

ALOS Kyoto & Carbon Initiative 23<sup>rd</sup> Science Team meeting (KC#22)

# Asia-RiCE: Rice Crop Estimation and Monitoring (the role of PALSAR-2)

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*On behalf of Asia-RiCE team*

January 18, 2017  
at TDU Hatoyama Japan

# Contents

- ❖ Introduction of Asia-RiCE
- ❖ Introduction of INAHOR Software
- ❖ Implementation status
- ❖ Summary

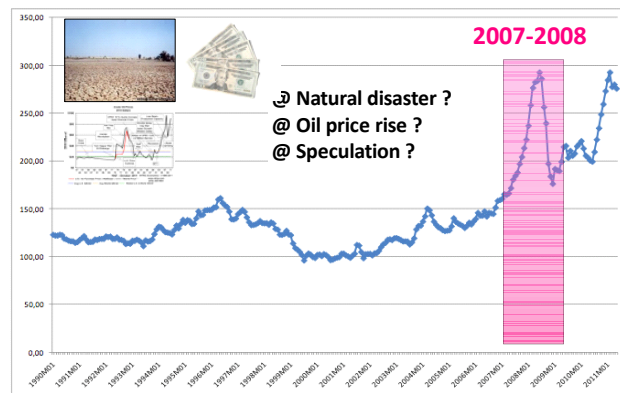
# Introduction of Asia-RiCE

# Introduction of Asia-RiCE

- Asia-RiCE was launched by JAXA with collaborative effort between a number of Asian organizations, in order to contribute to AMIS / GEOGLAM which were launched under the agreement of G20 Agriculture Ministers at the G20 France summit 2011.
- Asia-RiCE are working to develop a methodology for monitoring Asian rice since rice is the main commodity crop in Asia.
- The aim is to provide accurate / objective information to the market through the AMIS / GEOGLAM.



Figure 1: Food Price Index, monthly, January 1990–May 2011 (2000 = 100)



Source: World Bank (2011)



- \* AMIS: Agricultural Market Information System
- \* GEOGLAM: Group on EO – Global Agricultural Monitoring



# Asia-RiCE Home Page – [www.asia-rice.org](http://www.asia-rice.org)



The screenshot shows the Asia-RiCE Home Page in a web browser. The URL is [www.asia-rice.org/index.php](http://www.asia-rice.org/index.php). The page features the Asia-RiCE logo (Crop Estimation and Monitoring) and the GEOGLAM logo (Global Agricultural Monitoring). A navigation bar includes links for Home, About, Work Plan, News/Events, GEOGLAM, Contacts, and Links. A large image of rice stalks is displayed with a text box stating: "Rice is the staple food for more than half of humanity, with 90% of the world crop grown and consumed in Asia." Below this, the "About" section describes the work of an ad hoc team of stakeholders. A "Download the latest Work Plan" button is visible. The "Objectives" section lists three goals: ensuring Asian countries receive full benefits of GEOGLAM, ensuring rice crop monitoring issues are given suitable priority, and establishing a framework for coordination. The footer mentions the website is provided by AXA and GEO Group on Earth Observations.

Asia-RiCE  
Crop Estimation and Monitoring

GEOGLAM  
Global Agricultural Monitoring

Home About Work Plan News/Events GEOGLAM Contacts Links

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**

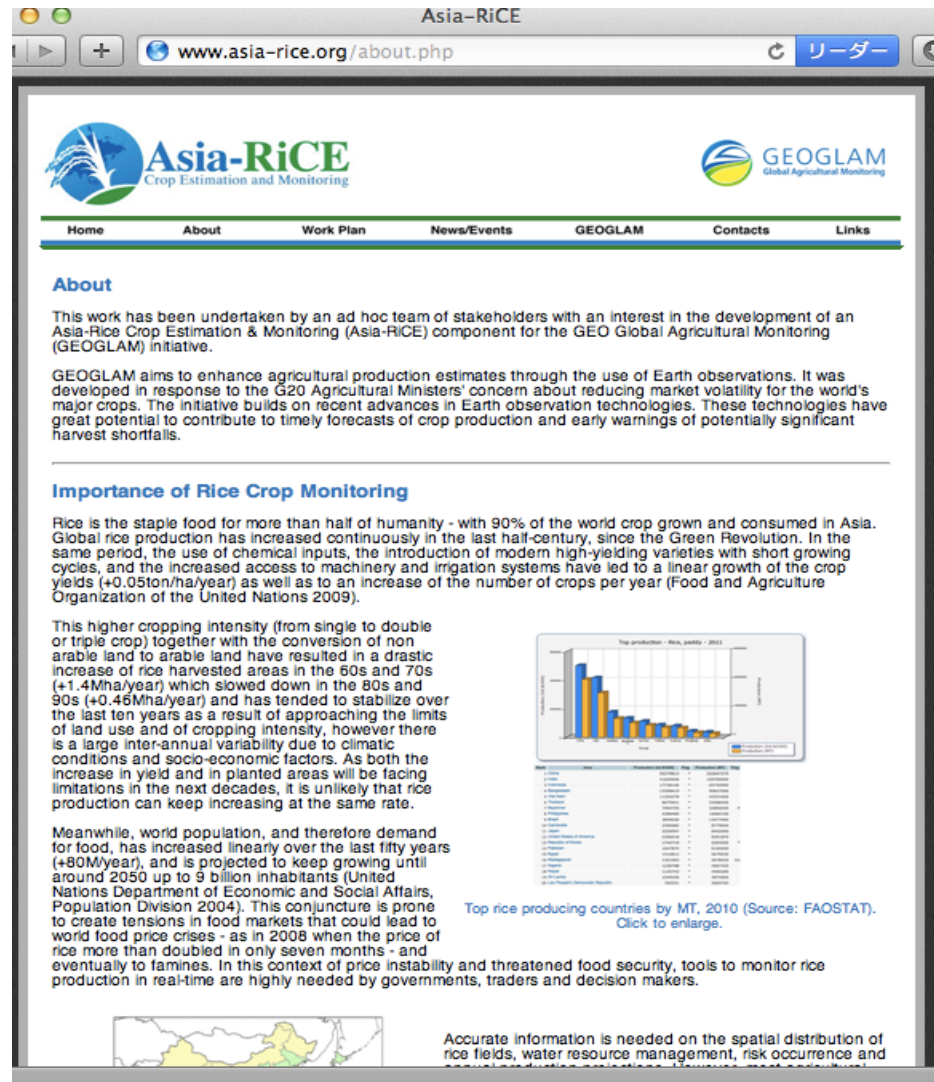
Asia-RiCE describes a work plan for the definition and development of the Asia-RiCE component for GEOGLAM. The objectives are:

- 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 AXA

GEO GROUP ON EARTH OBSERVATIONS



The screenshot shows the Asia-RiCE About Page in a web browser. The URL is [www.asia-rice.org/about.php](http://www.asia-rice.org/about.php). The page features the Asia-RiCE logo and the GEOGLAM logo. A navigation bar includes links for Home, About, Work Plan, News/Events, GEOGLAM, Contacts, and Links. The "About" section describes the work of an ad hoc team of stakeholders. The "Importance of Rice Crop Monitoring" section discusses the need for accurate information on rice production and the challenges of increasing rice production. A bar chart titled "Top production - Rice, 2010" shows the top rice-producing countries by MT. A table below the chart lists the top rice-producing countries by MT, 2010. The footer mentions the website is provided by AXA and GEO Group on Earth Observations.

Asia-RiCE  
Crop Estimation and Monitoring

GEOGLAM  
Global Agricultural Monitoring

Home About Work Plan News/Events GEOGLAM Contacts Links

**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 (+0.45Mha/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.**

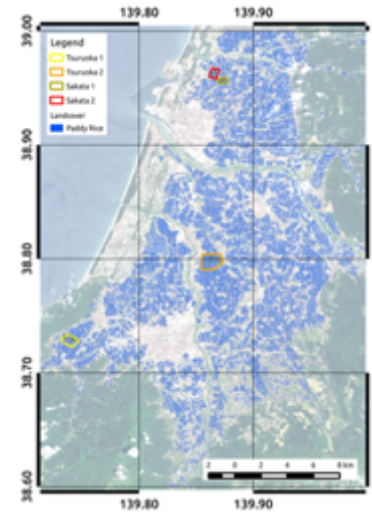
Accurate information is needed on the spatial distribution of rice fields, water resource management, risk occurrence and

For more information, please visit our home page.

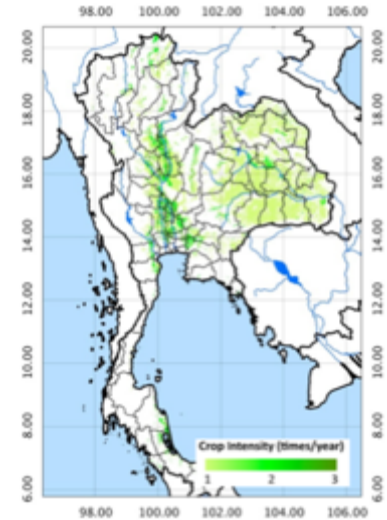
# Asia-RiCE Target Products

ID	Product
P1	<b>Rice Planting Area Estimates and Mapping</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>

