

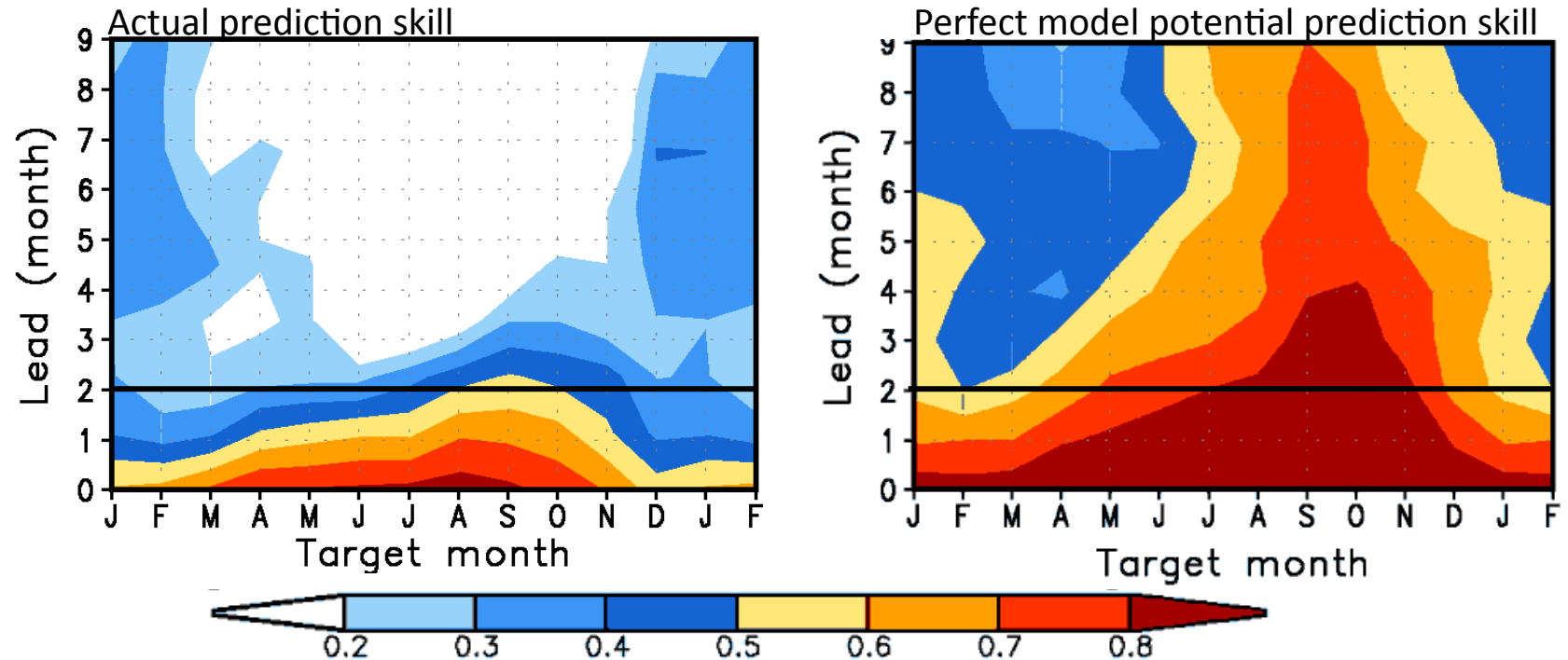
The need of better initial conditions for improved seasonal sea ice predictions in CFS

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NOAA/NWS/NCEP

Anomaly correlation coefficient (ACC) of sea ice extent (SIE) interannual anomalies CFSv2 hindcast (1982-2007)



- September SIE predictable up to 3-month lead time
- September SIE potentially predictable beyond 9 months

Consistency with relevant studies:

Merryfield et al. (2013): Skillful sea ice area prediction at 3-month lead time in CanSIPS.

Blanchard-Wrigglesworth et al. (2011): Sea ice area potentially predictable beyond 1 year.

What caused the gap between the current prediction capability and potential predictability?

