Asia-RiCE

Phase 1/2015
Implementation Report

March 2016

Asia-RiCE has been organised to develop the rice crop estimation and monitoring component for the GEO Global Agricultural Monitoring (GEOGLAM) initiative. GEOGLAM aims to enhance agricultural production estimates through the use of Earth observations, and Asia-RiCE seeks to ensure that the observational requirements for Asian rice crop monitoring are reflected in the GEOGLAM priorities.

This report summarises the activities and achievements of Asia-RiCE in Phase 1/2015 by providing examples of Technical Demonstration Site (TDS) outputs that have been enabled by the initiative. This document also aims to acknowledge and highlight the impact of contributions from data providers, and the role of the Asia-RiCE initiative in facilitating these inputs.

Results: Rizatus Shofiyati (ICALRD/IAARD/MOA); Mahmud Raimadoya (IPB); Thuy Le Toan (CESBIO); Lam Dao Nguyen (STAC/VAST); Sang Il Na, Suk Young Hong, Yi Hyun Kim, Kyoung Do Lee, Soyeong Jang (RDA); K.R. Manjunath, Sushma Panigrahy (ISRO); Shinichi Sobue, Kei Oyoshi (JAXA), Andrew Nelson (IRRI); Preesan Rakwatin (GISTDA)

Compiled by: Matthew Steventon (Symbios Communications)

Edited by: Matthew Steventon, Stephen Ward, George Dyke (Symbios Communications); Shinichi Sobue, Kei Oyoshi (JAXA)

Table of Contents

Introduction

Background and Scope

The Asia-RiCE initiative has been organised to develop the Asian Rice Crop Estimation and Monitoring (Asia-RiCE) component for the GEO Global Agricultural Monitoring (GEOGLAM) initiative. GEOGLAM aims to enhance agricultural production estimates through the use of Earth observations, and Asia-RiCE seeks to ensure that the observational requirements for Asian rice crop monitoring are reflected in the GEOGLAM priorities.

The goal of Asia-RiCE is to foster the widespread use of EO for 'wall-to-wall', whole country, timely and accurate forecasts of rice production at national, regional, and global scales, as an input to the GEOGLAM Crop Monitor and AMIS Market Monitor.

Asia-RiCE is leveraging existing agricultural monitoring programs and initiatives at local levels (which serve as the Asia-RiCE Technical Demonstration Sites (TDS)) to develop, exercise and refine processes – from stakeholder engagement, through resource marshalling and deployment, and on to trial implementation and product generation using SAR (i.e. radar) and other Earth observation data for rice crop monitoring.

To achieve the overall goal of timely and accurate forecasts of rice production, TDS sites will need to develop and refine the generation of a number of key products, including rice crop area and yield estimations.

These target crop and agricultural products are summarised in Table 1. It is expected that these products will be generated with national resources as input to crop forecasting systems.

Table 1 – Target Products for Asia-RiCE

Product	Description
P1: Rice Crop Area Estimates/ Maps	Cultivated area (every year). Inventory of agricultural facilities.
P2: Crop Calendars/Crop Growth Status	Timing of sowing, planting, growing and harvesting/growing status. Identification of growth stages. Planted area progress (every month) per season. Crop growth anomaly.
P3: Crop Damage Assessment	Detection of flooding and other disaster impacted area. Detection of drought or inundated area. Detection of diseased plants, pests and diseased infestation.
P4: Agro-Meteorological Information Products	Early warning. Anomaly detection (drought, extreme temperatures). Crop growth anomaly.
P5: Yield Estimation And Forecasting	Empirical-statistical model estimate. Crop-growth simulation model estimates.

Figure 1 – Asia-RiCE Technical Demonstration Sites (TDS)

Phase 1 (2013 – 2015)

The activities of Asia-RiCE have been arranged into phases. Phase 1A (2013-2014) consisted of four TDS in three countries: Indonesia, Thailand and Vietnam). Each of these was focused on the development of provincial-level rice crop area estimations. Note: Phase 1A only covers rice area statistics, maps, and yield estimates. The other products will be covered in Phase 1B/2. In Phase 1B (2014-2015), additional technical demonstration sites in Chinese Taipei, Japan, and Malaysia were added.

Phase 2 (2016+)

Following the successful demonstration of the core functionality of Asia-RiCE, the initiative has moved into Phase 2, which increases the scope to whole country (or major crop area) estimates (with an initial focus on Thailand and Indonesia) to support the operational use of rice crop production information.

Scope

This report will summarise the activities and achievements of Asia-RiCE to date by providing examples of TDS outputs that have been enabled by the initiative.

This document also aims to acknowledge and highlight the impact of the substantial contributions from CEOS space agencies and the role of the Asia-RiCE initiative in facilitating these inputs.

Key Achievements

Asia-RiCE works to connect in-country agricultural agencies, space agencies, and global agricultural initiatives. It's activities are therefore broad, but can be broken down into three major categories: data coordination, software/tool development, and reporting.

Data Coordination

The Committee on Earth Observation Satellites (CEOS) and its agencies are critical partners for Asia-RiCE. Asia-RiCE works with these space agencies to secure the data required by TDS teams for development of the target products outlined in Table 1 as well as other research activities. Key efforts and contributions in Phase 1/2015 are summarised below.