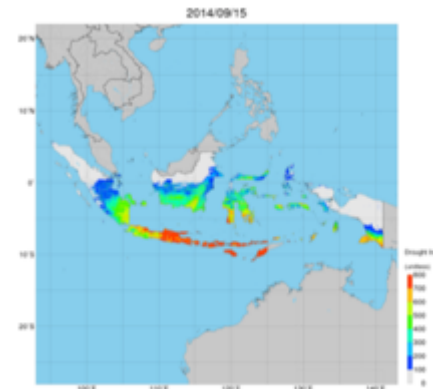
## Example of Products



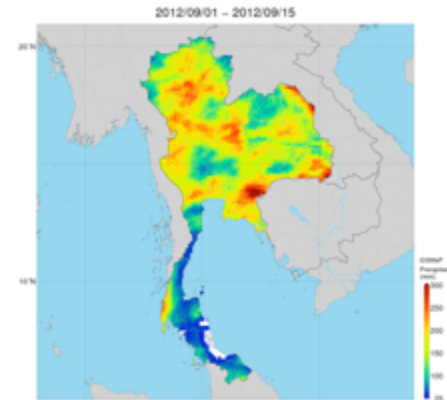
P1: Planted Area



P2: Crop Calendar



P3: Drought Warning



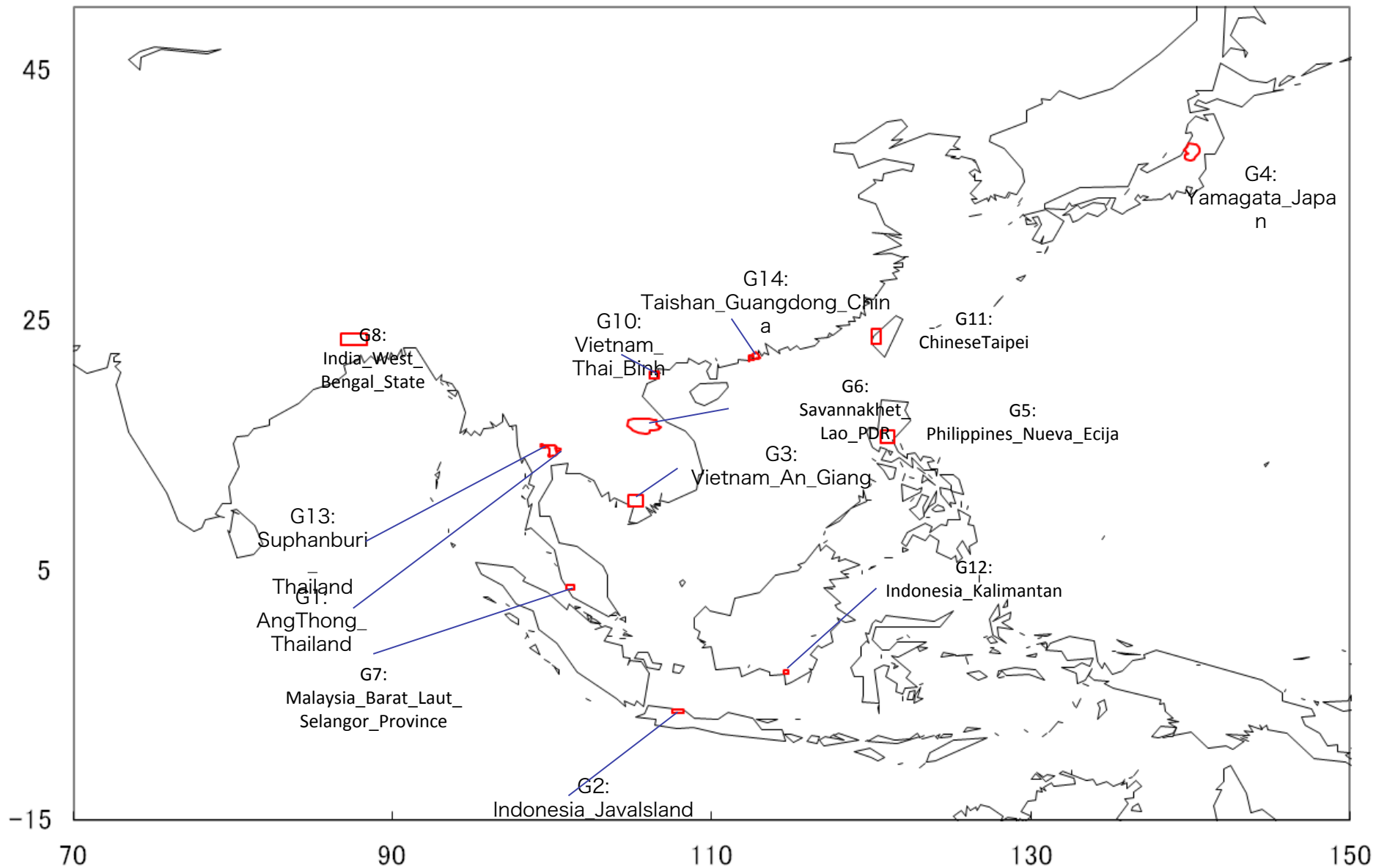
P4: Precipitation



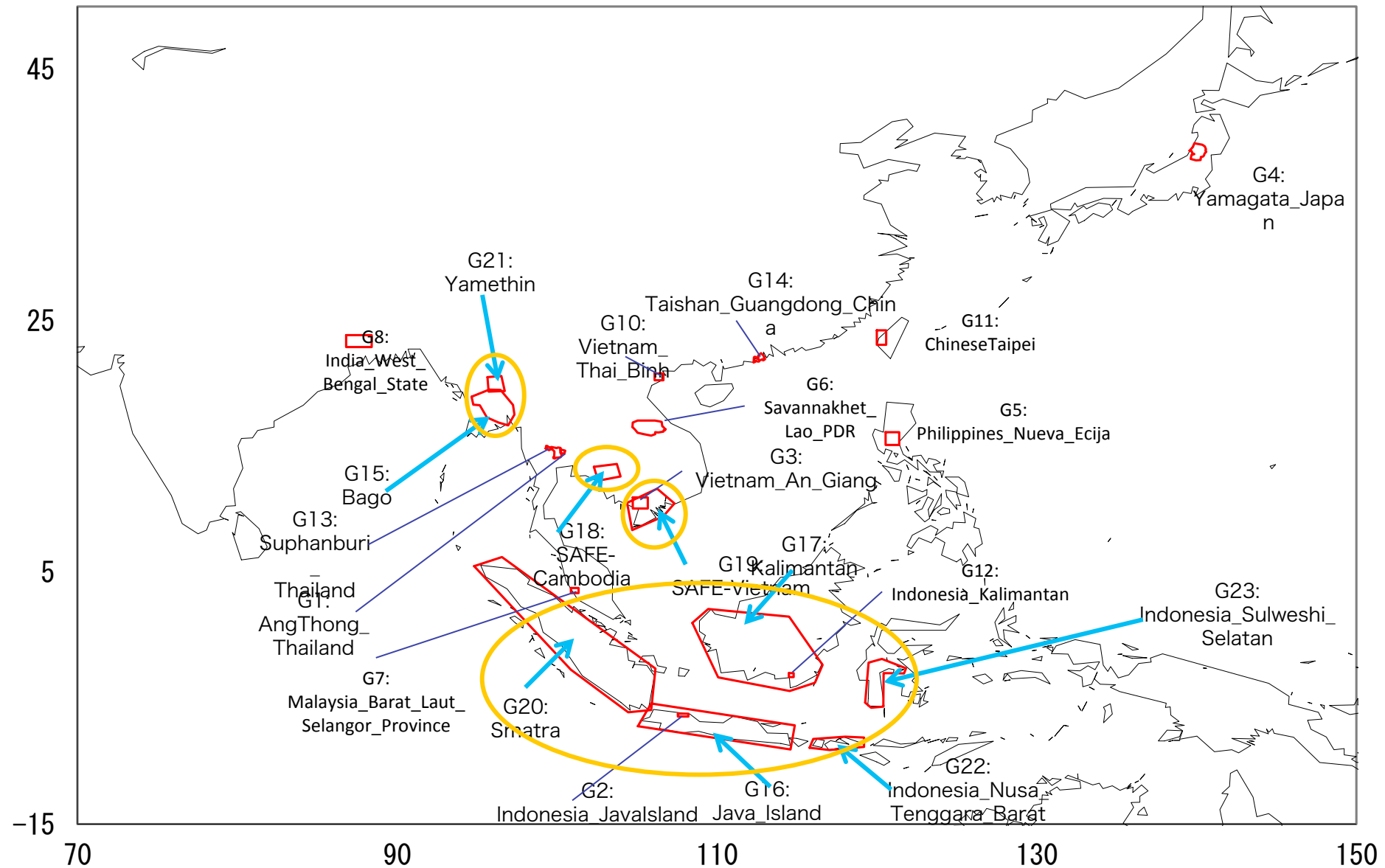
# Asia-RiCE Technical Demonstration Sites (TDS)










# PALSAR-2 observation request in 2015 for Asia-RiCE Technical Demonstration Sites



# PALSAR-2 observation request in 2016 for Asia-RiCE Technical Demonstration Sites



# Asia-RiCE Progress schedule

Target Countries	2014	2015	2016	2017	2018
Indonesia, Vietnam(S)	 Phase1 Provincial Level		 Phase2 Country/Main areas Level		
Myanmar, Cambodia			 Phase1 Provincial Level		
Japan, Chinese Taipei, Malaysia, ...			Phase1 Provincial Level		
Philippines, Thailand, Lao PDR, Vietnam(N)	 Phase1 Provincial Level				

- SAFE (Space Applications for Environment ) Project under APRSAF (Asia-Pacific Regional Space Agency Forum)
- ADB (Asian Development Bank ) Project \*related activity
- Individual activity by each country

# Introduction of INAHOR Software



# Rice planted area/production estimation software

JAXA developed a software named INAHOR which can estimate rice planted area and production using SAR data,  
In order to standardize a methodology for monitoring rice using satellite data in Asian countries.

## INAHOR :

**I**nternational **A**siatic **H**arvest **m**onitoring system for **R**ice  
(and “INAHOR” also means “**rice year**” in Japanese)

## The main functions :

- Providing a rice planted area map (including the growing stages classification)
- Providing a rice planted area and production (need yield information)

## Input satellite data :

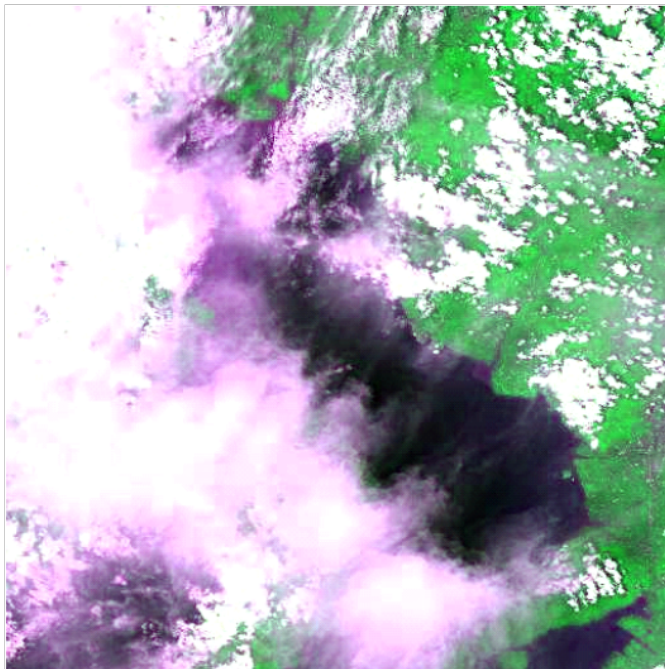
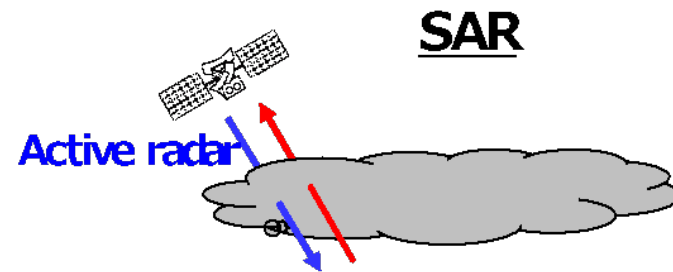
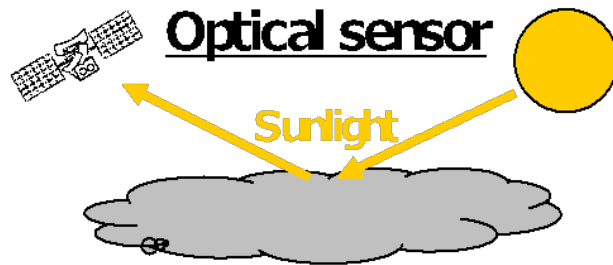
Time-series SAR data (ALOS PALSAR,  
ALOS-2 PALSAR-2, RADARSAT-2, Sentinel-1)



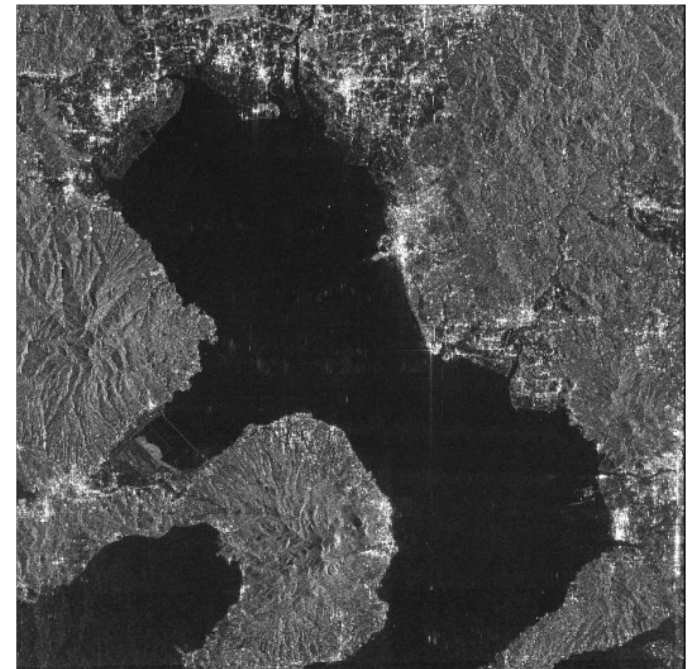


# Advantage of synthetic aperture radar (SAR)

SAR is useful in Asian countries which have a lot of cloud, since microwave can penetrate the cloud.



