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## Changes in winter warming events in the Nordic Arctic Region

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# Warm spell and rain-on-snow events at Svalbard: 26 Jan-9 Feb 2012

Station	Days $T_{\max} > 3^{\circ}\text{C}$	Precipitation
Svalbard airport	11	70 mm (37% of 190 mm annual normal)
Ny Ålesund	10	272 mm (71% of 385 mm annual normal)

**Impacts:** Ground ice,

starving reindeers,

snow avalanches



# Aim:

## Study changes and trends in winter warming events in the Nordic Arctic region

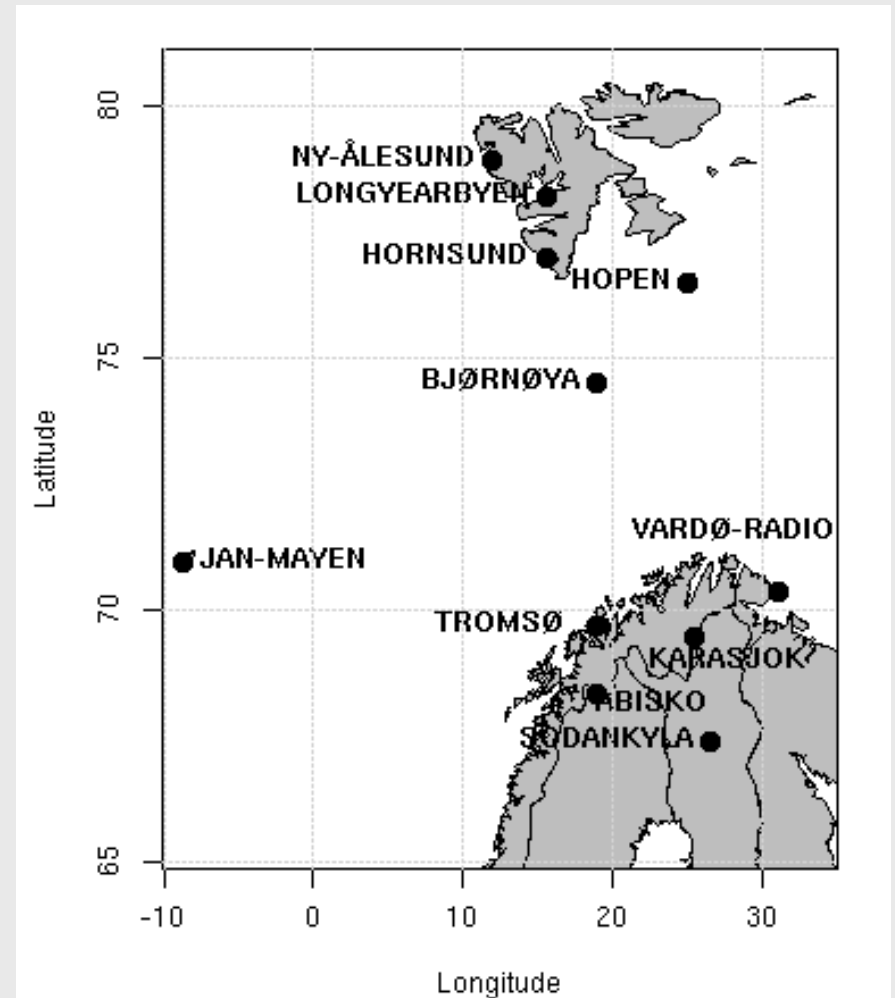
**Past 50-100 years**

Present climate (past 15 years)

Future 50-100 years

### 11 weather stations:

- Longest time series
- 7 stations with > 90 years of precipitation and temperature observations

