Linking More Prevalent Summer Greenland Blocking to Retreating Spring North American Snow Cover Extent Under Arctic Amplification

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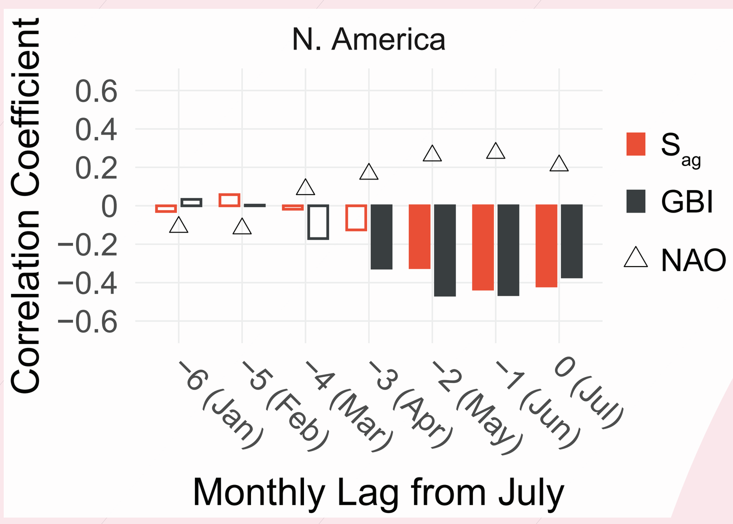
1. Motivation

- Summer atmospheric circulation over Greenland has been characterized by a more negative North Atlantic Oscillation (NAO) and an increase in Greenland blocking episodes[1-3].
- These atmospheric conditions have been the primary cause of accelerating Greenland Ice Sheet (GrIS) surface runoff[1,2,4,5].
- The rapid retreat of spring snow cover extent (SCE) under Arctic Amplification is cited as a possible reason for this change in atmospheric circulation[6].