Observed  
simultaneously



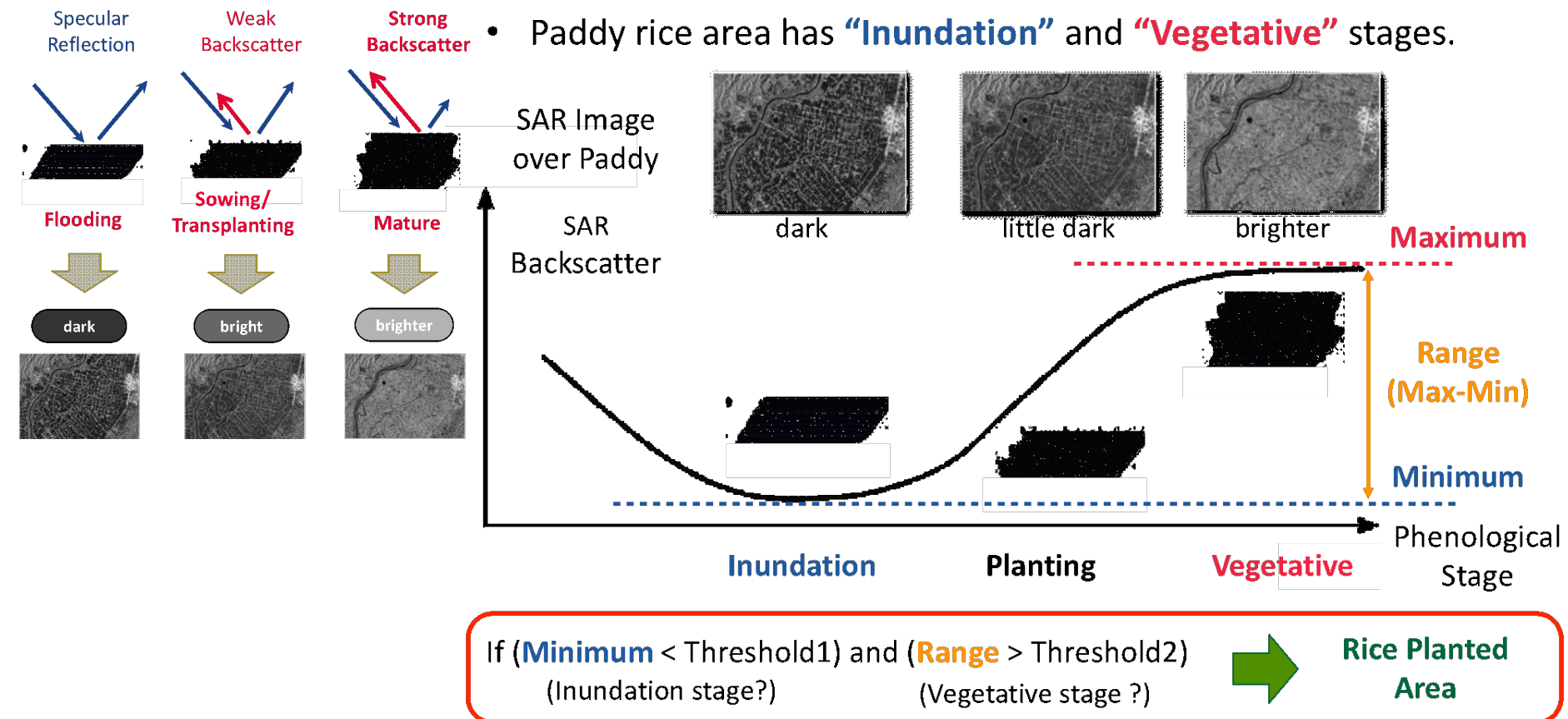
ALOS AVNIR-2 : The cloud covers the ground in the optical sensor image.

ALOS PALSAR : SAR can observe the ground under the cloud.

# Basic concept for identifying rice planted area

Rice area can be identified by analyzing characteristics which is the change of backscatter at rice field with time-series SAR data.

The area where is dark in planting stage and becomes brighter in vegetative stage is paddy field.



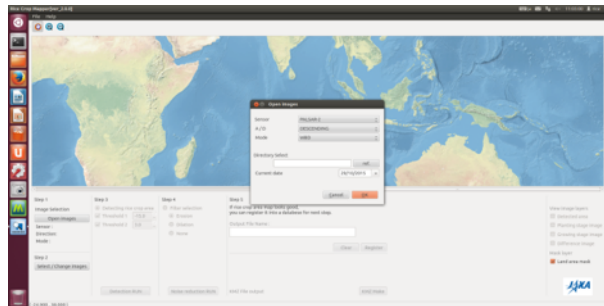
# Rice planted area/production estimation software

## Significant feature in the design of INAHOR :

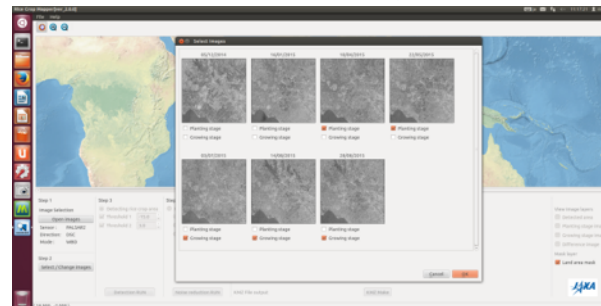
The software was designed for a local officer so that they can get easily the useful information from satellite data.

You can get the rice mapping result, only 5 steps, from open the data until save the result.

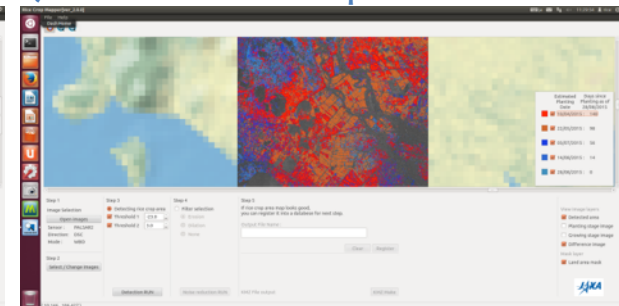
### 1) Select satellite data



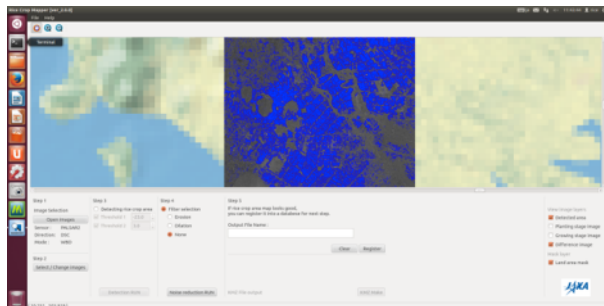
### 2) Select image data



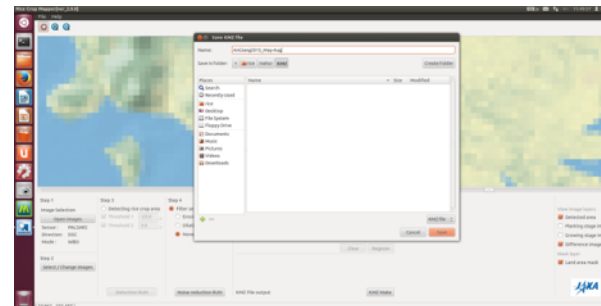
### 3) Detect rice planted area



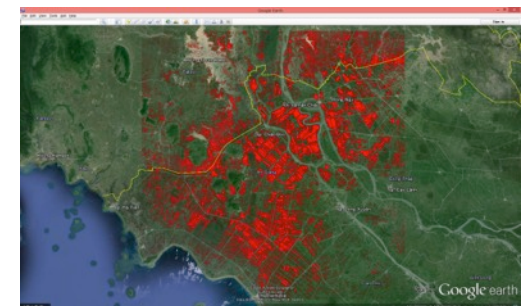
### 4) Binarization



### 5) Save the result



### Export to KMZ



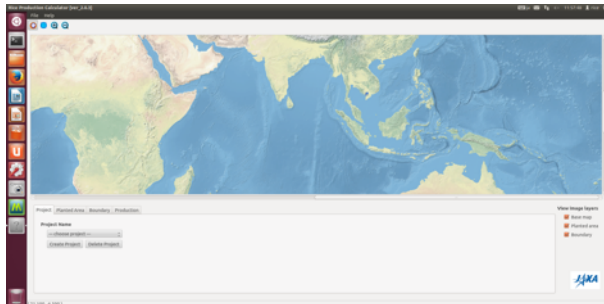
# Rice planted area/production estimation software

## Significant feature in the design of INAHOR :

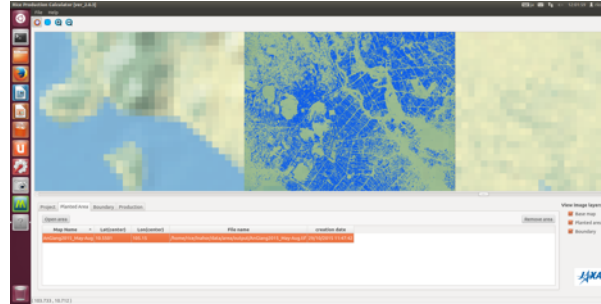
After rice crop mapping, you can get the planted area and the production easily.

The calculating procedures are 5 step only as well.

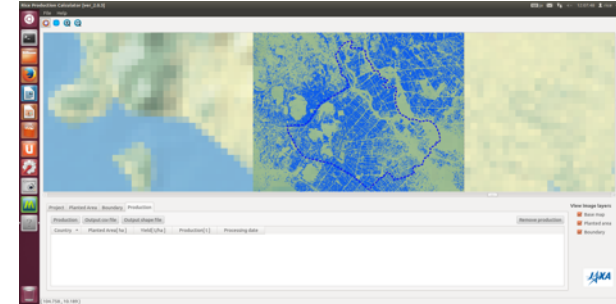
### 1) Launch calculator



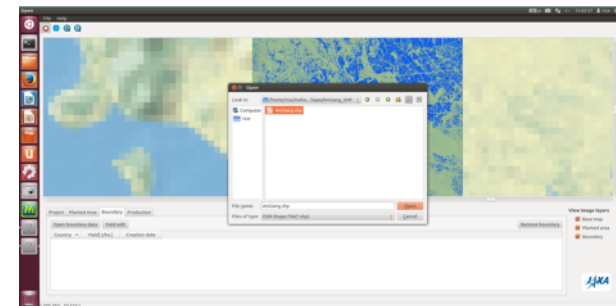
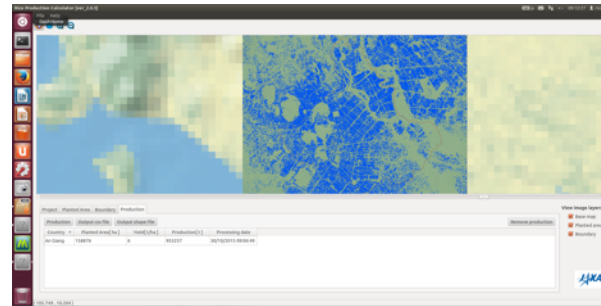
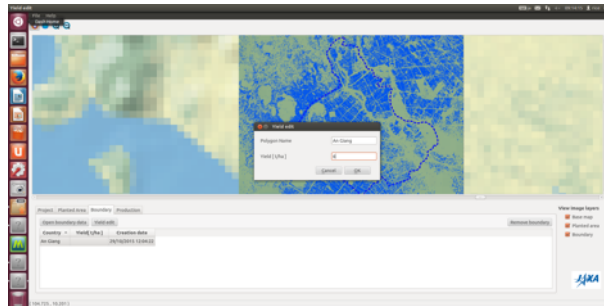
### 2) Load the rice map