- Increased Seninel-1A coverage over South East Asia by working closely with mission managers at ESA. This includes the establishment of a Mekong Delta Sentinel-1A Reference Site, which secured early ramp-up phase Sentinel-1A data for researchers and production of operational products for TDS (GEORICE);
- Worked with CSA/MDA to organise the acquisition and provision of RADARSAT-2 data to the TDS;
- Worked with JAXA to organise the acquisition and provision ALOS/ALOS-2 ScanSAR data under Kyoto & Carbon Phase 4;
- Arranged 42 TerraSAR-X datasets for the TDS free of charge thanks to DLR;
- ISRO collected and delivered RISAT-1 data to the Phase 1A TDS;
- Worked with ESA to organise the acquisition and provision of SPOT 5 data for TDS in Vietnam and Japan through the SPOT 5 Take 5 initiative;
- Worked with CNES to propose Venus observations of Asia-RiCE TDS.

A key feature of the coverage being provided by CEOS agencies is the multiple band SAR (C/L/X), which facilitates important intercomparability studies. Time series SAR data from multiple sources have been used to estimate rice planted area and growing status.

Software/Tools

JAXA/RESTEC continued development of the INAHOR (INternational Asian Harvest mOnitoring system for Rice; crop planted area estimation software) and JASMIN (agro-met information provision system for outlook) tools.

INAHOR estimates rice crop acreage and production using space-based Synthetic Aperture Radar (SAR) from the ALOS series, RADARSAT-2 and Sentinel-1.

JASMIN provides satellite derived agro-meteorological information including precipitation, drought index, soil moisture, solar radiation, land surface temperature, and vegetation index. The tool is able to generate two types of product for each parameter – current condition, and anomaly, which is the deviation from past year's averages. JASMIN can generate either a map of the whole country or time series graphs at a number of pre-defined locations. The outputs assist the ASEAN Food Security Information System (AFSIS) and target country agricultural statistics experts in preparing AMIS outlooks for Asia-RiCE.

2015 saw the following improvements/additions made to the tools:

INAHOR

- Support for ALOS-2, RADARSAT-2 and Sentinel-1 time series;
- *Planting Date* and *Days Since Planting* estimation; and,
- KML output.

JASMIN

- Increased geographic coverage, expanding to the whole of South East Asia, East Asia, and South Asia by March 2016.

The CEOS Systems Engineering Office (NASA) is providing cloud computing storage and processing capability using their Space Data Management System (SDMS) to allow JAXA to test INAHOR on RADARSAT-2 data over Indonesia to demonstrate the enhanced performance over using local JAXA systems for downloading and processing data.

The partnership continued in 2015, with server optimisation taking place throughout the year. Cloud server hosting was migrated to South East Asia (Singapore) in an effort to decrease latency and improve performance. The SDMS is being used by teams at the Indonesian Center for Agricultural Land Resources Research and Development (ICALRD) and Bogor Agricultural University (IPB).

Reporting

Asia-RiCE continued its work with the ASEAN Food Security Information System (AFSIS) to provide crop condition overview information and outlooks to the GEOGLAM Crop Monitor for AMIS, expanding the effort to include reports for The Philippines (in addition to Indonesia, Thailand, Vietnam and Japan). Lao PDR, Cambodia and Myanmar will provide reports from mid-2016.

The following sections, separated by country, highlight some of the major results achieved using data supplied by CEOS agencies.

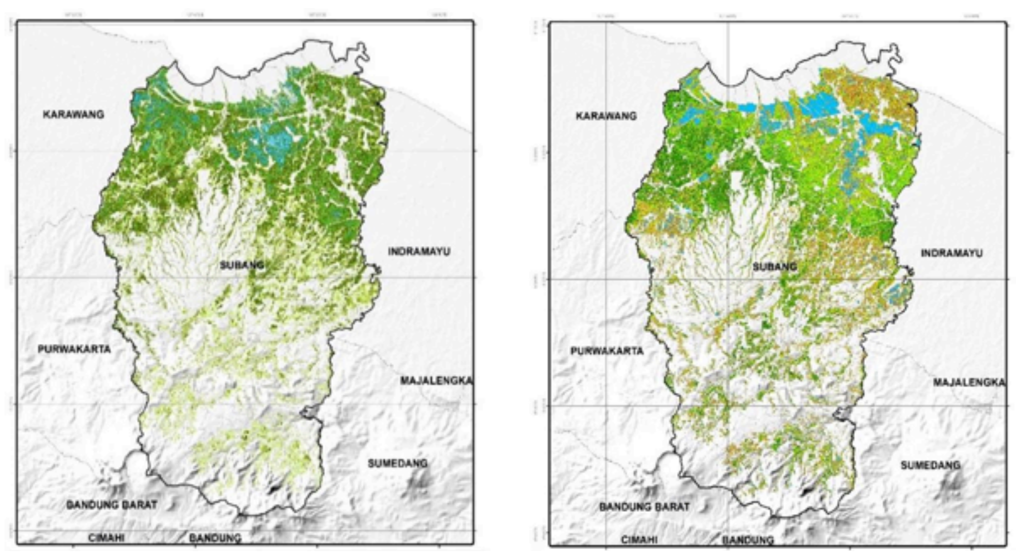
Indonesia

The National Institute of Aeronautics and Space of Indonesia (LAPAN) are the technical implementer and optical data provider of this TDS. LAPAN are also receiving and disseminating RADARSAT-2 data to the Indonesian teams that make up the TDS. LAPAN is developing a rice growth model based on RADARSAT-2 data, monitoring paddy growth stages using MODIS (every 8 days), and identifying drought/flood in paddy fields using MODIS and TRMM data.

