Multi frequency altimetry and sea ice - SRL and open questions

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Keynote

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- How would we improve the methodology?
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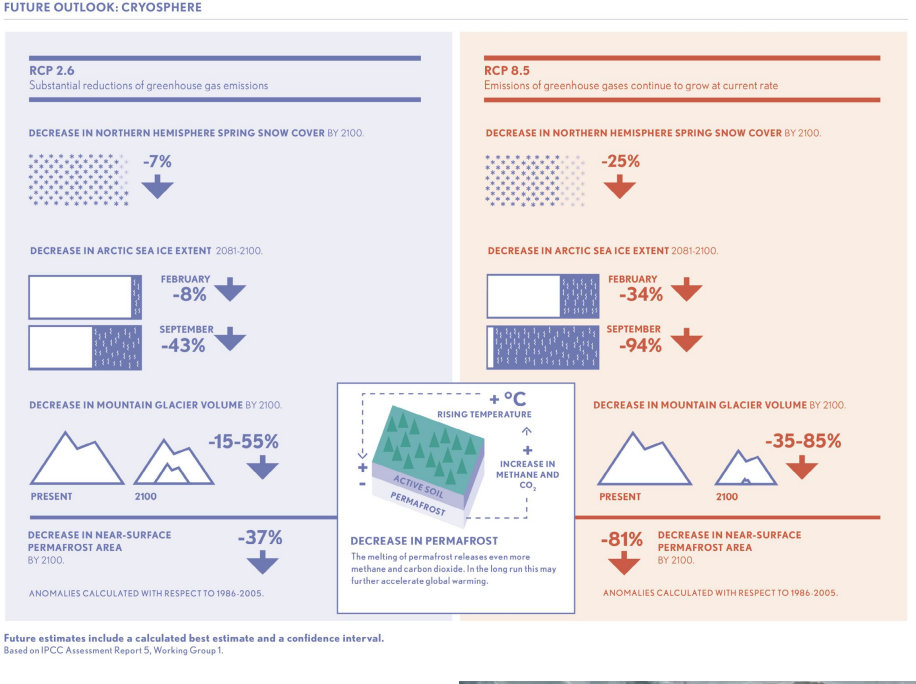
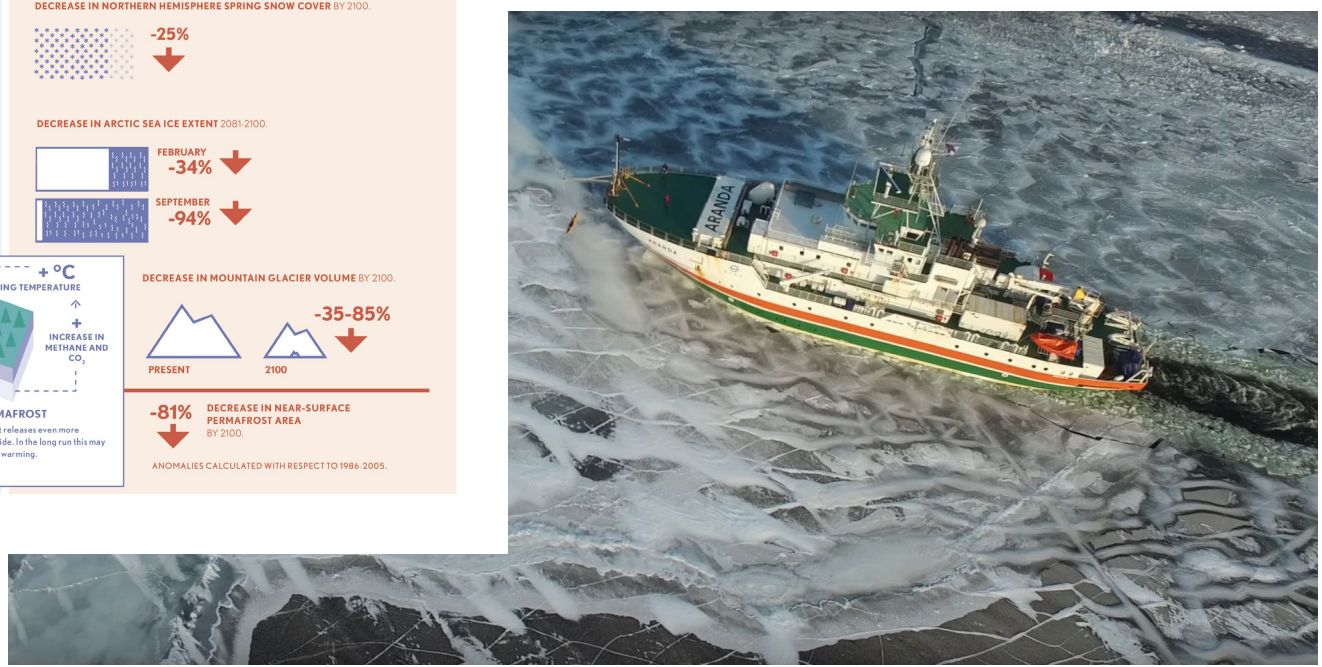
- What benefit does ICESat-2 bring?
- Who would use the product?
- ***So what?***

