Changing Arctic Ocean NERC

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HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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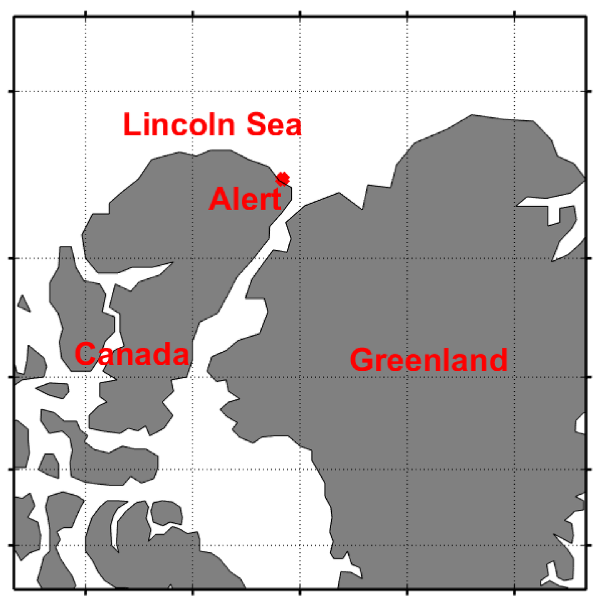
Spectral Light Transmittance through Arctic Sea Ice

Background

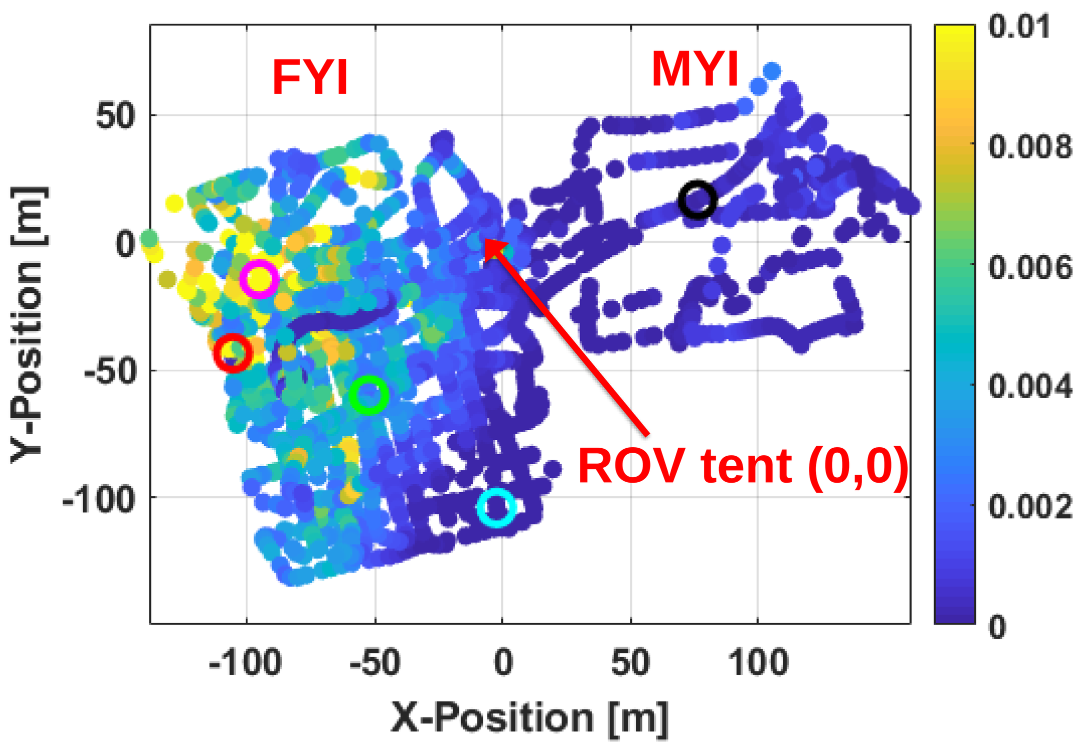
- Light transmittance through sea ice has important impacts on both the ocean heat content and the ice associated ecosystem
- We investigate the solar shortwave radiation transmitted through snow and sea ice and its spatio-temporal variability
- We aim to deduce surface topography and sea ice draft from the spectral transmittance and combine these data sets for upscaling onto the aggregate scale

Light transmittance

- Comparison between First Year Ice (FYI) and Multi Year Ice (MYI) off Alert, Canada (Last Ice Area project)
- Light transmittance is determined using measurements of transmitted irradiance under the sea ice and of incoming irradiance at the surface
- Very low transmittances of 0.2 – 1.0% through FYI and < 0.1% through MYI



Location of the survey area in the Lincoln Sea off Alert, Canada.

