



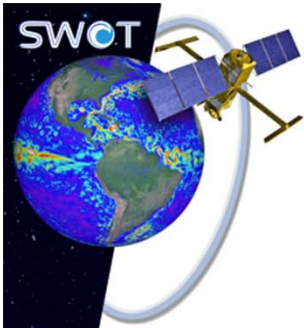
Surface Water and Ocean Topography (SWOT) Mission eST meeting September 13, 2021

Update on Algorithm Development

Nicolas Picot⁽²⁾, Shailen Desai⁽¹⁾,
Curtis Chen⁽¹⁾, Roger Fjortoft⁽²⁾, Alejandro Bohe⁽²⁾
on behalf of JPL/CNES Algorithm Development Team

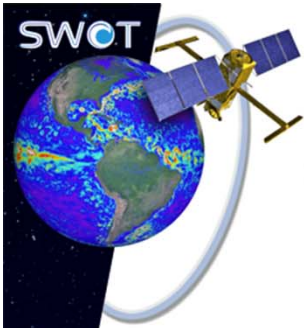
⁽¹⁾Jet Propulsion Laboratory, California Institute of Technology

⁽²⁾Centre National d'Etudes Spatiales



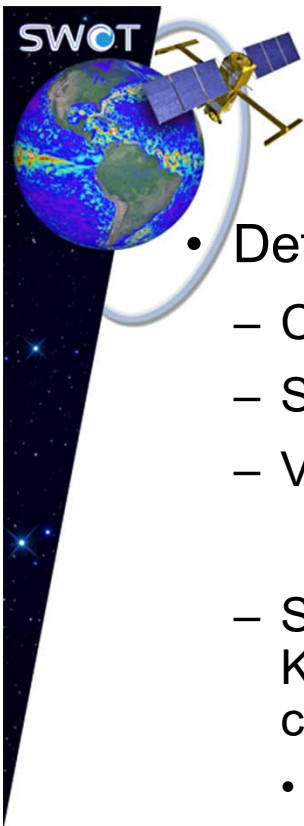
ADT status - Outline

- Brief status on the algorithm development.
- Summary of simulated datasets recently circulated on PODAAC server.
- Approach for Geophysical and Environmental Correction (GECO) software and data.



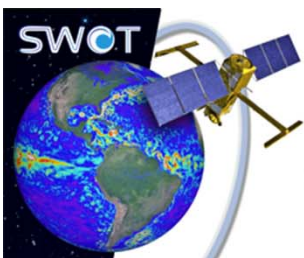
ADT status - Outline

- Brief status on the algorithm development.
- Summary of simulated datasets recently circulated on PODAAC server.
- Approach for Geophysical and Environmental Correction (GECO) software and data.



Algorithm Status

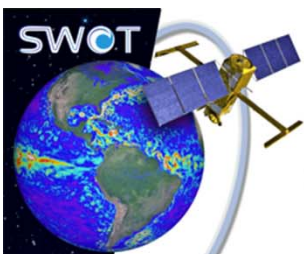
- Definition of algorithms
 - Core algorithms are nearly mature, with a limited number of exceptions.
 - Specific choices for some algorithms are still being tuned.
 - Validation through simulation is underway and guides this tuning.
- Some aspects of the processing deal with phenomena whose impact on KaRIn measurements is challenging to model (e.g. Sea State Bias correction, Layover...).
 - Improved algorithms will be developed after launch, once we have actual flight data.
- Release of Algorithm Theoretical Basis Documents (ATBDs) to ST in 2022.
 - Current draft ATBDs contain nearly full descriptions of the algorithms.
 - Performance analyses are ongoing.
 - To be reviewed by Subject Matter Experts (SMEs) and Lead SMEs from Science Team through 2021-2022.
 - Dedicated meetings with SMEs through review cycle.



