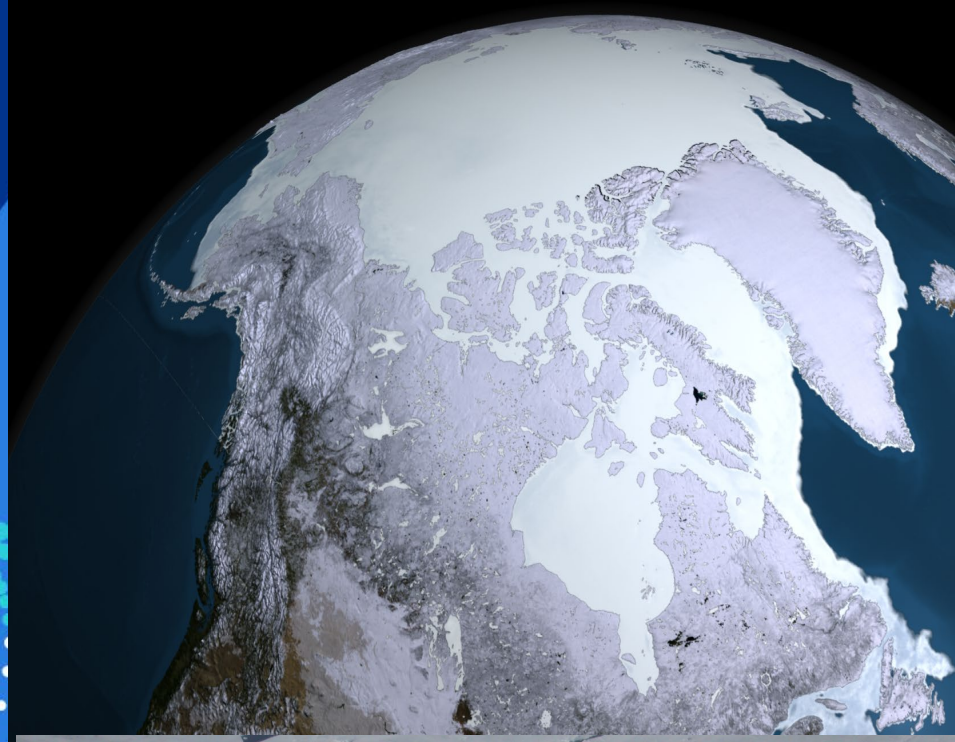
Verisk™ | Atmospheric and Environmental Research

Observing Arctic Ice Leads from ICESat-2



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Christopher Little

CAMAS workshop
02/15/2024

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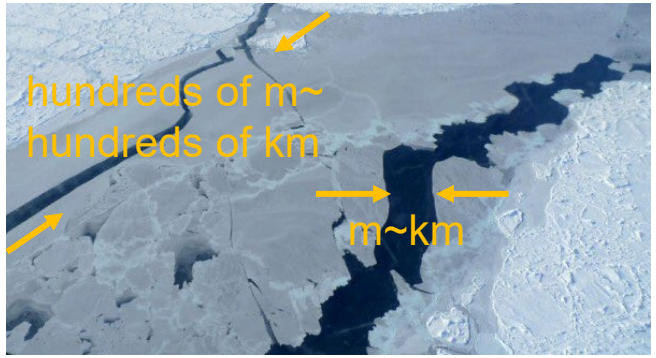
Ice Leads

- Elongated cracks
- Width: m ~ km, Length: hundreds of m ~ hundreds of km
- Formation: by divergence and shear in the ice motions in response to external forcing (winds, ocean currents)



- Ice leads play an important role in climate:
  - vents of heat and moisture exchange
  - sites of gas flux (e.g., methane release)
  - ecosystem (e.g., initiated and sustained the phytoplankton blooms)
  - sites of active mixing (brine rejection)