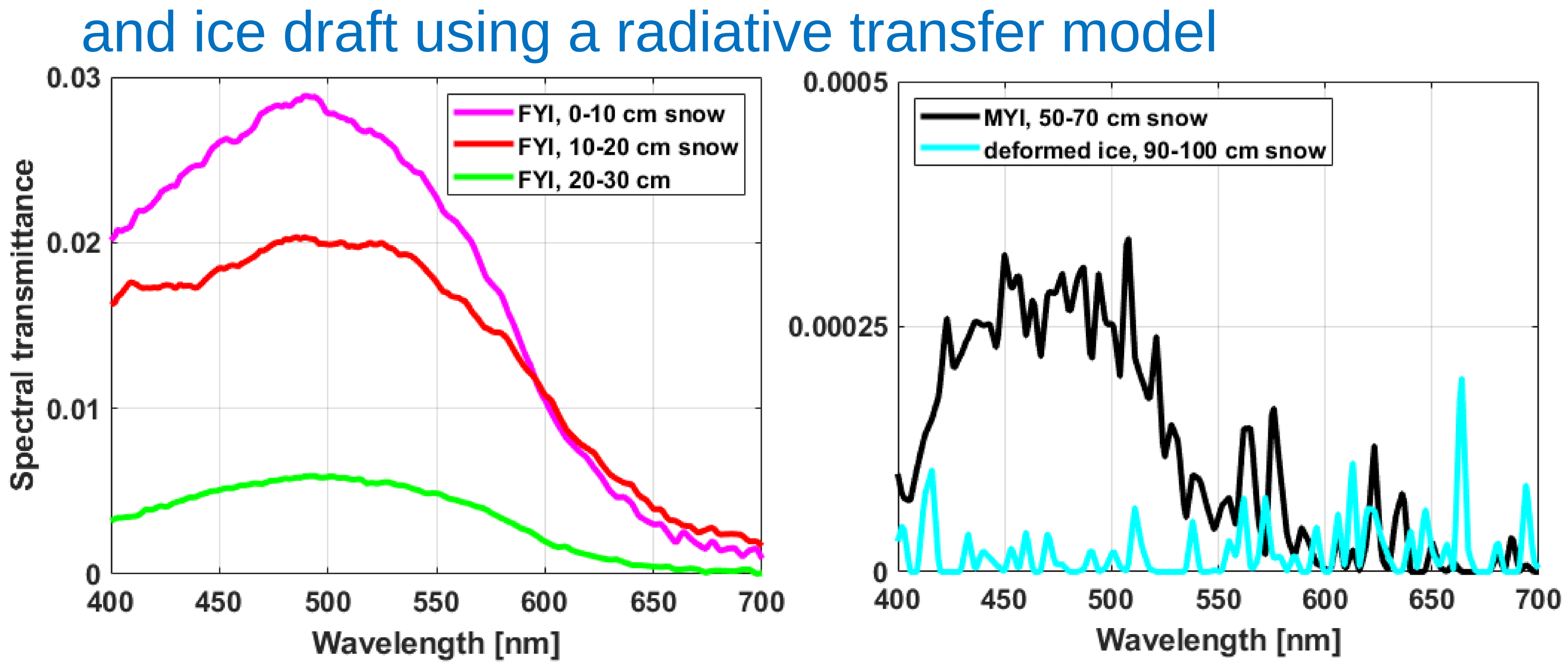


Light transmittance through snow and sea ice as measured off Alert on 17 May 2018.

