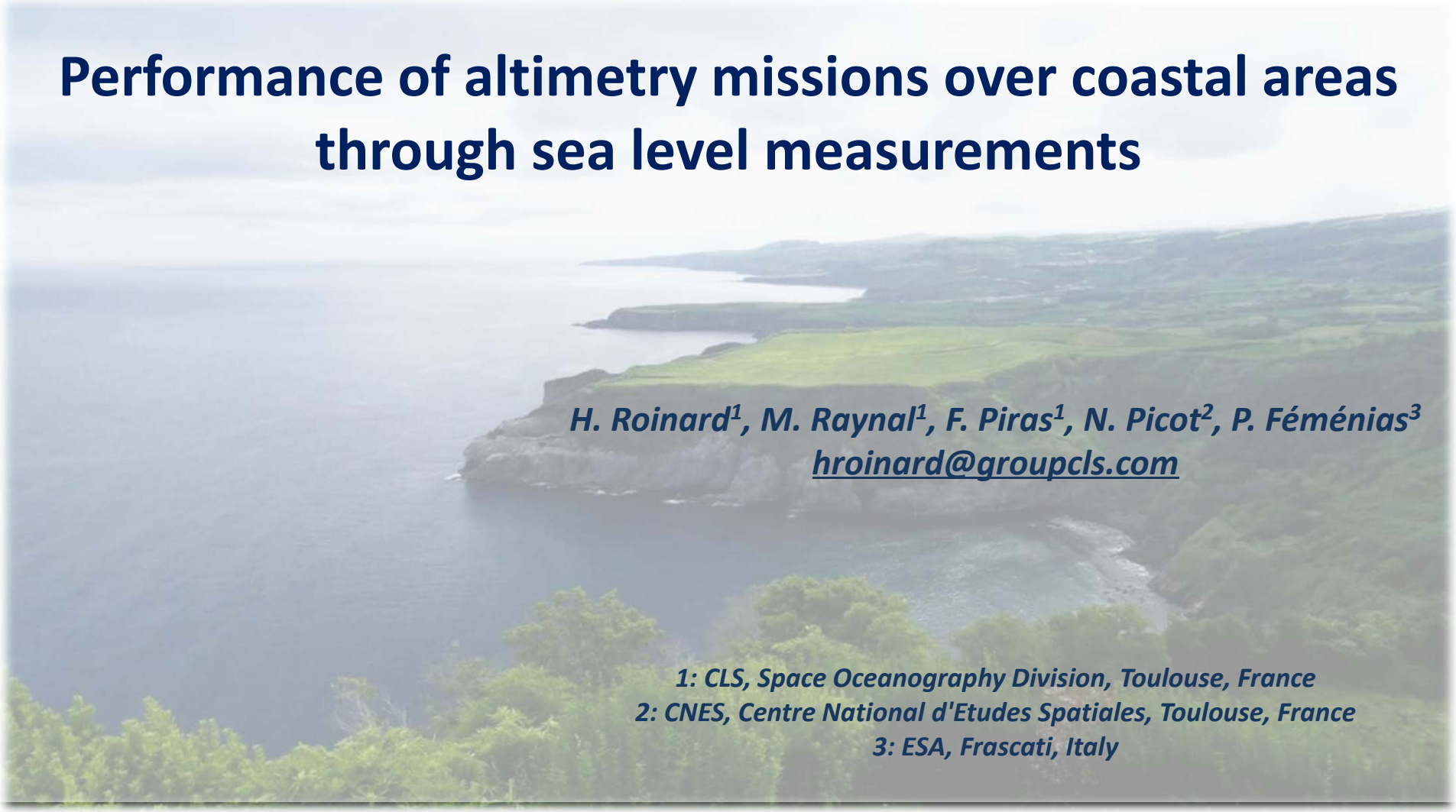
Performance of altimetry missions over coastal areas through sea level measurements



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Context

Altimetry missions are providing measurements all over the globe and in particular over coastal areas, with performances that depend on the mission characteristics

- Jason-2/3 missions in Low Resolution Mode and Ku frequency (20Hz)
- SARAL/AltiKa mission in Low Resolution Mode but Ka frequency (40Hz)
- Sentinel-3A in Ku frequency but Delay-Doppler mode (20Hz)

Overview

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- Jason-2/3 missions in Low Resolution Mode and Ku frequency (20Hz)
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- Noise level
- Data availability
- Data quality
  - Ability to interpret waveform
  - SLA mean variations near coast
  - SLA global standard deviation
- Conclusions and perspectives

SLA (corrections)

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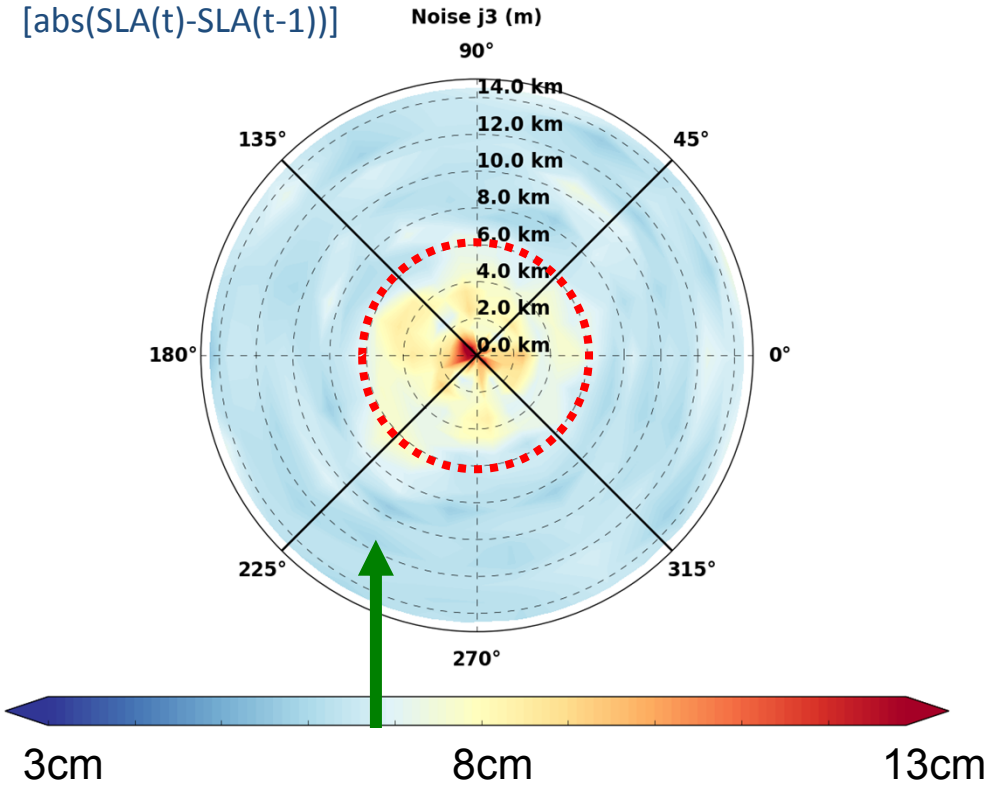
- ECMWF model wet tropospheric corr.
- GIM model ionospheric correction

SLA Noise level (no ssb correction)

Jason-3

Measurement noise
[abs(SLA(t)-SLA(t-1))]



✓ **Jason-3:** Noise around 6.9cm until 6km to coast, then rise.