Subject Matter Experts : KaRIn Low Resolution (Oceans) Science Algorithms

Lead SMEs : Global co-ordination : T. Farrar (US); G. Dibarboure (FR)

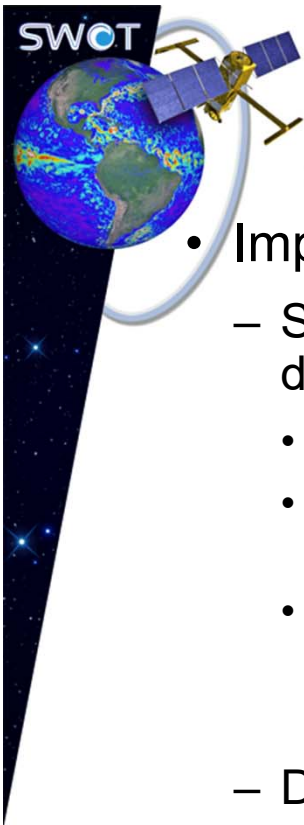
| Science Algorithm | Description | Subject Matter Experts |
|--|--|---|
| L2_RAD_GDR | Generates Level 2 radiometer product with measurements of wet troposphere delay and sigma0 atmospheric attenuation from downlinked data. | S. Brown B. Picard |
| INT_LR_XOverCal | Generates cross-over calibration product to mitigate systematic errors (e.g., bias, roll/phase, baseline length) from KaRIn and nadir altimeter sea surface height measurements. | E. Rodriguez P. Bonnefond Co-I : C. Watson |
| L1B_LR_INTF | Generates Level 1B product with 9-beam interferometric, correlation, and power data corrected for instrument effects from 9-beam downlinked data. | F. Nouguier Co-I : B. Chapron D. Vandemark |
| L2A_LR_NativePreCalSSH L2B_LR_FixedPreCalSSH L2A_LR_NativeSSH L2B_LR_FixedSSH | Generates Level 2 sea surface height data products. L2A at KaRIn native center-beam with 2/2 km and 250/500 posting/resolution. L2B on geographically fixed grid with 2/2 km posting/resolution. LR_NativeSSH appends crossover calibration to LR_NativePreCalSSH. LR_FixedSSH appends crossover calibration to LR_FixedPreCalSSH. | S. Gille Co-I : Ed Zaron E. Cosme Co-I : E. Salameh & N. Ayoub |



Subject Matter Experts : KaRIn High Resolution (Hydrology) Science Algorithms

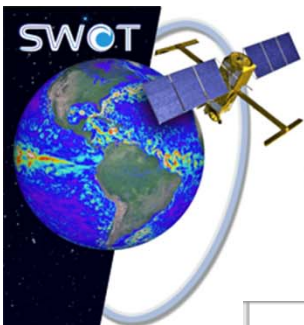
Lead SMEs : Global co-ordination : M. Durand (US); S. Biancamaria (FR) (TBC)

| Product | Description | Subject Matter Experts |
|---|--|---|
| L1B_HR_SLC | Level 1B single-look-complex (SLC) data product with SLC images, calibration information, time-varying platform and radar system parameters, and digital elevation model. | S. Hensley H. Yésou for the DEM |
| L2_HR_PIXC | Level 2 pixel cloud data product from SLC product with reconstructed height, water detection, flagging. | M. Durand H. Yésou D. Blumstein |
| L2_HR_RIVER_TILE L2_HR_RIVER_SP L2_HR_RIVER_AVG | Level 2 river data products from pixel cloud data and provides center-line locations, widths, heights, slopes, discharge, and flags for sub-reaches and total reach. _TILE product extends over single tile of data. _SP product extends over single pass over continent. _AVG product aggregates over one basin (or region) within one repeat cycle. | L. Smith P.A. Garambois S. Ricci |
| L2_HR_LAKE_TILE L2_HR_LAKE_SP L2_HR_LAKE_AVG | Level 2 lake data products pixel cloud data and provides height, geolocation, and shape. _TILE product extends over single tile of data. _SP product extends over single pass over continent. _AVG product aggregates over one basin (or region) within one repeat cycle. | J. Wang J.F. Cretaux H. Yésou |
| L2_HR_RASTER | Level 2 raster product from pixel cloud data product by resampling single-pass data onto a 2-D fixed grid. | M. Simard S. Biancamaria M. Grippa F. Pappa (for wetlands) |

