



Sentinel-6 Poseidon-4 RMC mode processing and expected performance

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Outline

1. ESA study

- On-board RMC Algorithm
- Error Analysis
- Simulations and results of performance estimation

2. CLS study

- Reconditioning of S3 data
- Analysis and results

3. isardSAT study

- RMC vs. RAW data L1GPP
- Fully focused processing on RAW and RMC data

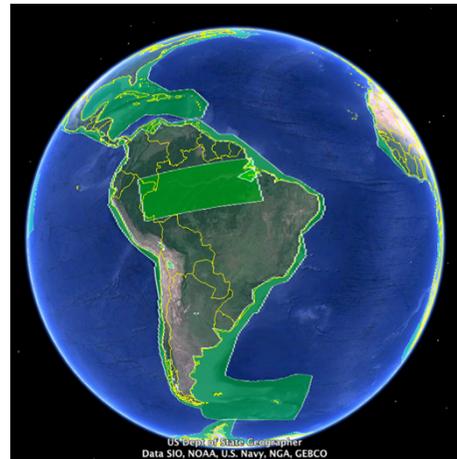
Rational behind on-board RMC processing



- Current default ground station network cannot support operations in SAR RAW mode over open ocean

Radar Altimeter data acquisition data rates

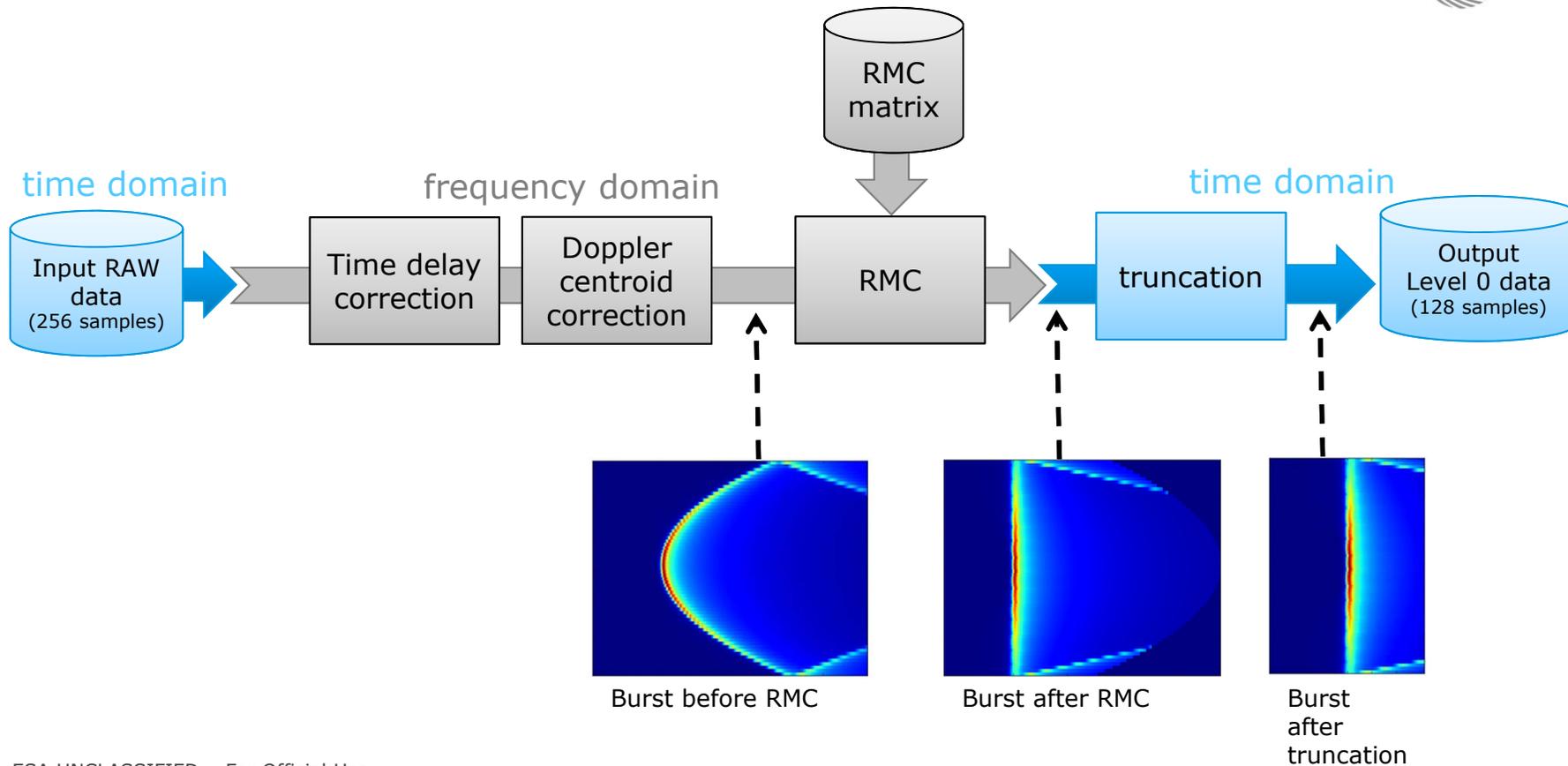
- SAR Ocean (RMC): **19 Mbit/s** (**37.3 Mbit/s** in case of SAR RAW)
- SAR Coastal (SAR RAW): **37.7 Mbit/s**
- LRM always on (100% of the orbital period): **0.18 Mbit/s** (LRM data volume per orbit \sim 1.2 Gb per orbit \rightarrow \sim 9 seconds downlink time)



