

# 11 なぜレーダ・ポラリメト リを使うのか



# Outline

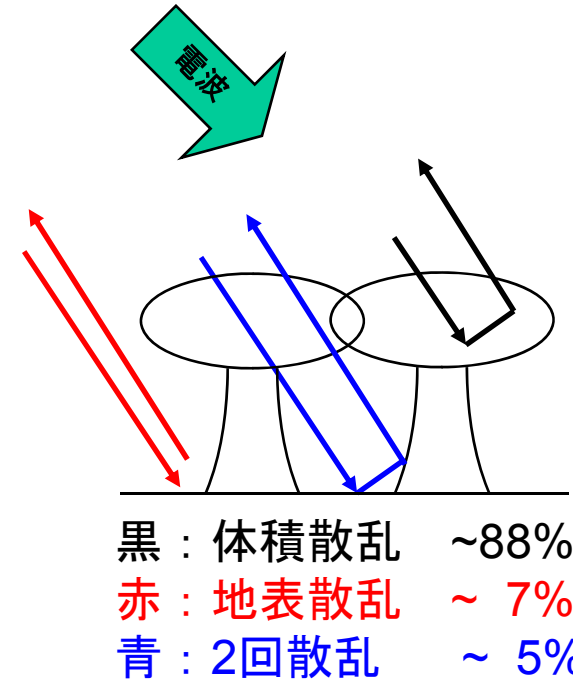
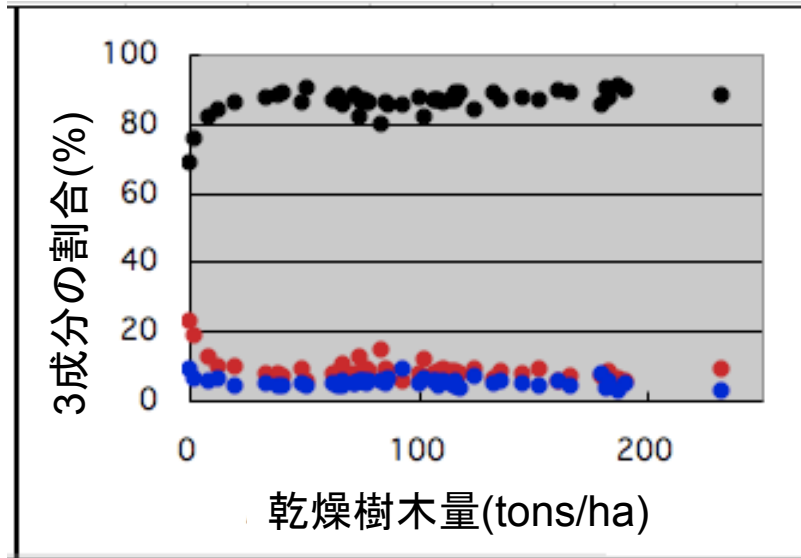
## ポーラリメトリックレーダの 能力を活用するために

- ・ レーダポーラリメトリで得られる情報
- ・ 散乱メカニズムによるターゲット分類
- ・ 定量的な情報
- ・ 微細な変化の検出
- ・ GB-SARによる地上検証実験

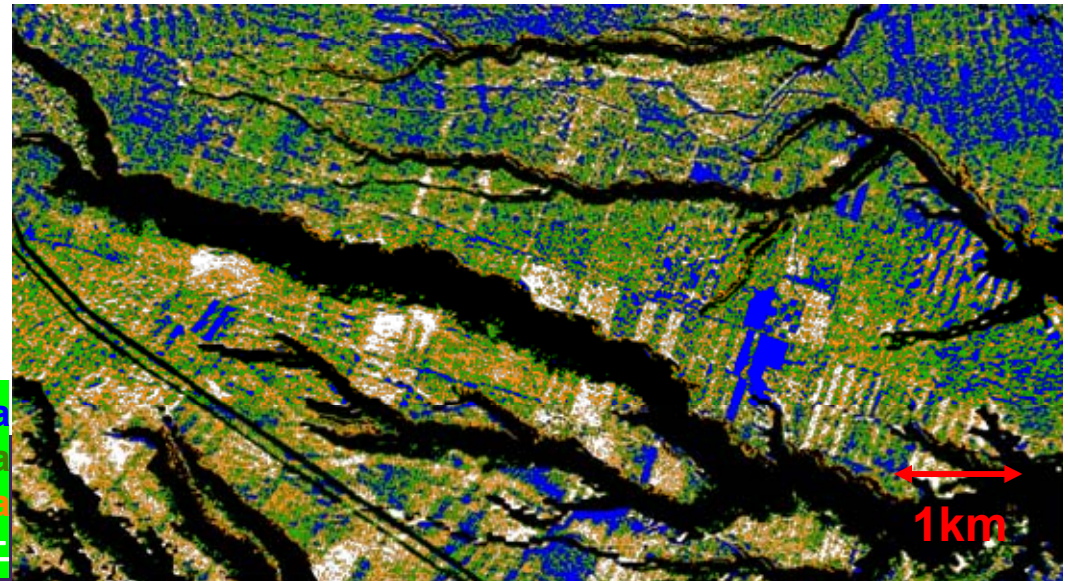
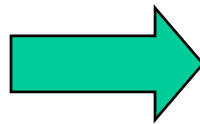
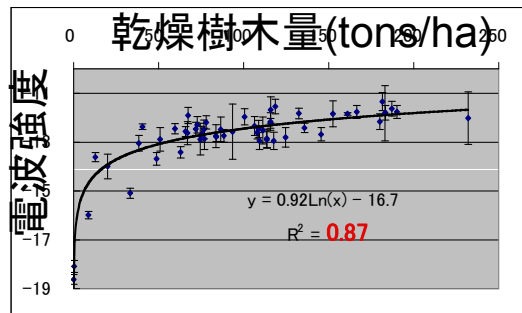


# 森林の散乱メカニズム

## ◆ 散乱成分の推定(3成分分解モデルの適用)



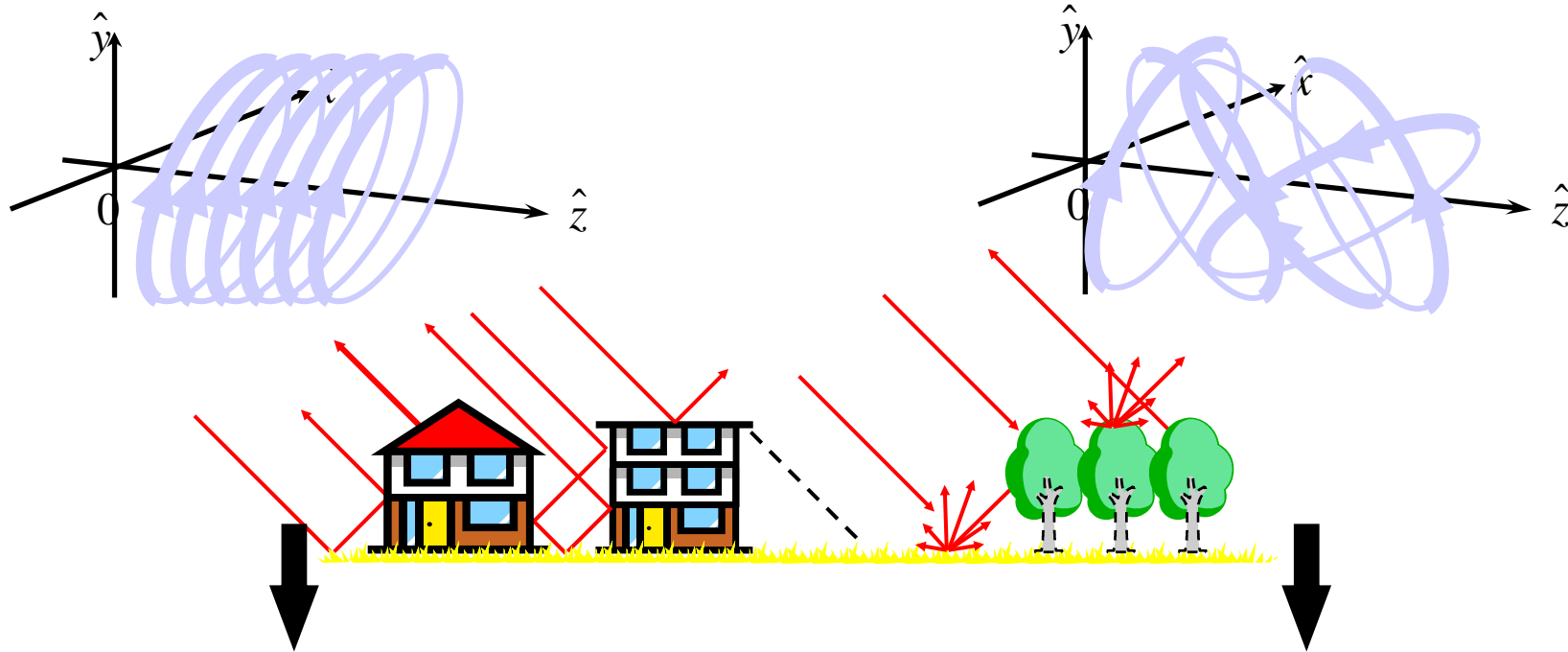
## ◆ 樹木量マップ試作



分類精度  
68.5%

青：0 ~ 25tons/ha  
緑：25 ~ 50tons/ha  
橙：50 ~ 100tons/ha  
白：100tons/ha以上

# Partially Polarized Waves

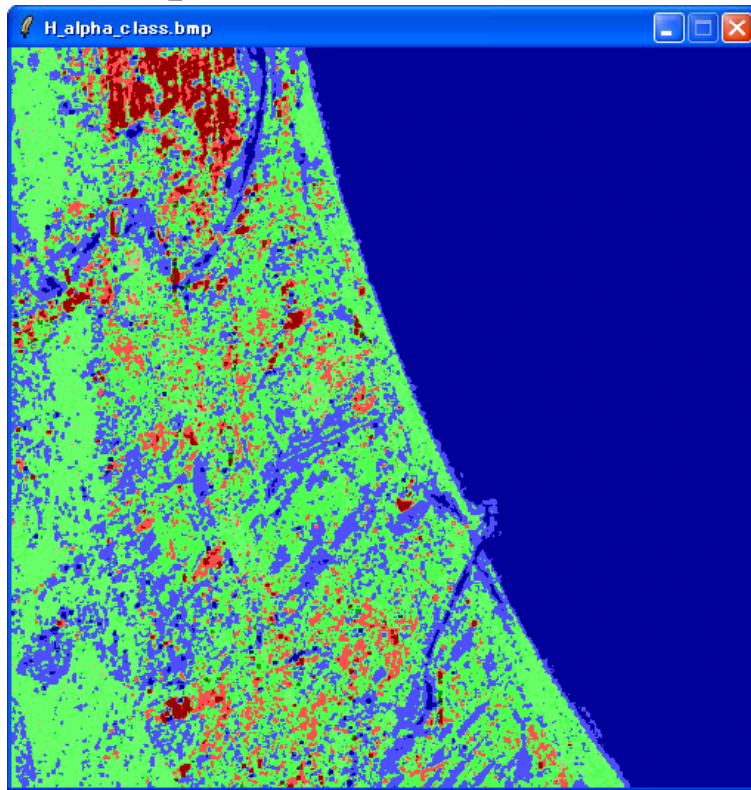


DETERMINISTIC SCATTERING  
COMPLETELY POLARISED WAVE  
STATISTICAL DESCRIPTION

RANDOM SCATTERING  
PARTIALLY POLARISED WAVE  
Polarisation Ellipse varies in time  
Amplitude, Phase: Random processes

