An Intercomparison of Changes Associated With Earth's Lower Tropospheric Temperature Using Traditional and AMIP-style Reanalyses

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Motivation

- Observations and reanalyses have demonstrated the Arctic has warmed more rapidly than anywhere else in the world, referred to as "Arctic Amplification"
- Arctic Amplification has been connected to a southward shift in the jet stream as well as a "wavier" jet stream, though uncertainty remains regarding the influence of the Arctic on the mid-latitudes (Francis and Vavrus, 2015)
- Time series in near surface temperature anomalies in MERRA-2 exhibit shifts associated with changes in boundary conditions (Simmons et al., 2017)

Datasets

- The Modern Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2; Gelaro et al., 2017)
- M2AMIP = 10 member ensemble of AMIP-style simulations using identical forcing and boundary conditions to MERRA-2
- M2AMIP_ERAISST = A single realization of M2AMIP except sea surface temperature (SST) and sea ice concentration (SIC) are prescribed based on ERA-Interim (Dee et al., 2011)

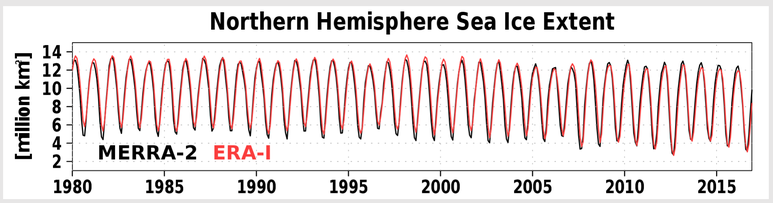

Figure 1: Monthly mean Northern Hemisphere sea ice extent from the MERRA-2 and ERA-I forcing used for the AMIP experiments

Results: Arctic Amplification During SON

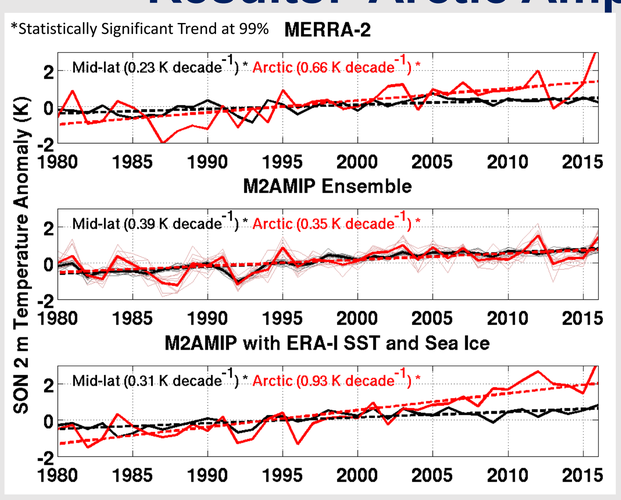

Figure 2 (above): Anomaly in 2 m temperature during SON relative to the climatology period of 1981- 2010 in the Arctic and Mid-latitudes in (a) MERRA-2, (b) M2AMIP, and (c) M2AMIP with SST and SIC from ERA-I

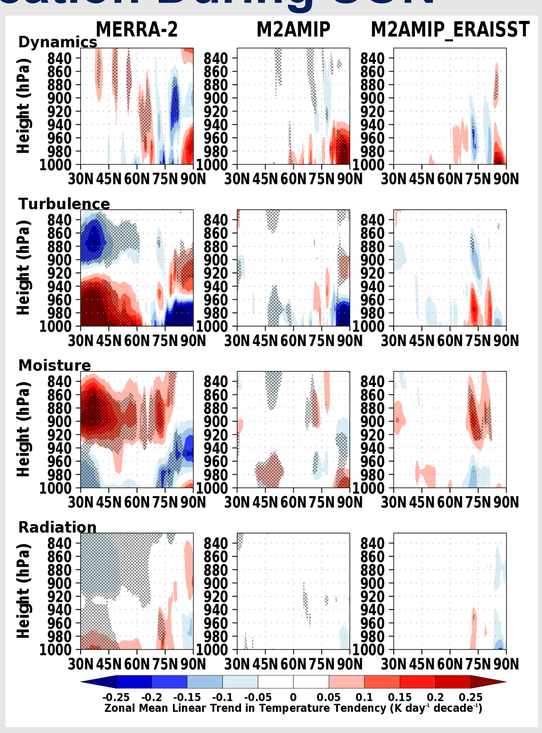

Figure 3 (above): Linear trends in the zonal mean temperature tendency during SON over the period of 1980 through 2016 due to dynamics (top row), turbulence (2nd row), moist processes (3rd row), and radiation (bottom row) in MERRA-2 (left), M2AMIP (middle), and M2AMIP with ERA-I SST and Sea Ice (right). Hatching = 99.9% Confidence.

