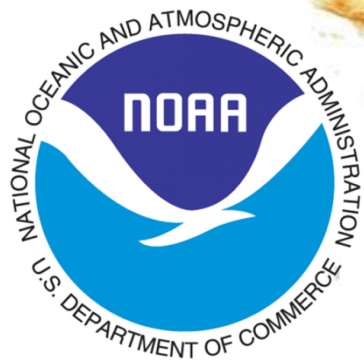


New realtime tool for subseasonal forecasting of US extreme heat at the CPC

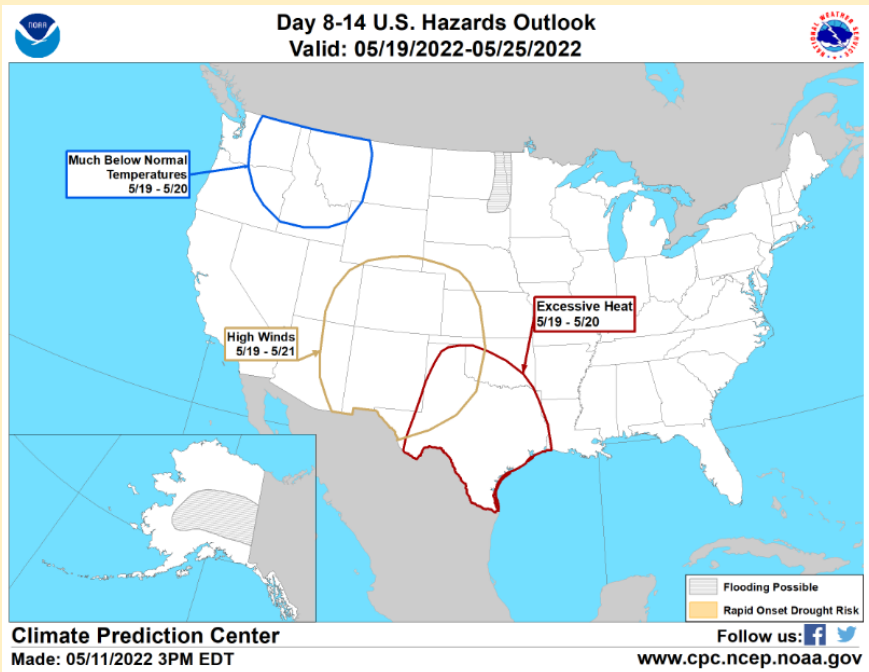
Evan M Oswald
Jon Gottschalk
05-26-22
CPASW 2022



Exceed Expectations

CPC's role in forecasting extreme heat for the US

- US Hazards report
- Daily M-F product that goes out at 3pm Eastern



Valid Thursday May 19, 2022 to Wednesday May 25, 2022

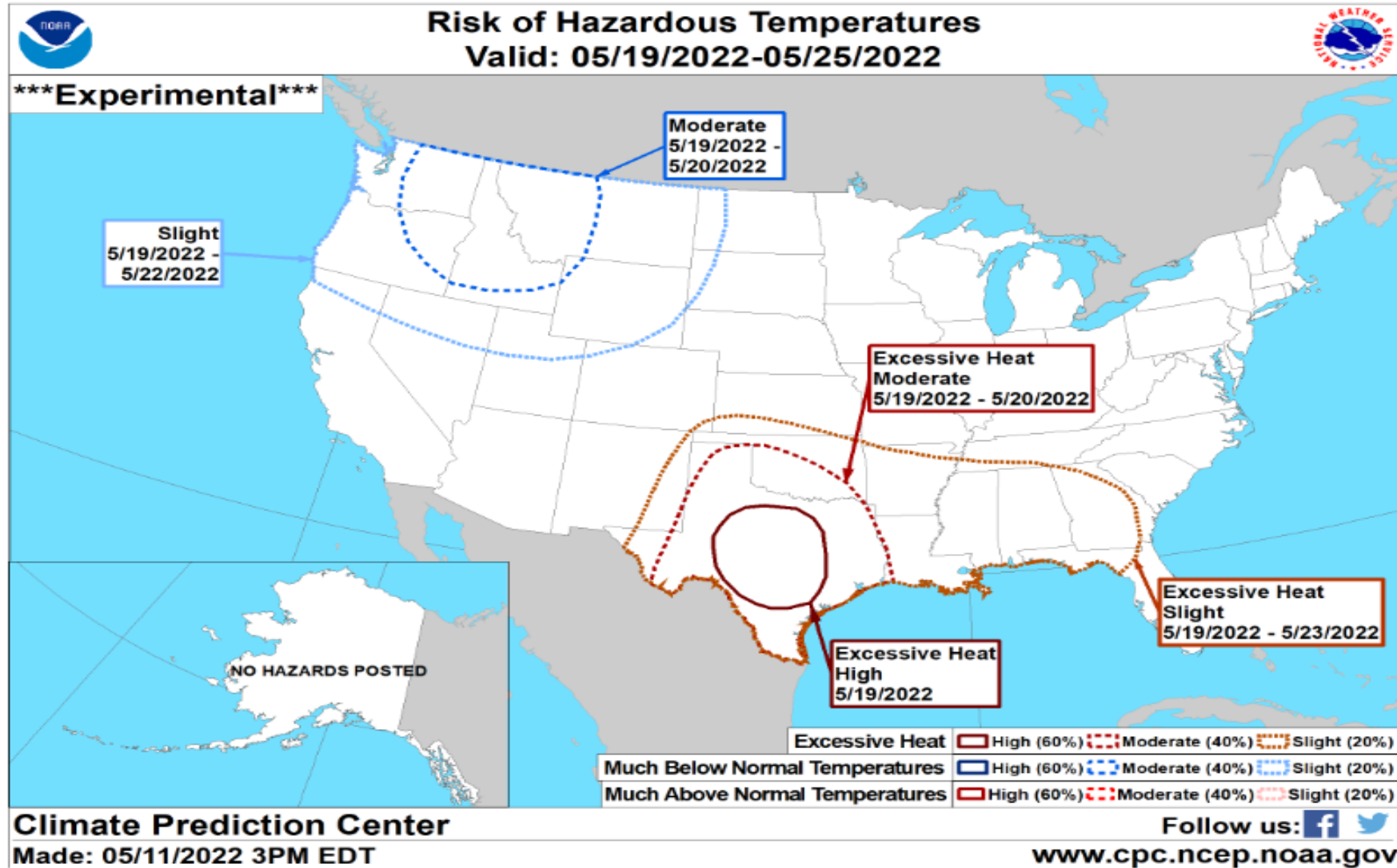
US Hazards Outlook
NWS Climate Prediction Center College Park MD
300 PM EDT May 11 2022

