Alaska tundra vegetation trends and their links to the large-scale climate

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Key Findings:

- Beaufort High has strengthened in summer, decreased cloudiness
- Decreased cloudiness likely responsible for the SWI increases
- Spring SWE decreasing in East Bering region, consistent with browning
- Large-scale climate has a major role in controlling sea ice, SWI

http://www.arcticatlas.org/photos/mapunits/vegPhotos

NDVI & SWI trends/variability similar
Ground measured biomass follows NDVI

Peak NDVI by Subzone

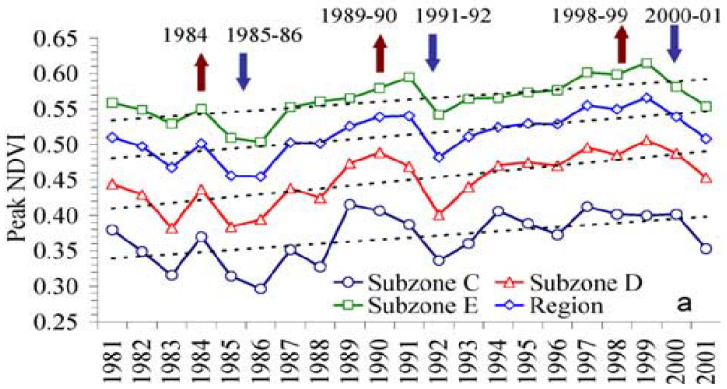


Figure 2. Time series of peak NDVI derived from 8-km resolution AVHRR data from 1981 to 2001 (a) and SWI over the past 22–50 years (b) among bioclimate subzones. Dashed lines are linear regressions. The shaded area highlights the period of SWI covered by NDVI data.

North Slope peak NDVI vs. Biomass

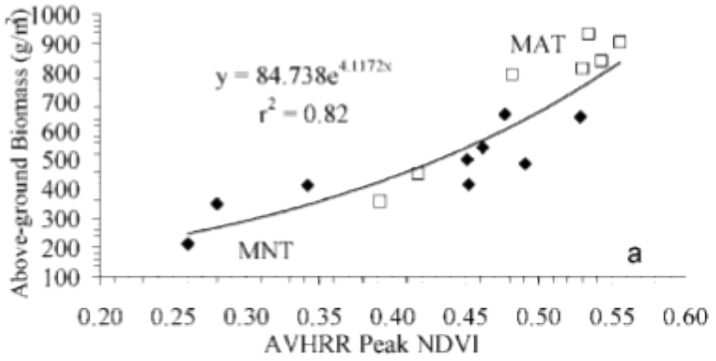


Figure 4. Correlations between NDVI and aboveground plant biomass. (a) AVHRR Peak-NDVI vs. total biomass on the North Slope; (b) ground measured NDVI vs. shrub biomass in Ivotuk.

[Jia et al. 2003, GRL]

Normalized Difference Vegetation Index

NDVI = (NIR – RED)/(NIR + RED)

Deering (Ph.D. 1978) & Tucker (1979)

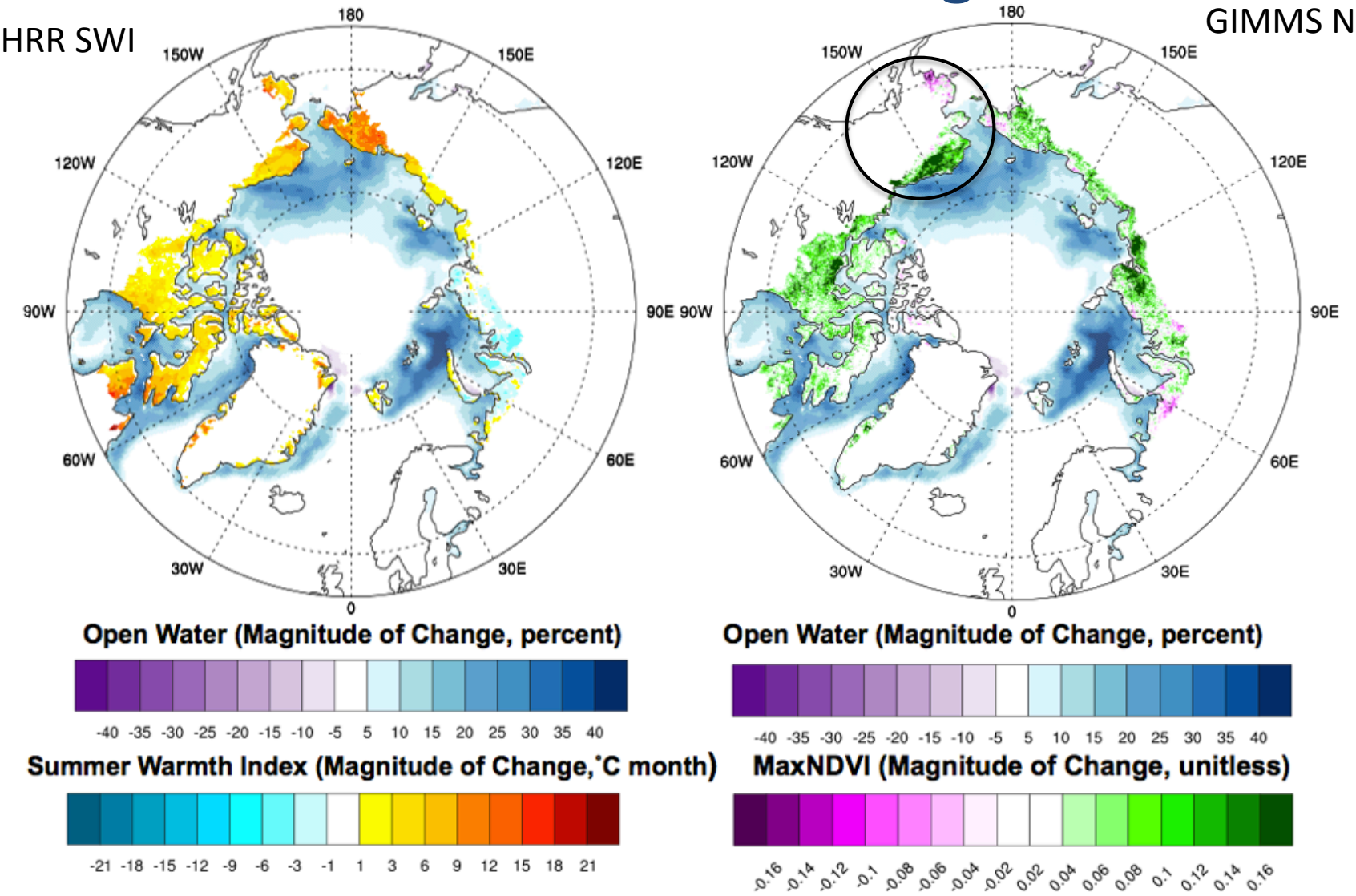
SWI - Summer Warmth Index- degree months > 0°C

•Arctic NDVI increasing 1981-2005 [Goetz et al. 2005, Bunn et al. 2007]