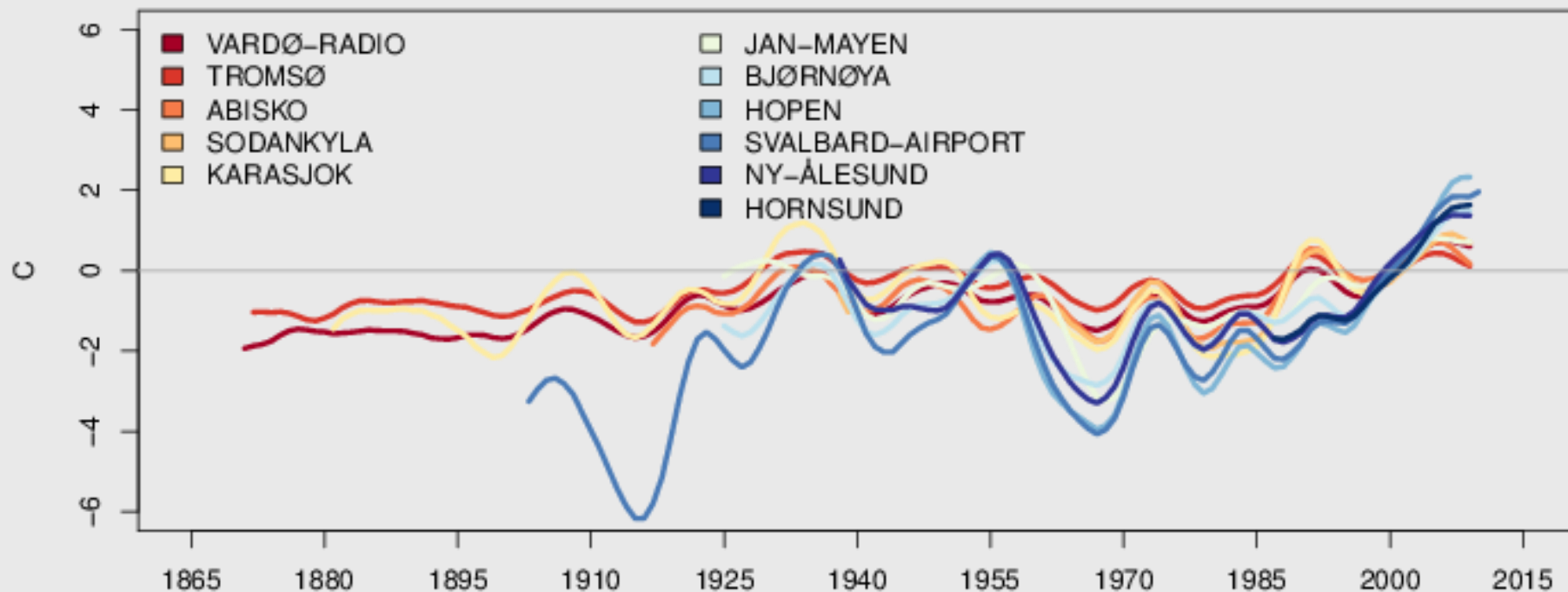


# October-April temperature deviation, relative to 1985-2014

## Mainland

(Sweden, Norway, Finland)

## Arctic islands



# Methods

# Winter warming indices

Fixed threshold for all stations

Threshold = 0°C:

- Transition between liquid and frozen water. Selected to study impacts on melting snow and ice.

Index	Description	Type
$T > 0^{\circ}\text{C}$	Melt day	Frequency
$\Sigma(T > 0^{\circ}\text{C})$	Positive degree day sum	Intensity
$T > 0^{\circ}\text{C} \& P > 0 \text{ mm}$	Rainy winter days	Frequency
$\Sigma(P)$ for days with $T > 0^{\circ}\text{C} \& P > 0 \text{ mm}$	Precipitation sum for rainy winter days	Intensity

