DTU Space
National Space Institute

Sea surface retracking and classification of CryoSat-2 altimetry observations in the Arctic Ocean

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DTU15 are state of the art global high-resolution altimetry derived models including a mean sea surface (MSS), a mean dynamic topograpy (MDT), and a geoid.
Existing altimetry derived models generally lack observations above 82° latitude, making high Arctic models unreliable. DTU15 includes CryoSat-2 data to extent the altimetric coverage to 88° latitude, and novel classification and retracking methods adapted to the special sea-ice contaminated radar returns.

Classification and retracking

In the Arctic Ocean less than 20% of the radar pulses are actually returned from the ocean surface in the leads but instead from sea ice floes, ice ridges and other ice surfaces. For the CryoSat-2 SAR and SARin mode data the pulse peakiness (PP) and stack standard deviation (SSD) is used to classify the radar returns from leads and non-leads, see Figure 1. For DTU15 returns are classified as leads when SSD<3 and PP>0.26 and ocean when SSD>40 and PP<0.1. Lead waveforms are very narrow peaked and are retracked with a threshold retracker using a stabilized maximal threshold.

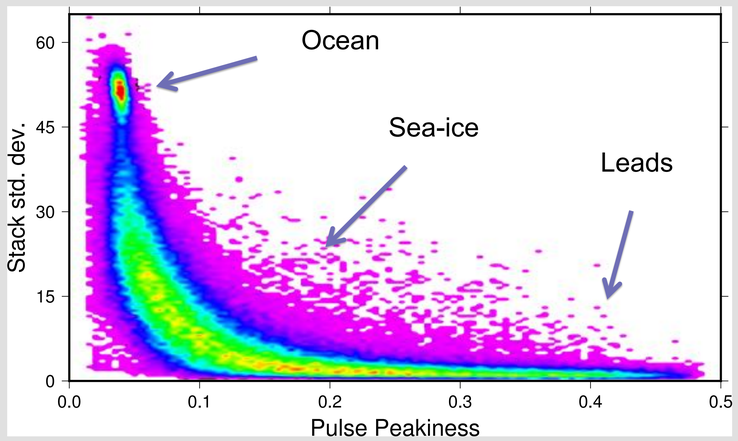

Figure 1: Density of SAR wavefoms as a function of the pulse peakiness and the stack standard deviation of the beams.

Comparison with IceBridge airborne data

A procedure to detect areas with open water or newly refrozen leads in aerial photos has been developed and applied on data from three IceBridge in 2012 and 2013 to validate the classification of the radar returns.

For the IceBridge underflights 80% of leads above 500 m^2 were classified correctly, see figure 2. When comparing the IceBridge laser height with collocated retracked CryoSat-2 the average difference is 0 cm, but only 34 point were available for the comparison.

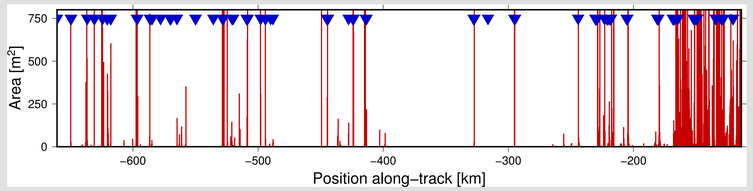

Figure 2: CryoSat-2 waveforms classified as leads (blue triangles) and areas with open water or newly formed ice detected in IceBridge aerial photos from under-flight April 2nd, 2012, north of Greenland (50° W, 86° N)

DTU15MSS with CryoSat-2 data included

To minimize the effect of orbit errors, tilt and bias are removed from the individual tracks. Next short wavelength tilt and bias are removed to minimize residual errors and finally the corrected heights are interpolated onto a regular grid and merged with available satellite radar altimetry product, see Figure 3 and 4.

