SAR DATA COLLECTION OVER RAIN FORESTS AT VHF- AND UHF-BAND

Björn Flood, Per-Olov Frölind, Anders Gustavsson, Tommy Jonsson, Björn Larsson, Mikael Lundberg, Daniel Murdin, Gunnar Stenström, and Lars M.H. Ulander

Swedish Defence Research Agency (FOI), P.O. Box 1165, SE-581 11 Linköping, Sweden
anders.gustavsson@foi.se

1. INTRODUCTION

The growing concern over climate change has increased the interest to measure the vegetation-based carbon stock. A considerable part of this is held by the rain forests, located in the world's cloud belt regions which gives imaging radar techniques an important role as a remote sensing tool for monitoring and management. In addition, to penetrate dense mature forests will require low radar frequencies. The first SAR data collections at P-band over rain forests were conducted with AIRSAR (f_c ~ 428 MHz, bandwidth 40 MHz, quad-polarization) in Central America more than 20 years ago. This airborne sensor system, while in operation by NASA/JPL, also mapped tropical forests in South America, South East Asia as well as Australia with Papua New Guinea. In the new millennium, a number of airborne sensors with a capability to register fully polarimetric P-band SAR data has been developed and operated in the tropics to assess the potential to estimate the aboveground biomass in a robust and accurate manner [1][2][3]. On a global scale, the need for a future operational satellite system to provide this kind of measurements is currently studied [4]. In support to this ESA program, dedicated SAR campaigns at P-band have been conducted over boreal forests and recently also over rain forests [5].

FOI was given an opportunity in 2009 to perform SAR measurements in Thailand at VHF- and UHF-band with the two airborne sensors CARABAS-II and LORA, respectively [6][7]. Data over rain forests could be gathered and are currently analyzed. Although only HH-polarized, this data set is unique in the sense that comparisons between UHF-band (P-band) and frequencies about one order of magnitude lower can be made for rain forest backscattering. The only similar dual-frequency analysis reported, based on SAR data from another sensor source, is from registrations over ponderosa pine forests [8].

2. TEST SITE

The test site selected for the VHF and UHF SAR data collection campaign was located about 200 km northeast of Bangkok in Thailand. The major part of the imaged area is found within the national park Khao Yai. Hence, it is an uninhabited rural area with very small impact from man in terms of logging and infrastructure. The heavily foliated terrain is very rough with dramatic topographic variations. The mountainous characteristics exhibit steep slopes with deep gorges and dense rain forest is found more or less at all altitudes, ranging from about 1300 m down to 10 m at the southern borders where flat farm land begins all the way towards Bangkok and the coast, see Fig. 1. The Sabreliner aircraft used for CARABAS-II and LORA was based at Don Mueang airport in Bangkok. A 5-m trihedral was deployed close to the airfield for calibration purposes and imaged before landing. During each flight mission a GPS reference station at the airport was collecting data used for carrier-phase differential GPS post-processing to accurately position the different flight paths in which airborne SAR data were gathered.

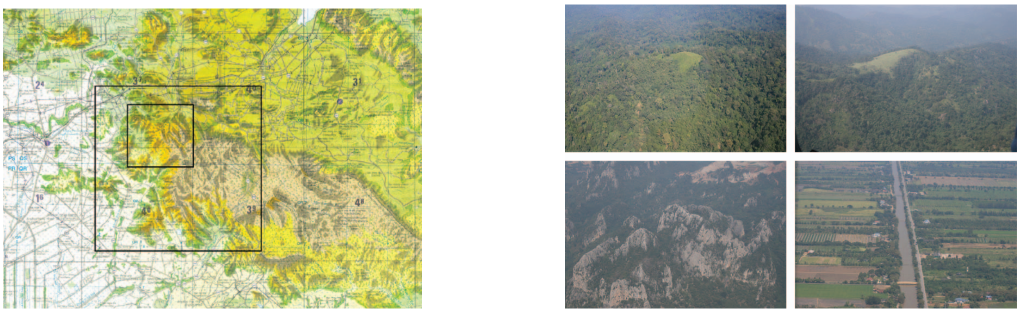

Figure 1. Locations of the 40 km x 40 km and 15 km by 15 km large areas imaged by CARABAS-II and LORA, respectively (left). The photos show typical views from the air over Khao Yai with ridges and steep hillsides, mostly covered by dense rain forest. In the vicinity of the national park flat farm land is found (photo lower right), in particular to the south and west as indicated by white colour on the map.

