Modulation of Arctic Sea-Ice Loss by Atmospheric Teleconnections from Atlantic Multi-Decadal Variability (AMV)

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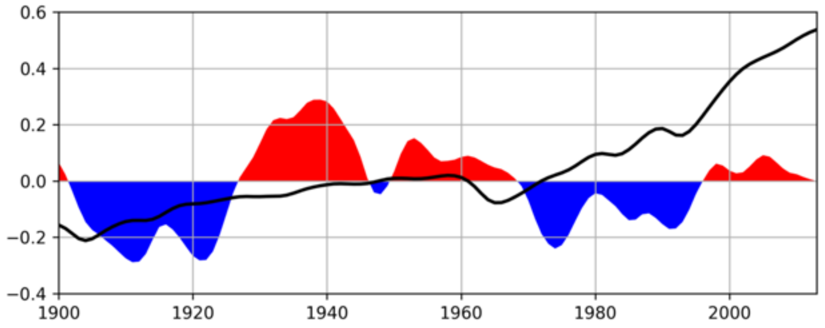
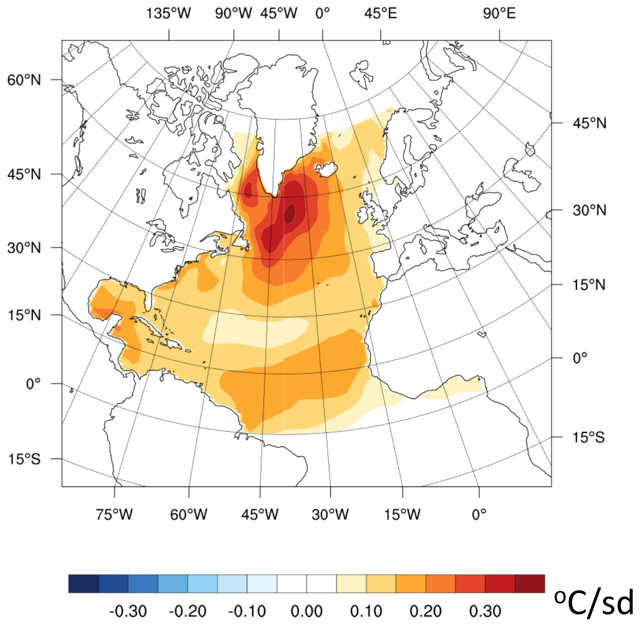
Background and Motivation

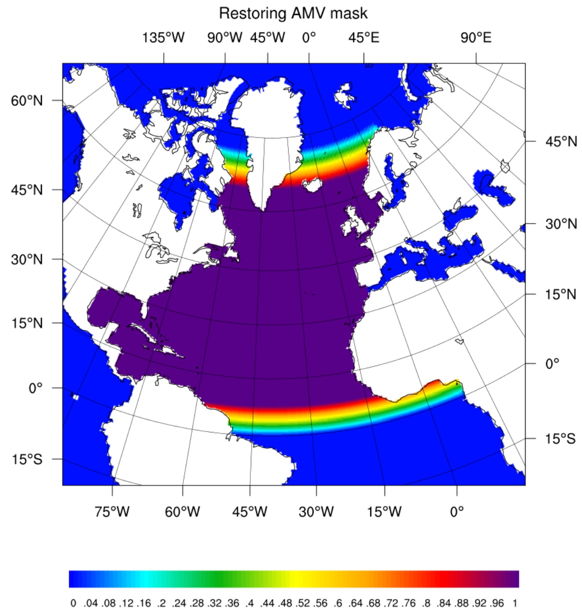
- The present study represents a component of our overarching goal of documenting climate impacts of sea surface temperature (SST) variability associated with AMV.
- We follow an experimental protocol designed to isolate impacts from atmospheric teleconnections that result from imposed SST anomalies, i.e., the dynamical adjustments of the ocean are minimized.
  - Global impacts (Ruprich-Robert et al. 2017*, J. Climate*)
  - Impacts on North American summer climate and heat waves (Ruprich-Robert et al. 2018, *J. Climate*)

Experimental Setup

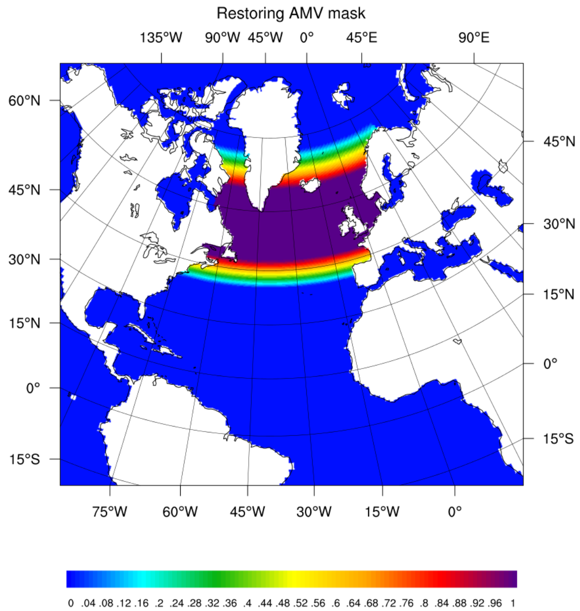


AMV pattern (based on Ting et al. 2009)