Greening pan-arctic tundra, warmer summers and decreasing sea ice

AVHRR SWI

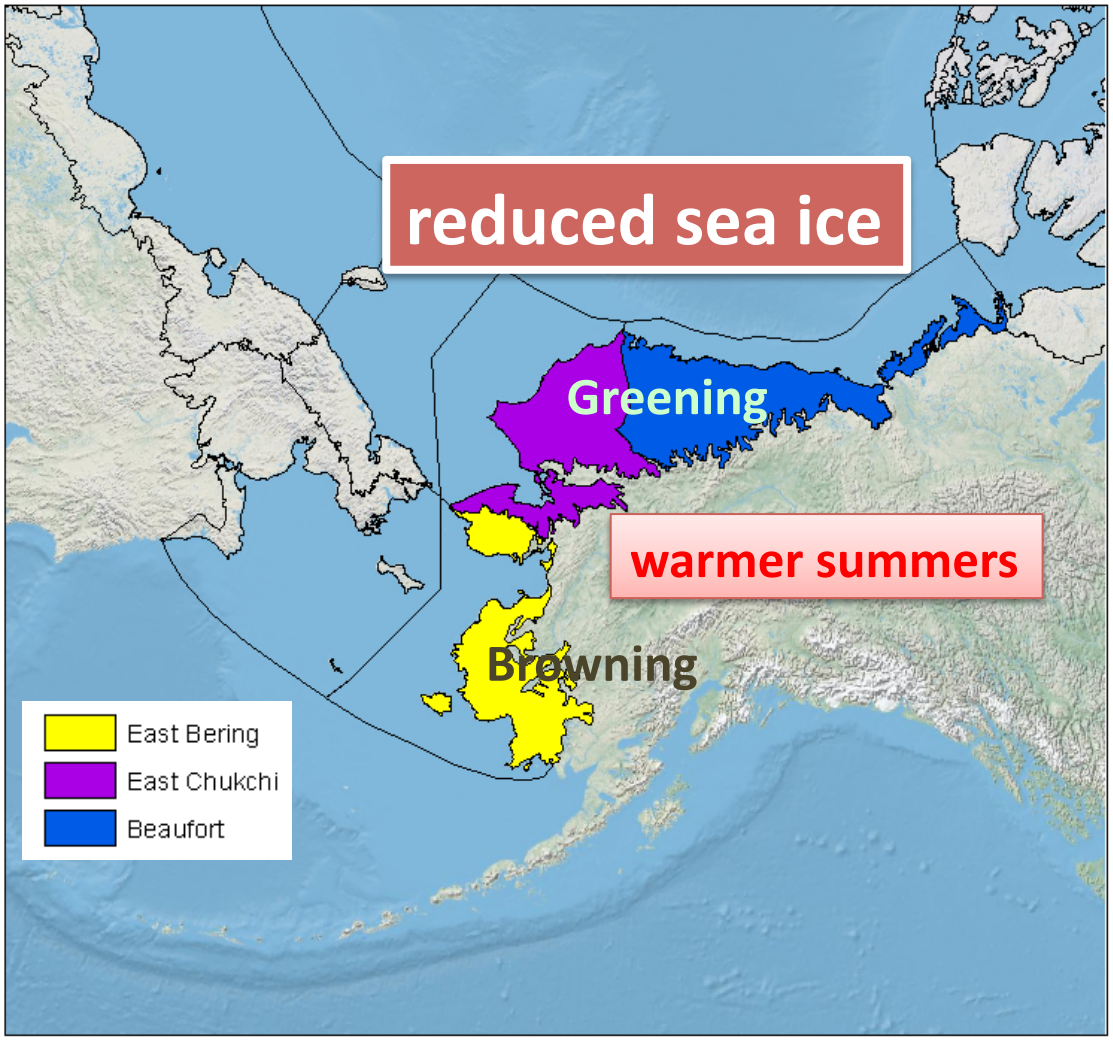
GIMMS NDVI3g+



Updated from Bhatt et al. (2010)

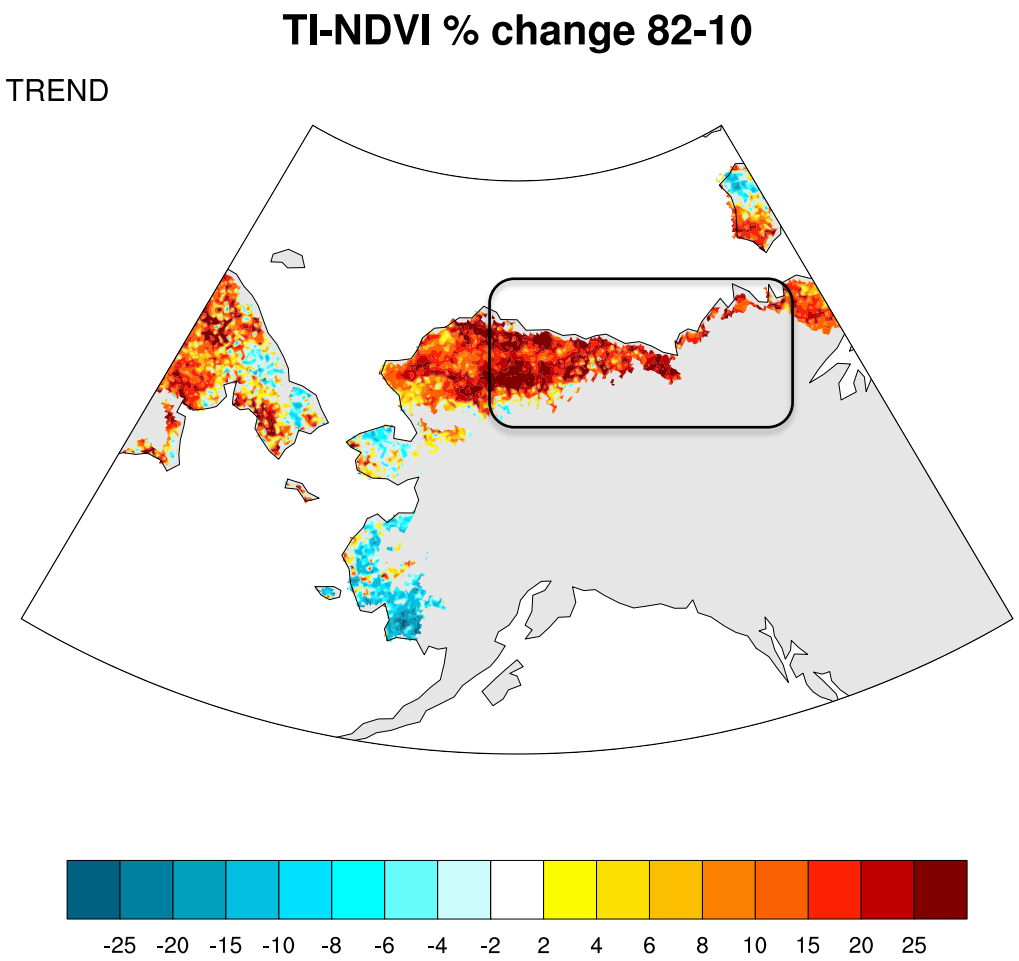
What we know: Alaska summer trends

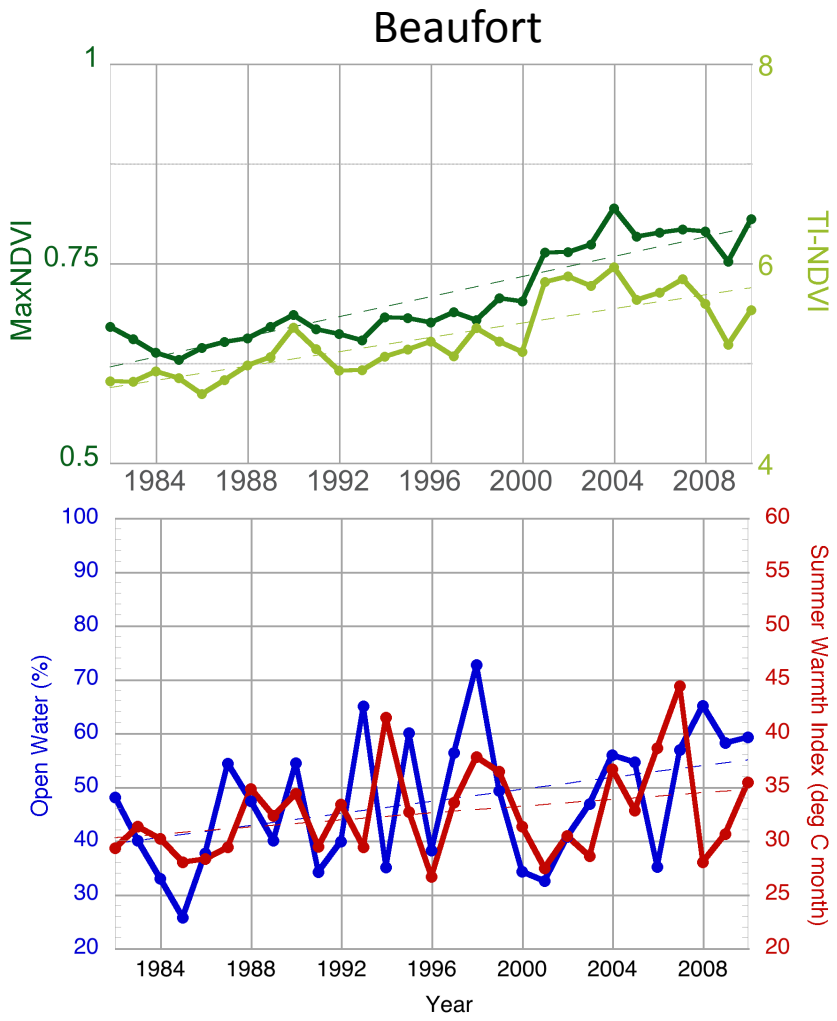
- What climate mechanism explains the NDVI changes?
- Evaluate each region separately



