Surface Water and Ocean Topography (SWOT) Project

Release Note
Version C KaRIn Science Data Products

March 6, 2024

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

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1 Purpose

This document serves as the Release Note for Surface Water and Ocean Topography (SWOT) Version C Ka-band Radar Interferometer (KaRIn) science data products. **Users are strongly encouraged to refer to the description of known features and issues with the Version C products before using these products (see Section 6), as well as the respective Product Description Documents (see Section 4.1).**

The SWOT KaRIn science data products consist of:

1. Global Low Rate (LR) oceanography science data products, including:
    a. Level 1B KaRIn Low Rate Interferogram Data Product (L1B_LR_INTF)
    b. Level 2 KaRIn Low Rate Sea Surface Height Data Product (L2_LR_SSH)
2. Global High Rate (HR) hydrology science data products, including:
    a. Level 1B KaRIn High Rate Single Look Complex Product (L1B_HR_SLC)
    b. Level 2 KaRIn High Rate Water Mask Pixel Cloud Product (L2_HR_PIXC)
    c. Level 2 KaRIn High Rate River Single Pass Vector Product (L2_HR_RiverSP)
    d. Level 2 KaRIn High Rate Lake Single Pass Vector Product (L2_HR_LakeSP)
    e. Level 2 KaRIn High Rate Pixel Cloud Vector Attribute Product (L2_HR_PIXCVec)
    f. Level 2 KaRIn High Rate Raster Product (L2_HR_Raster)
    g. Level 2 KaRIn High Rate River Average Vector Product (L2_HR_RiverAvg).
    h. Level 2 KaRIn High Rate Lake Average Vector Product (L2_HR_LakeAvg).
    i. Level 2 KaRIn High Rate Floodplan DEM Product (L2_HR_FPDEM)

The L2_HR_RiverAvg and L2_HR_LakeAvg products are cycle-average products and therefore only generated after the completion of a repeat cycle. They are only generated for data in the science phase of the mission. The L2_HR_FPDEM product is only generated after at least one year of science phase data products have been generated, and therefore is not currently available.

The KaRIn LR data are downlinked globally, whereas KaRIn HR data are downlinked only from regions defined by a programmable HR downlink mask. The associated LR and HR products are generated where the respective downlinked data are available. (Refer to the following presentation for more details on the HR downlink mask: https://swotst.aviso.altimetry.fr/fileadmin/user_upload/SWOTST2023/20230922_1_going_forward/10h00-SWOT_HR_Coverage_Update.pdf). Due to wildfires affecting the Inuvik downlink station, the HR downlink mask was significantly reduced from August 11, 2023 to September 15, 2023. As a result, HR products have significantly lower coverage during this period.

For reference, Table 1 provides a timeline of the primary SWOT orbit and mission phases.

Table 1. SWOT Orbit and Mission Phase Timeline

Date	Orbit and Mission Phase
December 16, 2022	Launch
December 16 - 24, 2023	Launch and Early Operations Phase (LEOP)
December 16 – January 14, 2023	Orbit Maneuvers and Drift
January 14, 2023	Start of 1-day Repeat Orbit
January 3 – March 30, 2023	Commissioning Phase
March 30 – July 10, 2023	Calibration Phase
July 11 – July 20, 2023	Orbit Maneuvers and Drift
July 21, 2023	Start of 21-day Repeat Orbit
July 21, 2023	Science Phase Begins (no useful KaRIn data until July 26)

2 Scope of Product Release

The best available science data processing algorithms have been applied into the operational forward processing of KaRIn data from January 25, 2024 (repeat cycle 10 of science phase) onward. The same algorithms are also being used to reprocess all available data from March 30, 2023 to January 25, 2024 (repeat cycles 475-578 of calibration phase, and repeat cycles 1-9 of science phase).

At this time, all KaRIn LR and HR science data products from the operational processing of cycle 10 onward are being released. This release also includes forward-processed KaRIn LR products from November 23, 2023 to January 25, 2024 (cycles 7-9), as the LR science data processing algorithms have been stable since then. The forward-processed LR products from cycles 7-9 will be superseded by reprocessed LR products when they become available using higher accuracy ancillary data.

Reprocessing of science data products from March 30, 2023 to January 25, 2024 is ongoing. They will gradually be released as they become available over the next few weeks. Users will be provided with updates on data product availability. We expect to have reprocessed LR products become available earlier than the HR products, by the very nature of the processing flow and respective data volumes.

Forward and reprocessed science data products can be identified by a field in the product file names, as described in Section 3 below.

As a reminder, SWOT nadir altimeter and microwave radiometer Operational and Interim Geophysical Data Records (OGDRs and IGDRs) have already been available since July 2023. The validated Geophysical Data Records (GDRs) were released on February 28, 2024.

3 Product Version Identifier

As described in each of the KaRIn product description documents (see Section 4), all KaRIn science data products include a Composite Release IDentifier (CRID) and a Product Counter in the individual product file names, for example <CRID>_<ProductCounter>.

