EGU2017-3529. SPICE: Sentinel-3 Performance improvement for Ice sheets

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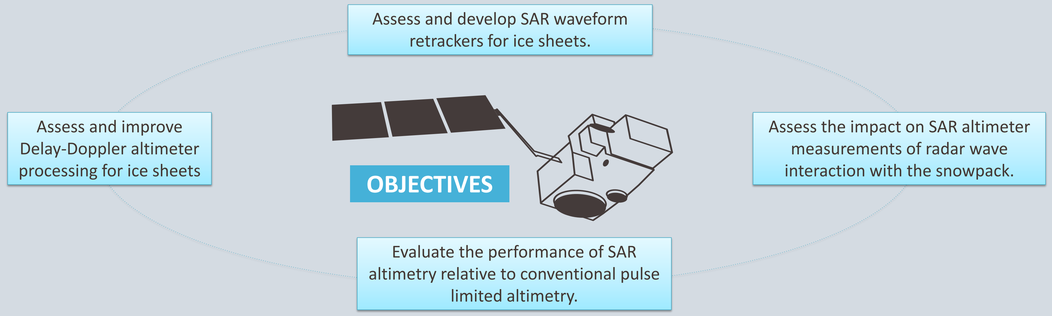
SUMMARY

- SPICE (Sentinel-3 Performance improvement for Ice sheets) is a 2 year study funded by ESA's SEOM (Scientific Exploitation of Operational Missions) program.
- The project aims to develop and evaluate **novel Synthetic Aperture Radar (SAR) altimetry processing methods over ice sheets**, to contribute to the future exploitation of Sentinel-3.
- SPICE is processing full bit rate (FBR) CryoSat-2 SAR acquisitions using existing baselines and also generating novel SAR and pseudo-LRM (pLRM) products, with a view to investigating and improving the performance of Sentinel-3 over ice sheets.
- SPICE Phase 1 data is now available to the community, and can be requested by contacting us via our website, www.seom-spice.org.



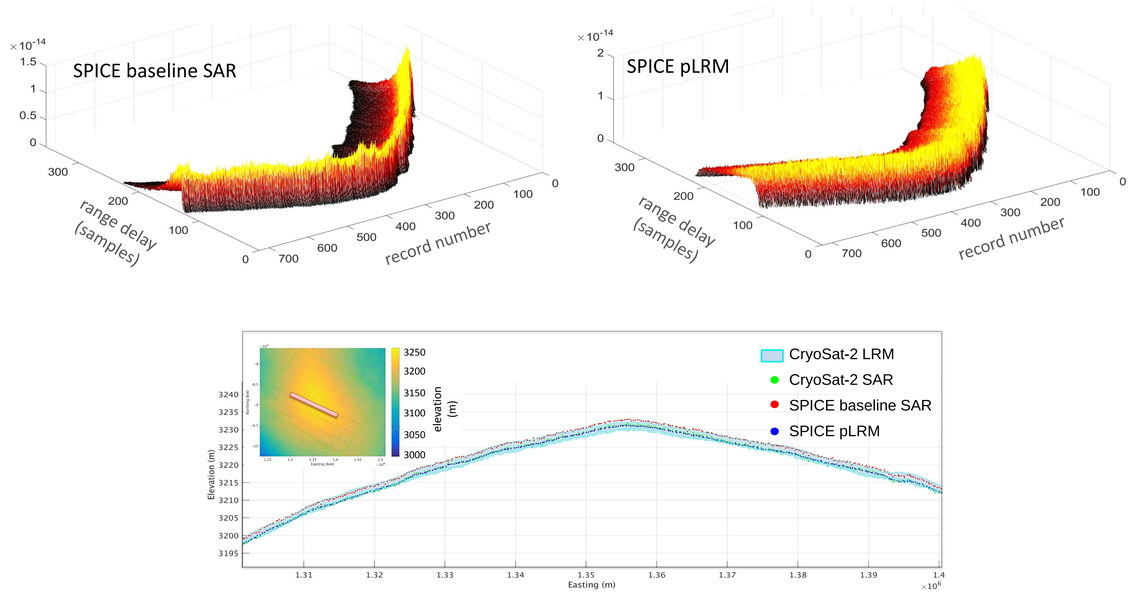
SAR PROCESSING IMPROVEMENT OVER ICE SHEETS

The SPICE project is developing and testing SAR processing algorithms, aiming ultimately to contribute to improved Sentinel-3 performance over ice sheets.

