# Requirements for improved seasonal sea ice prediction in the NCEP Climate Forecast System

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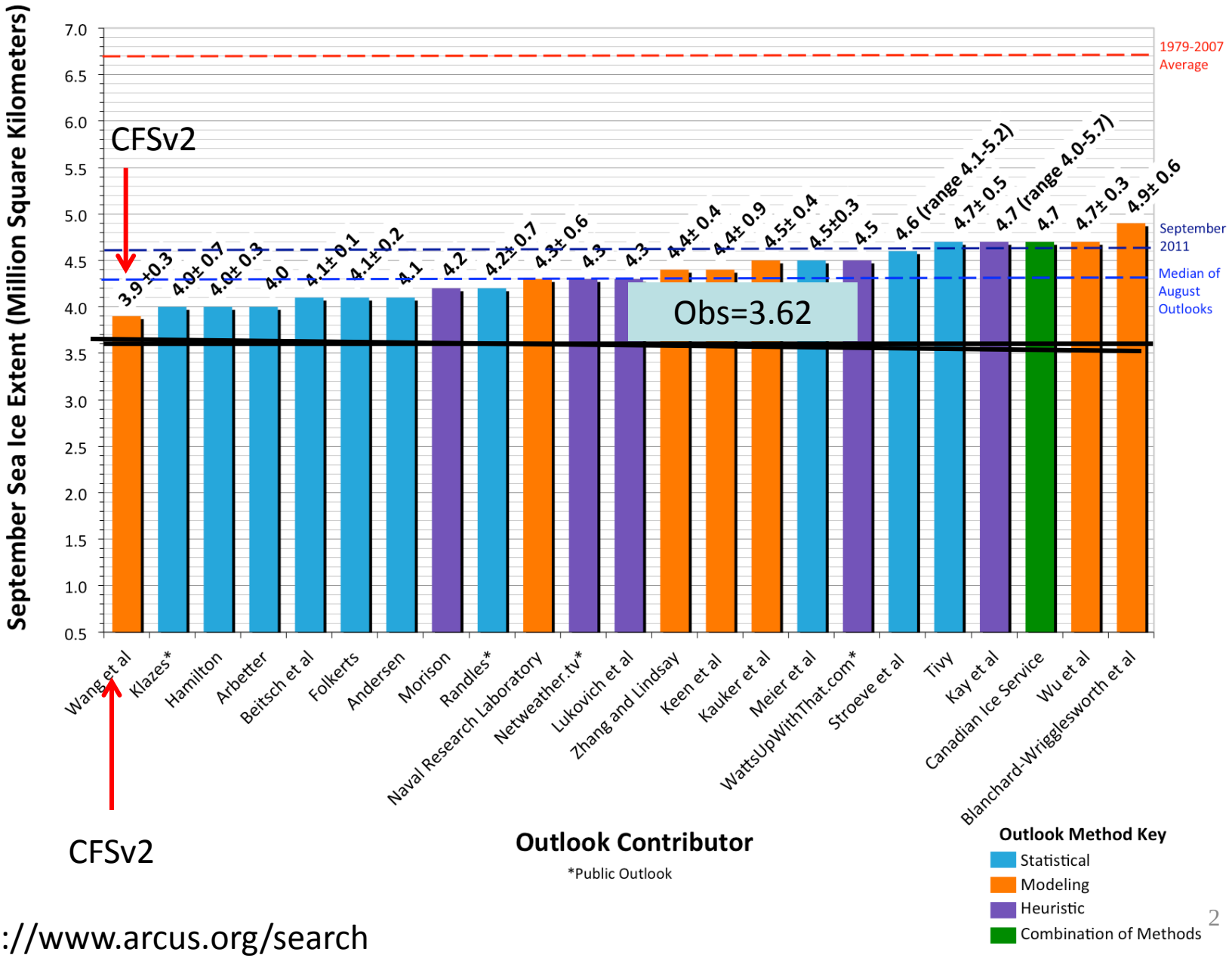
**40th Climate Diagnostics and Prediction Workshop**
**Denver, CO**
**October 29, 2015**

