

Jeudi 14 Juin 2017 | CNES | Atelier

Glaciologie

# Statut des produits CryoSat-2

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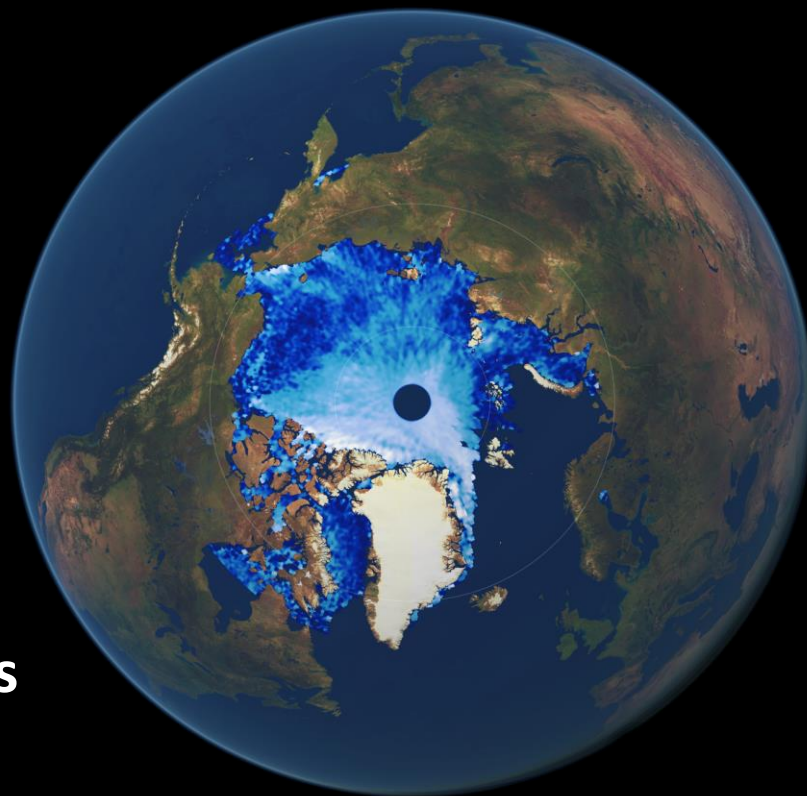
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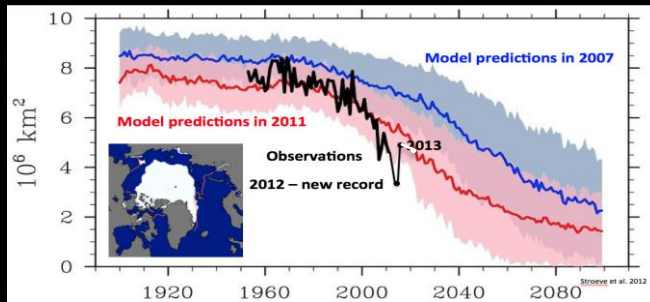
✧ Next Product Evolutions

✧ Conclusions & Perspectives



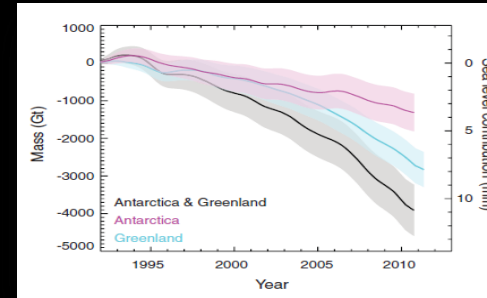
## Mission Challenges

✧ How the thickness of the ice is changing to understand...



Evolution of the Arctic Sea ice extend (Stroeve et al., 2012)

How the  
Global  
warming  
affect polar  
regions

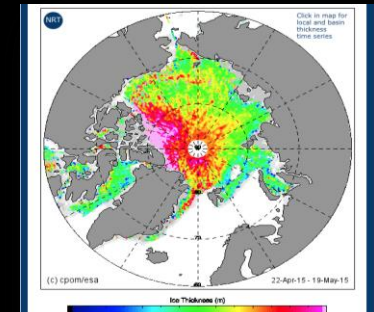
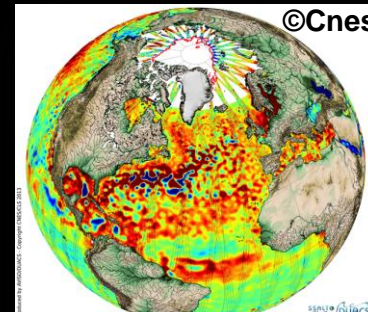


Contribution to sea level rise (Sheperd et al., 2012)

