DTOp: Arctic Case Study

Einar Ólason, ***Anton Korosov****, Jonathan Rheinlænder, and Julien Brajard*

Nansen Environmental Remote Sensing Center, Bergen, Norway

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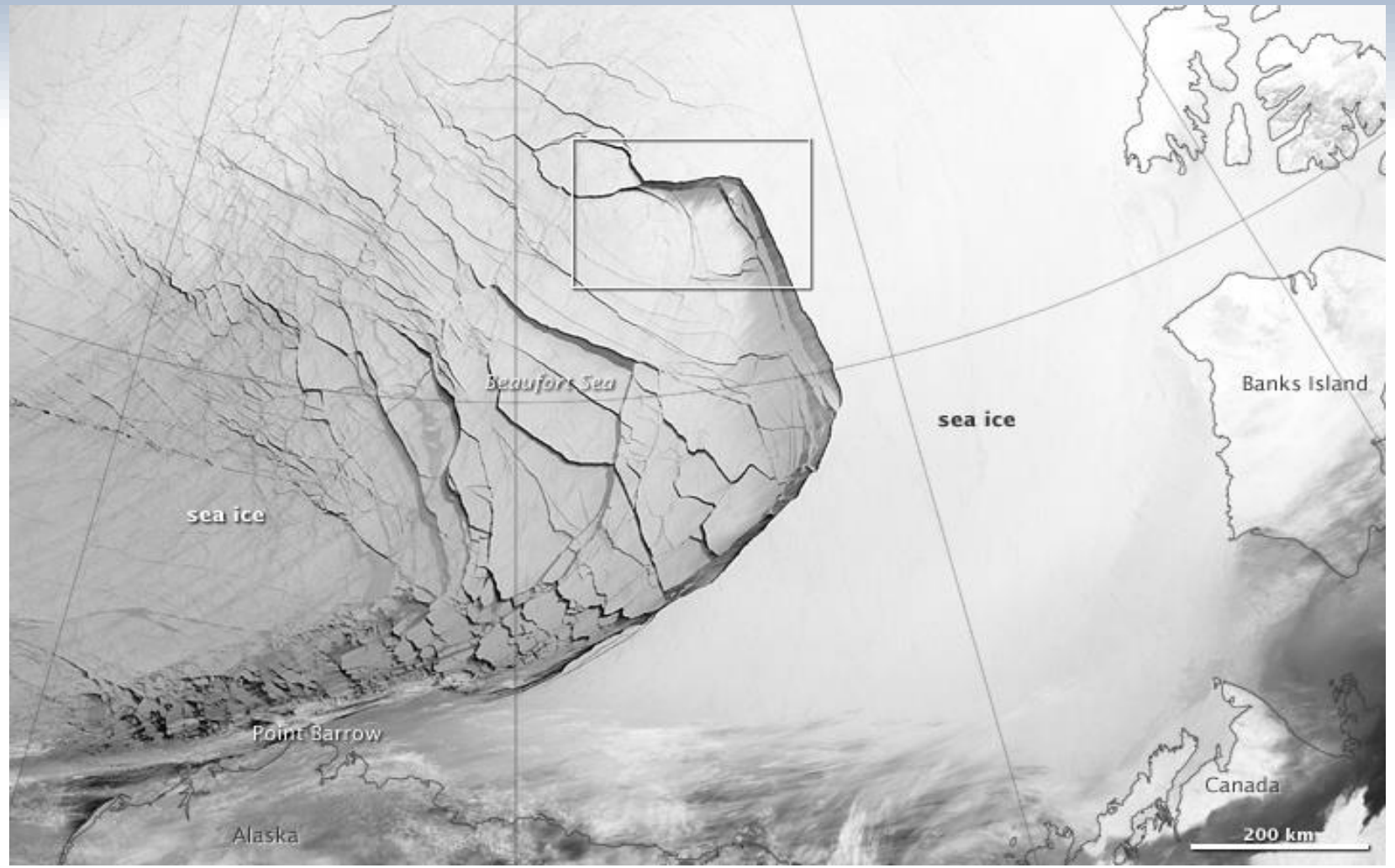
Sea-ice break-up in the Beaufort Sea in 2013



1. In 2013 an extreme break-up event occurred in the Beaufort Sea , mid-winter.
2. The event can be characterised by large arc-shaped fractures.
3. The break-up started in late January at Point Barrow off the Alaskan coast and gradually propagated east towards Banks Island.

Objective

Sea ice breakup events are striking and impossible to simulate without the advanced model and data combination that constitutes the DTE.

Breakup events drastically change the energy balance at the air–ice–ocean interface. Their presence may influence weather and climate in the Arctic and beyond. So far, this effect is not estimated.

