Arctic Sea-Ice Prediction in the GFDL Forecast System

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With contributions from:
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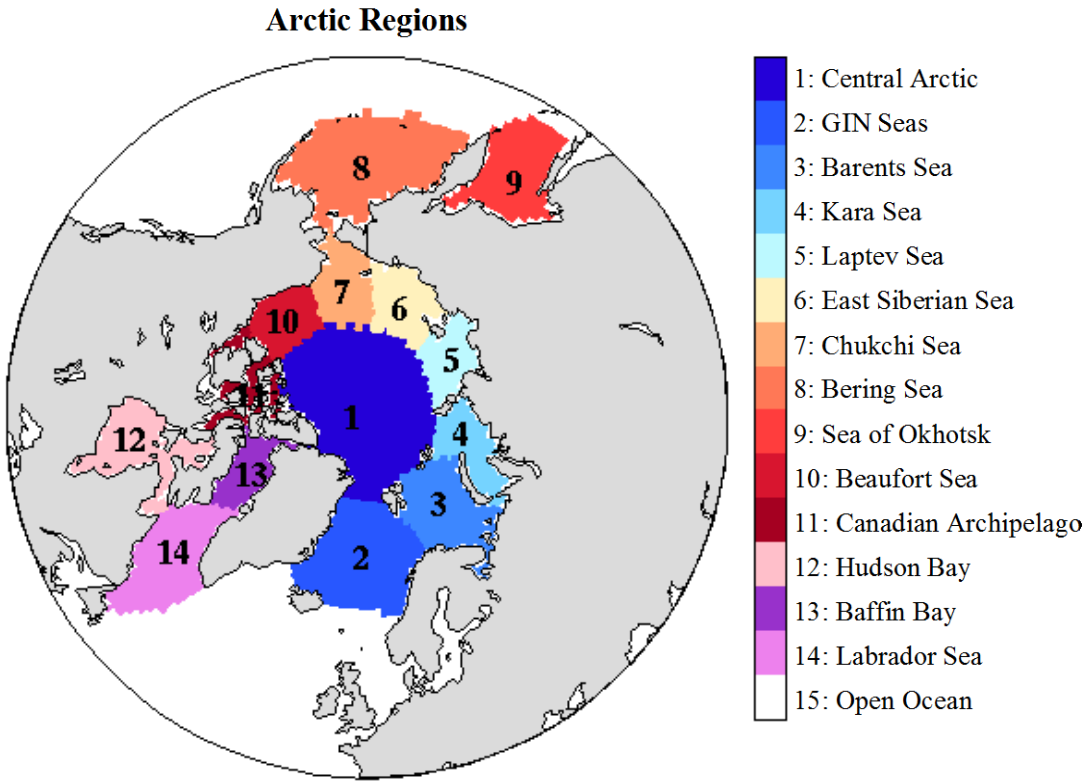
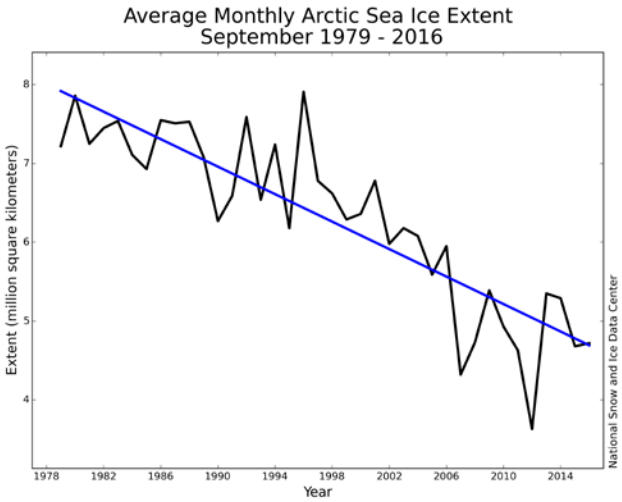
JPSS-CPO Meeting
January 30, 2017