The CRID consists of four characters. The first character is always "P". The second character can be used to distinguish between forward-processed and reprocessed products, where "I" is used for forward processed products, and "G" is used for reprocessed products. The third character identifies the major product version number, which is "C" for this release. The fourth character identifies minor changes to the version and in this release is currently set to 0. So for example, in this release, the CRID has values of:

1. PIC0 for forward-processed version C products.
2. PGC0 for reprocessed version C products.

Where PIC0 and PGC0 products both exist for a particular time, users are advised to use the PGC0 products. This is expected when reprocessed LR products are generated for cycles 7-9.

The Product Counter reflects the number of attempts made by the automated production system to generate the particular granule (product file). It will typically have a value of "01". Users are advised to use the product with the highest Product Counter.

4 User Documentation

4.1 Product Description Documents

Product description documents for all of the products in this release are available at: https://podaac.jpl.nasa.gov/swot?tab=datasets-information&sections=about.

4.2 Algorithm Theoretical Basis Documents

Algorithm Theoretical Basis Documents describe the algorithms that are used to perform the ground processing of instrument data. These documents are available at: https://podaac.jpl.nasa.gov/swot?tab=datasets-information&sections=about.

4.3 Satellite Events Impacting Data Quality and Availability

Satellite events that impact data quality and availability are updated regularly and provided at: https://podaac.jpl.nasa.gov/SWOT?tab=mission-events&sections=about%2Bdata%2Bnews

4.4 User Feedback

The SWOT KaRIn measurement system, science data processing algorithms, and science data products are all novel. Our experience and knowledge of their features and issues are expected to continually evolve. **Users are strongly encouraged to review Section 6 below for the**

currently known features and issues. Nevertheless, we welcome user feedback on features and issues not identified in Section 6. User feedback can be provided via:

- Email to podaac@podaac.jpl.nasa.gov or through the PODAAC forum topic titled "SWOT Data Product User Feedback". The PODAAC forum is at: https://forum.earthdata.nasa.gov/viewforum.php?f=7&tagMatch=all&DAAC=146&keywords=&.
- Email to exp.hysope2@cnes.fr or simply using the "contact us" icon on https://hydroweb.next.theia-land.fr.

5 Data Access

Identical SWOT data can be accessed from both the CNES and NASA PO.DAAC data centers. Access details are provided below.

5.1 NASA PO.DAAC

The KaRIn datasets in this release are available through NASA Earthdata Search client (https://search.earthdata.nasa.gov/search?q=SWOT_*_2.0) and downloadable using PO.DAAC scripts by their unique collection IDs, which are given in the table below with usage examples for each dataset. Additional tips for searching HR data products can be found in the PO.DAAC Cookbook - SWOT Chapter.

Table 2. PO.DAAC KaRIn Data Collection IDs and Examples to Access

NASA PO.DAAC Collection ID	Dataset Name	Example data access script (Obtain PO.DAAC data download tool)
SWOT_L1B_LR_INTF_2.0 DOI:10.5067/SWOT-INTF-2.0	Level 1B KaRIn Low Rate Interferogram Data Product (Reprocessed calibration phase data)	INTF products for 2023-11-23 to 2024-03-06: podaac-data-downloader -c SWOT_L1B_LR_INTF_2.0 -d ./SWOT_L1B_LR_INTF_2.0/ --start-date 2023-11-23T00:00:00Z –end-date 2024-03-06T23:59:59Z
SWOT_L2_LR_SSH_2.0 DOI:10.5067/SWOT-SSH-2.0 Sub-collections: • Basic • Expert • Windwave • Unsmoothed	Level 2 KaRIn Low Rate Sea Surface Height Data Product (Reprocessed calibration phase data)	SSH products for 2023-11-23 to 2024-03-06: podaac-data-downloader -c SWOT_L2_LR_SSH_2.0 -d ./SWOT_L2_LR_SSH_2.0/ --start-date 2023-11-23T00:00:00Z –end-date 2024-03-06T23:59:59Z
SWOT_L1B_HR_SLC_2.0 DOI:10.5067/SWOT-SLC-2.0	Level 1B KaRIn High Rate Single Look Complex Product	SLC products for 2024-01-25 to 2024-03-06:

		podaac-data-downloader -c SWOT_L1B_HR_SLC_2.0 -d ./SWOT_L1B_HR_SLC_2.0/ --start-date 2024-01-25T00:00:00Z --end-date 2024-03-06T23:59:59Z
SWOT_L2_HR_PIXC_2.0 DOI:10.5067/SWOT-PIXC-2.0	Level 2 KaRIn High Rate Water Mask Pixel Cloud Product	PIXC products for 2024-01-25 to 2024-03-06: podaac-data-downloader -c SWOT_L2_HR_PIXC_2.0 -d ./SWOT_L2_HR_PIXC_2.0/ --start-date 2024-01-25T00:00:00Z –end-date 2024-03-06T23:59:59Z
SWOT_L2_HR_PIXCVec_2.0 DOI:10.5067/SWOT-PIXCVEC-2.0	Level 2 KaRIn High Rate Water Mask Pixel Cloud Auxiliary Data Product	PIXC products for 2024-01-25 to 2024-03-06: podaac-data-downloader -c SWOT_L2_HR_PIXCVec_2.0 -d ./SWOT_L2_HR_PIXCVec_2.0/ --start-date 2024-01-25T00:00:00Z –end-date 2024-03-06T23:59:59Z
SWOT_L2_HR_RiverSP_2.0 DOI:10.5067/SWOT-RIVERSP-2.0 Sub-collections: • Nodes • Reaches	Level 2 KaRIn High Rate River Single Pass Vector Product	RiverSP products for 2024-01-25 to 2024-03-06: podaac-data-downloader -c SWOT_L2_HR_RiverSP_2.0 -d ./SWOT_L2_HR_RiverSP_2.0/ --start-date 2024-01-25T00:00:00Z --end-date 2024-03-06T23:59:59Z
SWOT_L2_HR_RiverAvg_2.0 DOI:10.5067/SWOT-RIVERAVG-2.0	Level 2 KaRIn High Rate River Cycle-Averaged Data Product	RiverAvg products for 2024-01-25 to 2024-03-06: podaac-data-downloader -c SWOT_L2_HR_RiverAvg_2.0 -d ./SWOT_L2_HR_RiverAvg_2.0/ --start-date 2024-01-25T00:00:00Z --end-date 2024-03-06T23:59:59Z
SWOT_L2_HR_LakeSP_2.0 DOI:10.5067/SWOT-LAKESP-2.0 Sub-collections: • Obs • Prior • Unassigned	Level 2 KaRIn High Rate Lake Single Pass Vector Product	LakeSP products for 2024-01-25 to 2024-03-06: podaac-data-downloader -c SWOT_L2_HR_LakeSP_2.0 -d ./SWOT_L2_HR_LakeSP_2.0/ --start-date 2024-01-25T00:00:00Z --end-date 2024-03-06T23:59:59Z
SWOT_L2_HR_LakeAvg_2.0 DOI:10.5067/SWOT-LAKEAVG-2.0	Level 2 KaRIn High Rate Lake Cycle-Averaged Data Product	LakeAvg products for 2024-01-25 to 2024-03-06:

		podaac-data-downloader -c SWOT_L2_HR_LakeAvg_2.0 -d ./SWOT_L2_HR_LakeAvg_2.0/ --start-date 2024-01-25T00:00:00Z --end-date 2024-03-06T23:59:59Z
SWOT_L2_HR_Raster_2.0 DOI: 10.5067/SWOT-RASTER-2.0 Sub-collections: • 100m • 250m	Level 2 KaRIn High Rate Raster Product	Raster products for 2024-01-25 to 2024-03-06: podaac-data-downloader -c SWOT_L2_HR_Raster_2.0 -d ./SWOT_L2_HR_Raster_2.0/ --start-date 2024-01-25T00:00:00Z --end-date 2024-03-06T23:59:59Z

Note: Several datasets listed in Table 2 are available through "sub-collections" that simplify access to KaRIn products that are distributed in multiple formats.

Resources for users of SWOT datasets distributed by the PO.DAAC

Note: At the time of this Release Note, data access examples provided in the resources below are being updated to use Version C (i.e. v2.0) SWOT data, but some delay may occur. (Users may still encounter remnants of examples using previous versions of SWOT data e.g. v1.1 (Beta pre-validated) for a limited time. If that is the case a similar pattern can be used with the Version C datasets (i.e. v2.0) using the SWOT collection ID listed in the table above.)

Search, Download, and Access:

- PO.DAAC Cookbook - SWOT Chapter
- PO.DAAC Data Subscriber/Downloader
  - Video tutorial on using the podaac-data-subscriber
- Data search
  - Earthdata Search (GUI)
  - Earthdata Search tutorial
  - Earthaccess python library (using CMR API on backend)
- General information about Earthdata (AWS) cloud
  - Obtain Earthdata Login Account
  - Earthdata Cloud Primer documents
  - Earthdata Common Metadata Repository (CMR) API

Subsetting and Visualization:

SSH products can be subset using the High-level Tool for Interactive Data Extraction (HiTIDE):

- SWOT_L2_LR_SSH_BASIC_2.0
- SWOT_L2_LR_SSH_EXPERT_2.0
- SWOT_L2_LR_SSH_WINDWAVE_2.0

- SWOT_L2_LR_SSH_UNSMOOTHED_2.0 products are not available in HiTIDE.

5.2 CNES AVISO

Identical KaRIn L2_LR_SSH products are also available at the CNES AVISO distribution center (https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/global/swot-karin-low-rate-ocean-products.html). They can be accessed via FTP/SFTP and a THREDDS Data Server (TDS) using AVISO+ credentials. The L1B_LR_INTF products are available by specific request only.