Our goal

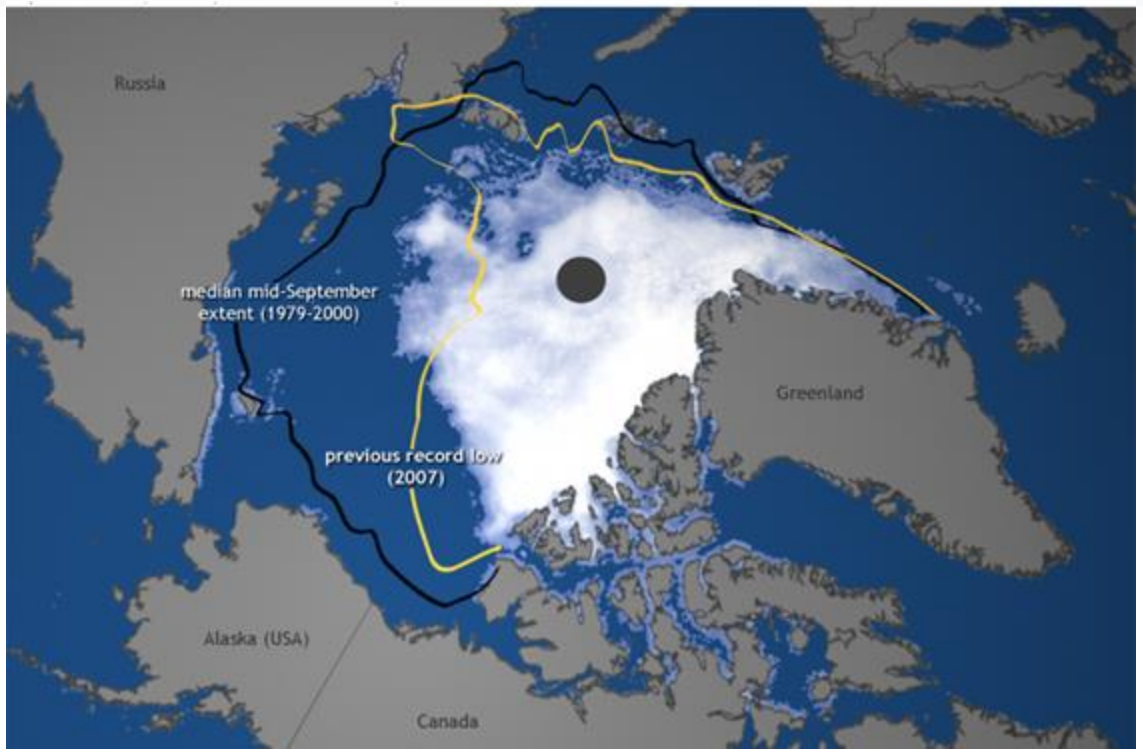
To illustrate reconstruction of Earth systems process by a satellite data driven model with focus on the ice-breakup and impact on sea ice-growth feedback.

Precursor structure

1. Physical modelling of a ice breakup
2. ML methods to determine weak ice
3. Presentation and outreach

What factors influenced the break-up?

