Sub-Seasonal to Seasonal (S2) Prediction Motivation, Challenges, and Recent Progress

Dr. David. G. DeWitt
Director, Climate Prediction Center (CPC)

Agenda

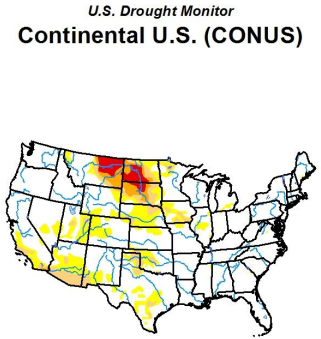
- Motivation/Framing
- Prediction Challenges
- Recent Progress
- Final Thoughts

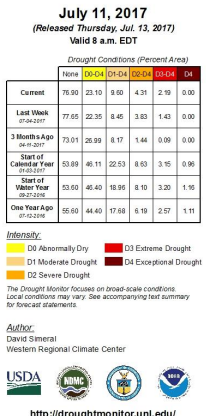
Why we need to keep pushing the skill envelope for improved S2S (precipitation) forecast skill

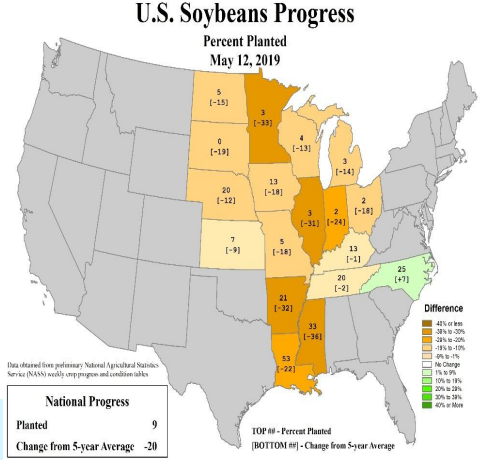
S2S predictions are characterized by a small signal and large noise.

Hence they are inherently probabilistic.

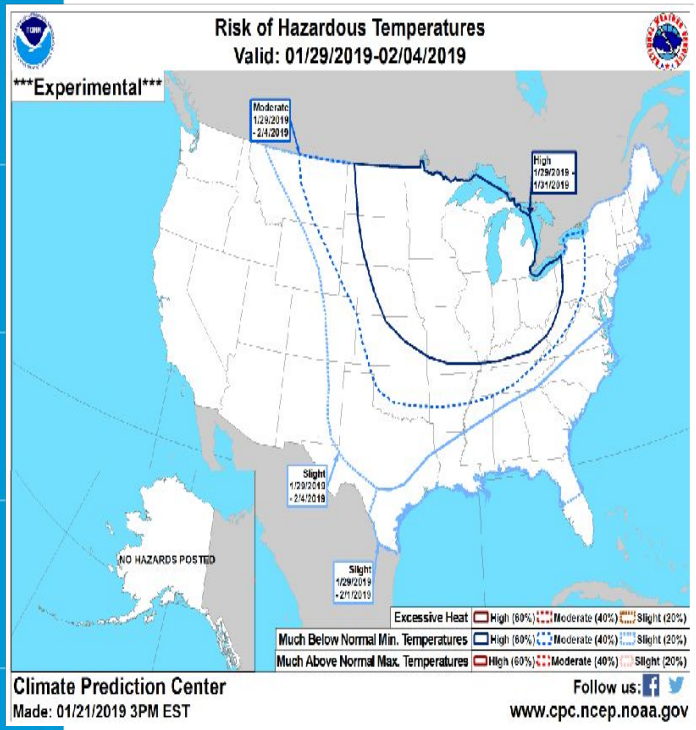
The key tool for informing forecasts are ensembles of dynamical models.



