

Influence of Trends on Weeks 3-4 Temperature Prediction

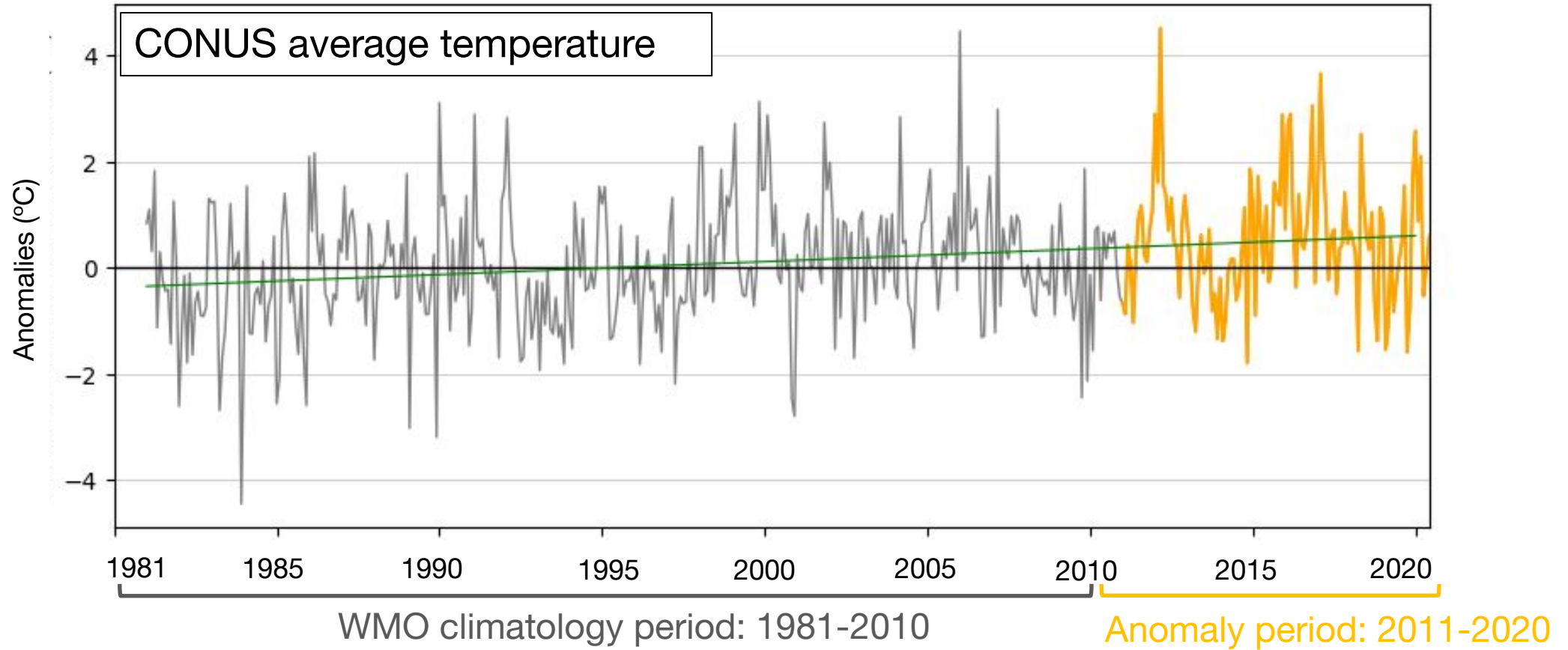
Yuan-Ming Cheng^{1,2}, John Albers², Matt Newman², and Maria Gehne^{1,2}

¹CIRES, University of Colorado, Boulder, Colorado, USA

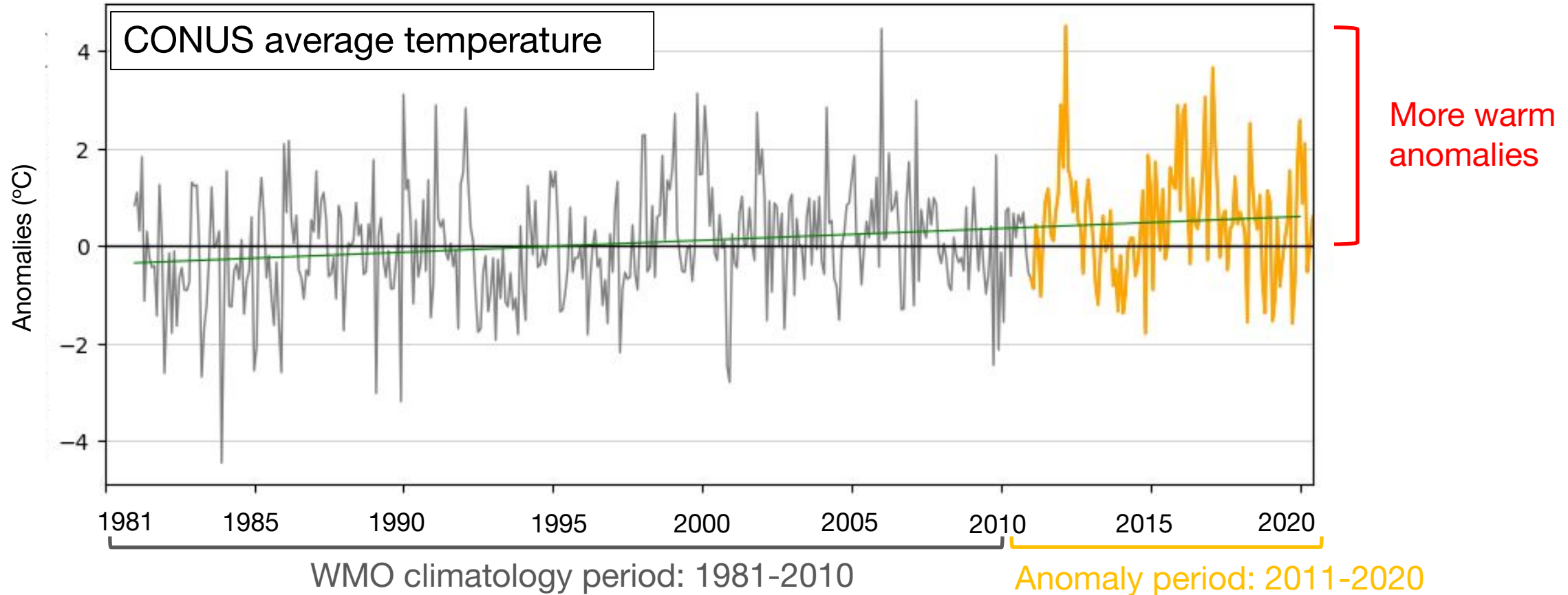
²NOAA Physical Sciences Laboratory, Boulder, Colorado, USA



How does warming trend affect temperature anomalies?

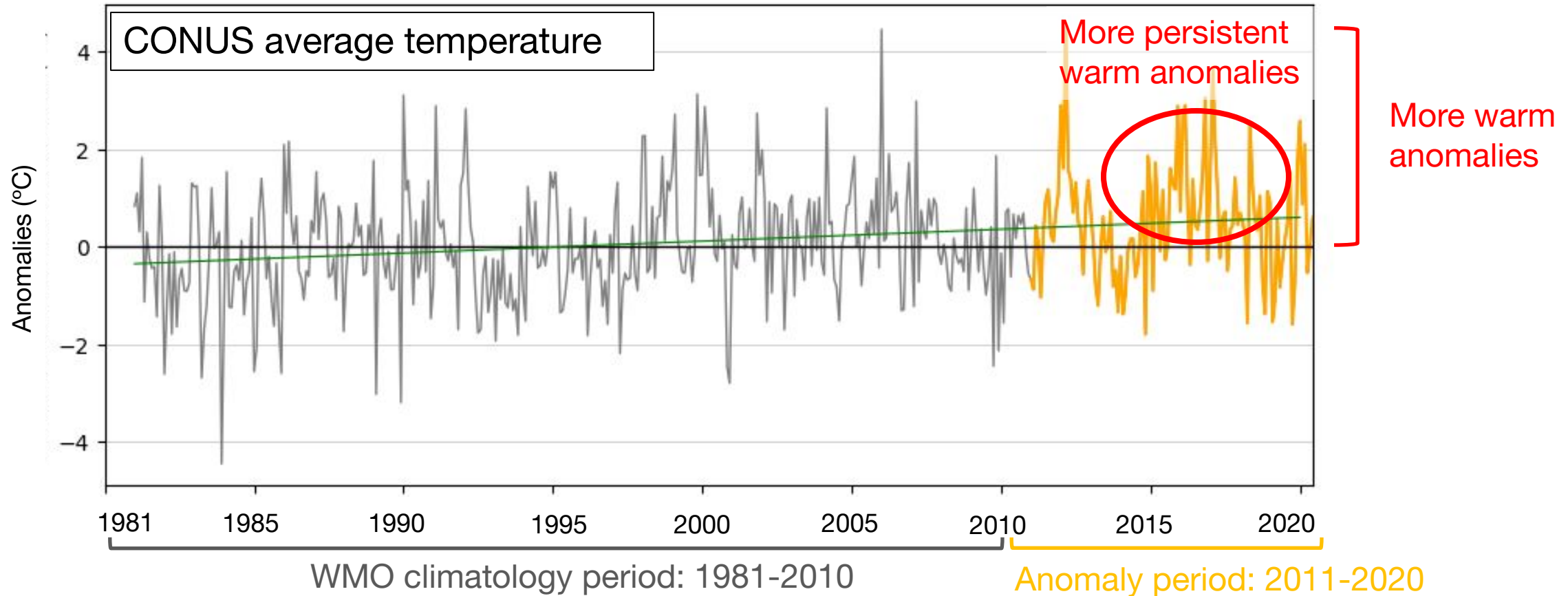


How does warming trend affect temperature anomalies?



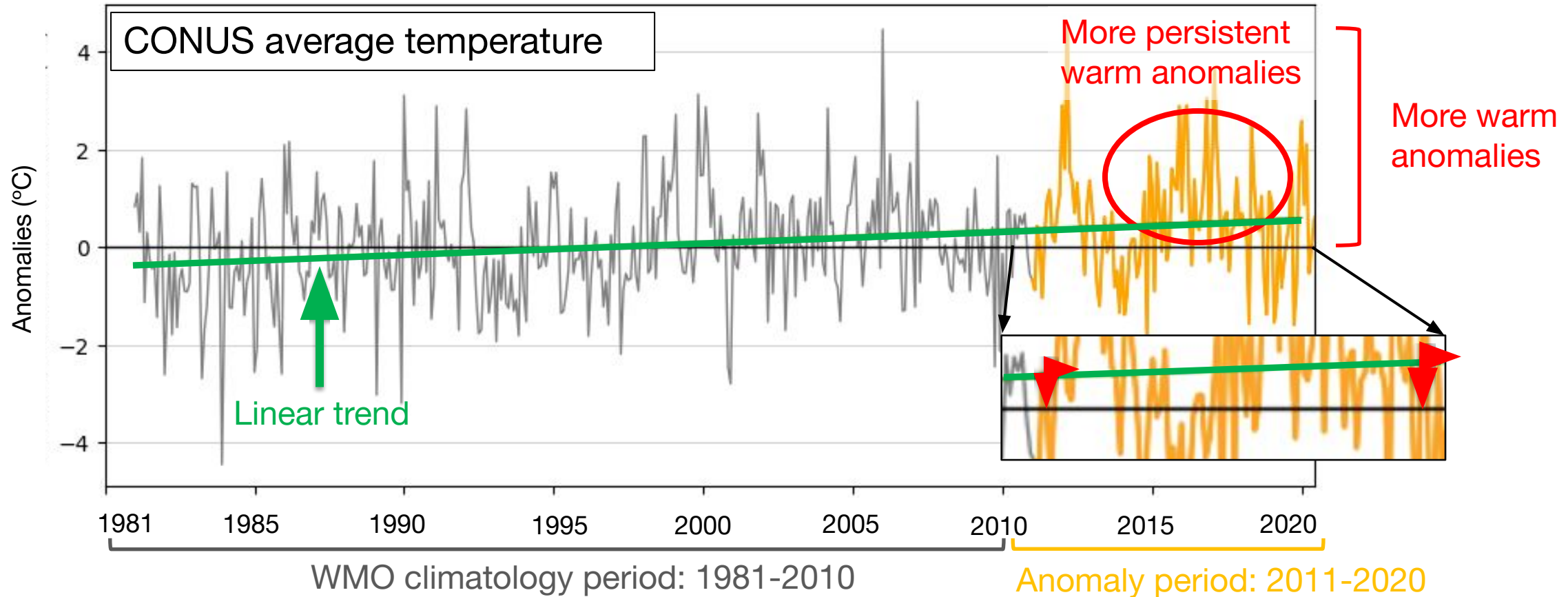
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How does warming trend affect temperature anomalies?