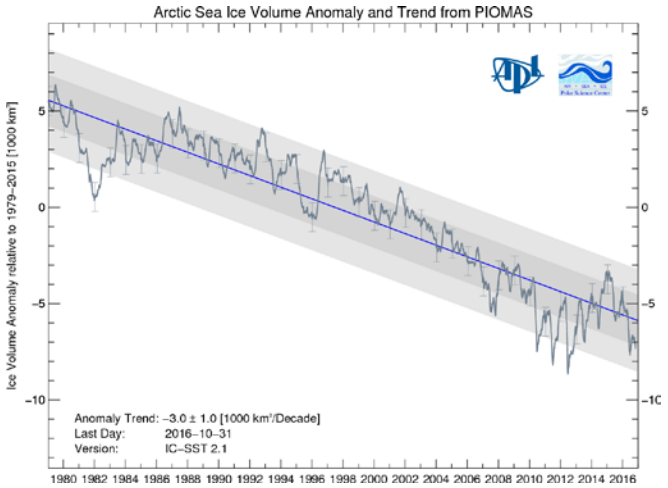


The Changing Arctic Sea-Ice Cover

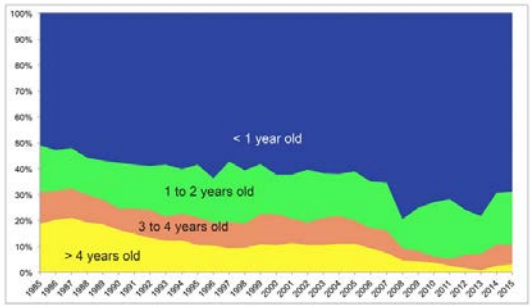
Negative extent trend

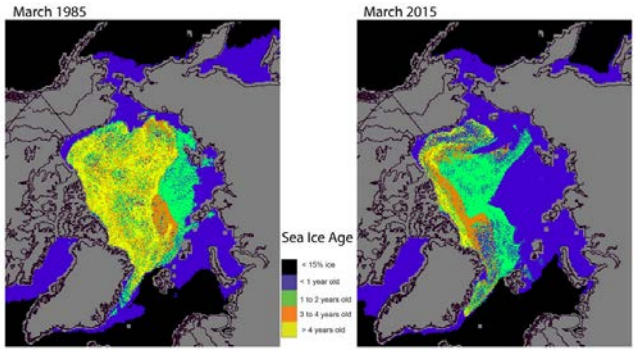


Negative volume trend

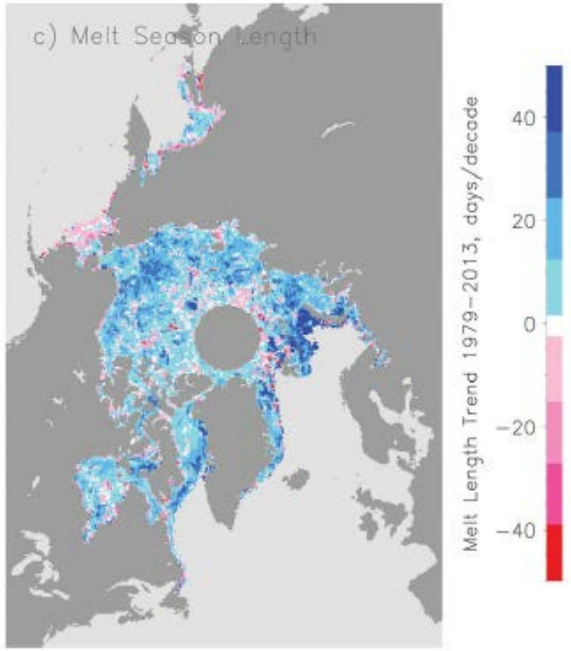


Younger and thinner ice cover

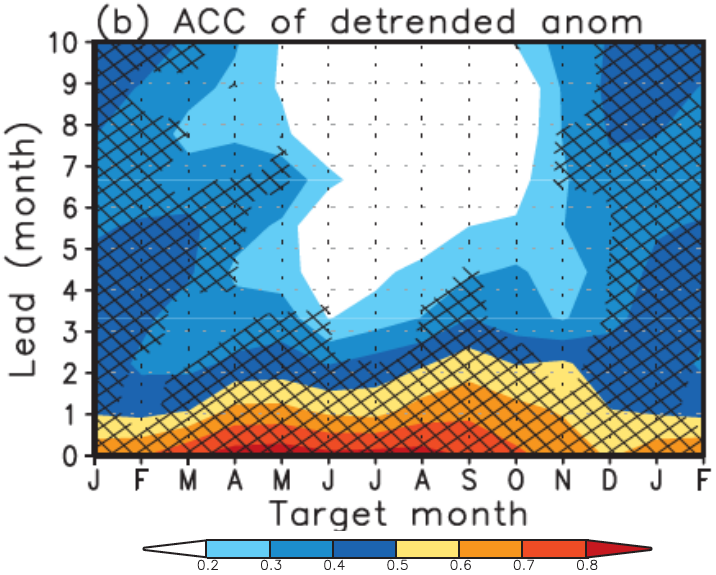




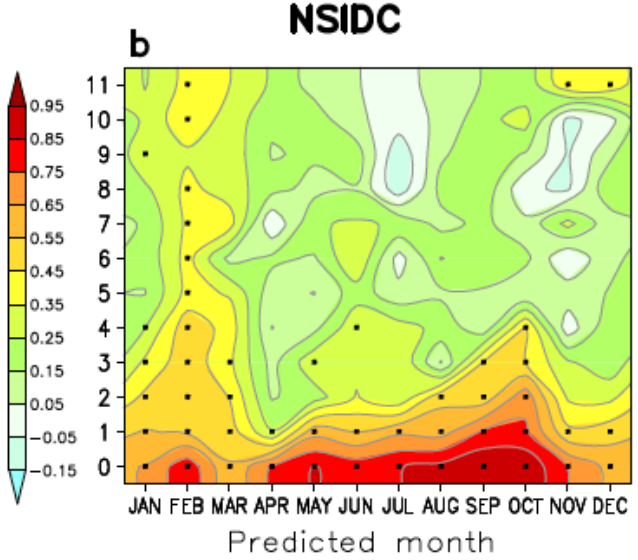
Longer melt seasons



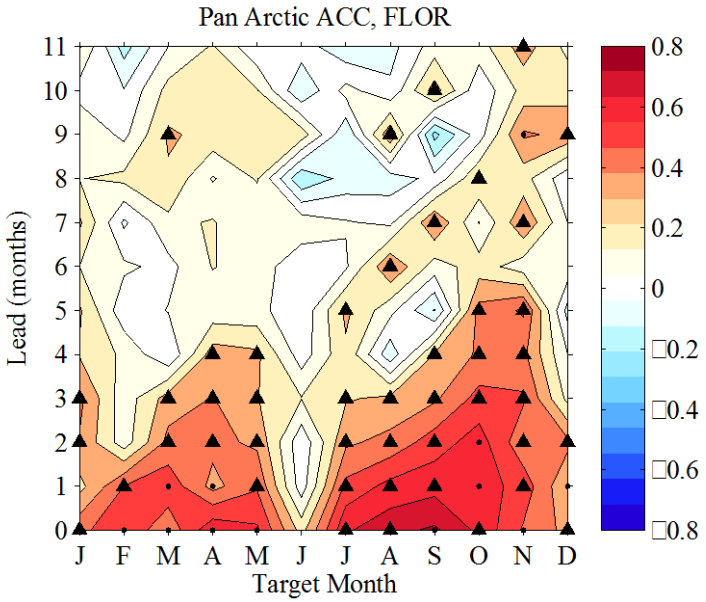
Pan-Arctic Prediction Skill for Detrended SIE anomalies



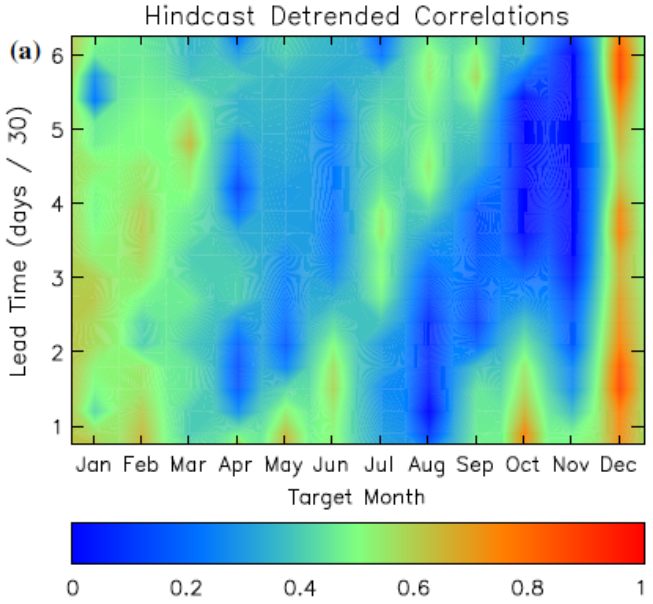
Wang et al. 2013, *Mon. Wea. Rev.*



Merryfield et al. 2013, *GRL;*
Sigmond et al. 2013, *GRL*



Msadek et al. 2014, *GRL*



Peterson et al. 2015, *Clim. Dyn.*

Motivating Questions

(1) How skillful are regional predictions of Arctic sea ice?

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The Dynamical Forecast Model

GFDL-FLOR[1]: **F**orecast-oriented **L**ow **O**cean **R**esolution

- Fully-coupled global model
- Atmosphere and Land (50km)
- Ocean and Sea Ice (1°)

1: Vecchi et al. 2014, *J. Climate*; 2: Zhang et al. 2007 *Mon. Wea. Rev.*

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Initialization Procedure

ECDA[2]: **E**nsemble Kalman Filter **C**oupled **D**ata **A**ssimilation

- Atmosphere assimilates NCEP reanalysis
- Ocean assimilates satellite SST, ARGO, CTD, XBT
- No assimilation of sea ice data

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Forecast Experiments

- Forecasts initialized on the first of each month; run for one year
- 12-member ensemble
- Retrospective forecasts spanning 1980-2016

1: Vecchi et al. 2014, *J. Climate*; 2: Zhang et al. 2007 *Mon. Wea. Rev.*

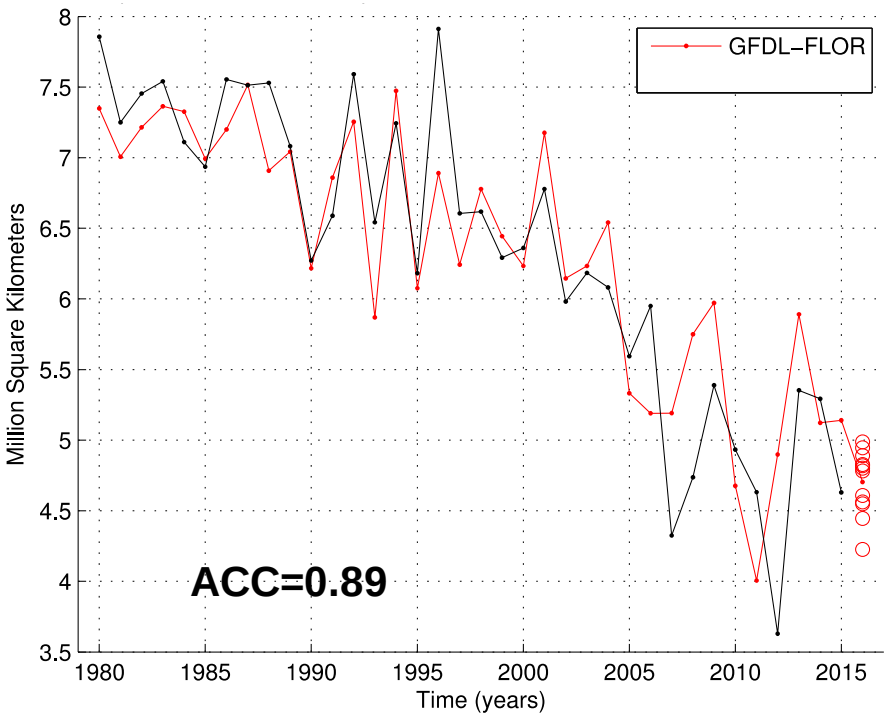
Prediction Skill in Retrospective Forecasts

Target month: Month we are trying to predict

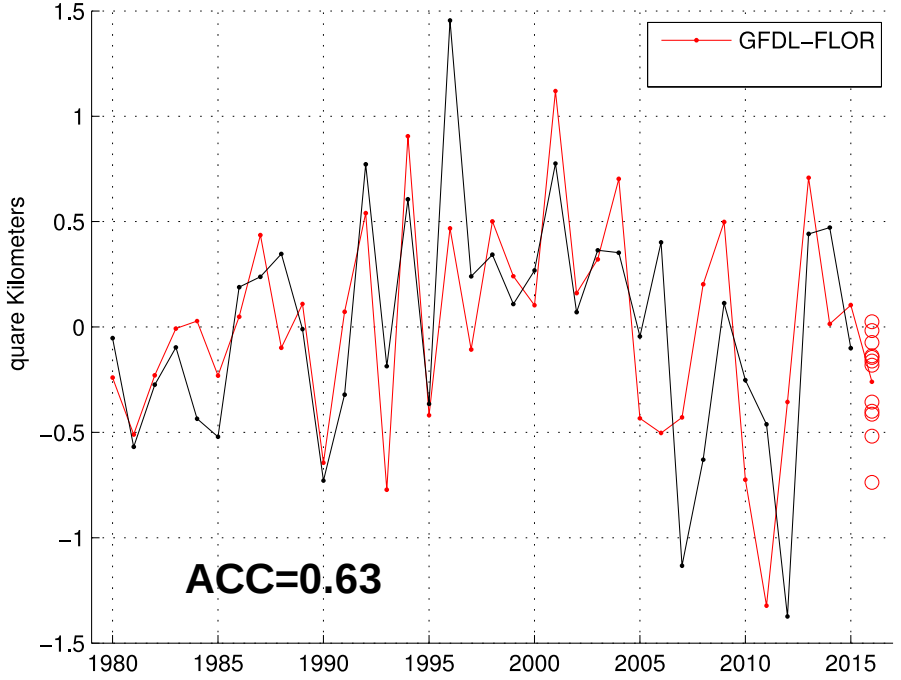
Lead time: Number of months prior to target month that forecast was initialized

Anomaly correlation coefficient (ACC): Correlation between observed and predicted SIE