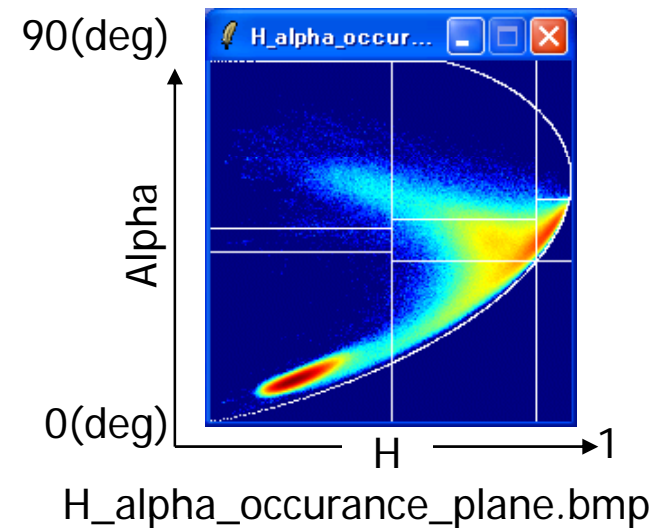
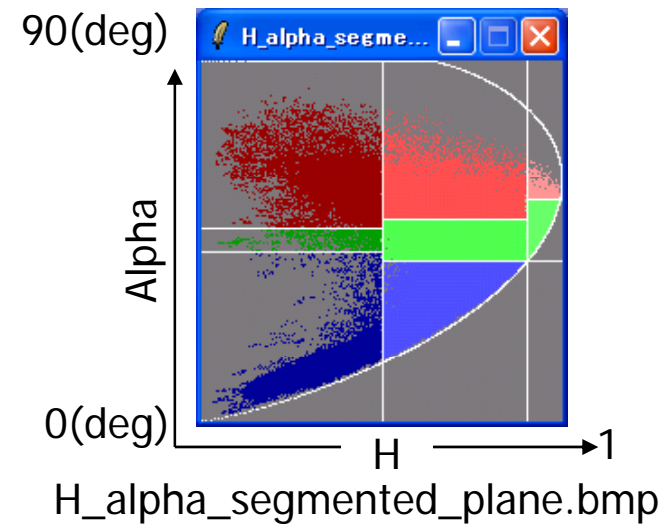


