The observed recent surface air temperature development across Svalbard and concurring footprints in local sea ice cover

Sandro Dahlke[1], Nicholas E. Hughes[2], Penelope M. Wagner[2], Sebastian Gerland[3], Tomasz Wawrzyniak[4], Boris Ivanov[5,6], Marion Maturilli[1]

[1] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam, Germany
[2] Norwegian Ice Service, Norwegian Meteorological Institute, Tromsø, Norway
[3] Norwegian Polar Institute, Fram Centre, Tromsø, Norway
[4] Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland
[5] Arctic and Antarctic Research Institute, Polar Climate Department, St. Petersburg, Russia
[6] Saint-Petersburg State University, Oceanographic Department, St. Petersburg, Russia

Related publication:

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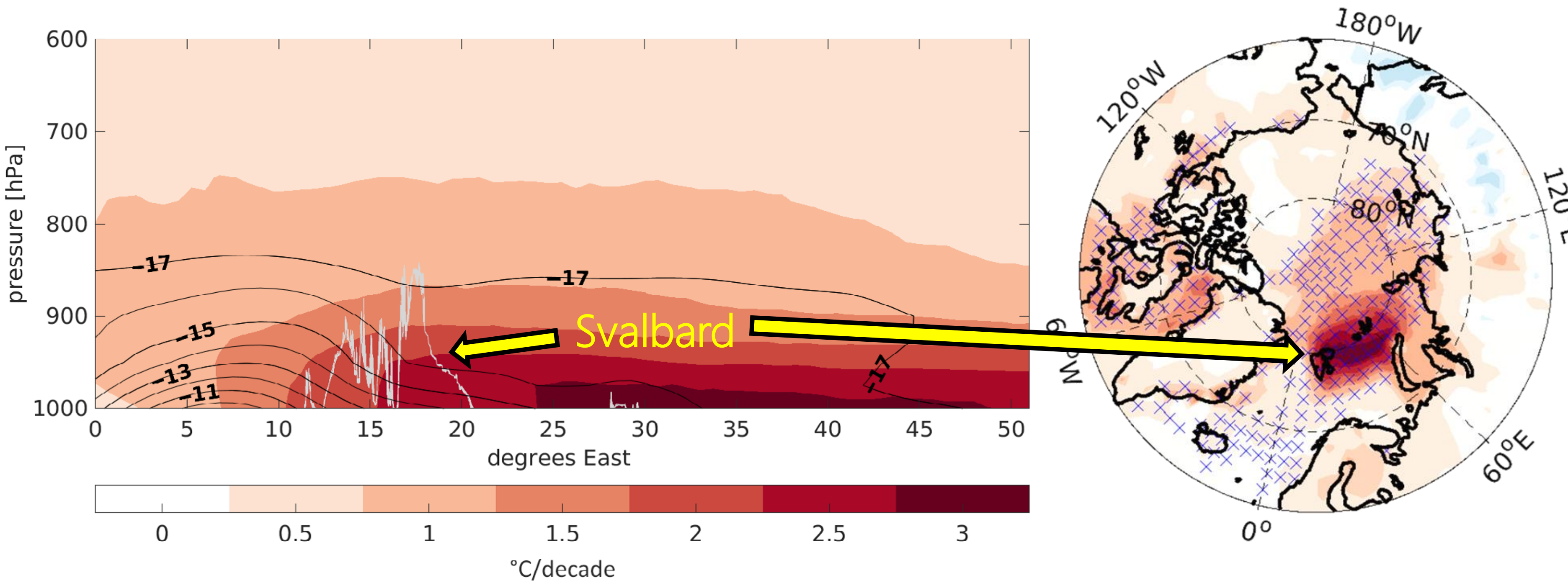
Motivation

- Svalbard is hotspot of recent Arctic warming, but there are strong regional gradients in both temperature trends and climatology
- Natural observatory of ongoing changes



1980-2016 decadal temperature trend from Era-Interim during winter (DJF). Shown as cross section along 79°N (left), and 2m Temperature (right). Black isoline shows climatology in °C.

Aim of the Study

- Systematic characterization of differences in surface air temperature (SAT) and regional sea ice extent (SIE) evolution across Svalbard

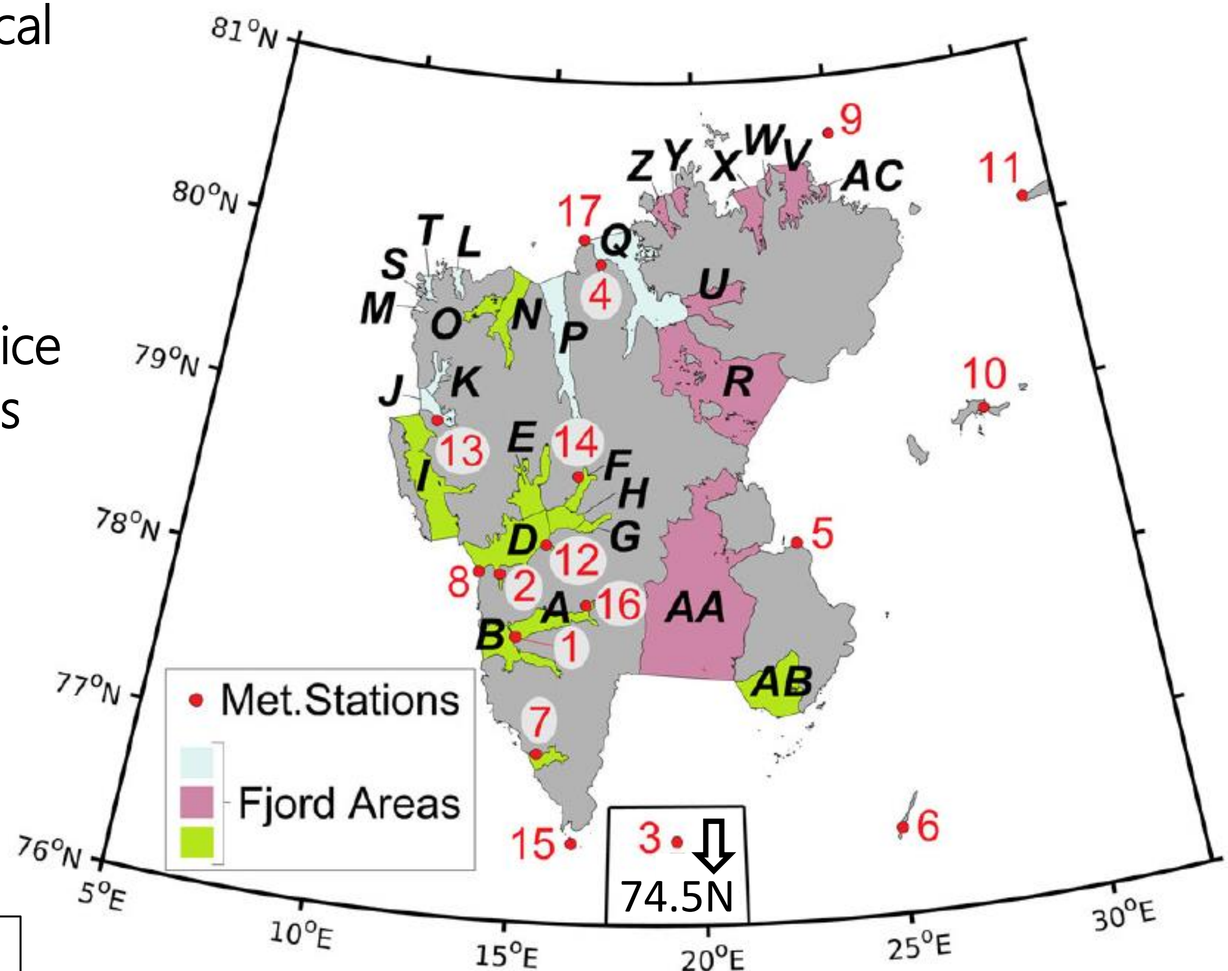
- Identification of drivers for interannual SAT and SIE variability

