Calval and path processing

M. Shimada
TDU, JAXA

KC#22 at RESTEC Tokyo

path processing

strip
- prf change
- Coverage -> shortage

- minor agc correction -> improvement of the caibration
- chirp update
- ud azimuth pc

scansar
- prf change
- chirp update
- ud azimuth phase coding
- Dual receivers -> Azimuth Ambiguity

Calibration
Validation

slope correction same
ortho rectification same

DEM same: 30m/90m, AI by Paul or Kyle

ps : 4 times slower

ALOS-2 Schedule and status

ALOS-2 is in good condition and the everything is on-going.

2014

- May 24-26 launched and PALSAR-2 antenna deployed.
- June 19-21 PALSAR-2 first images were acquired.
- Aug. 4 Initial Calibration started
- Aug. 20 Move to the operational observation phase。
- Nov. 25 starts the product distribution

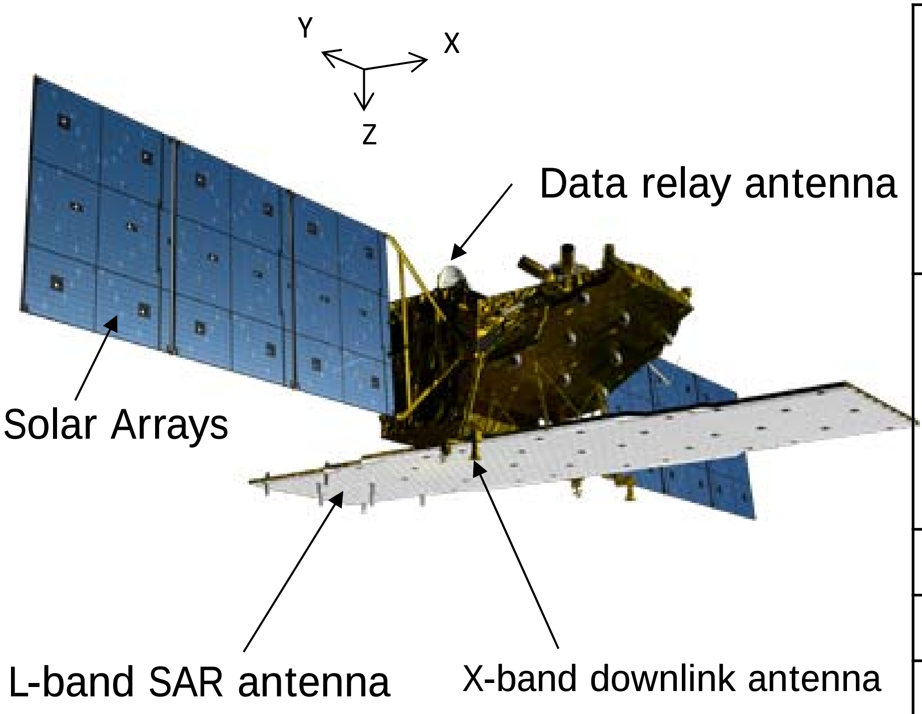
2015 Ongoing global observation and the emergency observation

Initial Cal.

Routine Cal.

ALOS-2 satellite

ALOS-2 in-orbit configuration



Specification

L-band SAR (PALSAR-2)	**Stripmap**: 3 to 10m res., 50 to 70 km swath **ScanSAR**: 100m res., 350km/490km swath **Spotlight**: 1×3m res., 25km swath
Orbit	Sun-synchronous orbit Altitude: 628km Local sun time : 12:00 +/- 15min Revisit: 14days Orbit control: ≦+/-500m
Life time	5 years (target: 7 years)
Launch	May 24, 2014, H-IIA launch vehicle
Downlink	X-band: 800Mbps(16QAM) 400/200Mbps(QPSK) Ka-band: 278Mbps (Data Relay)

Experimental	Compact InfraRed Camera (CIRC) SPace based Automatic Identification System Experiment(SPAISE2)

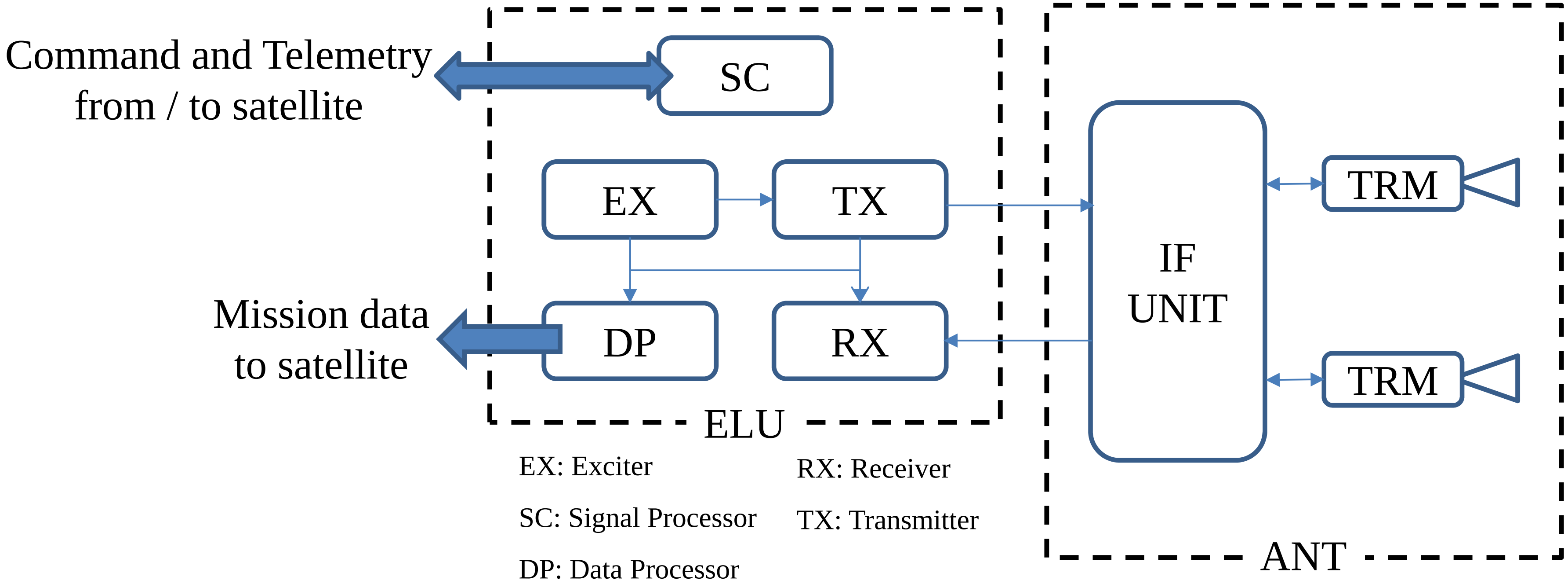
Four new techniques

- **High power and efficiency device**
  - GaN HEMT, the first flight for satellite in the world, for lower NESZ (37.1 W/TRM)
- **Dual receive antenna system**
  - wider swath with lower PRF
  - Five electric panels are in full aperture for transmission and are divided for receiving
- **Chirp modulation (+Azimuth Phase Coding(APC))**
  - Up/Down and Phase modulation for higher SA
- **New data compression**
  - updated BAQ algorithm

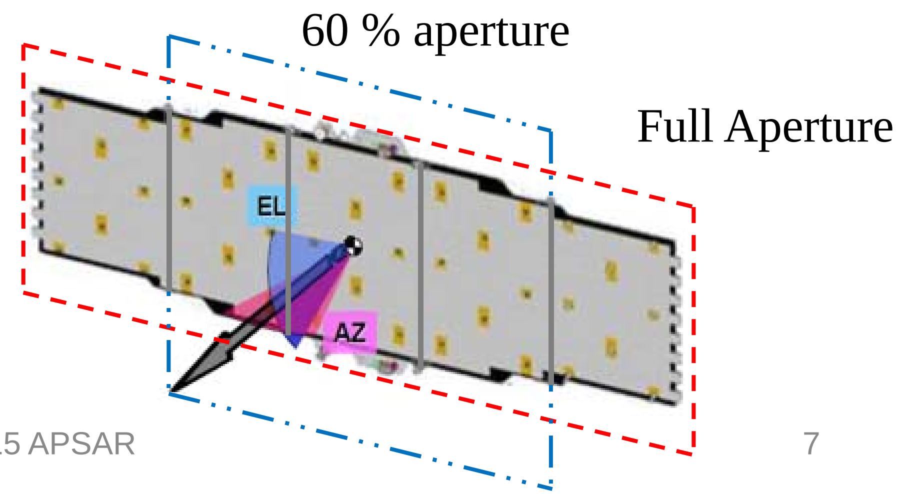
ALOS-2 Mission Objectives

- Disaster Monitoring (including the solid earth research-Polarimetry application)
- Environmental monitoring for Biosphere, Geosphere, Cryosphere, and Hydrosphere
- Natural Resources (Agriculture, Ocean monitoring, and Resources)
- Technology Development for the Future Earth Remote sensing (satellite and sensor)

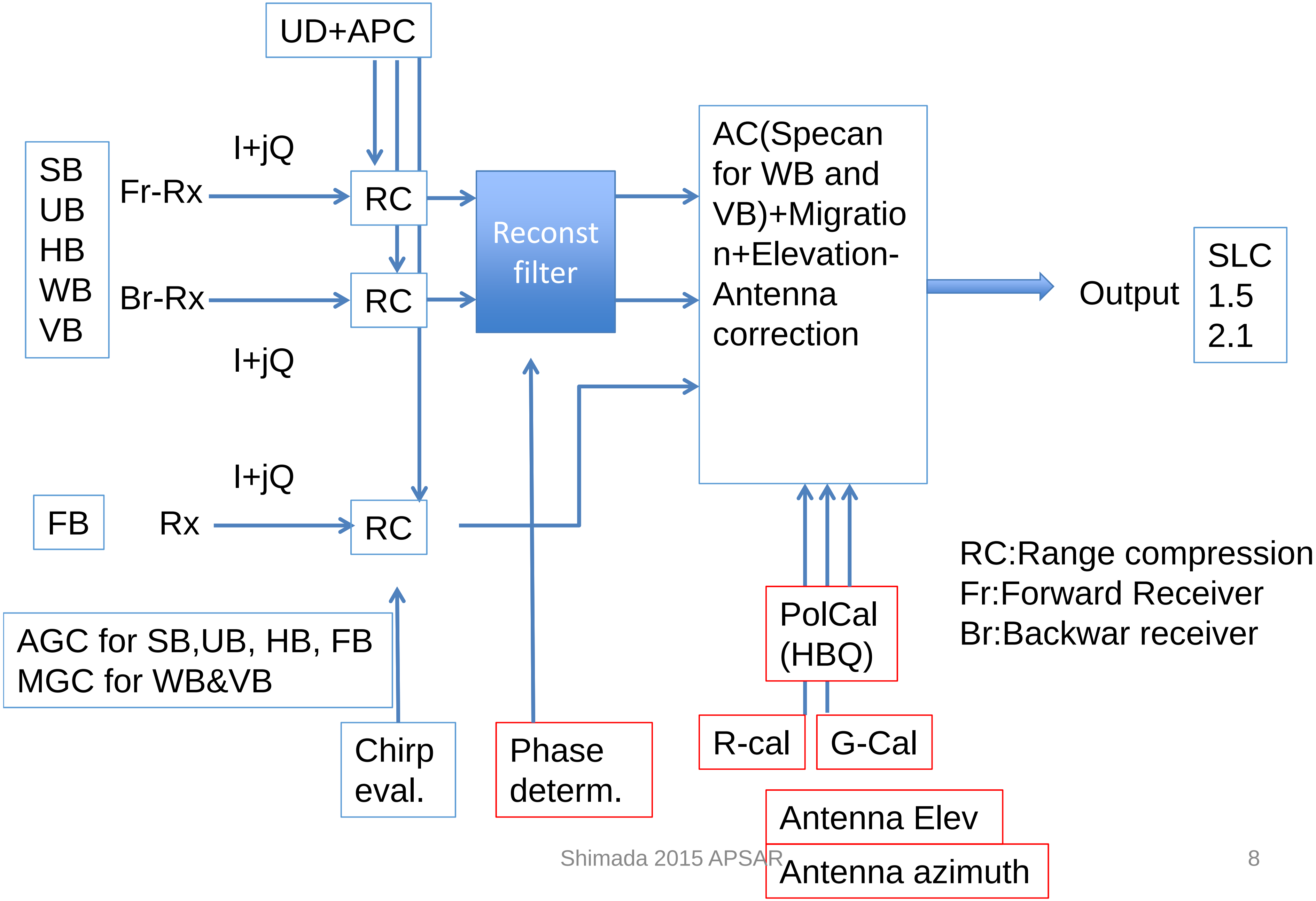
2. Technical overview of PALSAR-2



Mode	Transmit	receive
SB/UB(84 MHz)	60% aperture	full
HB, FB, WB, VB	Full aperture	full



Imaging and calibration Strategy (i.e., Range Doppler)



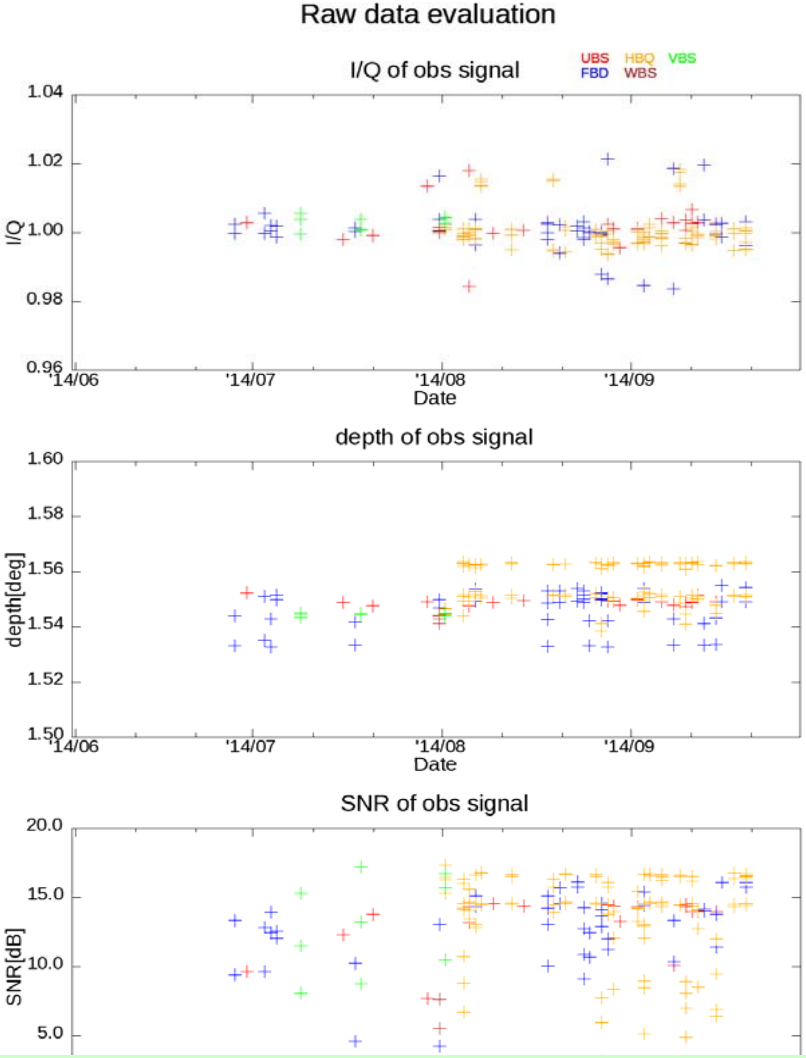
PALSAR-2 Calibration

- Initial cal: Aug. 4 2014-Nov. 20, 2014
- Routine Cal: Nov. 25, 2014 –

- Raw data evaluation
- Processor tuning (Dual Receiver)
- Antenna Pattern Evaluation
- Polarimetric Calibration
- Image Quality

- Calibration, Validation and science Team (CVST) activity. Acknowledgement of the PIs' contributions on analysis and CR deployments.

4.2.4 Long term variation of the raw data



Global Average(std dev.)

mode	I/Q	depth [deg]	SNR [dB]	Sat [%]	Scene
3m	1.0022 (0.0065)	1.5491 (0.0012)	13.2852 (1.9119)	0.205	21
6m	1.0002 (0.0052)	1.5557 (0.0071)	13.7788 (3.2357)	0.295	29
10m	1.0009 (0.0068)	1.5445 (0.0075)	12.6178 (2.7583)	0.526	26
ScanSAR [350km]	1.0003 (0.0006)	1.5458 (0.0030)	9.3965 (6.7832)	0.012	2
ScanSAR [490km]	1.0029 (0.0021)	1.5446 (0.0005)	13.0030 (3.4342)	5.551	3

（Ref）PALSAR

mode	I/Q	dPH	SNR	Sat
FBS	1.007	1.598	8.423	LS 5%
FBD	1.010	1.579	3.358	LS 5%
PLR	1.001	1.577	8.712	LS 5%
WB1	1.015	1.581	7.926	LS 5%
WB2	1.008	1.597	8.733	LS 5%

PALSAR2 exceeds PALSAR at SNR by 5dB.

Ambiguity suppression and Wider Swath Provision

1) Dual receivers (DR)
allowing wider swath with lower PRF

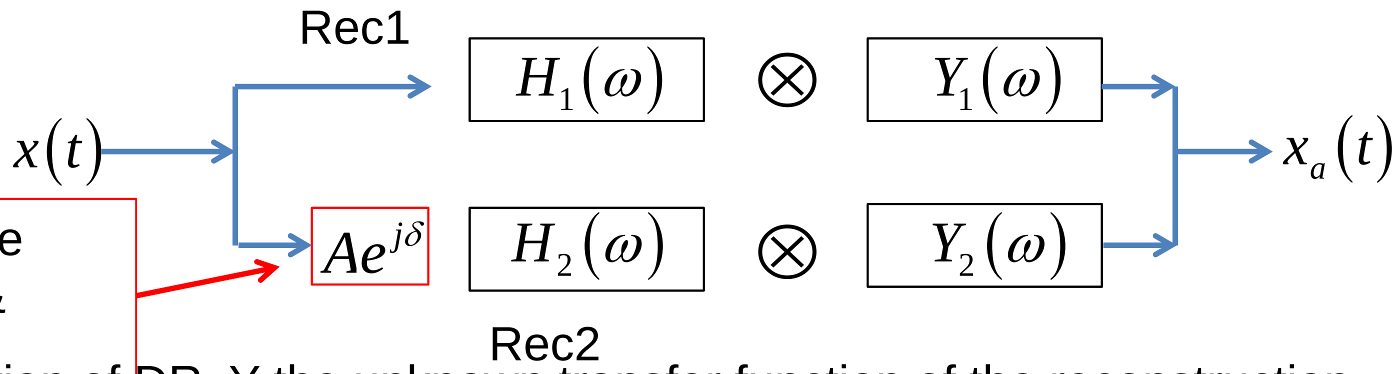
2) Alternative Up/Down chirp and random phase shift
suppressing range ambiguity:

were adopted.

