Impact of model physics on seasonal forecasts of surface air temperature in the Arctic

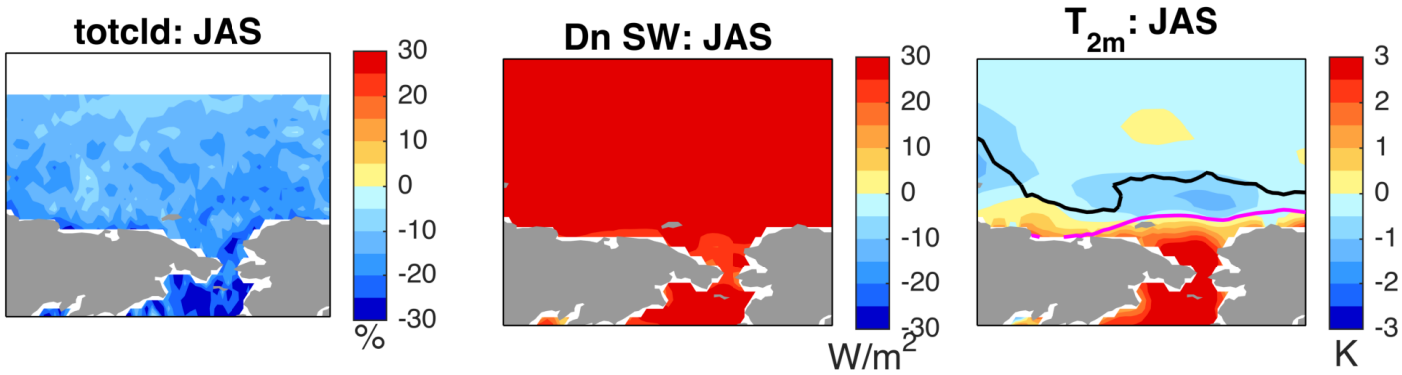
Qiong Yang[1,2], Muyin Wang[1,2], James Overland[2], Wanqiu Wang[3] and Thomas Collow[3,4]

[1] JISAO, University of Washington, Seattle, Washington
[2] NOAA/PMEL, Seattle, Washington
[3] NOAA/NWS/NCEP/CPC, College Park, Maryland
[4] INNOVIM, LLC, Greenbelt, Maryland

Yang, Q., M. Wang, J. Overland, W. Wang, and T. Collow, 2017: Impact of model physics on seasonal forecasts of surface air temperature in the Arctic. *Mon. Wea. Rev.* doi:10.1175/MWR-D-16-0272.1.

Motivation

CFSv2 (Climate Forecast System Version 2) operational forecast



Wang et al. 2016

Insufficient cloud cover → excessive downward SW → significantly high T_{2m} over the Chukchi/Bering Sea

- Marine stratus cloud scheme is turned ~~off~~ on
- ~~An artificial upper limit is set to constraint the bottom heat flux from ocean water to sea ice~~

Q: modified model physics improve seasonal forecasts of T_{2m}?

Goal

Understand the impacts of model physics and initial sea ice thickness on seasonal forecasts of surface energy budget and air temperature in summer (July – September).

