CryoSat Processing Prototype,

LRM and SAR Processing on CNES Side

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Study Context

To prepare the CNES proposed SAR retracking for Sentinel-3 mission,
CNES decided **to take the opportunity of the availability of CRYOSAT/SIRAL data**:

- To develop and test processing methods of SAR data over ocean,
- To assess SAR processing performances,
- To define how to ensure data quality continuity between SARM and LRM
- To define how to provide a LRM reference during SAR mode (so called RDSAR or pseudoLRM or TRK data).

To achieve those goals,

- CNES started the development of a processing module of CRYOSAT data **CPP (CRYOSAT Processing Prototype)** two years ago.
- **Access to telemetry data has been kindly granted by CryoSat project**. Knowing that the CNES processing results are not to be distributed outside the S3 project team without a prior permission from ESA.

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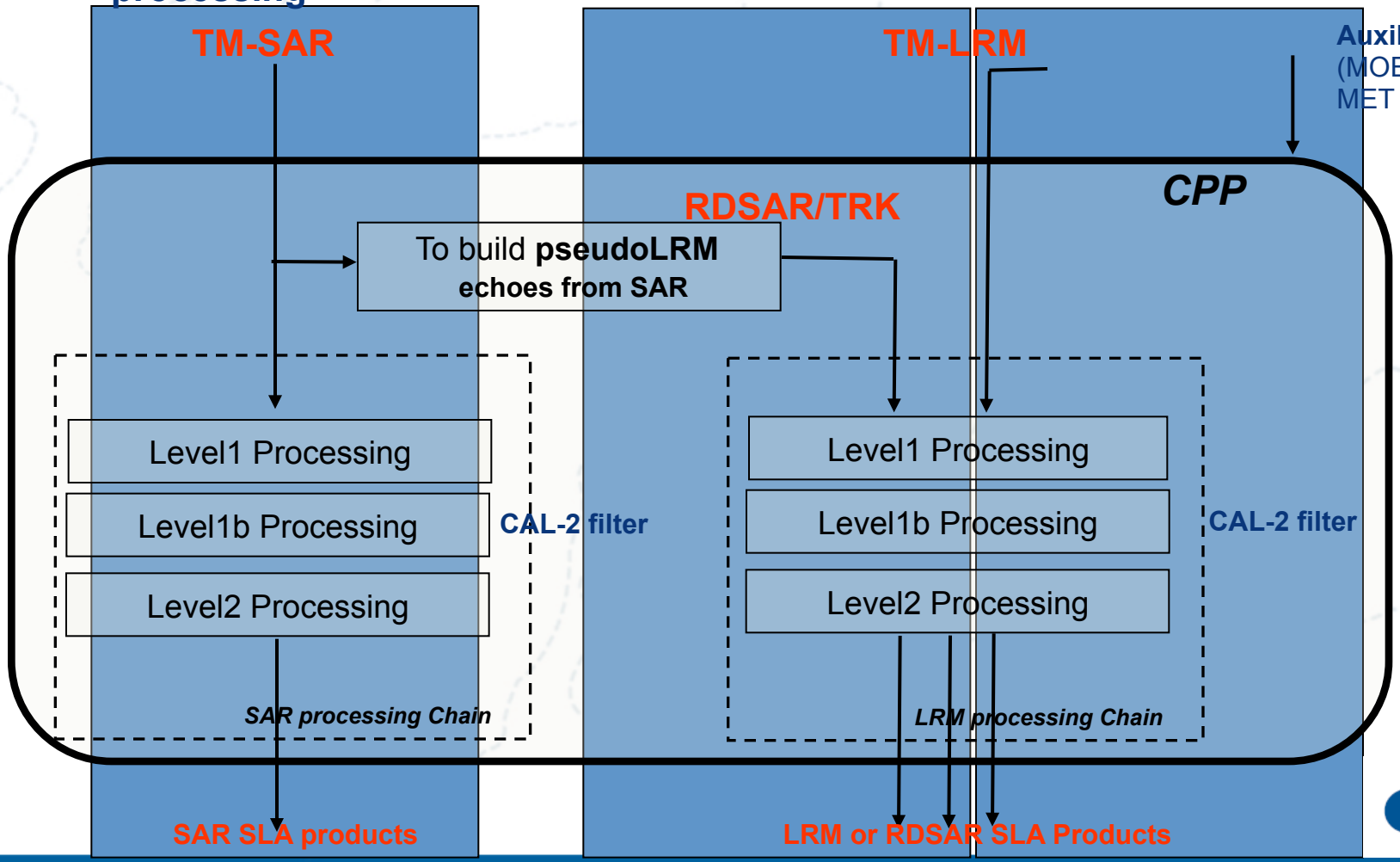
CPP Interfaces and Architecture

Core Objective :
To perform SAR processing

To provide a LRM reference during SAR mode (RDSAR)

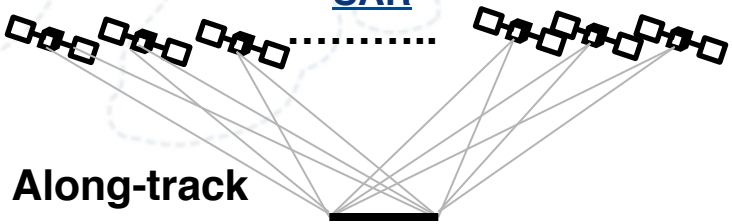
To analyze continuity between LRM <-> SAR



What are SAR and RDSAR 20Hz measurements?

From SAR BURST mode

Delay/Doppler processing (multilook):
SAR



Accumulation of 256 looks over the same doppler band → Doppler Echo

The Reduced SAR is a
validate the S

But, given that only 32 echoes are accumulated, this reference is more noisy than real LRM (sqrt(3) higher than real LRM).

CNES SAR Retracking solution

• **Based on a numerical Doppler model:** Numerical computation of the radar echo:

$$\text{Echo} = \text{FFSR} \otimes \text{IRs} \otimes \text{PDF}$$

Single Looks

– Computation of the FSSR for each doppler band (64). A configuratior

– Convolution Impulse Resp

– Convolution

Multi Look

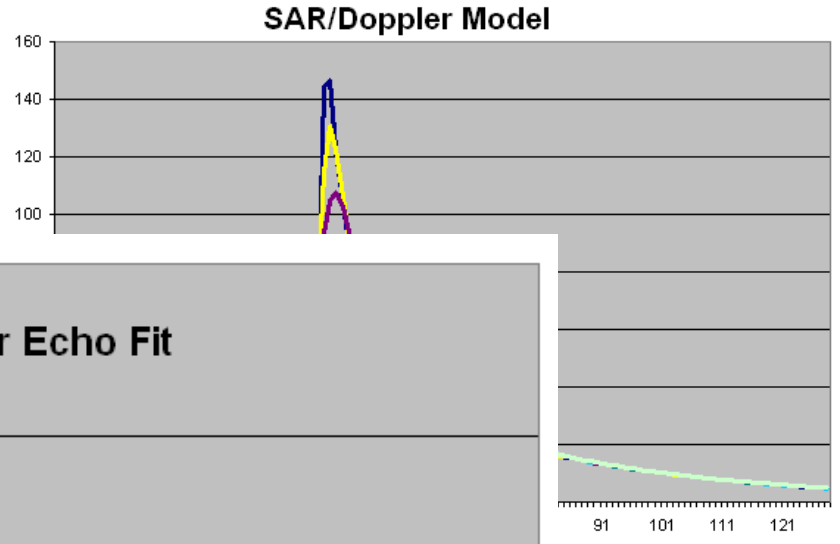
– Then, range align each sir

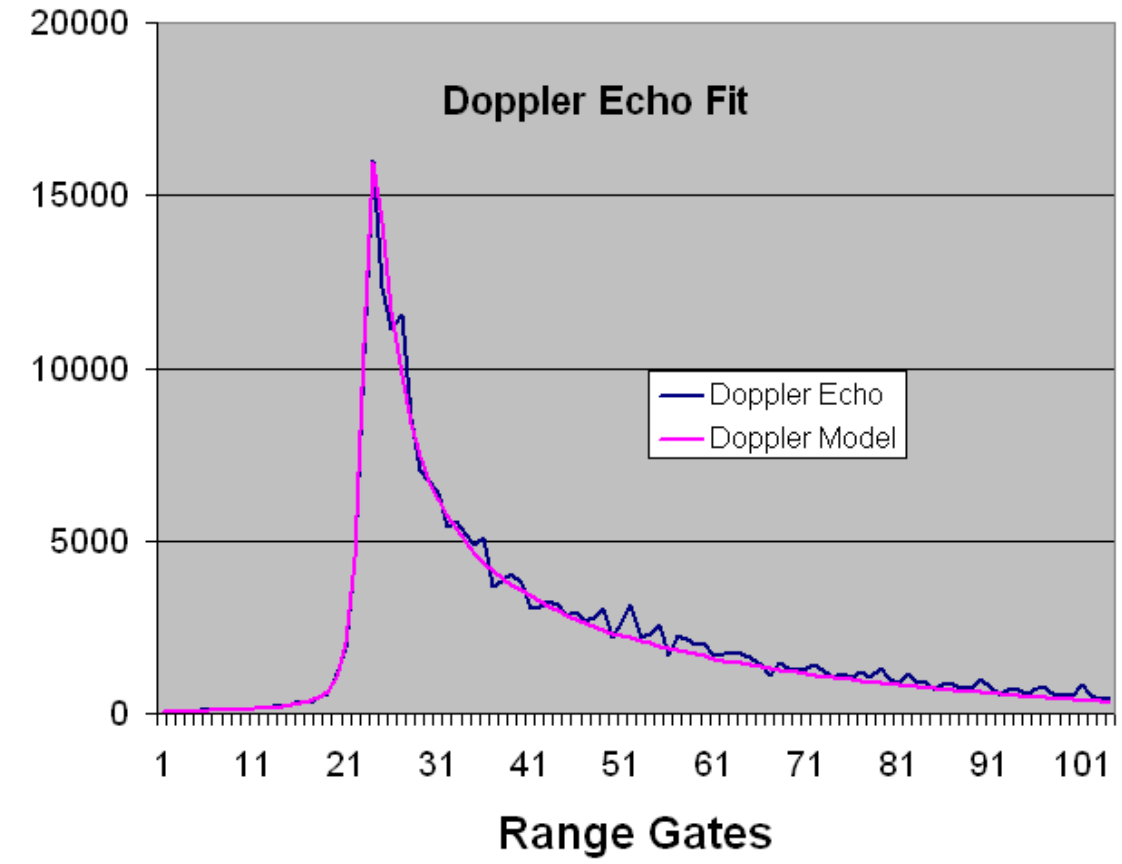
– Sum of each Doppler echc

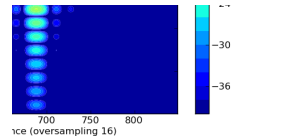
• Retracking: **inheritag** (mispointing is not esti

