# Rice Crop Monitoring in Tsuruoka, Japan by using Multiple Satellite Data

Kei Oyoshi[1]、Yuka Sasaki[2], Jun Sato[3],
Shinichi Sobue[1], Yutaka Kaneko[1], Genya Saito[1]

[1] Japan Aerospace Exploration Agency (JAXA)
[2] Yamagata University
[3] National Institute of Technology, Tsuruoka College

GEOSS Asia-Pacific Symposium WG5
@Tokyo, Japan
12th Jan 2017

GEOGLAM
Global Agricultural Monitoring

Asia-RiCE
Crop Estimation and Monitoring

独立行政法人 国立高等専門学校機構
鶴岡工業高等専門学校

山形大学
YAMAGATA UNIVERSITY

Tsukuba Space Center
Japan Aerospace Exploration Agency
JAXA

# GEOGLAM/Asia-RiCE

## ❖ GEOGLAM (GEO Global Agriculture Monitoring)

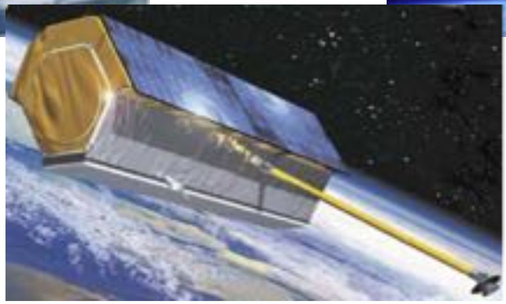
- Endorsed by the G20 in 2011
- An initiative aimed at providing transparent, timely and actionable information on crop prospects through the use of earth observations
- Focuses on four crops (wheat, maize, soybeans, and rice)

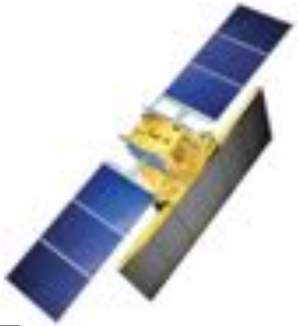
## ❖ Asia-RiCE (Asia-Rice Crop Estimation and Monitoring)

- Asian region produces and consumes 90% of the global rice
- Asian space and agricultural agencies are implementing Asia-RiCE to strengthen rice crop monitoring ability by using remote sensing, Asia-RiCE is a component for GEOGLAM
- SAR would be a strong tool for the cloudy area [Whitcraft et al., 2015]
    - `C/L band are useful to estimate rice growth [Inoue et al., 2002]

# Synthetic Aperture RADARs (SARs)

- ❖ Fleet of multi-frequency SAR is being available
  - RADARSAT-2, RISAT-1, ALOS-2, Sentinel-1A/1B, TerraSAR-X etc.
- ❖ Multiple-SAR data can:
  - Enhance data acquisition reliability;
  - Improve data acquisition interval;
  - Identify different physical characteristics of rice crop.

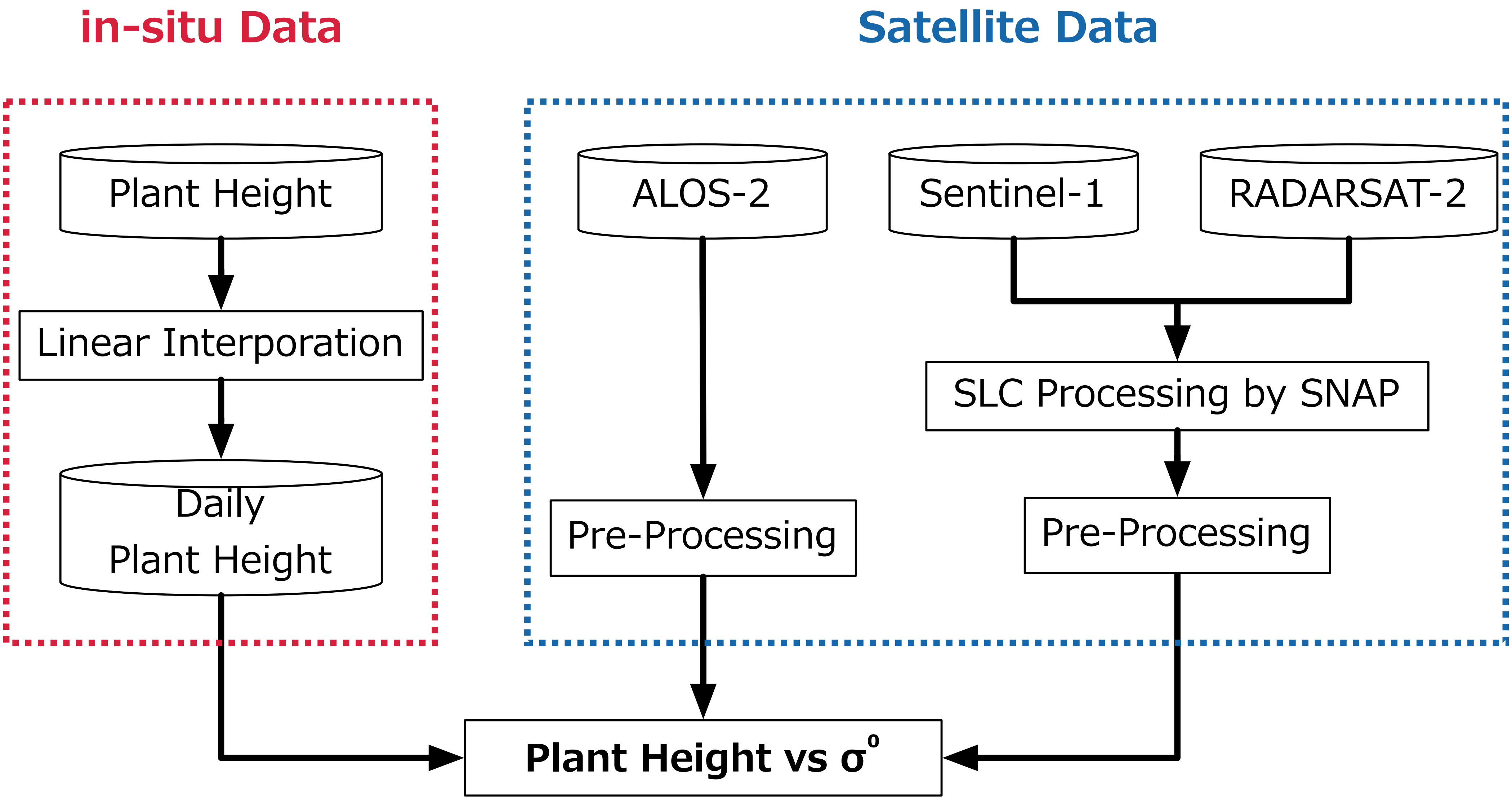



# Objectives

- To investigate how to integrate multi-frequency SAR for rice growth monitoring;
  - Clarifying the characterizations of band frequencies (C- and L-band) or polarizations for rice crop growth monitoring by comparing each SAR backscatter and rice plant height collected by in-situ measurement.