- Combining observational data from meteo stations and sea ice charts across whole Svalbard

Observational data

- SAT from 17 meteorological stations *(MET Norway, IOPAN, AARI)*

- SIE from operational sea ice charts for 29 fjord regions *(MET Norway)*



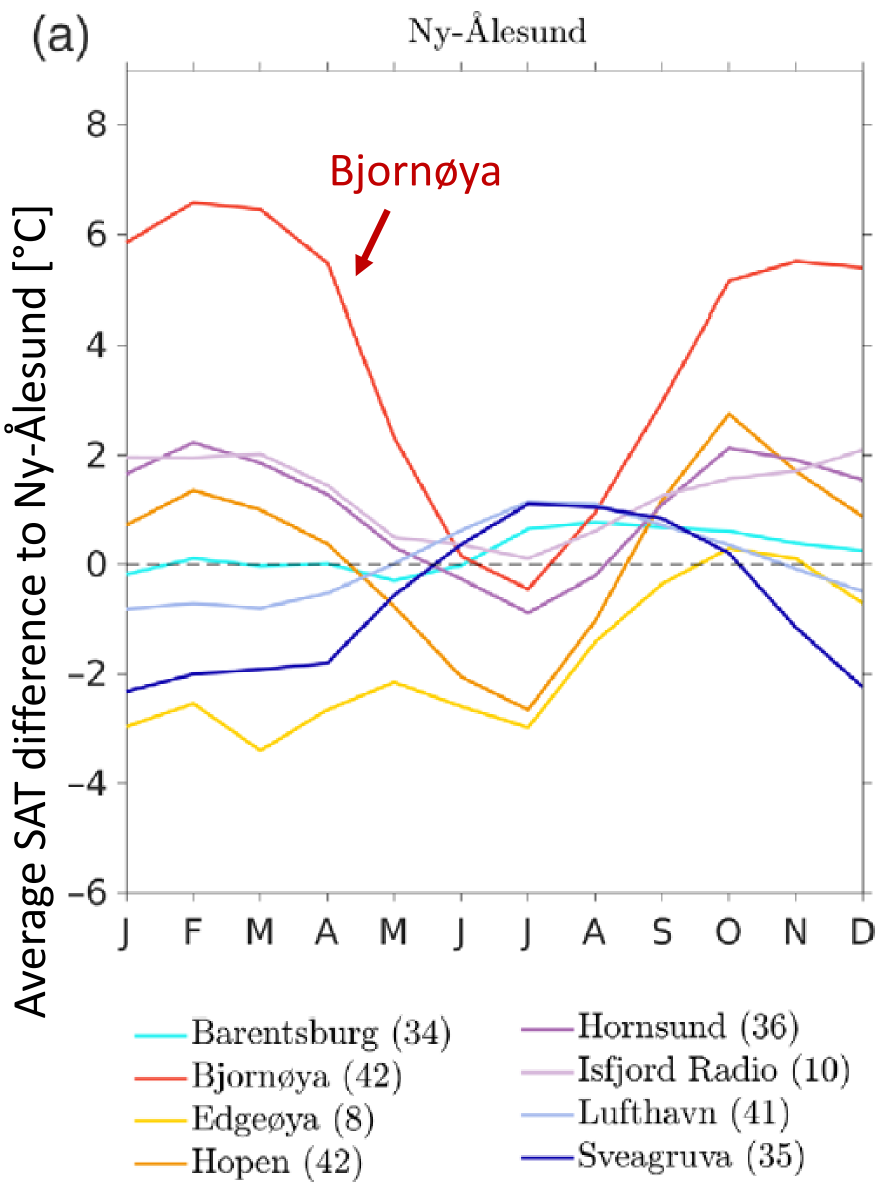
Dataset of monthly mean and seasonal mean data from 1980-2016

Comparing SAT seasonal cycles

Problem:
SAT data record comprises long term stations (starting 1980 and ongoing) as well as recently launched stations (years after 2010) and partial data gaps.

Solution:
Restrict comparison to years when both compared stations recorded 12/12 months data.

