CASE STUDY

WP6800. Polar Ocean: Sea Surface Height in the West Spitsbergen Current Region

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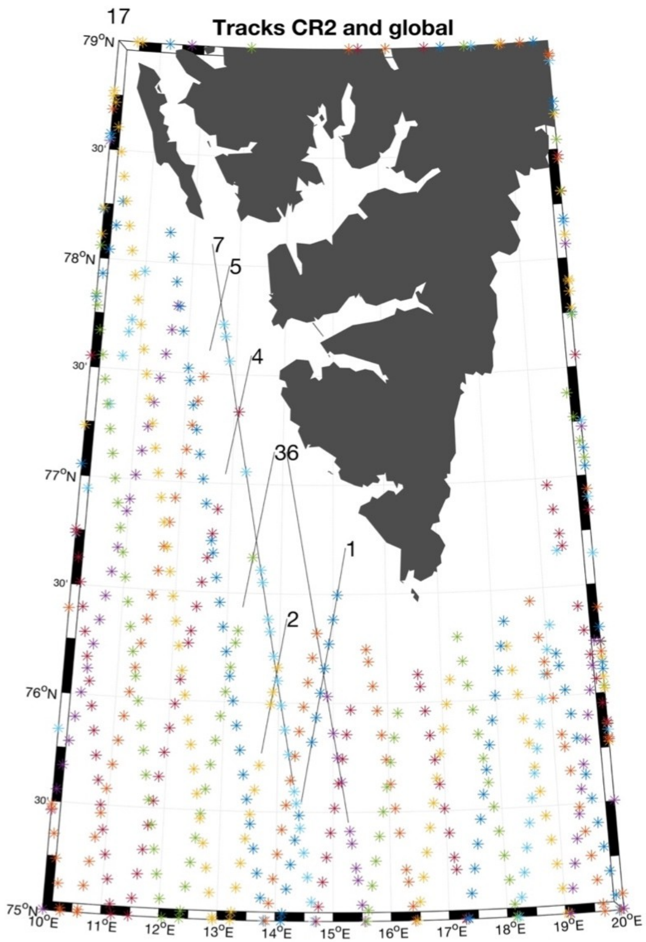
Aims

The **aim** of the case study for the DeDop project is to investigate if different configurations of the lower level altimetry processing from level 1A to level 1B, available in the DeDop processor, impact Level 2 output of SSH and its relationship to the in situ temperature and salinity. The improvement in the relationship with the in-situ data may demonstrate which configuration is better and support recommendations for future studies.

The scientific objective of the research is to find out if the high resolution SSH next to the south-western Svalbard, in the WSC region, relates to the in situ temperature and salinity, or to SST.

ALTIMETRY TRACKS AND PROCESSING



From the 1 month of data gathered in the SAR mode, only 7 tracks were located in the region of interest. Those tracks were chosen for the further analysis.

Both L1B and L1BS data were used. The tracks are located in the south-western Spitsbergen, in the close proximity of the coast. Tracks 1-5 are located in the north-eastern direction towards land and tracks 6-7 from the south to north. The distance of each track is 45km for Track 5 and 270km for Track 7, and spatial resolution is 300m.

Satellite tracks used in black, numbered. In color available C2 data from CMEMS

DEDOP PROCESSING 1A TO 1B

2 DeDop configurations used

The DeDop processor was used to process the input 1A orbits into Level 1B and 1BS outputs. Two configurations were used in this process:

- The “default” **Sentinel-3** like baseline, with no Hamming windowing or zero padding,
- **CryoSat-2** baseline with Hamming Windowing and Zero Padding.

The reason why those 2 configurations were investigated is that the Cryosat-2 configuration can have following advantages for the noise reduction:

- **Zero-padding** helps in the retracking as there are more samples in the waveform, specially for those peaky waveforms at low SWH. We have observed that zero-padding provides improved noise in SSH and SWH retrieval for low SWH (below 2 m).
- **Hamming intra-burst** (reducing the impact of azimuth or along-track sidelobes produces a cleaner stack specifically in the noise area, removing the interferences of along-track sidelobes folding back after geometry corrections that results in the cleaner waveforms in the noise area before the leading edge) is helping to reduce the error in estimation of SSH and SWH for higher SWH above 4-m. The noise in sigma0 is improved over the different SWH compared to processing with Sentinel-3 configuration.

Considering the above advantages, it was expected that **Cryosat-2** baseline will result in a **better retracking and more accurate estimation** of geophysical parameters such as SSH and SWH.

ADDITIONAL PROCESSING LEVEL 1B TO 2

SHAPE Processor

The tracks were retracked using an in-house L2 processor exploiting an implementation of the SAR ocean retracker based on the model proposed by Chris Ray in TGRS Ray et al. (2015).

Two different re-tracking options have been considered:

- 1st retracker the SWH is being fitted and MSS is fixed (ocean-like waveforms), the retrieved geophysical parameters are SSH, sigma0 and SWH
- 2nd (more specular-like scenarios) the MSS is being fitted, fixing the SWH, the retrieved parameters are SSH, sigma0 and MSS.

