Atmospheric response to reduced Arctic sea ice cover in coupled and uncoupled simulations of GEOS-5 and numerical analyses

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Coupled Experiments

Ocean	Atmosphere
0.5 Degree Resolution	1 Degree Resolution
40 Vertical Levels	72 Vertical Levels

- Primary Goal: Evaluate the influence of varying initial conditions for sea ice thickness on forecasts of the atmospheric state
- Initialized April 2012 and run for 1 full year
- 21 ensemble members for each experiment
- 3 experiments with different initial conditions for sea ice thickness
  - -PIOMAS Climatology (1981-2010) -Model Derived -Assimilated Cryosat-2

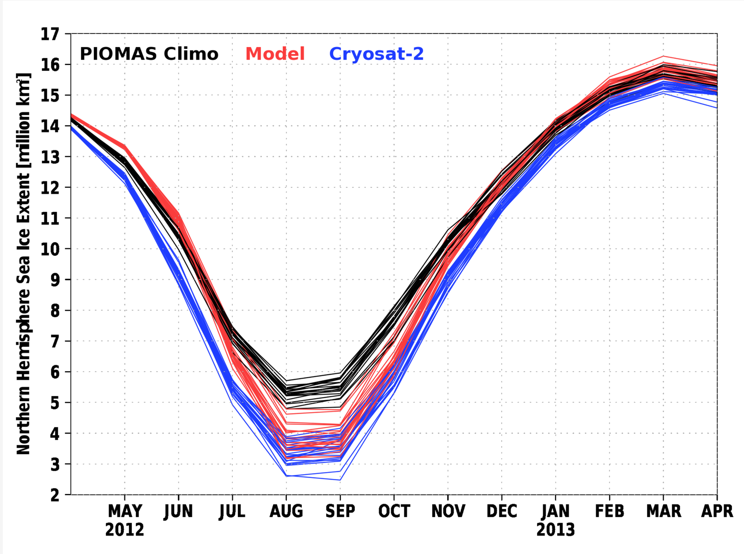


Figure 1 (left): Northern hemisphere sea ice extent from each ensemble member for PIOMAS climatology (black), model derived (red), and assimilated Cryosat-2 initial conditions for sea ice thickness

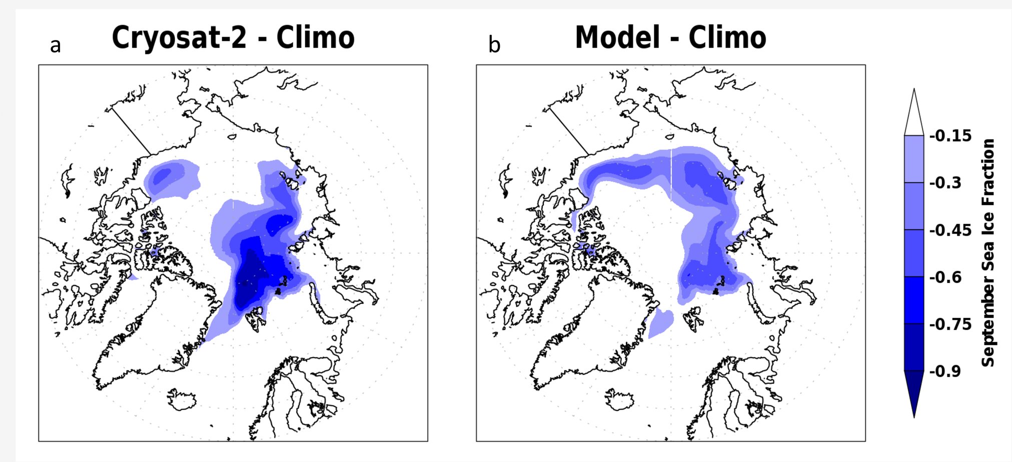


Figure 2 (right): Ensemble average differences in sea ice fraction in September 2012 for (a) Assimilated Cryosat-2 minus PIOMAS climatology and (b) model derived minus PIOMAS climatology sea ice thickness initial conditions