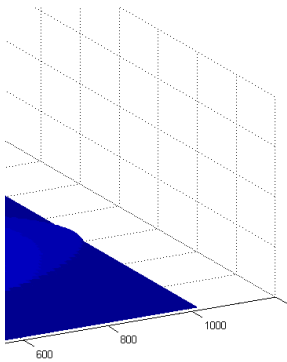
Derivatives are

Mispointing configura (based on W. Smith *et*

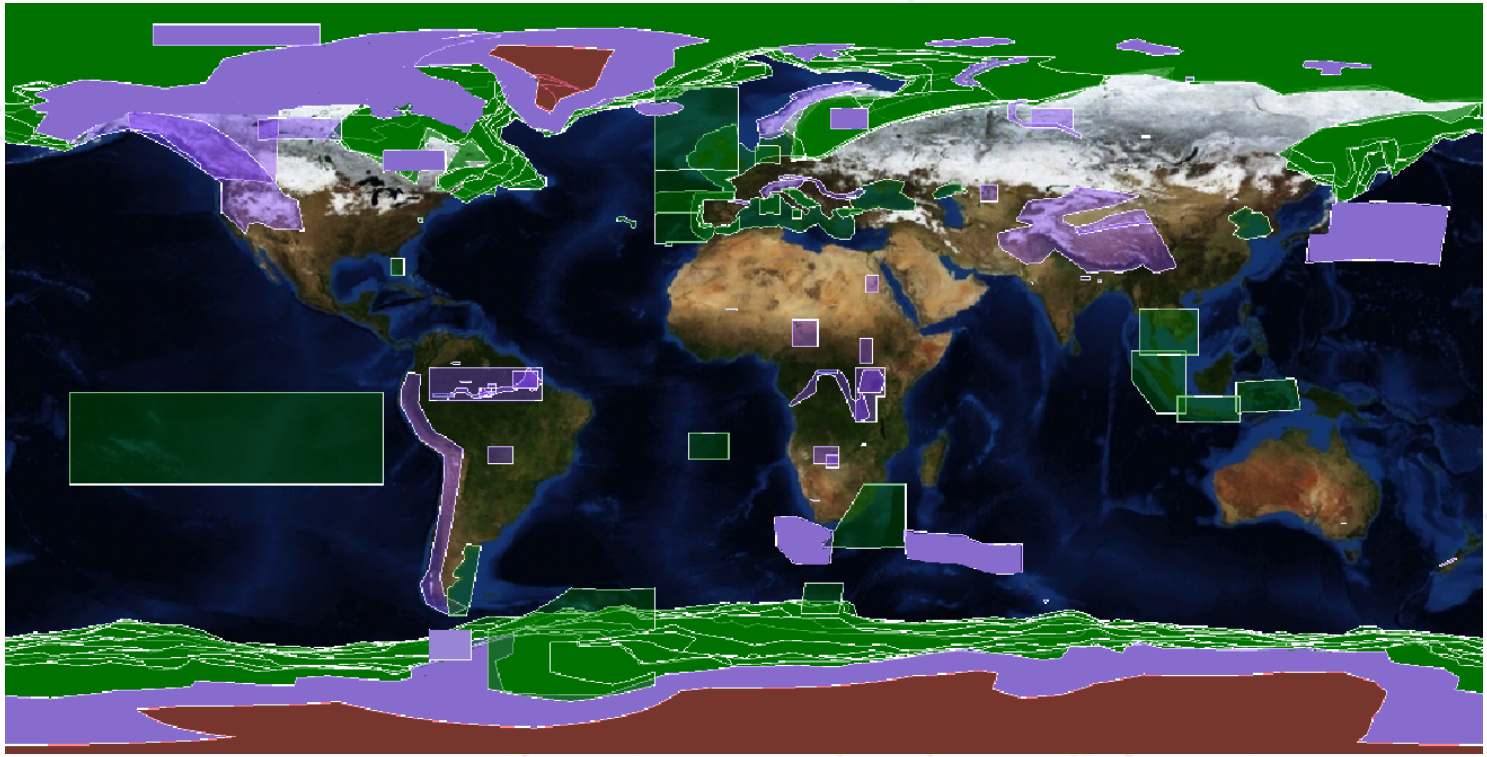








CRYOSAT mode Mask

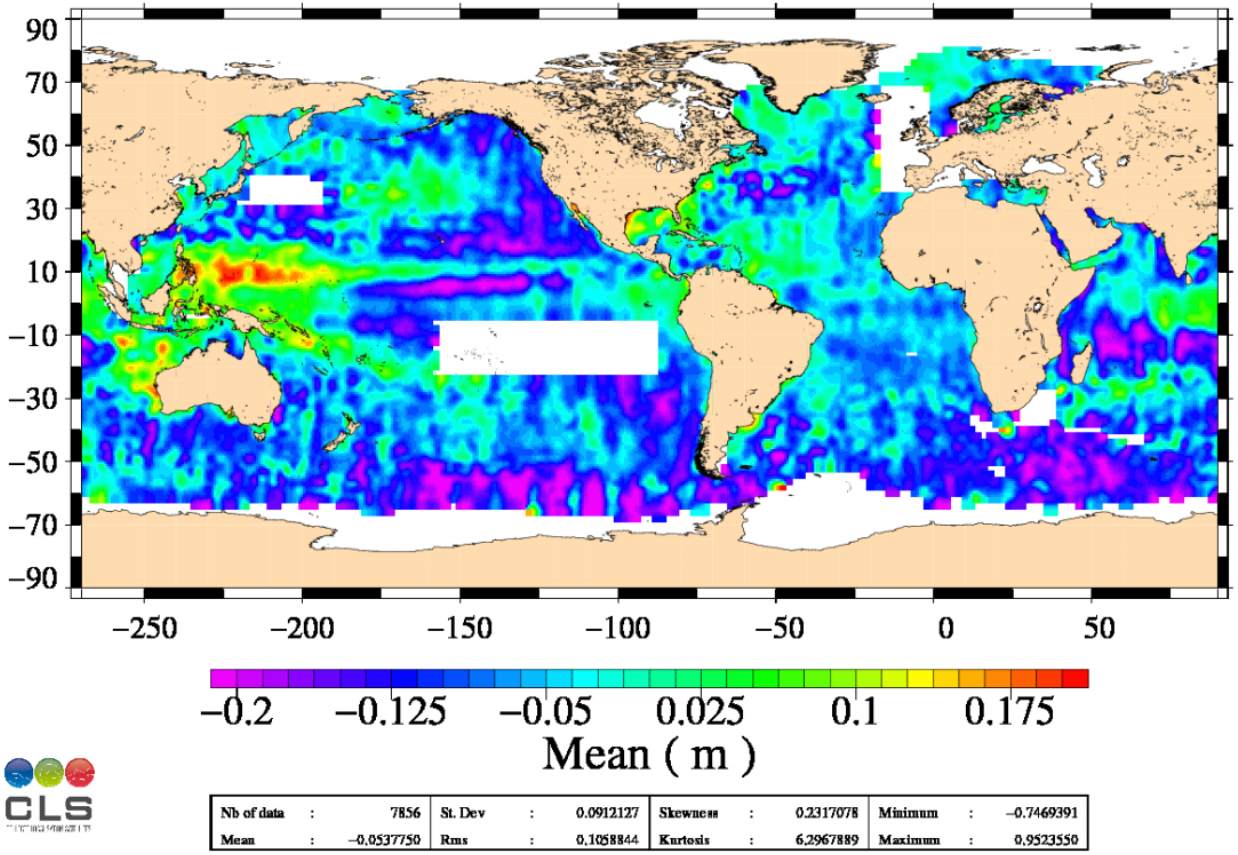


Green: SARM

Ocean Surfaces: LRM

CPP processing results on CRYOSAT-2 data

Cryosat LRM is at the same level of accuracy than Envisat and Jason-2.
(F.Boy, OSTST San Diego, 2011)



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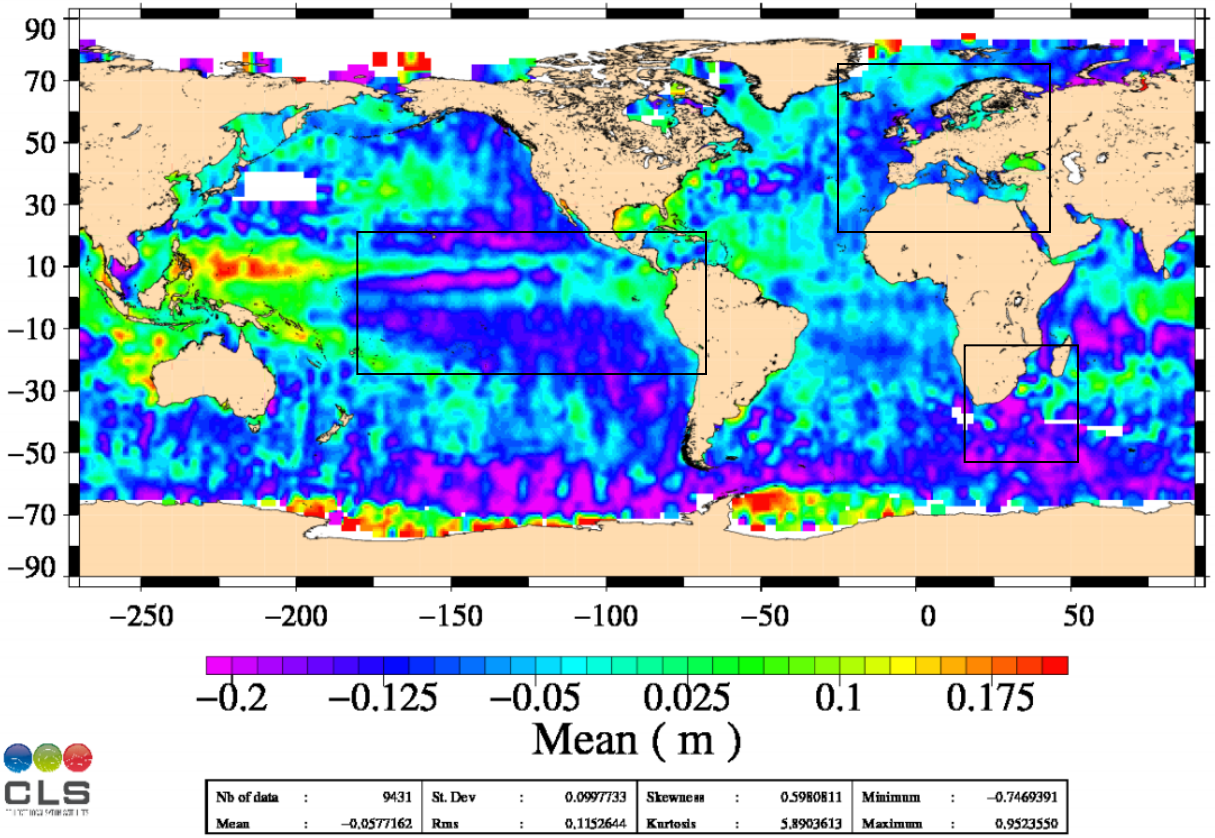
CPP processing results on CRYOSAT-2 data

