香港中文大學 The Chinese University of Hong Kong

Joint Laboratory for Geoinformation Science

Application of C band SAR in monitoring crop growth

Hui Lin, J. S Chen, et al.
(presented by Long Chiu)
Institute of Space and Earth information Science
Chinese University of Hong Kong

ALOS PI Team meeting, Kyoto Japan 19-23 Nov., 2007

Outline

- SAR Mapping of Rice Crop Area
  - Advantages
  - Basis of SAR estimation
- ISEIS Rice Monitoring System
  - Background
  - ASAR measurements
  - Leaf Area Index (LAI) model
  - Mixture model
  - Preliminary results

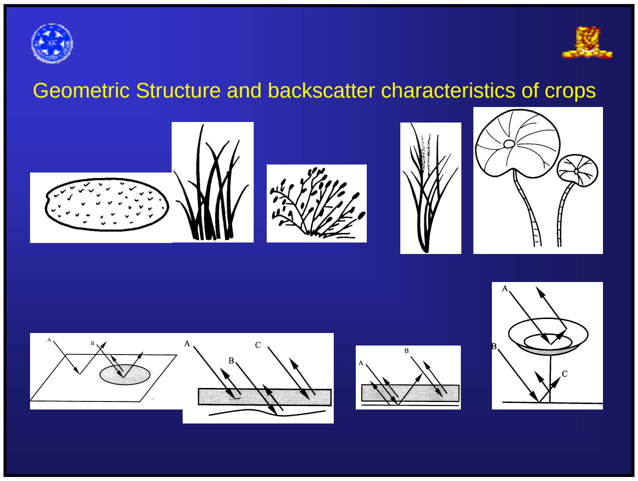
Radar Remote Sensing Advantages and Agricultural Applications

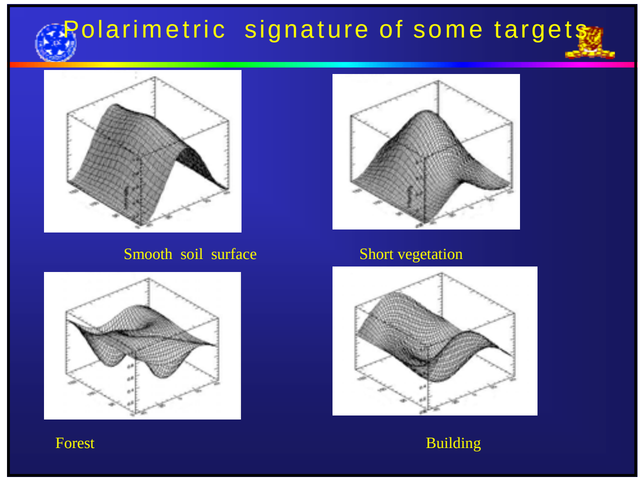
➢ All –weather, day/night imaging capabilities, sensitivity to geometry, moisture content, and surface roughness, penetration capability into a volume such as a soil or vegetative canopy

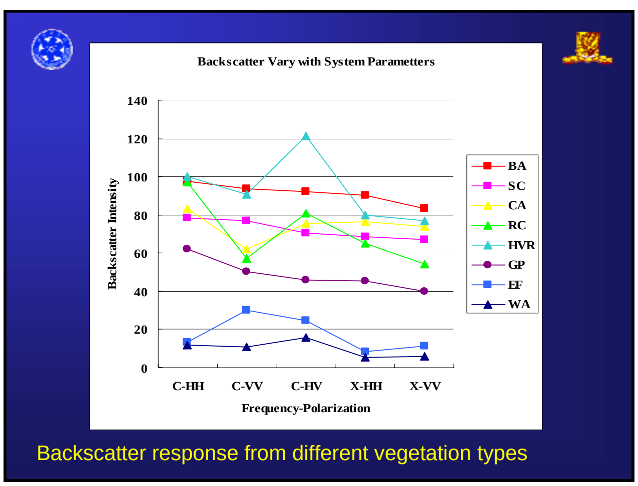
➢ Crop assessment and compliance land use monitoring, and soil condition monitoring. Within each of these applications, information on crop type, crop damage, farming activity, land use and land use change, tillage practices and soil moisture can be derived directly from radar imagery.

