

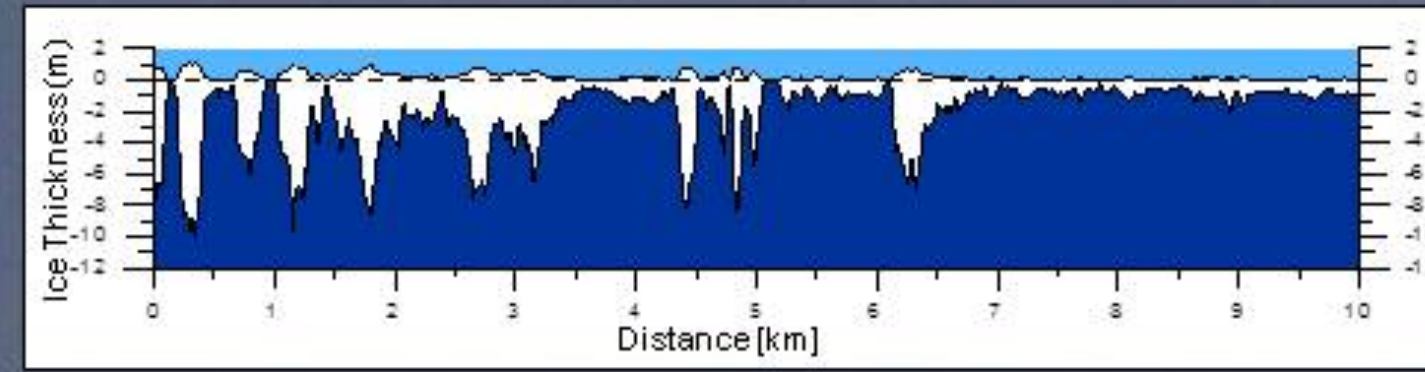
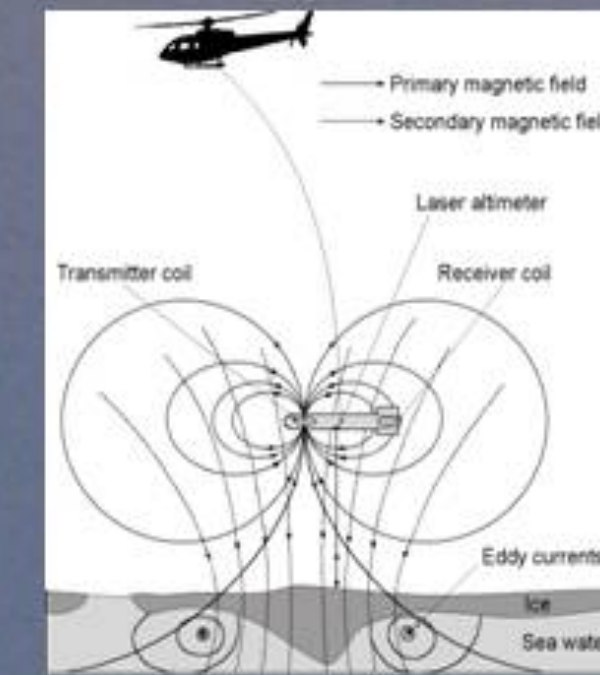
Regional Sea Ice Thickness Distribution in the Svalbard Region and Fram Strait from Airborne and *in situ* Observations

Sebastian Gerland¹, Angelika H.H. Renner¹, Mats Granskog¹, Edmond Hansen¹, Christian Haas², Marcel Nicolaus^{1,3}, Stefan Hendricks³, Olga Pavlova¹, and Justin Beckers²

1: Norwegian Polar Institute, Fram Centre, Tromsø
2: University of Alberta, Edmonton, Canada
3: Alfred Wegener Institute, Bremerhaven, Germany

Measurement Techniques

- Ice thickness on a regional scale is measured with helicopter borne electromagnetics (EM-Bird, EMB; Haas et al. 2009); the sensor responds to the seawater; a laser altimeter determines the height
- Ice thickness on local scale is measured with drillings and/or ground electromagnetics (Haas et al. 1997) - also used for calibration of helicopter surveys

