Jiangsu, China

JECAM/GEOGLAM Science Meeting

Ottawa, Canada

21-23 July 2014

Team Leader and Members:

Yun Shao,

Kun Li, Long Liu, Zhi Yang, Brian Brisco,

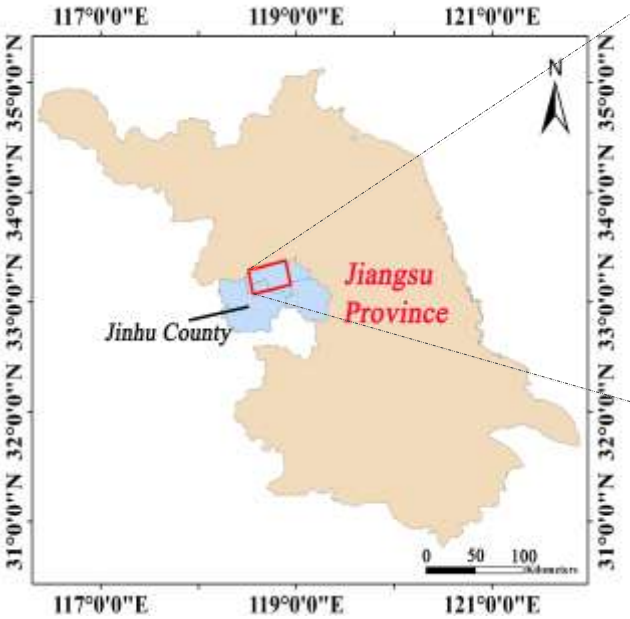
Fengli Zhang, Weiguo Li

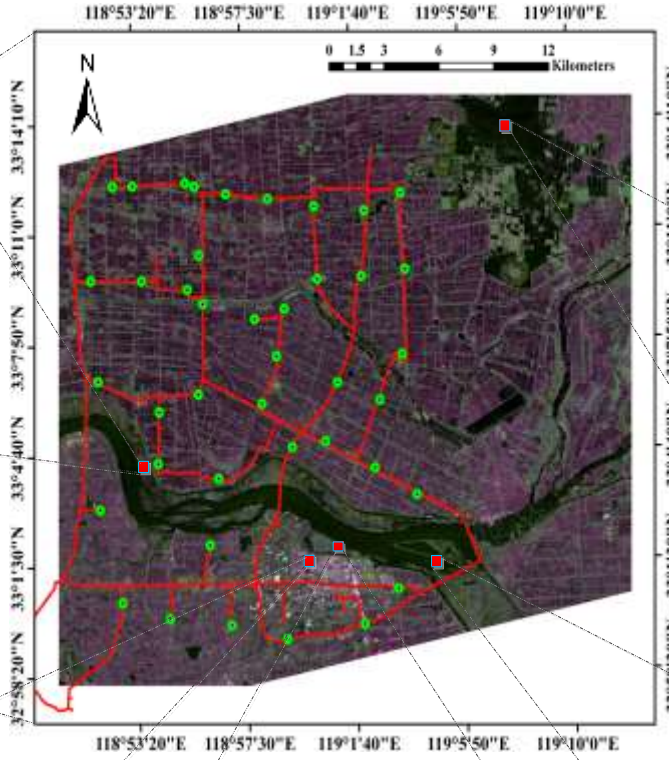
Outline

- Site description
- Objectives
- SAR data used
- In site data
- Collaboration
- Results
- Conclusion
- Future work

Site description

Site name: Jiangsu





Bared land (B-L)

Crab pond (C-P)

Urban (Buildings)

Poplar forest

River water

JECAM
Joint Experiment for Crop Assessment and Monitoring

GEO GROUP ON EARTH OBSERVATIONS

Project objectives

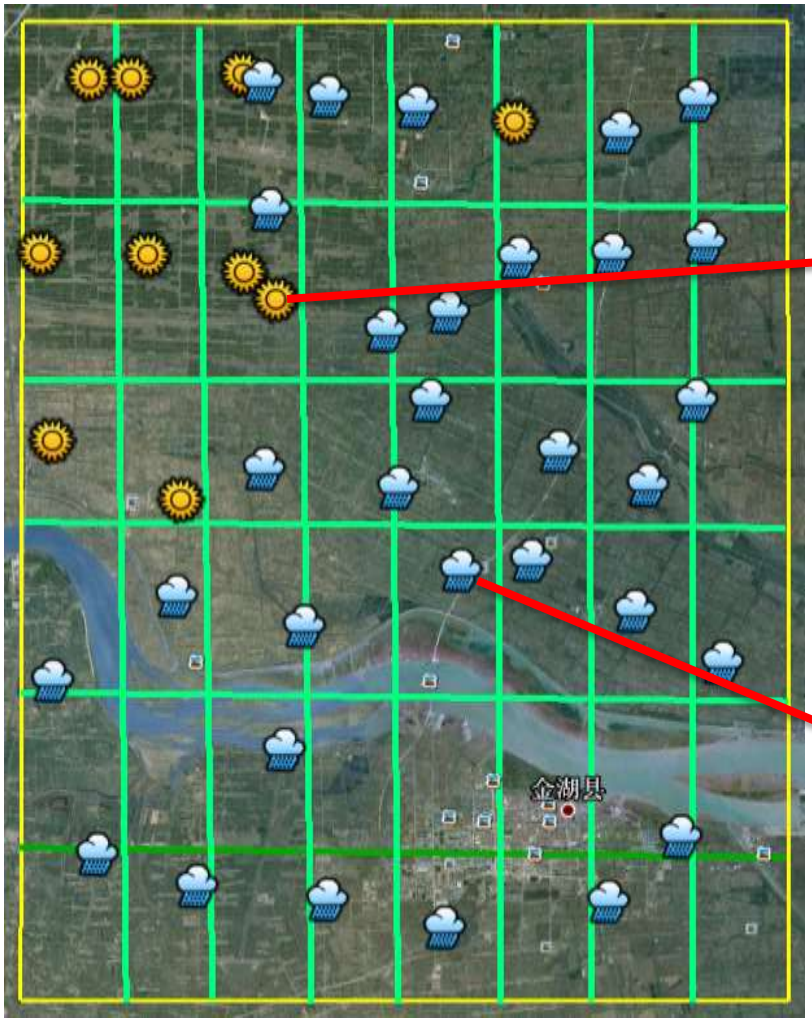
- **Rice mapping**
  - **Rice identification**
  - **Rice species discrimination**
- **Rice monitoring**
  - **Rice phenology retrieval**
  - **Rice parameters estimation**

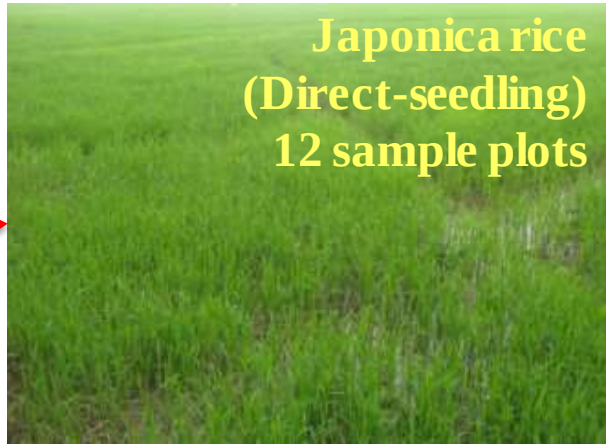
SAR data used

Ten temporal RADARSAT-2 data in FQ20W and FQ9W mode were acquired, and the corresponding compact-pol data were simulated.

Date	Mode	Product	Resolution（m）		Image size（km^2）	Incidence angle（°）	Look	Polarization
			Range	Azimuth				
2012-06-27	FQ20W	SLC	5.2	7.6	565	38.89	1	HH/HV/VH/VV
2012-07-11	FQ9W	SLC	5.2	7.6	571	27.53	1	HH/HV/VH/VV
2012-07-21	FQ20W	SLC	5.2	7.6	565	38.89	1	HH/HV/VH/VV
2012-08-04	FQ9W	SLC	5.2	7.6	571	27.53	1	HH/HV/VH/VV
2012-08-28	FQ9W	SLC	5.2	7.6	571	27.53	1	HH/HV/VH/VV
2012-09-07	FQ20W	SLC	5.2	7.6	565	38.89	1	HH/HV/VH/VV
2012-09-21	FQ9W	SLC	5.2	7.6	571	27.53	1	HH/HV/VH/VV
2012-10-15	FQ9W	SLC	5.2	7.6	571	27.53	1	HH/HV/VH/VV
2012-10-25	FQ20W	SLC	5.2	7.6	565	38.89	1	HH/HV/VH/VV
2012-11-08	FQ9W	SLC	5.2	7.6	571	27.53	1	HH/HV/VH/VV

In situ data





JECAM
Joint Experiment for Crop Assessment and Monitoring

GEO GROUP ON EARTH OBSERVATIONS

In situ Data

Category		Parameters	
Geographic Information		Location, plots boundaries, elevation, topography, etc.	
Meteorological data		Temperature, humidity, wind direction, precipitation, etc.	
Calender		Planting dates, growth stages, cultivation methods, irrigation, rice varieties	
		Geometry	Bio-physical
Rice	Plant	Height, diameter of cluster, density	LAI、moisture、fresh weight
	Stem	Length, diameter, inclination	Fresh weight, dry weight, moisture
	Leaf	Length, width, depth, inclination, density	Fresh weight, dry weight, moisture
	Ear	Length, diameter, inclination, density	Fresh weight, dry weight, moisture
Surface	Water	Depth	
	Soil	Roughness	Types , moisture, Organic, pH, TN, etc.









