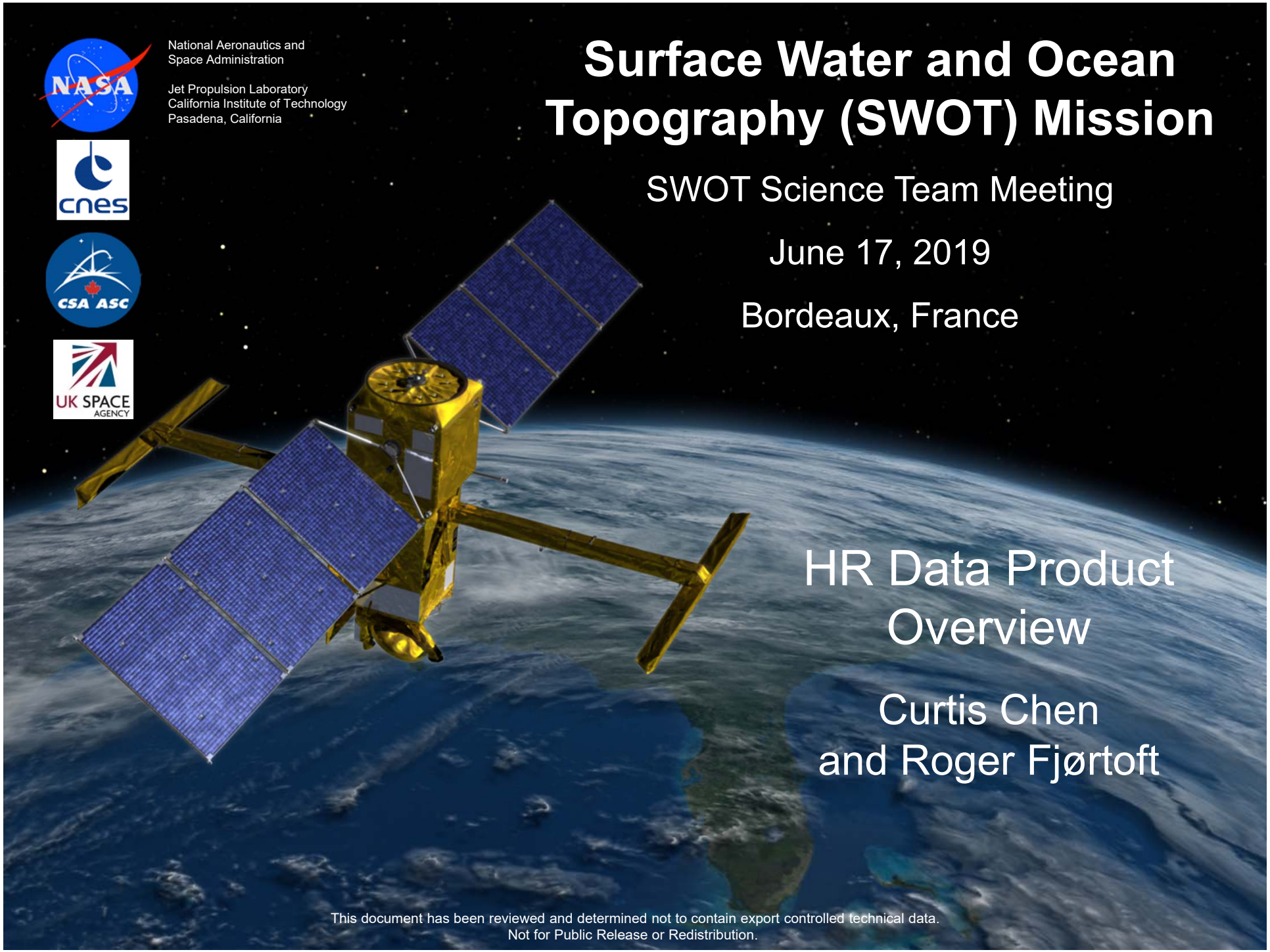
National Aeronautics and
Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
Surface Water and Ocean Topography (SWOT) Mission
SWOT Science Team Meeting
June 17, 2019
Bordeaux, France
HR Data Product Overview
Curtis Chen
and Roger Fjørtoft
This document has been reviewed and determined not to contain export controlled technical data.
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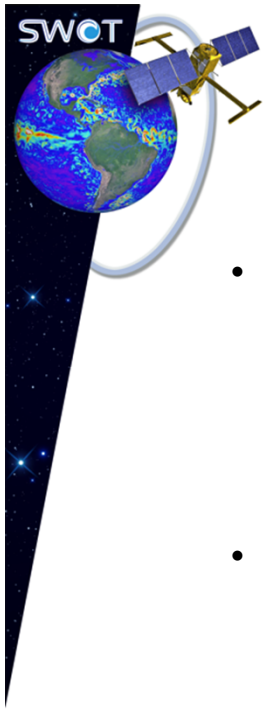
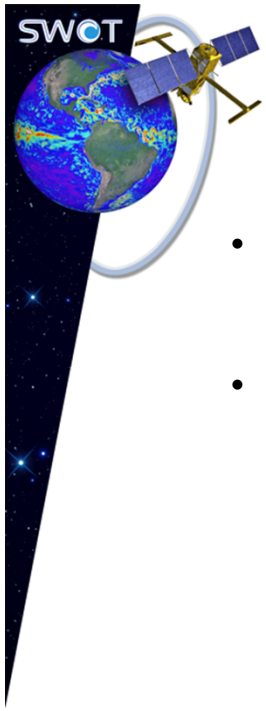


