

Response of the cryosphere to multiple drivers in the Baltic Sea region

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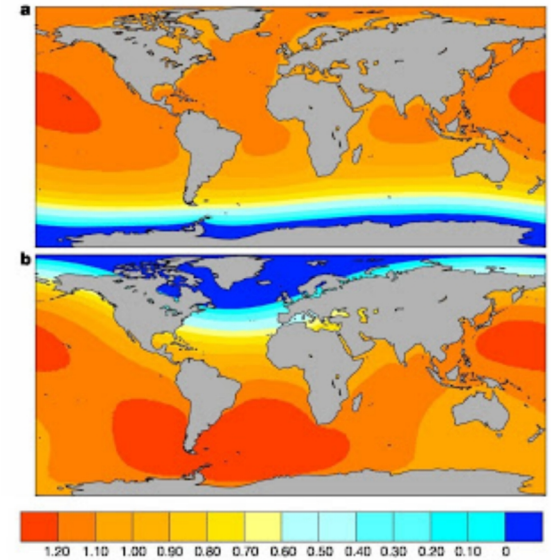
Components of Cryosphere

- Sea ice
- Lake and river ice
- Glaciers, ice sheets
- Frozen ground, permafrost
- Snow



Impact of Global Cryospheric Changes to the Baltic Sea

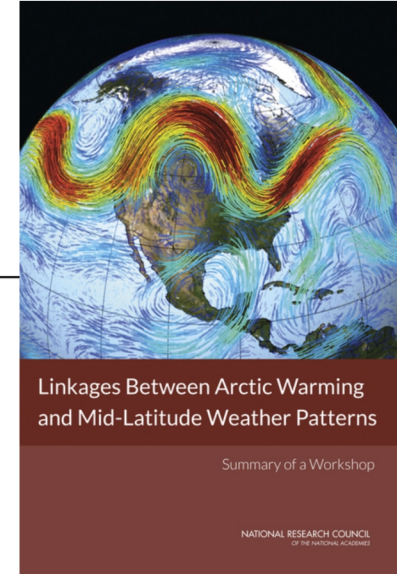
- Glacier and ice sheet melting
 - sea level rise
 - gravitational effect
- Arctic sea ice change is expected to impact on mid-latitudes weather



Surv Geophys (2014) 35:1175–1214
DOI 10.1007/s10712-014-9284-0

Effects of Arctic Sea Ice Decline on Weather and Climate: A Review

Timo Vihma



Snow and sea impacts on society

- Nuisance for traffic, energy production and distribution, buildings etc.
- Winter snow and ice conditions enable heavy traffic in forests and other remote areas
- Snow provides insulating blanket for habitats
- Essential for recreation activities and tourism



The screenshot shows the BBC News homepage. The main headline is "Dozens of ships freed from Baltic Sea ice" with a video player below it. The page is dated Friday, 5 March 2010. The left sidebar contains navigation links for various regions and topics.



Live: Snökaos vid kusten

VÄDER. Vädervarningarna för kusten har utökats.



No snow in Lapland could spell a festive flop

Matthew Robinson, CNN • Updated 22nd November 2018

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Friday 23 November 2018

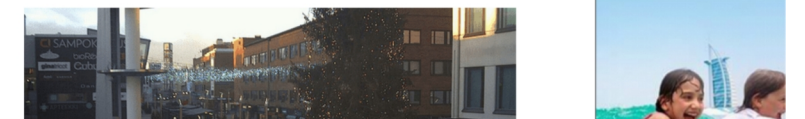
News Irish News

Poor snowfall in Lapland throws Irish families' Christmas trips to visit Santa into doubt



Let's visit Lordi's Square: what to do if you're stuck in Lapland with no snow this Christmas

Tourists heading to northern Finland to see Santa are likely to be disappointed because of the unseasonably warm weather. But there are other 'fun' activities on offer



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All Travel News Beach City Cruise UK Family £9.50 Hols Superdays Deals

Black Friday KATSO PÄÄTÄRJOUKSET NYT VERKOSTA. TARJOUKSIIN

FLAKE OUT Brits visiting Lapland with the kids may be left heartbroken as there's NO snow

Thousands of families head to the 'home' of Santa every year but unusually high temperatures mean that for the first time in living memory there is currently a complete lack of snow

EXCLUSIVE By Andrew Parker 20th November 2018, 10:30 pm | Updated: 21st November 2018, 5:35 pm