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- Extended periods of warmth are more common—more persistent warm anomalies

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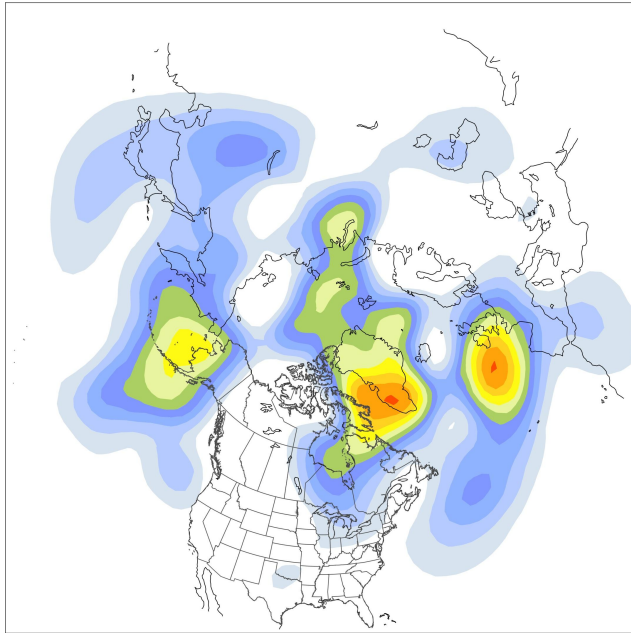


- Rising temperature leads to anomalies skewed toward warmth
- Extended periods of warmth are more common—more persistent warm anomalies
- The period chosen for defining the climate significantly influences the anomalies

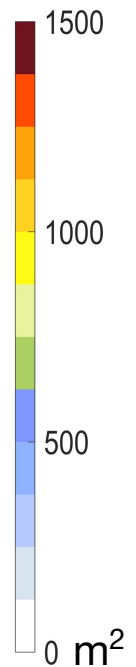
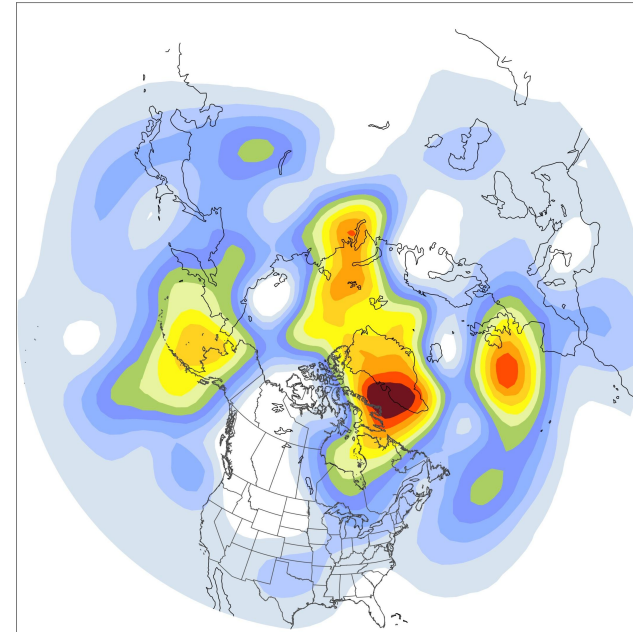
“Trend anomaly” leads to more persistent warm anomalies

21-day lag-covariance of 500-hPa geopotential heights for 1999-2018

Anomalies from 1999-2018 base state



Anomalies from 1958-2018 base state



Any data-driven machine learning method is prone to learning warm biases and persistent warm stretches in the data

Objective

Understand how the temperature trend impacts S2S forecast tools and skill evaluation

- Improve week 3-4 Temperature outlooks
- Compare IFS operational model, Linear Inverse Model (LIM), and Optimal Climate Normals (OCN)

Method: 3 forecast models and verification

Operational IFS forecast

- uses anomalies derived from *fair-sliding 20-year climate* of retrospective forecasts

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Linear Inverse Model (LIM) v2.0

- approximates S2S variability as linear stochastically forced dynamics
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- calculates the running average of the last 10 years as forecasts
- uses the same JRA-55 anomalies from *fair-sliding 20-year climate*

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Verification: Heidke Skill Score (HSS)

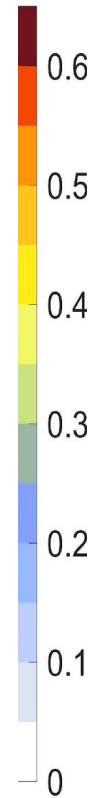
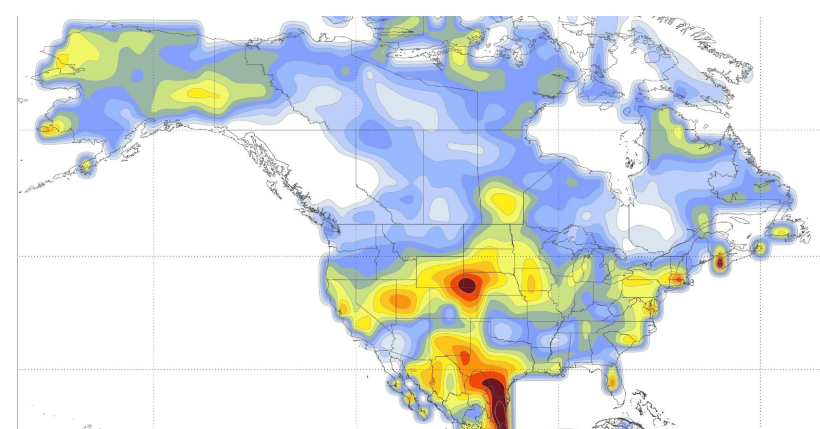
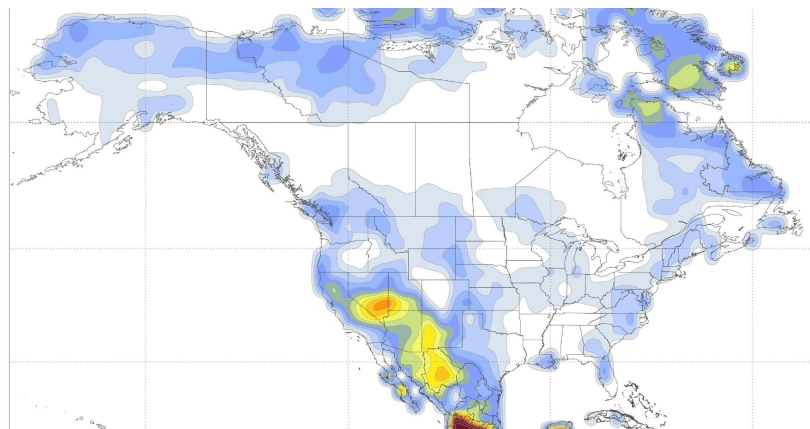
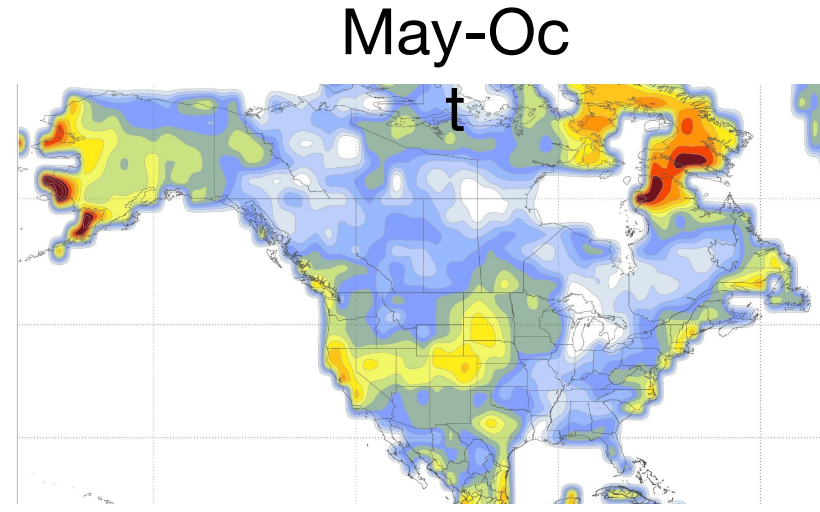
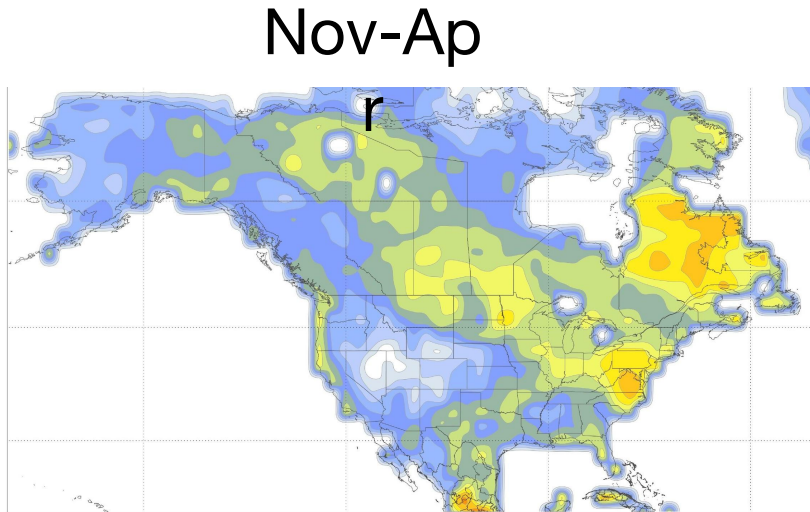
- Forecasts are scored against JRA-55 using the same IFS forecast dates in **2017-2022**

Weeks 3-4 real-time T2m Heidke skill score, 2017-2022

IFS

Operational
bias-corrected

CONUS: 0.27



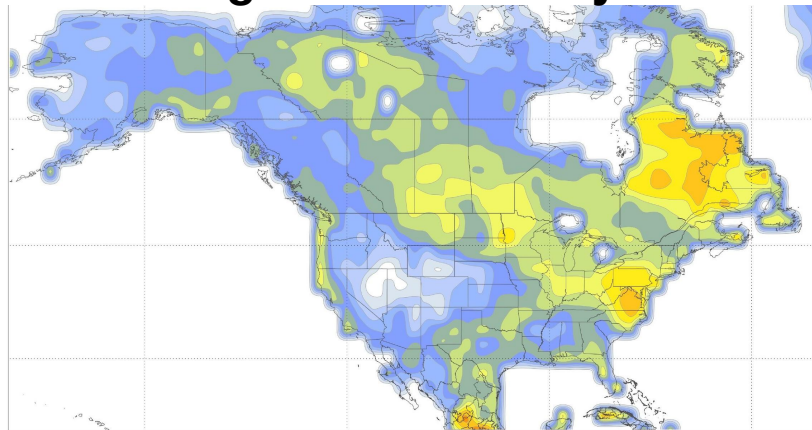
Weeks 3-4 T2m Heidke skill, verified against WMO 30-year climatology

Verifying against anomalies from WMO 30-yr climatology could inflate forecast skills