# SIPN

## 2012 Sea Ice Outlook: August Report

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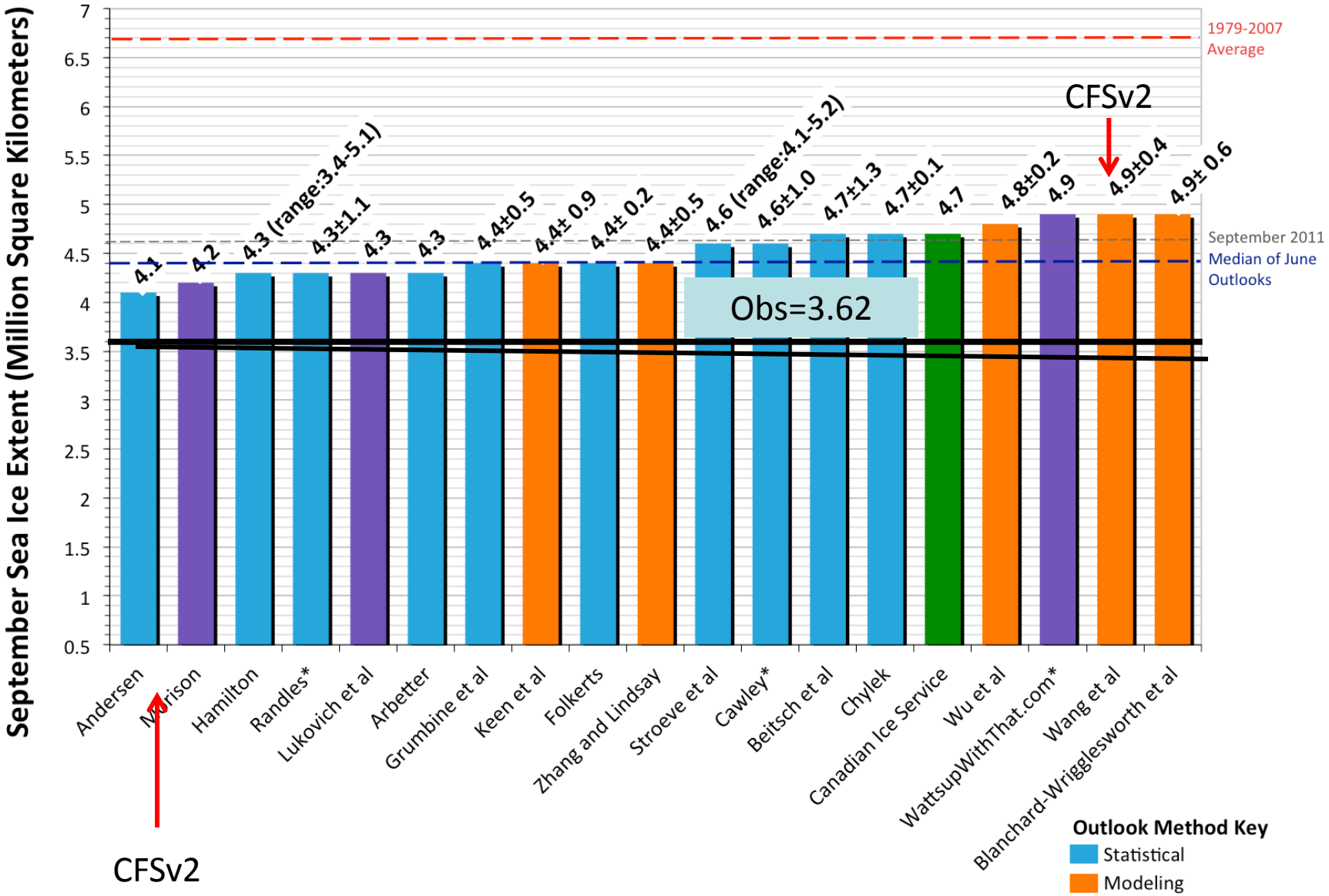
# SIPN

