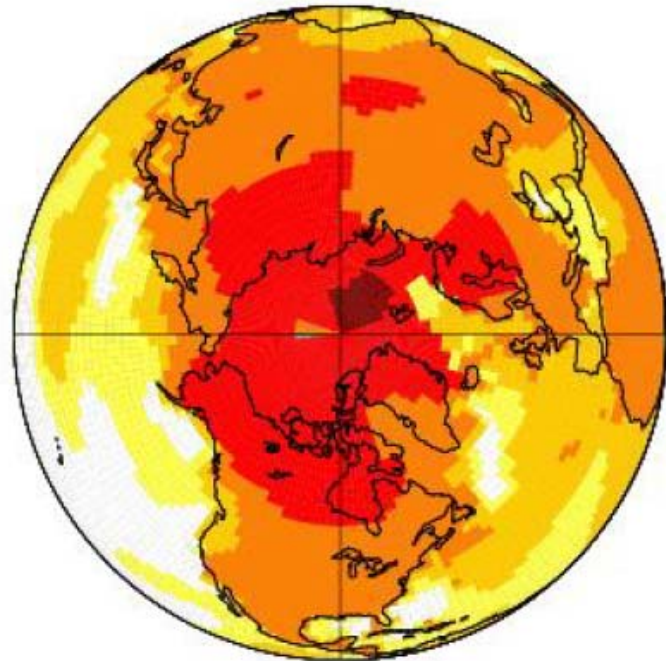
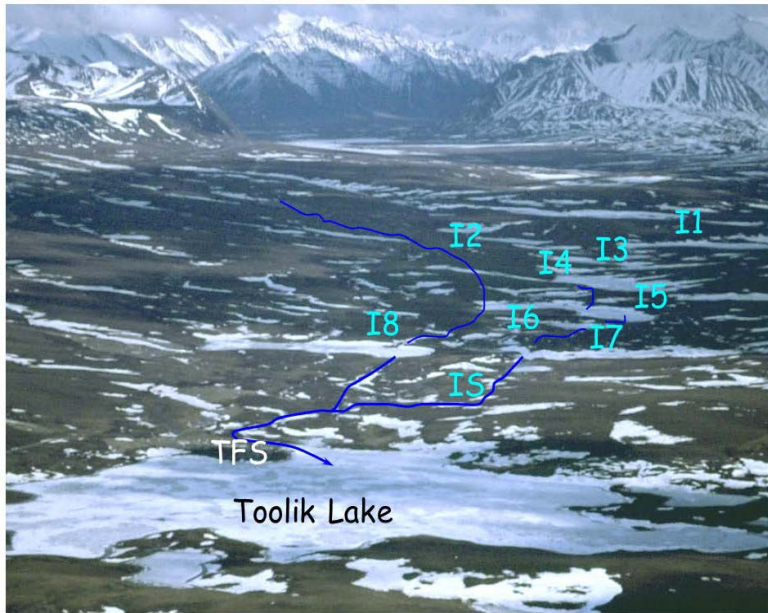


Toolik in the broader picture of Arctic change

John Walsh

IARC/UAF



Toolik Workshop, Portland, OR, January 2017

Question for discussion:

How representative is Toolik's climate?

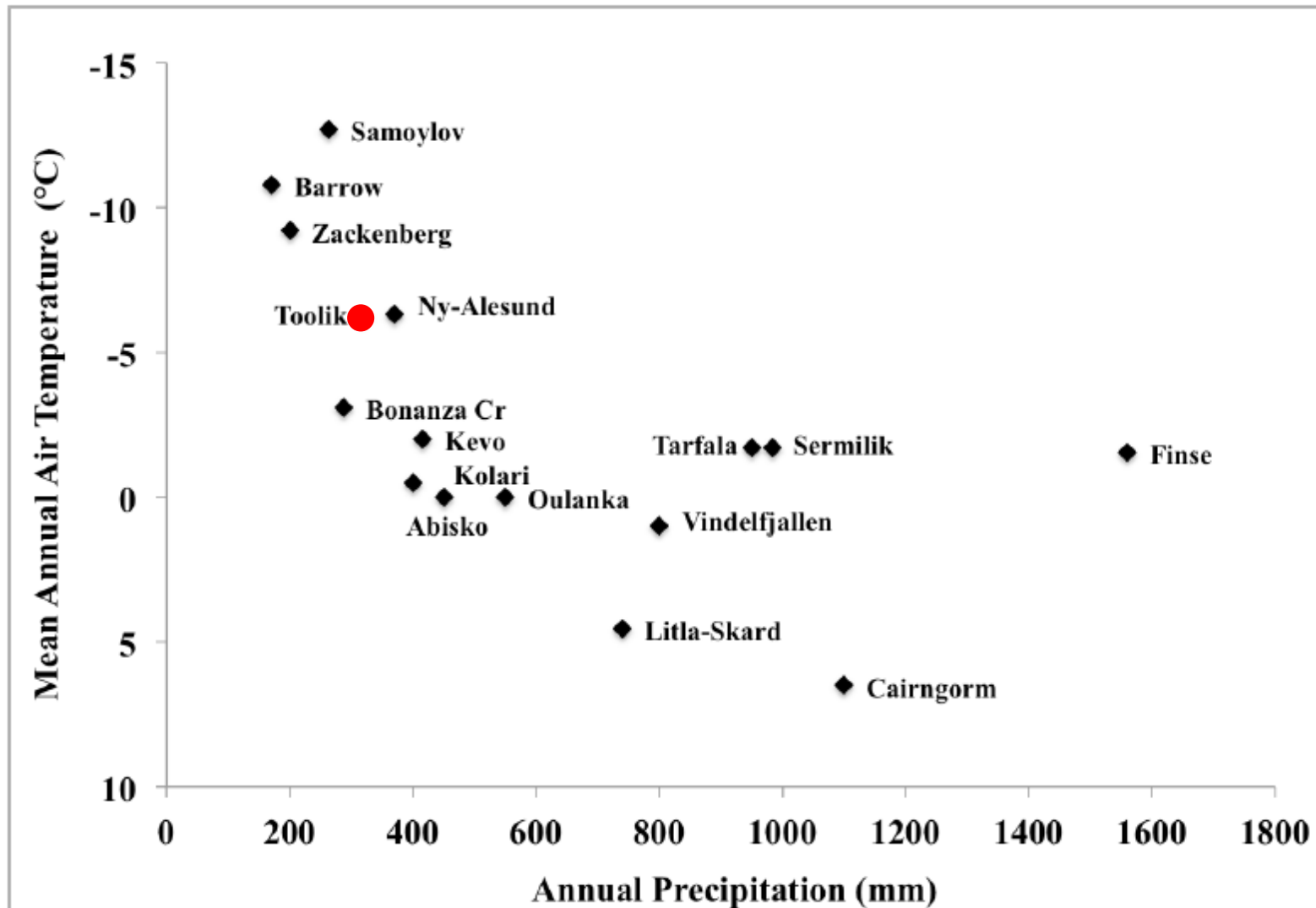
-- means

-- trends and variations

-- extreme events

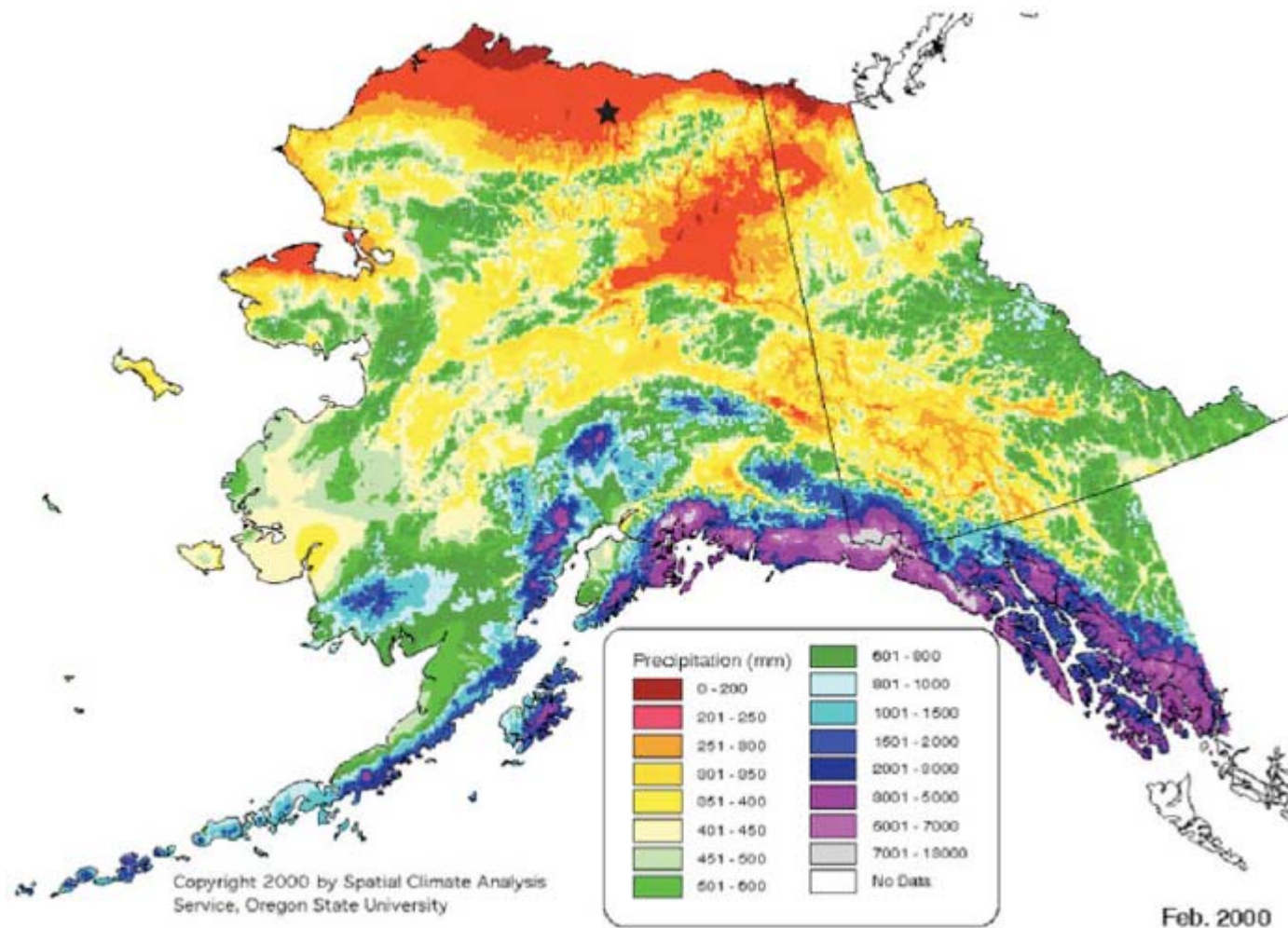
Scales to consider: local, regional, pan-Arctic

