Why has the Arctic Warmed?

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Motivation

• Research is motivated by the claim that Arctic sea ice loss and related Arctic Amplification are a principal driver for occurrence of more persistent mid-latitude weather patterns which lead to weather and climate extremes.
Chain of Events Linking Arctic Amplification (AA) with Increased Extreme Weather in Mid-Latitudes

AA: Arctic warming 2-3 times faster than N. hemisphere

Poleward temperature gradient weakening

500 mb zonal winds decreasing where gradient weakens

Upper-level flow becoming more meridional

Amplitude of Rossby waves increasing, blocking more likely

Large-scale waves progress more slowly eastward

More persistent weather patterns, extremes more likely

J. Francis (NAS Workshop)
Goal: Quantify the magnitude of tropospheric Arctic warming resulting from various factors

Experiments (1979-2012) using CAM4 and ECHAM5 model (10-20 member ensembles)

- **CTL** (300yrs) 1981-2010 climatology
- **Fully Forced:** RF and observed SST and SIC
- **FixedSIC:** 1979-2012 RF, 1979-1989 SIC climatology and 1979-1989 SSTs climatology where SIC has changed
- **NatSST:** 1880 RF, 1979-2012 SST with zonal mean climate change component removed which is determined based on century long SST trends, SIC 1979-1989 climatology
OND SST Change

SIC Change

[Legend: %]
OND SST change
Observed and simulated OND zonal mean temperature change 2003-2012 minus 1979-1988
OND 1000-500hPa Thickness Change over Polar Cap (60-90N)
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OND 1000-500hPa Thickness Change

SIC Change

Reanalysis

Sea Ice Effect

Fully Forced

NatSST

[m]
OND 1000-500hPa Thickness Change over North Atlantic Region (90W-0,45-80N)
Contributions to Observed Tropospheric Arctic Warming

• Remote forcing by natural fluctuations in sea surface temperatures mainly outside the polar cap: about 50%
• Sea ice decline: about 20%
• Unforced random atmospheric variability: up to 25%
Implications

• Arctic troposphere has been mainly responding to rather than forcing mid-latitude weather and climate.

• A reduced rate of tropospheric warming or even short-term cooling may occur in the Arctic in the future in response to remote forcing by natural decadal modes of variability.