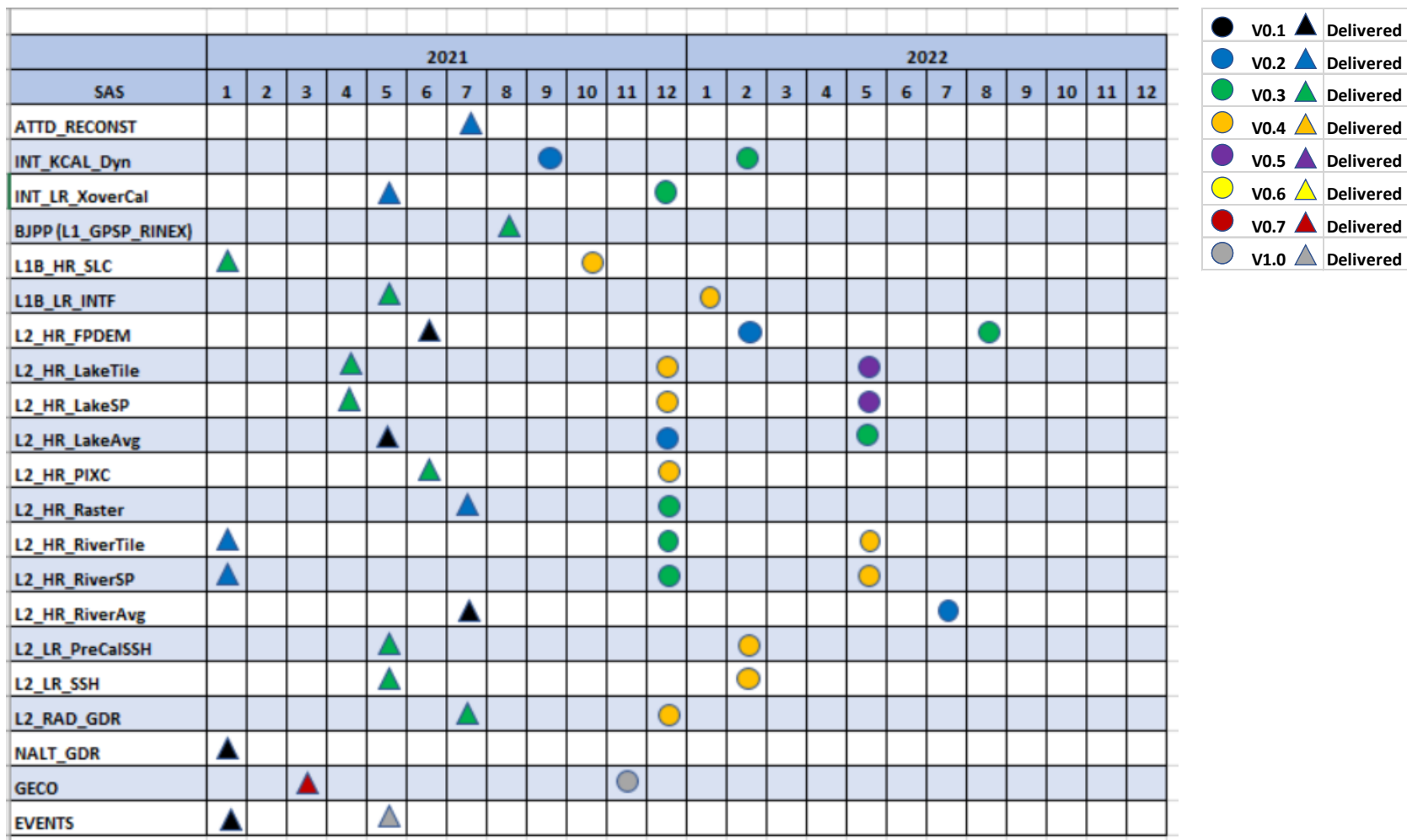


Algorithm Status

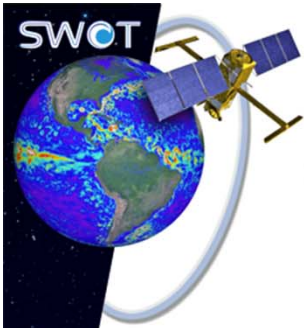
- Implementation and infrastructure
 - Science Algorithm Software (SAS) implementing the algorithms regularly delivered for integration in Science Data System (SDS).
 - Current SAS versions are compliant with PDDs, interfaces (with minor exceptions).
 - Ongoing work on SDS system constraints (CPU, memory, i/o...) to be compatible with the CNES infrastructure used for daily forward processing.
 - Future versions are planned, but not yet in schedule (**next slide**), to accommodate ATBD inputs and in-flight data.
 - Developing “Expertise Center” for post-launch troubleshooting and cal/val.



