1　電波による地球環境計測

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東北大学　東北アジア研究センター

リモートンシング用センサ

光学センサ

多周波数情報が得られる

マイクロ波センサ

雲の影響を受けない

受動センサ

送信器がいらない

能動センサ

季節・時間・天候に左右されない

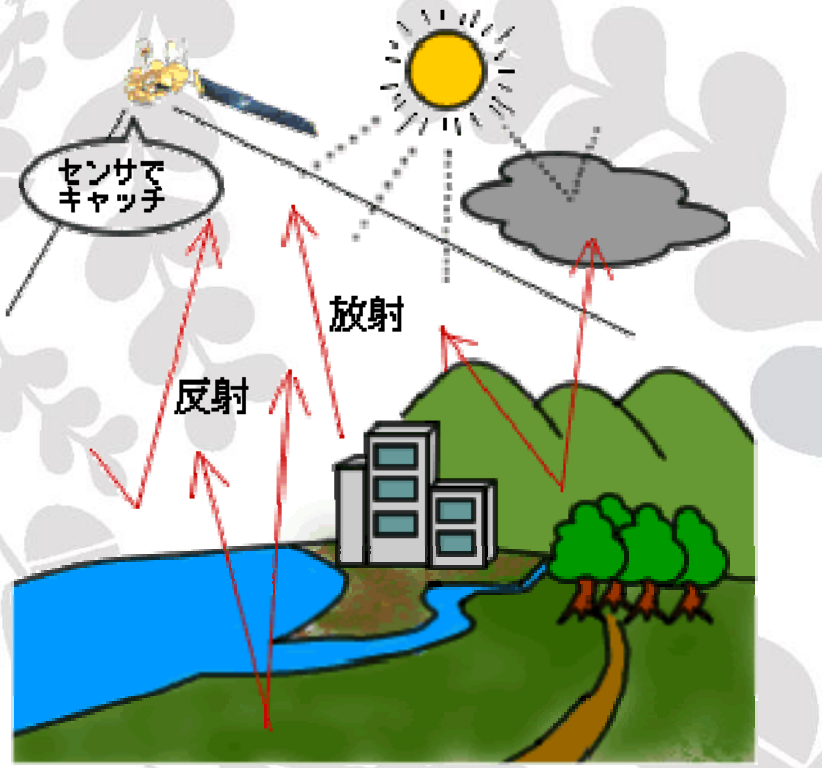
受動センサ

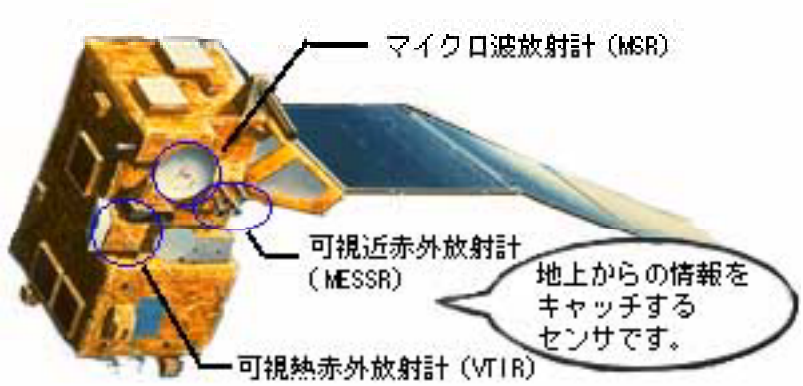
太陽光などの物体表面での反射

熱によって発生する固有の電磁波

- 赤外線
- 可視光線
- マイクロ波

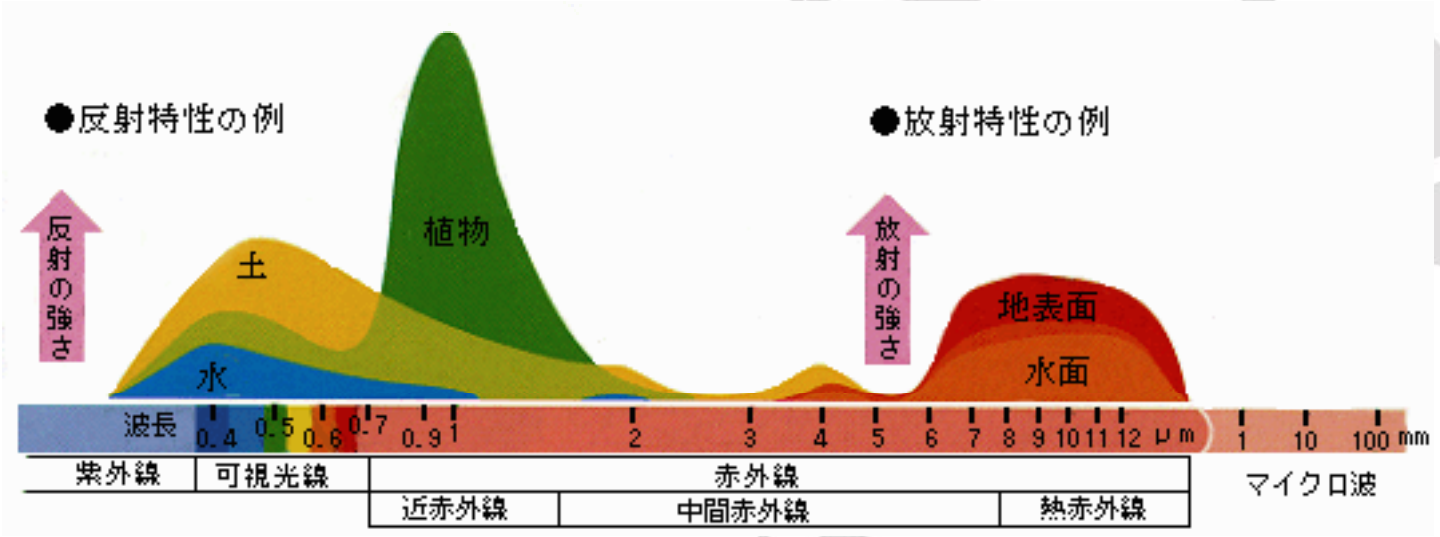
（これらの総称が電磁波）

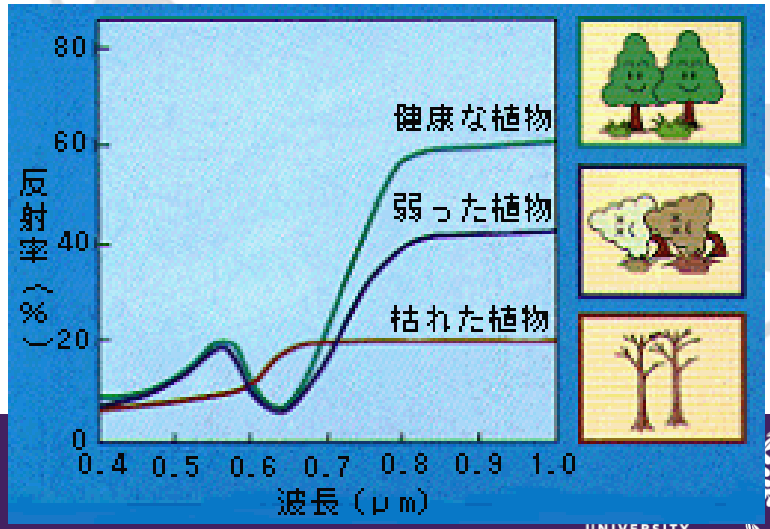




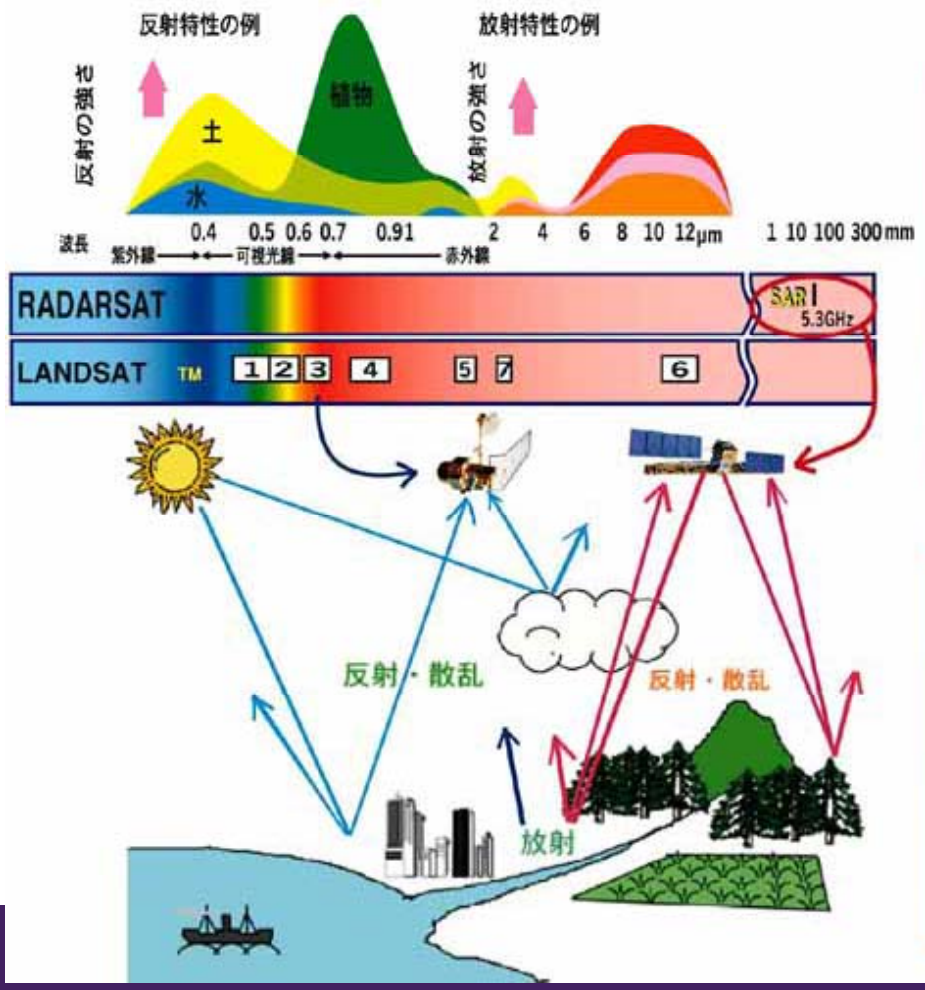
海洋観測衛星1号「もも1号」（MOS-1）

物質による電磁波の反射と放射





光学センサとマイクロ波センサ



マイクロ波 (SAR) センサ

光学センサ

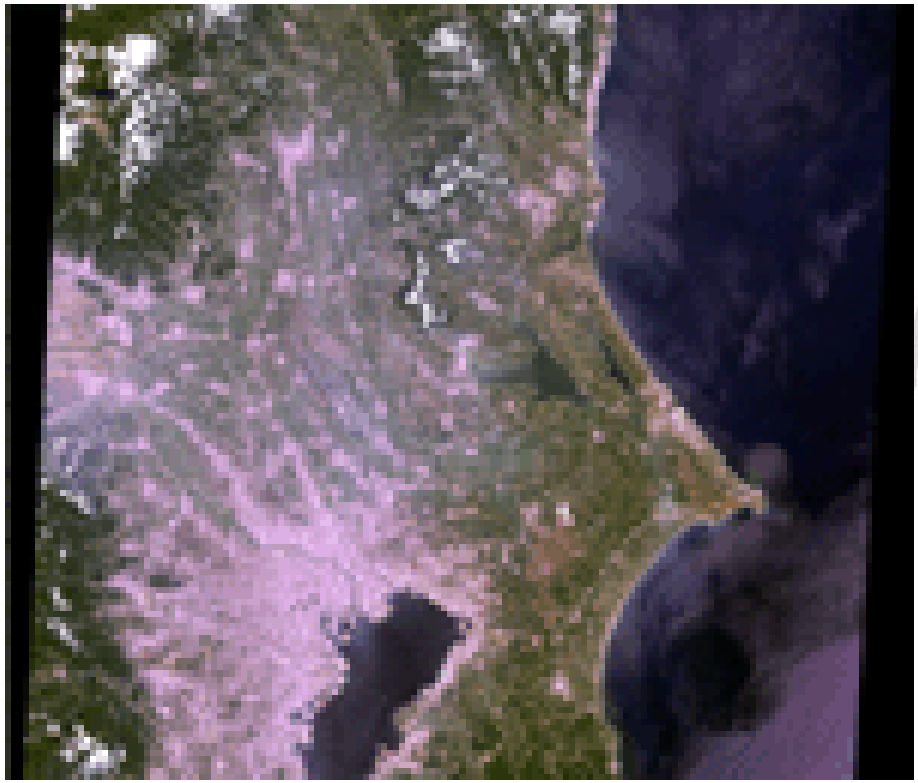
マルチチャネル情報

地表の状態・地表利用識
別に必要な情報と解析

ハイパースペクトル（多周波情報）

ポーラリメトリ　　（偏波情報）