CNES AVISO FTP/SFTP (with AVISO+ credentials):
- FTP access: ftp://ftp-access.aviso.altimetry.fr:21/
- SFTP access: sftp://ftp-access.aviso.altimetry.fr:22/

FTP/SFTP Server Directory Main Tree
- /swot_products/l2_karin/l2_lr_ssh

CNES AVISO TDS (with AVISO+ credentials):
- TDS access: https://tds.aviso.altimetry.fr

TDS Directory Main Tree
- https://tds.aviso.altimetry.fr/thredds/L2/L2-SWOT-DATA/L2-SWOT.html

The KaRIn L2_LR_SSH products in this release are listed below along with the corresponding Digital Object Identifier (DOI) landing pages:

KaRIn L2_LR_SSH product files
* SWOT_L2_KaRIn_SSH_Basic (https://doi.org/10.24400/527896/a01-2023.013)
* SWOT_L2_KaRIn_SSH_WindWave (https://doi.org/10.24400/527896/a01-2023.014)
* SWOT_L2_KaRIn_SSH_Expert (https://doi.org/10.24400/527896/a01-2023.015)
* SWOT_L2_KaRIn_SSH_Unsmoothed (https://doi.org/10.24400/527896/a01-2023.016)

5.3 CNES hydroweb.next

The KaRIn global High Rate (HR) hydrology products can be accessed via the CNES hydroweb.next portal: https://hydroweb.next.theia-land.fr, with the exception of the Level-1B Single Look Complex products which are currently only available at PO.DAAC, see Table 3.

hydroweb.next provides a centralized access to a collection of hydrology data products complementing SWOT HR that may be of interest for users.
The following instructions will guide you through your first visit. They are not an exhaustive list of possibilities. Those can be found in the help section  .

Searching for SWOT datasets:

Once on hydroweb.next.theia-land.fr, simply type SWOT in the searchbar. This will (i) trigger an autocompletion feature proposing some SWOT dataset or (ii) if you press enter, add a SWOT keyword filter and update the results Pane accordingly. Control the filters Filters and remove unwanted ones, if any. You may also add spatial Where or temporal When filters.

Visualization:
The visualization of datasets is possible –for some datasets- once imported in your project. Some of the products are available for visualization on the map or directly as timeseries, see Table 3.

From the Results pane Results, click on "add product into project" - Project or Project- for each dataset of interest. The Project icon indicates that the dataset will be available for visualization. You can have several projects, and retrieve them when you come back, they will be automatically stored in your browser local storage.

Once added to your project Project, and if the dataset is available for visualization, the corresponding layers will appear on the map, providing:

- your map is zoomed on a region that is consistent with the spatial filters, if any, set for this dataset when you added it (filters are static once in the project)
- the timeline Timeline is set on dates compatible with the product. Contrary to spatial restrictions, you can visualize dates that where outside your time filters, if any.

You can rename all layers, change the order, group, etc just as any GIS software.

Use Select Select to click on the map. For all active layers, the select pane will show the precise values of the pixel/feature for the selected dates. For some datasets (vector datasets such as Lake Single Pass – Prior and River - Reach), a timeseries icon will appear. Click on it to visualize the time evolution in a graph.

Download:
Downloading datasets is only possible once you are logged in. You must first create an account, or use your Theia account if already have one.
Once logged in, the download icons will be unlocked. You may either download your datasets individually from the Result Results pane with Download, or download your entire Project Project with Download. In either case, this will open the download pane and propose several options:

- download an archive Product (9GB), or a sample archive Sample (516KB), in your browser *(ndlr: not recommended if the archive exceeds 10GB)*
- download a python script Script . All necessary instructions are in the script. You can also modify it later (dataset, region of interest, time restrictions), it is quite straightforward. It requires you to provide an API-Key that you can create from the settings. Your API-Key is private and has no time limitation.

Table 3. hydroweb.next KaRIn High Rate Data Dataset Names and IDs

Dataset Name	hydroweb.next Dataset ID (for STAC Search purposes)	Visualization
SWOT Level-2 HR Pixel Cloud	SWOT_L2_HR_PIXC	no
SWOT Level-2 HR River Single Pass - Reach	SWOT_L2_HR_RIVERSP_REACH	map, timeseries
SWOT Level-2 HR River Single Pass - Node	SWOT_L2_HR_RIVERSP_NODE	no
SWOT Level-2 HR Lake Single Pass - Prior	SWOT_L2_HR_LAKESP_PRIOR	map, timeseries
SWOT Level-2 HR Lake Single Pass - Observed	SWOT_L2_HR_LAKESP_OBS	no
SWOT Level-2 HR Lake Single Pass - Unassigned	SWOT_L2_HR_LAKESP_UNASSIGNED	no
SWOT Level-2 HR River Average	SWOT_L2_HR_RIVERAVG	map, timeseries
SWOT Level-2 HR Lake Average	SWOT_L2_HR_LAKEAVG	map, timeseries
SWOT Level-2 HR Pixel Cloud Vector	SWOT_L2_HR_PIXCVEC	no
SWOT Level-2 HR Raster - 100m	SWOT_L2_HR_RASTER_100M	map
SWOT Level-2 HR Raster - 250m	SWOT_L2_HR_RASTER_250M	map

Table 4: hydroweb.next ancillary datasets for SWOT

Dataset Name	hydroweb.next Dataset ID (for STAC Search purposes)	Visualization
SWOT Prior Lake Database	SWOT_PRIOR_LAKE_DATABASE	map
SWOT Prior River Database - SWORD	SWOT_PRIOR_RIVER_DATABASE	map