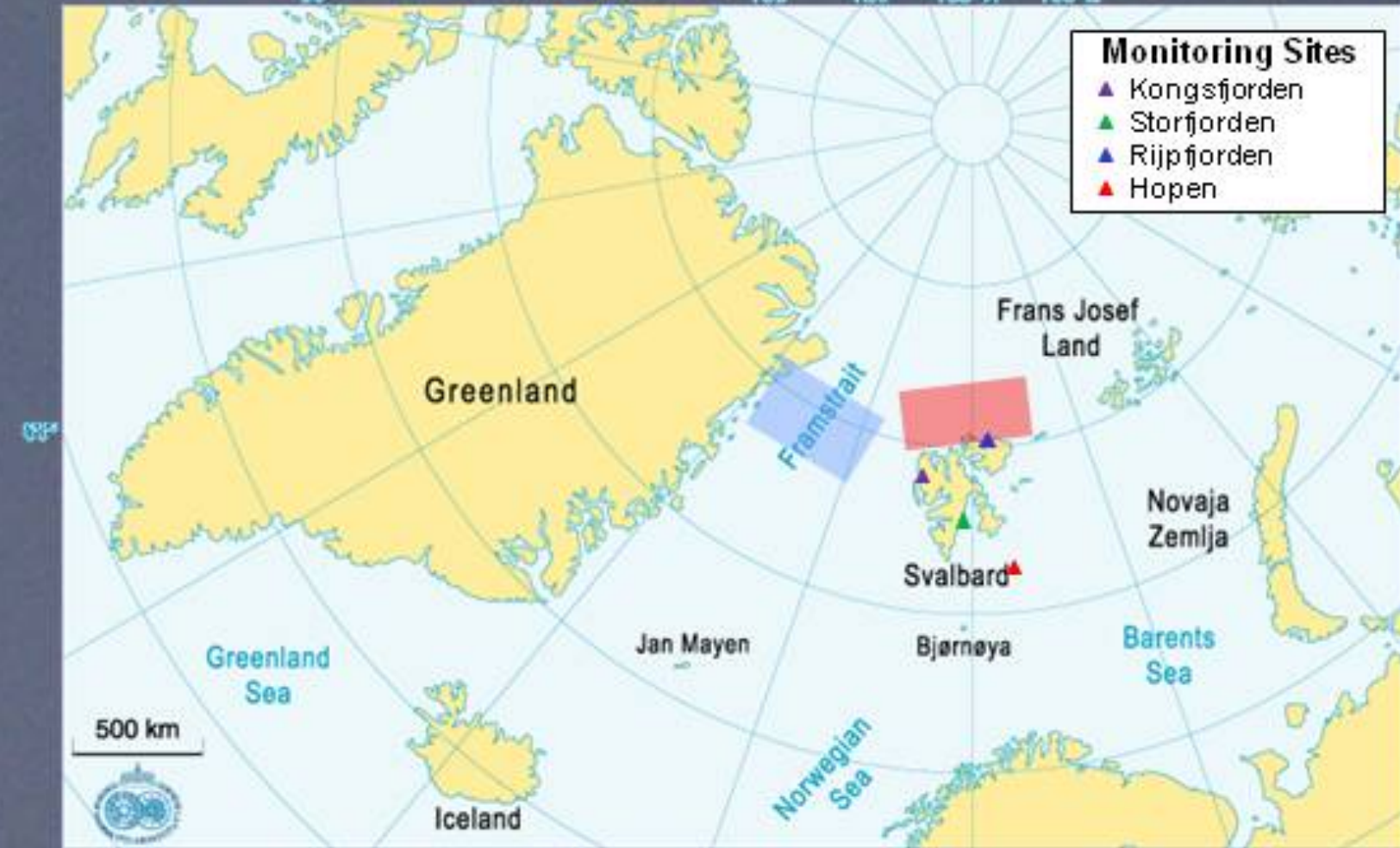


Background and Motivation

- Arctic sea ice thickness is a crucial parameter when quantifying and assessing the status of the ice cover in connection with climate research
- Ice thickness changes affect the mechanical properties in dynamic ice processes, energy fluxes between atmosphere and ocean, the ocean freshwater budget and the ecosystem
- Knowledge on the regional distribution of ice thickness is important for improving coupled climate models and for calibration and validation of satellite remote sensing products (e.g. the new ESA CryoSat-2 satellite)
- While ice extent is studied daily from satellites with partly high resolution, the knowledge about sea ice thickness distributions in the Arctic is in general still quite limited

