Towards an Operational System for Rice Crop Inventory in the Mekong River Delta, Vietnam Using Envisat ASAR Data

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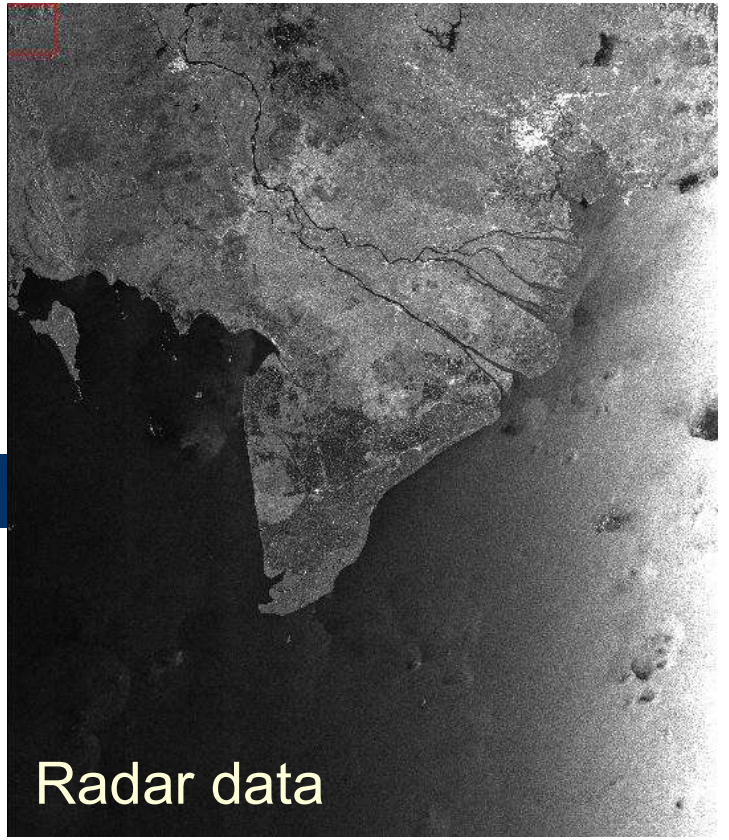
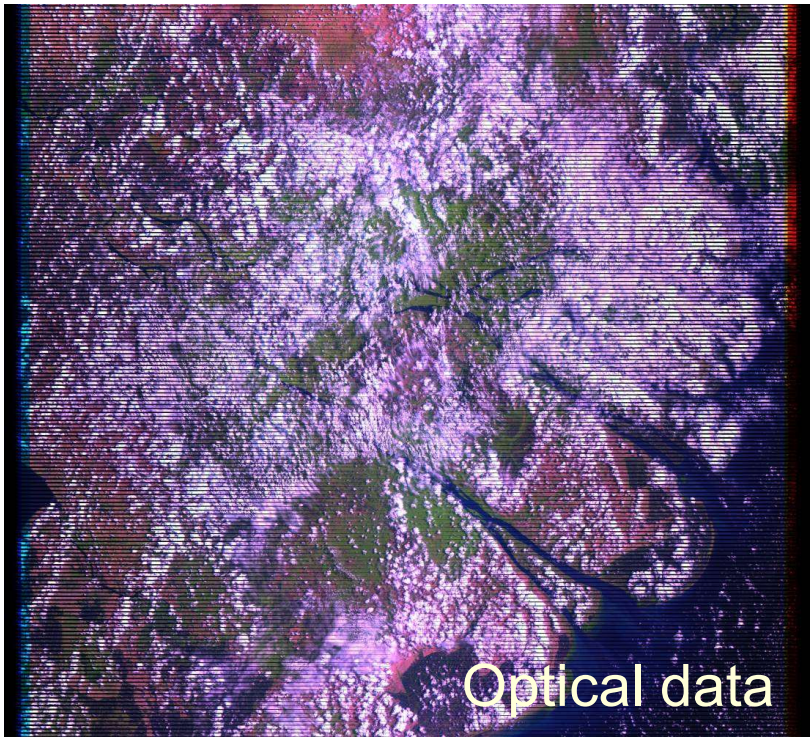
Contents

Introduction

Why Radar RS ?

- **All weather capability** (small sensitivity of clouds, light rain);
- **Day and night operation** (independence of sun illumination);
- **No effects of atmospheric constituents** (multi-temporal analysis);
- Etc.





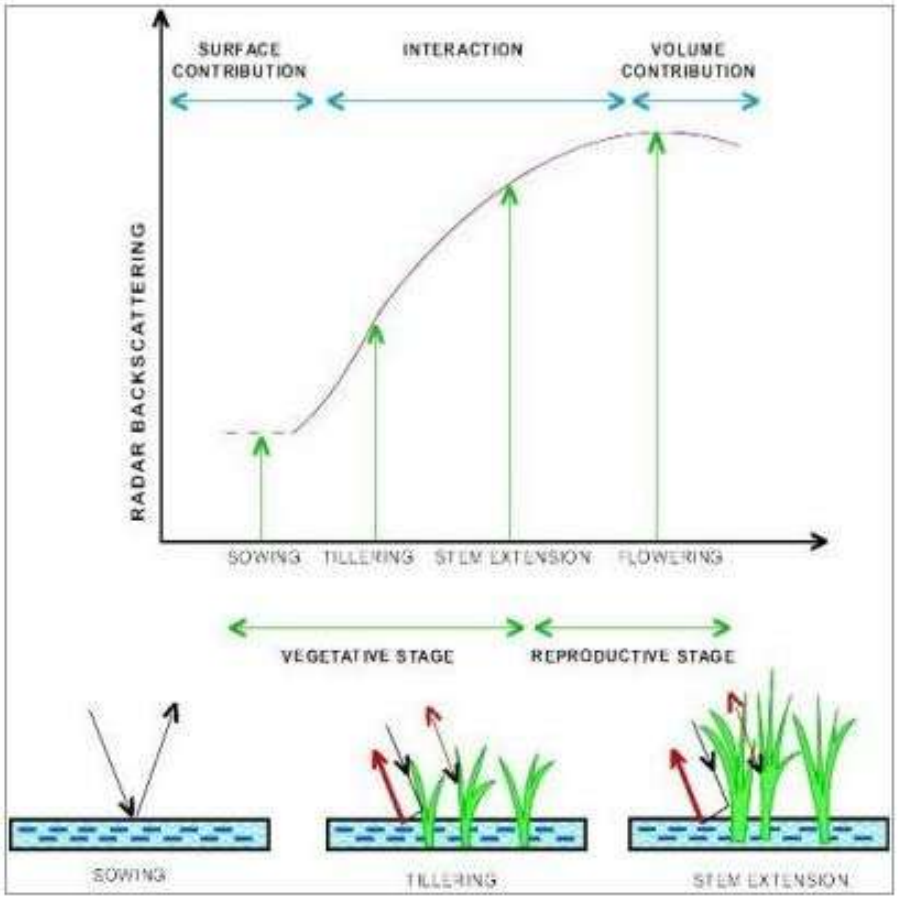
Introduction: Spaceborne SARs

Satellite	Years	Agency	Frequency - Polarisation	Resolution - Swath	Special
ERS-1	1991-2000	ESA	C - VV	25 m 100 km	Interferometry (with ERS-2)
JERS	1992-1998	NASDA	L-HH	25 m 100 km	Region. mosaic available
ERS-2	1995	ESA	C - VV	25 m 100 km	Interferometry (with ERS-1)
RADARSAT-1	1995	CSA	C - HH	10 -100 m 45 - 500 km	Multi-incidence
ENVISAT - ASAR	2002	ESA	C - HH/VV/HV	25 - 1000 m 50 - 500 km	Multi-incidence
ALOS - PALSAR	2006	JAXA	L - Polarimetric	10 - 100 m 100 - 350 km	Multi-incidence
TerraSAR-X	2007	DLR	X-Polarimetric	1 m	Interferometry 1 day
RADARSAT 2	2007	CSA	C - Polarimetric	< 10 m	Multi-incidence

Introduction

Why Radar RS for Rice ?

