

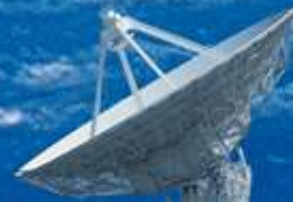


Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences

Rice Monitoring using Simulated Compact SAR

Kun Li, Yun Shao

Institute of Remote Sensing and Digital Earth



Outlines

- **Introduction**
- **Test site and data**
- **Results**
 - **Rice type discrimination**
 - **Rice phenology retrieval**
- **Conclusion**
- **Future work**



Introduction

- Rice is the staple food of about half population of the world.
- Rice monitoring is very important. Previous works mostly concentrated on rice identification and yield estimation.
- Full-pol SAR is an effective tool for rice monitoring.
- Compact polarimetric (CP) SAR provides wider swath than full-pol SAR, while it includes similar information.
- Rice variety classification is very important for yield estimation.
- Phenology can help farmers know the current situation of rice and plan cultivation practices.

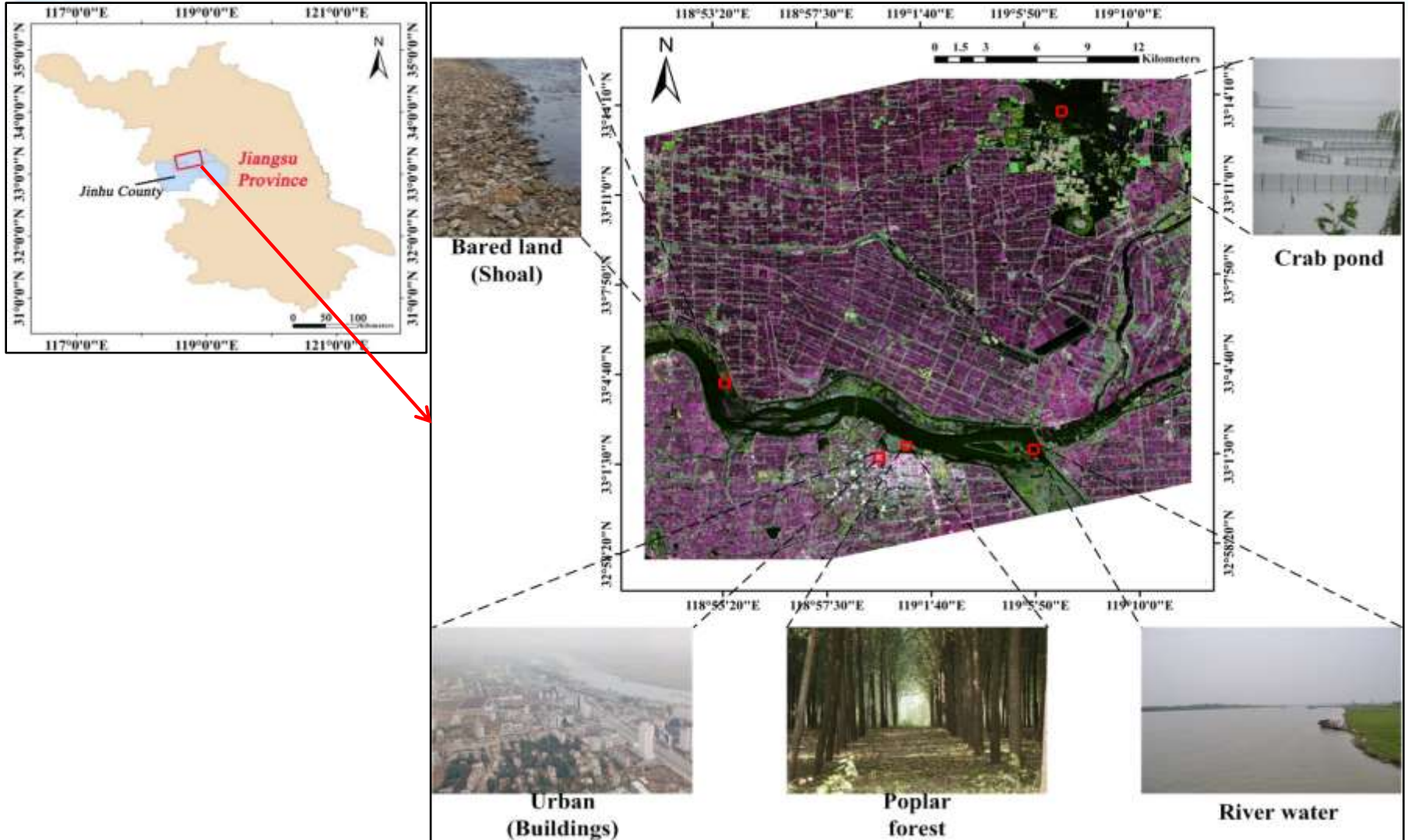


Objectives

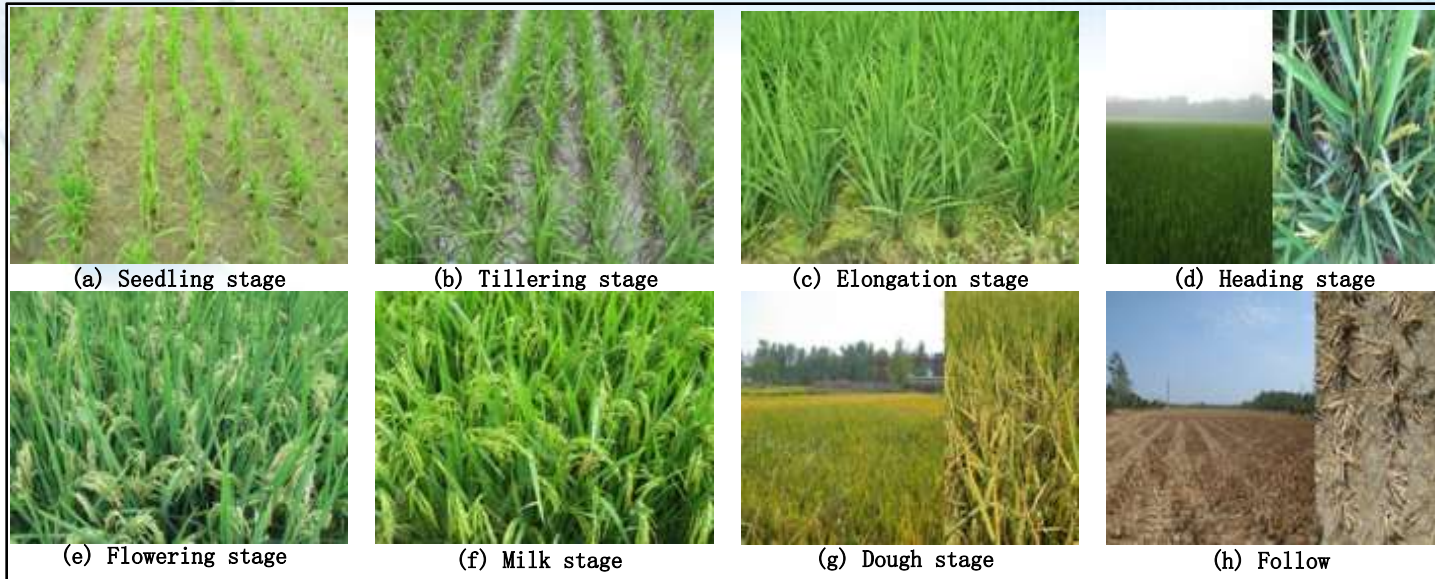
- To explore the potentiality of Compact SAR data in rice variety discrimination and rice phenology retrieval, then to guide farming activities and management of domestic supplies and market value for farm managers.



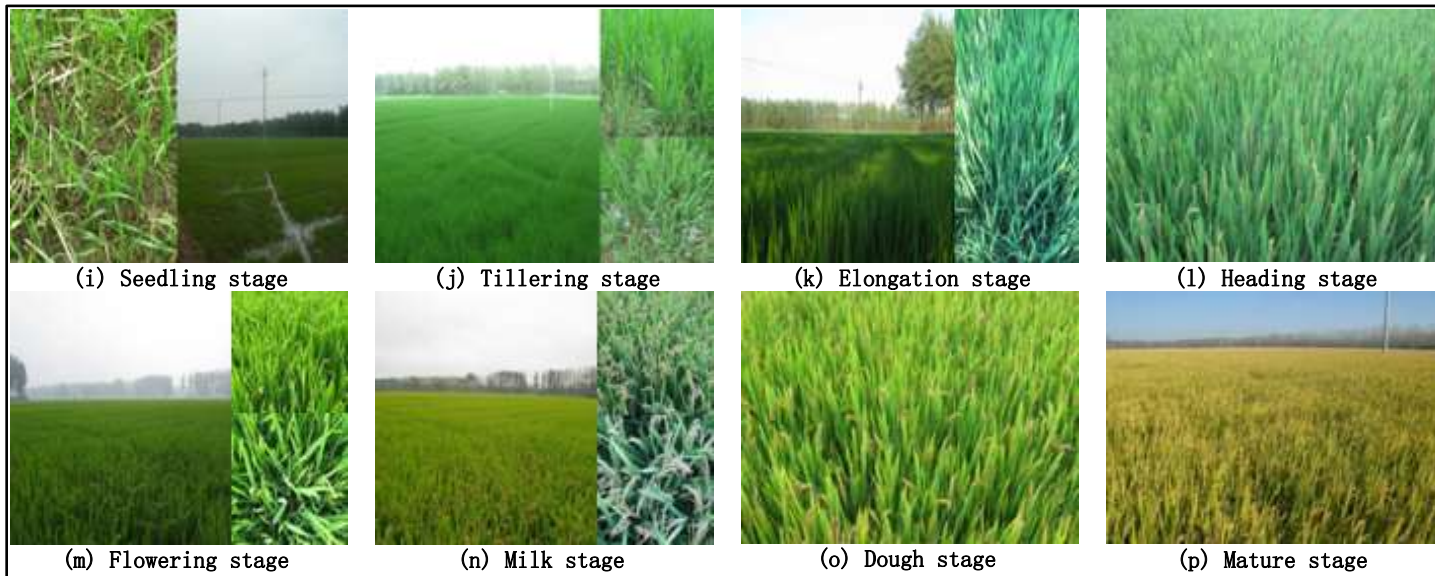
Test site and data



Rice morphology



Hybrid rice



Japonica rice

SAR data

Date	Mode	Incidence	Pixel spacing	Phenology stage		
		angle($^{\circ}$)	(A \times R, m)	J-R	H-R-I	H-R-II
2012-06-27	FQ20W	38~41	5.2 \times 7.6	Seeding	Seeding	Seeding
2012-07-11	FQ9W	27~30	5.2 \times 7.6	Tillering	Tillering	Tillering
2012-07-21	FQ20W	38~41	5.2 \times 7.6	Tillering	Elongation	Elongation
2012-08-04	FQ9W	27~30	5.2 \times 7.6	Elongation	Heading	Elongation
2012-08-28	FQ9W	27~30	5.2 \times 7.6	Heading	Heading	Heading
2012-09-21	FQ9W	27~30	5.2 \times 7.6	Heading	Milk	Milk
2012-10-15	FQ9W	27~30	5.2 \times 7.6	Milk	Follow	Dough
2012-10-25	FQ20W	38~41	5.2 \times 7.6	Dough	Follow	Follow
2012-11-08	FQ9W	27~30	5.2 \times 7.6	Mature	Follow	Follow