The Indonesian Center for Agricultural Land Resources Research and Development (ICALRD), Indonesian Agency of Agricultural Research and Development (IAARD), and the Ministry of Agriculture (MoA) of the Republic of Indonesia support the production of information including paddy planted area and harvested area for the National Bureau of Statistics of Indonesia (BPS). Specifically, the MOA are implementing the RADARSAT-2 growth model and producing rice area maps.

Bogor Agricultural Institute (IPB) is acting as a technical supporter and field statistical data is provided by Badan Pusat Statistik (BPS, the National Bureau of Statistics of Indonesia, sub-directorate of food crops).

Figure 2 – Paddy cultivation area and growth stage classification map derived using ALOS-2 (left, August 2014 – January 2015) and RADARSAT-2 (right, June 2015 – August 2015). Subang Area, West Java, Indonesia.



The Indonesian TDS team has focused on rice phenological stage classification, and some results (using RADARSAT-2 data) are presented in Figures 2 and 3. Indonesia also continues to provide outlook reports to AMIS.

ICALRD are also working with ALOS PALSAR data (provided by JAXA) for paddy growth stage analysis, and have also performed rice phenological stage classification using ALOS-2 PALSAR-2 data supplied via the Kyoto & Carbon framework. Sample areas were classified into 6 phenological stages based on the visual interpretation of photos.

In 2016, the Indonesian rice crop monitoring initiative will be expanded to cover the top 10 ‘high priority’ rice crop areas (in part because the East-West extent of the country means a larger number of satellite passes would be required to cover all areas).

Contributors: Rizatus Shofiyati (ICALRD/IAARD/MOA), Mahmud Raimadoya (IPB), Kei Oyoshi (JAXA)

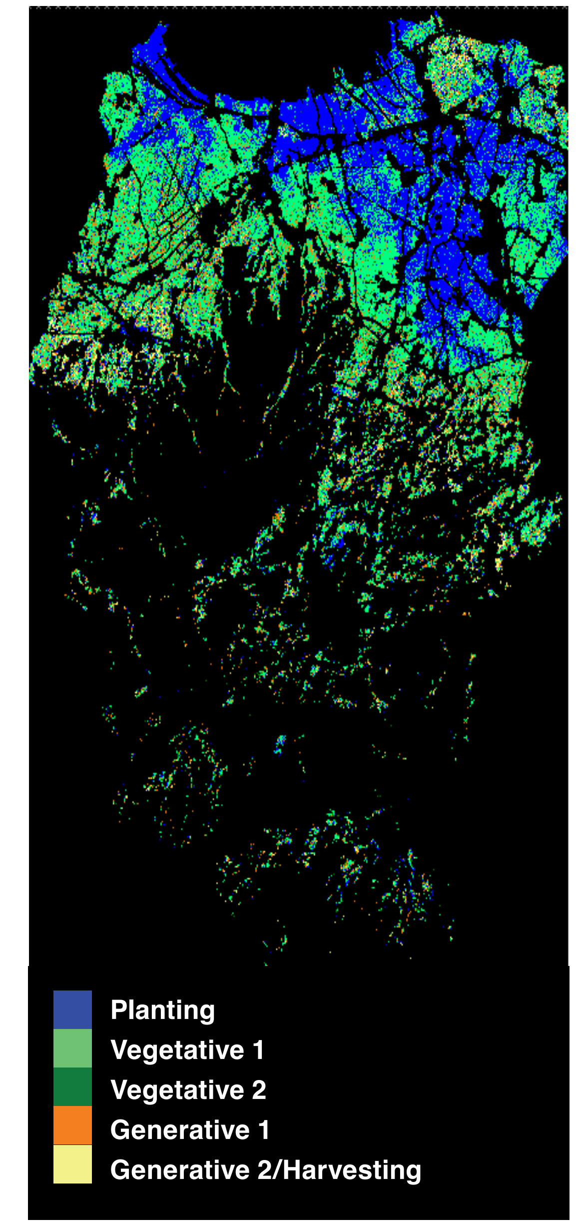


Figure 3 – Rice phenological stage classification using RADARSAT-2 data. Subang Area, West Java. Analysis by Indonesian MOA and LAPAN with JAXA.

South Vietnam

The Vietnamese study region is located in An Giang province, and a selection of sampling sites are used in order to capture the diversity in rice cropping systems (two or three crops per year) and different cultural practices. For each site, measurements are performed on several fields. Ho Chi Minh City Institute of Resources Geography (HCMIRG), Vietnam Southern Satellite Technology Application Center (STAC-VNSC), and Vietnam Academy of Science and Technology (VAST) perform surveying, process and analyse data, and develop tools and models. Centre d'Etudes Spatiales de la BIOsphère (CESBIO), France, provides technical advice on satellite data processing and field surveys.