Very good consistency between SARM and LRM Sea Level Anomalies



Nb of data	:	9431	St. Dev	:	0.0997733	Skewness	:	0.5980811	Minimum	:	−0.7469391
Mean	:	−0.0577162	Rms	:	0.1152644	Kurtosis	:	5.8903613	Maximum	:	0.9523550

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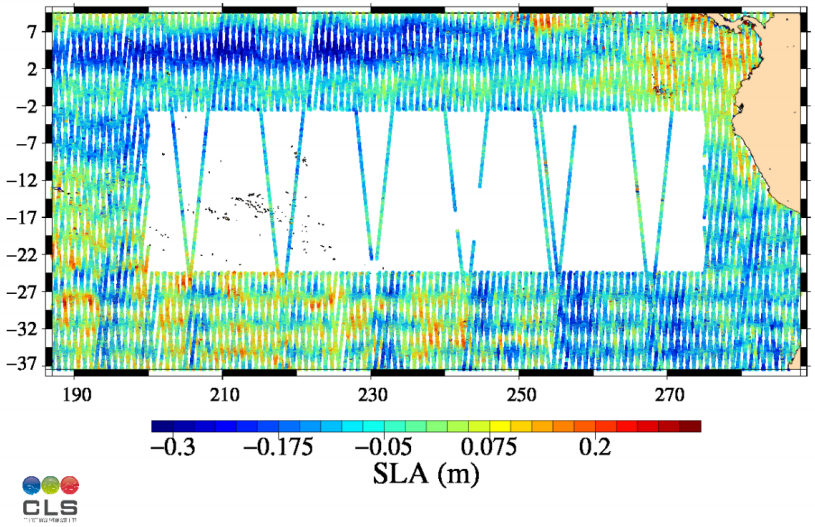
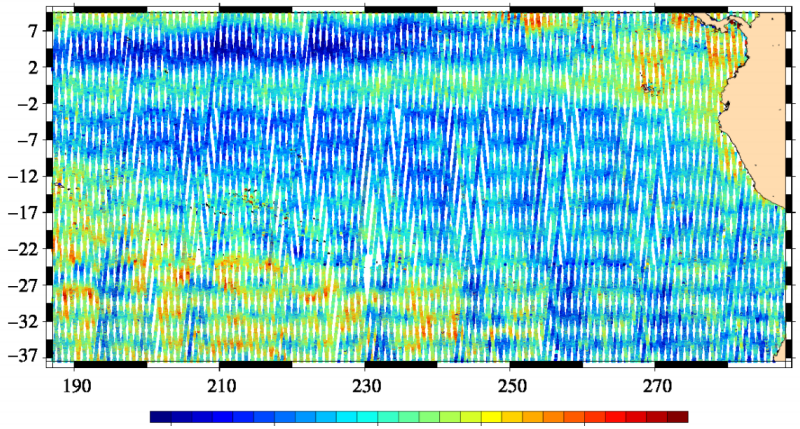
Focus on Pacific area

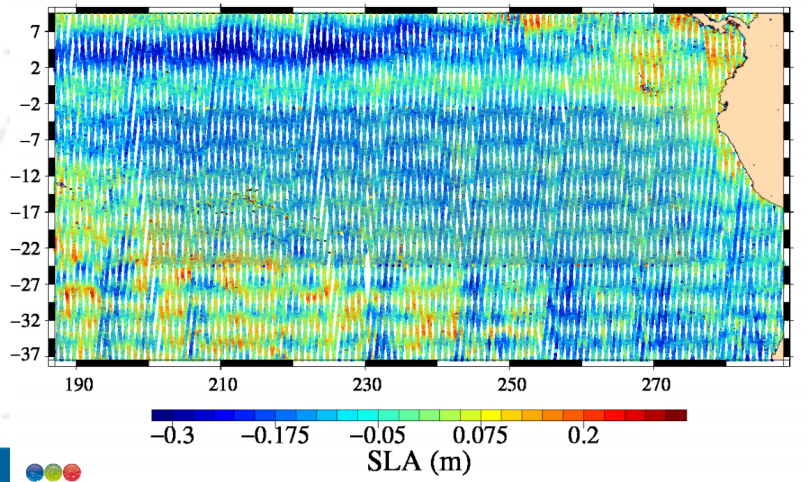
Cartography of CryoSat–2 SLA, LRM June 2012



LRM + SAR

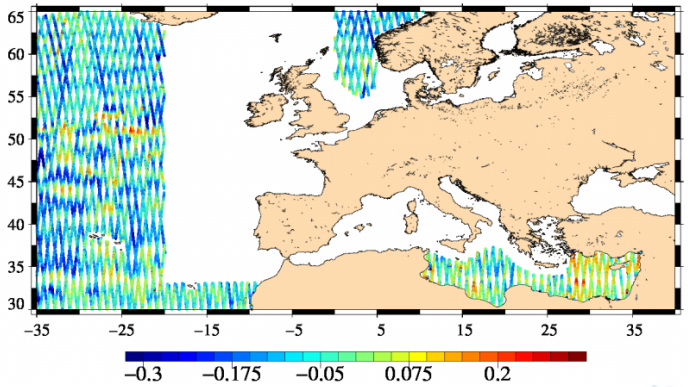


LRM + RDSAR

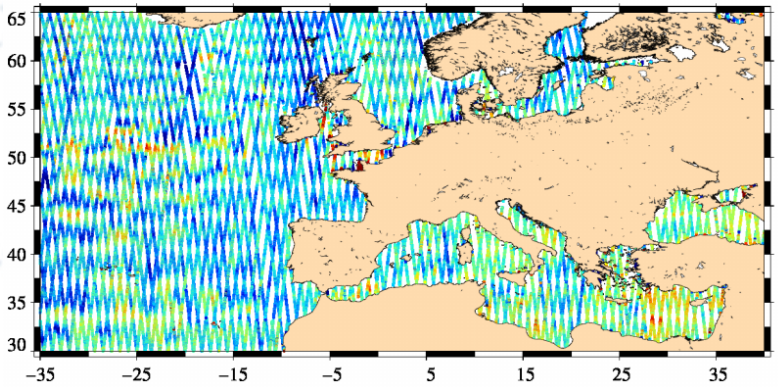


Focus on Atlantic Ocean

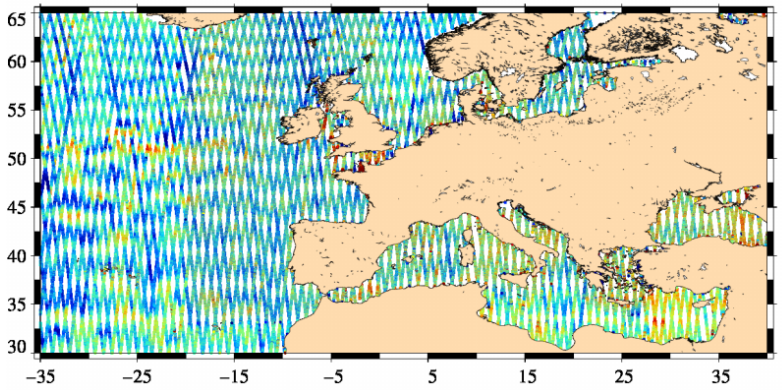
Cartography of CryoSat–2 SLA, LRM June 2012