Field work, Jinhu, Jiangsu, China

Collaboration

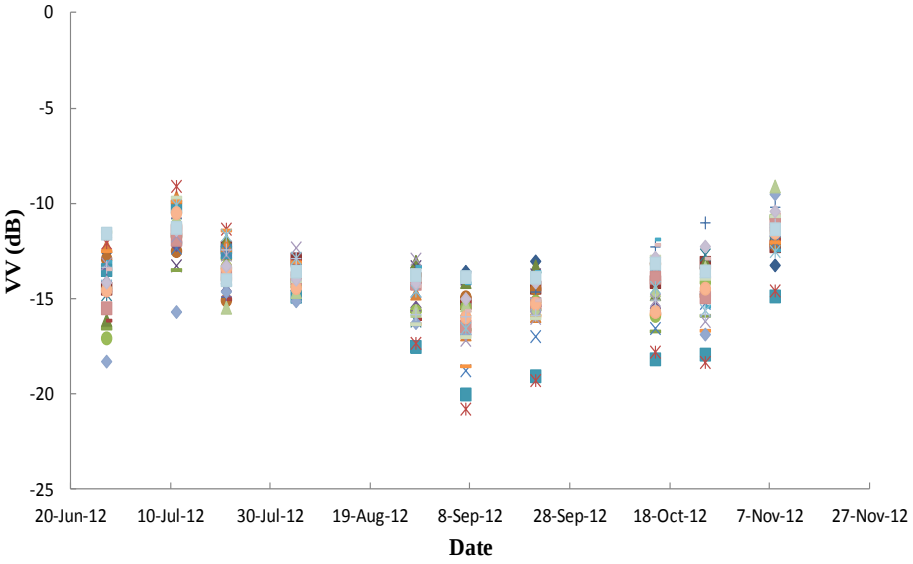
- **Weiguo Li, from Jiangsu Academy of Agricultural Sciences, has extensive experiences in situ observation. We work together for field work and in site data collection.**
- **Brian Brisco, research scientist in CCRS, who is an expert in SAR and rice. We collaborate to explore the potential of compact SAR data in rice monitoring.**

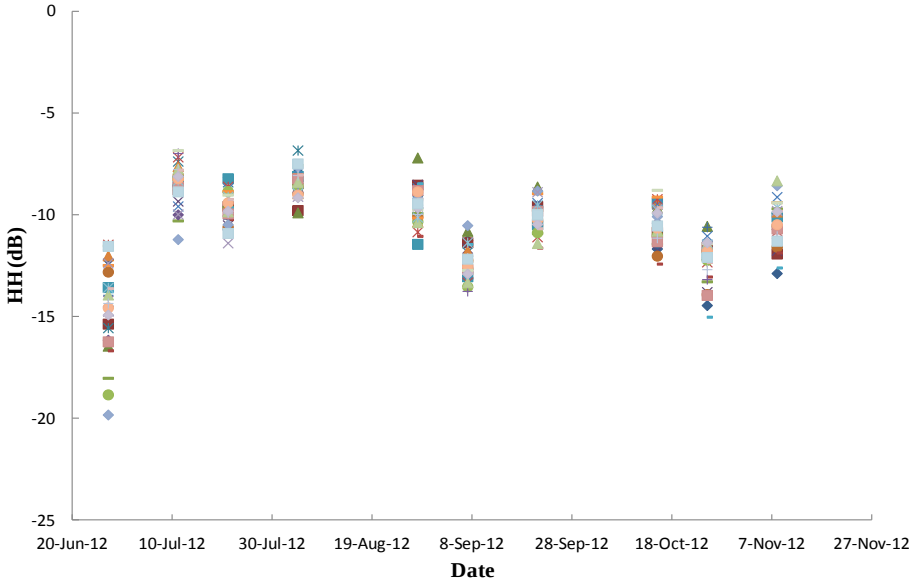
Results

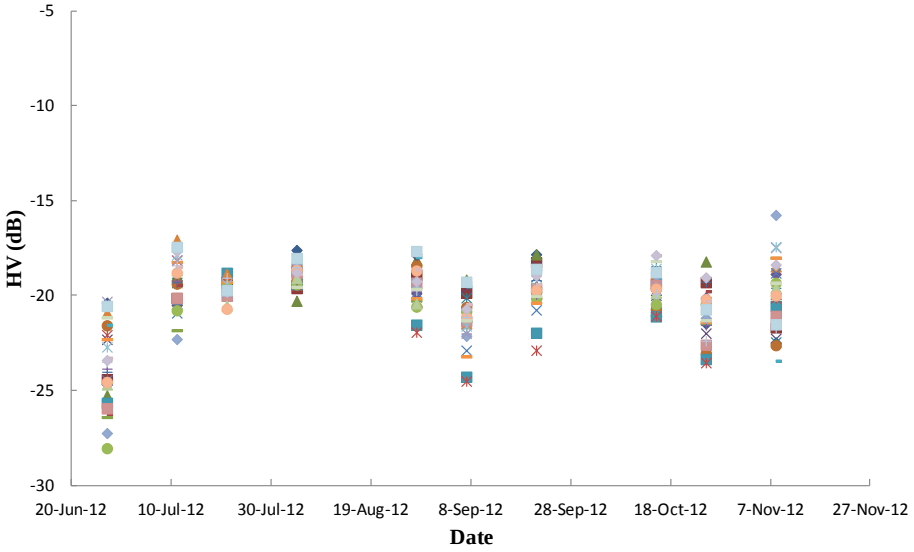
- Backscatter behavior of rice
- Scattering mechanism of rice
- Fine rice mapping
  - Rice species discrimination
- Rice monitoring
  - Rice phenology retrieval (qualitative)
  - Rice parameters estimation (quantitative)

Backscatter behavior of hybrid rice

Contrary to the conventional backscatter behavior of rice, especially VV polarization.





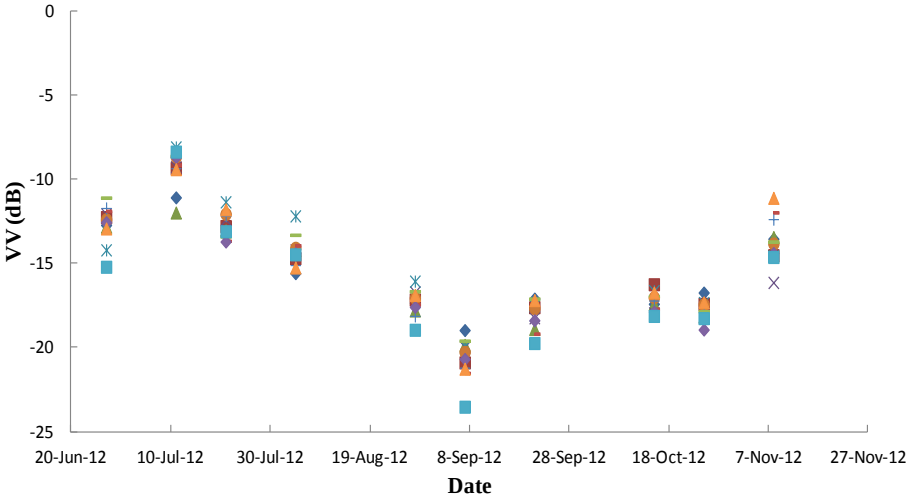


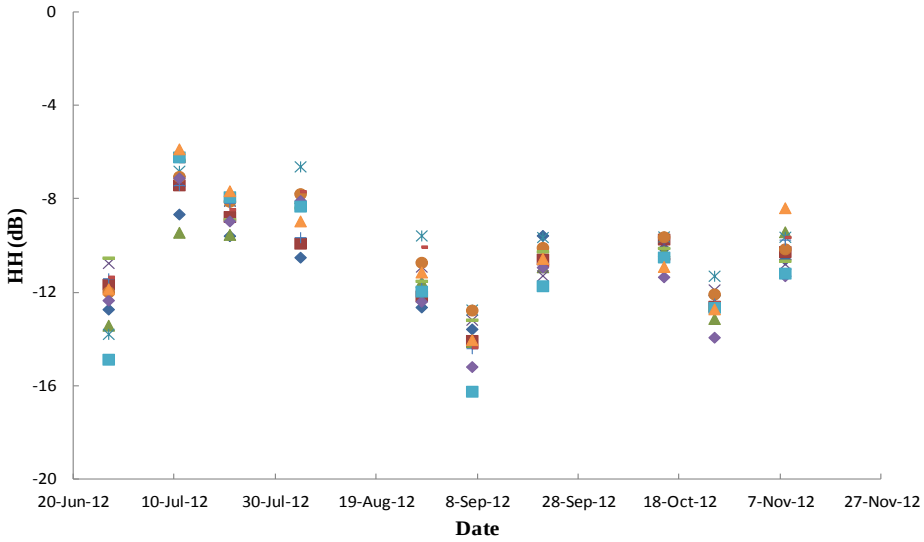
JECAM
Joint Experiment for Crop Assessment and Monitoring

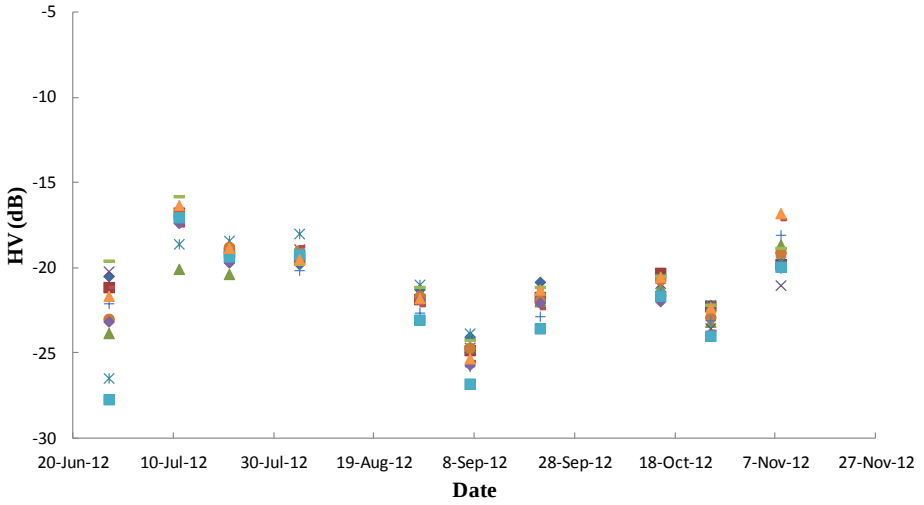
GEO GROUP ON EARTH OBSERVATIONS

Backscatter behavior of japonica rice

Contrary to the conventional backscatter behavior of rice. The min value exits on Sep. 7, heading stage.