# Winter warming indices:

Variable threshold determined using station climatology

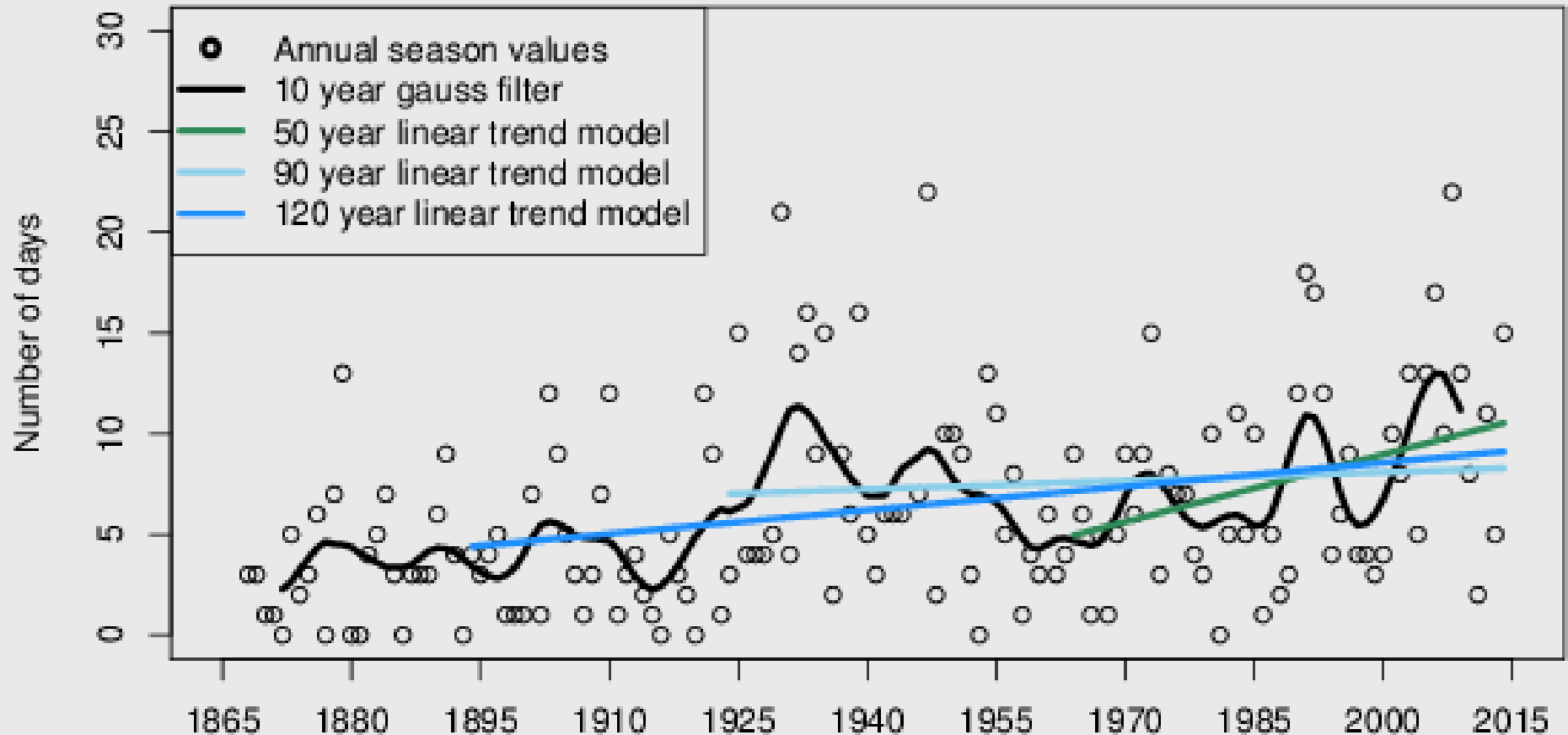
Temperature threshold = 90th percentile of 1985-2014 climatology

- for each season
  - for each station
- study extremes for a station

Index	Description	Type
$T > T_{90}$	Warm days -days with daily temperature exceeding the $T_{90}$ threshold	Frequency

