Microwaves and Radar Institute

TanDEM-X

Forest/Non-Forest Map Product Description

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DOCUMENT PREPARATION

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DOCUMENT CHANGE CONTROL

This document is under configuration control. Latest changes to the document are listed first.

Issue	**Date**	**Chapter**	**Changes**
1.0	15.03.2019	All	First Issue

Contents

1 Introduction

The TanDEM-X Forest/Non-Forest Map is a project developed by the Microwaves and Radar Institute at the German Aerospace Center (DLR), within the activities of the TanDEM-X mission. The goal is the derivation of a global forest/non-forest classification mosaic from TanDEM-X bistatic interferometric synthetic aperture radar (InSAR) data, acquired for the generation of the global digital elevation model (DEM) between 2011 and 2015 in stripmap single polarization (HH) mode. In this work, the global data set of quicklook images, characterized by a ground resolution of 50 m x 50 m, was used, in order to limit the computational burden.
For classification purposes several observables, systematically provided by the TanDEM-X system, can be exploited, such as the calibrated amplitude, the bistatic coherence, and the digital elevation model (DEM) height information.
In particular, the volume correlation factor quantifies the amount of decorrelation due to multiple scattering within a volume, which typically occurs in presence of vegetation. This quantity is directly derived from the interferometric coherence and used as main indicator for the identification of vegetated areas.
For this purpose, a fuzzy multi-clustering classification approach, which takes into account the geometric acquisition configuration for the definition of the cluster centers, is individually applied to each acquired scene. A certain variability of the interferometric coherence in X-band has been observed among different forest types, mainly due to changes in forest structure, density, and tree height. This leads to an adjustment of the algorithm settings, and in particular to the derivation of different cluster centers, depending on the considered type of forest.

1.1 Purpose

The purpose of this document is to describe the TanDEM-X Forest/Non-Forest Map products and their formats.

1.2 Scope

The current document includes the product description and raster format of the TanDEM-X Forest/Non-Forest Map and its auxiliary maps.

2 Documents

2.1 List of Abbreviations

The following symbols and acronyms have been used.

Symbol	Description
TDX	TanDEM-X
FNF	Forest/Non-Forest
DEM	Digital elevation model

2.2 Applicable Documents

The following documents are fully applicable together with this document.

	Document
[AD1]	License agreement regarding the use of the TanDEM-X Forest/Non-Forest Map data product.

2.3 Reference Documents

The following references have been used for preparing the document on hand.

	Document
[RD1]	M. Martone, P. Rizzoli, C. Wecklich, C. Gonzalez, J.-L. Bueso-Bello, P. Valdo, D. Schulze, M. Zink, G. Krieger, and A. Moreira, "The Global Forest/Non-Forest Map from TanDEM-X Interferometric SAR Data", Remote Sensing of Environment, vol. 205, pp. 352-373, Feb. 2018.

3 TanDEM-X FNF Map Products

3.1 FNF Map Usage Policy

The license terms [AD1] for the use of the TanDEM-X Forest/Non-Forest Map products are automatically accepted by downloading the data. The license is granted only for scientific utilization and non-commercial utilization of the TanDEM-X Forest/Non-Forest Map data set provided by DLR.
To acknowledge the scientists who have generated and provided the FNF Map, we request that users include a bibliographic citation in their work. Following references shall be cited:

- M. Martone, P. Rizzoli, C. Wecklich, C. Gonzlez, J.L. Bueso-Bello, P. Valdo, D. Schulze, M. Zink, G. Krieger, and A. Moreira, "The Global Forest/Non-Forest Map from TanDEM-X Interferometric SAR Data", Remote Sensing of Environment, vol. 205, pp. 352-373, Feb. 2018.
- T. Esch, W. Heldens, A. Hirner, M. Keil, M. Marconcini, A. Roth, J. Zeidler, S. Dech, and E. Strano, "Breaking new ground in mapping human settlements from space - the global urban footprint", ISPRS Journal of Photogrammetry and Remote Sensing, no. 134, pp. 30-42, Dez 2017.

