Observational Evidence for Predictive Skills from Arctic Summer Sea Ice Extent

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Research Questions

- Are Arctic sea ice anomalies predictable?
- Are Arctic sea ice anomalies impacting the large-scale atmosphere?

Conclusions

- Winter and summer Arctic sea ice extent can largely be predicted from preceding season; spring and autumn conditions not.
- Impacts of anomalous Arctic sea ice on deep atmospheric temperature and circulation mainly confined to summer.

Motivation

- Arctic warming at twice the rate of global average (Arctic amplification; Fig. 1), associated with rapid sea ice loss[ii] (Fig. 2).
- Link to midlatitude extreme weather proposed[iv].
- The path towards a "Blue Arctic" enhances interest in sea ice prediction also from actors outside academia[v].

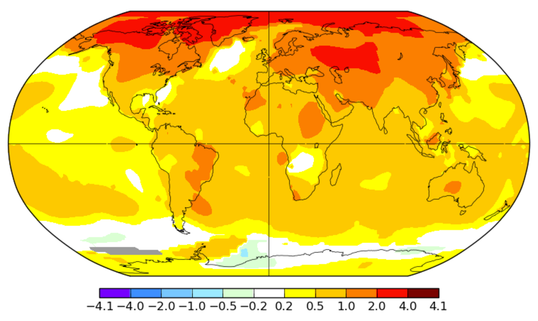

Fig. 1: Cold season (November-April) surface temperature (in °C) anomalies 2000-2016 relative to 1881-1999. Data from GISTEMP Team (2016)[i].

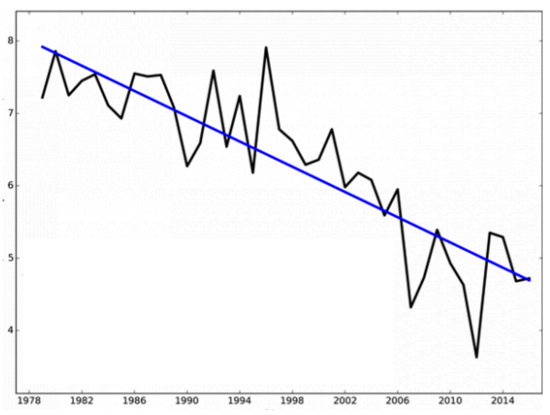

Fig. 2: September Arctic sea ice extent (in 10^6 km²) 1979-2016. From Wiggins & Turner-Bogren (2016)[iii].

Lead/Lag Correlations

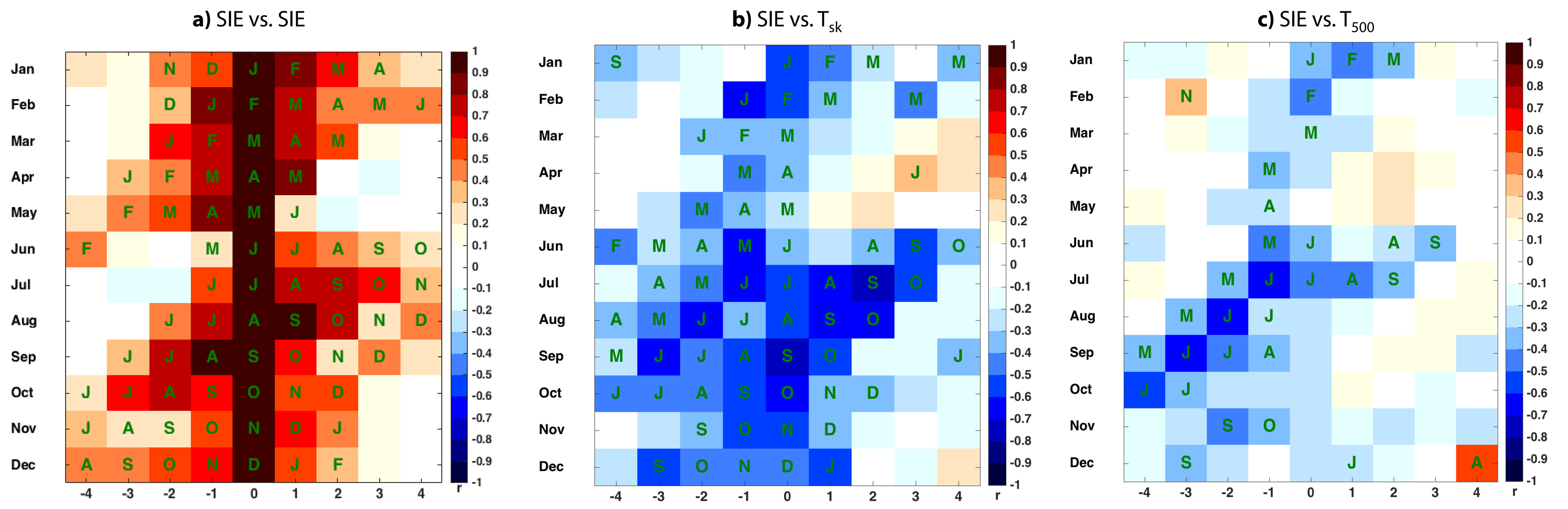

Fig. 3: Lead/lag correlation coefficients between (a) Arctic sea ice extent (SIE) and SIE (i.e. autocorrelation), (b) SIE and skin temperature (T_{sk}) and (c) SIE and 500 hPa temperature (T_{500}). For each SIE month along the y-axis, negative (positive) values along the x-axis represent correlation from a previous (the current) SIE, T_{sk} or T_{500} (SIE) month to the current (a coming) SIE (SIE, T_{sk} or T_{500}) month. Significant correlations are indicated by the initial of the lead/lag month (α = 0.05). All data are deseasonalized and detrended, and T_{sk} and T_{500} are spatially averaged over the Arctic (defined 66.5–90.0°N).