Actual **mode mask** for coastal and ocean areas (used to calculate the SAR data volume)



On-board RMC algorithm - overview



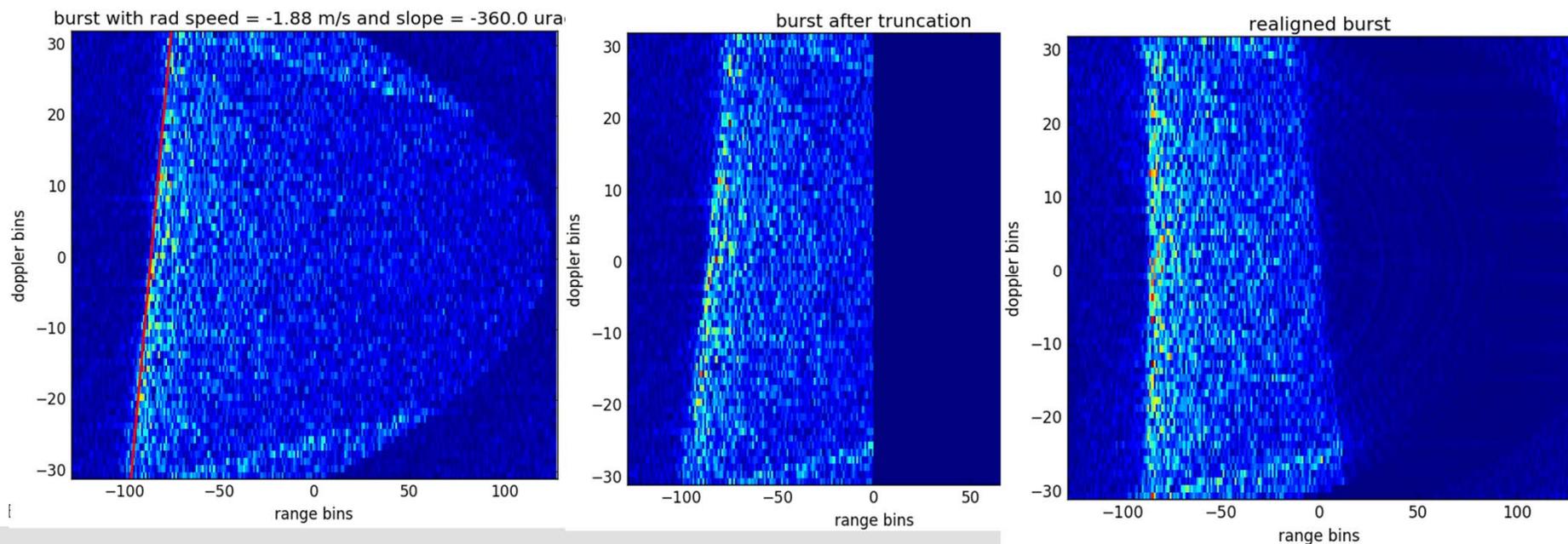
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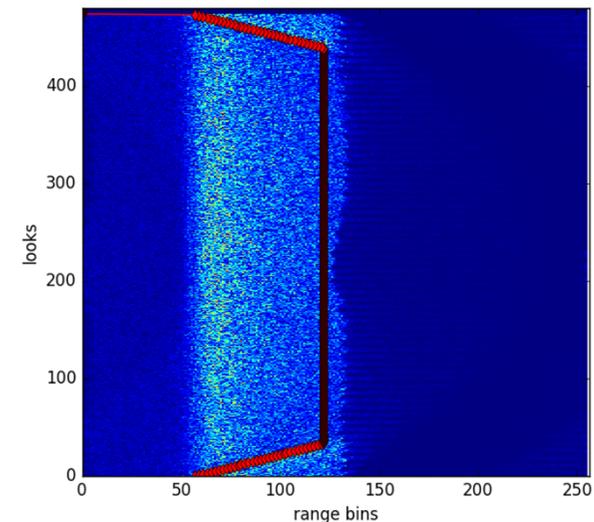
On-board RMC algorithm - Errors in Doppler centroid