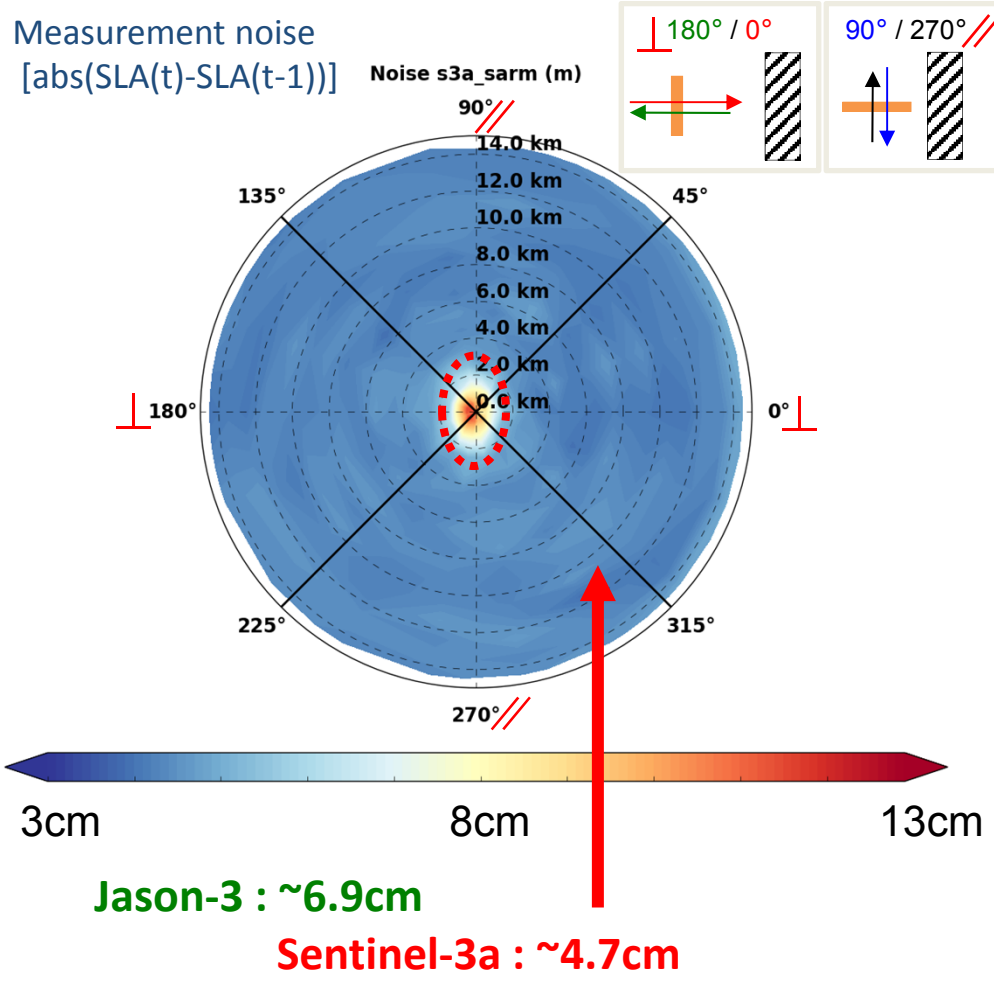
Jason-3 : ~6.9cm

Data computed over 1 month , using HR data
|latitude|<50°, surface_type_20Hz=ocean

SLA Noise level (no ssb correction)

Sentinel 3a

Measurement noise
[abs(SLA(t)-SLA(t-1))]



✓ **Jason-3:** Noise around 6.9cm until 6km to coast, then rise.

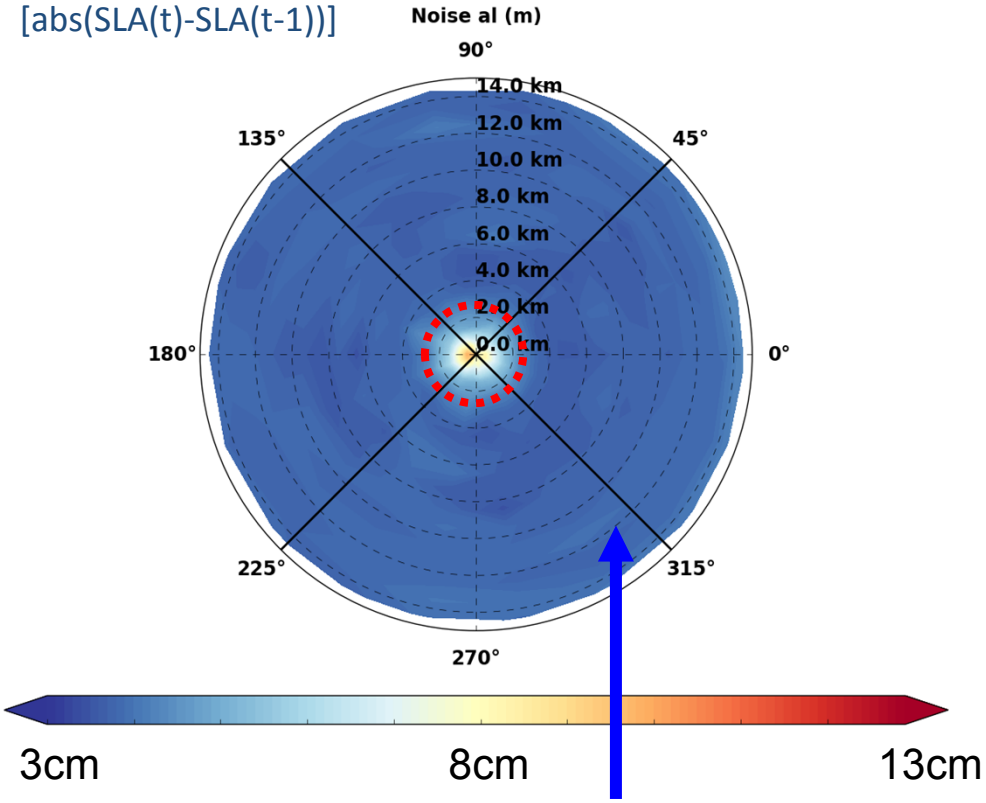
✓ **Sentinel-3a:** Less noise on SLA measurements with SAR (4.7cm), and coastal angle dependance due to particular footprint under 3km to coasts.

Data computed over 1 month , using HR data
|latitude|<50°, surface_type_20Hz=ocean

SLA Noise level (no ssb correction)

SARAL/AltiKa

Measurement noise
[abs(SLA(t)-SLA(t-1))]



Jason-3 : ~6.9cm **SARAL/AltiKa : ~4.2cm**

Sentinel-3a : ~4.7cm

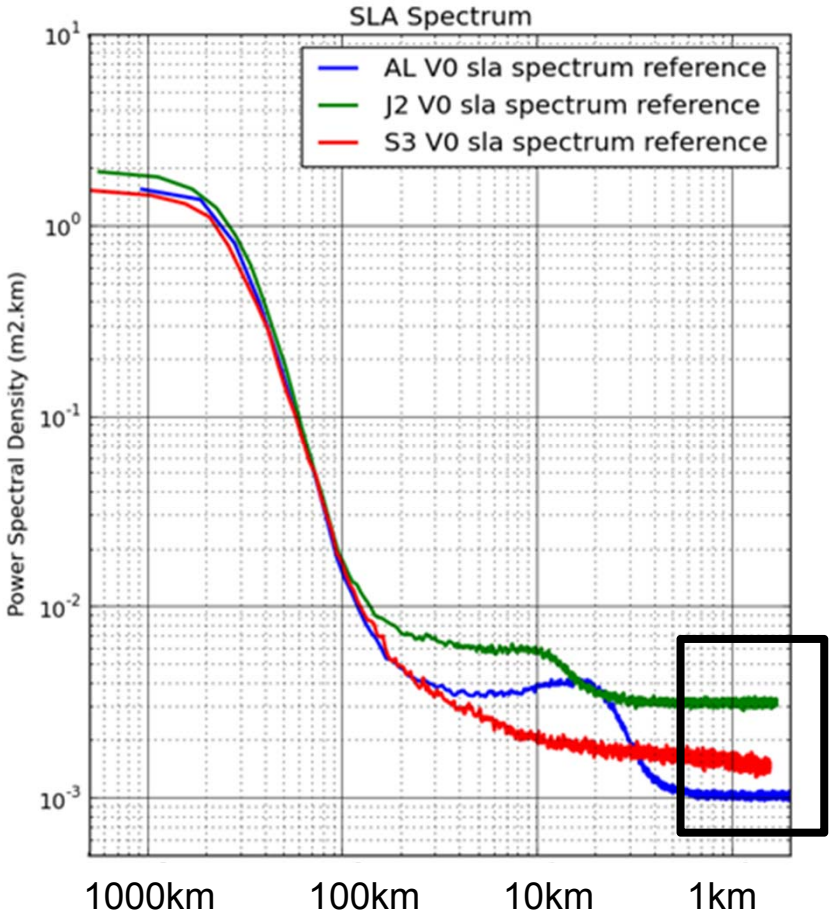
✓ **Jason-3:** Noise around 6.9cm until 6km to coast, then rise.

✓ **Sentinel-3a:** Less noise on SLA measurements with SAR (4.7cm), and coastal angle dependance due to particular footprint under 3km to coasts.

✓ SARAL/AltiKa: Less noise on SLA measurements (4.2cm) with Ka-band (40Hz + narrower gain antenna pattern). Rise under 2km.

