SWOT Project

Release Note for Sample Data Products

Version 1.2

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CHANGE LOG

VERSION	DATE	SECTIONS CHANGED	REASON FOR CHANGE
1.0	2021-03-15	ALL	Initial Release (CL#21-1106, URS298907)
1.1	2021-04-16	3	Revised L2_HR_RiverSP sample products. (CL#21-1106, URS298907)
1.2	2021-08-30	3	Add Unsmoothed Level 2 LR sample files. (CL#21-4084, URS302544)

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1 General Information

1.1 Purpose

This document is the Release Note for Version 1.2 of Surface Water and Ocean Topography (SWOT) sample data products. This release of sample data products is intended to enable users to become familiar with the format and content of the expected science data products from the SWOT mission. **These products should not be used in any way to interpret performance of the inflight data or to perform scientific analyses.** This version 1.2 release adds sample files for the "Unsmoothed" L2_LR_SSH product, which were not available in prior releases.

1.2 Background

The SWOT mission is a partnership between the National Aeronautics and Space Administration (NASA) and the French Space Agency, Centre National d'Études Spatiales (CNES), with contributions from the United Kingdom Space Agency (UKSA) and the Canadian Space Agency (CSA). The SWOT satellite is currently scheduled for launch in 2022 with a nominal mission lifetime of 3 years. It will fly at an altitude of 891 km, an orbit inclination of 77.6 degrees, and has a nominal 21-day repeat period during its science phase. The SWOT mission has two primary science objectives:

- Oceanography: Characterize the ocean mesoscale and sub-mesoscale circulation at spatial resolutions of 15-1000 km.
- Hydrology: Provide a global inventory of all terrestrial water bodies whose surface area exceeds 250×250 m^2 (lakes, reservoirs, wetlands), and rivers whose width exceeds 100 m.

SWOT carries the following payload instruments:

- Ka-band synthetic aperture radar (SAR) interferometric (KaRIn) system to measure sea surface height (SSH) over the oceans and water elevations over land on 2 swaths spanning 10 to 60 km from nadir.
- Conventional Jason-class nadir altimeter to measure sea surface height at nadir.
- Two microwave radiometers to measure wet tropospheric delay at the middle of each swath.
- Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) tracking system for precise orbit determination (POD).
- Global Positioning System (GPS) tracking system for POD.
- Laser Retroreflector Array (LRA) in support of satellite laser ranging (SLR) tracking measurements for POD verification.

For more information, refer to https://swot.jpl.nasa.gov and https://swot.cnes.fr/en.

2 Summary of SWOT Standard Data Products

A complete list of the expected SWOT standard data products is provided in Table 1 below. Level 2 products, indicated by the prefix "L2" in the dataset names provide time-tagged and georeferenced geophysical variables. Level 2 products are targeted towards the majority of science applications. Level 1 products, indicated by the prefix "L1" in the dataset names, provide time-tagged measurements that have been processed into sensor units. Where applicable, L1 products may also provide some radiometric and calibration parameters and georeferencing information. L1 products are typically targeted to expert users who are interested in measurements as close as possible to the instrument level.

Data from the KaRIn instrument are downlinked in two modes: Low Rate (LR) and High Rate (HR). The LR data are available globally, but the standard data products generated from the LR data are targeted to ocean science. The HR data are available over only a portion of the globe, mostly over continents, consistent with the available downlink capabilities. The standard data products generated from the HR data are targeted to hydrology science. The dataset names include the "LR" and "HR" as an indication of the root source downlinked data that have been used to generate the product.

The most recent versions of documents providing detailed descriptions of the SWOT products can be found at: https://podaac.jpl.nasa.gov/SWOT?tab=datasets&sections=about. **These product descriptions are subject to revision, and minor changes to the available descriptions are to be expected.** Documents detailing the L2_HR_RiverAvg, L2_HR_LakeAvg, and L2_HR_FPDEM products are not available at this time.