### 3) Load a boundary



### 4) Input yield data      5) Calculate area & production      Export to shp and csv



## Implementation status in Indonesia by MOA

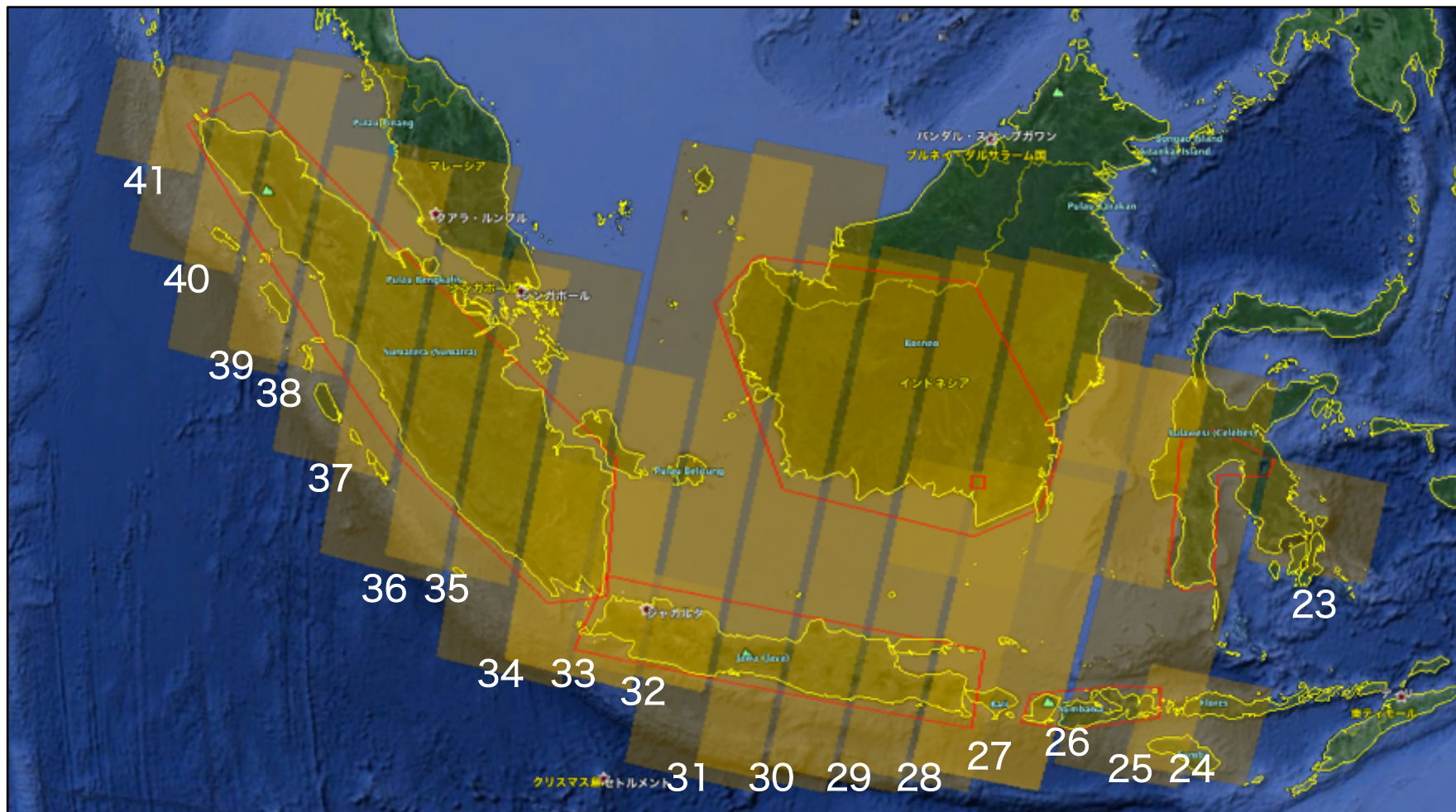


# Indonesia, phase 2



Figure 1. selected 10 top provinces for upscaling of SAR modeling of paddy

# Indonesia, phase 2



41 ALOS-2 Path ID 23

# Indonesia, phase 2

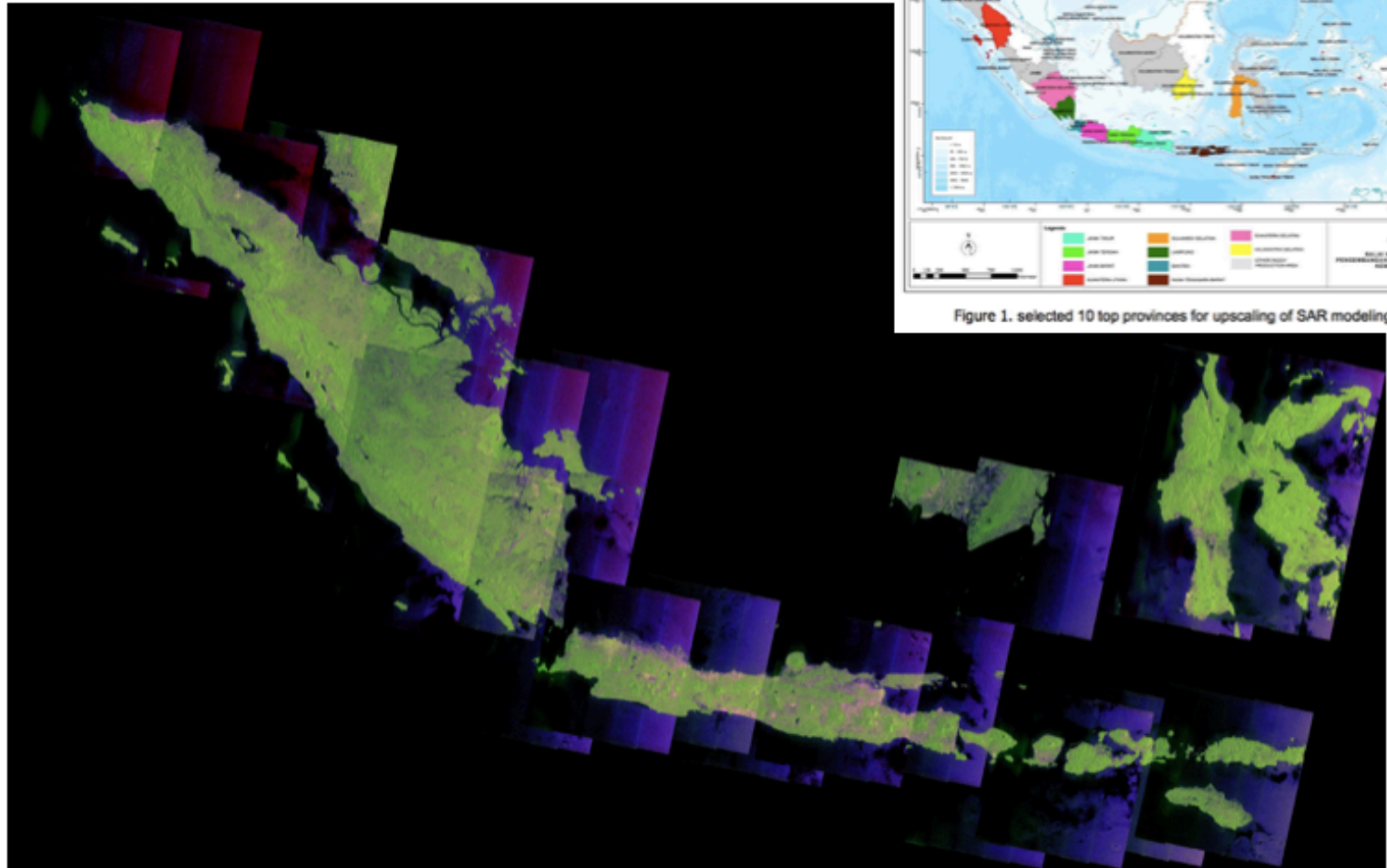


Figure 1. selected 10 top provinces for upscaling of SAR modeling of paddy

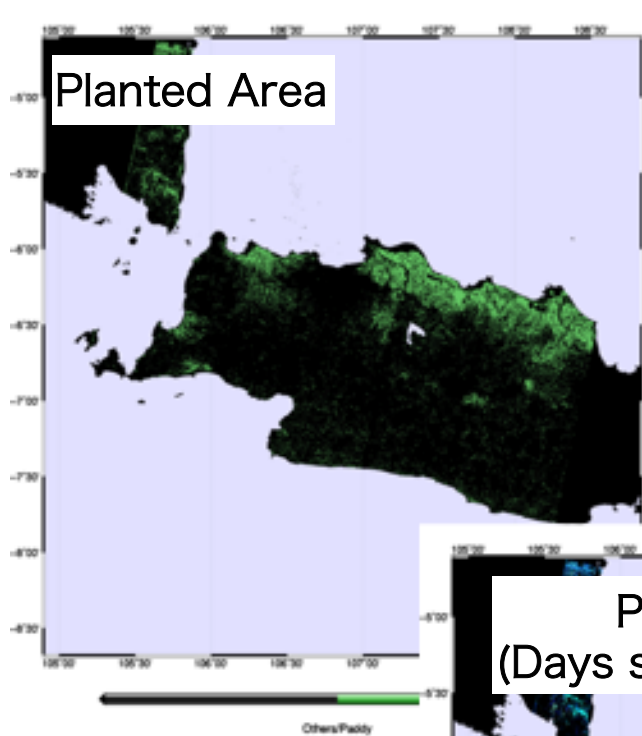
3000 km



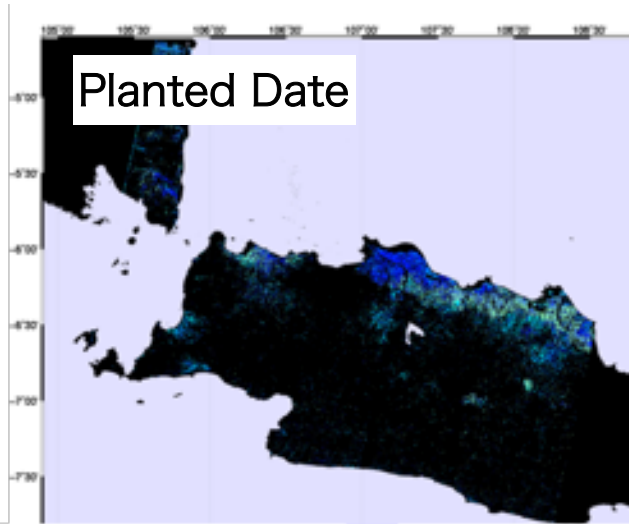
# Indonesia, phase 2

As of  
22 Jul 2016

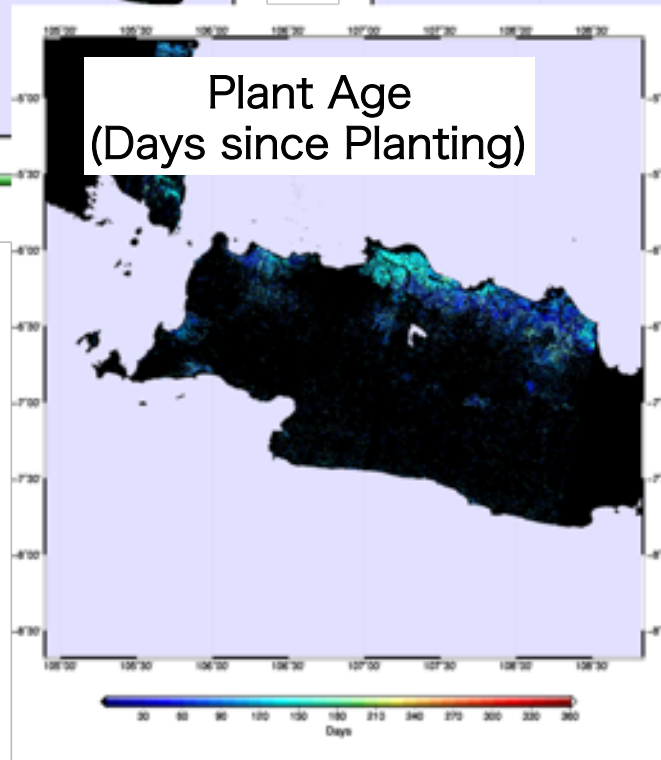
Planted Area



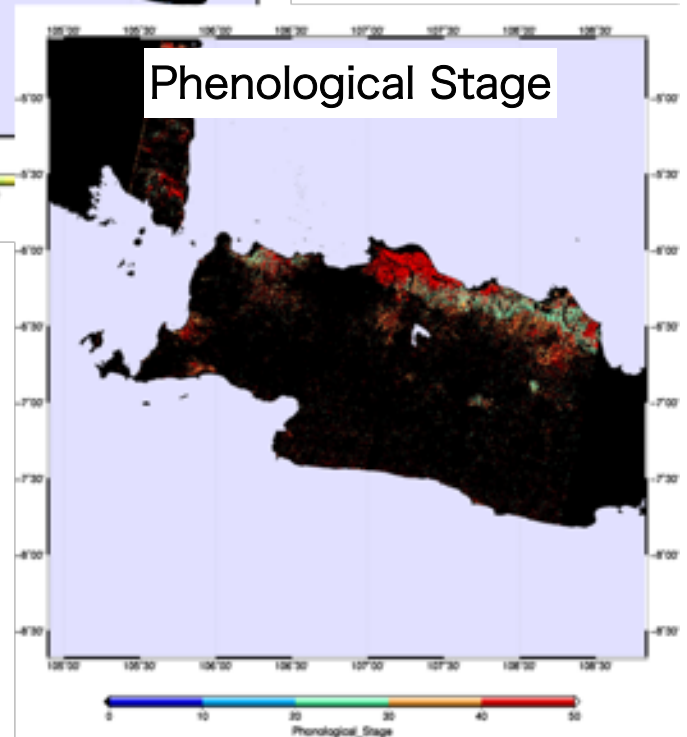
Planted Date



Plant Age  
(Days since Planting)