ADT Software schedule (SAS : Science Algorithm Software)

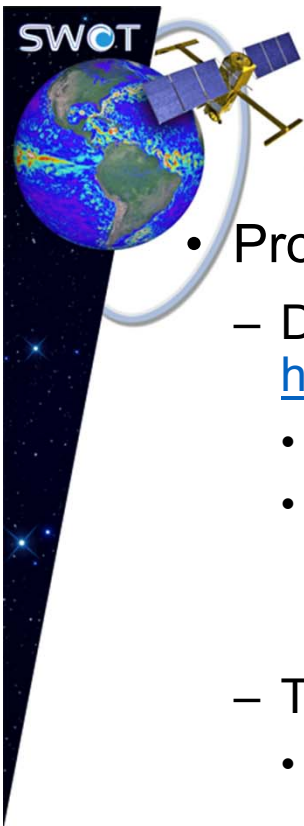


Future versions are planned, but not yet in schedule, to accommodate ATBD review inputs and in-flight data.



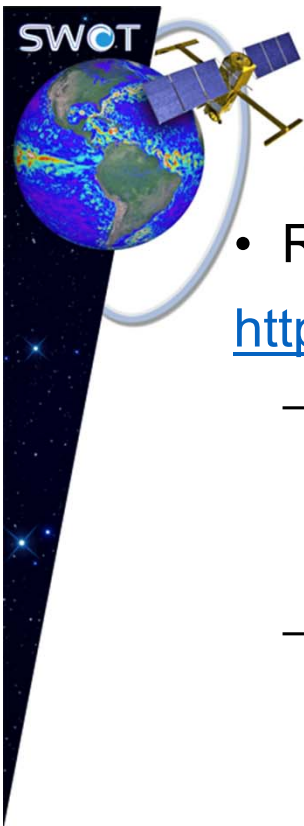
ADT status - Outline

- Brief status on the algorithm development.
- Summary of simulated datasets recently circulated on PODAAC server.
- Approach for Geophysical and Environmental Correction (GECO) software and data.



Product status from last February presentation

- Product definitions are mature for most products.
 - Detailed product description documents available at: <https://podaac.jpl.nasa.gov/SWOT?tab=datasets§ions=about>
 - Completed review by Subject Matter Experts from the Science Team.
 - **Minor evolutions to product descriptions are expected over next 2 years.**
 - **Definition of data flags in particular.**
 - Three pending product description documents:
 - RiverAvg and LakeAvg products by mid-2021.
 - **Review at project level completed, under review by SMEs for RiverAvg.**
 - Flood Plain Digital Elevation Map (FPDEM) by end of 2021.
 - **Review at project level completed.**
 - First FPDEM product after one year of in-flight data available.
- User handbook to be generated in 2022.



Sample data products on PODAAC side

- Refer to the release note circulated by PODAAC team at <https://podaac.jpl.nasa.gov/SWOT?tab=datasets>
 - Aimed towards allowing users become accustomed to the **KaRIn data product formats and data distribution interfaces**.
 - **Not to be used to evaluate instrument performance or for scientific research.**
 - **Very small data set circulated on the portal**
 - Questions and feedback on sample data products can be sent to podaac@podaac.jpl.nasa.gov.