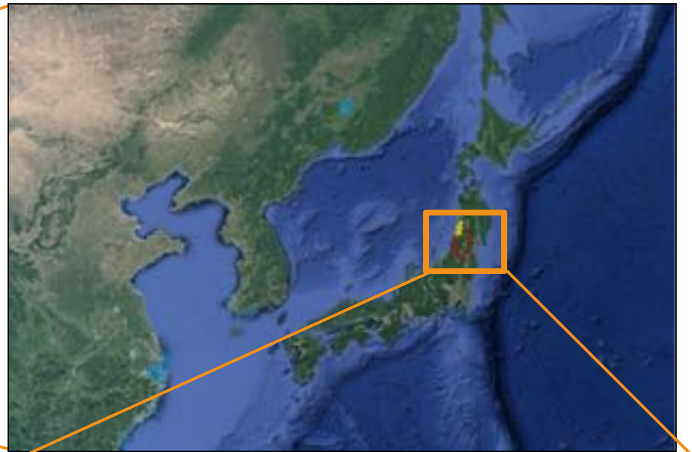
# Framework




*pre-processing includes median filter (3x3) and image subset

# Study Area : Asia-Rice Site in Japan

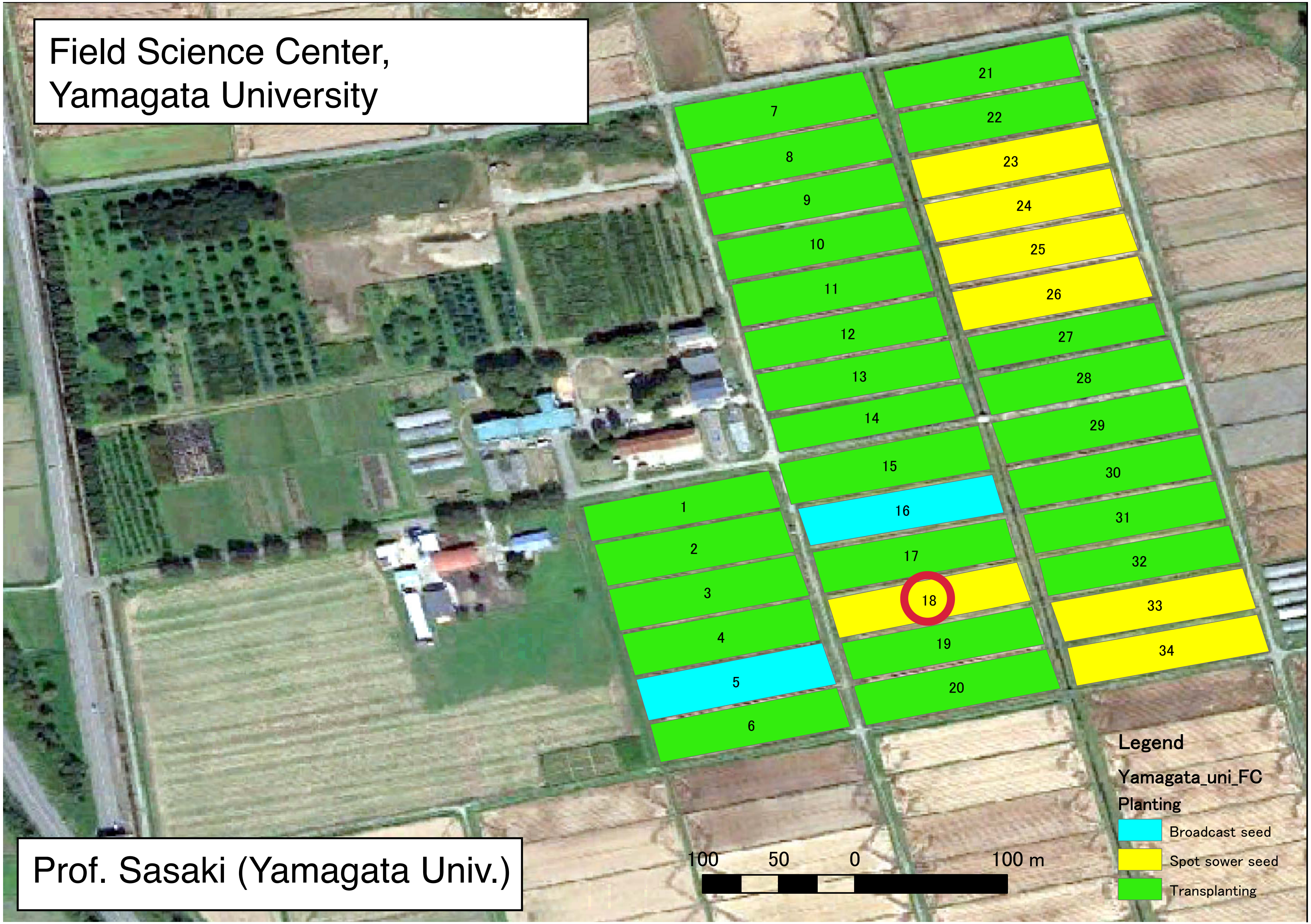
Asia-RiCE TDS




**Rice Crop Calendar in Yamagata Prefecture**

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

# Study Area: Tsuruoka City, Yamagata Pref.



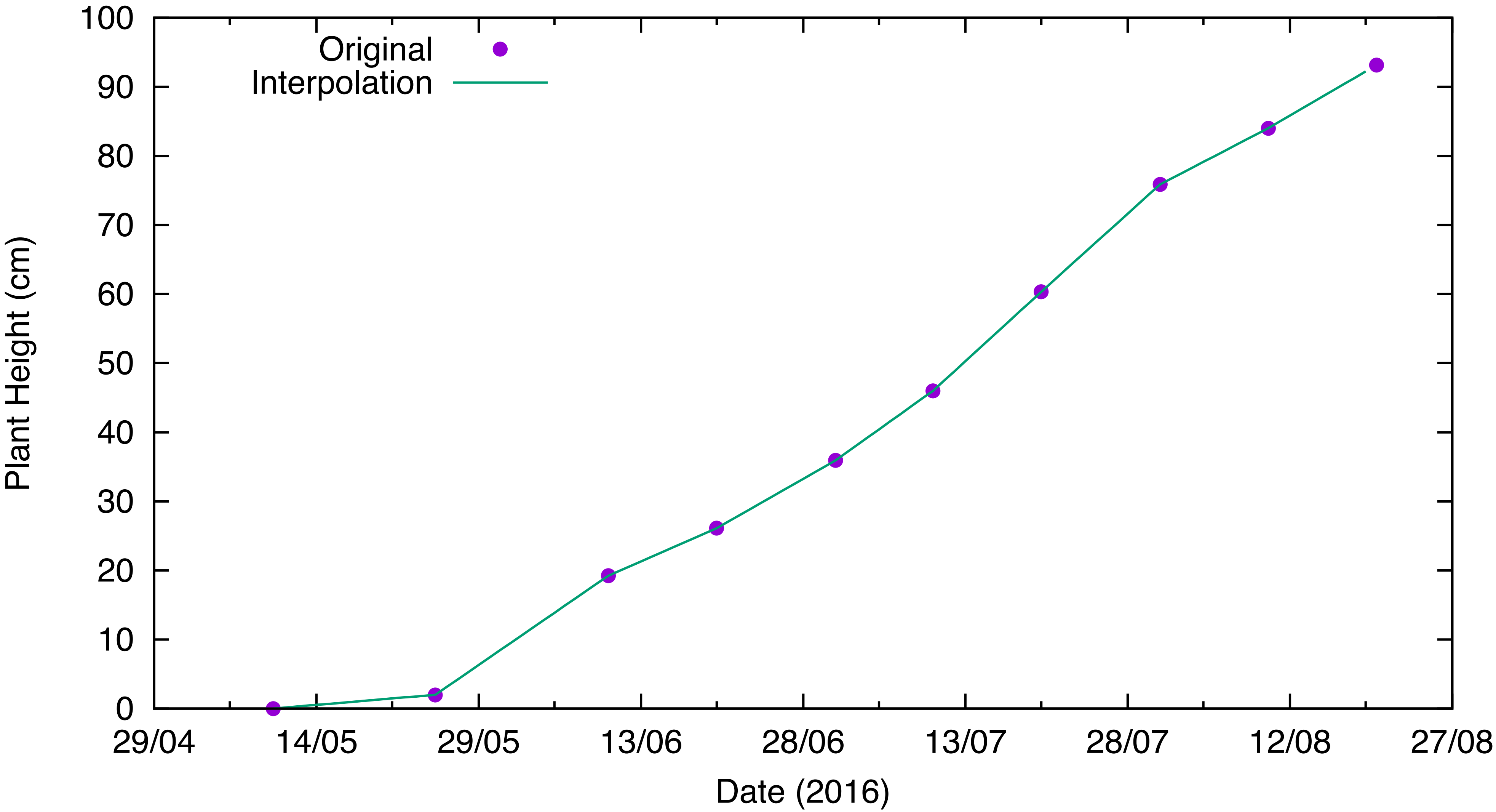