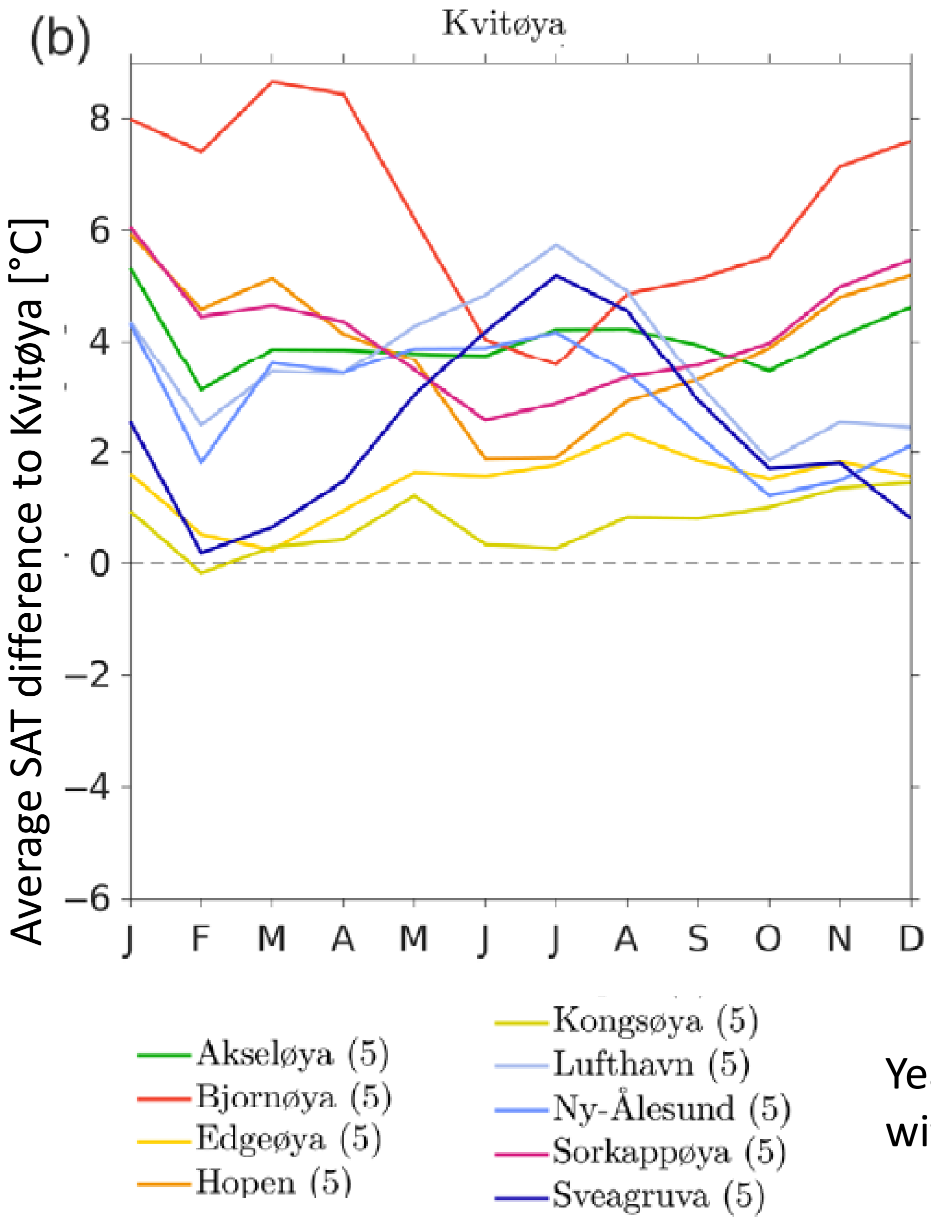
Comparing SAT seasonal cycles: Ny-Ålesund



Years of overlap with Ny-Ålesund

- Ny-Ålesund (#13) in the north-west of Svalbard is rather representative for an average Svalbard station
- Stations of both higher and lower average SAT exist
- Bjornøya (#3), given its exposed location approx. 250 km south of Spitsbergen exhibits SAT estimates that are more than 6°C higher than those in Ny-Ålesund in winter (red curve)

Comparing SAT seasonal cycles: Kvitøya



Years of overlap with Kvitøya

- Kvitøya (#11) in the north-east of Svalbard is the coldest within all analysed stations
- Throughout the whole year, SAT at most other stations is between +2°C and +4°C degrees higher than at Kvitøya
- During winter and spring, SAT at Bjornøya (#3) is about 8°C higher

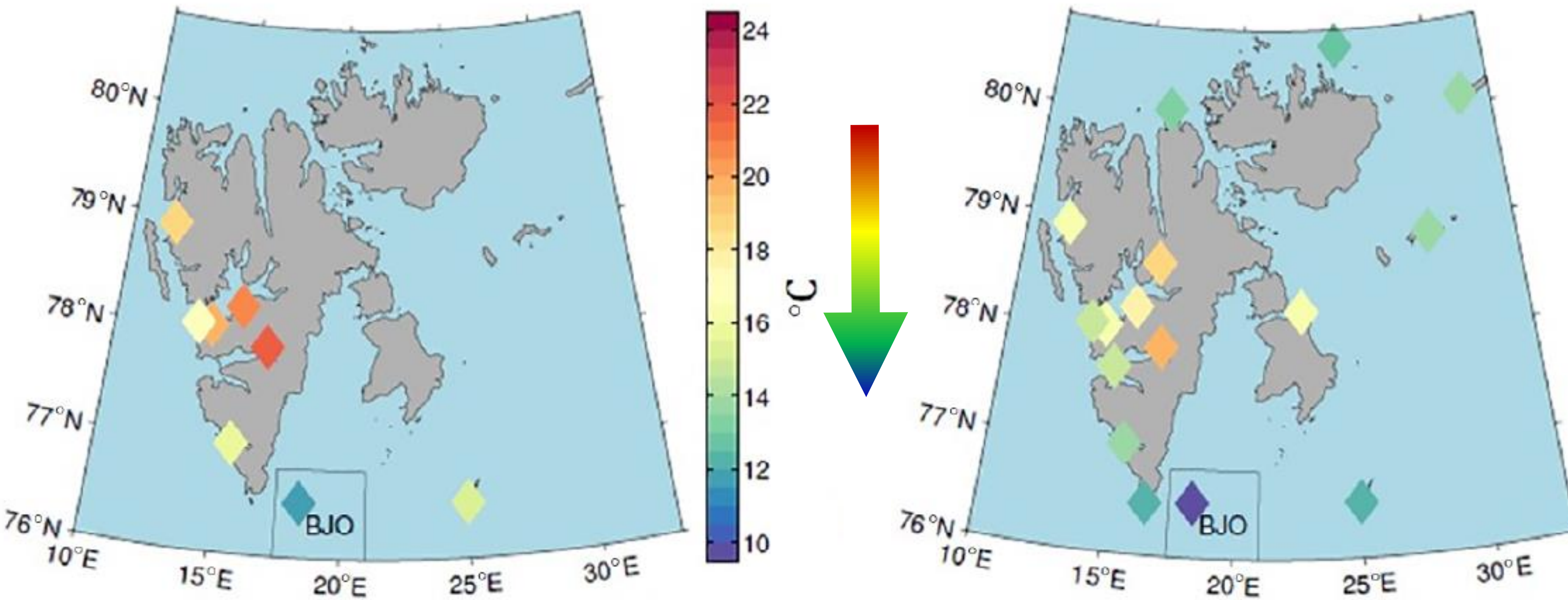
Annual Temperature Range

The annual temperature range (ATR) is the SAT difference between the warmest and the coldest month of the year, and is a measure of continentality of climate.