Results

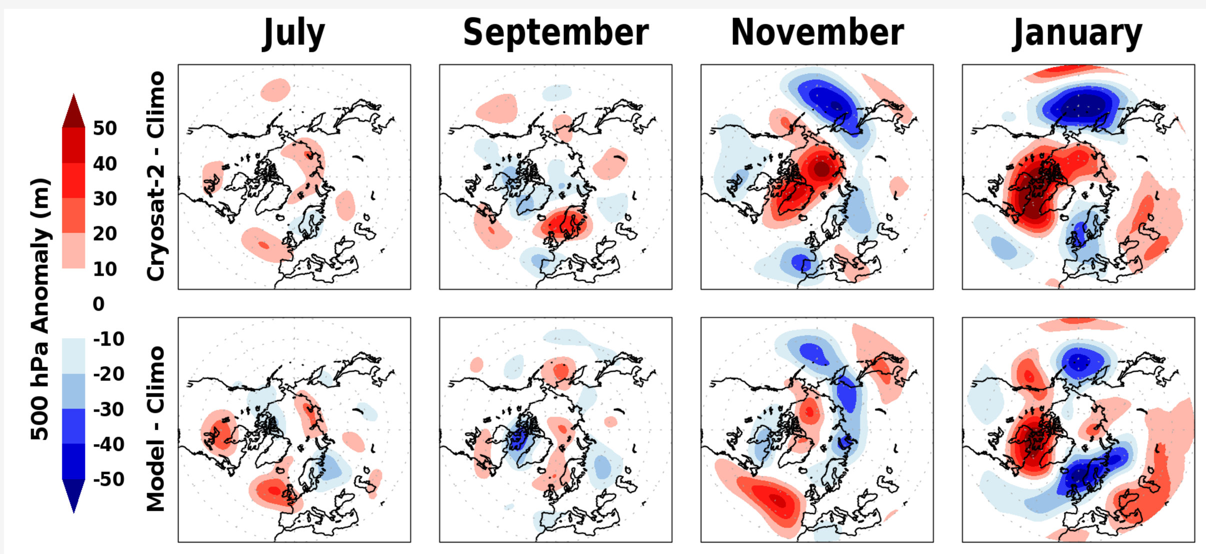


Figure 2 : Difference in forecasted 500 hPa height initialized with Cryosat-2 assimilated (top) and model derived (bottom) minus PIOMAS climatology sea ice thickness

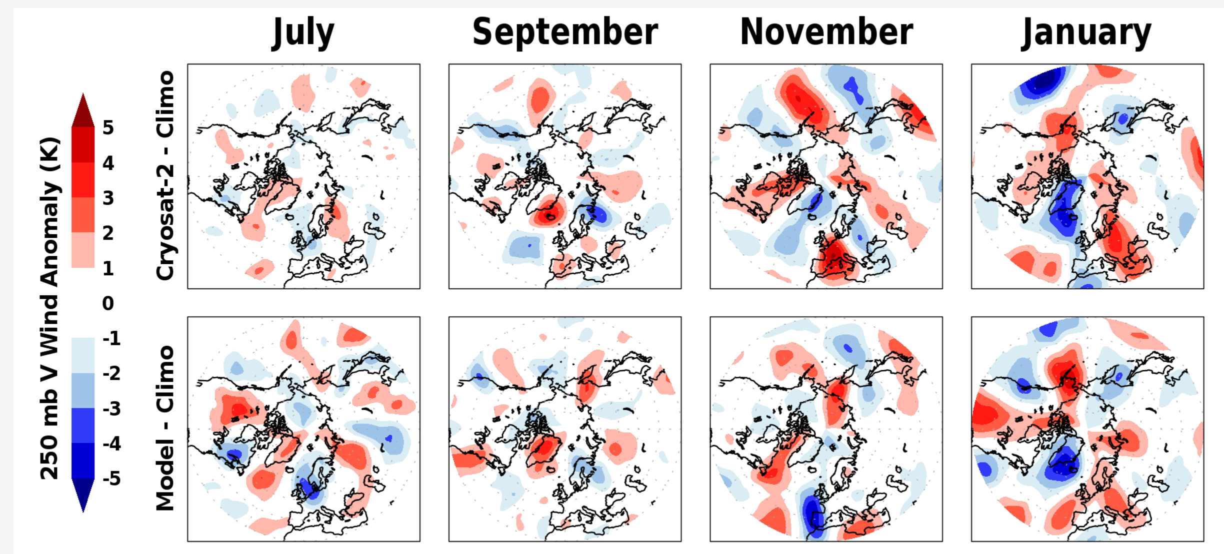


Figure 3 : Difference in forecasted 250 hPa meridional winds initialized with Cryosat-2 assimilated (top) and model derived (bottom) minus PIOMAS climatology sea ice thickness