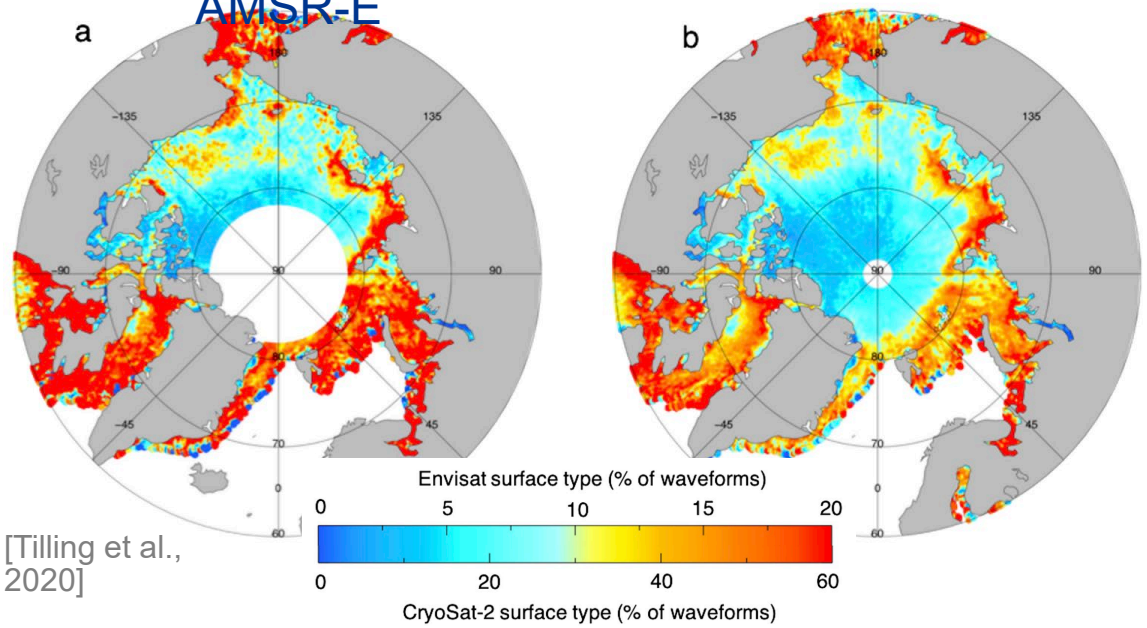
Arctic Ice Leads

- What do we know about Arctic ice leads after satellite era?

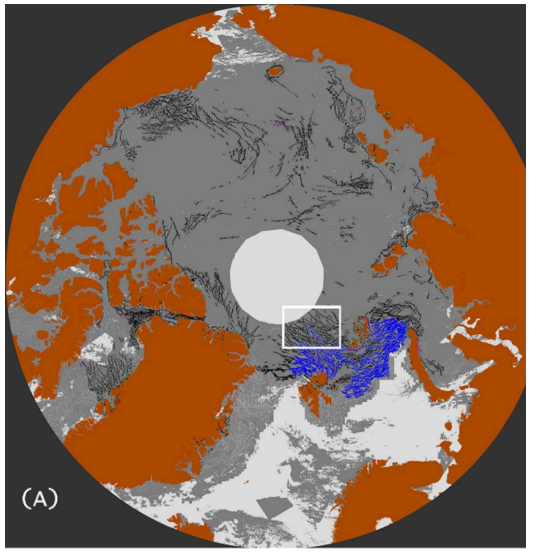
Envisat AMSR-E

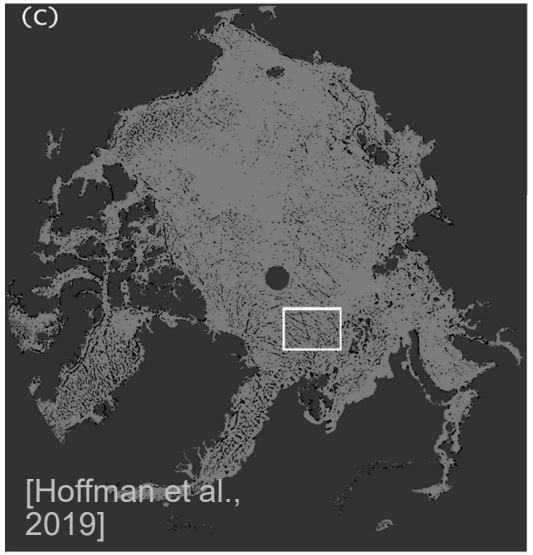
CryoSat-2

MODIS



[Tilling et al., 2020]