Table 1. SWOT Standard Data Products

Dataset	Description	Coverage	Format
L2_LR_SSH	Sea surface height data product with data from the KaRIn swath spanning 60 km on both sides of nadir with a nadir gap. Product provides sea surface height, sea surface height anomaly, wind speed, significant waveheight, on a geographically fixed, swath-aligned 2x2 km^2 grid, as well as sea surface height on a 250x250 m^2 native grid. Consists of four files: "Basic", "WindWave", "Expert", and "Unsmoothed".	Gridded; full swath for each half orbit	netCDF
L2_HR_PIXC	Point cloud of water mask pixels ("pixel cloud") with geolocated heights, backscatter, geophysical fields, and flags.	Point cloud over tile (approx 64x64 km^2); half swath (left or right side of full swath)	netCDF
L2_HR_RiverSP	Shapefiles of river reaches (approximately 10 km long) and nodes (approximately 200 m spacing) identified in prior river database. Reach attributes include water surface elevation, slope, width, derived discharge.	Full swath covering individual continents for each half orbit	shapefile
L2_HR_RiverAvg	Cycle average and aggregation of river reach pass data within predefined hydrological basins.	Basin for each cycle	shapefile
L2_HR_LakeSP	Shapefiles of lakes identified in prior lake database and detected features not in the prior river or lake databases. Lake attributes include water surface elevation, area, derived storage change.	Full swath covering individual continents for each half orbit	shapefile
L2_HR_LakeAvg	Cycle average and aggregation of lake pass data within predefined hydrological basins.	Basin for each cycle	shapefile
L2_HR_PIXCVec	Auxiliary information for pixel cloud product indicating to which water bodies the pixels are assigned in river and lake products. Also includes height-constrained pixel geolocation after reach- or lake-scale averaging.	Point cloud over tile (approx 64x64 km^2); half swath (left or right side of full swath)	netCDF
L2_HR_Raster	Rasterized water surface elevation and inundation extent in geographically fixed tiles at resolutions of 100 m and 250 m in a Universal Transverse Mercator projection grid. Provides rasters with	Gridded scene (approx 128x128 km^2, georeferenced); full swath	netCDF

	water surface elevation, area, water fraction, backscatter, geophysical information. On-demand processing available to users for different resolutions, sampling grids, scene sizes, and file formats.		
L2_HR_FPDEM	Flood Plain Digital Elevation Map in raster format, derived from multiple cycles of SWOT acquisitions. Final resolution is not fixed yet (approx 50m). A large portion of the raster pixels will be void. Provides height and quality flag for each pixel.	Gridded scene (approx 1°, georeferenced); geographically fixed tiles (not aligned with SWOT swath).	netCDF
L1B_LR_INTF	Interferograms for each of the 9 Doppler beams formed and spatially averaged (low rate) by the On Board Processor, corrected on the ground for phase biases (inherent to the processing applied on board). The geometry of the measurements is also reported for use in subsequent processing.	Gridded; full swath for each half orbit	netCDF
L1B_HR_SLC	High rate data processed to single-look complex SAR images for each antenna.	Gridded tile (approx 64x64 km^2); half swath (left or right side of full swath)	netCDF
L2_NALT_GDR	Nadir Altimeter Geophysical Data Record (GDR) product similar to those from ongoing nadir altimeter missions such as Jason-3. Provide sea surface height, significant wave height and wind speed measurements from the nadir altimeter. GDR uses restituted auxiliary data and Precise Orbit Ephemeris (POE). Available with latency of < 90 days.	Discrete measurements at nadir for each half orbit, along the ground track.	netCDF
L2_NALT_IGDR	Same as L2_NALT_GDR, using preliminary values for some auxiliary data. Uses Medium-accuracy (preliminary) Orbit Ephemeris (MOE). Available with latency of < 1.5 days.	Discrete measurements at nadir for each half orbit, along the ground track.	netCDF
L2_NALT_OGDR	Same as L2_NALT_GDR using predicted values for some auxiliary data, and does not have GIM ionosphere model values. Uses the onboard DORIS orbit ephemeris. Available with latency of < 7 hours.	Discrete measurements at nadir for each data downlink, along the ground track.	netCDF
L2_RAD_GDR	Radiometer Geophysical Data Record (GDR) product with values based upon analyzed calibrations and Precise Orbit Ephemeris (POE). Provides radiometer measurements of wet troposphere content, atmospheric attenuation to backscatter, cloud liquid water, water vapor content, and wind speed. Available with latency of < 90 days.	Discrete measurements at ~30 km on each side from nadir for each half orbit, along the ground track.	netCDF
L2_RAD_IGDR	Same as L2_RAD_GDR with values based upon preliminary calibrations and Medium-accuracy (preliminary) Orbit Ephemeris (MOE). Available with latency of < 1.5 days.	Discrete measurements at ~30 km on each side from nadir for each half orbit, along the ground track.	netCDF
L2_RAD_OGDR	Same as L2_RAD_GDR with values based upon preliminary calibrations and onboard DORIS orbit ephemeris. Available with latency of < 7 hours.	Discrete measurements at nadir for each data downlink, along the ground track.	netCDF
POE	Precise Orbit Ephemeris (POE) providing position and velocity vectors of satellite center of mass. Available with latency of < 35 days.	Daily 26-hour files centered at 12:00:00 (TAI).	netCDF
MOE	Medium-accuracy Orbit Ephemeris (MOE) providing position and velocity vectors of satellite center of mass. Available with latency of < 1.5 days.	Daily 26-hour files centered at 12:00:00 (TAI).	netCDF
ATTD_RECONST	Satellite attitude reconstructed from combination of onboard gyro and star tracker data. Available with latency of < 1.5 days.	Daily 26-hour files centered at 12:00:00 (TAI).	netCDF
SAT_COM	Satellite center of mass position with respect to satellite reference point. Available with latency of < 1.5 days.	Duration of mission.	netCDF
L1_DORIS_RINEX	Tracking data from onboard Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) instrument. Available with latency of < 2 days.	One file per day	RINEX
L1_GPSP_RINEX	Tracking data from onboard Global Positioning System Payload (GPSP). Available with latency of < 2 days.	One file per data downlink.	RINEX

