



Met Office
Hadley Centre

Initialization of the ocean and sea ice in the GloSea5 Seasonal Forecast System



Seasonal-to-decadal climate Prediction for the
Improvement of European Climate Services

Drew Peterson

Applications of
Satellite Climate Data Records
in Numerical Modeling

ECMWF

16 NOV 2016



EVALUATION OF OCEAN SYNTHESSES

COST Action 1402

COST
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY



COST is supported by the EU Framework

GloSea5-GC2 Seasonal Forecast System

- Met Office Seasonal forecast system.
 - ▶ N216 (0.7°) / ORCA025 (0.25°) resolution.
 - ▶ MacLachlan et al. [2015], QJRMS, 141, doi:10.1002/qj.2396
- HadGEM3 Global Coupled 2.0 Williams et al. [2015]
 - ▶ UM (atmos), NEMO (ocean), CICE (sea-ice), JULES (land)

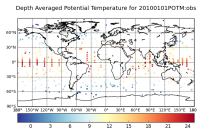
HINDCASTS (to support forecast)

- 1993–2015: New for C3S system.
- Hindcasts are run operationally so system is easy to update.
- Forecasts Initialized:
 - ▶ **Atmosphere:** Met Office NWP 4DVAR atmospheric analysis
 - ▶ **Ocean/Ice** Forecast Ocean Assimilation Model (FOAM)
- Hindcasts Initialized:
 - ▶ **Atmosphere:** ERAi atmospheric analysis
 - ▶ **Ocean/Ice** GloSea5 Ocean and Sea Ice Analysis (GS5-OSIA)

Observations Assimilated

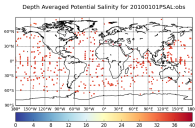
In situ Surface Data

Temperature Profiles

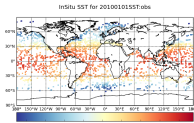


EN4: Argo, moored buoys, XBTs, CTDs, marine mammals, gliders

Salinity Profiles

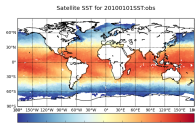


EN4: Argo, moored buoys, CTDs, gliders



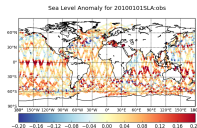
ICOADS: Ships, moored and drifting buoys

Satellite SST



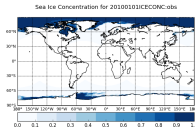
NOAA and MetOP
AVHRR, (A)ATSR,
AMSRE

Altimeter Data



AVISOv3

Sea Ice concentration



OSI-SAFv2 SSMI/S

Forecast/Hindcast Initialization

Hindcast/Forecast Initialization
are *the same*

- NEMO/CICE ORCA025
 - ▶ Global Ocean 5.0 (GO5)
Megann et al. [2014]
 - ▶ Global Sea Ice 6.0 (GSI6)
Rae et al. [2015]
- NEMOVAR (3D-VAR)
 - ▶ Multivariate with balance relationships
 - ▼ Waters et al. [2014]
 - ▼ Preservation of T/S relationship
 - ▼ Geostrophic balance

Hindcast/Forecast Initialization
differ

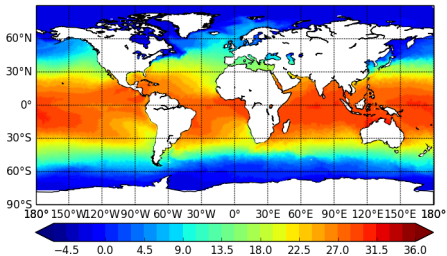
- CORE Surface Bulk Forcing:
 - ▶ GS5-OSIA: ERAi atmosphere
 - ▶ FOAM: Met Office NWP atmosphere
- Separately spun up.
- May affect non and sparsely assimilated fields:
 - ▶ Sea Ice Thickness
 - ▶ Surface salinity
 - ▶ Assimilate Observations!