Team Organization

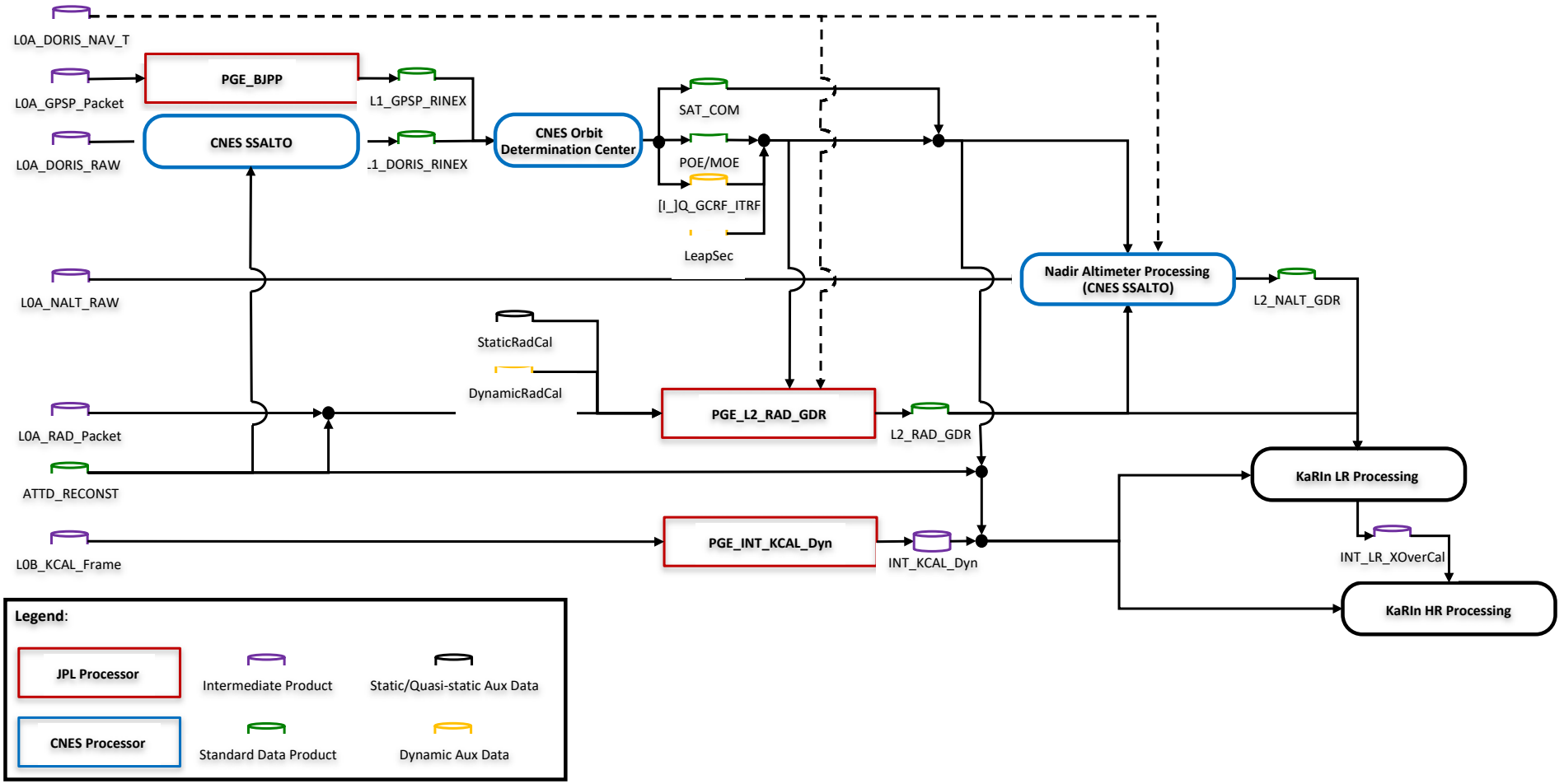
- Joint US+French Algorithm Development Team (ADT):
  - Develops and implements L1 and L2 science processing software
  - Defines L1 and L2 data products for science users
  - ADT includes JPL/CNES Project and Science Team representatives
- JPL and CNES Science Data Systems (SDSs) run common set of science processors built from ADT-delivered code (albeit within different production environments)
  - All L2 data will be distributed by both US and French distribution centers (there will not be “US version” and “French version” of data)
- Calibration and validation (Cal/Val) of SWOT products will be done by joint US+French team that includes Science Team representatives