2. Snow Cover & Greenland Blocking

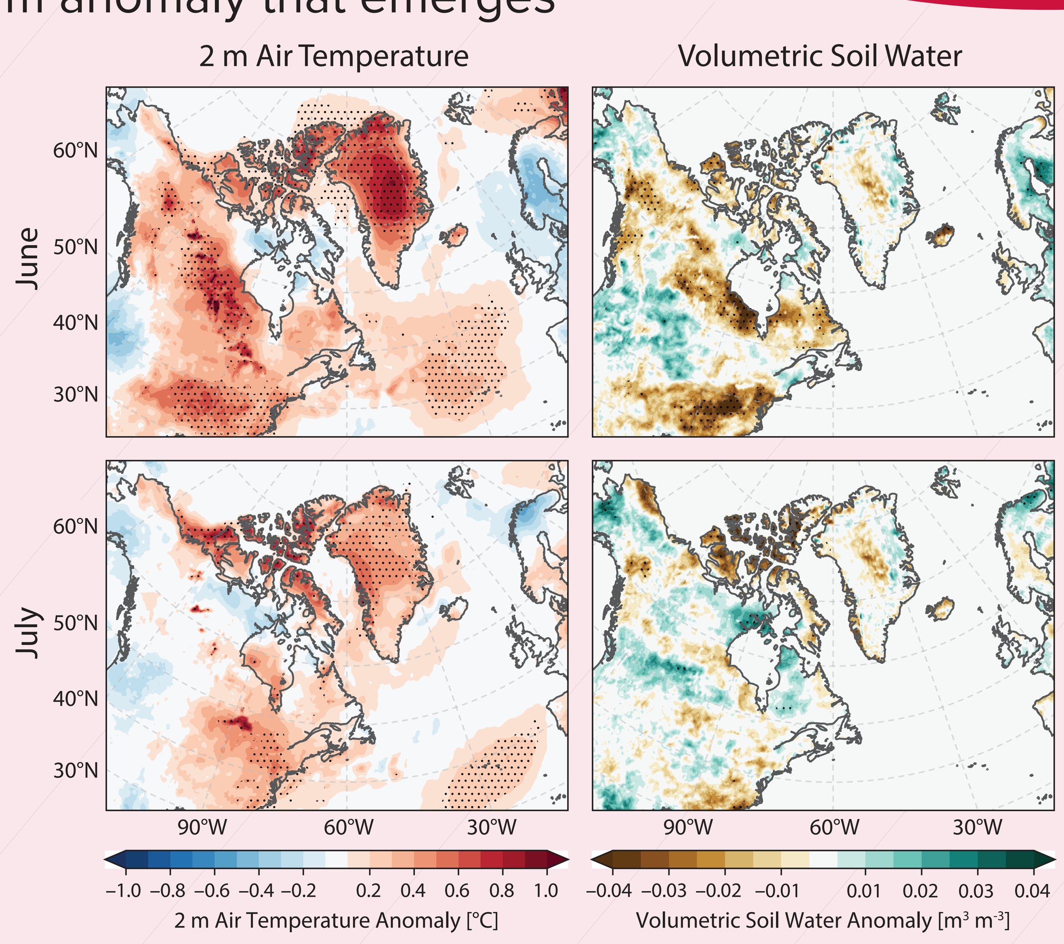


Correlation between measures of July circulation (ERA5)[7] over Greenland and antecedent North American SCE area (Rutgers GSL)[8].

- Low spring N. American SCE is followed by more frequent Greenland blocking in July.