## 2012 Sea Ice Outlook: June Report

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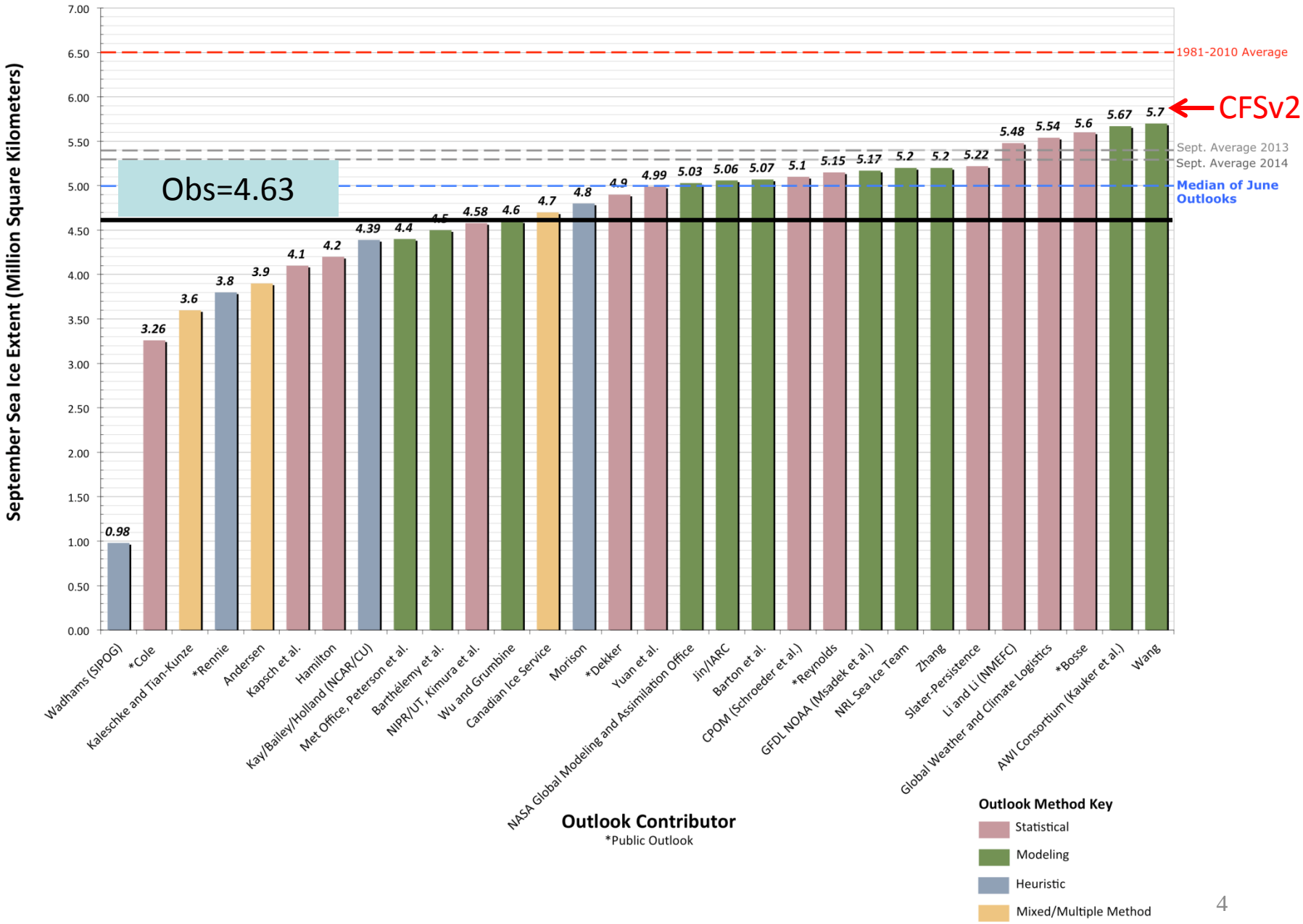
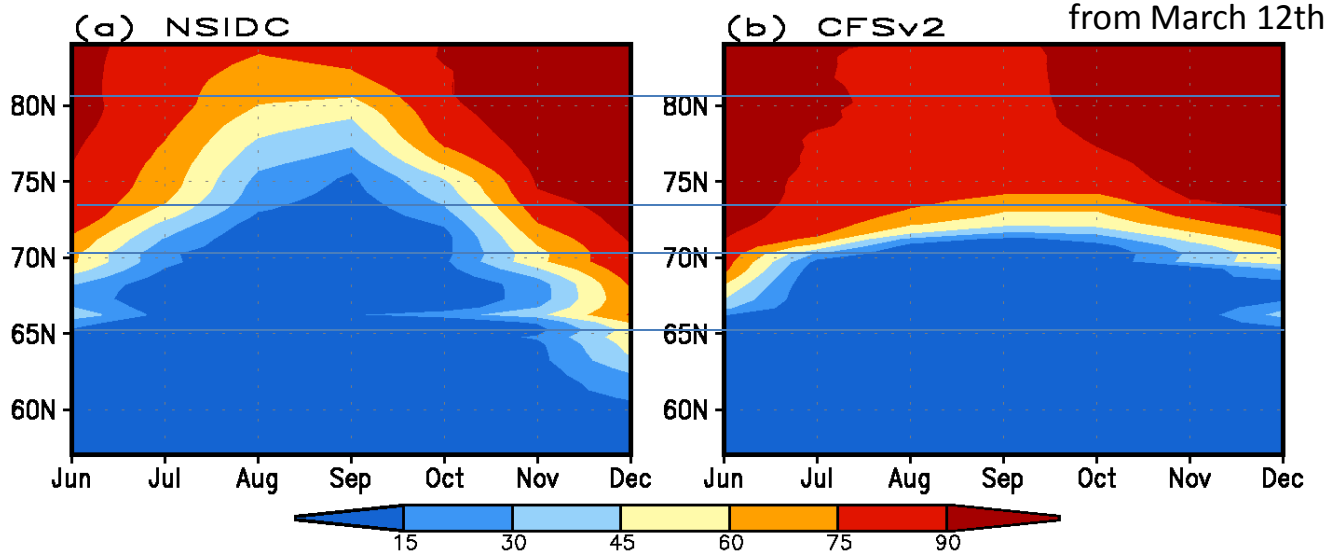
# 2015 Sea Ice Outlook: June Report

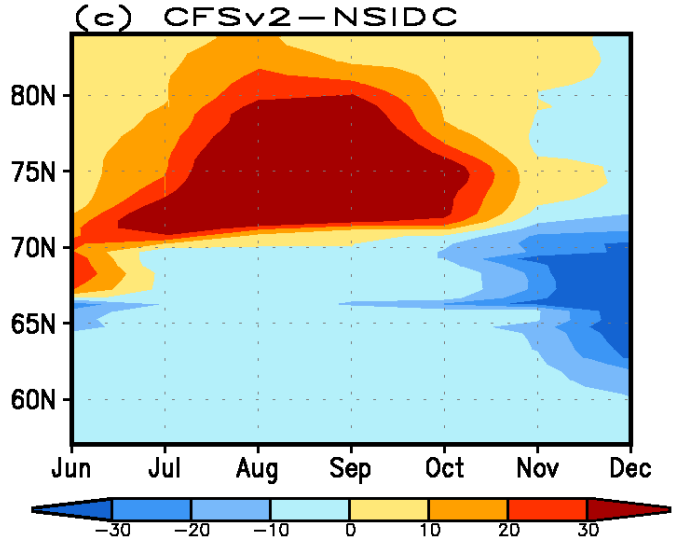


# Zonal mean sea ice concentration (%) around Bering Sea and Chukchi Sea (170-200E)

(2009-2013 average)

