

# SEA ICE THICKNESS VARIABILITY IN STORFJORDEN, SVALBARD ARCHIPELAGO

S. Hendricks<sup>1</sup>, S. Gerland<sup>2</sup>, L. H. Smedsrud<sup>3</sup>, C. Haas<sup>4</sup>,  
A. A. Pfaffhuber<sup>5</sup>, F. Nilsen<sup>6,7</sup>



<sup>1</sup> Alfred-Wegener Institute, Bremerhaven



<sup>2</sup> Norwegian Polar Institute, Tromsø



<sup>3</sup> Bjerknes Centre for Climate Research, Bergen



<sup>4</sup> University of Alberta, Edmonton



<sup>5</sup> Norwegian Geotechnical Institute, Oslo



<sup>6</sup> University Centre in Svalbard, Longyearbyen, Svalbard



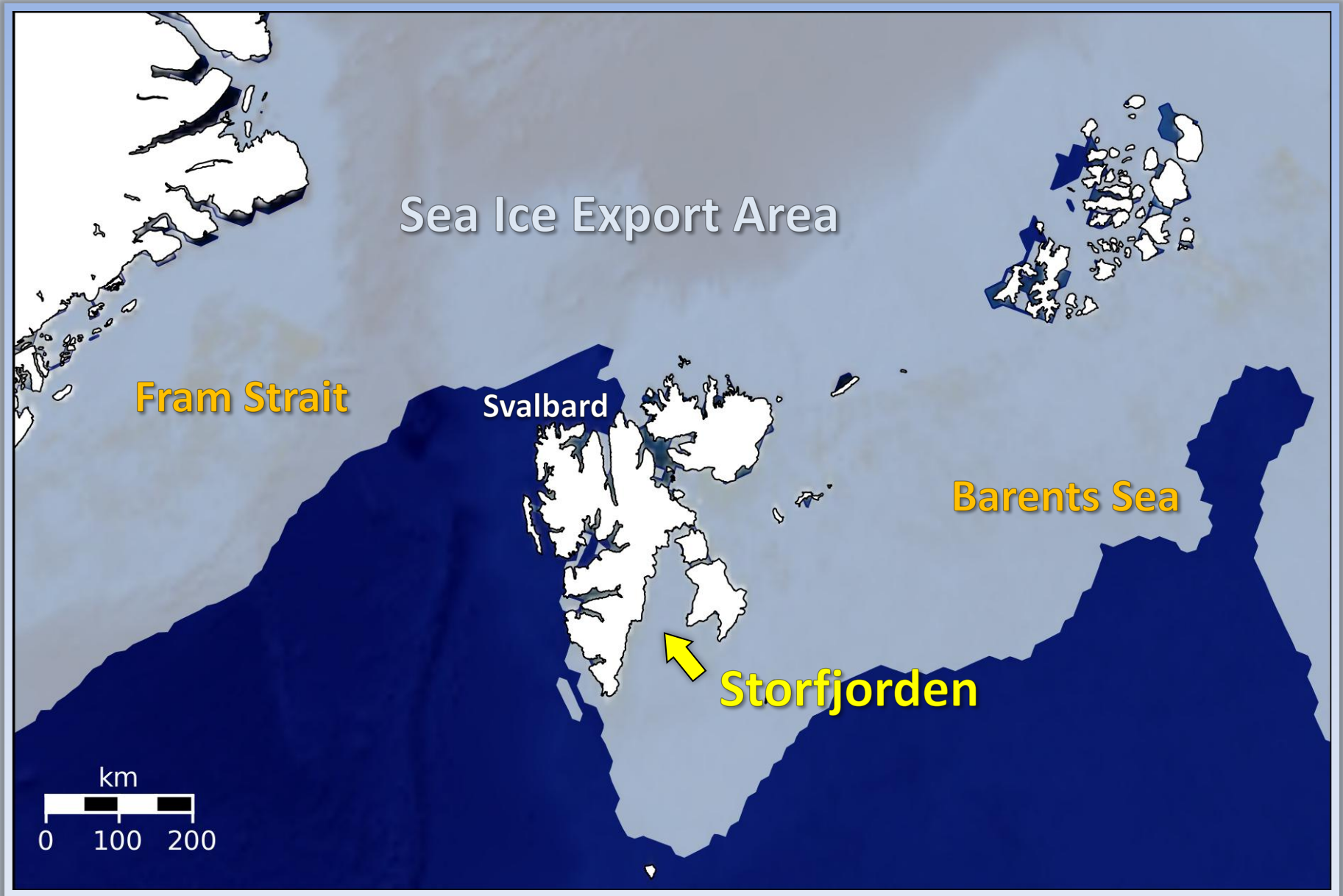
<sup>7</sup> Geophysical Institute, University of Bergen, Bergen



Study Area



Introduction  
Field Experiment



## Thin Ice

- ◆ Storfjorden polynya opens at northerly winds
- ◆ Significant contribution to bottom water formation in the Arctic



## Deformed Ice

- ◆ Sea ice from the Barents Sea might be advected into Storfjorden
- ◆ Heavy deformation processes in the central fjord region at southerly winds