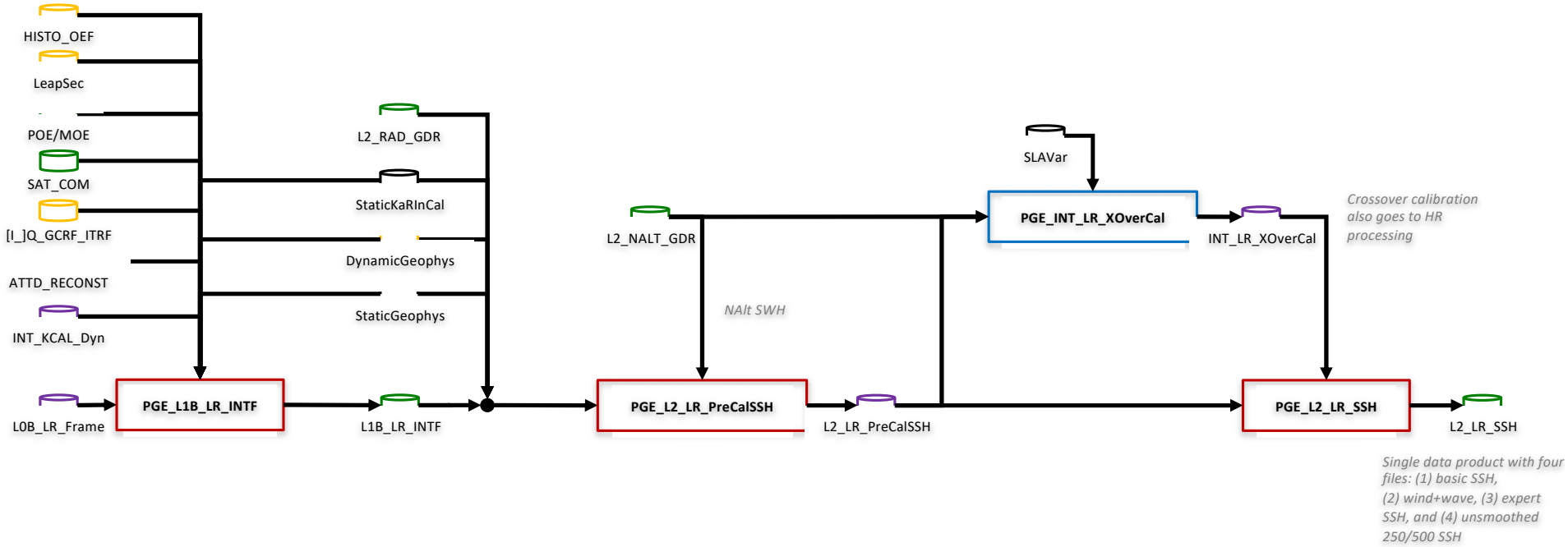
Processing System Organization

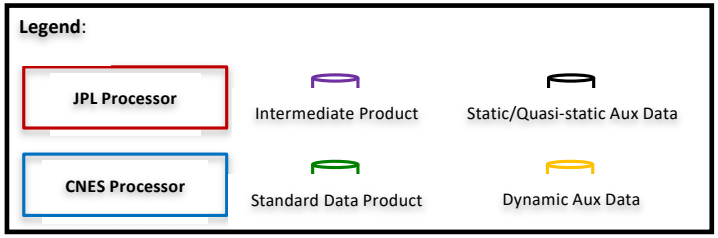
- Processing related to Nadir Altimeter (including Radiometer, Orbit Ephemeris, etc.) has high heritage from previous missions
- KaRIn processing is new for SWOT and is main focus of ADT effort
  - Data are split into Low-Rate (LR, ~17 Mbps) and High-Rate (HR, ~350 Mbps) data streams out of KaRIn
  - LR and HR data streams are processed by separate ground processing chains in SDS
    - HR algorithms are tailored to hydrology; collected as specified by HR mask
    - LR algorithms are tailored to oceanography but collected globally
  - Within each SDS processing chain, flow is split into ‘processors’ and ‘products’, which are basic organizational units for documentation, work split, etc.
    - Processors run ADT-developed algorithms and software to produce data products
    - Standard data products will be archived and made available to Science Team

