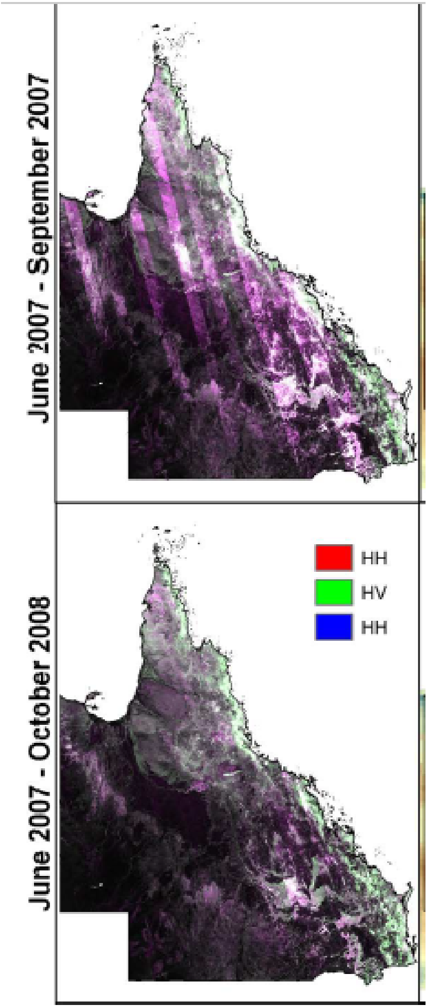
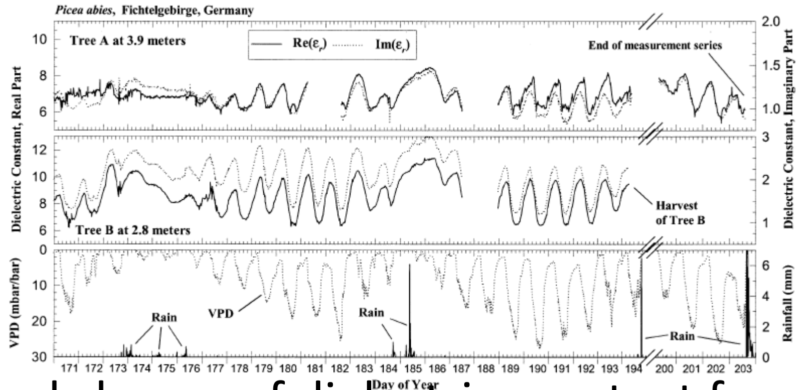
L-band ground based radar data analysis from trees

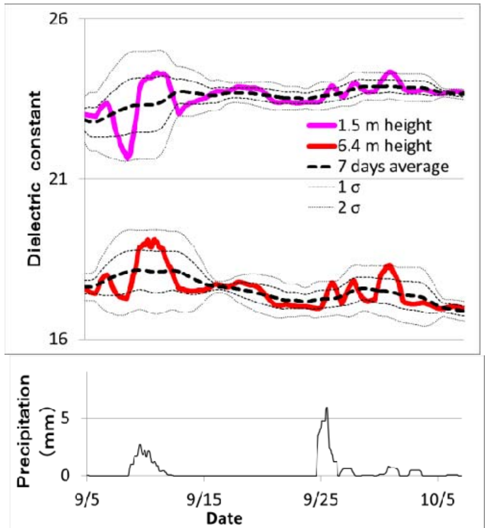
JAXA/EORC
Manabu Watanabe

Tree moisture variation affect the L-band SAR signal from a forest





Diurnal change of dielectric constant for a tree



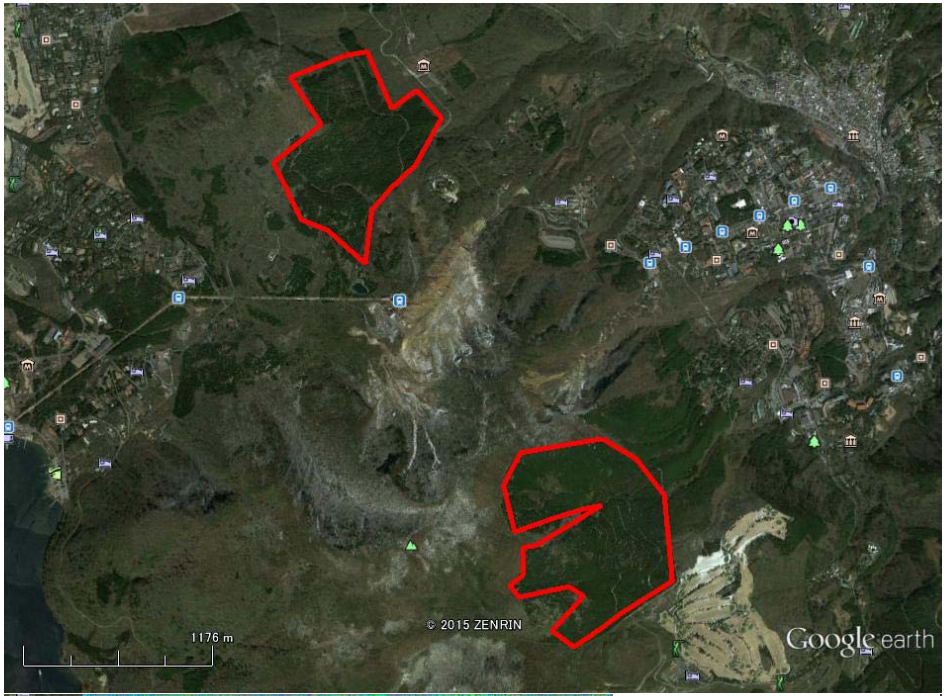
Tree moisture often increase after rain.

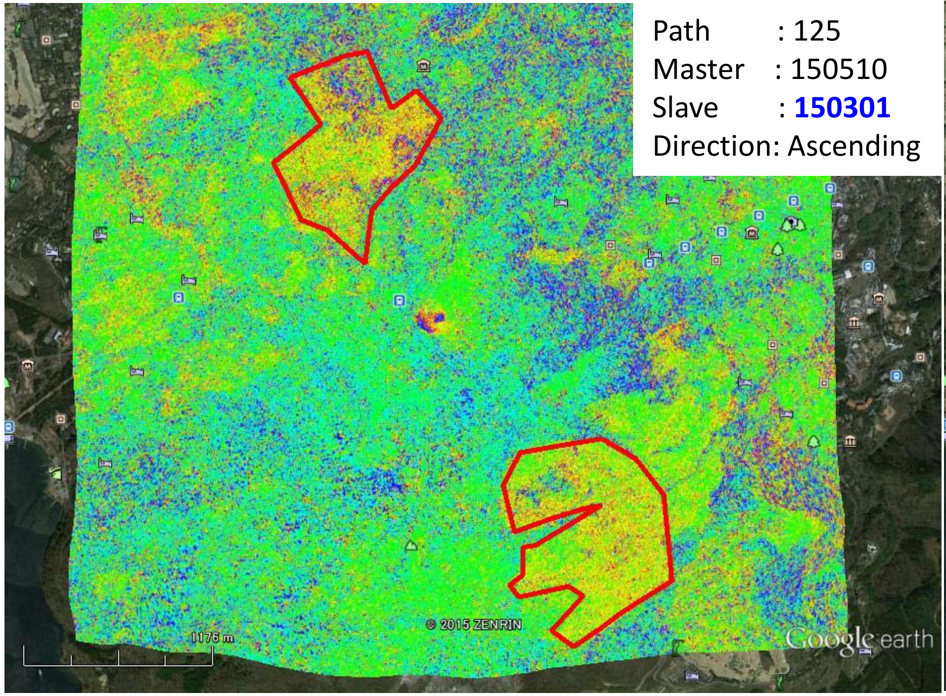
R. Lucas, et al., An Evaluation of the ALOS PALSAR L-Band Backscatter—Above Ground Biomass Relationship Queensland, Australia: Impacts of Surface Moisture Condition and Vegetation Structure, TGARSS, 3(4), pp576-593, 2010
K. C. McDonald, et al., Diurnal and Spatial Variation of Xylem Dielectric Constant in Norway Spruce (*Picea abies* [L.] Karst.) as Related to Microclimate, Xylem Sap Flow, and Xylem Chemistry, IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, 40(9), 2063-2082, 2002
M. Watanabe, et al., Multi-temporal Fluctuations in L-band Backscatter from a Japanese Forest, 53(11), 5799-5813, 2012

