

## GENERATION OF DECADAL GLOBAL HIGH RESOLUTION L-BAND SAR DATASET FOR FOREST CARBON TRACKING

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**Abstract** Recently, the forest observation using the spaceborne sensor becomes a top issue in the carbon monitoring. Covering more than 20% of the global terrestrial areas, forests are rapidly decreasing, corresponding to 20% carbon dioxide release from the land. Deforestation and forest degradation mainly occurred in the developing country. L-band SAR is sensitive for monitoring the forest biomass, forest-non-forest classifications because of its sensitivity. JAXA has been observing the global land surface since 2006 by ALOS/PALSAR and from 1992 to 1998 by JERS-1/SAR. Making all the data archives and converted to 10m high-resolution global mosaic data sets for these years can be fully utilized for detection of the forest carbon changes. JAXA recently decided to create these high-resolution global mosaic datasets and generate the forest/non-forest classification. In this paper, we will introduce the current status of generation of the mosaic and high-level data sets.

**Keyword:** PALSAR, Orthorectified mosaic, Kyoto and Carbon initiative

### 1. INTRODUCTION

Synthetic Aperture Radar (SAR) is an all-weather sensor suitable for repetitive monitoring. With its long wavelength, L-band SAR on board ALOS specifically useful for land-cover monitoring, owing to its high signal penetration through vegetation-covered targets and sensitivity for detecting deforestation and forest inundation. To this end, JAXA is leading an international global monitoring project - the ALOS Kyoto & Carbon Initiative - in collaboration with some 20 organizations and research institutes worldwide [1]. While medium resolution optical imagers onboard polar orbiting satellites, such as e.g. Terra MODIS, ADEOS-II GLI and ADEOS, are often used to monitor the global state and changes in the atmosphere, oceans and on land, high resolution SAR sensors enables the retrieval of different geophysical parameters under all weather conditions and with other observation aspects. The geophysical parameters relevant for SAR are the scientific parameters for solid earth, biosphere and cryosphere, and are represented by e.g. crustal deformation, biomass estimation and snow and ice cover changes in the Polar Regions. PALSAR and the two optical sensors onboard ALOS feature high radiometric and geometric performances, and through a long observation capacity of 11 hours daily can collect long time-series for global monitoring of water, carbon and climate change parameters. JAXA is performing forest- and wetlands monitoring to assess the status of the water cycle in wetlands, forest coverage and estimation of biomass volumes, as well as seasonal monitoring of the Polar Regions [2][3]. In this paper, we introduce the forest monitoring activity using the semi-global PALSAR observation dataset. In this paper we also describe the following issues: 1) generation of the strip processing, 2) slope corrected ortho-rectification, 3) semi-continent scale mosaicking in high resolution scale, 4) generation of the regional forest classification data, and 5) validation issues.

### 2. SEMI-GLOBAL PALSAR MOSAIC

There are two typical mosaicking methods: The first is

to paste and stitch individual images onto one large canvas. It does not require large-scale memory and is an easy way of processing. Ortho-rectification of an image using the SRTM-DSM can allow accurate co-registration with the surrounding scenes (even if the orbital accuracy is insufficient) and generate a mosaic including even island areas. The second method is to process all the long-strip data (inclusion of the SAR imaging and its ortho-rectification) and paste them to the canvas. This method was once adopted for the generation of the JERS-1 SAR mosaic of South East Asia for 1994-1996-1998 [4] and Siberia and Africa of GBFM [5] although they were 100-m slant range images. The problem of both methods is the intensity tuning between the target and its surrounding scenes or between neighboring strips. Because most of the SARs are radiometrically stable and sensitive to detecting real target reflectivity, the intensity difference appearing as a patch-like pattern may cause an error at higher-level processing (e.g., classification). Thus, the development of a robust and simple intensity tuning method is highly required. While the first method has some unknown parameters for intensity tuning among the scenes, the second method can simply adjust the intensity only between neighboring strips and can maintain a higher performance in generation of the mosaic.

#### 2.1 Generation of the strip processing

Qualified long-strip processing has been requested to produce the continent-scale mosaic although both algorithm development and handling the large amount of data make this a challenge. As preparation for creating semi-continent-scale mosaics, we adopted long-strip processing rather than the conventional scene-by-scene processing. This adoption is our innovation to generate the mosaic dataset. The biggest advantages of adopting the long-strip processing are to reduce the number of associated image borders, to reduce the problems of the radiometric and geometric discontinuity issues, and to conduct mosaicking of even ocean images. The following figures (Fig. 1 and Fig. 2) shows one sample strip passing from the south of Tasmania to the central Russia [6].



