points thru the photogrammetric process.

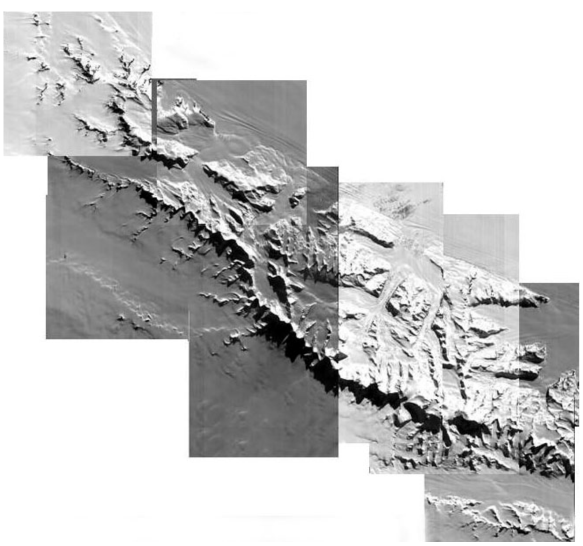

Figure 3. PRISM nadir image coverage of Ellsworth Mountains Range.

Summary

This paper provides Antarctic scientists information on the usefulness and limits of mapping with ALOS data in Antarctica. With improved geopositioning, the ALOS PRISM and AVNIR-2 sensors offer new possibilities for mapping scientists. PRISM potential capacity of precise positioning and high resolution stereo mapping at scales up to 1:25,000 introduce the prospect of developing a consistent, seamless horizontal and vertical baseline to underpin geospatial data of the Antarctic continent; as well as, updating existing maps within a reasonable time period, and providing faster and more affordable results.

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