

The Evaporative Demand Drought Index (EDDI): an emerging drought-monitoring & early warning tool

Mike Hobbins

NOAA/ESRL/Physical Sciences Division &
University of Colorado/Cooperative Institute for Research in the Environmental Sciences

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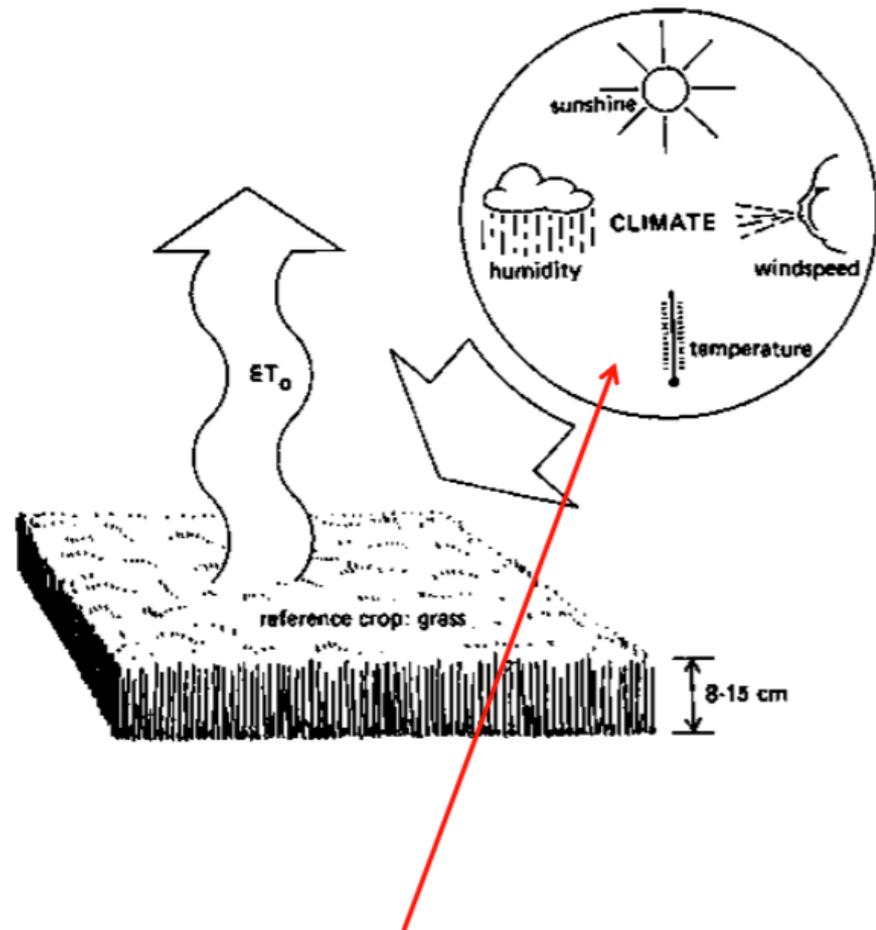
Cooperative Institute for Research in Environmental Sciences
UNIVERSITY OF COLORADO BOULDER and NOAA



What is Evaporative Demand?