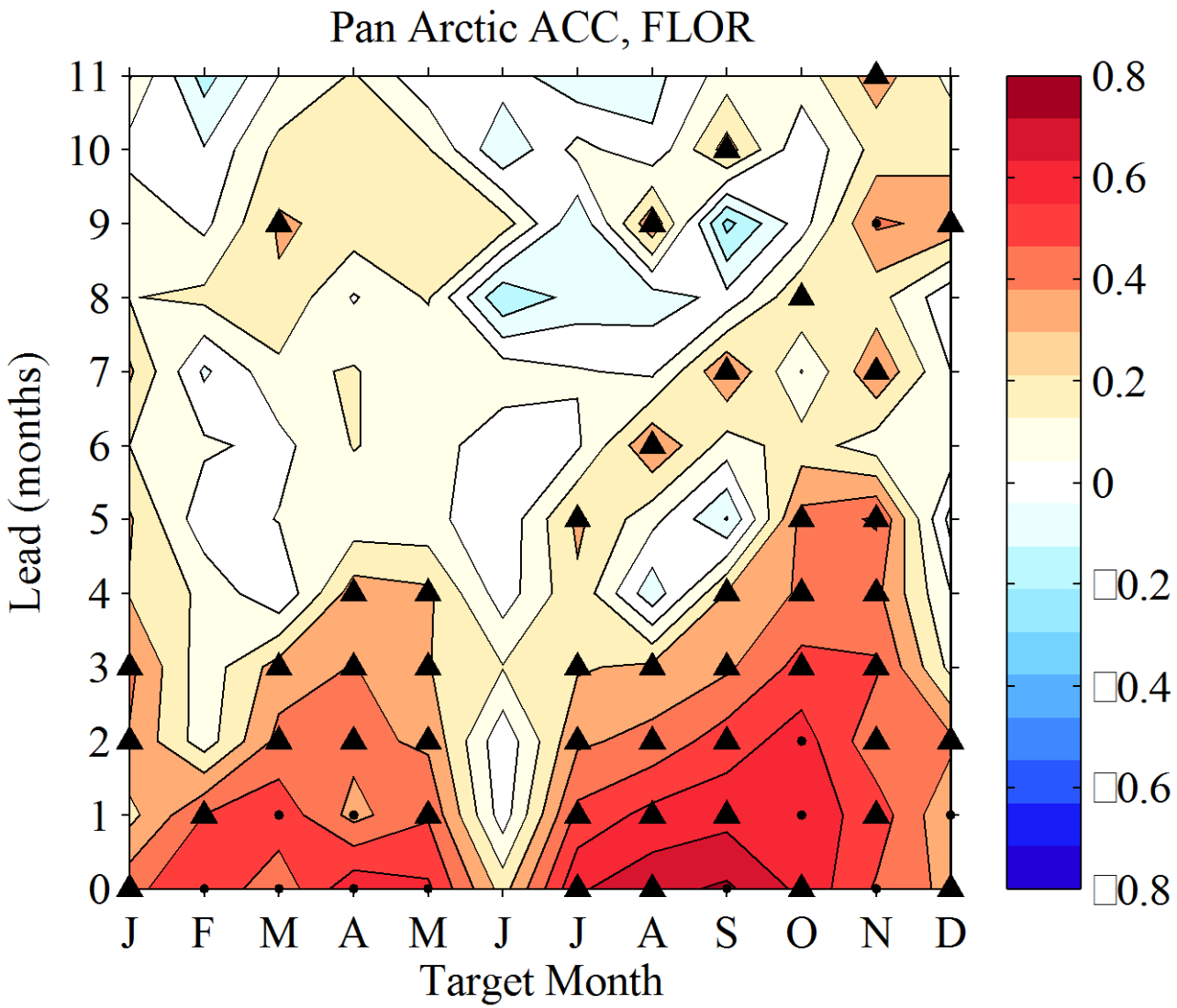
Target: September; Lead: 2



Target: September; Lead: 2; Detrended



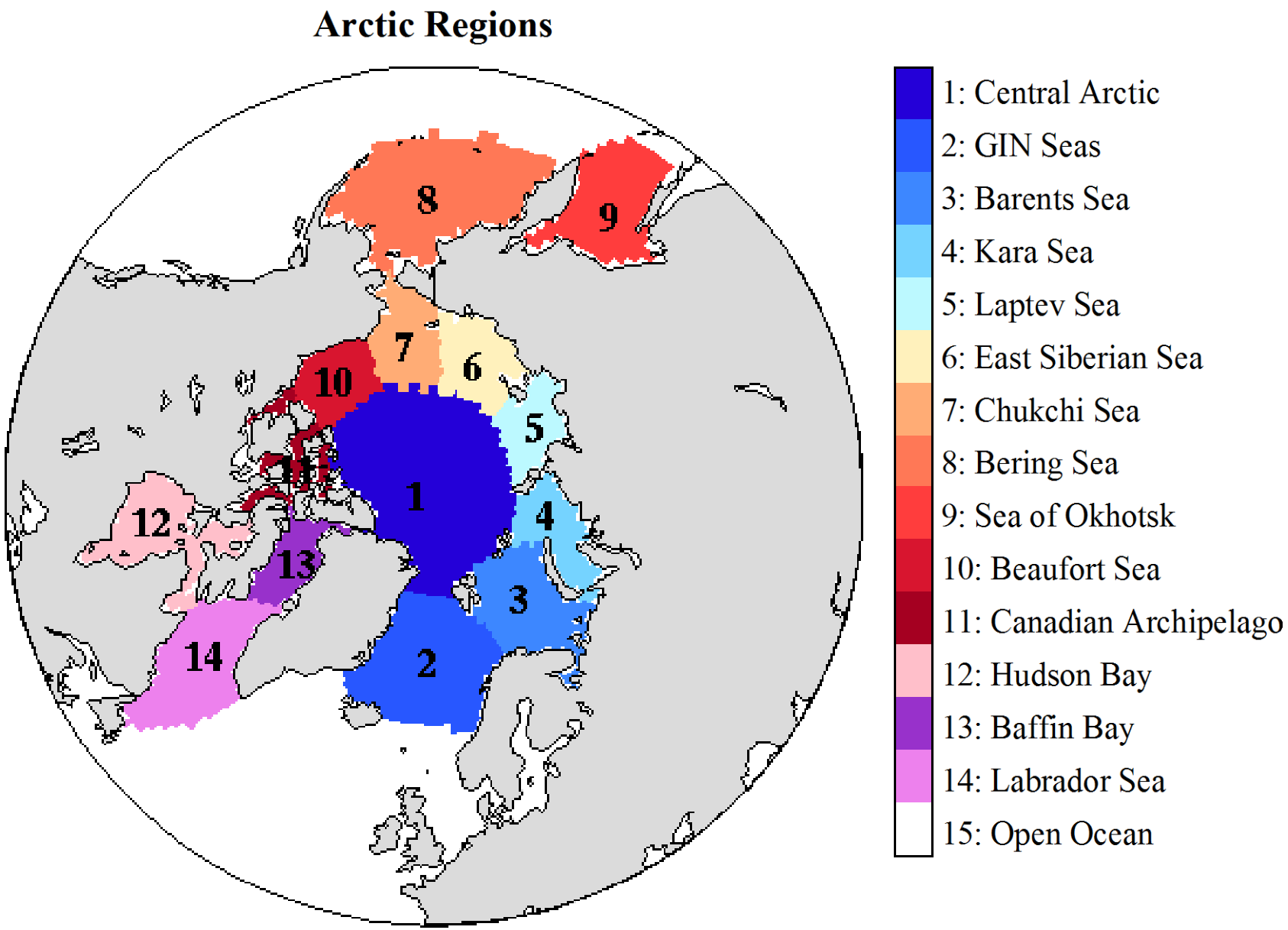
Pan-Arctic Prediction Skill: All target months and lead times 0-11 months