- Initialization
- Physical parameterization

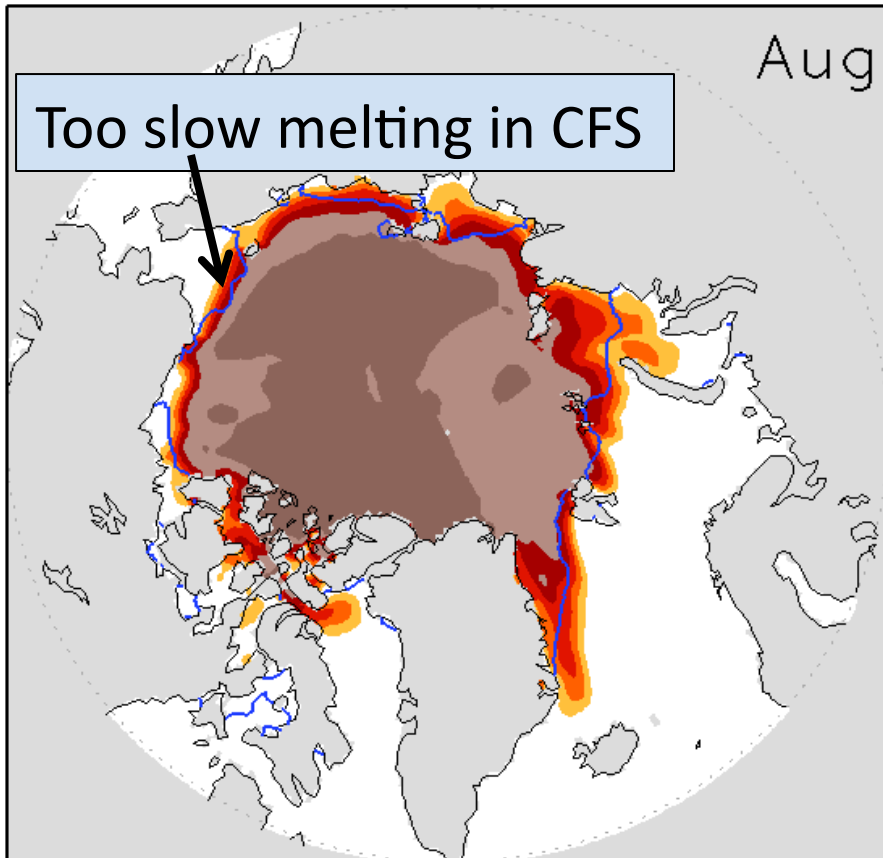
Outline

1. Forecast sea ice errors in the operational CFS.
2. What caused these errors?
3. What can we do to improve the prediction?

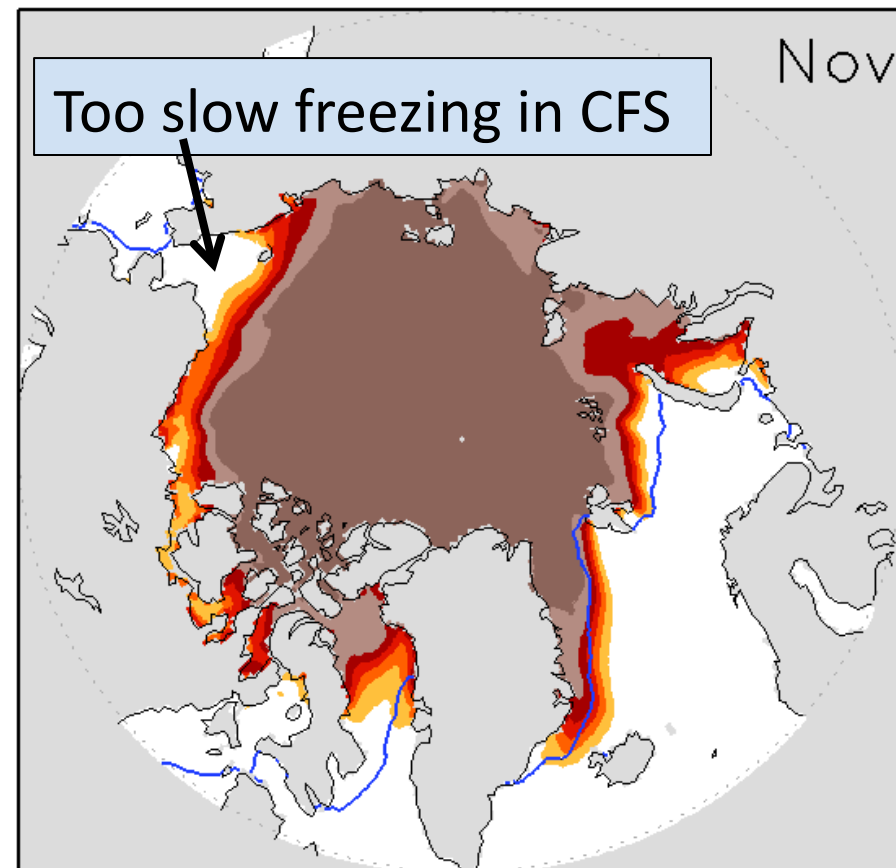
1. Forecast sea ice errors in the operational CFS