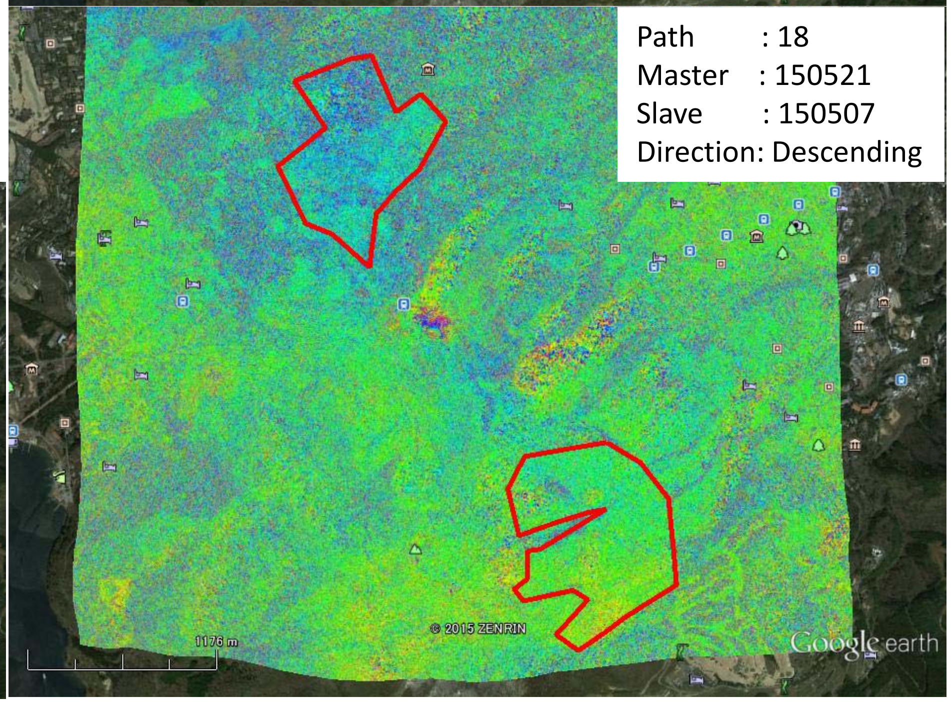
Tree moisture variation affect the L-band phase shift from a forest

Sensor : PALSAR-2
Obs. date : 1) 2015年5/10-3/1
2) 2015年5/21-5/07

<u>Obs. pair 1</u>
Longer path (3cm, 90°) in coniferous forest on March 1, 2015.







M. Watanabe, et al., Phase shift observed over a forest stand with PALSAR-2 SAR interferometry in Hakone, JpGU, submitting

About field experiment

Place : Tsukuba space center
GB radar experiment : Jan. 26 to 27, 2016
Every 15 minutes
GB Lidar experiment : Jan. 27, 2016

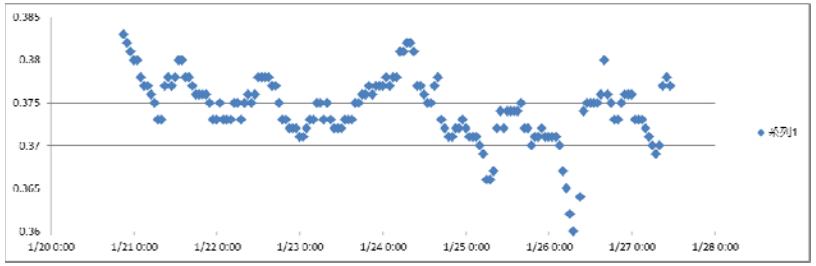
Deploy antennas at 16 m height

H pol. and V pol.

Tree moisture measurement

(Jan. 20 17:00 – Jan. 27 13:00)

Weak (about 1%) daily variation



Two corner reflectors

The one CR is behind a tree

About field experiment

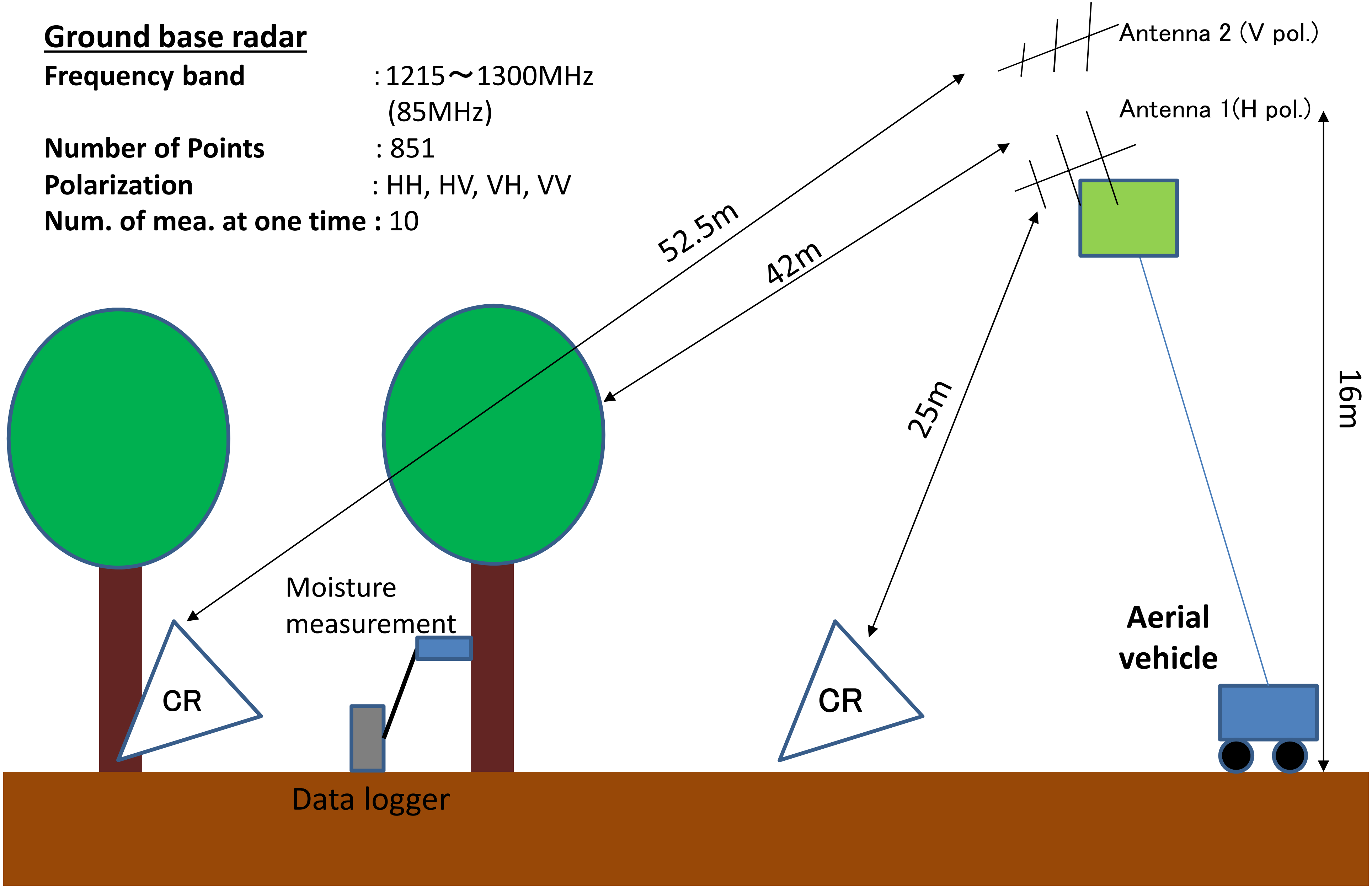
<u>Ground base radar</u>

Frequency band : 1215～1300MHz (85MHz)

Number of Points : 851

Polarization : HH, HV, VH, VV

Num. of mea. at one time : 10



Polarimetric calibration for the GB radar

Simple full pol. calibration
with a trihedral CR

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

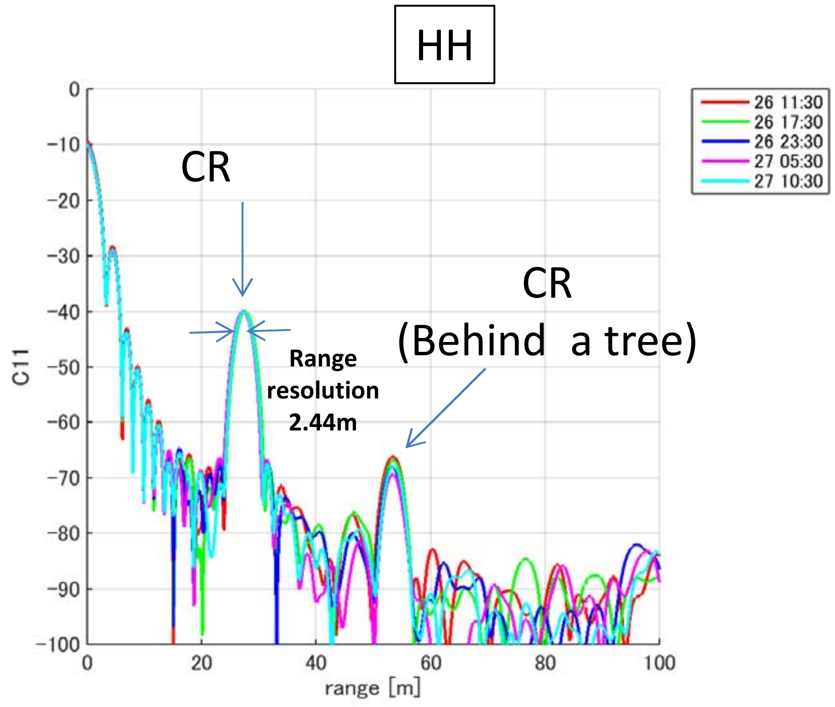
$$\begin{bmatrix} M_{HH} & M_{HV} \\ M_{VH} & M_{VV} \end{bmatrix} = \begin{bmatrix} 1 & \delta \\ \delta & f \end{bmatrix} \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix} \begin{bmatrix} 1 & \delta \\ \delta & f \end{bmatrix}$$