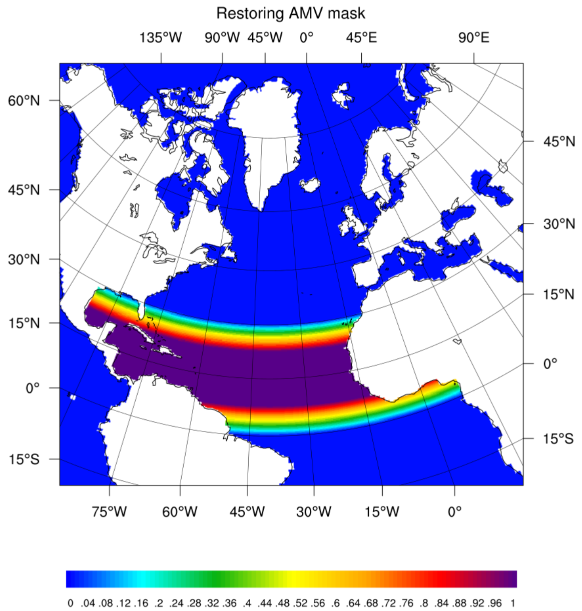




Full NA restoring



SPNA restoring



TA restoring

Ruprich-Robert et al. (2017, *J. Climate*)

Time-independent SST anomalies corresponding to 1 SD of the AMV index are added to (subtracted from) the model daily climatological SSTs for the AMV+ (AMV-) experiments.

The restoring time scale is usually 5 days over 10 m.

10-year simulations under pre-industrial conditions: long enough for atmospheric teleconnections to arise, yet short enough to limit oceanic drift issues in the North Atlantic.

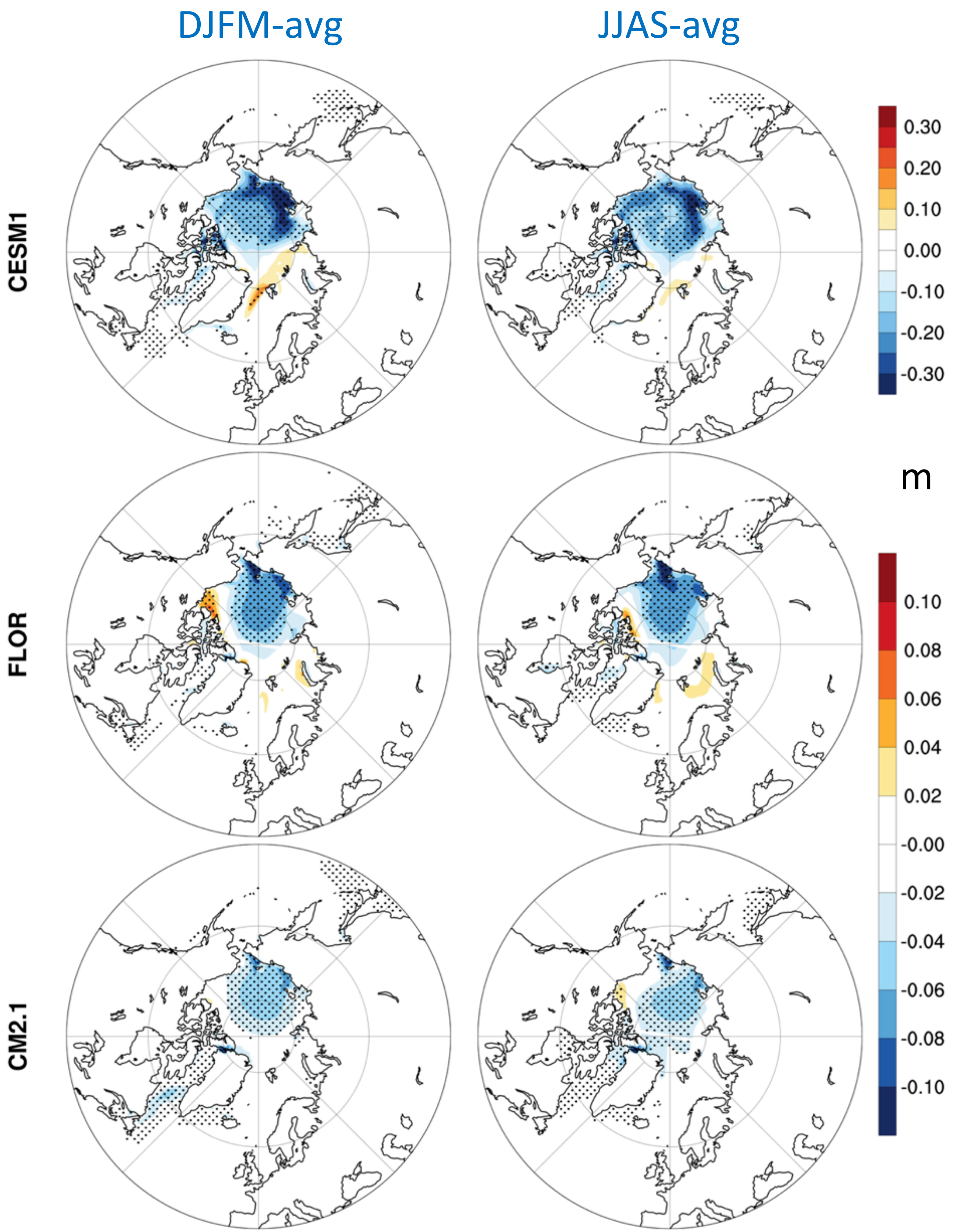
Models

- Community Earth System Model version 1 (CESM1): 30 members
- GFDL Forecast-oriented Low Ocean Resolution (FLOR): 50 members
- GFDL Climate Model version 2.1 (CM2.1): 100 members

All three models use nominal 1^{o} horizontal resolution in their ocean components, but employ different atmospheric resolutions: 2^{o} CM2.1; 1^{o} in CESM1; and 0.5^{o} in FLOR.