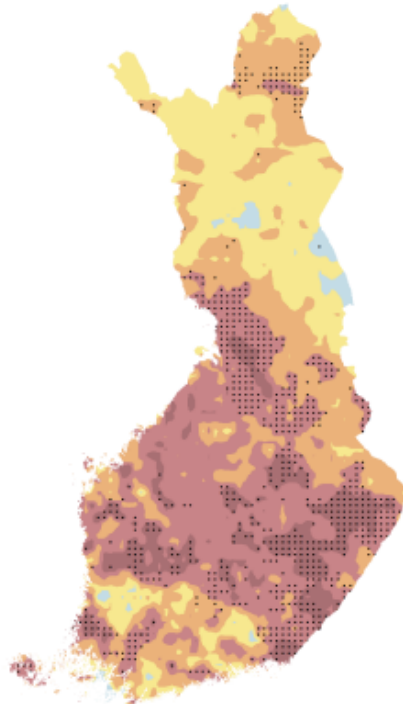
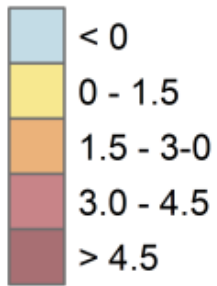


Permanent snow season has shortened everywhere

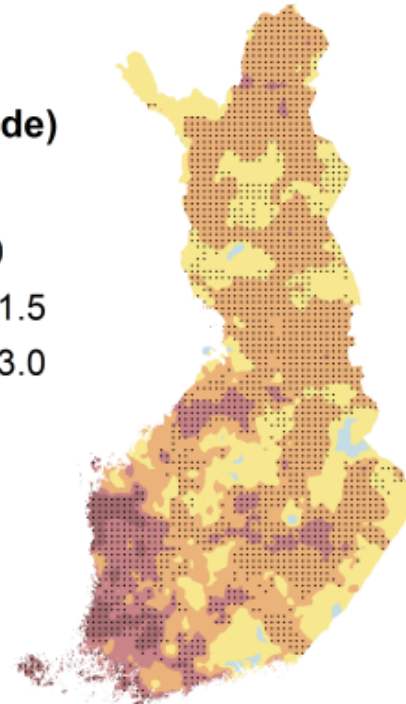
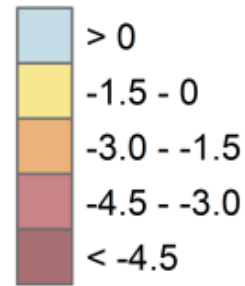
BEGINNING DATE

MELTING DATE

e) BEG
(day/decade)



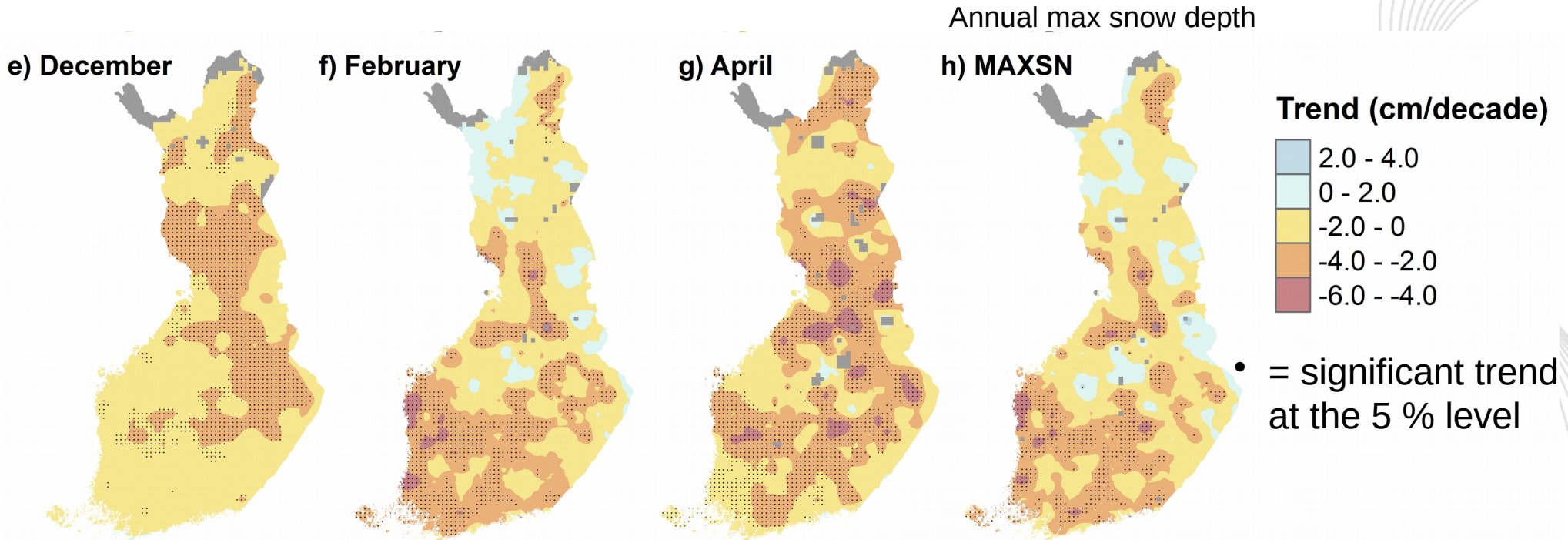
f) SOD
(day/decade)