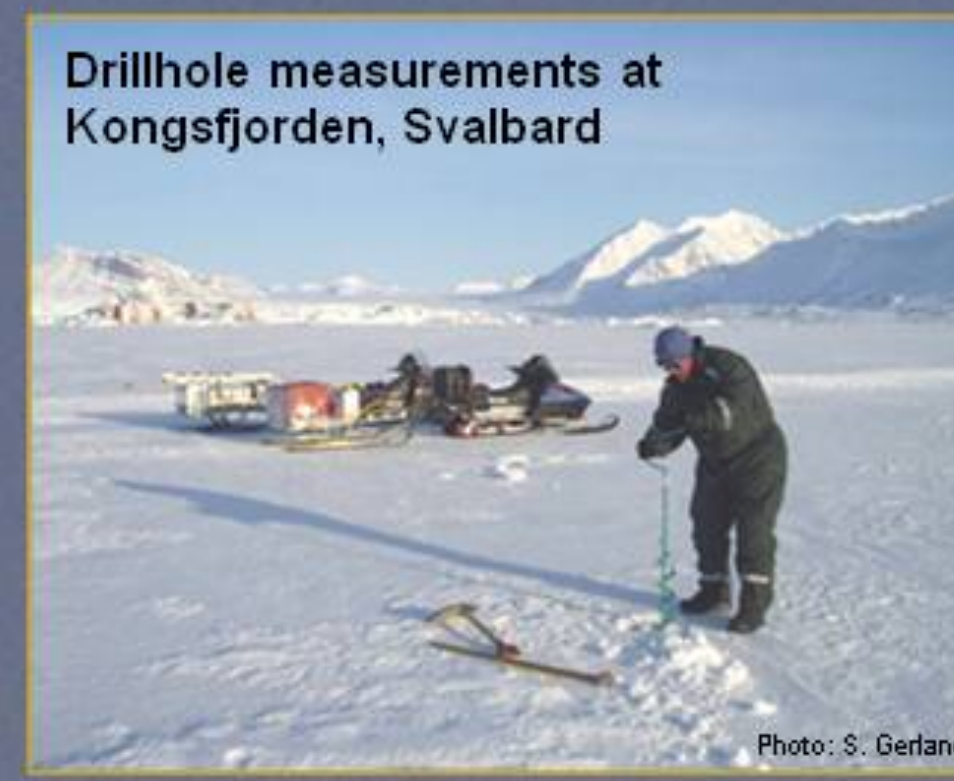
Observation Regions

- Fram Strait (blue box) is the only deepwater connection between Arctic Basin and other oceans, and the main export route for sea ice leaving the Arctic
- Sea ice north of Svalbard (red box) borders directly to the transpolar drift ice in the Arctic Basin
- Monitoring at coastal sites at four Svalbard locations (triangles, see legend), contributes to Arctic coastal fast ice monitoring



Sea Ice Thickness Monitoring at Coastal Sites

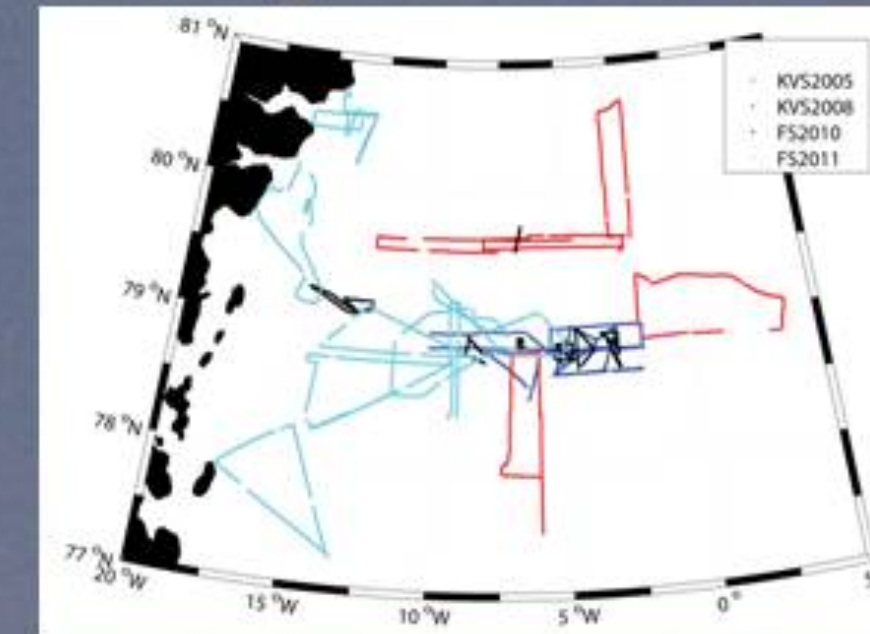
- Norwegian Polar Institute conducts/coordinates fast ice monitoring at four Svalbard sites: Hopen (since 1966), Kongsfjorden (since 1997/2003, Gerland & Renner 2007), Ingfieldbukta, Storjorden (since 2005) and Rijpfjorden (since 2011)
- The longest time series, measured at Hopen reveals a negative trend in ice thickness, but also large interannual variations (Gerland et al. 2008)
- Storjorden ice can have large amounts of snow cover



Regional Sea Ice Thickness in Fram Strait

- During four expeditions, the ice thickness in Fram Strait was investigated with EMB flights in spring (2005, 2008; Pedersen et al. 2009) and late summer (2010, 2011)
- Modal ice thickness in Fram Strait drops from spring to late summer by more than 1 m
- Recent measurements from late summer 2011 show hardly thicker (often multiyear) ice left