3.2 FNF Map Product Overview and Format

The TDX FNF Map Dataset includes:

- The global FNF classification map
- User license agreement

and the following auxiliary maps:

- Coverage map
- Super pixels date map
- Super pixels count map
- Acquisitions information files

The products are distributed as compressed ZIP files, including all TDX FNF Map Dataset. They are partitioned in geocells ($1° \times 1°$ latitude/longitude).
All maps are available as raster datasets in GeoTiff format (LZW compressed, 8-bit) and provided with a ground resolution at the equator of 50 m x 50 m, which corresponds to a 1.6 arcsec x 1.6 arcsec in latitude/longitude.

3.2.1 Naming Convention

The file naming convention of TanDEM-X FNF Map products refers to the latitude and longitude value of the center of the lower left or southwest corner pixel of a FNF Map product. The prefix string in the file base name has the general form:

"TDM_ttt_nn_BbbXxxx_FFF" (e.g. TDM_FNF_20_N22E040.zip).

The meaning of the letter codes in particular is given in Table 1.

Table 1: Naming convention for the TanDEM-X FNF Map products.

Letter	**Meaning**	**Example**
ttt	product type, i.e. FNF	FNF
nn	Spacing, 20: original spacing, 1.6-arcsec grid	20 (read 1.6-arcsec for the 50m FNF Map)
B	N if the center of southwest corner pixel of a tile is on the Equator or north of it. S if it is south of the Equator	N
bb	2-digit latitude value of the center of the southwest corner pixel of a tile in degrees	22
X	E if the center of the southwest corner pixel of a tile is in the eastern hemisphere, W in the west one. If the center of the southwest corner pixel of the tile is exactly at 0 longitude, this is E. If the center of the southwest corner pixel is exactly at 180 longitude, this is W	W
xxx	3-digit longitude value of the center of the southwest corner pixel of a tile in degrees	040
FFF	No prefix for the forest/non-forest data Auxiliary files type, will be one of the following: COV (for the coverage map) SPD (for the super pixels date map) SPC (for the super pixels count map) INF (for the acquisitions information file)	COV

3.2.2 FNF Map Tile Extent and Pixel Spacing

All FNF Map products between 0° - 60° North/South latitude have a file extent of 1° × 1° in latitude and longitude coordinates. Between 60° - 80° North/South latitudes the products have an extent of 1° x 2°. Over 80° North/South latitudes the product tiles have an extent of 1° × 4°.

The pixel spacing for the TanDEM-X 50m FNF product in latitude direction towards the poles is constant at 1.6 arcsec, but the pixel spacing in longitudinal direction is not. Instead 3 different zones with different longitudinal pixel spacing ranging from 3.2 arcsec to 6.4 arcsec are defined for both the Northern and Southern hemisphere. All details are summarized in Table 2.

Table 2: Geocell extent and pixel spacing for the TanDEM-X 50m FNF product.

Latitude extension	**Product tile extent Latitude x Longitude**	**Pixel spacing Latitude x Longitude**
80° - 89° N	1° x 4°	1.6” x 6.4”
60° - 80° N	1° x 2°	1.6” x 3.2”
0° - 60° N	1° x 1°	1.6” x 1.6”
0° - 60° S	1° x 1°	1.6” x 1.6”
60° - 80° S	1° x 2°	1.6” x 3.2”
80° - 89° S	1° x 4°	1.6” x 6.4”

3.3 FNF Map Generation Process

For information and details on the generation process of the FNF Map products, the characteristics of the input data, the applied classification approach, and the resulting mosaic process, refer to [RD1].

3.4 FNF Map Product Description

This section presents the raster format for each delivered map.

3.4.1 Global FNF Classification Map

The global TanDEM-X FNF Map is shown in Figure 1.

