

# GEOGLAM Asia-RiCE Team Activities Update and Accomplishments

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*On behalf of the GEOGLAM Asia-RiCE team*

**2015/11/16**



<http://www.asia-rice.org>

# Asia-RiCE Home Page – www.asia-rice.org

Asia-RiCE  
Crop Estimation and Monitoring

GEOGLAM  
Global Agricultural Monitoring

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Rice is the staple food for more than half of humanity, with 90% of the world crop grown and consumed in Asia.

### About

Asia-RiCE is the work of an ad hoc team of stakeholders with an interest in the development of an Asian Rice Crop Estimation & Monitoring (Asia-RICE) component for the GEO Global Agricultural Monitoring (GEOGLAM) initiative.

**Rice is the staple food for more than half of humanity - with 90% of the world crop grown and consumed in Asia.**

World population, and therefore demand for food, has increased linearly over the last fifty years (+80M/year), and is projected to keep growing until around 2050 up to 9 billion inhabitants (United Nations Department of Economic and Social Affairs, Population Division 2004). This conjuncture is prone to create tensions in food markets that could lead to world food price crises, as in 2008 when the price of rice more than doubled in only seven months. In this context of price instability and threatened food security, tools to monitor rice production in real-time are highly needed by governments, traders and decision makers.

Accurate information is needed on the spatial distribution of rice fields, water resource management, risk occurrence and annual production projections. However, most agricultural surveys rely mainly on statistics based on limited ground samplings at which data are extrapolated on a national scale. Although the census can provide statistical estimates, slow and unsystematic collection of data can limit the ability to make timely decisions.

Moreover, rice agriculture is strongly linked to environmental issues, from water management to climate change. For these reasons, long term inter-annual monitoring is also required in order to study the production and cultural impacts of these factors. Satellite remote sensing can support this long term monitoring requirement at regional and global scales.

### Objectives

Asia-RICE describes a work plan for the definition and development of the Asia-RICE component for GEOGLAM. The objectives are:

- To ensure that Asian countries receive the full potential benefits of GEOGLAM, and that they are suitably engaged and prepared to do so;
- To ensure that rice crop monitoring issues are given suitable priority and attention within the scope of the full GEOGLAM initiative, including in the development of the observing requirements; and
- To establish a framework for the coordination necessary to engage, manage and support the various stakeholders.

The regional activities suggested by the Asia-RICE Work Plan will be consistent with and undertaken within the broader GEOGLAM Work Plan and there will be a number of interdependencies and interchanges between the two Plans.

Website provided by MKA

GEO GROUP ON EARTH OBSERVATIONS

Asia-RiCE  
Crop Estimation and Monitoring

GEOGLAM  
Global Agricultural Monitoring

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### About

This work has been undertaken by an ad hoc team of stakeholders with an interest in the development of an Asia-Rice Crop Estimation & 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. It was developed in response to the G20 Agricultural Ministers' concern about reducing market volatility for the world's major crops. The initiative builds on recent advances in Earth observation technologies. These technologies have great potential to contribute to timely forecasts of crop production and early warnings of potentially significant harvest shortfalls.

### Importance of Rice Crop Monitoring

Rice is the staple food for more than half of humanity - with 90% of the world crop grown and consumed in Asia. Global rice production has increased continuously in the last half-century, since the Green Revolution. In the same period, the use of chemical inputs, the introduction of modern high-yielding varieties with short growing cycles, and the increased access to machinery and irrigation systems have led to a linear growth of the crop yields (+0.05ton/ha/year) as well as to an increase of the number of crops per year (Food and Agriculture Organization of the United Nations 2009).

This higher cropping intensity (from single to double or triple crop) together with the conversion of non arable land to arable land have resulted in a drastic increase of rice harvested areas in the 60s and 70s (+1.4Mha/year) which slowed down in the 80s and 90s (+0.46Mha/year) and has tended to stabilize over the last ten years as a result of approaching the limits of land use and of cropping intensity, however there is a large inter-annual variability due to climatic conditions and socio-economic factors. As both the increase in yield and in planted areas will be facing limitations in the next decades, it is unlikely that rice production can keep increasing at the same rate.

Meanwhile, world population, and therefore demand for food, has increased linearly over the last fifty years (+80M/year), and is projected to keep growing until around 2050 up to 9 billion inhabitants (United Nations Department of Economic and Social Affairs, Population Division 2004). This conjuncture is prone to create tensions in food markets that could lead to world food price crises - as in 2008 when the price of rice more than doubled in only seven months - and eventually to famines. In this context of price instability and threatened food security, tools to monitor rice production in real-time are highly needed by governments, traders and decision makers.

Top rice producing countries by MT, 2010 (Source: FAOSTAT).  
Click to enlarge.

Accurate information is needed on the spatial distribution of rice fields, water resource management, risk occurrence and

# Asia-RiCE Target Agricultural Products

<b>ID</b>	<b>Target Agricultural Products</b>
P1	<b>Rice Crop Area Estimates/Maps</b>
P2	<b>Crop Calendars/Crop Growth Status</b>
P3	<b>Crop Damage Assessment</b>
P4	<b>Agro-meteorological Information Products</b>
P5	<b>Production Estimation and Forecasting</b>



# Major Achievements 2015

## - Rice Crop Area Estimates/Maps -

### 1. Content

- Time series SAR data from multiple providers to estimate rice planted area, growing status, etc. (Indonesia, Vietnam, Thailand, Japan and others)
- JAXA/RESTEC teams developed the INAHOR (rice crop planted area estimation) software
- NASA/CEOS SEO developed & tested a cloud computing SAR processing (INAHOR) platform for Indonesia

### 2. Target area and period

- **Asia-RiCE Phase 1 (from 2014).**  
**Technical demonstration sites (100x100km) in Asia countries & focus on development of provincial-level rice crop area estimations.**
- **Phase 2.**  
**Whole country (“wall-to-wall”) rice crop area estimates using wide area mode SAR & other data.**





# Indonesia rice growing calendar for Outlook

Indonesia	Season	Type of Rice		Status	This Year									Next Year						
		Wet Season	Dry Season		Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Marc	Apr	May	Jun	
Whole Country	Rainy	Wet Season		Seeding								10	11	12	1	2	3			
				Harvesting	1	2	3							10	11	12	1	2	3	
	Dry	Dry Season		Seeding	4	5	6	7	8	9										
				Harvesting				4	5	6	7	8	9							
Java	Rainy	Wet Season		Seeding								10	11	12	1	2	3			
				Harvesting	1	2	3							10	11	12	1	2	3	
	Dry	Dry Season		Seeding	4	5	6	7	8	9										
				Harvesting				4	5	6	7	8	9							
Sumatera	Rainy	Wet Season		Seeding								10	11	12	1	2	3			
				Harvesting	1	2	3							10	11	12	1	2	3	
	Dry	Dry Season		Seeding	4	5	6	7	8	9										
				Harvesting				4	5	6	7	8	9							
Sulawesi	Rainy	Wet Season		Seeding								10	11	12	1	2	3			
				Harvesting	1	2	3							10	11	12	1	2	3	
	Dry	Dry Season		Seeding	4	5	6	7	8	9										
				Harvesting				4	5	6	7	8	9							

Definition :

Dry Season Rice refers to rice planted during April to September to April of this year

Wet Season Rice refers to the rice planted during October of this year to March of next year

Note: color show the desnity of planting and harvesting



Source: Statistic Indonesia 2012-2013, Discussion with AFSIS expert.

- The habits of most Indonesian farmers are planting when water is available so there is no firm timetable at planting and harvest time.

Rainy (wet) crop : Rice1,  
Dry crop: Rice 2



# RADARSAT-2 DATA ANALYSIS



The screenshot displays the ENVI software interface. The main window shows a false-color composite of radar data. The left sidebar contains a 'Products view' tree with folders for 'sigma\_0\_VH\_TC\_RLee', 'sigma\_0\_VH\_TC\_RLee\_db', and 'sigma\_0\_VV\_TC\_RLee'. The 'Products view' for 'sigma\_0\_VH\_TC\_RLee' is expanded, showing 'Identification', 'Metadata', 'Vectors', and 'Bands' (Sigma0\_VH, virtual\_red, virtual\_green, virtual\_blue). The 'Navigation' window shows a zoomed-in view of the data. The 'Pixel Info' window is visible at the bottom left. The status bar at the bottom indicates '20239 x 12898' and '-439M of 901M'. The system tray shows the date '16/07/2014' and time '13:33'.

**Software used**

- Preprocessing: The Next ESA SAR Toolbox (NEST)
- Planted area identification: INAHOR
- Growing stage classification: ENVI & ErMapper

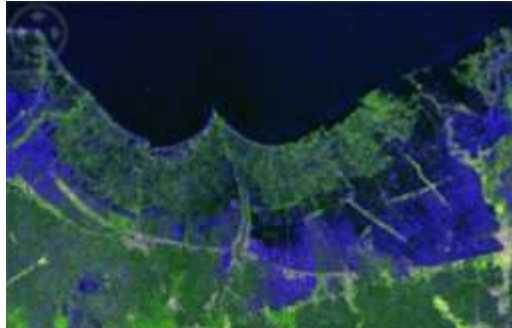
**Radarsat-2**

- Red : VV
- Green : VH
- Blue : VV/VH

# Example Achievements – Indonesia

## RADARSAT-2 Rice Phenological Stage Classification (RGB composite)

23 August



3 November



Frequent acquisitions allow backscatter ratio (and hence growth stage) to be tracked over time.

Subang Area, West Java. Analysis by Indonesian MOA and LAPAN with JAXA.