# H-Alpha による地表分類 (自然環境の分類で有効)

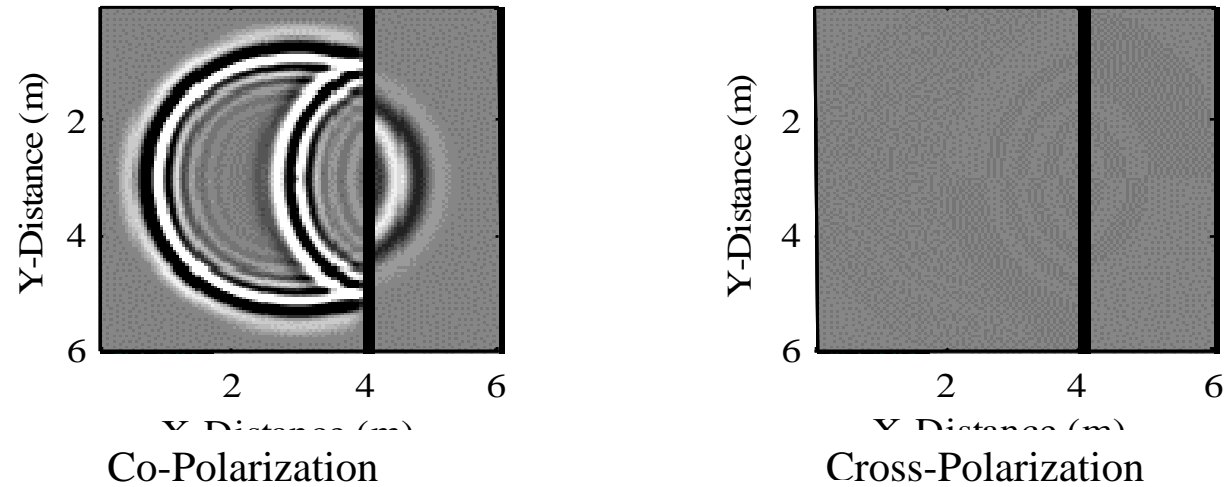


H\_alpha\_class.bmp

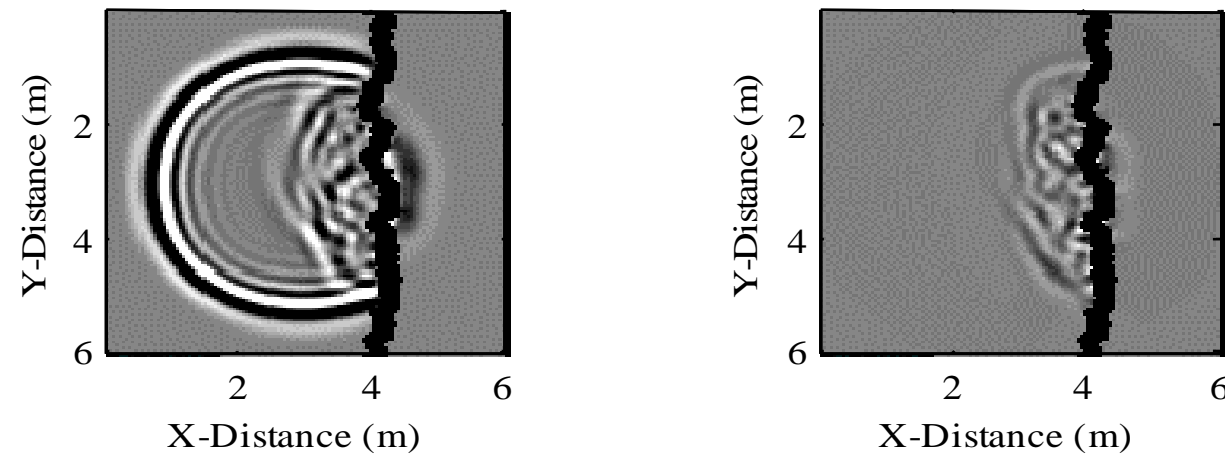
Entropy: 散乱の乱雑さ  
Alpha: 散乱のメカニズム



# 粗さを持つ表面からのポーラリメトリック散乱



(a) Flat surface



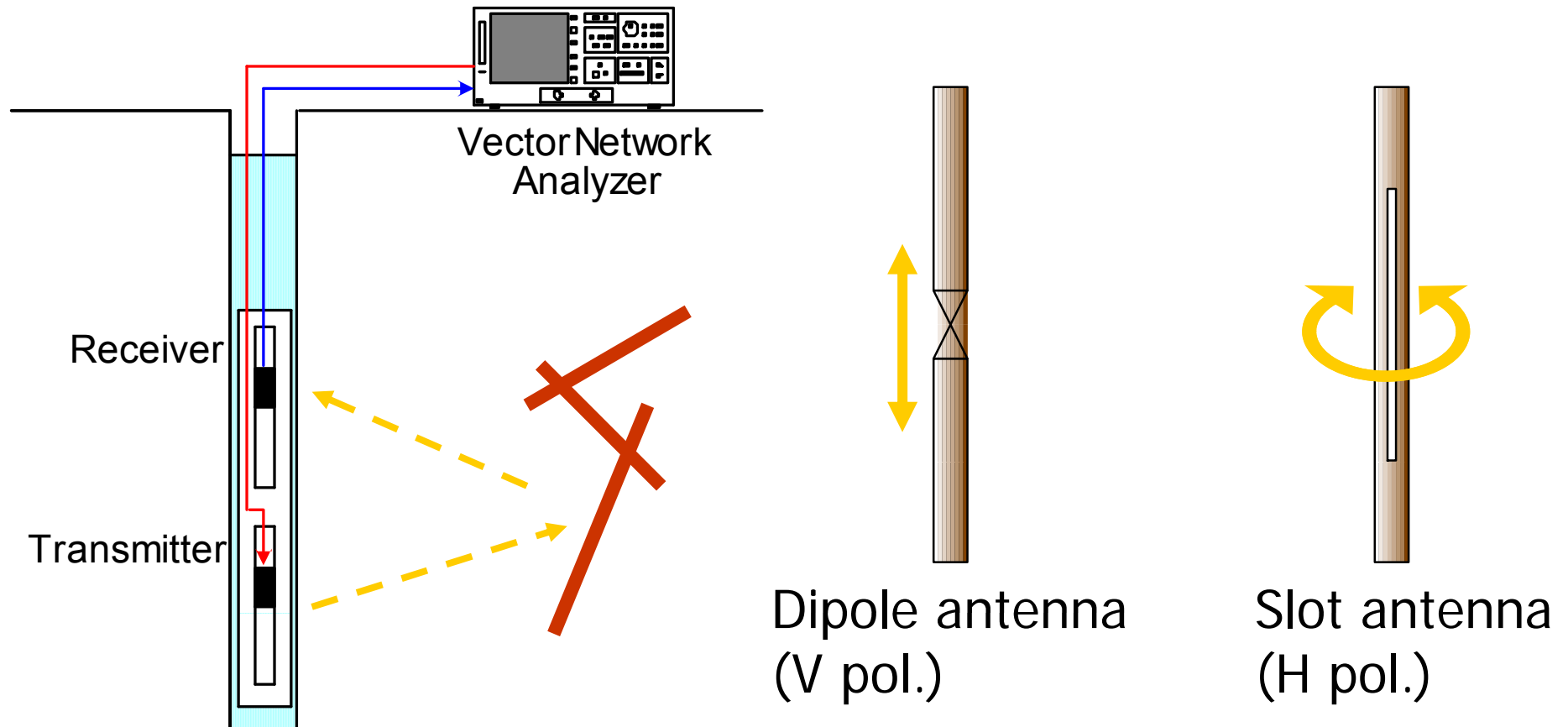
(b) Rough surface

Co-Polarization

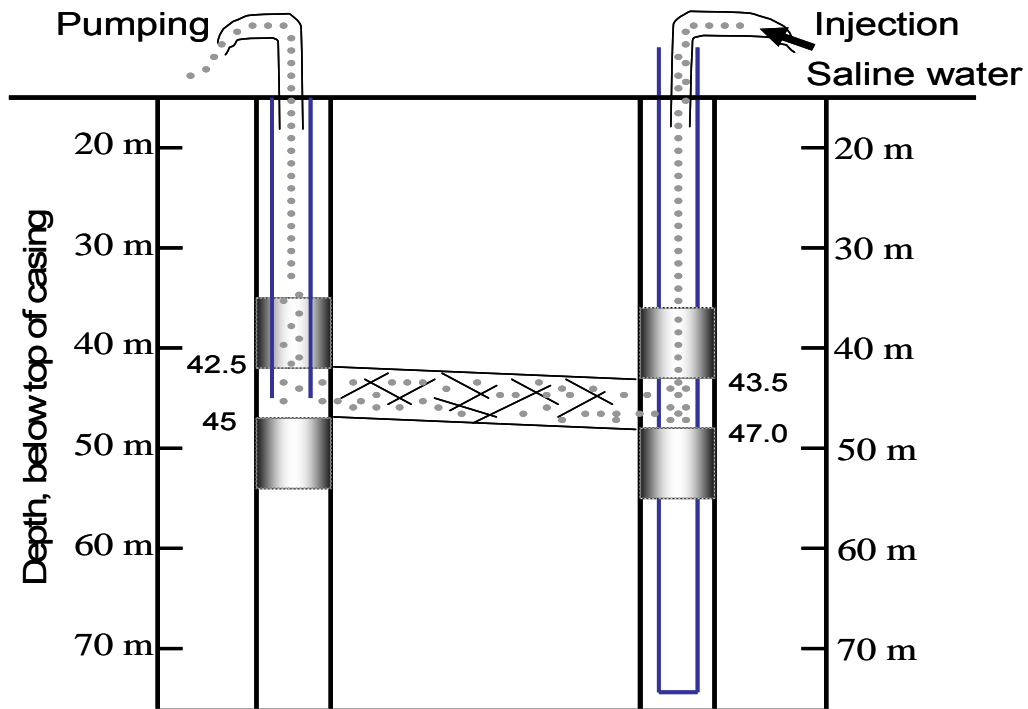
Cross-Polarization



# Polarimetric Borehole Radar



# Tracer Tests (by USGS)



Two transmissive zones

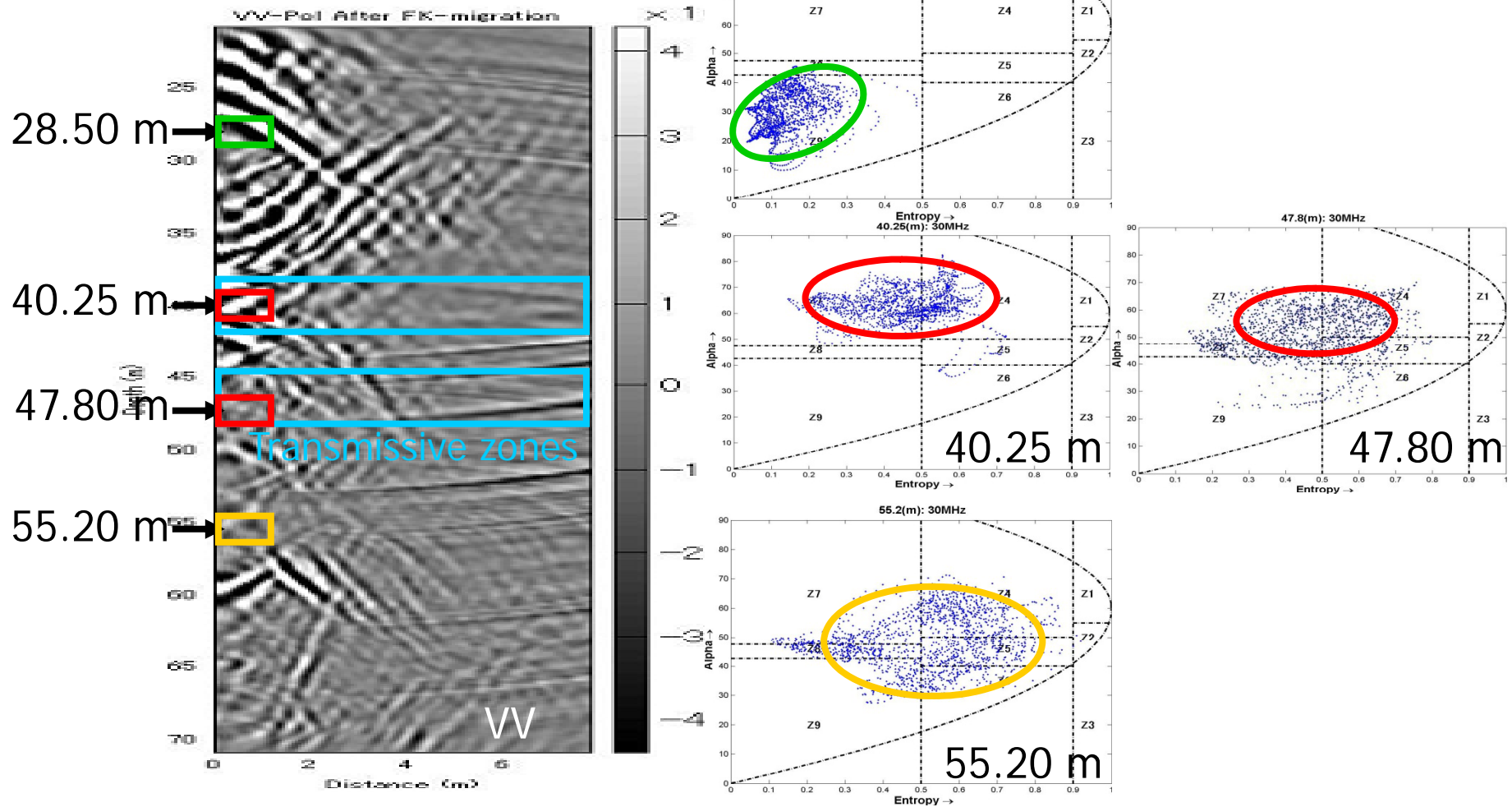
Zone #1: 40 m

Zone #2: 47 m



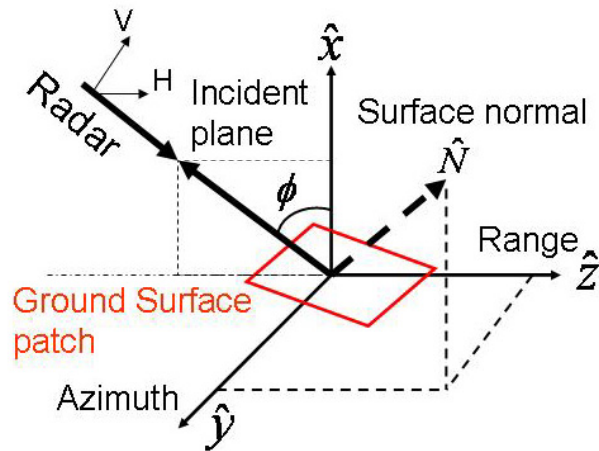


# H-Alpha Decomposition and Tracer Tests



# Polarization Orientation Angle

(直交円偏波基底の位相差)



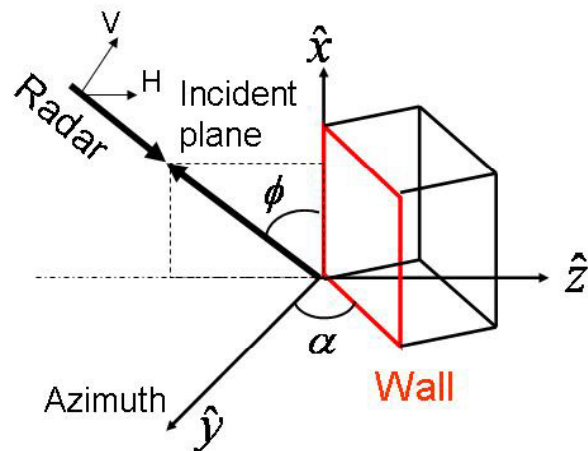
## Induced by Ground Surface Patch

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

The induced polarization orientation angle shift  $\theta$  is represented,

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

Where  $\tan \omega$  is the azimuth slope,  $\tan \gamma$  is the range slope,  $\phi$  is the radar look angle.



## Induced by Dihedral Structure

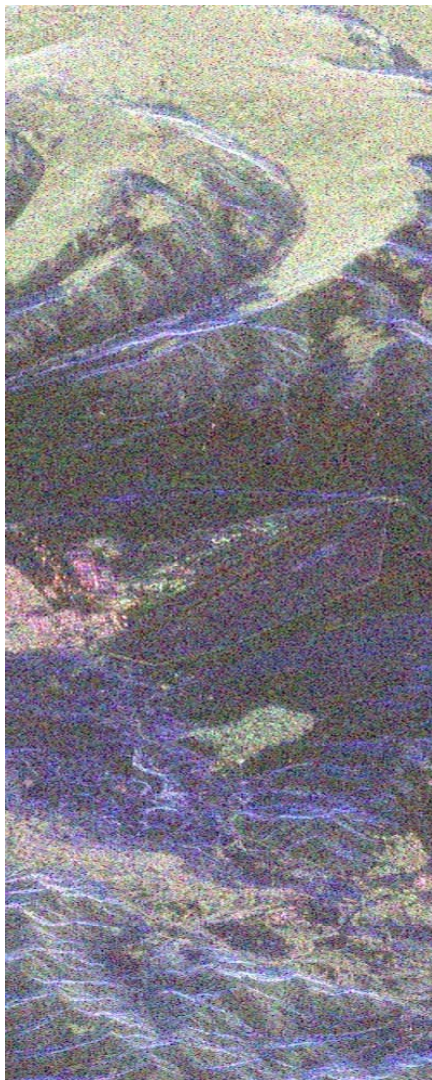
Hiroshi Kimura, et al.

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

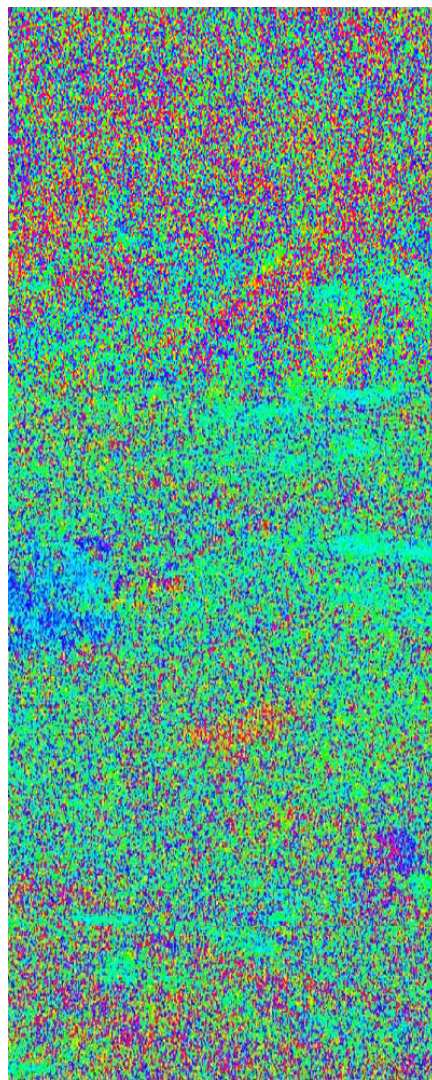
Where  $\tan \alpha$  is the target azimuth angle,  $\phi$  is the radar look angle.



