An Evaluation of Arctic Surface Temperature in Hind-cast and AMIP runs in CAM4 and CAM5

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Neil P. Barton, Stephen A. Klein,
and James S. Boyle

Lawrence Livermore National Laboratory

PCMDI

CAPT
Cloud-Associated Parameterizations Testbed

ASR
Atmospheric System Research

U.S. DEPARTMENT OF ENERGY

Office of Science

LLNL-PRES-617972

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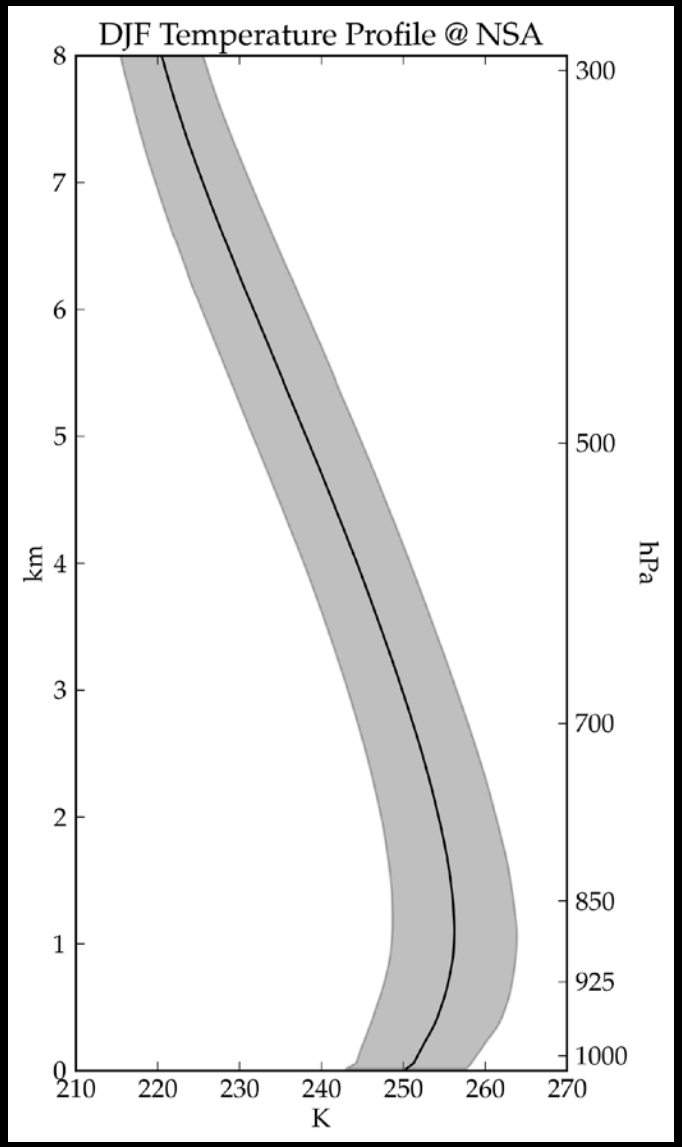
Motivation


DJF Temperature Profile @ NSA
km
hPa
K
0
1
2
3
4
5
6
7
8
210
220
230
240
250
260
270
300
500
700
850
925
1000


Barrow, Alaska (NSA)