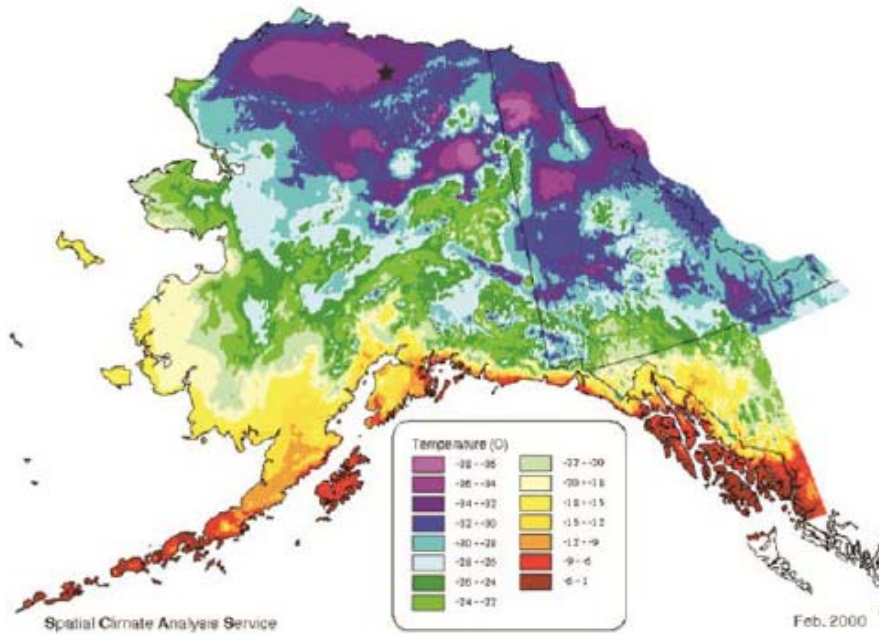
Toolik relative to other northern field stations in annual mean temperature-precipitation space



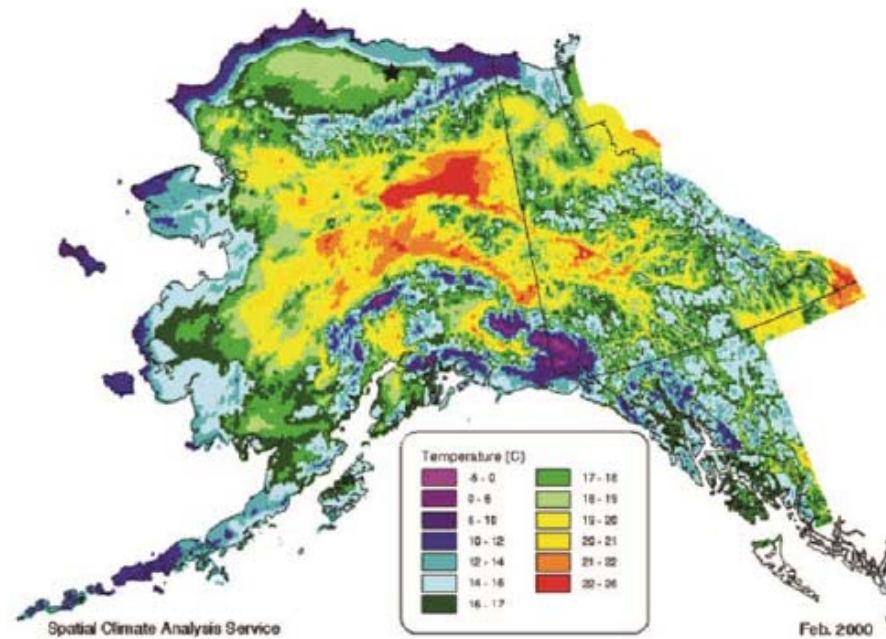
From Kling et al., 2015, LTER ASM

Annual mean precipitation, 1961-2000: Toolik and the Alaska setting





**January mean minimum
temperature**



**July mean
maximum temperature**

Question for discussion:

How representative is Toolik's climate?

-- means

-- trends and variations

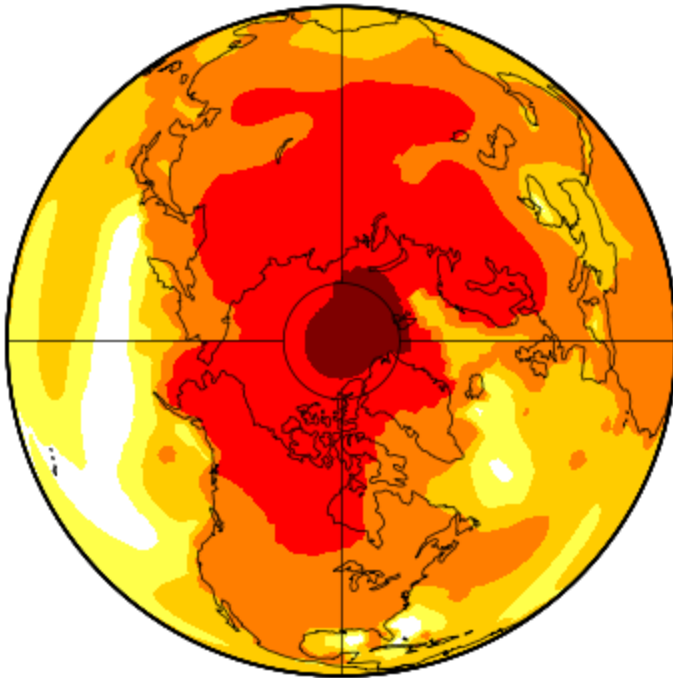
-- extreme events

Scales to consider: local, regional, pan-Arctic

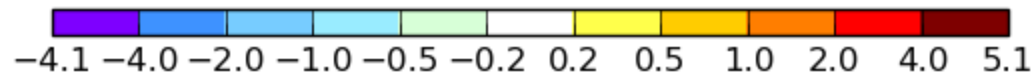
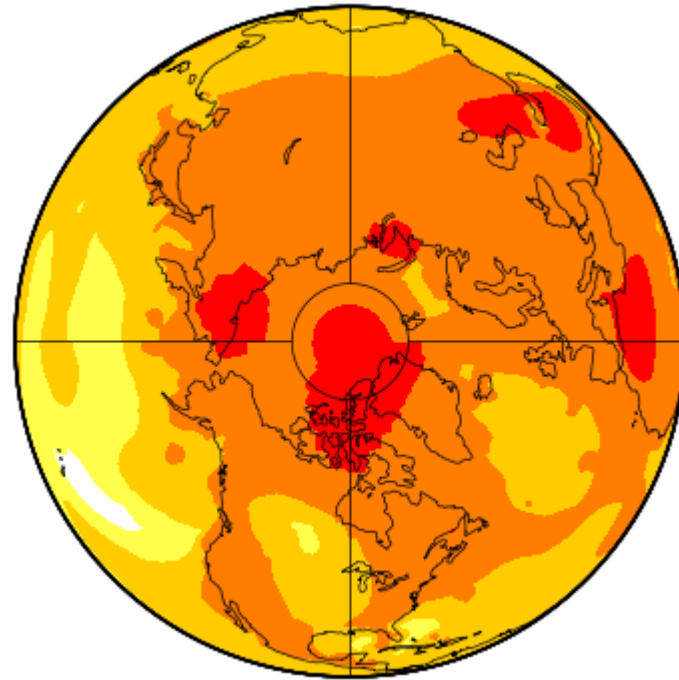
Trends of surface air temperature (°C), 1961-2016

[from NASA GISTEMP]