ET = actual evapotranspiration
 E_0 = evaporative demand

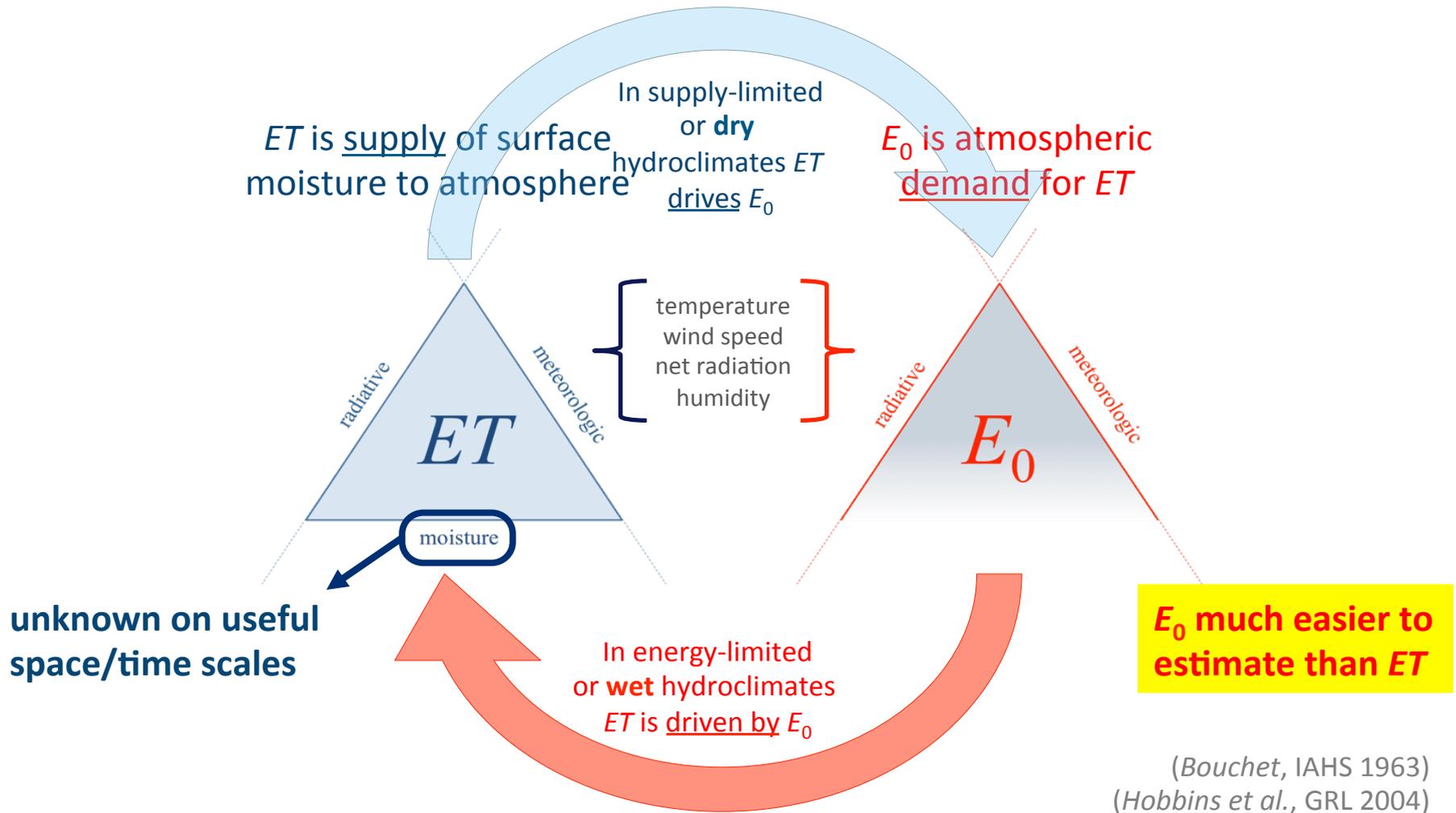
- “Thirst of the atmosphere”
- ET occurring given an unlimited moisture supply
 - Reference ET
 - Potential ET (“ PET ”)
 - Pan evaporation
- There are good estimates and bad estimates:
 - physically based
 - temperature-based



Physically-based E_0 contains valuable information related to drought dynamics

Why Evaporative Demand?

