TanDEM-X High-Resolution Coastline Product Description

DFD- German Remote Sensing Data Center
EOC – Earth Observation Center

prepared:	C. Keller, L. Warmedinger	Date
approved:	B. Wessel, M. Huber	Date
released:	A. Roth	Date

DOCUMENT PREPARATION

The document on hand was prepared with contributions from the personnel listed below:

Name (surname, name)	**Organizational Unit**
German Remote Sensing Data Center (DLR-DFD)	
Gorzawski, Larissa	DFD- Land Surface Dynamics
Keller, Carolin	DFD- Land Surface Dynamics
Roth, Achim	DFD- Land Surface Dynamics
Warmedinger, Leena	DFD- Land Surface Dynamics
Wessel, Birgit	DFD- Land Surface Dynamics

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TABLE OF CONTENTS

1 Introduction

This document describes the specifications and format of the global TanDEM-X High-Resolution Coastline Product. This global vector dataset outlines the boundary between ocean and land at a spatial resolution of 10 m. The TanDEM-X coastline product, developed within the TanDEM-X and HydroSHEDS v2.0 projects, was generated by the German Remote Sensing Data Center at the German Aerospace Center (DLR).

The TanDEM-X coastline product is based on the first global TanDEM-X DEM (2010 – 2015) provided by the TanDEM-X mission [5] as described in the TanDEM-X DEM specification document [1]. The TanDEM-X coastline extraction is a semi-automatic process. First, the coastline is extracted automatically from the TanDEM-X DEM and its accompanied quality layers including amplitude images (AMP) and the height error map (HEM) by modifying an external reference coastline. As the derived coastline remains within a specific margin of the reference coastline, a manual quality control is conducted in a second step to ensure global consistency. This applies especially where the coastline is located at the transition from inland water to the ocean, e.g. at river deltas, estuaries, and lagoons. Additionally, minor corrections of the coastline are performed in this step, including the addition of missing islands and the removal of misalignments between tiles originating from the stepwise data processing.

The TanDEM-X coastline product was developed with the aim of editing and refining the first global TanDEM-X DEM. Within the DEM production, the coastline is used to mask out ocean heights and fill the identified area with geoid heights corresponding to the mean sea level. Furthermore, the TanDEM-X coastline product fulfills the requirements of deriving global hydrographic data specified within the HydroSHEDS v2.0 project. In this context, the coastline defines the outer boundary of watersheds and rivers at the coast. To serve this purpose, the creation emphasized a systematic and consistent representation along estuaries and river deltas.

The final TanDEM-X coastline product is a global data set in vector format. It is released in different versions and multiple projections, e.g. for polar regions.

1.1 Purpose

The purpose of this document is to describe the global TanDEM-X High-Resolution Coastline Product, including its generation process, format and further specifications.

1.2 Scope

The current document includes the product description of the global TanDEM-X High-Resolution Coastline Product. The document is public.

2 References

	Document ID	Document Title	Issue
[1]	TD-GS-PS-0021	"TanDEM-X Ground Segment – DEM Products Specification Document", EOC, DLR, Oberpfaffenhofen, Germany, Public Document TD-GS-PS-0021, Issue 3.2, 2018. [Online]. Available: https://tandemx-science.dlr.de/	Issue 3.2, 2018
[2]	Wessel et al., 2021	Wessel, B., Huber, M., Wohlfart, C., Bertram, A, Marschalk, U., Abdullahi, S., Georg, I.,, Roth, A.: TanDEM-X Polar DEM 90 m of Antarctica: Generation and Error Characterization of a filled and edited DEM, *The Cryosphere*, 15 (11), pp.5241 – 5260, https://doi.org/10.5194/tc-15-5241-2021, 2021	2021
[3]	Huber, M., 2022	TanDEM-X PolarDEM Product Description, EOC, DLR, Oberpfaffenhofen, Germany,Public Document TD-GS-PS-0208, Issue 1.5, 2022. [Online]. Available: https://geoservice.dlr.de/web/maps/	Issue 1.5.2022
[4]	Huber et al., 2021	Huber, M., Osterkamp, N., Marschalk, U., Tubbesing, R., Wendleder, A., Wessel, B., Roth, A.: Shaping the Global High-Resolution TanDEM-X Digital Elevation Model. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 14, Seiten 7198-7212, https://doi.org/10.1109/JSTARS.2021.3095178, 2021.	2021
[5]	Rizzoli et al 2017	Rizzoli, Paola; Martone, Michele; Gonzalez, Carolina; Wecklich, Christopher; Borla Tridon, Daniela; Bräutigam, Benjamin et al. (2017): Generation and performance assessment of the global TanDEM-X digital elevation model. In *ISPRS Journal of Photogrammetry and Remote Sensing* 132, pp. 119–139. DOI: 10.1016/j.isprsjprs.2017.08.008.	2017
[6]	Warmedinger et al.	Warmedinger, Leena Julia, Keller, Carolin, Gorzawski, Larissa, Roth, Achim, Lehner, Bernhard, Marschalk, Ursula, Huber, Martin, Wessel, Birgit (2026): The Global TanDEM-X High-Resolution Coastline Product, Earth System Science Data, submitted.	submitted (2026)

