The impact of snow products on detecting trends in sea ice thickness during the CryoSat-2 era

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Why does snow on sea ice matter?

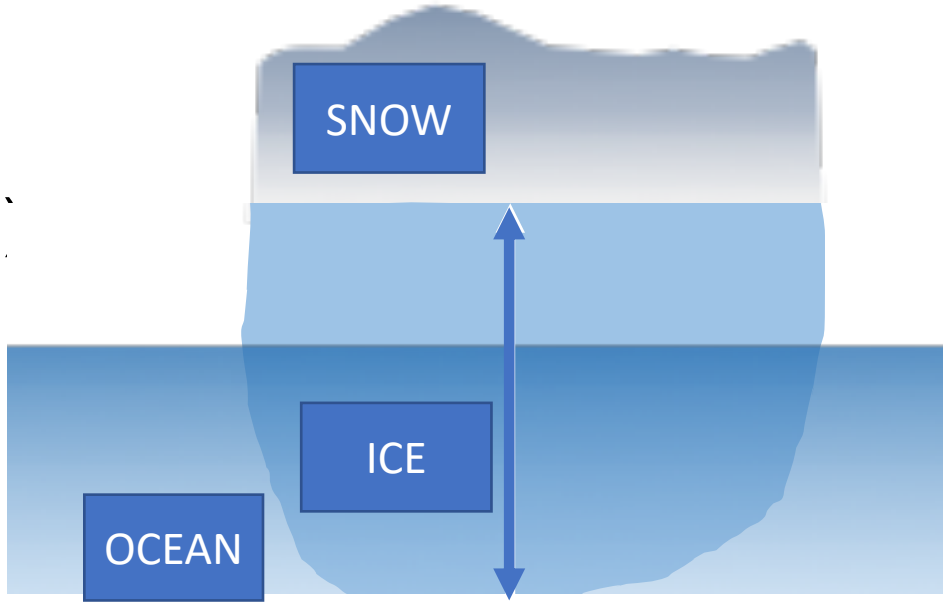
- Surface energy balance (high albedo)
- Summer melt into melt ponds- albedo change
- Insulates ice from low air temperatures, inhibits winter growth
- Affects surface radiative properties (thus modifies remote sensing signal)
- Snow thickness required for freeboard based estimation of sea ice thickness from lidar/radar altimetry

We need to know h_s to calculate sea ice thickness accurately:

$$\text{Sea ice thickness} = \frac{f_i\,\rho w + h_s\,\rho_s}{\rho_w - \rho_i}$$

where:

f_i = sea ice freeboard (= radar freeboard + 0.25 h_s)
ρ_w = sea water density
ρ_i = ice
h_s = snow depth
ρ_s = snow density



Even small errors in h_s can lead to much larger errors in sea ice thickness :