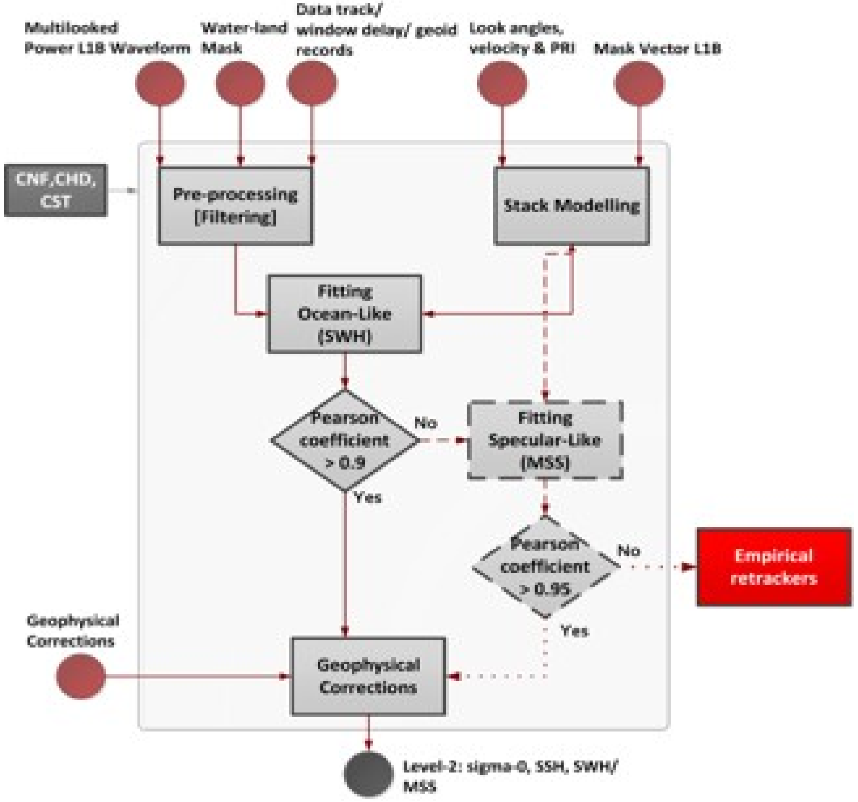
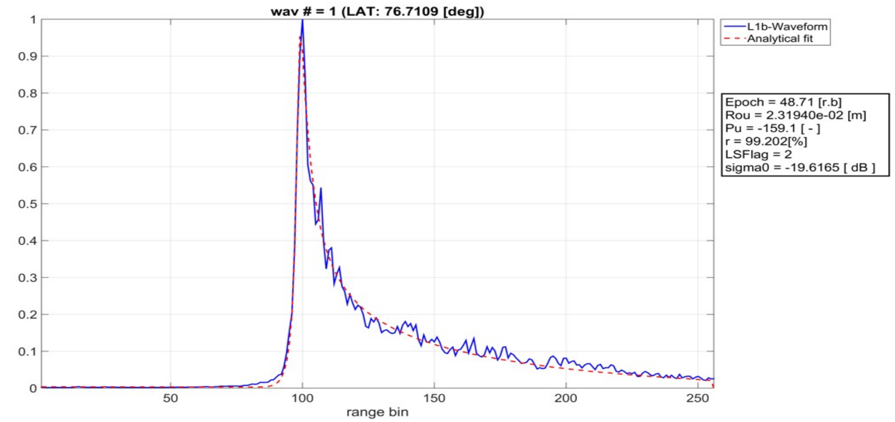


Figure. Physically-based SAR ocean retracker block diagram. (CNF, CHD and CST stand for configuration, characterization and constants' files provided as inputs to the L2 processor) (credit: isardSAT).

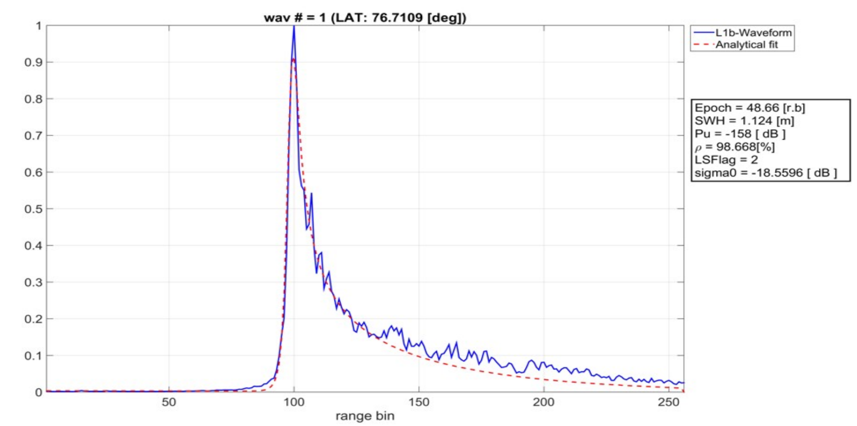
Retracking

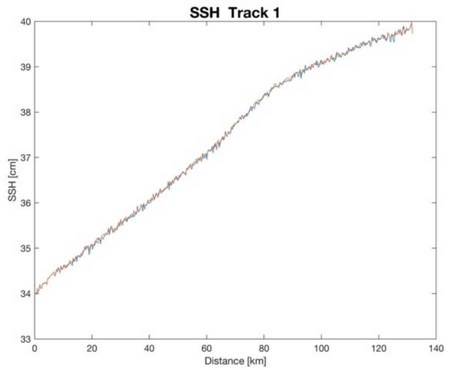
- The geophysical corrections were applied to correct the SSH – we have used a Dedop version the same as for SPICE, SCOOP and SHAPE isardSAT projects, where geophysical corrections are directly included in Level 1B (Makhoul et al, 2017, MTR SHAPE).