from March 12th




## Major errors:

- Slow melt in summer
- Slow freeze in fall

# Outline

1. Causes of the forecast errors
2. Impacts of model configurations
3. Future plans

# Causes of the forecast errors

i. Errors in initialization

ii. Inaccurate model physics

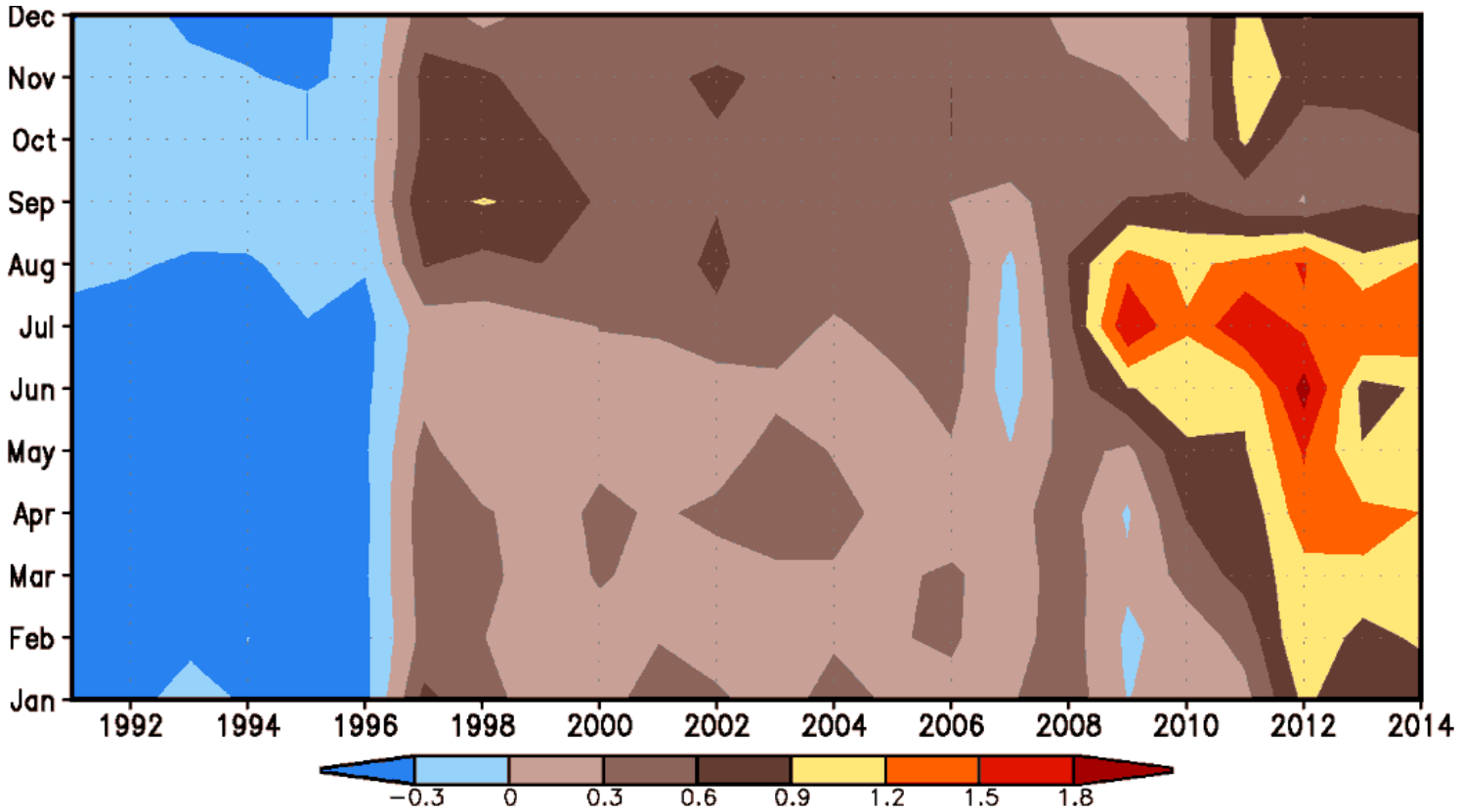
# Sea ice errors in the initialization

i. Initial sea ice coverage

ii. Initial sea ice thicknesss

# Errors in initialization: Sea ice concentration

Differences in sea ice extent between CFSR and NASA Team ($10^6$ $km^2$)