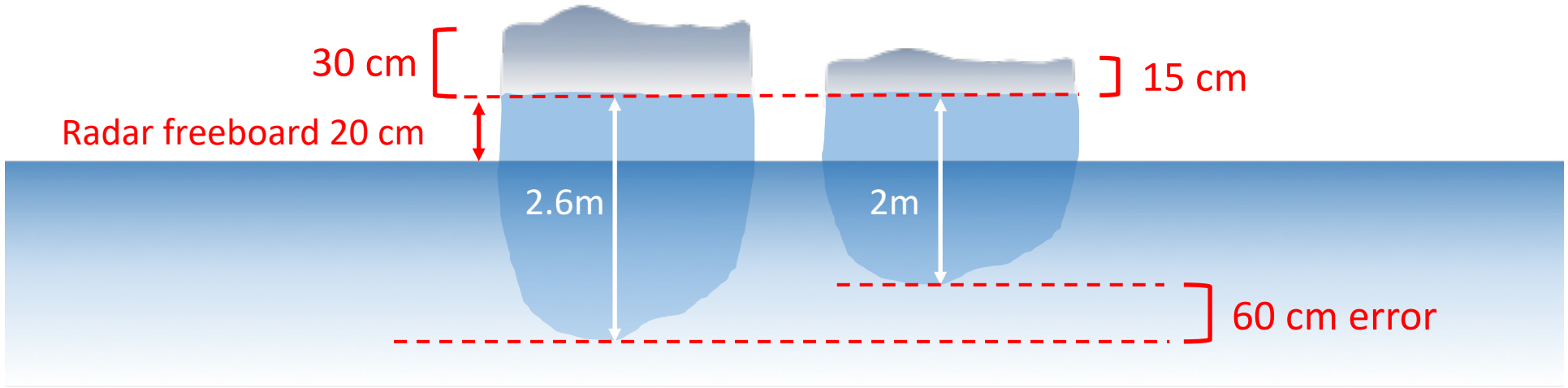
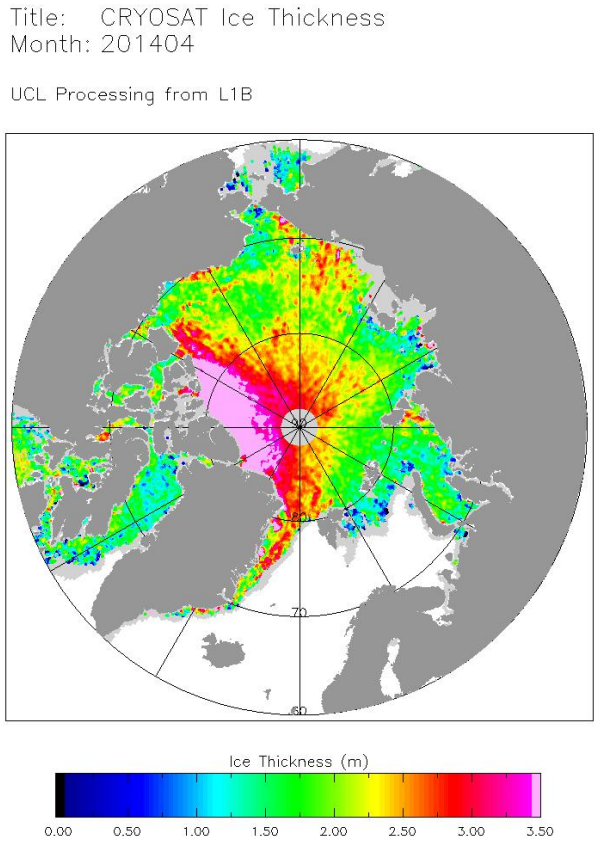
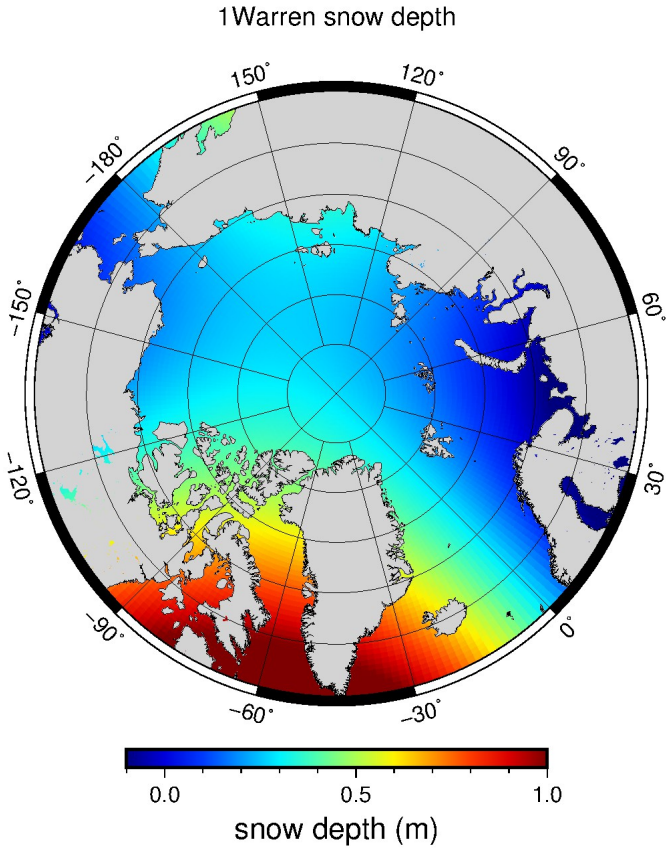