- Fixed RMC matrix for mean altitude (1347 km)
- Misalignment in range is corrected on board, residual errors are negligible
- Misalignment in azimuth can lead to errors over sloping surfaces: loss of up to 3 range bins per 100 μ rad of unaccounted surface slope



Simulation scenarios and processing

- Nominal case: 2 m SWH, low altitude rate, flat surface
- Extreme cases:
 1. 1 m SWH at low altitude rate (around 0 m/s) : along track surface slope ($\sim 360 \mu\text{rad}$), across track surface slope ($\sim 360 \mu\text{rad}$)
 2. 8 m SWH at max altitude rate (14.8 m/s) : along track surface slope ($\sim 360 \mu\text{rad}$), across track surface slope ($\sim 360 \mu\text{rad}$)
- **RMC processing reversed on ground**
- SAR processing with zero-padding factor 2
- Adaptive stack mask to radial velocity, does not consider surface slopes

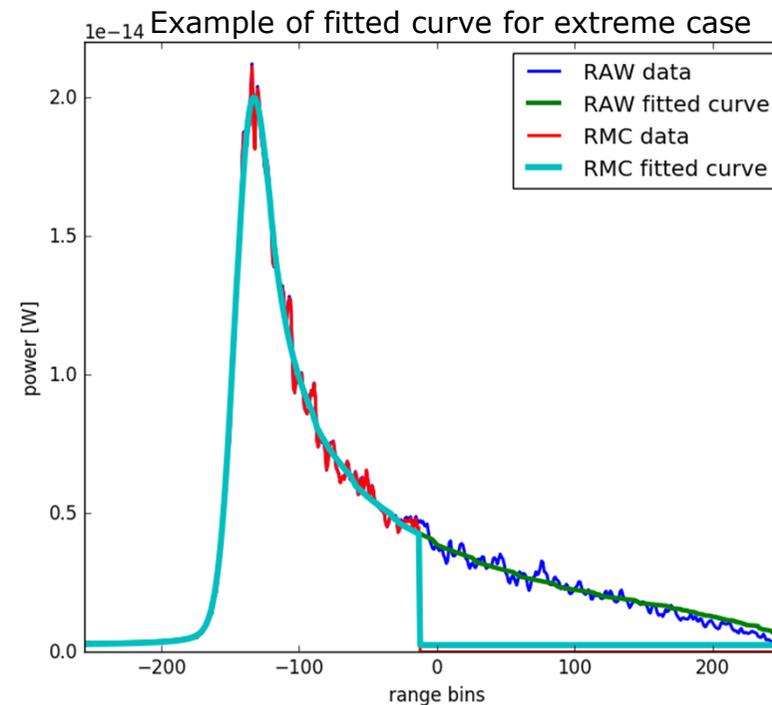


Comparison RAW-RMC

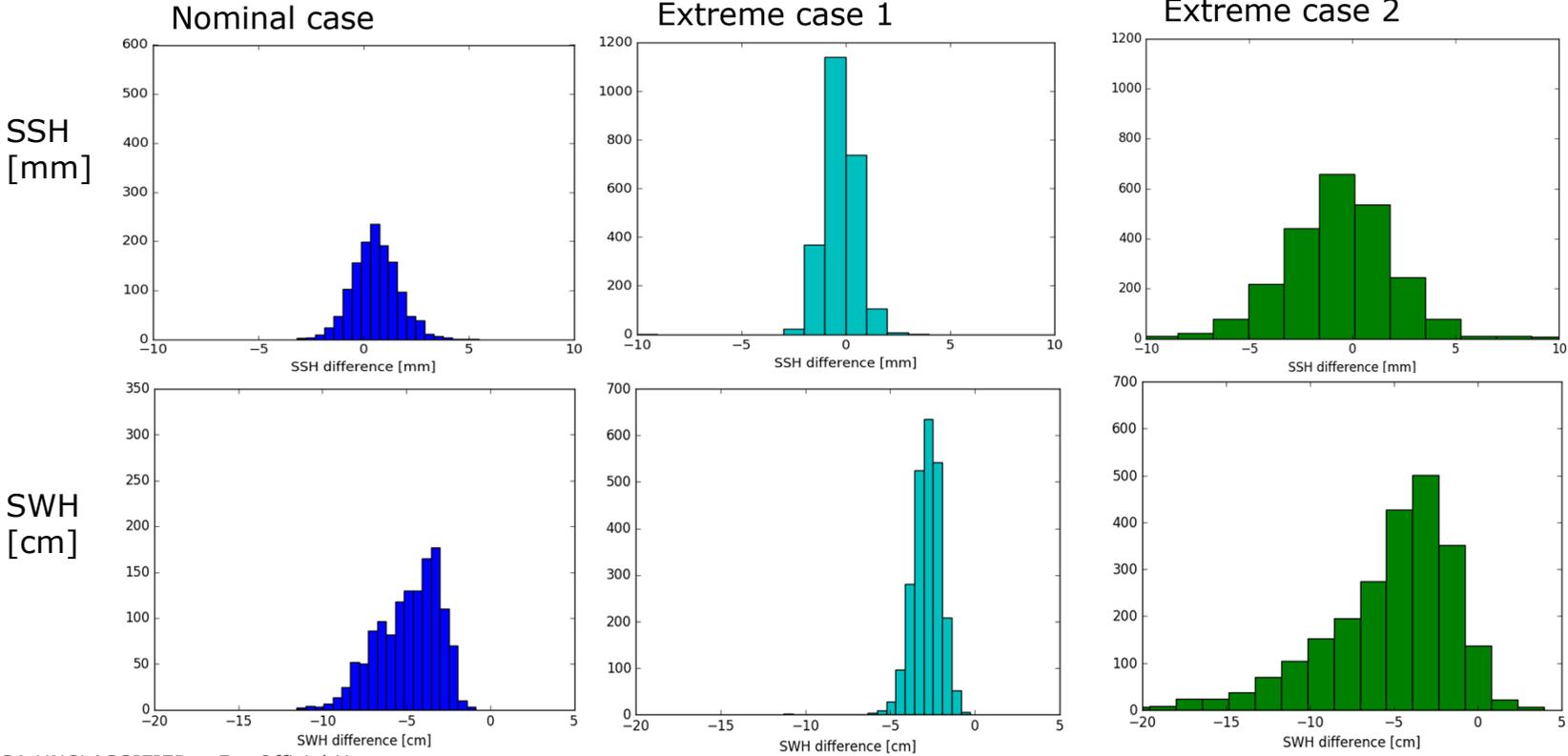
After RMC is reversed on ground:

- Sigma_0 and SSH are nearly identical for RAW and RMC data
- SWH are slightly overestimated for RMC data

		mean	std
Nominal case	SSH	-0.05 cm	0.1 cm
	SWH	-4.8 cm	1.74 cm
	Sig_0	-0.006 dB	0.01 dB
Extreme case	SSH	-0.08 cm	0.26 cm
	SWH	-5.07 cm	3.67 cm
	Sig_0	-0.001 dB	0.01 dB



