

CryoSat Mission Update

A brief overview of characteristics and status

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On the behalf of Tommaso Parrinello, Pierre Femenias and the Cryosat Team

Table of content



- 
- A detailed illustration of a satellite in orbit above Earth. The satellite has a large, rectangular solar panel array with a grid of solar cells. It has a complex structure with various instruments and antennas. The Earth's surface is visible below, showing a mix of land and water.
- **Chronology**
 - **Mission objectives and characteristics**
 - **Status: Payload, platform and ground segment**
 - **Product availability and evolution**
 - **Conclusions and perspectives**

- CryoSat-1 selected as the first Earth Explorer Opportunity mission in 1999
- CryoSat-1 destroyed in a launch failure in 2005
- PB-EO decision to rebuild the satellite in 2006:
"CryoSat is more important now than when it was first selected"
- CryoSat-2 launch: 8 April 2010
- Commissioning phase: April – October 2010
- Start of operational phase: 1st November 2010
- ***Cryosat Mid-Term Review: 13 May 2014***
ESA Science Advisory Committee would recommend the continuation of the C-2 until Feb 2017



Mission objectives and characteristics



Slide adapted from Parrinello et al 2014

Primary Mission Objectives

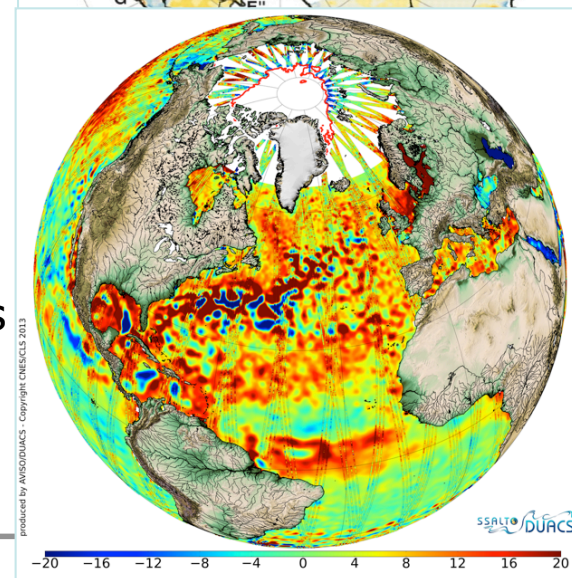
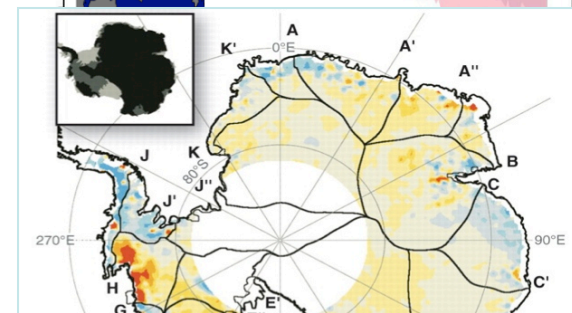
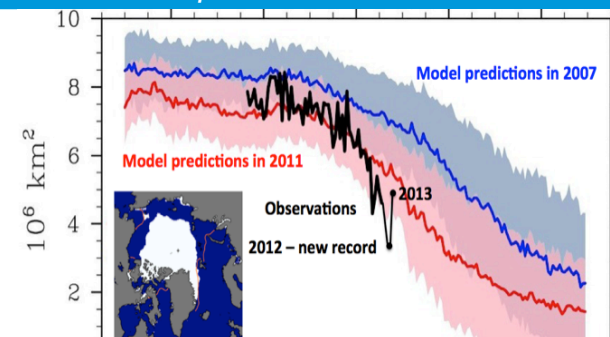
- Determination of regional and basin-scale **trends** in perennial **Arctic sea ice** thickness and mass
- Determination of contributions to global **sea-level** of the **Antarctic** and **Greenland** ice sheets

Secondary Mission Objectives

- Observation of **seasonal cycle** and **variability** of Arctic and Antarctic sea ice mass and thickness
- Observation of variation in thickness of the world's ice **caps and glaciers**

Additional portfolio: NEW ocean Products

- Ocean products to **bridge the gap between** previous ocean-oriented missions and the future S3
- Contribute to our knowledge on **Cryosphere Ocean interactions**



Ocean Product characteristics

Why ?