3. IMAGING GEOMETRY AND DATA COLLECTION

The ground coverage indicated in Fig. 1 was accomplished by building a mosaic from separate basic ground swaths with enough overlap in between to avoid any gaps in the mapping. CARABAS-II can be operated in a ping-pong like manner where the transmitted pulse toggles between being sent to the left- or right-hand side of the aircraft as illustrated in Fig. 2, i.e. similar mode to what is found for the GeoSAR system [3]. LORA, on the other hand, can only illuminate to the left of the aircraft. This reduces the registration capacity accordingly and explains the smaller area covered, taking into account a maximum number of flight hours available for the campaign. In addition, both sensors illuminated the ground from six different headings so that a circular area inscribed by the pre-defined squares of Fig. 1 should be covered from all these directions. A reason to include multiple headings was to avoid any shadowing effects and enable imaging of a ground spot from at least one imaging pass.

Analyses of low frequency SAR data acquired with CARABAS-II and LORA over coniferous forests have shown that the scattering for this forest type is dominated by the trunk-ground dihedral mechanism. On sloping terrain, however, the backscattering is sensitive to the topography and radar viewing geometry because the tree trunks no longer stand perpendicular to the ground surface and this will result in a reduction of the backscatter [9]. The effect can be significant and must be taken into account since it may obscure variations caused by differences in forest parameters, e.g. aboveground biomass, that one wants to retrieve from the acquired SAR data. With access to multiple headings over Khao Yai this phenomenon can be investigated for horizontal polarization over areas with moderate topography covered by rain forest with a larger variety of tree structures, e.g. much larger branches compared to coniferous tree species..

In addition, a designated smaller part of the area was imaged by LORA from three of the headings using five parallel but shifted flight tracks defined for each look direction to enable interferometic and/or tomographic SAR investigations at UHF-band.

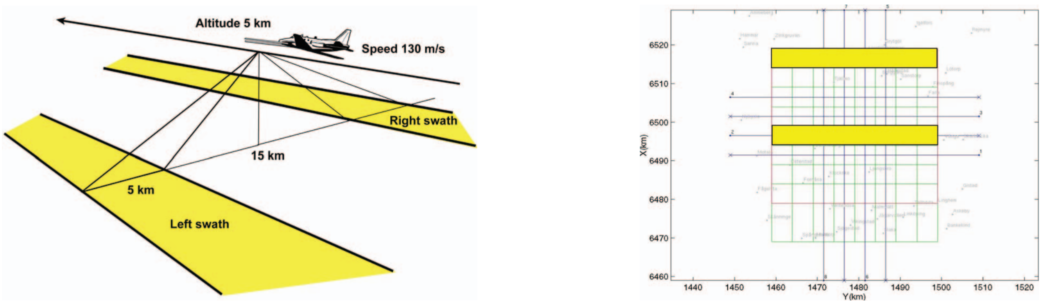

Figure 2. The typical imaging geometry for CARABAS-II and LORA used in the Khao Yai mission (left). LORA can only provide a one-sided swath to the left whereas CARABAS-II can provide either one- or two-sided swaths. The latter option was used during this campaign. The full ground coverage is generated as a mosaic of separately acquired and overlapping swaths. This is illustrated for two flight headings (north-south and east-west) with one contribution from the two-sided CARABAS-II registration mode depicted in yellow (right).