Sea ice concentration climatology

August Forecast from March IC

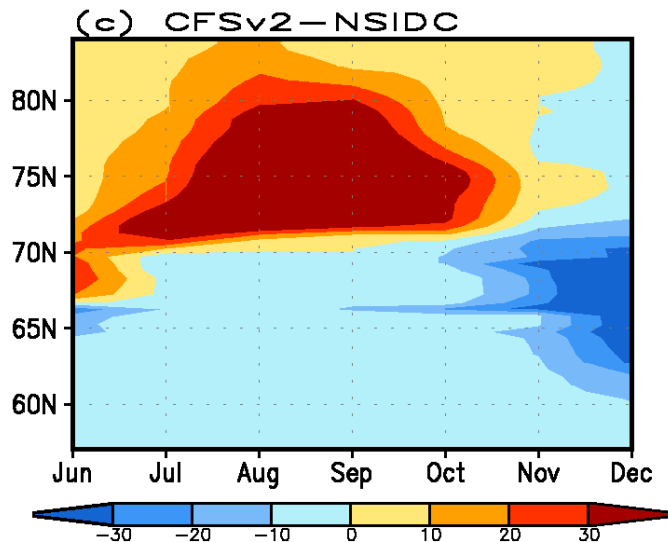
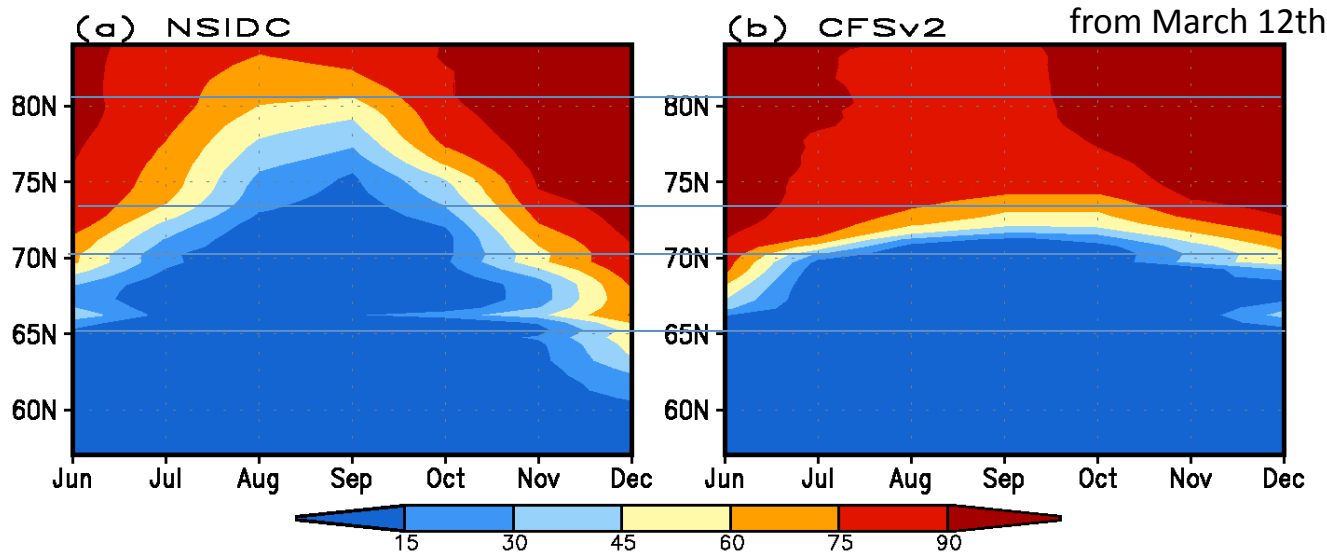