ATR 1980-2000

More continental

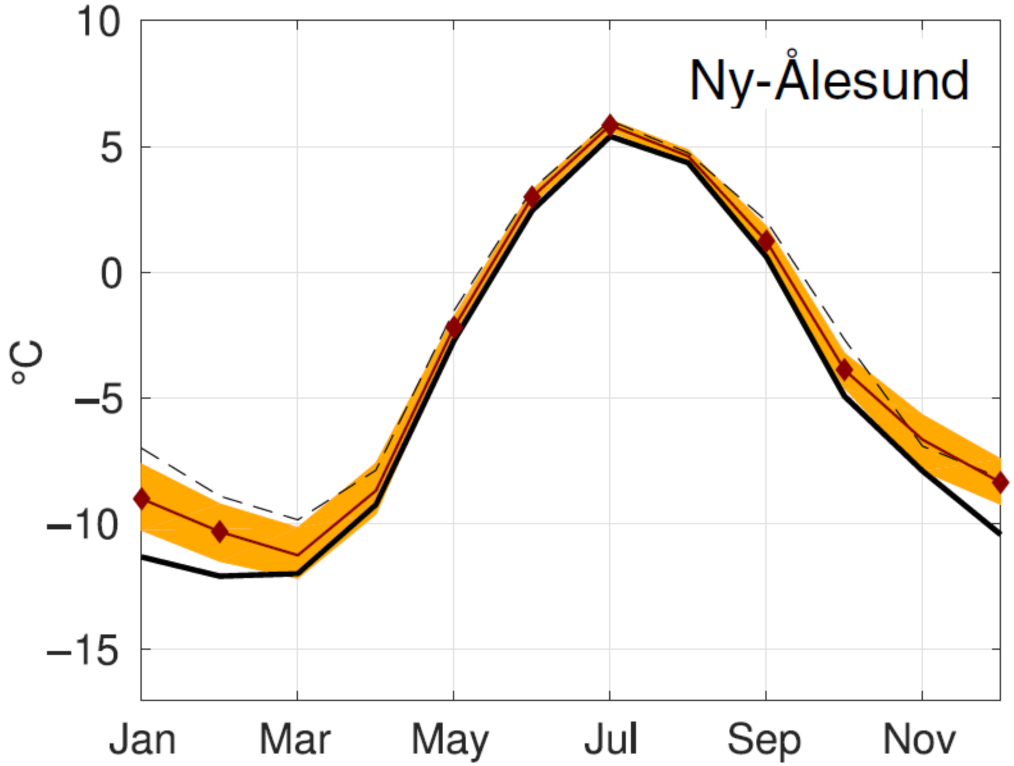
ATR 2010-2016



More maritime

Amplified winter warming reduces continentality in recent decades.

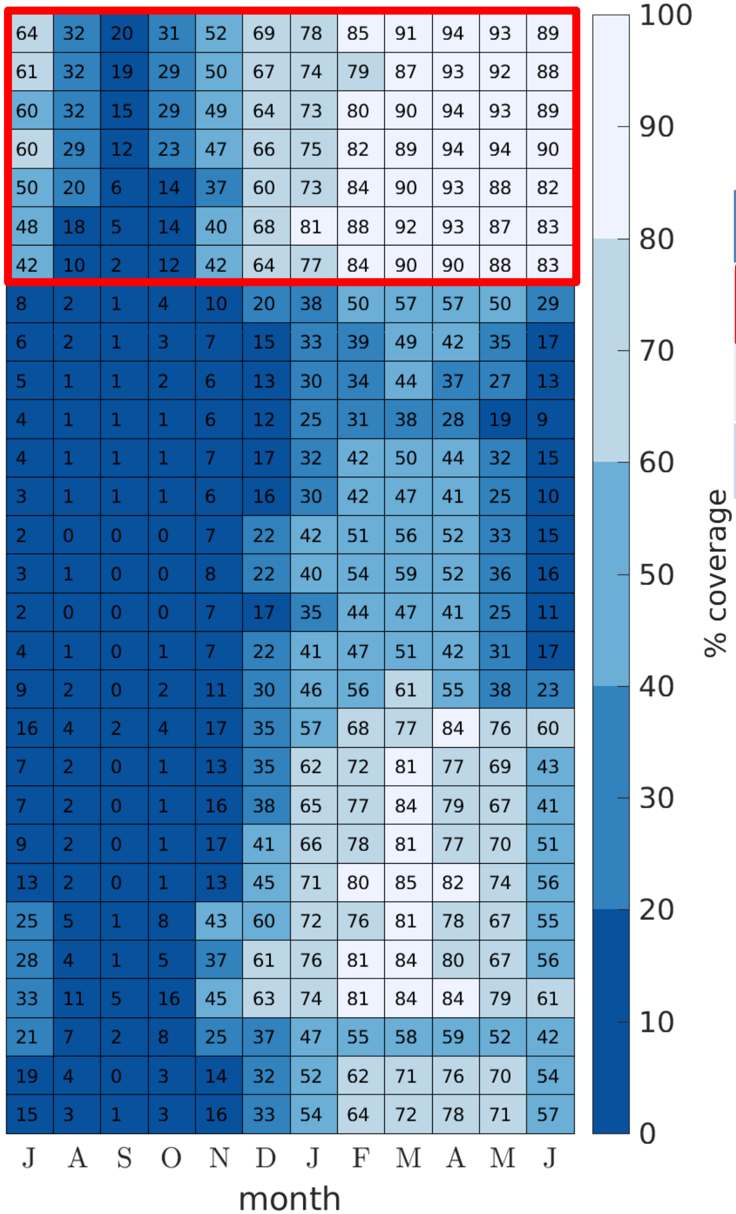
SAT trends



1980-2016 climatology (black solid), 2010–2016 mean (black dashed), linear decadal trend added upon the climatology (red), and the 95% confidence interval of the trend (ocher). Diamonds indicate if the trend is significantly different from zero.