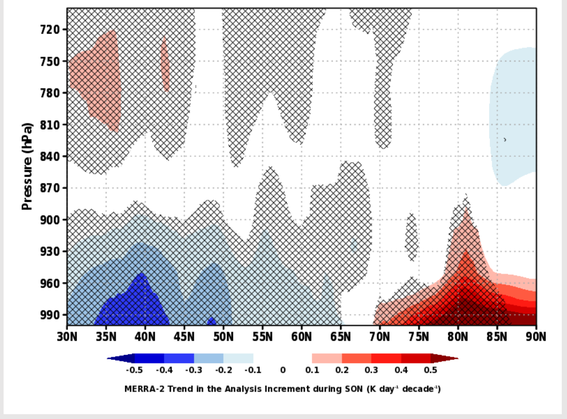

Figure 4: Linear trends in the zonal mean temperature tendency during SON over the period of 1980 through 2016 due to the analysis increment in MERRA-2. Hatching = 99.9% confidence. Note the change in scale from Figure 3.

Results (cont'd): Changes in Atmospheric Circulation over Time

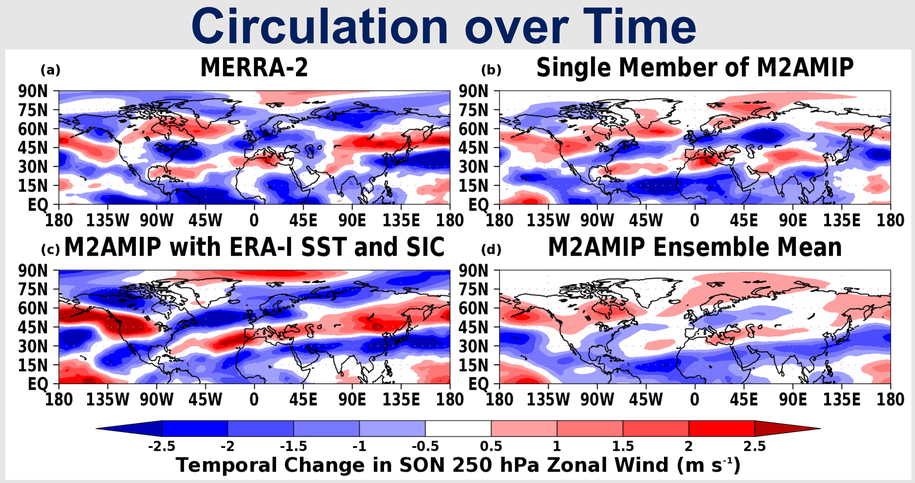

Figure 5 (above): Difference in SON mean 250 hPa zonal wind between 1997-2016 and 1980-1996 in (a) MERRA-2, (b) a single member of M2AMIP, (c) M2AMIP with SST and SIC from ERA-I, and (d) the M2AMIP ensemble mean.

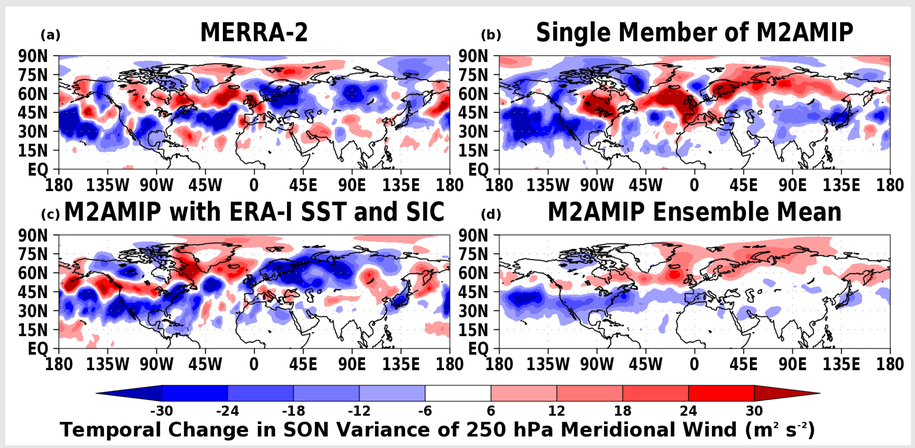

Figure 6 (above): Difference in SON variance of the 250 hPa meridional wind between 1997-2016 and 1980-1996 in (a) MERRA-2, (b) a single member of M2AMIP, (c) M2AMIP with SST and SIC from ERA-I, and (d) the M2AMIP ensemble mean