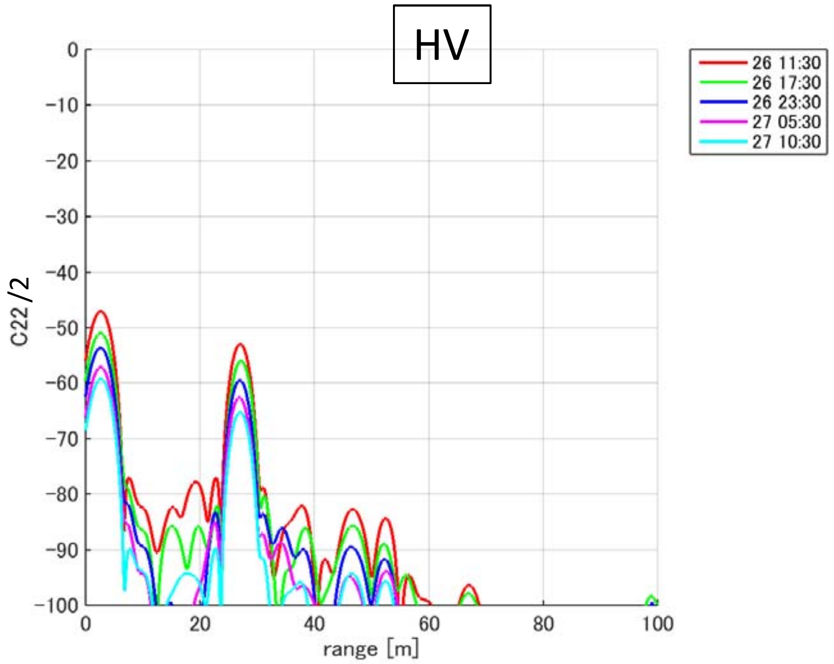
Observed — **Cal. Coeff.** (Rx antenna) — Target — **Cal. Coeff.** (Tx antenna)

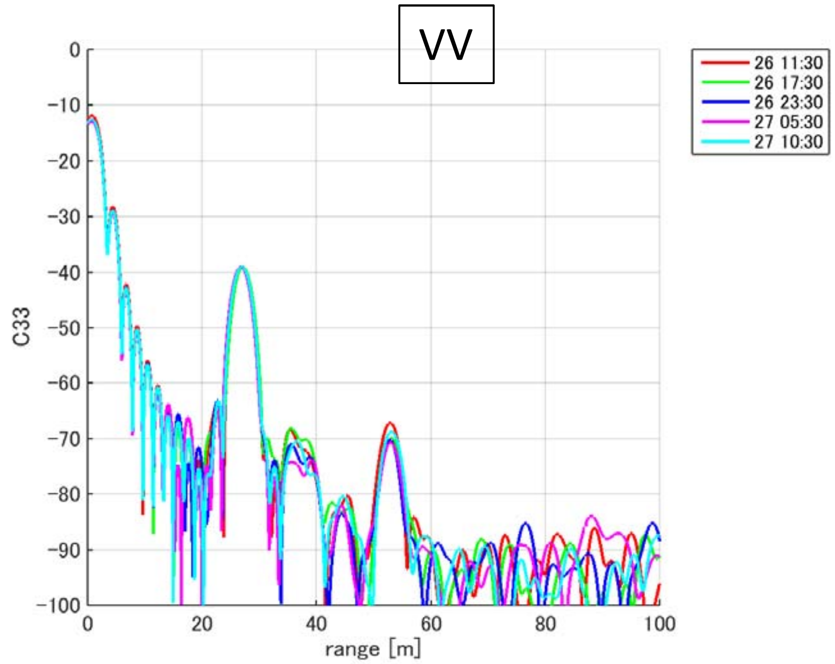
Polarimetric calibration for the GB radar

Range profile **betore the cal.**
(Linear basis)

Signal from Tri. CR in HV pol.
Cross talk :– 14dB



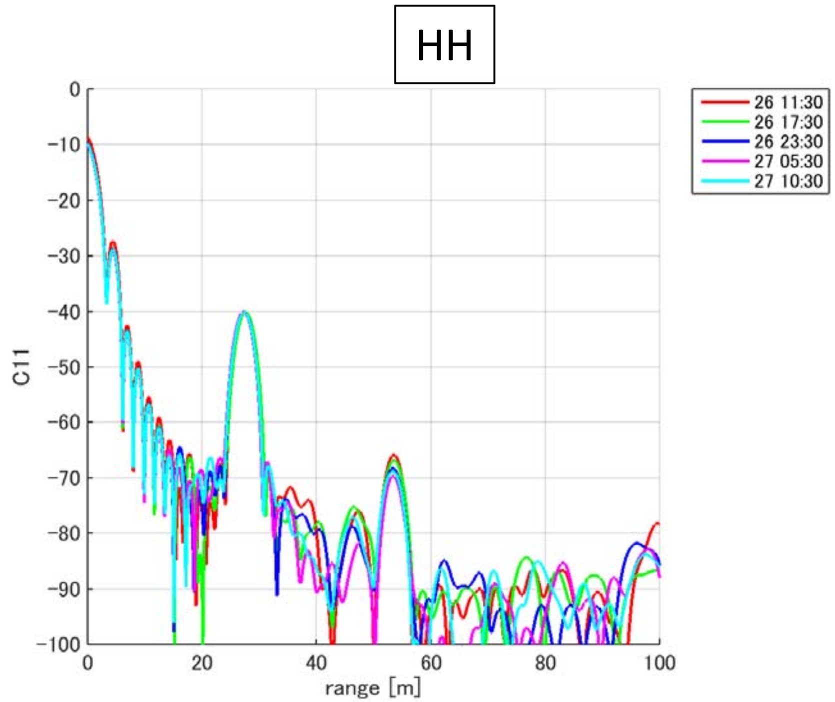


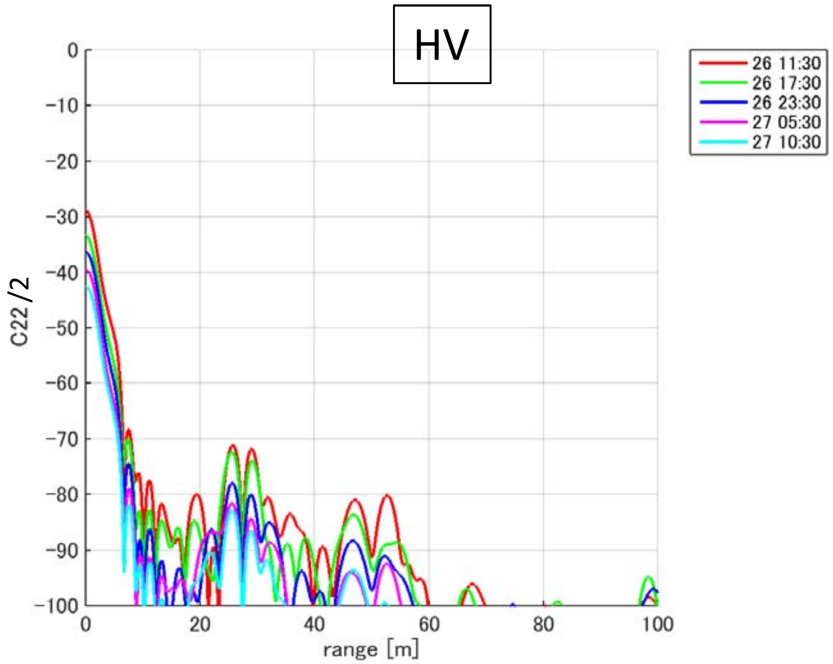


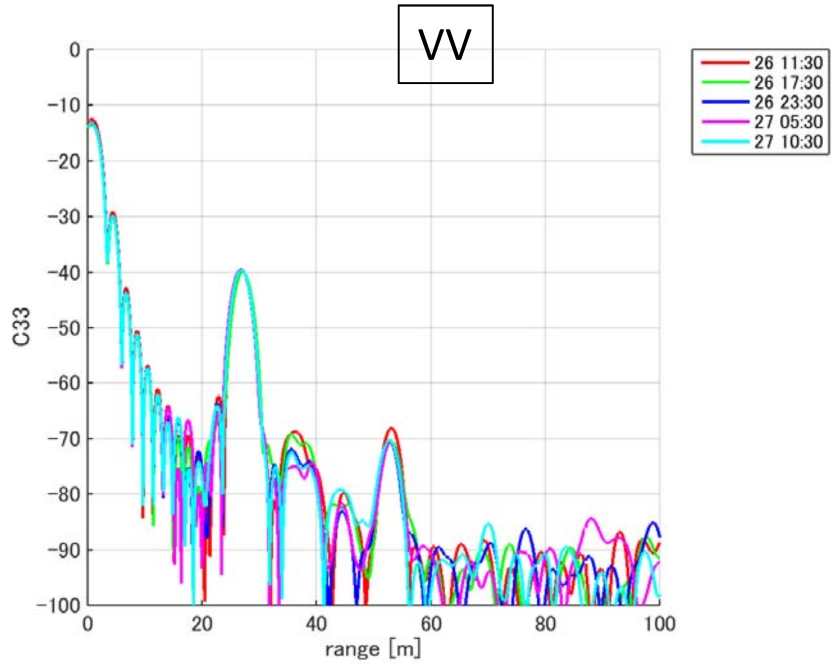
Polarimetric calibration for the GB radar