Compact SAR parameters



Symbol	Meaning
RH	Sigma naught backscatter value at RH polarization
RV	Sigma naught backscatter value at RV polarization
RR	Sigma naught backscatter value at RR polarization
RL	Sigma naught backscatter value at RL polarization
m	Degree of polarization
alphas (α_s)	Dominant scattering angle related to the wave ellipticity
delta (δ)	Relative phase of RH and RV
μ	Conformity coefficient
m-chi-db	Double bounce scattering based on m-chi decomposition
m-chi-v	Volume bounce scattering based on m-chi decomposition
m-chi-s	Surface bounce scattering based on m-chi decomposition

Results

- Rice variety discrimination
 - Rice fine-classification in whole growth season;
 - Rice classification in early growth season (before heading stage);
- Retrieval of rice phenology

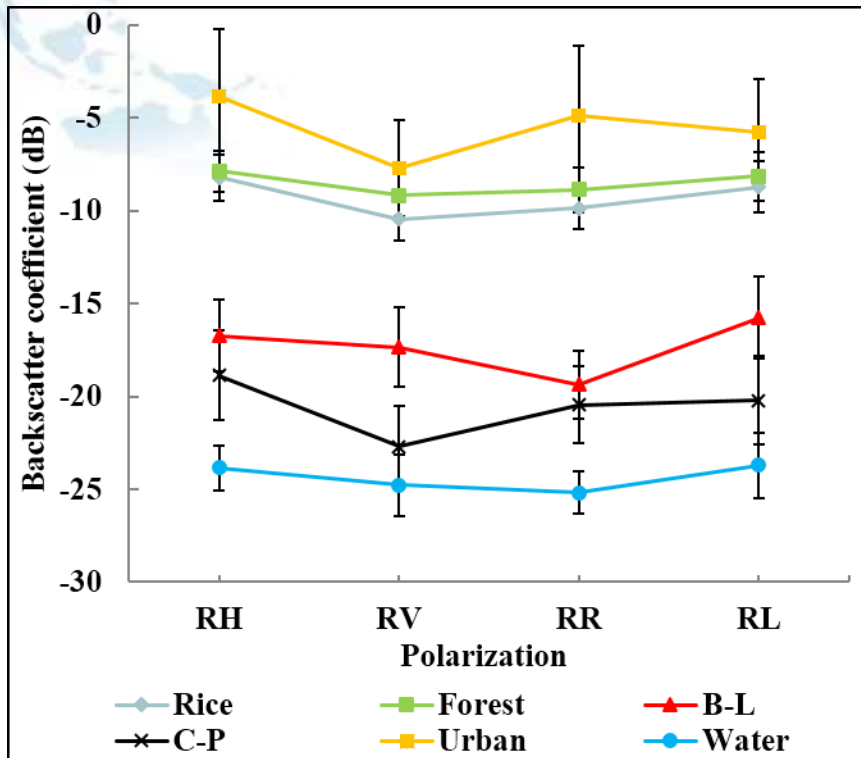
Rice fine-classification in whole season



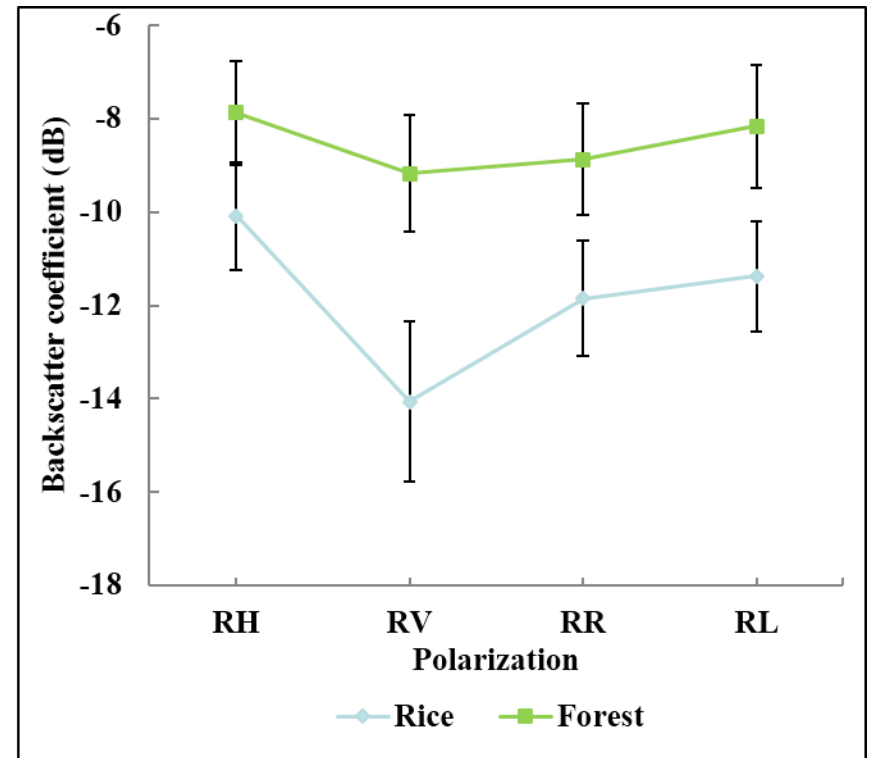
➤ Methodology

- Rice identification;
- Hybrid and japonica rice discrimination;