Treshnikov (1985)

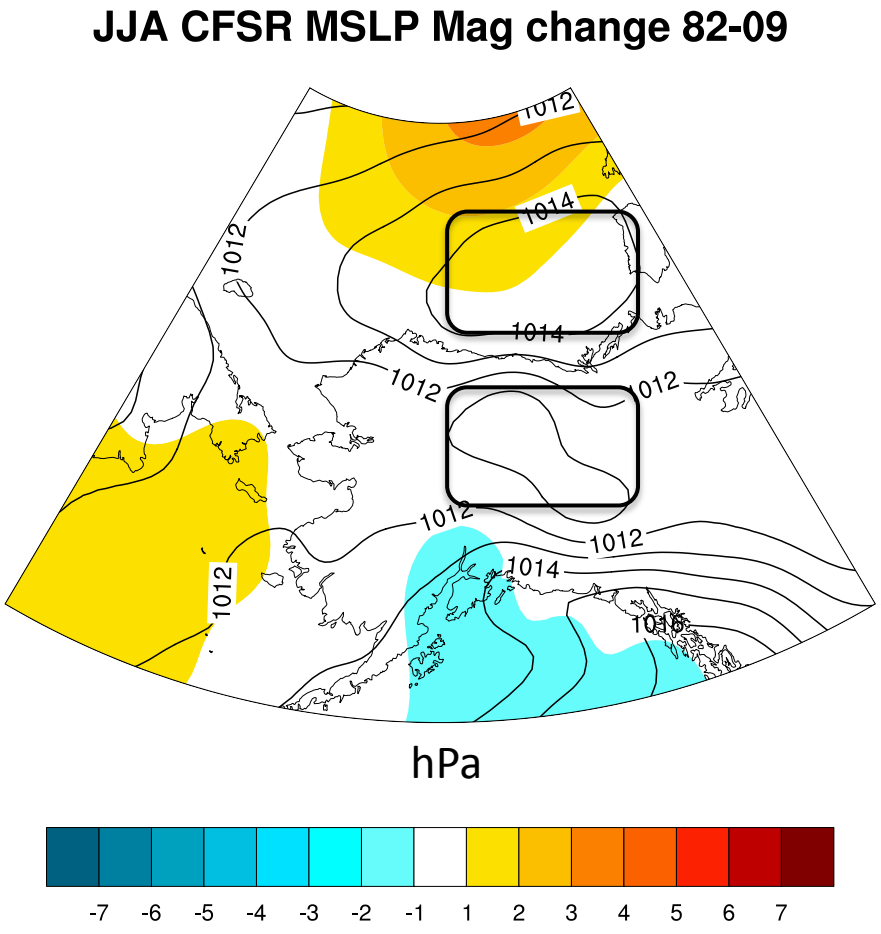
Beaufort open water, SWI and NDVI have all increased

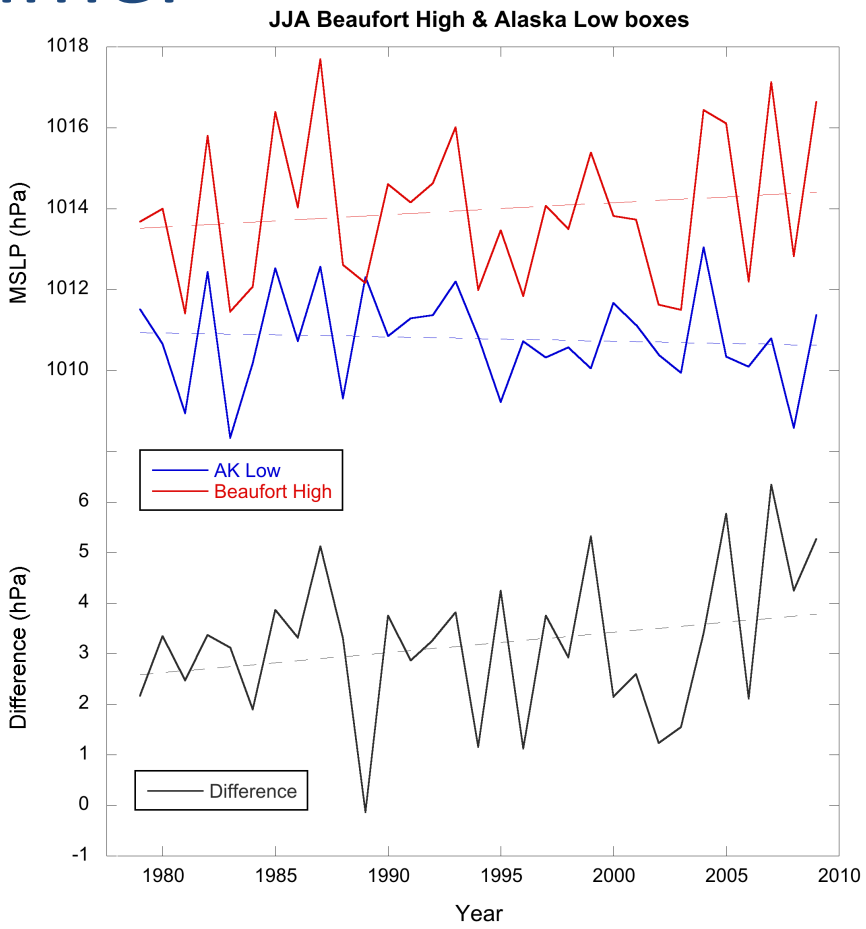




Updated from Bhatt et al. (2010)

