Global 25 m Resolution JERS-1 SAR Mosaic

(Ver.2.0.0)

Dataset Description

Japan Aerospace Exploration Agency (JAXA)

Earth Observation Research Center (EORC)

Revision history

Version	Release Date	Revised Content
Ver.2.0.0	Nov. 15, 2024	-

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1 Overview of the dataset

The global 25 m resolution JERS-1 SAR mosaics (hereinafter referred to as "JERS-1 global mosaics") are free and open dataset generated by JAXA and Gamma Remote Sensing using the L-band Synthetic Aperture Radar (SAR) on Japanese Earth Resources Satellite-1 (JERS-1).

The datasets are available in HH polarizations, given as linear amplitude Gamma-0 backscatter. They are provided as 1x1 degree tiles in geographical (lat/long) coordinates with a pixel spacing of 0.8 arc seconds (approx. 25 m at the Equator).

2 Mosaic processing algorithm

The flowchart in Figure 2.1 provides an overview of the processing workflow that was implemented and undertaken by Gamma Remote Sensing, based on the GAMMA InSAR software (www.gamma-rs.ch). The processing was organized on a per-orbit basis, i.e., all Level 0 images acquired from the same orbit were processed simultaneously. For each of the raw images the processing included:

1. Focussing to Single Look Complex format including filtering for radio frequency interference (RFI) effects, antenna gain related corrections in range, as well as corrections for the noise equivalent sigma zero.
2. 2 x 7 multi-looking in range and azimuth, respectively, to obtain multi-look intensity images (MLI) with a pixel posting in the range of 25 m.
3. Calculation of transformation functions (so called geocoding look-up tables) for resampling between slant-range and map geometry based on the available orbit information and the global ALOS PRISM Digital Surface Model AW3D30 (https://www.eorc.jaxa.jp/ALOS/en/dataset/aw3d30/aw3d30_e.htm) with 1 arc-second resolution as the reference DEM.
4. Alongside the geocoding look-up table, maps of the local incidence angle and layover/shadow masks are produced.
5. Refinement of the geocoding look-up tables (discussed in more detail below),
6. Pixel area normalization as with Frey et al. (2013) to obtain radiometrically-terrain-corrected Gamma-0 backscatter images.
7. Resampling to the target map geometry in geographic spatial reference system based on the refined geocoding look-up tables.

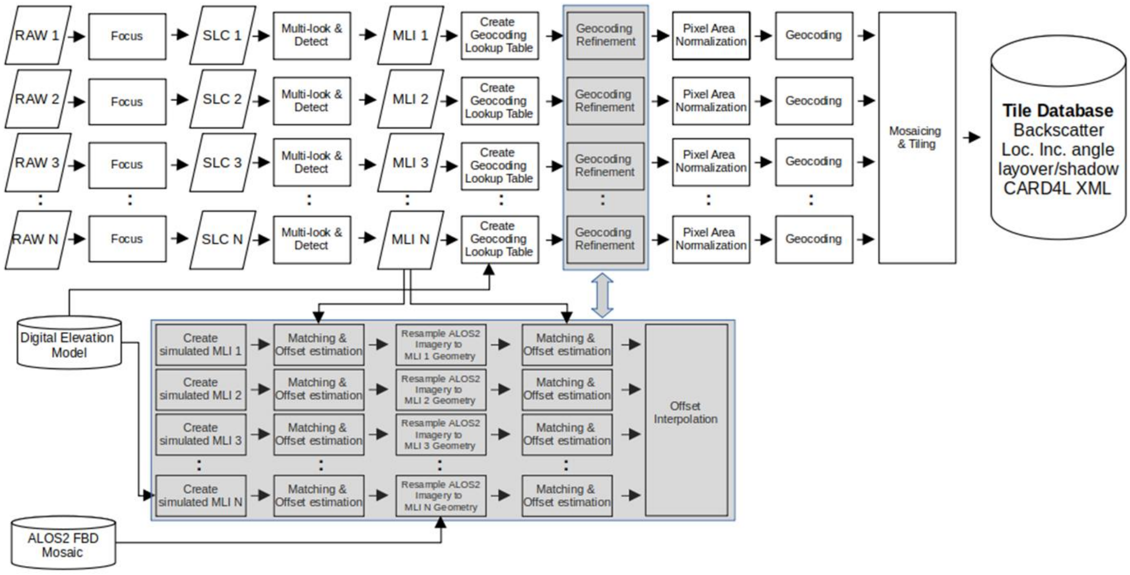

Figure 2.1 Workflow for processing one orbit of JERS-1 L0 imagery to RTC level.