Rice identification

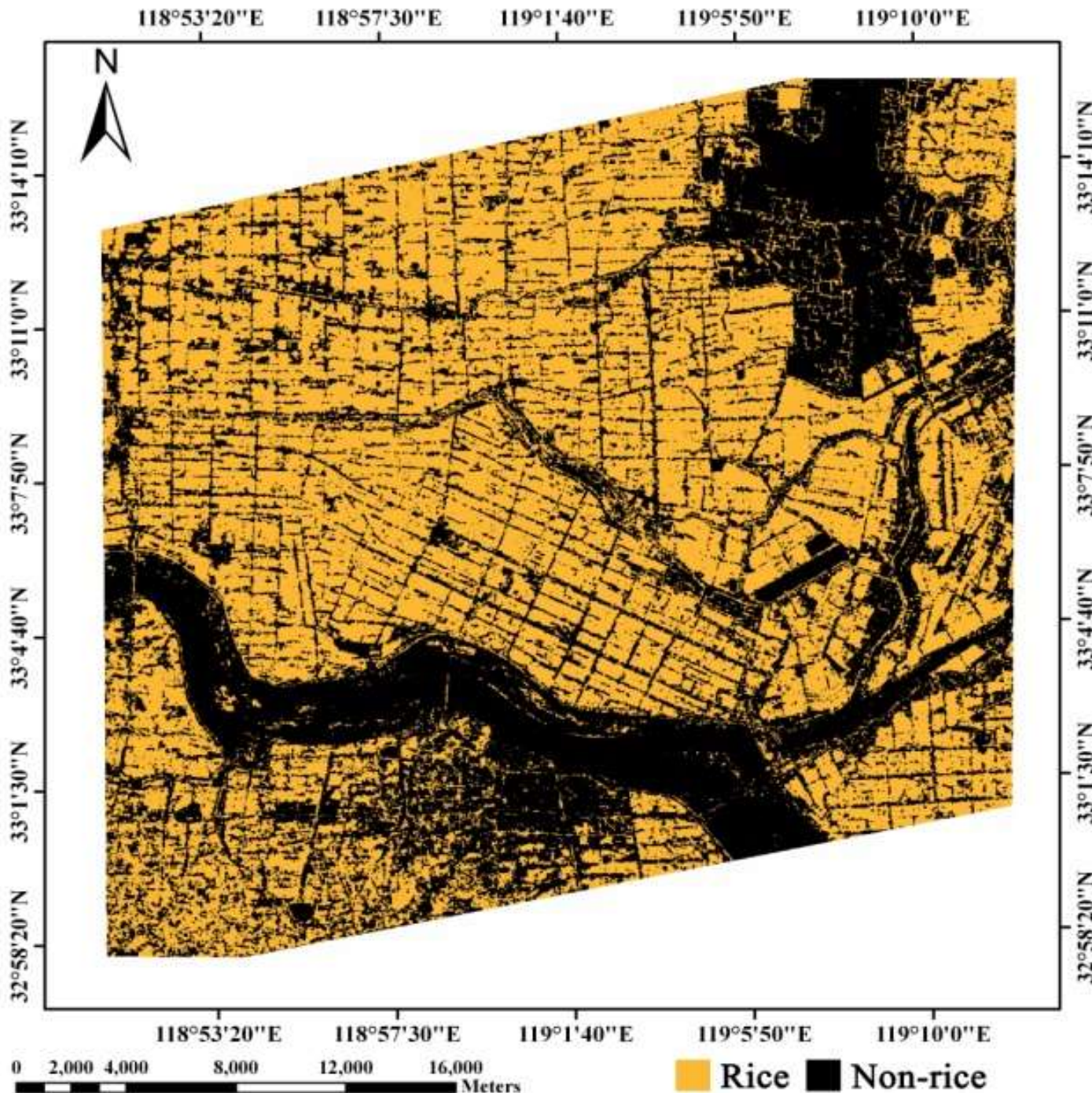


(a) Jul. 11



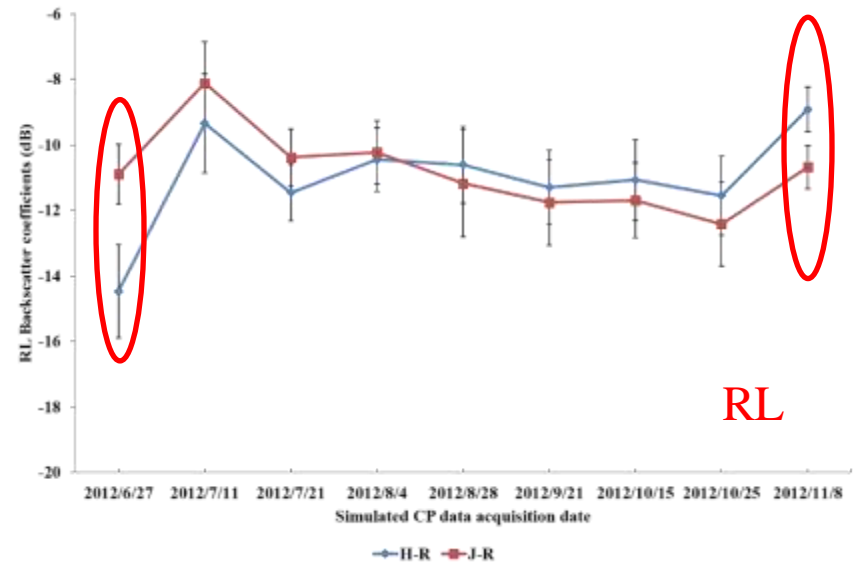
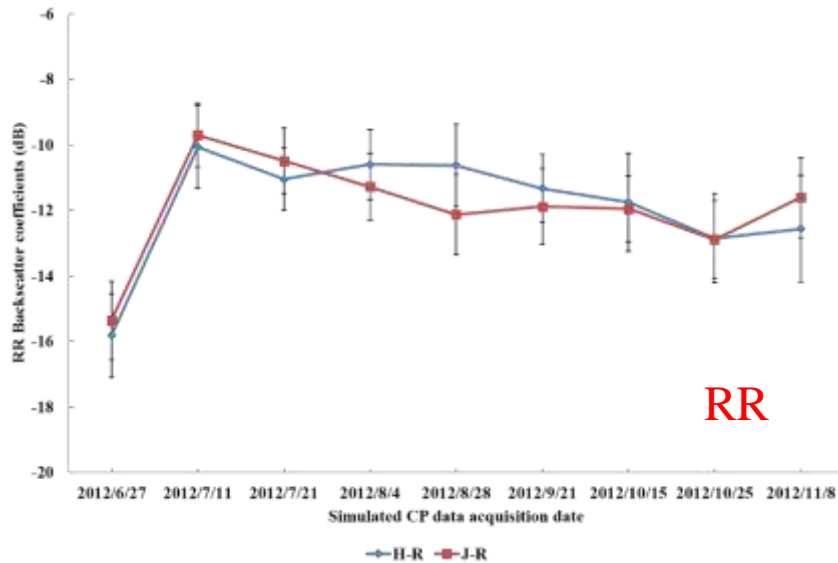
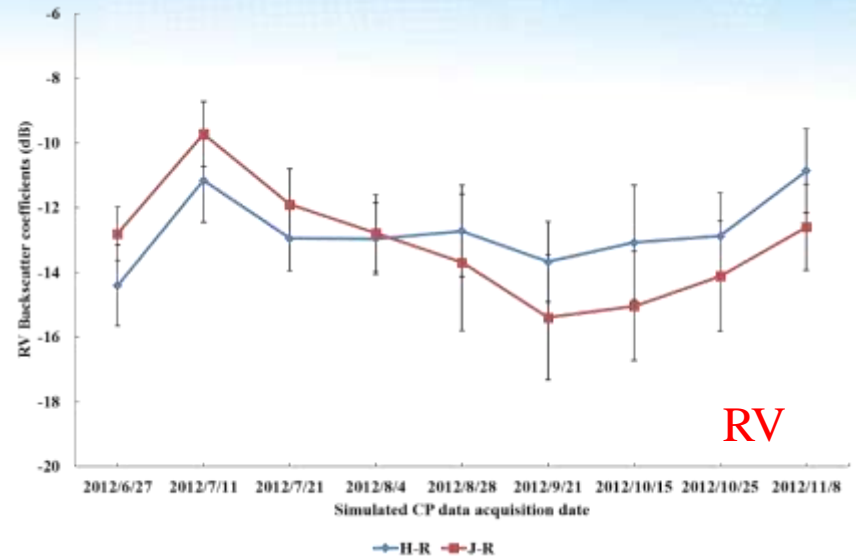
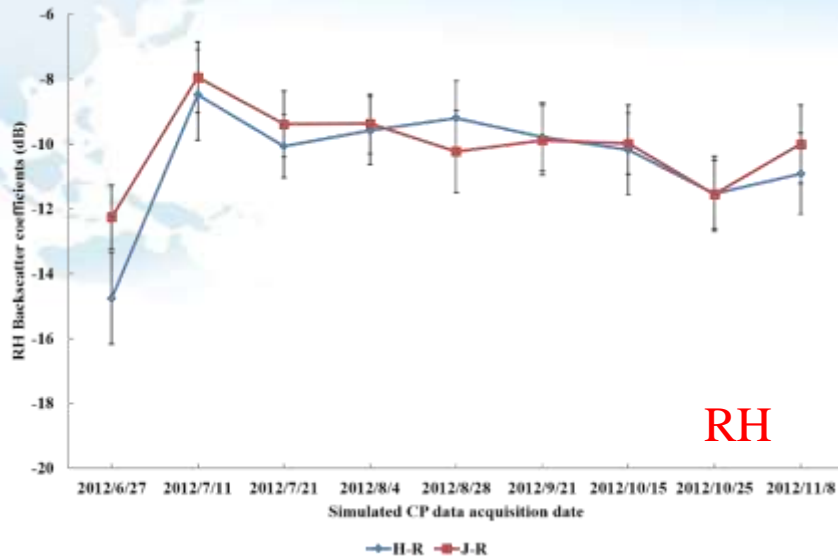
(b) Oct. 15