Experiment

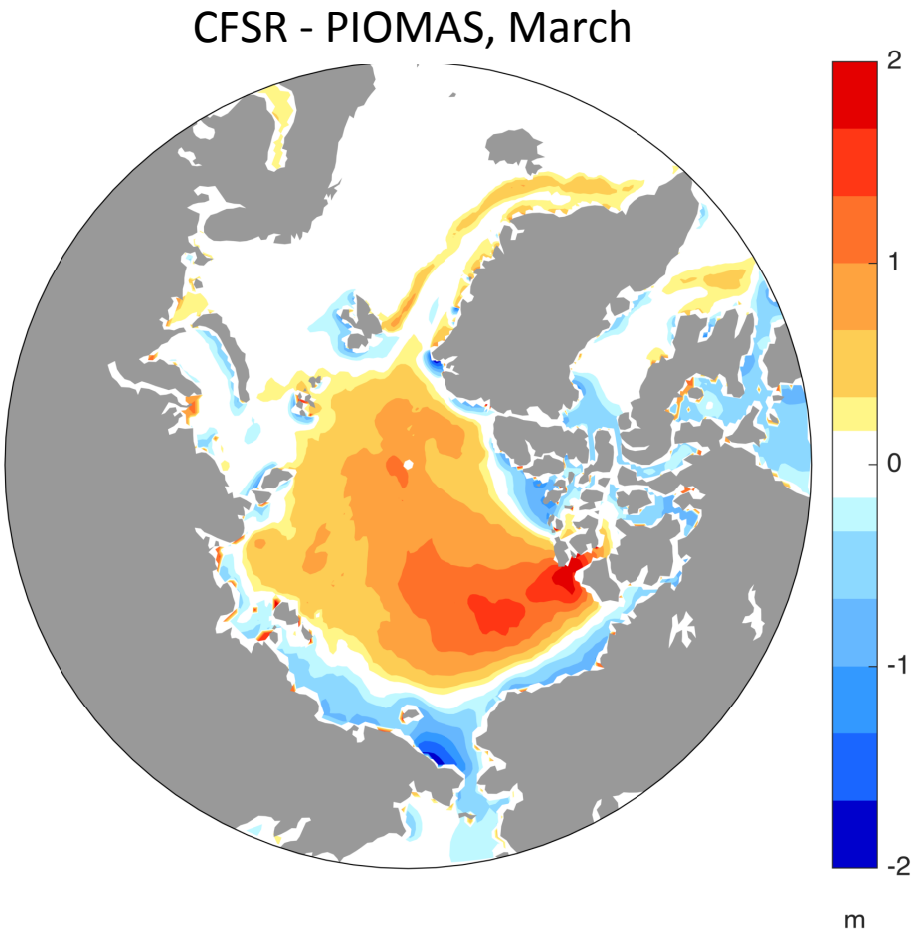
Model experiment	Physics modification	Initial sea ice thickness	Run period*	# of runs per month
CFSv2-ctrl	✗	CFSR	2009--2013	5 X 5
CFSv2-piomas	✗	PIOMAS	2009--2013	5 X 5
CFSv2-phys	✓	CFSR	2009--2013	5 X 5
CFSv2-phys-piomas	✓	PIOMAS	2009--2013	5 X 5