- Growing mainly in **tropical regions**;
- Rice: **staple food**;
- Population growth and Climate change → **Food security**.

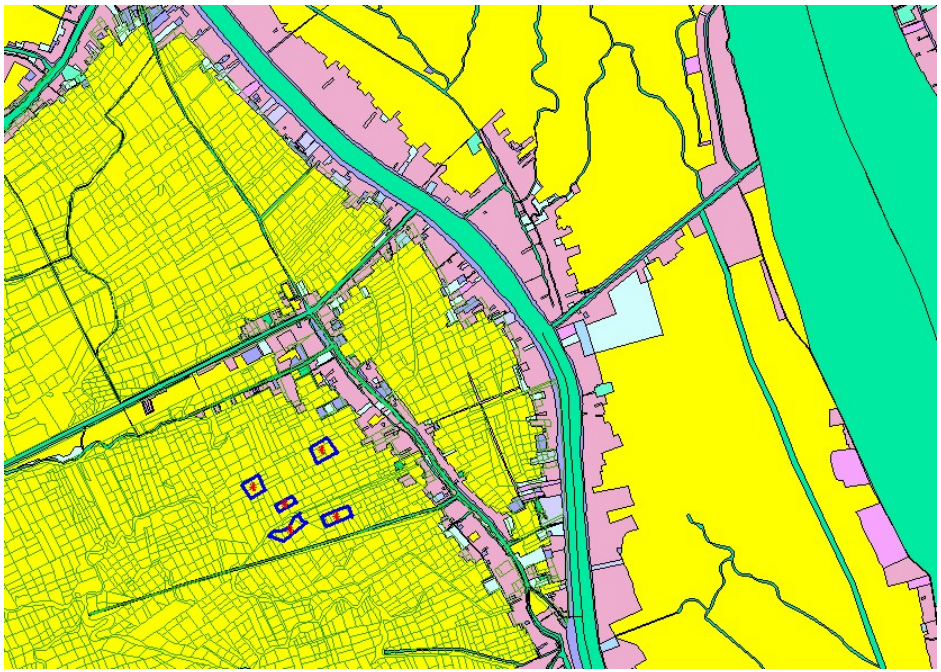


Operational System for Rice Crop Inventory

Introduction

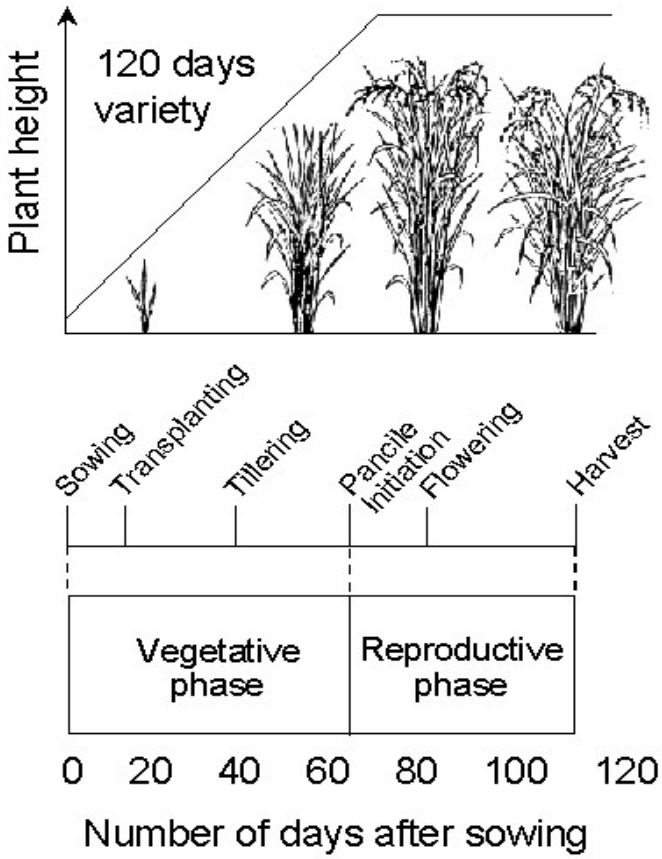
Why Radar RS for Rice in MRD?

- **Size of rice field** ranging from small (0.5 – 2 ha) to large;
- **Sowing dates** are different from field to field (1-2 weeks);
- Different **rice cropping systems** from one area to another;
- **Cultural practices** (sowing, transplanting);
- **Seeds**.

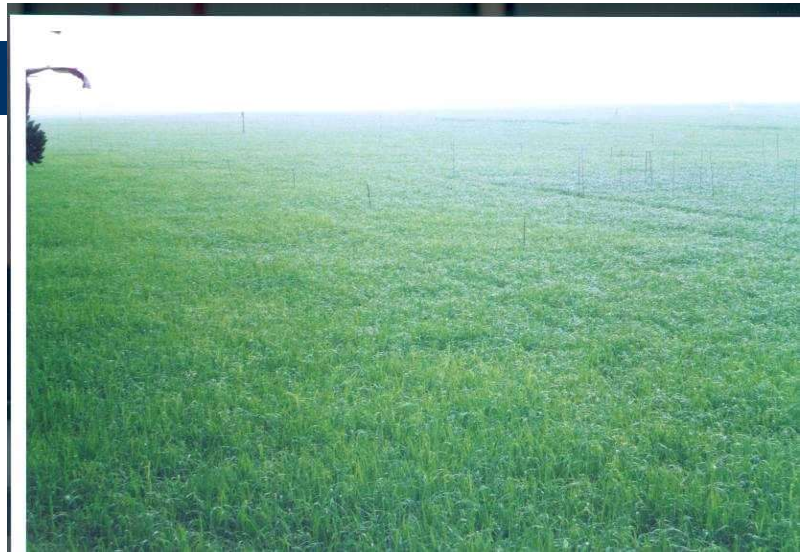


Rice growing stages

- The sowing-transplanting period;
- The growing period:
  1. **Vegetative** stage,
  2. **Reproductive** stage,
  3. **Ripening** stage;
- Fallow.