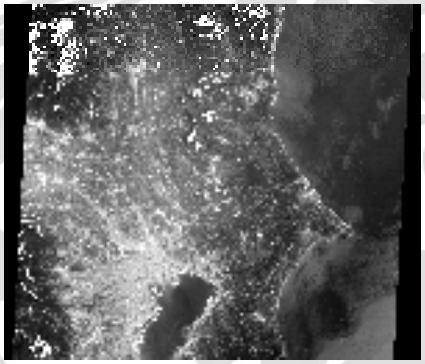
カラー表示



Landsat　TM

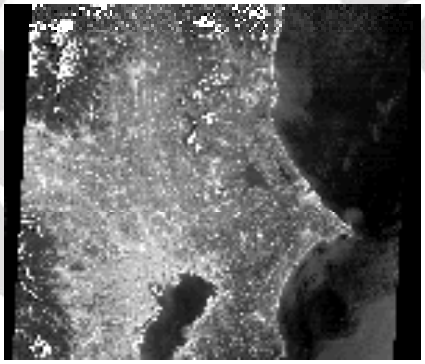
Blue

band1



Green

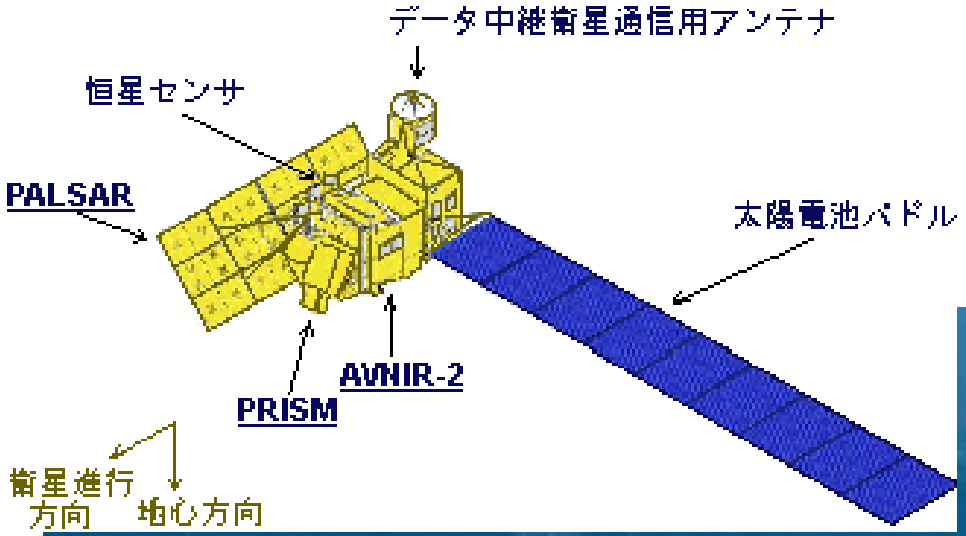
band2



Red

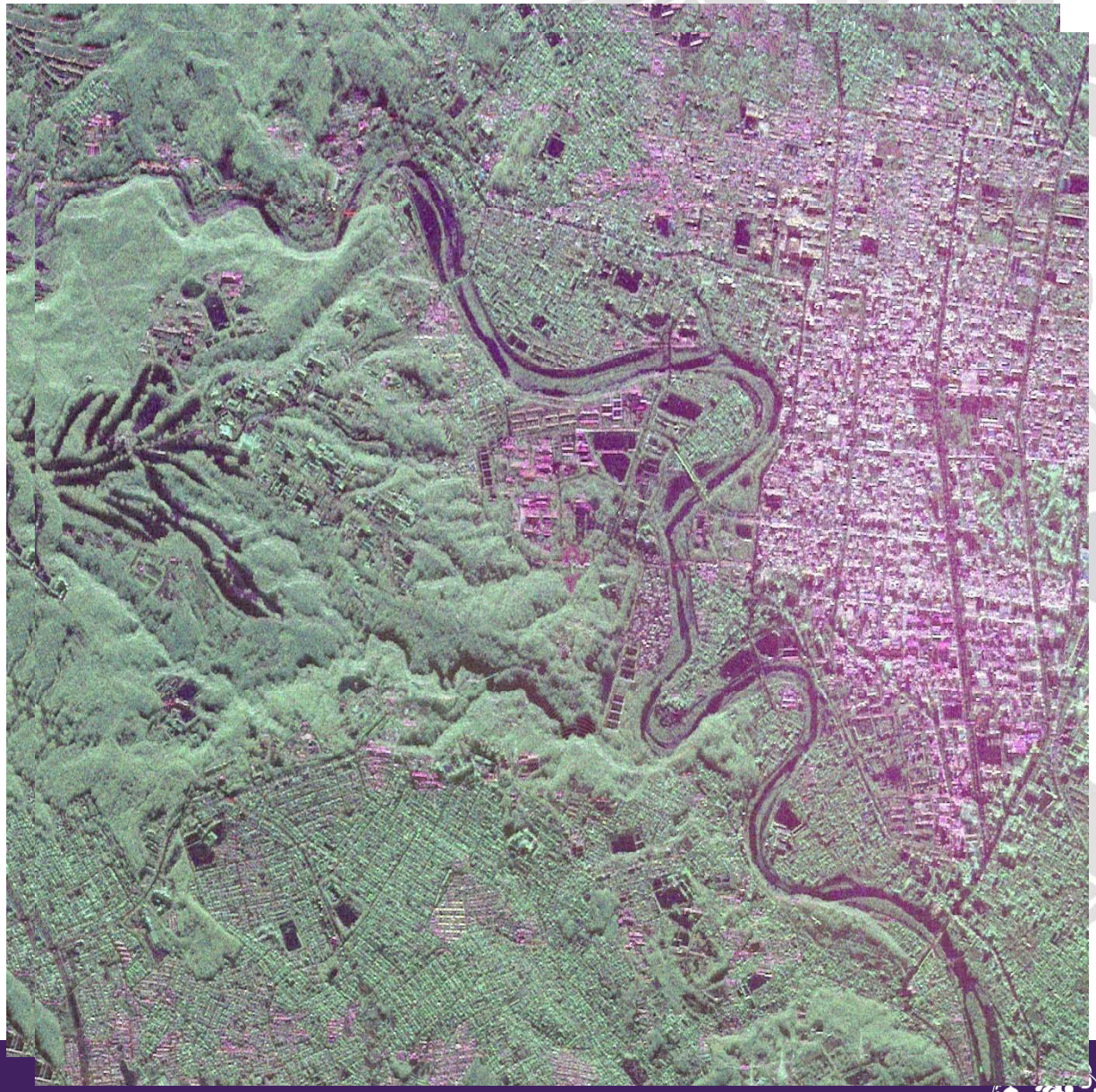
band3

Pi-SAR+ALOS


データ中継衛星通信用アンテナ
恒星センサ
PALSAR
太陽電池パドル
AVNIR-2
PRISM
衛星進行方向
地心方向


DAS
JA8431
Diamond Air Service

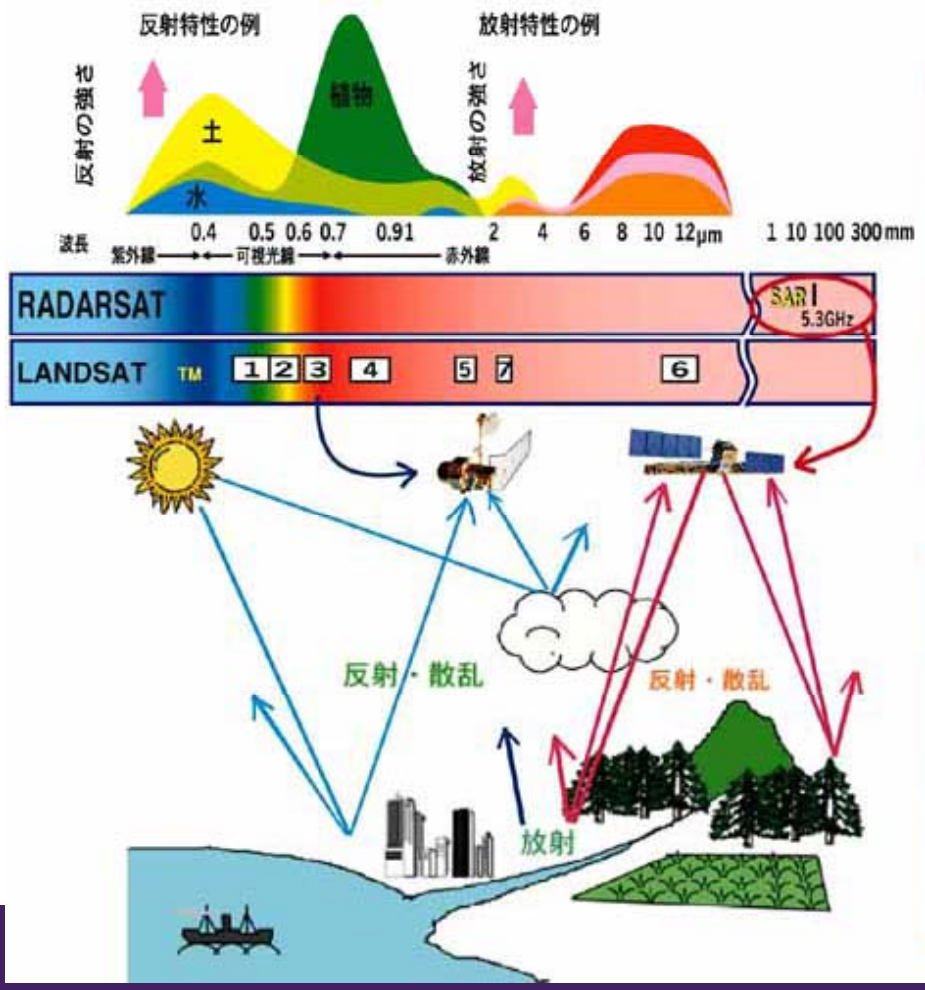
Pi-SAR



Red:HH
Green:HV
Blue:VV

L-band,
30/08/2001 仙台市

光学センサとマイクロ波センサ



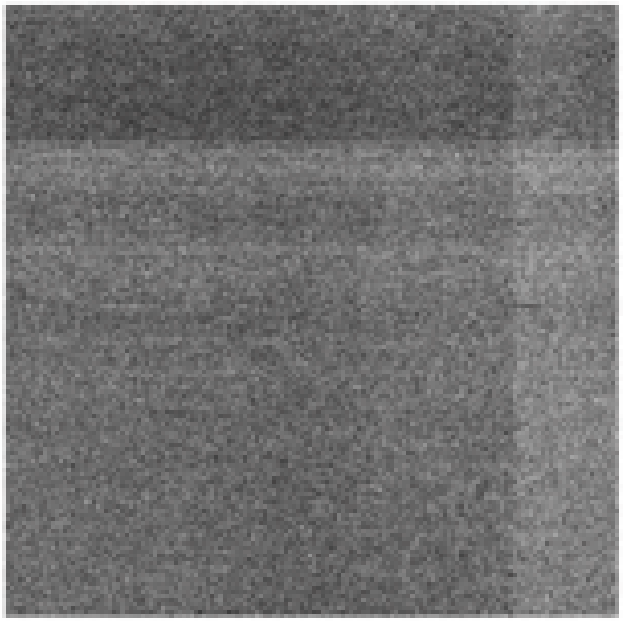
マイクロ波 (SAR) センサ

光学センサ

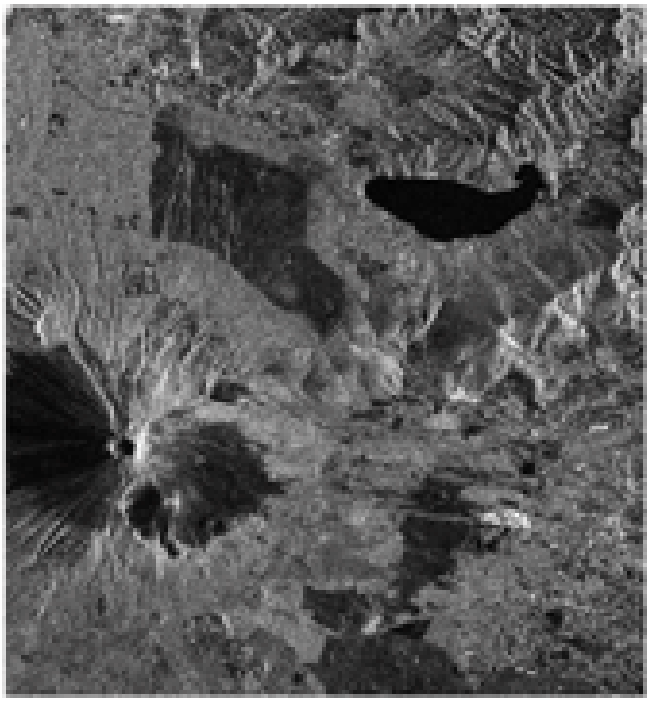
JERS-1 （ふよう）

JERS-1は地球の全陸域を観測し、資源探査を主目的に国土調査、農林漁業、環境保全、防災、沿岸監視等の定常観測を行う地球観測衛星。平成４年２月１１日に種子島射場よりH-Iロケットで衛星高度568km、回帰日数44日の太陽同期準回帰軌道に打ち上げ。