In **Phase 1**, SPICE has generated and evaluated 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.

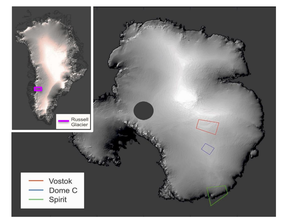
- **Delay-Doppler Processing (DDP).** SPICE processor developments will include:
  1. Accounting for the antenna pattern at the stack level, so as to consider the angle of each Doppler beam.
  2. Enabling Doppler beam focussing on particular targets of interest.
  3. Cleaning the stacks so that the range bins of Doppler beams with no useful information are removed.
- **SAR retracking.** In Phase 1, SPICE has implemented and evaluated the performance of existing retrackers. In Phase 2, we will then build upon these experiences to investigate new approaches to SAR retracking.
- **Pseudo-LRM (pLRM) processing.** SPICE has developed a pLRM processing chain, to assess the feasibility of generating a low resolution product from a closed burst SAR system. 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.



Top panels. SPICE SAR and pLRM 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.

CONTEXT & STUDY SITES

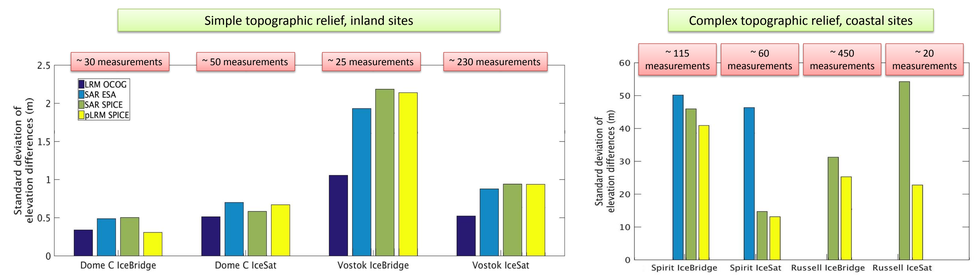
- Interferometric and SAR altimetry processing techniques were first implemented on an Earth Observing satellite in 2010, when CryoSat-2 was launched. CryoSat-2 operational non-interferometric SAR acquisitions were, however, primarily limited to sea ice and water surfaces.
- Sentinel-3, which launched 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 SPICE, we are conducting a high level evaluation of all data products, to assess their ability to determine reliable measurements of surface elevation.
- At each study site, co-located measurements from airborne (IceBridge) and satellite (ICESat) reference datasets are used to assess the SPICE elevation products.
- To date, Phase 1 datasets, which utilise existing processing methods, have been analysed at all study sites. Results (figure below) indicate standard deviations from reference datasets of ~ 0.3-2.2 metres at inland sites, rising to ~ 15-50 metres at more complex coastal sites, where multi-peak waveforms make retracking more challenging. In Phase 2 we aim to develop new processing approaches, which further improve upon these statistics. The exploratory SPICE pLRM processing shows promising results at all study sites.



Independent evaluation of altimeter elevations at the SPICE study sites, using airborne (IceBridge) and satellite (ICESat 2009 campaigns) datasets. At each site, the available datasets have been compared to co-located reference measurements, and the distribution of elevation differences has been calculated. Here we show the standard deviations of the differences between the SPICE and reference datasets.

FUTURE WORK

- **SPICE Phase 2**
  During Phase 2, we will develop and assess 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 ocean retrackers) to develop SAR altimetry processing methods 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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