Fig. 1. Pass catalog showing the passage of the PALSAR data observation.



Fig. 2 Comparison of the images and metadata generated by the ortho-rectification process, where we examined a long-strip of 2,220 km in length and 70 km in width acquired on August 9, 2009 over the Indonesian islands. (a) shows the non-slope corrected ortho-rectified georeferenced data (an angle rotated around the center of the image), (b) is the slope-corrected data, (c) is the total days since the launch of the satellite, which is given to the acquired image, (d) is the local incidence angle generated from the SRTM DSM, and (e) is the mask information containing valid/invalid, layover, shadowing, and ocean information. There are five masked classes shown in, i.e., dark for land, red for invalid area, moss-green for ocean, white for layover, and pink for shadow although the pink is hard to recognize.

## 2.2 Slope corrected ortho-rectification

Slope correction effectively reduces or suppresses variation of the sigma-naught caused by area variation of the SAR imaging pixel, which is affected by mountainous relief. To correct this effect, we used the

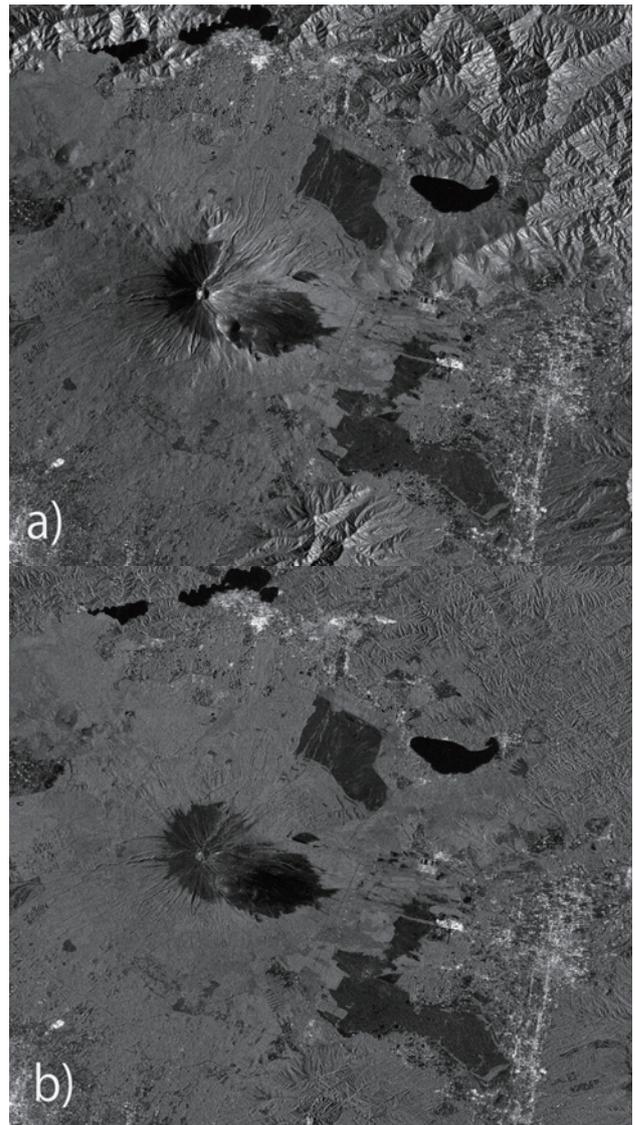


Fig. 3 Ortho-rectified and geo-coded image for the Mt. Fuji region. a) Without slope correction and b) With slope correction. Horizontal image size is 40 km and vertical one is 35 km.

STRM 90-m-resolution DSM located at latitude within  $\pm 60$  degrees. The effectiveness of the slope correction described in [7] can be confirmed by Fig. 3.

## 2.3 Semi-continent scale mosaicking in high-resolution scale

We consider how to suppress the possible intensity offset between neighboring strips. An intensity offset is caused by changing in surface conditions along the strips, which are closely related to daily or seasonal conditions. As long as the SAR radiometric sensitivity is stable enough, the intensity expresses the real backscattering property of the target. Suppression of banding means slight deformation of reality. However, the continuous connection of two adjacent strips is strongly required by the researchers who conduct some applications from SAR mosaic dataset because the banding easily degrades the accuracy of post-processing methods (e.g., classification). Here we propose one type of connection, which uses the radiometric property of the image chips that are

selected from the overlapped regions and aligned in X and Y directions as two-dimensional arrays. We show the effectiveness of the destriping function within the proposed mosaicking method below (See Fig. 4-5).