Synopsis: Early in the period, forecast mid-level high pressure is expected to lead to a continued period of anomalous warmth and possible excessive heat conditions across the south-central and southeastern U.S. Amplified mid-level low pressure favored over the northwestern contiguous U.S. elevates chances for anomalous cold and possible much below normal temperatures, high winds, high elevation snow and heavy precipitation over many parts of the western and central lower 48. Springtime flooding remains a concern along the Red River of the North and across central and eastern Mainland Alaska.

Hazards

- High risk of excessive heat over portions of central Texas, Thu, May 19.
- Moderate risk of excessive heat over much of the Southern Plains, Thu-Fri, May 19-20.
- Slight risk of excessive heat over the Southern Plains, Lower Mississippi and Tennessee Valleys, and Southeast, Thu-Mon, May 19-23.
- Moderate risk of much below normal temperatures for parts of the Northern Intermountain, Northern Rockies, and Northern Plains, Thu-Fri, May 19-20.
- Slight risk of much below normal temperatures over the northwestern CONUS, Thu-Sun, May 19-22.
- Slight risk of heavy snow for the higher elevations of the Northern and Central Rockies, Thu-Sat, May 19-21.
- Moderate risk of high winds for parts of the Great Basin, Rockies, and Central and Southern High Plains, Thu-Sat, May 19-21.
- Slight risk of high winds for much of the central CONUS, Thu-Mon, May 19-23.
- Slight risk of heavy precipitation for many parts of the Great Plains, Mississippi, Tennessee and Ohio Valleys, Great Lakes, and Southeast, Thu-Mon, May 19-23.
- Flooding possible along parts of the Red River of the North.
- Flooding possible for parts of central and eastern Mainland Alaska.

CPC's role in forecasting extreme heat for the US



Tools supporting Extreme Heat forecasting

- Week 2

- Product: Week 2 extend range forecasts (6-10day, 8-14day); US Hazards report
- Dynamical model based forecasts
 - Probs extremes (daily focus)
 - Heatwave probability (climate focus)
 - National Blend of Models (WPC)

- Week 3-4

- Product: Week 3-4 experimental above/below normal forecasts (15-28day)
- Week 3-4 Dynamical model based forecasts
- Local soil moisture forcing/response (statistical) model
- Wavenumber 5 pattern monitoring/analog forecasting tool
- *NEW* Multiple linear regression based on SST pattern/Soil Moisture pattern

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SST/Soil Moisture pattern MLR tool *origins*

