

Flash Droughts over the United States

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outline

- Define flash droughts
- Physical mechanisms for flash droughts
- Flash drought prediction from the CFSv2 seasonal forecasts

Data sets from UCLA

- Data period: 1916-2013
- Interval: Pentads (5-day means)
- **Four variables (T_{air} , P, ET and SM):**
 - T_{air} , P (gridded from observed stations 0.5 degrees),
 - ET and total SM (reconstructed from land models: Noah, Catchment, SAC and VIC).

We process each model separately, then took the ensemble mean

flash droughts

Flash droughts == Heat wave meets low soil moisture

High temperature

Low soil moisture

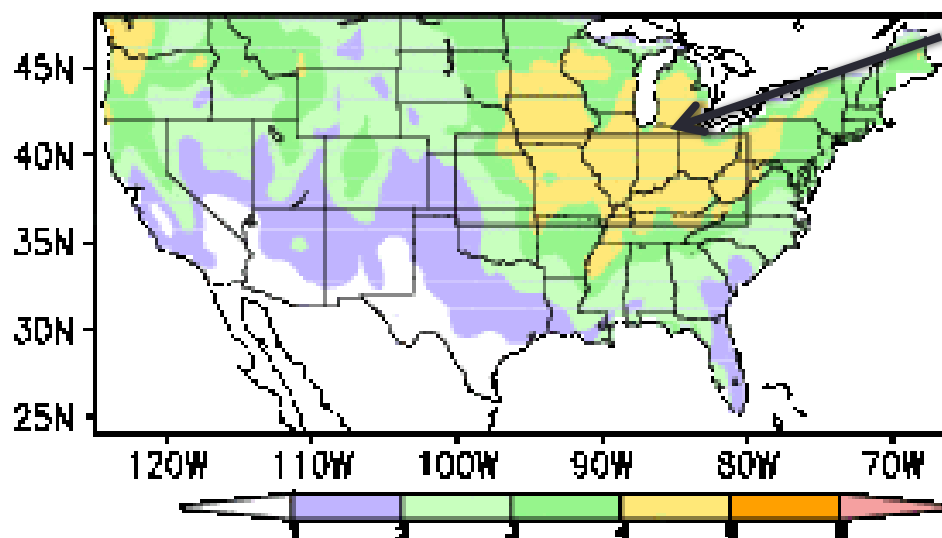
Lack of precipitation

There are two types of flash droughts

- One starts with heat waves--- Heat wave flash drought
- One starts with P deficits----P deficit flash drought

Heat wave flash drought

Frequency of occurrence=
Number of events/record length

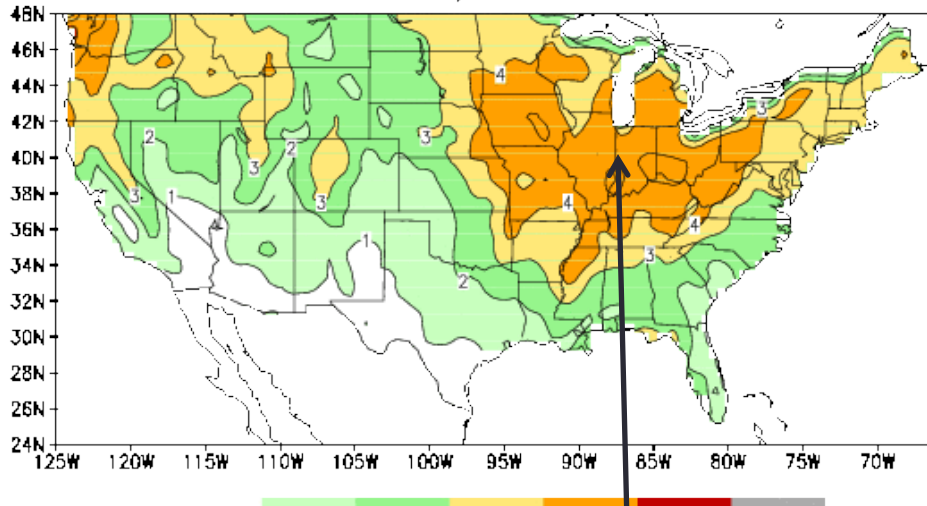


Definition

High temperature == $T_{air} > 1$ standard dev
ET increases (anomaly > 0 .)
SM decreases— to 30% or lower