Strength of Beaufort high is increasing in summer



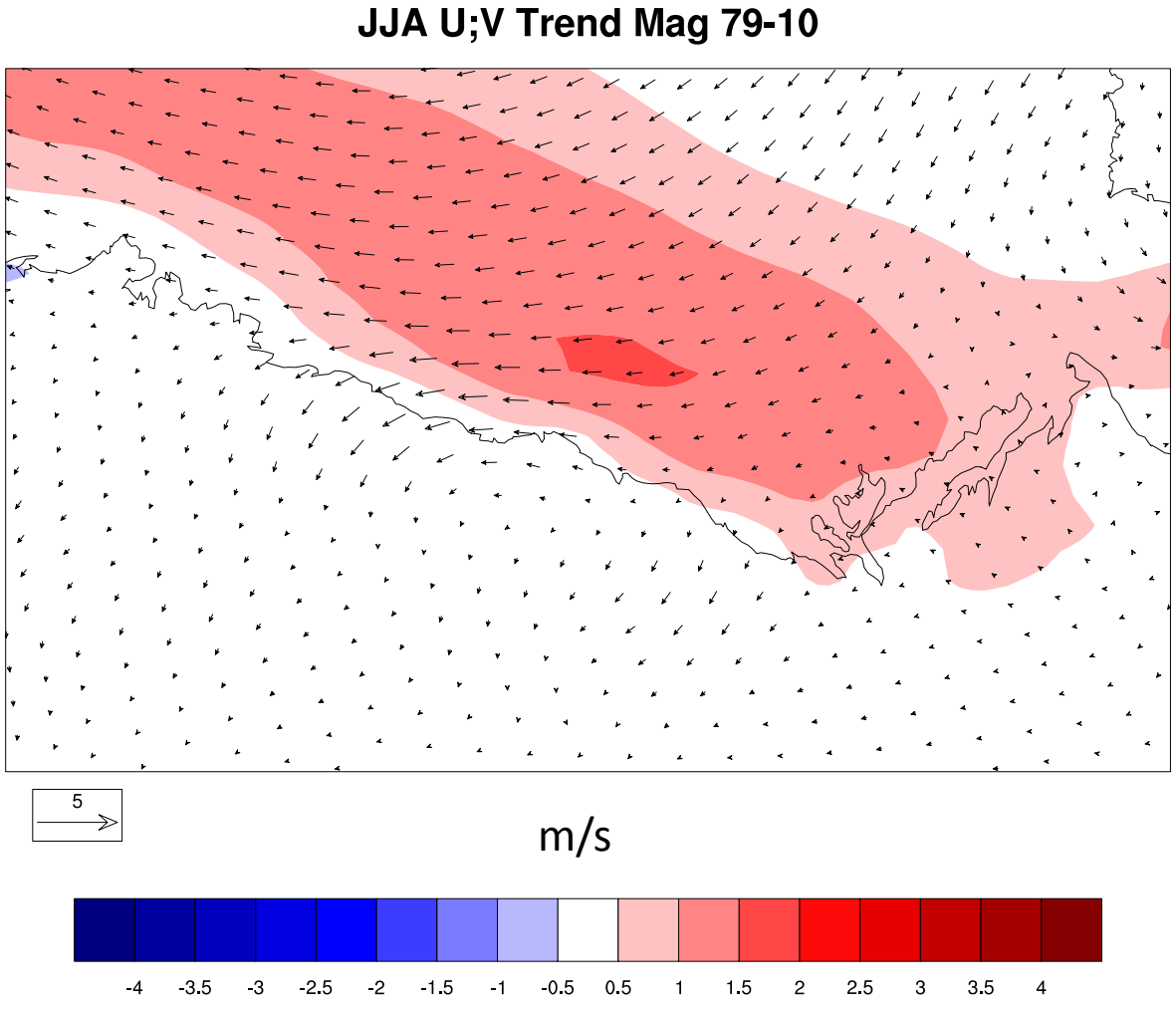


- Gradient is getting stronger

Climate Forecast System Reanalysis

CFSR: Saha et al. (2010)

Wind speeds increasing along Beaufort sea coast in summer,

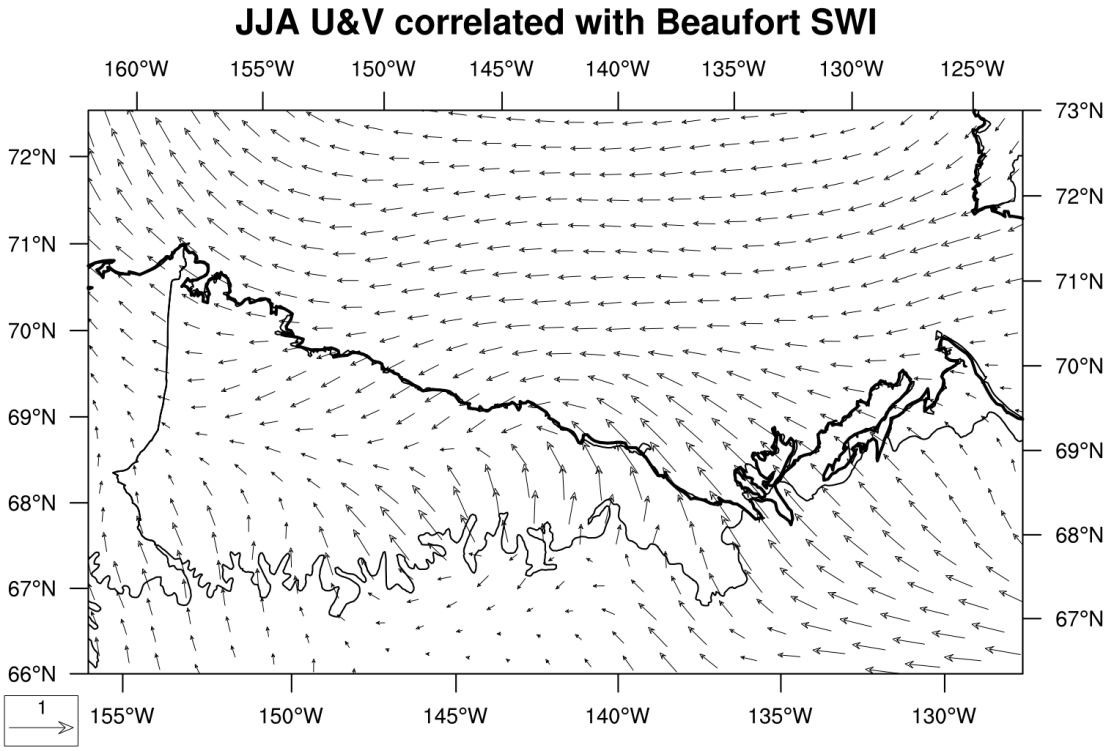


38km CFSR 10m winds

- Increasing wind speed off shore
- No change in direction
- Increase due to the stronger pressure gradient

Warmer summers with onshore winds?

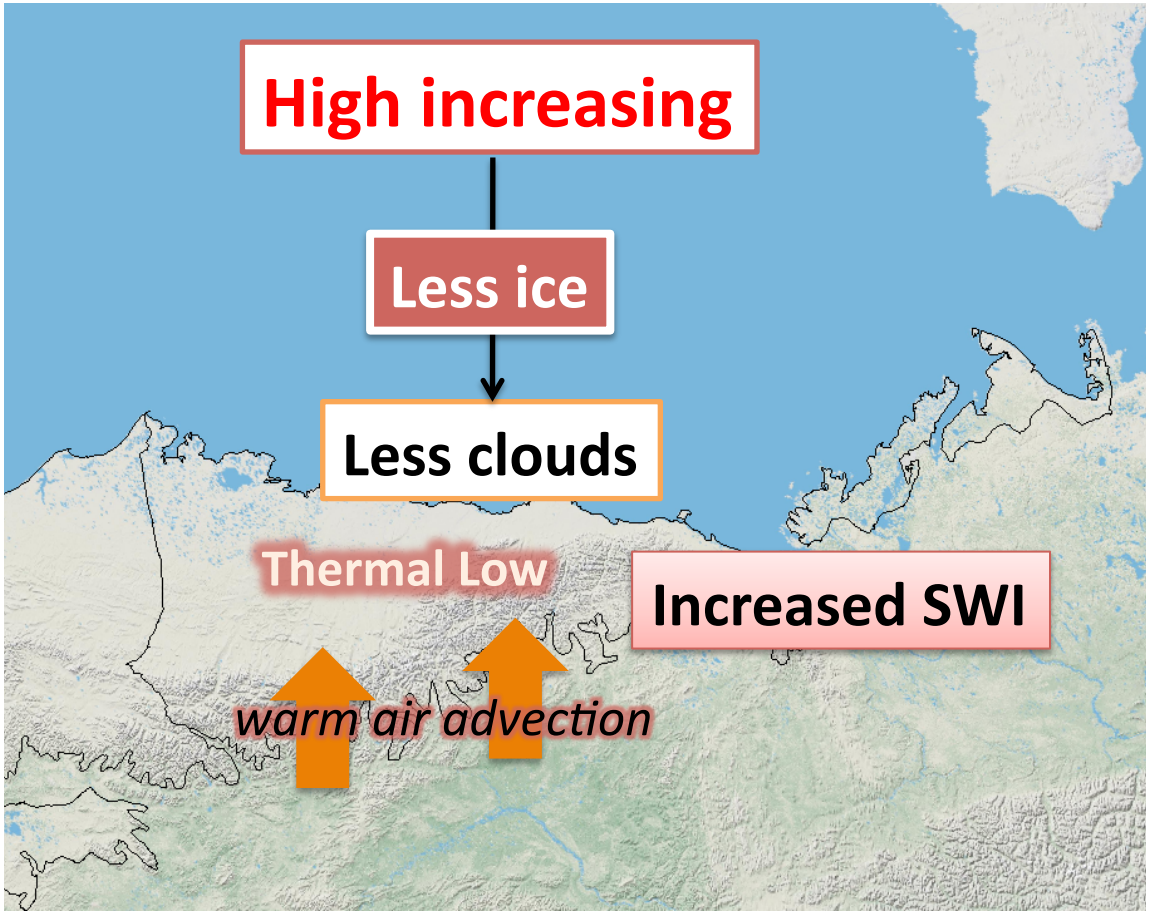
- Less cloudiness due to strengthened high
  - Increased solar insulation
- Cyclonic circulation over land
  - Thermal low formation due to surface heating
  - Would enhance onshore flow and warm southerly flow