Data computed over 1 month , using HR data
|latitude|<50°, surface_type_20Hz=ocean

SLA Noise level



These measured Noise levels :

Jason-3 : ~6.9cm

Sentinel-3a : ~4.7cm

SARAL/AltiKa : ~4.2cm

lead to variance gain of:

Jason-3 → Sentinel-3a : **-54%**

Sentinel-3a → SARAL/AltiKa : **-20%**

Jason-3 → SARAL/AltiKa : **-63%**

Data availability against coastal distance

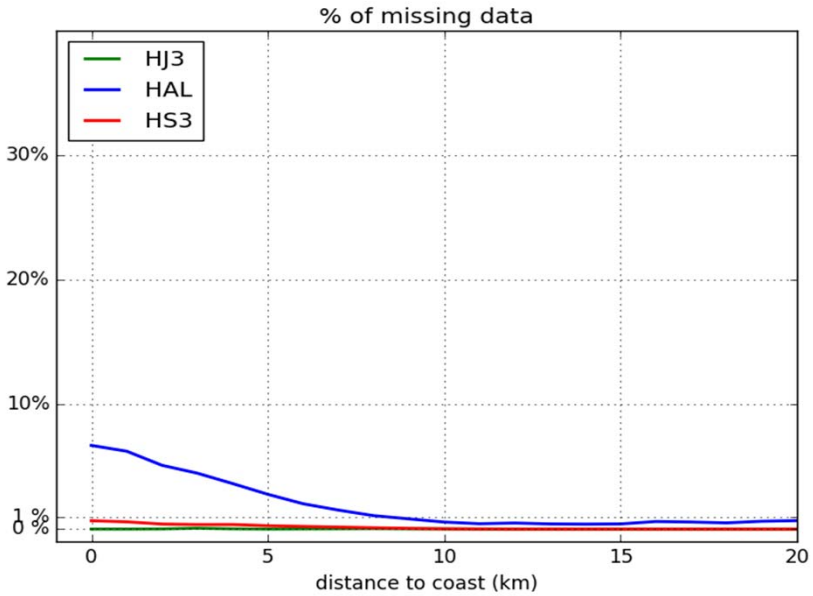
SARAL/AltiKa: close loop

Jason-3: switch open loop over ocean and hydro targets / close loop over land

Sentinel-3a: switch open loop / close loop (mask)

→ Good availability of data for all missions (>99% in open ocean)

Data availability against coastal distance



SARAL/AltiKa: close loop

Jason-3: switch open loop over ocean and hydro targets / close loop over land

Sentinel-3a: switch open loop / close loop (mask)

→ Good availability of data for all missions (>99% in open ocean)

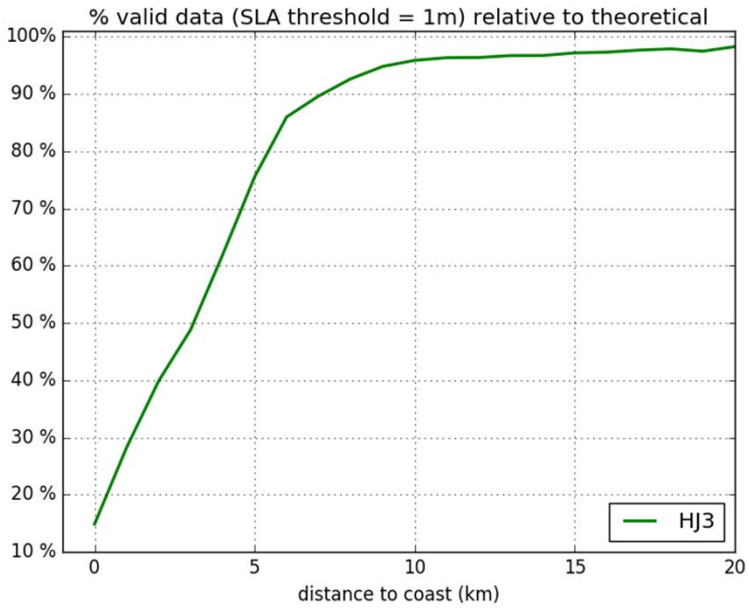
→ measurements are always available for Jason-3 and Sentinel-3a over ocean (DEM mode), whereas there are few more missing data for AltiKa (median tracker)

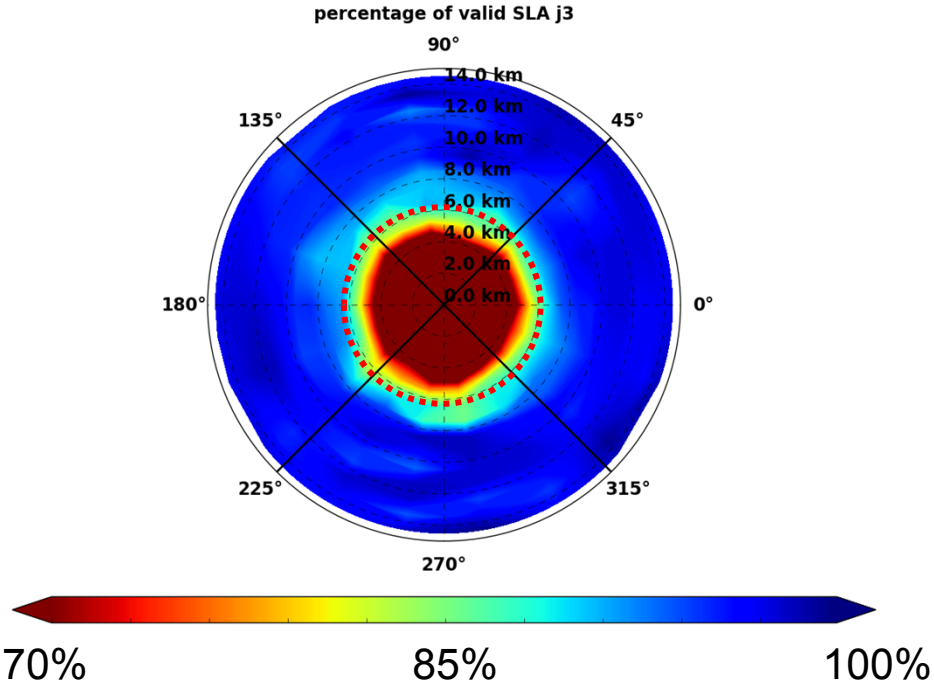
→ Near coasts, close to 7% of missing data in the last km with AltiKa

Data computed over 1 month , using HR data whose |latitude|<50°, with selection on surface_type_20Hz=ocean

Quality: valid measurements

Jason-3



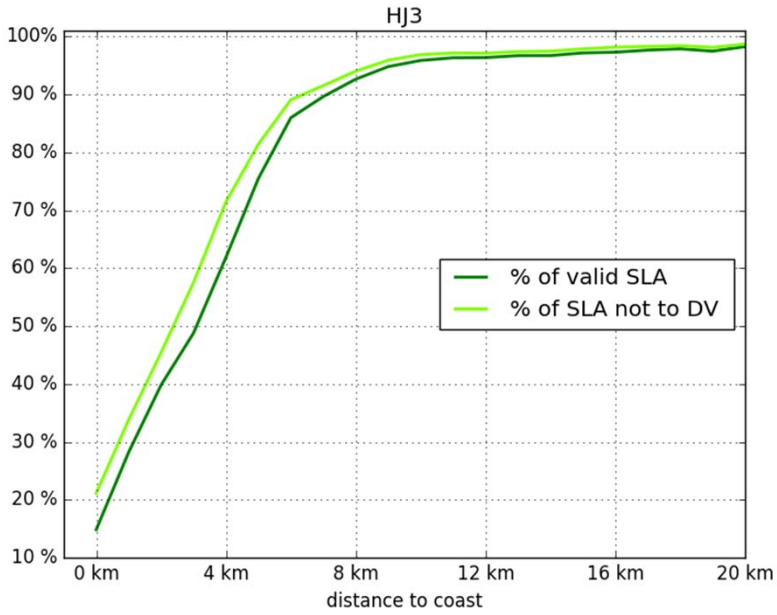


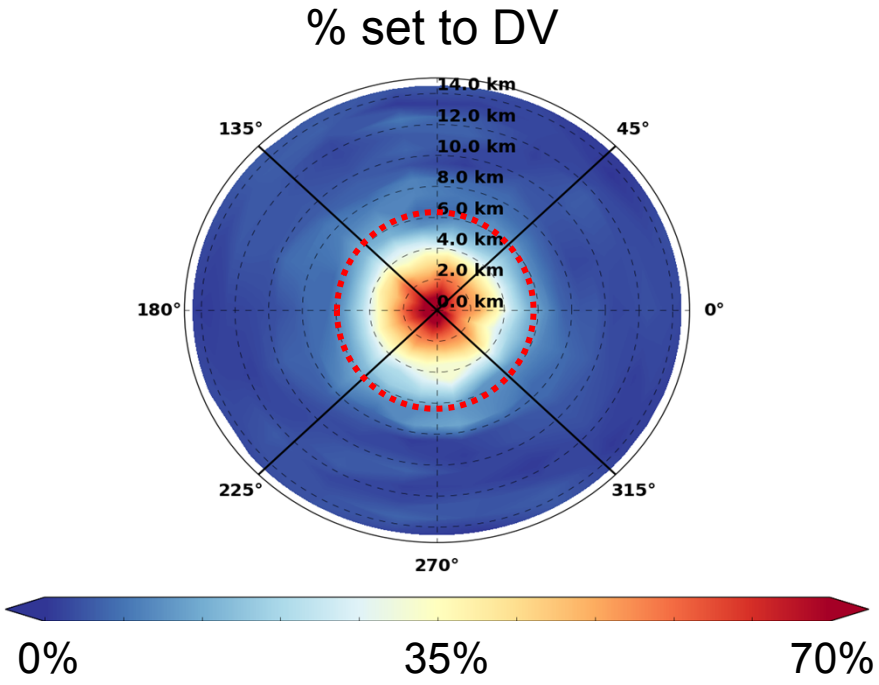
Less valid measurements for J3 when coastal distance <~6km

Why such a rate of non valid measurements?