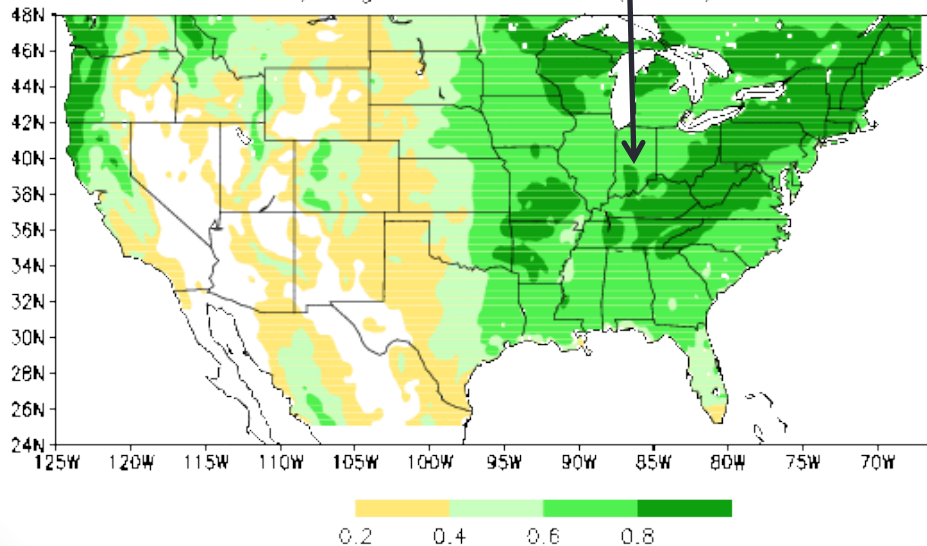
Heat wave flash drought

a) FOC



Vegetation coverage (Clim)

b)vegetation flux (clim)



FOC= Number of events/record length

1. It occurs in the vegetation dense areas
2. Physical mechanisms

High temperature
⇒ Increase of the transpiration and (ET)

⇒ Decrease SM

heat wave flash drought occurs in the vegetation dense areas

P deficit flash drought

Definition

$T > 1SD$

$ET \text{ anom} < 0$

$P < 40\%$

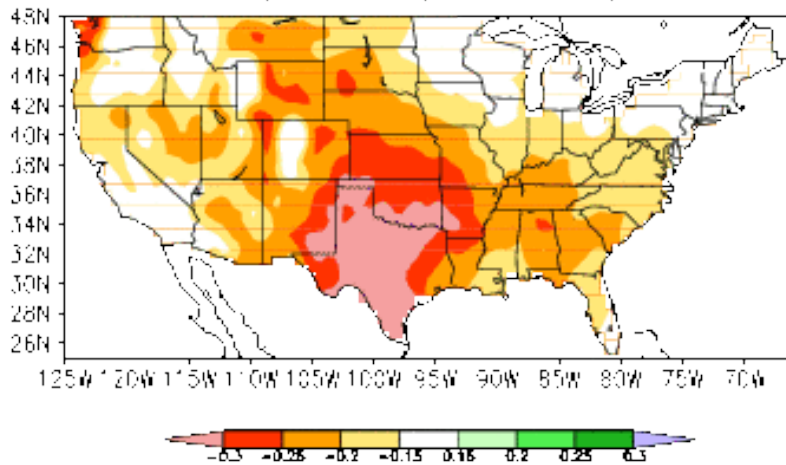
Physical mechanisms

- It starts from the lack of precipitation (P)
- P deficits = > *decreases of SM*
- **IF** => *decreases of ET*
- => balanced by increases of sensible heat
- => increases of Temperature