CFSR: Climate Forecast System Reanalysis

PIOMAS: Pan-Arctic Ice Ocean Modelling Assimilation System (Zhang and Rothrock, 2003)

*For each year, five ensemble runs were initialized at March 8-12 00UTC and run for 9-month forecasts to December

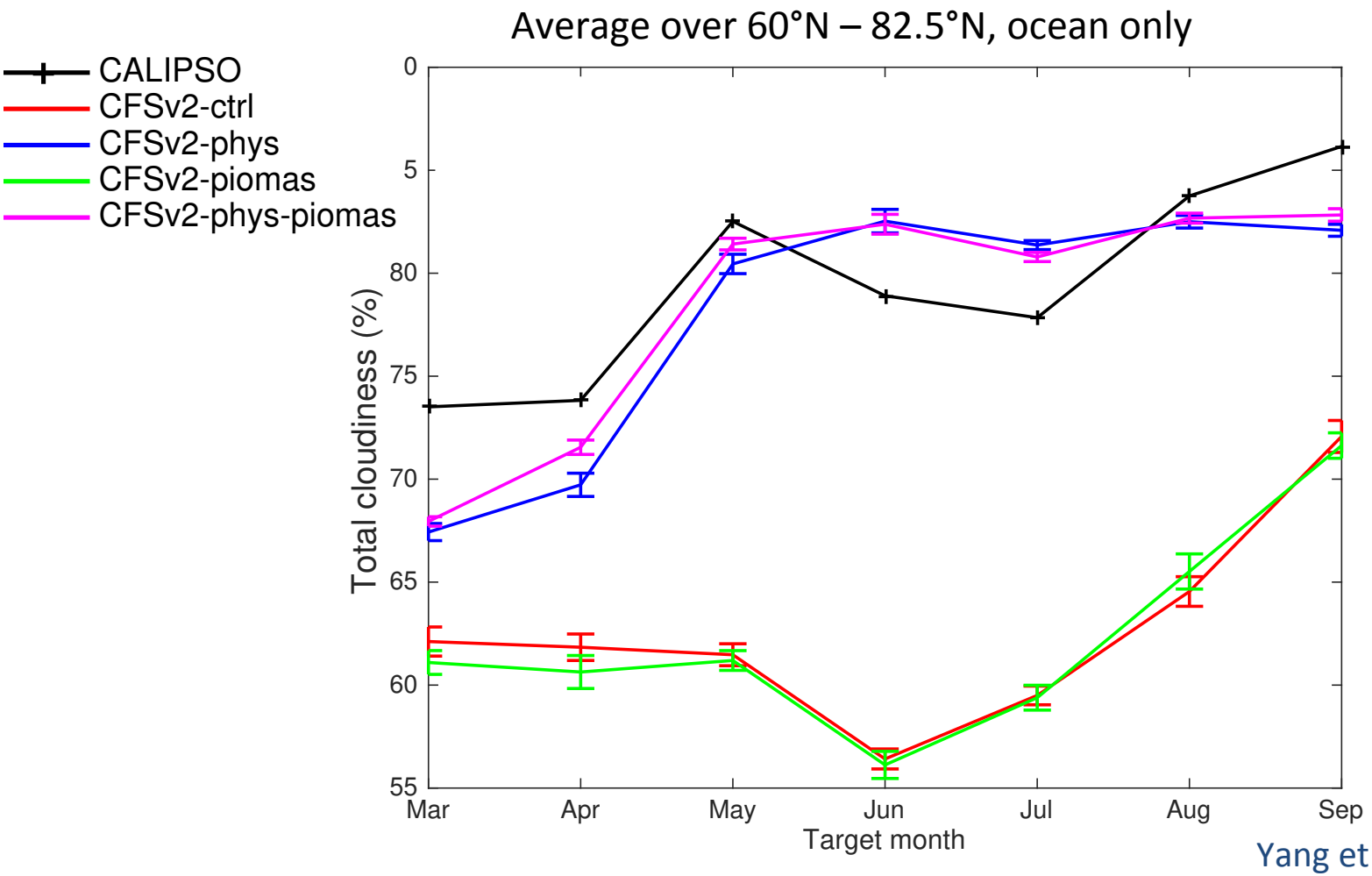
Initial sea ice thickness from PIOMAS vs CFSR