Quality: non valid measurements due to SLA set to DV

Jason-3





Less valid measurements for J3 for short coastal distance (<~6km)

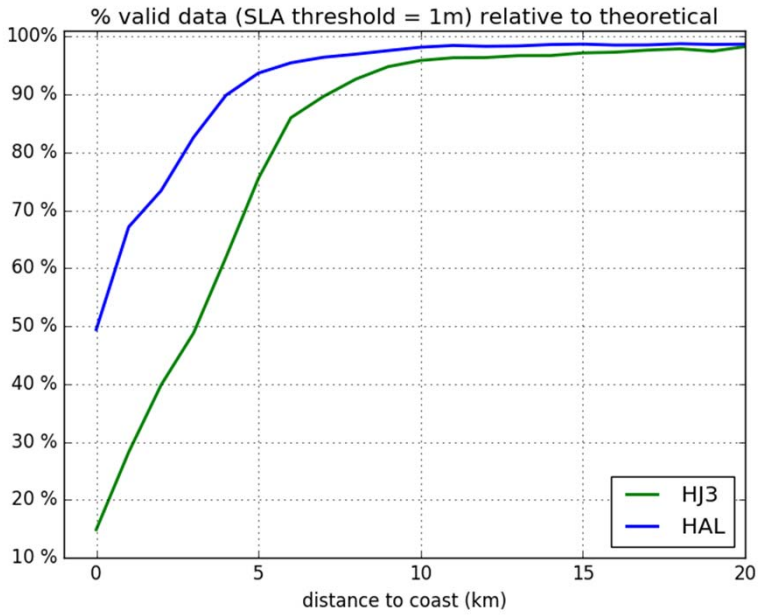
→ Jason-3 footprint is 9.6km: **measurement corrupted by land returns**

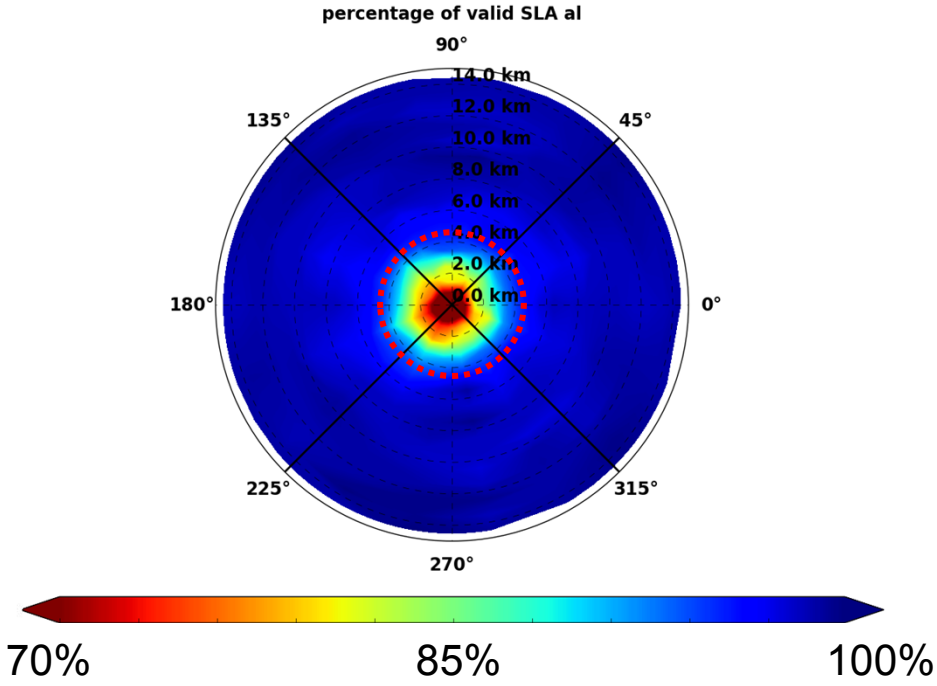
→ mainly due to **range measurements set to DV** (>30% for coastal distance <4km)

(+ some rejected measurements due to selection on | SLA – $SLA_{mean(8\text{-}15km)}$ | < 1m)

Quality: valid measurements

SARAL/AltiKa



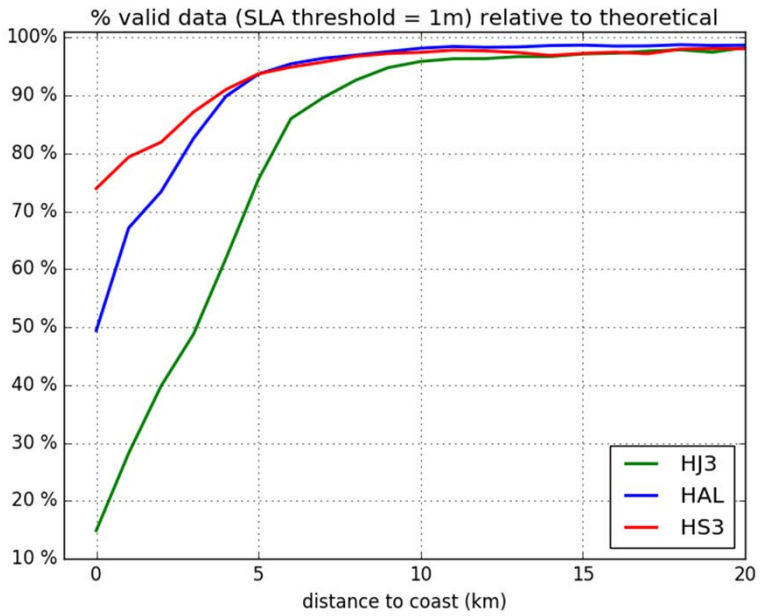


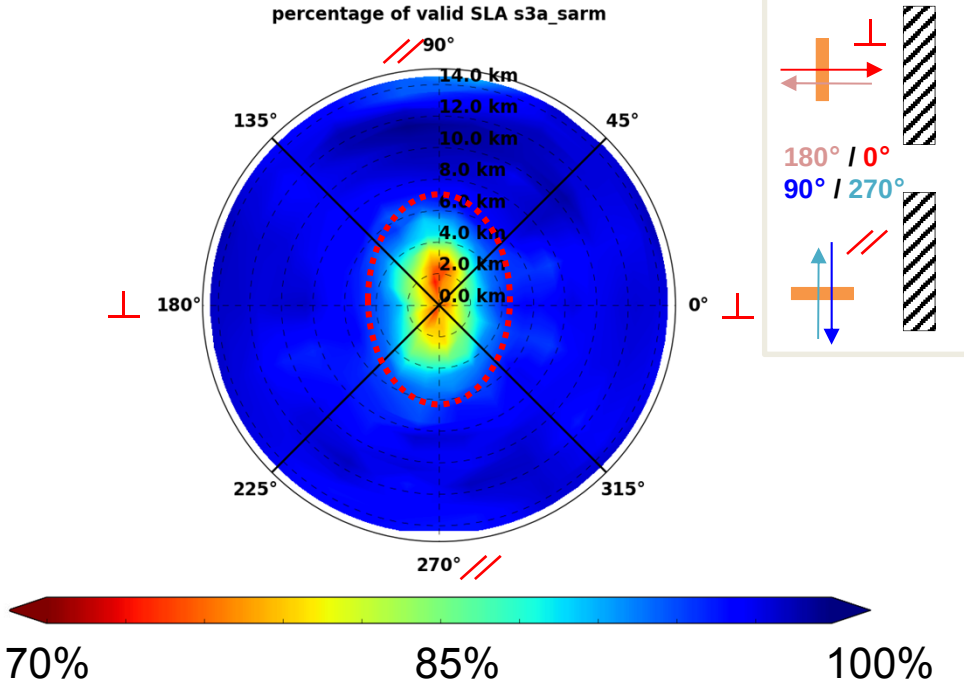
Less valid measurements for AltiKa when coastal distance <~3to4km