Range profile **after the cal.**
(Linear basis)

Decrease signal from tri. CR in HV pol.
Cross talk ：– 14dB → –32 dB



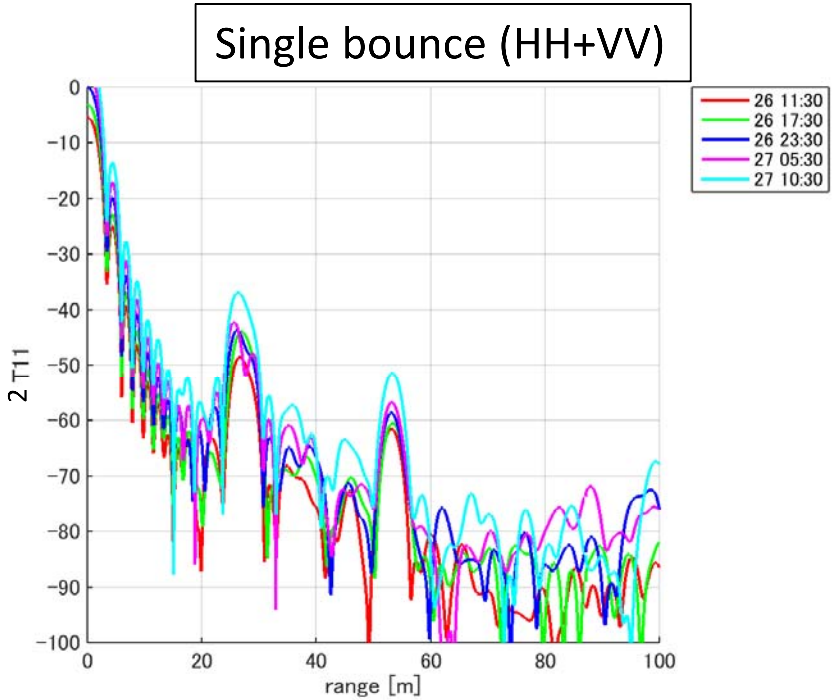


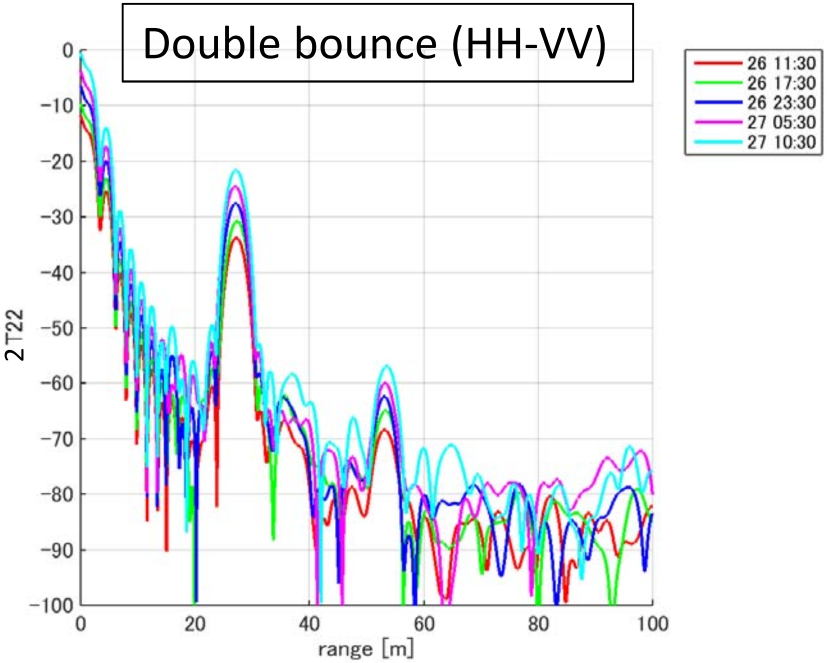


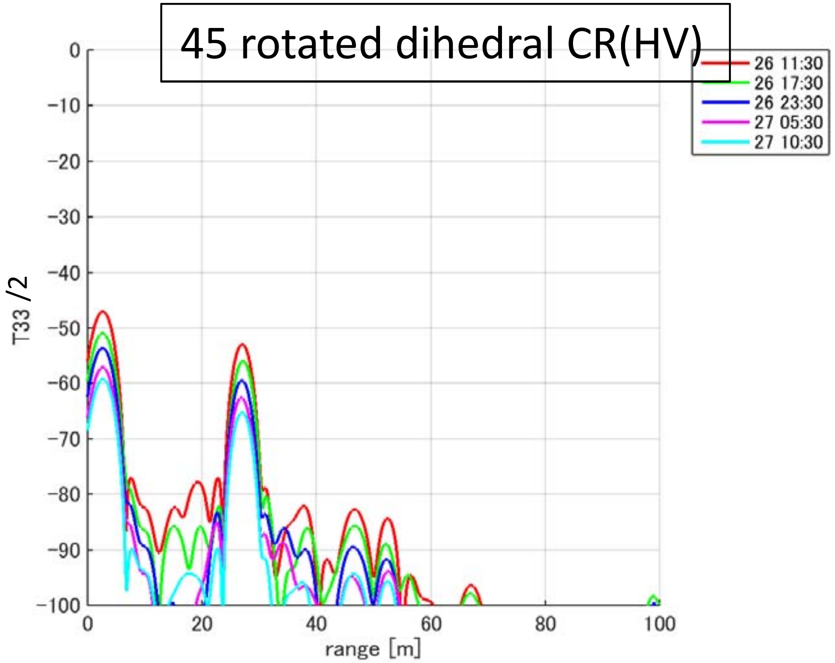
Polarimetric calibration for the GB radar