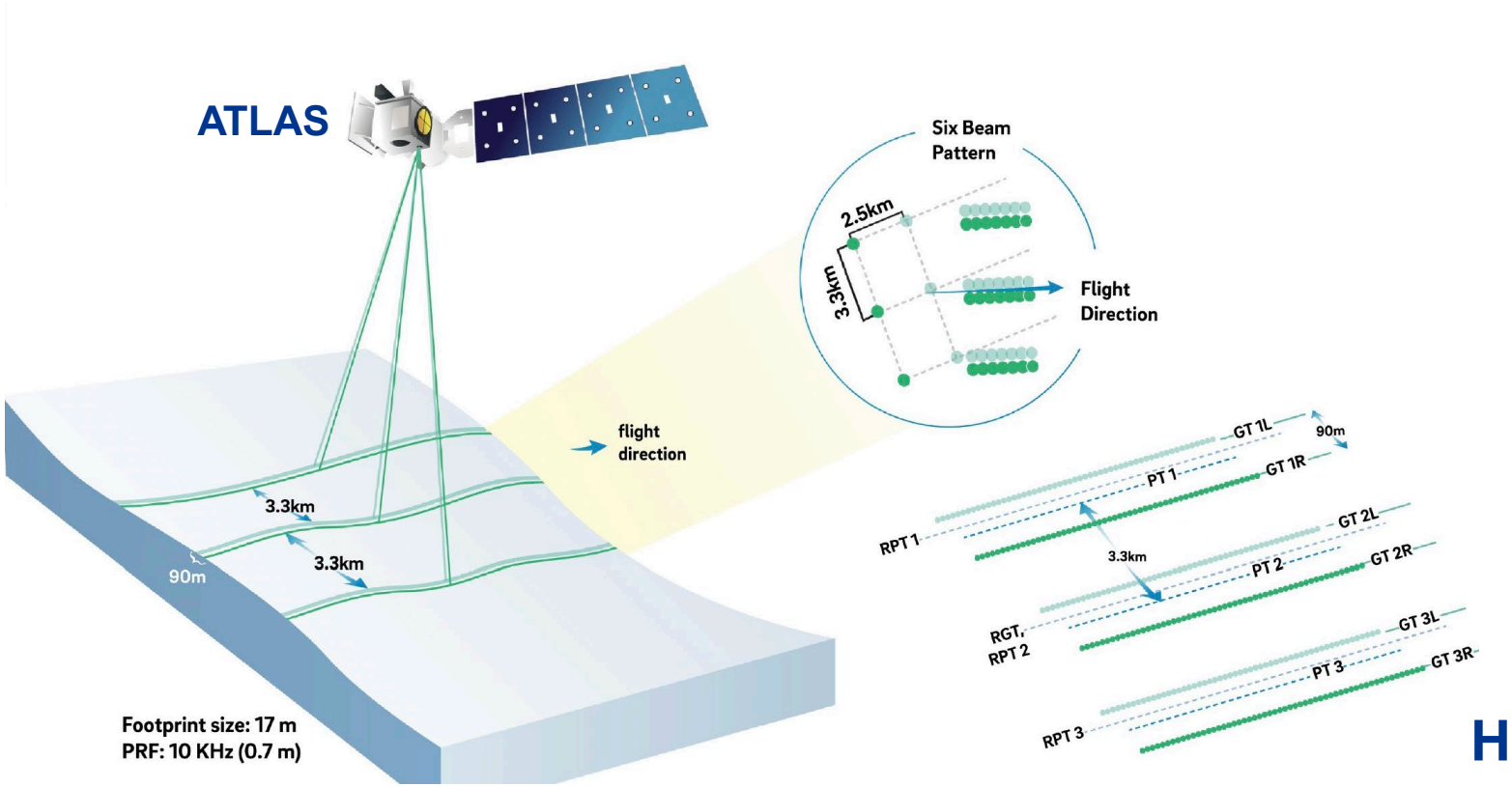


[Hoffman et al., 2019]

- spatial pattern: largest lead fraction/frequency in ice marginals
- magnitude: large discrepancy between products/algorithms
- resolution: 250 m ~ 1 km