→ smaller footprint (5.7km) wrt Jason-3 (9.6km) + Ka-band

Quality: valid measurements

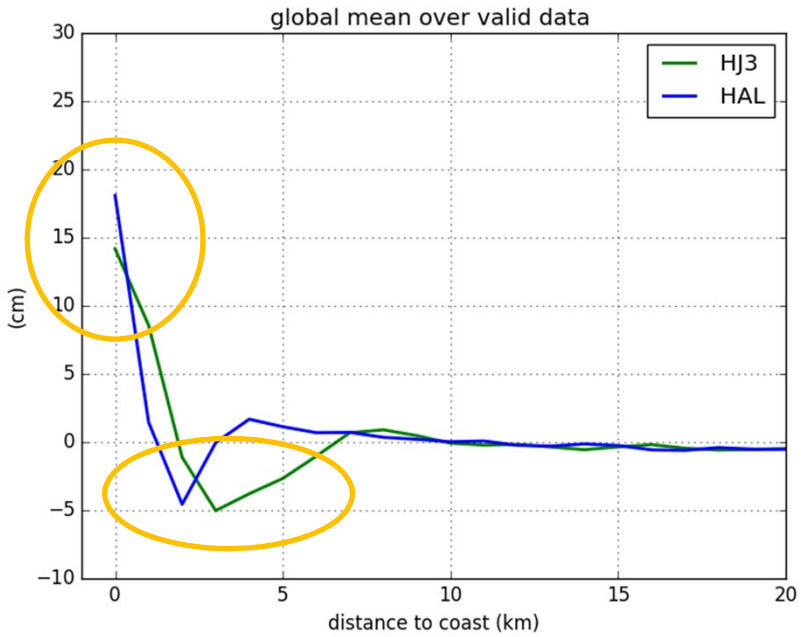
Sentinel-3a



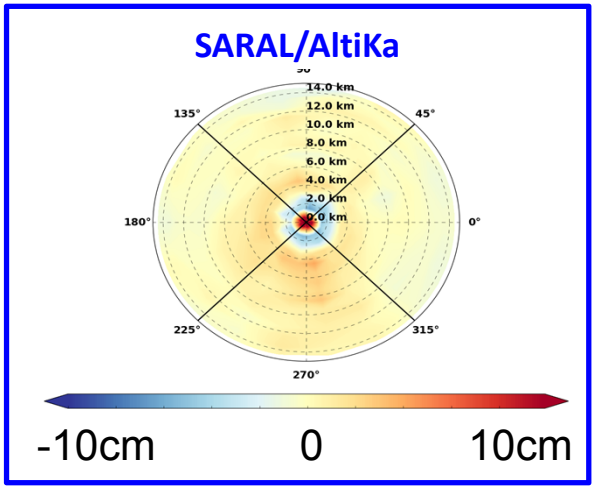


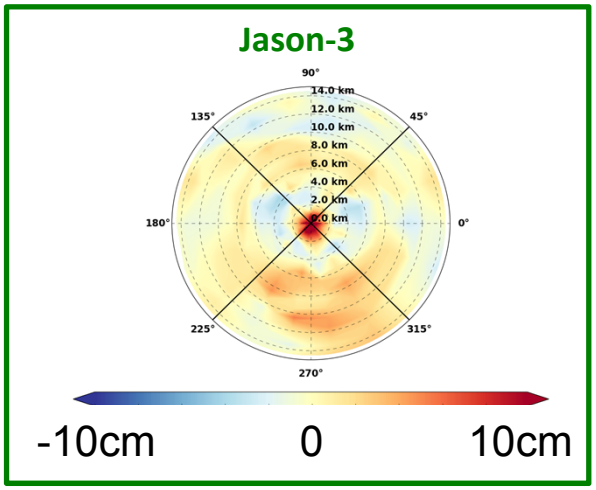
- ✓ Results are different depending on the attack angle to the coast due to SARM footprint
- ✓ More valid points nearest the coast for angles of 0° or 180°

SLA global mean near coasts



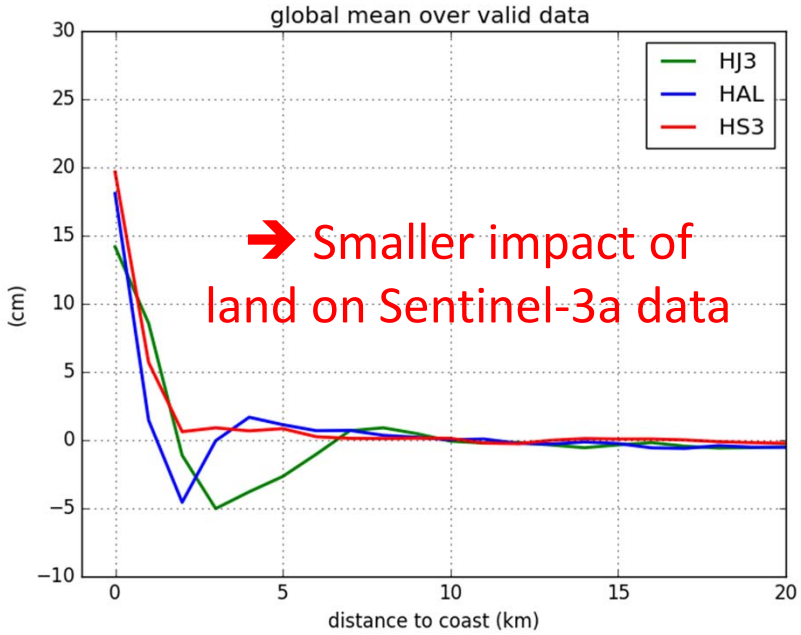
SLA mean drops then goes up when approaching coast mainly visible using LRM (AltiKa & Jason-3), due to land contamination in waveform.