3 Sample Data Products Included in this Release

A summary of the sample data products that are provided in this release is given in Table 2 below. **Users are advised to refer to the detailed product description documents when attempting to use the sample data products** (https://podaac.jpl.nasa.gov/SWOT?tab=datasets&sections=about)**.** High level descriptions of the methodologies used to generate the SWOT sample data products in this release are provided in Section 4 below. Note that many fields in the sample data products may have default values. While the product description documents continue to evolve, attempts have been made to ensure consistency of the sample data products in this release with the versions of the documents, as indicated by the cover dates provided in Table 3 below.

Samples for the L2_HR_RiverAvg, L2_HR_LakeAvg, and L2_HR_FPDEM products are not available in this release as the product definitions are not available at this time. Samples for the Level 1 products are also not included in this release.

Table 2. Summary of Sample Data Products included in this release.

Dataset	Sample File
L2_LR_SSH	SWOT_L2_LR_SSH_Basic_001_<*pass*>_<*starttime*>_<*endtime*>_DG10_01.nc SWOT_L2_LR_SSH_WindWave_001_<*pass*>_<*starttime*>_<*endtime*>_DG10_01.nc SWOT_L2_LR_SSH_Expert_001_<*pass*>_<*starttime*>_<*endtime*>_DG10_01.nc SWOT_L2_LR_SSH_Unsmoothed_001_<*pass*>_<*starttime*>_<*endtime*>_DG10_01.nc 40 files (10 per 4 file types) with <*pass*> = 1-10.
L2_HR_PIXC	SWOT_L2_HR_PIXC_001_042_<*TileID*>[*L/R*]_<*starttime*>_<*endtime*>_Dx0000_01.nc 35 files with TileID = 67-86
L2_HR_RiverSP	SWOT_L2_HR_RiverSP_Node_001_042_EU_20220402T112030_20220402T112249_PGA0_01.<ext> SWOT_L2_HR_RiverSP_Reach_001_042_EU_20220402T112030_20220402T112249_PGA0_01.<ext> <ext> = .shp, .shx, .dbf, .prj, .shp.xml (10 files total)
L2_HR_RiverAvg	Not available at this time. Expected late 2021.
L2_HR_LakeSP	SWOT_L2_HR_LakeSP_Obs_001_042_EU_20220402T112019_20220402T112339_Dx0000_01.<*ext*> SWOT_L2_HR_LakeSP_Prior_001_042_EU_20220402T112019_20220402T112339_Dx0000_01.<*ext*> SWOT_L2_HR_LakeSP_Unassigned_001_042_EU_20220402T112019_20220402T112339_Dx0000_01.<*ext*> <*ext*> = .shp, .shx, .dbf, .prj, .shp.xml (15 files total)
L2_HR_LakeAvg	Not available at this time. Expected late 2021.
L2_HR_PIXCVec	SWOT_L2_HR_PIXCVec_001_042_<*TileID*>[*L/R*]_<*starttime*>_<*endtime*>_Dx0000_01.nc 35 files with <*TileID*> = 67-86
L2_HR_Raster	SWOT_L2_HR_Raster__<*descriptor*>_001_042_<*scene*> _<*starttime*>_<*endtime*>_Dx0000_01.nc 20 files including 10 with 100 meter resolution and 10 with 250 meter resolution, spanning scenes 036F to 042F.
L2_HR_FPDEM	Not available at this time. Expected 2022.
L1B_LR_INTF	Not available at this time.
L1B_HR_SLC	Not available at this time.
L2_NALT_OGDR L2_NALT_IGDR L2_NALT_GDR	Users are referred to the Jason-3 version F nadir altimeter Geophysical Data Records. SWOT will adopt the best available product and algorithm standards for the nadir altimeter science data products.
L2_RAD_GDR L2_RAD_IGDR L2_RAD_OGDR	SWOT_GPRAD_2PaP021_001_20160902_175919_20160902_185532_PGA2_00.nc SWOT_IPRAD_2PaP021_001_20160902_175919_20160902_185532_PIA2_00.nc SWOT_OPRAD_2PaS021_001_20160902_184847_20160902_204657_POA2_00.nc
MOE	SWOT_POR_AXVCNE20191119_105032_20160901_225924_20160903_005924.nc
POE	SWOT_VOR_AXVCNE20191122_165139_20160901_225924_20160903_005924.nc
ATTD_RECONST	SWOT_ATTD_RECONST_20160901T225924_20160903T005924_PGA000_01.nc
SAT_COM	SWOT_SAT_COM_20191205_162427_20160901_065604_20160906_115924.nc
L1_DORIS_RINEX	Not available at this time.
L1_GPSP_RINEX	Not available at this time.

Table 3. Cover Date of Product Description Documents Applicable to this Release of Sample

Data Products.

Dataset	Cover Date
L2_LR_SSH	August 6, 2020
L2_HR_PIXC	August 10, 2020
L2_HR_RiverSP	August 25, 2020
L2_HR_RiverAvg	Not available at this time. Expected late 2021.
L2_HR_LakeSP	June 22, 2020
L2_HR_LakeAvg	Not available at this time. Expected late 2021.
L2_HR_PIXCVec	June 8, 2020
L2_HR_Raster	November 5, 2020
L2_HR_FPDEM	Not available at this time. Expected 2022.
L1B_LR_INTF	August 10, 2020
L1B_HR_SLC	September 29, 2020
L2_NALT_OGDR L2_NALT_IGDR L2_NALT_GDR	December 18, 2020
L2_RAD_GDR L2_RAD_IGDR L2_RAD_OGDR	September 25, 2020
MOE	September 15, 2020
POE	September 15, 2020
ATTD_RECONST	September 29, 2020
SAT_COM	June 4, 2019
L1_DORIS_RINEX	September 30, 2020
L1_GPSP_RINEX	February 3, 2020

4 Methodology Used to Generate Sample Data Products

4.1 KaRIn Low Rate (LR) Products

Samples of the KaRIn Level 2 Low Rate (LR) Sea Surface Height (L2_LR_SSH) product have been generated using the approach described below. Figure 1 gives an illustration of sea surface height anomaly from one of the provided samples. Note that the sample "Expert" files include some extra information about how the product was generated that will not be in the inflight data product and therefore also not described in the product description document. This extra information is provided in variables whose name is prefixed with "*simulated_*", as indicated below.