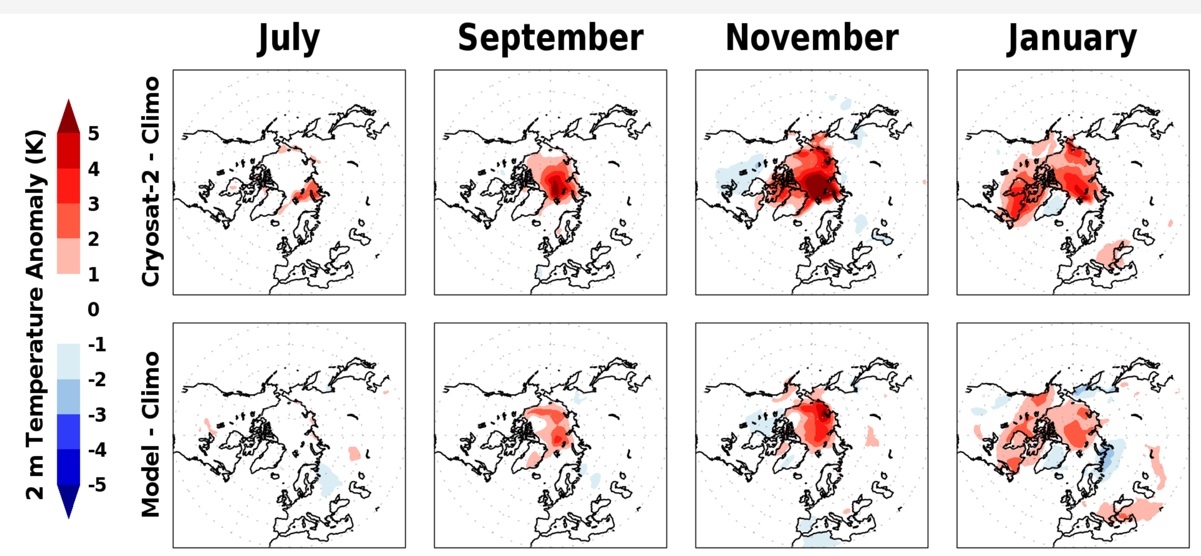


Figure 4 : Difference in forecasted 2 m temperature initialized with Cryosat-2 assimilated (top) and model derived (bottom) minus PIOMAS climatology sea ice thickness