Permanent snow season = a period in winter when snow depth > 0 cm

Luomaranta et al., Int. J. Climatology (in review)

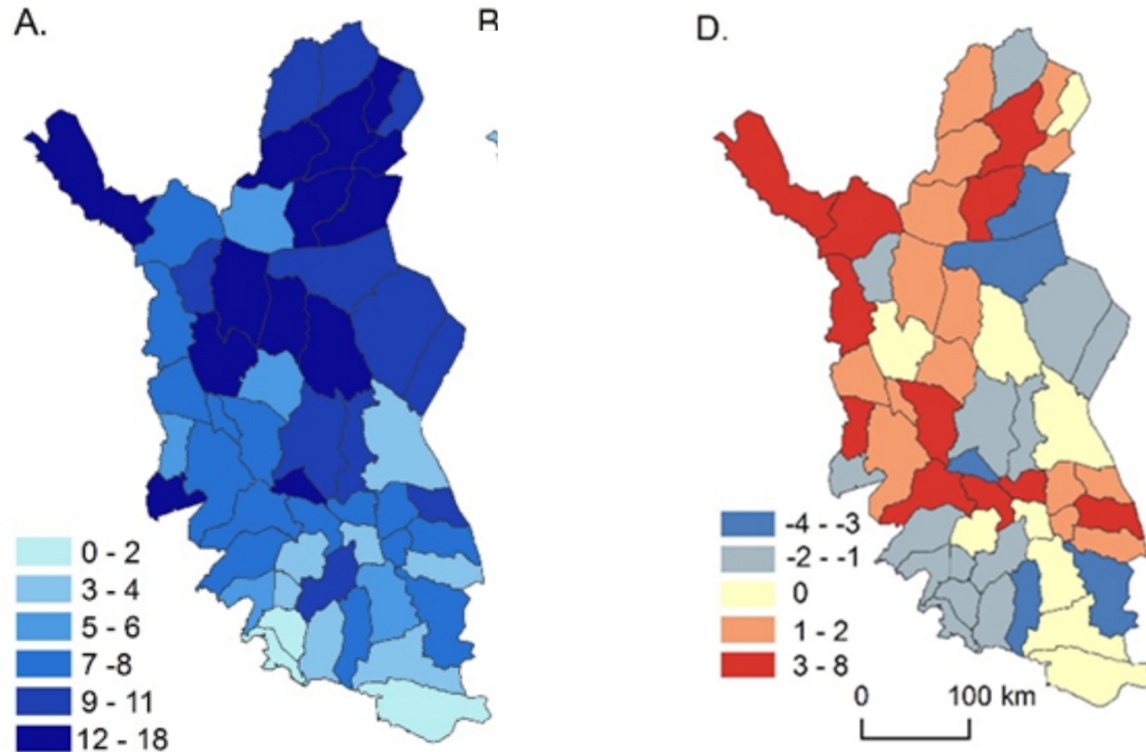
Snow depth has decreased in wide areas



Luomaranta et al., Int. J. Climatology (in review)

- The strongest decrease in southern and western Finland in February and March
- The strongest decrease in central and northern Finland in April and May