Phase tuning of the dual receivers are necessary

DR reconstruction algorithm

$$HY = R$$



Phase and amplitude difference of Rec1 & Rec2

H=transfer function of DR, Y the unknown transfer function of the reconstruction filter, and R is the condition

Determine the delta trial and error

Signals can be reconstructed by solving the above equations.

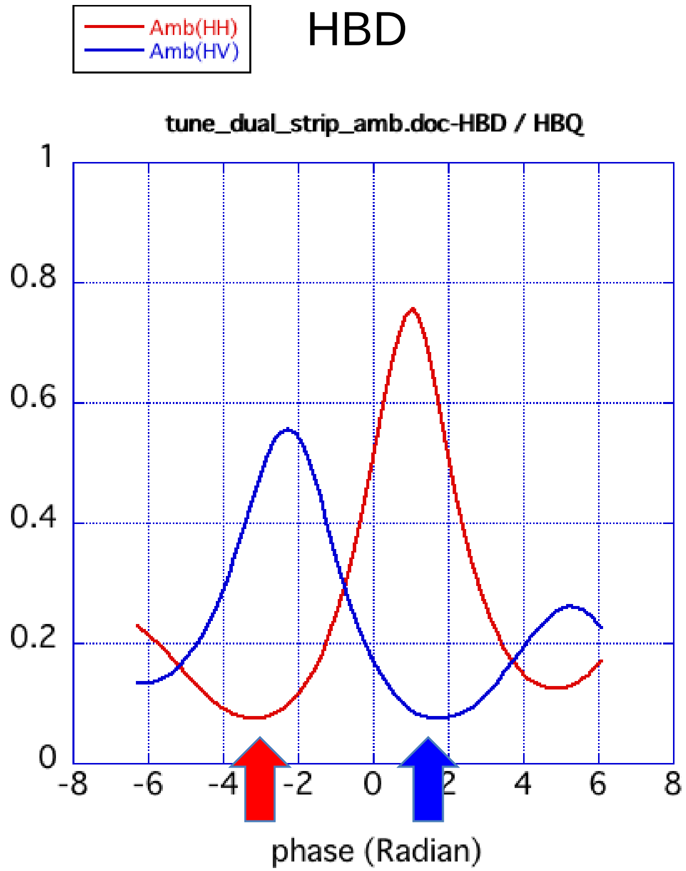
$$Y_1(f) = \begin{cases} \dfrac{e^{\frac{j\pi\Delta x_1^2}{2\lambda r_0}+\frac{j\pi\Delta x_1 f}{v}}}{1-e^{\frac{j\pi PRF(\Delta x_2-\Delta x_1)}{v}}} & -PRF < f < 0 \\ \dfrac{e^{\frac{j\pi\Delta x_1^2}{2\lambda r_0}+\frac{j\pi\Delta x_1 f}{v}}}{1-e^{\frac{j\pi PRF(\Delta x_1-\Delta x_2)}{v}}} & 0 < f < PRF \end{cases} \qquad Y_2(f) = \begin{cases} \dfrac{e^{\frac{j\pi\Delta x_2^2}{2\lambda r_0}+\frac{j\pi\Delta x_2 f}{v}}}{1-e^{\frac{j\pi PRF(\Delta x_1-\Delta x_2)}{v}}} & -PRF < f < 0 \\ \dfrac{e^{\frac{j\pi\Delta x_2^2}{2\lambda r_0}+\frac{j\pi\Delta x_2 f}{v}}}{1-e^{\frac{j\pi PRF(\Delta x_2-\Delta x_1)}{v}}} & 0 < f < PRF \end{cases}$$

Brown, "Multi-Channel Sampling of Low-Pass Signals," IEEE Trans on Circuits and Systems, Vol. CAS-28, No.2 Feb. 1981
Krieger et al, "Unambiguous SAR Signal Reconstruction From Nonuniform Displaced Phase Center Sampling, " IEEE GRS Letters, Vol. 1, No. 4, Oct. 2004

Correction 2

Input data: Observation data + Chirp Data

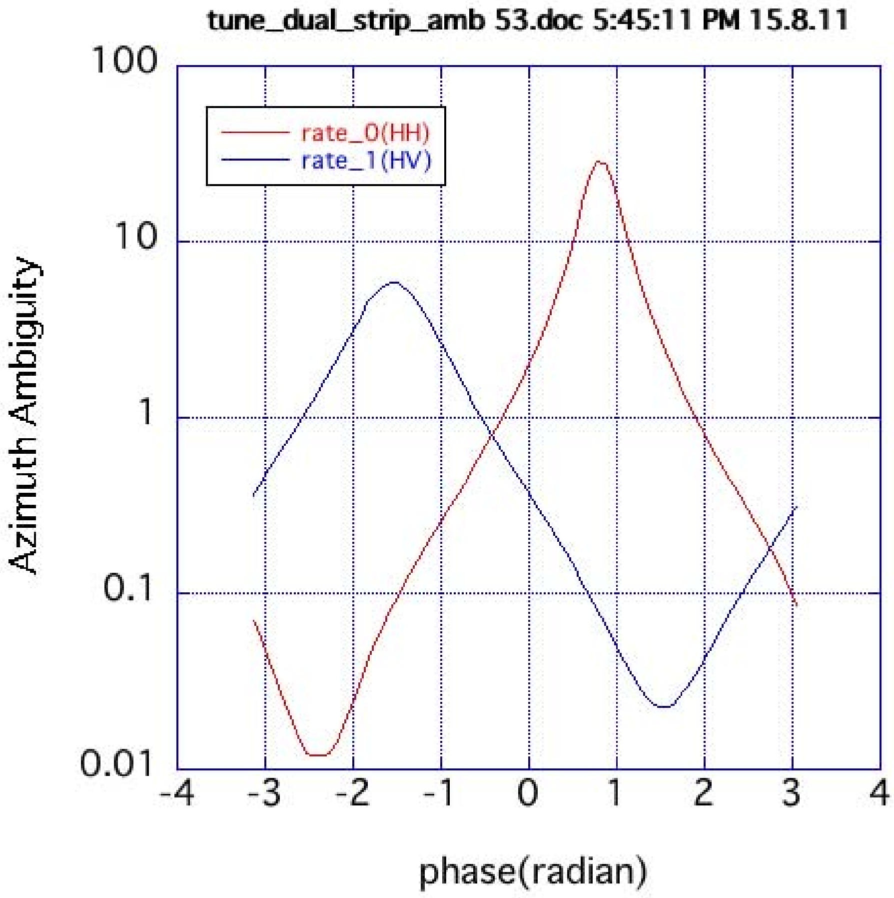
Method : find the best angle (delta) to minimize the ambiguity



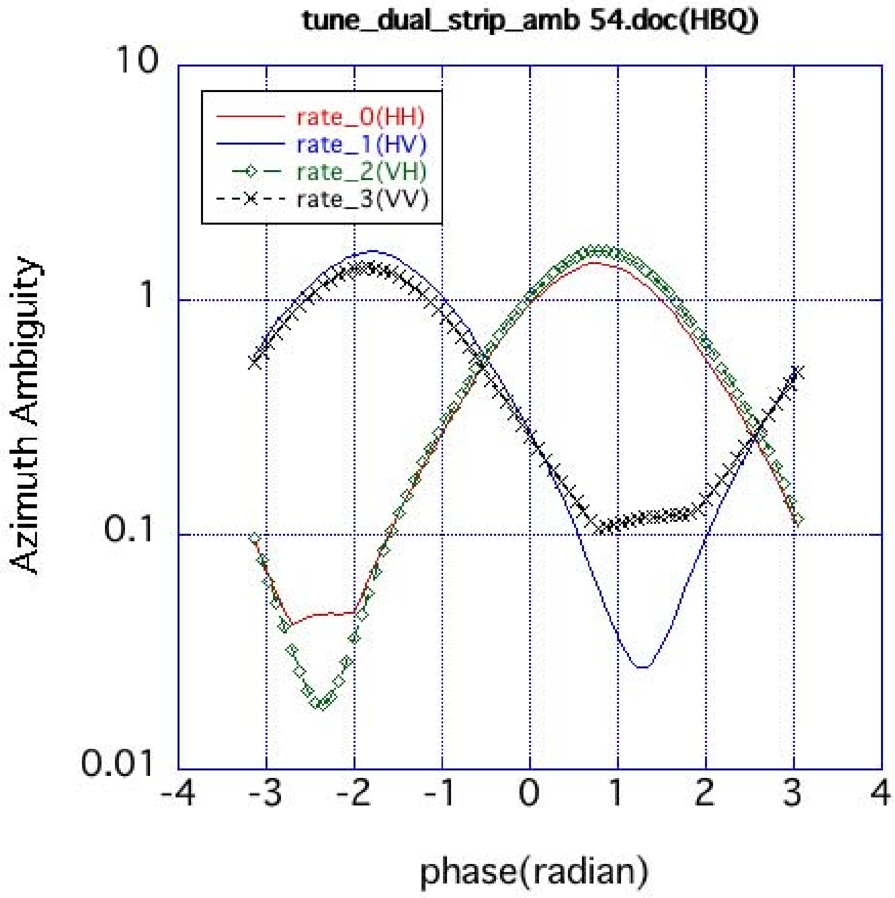
Find the minimum values for HH and HV (individually)

HH pol of HBD at Hokkaido

Correction 2(other modes, UB, HBQ, ScanSAR)



UB



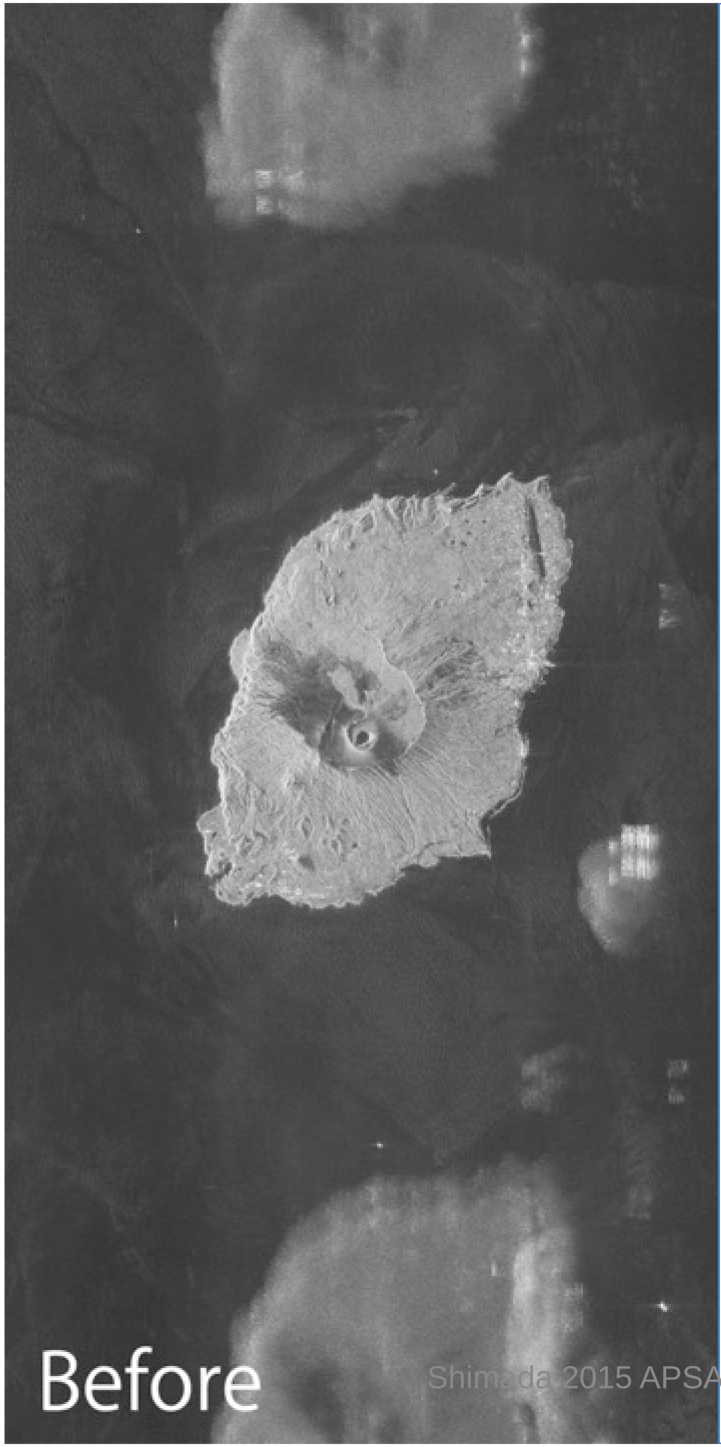
HBQ

They show almost the same values depending on the polarizations.

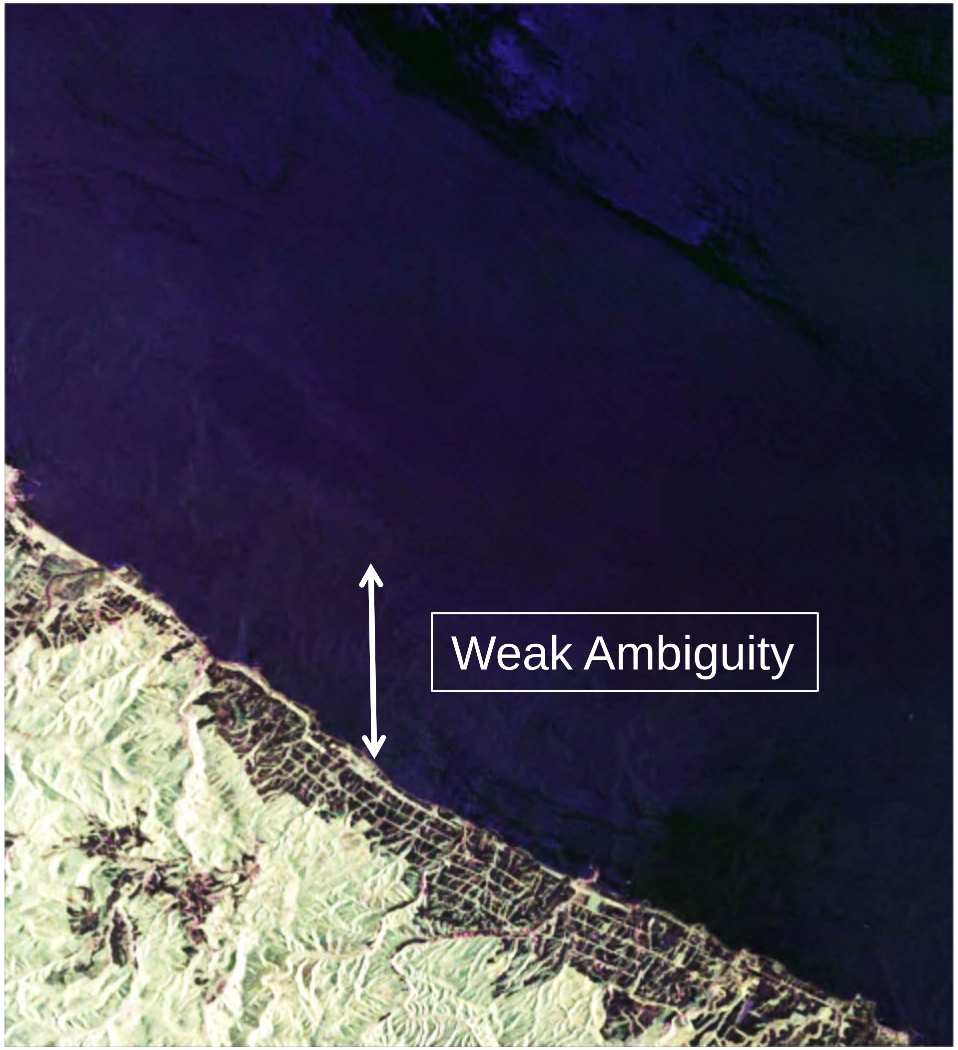
UB HH image

2014/6/19

伊豆大島



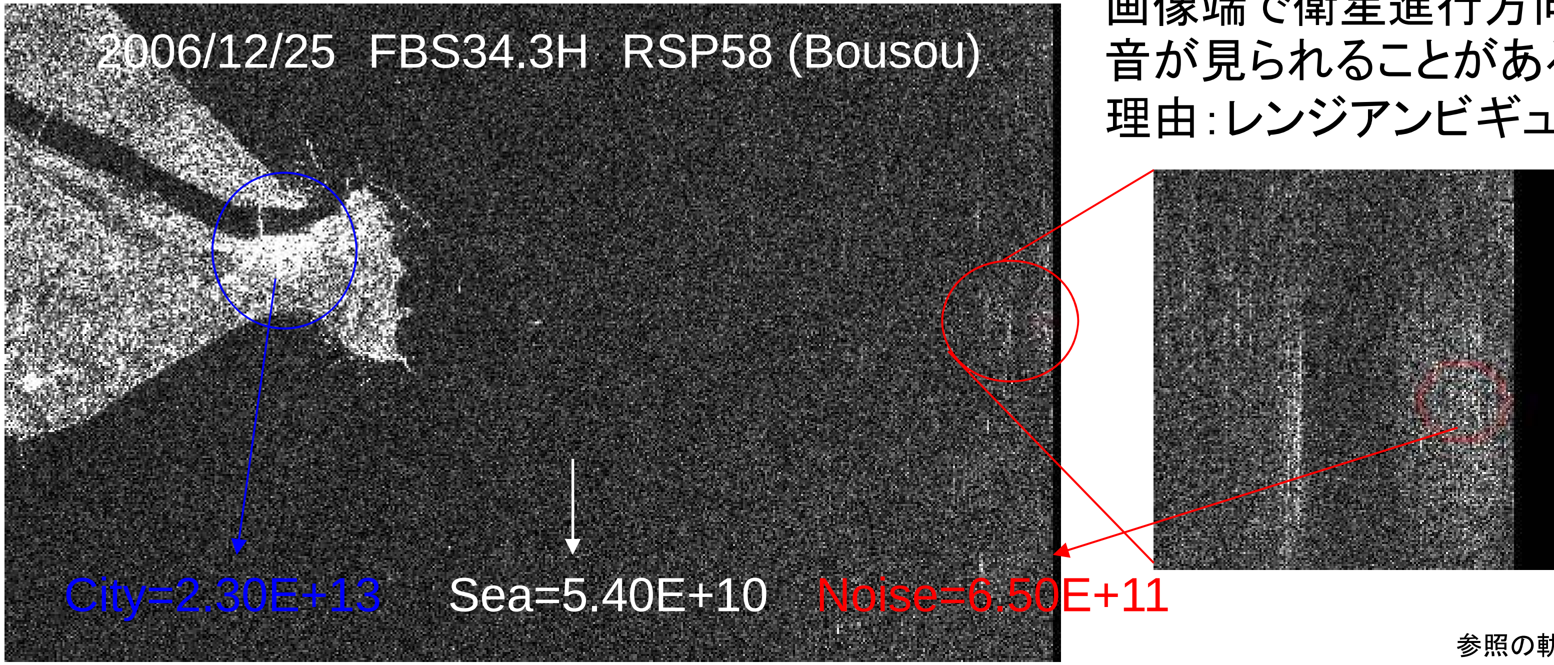
Before (HBQ)