- Strong interest in the oceanographic Community since Cryosat was selected as an Explorer + Recommendations from the last Cryosat WS

How ? What ? When ?

- COP developed with the **kind and valuable support of CNES** and partners
- The processing of the Cryosat data is limited to the LRM and SAR modes. SAR mode is processed in Pseudo-LRM (continuity ...)
- IOP generated in **2-3 days** from sensing (available from data acquired on 10 April 2014)
- GOP generated in **30 days** from sensing (available from data acquired on 9 April 2014)
- Official data release to the user community on 4 June 2014

Validations

- Operational validation of the IOP & GOP products is performed by NOCS. Collaboration expected with ECMWF for SWH and WS fields.

Mission objectives and characteristics



Slide adapted from Parrinello et al 2014

Mission and System Requirements

Requirements	Sea Ice 10^5 Km^2	Ice Sheets Regional scale 10^4 Km^2		Ice Sheets $13.8 \cdot 10^6 \text{ Km}^2$	Ocean
Minimum Latitude	50°	72°		63°	No yet defined (But ~ RA2 ...)
Mission Requirement	3.5 cm/yr	8.3 cm/yr		1.0 cm/yr (130 Gt/y)	
Mode	SAR	LRM	SARIn	SARIn / LRM	(P)LRM : IOP/ GOP SAR SARIn : CP4O



- Dedicated **mode** operating function of the considered areas
- **Orbit** allowing a high density of measurements over the Poles

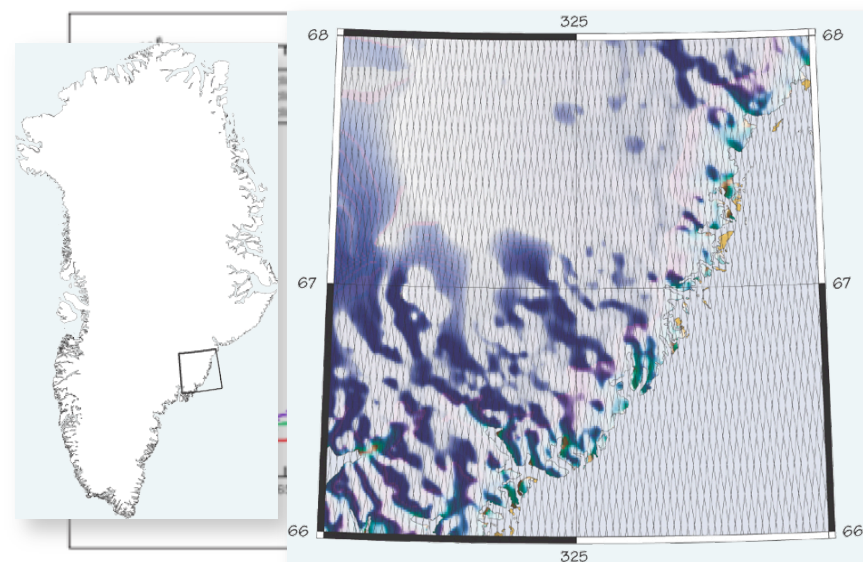
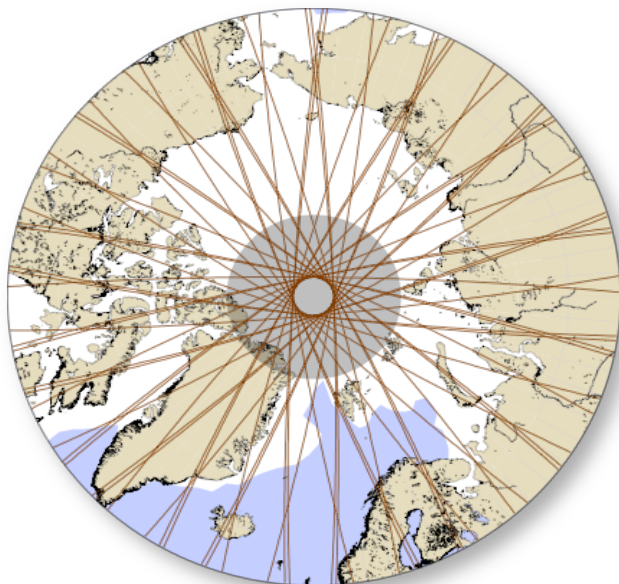
Mission objectives and characteristics



Slide adapted from Parrinello et al 2014

An usual orbit to meet the mission requirement (a trade off ...)