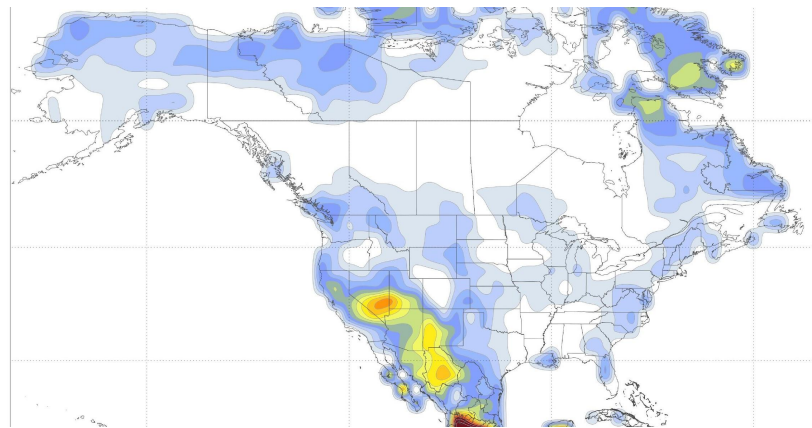
Weeks 3-4 T2m HSS, Nov-Apr 2017-2022

Verified against WMO 30-yr climate

IFS



LIM

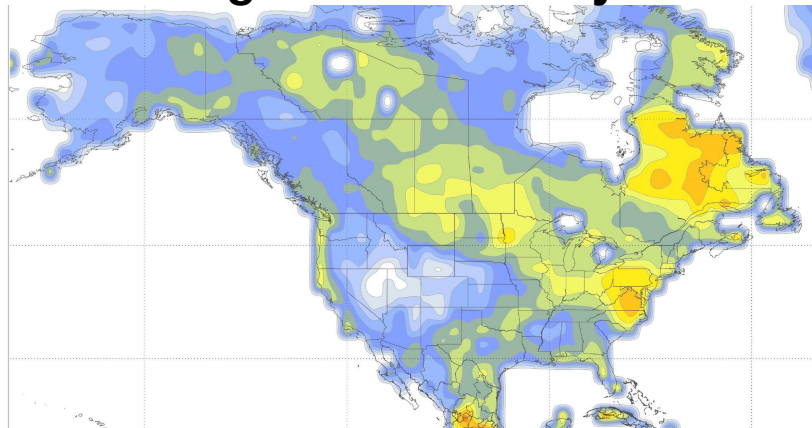


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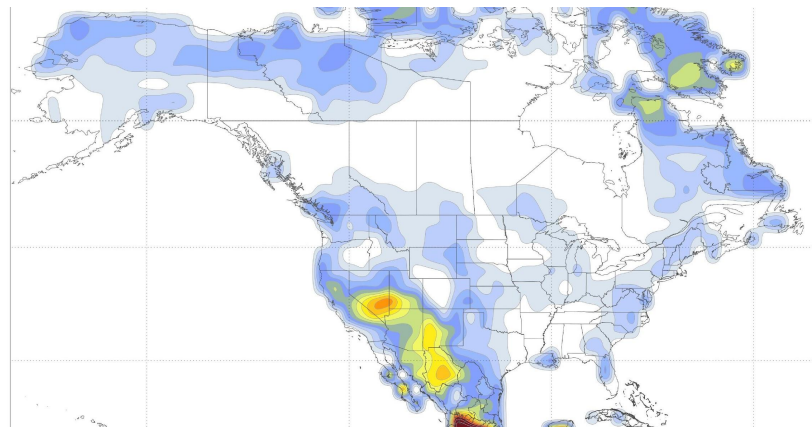
Weeks 3-4 T2m HSS, Nov-Apr 2017-2022

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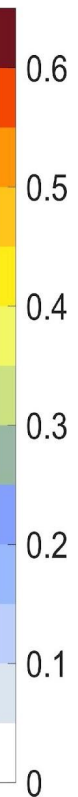
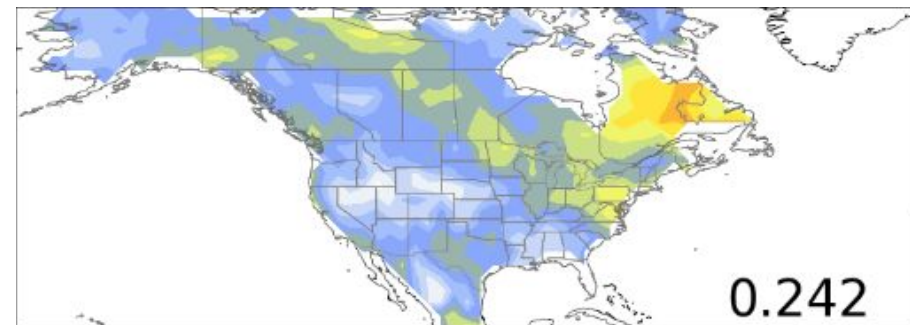
Verified against WMO 30-yr climate



LIM



Verified against fair sliding 20-yr climate

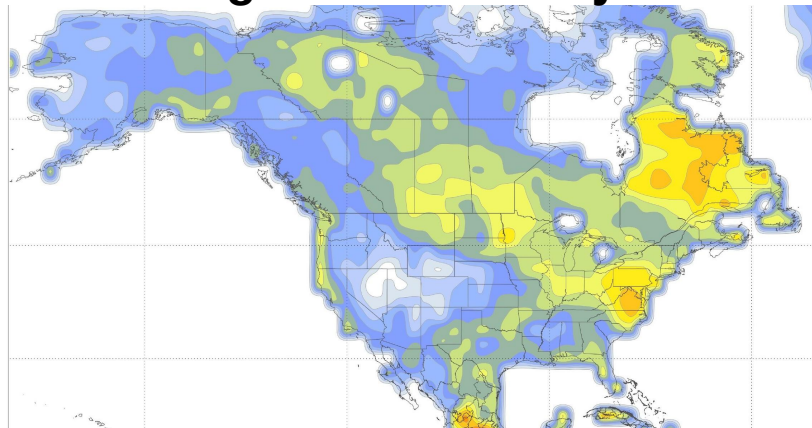


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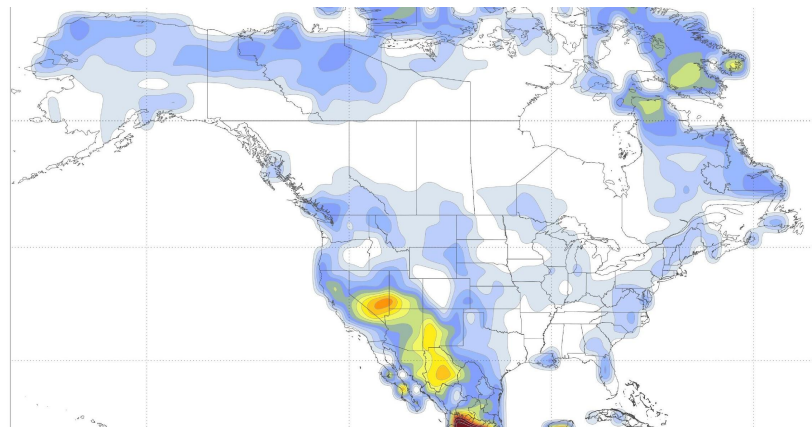
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IFS

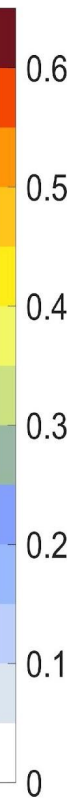
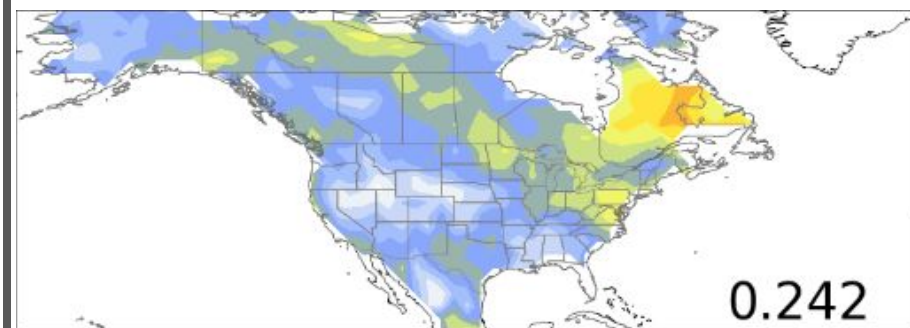
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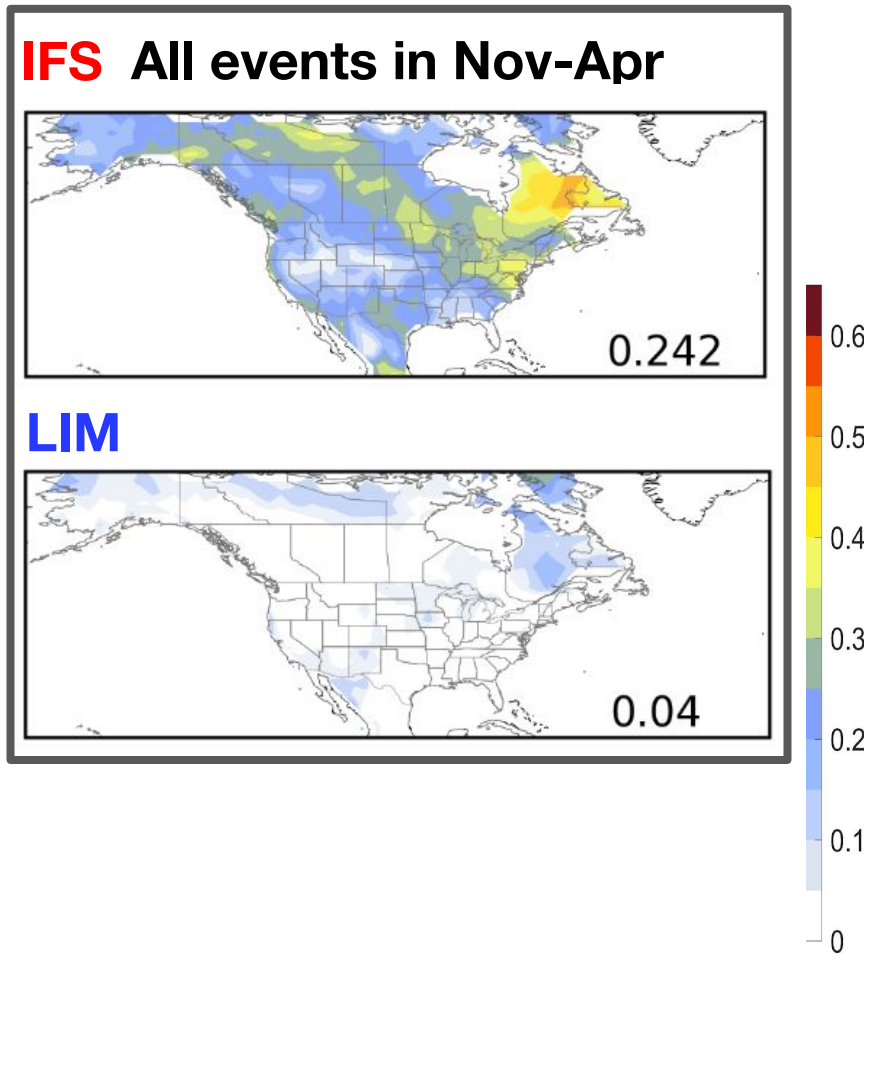
LIM



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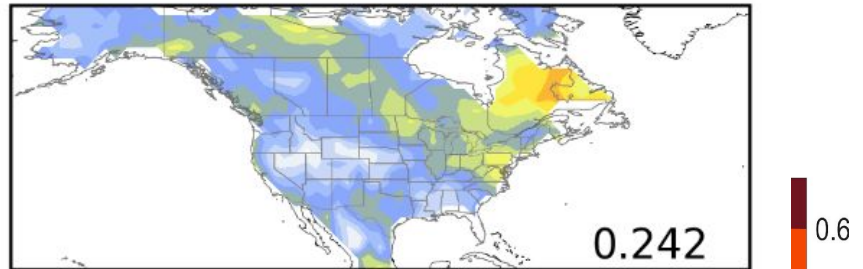
Are model skills inflated by the warming trend?



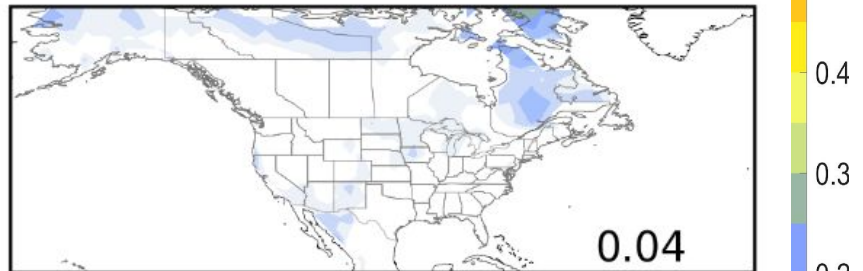
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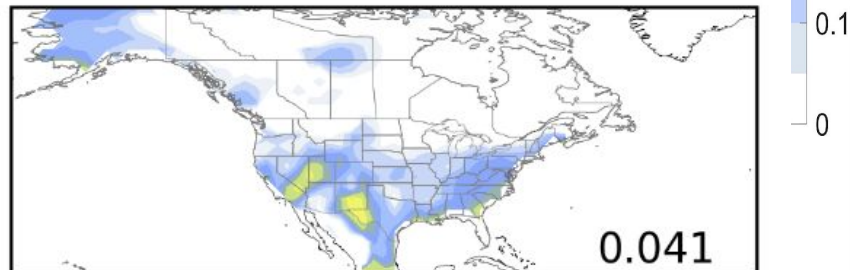
IFS All events in Nov-Apr