# Count warm days/season/year

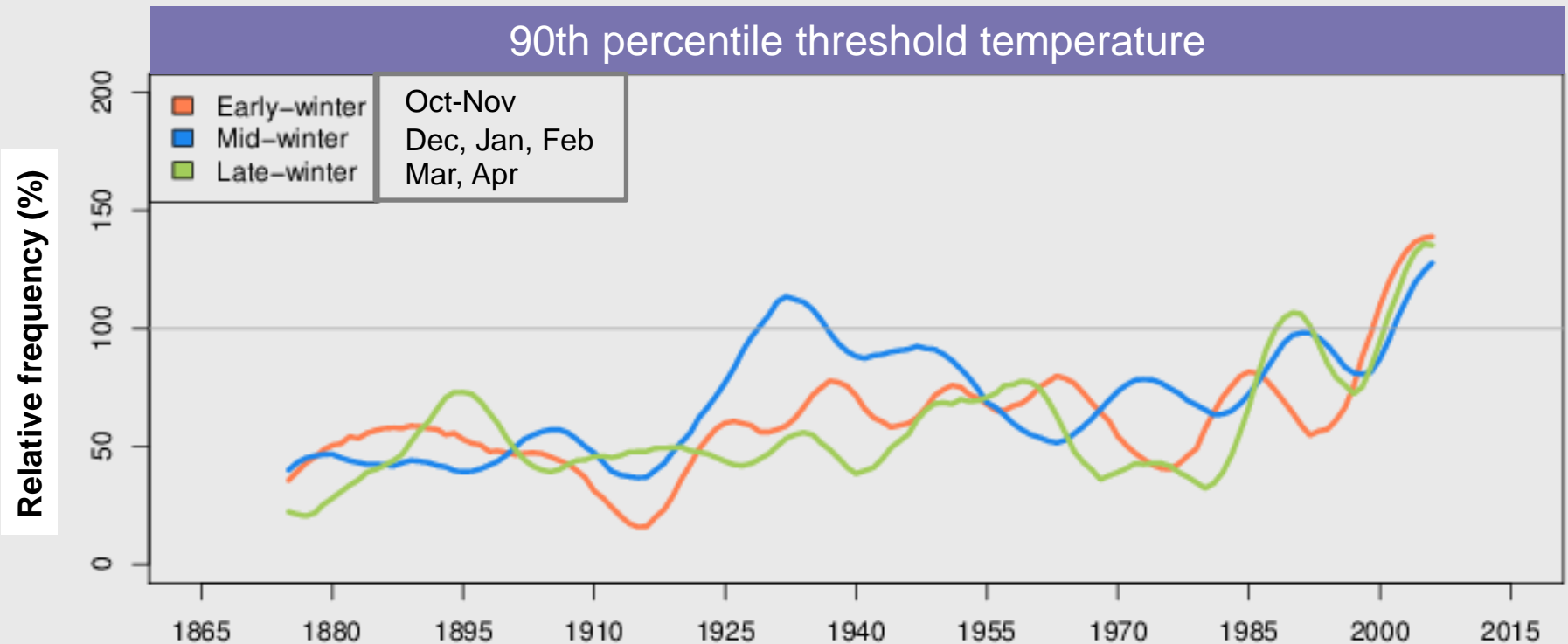
Example: Vardø station, mid-winter,  
the 90th percentile threshold temperature