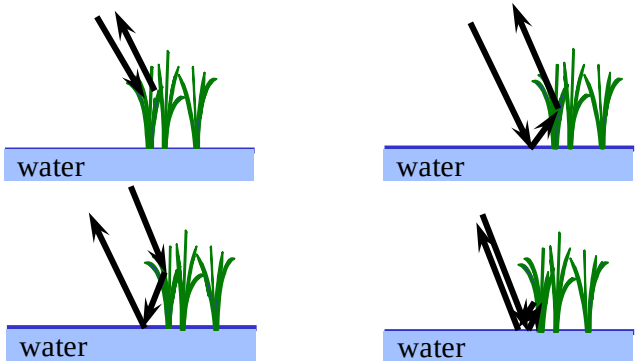
JECAM
Joint Experiment for Crop Assessment and Monitoring

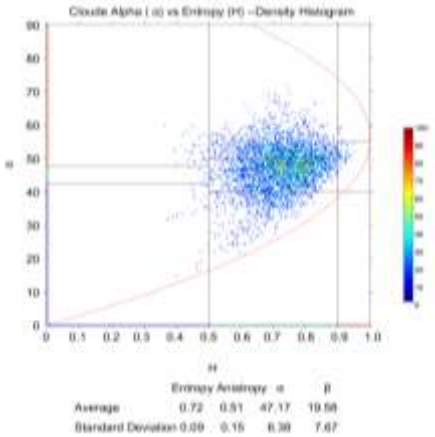
GEO GROUP ON EARTH OBSERVATIONS

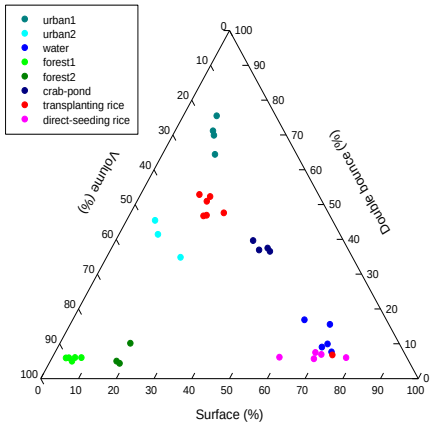
Scattering mechanisms of rice

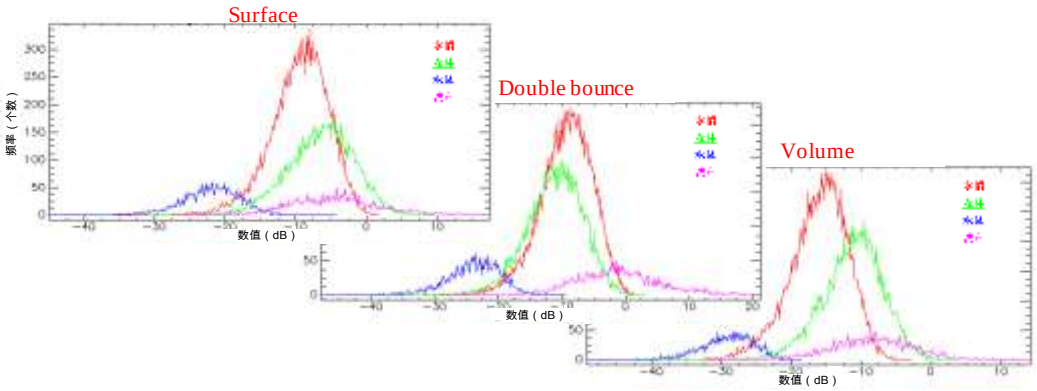
- **Backscatter is the result of interaction between targets and radar signal, which is influenced by many factors, such as incidence angle, precipitation etc.**
- **Scattering mechanisms present how the interaction of radar signal with the targets, which indicate the essential characteristics of targets.**

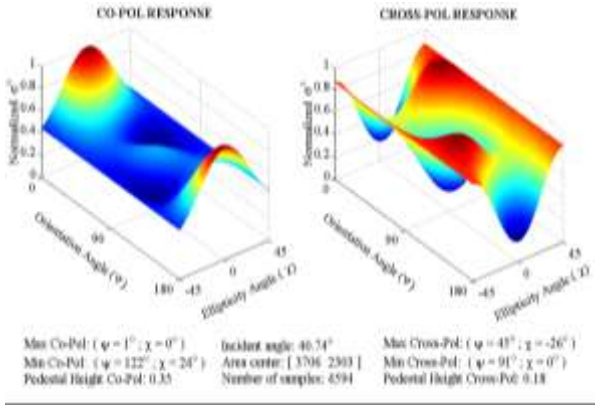
Scattering Mechanisms Analysis of rice







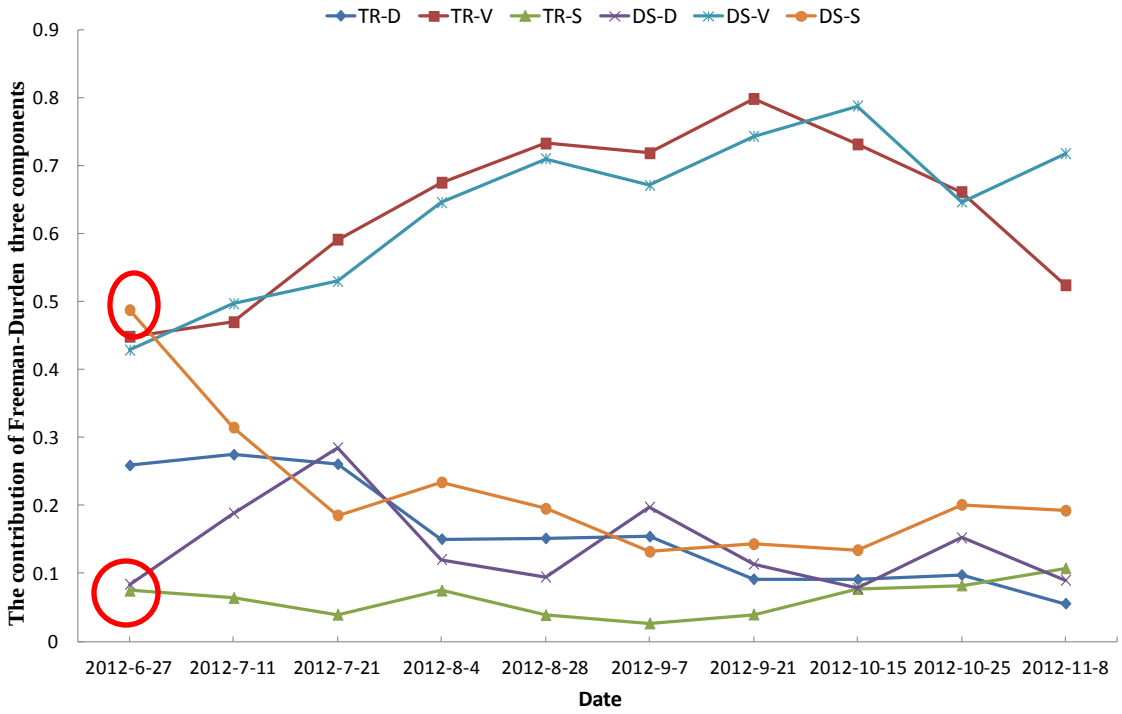




JECAM
Joint Experiment for Crop Assessment and Monitoring

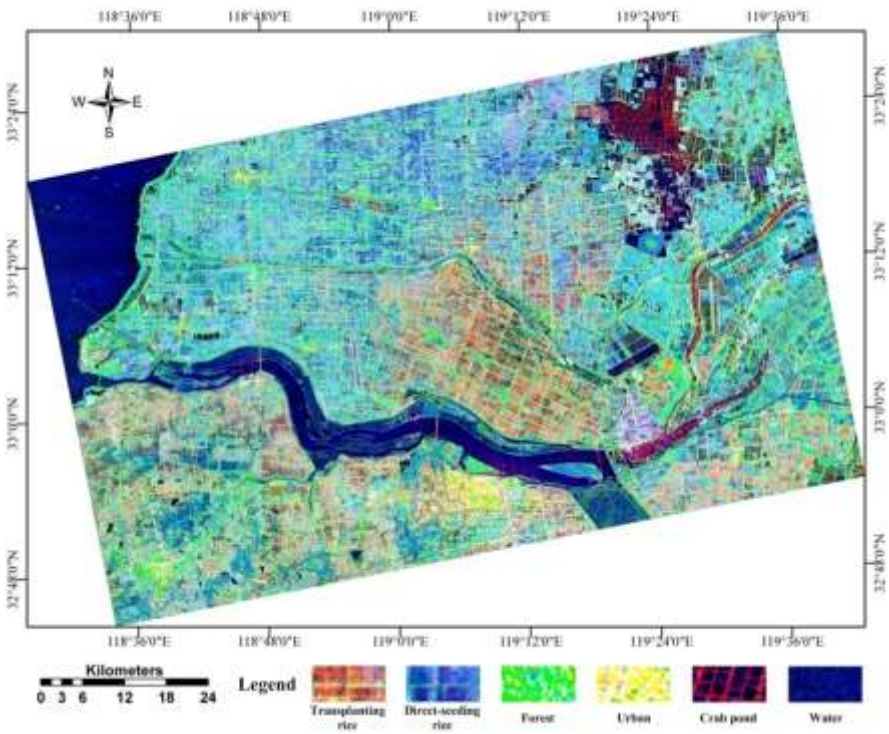
GEO GROUP ON EARTH OBSERVATIONS

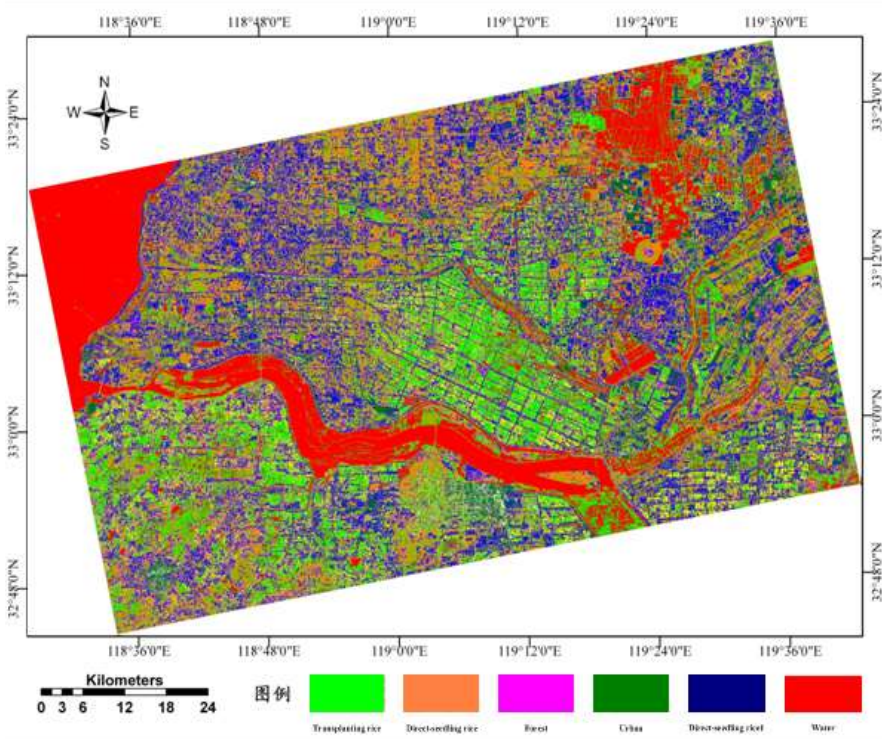
Scattering mechanisms analysis of different rice species



The surface scatterings of two kinds of rice fields have great difference on June 27 (15 days after transplanting) , which is the optimal temporal for rice species discrimination.