## ▶ Mapping of Ice Thickness Distribution

# Ship- and Airborne Electromagnetics

Introduction  
Field Experiment  
Results

Shipborne

## Instrument

Geonics EM31

## Point Spacing

Depending on ship speed

## Altimeter

Ultrasonic

30-35 m

10-15 m

2-5 m

Airborne

## Instrument

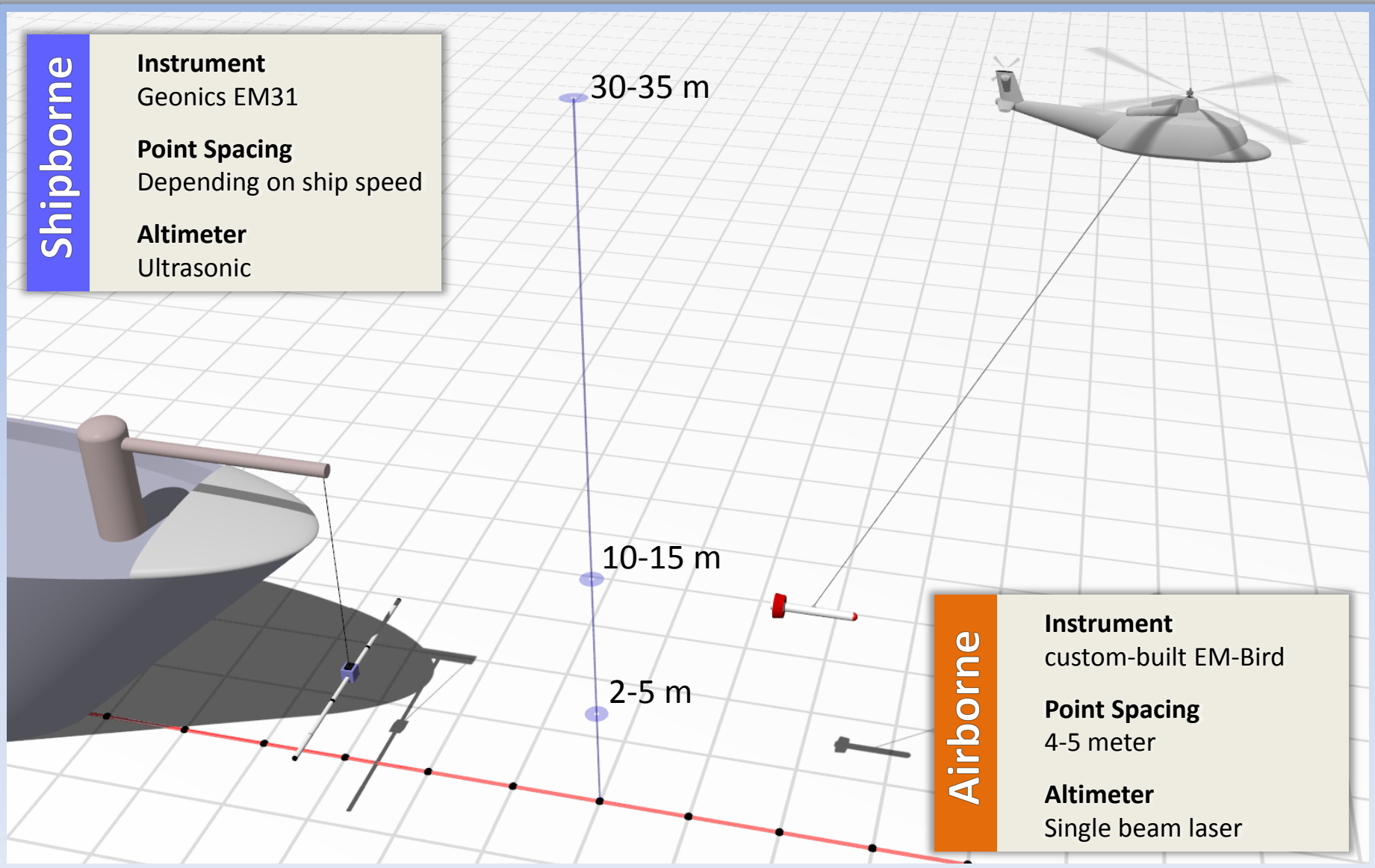
custom-built EM-Bird

## Point Spacing

4-5 meter

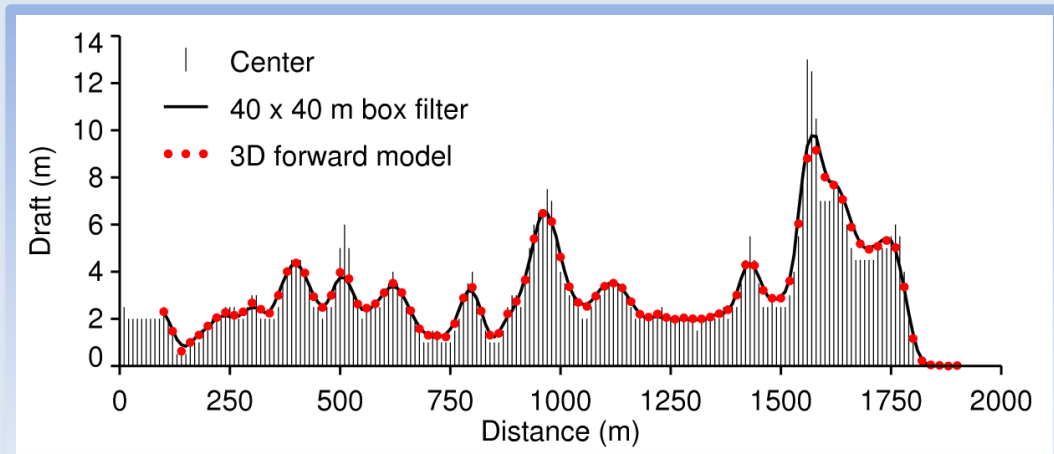
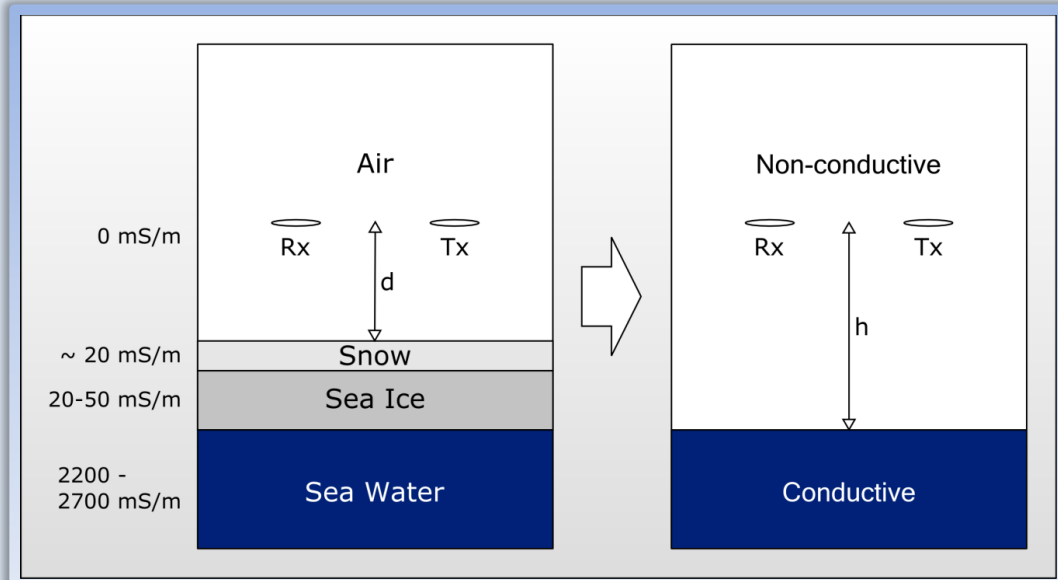
## Altimeter