# In-Situ Data Measurement

- **Collection Period**
  - May to Aug (almost every 10 days)
- **Physical Parameters**
  - Plant height/length
  - Water depth
  - Number of tillers
- **Photo by AWS**



# Daily Plant Height by Linear Interpolation

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



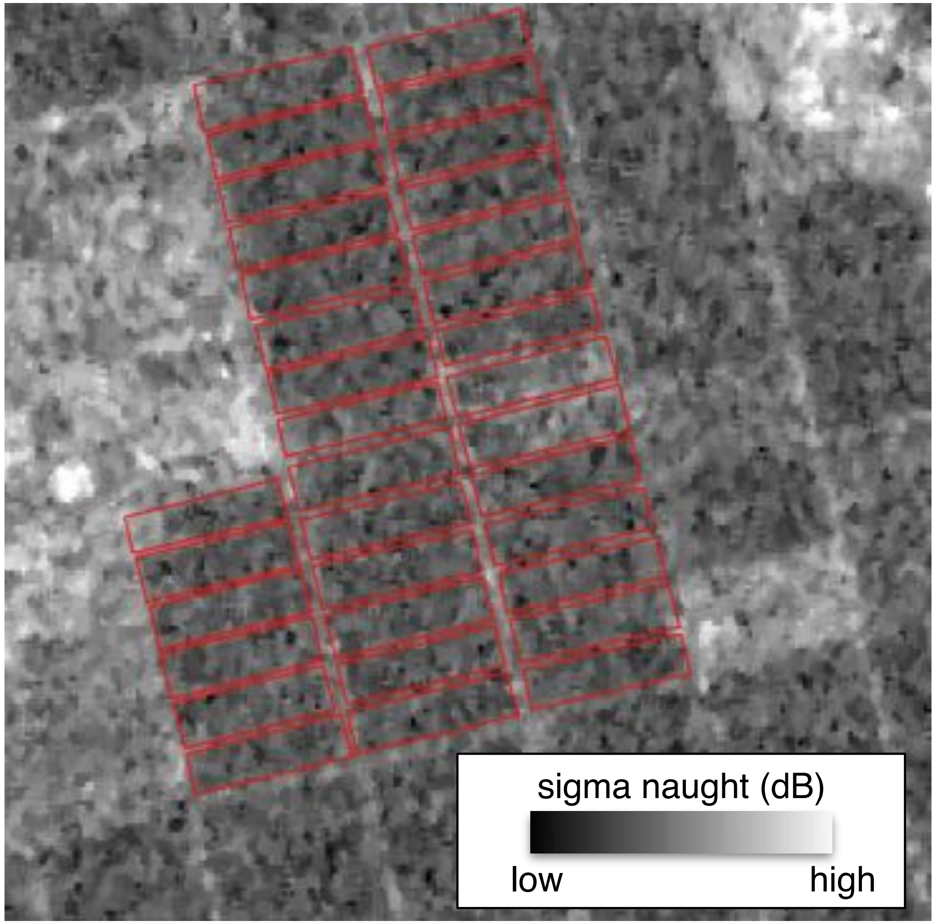
# Specifications of SARs Used in This Study

