C13B-1153. SPICE: Sentinel-3 Performance improvement for Ice sheets



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SUMMARY

- penetration through comparisons of Ku- and Ka-band satellite measurements.
- investigating and improving the performance of Sentinel-3 over ice sheets.

CONTEXT & STUDY SITES

- Since 2010, CryoSat-2 Interferometric SAR altimetry has provided detailed measurements of ice sheet change.
- Non-interferometric SAR acquisitions have, however, been primarily limited to sea ice and water surfaces.
- In preparation for Sentinel-3, which is a global SAR mission, several dedicated SAR campaigns have been made by CryoSat-2 over East Antarctica.
- The SPICE study is using this unique dataset to evaluate and develop SAR processing techniques for ice sheet surfaces.
- SPICE is also assessing the impact of Ku-band penetration on SAR altimeter measurements, through comparison to Kaand Ku-band LRM data.
- SPICE has focused 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 has been used to generate pseudo-SAR measurements.

RADAR WAVE INTERACTION WITH THE SNOWPACK

- To evaluate the impact of volume scattering on waveform shape across different modes and frequencies bands, mean ocean and ice sheet waveforms were compared.
- To minimise the impact of ice sheet surface topography on the detected echo, waveforms from the flat surface above Lake Vostok were used.
- The AltiKa Ka-band LRM data show some sensitivity to volume scattering, but the oceanic and ice sheet leading edges have similar shapes.
- The CryoSat-2 Ku-band SAR and pLRM waveforms are modified more by volume scattering.
 - The Ku pLRM leading edge is affected from around mid-power. Ο
 - The Ku SAR leading edge is not impacted, but the effect can be seen in the trailing edge.

[Left panel] CryoSat-2 SAR tracks across the smooth Lake Vostok site, East Antarctica. [Right panels] Comparison of ocean (dashed lines) and ice sheet (solid lines) waveforms acquired at different frequencies and in different operating modes. The plotted waveforms are 4 second averages.

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• 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, and investigate radar wave

• Dedicated Full Bit Rate CryoSat-2 SAR acquisitions over several ice sheet sites have been processed using both existing and novel methodologies, with a view to



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











SAR ALTIMETRY PROCESSING IMPROVEMENT OVER ICE SHEETS

- The SPICE study has developed and tested new SAR altimetry processing algorithms, with a view to ultimately improving Sentinel-3 performance over ice sheets.
- One of the primary objectives has been to develop novel approaches to SAR retracking.
- This activity aims to improve non-interferometric elevation retrievals across ice margin regions, where rugged topography produces complex waveforms and complicates conventional retracking approaches.
- We have developed two approaches that are designed to improve retrievals for complex, multiple peak waveforms, where reflections are received from several distinct surfaces:
 - o In the first approach an auxiliary Digital Elevation Model is used to select a consistent peak (i.e. target within the beam footprint) to retrack. By choosing to identify peaks corresponding to the nadir echo, we also eliminate the need to apply a slope correction (i.e. echoing point relocation), as is the case with conventional Level-2 processing.
 - In the second approach, batch processing of waveform sequences is used to maintain along-track consistency in the choice of peak selection. This is designed to increase the along-track stability of the retracking algorithm in the presence of multi-peaked waveforms, by using the epoch history to avoid switching between different peaks in the echo.



Comparison of elevation profiles derived with and without Batch processing, for a SAR track crossing the Spirit study site. In both cases, waveforms are retracked using a Threshold Peak Retracker (TPR). The Batch processing (green) eliminates several discontinuities and jumps that are evident in the standard processing (blue), due to its capacity to track a consistent waveform peak over successive records. Note that elevations shown here are computed as altitude – range + geophysical corrections, and so are not fully corrected for surface topography.

• Assess accuracy of Sentinel-3 elevation & elevation change at SPICE

• Integrate waveform pre-retracking modules & apply to Sentinel-3 data.

• Investigate refinements to analytical retracker for ice sheet surfaces.







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