Single beam laser



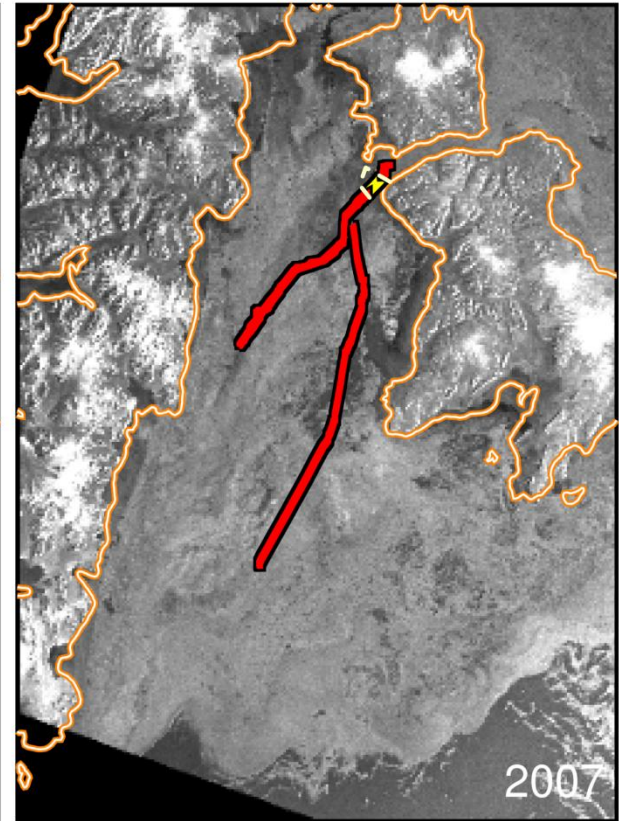
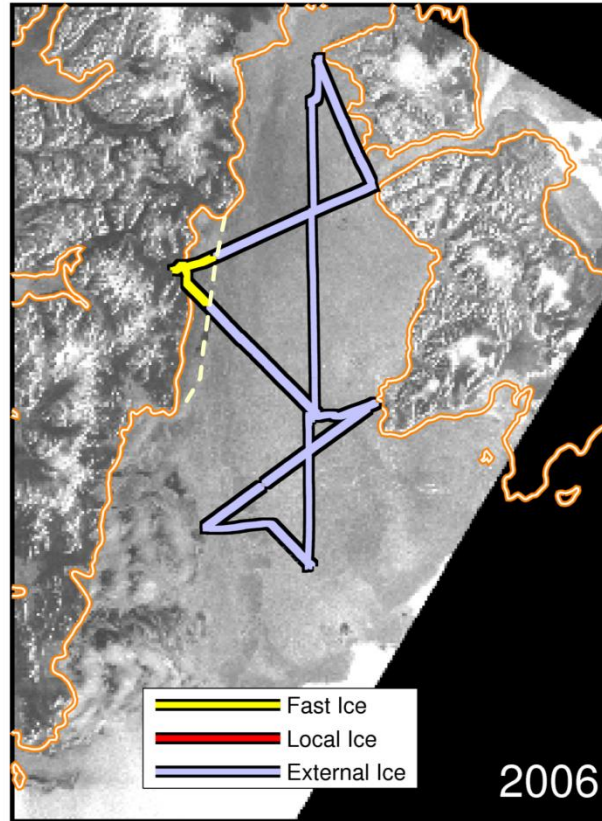
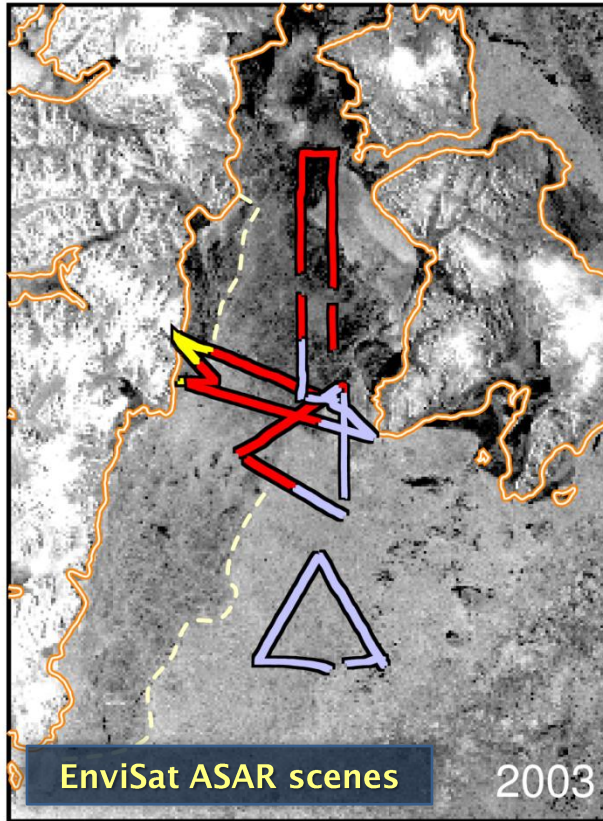
## Induction method