The team aims to evaluate the use of SAR data in rice mapping and yield estimation, towards an operational system for a rice crop inventory in the Mekong Delta, Vietnam.

In 2013-2014, COSMO-SkyMed (ASI) and RADARSAT-2 (CSA/MDA) were used to produce rice crop area estimates and maps, and to perform yield estimation and forecasting, achieving accuracies of over 80%.

In 2014-2015, the scope of activities was increased to the whole Vietnamese Mekong Delta region.

The Vietnamese team has led the way in the application of newly available Sentinel-1A data

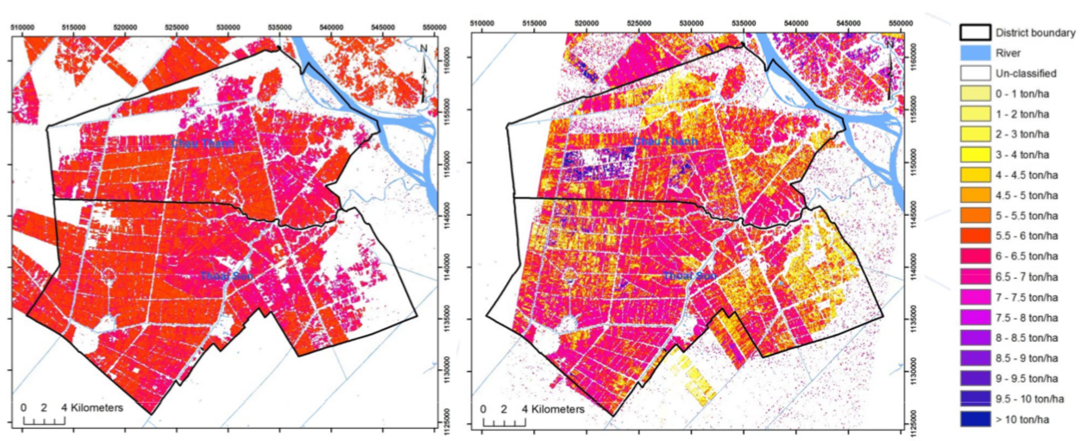


Figure 4 – Distribution maps of estimated rice yield in Chau Thanh and Thoai Son. RADARSAT-2 (left) and COSMO-SkyMED (right). Data from three points approximately 1 month apart.

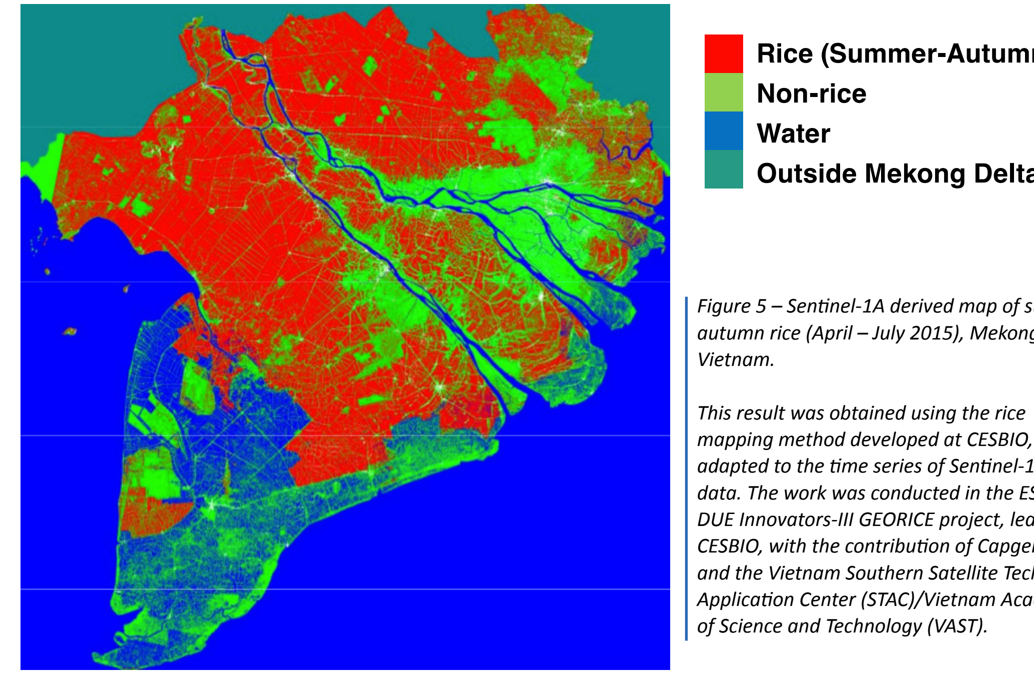


Figure 5 – Sentinel-1A derived map of summer-autumn rice (April – July 2015), Mekong Delta, Vietnam.

This result was obtained using the rice mapping method developed at CESBIO, adapted to the time series of Sentinel-1 WS data. The work was conducted in the ESA DUE Innovators-III GEORICE project, lead by CESBIO, with the contribution of Capgemini and the Vietnam Southern Satellite Technology Application Center (STAC)/Vietnam Academy of Science and Technology (VAST).

for rice monitoring, and early results can be seen in Figure 5.