| 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 |

# SAR Image of Study Area

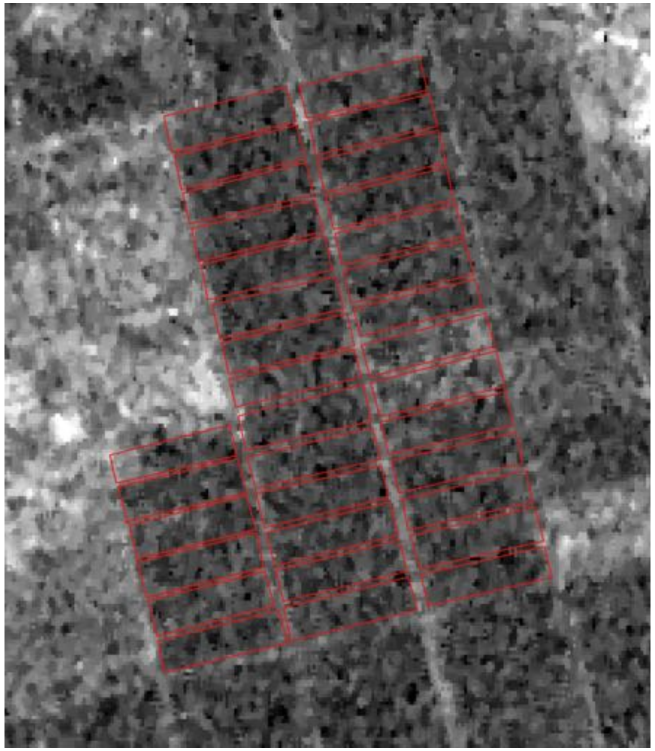
- Rice Field in Yamagata Univ.
  - One plot of test fields is used in this study


Google Earth

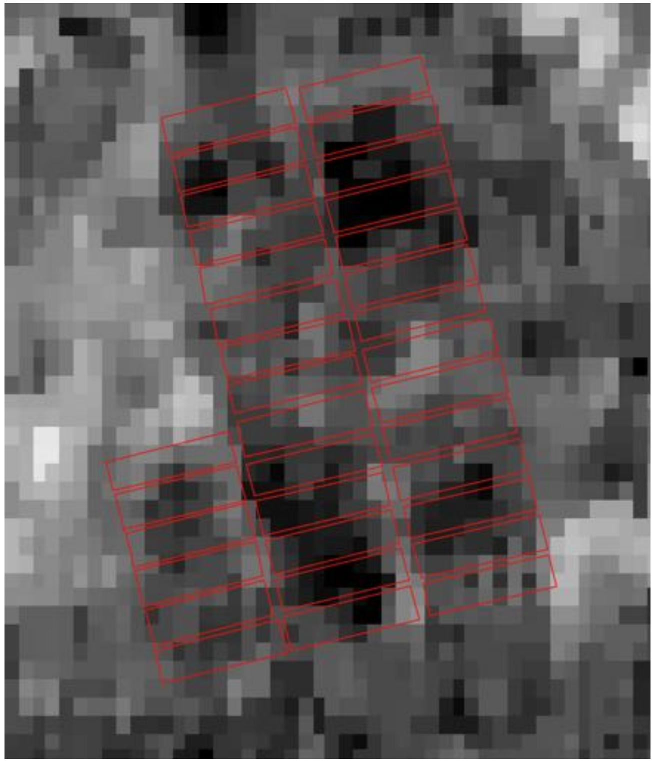



ALOS-2
(2.5m, Median Filter 3x3)

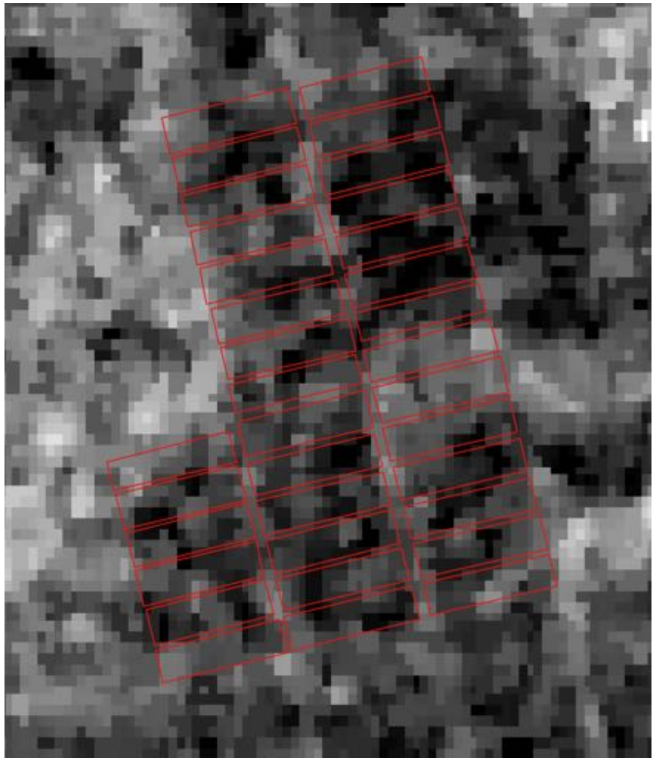
# ALOS-2/Sentinel-2/Radarsat-2 Images



ALOS-2
(24 May, HH)