Yang et al. 2017, MWR

- CFSR has thicker sea ice over the central Arctic (~0.85 meter thicker on average) but thinner sea ice near the ice edge.

Simulated total cloud cover



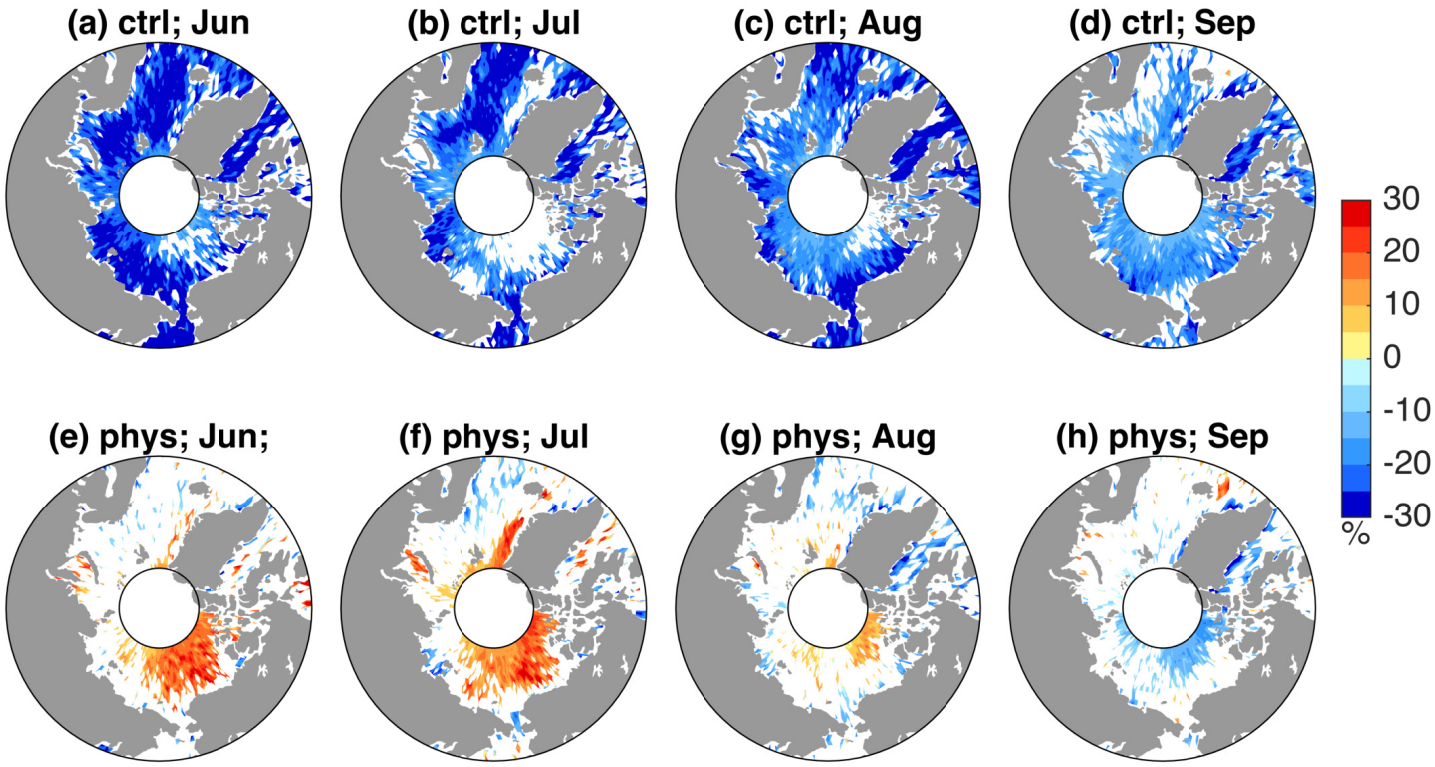
Yang et al. 2017, MWR

- After enabling the marine stratus cloud scheme, the simulated total cloud cover well captures the observed seasonal cycle except for the summer dip.

