Arctic Levers:
Unraveling a Hot Mess of Natural Shifts, Forced Warming, and Feedbacks

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Global Warming Is Not Created Equal

Surface Temperature (°C) Relative to 1880–1920 Mean

Data from NASA/GISS
Cold-Season (Oct.-Feb.) SST Anomalies

Arctic trend is 5x NH!

data from NCEP Reanal., PSL/ESRL/NOAA
Warming in Arctic
>> land areas
>> oceans

Temperature change relative to global average

Since mid-1900s
Data from @BerkeleyEarth
Plot by Ed Hawkins
Surface temperature trends
October 1982-2020

HOTSPOTS

SEA SURFACE TEMPERATURE TRENDS (°C PER DECADE)
Calculated for 1982-2020

by Zack Labe @ZLabe
Arctic Amplification: N. Pacific

Temperature anomalies 2000 to 2022 (annual)

Height anomalies 2000 to 2022

Zonal wind anomalies 2000 to 2022
Pacific Decadal Oscillation (PDO)

Negative PDO => stronger Arctic amplification (Screen & Francis 2016)
Positive PDO => stronger west-coast ridge (Sung et al 2016, Lee et al 2015)
The "It Takes Two to Tango" Hypothesis*

Extra heating intensifies ridge, making it more persistent.

Ice loss has no effect

*Francis et al, 2017
Obs and model simulations show stronger Pacific ridging when PDO+ and warm Arctic in Pacific sector.

Sung et al, ERL 2016
Change in summer persistence from 1981-2000 to 2018-2100

from Coumou and De Luca (2020)
Surface temperature trends

October 1982-2020

HOTSPOTS

SEA SURFACE TEMPERATURE TRENDS (°C PER DECADE)

Calculated for 1982-2020

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Arctic Amplification: N. Atlantic

Temperature anomalies
2000 to 2022 (annual)

Height anomalies
2000 to 2022

Zonal wind anomalies
2000 to 2022
Cohen et al, Nature Geosciences, 2014

Evidence of “Two to Tango” in Eurasia

Sea-ice loss/AA intensifies ridge and downstream trough

Wave energy transferred to stratosphere

Polar vortex disrupted

Siberian High strengthens => cold northerlies, snow

Reinforces wavy jetstream

Climatological ridge
Texas Freeze Feb. 2021

Temperature differences from average
Near-surface air temperature trends – DJF (1990-2013)

from Cohen et al. (2014)
Changing Patterns of the Stratospheric Polar Vortex

from Cohen et al. Science (2021)
BARENTS SEA ICE

SOURCE: ftp://psdo2s.colorado.edu/DATASETS/NOAA/G02135/seaiceanalysis/
DATA: National Snow & Ice Data Center, Boulder CO (Sea Ice Index via: 1979-2022)
GRAPHIC: Zachary Labe (92a.jpg)

Parting points:

- Temperature gradients make winds. Mess with those gradients and winds will change, weather will change.
- Regional Arctic amplification can enhance or reduce influences of SST fluctuations (natural or forced), and vice versa (“Levers”) 
- Ocean-ice-jetstream feedbacks accelerate sea-ice loss via poleward heat fluxes
- Latest research suggests rapid Arctic warming will contribute to:
  - Increased frequency of polar vortex disruptions
  - Increased persistence of weather regimes
  - Increased heat, drought, and fires in western U.S.
- Ocean influence on Barents/Kara region may be waning ala Cold Blob
Thank-you!

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Extras
ERA5
Oct to Feb 2000-2021
850mb Air Temperature Anomaly 1981-2010 Climatology

degK

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5
Arctic versus ENSO impacts on winter (DJF) zonal-mean zonal winds and temperatures.

Observed trends in U (contours) and continental T (color)

Portion of trends explained by Barents/Kara ice loss in Nov. and Eurasian snow advance in Oct.
=> Cooling over mid-latitude continents and U contours similar to observed trends.

Portion of observed trends explained by ENSO.
=> None in mid-latitudes.

Cohen GRL 2016
Pacific ridge initiated by SST anomalies (PDO+) is intensified by ice loss in Pacific sector of Arctic => Stronger ridge more persistent

Lee et al, GRL 2015
REGIONAL TEMPERATURE ANOMALIES IN 2022

MONTHLY AIR TEMPERATURE ANOMALY (°C)

HIGH ARCTIC

ATLANTIC ARCTIC

WESTERN SIBERIA

EASTERN SIBERIA

PACIFIC ARCTIC

GREENLAND

DATA: Copernicus Climate Change Service/ECMWF (Preliminary) ERA5/ERA5: 2 m T: Shading (areas) from 1950-2021
SOURCE: https://climate.copernicus.eu/
GRAPHIC: Zachary Jaffe (2022, CC0)

BASELINE: 1951-1980
NORTHERN HEMISPHERE: TEMPERATURE TRENDS (°C PER DECADE)

DATA: Copernicus/ECMWF (ERA5; T; Annual)
SOURCE: https://climate.copernicus.eu/
TREND PERIOD: Calculated over 1979-2021
GRAPHIC: Zachary Labe (9/2/2018)