The critical element →
relationship btw SM and ET

Physical mechanisms for P deficit flash drought

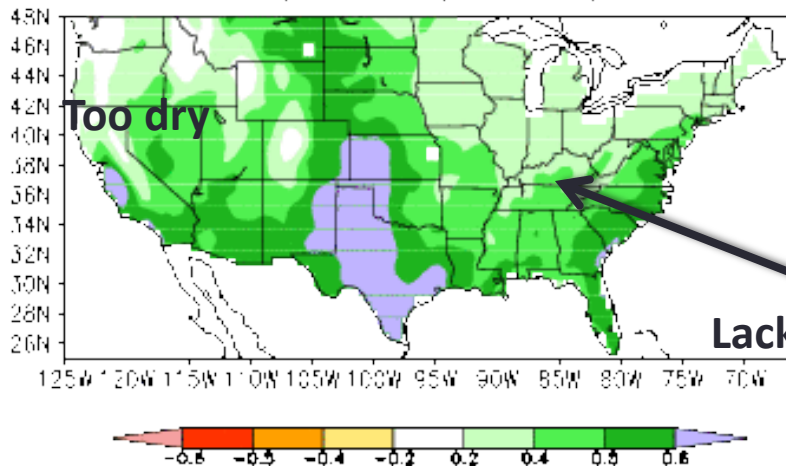
a) $\text{corr}(sm, T_{air})$



In the areas where the lack of SM => increase of T_{air}

Pathway through ET

b) $\text{corr}(ET, SM)$



Only occurs in the areas where ET and SM have a near linear relationship

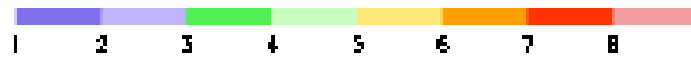
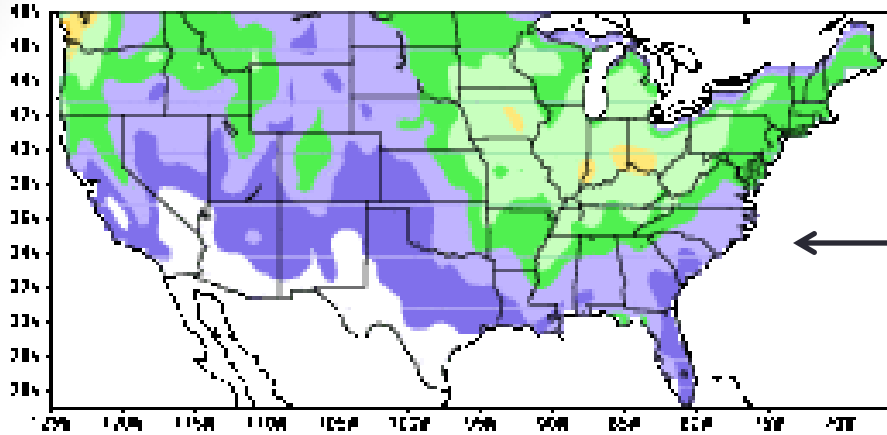
Lack of variability

Koster et al 2009

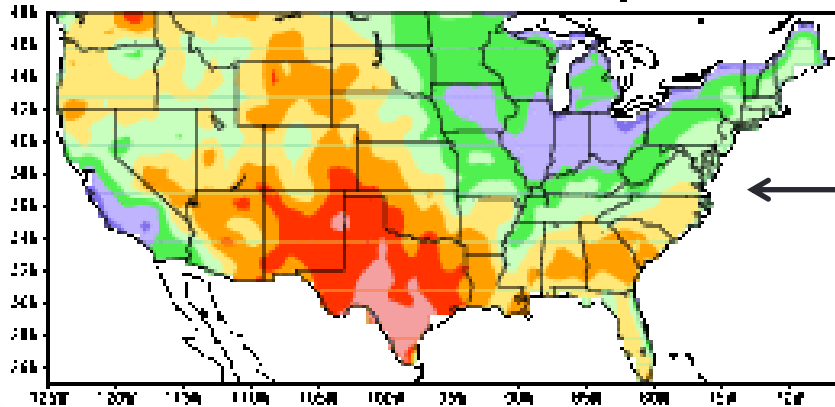
Monthly mean correlation (apr-sep)

Frequency of occurrence

a) heat wave flash drought



b) P deficit flash drought



Can CFSv2 seasonal forecasts predict flash droughts?

- CFSv2 seasonal (first 90-day) forecasts from April to July
- A) whether forecasts can predict the preferred regions for flash droughts to occur?
- B) whether the CFSV2 can predict each event?
- C) if B is too much to ask, then whether the CFSV2 can predict the occurrence of flash droughts in 3 categories: below, normal and above?