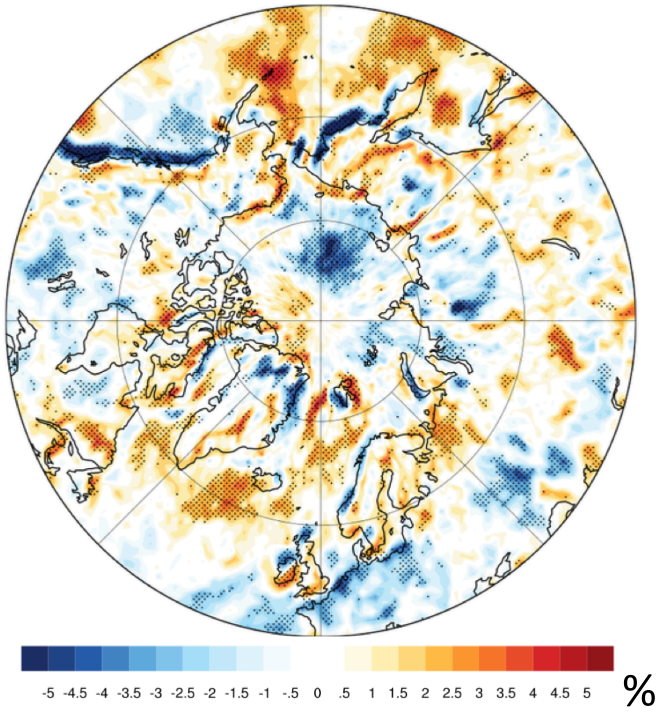
10-year average, AMV+ minus AMV- ensemble-mean differences are shown.

Differences in Sea-Ice Thickness



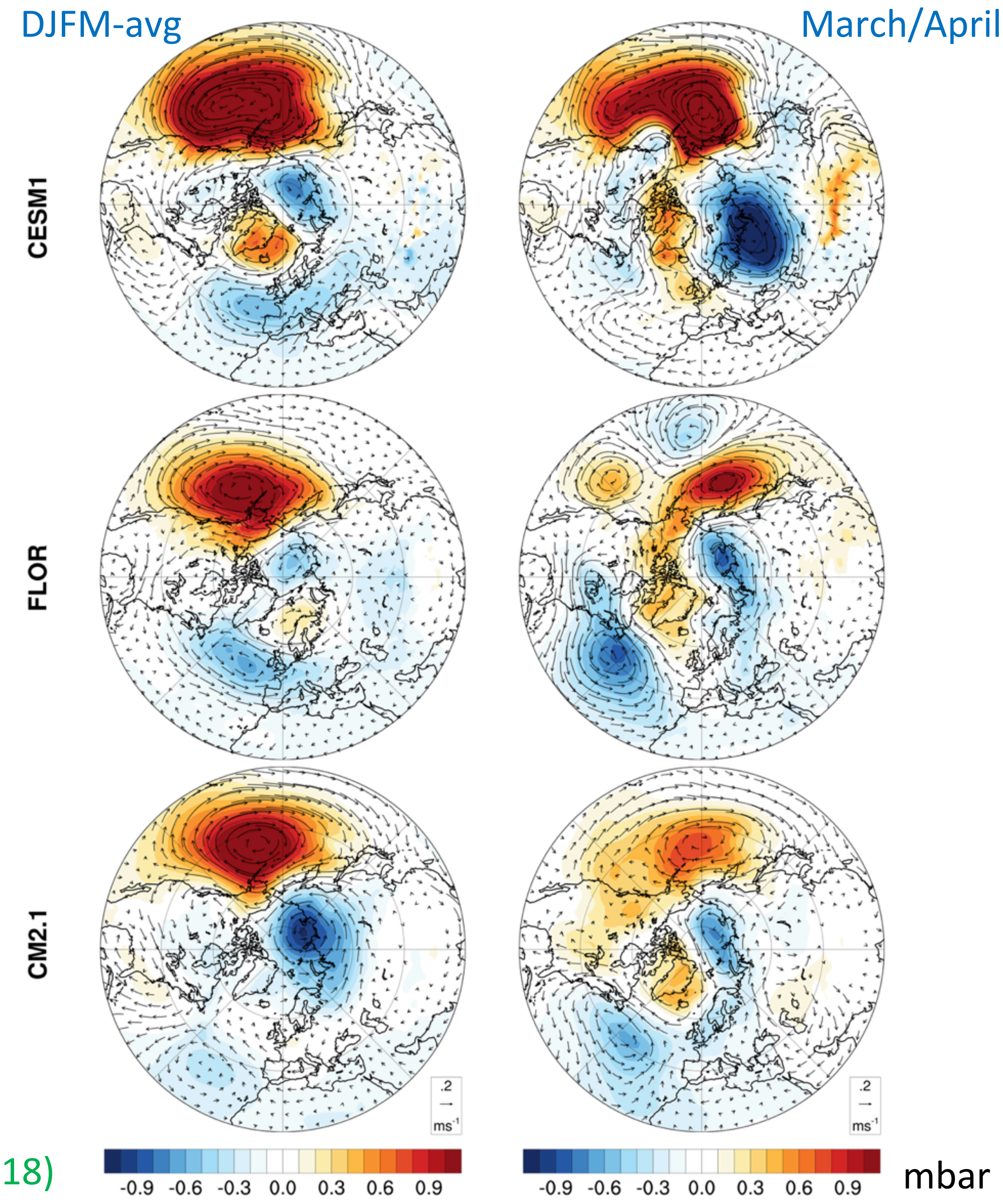
Differences in Sea Level Pressure and Winds