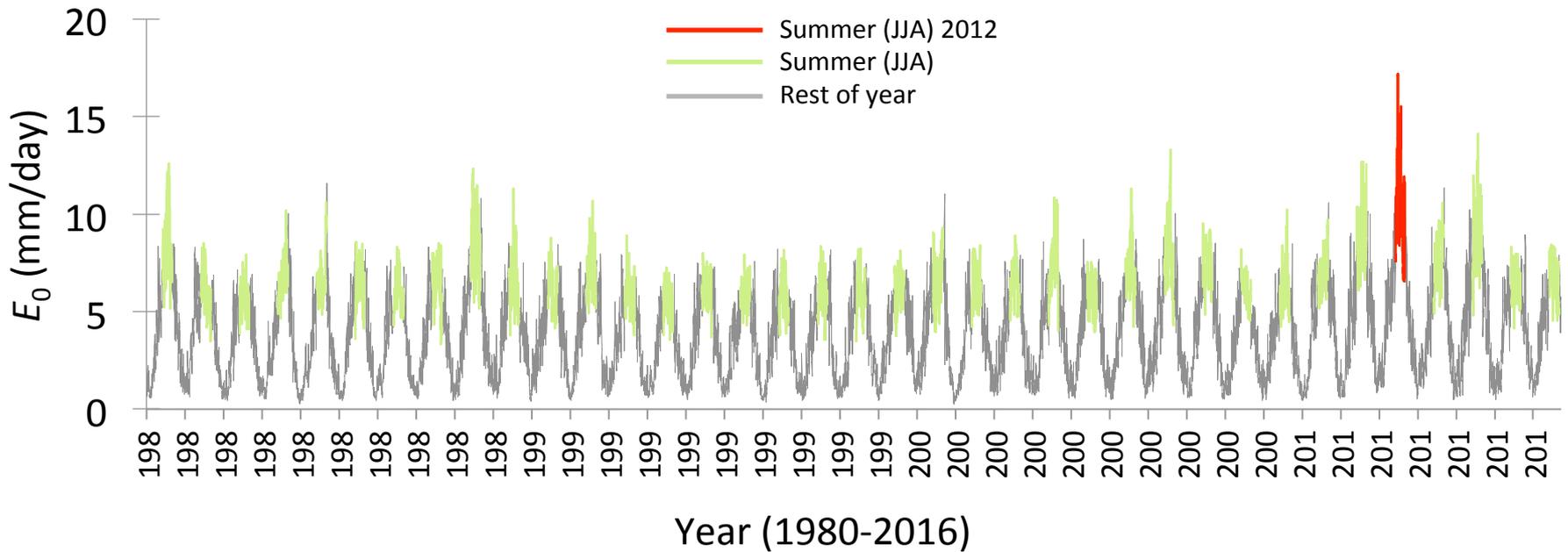
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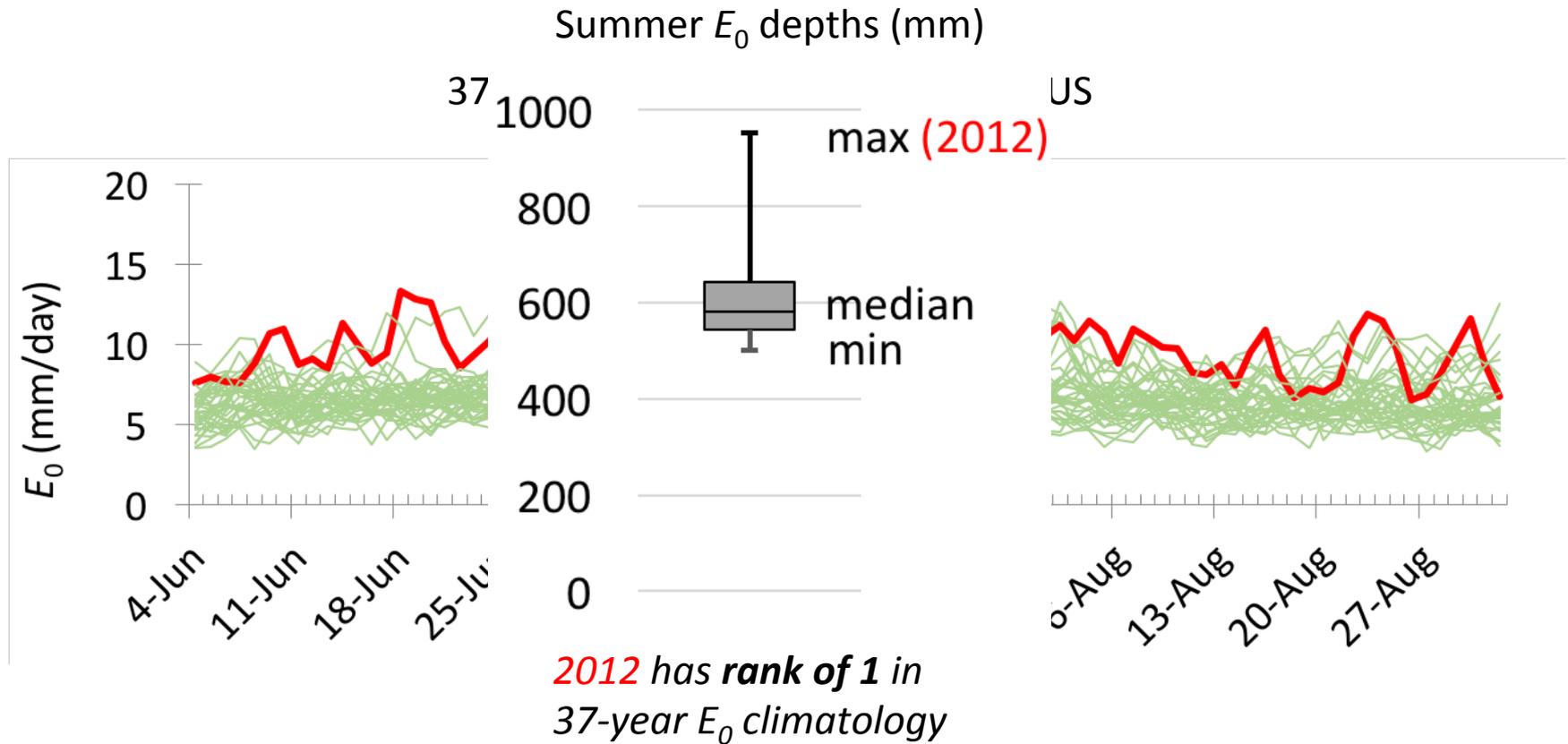
(Bouchet, IAHS 1963)
(Hobbins et al., GRL 2004)