Data from CFSV2 hindcasts

Data:

For each month

- 12 ensemble members
- 18 pentads (90day)
- 29 years (1982-2010) so we have total $12 \times 18 \times 29$ members

4 variables (T,P,ET,SM)

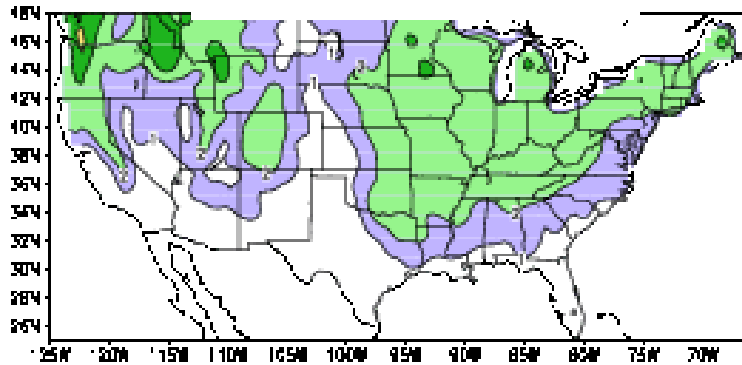
- Correct systematic error of T and P
- Drive a VIC model to get ET and SM
- Bias correct ET and SM
- Get (T (std), ET (anom), P and SM(percentiles))

Verification

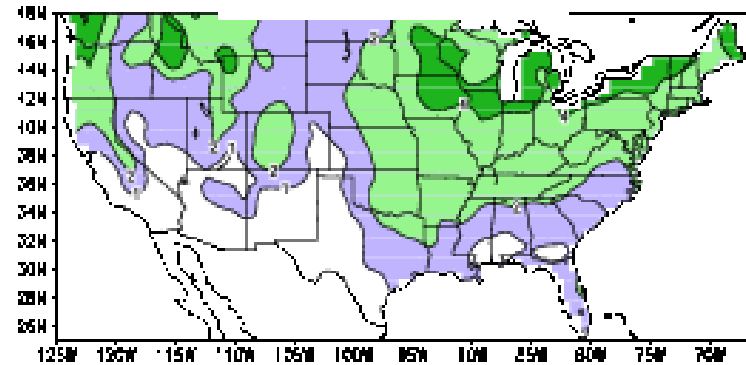
- VIC(SIM) – observed T and P to drive a VIC model to get ET and SM
- Same criteria for flash droughts