November Forecast from June IC



(Blue lines: NSIDC 15% concentration)

Zonal mean sea ice concentration (%) around Bering Sea and Chukchi Sea (170-200E) (2009-2013 average)



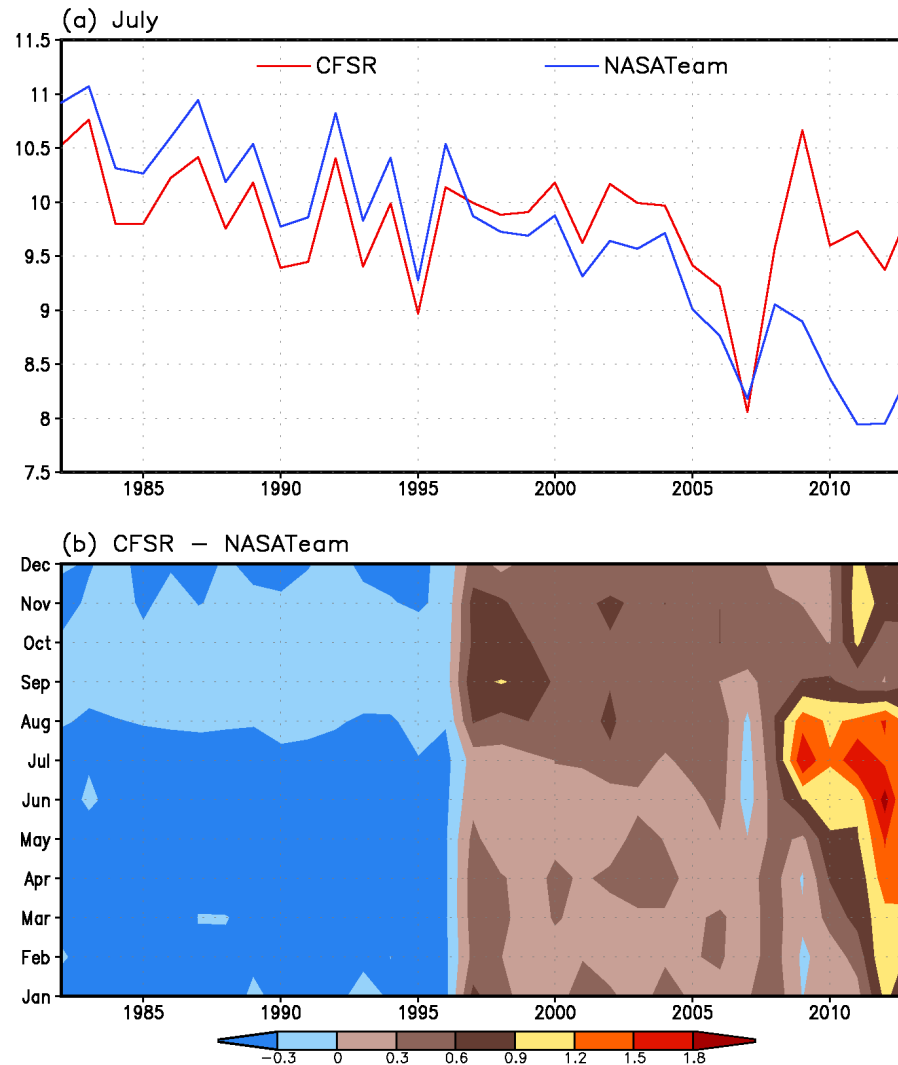
- Slower melting in summer
- Slower freezing in fall
- Weaker seasonal cycle

