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Innovations for satellite altimetry processing in the Arctic Ocean: development and application of a new sea level record (1992-2016)

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Although Satellite Altimetry has provided repeated global measurements, sea level data at high latitudes are scarce and largely unexploited due to presence of seasonal or permanent sea ice cover on top of the ocean surface. In these areas, sea level estimation is possible only through the detection of apertures in the sea ice (leads and polynyas).

The radar echo (waveform) from the leads differ significantly from the typical open ocean response. For this reason, it is difficult to fit (in jargon ‚retrack‘) the two signals and estimate the sea level using only one algorithm, Nevertheless, a homogenous solution is needed to avoid biases.

In the context of the European Space Agency Sea Level Climate Change Initiative (ESA SL CCI), we have modified the already existing ALES retracking algorithm, designed to avoid perturbances near the coast: Here, we present and validate ALES+, a retracking solution that is able to fit signals coming from leads, perturbed by the coast or typical of the open ocean with the same solution.

The waveform

The typical open ocean signal (Fig 1a) is characterised by a fast-rising leading edge and a slow-decaying trailing edge and described by the so called Brown-Hayne (BH)‘ model. In the coastal ocean spurious strong backscatter from land or calm water in the satellite footprint produces the ‚bright targets‘ seen in figure 1b. The return from the leads is instead characterised by very peaky waveforms with fast-rising leading edge, steep trailing edge slope and high peak power(Fig 1c).