Facilitated by the numerous SAR datasets provided by CEOS agencies over a number of years, a substantial amount of work has been done to compare results derived using various SAR bands (C/L/X). Products derived from ERS-2, ENVISAT, TerraSAR-X, RADARSAT-2, COSMO-SkyMED, and Sentinel-1A have been compared. Results show that backscatter signatures vary significantly for different bands, however all results have provided a high accuracy of planted rice areas. The studies also found that a minimum of three-date SAR data can be used to accurately estimate rice yield and production in combination with an appropriate statistical model (multi linear regression analysis).

CESBIO, under the GEORICE project funded by ESA, has defined a standard ground observation data collection method in cooperation with VAST.

In 2016, ALOS-2 data courtesy of the Kyoto & Carbon initiative will also be evaluated, along with further Sentinel-1 data from ESA. A Sentinel-1 reference site has been established (by GEORICE, VAST, ESA and JAXA) to explore opportunities for collaboration and data sharing, and this will continue in 2016.

Contributors: Thuy Le Toan (CESBIO), Lam Dao Nguyen (STAC/VAST)

South Korea

With thanks to CSA/MDA, the South Korean Asia-RiCE team has been doing substantial work with RADARSAT-2 data.

Papers published in 2013 and 2014 demonstrated the relationship between backscatter coefficients of rice measured by RADARSAT-2 SAR and growth parameters (such as Leaf Area Index (LAI), fresh weight, and Vegetation Water Content (VWC)) during a rice growth period.

Based on the observed relationships between backscatter coefficient and variables of cultivation, prediction equations were developed using the HH-polarized backscatter coefficients.

LAI distributions from RADARSAT-2 were compared to those derived from RapidEye, and some results are presented below.

Contributors: Sang Il Na, Suk Young Hong, Yi Hyun Kim, Kyoung Do Lee, Soyeong Jang (RDA)

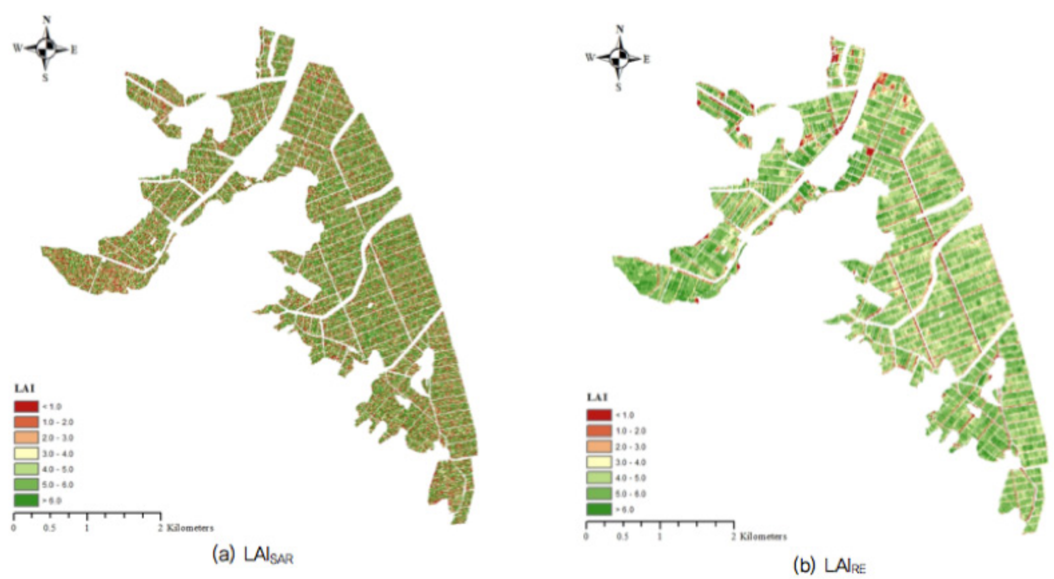


Figure 6 – Leaf Area Index distribution using RADASAT-2 on August 3, 2012 (a) and using RapidEye on August 5, 2012 (b) over Seosan region. Source: Evaluation of the Applicability of Rice Growth Monitoring on Seosan and Pyongyang Region using RADARSAT-2 SAR (Na et al., 2014).

India

The Indian Asia-RiCE team aims to upgrade existing algorithms for rice crop detection, area mapping/estimation and to validate accuracy for block-level use. Secondly, they aim to upgrade and validate models for wet biomass estimation, crop planting progress, and block-level yield estimation. Figure 7 shows Normalised Difference Vegetation Index (NDVI) and is constructed using multi-date SPOT VGT 10-day composite data along with RADARSAT SAR and IRS WiFS data. This data is used to map rice area and generate the seasonal rice cropping pattern and crop calendar (Manjunath & Panigrahy, 2009).