Figure: Isobel Lawrence, University of Leeds

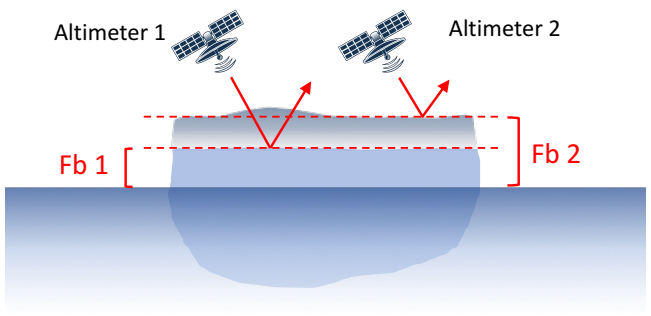
Currently sea ice thickness products use the Warren climatology for snow depth, but the Arctic has changed since these measurements were taken.





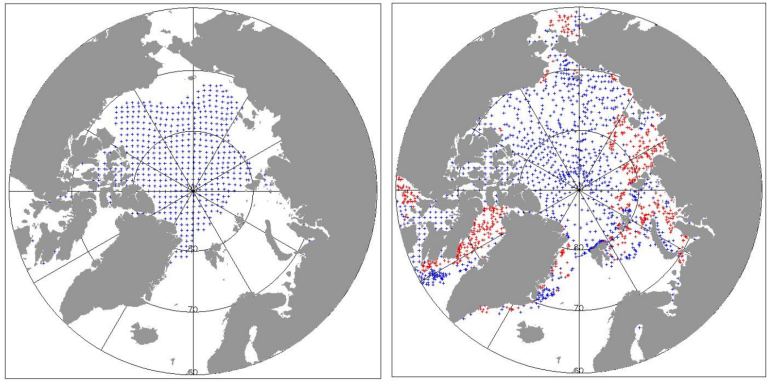
Multiple snow on sea ice products are now being developed to resolve this issue, including:

Dual-altimeter Snow Thickness (DuST)



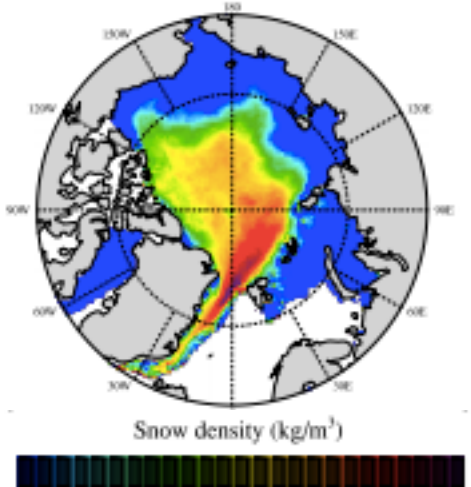
Lawrence et al (2018)

SNODSI



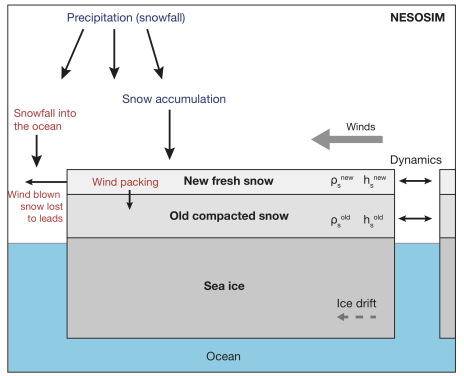
Tilling et al. (in prep)

SnowModel(MERRA2)