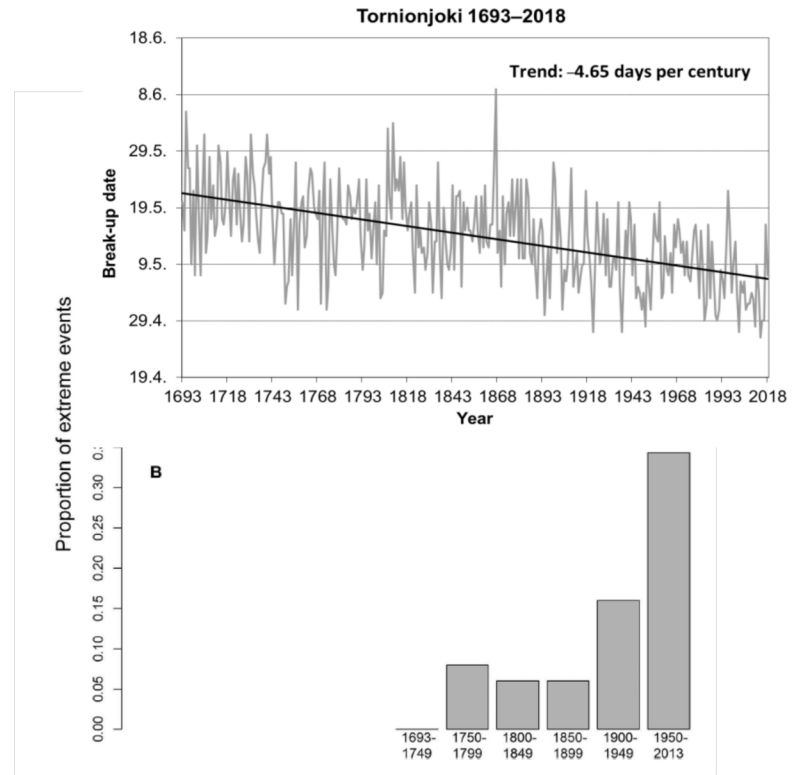
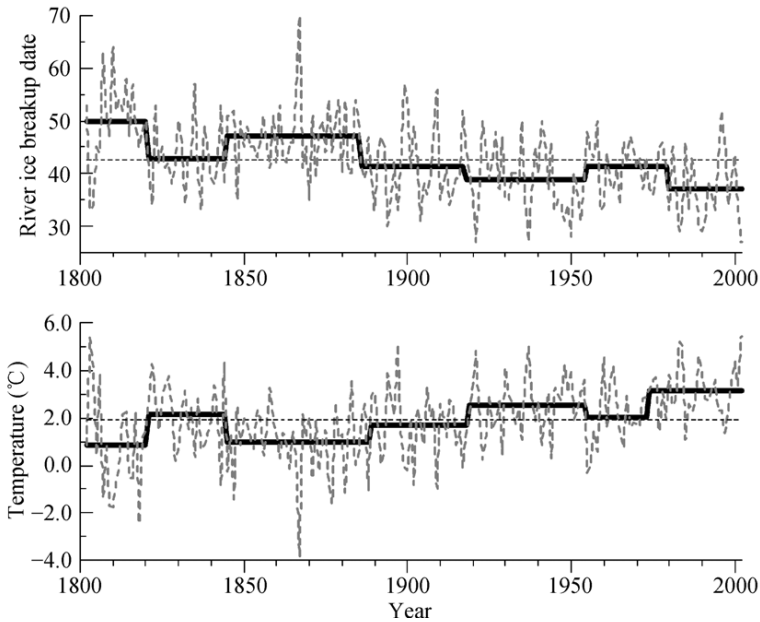
Basal ice formation becoming more frequent



- Number of winters with basal ice formation (freezing of the bottom layer of the snow cover) during 68 year period (A)
- More basal ice winters in many regions, comparing 1983-2016 to 1948-1982 (D)
- Five of seven most extensive basal ice winters experienced during 1991-2016

Rasmus, S., Kivinen, S., Irannezhad, M. 2018. Basal ice formation in Northern Finland snow covers during 1948-2016. Environmental Research Letters.