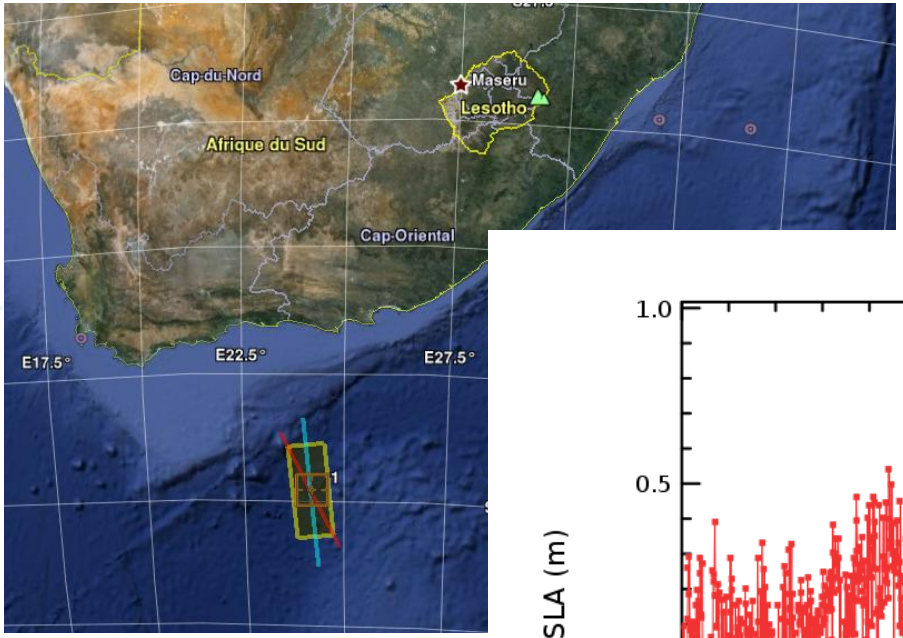
LRM + SAR



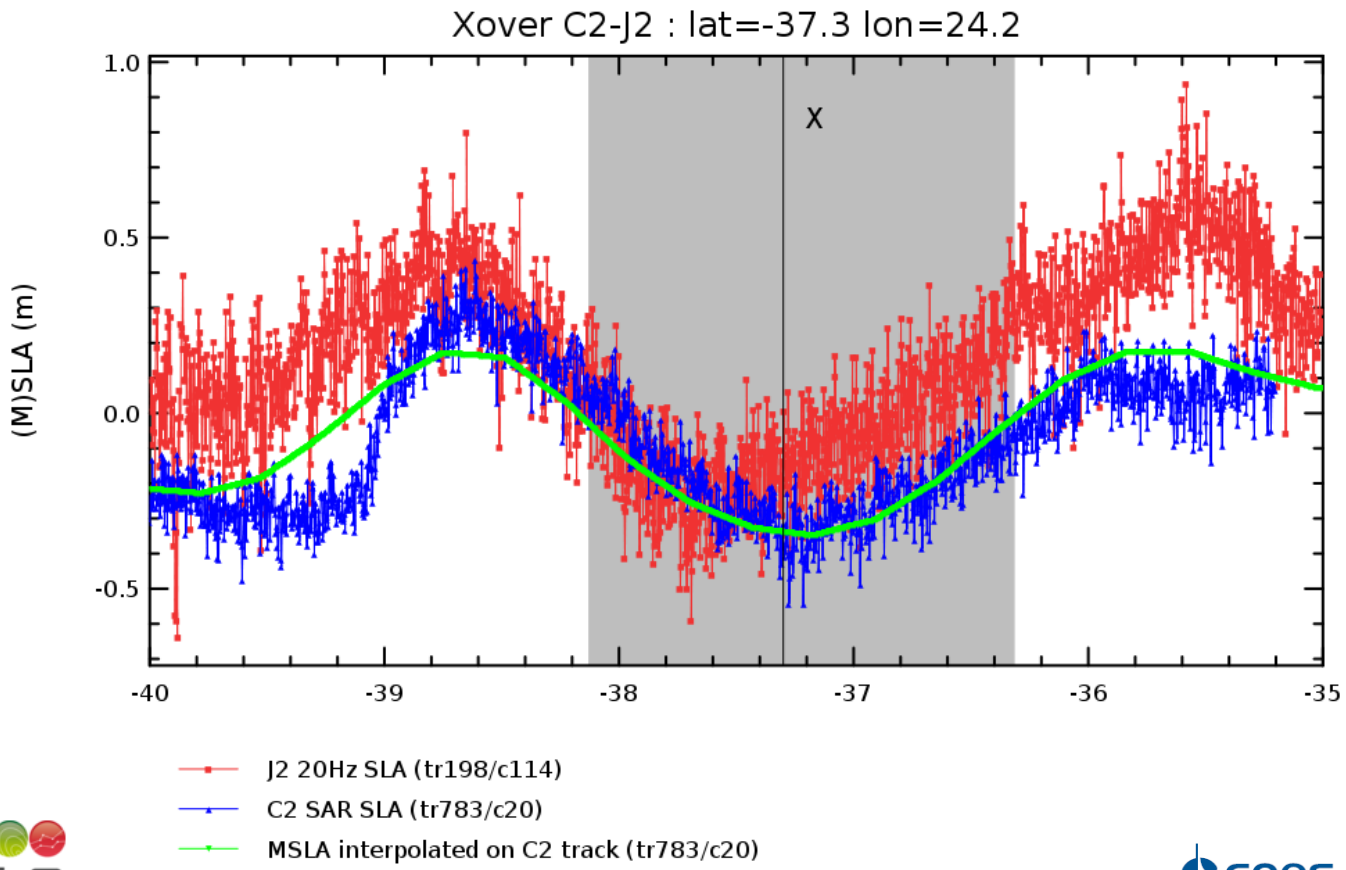
LRM + RDSAR



First along track example



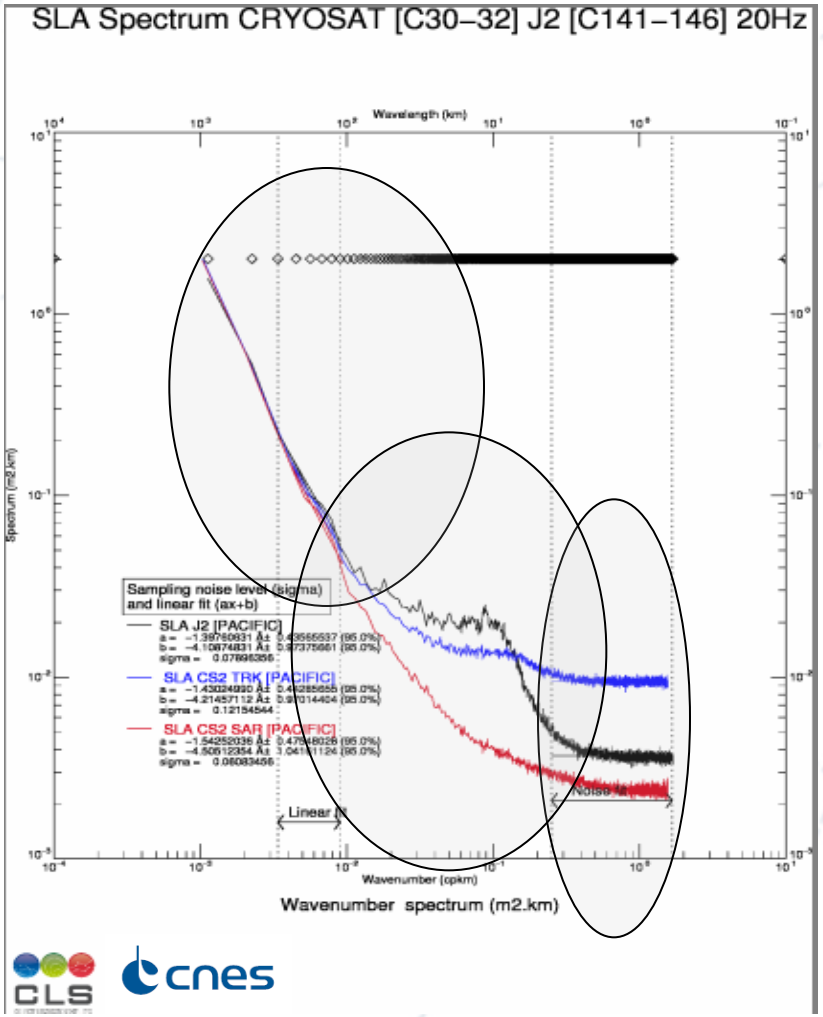
J2/C2 cross over points over Aghulas current