2. What caused these errors?

- Errors in initialization
- Errors in physics

Errors in the initialization

Errors in initial Sea Ice Extent (10^6 km^2) in CFSR

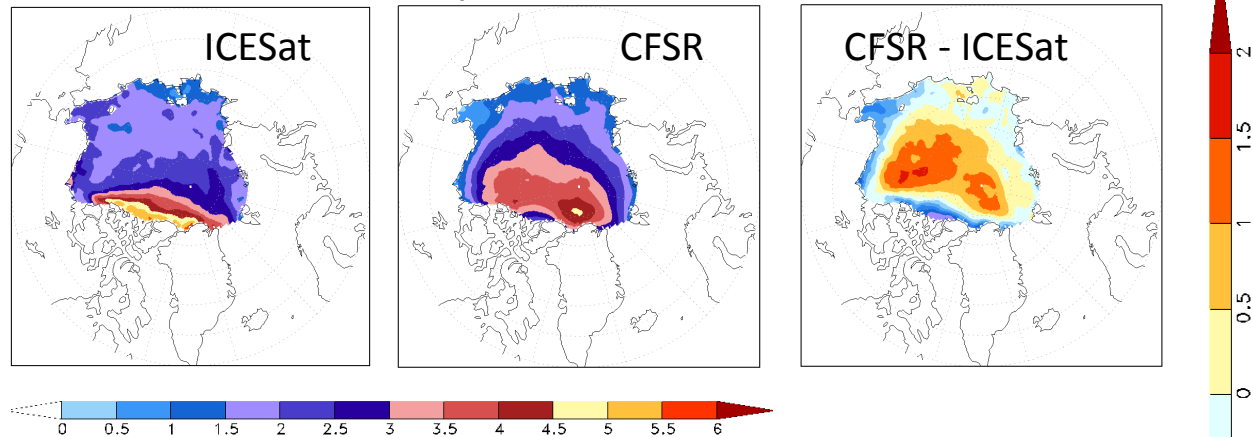


CFSR: Climate Forecast System Reanalysis providing initial conditions for CFSv2

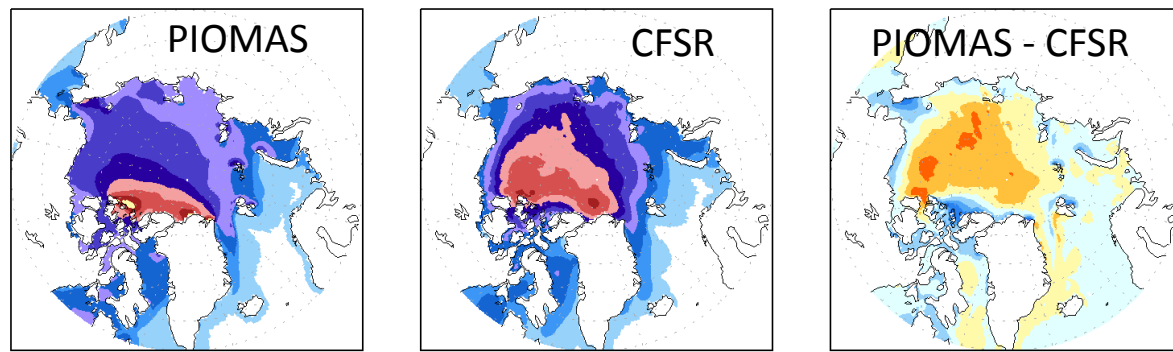
- 1) Significant jumps in 1997 and 2008
- 2) The resulting time-dependent systematic bias in forecast is difficult to remove 10

Errors in initial CFSR ice thickness (m)

February – March (2004-2008)



March (2004-2008)

