The Role of Atmospheric Circulation in the Seasonal Melt of Snow and Sea Ice in the Pacific Arctic

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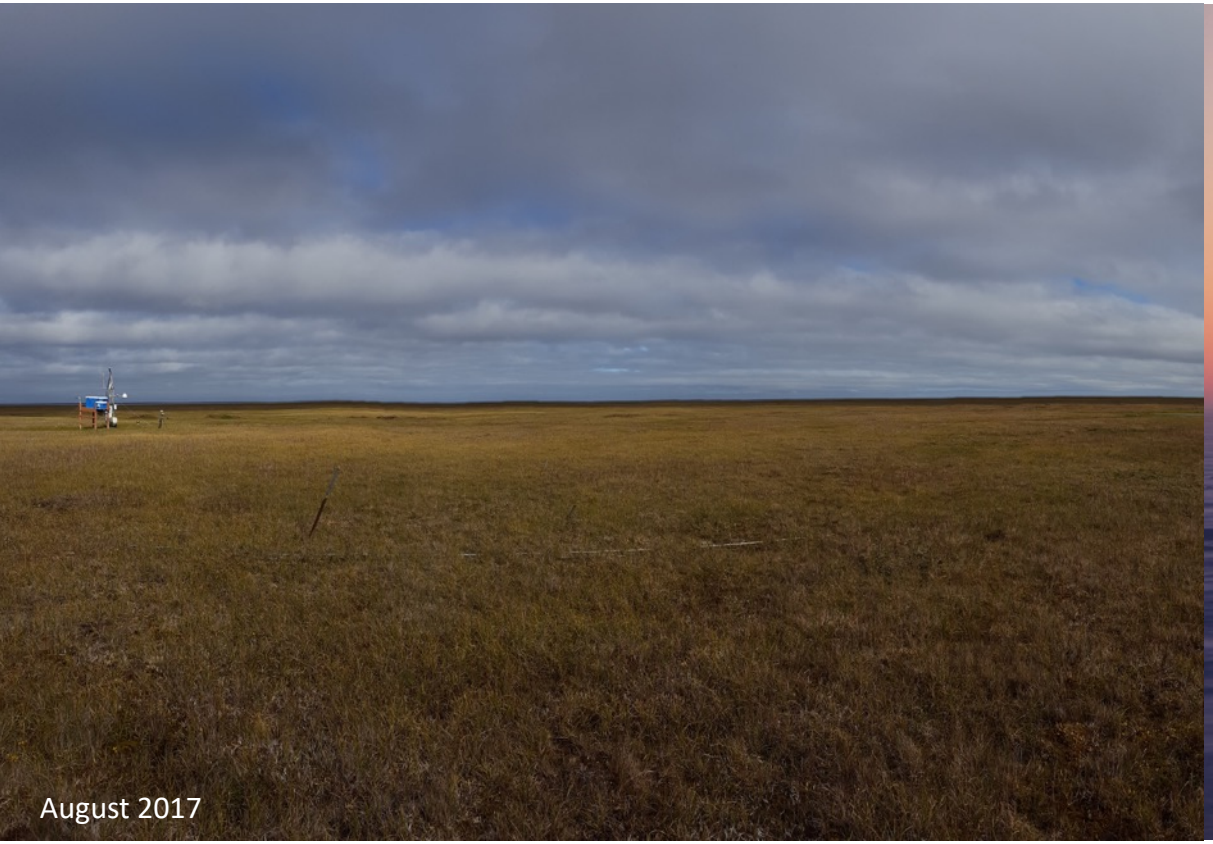
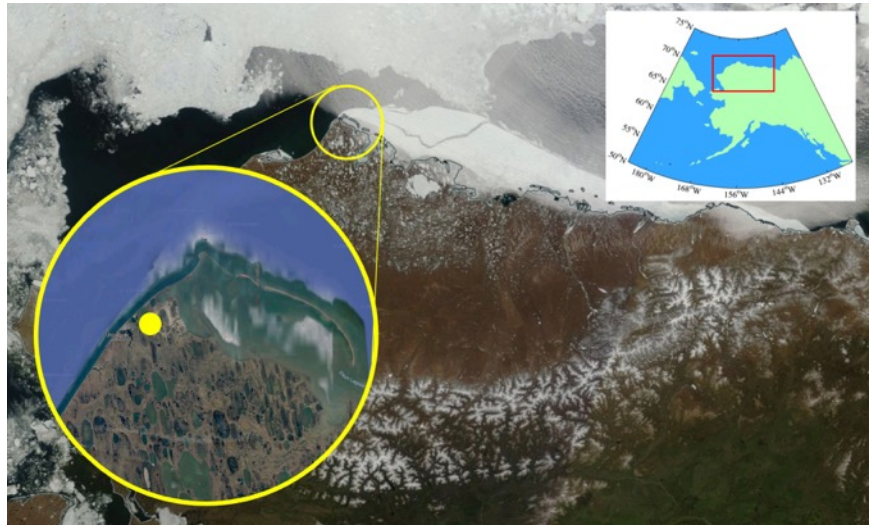


2018 ESRL/GMD GMAC
Boulder, Colorado, May 22-23, 2018

Date of snowmelt at Barrow, 1901-2016



Day of Year

180
175
170
165
160
155
150
145
140
135
130

1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

YEAR

-2.68 days/decade

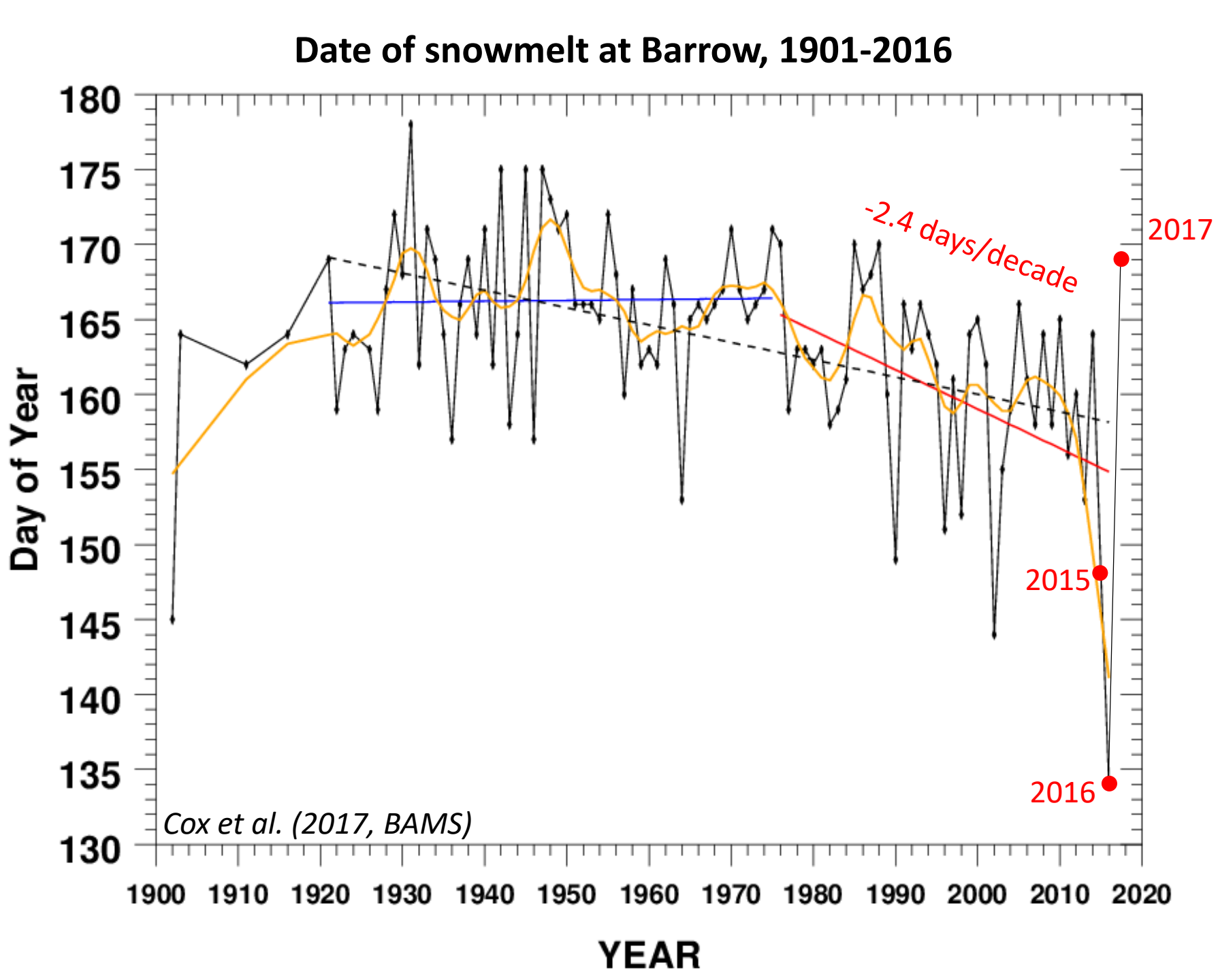
2015

2016

2015: 4th earliest on record

2016: 1st earliest on record

Cox et al. (2017, BAMS)