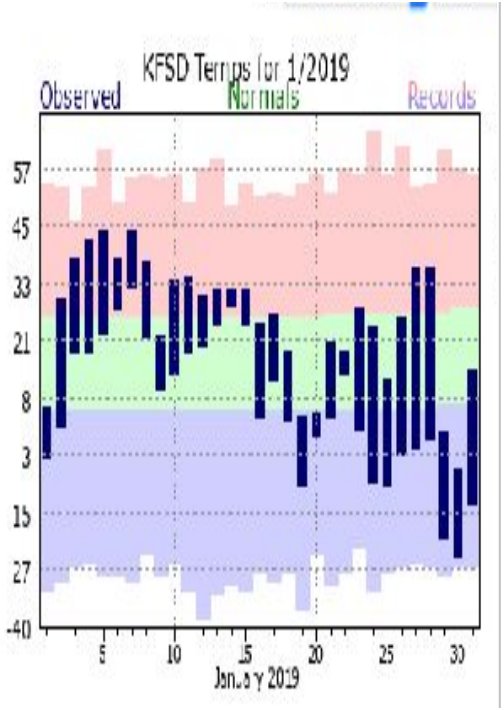




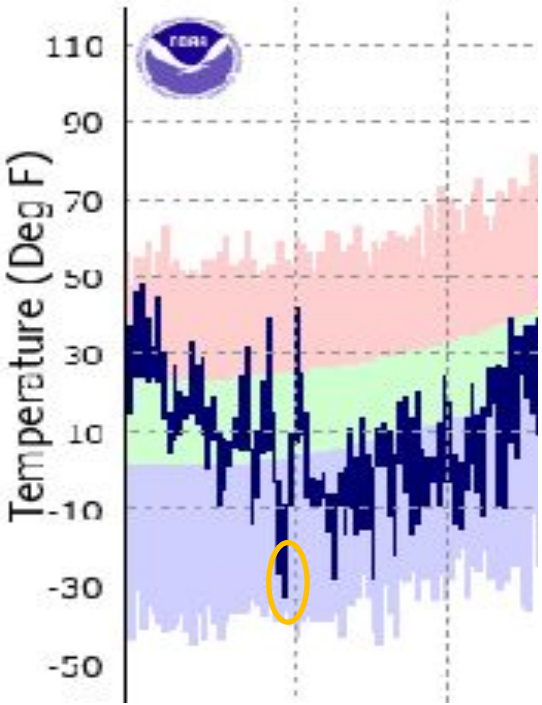
Exceptionally Cold Air Outbreak: Jan. to Feb. 2019