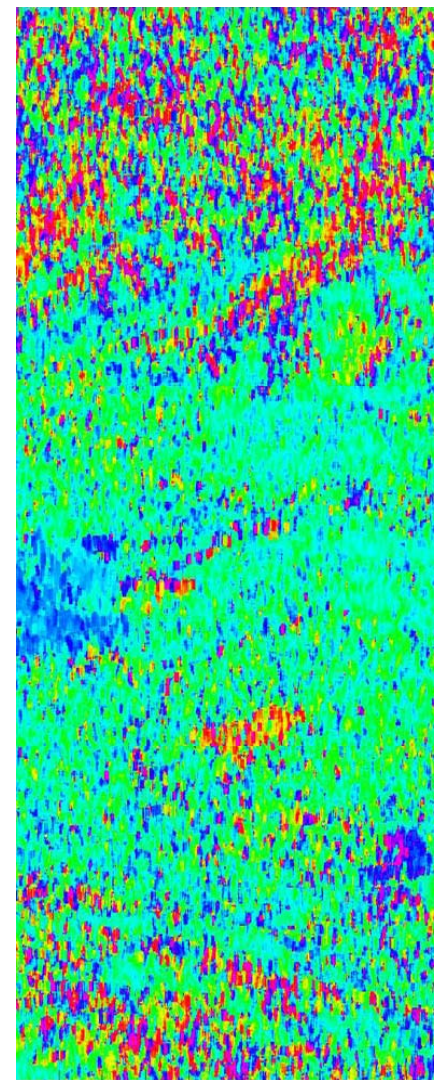
# Terrain effect (Orientation angle shift)



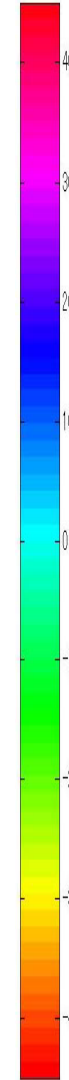
HH-VV, 2HV, HH+VV



3x3 pixels



9x9 pixels

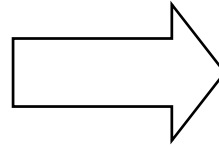


Polarization Orientation Angle



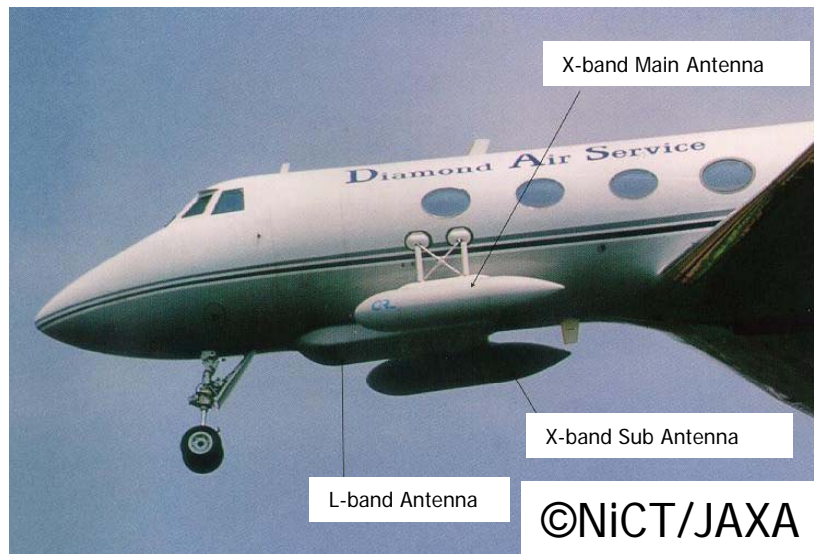
# Pi-SAR

New R&D for monitoring Earth Environment.

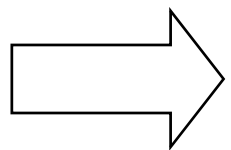


**NiCT** and **JAXA** developed Pi-SAR in 1996.

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



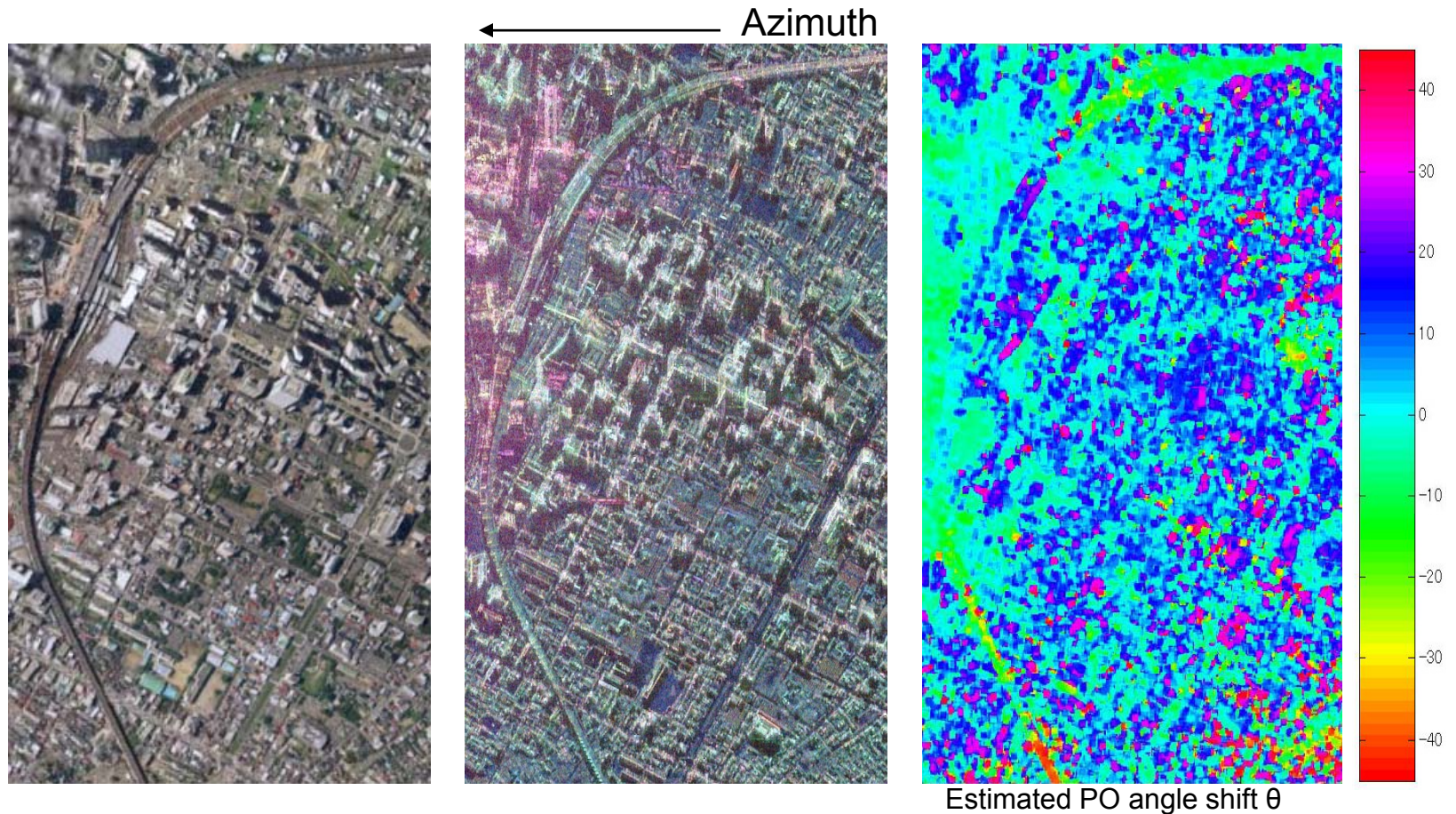
|                  | X-band                                      | L-band                    |
|------------------|---|---------------------------|
| Frequency        | 9.55GHz                                     | 1.27GHz                   |
| Wave length      | 3.14cm                              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



**Investigation of the frequency dependence.**



# 仙台市街地



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

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

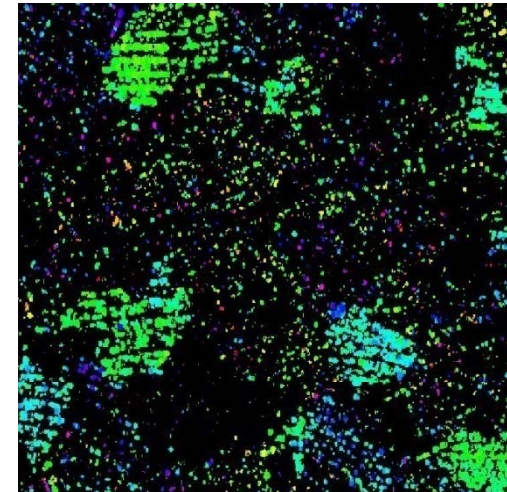
# 住宅地



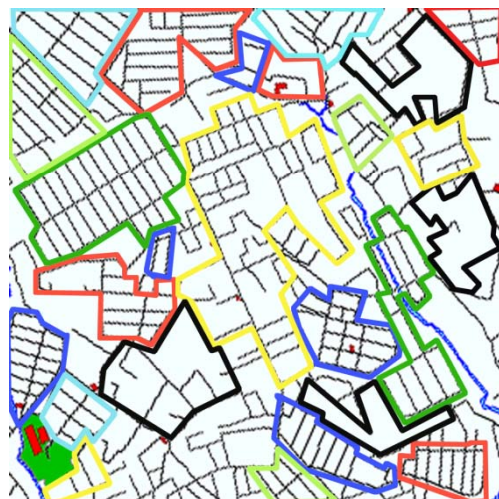
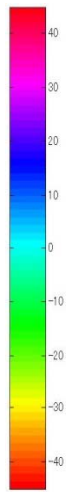
Residential block