2015: 4th earliest on record

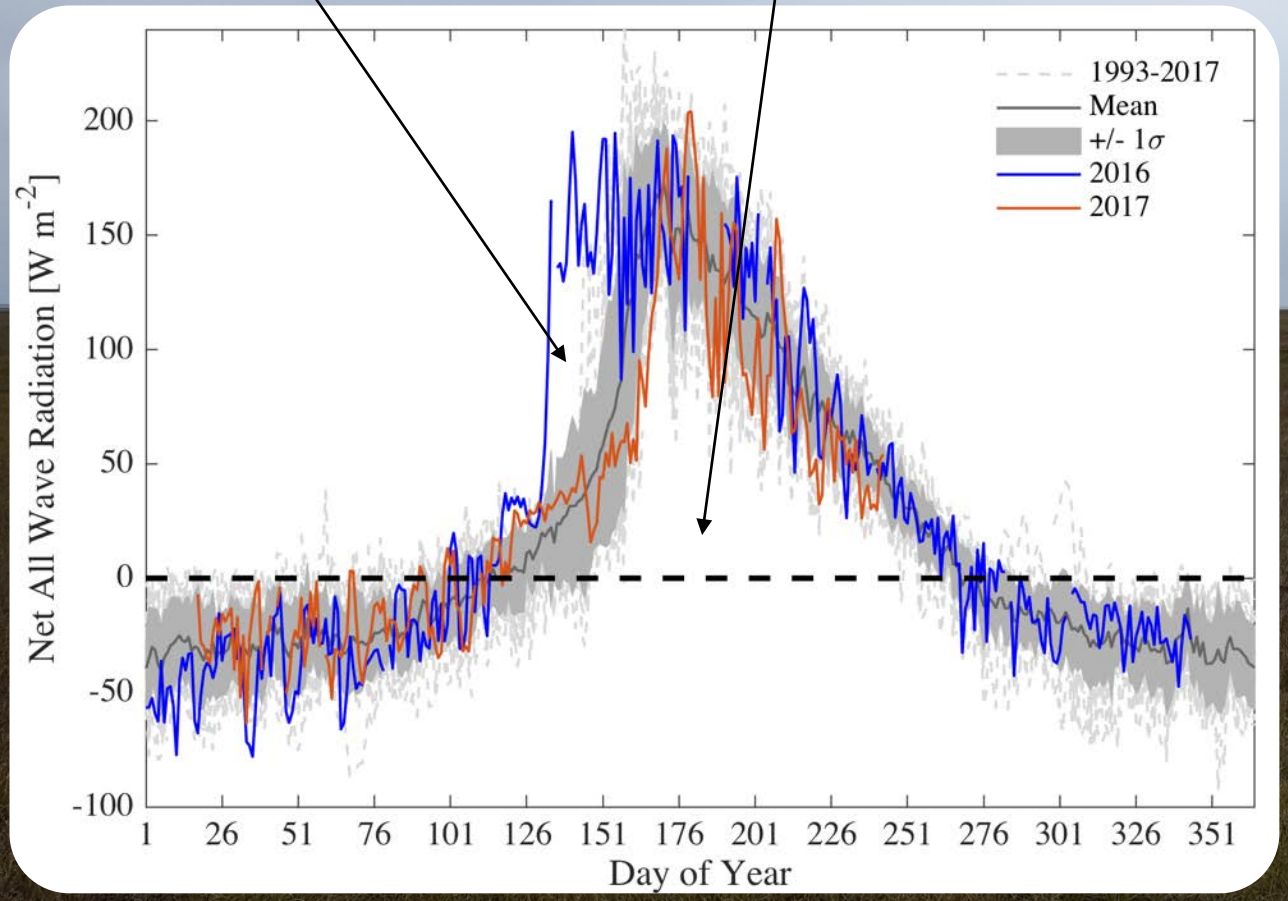
2016: 1st earliest on record

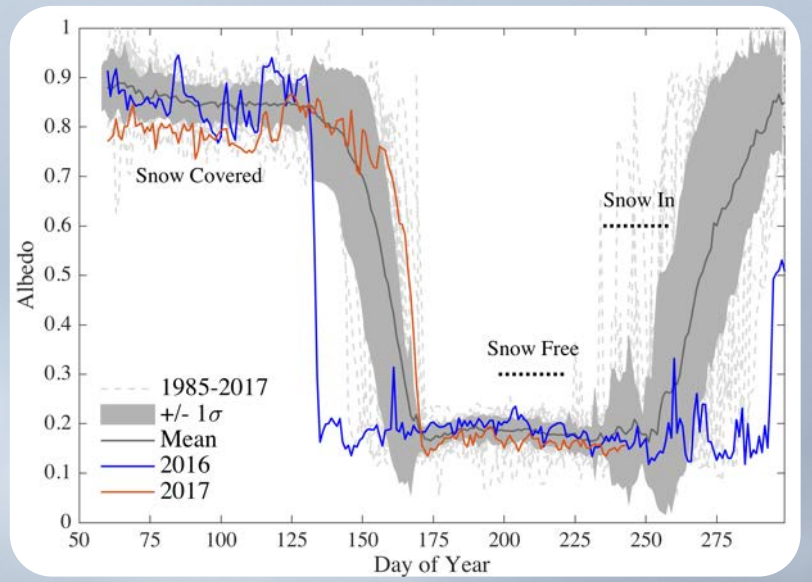
2017: latest since 1988

Impact on the surface radiation budget

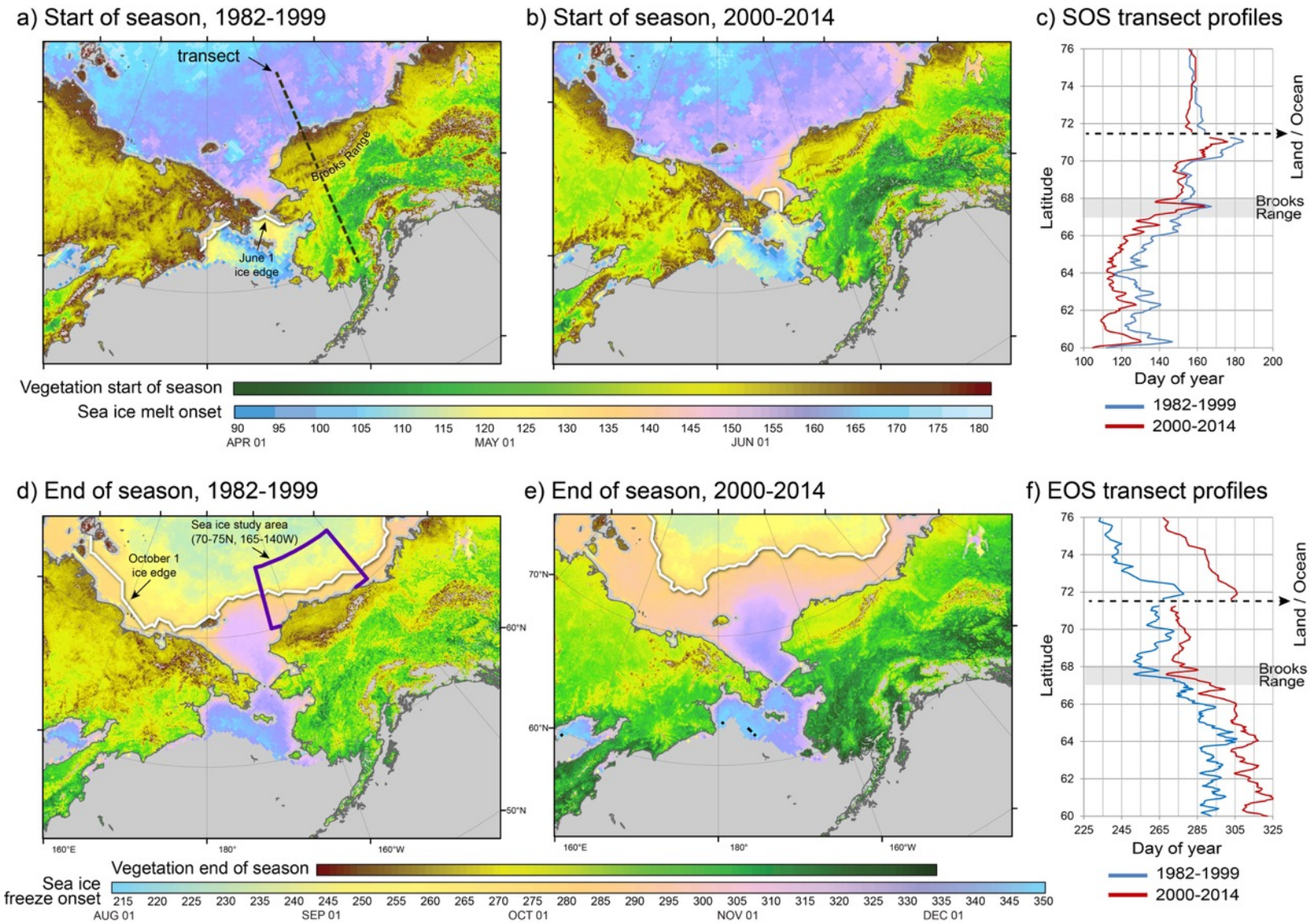
~294 MJ more in 2016 than 2017

~969 MJ avg for positive net-rad period



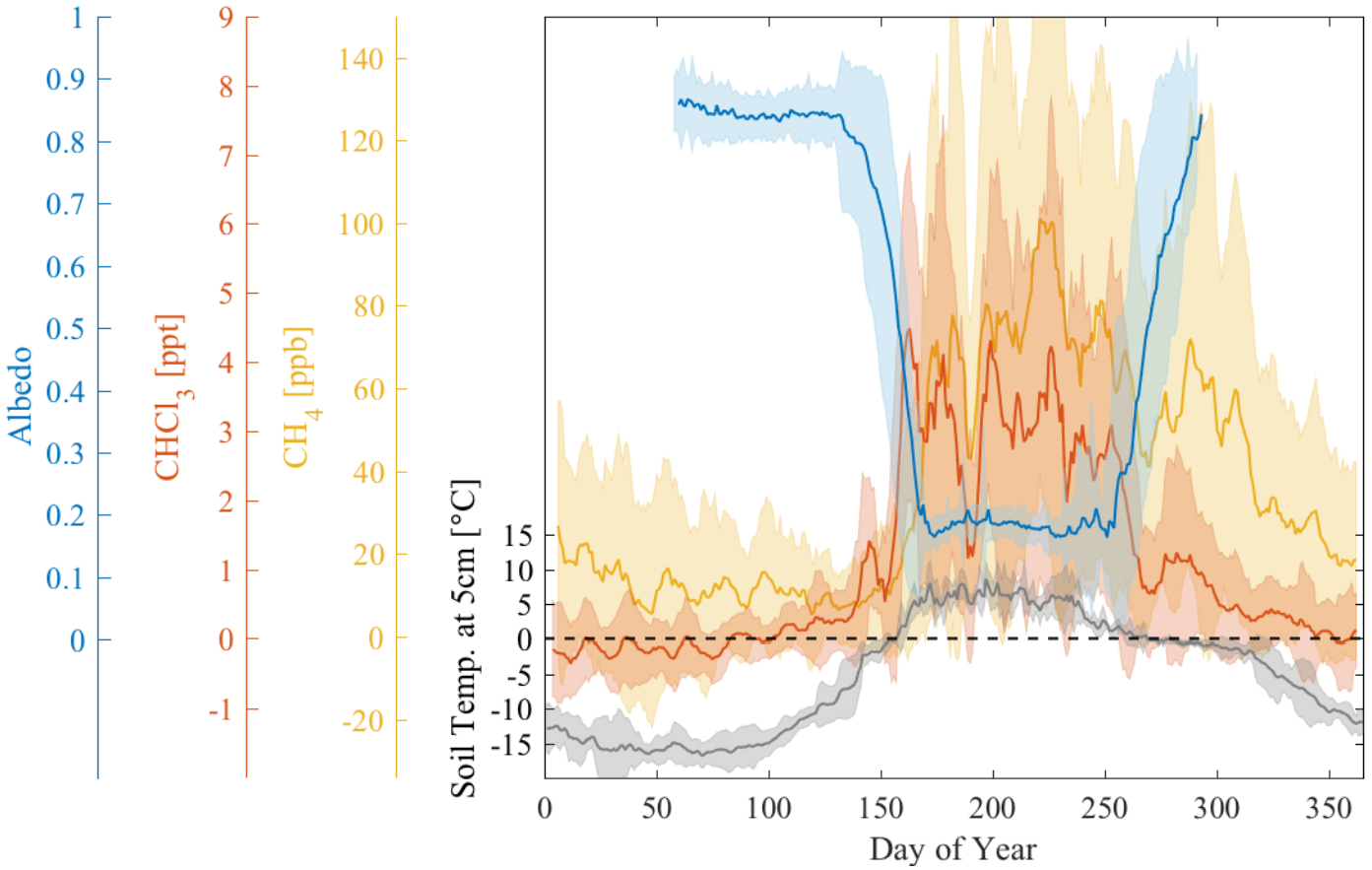


Why does this matter?