- ◆ Based on conductivity contrast between sea ice and sea water
- ◆ Result: total (ice + snow) thickness
- ◆ Footprint limits small scale resolution
  - ▶ Underestimation of maximum pressure ridge thickness as much as 50 %
- ◆ Mean EM thickness across ridges represents true mean thickness (based on 3D FEM modelling)



# Data Collection

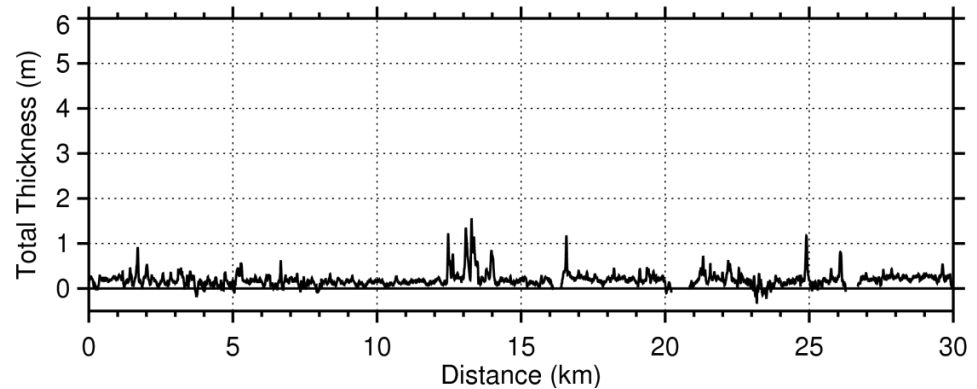
Introduction  
Field Experiment  
Results



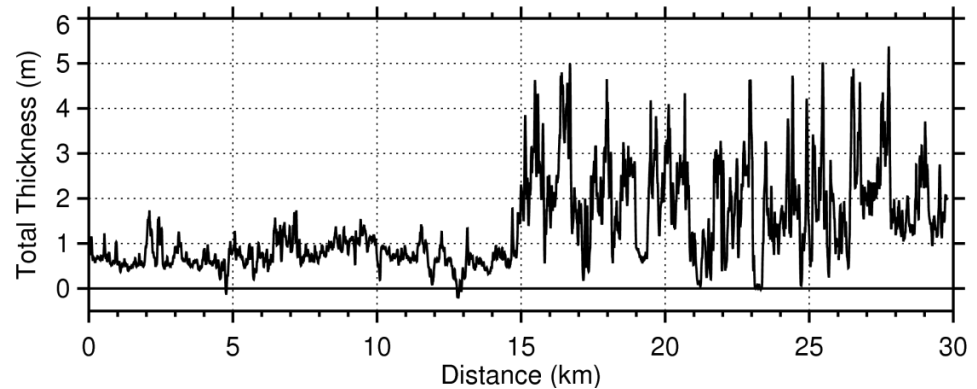
© Eric Brossier



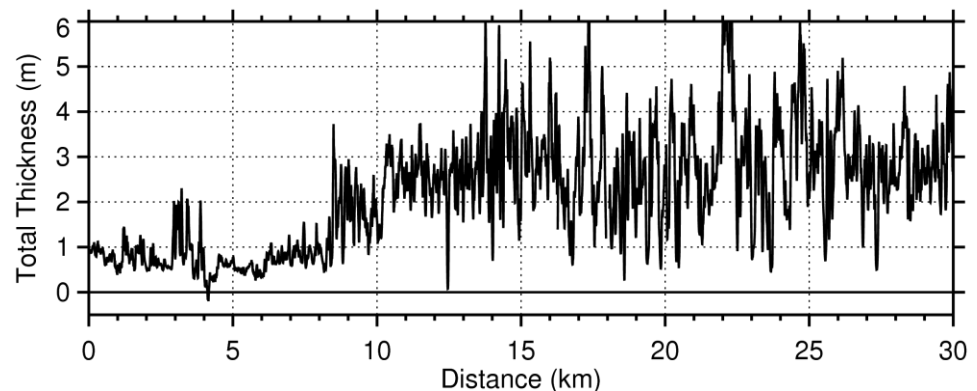
## Polynya Ice (2003)