Record low sea ice extent

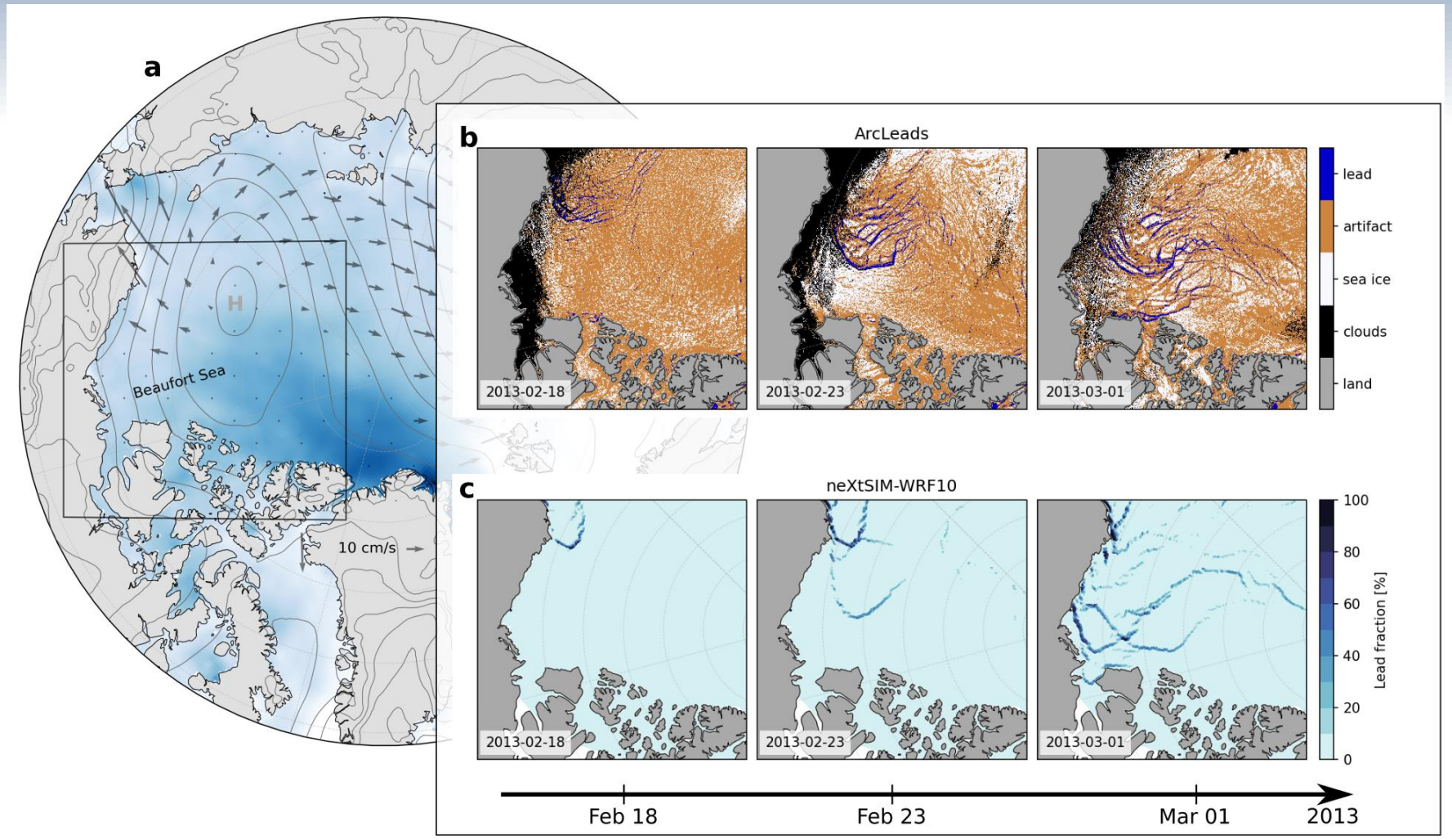


=> Record low sea-ice extent in fall 2012 leads to thin ice in the Beaufort Sea in 2013

Extreme Arctic storm event

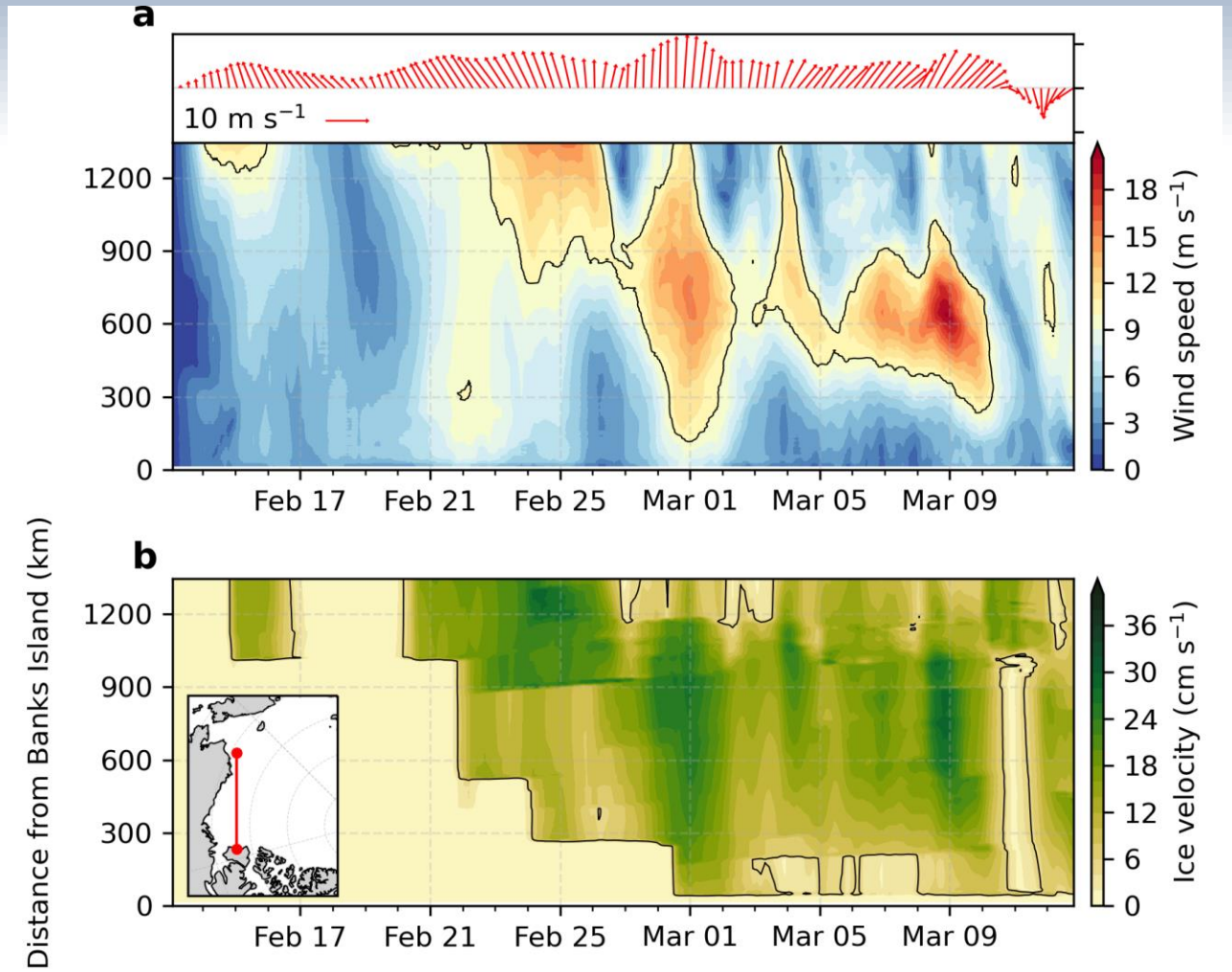
=> Strong winds associated with a persistent anti-cyclone over the Beaufort Sea in February—March