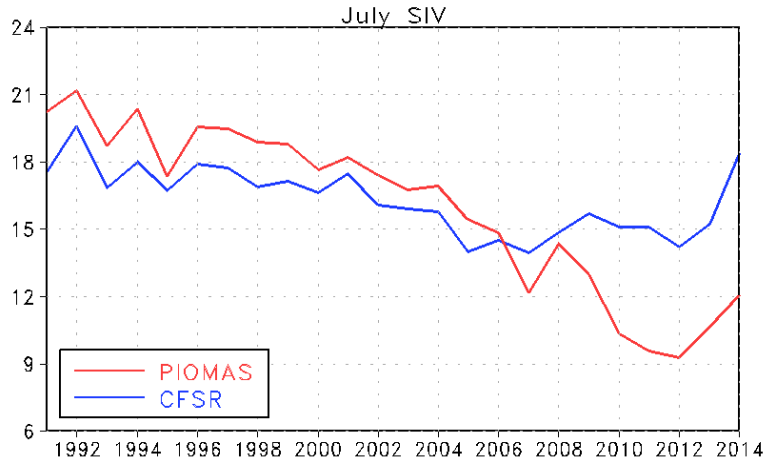


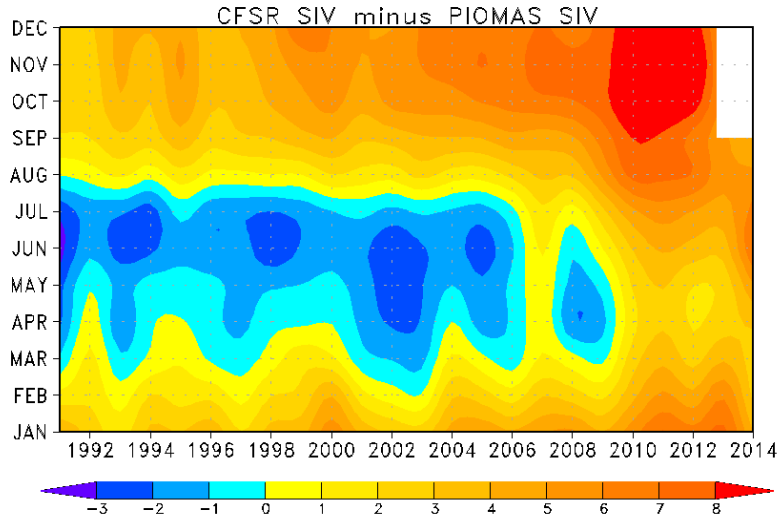

**CFSR**: Climate Forecast System Reanalysis providing initial conditions for CFSv2

- Significant jumps in 1997 and 2008
- Difficult to remove time-dependent systematic bias.

# Errors in initialization: Sea ice thickness trend

Differences in sea ice volume between CFSR and PIOMAS analysis ($10^3$ $km^3$)




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

- Differences depending on year and month
- Difficult to remove time-dependent systematic bias

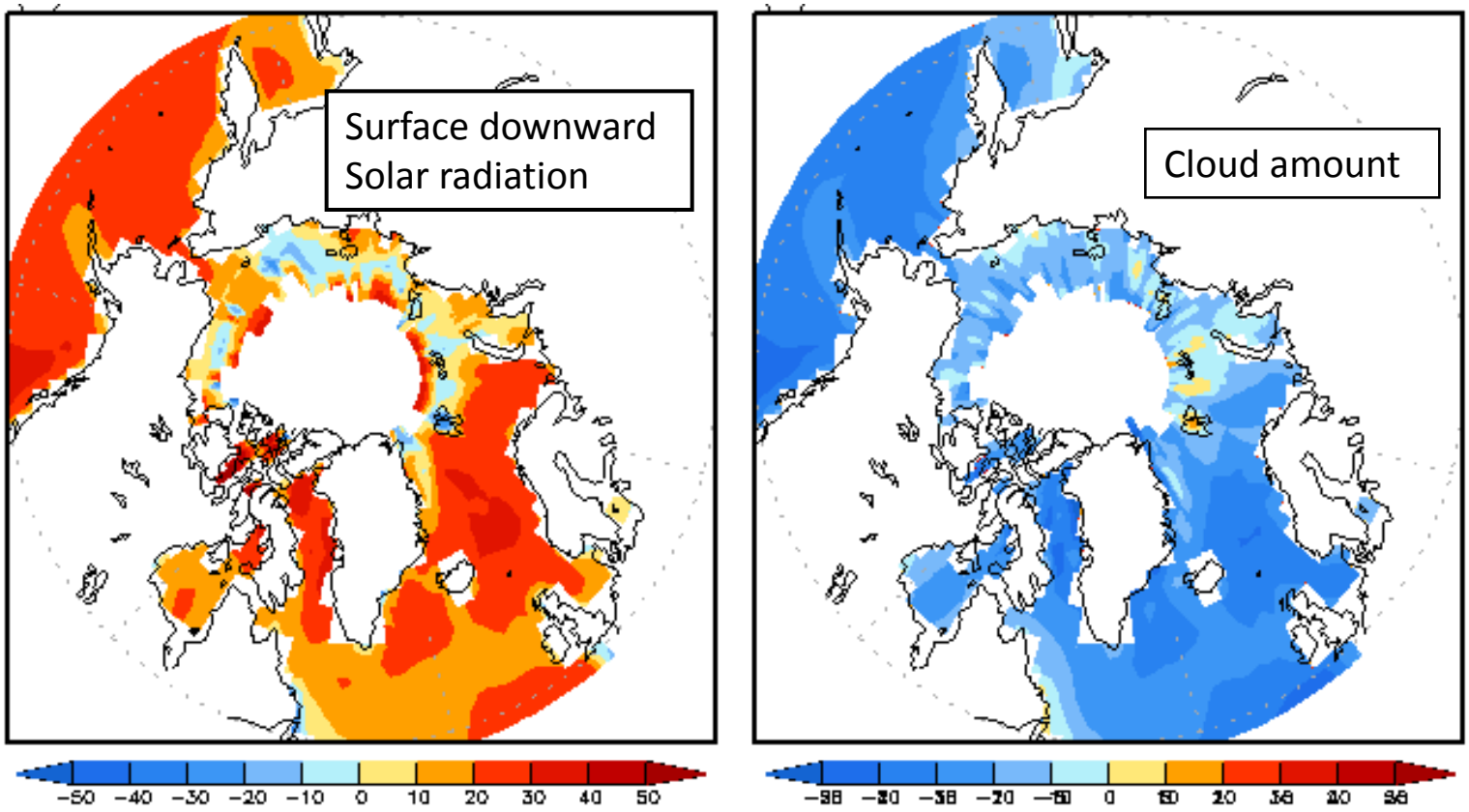
# Impacts of model configuration

i. Inaccurate surface fluxes from the atmosphere and ocean

ii. Insufficient model resolutions

# Excessive surface downward solar radiation flux

Jul-Nov Model bias




- CFSv2 produce excessive surface downward solar radiation flux
- The solar radiation flux bias is related to negative bias in cloud amount