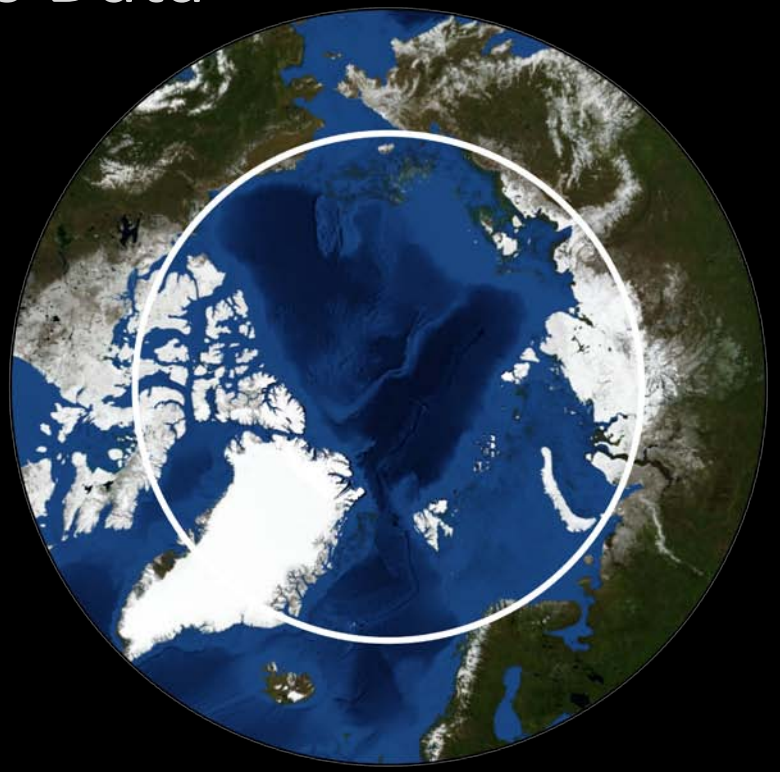
Atmospheric Models

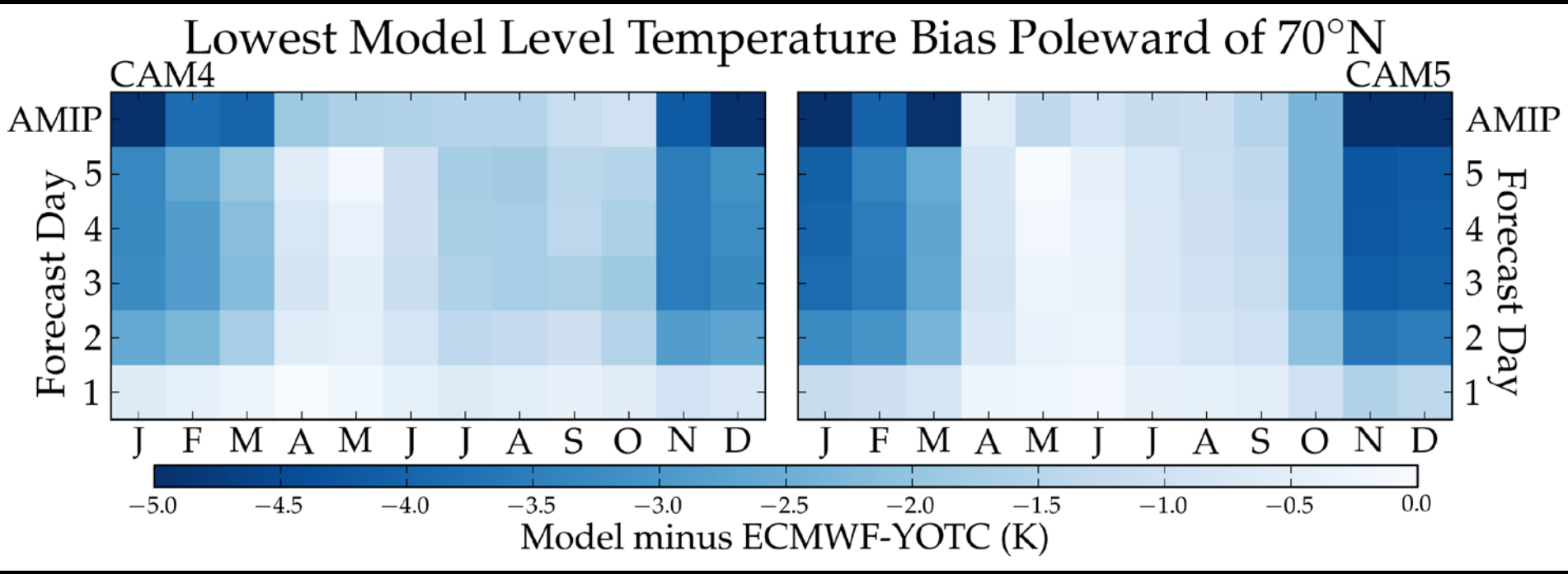
- CAM4 and CAM5
- Hind-Cast/CAPT mode and AMIP mode
  - Forecast runs are forced by analysis from the European Center for Medium Range Forecasting Year of Tropical Convection (ECMWF-YOTC)
  - From 2008-05 to 2010-03
  - 3 Hour Temporal Resolution over Globe
  - 1 Hour Temporal Resolution at Barrow, AK

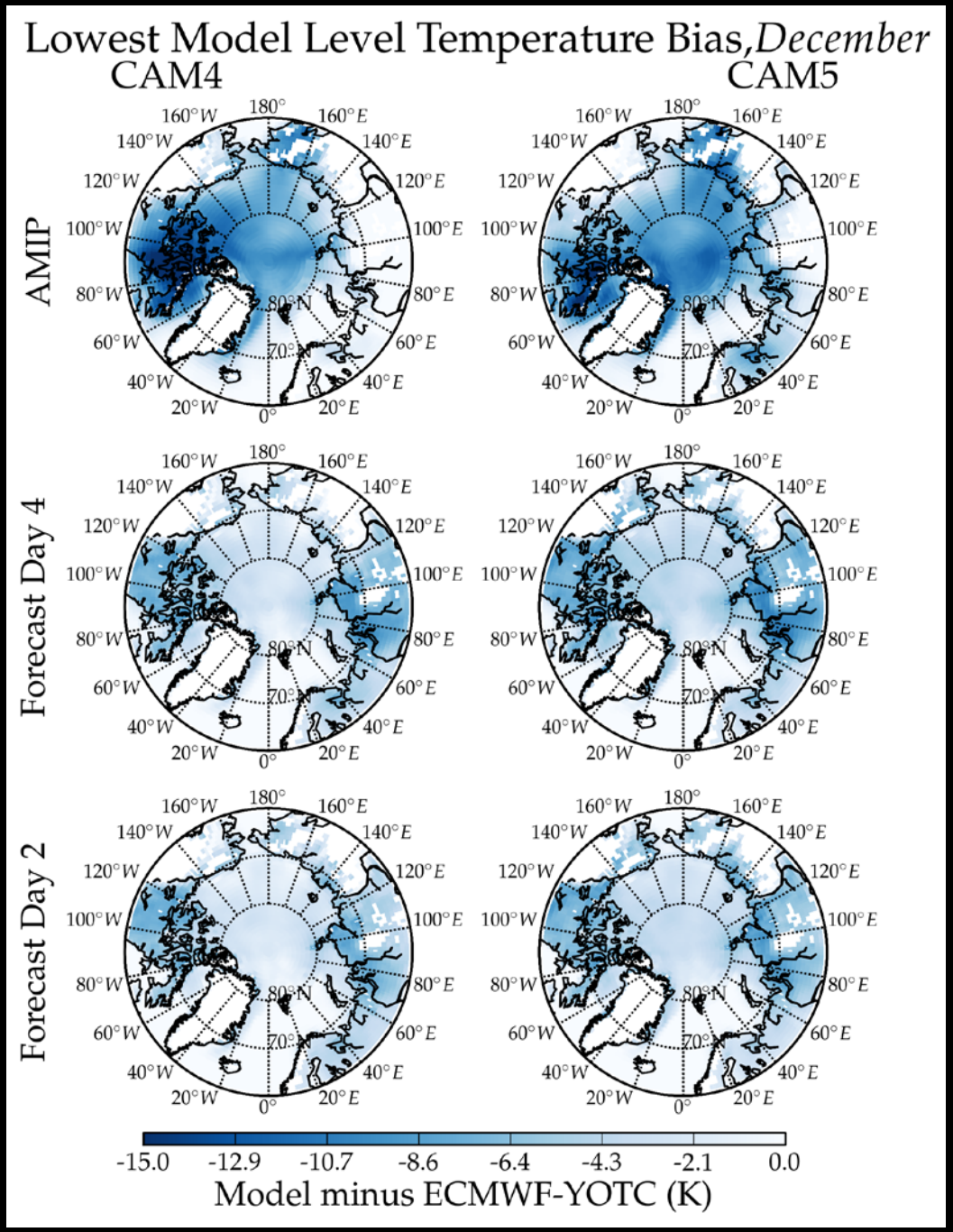
	CAM4	CAM5
Cloud Macrophysics Parameterization	Zhang et al. (2003)	Park-Bretherton-Rash (2010)
Cloud Microphysics Parameterization	Rasch-Kristjansoon (1998)	Morrison and Gettelman (2008)
Marine Stratocumulus Parameterization	based on Klein and Hartmann (1993)	none
Freeze-Dry Cloud Parameterization	Vavrus and Waliser (2008)	none
Boundary Layer Turbulence Parameterization	Holtslag-Boville (1993)	Bretherton and Park (2009)
Shallow Convection Parameterization	Hack (1994)	Park and Bretherton (2009)
Deep Convection Parameterization	Zhang and McFarlane (1995)	Zhang and McFarlane (1995)
Number of Vertical Levels	26	30