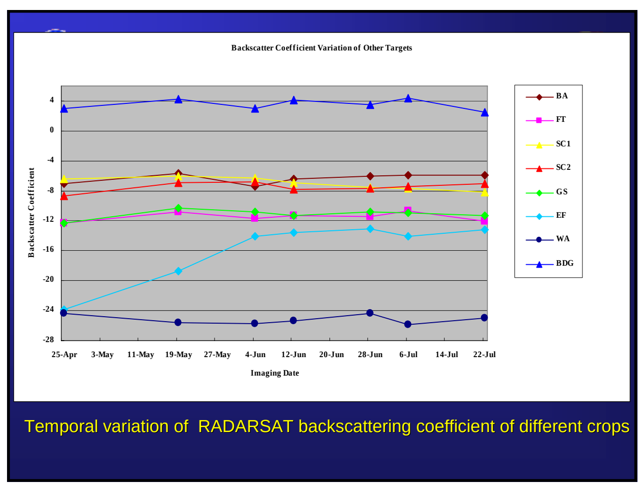
Precondition of application of SAR data in agriculture

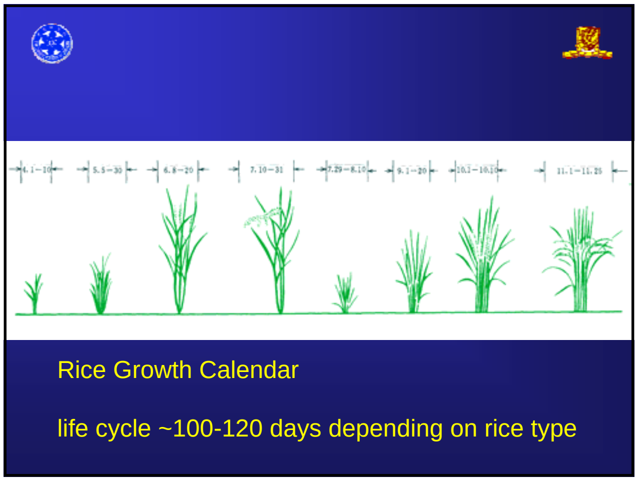
- Crop with different bio-physical condition has different backscattering features
- Temporal variation of backscattering of crop depend on the species of crop.

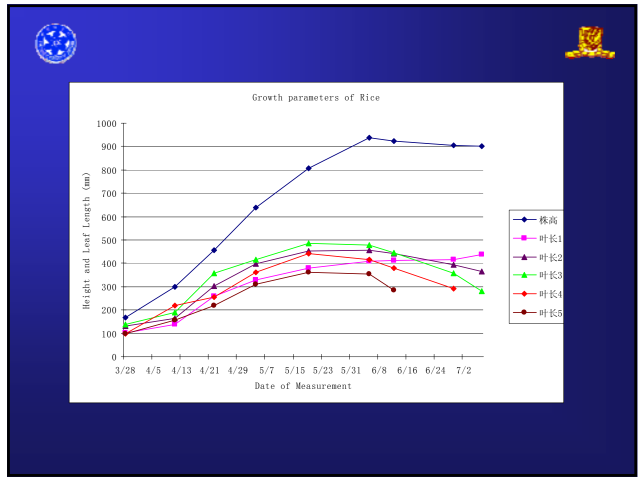

Geometric Structure and backscatter characteristics of crops

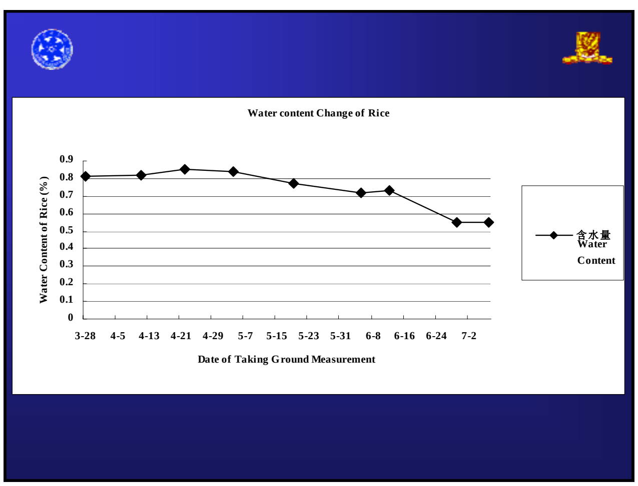

Polarimetric signature of some targets
Smooth soil surface
Short vegetation
Forest
Building