Rice mapping with scattering mechanisms



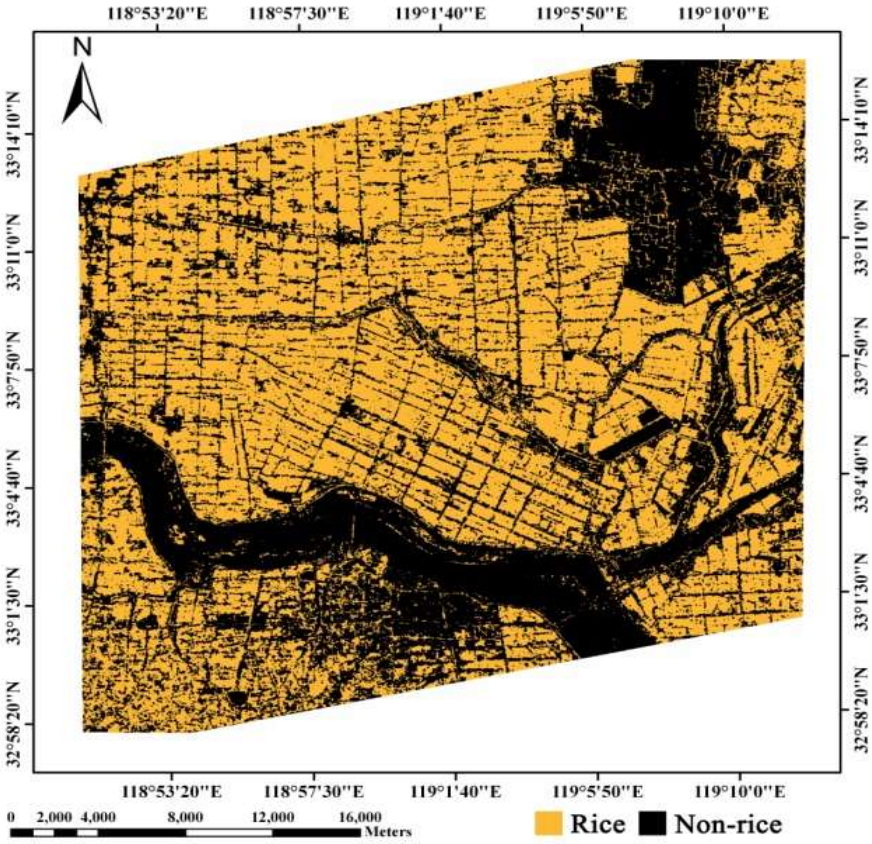


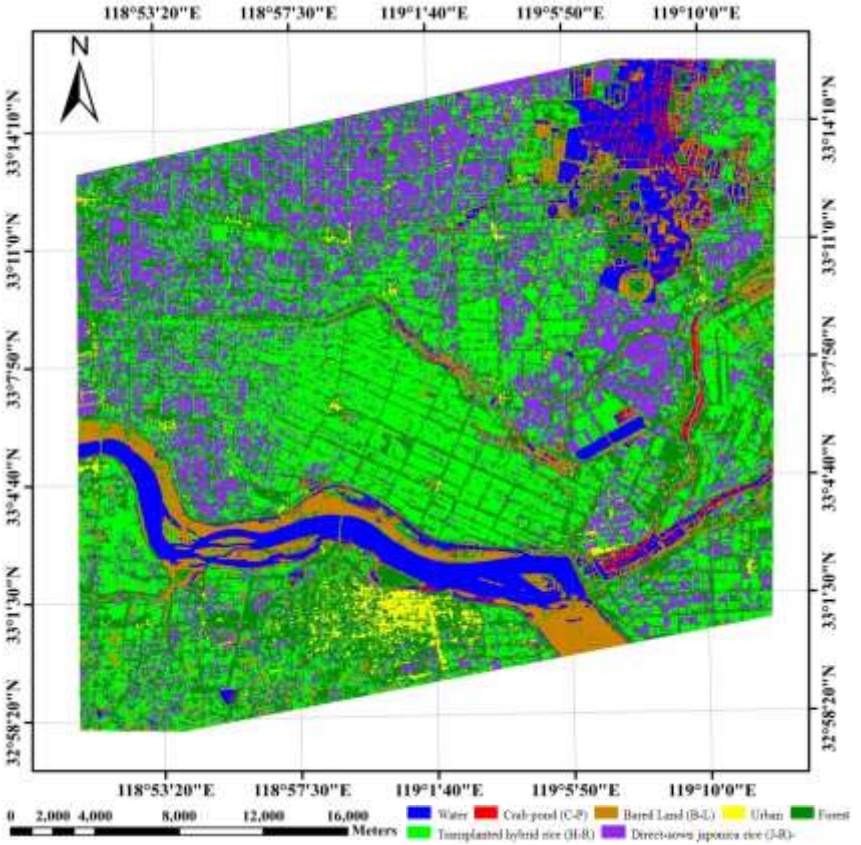
Rice mapping using polarimetric SAR data on June 27, 2012
Direct-seedling： 84.25%; Transplanting： 89.16%

JECAM
Joint Experiment for Crop Assessment and Monitoring

GEO GROUP ON EARTH OBSERVATIONS

Rice mapping with muti-temporal CP SAR





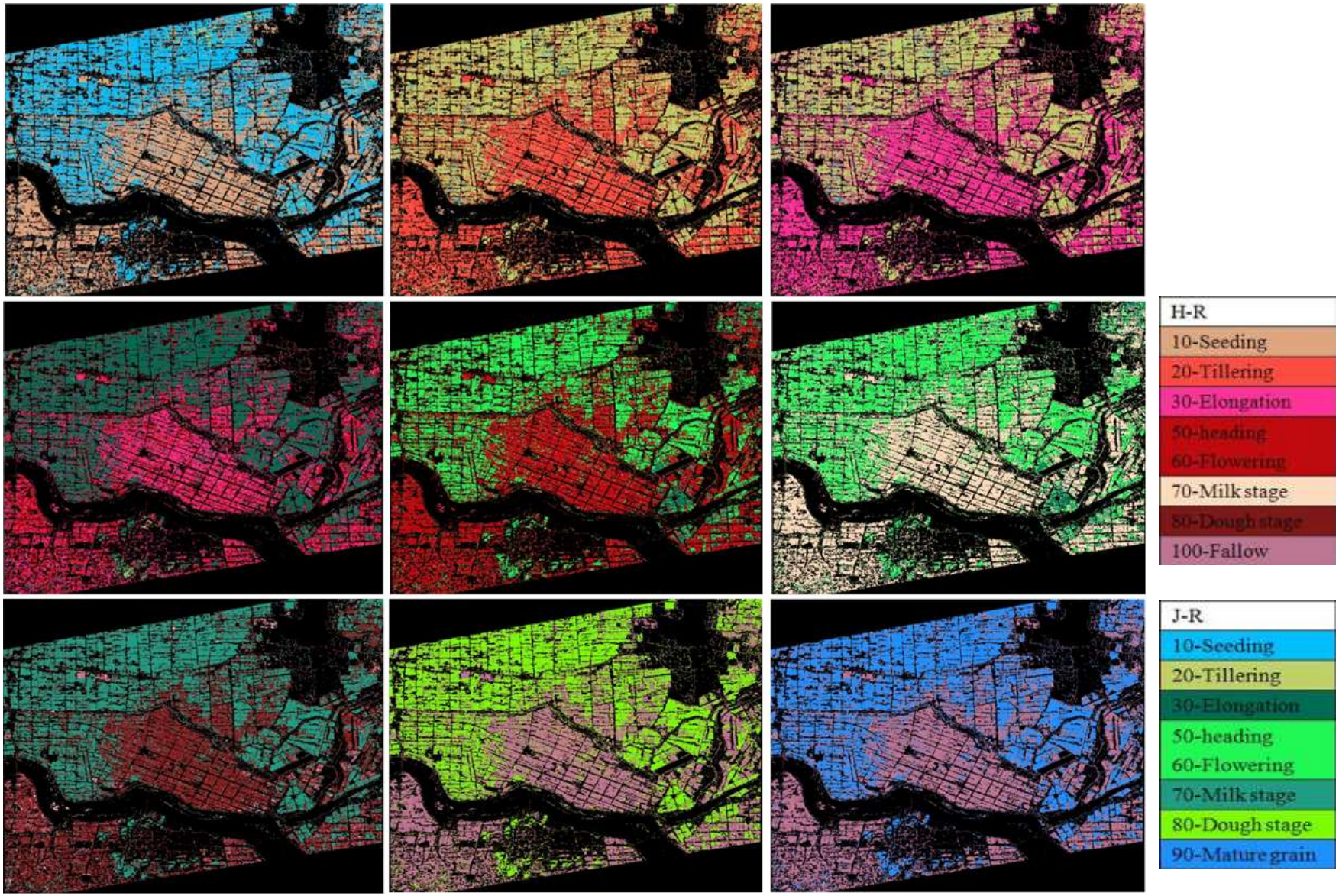
Two scenes(July 11, Oct. 15)

Eight scenes (all data except Aug. 28 and Sep. 7)
Direct-seedling：86.38%；
Transplanting：94.23%