Analysis Across the Arctic Domain

- ECMWF-YOTC Analysis Data
  - Monthly Results

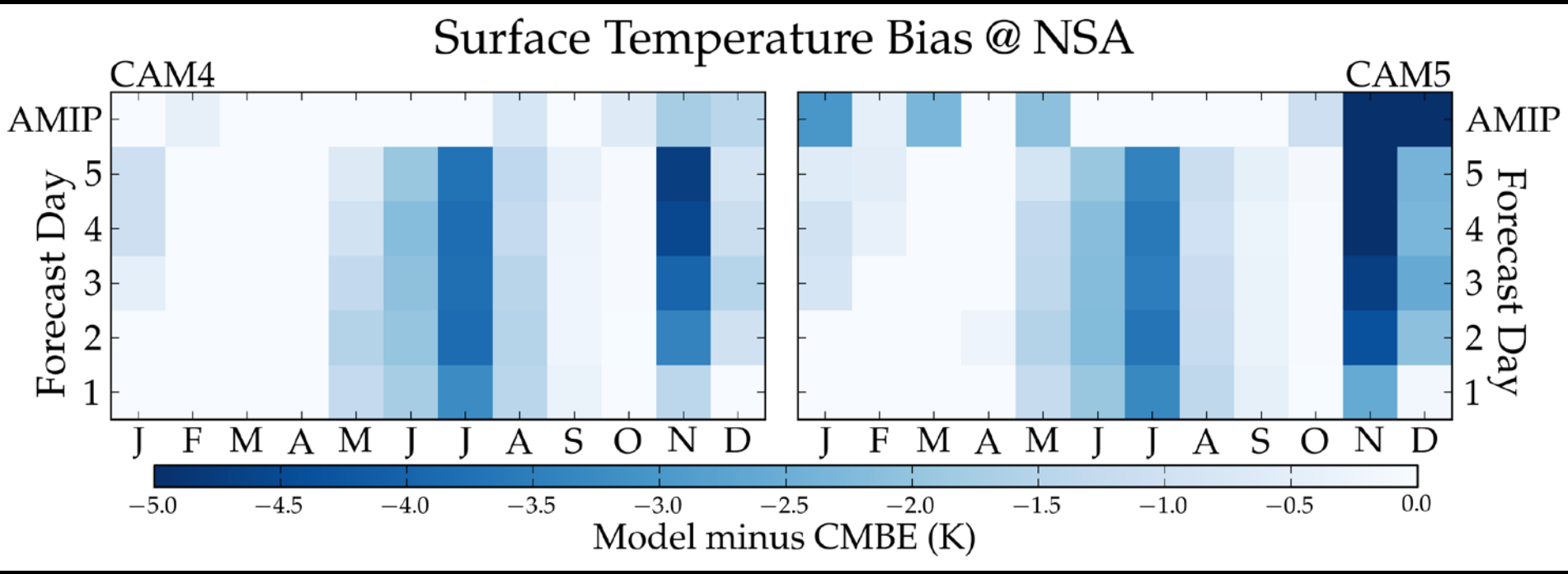


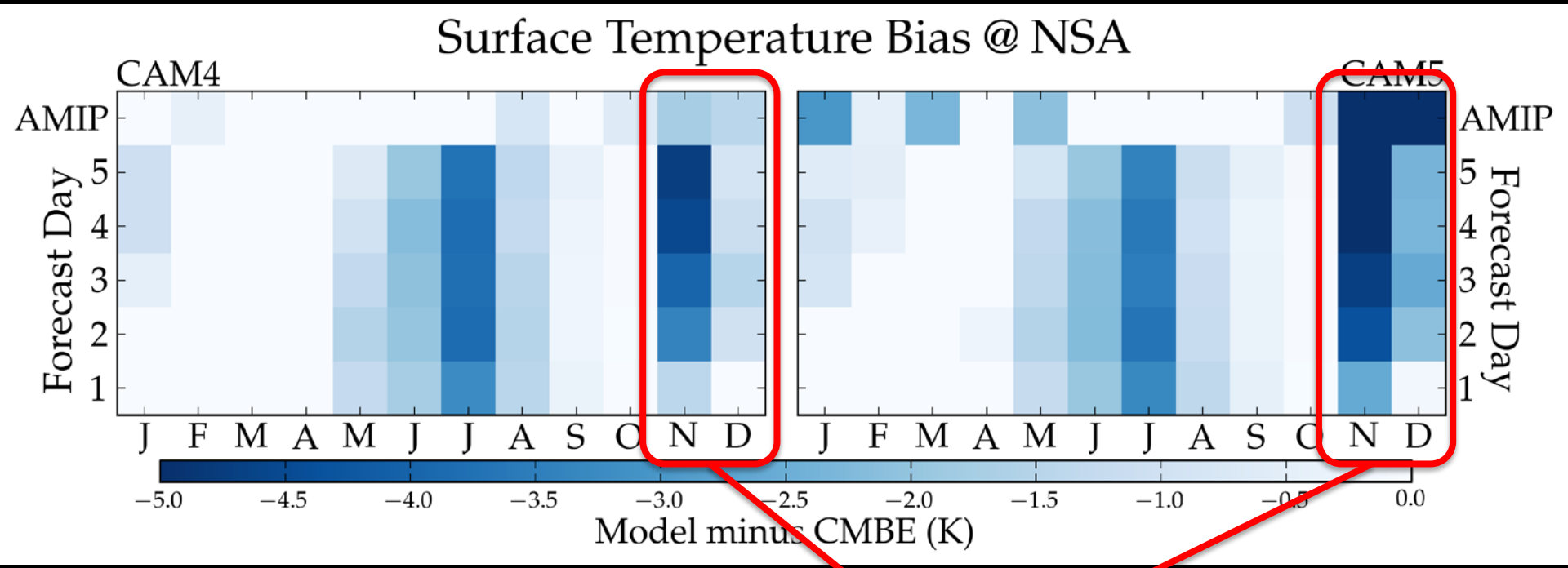

Lowest Model Level Temperature Bias Poleward of 70°N
CAM4
CAM5
AMIP
AMIP
Forecast Day
Forecast Day
5
4
3
2
1
J F M A M J J A S O N D
J F M A M J J A S O N D
−5.0 −4.5 −4.0 −3.5 −3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0
Model minus ECMWF-YOTC (K)


Lowest Model Level Temperature Bias, December
CAM4
CAM5
AMIP
Forecast Day 4
Forecast Day 2
-15.0
-12.9
-10.7
-8.6
-6.4
-4.3
-2.1
0.0
Model minus ECMWF-YOTC (K)

What About Actual Data?

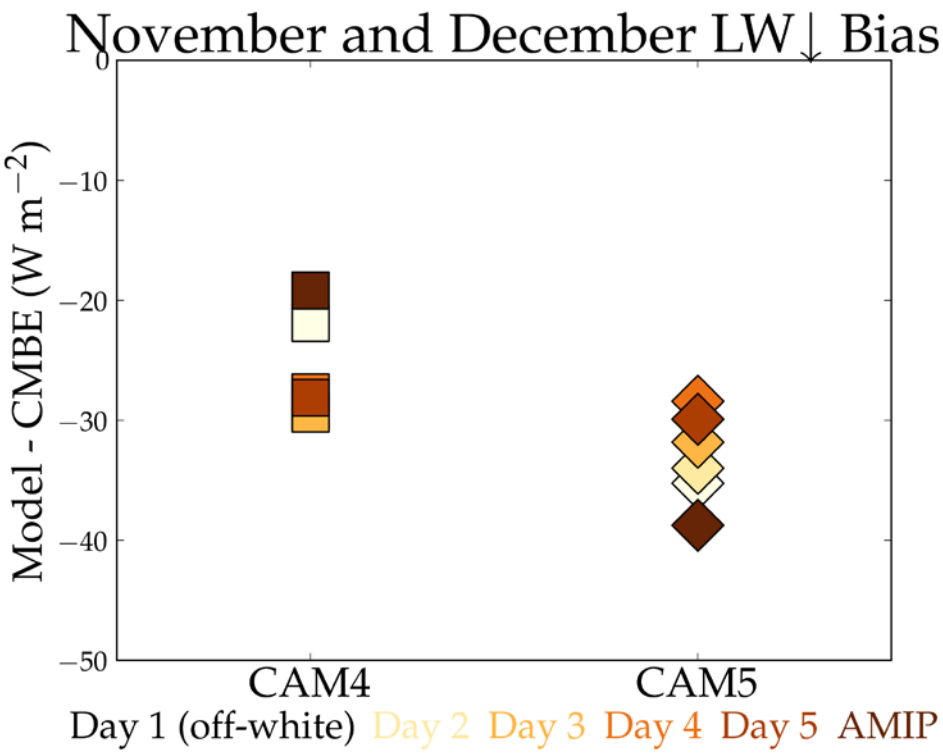
- Climate Modeling Best Estimate (CMBE) data
  - 1 hour temporal resolution