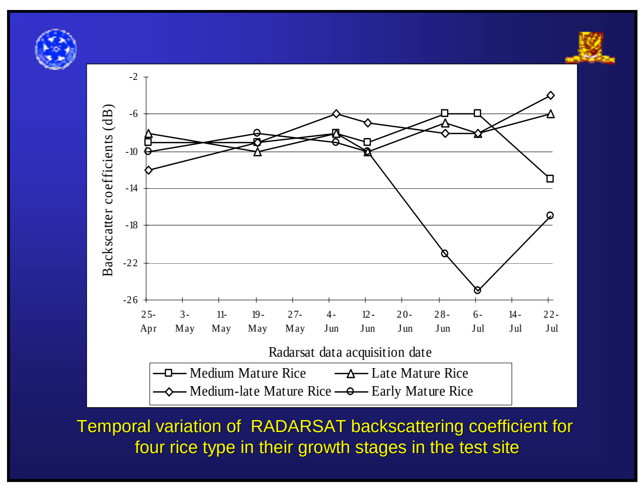

Backscatter Vary with System Paramettes
Backscatter Intensity
140
120
100
80
60
40
20
0
C-HH
C-VV
C-HV
X-HH
X-VV
Frequency-Polarization
BA
SC
CA
RC
HVR
GP
EF
WA
Backscatter response from different vegetation types

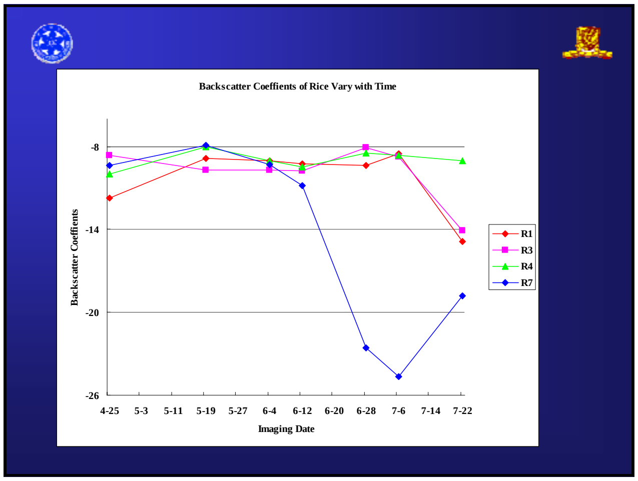

Backscatter Coefficient Variation of Other Targets
Backscatter Coefficient
4
0
-4
-8
-12
-16
-20
-24
-28
25-Apr
3-May
11-May
19-May
27-May
4-Jun
12-Jun
20-Jun
28-Jun
6-Jul
14-Jul
22-Jul
Imaging Date
BA
FT
SC1
SC2
GS
EF
WA
BDG
Temporal variation of RADARSAT backscattering coefficient of different crops