How polar  
regions  
contribute to  
global  
Changes

✧ Additional Portfolio

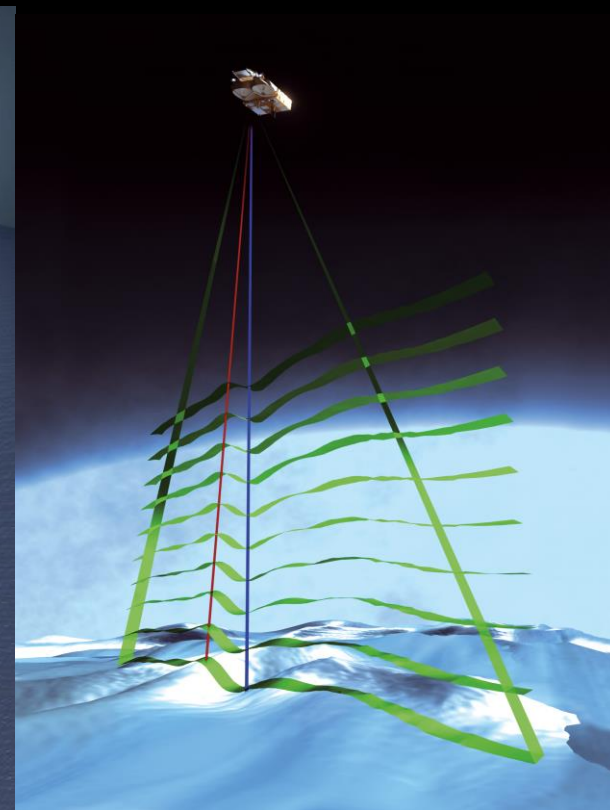
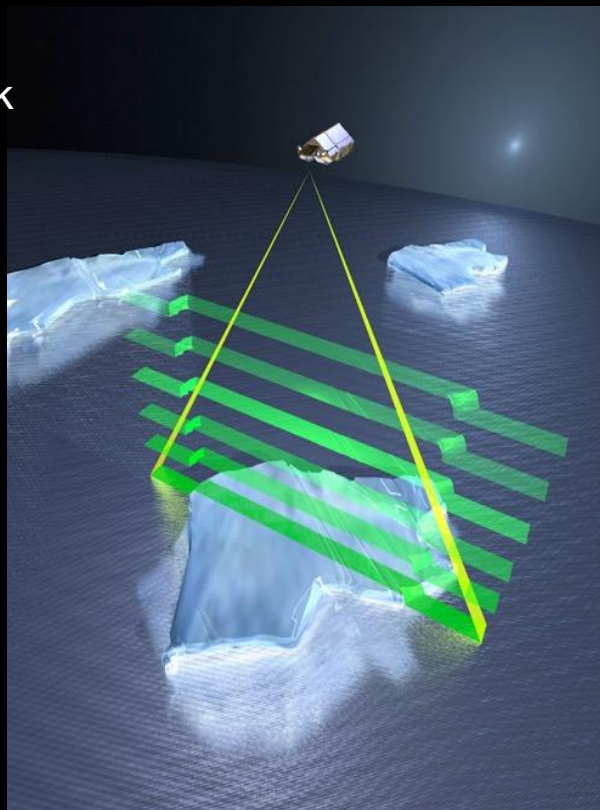
- Generate new CryoSat Ocean products
- Develop new Operational applications over Ocean/Polar zones (NRT ice charting)



Require a dedicated Orbit, New sensors and processing approaches

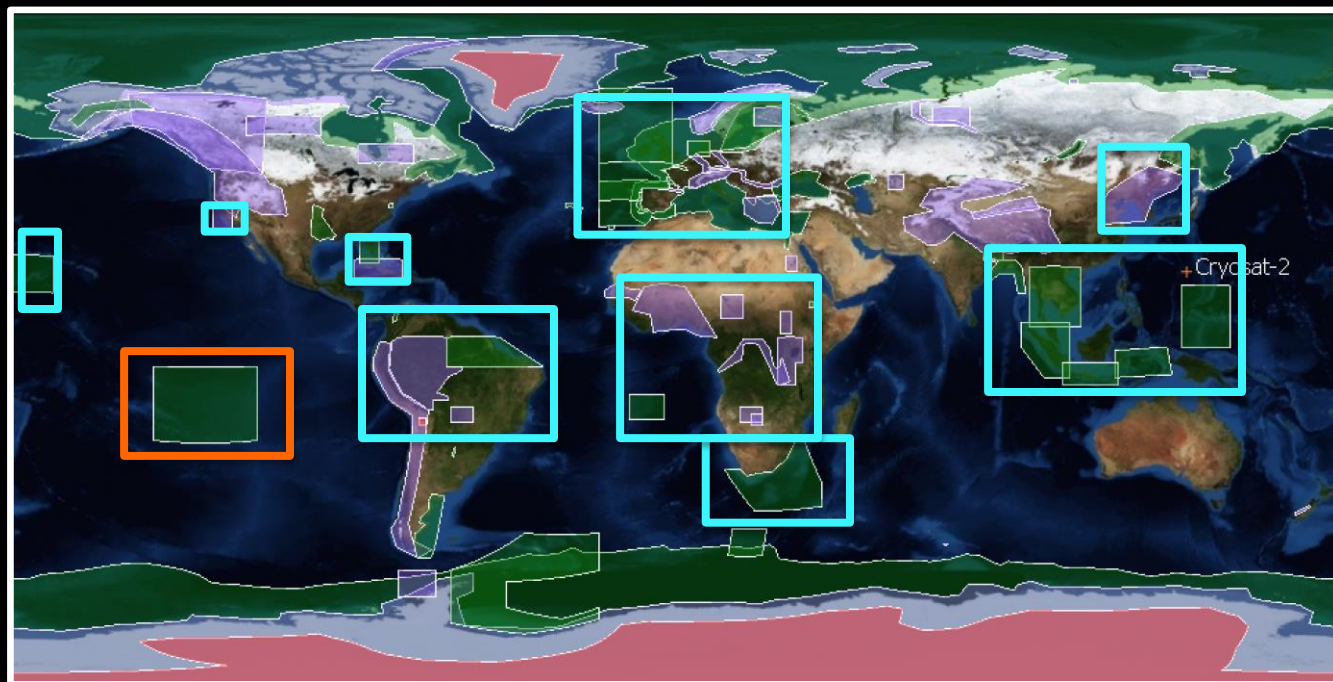
## Finer spatial resolution

- ❖ **SAR mode** improves along track resolution with improvement in capacity to detect floes & leads
- ❖ **SARIn mode** improves across track resolution, designed for rugged terrain. Measure the angle from which echo originates. Source point can be located on the ground.