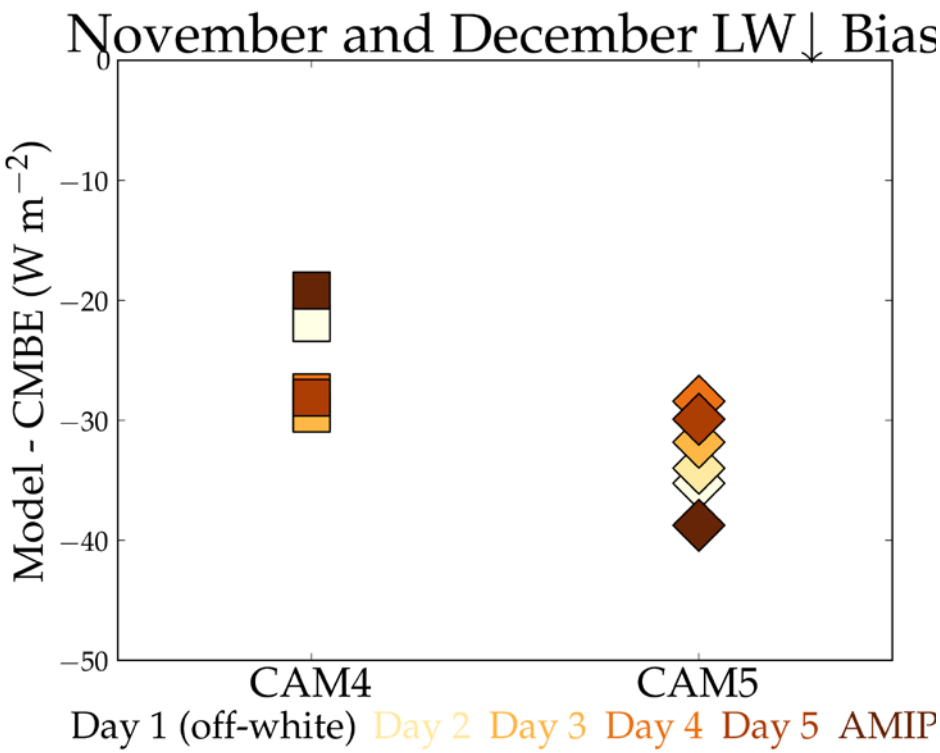

Surface Temperature Bias @ NSA
CAM4
CAM5
AMIP
AMIP
Forecast Day
Forecast Day
5
4
3
2
1
J F M A M J J A S O N D
J F M A M J J A S O N D
−5.0 −4.5 −4.0 −3.5 −3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0
Model minus CMBE (K)



Focus on November and December because these biases are most similar to the Arctic domain Average.

Why Does This Bias Exist?


November and December LW↓ Bias
Model - CMBE (W m^{-2})
0
−10
−20
−30
−40
−50
CAM4
CAM5
Day 1 (off-white) Day 2 Day 3 Day 4 Day 5 AMIP


November and December LW↓ Bias
Model - CMBE (W m^{-2})
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−10
−20
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−40
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CAM4
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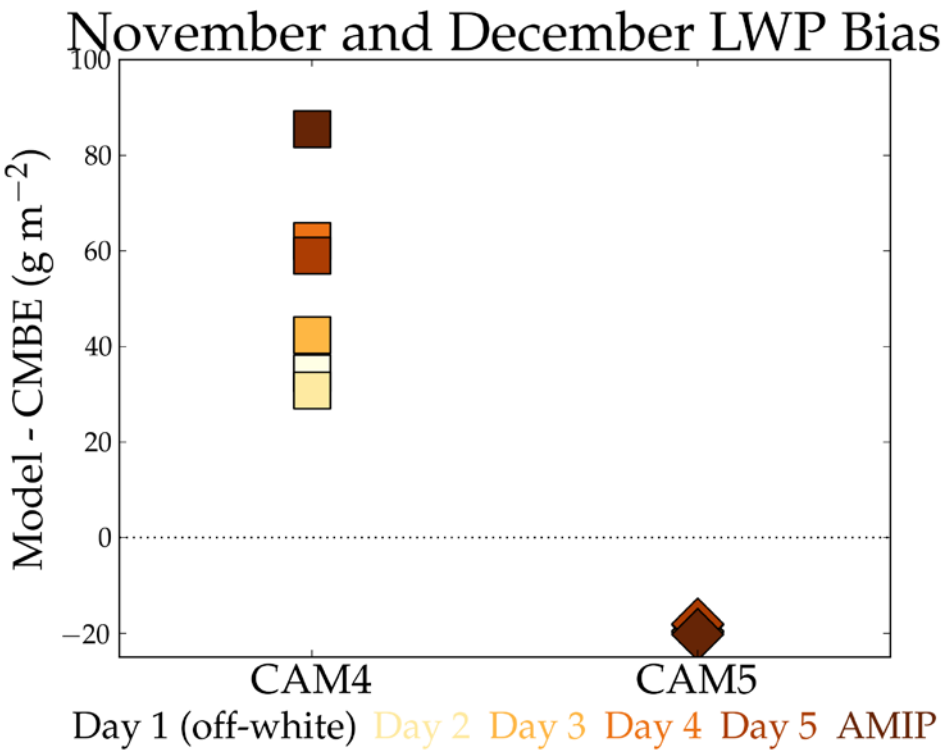
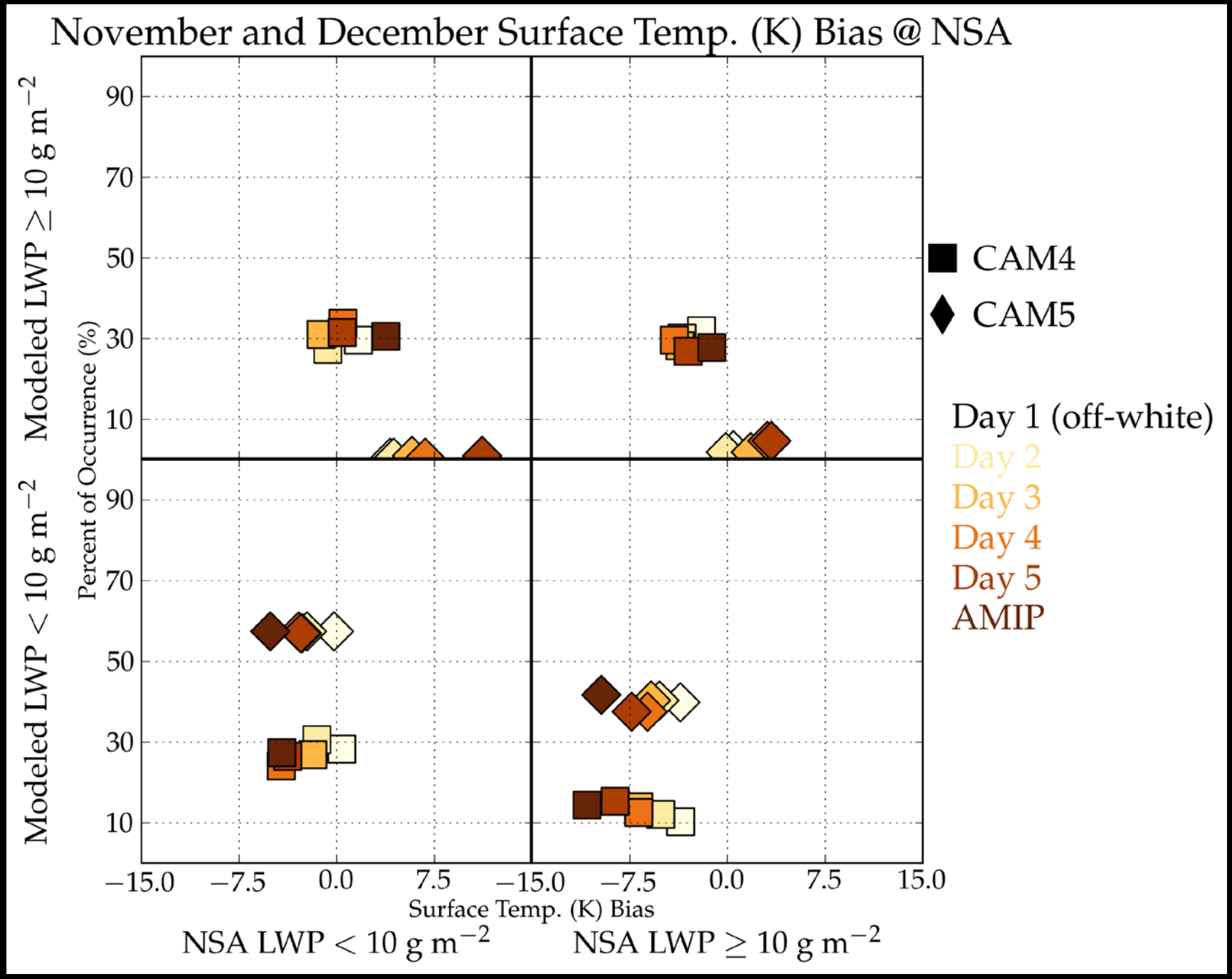