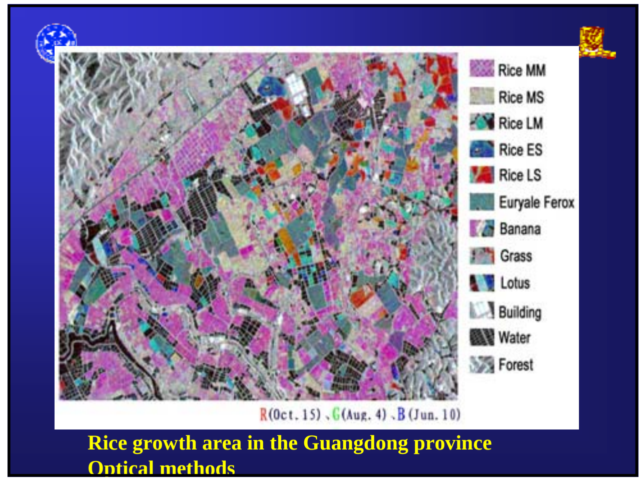

Rice Growth Calendar
life cycle ~100-120 days depending on rice type

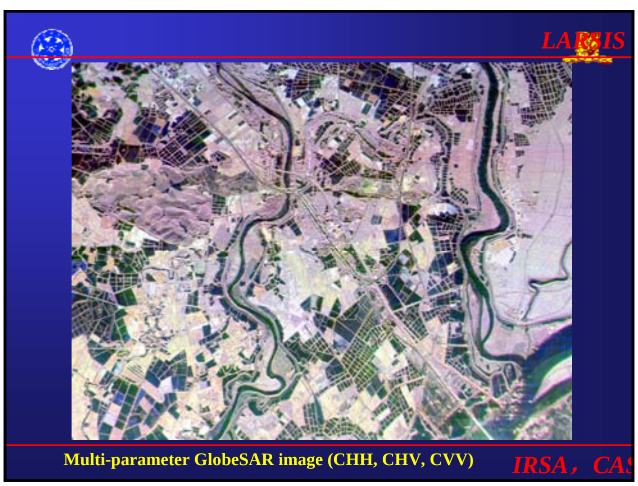

Growth parameters of Rice
Height and Leaf Length (mm)
Date of Measurement
株高
叶长1
叶长2
叶长3
叶长4
叶长5

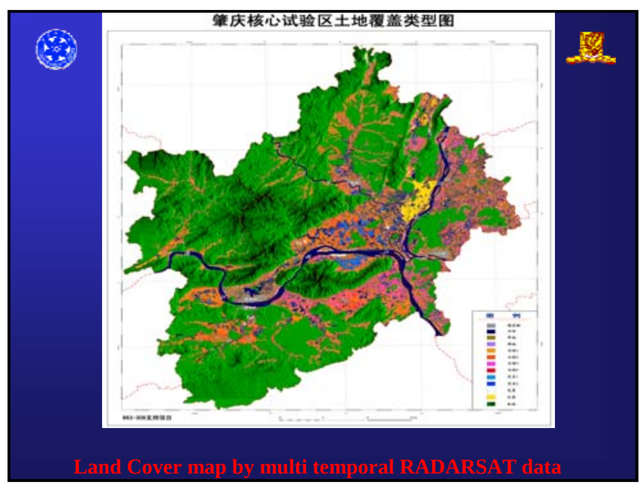

Water content Change of Rice
Water Content of Rice (%)
Date of Taking Ground Measurement
含水量 Water Content


Backscatter coefficients (dB)
Radarsat data acquisition date
Medium Mature Rice
Late Mature Rice
Medium-late Mature Rice
Early Mature Rice
Temporal variation of RADARSAT backscattering coefficient for four rice type in their growth stages in the test site

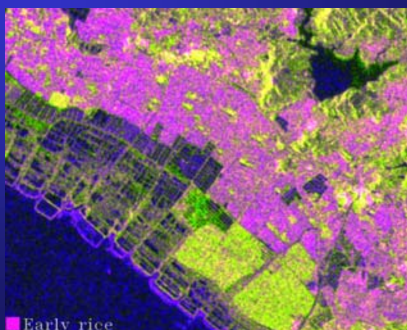

Backscatter Coeffients of Rice Vary with Time
Backscatter Coeffients
-8
-14
-20
-26
4-25
5-3
5-11
5-19
5-27
6-4
6-12
6-20
6-28
7-6
7-14
7-22
Imaging Date
R1
R3
R4
R7


Rice MM
Rice MS
Rice LM
Rice ES
Rice LS
Euryale Ferox
Banana
Grass
Lotus
Building
Water
Forest
R(Oct. 15)、G(Aug. 4)、B(Jun. 10)
Rice growth area in the Guangdong province
Optical methods