Range profile **betore the cal.**
（Pauli basis）

Signal from Tri. CR : **HV and double bounce**



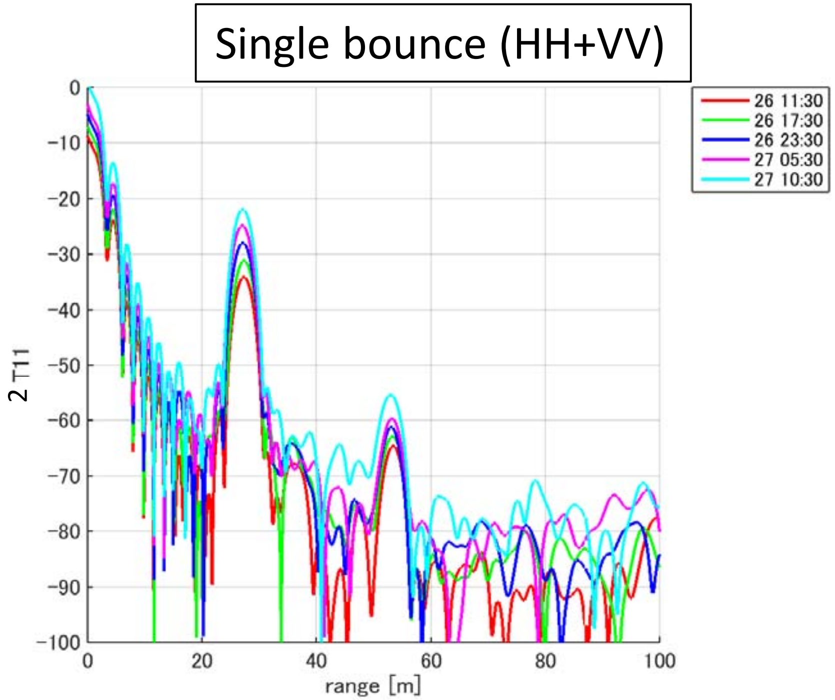


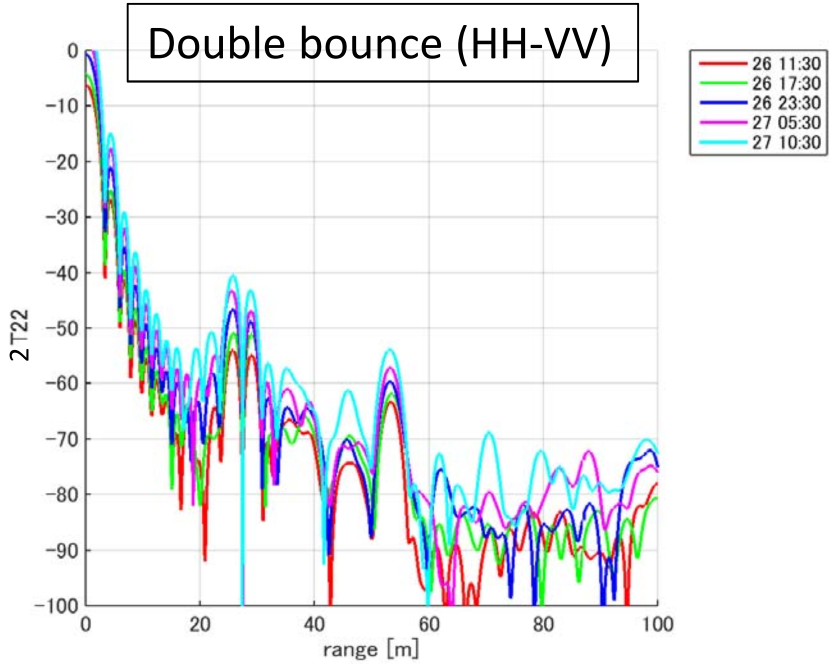


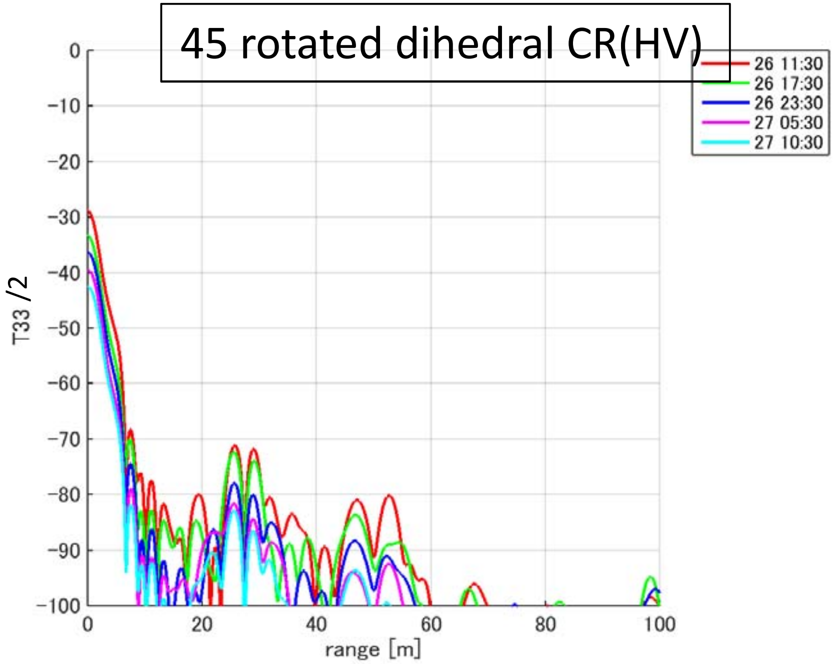
Polarimetric calibration for the GB radar

Range profile **after the cal.**
（Pauli basis）

Signal from Tri. CR : **Single bounce**



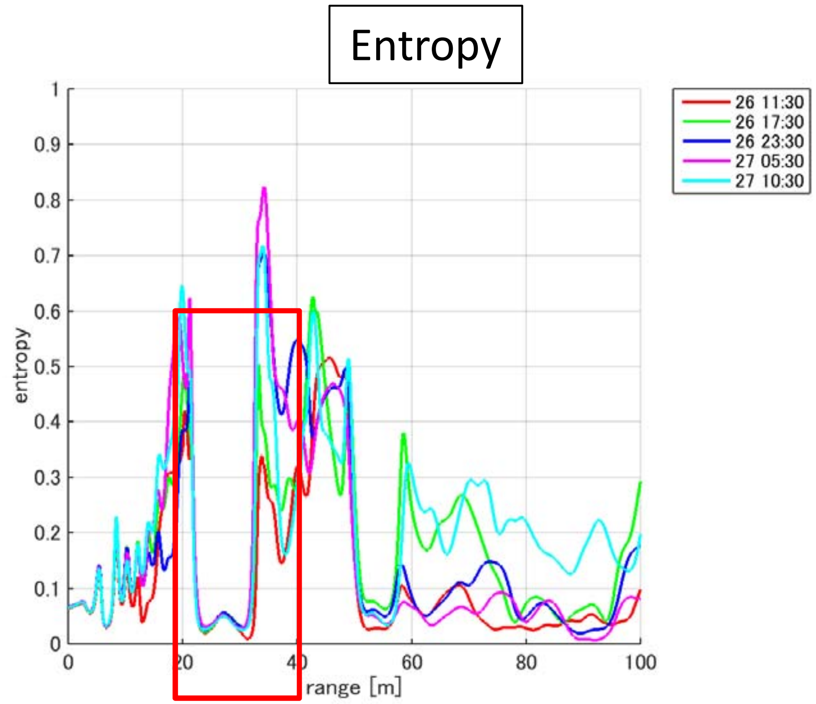


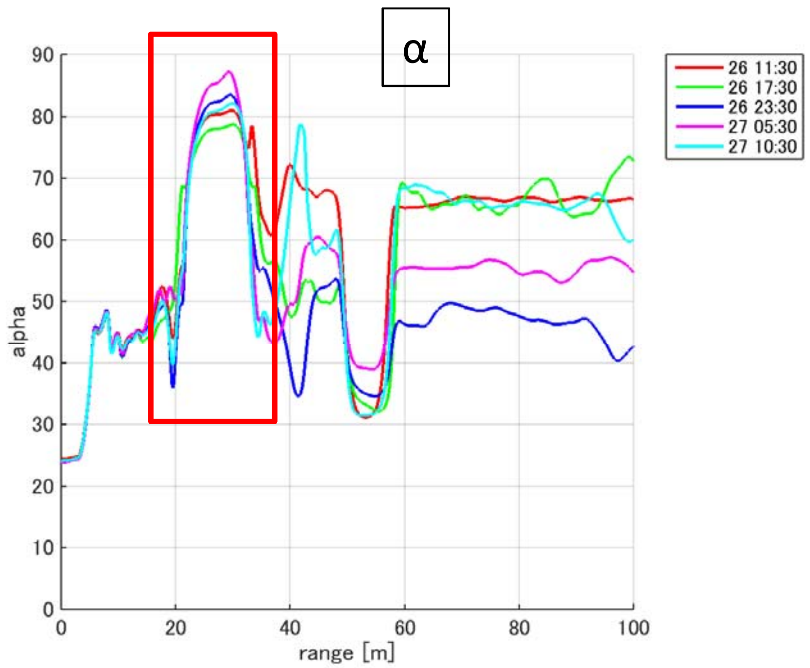


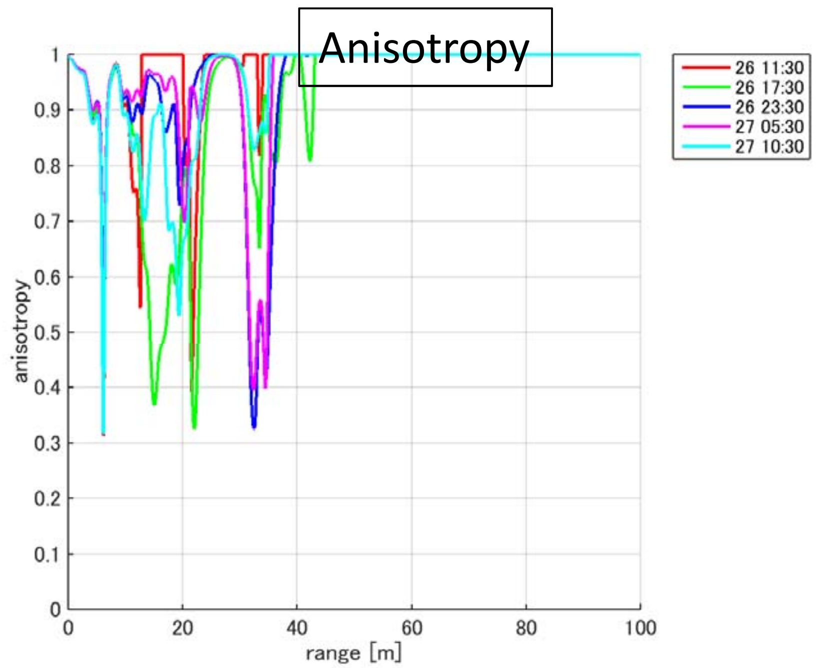
Polarimetric calibration for the GB radar