LIM



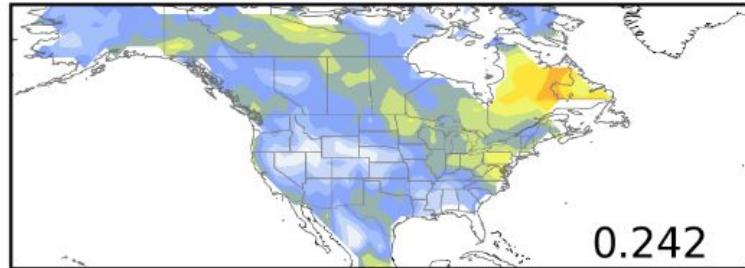
OCN



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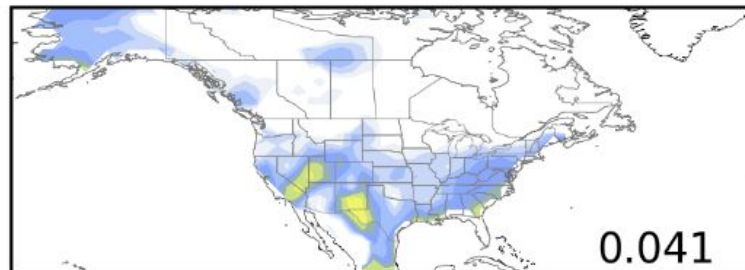
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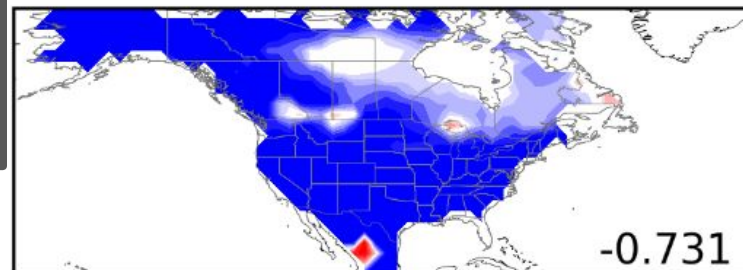
LIM



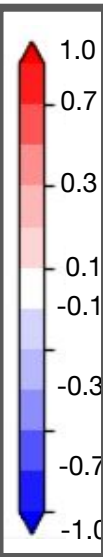
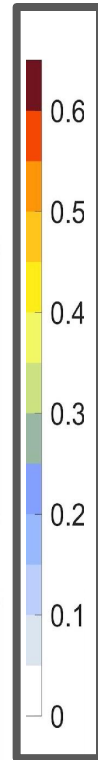
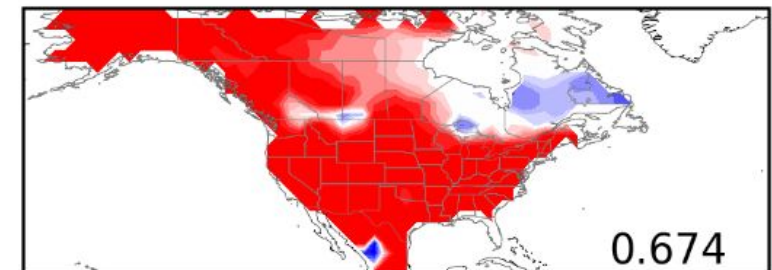
OCN



Cold events



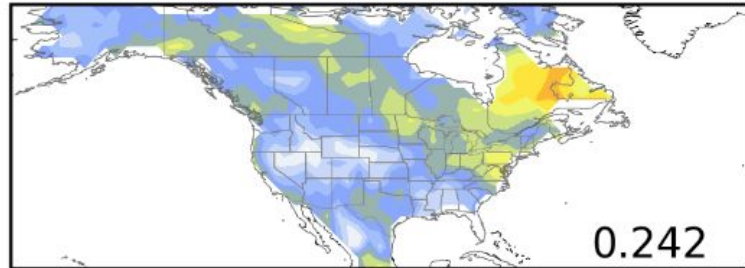
Warm events



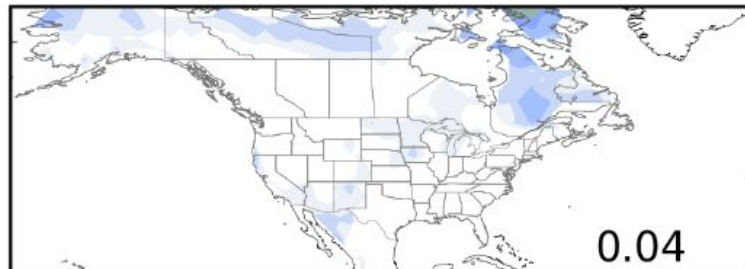
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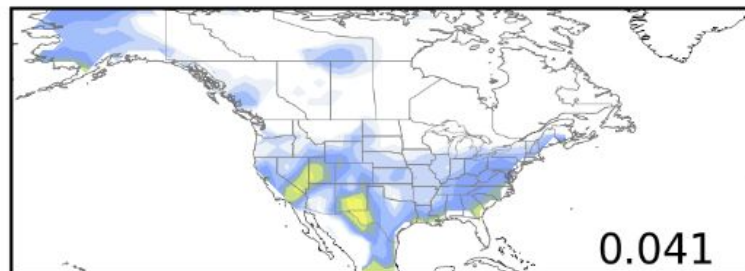
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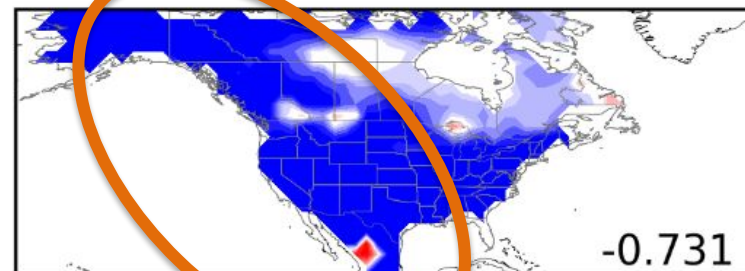
LIM



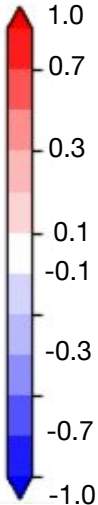
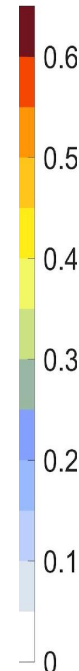
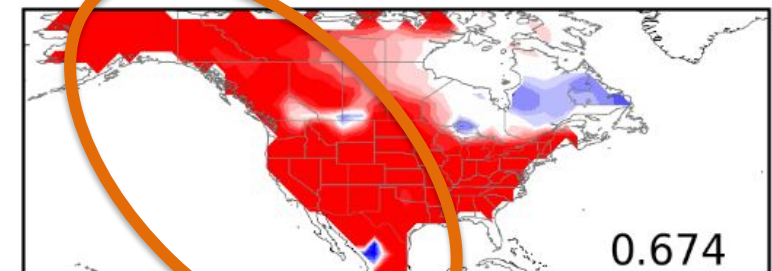
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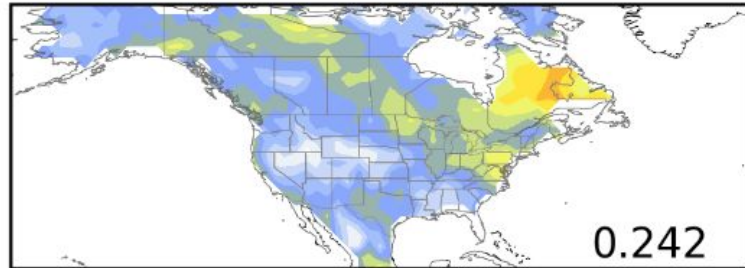


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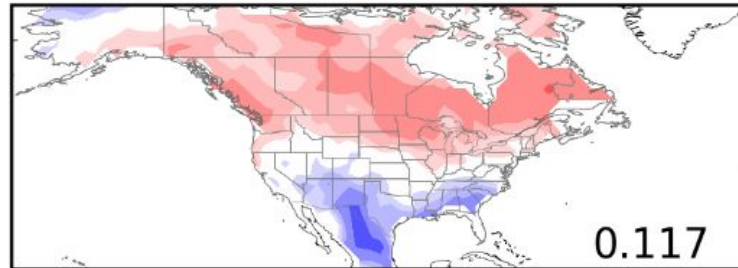
Skill likely from trend

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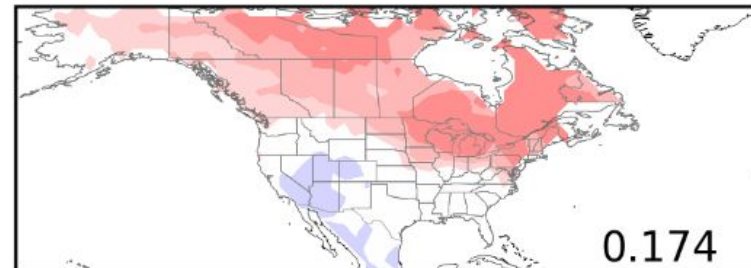
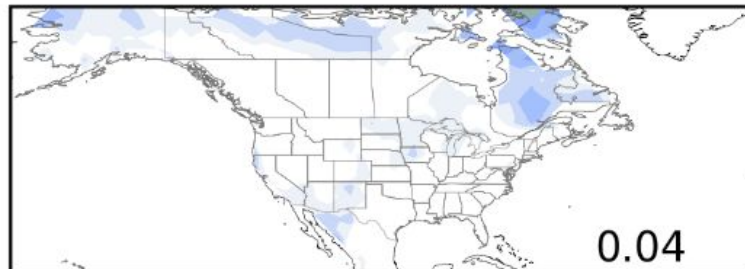


Cold events

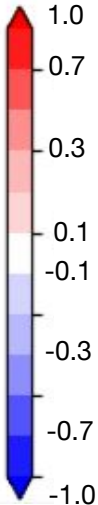
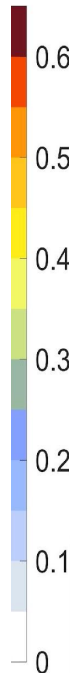
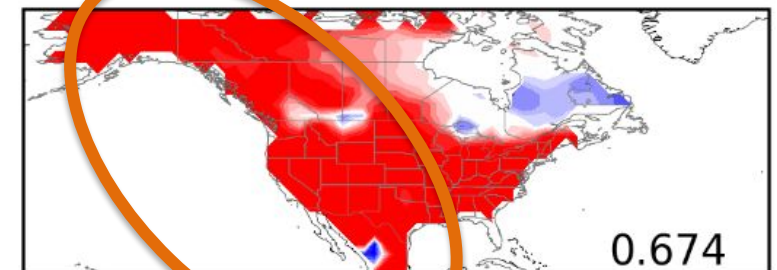
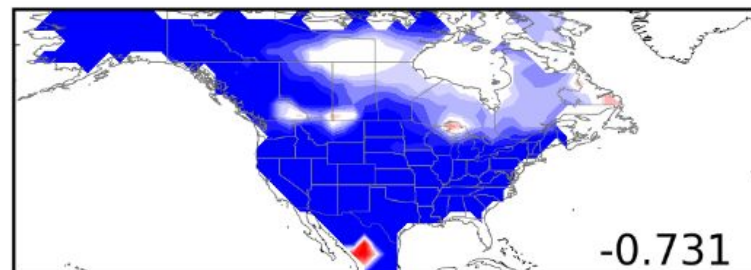
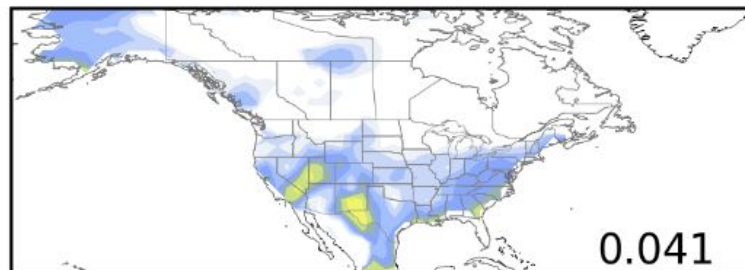


