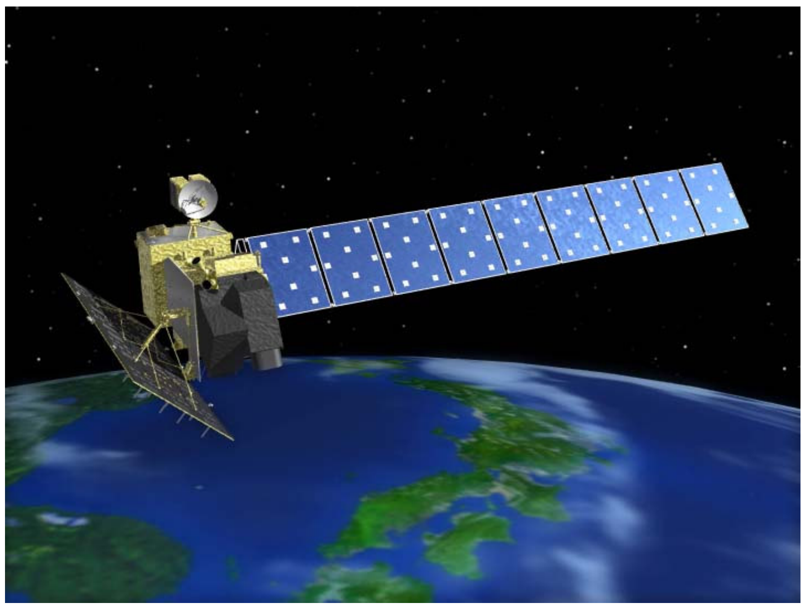
ALOS PALSAR CYCLIC REPORT

7 SEPTEMBER 2007 TO 23 OCTOBER 2007



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Initial Issue	1	0	05 December 2007
Addition of new processor information, minor modifications following review (pagination, historical data added to Section 6.1)	2	0	10 January 2008

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1 INTRODUCTION

The PALSAR Cyclic Report is distributed by the PALSAR QC team to keep the PALSAR community informed of any modification regarding instrument performances, the data production chain and the results of calibration and validation campaigns at the end of each ALOS cycle, which represents 671 orbits, or 46 days.

The PALSAR instrument is part of the ALOS mission and its products are received and processed via the ADEN ground segment across Europe. A series of quality checks are undertaken in order to assess the ground segment and instrument performance and the product quality.

Checks are currently made on a weekly (header parameters, PDS status) or bi-monthly (visual report) basis to have a constant view on the mission status. The cyclic report presents the results of the analysis for the different part of the chain, from satellite to end-product.

1.1 Acronyms and Abbreviations

ADEN	ALOS Data European Node
ALE	Absolute Localisation Error
ALOS	Advanced Land Observing Satellite
EO Help	Earth Observation Help Desk
DN	Dynamic Number
IRF	Impulse Response Function
FR	Faraday Rotation
NRCS	Normalised Radar Cross Section
OCM	Orbit Control Manoeuvre
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PDS	Payload Data Segment
QC	Quality Control
SAR	Synthetic Aperture Radar
SPPA	Sensor Performance Products Algorithms
SNR	Signal to Noise Ratio
RCS	Radar Cross Section
WS	Wide Swath

1.2 Reference Documents

[1] ALOS PALSAR Product Verification Report, PS-CAL-TN-003, June 2007

[2] Shimada, M., “PALSAR CALVAL Summary and Update 2007”, IGARSS, 2007

[3] Wright, P., Quegan, S., Wheadon, N. & Hall D., "Faraday Rotation Effects on L-band Spaceborne SAR Data", IEEE Trans on Geoscience and Remote Sensing, Vol 41, 12, 2003.

1.3 Background Information

The background information has been extracted from reports issued by ESA during the PALSAR commissioning phase [1]. Information on instrument anomalies and image quality parameters produced during the commissioning phase are quoted here for comparison with the current phase.

The PALSAR instrument is a Synthetic Aperture Radar instrument that is part of the ALOS mission built by the Japanese Space Agency (JAXA).

The ALOS mission has its data produced and disseminated through geographical nodes. The European node (ADEN) was set up and is operated by ESA through the Tromso, Matera, Mas Palomas and Frascati ground stations. As a third party mission (TPM), only the ground segment and data processing are dealt with by ESA, the platform being the responsibility of the owner: JAXA. Each node operates their ground segment independently and shares results with JAXA when required.

The ADEN-ALOS team is responsible for the operation and maintenance of the data received in Europe and North Africa. The ADEN team took part in the Cal/Val activities during the ALOS commissioning phase (January to October 2006). The methodologies used and results obtained are documented in document [1]. Information related to the mission and product are made available to the user through the site: http://earth.esa.int/object/index.cfm?fobjectid=3738

As part of the ADEN operations, a series of quality checks are undertaken in order to assess the ground segment and instrument performance and the product quality for products requested by European users. Checks are currently made on a weekly basis (header parameters, PDS status) to have a constant view on the mission status.

Details on the commissioning phase will be placed on the ALOS PCS website, location http://earth.esa.int/pcs/alos/.

2 SUMMARY

Cyclic Report	14
Cycle Start	7 September 2007
Cycle End	23 October 2007

The main issues during this cycle have been as follows:

- Visual inspections have highlighted a number of problems with Wide Swath (WS) mode data, including visible subswath boundaries, scalloping, and azimuth ambiguities.
- Interference effects have been identified in several PALSAR images.
- In fine mode and polarimetric mode, the radiometric error at far range is still visible.

