Seamless prediction systems prove potential for skillful Arctic sea-ice forecasts far beyond weather time scales

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Outlook

Predictability and ensemble forecasting

Research Motivation

The S2S Prediction Project

Verification metrics

Predictive skills

Dynamical models vs Climatology
Predictability and Ensemble Forecasting
A simple set of equations…

\[
\begin{align*}
\frac{dX}{dt} &= -\sigma X + \sigma Y \\
\frac{dX}{dt} &= -XZ + \rho X - Y \\
\frac{dZ}{dt} &= XY - \beta Z
\end{align*}
\]

Lorenz, E. N. (1963) Deterministic nonperiodic flow.
…with an interesting solution

J. Slingo and T. Palmer (2011)
Ensemble Forecasting

J. Slingo and T. Palmer (2011)
Research Motivations
S2S
Sub-seasonal to Seasonal Prediction Project
The S2S timescale

Long-range

2 month

Medium-range

2 week

S2S timescale

Short-range

Nowcasting

Prediction forecast timescale

Image from the S2S Promotional Video
The S2S Database

- Coupled models from operational weather forecast centers

<table>
<thead>
<tr>
<th>UK Met Office</th>
<th>ECMWF</th>
<th>KMA</th>
<th>CMA</th>
<th>Météo France</th>
<th>NCEP</th>
</tr>
</thead>
</table>

- Ensemble forecasts
- Dynamical sea ice components
- Assimilated sea surface temperature and sea-ice concentration
- Long temporal coverage (25 years)
Verification Metrics
The sea-ice edge position

Integrated Ice Edge Error

$\text{IIEE} = O + U$
The Spatial Probability Score

Ensemble sea-ice forecasts

Probabilistic verification metric required

Spatial Probability Score

$$SPS = \iint_{A} (p_f - p_o)^2 \, dA$$

Spatial Probability Skill Score

$$SPSS = 1 - \frac{SPS}{SPS_{CLIM}}$$
Ensemble Forecasting

J. Slingo and T. Palmer (2011)
Methods Summary

- Ensemble S2S sea-ice forecasts
- Verification against satellite observations through the SPS
- Forecast SPS compared with the climatological CSPS
- Assessment of the forecast predictive skills
- Evaluation of the forecast errors and biases
Skills of S2S forecast systems

Results averaged over 12 years of hindcasts (1999-2010)
Forecasting the 2007 minimum
Skills of the climatological forecasts based on the previous 10 years of observations

15/09/2007 forecast is based on:
ECMWF & UKMO

SPSS

AEE and ME

O and U

ECMWF

UKMO

Initial

Day 8

Day 18

Day 32

Day 44

Day 60
Improvements in ECMWF system

NEW!

ECMWF

ECMWF Pres.

SPSS

AEE and ME

O and U

Target Time

-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0

Jan 01 Mar 01 May 01 Jul 01 Sep 01 Nov 01 Jan 01

0 20 40 60 80 100

Jan 01 Mar 01 May 01 Jul 01 Sep 01 Nov 01 Jan 01

0 20 40 60 80 100

Jan 01 Mar 01 May 01 Jul 01 Sep 01 Nov 01 Jan 01

Initial

Day 8

Day 18

Day 32

Day 44

Day 60
Improvements in ECMWF system
Conclusions

• Spread of predictive skills between different forecast systems
• Errors during the data assimilation and relevant model biases affect the forecasts
• Lack of model tuning
• The ECMWF system shows encouraging results. Predictive skills after 46 days.
• Assimilation of new sea-ice thickness observations could be beneficial