Performance comparison RAW-RMC over sloping surfaces

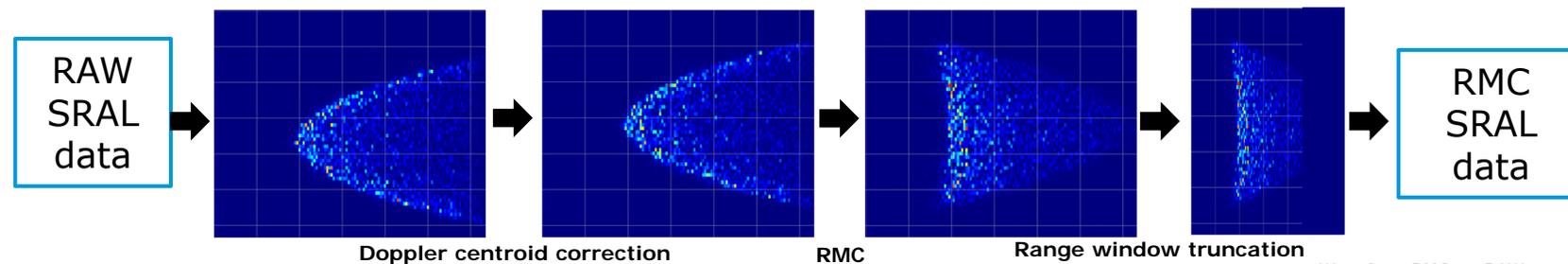


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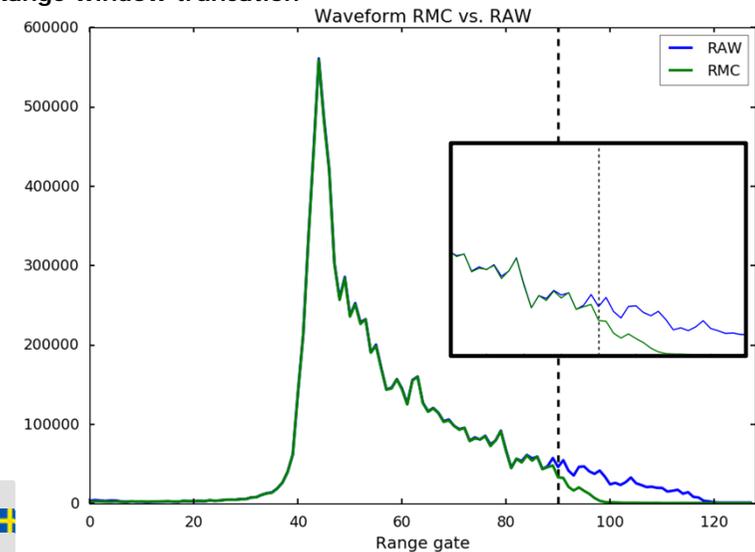
Analysis of on-board RMC processing impact with SRAL data (CLS)



- The on-board RMC algorithm is applied to S3A SRAL raw data : pulses alignment in range, Doppler centroid correction (MOE radial speed + error), Doppler beam forming, RMC (@ $V_s = 7444$ m/s and $H_s = 814,5$ km), range compression, range window truncation at range gate 90.



- Reverse RMC is then applied to RMC SRAL data, and processed with the CNES Sentinel-3 Processing Prototype. Level 2 is adapted to fit only the first 90 bins of the RMC waveform.
- Since the RMC waveform is impacted before range gate 90, the waveform retracking window has been reduced (to range gate 80). **L2 RAW : from bin 12 to 116, L2 RMC : from bin 12 to 80.**
- Typical error on the radial speed measurement by the DIODE instrument is expected to be very low (3 mm/s). Such errors were not found to have any impact on estimated parameters so no radial speed error is considered in the RMC processing.

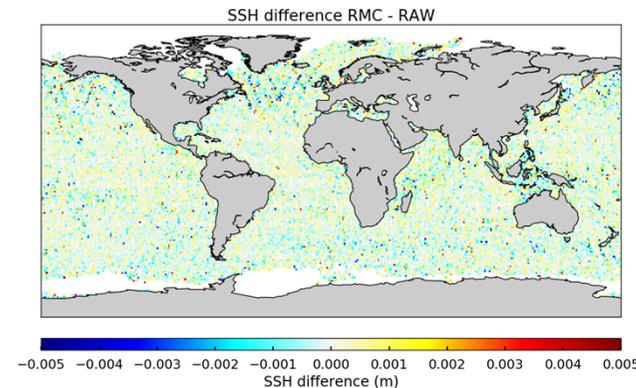
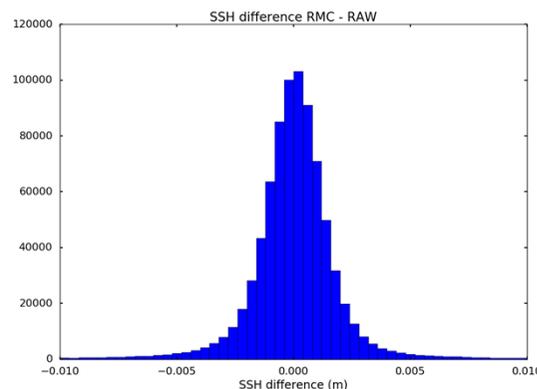


Analysis of on-board RMC processing impact with SRAL data

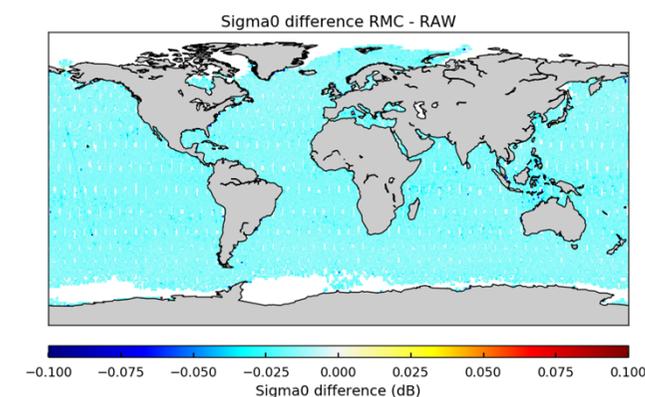
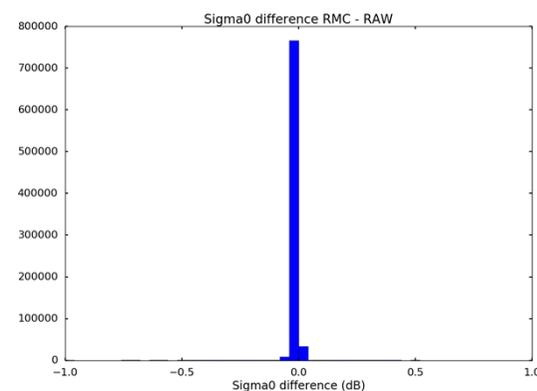


- One month of data (December 2016) have been processed and averaged at 1 Hz.