- Six long-term stations allow investigation of 1980-2016 SAT trends
- Warming in winter months (2-3°C/decade) outclasses warming in summer (<1°C/decade)
- Within uncertainty limits, trends do not differ among the six stations
- Winter-heavy warming leads to March becoming the coldest month of the year at all stations

SIE climatology 1980-2016



	J	A	S	O	N	D	J	F	M	A	M	J
Finn Malmgrenfjorden	64	32	20	31	52	69	78	85	91	94	93	89
Duvefjorden	61	32	19	29	50	67	74	79	87	93	92	88
Zorgdragerfjorden	60	32	15	29	49	64	73	80	90	94	93	89
Rijpfjorden	60	29	12	23	47	66	75	82	89	94	94	90
Brennevinsfjorden	50	20	6	14	37	60	73	84	90	93	88	82
Lady Franklinfjorden	48	18	5	14	40	68	81	88	92	93	87	83
Wahlenbergfjorden	42	10	2	12	42	64	77	84	90	90	88	83
Raudfjorden	8	2	1	4	10	20	38	50	57	57	50	29
Bjørnfjorden	6	2	1	3	7	15	33	39	49	42	35	17
Smeerenburgfjorden	5	1	1	2	6	13	30	34	44	37	27	13
Magdalenefjorden	4	1	1	1	6	12	25	31	38	28	19	9
Krossfjorden	4	1	1	1	7	17	32	42	50	44	32	15
Kongsfjorden	3	1	1	1	6	16	30	42	47	41	25	10
Forlandsundet	2	0	0	0	7	22	42	51	56	52	33	15
Sassenfjorden	3	1	0	0	8	22	40	54	59	52	36	16
Isfjorden	2	0	0	0	7	17	35	44	47	41	25	11
Bellsund	4	1	0	1	7	22	41	47	51	42	31	17
Hornsund	9	2	0	2	11	30	46	56	61	55	38	23
Liefdefjorden	16	4	2	4	17	35	57	68	77	84	76	60
Tempelfjorden	7	2	0	1	13	35	62	72	81	77	69	43
Billefjorden	7	2	0	1	16	38	65	77	84	79	67	41
Ekmanfjorden	9	2	0	1	17	41	66	78	81	77	70	51
Van Mijenfjorden	13	2	0	1	13	45	71	80	85	82	74	56
Tjuvfjorden	25	5	1	8	43	60	72	76	81	78	67	55
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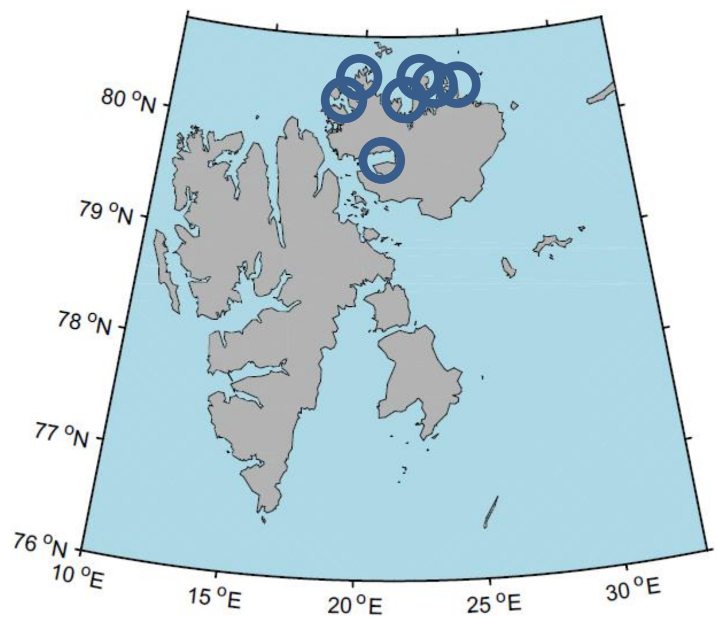
Woodfjorden	15	3	1	3	16	33	54	64	72	78	71	57

Approximately three groups of fjords can be classified:

Group	Virt. icefree	Maximum
Northeast	1-3 months	> 80%
Westcoast	ca. 5 months	< 60%
Center	ca. 4-5 months	> 80%



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month

% coverage (colour scale 0–100)

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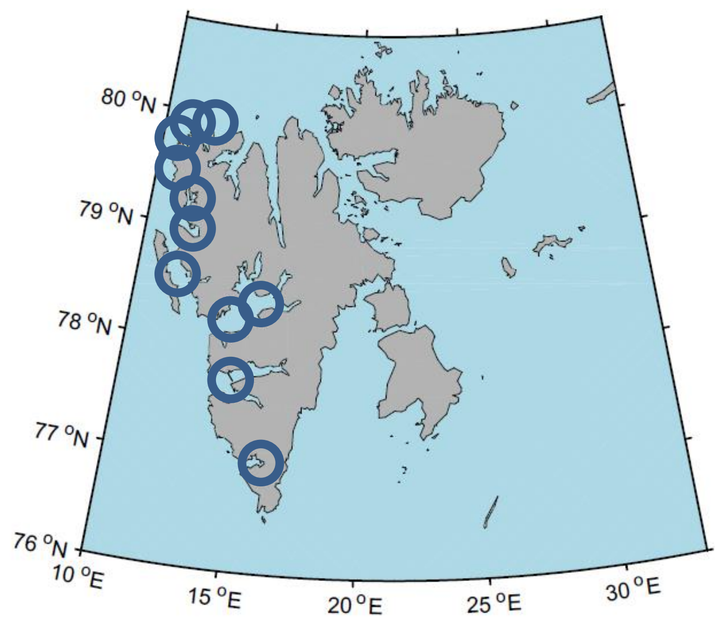

