ASF Radiometrically Terrain Corrected ALOS PALSAR products

Product guide

ASF engineering

ABSTRACT

This document serves as product guide for users of radiometrically terrain corrected ALOS PALSAR products processed by the Alaska Satellite Facility.

Document Preparation

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Document Change Log

Revision	Date	Page	Change Description
1.0 Draft	03/07/2014	all	Initial draft
1.1	10/01/2014	all	General revision
1.2	06/01/2015	all	Changed document structure

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Acronyms and Abbreviations

ALOS	Advanced Land Observing Satellite
ASF	Alaska Satellite Facility
CONUS	Contiguous United States
DEM	Digital Elevation Model
GeoTIFF	Geo-referenced Tagged Image File Format
GIS	Geographic Information System
ISO	International Organization for Standardization
KMZ	Keyhole Markup Language Zip file
NASA	National Aeronautics and Space Administration
NED	National Elevation Dataset
PALSAR	Phase Array type L-band Synthetic Aperture Radar
RTC	Radiometric Terrain Correction
SAR	Synthetic Aperture Radar
SLC	Single Look Complex
SRTM	Shuttle Radar Topography Mission
XML	Extensible Markup Language

1   Document structure

The document is structured as follows:

Chapter 1 introduces the structure and scope of the document.

Chapter 2 describes the data processing in detail. First, it supplies information about the digital elevation models used in terrain and radiometric correction. The remainder of the chapter comprehensively covers the processing flow for terrain correction.

Chapter 3 provides terrain correction examples, showing how the terrain corrected products can be used.

Chapter 4 summarizes the product packaging.

Chapter 5 provides the necessary information to access the RTC products.

2   Data processing

2.1   Digital elevation models

The quality of the terrain correction results is directly related to the quality of the digital elevation models (DEMs) used in the process of geometrically and radiometrically correcting the SAR imagery. Table **1** summarizes the various DEM sources and the way they are used in the radiometric terrain correction (RTC).

Table 1: DEMs used and their priority in RTC processing

|	DEM	Datum	Area	Posting	Sampling	Product
High-res. DEM	NED13	NAVD88	CONUS, Hawaii, parts of Alaska	10 m	No	12.5 m
				30 m	Down sampling DEM to 30 m	30 m
Medium-resolution DEM	SRTM GL1	EGM96	60 N to 57 S latitude	30 m	No	30 m
					Up sampling 30 m product	12.5 m
	SRTM US1	EGM96	CONUS, Hawaii, parts of Alaska	30 m	No	30 m
					Up sampling 30 m product	12.5 m
	NED1	NAVD88	CONUS, Hawaii, parts of Alaska, Canada, Mexico	30 m	No	30 m
					Up sampling 30 m product	12.5 m
	NED2	NAVD88	Alaska	60 m	No	30 m
					Up sampling 30 m product	12.5 m
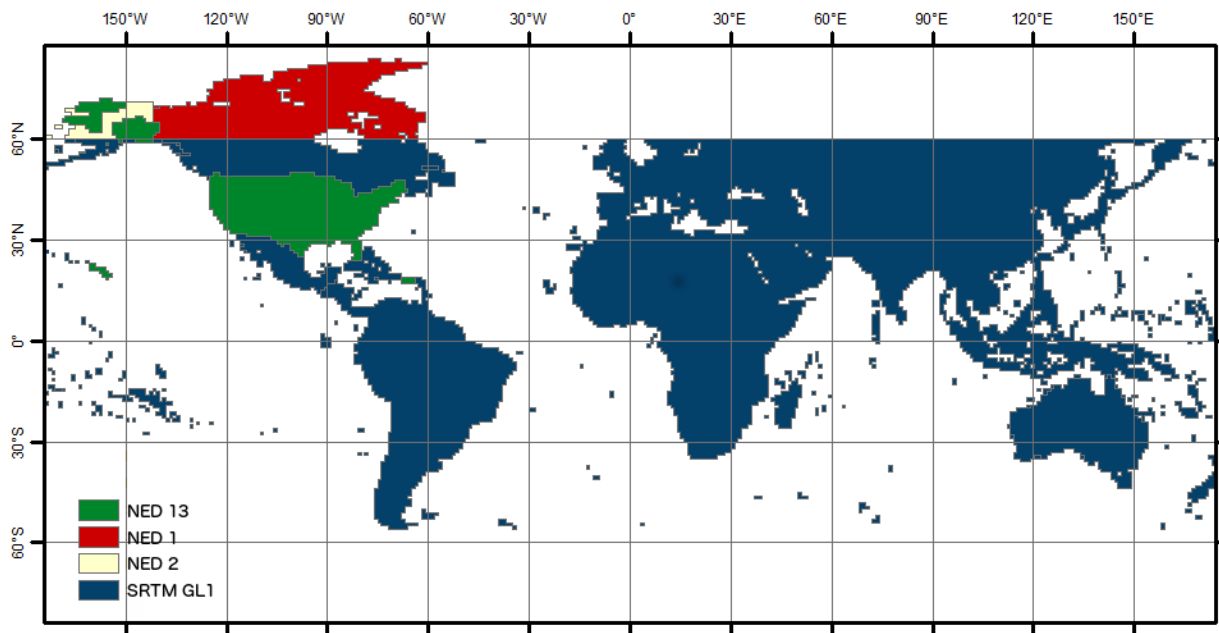
Figure 1: Coverage of the various DEM sources used for terrain correction