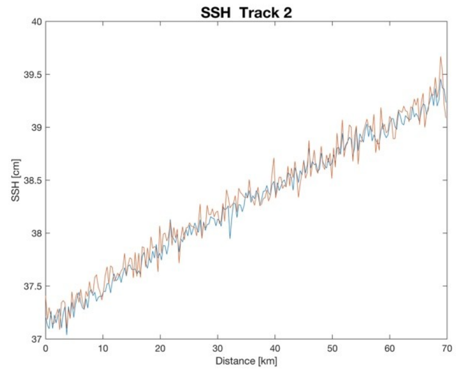
In the top SWH is being fitted and MSS is fixed (ocean-like waveforms)

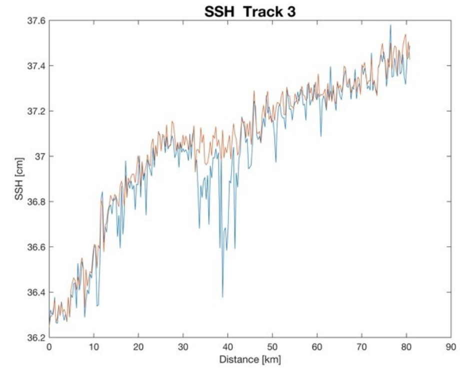


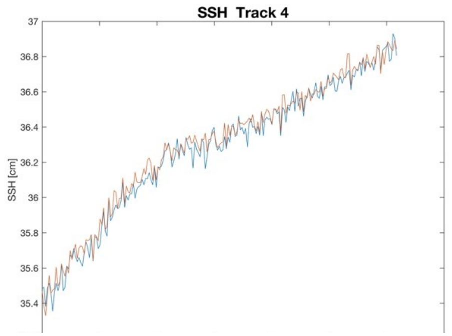
More specular-like scenarios, the MSS is being fitted, fixing the SWH

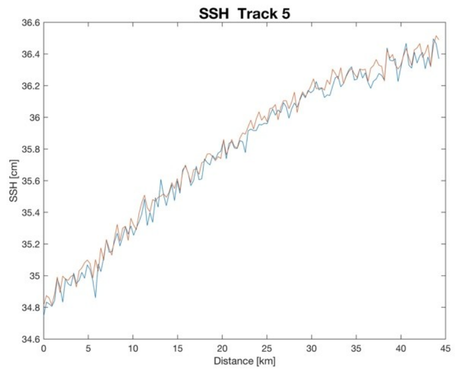


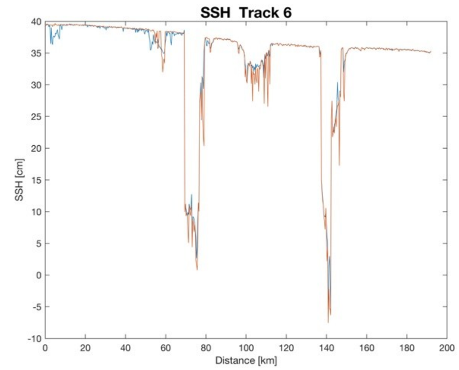


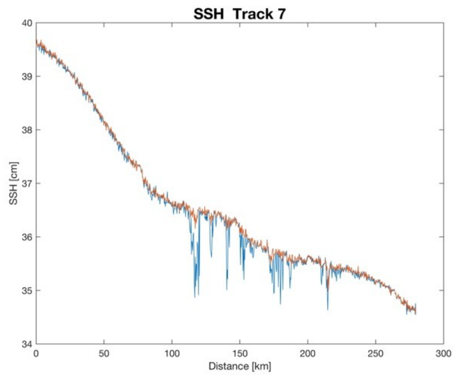












L1B data was retracked to Level 2 using SAR ocean retrackers. The results of the 2 output SSH are visible for each track. In blue SWH is being fitted and MSS is fixed, in red MSS fitted and SWH is fixed.

OTHER DATA USED

- Profiles of temperature and salinity measured during an oceanographic cruise in 20/06/2011-20/07/2011 by IO PAS.
  The measurements were interpolated to the location of the satellite altimetry tracks. Note that the resolution of those measurements is around 10-30km along the hydrographic section and 50-100km between the sections.