Fig. 4 Australian mosaic of five associated strips, including one test area in the northern part. Here, the image was rotated counterclockwise 90 degrees to fit the paper. This image depicts HH polarization corrected for the stripes (See Fig. 5 for a comparison of the effectiveness of the proposed method at the zoomed image).

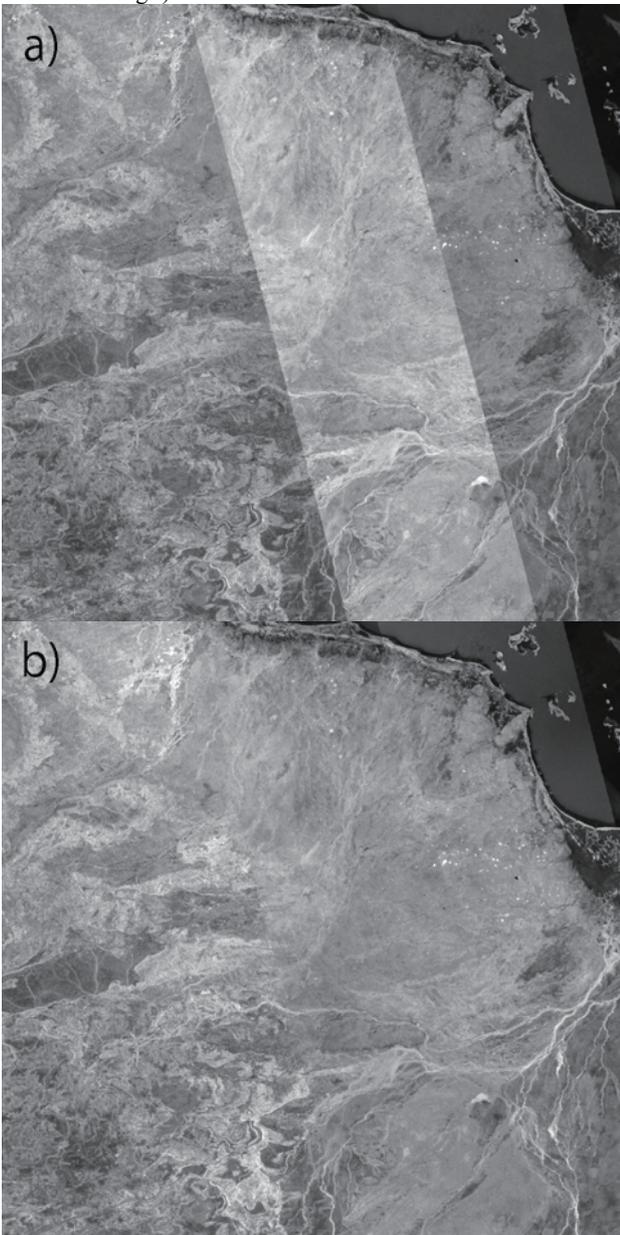


Fig. 5 Impact of the proposed methodology for the test area (a) before correction (b) after correction.

#### 2.4. Generation of the regional forest classification data

We generated the ortho-corrected and slope-corrected PALSAR regional mosaic for the Borneo, as shown in Fig. 6. We experimentally generated the forest classifications in Fig. 7. The attached is the classification map of the Borneo using the method developed in [8][9]. Fig. 8 shows open-layer based forest/non-forest information system. This is under development by JAXA/EORC.

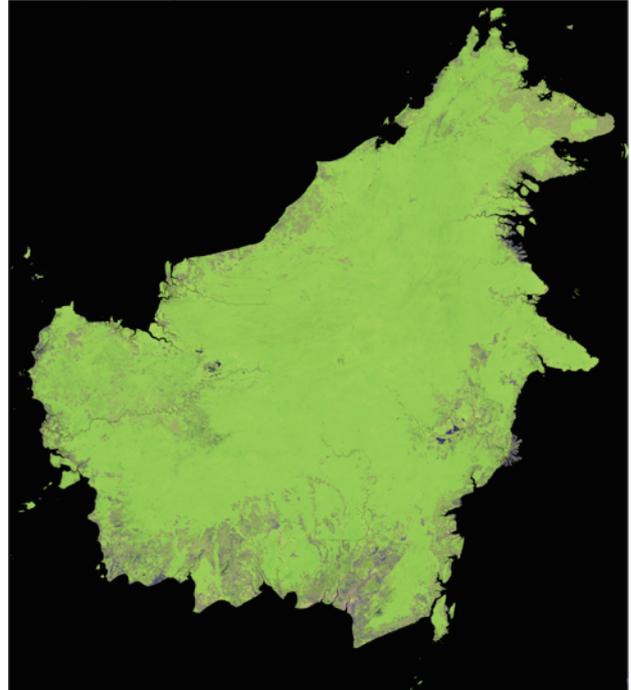


Fig. 6. Ortho and slope corrected PALSAR mosaic for Borneo.