3. The Snow Hydrological Effect

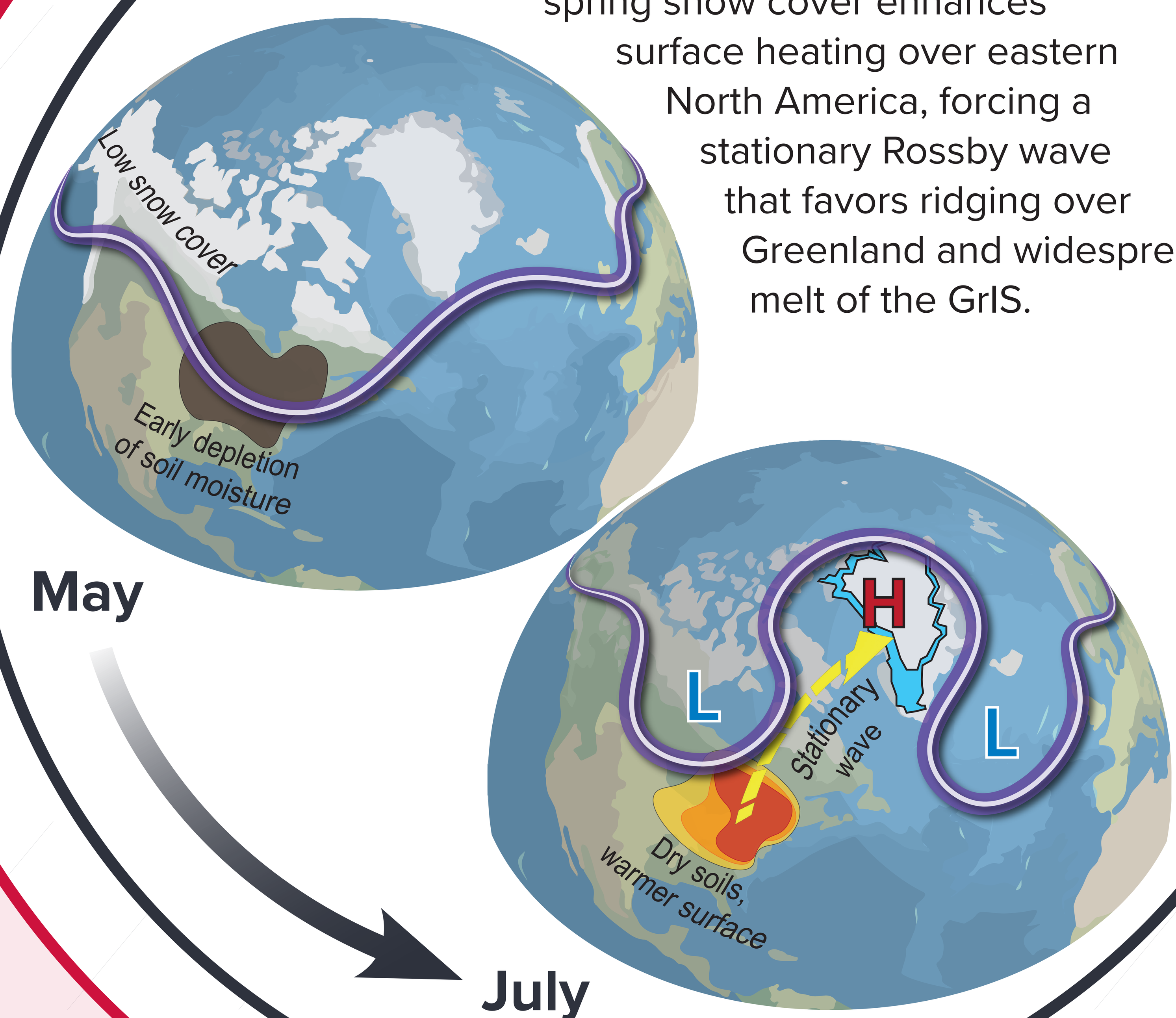
- May SCE is linked to July surface conditions via soil moisture.
- Dry soils in eastern N. America cause enhanced surface heating with a warm anomaly that emerges in June and persists into July.



