Recent advancements in domestic forecasting and observations of extreme heat in the US at the Climate Prediction Center

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Extreme heat and the CPC

Subseasonal forecasting of extremely warm weather

1. Domestic: Weather Research and Forecasting Innovation Act of 2017, H.R. 353
2. Globally: deep interest due to economic, public health, and agricultural reasons

CPC Products: US Hazards report; Int'l desk product

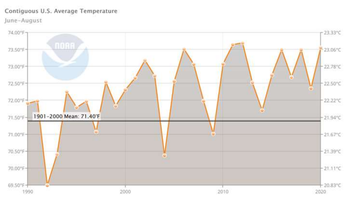
CPC Running tools

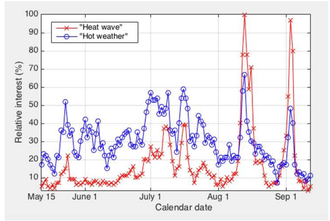
1. Probabilistic Extremes tool (lead 8-14 days)
2. Sub-seasonal Excessive Heat Outlook System (SEHOS; lead 8-14 days)
3. Week 3-4 probabilities of 3 or 6 hot dates (lead 15-28 days)

Promising R&D tools at CPC

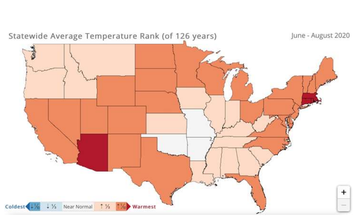
1. Soil moisture tool (lead 15-28 days)
2. Week 3-4 "expansion" into probabilities of hot weekly avgs (lead 15-28 days)
3. 500mb height anomalies and extreme surface temperature probabilities (lead 15-28)
4. Bermuda High Index and extreme surface temperature probabilities

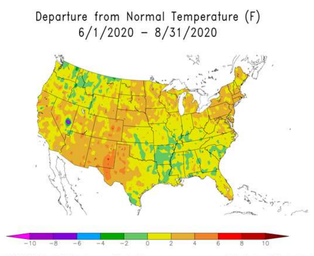
The 2020 heat season





(Left) NCEI's first-order observing station-derived CONUS summer (JJA) average temperature time series for the past 30 years, (Right) Google-derived national search-frequency as a function of time through the 2020 summer (May 15-Sept 15).





(Left) NCEI's first-order observing station-derived state-level ranking (1895-2020) of summer (JJA) average temperatures, (Right) Second-order observing station-derived departures from normal (1981-2010) summer (JJA) temperatures.

Coronavirus as a confounding variable

Ways weather impacts Coronavirus	*Ways Coronavirus impacts heat stress in the public*	
Transmission, misc	**Vulnerability**	**Stifling mitigation efforts**
Temperatures -> lifetime on surfaces	Socially isolated people even more isolated	Buses reduced operations
Temperatures -> peoples behavior	Directly exasperate health conditions	Cooling centers dangerous
Hurricanes -> peoples ability to social distance	Overstressed health system	
Wildfires -> directly exasperate health conditions	Difficulty eating healthy diets	
	Difficulty getting medicine with reduced mail services	

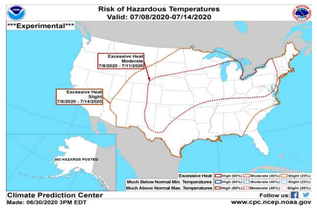
Overall performance of SEHOS in 2020

	AUC-ROC (+1, +0.5, 0)		Max. SEDI (+1, 0, -1)	
	2020	1996-2014	2020	1996-2014
Heat Index based heat event				
GEFS	0.522, 0.548	0.641, 0.636	0.220, 0.165	0.30, 0.30
ECMWF	0.586, 0.521	0.666, 0.668	0.213, 0.133	0.34, 0.36
GEFS-ECMWF	0.627, 0.655	0.675, 0.686	0.272, 0.312	0.36, 0.38
Air temperature (dry) based heat events				
GEFS	0.570, 0.510	0.606, 0.604	0.161, 0.139	0.24, 0.29
ECMWF	0.606, 0.546	0.637, 0.636	0.244, 0.194	0.29, 0.29
GEFS-ECMWF	0.648, 0.662	0.641, 0.646	0.329, 0.356	0.29, 0.30

CONUS-wide values of two skill metrics from forecasts of heat events based on 90th (first value) and 95th (second value) percentile thresholds. Values organized by forecast model, time period (124 vs 2,367 dates), and met. variable associated with heat event. Values are +1 for perfect skill, 0.5 or 0.0 for zero skill, and 0.0 or -1 for the perfect opposite forecast.

- Metrics included Area Under the Receiver Operating Curve (AUC-ROC) and the Symmetric Extremal Dependence Index (SEDI). Many common metrics (Brier Skill Score) are not appropriate for rare events (low base rate)
- Both metrics, for the historical period and 2020 season alike, show a skill of roughly a quarter of the "difference" between "no skill" and "perfect skill"
- Found patterns
  1. 2-model blend > ECMWF > GEFS
  2. Historical (reforecasts) > 2020 (operational forecasts)
  3. HI > air temperature (dry)

July 8 – July 15 event

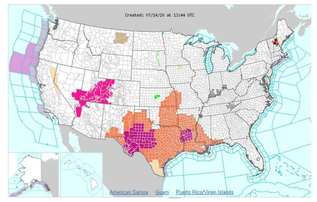


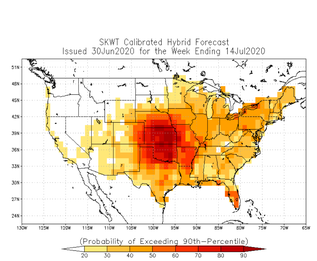
(Top Left) CPC official risk of excessive heat for the event, made on June 30.