How do we calculate EDDI?

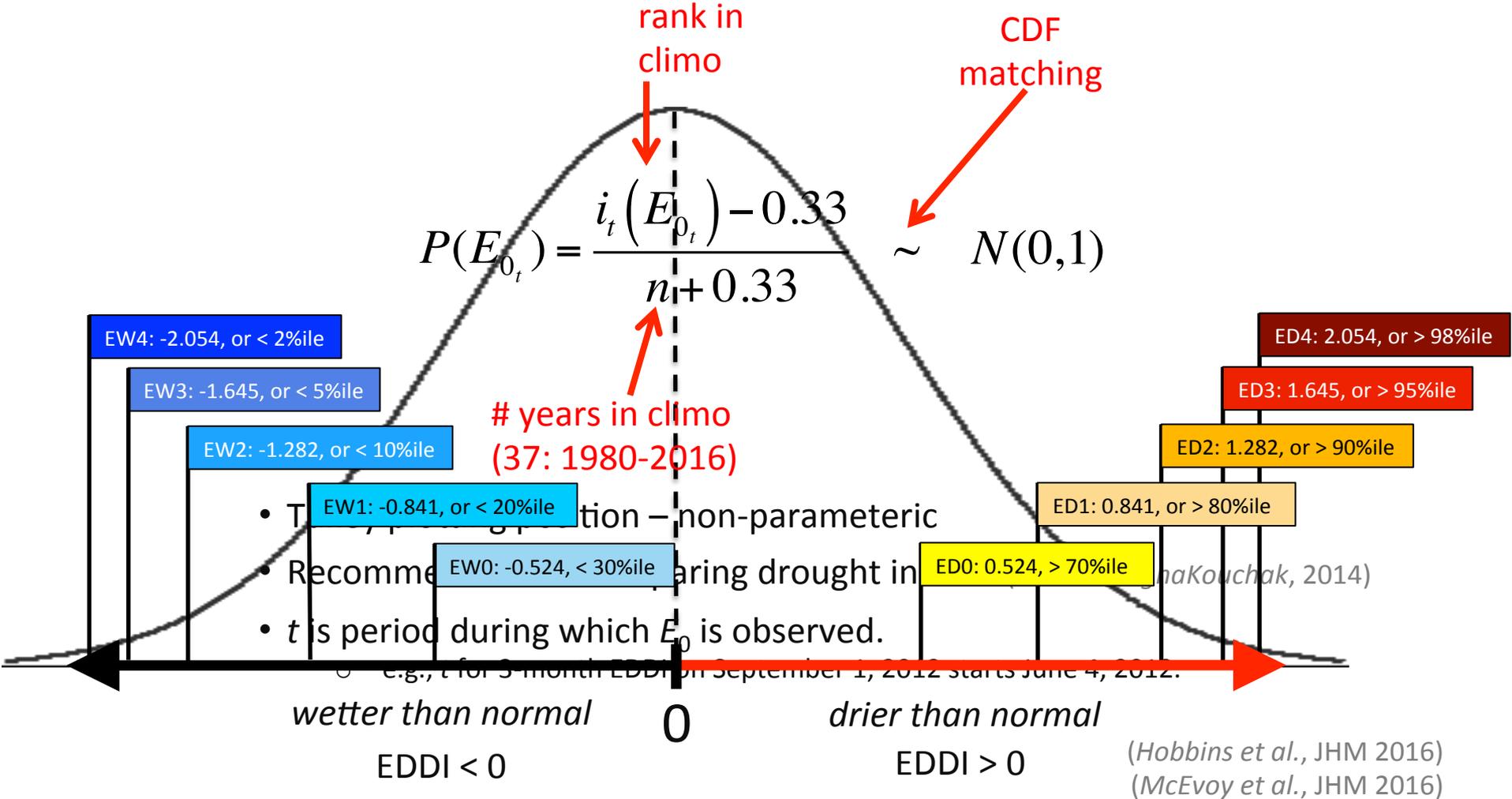
E_0 (reference ET) – Midwest US