- SSH difference :
no significant impact
(millimeters)



- Sigma0 difference :
no significant impact
(less than 0.1 dB)



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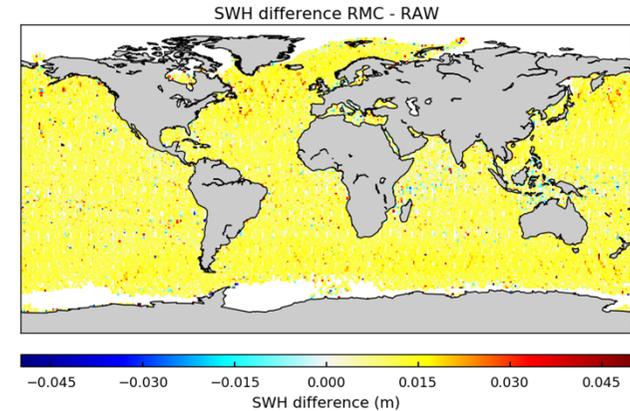
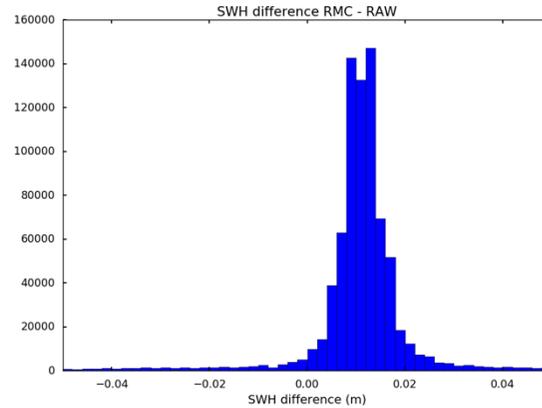


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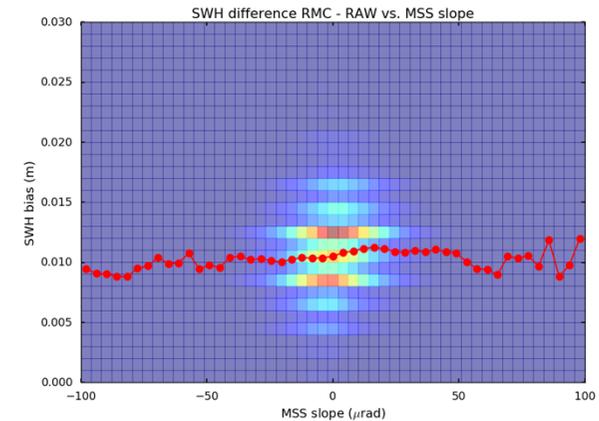
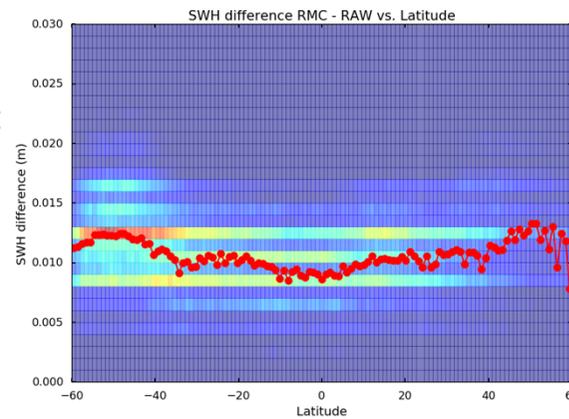
Analysis of on-board RMC processing impact with SRAL data



- SWH difference : very small impact (approximately 1 cm).



- Small dependence on the latitude (RMC matrix ?) but no visible effect of the along-track MSS slope