6 Known Features and Issues

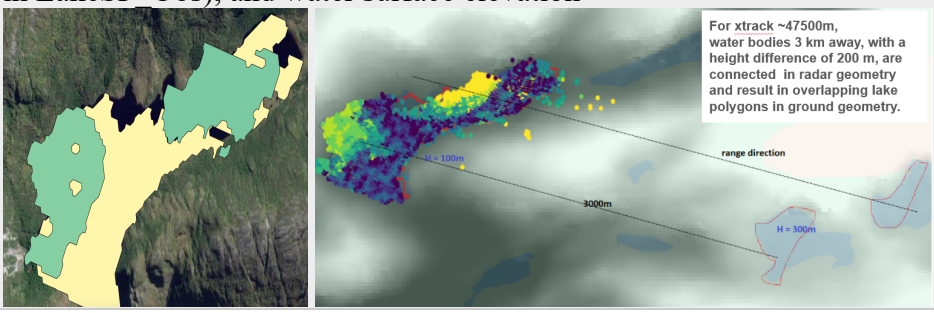
6.1 Known Features

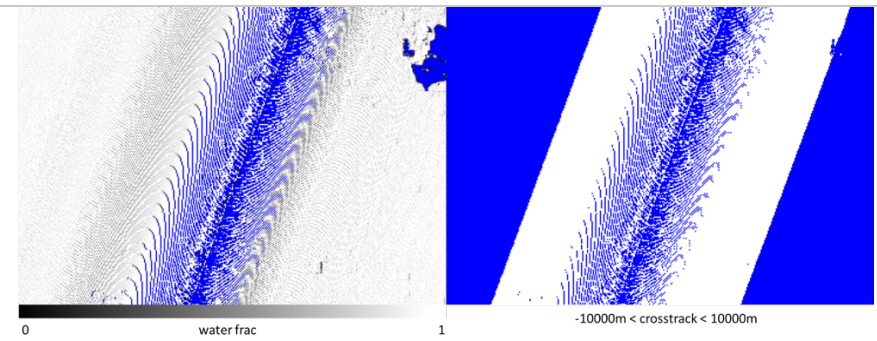
There are various known features of the SWOT measurement system, science processing algorithms, and science data products. Many of these are already described in the individual product description documents (see Section 4.1), as well as a forthcoming SWOT User Handbook. Some of these are emphasized in Table 5 below.

Table 5. Known Features of SWOT Science Data Products.

Product	Description of Feature
All	**Spacecraft Events Impact Data Quality.** Various spacecraft events will degrade the quality of the KaRIn data. These are typically flagged in the data products. These include degraded KaRIn data for a few hours after satellite maneuvers, for a few hours after satellite yaw flips, for ~15 minutes after solar panel rotations, and for a few minutes during entry and exit of solar and lunar eclipses.
All	**Solid State Recorder (SSR) Data Loss.** Some data gaps may occur due to occasional single event upsets in the SSR. Lengthy SSR data loss events are provided at https://podaac.jpl.nasa.gov/SWOT-events/SWOT_events.html.
LR Products	**Reference Surface Values In 2-km Product.** The On-Board Processor and L1B_LR_INTF reference surfaces have a much finer native spacing than the 2 km fixed grid on which they are reported in the L2_LR_SSH fixed grid products. Users are advised that these variables are for information only; they should not be treated as perfectly accurate representations of the reference surfaces. The *doppler_centroid* reported on the 2-km fixed grid is similarly intended for information only.
LR Products	**Unreliable Height Estimates Over Land and Ice.** Height estimates over land and ice are often unreliable because the LR on-board and ground processing is optimized for ocean surfaces.
L2_LR_SSH	**Crossover Correction Not Applied to Reported SSH and SSHA.** The crossover correction is reported in the product but is not applied. Large cross-track tilts will therefore be evident in the reported SSH and SSHA unless users themselves apply *height_cor_xover*.
L2_LR_SSH	**Global Attribute *good_ocean_data_percent.*** This attribute refers to the percent of the fixed grid pixels for which ocean is flagged "good". Since the SWOT swath does not fill up the entire fixed grid, this value is not expected to reach 100% (it typically maxes out at about 75%).
L2_LR_SSH	**Global Attribute *ssha_variance.*** This attribute is computed for *ssha karin 2* without *height cor xover* applied, so the variance may be larger than one might expect.
L2_LR_SSH	**Change to Sources for Sea State Bias Correction Compared to PIB0 Product Release.** The sources of significant wave height (SWH) and wind speed have changed for the computation of the sea state bias (SSB) corrections relative to the beta pre-validated (PIB0) data