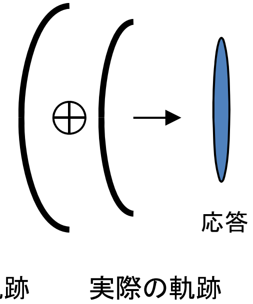
After(HBQ)

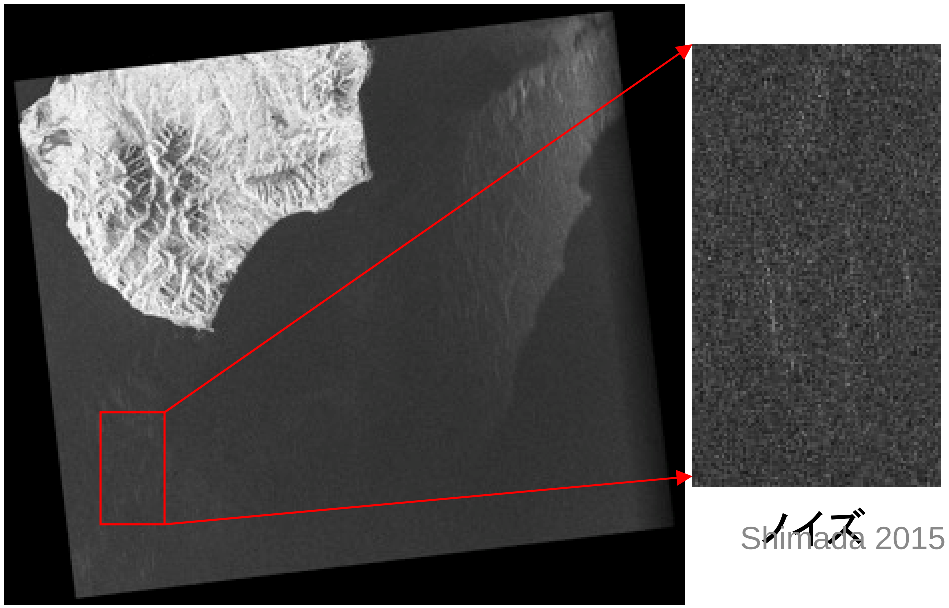
Range ambiguities in PALSAR images

画像端で衛星進行方向に線状雑
音が見られることがある。
理由：レンジアンビギュイティ



SA=16 dB





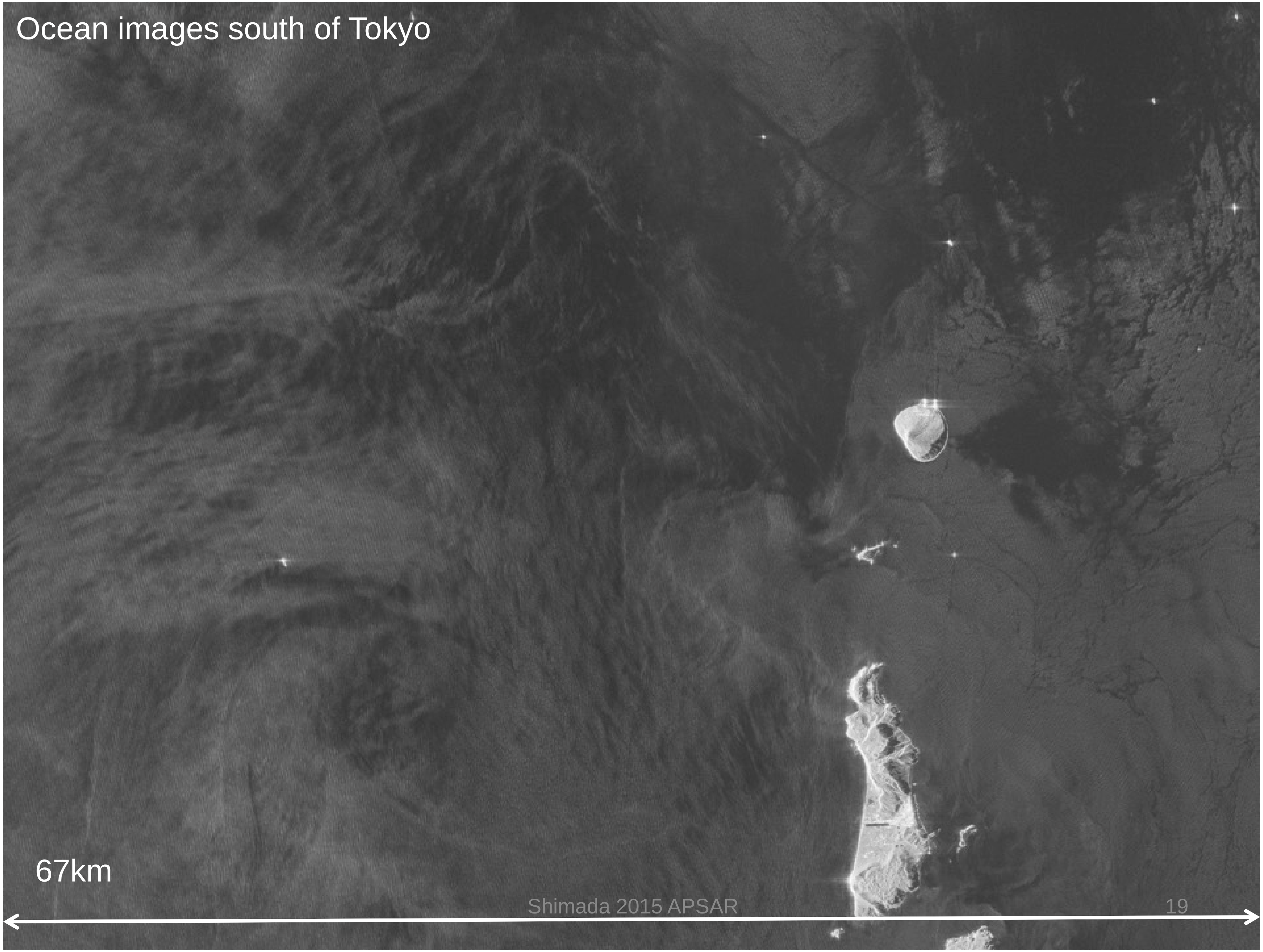
ノイズ

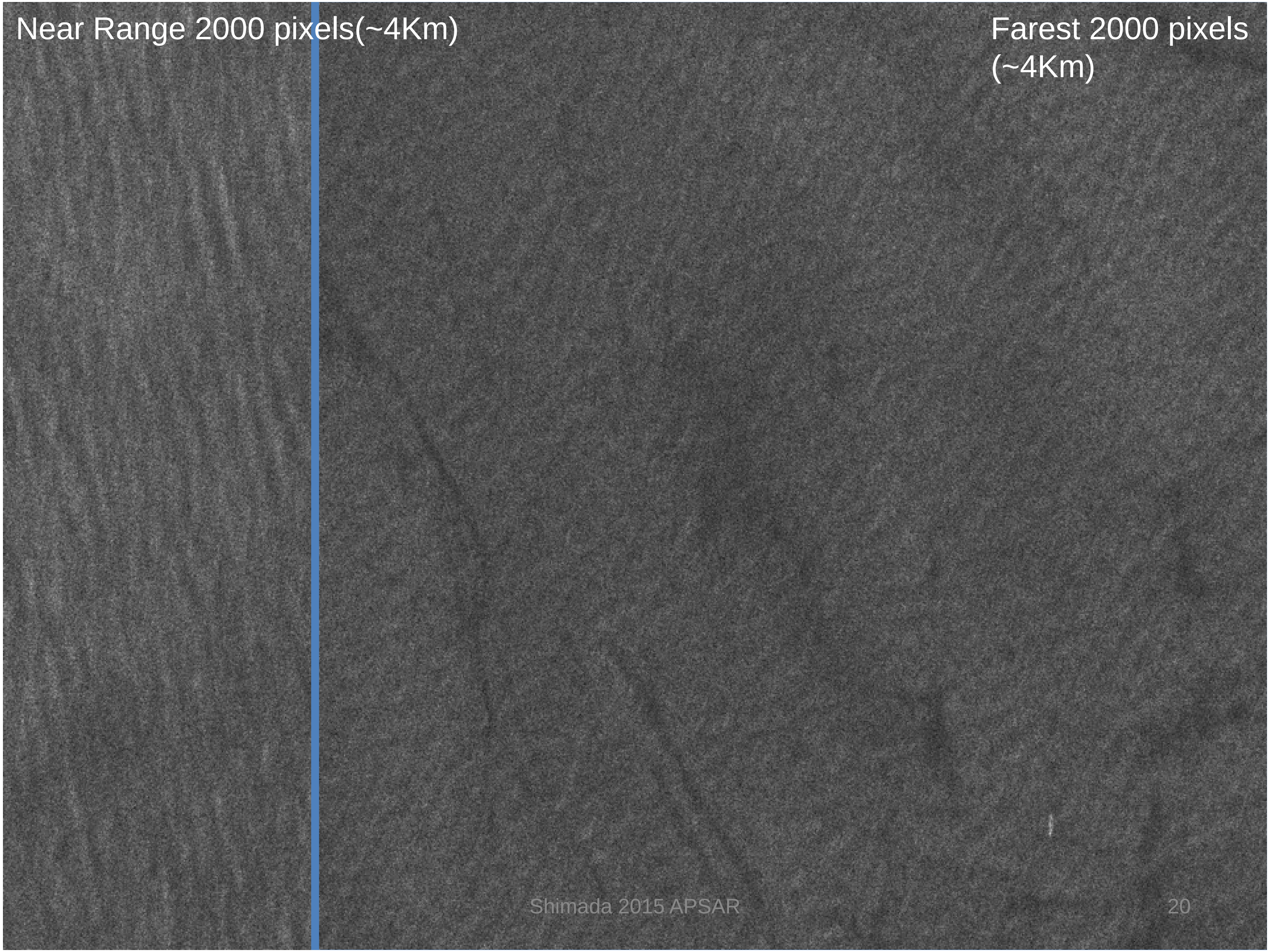
One example of the UD-chirp and the azimuth phase codings (UBD)

Time

no	HH	updown	0-pai	moden	re	no	HV	updown	0-pai	moden	repID
0		1	0	1	0	0		1	0	1	0
1		1	0	1	0	1		1	0	1	0
2		0	0	0	0	2		0	0	0	0
3		0	0	0	0	3		0	0	0	0
4		1	0	1	0	4		1	0	1	0
5		1	0	1	0	5		1	0	1	0
6		0	0	0	0	6		0	0	0	0
7		0	0	0	0	7		0	0	0	0
8		1	0	1	0	8		1	0	1	0
9		1	0	1	0	9		1	0	1	0
10		0	0	0	0	10		0	0	0	0
11		0	0	0	0	11		0	0	0	0
12		1	0	1	0	12		1	0	1	0
13		1	0	1	0	13		1	0	1	0
14		0	0	0	0	14		0	0	0	0
15		0	0	0	0	15		0	0	0	0
16		1	1	3	0	16		1	1	3	0
17		1	1	3	0	17		1	1	3	0
18		0	0	0	0	18		0	0	0	0
19		0	0	0	0	19		0	0	0	0
20		1	1	3	0	20		1	1	3	0

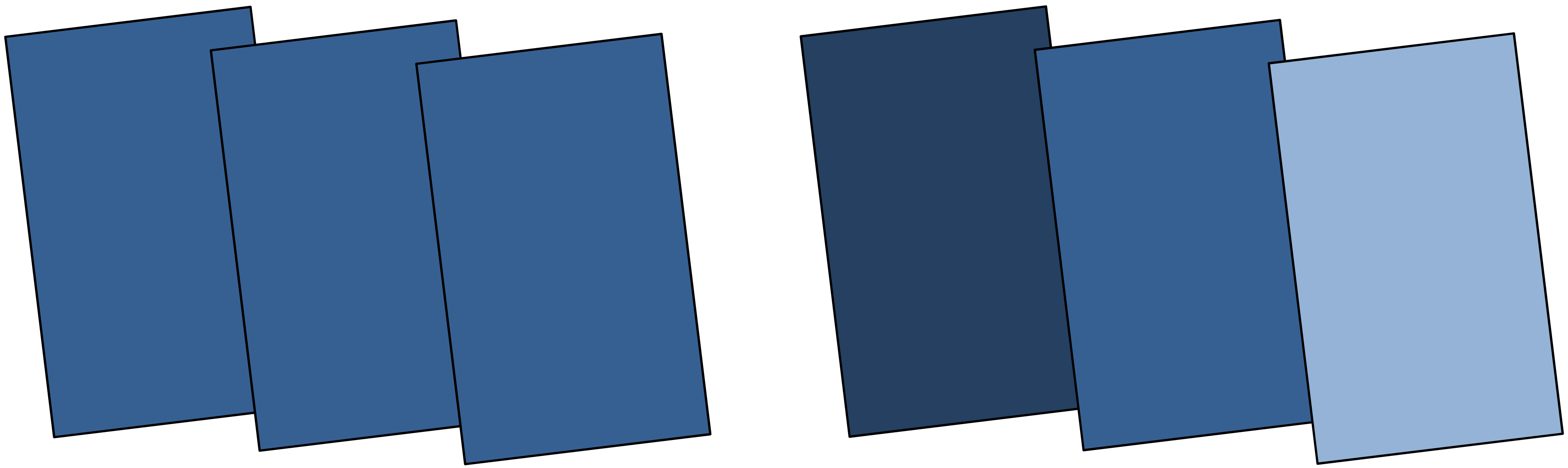
Ocean images south of Tokyo



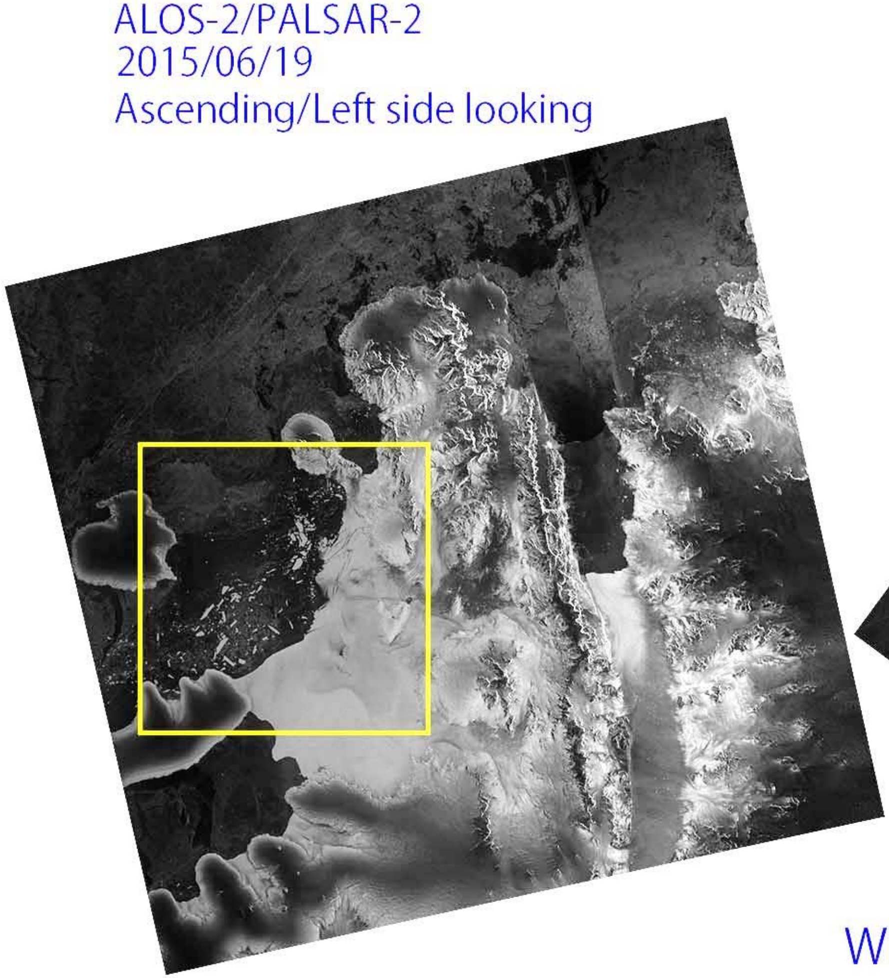

Near Range 2000 pixels(~4Km)
Farest 2000 pixels (~4Km)

