Quality Status of the CryoSat Data Products

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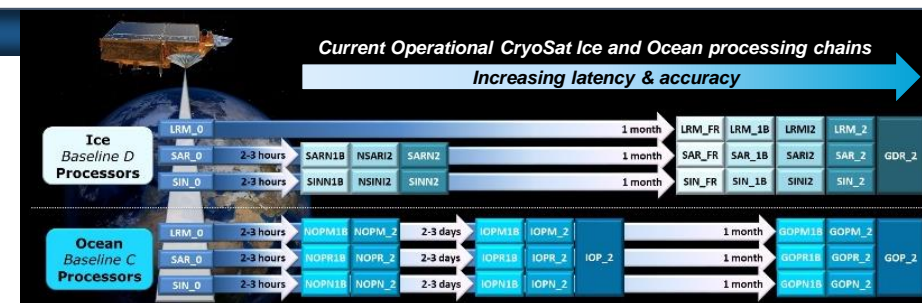
CryoSat Mission

- Launched in April 2010, CryoSat is **ESA's dedicated ice mission**. It was specifically designed to measure changes in the thickness of polar sea ice and the elevation of the ice sheets and mountain glaciers.
- Going beyond its original mission objectives, CryoSat is now a valuable source of data for the oceanographic community.
- CryoSat's sophisticated **SAR Interferometric Radar Altimeter (SIRAL)** can measure high-resolution geophysical parameters from the open ocean to the coast.
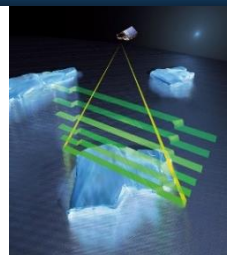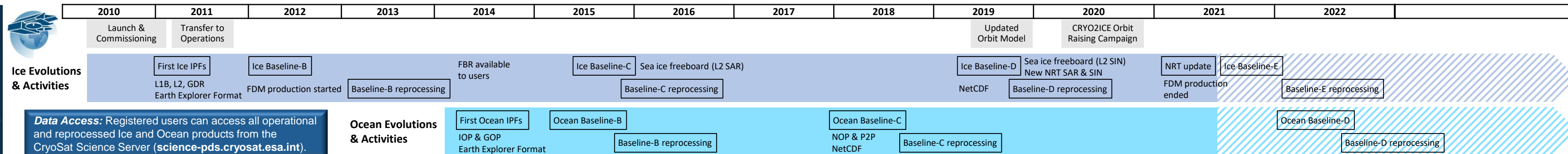
CryoSat Data Processing

- **SIRAL** operates in three modes: Low Resolution Mode (LRM), Synthetic Aperture Radar (SAR) and SAR Interferometric (SARIn).
- CryoSat Level 0 (L0) data is processed operationally to science Level 1B (L1B) and Level 2 (L2) products using two independent processing chains: **Ice** and **Ocean**. Both processors generate a range of operational products with increasing latencies and accuracies.
  - ➤ **Ice:** Near Real Time (NRT) SAR & SARIn products, Offline LRM, SAR, SARIn and Global Data Record (GDR) products
  - ➤ **Ocean:** Near Real Time Ocean Products (NOP), Intermediate Ocean Products (IOP) and Geophysical Ocean Products (GOP)
- To enable their full scientific and operational exploitation, the CryoSat products are continuously evolving, through updates and improvements to the **Instrument Processing Facilities (IPFs)**.

Current Operational CryoSat Ice and Ocean processing chains — Increasing latency & accuracy

CryoSat Timeline

Timeline (2010–2022):

- Launch & Commissioning
- Transfer to Operations
- Updated Orbit Model (2019)
- CRYO2ICE Orbit Raising Campaign (2020)

Ice Evolutions & Activities
- First Ice IPFs
- L1B, L2, GDR Earth Explorer Format
- Ice Baseline-B
- FDM production started
- Baseline-B reprocessing
- FBR available to users
- Ice Baseline-C / Sea ice freeboard (L2 SAR)
- Baseline-C reprocessing
- Ice Baseline-D / Sea ice freeboard (L2 SIN) / New NRT SAR & SIN
- NetCDF
- Baseline-D reprocessing
- NRT update / FDM production ended
- Ice Baseline-E
- Baseline-E reprocessing

Data Access: Registered users can access all operational and reprocessed Ice and Ocean products from the CryoSat Science Server (**science-pds.cryosat.esa.int**).