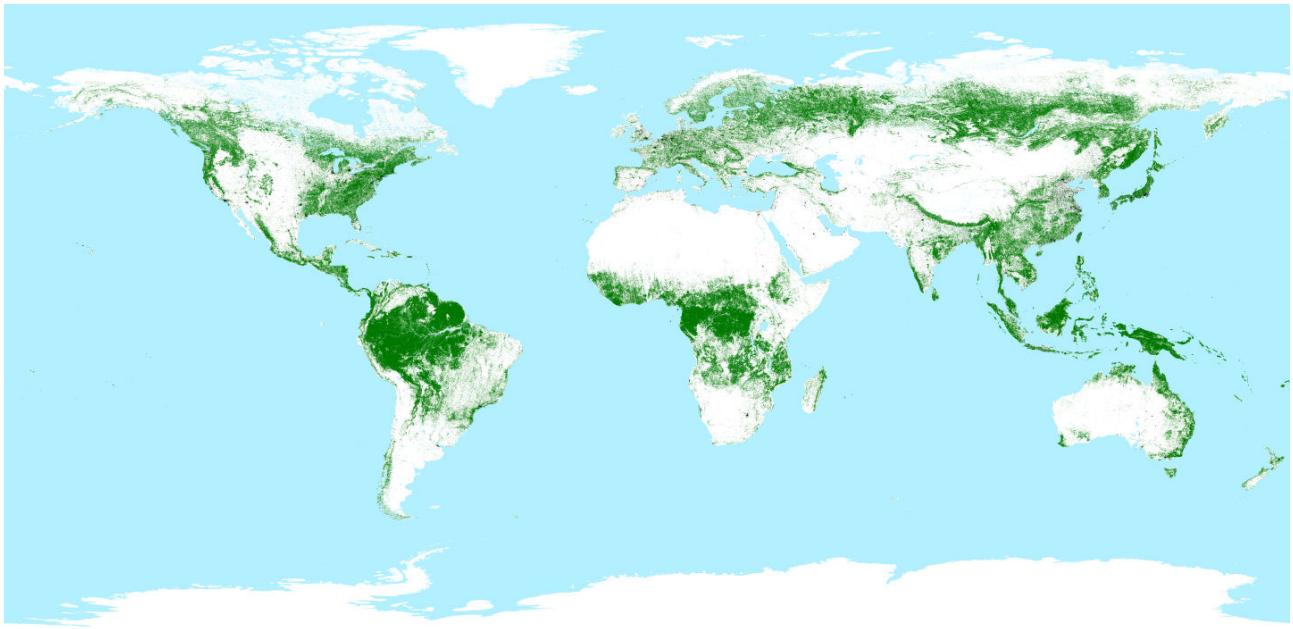

Figure 1: TanDEM-X global Forest/Non-Forest Map.

The raster values in the GeoTiff file mean:

0: for invalid pixels and urban areas
1: for forested areas
2: for non-forested areas
3: for water bodies

3.4.2 FNF Coverage Map

The coverage map indicates the number of mosaicked acquisitions for a specific ground area and is depicted in Figure 2.

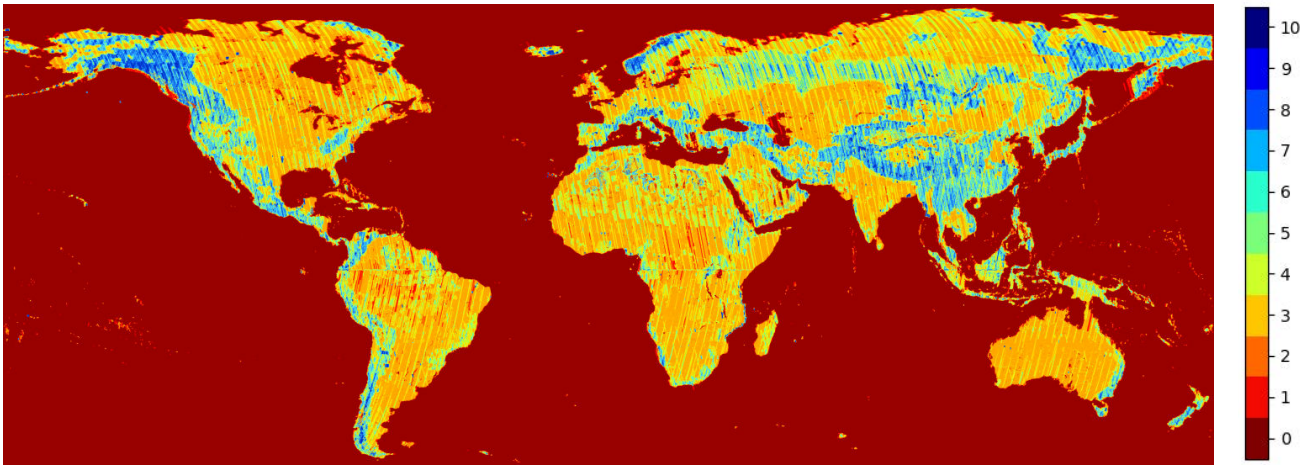

Figure 2: Number of TanDEM-X scenes used to generate FNF Map.