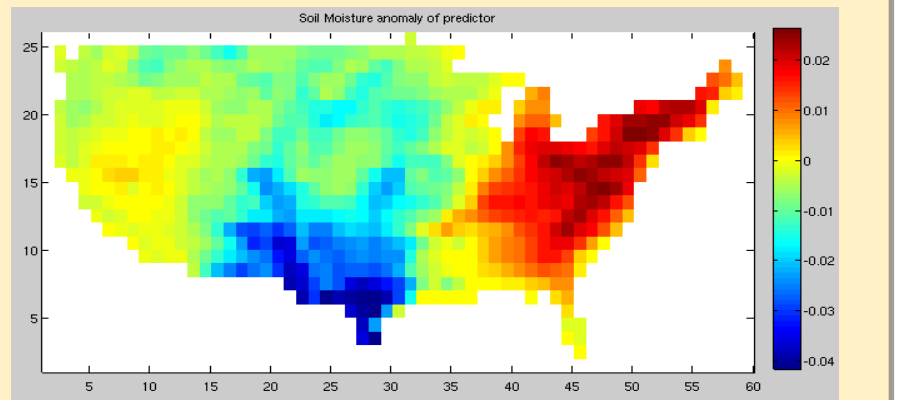
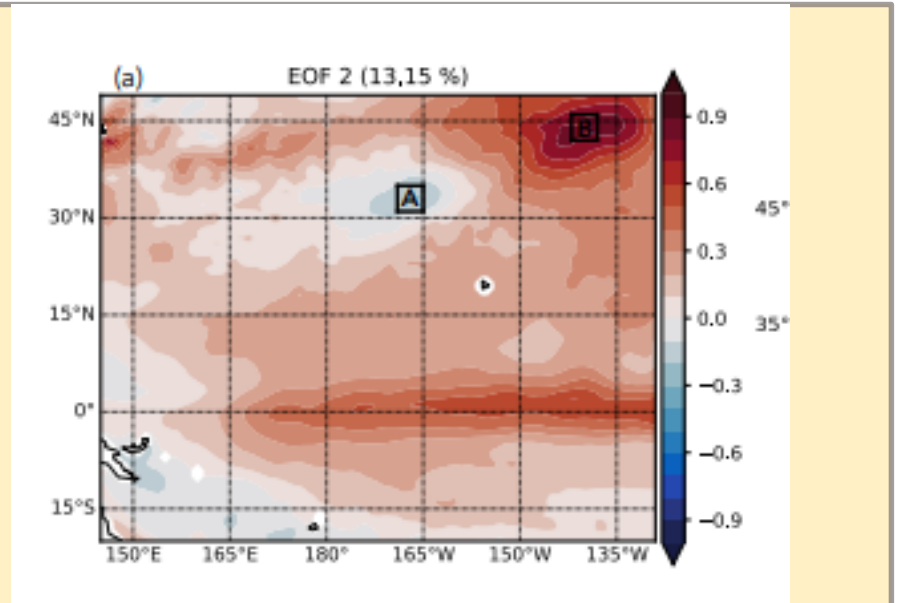
- Douglas Miller and Zhuo Wang designed the study in 2020, during Douglas Miller's Ph.D. work at the University of Illinois at Urbana-Champaign
- Work was supported by the National Oceanic and Atmospheric Administration (NOAA) Grants NA18OAR4310271 and NA18NWS4680065, which were awarded to Zhuo Wang
- *Mckinnon et al., 2016*, demonstrated the importance of Pacific SSTs in influencing hot days over the eastern US. This paper motivated NPSST index predictor
- Trent Ford (Illinois State Climatologist) aided them in discussions re: soil moisture
- Dan Harnos (CPC) provided information regarding what the CPC looks for in models, and useful verification metrics
- Outperformed the NCEP's Climate Forecast System version 2 (CFSv2) at timescales of 3-4 weeks and in the eastern US; for July. (*Miller et al. 2021*)

SST/Soil Moisture pattern MLR tool: CPC

- Development at the CPC (March 2021)
- Notable changes
 - Summer vs July (model a function of calendar date)
 - Instantaneous vs Lagged
 - CONUS + AK
 - Expanded forecast variables, timescales
- New datasets (ERA Interim Reanalysis was old dataset)
 - NOAA 1/4° Daily Optimum Interpolation Sea Surface Temperature (OISST) for the North Pacific Sea Surface Temperature-based (NPSST) index
 - Leaky Bucket model (CPC tool) output for the soil moisture-based index

SST/Soil Moisture pattern MLR tool

- North Pacific SST Index
- Calculated daily - past 5 days
- Values of A and B normalized, then subtracted
- ERA-5 soil moisture top 28cm & Leaky Bucket 180cm soil moisture
- Timescales
- Composite Doug Miller used
- Index: pattern correlation (-1, +1)

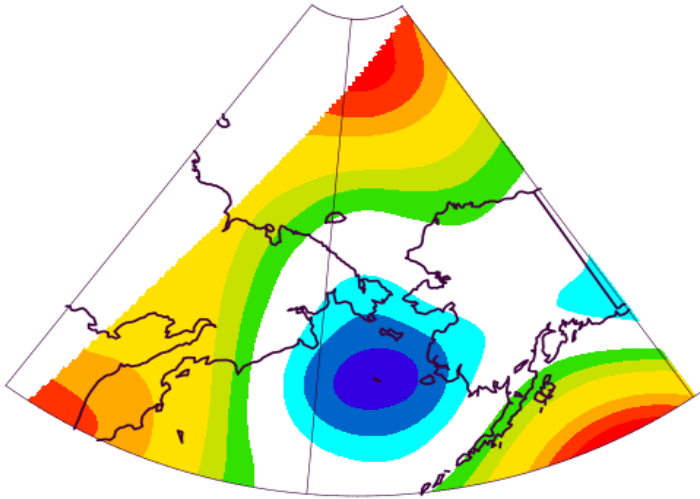


SST/Soil Moisture pattern MLR tool

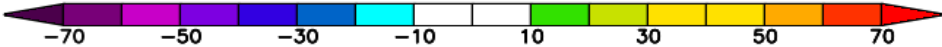
- North Pacific SST Index

Negative phase

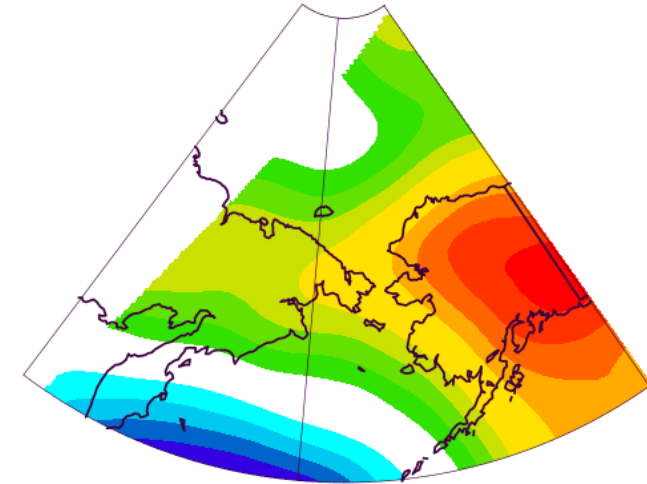
NCEP North American Regional Reanalysis
250mb Geopotential Height (m) Composite Anomaly 1981–2010 climo
NOAA Physical Sciences Laboratory