August 30, 2021

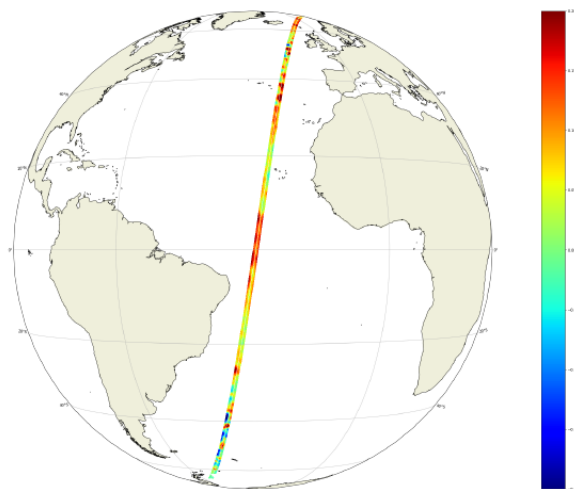


Figure 1. Illustration of sea surface height anomaly from one pass (pass 7) of the L2_LR_SSH product.

August 30, 2021

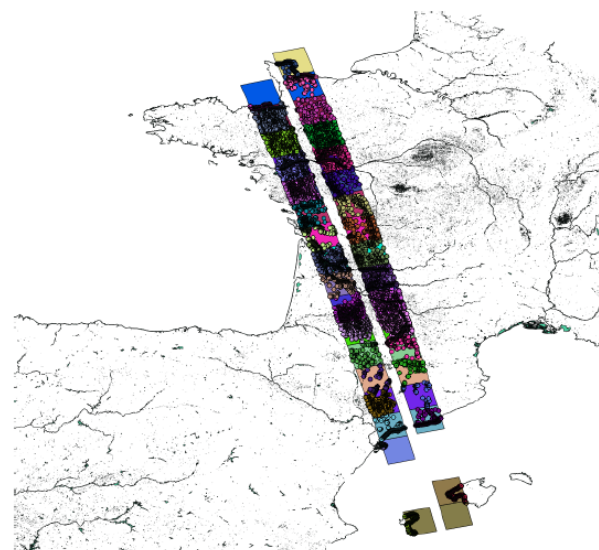


Figure 2. Illustration of the coverage of the KaRIn High Rate sample data products.

Surface Water and Ocean Topog x +

https://podaac.jpl.nasa.gov/SWOT?tab=datasets

Version 1.2
Release Note for Sample Data Products

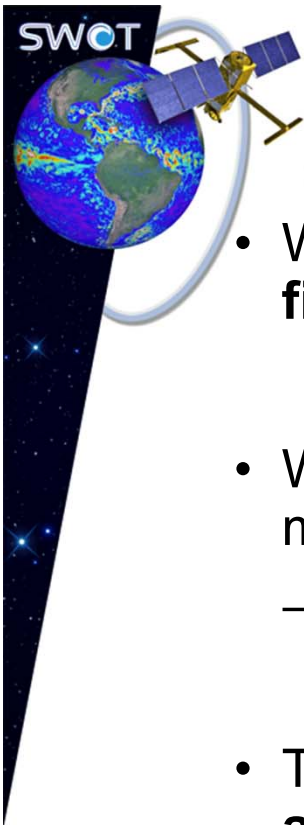
cean Topography (SWOT)

TERRESTRIAL HYDROSPHERE COAST

NEWS & ANNOUNCEMENTS RESOURCES

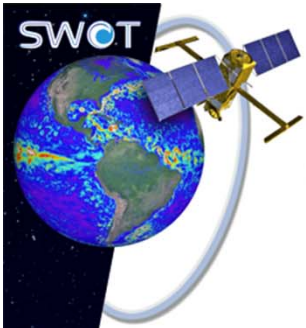
data products, along with product descriptions and sample data for these sample files is SWOT Sample Data Products v1.2 and all

| erage | Format | Product Description Document | Sample Data Product v1.2 |
|------------------------------|--------|-------------------------------|------------------------------|
| Ided; full th for each orbit | netCDF | L2_LR_SSH Product Description | L2_LR_SSH.tar.gz Sample Data |