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



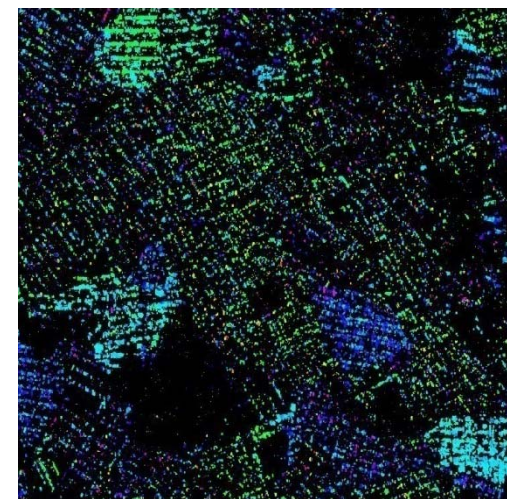
Estimated PO Angle  $\theta$



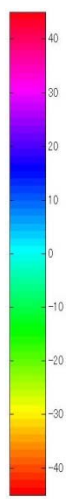
1250m\*1250m



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



Estimated PO Angle  $\theta$



# 衛星搭載ポーラリメトリックSARの特長

- 天候、昼夜を問わない計測
- 微少な変化量の検知
- 散乱構造の変化の理解

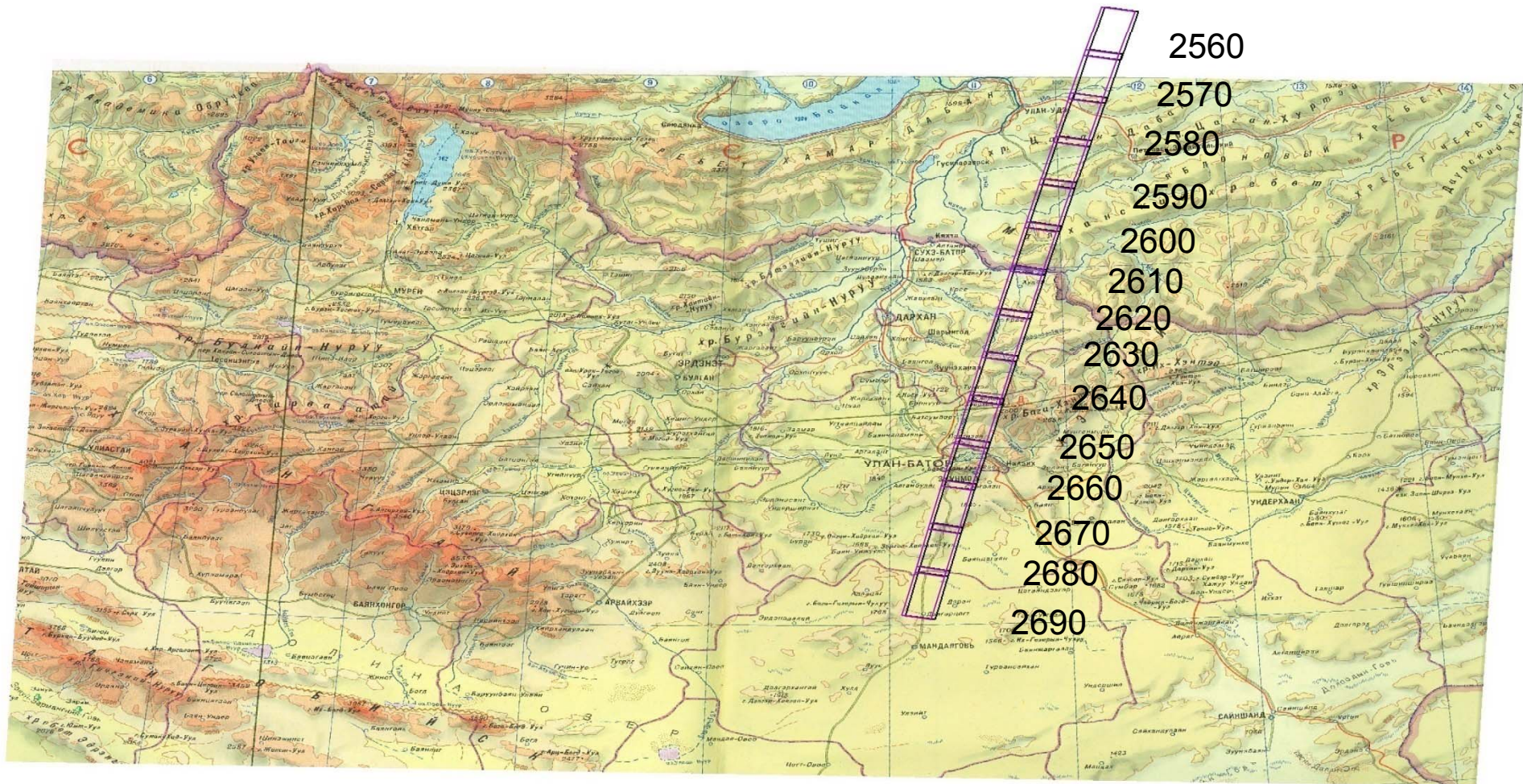
➤ **被災家屋検知**

➤ **土砂崩れの検知**

➤ **不法投棄物検知**



# モンゴルとPALSAR観測域



14 scenes in the north-south direction. 1 scene is about 36km\*66km.