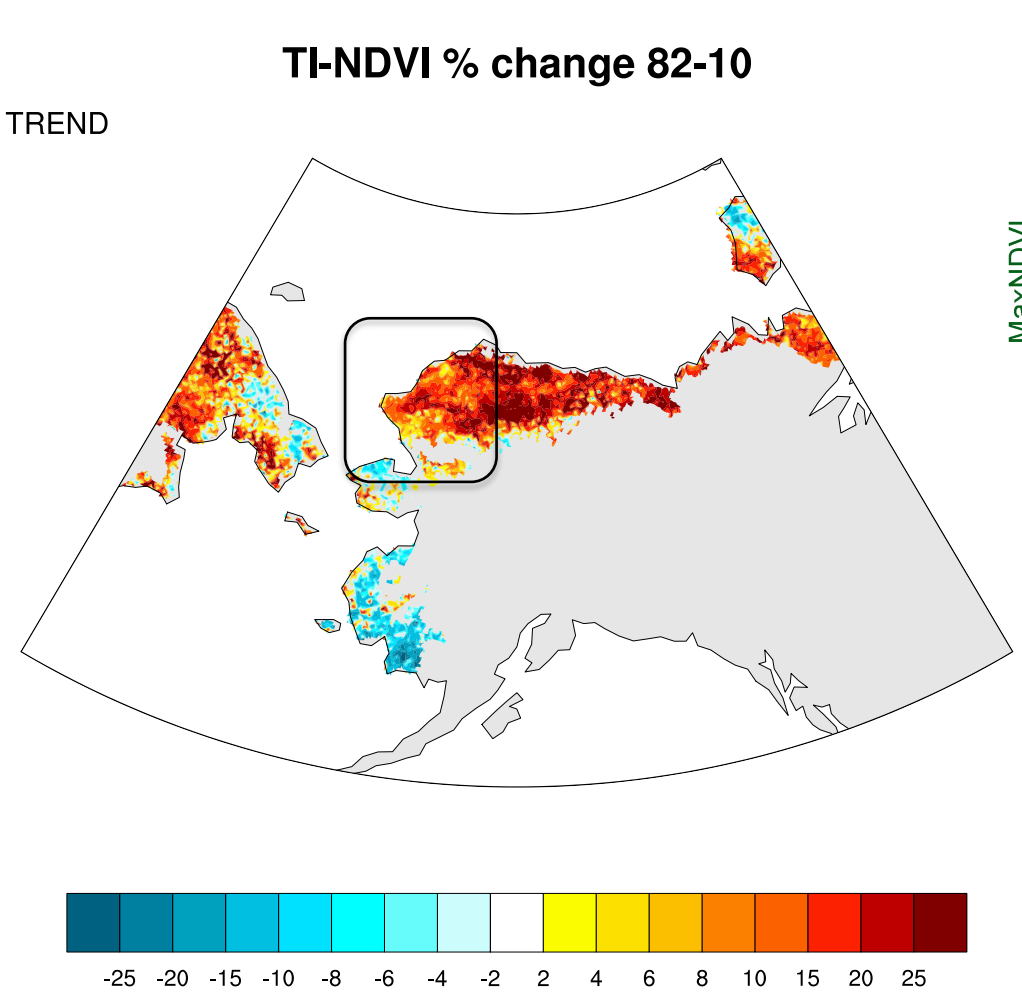
Correlation vectors

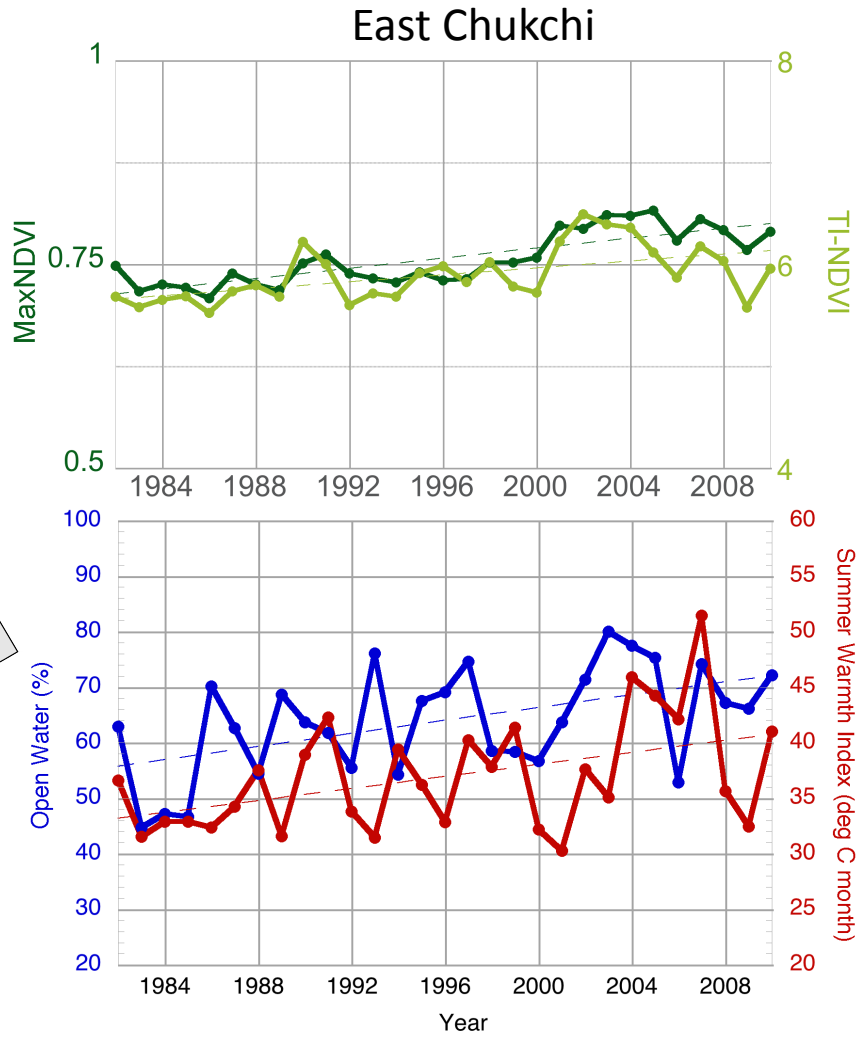
Increased high pressure, less clouds warming Beaufort in summer

- Strength of Beaufort High increasing
- Results in less sea ice and cloudiness
- Increased solar insulation
- Thermal low develops in heating
  - Results in advection form the south?
- Onshore winds cooling, advecting moisture?