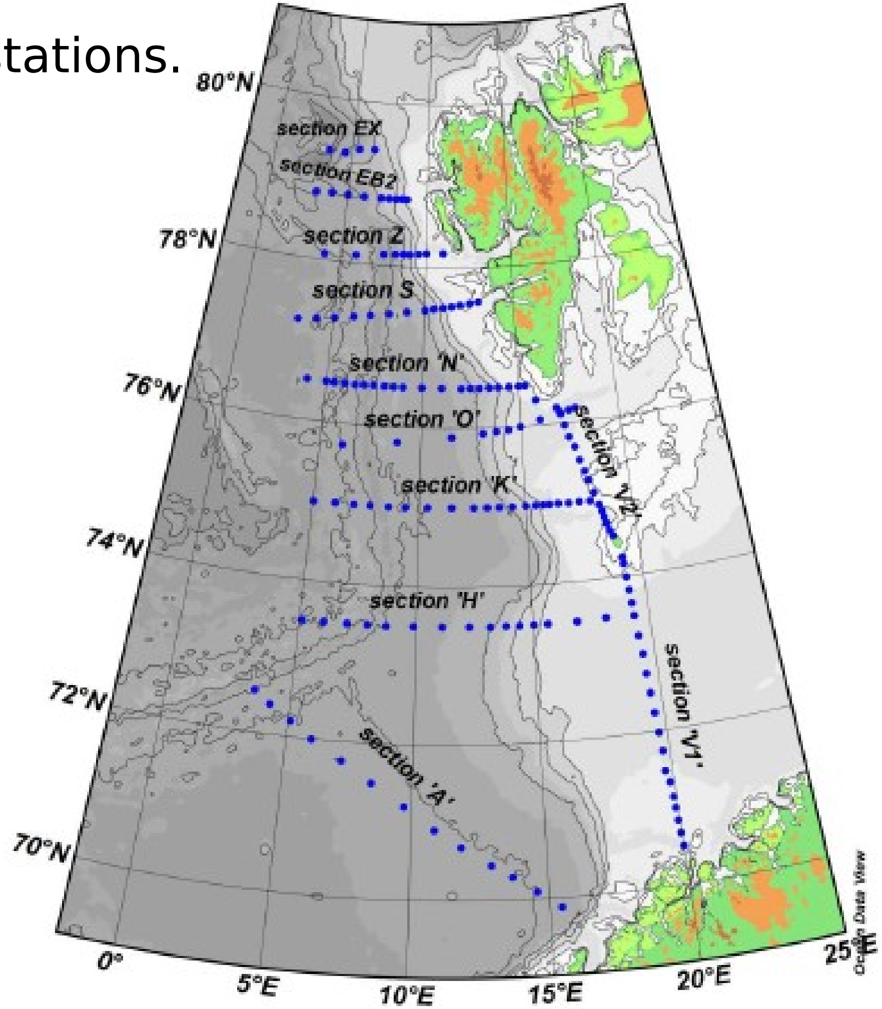
Additionally:

- Remotely sensed SST (15th May, 15h June, 15th July)

LOCATIONS OF IN SITU DATA

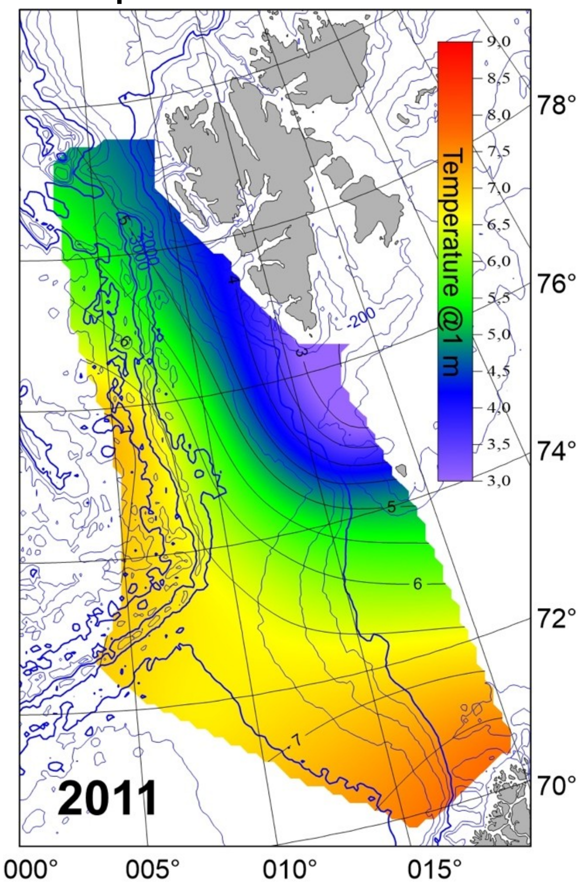
Study period: 20.06.2011-20.07.2011

Positions of CTD stations.