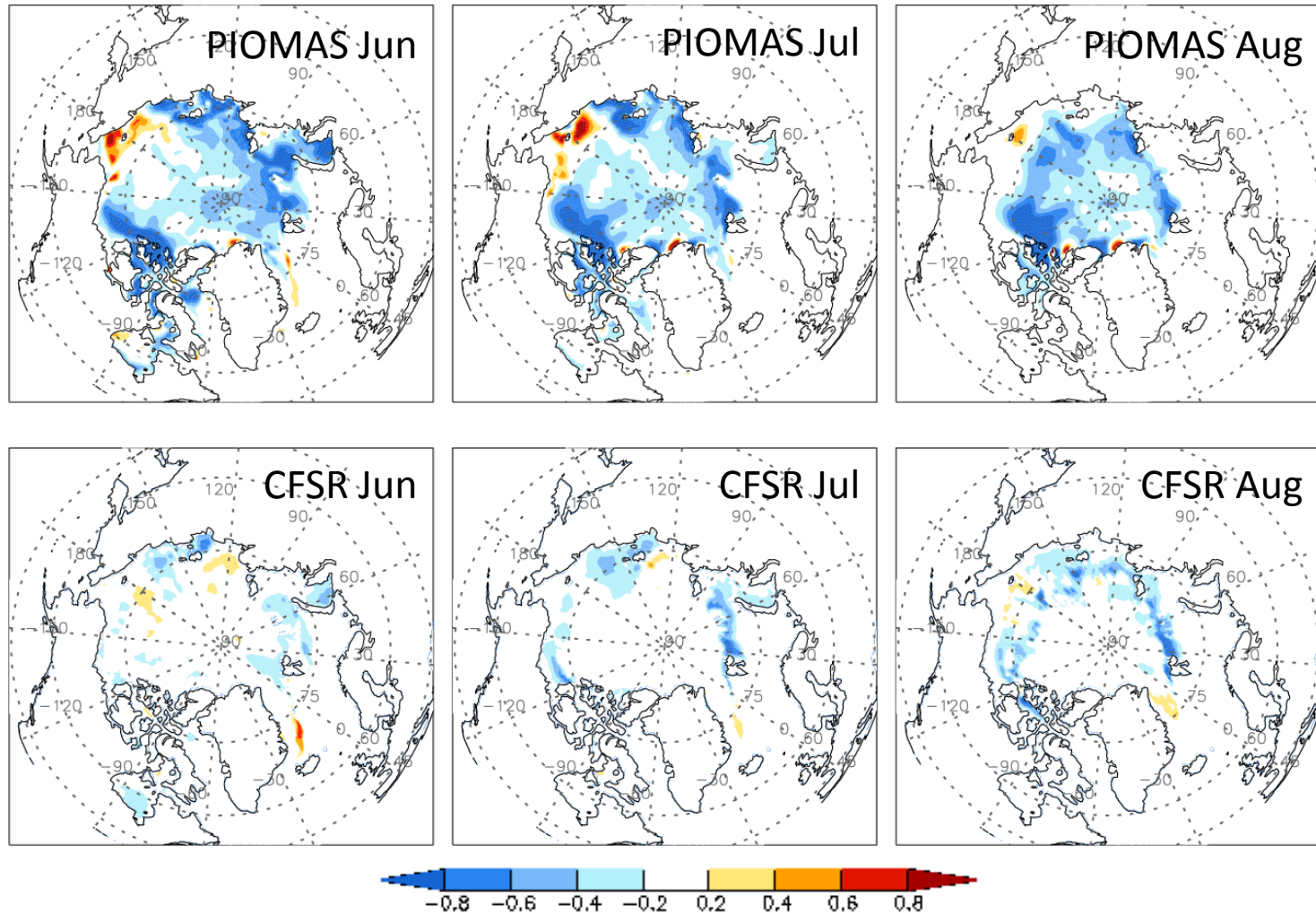


PIOMAS:

University of Washington
Pan-arctic Ice/Ocean
Modeling and
Assimilation System

- 1) CFSR is too thick over the central Arctic regions
- 2) PIOMAS is more realistic

Initial 2012 sea ice thickness Anomalies from 2008-2011



The 2012 September minimum could be better predicted by CFSv2 if PIOMAS initial sea ice thickness were used.