Red : VV

Green : VH

Blue : VV/VH

11 February



# SAR Images of Phenological Stages

- Each Sample Area was classified into 6 phenological stages based on the visual interpretation of photos



Planting



Vegetated1



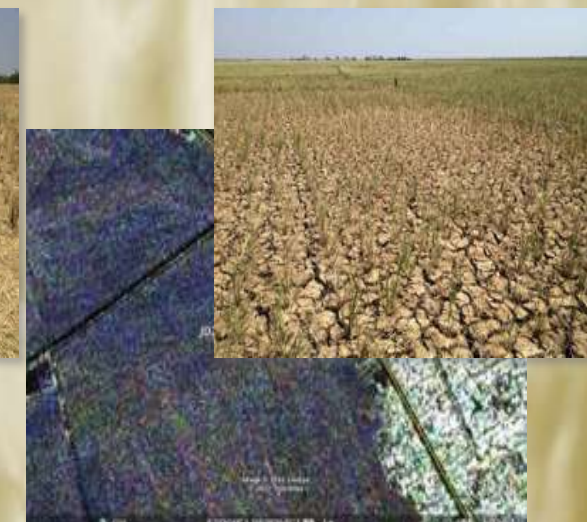
Vegetated2



Harvesting

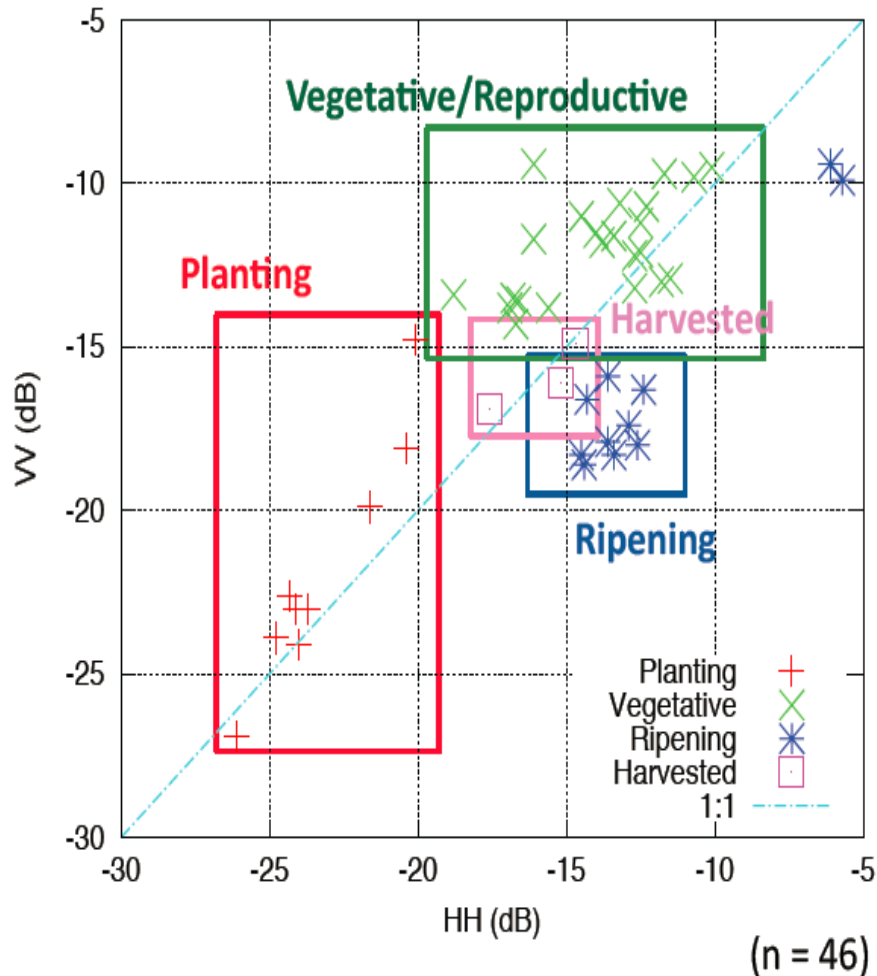


Harvested



Drought

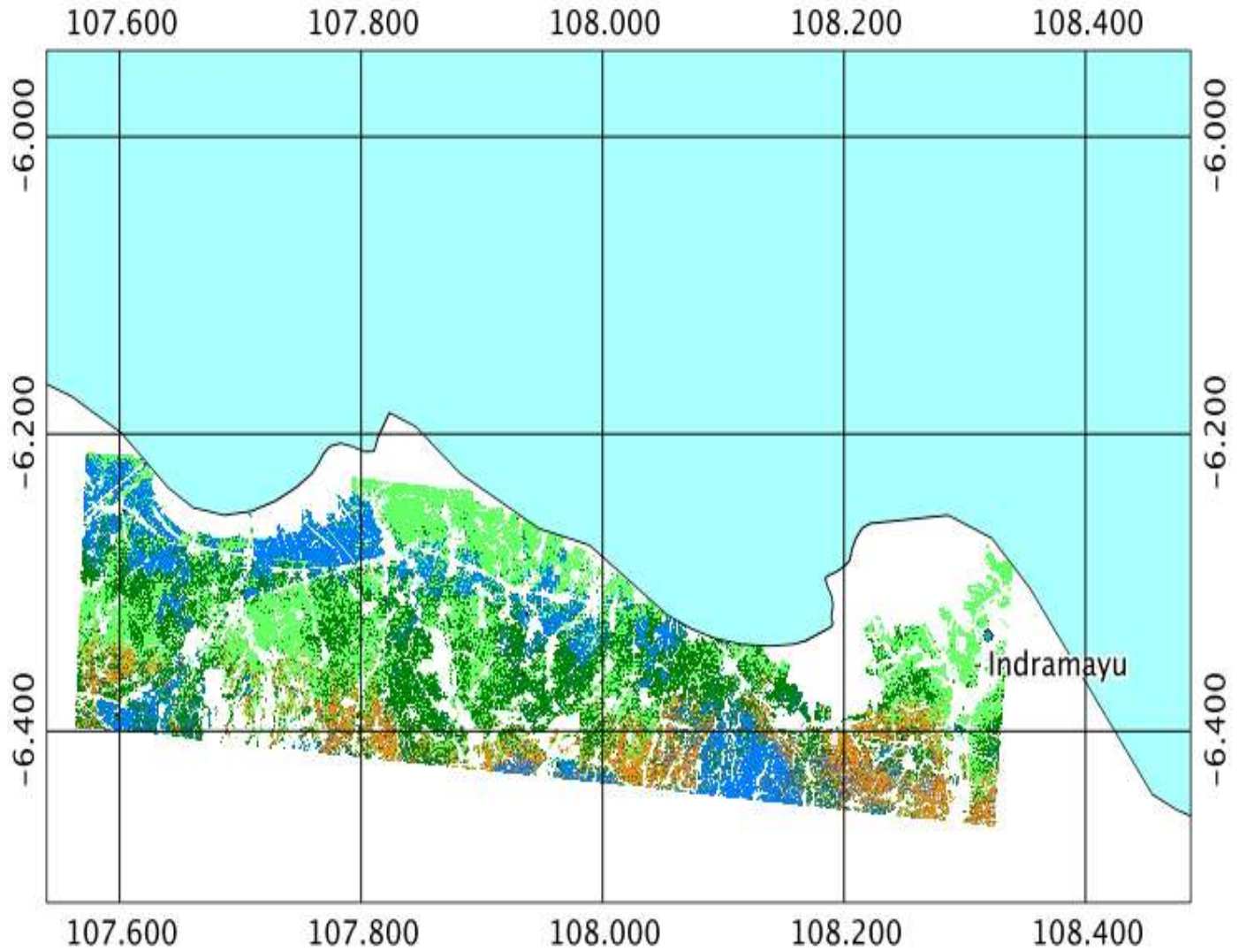
# Relationships between Rice Phenology and HH/VV



- ❖ **Planting**
  - Low HH and VV
- ❖ **Vegetative/Reproductive**
  - High HH and VV
  - $VV > HH$
- ❖ **Ripening**
  - $HH > VV$
- ❖ **Harvested**
  - $HH \approx VV$

Each phenological stage (Growth Profiles) has its HH/VV signature.