	products. The SSB correction for *ssh_karin* uses the wind speed estimate from the nadir altimeter (no longer from KaRIn) for this release. The SSB correction for *ssh_karin_2* uses the SWH estimate from the ECMWF model (no longer from the nadir altimeter) for this release. The SSB correction may continue to evolve in future product releases.
L2_LR_SSH	**Discontinuity in *sea_state_bias_cor_2* correction (and therefore *ssh_karin_2* and *ssha_karin_2*) when *swh_model* becomes fill-valued (typically below 66°S, due to the presence of ice).** When entering the region where *model_swh* is fill valued, the *sea_state_bias_cor_2* correction cannot be computed and no ssb correction is applied, making *ssh_karin_2* and *ssha_karin_2* discontinuous at the boundary. Inside that region, the data is appropriately flagged since no ssb correction has been applied.
L2_LR_SSH	**Change to Mean Sea Surface Model.** The mean sea surface (MSS) used to compute SSHA from SSH is now the CNES/CLS 2022 MSS, whereas the CNES/CLS 2015 MSS was used for the beta pre-validated (PIB0) products.
HR Products	**Areas Incorrectly Flagged as Dark Water.** Areas may be incorrectly flagged as dark water where the historical occurrence of water is characterized by large changes in the actual location of the water (for example, river channels that migrate significantly). Currently unclear if this can be improved.
HR Products	**Specular Ringing.** Ringing of very bright, specular features near nadir can contaminate the measurements areas far from nadir. This may cause false detection of water and consequent errors in assigning pixels to water features in the river, lake, and raster products. This may also cause missing data that results in "holes" in some water features.
HR Products	**Phase Unwrapping Errors.** Phase unwrapping errors can cause very large errors in the height and cross-track geolocation of contiguous water features. Currently unclear if this can be improved.
HR Products	**Classification Errors.** Classification errors are not uncommon: • Dark water is common. Dark water may be flagged, but the dark water flag itself has errors. • Overdetection of water ("bright land") is common due to highly reflective features such as urban areas, ice, snow, wet fields, and layover. • Boundaries between water and land may be especially prone to classification errors
HR Products	**Layover Errors.** Layover is known to cause errors. These errors tend to be worst when bright features (including other water features) lay over into an observed water feature. They are especially significant if the desired water feature is itself dark.
L2_HR_PIXC	**Water Fraction Outside Physical Limits.** The reported water fraction may be less than 0 or greater than 1 because of noise; this field is meant to be aggregated, not used at the pixel level.

L2_HR_PIXC	**Noisy Geolocations.** Pixel-level geolocations are quite noisy (as expected), and the variability is generally larger than the pixel size itself.
L2_HR_RiverSP	**Discharge Not Yet Available.** Discharge estimates are not expected to be available in river products until after sufficient SWOT data are collected and processed to inform the selection of appropriate algorithm parameters.
L2_HR_LakeSP	**Storage Change only for a few lakes.** Storage change is only available for the following 26 lakes: • North America: Achigan, Argent, Becancour, Bois-Verts, Bouard, Brome, Brompton, Camatose, Canimina, Carre, Elgin, Kiamika, Lovering, Massawippi, Montagne-Noire, Nord-Est, Stukely, Theodore, Victoria, and Waterloo • South America: Bariri, Caconde, and Segredo • Europe: Estanyol, Fontargente, and Orient This will be progressively improved through updates of the Prior Lake Database.
L2_HR_LakeSP	**Lakes Missing From Shapefiles.** Lakes may be missing from the LakeSP_Prior and LakeSP_Obs shapefiles for several reasons: • Lake not identified in the Prior Lake Database (or with an erroneous extent or location). Note that such unknown lakes, if correctly detected, should be represented in the LakeSP_Unassigned shapefile. Future versions of the PLD will include additional lakes. • Water body is not detected in the L2_HR_PIXC product. Note that unobserved lakes within the swath will be present in LakeSP_Prior (as an empty shape), but not in LakeSP_Obs.
L2_HR_LakeSP	**Water-water Layover.** Water-water layover (e.g. separate lakes at different altitudes, intersecting each other in radar geometry) may cause errors in lake extent (joint polygon LakeSP_Prior, overlapping polygons in LakeSP_Obs), and water surface elevation 
L2_HR_Raster	**Artifacts in Water Area and Fraction Near Nadir.** Artifacts are present in the water area and fraction near nadir, where the intrinsic KaRIn resolution is coarse compared to the resolution of the L2_HR_Raster product. Areas within 10 km of nadir are flagged.



6.2 Known Issues

There are various known issues with this Version C release of the KaRIn science data products that are either under investigation or will be corrected in a future release. These are summarized in Table 6 below.

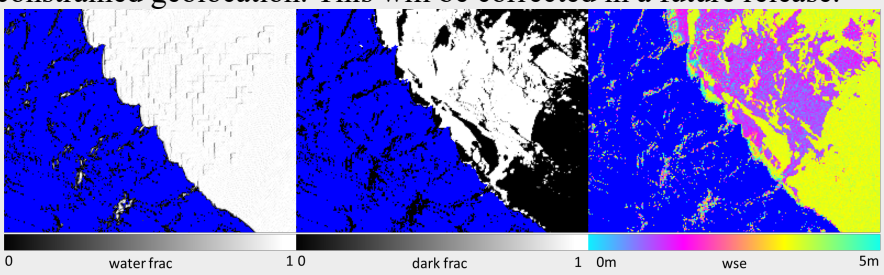
Table 6. Known Issues with Version C Science Data Products.