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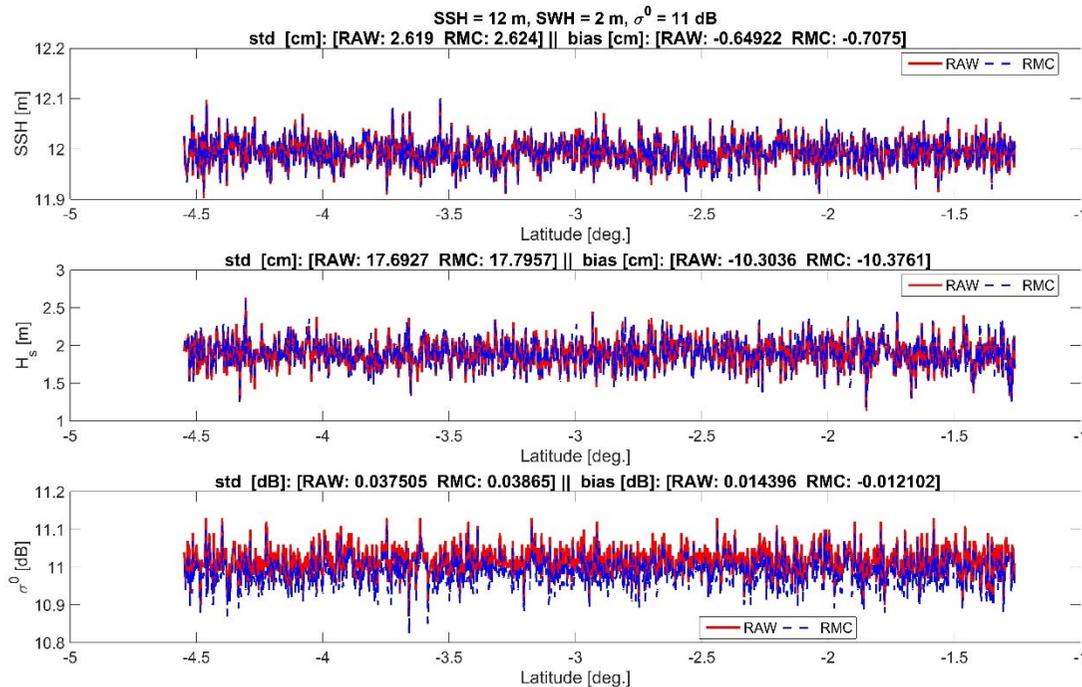


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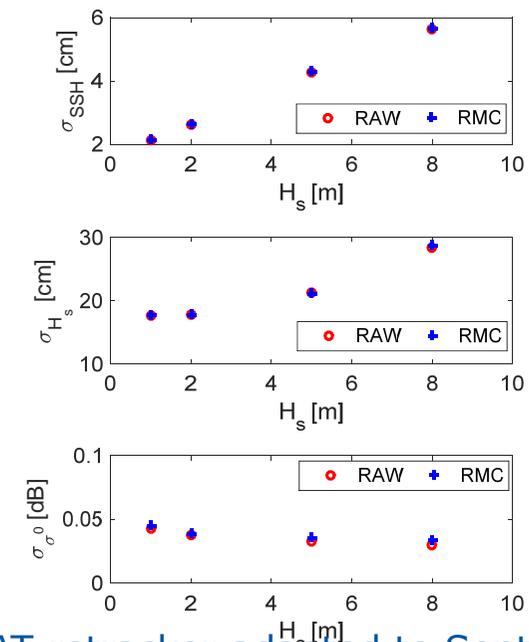
RAW vs RMC: L1 GPP (isardSAT)



Geophysical retrievals for scenario of 2-m SWH



Precision versus SWH
 (ESA/ESTEC simulated scenarios)



- Geophysical retrievals implemented using an in-house isardSAT retracker adapted to Sentinel-6
- Performance of RAW and RMC are almost identical and meet the requirements for L1 GPP

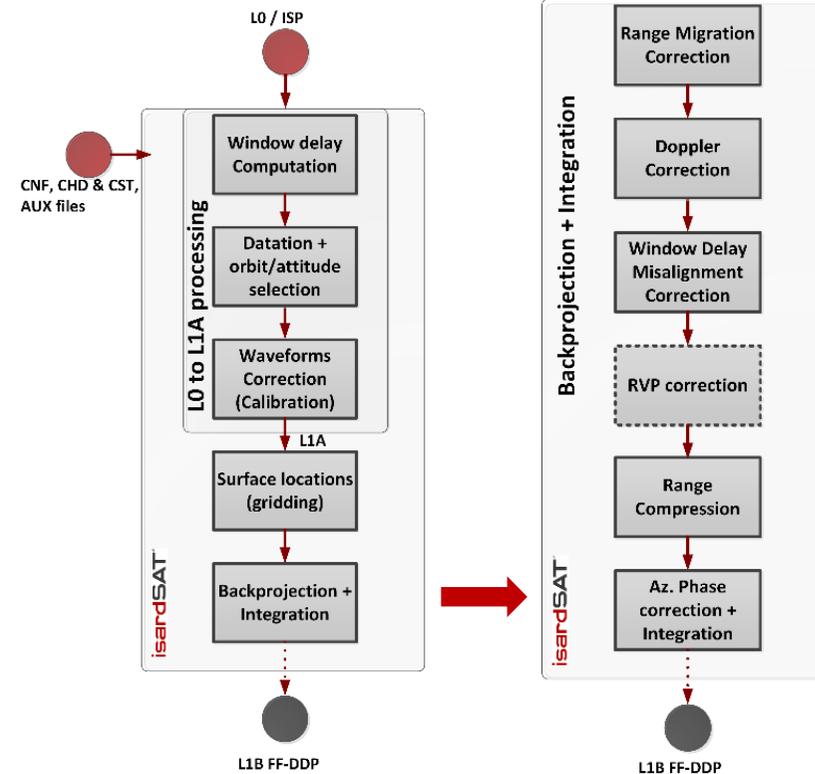
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Fully-Focused DDP: Initial processing chain