How do we calculate EDDI?



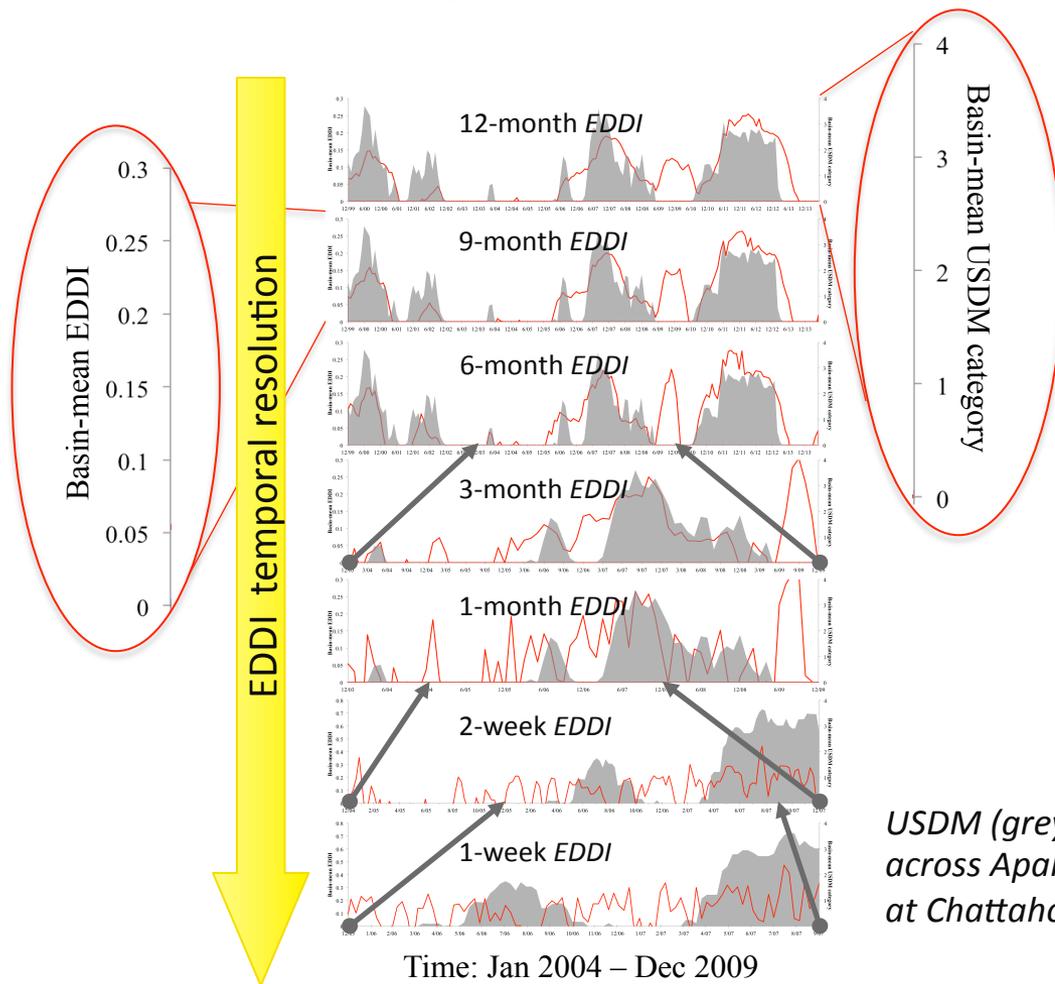
How do we calculate EDDI?