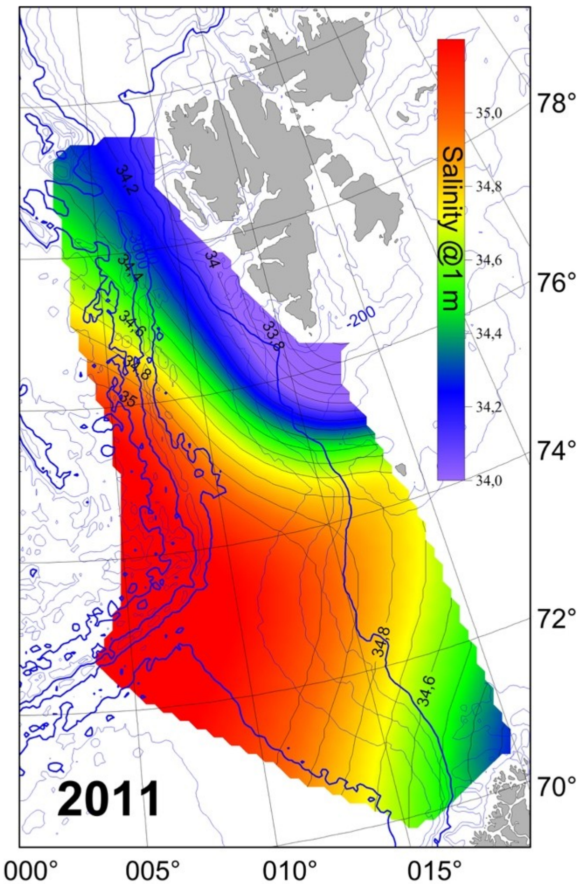


Relationship of SSH and in situ Temperature at 1m depth

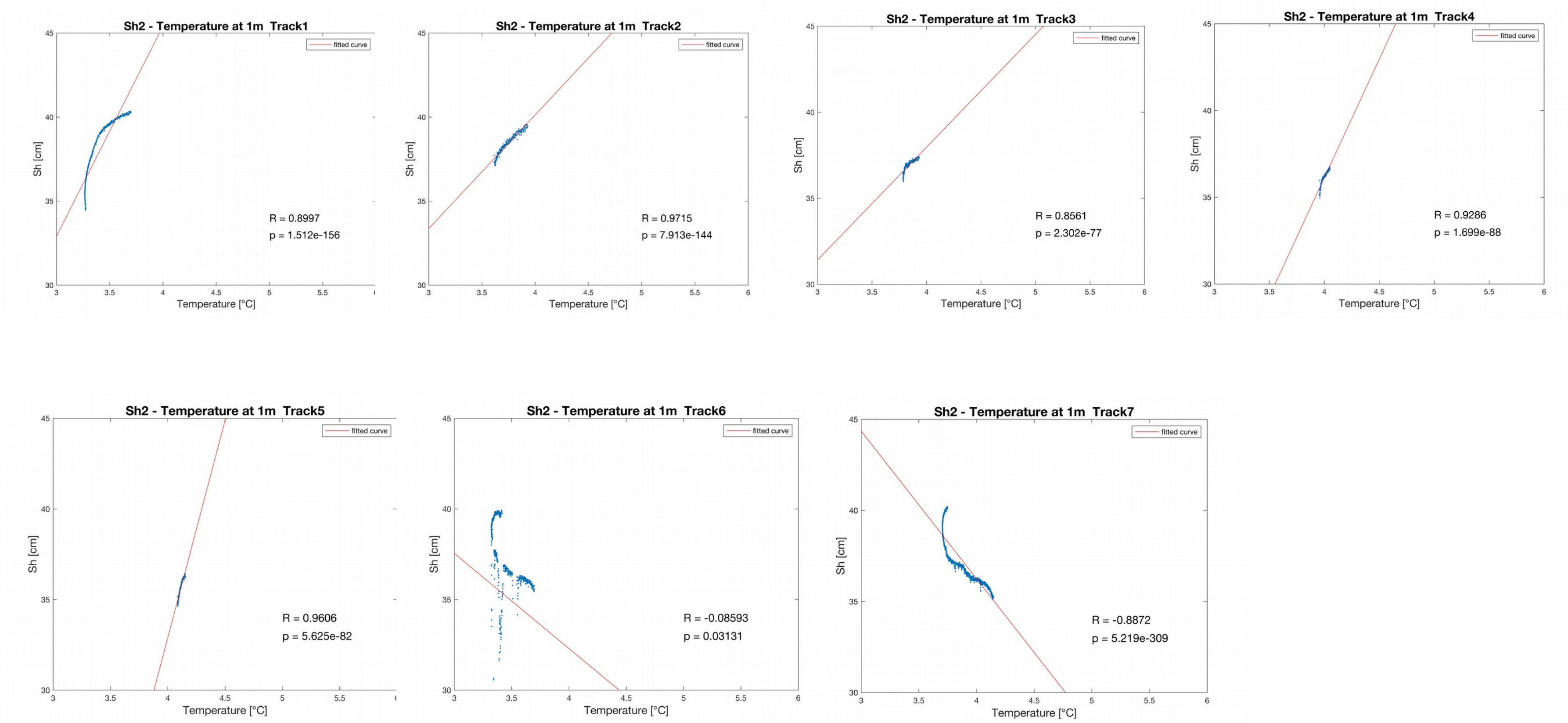
Temperature at 1m



Salinity at 1m



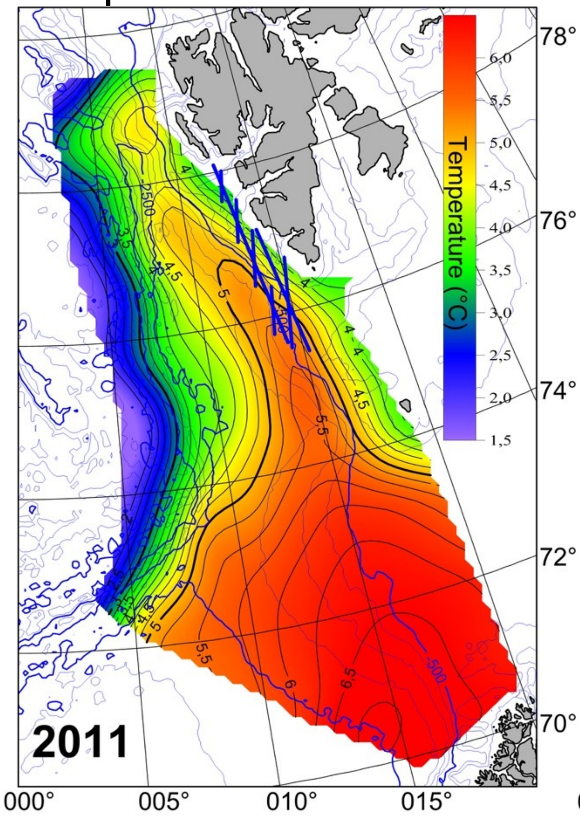