JECAM
Joint Experiment for Crop Assessment and Monitoring

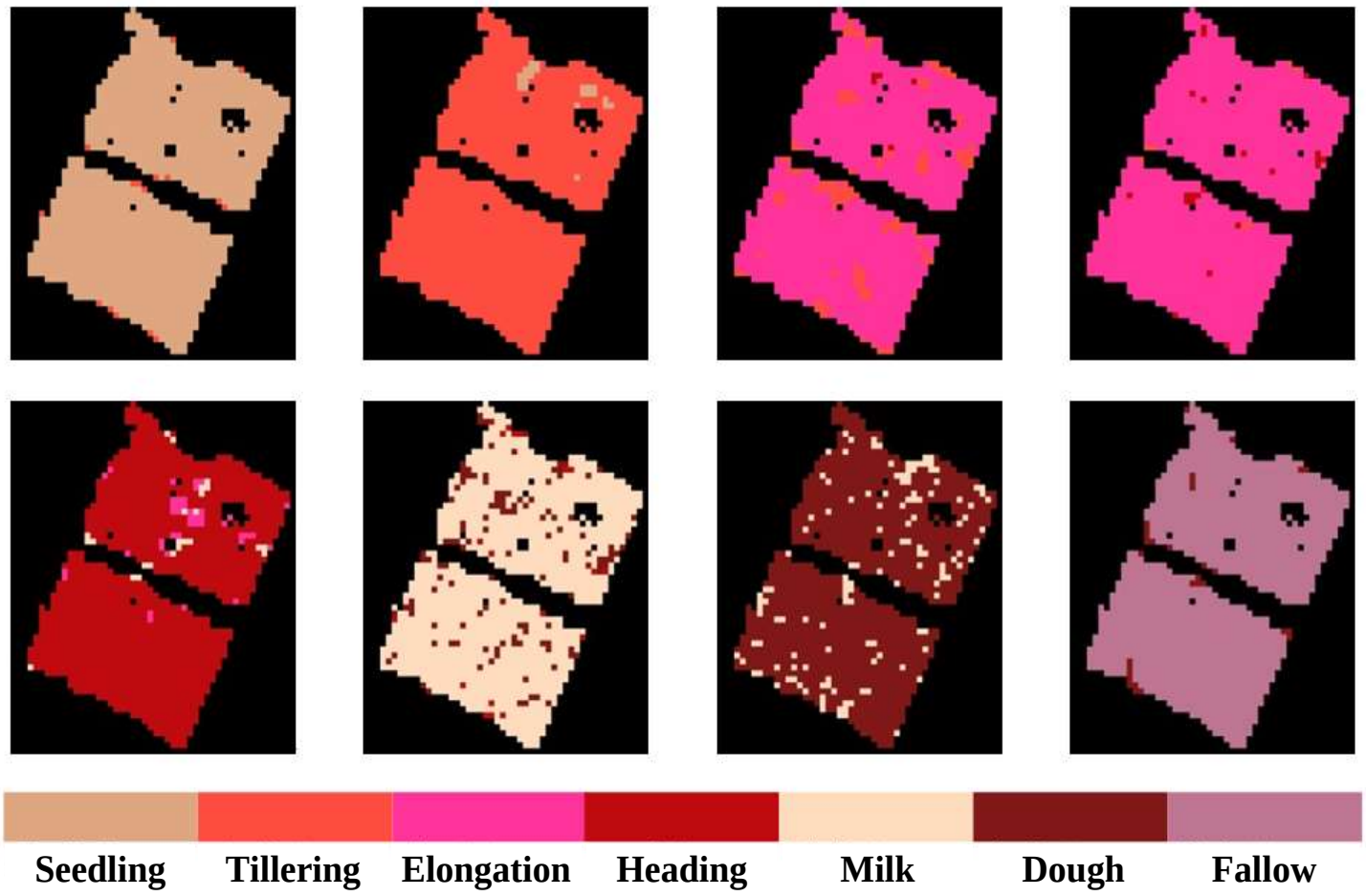
GEO GROUP ON EARTH OBSERVATIONS

Rice phenology retrieval



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%

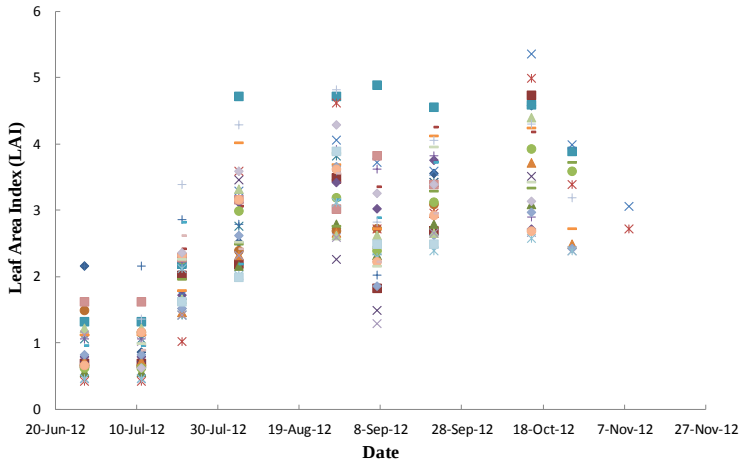
Rice phenology retrieval



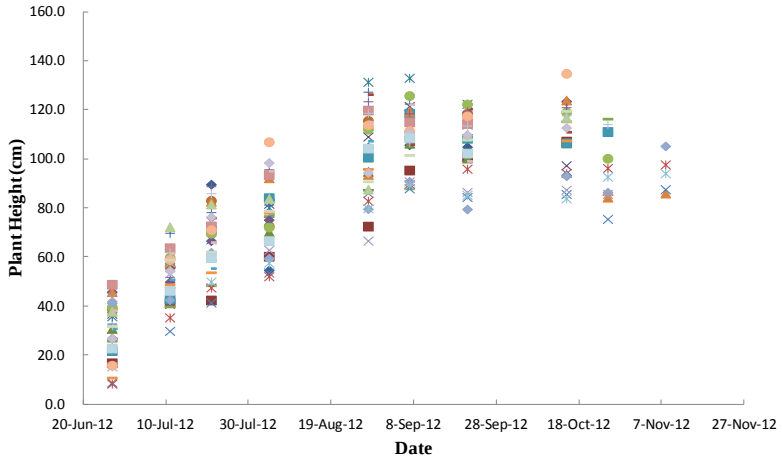
JECAM
Joint Experiment for Crop Assessment and Monitoring