Figure **1** shows the coverage of the various DEM sources. The continental U.S., Hawaii, and parts of Alaska are covered with ⅓ arc sec National Elevation Dataset (NED) at a 10 m resolution. The rest of Alaska above 60 degrees northern latitude is only available at 60 m resolution with 2 arc sec NED data. The best resolution for Canada and Mexico at 30 m is given by 1 arc sec NED. For the remaining globe, Shuttle Radar Topography Mission (SRTM) GL1 data at 30 m resolution is used. Greenland and Antarctica are mostly covered by ice and glaciers and not suitable for terrain correction. For areas in Eurasia above 60 degrees northern latitude, no suitable DEMs are available.

The DEMs were pre-processed by ASF to a consistent raster format (GeoTIFF) from the original source formats: height (*.hgt), ESRI ArcGrid (*.adf), etc. Many of the NASA-provided DEMs were provided as orthometric heights with EGM96 vertical datum. These were converted by ASF to ellipsoid heights using the ASF MapReady tool named *geoid_adjust*. The pixel reference varied from the center (pixel as point) to a corner (pixel as area). The GAMMA software, used to generate the terrain corrected products, uses pixel as area and adjusts DEM coordinates as needed. Where more than one DEM is available, the best-resolution DEM is used for processing. Complete DEM coverage from a single DEM source is required for processing to proceed.

2.2   Terrain correction processing flow

The processing flow for the terrain correction is summarized in Figure **2**. A more detailed coverage about the processing flow can be found in the Algorithm Theoretical Basis Document.
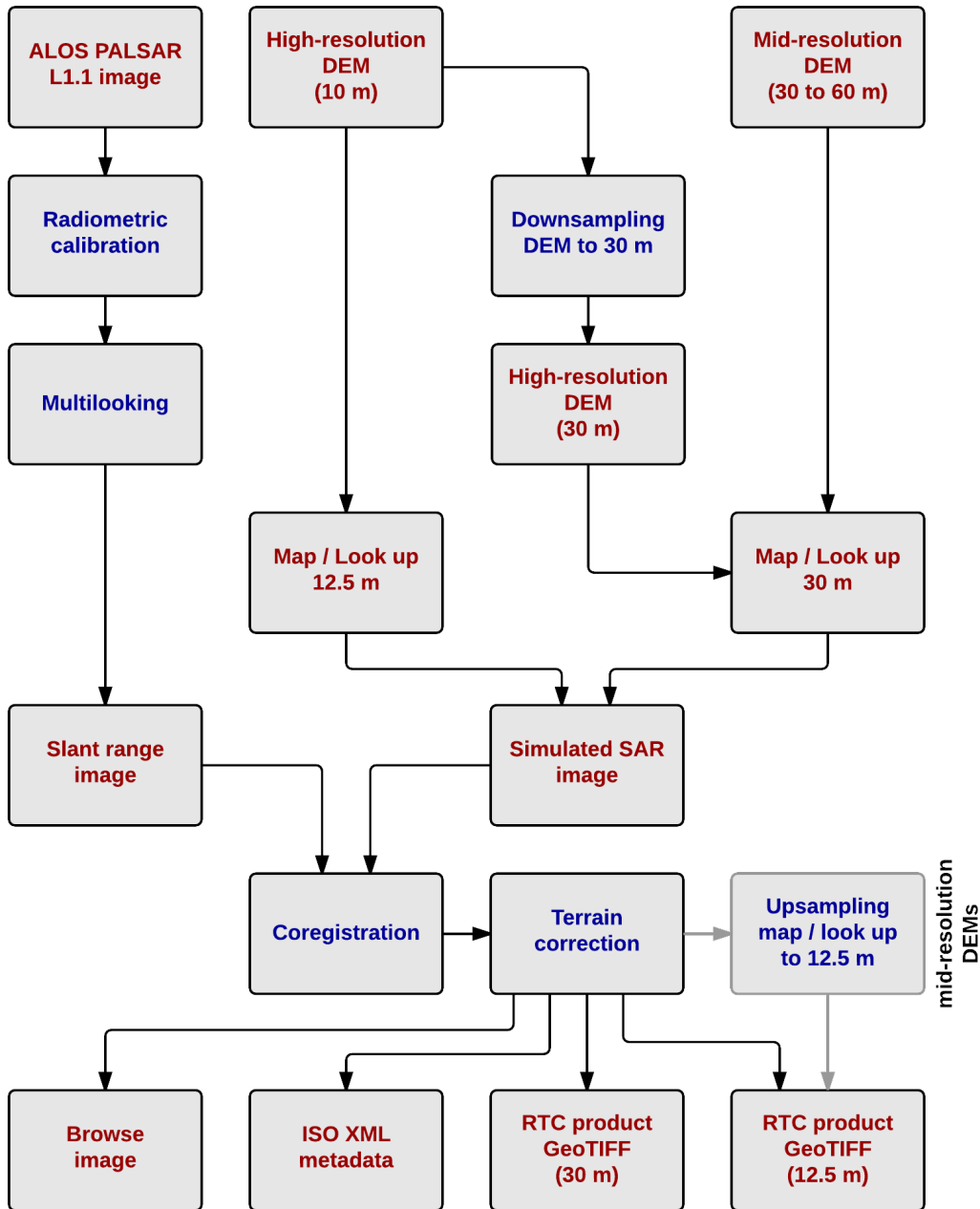