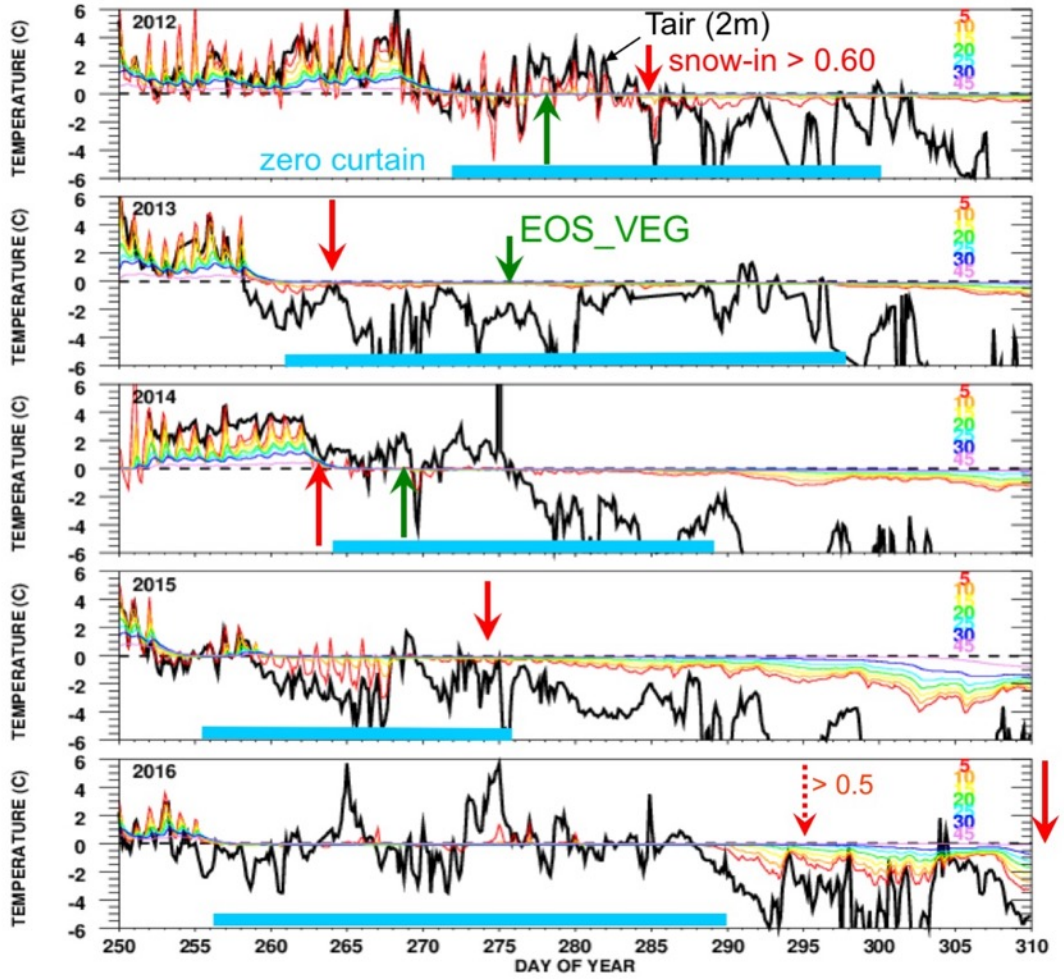
- Vegetation Phenology

Why does this matter?



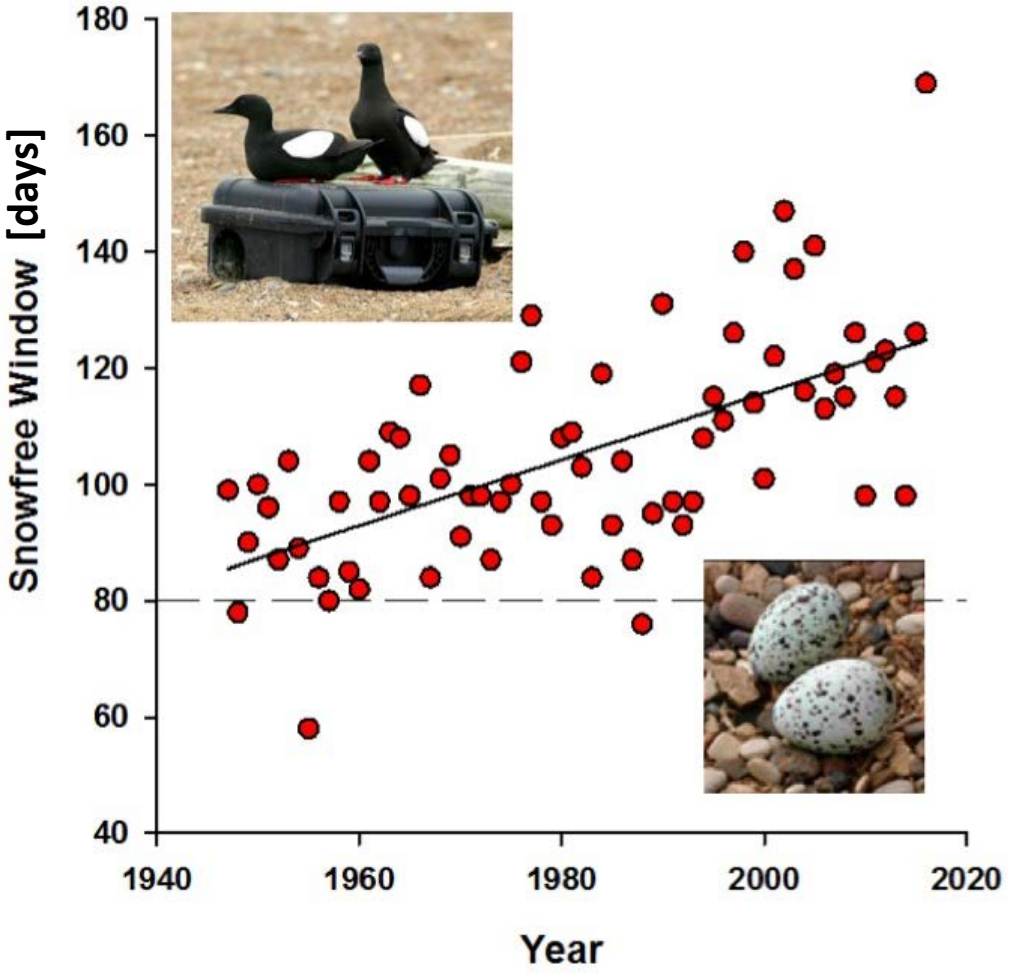
- Vegetation Phenology
- Biogeochemical Cycles

Why does this matter?



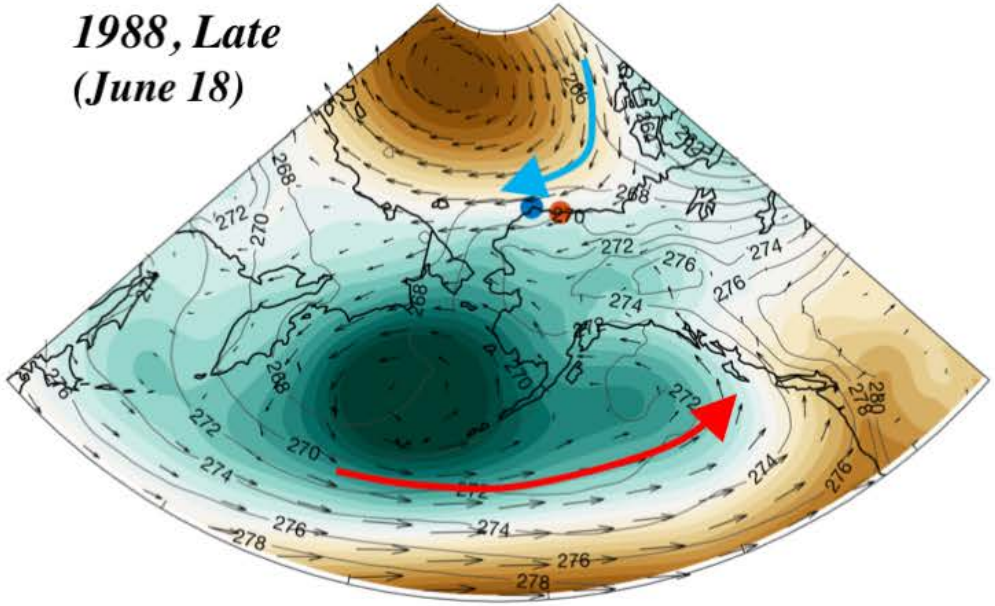
- Vegetation Phenology
- Biogeochemical Cycles
- Soil Temperature and Active Layer Depth

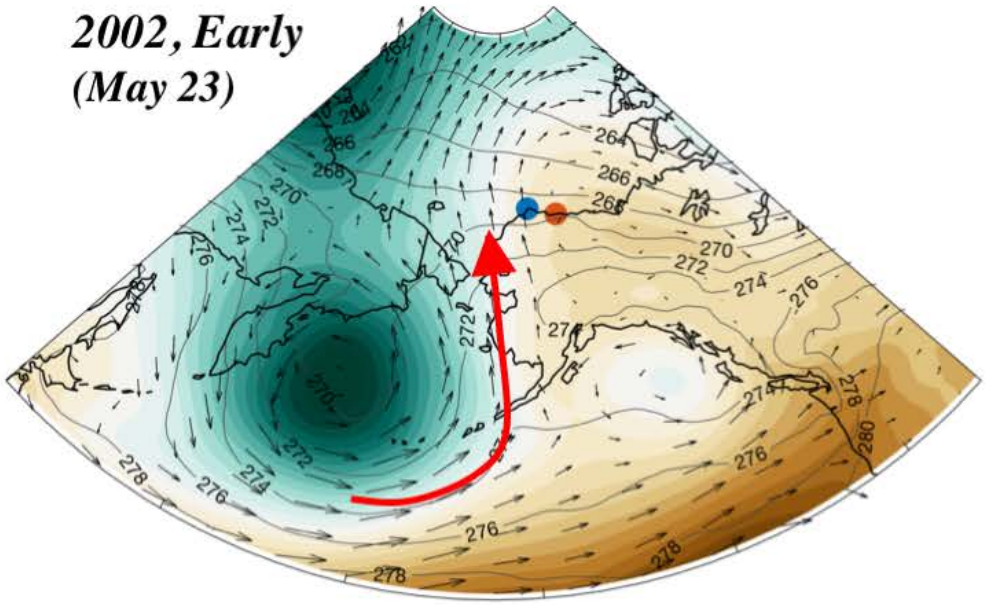
Why does this matter?