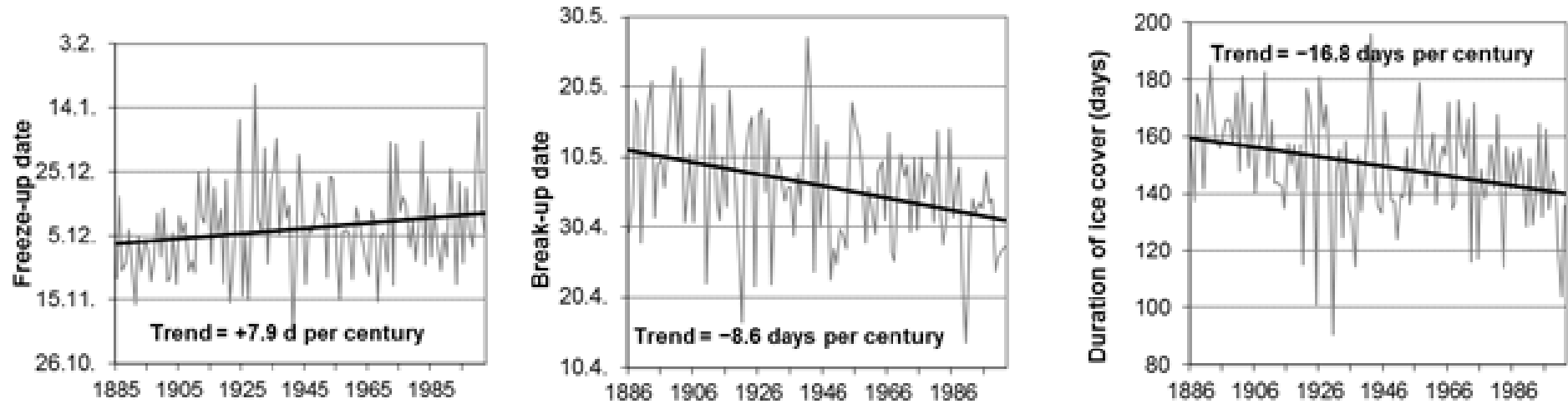
River ice break-ups earlier



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Helama, S., Jiang, J., Korhonen, J., Holopainen, J. & Timonen, M. 2013. Quantifying temporal changes in Tornionjoki river ice breakup dates and spring temperatures in Lapland since 1802. *Journal of Geographical Sciences* **23**(6), 1069–1079.
Sharma, S., Magnuson, J.J., Batt, R.D., Winslow, L.A., Korhonen, J. & Aono, Y. 2016. Direct observations of ice seasonality reveal changes in climate over the past 320–570 years. *Scientific Reports* **6**, 25061.

Lake ice duration and thickness have decreased



- Ice freeze-ups have become later, ice break-ups earlier and ice cover duration shorter, many new records for the 21st century (mild winters)
- Maximum ice thickness have decreased in the southern Finland



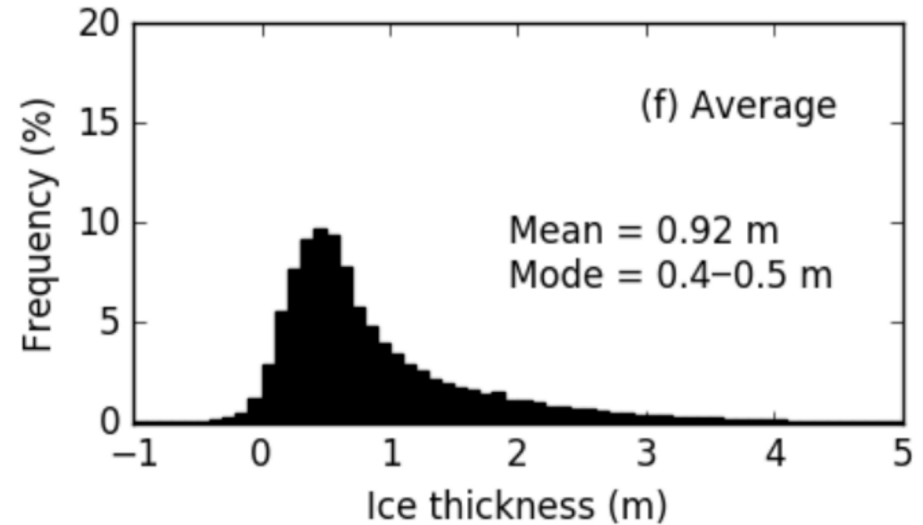
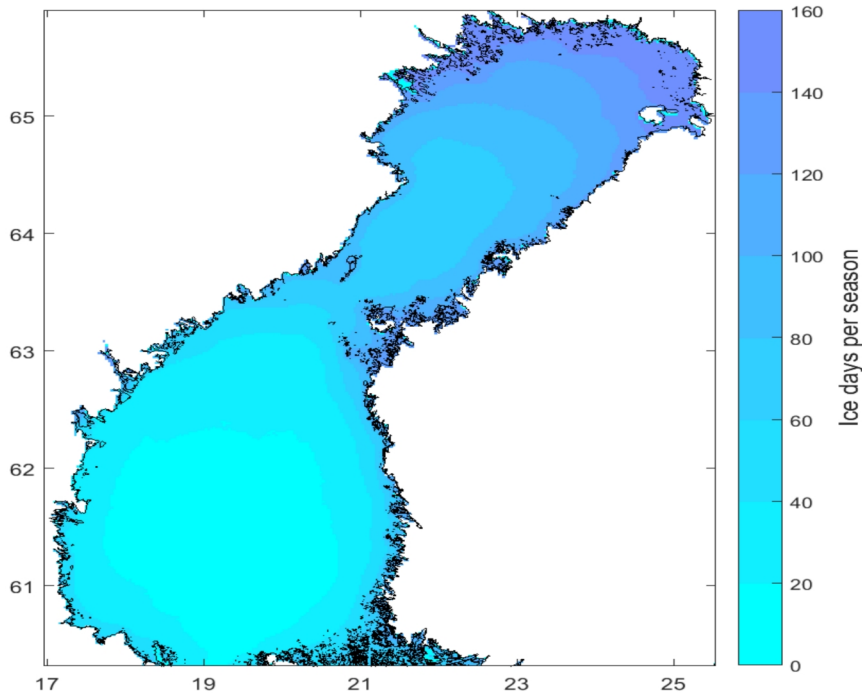
IMPACT OF SHIPPING ON SEA ICE ?



