# Let’s SAR: Mapping and monitoring of land cover change with ALOS/ALOS-2 L-band data

**Rajesh Bahadur THAPA, Masanobu SHIMADA, Takeshi MOTOHKA, Manabu WATANABE and Shinichi SUZUKI**
**rajesh.thapa@jaxa.jp; thaparb@gmail.com**

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**SUMMARY**

Mapping and monitoring of forest land use and land cover change using spaceborne remote sensing techniques are emerging rapidly. Currently, optical and synthetic aperture radar (SAR) data are widely available from spaceborne sensors. Depending on applications each of them has limitations and benefits. For instance, the optical images are easy to interpret visually but prone to daylight, cloud, and atmospheric hazes while radar images are independent from the latter problems but difficult to interpret visually. Therefore, utilizing these two techniques complementing each other can improve mapping accuracy. In this paper, we aim to report a practical approach to L-band SAR data analysis for mapping of land covers and their changes. We are developing “Let’s SAR” tool, a scientific package to explore and analyze SAR data such as from ALOS/ALOS-2 aiming to ease SAR data analysis and boost the capacity among the remote sensing users. This package is free-for-all and comes with basic concept on SAR and do-it-your-self exercises with a set of sample data and software. The software provides multiple options for land cover classification with image segmentation, land cover change detection using radar backscatters, and other applications. As JAXA made available yearly global mosaics of PALSAR data at no cost, the tool can be utilized to analyze the mosaics for any mapping purpose regardless of location. Using the tool, the other products higher than the level 1.1 of ALOS and ALOS-2 can also be analyzed. This effort may help to build capacity in SAR data analysis for making better maps and more accurate informed decisions. It can be a milestone on SAR remote sensing for enhancing knowledge on utilization of L-band SAR data and complementing the optical remote sensing techniques.

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## 1. INTRODUCTION

Forests play key role in living environment by providing a range of ecosystem services such as carbon sequestration, natural habitats for biodiverse fauna and flora, and food and fiber for human consumption. However, the world's intact forest landscapes are being rapidly deforested due to demand for agricultural land, wood products, energy, developmental projects, and disaster occurrences. Changes in natural forest to non-forest cover have had a significant impact on the accumulation of greenhouse gases (GHGs) in the atmosphere. For this reason, there is an ever-increasing need to assess the extent and state of the forest resource, and how this is changing, and likely to change, into the future (Thapa et al., 2013, 2014, Shimada et al., 2014). To obtain sound information for management, protection, and restoration of forests, we need mapping of forest extent, identification of areas of disturbance, and estimation of above ground biomass. As forest areas are often large and inaccessible, satellite earth observation and remote sensing techniques provide ultimate solutions to the needs.

Accurate mapping of forest cover is crucial for many applications, such as monitoring forest extent and processes, reducing uncertainties in biomass estimation, and developing a measurement, reporting, and verification (MRV) system. Currently, optical and synthetic aperture radar (SAR) data are widely available from spaceborne sensors. Depending on applications each of them has limitations and benefits. For example, the optical images are easy to interpret visually but prone to daylight, cloud, and atmospheric hazes while radar images are independent from the latter problems but prone to earth topography and difficult to interpret visually. Therefore, utilizing these two techniques complementing each other can improve mapping accuracy. In recent years, synthetic aperture radar (SAR) system is considered as more reliable for forest monitoring due to penetration capability to the forest canopy and decreases the dependence on weather conditions. SAR, an active system, transmits short pulses of microwave energy toward the surface below, interacts with surface features such as forest vegetation, and returns backscattering coefficients. Among the space borne SAR sensors are available in different bands (X, C, and L), the L-band SAR sensor consists of a longer wavelength (ranging from 15 to 30 cm). Due to longer wavelengths, it is particularly useful in monitoring forest areas because the microwave energy transmitted by this sensor penetrates into the forest canopies. As a result of this greater penetration of vegetation and weaker reflection from rough surfaces, L-band SAR data yield important information for forest cover and biomass interpretation (Shimada et al., 2014; Shiraishi et al., 2014, Motohka et al., 2014; Thapa et al., 2015). However, the amount of backscattered energy is dependent on the size and orientation of the structural elements of the canopy (i.e., leaves, branches, and stems), the moisture content of the vegetation, and the underlying soil conditions.