GEO GROUP ON EARTH OBSERVATIONS

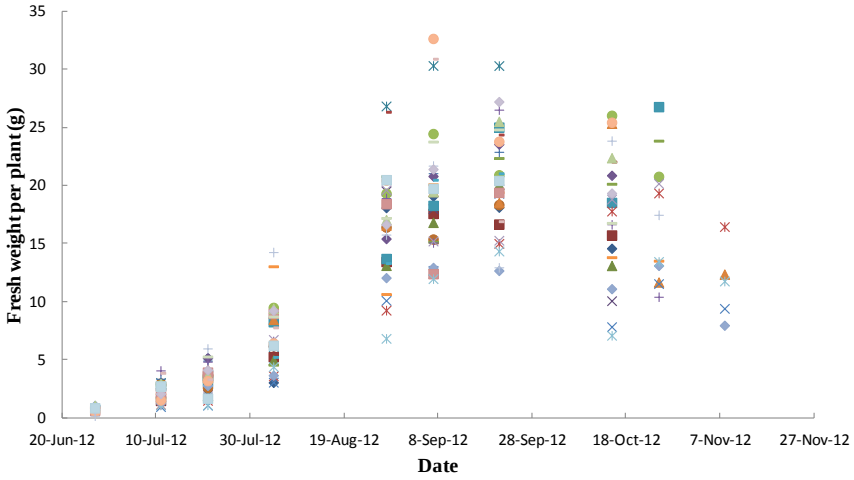
Rice parameter estimation



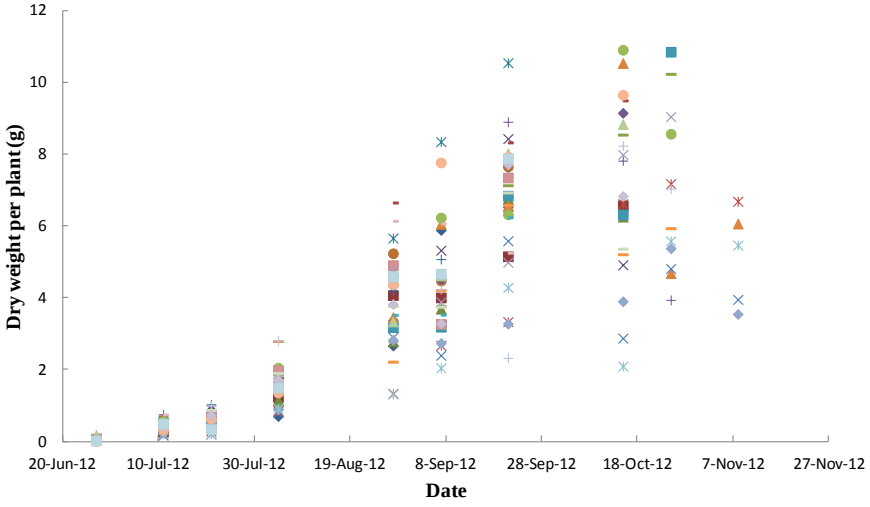
LAI



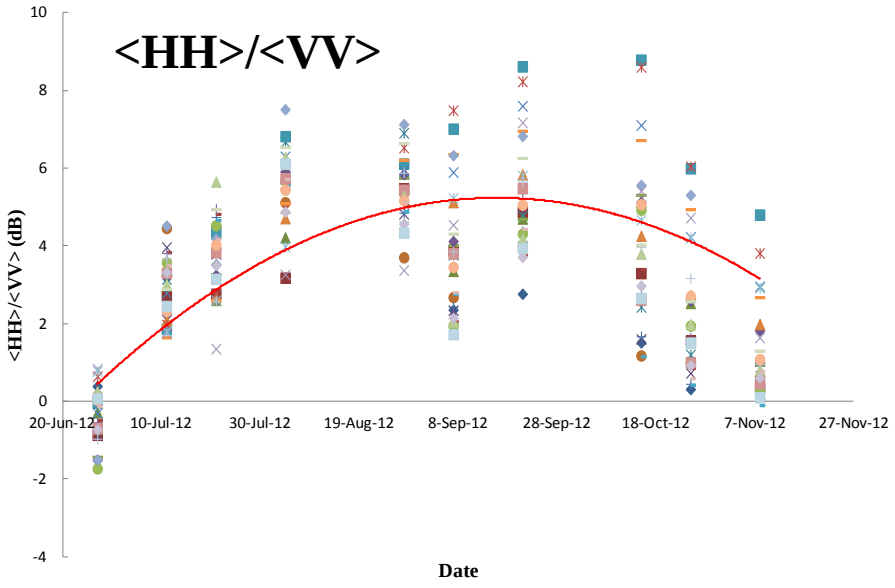
Plant height

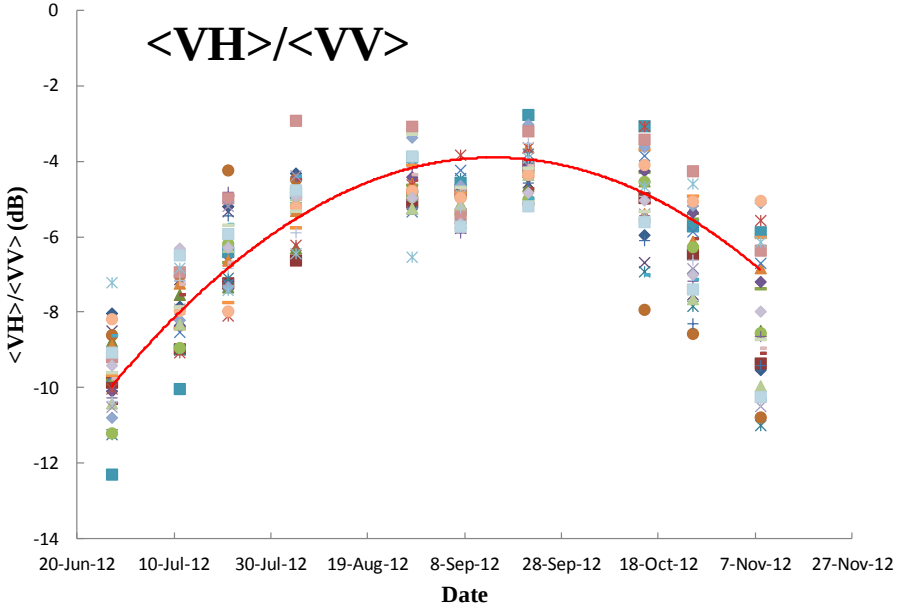


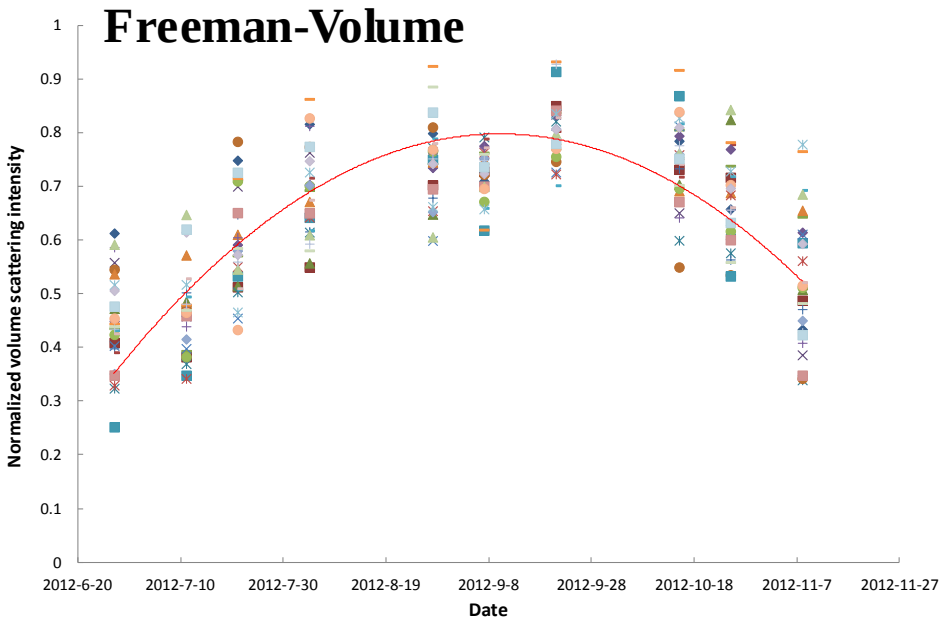
Fresh weight



Dry weight





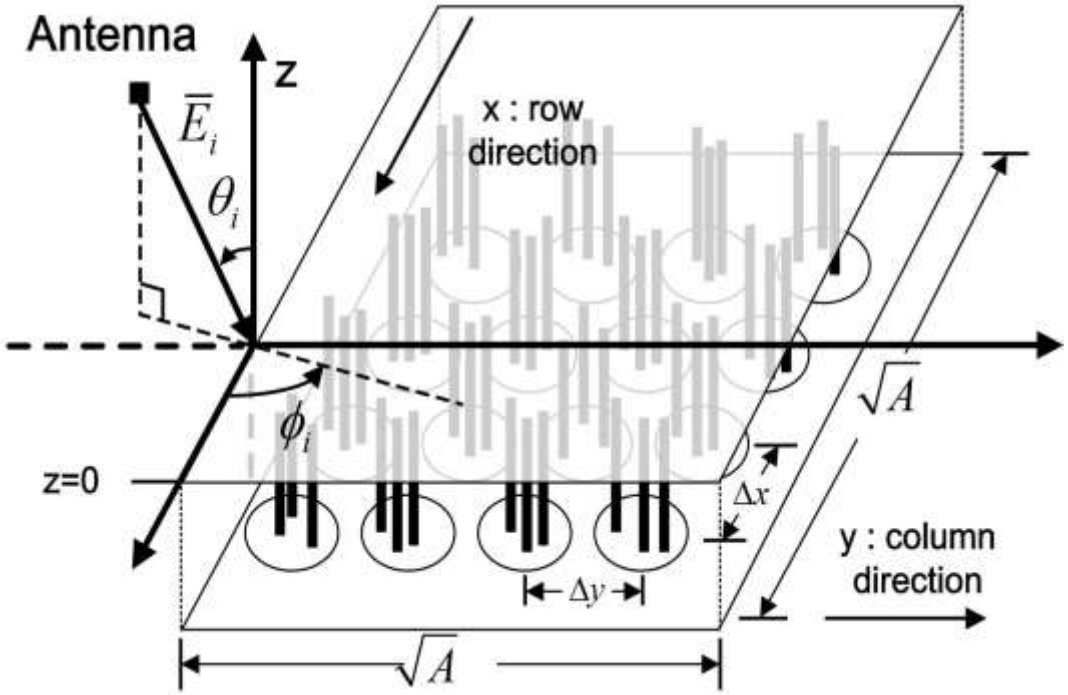


<HH>/<VV>, <VH>/<VV>, Freeman_Volume are most sensitive to rice parameters with growth change.

Rice scattering model

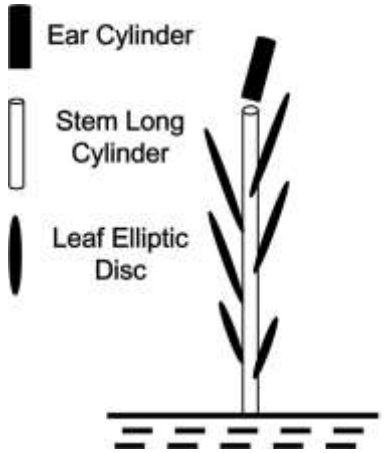
- **Scattering model is the key point for rice parameter estimation using SAR data.**
- **A coherent microwave scattering model of rice using Monte-Carlo numerical simulation methods, considering the ear layer, was developed to simulate backscatter of rice in the whole growth stage.**

Rice field simulation



Radar observation pattern and rice field configuration

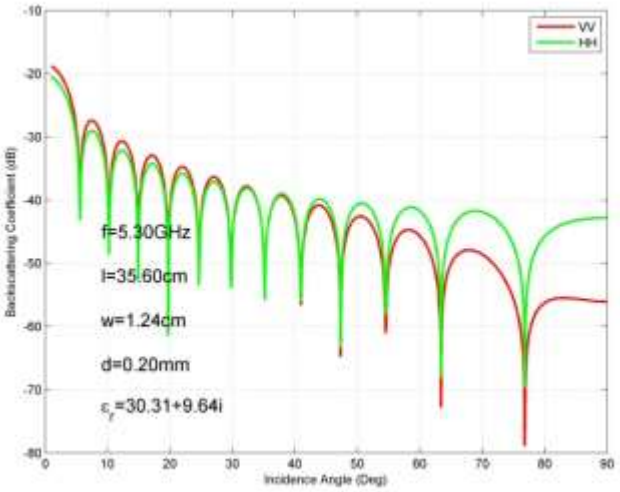
Rice scattering elements



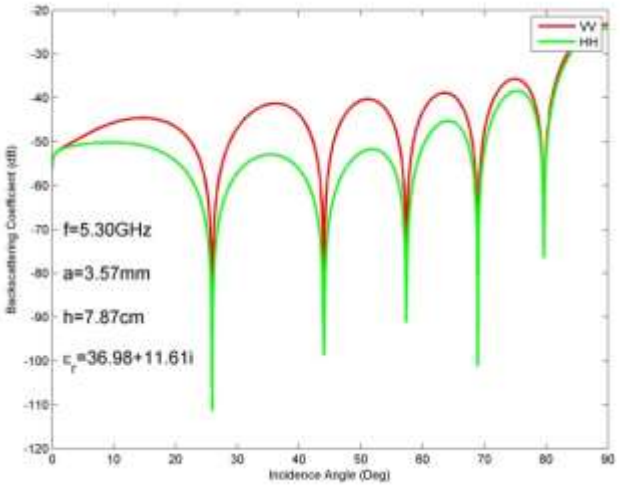
JECAM
Joint Experiment for Crop Assessment and Monitoring