Backscatter coefficients of rice and non-rice in compact mode



Overall
accuracy:
96.72%

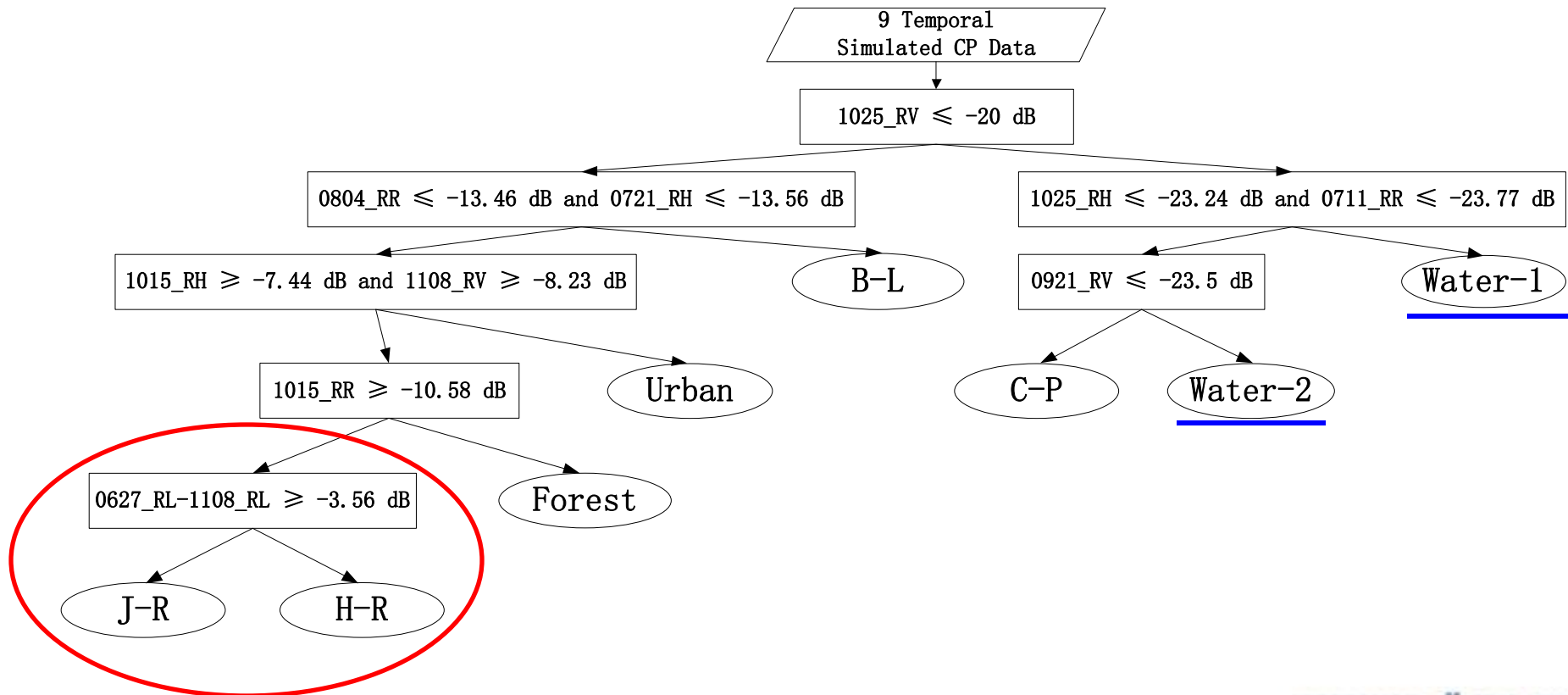
Hybrid and japonica rice identification

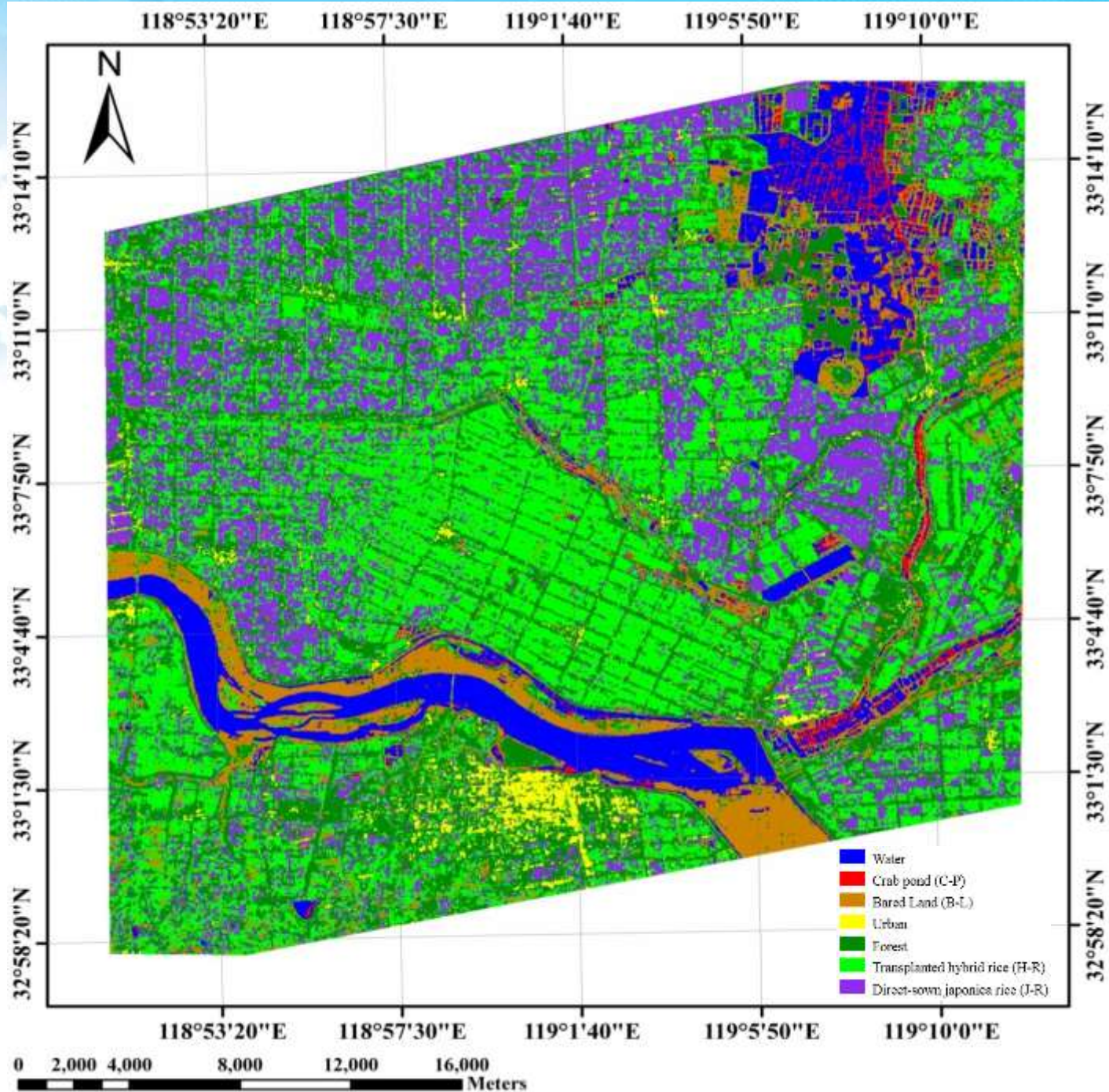


Algorithm of rice fine-classification



- Water, C-P (Crab Pond), B-L (Bare Land), Forest and Urban can be classified by importing Compact SAR parameters on Aug. 04, Sep. 21 and Oct. 25, based on rice variety identification.





Rice fine-classification in whole season

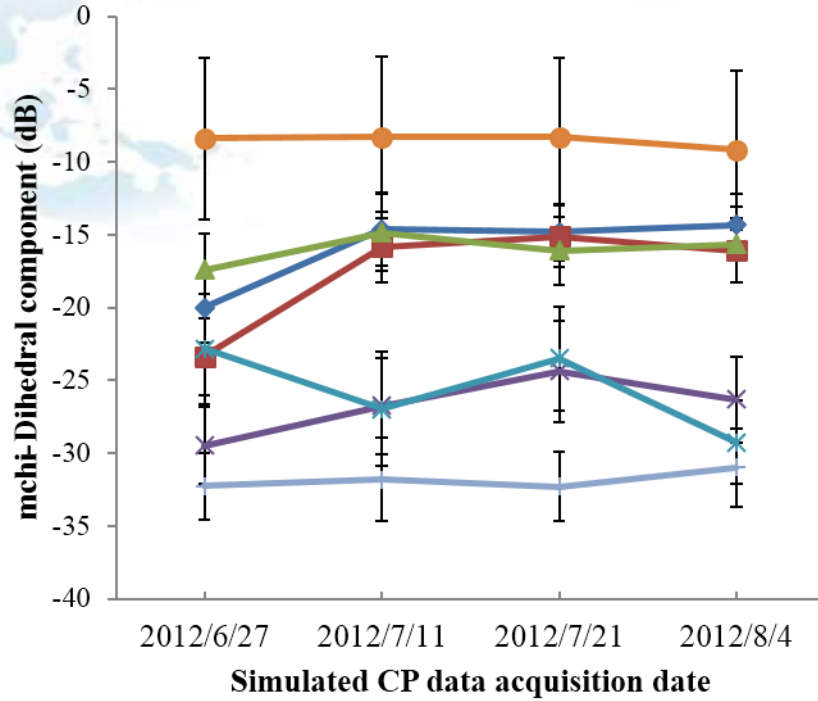
Class	Water	C-P	B-L	Urban	Forest	H-R	J-R	Total	User' Acc. (%)
Water	5238	31	0	0	0	0	0	5269	99.41
C-P	50	198	0	0	0	0	0	248	79.84
B-L	2	0	2956	0	14	3	0	2975	99.36
Urban	0	0	0	2535	0	8	3	2546	99.57
Forest	0	0	82	572	3039	212	24	3929	77.35
H-R	0	0	16	55	127	4670	88	4956	94.23
J-R	0	0	0	16	109	261	2449	2835	86.38
Total	5290	229	3054	3178	3289	5154	2564	22758	
Prod' Acc. (%)	99.02	86.46	96.79	79.77	92.40	90.61	95.51		
Overall Acc. = 21085/22758 = 92.65%, Kappa Coefficient = 0.91									

Rice classification in early of season

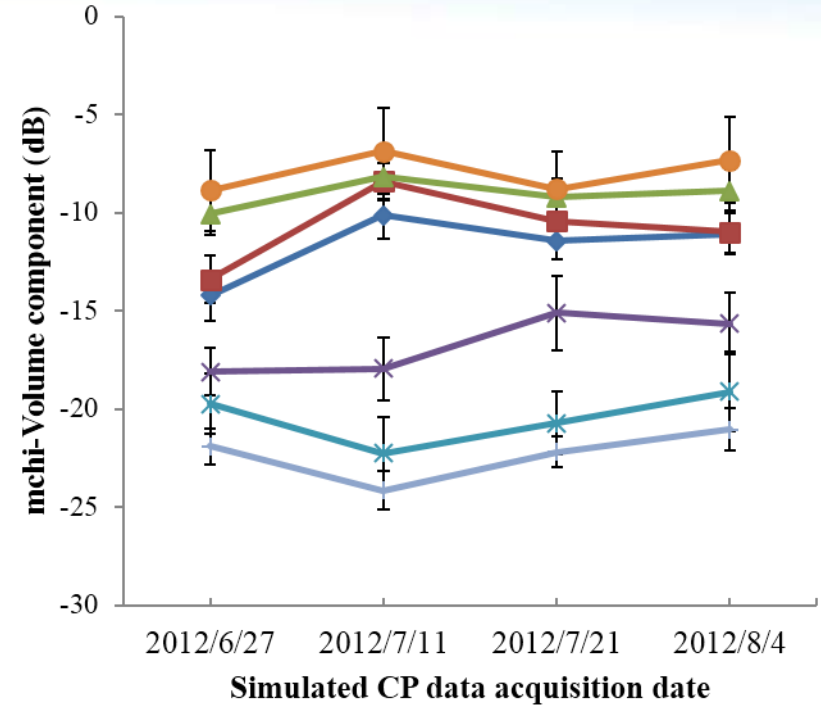


- Early rice monitoring are important to facilitate food price stability for regions at risk, and for agriculture exporters, to set market price.
- The temporal Compact SAR parameters on June 27 (seedling), July 11 (early of tillering), July 21 (tillering) and August 4 (elongation) are analyzed. (4 temporal before heading stage)
- Through analysis of parameters, rice and non-rice can be classified firstly, then June 27 (seedling) is the optimal for classifying hybrid and japonica rice in early of season.

Rice identification



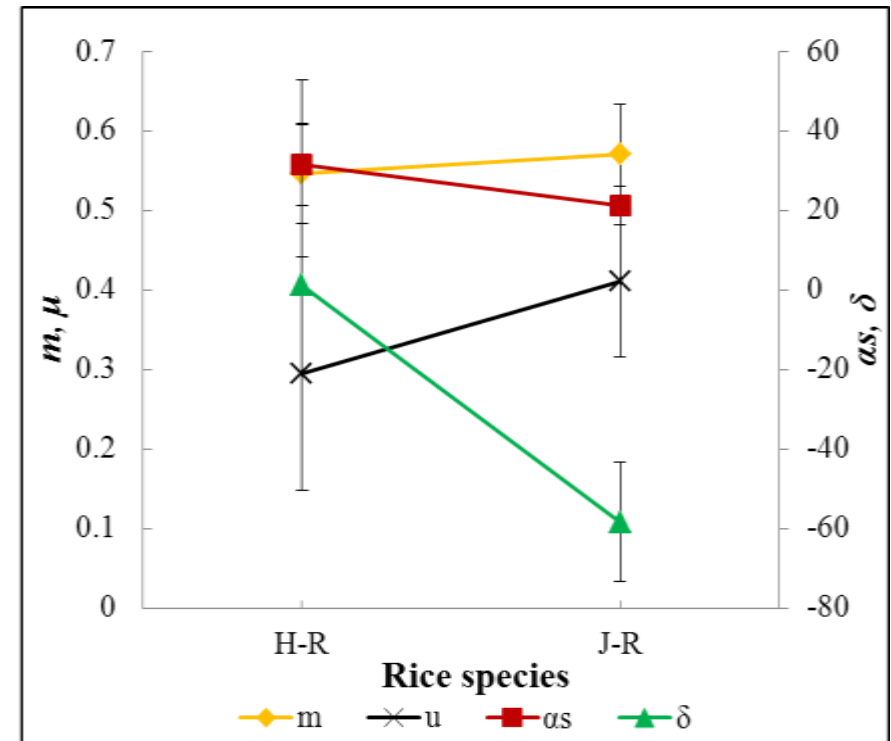
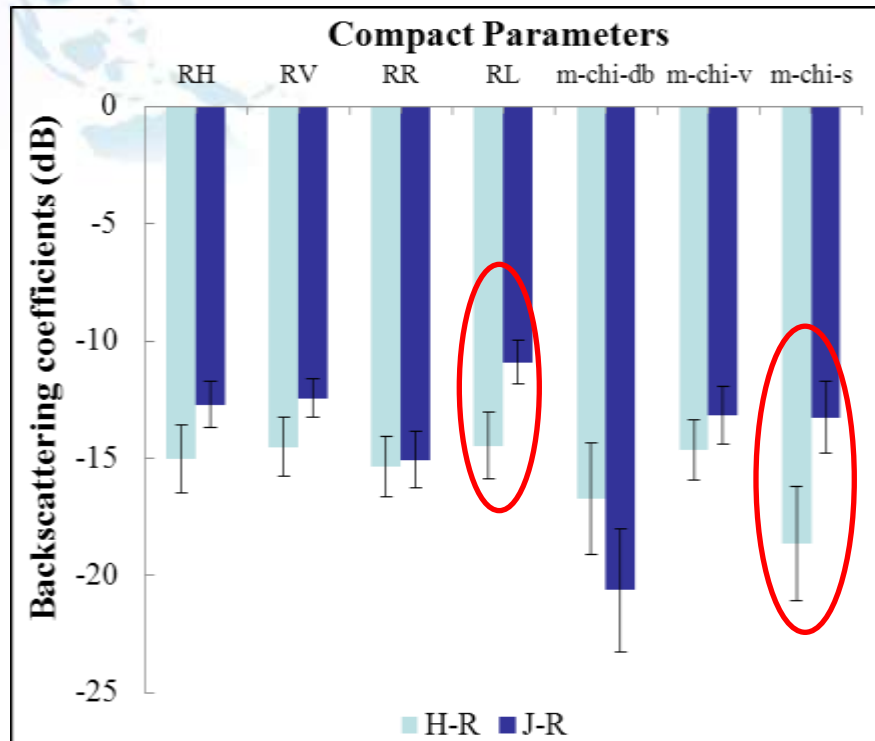
(a) m-chi-db