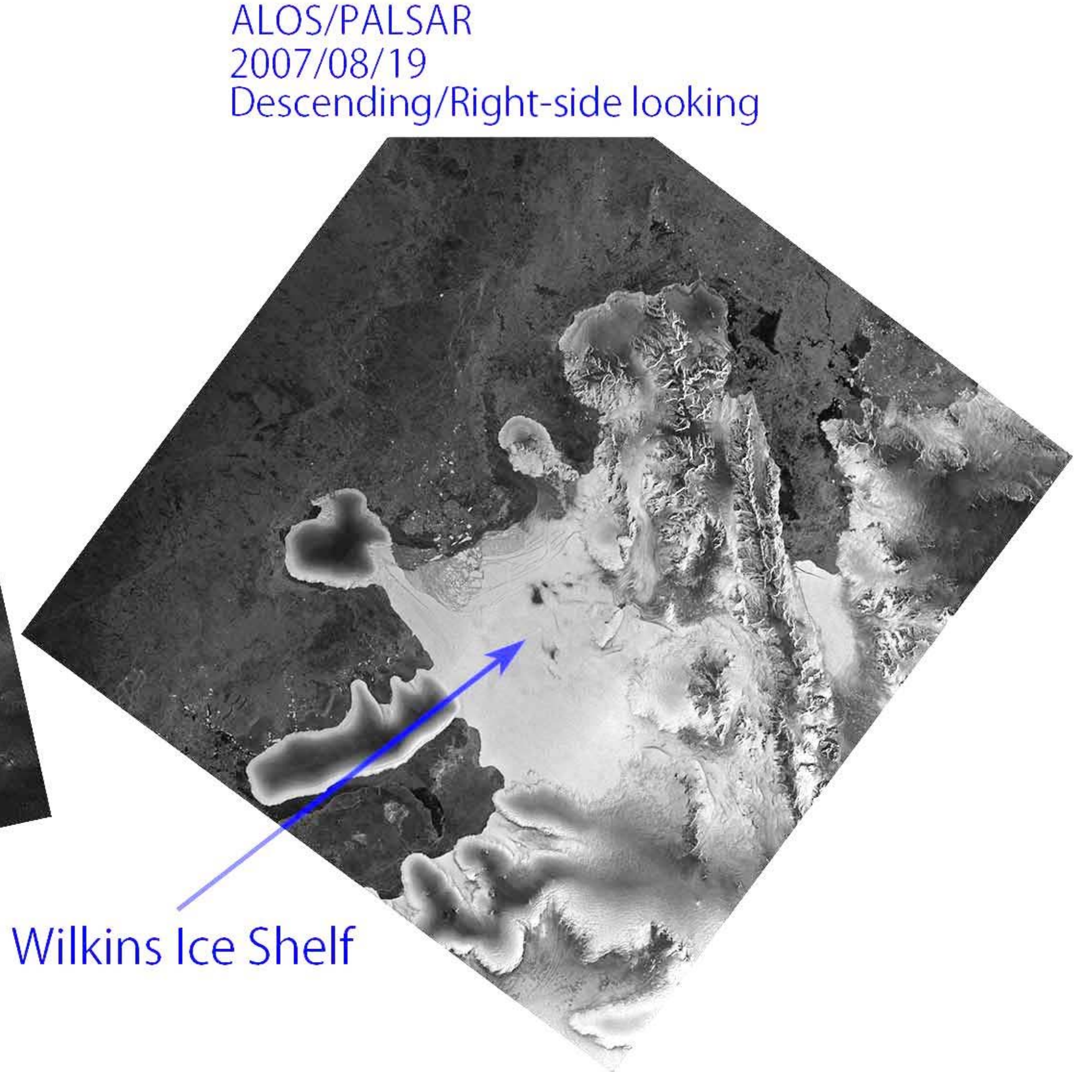
Differences between PALSAR/PALSAR-2

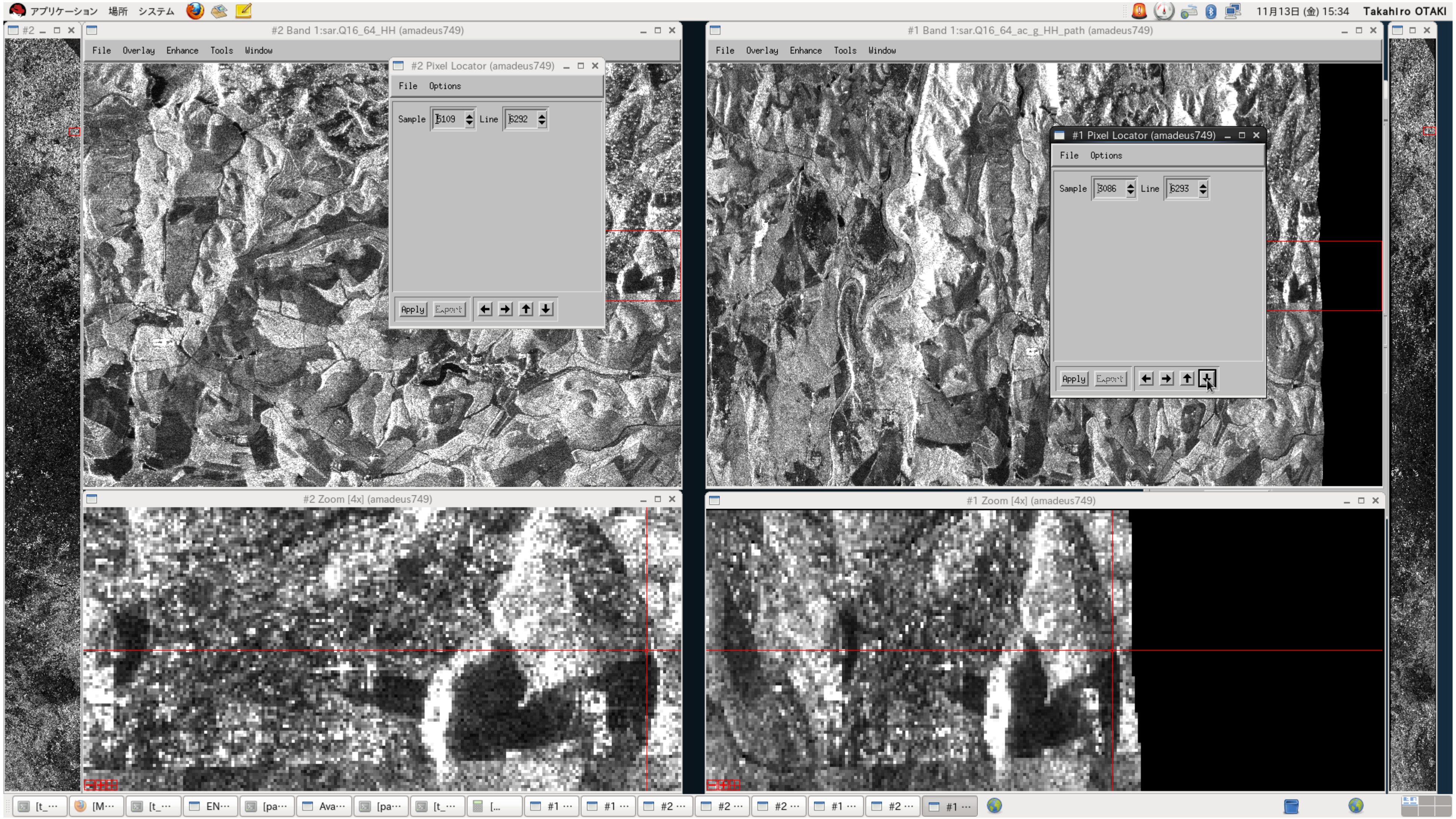
	PALSAR	PALSAR-2
Orbits and width/orbit over equator	671 59.6 km	207 64.4 km
Image width	70km	70km
Gain	MGC	AGC
Incidence angle range	~5 degrees (33~38 degrees)	~14degrees (28.5~33.9,33.7~ 38.5,38.3~42.5 degrees)
Overlap	large	small



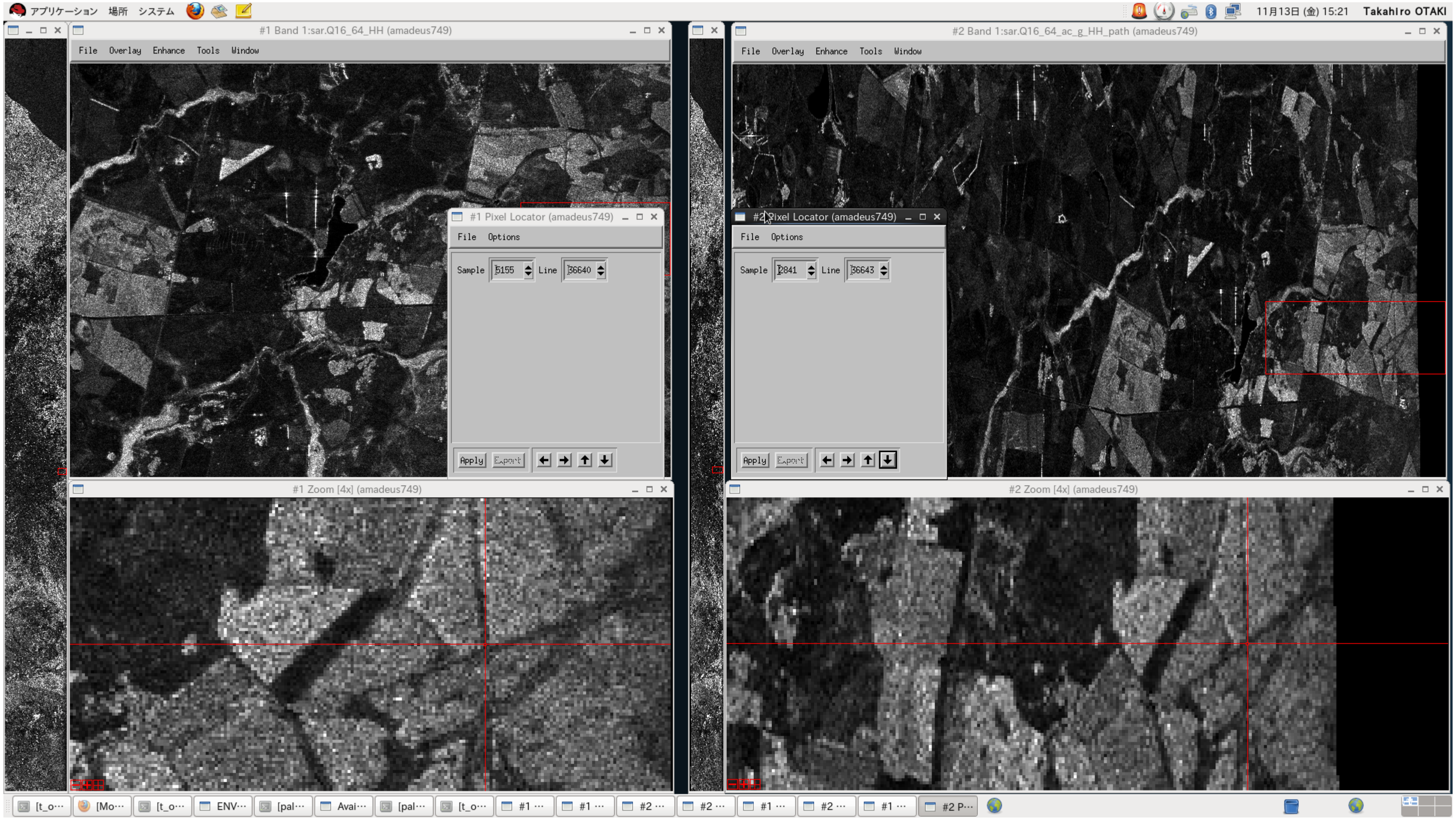
Sea ice retreat around Antarctic Peninsula/Wilkins Sound



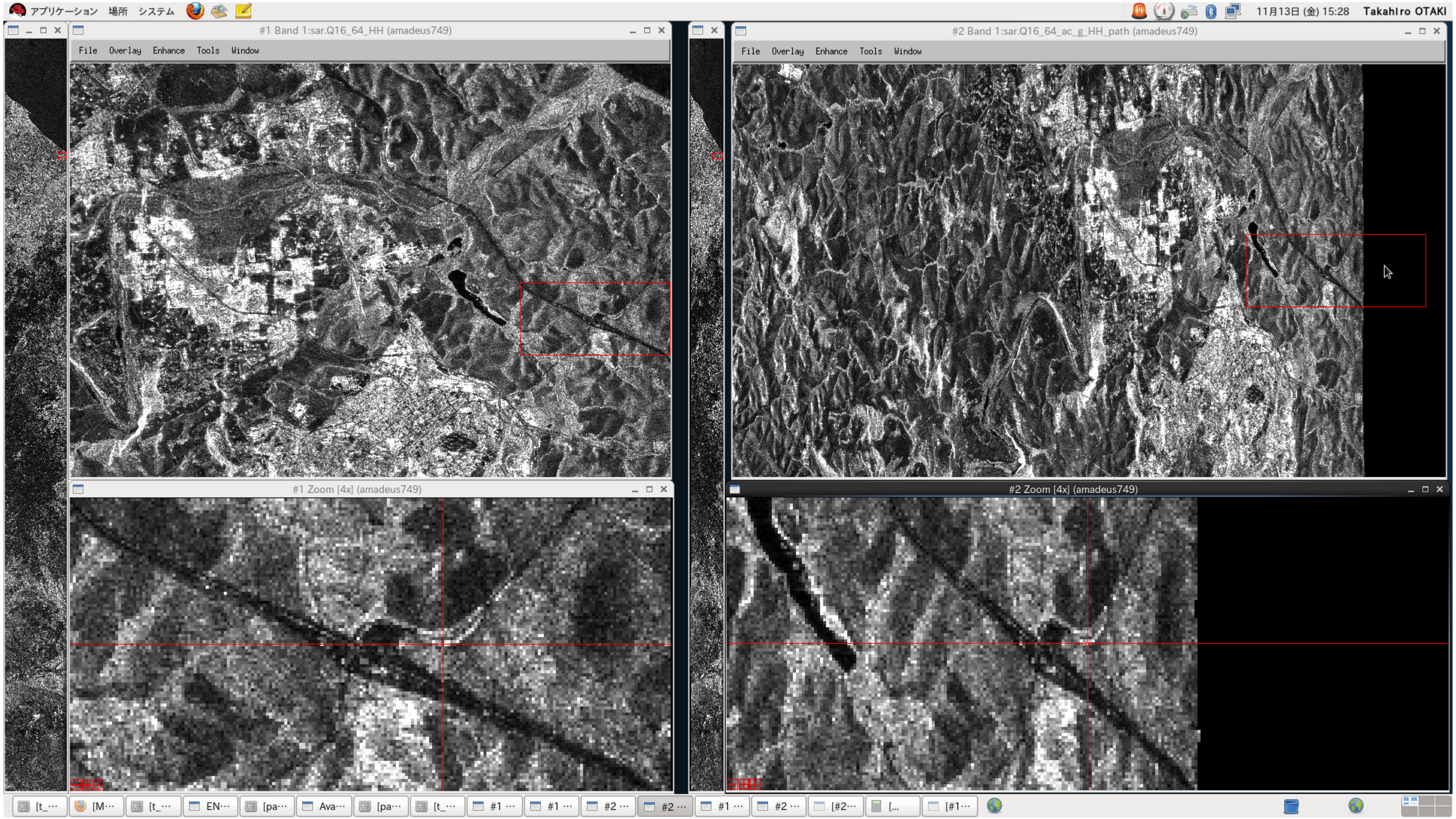




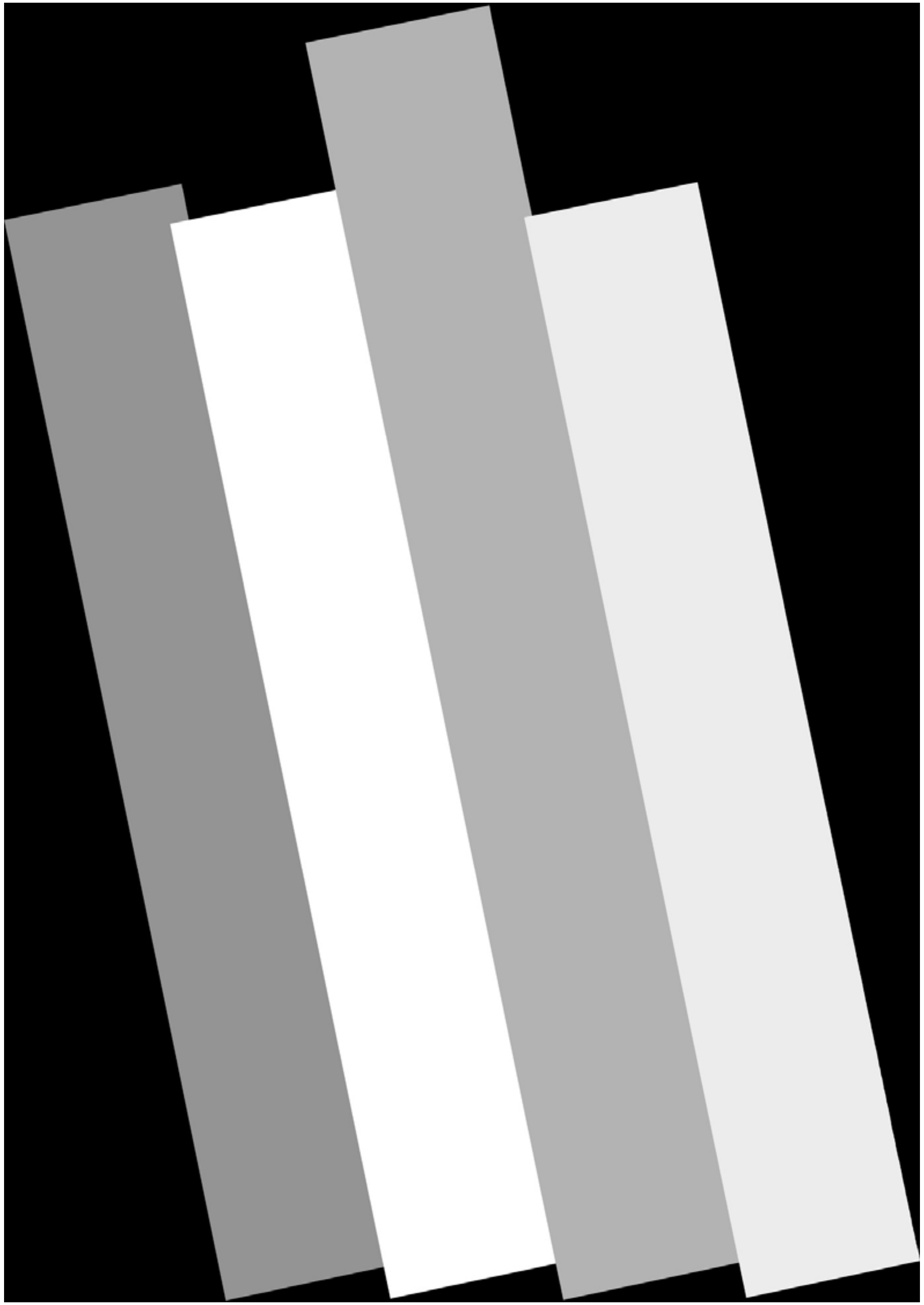
アプリケーション 場所 システム
11月13日 (金) 15:34 Takahiro OTAKI
#2 Band 1:sar.Q16_64_HH (amadeus749)
File Overlay Enhance Tools Window
#2 Pixel Locator (amadeus749)
File Options
Sample 5109 Line 6292
Apply Export
#1 Band 1:sar.Q16_64_ac_g_HH_path (amadeus749)
File Overlay Enhance Tools Window
#1 Pixel Locator (amadeus749)
File Options
Sample 3086 Line 6293
Apply Export
#2 Zoom [4x] (amadeus749)
#1 Zoom [4x] (amadeus749)