## Older Polynya Ice – External Ice (2003)

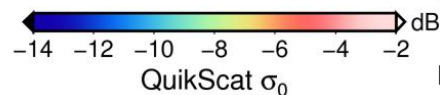
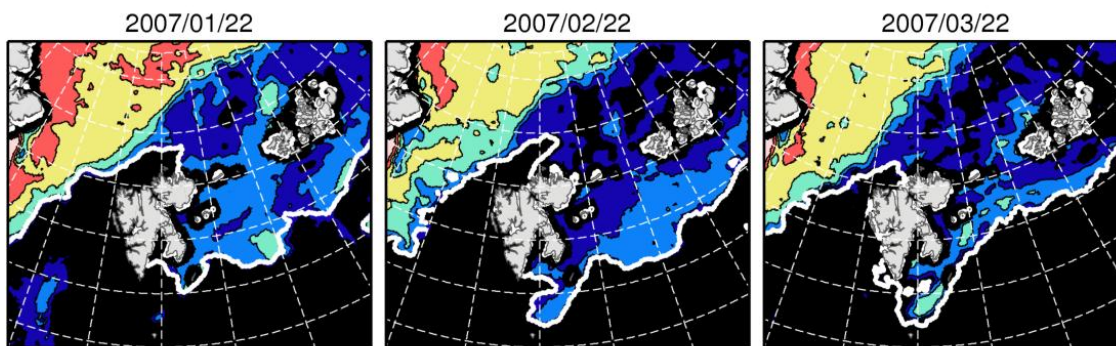
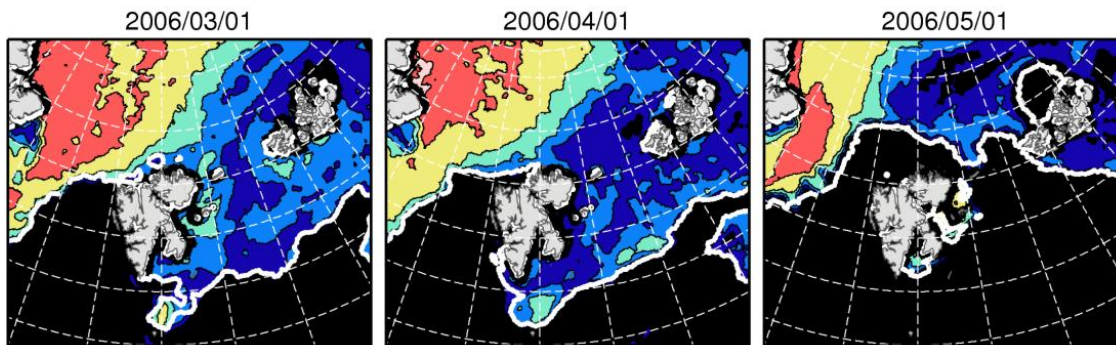
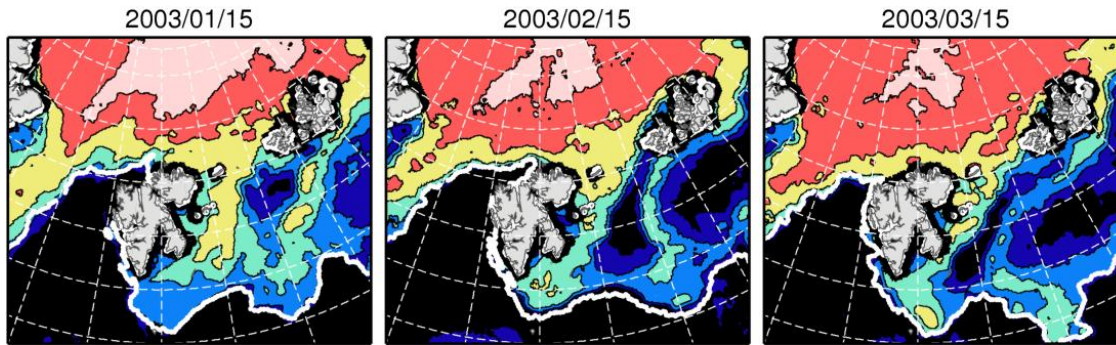


## Fast Ice – External Ice (2006)

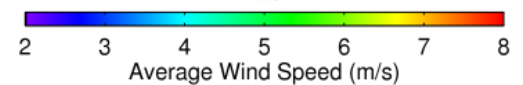
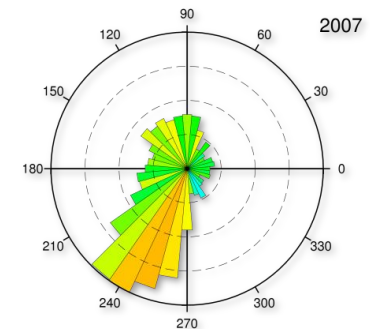
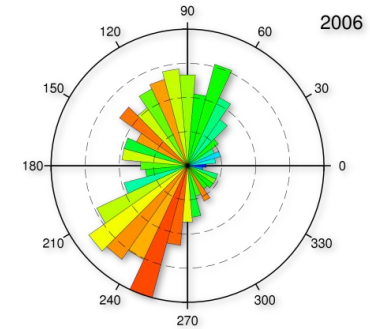
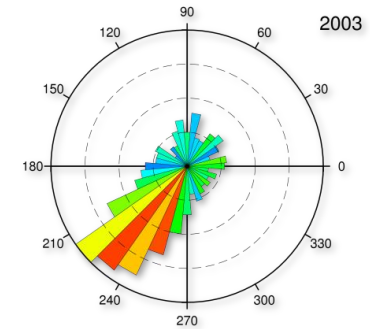