EMB flight tracks Fram Strait

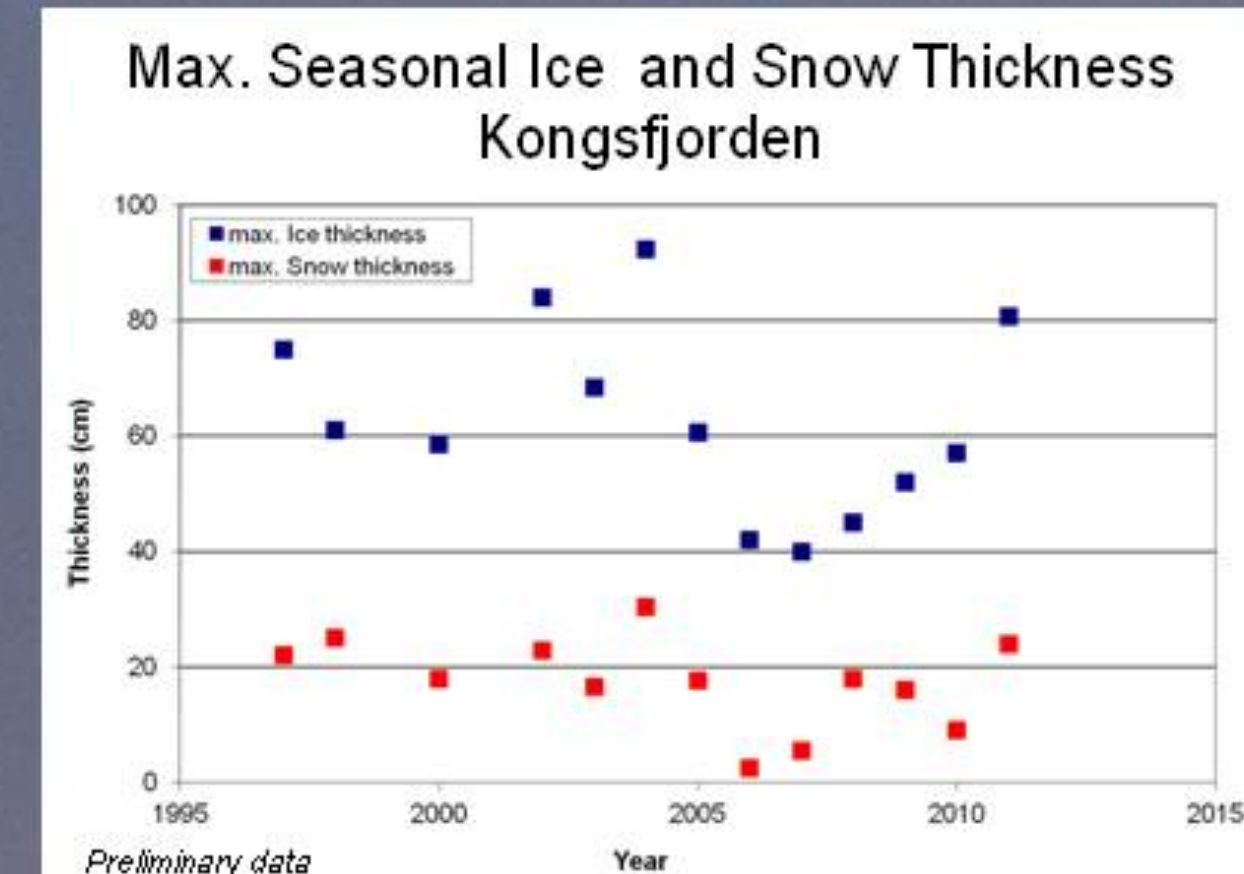
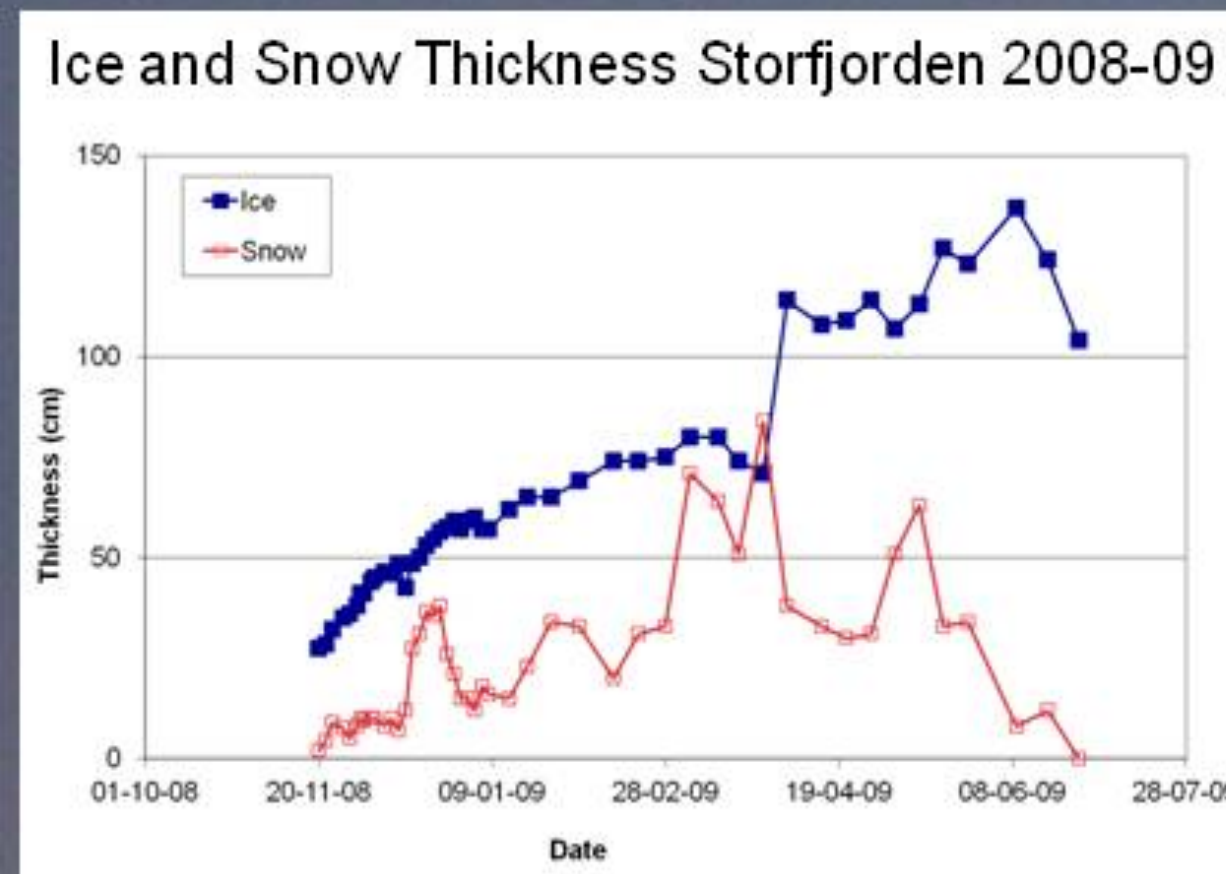
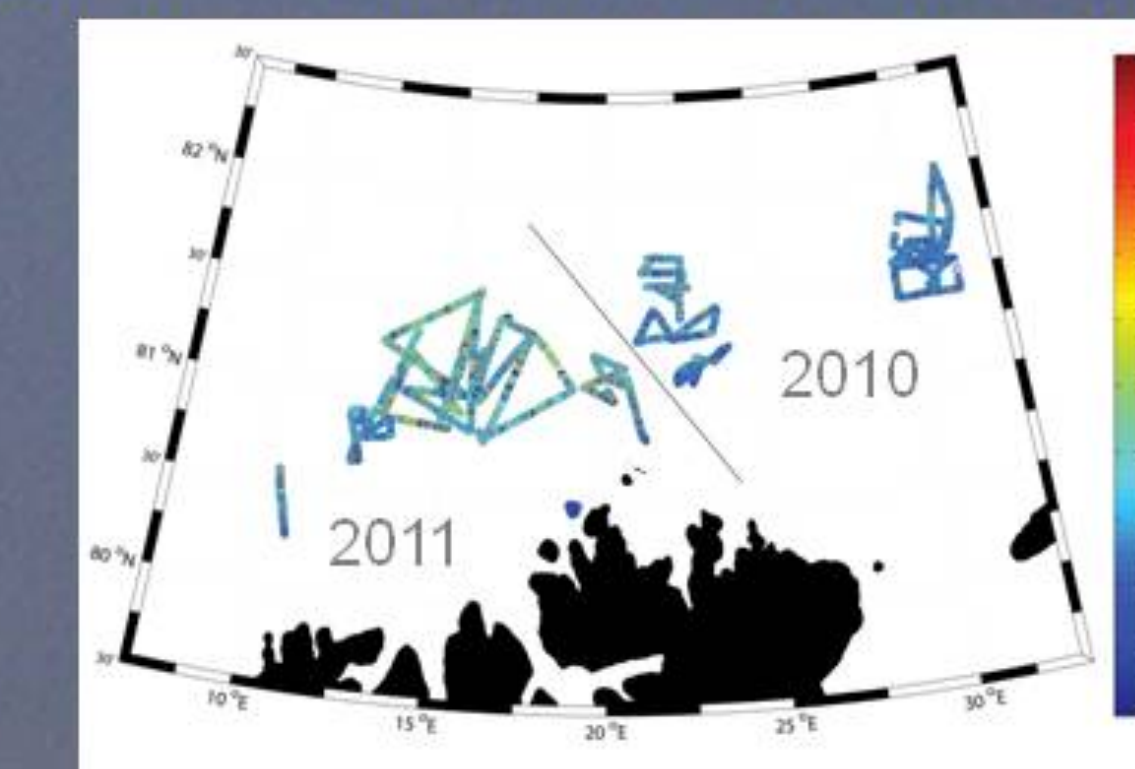