Figure 2: Terrain correction processing flow

2.2.1   Pre-processing

The first step of pre-processing is the selection of the best DEM for the terrain correction. The DEM tiles are assembled to ensure sufficient coverage for the terrain correction of the ALOS PALSAR L1.1 single look complex (SLC) image. For the generation of low-resolution RTC products from high-resolution DEMs, the original DEM is down sampled from 12.5 m to 30 m. The application of the calibration parameters and multilooking are the only pre-processing steps to the SAR image.

2.2.2   Terrain correction

The terrain correction is performed in slant range geometry. The actual mapping of the initial image into projected space is only applied once to mitigate the propagation of any resampling errors. All intermediate steps only update the look up table used for the mapping.

The first step is the co-registration of the SAR image with a simulated SAR image derived from the DEM. An initial offset is first attempted as a single match, if failed with a larger number of image chips to determine an average offset in azimuth and range direction. This initial offset is then refined using strict matching criteria. The *dead reckoning* approach is taken when matching fails. No offsets are also applied when the magnitude of the residual offset errors is greater than 2 pixels or the maximum calculated offset is greater than 50 m. This approach solely relies on the geolocations calculated from state vectors.

Once the images are co-registered, a normalization area image is generated. The terrain correction results in a radiometrically calibrated multilooked image with γ_0 power scale values. The ratio between the pixel area of the uncorrected and the corrected images is determined and stored in an image. In order to create the RTC product, the SAR image is multiplied by the ratio image. In a final step the RTC product is geocoded into map-projected space.

2.2.3   Post-processing

After the terrain correction is completed, the RTC products are exported to GeoTIFF format. The high resolution RTC products from medium resolution DEMs are up sampled from the 30-m version to 12.5 m. In addition, a browse image and ISO XML metadata files are generated.