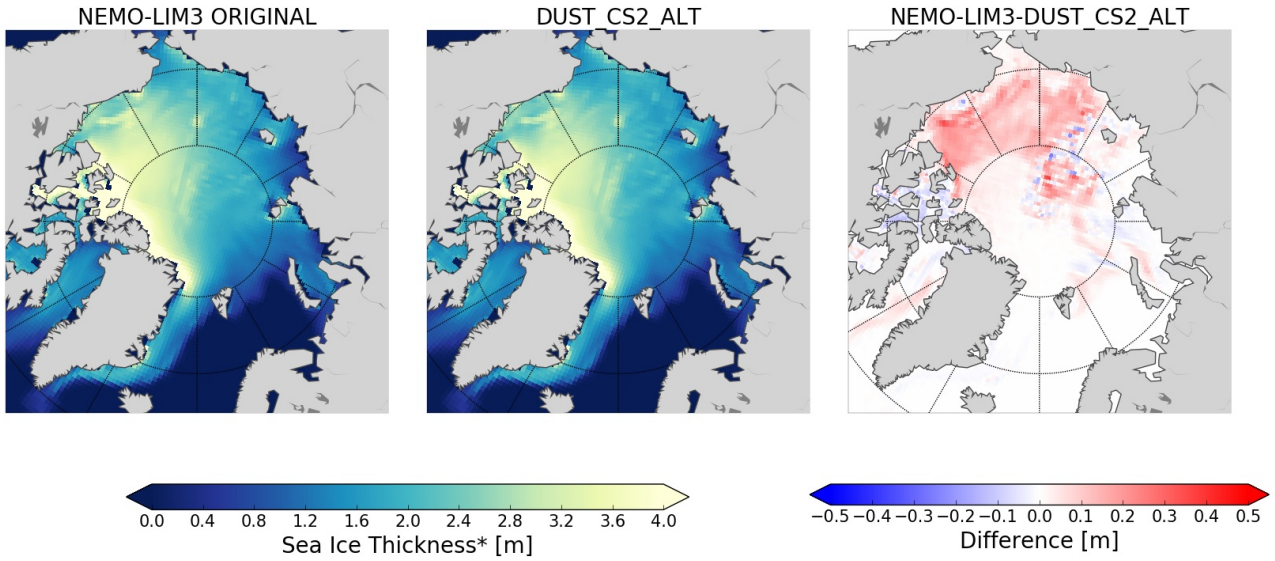
Strove et al. in review)

NESOSIM

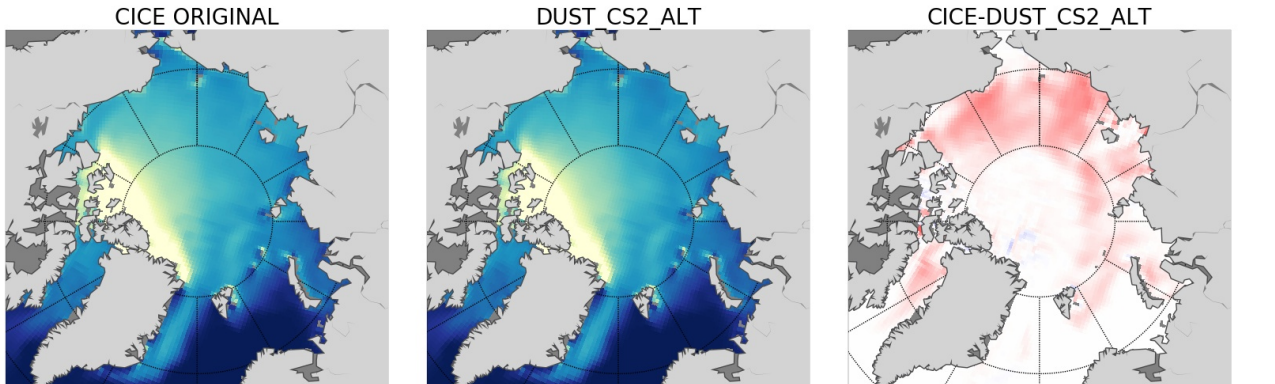


Petty et al. (2018)