SHIP INDUCED FRACTURES

NATURAL FRACTURES

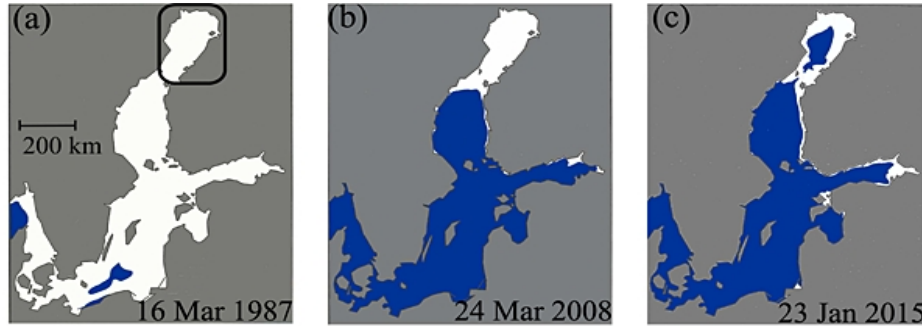
PRESENT SEA ICE CHARACTERISTICS



Ronkainen et al. 2018: Interannual sea ice thickness variability in the Bay of Bothnia, *The Cryosphere*, 12, 3459-3476

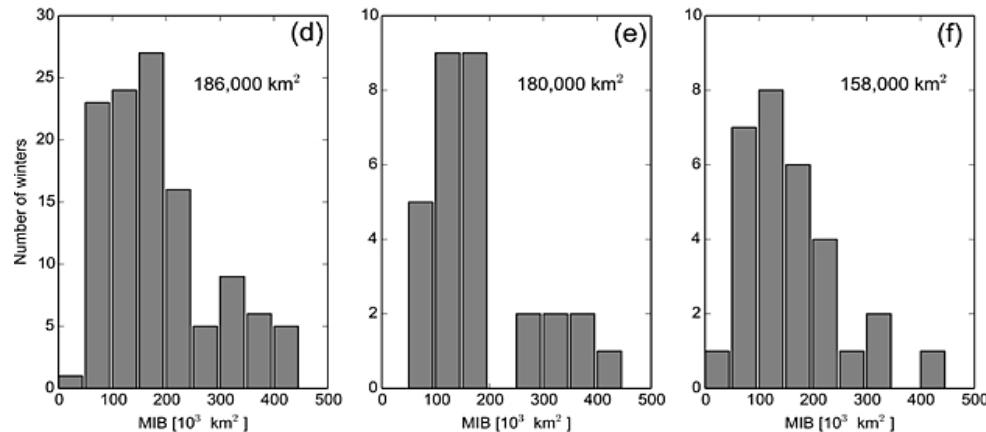
- Average Ice covered period from 10 to 160 days, max ~ 200 days
- Average level ice thickness 5 – 50 cm, max ~120 cm
- Ridged ice thickness 3-30 meters
- Large inter-annual variability driven by large scale atmospheric circulation

Bay of Bothnia was only partially ice covered on winter 2015 No hard evidences that it has occurred before



Probability distribution of ice extent is now statistically significantly different than any other 30 years period since 1720.