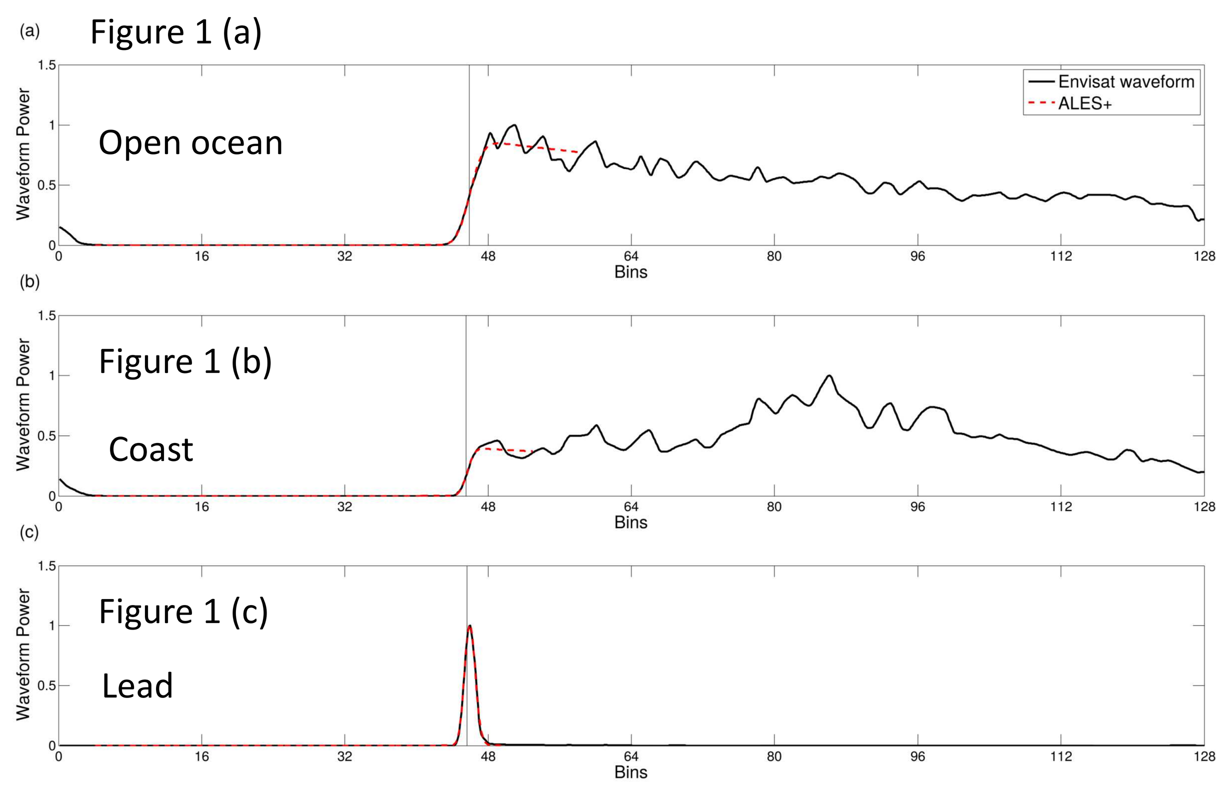
ALES+

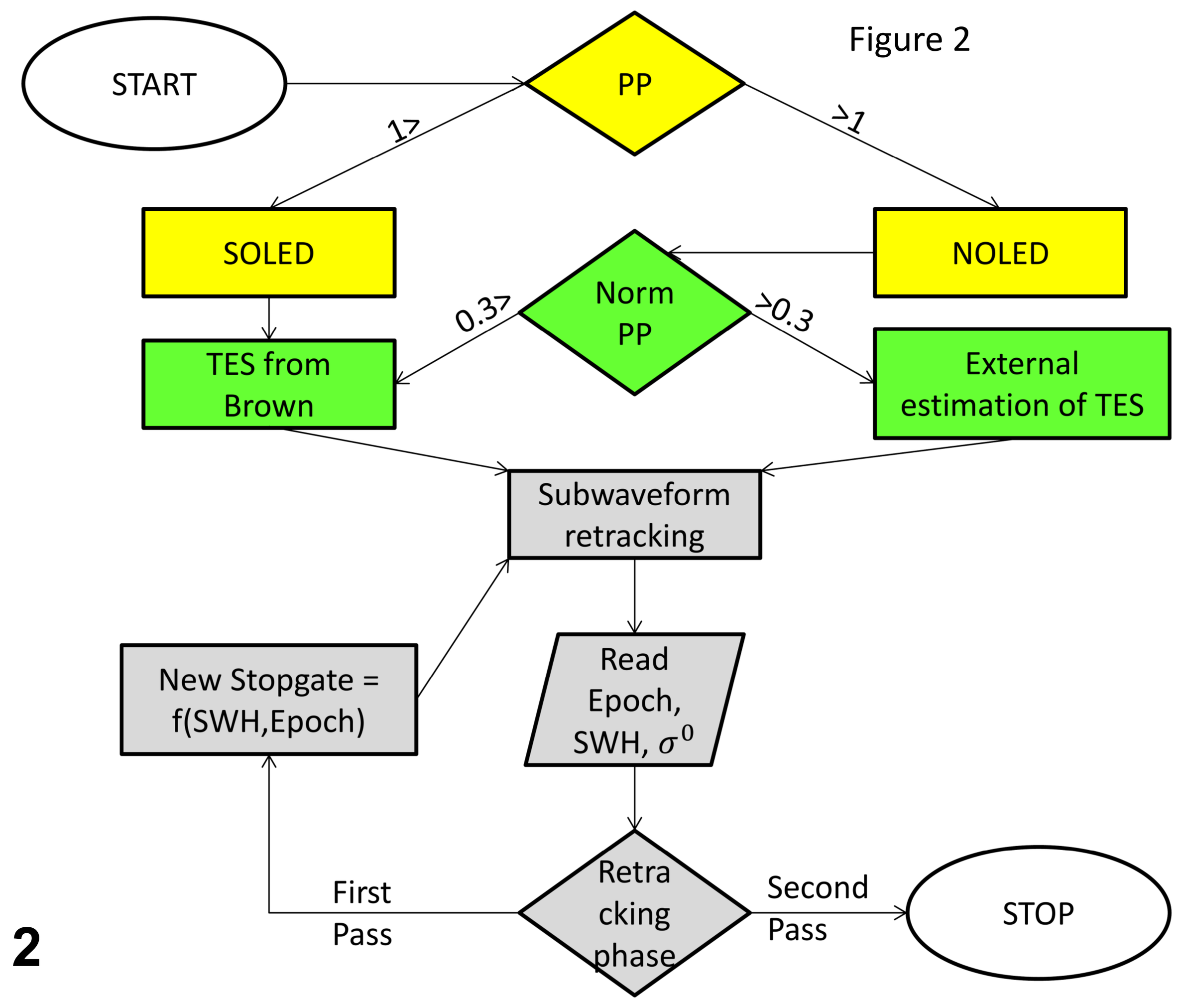
The objective of the retracker is the estimation of the point of the leading edge corresponding to the sea level (the EPOCH). Moreover, the Significant Wave Height SWH and the backscatter are estimated. Figure 2 describes the procedure:

YELLOW: detection of the leading edge, two strategies depending on the Pulse Peakiness (PP), one for standard ocean waveforms (SOLED) and one for the non standard case (NOLED)

GREEN: after a second check on the normalised PP, the TRAILING EDGE SLOPE (TES) is estimated either by the normal BH equation or, for peaky waveforms, by an external BH fitting in which TES is considered unknown.