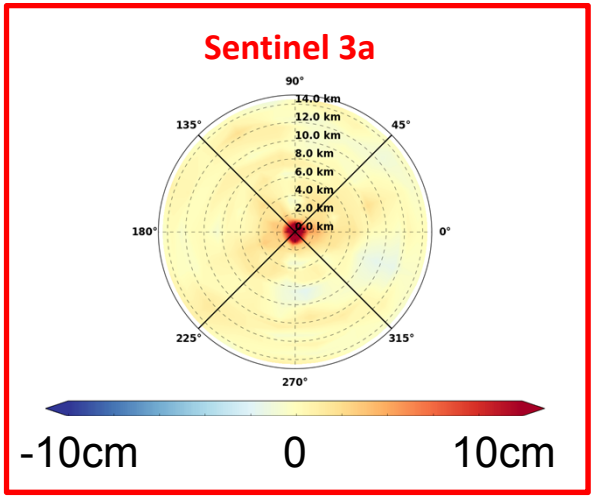


SLA global mean near coasts

Sentinel 3a



➔ Smaller impact of land on Sentinel-3a data



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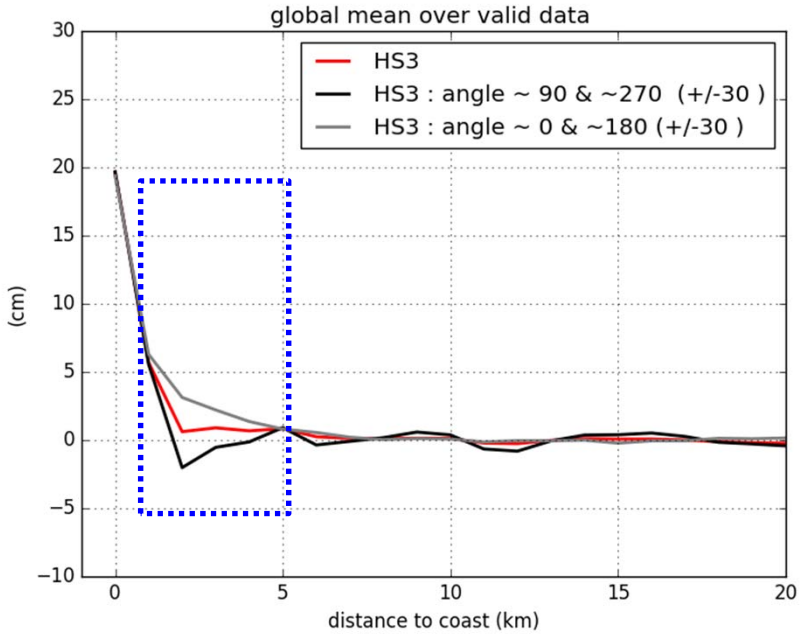
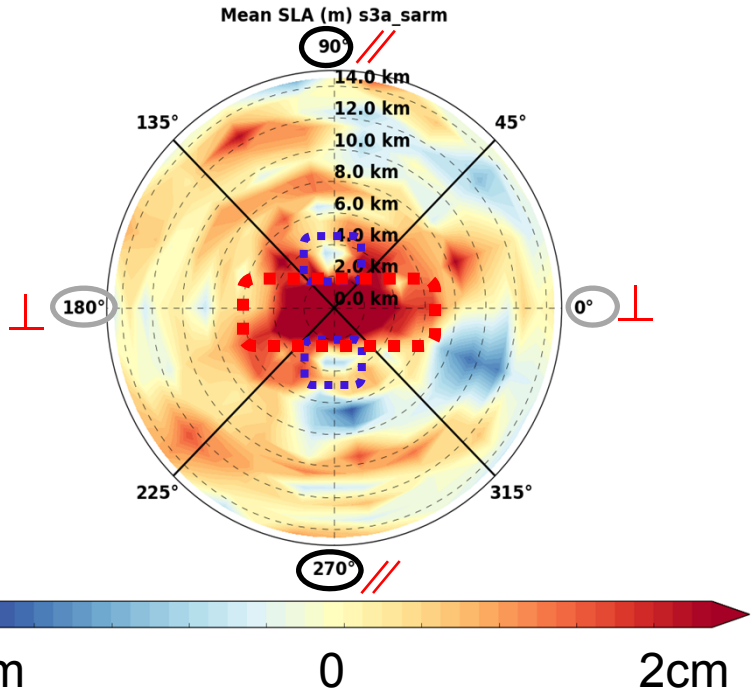
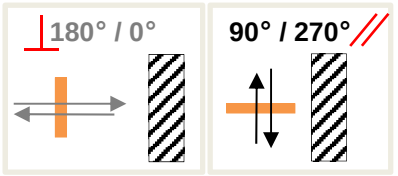
Sentinel 3a

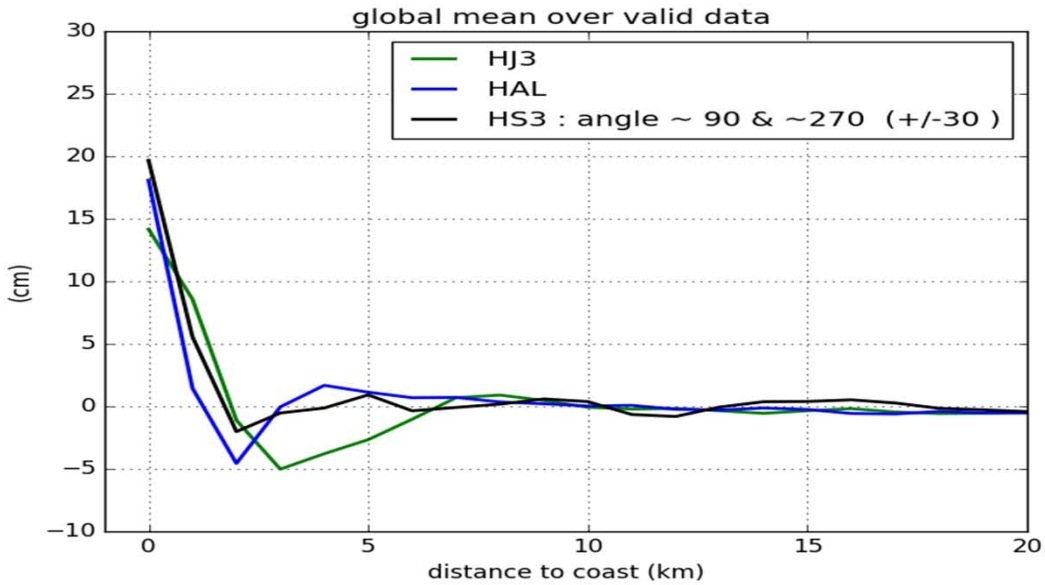


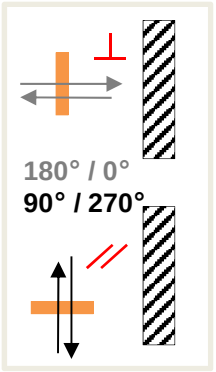


Impact on Sentinel-3 depends on attack angle to coast:
Visible when satellite is moving // to the coast (footprint is of 15km length in cross track direction)



SLA global mean near coasts

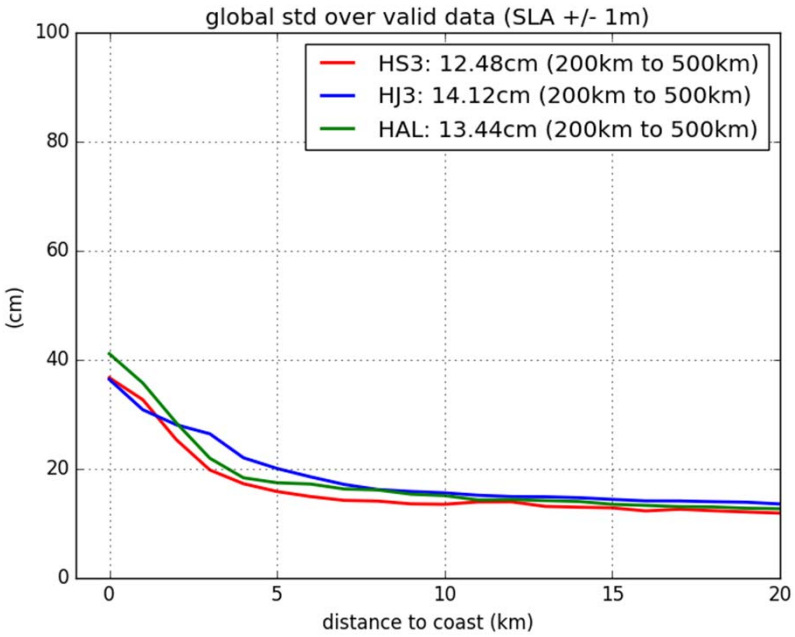


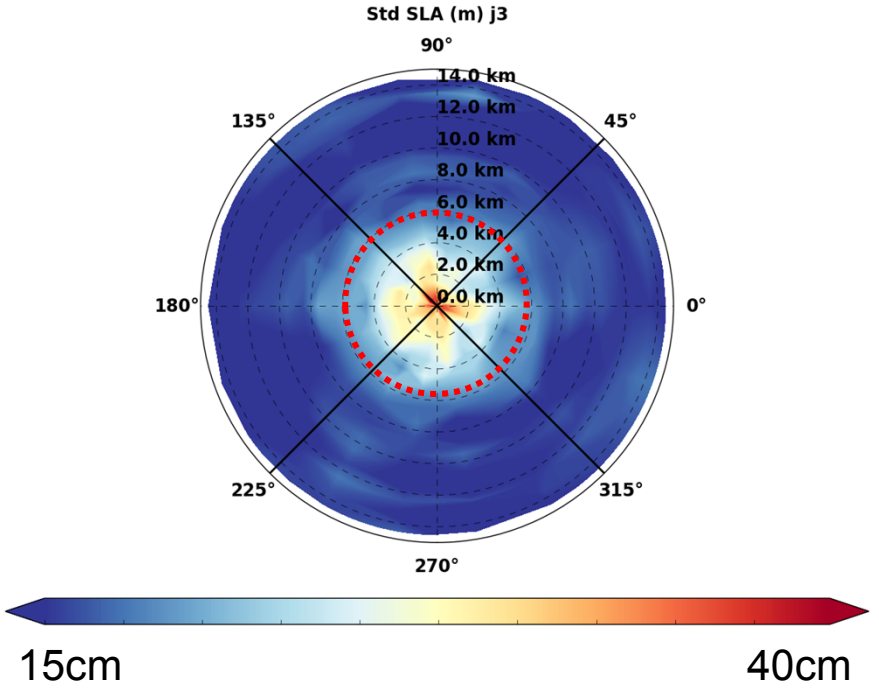


➔ Smaller impact of land on Sentinel-3a data than with SARAL/AltiKa or Jason-3, even for non optimal configuration (satellite is moving // to the coast),