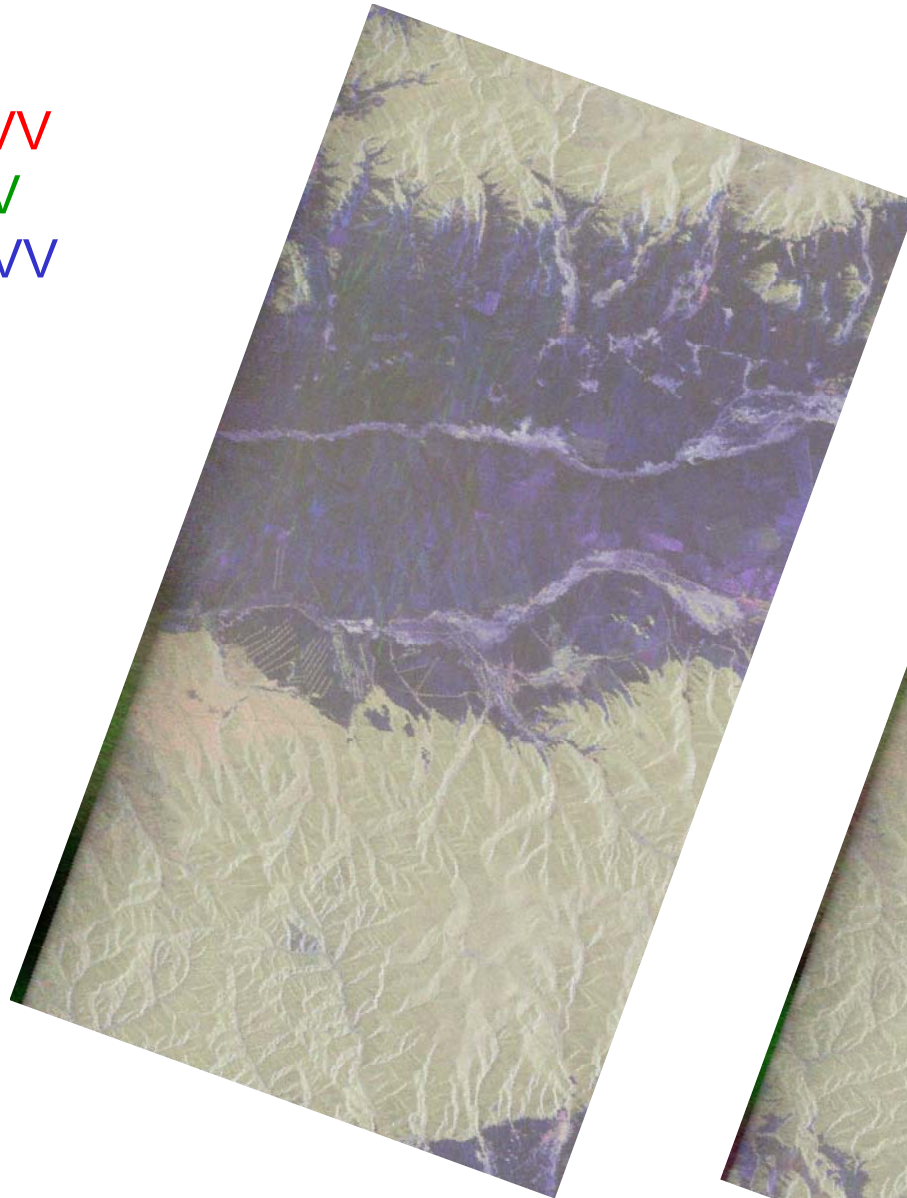


Scene ID: 2580

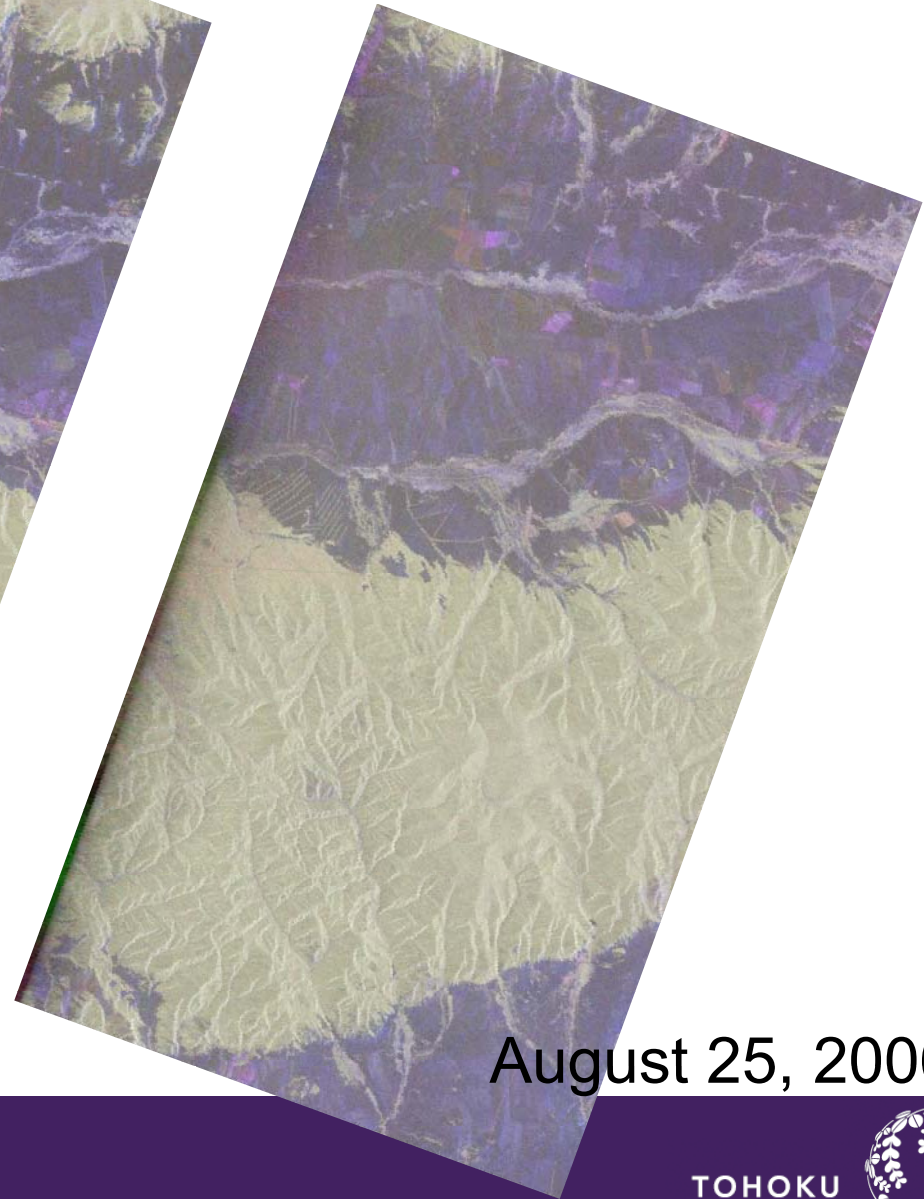
HH-VV

2HV

HH+VV



May 25, 2006

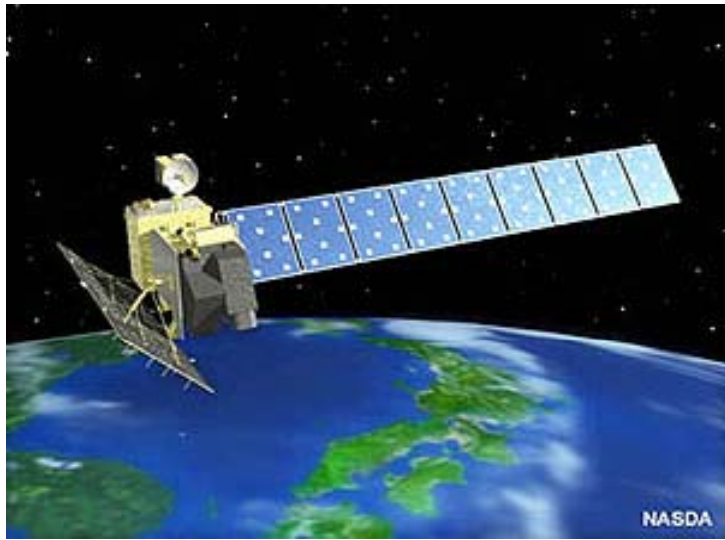


August 25, 2006

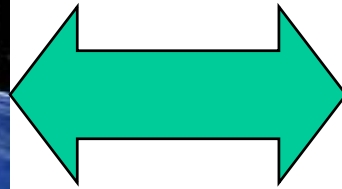
TOHOKU  
UNIVERSITY



# GB-SAR(地表設置型SAR)



広範囲の地表面偏波情報を取得、しかしその解釈は困難

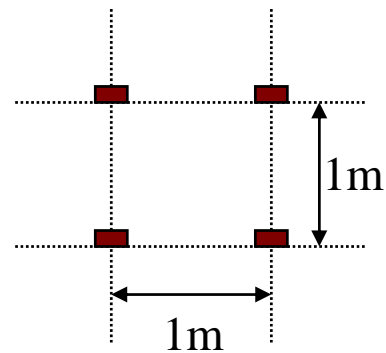
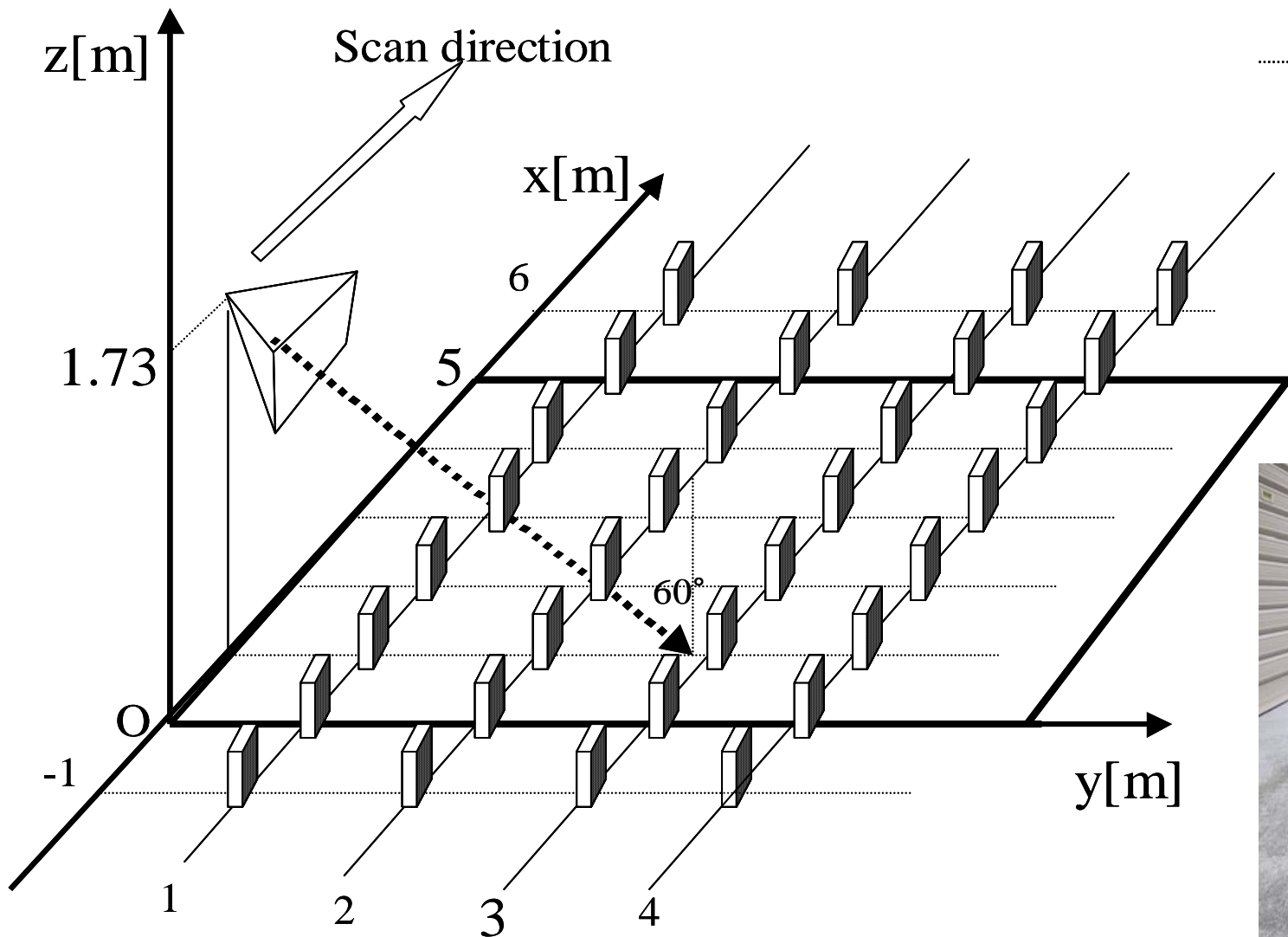


制御されたターゲットの偏波情報を取得可能

## GB-SARによる地表面偏波過程の解析



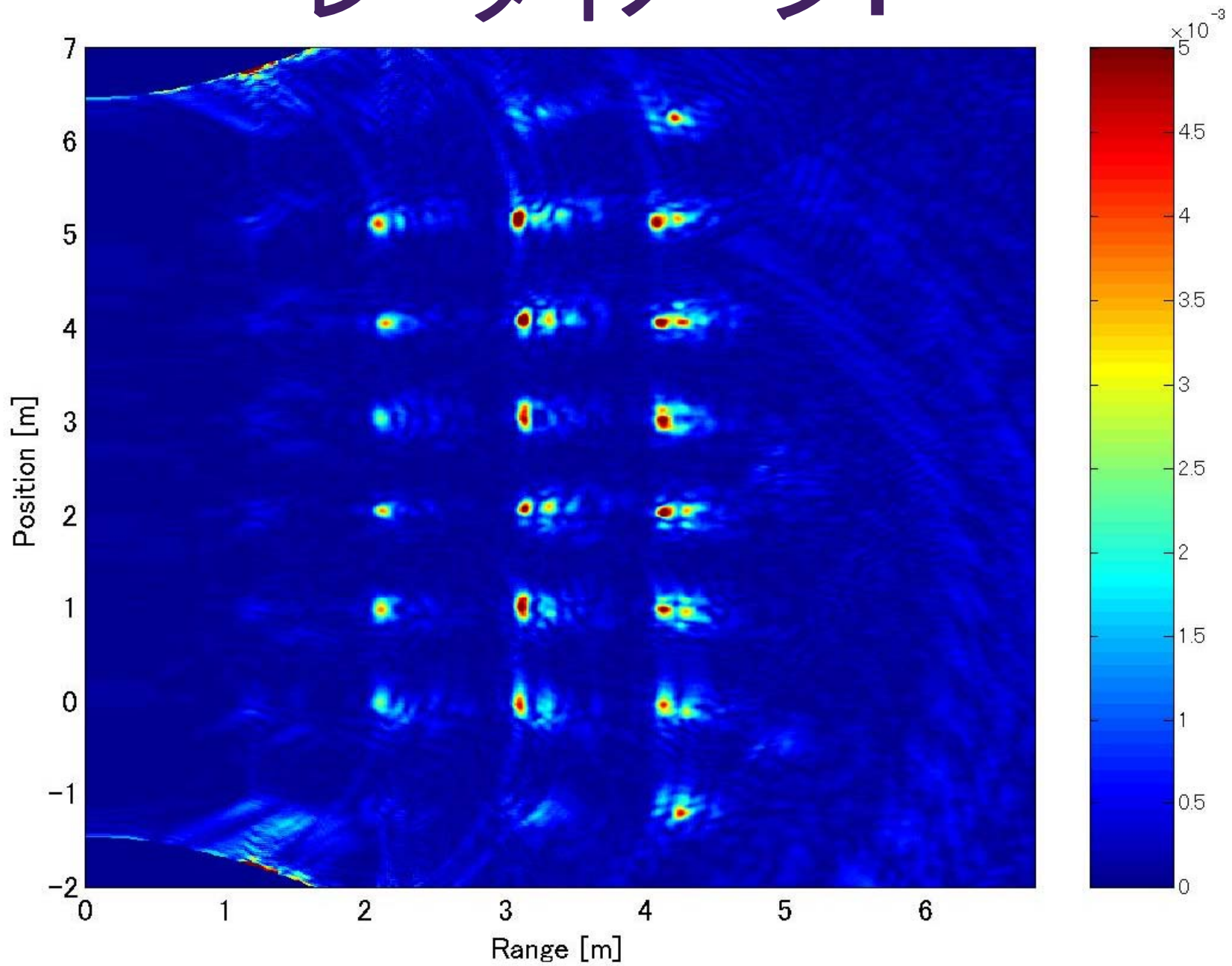
# 実験2構成



# 実験2 風景

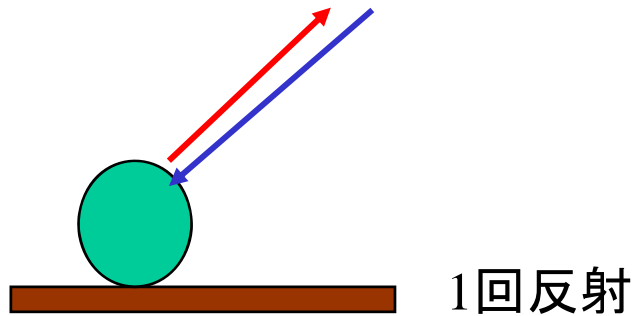


# レーダイメージ1

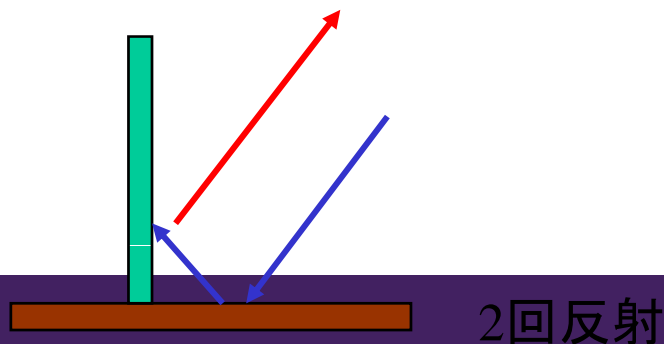


# パウリ行列分解法

$$\begin{pmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{pmatrix} = \alpha \underbrace{\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}}_{\text{1回反射}} + \beta \underbrace{\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}}_{\text{2回反射}} + \gamma \underbrace{\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}}_{\text{その他}}$$