3 Abbreviations

Abbreviation	Meaning
AMP	Amplitude
DEM	Digital Elevation Model
DFD	German Remote Sensing Data Center
DLR	German Aerospace Center
EOC	Earth Observation Center
EPSG	European Petroleum Survey Group Geodesy
HEM	Height Error Map
IEEE	Insitute of Electrical and Electronics Engineers
SAR	Synthetic aperture radar
TanDEM-X	TerraSAR-X add-on for Digital Elevation Measurements
WGS84	World Geodetic System 1984

4 Generation of the global TanDEM-X High-Resolution Coastline Product

The TanDEM-X High-Resolution Coastline product is based on the global TanDEM-X DEM dataset. The product outlines the boundary between land and ocean at a high resolution of 10m. The coastline extraction method is semi-automatic. To accommodate hydrological applications, the automatically derived coastline is manually refined in transitional water bodies between inland waters and the ocean. The production workflow is depicted in Figure 1. The generation process is briefly described in the following. Further details on the automatic extraction proceedure are provided in [4] and details on the manual correction are presented in [6].

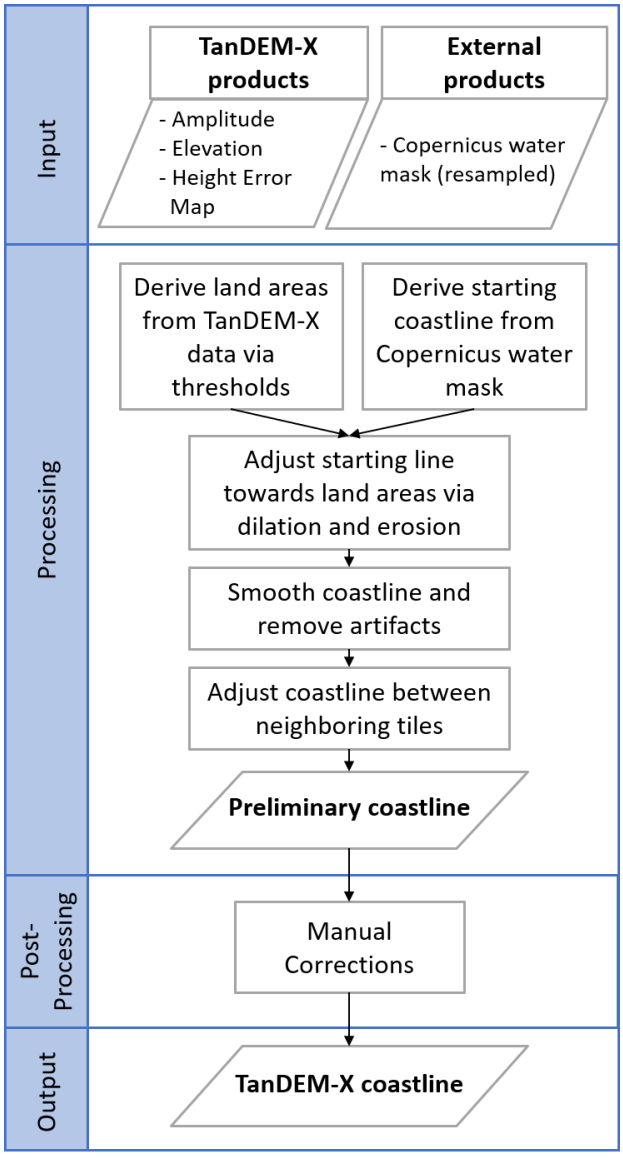

Fig. 1 Workflow for semi-automatic TanDEM-X coastline delineation.

The TanDEM-X coastline product is derived from TanDEM-X DEM data acquired between 2010 and 2015. Consequently, the coastline vector reflects the water levels and coastal conditions at the time of SAR data acquisition. No corrections, such as adjustments to mean tidal levels, have been applied, and the classification of areas as land or ocean relies solely on the appearance of coastal features in the SAR data.