Simulated total cloud cover - CALIPSO

Control

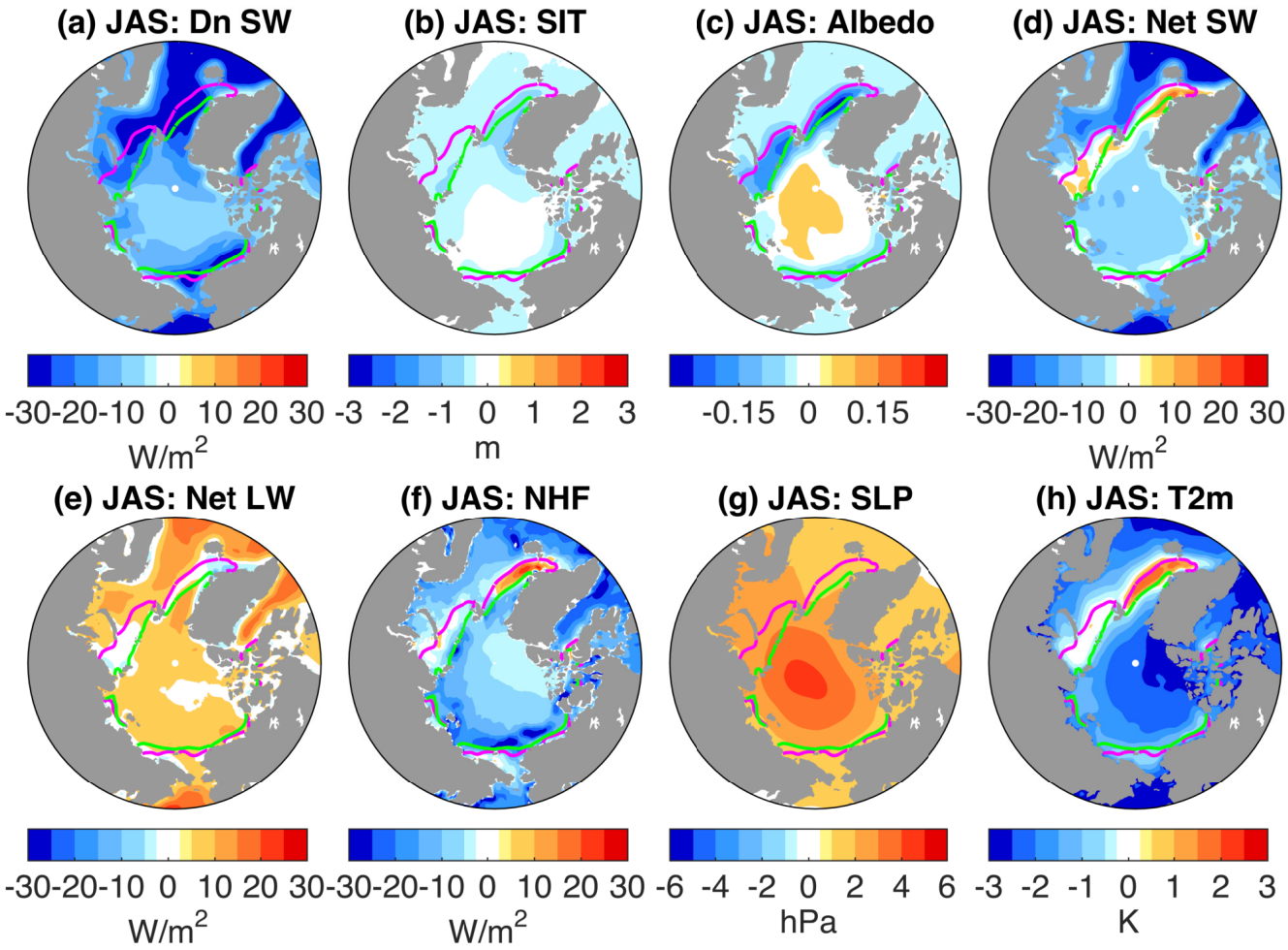
Turning on Stratus cloud scheme



Yang et al. 2017, MWR

- After enabling the stratus cloud scheme, the simulated total cloud cover is largely improved. The positive bias found in June and July is mainly located over the Beaufort Sea.