3 SOFTWARE AND AUXILIARY FILE VERSION CONFIGURATION

The current processor version of the PALSAR instrument, and the date on which it was installed at each of the stations is detailed in Table 3-1:

Current PALSAR Processor Version	ESRIN	Matera	Tromso
4.00	Pre 01/07/07	03/07/07	25/09/07*

Table 3-1 PALSAR Processor Versions

* Tromso was upgraded from v4.00 to v4.01 on 20/08/07, however, due to bad data quality of the generated products, it was downgraded back to v4.00 on 25/09/07.

A history of the ADEN processor release notes will be made available on the ALOS ADEN PCS website, location: http://earth.esa.int/pcs/alos/.

4 PDS STATUS

4.1 Planned Instrument Unavailability

None.

4.2 Unplanned Instrument Unavailability

An anomalous operation found in PALSAR observations on 5th September and 8th September 2007; PALSAR shifted into standby mode in the middle of its observation.

4.3 Current Platform Status

Information on the platform provided by JAXA:

None reported during this cycle.

4.4 ADEN PDS Unavailability

None

4.5 Periods of missing precision orbit data

For the periods described in Table 4-1, JAXA has announced that precision orbit data is missing.

From (UT)		To (UT)		Reason
Date	Time	Date	Time	
Oct. 12, 2007	19:09:00.000000	Oct. 12, 2007	20:13:00.000000	Due to OCM
Oct. 6, 2007	05:16:00.000000	Oct. 6, 2007	06:19:00.000000	Due to OCM
Sep. 29, 2007	10:35:00.000000	Sep. 29, 2007	11:38:00.000000	Due to OCM
Sep. 7, 2007	22:09:00.000000	Sep. 7, 2007	23:13:00.000000	Due to OCM

Table 4-1 Missing Precision Orbit Data

4.6 JAXA Observation Strategy

The JAXA observation strategy can be found at:
http://www.eorc.jaxa.jp/ALOS/obs/overview.htm

5 DATA QUALITY CONTROL

5.1 *Instrument related anomalies*

ADC saturation effects have been observed in Wide Swath (WS) mode imagery.

Interference effects have also been noted in Wide Swath (WS) mode imagery.

The platform Yaw steering underwent a scheduled switch off between 23rd February at 00:12 UT to 24th February 2007 at 23:01 UT. Imagery from this period has been inspected and no problems with azimuth focussing have been detected. There will be an issue with the absolute localisation accuracy (ALE) of imagery acquired during this period.

Appendix C gives a full list of PALSAR instrument anomalies.

5.2 *Processor related anomalies*

In fine mode and polarimetric mode, the radiometric error at far range is still visible. JAXA have indicated that there is a processor up -grade which will alleviates this problem, but all data on the ESA ftp sites to date have been processed with version 1 of the processor.

Visual inspections have highlighted a number of problems with WS mode data including, visible sub swath boundaries, azimuth ambiguities and scalloping.

5.3 *Daily Report Issues*

The yaw steering scheduled switch off (23rd February at 00:12 UT to 24th February 2007 at 23:01 UT) has a visible effect in the daily report. The attitude and Doppler plots for the period of interest shows a huge discrepancy with the normal attitude parameters, as showed in the Figure 6-1

5.4 *User Queries*

A PALSAR FAQ containing the common user requests can be found at on the ESA PCS website.

The link to this site is: http://earth.esa.int/pcs/alos/

6 CALIBRATION/VALIDATION ACTIVITIES AND RESULTS

This section gives the results of the calibration/validation activities undertaken during the reporting period.

6.1 Doppler centroid frequency monitoring

Figure 6-1 gives the Doppler centroid frequencies of products generated during the cycle, and all previous cycles since April 2007. During Cycle 14, 97 additional products were generated and analysed. The Doppler centroid frequency stayed fairly stable over the different repeat cycles for which the data were acquired, except during the period when the Yaw steering was off (see 5.3). The effect of this Yaw steering operation is visible on the Doppler frequency as seen in Figure 6-1. The frequency drops from few hundreds Hz to -1500 Hz.

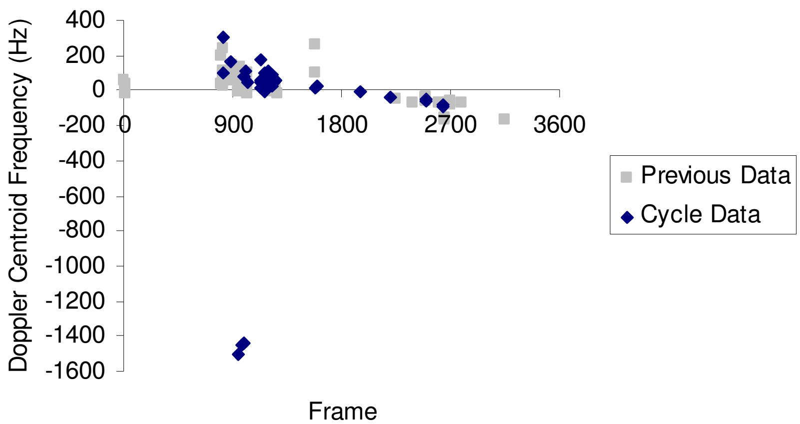

Figure 6-1 Doppler Centroid frequency given in function of the frame number

The Doppler frequency is very low the nearer the North Pole as it can be seen in Figure 6-2 and Figure 6-3.