Ice Leads – ICESat-2

- Ice, Cloud, and Land Elevation Satellite-2
  - collects elevation data from different surfaces



[Smith et al., 2019]

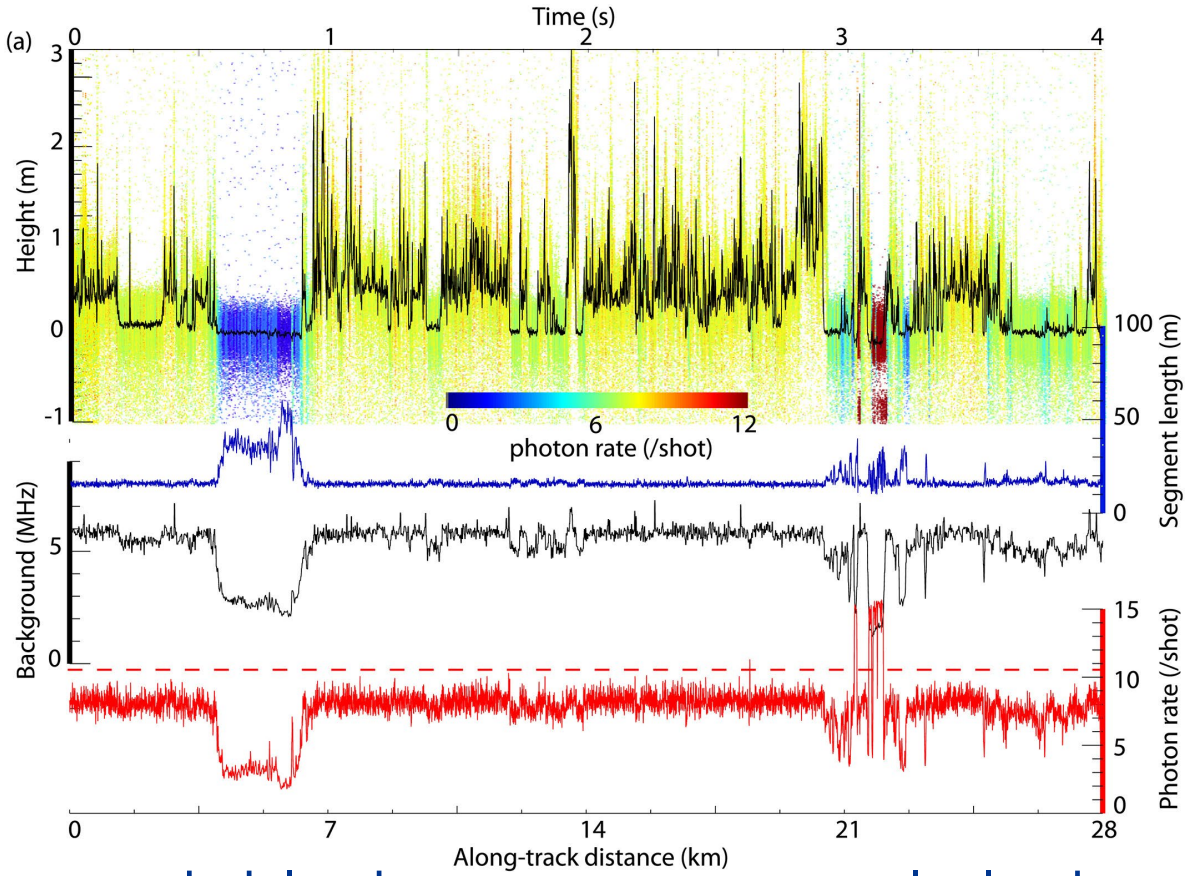
- emit 6 beams of laser pulses
- 3 pairs of strong-weak beams
- 10,000 pulses/sec; 200 trillion photons/pulse; ~12 photons returns
- 88S to 88N
- 15 tracks/day
- total of 1387 tracks
- 91-day revisit

Height of each individual photon with resolution < 1m!