Soil moisture (left) and surface air temperature (right) during June (top) and July (bottom) regressed against inverted May N. American SCE area. Stippling indicates significance (α=0.05). Surface variables from ERA5 reanalysis[7]. SCE area from Rutgers GSL[8].

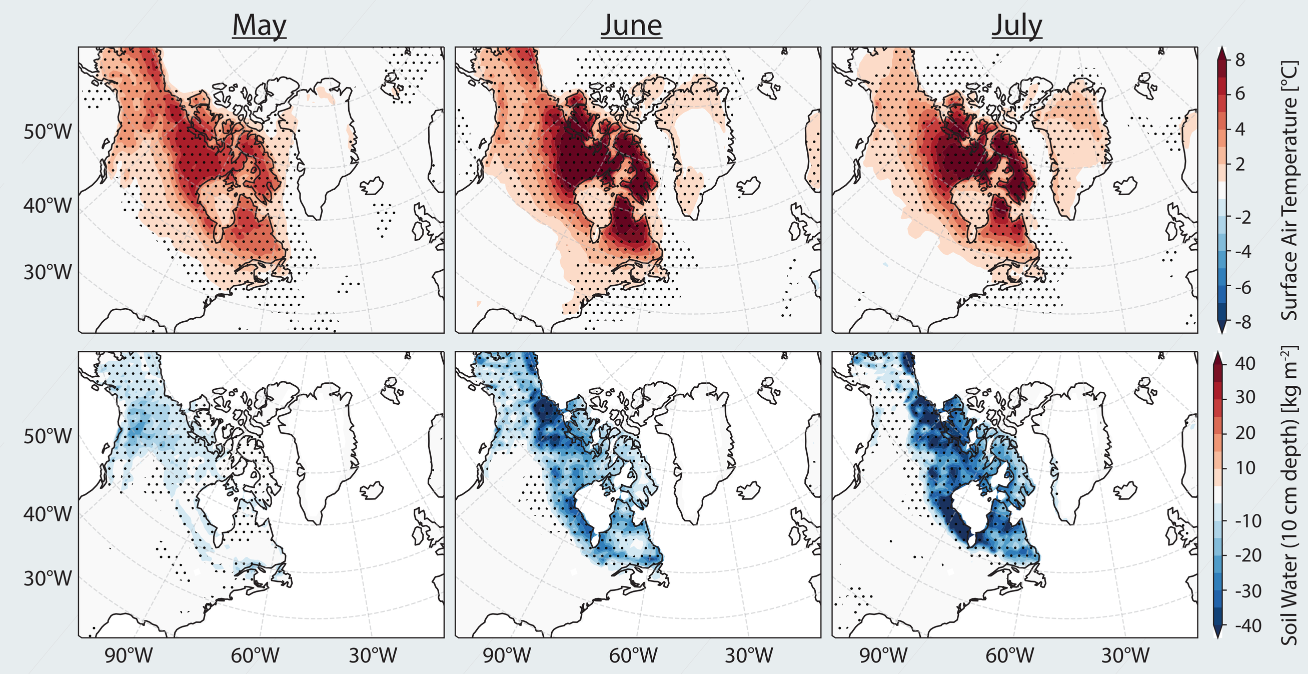
Summary

Depleted soil moisture in years of low spring snow cover enhances surface heating over eastern North America, forcing a stationary Rossby wave that favors ridging over Greenland and widespread melt of the GrIS.

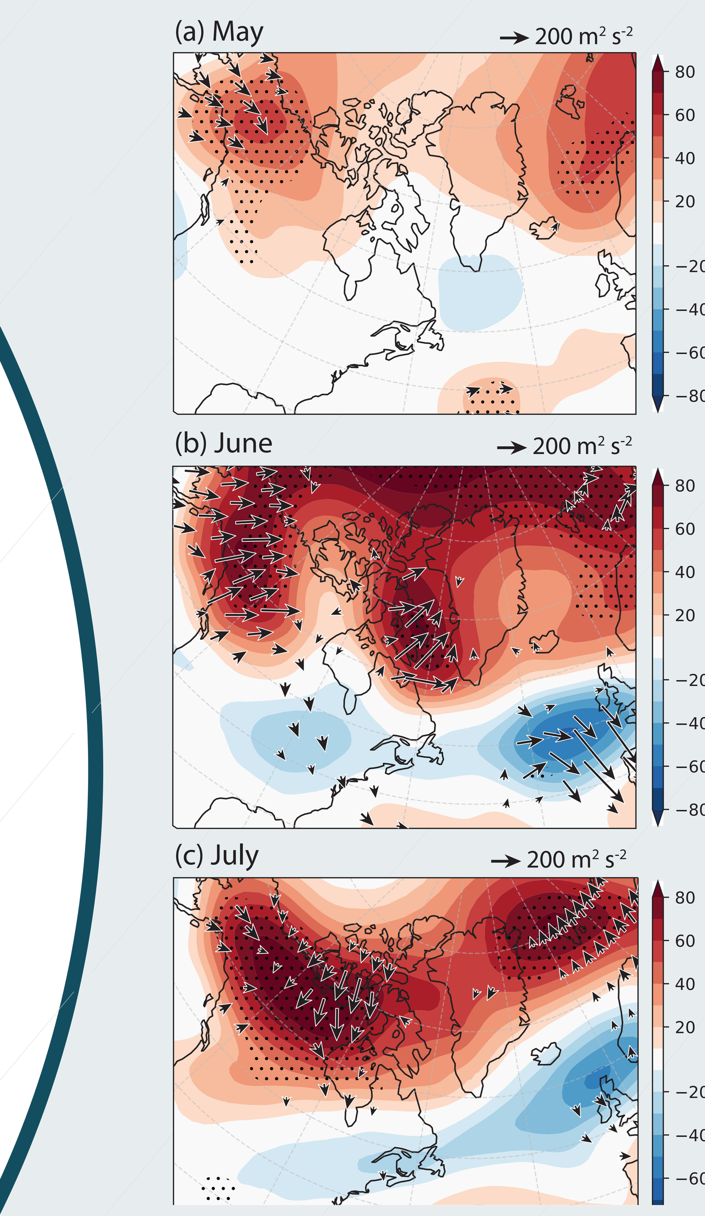


5. Prescribed GCM Experiment

CESM2[10] simulated surface temperature (top) and soil water (bottom) response to prescribed zero May N. American snow cover from May through July.