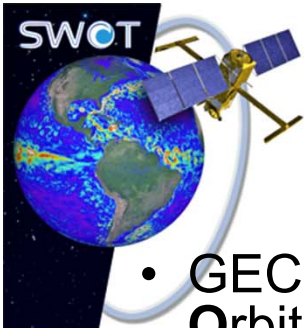
Sample data products on PODAAC side

- We have recently added the **Unsmoothed Level 2 LR sample files**.
- We are **currently working on the nadir products** using the same means (to be released before end 2021).
 - Very similar to those from Sentinel-6 and Jason-3 GDR-F.
- There were several discussions, led by the lead SMEs, to **circulate a much longer data set to support ST needs**.
 - Longer duration data already generated LR or HR products using similar approach as short-duration samples released to ST.
 - Years for the LR, basin scale over one cycle for the HR.
 - Primarily aimed towards SDS/PODAAC needs or for algorithms validation (in particular Xover).
 - Decision to circulate to the ST community has not been reached as not beneficial to science applications.
 - **Note: Available simulated data today are not useful for scientific purposes.**



ADT status - Outline

- Brief status on the algorithm development.
- Summary of simulated datasets recently circulated on PODAAC server.
- Approach for Geophysical and Environmental Correction (GECO) software and data.



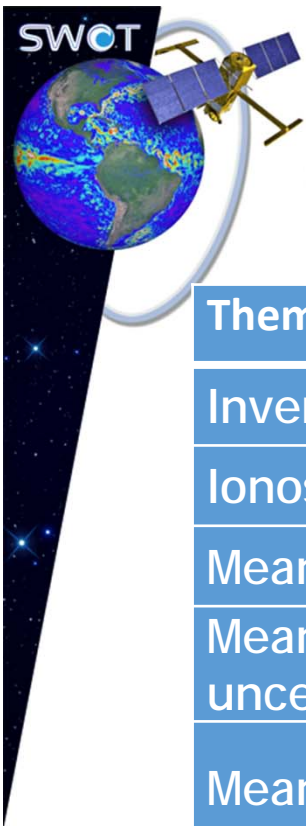
GECO library : what it is

- GECO means : **G**eophysical/**E**nvironment **C**orrections and **O**rbitography module
- GECO is the geophysical library used to compute **all** geophysical and environmental corrections on **all** Karin LR and HR products. GECO is used also to manage and process orbit ephemeris and attitude files.
- GECO is inherited from the algorithms developed for the nadir processing and is using similar models standards (so called 'GDR-F' standard), but is also adapted to SWOT Karin needs.
- But GECO is a new algorithm software suite, compliant to SWOT SDS ground processing constraints, validated with a comparison to the corresponding nadir algorithms. However some slight differences exist between nadir and KaRin processing approaches and we are working towards a common approach.



GECO library current models standards

| Theme | Current Model Standard |
|--------------------------------|--|
| Bathymetry | ESA ACE-2 |
| Distance to coastline | GSHHG v2.3.7 |
| Dry tropospheric correction | 2D from ECMWF data for LR processing. 3D from ECMWF multi-level model data for HR processing. |
| Dynamic Atmospheric Correction | MOG2D |
| Earth tide | Cartwright/Taylor/Edden |
| Geoid | EGM2008 |
| Ice map concentration and flag | EUM OSI SAF |
| Internal tide | HRET 8.1 (Zaron) |



GECO library current models standards

| Theme | Current Model Standard |
|-------------------------------------|--|
| Inverted barometer | from ECMWF data |
| Ionospheric delay | JPL Global Ionosphere Maps |
| Mean dynamic topography | CNES/CLS 2018 |
| Mean dynamic topography uncertainty | CNES/CLS 2018 |
| Mean sea surface | CNES/CLS 2015 and DTU 18 |
| Mean sea surface uncertainty | CNES/CLS 2015 and DTU 18 |
| MF WAM | from ECMWF data |
| Ocean tide | FES2014b solution on regular grid GOT4.10c solution on regular grid |
| Pole tide | Desai 2017 |



GECO library current models standards

| Theme | Current Model Standard |
|-------------------------------------|------------------------|
| Rain rate | from ECMWF, not flag |
| Sea State Bias | Saral GDR-C 2014, 2D |
| Surface_type | Glob Cover, 7 states |
| Sea surface pressure | from ECMWF |
| Wet tropospheric correction | 2D from ECMWF data |
| Wind meridional and zonal component | from ECMWF |