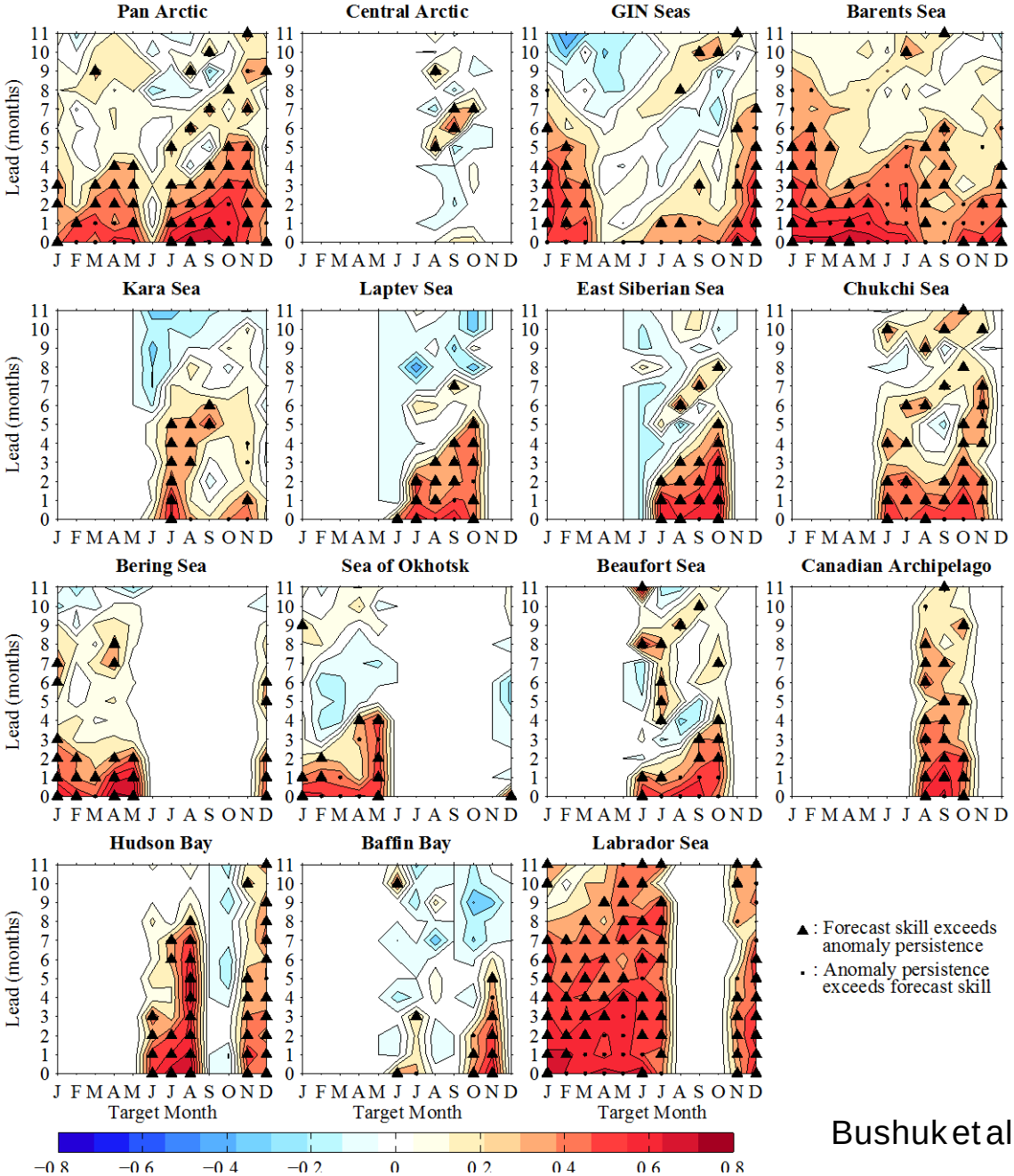
▲: Anomaly correlation coefficient (ACC) exceeds persistence forecast and is significant at 95% level

Note: All correlations computed using **linearly detrended** data

Regional Prediction Skill



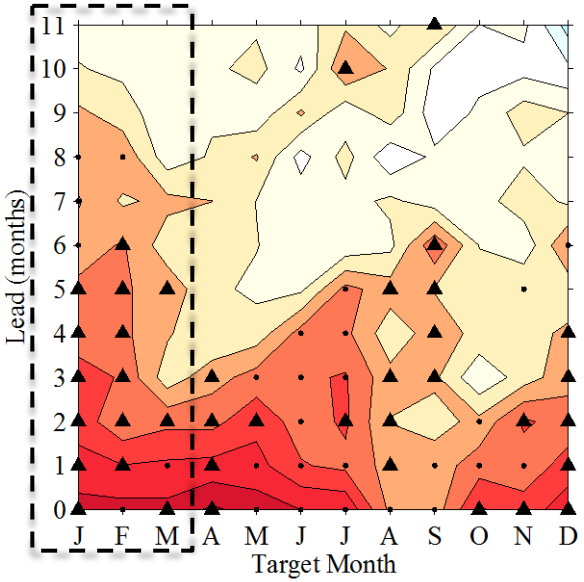
Regional Prediction Skill (ACC) for detrended SIE



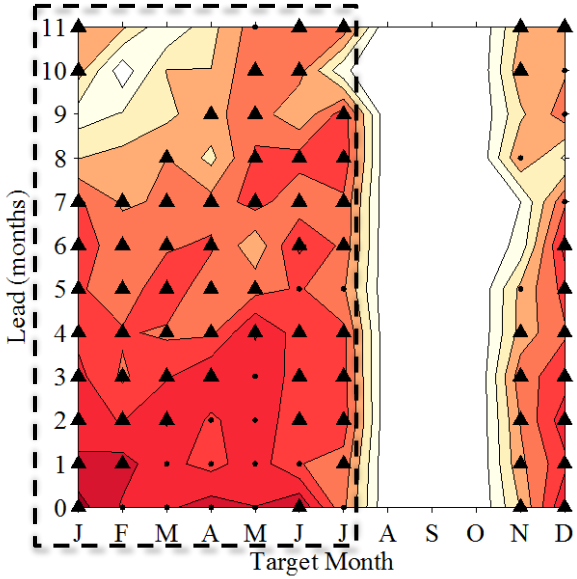
Bushuk et al. 2017, *in prep*

Prediction Skill For Winter Ice Regions (Region # in parentheses)

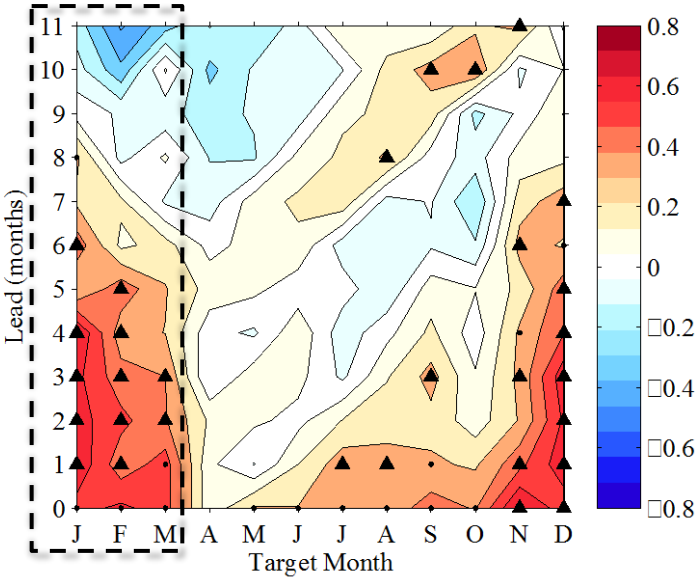
Barents Sea (3)



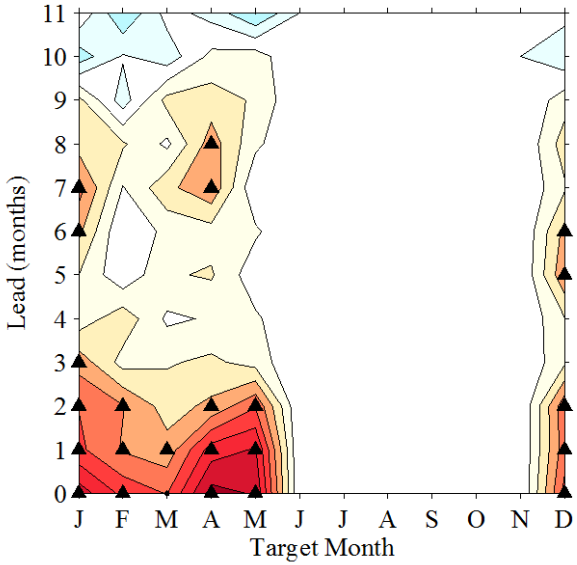
Labrador Sea (14)



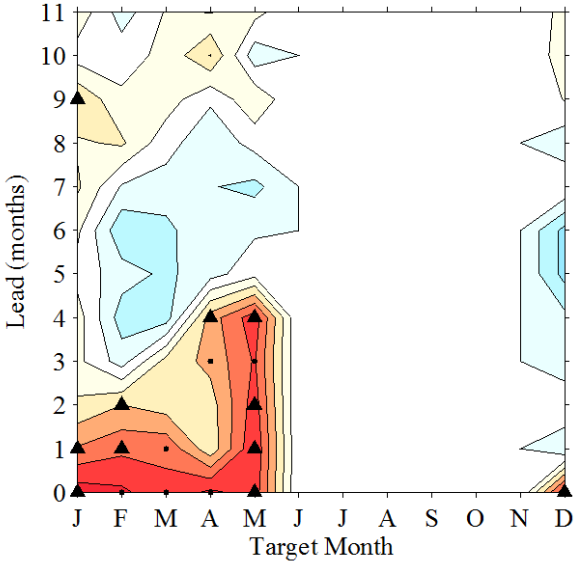
GIN Seas (2)

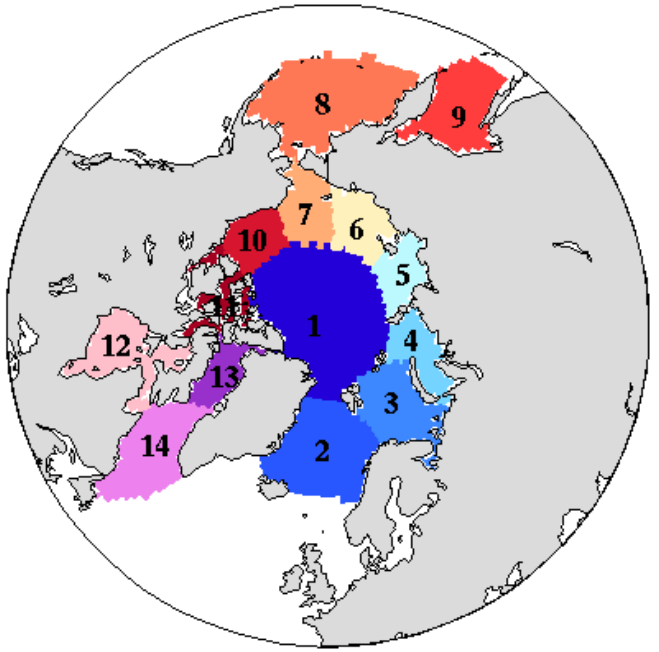


Bering Sea (8)