# External Conditions

Introduction  
Field Experiment  
Results



Date of Measurements



ECMWF

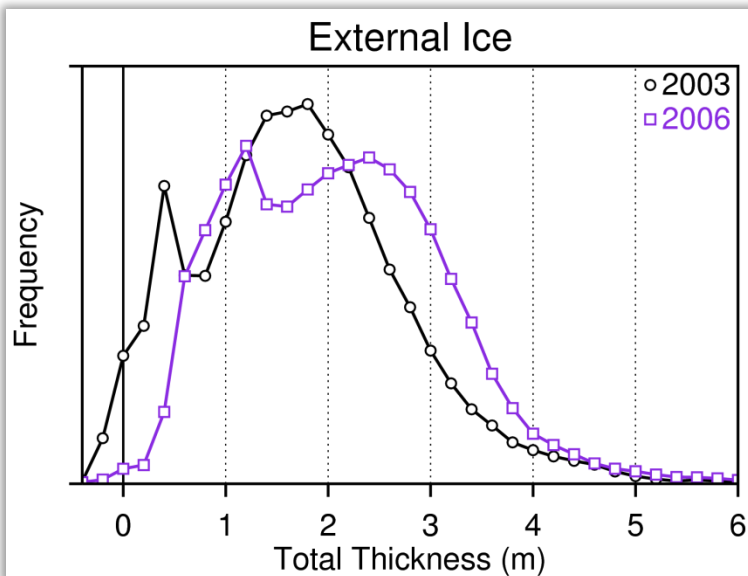
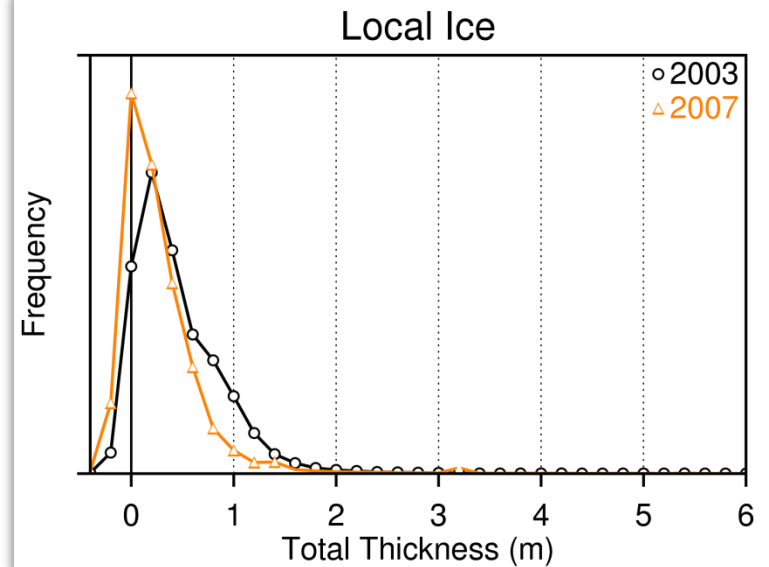
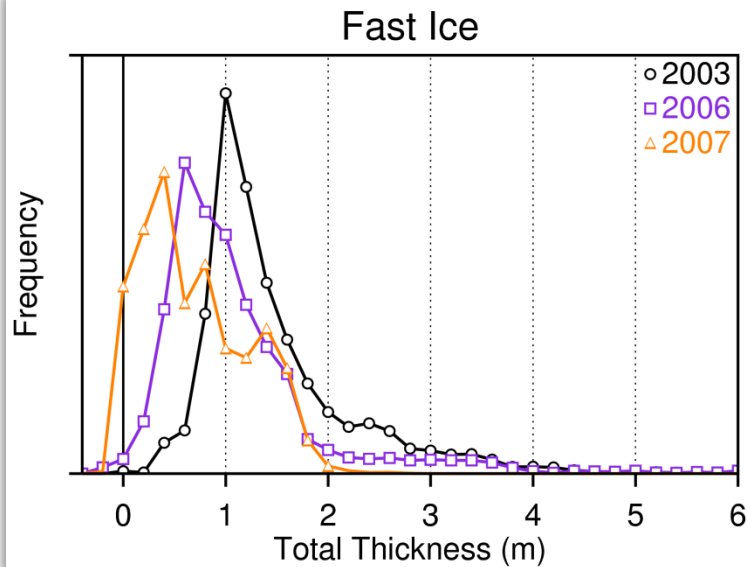