Nov-Apr

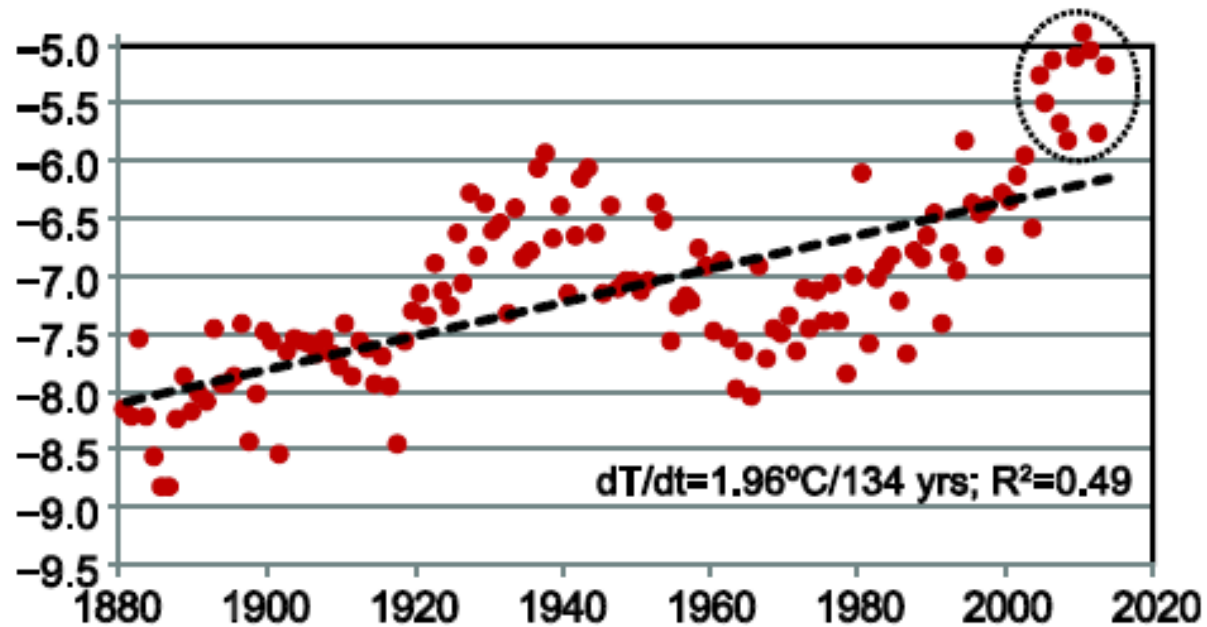


May-Oct



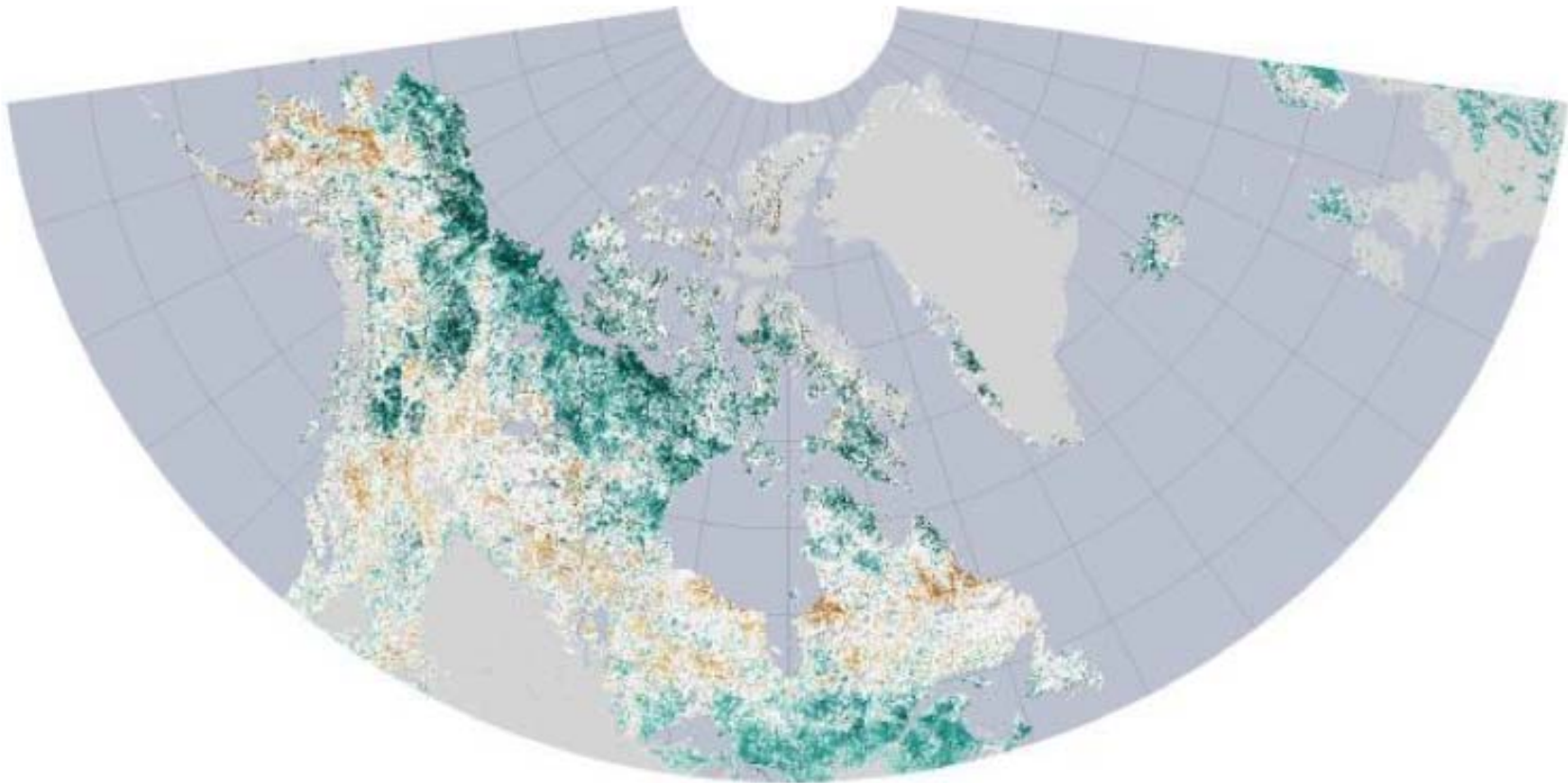
Annual mean Arctic surface air temperature (°C), 1880-2015

[Groisman et al., 2016]



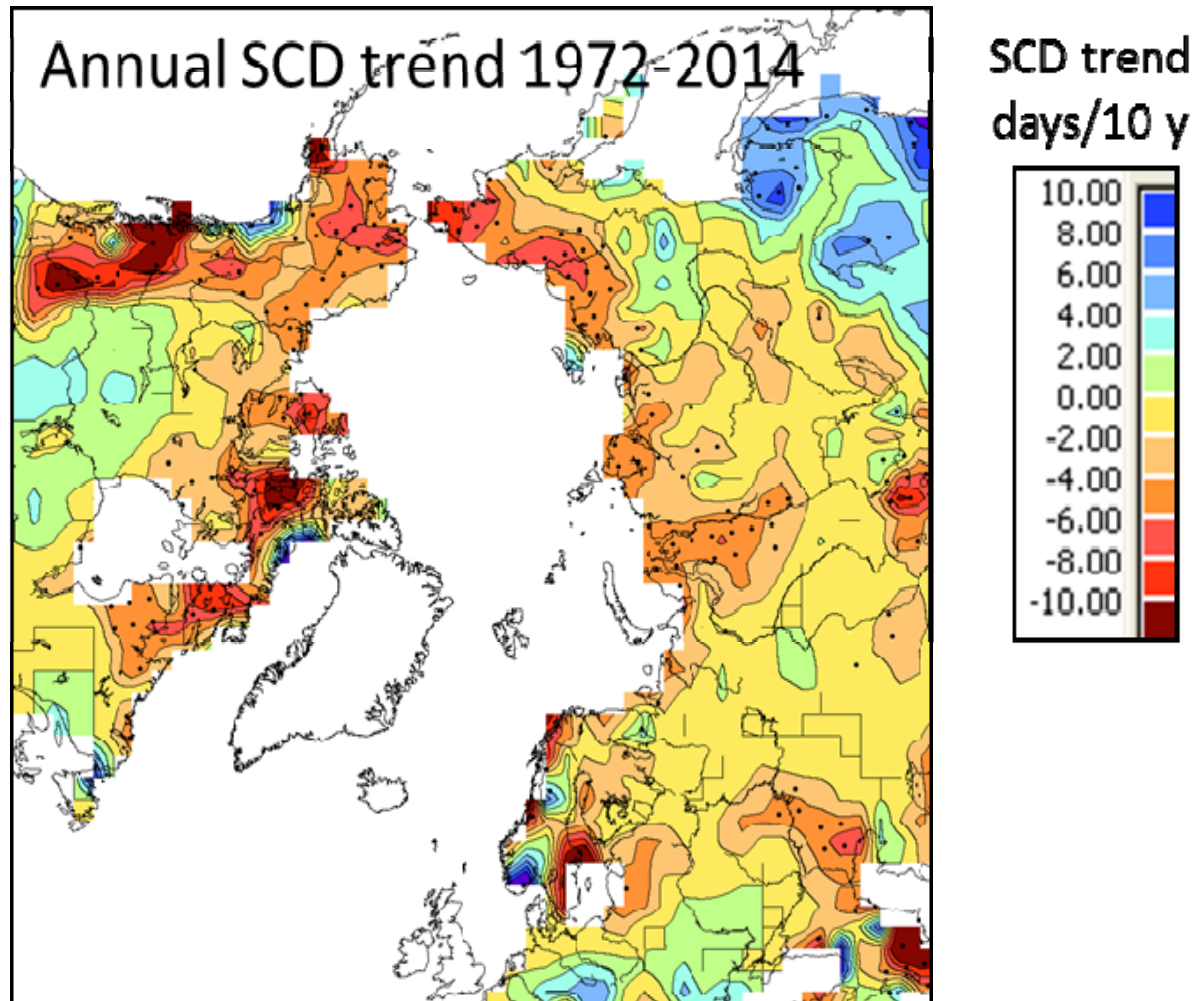
Trend in vegetative greenness (NDVI), 1982-2011