Observed and simulated lead formation



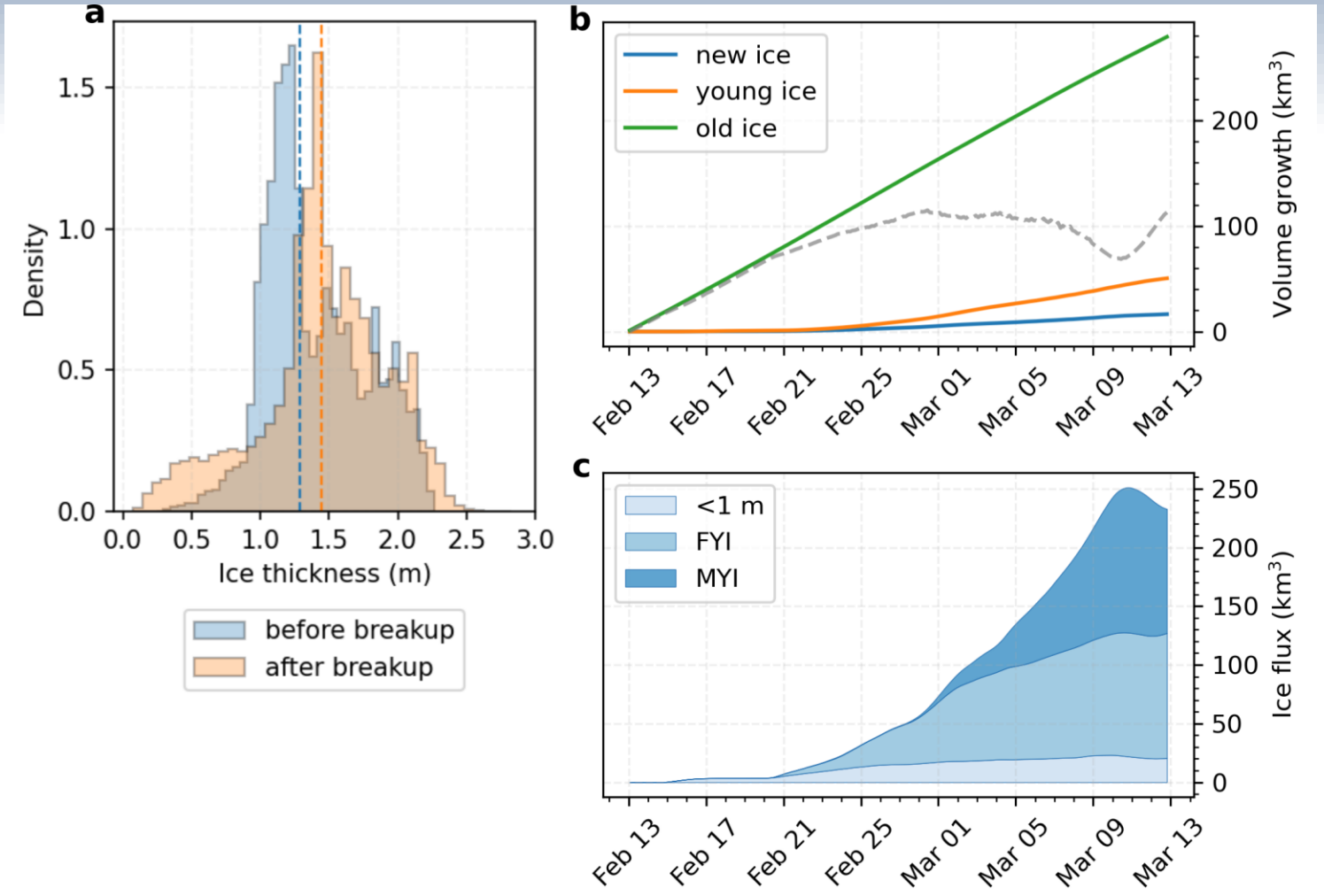
Qualitative comparison of observed and modelled lead fraction is very reasonable.