Sea ice vs. land ice

- Sea ice is a more heterogeneous target than land ice
- Colocated measurements require both instruments to fly on the same platform (or within minutes of each other)
- Winter navigation user community in addition to science users

Remember the users!





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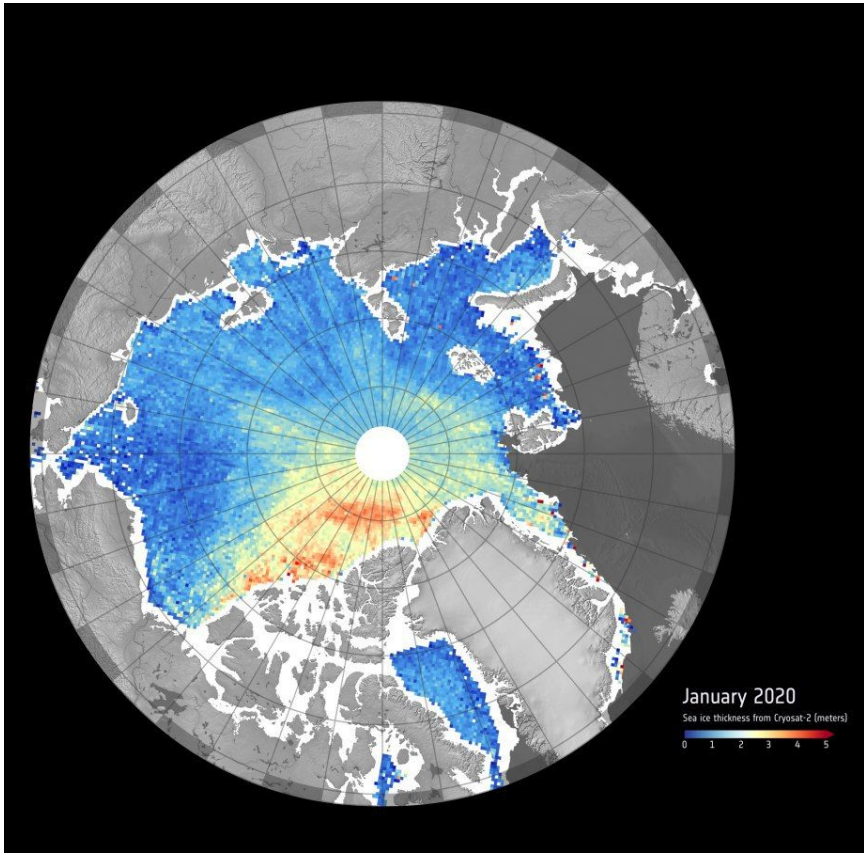
Nutshell

- Sea ice thickness retrieval for Ku SAR mode is mature (SRL=9)
- Ka applications for SIT are much less mature, but exist.
- Much work to be done with dual-frequency!