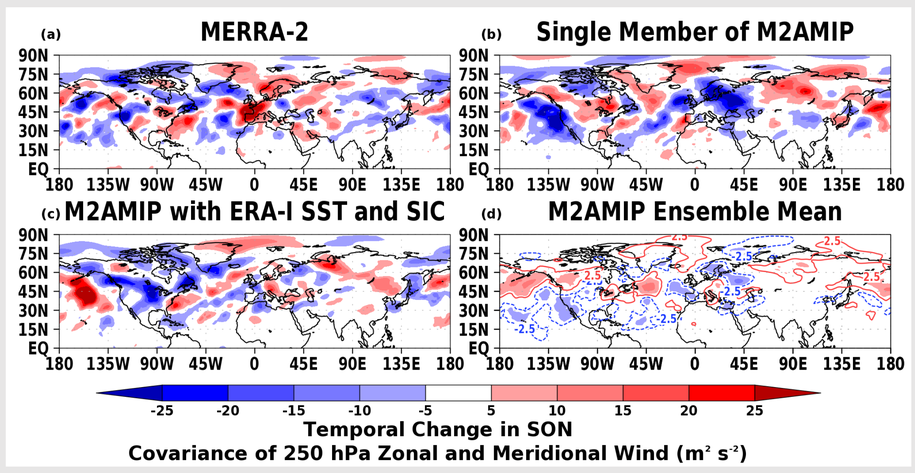

Figure 7 (above): Difference in SON covariance of the 250 hPa zonal and meridional wind between 1997-2016 and 1980-1996 in (a) MERRA-2, (b) a single member of M2AMIP, (c) M2AMIP with SST and SIC from ERA-I, and (d) the M2AMIP ensemble mean

Results (cont'd): Greenland Blocking Index

- GBI is a proxy for the NAO and is defined as the area averaged 500 hPa height over 60–80°N, 20–80°W (Hanna et al., 2013)

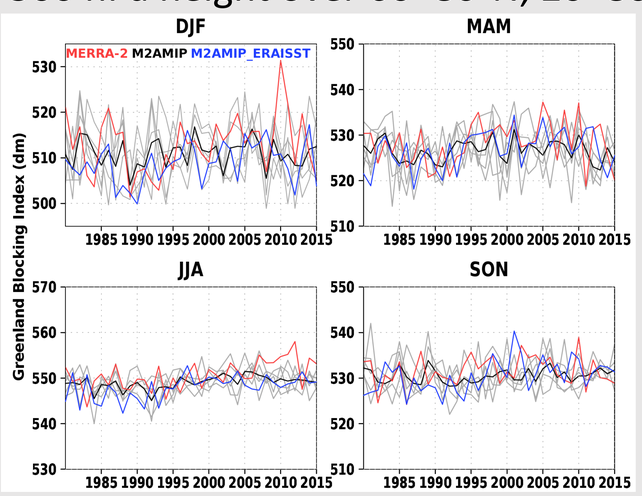

Figure 8 (left): GBI time series for (a) DJF, (b) MAM, (c) JJA, and (d) SON from MERRA-2 (red), M2AMIP (black), and M2AMIP with ERA-I SST and sea ice (blue) for the period of 1980 through 2015

Conclusions

- Arctic Amplification is not present in M2AMIP, however using boundary conditions from ERA-I mitigates this issue
- Analysis increments play a large role in Arctic Amplification in MERRA-2, but the ratio between turbulence and dynamics matters as well
- The zonal progression within the North Atlantic storm track has slowed in all datasets, but the variance in meridional winds has not increased
- Uncertainty remains regarding the influence of Arctic Amplification on blocking over Greenland and the North Atlantic Oscillation

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