# Sea Ice Thickness Distribution

Field Experiment

Results

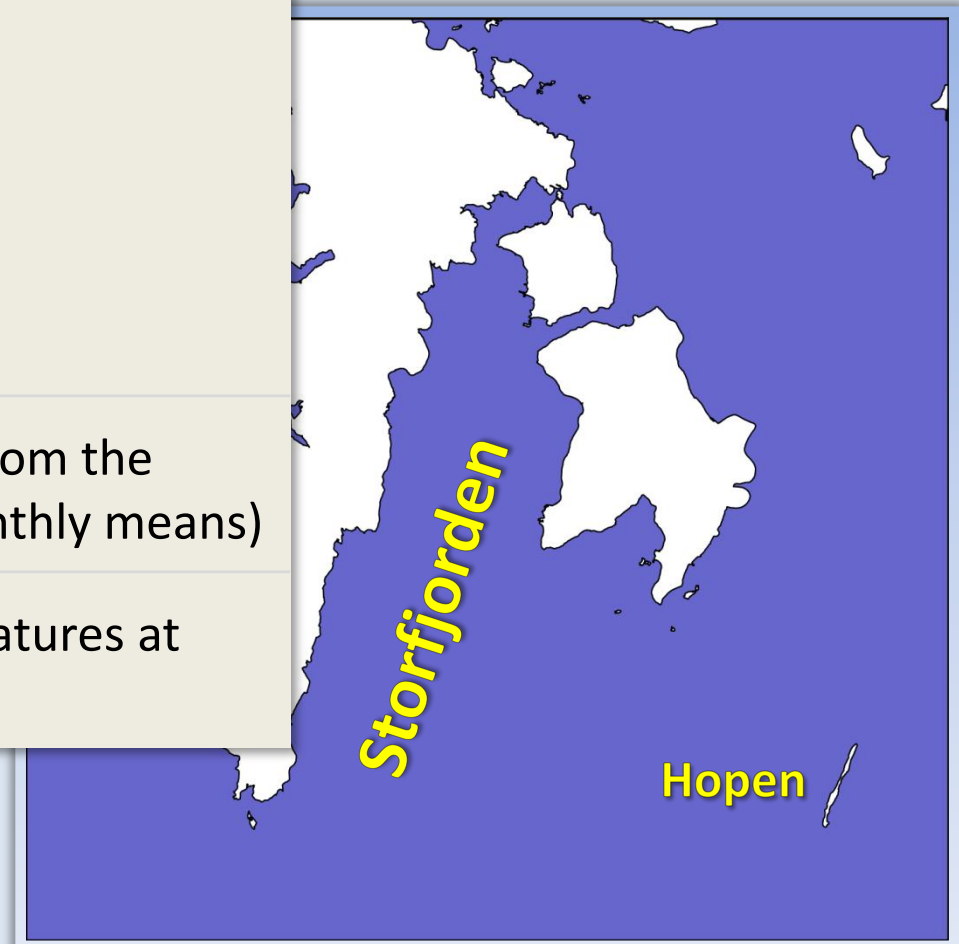
Conclusion



	2003	2006	2007
<b>Fast Ice</b>			
Mean	1.58	1.25	0.8
Mode	1.0	0.6	0.4
<b>Local Ice</b>			
Mean	0.55	-	0.37
Mode	0.2	-	0.0
<b>External Ice</b>			
Mean	1.83	2.21	-
Mode	1.8	1.2 (2.4)	-

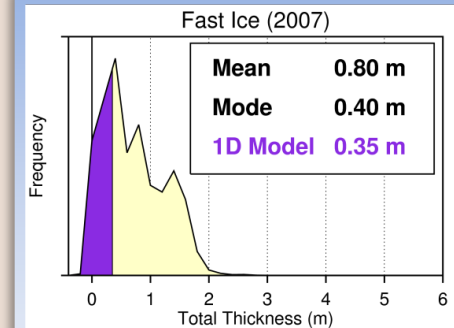
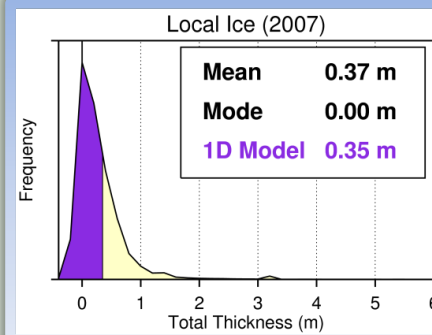
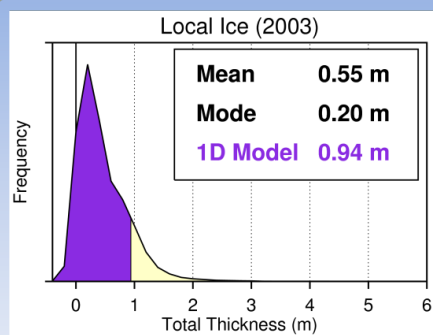
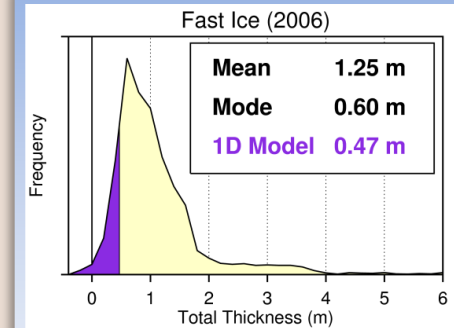
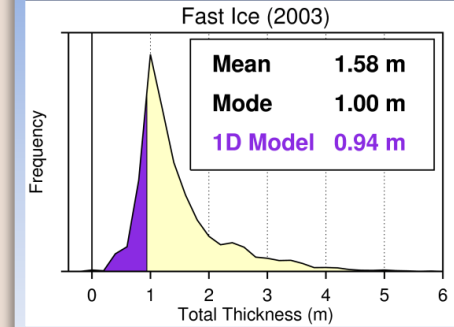
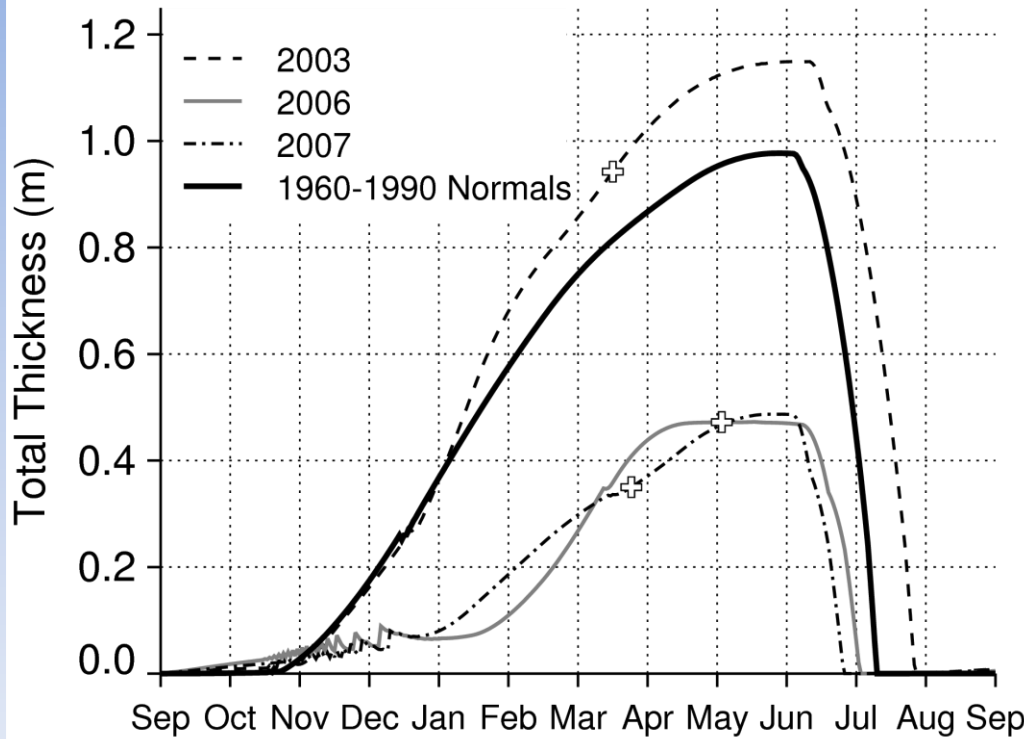
## 1D ICE (Björk 1989)