FOC predicted by the CFSv2 seasonal fcsts

Analysis
Heat wave

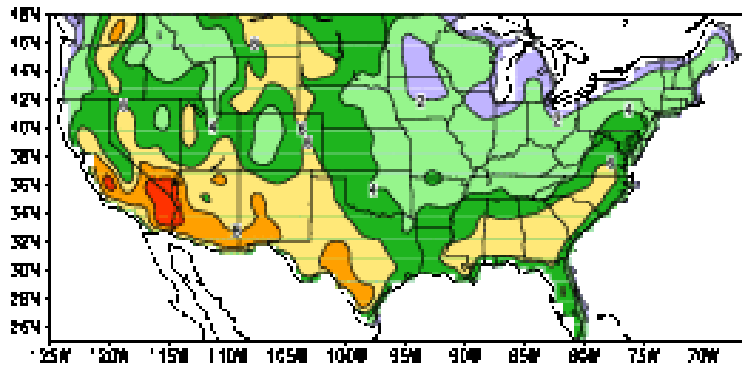


FCST
Heat wave

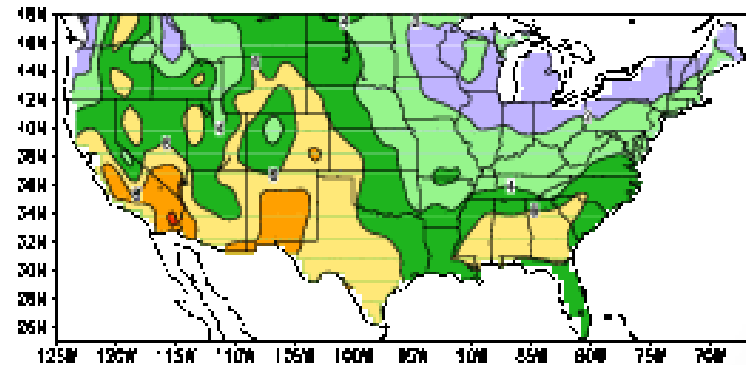


P deficit

5



P deficit

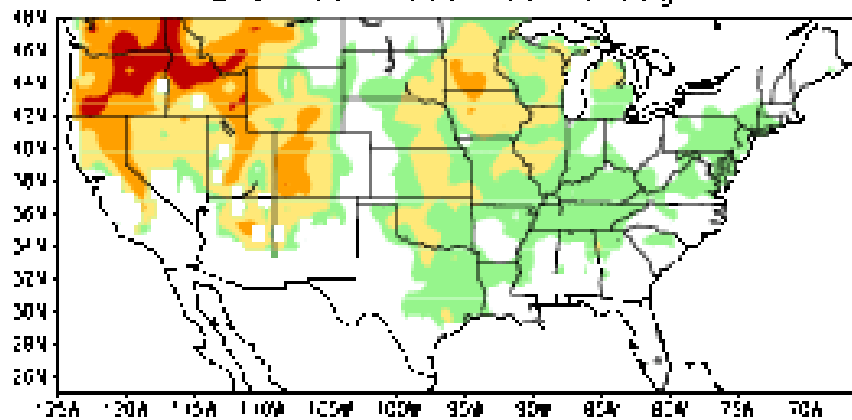


ETS score of flash drought events /yr

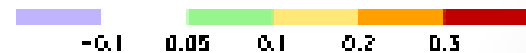
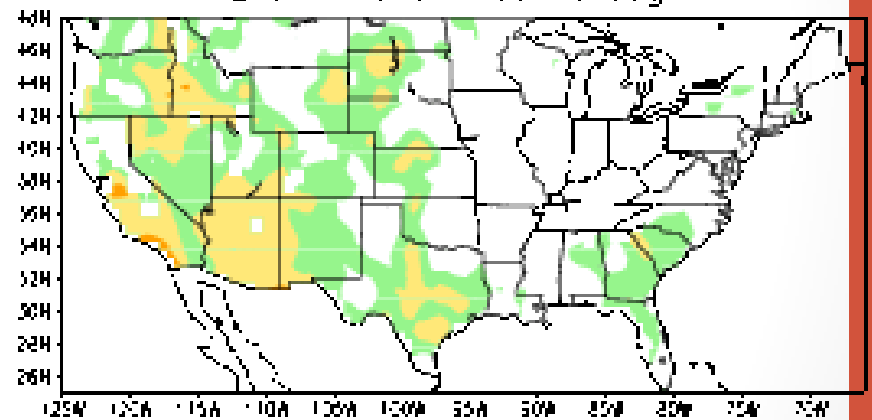
- $ETS = \text{hit} / (\text{hit} + \text{miss} + \text{false alarm})$
- Hit--- both obs and fcst indicate there are flash drought events in the following season
- Miss- obs indicates events, but not forecasts
- False alarm- fcst indicates events, but not obs
- We also correct the random occurrence of flash droughts

ETS scores

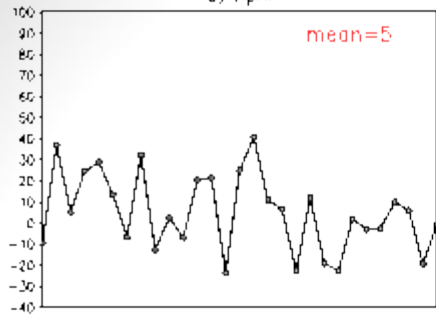
ETS heat wave flash drought



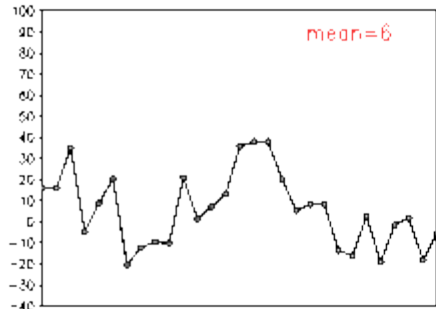
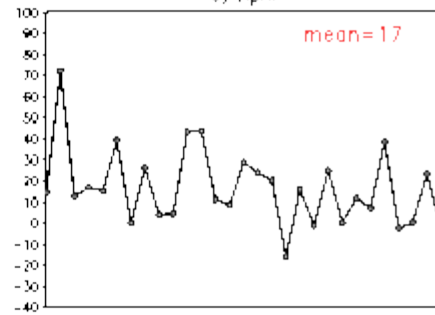
ETS P deficit flash drought