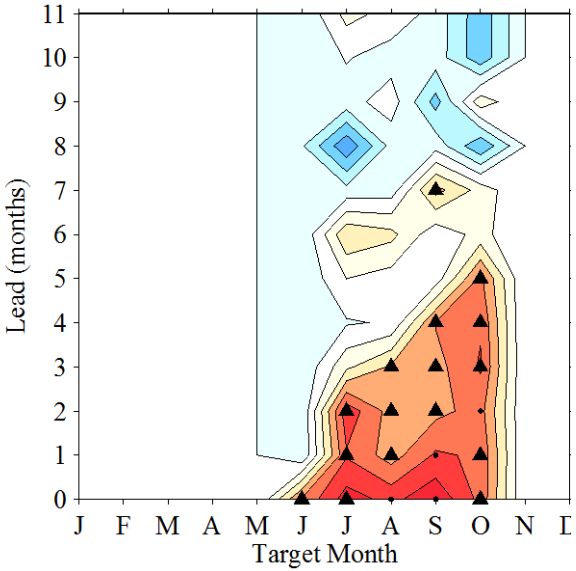
Sea of Okhotsk (9)



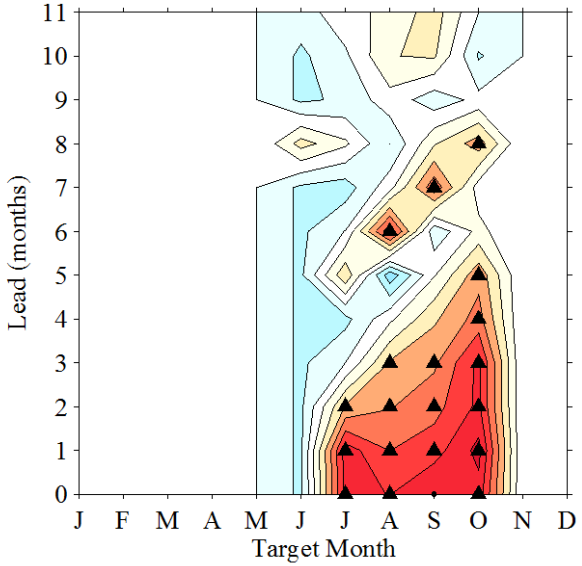


Prediction Skill For Summer Ice Regions (Region # in parentheses)

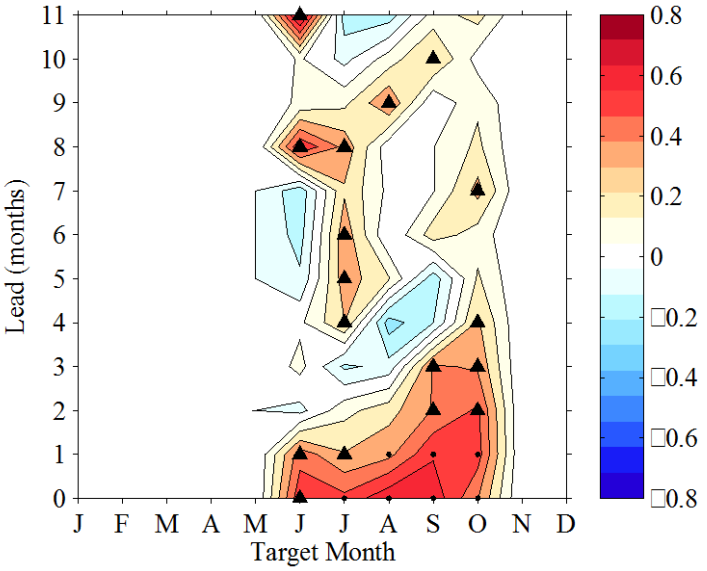
Laptev Sea (5)



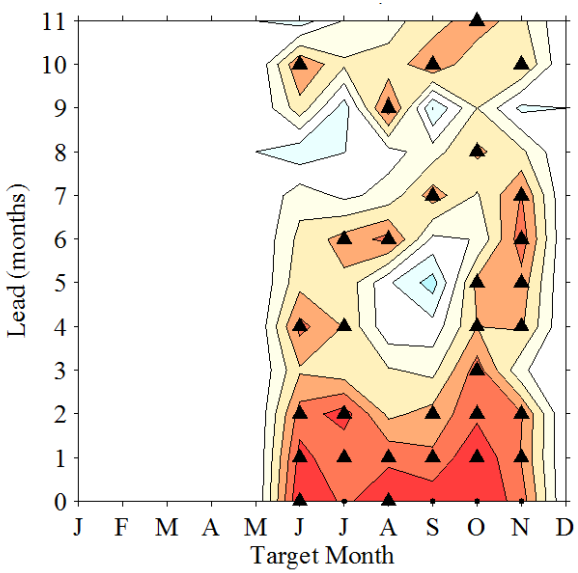
East Siberian Sea (6)



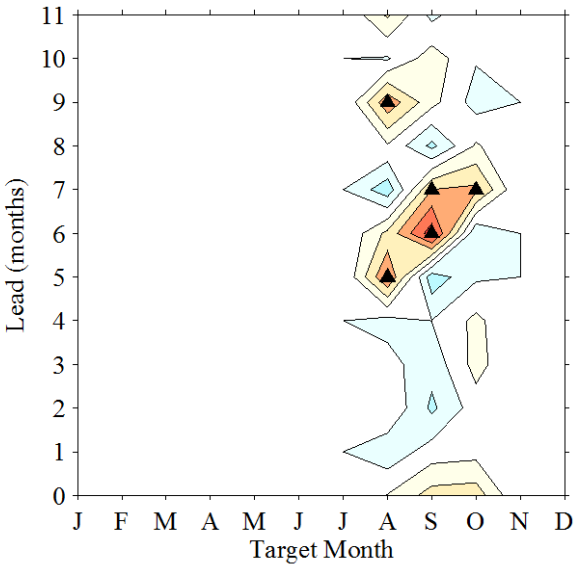
Beaufort Sea (10)

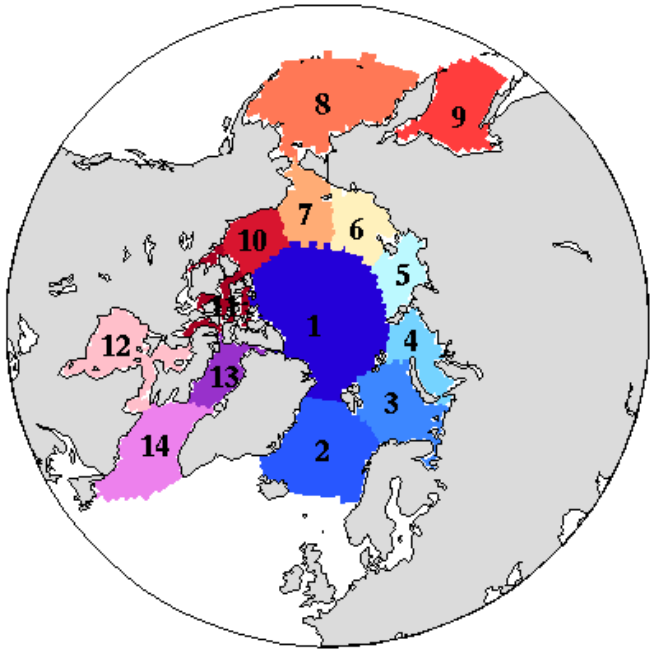


Chukchi Sea (7)



Central Arctic (1)





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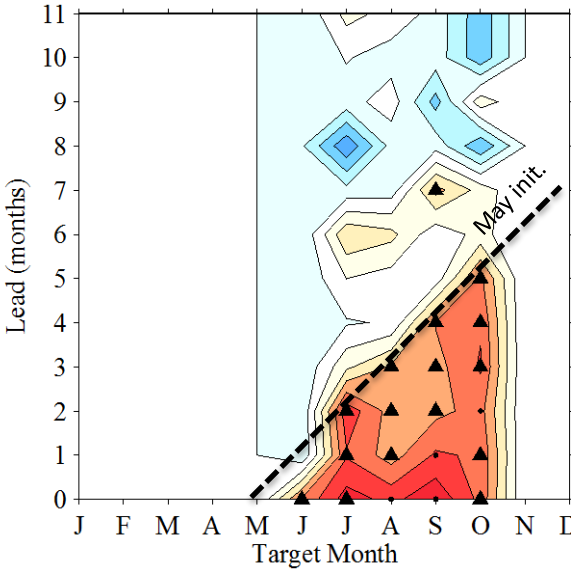