In the case of JERS-1, further refinement of the geocoding look-up table is required. Existing assessments of the accuracy of the orbit information available for JERS-1 indicated errors resulting in offsets of several tens of meters in range and 100 m in azimuth (Shimada and Isoguchi, 2002). An iterative refinement procedure had therefore been implemented for processing all available JERS-1 images to the highest possible spatial accuracy. In the refinement of the geocoding look-up table, a simulated backscatter image is calculated from the DEM and subsequently resampled to the slant-range geometry of the respective MLI. A cross-correlation between small image chips distributed evenly across the simulated image and MLI is then performed to identify offsets in range and azimuth and to calculate polynomials describing the variation of offsets along the range and azimuth dimensions of the MLI. The polynomials are then used to update the geocoding look-up table. Since based on a DEM only, the simulated SAR image that serves as reference only presents topographic features. In areas without topography, a refinement is therefore not possible. In such cases, an existing 25 m resolution ALOS-2 PALSAR-2 Fine-Beam Dual-polarization (FBD) L-band HH polarization backscatter dataset released by JAXA in the form of global mosaics (Shimada and Ohtaki, 2010; Shimada et al., 2014) served as geometric reference for the refinement. The corresponding subset in the ALOS-2 HH polarization mosaic was resampled to the slant-range geometry of the JERS-1 MLI and the cross-correlation was performed again to identify the offsets.

A refinement of the geocoding look-up table based on cross-correlation either against a simulated SAR image or the ALOS-2 FBD mosaic allowed for accurate geocoding of 258,629

JERS-1 frames. For the rest of the images, offsets had to be interpolated from adjacent frames acquired from the same orbit for which the refinement procedure described above produced accurate offset estimates. Due to the relatively small changes of the offsets in range in azimuth between adjacent frames acquired along the same orbit, high geospatial accuracy at sub-pixel level can still be achieved even when having to interpolate offsets across consecutive frames. However, primarily in the Antarctic a refinement of the geocoding look-up tables was often not possible due to the temporal mismatch between the AW3D30 DEM, which was produced from imagery acquired more than 10 years after the acquisition of the JERS-1 imagery, thus no longer representing the location of inland glaciers in the time frame of the JERS-1 acquisitions.

Figure 2.2 illustrates the tiled backscatter imagery for an area in Germany (10°-11° E, 49°-50° N). In total, 79 images acquired between 1993 and 1997 (partially) cover the particular tile. Globally, we find the best coverage over Northern Europe, Eastern and Southeastern Asia (Figure 2.3), which is explained with the location of receiving stations.