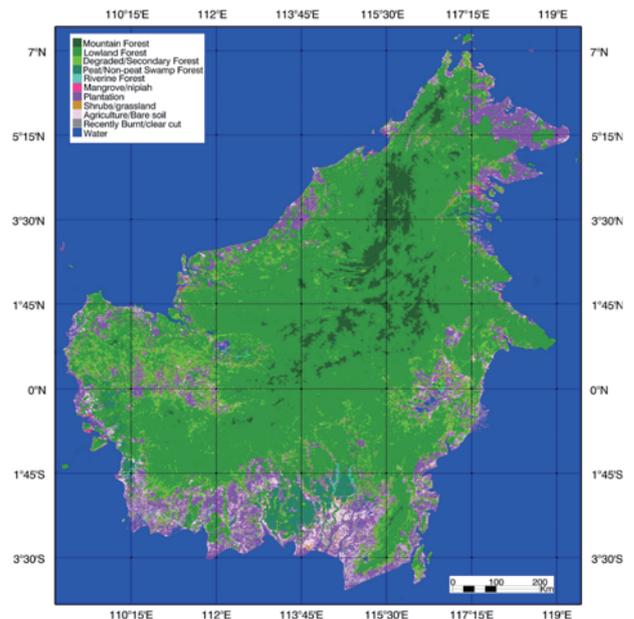


Fig.7 Classification result for Borneo in 2009, mainly classified as forest (mountainous or lowland), degraded forest or plantations [8][9].



Fig. 8 PALSAR global mosaic and forest/non-forest classification data viewer.

### 3. Conclusion

We have been generating the semi-global scale mosaic data sets using the PALSAR and SRTM DSM. The ortho-rectified and slope corrected data can be used for the classification of the tropical rainforest. In addition to this, JAXA is going to generate the 10m-spaced global data set and forest/non-forest classification mapping.

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### References

[1] A. Rosenqvist et al., "ALOS PALSAR: A Pathfinder Mission for Global-Scale Monitoring of Environment," IEEE Geoscience and remote sensing, Vol. 45, No. 11, November 2007, pp. 3307-3316  
 [2] M. Shimada, T. Tadono, A. Rosenqvist, "Advanced Land Observing Satellite (ALOS) and Monitoring Global Environmental Change," Proceedings of the

IEEE, Vol. 98, No.5, May 2010, pp.780-799.

[3] M. Shimada, O. Isoguchi, T. Tadono, and K. Isono, "PALSAR Radiometric and Geometric Calibration," IEEE Trans. GRS, VOL. 47, NO. 12, Dec. 2009, pp.3915-3932.

[4] M. Shimada and O. Isoguchi, "JERS-1 SAR mosaics of Southeast Asia Using calibrated path images," INT. J. Remote Sensing, Vol.23, No.7, pp.1507-1526, 2002

[5] De Grandi, G., Spirolazzi, V., Rauste, Y.A., Curto, L., Rosenqvist, A., Shimada, M., "The GBFM radar mosaic of the Eurasian Taiga: Selected topics on geo-location and preliminary thematic products," IGARSS 2004 (20-24 September, 2004, Anchorage, Alaska) International Geoscience and Remote Sensing Symposium, Anchorage, AK, ETATS-UNIS (2004) 2004

[6] M. Shimada and T. Otaki, "Generating Continent-scale High-quality SAR Mosaic Datasets: Application to PALSAR Data for Global Monitoring," IEEE JSTAR special issue on Kyoto and Carbon Initiative, in review.

[7] M. Shimada, "Ortho-rectification and Slope Correction of SAR Data Using DEM-based Simulated Data and Its Accuracy Evaluation," IEEE JSTAR special issue on Kyoto and Carbon Initiative, in review.

[8] Longépé N., Rakwatin P., Isoguchi O., Shimada M., Uryu Y., Yulianto K., "Assessment of ALOSPALSAR 50m Orthorectified FBD Data for Regional Land Cover Classification by Support Vector Machines", under review, IEEE Transactions Geosciences and Remote Sensing.

[9] Longépé N., Rakwatin P., Isoguchi O. Shimada M., Uryu Y., "Large Scale Land Cover Classification using PALSAR/ALOS data: Case of the Tropical Rain Forest in Indonesia", Proc. of the ESA Living Planet Symposium, Bergen (Norway), Jun. 2010.