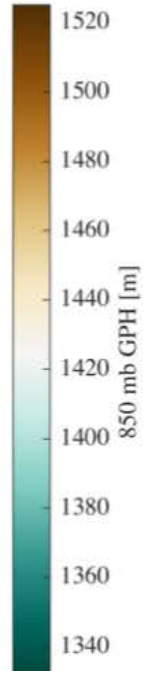


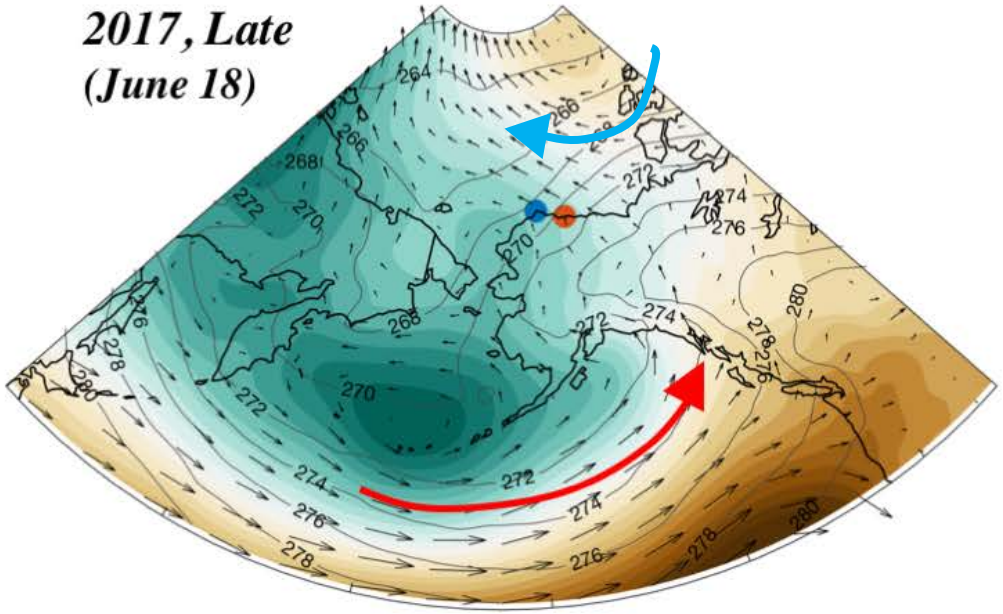
- Vegetation Phenology
- Biogeochemical Cycles
- Soil Temperature and Active Layer Depth
- Ecology

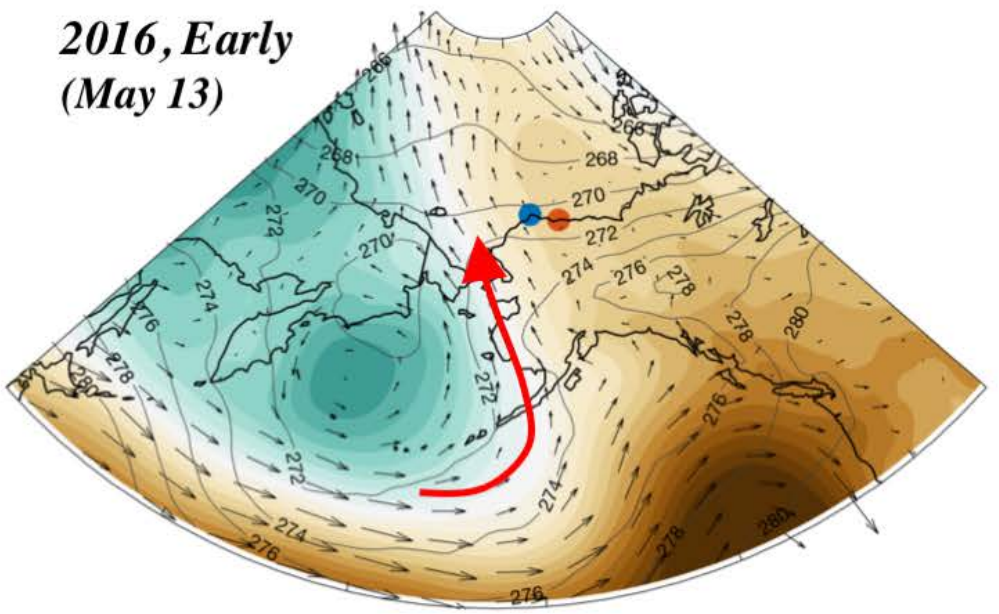
May Average

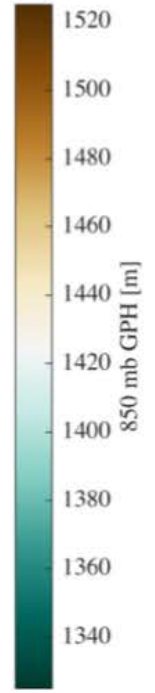

1988, Late
(June 18)

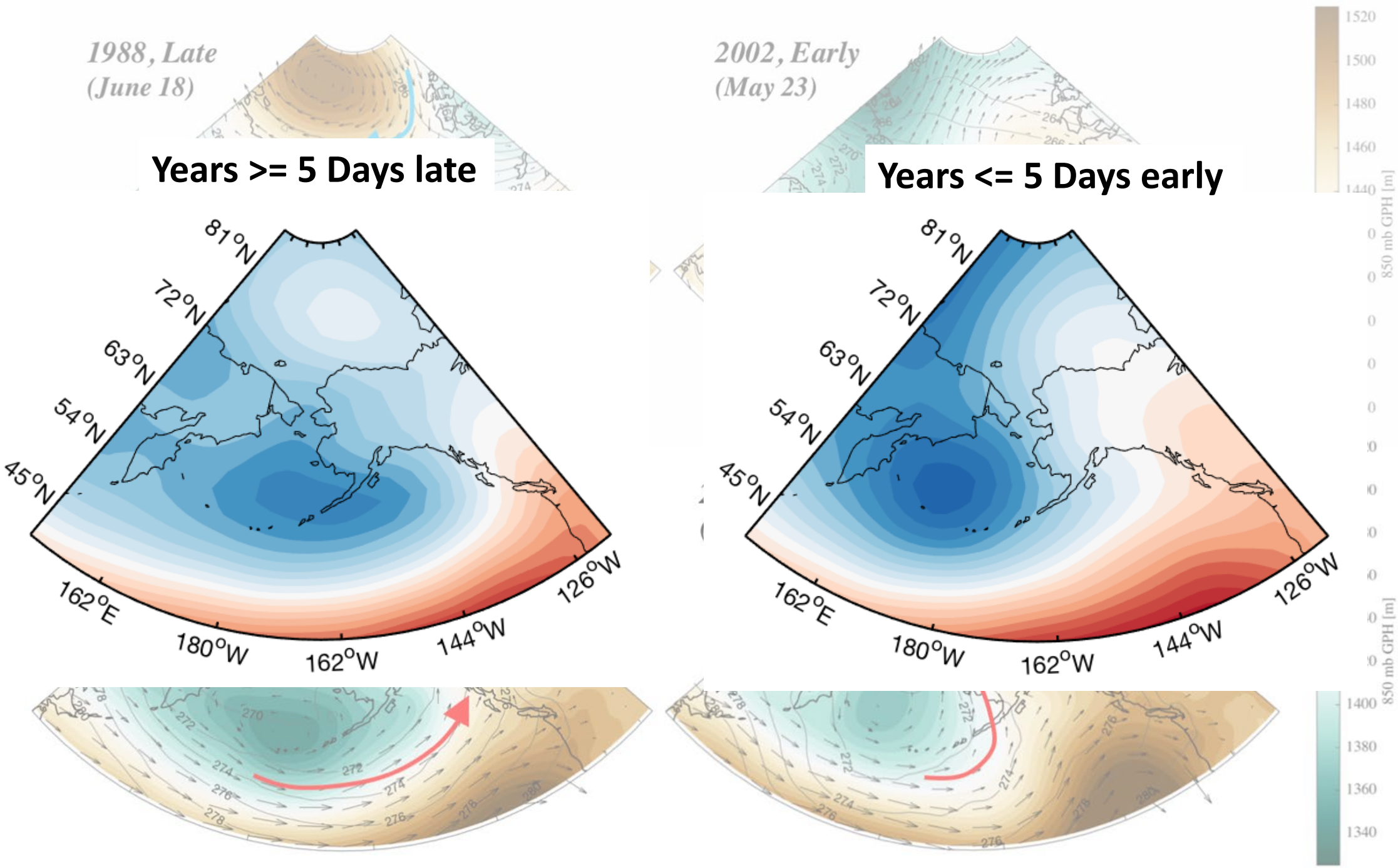

2002, Early
(May 23)

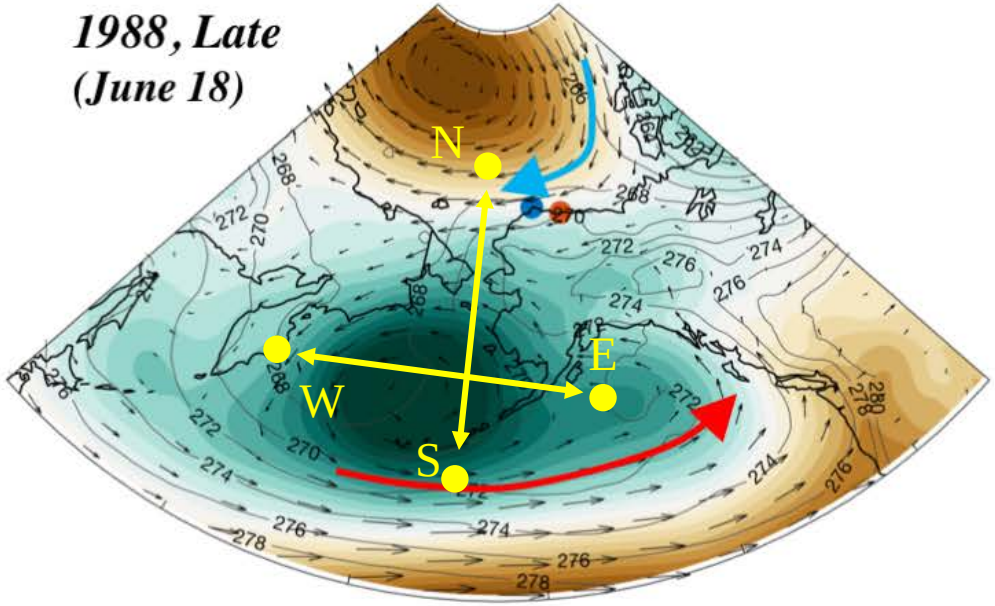

1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
850 mb GPH [m]

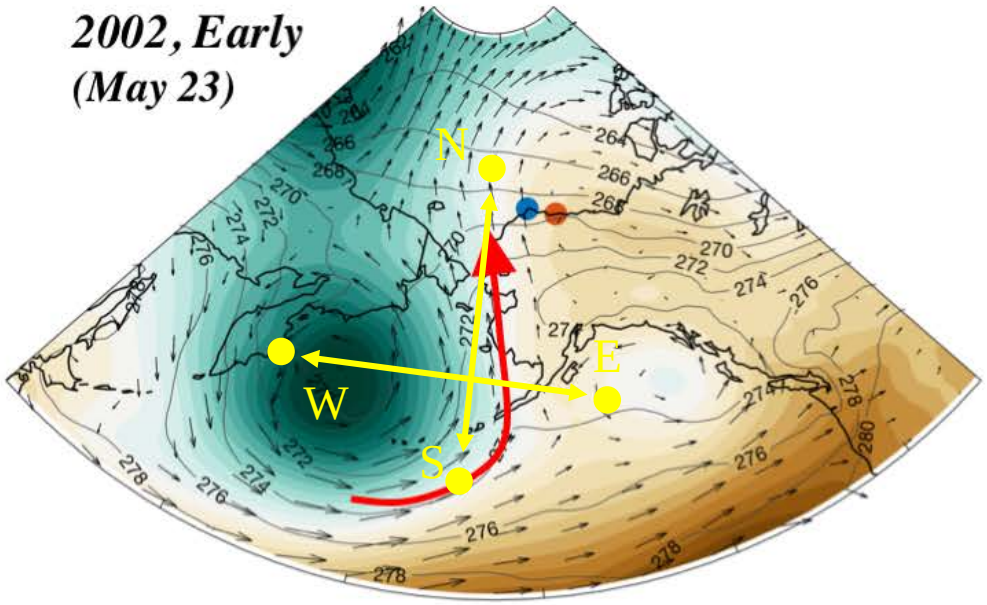

2017, Late
(June 18)