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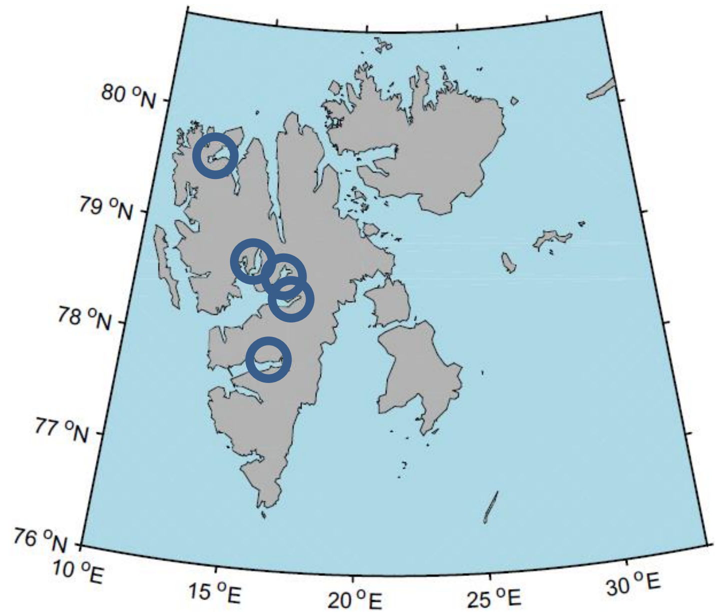
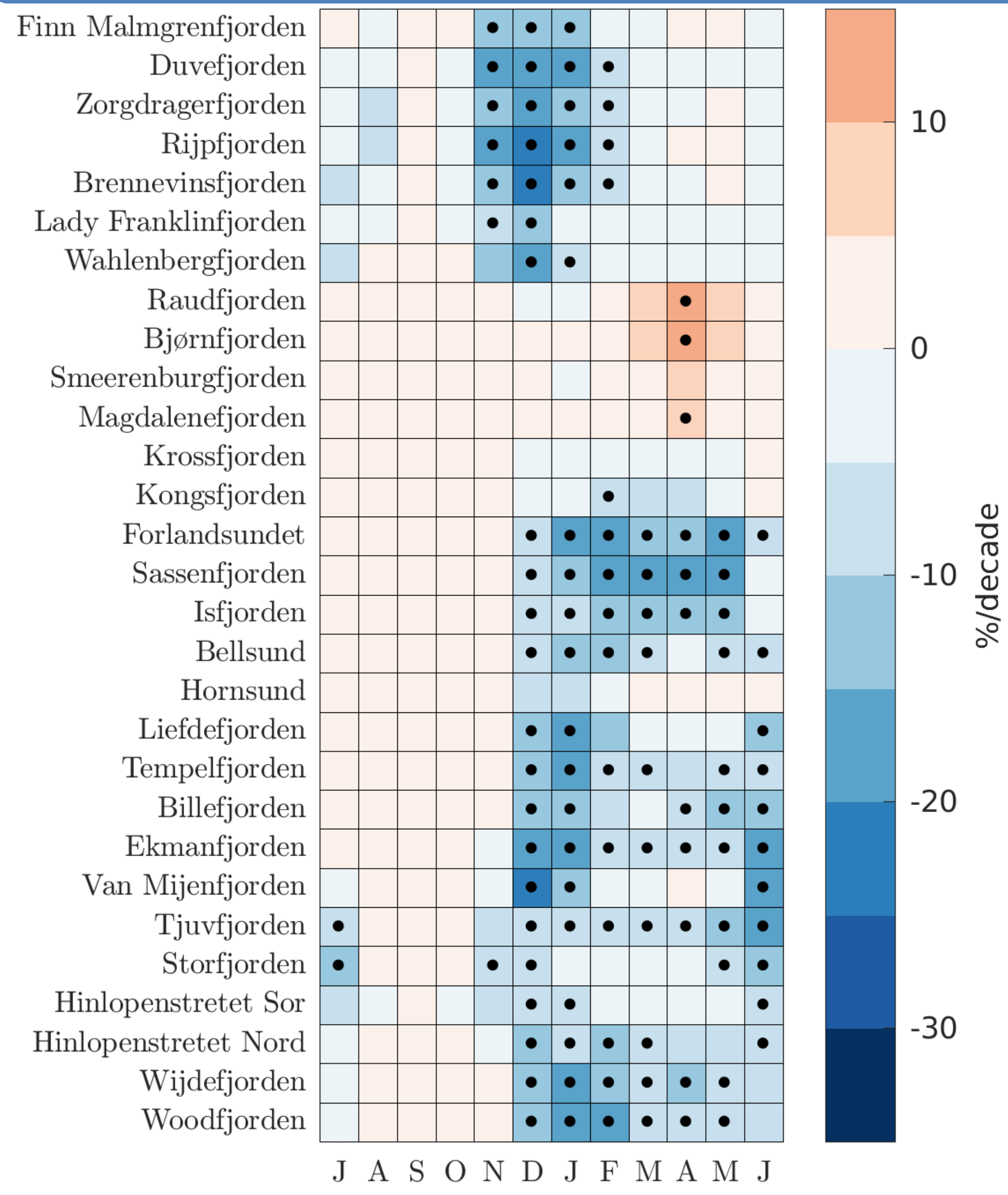