Differences in DJFM Surface Anticyclonic Winds

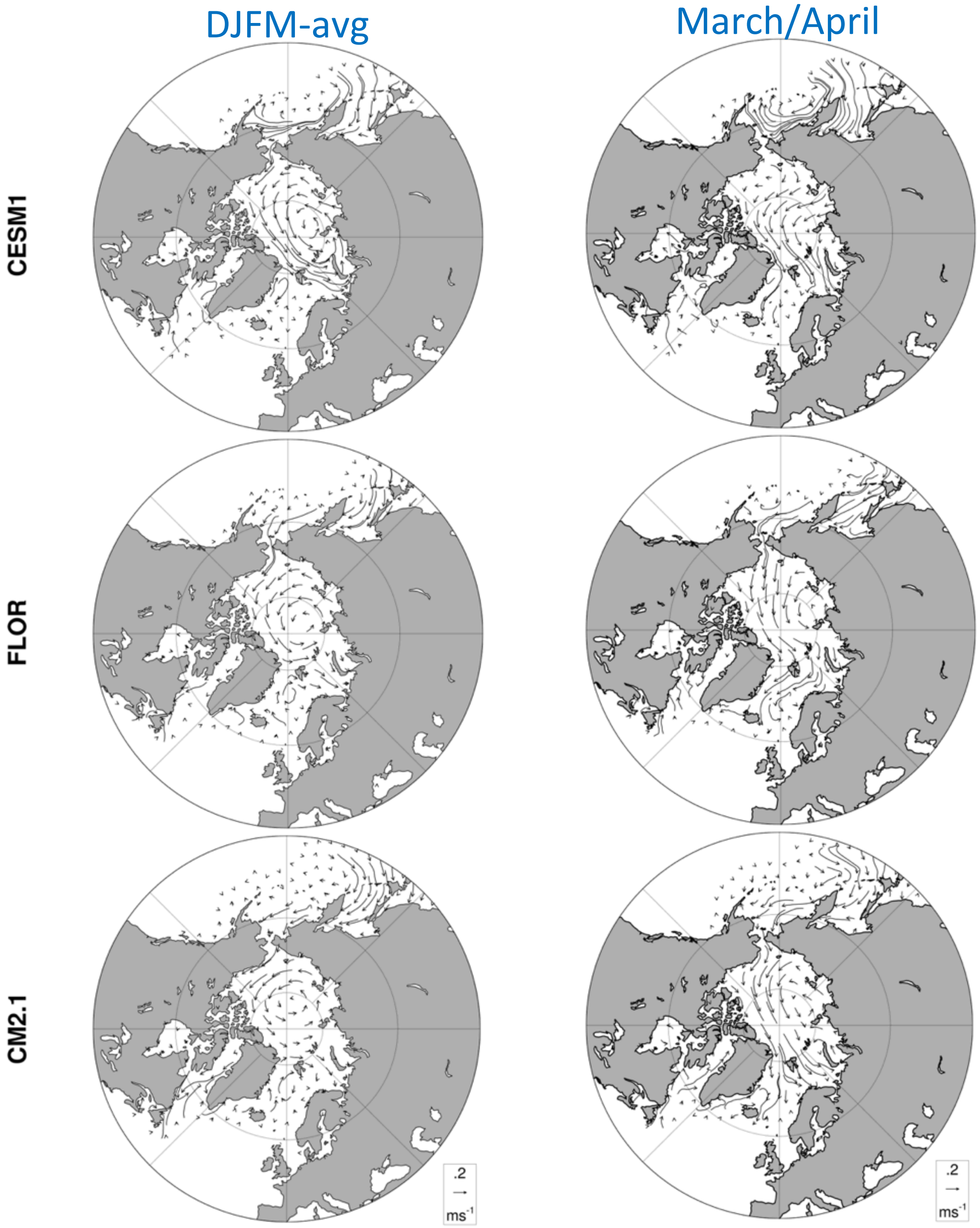


From CESM1

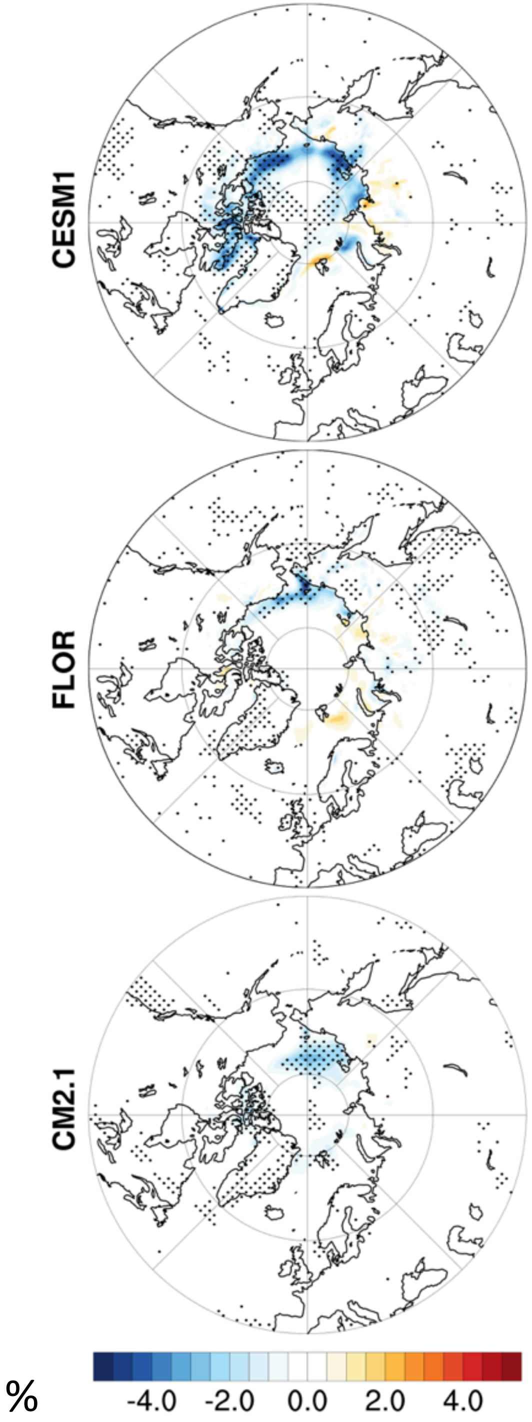
Consistent w/ Wernli and Papritz (2018)