Regional Sea Ice Thickness North of Svalbard

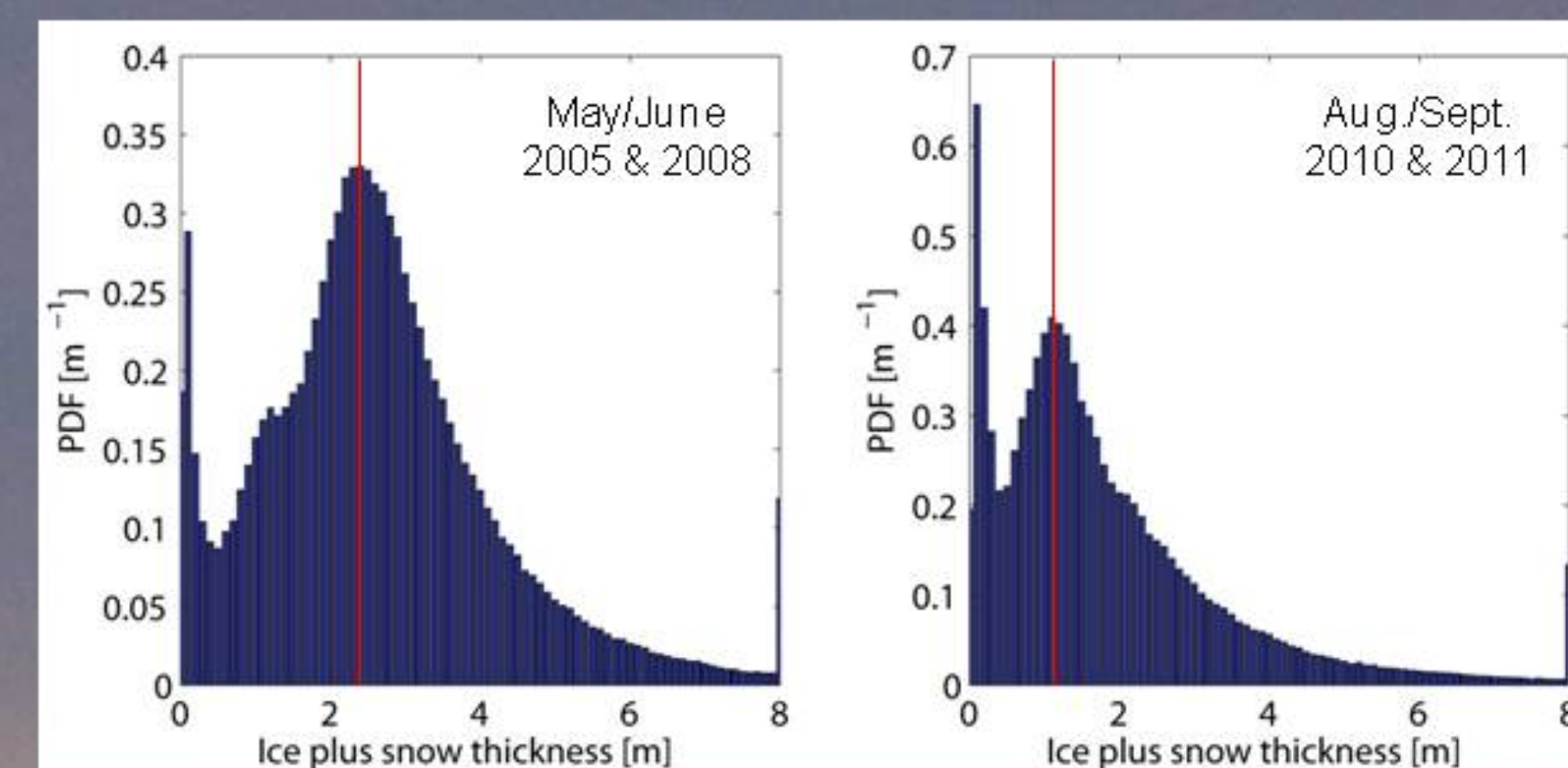
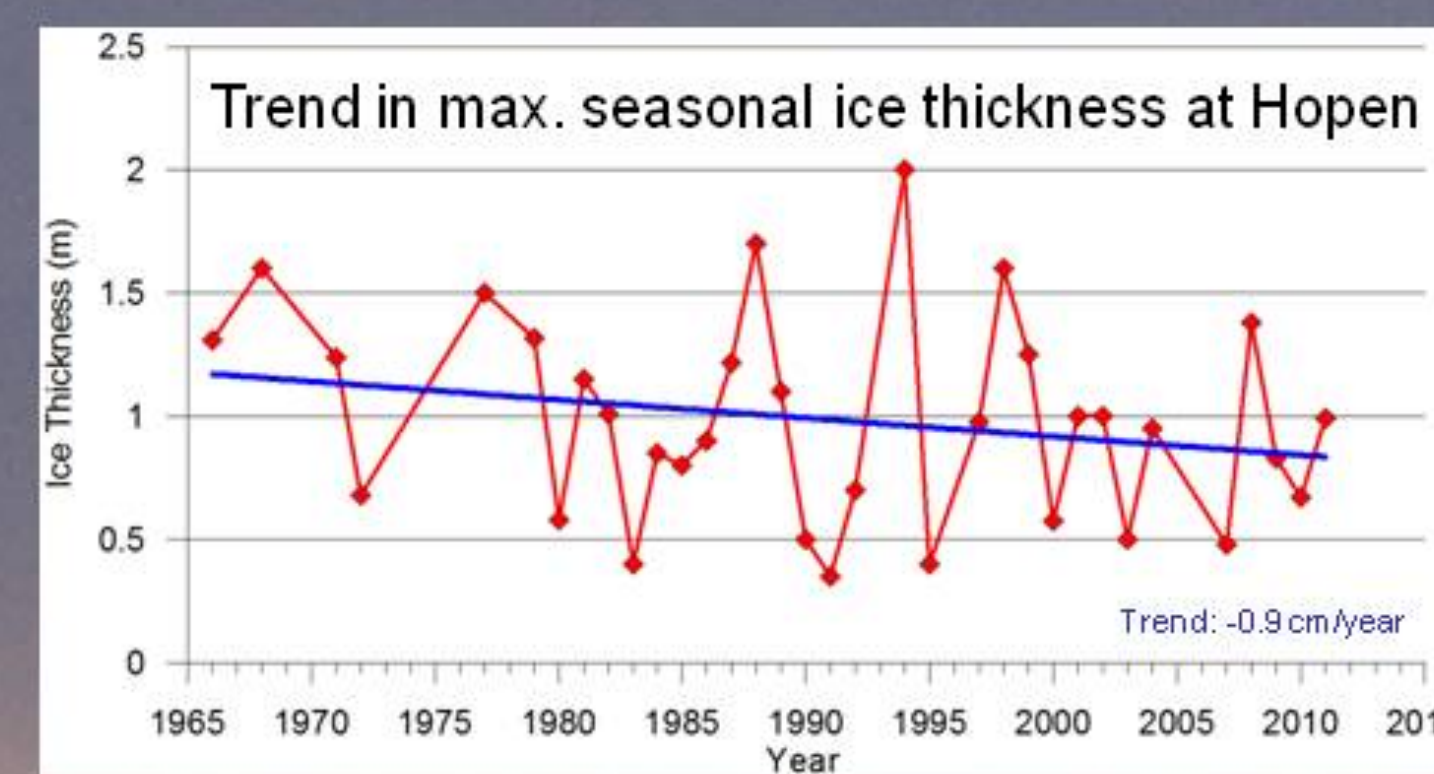
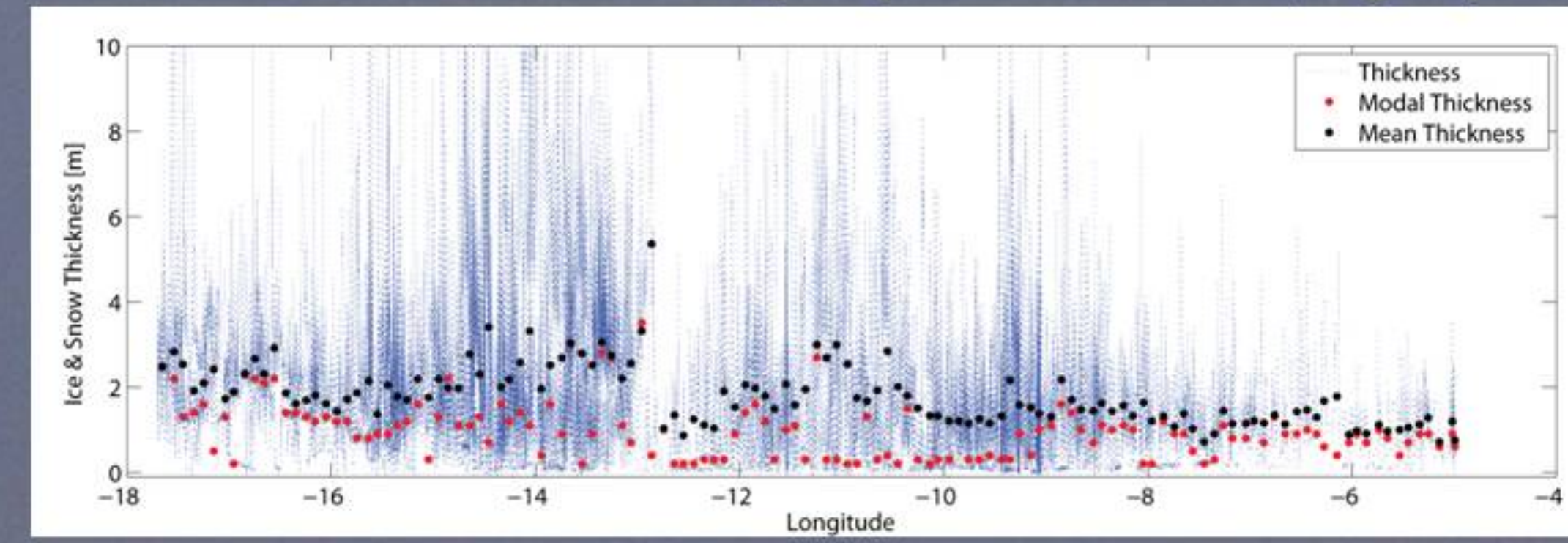
- Ice thickness north of Svalbard was investigated in late summer 2010 and spring 2011 with EMB flights and *in situ* during expeditions with RV Lance and KV Svalbard
- Modal ice thicknesses were slightly below 2 m in spring and at about 1 m in late summer
- The region is characterized by first-year ice and young sea ice types



