

Review of **The Global TanDEM-X High-Resolution Coastline Product** by Warmedinger et al.
submitted for publication at Earth System Science Data. <https://doi.org/10.5194/essd-2026-277>

Reviewer Comments (RC) are presented in black italics.

Author Responses (AR) are presented in blue.

Changes in the Manuscript (CM) are presented in red.

Response to Reviewer 2:

Summary

RC2.1: *The manuscript presents the TanDEM-X high-resolution global coastline product, a vector dataset delineating the land-ocean boundary, derived from the TanDEM-X global DEM and refined through a combination of automated extraction and expert-based manual correction. The value of this contribution a globally consistent, high-resolution coastline product derived from a single, homogeneous SAR-based data source. The product's intended role in supporting hydrological applications such as HydroSHEDS v2.0, and its potential utility for a broad range of coastal and hydrological research communities, is well motivated.*

AR2.1 We sincerely thank the reviewer for the careful reading of the manuscript, this positive summary and for recognizing the value of a globally consistent, high-resolution coastline product derived from a single, homogeneous SAR-based source. We address the reviewer's more detailed concerns, in particular regarding the reporting of absolute positional accuracy, in our responses to the specific comments below. We believe that the reviewer's constructive comments have improved the quality and clarity of the manuscript.

RC2.2: *However, the manuscript in its current form falls short of substantiating the quality claims it makes about the product. Most critically, no absolute horizontal accuracy is reported anywhere in the manuscript. This is, in my assessment, the single most important number missing from this work, without which a reader cannot judge whether the product is fit for their intended purpose. Related to this, several other sources of uncertainty that are essential to a rigorous data descriptor are not quantified or, in some cases, not mentioned at all: geometric/positional uncertainty from the extraction and vectorization workflow, operator bias introduced during manual correction, omission error, the influence of tidal stage at acquisition, and the effect of coastal change occurring across the multi-year (2010–2015) acquisition window on the internal consistency of a product presented as a single static dataset.*

AR2.2: We thank the reviewer for raising this point. We agree that reporting an absolute horizontal accuracy would be highly desirable. However, we do not see a way to reliably obtain such a figure at global scale, because no true reference coastline exists against which the global coastline product could be validated. For this reason, our approach is to characterize product quality through comparison with multiple existing coastline products across a range of coastal settings and combining it with a visual comparison. This way, we aim to capture characteristics of the coastline that cannot be reduced to a single statistical measure, rather than relying on a single absolute accuracy value derived from an assumed ground truth.

That said, we recognize that a statistical evaluation is decisive for the description of a dataset. The statistical measures presented in Table 3 are based on high-accuracy local reference datasets (i.e., LfU, CUSP, DEA) and provide a reasonable proxy for absolute accuracy in the specific areas, where such references are available. We have extended this analysis by adding OSM and S2Coast-2023

coastlines to all study areas of the statistical analysis, more clearly framing these statistics as an approximate accuracy estimate valid for well-resolved coastal settings, while being explicit that this cannot be generalized as a single global accuracy figure. Please, refer additionally to our answers to RC2.5 and RC2.15.

In addition, we have added a dedicated paragraph discussing limitations and sources of uncertainty raised by the reviewer. Sect. 3.3. addresses in particular the following points: effects of the multi-year acquisition period of the TanDEM-X mission, the influence of the coastline extraction method on the positional accuracy, acknowledgement of an operator bias and omission error, and limitations of the radar system.

CM2.2: While the TanDEM-X coastline benefits from the homogeneous, weather- and daylight-independent radar acquisition capability of the TanDEM-X mission, some sources of uncertainty need to be considered when interpreting the coastline product. Therefore, limitations are discussed in the following.

A source of uncertainty arises from the multi-year acquisition and mosaicking of the TanDEM-X DEM and its ancillary layers, which were collected between 2010 and 2015 and fused at the pixel level via weighted averaging. As a result, the coastline product does not correspond to a specific date or time. In particular, the tidal stage at the time of each individual SAR acquisition is not known or corrected, and its influence on the resulting coastline position is therefore not quantifiable. Across multiple mosaicked acquisitions, this influence is effectively randomized and smoothed rather than removed. Particularly along sandy and tidally influenced coasts and in dependence of the purpose outside of the refinement of the TanDEM-X DEM and HydroSHEDS v2, this unawareness can be considered a limitation.

The positional accuracy of the extracted coastline is influenced by multiple factors along the processing chain. It is fundamentally linked to the geolocation accuracy of the underpinning TanDEM-X DEM and its input SAR scenes, which primarily depends on the accuracy of the orbital data. While horizontal accuracies at the centimeter level are theoretically achievable, unmodelled atmospheric and ionospheric effects typically reduce this to the sub-meter level in practice. This level of accuracy is, however, small in relation to the 10 m spatial resolution of the DEM (Balss et al., 2018). Beyond this underlying geolocation accuracy, the extraction and vectorization workflow introduces additional uncertainty at several stages, including thresholding of the DEM and ancillary layers to delineate the land-water boundary, morphological operations applied to the resulting raster mask, vectorization of the coastline polygon, and subsequent manual editing of the preliminary coastline. As the coastline is derived from a raster dataset and only includes a pixel-based smoothing, its geometry retains a slightly jagged, pixel-based character. This is a limitation along straight coastal stretches such as sandy beaches, whereas it represents irregular coast types such as skerries and cliffs more naturally. A further source of geometric inaccuracy arises from the final post-processing step enforcing a minimum vertex spacing of 10 m, as manually introduced details finer than this spacing were, in some cases, partially lost. We do not provide a separate quantitative estimate for the combined effect of these processing steps on positional accuracy.

Manual correction of the preliminary coastline was carried out by operators trained in small groups of 2–3. Challenging or ambiguous cases were discussed collectively within a larger group. Additionally, hydrological expert knowledge was consulted for particularly demanding areas with complex hydrological conditions, such as large deltas and river systems. While this process promotes consistency, some degree of operator-dependent bias cannot be fully excluded and has not been evaluated. Corrections were additionally based on higher-resolution optical imagery (Google Earth) than the 10 m input DEM and are therefore also subject to the positional accuracy and

interpretability limitations of the imagery source. This is closely related to the treatment of human-made structures, as we generally consider permanent anthropogenic structures, such as harbors, to be part of the coastline. Floating or non-permanent structures (e.g., floating piers, boats, bridges), on the other hand, are intended to be removed during manual correction. In practice, however, it can be difficult to reliably distinguish non-permanent from permanent structures solely based on satellite imagery.

Coastline segments may further be omitted where small islands fall below the effective resolution of the TanDEM-X radar data, or where remote, small islands were not included for acquisition tasking. Coverage of the coastline product therefore generally follows the coverage of the underpinning TanDEM-X acquisitions, and features outside this coverage are necessarily absent from the product. Finally, layover and shadow effects in the SAR input data can locally occur in areas of steep terrain, such as fjords, and cannot be compensated for during processing, which may cause local displacement of the coastline in such settings.

Taken together, these uncertainties vary with coastal setting and cannot be summarized in a single accuracy figure. The TanDEM-X coastline is best suited to large-scale and regional applications, whereas high-precision studies of coastline position or change should validate it against locally appropriate reference data.