GREY: a subwaveform up to the leading edge is fitted using BH with the TES from GREEN. Subsequently, depending on the first SWH estimation, the subwaveform is enlarged to produce a more precise estimation. These last steps are in common with ALES [1].





Validation Part 1

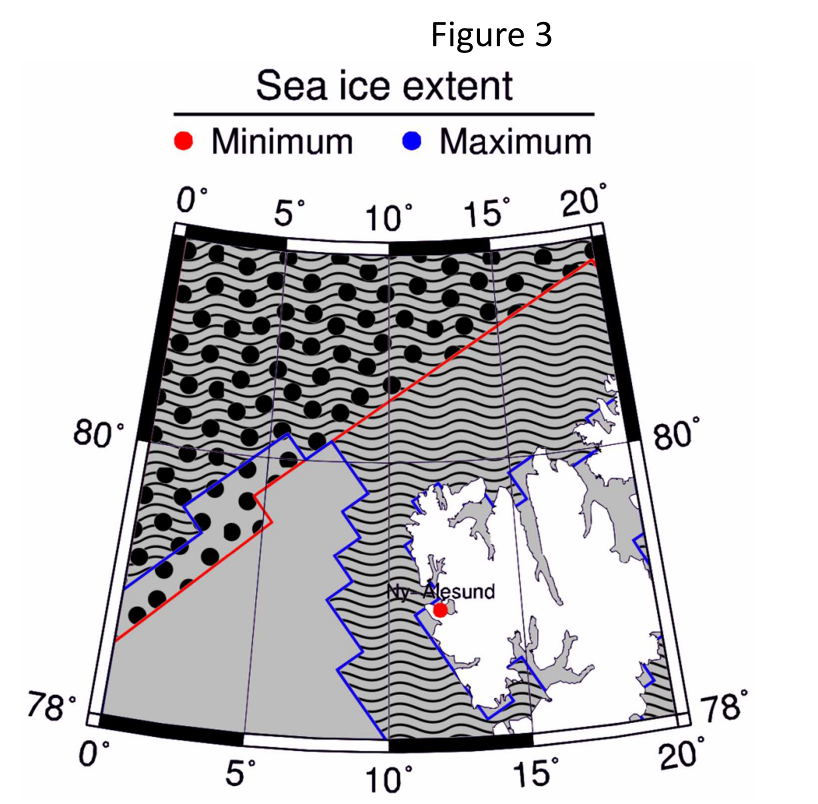
We validate the algorithm in the Arctic Ocean, north and west of the Svalbard Islands (Fig.3), an area characterised by coast, seasonal/permanent sea ice coverage and open ocean, for the ERS-2 and Envisat missions (1995-2010).