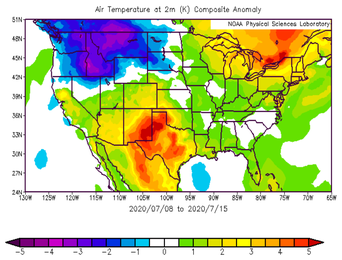
(Top Right) NWS front page Warnings, Watches and Advisories map during the even (July 14). Orange represents "Heat Advisories" and magenta "Excessive heat warnings"

(Bottom Left) Forecast of 90th percentile heat event from skill-weighted blend of the GEFS and ECMWF models

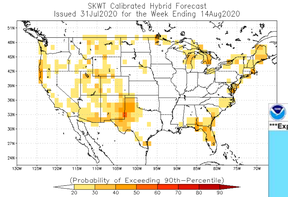
(Bottom Right) The event-average 2m air temperature anomaly as depicted by the NARR





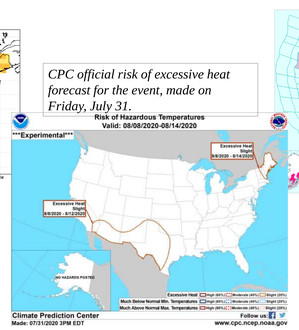


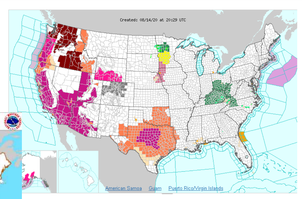
August 8 - 15 event



Forecast of 90th percentile heat event from historical skill-weighted blend of the GEFS and ECMWF

CPC official risk of excessive heat forecast for the event, made on Friday, July 31.





NWS front page Warnings, Watches and Advisories map during the event (aug 15).

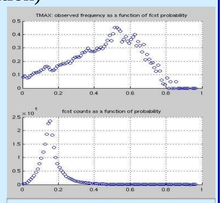
Soil Moisture Tool

Concept

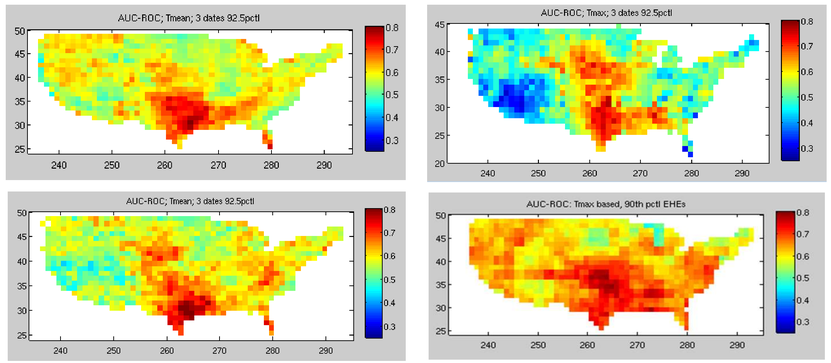
- Soil (2m) moisture positive anomaly ability to impact/reduce daily high temperatures
- Persistence of soil moisture anomaly (~20-23 days 0.50 autocorrelation)

In practice

- Leaky bucket model (CPC internal) soil moisture (3 days ago)
- Historical-statistical lag-relationship established; executed
  1. 18-day lag
  2. 2-week period
  3. 3+ days 92.5th Tmax
- Regionally skillful; reliability challenging
- Runs daily April 1 – Oct 1st



(Top) Observed reliability analysis; (Bottom) Counts per forecast probability

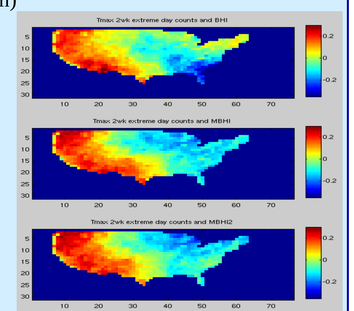


*(Top Left) **CFS**-based historical reforecast AUC-ROC skill score for the week 3-4 period forecasting the probability of three or more hot (92.5th percentile daily mean air T) dates. (Top Right) **Soil moisture**-based historical AUC-ROC skill score for the week 3-4 period forecasting the probability of three or more hot (92.5th percentile daily max air T) dates. (Bottom Left) **ECMWF**-based historical reforecast AUC-ROC skill score for the week 3-4 period forecasting the probability of three or more hot (92.5th percentile daily mean air T) dates. (Bottom Right) ECMWF-based historical reforecast AUC-ROC skill score for the **week 2** period forecasting the probability of two or more consecutive hot (90th percentile daily max air T) dates.*

Bermuda high Index Project

Concept

- CDAS historical reanalysis (1981-2019) MLSP, May1-Sep17
- Customized Bermuda High Index
  1. BHI: New Orleans – Bermuda (MSLP std anom)
  2. MBHI_1: Nashville-Bermuda
  3. MBHI_2: Pittsburg-Bermuda
- Number of hot dates (deterministic)
  1. daily high temperature
  2. percentiles (92.th)
  3. Simultaneous (need to move to forecast)
- Looking for tips!
  - Forecast Bermuda High Indices
    1. Internal via recent temporal
    2. External factors
  - Bridging with CFS and/or ECMWF forecast



*(Top) Historical **anomaly correlation with BHI***
*(Middle) Historical **anomaly correlation with MBHI_1***
*(Bottom) Historical **anomaly correlation with MBHI_2***

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