Microwave Remote sensing
SAR



a)raw data



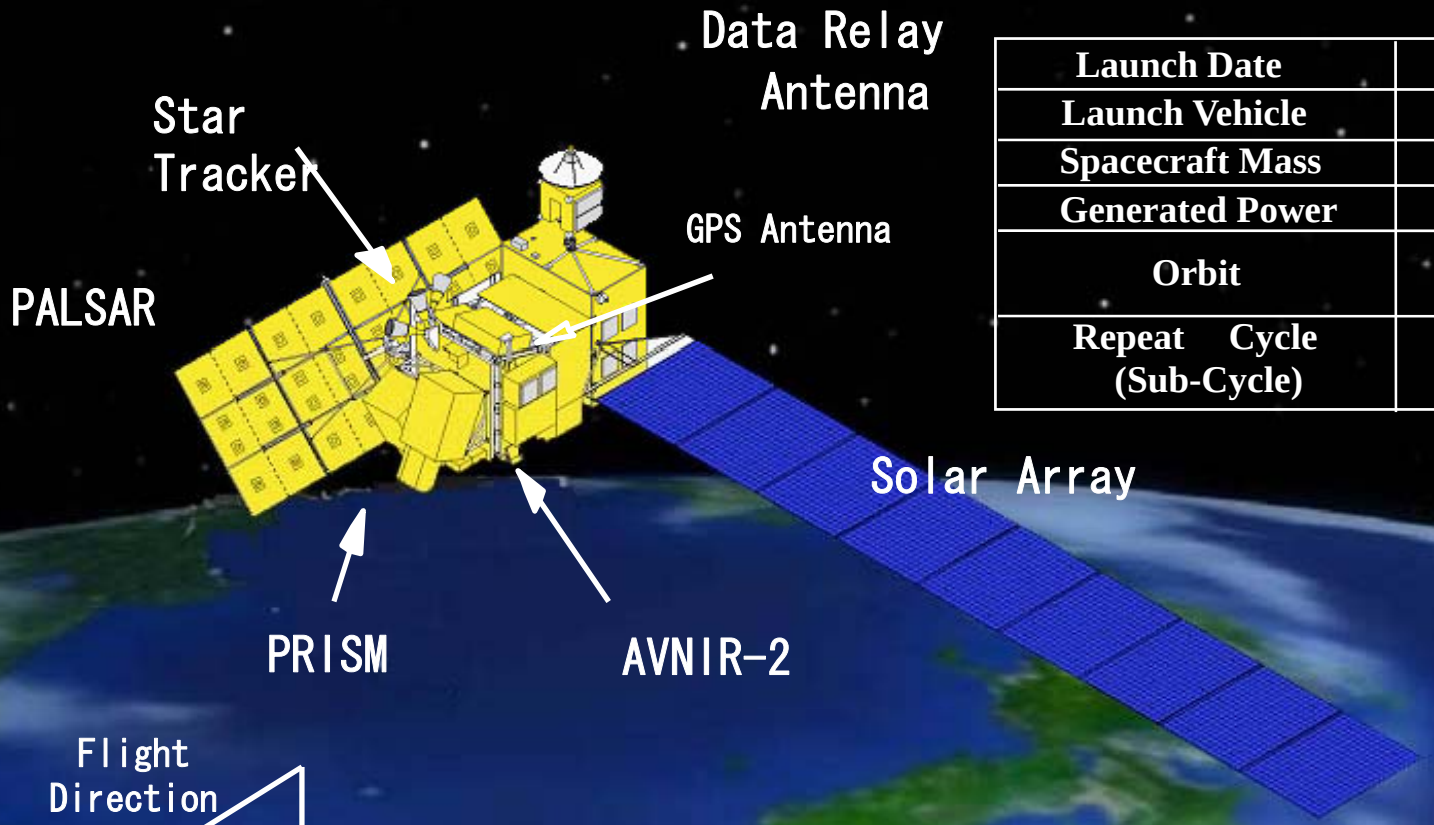
b)correlated data

Raw data

SAR processed image

JERS-1, ©METI/NASDA

ALOS　2006年1月24日打ち上げ



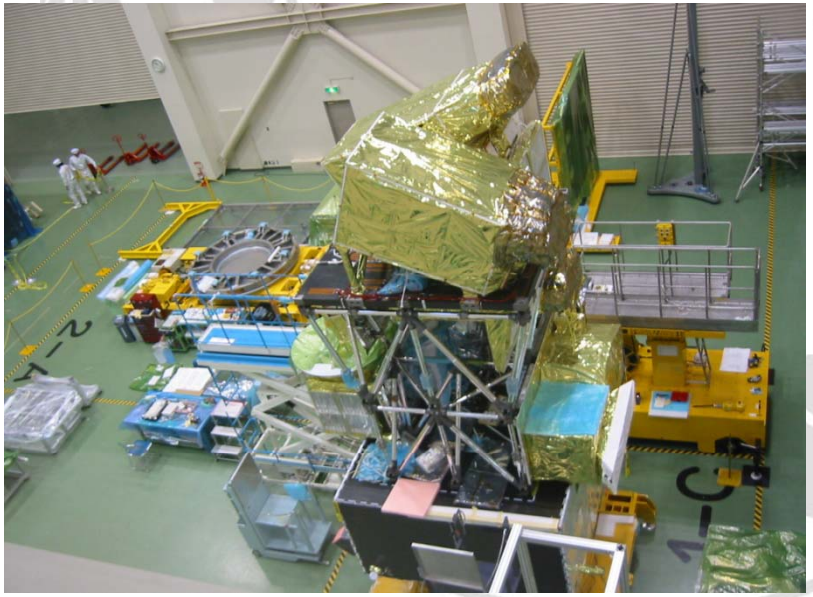
Launch Date	January 2006
Launch Vehicle	H-IIA
Spacecraft Mass	4,000kg
Generated Power	7kW
Orbit	691.65km Sun Synchronous
Repeat Cycle (Sub-Cycle)	46 days (2 days)

PRISM　:標高抽出を行うためのパンクロマチック立体視センサ
AVNIR-2:土地被覆の観測を行うための高性能可視近赤外放射計2型
PALSAR:フェーズドアレイ方式Lバンド合成開口レーダ

H-IIA 8th Launch

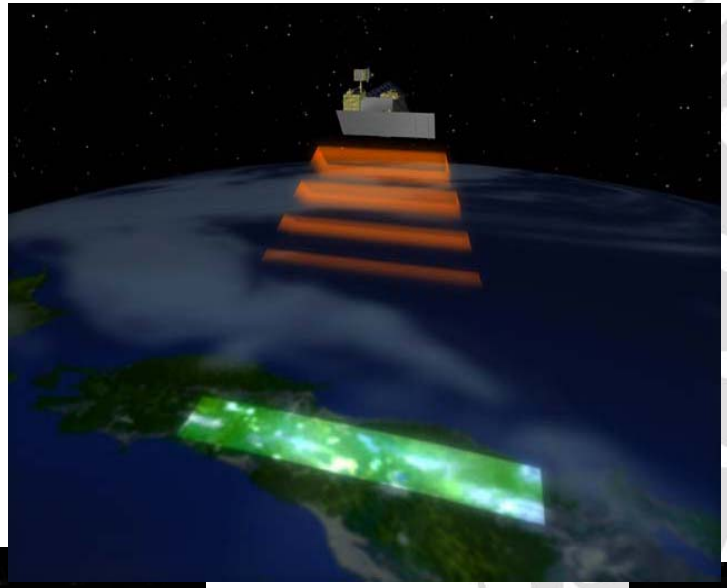
January 2006 (JAXA:宇宙航空研究機構)

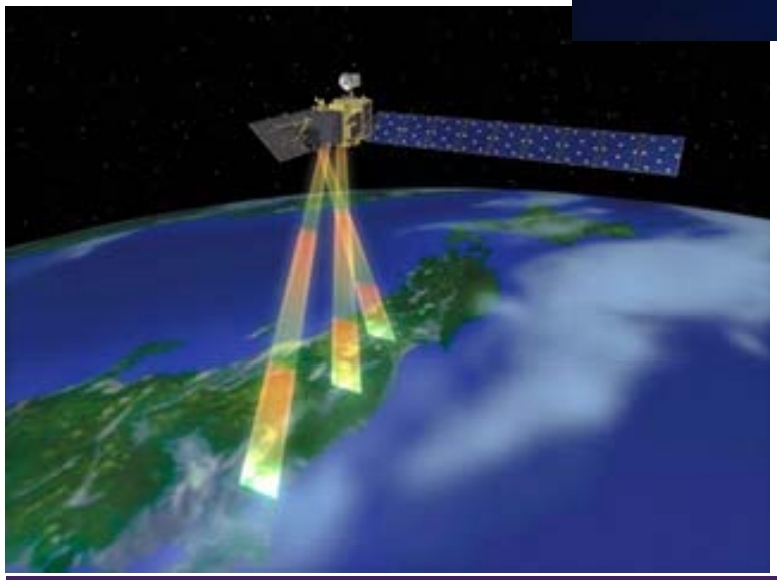
ALOS under assembly in Tsukuba Center

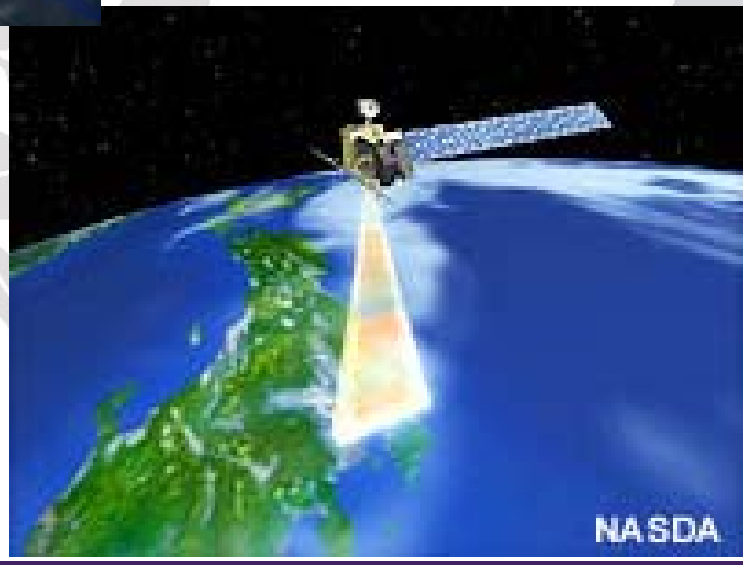


http://www.jaxa.jp/missions/projects/sat/eos/alos/index_j.html

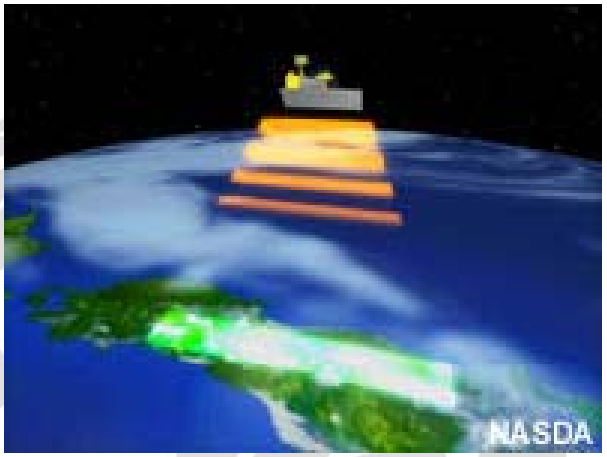
ALOS/PALSAR-PRISM-AVNIR2







PALSAR specifications

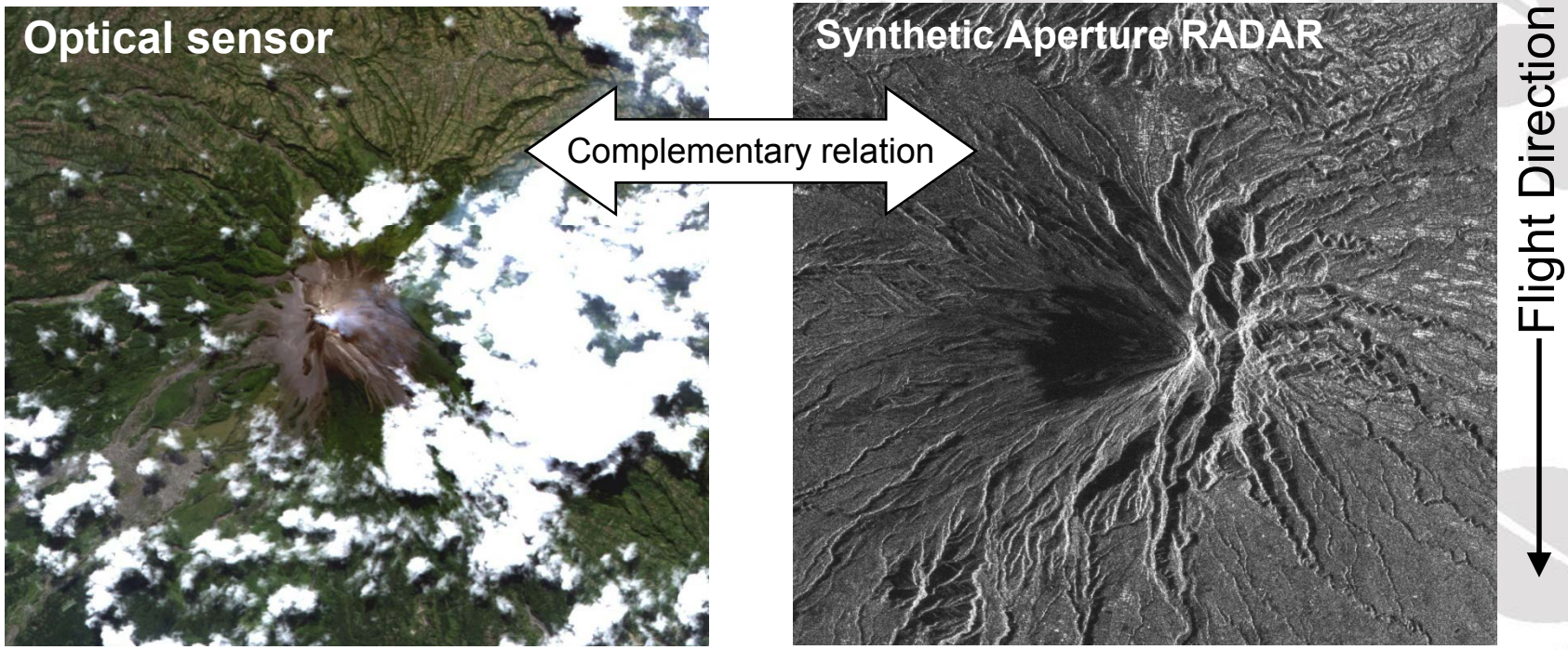


Observation mode	High resolution	Broad observation
Frequency	L-band(1.27GHz)	
Polarization	HH,VV,HH&HV,VV&VH	HH,VV
Resolution	10m	100m
Swath width	70km	250-350km
Off nadir angle	10-51 degree	
Noise-RCS	Ca. -23dB	

Optics vs. SAR

Advantages of RS by EOS
- -Extensive Coverage and Contemporaneousness
- -Periodicity
- -Workability

Mt. Merapi, Indonesia, April 29th, 2006

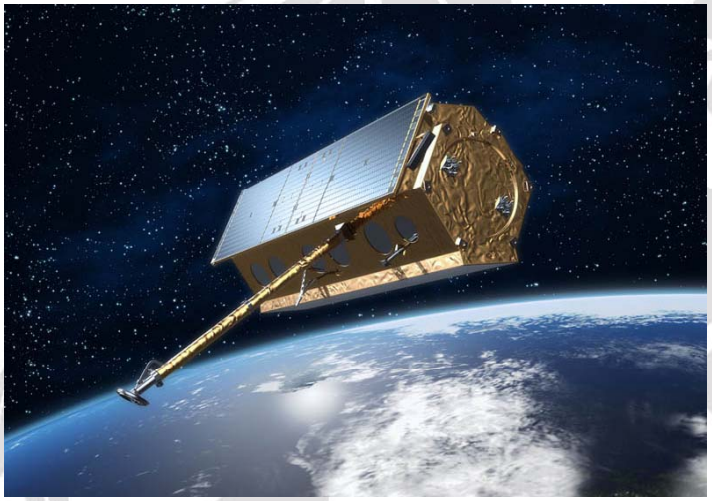


ALOS/AVNIR-2（可視近赤外放射計2型）

ALOS/PALSAR

SAR Remote Sensing by Satellite

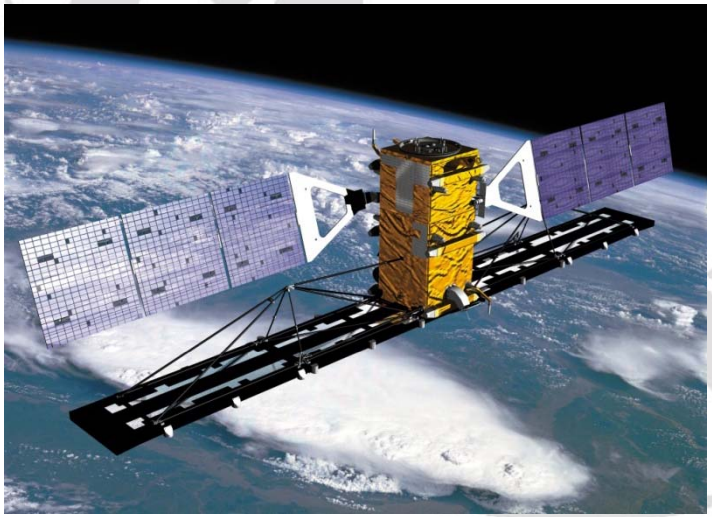
ALOS/PALSAR, Japan, January 24, 2006, L-band
(Nicknamed as “Daichi”.)