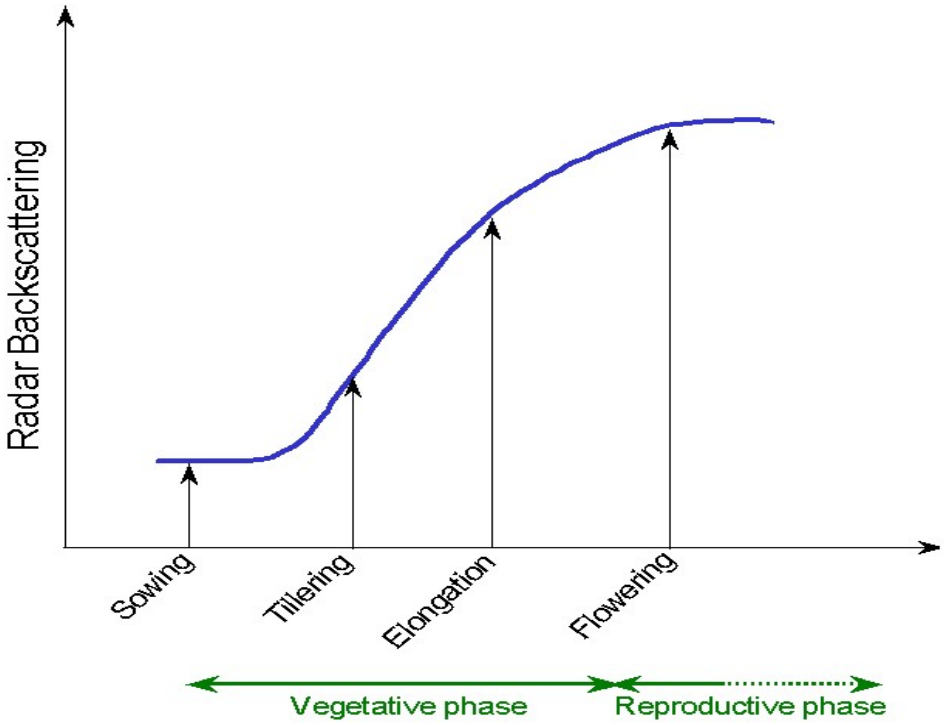


Pictures of Rice Growing Stages



Physical basis of the radar backscatter from rice fields

- Before sowing: **very low** radar backscattering;
- During the vegetative phase: **steady increase** of the radar response;
- At the end of the ripening: **slight decrease** of the σ^o
- After the harvest: **low** radar backscattering.



Previous Studies

Methods were used for rice mapping:

- Visual interpretation;
- Unsupervised classification;
- Maximum likelihood classifier;
- Artificial neural network classifier;
- Knowledge-based classifier;
- Temporal change measurement;
- Objected-oriented classifier;
- Single-date mapping algorithm;
- PCA based method.

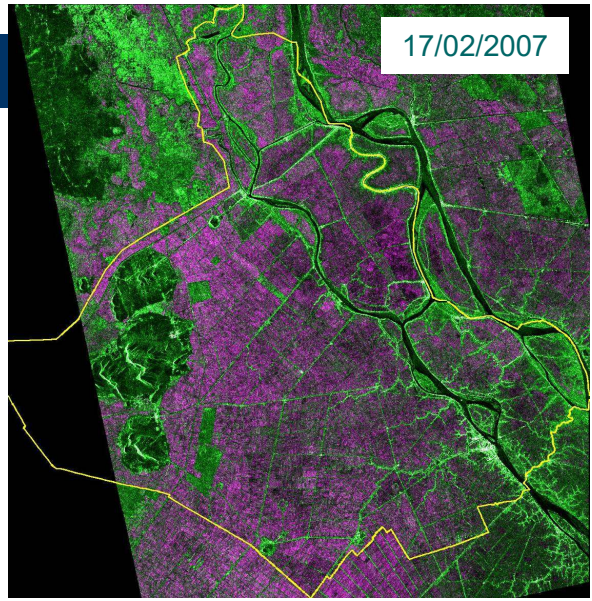
Previous Studies

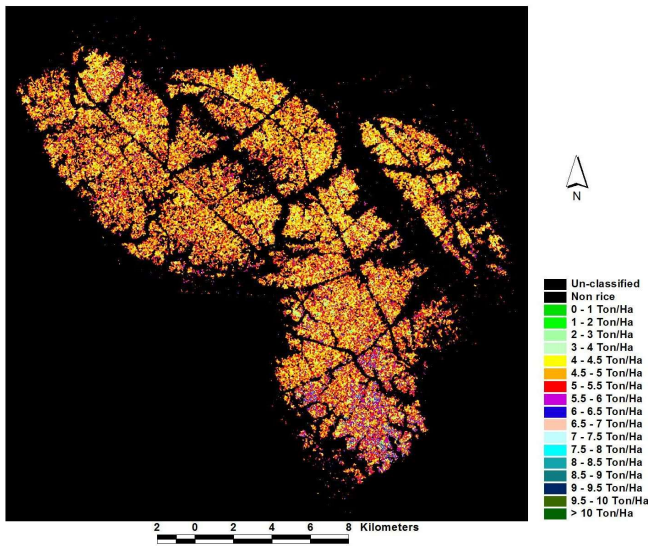
Methods were used for rice yield estimation:

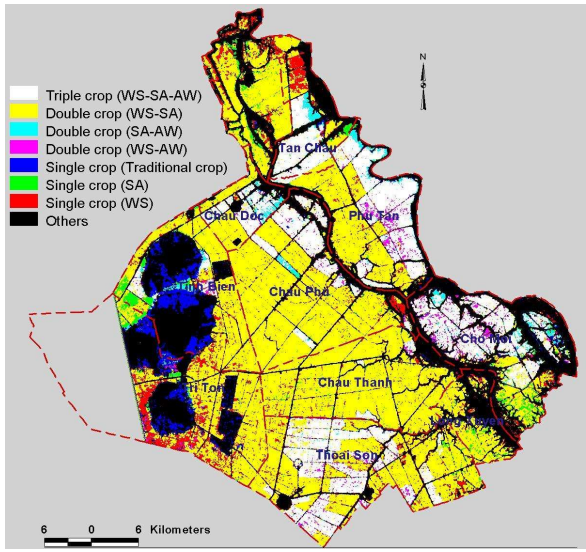
- **Agro-meteorological model-based method** (Ribbes and Le Toan,1999);
- **Statistical model-based method** (Li et al., 2003, Chen and Mcnairn, 2006).

