

C11A-0747. Sentinel-3 Performance improvement for Ice sheets

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SUMMARY

- SPICE (Sentinel-3 Performance improvement for Ice sheets) is a 2 year study funded by ESA's SEOM (Scientific Exploitation of Operational Missions) program.
- In preparation for Sentinel-3, the project aims to contribute to the development and evaluation of **novel Synthetic Aperture Radar (SAR)**

Assess and improve **Delay-Doppler altimeter** processing for ice sheets Assess and develop SAR waveform retrackers for ice sheets.



Assess the impact on SAR altimeter measurements of radar wave interaction with the snowpack.

altimetry processing methods over ice sheets.

• SPICE will process full bit rate (FBR) CryoSat-2 SAR acquisitions using existing baselines, generate novel SAR and pseudo-LRM (pLRM) products, and investigate the expected performance of Sentinel-3 prior to operational data availability.



Evaluate the performance of SAR altimetry relative to conventional pulse limited altimetry.

SAR PROCESSING IMPROVEMENT OVER ICE SHEETS

SPICE will develop and test SAR processing algorithms, aiming ultimately to improve Sentinel-3 performance over ice sheets. In **Phase 1**, SPICE will generate baseline solutions, using currently implemented processing approaches. In **Phase 2**, SPICE will investigate novel algorithm developments aimed at improving SAR retrievals of ice sheet elevation.

- **Delay-Doppler Processing (DDP).** SPICE processor developments will include:
 - Accounting for the antenna pattern at the stack level, so as to consider the angle of each Doppler beam.
 - 2. Enabling Doppler beam focussing on particular targets of interest.
 - Cleaning the stacks so that the range bins of Doppler beams with no useful information are removed.
- SAR retracking. In Phase 1, SPICE will investigate the performance of existing retrackers. In Phase 2, SPICE will develop two new SAR retrackers, based on both a new physical and a new empirical model.
- **Pseudo-LRM (pLRM) processing.** SPICE will develop a pLRM processing chain, to assess the feasibility of generating a low resolution product from a closed burst SAR system. If successful, pLRM can facilitate the cross comparison of pulse limited and SAR altimetry, as both higher level products can be generated from the same FBR data.

CONTEXT & STUDY SITES

- Interferometric and SAR altimetry processing techniques were first implemented on an Earth Observing satellite in 2010, when CryoSat-2 was launched. CryoSat-2 SAR acquisitions were, however, primarily limited to sea ice and water surfaces.
- Sentinel-3, which launched early in 2016, now provides operational SAR altimetry over both ice sheets. The SPICE study aims to address the need to evaluate and optimise SAR processing techniques for these environments.
- SPICE will focus on four study sites:
 - The Lake Vostok, Dome C and Spirit sites in Antarctica, where dedicated SAR acquisitions have been made by CryoSat-2.
 - The Russell Glacier in Greenland, where SAR interferometric (SARIn) Full Bit Rate (FBR) data will be used to generate pseudo-SAR measurements.



The location of SPICE study sites in Antarctica (main panel) and Greenland (inset).



SPICE PERFORMANCE EVALUATION

- As part of the SPICE study, we are conducting a high level evaluation of all data products, to assess the ability of SAR and pulse limited altimetry to determine reliable measurements of surface elevation.
- At each study site, reference datasets comprised of airborne (IceBridge) and satellite (ICESat) measurements will be used to assess the SPICE elevation products.
- Intersections between ground tracks are identified (figure right) and elevation differences relative to each reference dataset are computed.
- To date, SPICE baseline datasets at Dome C and Vostok have been analysed. Results (figure below) indicate comparable levels of performance between different operating and processing modes. In particular, the SPICE pLRM solution shows promising results at these low relief study sites.





Surface elevation (m) Intersections between SPICE and IceBridge reference datasets at Dome C.



ndependent evaluation of altimeter elevations at the Dome C and Vostok sites, using airborne (IceBridge) and satellite (ICESat 2009 campaigns) datasets. At each site, SAR, LRM and pLRM elevation measurements have been compared to each of the reference datasets, and the distribution of elevation differences has been calculated.



Top and middle panels. SPICE pLRM and SAR waveforms generated from the same SAR FBR data, for a track crossing Dome C. Bottom panel. SPICE baseline SAR and pLRM elevations for a track crossing Dome C (location shown in inset figure), compared to the range of CryoSat-2 Baseline C LRM solutions. SAR and pLRM profiles are from dedicated SAR acquisitions in 2014. The LRM data are from a near coincident track from the following orbit cycle. All solutions resolve a broadly consistent topography, with offsets of the order of 1 meter due to the different retrackers used.

FUTURE WORK

• SPICE Phase 2.

During Phase 2, we will develop and asses new algorithms, aimed at improving the Delay-Doppler and retracking processing chains. SPICE aims to draw on experiences from other missions (for example Sentinel-6 development) and related fields of research (for example SAMOSA ocean retracking) to contribute to the improvement of SAR altimetry over ice sheets.

• Radar wave interaction with the snowpack.

SPICE will also investigate the impact on SAR altimetry of radar wave interaction with the snowpack. Firstly, the effect of backscattering anisotropy will be assessed by comparing measurements acquired from different viewing directions. Secondly, a comparison between CryoSat-2 Ku-band and SARAL Ka-band measurements will be used to investigate radar wave penetration into the snowpack.

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