The values in the coverage map refer to the number of mosaicked acquisitions for each pixel and range from 0 and 10. 0 indicates no acquisition coverage. 10 represents 10 or more mosaicked acquisitions.

3.4.3 Super Pixels Count Map

Together with the acquisition date of the last super pixel, the total number of detected super-pixels for the considered pixel is provided as well, as depicted in Figure 3.

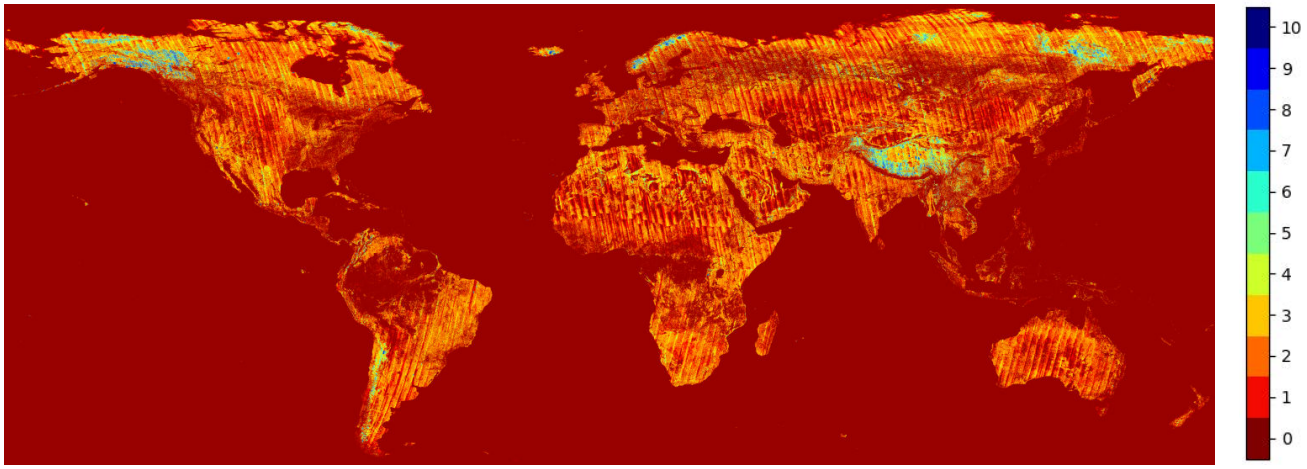

Figure 3: Super pixels count map obtained from the TanDEM-X FNF Map.

The values in the super pixel count map range from 0 to 10. 0 indicates no super pixel. 10 represents 10 or more detected super pixels.

3.4.4 Super Pixels Date Map

Super pixels are classified as very reliable non-forested areas. They are introduced in order to take into account vegetation changes as farming activities or seasonal effects, as displayed in Figure 4. The super pixels date map provides the date of the most recent super pixel, if present. In this sense, the presence of a recent super pixel reasonably allows one to exclude possible regrowth. Where no super pixel has been detected, the date of the first mosaicked image is provided.