Objectives

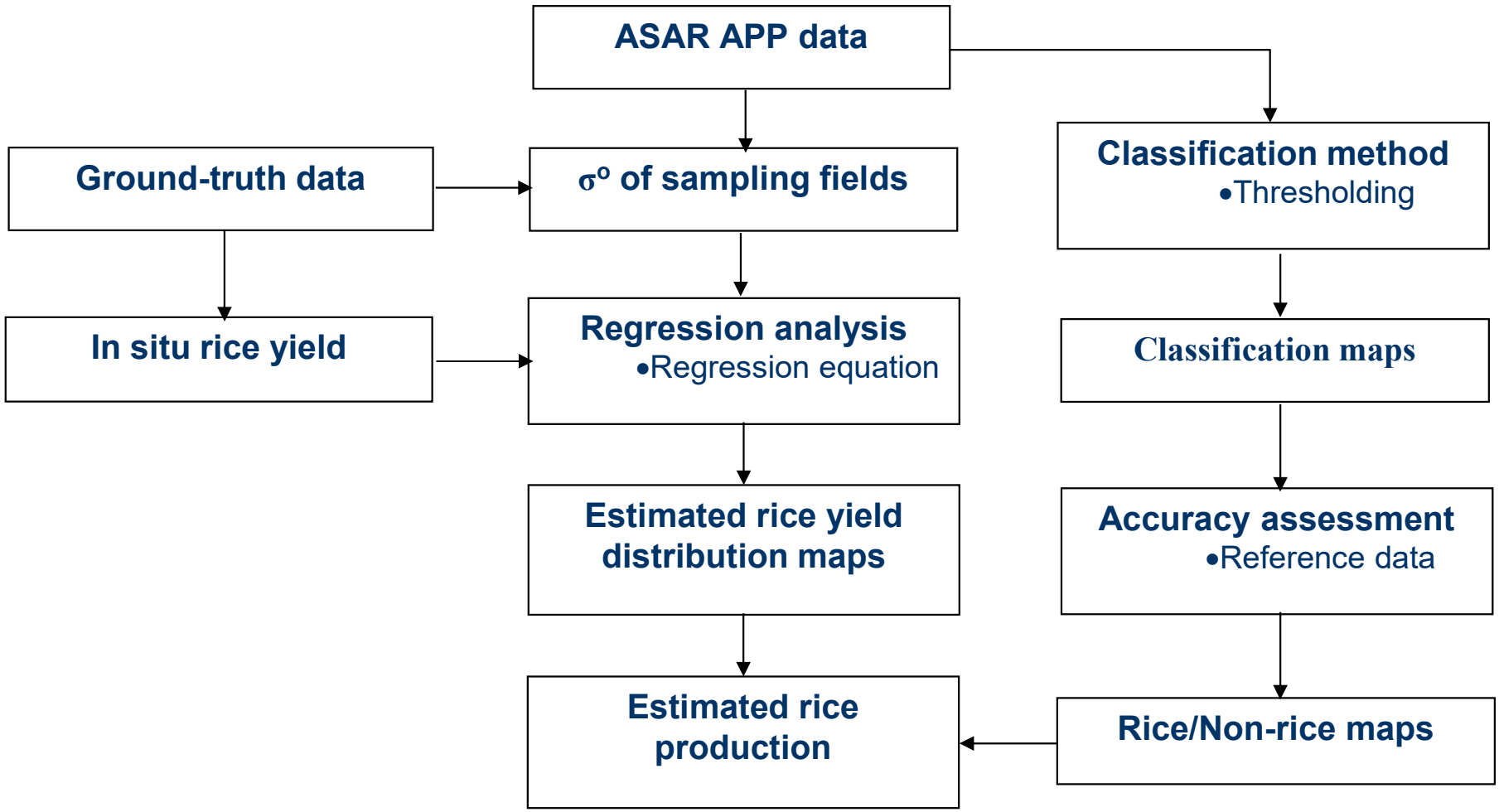
- To evaluate the use of SAR data in **rice mapping** and **yield estimation**, towards **an operational system** for rice crop inventory in the Mekong River Delta.



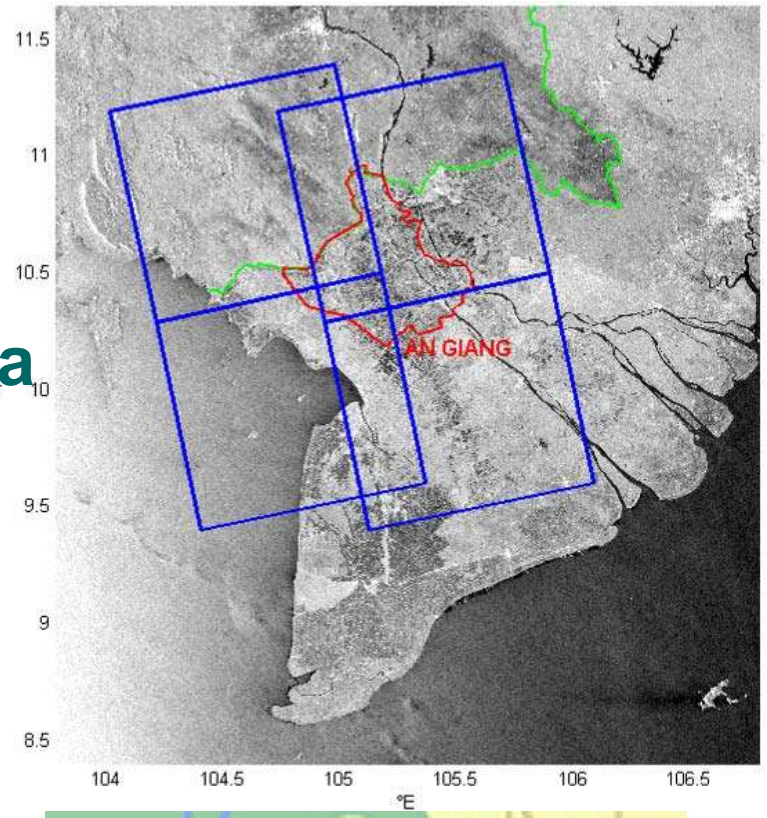




Methods


ASAR APP data
Ground-truth data
σ° of sampling fields
Classification method
•Thresholding
In situ rice yield
Regression analysis
•Regression equation
Classification maps
Estimated rice yield distribution maps
Accuracy assessment
•Reference data
Estimated rice production
Rice/Non-rice maps

Study area: An Giang, Mekong Delta



- Previous study: No
- Rice cropping system: 1, 2 or 3 crop seasons
- Affected by flood: Strong
- Distance to HCMC: 200 km
- Local support: AGU

Rice cropping systems

Rice cropping system	Rice season
Single rice crop	Traditional rice (rain-fed)
Double rice crop	Summer Autumn – Autumn Winter (rain-fed)
	Winter Spring – Summer Autumn (irrigated)
Triple rice crop	Winter Spring – Summer Autumn - Autumn Winter