Phenological Stage



## Implementation status in Vietnam (S) by VNSC

# Vietnam (S), phase 2



## Introduction



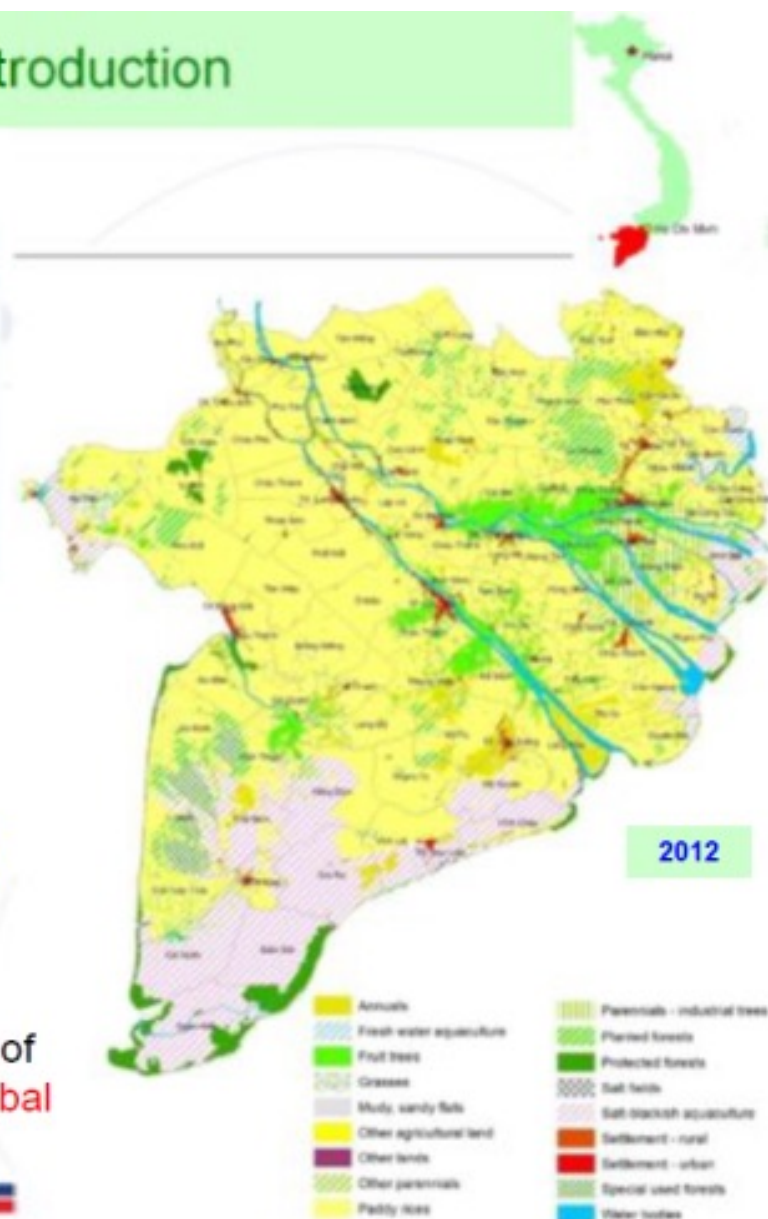
Source: Parry, M.L. et al., 2007

### Mekong Delta (Source: GSO, 2015)

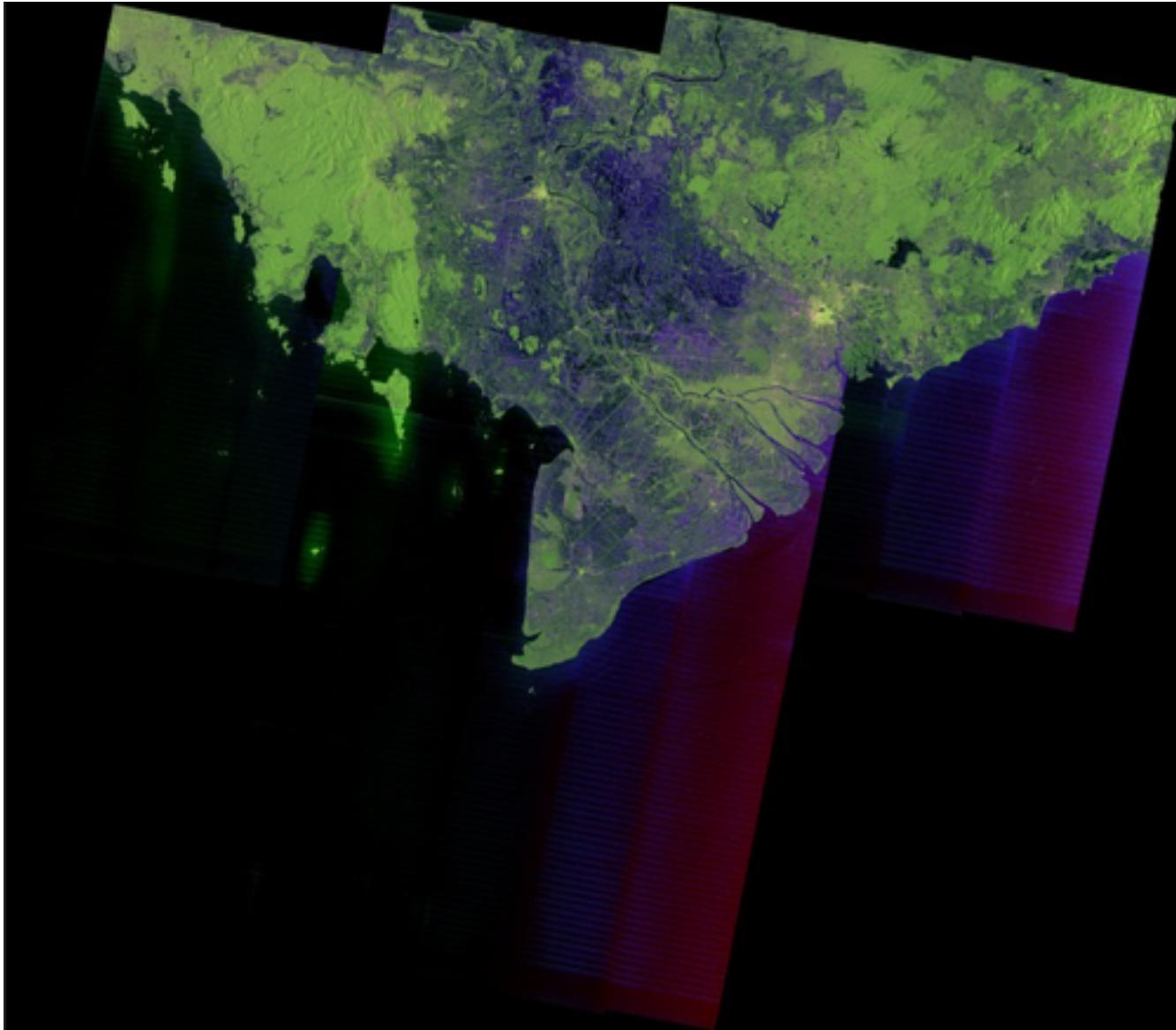
- Area: 40,576 Km<sup>2</sup> (1/8)
- Population: 17.590 M (~1/5)
- MD accounts for more than half (25.7 / 45.2 Mt) of the country's rice production (>1/2)

→ Food security

The Mekong Delta, South of Vietnam is one of the most affected regions in the world by global warming.



# Vietnam (S), phase 2





# Vietnam (S), phase 2

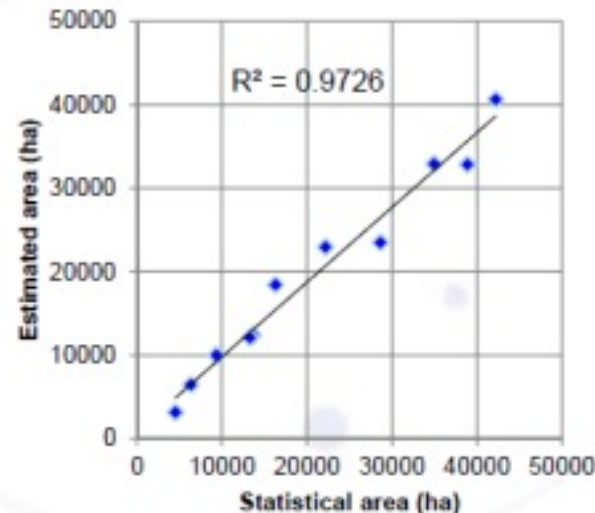


Data set: ALOS-2, 2016



SA 2016 crop (using 5-date ALOS-2 HH image,  
08 Apr, 20 May, 01Jul, 29Jul, 09 Sep)

District	Agency data (ha)	Estimated area (ha)	Percentage error (%)
An Phu	13640	12431	-8.9
Cho Moi	13304	12080	-9.2
Chau Phu	34940	32921	-5.8
Chau Thanh	28630	23507	-17.9
Phu Tan	22151	22962	3.7
Tinh Bien	16288	18441	13.2
Chau Doc	6315	6445	2.1
Long Xuyen	4518	3153	-30.2
Thoai Son	38882	32846	-15.5
Tri Ton	42210	40625	-3.8
Tan Chau	9321	10007	7.4
Total	230199	215418	-6.4