Product	Description of Issue
All	**Absolute Radiometric Calibration.** The reported sigma0 values are approximately 2.5 dB larger than they should be, as measured by comparisons to Global Precipitation Measurements (GPM). They will be revised in a future release.
All	**KaRIn height calibration.** Changes to the KaRIn calibration that affect heights at the level of ~1 cm will be applied in a future release.
All	**Temporal Errors.** KaRIn height errors of ~1 cm or smaller with slow temporal variations (orbital and beta-cycle time scales) are present in the data and are being investigated.
All	**Moon Eclipse Flagging.** Possible data degradation when the spacecraft enters or exits eclipse by the moon are not flagged. This will be corrected in a future release.
All	**Doppler Correction.** Range-Doppler coupling results with a slowly varying height error of up to 2.5 cm that is proportional to the vertical component of the spacecraft velocity. Application of the crossover correction to the heights may remove some of this effect. This will be corrected in a future release.
All	**Contact Global Attribute.** The 'contact' global attribute or metadata field in most products is incorrect. This will be corrected in a future release.
LR and HR L2 Products	**Incorrect crossover calibration flags.** In some cases, the crossover correction is zero filled but only flagged as suspect when it should be flagged as bad. This may cause large height errors when the crossover correction is applied and interpreted as zero.
LR Products	**Artifacts not flagged.** Artifacts that appear as stripes in along track are present and not flagged in some granules. They are due to radiation

	events that affect on-board processing. A flagging approach is under investigation.
LR Products	**Artifacts Near Land-Water Boundaries.** Data near land-water boundaries often have artifacts due to the interpolation of the L1B phase bias correction. This will be corrected in a future release.
LR Products	**Inland Water and Near Coasts Not Validated.** Data over inland water and near coasts have not been well validated and sometimes contain large errors due to the optimization of the on-board and ground processing for ocean surfaces. Validation is ongoing.
LR Products	**Missing Values In Reference Surface.** Some ocean areas (especially at high latitudes near coasts) have fill values due to missing values in the reference surface used for Level 1B processing. This will be corrected in a future release.
L1B_LR_INTF	**Missing Auxiliary Parameters.** Some auxiliary parameters used to generate this product are not reported in the global attributes. This will be corrected in a future release.
L2_LR_SSH	**Ice and Rain Flags Not Always Reliable.** The ice and rain flags are not always reliable as they are based upon meteorological models. (for example, *ssha_karin_qual* may be 0, indicating "good" data, even if *rain_flag* and/or *dynamic_ice_flag* are nonzero). The reliability of those flags is a subject of investigation.
L2_LR_SSH	**Icebergs, Ships Not Flagged.** Icebergs, ships, and other features that may affect the quality of the reported SSH and SSHA may not be flagged. This is a subject of investigation.
L2_LR_SSH	**Occasional large values in *mean_wave_period_t02*, *mean_wave_direction*, and *swh_model*.** These variables occasionally have large values where a fill value was intended. This will be corrected in a future release. The erroneous values may impact the quality flag bits for SSH and SSHA.
L2_LR_SSH	**Incorrect Quality Flag Bits.** The quality flag bits *suspect_large_ssh_delta*, *suspect_large_ssh_std*, *suspect_large_ssh_window_std*, *suspect_large_nrcs_delta*, *suspect_large_nrcs_std*, and *suspect_large_nrcs_window_std* may sometimes be set incorrectly over cross-track spans of pixels at processing boundaries due to a software bug. This will be corrected in a future release.
L2_LR_SSH	**Tuning of *swh_karin*.** The algorithm used to compute this parameter has not been tuned and is expected to evolve in future product releases.
L2_LR_SSH	**Non-equilibrium ocean tide not applied to SSHA.** The reported SSHA does not apply the non-equilibrium ocean tide correction (ocean_tide_non_eq), whereas it is applied in the nadir altimeter SSHA field. This will be corrected in a future release.
L2_LR_SSH	**Radiometer Land and Rain Contamination Impact to *ssh_karin* and *ssha_karin***. The current implementation of the interpolation of the radiometer measurements on each swath can result in degraded or

	defaulted *ssh_karin* and *ssha_karin* measurements at surrounding measurements.
HR Products	**Validation of Crossover Correction.** Currently, the crossover correction has not been well validated over land. Validation is ongoing.
HR Products	**Crossover Correction Quality Flag.** The crossover correction quality flag reported in the HR products has a deficiency such that the indicated quality of the correction is marked as "bad" more than expected. This will be corrected in a future release.
HR Products	**Duplicate Water Features.** Errors in the reference digital elevation model (DEM) sometimes cause dark water or bright land flags to be set for features at the incorrect horizontal locations. This can cause what appears as a "doubling" of water features. In such cases, the feature itself is correctly detected as water and is correctly geolocated, but an improperly geolocated copy of the feature is also identified as dark water at a shifted location in cross track. This is under investigation.
HR Products	**Uncertainty Estimates Not Validated.** Uncertainty estimates reported in the products have not been validated. Validation is ongoing.
L1B_HR_SLC	**Geospatial Global Attributes.** These attributes may be populated incorrectly, particularly in granules that include missing data. This will be corrected in a future release.
L1B_HR_SLC	**Filled Complex SLC Values.** The complex SLC values for some granules may be filled with zero even though the flag values indicate good data. These data are related to an off-nominal KaRIn state and will be flagged in a future product release.
L2_HR_PIXC	**Geospatial Global Attributes.** These attributes may be populated incorrectly, particularly in granules that include missing data. This will be corrected in a future release.
L2_HR_PIXC	**Troposphere Delay Error Over Caspian Sea.** The tropospheric delay estimates may have errors of around 1 cm over the Caspian Sea due to an inconsistency in how the model is referenced. This will be corrected in a future release.
L2_HR_RiverSP	**Node Quality Flags.** The majority of nodes are flagged as suspect or degraded (quality flag variables *node_q* and *node_q_b*) due primarily to an over-sensitive propagation of pixel-level quality flags to node-level quality flags and the large number of suspect and/or degraded PIXC pixels. This is under investigation.
L2_HR_RiverSP	**Reach Level Quality Flags.** Nearly all reach-level quality flags (variables *reach_q* and *reach_q_b*) are non-zero due to the propagation of node-level quality flags to reach-level quality flags. See above.
L2_HR_RiverSP	**Extra Pixels Assigned to Rivers.** Water over-detection in L2_HR_PIXC leads to extra pixels assigned to river channels (affecting both reaches and nodes). This causes overestimates in river area and spurious heights for some river nodes near bright fields, cities, wetlands, and/or snow and ice. This is under investigation.
L2_HR_RiverSP	**Clipped River Widths.** River widths are sometimes clipped. The prior *max_width* in SWORD (Prior River Database) is too narrow in some