[from Xu et al., 2013]



Trend in annual snow cover duration, 1972-2014

[from AMAP/SWIPA, 2017]



2015 LTER ASM Estes Park, CO - August 30 - September 2, 2015

Toolik Lake: A 40-year record of geochemical change in the absence of trends in thaw depth, precipitation, and air and water temperatures

Presenter/Primary Author:

[George Kling](#)

Co-Authors:

George Kippbut

Neil Bettez

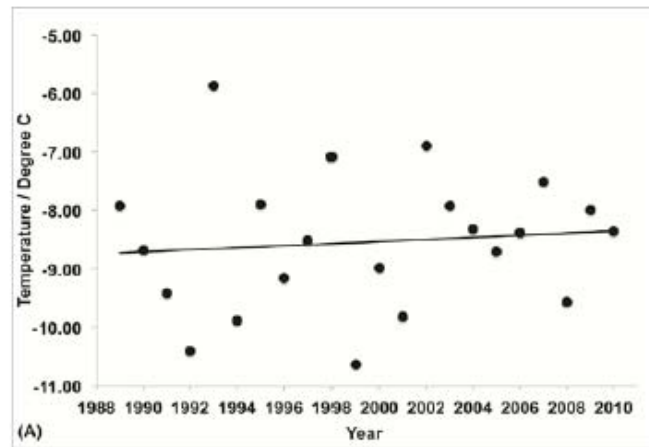
Jason Dobkowski

Anne Giblin

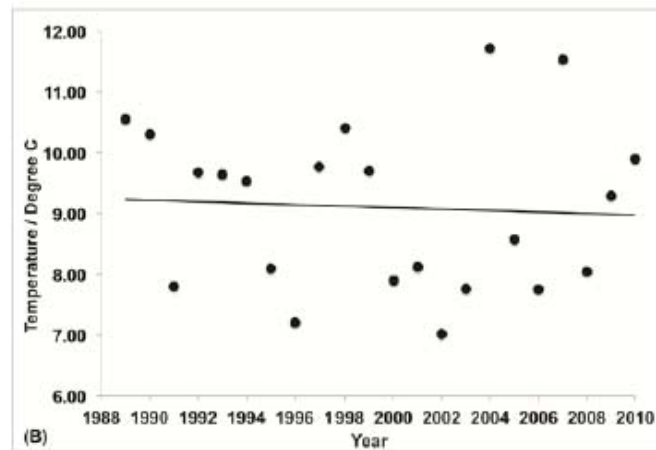
John Hobbie

Vladimir Romanovsky

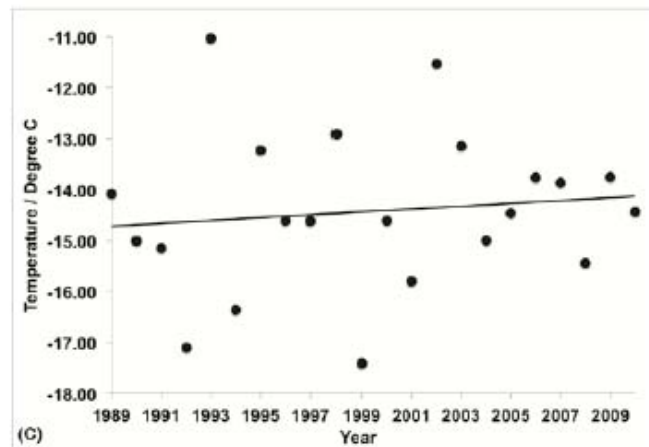
“...However, while deep (20 m) permafrost temperatures in nearby boreholes have increased, there has been no thawing and no increase in the measured summer thaw depth of tundra at Toolik in the last 25 years. In addition, there has been no significant warming of annual air temperatures or increases in precipitation at Toolik over the last 25 years, and there has been no warming of Toolik Lake water temperatures over the last 40 years.”



**Toolik annual
mean temperature,
1989-2010**

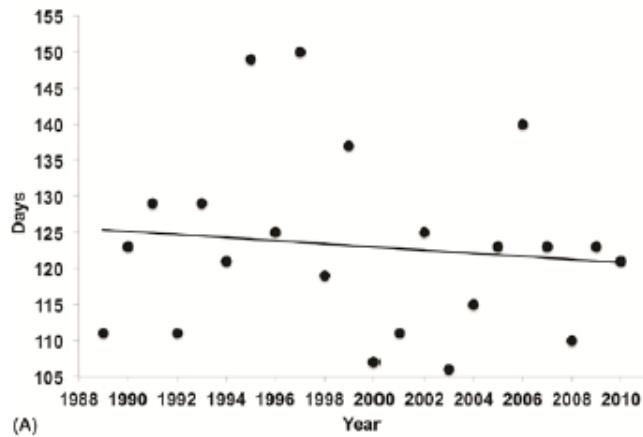


Summer

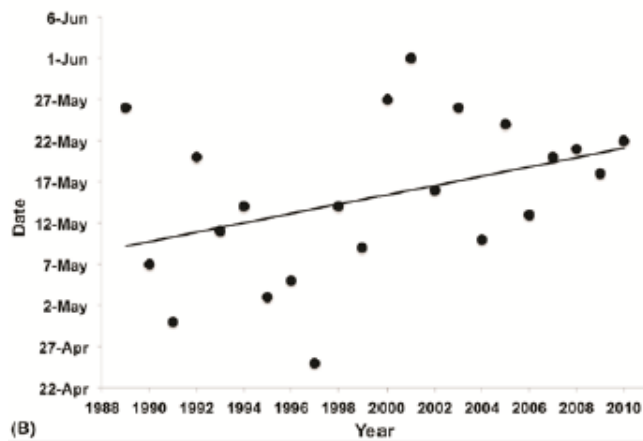


Winter

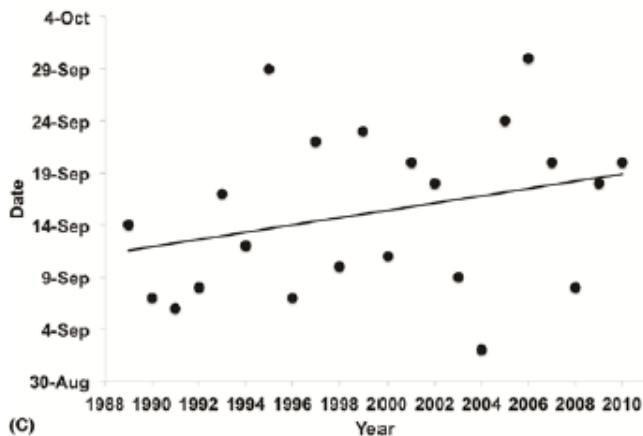
(Hobbie and Kling, 2014)



Toolik growing season length, 1989-2010

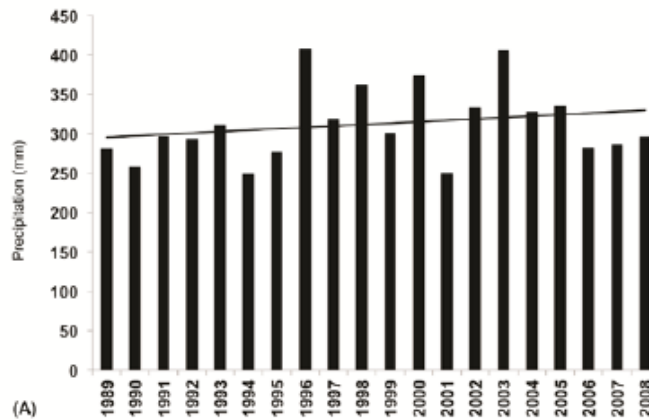


Start date

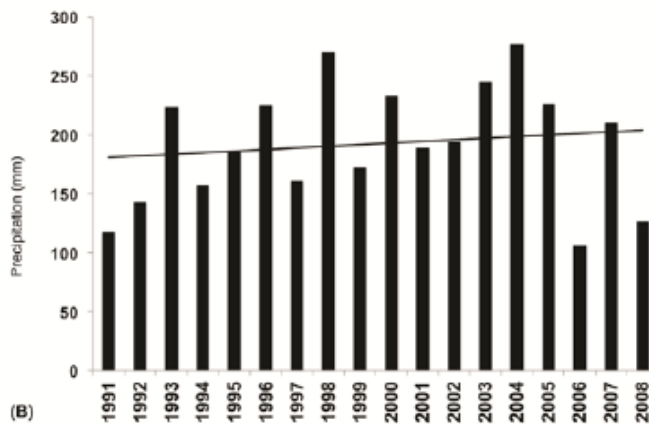


End date

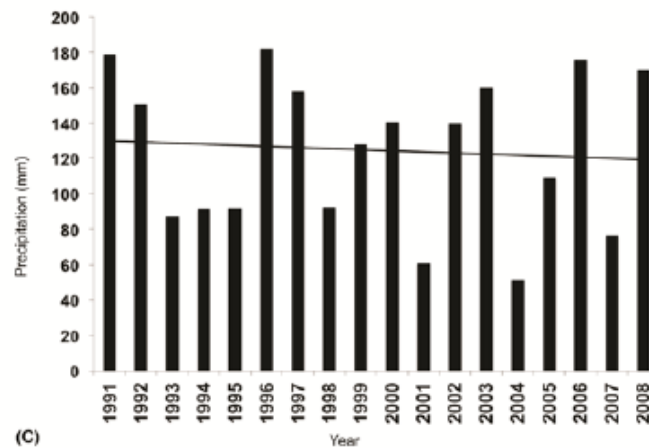
(Hobbie and Kling, 2014)