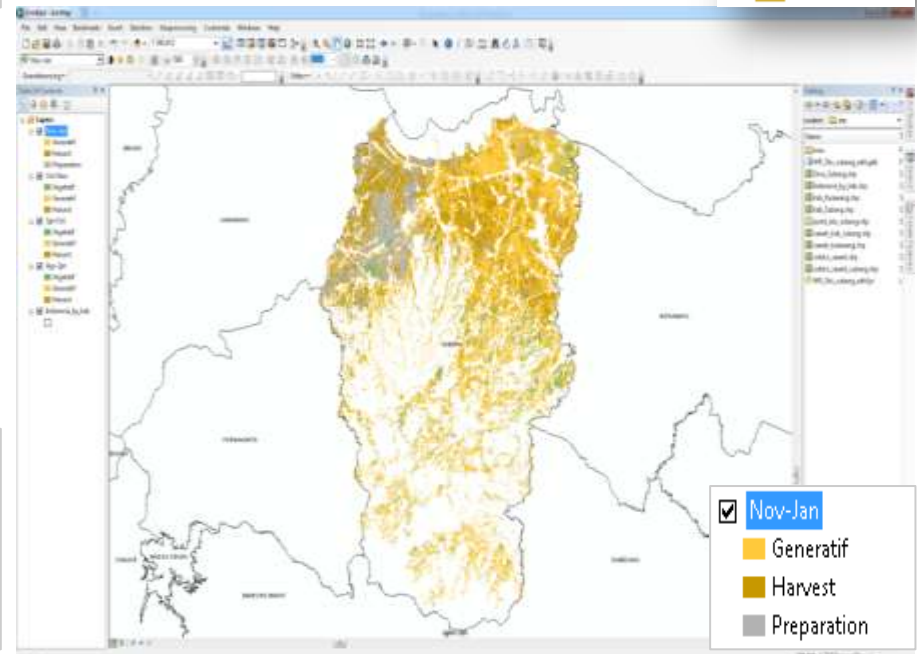
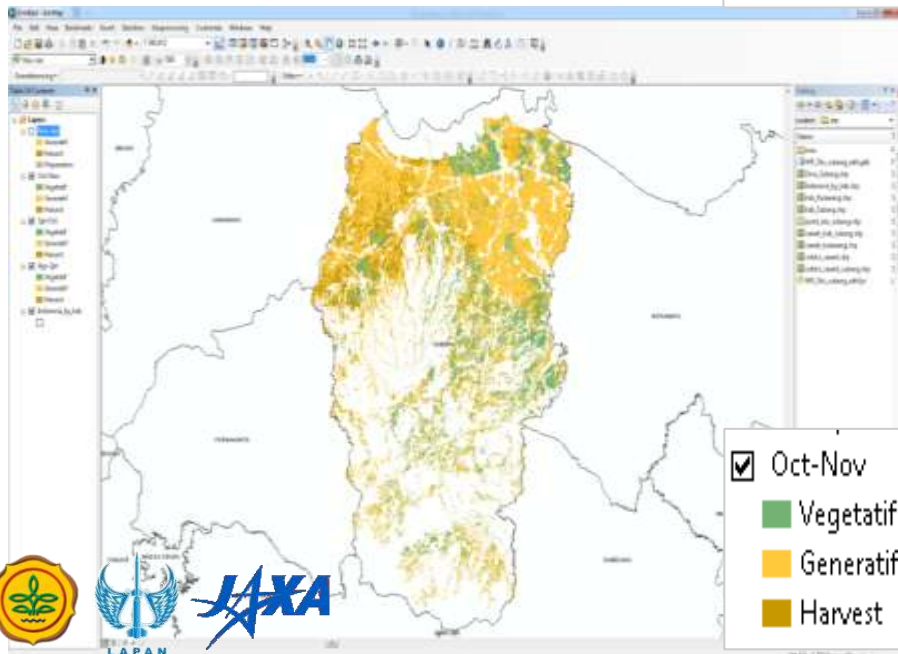
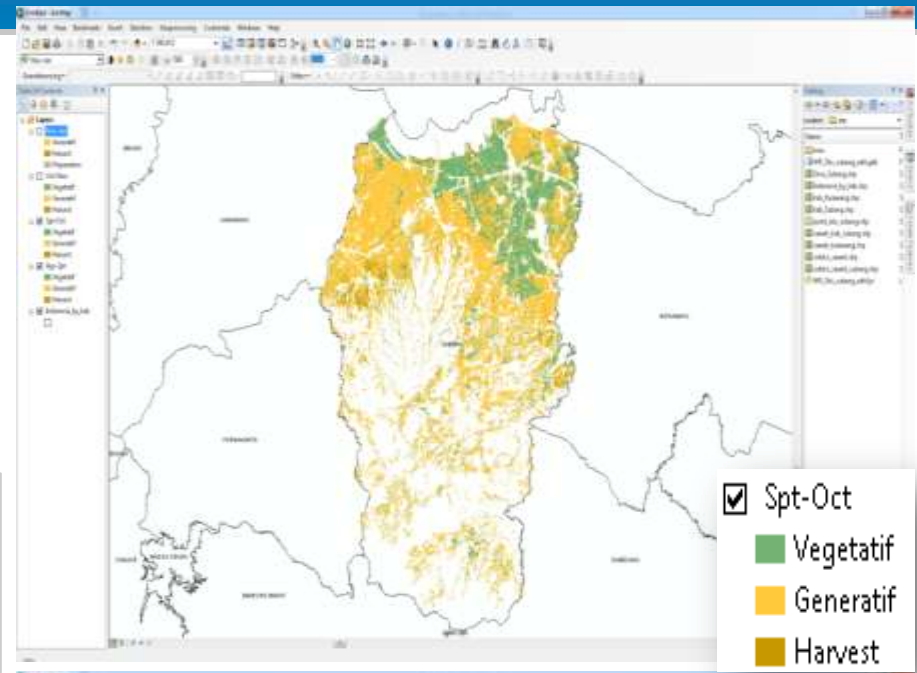
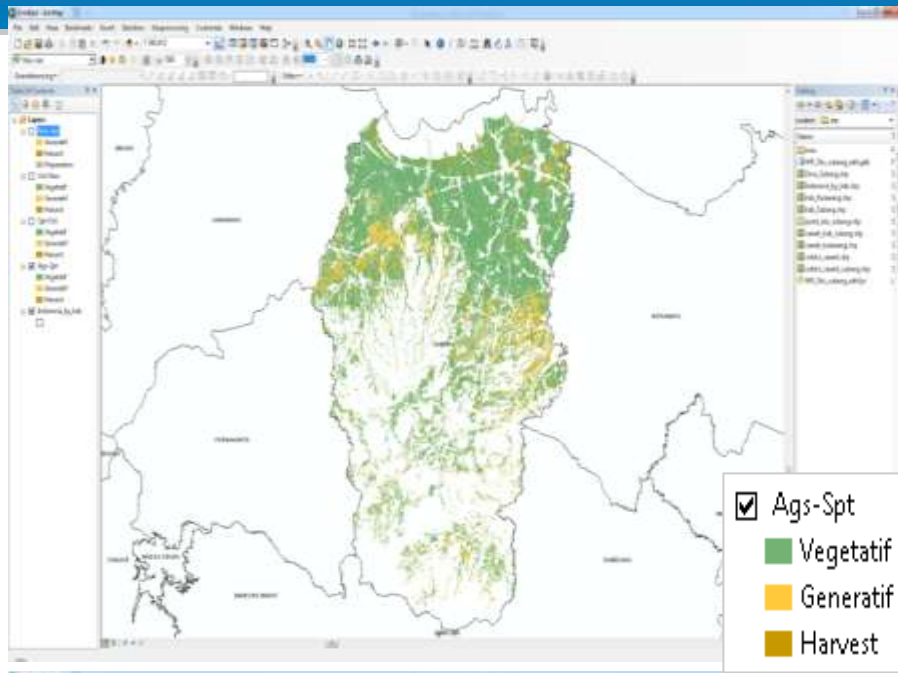
# Mapping Result with Paddy Field Mask



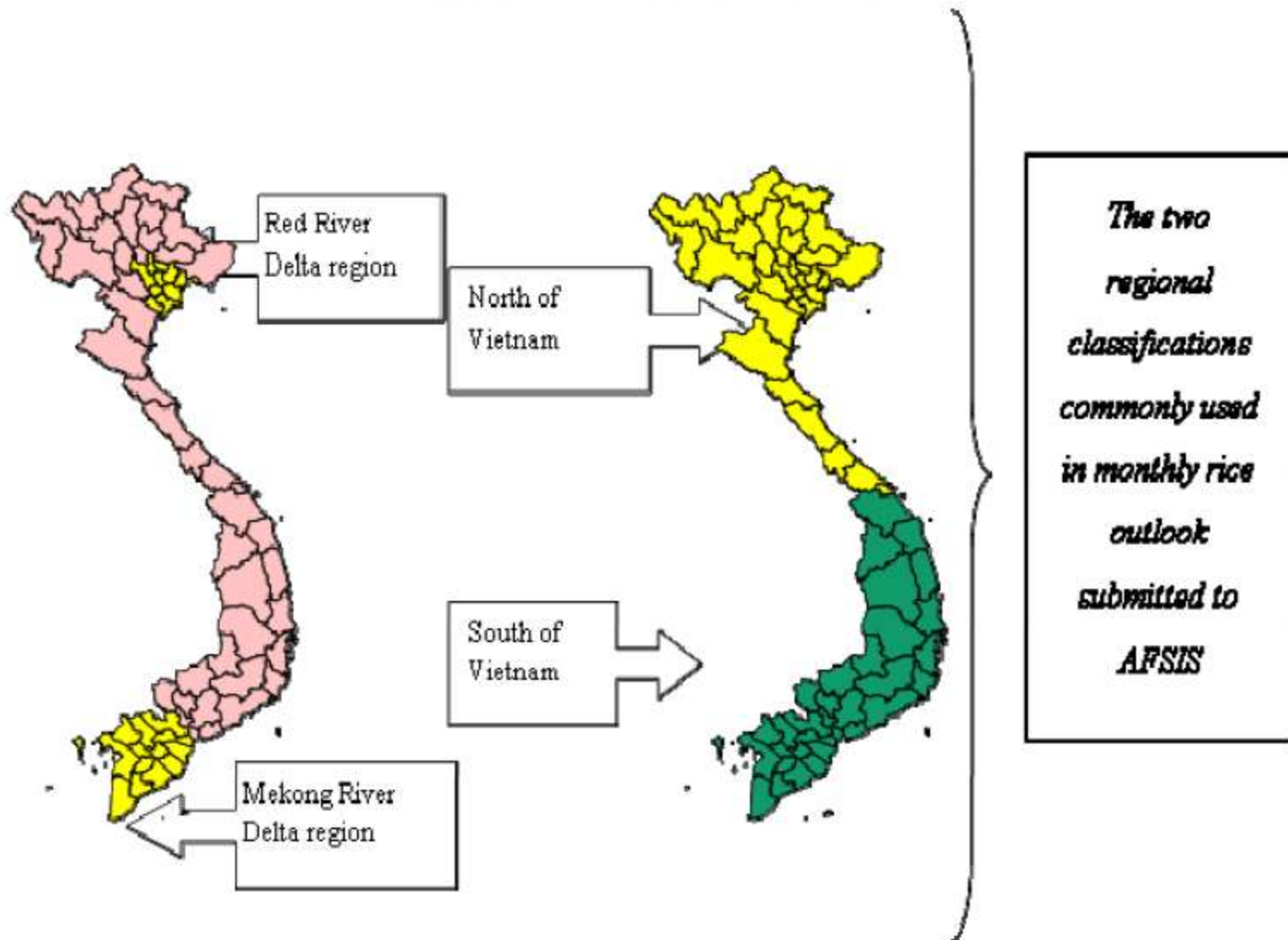
- Planting
- Vegetated 1
- Vegetated 2
- Harvesting

# Rice Phenological Stages Classification using ALOS PALSAR 2 Data (VH\_VV)

August 2014 - Jan 2015 (Subang Area, West Java)