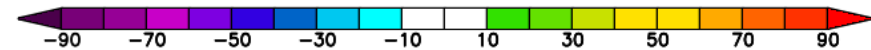
04/21 ,2006/04/25 ,2006/04/30 ,2011/05/09 ,2011/05/18 ,2011/05/28 ,2011/06/01 ,20



NCEP North American Regional Reanalysis
250mb Geopotential Height (m) Composite Anomaly 1981–2010 climo
NOAA Physical Sciences Laboratory



3/05/07 ,2013/05/11 ,2014/04/13 ,2015/04/02 ,2015/04/06 ,2015/07/02 ,2015/07/07 ,2015/07/13 ,20

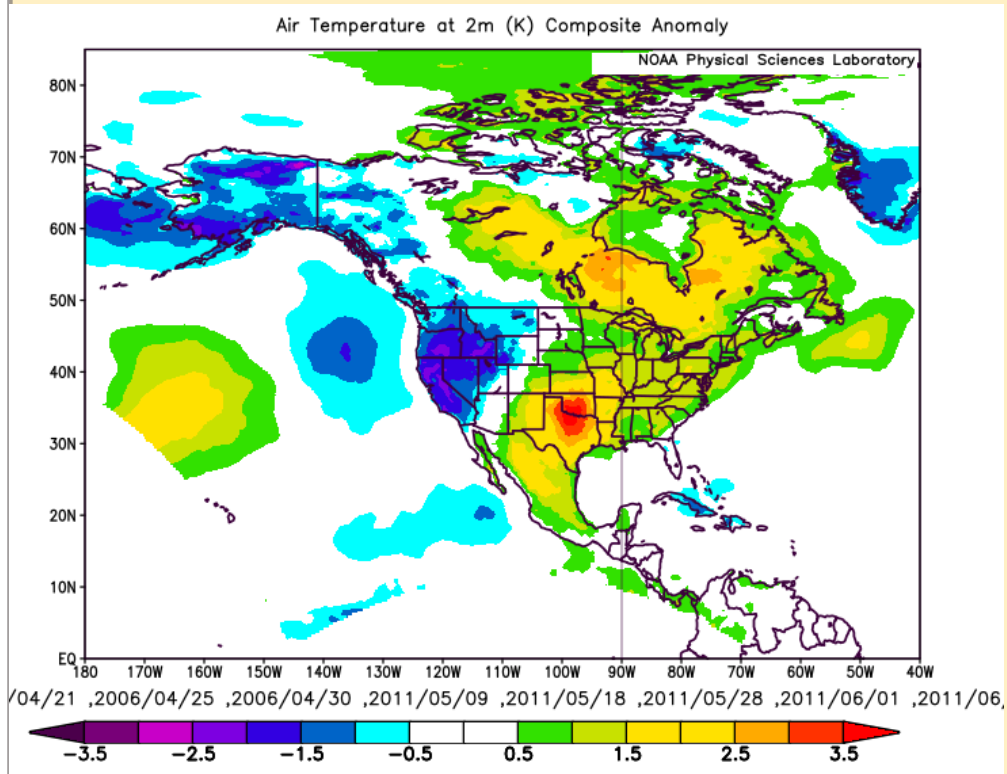