The coastline extraction starts with the generation of a coastline polygon based on multiple layers of the TanDEM-X DEM dataset, including the raster layer digital elevation model (DEM), amplitude imagery (AMP), and height error map (HEM), at a resolution of 0.4 arcseconds. Open water areas, corresponding to the ocean, typically exhibit noisy elevation values, low amplitude signals, and high errors in the HEM due to a loss of coherence in the backscattered signal, whereas land areas are assumed to lie above mean sea level, including a defined margin. An external coastline, derived from the Water Body Mask Quality Layer of the Copernicus DEM GLO-30, serves as a starting point for the TanDEM-X coastline. This input coastline is modified via dilatation or erosion using a threshold approach for the input raster layers (DEM, AMP, HEM). If the values from DEM, AMP, or HEM exceed a certain threshold for a given pixel, the pixel is assigned to the land or water mask, respectively. Open water areas typically exhibit noisy elevation values in the DEM, low amplitude signals (AMP), and high errors in the HEM due to a loss of coherence in the backscattered signal. Furthermore, land areas are assumed to be higher than the mean sea level. Because inland water areas and the ocean cannot be differentiated from the radar data, the automatically derived coastline remains within a specific boundary around the externally defined starting point. In the next step, artifacts are removed, e.g., falsely identified ocean pixels fully enclosed by land area are eliminated, and a pixel-based smoothing is applied. Nonetheless, the vector dataset maintains its edgy shape originating from the raster-based approach. Lastly, the coastline polygons of neighbouring tiles are adjusted to achieve a smoothed transition. The result is a preliminary global coastline polygon.

Following the automatic extraction, manual adjustments are performed to address limitations of the automated approach and to ensure a consistent global coastline. Islands included in the TanDEM-X coastline must be detectable in the source data, covering at least one pixel, and sufficiently separated from other islands or the mainland to be recognized as distinct features. Non-permanent features, such as tidal flats, are removed, whereas islands are considered permanent if vegetation is present or satellite imagery indicates rocky terrain. Narrow, elongated man-made structures, such as piers, that appear as multiple pixel-sized features are merged into single features, and floating or non-permanent structures, including small boat harbors, are excluded. Coastal features such as lagoons, inlets, and estuaries are classified as ocean if their openings to the sea are visible either in the DEM, where the width exceeds the data resolution or the elevation has been smoothed, or in the amplitude imagery, taking into account that wet sand appears similar to water. These features are also cross-checked against reference datasets, including the GSHHG coastline, HydroSHEDS v1.0, and HydroLAKES, to ensure consistency. River deltas and estuaries are individually adapted to local conditions due to their natural variability and the unique morphology of each river mouth. The position of the coastline cannot be tied to specific parameters, such as the width of a river. For example, one distributary of the Amazon River can exceed the width of another river's main channel at its widest point. During manual editing, reference coastlines are considered to guide adjustments, ensuring that river mouths are represented in the TanDEM-X coastline in a manner that allows their presence to be inferred directly from the dataset, even without supplementary imagery. Minor corrections further include the addition of missing islands and the removal of misalignments between tiles resulting from the stepwise processing.

The post-processing concludes with the merging of individual coastline tiles into a single global polygon. During this process, the removal of inland holes is verified, and a maximum point spacing of 10 m is maintained. The final TanDEM-X coastline product is provided as closed polygons. In polar regions, the coastline follows shelf ice fronts and includes floating glacier tongues, while in tropical tidal regions, mangrove forests are classified as land because the vegetation does not indicate water in the SAR data. Overall, the coastline exhibits both temporal and spatial variability; however, as a dataset, it accurately reflects the coastal features captured in the TanDEM-X data.

5 TanDEM-X High-Resolution Coastline Product

The TanDEM-X High-Resolution Coastline product describes the separating line between ocean and land. This outline is produced within the TanDEM-X DEM editing process and has a resolution of 10 m. The TanDEM-X coastline product is a global vector dataset converted to the World Mercator procection EPSG:3395 with a final minimum distance of 10m. Regional subset products are also available separately and have been released within the TanDEM-X PolarDEM framework [3].

5.1 TanDEM-X High-Resolution Coastline Product (10m), 2010-2015

The TanDEM-X coastline product is available at a global scale and is derived from data acquired between 2010 and 2015. The product details are outlined in the following.

5.1.1 Product extent

The TanDEM-X coastline product has a global coverage. The completeness of features, e.g. specific islands, depends on their representation within the TanDEM-X DEM data.