Contributors: K.R. Manjunath, Sushma Panigrahy (ISRO)

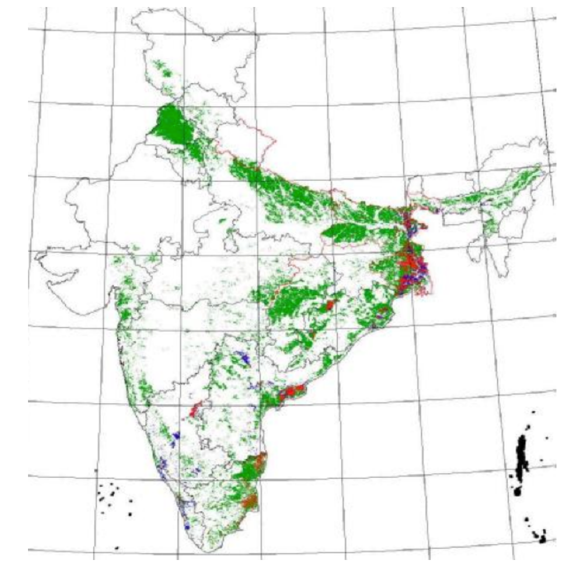


Figure 7 – Rice map of India derived using satellite data. Green is wet season rice (main season/rainy season), red is dual season rice, blue is second season rice.

The Philippines

The International Rice Research Institute (IRRI) and The Philippine Rice Research Institute (PhilRice) are engaged in Asia-RiCE. IRRI conducts rice area mapping and PhilRice lead ground validation work.

In 2015 IRRI released MODIS-based rice extent maps for Asia – providing a baseline of the where, how and when of rice. Asia-RiCE team members contributed to the effort through validation and verification of the products.

ALOS-2 data provided by JAXA was also put to use in rapid assessment of rice crop flooding damage caused by Typhoon Koppu, which struck The Philippines in October 2015. Rice planted areas (generated by the INAHOR tool) were compared with flooding extent (from ALOS-2) to identify regions that might experience lower than expected yields due to the event.

Contributors: Andrew Nelson (IRRI), Shinichi Sobue, Kei Oyoshi (JAXA)

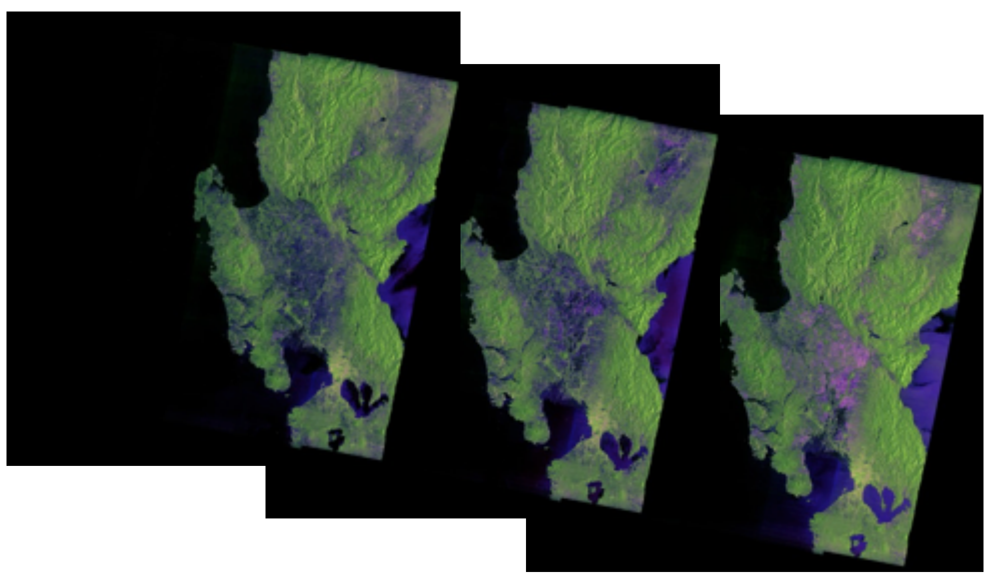


Figure 8 – Rice planted area detection in The Philippines using ALOS-2. 24th May (left), 2nd August (centre), 27th September (right). ALOS-2 provided rapid support to assess flooding damage caused by Typhoon Koppu (October 2015).