Main rice-based cropping systems

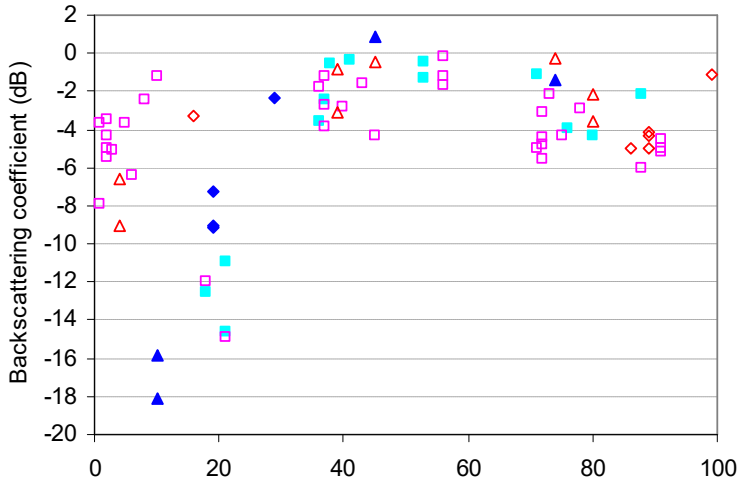
Rice seasons

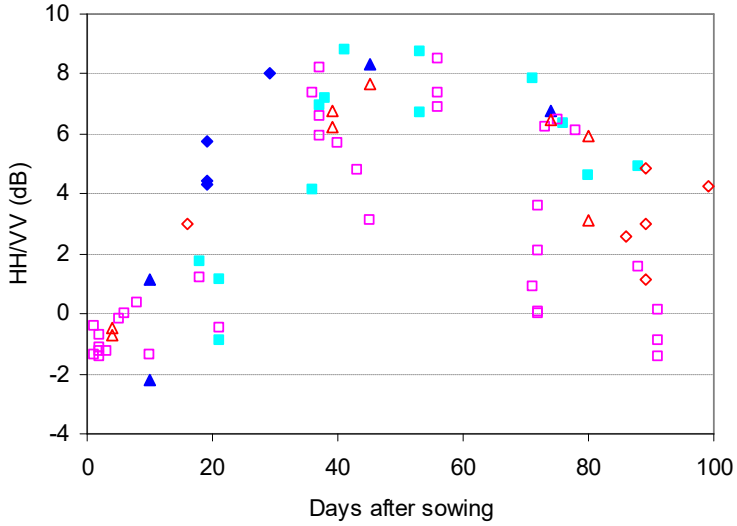
Rice crop		Planting	Harvesting
English name	Local name		
Winter Spring	Dong Xuan	Nov./Dec.	Mar./Apr.
Summer Autumn	He Thu	Apr./May	Jul./Aug.
Rainy season	Thu Dong (Autumn Winter)	Jul./Sep.	Oct./Dec.
	Mua (Traditional rice)	Jul./Sep.	Nov./Jan.