Relationship of SSH and in situ Temperature at 1m



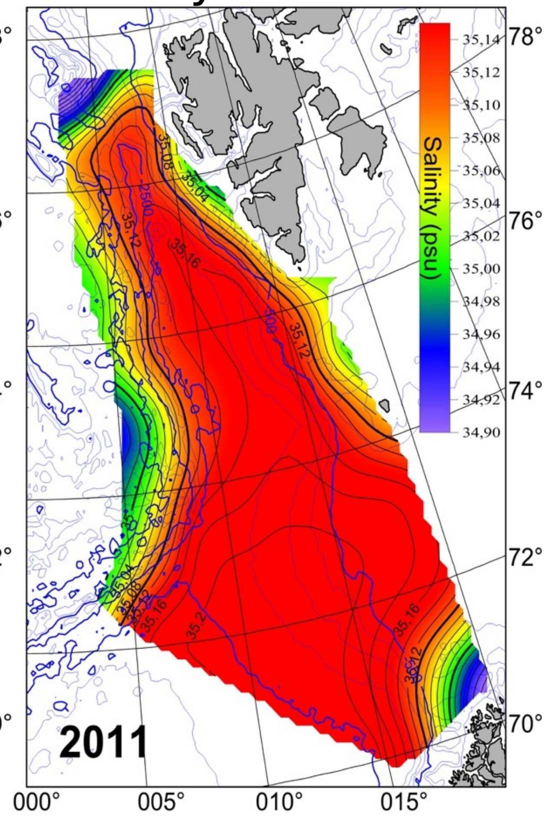
Positive correlations ~0.9 for Tracks 1-5,
No correlation for Track 6 due to large errors
Negative correlation for Track 7.