Top Level Algorithm Flow

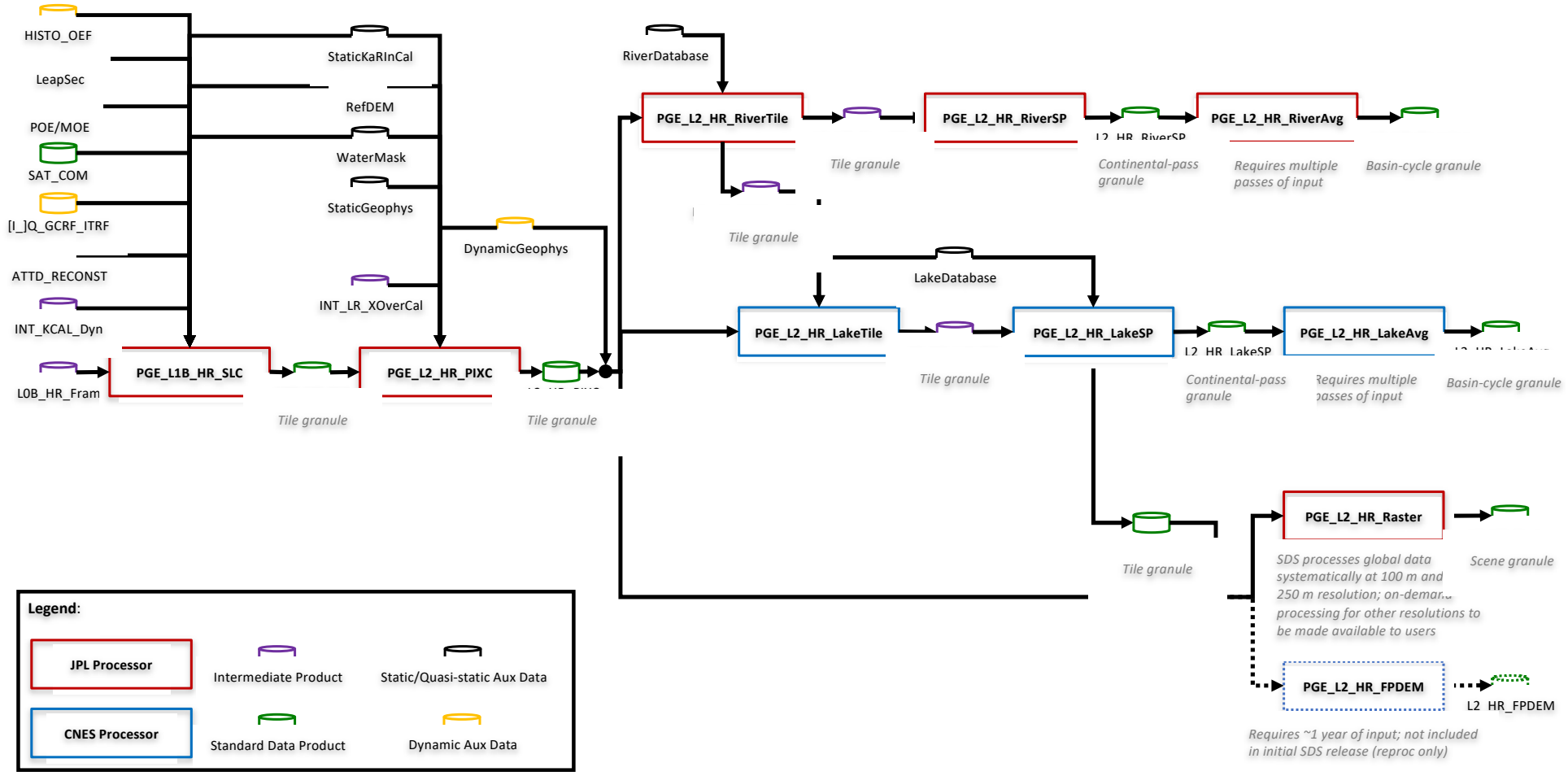


Low Rate Algorithm Flow



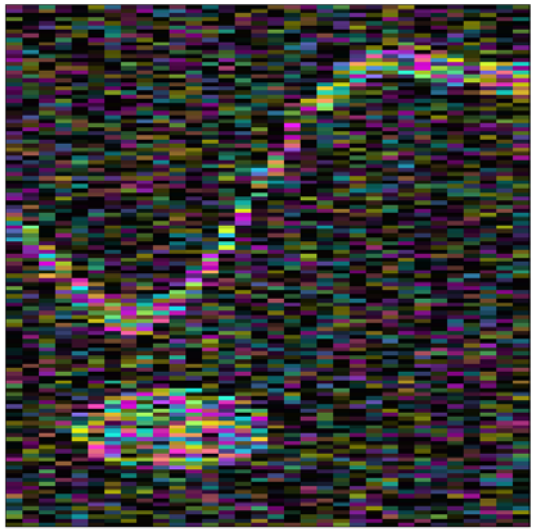


High Rate Algorithm Flow



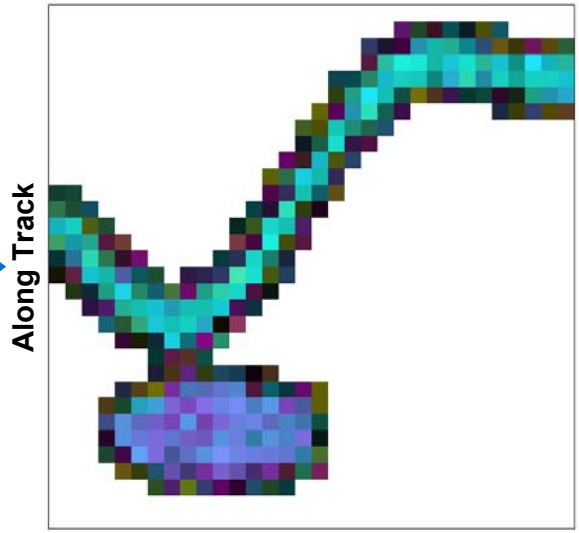
Data Product Illustration

SLC Product



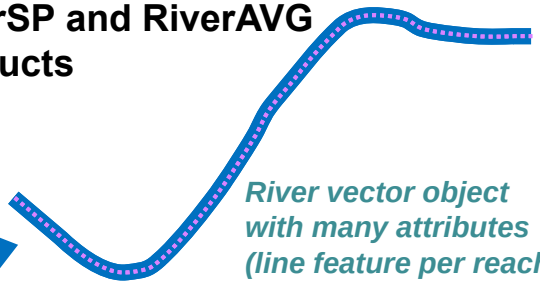
Pair of complex radar images; water is brighter than land

PIXC Product



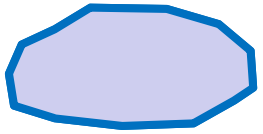
Sparse array or cloud of geolocated points in 3-D space with many pieces of information per point; most land pixels are discarded

RiverSP and RiverAVG Products



River vector object with many attributes (line feature per reach)

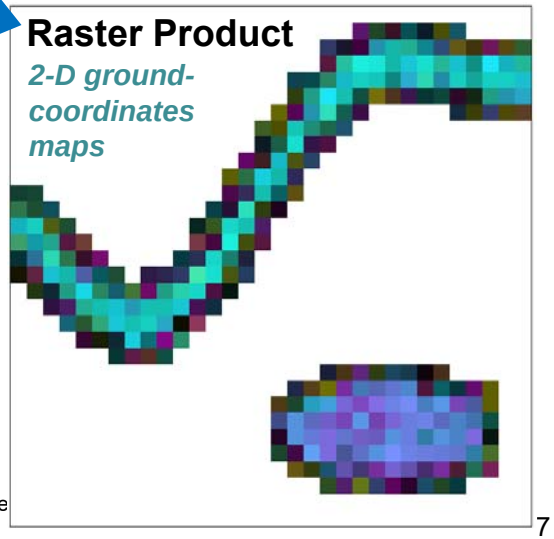
LakeSP and LakeAVG Products



Lake vector object with many attributes (polygon feature per lake)

Raster Product

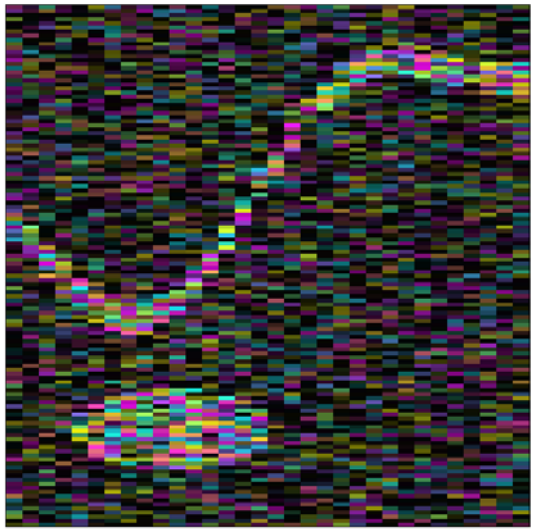
2-D ground-coordinates maps



Caution: This cartoon is highly simplified and omits many details; for conceptual purposes only

Data Product Illustration

SLC Product



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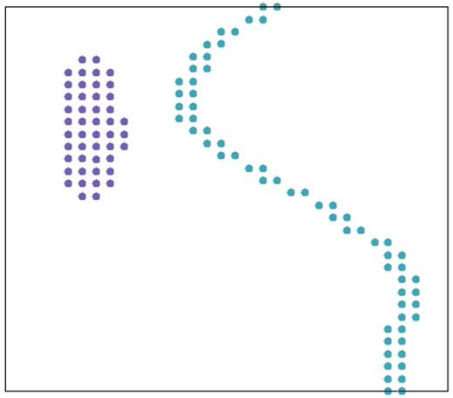
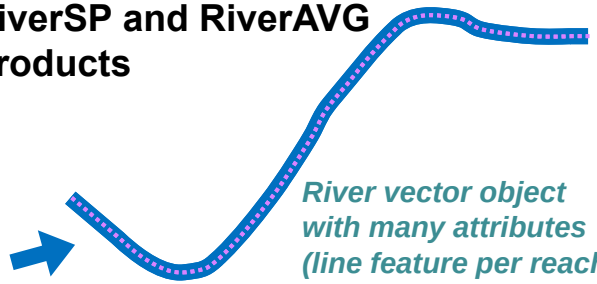
PIXC Product