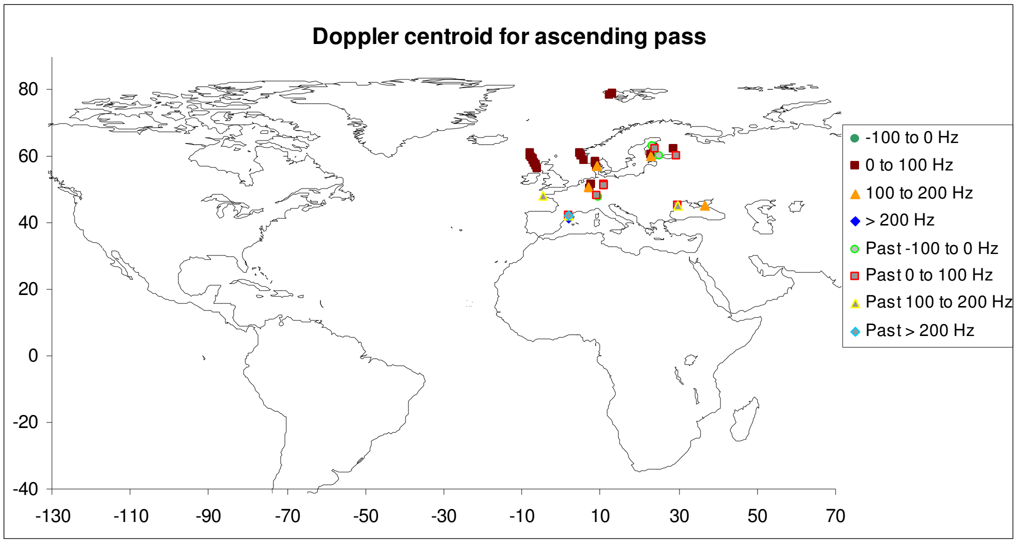

Figure 6-2 Doppler centroid frequency for ascending passes

The same results are visible for the descending passes

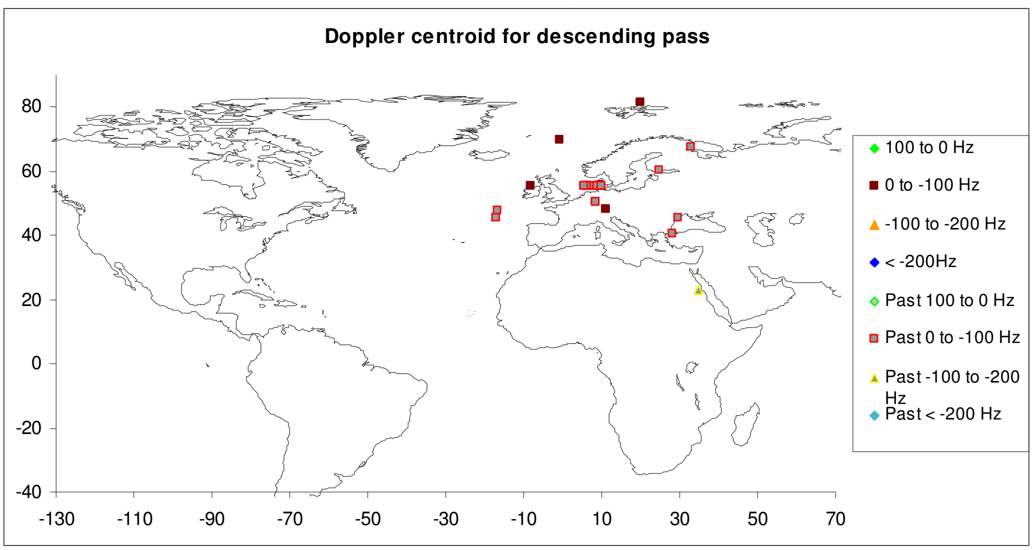

Figure 6-3 Doppler centroid frequency for descending passes

The product header also gives the pitch, roll and yaw angles of the ALOS spacecraft as shown in the following figure:

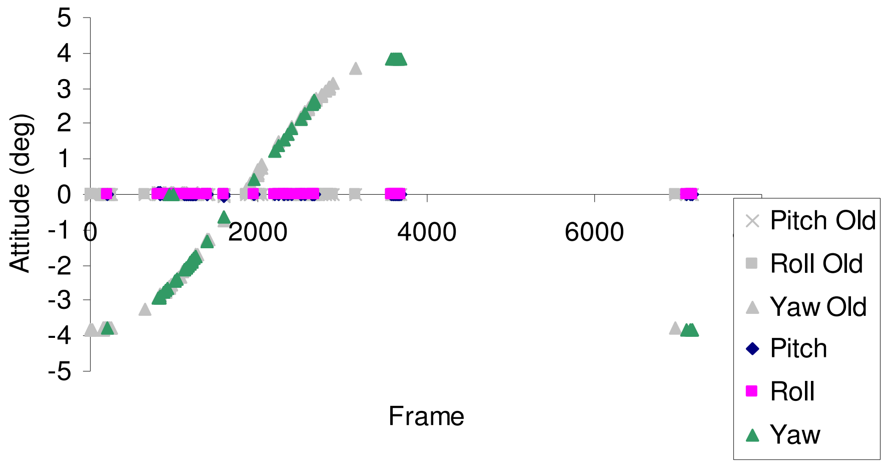

Figure 6-4 Satellite attitude as a function of the frame number

The satellite attitude stays stable for the analysed products except for the period during which the Yaw steering was switched off. Apart from this specific Yaw value, Figure 6-4 shows the expected low deviation of the Pitch and Roll and the Yaw getting bigger with the latitude (or frame number). This attitude is the expected behavior of a Yaw steering satellite with Yaw axis is aligned with the centre of the earth.