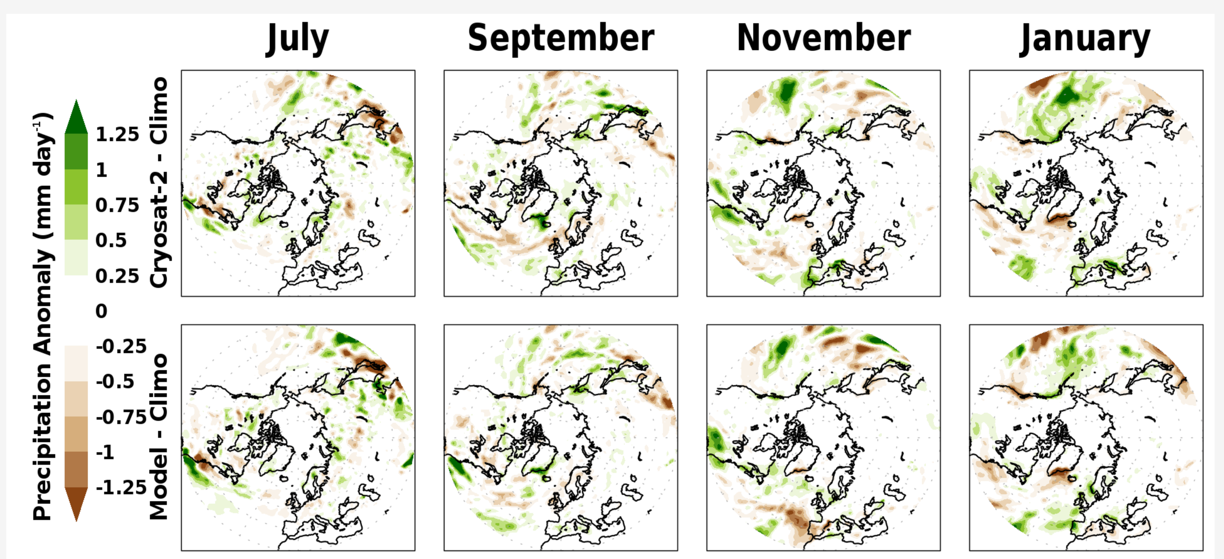


Figure 5 : Difference in forecasted precipitation initialized with Cryosat-2 assimilated (top) and model derived (bottom) minus PIOMAS climatology sea ice thickness

Conclusions

- The atmospheric effects of varying sea ice thickness initial conditions are mostly localized in subsequent months.
- Averaged temperature anomalies indicate warming over the central Arctic in autumn and winter associated with decreased summer ice cover. There is also modest cooling over midlatitudes.
- -Decreased ice cover also shows enhanced autumn and winter precipitation over the northern Gulf Stream and eastern continental US, as well as southern Europe.

Uncoupled Experiments

- AMIP-style simulations performed using the MERRA-2 model (M2AMIP)
- 5 ensemble members spanning 1980 through 2015
- 10 additional ensemble members for the year 2012 (M2AMIP2012)
- SST and Sea Ice Extent are prescribed and identical to MERRA-2

Atmosphere
0.5 Degree Resolution
72 Vertical Levels

Preliminary Results: Evaluation of Arctic Amplification

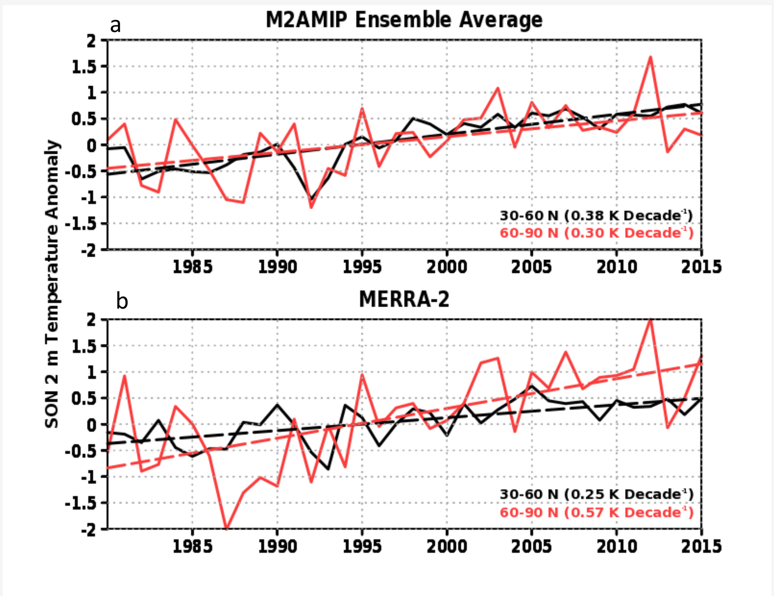
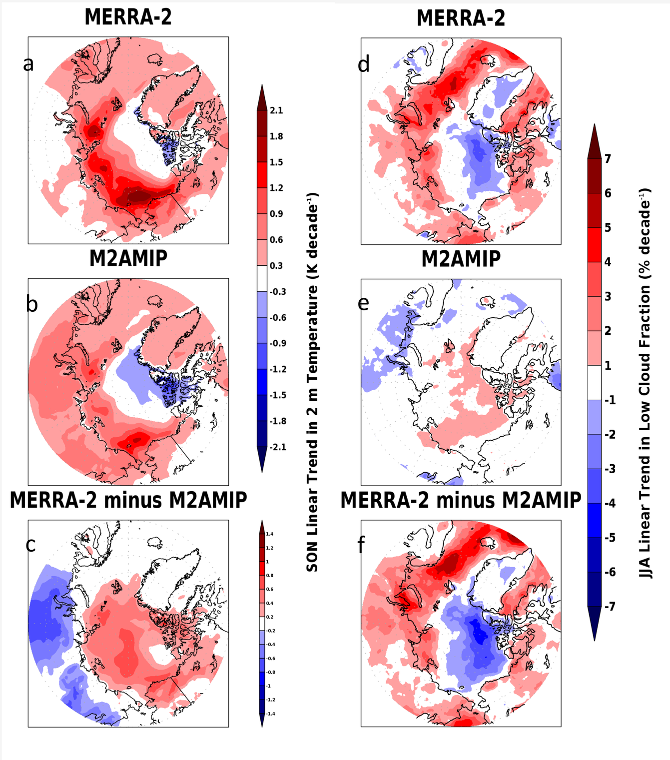