Greening, warmer summers in East Chukchi tundra region

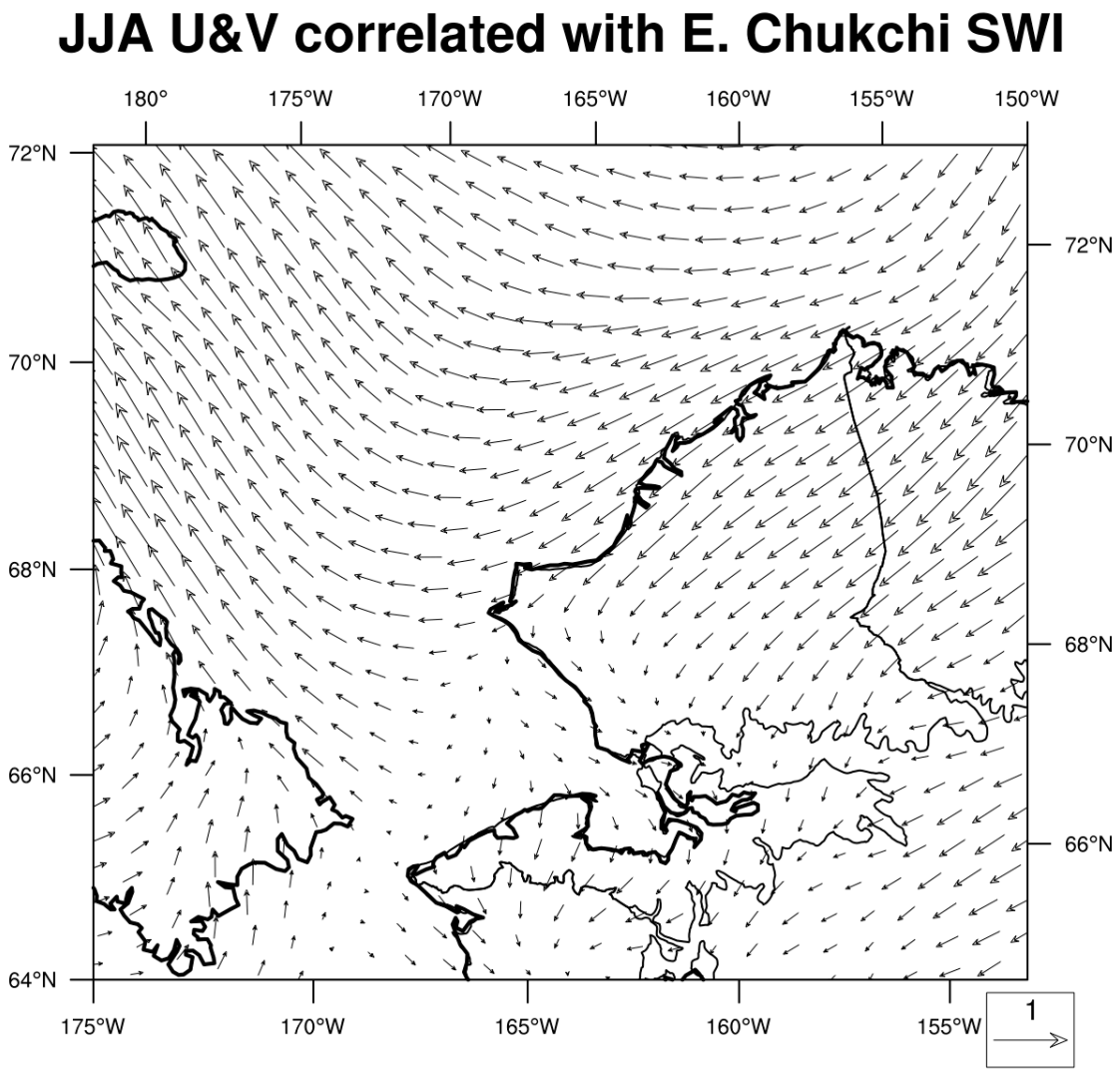




Updated from Bhatt et al. (2010)

Warmer summer in E. Chukchi under NW flow

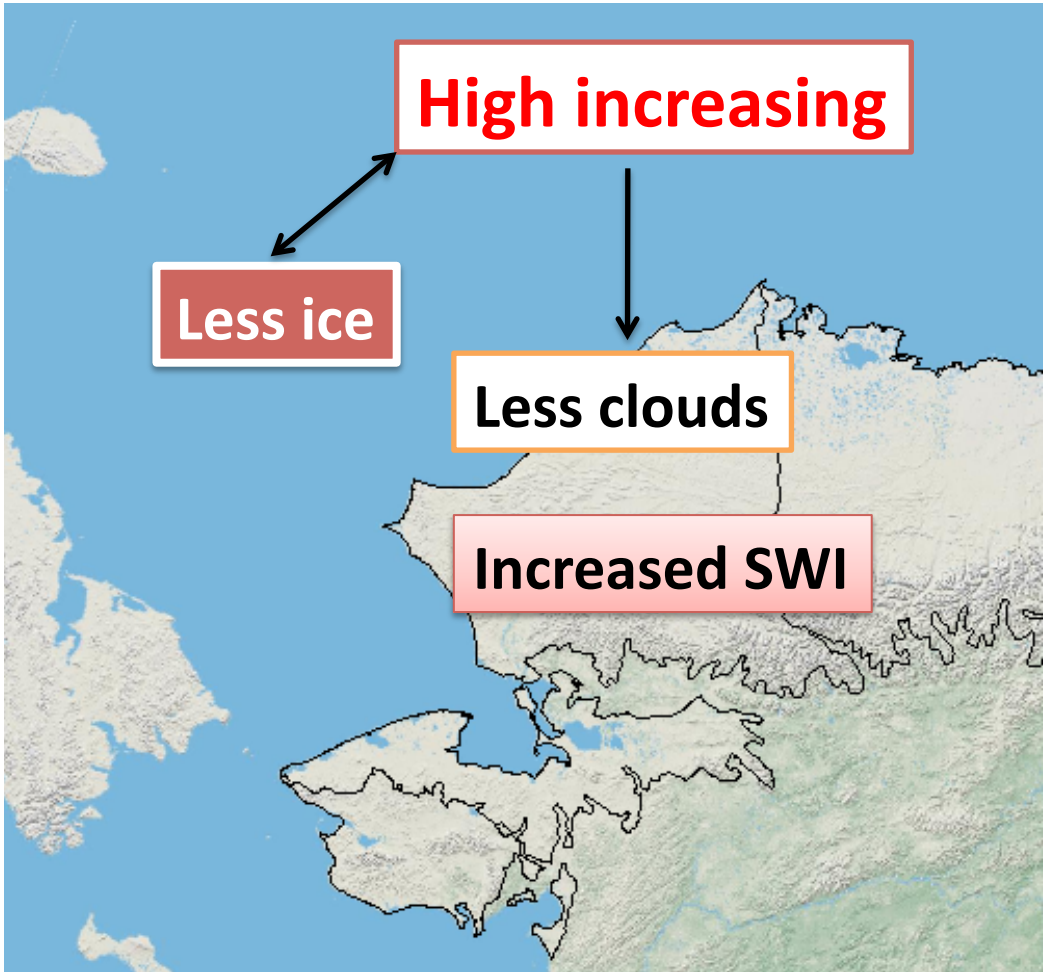
- Warmer with NW winds
- Shifted position of Beaufort High
- No thermal low like in Beaufort zone