## Modifications of the Geographical Mask

✧ Ku-band pulse-limited radar altimeter operating in 3 modes



Land ice  
and Ocean:  
LRM LRM

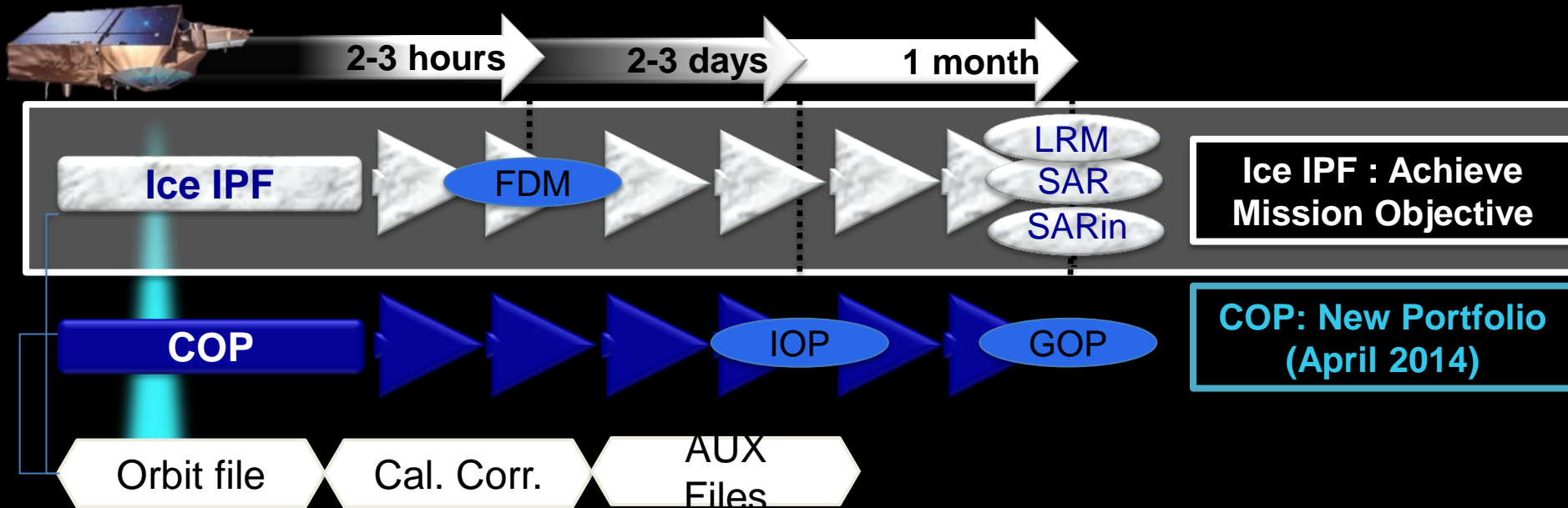
Sea-Ice  
Regions:  
SAR

Margins:  
SARin  
SARin

Support S-3 commissioning phase & stimulate more SARin applications

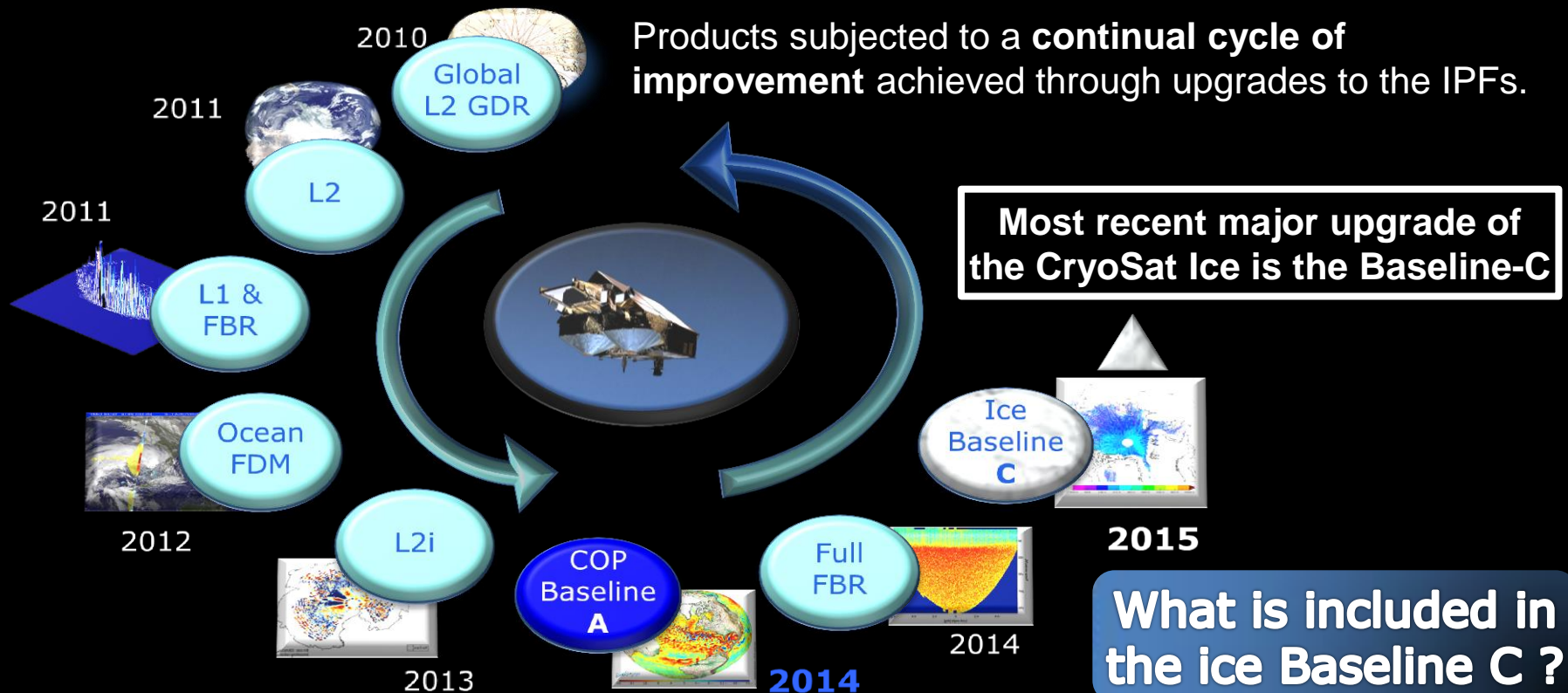
## CryoSat Operational Processing chains

✧ Data processed over ocean & ice with 2 independent processors



Require different QCV approaches & Processing baselines

# Continuous cycle of product upgrades



## ice Processing: Baselines C

More details in *Bouffard et al 2017, ASR*

**New Retracker for Land Ice** (LRM) developed by UCL, providing an alternative to the existing CFI retracker, which can be tuned as necessary in the future to increase performance.