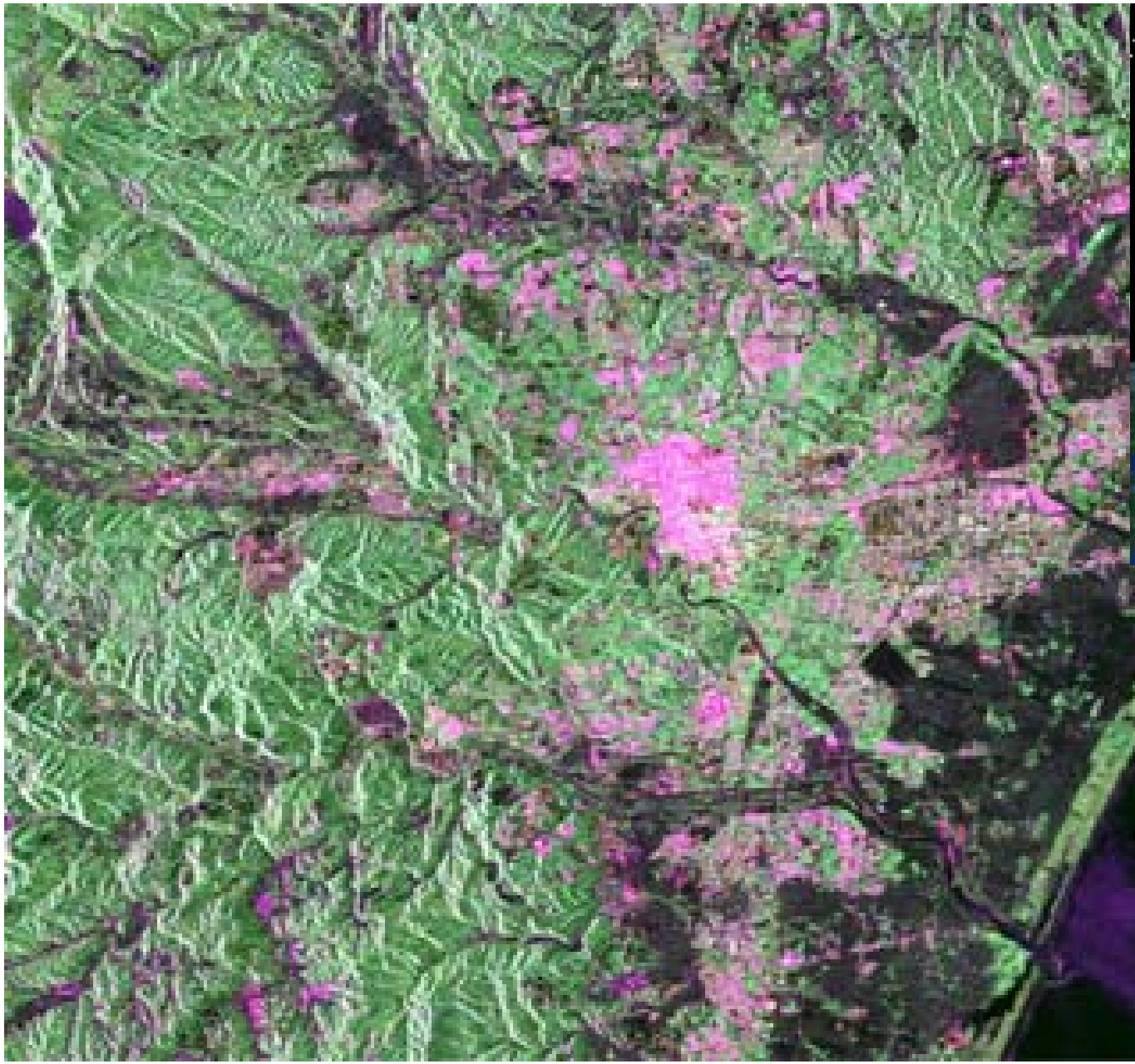
TerraSAR-X, Germany、June, 2007, X-band

-Each sensor can operate
Quad polarizations observation.
(HH, HV, VH, VV)

⇨ Polarimetric SAR
(POLSAR)



RADARSAT-2, Canada, March, 2007, C-band



CENTER FOR
NORTHEAST
ASIAN STUDIES

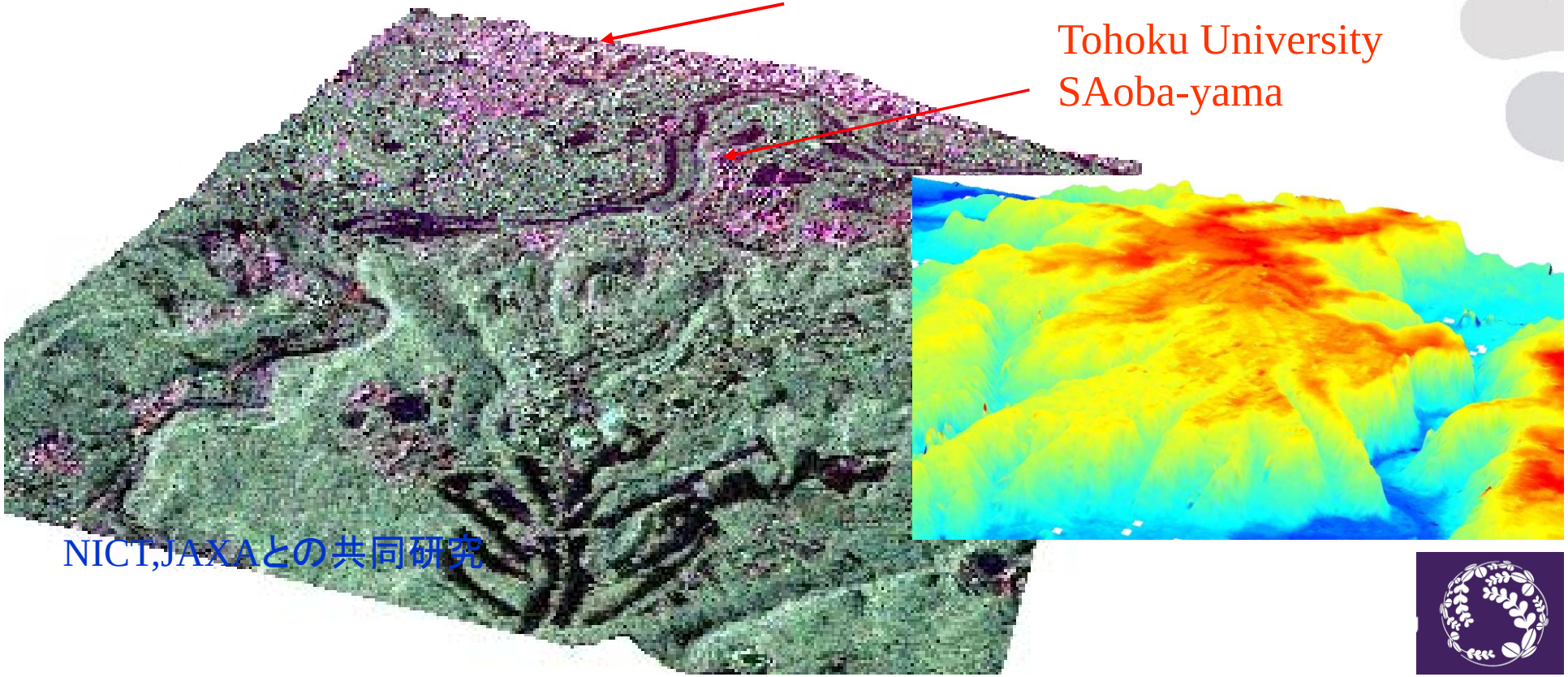
ALOS 「だいち」

TOHOKU
UNIVERSITY

DEM of Sendai city by Pi-SAR

Tohoku University
Amemiya

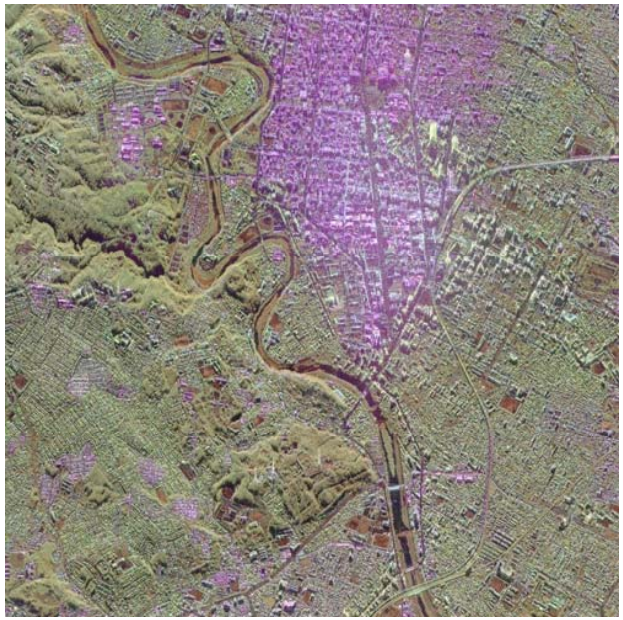
Tohoku University
SAoba-yama



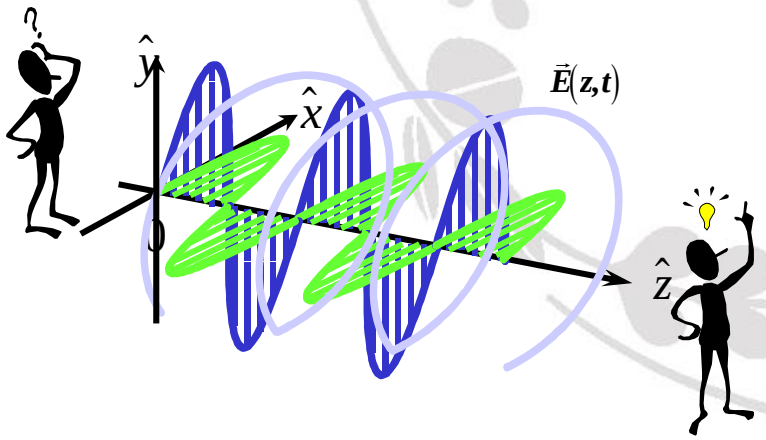
NICT,JAXAとの共同研究

Direct Information provided by Radar Polarimetry

$$[\mathbf{S}] = \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix} = \left|\sigma^0\right| e^{j\phi_{HH}} \begin{bmatrix} 1 & \tilde{S}_{HV} \\ \tilde{S}_{VH} & \tilde{S}_{VV} \end{bmatrix}$$