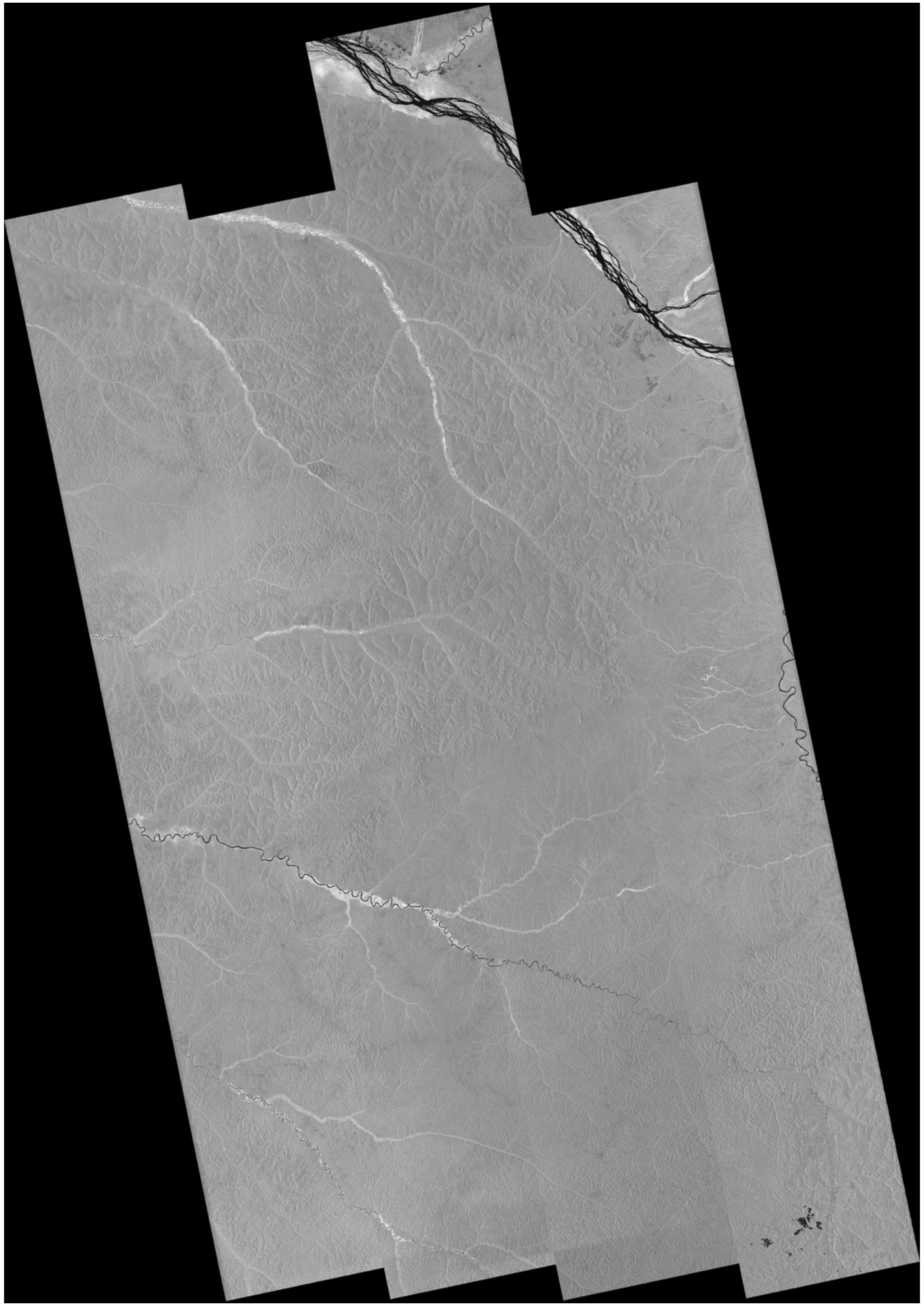
アプリケーション 場所 システム
11月13日 (金) 15:21 Takahiro OTAKI
#1 Band 1:sar.Q16_64_HH (amadeus749)
File Overlay Enhance Tools Window
#1 Pixel Locator (amadeus749)
File Options
Sample 5155 Line 36640
Apply Export
#1 Zoom [4x] (amadeus749)
#2 Band 1:sar.Q16_64_ac_g_HH_path (amadeus749)
File Overlay Enhance Tools Window
#2 Pixel Locator (amadeus749)
File Options
Sample 2841 Line 36643
Apply Export
#2 Zoom [4x] (amadeus749)

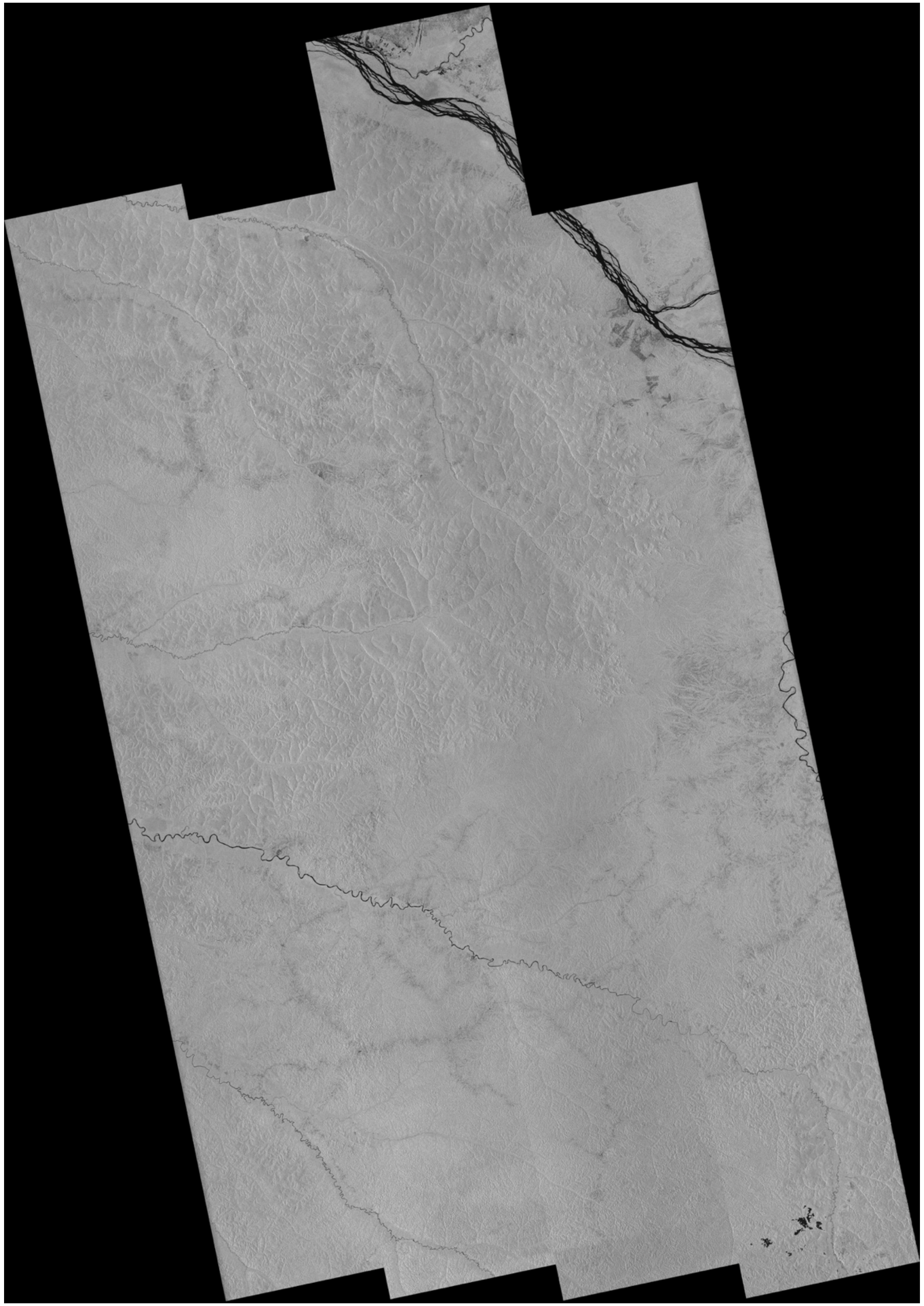


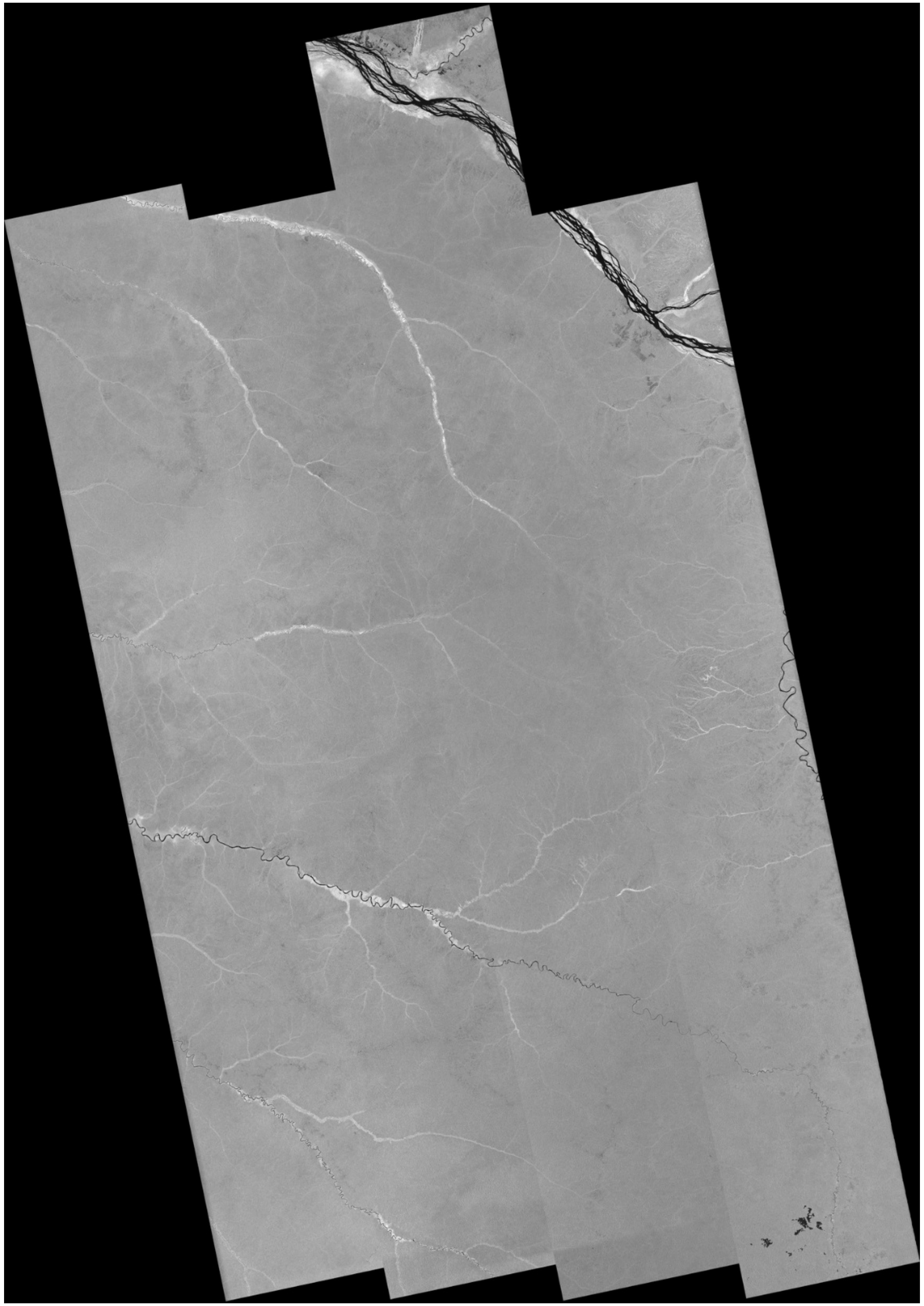
アプリケーション 場所 システム
11月13日 (金) 15:28 Takahiro OTAKI
#1 Band 1:sar.Q16_64_HH (amadeus749)
File Overlay Enhance Tools Window
#2 Band 1:sar.Q16_64_ac_g_HH_path (amadeus749)
File Overlay Enhance Tools Window
#1 Zoom [4x] (amadeus749)
#2 Zoom [4x] (amadeus749)

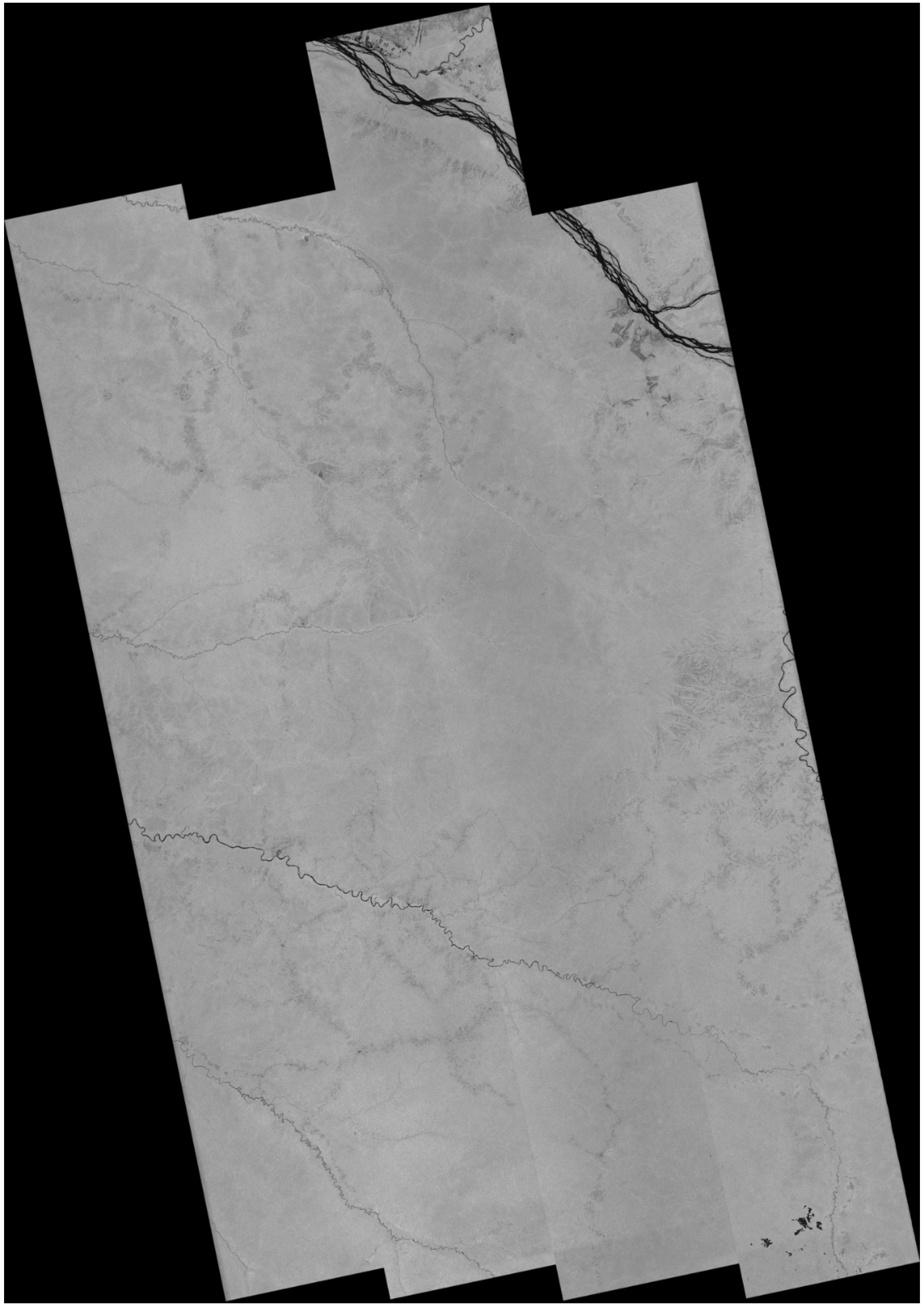


Some concern on the accuracy at the overlapping area (espetially on the equator)