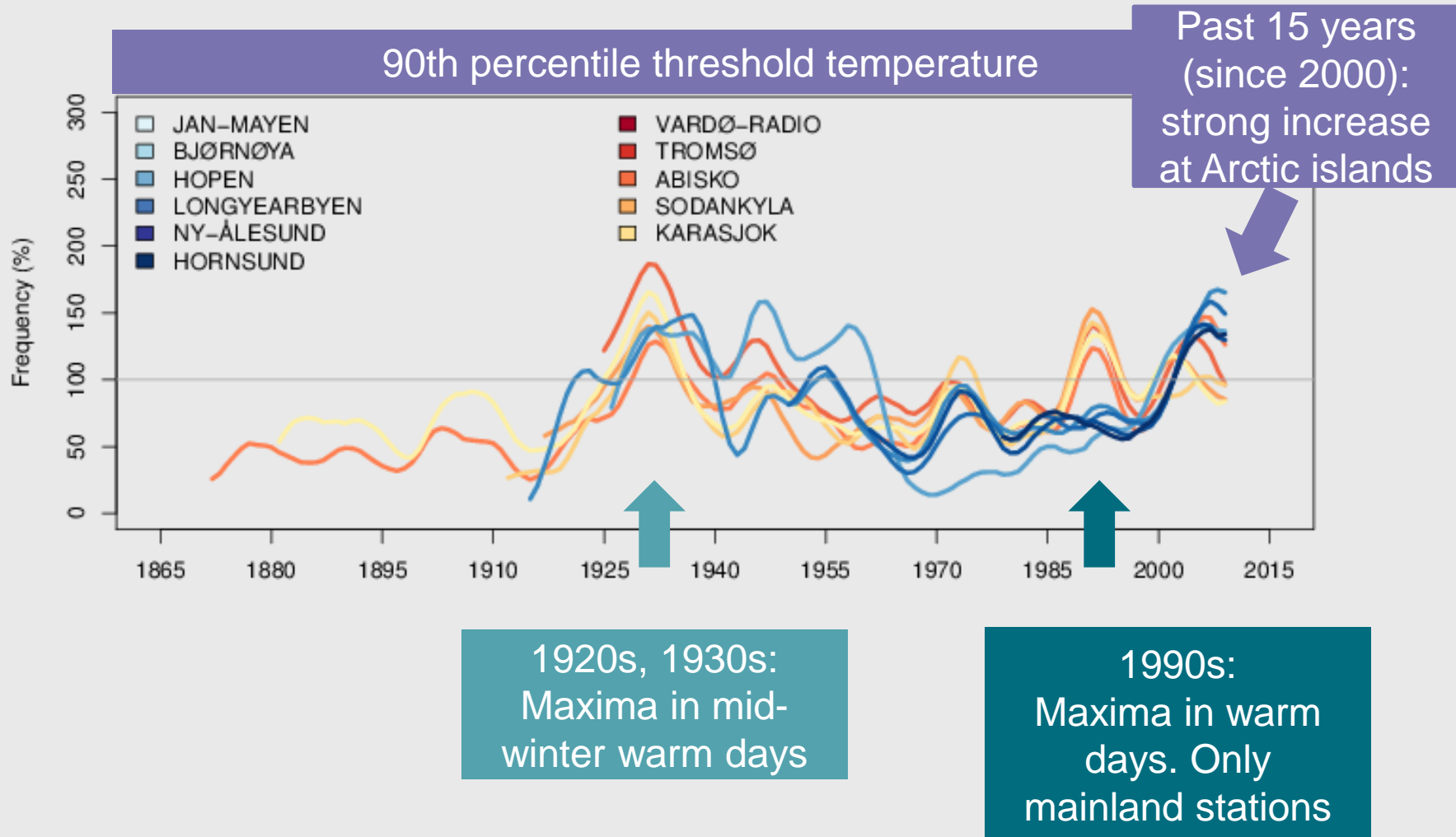
**Results:  
past ~100  
years**

# Warm days per year relative to 1985-2014 - 3 winter seasons, Vardø station



- Mid-winter: Strongest natural variability. 1920/30's winter climate similar to present climate.
- Early/Late-winter: Strongest change past 50 years

# Mid-winter (Dec-Feb) warm days for all stations, relative to 1985-2014



# Change in number of warm days per decade (October-April)

Linear trends over the past			
Station	50 years	90 years	120 years
Jan-Mayen	5.5*	-0.6	-
Svalbard airport	3.6*	-	-
Bjørnøya	3.4*	0.6	-
Hopen	3.2*	-	-
Vardø	3.1*	0.8	0.9*
Sodankylä	3.0*	0.8*	-
Abisko	2.6*	0.4	-
Tromsø	2.2*	0.2	0.3*
Karasjok	2.2*	0.7	0.4*

All stations:

- Past 90 years: small changes (all stations)
- Past 50 years strongest increase in warm spell days.
  - Arctic islands on top of the list

# Change in number of melt days per decade (October-April)

Linear trends over the past			
Station	50 years	90 years	120 years
1. Jan-Mayen	9.2*	0.2	-
2. Vardø	7.2*	2.2*	2.1
3. Bjørnøya	6.7	1.5*	-
4. Tromsø	5.1*	0.6	0.7*
5. Abisko	3.2*	0.6	-
6. Sodankylä	3.1	1.2*	-
7. Karasjok	2.5	0.8*	0.6*
8. Svalbard airport	2.1	-	-
9. Hopen	2.1*	-	-

