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

Christopher J. Cox\textsuperscript{1,2}, Robert S. Stone\textsuperscript{3}, Diane Stanitski\textsuperscript{4}, David C. Douglas\textsuperscript{5}

\textsuperscript{1} Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, CO, \textsuperscript{2} NOAA-ESRL Physical Sciences Division (PSD), Boulder, CO, \textsuperscript{3} (retired) NOAA-ESRL Global Monitoring Division (GMD), Boulder, CO, \textsuperscript{4} NOAA-ESRL Global Monitoring Division (GMD), Boulder, CO, \textsuperscript{5} U.S. Geological Survey Alaska Science Center (ASC), Juneau, AK
2015: 4th earliest on record
2016: 1st earliest on record

Cox et al. (2017, BAMS)
Date of snowmelt at Barrow, 1901-2016

2015: 4th earliest on record
2016: 1st earliest on record
2017: latest since 1988

Cox et al. (2017, BAMS)
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
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
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).
ALBSA Mean over 30 days prior to melt

Melt Date

ALBSA Mean over 30 days prior to melt

2016 MD-30 -> MD  2016 MD-7 -> MD

Year

ALBSA [m]  Melt Date Anomaly [days]
2015: 4\textsuperscript{th} earliest on record
2016: 1\textsuperscript{st} earliest on record
2017: latest since 1988

2018: \textit{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.

\textit{Cox et al. (2017, BAMS)}
Long Term ALBSA Record – 20th C. Reanalysis

Dots are years when $|\text{ALBSA}| > 0$ (p<0.01)

Thanks to Gil Compo for help with 20CR

Time Lengths of Relevant Data Sets
- Utqiaġvik Snowmelt Record
- 20th Century Reanalysis
- BRW Met Observations
- BRW Radiation
Conclusions

• Long term records of the date of snowmelt at Utqiâgvik 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.