EGU23-9347, updated on 01 Dec 2023
https://doi.org/10.5194/egusphere-egu23-9347
EGU General Assembly 2023

Assessment of Sentinel-3 Altimeter Performance over Antarctica

Joe Phillips and Mal McMillan
Lancaster University, Lancaster Environment Center, United Kingdom of Great Britain – England, Scotland, Wales
(j.phillips5@lancaster.ac.uk)

Although much progress has been made into satellite-based observations of Antarctic ice sheet (AIS) change in recent decades, to further reduce remaining uncertainties in existing methodologies, we need to better understand limitations in source data quality. Whilst a range of techniques exist for remote observation of the cryosphere, our understanding of ice sheet change is largely informed by satellite observations, with the longest continuous record coming from satellite radar altimetry. This technique derives information relating to the topographic and electromagnetic scattering characteristics of the ice surface, by emitting radar pulses and recording the timing and shape of the backscattered echoes.

Launched in 2016, the Copernicus Sentinel-3 (S3) mission is the most recent in a 25-year long series of satellite altimetry missions, comprised of twin satellites dedicated to water surface topography, temperature and optical radiometry over land and ocean. S3 carries a Ku-band synthetic aperture radar altimeter (SRAL), which utilises delay-doppler processing to generate high-resolution (~300 m) along-track measurements every 27 days, thereby maximising information retrieval over more variable terrain surfaces that are challenging for conventional pulse limited altimeter systems. Whilst S3 provides high accuracy and sub-decimetre precision over oceans and uniform terrain, performance over more complex topography is challenging, with waveforms strongly diverging from their theoretical shape, as well as difficulties in capturing returns and successfully locating the true echoing point within the satellite beam footprint. As these issues significantly complicate the reliable retrieval of surface elevation information, handling them is one of the major challenges associated with processing altimetry data over regions of high-interest, complex topography, such as the Antarctic peninsula, outlet glacier interiors, and coastal ice sheet regions. These concerns are further exacerbated by the fact that S3 has a much smaller range window than other missions (such as Cryosat-2) due its primary use in oceanography.

Several validation studies have already been performed for S3 in the context of the cryosphere, including cyclical and annual reports by the Sentinel-3 Mission Performance Centre. Whilst these studies predominantly concentrate on measured elevation accuracy and precision, they do not always perform investigations into lower-level performance, and hence a comprehensive understanding of the origin of measurement variability. Here we therefore investigate S3 performance in more depth using REMA (Reference Elevation Model of Antarctica), a widely used, high-resolution digital elevation model that covers almost all of Antarctica. Specifically, we investigate three components of performance, (1) echo capture within the L1b range window, (2) variations in the assumed echoing point, and (3) waveform correlation along-track. By comparing this information to ice sheet-wide REMA-derived surface slope and roughness statistics, we can assess the impact of ice sheet surface topography on S3 performance, at scale. By doing so, we hope to ultimately improve our understanding of S3 performance over ice sheets and provide insight useful for the design of future missions such as CRISTAL.