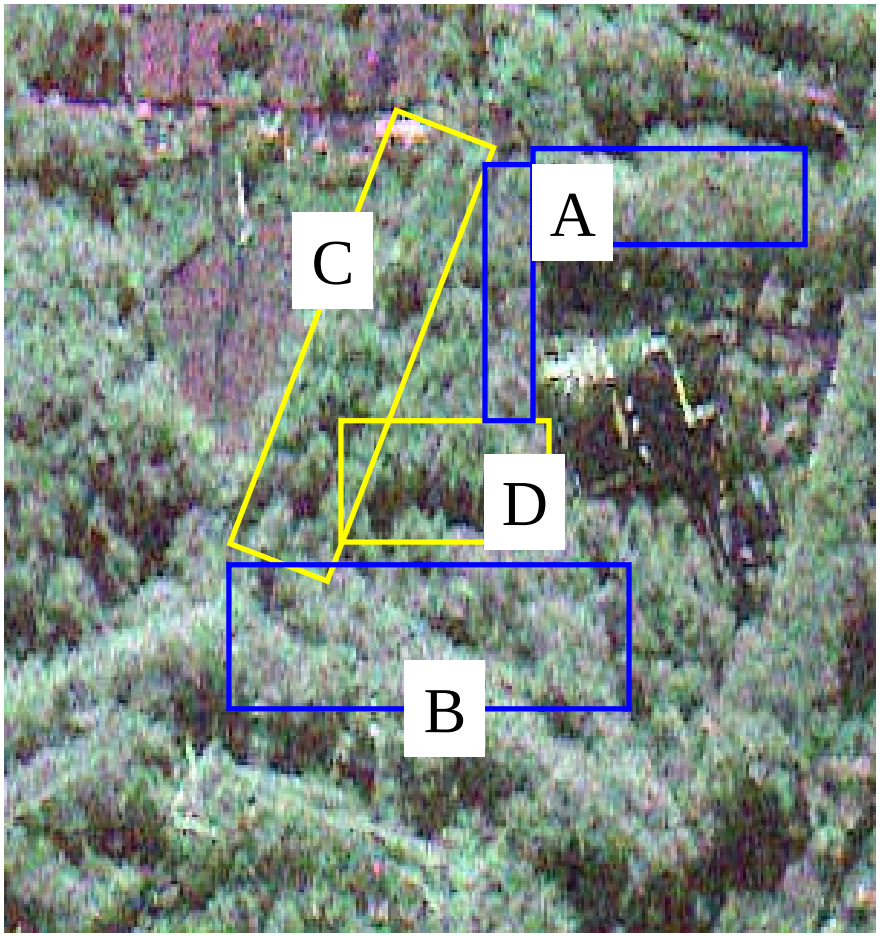


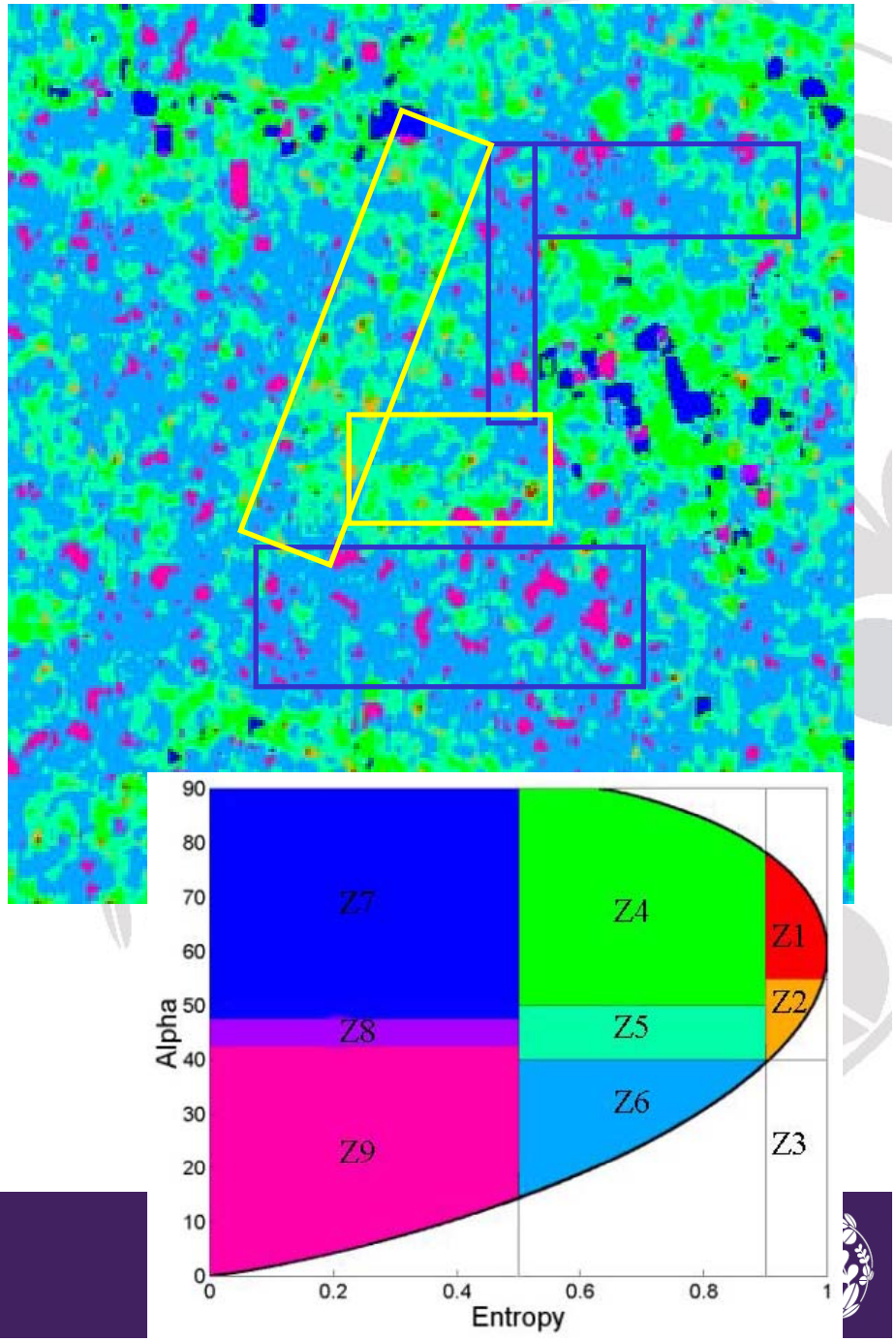
Sinclair Matrix
Scattering Matrix




Sendai by ALOS/PALSAR

Pi-SAR classification of forest trees

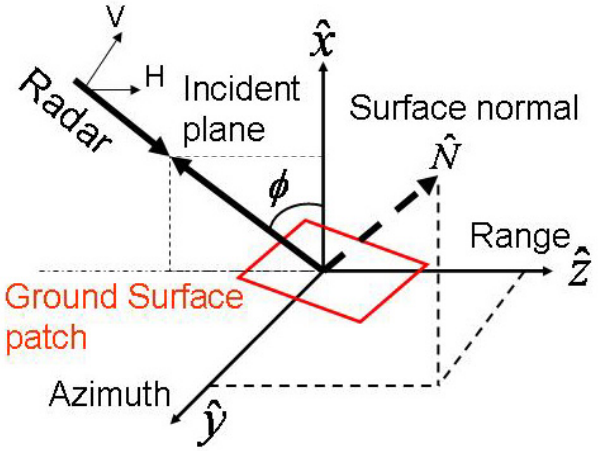




X-band, 30/08/2001　375m*400m

Polarization Orientation Angle

(直交円偏波基底の位相差)



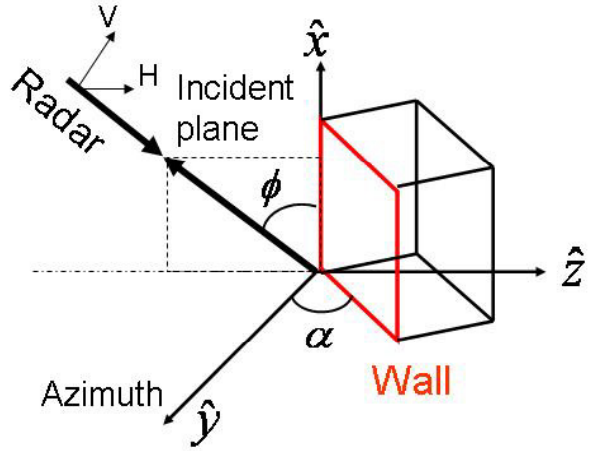
Induced by Ground Surface Patch

Jong-Sen Lee, Dale L. Schuler, et al.

The induced polarization orientation angle shift θis represented,

$$\tan\theta = \frac{-\tan\omega}{-\tan\gamma\cos\phi + \sin\phi}$$

Where tanω is the azimuth slope, tan**γ** is the range slope, **φ** is the radar look angle.



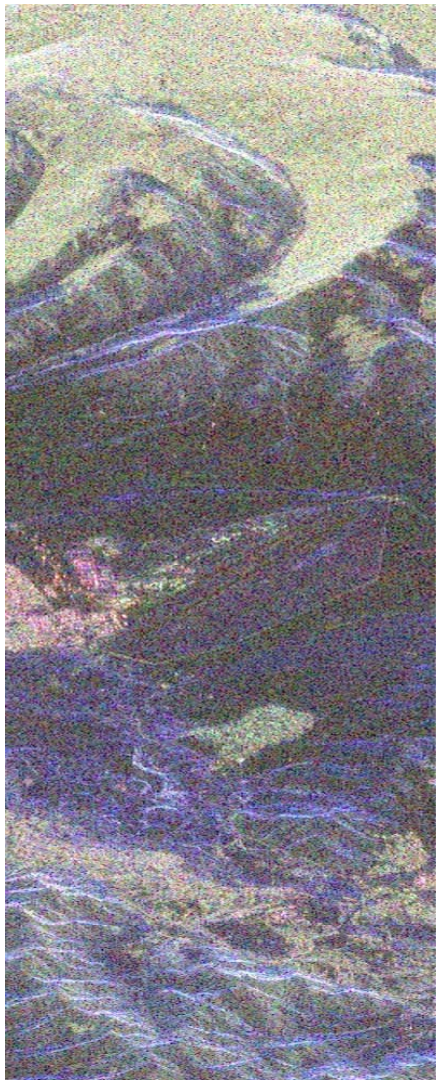
Induced by Dihedral Structure

Hiroshi Kimura, et al.

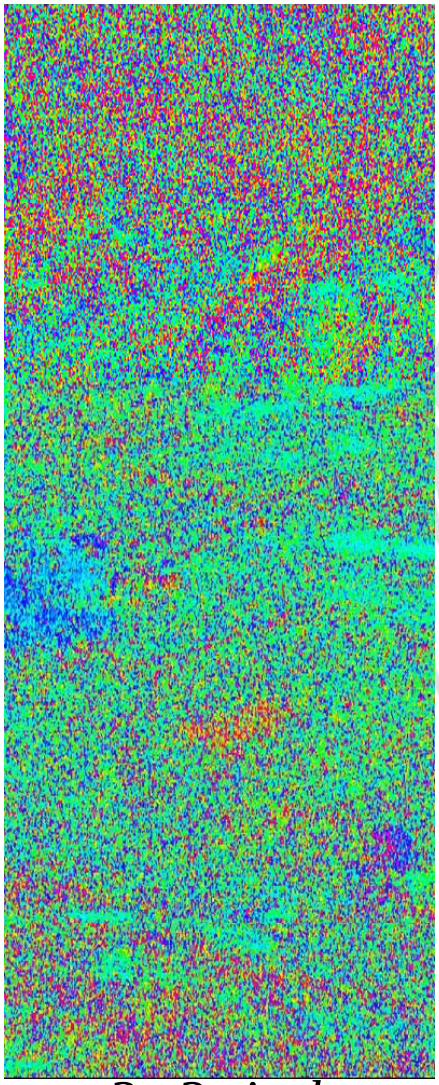
$$\tan\theta = \frac{-\tan\alpha}{\cos\phi}$$

Where tan**α** is the target azimuth angle, **φ** is the radar look angle.

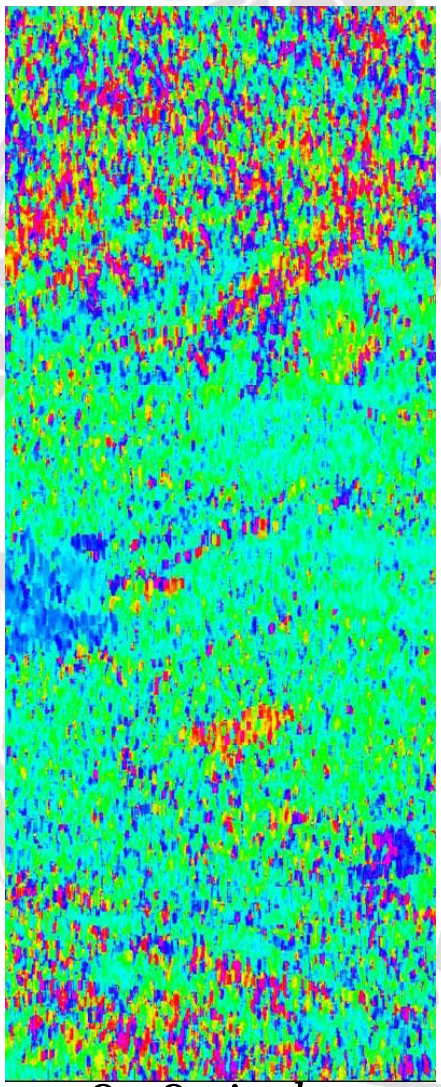
Terrain effect (Orientation angle shift)



HH-VV, 2HV, HH+VV



$3 \times 3 pixels$



$9 \times 9 pixels$

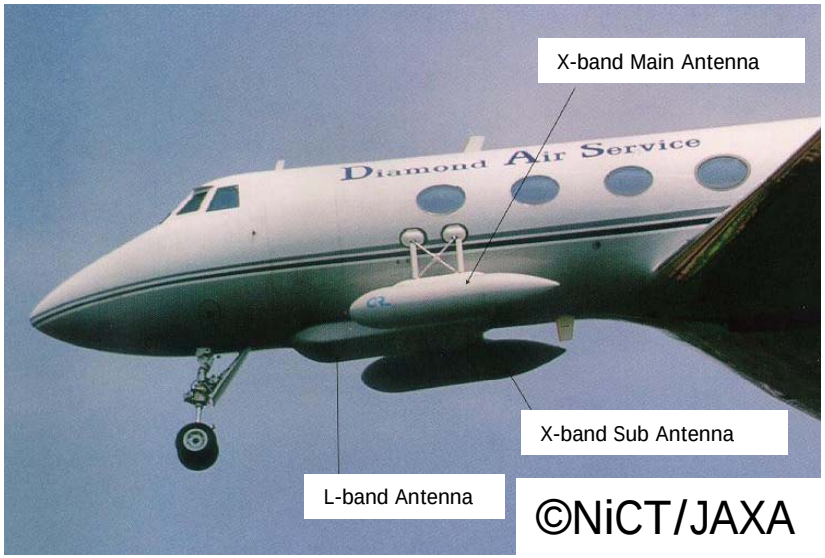
Polarization Orientation Angle

Pi-SAR

New R&D for monitoring Earth Environment.

NiCT and **JAXA** developed Pi-SAR in 1996.

Pi-SAR: Airborne High-resolution Multi-parameter SAR

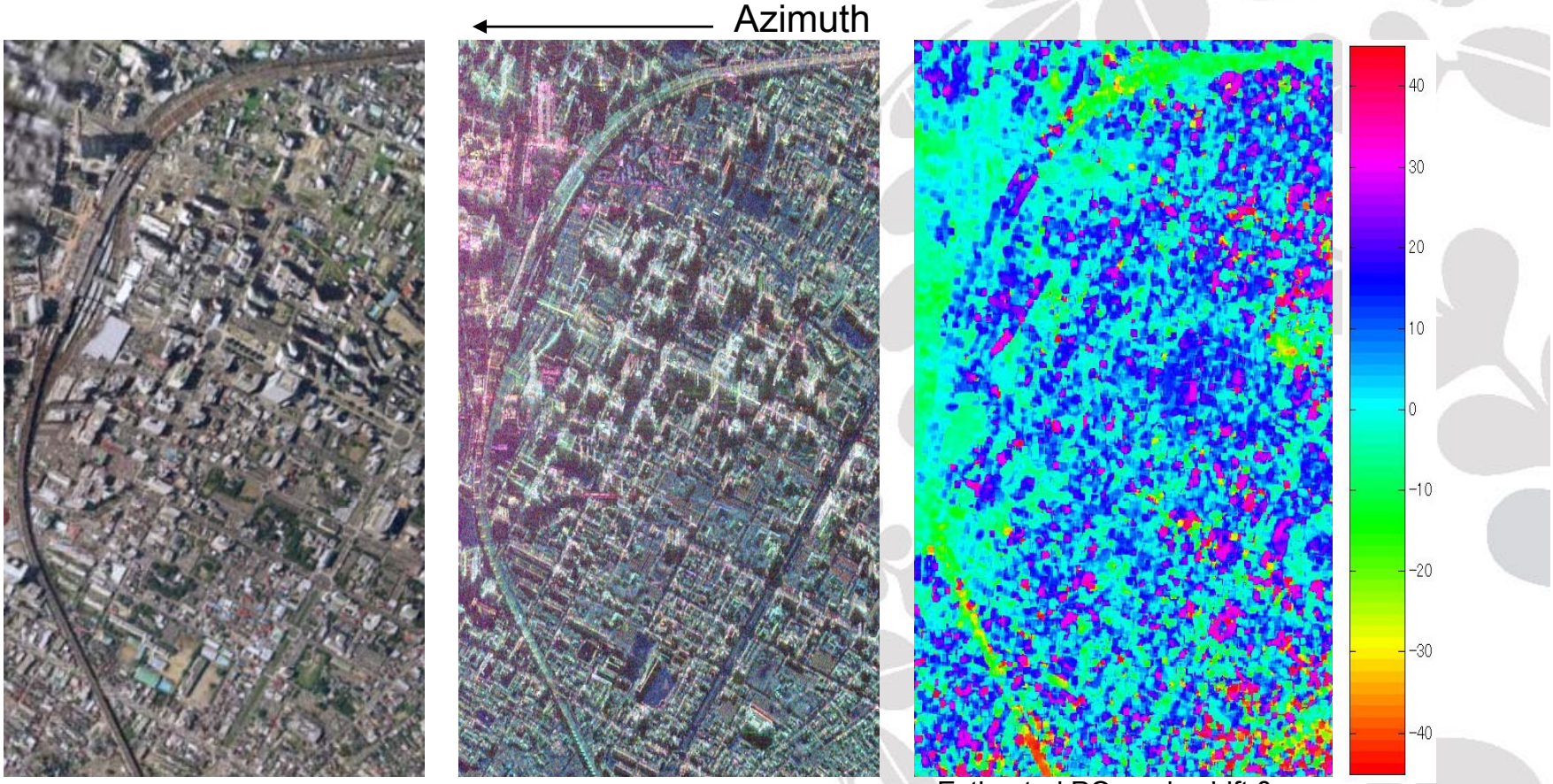


©NiCT/JAXA

	X-band	L-band
Frequency	9.55GHz	1.27GHz
Wave length	3.14cm	23.6cm
Resolution	1.5m	3m
Observation mode	Polarimetry [HH/HV/VH/VV] Interferometry	Polarimetry [HH/HV/VH/VV]

Investigation of the frequency dependence.