Positive phase

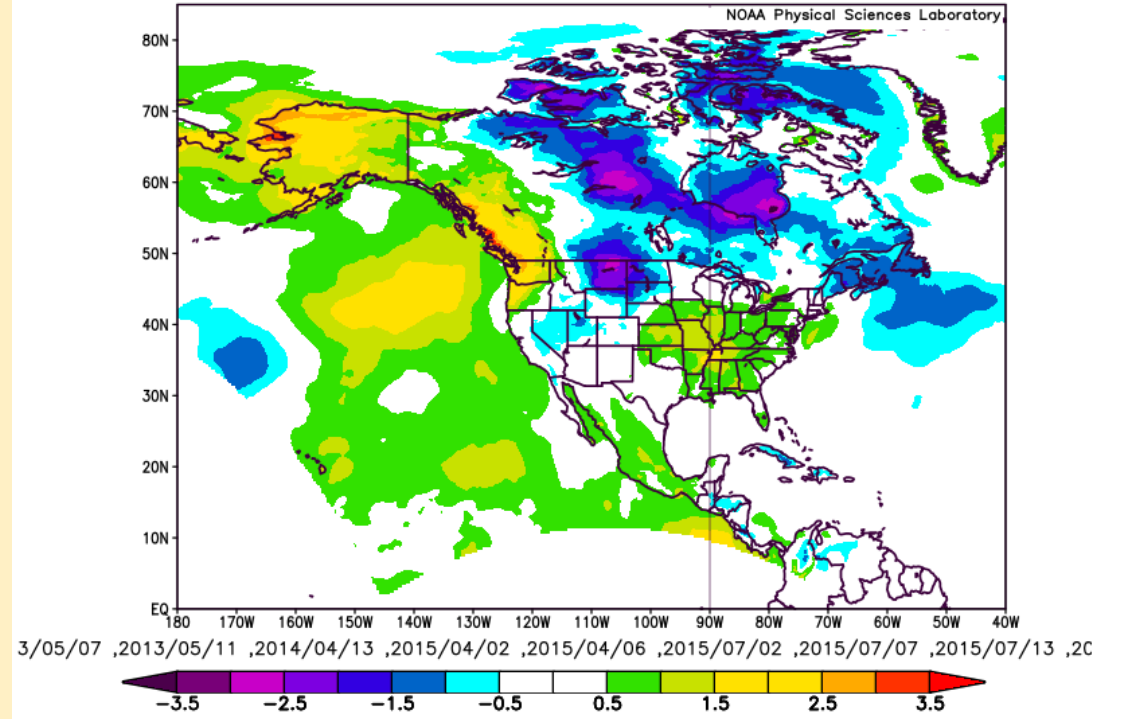
SST/Soil Moisture pattern MLR tool

- North Pacific SST Index

Negative phase



Air Temperature at 2m (K) Composite Anomaly

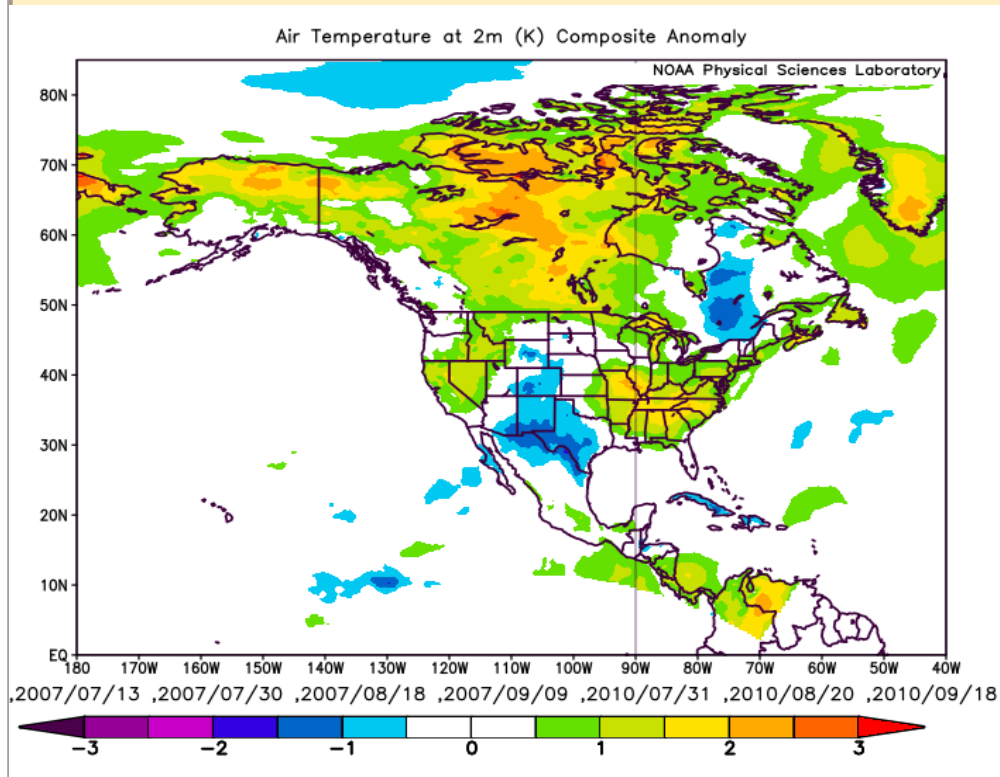


Positive phase

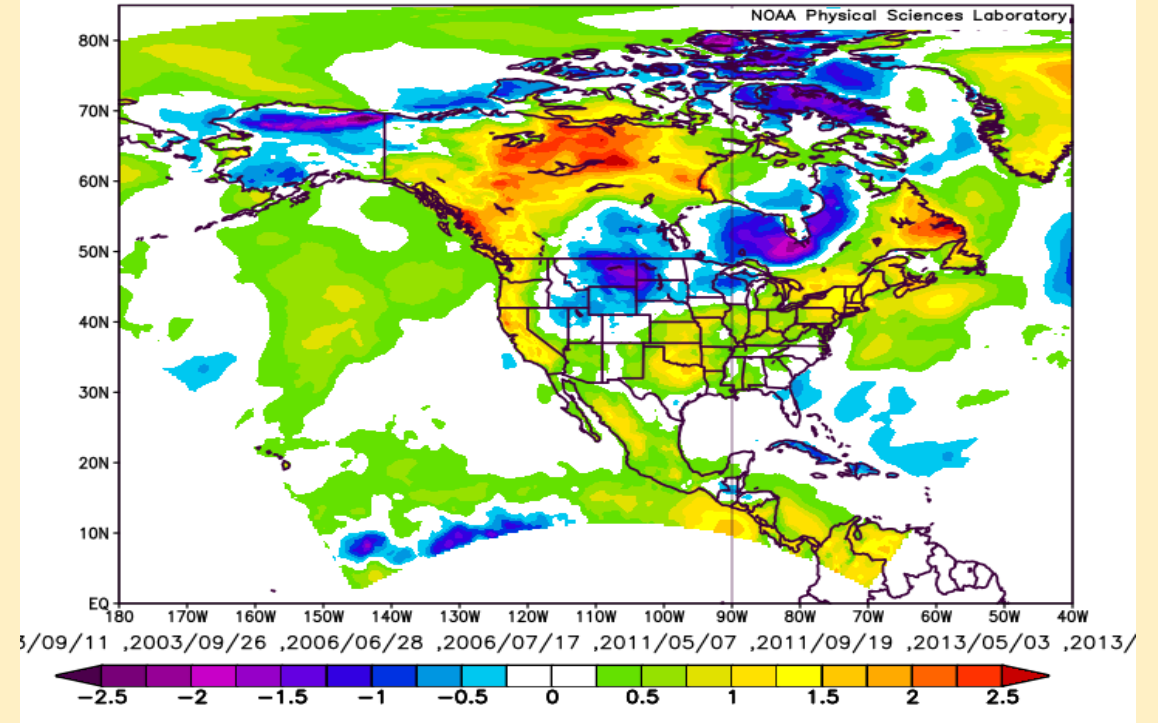
SST/Soil Moisture pattern MLR tool

- Soil Moisture Index

Negative phase



Air Temperature at 2m (K) Composite Anomaly