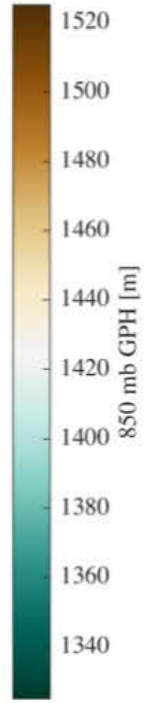

2016, Early
(May 13)

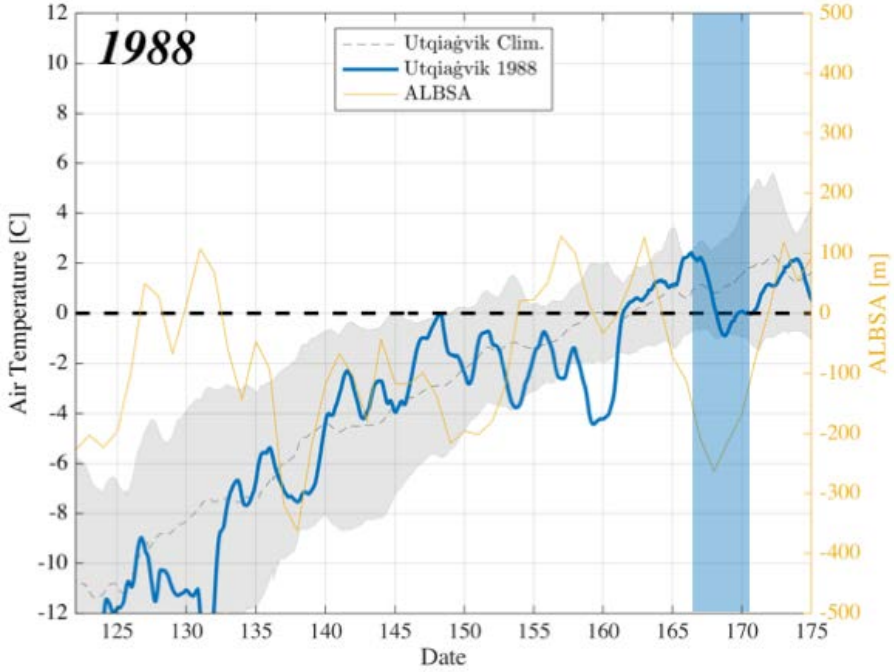

1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
850 mb GPH [m]

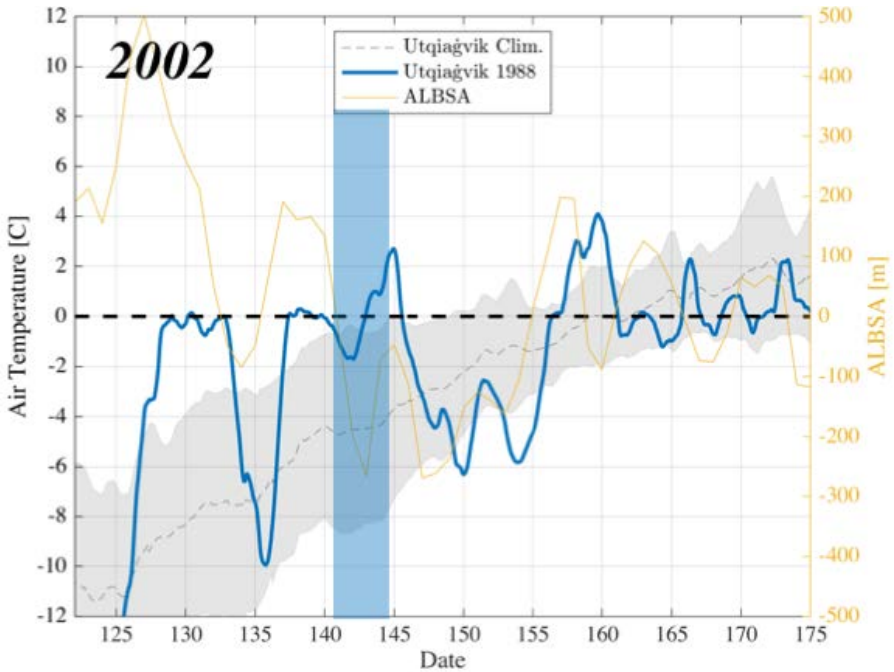

1988, Late
(June 18)
2002, Early
(May 23)
Years >= 5 Days late
Years <= 5 Days early
81°N
72°N
63°N
54°N
45°N
162°E
180°W
162°W
144°W
126°W
850 mb GPH [m]
1520
1500
1480
1460
1440
1400
1380
1360
1340


1988, Late
(June 18)
N
W
E
S


2002, Early
(May 23)
N
W
E
S

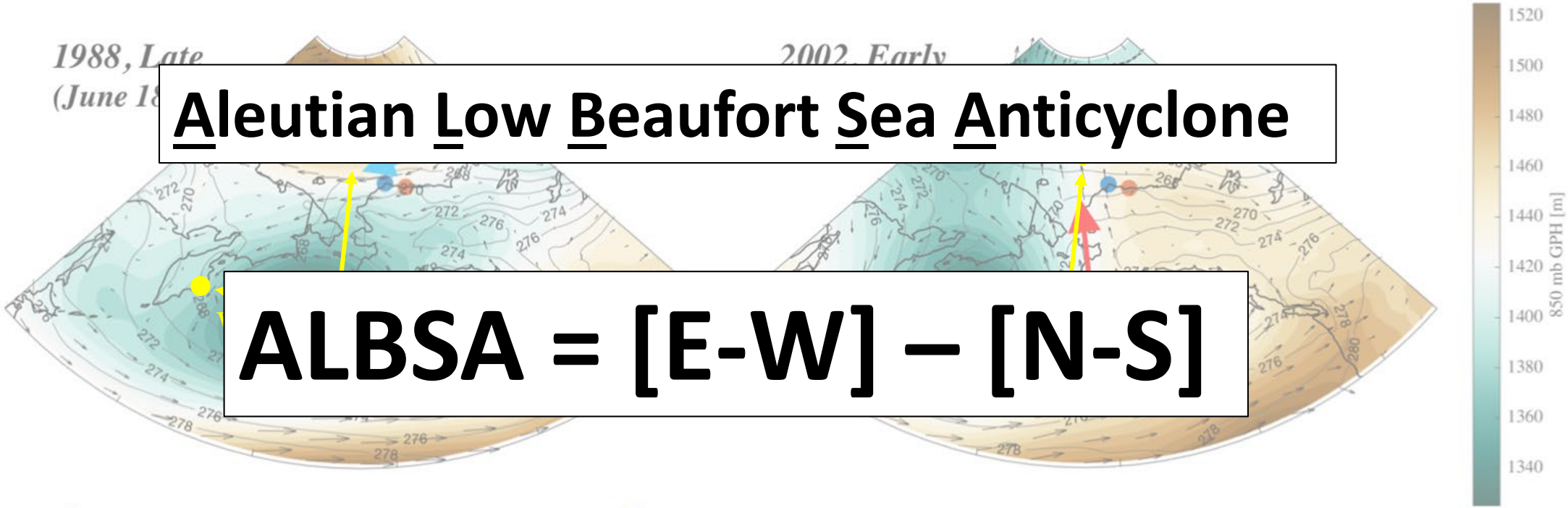

1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
850 mb GPH [m]

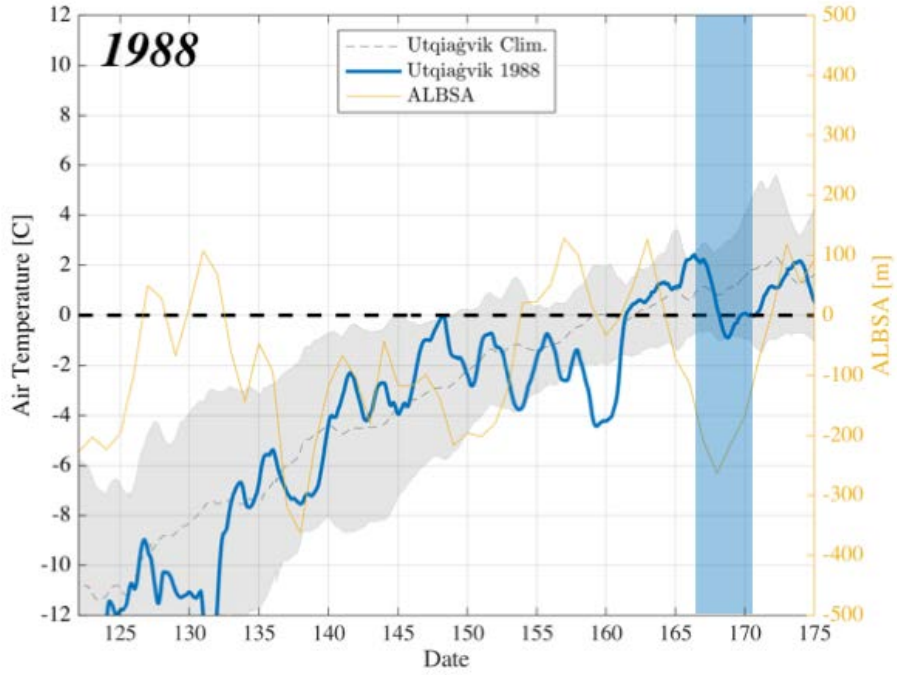

1988
Utqiaġvik Clim.
Utqiaġvik 1988
ALBSA
Air Temperature [C]
ALBSA [m]
Date

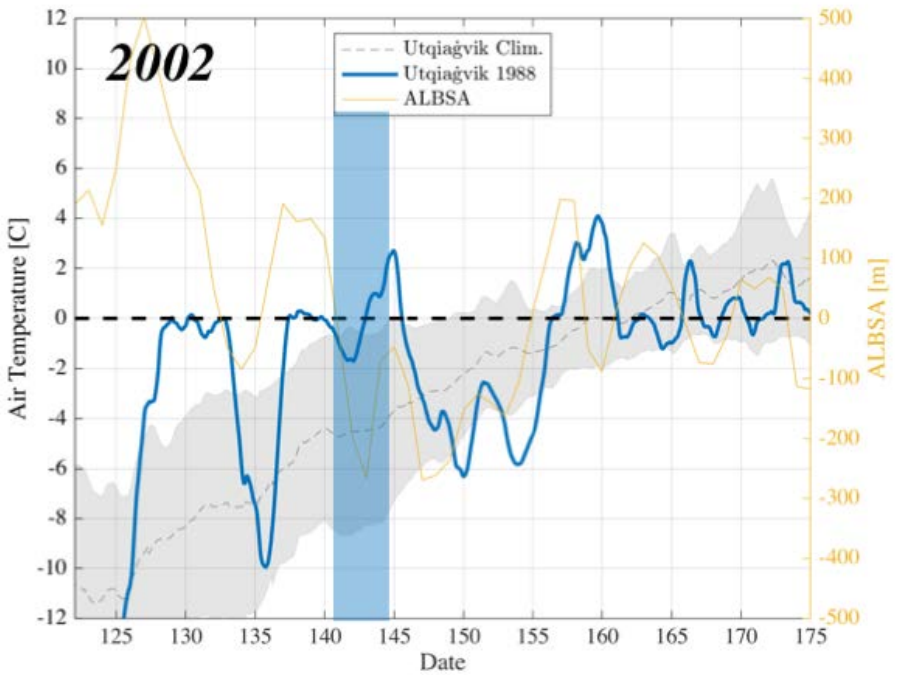

2002
Utqiaġvik Clim.
Utqiaġvik 1988
ALBSA
Air Temperature [C]
ALBSA [m]
Date

Aleutian Low Beaufort Sea Anticyclone

ALBSA = [E-W] – [N-S]