Toolik annual precipitation, 1991-2008

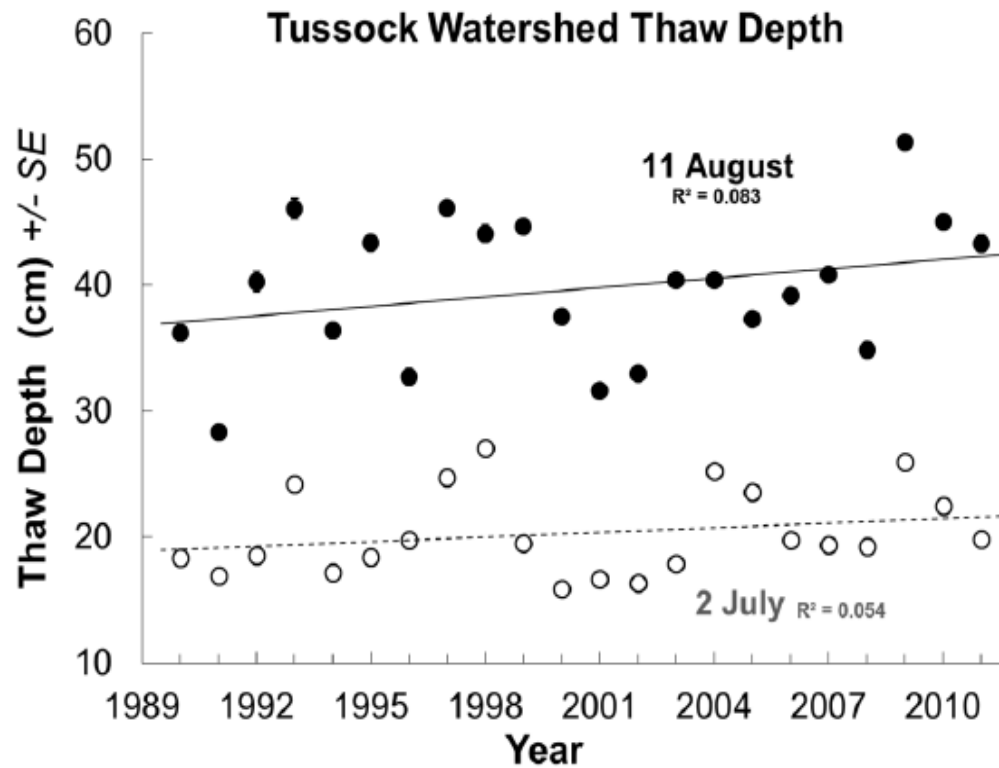


Summer



Winter

(Hobbie and Kling, 2014)



**Summer thaw depth
at Toolik**

(Tussock Watershed)

(Hobbie and Kling, 2014)

Data suggest a disconnect between Toolik and pan-Arctic trends

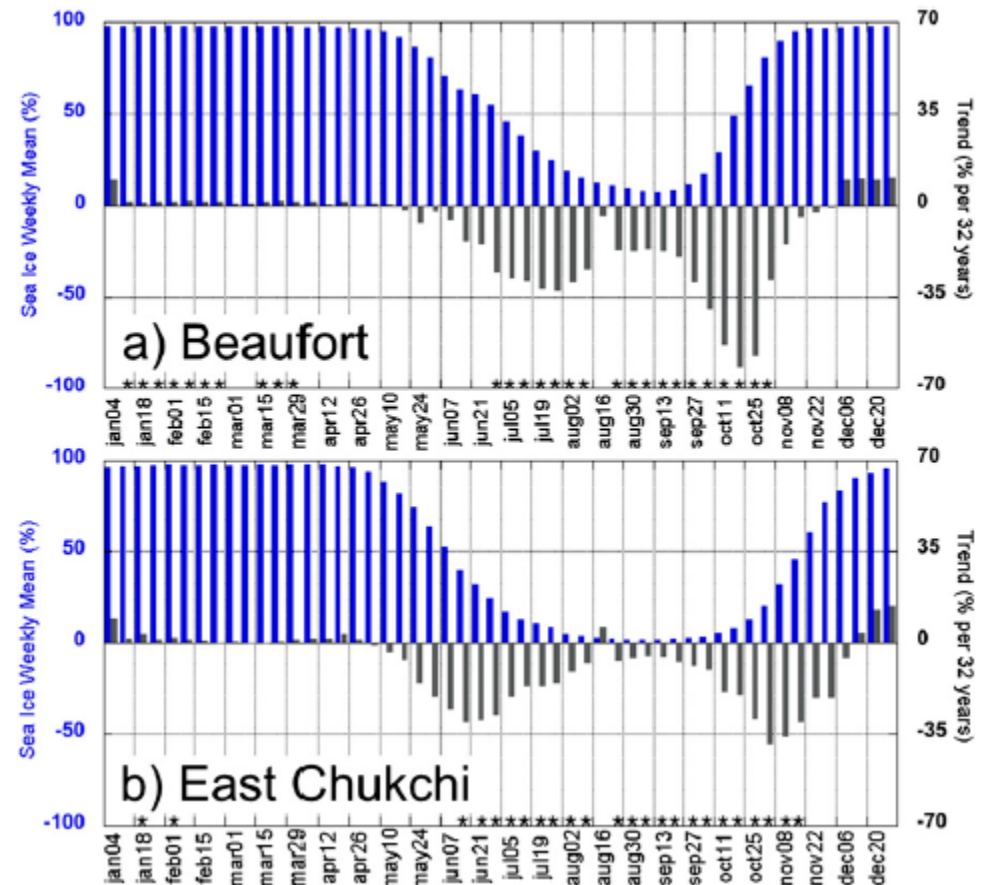
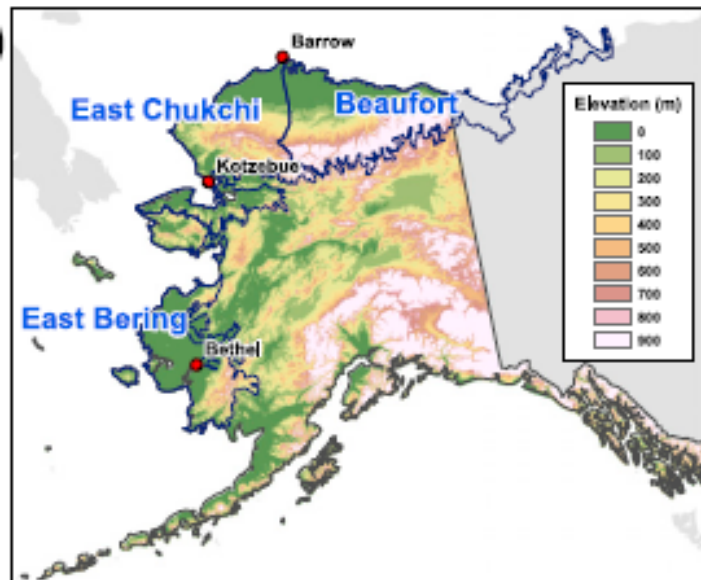
- **Is the North Slope deviating from the rest of the Arctic?**
- **Is Toolik not representative of the North Slope?**