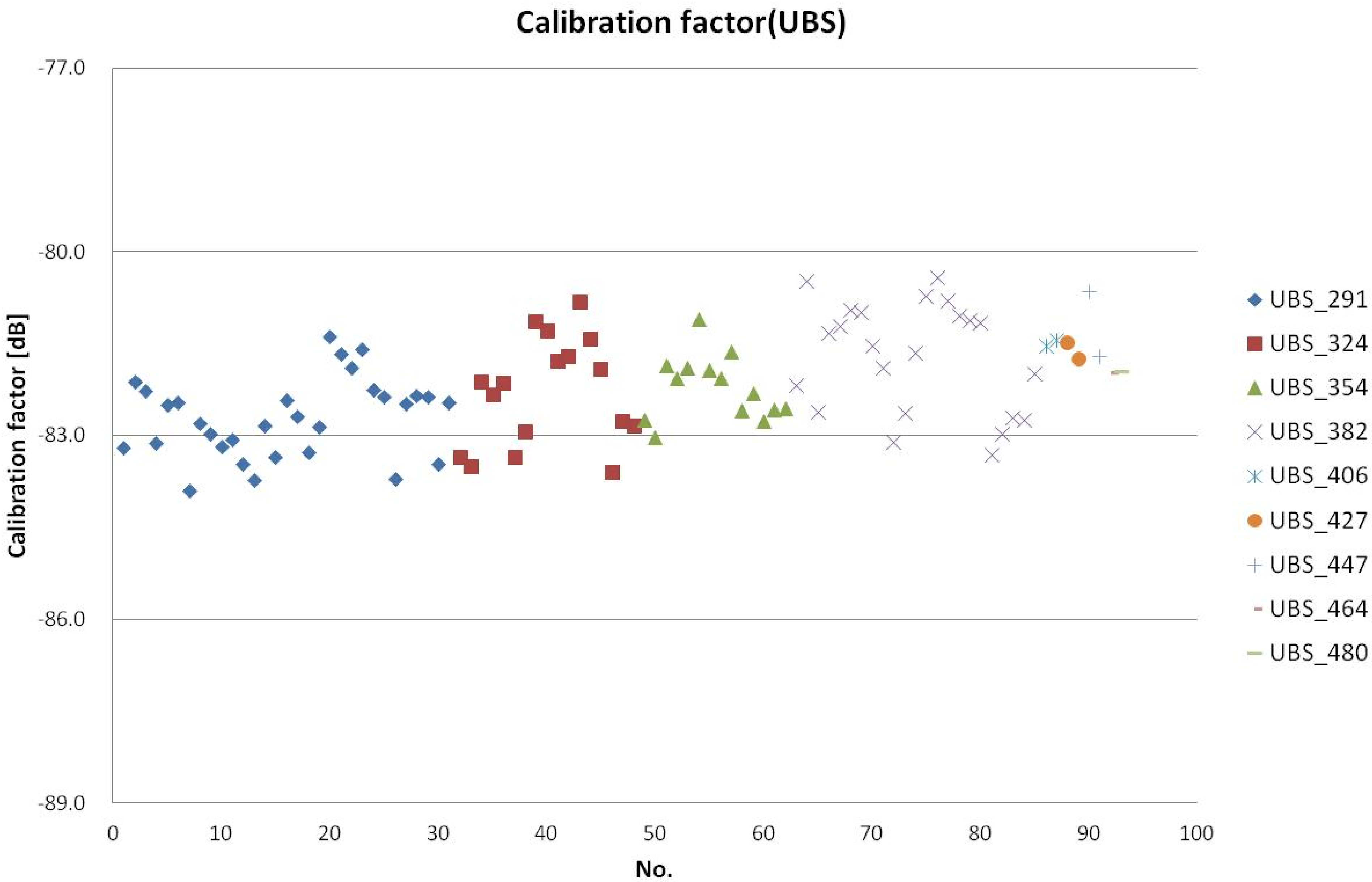




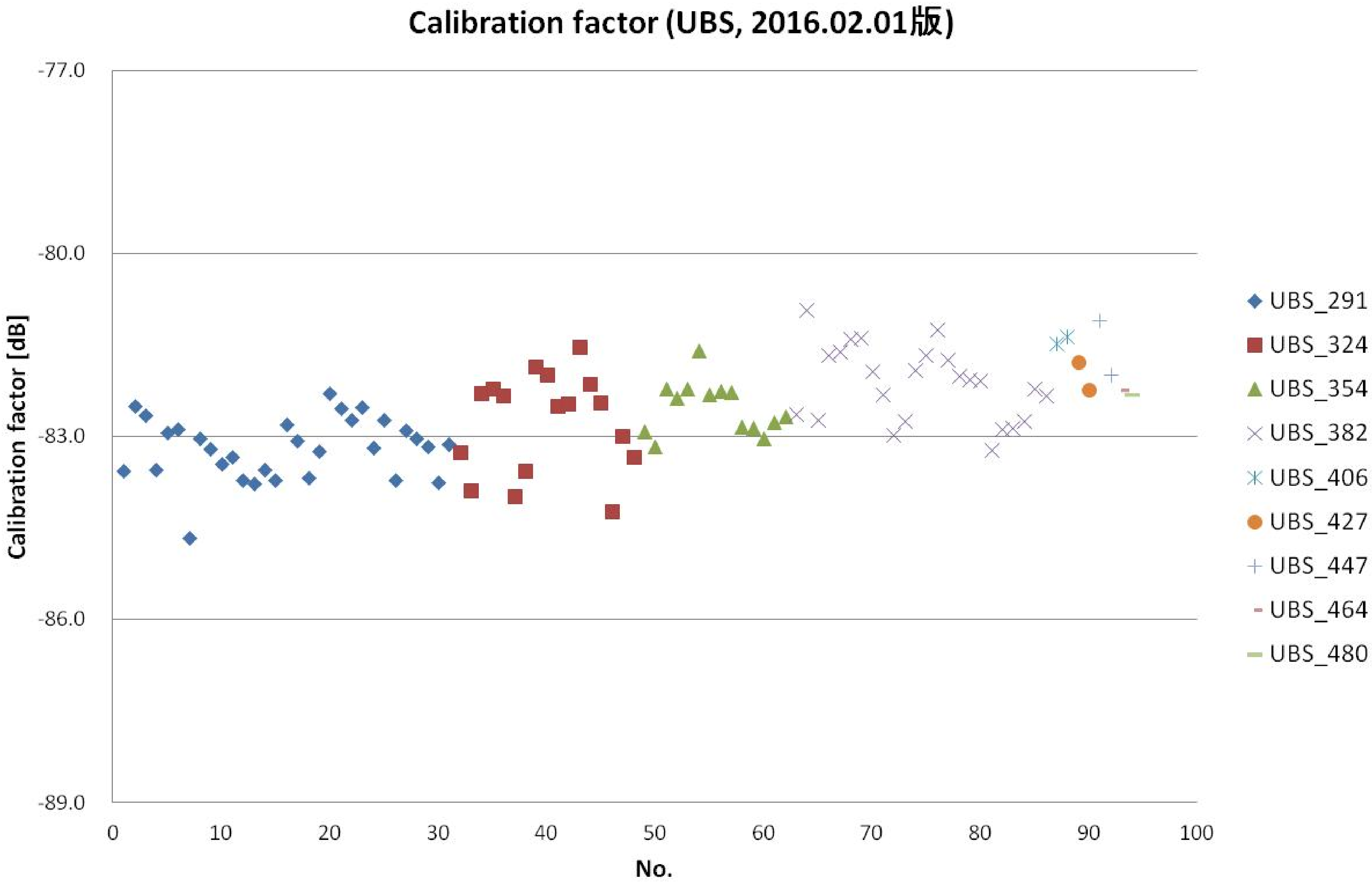


ポイントターゲット評価結果
(2016.02.01版SIGMA-SAR)

１－１. 校正係数グラフ(2015.09.17版, UBS)



１－２. 校正係数グラフ(2016.02.01版 , UBS)



１－３. 校正係数 統計値（UBS）

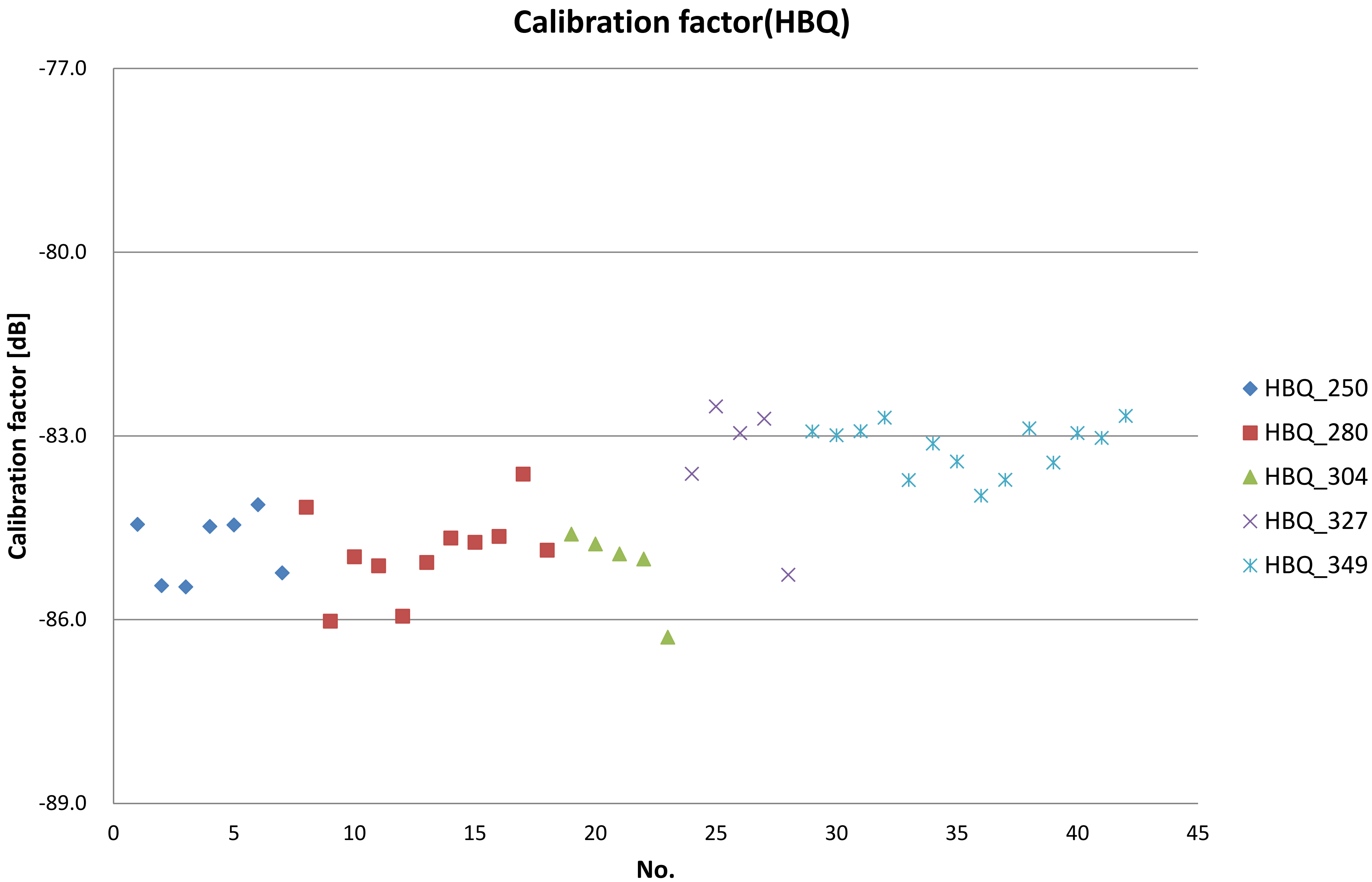
【2015.09.17版】

モード	ポイント数	平均値[dB]	標準偏差
UBS_291	31	-82.72	0.64
UBS_324	17	-82.29	0.88
UBS_354	14	-82.22	0.52
UBS_382	23	-81.72	0.90
UBS_406	2	-81.49	0.06
UBS_427	2	-81.61	0.19
UBS_447	2	-81.18	0.74
UBS_464	1	-81.97	-
UBS_480	1	-81.95	-
UBS	93	-82.22	0.84

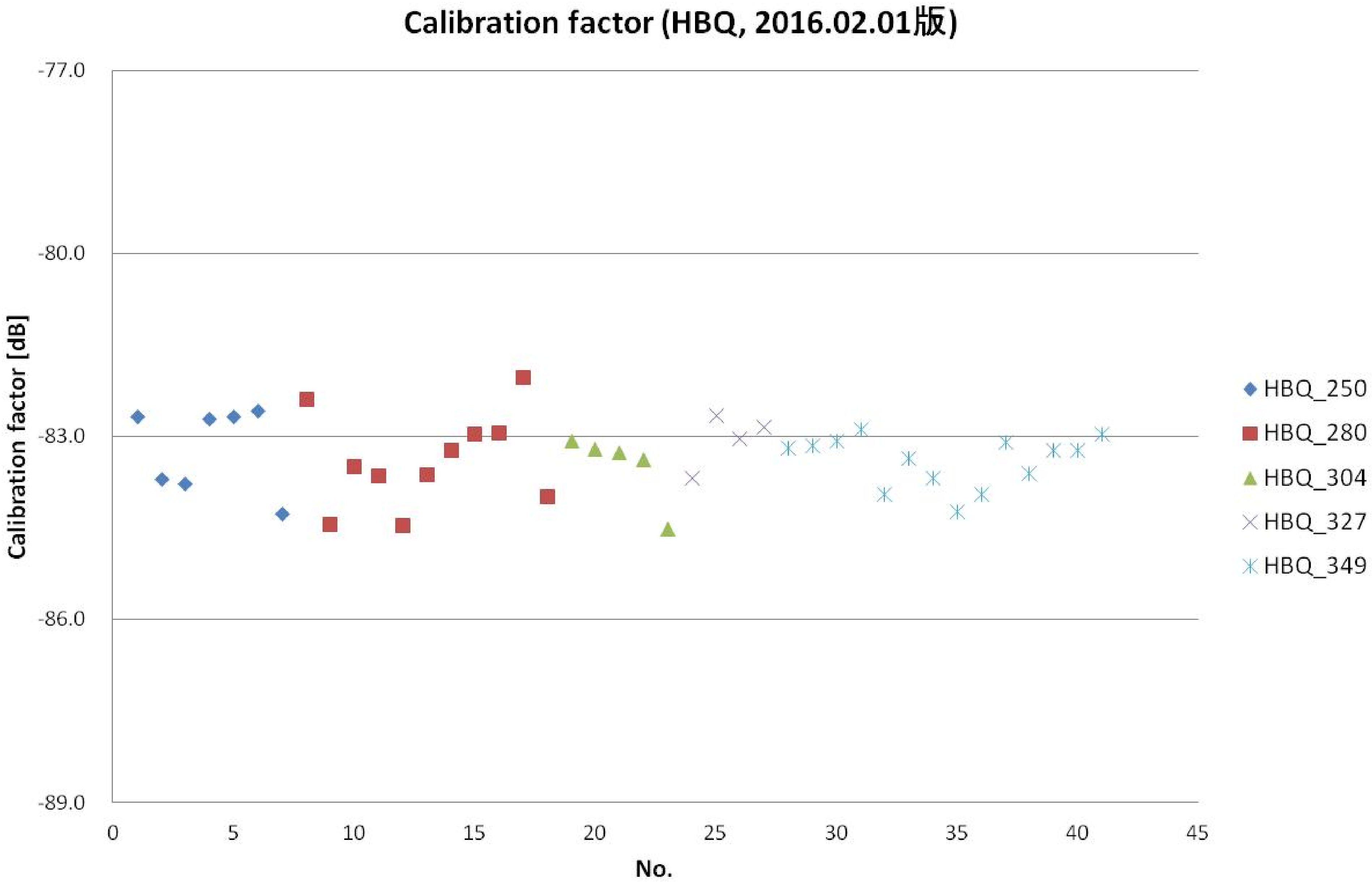
【2016.02.01版】

モード	ポイント数	平均値[dB]	標準偏差
UBS_291	31	-83.18	0.51
UBS_324	17	-82.76	0.81
UBS_354	14	-82.53	0.43
UBS_382	24	-82.13	0.62
UBS_406	2	-81.42	0.09
UBS_427	2	-82.00	0.32
UBS_447	2	-81.54	0.63
UBS_464	1	-82.22	-
UBS_480	1	-82.30	-
UBS	94	-82.62	0.75

２−１. 校正係数グラフ(2015.09.17版, HBQ)



２－２. 校正係数グラフ(2016.02.01版, HBQ)