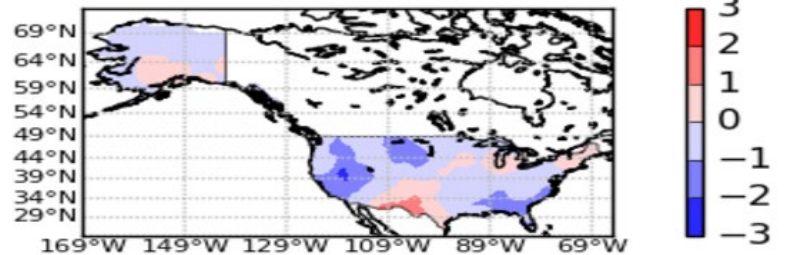
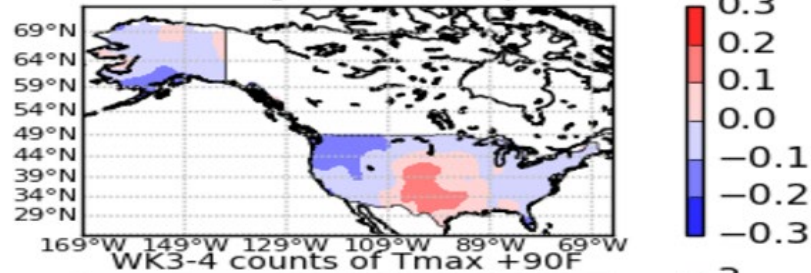
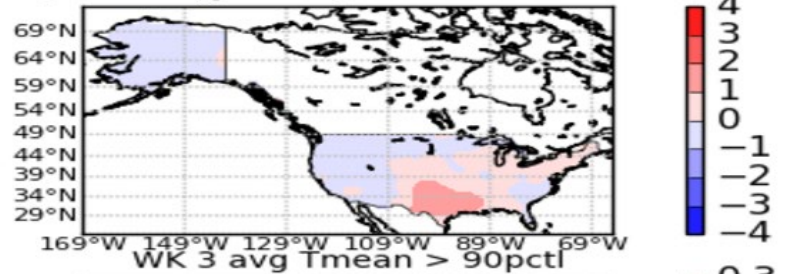
Positive phase

SST/Soil Moisture pattern MLR tool

- Tool forcings early in the season

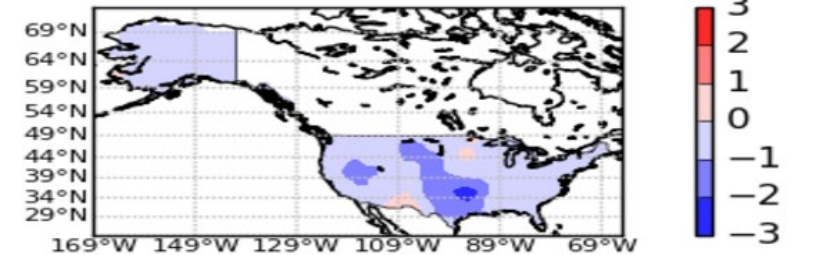
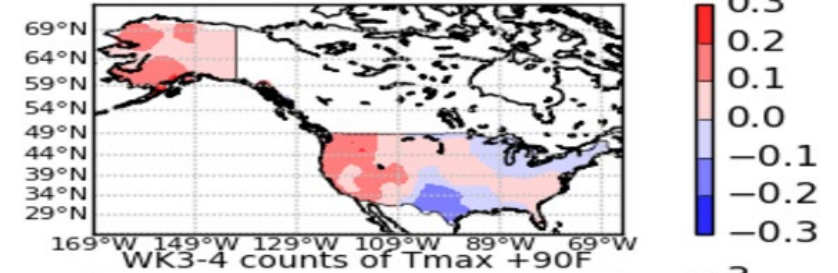
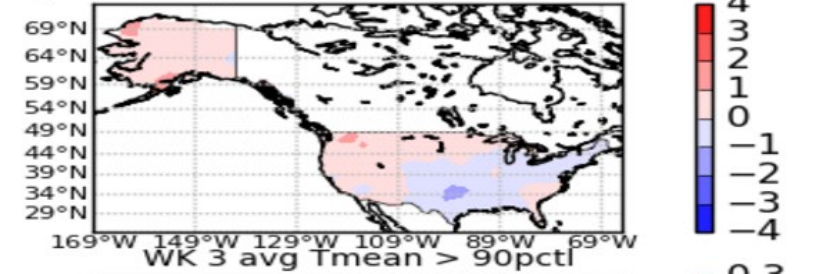
Positive Soil Moisture index + Negative NPSST index