Japan Aerospace Exploration Agency (JAXA) has continuously observed world forests using L-band SAR since 1992. JERS-1, ALOS, and ALOS-2 archives provide systematic time-series L-band SAR data for all tropical and boreal zones of the Earth; these data are very useful for wide area mapping of forest land use and land cover (Shimada et al., 2014; Shiraishi et al., 2014), detecting forest changes and degradation (Motohka et al., 2014), analyzing forest policy impact (Thapa et al., 2013), and estimating aboveground forest carbon stocks (Thapa et al. 2015, Thapa et al., in press). In this paper, we aim to report a practical approach to L-band SAR data analysis for mapping of forest land use and land covers and their changes. The ideas developed during the JAXA-MRV scientific research are framed in this approach by developing software package named "Let's SAR". This is a scientific package to explore and analyze SAR data such as from ALOS/ALOS-2 aiming to ease SAR data analysis for forest applications and boost the capacity among the remote sensing users.

## 2. LET'S SAR TOOL

Let's SAR is a simple package developed by JAXA to use SAR data such as ALOS PALSAR mosaics for forest classification, change detection, and other major applications. As JAXA made available yearly global mosaics of PALSAR data at no cost, the tool can be utilized to analyze the mosaics for any mapping purpose regardless of location. Using the tool, the other products higher than the level 1.1 of ALOS and ALOS-2 can also be analyzed. The aim of the tool is to provide the first step in utilization of SAR data. This whole package is free-for-all and comes with basic concept on SAR and do-it-your-self exercises with a set of sample data and software. The software package includes following two tools designed to run in 64 bits Microsoft Windows operating system 7/8/10. Detail installation procedure is provided in the package.

1. LUC (Land Use/cover Classification): This tool generates the land cover and land use classification map from ALOS/ALOS-2 data or PiSAR-L2 data. It has two major functions: Segmentation and Classification. The Segmentation function divides a PALSAR image into region of homogeneous feature. The Classification function classifies the divided images into any type of land cover based on training data set. Five major classifiers including Bayes, Support Vector Machine, Random Tree, Multi-Layer Perceptron, and Boosting are provided. This tool is written in C++ and shares the Open-CV libraries. A simple experimental aboveground biomass estimation function is also added recently. Self-learning materials with step-by-step hand-out and lecture-notes are provided in the package.

2. Gamma-zero change: This tool extracts forest changes using differences of backscattering coefficients observed in SAR imageries acquired in different times. This is very useful for tracking changes in forested areas, detecting of illegal

logging, and forest degradation. As similar to the LUC tool, this tool also includes self-learning materials with step-by-step hand-out and lecture-notes in the package.

The Figure 1 shows a snapshot of the Let's SAR tool package. We organize training on Let's Tool frequently. The following websites provide more information on the JAXA Let's SAR tool and activities.

For downloading most recently updated Let's SAR package:
http://www.eorc.jaxa.jp/ALOS-2/en/doc/pal2_tool.htm.

For training course on Let's SAR:
http://www.eorc.jaxa.jp/ALOS/en/conf/conf_index.htm.

Global mosaic data and other products:
http://www.eorc.jaxa.jp/ALOS/en/dataset/dataset_index.htm.