# Vietnam rice crop area



# Vietnam rice growing calendar for Outlook

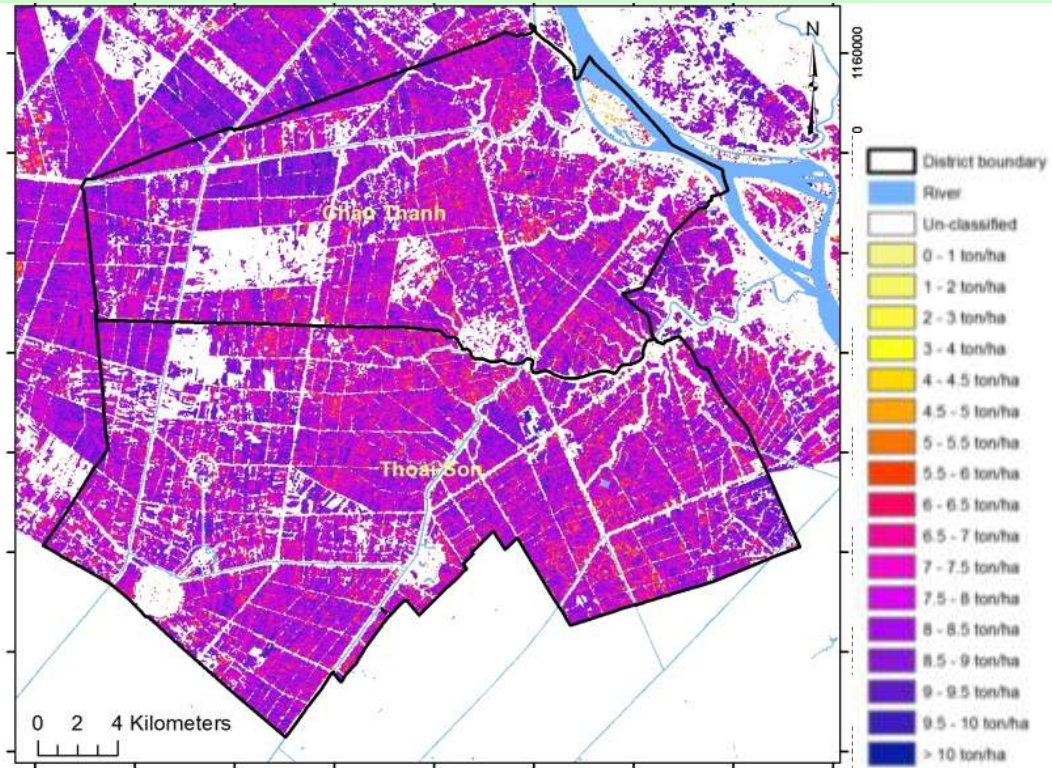
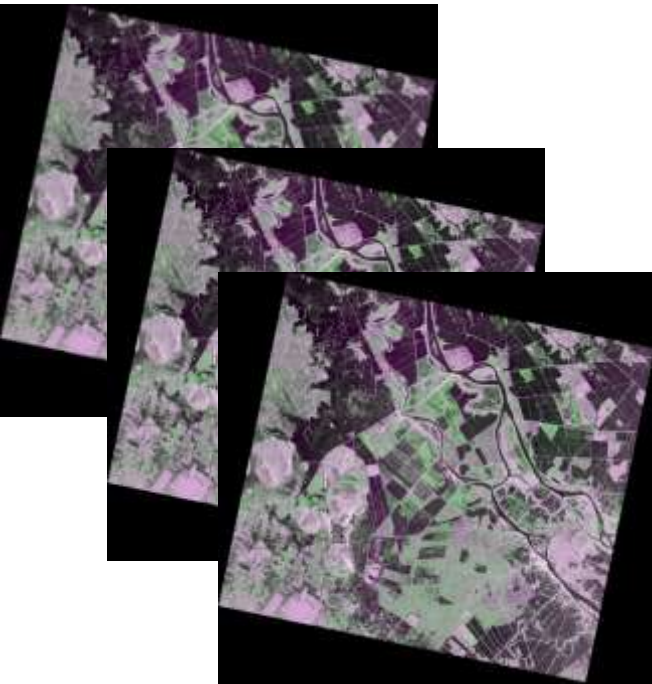
Vietnam	Season	Type of rice		Status	Months											
		Wet season	Dry season		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North	Winter-Spring		●	Seeding	■	■								■	■	■
				Harvesting		■	■	■	■	■						
	Summer-Autumn	●		Seeding					■	■	■	■	■	■	■	
				Harvesting	■	■	■	■								■
	Summer	●		Seeding					■	■	■	■	■			
				Harvesting								■	■	■	■	
South	Winter-Spring	●	●	Seeding	■								■	■	■	
				Harvesting			■	■	■	■	■					
	Summer-Autumn	●		Seeding			■	■	■	■						
				Harvesting					■	■	■	■	■			
	Summer	●		Seeding					■	■	■	■	■			
				Harvesting											■	■
	Autumn-Winter	●		Seeding								■	■			
				Harvesting	■											■
			<b>Note:</b>	Seeding	■											
				Harvesting	■											

– Above table is the result of the Discussion between CIS and an expert of the Cultivation Department in September 2013.

Summer and Autumn-Winter (WET) : Rice1,  
 Summer-Autumn (WET): Rice 2,  
 Winter-Spring (DRY): Rice 3



# Rice area and yield estimation using R2 in Ann Gang by Lam Dao Nguyen, Thuy Toan et al



$$Y_{Ra} = 11.73063 + 13.5107 \cdot Ra_1 - 85.4393 \cdot Ra_2 - 78.03883 \cdot Ra_3$$

$$r^2 = 0.779, se_y = 0.3 \text{ ton/ha}$$

Where:

$Y_{Ra}$  : rice yield (ton/ha),

$Ra_1$  :  $\cdot^\circ$  of VH polarisation of first date image,

$Ra_2$  :  $\cdot^\circ$  of VH polarisation of second date image,

$Ra_3$  :  $\cdot^\circ$  of VH polarisation of third date image,

$r^2$  : the coefficient of determination,

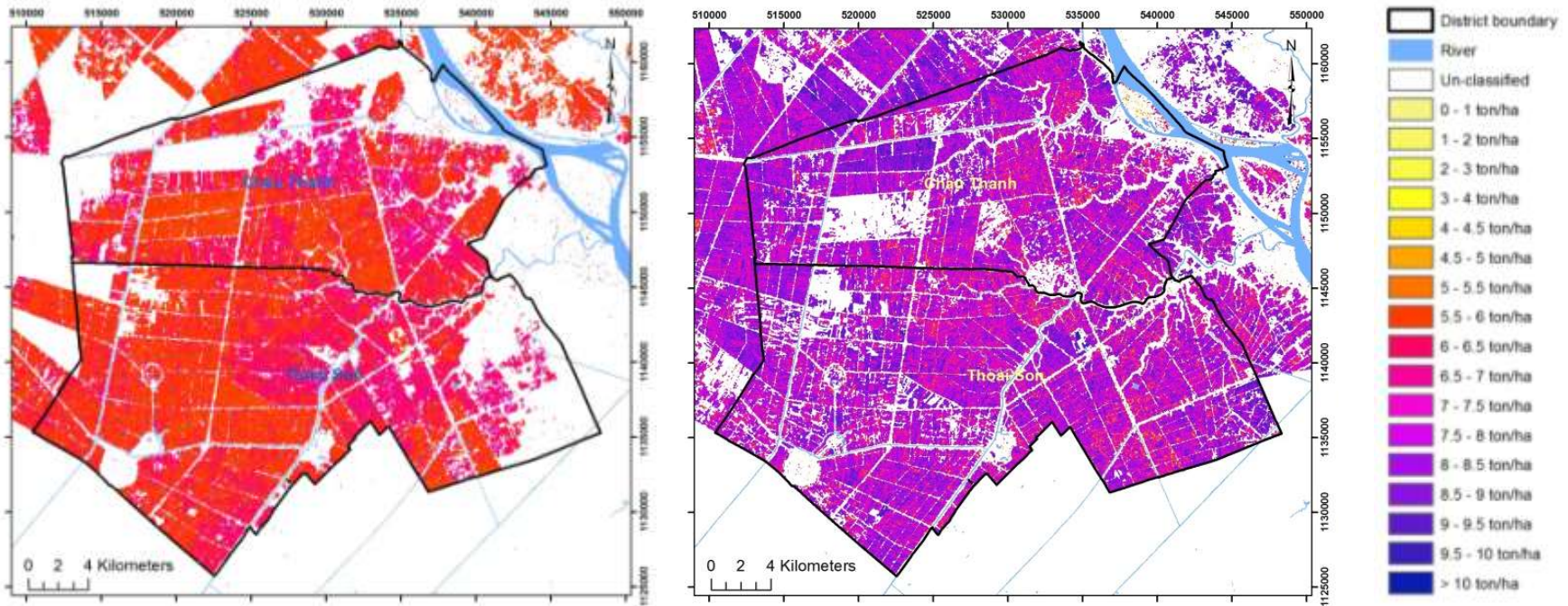
$se_y$  : the standard error for the y estimate.

A distribution map of estimated rice yield in WS 2014 crop at Chau Thanh and Thoai Son district using three-date VH polarisation:

- RADARSAT-2 27 Dec 2013
- RADARSAT-2 20 Jan 2014
- RADARSAT-2 13 Feb 2014



# Rice area and yield estimation using R2 in Ann Gang by Lam Dao Nguyen, Thuy Toan et al



A distribution map of estimated rice yield in **AW 2013 crop** at Chau Thanh and Thoai Son district using three-date VH polarisation:

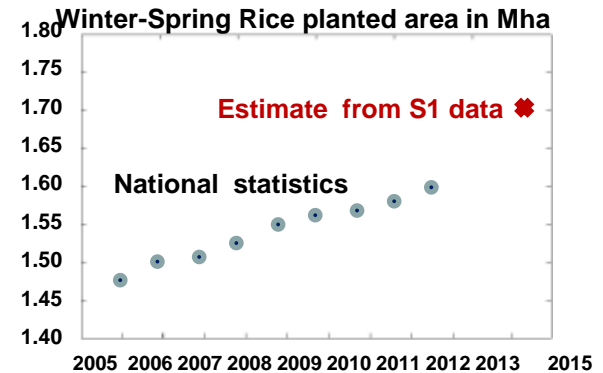
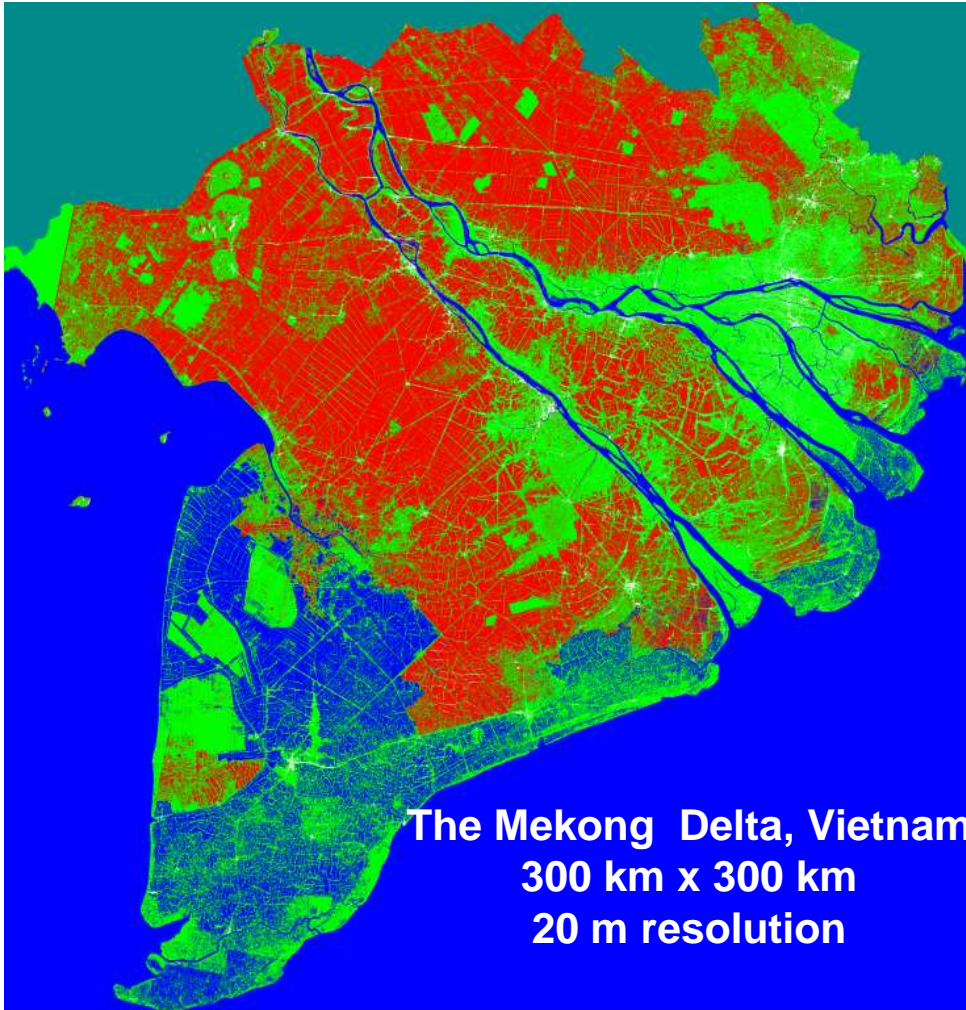
- RADARSAT-2 29 Aug 2013
- RADARSAT-2 16 Oct 2013
- RADARSAT-2 09 Nov 2013