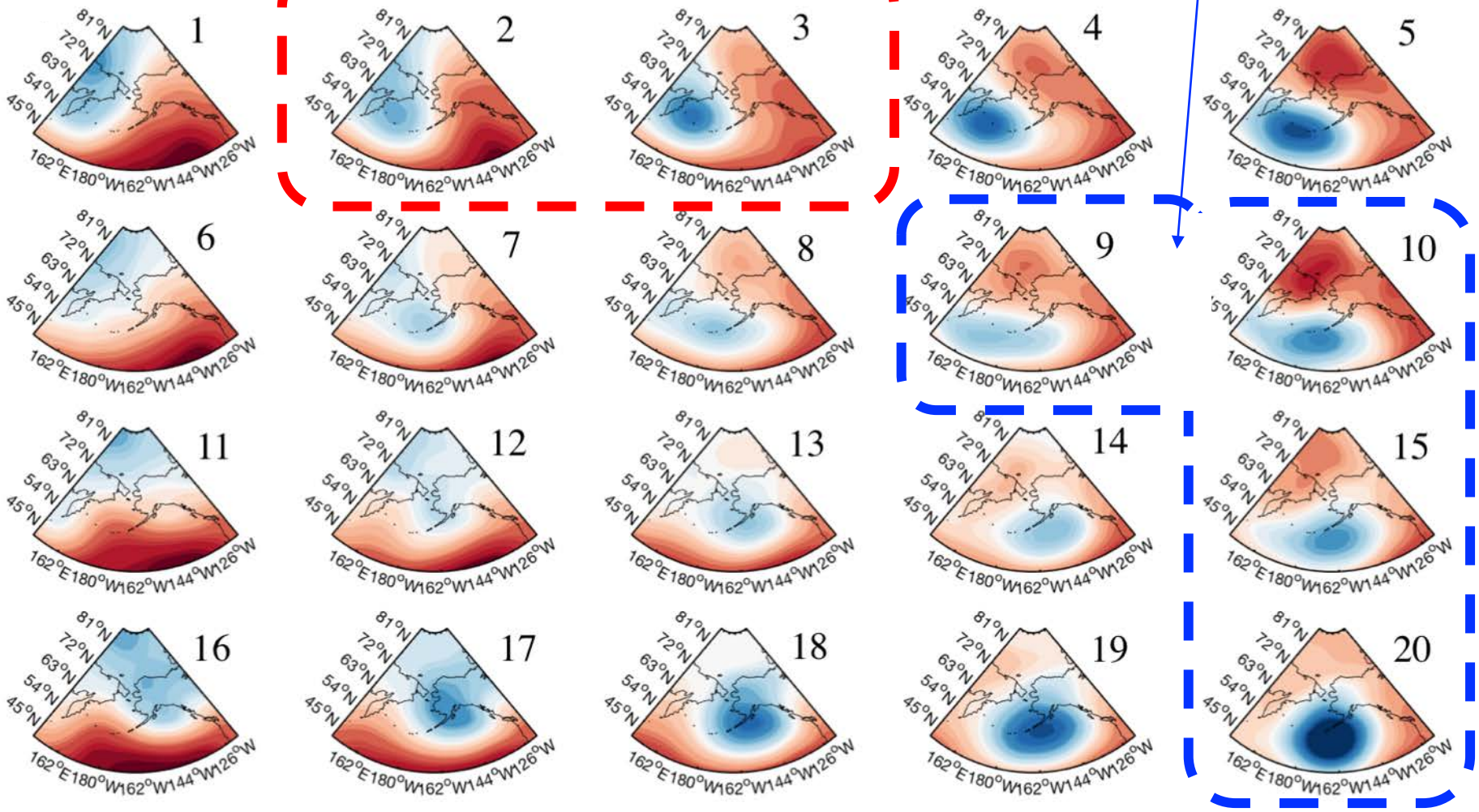


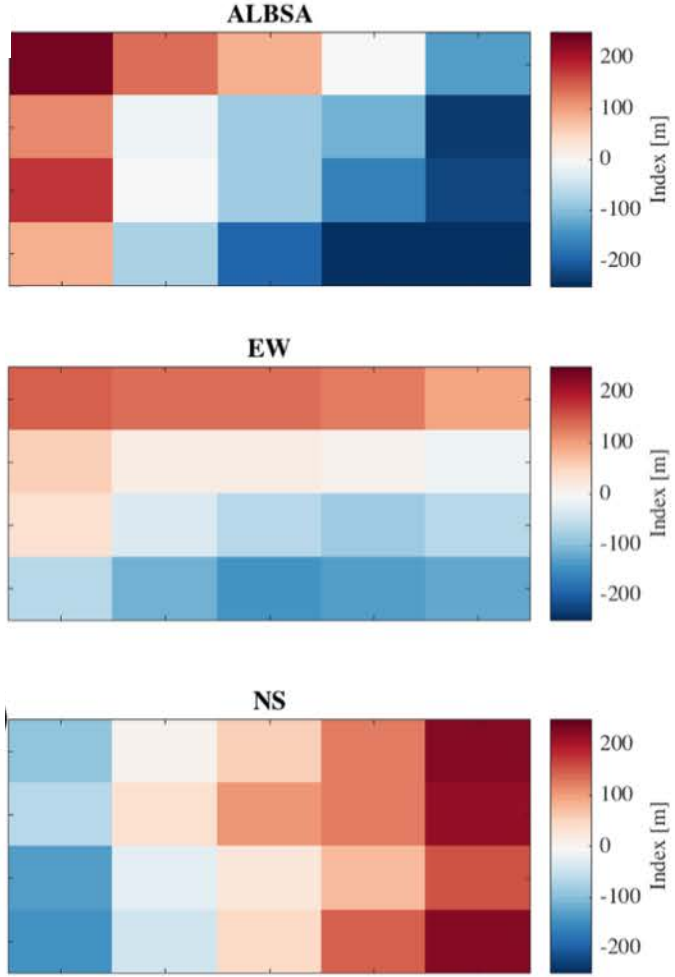


Mapping May-average ALBSA to a Self Organizing Map

These are the main early melt patterns

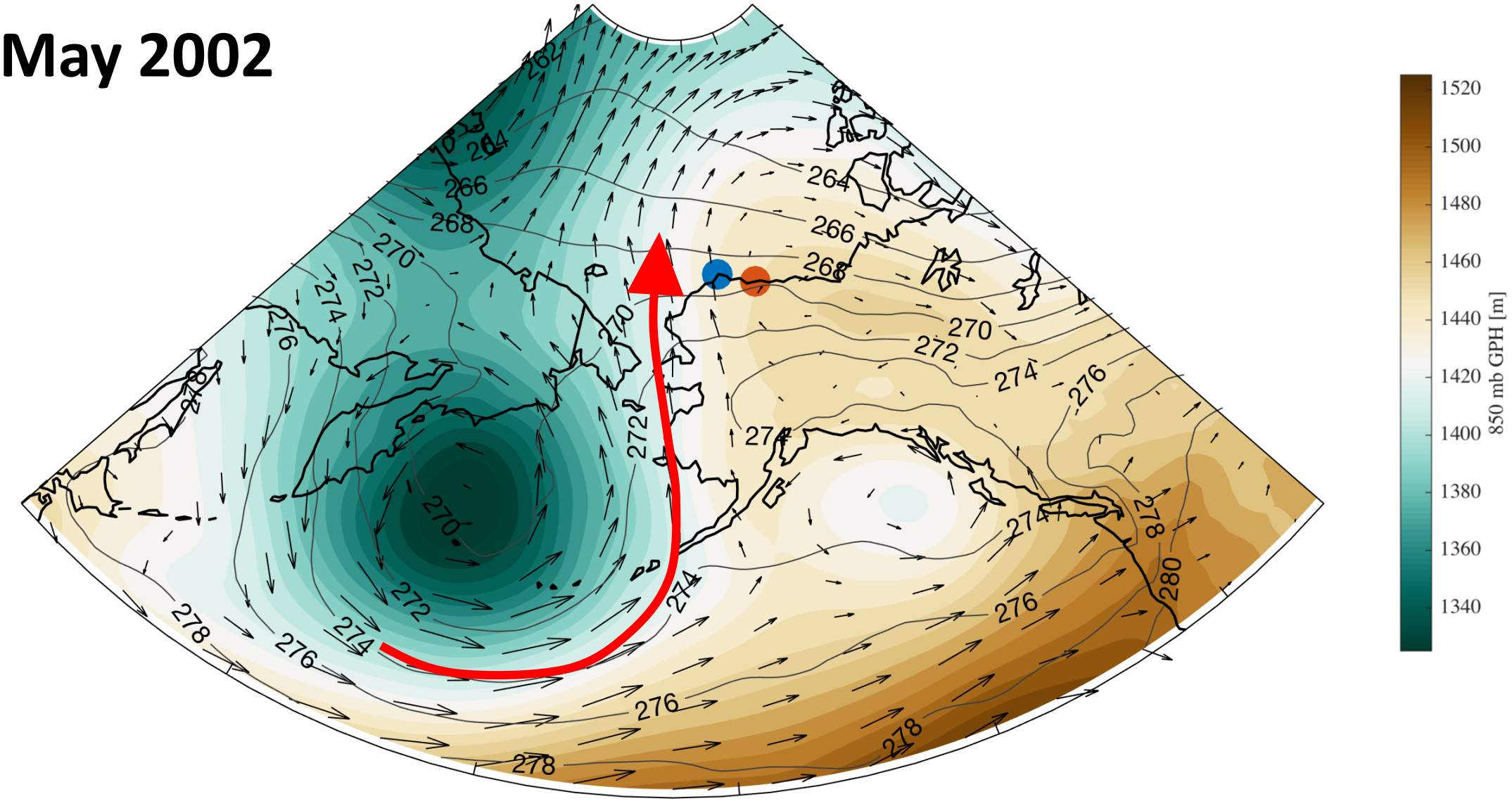
These are the some late melt patterns



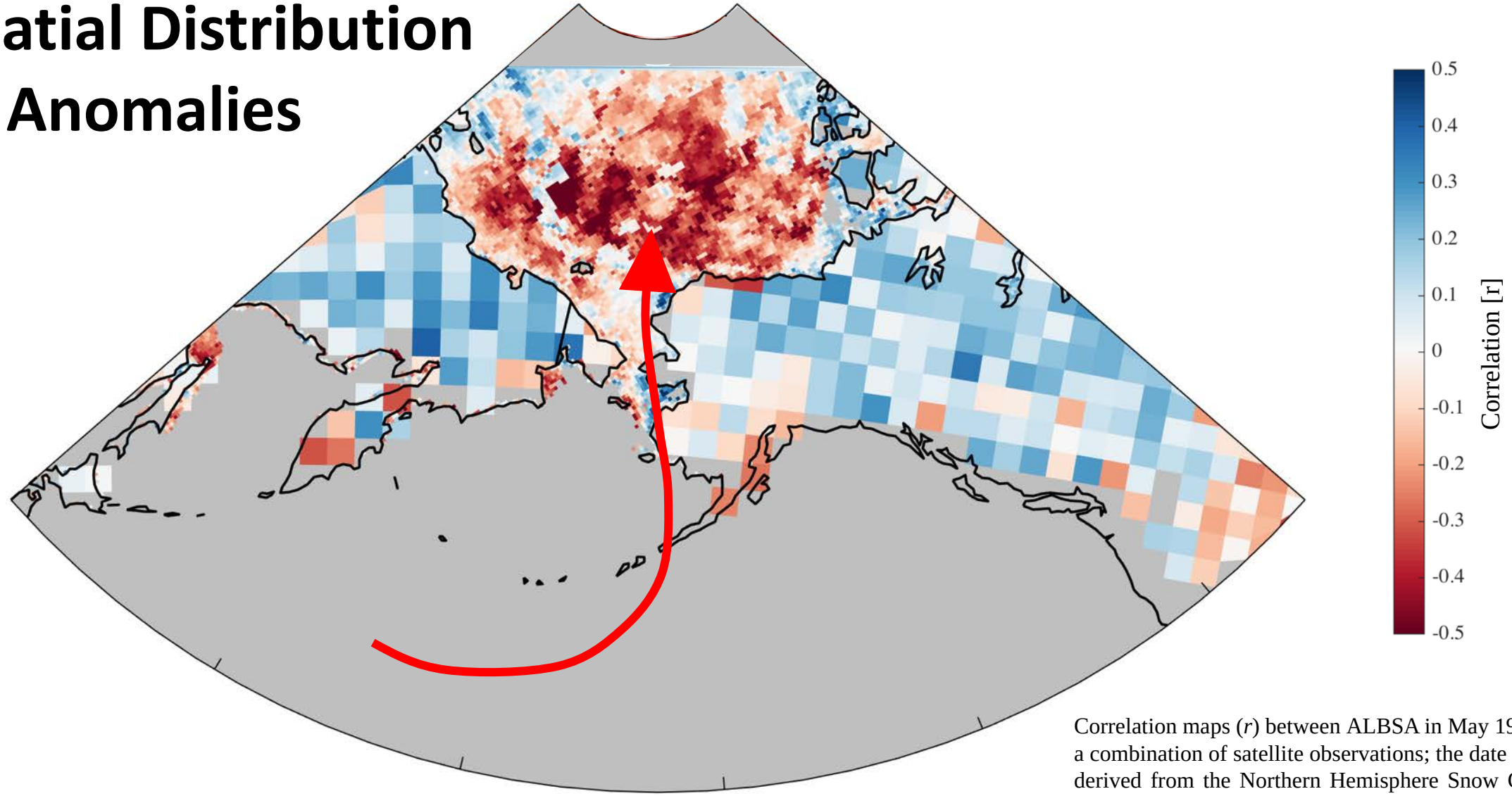


Thanks to Michael Gallagher and Matt Shupe for the SOM

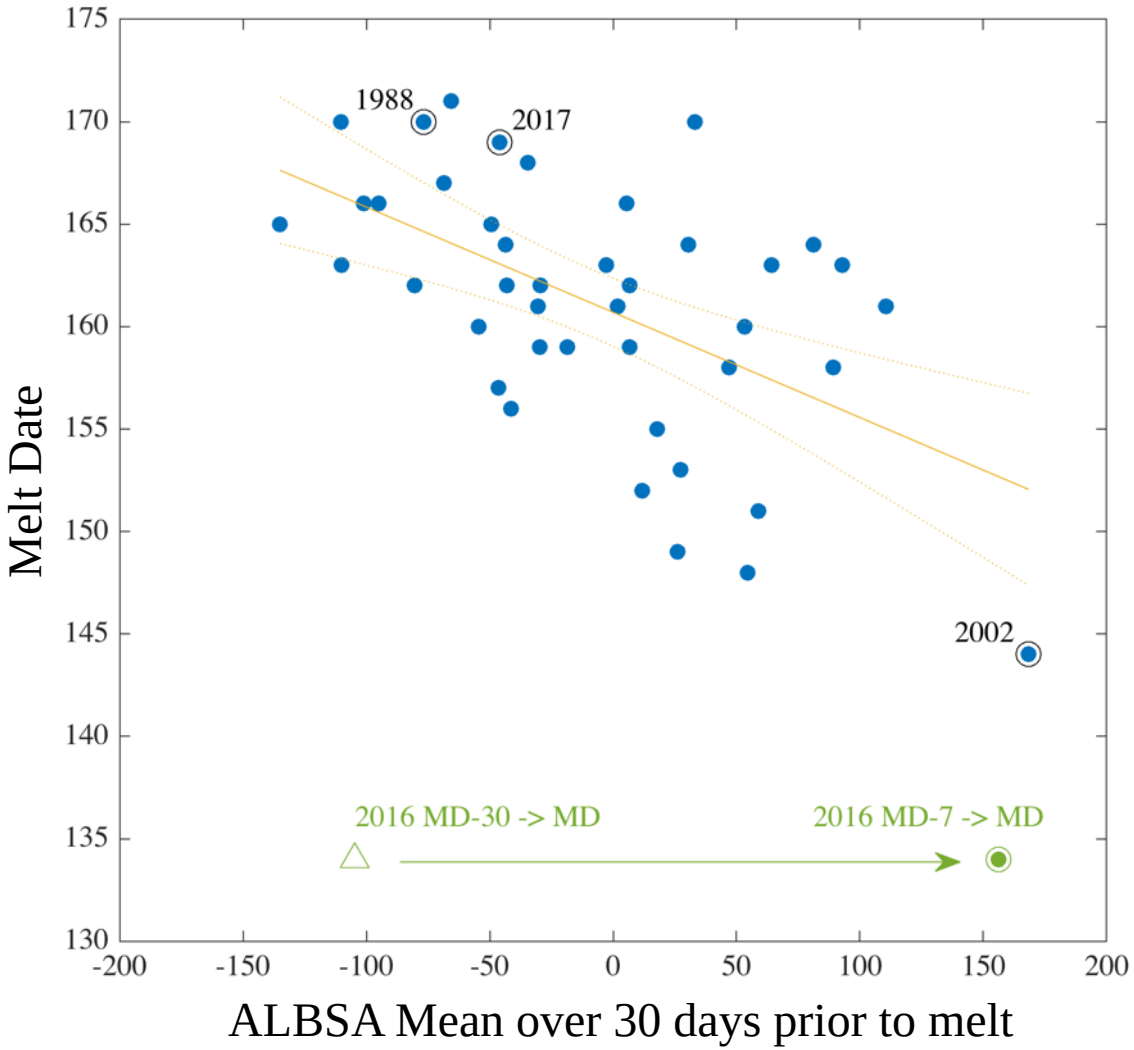
May 2002

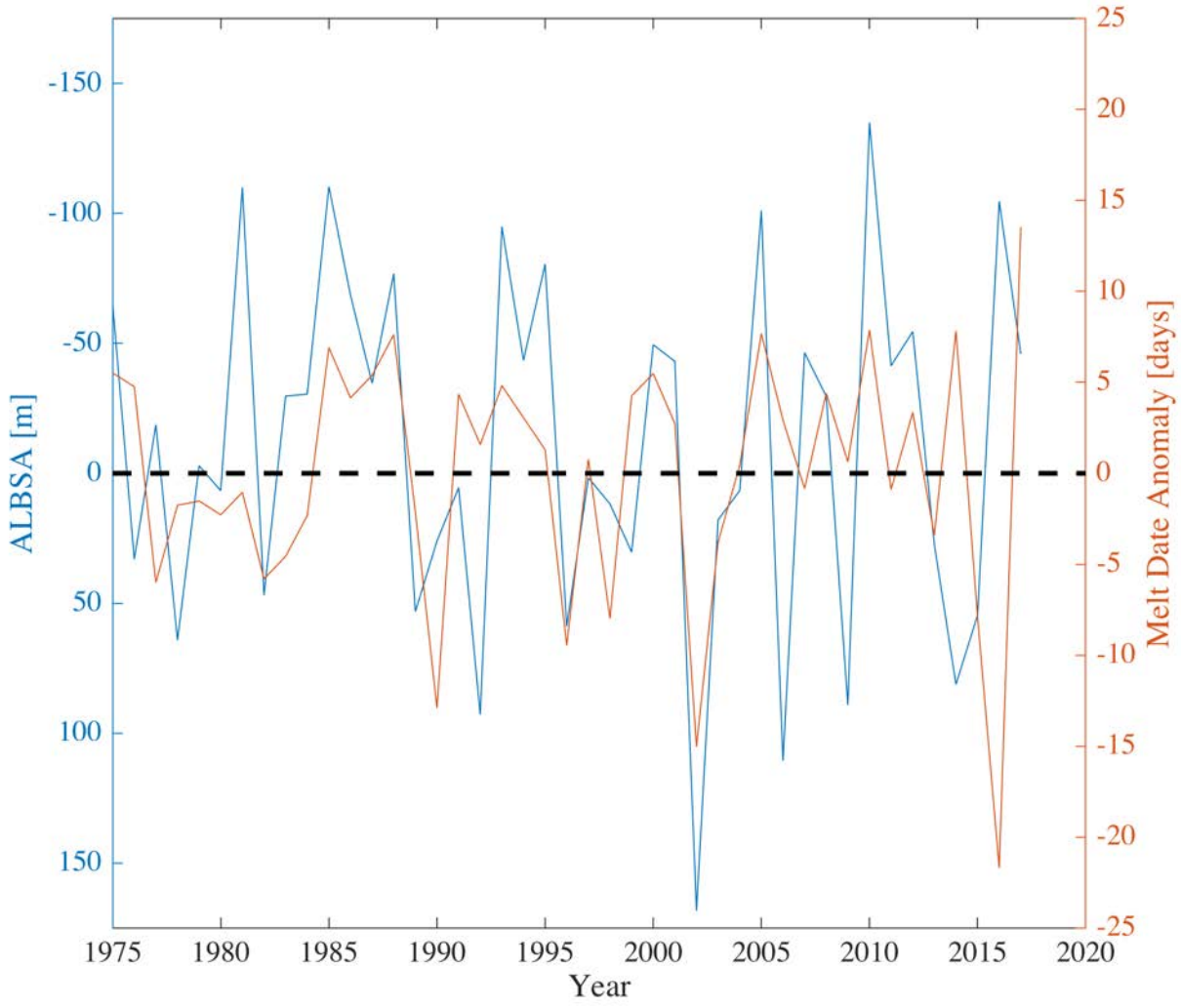


Spatial Distribution of Anomalies

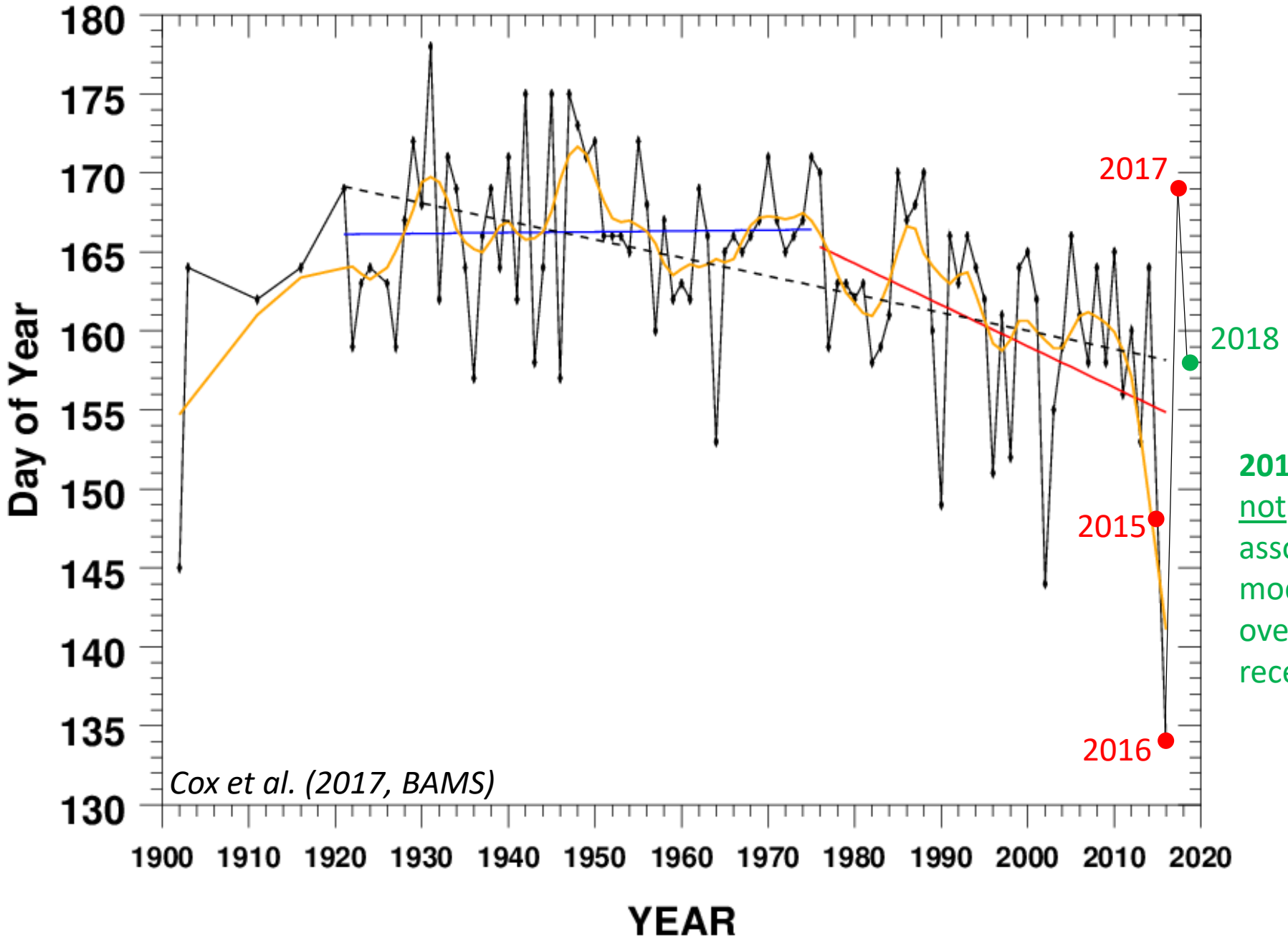


Correlation maps (*r*) between ALBSA in May 1979-2017 and a combination of satellite observations; the date of snow melt derived from the Northern Hemisphere Snow Cover Extent (NH-SCE) data set (terrestrial regions) and the first date of initiation of surface melt over sea ice derived from SSM/I passive microwave data (sea ice regions).