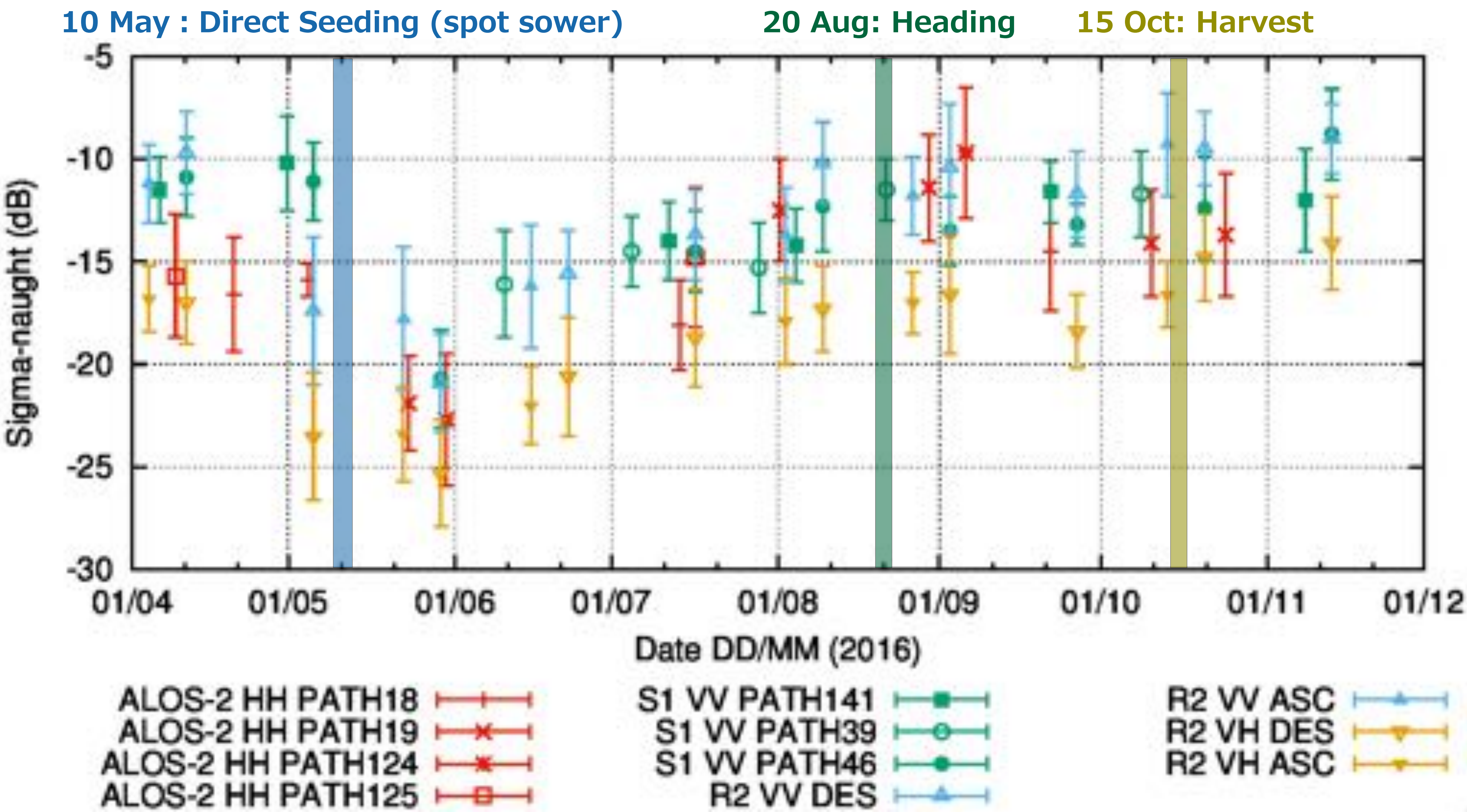


Sentinel-1
(30 May, VV)



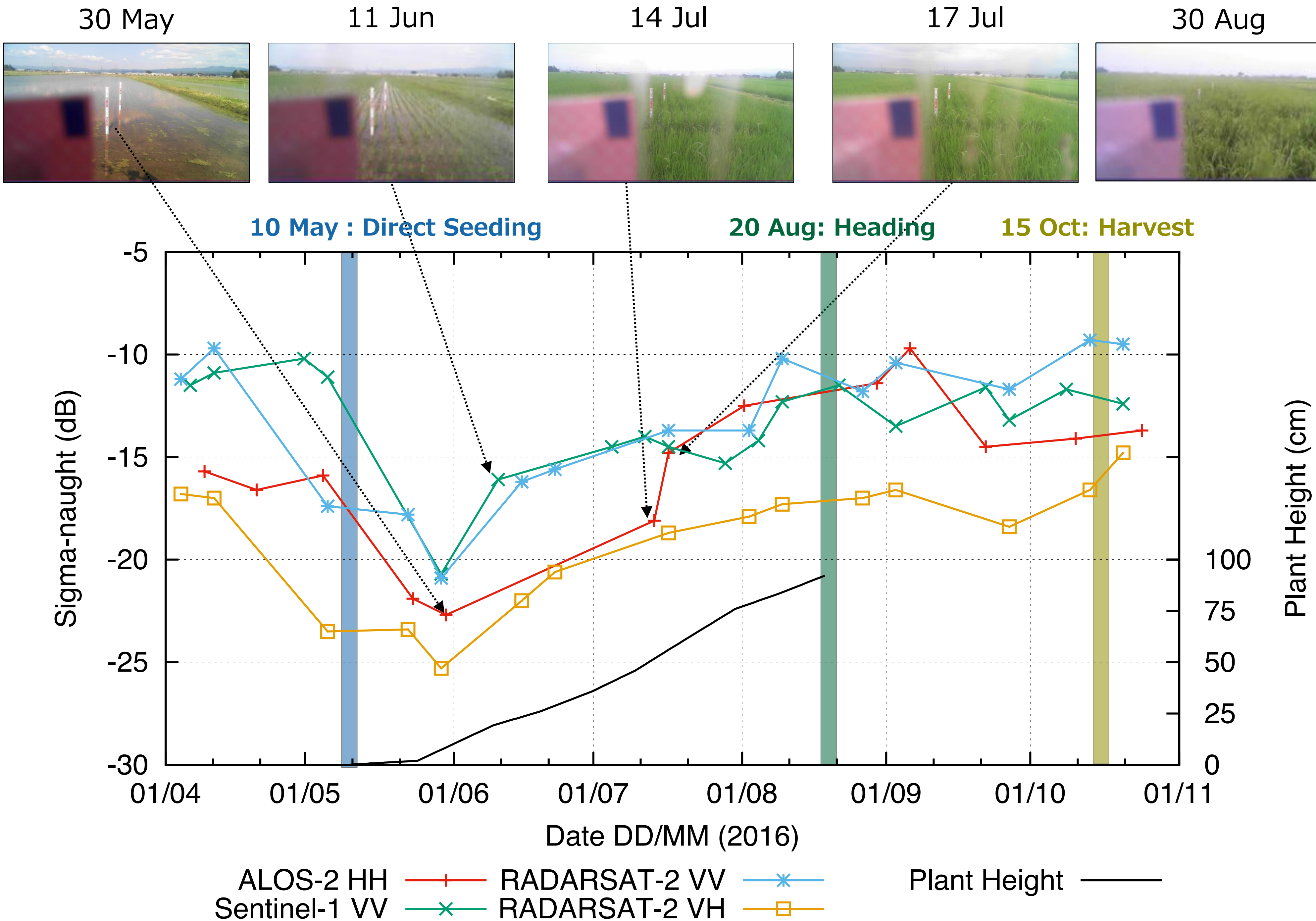
RADARSAT-2
(30 May, VV)