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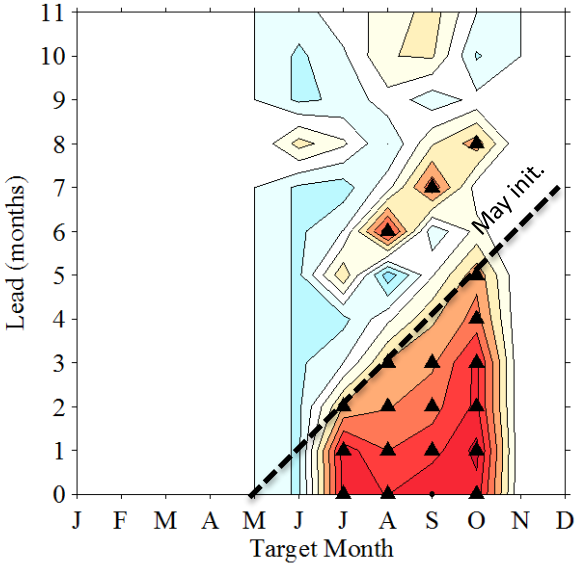

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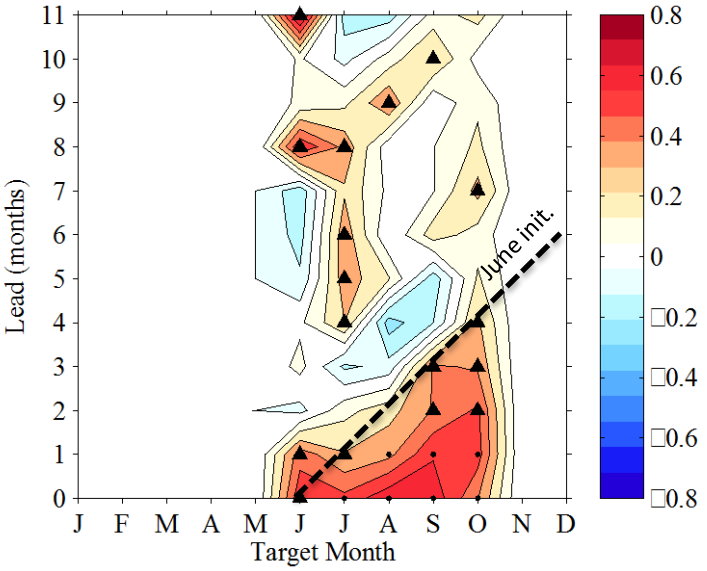

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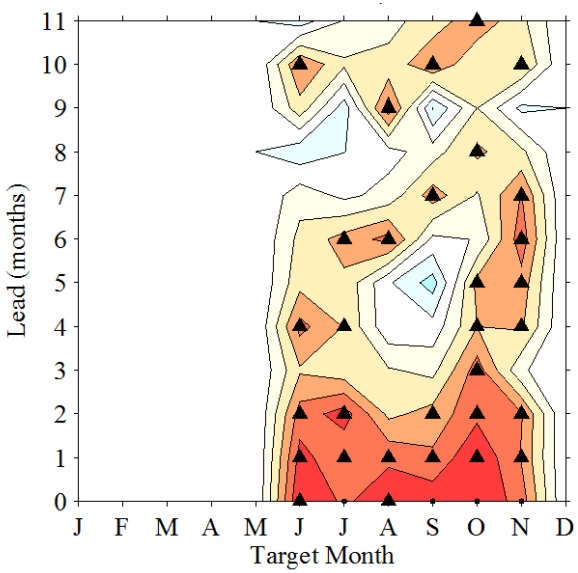

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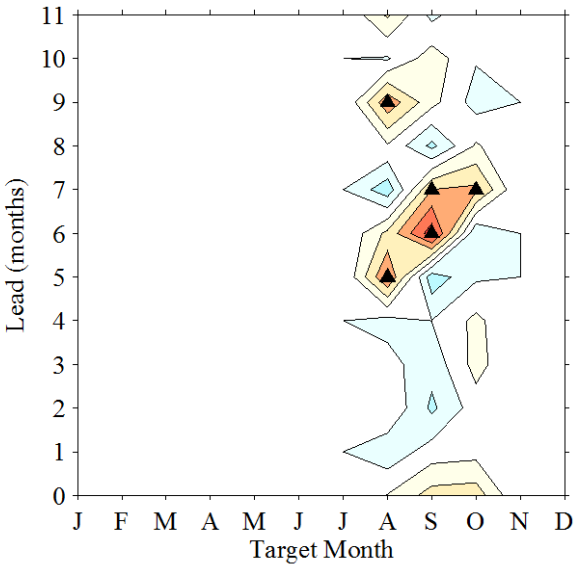