(b) m-chi-v

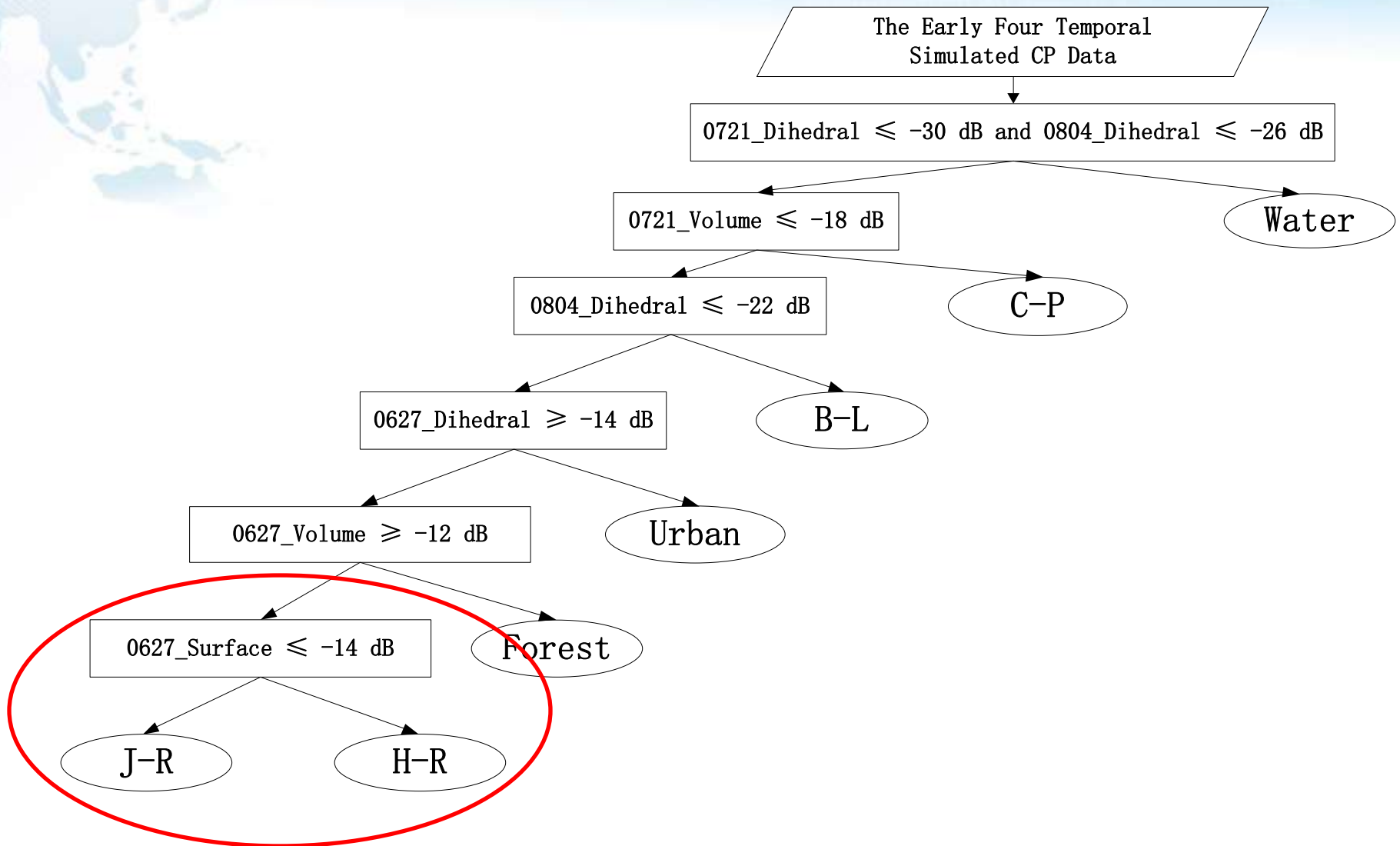
(a) and (b) can be used to classify the rice and non-rice.

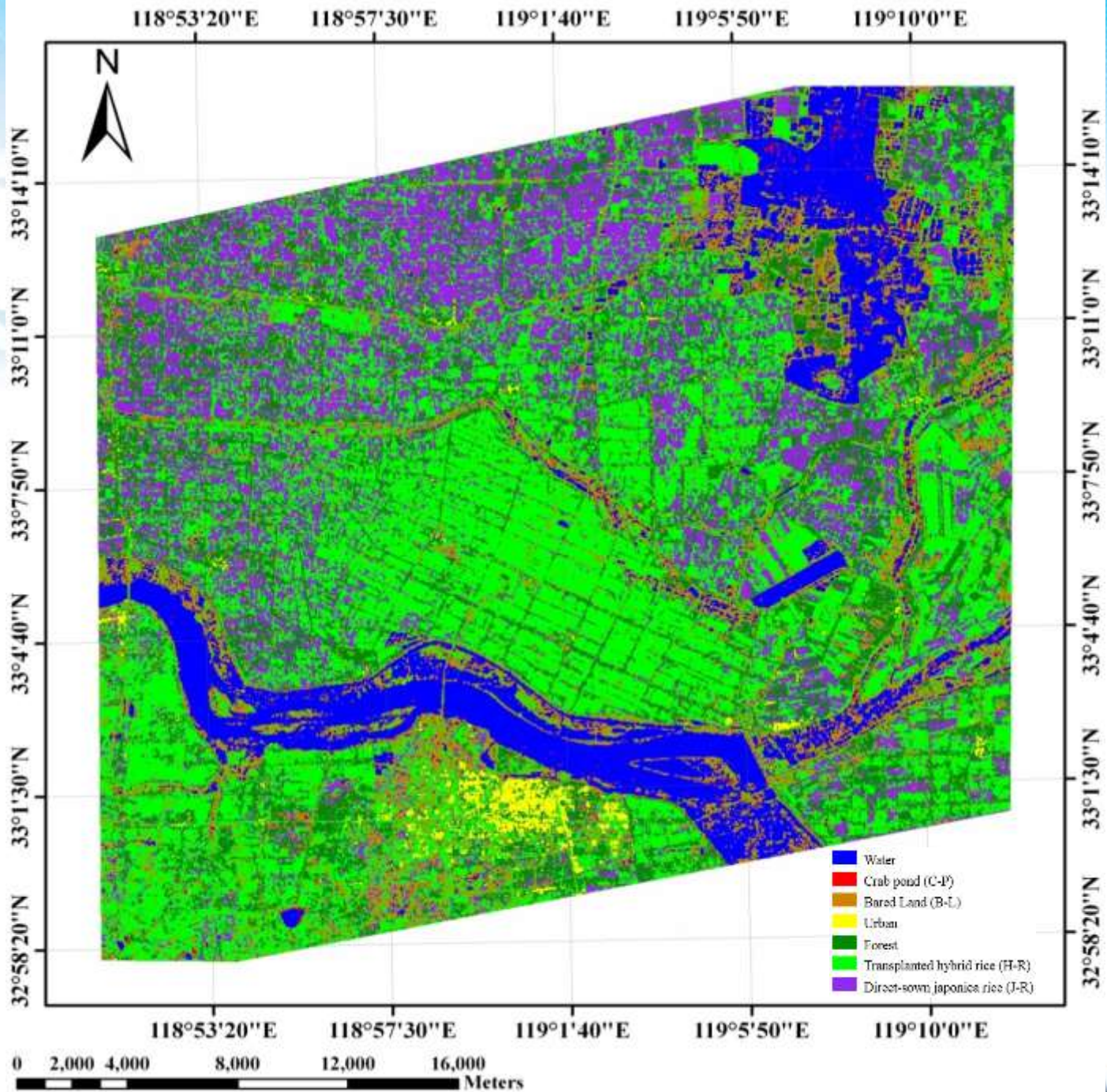
Hybrid and japonica rice identification



The parameter of m-chi-s or RL in June 27 (seedling) is the optimal for classifying hybrid and japonica in early of season.

Rice classification in early of season





Rice identification in early season

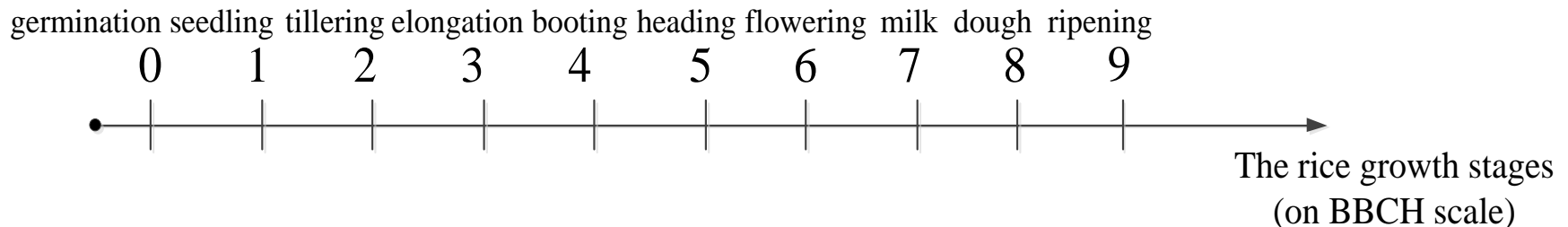


Class	Water	C-P	B-L	Urban	Forest	H-R	J-R	Total	User' Acc. (%)
Water	5245	124	907	2	31	6	0	6315	83.06
C-P	45	84	0	0	0	0	0	129	65.12
B-L	0	21	2114	41	310	130	48	2664	79.35
Urban	0	0	0	2705	88	34	4	2831	95.55
Forest	0	0	2	313	2532	337	208	3392	74.65
H-R	0	0	6	105	282	4171	411	4975	83.84
J-R	0	0	25	12	46	476	1893	2452	77.20
Total	5290	229	3054	3178	3289	5154	2564	22758	
Prod. Acc. (%)	99.15	36.68	69.22	85.12	76.98	80.93	73.83		