# ALOS-2 (HH) vs Sentinel-1 (VV) vs RADARSAT-2 (VV, VH)




- ALOS-2 (13) + Sentinel-1 (18) + RADARSAT-2 (15) = **46 scenes !**
- 210 days / 46 scene = **4.6 days/scene !**

# ALOS-2 (HH) vs Sentinel-1 (VV) vs RADARSAT-2 (VV, VH)



# Discussions

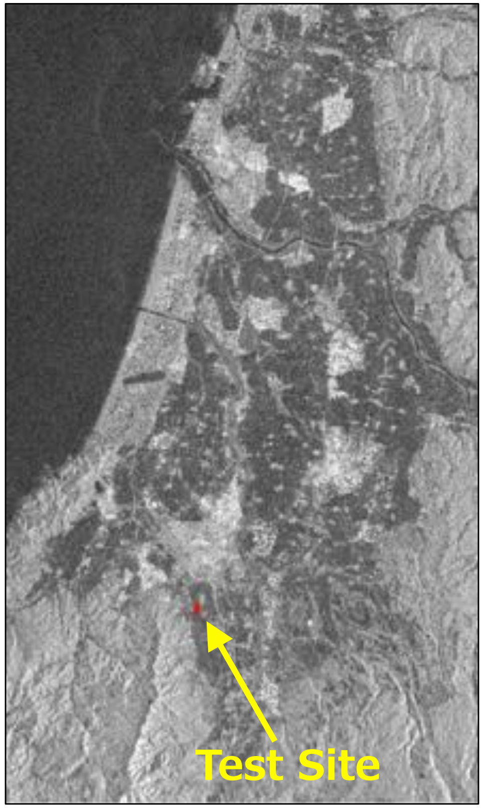
- C-band (VV, VH)
  - VV pol rapidly rises just after planting
  - VH pol gradually rises until heading (-25dB to -17dB)
    **—> high sensitivity in plating phase**

- L-band (HH)
  - HH pol rises until maturing (-23dB to -10dB )
  - HH pol rapidly rises in July-Aug (PH = 50)
    **—> high sensitivity in vegetative/reproductive phase**

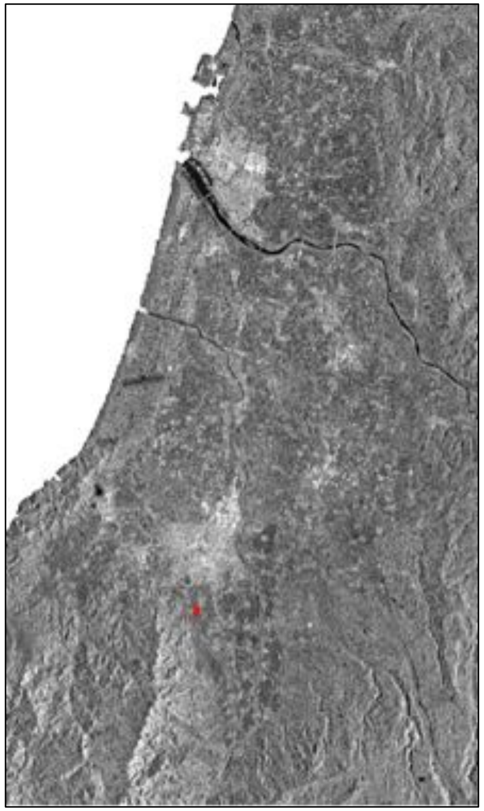
- Improve Observation Interval
  - Integrated use of ALOS-2 + Sentinel-1 + RADARSAT-2 can utilize SAR data every **4.6 days on average**, but **there are some gaps in observation (sometimes more than 15 days)**

# SAR Images : Vegetative Season (July 2016)

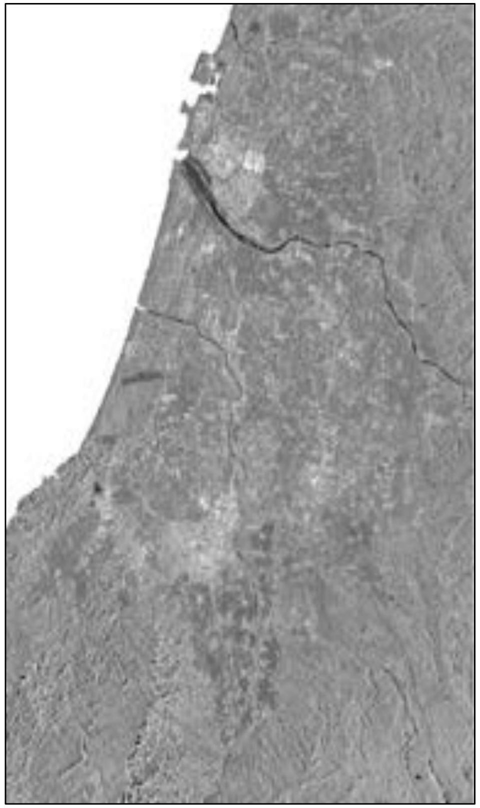
- ❖ L-band still shows low backscatter even in vegetative seasons.
- ❖ Bragg scattering effect can be seen in L-band image.