Ocean Evolutions & Activities
- First Ocean IPFs
- IOP & GOP Earth Explorer Format
- Ocean Baseline-B
- Baseline-B reprocessing
- Ocean Baseline-C
- NOP & P2P NetCDF
- Baseline-C reprocessing
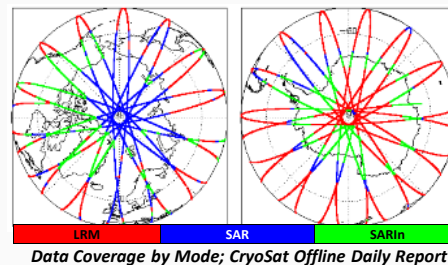- Ocean Baseline-D
- Baseline-D reprocessing

Operational Quality Control

- The Quality Assurance for Earth Observation (IDEAS-**QA4EO**) service (formerly IDEAS+) is a Telespazio UK led consortium providing support to the ESA/ESRIN Sensor Performance and Algorithms (SPPA) office.
- Since launch, IDEAS-QA4EO has performed routine **Quality Control (QC)** on all operational and reprocessed CryoSat products.
- IDEAS-QA4EO also plays an important role throughout the **IPF evolution** and validation process, providing support to software development, test data set generation and verification.

Daily Product Quality Monitoring

- Production completeness & processing failures monitoring
- Product format, header and quality checks
- Auxiliary Data File (ADF) availability and usage
- Analysis of key measurement parameters

Daily QC reports are uploaded to the ESA CryoSat webpage https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/cryosat/.

*Data Coverage by Mode; CryoSat Offline Daily Report*

Long Term Product Quality Monitoring

IDEAS-QA4EO use C2QC, the Horus Tool, and MSSL Quality Assurance (QA) monitoring facility for long term analysis of:

- SIRAL instrument health and data availability
- Star tracker attitude parameters
- Key L2 parameters, e.g. freeboard and Sea Surface Height Anomaly (SSHA)
- Retracker failure statistics and L2 quality flags
- Crossover analysis
- Availability and magnitude of external corrections

Results are presented in Monthly Quality reports, and uploaded to the ESA CryoSat webpage: https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/cryosat/cyclic-reports


Loss of Track in L0 data during February 2021
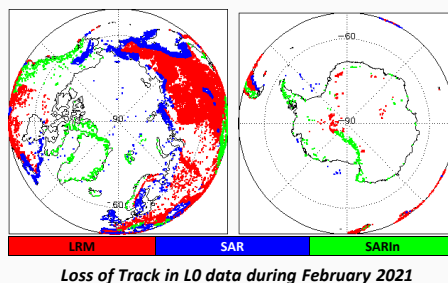
Current CryoSat Ice Processor: Baseline-D

| IPF1 vN1.1 | IPF2 vN1.2 |

Since **May 2019** the CryoSat ice products are generated with **Baseline-D**. This major processor upgrade implemented significant improvements for the exploitation of CryoSat measurements over land ice and sea ice. Following completion of the reprocessing campaign, Baseline-D Ice products are available for the entire mission.

Key features of Baseline-D:

- Product format change from Earth Explorer Format to Network Common Data Form (**netCDF**).
- Generation of NRT SAR & SARIn products in **near real time** (2-3 hours after acquisition) with the L0 Star Tracker products instead of delayed STR_ATTREF.
- **L2 SARIn freeboard** computation activated to provide freeboard values over the Arctic Ocean and marginal polar regions.