Ice Leads – ICESat-2

- ATL07: along-track sea surface and ice height and type

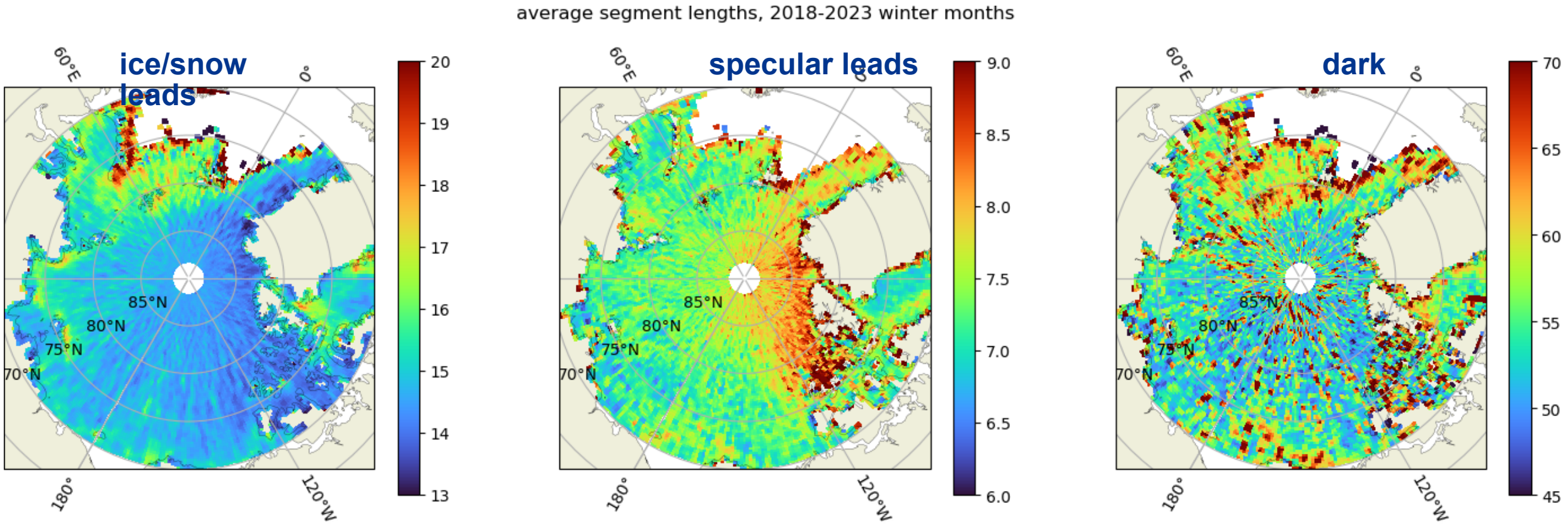
- each segment aggregates 150 photons, segment length varies
- use statistics based on histogram (widths, height, etc.), background photon, photon rate to identify segment type (ice/snow, leads)



[Kwok et al. 2015]

Ice Leads – ICESat-2

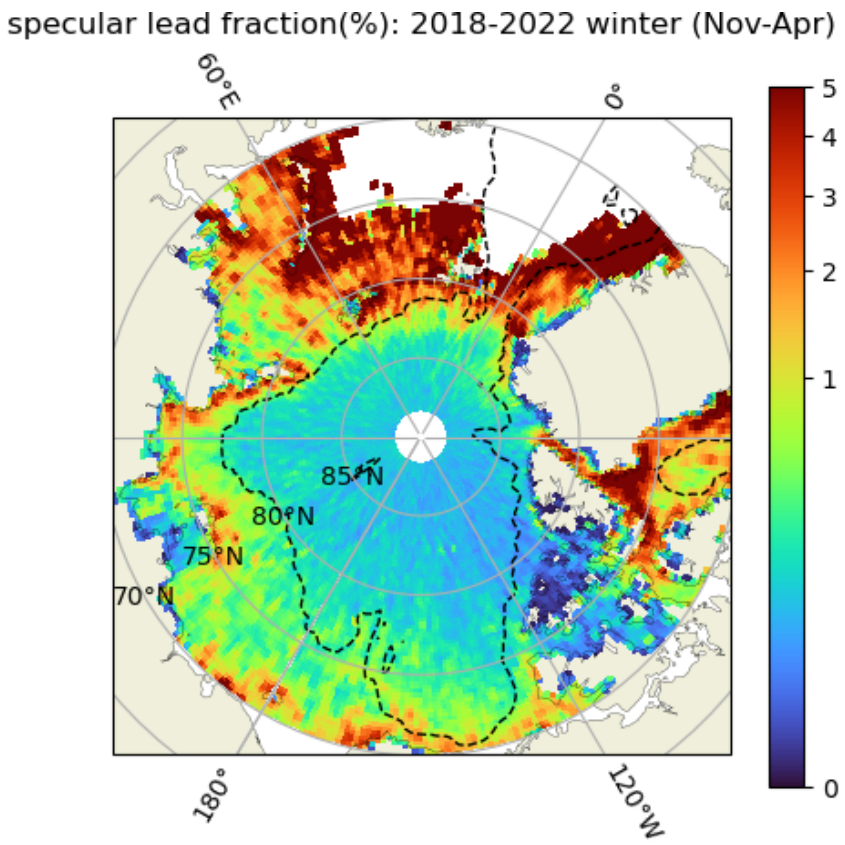
- Average segment length (resolution):