LARSIS
Multi-parameter GlobeSAR image (CHH, CHV, CVV)
IRSA，CAS


肇庆核心试验区土地覆盖类型图
Land Cover map by multi temporal RADARSAT data

Hong Kong Innovative Fund（ITF)—Rice monitoring system

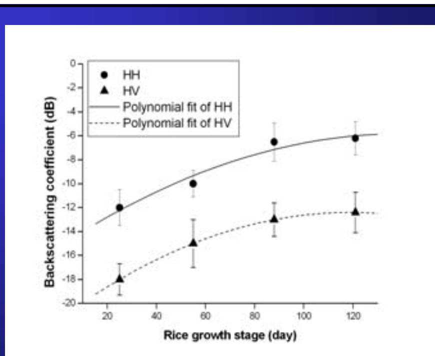


香港中文大学卫星地面站第一期工程地址
Location of first phase of CUHK Ground Station

地面站控制中心 Ground Control Center

ENVISAT ASAR parameters

Product ID	Product Name	Nominal Resolution(m) (range x azimuth)	Nominal Pixel Spacing (m) (range x azimuth)	Approx.Coverage (km) (range x azimuth)	Equivalent No. of Looks
IMP	Image Mode Precision 2.6.2.1.1.2.1.2.	30 x 30	12.5 x 12.5	56-100 x 100	> 3
IMS	Image Mode Single-Look Complex 2.6.2.1.1.2.1.1.	9 x 6 - -	natural	56-100 x 100	1
IMG	Image Mode high-resolution Ellipsoid Geocoded 2.6.2.1.1.2.1.3.	30 x 30	12.5 x 12.5	56-100 x 100	> 3
IMM	Image Mode medium-resolution 2.6.2.1.1.3.1.1.	150 x 150	75 x 75	56-100 x 100	40
IMB	Image Mode Browse 2.6.2.1.3.1.1.	450 x 450	225 x 225	56-100 x 100	80
APP	Alternating Polarisation Precision Image 2.6.2.1.1.2.1.5.	30 x 30	12.5 x 12.5	56-100 x 100	> 1.8
APS	Alternating Polarisation Single-Look Complex 2.6.2.1.1.2.1.4.	9 x 12	natural	56-100 x 100	1
APG	Alternating Polarisation Mode high-resolution Ellipsoid Geocoded 2.6.2.1.1.2.1.6.	30 x 30	12.5 x 12.5	56-100 x 100	> 1.8
APM	Alternating Polarisation Mode medium-resolution 2.6.2.1.1.3.1.2.	150 x 150	75 x 75	56-100 x 100	50
APB	Alternating Polarisation Mode Browse 2.6.2.1.3.1.1.	450 x 450	225 x 225	56-100 x 100	75
WSM	Wide Swath Mode medium-resolution 2.6.2.1.1.3.1.3.	150 x 150	75 x 75	400 x 400	11.5
WSB	Wide Swath Mode Browse 2.6.2.1.3.1.3.	1500 x 1500 (approximately)	900 x 900	400 x 400	30 to 40
WVI	Wave Mode Imagette and Imagette Power Spectrum 2.6.2.1.2.1.1.	9 x 6	natural	5 x 5	1
WVS	Wave Mode Image Spectra 2.6.2.1.2.1.2.	N/A	N/A	5 x 5	N/A
GMI	Global Monitoring Mode Image 2.6.2.1.1.3.1.4.	1000 x 1000	500 x 500	400 x 400	7 - 9
GMB	Global Monitoring Mode Browse	2000 X 2000	1000 x 1000	400 x 400	11 - 15



Temporal variation of ASAR backscattering coefficient in four rice growth stages in the test site

April *July*

Estimation of Rice LAI

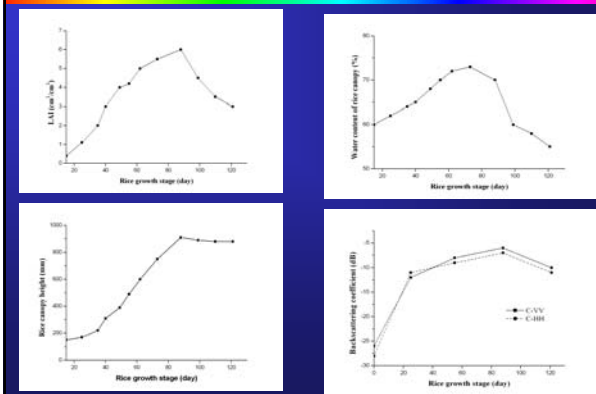
- Rice is China staple grain and accounts for about 42% of the crop yield of China
- Quantify crop yield using LAI
- Crop growth area and yield can be estimated if the growth of the crops is being monitored during the growing season.
- The crop variable leaf area index (LAI) is an important measure of crop growth
- Optical remote sensing data has been used in estimating the LAI regularly during the growing season
- Need to examine the use of SAR data

- Most paddy rice in southern China grows in a warm, humid environment with heavy cloud cover and rainfall. Acquisition of cloud-free optical remote sensing data in rice growing regions is difficult.
- Synthetic Aperture Radar (SAR) can provide coverage for crop monitoring in tropical and sub-tropical regions due to its all day and all weather imaging capability and frequent revisit schedule.
- The use of SAR for estimating LAI of rice has not been fully exploited.