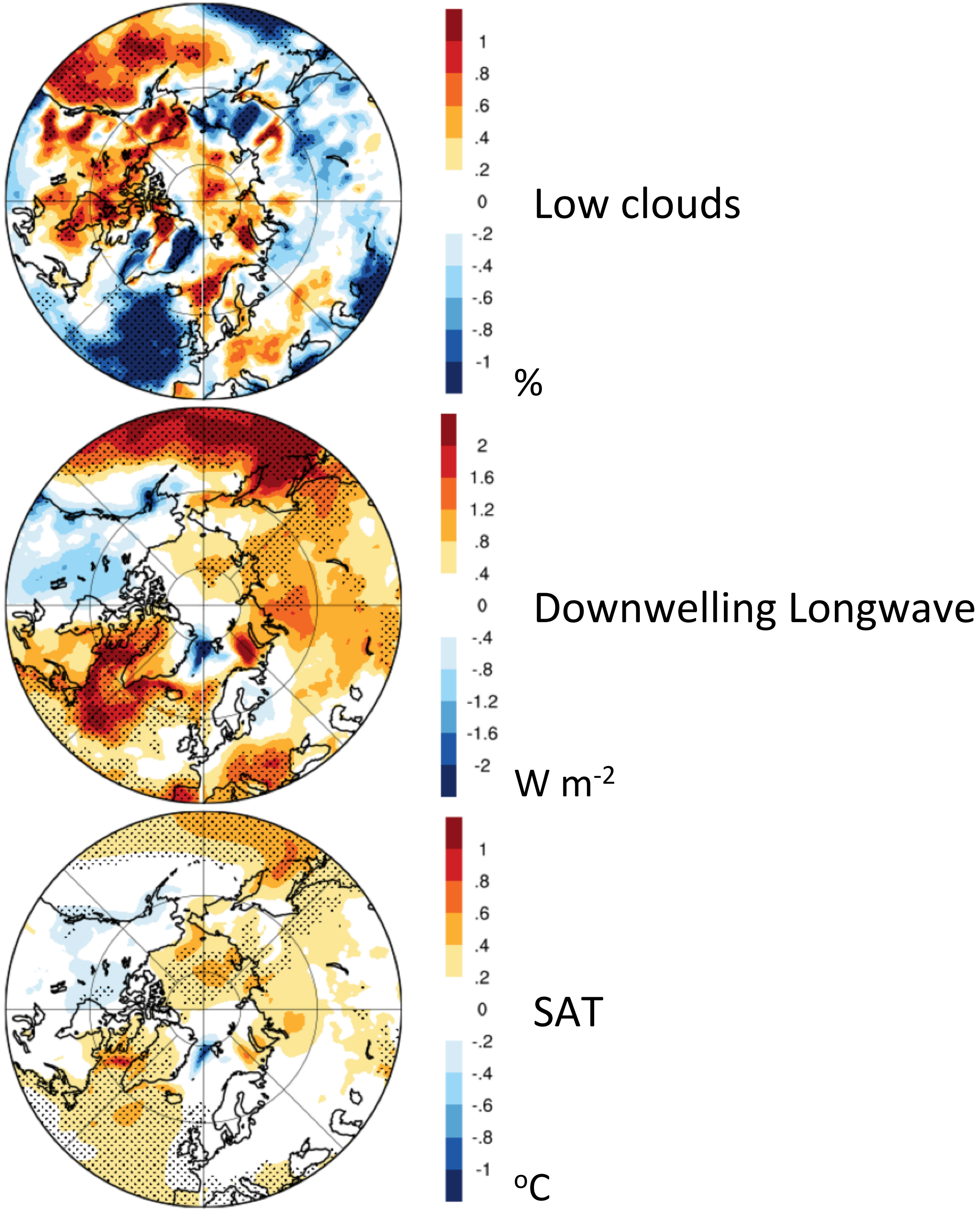
Differences in Sea-Ice Motion



Differences in September Albedoes



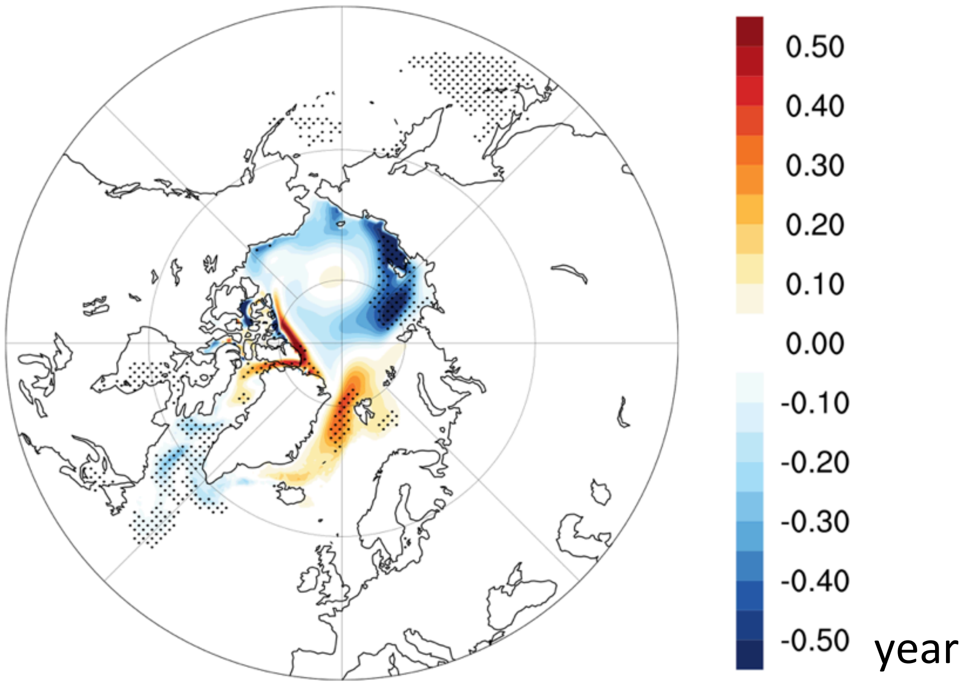
Differences in DJFM-average ……