- High density coverage of crossover points
- Need cover sufficiently the south Greenland
- ❖ LEO, non sun-synchronous, 369 days (30 day sub-cycle) | Mean altitude: 717 km
- ❖ Nodal regression: $0.25^\circ/\text{day}$ (i.e. the sun angle drifts $0.75^\circ/\text{d}$) | Inclination: $92^\circ \rightarrow$ increased coverage at poles



*C2 **over ocean** complements the current fleets thanks to its **drifting** orbit*

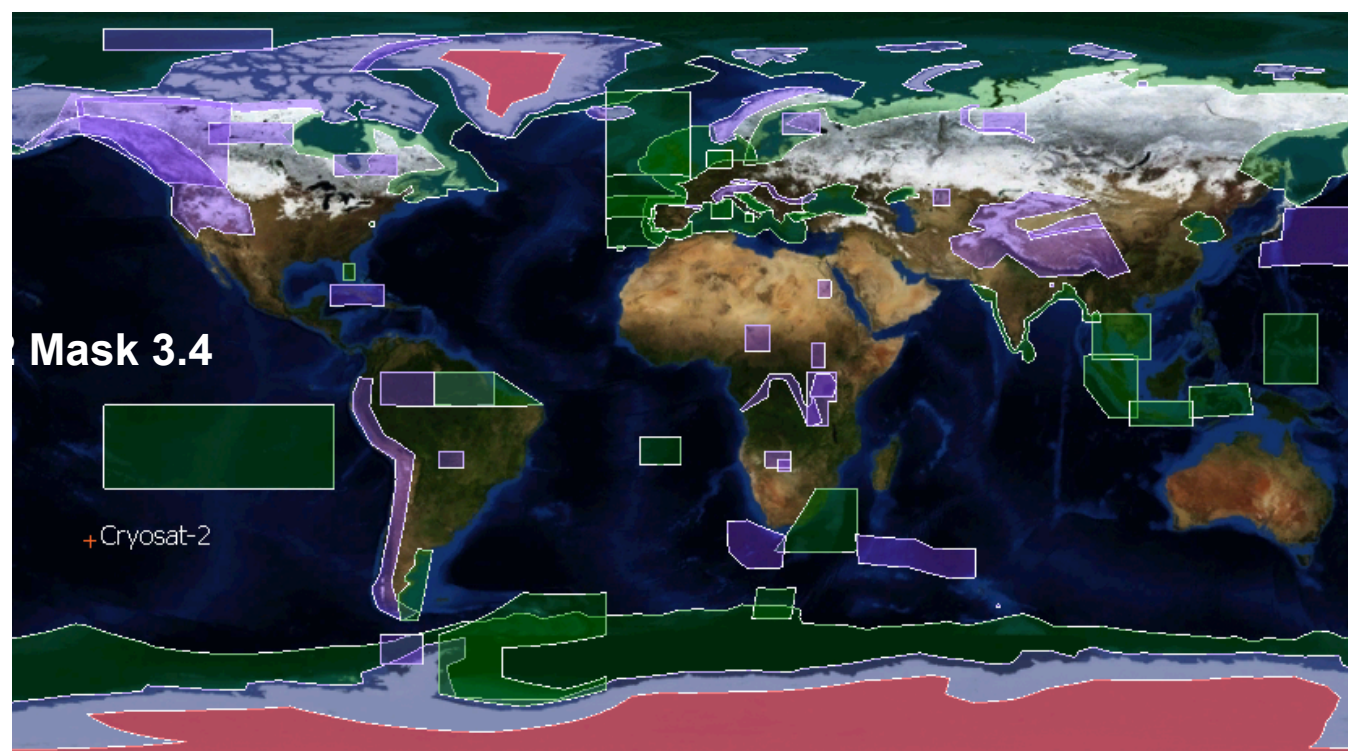
*Source of data at **high latitude** not reached by other missions (new MDT..)*