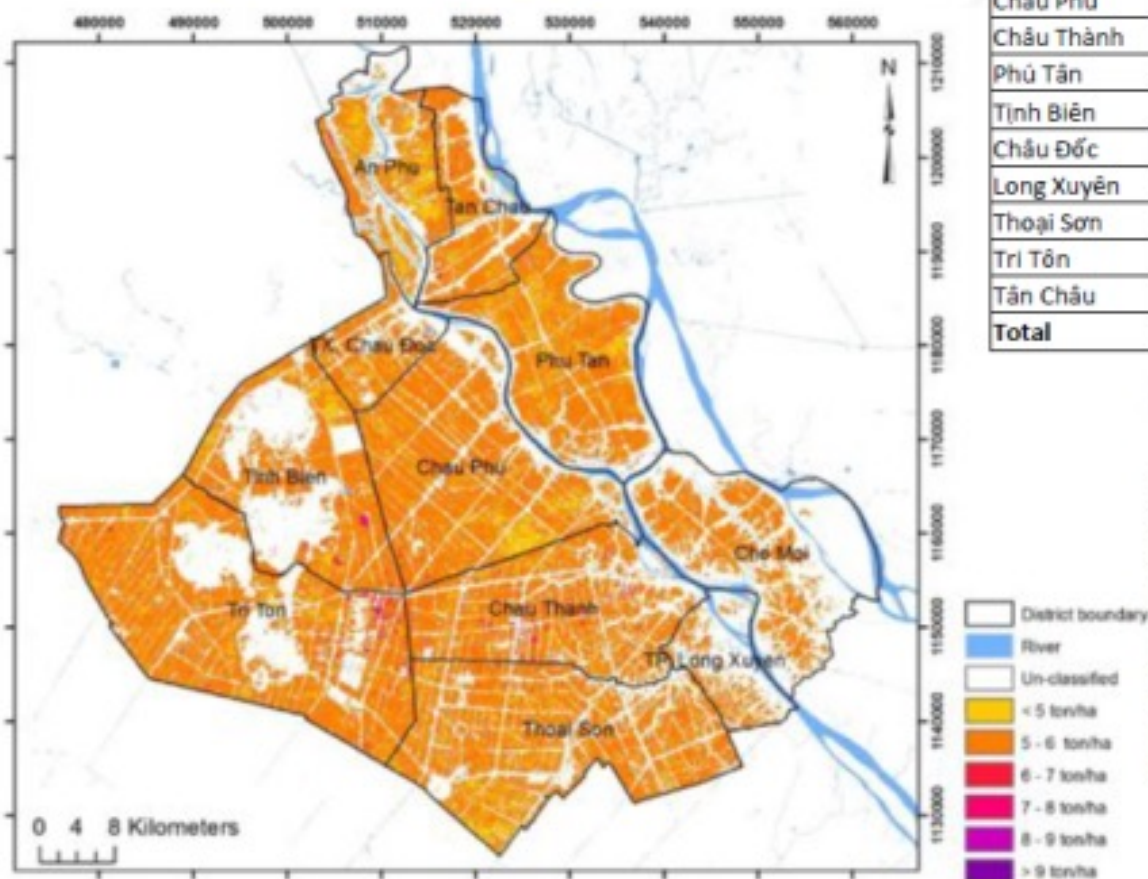


# Vietnam (S), phase 2

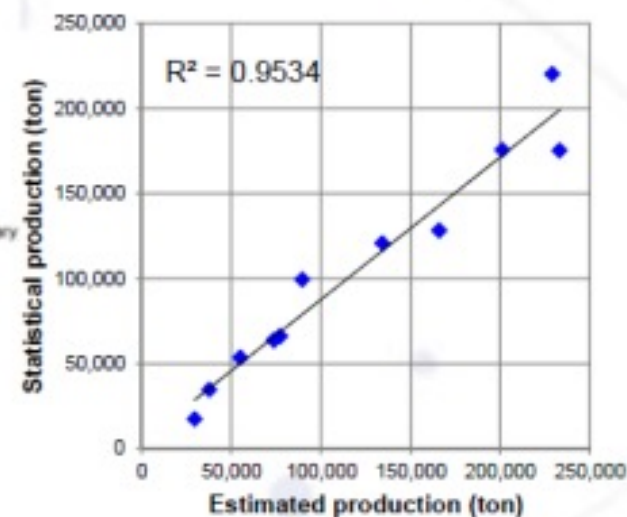


Data set: ALOS-2, 2016

A distribution map of estimated rice yield of An Giang in SA 2016 crop using ALOS-2 data



District	Agency data (ton)	Estimated production (ton)	Percentage error (%)
An Phú	73,656	63,717	-13.5
Chợ Mới	77,296	66,103	-14.5
Châu Phú	201,254	175,556	-12.8
Châu Thành	166,054	128,187	-22.8
Phú Tân	134,457	120,703	-10.2
Tịnh Biên	89,584	99,328	10.9
Châu Đốc	37,890	34,638	-8.6
Long Xuyên	29,503	17,422	-40.9
Thoại Sơn	233,292	175,277	-24.9
Tri Tôn	229,200	220,147	-3.9
Tân Châu	54,994	53,576	-2.6
<b>Total</b>	<b>1,325,946</b>	<b>1,154,655</b>	<b>-12.9</b>





# Vietnam (S), phase 2



SA 2016 crop  
(using ALOS-2 images)



SA 2016 crop (using S-1 images)

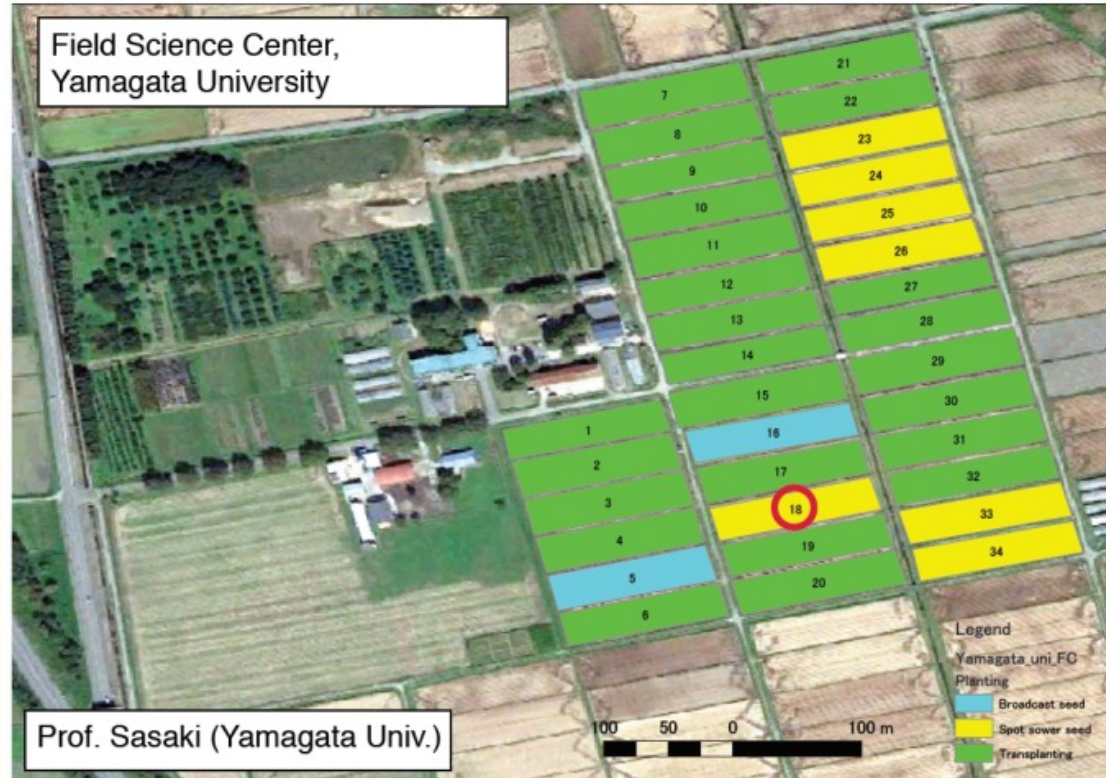
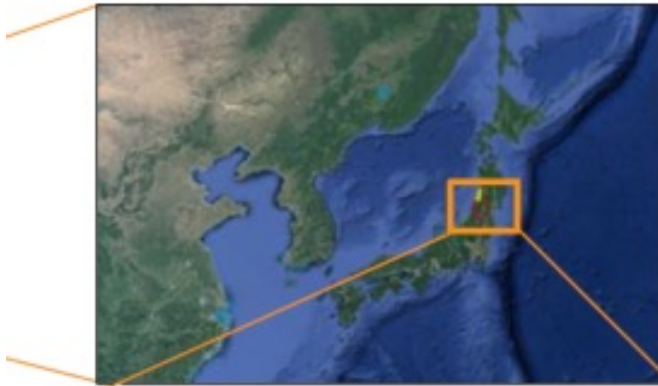


SA 2016 crop (using R-2 images)

## Implementation status in Japan by JAXA



# Japan, phase 1

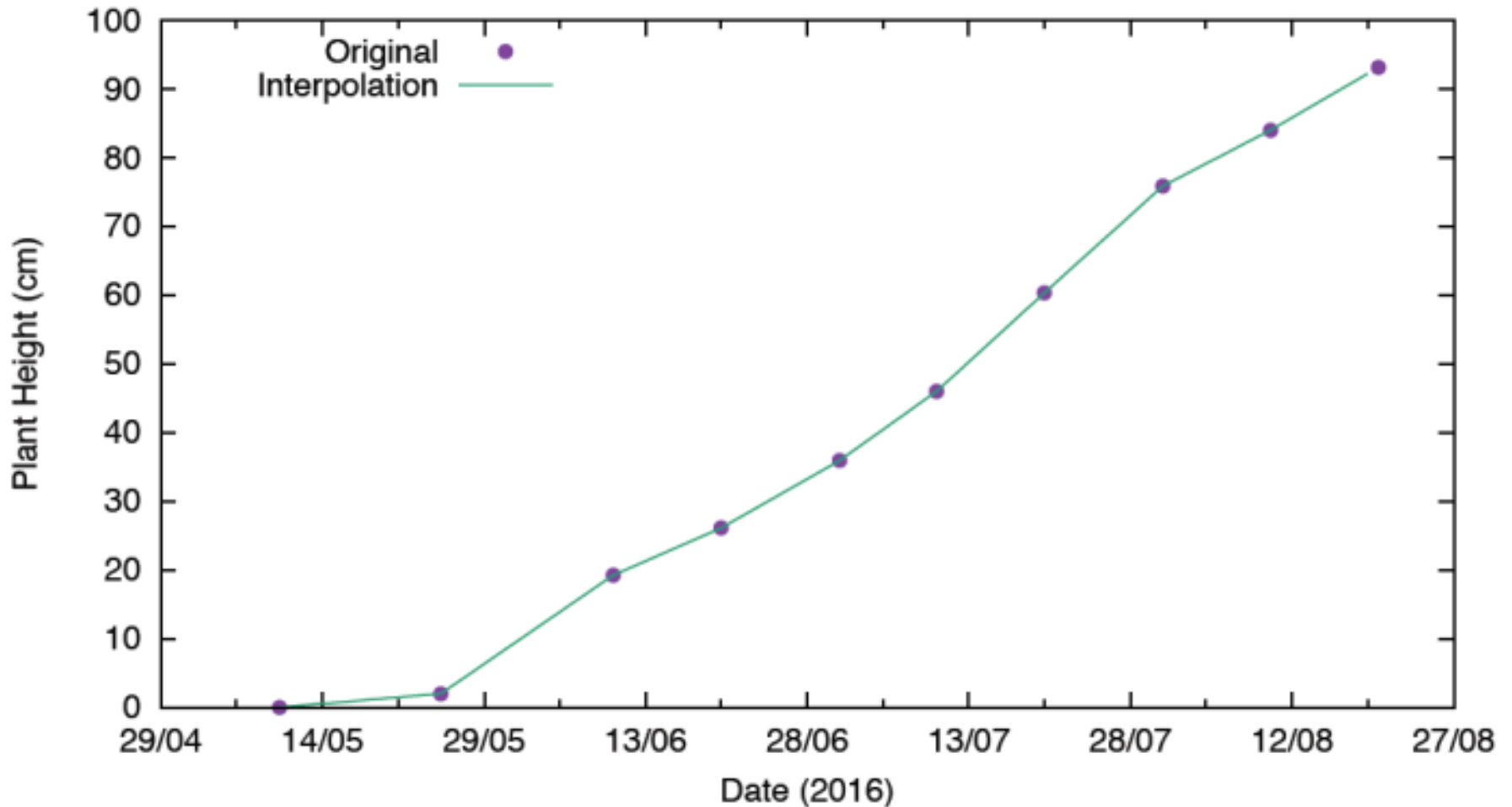


## Rice Crop Calendar in Yamagata Prefecture

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calendar					Planting				Harvesting			