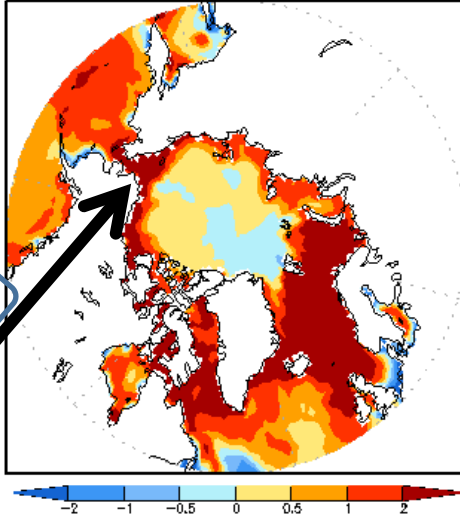
Errors in physics

- i. Deficient cloudiness causing warm SST bias
- ii. Use of a constraint for sea ice bottom heat flux

Deficient cloudiness causing Warm SST bias

Jul-Nov
Model
bias

(a) SST

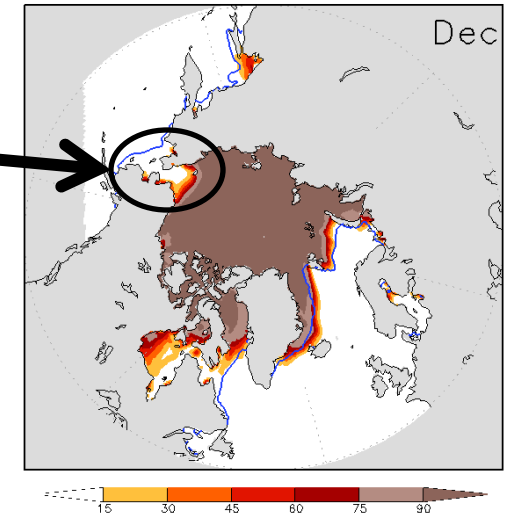


Too warm SSTs

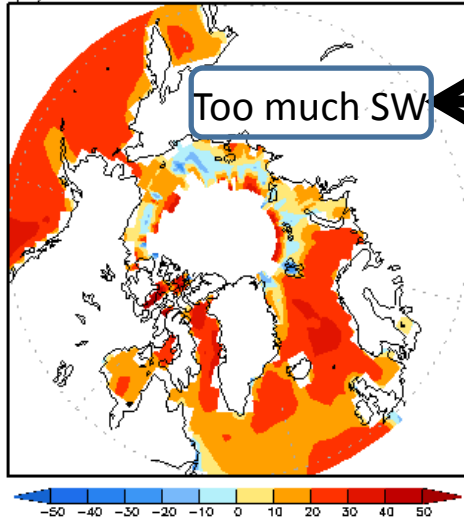
Delayed sea ice formation

December sea ice concentration

Shading: CFSv2; Contour: NCDC 15%

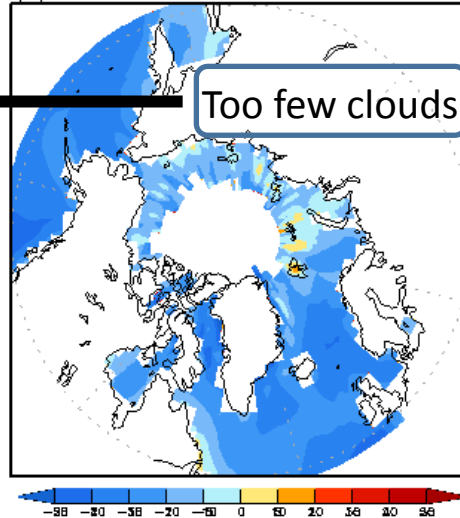


(b) Net Downward SW



Too much SW

(c) Total cloud amount



Too few clouds

- CFSv2 SSTs are too warm resulting in a delayed sea ice formation
- The warm SSTs are due to excessive downward surface solar radiation which is related to negative bias in cloud amount