- A simulated true sea surface height anomaly (SSHA) is computed along the SWOT ground track using the AVISO Sea Surface Height Product (https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products.html). This value is provided in the sample "Expert" files in a variable named *simulated_true_ssha_karin*.
- Simulated expected errors, based upon requirements, are computed and provided in the "Expert" file in the variables named *simulated_error_timing, simulated_error_karin, simulated_error_troposphere, simulated_error_roll, simulated_error_phase*.
- The variable *ssha_karin* is computed as the total of all six "*simulated_*" variables.
- The variable *ssh_karin* is computed from *ssha_karin* by adding the effects of the mean sea surface, solid Earth tide, ocean and load tide, internal tide, pole tide, and dynamic atmosphere correction using models. Values for these effects are provided in the "Expert" file in variables named *mean_sea_surface_cnescls, solid_earth_tide, ocean_tide_fes, internal_tide_hret, pole_tide, dac*, respectively.
- The variable *swh_karin* is computed from the Meteo France Wave Model (MF-WAM) without any errors.
- Where feasible, other variables in the product are also generated (e.g., *distance_to_coast, ancillary_surface_classification_flag, dynamic_ice_flag, mean_sea_surface_dtu, geoid, mean_dynamic_topography, depth_or_elevation, ocean_tide_got, load_tide_fes, load_tide_got, ocean_tide_eq, ocean_tide_non_eq, model_dry_tropo_cor, model_wet_tropo_cor*.)
- The "Basic" and "WindWave" files are then subsets of the "Expert" file as described in the respective L2_LR_SSH product description document.
- All other variables are set to default values.

As mentioned above, samples for the KaRIn Level 1 Low Rate Interferogram (L1B_LR_INTF) product are not provided in this release.