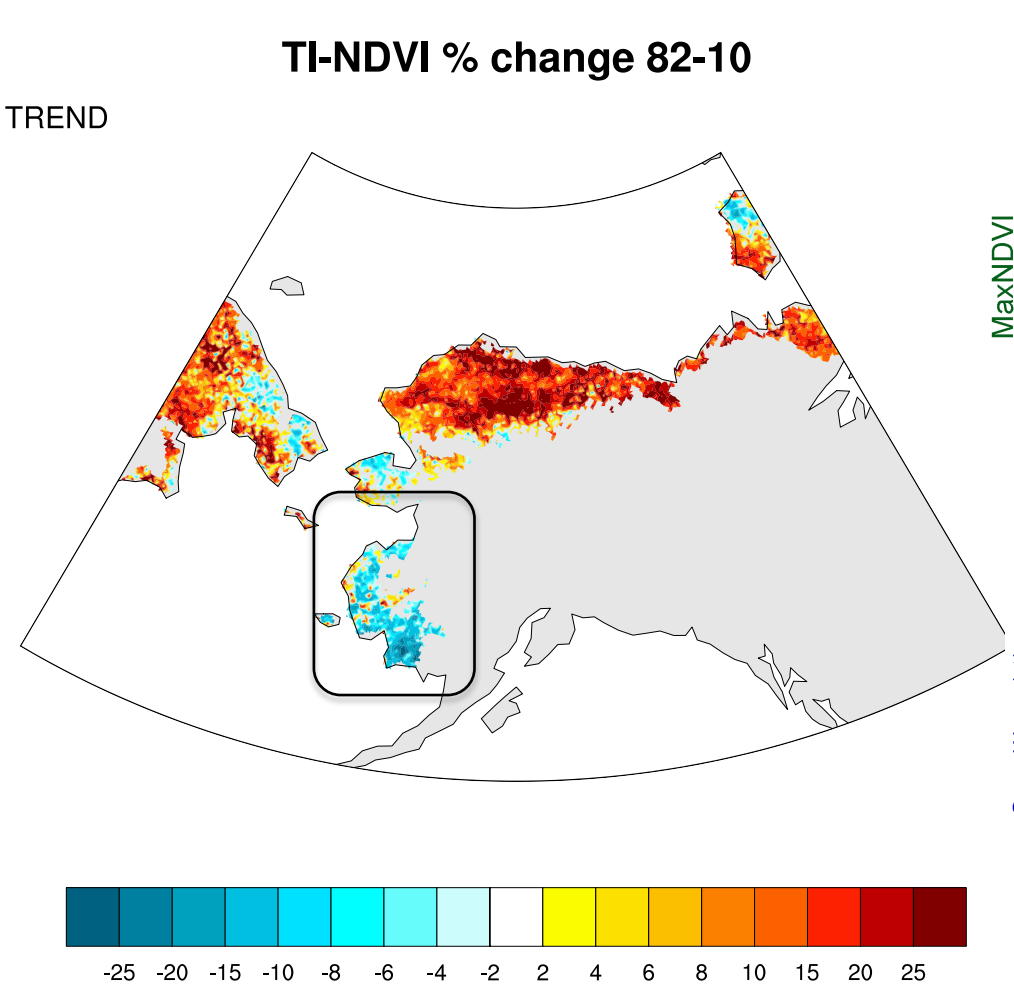
Correlation vectors

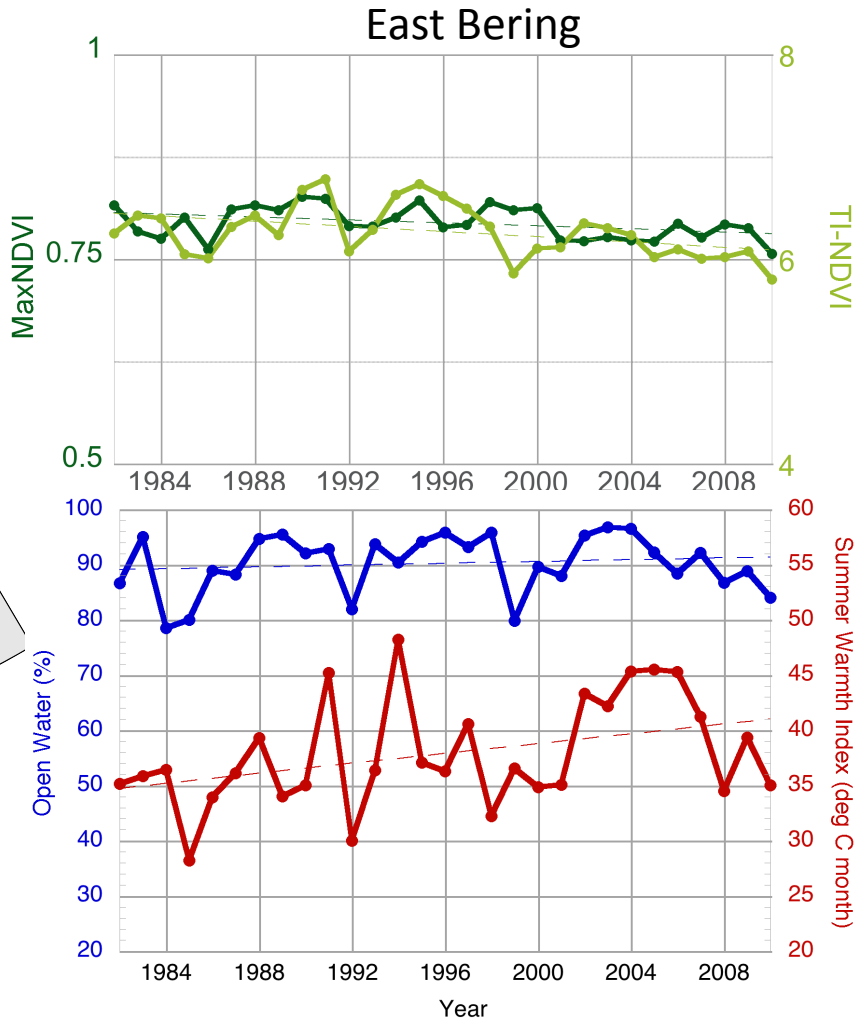
E. Chukchi SWI increases with less cloudiness due to High pressure

- Less cloudy due to increased Beaufort High
- Increased solar radiation = warmer
- NW winds occur with the high
  - Are they warming or cooling?
  - Advecting moisture?



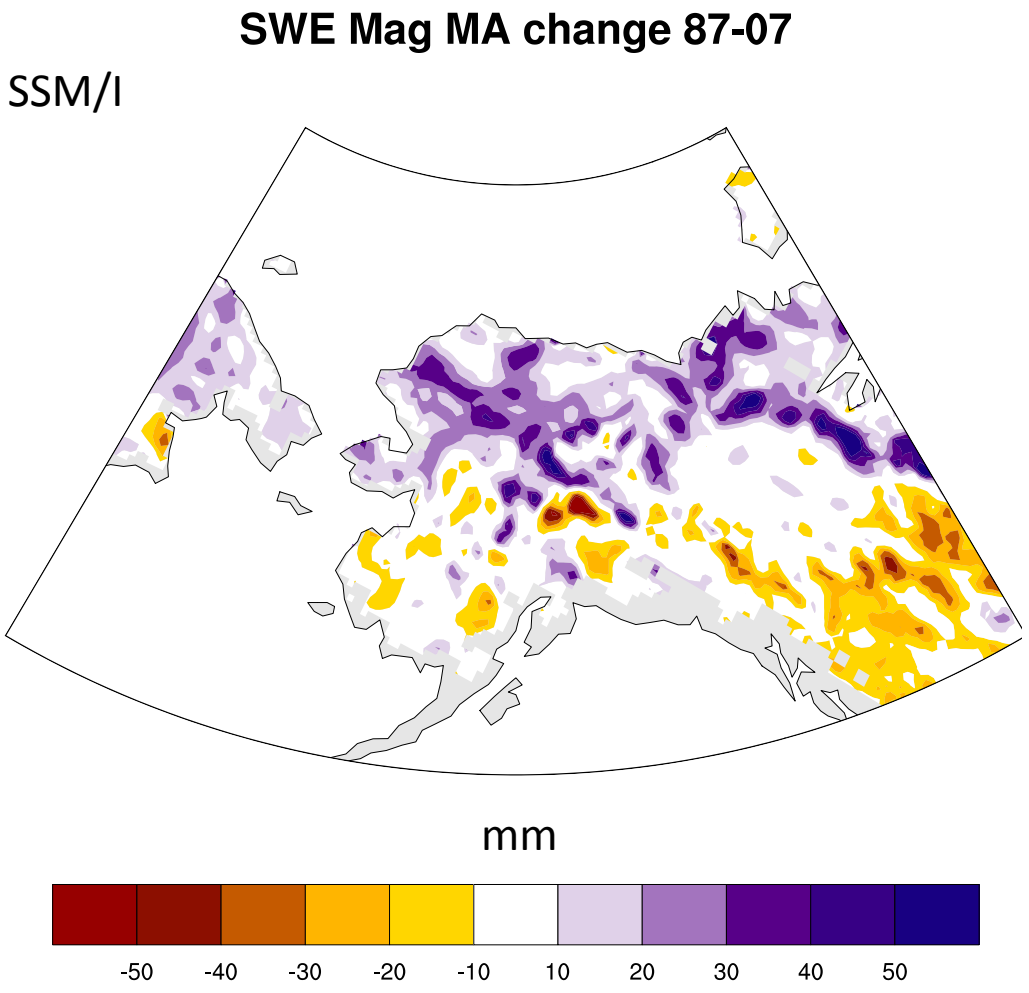
Browning in East Bering, summers getting warmer



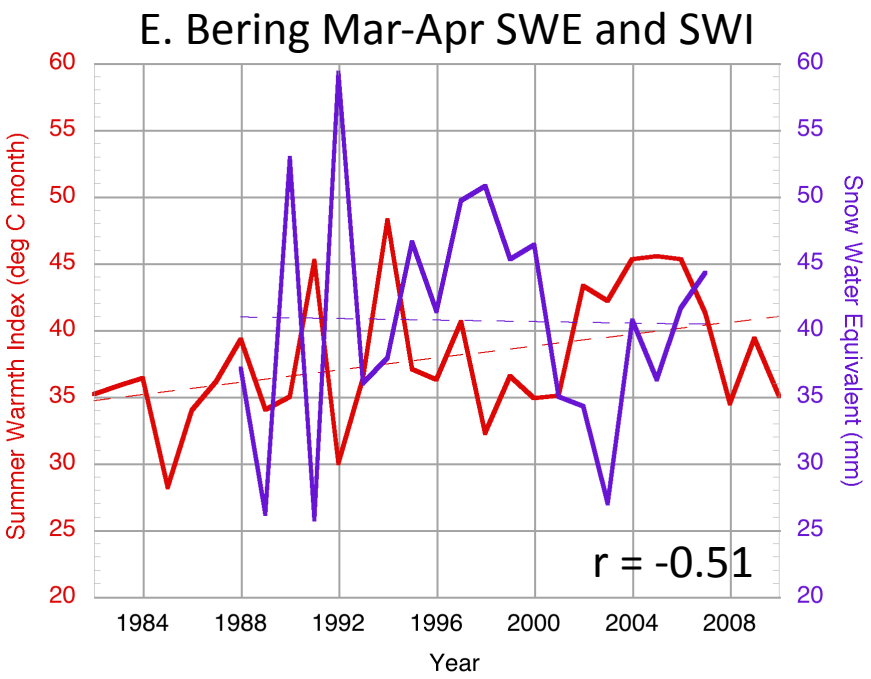


Updated from Bhatt et al. (2010)