Downtown Sendai

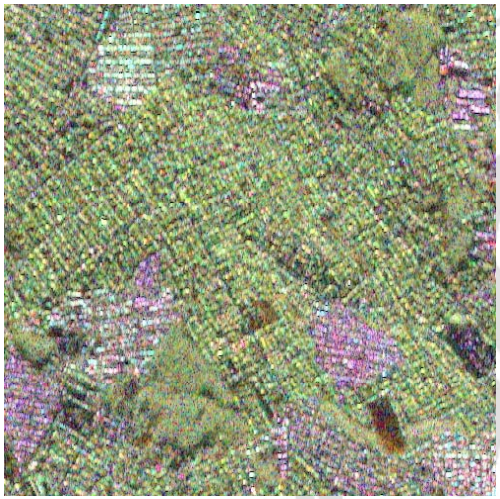


Difficulties, such as layover, shadowing, and multi-bounce, etc.
In addition, our targets are dihedral structures.

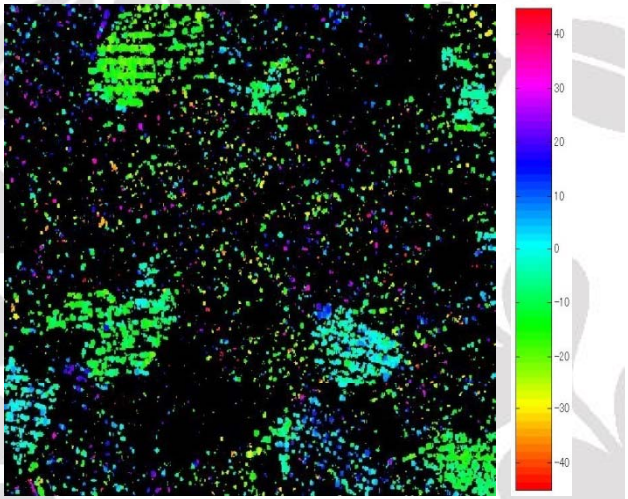
⇨ **A model fit for Urban structures.**

Residential Area in Sendai

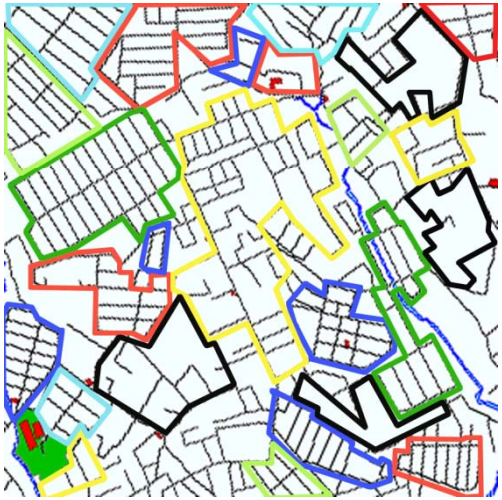
Residential block



L-band, HH-VV, 2HV, HH+VV

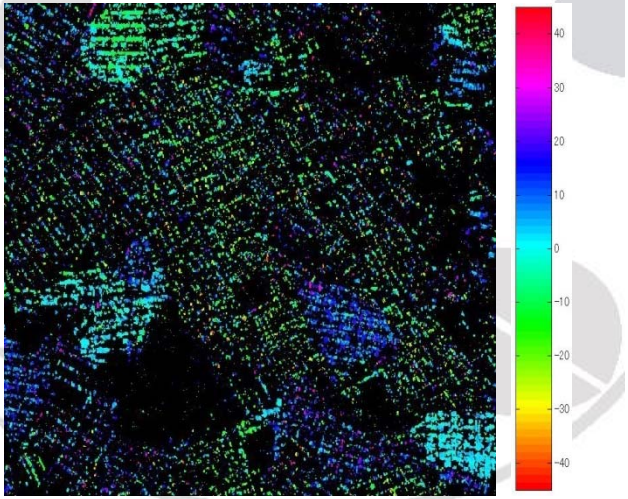


Estimated PO Angle θ



1250m*1250m

X-band, HH-VV, 2HV, HH+VV



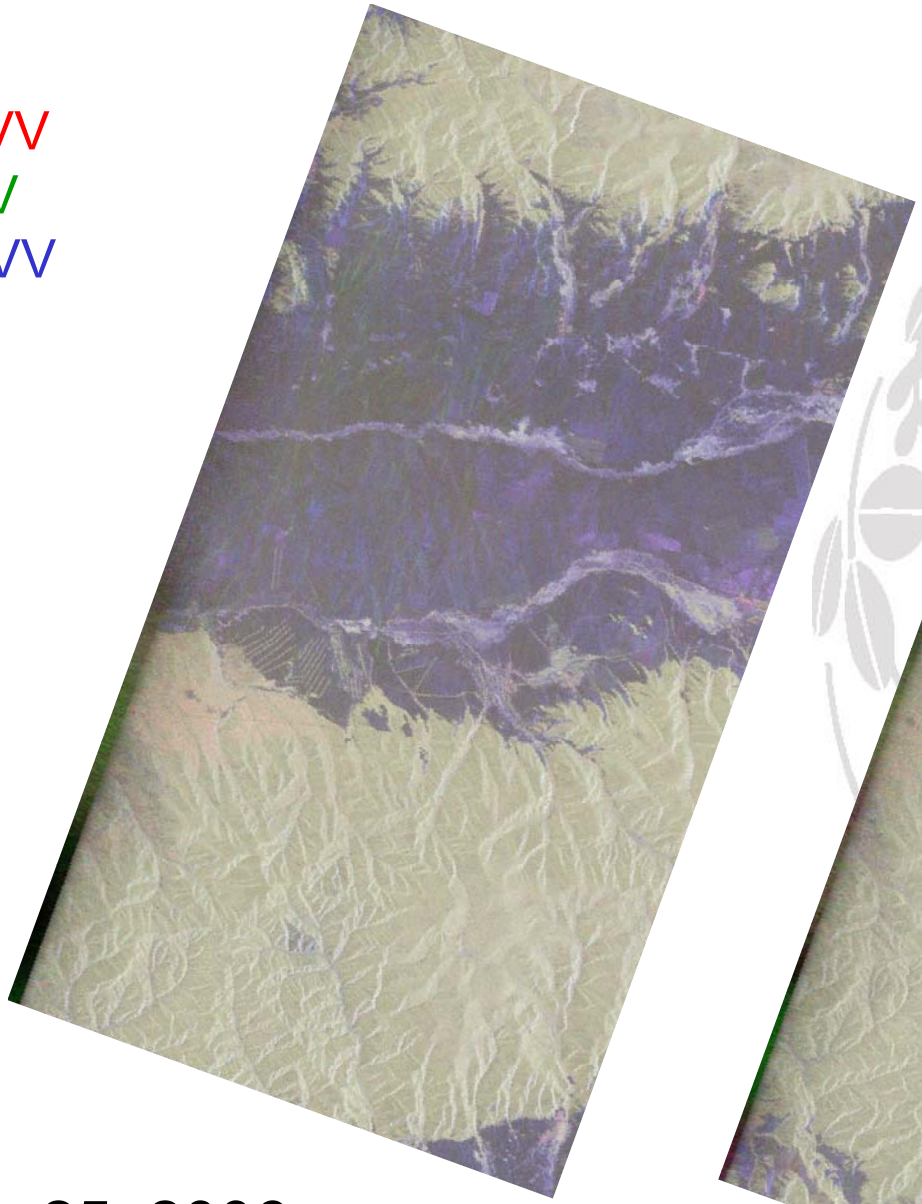
Estimated PO Angle θ

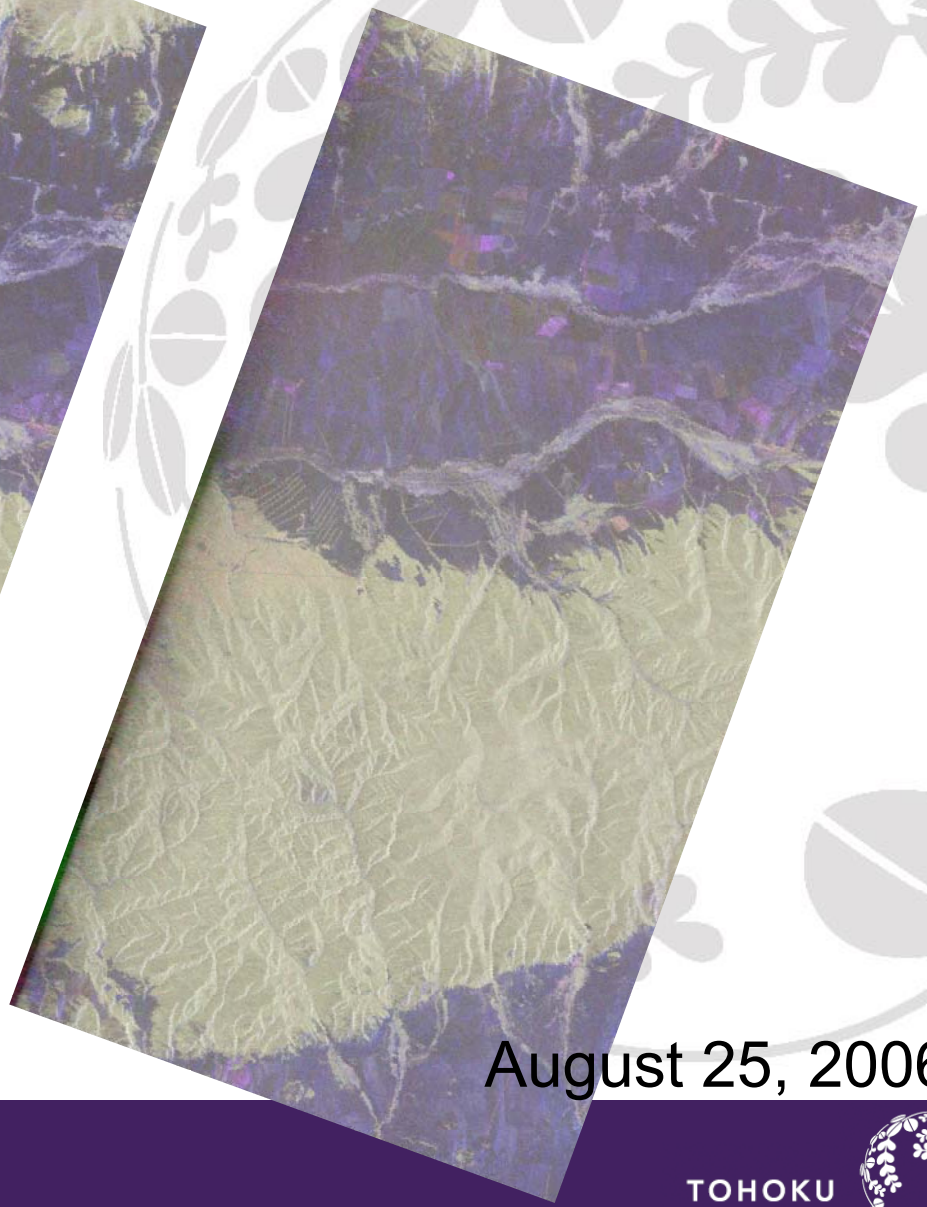
Space Borne PolarimetricSAR

- 24-hour Operation
- Detection of Small Changes
- Understanding of the Change of Scattering Mechanism
  - ➢Collapsed Houses
  - ➢Detection of Land Slide
  - ➢Detection of Abandoned Objects