Sea Ice Thickness* 2015 Feb-Mar



Sea Ice Thickness 2015 Feb-Mar



Using these new products impacts the sea ice thickness found using models:

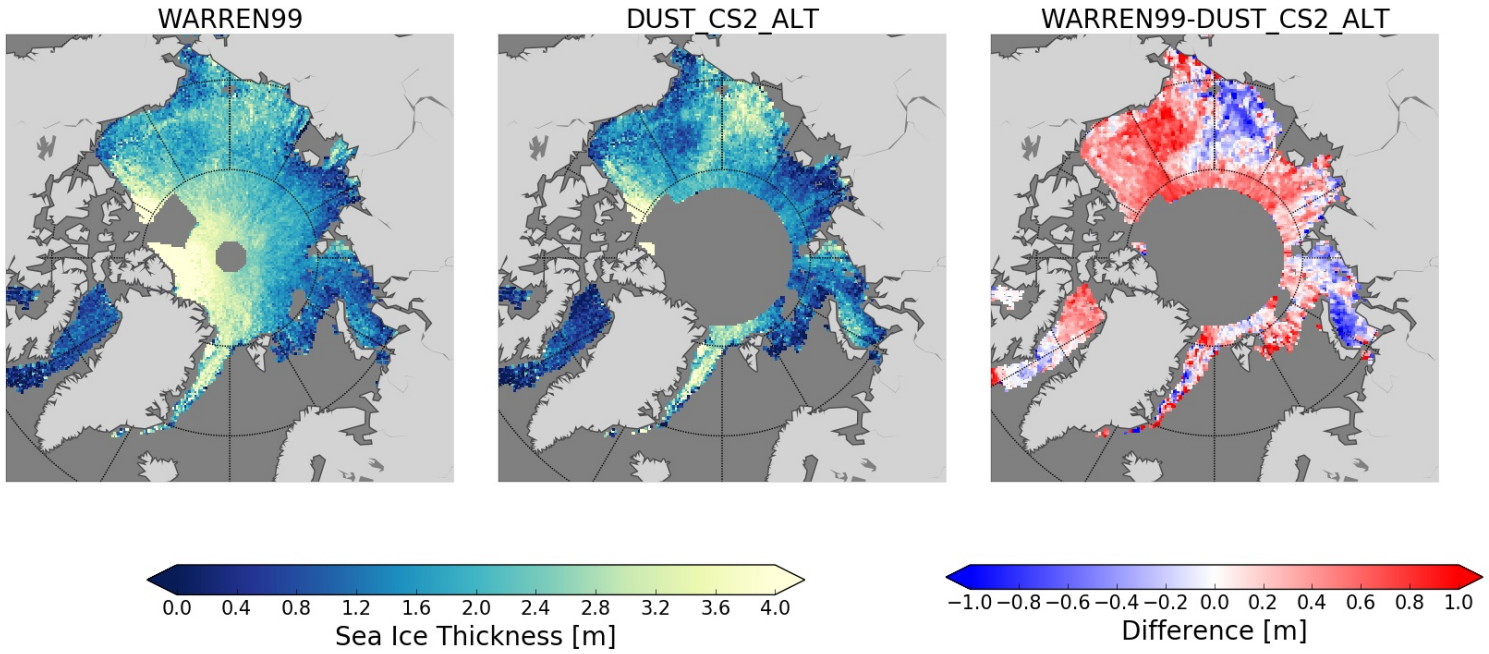
NEMO-LIM modelling studies

2015 Feb-Mar

CICE modelling studies

They also impact sea ice thickness calculations in the radar processing chain :

Sea Ice Thickness 2014 Apr



Pysiral radar processing chain

Conclusions

- Snow products show difference from Warren but more validation data needed
- Clear impact on ice thickness
- Sallila et al (in prep)- snow in sea ice thickness modelling
- Buzzard et al (in prep)- snow in sea ice thickness processing

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