Seasonal prediction of Arctic sea ice extent in the CFSv2

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Sea ice extent (SIE): Sum of areas where sea ice concentration > 15%

Shadings: CFSv2 concentration

Blue lines: NSIDC 15% concentration
Observed September sea ice extent ($10^6$ km$^2$)
Outline

1. Hidcast and observed data
2. Mean bias in CFSv2
3. SIE prediction skill and predictability
4. Factors affecting the prediction and predictability
   • Model errors
   • Initialization
5. Summary
Data

1. Forecast
   i) CFSv2 hindcasts from 1982-2007
   ii) 16 forecast ensemble members from each month
   iii) 10 target months

2. Observed data
   i) NSIDC sea ice concentration
   ii) NCEP sea ice concentration analysis
Mean bias in CFSv2
Errors in SIE climatology (CFSv2 - NSIDC)
Sea ice coverage

Shadings: CFSv2 concentration at 5-month lead
Blue lines: NSIDC 15% concentration

Target month
Sea ice coverage

Shadings: CFSv2 concentration at 5-month lead
Blue lines: NSIDC 15% concentration
Sea ice coverage

Shadings:  CFSv2 concentration at 5-month lead
Blue lines:  NSIDC 15% concentration
Sea ice coverage

Shadings: CFSv2 concentration at 5-month lead
Blue lines: NSIDC 15% concentration
Prediction skill and predictability
March sea ice extent anomalies ($10^6$ km$^2$)

Total anomalies

L0: 0-month lead
L2: 2-month lead
September sea ice extent anomalies ($10^6$ km$^2$)

Total anomalies

- **LO**: 0-month lead
- **L2**: 2-month lead

Year

Data sources:
- CFSv2 L0
- CFSv2 L2
- NSIDC
September sea ice extent anomalies ($10^6 \text{ km}^2$)

- L0: 0-month lead
- L2: 2-month lead

Detrended

SIE anomaly

Year

September sea ice extent anomalies ($10^6 \text{ km}^2$)

$Y_2Y(n) = Y(n+1) - Y(n)$

- L0: 0-month lead
- L2: 2-month lead
Factors affecting the prediction and predictability

(1) **Model errors**
   i) Mean bias
   ii) Variability in the forecast system

(2) **Initialization**
   i) Sea ice coverage
   ii) Sea ice thickness
SIE standard deviation (10^6 km^2)

- CFSv2 L0
- CFSv2 L2
- CFSv2 L5
- NSIDC

**Total**

**Y2Y**

- CFSv2 too strong
- CFSv2 too weak
For September, too weak variability in CFSv2 may have resulted in an overestimate of predictability.
For March, too strong variability in CFSv2 may have resulted in an **underestimate** of predictability.
Factors affecting the prediction and predictability

(1) **Model errors**
   i) Mean bias
   ii) Variability in the forecast system

(2) **Initialization**
   i) Sea ice coverage
   ii) Sea ice thickness
Impacts of initial sea ice coverage
August sea ice extent anomalies ($10^6$ km$^2$)

- Negative differences before 1997
- Positive differences after 1997
- Additional increase after 2008
September sea ice extent (10-year average)
September sea ice extent (10-year average)
Impacts of initial sea ice thickness
September sea ice extent anomalies ($10^6 \text{ km}^2$)

$Y_{n+1} - Y_n = Y_{2Y(n)}$

L0: 0-month lead
L2: 2-month lead

2007-2006
September Y2Y ($10^6$ km$^2$)


2007 - 2006

Observation

CFSv2
CFSR sea ice concentration and thickness
Summary

• CFSv2 forecast contains mean SIE biases that vary with target seasons: Negative in Oct-Dec, and positive in other months. (Spatially, negative biases over Bering Strait, Hudson Bay and David Strait, and positive biases in Labrador Sea, Greenland Sea, Barents Sea.)

• CFSv2 underestimates long-term trend. Overall forecast skill for interannual variations is about two months.

• Improvements needed for a better sea ice prediction
  i) Mean bias
  ii) Representation of interannual variability
  iii) Consistency of the sea ice initialization
  iv) Accuracy of initial sea ice thickness