November and December LWP Bias
Model - CMBE (g m^{-2})
100
80
60
40
20
0
−20
CAM4
CAM5
Day 1 (off-white) Day 2 Day 3 Day 4 Day 5 AMIP


November and December Surface Temp. (K) Bias @ NSA
Modeled LWP ≥ 10 g m−2
Modeled LWP < 10 g m−2
Percent of Occurrence (%)
90
70
50
30
10
−15.0
−7.5
0.0
7.5
15.0
Surface Temp. (K) Bias
NSA LWP < 10 g m−2
NSA LWP ≥ 10 g m−2
CAM4
CAM5
Day 1 (off-white)
Day 2
Day 3
Day 4
Day 5
AMIP

What About Other Models?

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Transpose AMIP

- HadGEM2-A, IPSL-CM5A-LR, CNRM-CM5, MIROC5, CAM4, & CAM5
- 16 Forecast Runs for Each Season
  - Autumn (October 15th, 2008 to November 2nd, 2008)
  - Winter (January 15th, 2009 to February 2nd, 2009)
  - Spring (April 15th, 2009 to May 3rd, 2009)
  - Summer (July 15th, 2009 to August 2nd, 2009)

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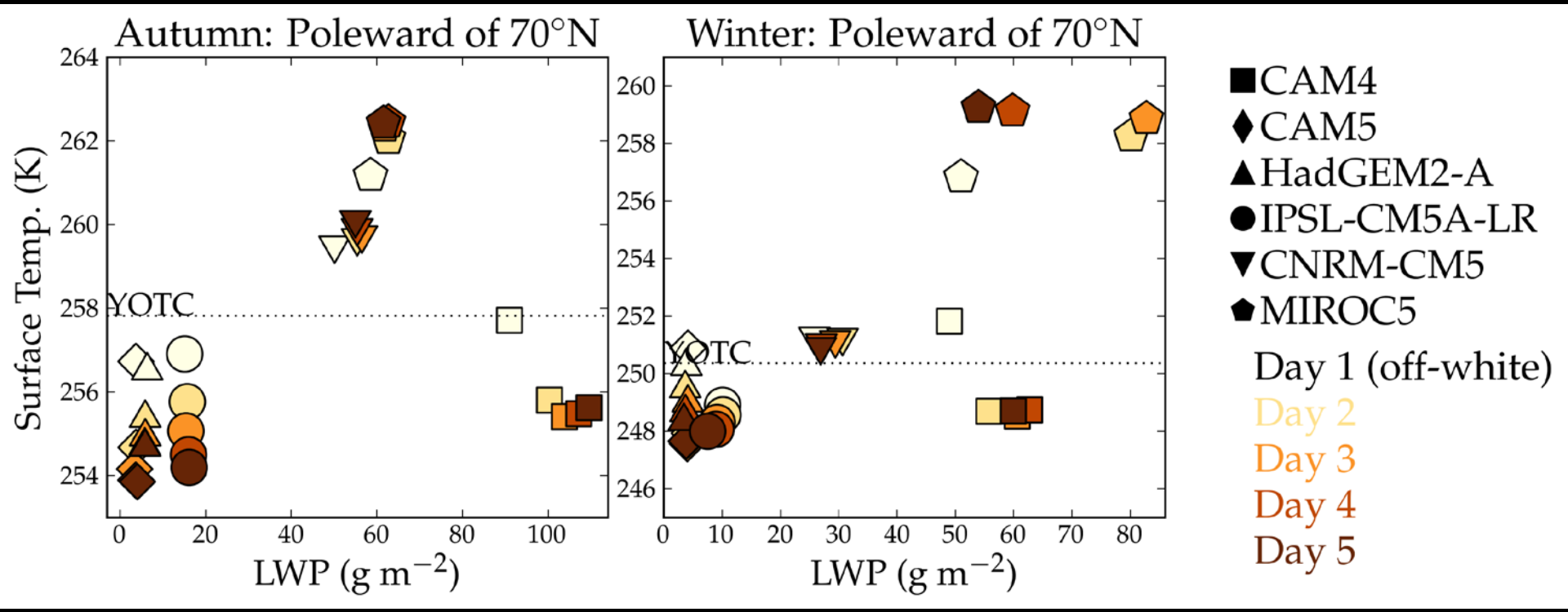
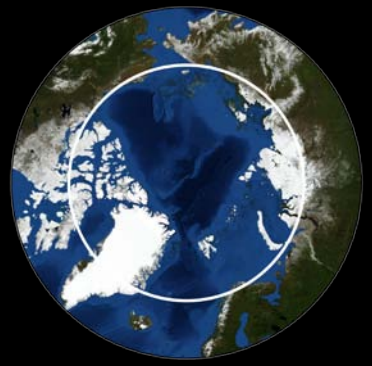
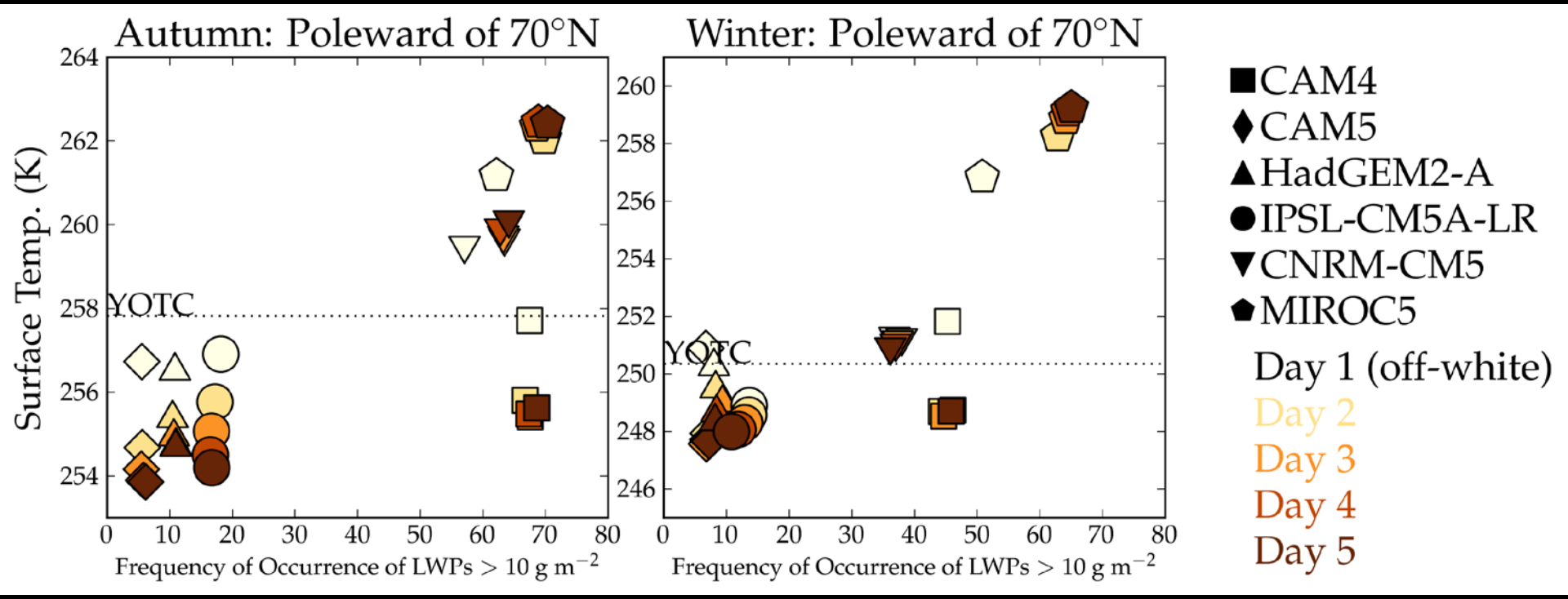
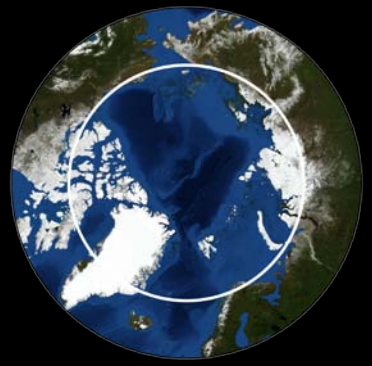
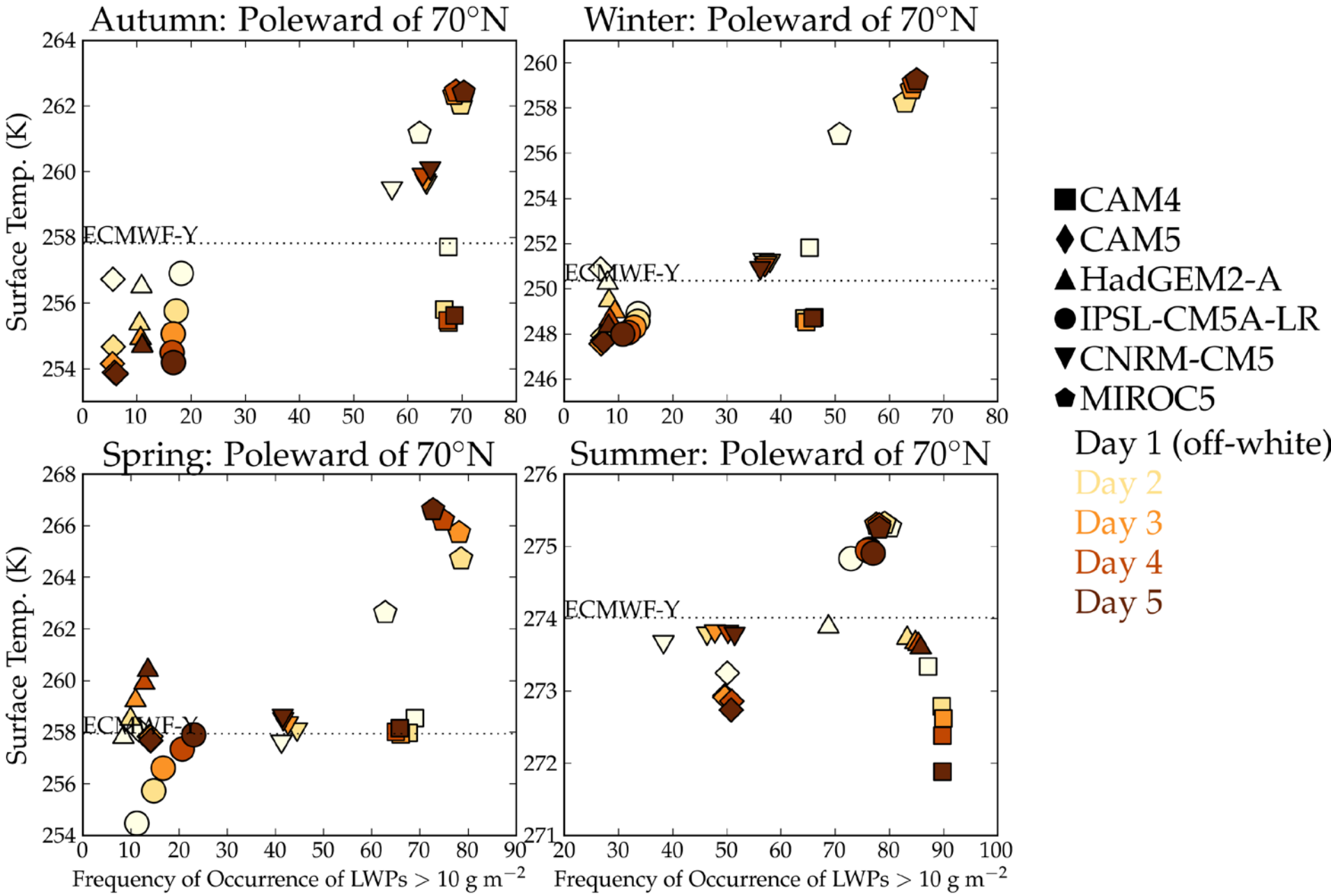