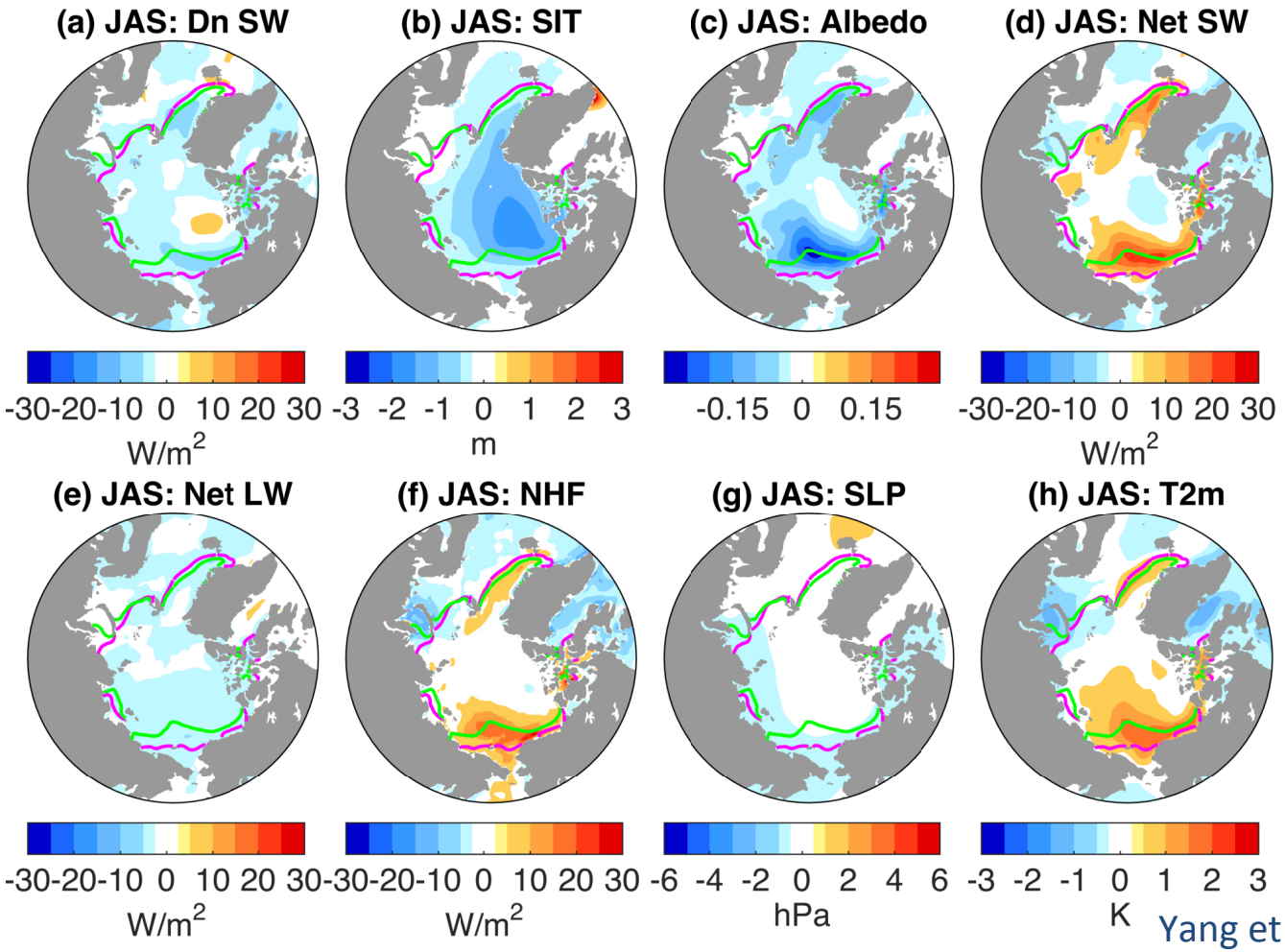
Surface energy budget: CFSv2-phys minus CFSv2-ctrl



