Pre-processing and geocoding of ALOS PALSAR data over Queensland, Australia

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Abstract
To support the characterisation and mapping of wooded savannas in northern Australia from ALOS PALSAR strips, provided as part of the Japanese Space Exploration Agency (JAXA) Kyoto and Carbon (K&C) Initiative, finer spatial resolution data have been acquired over a number of sites in Queensland. These sites are associated with different forest structural types but also areas of deforestation, degradation and regeneration. To facilitate mapping, accurate co-registration to Landsat-derived Foliage Projected Cover (FPC) data is required, particularly for mapping woody regrowth. This paper provides a brief overview of the pre-processing and geocoding stages implemented.

Keywords: ALOS PALSAR, pre-processing, geocoding, DEM, optical, regrowth, forests, Australia

1. INTRODUCTION

For characterising wooded savannas in northern Australia, ALOS PALSAR data strips, provided as part of the Kyoto and Carbon (K&C) Initiative, are being combined with Landsat-derived Foliage Projective Cover (FPC) regional datasets that are produced routinely by the Queensland Department of Natural Resources and Water (QDNRW). Algorithms for biophysical parameter retrieval and methods for the classification of the strip data are also being developed using fine beam PALSAR and associated optical datasets. However, to effectively integrate these datasets, the ALOS PALSAR data must first be converted from SAR coordinates to the base map reference system (with a given map projection and associated datum) associated with the Landsat sensor data. The following sections therefore provide an overview of the steps taken to convert from raw (JAXA level 1.0) to Geocoded Terrain Corrected (GTC) Multi-Look Intensity (MLI) (equivalent to JAXA level 1.5) ALOS PALSAR data.

2. DATA

For sites across Queensland, fine beam single (FBS, HH polarisation), fine beam dual (FBD, HH+HV polarisations), and fully-polarimetric (PLR, HH+HV+VH+VV polarisations) data have been provided. The data used in this example are a set of 17 raw ALOS PALSAR scenes (JAXA level 1.0), acquired over Injune in central southeast Queensland between 18/08/2006 and 28/02/2007 and across a wide range of incidence angles (Table 1).

Table 1. Polarisation and incidence angles of the ALOS PALSAR scenes acquired over Injune (Queensland, Australia), between 18/08/2006 and 28/02/2007.

Polarisation	# scenes	Incidence angle (degrees)
FBS	7	38.9
FBD	6	11.2, 24.1, 47.4, 59.4
PLR	4	15.7, 29.5

3. CONVERSION FROM RAW (JAXA LEVEL 1.0) TO SINGLE LOOK COMPLEX (SLC) (JAXA LEVEL 1.1) FORMAT

The Modular SAR Processor (MSP) developed by Gamma Remote Sensing AG (GAMMA) [1] was used to process data from level 1.0 (raw) to 1.1 (Single Look Complex, SLC). This processing includes basically two steps, (i) pre-processing and quality control (*e.g.*, raw data and leaderfile transcription, extraction of parameters from leaderfile, Doppler centroid estimation), and (ii) a range-Doppler processing sequence (*e.g.*, range compression, autofocus, azimuth compression). During azimuth compression the following calibration factors were applied: FBS (HH: -49.8

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dB), FBD (HH: -49.8 dB, HV: -49.8 dB), PLR (HH: -45.3 dB, HV: -52.0 dB, VV: -44.0 dB). The VH polarisation was not processed because of the reciprocity theorem.

4. CONVERSION FROM SLC (JAXA LEVEL 1.1) TO GEOCODED TERRAIN CORRECTED (GTC) MULTI LOOK INTENSITY (MLI) FORMAT (JAXA LEVEL 1.5)

Prior to geocoding, conversion of the SLC data to MLI format was undertaken. To obtain approximately square pixels in ground range coordinates, the multi-look factor used was calculated by: (i) determining the ground range pixel spacing (slant-range pixel spacing divided by the sine of the incidence angle), (ii) obtaining the multi-look factor by dividing the ground range pixel spacing by the azimuth pixel spacing, (iii) and using the integer value of that division, or the integer value plus one as the multi-look factors.

Geocoding of SAR data refers to a transformation from the slant-range/azimuth geometry to map projection geometry, and can be ellipsoid corrected (Geocoded Ellipsoid Corrected, GEC) or terrain corrected (Geocoded Terrain Corrected, GTC). GTC requires a digital elevation model (DEM), and was applied to the scenes acquired over Injune. The geocoding procedure implemented in the Differential Interferometry and Geocoding (DIFF&GEO) module of GAMMA includes three main steps, (i) initial determination of the geometric transformation, (ii) refinement of the geometric transformation, and (iii) resampling of the image(s) from one coordinate system to another [2].

For GTC, the initial determination of the geometric transformation is based on orbital data, ancillary information concerning the image, and DEM parameters. Often, orbital state vectors are affected by errors, and so the initial transformation is therefore not completely accurate because of limitations in the knowledge of the SAR imaging geometry. Consequently, a refinement of the transformation is required to produce a correctly geocoded terrain image. This requires that offsets between the SAR image and a reference image are computed. In GAMMA these two steps are performed by using a look-up table (LUT), that makes a correspondence between the position of a given pixel in SAR coordinates and map coordinates [2]. The refinement step is performed by an automated cross-correlation analysis between the SAR image and the reference image. Over more mountainous areas, using a DEM to produce GTC images is generally sufficient, both for the initial determination of the geometric transformation and for the refinement. However, over flat areas with minimal relief (as is the case of the Injune study area), the initial determination of the geometric transformation is accomplished through the use of a DEM, but the refinement is best achieved using another dataset (in this case, the Landsat sensor data or derived FPC). Subsequently, the refined LUT is used to transform between SAR coordinates and map coordinates.