Extreme severe winters has become even more uncommon.



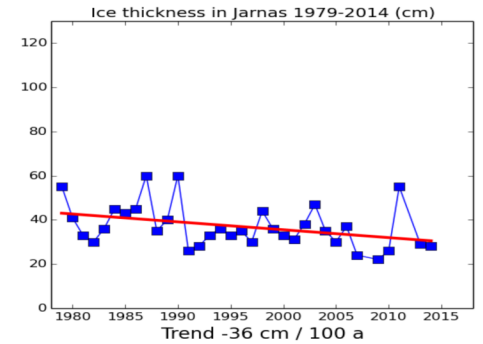
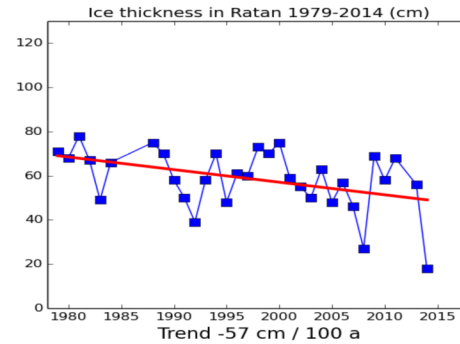
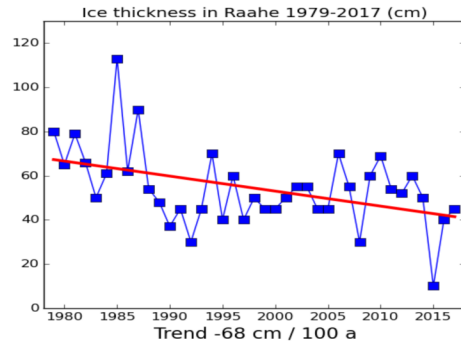
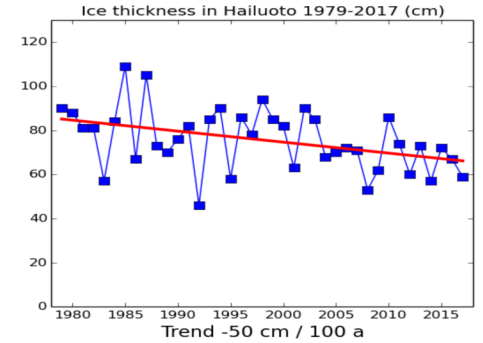
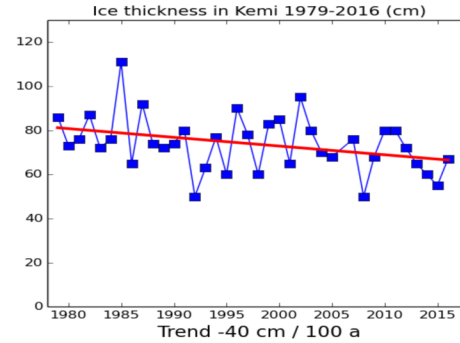
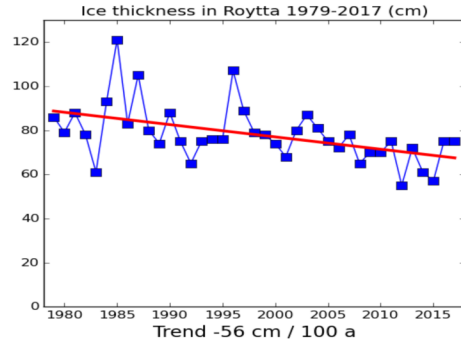
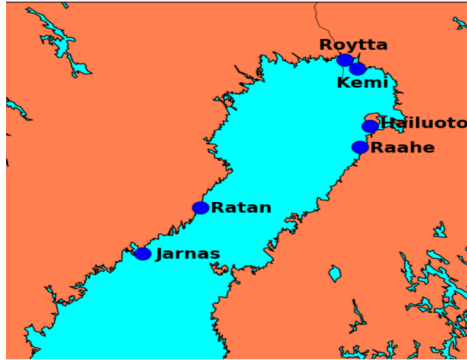
1900 – 2015