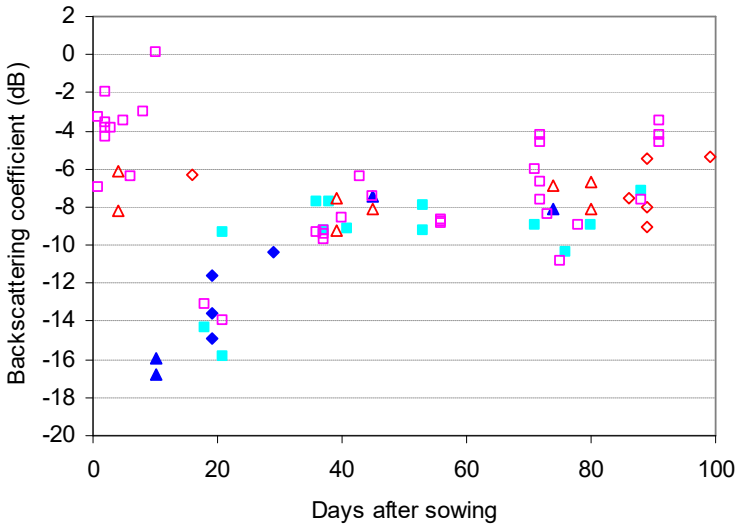
Main rice seasons

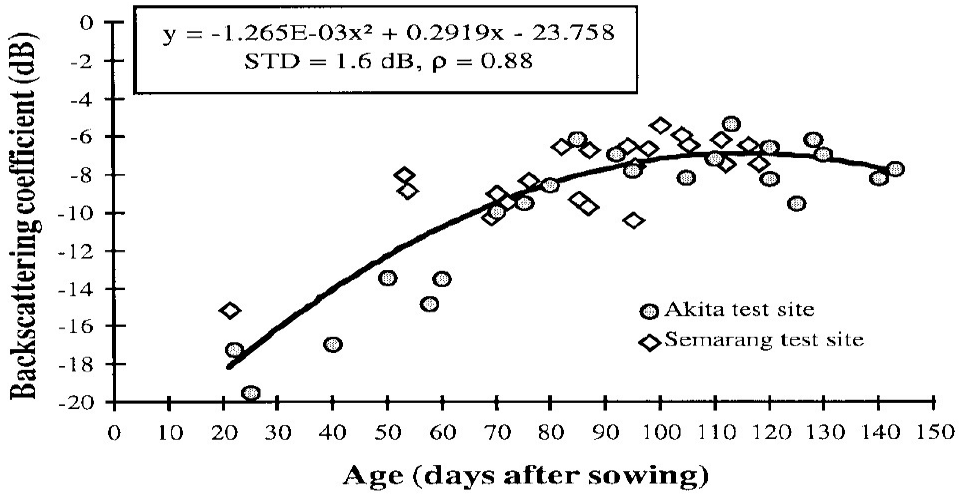
Methods – Rice backscatter analysis

Effect of water / no water



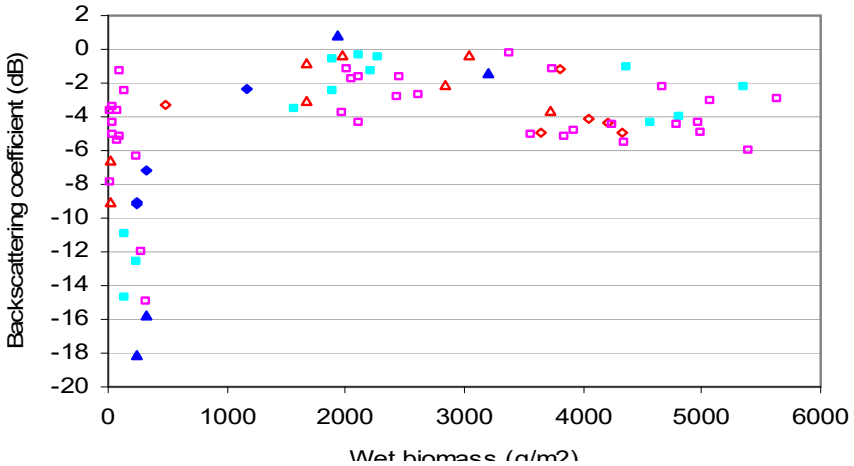


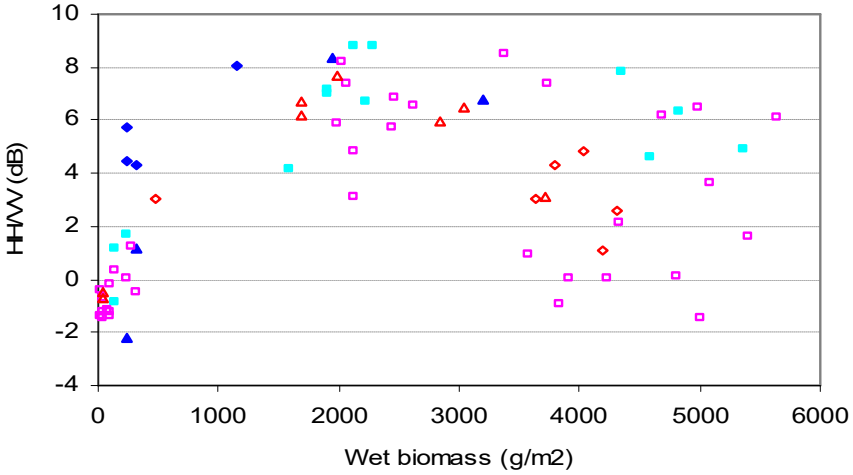


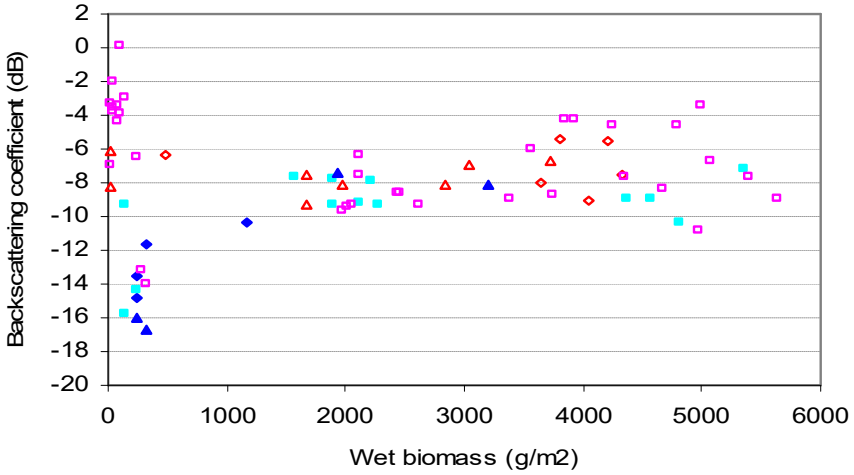


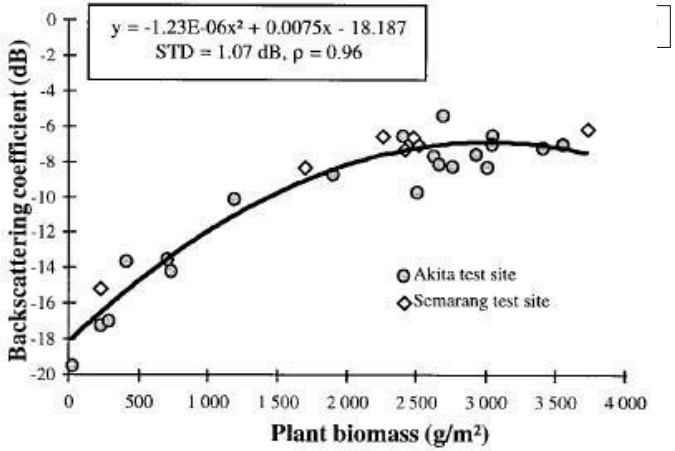
δ_O charts of HH (UL), VV (LL) & HH/VV (UR) data