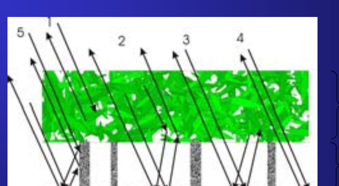
➢In this study LAI, water content and height of rice were measured at the same time as the acquisition of ENVISAT Advanced Synthetic Aperture Radar (ASAR) alternating polarization data over the whole growth season for the test site in southern China’s Guangdong Province.

➢The data are analyzed using a semi-empirical backscattering model based on LAI and water content

Experimental measurements

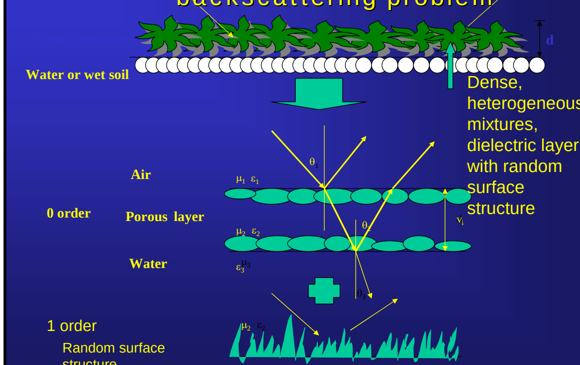


Microwave scattering model



. MIMICS forest model

Physical model of paddy field backscattering problem



Method

The relations between LAI, water content and height of rice may be established so that LAI can be used as an input in a backscattering model instead of water content and height:

$$LAI = a*m_g*h + b \qquad (1)$$

Semi-empirical model

Rice stalk Is short compared to tree, and so the scattering component associated with ground-trunk scattering in backscattering physical model like MIMICS can be further simplified to get a semi-empirical model similar to cloud models for describing the backscattering behavior of rice:

$$\sigma pq = \sigma v *(1-Tpq) + \sigma s*Tpq \qquad (2)$$

$$Tpq=exp(-k*h*sec\,\theta) \qquad (3)$$

Semi-empirical model

$$K = \frac{2\pi\varepsilon_m''}{\lambda\sqrt{\varepsilon_m'}}$$

$$\varepsilon_m = \varepsilon_h + \frac{v}{3}(\varepsilon_i - \varepsilon_h)\left(2 + \frac{\varepsilon_m}{\varepsilon_i}\right)$$

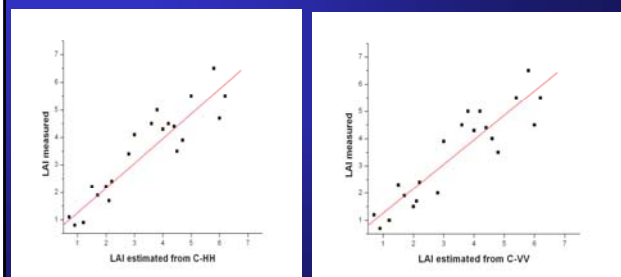
ε_m, ε_i and ε_h are complex dielectric of mixture, rice and air, respectively. Air is host material in this mixture model. ν is fractional volume of vegetation material

Previous research has shown that the backscatter of the crop canopy displays an approximately exponential function response to gravimetric moisture of crop canopy and the extinction coefficient of a vegetation leaf of the crop canopy varies approximately linearly with the gravimetric moisture. Therefore, the parameters in (2) can be assumed as :

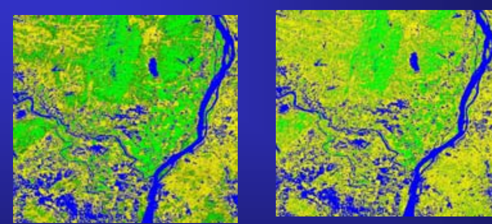
$$\sigma v = a*mwb * \cos(\theta)/ 2k$$

σs can be calculated using volumetric soil moisture mv and root square mean roughness deviation s of soil

Backscatter and measured LAI relation



Comparison of ASAR with TM Retrieval



TM LAI

Estimated LAI from ASAR C-HH

LAI 0.2 → 7.6

Great potential of L band PALSAR in agriculture application

- Higher spatial resolution capability
- Higher wave length
- Full polarimetry

Thanks for your attention!