SLA global standard deviation

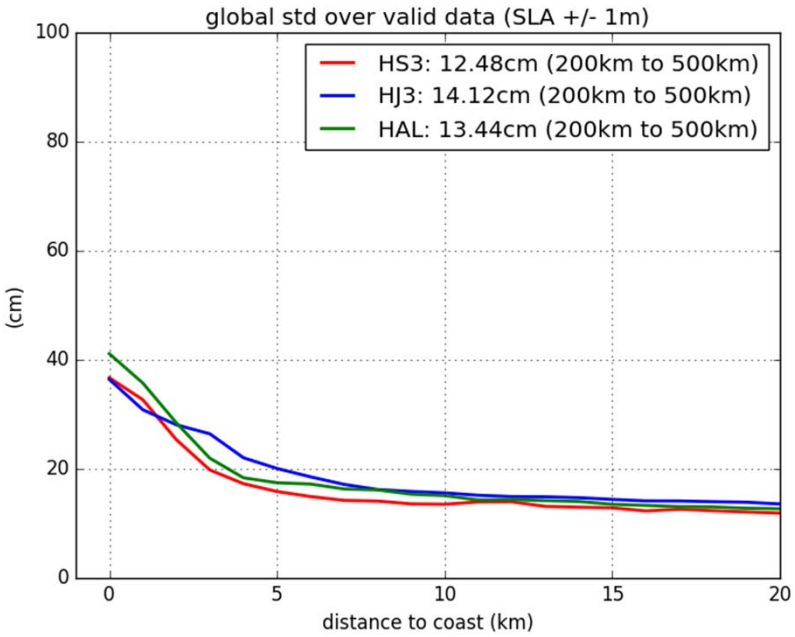
Jason-3

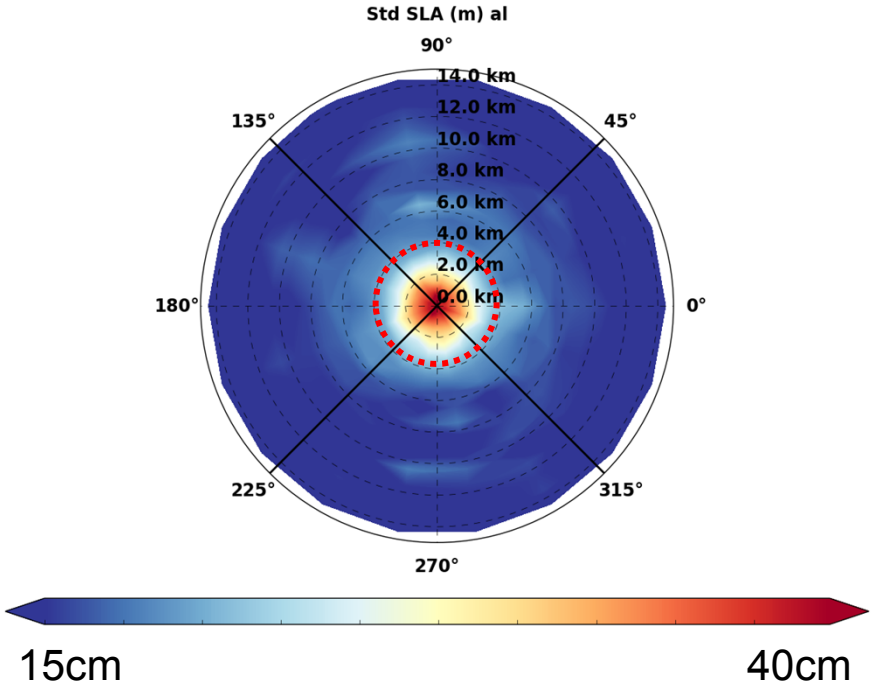




SLA global standard deviation

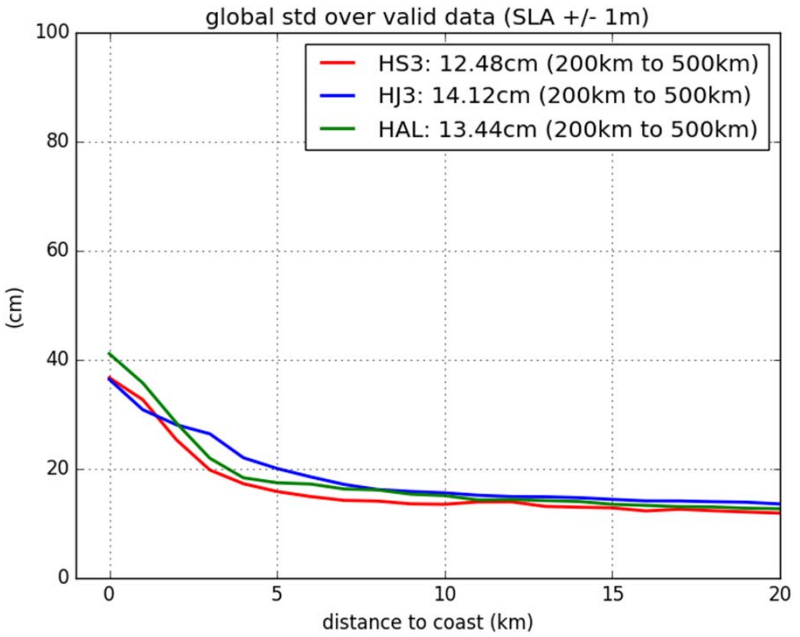
SARAL/AltiKa

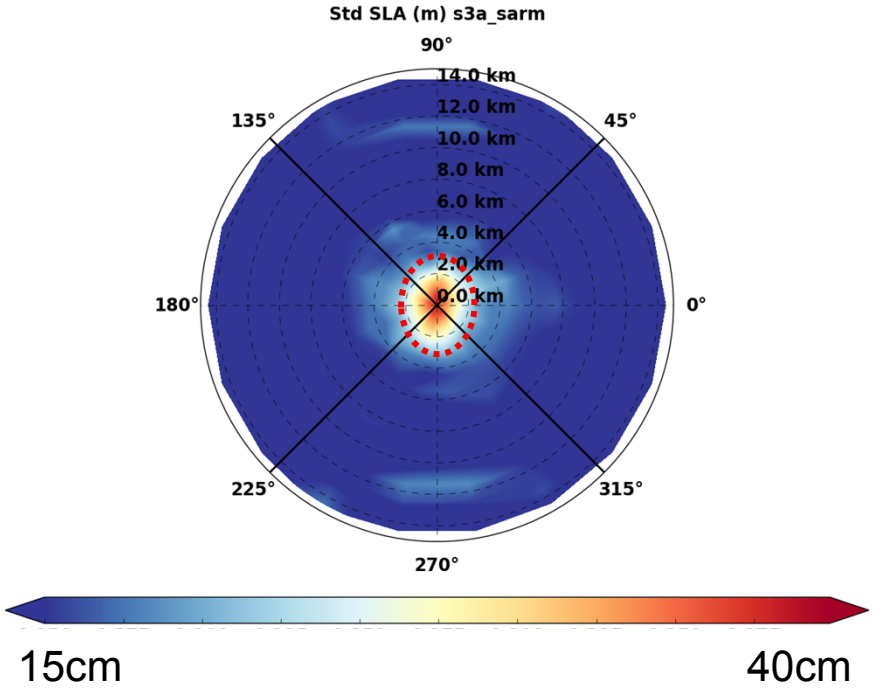




SLA global standard deviation

Sentinel-3a





With the selection done on this study (remove only outliers >1m, chosen to keep significant number of points), SLA std computation at HR leads to global std of 12 to 14cm in average in open ocean (lower for S3a SAR mode than for lower resolution mode).

Global std of SLA significantly increases when approaching coast for all missions.

Conclusions and perspectives

- ✓ Open loop mode allows to have more available data near coasts
- ✓ Ka-band allows to better use data near coasts thanks to
  - ✓ a smaller footprint
  - ✓ antenna gain: land contamination inside the footprint impact is smaller, so that it is easier to interpret waveform
  - → more valid range measurement with AltiKa than Jason-3
- ✓ Less noise with AltiKa (Ka-band – 40Hz) and Sentinel3 (SAR mode - 20 Hz) than with Jason (Ku-band – 20Hz)
- ✓ Sentinel SAR mode improves performances when approaching coast thanks to its smaller along-track footprint and low noise level. That allows to compute more accurate range

To complete this study:

- Complete tests with different retracking methods (Adaptive, LR-RMC, ALES approach, etc.)
- Optimize data selection, computing a performant editing procedure near coasts
- Use of other mission's data (C2, HY-2A, S3B, …)
- Decline the study in different oceanic basins / regional particularities
- Study the impact of corrections used for SLA computation
- Add radiometer behavior impact

Future missions : SAR in Ka-band would strongly improve near coasts studies thanks to the benefit brought by both Ka-band **and** SAR mode