3   Terrain correction examples

The RTC products are generated in GeoTIFF, a user-friendly format that is GIS compatible. The main reason for the generation of these products is the correction of all the geometric distortions caused by the side-looking SAR geometry. Once corrected, the products can be used as "just another layer" within a GIS. The SAR data can be combined in a number of ways.
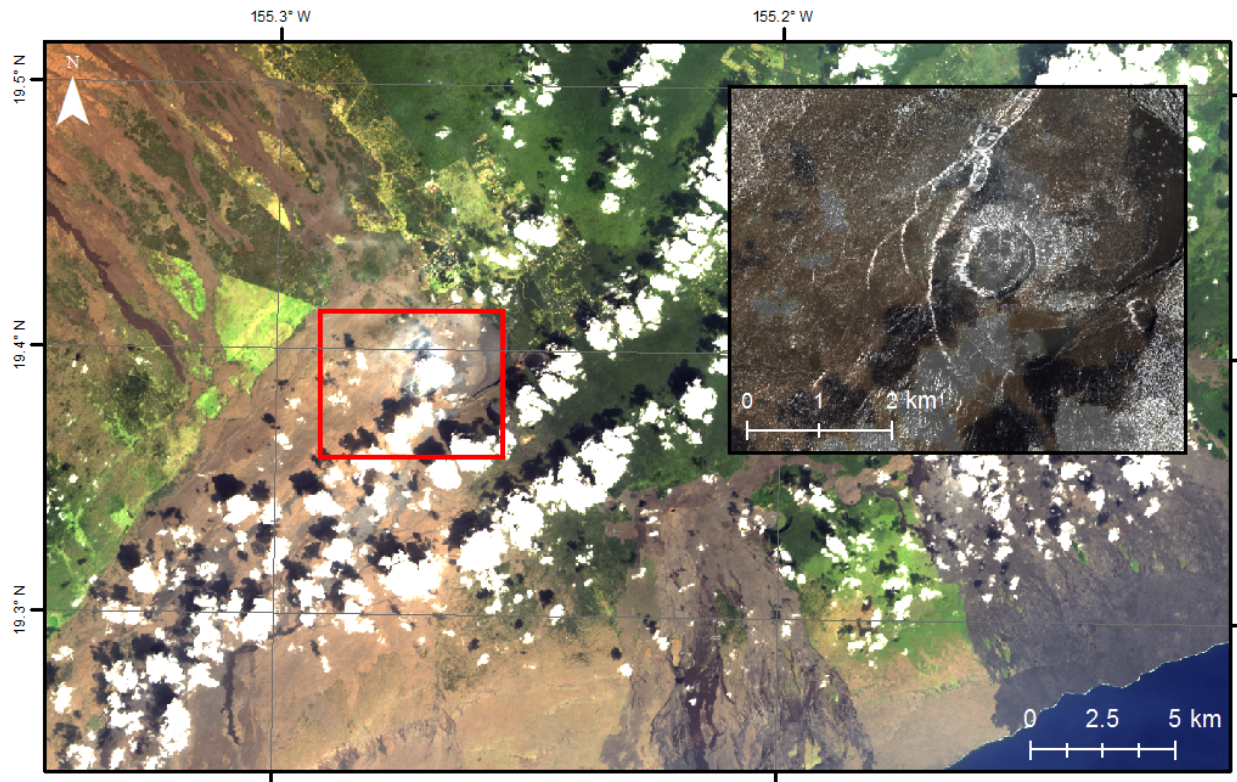

Figure 3: Landsat 8 image of the Kilauea volcano, Hawaii.