Differences SST

Short period of overlap

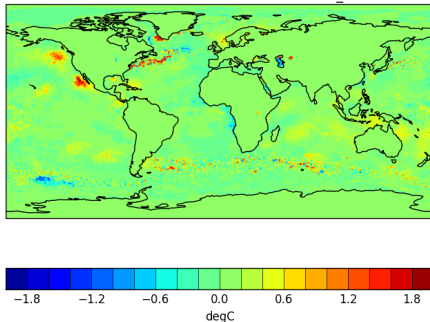
201503 Hindcast Initialization

potential temperature(degC) at 0.51 m at 12:00:00 on 16/03/2015
Extrema (-2.180,32.267)



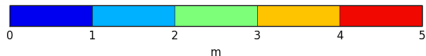
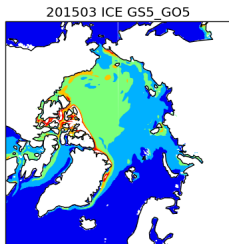
Forecast - Hindcast Initialization

201503 SST difference FOAMv13 - G55_G05



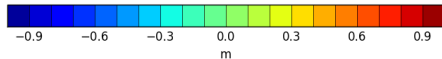
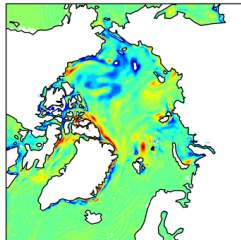
Differences Sea Ice

201503 Hindcast Initialization



Forecast - Hindcast Initialization

201503 ICE difference FOAMv13 - GS5_G05

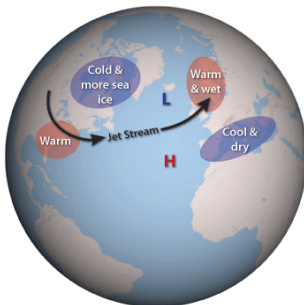


North Atlantic Oscillation

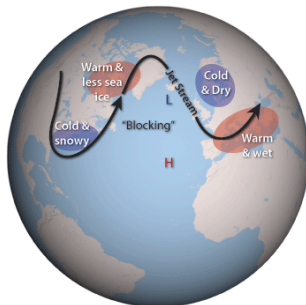
In the meantime the weather is fair, though the cold is intense. For it is in the nature of the glacier to emit a cold and continuous breath which drives the storm clouds away from its face so that the sky above is usually clear. But the neighbouring lands often have to suffer because of this; for all the regions that lie near get severe weather from this ice, inasmuch as all the storms that the glacier drives away from itself come upon others with keen blasts.

Norse book King's Mirror circa 1230, taken from Stephenson et al. [2013]

Positive NAO



Negative NAO



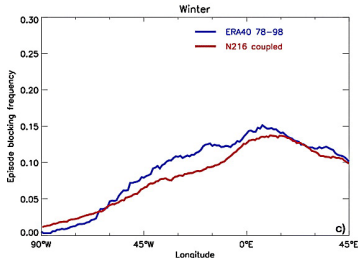
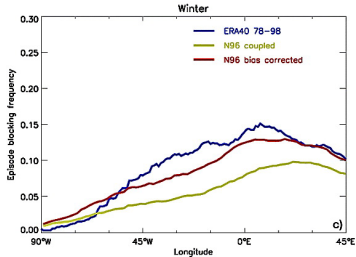
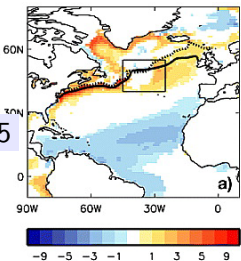
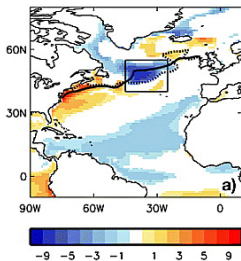
$$NAO_i = SLP'_{Lisbon} - SLP'_{Reykjavik}$$