GEO GROUP ON EARTH OBSERVATIONS

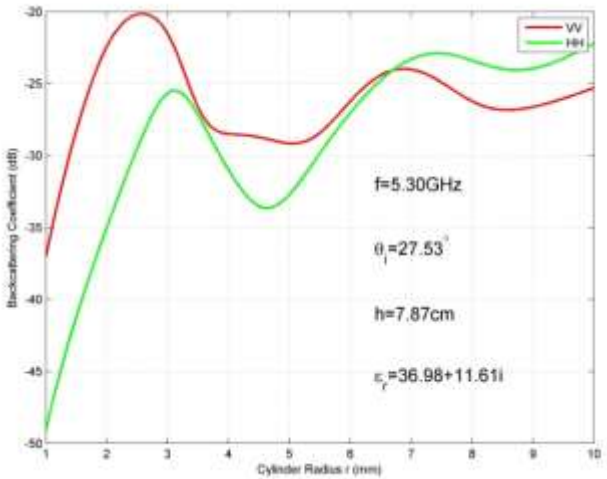
Rice components backscatter calculation



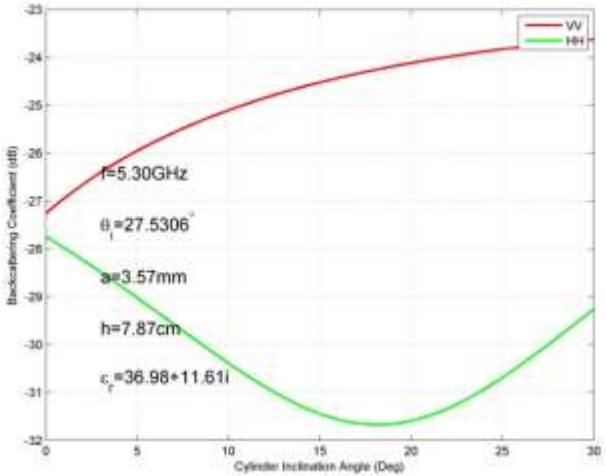
Leaf backscatter with incidence angle



Stem backscatter with incidence angle

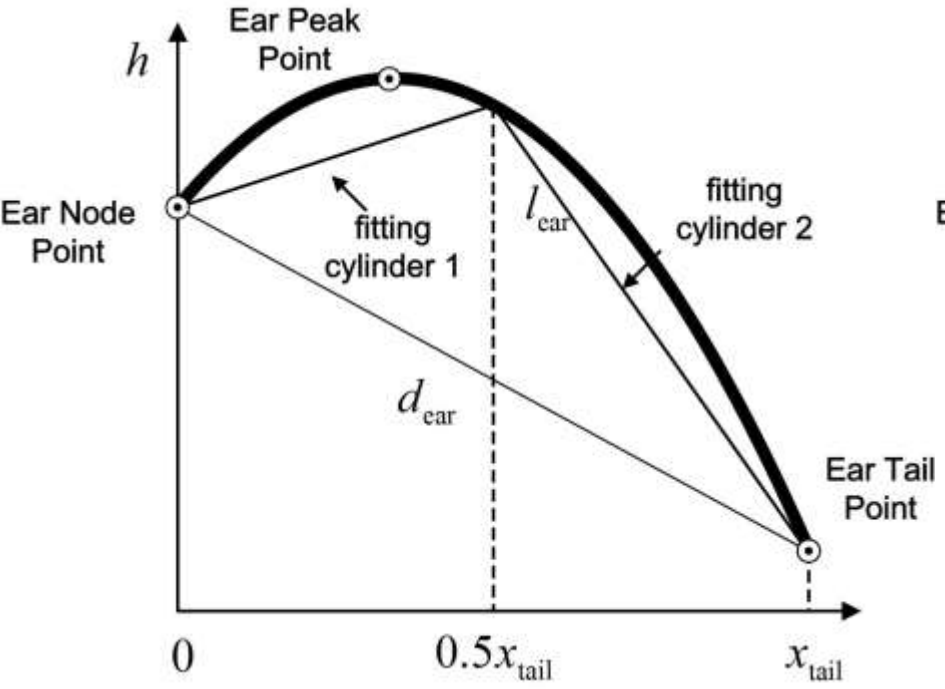


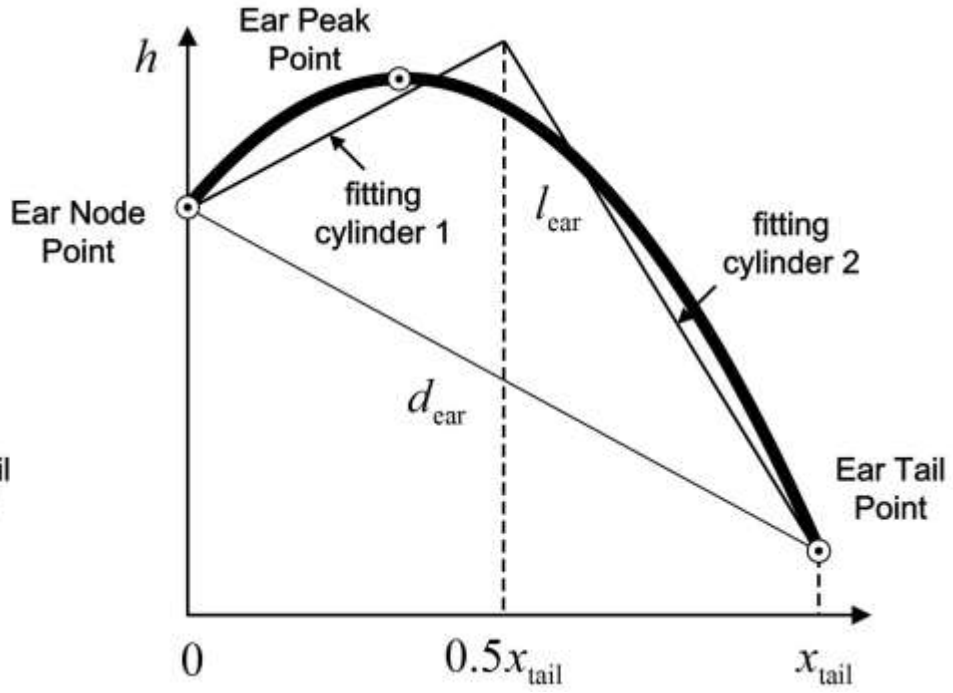
Stem backscatter with its diameter

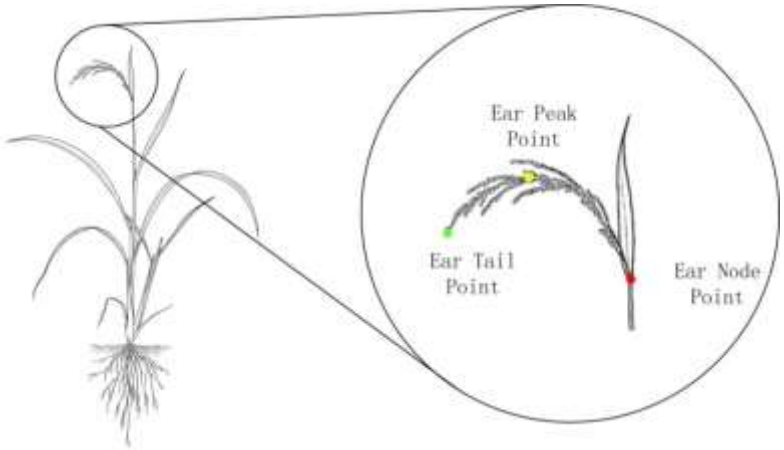


Stem backscatter with its angle

Rice ear backscatter calculation

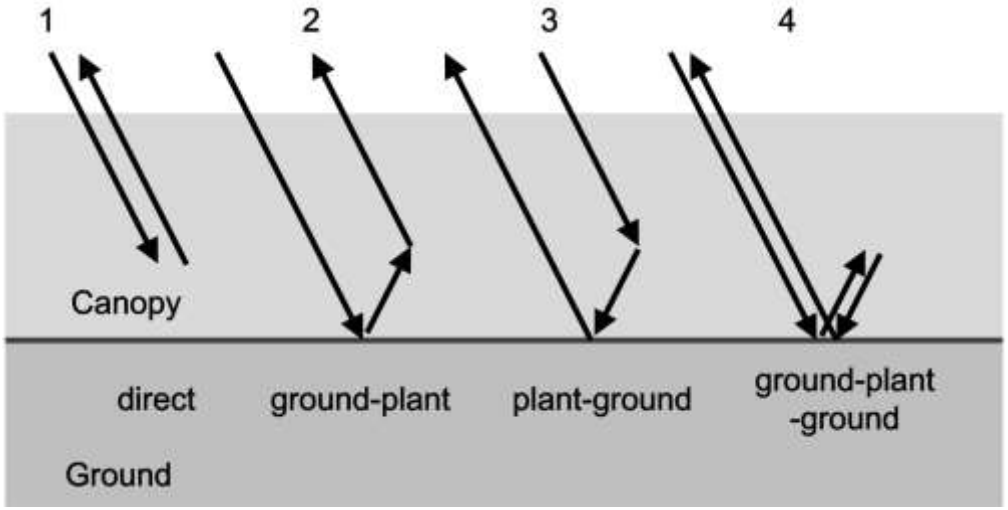


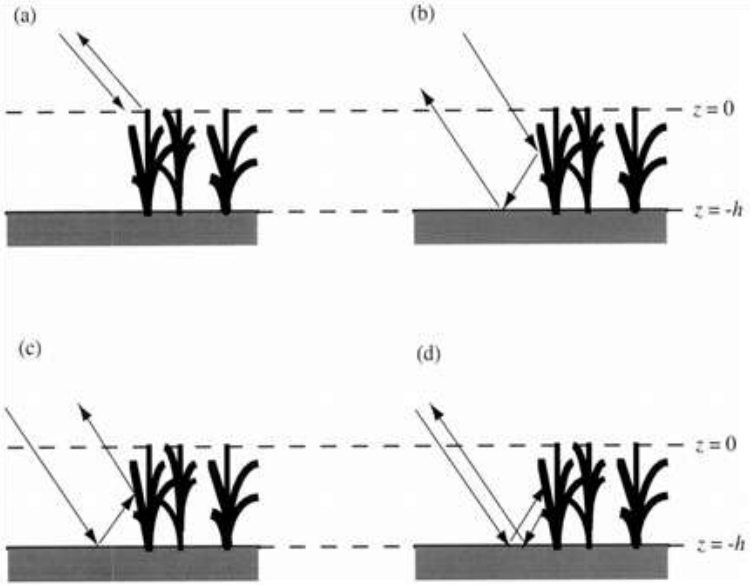




Approx. 1	*Approx.2*
$\alpha_1 = \arctan(0.5a\rho_t + b)$	$\alpha_1 = \frac{2}{\rho_t}\int_0^{0.5\rho_t} \arctan(2a\rho + b)d\rho$
$\alpha_2 = \arctan(1.5a\rho_t + b)$	$\alpha_2 = \frac{2}{\rho_t}\int_{0.5\rho_t}^{\rho_t} \arctan(2a\rho + b)d\rho$
$L_1 = \int_0^{0.5\rho_t} \sqrt{1 + (2a\rho + b)^2}d\rho$	$L_1 = 0.5\rho_t / \lvert\cos\alpha_1\rvert$
$L_2 = \int_{0.5\rho_t}^{\rho_t} \sqrt{1 + (2a\rho + b)^2}d\rho$	$L_2 = 0.5\rho_t / \lvert\cos\alpha_2\rvert$

Four scattering mechanism





Coherently summing the four scattering mechanisms as the total backscatter :