Backscatter behaviour of rice



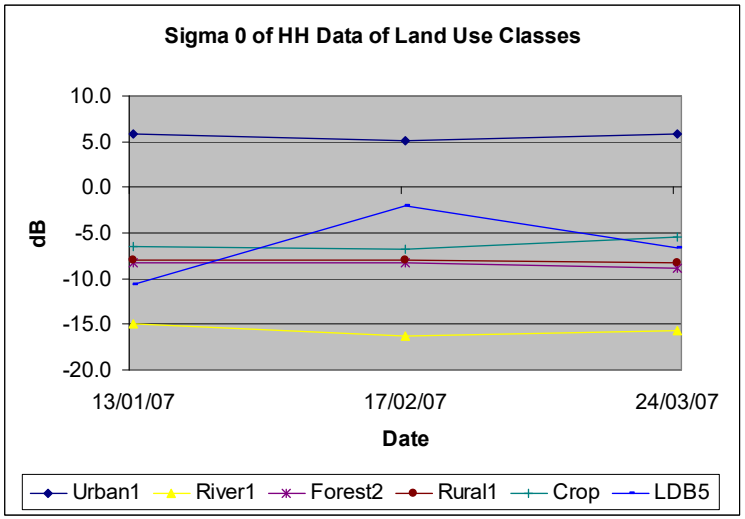


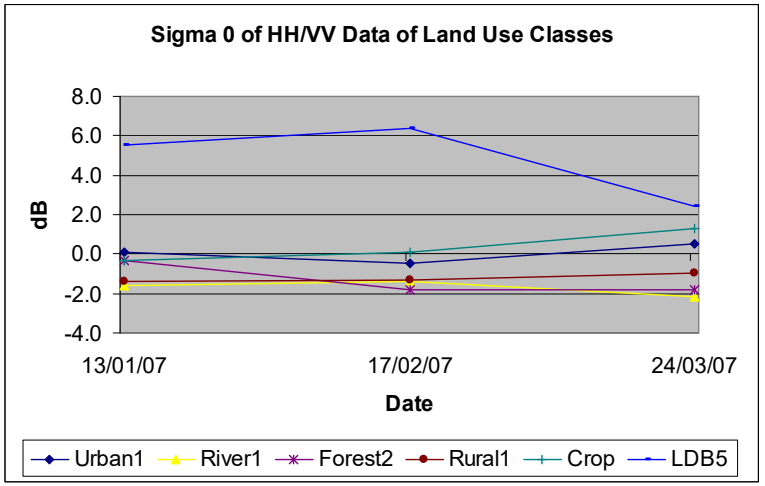


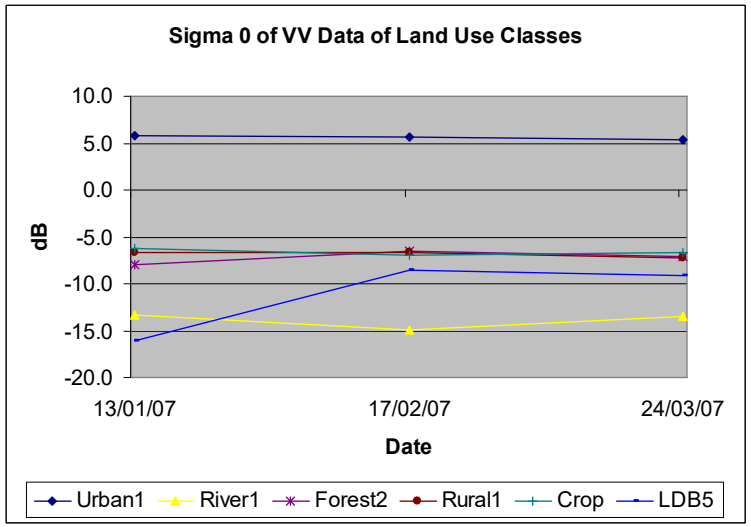


δ_O charts of HH (UL), VV (LL) & HH/VV (UR) data

Methods – Rice backscatter analysis





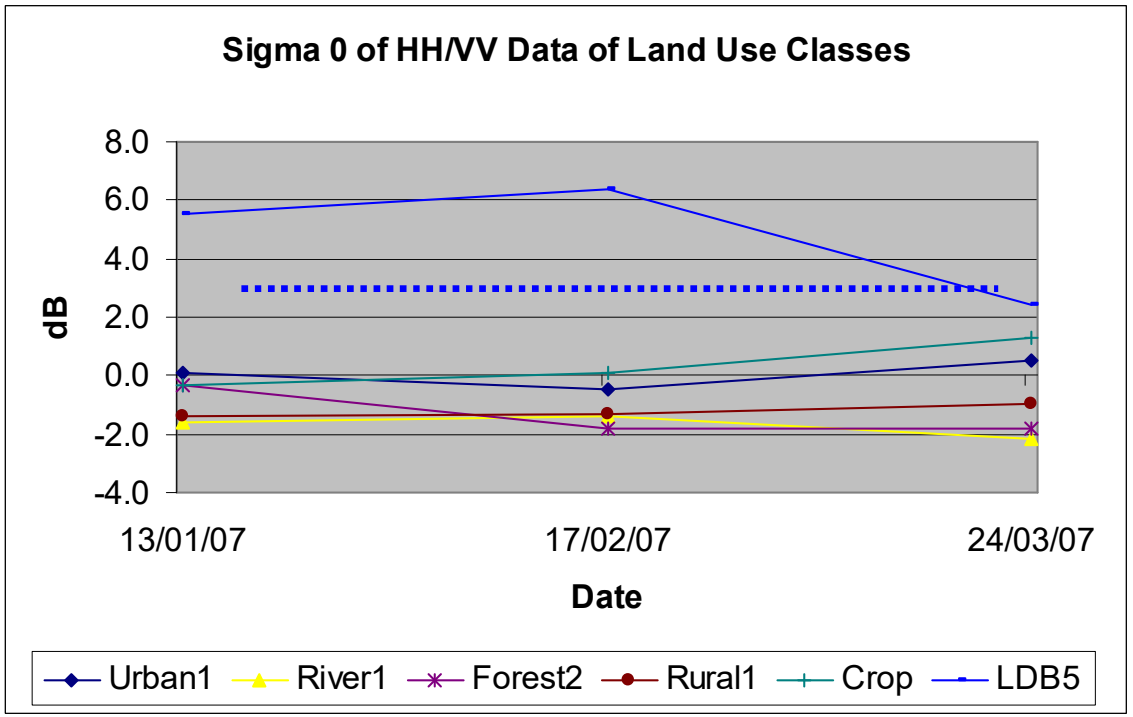


Sigma nought of HH, VV & HH/VV data of land use / land cover classes

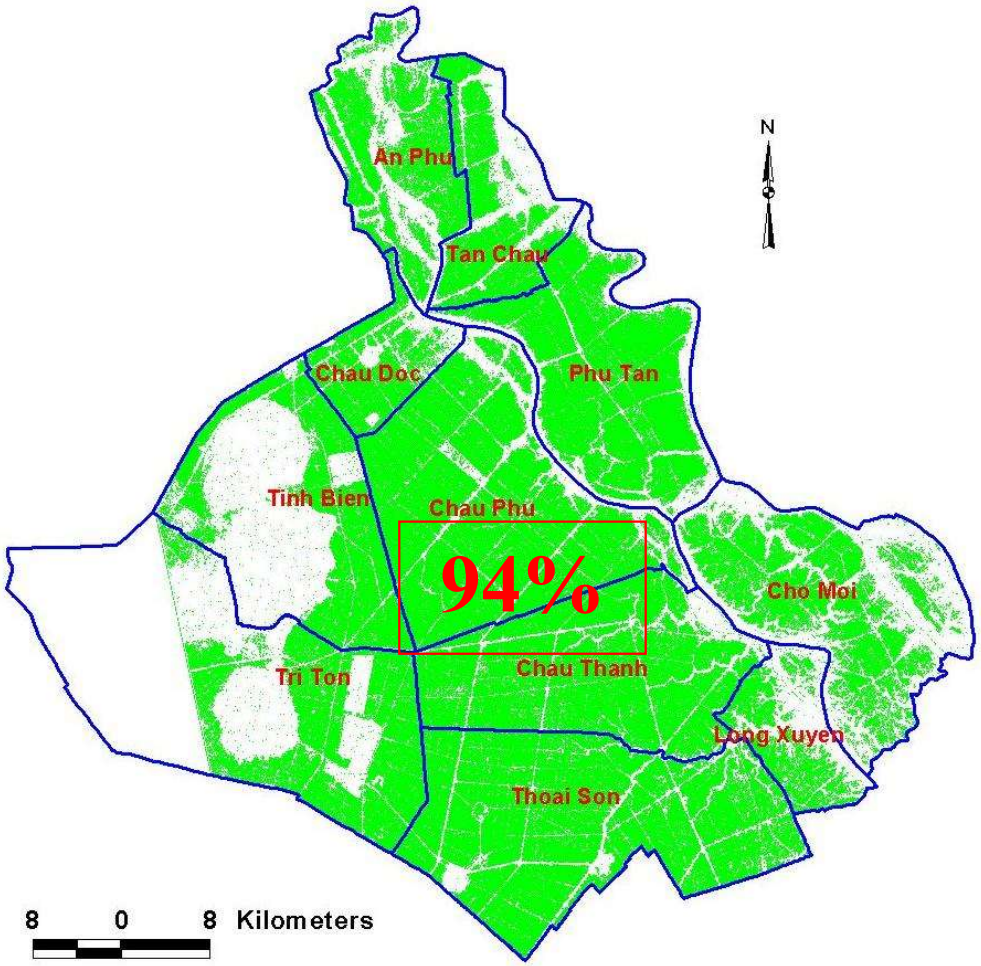
Rice mapping

Using **single-date ASAR image taken at the middle of crop season** (i.e. Feb. 2007 for Winter Spring crop)

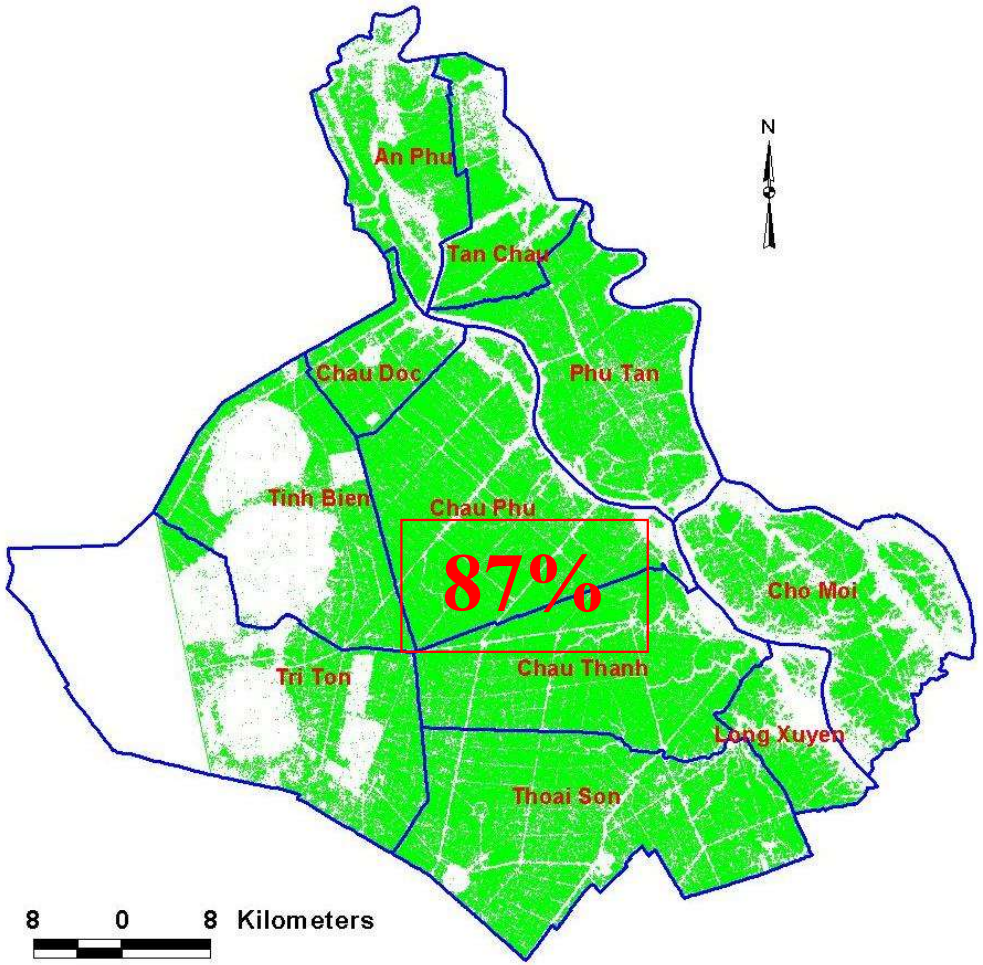
- HH/VV ratio > 3 dB, and
- δ_O of VV data < -6 dB