Ku vs. Ka

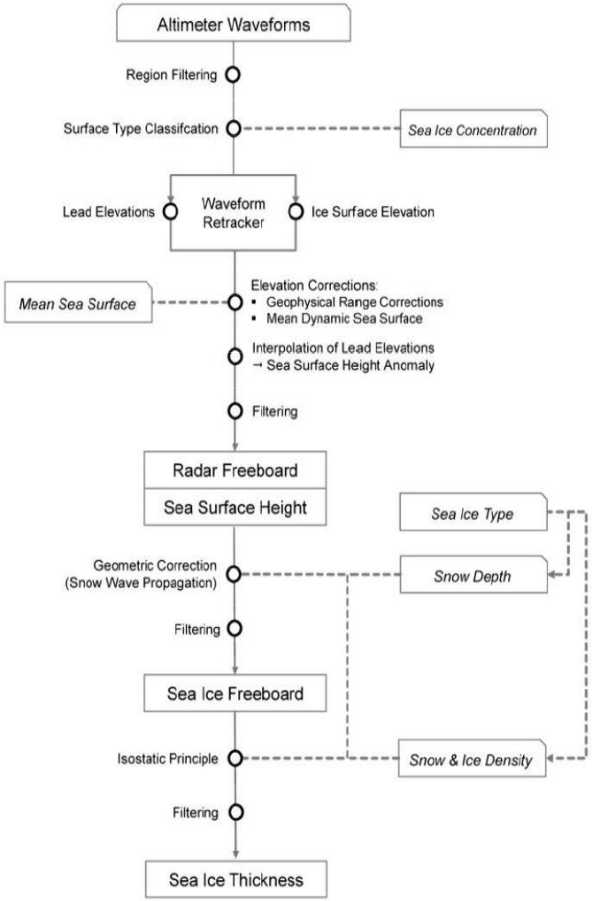
No SAR mode Ka data available!

For Ku, several SIT algorithms exist. Different choices are made on:

- retracking
- surface type classification
- auxiliary data

Many of these choices have not been tested on (LRM) Ka data - should they?

The smaller SRL for Ka is not unique to sea ice but stands for L1 processing as well.



Snow retrieval (satellite)

Snow retrieval with AltiKa / CryoSat-2 has been published (Armitage & Ridout 2015, Guerreiro et al. 2017, Lawrence et al. 2018). However, there is much work to be done before reaching the snow retrieval requirement for CRISTAL.

IRIS altimeter is to operate in delay-Doppler mode for both Ku- and Ka-bands. This will make the difference in footprint size much smaller than is the case with AltiKa and CryoSat-2. However, the effect of ambiguous penetration depths still stands even if the footprints would be identical (which, even for IRIS, is not the case). Thus in order to build and validate a snow thickness algorithm shall still require coincident, large scale airborne measurements of snow thickness as well as theoretical work on the effect of surface roughness, snow grain size etc. on the range for both channels.

Snow retrieval (satellite)