# Japan, phase 1

❖ Yamagata Univ., Tsutsumi City, Yamagata Pref., Japan

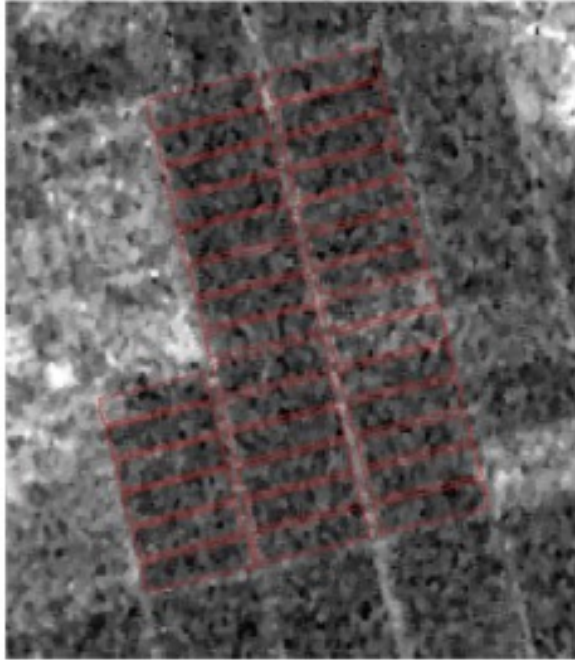


# Japan, phase 1

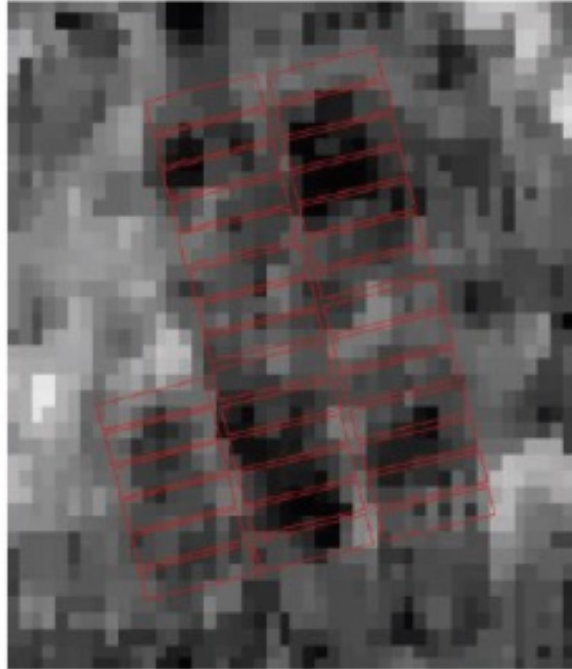
Sensor (Mode)	ALOS-2 (Fine)	Sentinel-1 (Interferometric Wide Swath)	Radarsat-2 (Wide Fine)
Frequency	1.25 GHz (L-Band)	5.405 GHz (C-Band)	5.405 GHz (C-Band)
Spatial Resolution (Pixel Spacing)	3.0 m (2.5m)	5 x 20 m (10.0m)	5.2 x 7.7 m (8.0m)
Polarization	HH	VV	VV, VH
Swath	50 km	250 km	150 km



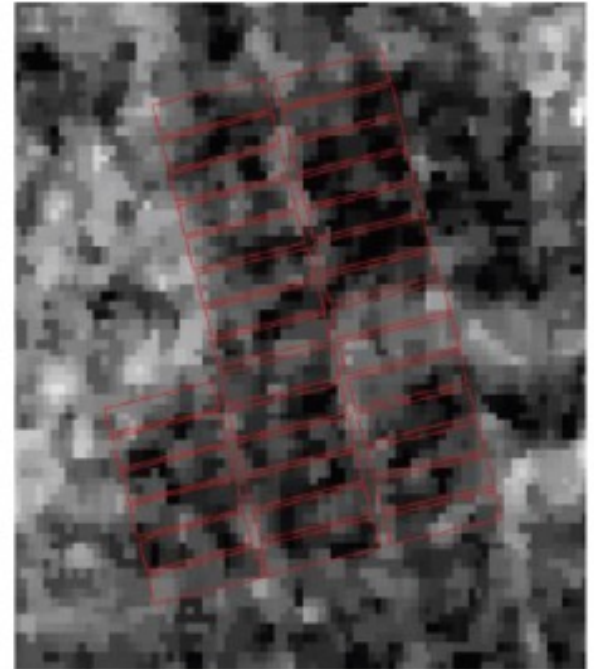
# Japan, phase 1



ALOS-2  
(24 May, HH)



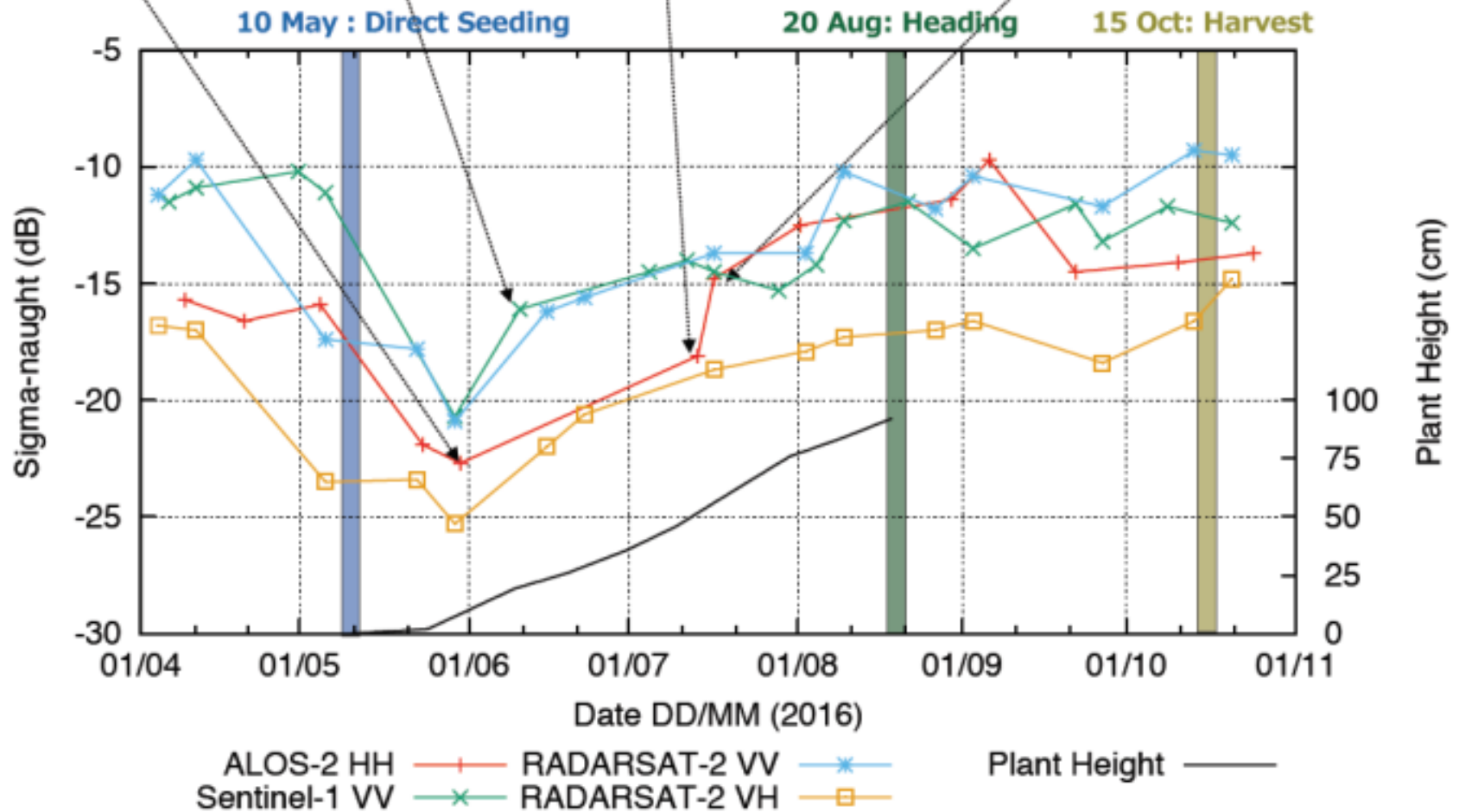
Sentinel-1  
(30 May, VV)



RADARSAT-2  
(30 May, VV)



# Japan, phase 1



# Japan, phase 1

- ❖ This study investigated the rice plant height estimation by L-band (ALOS-2) and C-band (Sentinel-1, RADARSAT-2) data.
- ❖ L-band HH (ALOS-2) showed highest accuracy (10.2 cm), C-band VH (RADARSAT-2) showed the second-highest (11.6 cm).
- ❖ Spatial resolution would be also significant factor to estimate plant height because the study area is heterogeneous and small (25x100m).
- ❖ Further studies including the integration of optical data, biomass estimation or detailed phenological stage classification are important in terms of a practical use.
- ❖ Also, understanding of the physical mechanism between EM wave and rice plant using radiative transfer model would be quite important to consider observing conditions (e.g. frequency, incidence angle etc.) and generalize the rice crop monitoring using SAR.

## Implementation status in pilot 4 countries by ADB

## ❖ OUTPUTS

1. Customized INAHOR software 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.

❖ Implementation Period: June 2013 to November 2016.

❖ Executing Agency: Asian Development Bank

❖ Consulting firm: RESTEC/AIT

❖ Technical Adviser: Japan Aerospace Exploration Agency (JAXA)