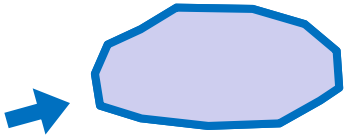
Sparse array or cloud of geolocated points in 3-D space with many pieces of information per point; most land pixels are discarded

RiverSP and RiverAVG Products



River vector object with many attributes (line feature per reach)

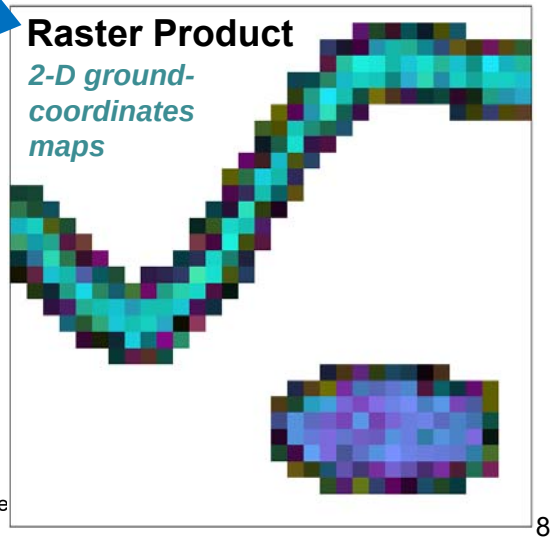
LakeSP and LakeAVG Products



Lake vector object with many attributes (polygon feature per lake)

Raster Product

2-D ground-coordinates maps



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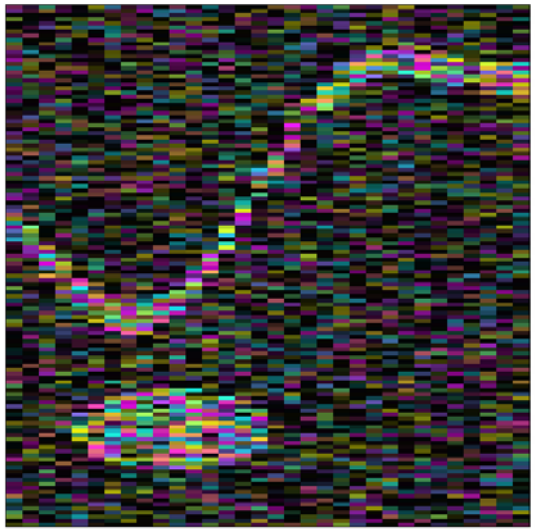
Data Product Illustration

SLC Product



Pair of complex radar images; water is brighter than land

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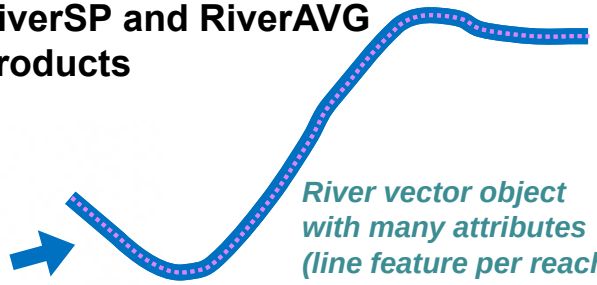
RiverSP and RiverAVG Products



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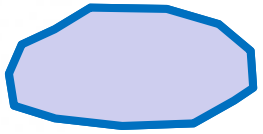
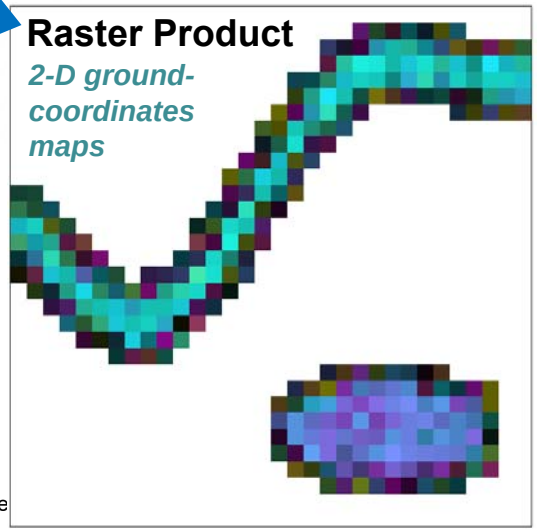


Lake vector object with many attributes (polygon feature per lake)