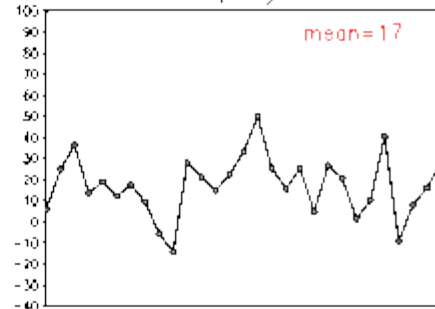
Heat wave flash droughts
a) April



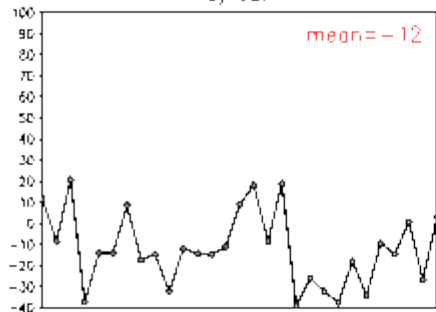
P deficit flash droughts
e) April



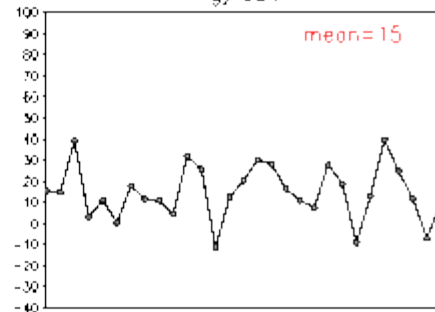
f) May



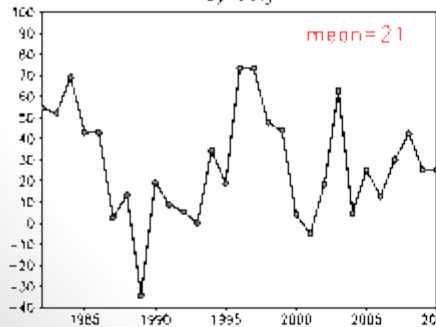
c) Jun



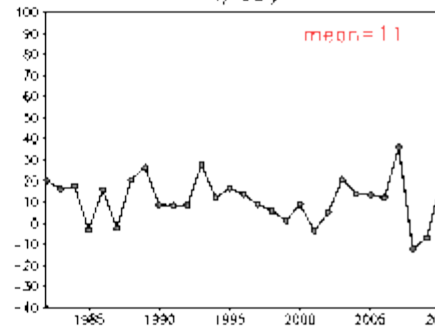
g) Jun



d) July



h) July



Heidke skill of forecasts of the yearly total flash drought events over the United States in 3-category forecasts

1. There are negative scores
2. It is not influenced by ENSO

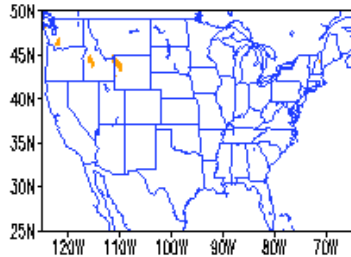
Can CFSv2 seasonal forecasts predict flash droughts?

- A) whether forecasts can predict the preferred regions for flash droughts to occur? **YES**
- B) whether the CFSV2 can predict each event? **NO**
- C) if B is too much to ask, then whether the CFSV2 can predict whether there are flash drought events in the coming season?

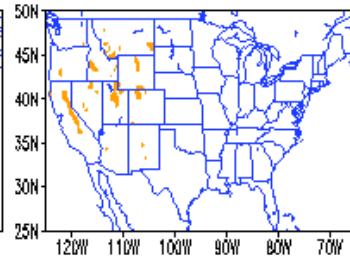
Skill is similar to the 5-10 day forecasts of temperature and precipitation