GECHO library next evolutions

- As for the Nadir algorithm suite, CNES will continue to implement new standards in GECHO. There are many ongoing developments (internal tides, FES2022, GOT, MSS, MDT,) that we might need to take into account in the future.
- However, those models need to be:
 - Developed,
 - Fully validated (potentially by an independent team to verify the metrics),
 - Recommended by ST for integration in SWOT Karin processing standard,
 - And finally evaluated by project in terms of feasibility, cost and schedule (software, integration, documentation ...).
 - The operational ground system expects to have a SWOT frozen launch version mid-2022.
 - Future evolutions are certainly possible (in the operational ground system and/or in the expertise center).
- CNES has secured some funding for the coming years to support this activity



Backup Slides



User Documents

User Handbook

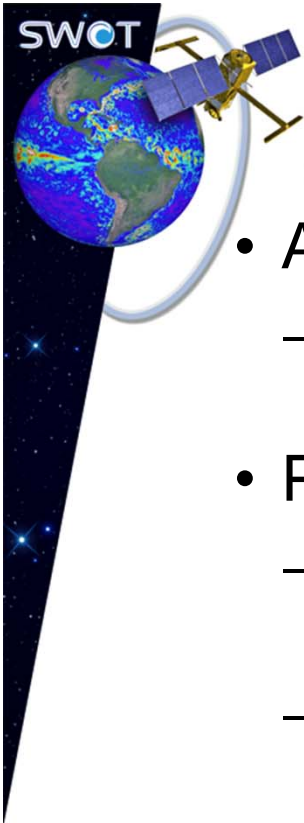
- Mission Overview, Terminology and Definitions
- Mission Design and Payload
- Basic Measurement Principles of Payload
- Radar phenomenology
- Geophysical contributors to measurements
 - E.g., media delays, MSS, tides, etc.
- Processing flow

Product Description Documents

- Separate document for each science data product
- Product-specific content
- Structure
- Qualitative description
- Detailed format and content
- Size and latency

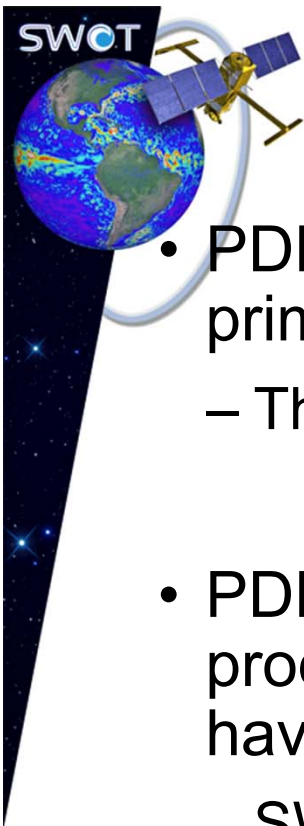
Algorithm Theoretical Basis Documents

- Separate document for each science data product
- Physical and mathematical basis of algorithms.
- Describes how variables in products are computed.
- Qualitative description of input and output data



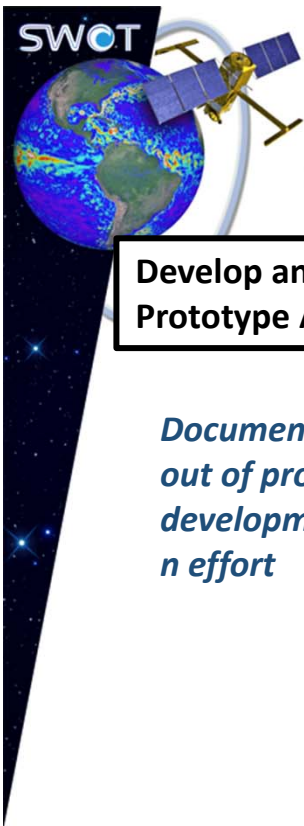
Context of ATBD, PDD, and User Handbook

- ATBD targeted to the more-expert user.
 - Users interested in the details of how reported variables are computed.
- PDD targeted to the general user.
 - Capture as wide of an audience as technically feasible.
 - High level qualitative descriptions of parameters in the product.
 - Especially, users likely to find the ATBD to be challenging.
 - Some (but only where necessary) references to ATBD primarily as recommended reference for more-expert user.
 - Where lengthy technical description would be alternative.
 - No references to specification sections or equations from the ATBD.
 - Aimed to be as self-contained as feasible.
- User Handbook targeted to ALL users.
 - Provides general context of SWOT and its measurements that apply to all of the ~10 SWOT standard data products.