$$\alpha = \frac{S_{HH} + S_{VV}}{2}$$

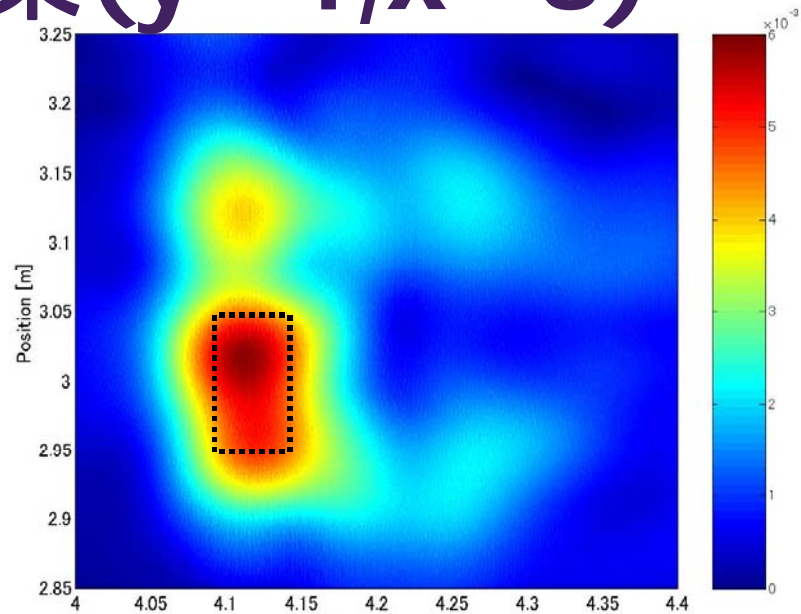
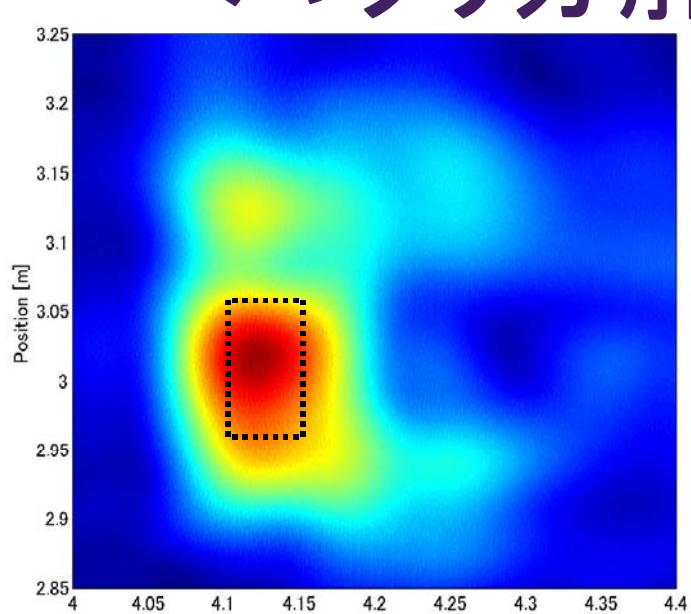


$$\beta = \frac{S_{HH} - S_{VV}}{2}$$

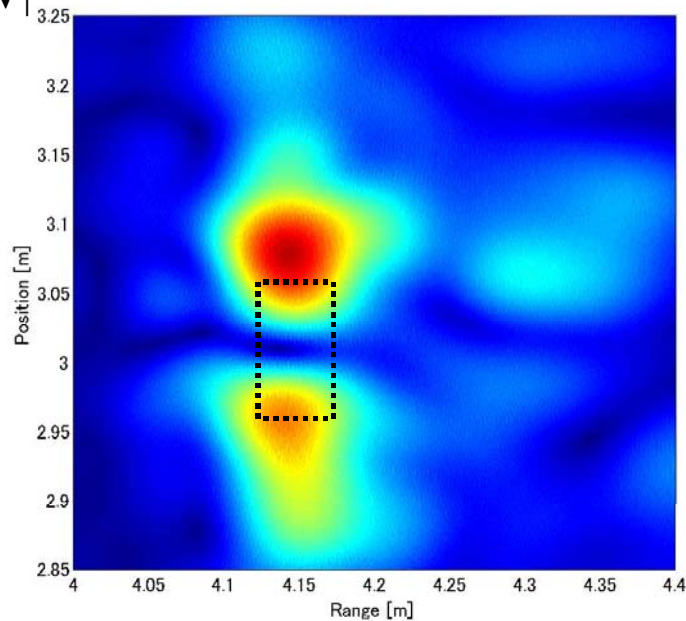
$$\gamma = S_{HV}$$



# パウリ分解の結果 ( $y=4, x=3$ )



$|HH+VV|$

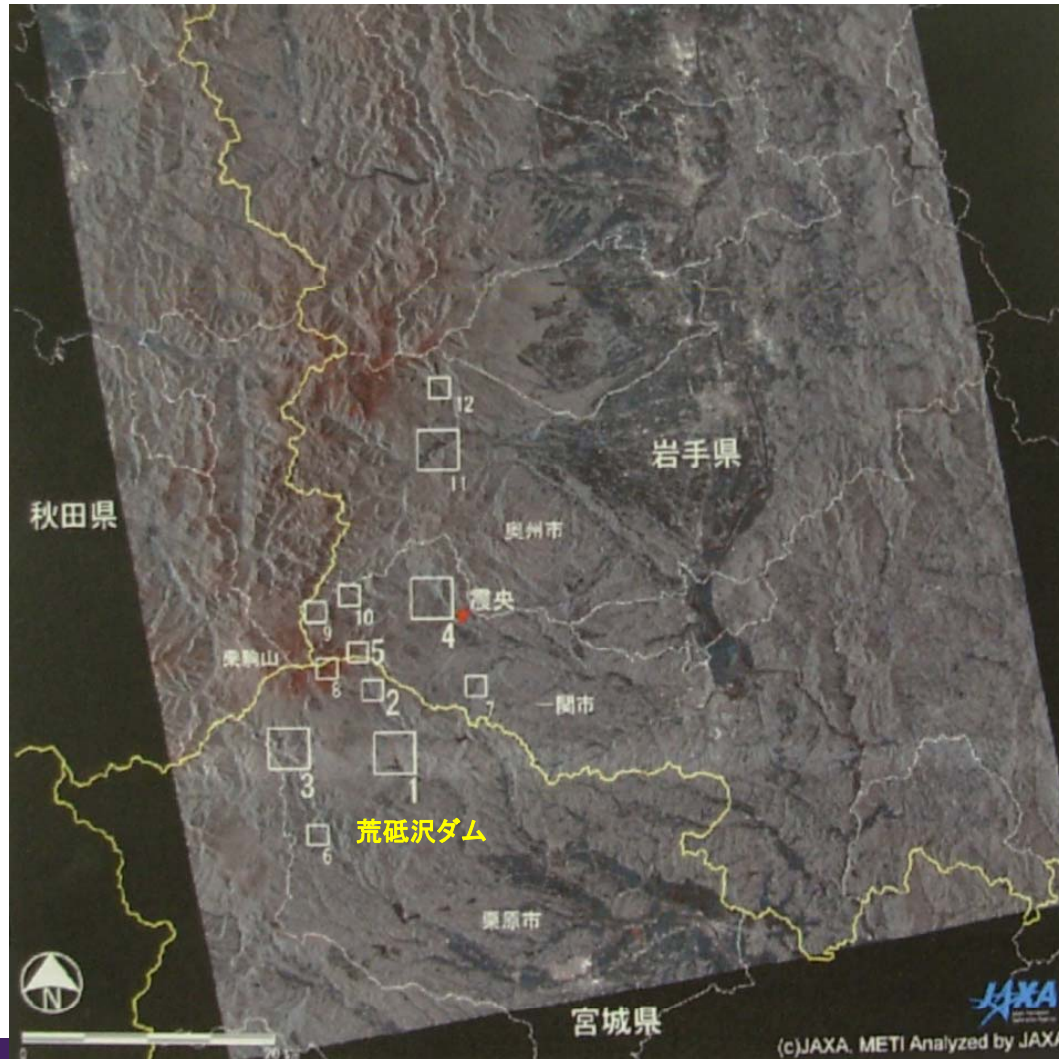


$|HH-VV|$

$|2HV|$



# だいち(ALOS)搭載合成開口レーダ(PALSAR)を用いた、 岩手・宮城内陸地震の観測



## 合成開口レーダの特徴

昼夜天候に関係なくデータ  
取得可能

## 使用画像

2008年3月23日(緑、青)

2008年6月23日(赤)

赤:電波強度明るくなる

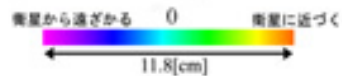
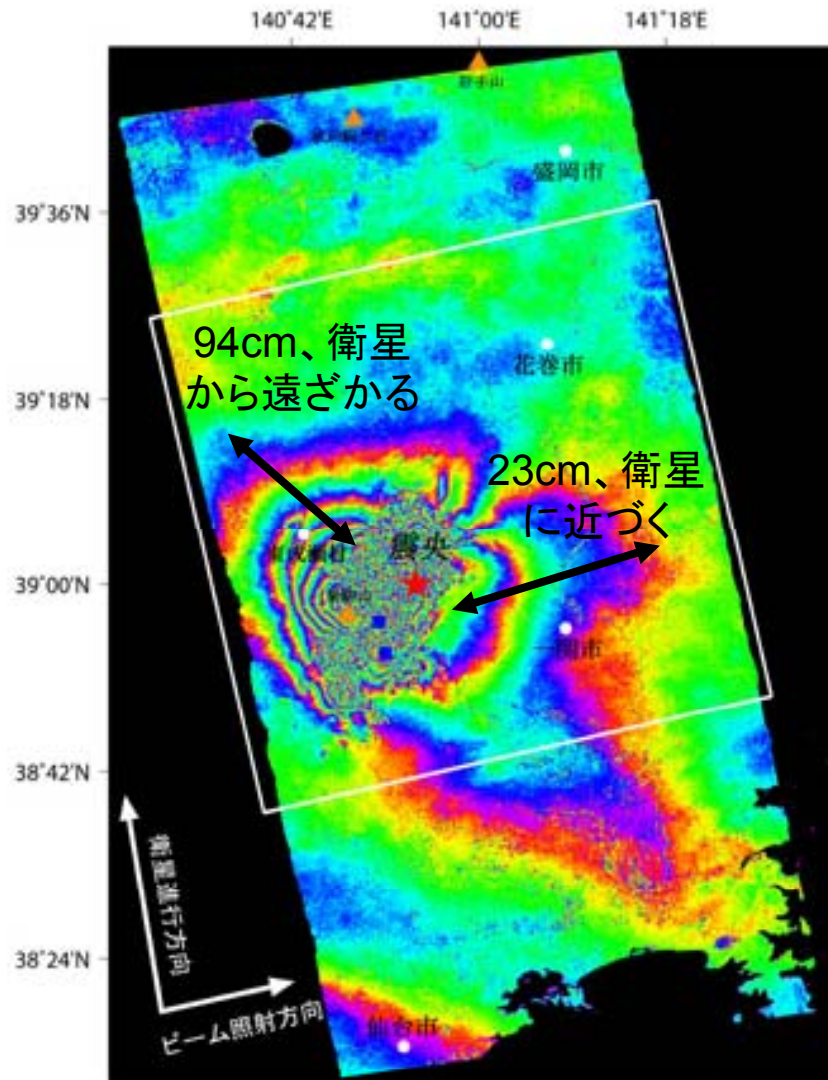
青:電波強度暗くなる

