# Sentinel-3 Surface Topography Mission
## *New Land Ice thematic products*

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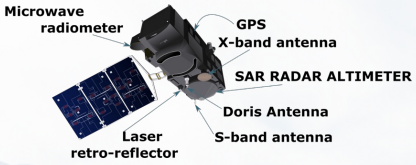
## Overview of Sentinel-3 Surface Topography Mission (STM)

### Sentinel-3 is an Earth observation satellite series developed by ESA as part of the Copernicus Programme

- **The current constellation includes Sentinel-3A and Sentinel-3B**, launched respectively on February 2016 and April 2018. **Sentinel-3C and Sentinel-3D will follow** (respectively planned for ~2025 and 2027)
- Sentinel-3 carries SRAL, **the first radar altimeter operating exclusively in SAR mode over all surfaces,** to provide topography measurements of Earth surfaces at high resolution (~300 m in along-track)



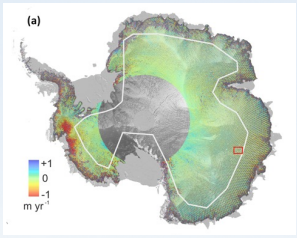

**Orbit characteristics**

*Altitude: 814.5 km*
*Orbit cycle: 27 days*
*Inclination: 98.65°*

### Land ice monitoring

For Land ice, the main objective of the Sentinel-3 constellation is to provide accurate measurements of the polar ice sheets' topography, to support ice sheet mass balance studies.

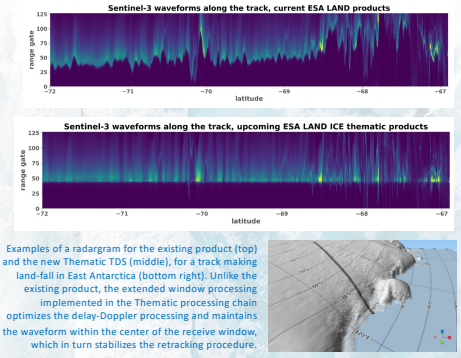
- Every orbit cycle, about **3.4 million and 500,000 elevation estimates** are provided by ESA in the LAND level-2 products, respectively **over the Antarctic and Greenland ice sheets** (for each Sentinel-3 satellite).
- Data are available on open access in the Copernicus Data Hub.




Rates of Antarctic surface elevation change derived from Sentinel-3A acquisitions (McMillan et al., 2019).

## Sentinel-3 LAND MPC, and new Land Ice thematic products

- **The Sentinel-3 LAND Mission Performance Cluster (MPC) is tasked by ESA to monitor the health of the Copernicus Sentinel-3 SRAL and MWR sensors, and ensure a high data quality of LAND level-2 products to users.** At the end of 2021, a new MPC consortium has been built with recognized experts spanning the different thematic areas covered by the mission.
- **ESA, together with the past and present MPC's, are developing dedicated and specialized delay-Doppler and Level-2 processing chains over Hydrology, Sea-Ice, and Land Ice,** to generate dedicated thematic products with enhanced performances (Level-2 products).
- **Compared to current LAND products, the new Land Ice thematic products are now generated with the "extended-window processing"** to optimize the generation of SAR waveforms over steeply sloping surfaces. The approach used to relocate the measurements to the Point Of Closest Approach (POCA) has also been improved.




Examples of a radargram for the existing product (top) and the new Thematic TDS (middle), for a track making land-fall in East Antarctica (bottom right). Unlike the existing product, the extended window processing implemented in the Thematic processing chain optimizes the delay-Doppler processing and maintains the waveform within the center of the receive window, which in turn stabilizes the retracking procedure.

## Preliminary assessments of Land Ice thematic products

A Test Data Set (TDS) of the new Land Ice thematic products is available for S3A cycle 54 coving 15th Jan. to 11th Feb 2020.

### Measurement Quantity – Additional Data Recovery

- The extent to which additional useable data was recovered by the new TDS processing was assessed by computing the change in the proportion of invalid or poor-quality data within 50x50 km grid cells.
- Data were defined as invalid or poor quality where (1) the onboard tracker lost lock, (2) Sigma-0 was below -12 dB, or (3) the waveform quality flag was set within the product.

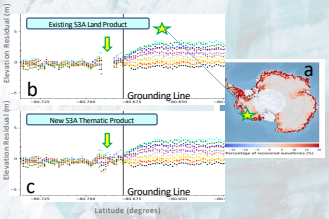
### Greenland cross-overs

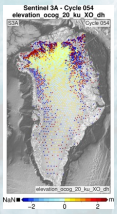
- Evaluate the accuracy of the existing S3 land product and the new thematic TDS from the orbital crossing and the elevation difference over Greenland (dh).
- Both the median difference, standard deviation, and observation below 1 meter are improved.
- This is due to the better retrieval of sloping area in the new TDS

### Measurement Quality – Comparison to ICESat-2

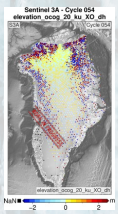
- The accuracy of the existing S3 land product and the new thematic TDS was evaluated by computing differences in elevation between co-located (within 50 m and 46 days) S3A and ICESat-2 measurements.
- Elevation differences were binned as a function of surface slope, and the spread (Median Absolute Deviation from the median) within each bin was used to characterize measurement precision.
- This analysis indicates the superior performance of the TDS, especially in high-slope regions where the topography is more complex.

(a) The percentage of additional records retrieved by the new TDS over Antarctica, relative to the existing S3A Land product, showing the improvement in coverage due to the extended window processing, especially around the coastal margin where topography is more complex. (b) and (c) Examples of data coverage of repeated cycles from the existing product (b) and the TDS (c) close to the grounding line of the Filchner-Ronne Ice Shelf, illustrating the additional data retrieved (yellow arrow) within this glaciologically important region.



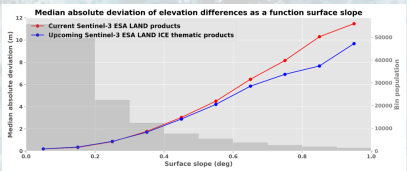




Left: Crossings in the NTC product, and to the right crossings in the TDS (missing point in the southwest due to missing ionosphere correction in TDS).




| | NTC | TDS |
|---|---|---|
| # of Obs. | 68000 | 6004 |
| Median | 2.7 cm | 0.6 cm |
| Standard deviation | 116.82 m | 81.37 |
| Observations dh < 1 m | 43 % | 52 % |

The Median Absolute Difference of Sentinel-3A – ICESat-2 elevation differences over Antarctica, as a function of surface slope, for the current Sentinel-3 LAND product (red) and the new Thematic TDS (blue). The dark grey bars indicate the number of co-located measurements within each slope bin.




Information about TDS data access is available in Sentinel Online: https://sentinels.copernicus.eu

## Conclusions & Perspectives

- With new dedicated Level-2 processing chains, the Sentinel-3 Land Ice thematic products will evolve and improve more efficiently over time. The next main goals are **implementing the TFMRA retracker** and **improving the relocation** processing.
- The operational deployment of the new Sentinel-3 thematic products is planned for **Q2 2023**, in parallel with the current operational Sentinel-3 STM LAND processing. Additionally, **a mission reprocessing of S3A and S3B Thematic products will start in Q4 2022**.
- Sentinel-3 Sea Ice and Hydrology thematic products will be also available (**see dedicated OSTST posters**).