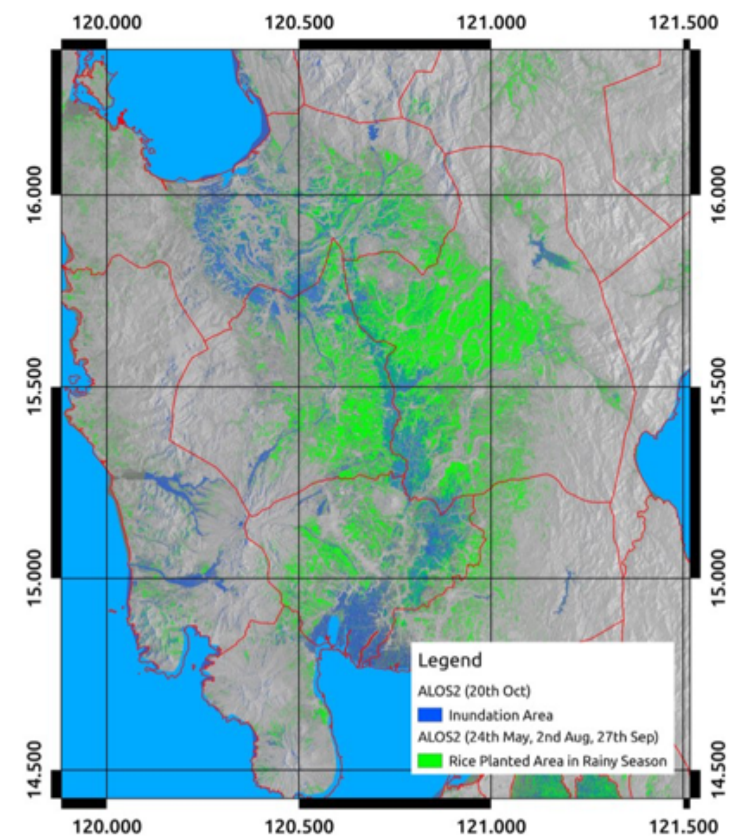


Figure 9 – Early flood damage assessment using ALOS-2

Japan

From 2015, Japan has been supplying ALOS-2 data to Asia-RiCE members under the Kyoto & Carbon (K&C) framework. 11 regions/countries are currently covered under the agreement.

JAXA/RESTEC provide the INAHOR (INternational Asian Harvest mOnitoring system for Rice, crop planted area estimation software) and JASMIN (agro-met information provision system for outlook) tools to assist the ASEAN Food Security Information System (AFSIS) and target country agricultural statistics experts in preparing AMIS outlooks for Asia-RiCE.

In addition to supporting the work of the other groups, the Japanese TDS team also performs field work and research using multiple SAR and optical datasets (Figure 11).

Contributors: Shinichi Sobue, Kei Oyoshi (JAXA)

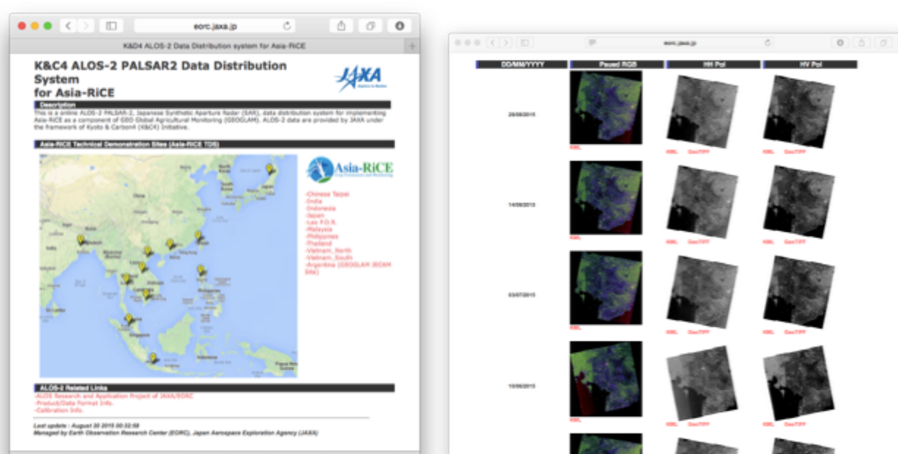


Figure 10 – K&C Phase 4 ALOS-2 Data Distribution System

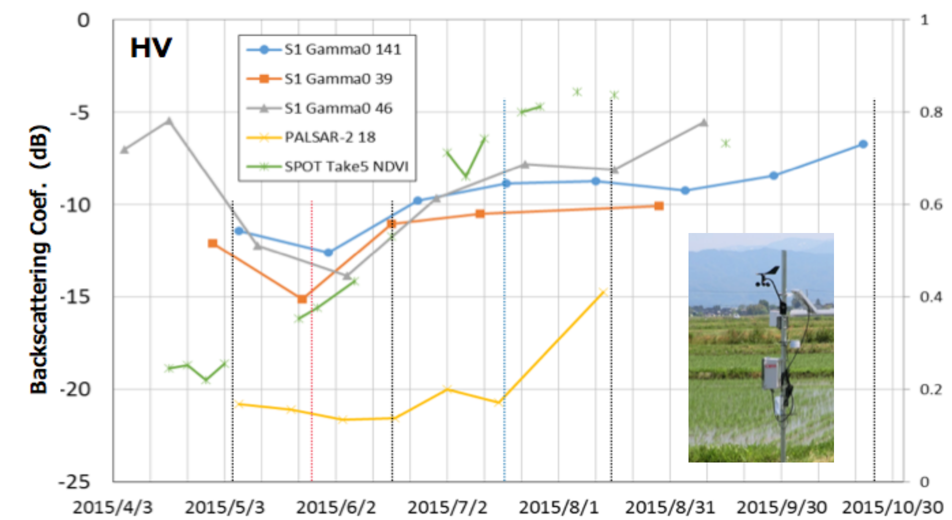
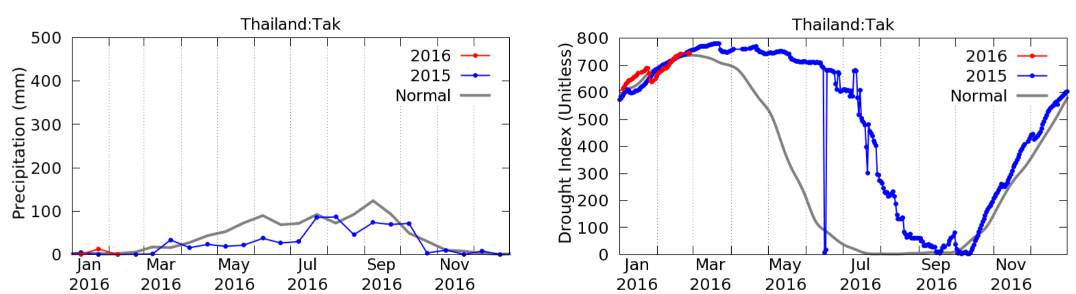