２－３. 校正係数 統計値（HBQ）

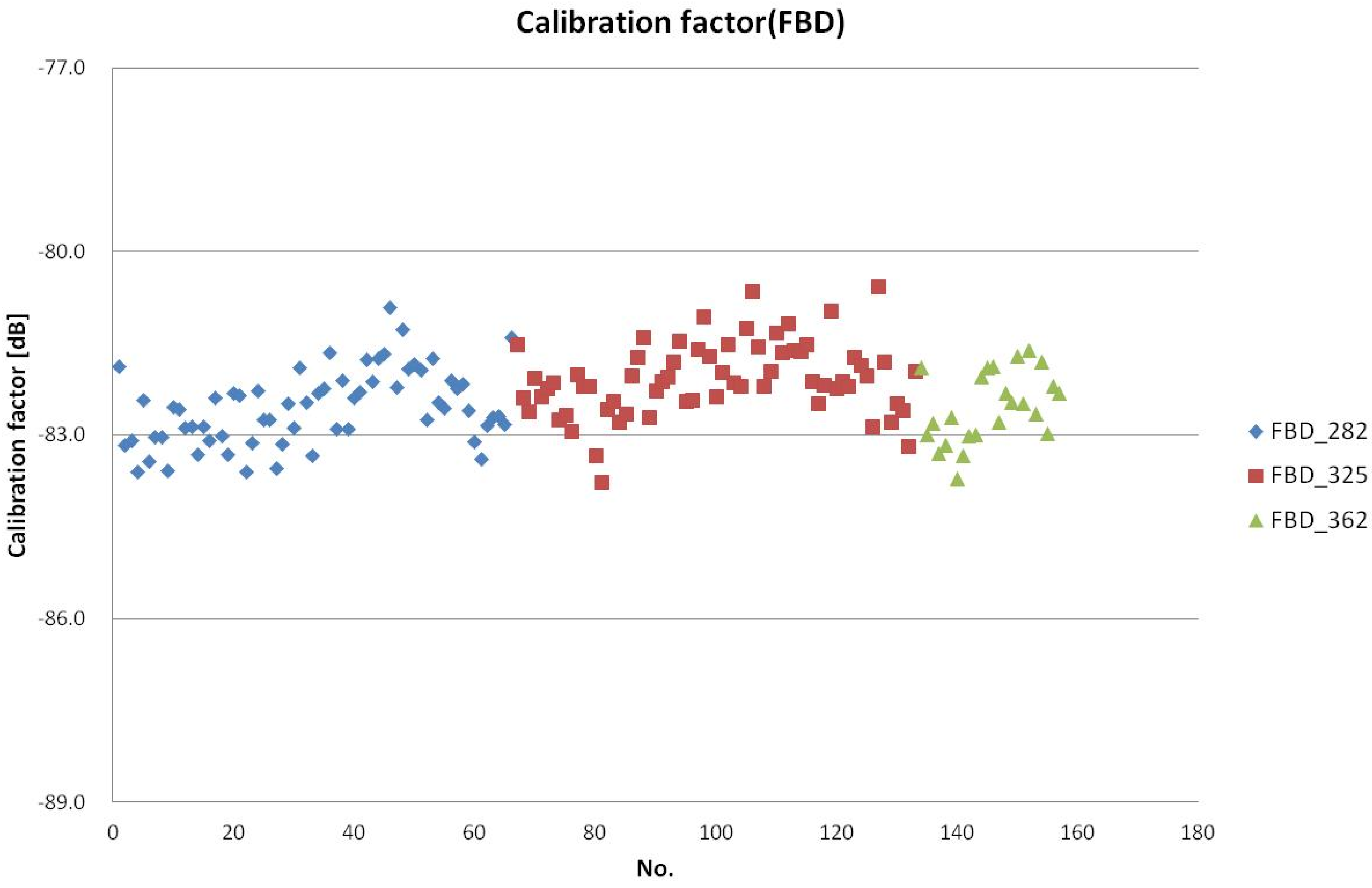
【2015.09.17版】

モード	ポイント数	平均値[dB]	標準偏差
HBQ_250	7	-84.81	0.56
HBS_280	11	-84.89	0.69
HBQ_304	5	-85.12	0.67
HBQ_327	5	-83.41	1.12
HBQ_349	14	-83.18	0.41
HBQ	42	-84.16	1.05

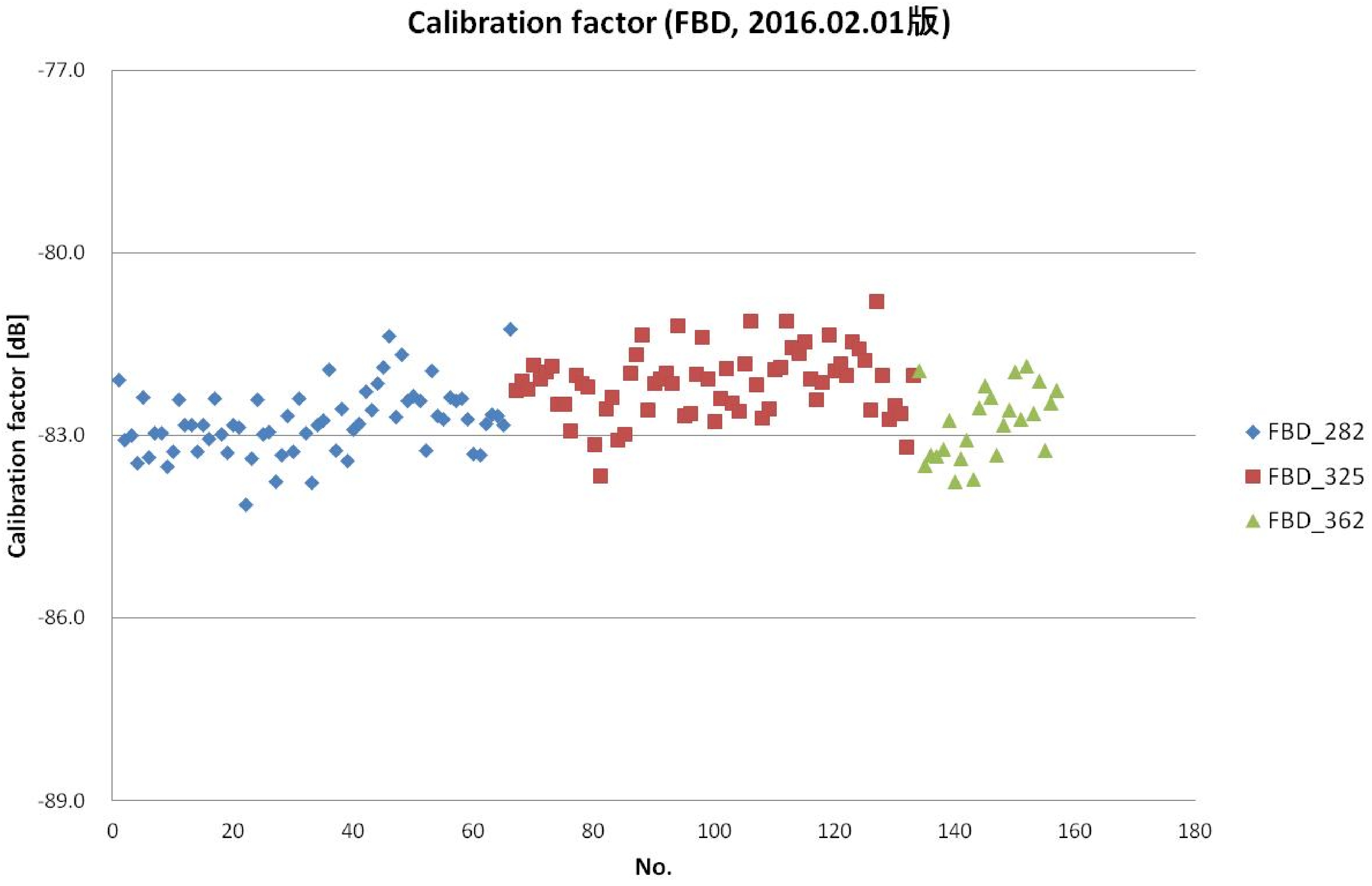
【2016.02.01版】

モード	ポイント数	平均値[dB]	標準偏差
HBQ_250	7	-83.19	0.70
HBS_280	11	-83.37	0.77
HBQ_304	5	-83.48	0.59
HBQ_327	4	-83.04	0.44
HBQ_349	14	-83.39	0.41
HBQ	41	-83.33	0.59

３－１. 校正係数グラフ(2015.09.17版, FBD)



３－２. 校正係数グラフ(2015.02.01版, FBD)



３－３. 校正係数 統計値（HBQ, FBD）

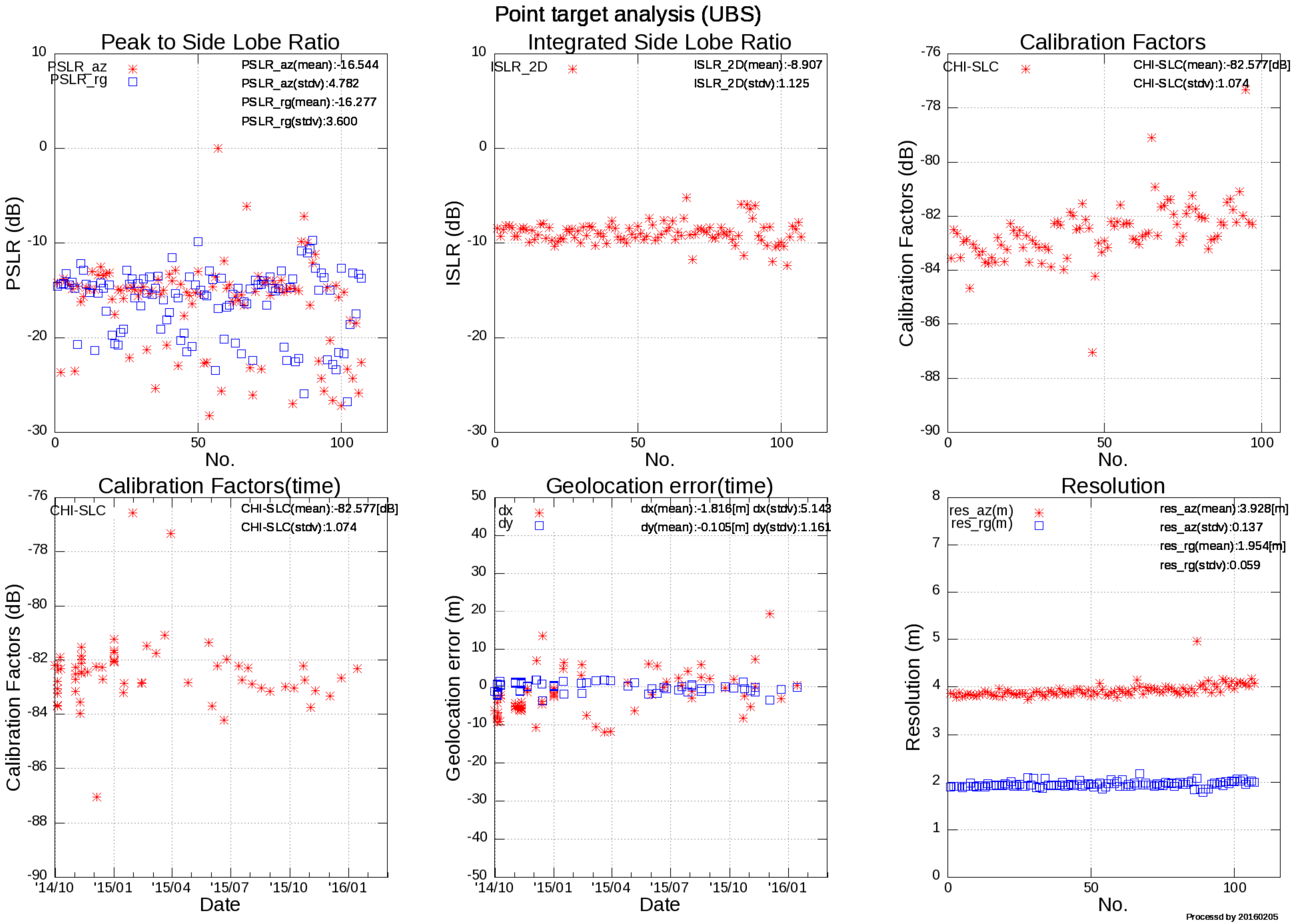
【2015.09.17版】

モード	ポイント数	平均値[dB]	標準偏差
FBD_282	66	-82.55	0.61
FBD_325	67	-82.08	0.60
FBD_362	24	-82.54	0.58
FBD	157	-82.35	0.64

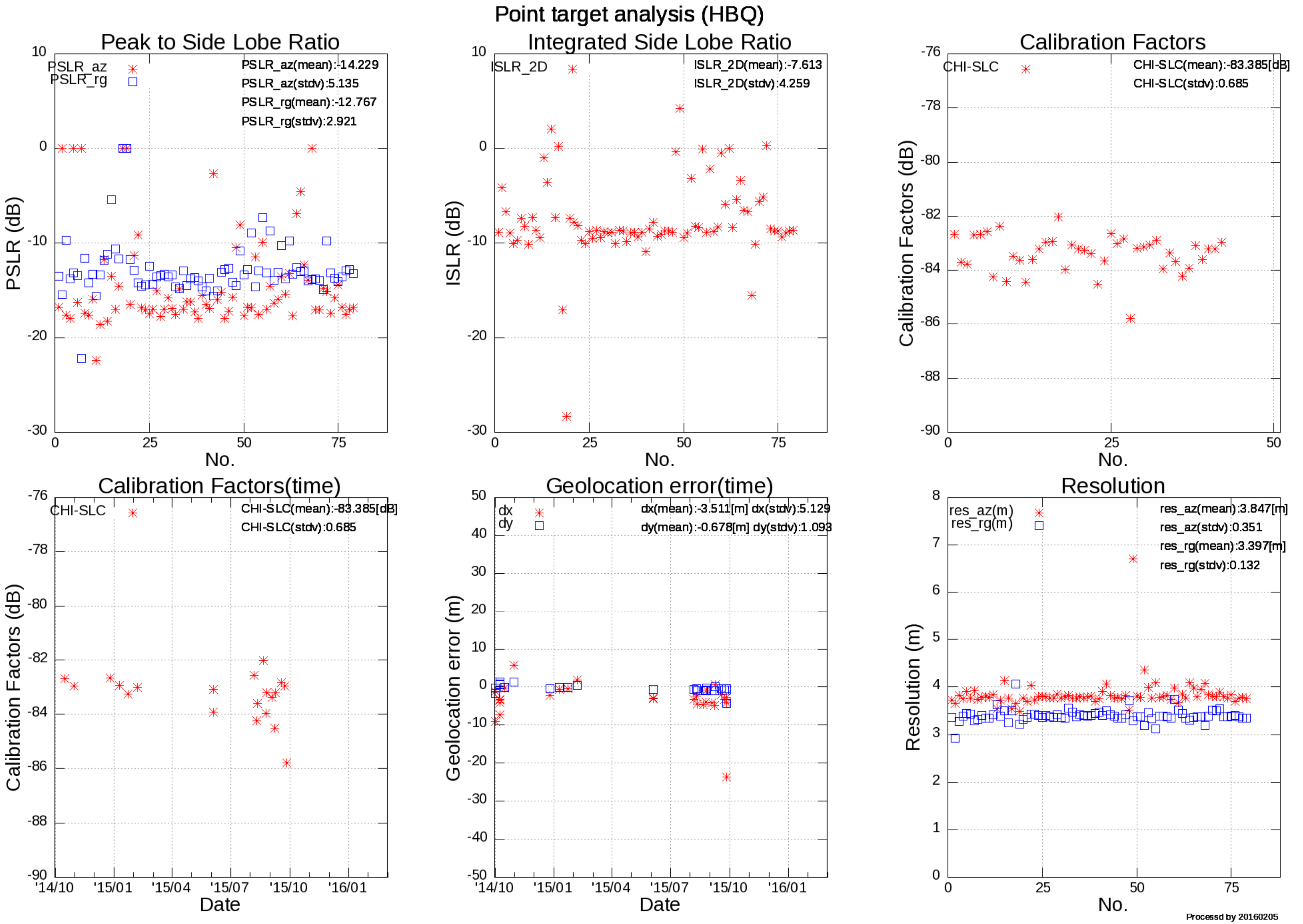
【2016.02.01版】

モード	ポイント数	平均値[dB]	標準偏差
FBD_282	66	-82.76	0.54
FBD_325	67	-82.13	0.55
FBD_362	24	-82.79	0.58
FBD	157	-82.50	0.63

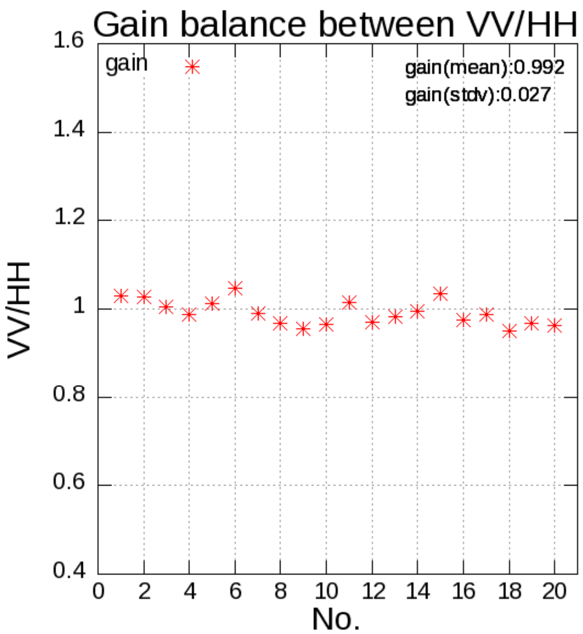
４－１. ポイントターゲット評価結果グラフ(2015.02.01版, UBS)

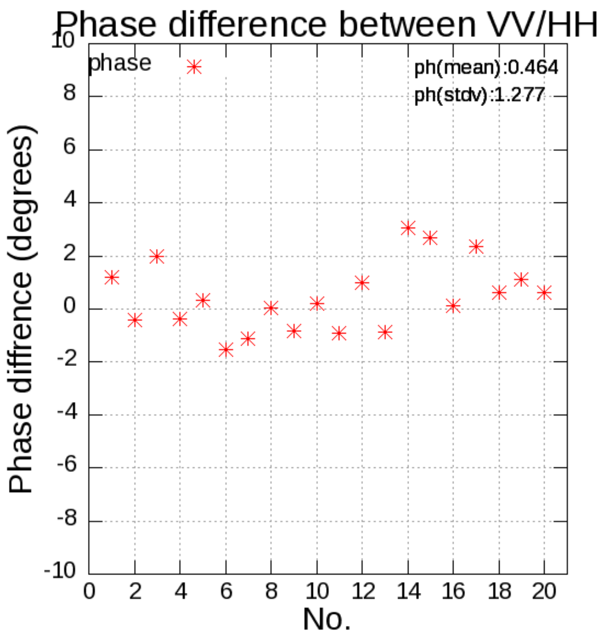


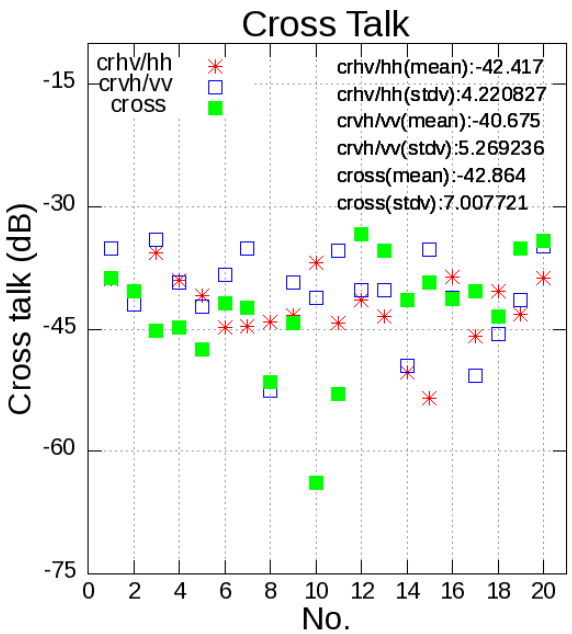
４－２. ポイントターゲット評価結果グラフ(2016.02.01版, HBQ(1/2))