In many coastal areas, such as that of Hawaii's Kilauea volcano, shown in Figure **3**, cloud cover is a frequent occurrence. The inset shows that the SAR image can be used to replace optical-image information.
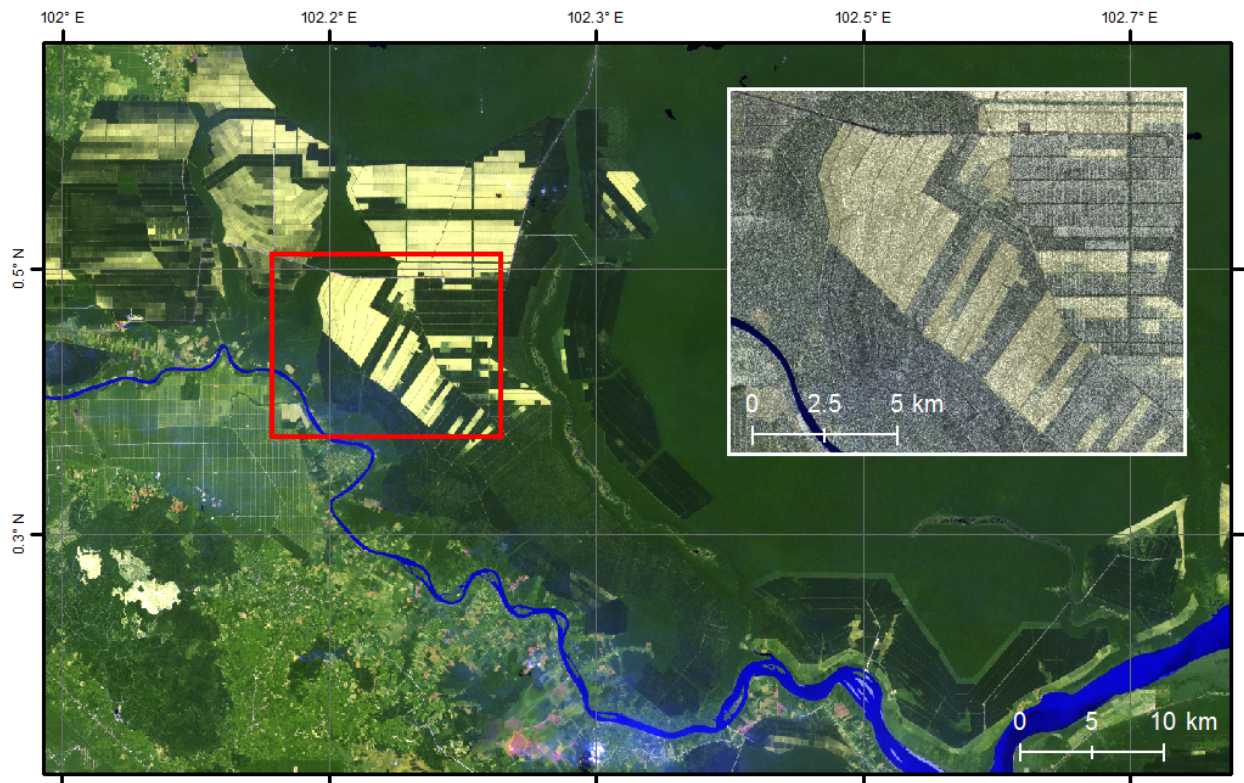
Figure 4: Landsat 8 of Sumatra, Indonesia, along with a SAR image of the same area.

In another example, a false-color composite of a Landsat 8 image (Figure **4**) shows Sumatra, Indonesia, which is mostly covered with tropical rainforest. As can be seen in the optical image, some areas have a similar spectral reflectance and are very homogeneous. The SAR image, overlaid with a 50 percent transparency in the inset, indicates that the backscatter offers complementary information for uses such as improving land-cover classification.

More advanced processing techniques include data fusion, either on a pixel level or on a feature level, using an object-oriented approach.

4 Product packaging

The naming convention for the RTC products follows as base name of this pattern:
AA_BBBBB_CCC_FDDDD_RTE (e.g. AP_26939_FBS_F3170_RT1)

Component	Definition	Example
AA	mission	AP
BBBBB	orbit number of image	26939
CCC	beam mode of image	PLR
DDDD	frame number of image	3170
E	terrain correction resolution (1=high, 2=low)	1

All files are stored in a folder with the base name. The file extensions used are:

Extension	Description	Example
_HH.tif _HV.tif _VH.tif _VV.tif	terrain corrected product stored in separate files for each available polarization in GeoTIFF format	AP_26939_PLR_F3170_RT1_HH.tif AP_26939_PLR_F3170_RT1_HV.tif AP_26939_PLR_F3170_RT1_VH.tif AP_26939_PLR_F3170_RT1_VV.tif
.iso.xml	ISO compliant metadata in XML format	AP_26939_PLR_F3170_RT1.iso.xml
.dem.tif	digital elevation model used for terrain correction in GeoTIFF format	AP_26939_PLR_F3170_RT1.dem.tif
.inc_map.tif	layover/shadow mask in GeoTIFF format	AP_26939_PLR_F3170_RT1.inc_map.tif
.ls_map.tif	layover/shadow mask in GeoTIFF format	AP_26939_PLR_F3170_RT1.ls_map.tif
.geo.jpg	browse image of the amplitude (including world and auxiliary file) in JPEG format	AP_26939_PLR_F3170_RT1.geo.jpg
.kmz	browse image in Google Earth format	AP_26939_PLR_F3170_RT1.kmz

The format of the RTC product, particularly its ISO XML metadata, is described in further detail in the product format specification document.

5 Data access

Products are available to researchers who complete a two-page NASA proposal:
https://www.asf.alaska.edu/data-tools/submit-a-proposal/

To obtain information from ASF, or to view or download ALOS PALSAR RTC products, please see the links below:

ASF website: https://www.asf.alaska.edu/sar-data/palsar/
Vertex: https://vertex.daac.asf.alaska.edu/
API: https://www.asf.alaska.edu/get-data/api/

For details on accessing data, including other SAR datasets, see ASF's Get Started guide:
https://www.asf.alaska.edu/get-data/get-started/