What does EDDI offer?

A multi-scalar drought estimator

USDM = United States Drought Monitor



Signals of different drying dynamics are evident at different time-scales

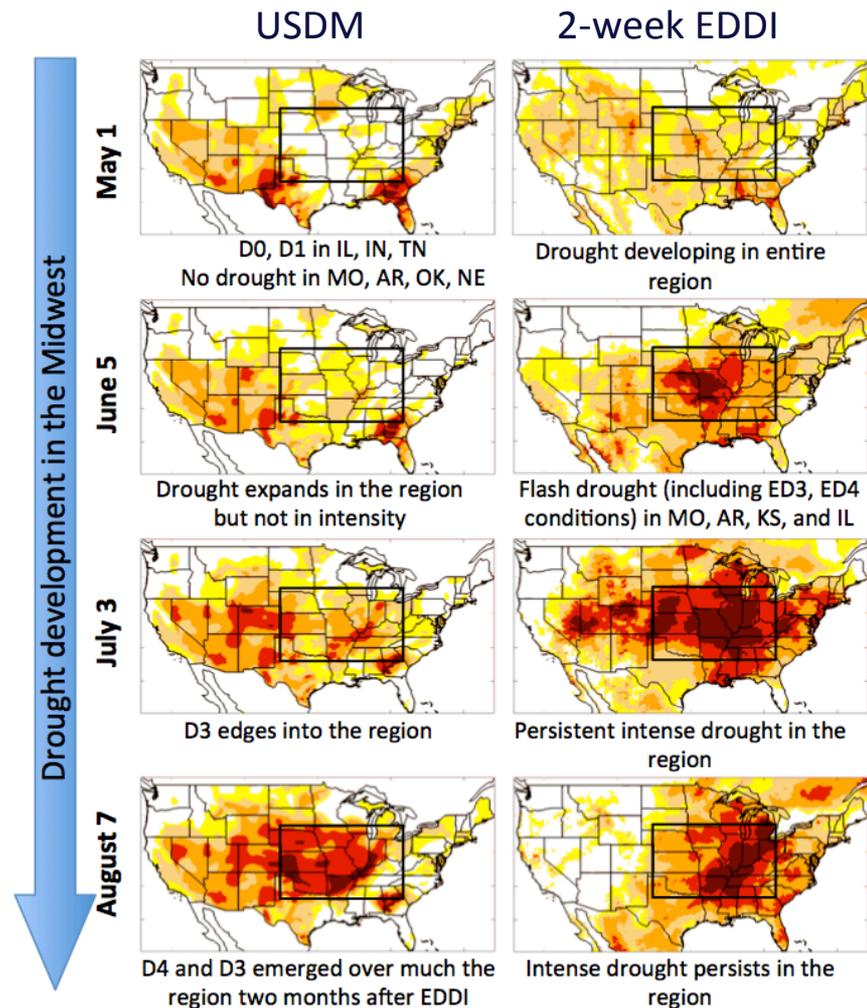
USDM (grey) and EDDI (red) across Apalachicola River basin at Chattahoochee, FL.