Mission objectives and characteristics



Different modes operating to meet the mission requirement

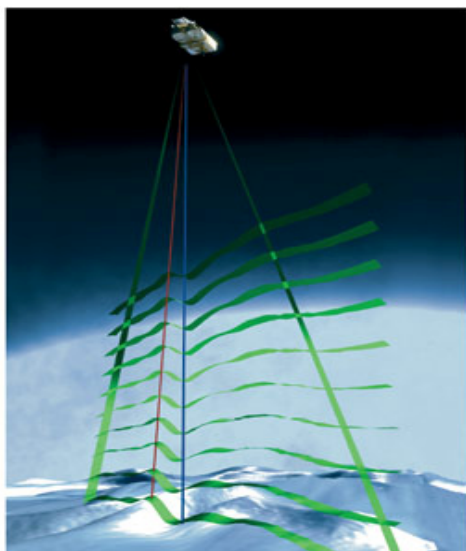
- Mode of operation selected from a mask of geographical zones
- Mask **updated** every two weeks to allow for changes in sea ice extend
- Mask **not frozen**, specific request can be taken on-board (several **ocean testing areas** in SAR/SARin mode → CP40 presentations)



Mission objectives and characteristics

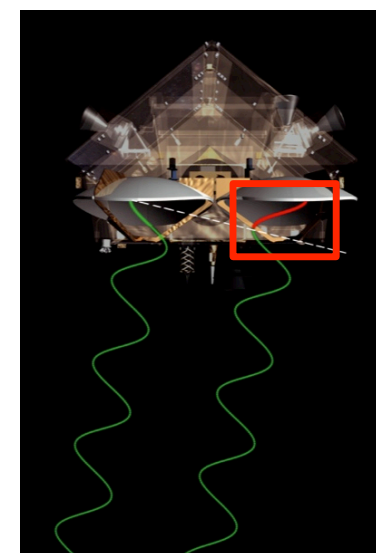
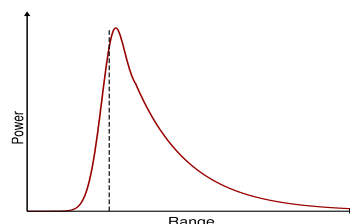
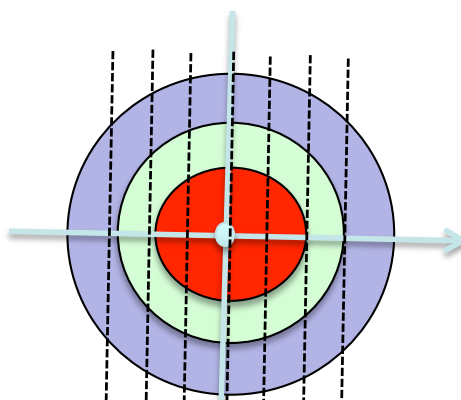
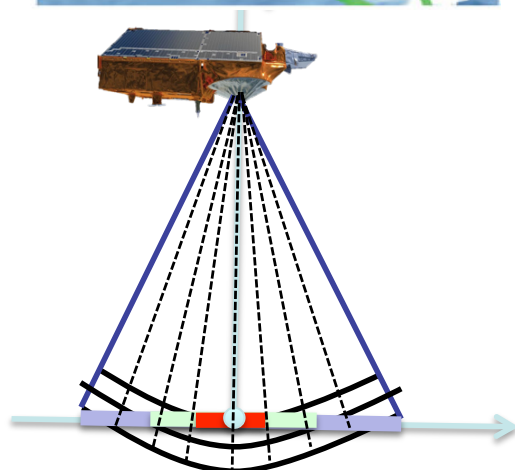


