Combining Fully Focused and Swath Processing for Glacier applications

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ABSTRACT

High PRF altimeters transmit pulses at a high pulse repetition frequency thus making the received echoes suitable for coherent processing on-ground.

Conventional delay-Doppler processing (DDP, commonly called SAR or High Resolution) coherently integrates echoes in a burst-by-burst basis to provide single look waveforms referred to a specific ground location, which after being correctly aligned (compensating for the slant-range migration, among others) can be incoherently averaged, increasing the performance in terms of the speckle reduction and the along-track resolution compared with the traditional Low Resolution Mode and in turns in terms of geophysical retrieval.

The Fully Focused delay-Doppler processing (FF-DDP, also known as Fully Focused SAR) moves one step ahead and intends to coherently integrate the echoes over a time longer than a burst to get an even higher along-track resolution with an improved speckle reduction with respect to DDP.

The Open Burst (or interleaved) transmission mode to be implemented in Sentinel-6 and the Copenicus polaR Ice and Snow Topography Altimeter (CRISTAL) missions makes more suitable the exploitation of the FF-DDP thanks to the uniform along track sampling of the scene. However, in the conventional Closed Burst mode (like in CryoSat-2), replicas induced by the non-uniform sampling of the Doppler spectrum will be mixed with the main echo and, in most cases, will not be able to be filtered out.

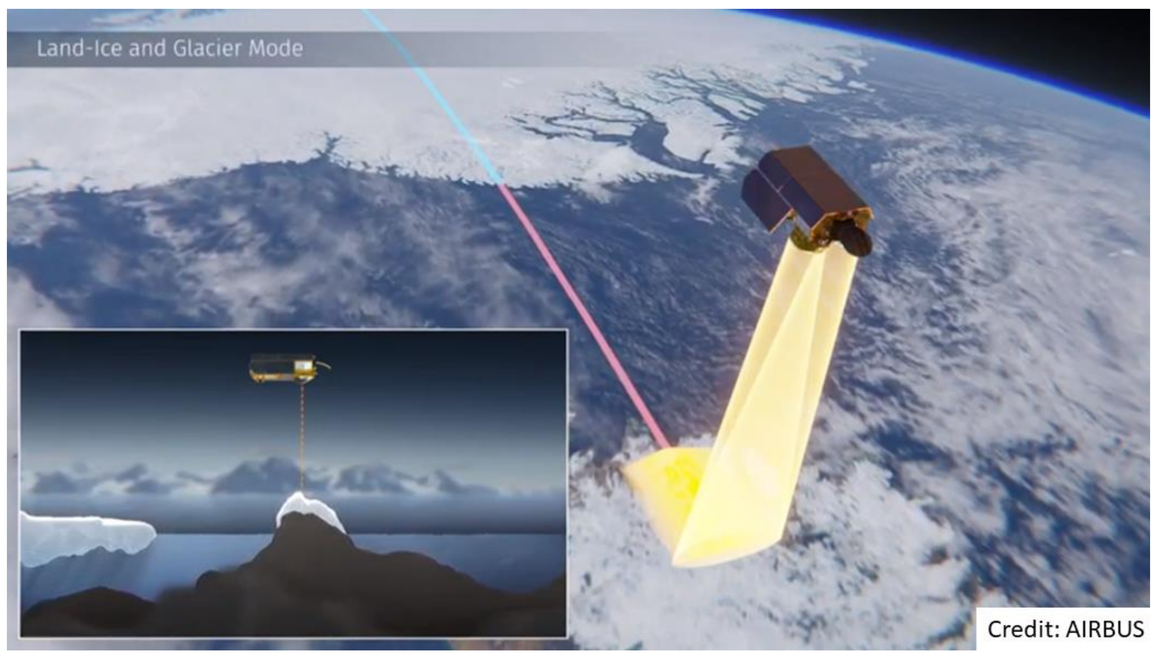
Swath mode processing has been used to monitor elevation of areas with complex topography such as over ice sheet margins, ice caps and mountain glaciers, improving upon the resolution of conventional radar altimetry. Swath mode relies on an accurate angle of arrival of the measured echo, this is obtained from the SAR Interferometric mode of CryoSat-2 and CRISTAL and post-processing strategies resolving the ambiguous nature of the phase measurement.