地震前後のカラー合成画像

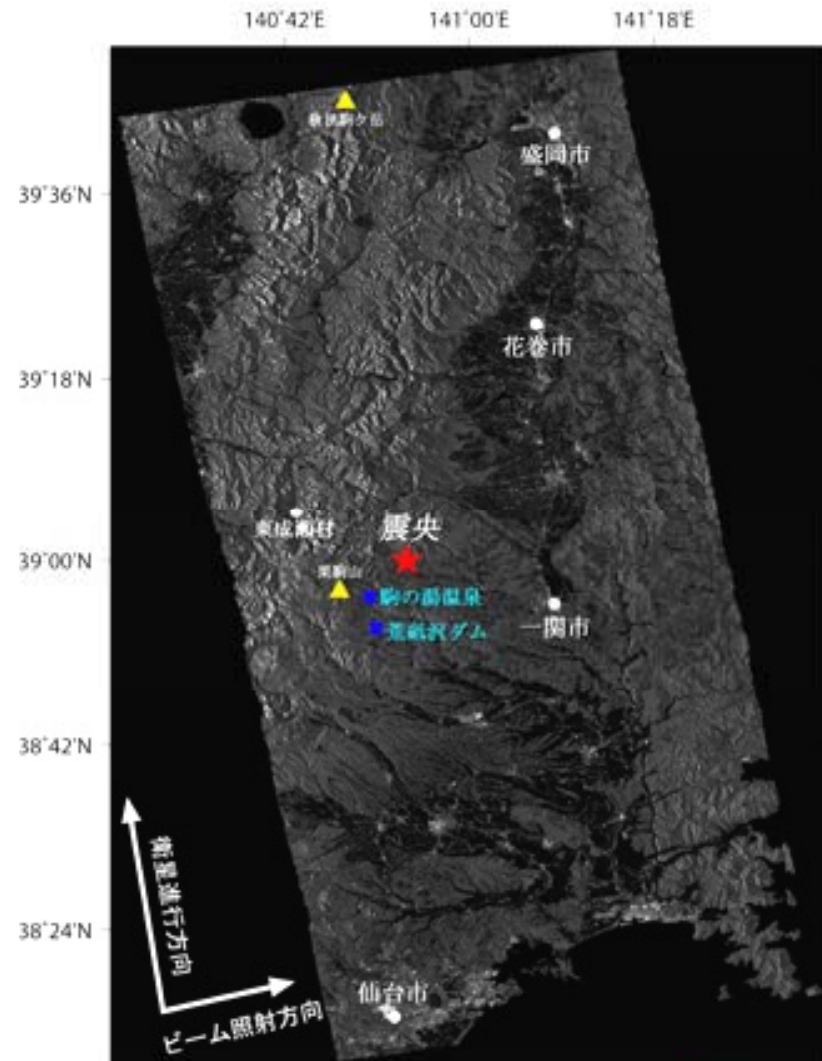




# SAR干渉解析を用いた、地殻変動量の検出



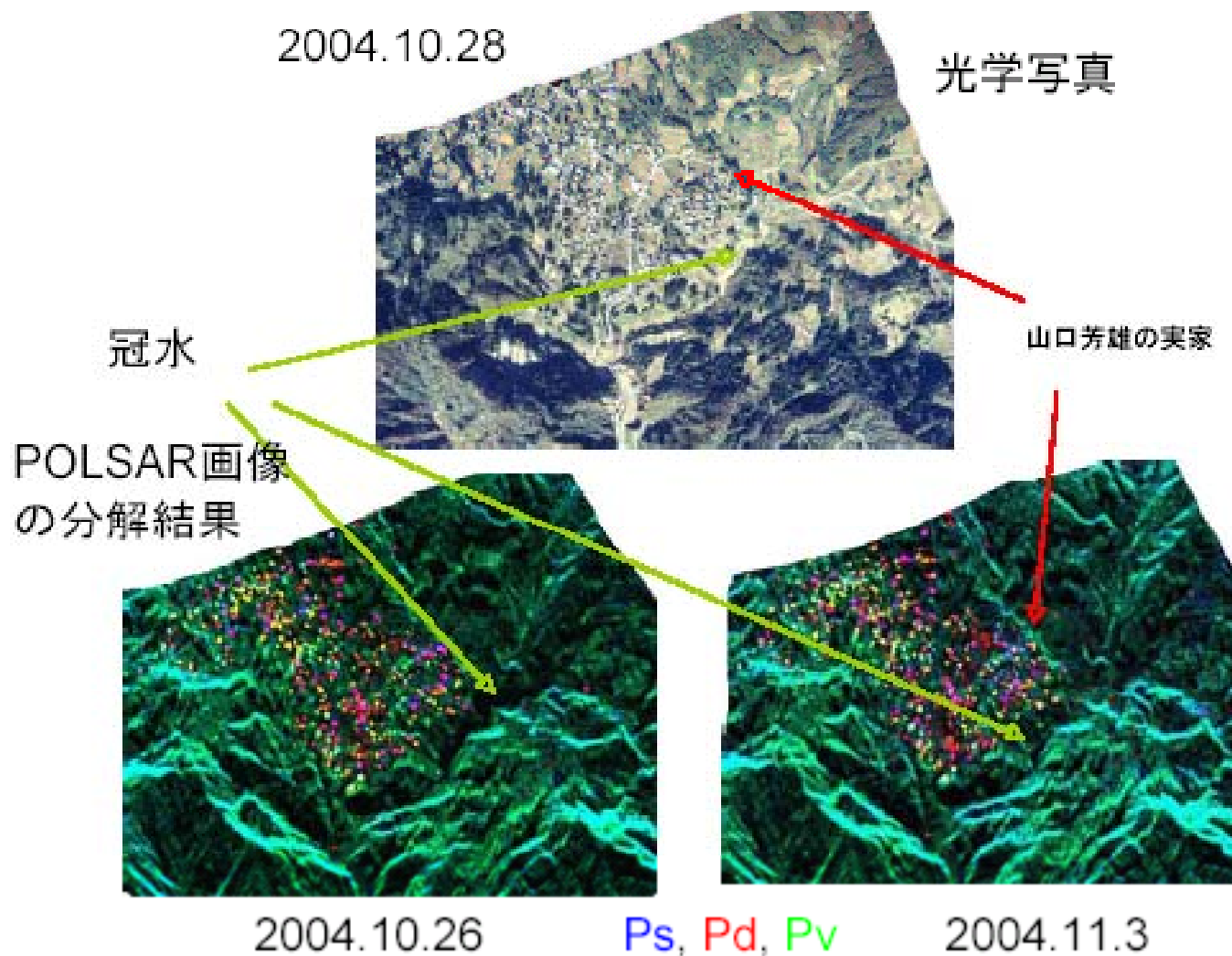
JAXA  
(C)JAXA,METI Analyzed by JAXA

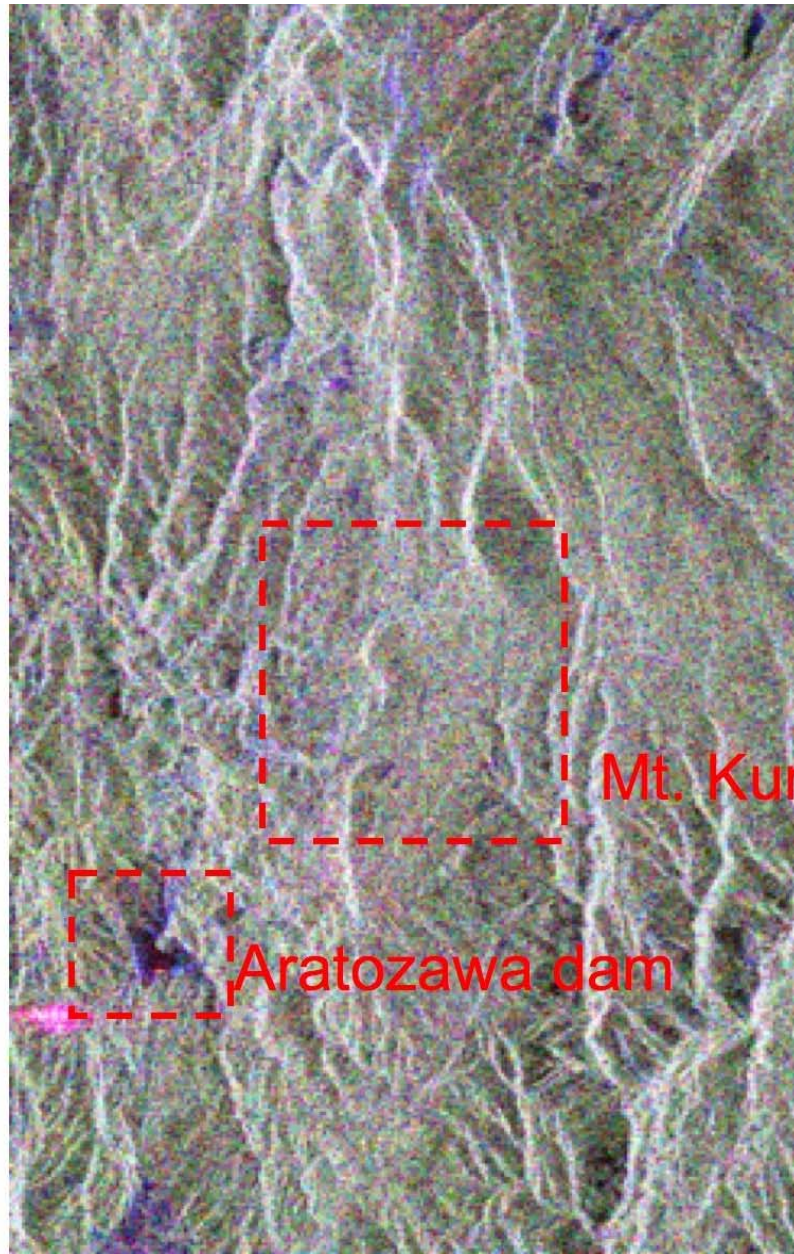


JAXA  
(C)JAXA,METI Analyzed by JAXA



# Pi-SARによる中越地震被災地の検出





Mt. Kurikoma

Aratozawa dam



# まとめ

- レーダポーラリメトリの情報は十分に活用されていない
- 分解能以下でも目標分類が可能(物の形を見るのではない)
- 定量計測に特徴
- 実例の積み重ねが必要
- 多様なプラットフォーム・多周波数・多偏波  
(ENVISAT/PALSAR/TerraSAR/RADARSAT2)



# IGARSS 2011

## Sendai, Japan

IEEE GRSS Japan Chapter  
1 - 5 August, 2011



<http://www.grss-ieee.org/>