Raster Product

2-D ground-coordinates maps



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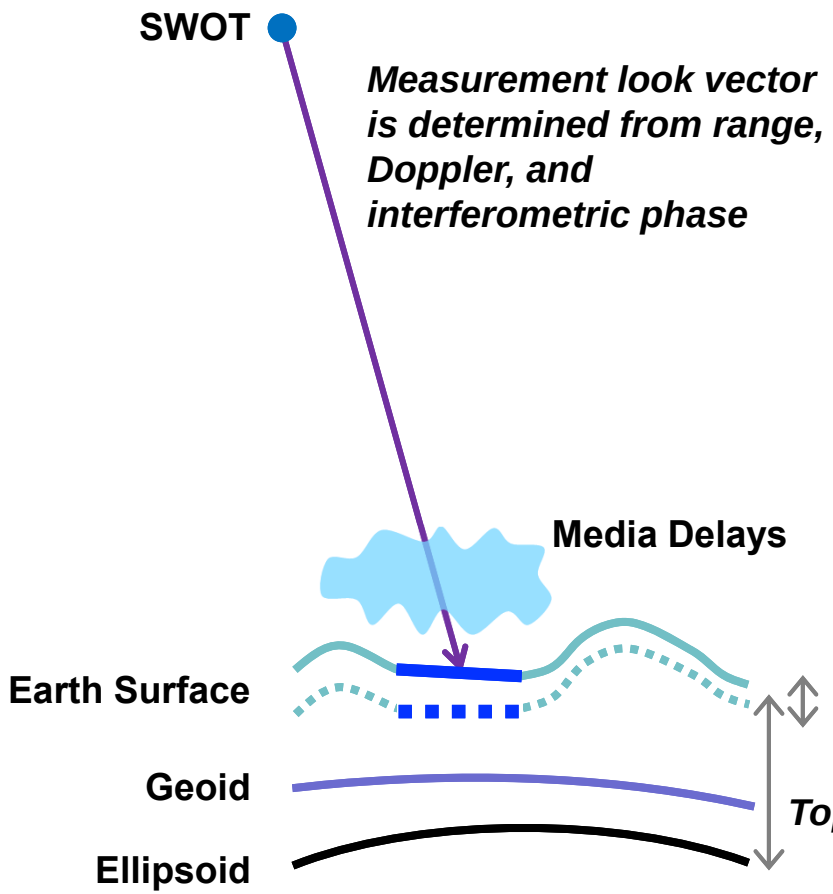
Height References and Corrections



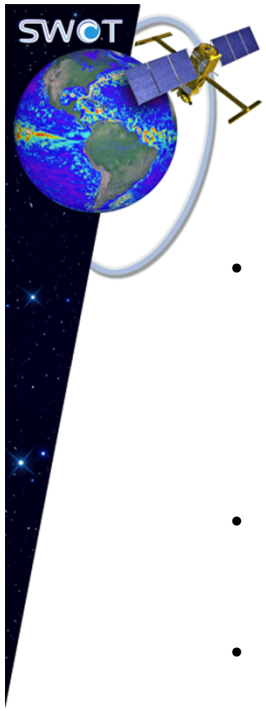
PIXC and PIXCVec products gives physical, absolute surface height relative to ellipsoid; media delays are corrected, but geoid and tide variations are still in measurement:

$$h_{\text{meas}} = \text{Physical, time-varying height above ellipsoid}$$

River, lake, and raster products give water surface elevation (WSE) after removing geoid and tides:

$$\text{WSE} = h_{\text{meas}} - h_{\text{geoid}} - h_{\text{tide}}$$

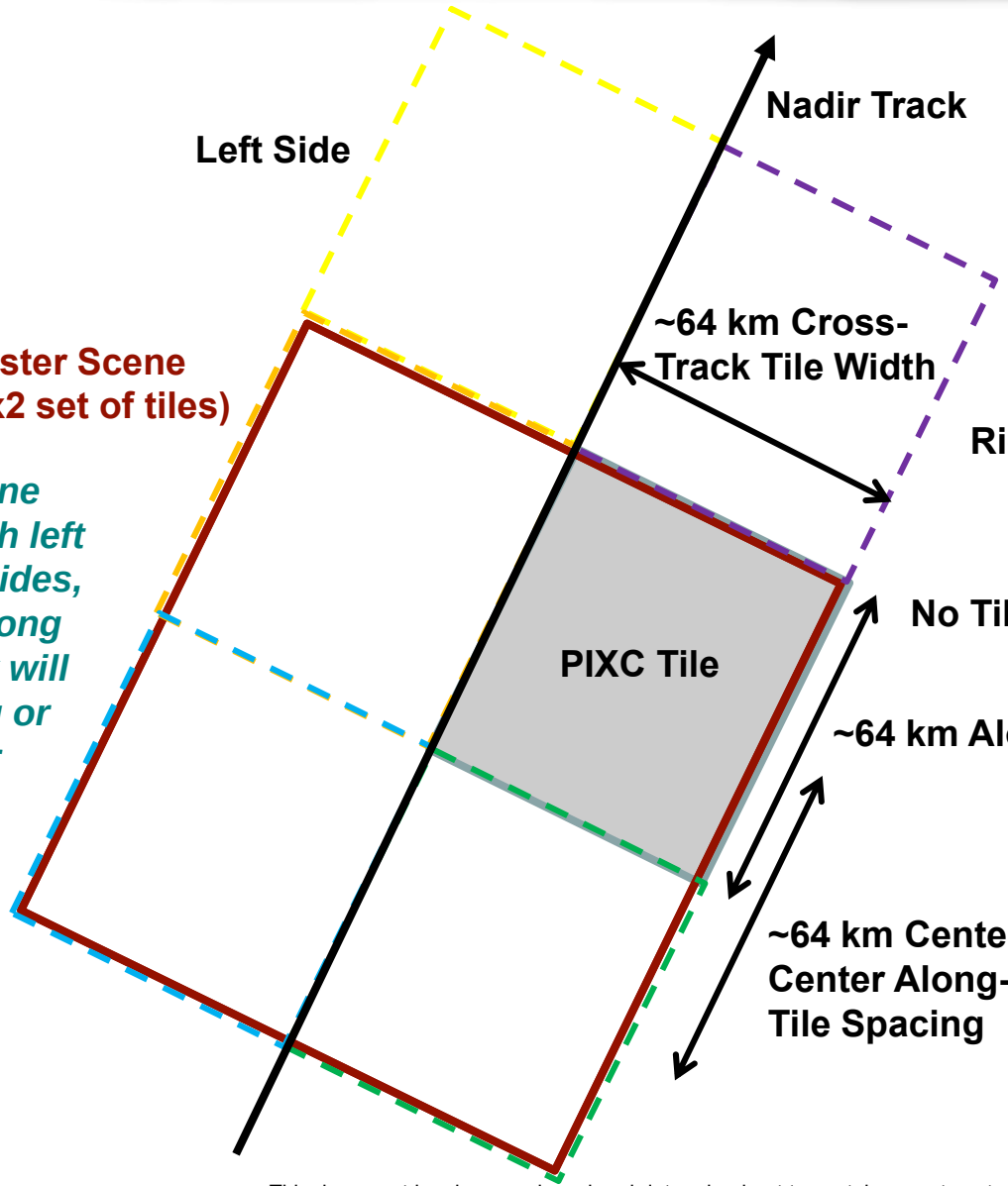
Values for media delays, geoid, and tide terms come from models, not SWOT observations. Model values used are reported in data products.