The CRISTAL Mission will include Open Burst and Interferometric capabilities. It will be the first altimeter to be able to combine both methodologies to increase both the along and across-track resolutions improving the current performances of CryoSat-2 over small glaciers that can't be observed properly.

In this poster we are presenting the first approach of the combined Fully Focussed and Swath development and the preliminary results obtained.

CRISTAL Mission

CRISTAL mission draws from the heritage experience of several in-orbit missions and from the on-going development of the Sentinel-6 and MetOp-SG programmes. It will carry a multi-frequency radar altimeter and microwave radiometer to measure and monitor sea ice thickness and overlying snow depth. It would also measure and monitor changes in the height of ice sheets and glaciers around the world. Measurements of sea-ice thickness would support maritime operations in polar oceans and, in the longer term would help in the planning of activities in the polar regions.



Enhancement	Mission heritage	Applications/Benefits
Optimisation of altimeter modes, continuous operation SAR(In)	Sentinel-6	• Improved performance
Swath processing mode	CryoSat-2	• All applications requiring frequent revisits
Addition of Ka band channel	AltiKa [GPM, OIB and Cryovex campaigns]	• Snow thickness • Improved ice thickness • Coupling ice-atmosphere • Glacier topography • Inland waters (lakes, rivers) • Ionospheric correction
Dual- or tri-band radiometer	MWR (Sentinel-3) AMR-C (Sentinel-6)	• Ocean and coastal altimetry • Sea level rise (global) • Atmospheric correction in NRT products
High resolution multi-frequency radiometer	MHS (MetOp) MWS (MetOp-SG)	• Coastal & inland altimetry • Glacier topography • Sea ice concentration • Snow cover and water content

ALTIMETER SIMULATOR

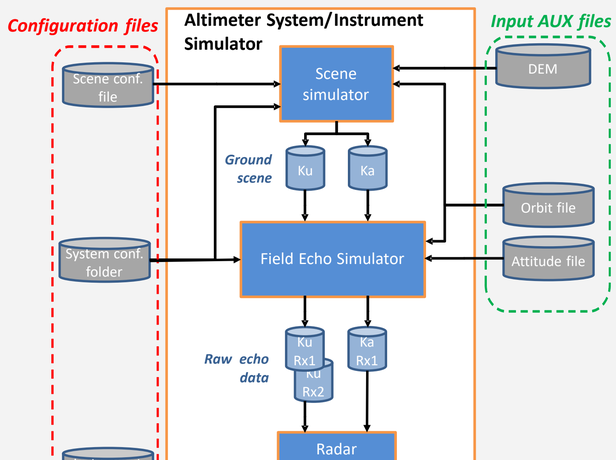
The Altimeter System/Instrument Simulator (SIS) is composed by three modules:

• Scene generator, that generates the ground scene file, that defines the position and the Radar Cross Section of each simulated point target according to selected surface model.

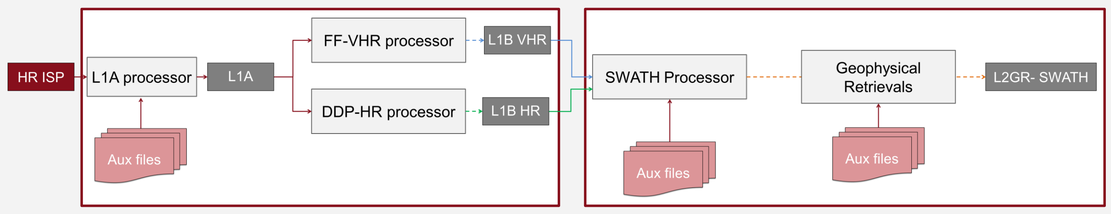
• Field echo simulator, that generates the raw echoes gathered by the instrument according to selected timeline.