Warm events

LIM



OCN



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Skill likely from trend

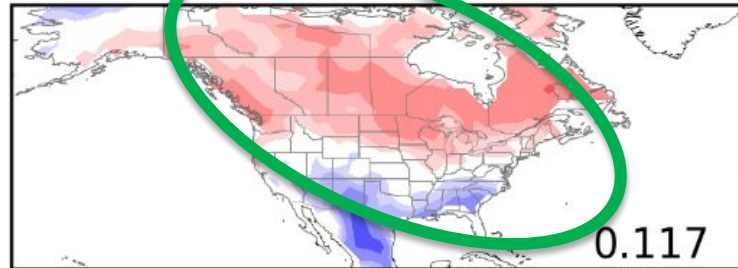
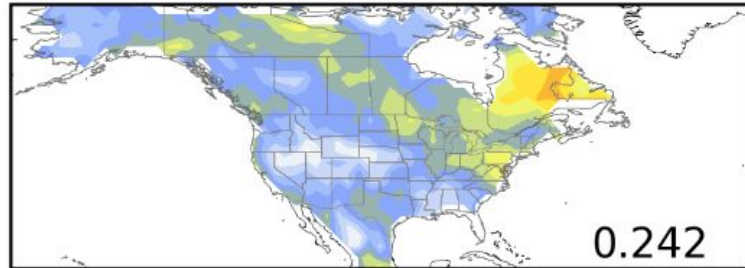
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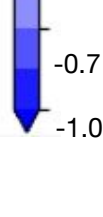
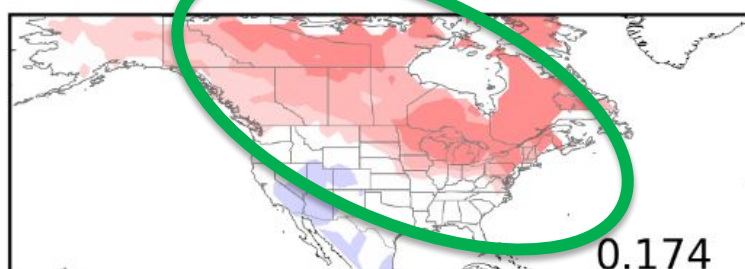
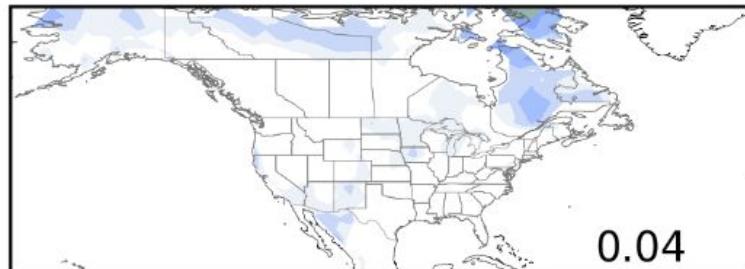
IFS All events in Nov-Apr

Cold events

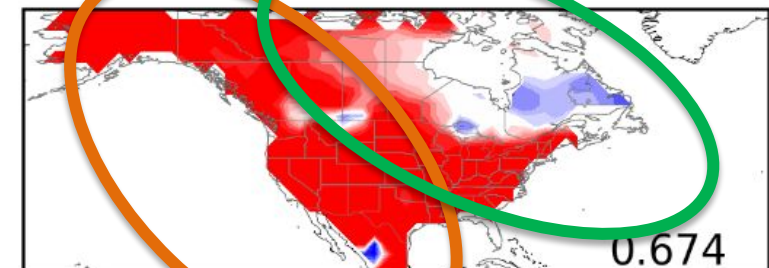
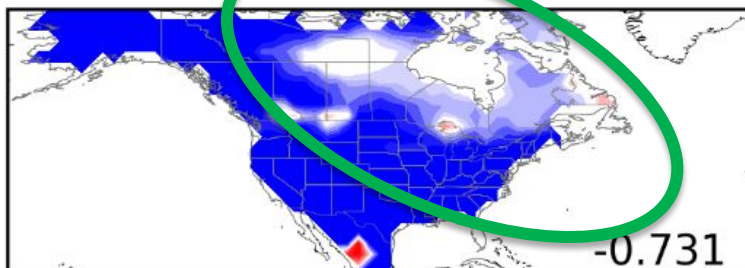
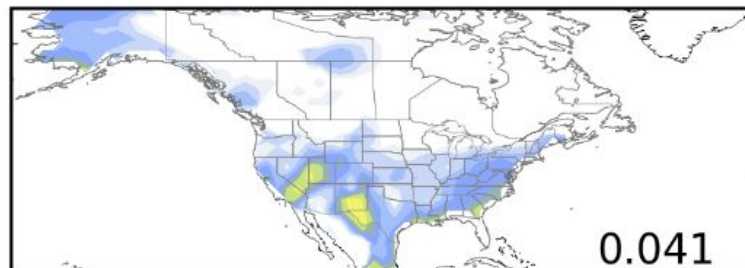
Warm events



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OCN



Verified against fair sliding 20-yr climate

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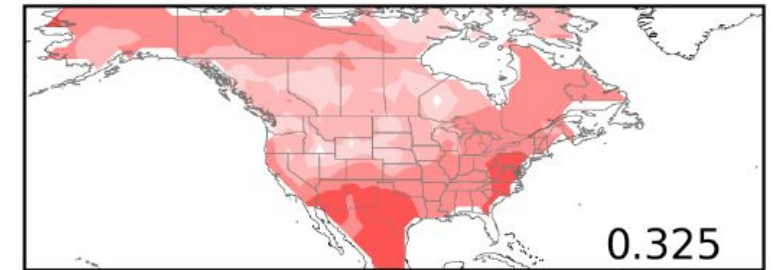
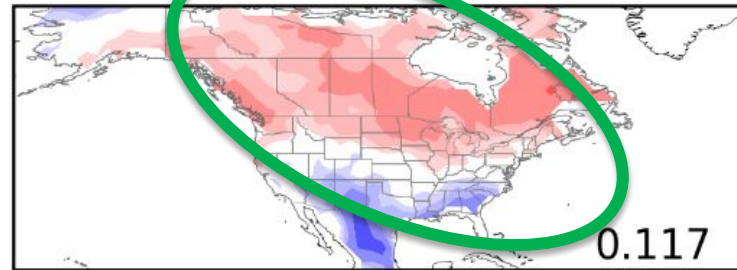
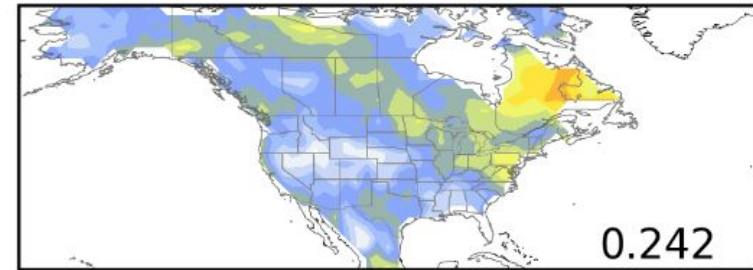
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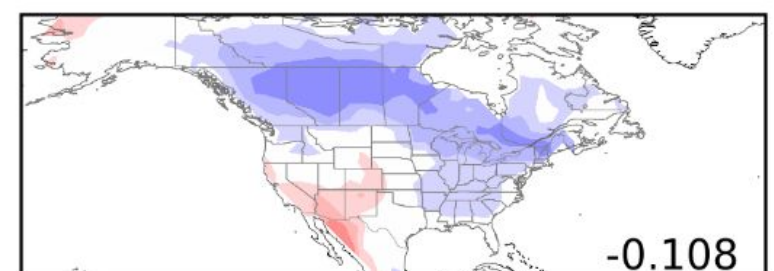
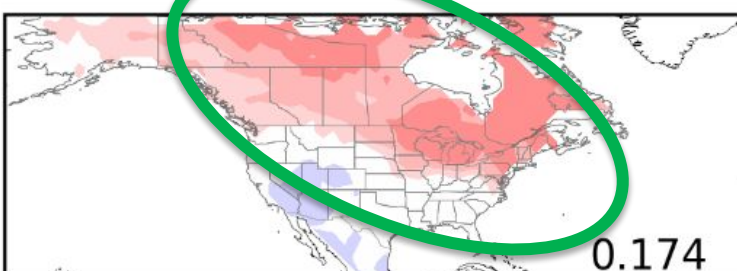
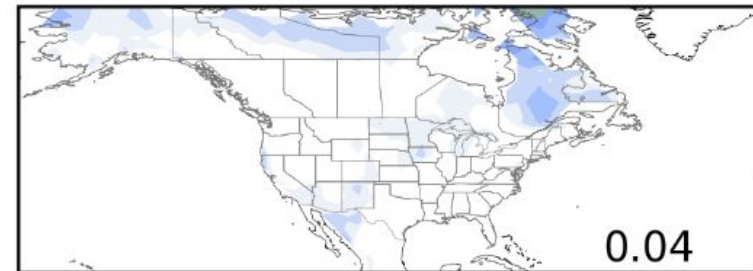
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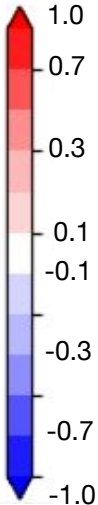
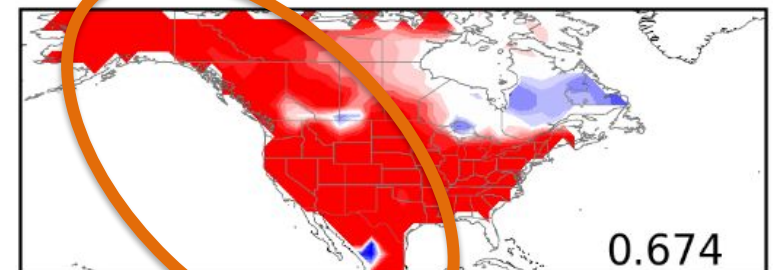
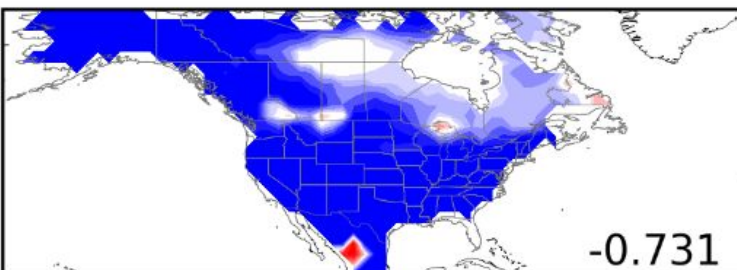
Warm events



LIM



OCN



Verified against fair sliding 20-yr climate

Skill likely from trend

Lessons Learned

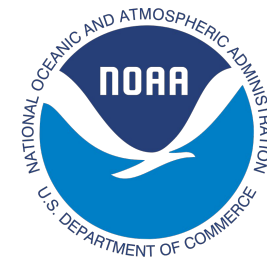
- Trend is an issue for making S2S machine learning tools and proper skill evaluation
 - Relative to a fixed long-term climate, recent anomalies are skewed toward warmth and are more persistent
 - A fair-sliding climate mitigates this issue

Lessons Learned

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- Models exhibit a conditional bias, showing better skill in predicting warm events

Lessons Learned

- Trend is an issue for making S2S machine learning tools and proper skill evaluation
 - Relative to a fixed long-term climate, recent anomalies are skewed toward warmth and are more persistent
 - A fair-sliding climate mitigates this issue
- Models exhibit a conditional bias, showing better skill in predicting warm events
- When designing an empirical forecasting system, we need to balance between operational priorities and forecasting accuracy
 - We could maximize skill by including trend or
 - We could degrade skill and perhaps have a model that can differentiate between cold and warm forecasts more skillfully



THANK YOU. QUESTIONS?