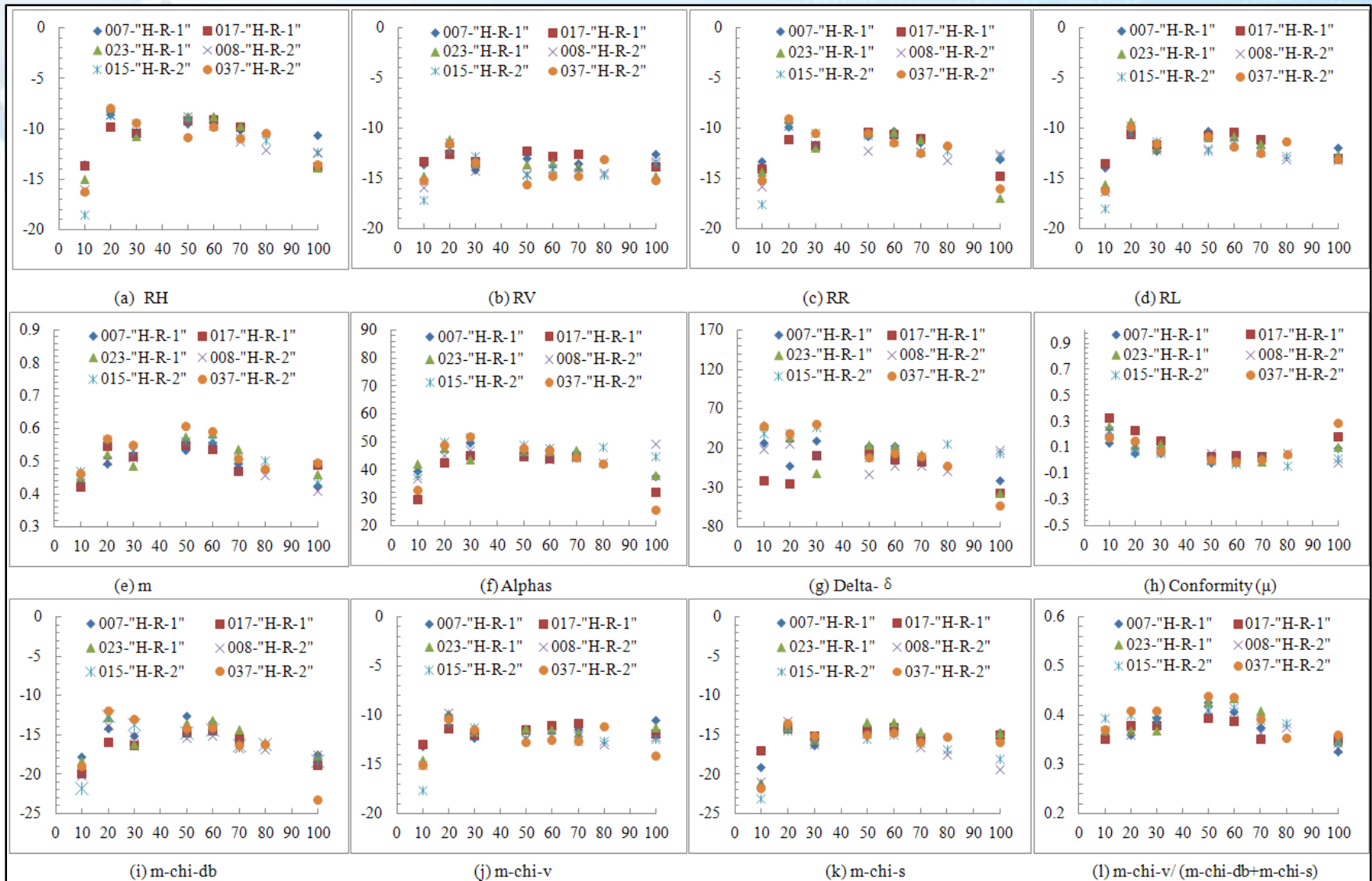
Overall Acc. = $18744/22758 = 82.36\%$, Kappa Coefficient = 0.79

Retrieval of rice phenology

- As the phenology of hybrid and japonica rice are different, their phenology retrieval should be considered respectively.
- The rice phenology is quantized using BBCH scale. And all Compact parameters are analyzed with different rice phenology stages.
- Based on different features of these parameters, rice phenology was retrieved using decision tree algorithm.

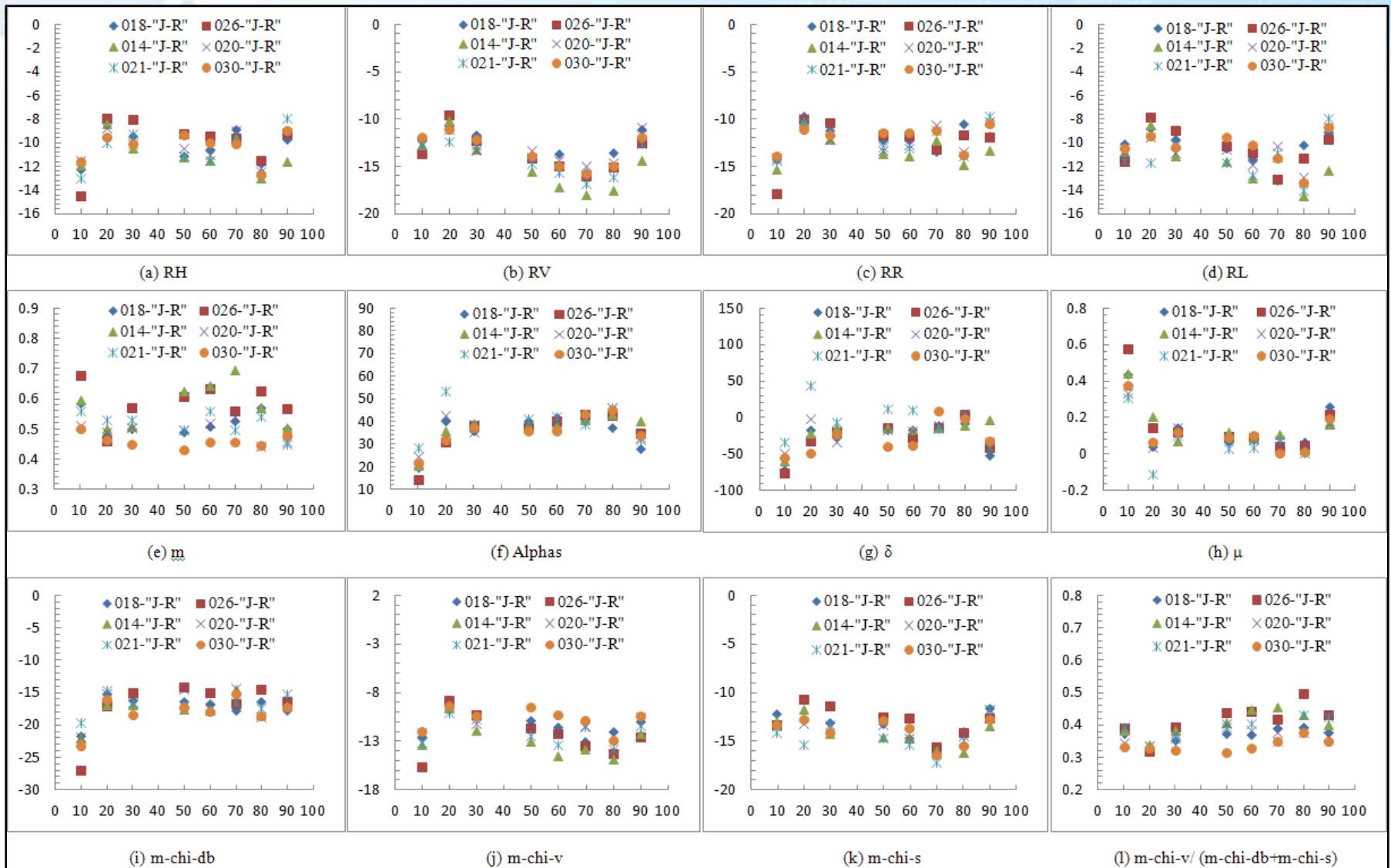


Analysis of Compact parameters

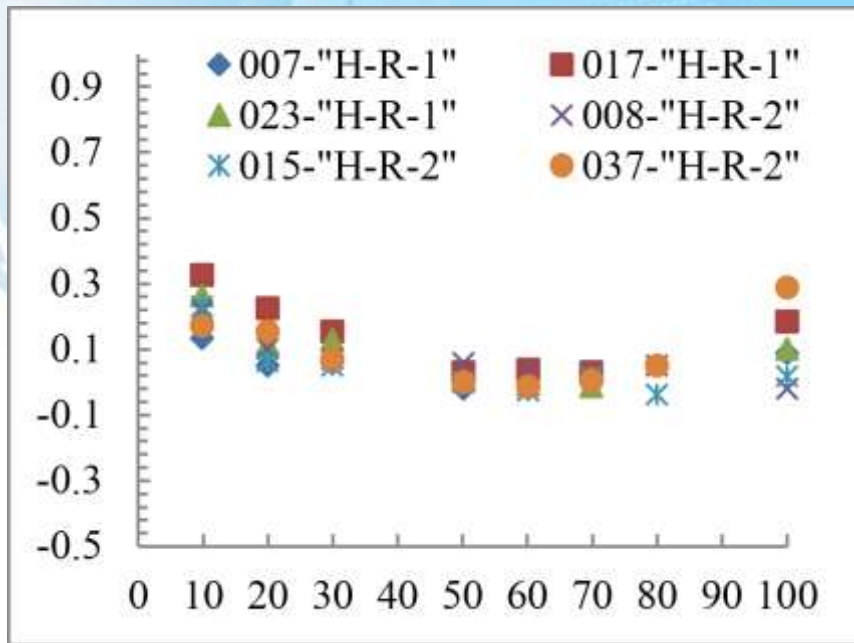


Hybrid rice

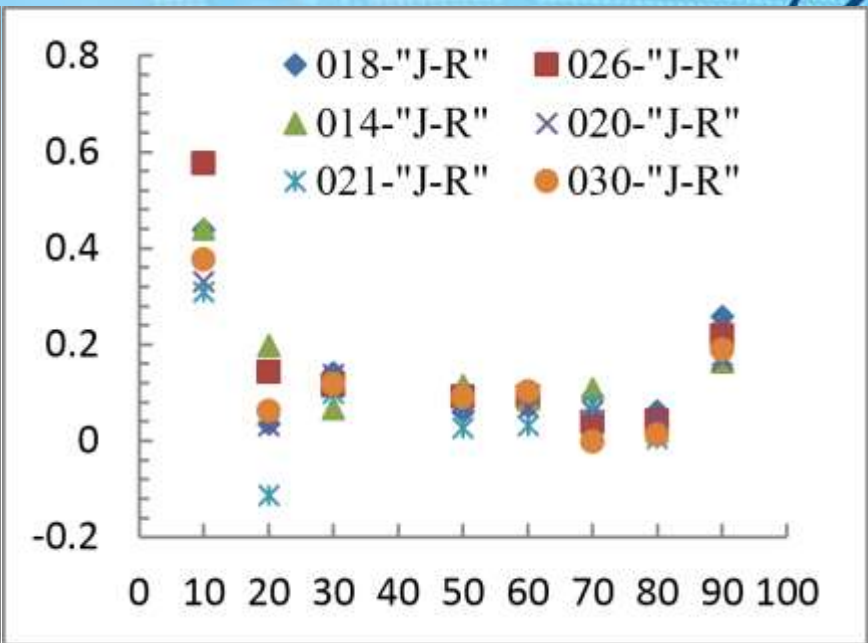
Analysis of Compact parameters



Japonica rice



(a) μ for hybrid rice



(b) μ for japonica rice

μ – the conformity coefficient

$0.3 < \mu < 1$, the scattering element is identified as a surface;