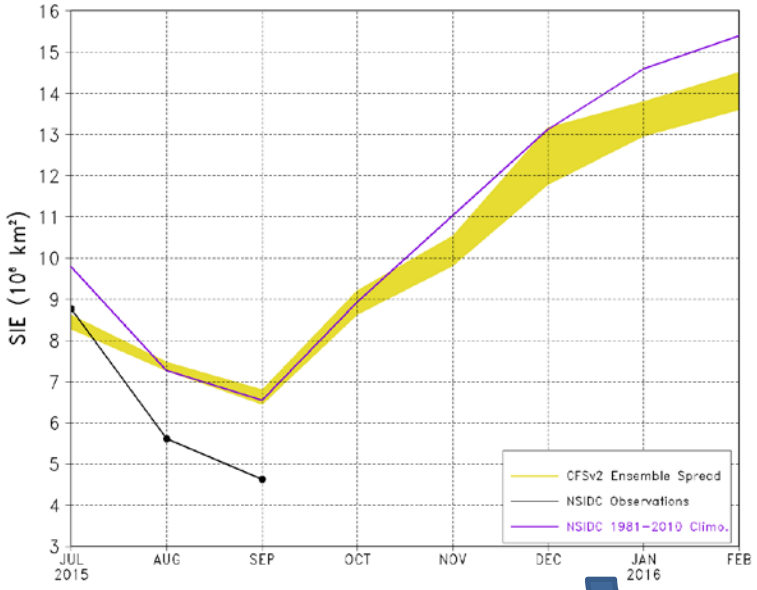
# Impacts of model configurations

A. Impact of initial sea ice
- CFSR (Climate Forecast System Reanalysis)
- PIOMAS (Pan-arctic Ice/Ocean Modeling and Assimilation System)

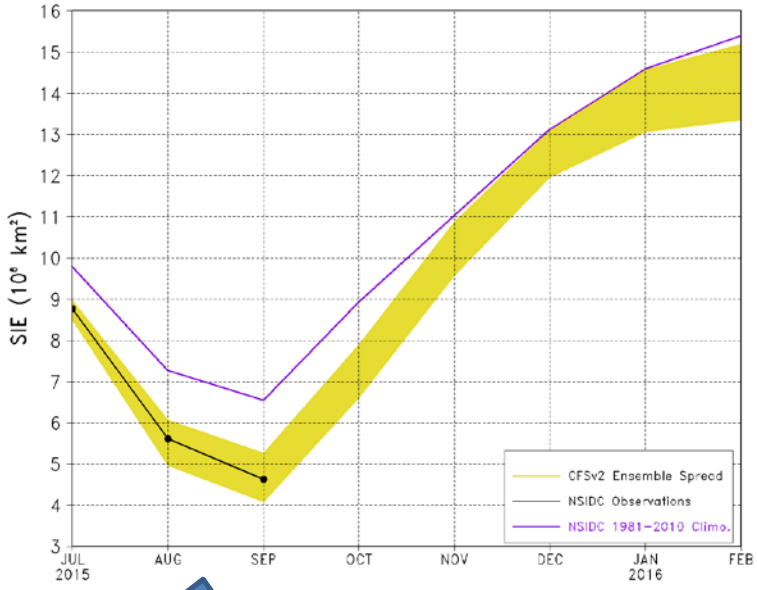
B. Impact of model physics
- CFSv2 (Climate Forecast System version 2)
- CFSv2p (Modified model physics)
  - ✓ Use a marine stratus parameterization (Moorthi et al. 2010).
  - ✓ Remove water-ice heat flux constraint