Range profile **betore the cal.**
（Eigen value decomposition）

Signal from Tri. CR : **α≈90° (double bounce)**



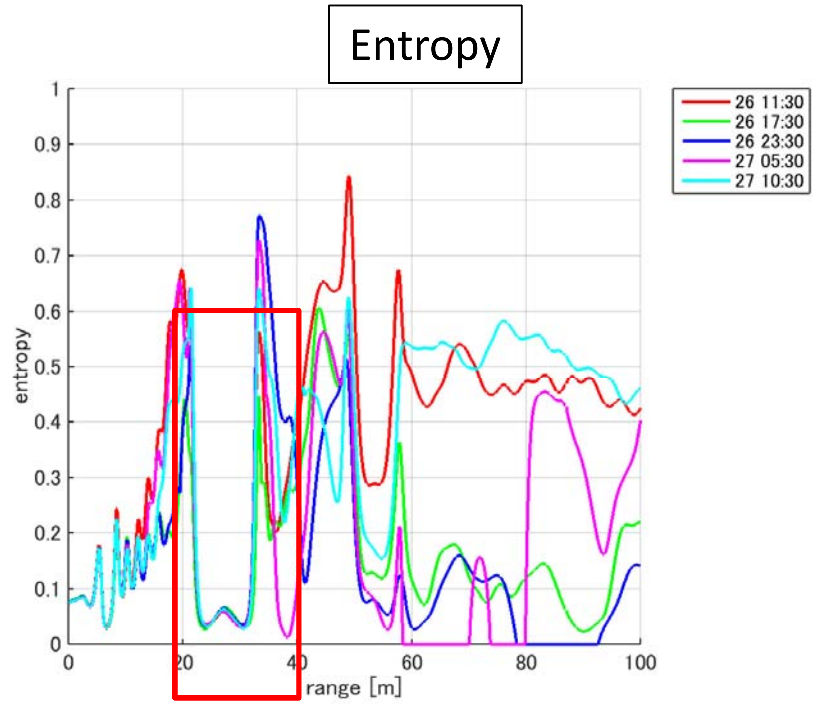


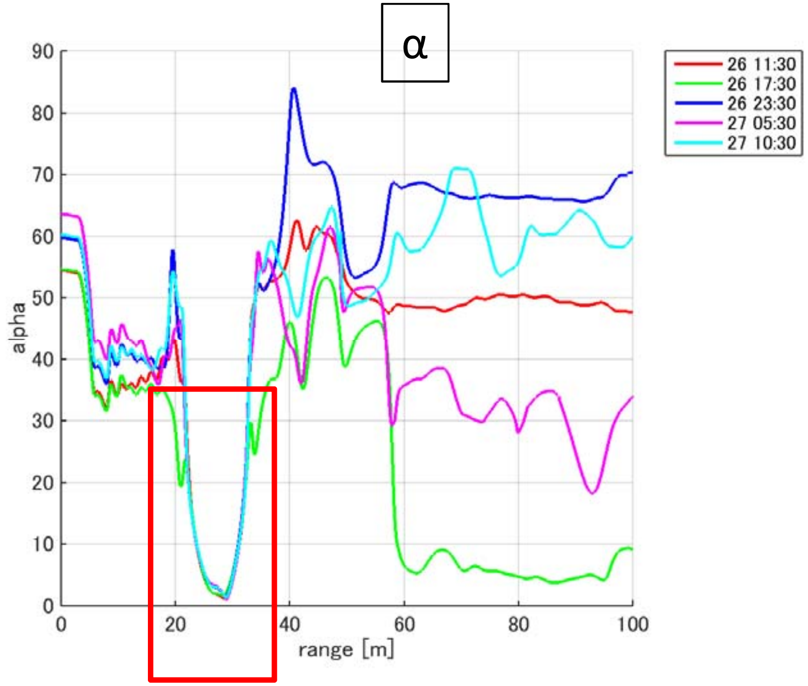


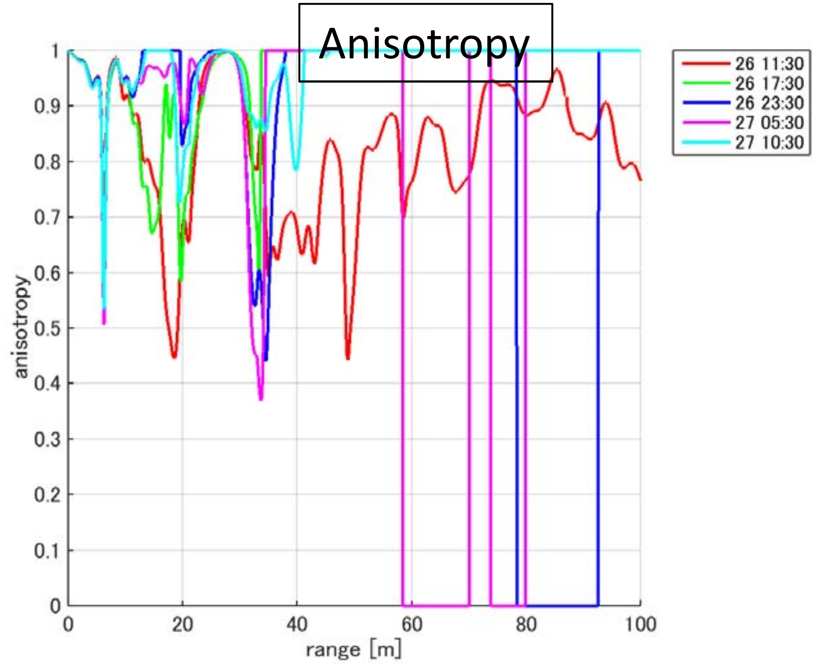
Polarimetric calibration for the GB radar

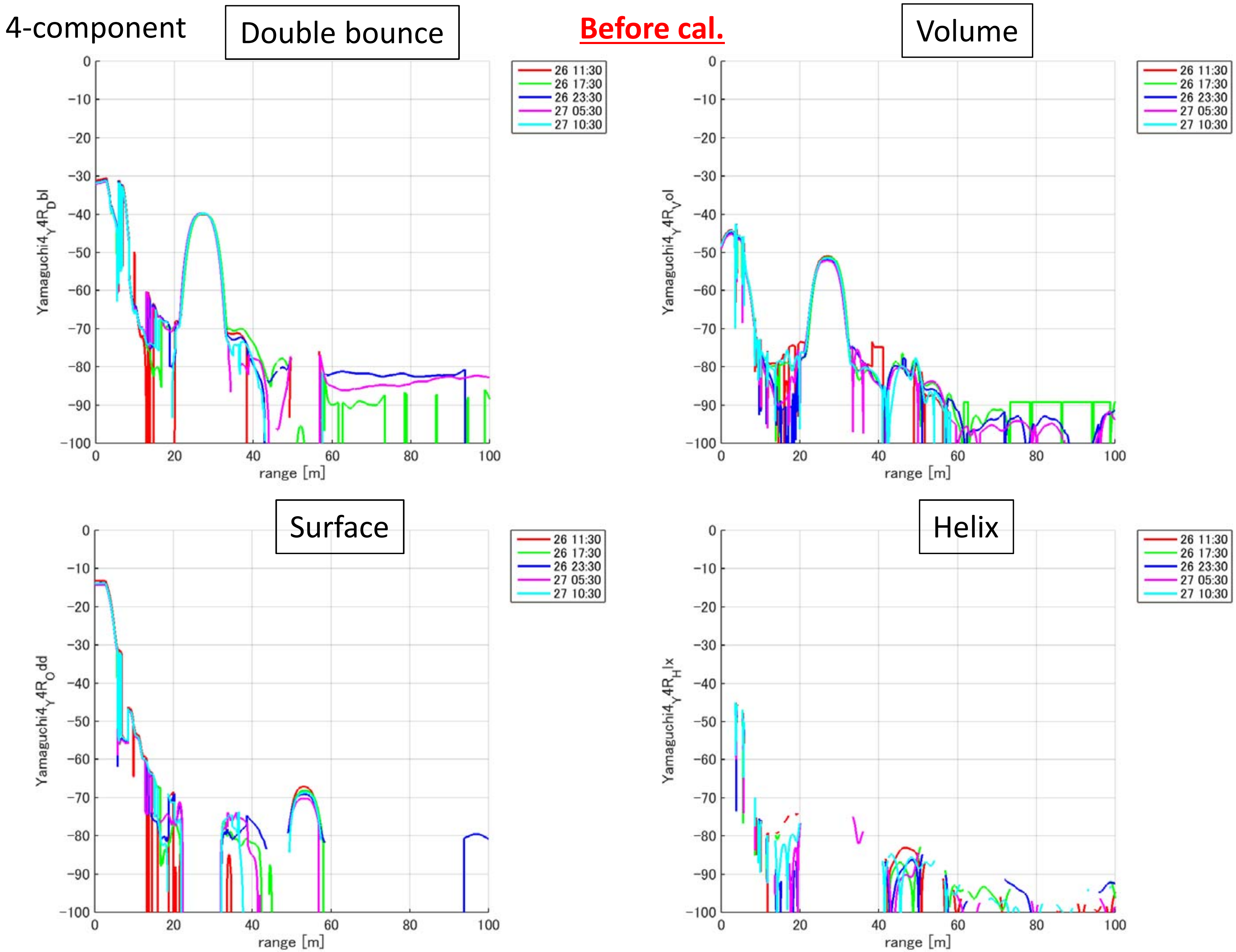
Range profile **after the cal.**
（Eigen value decomposition）