４－３．ポイントターゲット評価結果グラフ(2016.02.01版, HBQ(2/2))

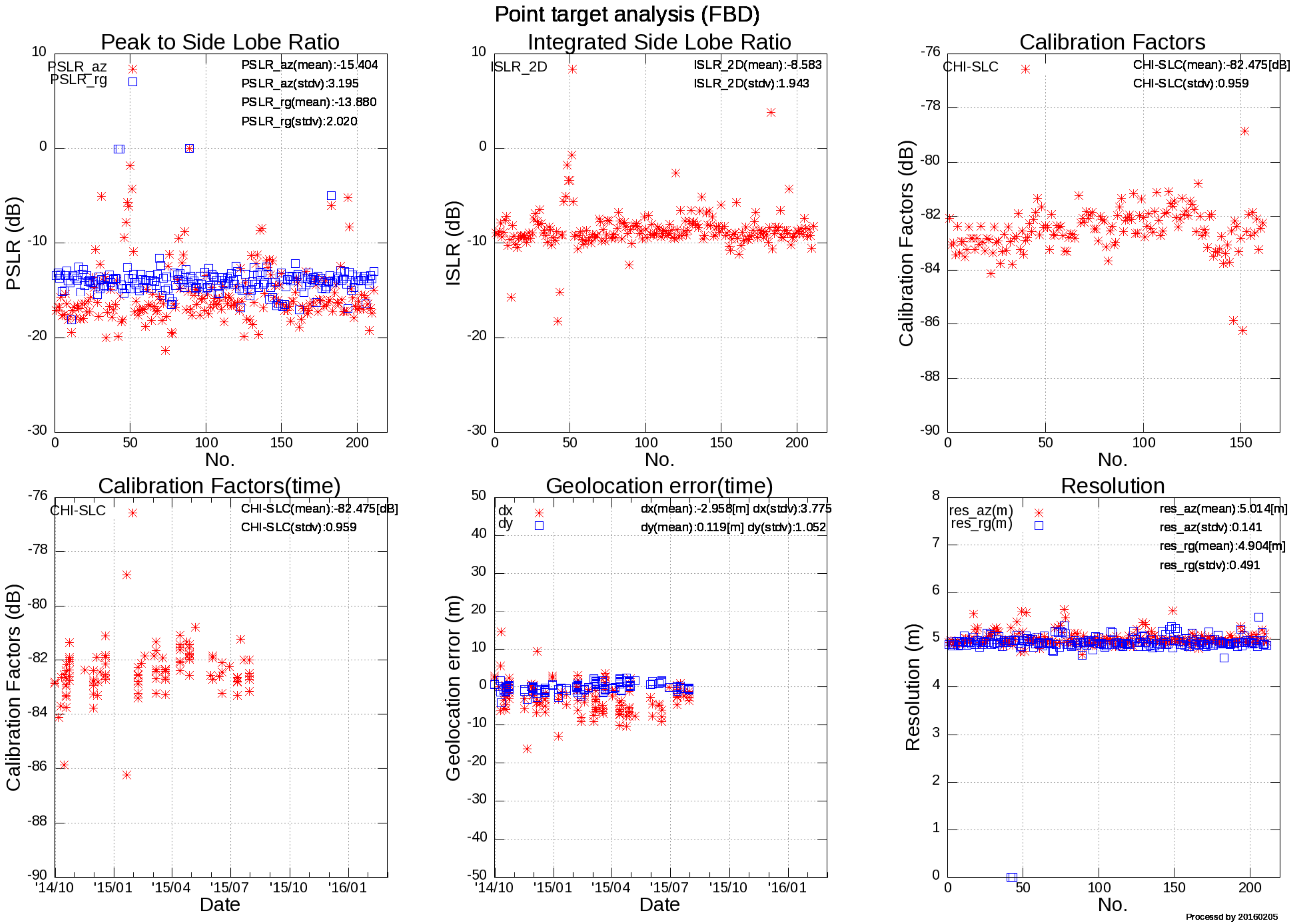






Processd by 20160205

４－４. ポイントターゲット評価結果グラフ(2016.02.01版, FBD)



5. 各評価項目の統計値(1/2)

評価項目	モード	ポイント数	SIGMASAR (2015.09.17版)		SIGMA-SAR (2016.02.01版)		要求精度の仕様値
			平均値	標準偏差	平均値	標準偏差	
PSLR(range) [dB]	-	396(397)	-14.256	2.784	-14.305	2.999	-13.26dB+2dB
PSLR(azimuth) [dB]	-	396(397)	-15.263	3.942	-15.478	4.183	-13.26dB+2dB
ISLR [dB]	-	396(397)	-8.415	2.404	-8.477	2.486	-10.16dB+2dB
CF [dB]	SBS	-	-	-	-	-	
	UBS	93(94)	-82.22	0.84	-82.62	0.75	
	HBQ	42(41)	-84.16	1.05	-83.33	0.59	
	FBD	157(157)	-82.35	0.64	-82.50	0.63	
dx_grd [m]	-	396(397)	-2.882	4.763	-2.760	4.513	20m
dy [m]	-	396(397)	-0.503	1.094	-0.100	1.133	20m
Resolution [m] (range)	SBS	-	-	-	-	-	1.78
	UBS	106(107)	1.955	0.061	1.954	0.060	1.78
	HBQ	79(79)	3.398	0.139	3.397	0.133	3.57
	FBD	211(211)	4.941	0.101	4.904	0.492	5.36
Resolution [m] (azimuth)	SBS	-	-	-	-	-	1.00x1.1(1.10)
	UBS	106(107)	3.924	0.135	3.928	0.137	2.75x1.1(3.025)
	HBQ	79(79)	3.853	0.356	3.847	0.353	3.75x1.1(4.125)
	FBD	211(211)	4.991	0.123	5.014	0.141	5.00x1.1(5.500)

5. 各評価項目の統計値（2/2）

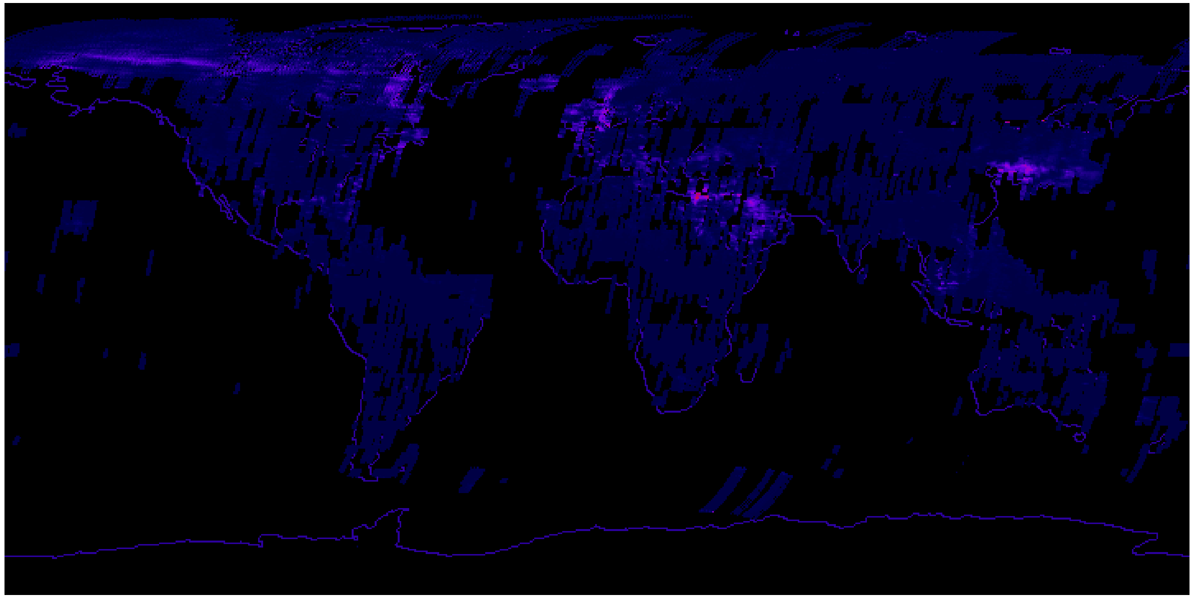
評価項目	ポイント数	SIGMA-SAR (2015.09.17版)		SIGMA-SAR (2016.02.01版)		要求精度の仕様値
		平均値	標準偏差	平均値	標準偏差	
Gain balance VV/HH	20(20)	0.993	0.027	0.990	0.028	1.047
Phase balance VV/HH	20(20)	0.278	1.163	0.463	1.277	5 [deg]
Cross talk HV/HH	20(20)	-44.195	5.725	-42.462	4.226	-30 [dB]
Cross talk VH/VV	20(20)	-40.940	5.383	-40.983	5.456	-30 [dB
Cross talk	20(20)	-43.032	8.202	-42.851	7.008	-30 [dB]

※　()内の数字は206.02.01版評価におけるポイント数

Sigma-SAR

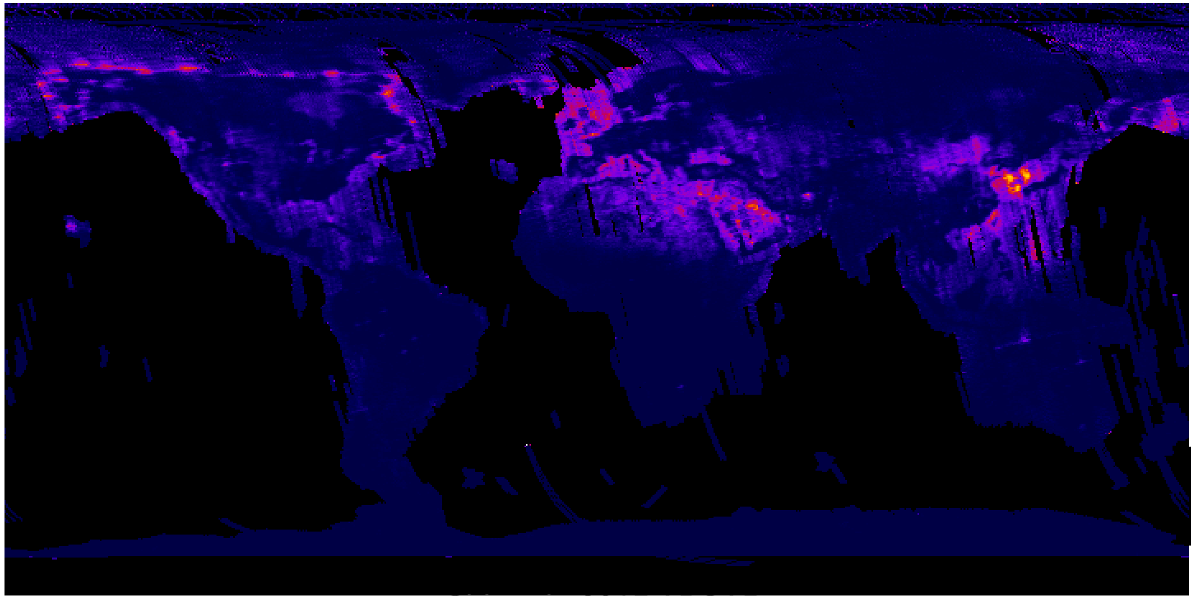
- SAR imaging from the L1.0 data
- Updated from the original version, often
- Calibration and imaging, ortho rectification, slope correction
- JAXA-Shimada agreement for copy right.
- Commertical use can be available (after the contract), after April 2016

RFI monitoring by JERS-1 SAR (1992-1998)

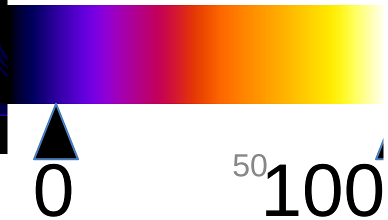


BW=15MHz
HH

RFI monitoring by PALSAR (2010/4~2011/4)

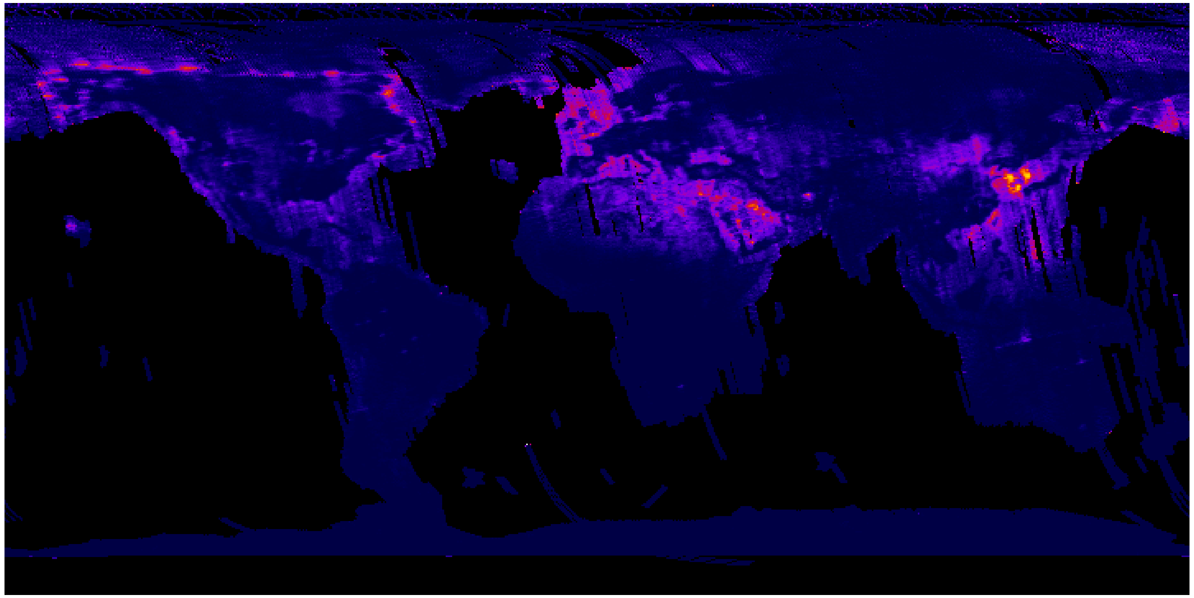


BW=14MHz
HV



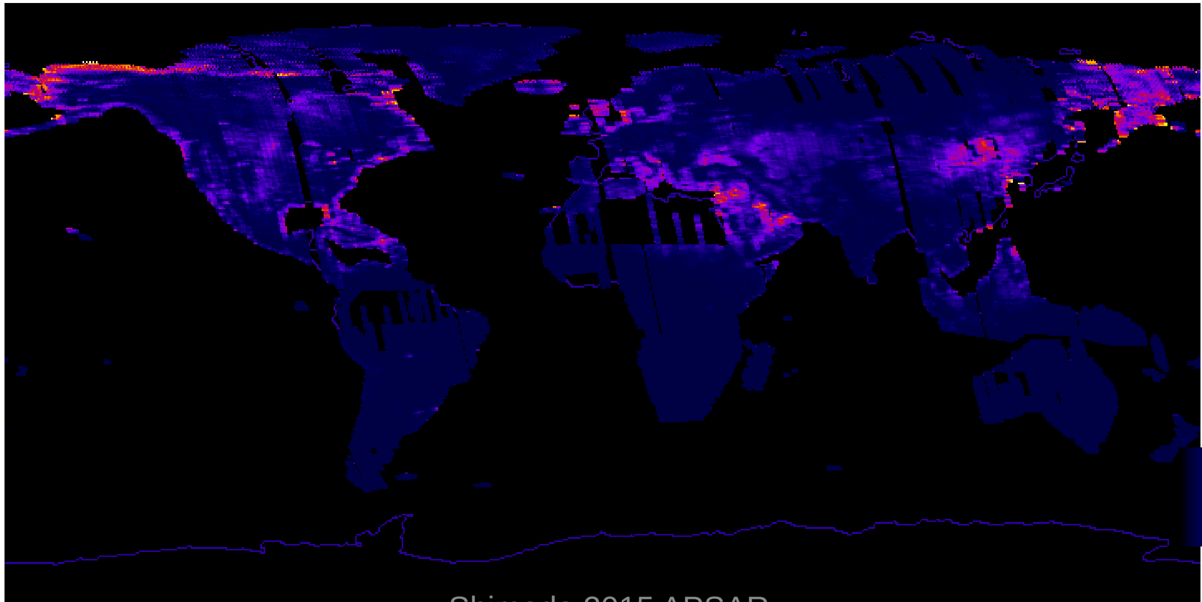
Normalized zero padded bandwidth (%)

RFI monitoring by PALSAR (2010/4-2011/4)



BW=14MHz
HV

RFI monitoring by PALSAR2 (2014/8~2014/12)



Corresponding
BW=14MHz
HV

FBD is used.
Japan is not
observed by FB

Normalized zero padded bandwidth (%)

Path processing

- Time consuming
- 4 times slower than PALSAR products
- Ortho is OK
- Slope correction is OK
- The product seems stable

RFI summary

- RFI increases temporally.
- Comparing RFIs of PALSAR and PALSAR-2, RFI (2014) became at double of 2010 (while those regions near Japan and neighbors, Saharan area, middle east with highest RFI were not measured yet)
- RFI depends on the polarizations, and HV is more sacrificed than HH.

Conclusions

- Calibration of the KC product is on-going.
- ALOS-2 PALSAR mosaic has be generated.
- Ionospheric sincillation is the issue.