Strong winds break up the ice cover



- Strong winds break up the ice — once a wind speed threshold is exceeded
- This results in a step-like behaviour in the break-up

Thin ice replaces thick

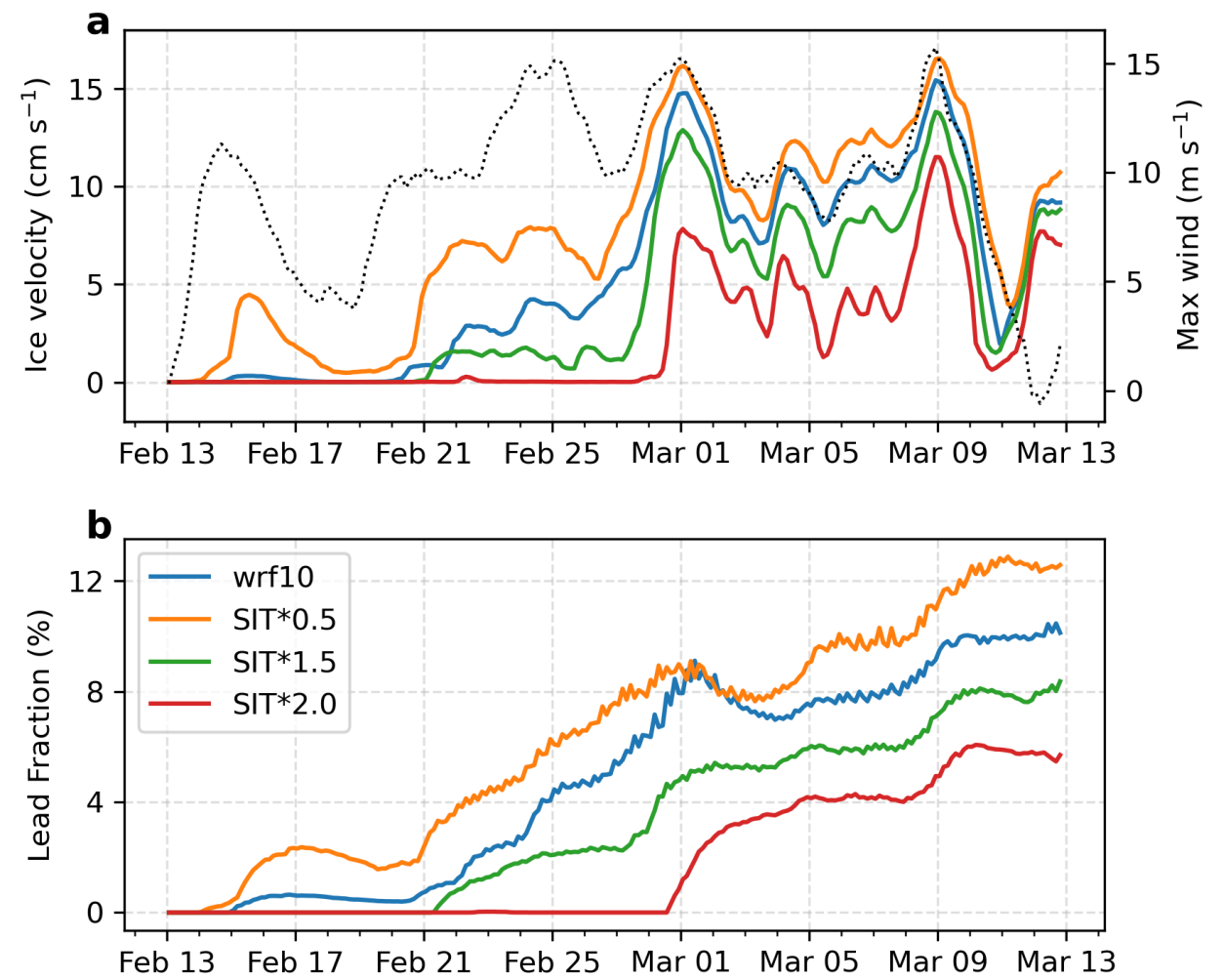


a. A large amount of thin ice is created in the leads

b. The total volume growth is still dominated by old-ice growth

c. A large amount of thick ice is exported from the region, to be replaced by thin ice.

What if … the ice was thicker/thinner?



- Thick ice (red) still breaks up – but the drift is slower and increase in lead fraction is lower
- Thin ice (orange) breaks up much more easily and the lead fraction is substantially higher
- The red and orange lines are representative of pre-industrial and future-climate scenarios