Pantad2 11Jul2017 to 16Jul2017

heat wave FD
occurrence

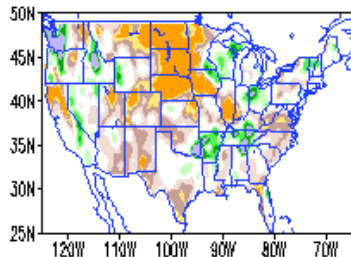


p-deficit FD
occurrence

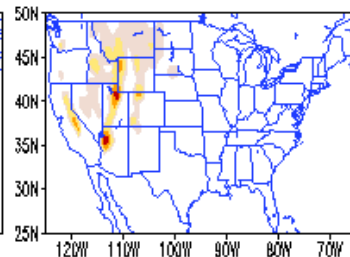


locations of flash drought occurrence are colored

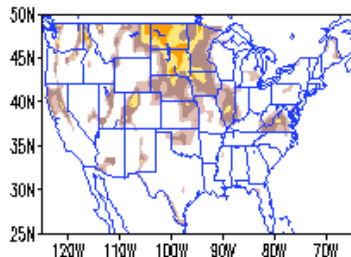
ET anom



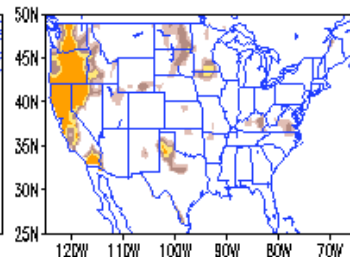
T2m std anom



sm %



P %



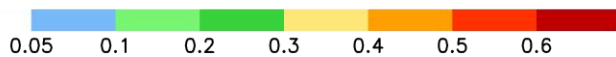
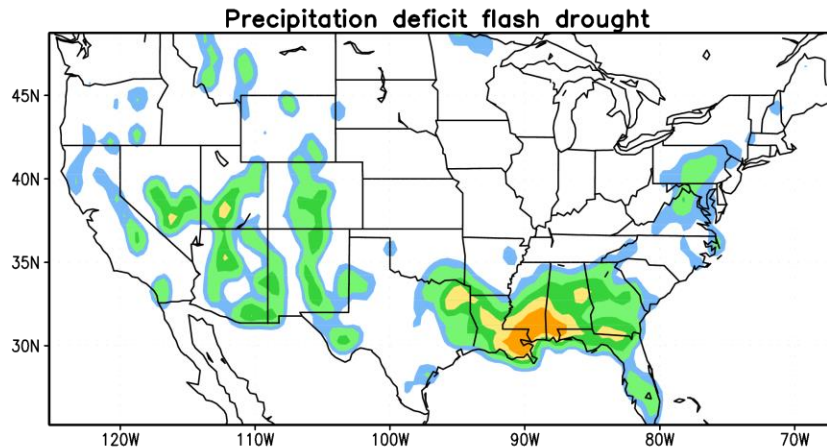
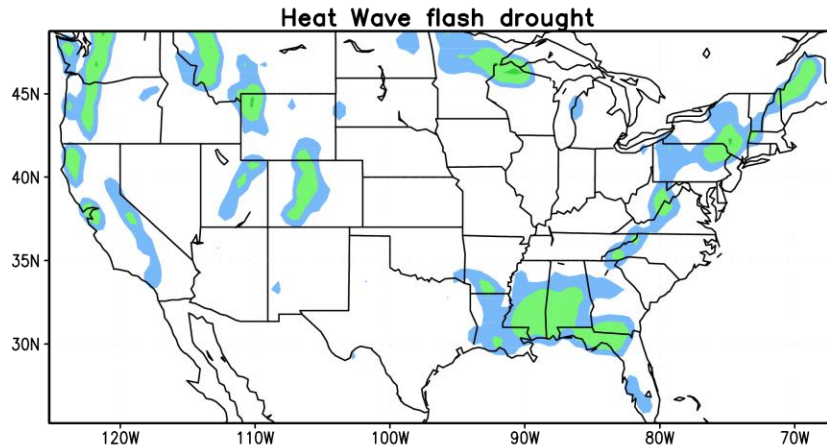
base period 1979–2015

Operational monitoring started from 1May 2017 to the present

1. We display ET anomaly, T2m stand. Anom and SM and P percentiles
2. Update daily
3. Every 5 days from 10 days ago to the present pentad

Seasonal flash drought fcsts

Seasonal flash drought forecast for 01May to 31Jul 2017
Frequency Of Occurrence



FOC: number of flash droughts per season

Summary

There are two types of flash droughts

1. Heat wave flash drought

- Occurs in the North Central and the Pacific Northwest
- Max frequency of occurrence is 4-5%
- Temperature driven
- High temp=> increasing ET=> decreasing SM

2. P deficit flash drought

- Occur over the Great Plains and southern states with a maximum over Texas
- Max frequency of occurrence is 8-10%
- Precipitation driven
- P deficits=> Decreasing SM=> decreasing ET => Temp increases

3. CFSv2 seasonal forecasts

- It is able to capture the frequency of occurrence and the
- Heidke skill for 3-category forecasts is overall positive