or

- **Does something else explain the discrepancies in trends?**

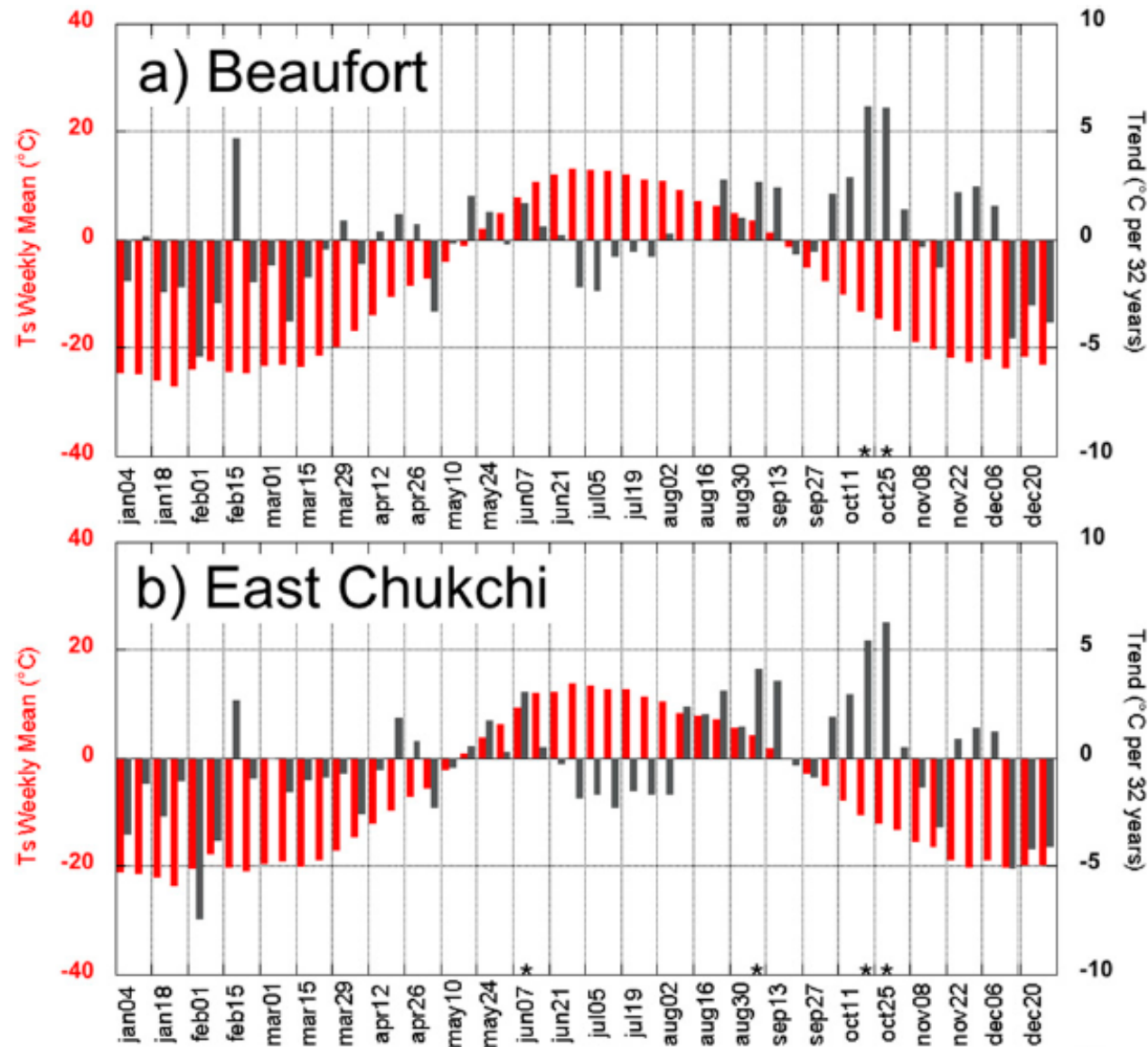
Seasonal cycle and bi-weekly trends (black) of sea ice, 1982-2013

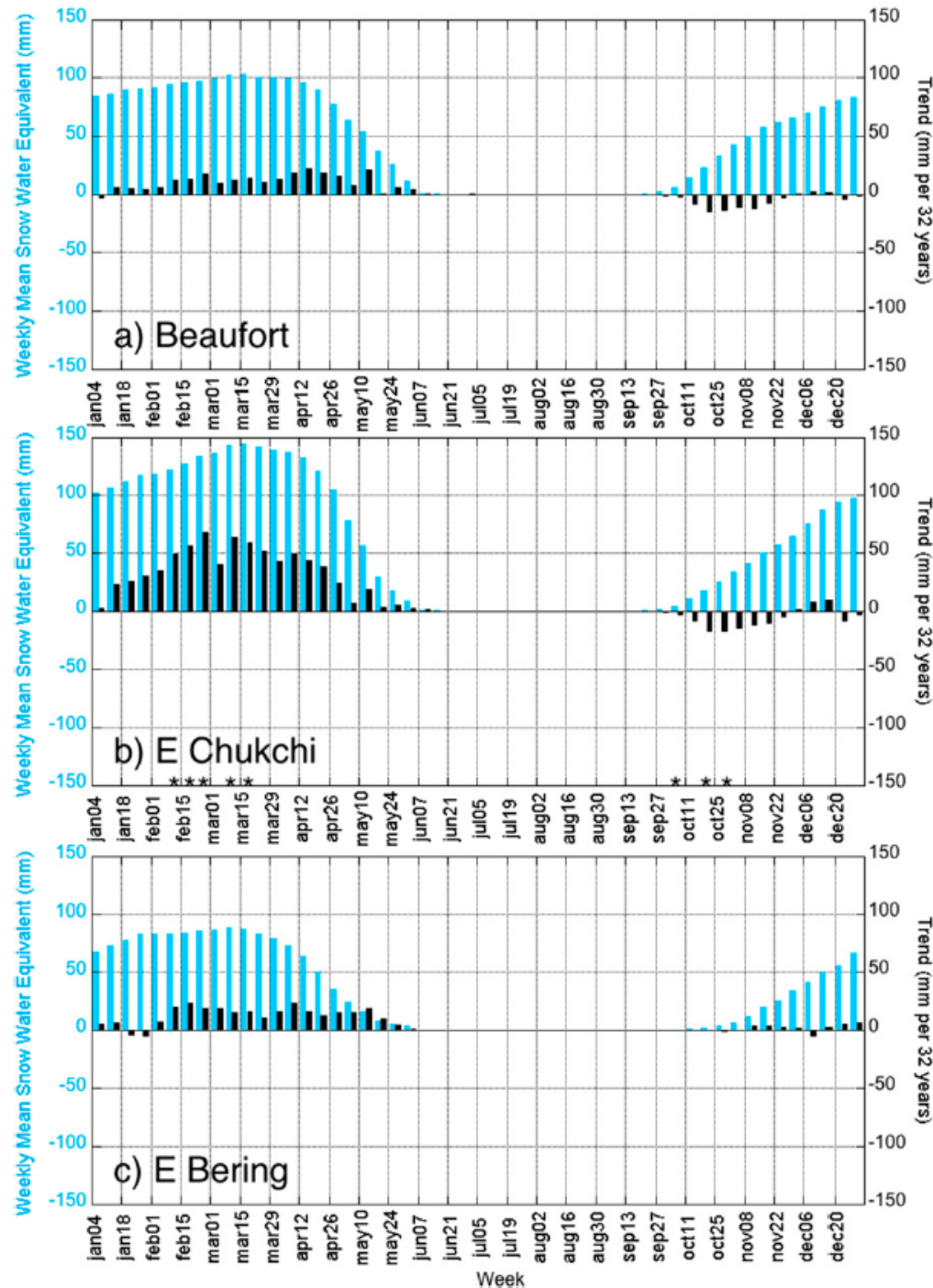
[Bieniek et al., 2015, *Earth Interactions*]



Seasonal cycle and trends (black) of air temperature, 1982-2013

[Bieniek et al., 2015]





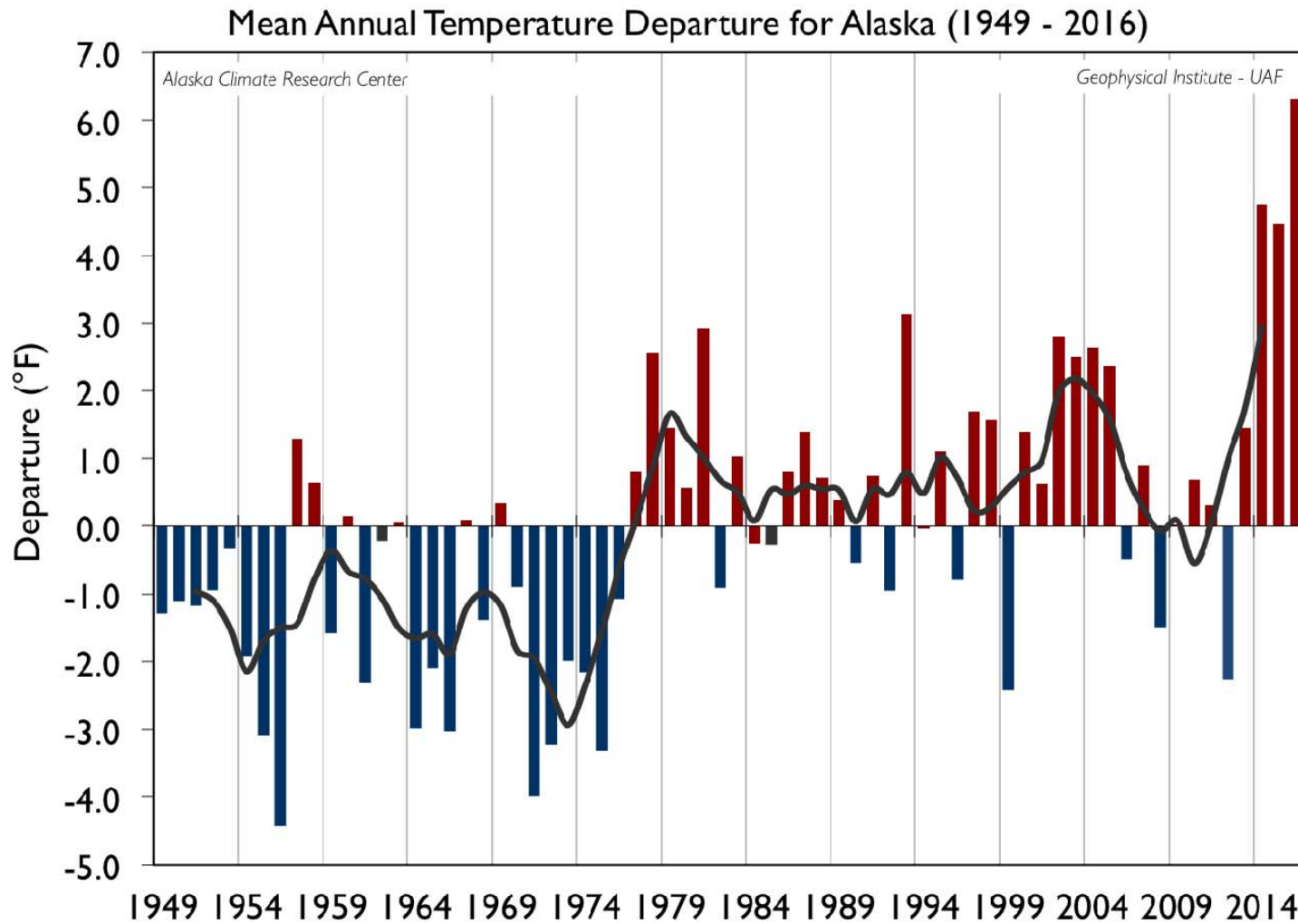
**Seasonal cycle and
bi-weekly
trends (black)
of snow water
equivalent,
1982-2013**