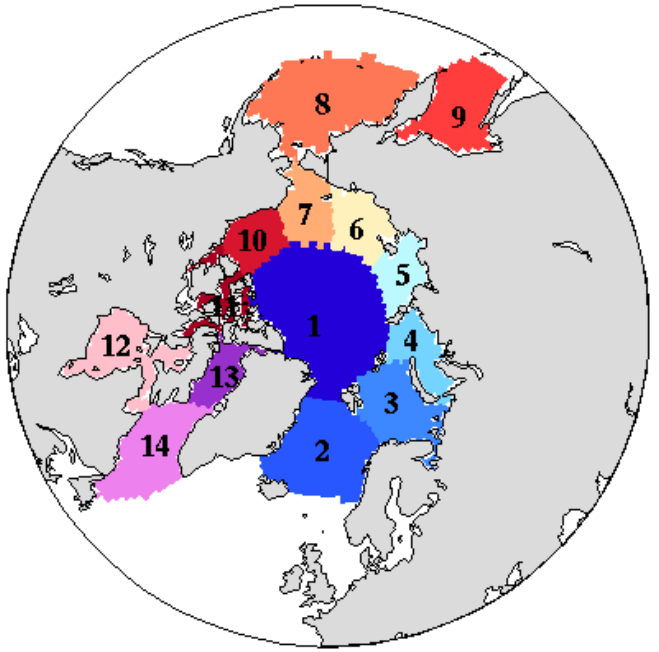

Motivating Questions

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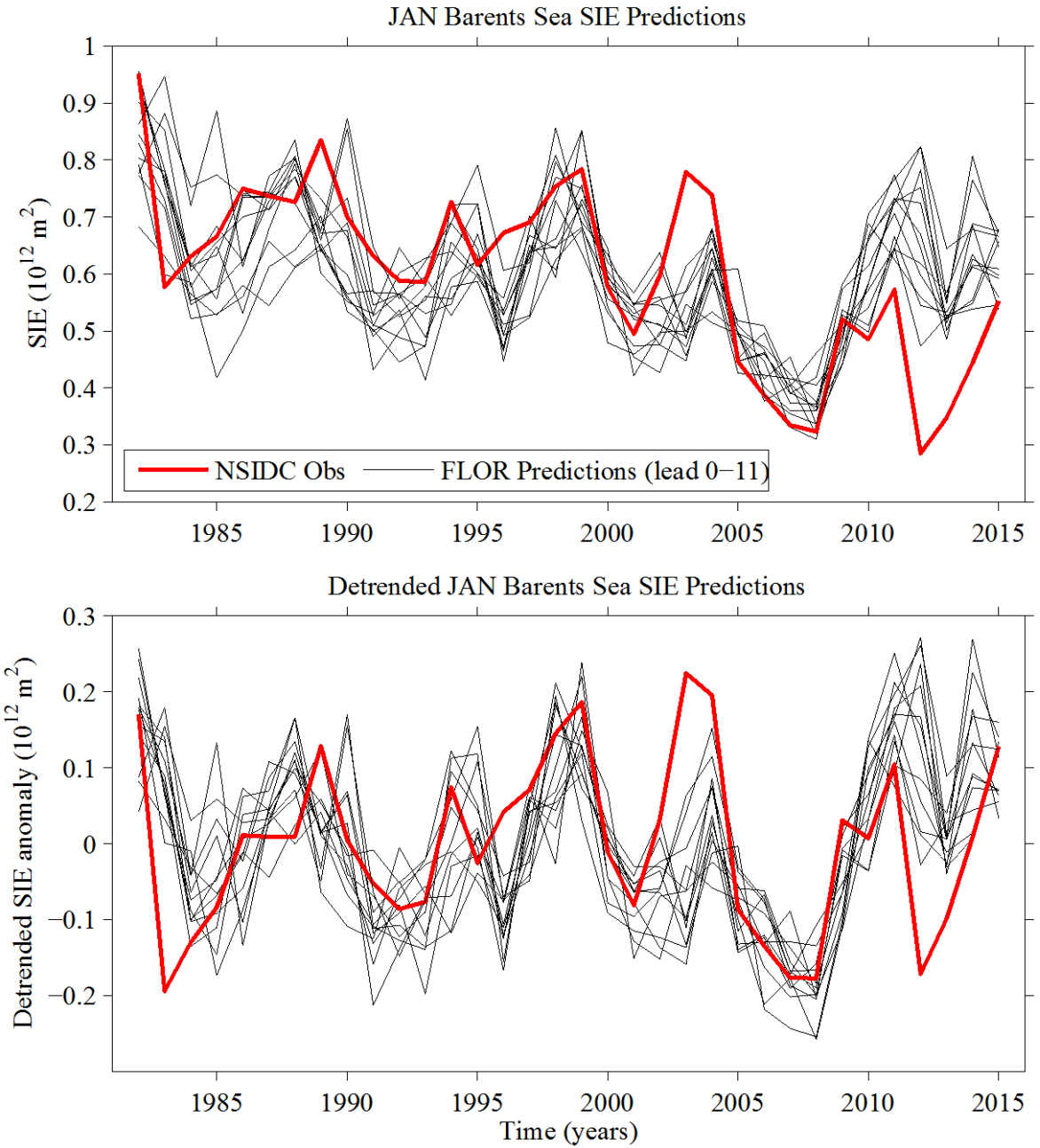
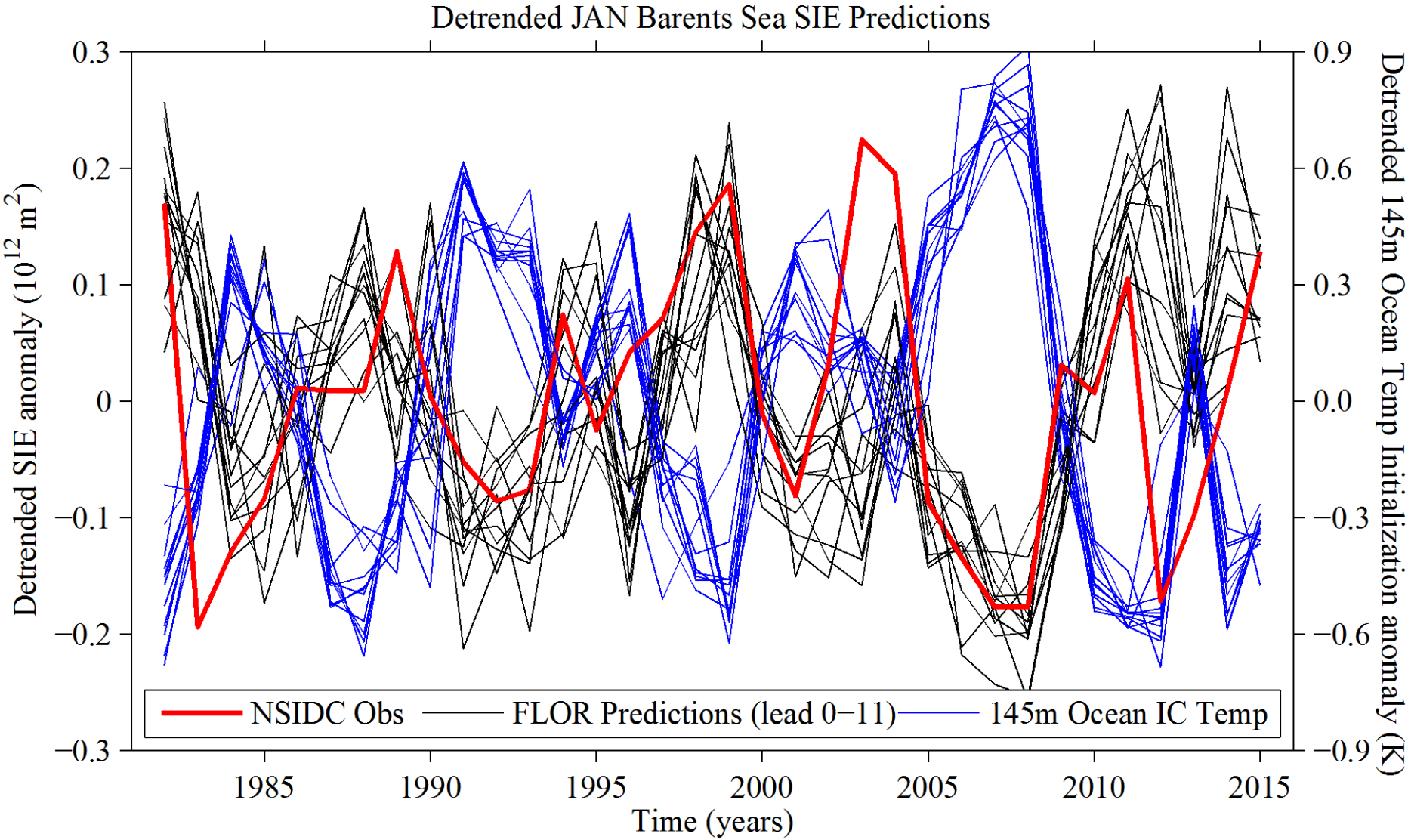
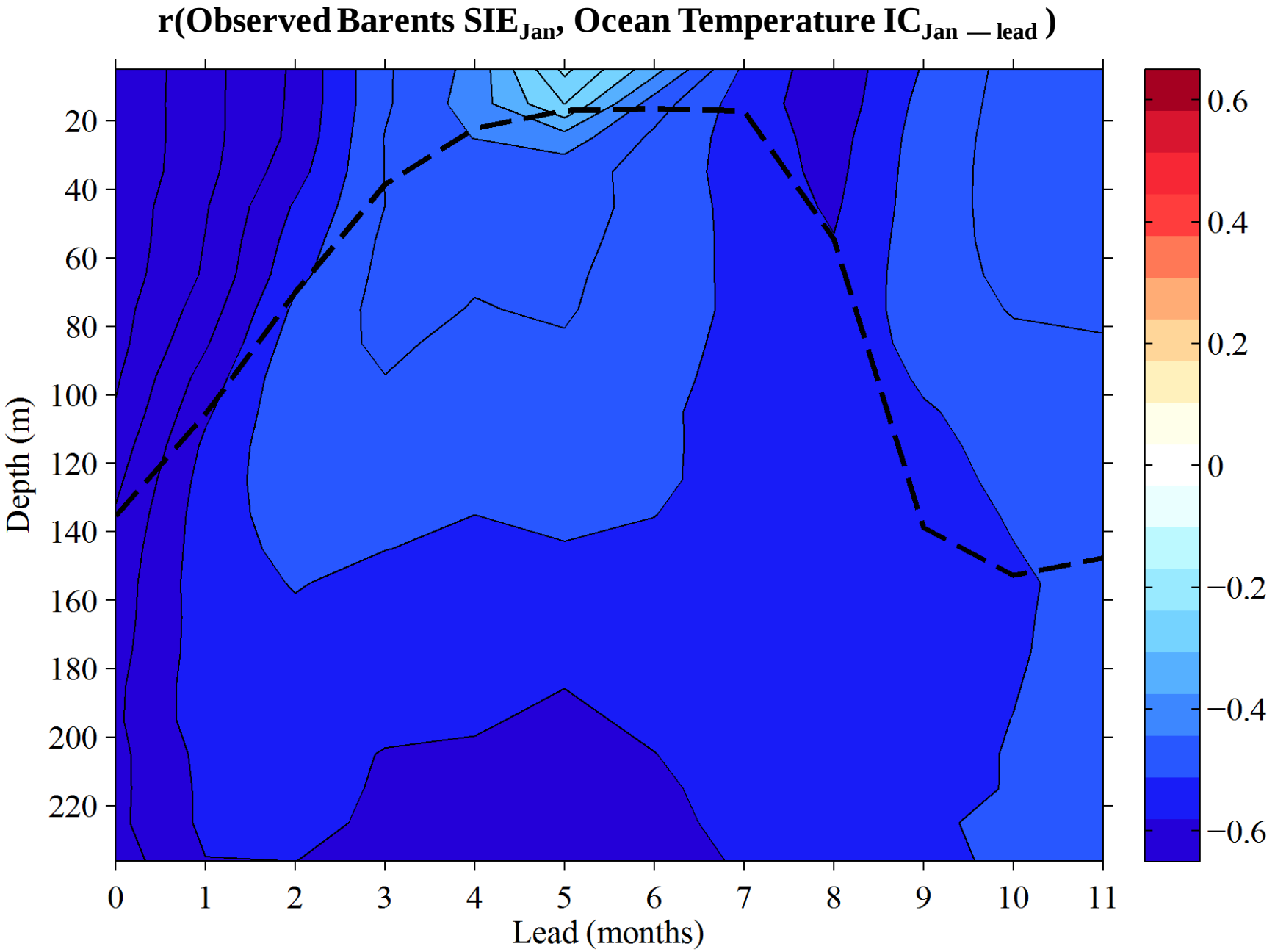
Barents Sea January SIE Predictions



Where is Barents winter skill coming from?