General comments

RC2.3: *The abstract would benefit from following a clearer, more standard structure: (1) context/motivation, (2) what was done (data and methods, briefly), (3) key results with concrete numbers, and (4) significance/outlook. As currently written, the abstract focuses heavily on motivation and downstream applications (HydroSHEDS, DEM refinement) but omits several details a reader needs to assess the product itself, most notably the uncertainty estimates from the validation. Since this is a data descriptor, readers will expect the abstract to answer, at minimum: what was mapped, at what resolution and extent, how it was validated, and how accurate it is, ideally with at least one headline number for each.*

AR2.3: We thank the reviewer for this suggestion and have revised the abstract accordingly, restructuring it to a more standard structure. Furthermore, we have included important information for data descriptors and headline numbers.

CM2.2: Coastlines are a key element of coastal mapping and hydrographic applications. However, globally consistent, high-resolution coastline products derived from a single, homogeneous data source remain scarce. We present a globally consistent, hydrologically standardized coastline product (DOI: <https://doi.org/10.15489/entfdgi5es81>, German Aerospace Center (DLR), 2026) derived from the 10 m DEM product of the German SAR satellite mission TanDEM-X. The TanDEM-X coastline was first extracted automatically from the TanDEM-X DEM and its ancillary layers, using an external coastline from the Copernicus DEM's Water Body Mask as a starting point, and subsequently manually verified and improved to meet hydrological consistency requirements. The product supports the refinement of the TanDEM-X DEM and serves as a key input for deriving the outer boundary of watersheds and rivers in the production of the global hydrographic database HydroSHEDS v2. The TanDEM-X coastline maps a total coastline length of 1,908,532 km and includes 396,543 islands. In the absence of a global coastline product suitable as a ground-truth reference, the product quality was assessed against six existing global and three national coastline products. Statistical evaluation was performed across eight globally distributed coastal study areas, and qualitative assessment across fourteen. Against high-accuracy local reference datasets, the TanDEM-X coastline shows a mean distance and standard deviation between 13 and 35 m. Larger deviations are observed along sandy coasts in the quantitative assessment and at tidal flats and transitional

water bodies in the qualitative comparison. The results demonstrate that the TanDEM-X coastline is a globally consistent product suitable for large-scale hydrological and coastal applications, while identifying specific coastal environments in which positional uncertainty remains elevated.

RC2.4: *The manuscript states the coastline product has a "spatial resolution of 10 m," directly equating this to the resolution of the underlying TanDEM-X DEM. This equivalence is not strictly valid and should be clarified or qualified. Raster spatial resolution refers to the pixel/grid spacing of the source data. A derived vector product, by contrast, does not inherit this resolution directly: its positional accuracy and level of geometric detail depend on the full processing chain used to extract it, including the threshold used to identify the land-water boundary, any smoothing, generalization, or simplification applied to the vector geometry, the manual verification and editing and the interpolation behaviour of the extraction method itself. As a result, the vector coastline could plausibly have effective positional accuracy coarser than 10 m (e.g., if extraction or smoothing introduces additional uncertainty) or, in principle, appear more detailed at some locations (e.g., where manual editing refines the automatically extracted line beyond the native pixel grid). I would recommend the authors either substantiate the 10 m resolution claim for the vector product specifically, ideally through a quantitative positional accuracy assessment, or rephrase the statement to make clear that 10 m refers to the resolution of the source DEM, with the vector product's own positional accuracy reported separately and explicitly.*

AR2.4: We thank the reviewer for this important clarification. We agree that equating the "10 m" resolution of the source TanDEM-X DEM directly with the positional accuracy of the derived vector coastline is not strictly valid. We have revised the manuscript accordingly. We now clarify that the 10 m refer specifically to the raster grid spacing of the source DEM and ancillary datasets, which determine the level of geometric detail that can plausibly be captured by the extraction process, but does not by itself define the positional accuracy of the resulting vector product. Furthermore, we have specified in the product description (Sect. 2.4) that the minimum spacing between two adjacent vertices is 10 m or greater (see specific comment L84).

Regarding positional accuracy, we have quantified this through comparison against several reference coastline products at multiple test sites. This is presented in the validation Sect. 3.1 (Table 3 and Table 5 (Appendix)). We do not, however, provide a single globally valid positional accuracy figure, and have adjusted the manuscript's wording to avoid implying such a general claim.

CM2.4: It is derived from the 10-m-resolution TanDEM-X DEM data. The minimum spacing between two consecutive vertices of the coastline polygon is 10 m and established in the final step of the dataset production. However, no maximum spacing is enforced, so vertex spacing can be considerably larger along straight or gently curved stretches of the coast.

RC2.5 *The manuscript would benefit from situating the TanDEM-X coastline product relative to other established automated coastline mapping efforts, most notably Duan et al.'s S2Coast-2023 (<https://doi.org/10.1016/j.rse.2025.115186>), and Vos et al.'s CoastSat (<https://doi.org/10.1016/j.envsoft.2019.104528>). Both are widely used, openly available products against which readers will naturally want to benchmark a new global coastline dataset. I would recommend the authors include a direct quantitative comparison in the validation section.*

AR2.5 We thank the reviewer for this suggestion and highlighting the coastline mapping efforts of Duan et al. (2025) and Vos et al. (2019). We have added a reference to Vos et al. (2019) in the introduction. In addition, we decided to include the S2Coast-2023 product as an additional reference dataset in the validation section. We performed a quantitative evaluation and have included the results in Table 3 and Table 5 (Appendix). We furthermore included it as a reference in the qualitative comparison (see Figures 5-8). We acknowledge the S2Coast-2023 product as a high-quality coastline

improving the quantitative validation of the TanDEM-X coastline. From a quantitative perspective, we have noticed that the S2Coast-2023 reaches partly quite far inland and appears to be terminated once it reaches a specific threshold width. This would imply that no hydrological effects were taken into account. Furthermore, the existing dataset does not cover polar areas likely because S2-coverage is scarce due to polar nights.

On the other hand, we did not include CoastSat, as it does not provide a single global coastline product. It is rather an open-source toolkit that allows users to generate shorelines for a given region by selecting the corresponding satellite imagery. A direct comparison would therefore require us to first generate a CoastSat-derived shoreline for our study areas.

CM2.5: S2Coast-2023 is a global 10-m coastline dataset derived from a cloud-free annual composite of Sentinel-2 imagery acquired in 2023 using the Google Earth Engine-based S2Coast framework. The processing includes the delineation of the stable extent of high seawater submergence based on multi-temporal observational information, spectral characteristics and spatial features, as well as the derivation of boundaries through integrated threshold segmentation, and raster-to-vector conversion (Duan et al., 2026). The S2Coast-2023 product includes all continents, most inlands with an area larger than 100 m² but excludes Antarctica and remote polar islands.

RC2.6: *Bridges and other man-made structures that visually resemble a coastline in the source data do not appear to be resolved correctly by the workflow. Please clarify how such features are identified and excluded (or corrected) during processing, and whether this is a systematic limitation the authors are aware of.*

AR2.6: We thank the reviewer for raising this point. We do not employ a dedicated algorithm to identify and exclude bridges or other human-made structures. Such structures are present in the input radar data (e.g. AMP) and are in part already treated during the generation of the TanDEM-X DEM itself; however, we have neither insight into nor control over this upstream processing.