Figure 11 – Rice paddy monitoring in Tsuruoka province using multiple SAR (ALOS-2, Sentinel-1) and optical (SPOT5) data. Field data is collected using automated data collection stations, shown inset.

Thailand

In 2015, the JASMIN tool was particularly useful for calculating the increased KBDI drought index associated with the ongoing El Niño. JAXA provided drought index and cumulative precipitation statistics for the Thai province of Tak (the main water reservoir for Thai rice growing regions) to assist AFSIS and national experts with their rice crop outlooks and NDVI time series for Ang Thong province (Figure 12).

Contributors: Preesan Rakwatin (GISTDA); Shinichi Sobue, Kei Oyoshi (JAXA)



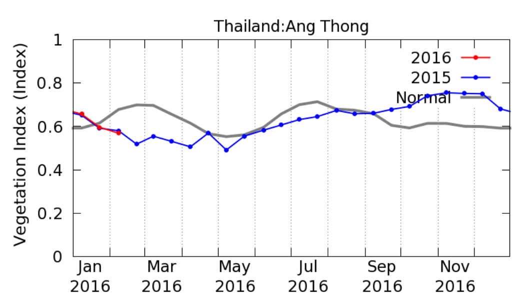


Figure 12 – Seasonal changes of drought index and precipitation in Tak Province, location of one of Thailand's biggest water storage dams – Bhu Mi Bol (upper panels).

Seasonal changes of vegetation index in Ang Thong province, the major rice production province below the Bhu Mi Bol dam (lower panel).

2016 and Beyond

2016+ Plans and Expectations

Asia-RiCE is in the initial steps of Phase 2, which increases scope to whole country estimates – with an initial focus on Thailand and Indonesia (top 10 rice growing provinces).

In addition, in 2016 and beyond, Asia-RiCE will:

- Continue working with Phase 1A/1B TDS to generate target products using SAR data from CEOS agencies including RADARSAT-2, Sentinel-1, ALOS-2, COSMO-SkyMed, TerraSAR-X , RISAT, etc. and continue working closely with CSA, DLR, ESA, JAXA, ISRO and other CEOS Agencies to ensure continuity of data supply for the TDS;
- Continue Sentinel-1 reference site work with GEORICE, VAST, ESA and JAXA; and explore the possibility of expansion to other South East Asian sites. Continue working with GEORICE to maximise the potential of the ESA DUE Innovator III program;
- Initiate integrated usage of high-resolution optical and SAR data for phenology studies (and others) using SPOT 5 Take 5, Venus, Landsat and Sentinel-2, along with coarse resolution satellites such as Terra/Aqua (MODIS) and GCOM-C;
- Continue to work with AFSIS and international donors to promote the practical use of rice crop area and production estimates for outlooks in Asia (in cooperation with JECAM, AFSIS, ESCAP, MRC, APRSAF, SERVIR MEKONG, etc.);
- Assist the JECAM SAR study;
- Adopt and promote the standard field survey procedure developed by CESBIO;
- Jointly publish Asia-RiCE TDS results and hold Asia-RiCE meetings/workshops in conjunction with international conferences such as ACRS.

2016+ Challenges and Issues

Some challenges being worked by the team include:

- Securing further observations and continued access to data. Observations from multiple satellites are very useful to validate rice growth and production estimates (especially for wall-to-wall/whole country activities – in conjunction with standardized field surveys/ground observations);
- Sharing of data analysis knowledge between team members (especially on incidence angle effects, etc.);
- Supporting ICT application development; expansion of the SDMS for use by end users such as ministries of agriculture;
- Promotion of EO data and related information sharing (especially ground data and base line maps such as LULCC, crop calendar, etc.);
- Promotion of cross-validation for outlooks and rice crop growing and production estimations;
- There are some Sentinel-1 observation gaps in Thailand, and ALOS-2 observations are lacking for some TDS.

A Critical and Unique Space Agency Service

Asia-RiCE Phase 1 has demonstrated the great utility of the initiative, with substantial amounts of CEOS data flowing from space agencies to in-country agricultural agencies and researchers – an achievement that would not have been possible without the collective efforts of the group and its connections to GEOGLAM and CEOS.

As a result of Asia-RiCE, improved rice production estimates are being generated at national, regional, and global scales – valuable inputs to the GEOGLAM Crop Monitor and AMIS Market Monitor that would not otherwise be present.

Asia-RiCE thanks all CEOS agencies for their unique and critical contributions – in particular CSA, DLR, ESA, ISRO and JAXA.