Figure 1 (left): Area averaged 2 m temperature anomalies for the Arctic (70 to 90 N) and Midlatitudes (30 to 60 N) during SON for the period of 1980 – 2015 in the ensemble average for M2AMIP (top) and MERRA-2 (bottom).

Figure 2 (right): Linear trend in 2 m temperature during SON for the period of 1980-2015 in (a) MERRA-2, (b) M2AMIP, and (c) MERRA-2 minus M2AMIP. Linear trend in low cloud fraction during JJA for the period of 1980-2015 in (d) MERRA-2, (e) M2AMIP, and (f) MERRA-2 minus M2AMIP



- Arctic amplification is not present in M2AMIP
- Decreased albedo from melting sea ice counteracted by increase in albedo from increasing low clouds

Blocking through the Greenland Blocking Index

- Greenland Blocking Index used as a proxy for NAO (Hanna et al. 2013)
- No trend, aside from JJA in MERRA-2, most variable in DJF
- Larger influence from large scale features than sea ice extent

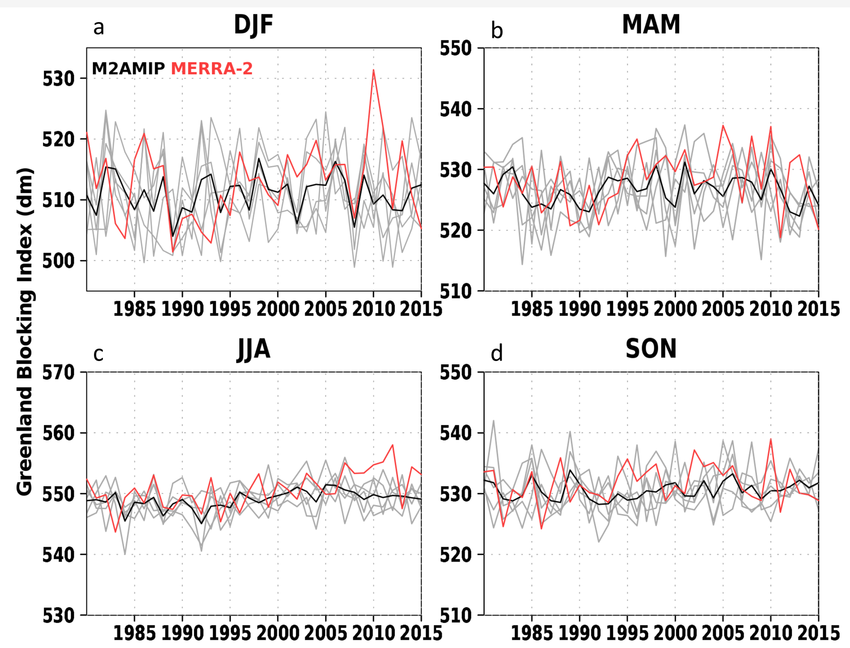
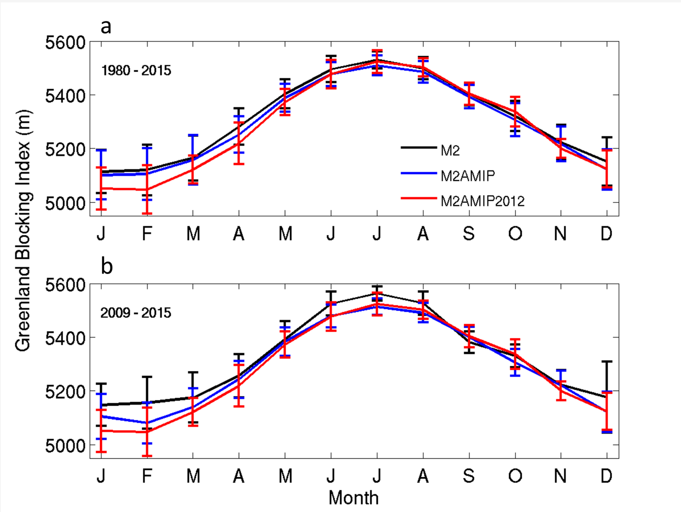