CPC Prob. Hazards Outlook from 1/21/2019

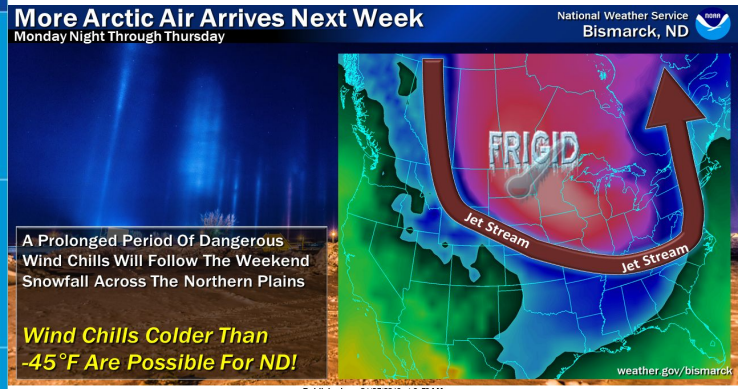


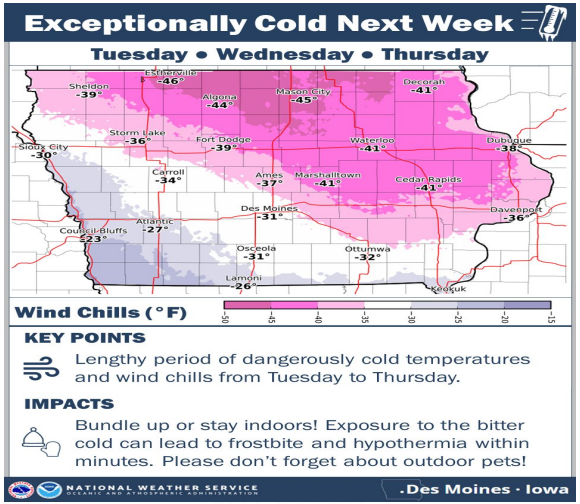
Obs. Temp.: Sioux Falls, SD

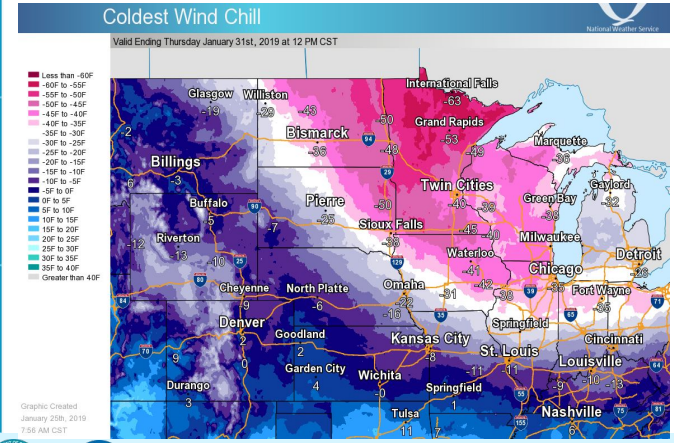


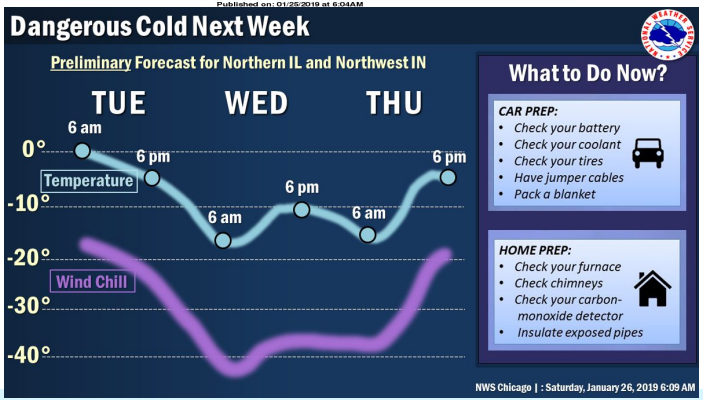
Obs. Temp.: Bismarck, ND

NWS Offices Message the Event



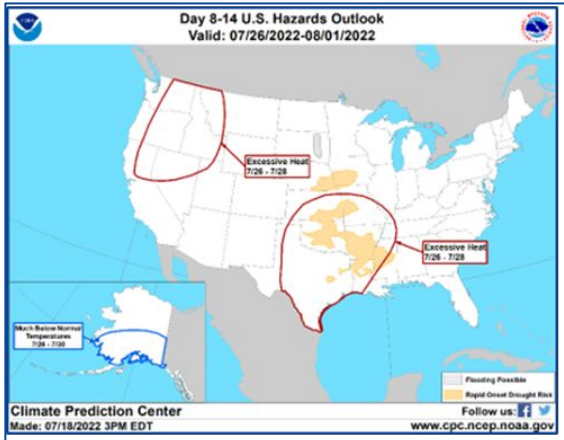




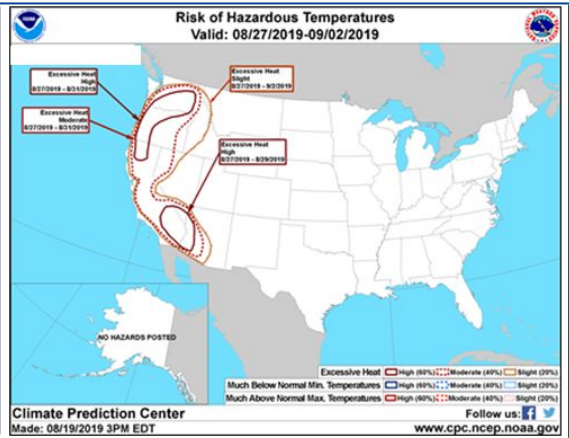


IDSS - CPC Key Messages

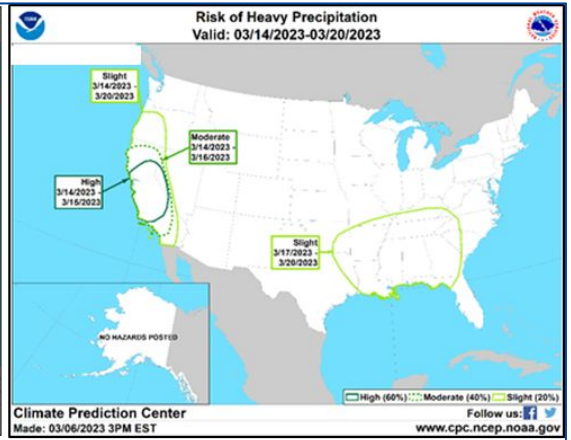
Week-2 U.S. Hazards Outlook (HAF)



Composite Map



Temperature Related



Precipitation Related

(1) A high risk of hazardous conditions depicted in the HAF and so significant impacts are implied.

(2) A moderate risk of hazardous conditions depicted in the HAF and significant impacts are expected depending on regional factors such as antecedent conditions, time of year, *etc*.

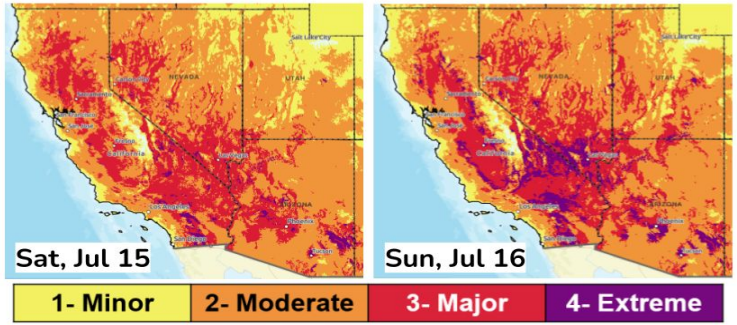
Key Messages for Southwest U.S. Heat Wave

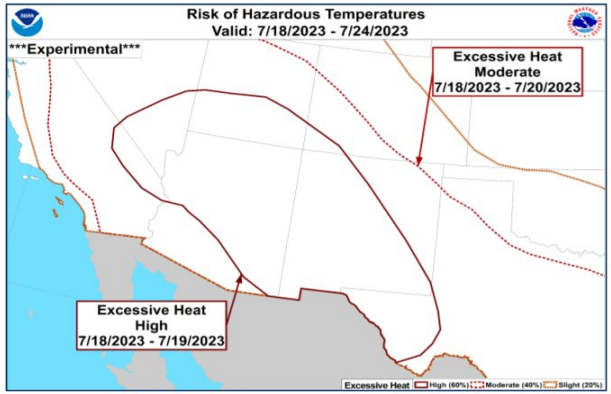
Updated Jul 10, 2023
1:00 PM PDT

Building heat in the Southwest U.S. will become extremely dangerous by this weekend