SIRAL: A new generation of altimeter



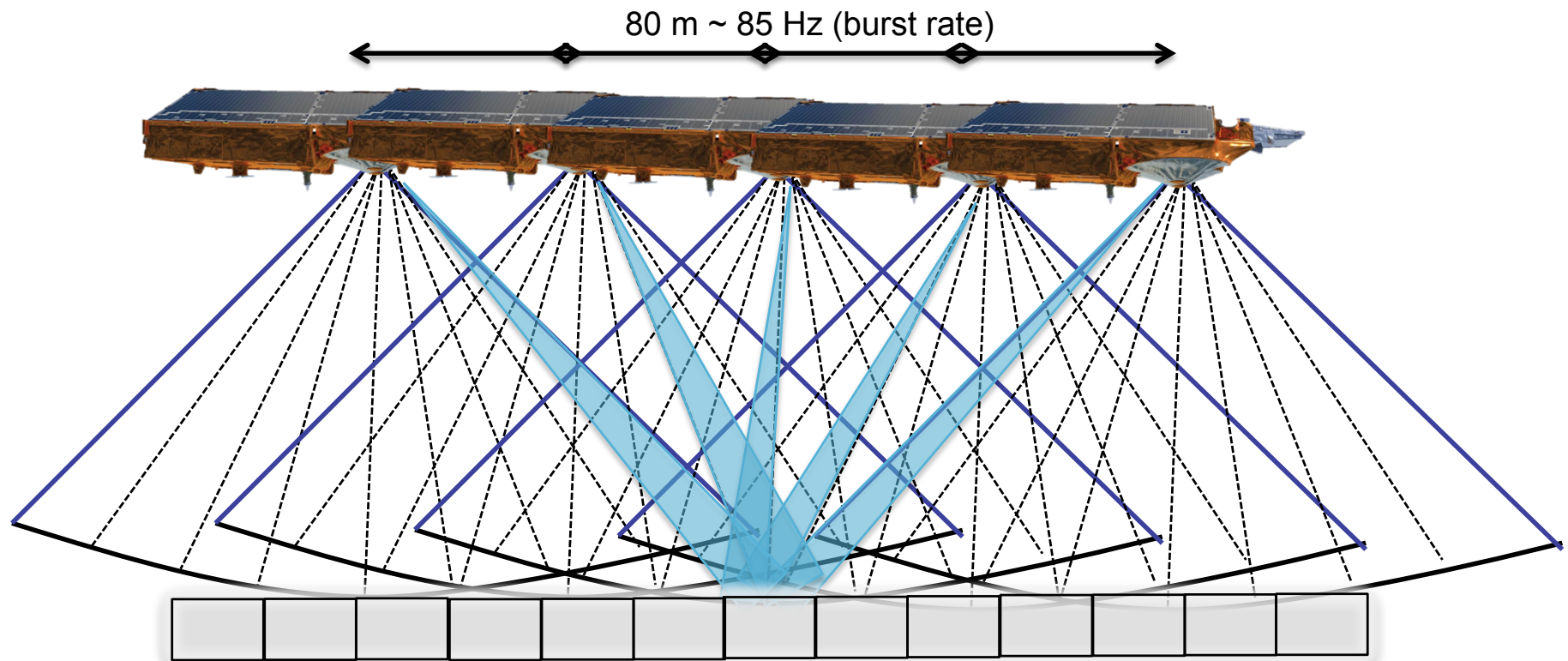
SAR: Over sea ice and ocean, coherently transmitted echoes are combined, to reduce the illuminated surface area to carry out HR measurements

SARIn: Around ice sheet margins and glaciers. Uses a 2nd antenna as an interferometer to determine the across-track angle to the earliest radar returns



Raney, R.K., *The Delay / Doppler Radar Altimeter*, IEEE Trans. Geosci. Remote Sensing, 36, 1578-1588, 1998.

SIRAL: First SAR altimeter concept to be flown on Earth !