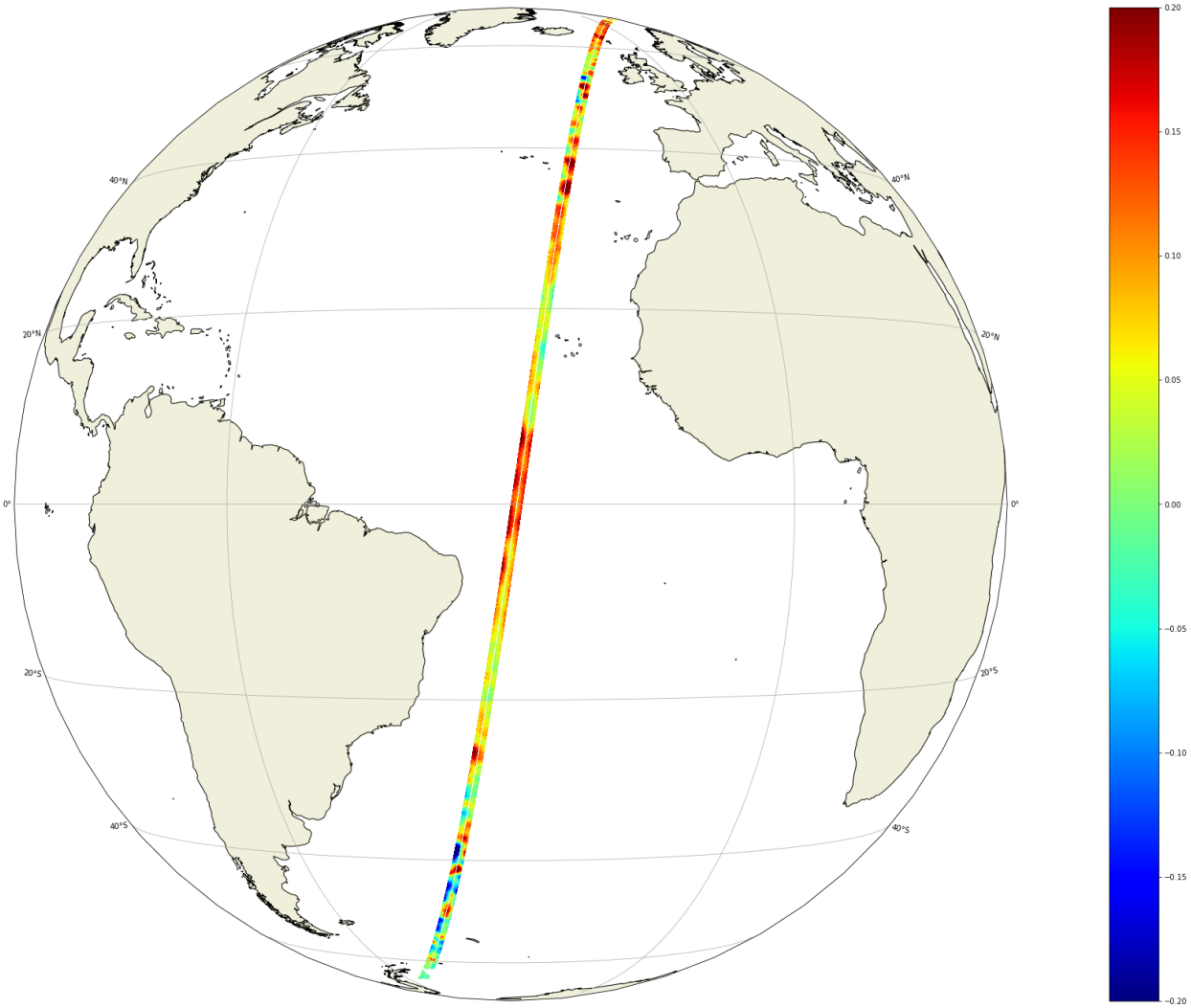

Figure 1. Illustration of sea surface height anomaly from one pass (pass 7) of the L2_LR_SSH product.

4.2 KaRIn High Rate (HR) Products

The samples of the KaRIn High Rate (HR) products cover one continent pass over France, as shown in Figure 2. These samples span the L2_HR_PIXC, L2_HR_RiverSP, L2_HR_LakeSP, L2_HR_PIXCVec, and L2_HR_Raster products. As mentioned above, samples for the L2_HR_RiverAvg, L2_HR_LakeAvg, and L2_HR_FPDEM products are not available in this release.

The sample dataset was generated using the following Open Source tools:

- SWOT Hydrology Toolbox: https://github.com/CNES/swot-hydrology-toolbox (L2_HR_PIXC, L2_HR_LakeSP, L2_HR_PIXCVec)
- RiverObs: https://github.com/SWOTAlgorithms/RiverObs (L2_HR_RiverSP)
- Raster processor: https://github.com/SWOTAlgorithms/Raster-Processor (L2_HR_Raster)

Several simplifications and approximations have been made with respect to real SWOT data and processing:

- Direct simulation of L2_HR_PIXC product files (equivalent to idealized pixel cloud processing), followed by River, Lake and Raster processing using the current prototypes (which continue to be refined).
- No topography taken into account.
- Radar geometry grid constructed on sphere.
- No geometric distortions, no layover.
- Water elevations based on SRTM, not necessarily hydrologically meaningful.
- Synthetic "dark water" model (correlated random fields used to simulate low reflectivity water areas).
- Spherical Earth approximate geolocation equations (loss of accuracy at high latitudes, >60°).
- Random effective instrument noise added to height (and propagated to geolocation).
- Geoid taken into account (mean tide corrected EGM-2008), simulated residual tropospheric and cross-over correction errors.
- Some data fields are void (corrections, flags, uncertainty indicators...).

This sample dataset can be used to study the geometrical shapes of the observed water bodies in SWOT L2 HR products and have a rough idea of the noise level of water elevation and geolocation in SWOT L2 HR products. Figure 3 gives an illustration of the water surface elevations reported in some of the provided L2_HR_Raster sample product files, which were generated from the provided L2_HR_PIXC sample product files.

This sample dataset should not be used for studies that require an accurate representation of phenomenology (backscattering, layover...), hydrological characteristics (realistic elevation, slope), or errors and uncertainties.

As mentioned above, samples for the KaRIn Level 1 High Rate Single Look Complex (L1B_HR_SLC) product are not provided in this release.