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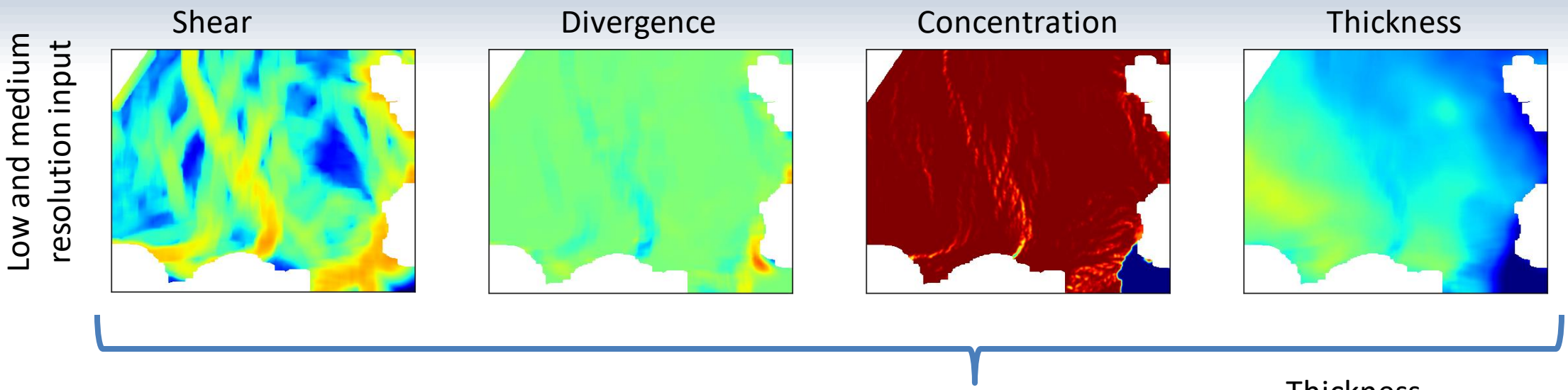
Super resolution of ice thickness

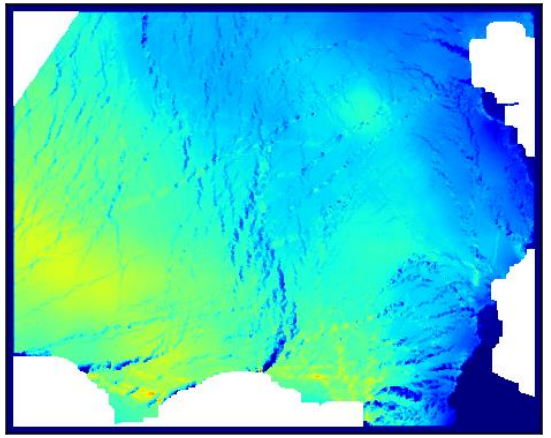


- Deformation alters concentration and thickness
- Use this to get higher resolution thickness from a low resolution source

⇒ Use neural network to deduce thin ice areas
  - Train with model results
  - Apply on observations