Importance of SST bias for NAO

ORCA1

A realistic mean state matters:
Biases in coupled model climate runs

ORCA025

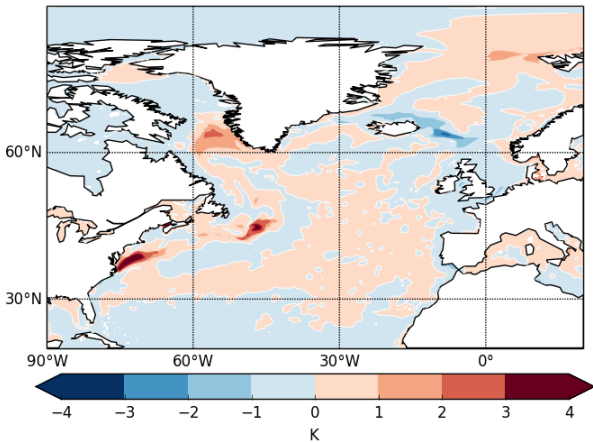


Scaife et al. [2011], Geophys. Res. Lett., 38, L23703,
doi:10.1029/2011GL049573

Bias in Coupled Hindcast

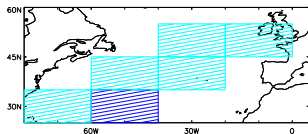
DJF Bias from 1 Nov start date

Temperature bias at Depth 0.50576

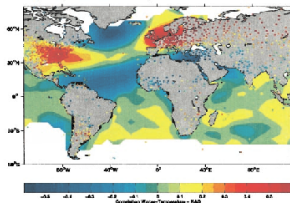


Re-Emergence 2009 to 2010

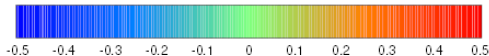
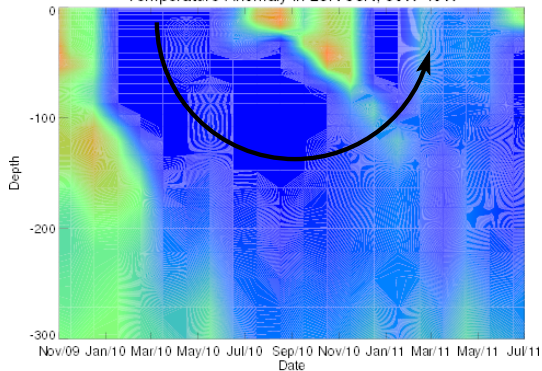
Can imprint of NAO on SST re-emerge in next winter to force NAO?



Winter (DJFM) SST and Land Temperature correlated with NAO index



Temperature Anomaly in 25N-35N, 60W-40W

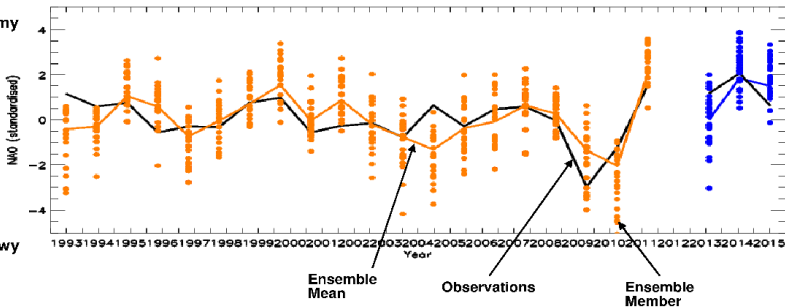


GloSea Forecasts of Winter NAO

+ NAO
Mild, wet
and stormy

- NAO
Cold, snowy
and still

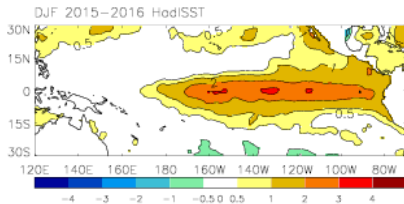
Retrospective and real time predictions



Scaife et al. [2014], Skillful long-range prediction of European and North American winters, *Geophys. Res. Lett.*, 41, 25142519, doi:10.1002/2014GL059637.