SIE trends 1980 - 2016

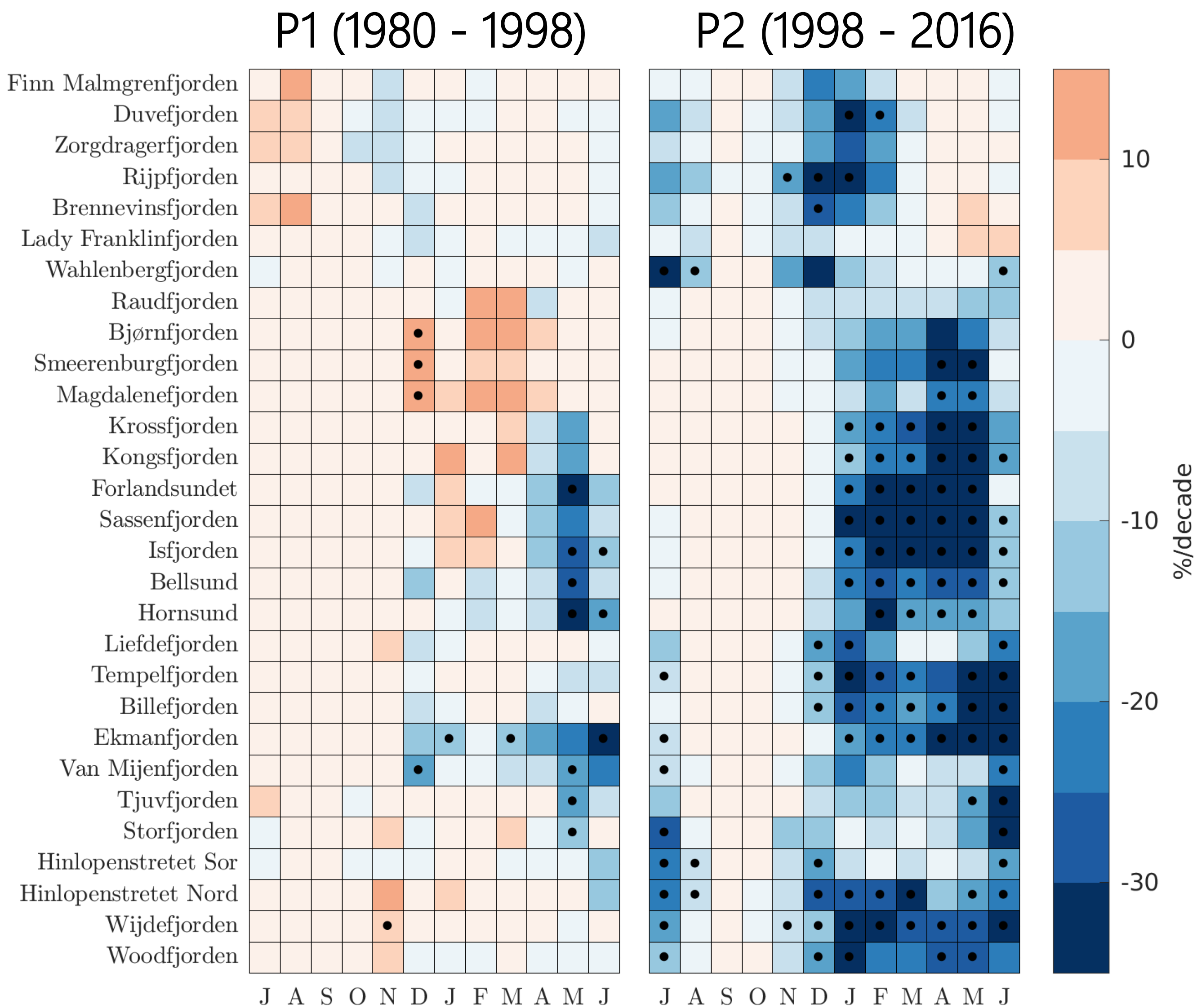


- Downward trend of -5 to -20%/decade in most regions from winter to late spring

- Fjords in the north-east of Svalbard show no ice retreat during spring – temperatures still cold enough to promote freezing (upper portion of plot)

1980-2016 decadal SIE trends per month per region. 95% significance is indicated by dot.

SIE trends 1980 -1998 vs 1998 - 2016



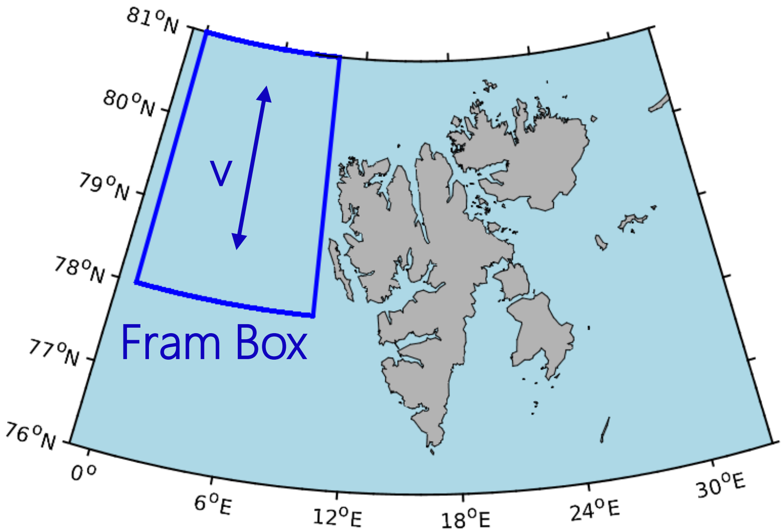
Further analysis shows that SIE reduction is markedly stronger in recent years (1998 – 2016) compared to earlier years, and also appears recently in fjords that showed no significant downward trend during the whole period (1980 - 2016).

Local Impact of wind and ice drift on SIE

Several studies found an increase in wind-driven southward sea ice drift through Fram Strait between 1985 – 1995 (See References and Discussion in Dahlke et al., 2020).

Question: *Did this event in particular, and does large scale circulation over Fram Strait in general, impact regional SIE evolution on Svalbard?*

Method: Average meridional wind speed in Fram Strait Box [1000 hPa, 0°E – 10°E, 78°N – 81°N], and investigate co-variability with SIE in Svalbard fjords during winter