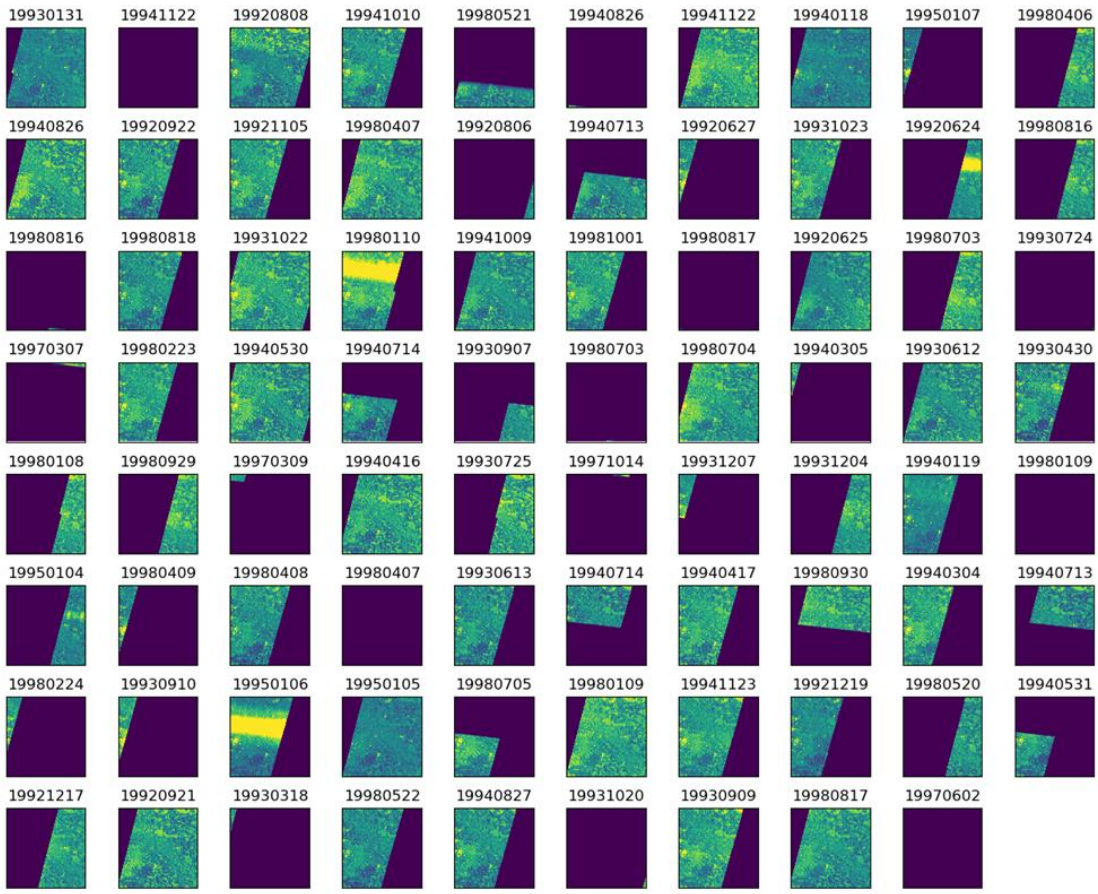

Figure 2.2 1° x 1° tiles of L-HH backscatter acquired between 1992 and 1998 in an area between 10° and 11° East and 49° and 50° North.

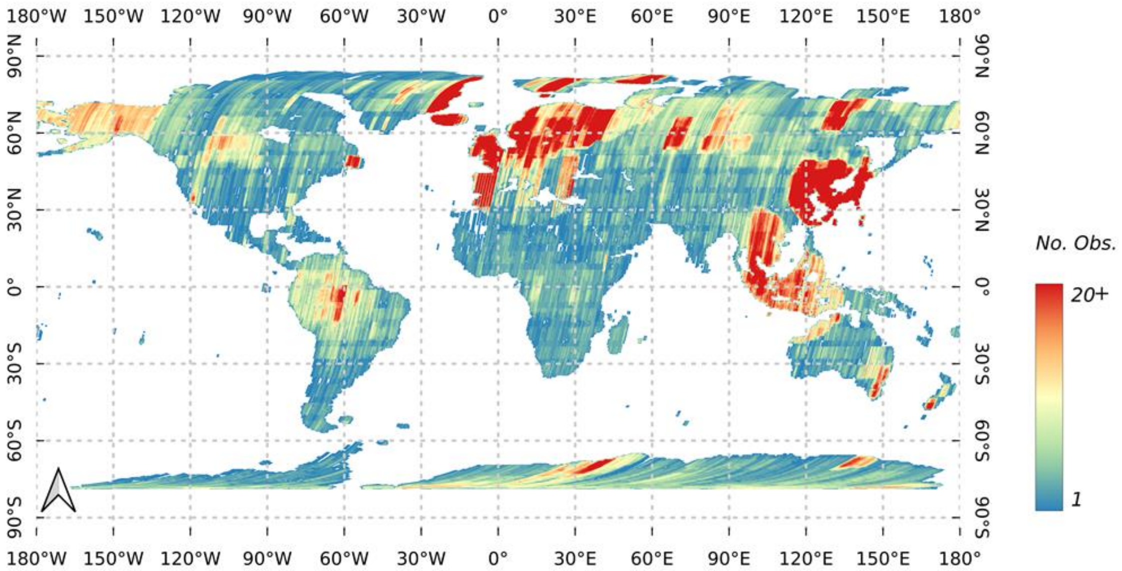

Figure 2.3 Number of images acquired by JERS-1 between 1992 and 1998.