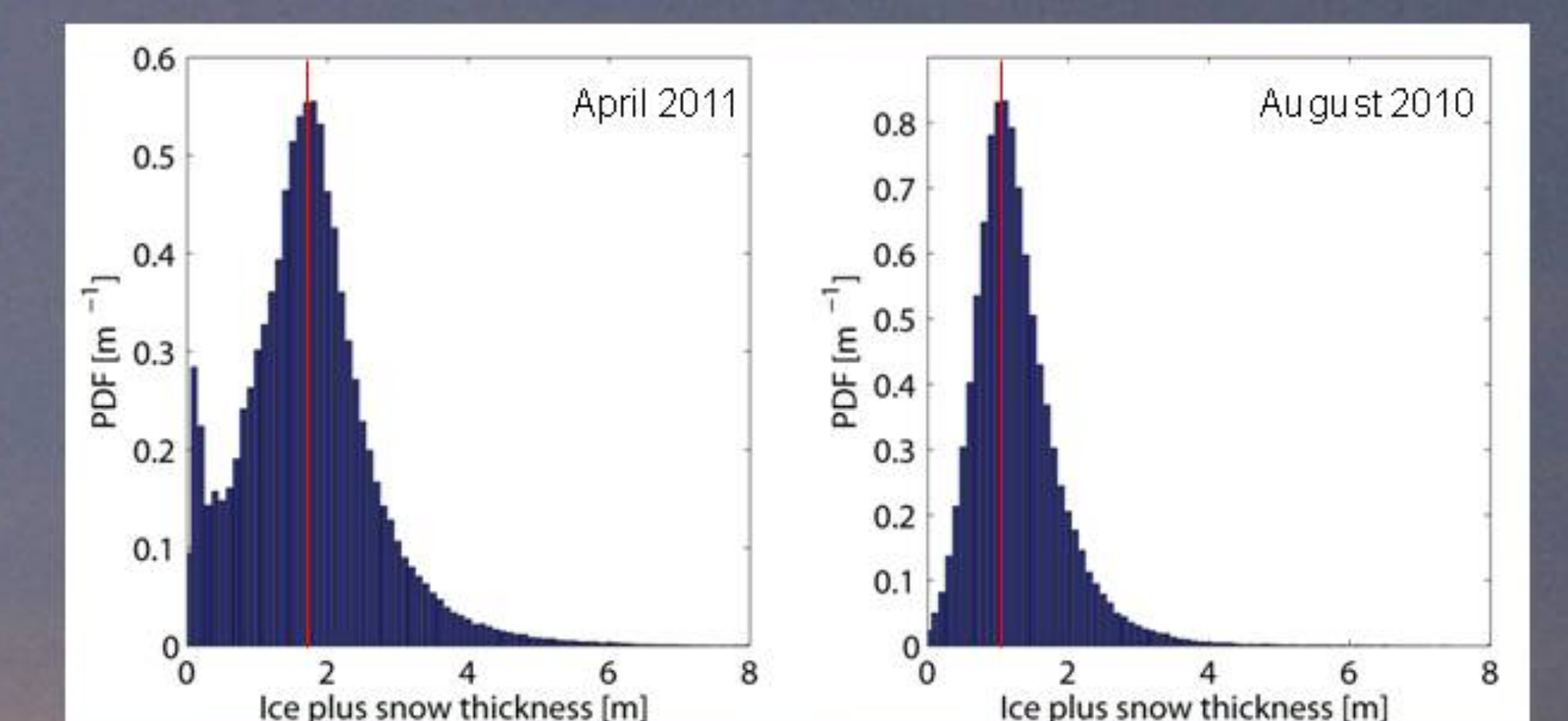
EMB tracks and thicknesses North of Svalbard