**New higher-resolution DEM** for Antarctica and Greenland developed by the CPOM and MSSL was to improve SARIn processing

**Freeboard Activation** for SAR derived from a **New Arctic MSS** (CLS2011 + CS2 polar data ) and improved retracker adapted for diffuse echo returns from open ocean & sea ice floes

**SAR/SARIn power scaling** corrected with the peak power values are now as expected according to the sigma-0 of the sea surface (Scagliola et al. 2015).

**Attitude information** less noisy and included at 20 hz in L1B at 20Hz

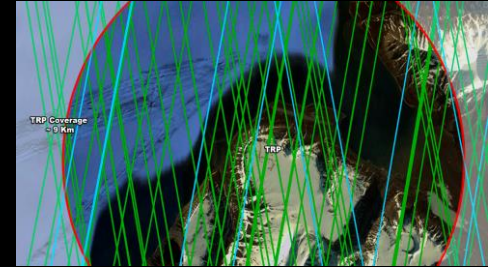
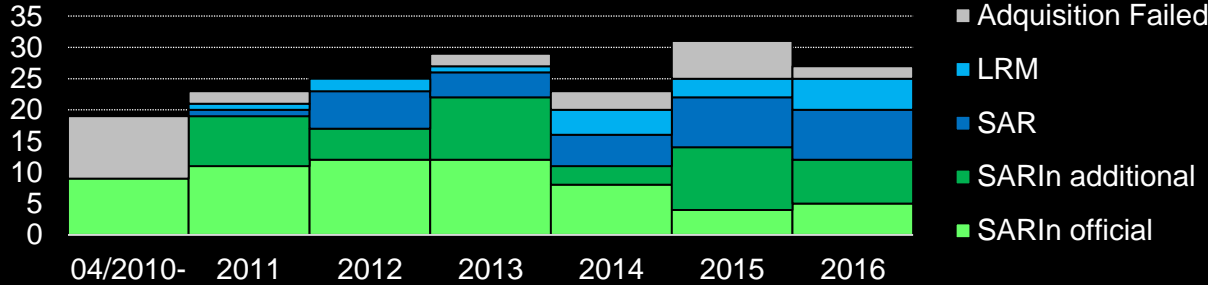
What are the improvements in terms of data quality ?



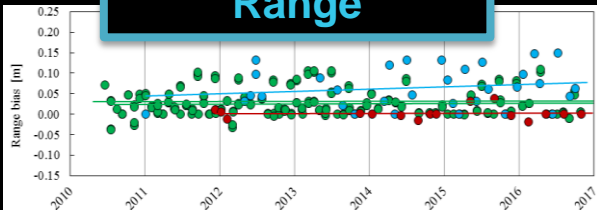
# SIRAL Calibration at Transponder

Details in *Garcia-Mondejar et al 2017, ASR*

## # Planned TRP Svalbard Passes

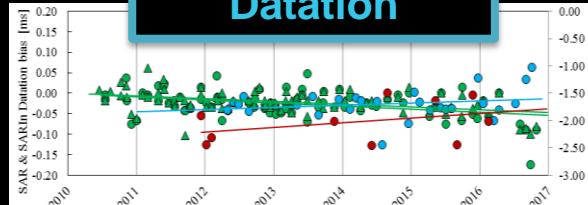


## Range



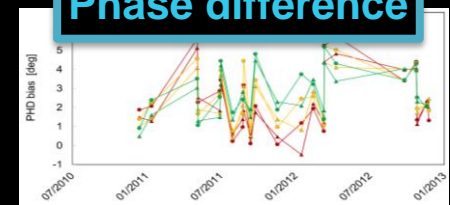
Mean range bias ~ 3.6 cm. Trend of 1.5 mm/y after compensating with the terrain motion.

## Datation



Datation bias negligible in the SAR/SARIn cases : ~-26  $\mu$ s for SAR and -23  $\mu$ s for SARIn

## Phase difference



Phase difference bias ~ 2.3 degrees, corresponding to 0.07 degree of Roll bias.

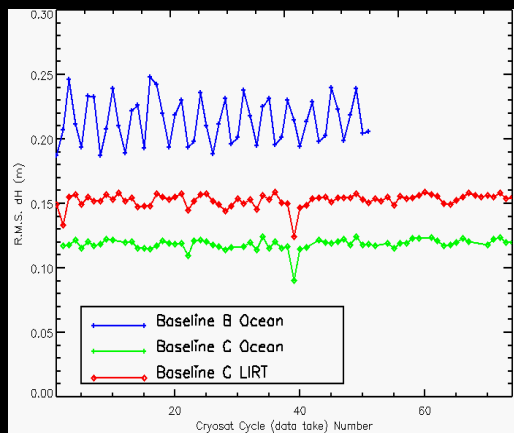
**Range, Datation & Phase biases reduced in the Baseline C products**

## QA over the Sea Ice and Land Ice

More details in  
<http://cryosat.mssl.ucl.ac.uk/qa>

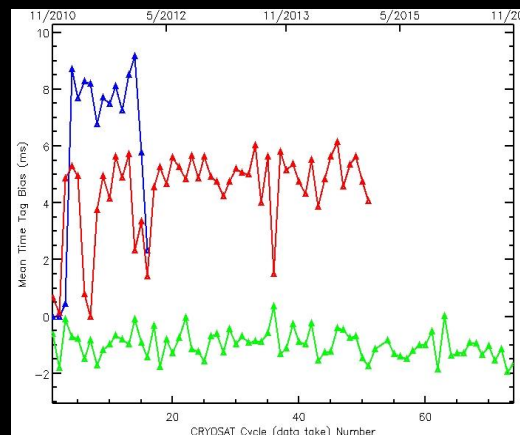
✧ MSSL performs Quality Analysis on selected L2 parameters