• Radar altimeter Simulator is in charge of simulating the Rx instrument chain and writing the ISP according to the selected format.

For this analysis a distributed target with 1.145 degrees of slope has been simulated.



PROCESSOR

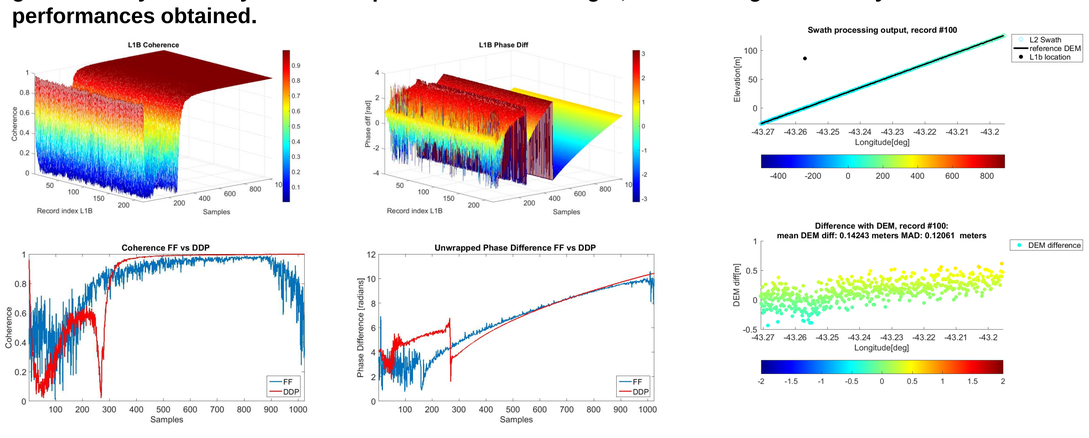


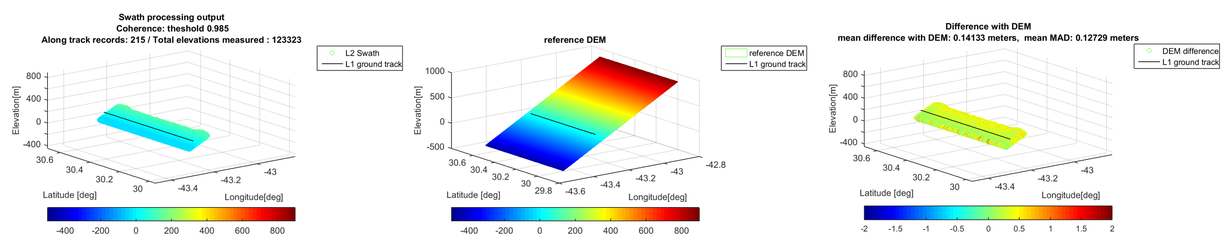
The Ground Processor Prototype for this activity is being developed within the CRISTAL Phase A/B1. It is composed by the following modules:

- L1A processor in charge of performing calibrations in power, phase and range.
- Delay Doppler Processor: it generates multi-looked along track geolocated and fully calibrated waveforms, coherence and interferometric phase difference.
- Fully Focussed Processor: two different versions of the Fully Focussed methods are being exploited: one in time and another in frequency domain. They generate along track geolocated, fully calibrated and fully focussed waveforms, coherence and interferometric phase difference.
- The Swath processor in charge of selecting and geolocating the swath measurements.
- The Geophysical retrieval module in charge of computing the final corrected elevation measurements.

RESULTS

L1B phase difference and coherence from the Delay Doppler processor and the comparison with the ones generated by the Fully Focussed processor. On the right, the swath generated by the DDP + Swath with the performances obtained.





- The combined FULLY FOCUSED + SWATH processing methods has been developed and validated
- The first results comparing the interferometric phase over a sloped distributed simulation from the current DDP and the FF are very promising.
- Further steps will be needed in order to provide an end-to-end validation and understand the improvements and the limitations of the combined methods.