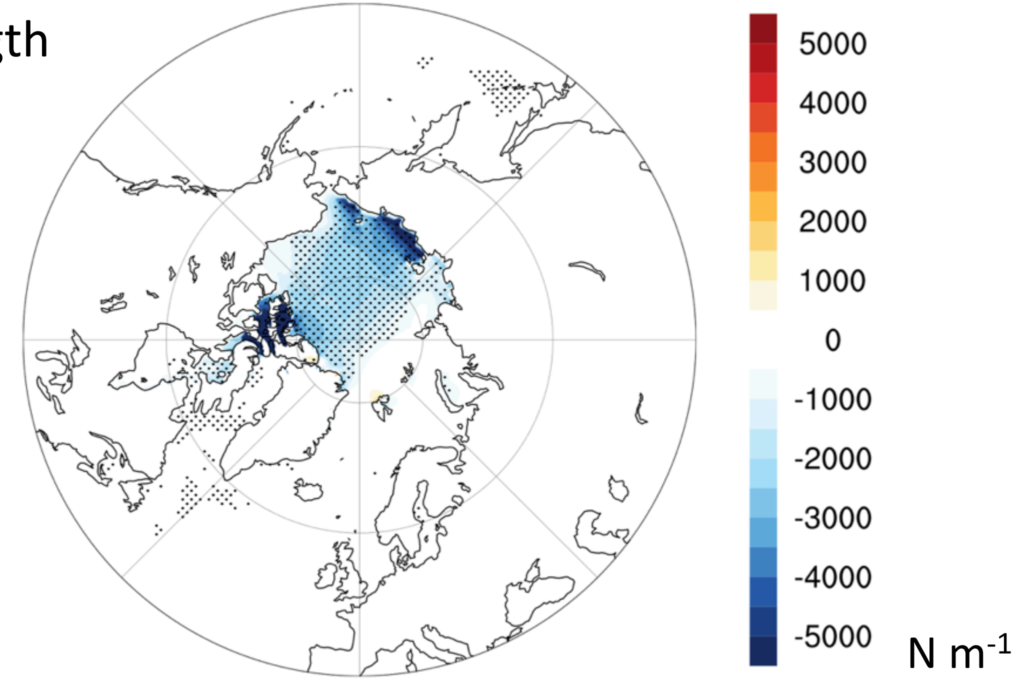
From CESM1

Differences in 10-year Average ……

Ice Age

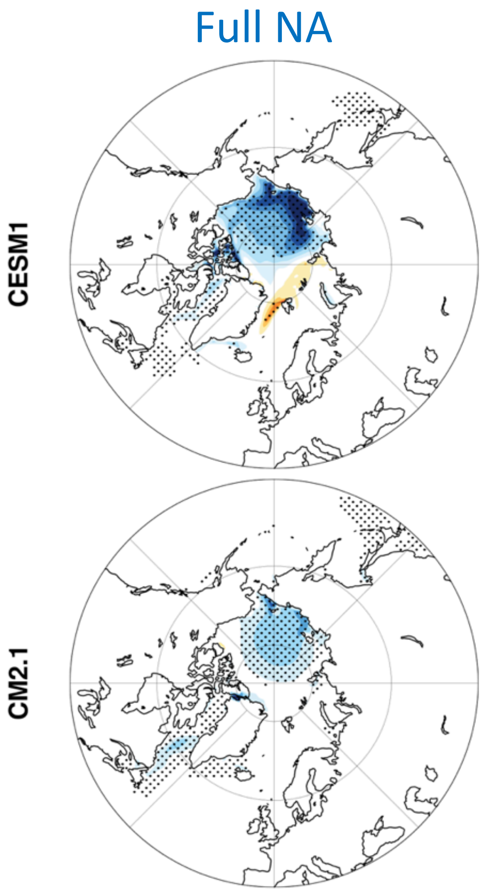


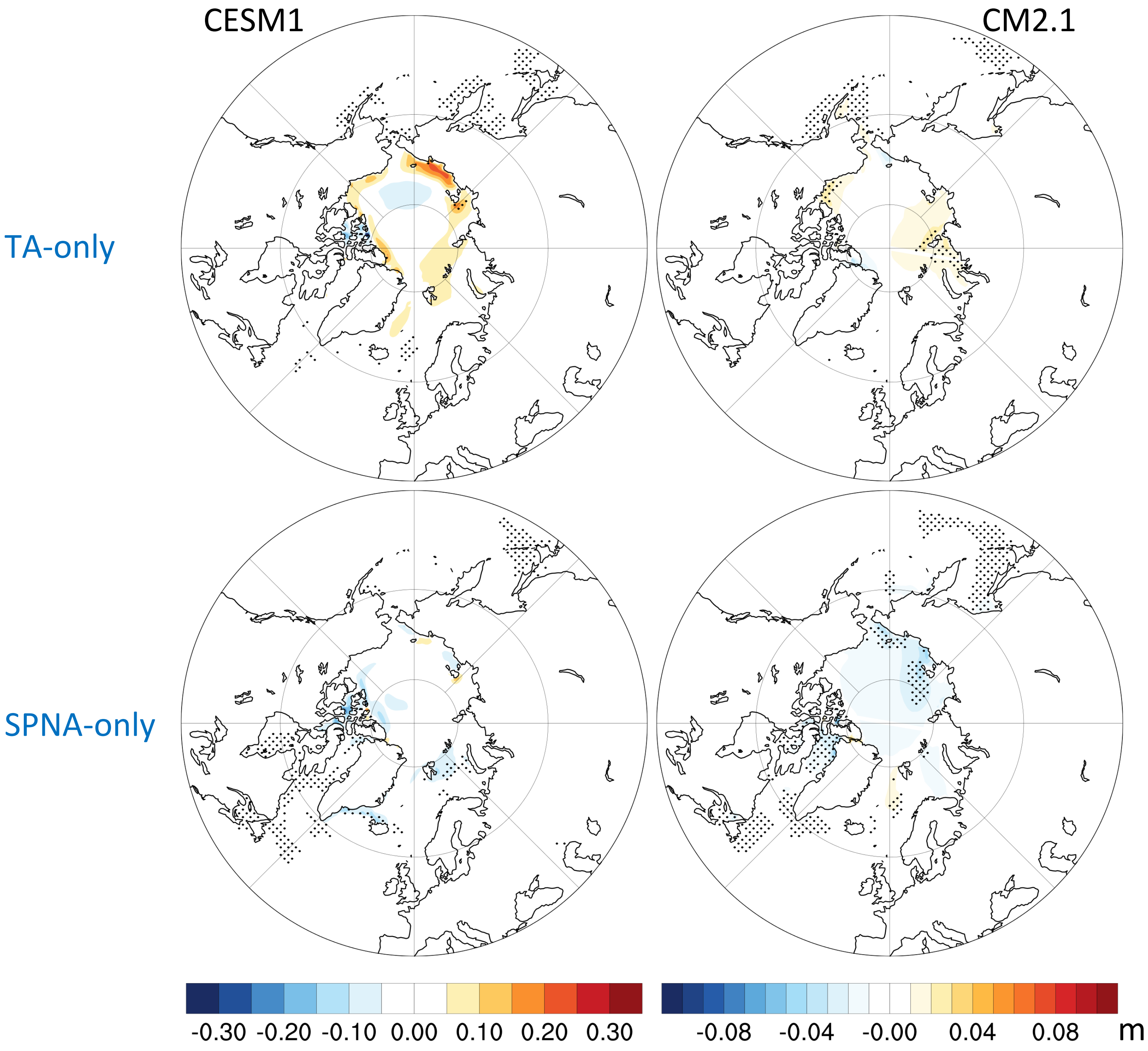
Ice Strength



From CESM1

DJFM-Average Sea-Ice Thickness Differences





Summary and Conclusions

Idealized AMV simulations with three global coupled climate models robustly show thinner sea-ice pack in the Arctic in response to AMV+.