### New LIRT & refined OCOG



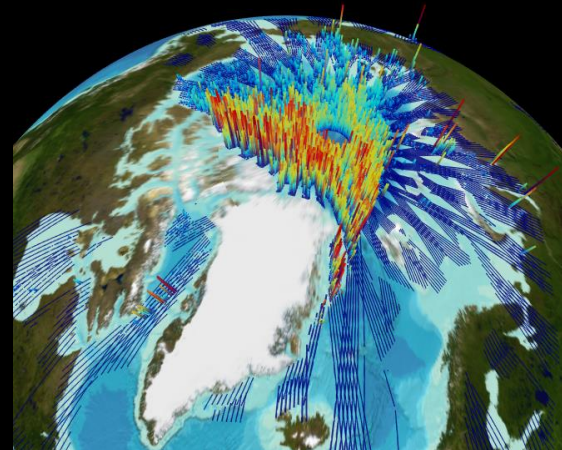
X-Over analysis : significant improvement wrt Baseline B.

### Time tag from Baselines A B C



X-Over analysis: time tag bias decrease

### Baseline C Freeboard



Freeboard from L2 data noisy but coherent distribution

**General improvements & Known issues appear fixed → Need to go further**

## CryoSEANICE: Project overview

### ✧ The Team



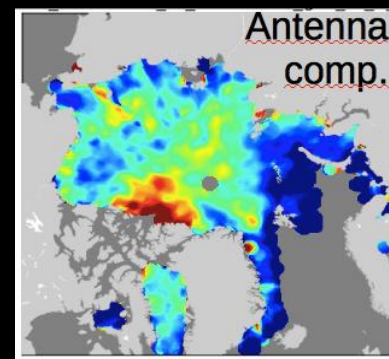
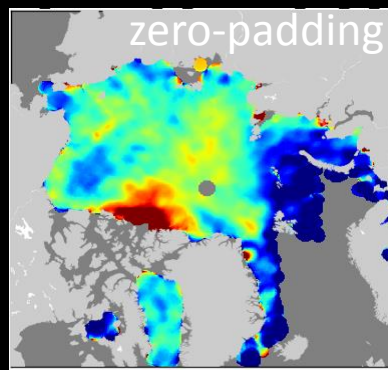
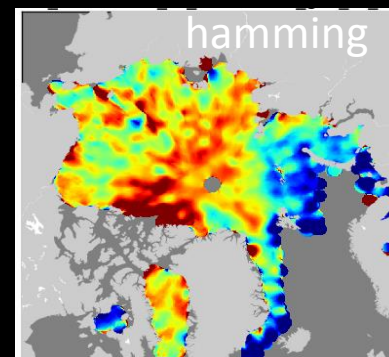
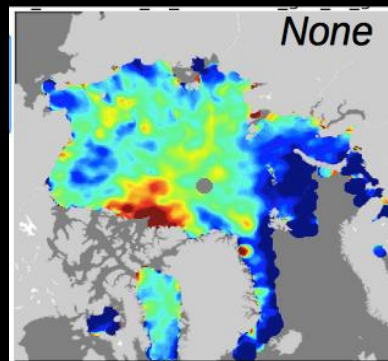
### ✧ Objective #1: Assess the potential for ESA products improvements :

- Quality of surface types in the products
- Analysis of freeboard SNR (could come from computation and gridding methods)
- Snow cover impact on freeboard measurement
- Assess the benefits of dual band (Ku/Ka) to better detect and account for Snow Depth (CryoVex/Karen spring 2017 campaign)
- Impact of Delay Doppler Processing options onto height and freeboard measurements

# CryoSEANICE: Project overview



L1b processing GPOD options	
<i>None</i>	(gdr)
Hamming	(h)
Zero-padding	(z)
Antenna pattern compensation	(a)
Exact beam focusing	(e)
Single-Look	(SL)
80Hz	(80hz)



## Focus on CryoSEANICE

### ✧ Emerging processing Approaches

- New Metrics & Diagnostic Tools : detailed analysis of waveforms, stacks, radar chronograms also in combination with SAR images (Sentinel-1)
- Geophysical retracking (CLS, SAMOSA+) : develop / test physical based retrackers for sea ice (improved space-time consistency : no space-time dependent threshold).
- New Freeboard computation & Gridding methods to be testest.
- Exploitation of Ku/Ka synergy (surface type, snow depth, freeboard) :
- Cryovex Campaign data (concomitant acquisitions) / CryoSat-2 / SARAL crossings @ short time interval/ Compare airborne vs spaceborne
- SARIN mode freeboard prototyping / SARIN swath processing over sea-ice : theoretical and experimental aspects

**Much More details in Sarah and Jean-Christophe Presentations**

# Ice and Ocean CONFORM

More details in the NACSM  
Poster *Mantovani et al, 2017*

## ❖ CryOsat Netcdf FORmat Migration

Major evolution planned for the Baseline D  
Ice & Baseline C Ocean

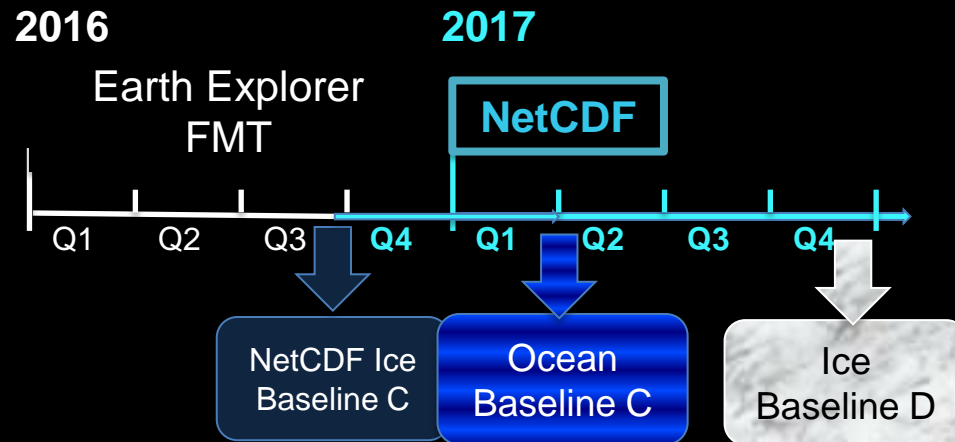
More user-friendly & flexible in comparison  
to the current EE Format