The individual JERS-1 images were used to produce annual mosaics for the 1992-1998 period (Figure 2.4). The mosaics were produced considering all imagery acquired each year. In case multiple images had been acquired, the mosaics were generated using the images which had been i) acquired under preferable imaging conditions (e.g., dry/unfrozen), and ii) geocoded with the highest accuracy. Since JERS-1 in none of the years between 1992 and 1998 acquired a complete global coverage, a nearly global mosaic was produced by combining data from all seven years. The production of mosaics with maximum coverage required consideration of images acquired in different seasons. Consequently, the mosaics do present striping between adjacent orbits associated with different environmental imaging conditions. No radiometric harmonization between adjacent orbits was attempted because the backscatter differences between seasons (e.g., summer vs winter) can be several dB and strongly dependent on the type of land cover. Users are therefore advised to consider the observation date layer provided with the backscatter imagery.

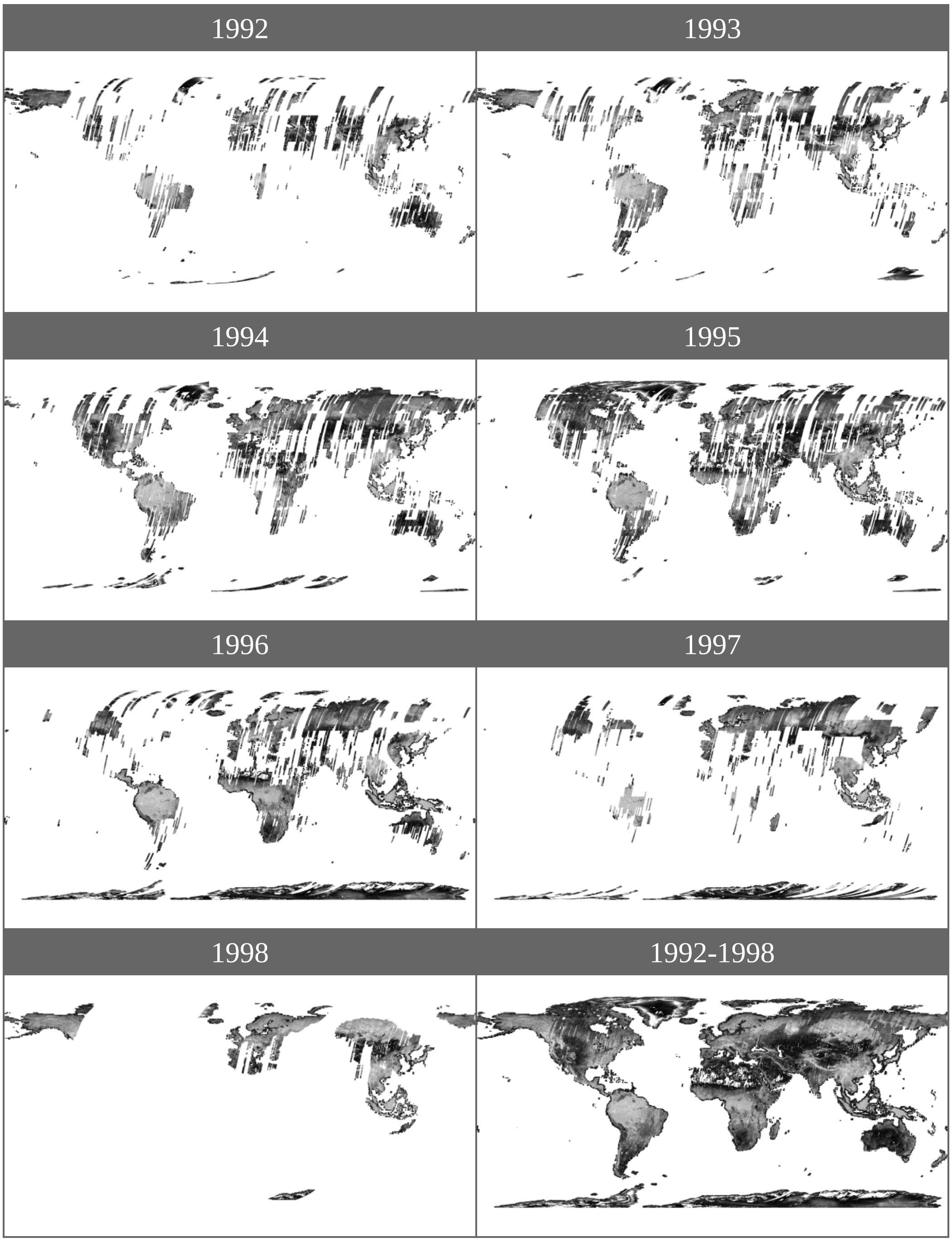

Figure 2.4 Annual mosaics for each year between 1992 and 1998 and a nearly global mosaic combining imagery acquired in all seven years.