Such thinner ice results from atmospheric teleconnections / circulation changes (dynamical effect) that lead to:

- Weakening of the Beaufort Sea High, driving an anomalous cyclonic ice motion;
- A dipole pattern in SLP in late winter / early spring that acts to enhance the Transpolar Drift Stream, enhancing sea-ice transport out of the Arctic Basin.

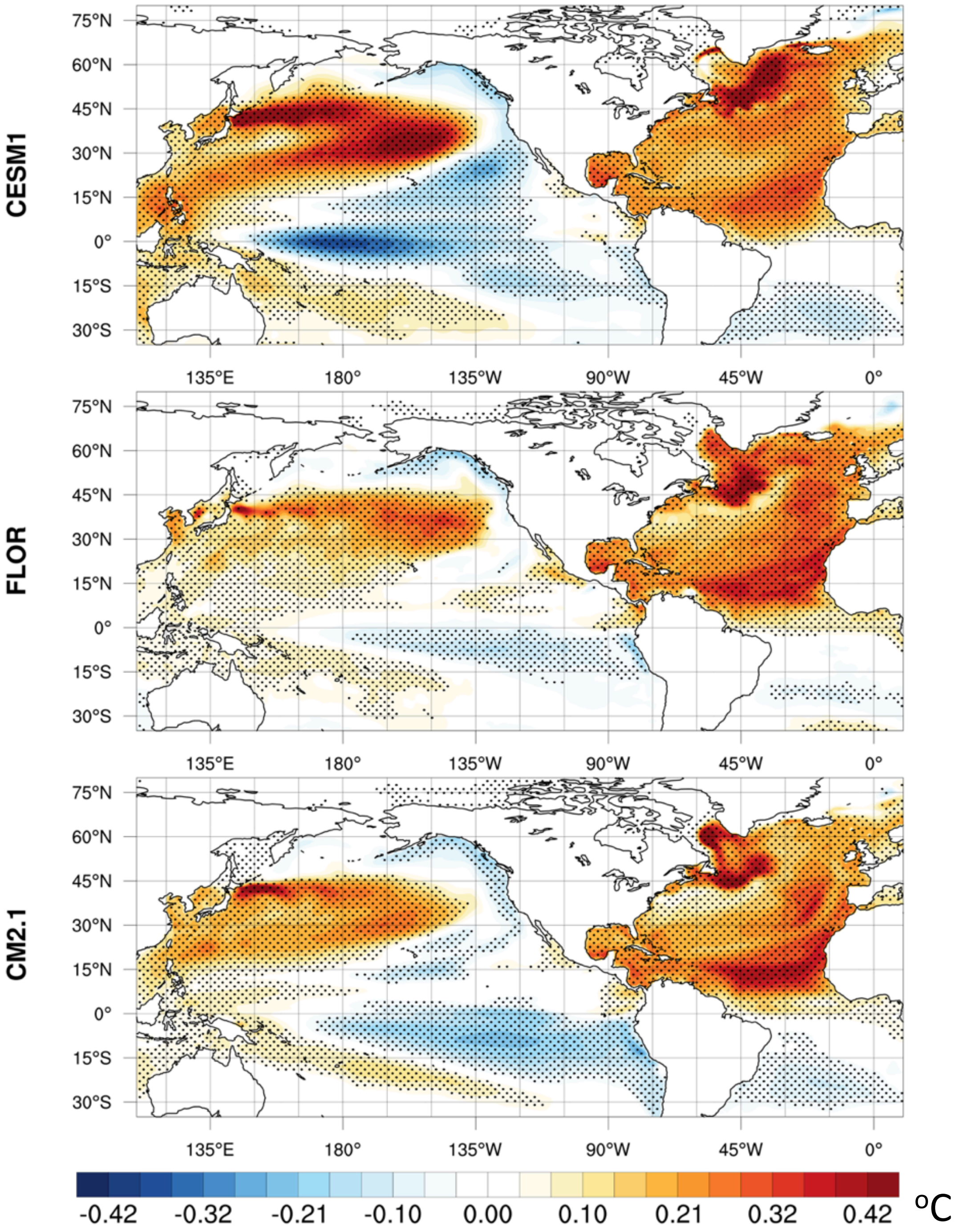
The AMV+ is also associated with (thermodynamic effect):

- Lower ice albedoes; increased low clouds; increased downwelling radiation;
- Higher surface temperatures

Thinner and younger ice is more prone to melt, resulting in less extensive sea-ice cover at the end of the melting season.

Weaker ice is more responsive to winds, i.e., positive feedback.

A Global Impact Example: Differences in DJFM Sea Surface Temperature



Differences in Sea-Ice Concentration