6.2 Point Target IRF Analysis

Since no point targets (transponder or corner reflectors) with known NRCS have been identified in the analysed PALSAR products, natural point targets have been used instead. Table 6.2.1 gives the natural point target NRCS values for a range of PALSAR products analysed during the cycle. Table 6.2.1 gives measurements for the HH polarisation per product type only. This allows measurements from all beams and products to be compared. Table 6.2.2 gives the polarimetric measurements averaged for all beams.

To date, data from only three beams have been analysed. No NRCS results have been obtained for more than one beam per product type.

Product	All beams	NRCS (dB)		
		B3 Mean(dB)	B7 Mean(dB)	B21 Mean(dB)
P1.1		47.76±3.87		
W1.5P				40.87
W1.5GP				49.39±5.28
H1.1			49.18±2.50	
H1.5U			35.34±2.38	

Table 6.2.1 Average PALSAR Image Radar Cross-Sections per product and beam in HH polarisation.

Table 6.2.2 gives RCS results per polarisation. As there is high NRCS variation across the various polarimetric channels, the results in the table are for strong point targets in each polarisation (i.e. the same point target is not necessarily used to obtain measurements in all four polarisations). Note the polarimetric mode data are all from Beam 3, while the fine mode data are all from beam 7.

Product	NRCS (dB)			
	VV Mean dB	HH Mean dB	VH Mean dB	HV Mean dB
P1.1	49.30±6.31	47.76±3.87	41.13±5.91	44.38±5.51
H1.1		49.18±2.50		39.18±6.30

Table 6.2.2 Average PALSAR Image RCS per product and polarisation.

The above measurements indicate typical NRCS values of non-saturated point targets that can be derived from PALSAR products. It is not possible to comment on the radiometric accuracy or stability of the natural point target results. Note that JAXA report a radiometric accuracy of 0.64dB compared to a 1.5dB specification and a stability of 0.5-1.0dB from measurements over the Amazon [2].

Tables 6.2.3 & 6.2.4 give the impulse response function (IRF) results for a variety of PALSAR products. In this table results for different polarisations are not segregated. For comparison, the predicted resolution values are also indicated. For fine and polarimetric mode, the resolutions are generally as expected. For wide swath mode, the azimuth resolution is higher than the nominal value by about 25-30m while in range the measurements are higher than the predicted values by up to 60m. However, it should be noted that the wide swath pixel size is 100m and thus these differences are not excessive.

Product	Azimuth res (m)	Range res (m)	Predicted Azimuth res (m)	Predicted range res (m)	No. results
P1.1	5.74±1.35	9.97±0.40	4.48	10.71	40
W1.5P	132.2	125.2	100	Fig 6.2.1	1
W1.5GP	126.38±1.20	126.24±4.20	100	Fig 6.2.1	2
W1.5GU	128.25±5.68	123.52±3.00	100	Fig 6.2.1	5
H1.1(FBD)	4.87±0.35	9.75±0.47	4.52	10.71	8
H1.5U(FBS)	9.87±1.11	12.08±3.19	9.04	Fig 6.2.2	2
H1.5GU(FBS)	9.83±0.07	10.56±3.35	9.04	Fig 6.2.2	4

Table 6.2.3 Average PALSAR resolution per product type. Note that the wide swath azimuth bandwidth is not available in the product headers therefore the nominal resolution from [2] is quoted.

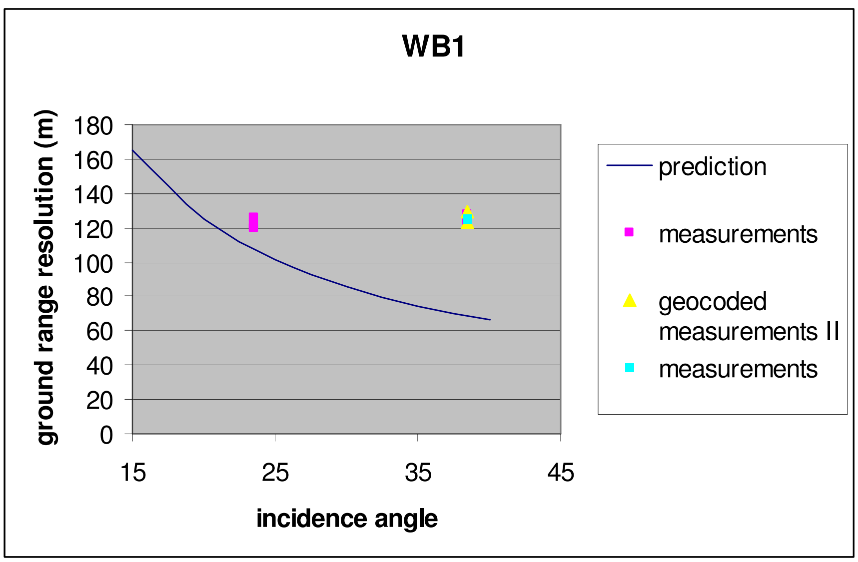

Figure 6.2.1 Ground range resolution for wide swath mode (WB1) data.

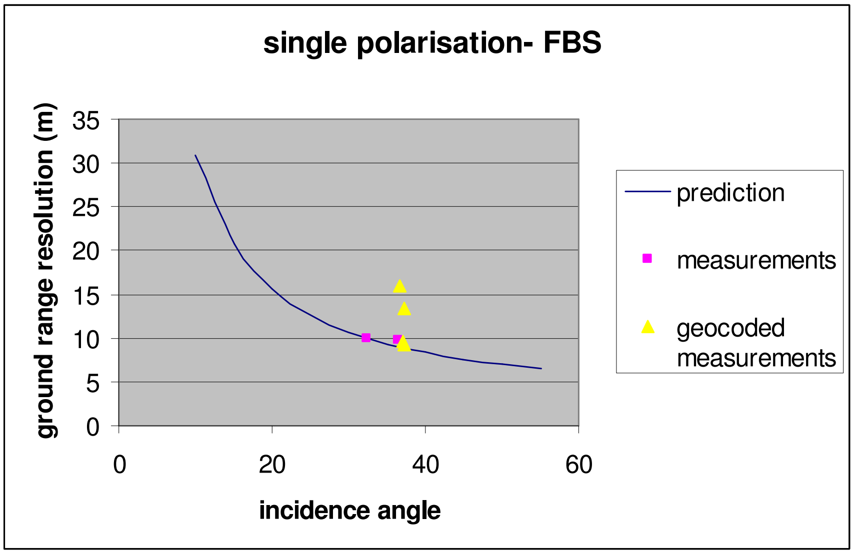

Figure 6.2.2 Ground range resolution for FBS data.

Product	ISLR (dB)	PSLR (dB)	SSLR (dB)	No. results
Specification	-8.0	-10.0	-	-
JAXA measure	-8.6	-12.5	-	-
P1.1	-6.25±3.13	-	-	31
W1.5P	-9.95	-7.76	-13.55	1
W1.5GP	-7.15±3.54	-8.03±0.49	-13.11±0.34	2
W1.5GU	-	-8.28±1.80	-10.89±3.28	5
H1.1(FBD)	-	-2.56±1.24	-	8
H1.5GU(FBS)	-2.19±1.38	-7.85±0.17	-5.93±3.71	2
H1.5GU(FBS)	-3.74±0.93	-8.36±1.65	-14.07±1.90	4

Table 6.2.4 Average PALSAR sidelobe measures per product type.

Note that it has not been possible to measure some of the IRF parameters using natural points. For comparison, the commissioning phase corner reflector measurements [1] are given in table 6.2.5. In general, the natural point target IRF measurements are as expected.

Product	Azimuth res (m)	Range res (m)	ISLR (dB)	PSLR (dB)	SSLR (dB)
1.5(FB)	7.67: 10.5	7.76: 11.23	-9.55 : -1.77	-14.2: -4.99	-15.15: -12.28
1.1(FB)	4.71: 4.78	4.72: 4.78	-8.47 : -5.49	-13.37: -10.84	-20.45: -18.82-

Table 6.2.5 Corner reflector measurement ranges from the commissioning phase [1].

6.3 Distributed Target Analysis

No suitable candidate distributed targets analysed in this cycle.

JAXA measurements indicate a stability of 0.5-1.0dB from measurements over the Amazon rainforest [2].

6.4 Noise Equivalent sigma zero

Table 6.4.1 gives the noise equivalent sigma zero measures for the products analysed in the current cycle. The table includes all polarisations for which measurements are available. The values are averaged over different beams and product types

Product	Mean Noise (dB)	No. results
Wide swath	-25.00	1
Fine mode HH	-23.04±2.56	4
Fine mode HV	-27.24 ±2.95	7
Fine mode VH	-25.75±3.03	3
Fine mode VV	-22.95±2.38	3

Table 6.4.1 PALSAR Noise equivalent sigma zero measurements by polarisation.

Figure 6.4.1 shows the variation of noise with incidence angle, while Figure 6.4.2 shows the published JAXA results for HH and HV polarisations. A couple of the co-polarisation measurements are above the instrument specification of -23dB. This could be due to measurement of an inappropriate test site, but will continue to be monitored. The cross polarisation measurements are below -25dB.

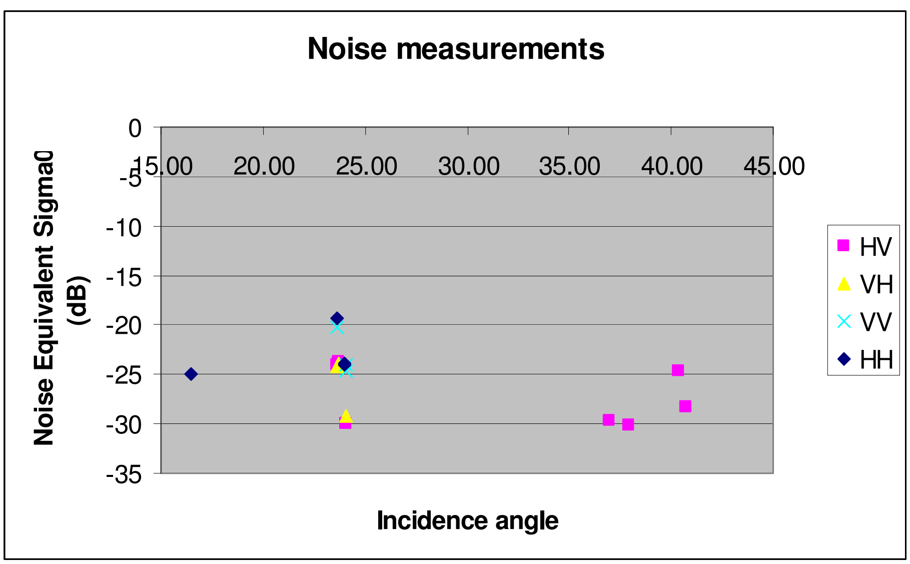

Figure 6.4.1 Measured Noise equivalent Sigma0 variation with polarization and incidence angle

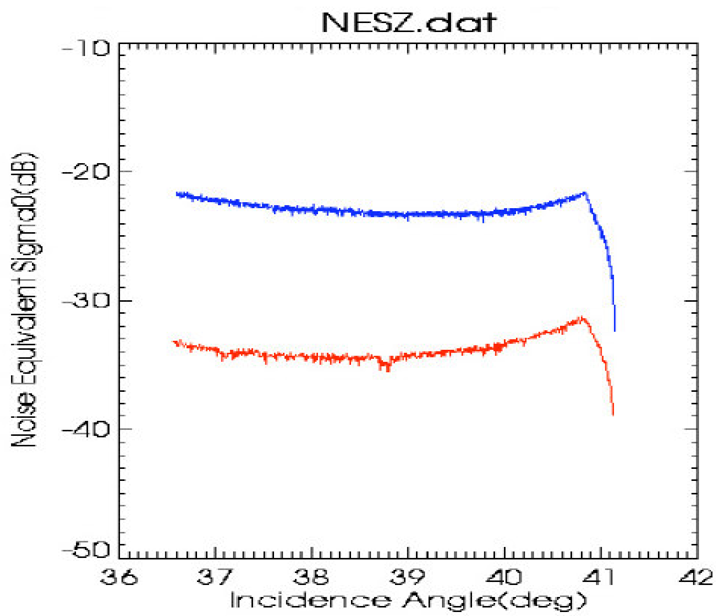

Figure 6.4.2 The blue curve is the HH polarisation values and the red curve is the HV polarisation values [2].

6.5 Radiometric Resolution and Equivalent Number of Looks

Table 6.5 gives the radiometric resolution and the equivalent number of looks for a range of products. The measures quoted are averaged over different beams and polarisations. There are discrepancies between the predicted and measured number of looks for all of the fine mode ground range products. This could be due to the small number of samples and/or use of inappropriate data. These radiometric measures will continue to be monitored.

Product	Predicted ENL	Equ. No. Looks(ENL)	Rad Res (dB)	No results
P1.1	1	0.87±0.08	3.17±0.10	9
P1.5GU	4	2.44±0.22	2.15±0.07	4
H1.1	1	0.82±0.02	3.24±0.04	2
H1.5GU	4	1.29±0.21	2.75±0.18	3
H1.5U	4	1.02	2.99	1
W1.5P	8	9.62±1.76	1.22±0.10	2
W1.5GP	8	5.38±0.53	1.56±0.06	3

Table 6.5.1 PALSAR measured equivalent number of looks and radiometric resolution.

6.6 Elevation Antenna Pattern Monitoring

The following is a profile from product PSR_MMC_FR__0000770001/IMG-HH-ALPSRP057310230-H1.5GUA of the Burkina Faso region of Africa. It shows the reasonably unvarying backscatter from a forested region and the significant drop off at far range due to the radiometric correction error.

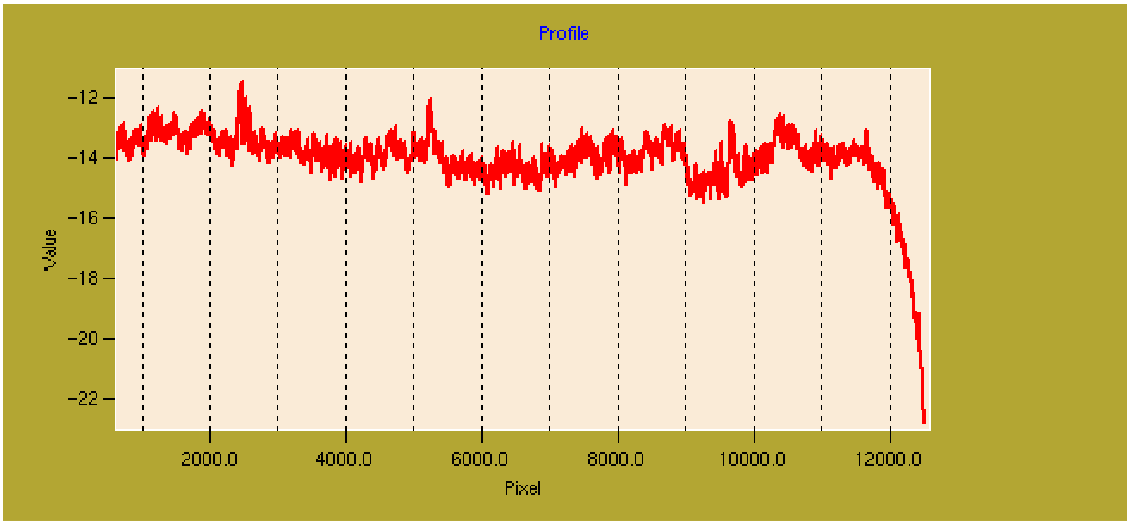

Figure 6.6.1 RCS range profile from PSR_MMC_FR__0000770001/IMG-HH-ALPSRP057310230-H1.5GUA

Product	Drop Off (dB)	Distance from far edge (pixels)[1]
P1.1	7dB	125
H1.5GU	8dB	680
H1.5U	7dB	222

Table 6.6.1 Elevation radiometric correction error.

Users should not use the far range element of the data affected by this radiometric drop off. Table 6.6.1 characterises where the drop off occurs for each product type in order to give an indication of where to crop data in range.

It is understood that JAXA have made changes to the processor to alleviate this problem. Data processed by processor version above 1.0 may be unaffected by this problem, but this needs to be verified.

6.7 Localisation Accuracy

No localisation measurements have been made to date as no point target calibration devices are deployed. Suitable targets of opportunity are yet to be identified

[1] Note that for geocoded products, the far edge is taken to be the far edge of the imaged area, at the top of the image. In terms of absolute pixel number, this will vary with azimuth location in the geocoded product.

JAXA quote a nominal measurement of 9.2m for fine resolution data and 70m for scanSAR data (100m specification). [2]

6.8 Ambiguities

JAXA [2] indicate that range ambiguities of -23dB have been observed, compared to a specification of -16dB. Azimuth ambiguities of -11dB have been observed in ADEN node data (compared to a specification of -16dB).

6.9 Dual and Quad Polarisation Calibration

Where data is not well calibrated (i.e. residual channel imbalances or high cross talk is measured) there will be an impact on the validity of retrieved geophysical parameters from the data. In this section the polarimetric calibration of the data is assessed.

6.9.1 CO- REGISTRATION

For Level 1.1 polarimetric data the mean channel registration in range is 0.92m (standard deviation 0.8m) and 0.87m in azimuth (standard deviation 1.02m) (i.e. sub-pixel).

6.9.2 CHANNEL COHERENCE, BALANCE AND SYMMETRY

In the following, parameters that may indicate problems with the data calibration are provided in Table 6.9.1. The coherence measures are calculated for level 1.1 polarimetric products only. The measures have been calculated using the Calix tool.

HV-VH coherence is used for the signal to noise ratio (SNR) calculation. The phase of the HVVH correlation (see Appendix B equ. (2)) is expected to have a zero mean distribution. Deviations from zero mean phase indicate a non compensated phase imbalance in the data calibration. The HV/VH amplitude ratio (see Appendix B equ. (3)) is also expected to have a zero mean distribution Deviations from zero mean indicate an uncompensated amplitude imbalance. The HHHV and VVVH coherence values should be zero, if greater than 0.3 they indicate the presence of uncorrected cross talk and/or Faraday rotation. If the values are not similar, they indicate a non reciprocal cross talk. A HH-VV (see Appendix B equ(4)) mean phase deviation from zero may indicate uncorrected phase imbalance, depending on the scattering surface.

Orbit	Frame	HVVH phase Mean	HV/VH amplitude Mean (dB)	SNR Mean (dB)	VVVH coherence Mean	HHHV coherence Mean	HHVV phase. Mean
6940	1260	23.06±24.55°	3.20±5.50	6.14±3.82	0.26±0.11	0.23± 0.11	19.26±9.61°
7072	1020	2.17±22.64°	-0.16±6.55	1.35±5.76	0.14±0.08	0.17±0.11	6.17±27.69°
6321	2640	3.04±33.07°	0.21±6.53	1.11±6.20	0.20±0.10	0.22±0.11	6.05±26.61°
5650	2640	2.11±21.11°	0.15±5.77	5.31±5.69	0.14±0.08	0.15±0.09	-4.62±23.68°

Table 6.9.1 PALSAR polarimetric coherence measures. The greyed out values are from the previous cycle

The product from orbit 6321 appears to have no polarimetric imbalances, apart from an HHVV phase of 6°, which may indicate a phase imbalance. JAXA measures of the average VV-HH phase were 0.32°, with a standard deviation of 1.01°. [2]. The product from orbit 5650 has large SNR.

6.9.3 CROSS TALK ANALYSIS

Table 6.9.2 gives the cross talk values calculated using SARCON, where:

A is the channel reciprocity
W is the transmit H to V cross talk
U is the receive H to V cross talk
V is the transmit V to H cross talk
Z is the receive V to H cross talk

The cross talk is calculated for polarimetric level 1.1 products only. In general the values are consistent with those measured by JAXA [2] and are as good as or better than the instrument specification of -30dB. The image from orbit 6321, frame 2640 has poor cross talk isolation.

Orbit	Latitude	Frame	Calculated values (mean)				
			A	U(dB)	Z(dB)	W(dB)	V(dB)
7072	51.077	1020	0.966	-32.69±4.98	-31.11±0.96	-35.65±2.57	-36.08±4.89
6940	62.286	1260	0.923	-29.68±0.00	-30.24±0.03	-30.81±0.10	-31.64±2.32
6321	48.137	2640	0.862	-21.19±2.38	-25.83±1.51	-23.66±0.54	-31.75±5.07
5650	48.136	2640	0.976	-33.03±0.10	-33.26±1.84	-34.77±2.82	-36.94±0.64

Table 6.9.2 Cross talk measured using SARCON.