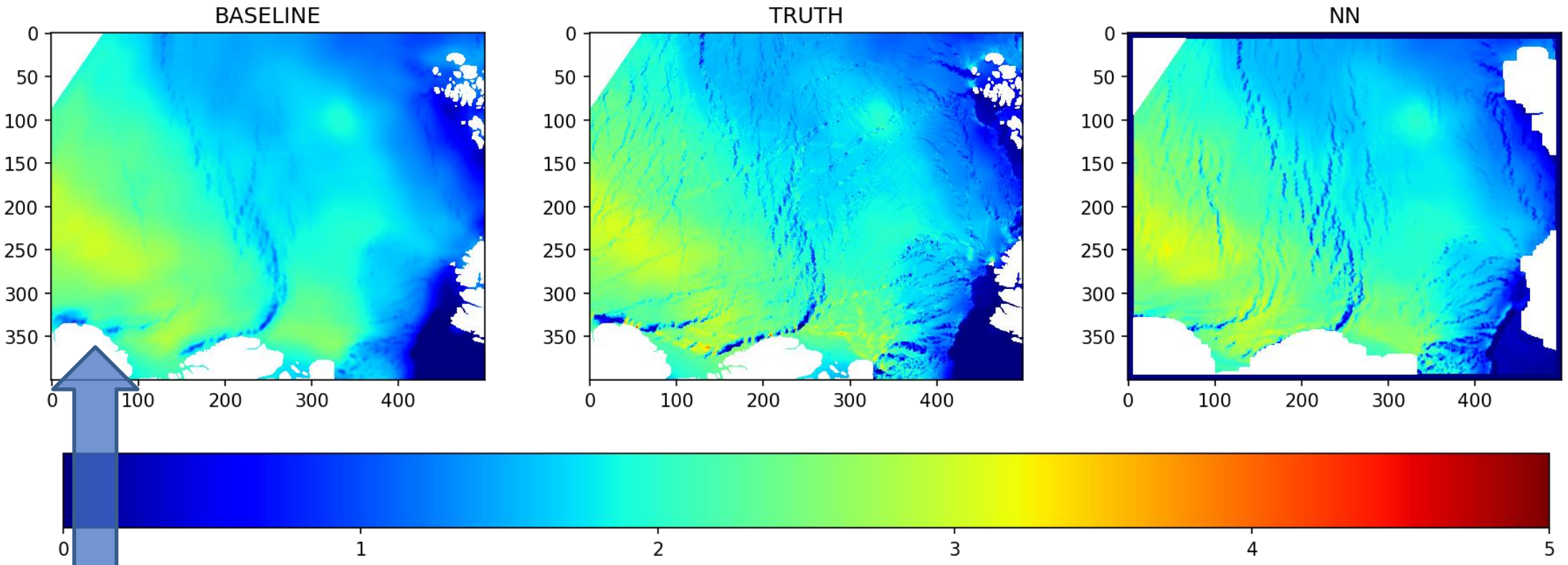
Neural Network

Thickness



NN vs. a simple base line

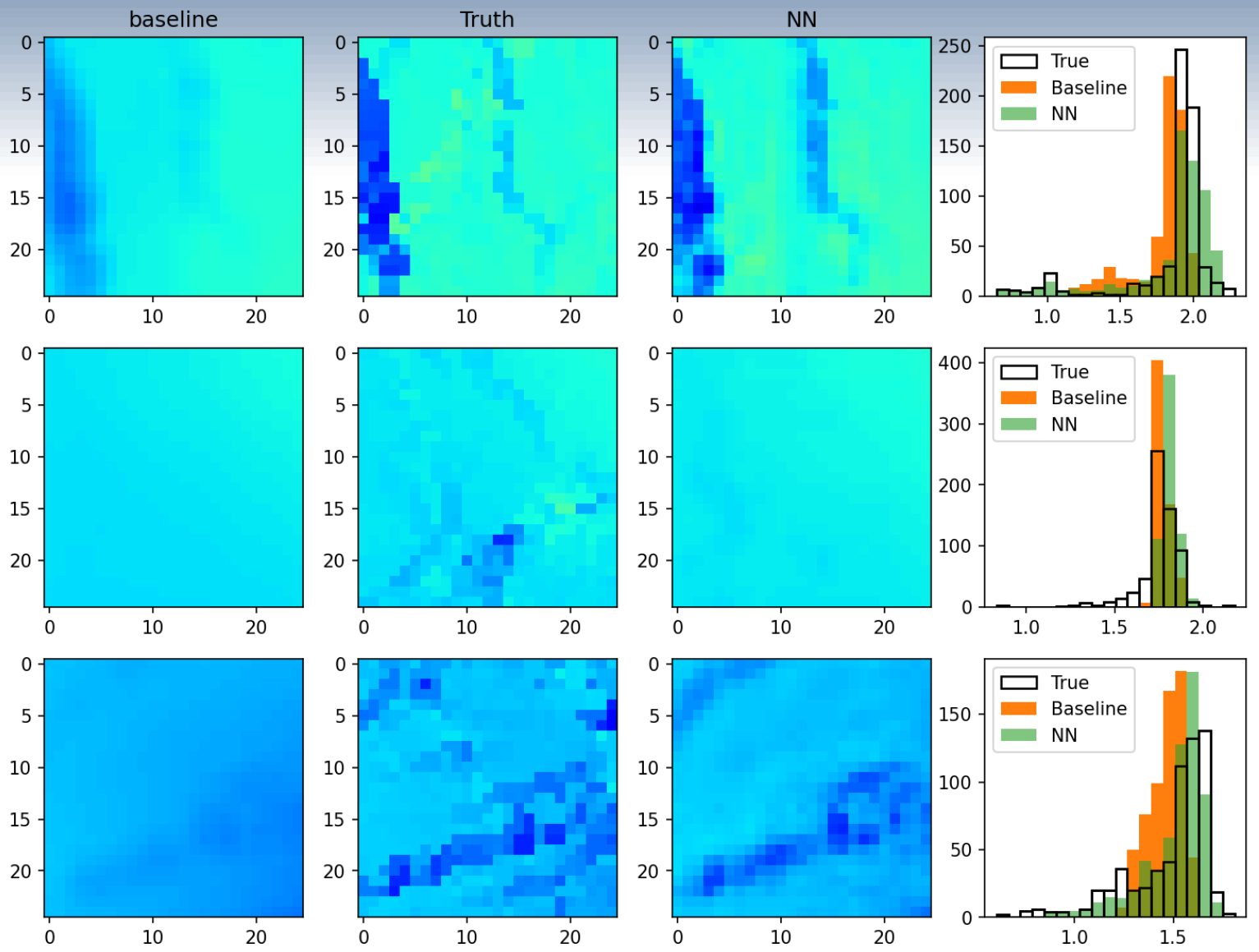
Thickness



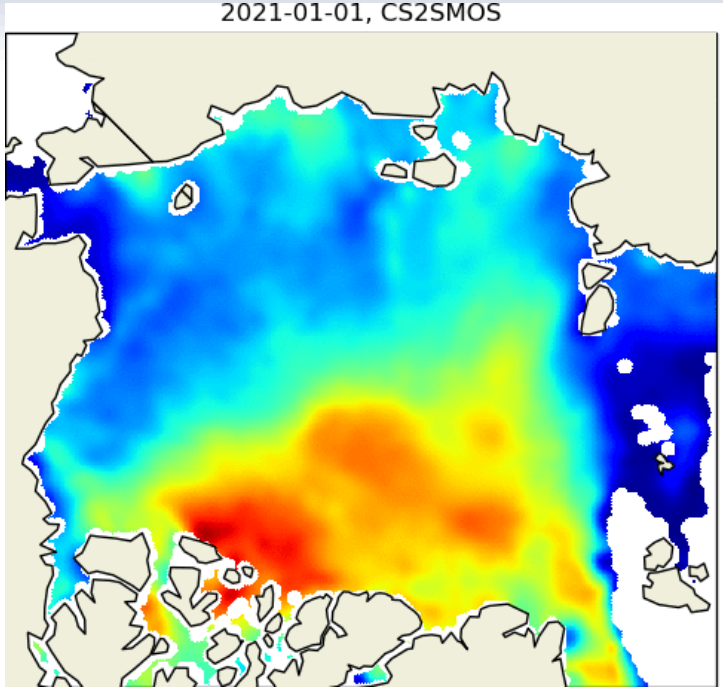
Baseline = Low resolution thickness x medium resolution concentration