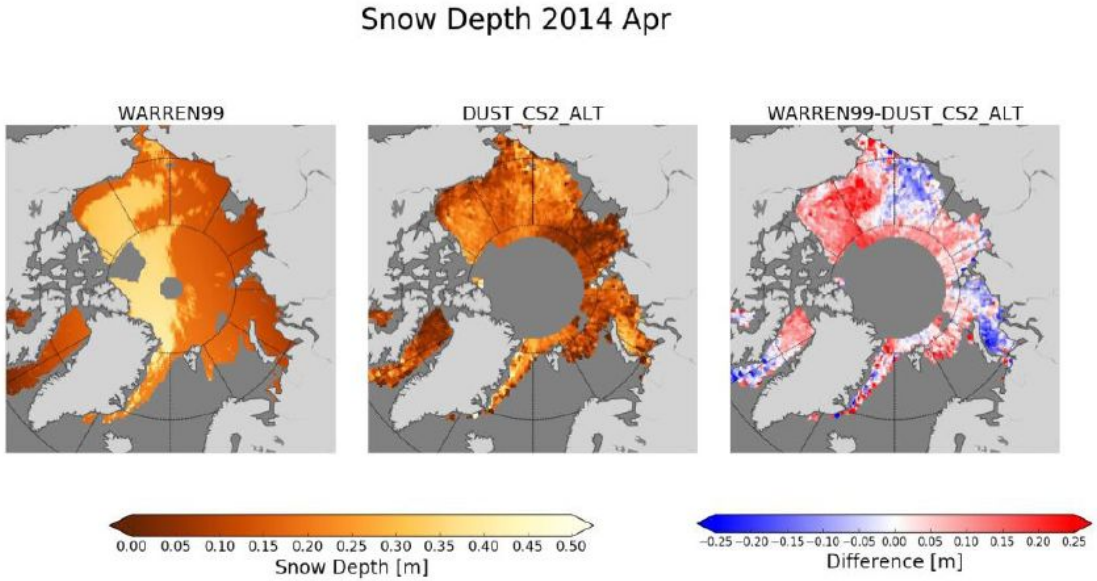


Figure 25: Examples of snow depth from Warren climatology (left), DuST product with CryoSat-2 and AltiKa (middle) and their difference (right).

Empirical of theoretical approach?

Empirical: Take the difference of the two bands, find the empirical relationship with snow thickness, maybe throw in a few waveform parameters and some auxiliary data and use that.

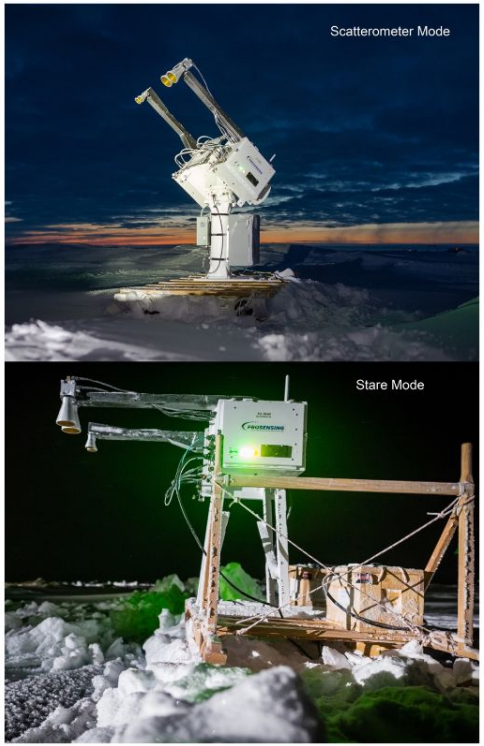
Theoretical: Properly understand the effect of frequency, surface roughness, difference in footprint size, radar penetration, etc.

Snow retrieval (airborne)

Several dual frequency campaigns flown in the past few years, presented in the talks later today.

On sea ice, satellite / airborne colocation is challenging and in-situ measurements expensive!

Snow retrieval (in-situ)



New exciting dataset from MOSAIC (Rosie Willatt's talk next)

KuKa radar setup during MOSAiC, from:
Stroeve, J., Nandan, V., Willatt, R., Tonboe, R., Hendricks, S., Ricker, R., Mead, J., Huntemann, M., Itkin, P., Schneebeli, M., Krampe, D., Spreen, G., Wilkinson, J., Matero, I., Hoppmann, M., Mallett, R., and Tsamados, M.: Surface-Based Ku- and Ka-band Polarimetric Radar for Sea Ice Studies, The Cryosphere, https://doi.org/10.5194/tc-2020-151

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If CRISTAL flies in 2040, what kind of a sea ice product will we build?

- How will sea ice change in 20 years? What uncertainty sources will become more dominant?