Product Granules

- PIXC/PIXCVec products distributed in ~64x64 km ‘tile’ granules
  - Tiles aligned with SWOT nadir track, which repeats every 21 days
  - Separate tiles on each side of nadir
  - Tile boundaries approximately fixed geographically
- Raster product distributed in ~128x128 km ‘scene’ granules
  - Raster product scenes coincide with 2x2 sets of PIXC/PIXCVec tiles
- RiverSP and LakeSP products distributed in continent-pass granules
  - All river and lake vector data from given continent during given pass in same granule
    - Continent geographical boundaries same as used for prior river and lake databases
    - Pass is half of spacecraft orbit around Earth, split at southernmost and northernmost points in orbit
- RiverAVG and LakeAVG products distributed in basin-cycle granules
  - All river and lake vector data from given basin during given cycle in same granule
    - Basin geographical boundaries same as used for prior river and lake databases
    - Basins do not cross continent boundaries
    - Cycle is 21 day repeat period of spacecraft orbit

Tile and Scene Granule Illustration



Given location on the surface is likely covered by multiple tiles from different passes

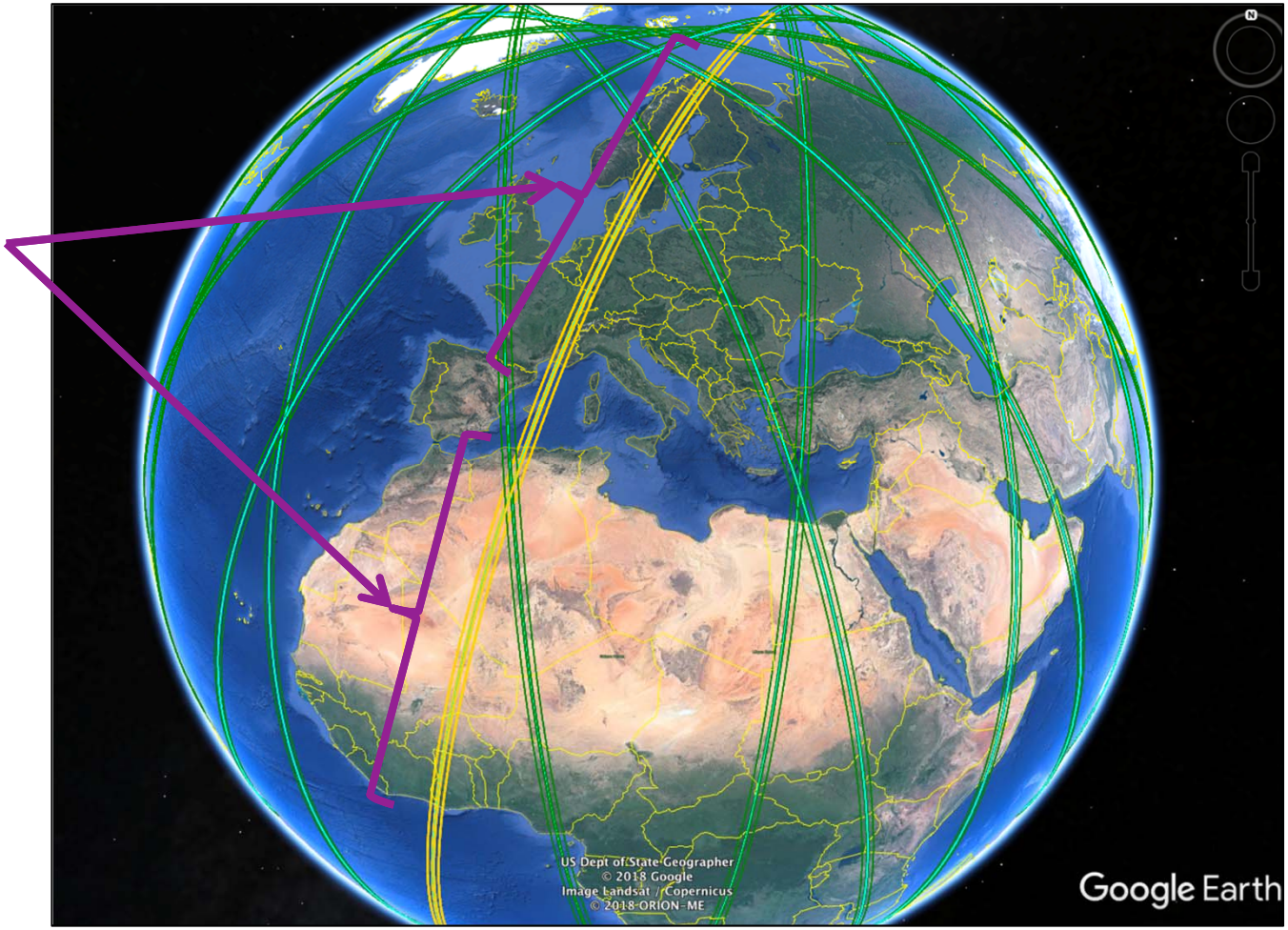
Raster scene covers both left and right sides, but data along nadir track will be missing or have lower quality

All river objects over continent (multiple tiles worth) for pass are in RiverSP granule; similar for lakes

Continent-Pass Granules

All river objects over continent (multiple tiles worth) for pass are in RiverSP granule; similar for LakeSP granules

Granules for RiverAVG and LakeAVG products are defined analogously but for basins instead of continents and for 21-day orbit cycles instead of passes

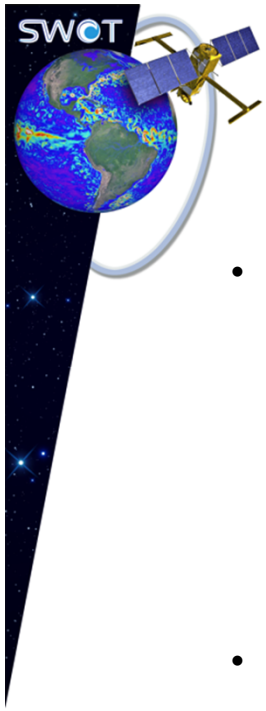


All passes for one day of 21-day repeat cycle are shown; one (ascending) pass is highlighted in yellow