A distribution map of estimated rice yield in **WS 2014 crop** at Chau Thanh and Thoai Son district using three-date VH polarisation:

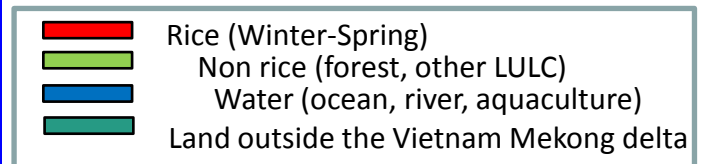
- RADARSAT-2 27 Dec 2013
- RADARSAT-2 20 Jan 2014
- RADARSAT-2 13 Feb 2014

# Rice monitoring using Sentinel-1A data

## Estimate and map of Winter-Spring Rice (January-April) 2015



Estimated Winter-Spring planted area in 2015:  
1.704 Mha

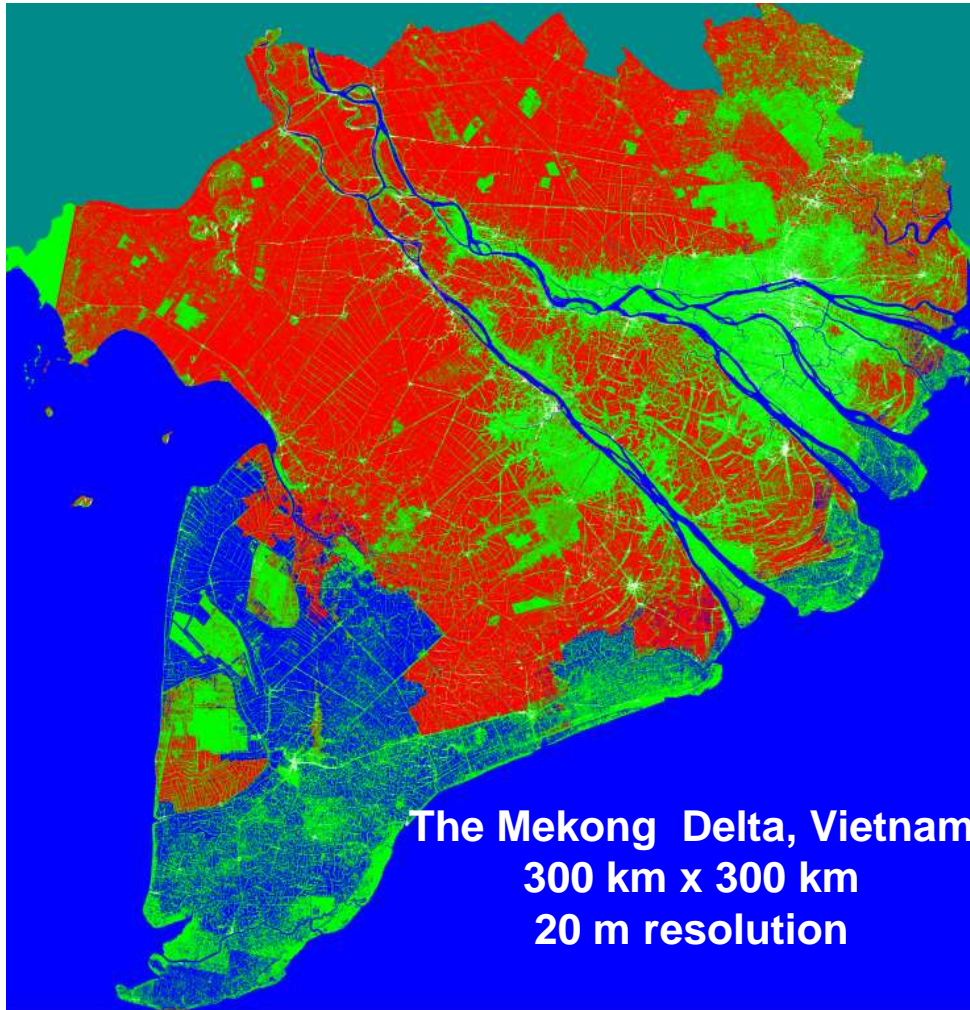


IW S1 Data: 10 January, 03 February, 27 February, 11 March, 23 March, 04 April, 16 April 2015



# Rice monitoring using Sentinel-1A data

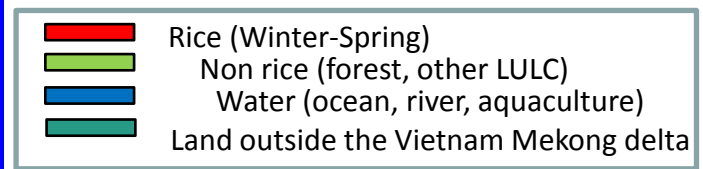
## Estimate and map of Spring-Summer Rice (April-July) 2015



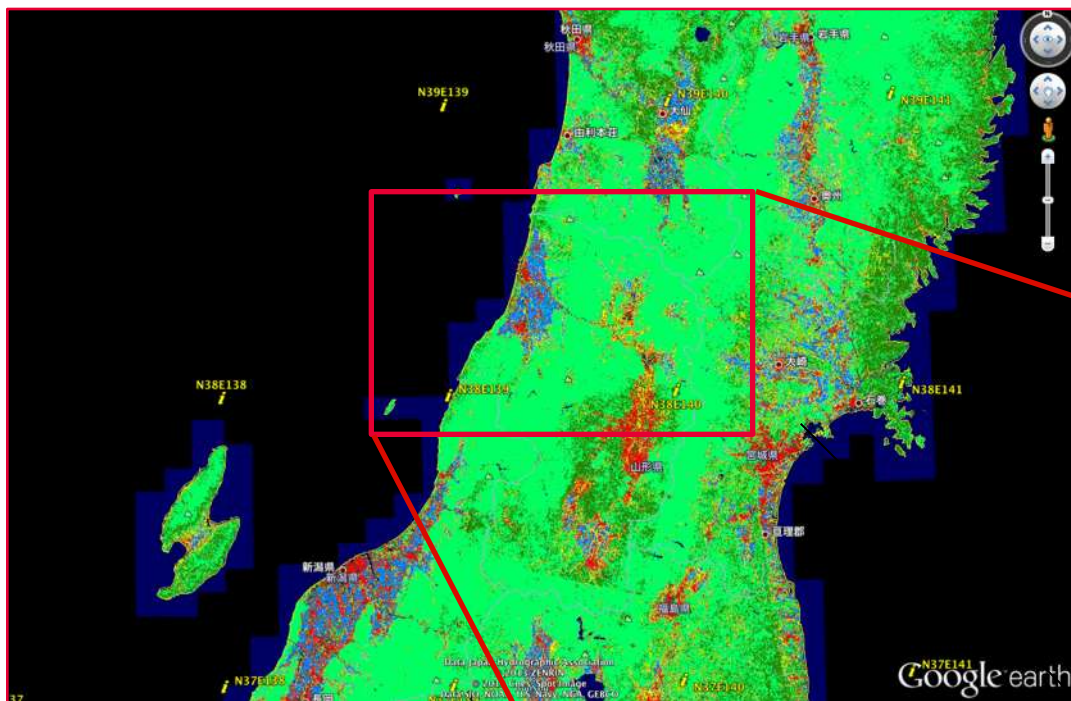
### Mapping result obtained by 21 July 2015

IW S1 Data: 28 April, 10 May, 16 May,  
15 June, 9 July, 21 July 2015

Estimated Spring-Summer planted area in 2015:  
2.14 Mha

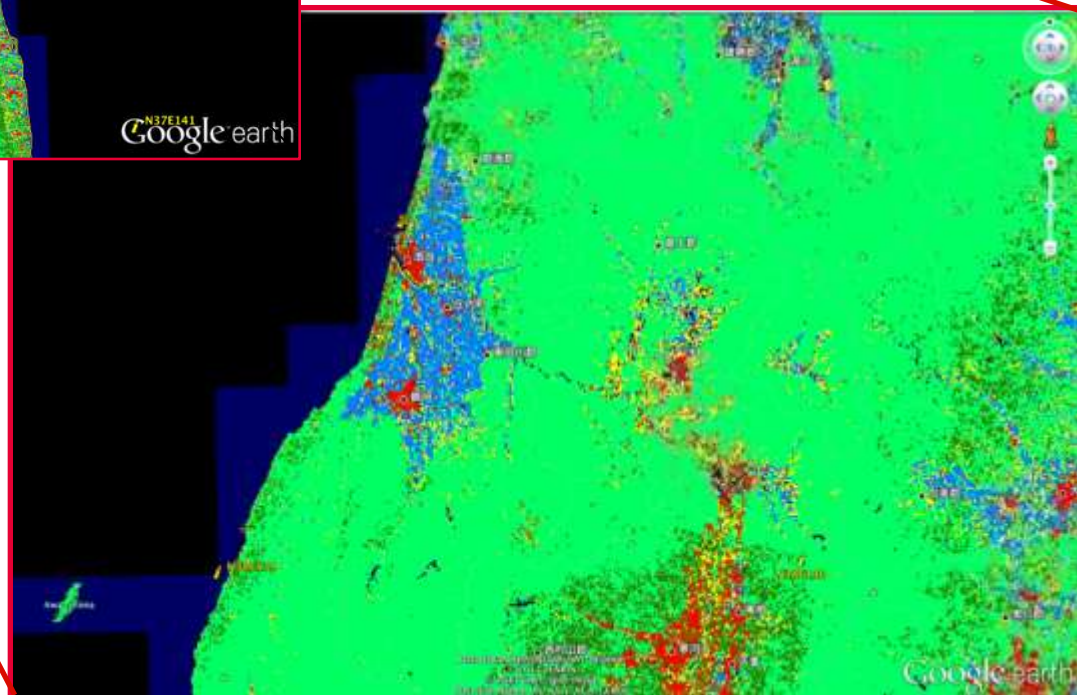


# Land Cover Map over Japan by ALOS



## カテゴリー Category

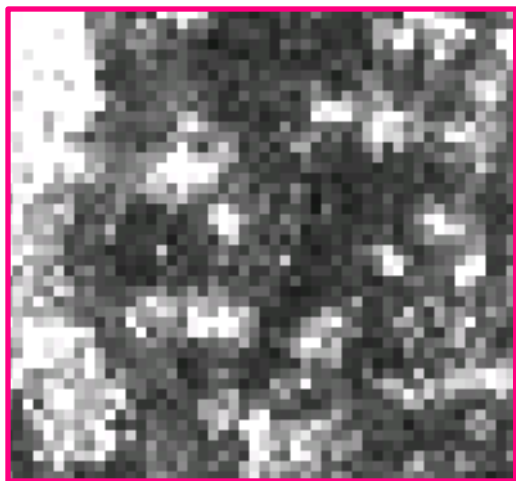
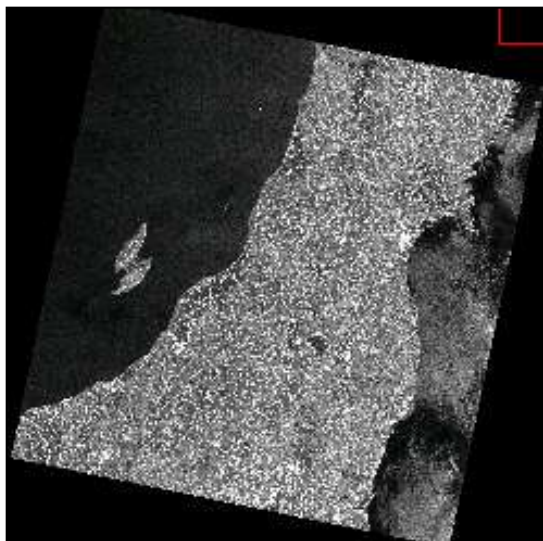
- |    |                      |
|----|----------------------|
| 1  | 水域 Water             |
| 2  | 都市 Urban             |
| 3  | 水田 Paddy             |
| 4  | 畑地 Crop              |
| 5  | 草地 Grass             |
| 6  | 落葉樹 Deciduous forest |
| 8  | 常緑樹 Evergreen forest |
| 10 | 裸地、砂地 Bare surface   |
| 11 | 雪水 Snow and ice      |
|    | その他 other            |



# Tsuruoka City, Yamagata, Japan

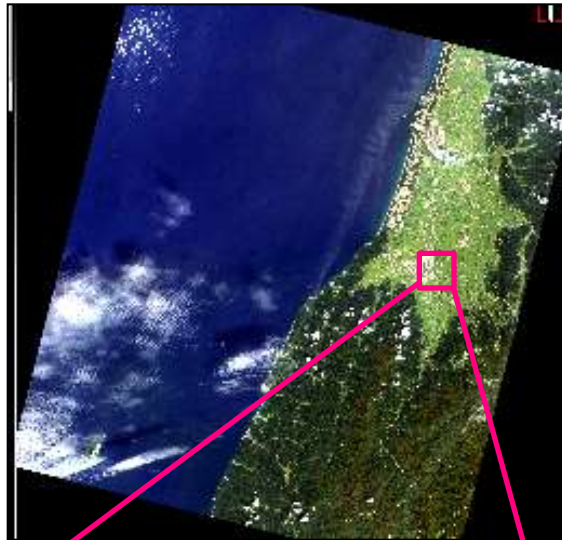
ALOS PALSAR ScanSAR  
(2010/06/28)

100m@350km



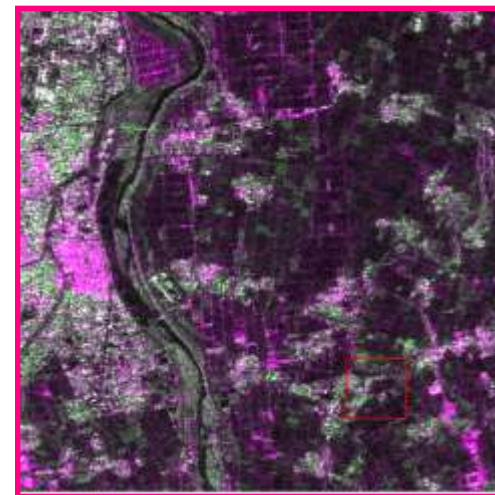
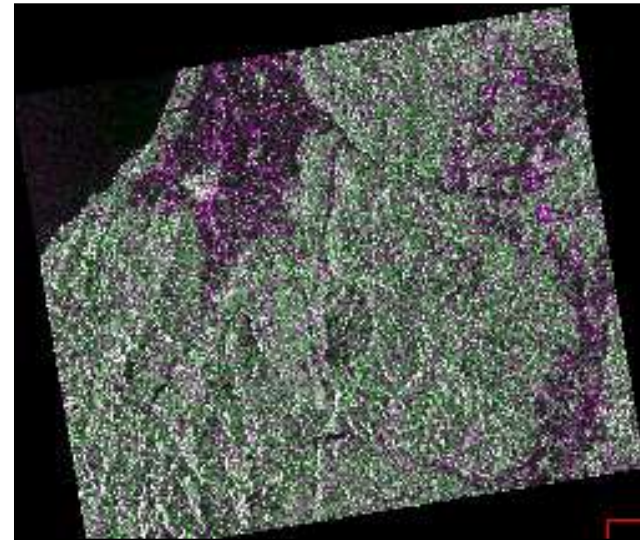
ALOS AVNIR-2  
(2010/08/28)

10m@70km



ALOS PALSAR Fine  
(2009/07/30)

15m@70km



# AWS in Tsuruoka, Yamagata, Japan



**14 Jun 2013**



**04 Aug 2013**



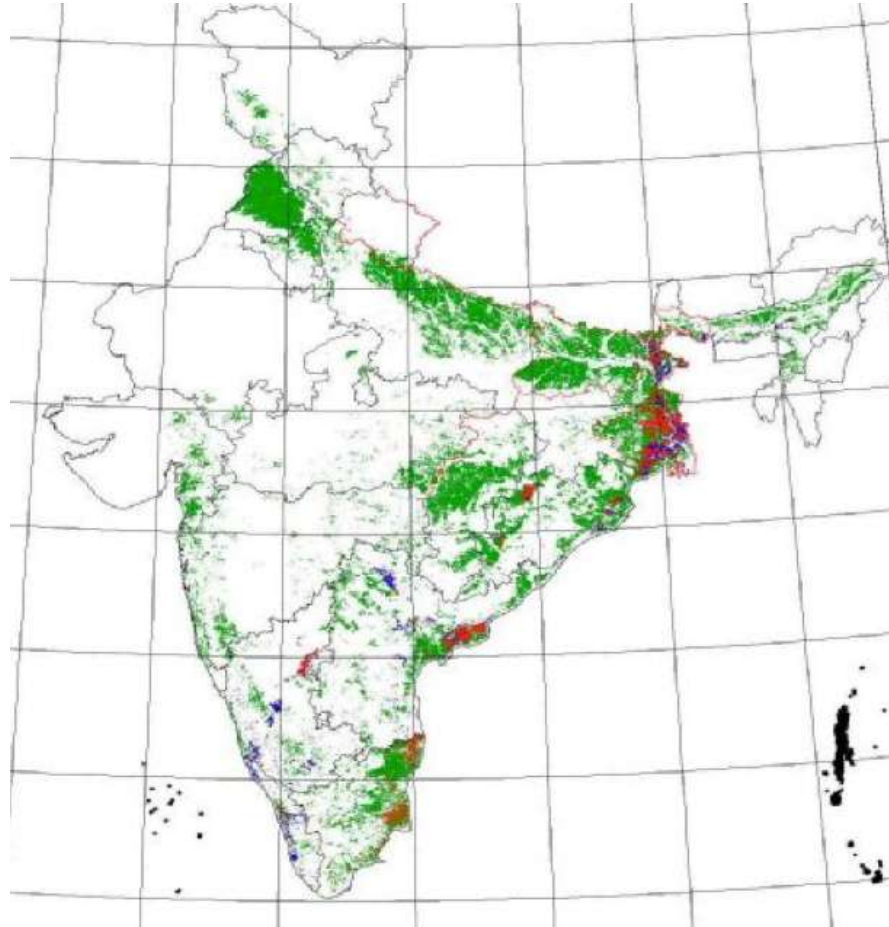
**14 Sep 2013**



<http://www.x-ability.jp/FieldRouter/vbox0098/>

# Asia-RiCE Team Member Highlights

## Example Achievements – India

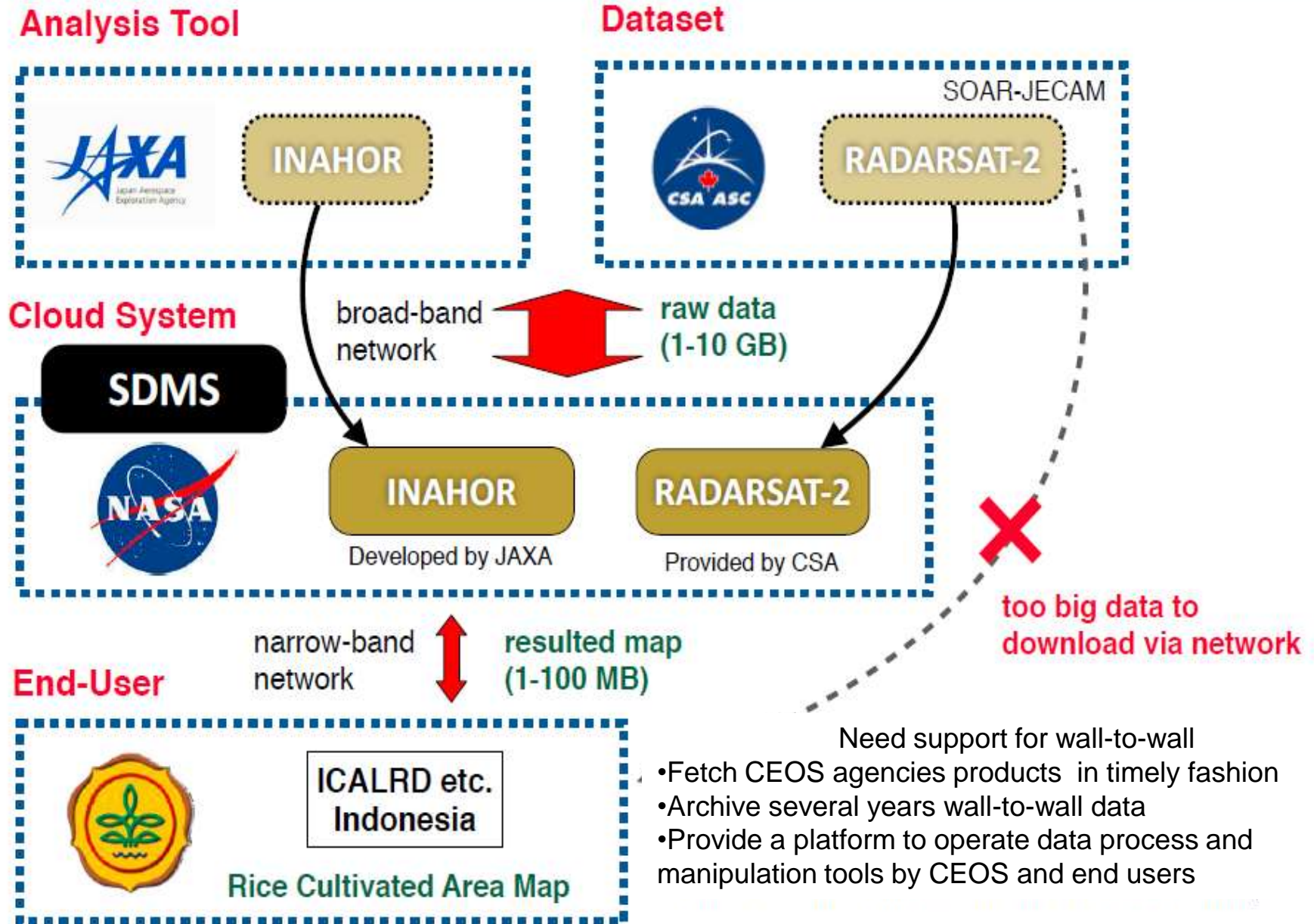


**Rice map of India derived using satellite data. Multi-date SPOT VGT 10-day composite Normalised Difference Vegetation Index data is used along with RADARSAT SAR and IRS WiFS data to map the rice area and generate the seasonal rice cropping pattern and crop calendar. Source: Spatial Database Generation Of The Rice-Cropping Pattern Of India Using Satellite Remote Sensing Data (Manjunath & Panigrahy, 2009)**

**The green color is we season rice (main season/rainy season), the red color is rice in both seasons, the blue color is rice in second season.**



# INAHOR on Cloud Computing System (SDMS)



This project aims to enhance the capabilities of **IN**ternational **A**sian **H**arvest **m**onitoring system for **R**ice (INAHOR), a software application developed by the Japan Aerospace Exploration Agency (JAXA) for estimating rice crop area and production using radar satellite imagery on Lao PDR, Philippines, Thailand and Viet Nam

Impact:

More evidence-based policies and programs on food security

Outcome:

Improved quality and timeliness of rice crop area and production estimates and forecasts.

Outputs:

1. Customized software applications on analyzing satellite imagery and similar tools provided to pilot countries.
2. Selected staff in pilot countries are able to use output 1 as inputs into rice crop estimation and forecasting methods.
3. Online training program on the use of satellite imagery and similar tools for agricultural and rural statistics provided for open access.

# What is INAHOR-AD?

“INternational Asian Harvest mOnitoring system for Rice”  
 – Advanced version

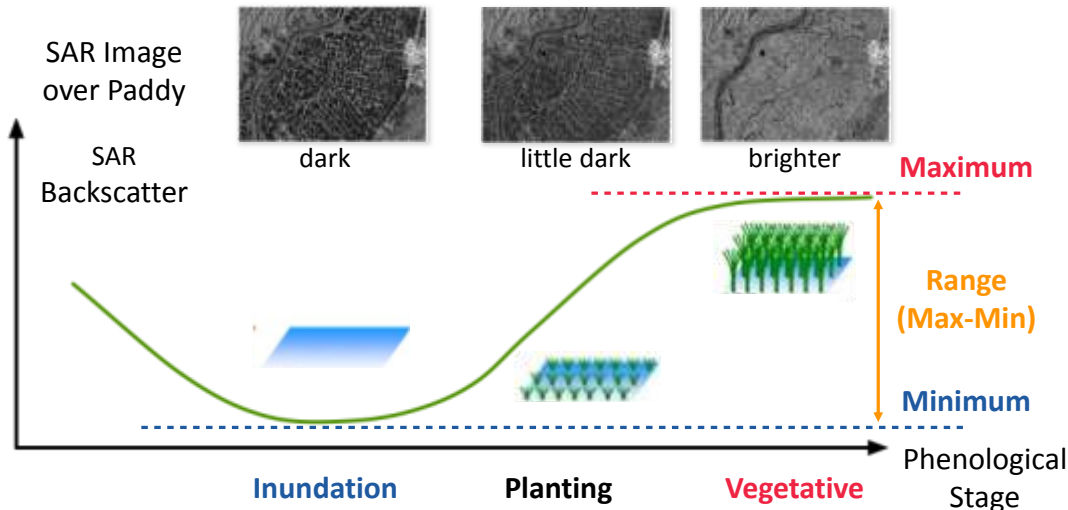
What can you expect ?

- Mapping of rice planted area
- Calculation of rice planted area
- Calculation of rice production (need yield data)



## Basic Concept of Rice Planted Area Detection

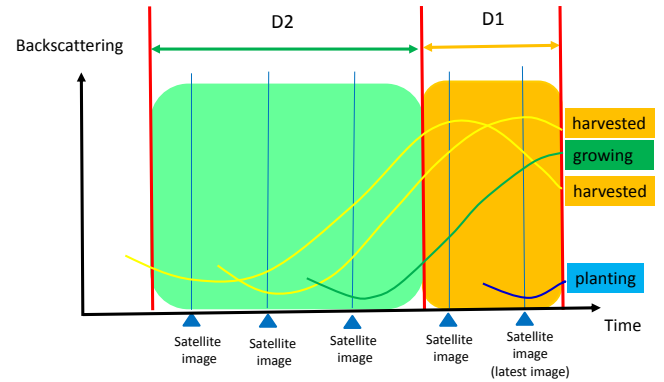
- Paddy rice area has “Inundation” and “Vegetative” stages.



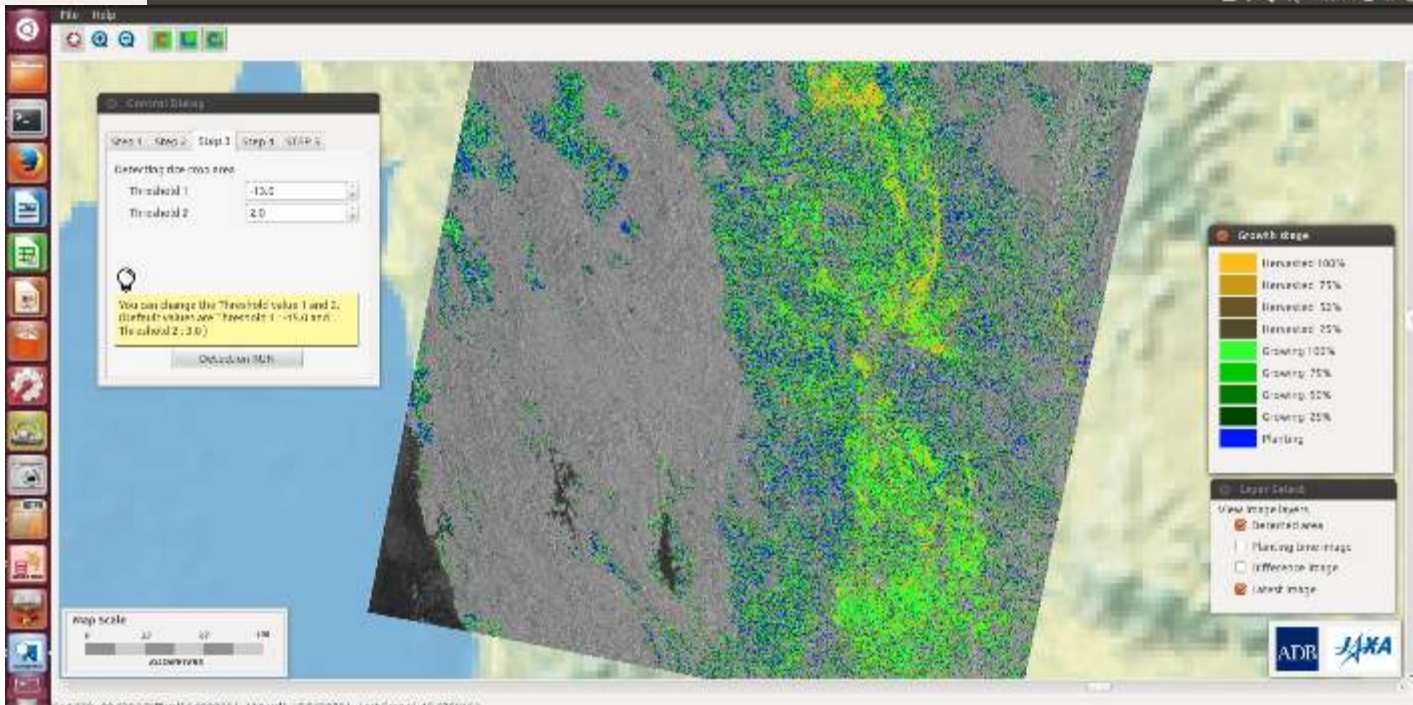
If (**Minimum** < Threshold1) and (**Range** > Threshold2)  
 (Inundation stage?) (Vegetative stage ?) → **Rice Planted Area**

# RCDTA 8369: Innovative Data Collection Methods for Agricultural and Rural Statistics

INAHOR-AD has been modified to identify not only rice area but also growing stages using time series SAR data.