Signal from Tri. CR : **Entropy ≈0**, **α≈0°**








4-component
Before cal.
Double bounce
Volume
Surface
Helix
26 11:30
26 17:30
26 23:30
27 05:30
27 10:30
range [m]

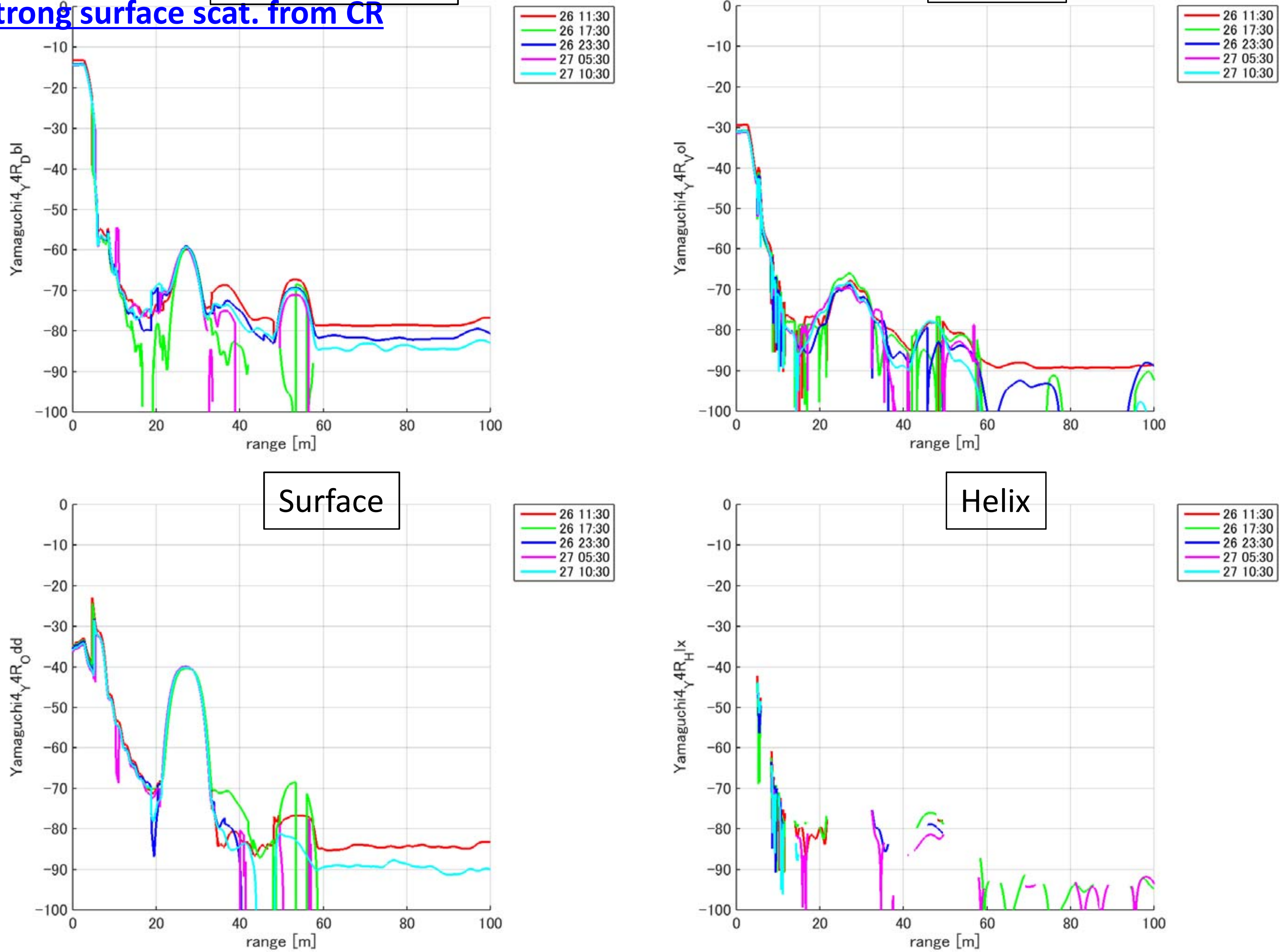
4-component

Strong surface scat. from CR

Double bounce

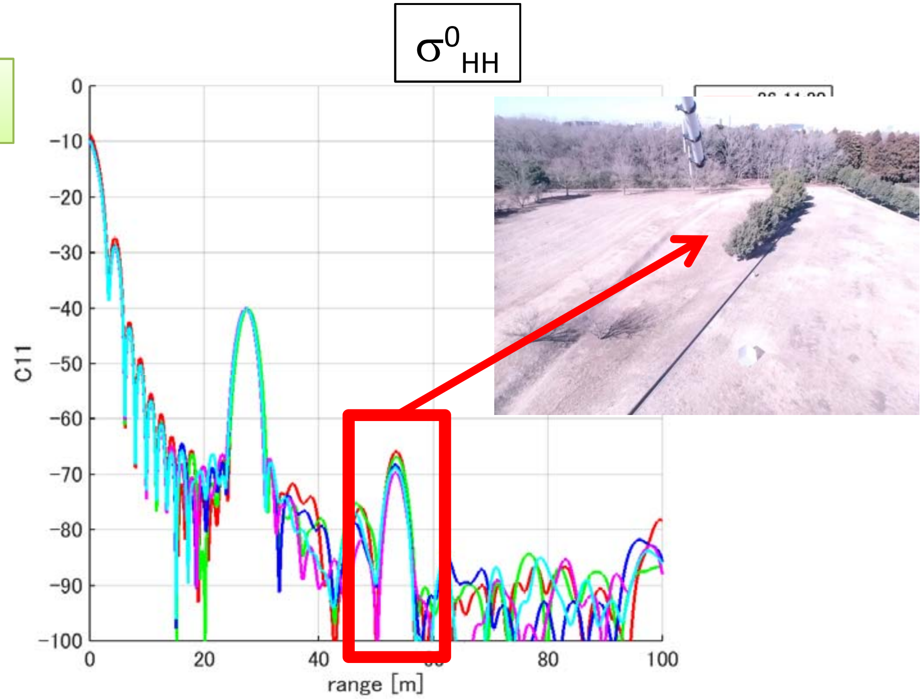
After the cal.

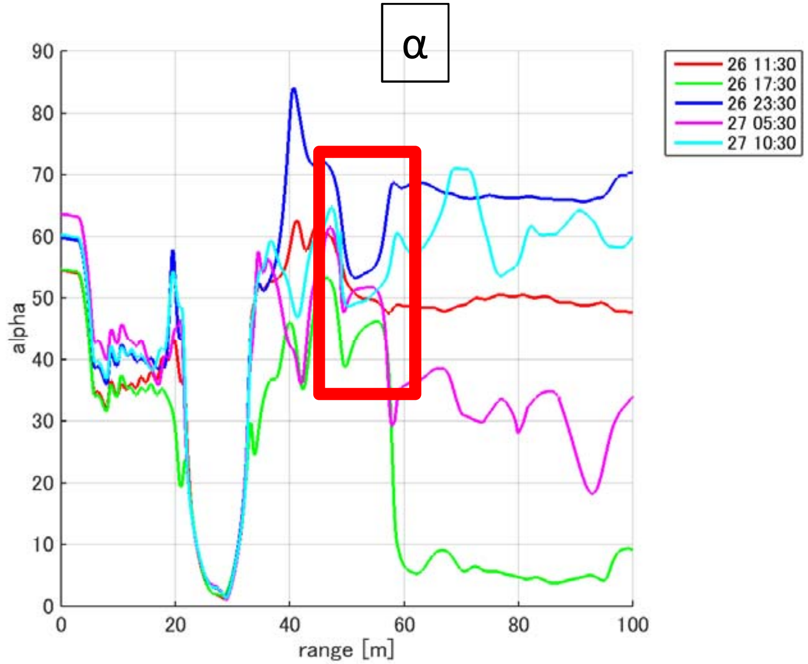
Volume

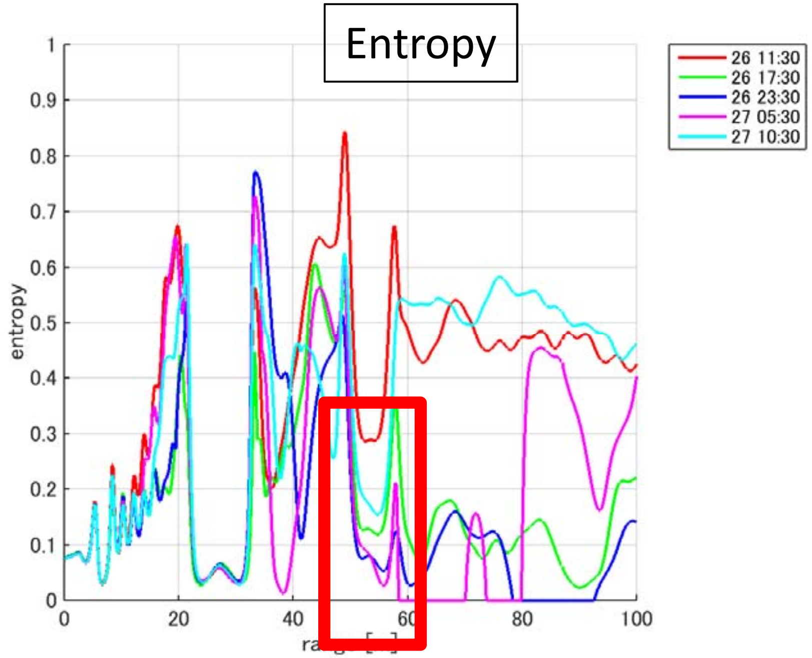


Radar reflection from a CR behind a tree.