Relationship of SSH and in situ Temperature and Salinity at 100m depth

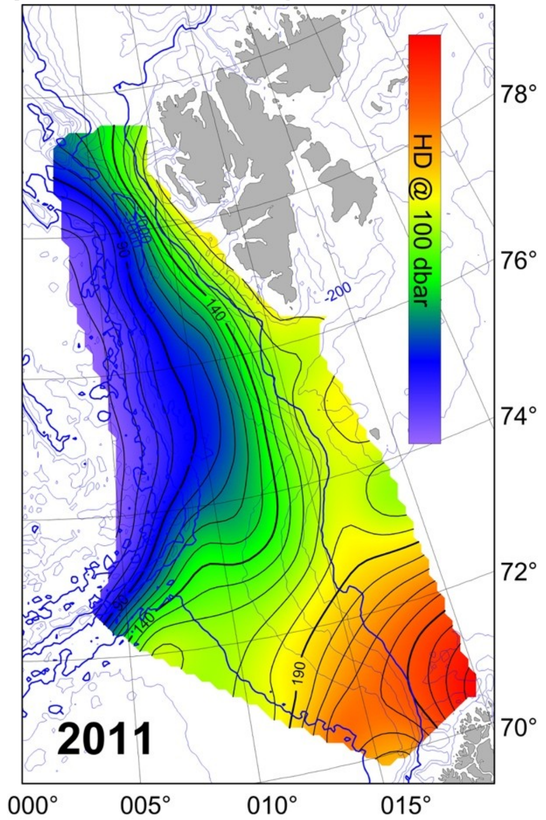
Temperature at 100m



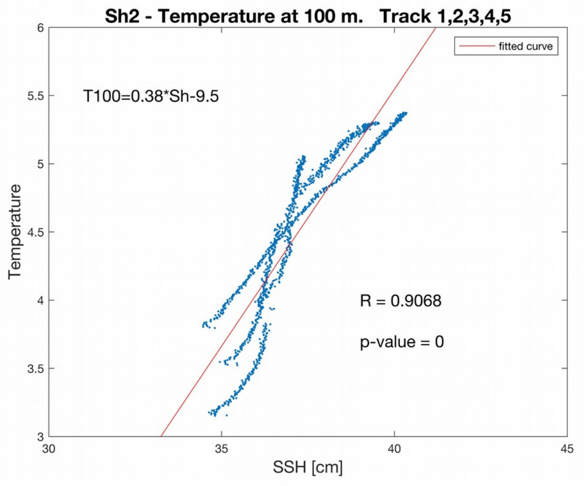
Salinity at 100m

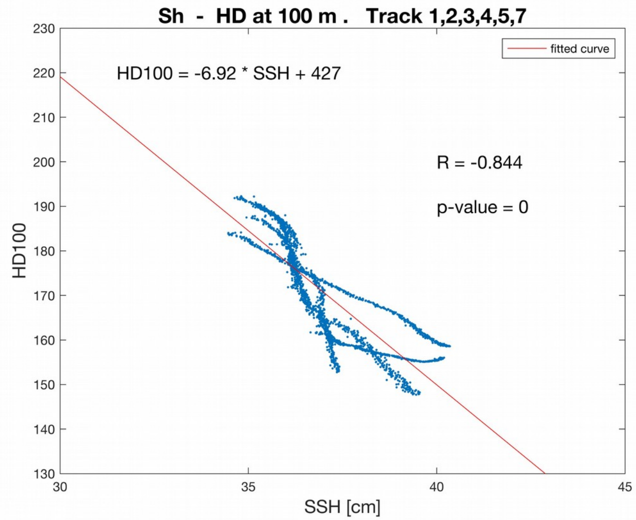


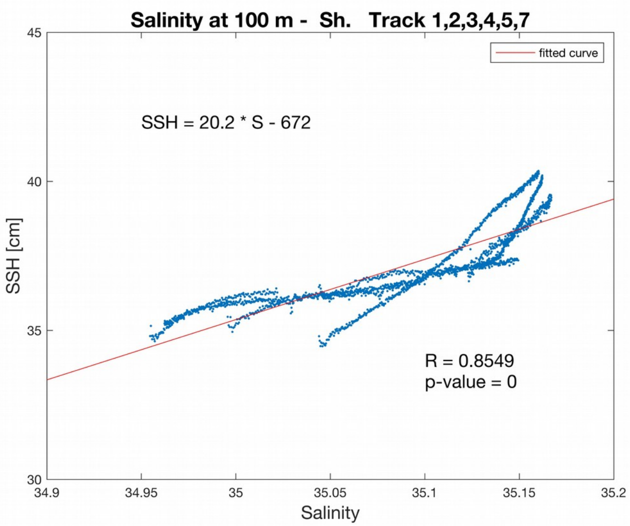
Dynamic height at 100m



Relationship of SSH and in situ Temperature at 100m depth







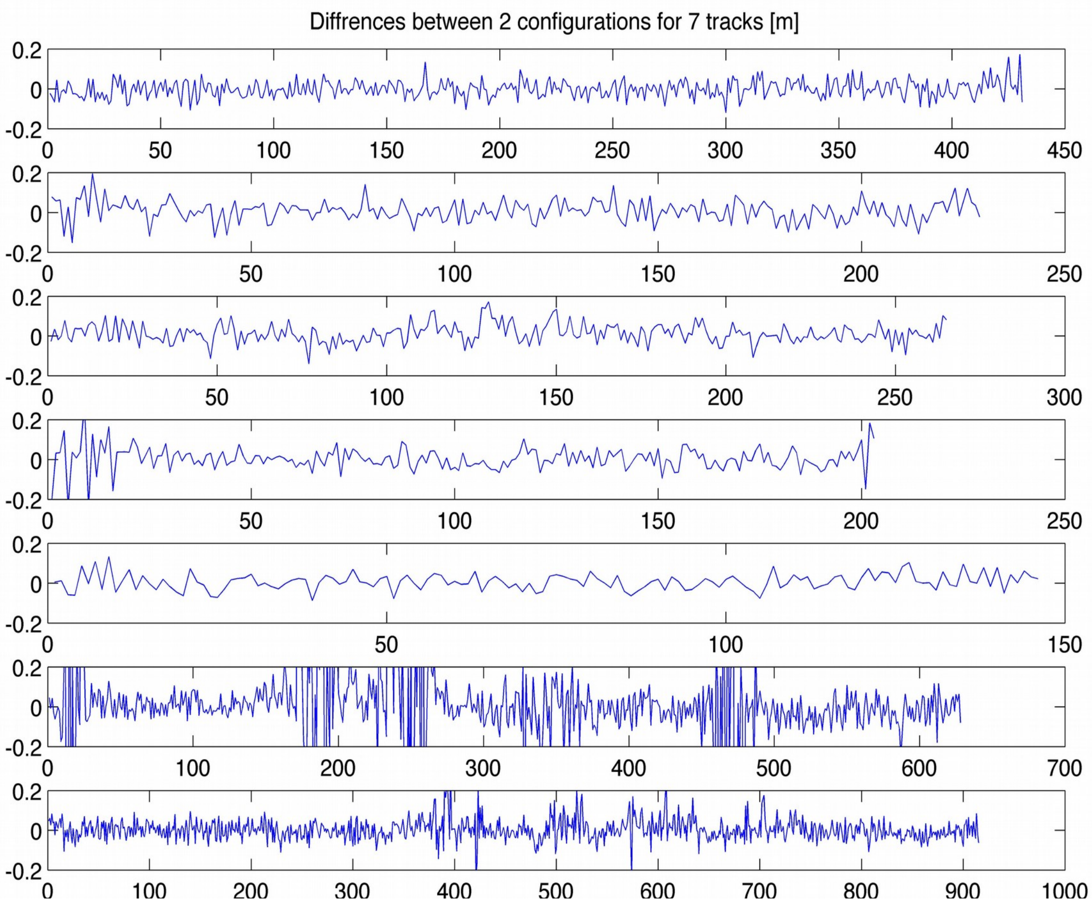
It is possible to derive an empirical relationship between SSH and Temperature, salinity and dynamic height at 100m for all tracks.