Baseline-C: Mean Freeboard /m from L2 SAR (Dec 2013), 10 km gridded [MSSL]
Baseline-D: Mean Freeboard /m from L2 SAR & SARIn (Oct 2019), 10 km gridded [MSSL]
SARIn mode gap

- **Laxon-Ridout sea ice retracker** improved for Arctic and Antarctic sea ice retracking; **UCL land ice retracker** tuned to reduce noise and the number of bad-flagged data points compared with Baseline-C.
- New **stack peakiness** parameter added to L1B SAR & SARIn products *(stack_peakiness_20_ku)*, useful for detecting leads and could aid sea ice discrimination and freeboard computation at L2.
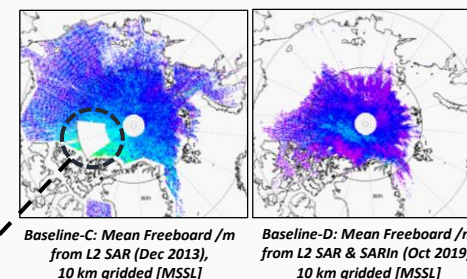
Current CryoSat Ocean Processors: Baseline-C

| COP IPF1 v3.7 | COP IPF2 v3.9 |

Since **November 2017** the CryoSat ocean products are generated with **Baseline-C**, the latest processor upgrade for the ocean products. Following a reprocessing campaign, Baseline-C GOP are available for the entire mission.

Key features of Baseline-C:

- Generation of ocean products for **all data acquisition modes** (LRM, SAR and SARIn).
- **Near Real Time Ocean Products (NOP)**, generated 2-3 hours after data sensing acquisition.
- **Pole-to-Pole (P2P)** products for IOP and GOP. These are multi-mode L2 products with half-orbit coverage.
- **Pseudo-LRM (PLRM)** estimates included in SAR and SARIn ocean products; good consistency with LRM.
- New **Wet Tropospheric Correction (WTC)** computed by University of Porto from the GNSS-derived Path Delay Plus (**GPD+**) algorithm, which combines all available observations to improve WTC for radar altimetry.
- Innovative new **SAR and SARIn retracker:** SAR Altimetry MOde Studies & Applications (SAMOSA). Existing LRM retrackers refined.

	LRM	SAR	SARIn
	Ocean MLE-4	SAMOSA	SAMOSA
	Ice OCOG	DPM 2.3	DPM 2.3

Ocean Baseline-C Retrackers

New CryoSat Ice Processor: Baseline-E

The next major Ice processor upgrade is **Baseline-E**. IDEAS-QA4EO are currently involved in verifying and validating Baseline-E Test Data ahead of the Transfer-to-Operations (TTO) in late Q3 2021.

Key features of Baseline-E:

- Improved filtering of outliers to improve the **interpolated SSHA** accuracy. By filtering out long range off-nadir leads, a small increase in SSHA is expected. This is expected to have the greatest impact on freeboard measurements in areas of thick sea ice where off-nadir leads have a greater impact.
- Improved **interpolation of SSHA** across file boundaries and mode changes, using data from adjacent files.
- Modification of the Warren **Snow Depth** according to sea ice type (new flags introduced), and subsequent use of this snow depth to compute a delay correction to the sea ice height.
- Addition of **20Hz Pseudo-LRM (PLRM)** estimates to the L1B SAR and SARIn products.
- Improvements to LRM and SARIn **land ice retracking**.
- **Compression** of the L1B and L2 netCDF products.

	LRM	SAR	SARIn
R1	CFI	UCL Sea Ice	UCL Margins
R2	UCL Land Ice		
R3	OCOG		

Ice Baseline-E Retrackers

- Generation of a new **L1B Stack (L1B-S) product**, available to specialist users on demand.
- Implementation of the updated **Earth Explorer CFI** software library, allowing the correct handling of the CryoSat Doris Navigator Orbit files. Resolution of a number of known anomalies in Ice Baseline-D products.

Future Evolutions for Ocean Processor: Baseline-D

The next major COP upgrade, **Baseline-D** is planned for early 2022 and will include the following evolutions:

Key features of Baseline-D:

- Update of the SAR/ SARIn **SAMOSA retracker** to the latest version (v2.5).
- Improved **Sea State Bias**, **wind speed**, and **Sigma-0** solutions. Improved continuity between modes.
- Upgraded **surface type mask** (7-states classification), **models and corrections** (latest FES library, DTU18 MSS, CNES-CLS 2018 MDT, Desai 2015 pole tide model).
- Implementation of the updated **Earth Explorer CFI** software library, allowing the correct handling of the CryoSat Doris Navigator Orbit files in NOP processing.
- Resolution of a number of known anomalies and processing failures affecting the Baseline-C products.