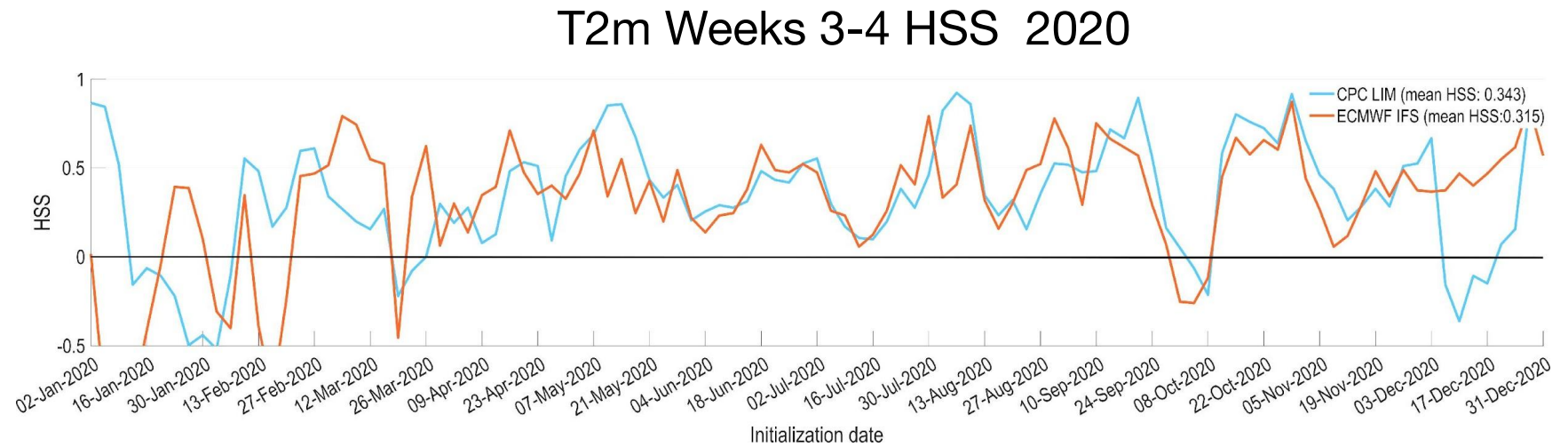
Yuan-Ming Cheng

NOAA Physical Sciences Laboratory/CIRES

yuan-ming.cheng@noaa.gov

LIM can capture variations of IFS skill from similar sources of predictability

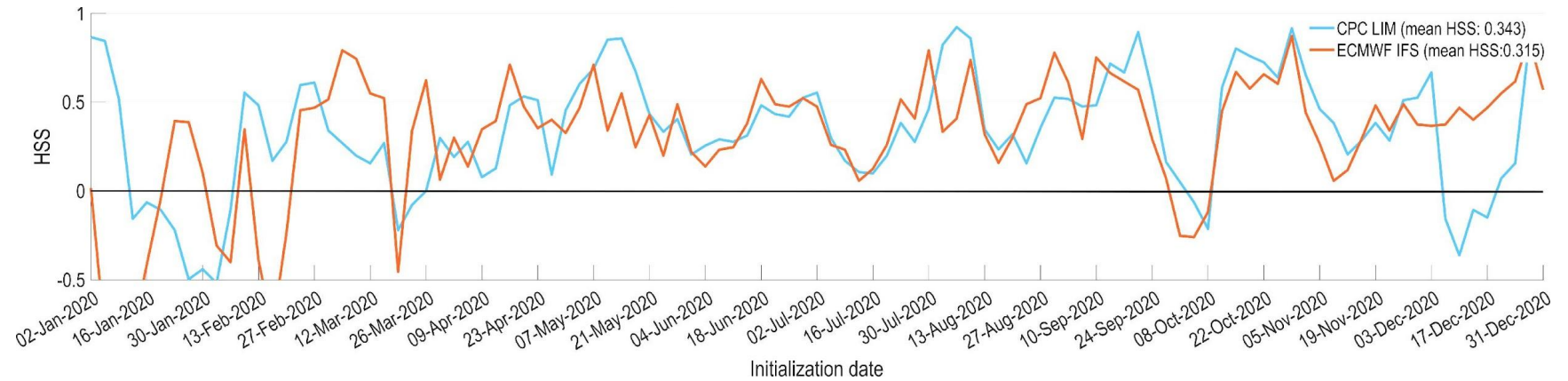
LIM vs IFS



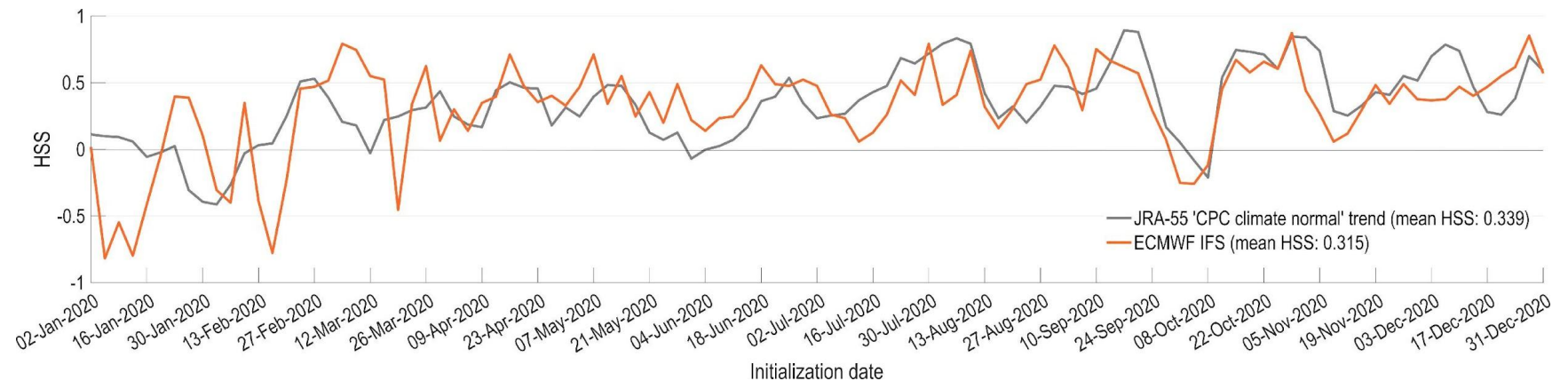
But maybe we are kidding ourselves, since the trend has a huge impact on S2S skill...

LIM vs IFS

T2m Weeks 3-4 HSS 2020

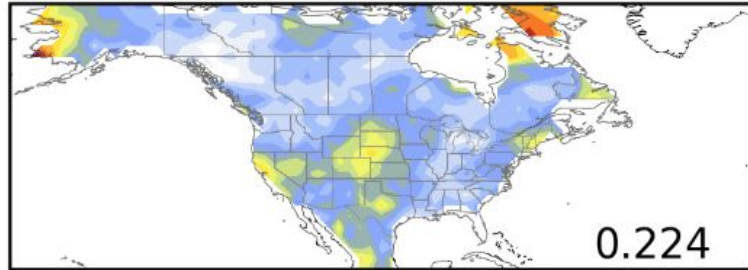


“Trend forecast” vs IFS

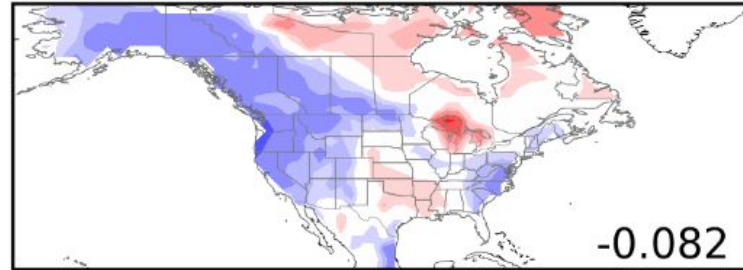


Are model skills inflated by the warming trend?

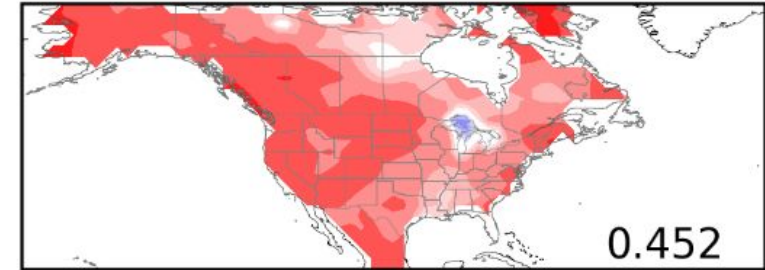
IFS All events in May-Oct



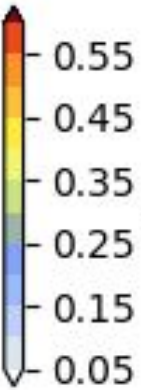
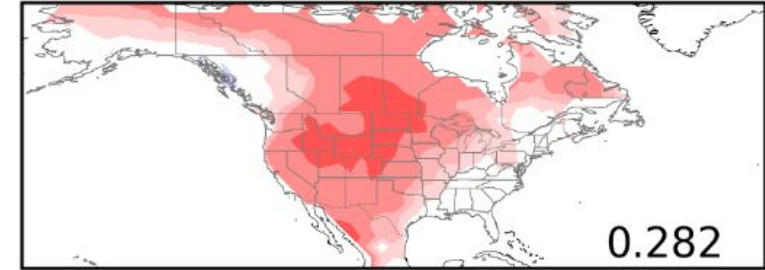
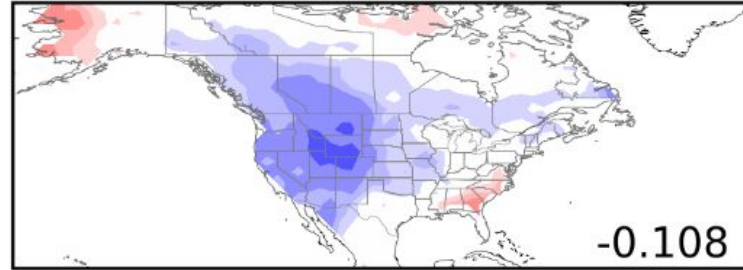
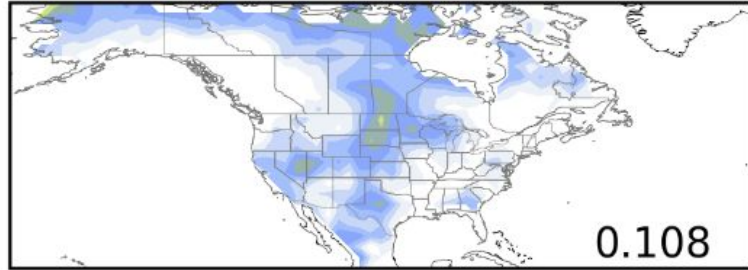
Cold events



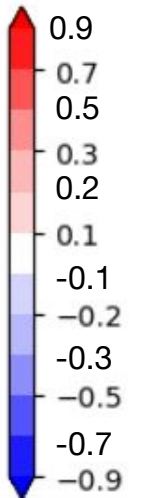
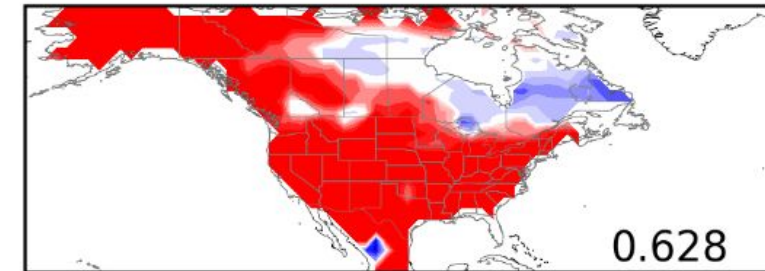
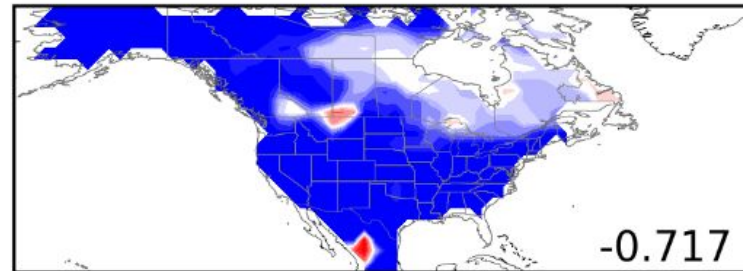
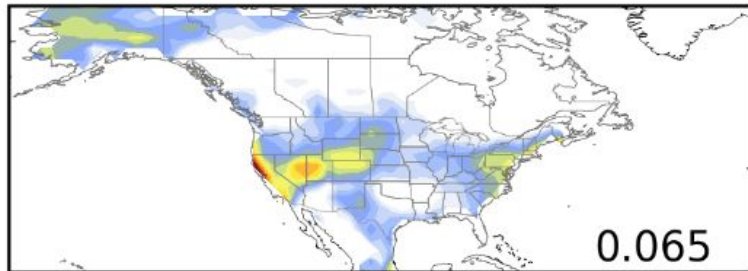
Warm events