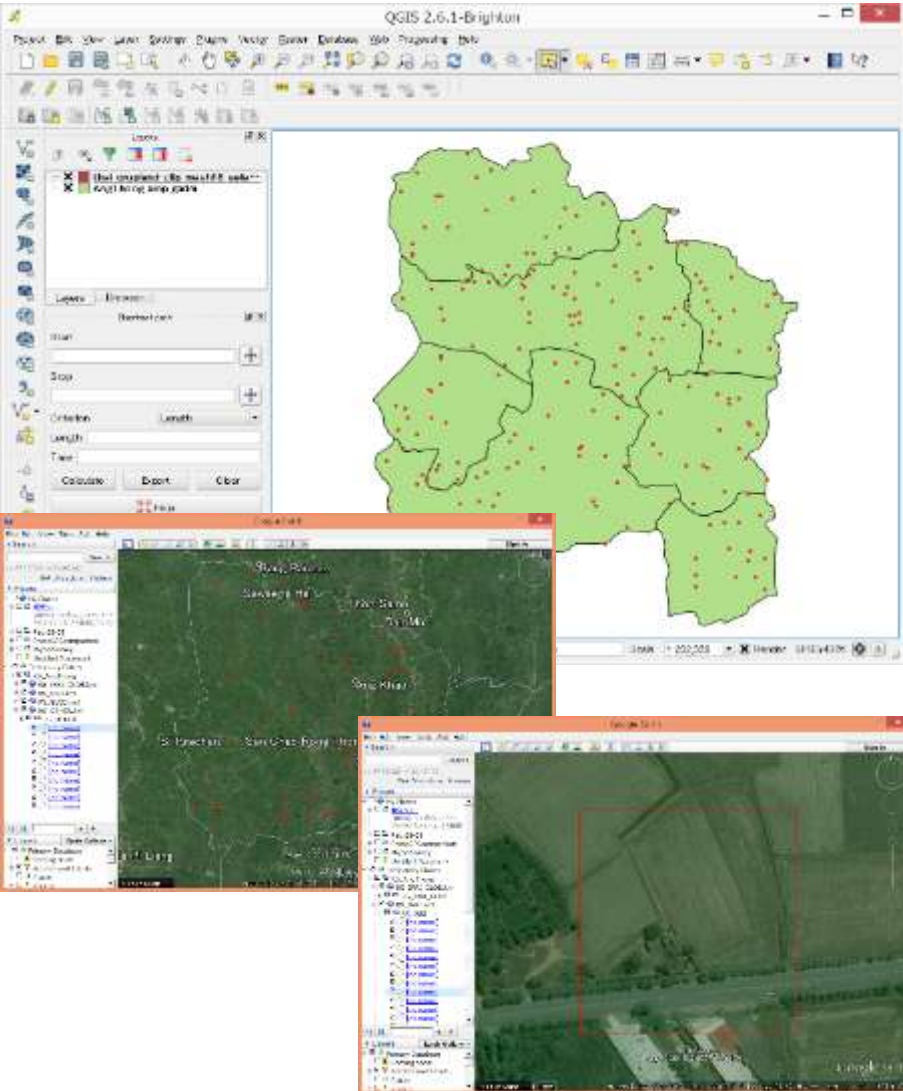


D1: Rice crop period (one rice crop cycle (default is 100 days))  
 D2: Period to use to check a planting season data for target season (default is 150 days)



## Innovative Data Collection Methods for Agricultural and Rural Statistics

Field survey training for validation of planted area and growing stage with iPad and GIS software. (random sampling 120 points - paddy and non paddy area)



# 2016+ Plans and Expectations

- Continue working with Phase 1A/1B TDS to generate target products using SAR data from CEOS agencies including Radarsat-2, Sentinel-1, ALOS-2, CSK, TerraSAR-X , RISAT, etc. 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 to explore the possibility of further expansion to other SE Asian sites. Continue working with GEORICE to maximize the potential outcomes from the ESA DUE Innovator III program;
- **Initiate integrated usage of HR optical and SAR for phenology studies** (and others) using SPOT 5 Take 5, Venus, Landsat and Sentinel-2 data along with coarse resolution satellites such as 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.); - JECAM SAR study
- **Define a standard field survey procedure;**
- **Jointly publish Asia-RiCE TDS results and hold Asia-RiCE meetings/workshops in conjunction with international conference such as ACRS.**

# Asia-RiCE ALOS-2 Data Distribution System

- ❖ ALOS2 data are provided under the framework of K&C (Kyoto & Carbon) initiative via JAXA/EORC web server for authorized Asia Rice partners and JECAM Argentine
- ❖ This data distribution include JECAM site in Argentine and Chinese Taipei (Taiwan).



GeoTIFF +

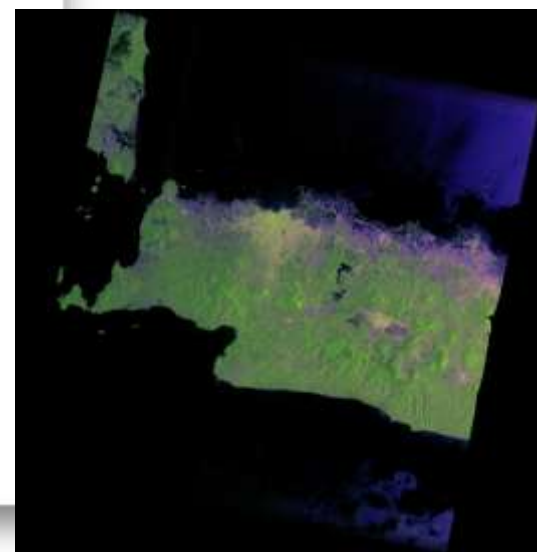
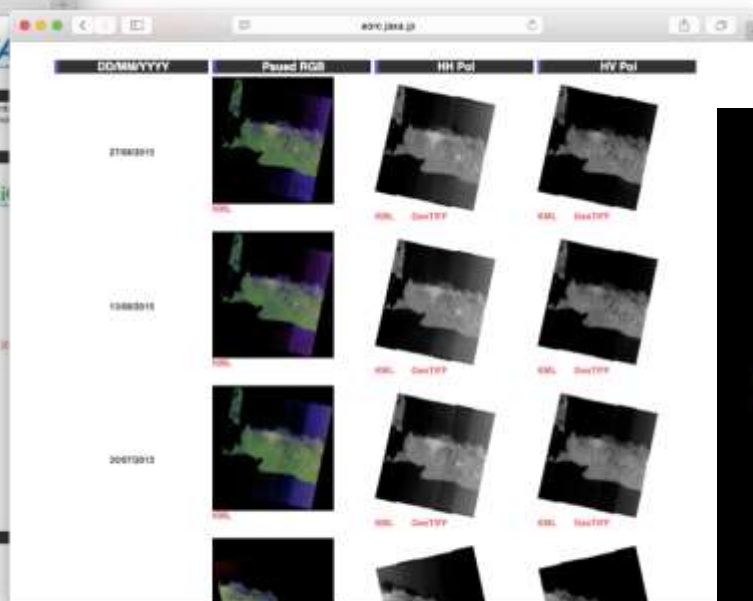


KML

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(11 regions/countries)



Data Catalog



# CEOS Coordination – Data Acquisition Requests

## 1. Dataset 1: SAR

- 1) Rainy season; May - Oct, 2016
- 2) Dry season Nov 2016 - April 2017

Temporal Resolution: 14-30 days (14 days is optimal but 24 - 30 days is still acceptable)

Spatial Resolution: 20-100m

Spectral: C & L band RADAR, dual polarization VV/VH or HH/HV

## 2. Dataset 2: Optical and NDVI

- 1) Rainy season; May - Oct, 2016
- 2) Dry season Nov 2016 - April 2017

Temporal Resolution: 14 days (reasonably cloud free)

Spatial Resolution: 20-500m

Spectral: Optical (e.g. MODIS, GCOM-C, Landsat 8, Sentinel-2, SPOT-5)

## 3. Dataset 3: Agromet info

- 1) Rainy season; May - Oct, 2016
- 2) Dry season Nov 2016 - April 2017

Temporal Resolution: Monthly

Spatial Resolution: 20-500m

Spectral: Microwave (GCOM-W, SMAP, SMOS, GPM, etc.) – precipitation, soil moisture, LST, PAR, NDVI



# CEOS Coordination – Target Areas

## **1. TDSs (provincial-level, 100km x 100km)**

## **2. Wall-to-wall**

Candidates: Thailand, Vietnam (Mekong + Red river (south and north main area) and Indonesia (top 10 rice producing provinces).

The Indonesian MOA will perform field surveys for the top 10 provinces.

GEORIIICE and VAST will do field surveys in the Mekong Delta.

GISTDA will be doing field surveys in the main rice crop provinces.

## **3. Current issues**

Sentinel-1 observation has a gap in Thailand. However, observations are made every 24 days in the main crop area (central plains).

ALOS-2 observations are lacking for some TDS.

# Asia-RiCE Strategic Issues

- **Secure observation, continued and easy data access:** Share observation / acquisition plan of multiple satellites at one site to conduct information validation for rice growing and production estimation (especially for wall-to-wall (whole country – country scale) starting from main crop area of Indonesia, Vietnam, and Thailand) in cooperation with CEOS
- **Need Support ICT environment with applications for data archive and processing**
- **Expand SDMS / cloud computing system to do practical use for end users such as Ministries of Agriculture**
- **Promote EO data and related information sharing** (especially ground base data and base line map such as LULCC / rice crop mask, rice crop calendar, etc.)
- **Promote cross validation** for outlook and rice crop growing and production estimation
- **Promote regional coordination** (need donor such as ADB, UN-ESCAP, MRC, CEOS, and GEO support, and contribution/endorsement from national monitoring systems)
- **Sustained institutional support to promote satellite data usage & validation** (many Asian countries are developing countries)

# Conclusion

- Promote regional work through inviting international donors, CEOS and GEO organizations and in-kind contribution from countries with high level governmental officers endorsement
- Continue working with Phase 1 of TDSs to generate target products using SAR data and optical sensors and scale up from TDSs to wall-to-wall (whole country)
- Continue working for rice crop outlook in cooperation with AFSIS



<http://www.earthobservations.org/geoglam>

<http://www.asia-rice.org>

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**Thank you**