Transect of Total Sea Ice Thickness (EMB) across Fram Strait, Aug./Sept. 2011



Probability density function for total ice thickness in Fram Strait in spring (May/June 2005 & 2008) and late summer (August/September 2010 & 2011)



Probability density function for total ice thickness north of Svalbard in spring (April 2011) and late summer (August 2010)

References

Conclusions and Outlook

Acknowledgements

Gerland, S., & A.H.H. Renner (2007), Sea ice mass balance in an Arctic fjord. *Annals of Glaciology* 46, 435-442.
Gerland, S., Renner, A.H.H., Godtliobsen, F., Divine, D., & Layning, T.B. (2009) Decrease of sea ice thickness at Hopen, Barents Sea, during 1966-2007. *Geophysical Research Letters*. Vol. 35, L06501, doi: 10.1029/2007GL032716.
Pedersen, C.A., Hall, R., Gerland, S., Sivertsen, A.H., Svenøe, T. & Haas, C. (2009) Combined Airborne Profiling over Fram Strait Sea Ice: Fractional Sea-Ice Types, Albedo and Thickness Measurements. *Cold Regions Science and Technology*, 55, 23-32.
Haas, C., Gerland, S., Eicken, H., & Miller, H. (1997) Comparison of sea-ice thickness measurements under summer and winter conditions in the Arctic using a small electromagnetic induction device, *Geophysics*, Vol. 62 (3), pp. 749-757.
Haas, C., J. Lobach, S. Hendricks, L. Rabenstein, & A. Pfaffling (2009) Helicopter-borne measurements of sea ice thickness, using a small and lightweight, digital EM system, *J. Appl. Geophys.*, 67(3), 234-241.

- Fram Strait and North-of-Svalbard sea ice exhibit strong seasonal and regional thickness variations, partly related to different origin of ice and different dynamic and thermodynamic regional conditions; we still work on the interpretation of the variability, and with linking up airborne, *in situ* and Upward Looking Sonar data for Fram Strait
- Monitoring of fast ice at four Svalbard coastal sites shows significant different characteristics (e.g. ocean heat flux, precipitation)
- Sea ice thickness, measured *in situ* over 45 years at Hopen shows a negative trend



We thank numerous helpers preparing and conducting field work and measurements. We are grateful to the wintering teams at Sverdrup Station (NPI, Ny-Alesund) and Hopen (met.no), to Eric Brossier, and to the crews of RV Lance, KV Svalbard and Airlift helicopters.

This study is financed by the Norwegian Polar Institute and its ICE Centre (project "ICE-Fluxes"). Additional funding is given by the Fram Centre project "Polhavet", the project "PRODEX CryoSat sea ice" (Norwegian Space Centre and ESA), and the project "AMORA" (Research Council of Norway).