Research goal

- Development of an algorithm that uses the spectral transmittance data to yield information about the surface topography and the under-ice structure

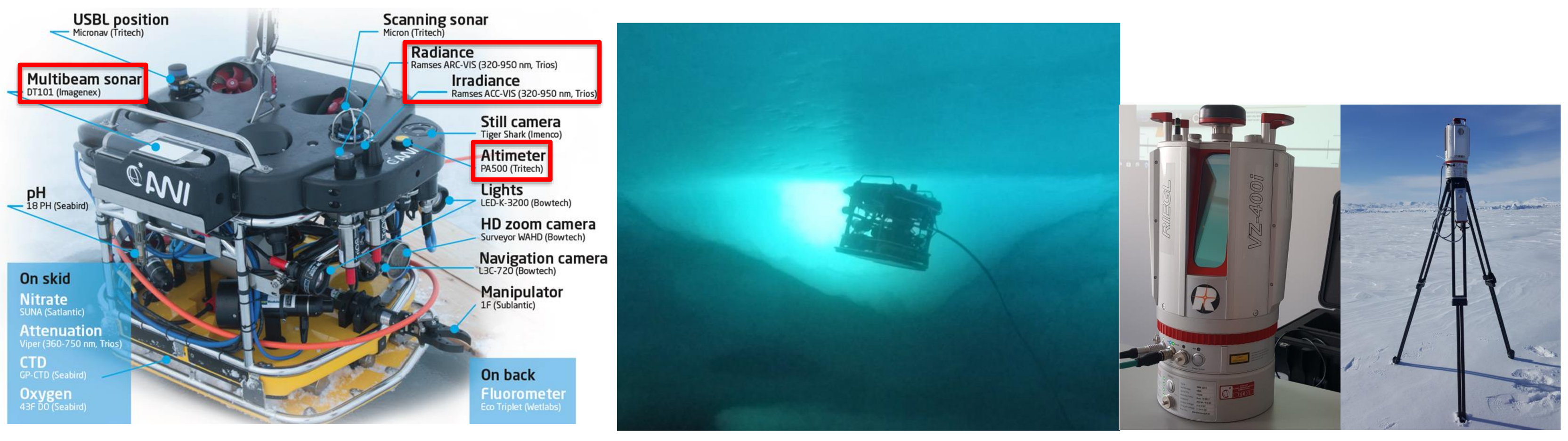
- **Multiplicative exponential function fit** for light transmission: $\sim \exp[-(\kappa_{snow}(\lambda) + \kappa_{ice}(\lambda) + \kappa_{bio}(\lambda))]$
- **Statistical approach**
  calculate normalized difference indices (NDI)
- Generate **synthetic spectra** from surface topography and ice draft using a radiative transfer model



Spectral transmittance as measured on 17 May 2018 off Alert for different ice and snow conditions. The spectra are noisy due to the very low light transmittance.