- An intense heat wave will build late this week, and particularly this weekend, across the Southwest U.S. with numerous daily record high temperatures likely. A few locations could even approach their all time heat records and register top-10 hottest days as the heat wave peaks.
- The heat will be extremely dangerous and potentially deadly due to the intensity, longevity, and a relatively cool start to summer that may have limited the ability for people to acclimate to more typical hot summer weather in this region.
- Areas most at risk include the Central Valley of California, and portions of the Mojave and Sonoran Deserts in southern California, southern Nevada, and Arizona. This includes Las Vegas, Phoenix, Fresno, and Bakersfield.
- Excessive heat is favored to continue into the next 8-14 days across much of the southwestern U.S., with the highest risk across portions of the southern Great Basin, Four Corners, and Southern High Plains, and lasting through at least July 19th.

Experimental Heat Risk this Weekend





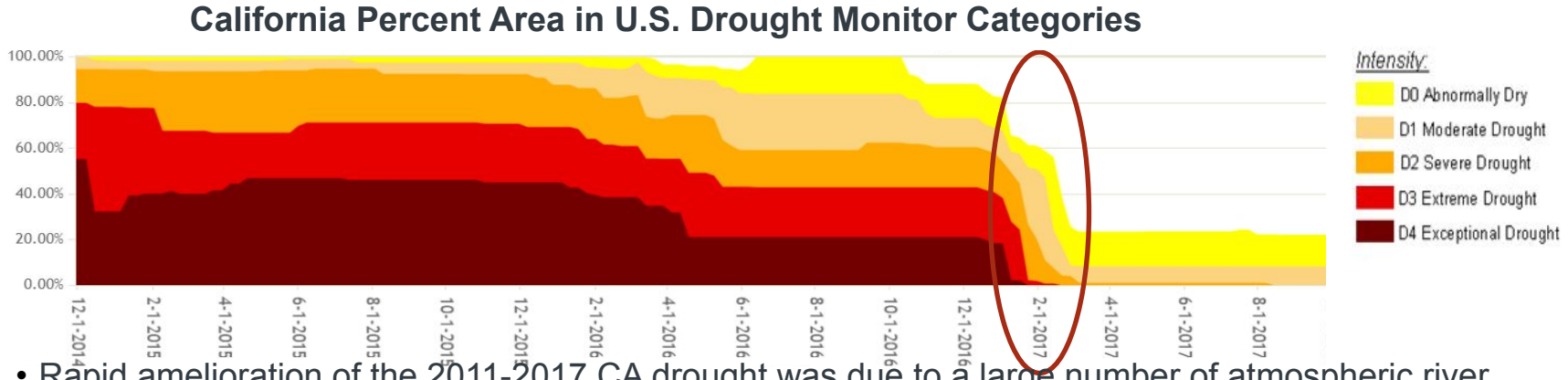
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

For more information go to:
www.wpc.ncep.noaa.gov, www.cpc.ncep.noaa.gov www.weather.gov

Weather Prediction Center
& Climate Prediction Center

Precipitation Prediction Skill Gap: Regime Transition

Failure to Predict Drought Amelioration

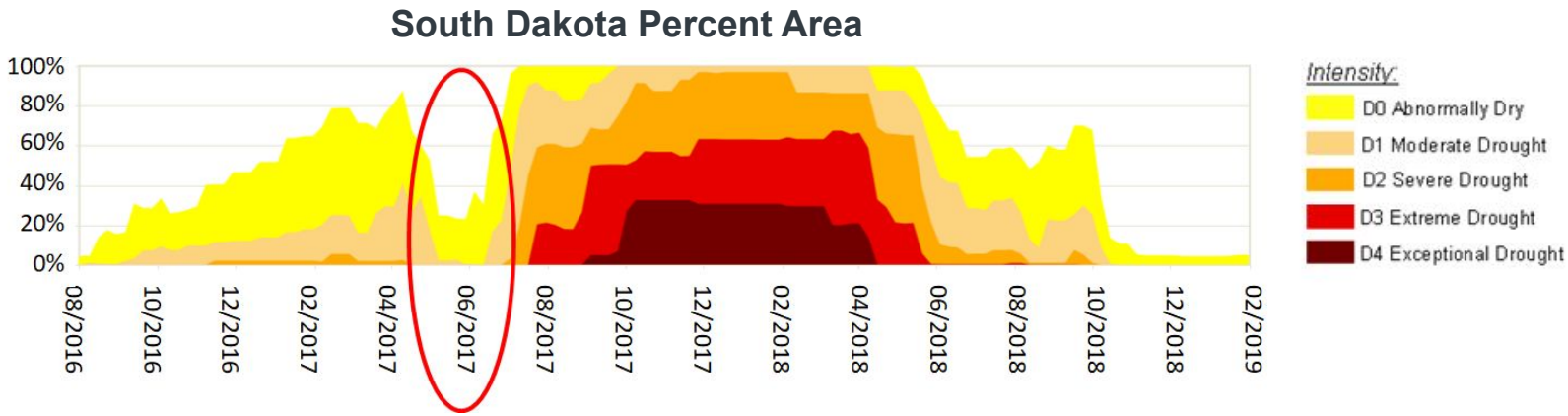


- Rapid amelioration of the 2011-2017 CA drought was due to a large number of atmospheric river events. They formed and penetrated to CA after persistent large-scaling ridging over the eastern Pacific broke down.
- This occurred despite an ongoing La Niña, which tends to support ridging and below-normal precipitation in this region.