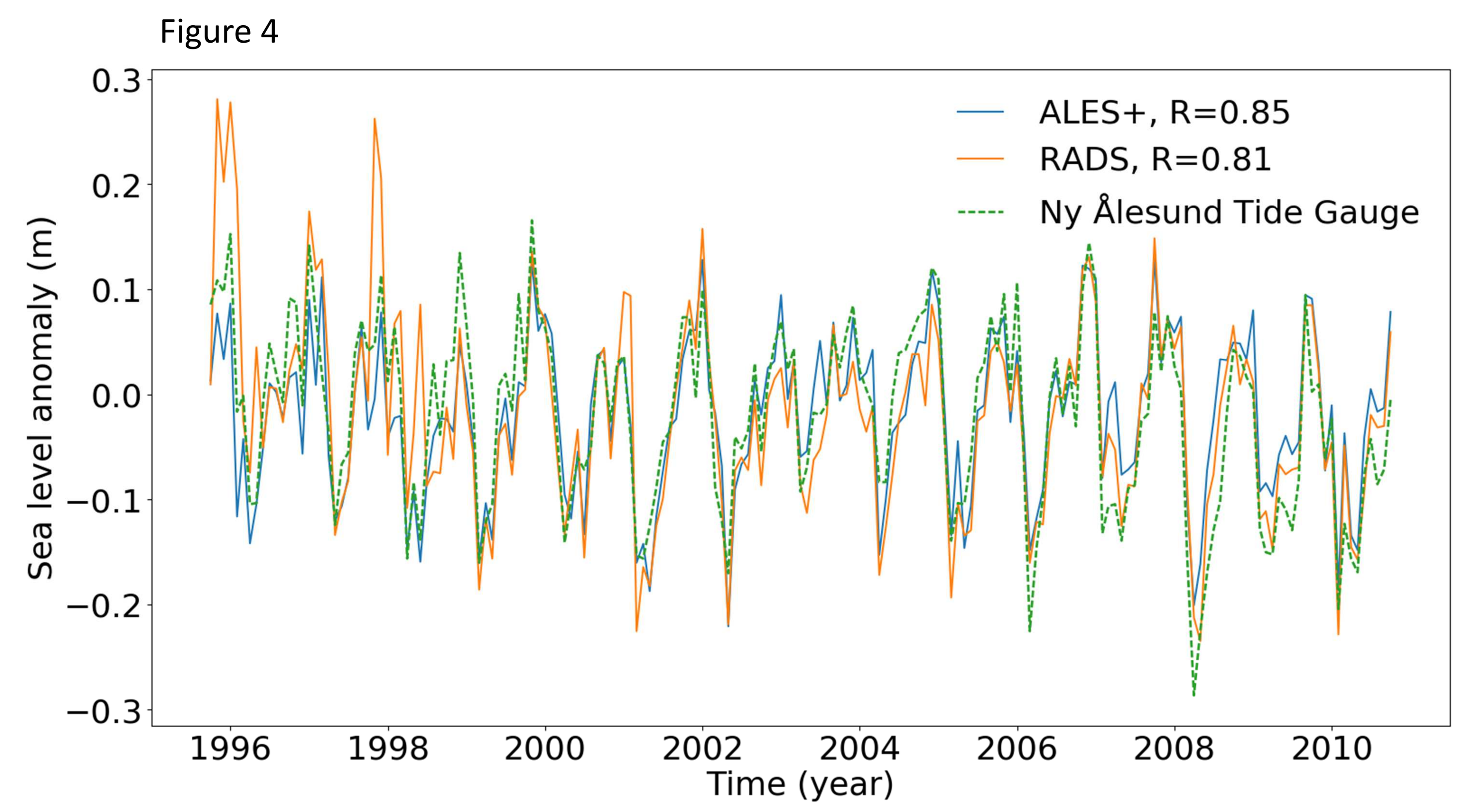
Compared to the Radar Altimetry Database (RADS) with standard settings, the Sea Level from ALES+ is more correlated with a local Tide Gauge (Fig 4). The improvement is stronger in the winter months of 1996-1998, when the sea ice coverage was more predominant.