We generally consider permanent human-made structures, such as harbors, to be part of the coastline. During the manual correction step, floating or non-permanent structures (e.g., floating piers, boats, bridges) are intended to be removed. In practice, however, it can be difficult to reliably distinguish non-permanent structures from permanent ones based on satellite imagery alone. We acknowledge this as a systematic limitation of the current workflow and will clarify this in the manuscript.

CM2.6: This is closely related to the treatment of human-made structures, as we generally consider permanent anthropogenic structures, such as harbors, to be part of the coastline. Floating or non-permanent structures (e.g., floating piers, boats, bridges), on the other hand, are intended to be removed during manual correction. In practice, however, it can be difficult to reliably distinguish non-permanent from permanent structures solely based on satellite imagery.

RC2.7: *The manuscript does not report or quantify several key sources of uncertainty that a reader would need to assess product quality, including: absolute horizontal positional uncertainty, geometric uncertainty from the extraction/vectorization workflow, operator bias introduced during manual correction, and omission error (i.e., coastline segments missed entirely). Given that the conclusion states the product's "strengths and limitations are visualized in a comparison," this is not sufficient. A quantitative uncertainty budget is needed for the product to be usable by downstream applications.*

AR2.7: We thank the reviewer for this comprehensive comment. We agree that a clear characterization of the different sources of uncertainty is important for downstream users of the TanDEM-X coastline product. We address the key sources of uncertainty specified by the reviewer

below. To acknowledge this in the manuscript, we have included a dedicated Sect. 3.3 on limitations and uncertainties of the TanDEM-X coastline product.

- Absolute horizontal positioning accuracy

The absolute horizontal positioning accuracy for the coastline is directly related to the geolocation accuracy of the TanDEM-X DEM and its input scenes. The geolocation accuracy of TerraSAR-X and TanDEM-X SAR scenes relies mainly on its accurate orbital data. In theory, horizontal accuracies up to centimeter level are possible, but usually unmodelled weather and ionospheric effects can degrade the accuracy to sub-meter level (Balss et al. 2018). This level of accuracy is still more than sufficient, i.e., negligible, relative to the 10 m spatial resolution of the TanDEM-X DEM.

Regarding the absolute positional accuracy of the coastline product itself, and as outlined in our response to RC2.2, we do not consider a single, globally valid figure for absolute horizontal positional accuracy to be feasible or meaningful, given the varying characteristics of coastlines and processing conditions across the globe. Instead, we quantify positional accuracy through comparison against reference coastline products at multiple representative test sites, as presented in the validation section (see Figure 3 and Appendix).

Due to the lack of a single, universally valid reference coastline, we do not report a globally applicable absolute horizontal positional accuracy for the TanDEM-X coastline. Instead, positional accuracy is assessed through quantitative evaluation against multiple reference coastline products at globally distributed test sites, restricted to coastal stretches where the compared products follow a broadly consistent path (see Table 3). At sites dominated by definitional ambiguity in the land-water boundary, such as mangrove coasts and river deltas, positional differences between products are instead assessed qualitatively, as such discrepancies primarily reflect differing conventions of what constitutes "the coastline" rather than positional inaccuracy.

The positional accuracy of the extracted coastline is influenced by multiple factors along the processing chain. It is fundamentally linked to the geolocation accuracy of the underpinning TanDEM-X DEM and its input SAR scenes, which primarily depends on the accuracy of the orbital data. While horizontal accuracies at the centimeter level are theoretically achievable, unmodelled atmospheric and ionospheric effects typically reduce this to the sub-meter level in practice. This level of accuracy is, however, small in relation to the 10 m spatial resolution of the DEM (Balss et al., 2018).

- Geometric uncertainty from the extraction/vectorization workflow

We do not provide a separate quantitative estimate of the geometric uncertainty introduced by the extraction and vectorization steps themselves. However, similar automated coastline/shoreline extraction studies using standard image processing techniques report positional uncertainties on the order of the pixel size of the respective input data (e.g., Vos et al. (2019), report a horizontal accuracies on pixel and sub-pixel level for shoreline extraction techniques using optical satellite imagery). Given that our workflow uses a comparable approach (thresholding and vectorization) applied to the 10 m resolution TanDEM-X DEM, a similar order-of-magnitude for the uncertainty, i.e., on the scale of the pixel size, can plausibly be expected. We consider this a reasonable qualitative estimate rather than a validated quantitative figure specific to our product. In addition, the final post-processing

step, which enforces a minimum vertex spacing of 10 m, introduces a further source of geometric inaccuracy. Manually introduced details finer than this minimum spacing were in some cases lost during this step. We consider these aspects reasonable qualitative estimates rather than validated quantitative figures specific to our product. The geometric uncertainty is now being addressed in the paragraph on uncertainties and limitations.

Beyond this underlying geolocation accuracy, the extraction and vectorization workflow introduces additional uncertainty at several stages, including thresholding of the DEM and ancillary layers to delineate the land-water boundary, morphological operations applied to the resulting raster mask, vectorization of the coastline polygon, and subsequent manual editing of the preliminary coastline. As the coastline is derived from a raster dataset and only includes a pixel-based smoothing, its geometry retains a slightly jagged, pixel-based character. This is a limitation along straight coastal stretches such as sandy beaches, whereas it represents irregular coast types such as skerries and cliffs more naturally. A further source of geometric inaccuracy arises from the final post-processing step enforcing a minimum vertex spacing of 10 m, as manually introduced details finer than this spacing were, in some cases, partially lost. We do not provide a separate quantitative estimate for the combined effect of these processing steps on positional accuracy.

- Operator bias introduced during manual correction

Manual corrections were carried out by operators trained in small groups of 2–3 people. Challenging or ambiguous cases were discussed collectively within a larger group of co-authors. Additionally, hydrological expert knowledge was consulted for particularly demanding areas, such as large deltas and river systems (e.g., Río de la Plata, IJsselmeer, Ganges-Brahmaputra-Delta). This group-based training and discussion process helps promote consistency across operators. Nonetheless, some degree of operator-dependent bias cannot be fully excluded. We have not quantified the extent of such inter-operator variability. In addition, the geometric accuracy of manual corrections is inherently difficult to quantify, as corrections were made based on higher-resolution imagery than the 10 m input DEM, specifically Google Earth imagery, and are therefore subject to the resolution and positional accuracy characteristics of that optical imagery source. We consider these aspects a qualitative limitation of the current workflow, which we included explicitly in the section on uncertainties and limitations.

Manual correction of the preliminary coastline was carried out by operators trained in small groups of 2–3. Challenging or ambiguous cases were discussed collectively within a larger group. Additionally, hydrological expert knowledge was consulted for particularly demanding areas with complex hydrological conditions, such as large deltas and river systems. While this process promotes consistency, some degree of operator-dependent bias cannot be fully excluded and has not been evaluated. Corrections were additionally based on higher-resolution optical imagery (Google Earth) than the 10 m input DEM and are therefore also subject to the positional accuracy and interpretability limitations of the imagery source.

- Omission error

We are not aware of systematic omissions within the processed TanDEM-X coverage itself. However, we expect that omission errors can occur in a few specific situations. First, very small islands and structural details of the coastline may fall below the effective resolution of the TanDEM-X radar data and therefore not be detected during processing. Second, TanDEM-X data acquisition is tasked based on the GSHHG coastline including a buffer zone. Islands not

included in this coastline may not have been acquired at all and are therefore absent from the product. As a result, the coverage of the coastline product generally follows the coverage of the underpinning TanDEM-X acquisitions in coastal areas, and any islands or coastline segments outside this acquisition coverage are necessarily omitted. We have stated this explicitly in the manuscript.