# Overview

## ❖ Pilot Countries & Target area



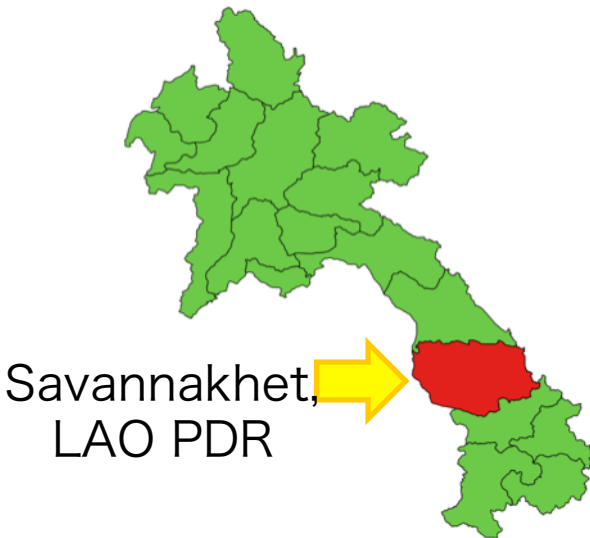
Neuva Ecija,  
the Philippines



Ang Thong,  
Thailand



Thai Binh,  
Vietnam



Savannakhet,  
LAO PDR

# Available data

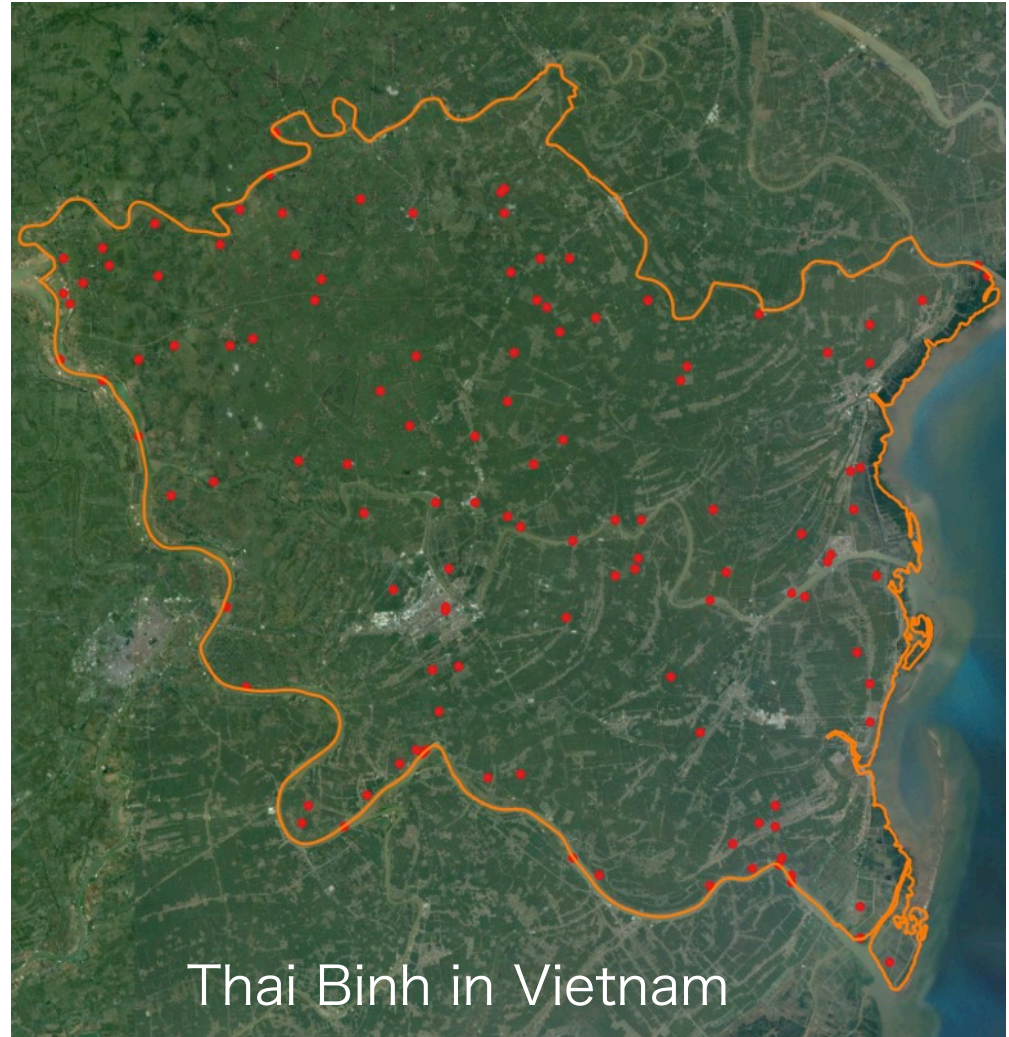
Target	Cycle	Observation Date	A/D	Path	Operation Mode	Plan O:Planned X:Not Planned	Observation O:OK X:NoData
Savannakhet_Lao_PDR	25	20150703	D	35	W 2R	0	0
Savannakhet_Lao_PDR	27	20150731	D	35	W 2R	0	0
Savannakhet_Lao_PDR	31	20150925	D	35	W 2R	0	0
Savannakhet_Lao_PDR	32	20151009	D	35	W 2R	X	–
Savannakhet_Lao_PDR	33	20151023	D	35	W 2R	0	0
Savannakhet_Lao_PDR	35	20151204	D	35	W 2R	0	0
Nueve_Ec ija_Philppines	22	20150524	D	27	W 2R	0	0
Nueve_Ec ija_Philppines	25	20150705	D	27	W 2R	0	X
Nueve_Ec ija_Philppines	27	20150802	D	27	W 2R	0	0
Nueve_Ec ija_Philppines	31	20150927	D	27	W 2R	0	0
Nueve_Ec ija_Philppines	32	20151011	D	27	W 2R	0	X
Nueve_Ec ija_Philppines	33	20151025	D	27	W 2R	0	0
AngThong_Thailand	22	20150523	D	38	W 2R	X	–
AngThong_Thailand	25	20150704	D	38	W 2R	0	0
AngThong_Thailand	27	20150801	D	38	W 2R	0	0
AngThong_Thailand	30	20150912	D	38	W 2R	0	X
AngThong_Thailand	33	20151024	D	38	W 2R	0	0
AngThong_Thailand	35	20151205	D	38	W 2R	0	0
ThaiB inh_V ietnam	25	20150624	D	36	W 2R	0	0
ThaiB inh_V ietnam	27	20150722	D	36	W 2R	0	0
ThaiB inh_V ietnam	30	20150902	D	36	W 2R	0	X
ThaiB inh_V ietnam	31	20150916	D	36	W 2R	0	0
ThaiB inh_V ietnam	33	20151014	D	36	W 2R	0	0

# Field survey

- ❖ Field survey was conducted for 120 points which were selected randomly from 200m x 200m mesh in the target province.

In order to

- Tune the parameters
- Validate the result

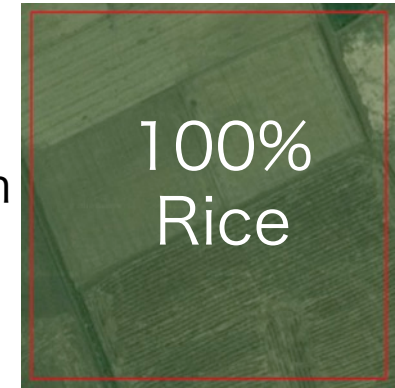
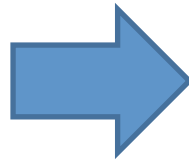
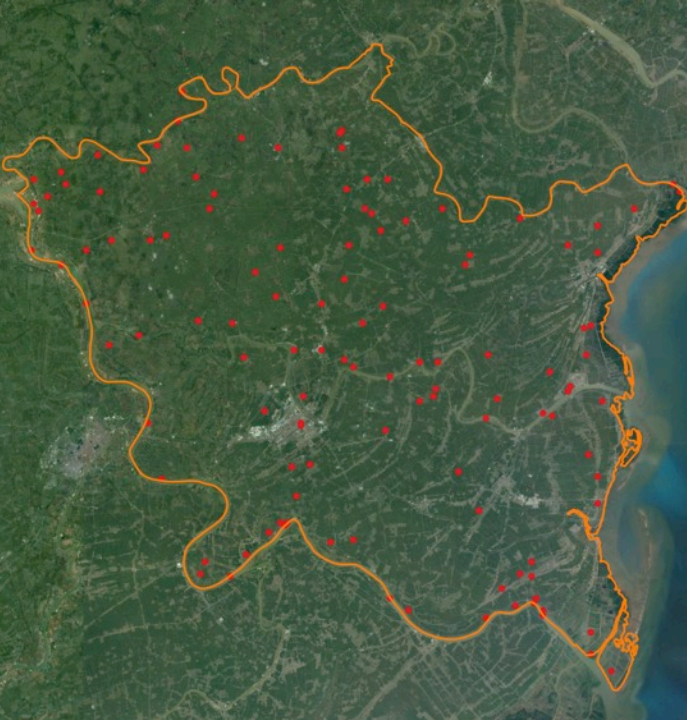


Thai Binh in Vietnam

# Summary of the tuning

- ❖ Parameter tuning was conducted to get the optimized threshold values which to detect inundation area and well-grown area.
- ❖ The random sampled field survey data was used for the tuning.
- ❖ One field survey data was 200m x 200m mesh.
- ❖ 5 points field survey data were used from 120.
- ❖ The conditions of the 5 points were 100% rice area and planting stage at the survey in early wet season.
- ❖ The estimated results with tuned parameters were validated by comparing with total rice planted area of 120 points .

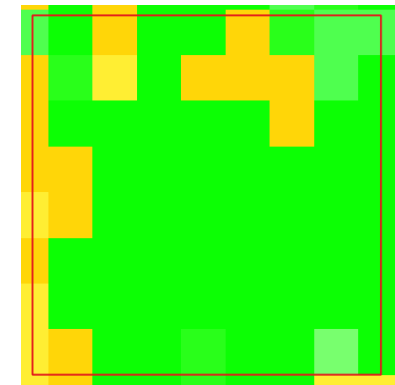
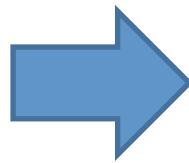




$$200\text{m} \times 200\text{m} \times 30\% = 1200\text{m}^2$$

$$200\text{m} \times 200\text{m} \times 100\% = 4000\text{m}^2$$

Sum of all surveyed mesh rice area = 1,842,000 m<sup>2</sup>



Calculated result for each mesh with INAHOR

$$= 1,777,800 \text{ m}^2$$

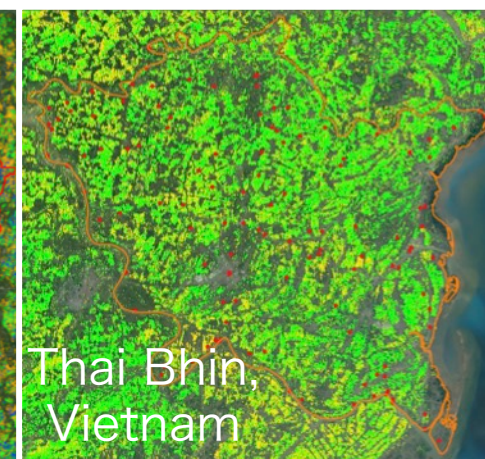
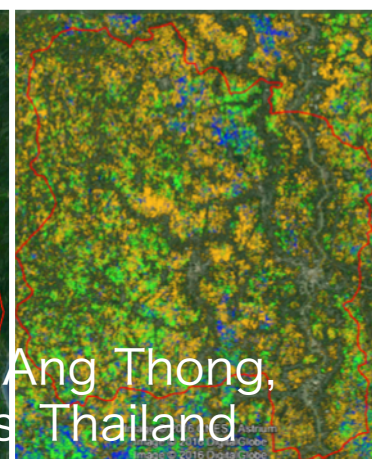
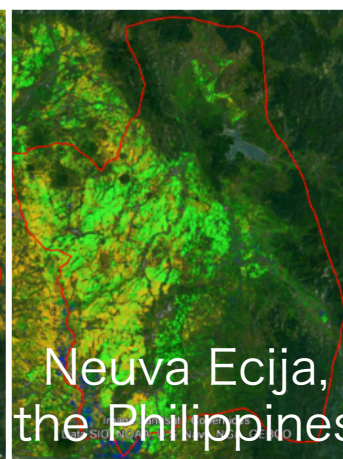
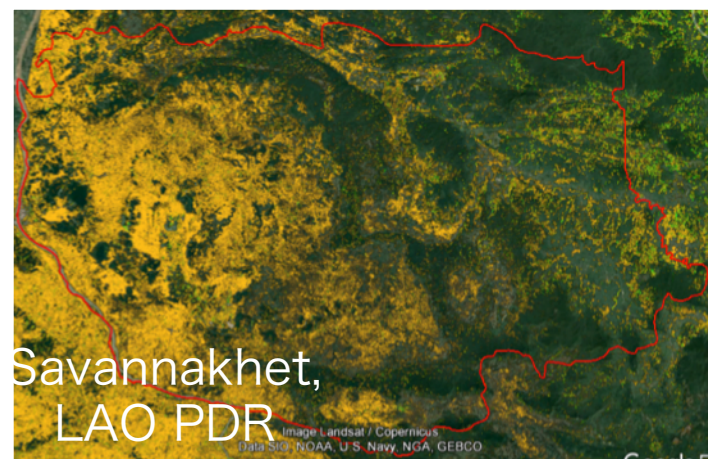
The estimated % = INAHOR / Survey = 96%

The estimated error is 4%



# Summary of the tuning

Country	Threshold 1	Threshold 2	Estimated % (error%)
LAO PDR	-18.51	6.13	96% (-4%)
Philippine	-17.86	8.13	93% (-7%)
Thailand	-17.58	3.58	106% (6%)
Vietnam	-17.46	5.99	96% (-4%)



# Summary of Validation

Consideration for the reasons of error was conducted, in order to understand the characteristic of the INAHOR result for using it correctly.

- ❖ Some rice paddy fields beside a bright target such as a residential building or forest/tree can't be detected sometimes.
- ❖ Some smooth surface areas in planting season, such as a pond, river or bare land are sometimes detected as rice paddy, if the smooth surface change to rough in 2nd half of the season.

# Summary

# Summary

- Asia-RiCE activities are steadily progressing.
- In Indonesia / Vietnam (S), phase 1 was finished. Then phase 2 is ongoing by expanding the target area to main rice production area such as top 10 provinces / Mekong Delta region. The results are validating now under the SAFE Project.
- In Myanmar / Cambodia, phase 1 was started. The results are validating now under the SAFE Project.
- In Japan, a study estimating plant height by using SAR data is ongoing, in order to estimate biomass.
- In ADB project, phase 1 was finished. The results was good. The next project is under consideration between ADB and JAXA.

Thank you for your attention !!