$-0.1 < \mu < 0.3$ identified a volume;

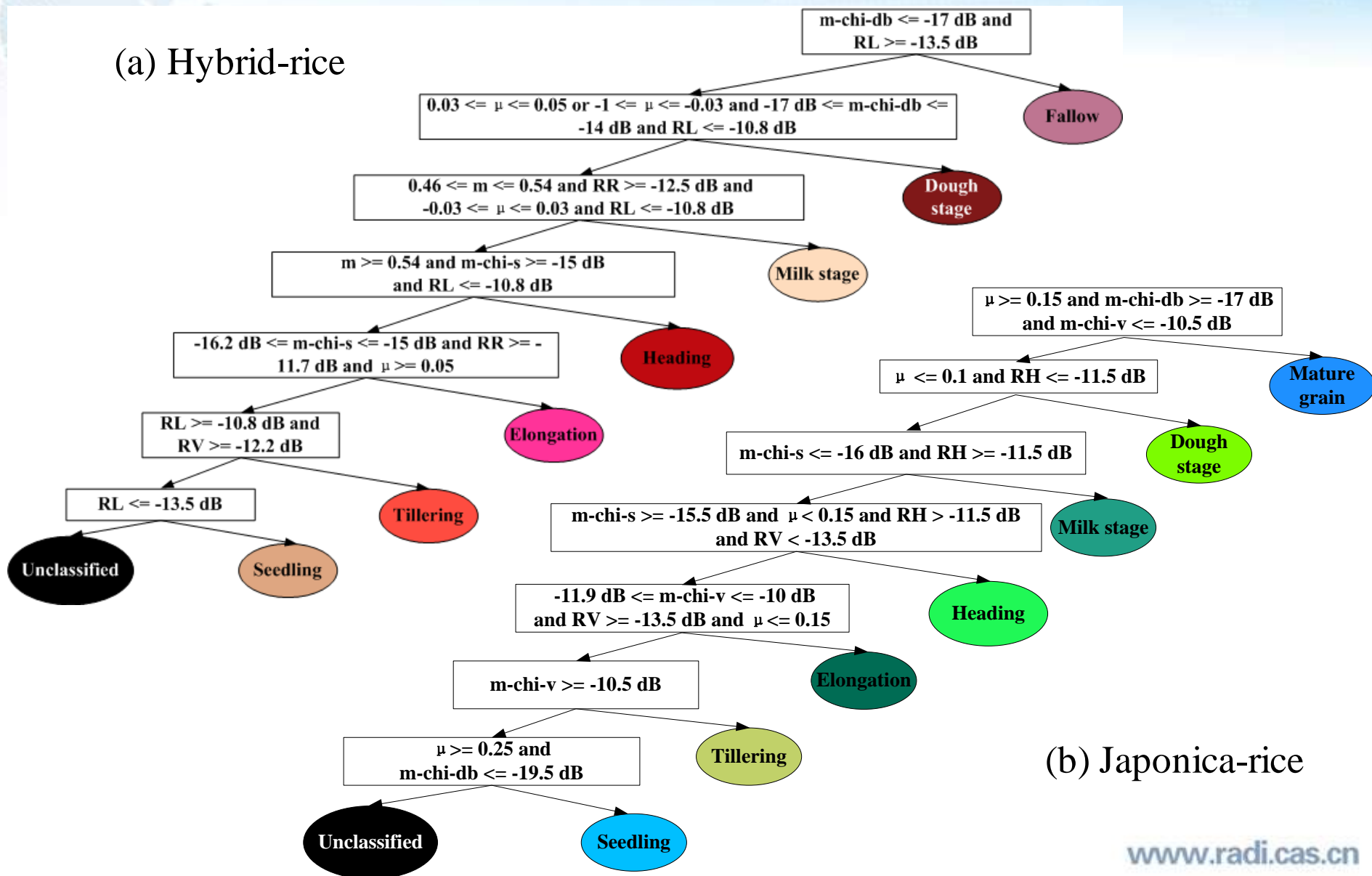
$-1 < \mu < -0.1$ describes a double-bounce scattering.

From stage 20~90, the dominant scattering of rice always is volume scattering.