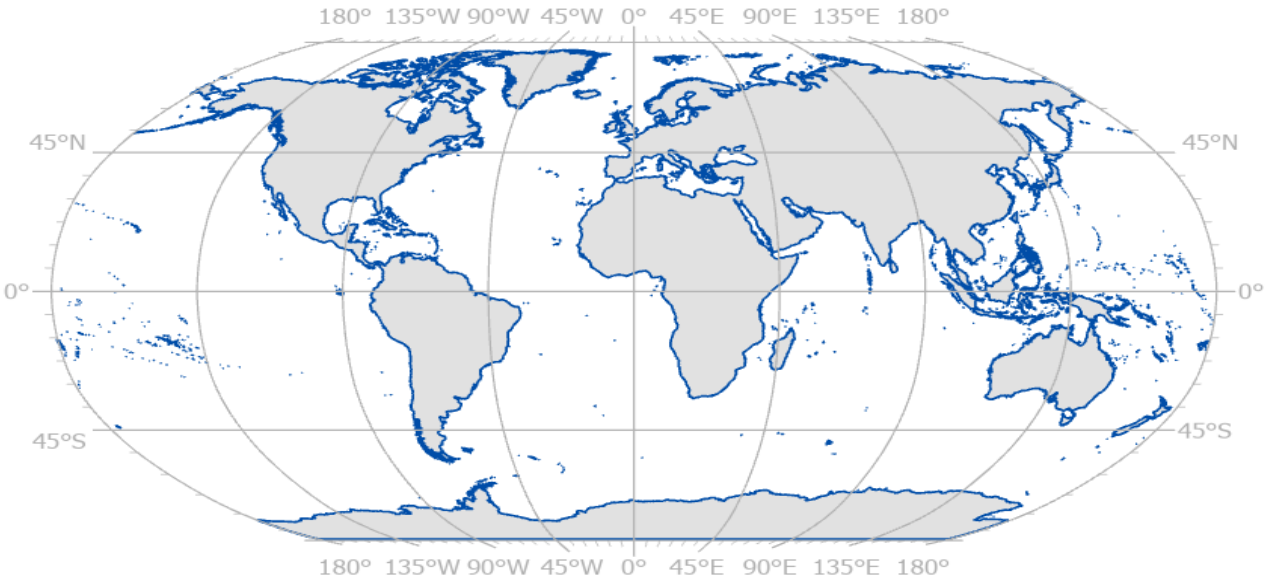

Fig. 2 Global extent of TanDEM-X High-Resolution Coastline Product

5.1.2 Product overview and format

The TanDEM-X high-resolution coastline product is a vector dataset. The coastline is provided as polygon and consists of one layer of information. Its projection is WGS 1984 World Mercator in EPSG:3395. The coastline product comprises polygons outlining landmasses. The coastline dataset has a total length of 1,908,532 kilometres and includes 396,543 islands in addition to the continents.

The product is provided in gpkp and shapefile format as compressed ZIP files.

5.1.3 Product parameter

The following product parameters are applicable:

TanDEM-X High-resolution Coastline	
file naming	TanDEM-X_hires_coastline_global_2010-2015_V1
Projection	World Mercator
EPSG	3395
Coverage	Global
Dataset size	~ 622 MB
Spacing	Variable, minimum distance 10 m
Elevation unit	N/A
Acquisition dates	10 December 2010 to 15 Januar 2015
Data format	Vector data, shapefile format (shp) and Geopackage (gpkg)
No data value	N/A
License	CC-BY 4.0
Available for download	https://download.geoservice.dlr.de/TDM_COASTLINE/files/

5.1.4 Copyright Notice

Please mark all data in such a way that the authorship and copyright of DLR is comprehensible to all, e.g.: "© DLR 2019-2025"and cite the paper [6]:

Warmedinger, Leena Julia, Keller, Carolin, Gorzawski, Larissa, Roth, Achim, Lehner, Bernhard, Marschalk, Ursula, Huber, Martin, Wessel, Birgit (2026): The Global TanDEM-X High-Resolution Coastline Product. Earth System Science Data (submitted)

5.2 TanDEM-X PolarDEM High-Resolution Coastline

The TanDEM-X coastline is partly published for specific geographic regions, e.g. for Antarctica as TanDEM-X PolarDEM High-Resolution Coastline within the PolarDEM framework. Special versions converted to the arctic UPS coordinate projection EPSG:3031 (Antarctica) and EPSG:3413 (Greenland) are separately available. The products are available for download under

https://download.geoservice.dlr.de/TDM_POLARDEM90/files/COASTLINES/

5.2.1 TanDEM-X PolarDEM High-Resolution Coastline of Antarctica 2013 – 2014

This product is described in detail in [2] and [3].

5.2.2 TanDEM-X PolarDEM High-Resolution Coastline of Greenland 2010 - 2014

When available, this product will be described in detail in [3].