All models failed to predict this regime transition of the large scale atmospheric state and subsequent heavy rains beyond about two weeks lead.

S2S Precipitation Prediction Skill Gap: Regime Transition

Failure to Predict Flash Drought Onset



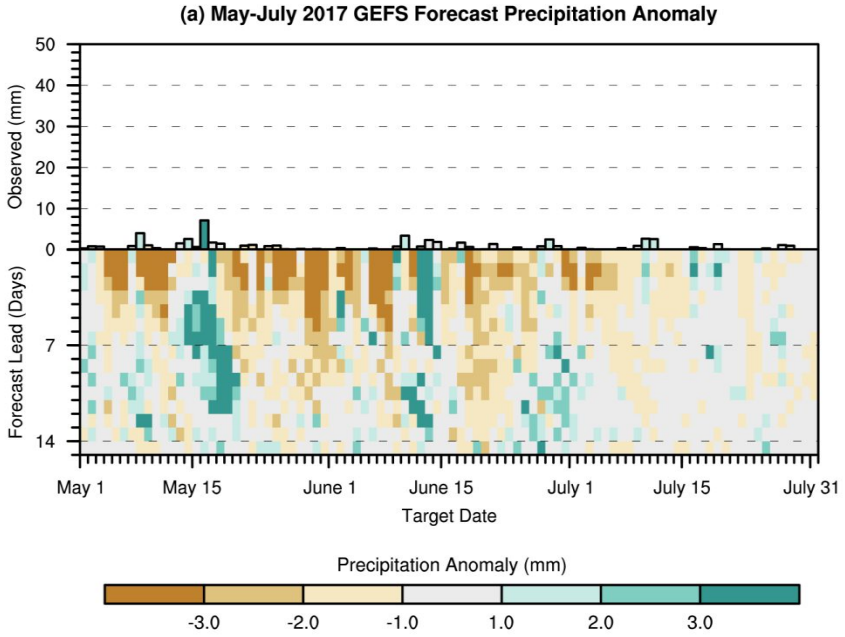
Transitioned from near normal conditions to severe drought over a ~60 day period.

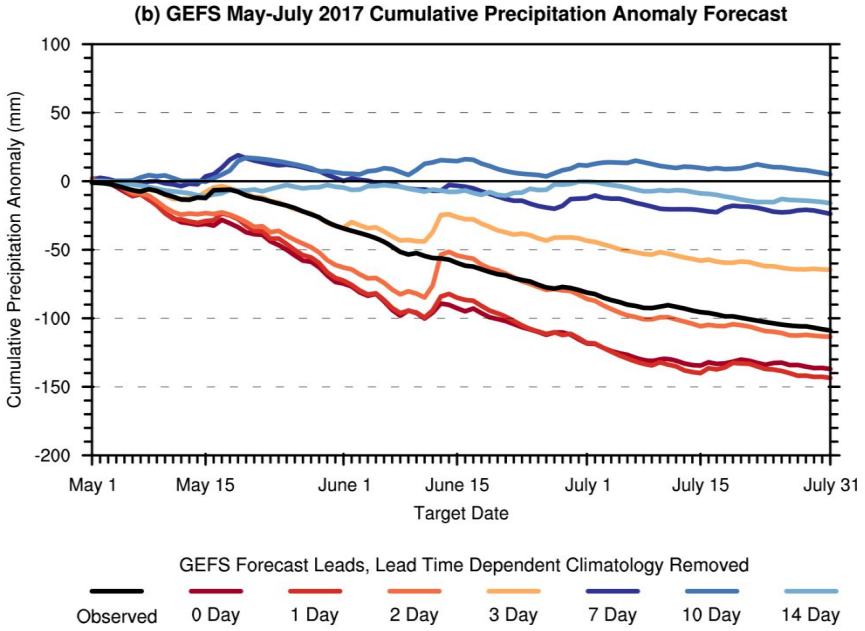
Science challenges in this case for improved spring/summer precipitation for the Northern Plains include:

- Land-atmosphere interactions
- Warm-season continental convection

All models failed to predict the onset of this drought beyond about one week lead-time.