+ soil moisture, - NPSST; June 11; WK 3-4 counts of Tmax 95th pctl



Negative Soil Moisture index + Positive NPSST index

- soil moisture, + NPSST; June 11; WK 3-4 counts of Tmax 95th pctl

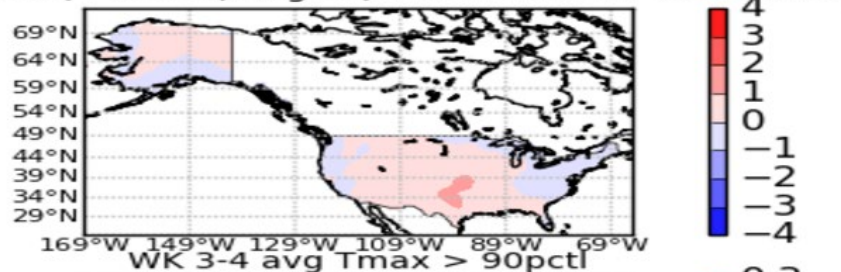


SST/Soil Moisture pattern MLR tool

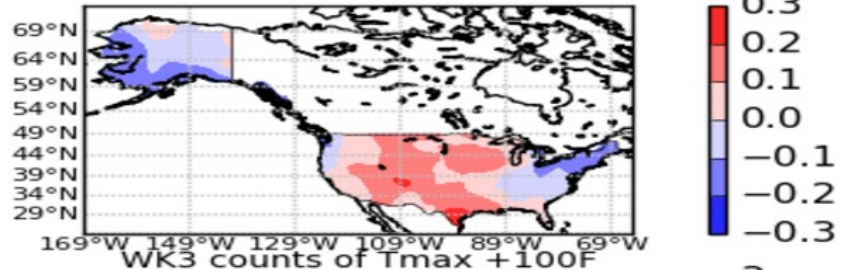
- Tool forcings late in the season

Positive Soil Moisture index + Negative NPSST index

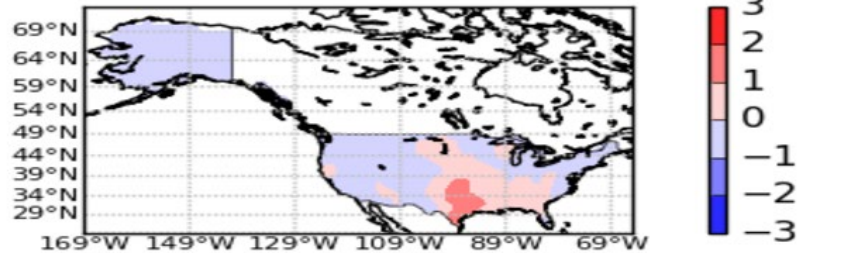
+ soil moisture, - NPSST; Aug 19; WK 3 counts of Tmax 90th pctl



WK 3-4 avg Tmax > 90pctl

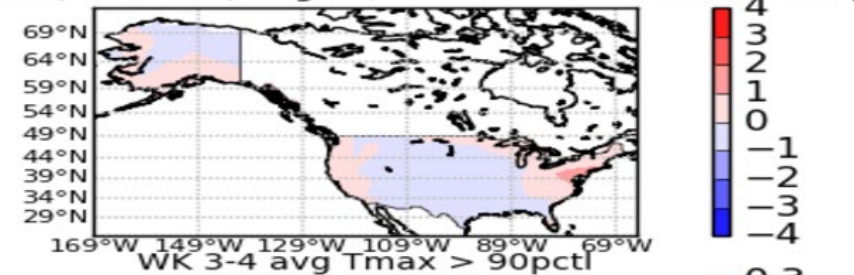


WK3 counts of Tmax +100F

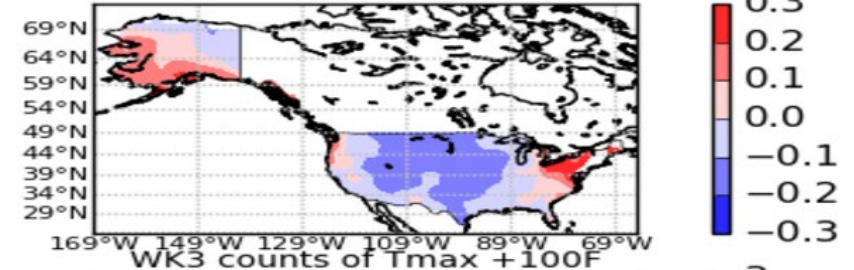


Negative Soil Moisture index + Positive NPSST index

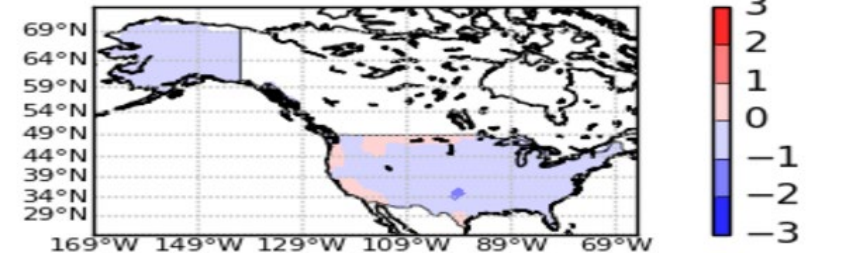
- soil moisture, + NPSST; Aug 19; WK 3 counts of Tmax 90th pctl