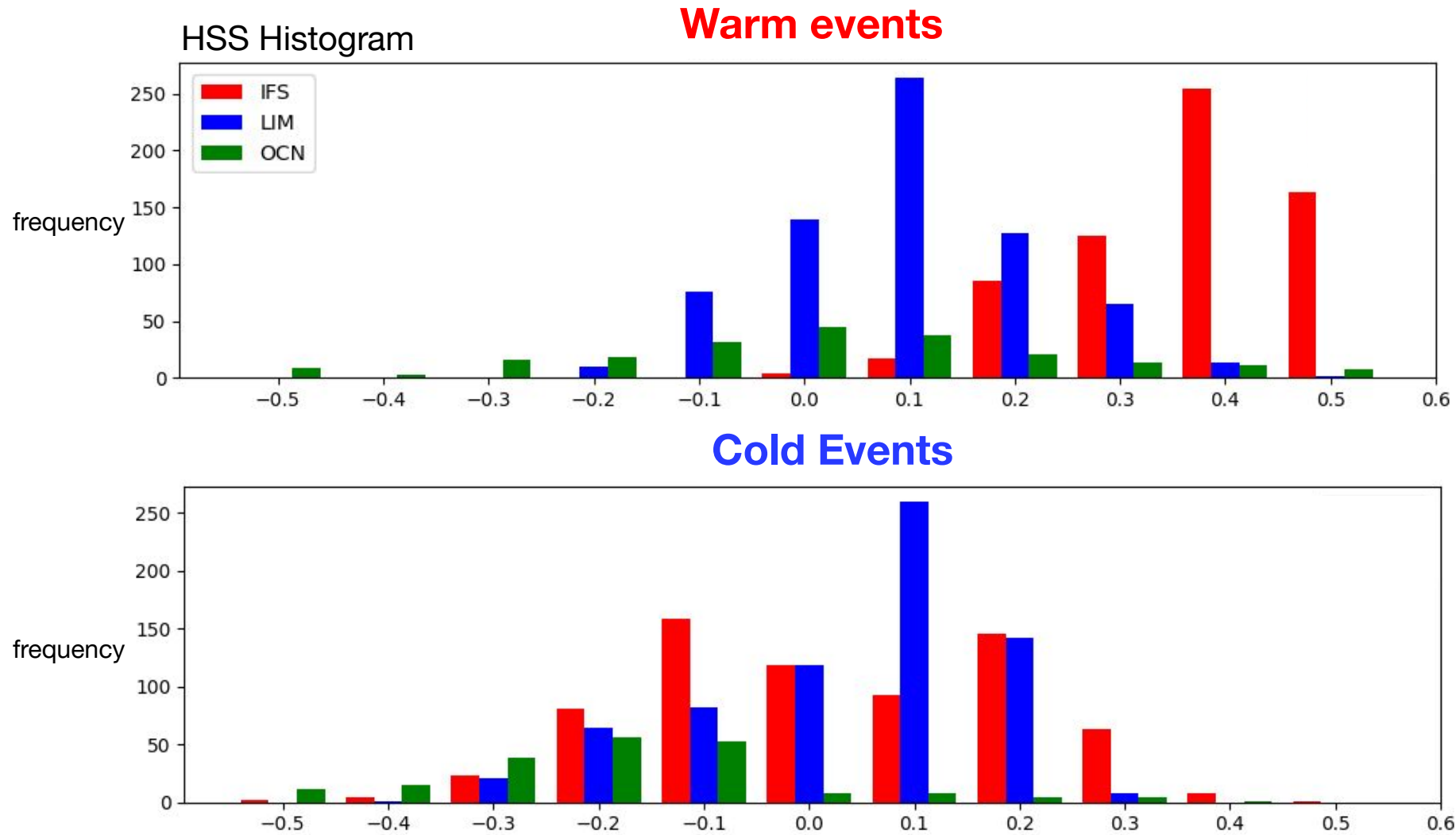
LIM



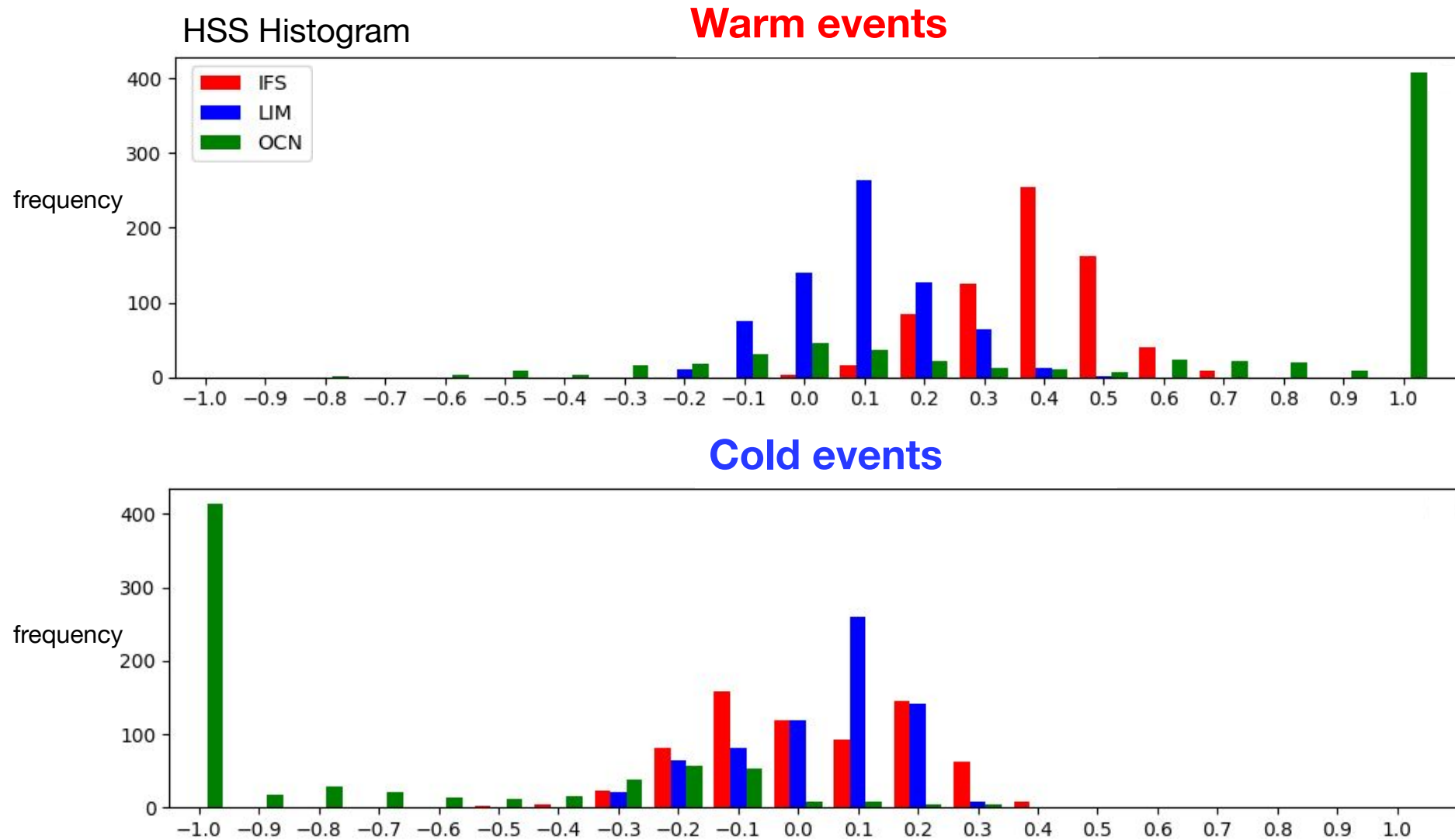
OCN



Models are more skillful in predicting warm events



OCN are not so good at predicting cold events



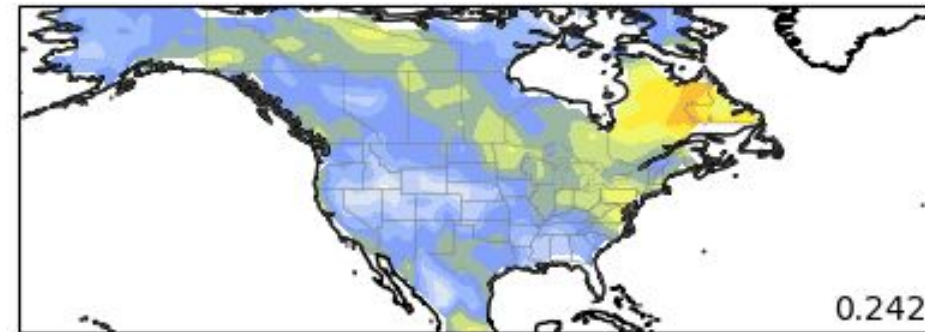
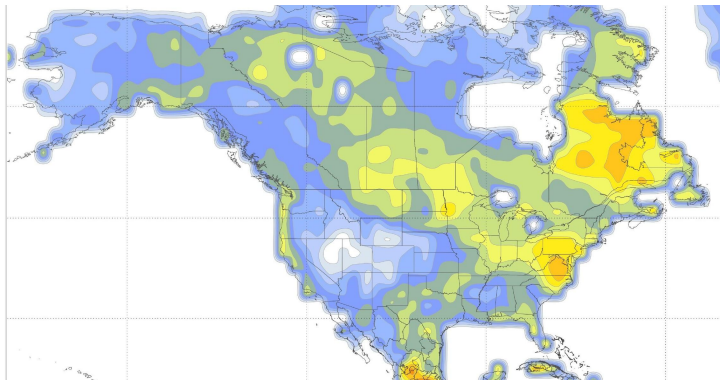
Verifying against anomalies from WMO 30-yr climatology could inflate forecast skills

Weeks 3-4 T2m Heidke score, Nov-Apr 2017-2022

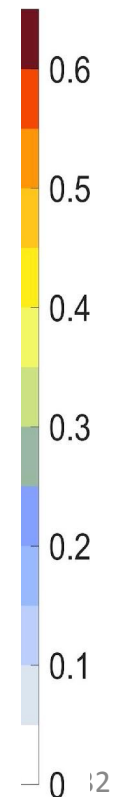
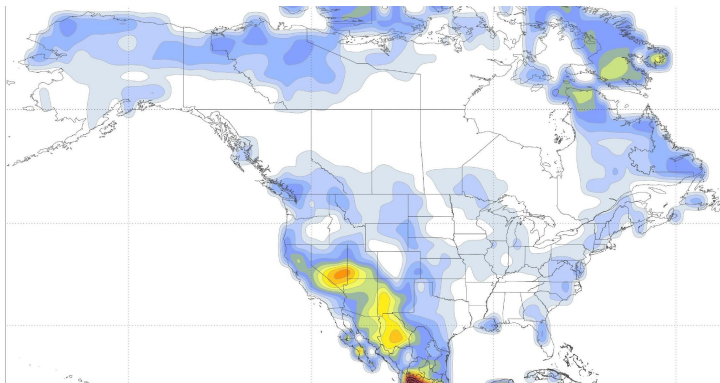
Verified against anomalies from the WMO 30-yr climate

Verified against anomalies from fair sliding 20-yr climate

IFS



LIM



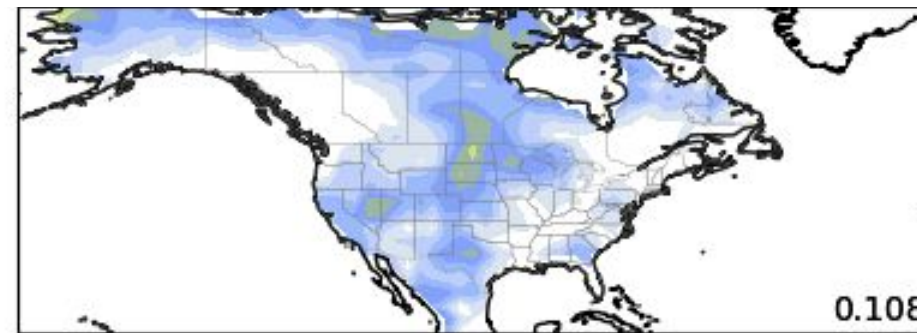
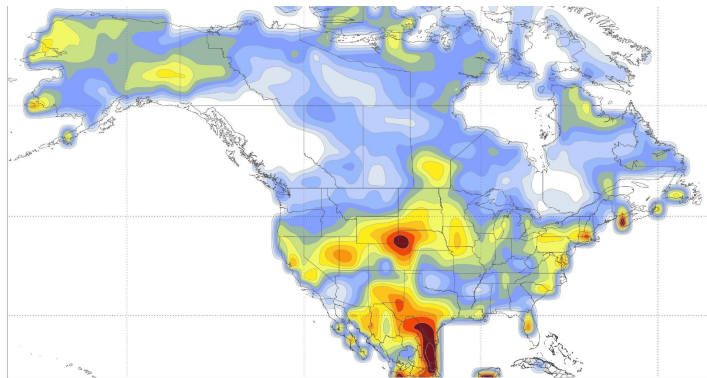
Verifying against official 30-yr climatology could inflate forecast skills

Weeks 3-4 T2m Heidke skill, **May-Oct 2017-2022**

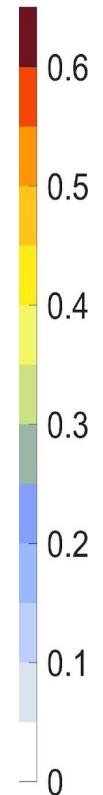
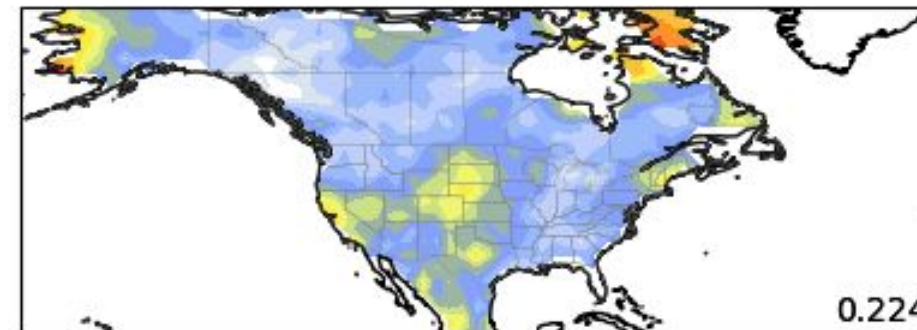
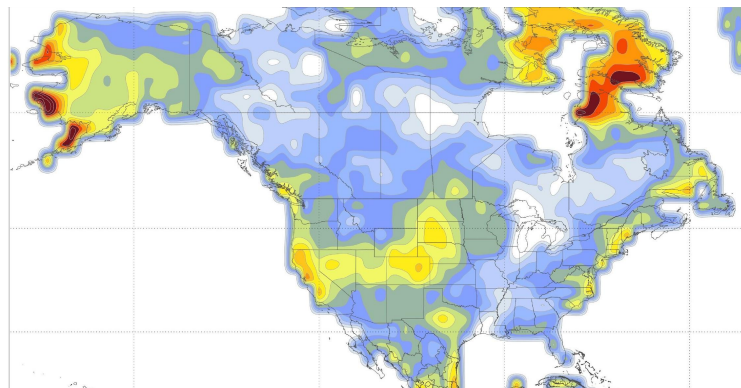
Verified against official 30-yr climate