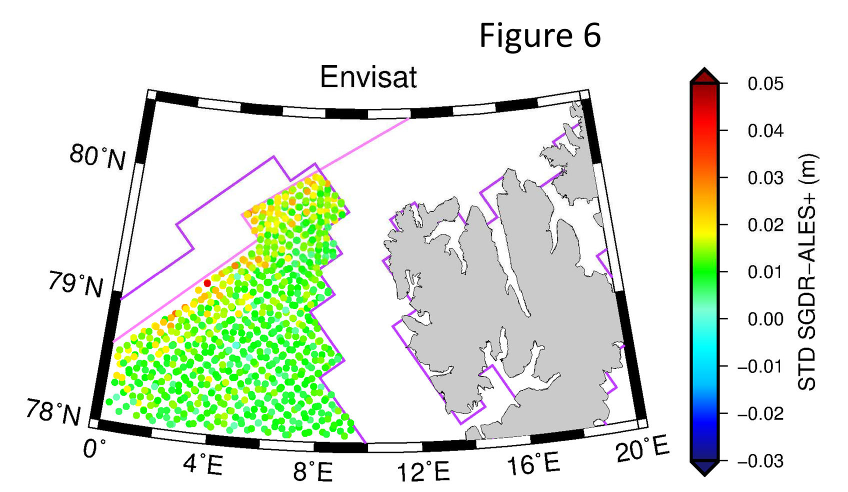
Validation Part 2

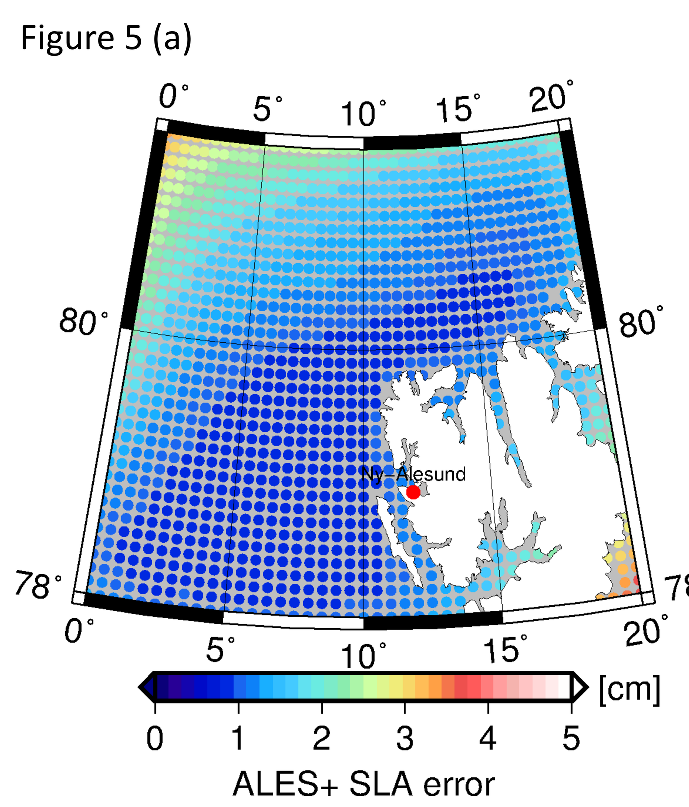
In Figure 5, RADS and ALES+ data have been gridded using a correlation length of 500 km. The covariance error (depending on the variance of the SLA in the grid points) is shown. The improvements in the sea ice area and at the coast (where RADS has no data) is evident.

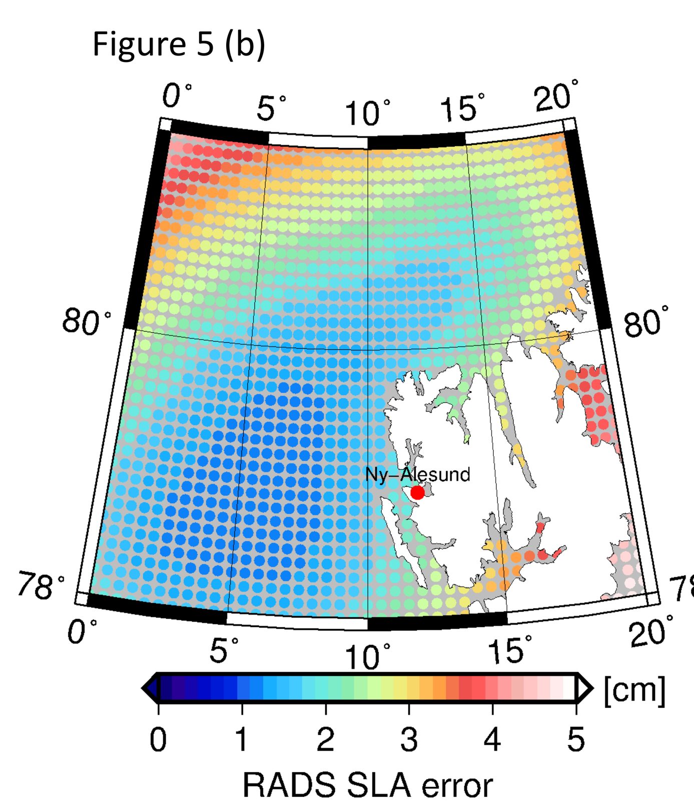
Figure 6 shows the mean difference of the noise (computed as the standard deviation of the measurements within 7 km) of the standard ocean retracker (SGDR) and ALES+. The latter is more precise also in the open ocean.











Conclusion: ALES+ will be the algorithm of choice of the SL CCI DTU/TUM Arctic/Antarctic Sea Level Product. It improves the quality and the amount of data of sea level records at high latitudes.

The improvements in the open ocean and the similarity of inland water waveforms to the lead case calls for a more general application of the retracker. For more details, see [2]

References

[1] M. Passaro, P. Cipollini, S. Vignudelli, G. Quartly, and H. Snaith, "ALES: A multi-mission subwaveform retracker for coastal and open ocean altimetry,"Remote Sensing of Environment, vol. 145, pp. 173–189, 2014.

[2] M. Passaro, S.K. Rose, O. Andersen, E. Börgens, F.M. Calafat, D. Dettmering, J. Benveniste, "ALES+: Adapting a homogenous ocean retracker for satellite altimetry to sea ice leads, coastal and inland waters", submitted to Remote Sensing of Environment
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