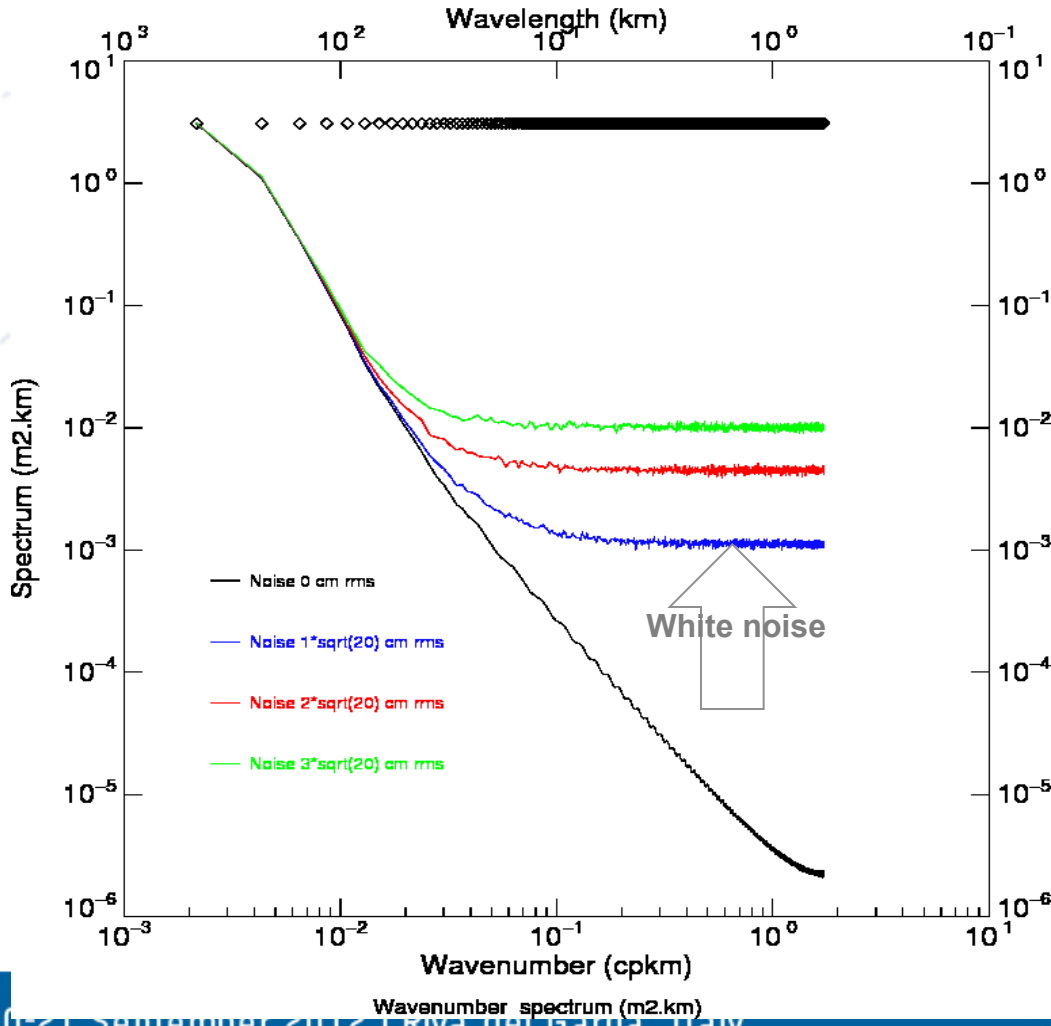
J2 trace 198 cycle 114 :
22505.242229
(2011-08-14 05:48:48)

C2 trace 783 cycle 20 :
22507.165698
(2011-08-16 03:58:36)