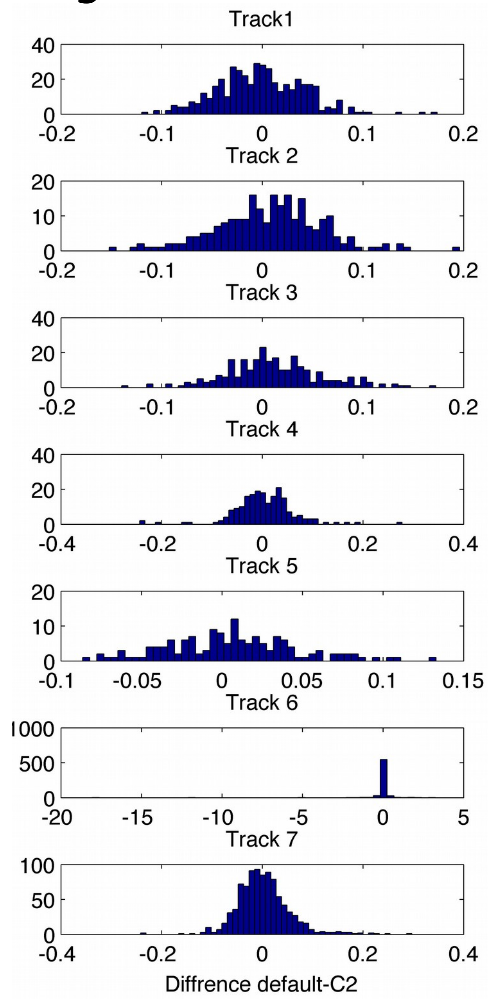
High correlation for Temperature, dynamic height and salinity and SSH for all tracks.

RESULTS

Impact of different Dedop Configurations on the SSH

Differences of about +-20cm between the two configurations





Distribution of the differences is close to normal

Impact of different Dedop Configurations on the SSH

Track no.	Mean difference [cm]	Standard deviation [cm]	Range [cm]
1	-0.2	4.2	29.3
2	0.8	5.2	34.8
3	1.2	4.8	31.2
4	0.3	6.0	52.1
5	0.6	4.1	21.9
6	-3.7	94.4	2128.0
7	0.2	5.2	53.9

When comparing the Pearson correlations between the two output SSH values and in situ Temperature, salinity and dynamic height at 1m and 100m depths no significant difference between the SSH outputs obtained by using 2 different DeDop configurations were found. The greatest impact on the resultant regression was found between temperature and SSH, the Pearson correlation coefficient increased slightly for the Sentinel-3 like configuration from R=0.9046 to R=0.9068, this demonstrates only a very small insignificant increase in the explained variance between the two variables.

CONCLUSIONS

- Positive significant correlation exists between sub-surface Temperature at 1m depth and SSH, showing overall god fit (R=0.9) but not for all tracks (mainly only those located along East-West direction). This could be explained by the increased activity of the freshwater current flowing from the Storfiord into western Svalbard, causing unusual pattern of SST characterized by the SST increasing northwards- This pattern causes a negative correlation with the SSH track 7 located along North-South direction.

- There is a significant relationship between the Atlantic Water temperature and salinity and SSH, that means that those two values are in good agreement and show the same pattern. It is possible to use the derived empirical relationship to predict the Temperature of AW at 100m using SSH and vice versa.

- The 2 DeDop configurations produced SSH values that were **not on average different** from each other for the 7 orbits considered, but their differences range was about 20 cm and their standard deviation was about 5cm. The comparison with in situ data produced similar results. This could be caused by the low spatial resolution of in situ data.

CONCLUSIONS

- The differences between SSH derived using 2 different Dedop configurations are significant ranging usually around +-20 cm, however their distribution is close to normal for all tracks and the mean difference for each track in close to zero .The standard deviation of the SSH difference is around 5 cm for all tracks, except for track 6 that has large errors. However, no significant difference for the SSH and in situ data was found.

- Comparison with the in situ measured temperature and salinity did not allow to choose any ‘better’ configuration. This could be caused by the low spatial resolution of the in-situ data which is between 10-50 km . It is therefore recommended to compare the high-resolution SAR altimetry outputs with the high resolution CTD that is of similar spatial resolution, this could be possible with other in situ data bases or different regions e.g. in the fjords of Svalbard.

RECOMMENDATIONS

The Dedop tool is very useful to try different processing configurations and testing the effects on the waveform outputs (L1B). It allows for the assessment and comparison of the different processing options when processing the altimetry data from the Level 1A to Level 1B and 1BS.

-We greatly recommend to extend the DeDop toolbox by the inclusion of Level 2 processing: retracking and geophysical corrections. It is not possible to assess the impact of different lower-level processing without analysing it impacts on the final output geophysical parameters such as SWH or SSH.

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