# Sea ice extent from June 2015 forecast

## Operational CFSv2/CFSR

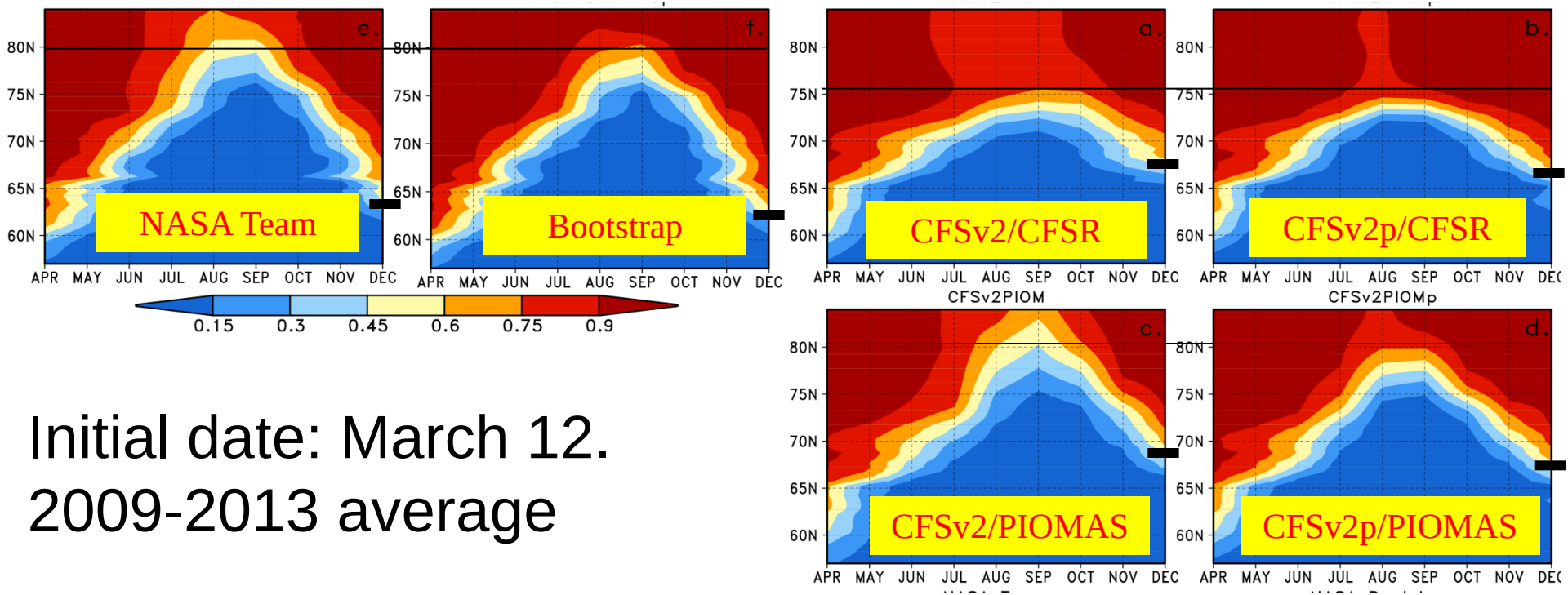



## Experimental CFSv2p/PIOMAS




- ✓ Consistent initial sea ice concentration
- ✓ More accurate initial sea ice thickness
- ✓ More realistic surface fluxes from the atmosphere and ocean

# Zonal mean sea ice concentration (170E-200E)

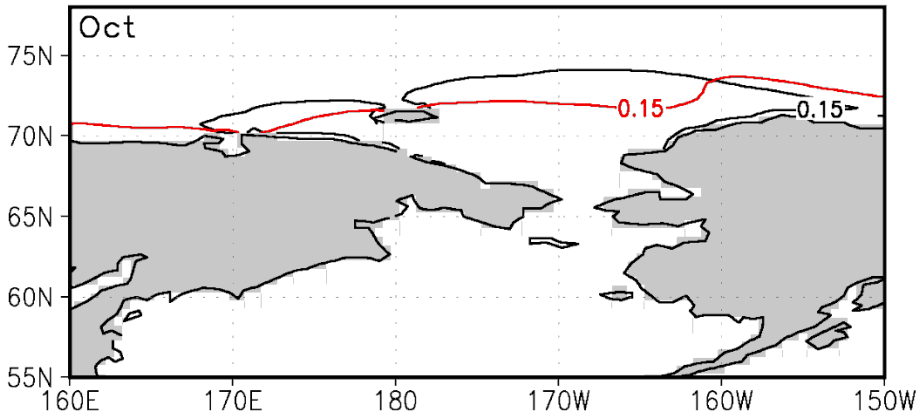


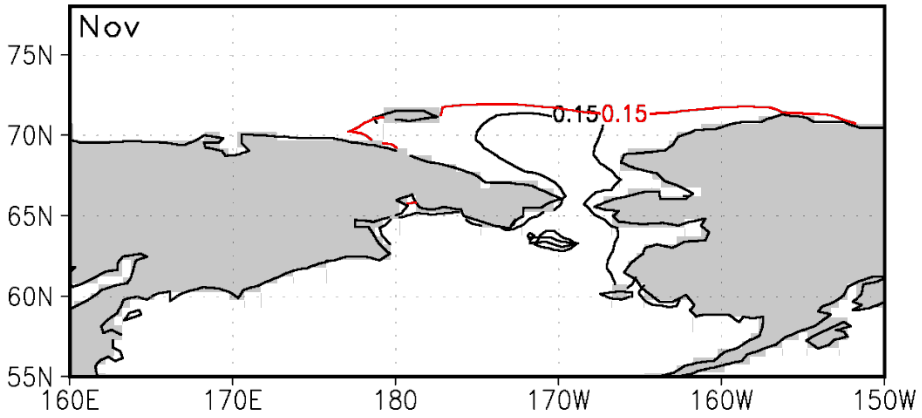

Initial date: March 12.
2009-2013 average

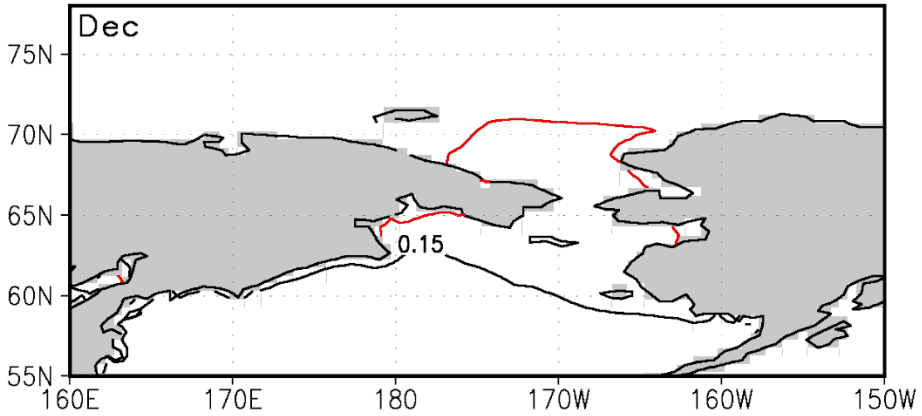
- CFSv2/CFSR: Seasonal cycle too weak
- CFSv2p/CFSR: Seasonal cycle slightly further weakened with changes in physics alone
- CFSv2/PIOMAS: Seasonal cycle enhanced with even stronger melt with changes in IC alone
- CFSv2p/PIOMAS: Seasonal cycle best simulated with changes in both ICs and physics