3 Dataset specification

Table 3.1 Dataset Specification (JERS-1 SAR)

	25m resolution dataset
Map projection	Geographic coordinates (Latitude/Longitude)
Datum	ITRF97 + GRS80
Data unit (one file)	1 deg. grid in latitude-longitude
Number of pixels for one tile	4500 pixels x 4500 lines
Size of one pixel	0.8 arcsec（approx. 25 m on the Equator）
Data size	121.5 MB/tile (before compression *)
Content	1. Normalised Radar Backscattering coefficient (Gamma-0) for HH polarizations 2. Observation date image 3. Local incidence angle image 4. Processing mask information image 5. XML metadata (in compliance with Combined CEOS-ARD for Synthetic Aperture Radar PFS)
Number of tiles	Year 1992: 9,260, Year 1993: 11,918, Year 1994: 14,802, Year 1995: 17,427 Year 1996: 15,130, Year 1997: 10,559, Year 1998: 5,898, Year 1992-1998: 24,545
Original SAR data	JERS-1 SAR: off-nadir angle 35 deg., resolution 18 m x 24 m, HH polarization
DEM for processing	AW3D30 Ver. 3.1 and 3.2
SAR algorithm	GAMMA InSAR software (www.gamma-rs.ch) + GDAL

* Actual data size will be smaller due to compression. The data size also varies depending on the area of valid image data within each mosaic tile.

4 Data list and naming convention

The version 2 mosaic datasets have been certified as fully compliant with Combined CEOS-ARD for Synthetic Aperture Radar PFS threshold requirements. CEOS-ARD are satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional user effort and interoperability both through time and with other datasets. Please see the following URL for further information about CEOS-ARD.

https://ceos.org/ard/

The data list and its file naming conversion are as follows.

- LLLLLLL: latitude/longitude
  e.g., North latitude 0 degree, East longitude 100 degrees: LLLLLLL = "N00E100"
- YY: year e.g.,year 1996: YYYY = "1996", year 1992-1998: YYYY = 1992-1998

Table 4.1 Data list, naming convention and format (JERS-1)

Data list	File name	Data type
Backscattering coefficient (HH pol.)	LLLLLLL_YYYY_sl_HH.tif	16-bit unsigned integer
Observation date	LLLLLLL_YYYY_date.tif	16-bit unsigned integer
Local incidence angle	LLLLLLL_YYYY_linci.tif	8-bit unsigned integer
Processing mask information	LLLLLLL_YYYY_mask.tif	8-bit unsigned integer

Further descriptions of each data are provided in Section 5.

5 Content of data

5.1 Backscattering coefficient

Data provided as linear amplitude backscatter, and are stored as digital number (DN) in 16-bit unsigned integer format. The DN values can be converted to gamma nought values in decibel unit (dB) using the following equation:

$$\gamma^0 = 10\log_{10}\langle DN^2\rangle + CF$$

where, CF is the calibration factor, and the expression within <> is the ensemble square (power) average value (calculated over several pixels to reduce the impact of speckle). The CF values are -83.0 (dB) for the JERS-1 SAR mosaic.

5.2 Observation date image

The pixel digital numbers (DN) in the observation date image represent the number of days after the satellite launch. The launch date of JERS-1 is Feb. 11, 1992. Observation dates are provided in Universal Coordinated Time (UTC).

JERS-1 mosaic example: DN = 1623 → July 22, 1996 (11/02/1992 + 1623 = 22/07/1996).

5.3 Local incidence angle image

The pixel digital numbers (DN) in the local incidence angle image represent the angle, expressed in integer degrees which round the number down after the decimal point, between the ground normal at the pixel location and the SAR antenna. DN values are stored as 8-bit unsigned integers (BYTE).

5.4 Processing mask information image

Table 4.1 shows how to translate values in the mask information image.