Summary of existing issues in CFS

(1) Initialization

- Jumps in sea ice concentration (1997, 2008)
- Errors in sea ice thickness

(2) Physics

- Warm SST bias due to excessive surface solar radiation
- Too little sea ice melting due to bottom heat flux constraint

3. What can we do to improve the prediction?

A. Use an alternative initial sea ice

- CFSR ==> PIOMAS

B. Modify model physics

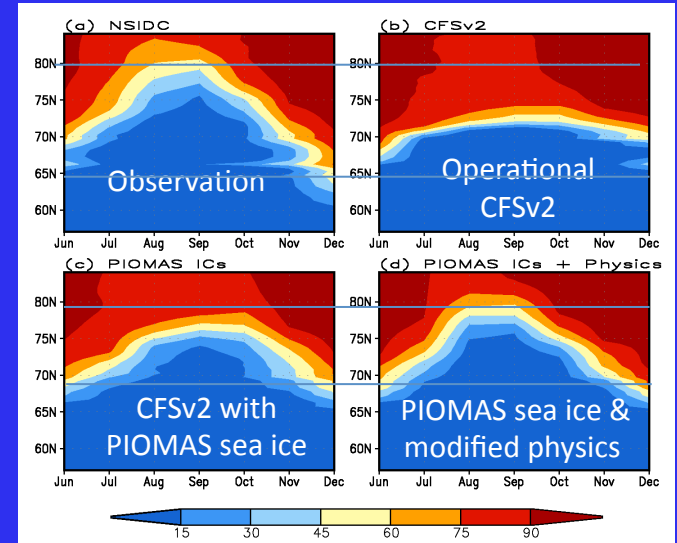
- CFSv2 ==> CFSv2p

- ✓ Increase stratus cloudiness to reduce SST warm bias
- ✓ Remove water-ice heat flux constraint

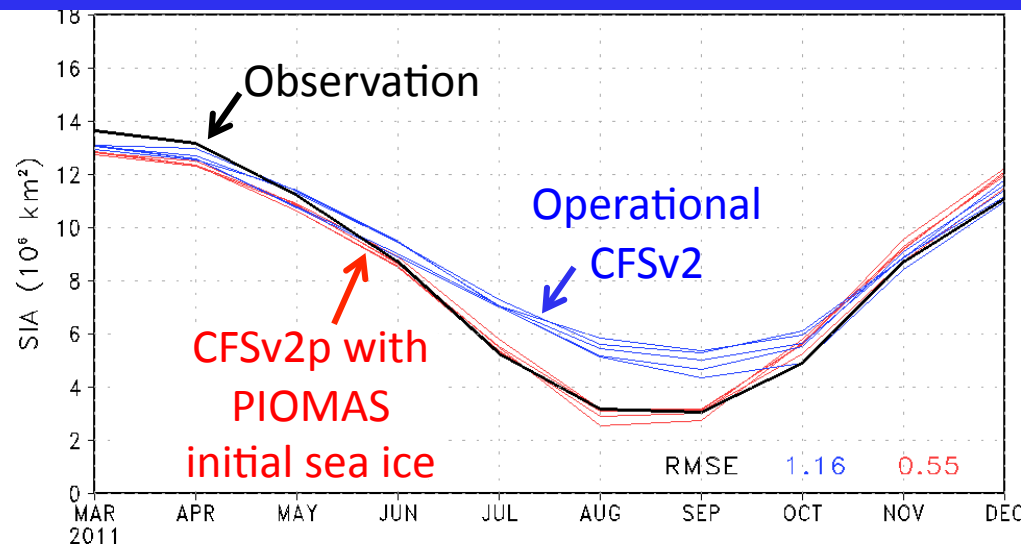
Preliminary results demonstrating improvements

Forecast experiments from March initial conditions for 2009-2013

Zonal mean sea ice concentration (170-200E)
2009-2013 average



2011 sea ice extent from March initial conditions



Summary

Required improvements for a better sea ice prediction

- i) Consistency of initial sea ice concentration
- ii) More accurate initial sea ice thickness
- iii) Reduced mean bias (SST, surface heat flux)