Arctic Sea-Ice Prediction in the GFDL Forecast System

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The Changing Arctic Sea-Ice Cover

**Negative extent trend**

Average Monthly Arctic Sea Ice Extent
September 1979 - 2016

**Negative volume trend**

Arctic Sea Ice Volume Anomaly and Trend from PIOMAS

**Younger and thinner ice cover**

**Longer melt seasons**
Pan-Arctic Prediction Skill for Detrended SIE anomalies

(b) ACC of detrended anom


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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(3) How can regional skill be improved? How much?
The Dynamical Forecast Model

GFDL-FLOR\textsuperscript{1}: Forecast-oriented Low Ocean Resolution

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

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- Ocean and Sea Ice ($1\degree$)

**Initialization Procedure**

ECDA$^2$: **Ensemble Kalman Filter Coupled Data Assimilation**
- 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

**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**

ACC = 0.89

**Target: September; Lead: 2; Detrended**

ACC = 0.63
Pan-Arctic Prediction Skill: All target months and lead times 0-11 months exceed persistence forecast and is significant at 95% level.

Note: All correlations computed using linearly detrended data.
Regional Prediction Skill

Arctic Regions

1: Central Arctic
2: GIN Seas
3: Barents Sea
4: Kara Sea
5: Laptev Sea
6: East Siberian Sea
7: Chukchi Sea
8: Bering Sea
9: Sea of Okhotsk
10: Beaufort Sea
11: Canadian Archipelago
12: Hudson Bay
13: Baffin Bay
14: Labrador Sea
15: Open Ocean
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)
- Sea of Okhotsk (9)
- Bering Sea (8)
- GIN Seas (2)
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)
Prediction Skill For Summer Ice Regions (Region # in parentheses)

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- East Siberian Sea (6)
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Barents Sea January SIE Predictions

JAN Barents Sea SIE Predictions

Detrended JAN Barents Sea SIE Predictions
Where is Barents winter skill coming from?
Sources of Summer Prediction Skill: SIT initialization

East Siberian Sea ACC

Target Month

Lead (months)

J F M A M J J A S O N D

Mayinit.

r(Observed East Siberian Sea SIE\text{target month}, SIT IC_{\text{target month} - \text{lead}})
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Potential Improvements in Winter Prediction Skill

\[ r(\text{Predicted Barents SIE}_{Jan}, \text{Ocean Temperature IC}_{Jan} - \text{lead}) \]

\[ \text{minus} \]

\[ r(\text{Observed Barents SIE}_{Jan}, \text{Ocean Temperature IC}_{Jan} - \text{lead}) \]
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?

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