4. IMAGERY EXAMPLES

The full data set for CARABAS-II in ping-pong mode was collected in four flight missions, including the deployed trihedral illuminated both from the left- and right-hand side of the aircraft. The smaller area defined for LORA required five missions in total with imaging on the left-hand side of the aircraft only, including the radar reflector as well as the multiple parallel tracks for interferometry and tomography studies. All data were processed on site to check the quality. The streamlined software developed to generate CARABAS-II images and the associated geo-coded mosaics contains a module also for radiometric calibration based on the radar response retrieved from the deployed 5-m trihedral. For the LORA processing chain this was not yet implemented during the campaign which means that the mosaics from this sensor are still uncalibrated. This can be seen in Fig. 3 with results from CARABAS-II and LORA. A sharp shift in intensity level is clearly visible in the latter case along the regions where contributions are coming from different radar swaths. The geo-referencing has been carried out with access to high resolution digital terrain elevation data of level 2 (DTED 2), i.e. a uniform gridded matrix with a post spacing of one arc second. The LORA data will be calibrated and quantitative values for rain forest measured at VHF- and UHF-band will be presented in the full length paper.

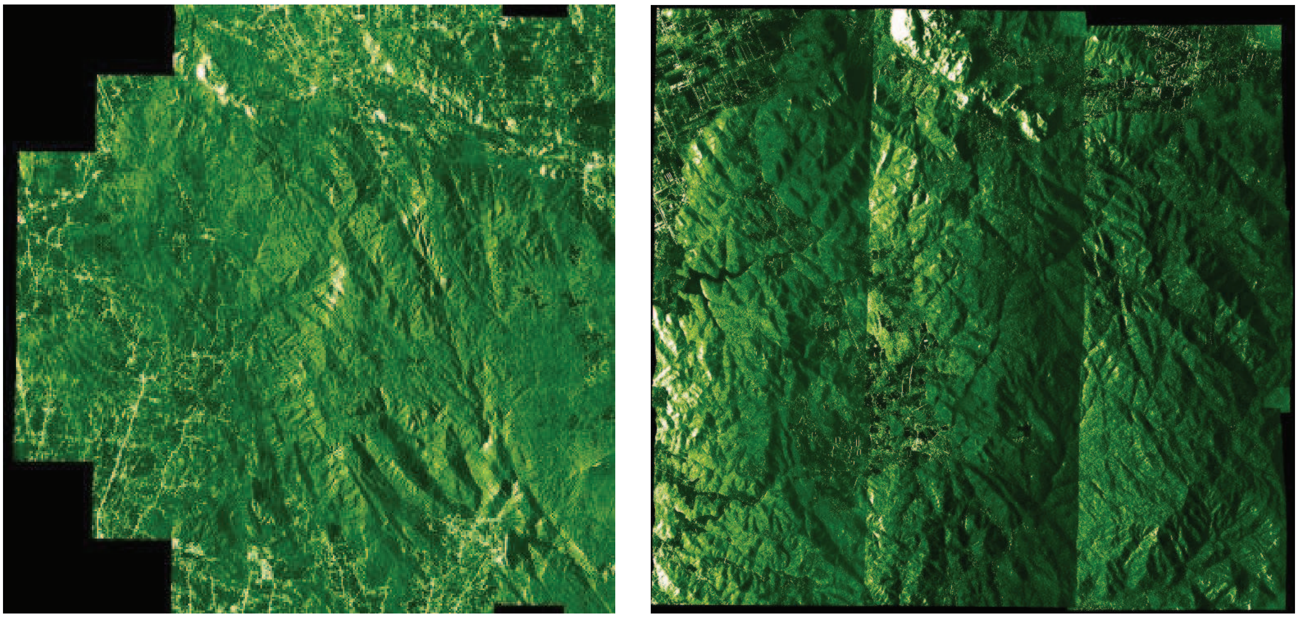

Figure 3. Calibrated CARABAS-II (left) and uncalibrated LORA (right) mosaics over Khao Yai. Both images are presented geo-referenced and the area has been illuminated by the SAR sensors towards the east.

5. REFERENCES

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