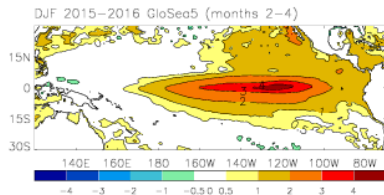
2015/16 El Niño Prediction

DJF Observed



Last winter was
near record El Niño

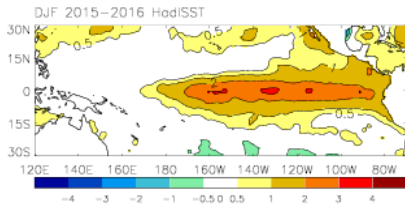
DJF Forecast



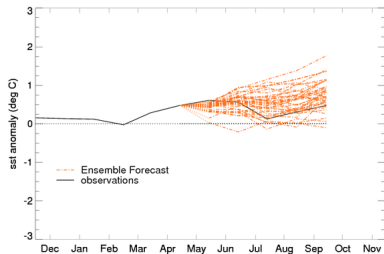
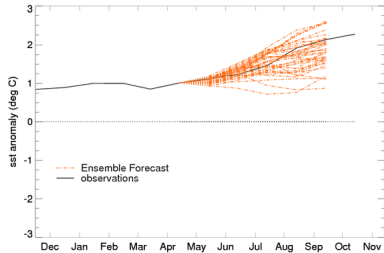
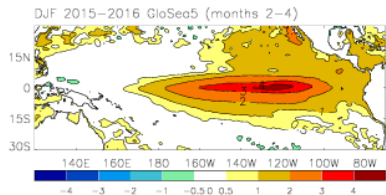
Excellent forecast
of SST from
November

2015/16 El Niño Prediction

DJF Observed

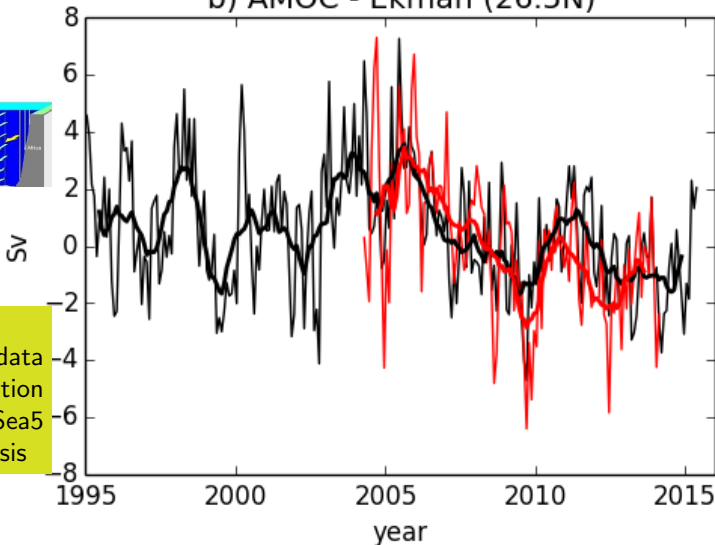


DJF Forecast



Atlantic Overturning Circulation

b) AMOC - Ekman (26.5N)

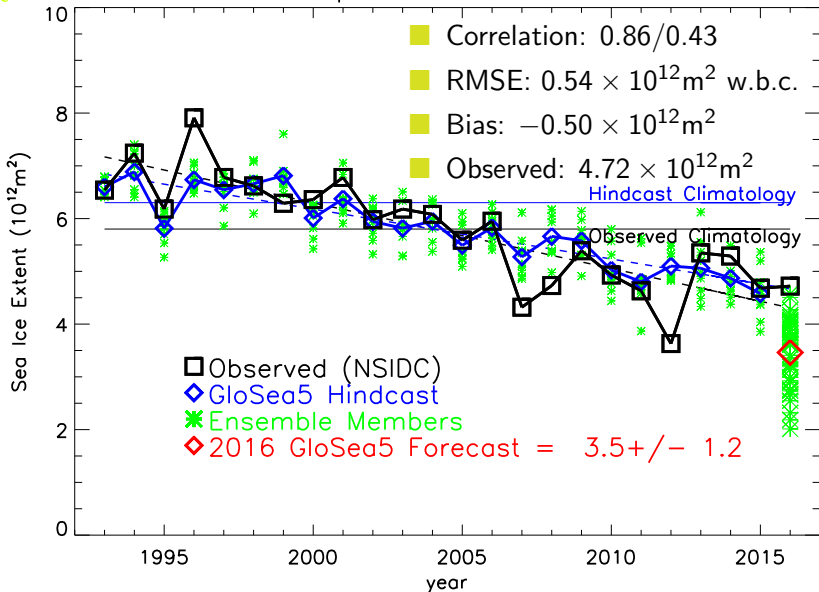


Note:

No RAPID data is assimilation in the GloSea5 Ocean Analysis

01 May Outlook for Sep 2016 Sea Ice

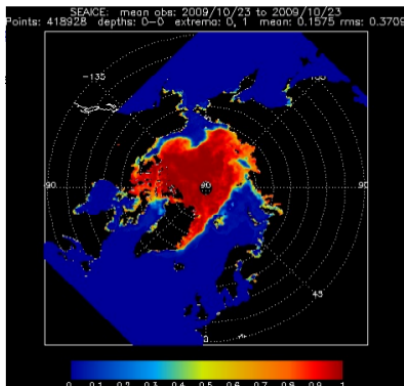
September Ice Extent



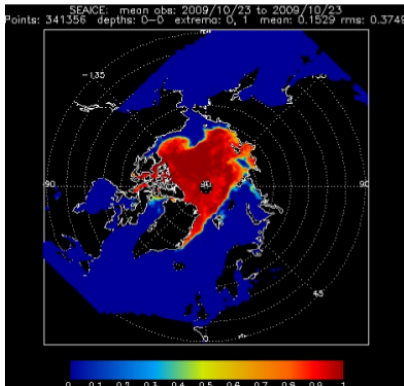
OSISAF Sea Ice v2 vs RT

23 October 2009

OSISAF-v2

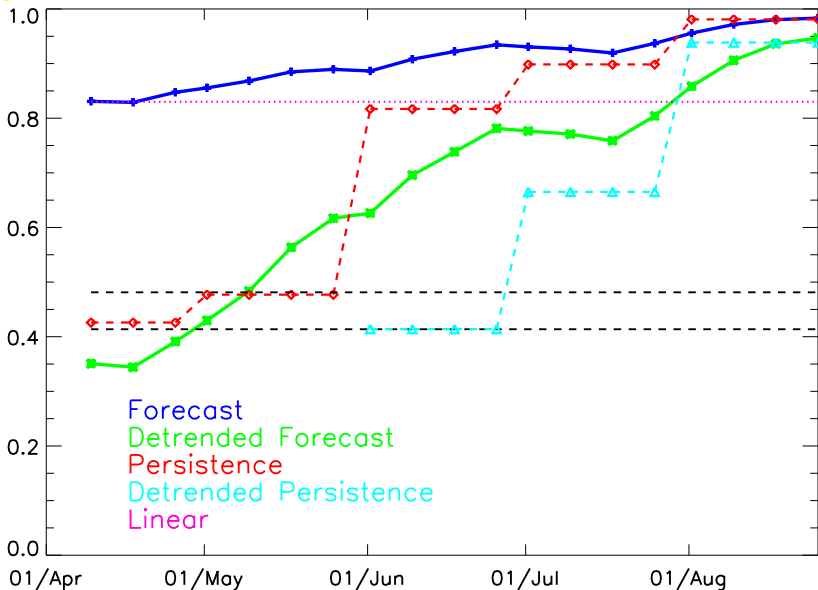


OSISAF-RT



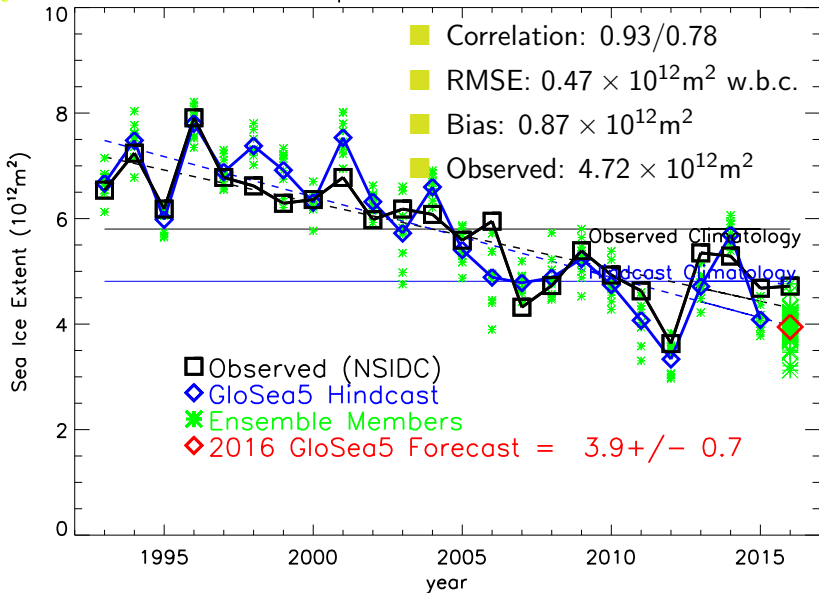
Correlation Skill Through Summer

Correlation versus initialization date for month 09



01 July Outlook for Sep 2016 Sea Ice

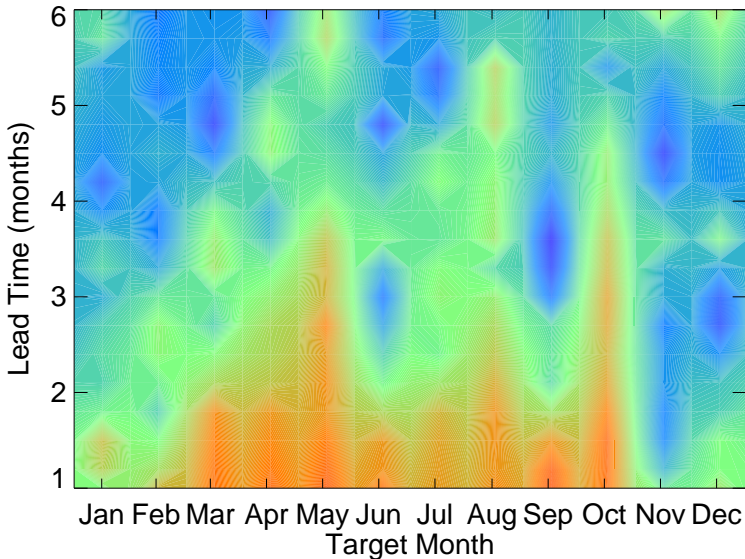
September Ice Extent



Correlation Skill Through Year

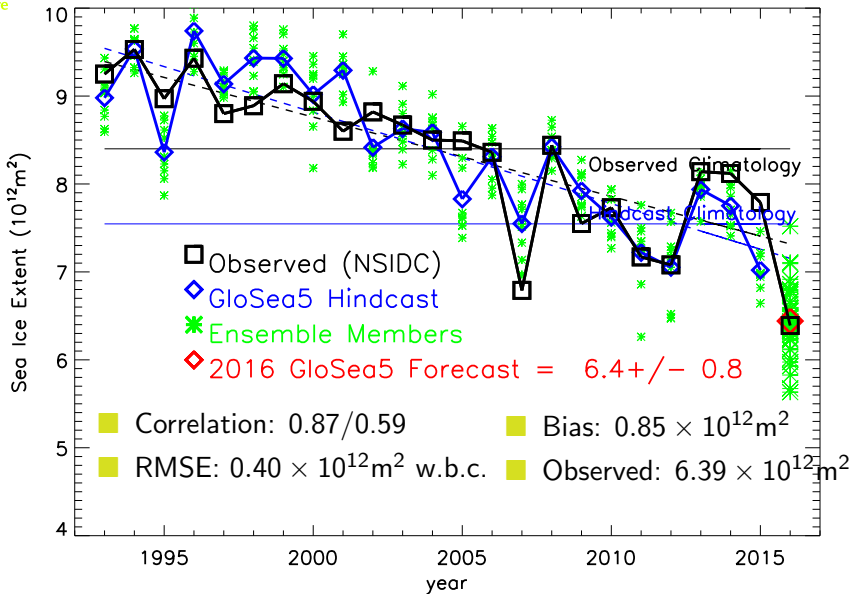
Hindcast Detrended Correlations

Warning: Some points are extrapolated.
January forecast not included.



01 June Outlook for Oct 2016 Sea Ice

October Ice Extent



GloSea5 Ocean Analysis

- Leads to skillfull NAO forecast
 - ▶ Underlying Model has good representation North Atlantic SST
 - ▶ Evidence that cold anomalies re-emerge in analysis
 - ▶ Good simulation of El Niño in analysis

- Ocean analysis captures observed AMOC at 26°N
- Assimilation of Sea Ice concentration leads to skillful Sea Ice forecasts.
- Biases may be complicated by ice thickness uncertainty
 - ▶ Assimilation of Sea Ice thickness

Global DJF SLP ensemble mean forecast

<http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-out>

Ensemble mean anomaly : mean sea level pressure : Dec/Jan/Fe
Issued November 2016