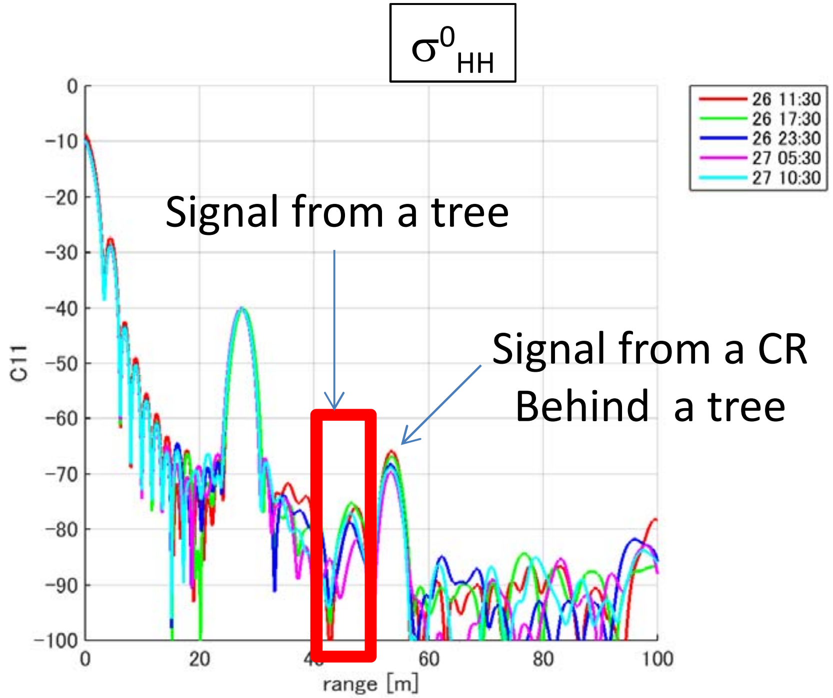
	CR	CR behind a tree
Optical	○	×
σ^0_{HH}	○	○
Entropy	≈0	≈0
α	≈0	**≈50°**







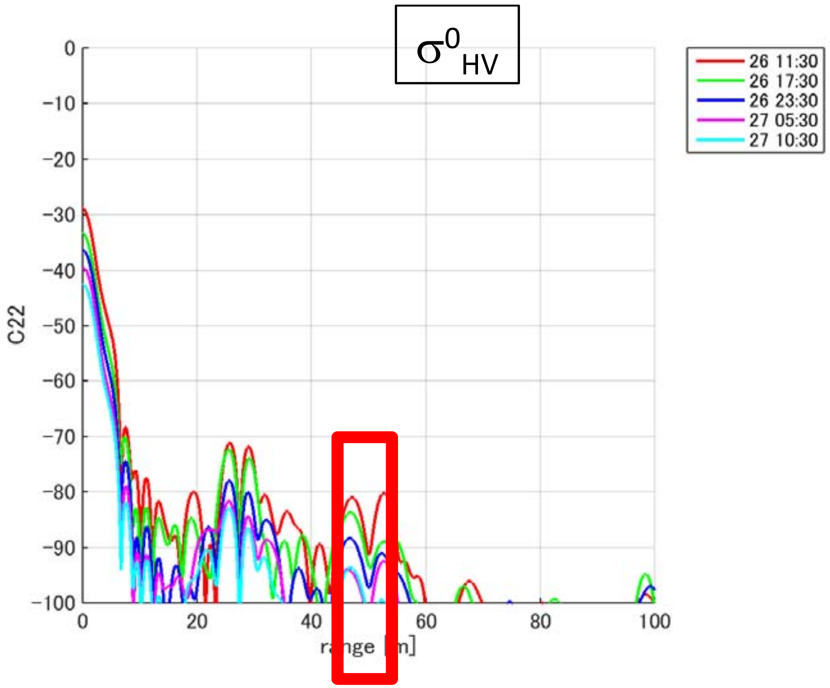
Radar reflection from a tree

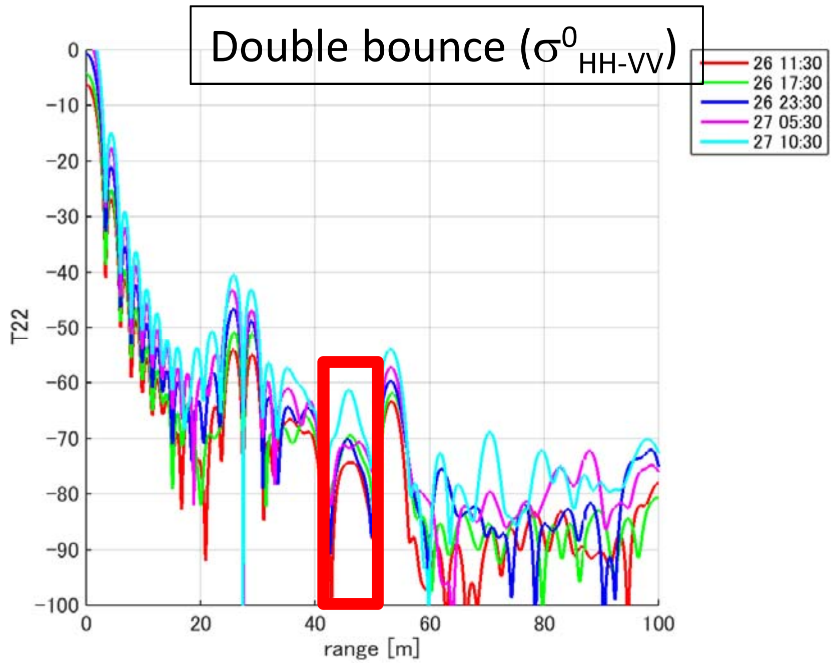


Weak signal from a tree

σ^0_{HV} : Volume scattering?

σ^0_{HH-VV} : Double bounce





Next experiment

4 pol. Calibration

$$\begin{bmatrix} M_{HH} & M_{HV} \\ M_{VH} & M_{VV} \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix} \begin{bmatrix} t_{11} & t_{12} \\ t_{21} & t_{22} \end{bmatrix}$$

Observed — Cal. Coeff. (Rx antenna) — Target — Cal. Coeff. (Tx antenna)

S. H. Yueh, and J. A. Kong, Journal of electromagnetic waves and applications, vol.4, no 1, 27-48, 1990

Ans. 1

$$r_{22} = \frac{c}{d} \frac{Y_{22}}{X_{11}} \frac{X_{11}Z_{21} - X_{21}Z_{11}}{Y_{22}Z_{11} - Y_{12}Z_{21}}$$

$$r_{12} = \frac{Y_{12}}{Y_{22}} r_{22}$$

$$t_{22} = \frac{c}{d} \frac{Y_{22}}{X_{11}} \frac{X_{11}Z_{12} - X_{12}Z_{11}}{Y_{22}Z_{11} - Y_{21}Z_{12}}$$

$$t_{21} = \frac{Y_{21}}{Y_{22}} t_{22}$$

Ans. 2

$$r_{22} = \frac{d}{e} \frac{Y_{22}}{X_{11}} \frac{X_{11}Z_{22} - X_{21}Z_{12}}{Y_{22}Z_{12} - Y_{12}Z_{22}}$$

$$r_{12} = \frac{Y_{12}}{Y_{22}} r_{22}$$

$$t_{22} = \frac{d}{e} \frac{Y_{22}}{X_{11}} \frac{X_{11}Z_{22} - X_{12}Z_{21}}{Y_{22}Z_{21} - Y_{21}Z_{22}}$$

$$t_{21} = \frac{Y_{21}}{Y_{22}} t_{22}$$

8 unknown

-> 3 targets for the calibration

Next experiment

Place : Tsukuba space center
GB radar obs. : March 18 – 19, 2016
Pi-SAR-L2 obs. : March 19, 2016
UAV obs. : March 19, 2016

Test site @ Tsukuba space center

Summary

1. Simple 4-pol. calibration for the ground based radar
   Cross talk : – 14dB → –32 dB
   Channel imbalance : ∼1
2. Radar reflection from a CR behind a tree

	CR	CR behind a tree
Optical	○	×
σ^0_{HH}	○	○
Entropy	≈0	≈0
α	≈0	**≈50°**

3. Radar reflection from a tree
   Weak volume (σ^0_{HV}) and double bounce ($\sigma^0_{HH\text{-}VV}$) scattering observed.

Future

- 4-pol. calibration for the ground based radar with 3 types of CRs.
- GB radar obs. with Pi-SAR-L2 and UAV (End of March)