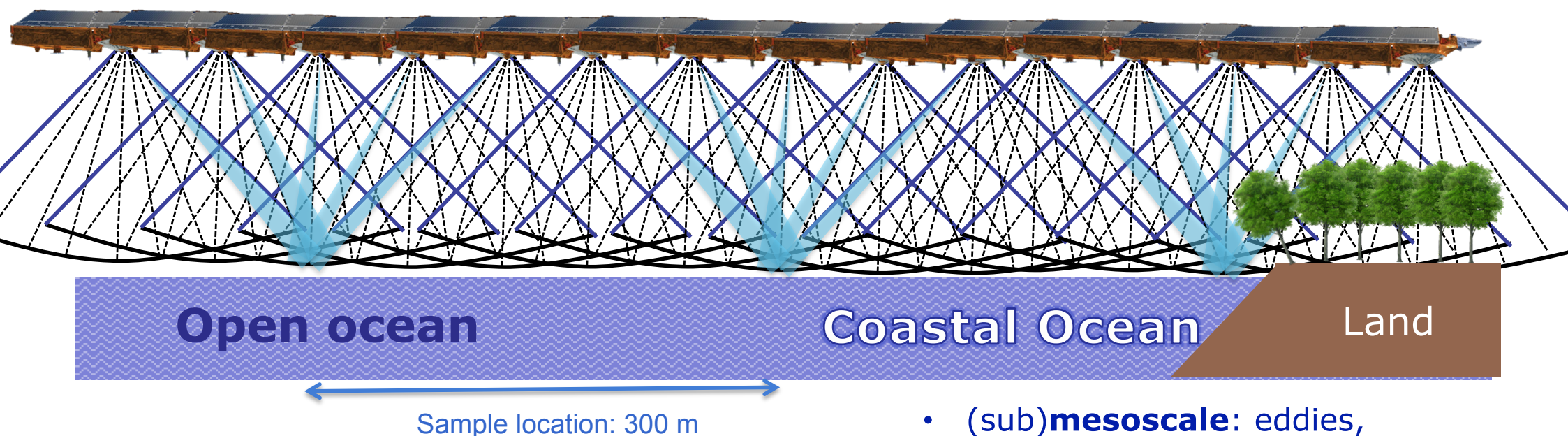


- The key idea is to use the Doppler effect (**shift in frequency**) to divide the radar footprint in slices by using 64 pulses per burst
- Doppler cells illuminated by **several beams** from different positions

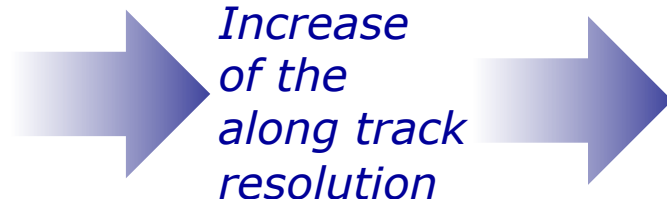
Mission objectives and characteristics



SIRAL: First SAR altimeter concept to be flown on Earth !



*The speckle noise is reduced by averaging (**multi-looking**) all the 230 return echos*



- (sub)**mesoscale**: eddies, filaments, meanders ~ 10 km
- Influence on **heat, bio. Elts** associated to the **Carbon cycle**
- **Slope current and cross-shelf exchanges**
- **Coastal operational oceano.**

Payload

- ❑ Payload in **very good conditions** after for 4 years of operations
- ❑ Excellent instrument availability **99.6%**
- ❑ Operations, scientific return and data quality are guaranteed till **2023** and beyond, unless unpredictable catastrophic events

Platform

- ❑ Platform in **good conditions** after for years 4 years of operations with an orbit and attitude **stable**
- ❑ Overall platform availability **98.9%**

Ground segment operation

- ❑ Ground Segment is **functioning well** with no major issues since launch.
- ❑ Ground segment in continuously evolving to satisfy growth on science community which has **increased by 170%** since launch.
- ❑ **Two major Product Baseline** released to users since launch and 1st data **reprocessing** completed in December 2013.