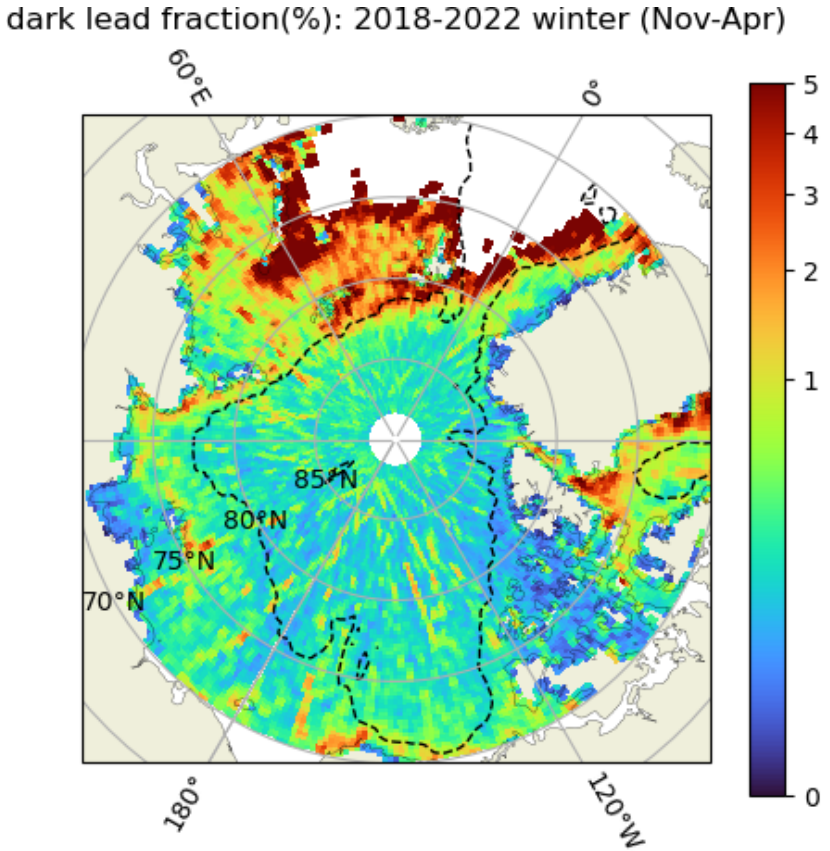


  - we can resolve leads with scales of a few meters

Ice Leads – Lead statistics

- Lead fraction:





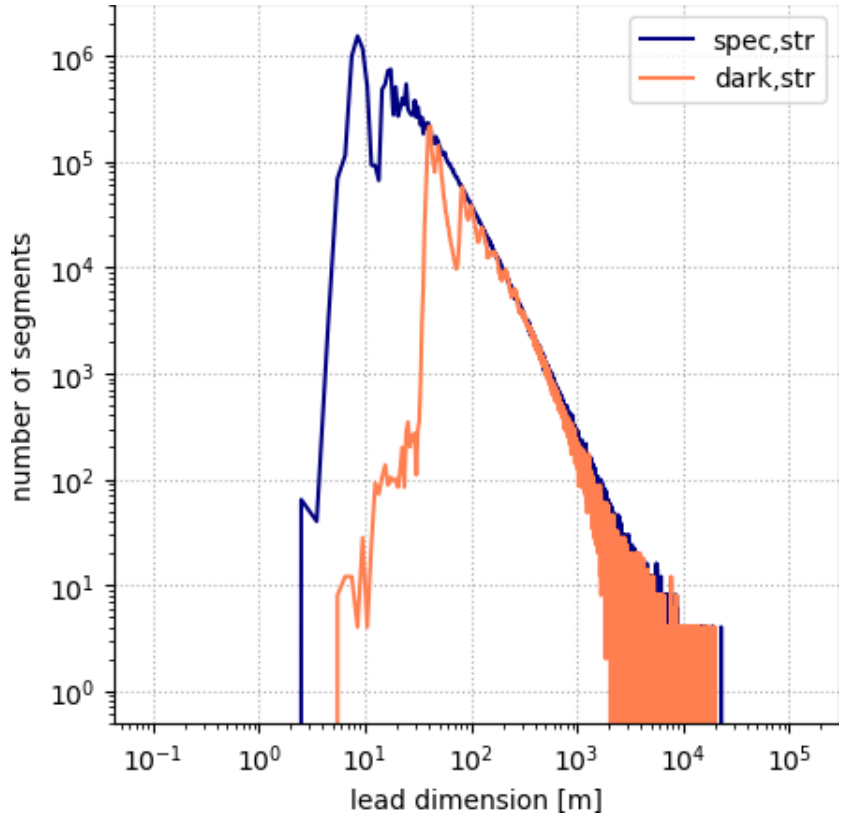
$$F_L(x, y, M) = \frac{\sum_{i=1}^{N_L} l_L(i)}{\sum_{i=1}^{N_{all}} l_{all}(i)}$$

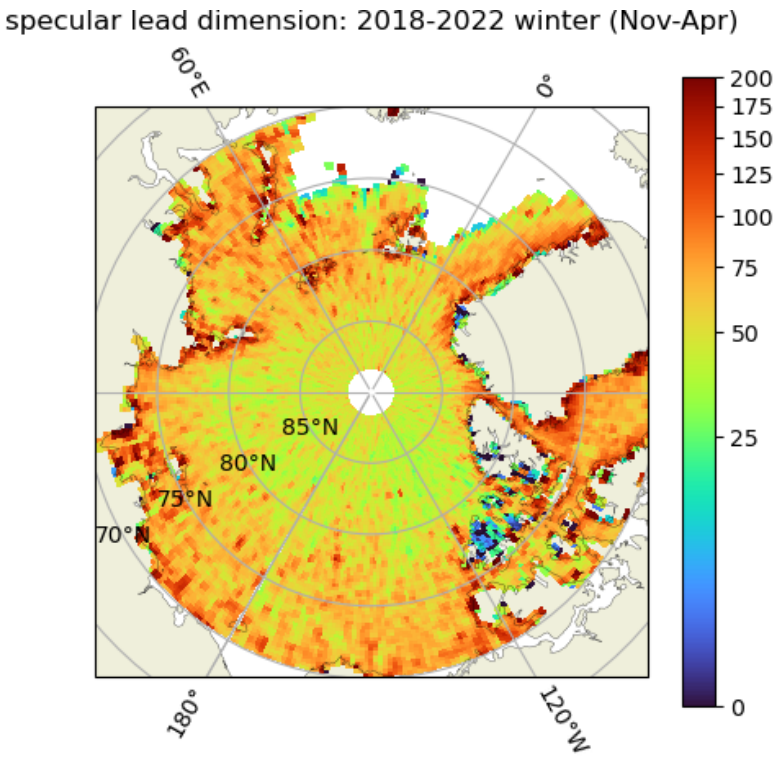
mean:
1.57%
1.11%

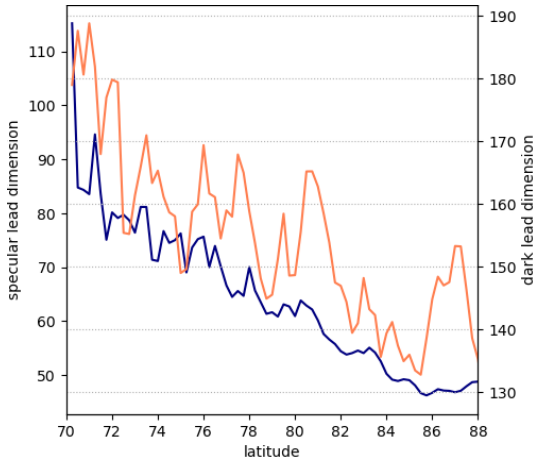
- Lead fraction roughly follows bathymetry, suggesting the role of the associated ocean currents and/or tides/waves.