Data Product Formats

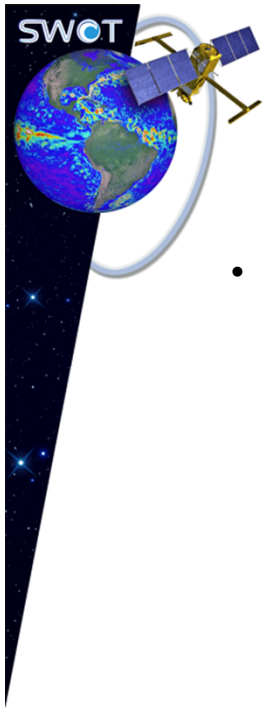
- NetCDF-4 format:
  - SLC
  - PIXC
  - PIXCVec
  - Raster
  - FPDEM
- Shapefile format:
  - RiverSP
  - RiverAVG
  - LakeSP
  - LakeAVG

- Note that single product can contain multiple files
  - Example: Granule of RiverSP product contains separate reach shapefile and node shapefile, which are both considered part of same product
  - Shapefiles each contain multiple parts in separate files (*.shp*, *.shx*, *.dbf*, *.prj*, *.shp.xml*)



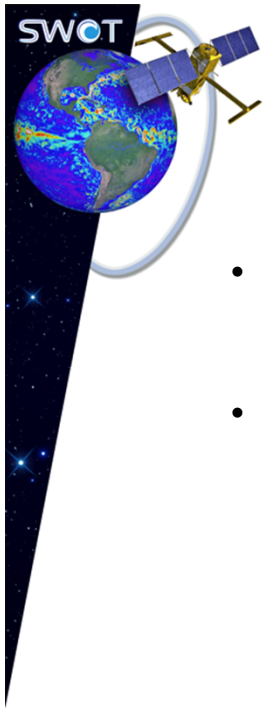
Level 0 Data

- L0 data contain raw telemetry from SWOT payload
  - Data from different instruments are in separate products
  - Data are generally in native, instrument-specific packet or frame format
    - Data are encoded into integer words following formats defined by instruments
    - Values are raw data numbers
- L0 data are not intended for science users
  - L0 data will not be available for download from distribution centers
  - Documentation describing L0 data will not be publicly released
- L0 data will be archived for reprocessing



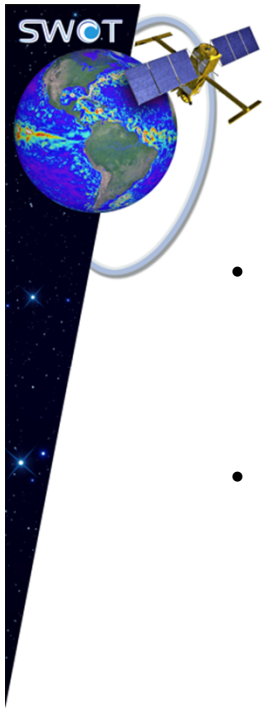
L1B HR SLC Product Overview

- Single-look complex (SLC) standard data product contains:
  - SLC images: Focused synthetic aperture radar (SAR) images from each of the two KaRIn antennas
    - *Single-look*: Images are focused to full intrinsic resolution of SWOT HR downlink data (no “multilooking” or spatial averaging has been applied yet)
    - *Complex*: Each image pixel has real and imaginary components (ie, magnitude and phase information)
  - Radiometric calibration (X factor) information
  - Noise estimates
  - Platform ephemeris, attitude, and related information to describe imaging geometry
  - Moderate-resolution DEM used for SLC processing, to which phase is referenced
    - SLC processing is not very sensitive to DEM accuracy or resolution
    - Later pixel-cloud processing is more sensitive to DEM accuracy and can use different DEM than SLC processor uses
- SLC product is intended only for users with very specific needs and expertise in interferometric SAR processing



ADT Near/Medium-Term Priorities

- Baseline product definitions for all standard products and create example L2 data products for ST users [2019]
- Continue nominal-case validation of algorithms, prioritized by risk [2019]
  - HR pixel-cloud algorithms (phase unwrapping, dark water flagging, water detection)
  - LR phase-bias correction algorithm with antenna dispersion
- Document baseline algorithms in ATBDs and review with subject matter experts from science team [2019-2020]
- Continue to deliver scheduled versions of operational software, test data, and documentation to SDS to allow SDS system development [continuing staggered deliveries software versions]
- Perform stress and robustness testing on operational processors [2020+]
- Continue refinement and enhancement of all algorithms [2020+]



Science Team Involvement

- Science Team / Science Definition Team representatives to ADT have been involved in data product definitions and algorithm choices to date
- Science Team interaction will continue in many ways:
  - ADT meetings with Science Team representation
  - Direct interaction between algorithm developers and Science Team
  - Review of Product Definition Documents (PDDs) and Algorithm Theoretical Basis Documents (ATBDs)
  - Review of prototype products
  - Selection and/or provision of geophysical models provided on products
  - Involvement in select code and simulation sharing
  - Science Team meetings, reviews, etc.

Backup

L1B HR SLC Product Details

- SLC processor uses time-domain backprojection SAR algorithm
- SLCs are coregistered and phase flattened
- SLCs are given on deskewed slant-plane grid
- Single-look samples are so noisy that they are generally not useful without spatial averaging
  - Intrinsic SLC resolution is not symmetric:
    - ~3 m along-track resolution
    - ~0.75 m slant-range resolution
      - ~60 m ground-projected range resolution at 10 km cross track
      - ~10 m ground-projected range resolution at 60 km cross track
  - Useful SWOT resolution is much coarser than intrinsic SLC resolution [*O*(100 m) or coarser for L2 products]
- SLC product is in NetCDF format