	places, leading to overly narrow pixel assignment where the extreme distance is small and/or there are multiple segments. Inaccuracies in the position of SWORD centerlines exacerbate this issue. This will evolve with future updates to SWORD.
L2_HR_RiverSP	**Inconsistent valid_min and valid_max for *dark_frac*.** The valid_min and valid_max metadata fields for the *dark_frac* variable are inconsistent between the node and reach files. This will be corrected in a future release.
L2_HR_RiverSP	**Lower than Expected Water Areas.** A software bug causes some water areas to be computed incorrectly, resulting in estimates that are lower than they should be (water fraction is applied twice). This will be fixed in a future product release
L2_HR_RiverSP	**Enhanced Slope Uncertainty.** A software bug causes the uncertainty for the enhanced slope (*slope2*) to be computed incorrectly. This will be corrected in a future release.
L2_HR_RiverSP	**Errors Near +/- 180-degree longitude.** A software bug may cause incorrect behavior for input L2_HR_PIXC tiles that span +/-180˚ longitude. This will be corrected in a future release.
L2_HR_RiverAvg	**Impact of L2_HR_RiverSP.** The above-mentioned errors in L2_HR_RiverSP will propagate into similar errors in the L2_HR_RiverAvg product.
L2_HR_LakeSP	**Exclusion of Bright Land.** The lake processing does not yet actively use the “bright land” flag in the L2_HR_PIXC product to exclude bright land (in particular urban areas, buildings) from lake features. This will be improved in a future release.
L2_HR_LakeSP	**River Portions Included in Lakes.** River portions connected to lakes may be erroneously included in the lake object (polygon) if the river reach is not present in SWORD (SWOT Prior River Database). This can propagate to larger areas, e.g. an estuary, if the river reach between the lake and an estuary is missing in SWORD. This problem may be reduced with future versions of SWORD.
L2_HR_LakeSP	**Missing Water Surfaces in the Middle of Reservoirs.** Water surfaces in the middle of reservoirs may be missing if SWORD identifies it as a regular river reach rather than a reservoir (connected lake). This may evolve with future versions of SWORD.
L2_HR_LakeSP	**Near Nadir Pixels Geolocated on Other Side of Nadir.** Near-nadir pixels are in some cases erroneously geolocated on the other side of nadir. This will be corrected in a future release.
L2_HR_LakeSP	**Lakes Divided into Several Polygons.** Some lakes are erroneously divided into several polygons, with small gaps in between, due to a bug in the handling of height-constrained geolocations for dark water patches. This will be correct in a future product release.
L2_HR_LakeAvg	**Impact of L2_HR_LakeSP.** The above-mentioned errors in L2_HR_LakeSP will propagate into similar errors in the L2_HR_LakeAvg product.

L2_HR_RiverAvg and L2_HR_LakeAvg	**Validation of L2_HR_RiverAvg and L2_HR_LakeAvg Products.** Currently these two products have not been well validated. Validation is ongoing.
L2_HR_PIXCVec	**Near Nadir Pixels Geolocated on Other Side of Nadir.** Near-nadir pixels are in some cases erroneously geolocated on the other side of nadir, leading to spurious extensions of lake polygons towards and across nadir. This will be corrected in a future release.
L2_HR_Raster	**"Blocky Artifacts".** "Blocky" artifacts in the reported water area and fraction can occur due to large variance in the heights used for height-constrained geolocation. This will be corrected in a future release. 
L2_HR_Raster	**Handling of Bright Land.** Areas that are flagged as bright land are reported but may also affect surrounding areas. The handling of bright land may change in future releases of the product.

Appendix A. **Acronyms**

AMR	Advanced Microwave Radiometer
ATBD	Algorithm Theoretical Basis Document
CNES	Centre National d'Études Spatiales
IGDR	Interim Geophysical Data Record
JPL	Jet Propulsion Laboratory
KaRIn	Ka-band Radar Interferometer
NALT	Nadir Altimeter
NASA	National Aeronautics and Space Administration
OGDR	Operational Geophysical Data Record
SWOT	Surface Water Ocean Topography
TBC	To Be Confirmed
TBD	To Be Determined