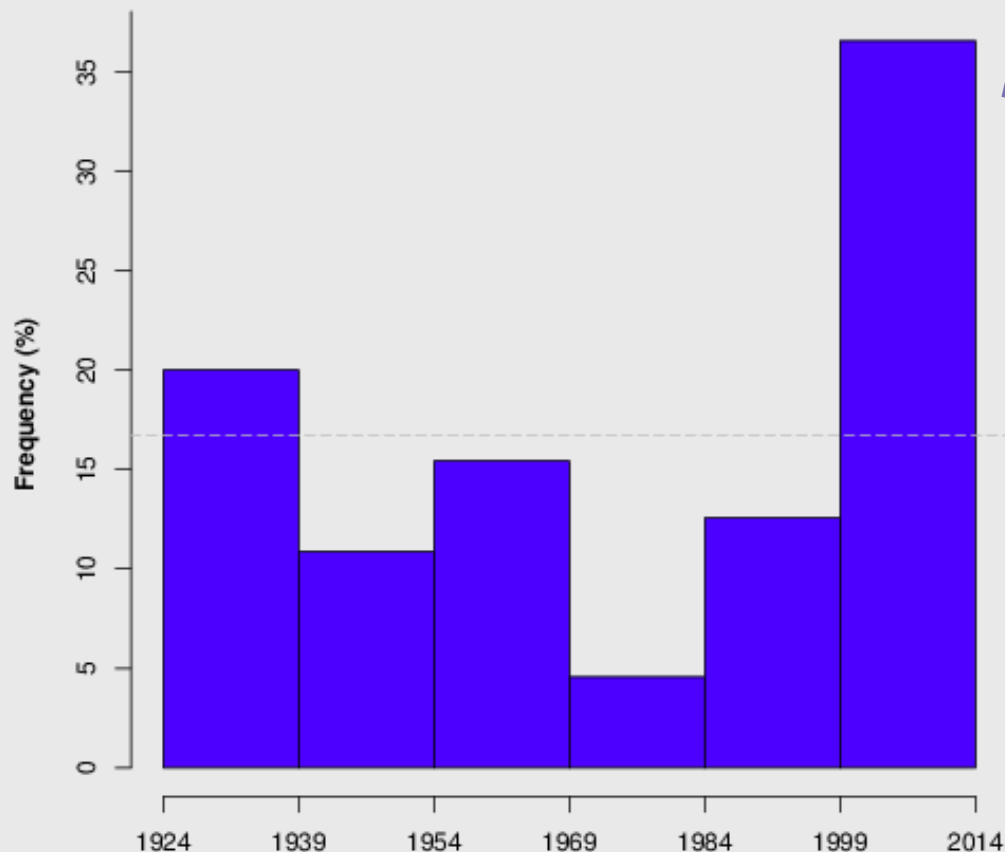


Past 50 years top 4 stations:

- Correspond to stations having highest winter temperatures. Coastal stations.
- Trends for positive degree days show the same strong historical increase

# Top 5 extreme winter warming years since 1924 (all indices)

Past 15 years,  
2000-2014:  
On Top!