SWI increasing in East Bering, correlated with spring SWE



SWE = Snow Water Equivalent (mm)

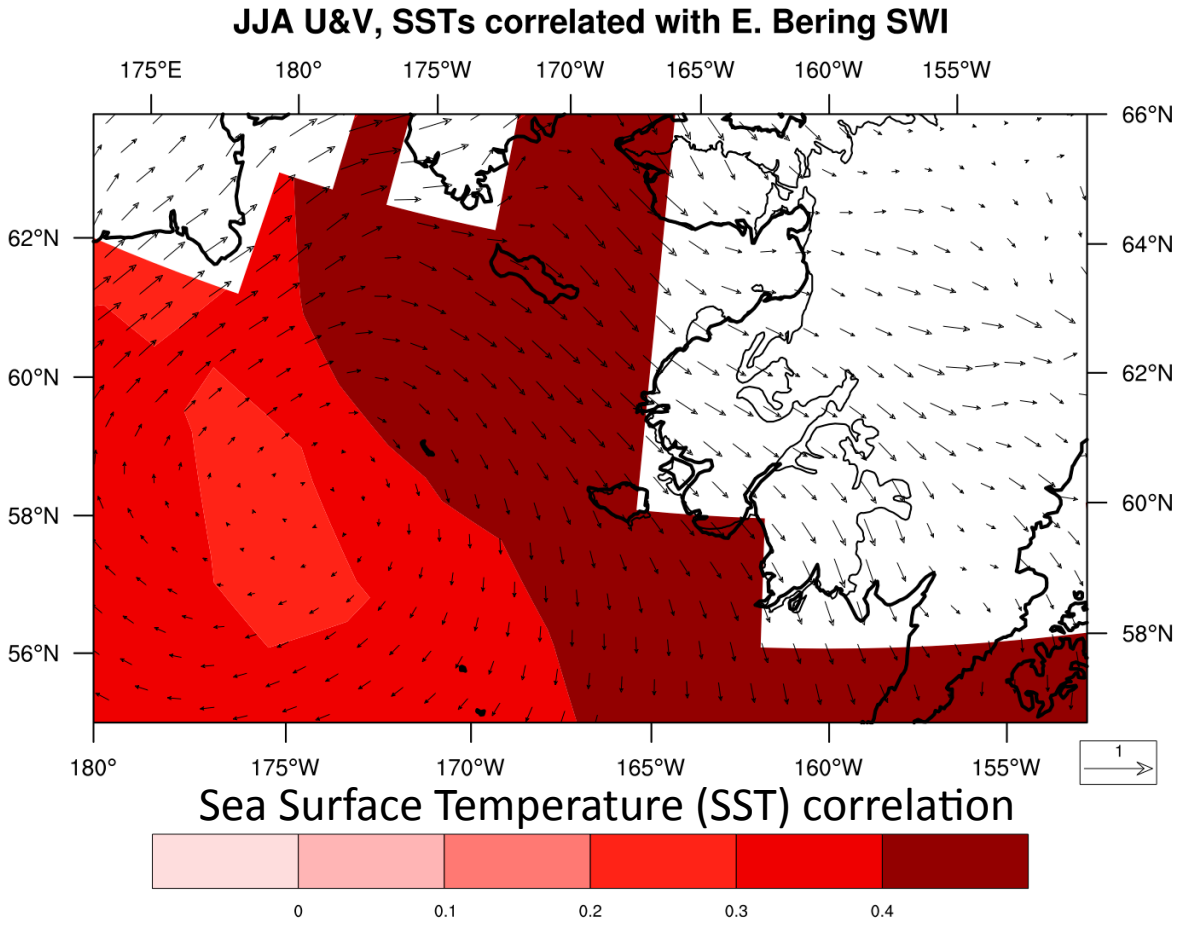


- Correlation between SWI & SWE
- SWE has smaller trend

SSM/I SWE: Armstrong et al. (2007)

Warmer summers in E. Bering under high pressure, warm SSTs

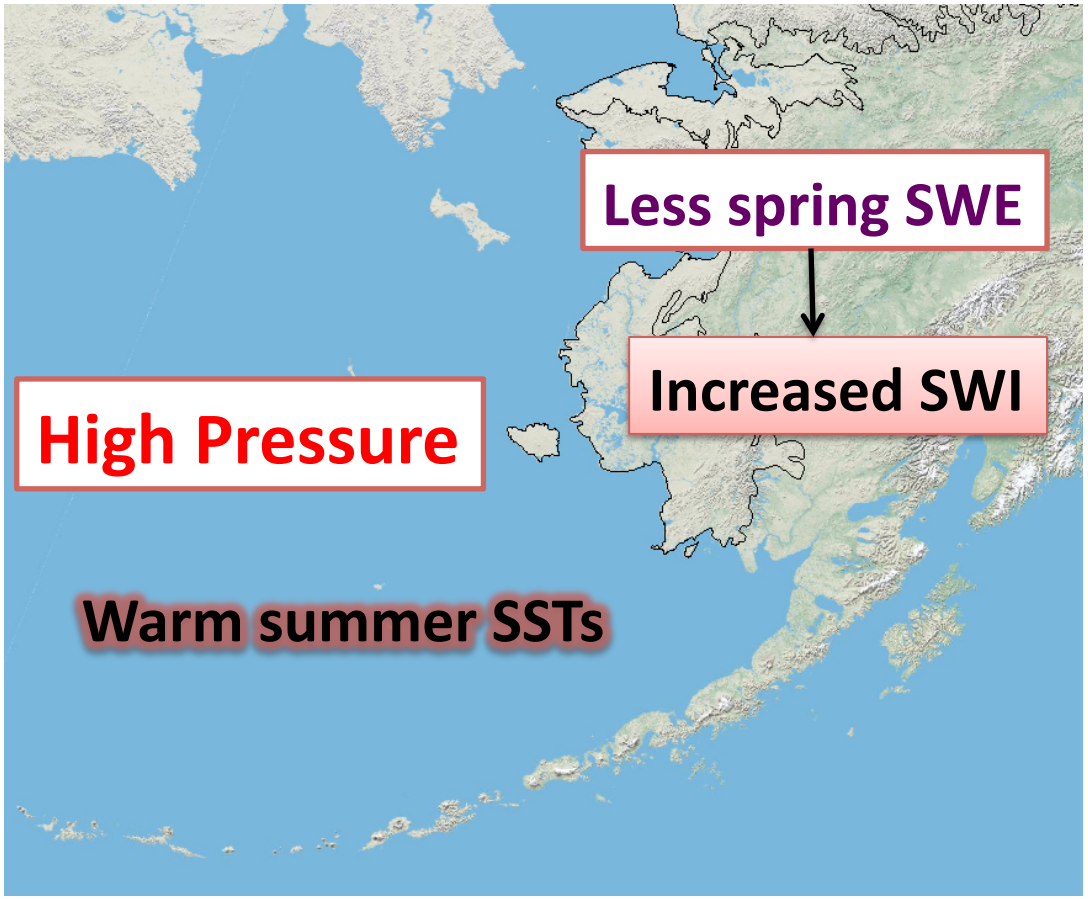
- High pressure results in reduced cloudiness
- Warmer SSTs in Bering Sea are also correlated with warmer summers over the tundra



NOAA extended reconstructed SST [Smith et al. 2008]

Summers getting warmer in E. Bering, less spring SWE

- Warmer ocean SSTs in summer
- High over Bering Sea
- Less snow on the ground in spring
- Drier conditions for plants



Conclusions

- Large-scale climate is of major importance for Beaufort/ Chukchi regions
  - Beaufort High in summer seems to be a key climate forcing
  - Beaufort High strength seems to reduce cloud cover over E. Chukchi and Beaufort tundra regions
  - Beaufort region has a thermal trough developing that may also be warming the region
  - Onshore anticyclonic winds may have a cooling a cooling effect, but would bring moisture
- East Bering generally has little/no sea ice in summer
  - SST warming/Bering Sea High pressure in the Bering may be important for SWI increase
  - Small decrease in spring SWE

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