Rice maps



Winter Spring crop



Summer Autumn crop

Rice yield estimation

Multiple linear regression analysis were performed using LINEST function:

Rice crop	r^2		
	HH	**VV**	**HH/VV**
WS 2007	0.575	0.661	0.675
SA 2007	0.653	0.328	0.833

Rice yield estimation

The regression equations between in situ rice yield and polarisation ratios of sampling fields at Cho Moi district in **WS & SA 2007** crop using LINEST function:

- WS crop: $\mathbf{Y_{Ra} = -0.033\ Ra_1 + 0.017\ Ra_2 + 0.019\ Ra_3 + 0.628}$

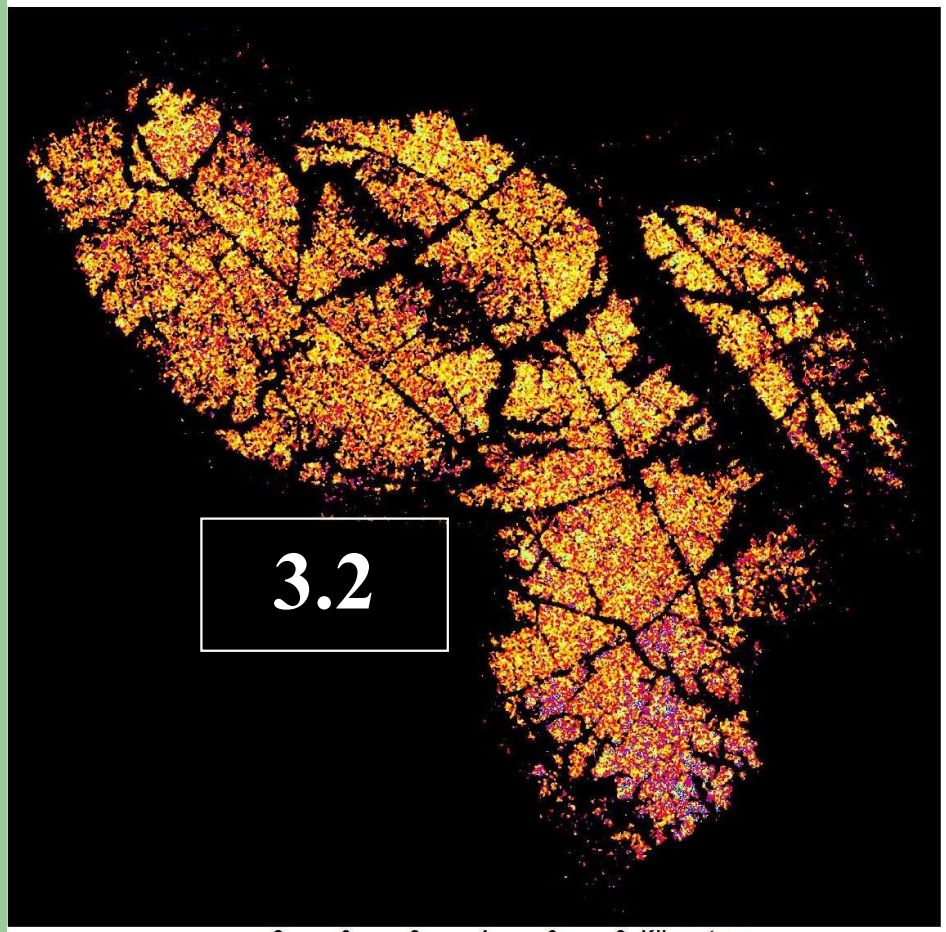
  $r^2 = 0.675$, $se_y = 0.38$ ton/ha

- SA crop: $\mathbf{Y_{Ra} = 0.072\ Ra_1 - 0.017\ Ra_2 - 0.002\ Ra_3 + 0.503}$

  $r^2 = 0.833$, $se_y = 0.11$ ton/ha

Y_{Ra} : rice yield (kg/m^2),
Ra_1 : polarisation ratio of first date image,
Ra_2 : polarisation ratio of second date image,
Ra_3 : polarisation ratio of third date image,
r^2 : the coefficient of determination,
se_y : the standard error for the y estimate.

Rice yield map



Rice crop	Statistical data (Ton)	Estimated Production (Ton)	Percentage error (%)
WS 2007	131,595	106,128	**-19.4**
SA 2007	79,256	81,820	**3.2**

Un-classified
Non rice
0 - 1 Ton/Ha
1 - 2 Ton/Ha
2 - 3 Ton/Ha
3 - 4 Ton/Ha
4 - 4.5 Ton/Ha
4.5 - 5 Ton/Ha
5 - 5.5 Ton/Ha
5.5 - 6 Ton/Ha
6 - 6.5 Ton/Ha
6.5 - 7 Ton/Ha
7 - 7.5 Ton/Ha
7.5 - 8 Ton/Ha
8 - 8.5 Ton/Ha
8.5 - 9 Ton/Ha
9 - 9.5 Ton/Ha
9.5 - 10 Ton/Ha
> 10 Ton/Ha

Summer Autumn rice crop

Rice yield estimation

- The rice yield estimation model varies from region to region, where the cultural practices and crop calendar were significantly different in the study site.
- Therefore, **the yield mapping strategy** using time series ASAR APP data is proposed as follows:
  - Stratification approach should be used in order to separately classify rice fields into areas with the same cultural practices;
  - Multiple regression analysis between polarisation ratio data and in situ rice yield is implemented for each district;
  - Based on this correlation, rice yield map is established,
  - Rice production is estimated.

Conclusions

- The radar backscattering behaviour of rice is much different from that of the traditional rice plant;
- HH/VV ratio of the single-date ASAR APP image acquired in the middle period of the crop season is a good rice classifier;
- Thresholding method for rice mapping provided high accuracy of 94 and 87% of WS and SA 2007 crops;
- The relationship between in situ measured yield and polarisation ratios derived from three-date ASAR APP images was positive with the high correlation coefficient;
- The statistical model-based method worked very well in the case of Cho Moi district where. The high accuracy of 97% was found in the case of SA 2007 crop when the rice production estimated from ASAR APP data in this case was compared to the government statistics.
- The rice yield estimation model varies from region to region, where the cultural practices and crop calendar were significantly different in the study site. Therefore, the yield mapping strategy using time series ASAR APP data is proposed

Further works

- Further works (2010 – 2011) using new datasets (ASAR APP & WS, TerraSAR-X) at different places (An Giang, Can Tho & Soc Trang) in the Mekong River Delta.

Acknowledgement

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thank you