1908 – 1938

1985 - 2015

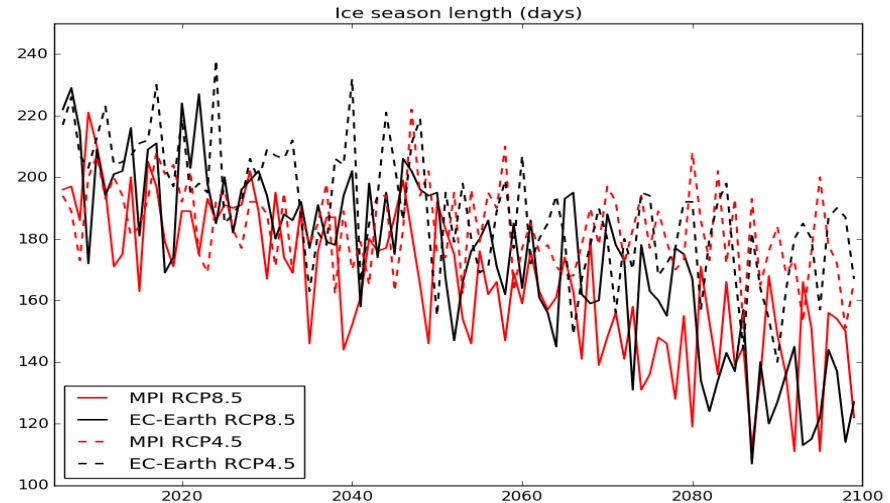
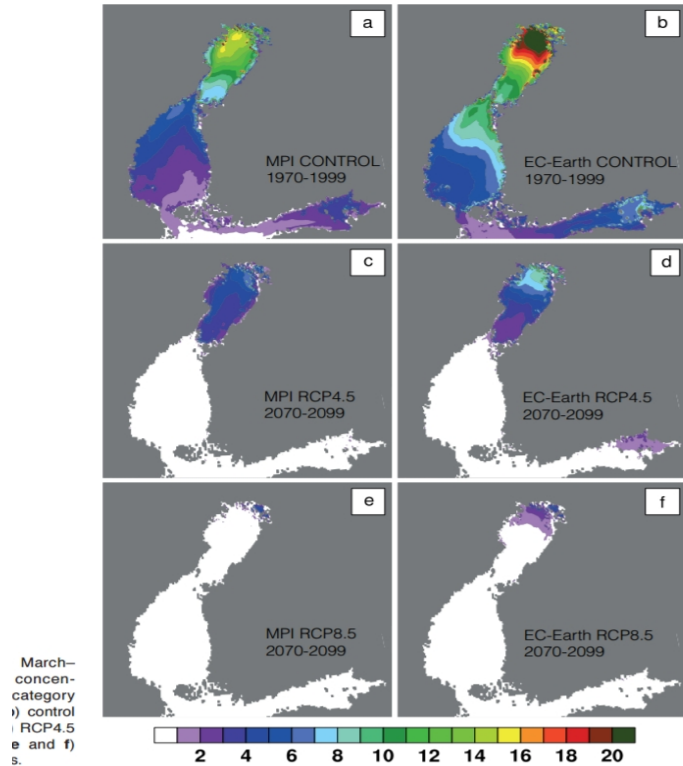
Uotila et al, 2015, GRL.

OBSERVED CHANGES IN SEA ICE THICKNESS



- Ice thickness has decreased during the last 30+ years in all stations
- Winter 2015 was the first year when the central BoB was certainly ice free

PROJECTED CHANGES



Höglund et al. 2017: Ice conditions for maritime traffic in the Baltic Sea in future climate, Boreal Environment Research 22

- Ice covered period will be shorter and thickness smaller, but sea ice will be formed still every winter in the Bay of Bothnia.
- Clear differences between RCP4.5 and RCP8.5 scenarios
- Inter-annual variability remains large

IMPACTS OF SEA ICE CHANGES

Physical environment

- More waves, mixing and turbulence in winter period
- Increased sea level variations in winter
- Increased coastal erosion

Ecosystem

- Ice dependent species losing environment to live
- Fast ice region provides a non-turbulent environment, how important that is for the ecosystem ?
- Does the timing of spring bloom change ?

Traffic

- Reduced need for icebreakers assistance
- Lesser possibilities to establish ice roads during winters

Tourism and wellbeing

- Longer period for boat fishing and shorter for ice fishing