Verified against fair sliding 20-yr climate

LIM

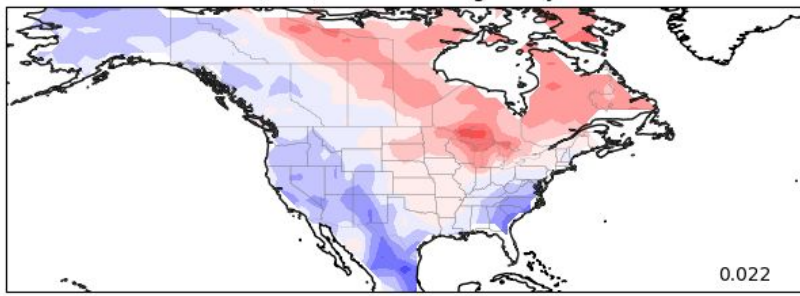


IFS

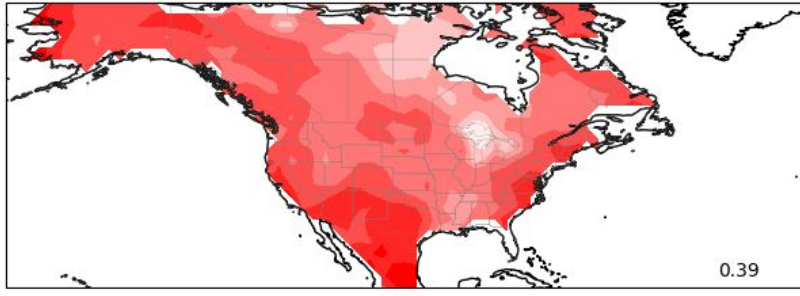


IFS

IFS, cold, all months against JRA

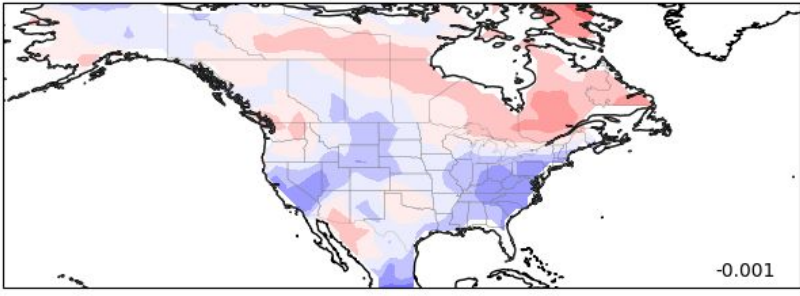


IFS, warm, all months, against JRA

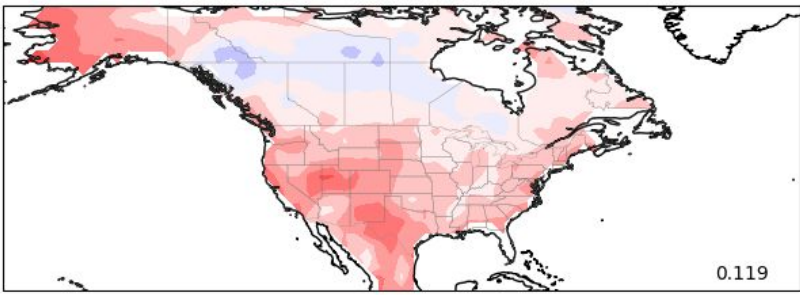


PER

PER, cold, all months

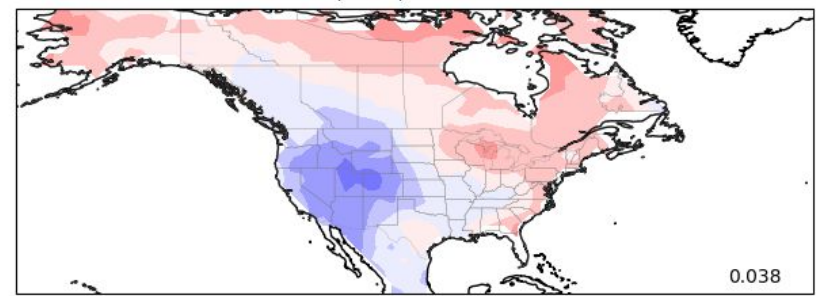


PER, warm, all months

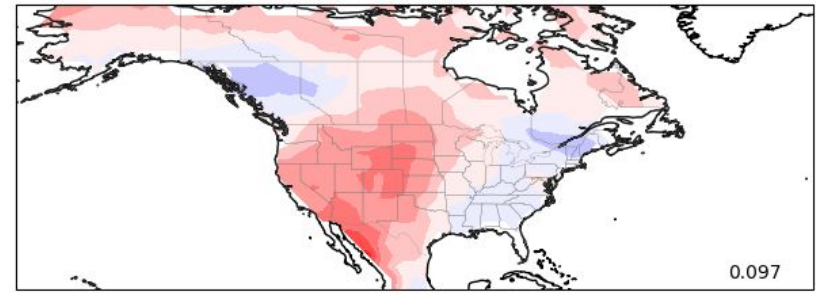


LIM

LIM, cold, all months

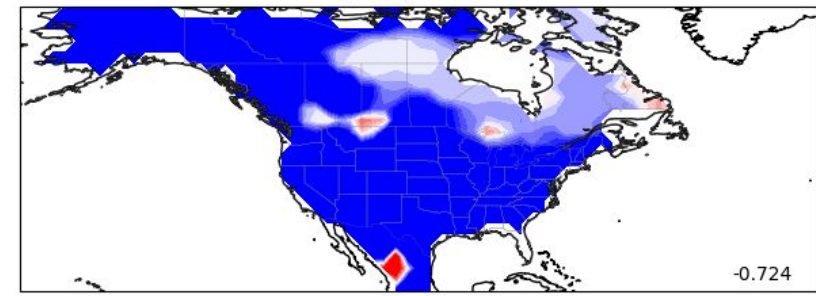


LIM, warm, all months

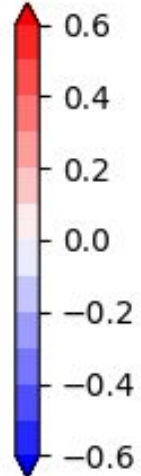
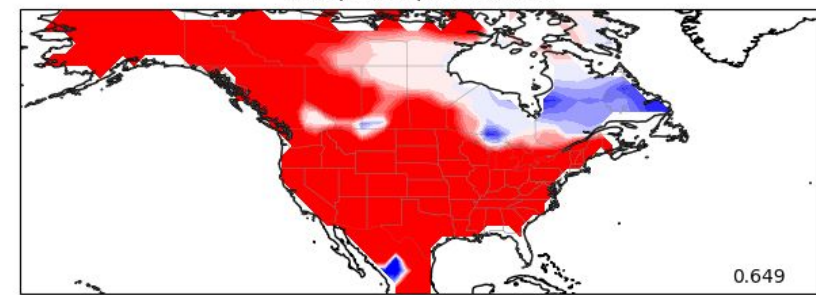


OCN

OCN, cold, all months

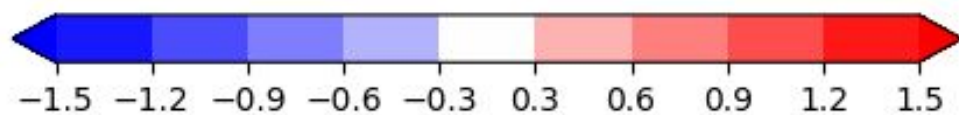
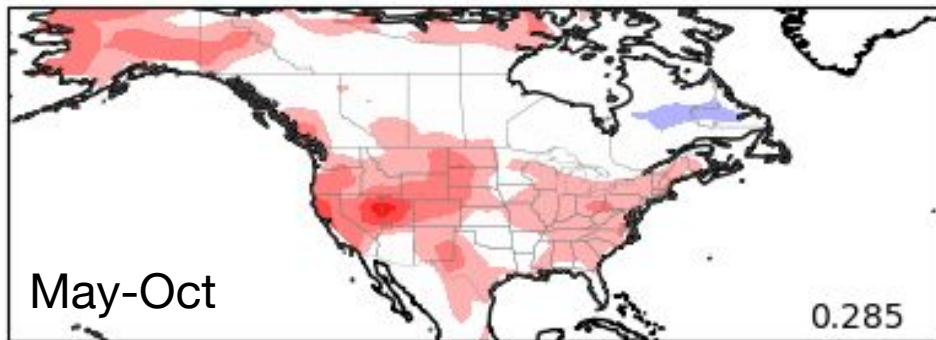
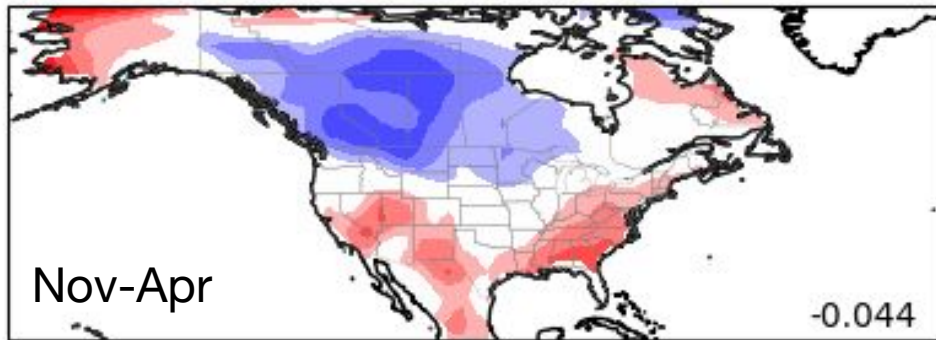
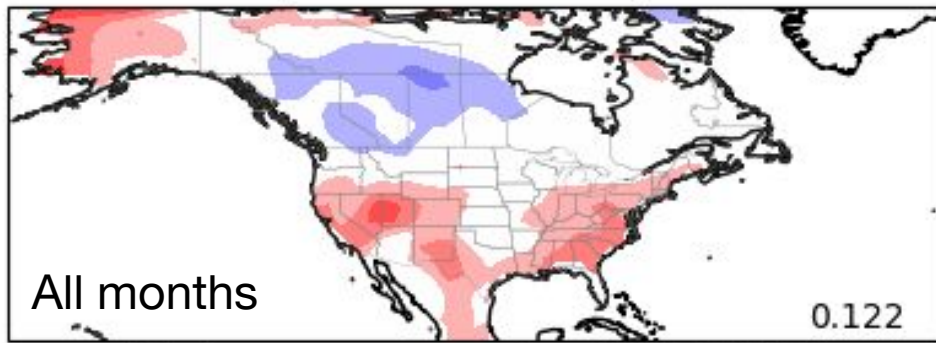


OCN, warm, all months



2017-2022

Average anomalies of the sliding mean
'Remaining trend from the sliding climatology'



LIM 2.0: mean state is 'fair-sliding' 20-yr climate

We added new variables to respond to forecasters' need – diagnosis of forecasts – and to potentially improve skill.

We extended training period to **1958-2016**

Trend is a significant part of the anomaly!

Partial solution: “fair-sliding” 20-yr climate: Fixed for 1958-1977, then increments a year at a time (e.g., 1990 anomalies relative to 1970-1989 mean)

Variable	Domain	PCs
Temperature at 2m	North America (24°N-74°N)	7
Soil moisture	North America (24°N-74°N)	5
Pressure at mean sea level	Northern Hemisphere (20°N – 90°N)	20
Tropical sea surface temps	Global Tropics (14°S – 14°N)	8
Tropical heating	Global Tropics (14°S – 14°N)	23
500-hPa Geopotential height	Northern Hemisphere (20°N – 90°N)	14
700-hPa streamfunction	Northern Hemisphere (20°N – 90°N)	8
100-hPa streamfunction	Northern Hemisphere (30°N – 90°N)	8