CPP processing results on CRYOSAT-2 data



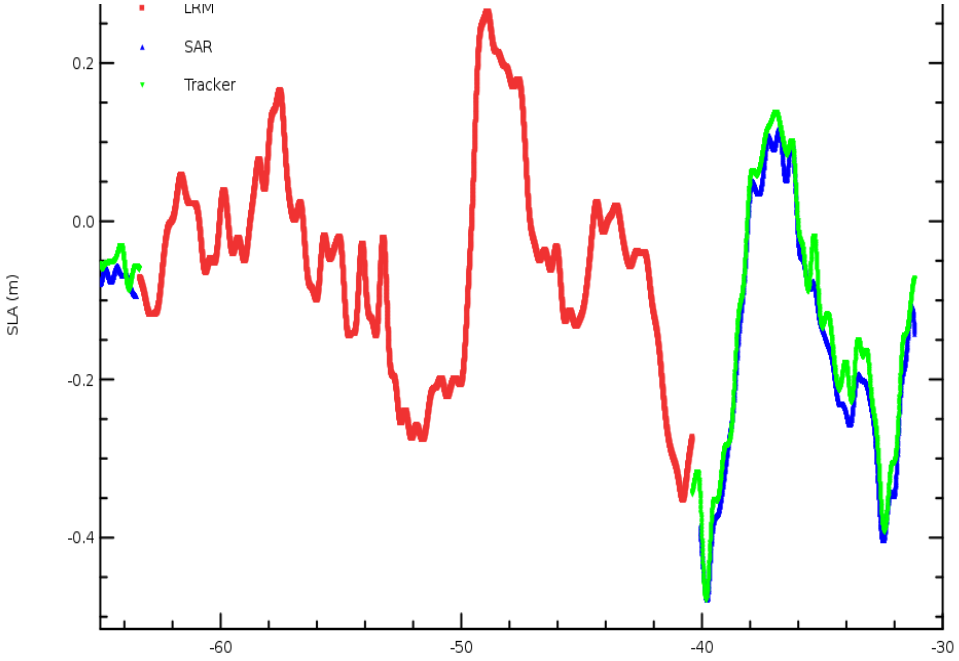
Simulated SSH + Noise @ 20 Hz



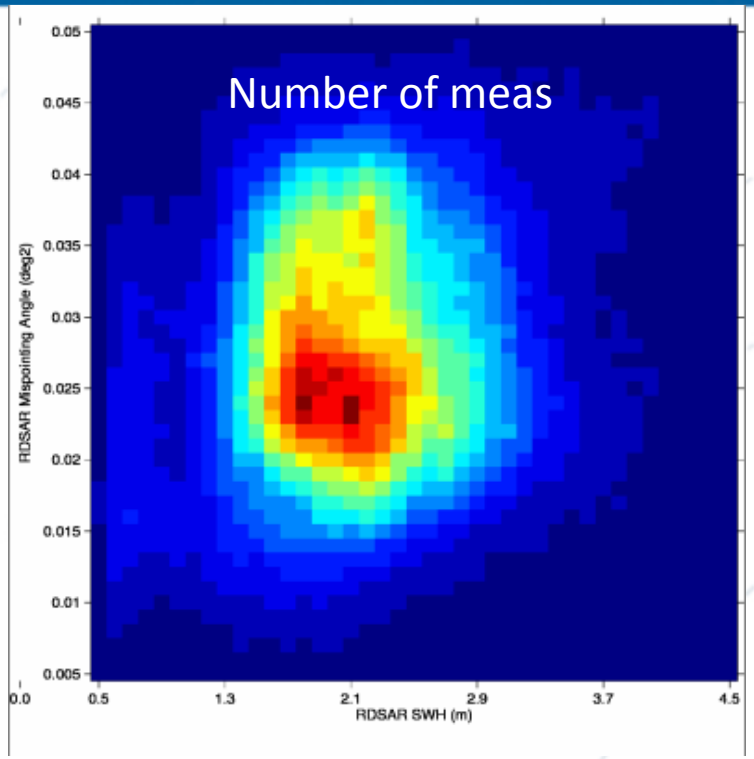
LRM-SAR Transition

Track 130 over Aghulas current

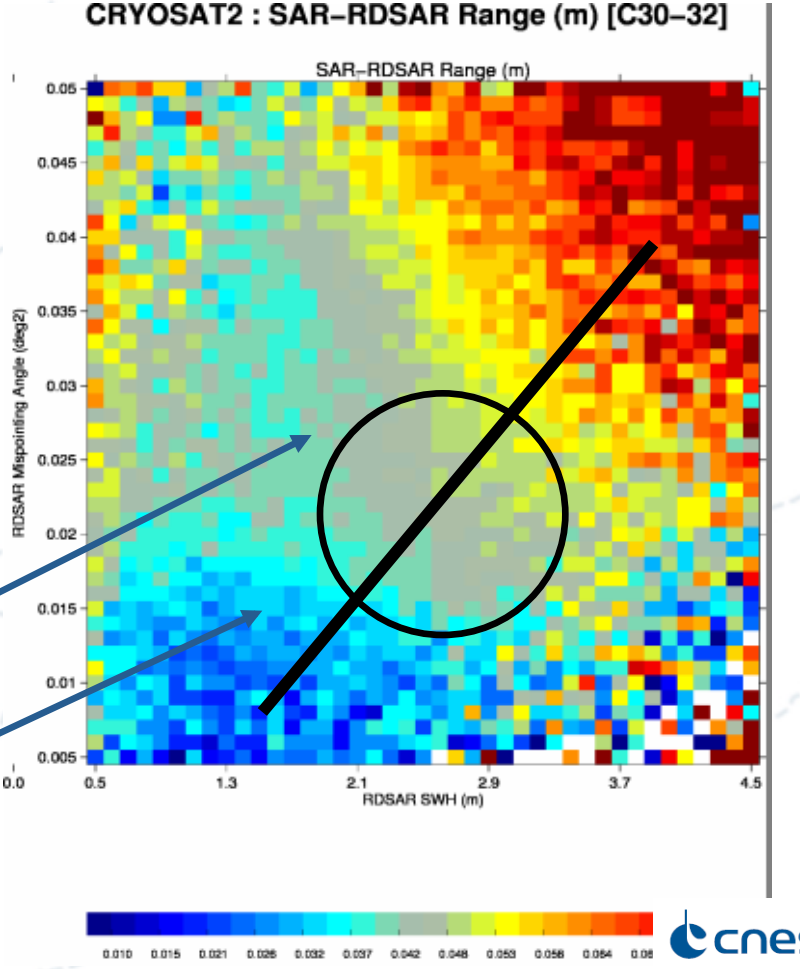
Red: LRM
Blue: SAR
Green: RDSAR



- **Good transition between LRM (red) and SAR (blue) measurements**
- **Analysis still on going to analyse precisely bias between LRM and SAR SLA (few cms). Hard to do since SSB is applied on LRM results but none on SARM.**
- **Low differences between SAR (blue) and RDSAR (green) – no SSB applied on RDSAR and SAR.**



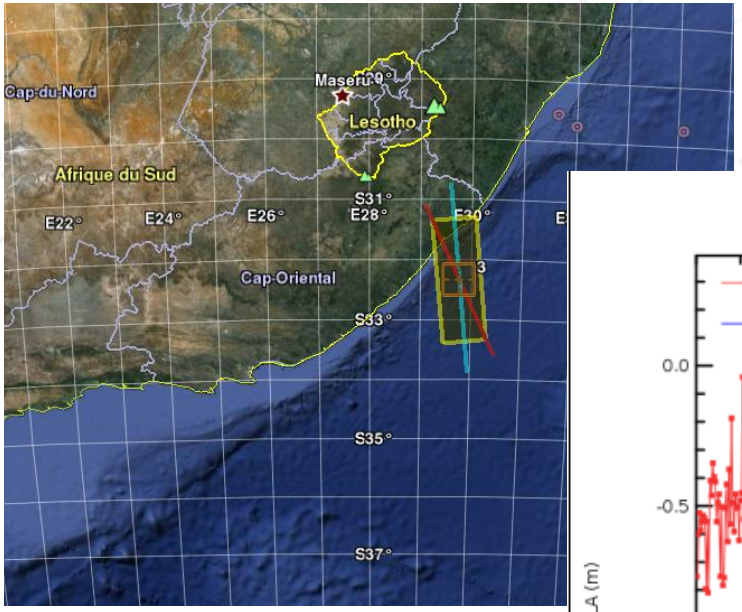
SAR-RDSAR bias



- For the mispointing configuration used in the retracking (0.02deg^2), SAR-RDSAR bias is about 4cm.

- Bias between SAR and RDSAR are correlated to SWH and mispointing values (variation of -/+2cm depending on swh and ksi values)