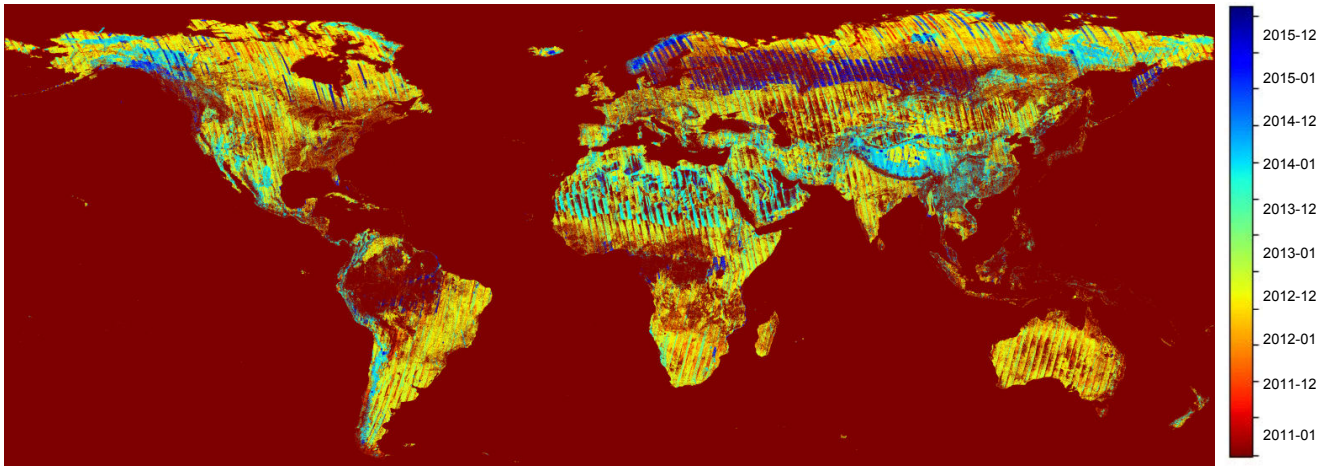

Figure 4: Super pixels date map obtained with the TanDEM-X FNF Map.

The values in the super pixel date map refer to the date of last occurrence of a super pixel. The dates refer to year and month. The Pixels Conversion Matrix for the delivered 8-bit GeoTiff is shown in Table 3.

Table 3: Pixels Conversion Matrix for the 8-bit GeoTiff representing the Map, displayed in Figure 4.

Year	**Month**	**Pixel Value**	**Year**	**Month**	**Raster Value**
2011	Jan	0	2013	Jul	46
2011	Feb	1	2013	Aug	47
2011	Mar	2	2013	Sep	48
2011	Apr	3	2013	Oct	49
2011	May	4	2013	Nov	50
2011	Jun	5	2013	Dec	51
2011	Jul	6	2014	Jan	60
2011	Aug	7	2014	Feb	61
2011	Sep	8	2014	Mar	62
2011	Oct	9	2014	Apr	63
2011	Nov	10	2014	May	64
2011	Dec	11	2014	Jun	65
2012	Jan	20	2014	Jul	66
2012	Feb	21	2014	Aug	67
2012	Mar	22	2014	Sep	68
2012	Apr	23	2014	Oct	69
2012	May	24	2014	Nov	70
2012	Jun	25	2014	Dec	71
2012	Jul	26	2015	Jan	80
2012	Aug	27	2015	Feb	81
2012	Sep	28	2015	Mar	82
2012	Oct	29	2015	Apr	83
2012	Nov	30	2015	May	84
2012	Dec	31	2015	Jun	85
2013	Jan	40	2015	Jul	86
2013	Feb	41	2015	Aug	87
2013	Mar	42	2015	Sep	88
2013	Apr	43	2015	Oct	89
2013	May	44	2015	Nov	90
2013	Jun	45	2015	Dec	91

3.4.5 Acquisition Information Files

The acquisition information files list all the acquisitions used in the generation of the FNF Map on a geocell level ($1° \times 1°$ in latitude/longitude). The list contains the datatake acquisition identifier, its scene number, and the date of the acquisition. An example is shown in Table 4.

Table 4: Example of the acquisition information files content.

Acq. ID	**Scene nr.**	**Date of acq.**
01013142	08	2011-03-24
01013142	09	2011-03-24
01084839	18	2012-06-28
01084839	19	2012-06-28
01099516	08	2012-10-27
01134414	11	2013-05-30
01150055	03	2013-09-06
01150055	04	2013-09-06
01150055	05	2013-09-06
01171384	03	2014-01-05
01171384	04	2014-01-05
01171384	05	2014-01-05