Over the Injune study area, a combination of a Shuttle Radar Topographic Mission (SRTM) DEM and optical data was used to generate GTC MLI images. For FBS data a Landsat ETM+ panchromatic image (acquired on 24/09/2002) was used to refine the LUT and geocoded to 10 x 10 m pixel spacing. For FBD and PLR scenes an image of Foliage Projected Cover (FPC) from 2006, which was derived from 25-m pixel spacing Landsat image acquired on 13/10/2006, was used. Table 2 shows the average geocoding errors for all the 17 scenes acquired over Injune, as well as the average number of offsets used to geocode the MLI images.

Figure 1 and Figure 2 show two examples of geocoded MLI data. Figure 1 refers to a FBS scene geocoded to 10 x 10 m pixel spacing, using a combination of the SRTM DEM and Landsat panchromatic data. Figure 2 shows a PLR scene geocoded to 20 x 20 m pixel spacing, using a combination of the SRTM DEM and Landsat-derived FPC.

Table 2. Average geocoding errors for 17 ALOS PALSAR scenes acquired over Injune (Queensland, Australia).

Polarisation	Range error	Azimuth error	# Offsets
FBS	0.425	0.214	378
FBD	0.263	0.127	395
PLR	0.264	0.117	586

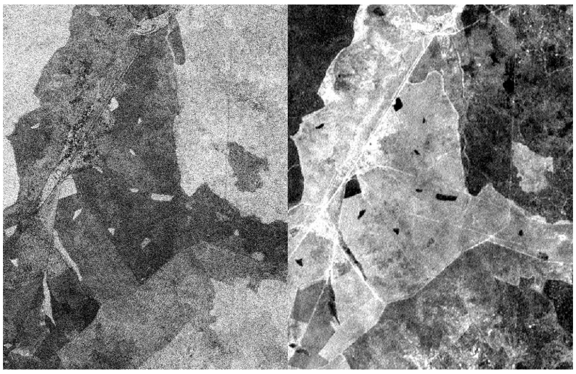

Figure 1. A section of GTC MLI FBS ALOS PALSAR data (HH) acquired on 28/02/2007 (left), and the Landsat panchromatic image acquired on 24/09/2002 and used to refine the geocoding LUT (right).

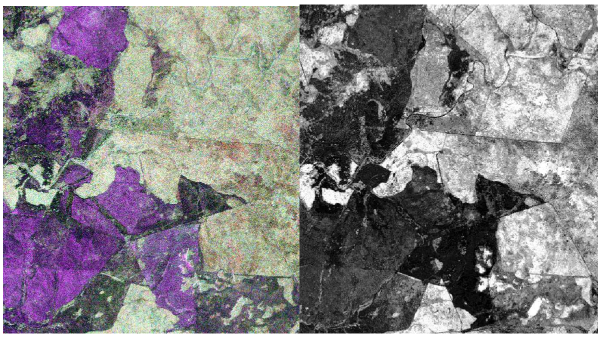

Figure 2. A section of a GTC MLI PLR ALOS PALSAR scene (RGB-HH/HV/VV) acquired on23/08/2006 (left), and a Landsat-derived FPC image (13/10/2006) used to refine the geocoding LUT (right).

5. DISCUSSION AND CONCLUSIONS

The construction and refinement of a LUT that transforms SAR coordinates to map coordinates, using both a digital elevation model (DEM) and optical (Landsat panchromatic or derived FPC) data, has produced geocoding errors consistently below half a pixel. Visually, these datasets also compare well on a pixel-by-pixel basis. The geocoding has also been achieved in areas of low relief and has benefited from the production of Landsat FPC and the high level of geometric accuracy required by QDNRW. The similarity of the panchromatic and FPC data to the SAR data has also contributed to the high level of registration achieved. The use of similar datasets in other regions of low relief is therefore recommended particularly where the number of common points between the SRTM DEM and the simulated SAR image are few.

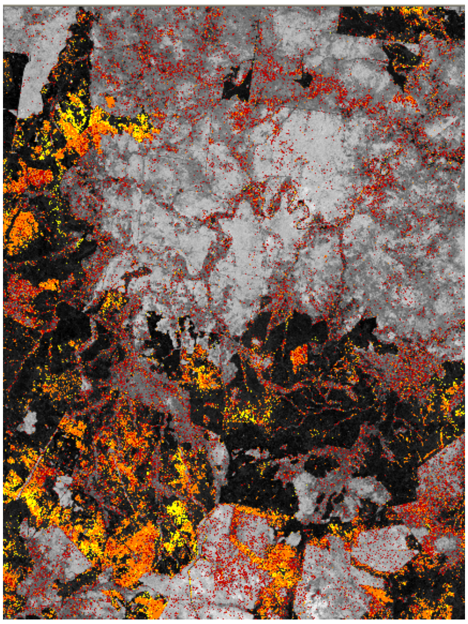

Figure 3. The extent of woody regrowth stages (yellow to orange and red) within the forested area mapped using thresholds of ALOS PALSAR FBS and Landsat-derived FPC data.

Using the combination of ALOS PALSAR and Landsat-derived FPC, maps of woody regeneration have been produced using methods developed in earlier studies [3] (Figure 3). Where even minor errors in registration occur (e.g., < 1 pixel), the accuracy of the mapping is reduced. The procedures implemented within GAMMA are therefore considered appropriate for integrating the SAR and optical datasets available for all of Queensland. Regional mosaics of Landsat FPC data are available and these procedures have also proved reliable for registering the ALOS strip data to this standard map base.

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