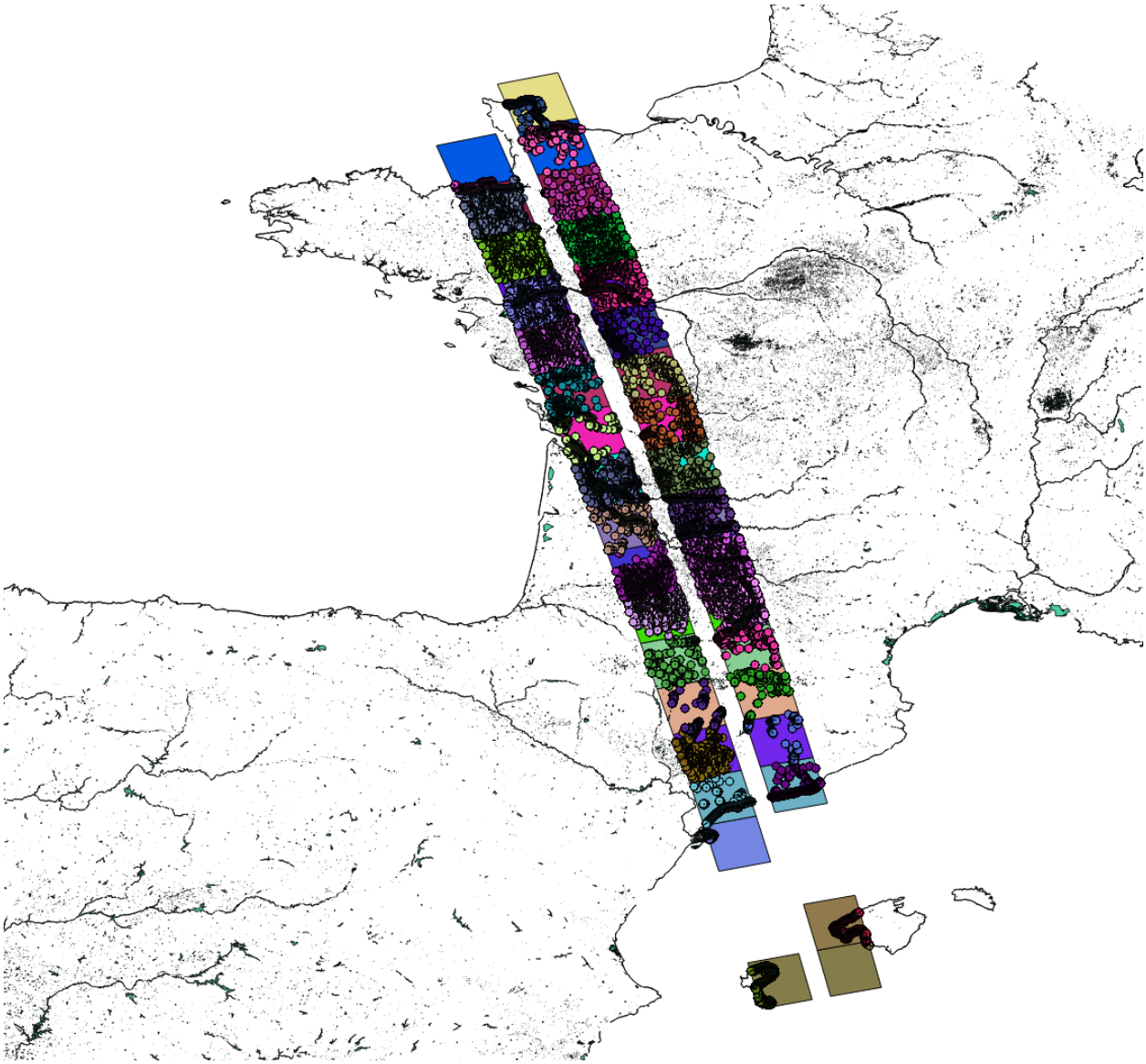

Figure 2. Illustration of the coverage of the KaRIn High Rate sample data products.

