

The ALOS PALSAR Global Systematic Acquisition Strategy: 4 Years in Operation

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Abstract — With the launch of ALOS in 2006, JAXA took the initiative to implement the first global-scale systematic acquisition strategy for satellite sensors at fine (2.5m-20m) spatial resolution. Comprising all three sensors on ALOS (PALSAR, PRISM, AVNIR-2), the plan is designed to serve all ALOS user categories and aims at producing spatially and temporally consistent coverages over the planet on a repetitive basis, to accommodate systematic global-scale, fine-resolution, monitoring of the environment. Unlike the common background missions defined for most fine-resolution Earth Observation satellites, the BOS has been implemented as a top-level foreground mission with a priority second only to that of special observation requests and emergency observations and sensor cal/val.

Presently 4 years in operation, the strategy has produced a comprehensive and homogeneous global archive in which consistent time-series of data are available for any arbitrary point or region on Earth. Clouds and haze inevitably constitute limitations for the optical sensors, while for the PALSAR instrument, two cloud-free and near-gap free (~95%) global coverages are achieved annually. Previously, such uniform data archives existed only for coarse and mid-resolution sensors such as AVHRR, MERIS and MODIS.

Keywords: ALOS PALSAR, BOS, systematic acquisition strategy

1. ALOS AND THE "BOS"

1.1 ALOS

The Advanced Land Observing Satellite (ALOS) was launched by the Japan Aerospace Exploration Agency (JAXA) on January 24, 2006. It carries three remote sensing instruments: the along-track 2.5 metre resolution Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM), the 10-metre resolution Advanced Visible and Near-Infrared Radiometer type 2 (AVNIR-2), and the variable resolution polarimetric Phased Array L-band Synthetic Aperture Radar (PALSAR). Following a 9-month commissioning phase, ALOS was declared operational on October 23, 2006.

1.2 The Basic Observation Scenario (BOS)

Apart from the technical characteristics of the satellite and its sensors, what makes the ALOS mission unique is the acquisition concept, which differs significantly from the "traditional" way fine resolution satellites are operated. The acquisition plan, which is referred to as the "Basic Observation Scenario" (BOS) by JAXA, is a fixed multi-year plan that was developed prior to the launch of ALOS in support of the science goals for the ALOS mission [1, 2]. It was developed in collaboration with an international team of experts—the Kyoto & Carbon Initiative Science Panel—and was designed to produce

spatially and temporally consistent coverages of the planet on a repetitive basis, to accommodate systematic global-scale, fine-resolution, monitoring of the environment. Unlike the common background missions defined for most Earth Observation satellites, the ALOS BOS has been implemented as a top-level foreground mission with a priority second only to that of emergency observations.

1.3 The PALSAR BOS characteristics

The Basic Observation Scenario has been implemented for all three sensors on ALOS, but is particularly effectual for the PALSAR sensor, which has the great advantage of not being constrained by clouds or haze. The PALSAR BOS follows the recommendations for systematic acquisitions outlined in [3] to fulfil the following general acquisition concepts:

- **Spatial consistency:** Continuous wall-to-wall acquisitions over continental areas.
- **Temporal consistency:** Each regional acquisition performed during limited time windows to maximise seasonal homogeneity in each wall-to-wall coverage
- **Revisit frequency:** Revisit frequency adapted to meet the requirements for the key applications (semi-annual repetition for forestry and land cover; every-cycle repetition over inundated wetlands).
- **Timing:** Acquisitions performed during the same time period(s) every year to minimize temporal bias.
- **Sensor consistency:** Selection of a limited number of operational default modes to maximize data homogeneity and minimize programming conflicts.
- **Mission-term continuity:** Strategy operations throughout the entire ALOS mission life.

The ALOS BOS is refined on a continuous basis and the latest plan updates are available for viewing at the JAXA EORC homepage: <http://www.eorc.jaxa.jp/ALOS/en/obs/overview.htm>

To limit the detrimental effect fragmented acquisitions due to mode changes and to assure spatio-temporal homogeneity over regional scales, PALSAR features an observation plan in which operations have been confined to a limited number of operational modes. Out of the 132 original mode options technically available for PALSAR, only five have been identified as the main default modes (Table A).

To reduce programming conflicts further, acquisitions are planned in units of whole (46-day) repeat cycles, during which only one of the available default modes is selected. Observations are also separated into descending and ascending passes, with PALSAR operations first and foremost planned for the latter to avoid conflicts with the optical sensors. As PRISM and AVNIR-2 are confined to daytime operations, they are assigned a higher observation priority than PALSAR, which, in descending mode, principally is limited to low data rate (120 Mbps) ScanSAR observations.

Table A. ALOS PALSAR operational modes

Mode (polarisations)	Off-nadir angle	Incidence range	Swath width	Resolution (4 looks)	Pass designation	Coverage
FBS - Single polarisation (HH)	34.3°	36.6°~40.9°	70 km	10 m	Ascending	Global
FBD - Dual polarisation (HH+HV)	34.3°	36.6°~40.9°	70 km	20 m	Ascending	Global
POL - Quad-pol (HH+HV+VH+VV)	21.5°	22.8°~25.2°	30 km	~30 m	Ascending	Semi-continental
POL - Quad-pol (HH+HV+VH+VV)	23.1°	22.8°~25.2°	30 km	~30 m	Ascending	Semi-continental
ScanSAR (HH)	5-beam	18.0°~43.0°	350 km	~100 m	Descending	Regional/Global

As a consequence of the high data rate, neither the PALSAR instrument nor PRISM or AVNIR-2 can achieve a full global coverage within a single 46-day cycle, and observations have to be divided regionally over several cycles. In the observation plan, the Earth has been divided into some 80 adjacent, non-overlapping geographical polygons which cover all land areas and coastal regions (the same polygons are used for PRISM and AVNIR-2). All passes within each polygon are then acquired to assure spatial and temporal consistency over regional scales. Figure 1 shows the acquisitions for PALSAR during two consecutive 46-day cycles in 2010, in which the geographical stratification of the plan can be seen.

To assure recurrent observations with consistent timing, the PALSAR observations are planned in groups of 8 (46-day) unit cycles that are repeated on an annual (368 days) basis.

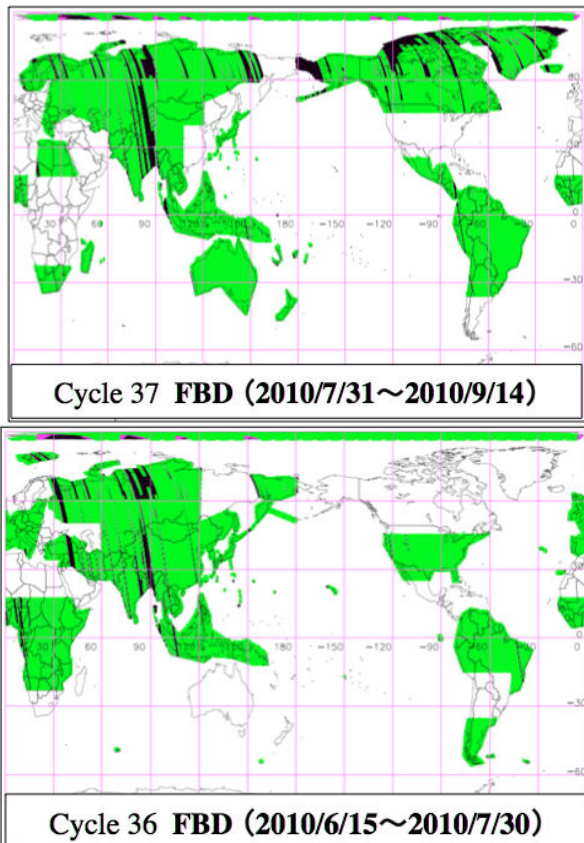


Figure 1. PALSAR acquisitions during two consecutive cycles during the mid-2010 dual polarisation (FBD) acquisition period. Green—passes successfully acquired; black—passes programmed, but not acquired.

The PALSAR acquisitions comprise four global dual-season coverages per year, two dual-polarisation (FBD) coverages in May/June-Sept/Oct and two global single-polarisation (FBS) coverages in Dec–March. Once every second year regional acquisitions campaigns (two cycles in March-May) in full polarimetric (POL) modes are undertaken. The Fine Beam (FBD, FBS and POL) acquisitions are all designated to ascending (night time) passes.

ScanSAR are planned to produce one full global coverage per year, as well as every-cycle acquisitions over significant wetland and forest change regions (South America, Central Africa, SE-Asia). To avoid conflicts with the Fine Beam acquisitions, ScanSAR acquisitions are all descending.

2. ACQUISITION RESULTS

The performance of the ALOS acquisition strategy during the first four years of operations (Dec 2006 - Dec 2010) is shown below in Table B. The figures represent the average acquisition success rate (ratio of #programmed scenes vs. #acquired scenes) for a 46-day cycle within the year indicated.

Table B. ALOS acquisition success rate (ratio of #programmed scenes vs. #acquired scenes) and number of scenes acquired for the first 4 years of operations (cycles 7-39).

	PALSAR				PRISM	AVNIR-2
	Fine Beam modes			ScanSAR		
	FBD	FBS	POL			
2007	80.4%	62.8%	65.3%	56.9%	69.8%	79.2%
2008	76.9%	84.4%	0.0%	69.0%	71.6%	74.0%
2009	75.5%	79.4%	79.1%	73.2%	68.7%	74.6%
2010	80.1%	85.1%	0.0%	79.1%	77.4%	75.5%
All	78.2%	78.6%	72.0%	67.5%	71.6%	75.0%
# scenes acquired	1,007,969			71,069	1,296,963	628,502

The table shows that the average success rates for the two PALSAR "work horse" modes—FBS and FBD—are in the order of 78% for a given cycle, with some minor variations between years. As gaps in the coverages always can be expected, the BOS was designed to cover each geographical region two times during each seasonal time window as a means of automated gap-filling. While the distribution of missed acquisitions is not entirely random and certain regions seem have a lower success rate (e.g. central Asia and Siberia in Fig. 1), approximately 95% complete coverage can generally be achieved over the 3-4 cycles of the seasonal FBS and FBD acquisition windows.