Yang et al. 2017, MWR

Green contour: September 15% sea ice cover boundary from CFSv2-phys
Magenta contour: September 15% sea ice cover boundary from CFSv2-ctrl

Surface energy budget: CFSv2-piomas minus CFSv2-ctrl

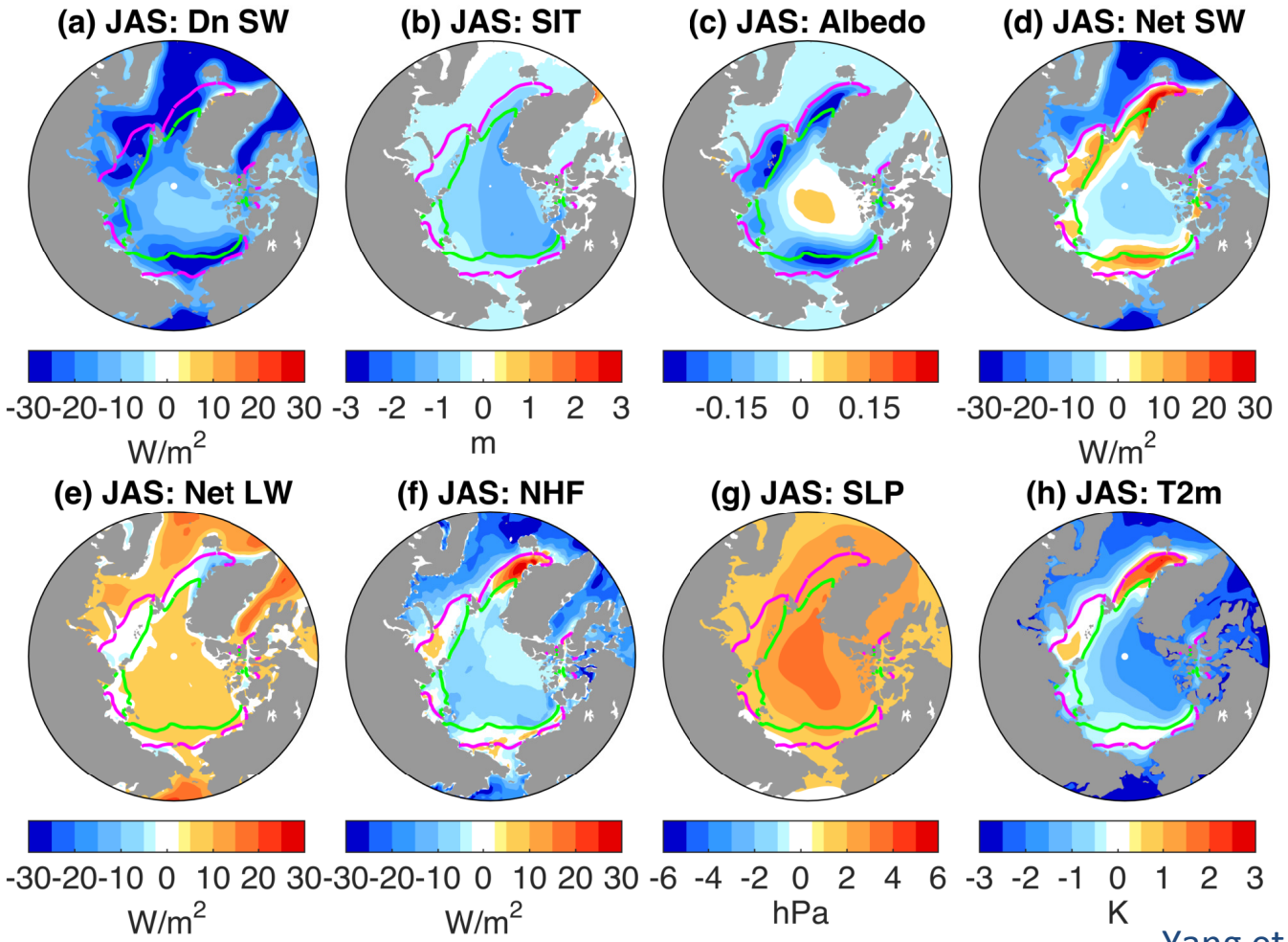


Yang et al. 2017, MWR

Green contour: September 15% sea ice cover boundary from CFSv2-piomas

Magenta contour: September 15% sea ice cover boundary from CFSv2-ctrl

Surface energy budget: CFSv2-phys-piomas minus CFSv2-ctrl

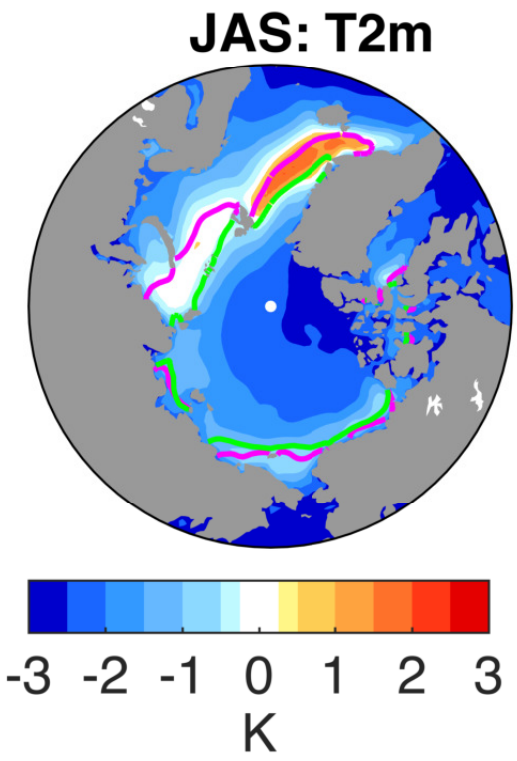


Yang et al. 2017, MWR

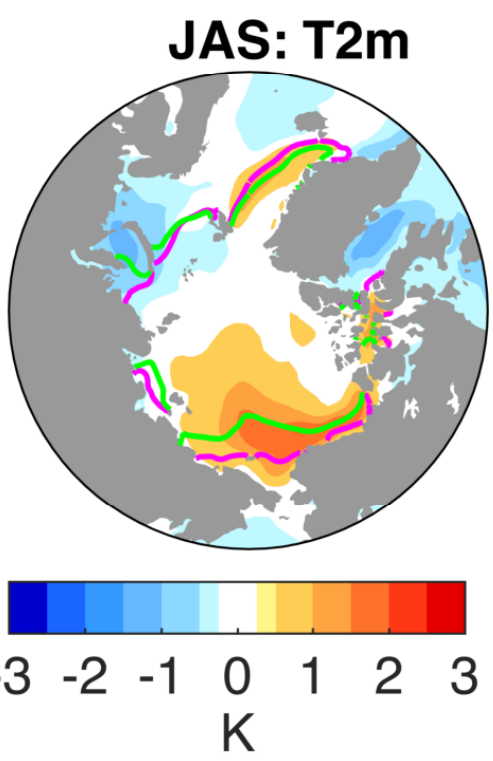
Green contour: September 15% sea ice cover boundary from CFSv2-phys-piomas
Magenta contour: September 15% sea ice cover boundary from CFSv2-ctrl