Figure 3 (left): Greenland Blocking Index time series for (a) DJF, (b) MAM, (c) JJA, and (d) SON from M2AMIP and MERRA-2 for the period of 1980 through 2015

Figure 4 (right): Month averaged Greenland Blocking Index from MERRA-2, M2AMIP, and M2AMIP2012 for the period of (a) 1980 through 2015 and (b) 2009 through 2015



Extreme Temperature Events in the U.S.

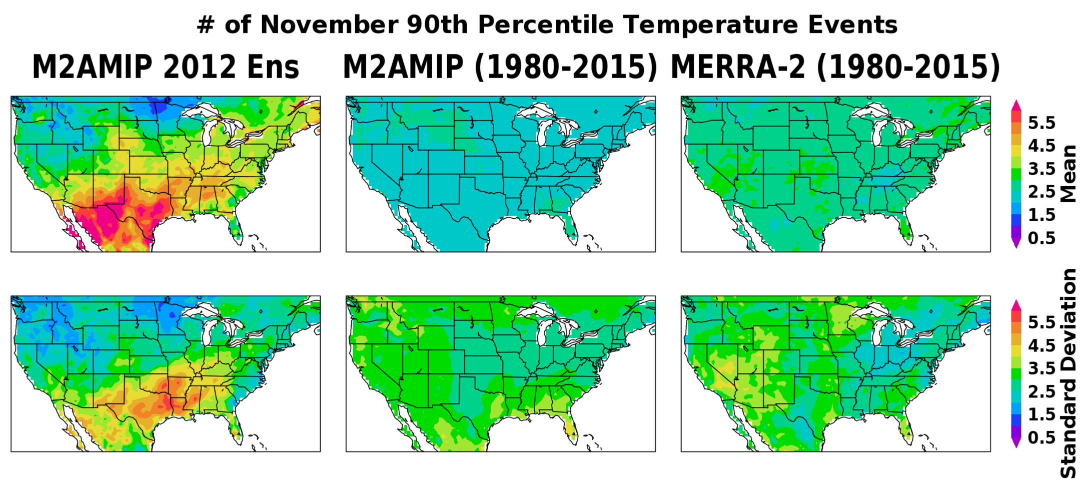


Figure 3 (left): Mean (top) and standard deviation (bottom) number of 90th percentile events in November 2012 from the M2AMIP ensemble (left), M2AMIP (middle), and MERRA-2 (right) for the period of 1980 to 2015.

- Increased extreme temperature events seen in 2012 in the Southern Great Plains (SGP)
- A week prior to an event in the SGP, anomalously high heights develop north and west of Alaska, which propagates a wave train across the globe

Figure 6 (right): Anomalies in 500 hPa height composited one week prior (a,c) and on the day of (b,d) an extreme temperature event in the US Southern Great Plains during November from M2AMIP (a,b) and M2AMIP2012 (c,d)

M2AMIP2012 (496 Events) M2AMIP2012 (82 Events)