**Delayed freeze in all runs**

# Possible impact of model resolutions



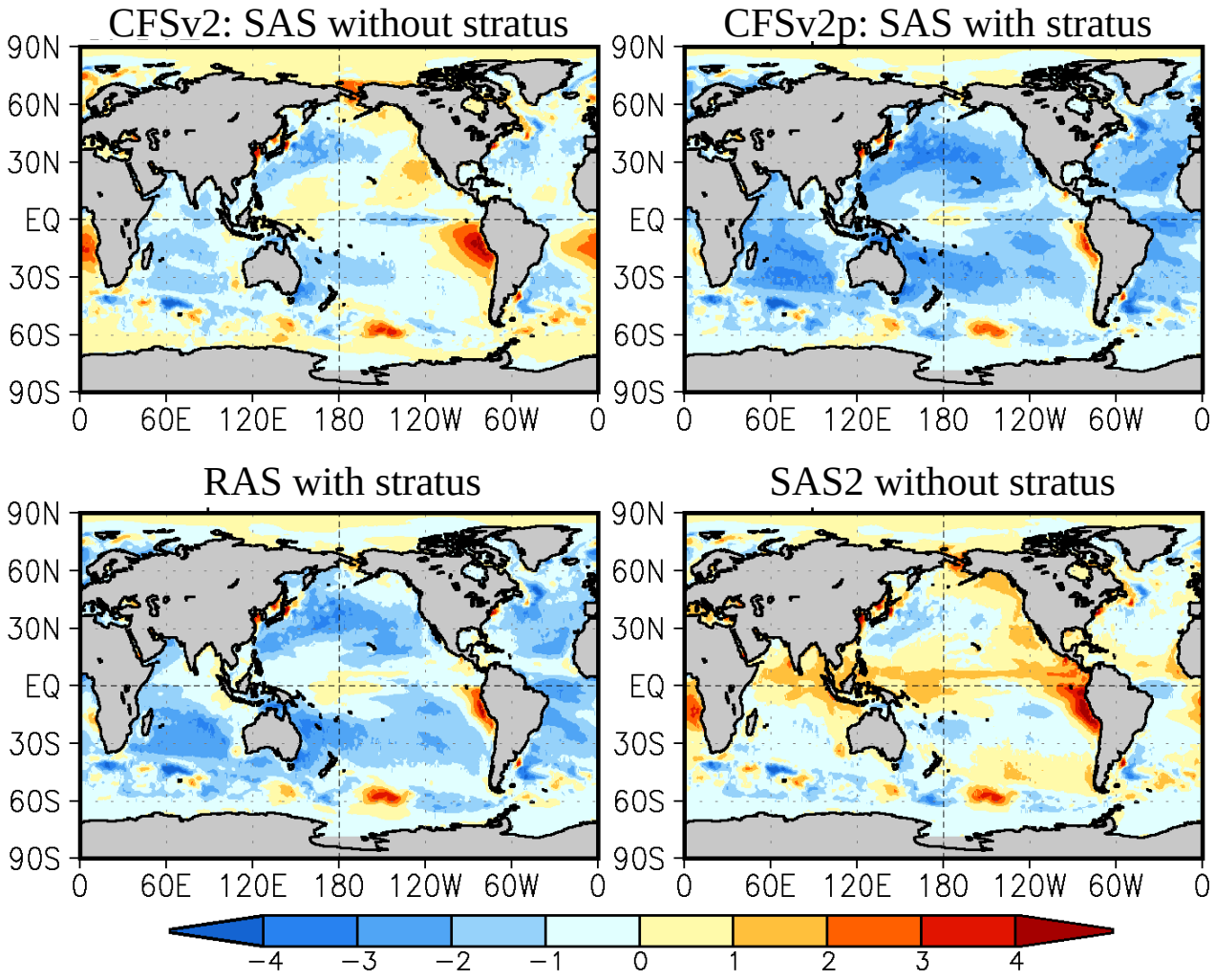

Sea ice edge (15% concentration)
CFSv2 Forecast from July
2005-2009 average

- Sea ice freeze in CFSv2 is delayed
- Possible reasons
  a. Horizontal resolutions too coarse to resolve land-sea contrast details
  b. Oceanic vertical resolution (10 m) too coarse to correctly ocean surface response to atmospheric cooling

# SST bias

# November SST bias in forecast from July with different convection schemes

- SAS: Simplified Arakawa Scheme
- RAS: Relaxed Arakawa Scheme
- SAS2: Revised SAS




It is possible to configure the model for improved prediction in both sea ice and SST.

# Summary

- Major CFSv2 forecast errors: slow melt and freeze
- The prediction of sea ice melt improves with
  - ✓ More consistent initial sea ice concentration
  - ✓ More accurate initial sea ice thickness
  - ✓ More realistic surface fluxes from the atmosphere and ocean
- These changes did not result in significant improvement in sea ice freeze which may require an increase in model resolutions

# Future Plan

- Test impacts of increased model resolutions on the prediction of sea ice freeze
- Develop a sea ice data assimilation system with CFS ocean component that assimilates both sea ice concentration and sea ice thickness
- Develop the CFS version 3 (CFSv3)

①Test the CFSv3 with improved atmospheric physics for a better representation of surface fluxes

①Test sea ice component model: CICE/SIS/SIS2/KISS