WK 3-4 avg Tmax > 90pctl

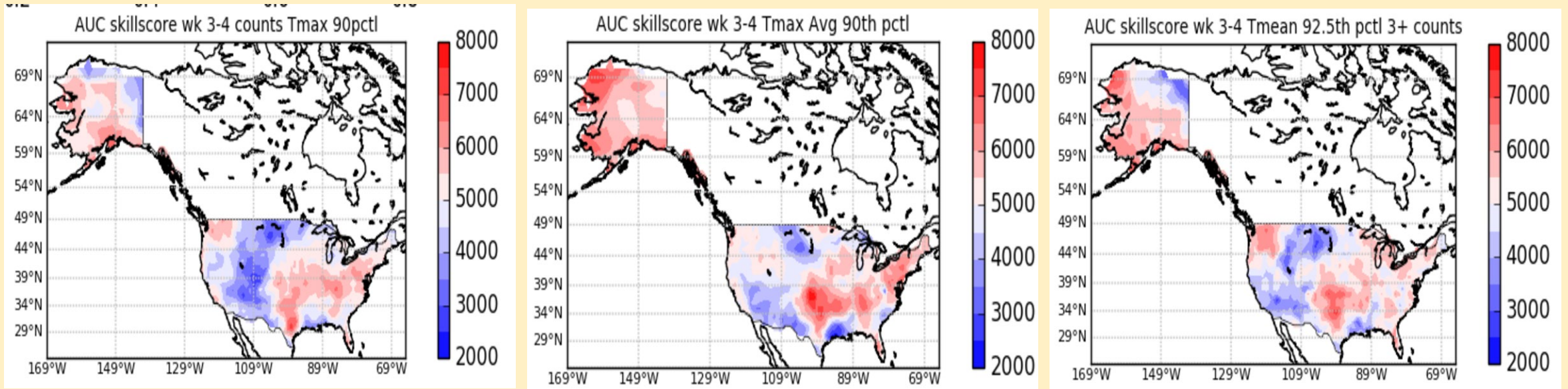


WK3 counts of Tmax +100F



SST/Soil Moisture pattern MLR tool

- Spatial patterns of skill



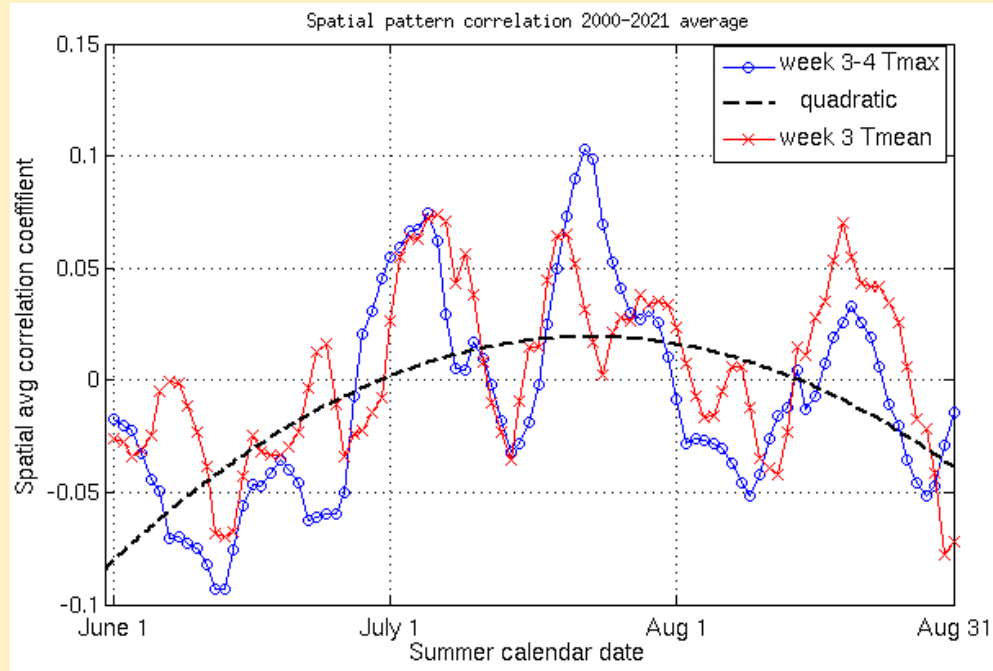
AUC skillscores, here, are 5000 at skill of climatology (guess).

Regions of skill: Eastern US, Northwest US, Alaska

SST/Soil Moisture pattern MLR tool

- Temporal patterns of skill

Historical monthly AUC skill scores for eastern region



Daily spatial correlations over entire domain, averaged over years

Variable	June	July	August
Biweekly Tmax 90pctl	0.468	0.584	0.507
Biweekly Tmax 95pctl	0.514	0.611	0.555
Biweekly Tmax 98.5 th pctl	0.527	0.613	0.535
Biweekly avg Tmax 90 th pctl	0.516	0.618	0.552
Biweekly avg Tmean 90 th pctl	0.488	0.604	0.548
Biweekly Tmean 92.5 th pctl counts 3+	0.423	0.603	0.528
Biweekly Tmean 92.5 th pctl counts 6+	0.485	0.656	0.537
Weekly Tmax 90pctl	0.511	0.596	0.539
Weekly Tmax 95pctl	0.530	0.609	0.554
Weekly Tmax 98.5 th pctl	0.510	0.597	0.528
Weekly avg Tmax 90 th pctl	0.511	0.599	0.562
Weekly avg Tmean 90 th pctl	0.480	0.590	0.562

SST/Soil Moisture pattern MLR tool

- Next steps for this tool:
 - Running it in real-time this heat season
 - Developing hybrid capability (dynamical models vs persistence of predictors)
 - Providing it to forecast team next summer
 - Investigating soil patterns
 - Machine learning
- Conclusions:
 - New forecasting tool at the CPC supporting subseasonal extreme heat forecasts
 - Based on SST patterns in the North Pacific and CONUS-wide soil moisture patterns

Works Cited

Mckinnon et al., 2016: Long-lead predictions of eastern United States hot days from Pacific sea surface temperatures. Natural Geosciences. 10.1038/ngeo2687

Miller et al. 2021: Skillful subseasonal prediction of U.S. extreme warm days and standardized precipitation index in boreal summer. Journal of Climate. 10.1175/JCLI-D-20-0878.1