Methods

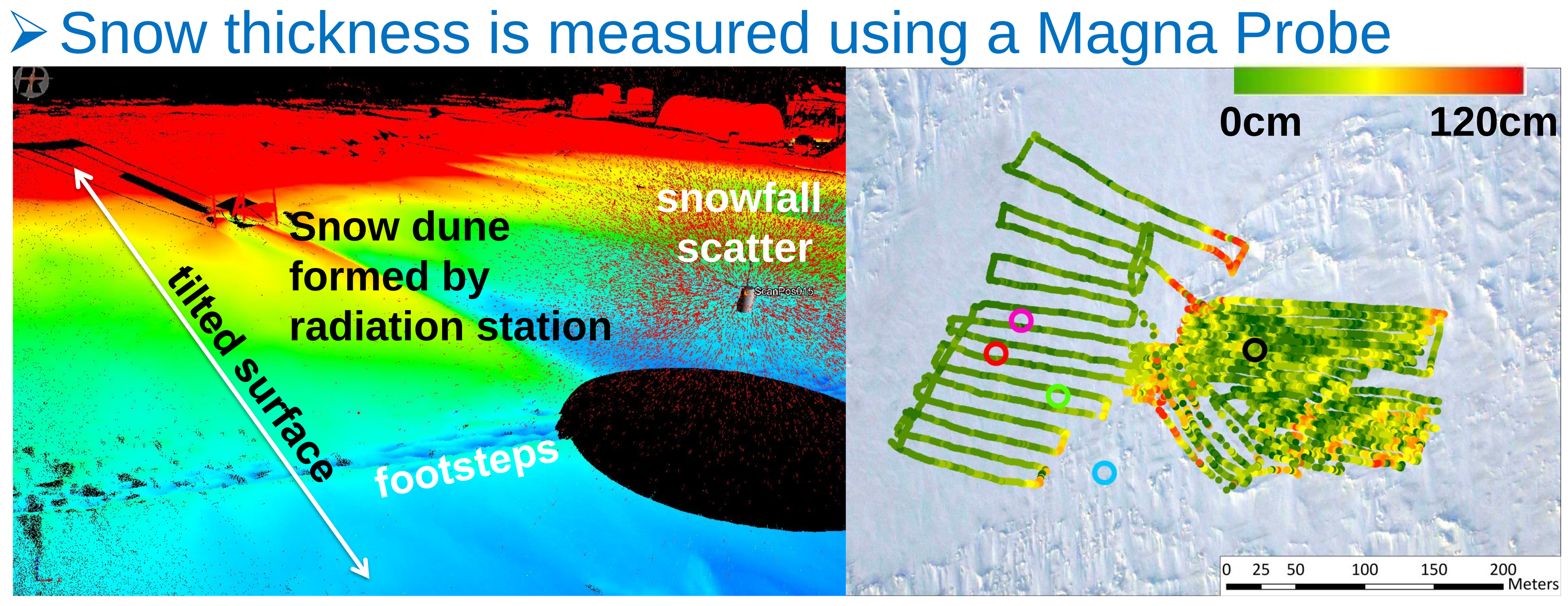
- Spectral radiance (7°) and irradiance (90° cos) are obtained using a Remotely Operated Vehicle (ROV)
- Sea ice draft is measured by a single-beam altimeter / multi-beam profiling sonar mounted on the ROV
- Snow thickness is derived from a Magna Probe and a Terrestrial Laser Scanner (TLS) which emits laser pulses in the near infrared (1550 nm)



From left to right: ROV with scientific payload, view of underside of sea ice, and TLS.

Snow thickness

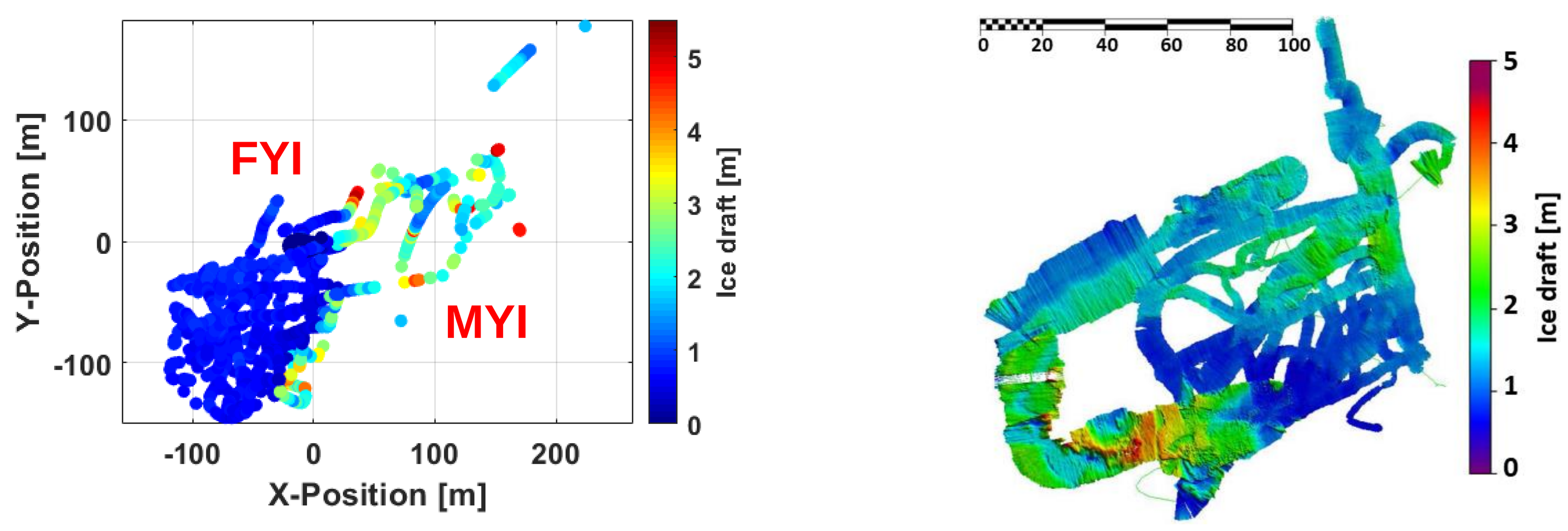
- Snow thickness distribution and temporal change can be derived from TLS scans
- Snow thickness is measured using a Magna Probe