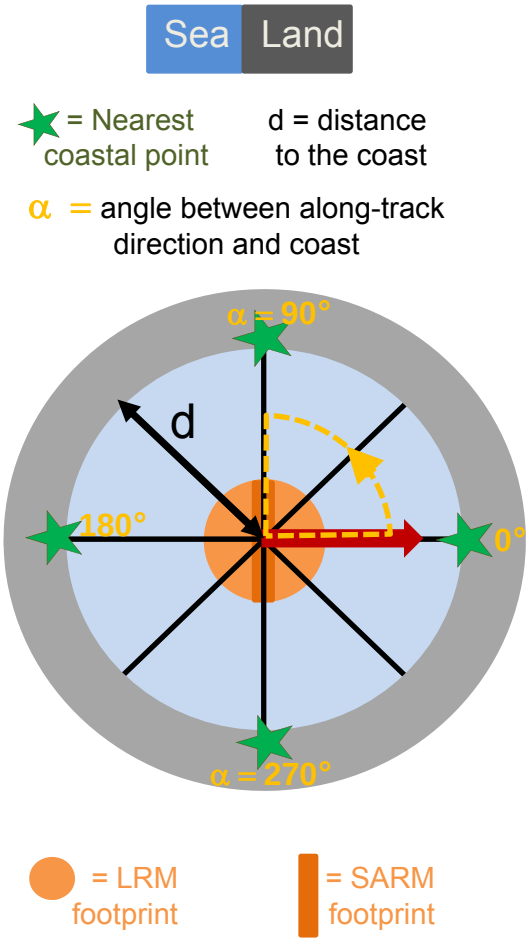
➔ **Applications** :

- more valid measurements close to the coast will help to improve MSS computation close to the coast.
- contribute to better evaluate Sea Level Rise near coast

Thank you for your attention

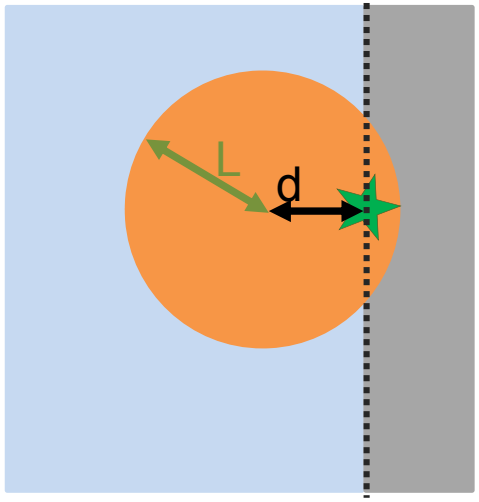
backup

Distance to coast and coastal angle



Conventional altimetry footprint is corrupted by LAND returns

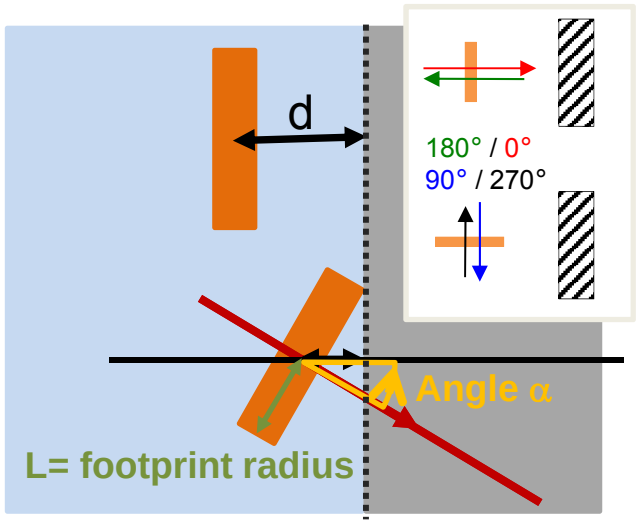
J3 footprint ~ 9.6km
AL footprint ~ 5.7km



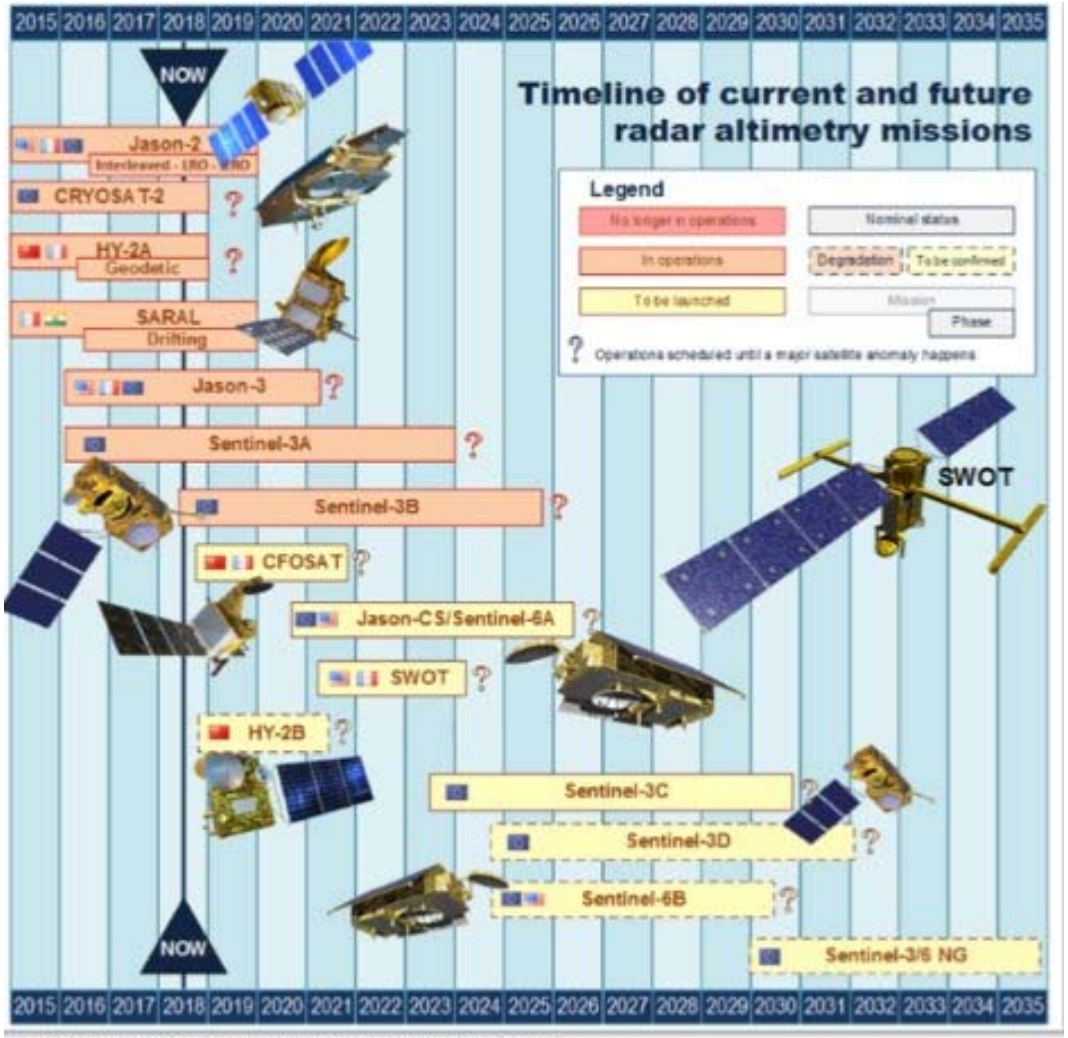
Footprint partly over land for d ≤ L

With an along-track resolution ~300m, SARM waveforms are later impacted by LAND returns

SAR : 320m (at angle 0 and 180)



SAR impacts from d = L * sin (α)



imeline of current and forthcoming radar altimetry missions. Credits CNES.

ABSTRACT

Data quality of altimetry missions is excellent over open ocean, but sea level measurements are tricky difficult to apprehend when approaching coasts. This is partly due to heterogeneous surface reflections within the altimeter footprint (over both ocean and land surfaces), as the altimeter beam illuminates a circle of ocean or land surfaces with a 3 to 10 km radius, depending on the sea state, the wave height or the corrugated land. Radiometers are impacted from 10km (SARAL) to 40km (Jason) to coast. Geophysical corrections' sensibility to shore distance can also impact the computed sea level.

Conventional altimetry (Jason-3 in Ku-band, SARAL in Ka-band) and Delay Doppler Mode (Sentinel-3A SARM) methods are used in altimetry with different footprint and instrumental noise. Thanks to a reduced footprint coupled with a lower instrumental noise, SARAL and Sentinel-3 should provide improved sea level observations over coastal regions compared to Jason-3.
We will focus on how different sources of error () interact during SLA computations for these three missions.
This presentation aims overviewing the performances of different altimetry missions over coastal areas, through the analysis of various data from Sentinel-3A, Jason-3, and SARAL/AltiKa.