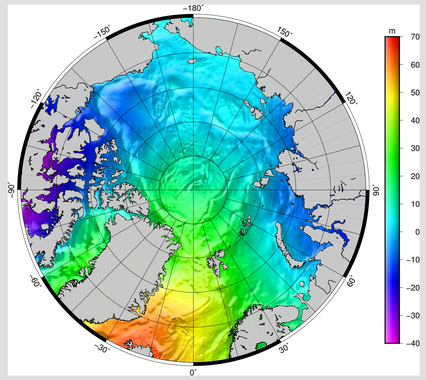

Figure 3: The Arctic DTU15MSS

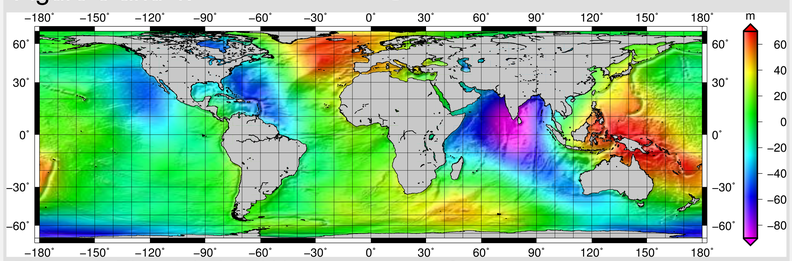

Figure 4: The global DTU15 mean sea surface.

Comparing DTU15 with UCL13

The DTU15MSS have been compared with UCL13.
UCL13 is a merge of CLS11 and CryoSat-2 data and is included as the default MSS in the CryoSat-2 Baseline-C products.
The UCL13 model is heavily contaminated with striping, see Figure 5 and 6, and have large errors near the coasts.
In large parts of the Arctic ocean UCL13 have a -20 cm bias compared with DTU15.

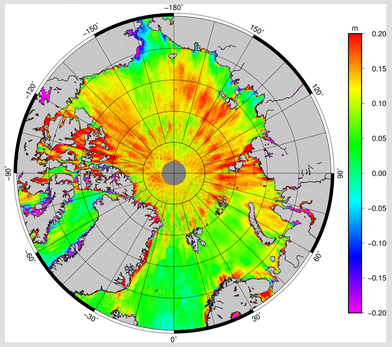

Figure 5: Difference in the Arctic between DTU15MSS and UCL13.

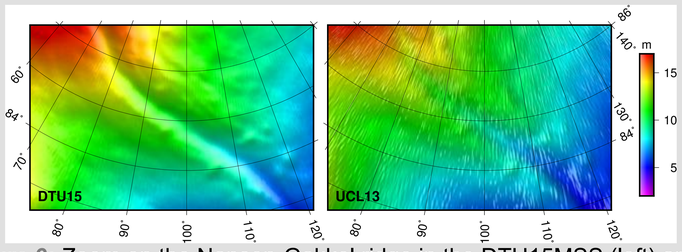

Figure 6: Zoom on the Nansen-Gakkel ridge in the DTU15MSS (left) and the UCL13MSS (right). The short wavelength details seen in DTU15 are obscured by track striping and hardly visible in UCL13.

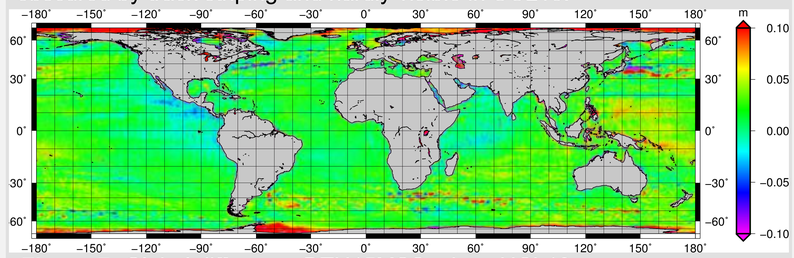

Figure 7: Global difference DTU15MSS minus UCL13.

Summary

The inclusion of almost four years of CryoSat-2 data in the new DTU15 models have proven to be major steps forward for altimetric ocean models in the Arctic and show good agreement with airborne data and the Arctic Ocean circulation models.

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DTU15MSS is available at ftp://ftp.space.dtu.dk/pub/DTU15/

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