Autumn: Poleward of 70°N
Winter: Poleward of 70°N
Surface Temp. (K)
LWP (g m^{-2})
YOTC
CAM4
CAM5
HadGEM2-A
IPSL-CM5A-LR
CNRM-CM5
MIROC5
Day 1 (off-white)
Day 2
Day 3
Day 4
Day 5




Autumn: Poleward of 70°N
Winter: Poleward of 70°N
Surface Temp. (K)
YOTC
YOTC
Frequency of Occurrence of LWPs > 10 g m^{-2}
Frequency of Occurrence of LWPs > 10 g m^{-2}
CAM4
CAM5
HadGEM2-A
IPSL-CM5A-LR
CNRM-CM5
MIROC5
Day 1 (off-white)
Day 2
Day 3
Day 4
Day 5




Autumn: Poleward of 70°N
Winter: Poleward of 70°N
Spring: Poleward of 70°N
Summer: Poleward of 70°N
Surface Temp. (K)
Frequency of Occurrence of LWPs > 10 g m^{-2}
ECMWF-Y
CAM4
CAM5
HadGEM2-A
IPSL-CM5A-LR
CNRM-CM5
MIROC5
Day 1 (off-white)
Day 2
Day 3
Day 4
Day 5

Conclusions

- CAM4 and CAM5 have a cold bias in the Arctic winter months
  - Forecast and AMIP runs
- Compared to the NSA data, the bias occurs during clear sky periods and when the observations are opaquely cloudy, but the models are radiative clear
- The spread of Arctic surface temperature in the transpose AMIP relates to the frequency of clouds with liquid water at a threshold

Thank You!

Source: NASA

Lawrence Livermore National Laboratory, Program for Climate Model Diagnosis and Intercomparison
barton30@llnl.gov

Neil P. Barton