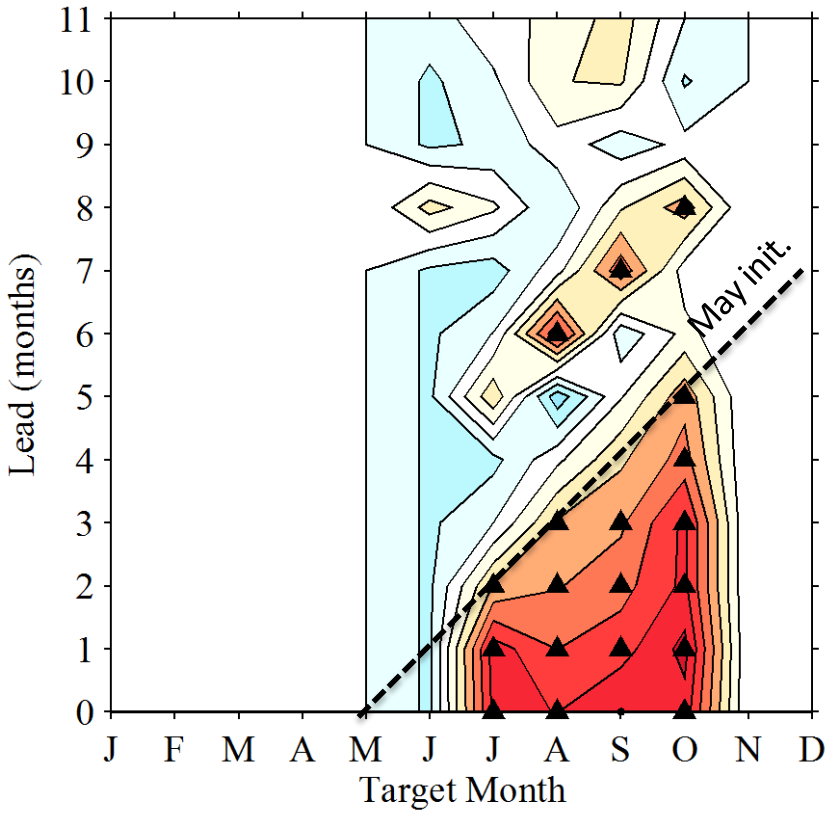


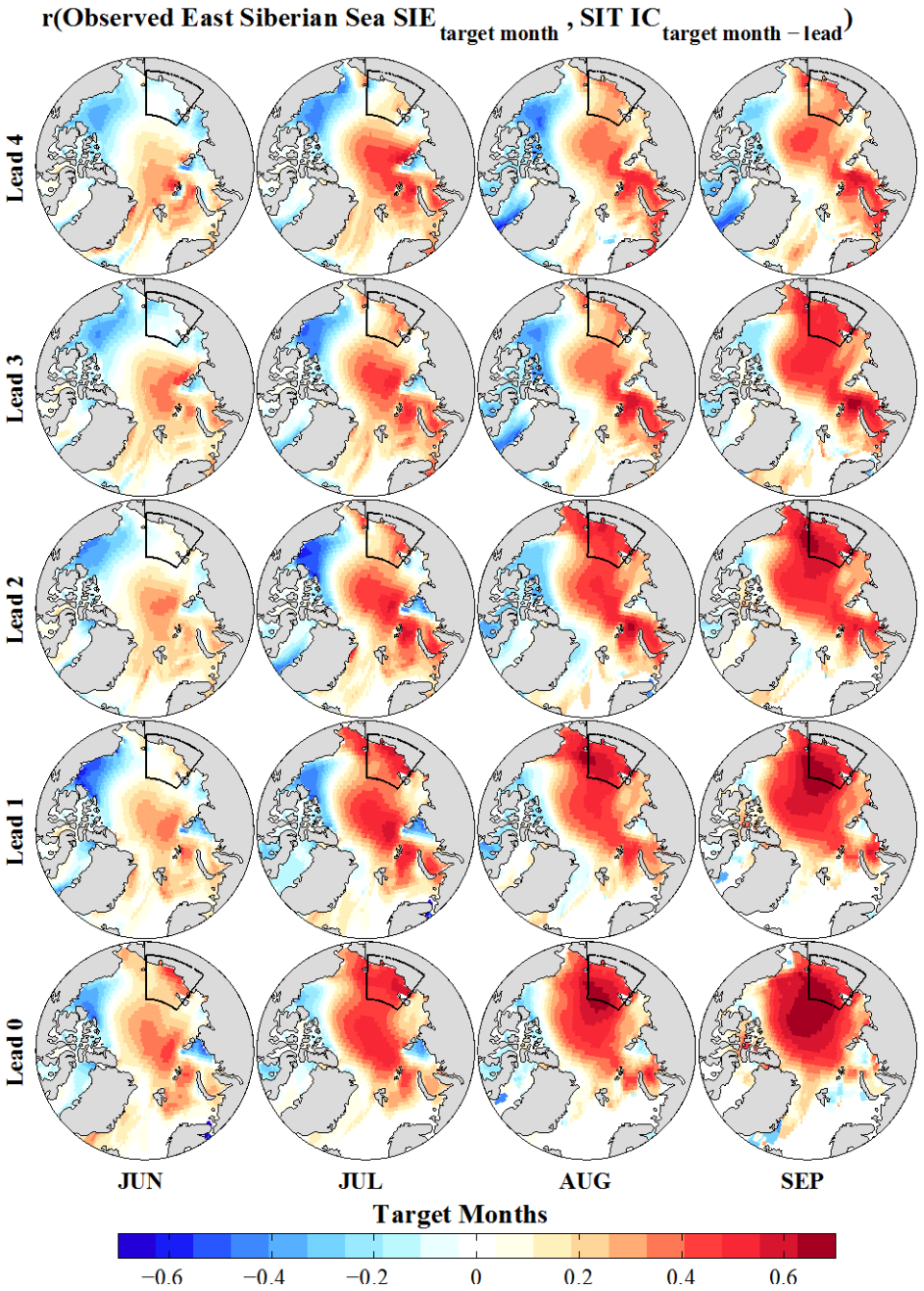
Sources of Winter Prediction Skill: Ocean Temperature Initialization



Sources of Summer Prediction Skill: SIT initialization

East Siberian Sea ACC





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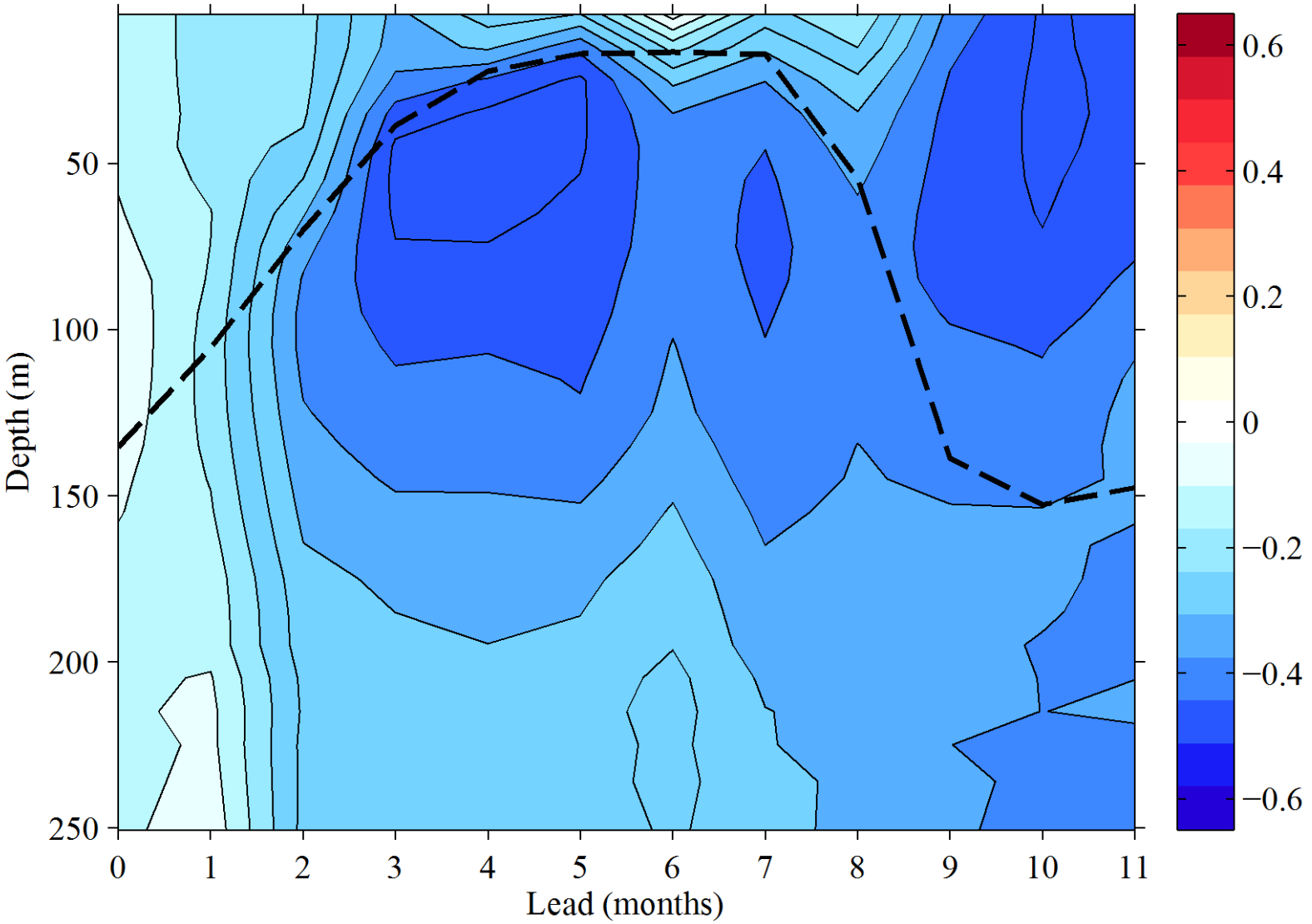
Potential Improvements in Winter Prediction Skill

r(Predicted Barents SIE_{Jan}, Ocean Temperature $IC_{Jan\ -\ lead}$)

minus

r(Observed Barents SIE_{Jan}, Ocean Temperature $IC_{Jan\ -\ lead}$)



Conclusions

1. Regional prediction skill generally exceeds the skill of an anomaly persistence forecast
2. Skill is notably high for winter SIE in the North Atlantic Sector
3. Winter SIE skill is partially attributable to accurate initialization of ocean temperature anomalies
4. Summer SIE skill is partially attributable to initialization of sea-ice thickness anomalies
5. Further skill improvements may be possible with improved subsurface ocean initialization and satellite-based sea-ice thickness initialization

Thank you!
Questions?

Contact me at: mbushuk@princeton.edu