Zoom at super-pixel resolution

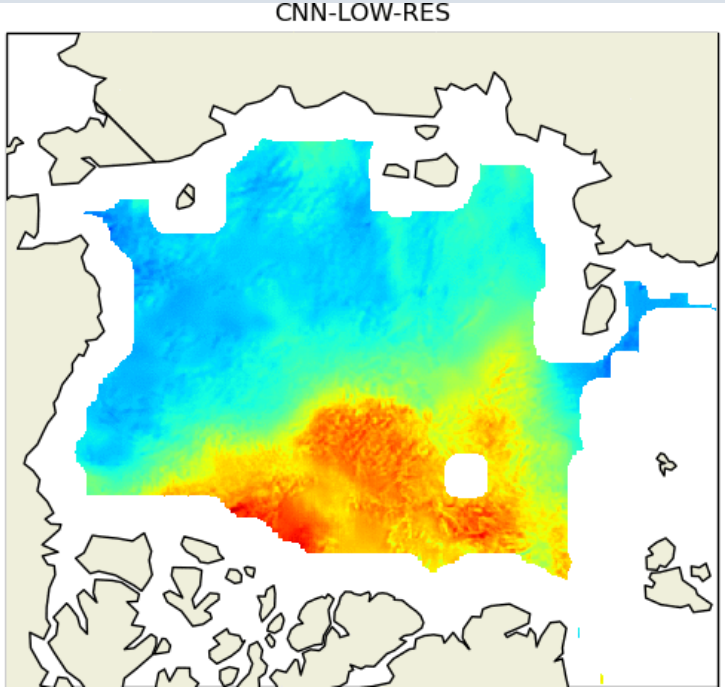
- The area here is equivalent to the size of a low-resolution pixel
- The NN can reproduce better the very high and low portions of the PDF



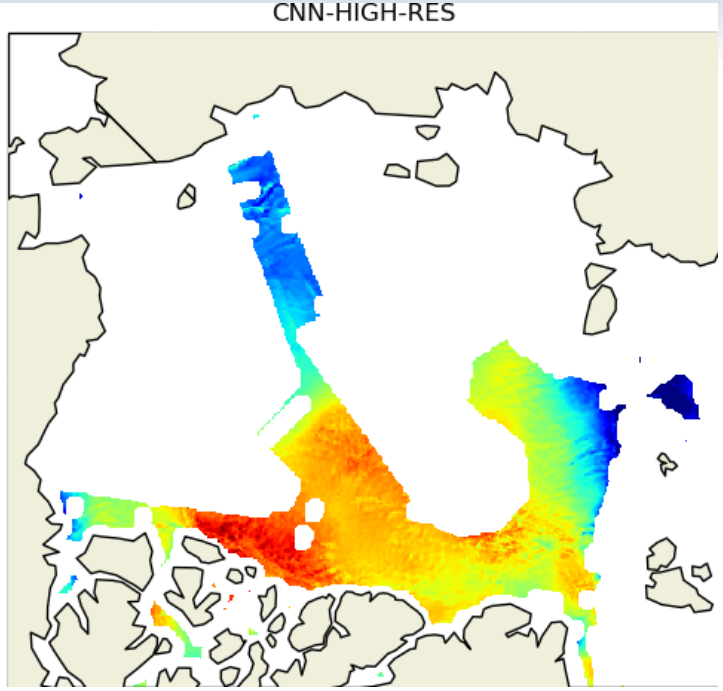
CNN applied to real satellite data



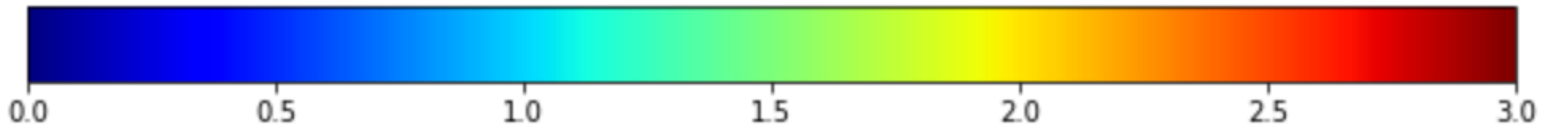
Input CS2SMOS



CNN for PMW ice drift



CNN for SAR ice drift



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Traditional and popular science

- We are working on a paper on the physical modelling for a high-impact journal
- LobeliaEarth are creating a story about the break-up for popular outreach