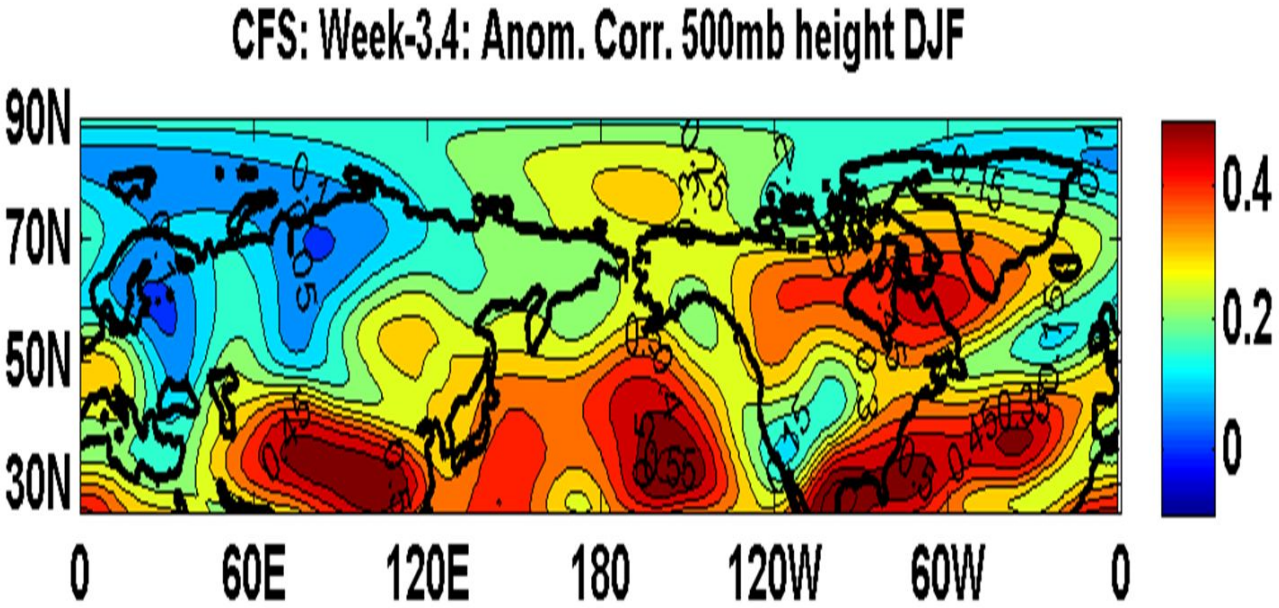
Predictability for the 2017 Northern Plains Flash Drought was Limited to Forecasts of 3 Day Lead





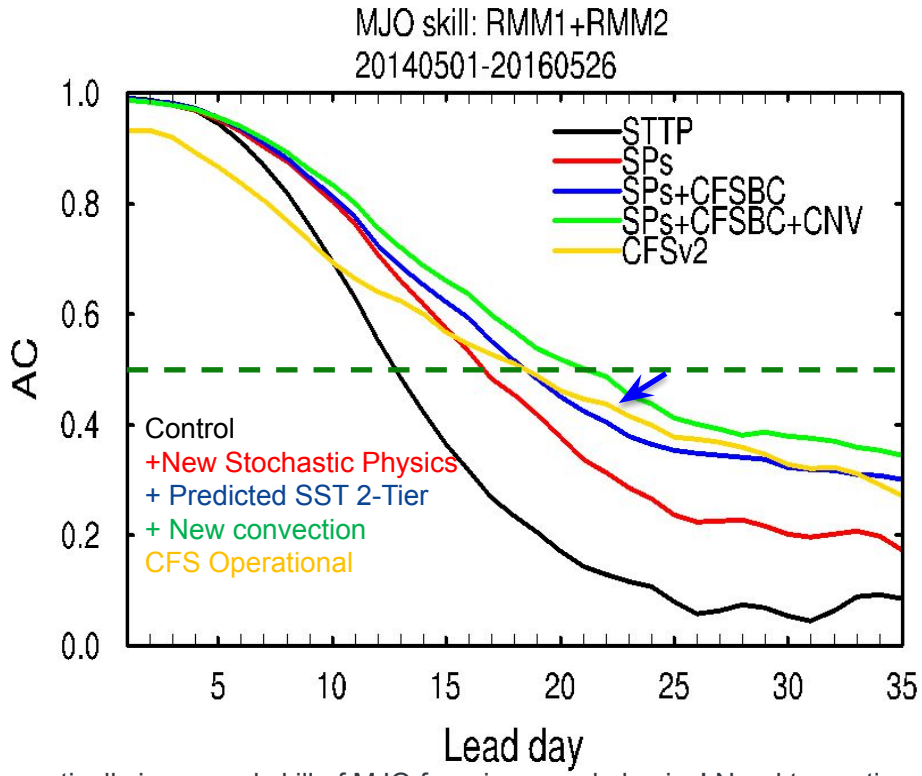
From Andy Hoell

Skill Gap: Predicting Mid-Latitude Steering Flow Beyond Week Two



Limited ability of ALL dynamical models to predict upper-level flow for western half of the US beyond week two. Is this an intrinsic limit of predictability or due to missing or misrepresented processes in these models?