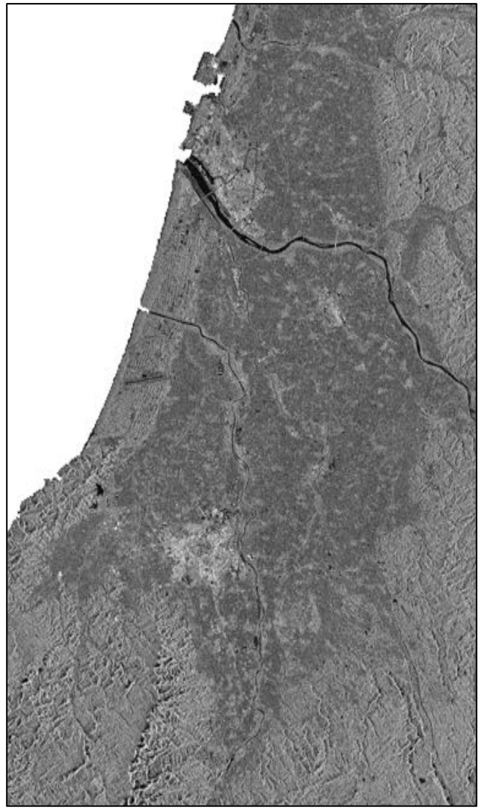

ALOS-2 HH
14 Jul 2016
Fine Mode (2.5m)



Sentinel-1 VV
17 Jul 2016
IW Mode (10m)



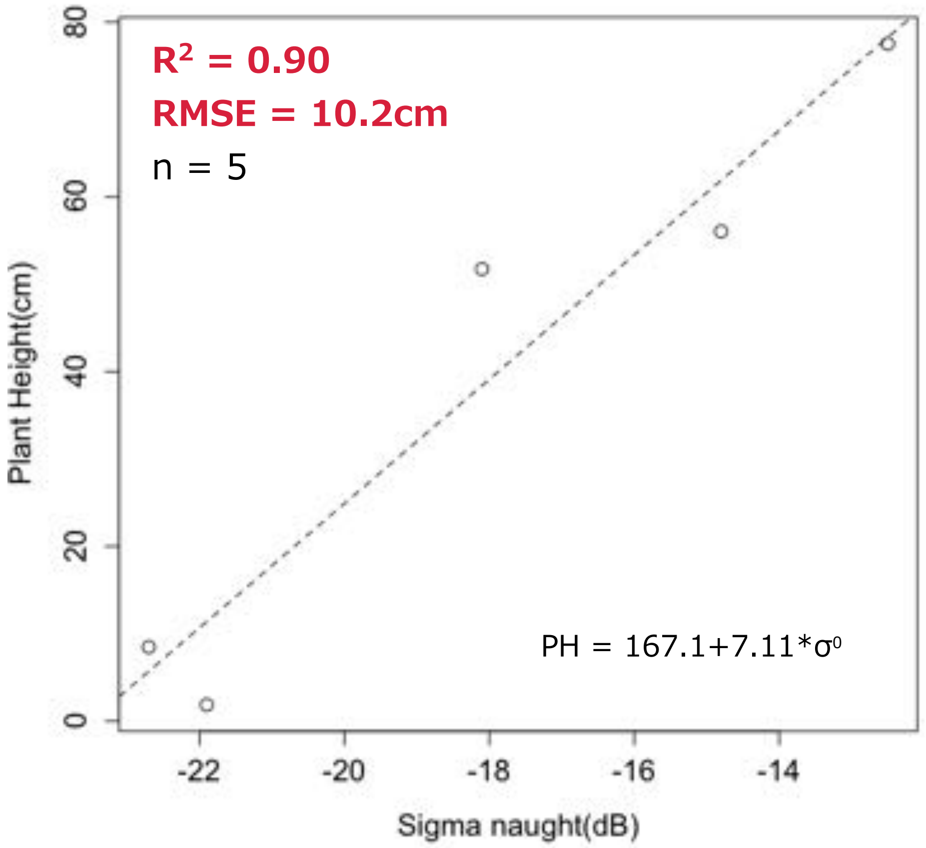
RADARSAT-2 VV
17 Jul 2016
Wide Fine (8m)



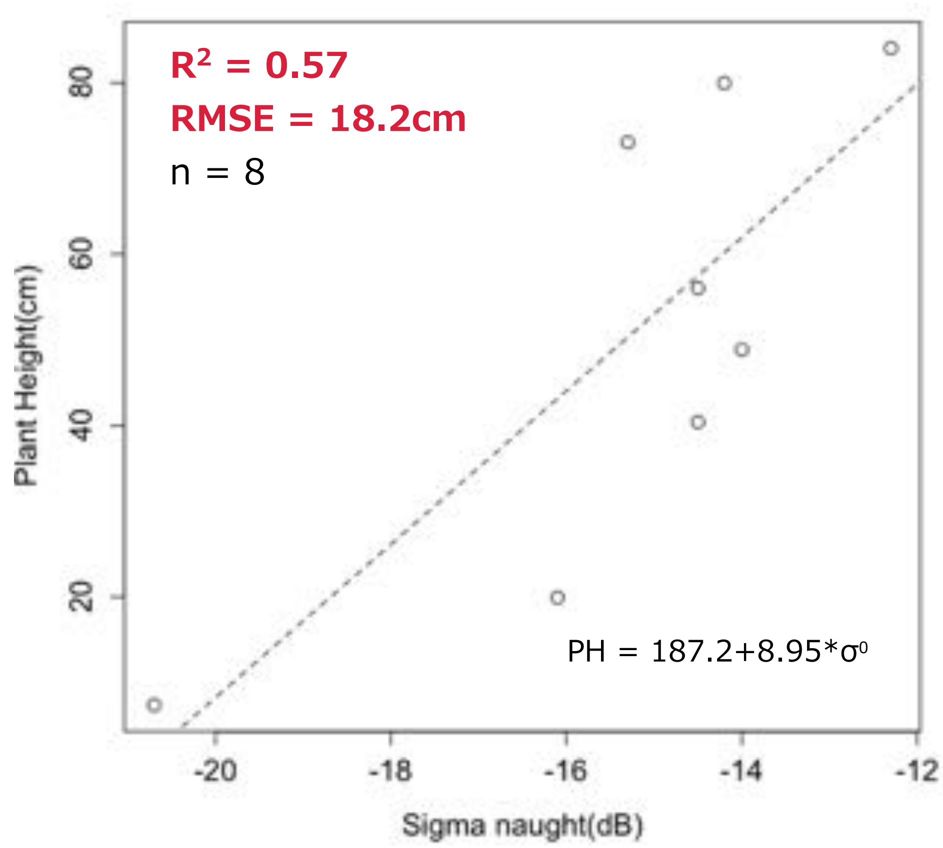
RADARSAT-2 VH
17 Jul 2016
Wide Fine (8m)