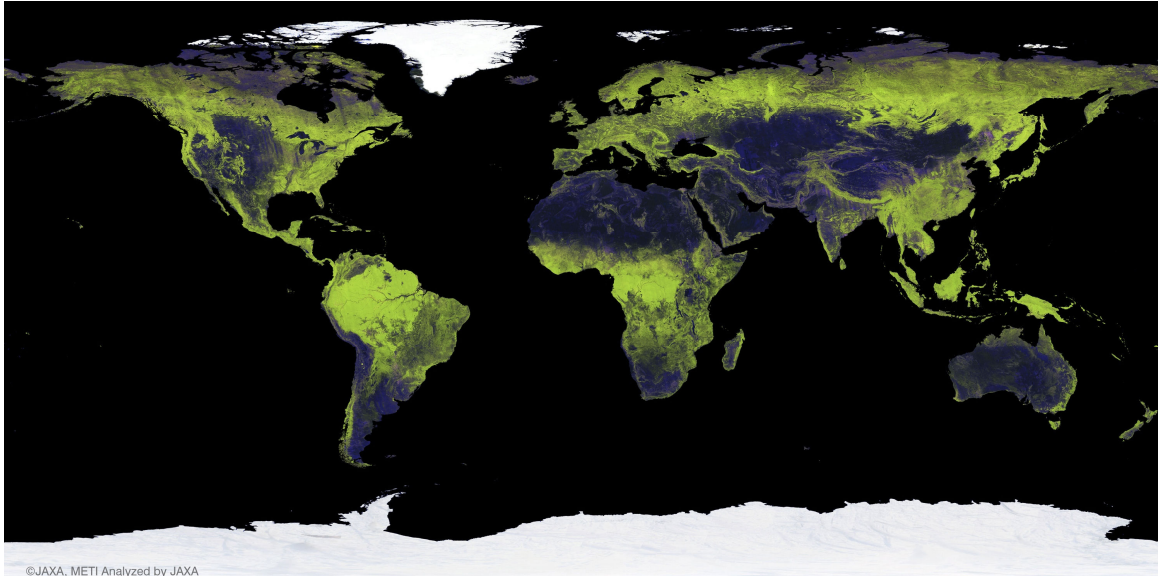


Figure 2. ALOS PALSAR coverage acquired during the mid-2009 observation window (3 cycles, June-October). 10 m resolution dual-polarisation (HH+HV) PALSAR mosaic (JAXA, 2010).
Colour composition: R–HH, G–HV, B–HH/HV ratio

An example of the above is the 2007 coverage over Africa, where 319 path segments were required to cover the whole continent. 276 of the passes were acquired during the first two 46-day cycles in June-August, 2007, another 27 passes during the next 46-day cycle (Sept-Oct, 2007), while 16 passes (i.e. 5% of the total) had to be filled in from the 2008 acquisitions.

Figure 2 shows a global mosaic generated by JAXA EORC from PALSAR FBD data acquired during 3 cycles in the period June to October, 2009 [4]. Such mosaics will be generated by JAXA on an annual basis from the year 2007 and onwards.

3. CONCLUSIONS

2.1 Future plans

Minor modifications to the BOS are incorporated by JAXA on a continuous basis and the latest schedules for the next few 46-day cycles are made available on the JAXA EORC web: <http://www.eorc.jaxa.jp/ALOS/en/obs/overview.htm>

The PALSAR BOS acquisitions are foreseen to continue without major changes, with the exception that the annual FBS acquisitions in December–March may be replaced by dual-polarisation FBD, to better accommodate dual-seasonal monitoring of the global forest cover.

A systematic acquisition strategy that builds on the PALSAR BOS is presently under development for the PALSAR-2 instrument on-board ALOS-2. ALOS-2 is an SAR-only satellite (L-band of course) that is scheduled for launch in mid 2013.

2.2 GEO FCT & CEOS coordinated acquisitions

The need for systematic satellite acquisitions to support monitoring of forest carbon in the UNFCCC post-2012 era was raised with the Group of Earth Observations (GEO) at the 2nd GEOSS Asia-Pacific Symposium in 2008, and the concept of coordinated multi-sensor acquisitions was proposed as part of a new GEO Task [5, 6]. The GEO Forest Carbon Tracking Task (GEO-FCT) was subsequently established [7] and several space agencies joined forces in 2009 to undertake the very first

coordinated multi-satellite acquisition campaign over national scales involving optical, L-band, C-band and X-band SAR sensors. The GEO-FCT observation plan was developed with the ALOS global acquisition strategy as the model, featuring semi-annual wall-to-wall acquisitions during common dual-season time windows (Dec-Feb and June-Aug), and with fixed sensor modes to assure spatial and temporal consistency.

The GEO-FCT acquisitions are coordinated by the Committee of Earth Observation Satellites (CEOS) and is lead by JAXA, ESA, CSA and USGS. GEO-FCT is planned to develop into an operational Global Forest Observation Initiative (GFOI), featuring a coordinated observation strategy for all forest areas on the globe.

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