GEFS week 3&4 forecasts (May 2014-May 2016) (Zhu et al.)

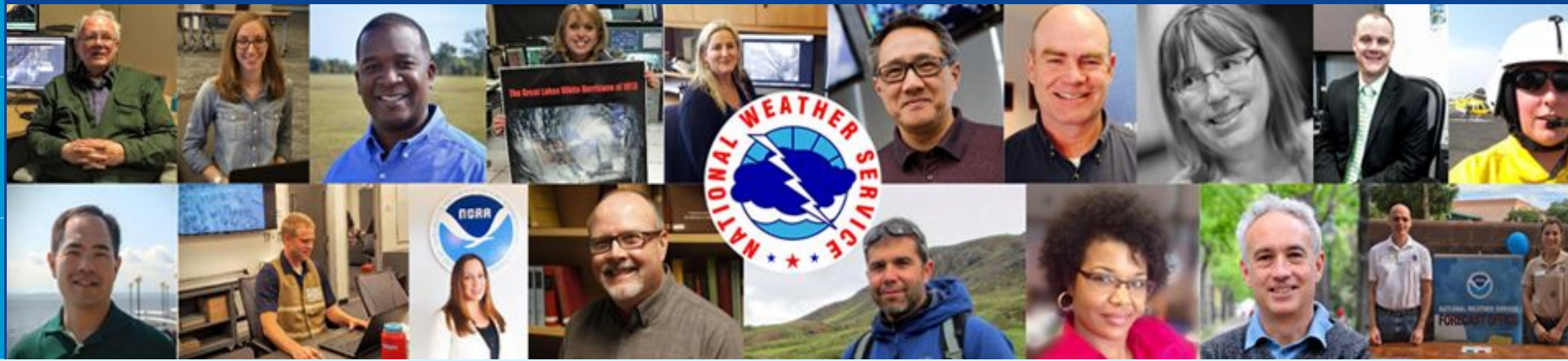


Dramatically increased skill of MJO from improved physics! Need to continue to improve teleconnections from MJO, i.e. precipitation forecast skill over western US.

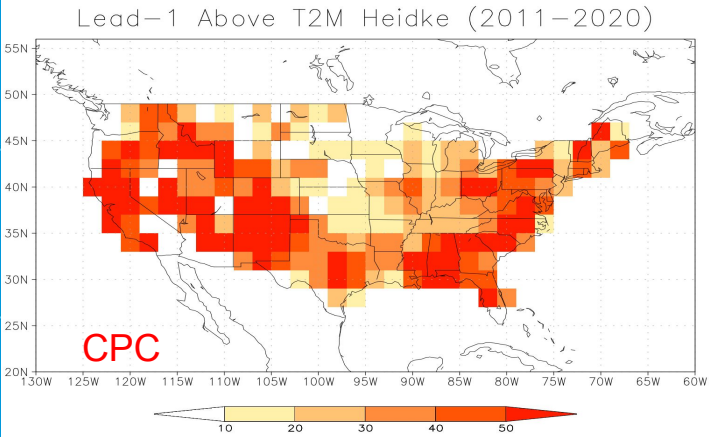
Final Thoughts

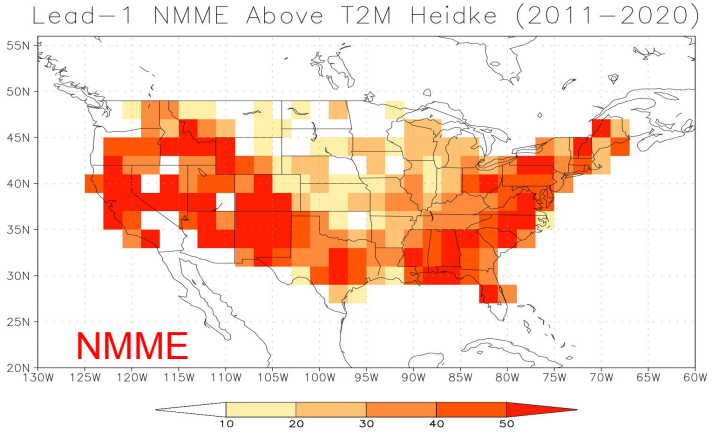
- CPC prediction products are inherently probabilistic. Therefore, ensemble systems are foundational to our work.
- The past 10 to 15 years has shown that sub-seasonal climate variability (MJO, atmospheric rivers, sudden stratospheric warming, flash drought) frequently dominates the seasonal variability. Therefore improving predictive skill for these phenomena is critical to improve seasonal prediction skill.
- Improving S2S prediction skill is a tough problem, but it would have a large benefit for society.
- We need bright folks like those attending this meeting to work to address this challenge.