Product availability and evolution



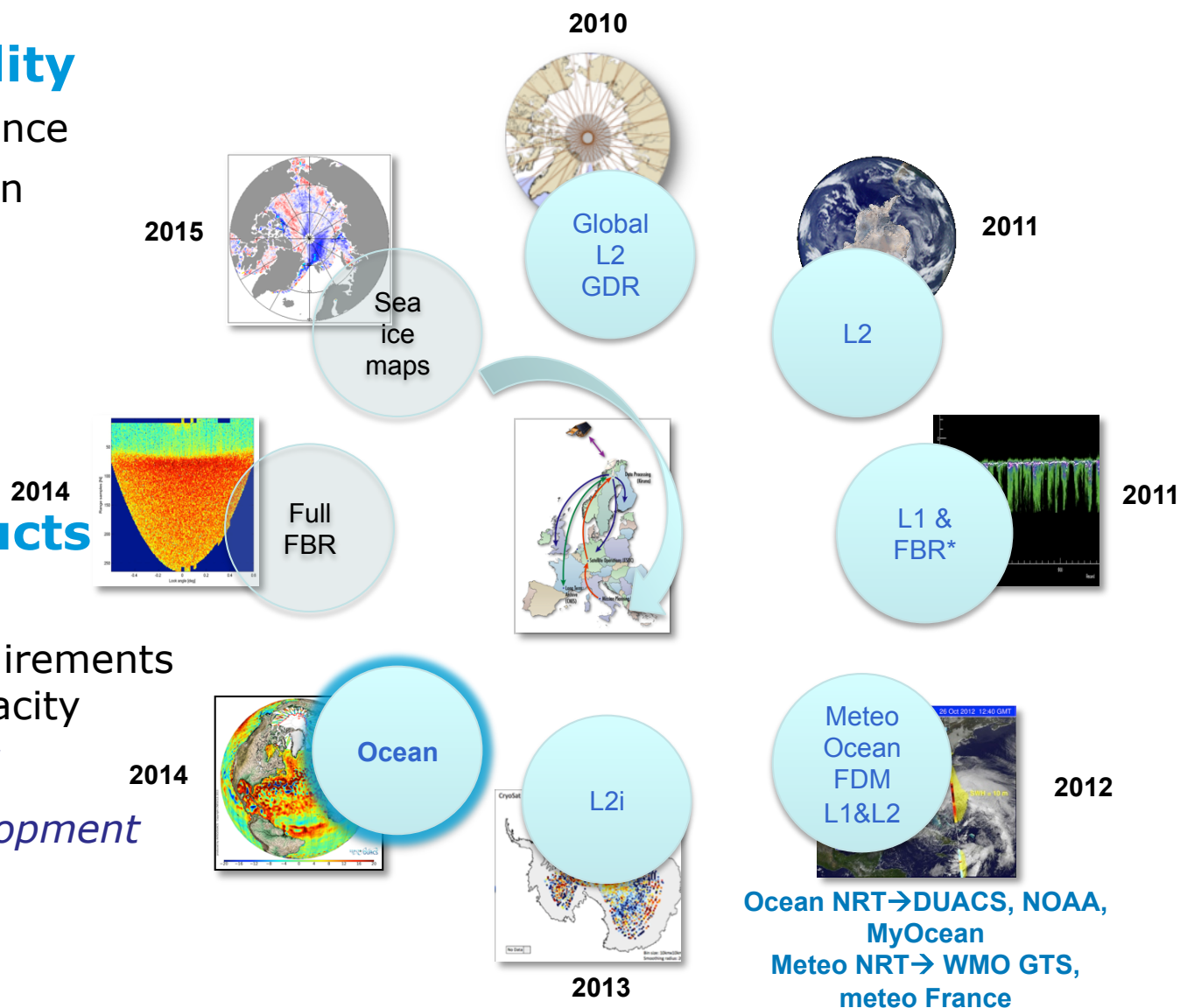
Slide adapted from Parrinello et al 2014

High data availability

- Overall mission performance **97.7%** well above mission expectation (i.e. >94%).
- Calibration: **0.4%** of observations

Evolution of Products Portfolio

- Driven by new user requirements and by improved GS capacity
- New **IOP/GOP** released
- **Baseline C** under development
- Preparation of the **2nd reprocessing** started



Conclusions and perspectives



Slide adapted from Parrinello et al 2014


- Novel technology: **first SAR and SARIN** altimeter in Earth space
- Represents a **bench mark** for new development in **SAR altimetry approaches for ocean** (particularly relevant to prepare Sentinel-3)
- GS, Platform and Payload full compliant to system requirements

 ***Mission extended until February 2017 !***

- **Everything is not perfect** but the GS **continuously evolving** to accommodate new products and demand from worldwide community

 ***New Baseline C , reprocessing campaign, IOP/GOP ...***

- Improve the C-2 data quality require the expertise and close cooperation with other SA (**CNES, EUMESAT...**), research laboratories and industrial partners

 ***Initiatives such as CP40 participate to address the challenge of monitoring, explaining and predicting small scale geophysical signals from space (for Coastal & open ocean, ice and hydrology)***

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Data Access:

<https://earth.esa.int/web/guest/-/how-to-access-cryosat-data-6842>

Requests, questions, feedback or problems relating to CryoSat products should be addressed and sent to :
eohelp@esa.int