- Significant memory from winter and summer sea ice to next season (Fig. 3a).
- Significant memory from annual sea ice minimum (September) only until December (Fig. 3a).
- Late spring/early summer temperatures important for late summer/early autumn sea ice conditions (Fig. 3b-c).

Data Sets and Methods

Data sets:

- National Snow and Ice Data Center satellite sea ice data.
- ERA-Interim reanalysis atmospheric data.

Time period:

- Monthly means 1979-2015.

Region:

- Arctic (66.5-90.0°N) for lead/lag correlations.
- High- and midlatitudes (40.0-90.0°N) for lead/lag regressions.

Methods:

- Lead/lag correlations and regressions.

Lead/Lag Regressions

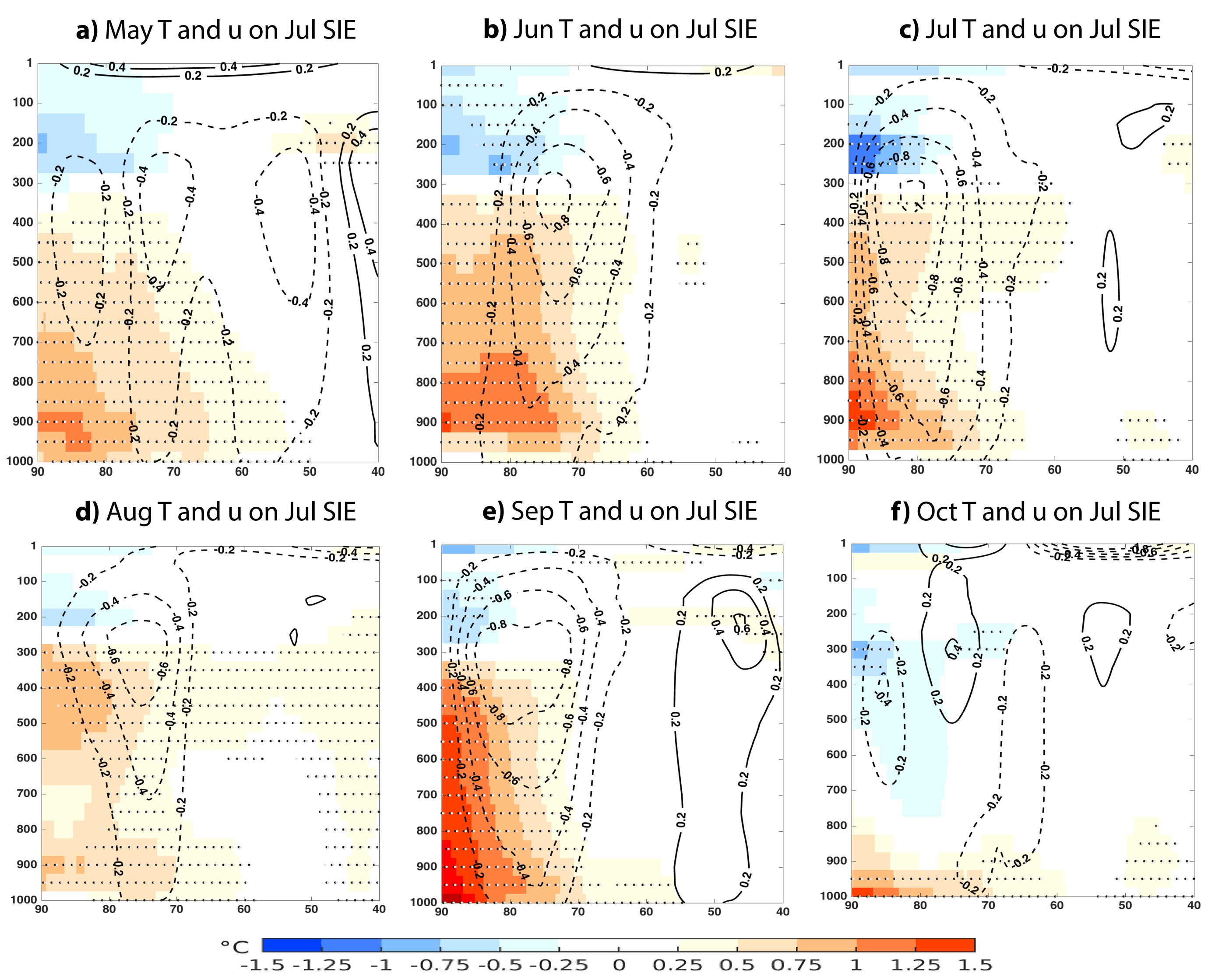

Fig. 4: Lead/lag regression of May-October zonally averaged temperature (T; shading; in °C) and zonal wind (u; contours; in m s⁻¹) on July Arctic sea ice extent (SIE). SIE is detrended and standardized, T and u deseasonalized and detrended. Significant correlations between SIE and T marked by black/white dots (α = 0.05).

- Anomalous low Arctic sea ice in July associated with a general warming of the high-latitude troposphere and weakening of high-altitude easterlies in May-September, with a maximum in September (Fig. 4a-e).
- Signals almost gone by October (Fig. 4f).
- Impact of sea ice retreat on the atmospheric column mainly confined to the surface from October (Figs. 3 and 4).

Acknowledgements

This work was supported by the Research Council of Norway through the project "Impact of Blue Arctic on climate at high latitudes" and the German Research Foundation through the Transregional Collaborative Research Centre TR 172 – "Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms (AC)³".

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