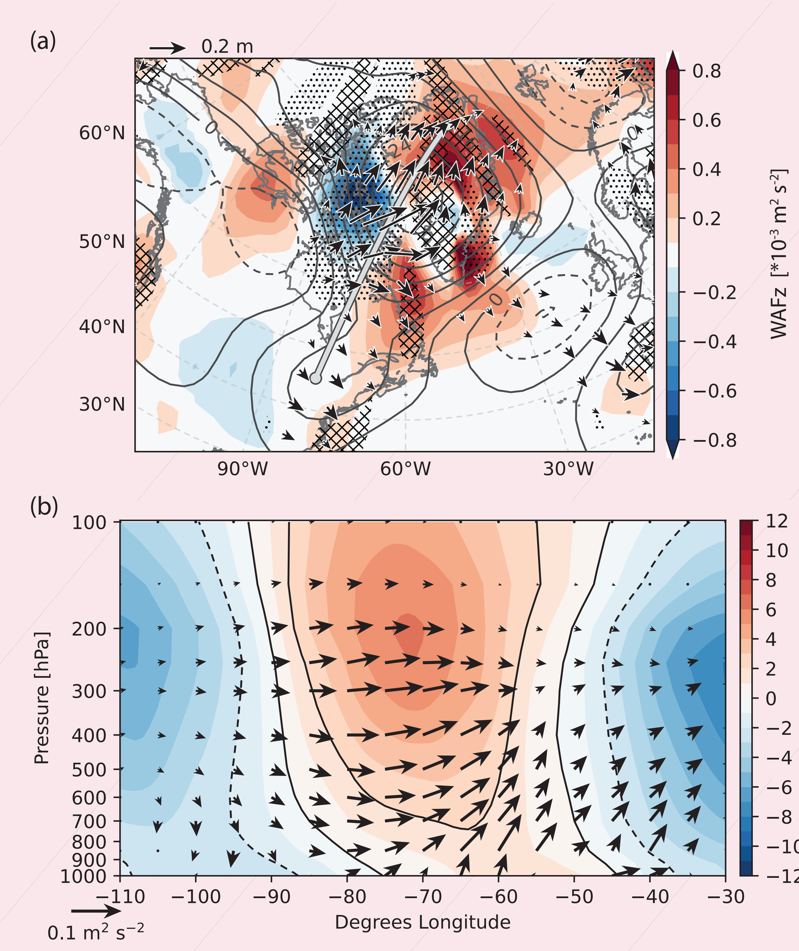


- N. American snow cover set to zero on May 1st on each of ten simulated years in CESM2.
- Modeled response closely resembles historical results; however stationary wave response occurs one month earlier in June.



CESM2[10] simulated anomalous 300 hPa geopotential height (shading) and associated 3D wave activity flux[9] (vectors)from May through July in response to prescribed zero May N. American snow cover.

4. Stationary Wave Forcing



- Anomalous surface thermal forcing generates a stationary Rossby wave response that favors ridging over Greenland.

Top: July 300 hPa geopotential height[7] (contours) regressed against inverted N. American SCE area[8]. Vertical (shading) and horizontal (vectors) components of associated 3D wave activity flux[9]. Stippling, flux divergence; hatching, convergence.

Bottom: 40-60° N eddy geopotential height anomaly. Westward tilt shows baroclinic origin of stationary wave.

See our paper in *Nature Communications* for full results:
https://doi.org/10.1038/s41467-023-39466-6

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