Melt Date
ALBSA Mean over 30 days prior to melt
1988
2017
2002
2016 MD-30 -> MD
2016 MD-7 -> MD
175
170
165
160
155
150
145
140
135
130
-200
-150
-100
-50
0
50
100
150
200


ALBSA [m]
Melt Date Anomaly [days]
Year
-150
-100
-50
0
50
100
150
25
20
15
10
5
0
-5
-10
-15
-20
-25
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

Date of snowmelt at Barrow, 1901-2016



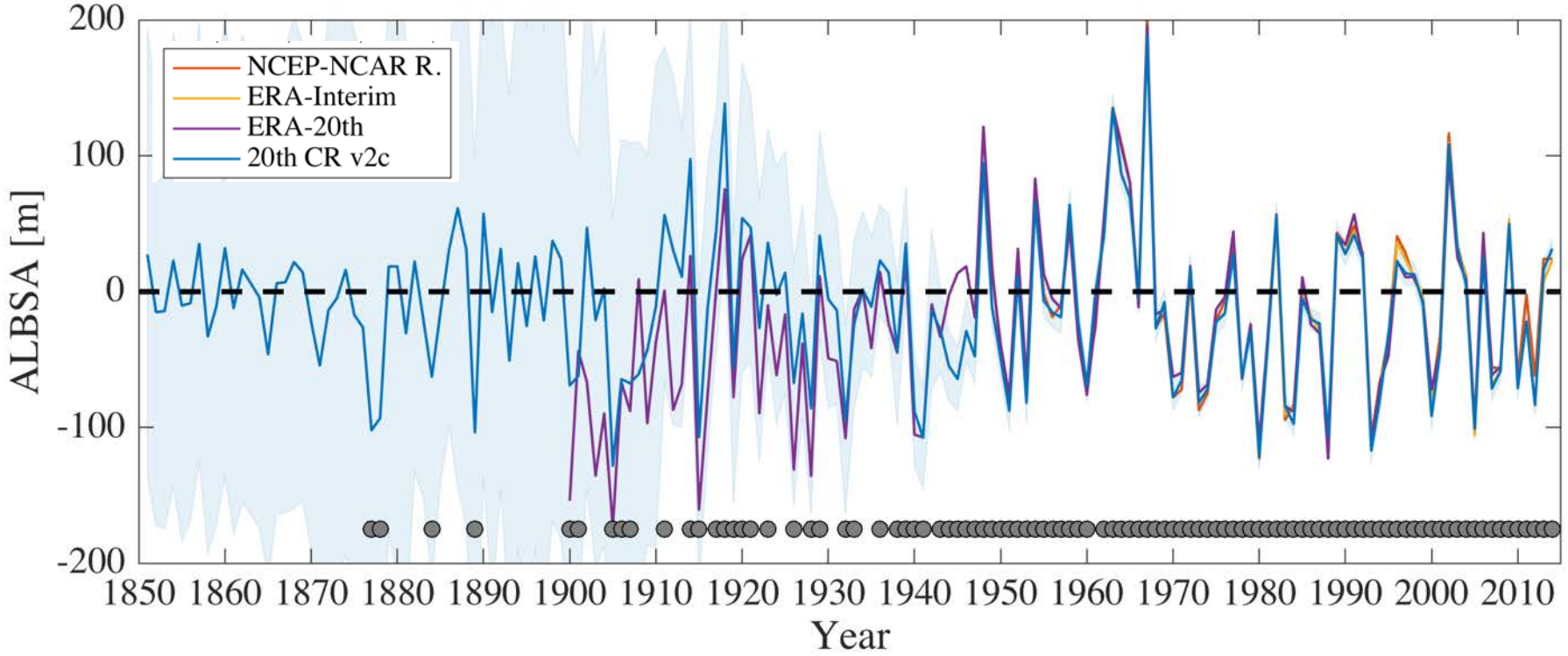
2015: 4th earliest on record

2016: 1st earliest on record

2017: latest since 1988

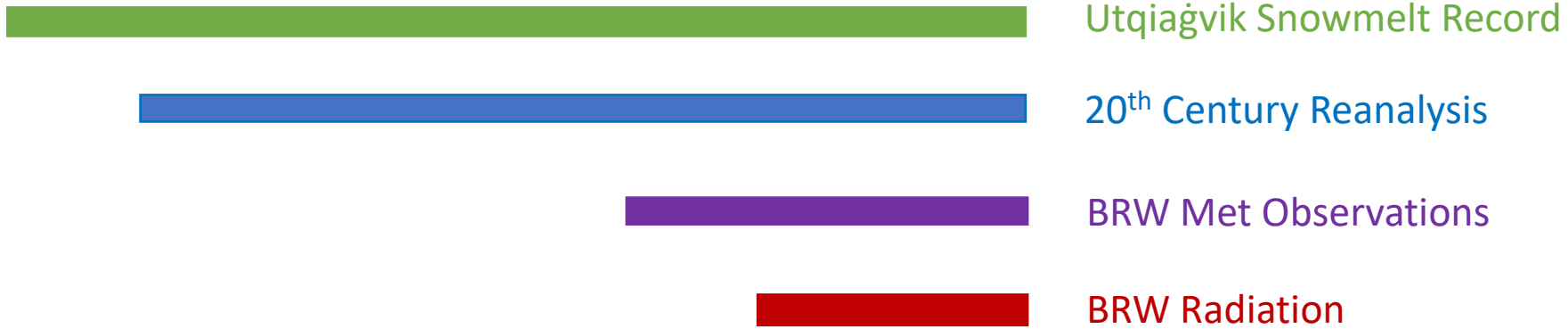
2018: *Experimental* projection does not indicate circulation patterns associated with early melt. Regressive model suggests "average" melt date overall, but late compared to many recent years.

Long Term ALBSA Record – 20th C. Reanalysis



Dots are years when |ALBSA| > 0 (p<0.01)

Time Lengths of Relevant Data Sets



Thanks to Gil Compo for help with 20CR

Conclusions

- **Long term records of the date of snowmelt at Utqiaġvik supported by NOAA-NWS/NOAA-GMD reveal a modern trend towards earlier arrival of spring with extraordinary interannual variability in recent years.**
- **The environment is sensitive to this variability.**
- **The timing of snowmelt on Alaska's north coast and melt onset over sea ice in the Beaufort and Chukchi Seas are linked to advection facilitated by the juxtaposition of the Aleutian Low and the Beaufort High.**
- **We developed a 4-pt climate index, "ALBSA", that represents the variability in Pacific-Arctic atmospheric circulation.**
- **We are currently working to assess subseasonal-to-seasonal scale (S2S) predictability of ALBSA.**