**Self-  
describing  
format**

**Easy to  
change and  
maintain**

**Tools for  
data  
visualization**

Widely used by the user community and new  
standard for all modern ESA EO missions



**NOT** operationally  
distributed



**TDS distributed on July 2017**

# The ice Baseline D

More details in the NACSM Poster Mantovani et al, 2017

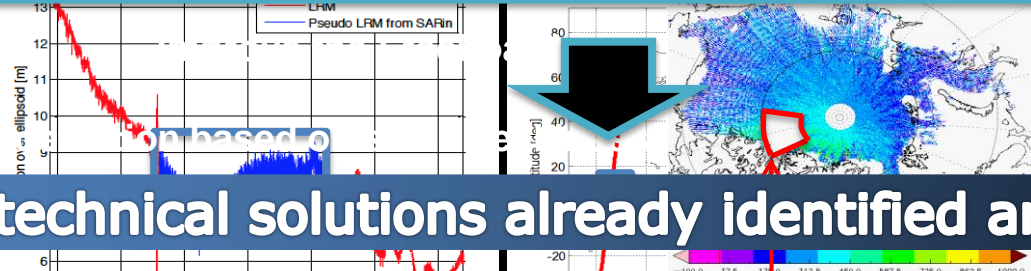
✧ **Why ?** Improve the quality of ice products to refine sea-ice thickness & ice sheet mass-balance variations at regional scales

✧ **How ?**



✧ **When ?**

To prepare mode-mask switch to SARin over land



Most of technical solutions already identified and tested

Ice Baseline D should go in operation on Q1 2018

Good continuity at LRM / PLRM transitions SARin with no freeboard

## Quality status & Evolution

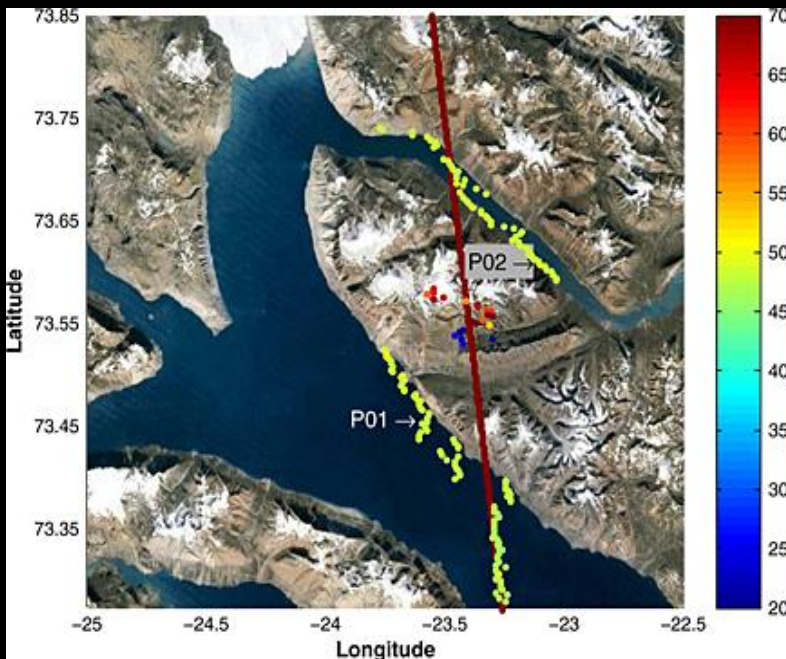
- ✧ **Ocean Baseline B Products** : Nominal/Suited for oceanographic applications  
**New COP baseline C released on 28 June / In operation on September 2017**
- ✧ **Ice Baseline C Products** : Exceed initial mission requirements  
**Platform Anomaly on 02/06 03:54 UTC. SIRAL re-enabled for science acquisition on 03/06/2017 09:25 UTC. Quality/availability of CS2 products not affected**  
**Ice IPF Baseline D** planed for Q1 2018 (QWG#7, October 2017, date TBD)

## Next steps: prepare the future ...

- ✧ Stimulate multi-sensor synergy (**Ka/Ku**, see [M. Davidson Presentation](#)) & **Operational/NRT applications** both over the sea-ice, land ice and ocean
- ✧ Stimulate new applications based on **SARin** measurements ...

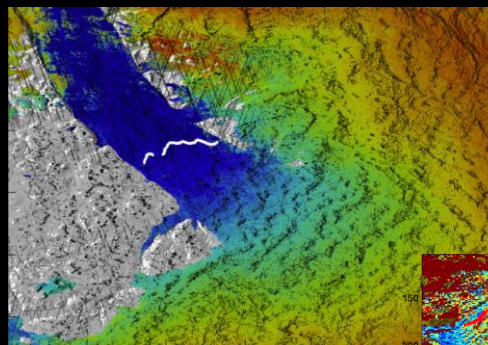


# SARin emerging applications

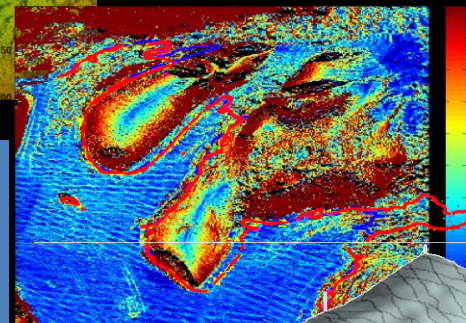


Across track sea surface elevation retrieved from SARin over Fjords of Norway (Abulaitijiang et al, GRL 2015)