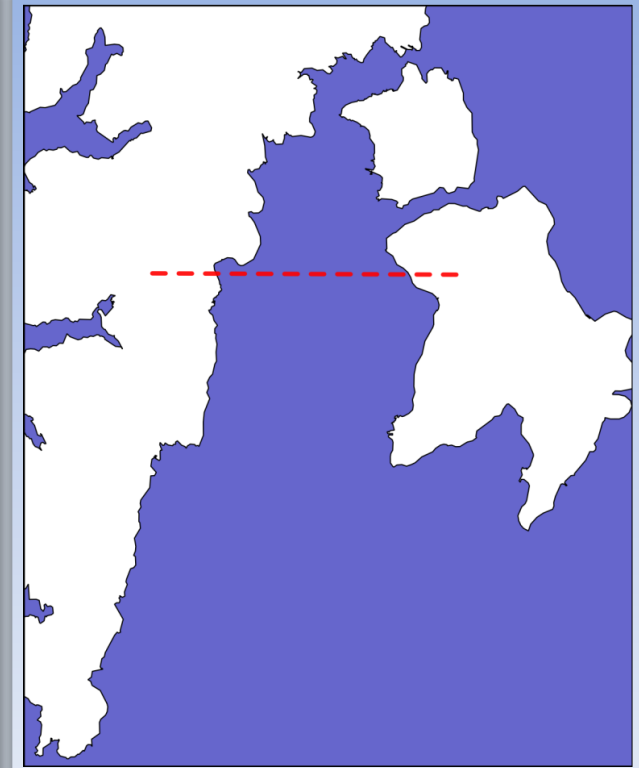
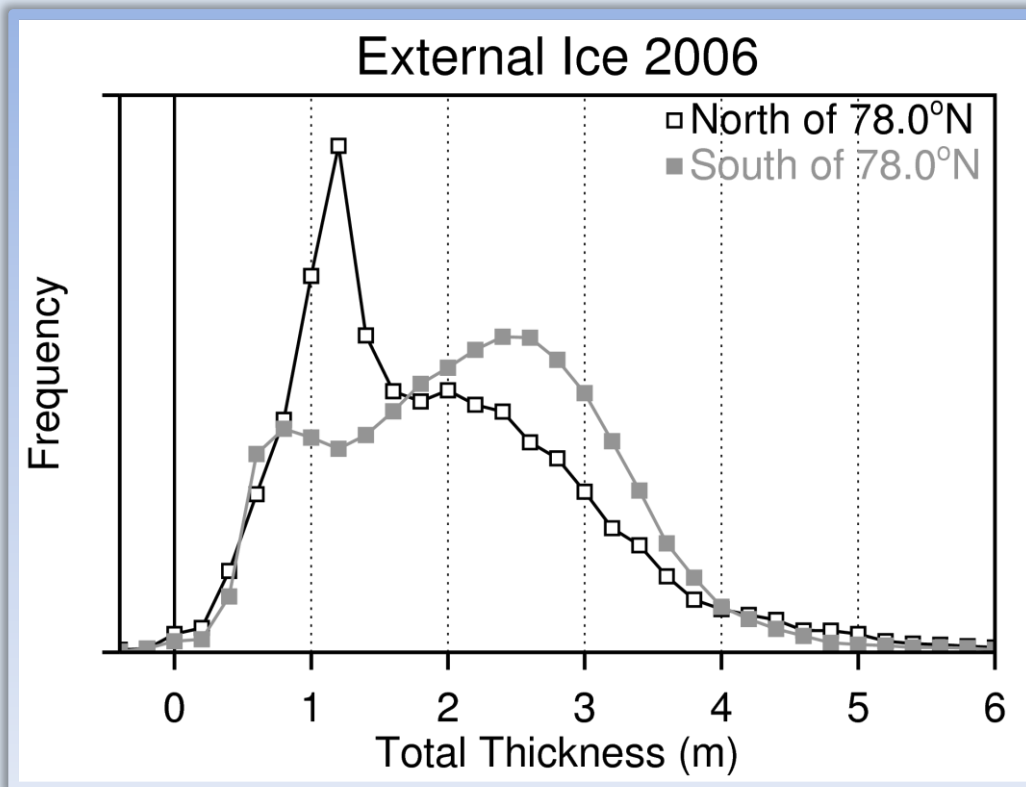
- ◆ Sea ice column model
  - air temperature
  - short & longwave radiation
  - air humidity
  - wind speed
  - snow fall
- ◆ Forced by observational data from the weather station of Hopen (Monthly means)
- ◆ Typically 1° warmer air temperatures at Hopen



# Thermodynamics vs. Dynamics

Field Experiment  
 Results  
 Conclusion





## Dynamic Thickness Redistribution

Assumption: Same initial state but different deformation history

Modal Thickness 1.2 m ► 2.4 m

Mean Thickness 2.1 m ► 2.28 m (+9%)

## Collected Data

**Ship- & Airborne EM ice thickness data** in 2003, 2006 & 2007

First time to assess **variable ice thickness regime** in Storfjorden

**3 ice classes:** Fast ice, mobile local and external sea ice

## Ice Thickness Distribution in Central Storfjorden

**Larger interannual variability** with periods of thick ice cover

**Thermodynamic ice growth** :  $\sim 1$  m (2003),  $> 0.5$  m (2006, 2007)

Mode in ice thickness distribution by **dynamic redistribution**

## Discussion

**Snapshot measurements**, limited comparability

**Imprints of external conditions** visible in ice thickness distributions

**Accessibility of Storfjorden** ideal for ice deformation studies

# Thank you for your attention