6.10 Faraday rotation analysis

For any given point in the solar cycle, faraday rotation (FR) is expected to be greatest at mid latitudes, at around 1-2pm local time, and at the equinoxes. Conversely, FR can be expected to be a minimum just before dawn, at polar and equatorial locations and at solstices. These generalisation can be used as a guide to assess whether the calculated FR and FR trends are plausible for a given location and time.

Faraday rotation has the effect or rotating the plane of polarisation of the transmitted and received signal. This can result in a much lower return than expected in the co-polarisation channels and a much higher return than expected in the cross-polarisation channel. This reduces the dynamic range of the co-polarised channels and drives the cross-polarised channel to resemble the co-polarised channels. This also reduces sensitivity to ground parameter variations and, for large values of FR, effectively turns a multi-polarisation radar into a single-channel system. Information products relying on the classification of L-band HV SAR data, such as crop and forest inventory or land cover maps, are likely to be affected by FR levels exceeding 10°. The accuracies of retrieved geophysical parameters such as soil moisture or vegetation biomass, which require good calibration and data accuracy, will be adversely affected once FR exceeds 5-8° (depending on land cover) [3].

The following measures have been calculated using the Calix tool. Only level 1.1 polarimetric products are used to calculate Faraday rotation.

Orbit	Latitude (deg)	Longitude (deg)	Frame	Acq. Date	UT	Local time[2]	Calculated FR (deg)
7072	51.077	11.017	1020	23/5/07	21:21	21:50	1.20±0.53
6940	62.286	23.88	1260	14/5/07	20:13	21:26	3.02±0.34
6321	48.137	11.276	2640	2/4/07	10:06	11:06	2.54±1.14
5650	48.136	11.285	2640	15/2/07	10:05	11:06	1.13±1.03

Table 6.10 Calculated Faraday rotation.

The FR values measured are consistent with those expected for the time of year, day and solar activity. The measures are also within the FR tolerance, hence these image data do not need to be corrected for FR before use in geophysical retrieval.

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[2] Calculated for 22:30 hrs ascending node crossing time and spacecraft nadir at latitude of scene.

7 DISCLAIMERS

During the cycle no disclaimers were issued.

8 EVENTS

The following section details events that may be of interest to ALOS data users.

- 19-23 November 2007
  The first join PI symposium of ALOS data nodes for the ALOS science program, Kyoto
  http://www.prime-intl.co.jp/alos-pi2007/index.html

- 19 September 2007
  New deadline for registration to the First Joint ALOS PI Symposium: 5 October 2007

- 5 April 2007
  Announcement of ALOS order opening

APPENDIX A PALSAR PRODUCT TYPES

Product identifier	Meaning
P	High resolution polarimetric data
W	Low resolution wideswath mode data
H	High resolution single (FBS) or dual (FBD) polarisation data
1.0	Level 0 – raw data
1.1	Level 1 SLC data
1.5	Level 1 multi-look data
G	Geocoded
P	Polar Stereographic projection
U	Universal Transverse Mercator projection
A/D	Ascending/Descending

APPENDIX B COHERENCE MEASURES

Cross polarisation coherence measure

$$\gamma_{HV-VH} := \frac{|< O_{HV} O^{*}_{VH} >|}{\sqrt{< O_{HV} O^{*}_{HV} >< O_{VH} O^{*}_{VH} >}} = \frac{1}{1-(SNR_{HV})^{-1}} \qquad (1)$$

Cross polarization phase Imbalance: $\Phi_{(HV\quad VH)} := \arg(O_{HV} O^{*}_{VH})$ (2)

Cross polarisation amplitude imbalance $A_{(HV\quad VH)} := \frac{|O_{HV}|}{|O_{VH}|}$ (3)

Co polarization phase Imbalance: $\Phi_{(HH\quad VV)} := \arg(O_{HH} O^{*}_{VV})$ (4)

APPENDIX C INSTRUMENT ANOMALIES

Below is a list of Palsar anomalies that will have an impact on image quality, radiometric calibration or localisation accuracy.

- Yaw steering suspended during 23rd February 00:12 UT to 24th February 2007 23:01 UT (yaw steering suspended due to calibrating operations for Star Tracker (STT) and Precision Attitude Determination).

- Yaw steering suspended during 22nd March 00:24 UT to 23rd March 2007 23:17 UT (yaw steering suspended due to calibrating operations for Star Tracker (STT) and Precision Attitude Determination).

- Yaw steering on/off switching on 10th April 2007:
  Yaw steering on to off: 12:57 – 13:22 UT (data unavailable)
  No yaw steering operation: 13:22 – 14:42 UT (data available)
  Yaw steering off to on: 14:42 – 15:45 UT (data unavailable)

- Yaw steering on/off switching on 31st July 2007:
  Switching in progress: 00:00 – 00:30, 21:57 – 22:46 UT (Observation suspended)
  No yaw steering observation: 00:30 – 21:57UT (Data available)

- An anomalous operation found in PALSAR observations on 23rd March, 12th July, 6th August, 17th August, 21st August, and 23rd August 2007. PALSAR shifted into Standby mode in the middle of the observations. Some of PALSAR data observed during the anomaly are corrupt.

- An anomalous operation found in PALSAR observations on 5th September and 8th September 2007; PALSAR shifted into standby mode in the middle of its observation.