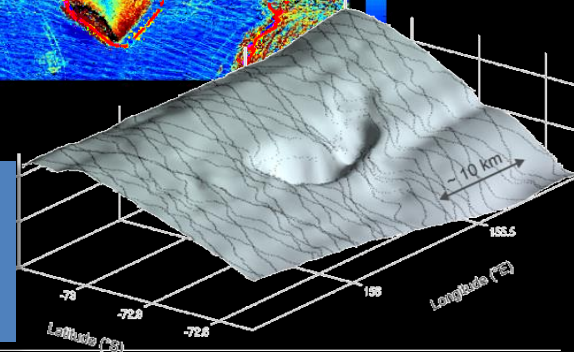
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Identification of grounding lines, thickness and ice flux using SAR/SARIN, identifying changes around ice sheet periphery useful for accurate estimation of ice sheet mass balance



Sub-glacial lakes, providing evidence of a dynamic hydrological system beneath the Antarctic Ice Sheet at high resolution using SARIN



Developing new algorithm (SWATH) to deliver SARIN measurements of fine glacier and ice sheet margin derived through CryoSat-2 interferometric altimeter. Turning an altimeter into imaging sensor!

# CryoSat Swath processing

Courtesy N. Gourmelen

- ❖ Need to investigate swath processing over Ocean & sea-ice ?
- ❖ Could CryoSat SARin be exploited in preparation to SWOT ?
- ❖ On going stimulating & fruitfull discussions with CNES/SWOT experts.

## Recent outcomes from the NACSM....

[www.cryosat2017.org](http://www.cryosat2017.org)



✧ Very good Science, strong support/interest from the EU/American users

✧ CryoSat Mission extended to mid-2019

✧ No technical restriction to maintain de mission after 2022 ...

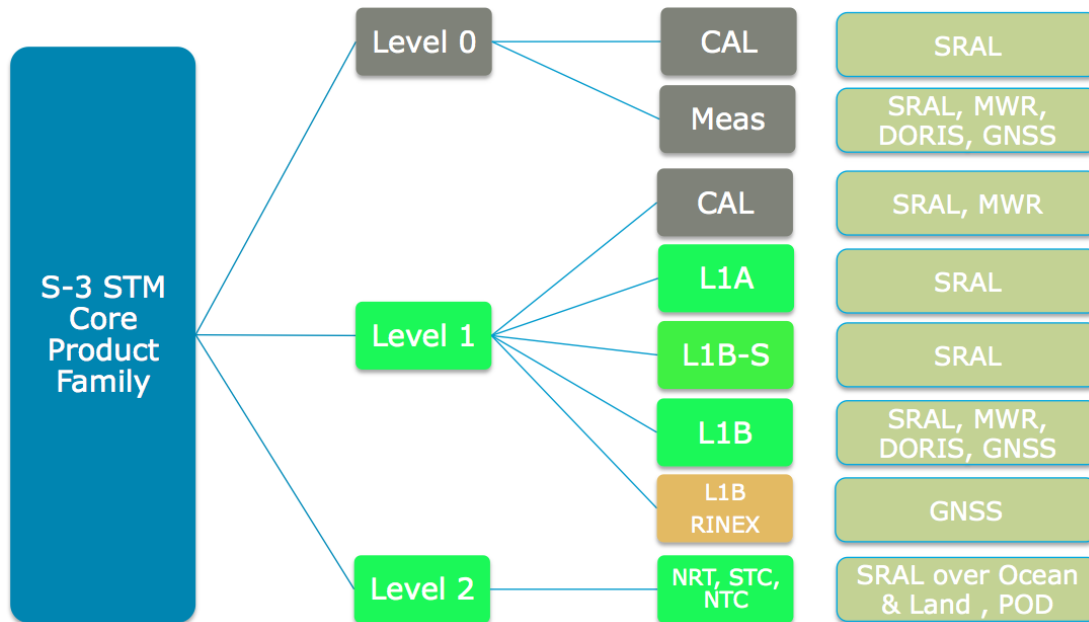
✧ ... Waiting for **Sentinel-like CryoSat FO** (see [Presentation from E. De Witte](#)) ?

# The Sentinel-3 Mission: Few Highlights

On behalf of Pierre Féménias

ESA S-3 STM Data Quality Manager

## S-3 STM Product Family (Core Products)



<ul style="list-style-type: none"> <li>SRAL L1B</li> <li>SRAL L2 MAR</li> <li>SRAL L2 LAN</li> </ul>	Timeliness: <b>NRT &amp; STC</b> Since: <b>Dec 2016</b>
<ul style="list-style-type: none"> <li>SRAL L2 LAN</li> </ul>	Timeliness: <b>NTC</b> Since: <b>Dec 2017</b>
<ul style="list-style-type: none"> <li>SRAL L2 MAR</li> </ul>	Timeliness: <b>NTC</b> Since: <b>Jan 2017</b>
<ul style="list-style-type: none"> <li>SRAL L1B</li> </ul>	Timeliness: <b>NTC</b> Since: <b>Jan 2017</b>
<ul style="list-style-type: none"> <li>SRAL L1A</li> </ul>	Timeliness: <b>STC, NTC</b> Since: <b>Mar 2017</b>
<ul style="list-style-type: none"> <li>SRAL L1B-S</li> </ul>	Timeliness: <b>STC, NTC</b> Since: <b>Mar 2017</b>

  **Not user product**
  **Officially released**
  **To be released (soon)**

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- **Last S-3 STM Processing Baseline (PB) delivered V2.15**
    - Include a fix of the S-3 MWR Side Lobe correction usage
  - **NEW S-3 STM Processing Baseline being developed**
    - Improvement of L2 MWR wet tropospheric retrieval (SIIIMPC-1653)
    - Improvement of L2 MWR over coastal areas (SIIIMPC-1654)
    - Update of SRAL/MWR L2 IPF SAR Ocean retracking using SAMOSA DPM V2.5.0 (SIIIMPC-1655 and SIIIMPC-1251)
    - Implementation of FES2014 oceanic tide model (SIIIMPC-1503)
    - Improvement of the 3D dry tropospheric correction
    - Sigma0 corrected for the atmospheric attenuation
    - Addition of orbit type in the L2 product
    - Addition of “Ice-sheet” waveform quality checks in L2 products
    - NEW MWR calibration scheme
    - ...
- SHALL nominally include “improved processing over sea-ice and continental ice”  
(on-going investigation - SIIIMPC-1606)!
- Expected to be the Launch PB for S-3B
- Once IPF qualified, a reprocessing campaign from 1 March 2016 shall be initiated.