HH-VV
2HV
HH+VV

Scene ID: 2580





May 25, 2006

August 25, 2006

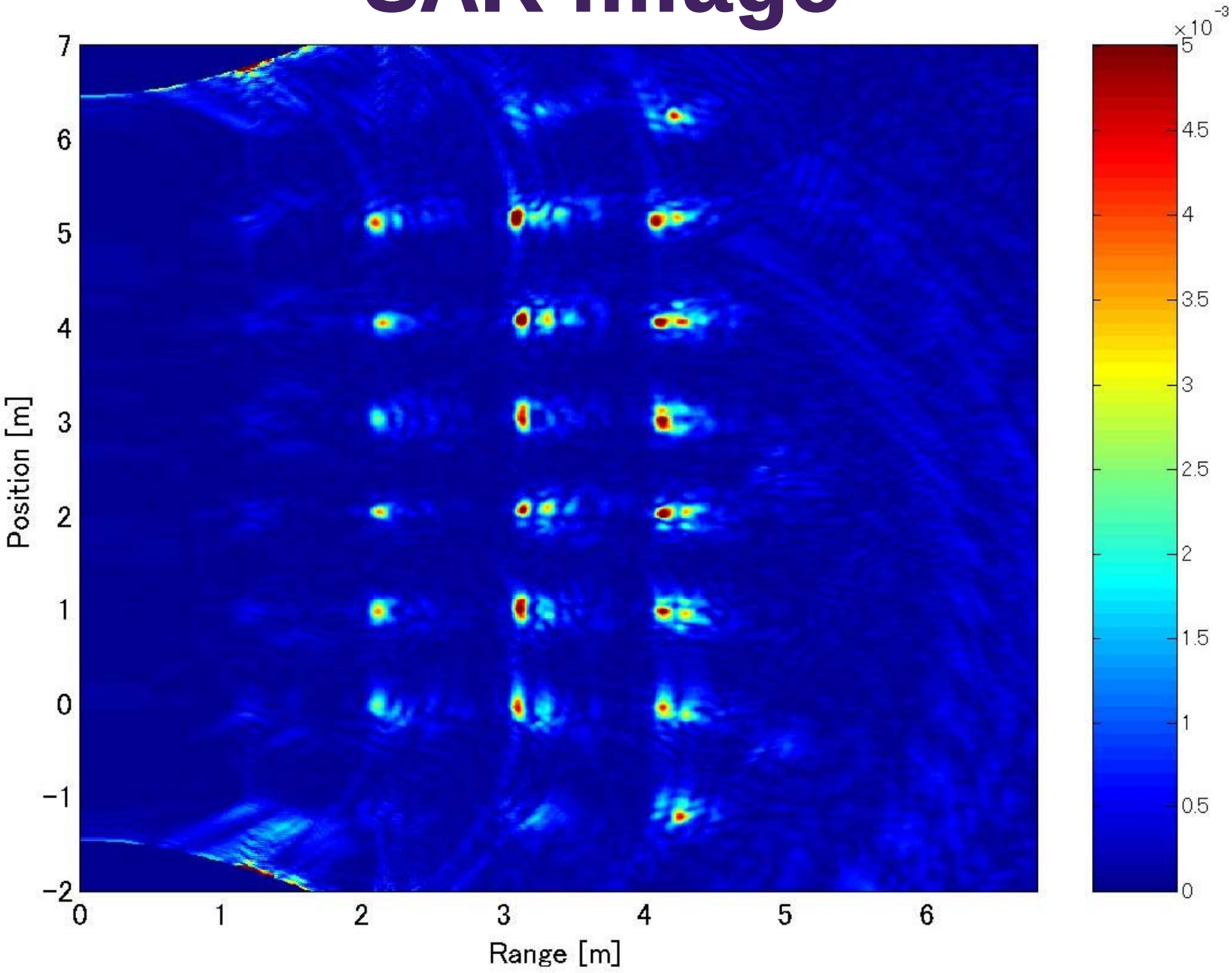
GB-SAR (Ground-Based SAR)

Wide-area observation

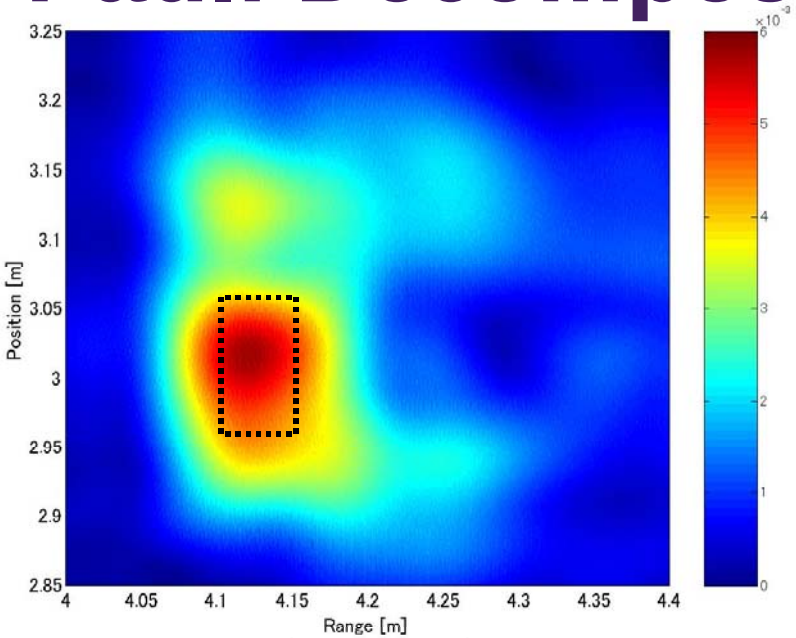
Polarimetric scattering from specific targets

Scattering Objects Setup

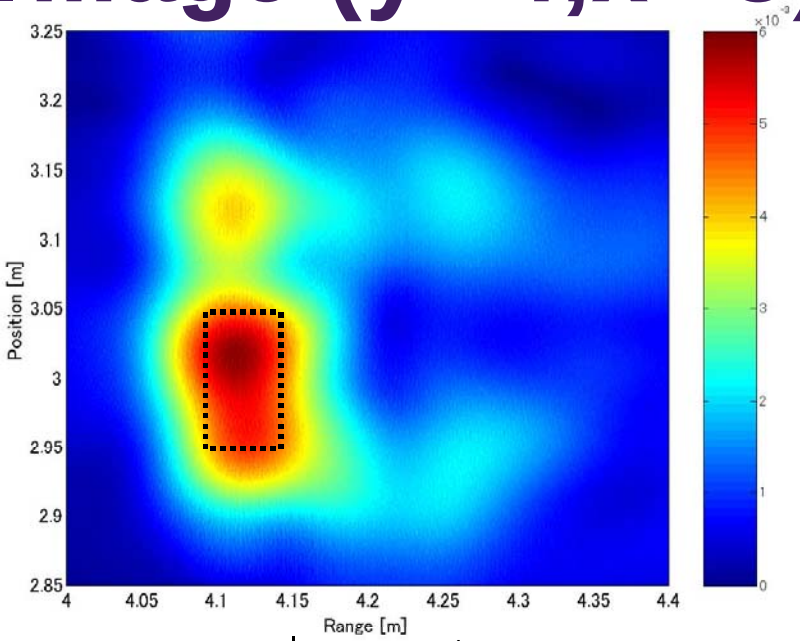
SAR image



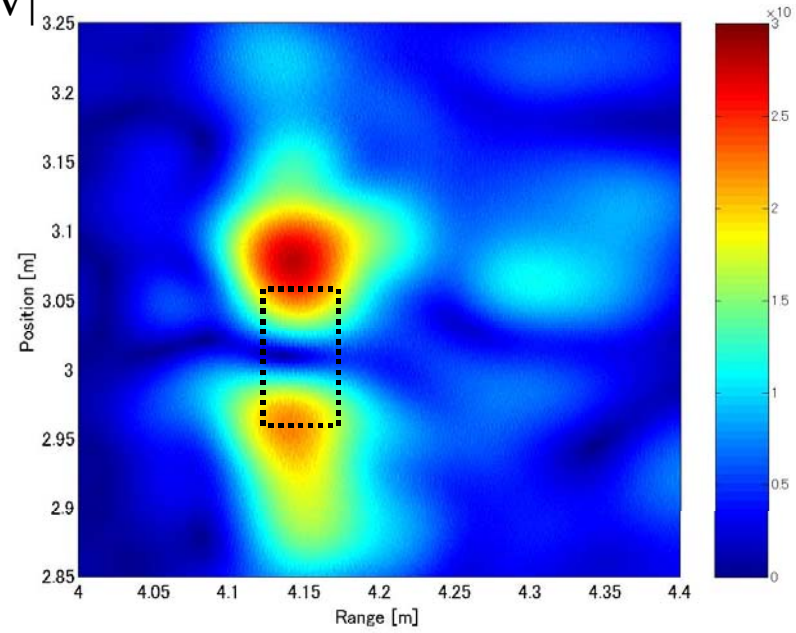
Pauli Decomposed Image (y=4,x=3)