# Sigma naught vs Plant Height

**ALOS-2 (HH, Fine)**
**L-band**



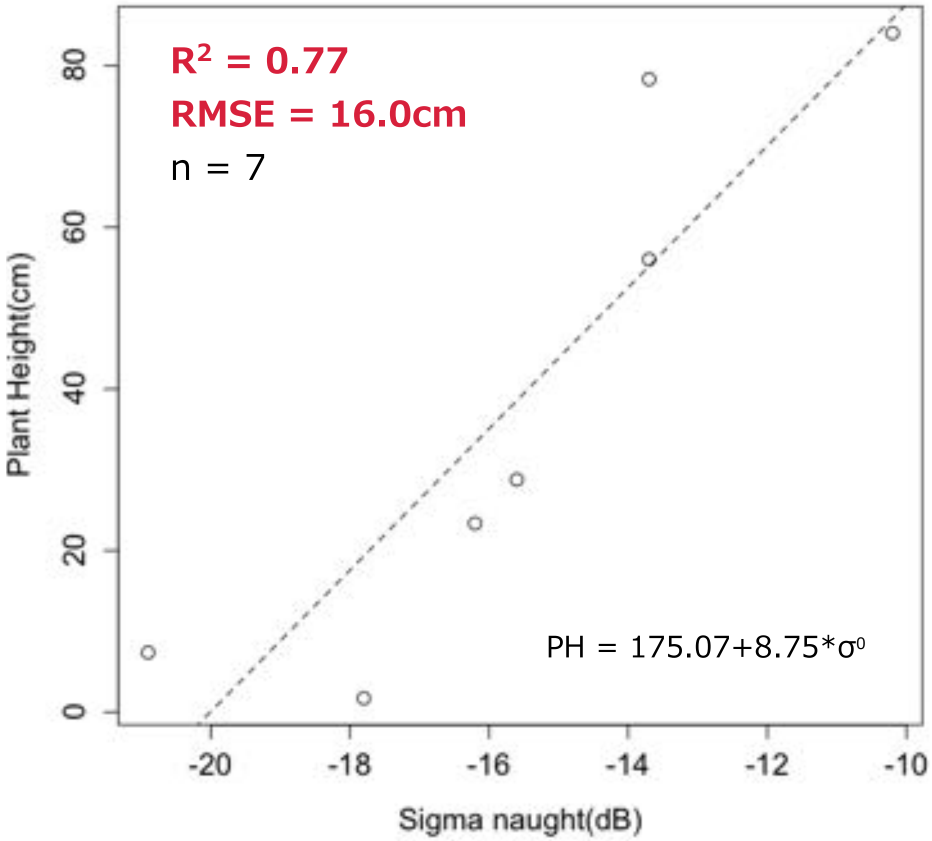

**Sentinel-1 (VV, IW)**
**C-band**



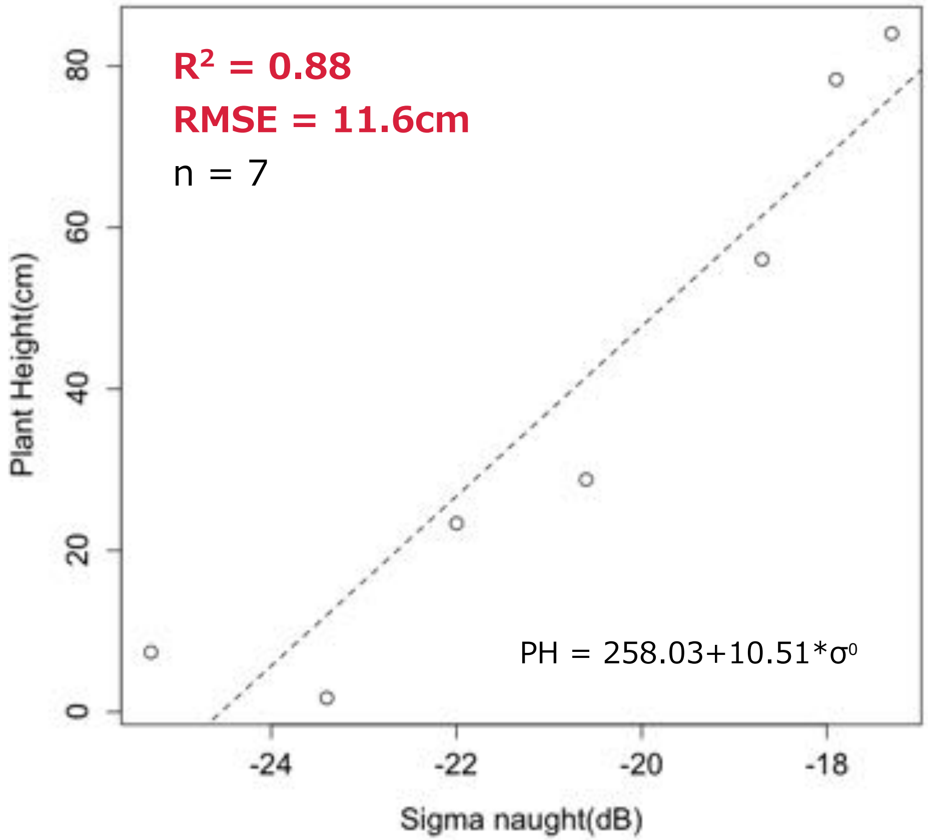

**ALOS-2 (L-band, 3m) shows strong linear relationship with plant height.**

# Sigma naught vs Plant Height

**Radarsat-2 (VV, WF)**
**C-band**




**Radarsat-2 (VH, WF)**
**C-band**




**VH shows higher accuracy and almost same RMSE as ALOS-2.**

# Concluding Remarks

- ❖ 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.

# Thank You for Your Attention !

ohyoshi.kei@jaxa.jp

JAXA
Explore to Realize