Ice Leads – Lead statistics

- Lead dimension:



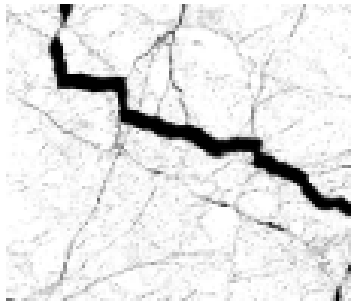


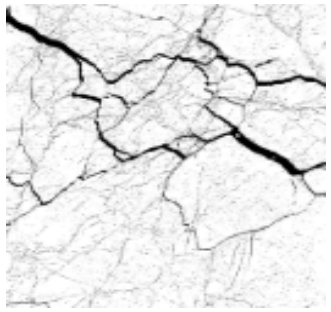


- Lead dimensions are power law distributed, down to <10 m.
- Lead dimensions decrease with latitudes.

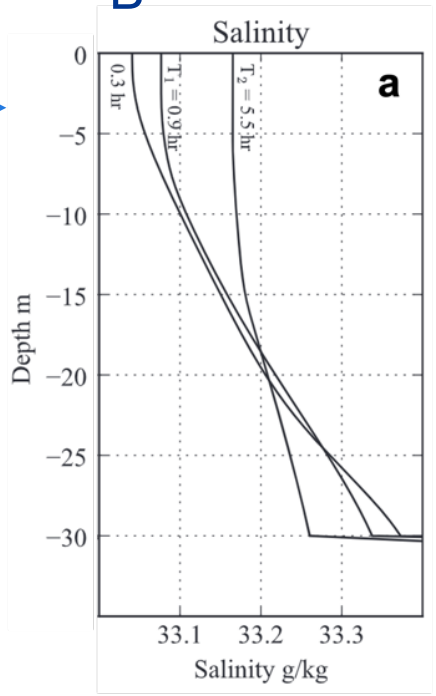
Ice Leads – Lead statistics

- Future work:
  - mechanisms of Arctic leads distribution
  - impacts on the upper ocean
  - model parameterization



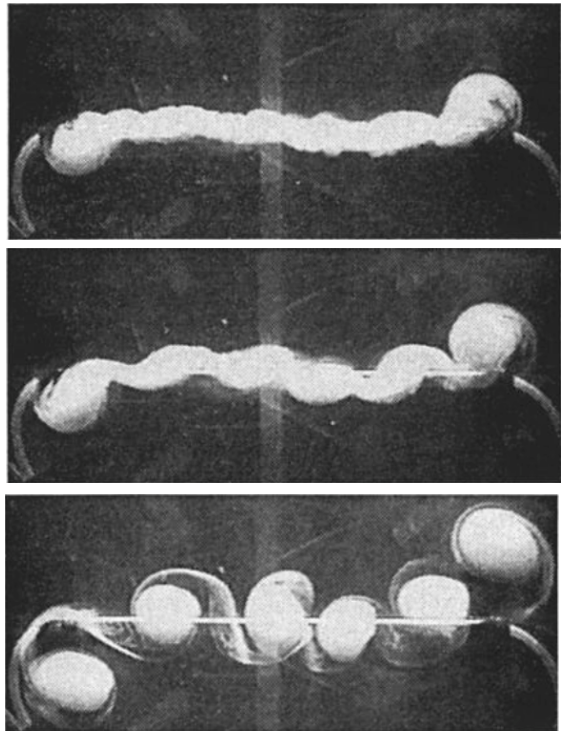


scenario A
B



[Heorton et al. 2017]

scenario



[Bush et al. 2000]

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Thank you!

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