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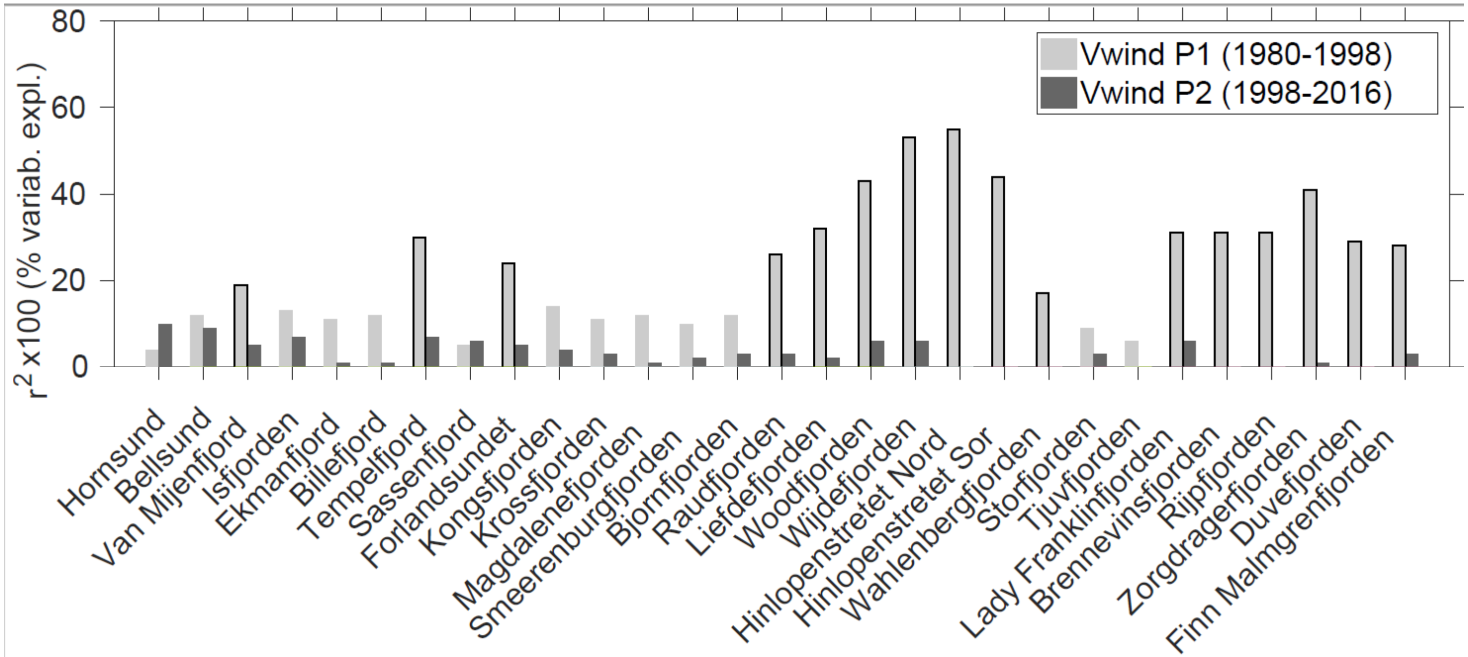
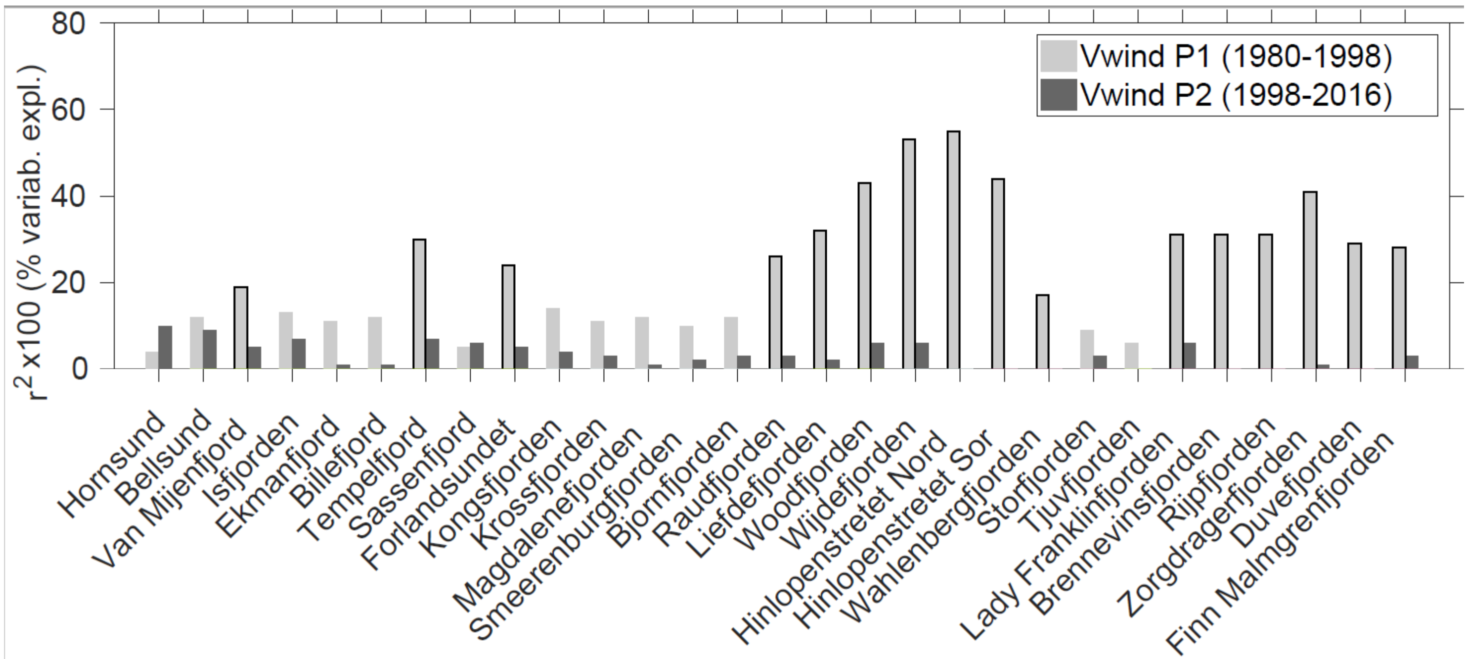


- Regionally significant r^2 = 20% - 50% only in P1, not in P2
- Significant r^2 predominantly in fjords in the north, whose axis extents in north-south direction

Squared pearson correlation coefficients (r^2) between area-averaged DJF-mean meridional wind speed in the Fram Box and regional SIE during P1 (light grey) and P2 (dark grey). Statistical significance is indicated by outlines of the bars.

Local Impact of wind and ice drift on SIE



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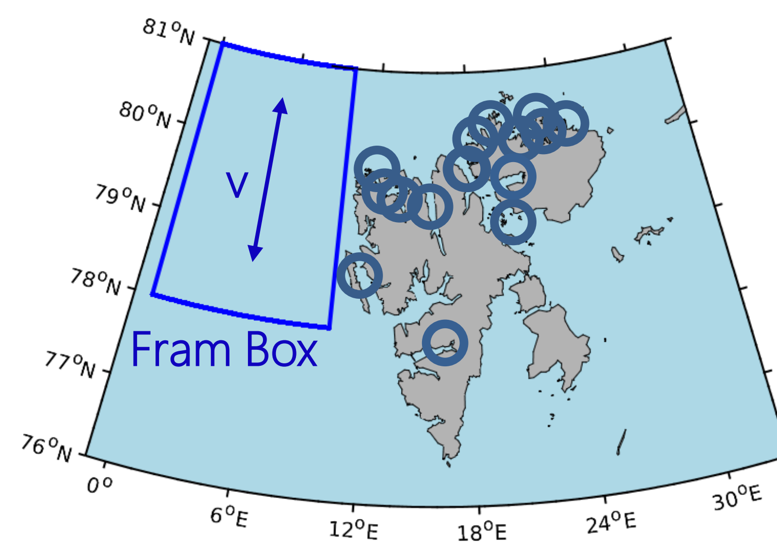

Summary

- Svalbard is a hotspot of recent Arctic warming and wintertime sea ice retreat
- Observational data across Svalbard for SIE and SAT evidence marked regional differences in SAT and SIE distribution over the 1980 – 2016 period
- While fjords on the west coast are recently becoming more often ice-free in winter, those in the north-east can still yield substantial SIE estimates
- strongest winter sea ice decline comes along with winter-amplified SAT warming and a less continental climate
- Additionally, large scale wind patterns and sea ice drift can drive variability of SIE in Svalbard fjords

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