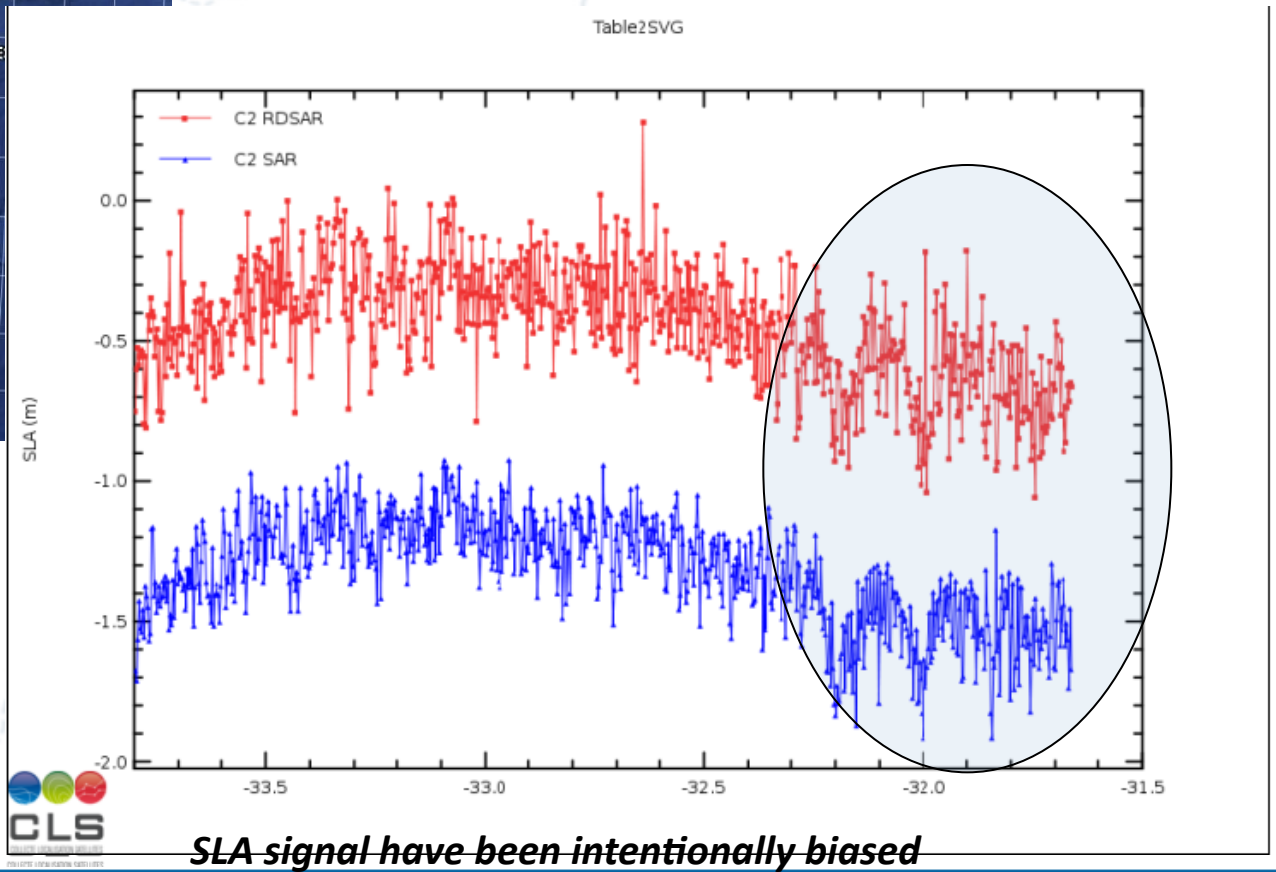
Let's focus on coastal areas



J2 trace 172 cycle 113:
22494.310367
(2011-08-03 07:26:55)

C2 trace 377cycle 20 :
22493.178512
(2011-08-02 04:17:03)

J2/CS2 cross over points over Aghulas current



SLA signal have been intentionally biased

Conclusion

Very promising results:

- SARM SLA noise is 30% lower than in LRM
- SARM provides with more trustworthy SLA dataset to observe scales ranging from 10 to 100km
- Thanks to the reduced azimuth resolution (320m vs 7km), SAR will improve the data coverage and quality approaching the coast.
- Low bias between LRM-SARM and SARM-RDSAR Sea Level Anomalies (few cm)

To optimize:

- The SAR/Doppler retracking must be upgraded to:
  - Reduce bias dependencies in SWH and mispointing
  - Improve the SWH estimates: about 15cm bias between LRM/RDSAR and SAR SWH
- The SAR/Doppler results must be more largely analyzed to:
  - Assess the continuity between LRM and SARM (SSB?, Doppler Model?)
  - Assess the SAR sensitivity to altitude, radial speed, …
  - Assess the SAR sensitivity to swell,
  - Assess the SAR retracking for very low SWH.

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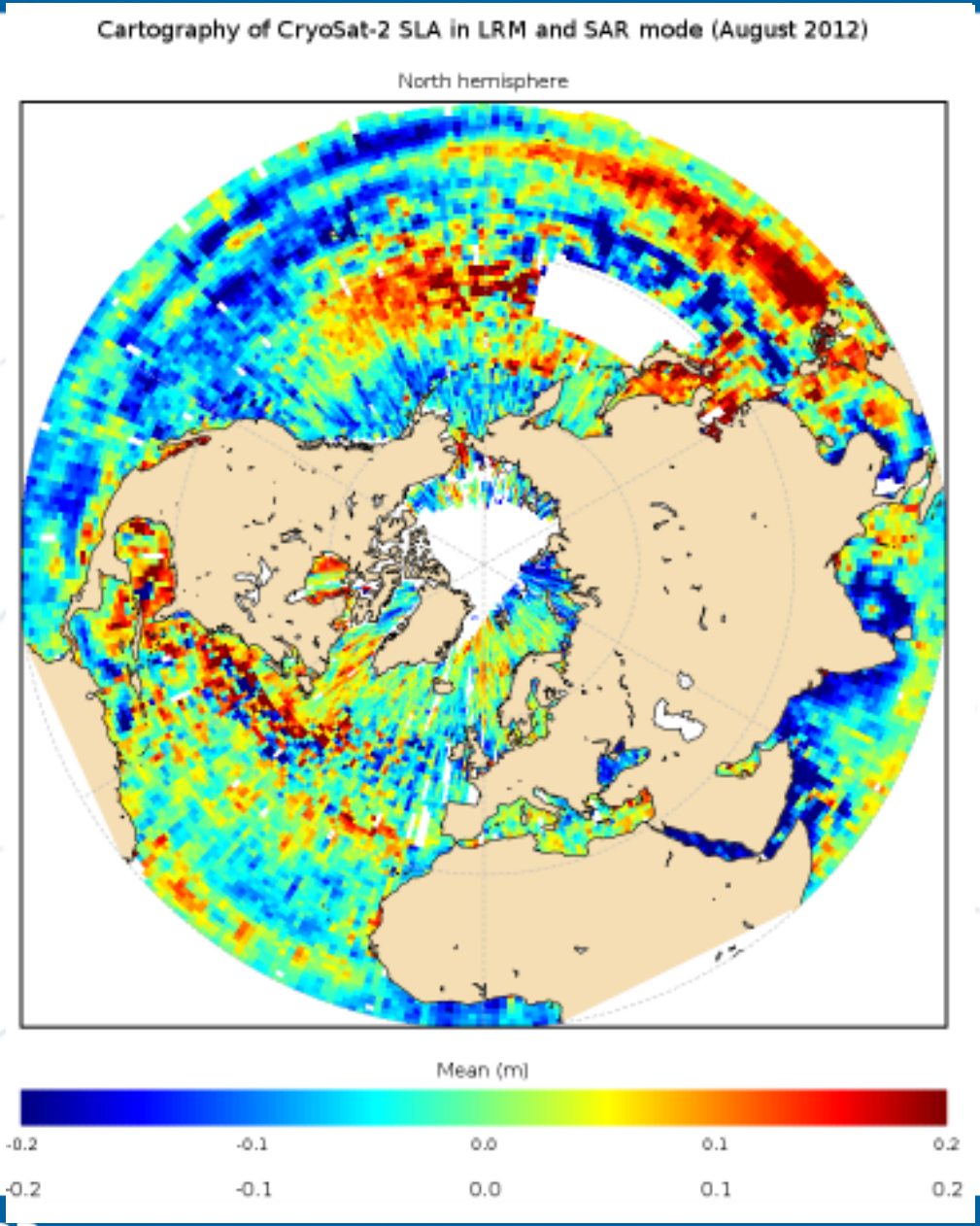
Thank you!


Cartography of CryoSat-2 SLA in LRM and SAR mode (August 2012)
North hemisphere
Mean (m)
-0.2
-0.1
0.0
0.1
0.2