15-year periods

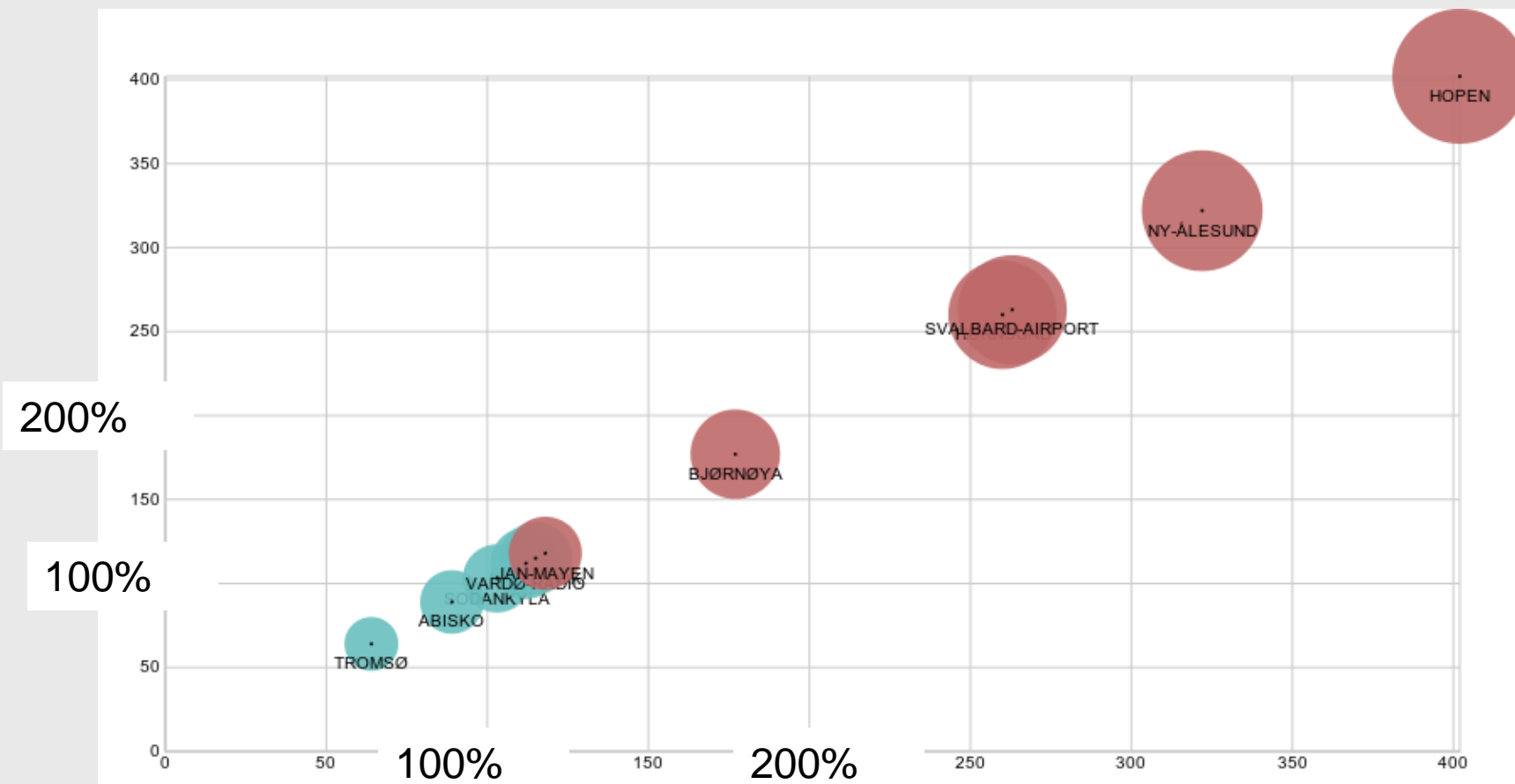


# Future projections

## Regionally downscaled scenarios:

- 14 simulations, ENSEMBLES, 25km grid scale, time period 1951-2100 (exl. Svalbard)
- 6 NorACIA (MET Norway) simulations, 25 km grid scale
- Bias corrected temperature and precipitation data (1985-2014)

# Relative change (%) in melt days ( $T > 0^{\circ}\text{C}$ ): From 1985-2014 mean to 2100.



- Arctic stations: strongest increase, 100-400%
- Mainland stations: smallest increase, 50-100%
- Similar results for other climate indices, other stations



# Summary: winter warming events

- **Present climate (past 10-15 years):**
  - **Frequent reports of warm spells from the Arctic. 35% of top 5 winter warming years from 2000-2014.**
- **Past 100 years: Oct-April season**
  1. **Small changes past 90 years.**
    - **Warm winters during 1920/30s.**
  2. **Strong increasing trends past 50 years.**
    - **Arctic winter temperatures increase more than mainland stations.**
- **Next 50-100 years:**
  - **strong historical trends seem to continue the next 50-100 years.**
  - **Northern Scandinavia: doubling the number of winter warming events.**
  - **Arctic islands: >3 times increase in winter warming events.**