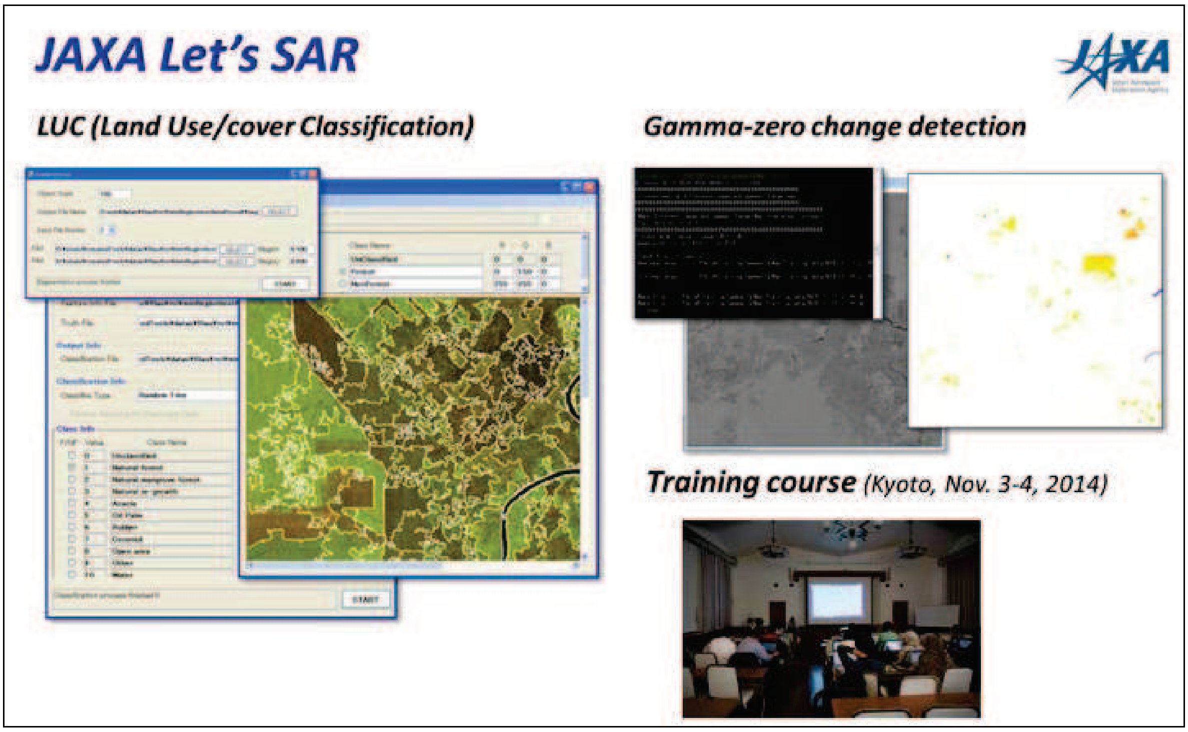


Figure 1. A snapshot of JAXA Let's SAR.

## 3. CONCLUSION

The Let's SAR tool provides basic knowledge on SAR, multiple options for land cover classification with image segmentation, land cover change and forest degradation detection using radar backscatters, and other applications. It can be a milestone on SAR remote sensing for enhancing knowledge on utilization of L-band SAR data and complementing the optical remote sensing techniques. Furthermore, this effort may help to build capacity in SAR data analysis for making better maps and more accurate informed decisions.

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## BIOGRAPHICAL NOTES OF THE PRESENTER

Dr. Thapa from Western Region of Nepal received the M.A. degree in Geography from Tribhuvan University (TU), Nepal, in 1998, the M.Sc. degree in RS&GIS from Asian Institute of Technology (AIT), Thailand, in 2003, and the Ph.D. degree in Geoenvironmental Science from the University of Tsukuba (UT), Japan, in 2009. He worked as a Lecturer with TU from 1998 to 2002, a Researcher with the AIT from 2004 to 2005, and a JSPS Postdoctoral Fellow with UT from 2009 to 2011. Since 2011, he is with Japan Aerospace Exploration Agency (JAXA) as a Researcher. Currently, he is also a Visiting Professor at the University of Tsukuba. He is working for JAXA's ALOS, ALOS-2, and PiSAR-L2 Programs. Beyond the extensive experiences in synthetic aperture radar, optical and LiDAR data processing, analysis, and applications development, he has skills in quantitative and qualitative data analysis, GIS analysis, spatial analysis and modeling. In recent years, he focuses on tropical forests monitoring, carbon stocks estimation, MRV/REDD+ development, deforestation modeling, urban growth modeling, and disasters monitoring. His research interests include retrieval of forest carbon stocks from SAR and lidar data, land use–land cover classification, spatial analysis and modeling, multi-criteria decisions analysis, linking policies to landscape patterns and spatial process, and remote sensing applications in natural disasters. He has conducted many fieldworks in Nepal, Thailand, Vietnam, Japan, and Indonesia. He published two books and contributed more than 130 scientific articles including journals, book chapters, conferences proceedings, and other scientific reports. He delivers JAXA's capacity building trainings on SAR data analysis. He serves as reviewer in 28 leading international journals in his areas of expertise. Dr. Thapa was a recipient of the University of Tsukuba Outstanding Research Award in 2008 and Nepal Biddya Bhusan First Class Award for academic achievement from the President of Nepal in 2010. He is a life member of NRSPS and NEGIS, and general member of many international societies including AAG, AGU, GISA, RSSJ, and JPGU.

## CONTACTS

Dr. Rajesh Bahadur Thapa
Japan Aerospace Exploration Agency
2-1 Sengen, Tsukuba, Ibaraki 305-8505
JAPAN
Tel. +81-50-3362-7444
Email: rajesh.thapa@jaxa.jp; thaparb@gmail.com
Web site: www.jaxa.jp