|HH+VV|



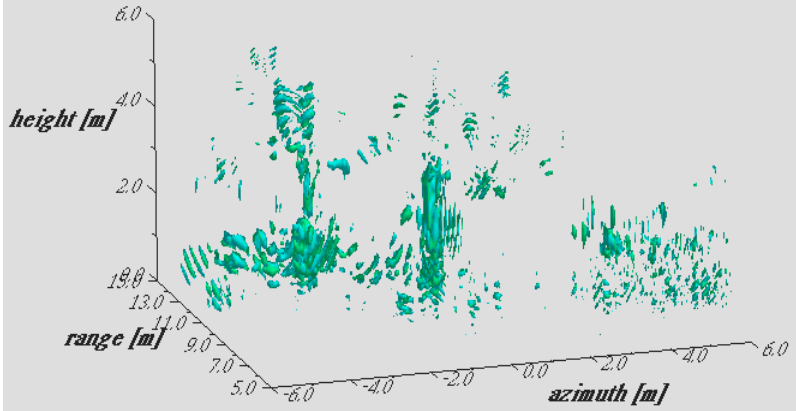
|HH-VV|



|2HV|

HH of exp#1

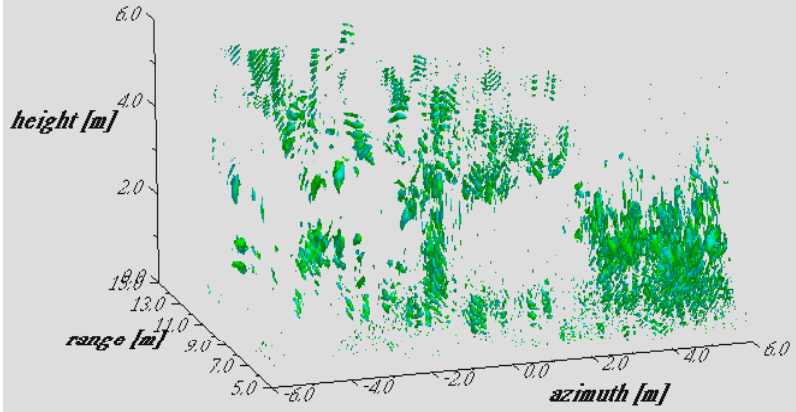
on April 19, 2002



春

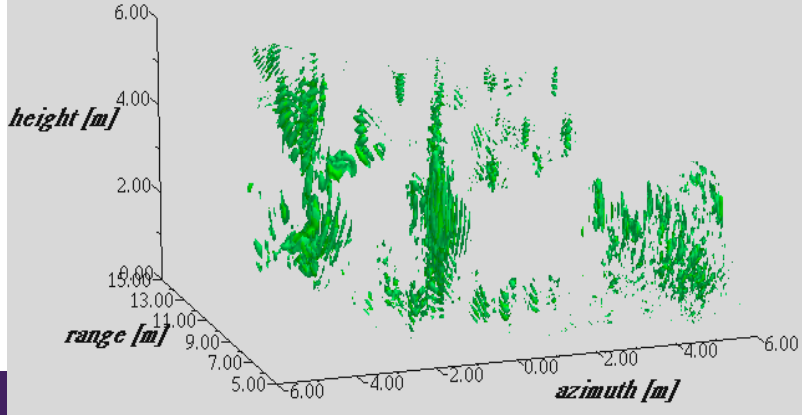
VH of exp#1

on April 19, 2002

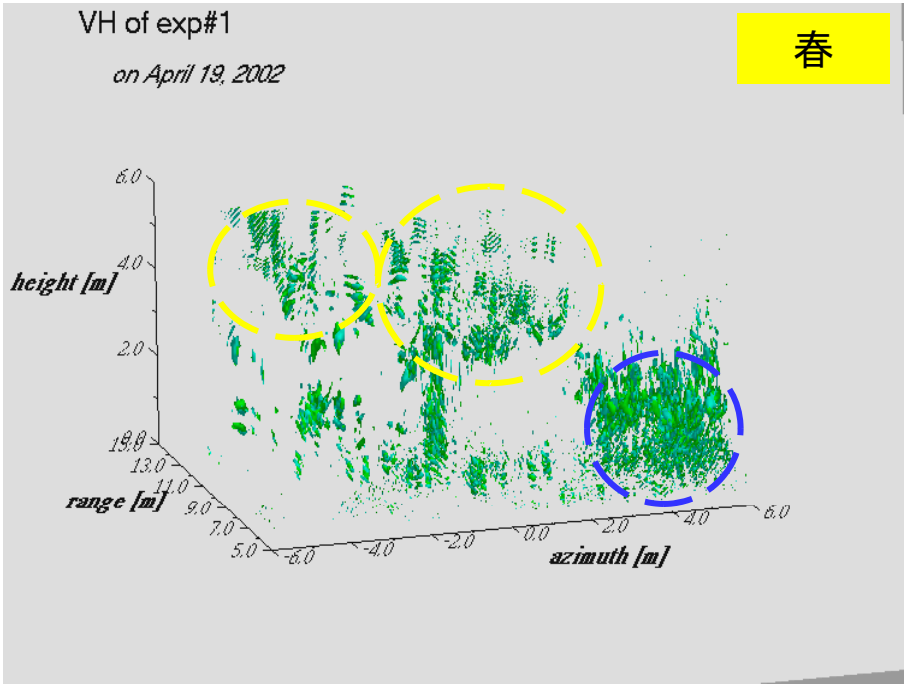


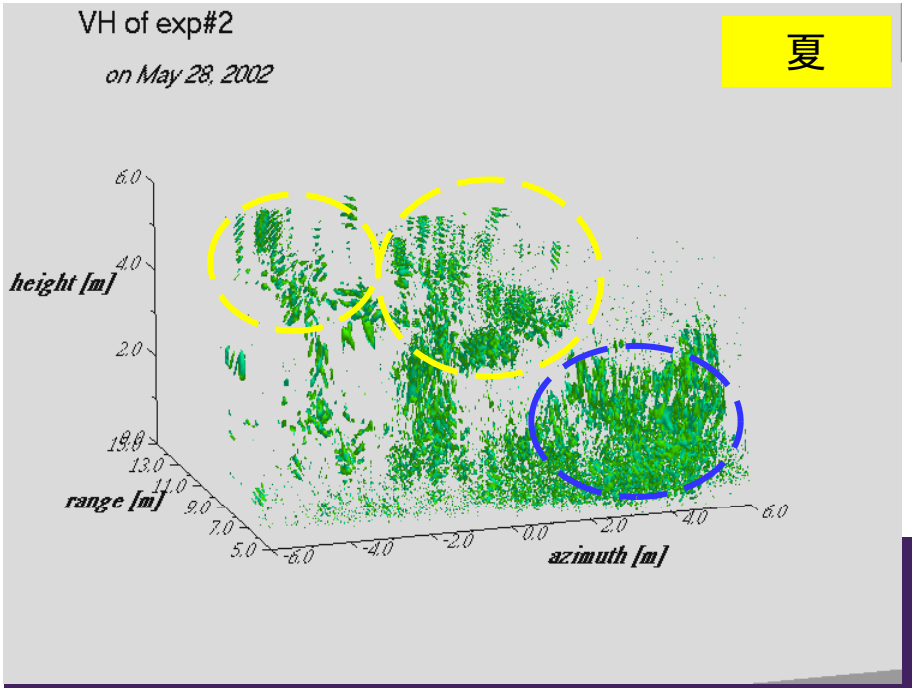
VV of exp#1

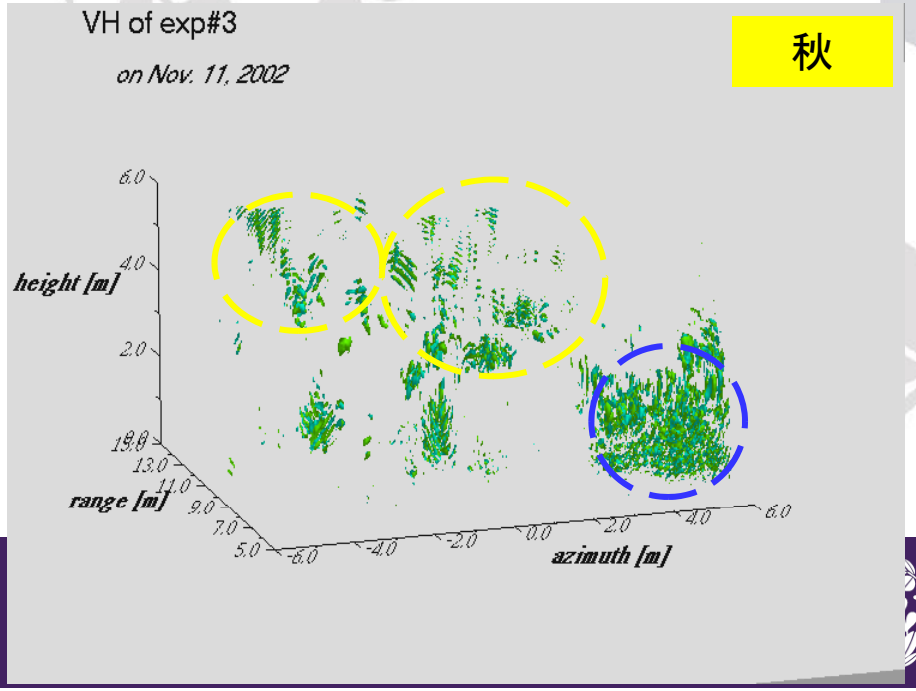
on April 19, 2002



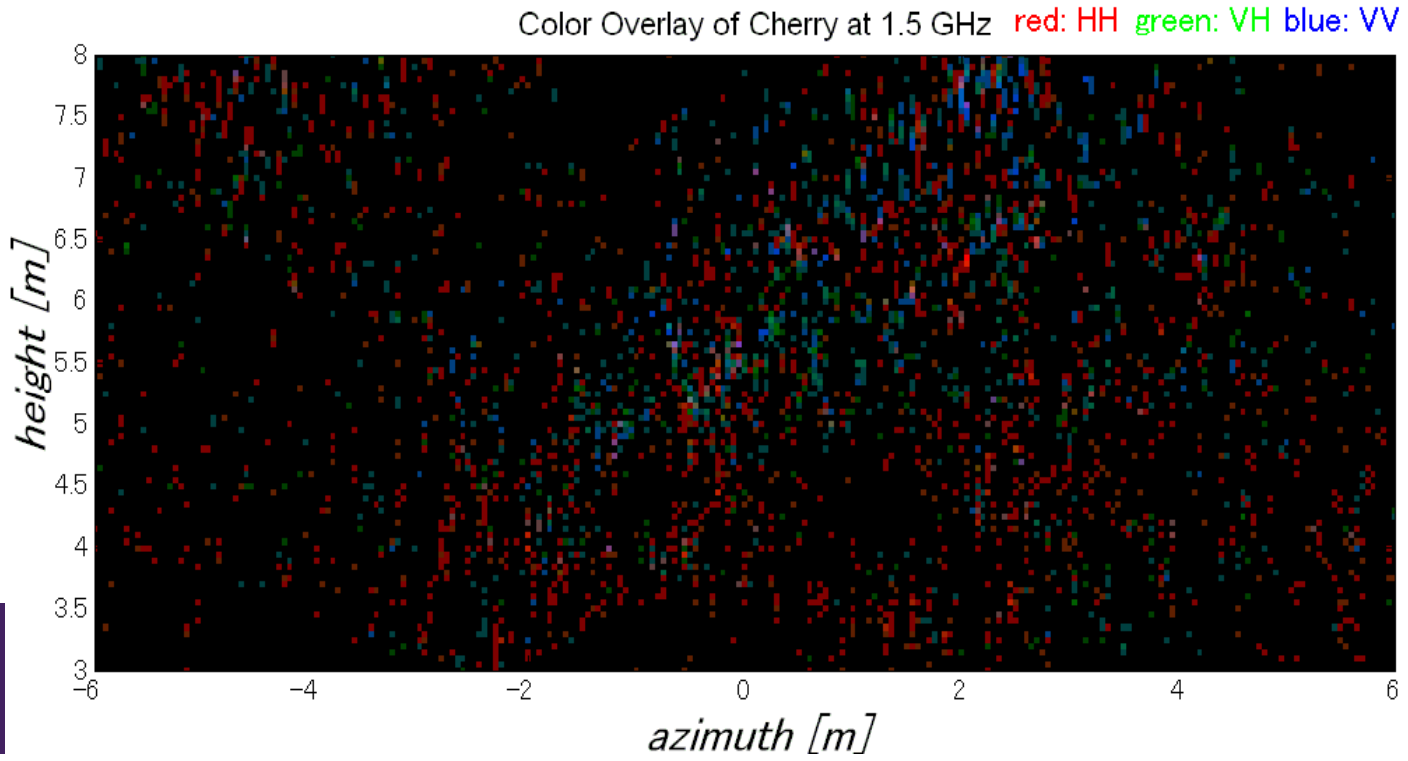
季節変化(HV)


VH of exp#1
on April 19, 2002
春
height [m]
range [m]
azimuth [m]


VH of exp#2
on May 28, 2002
夏
height [m]
range [m]
azimuth [m]


VH of exp#3
on Nov. 11, 2002
秋
height [m]
range [m]
azimuth [m]

桜1.5 GHz



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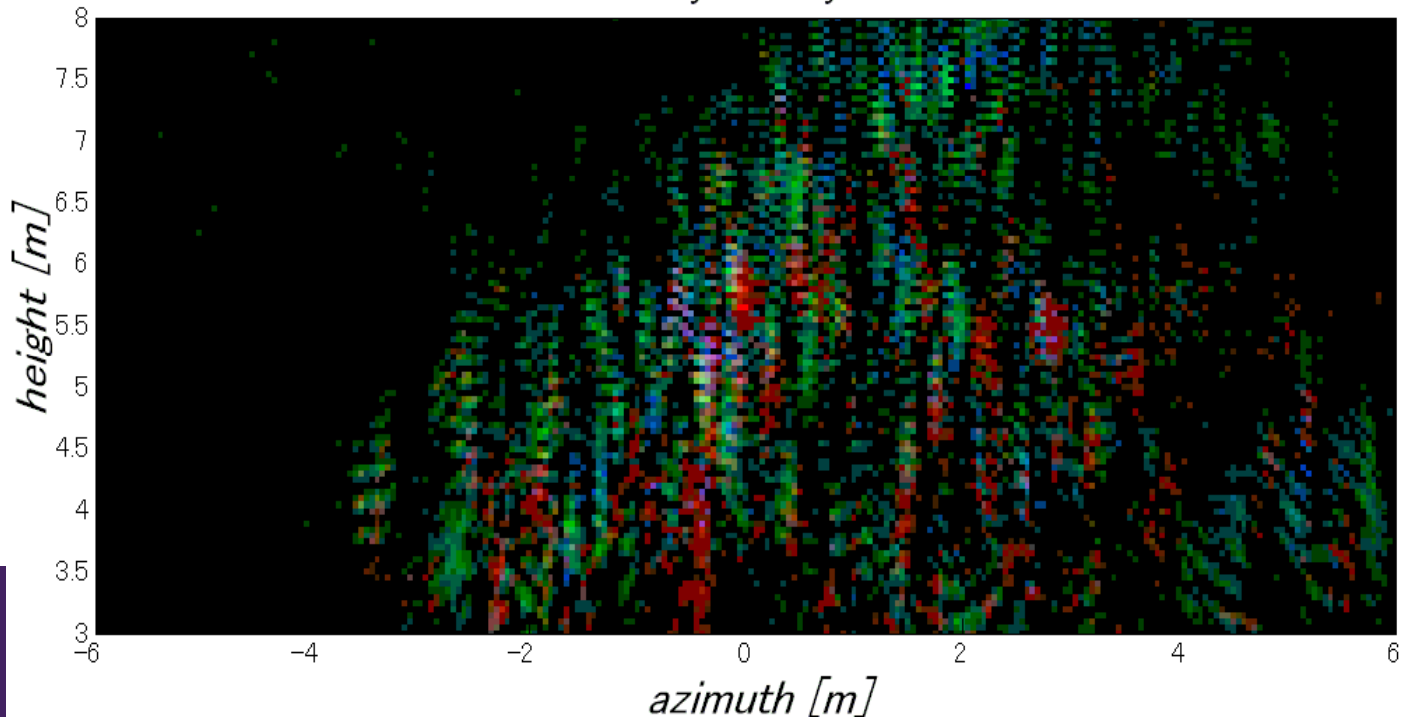
桜4.5 GHz

Color Overlay of Cherry at 4.5 GHz red: HH green: VH blue: VV



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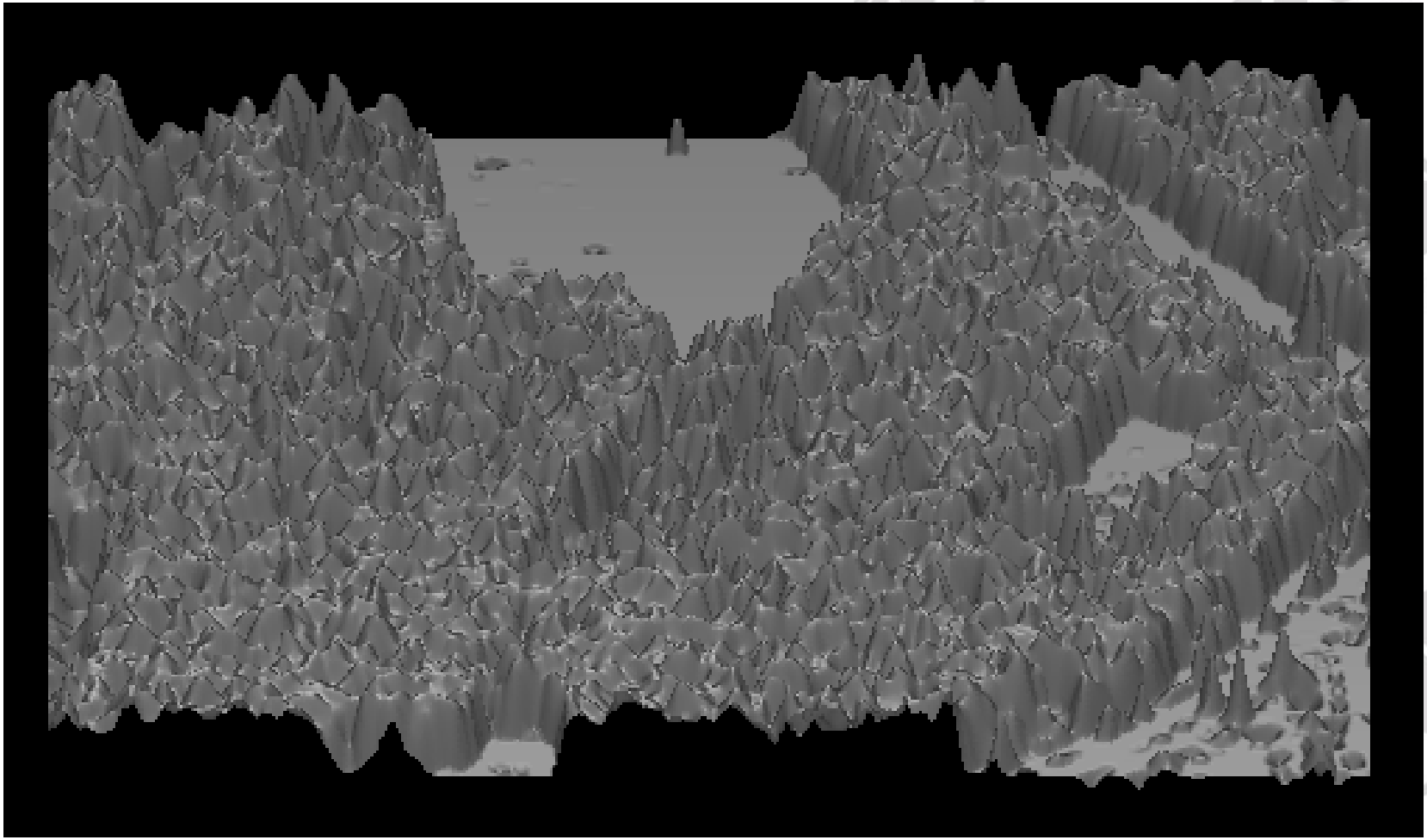
NORTHEAST
ASIAN STUDIES

POL-IN-SAR

3-Dimensional Forest Height Representation ***E-SAR / Test Site: Oberpfafenhoffen***

K. P. Papathanassiou and S. R. Cloude



Conclusion

- Radar polarimetric information has not fully been used
- Classification of targets under resolution
- Qualitative Measurement
- Need more practical applications
- Multiple Platforms-Frequencies-Polarizations

（ENVISAT/PALSAR/TerraSAR/RADASAT2）