Example surface topography as measured by the TLS off Alert (left) and snow thickness measured using a Magna Probe (right).

Ice draft

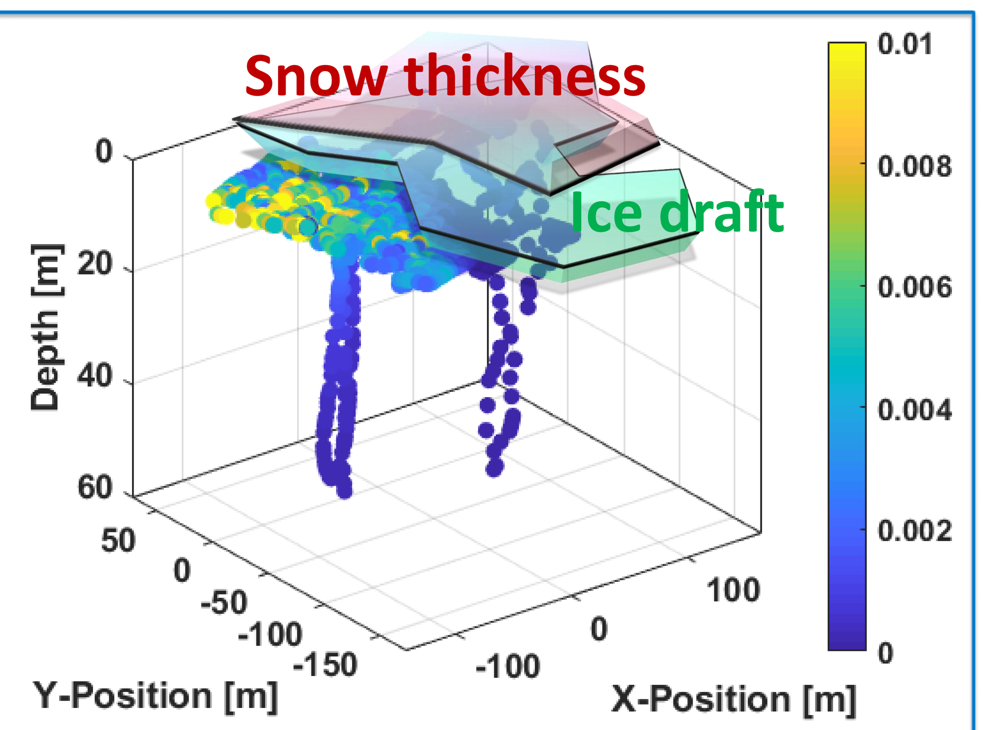
- Level FYI has a continuous thickness of about 1.5 m and structured MYI has thicknesses up to 5.5 m



Under ice draft as obtained by a single-beam altimeter off Alert on 10 May 2018 (left) and example data as obtained by a multi-beam sonar (right).

Combined data set

- Merge snow thickness, ice draft, and light transmittance on same coordinate system
- Allows detailed analyses of how snow and sea ice influences the light transmittance



Light transmittance through snow and sea ice (colored dots) and symbolized snow thickness (red) and ice draft (green).

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Acknowledgments
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