Coastline segments may further be omitted where small islands fall below the effective resolution of the TanDEM-X radar data, or where remote, small islands were not included for acquisition tasking. Coverage of the coastline product therefore generally follows the coverage of the underpinning TanDEM-X acquisitions, and features outside this coverage are necessarily absent from the product. Finally, layover and shadow effects in the SAR input data can locally occur in areas of steep terrain, such as fjords, and cannot be compensated for during processing, which may cause local displacement of the coastline in such settings.

RC2.8: *The source data used for manual coastline correction, and the associated positional uncertainty of that reference data, is not described. Since manual correction is stated to be central to achieving "global consistency," the reliability of the reference material used for this step directly affects the reliability of the final product and should be reported.*

AR2.8: Manual correction is primarily based on the TanDEM-X DEM and its ancillary layers (e.g., the amplitude (AMP) data), supplemented by visual inspection of Google satellite imagery used as a QGIS basemap. In addition, the reference coastline datasets (GSHHG, OSM, and HydroSHEDS) are consulted. To improve clarity of the manuscript, all data that was used for manual corrections are now mentioned in Sect. 2.1 describing the input data. As GSHHG and OSM are additionally used for the quality assessment of the TanDEM-X coastline product, these datasets are described in more detail in Sect. 2.5 on reference datasets. We agree that manual operations introduce an additional source of positional uncertainty due to operator-dependent interpretation, and we will state this explicitly as a limitation in the revised manuscript in Sect. 3.3 "Uncertainties and limitations of the TanDEM-X coastline product" (see also AR2.7).

CM2.8: For manual corrections, reference data are required. As coastline datasets, the GSHHG (Wessel and Smith, 1996), OSM (OSM, 2022) and HydroSHEDS v1 products (Lehner et al., 2008) were considered. Furthermore, the HydroLAKES database (Messenger et al., 2016) as well as high-resolution satellite basemap imagery (imagery © Google and respective data providers varying by location and date) supported the manual correction. The HydroSHEDS v1 database (Lehner et al., 2008) contains a landmask boundary of its hydrographic data. The HydroSHEDS database is derived from the DEM created within the Shuttle Radar Topography Mission SRTM and acquired in 2000, and filled with HYDRO1k elevation data north of 60°N. Correspondingly, the landmask boundary has a resolution of approximately 90 meters, and 500 meters north of 60°N. As global, standardized hydrographic dataset, the coastline extracted from the HydroSHEDS v1 database is valuable as reference dataset during the post-processing of the TanDEM-X coastline but omitted in the quality assessment due to its relatively low resolution. The HydroLAKES database presents lakes, including some lagoons, as vector shorelines at global extent. It was created from a variety of source datasets at different resolutions and scales.

RC2.9: *The tidal stage at the time of SAR image acquisition is not mentioned. Given that coastline position, particularly in tidal flats, estuaries, and other low-relief coastal zones, can shift substantially with tide, this is a significant omission that should be addressed, either by reporting how tidal stage was accounted for (or not) or by discussing it as a limitation.*

AR2.9: We agree that the tidal stage at the time of acquisition is an important factor affecting the coastline position, particularly in tidal flats, estuaries, and other low-relief coastal zones. The tidal

stage was not explicitly accounted for during the acquisition or processing of the TanDEM-X data. For TanDEM-X, typically two to four acquisitions were taken under randomly occurring tidal conditions and combined into a mosaic. No individual timestamp can be resolved for a given location or coastline segment. Consequently, no coastline change within this acquisition window can be identified or reported. Therefore, we have added this point in the manuscript as a limitation of the product, noting that in tidally influenced areas, the extracted coastline reflects the water level at the time of the respective SAR acquisitions rather than a defined tidal datum (e.g., mean sea level or mean high water).

CM2.9: A source of uncertainty arises from the multi-year acquisition and mosaicking of the TanDEM-X DEM and its ancillary layers, which were collected between 2010 and 2015 and fused at the pixel level via weighted averaging. As a result, the coastline product does not correspond to a specific date or time. In particular, the tidal stage at the time of each individual SAR acquisition is not known or corrected, and its influence on the resulting coastline position is therefore not quantifiable. Across multiple mosaicked acquisitions, this influence is effectively randomized and smoothed rather than removed. Particularly along sandy and tidally influenced coasts and in dependence of the purpose outside of the refinement of the TanDEM-X DEM and HydroSHEDS v2, this unawareness can be considered a limitation.

RC2.10: *Source data were acquired between 2010 and 2015, yet the manuscript does not discuss how coastal changes occurring across this ~5-year window are handled or how they affect the internal consistency of a product presented as a single, static, "globally consistent" dataset.*

AR2.10: The TanDEM-X coastline is derived from a single, mosaicked DEM product generated from acquisitions made between 2010 and 2015. However, the acquisitions for a local area were usually captured within a much shorter period than the 5-year period mentioned. The underpinning DEM merges multiple acquisitions into one static raster. More precisely, a TanDEM-X elevation value reflects the weighted average elevation from all acquisitions for a specific pixel. These weights are proportional to the pixel's coherence. This means that the lowest water levels are mainly preserved because pixels with temporary water cover have only a marginal influence on the elevation (i.e., due to a low coherence). Altogether, the effect of jumps between image frames is minimal, because there is a smoothing in transitional areas on one hand, and the ground sampling distance is already 10 meters on the other hand. Therefore, the five-year acquisition period influences the mosaicked DEM but this appears to be negligible on a global scale. A detail on this topic has been added to the description of the input data (Sect. 2.1).

CM2.10: The elevation value of the TanDEM-X DEM as well as the pixel values of the ancillary quality layers are the result of a weighted averaging of data that were acquired over a time span of up to four years. As such, the data do not refer to a specific date or time, nor are tidal effects accounted for.

RC2.11: *Please provide a clear list of all files and formats delivered with the dataset, e.g., whether the coastline is available as both polygon and line GeoPackages, whether a raster version is also provided, whether the product is available as regional/continental subsets in addition to a single global file, and whether a file documenting acquisition time per coastline segment is included. This information is currently missing and is important for usability.*

AR2.11: We have added further details to the description of the delivered data in the manuscript. The TanDEM-X coastline is provided as a MultiPolygon vector product, in both GeoPackage and Shapefile formats. No raster version is provided. The dataset is delivered as a single global file, without regional or continental subdivision. The coastline geometry is not segmented, and, as the

underlying TanDEM-X DEM does not retain acquisition-time information at the pixel/segment level, no per-segment acquisition time documentation is included.

CM2.11: The coastline product is delivered as a Multipolygon that outlines all landmasses in both GeoPackage (.gpk) and Shapefile formats (.shp). It is provided in WGS 1984 World Mercator projection (EPSG:3395).

RC2.12: *When comparing against other coastline products, how do the authors account for natural coastline variability between the TanDEM-X acquisition period and the acquisition period of the reference data? Without addressing this, apparent disagreement between products could reflect real coastal change rather than product error (or vice versa).*

AR2.12: We thank the reviewer for raising this question. We were concerned about simply providing quantitative accuracy numbers, so we placed a strong emphasis in our paper on the qualitative analysis of the variations along the coast. To account for natural coastline variability, we chose to perform an intensive visual assessment as part of the validation. This allows us to discuss the characteristics of different coastline products. A true product error cannot be determined, since no single "correct" coastline exists. Each product rather reflects a particular definition of the coastline (see Sect. 1, Introduction) as well as the specific data and methods from which it was derived (see Sect. 2.5, Reference data). The influence of real coastal change is discussed for several examples, including natural processes at islands, mudflats, and ice sheets, as well as human activities in the coastal zone. The study area of the island of Juist illustrates how coastline position depends on both the time of data acquisition (tides, erosion, and deposition) and the criteria used to define it (e.g., placement at the water–sand boundary versus closer to the vegetation scarp). While for individual examples one coastline product may better capture a specific feature or local characteristic, no single product can be considered categorically superior to the others across all coastal settings at a larger scale.

RC2.13: *As currently written, the sections 4.1 & 4.2 primarily describe the validation methodology rather than presenting and interpreting results. Please restructure so that the actual comparison outcomes and their implications for product quality are discussed, separate from the methodological description.*

AR2.13: We thank the reviewer for this comment. We agree that methodology and results should be clearly separated and have substantially restructured the manuscript accordingly. Validation methodology (including the description of reference datasets and the validation strategy) is now presented in the *Data and methods* chapter 2, while the actual comparison outcomes and their implications for product quality are presented and discussed in a dedicated *Validation results and discussion* chapter 3.

RC2.14: *Rather than focusing on a specific glacier (e.g., Petermann) and its individual retreat history, I would recommend a more general discussion of marine-terminating glaciers and floating ice tongues, and their particular challenges for coastline mapping. This would also be a natural place to reference dedicated efforts addressing highly dynamic marine-terminating glacier fronts, such as AutoTerm and Greene et al. 2024 (<https://doi.org/10.1038/s41586-023-06863-2>).*

AR2.14: We appreciate the reviewer's suggestion, the reference to Greene et al. (2024) and AutoTerm, and their efforts addressing highly dynamic marine-terminating glacier fronts. However, we consider a general discussion of marine-terminating glaciers and floating ice tongues to be beyond the scope of this manuscript. We included the Petermann Glacier as a representative example in the manuscript, to illustrate the specific challenges and limitations of coastline mapping in such highly dynamic settings. These include that (1) the ice front position can change substantially

within the multi-year (2010–2015) TanDEM-X acquisition window, so the extracted coastline does not represent a single, well-defined moment in time; (2) the definition of the coastline itself is ambiguous at floating ice tongues, where it is unclear whether the boundary should correspond to the grounding line, the ice front, or another feature, and different reference products may place this boundary differently; (3) similar radar backscatter and elevation signatures between floating ice, grounded ice, and sea ice can hinder reliable automated extraction, often requiring additional manual correction; and (4) seasonal and interannual advance, retreat, and calving mean that the true coastline position is inherently a moving target, so that even an idealized, error-free extraction would only be representative of the specific acquisition date. We further note that these factors, together with the fact that existing reference coastline products are not updated at a frequency capturing glacier dynamics, mean that a statistical accuracy comparison is not meaningful in such areas.

RC2.15: *This is, in my view, the manuscript's main shortcoming: nowhere is an absolute horizontal accuracy value provided for the coastline product. This is the single most important number for a reader to assess whether the product is fit for their purpose, and its absence undermines the "overall high quality" claims made throughout (see also my comment on L463).*

AR2.15: In summary, we agree that an absolute horizontal accuracy value is highly desirable, but do not consider it reliably obtainable at global scale due to the absence of a true reference coastline. We have revised the manuscript throughout to remove unqualified "high quality" claims. To ensure a more reliable quality assessments, we have added two additional global benchmarks—S2Coast-2023 and OSM—to our quantitative comparisons, in addition to the local benchmarks (update in Table 3). Together with a qualitative discussion of the different coastal settings, that illustrates characteristics of the TanDEM-X coastline, the quality of the coastline product is described. Altogether, this comment as been raised in previous comments and L463. We have addressed the issue of not providing one figure for absolute horizontal accuracy and revised the manuscript accordingly.

CM2.15:

Table 3: Comparison of the TanDEM-X coastline with local reference coastlines considering the LfU coastline for study areas in Germany, CUSP for Alaska and DEA for Australia. The TanDEM-X coastline is further evaluated against OSM and S2Coast-2023 coastlines at all eight study areas.

Study area	Region	Reference	Sample points [-]	Maximum distance [m]	Mean distance [m]	Standard deviation [m]
Bodde	Western Pomerania, Germany	LfU	58,782	351.65	18.04	25.08
		OSM		307.30	19.27	21.08
		S2Coast-2023		337.14	20.48	23.81
Firth	Kiel, Germany	LfU	11,687	137.31	13.43	14.24
		OSM		192.19	13.93	15.90
		S2Coast-2023		166.92	15.89	18.95
Fjord 1	Kenai Fjords NP, Alaska	CUSP	4,777	233.01	14.86	25.57
		OSM		148.50	17.04	19.35
		S2Coast-2023		148.50	17.04	19.35
Fjord 2	Lysefjord, Norway	-	44,049	-	-	-
		OSM		250.42	14.11	16.21
		S2Coast-2023		138.56	12.90	13.71
Ria	Ria Baixas, Spain	-	10,636	-	-	-
		OSM		297.46	14.68	31.16
		S2Coast-2023		1,693.43	77.60	256.78
Steep Coast 1	Rügen, Germany	LfU	1,901	54.33	13.89	11.14
		OSM		62.00	14.04	11.14
		S2Coast-2023		61.67	17.28	12.43
Steep Coast 2	Nullarbor NP, Australia	DEA	6,328	69.33	16.16	12.97
		OSM		204.09	36.09	32.04
		S2Coast-2023		74.37	15.96	12.39
Sandy Coast	KwaZulu-Natal province, South African	-	849	-	-	-
		OSM		98.08	34.46	22.09
		S2Coast-2023		104.59	30.83	20.57

Specific comments

L9–10: Please add "<https://doi.org/>" in front of the DOI so it resolves as a clickable link.

AR: Thank you for the comment, we have added <https://doi.org/> in front of the DOIs.

L10: Delete the first occurrence of "TanDEM-X" in this sentence. It is redundant with "TanDEM-X DEM product" later in the same sentence.

A10: We have deleted one "TanDEM-X".

L11: Please clarify which vector product is meant here: the coastline product itself? The sentence is also unclear on the direction of causality: the coastline is stated to be derived from the TanDEM-X DEM, yet this sentence states it was developed to refine the DEM.

AR11: As noted in our response to comment **RC2.3**, we have restructured the abstract. To clarify the causality: both directions are correct but refer to different stages of the workflow. The coastline is initially derived from the unedited TanDEM-X DEM data, and subsequently used to refine and produce the final, edited TanDEM-X DEM product. We will make this distinction explicit in the revised abstract to avoid this misunderstanding for other readers.

L13: Please define HydroSHEDS v2.0 on first use or remove the reference if it is not essential here.

AR13: We agree and have added a brief appositive clarifying that HydroSHEDS v2 is a global hydrographic database on first mention.

L14: Please clarify the mechanism by which a coastline product defines the outer boundary of watersheds and rivers. As written, this causal link is not self-evident to a reader unfamiliar with the HydroSHEDS workflow.

AR14: We agree and have clarified this mechanism in the introduction by specifying that the coastline defines the outer, seaward boundary along which the terrestrial hydrological network terminates. This is what determines whether rivers emptying into the same bay belong to the same or distinct watersheds.

CM14: At the same time, the TanDEM-X coastline defines the outer, seaward boundary along which the terrestrial hydrological network terminates.

L15–17: This sentence does not add new information. It effectively states that a coastal feature is located in the coastal zone, and that mapped features generally depend on source data, method, acquisition time, and purpose. Consider removing it or replacing it with a more specific statement about what this means for the TanDEM-X coastline product itself.

AR15-17: We agree and have restructured the abstract following **RC2.3**.

L17–18: Please define "true reference data" and briefly explain why it is unavailable for coastline validation (e.g., no globally consistent ground-truth coastline exists at comparable resolution/accuracy).

AR17-18: We will clarify this in the manuscript. By "true reference data" we mean a globally consistent, ground-truth coastline of higher resolution and accuracy against which the TanDEM-X coastline could be directly validated. As discussed in Sect. 2.6, no such dataset exists globally. We included local/national reference coastlines of sufficiently high accuracy, and existing global coastline products. These coastline products are subject to their own definitions, source data, and uncertainties, and therefore cannot serve as absolute ground truth.

CM17-18: To validate the TanDEM-X coastline by determining its absolute horizontal positional accuracy, a coastline dataset of well-established, higher accuracy would be required as ground truth. However, since no single reference dataset offers such reliable, consistently high accuracy across all coastal environments worldwide, we instead assess the product's quality through a combination of quantitative and qualitative comparisons against multiple existing high-resolution coastline products.

[...]

The quantitative statistical comparison is restricted to coastal study areas where the compared coastlines follow a broadly consistent path, whereas more complex coastal settings are instead evaluated through visual comparison.

L18-20: Comparison against multiple existing coastline products is reasonable, but as written this does not communicate what distinguishes your product's quality or accuracy from those alternatives. Please state the outcome of this evaluation.

AR18-20: We agree and have rewritten the abstract accordingly. Specifically, we have included further details on the statistical and qualitative comparison such as headline figures as well as a reference to coastal areas with larger deviations including sandy and bodden coasts in the statistical assessment where as the visual comparison shows the largest deviations at river deltas, mangroves and tidal flats. This is intended to communicate what distinguishes the TanDEM-X coastline's quality from the compared products.

CM18-20: Against high-accuracy local reference datasets, the TanDEM-X coastline shows a mean distance and standard deviation between 13 and 35 m. Larger deviations are observed along sandy coasts in the quantitative assessment and at tidal flats and transitional water bodies in the qualitative comparison.

L22-27: I agree with the general reasoning, but there are considerably more reasons why coastline mapping matters, and the manuscript undersells its own product by not engaging with this literature. Please see Vos et al. (2019, <https://doi.org/10.1016/j.envsoft.2019.104528>) for well-articulated reasoning on the importance of coastline mapping. More generally, I am surprised the manuscript does not include any comparison with Vos et al.'s CoastSat, given its prominence in the field.

AR22-27: We thank the reviewer for pointing us to Vos et al. (2019). We have expanded the motivation in the introduction to include additional reasoning on the importance of coastline mapping, citing this reference accordingly. Coastal zones are highly urbanized and are of major recreational, environmental, and economic importance, while being subject to a range of natural and anthropogenic drivers, including sea-level changes, wave forcing, storm surges, and river discharge. As highlighted by Vos et al. (2019), monitoring and quantifying these changes is essential for understanding past and ongoing coastal dynamics, while shoreline position provides a key indicator of coastal evolution. Reliable shoreline data are further required to characterize historical beach behavior and to support the calibration of numerical models. However, conventional in-situ observations are spatially and temporally limited, highlighting the value of satellite-based observations for large-scale and long-term coastal monitoring. The importance of coastline mapping datasets as described by Vos et al. (2019) consequently focusses on the temporal development of coastline position.

In this regard, we understand CoastSat primarily as a tool/algorithm for deriving shorelines from satellite imagery at user-defined sites to create coastline time series at a local scale suitable for regional policy makers, rather than being a pre-existing global coastline product. It is thus not comparable to other reference datasets in Table 1, which we used for comparison. While approaches

such as CoastSat enable the extraction of time series of shoreline positions from satellite imagery, a globally continuous and consistently derived coastline can provide a complementary spatial reference for coastal research.

CM22-27: In particular, monitoring coastline position and change is essential given the increasing exposure of densely populated and economically important coastal regions to these hazards (Vos et al. 2019).

L38: I still do not understand how the TanDEM-X-derived coastline improves the DEM. Please explain this mechanism in more detail.

AR38: We have revised the manuscript to clarify this mechanism. As inherent to radar-based DEMs, open water surfaces appear rough due to decorrelation effects (i.e., ocean pixels appear “noisy”). Therefore, the editing of ocean pixels is required. What areas are considered being ocean pixels is defined by the TanDEM-X coastline. Where there is ocean according to the TanDEM-X coastline, noisy height values are replaced with interpolated geoid heights that correspond to mean sea level. In this way, the coastline directly informs and enables the DEM editing process over ocean areas.

CM38: The coastline defines the boundary over which the editing is applied, enabling to identify noisy DEM values over the ocean and replacing them with interpolated geoidal heights. The edited ocean heights correspond to mean sea level.

L40: How is “well-established” defined here? I would recommend removing this term unless it can be substantiated.

AR40: “Well-established” has here used as long-standing and widely used. We did nonetheless remove “well-established,” as this qualifier is not essential to the sentence.

L54–60: I would not use “coastline” and “shoreline” interchangeably. A shoreline is the exact, constantly changing line where water meets land, shifting over short timescales. A coastline is a broader, more permanent boundary marking the general limit of the landmass meeting the sea, encompassing the wider zone affected by coastal and marine processes.

AR54-60: We agree with this distinction and have revised the manuscript accordingly. We consistently use the term “coastline” throughout but retain “shoreline” where referring directly to products or works that use the terminology “shoreline” themselves (e.g., product names).

CM54-60: In the following, we consistently use the term ‘coastline’. However, where other products or referenced works use ‘shoreline’, we retain the original terminology.

L61: Here the coastline is correctly described as a dynamic feature changing over time and space, which is inconsistent with L55, where it is described as a one-dimensional feature without transitional or dynamic extent. Please reconcile this discrepancy by revising L55.

AR61: We agree that there is an apparent inconsistency but would like to clarify that L55 and L61 describe two different aspects of the coastline. L55 refers to the geometric definition of the coastline as a mapping feature (“coastline data product”), i.e., one-dimensional and without width, while L61 refers to the coastline as a real-world, physical feature whose position is dynamic and changes over time and space. We will revise L55 to make this distinction explicit and avoid the impression of an inconsistency.

CM61: This refers to a coastline’s cartographic representation, which is independent of the coastline’s dynamic, real-world behavior described in the following.

L63: Coastline change through deposition and erosion can also occur very rapidly. Please avoid implying these processes are inherently slow.

AR63: We have rephrased the sentence to remove the "long-term scale", because deposition and erosion can occur both gradually and rapidly.

CM63: The position of the coastline varies due to sediment transport either through deposition or erosion as well as due to sea level rise and tectonic uplift or subsidence on longer temporal scales.

L63–64: Use either "deposition and erosion" or "depositional and erosional processes". The current phrasing mixes both forms.

AR63–64: We have revised the manuscript to consistently use "deposition and erosion".

L65: What about anthropogenic coastline change? See, for example, Sengupta et al. 2025 (<https://doi.org/10.1016/j.ocecoaman.2025.107579>).

AR65: We thank the reviewer for this reference. We agree that anthropogenic drivers are an important cause of coastline change alongside natural processes, which is why an example for human-made coastlines is included in the qualitative comparison in Sect. 3.2. We have consequently also added anthropogenic causes as an important driver to coastline change to the introduction. Mentaschi (2018) and Sengupta (2023) provide global, quantitative evidence of anthropogenic drivers of coastline change and land reclamation.

CM65: Beyond natural drivers, anthropogenic activity has been identified as a dominant factor of coastline change on a global scale, both directly through construction and land reclamation or indirectly for example by altering the sediment flow (Mentaschi et al., 2018; Sengupta et al., 2023).

L84: How should the "10 m spatial resolution" of a vector dataset be interpreted here? Is the implication that the mapped coastline lies within 10 m of the true coastline? If so, this should be stated explicitly and substantiated; if not, please clarify what the stated resolution actually means for the vector product.

AR84: The stated "10 m spatial resolution" does not imply that the mapped TanDEM-X coastline lies within 10 m of a "true" coastline. As noted in our response to a previous comment, no true reference coastline exists against which such a distance could be measured. Rather, the stated resolution refers to two related aspects of the product: (1) the coastline was derived from raster source data (TanDEM-X DEM and ancillary layers) with a grid-cell resolution corresponding to approximately 10 m, and (2) the minimum spacing enforced between consecutive vertices of the resulting vector polygon is 10 m. As already indicated in our response and change in manuscript above, we have adapted the corresponding phrasing in the manuscript to make this distinction explicit and to avoid implying a direct link between the stated resolution and absolute positional accuracy.

L89: This does not appear to be accurate. I have observed many locations where vertices are spaced considerably further apart than stated.

AR89: We believe this is a misunderstanding of the term "minimum spacing." The 10 m spacing refers to a lower bound, i.e., no two consecutive vertices are placed closer than 10 m apart. It does not imply a maximum or average spacing. Along straight or gently curved stretches of coast, where no directional change requires an additional vertex, the spacing can therefore be considerably larger than 10 m. This is consistent with the reviewer's observation. To avoid this ambiguity for other readers, we have rephrased the corresponding sentence in the manuscript to state explicitly that only a minimum vertex spacing is enforced and that no maximum spacing applies.

CM89: However, no maximum spacing is enforced, so vertex spacing can be considerably larger along straight or gently curved stretches of the coast.

L172–174: This sentence is unclear as written: "exceed a certain threshold... assigned to the land or water mask, respectively" does not logically follow, since a single exceedance condition cannot map to two different outcomes via "respectively." Presumably pixels above the threshold are assigned to one class (e.g., land) and pixels at or below the threshold to the other (e.g., water). Please rephrase accordingly.

AR172-174: We have rephrased the sentences to improve the logic to readers. Attributing a pixel to either the land or water class is not as straightforward as one would assume, because pixel values in the coastal zone are not sufficiently reliable. Elevation values above mean sea level may occur in the DEM above open water areas due to the noise in the radar signal. Therefore, the pixel can only be assigned to the land or water class when evaluating HEM and AMP in addition. Because DEM, AMP, and HEM always are interrelated due to the SAR characteristics, the information obtained from the three layers is not contradictory.

CM172-174: The thresholds for the layer DEM, AMP, or HEM determine whether a pixel is assigned to the land or water mask. The threshold is a fixed value assigned to each layer. However, it can be modified for each individual tile. This allows to adapt the processing to local conditions prevailing during data acquisition, e.g. frozen water. Open water areas generally 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. An elevation value above mean sea level in the DEM is, however, not a reliable indicator of land, because similar or even higher elevation values occur in noisy open water areas. Therefore, all input layers must be analyzed in combination.

L198–200: The 0.4 arcsecond resolution of the source DEM cannot simply be "transferred" to the vector coastline product. Raster resolution and vector positional accuracy are not equivalent, and the vectorization process (thresholding, morphological dilation/erosion, manual editing) introduces its own uncertainty that is not necessarily bounded by the original pixel size. Please either provide a quantitative positional accuracy assessment of the vector product to substantiate this claim, or rephrase to avoid implying a direct, lossless transfer of raster resolution to vector geometry.

AR198-200: We agree and have rephrased this sentence to avoid implying a direct, lossless transfer of raster resolution to the coastline vector's positional accuracy. We now state that the raster resolution provides a reference scale for the vector product, while its actual positional accuracy is assessed through the validation presented in chapter 3. The sentence has been removed in the updated version of the manuscript.

L235: What is the "certain minimum distance"? Please state the specific value.

AR235: We clarify that there is no fixed, user-defined "minimum distance" threshold applied in the processing. Rather, this refers to an effect of the underpinning 10-m raster grid: whether two nearby small islands are represented as separate features or merged into one depends on the real-world size of the mapped feature, how their true positions align with the raster grid cells, and is not governed by a single defined distance value. We have revised the manuscript to clarify this and avoid implying a specific, quantifiable threshold.

CM235: Furthermore, whether neighboring islands or an island and the mainland are detectable as separate features depends on their spacing relative to the underpinning 10 m raster grid, as sub-pixel alignment can cause closely spaced features to appear merged or distinct.

Figure 3: How were these sites selected? Are the red boxes shown to scale? Why do the sites appear in several distinct clusters rather than a more even global distribution?

AR: Study sites were selected to cover a broad range of representative coastal types and their associated challenges for coastline extraction, as outlined in the classification in Table 2 and Sect. 2.6 (e.g., steep coasts, deltas, mangroves, ice shelves, land reclamation areas). Selection was further guided by the availability of suitable high-accuracy local reference datasets for the statistical comparison (Sect. 3.1). The availability of local/national coastline products provided by authorities caused a selection of multiple study areas in Australia, Germany, and the USA. This availability constraint, combined with the aim of covering diverse coastal types, explains why sites appear in several regional clusters rather than a globally even distribution. The red boxes in Figure 3 are not shown to scale. We have clarified this in the figure caption. Furthermore, we have modified Figure 3 to differentiate study areas for quantitative and qualitative assessment.

L273: What are the "certain limitations" of the radar system? Please be specific.

AR273: We have revised this sentence to specify the relevant limitations explicitly. In particular, these include layover and shadow effects in steep terrain (e.g., at fjords and cliffs), and the similarity in radar backscatter between wet sand and open water (e.g., at lagoons, mudflats, and sandy beaches). These are inherent characteristics of the radar data that shape how the coastline can be delineated in these coastal settings.

CM273: Furthermore, certain limitations of the radar system itself, such as layover and shadow effects, affect the appearance of coastal areas, e.g., at fjords where terrain is very steep.

L283–291: This reads more like a figure caption than manuscript text. Consider moving this information into Table 3 with a clear reference to the site locations (red boxes) shown in Figure 3. Also, why does Figure 3 show considerably more red boxes than are described in the text or listed in Table 3?

AR283–291: We thank the reviewer for pointing this out and have shifted parts of the description to the figure caption of Table 3.

Figure 3 includes more locations than Table 3, because Table 3 only presents results of the quantitative analysis, while Figure 3 additionally includes all study areas from the qualitative assessment. For improved clarity, study areas are now shown in different colors. The study areas selected for the statistical comparison are limited to coastal areas where different coastline products generally represent the same physical coastline.

Table 3: What distinguishes Fjord 1 from Fjord 2, or Steep Coast 1 from Steep Coast 2? There also appears to be a strong bias toward Northern Hemisphere sites. Why are not all sites shown in Figure 3 listed in the table? Please also provide average values (mean and median) across all study sites, and clarify why standard deviation varies so substantially between sites despite broadly similar mean values.

AR Table 3: Fjord 1 and Fjord 2 as well as Steep Coast 1 and Steep Coast 2 show the same coastal type at a different location. Multiple sites were chosen when different local references were available for a coastal type. For example, two study areas were chosen for steep coasts because local high-resolution reference datasets are available for Australia and Germany. Similar, there appears to be a bias towards Northern Hemisphere sites, because of the availability of national reference coastlines for Australia, Germany, and USA and the main purpose of the statistical comparison to utilize higher resolution products. Similarly, Table 3 only lists the study area where coastlines follow a similar physical representation of the coastline. The remaining test sites are covered in the

qualitative comparison discussing the differences between coastlines. Regarding the qualitative comparison, the standard deviation is in a similar order of magnitude to the mean distance. When the standard deviation is larger, this typically coincides with a larger maximum distance. Without visual proof, the maximum distance indicates whether two coastlines show larger discrepancies, e.g. by cutting off fjords, rias or bays of a bodden at different locations. For the updated Table 3, please refer to **CM2.15**.

L308–309: How much is "relatively high" and "comparatively short"? What does "detailed assessment" refer to specifically? Please provide concrete figures.

AR308–309: We have rephrased the corresponding description in the paragraph and replaced the vague qualifiers with concrete figures. Furthermore, we have specified the wording for "detailed assessment".

CM308–309: For the Sandy Coast study area in KwaZulu-Natal Province, South Africa, the mean distances to OSM and S2Coast-2023 are approximately twice those observed for the two steep coast study areas, whereas the maximum distances remains around 100 m and is, thus, lower than those observed for the Bodden, Firth, and Fjord study areas.

L312–328: Given the coastline paradox, comparing total coastline length across products has limited value. I would instead like to see a proper quantitative uncertainty assessment, specifically, what is the absolute horizontal accuracy of your coastline product? This is the key figure needed for readers to assess product quality.

AR312–328: We agree that the total coastline length alone has limited value as a quality indicator due to the coastline paradox. The coastline lengths are presented in the manuscript only as a complementary, descriptive comparison, not as an accuracy measure. Regarding absolute horizontal accuracy, as discussed in our responses to earlier related comments, we do not consider a single global figure obtainable given the absence of a true global reference coastline. We refer the reviewer to our extended statistical analysis (Table 3 and Table 5 (Appendix)), which provides an approximate accuracy estimate for the specific coastal settings. To identify the suitability and quality of the TanDEM-X coastline for a specific purpose or specific coastal area, we furthermore suggest referring to the qualitative comparison. We have revised the manuscript to present this more clearly as the basis for assessing product quality.

L376: Replace "glacier tongues' bay" with "fjord."

AR376: We replaced "glacier tongue's bay" with "fjord".

L381: The grounding line is in fact visible in satellite imagery see for example Andersen et al. 2026 (<https://doi.org/10.5194/tc-20-1589-2026>).

AR381: We thank the reviewer for pointing us to Andersen et al. (2026). We agree that the grounding line can be identified through specialized techniques such as differential SAR interferometry. We have revised the sentence to clarify that the grounding line is not visible in the moderate to high-resolution satellite imagery underpinning the compared coastline products, but that its identification requires such specialized measurement techniques instead.

CM381: The grounding line is not visible in satellite imagery, and its identification requires complex measurements (Andersen et al. 2026).

L452: Technically, the provided DOI does not lead directly to the data, but only to the URL https://geoservice.dlr.de/web/datasets/tdm_coastline. I would suggest providing a DOI that resolves directly to the data rather than to a general webpage.

AR452: We thank the reviewer for this suggestion. We have replaced the URL such that it directs the user to the product page.

CM452: It can be accessed via the EOC Geoservice of the German Aerospace Center DLR at <https://doi.org/10.15489/entfdgi5es81>.

L463: "Overall high quality" is asserted without presenting the relevant key figures to support this claim. If I were to stand at any given point along the coast, how far would the TanDEM-X coastline be from the true coastline, and how confident are the authors in that estimate?

AR463: We have revised the wording and removed the unqualified claim of "overall high quality." The revised manuscript now states that the level of agreement between the TanDEM-X coastline and existing coastline products is not uniform, but varies considerably with coastal setting, reflecting the differing challenges posed by coastal type, source data, and the definition of the land–water boundary.

We thank the reviewer for raising this important and straightforward question and would like to use it to illustrate exactly why we do not provide a single global positional accuracy figure. The answer depends fundamentally on where along the coast, and under what conditions, this hypothetical point is located. The answer would differ depending on if the reviewer were standing in the dunes looking down onto a well-defined sandy beach or if the reviewer's feet were in the water with every incoming wave. Both points could be considered being the coastline depending on the coastline definition that is applied. In any case, the TanDEM-X coastline and the true coastline are likely to agree closely, i.e., within the range we report at our comparable test sites (see Table 3). If, however, the reviewer was standing in a branching delta or mangrove system, the very notion of a single "true coastline" becomes ambiguous, since the land-water boundary itself shifts continuously and is defined differently by different observers and products. This is precisely the reason we do not consider a single global horizontal positional accuracy figure meaningful. The answer is not primarily a limitation of our product's accuracy, but a reflection of the coastline itself being observer- and definition-dependent in many environments.

CM463: The 10-m resolution of the TanDEM-X DEM dataset determines the level of geometric detail of what can be captured during semi-automatic coastline extraction. The TanDEM-X coastline product has global coverage following the extent of the underpinning source data that were acquired between 2010 and 2015. A minimum vertex spacing of 10 m is additionally enforced during vectorization. Together, these define the resolution of the delivered product.

[...]

A quantitative evaluation with further coastline products shows that the TanDEM-X coastline is as accurate as existing global coastline products. The statistical evaluation shows a mean distance of 13–35 m to local references and global OSM or S2Coast-2023 coastlines. The qualitative comparison reveals, however, a considerable variability in agreement depending on the coastal setting, reflecting the challenges posed by coastal type, source data, and definition of the land–water boundary. Regarding transitional water bodies in the coastal zone, such as river deltas, estuaries, and lagoons, the TanDEM-X coastline attempts consistent positioning of the land-water transition line, which is informed by and benefits from the hydrological requirements established within the project HydroSHEDS v2 for which the TanDEM-X coastline provides the land boundary. This can be attributed to the manual corrections that were performed along mud flats, river delta systems and mangrove coasts.