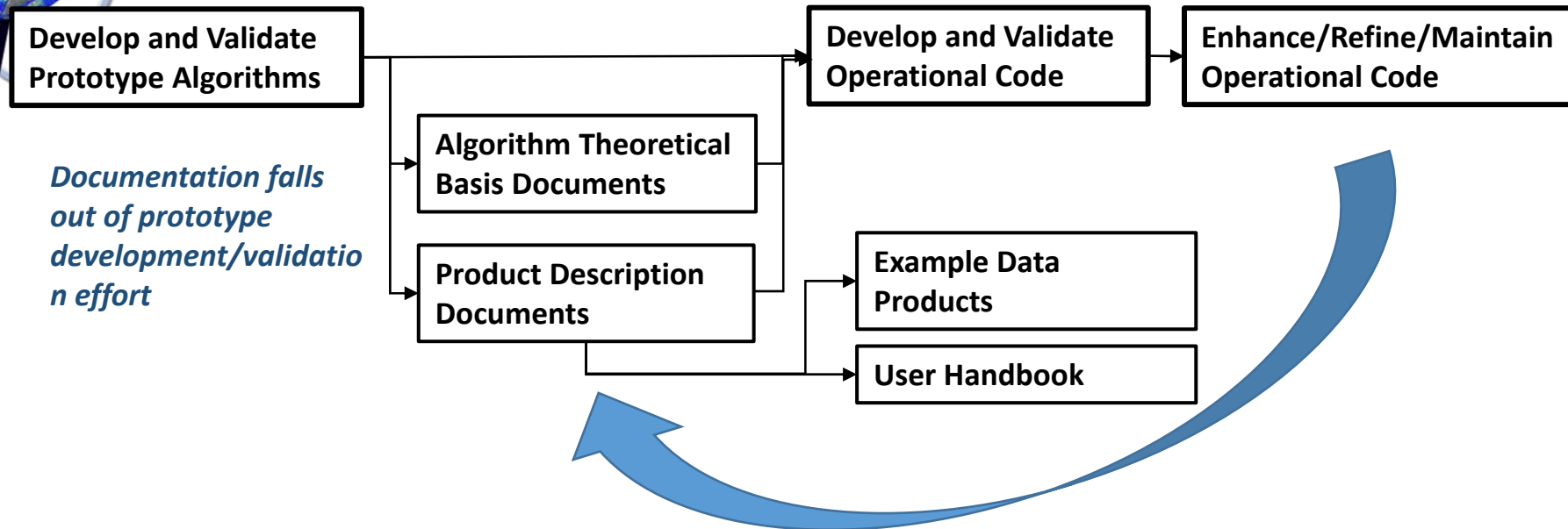


KaRIn vs. Nadir Altimeter

- PDDs and ATBDs for KaRIn science data products are the primary focus for review/input from SWOT science team.
 - These algorithms are novel for SWOT.
- PDDs and ATBDs for nadir altimeter science data products, including orbit determination(e.g., POE/MOE) have strong heritage from Jason-series (Jason-1/2/3).
 - SWOT to use best available Jason/Sentinel-6 standards.
 - ATBDs were comprehensively reviewed during Jason-1 mission development by Ocean Surface Topography Science Team.
 - Available to SWOT science team upon request to CNES project (@N. Picot).
 - Ongoing evolutions to align products and algorithms to Jason-CS standard.



KaRIn PDD/ATBD Development Approach



- All documents expected to evolve through pre-launch.
 - Potentially during reprocessing opportunities.
- Evolution begins with mature baseline version for review by subject matter experts.
 - Prototype algorithms serve as basis of baseline documents.