## ■ 1<sup>st</sup> 2017 Reprocessing Plan

### 1st - IPF Processing Baseline V2.15

- Data coverage: **From June 15 2016 up to 12 Apr 2017** (~ -25 days)
- Input product type: Pole-2-Pole L0
- Output product type: Pole-2-Pole L1A, L1B-S, L1B & L2
- Data latency: NTC
- Expected end date of reprocessing campaign before summer break

## ■ 2<sup>nd</sup> 2017 Reprocessing Plan

### 2nd - IPF Processing Baseline V2.XX

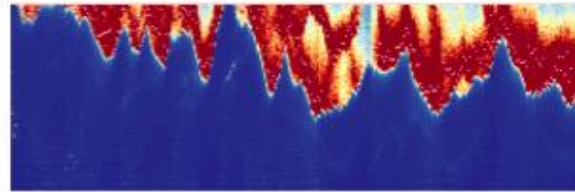
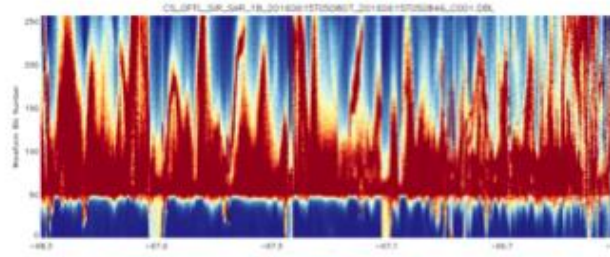
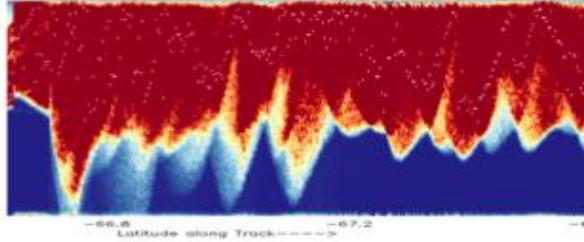
- The IPF PB shall correspond to the major STM IPF delivery expected in July/August
- Data coverage: **From BOM (1 Mar 2016) up to deployment of PB V2.XX**
- Input product type: expected Pole-2-Pole L0
- Output product type: Pole-2-Pole L1A, L1B-S, L1B & L2
- Data latency: NTC

- S-3 STM L1b processing not optimised for sloping surfaces but for ocean
- In the presence of sloping terrain, the Sentinel-3 L1b echoes after SAR processing are moving inside the L1b product range window, while the CryoSat L1b processing moves the product window and keeps the leading edge of the SAR processed echoes in a fixed position inside this window.
- The Level 2 ice re-tracker -originally designed for CryoSat- can then easily re-track these echoes but frequently fails when processing Sentinel-3 L1b data.

## Way forward

- ESA is currently looking into this issue to resolve it. Three main actions have been defined and are running in parallel:
  - Short term: identify possible tuning of the Level 2 ice processor to increase the rate of successful re-tracking with the current Sentinel-3 L1b product
  - Longer term: define and validate an improved L1b algorithm (similar to CryoSat) for implementation in the Sentinel-3 operational ground segment, ensuring optimum performance over ice surfaces
  - Short term validation: Implement an improved L1b algorithm in a prototype processor and assess any side effect on other non-ice surfaces (open ocean, coastal zones, rivers & lakes)





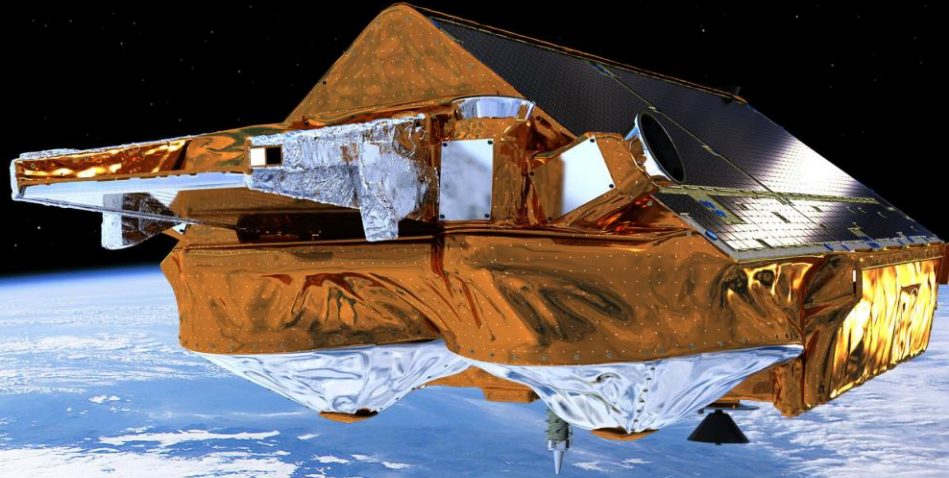
Pulse limited

SAR

- La plateforme et charge utile de S-3A est nominal / Pas d'anomalie à rapporter
- S-3B sera lancer pas avant Mars 2018.
- La CE devrait décider ce mois-ci en juin si le lancement de S-3B se fera sur VEGA ou pas....
- Il y a aura une tandem phase de 4-5 mois entre S-3A et S-3B

**Toute recommandation pour la Cal/Val des données glaces entre S-3A et S-3B est plus que bienvenue!!!!**

# Thank you for your attention



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