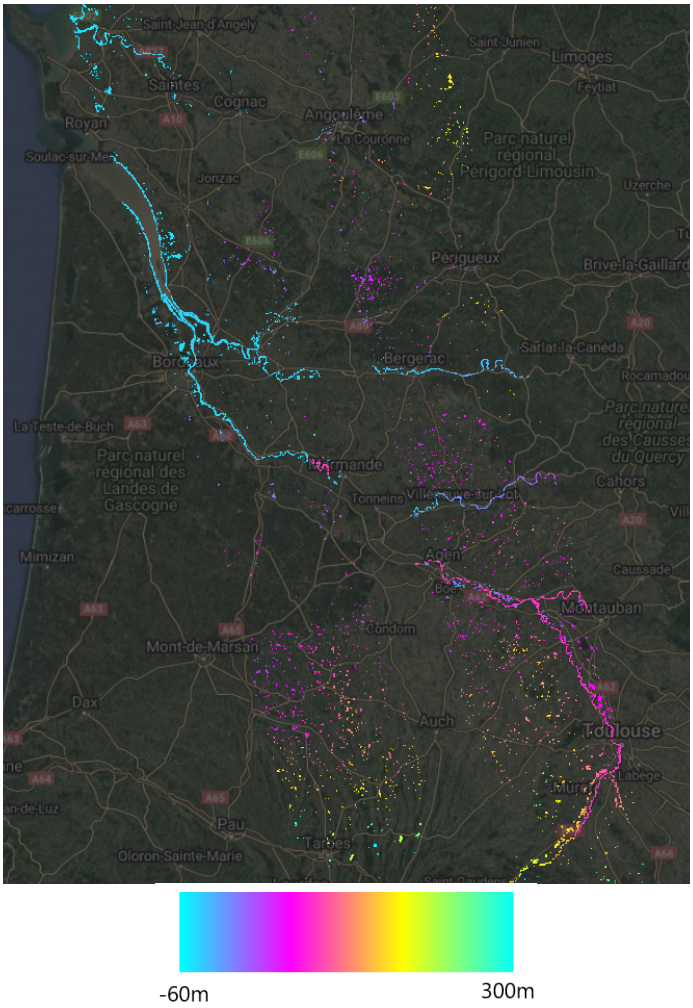

Figure 3. Illustration of water surface elevation represented in 100m resolution L2_HR_Raster sample products from scenes 037F, 038F, and 039F.

4.3 Heritage Products

As described in Table 2 the SWOT nadir altimeter products (L2_NALT_(O/I)GDR) are expected to use the best available standards and algorithms from the Jason-3 mission. The Jason-3 (O/I)GDR products are currently in version F. Users are referred to the Jason-3 version F products as representative samples of the respective SWOT nadir altimeter products.

SWOT carries two simultaneously active radiometers that facilitate measurements on the left and right sides of the satellite nadir point, approximately half-way across each of the two KaRIn swaths. The SWOT L2_RAD_(O/I)GDR products provide measurements from both active radiometers in a single netCDF file, but separated using netCDF groups. The sample L2_RAD_(O/I)GDR products in this release have been generated using in-flight (nadir-looking) Jason-2 and Jason-3 radiometer measurements during their tandem flight as a representation of measurements from two active radiometers on the same ground track.

Samples for the remaining heritage products, POE, MOE, ATTD_RECONST, and

SAT_COM, have new formats for SWOT. The samples are based upon in-flight Jason-3 data.

As mentioned above, samples for the Level 1 DORIS and GPSP products (L1_DORIS_RINEX and L1_GPSP_RINEX) are not provided in this release. However, they will follow the international RINEX file standards that are currently also adopted for Sentinel-6. Users are referred to the inflight Sentinel-6 DORIS and GPSP RINEX products as representative samples of the respective SWOT products.

5 Points of Contact

Questions and feedback regarding the sample data products should be referred to podaac@podaac.jpl.nasa.gov. The JPL and CNES algorithm team will respond to these on a best-efforts basis.

6 Acknowledgements

The provided sample data products have been generated by the CNES and JPL algorithm teams. Sample LR data products were generated by F. Briol (CNES/CLS). Sample HR products including provided images were generated by D. Desroches (CNES) and A. Corben (JPL). The work performed by SD and CC was carried out at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration.