COMPARISON OF SENTINEL-3 ALTIMETRY WITH IN SITU MEASUREMENTS OF SEA LEVEL IN THE NORTHERN ADRIATIC: CASE-STUDY OF GRADO-MARANO LAGOON

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HYDROCOASTAL

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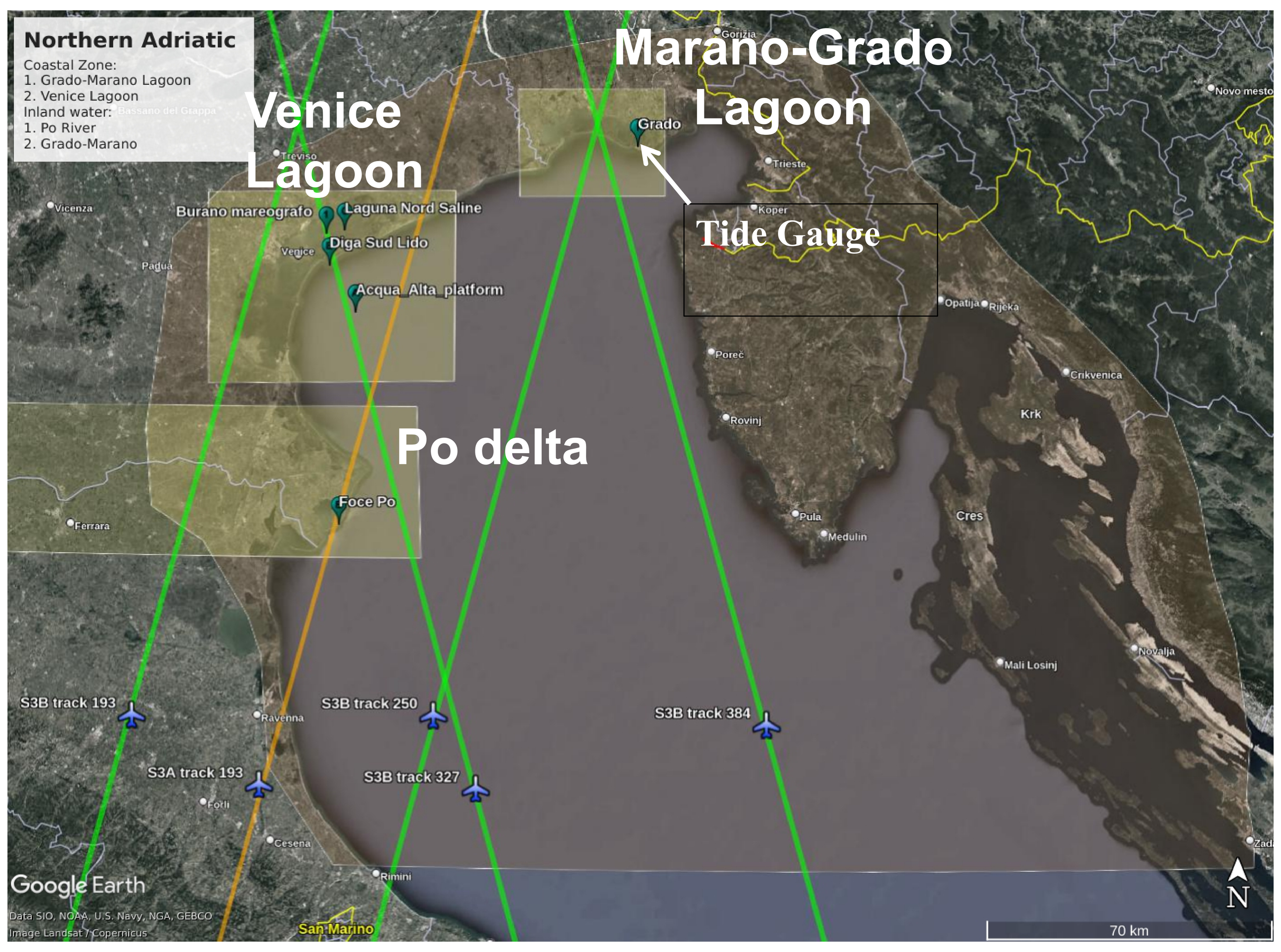
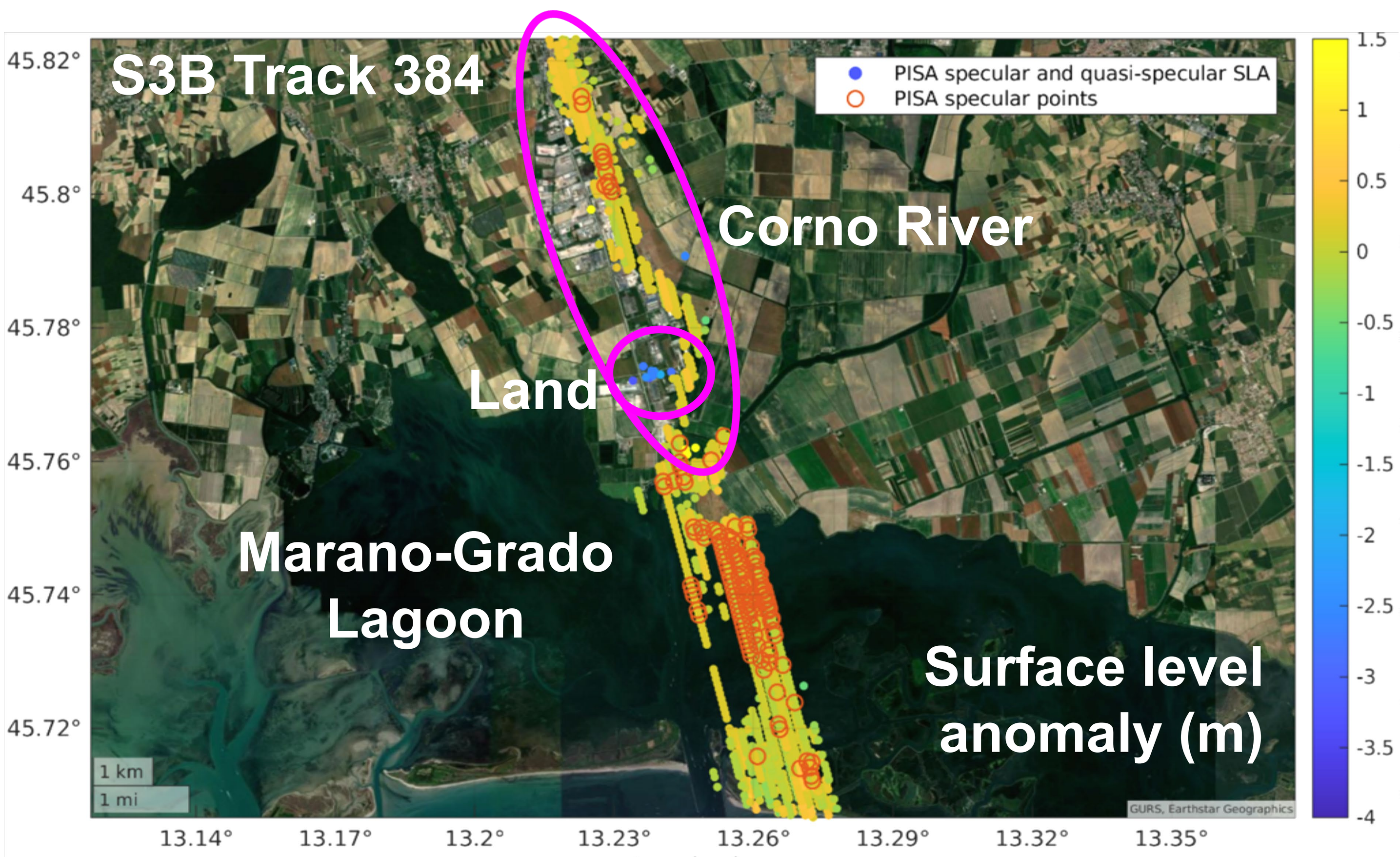
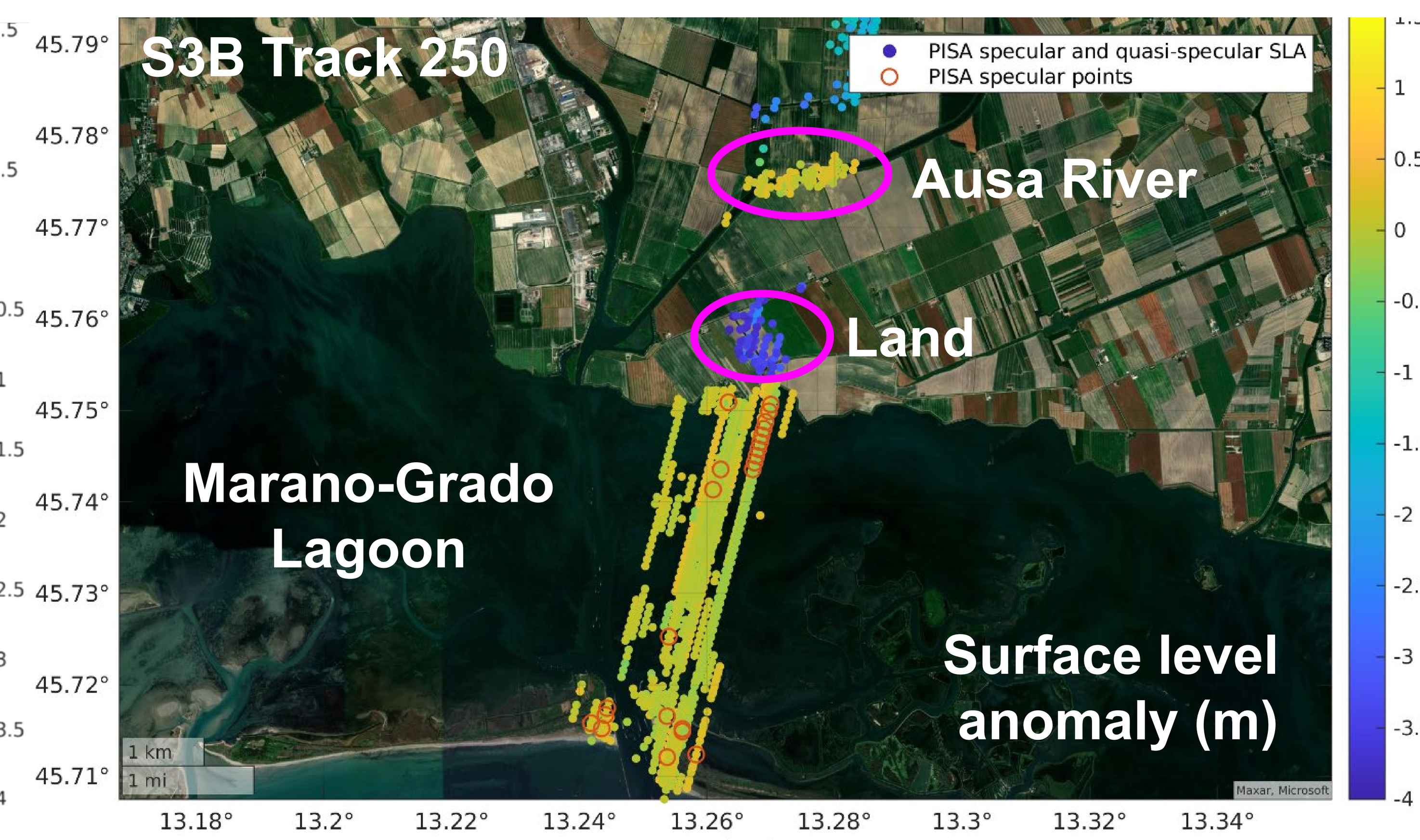


Motivations

Coastal lagoons are shallow transition zones characterized by intertidal marshes and slow water flow. **Around 32,000 lagoons (Carter et al., 1996) are identified along 13% of the world's coastline (Barnes, 1980).** They are vulnerable to changes of the water surface level, due to storm surges and climate in combination with anthropogenic causes. Because of sparse in situ measurements, especially in developing countries, the usage of satellite radar and lidar altimetry is currently the only option to monitor those changes. A prominent role is taken by the ongoing **HYDROCOASTAL project** funded by the European Space Agency (ESA), which aims at generating a global satellite altimetry data set for exploitation in rivers, estuaries, lagoons, deltas and coastlines. **The northern Adriatic Sea is a laboratory where to study the continuum from land to sea**. Several important inland water basins are found in the coastal zone: the lagoons of Venice and Grado-Marano, and the Po River with its delta. These areas rest in a fragile balance subjected to physical, geological, and biological processes: sea level rise, storm surges, shoreline erosion, subsidence, eustatism, habitat variability, ecosystem dynamics. **In this work, we start examining the Sentinel-3 radar altimetry dataset using the state-of-the-art products over the Grado-Marano lagoon during 2019-2021.** We use independent observations from the ICESat-2 lidar and from the Grado tide gauge to support the interpretation of the results.

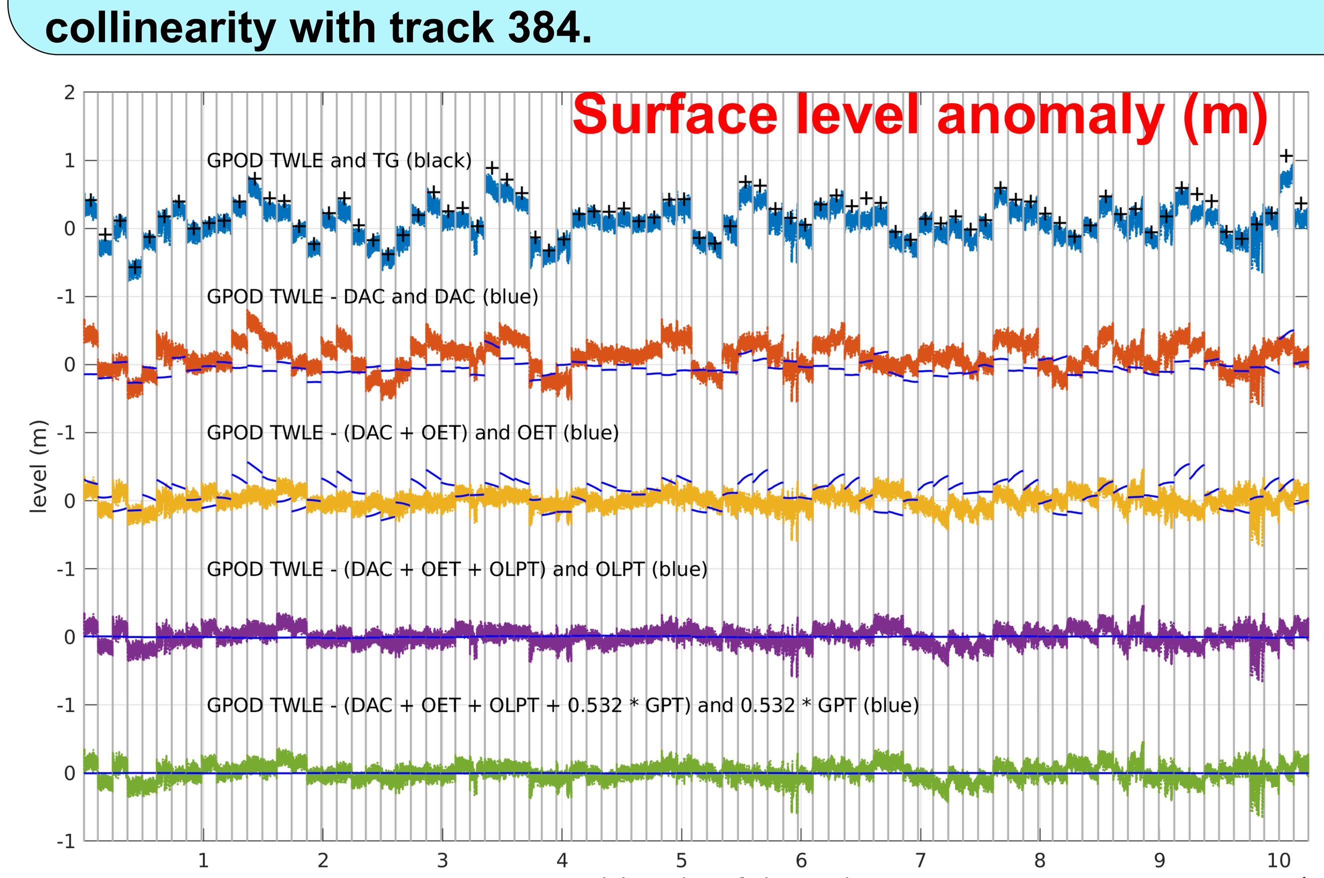




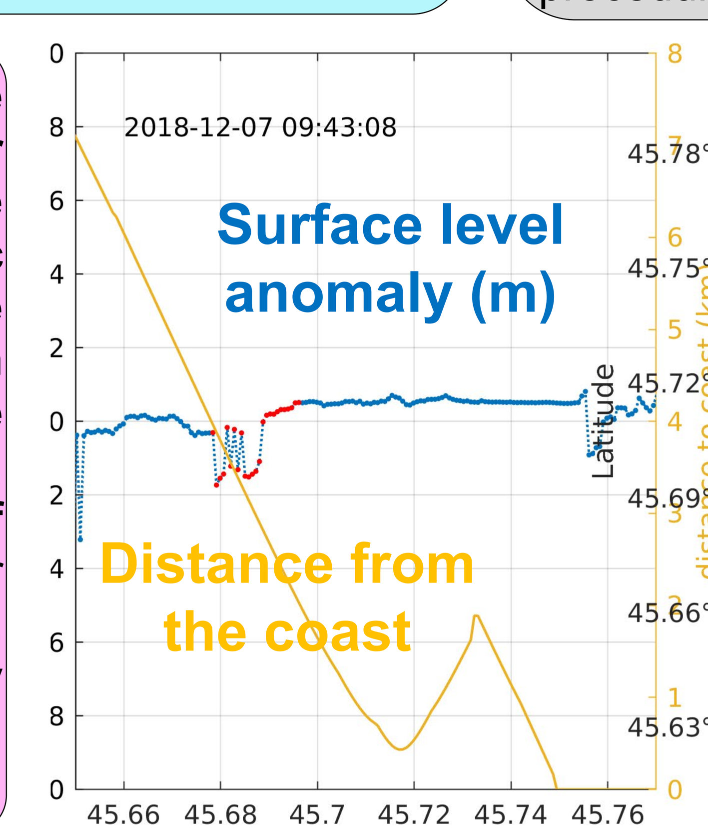
The above figures are maps of the surface with superimposed **surface levels derived from specular and quasi-specular bursts over the observational period**. Orange circles mark the pure specular bursts. The color-bar shows the surface level anomaly scale, for S3B ascending track 384 (left side) and S3B descending track 250 (right side). **Specular echoes have a much higher SNR than Brownian surfaces, which translates to more precise ranges.** In addition, **ranging of a specular burst is simpler than fitting Brown waveforms, as it requires only to find the peak in the fast Fourier transform output of 128 fast time echo samples**. Thus, **the surface water level measured from a specular surface is expected to be precise and accurate. While S3B track 384 has a higher number of specular and quasi-specular bursts, flashing particularly on the northern lagoon**, S3B track 250 is descending, and land interference can explain less than pure specular behavior over the same area. **Clusters of similar surface levels over time are identified over specific land areas and are consistent with the underlying topography. Quasi-specular echo clusters are found in the rivers, predominantly along the Corno River because of its collinearity with track 384.**