- **L0 to L1A processing:** datation, orbit/attitude selection (per pulse) & waveforms correction
- **Surface locations:** output grid where to focus the data
- **Backprojection focusing (per surface):**
 - Time-domain approach suited for any type of acquisition
 - Phase-ramp corrections in frequency domain for Range Migration, Doppler and Window Delay Misalignment corrections



(* residual video phase (RVP) correction to be applied only for instruments with on-board de-ramp

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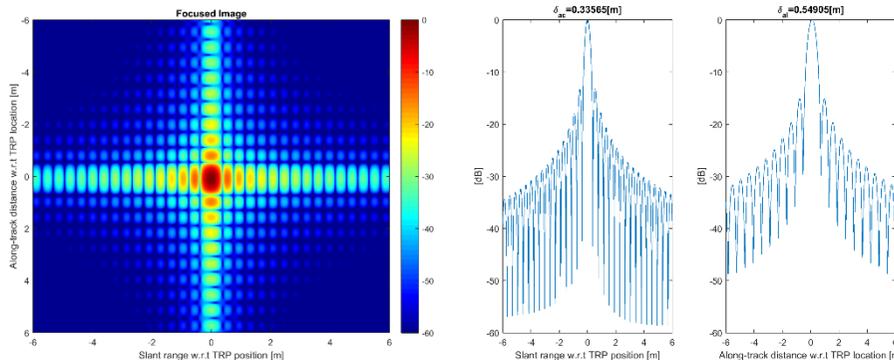


Fully-Focused DDP: Initial results

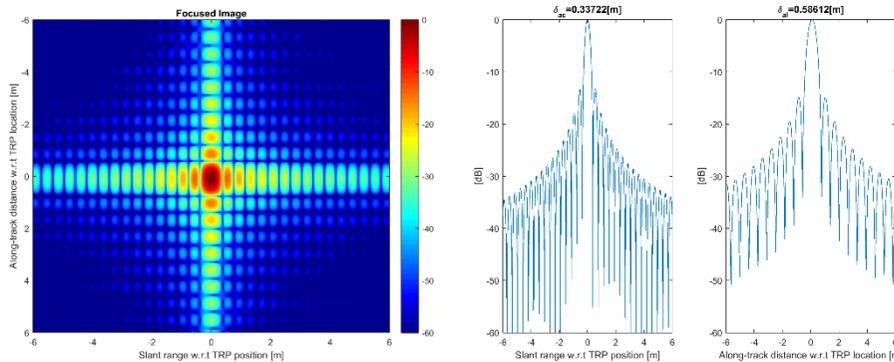
Initial validation with simulated RAW and RMC data over transponder



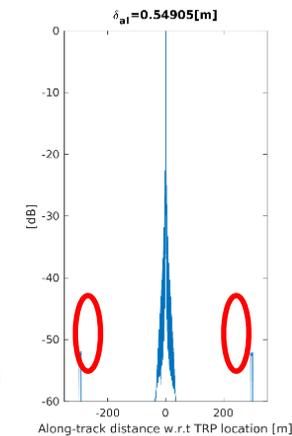
RAW



RMC



- FF-DDP over RMC shows a slight degradation on along-track resolution of only 4 cm: 0,54 m \rightarrow 0,58 m
- First ghost replicas due to CAL and C-band pulses are $\sim \pm 300m$ around TRP location with power 50 dB below TRP level



Results from poster at OSTST 2018: **S6 P4 L1 GPP: Fully Focused Delay-Doppler Processing applied on RAW and RMC data. Preliminary results.**

E. Makhoul, M. Roca, R. Escolà, A. Garcia, G. Moyano, P. Garcia, M. Fornari, M. Kuschnerus, R. Cullen



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Conclusions



1. ESA and isardSAT studies with simulated Sentinel 6 data and CLS study with reconditioned Sentinel 3 data show similar results
2. RMC does not affect the performance of parameter estimation over open ocean significantly
3. RMC can be used to efficiently reduce the data rate over open ocean
4. Initial analysis of fully focused SAR processing show comparable results for simulated RAW and RMC data over transponder

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