**-- ESA's GlobSnow
product**

[Bieniek et al., 2015]

Alaska statewide temperature (°F, departure from mean), 1949-2016

[from Alaska Climate Research Center]



Alaska temperature changes (°F) by season and location (station

1949-2016

Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2016						
Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	8.1	6.1	3.7	6.9	6.3
	Bettles	7.8	4.7	1.6	2.1	4.1
Interior	Fairbanks	7.8	4.2	2.1	1.1	3.7
	Delta Junction	9.7	4.1	0.8	1.1	3.9
	McGrath	8.8	5.0	2.6	2.7	4.8
	Kotzebue	8.1	2.5	3.2	3.5	4.4
	Nome	5.6	3.3	2.3	1.8	3.3
West Coast	Bethel	8.0	4.5	2.2	1.2	4.0
	King Salmon	9.9	4.8	1.8	2.0	4.7
	St Paul	1.1	1.7	2.9	1.7	1.9
	Cold Bay	2.4	1.7	2.3	1.4	2.0
	Talkeetna	9.8	5.6	2.9	3.6	5.4
Southcentral	Gulkana	8.3	3.1	0.9	0.3	3.0
	Anchorage	6.7	4.0	1.8	2.0	3.6
	Homer	7.1	4.2	3.4	2.6	4.3
	Kodiak	1.9	2.4	1.8	0.4	1.6
Southeast	Yakutat	5.9	3.3	2.3	1.2	3.1
	Juneau	7.0	3.4	2.2	1.6	3.5
	Annette	3.8	2.6	2.0	1.0	2.3
Average		6.7	3.7	2.3	2.0	3.7

Alaska Climate Research Center Geophysical Institute, University of Alaska Fairbanks

1977-2016

Total Change in Mean Seasonal and Annual Temperature (°F), 1977 - 2016						
Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	4.2	6.0	2.6	10.6	5.9
	Bettles	0.5	0.5	-0.4	2.0	0.6
Interior	Fairbanks	-1.4	-0.5	0.9	0.6	-0.1
	Big Delta	2.2	-0.3	0.0	0.9	0.8
	McGrath	2.2	2.1	2.0	3.2	2.4
	Kotzebue	0.8	1.9	1.2	3.5	1.9
	Nome	-1.3	-0.8	-0.7	1.2	-0.3
West Coast	Bethel	0.9	0.2	2.0	1.5	1.1
	King Salmon	1.2	-0.7	1.3	2.1	1.0
	St Paul	-1.9	-2.3	0.4	0.9	-0.8
	Cold Bay	0.1	-1.5	0.7	0.6	-0.1
	Talkeetna	3.3	2.1	2.2	3.1	2.7
Southcentral	Gulkana	0.3	0.2	1.0	-1.0	0.2
	Anchorage	0.4	0.0	0.7	0.9	0.5
	Homer	0.7	0.2	1.4	1.4	1.0
	Kodiak	-1.2	-1.6	0.5	-0.8	-0.8
Southeast	Yakutat	1.8	-1.0	1.3	0.6	0.7
	Juneau	2.7	-0.8	0.4	-0.3	0.5
	Annette	0.8	0.3	1.3	1.0	0.8
Average		0.9	0.2	1.0	1.7	0.9

Alaska Climate Research Center Geophysical Institute, University of Alaska Fairbanks

Conclusions

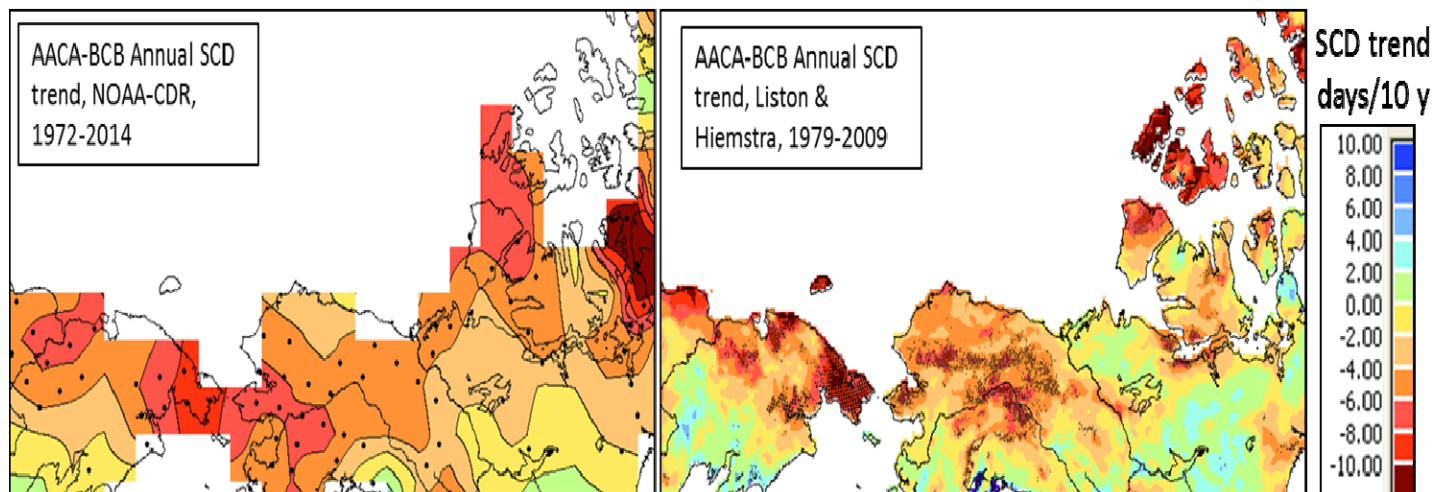
- Toolik's trends in climate variables appear to be generally consistent with the rest of the North Slope
 - *except for the coastal zone*
- Discrepancies (local vs. pan-Arctic) arise from different time periods of comparison
 - *trends are sensitive to start and end years*
- Some large-scale snow cover products: “alternative facts” ?

Trend in Snow Cover Duration over northern Alaska – two sources

[from Flato et al., Ch. 4 in AMAP/AACA/BCB, 2017]

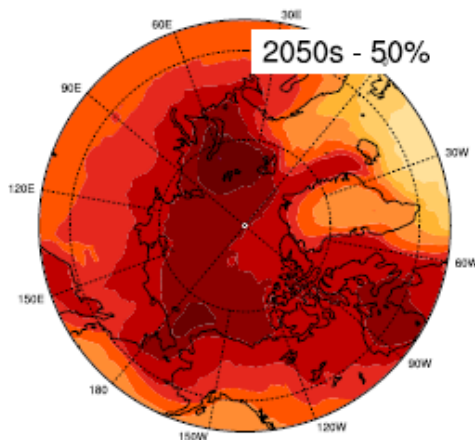
1972-2014 (NOAA)

1979-2009 (Liston/Heimstra)

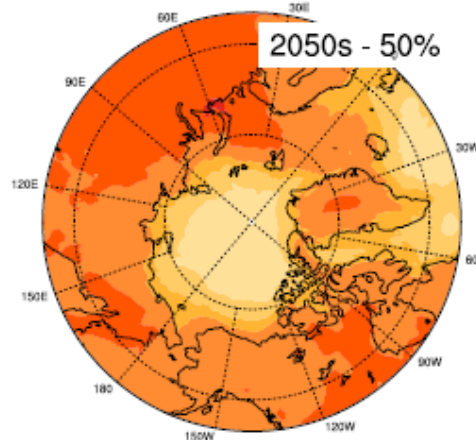


Looking ahead: Projected changes for 2050, RCP 8.5 scenario [AMAP/AACA, 2017]

Dec-Feb

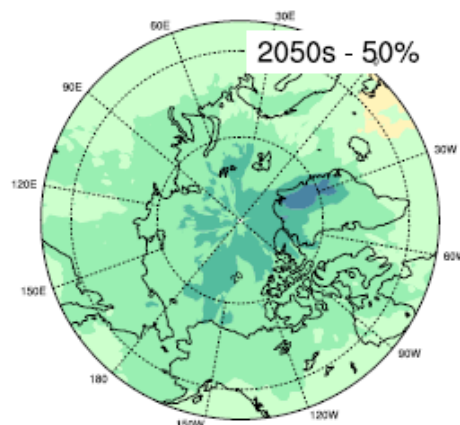
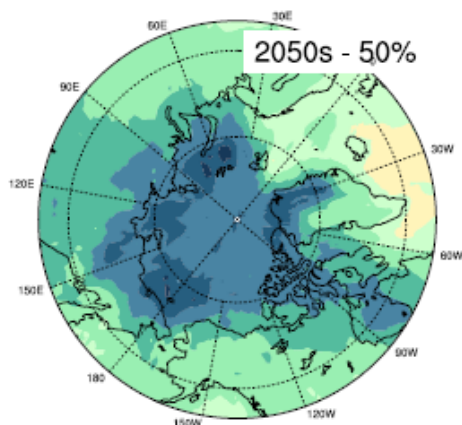
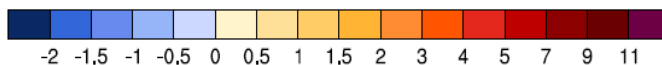