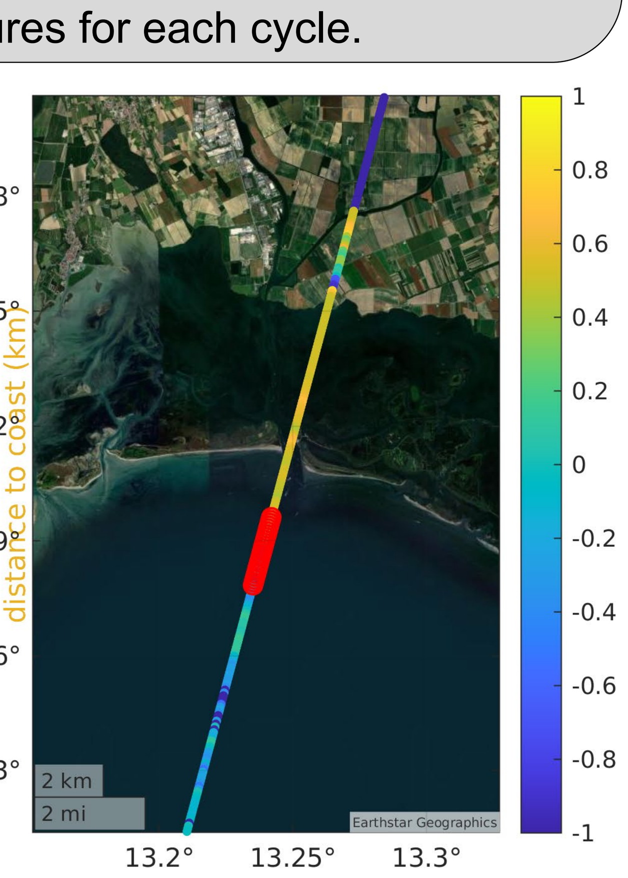
Methodology

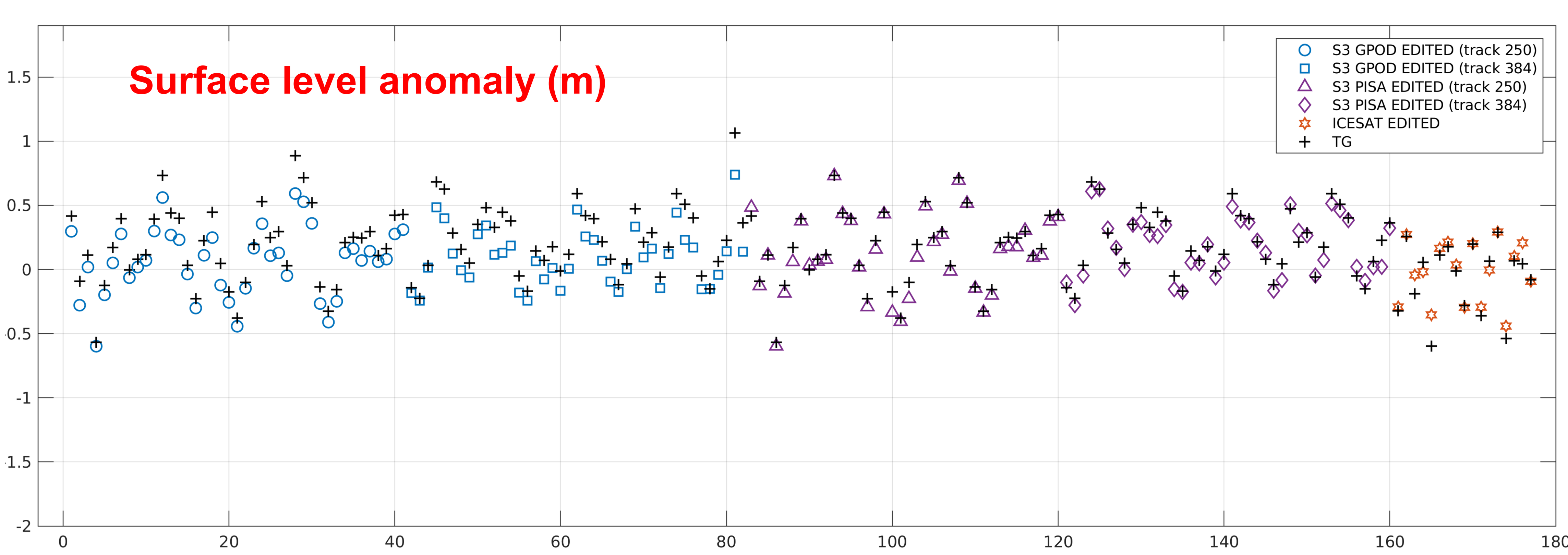
The satellite radar altimetry processing involves three stages: 1) bursts of individual echoes spaced 89 m apart are coherently summed; 2) the radar range is estimated from the echoes; 3) the ranges are translated to surface levels. In this study, radar ranges are derived with two methods: from the **Precise Inland Surface Altimetry (PISA)** algorithm (Abileah and Vignudelli, 2021) and from the **ESA GPOD/Earth Console® Altimetry** service, using the default "Inland Water High product Resolution)". Differently from the default ESA range product (GPOD), which fits the radar return Brown waveform to derive the range, the PISA algorithm identifies **specular** and **quasi-specular** echoes using the radar cross section, and derives the range without any ad-hoc retracking. The removal of surface level outliers (an example occurring offshore is shown in the below figure) is based on along track statistics detection procedures for each cycle.



The figure on the right shows **the impact of the geophysical corrections on the surface water levels within the lagoon**. The abscissas are the accumulated observations along both tracks. Dynamic Atmospheric Correction **(DAC) is the second source of level variability**, while astronomical tides (from FES2014 model) are the first; **to be noted the inverted slope of the tide between the two tracks, matching the expected latitudinal variability of tides in the lagoon**. The contribution of the other tides is negligible. Residual SLA includes currents, residuals pressure effects not corrected by instantaneous IB (typical of Mediterranean basin), seiches and halo- and thermo-steric effects.







The figure on the left shows **an instantaneous comparison of the edited surface level anomaly means of each cycle, supplied by the GPOD and PISA methodology, against ICESat-2 and tide gauge observations**. After editing, PISA and GPOD have 82 and 78 revisiting cycles respectively that can be exploited (ICESAT keeps only 17 cycles due to shorter observational period). **There is a clear consistency between the three satellite-based independent products.** PISA comparison against tide gauge results in a very good agreement, with correlation of 0.98 and RMS difference of 5 cm. For GPOD the correlation is similar (0.97) and RMS difference a little higher (6 cm). ICESat-2 has somewhat less performances than radar estimates (correlation of 0.95 and RMS difference of 8 cm).

Bottom message

Data selection and additional editing/flagging are key to exploitation in open sea and lagoons. Further analyses are necessary to investigate the physics of echoes and how they relate to surface types and wind conditions.

References

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