1.Rice canopy direct backscattering

2.Ground-Rice scattering

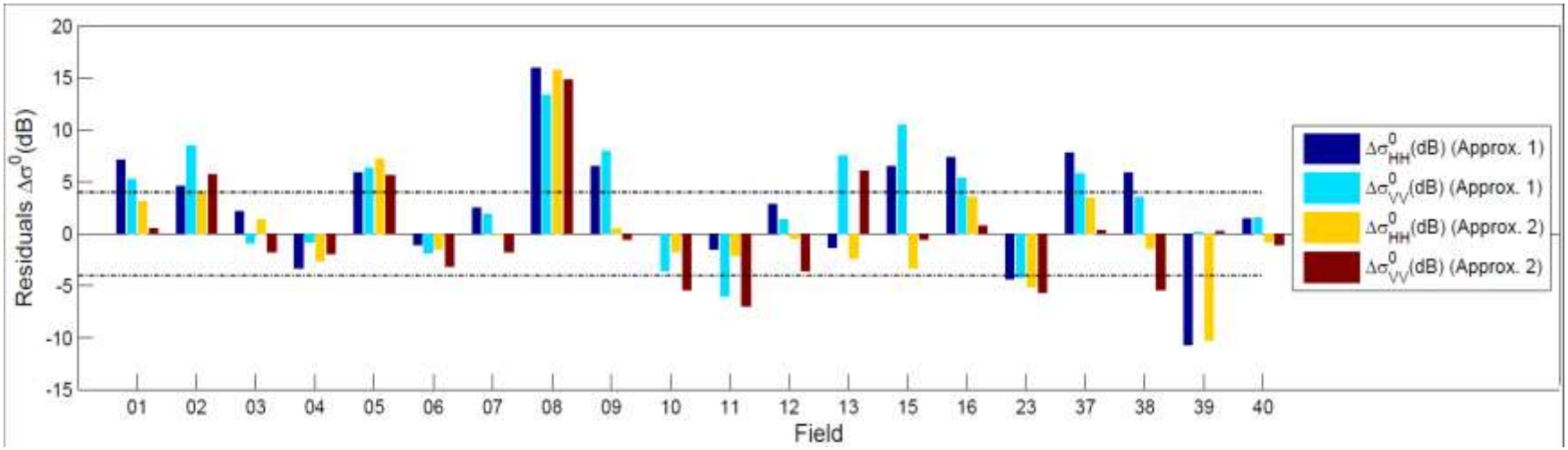
3.Rice-Ground scattering

4.Ground-Rice-Ground scattering

Model inputs and validation

Field	ϕ_0(°)	Δx(m)	Δy(m)	r_c(m)	N_s	r_{stalk}(m)	l_{stalk}(m)	ϵ_{stalk}	N_l	l_{leaf}(m)	w_{leaf}(m)	t_{leaf}(m)	θ_{leaf}(°)	ϵ_{leaf}
01	83.9	3.08E-01	1.45E-01	3.25E-02	16.00	3.23E-03	7.53E-01	(29.6,9.4)	3.33	4.51E-01	1.42E-02	2.00E-04	25.00	(30.6,9.7)
02	-2.8	3.26E-01	1.56E-01	3.47E-02	15.67	2.99E-03	5.94E-01	(30.2,9.6)	6.00	3.92E-01	1.73E-02	2.00E-04	21.39	(29.4,9.4)
03	-7.9	3.05E-01	1.57E-01	4.25E-02	17.33	2.98E-03	7.41E-01	(31.2,9.9)	4.33	4.10E-01	1.50E-02	2.00E-04	25.77	(31.4,9.9)
04	83.5	3.24E-01	1.76E-01	4.08E-02	10.67	3.10E-03	7.98E-01	(34.2,10.8)	4.00	5.07E-01	1.84E-02	2.00E-04	31.67	(25.6,8.2)
05	-8.9	3.15E-01	1.70E-01	3.92E-02	16.33	3.27E-03	8.58E-01	(33.6,10.6)	4.00	5.31E-01	1.65E-02	2.00E-04	22.92	(28.3,9.0)
06	81.2	3.11E-01	1.56E-01	4.17E-02	15.00	3.42E-03	6.65E-01	(33.2,10.5)	3.33	5.29E-01	1.26E-02	2.00E-04	37.50	(42.0,13.1)
07	-36.3	3.24E-01	1.85E-01	3.58E-02	14.00	3.14E-03	8.46E-01	(20.3,6.6)	4.33	5.83E-01	1.87E-02	2.00E-04	25.92	(35.7,11.2)
08	55.6	2.85E-01	1.54E-01	3.83E-02	14.67	3.39E-03	7.23E-01	(32.9,10.4)	4.33	5.71E-01	2.02E-02	2.00E-04	18.62	(27.5,8.8)
09	-31.8	3.33E-01	2.03E-01	4.33E-02	18.67	3.02E-03	7.59E-01	(33.7,10.7)	4.67	4.11E-01	1.64E-02	2.00E-04	21.21	(36.7,11.5)
10	-27.2	2.53E-01	1.59E-01	4.27E-02	16.67	3.20E-03	7.66E-01	(31.6,10.0)	4.67	4.44E-01	1.69E-02	2.00E-04	22.86	(27.9,8.9)
11	83.6	2.84E-01	1.97E-01	3.30E-02	15.67	3.26E-03	6.85E-01	(33.7,10.6)	4.33	5.81E-01	1.88E-02	2.00E-04	18.46	(29.3,9.3)
12	-7.5	3.10E-01	1.71E-01	3.05E-02	10.00	3.14E-03	7.96E-01	(33.4,10.6)	3.33	5.74E-01	1.64E-02	2.00E-04	19.00	(24.6,7.9)
13	86.3	2.78E-01	1.16E-01	3.10E-02	14.00	2.90E-03	6.42E-01	(33.1,10.5)	6.00	3.39E-01	1.32E-02	2.00E-04	17.22	(30.0,9.6)
15	-34.3	3.19E-01	1.60E-01	4.10E-02	18.33	3.94E-03	8.72E-01	(30.3,9.6)	5.00	5.08E-01	1.61E-02	2.00E-04	28.67	(28.7,9.2)
16	-29.0	3.20E-01	1.62E-01	4.22E-02	15.33	3.69E-03	8.72E-01	(29.9,9.5)	4.00	5.76E-01	2.00E-02	2.00E-04	33.75	(22.5,7.3)
23	-34.1	3.31E-01	1.59E-01	4.17E-02	26.67	3.07E-03	7.86E-01	(32.4,10.3)	3.67	5.23E-01	1.53E-02	2.00E-04	24.73	(28.3,9.0)
37	-33.4	3.27E-01	1.54E-01	4.92E-02	17.33	3.76E-03	7.30E-01	(32.4,10.3)	4.33	5.38E-01	1.88E-02	2.00E-04	19.62	(30.4,9.7)
38	-32.5	3.19E-01	1.94E-01	4.08E-02	17.67	3.52E-03	8.35E-01	(35.3,11.1)	4.00	5.22E-01	1.89E-02	2.00E-04	19.58	(32.2,10.2)
39	-10.2	3.25E-01	1.61E-01	2.92E-02	7.67	2.97E-03	6.31E-01	(36.7,11.5)	4.33	4.93E-01	1.98E-02	2.00E-04	19.23	(31.7,10.1)
40	58.1	3.21E-01	1.97E-01	4.43E-02	13.33	3.80E-03	7.24E-01	(36.8,11.6)	4.67	5.60E-01	1.85E-02	2.00E-04	25.00	(32.4,10.3)

Field	l_{ear}(m)	r_{ear}(m)	ϵ_{ear}	a	b	c
01	2.82E-01	9.00E-03	(13.6,4.5)	-2.80E+01	2.99E+00	6.75E-01
02	2.19E-01	7.50E-03	(24.9,8.0)	-1.37E+02	1.03E+01	5.22E-01
03	2.81E-01	7.50E-03	(24.2,7.8)	-2.51E+01	3.09E+00	7.20E-01
04	2.71E-01	7.80E-03	(9.9,3.3)	-2.12E+01	1.95E+00	7.75E-01
05	2.80E-01	8.10E-03	(11.8,3.9)	-2.25E+01	3.91E+00	7.20E-01
06	2.50E-01	8.60E-03	(11.9,3.9)	-4.37E+01	3.21E+00	7.26E-01
07	2.44E-01	7.60E-03	(19.3,6.3)	-2.27E+01	2.94E+00	8.65E-01
08	2.25E-01	8.30E-03	(22.1,7.2)	-3.11E+01	3.85E+00	7.31E-01
09	2.24E-01	8.60E-03	(31.3,9.9)	-1.73E+01	3.60E+00	7.38E-01
10	2.15E-01	6.90E-03	(25.8,8.3)	-2.50E+01	2.65E+00	7.20E-01
11	2.35E-01	7.20E-03	(37.3,11.7)	-1.67E+01	3.93E+00	7.00E-01
12	2.62E-01	7.20E-03	(12.5,4.1)	-1.67E+01	1.29E+00	7.05E-01
13	1.47E-01	5.50E-03	(27.3,8.7)	-5.20E+01	6.48E+00	6.58E-01
15	3.06E-01	7.10E-03	(17.0,5.6)	-2.42E+01	3.39E+00	8.71E-01
16	2.58E-01	9.40E-03	(14.8,4.9)	-1.74E+01	2.64E+00	9.20E-01
23	2.45E-01	7.80E-03	(14.5,4.8)	-2.14E+01	2.45E+00	7.10E-01
37	2.29E-01	6.30E-03	(29.6,9.4)	-2.74E+01	3.26E+00	7.13E-01
38	2.97E-01	7.60E-03	(22.9,7.4)	-1.44E+01	2.40E+00	8.90E-01
39	2.04E-01	5.90E-03	(31.0,9.8)	-5.02E+02	2.00E+01	6.50E-01
40	2.40E-01	7.30E-03	(27.9,8.9)	-6.02E+02	2.42E+01	7.45E-01



JECAM
Joint Experiment for Crop Assessment and Monitoring

GEO GROUP ON EARTH OBSERVATIONS

Conclusion

- **A single polarimetric SAR data acquired 15 days after rice planting can be used to discriminate hybrid and japonica rice, with the accuracy better than 84%.**
- **Eight-temporal Compact SAR data can be used to classify hybrid and japonica rice, with the accuracy above 86% ;**
- **Less than 4 compact parameters from a single compact SAR data can retrieve rice pheological stage, with accuracy of above 85%.**
- **<HH>/<VV>, <VH>/<VV>, Freeman_Volume are most sensitive to rice parameters with growth change.**
- **Based on model simulation, in reproductive stage, the ear layer plays an important role in rice total backscatter.**

Future work

- **Futher validation will be done for rice mapping and phenology retrieval algorithm;**
- **More Field work will be conducted to improved our rice scattering model in order to estimate rice parameters.**
- **The ear layer will be considered for rice yield estimation.**

Thanks!

Yun Shao

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

Email: **shaoyun@radi.ac.cn**

JECAM
Joint Experiment for Crop Assessment and Monitoring

GEO GROUP ON EARTH OBSERVATIONS