Table 4.1 Content of the processing mask information

Value	Category
0	No data
50	Ocean and water
100	Lay over
150	Shadowing
255	Land

6 Other information

6.1 Lack of data

In case of lack of data, “No data” (=0) is stored in the processing mask information.

Lack of data or tiles may be due to that:

- Data are not observed in the target year.
- Data are excluded in the mosaic generation process, e.g. due to strong ionospheric distortion effects, especially common in tropical regions.

6.2 Absolute geometric accuracy

Through the new processing methodology used for the version 2.0.0 datasets and beyond, it has become possible to bring out the high absolute geometric performance of orthorectified image products. As a result, geometric misalignment with previous (Ver.1) mosaic datasets may be observed.

6.3 Backscatter variations over high latitude regions

Differences in mosaic image brightness from path to path may sometimes be observed, in particular over high latitude areas due to variations in backscattering intensity caused by winter observations during frozen/un-frozen conditions. Please note that such backscatter differences may affect the classification of forest/non-forest.

7 Note for data use

- JAXA retains ownership of the dataset. JAXA cannot guarantee any problem caused by or possibly caused by using the datasets.
- Anyone wishing to publish any results using the datasets should clearly acknowledge the ownership of the data in the publication.
- For details on JAXA's site policy and terms of use, please check the following URL: https://earth.jaxa.jp/en/data/policy/

8 FAQ and Contact

If you have any questions regarding the dataset, please refer to the online “Frequently Asked Questions” (FAQ) on https://www.eorc.jaxa.jp/ALOS/en/inquiry/faq_e.htm

For further questions, please contact the Secretariat of the ALOS series Research Group, Earth Observation Research Center (EORC), Japan Aerospace Exploration Agency (JAXA)

E-mail: aproject@jaxa.jp

9 Acknowledgements

The JERS-1 global mosaic dataset was generated by Gamma Remote Sensing, under special commission by JAXA EORC. Special thanks to Oliver Cartus, Maurizio Santoro and Urs Wegmüller of Gamma Remote Sensing for their valuable contributions.

10 References

- Frey, O., Santoro, M., Werner, C.L., Wegmuller, U., 2013. DEM-based SAR pixel-area estimation for enhanced geocoding refinement and radiometric normalization. IEEE Geosci. Remote Sens. Lett. 10, 48–52. doi.org/10.1109/LGRS.2012.2192093
- Shimada, M, and Isogouchi, O., 2002. JERS-1 SAR mosaics of Southeast Asia using calibrated path images. Int. J. Remote Sensing, vol. 23, no. 7, 1507–1526. doi.org/10.1080/01431160110092678
- Masanobu Shimada and Takahiro Ohtaki, "Generating Large-Scale High-Quality SAR Mosaic Datasets: Application to PALSAR Data for Global Monitoring", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 3(4):637 - 656, January 2011. doi.org/10.1109/JSTARS.2010.2077619
- Masanobu Shimada, Takuya Itoh, Takeshi Motooka, Manabu Watanabe, Shiraishi Tomohiro, Rajesh Thapa, and Richard Lucas, "New Global Forest/Non-forest Maps from ALOS PALSAR Data (2007-2010)," Remote Sensing of Environment, 155, pp. 13-31, December 2014. doi.org/10.1016/j.rse.2014.04.014.
- Generation of Global Forest / Non-forest map Using ALOS/PALSAR: (Oct. 21, 2010) https://www.eorc.jaxa.jp/ALOS/en/dataset/fnf/forestmap_oct2010_e.htm
- PALSAR 10 m mosaic: (Nov. 4, 2010) https://www.eorc.jaxa.jp/ALOS/en/dataset/fnf/pal_10m_mosaic_e.htm
- Rosenqvist A., Killough B. (2018), “A Layman’s Interpretation Guide to Synthetic Aperture Radar Data.” Committee on Earth Observation Satellites, CEOS. https://ceos.org/ard/files/Laymans_SAR_Interpretation_Guide_2.0.pdf
- Committee on Earth Observation Satellites. Analysis Ready Data, CEOS-ARD. Product Family Specification: Synthetic Aperture Radar, version 1.0. https://ceos.org/ard/files/PFS/SAR/v1.0/CEOS-ARD_PFS_Synthetic_Aperture_Radar_v1.0.pdf