Impact on T_{2m}

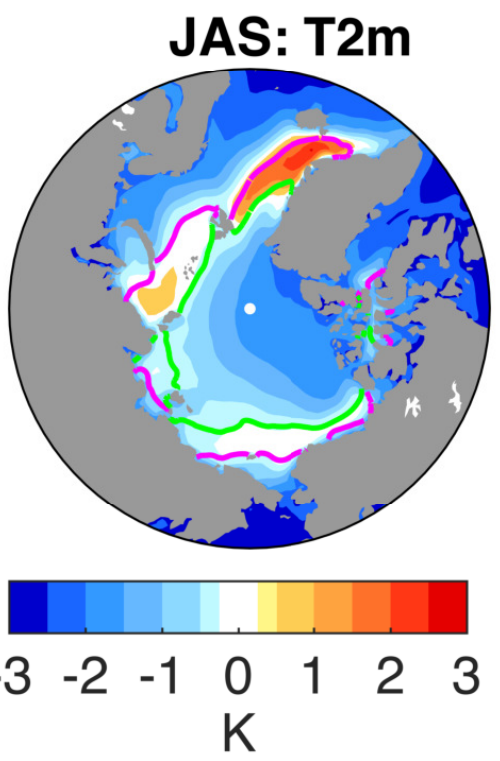
Model physics - Control



PIOMAS - Control

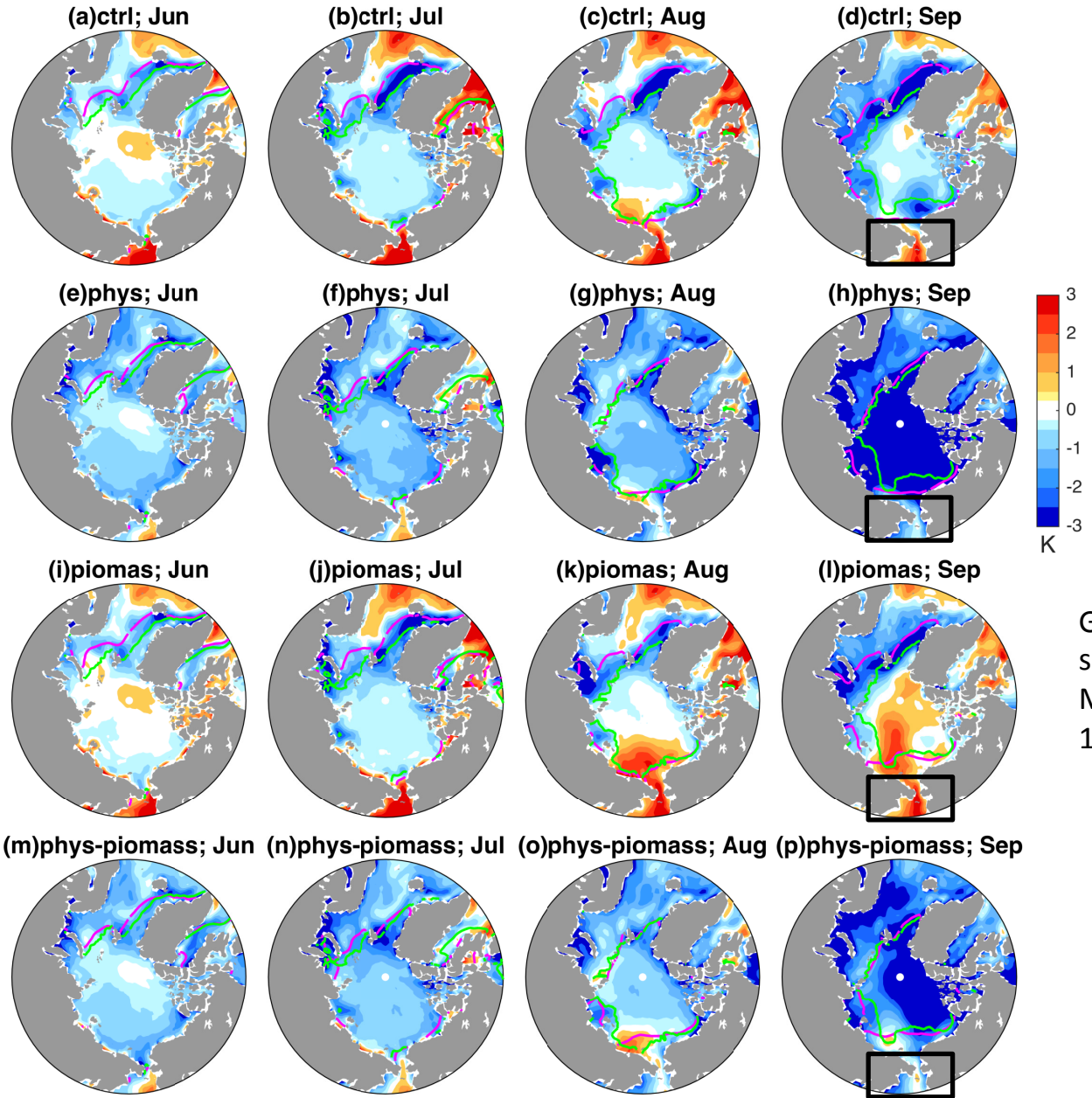


Model physics & PIOMAS - Control



Green contour: September 15% sea ice cover boundary from the corresponding simulation
Magenta contour: September 15% sea ice cover boundary from the control simulation

Predicted T_{2m} minus ERA-Interim



Control

Model physics

Initial sea ice thickness

Model physics + Initial sea ice thickness

Green: HadISST 15% sea ice cover
Magenta: CFS 15% sea ice cover

Summary

- After enabling the marine stratus cloud scheme, the simulated total cloud cover resembles the observed seasonal cycle well except for the mid-summer reduction.
- Over the Chukchi/Bering Sea, the model physics modification reduces the forecast bias in surface air temperature from >3°C down to 0.5°C .
- The initial sea ice thickness alone has little effect in improving the surface air temperature over the Chukchi/Bering Sea.

Yang, Q., M. Wang, J. Overland, W. Wang, and T. Collow, 2017: Impact of model physics on seasonal forecasts of surface air temperature in the Arctic. *Mon. Wea. Rev.* doi:10.1175/MWR-D-16-0272.1.

Acknowledgement

This work is supported by the NOAA Climate Progame Office, Arctic Research Program and by NOAA/OAR under the auspices of the National Earth System Prediction Capability (National ESPC).