Jun-Aug



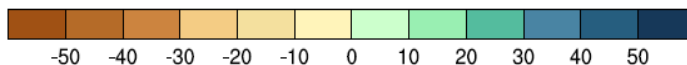
**Temperature
(change in °C)**

warmer in 2050s



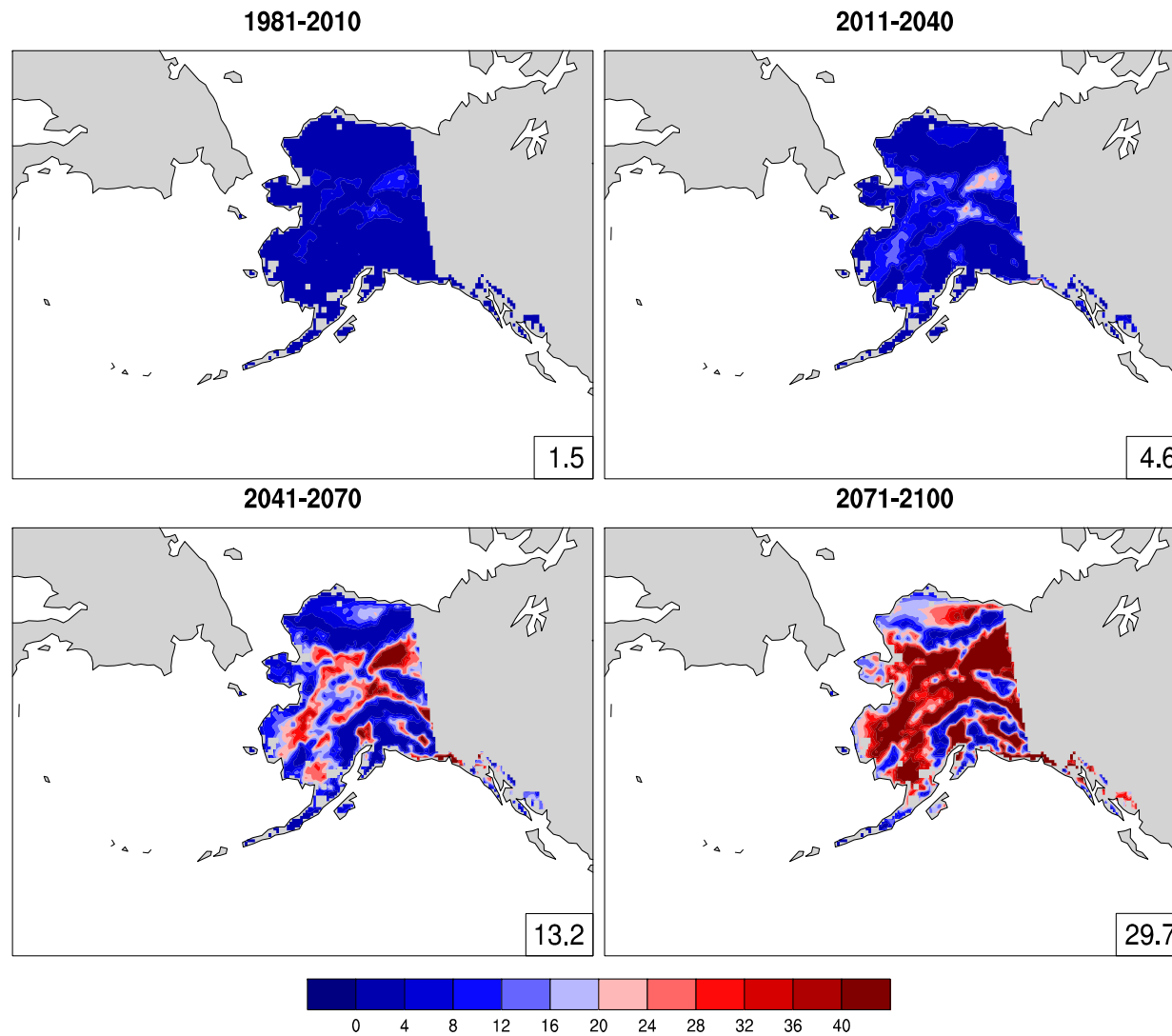
**Precipitation
(% change)**

wetter in 2050s

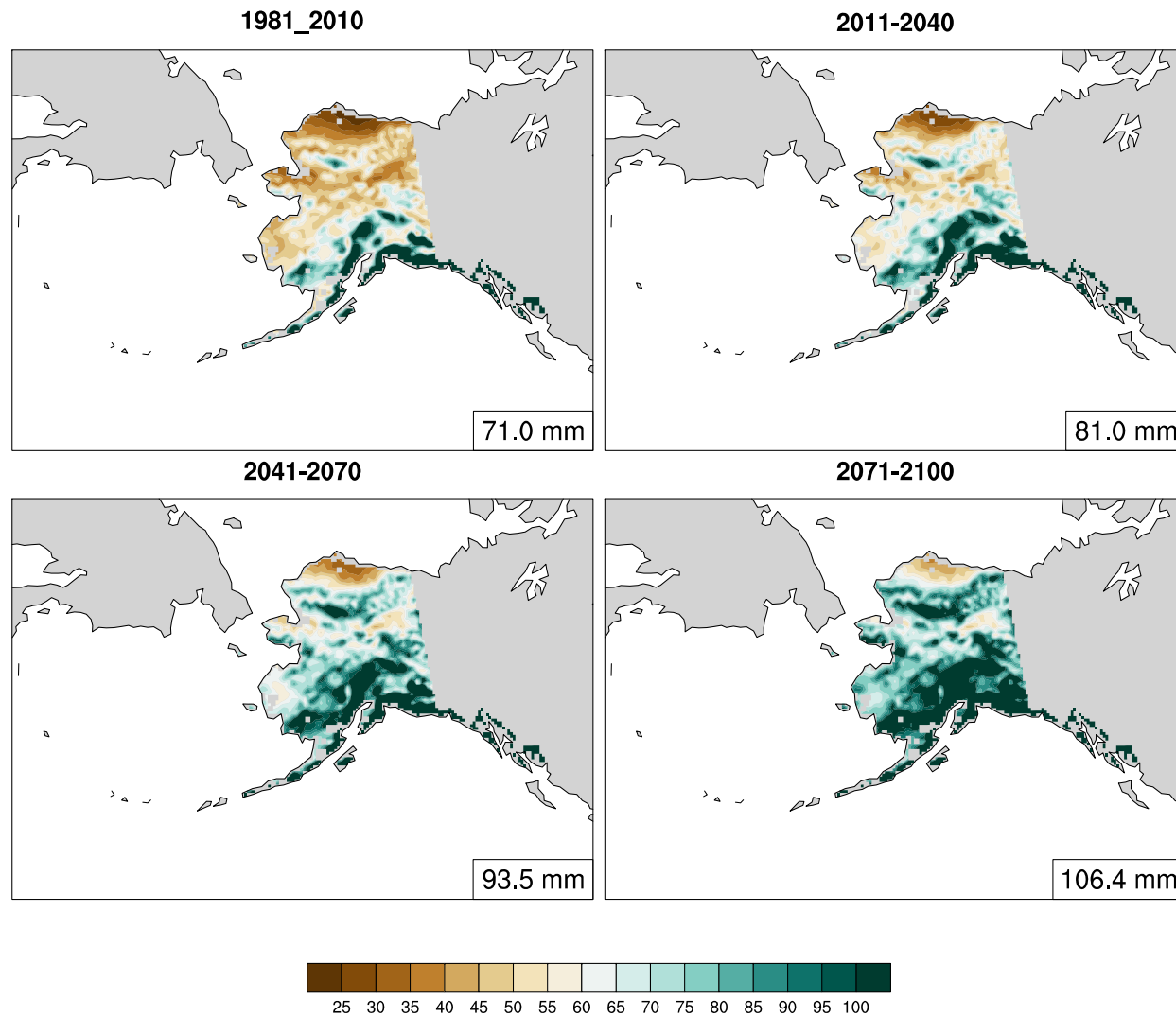


Average m

25°C (77°F)

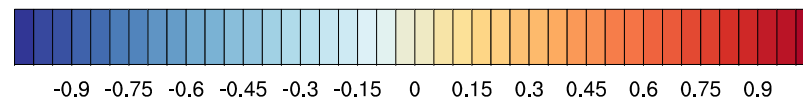


Annual maximum 5-day precipitation (mm) averaged for 30-year periods



[from R. Lader, IARC]

More frequent Rain-on-Snow events over much of Alaska:



Number of ROS days per
month/decade

ieniek, UAF/IARC

The models used to project climate changes have spatial resolutions of 100-200 km (global models) down to 20-30 km (regional climate models)

⇒ *Scaling challenges will need to be addressed in order to bridge climate model projections and changes at a particular location (e.g., Toolik)*

What could be done to advance scale-bridging?

- **high-resolution modeling**
 - perhaps the most viable strategy to fill spatial gaps
- **use of remote sensing products**
 - determination of scales of variability (snow, temperature,...)
- **exploit “local knowledge”**