Algorithm for phenology retrieval



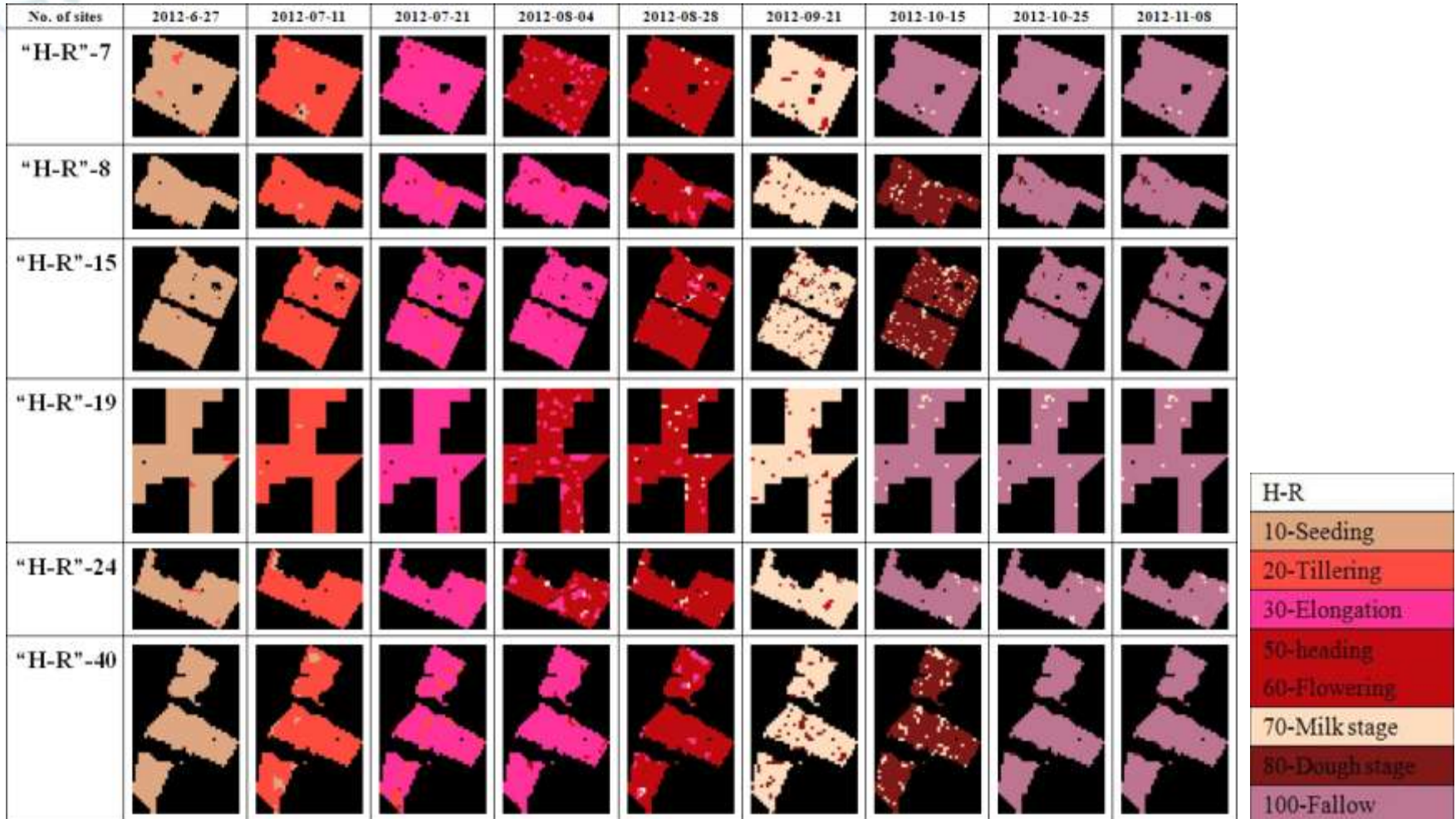
(a) Hybrid-rice



(b) Japonica-rice

Retrieval of rice phenology

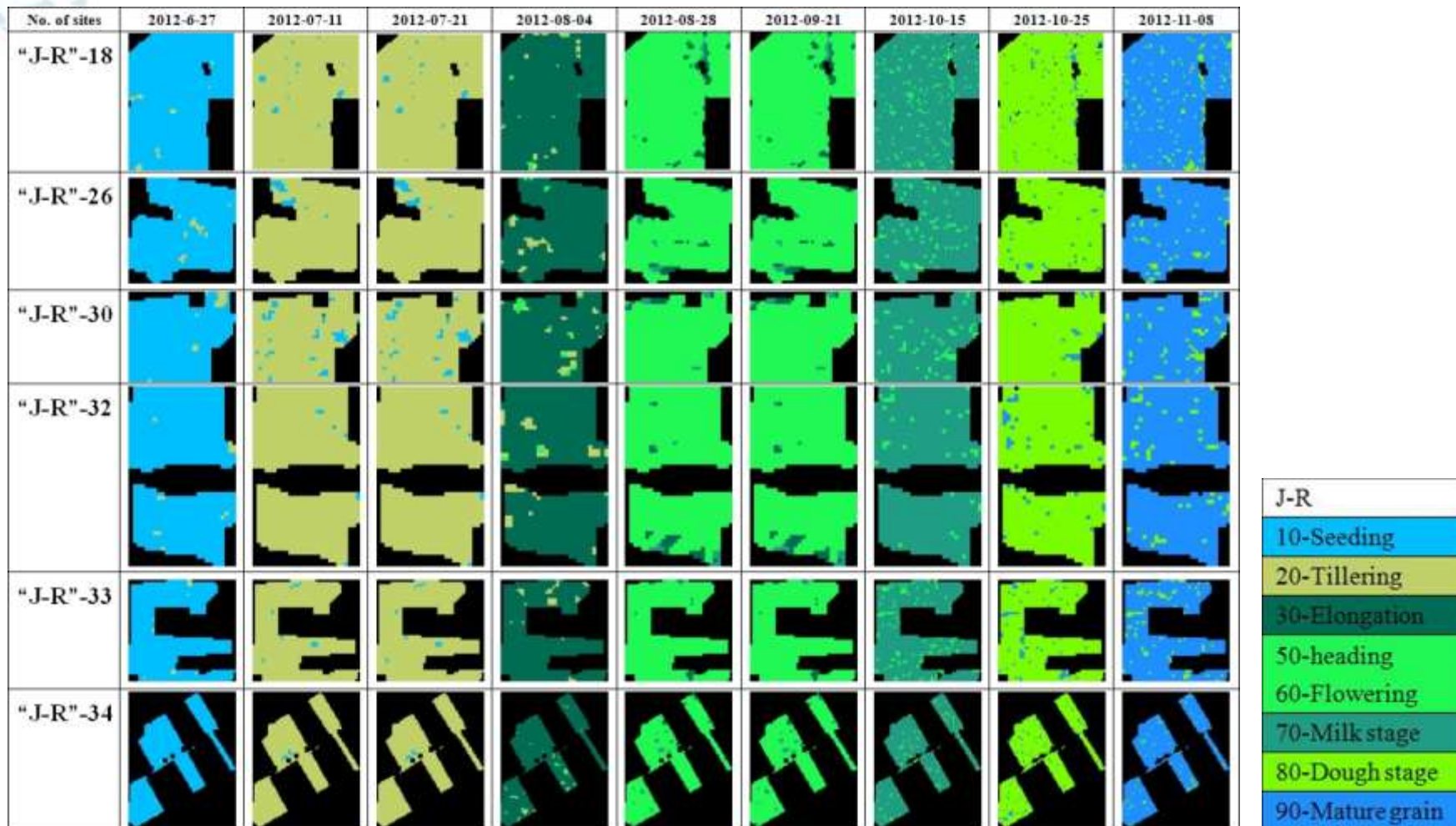
- Results and accuracy assessment



Retrieval of rice phenology



- Results and accuracy assessment



Retrieval of rice phenology

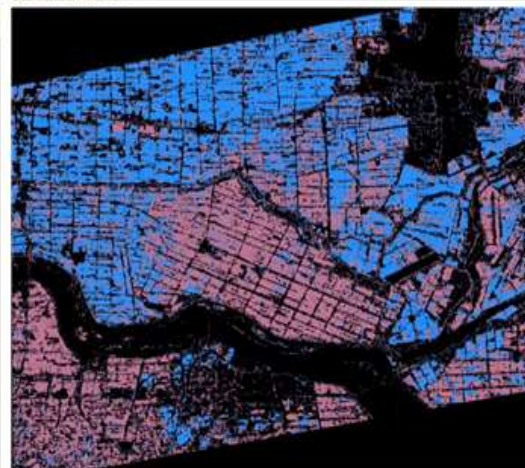
- Results and accuracy assessment

No. of sites	Percentage	2012-6-27	2012-07-11	2012-07-21	2012-08-04	2012-08-28	2012-09-21	2012-10-15	2012-10-25	2012-11-08
"H-R"-7	Correct	92.2177%	92.1169%	92.5202%	92.3185%	92.3185%	89.6976%	93.2258%	93.2258%	93.2258%
	Error	1.3105%	1.4113%	1.2096%	1.3105%	1.3105%	3.8306%	0.3024%	0.3024%	0.3024%
	Unclassified	6.4718%	6.4718%	6.4718%	6.4718%	6.4718%	6.4718%	6.4718%	6.4718%	6.4718%
"H-R"-8	Correct	94.2638%	94.0831%	92.7281%	92.7281%	90.3794%	90.0958%	89.4634%	93.3604%	93.3604%
	Error	0.2710%	0.4517%	1.8067%	1.8067%	4.1553%	4.4390%	5.0713%	1.1743%	1.1743%
	Unclassified	5.4652%	5.4652%	5.4652%	5.4652%	5.4652%	5.4652%	5.4652%	5.4652%	5.4652%
"H-R"-15	Correct	94.3051%	94.0678%	92.5763%	92.5763%	92.6102%	89.8983%	89.2712%	93.7627%	93.7627%
	Error	0.5424%	0.7797%	2.2712%	2.2712%	2.2373%	4.9491%	5.5763%	1.0847%	1.0847%
	Unclassified	5.1525%	5.1525%	5.1525%	5.1525%	5.1525%	5.1525%	5.1525%	5.1525%	5.1525%
"H-R"-19	Correct	92.6847%	93.3949%	93.3949%	92.6847%	90.7670%	90.3352%	92.6136%	92.6136%	92.6136%
	Error	0.9233%	0.2131%	0.2131%	0.9233%	2.8409%	3.2727%	0.9943%	0.9943%	0.9943%
	Unclassified	6.3920%	6.3920%	6.3920%	6.3920%	6.3920%	6.3920%	6.3920%	6.3920%	6.3920%
"H-R"-24	Correct	90.2564%	90.1709%	90.1709%	89.6581%	89.5726%	89.4872%	90.0855%	90.0855%	90.0855%
	Error	1.1111%	1.1966%	1.1966%	1.7094%	1.7949%	1.8804%	1.2821%	1.2821%	1.2821%
	Unclassified	8.6325%	8.6325%	8.6325%	8.6325%	8.6325%	8.6325%	8.6325%	8.6325%	8.6325%
"H-R"-40	Correct	92.8544%	91.1303%	91.0345%	91.0345%	90.1724%	89.1188%	88.6877%	92.4234%	92.4234%
	Error	0.0958%	1.8199%	1.9157%	1.9157%	2.7778%	3.8314%	4.2625%	0.5268%	0.5268%
	Unclassified	7.0498%	7.0498%	7.0498%	7.0498%	7.0498%	7.0498%	7.0498%	7.0498%	7.0498%
"J-R"-18	Correct	90.7363%	90.4537%	90.4537%	89.4176%	87.9733%	87.9733%	87.3673%	87.2873%	86.4976%
	Error	1.0361%	1.3187%	1.3187%	2.3548%	3.7990%	3.7990%	4.4051%	4.4851%	5.2747%
	Unclassified	8.2276%	8.2276%	8.2276%	8.2276%	8.2276%	8.2276%	8.2276%	8.2276%	8.2276%
"J-R"-26	Correct	91.1417%	90.7034%	90.7034%	89.4617%	88.8042%	88.8042%	87.3433%	90.1921%	89.3156%
	Error	1.6801%	2.1103%	2.1103%	3.3601%	4.0175%	4.0175%	5.4785%	2.6297%	3.5062%
	Unclassified	7.1782%	7.1782%	7.1782%	7.1782%	7.1782%	7.1782%	7.1782%	7.1782%	7.1782%
"J-R"-30	Correct	91.1075%	88.3692%	88.3692%	87.4564%	87.9919%	87.9919%	87.3550%	87.8032%	87.2535%
	Error	2.3327%	5.0710%	5.0710%	5.9838%	5.4483%	5.4483%	6.0852%	5.6369%	6.1866%
	Unclassified	6.5598%	6.5598%	6.5598%	6.5598%	6.5598%	6.5598%	6.5598%	6.5598%	6.5598%
"J-R"-32	Correct	91.9002%	92.3833%	92.3833%	88.6795%	89.1626%	89.1626%	89.2899%	89.4847%	89.0821%
	Error	1.0467%	0.5636%	0.5636%	4.2673%	3.7842%	3.7842%	3.6570%	3.4622%	3.8648%
	Unclassified	7.0531%	7.0531%	7.0531%	7.0531%	7.0531%	7.0531%	7.0531%	7.0531%	7.0531%
"J-R"-33	Correct	91.9427%	91.8933%	91.8933%	90.5593%	91.3498%	91.3498%	86.6067%	88.6818%	88.2372%
	Error	0.7905%	0.8399%	0.8399%	2.1739%	1.3834%	1.3834%	6.1265%	4.0514%	4.4960%
	Unclassified	7.2668%	7.2668%	7.2668%	7.2668%	7.2668%	7.2668%	7.2668%	7.2668%	7.2668%
"J-R"-34	Correct	91.8413%	91.7143%	91.7143%	90.8889%	90.5079%	90.5079%	89.2857%	88.7460%	88.4762%
	Error	0.1429%	0.2698%	0.2698%	1.0953%	1.4763%	1.4763%	2.6984%	3.2381%	3.5079%
	Unclassified	8.0159%	8.0159%	8.0159%	8.0159%	8.0159%	8.0159%	8.0159%	8.0159%	8.0159%

Result



H-R
10-Seeding
20-Tillering
30-Elongation
50-heading
60-Flowering
70-Milk stage
80-Dough stage
100-Fallow



J-R
10-Seeding
20-Tillering
30-Elongation
50-heading
60-Flowering
70-Milk stage
80-Dough stage
90-Mature grain

Conclusion

- Compact SAR has great potential in rice monitoring:
 - Hybrid and japonica can be discriminated by Compact SAR data, with the accuracy of 94% and 86% respectively;
 - Hybrid and japonica can be discriminated before heading stage, with accuracy of 84% and 77%;
 - Only 4 Compact parameters on one image can retrieve rice phenology successfully, with accuracy of above 85%.
 - RH/RV/RR/RL, m-chi decomposition components and conformity coefficient (μ) are sensitive to rice phenology;

Future Work

- FQ20W and FQ9W modes are combined to guarantee the short revisit time. Thus, the influence of incidence and orientation angle should be evaluated.
- The phenology retrieval models will be improved to be more robust and portable, avoiding the empirical threshold values.
- Inversion from Compact parameters to rice growth condition, such as the rice biomass, should be studied more.
- The short revisit time of Compact SAR data, such as RADARSAT constellation, are highly anticipated.

Thanks!



**Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences**

Add: No.9 Dengzhuang South Road,Haidian District,Beijing 100094,China

Tel: 86-10-82178008 Fax: 86-10-82178009

E-mail: office@radi.ac.cn

Web: www.radi.cas.cn