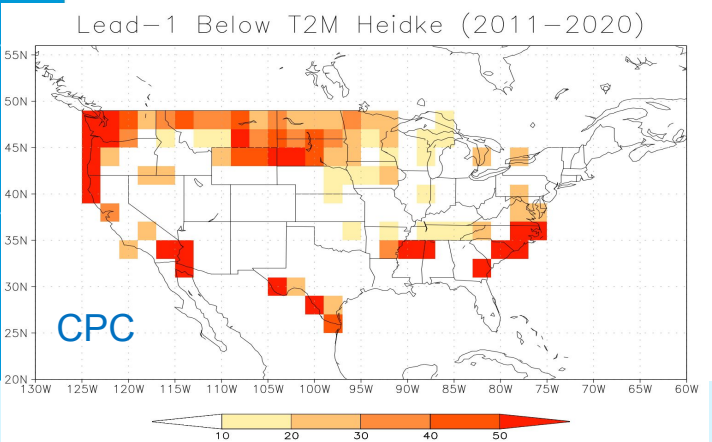
Thank you!

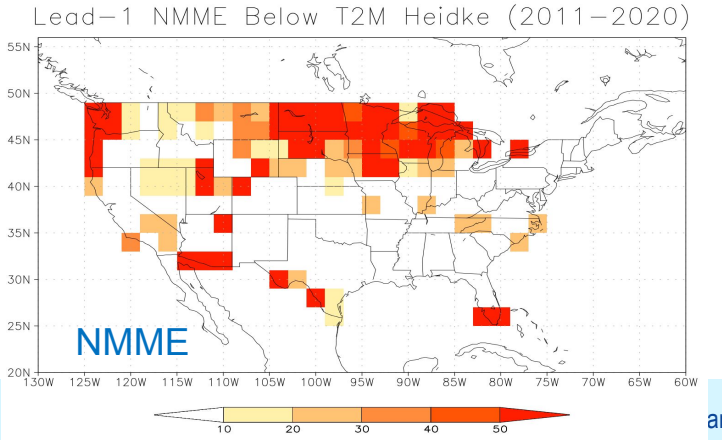


Skill Asymmetry for Below and Above-Normal Forecasts for CPC Official and NMME (2011-2020)









Forecasts of above normal temperatures have much higher skill than forecasts of below normal temperatures.

Even where below normal temperature forecasts are good – this can be deceiving because of how rarely they are issued.

S. Baxter

Major Systematic Errors Limiting S2S Prediction Skill: Magnitude and Spatial Distribution of Tropical Precipitation Variability

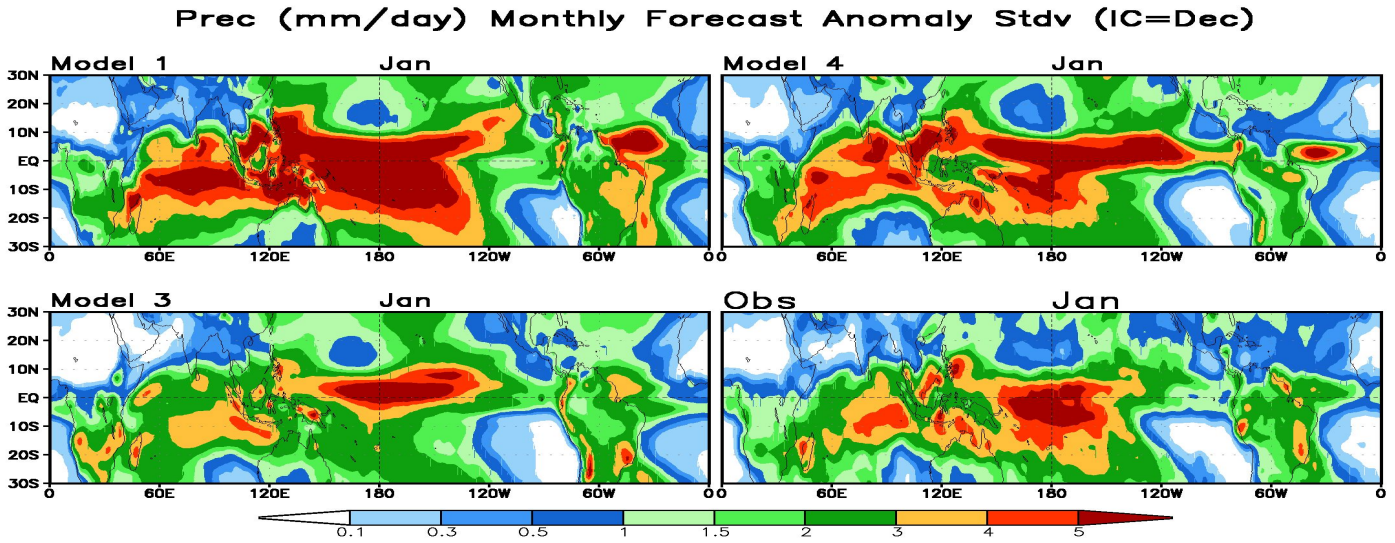


Figure compares standard deviation of precipitation from one month lead precipitation forecasts from 3 state of the art S2S models and observations. It demonstrates that models have errors of 100% or more in predicting mean statistics of tropical precipitation. Result is even worse if you remove large ENSO events.