What does EDDI offer?

Leading indication of drought

2-week EDDI captures
severe drought conditions
~2 months before USDM

*"Flash drought" in the
US Midwest, 2012*



What does EDDI offer?

Monitoring across sectors



AGRICULTURAL
DROUGHT

- soil moisture
- grazing health
- ET

HYDROLOGIC
DROUGHT

- streamflow
- snowfall



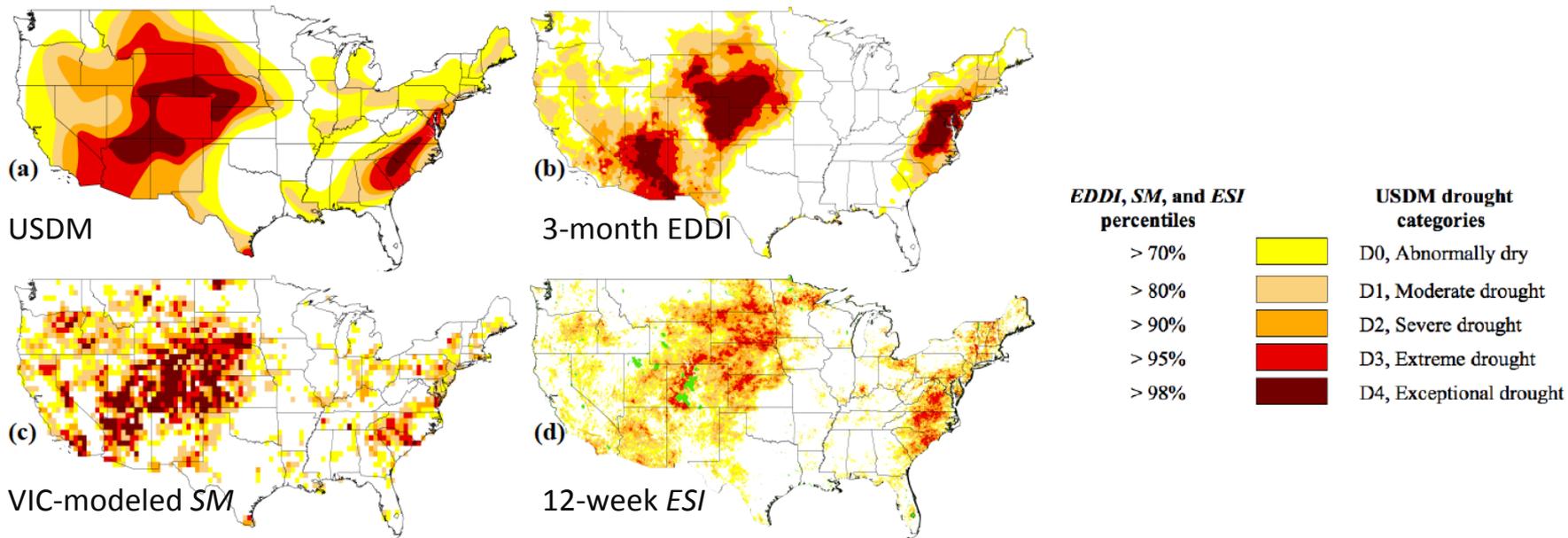
FIRE-RISK
MONITORING

- weather
- fuel loads

What does EDDI offer?

Agricultural drought monitoring

VIC = Variable Infiltration Capacity model
 ESI = Evaporative Stress Index



Agricultural drought across CONUS, July 31, 2002

(Hobbins et al., JHM 2016)

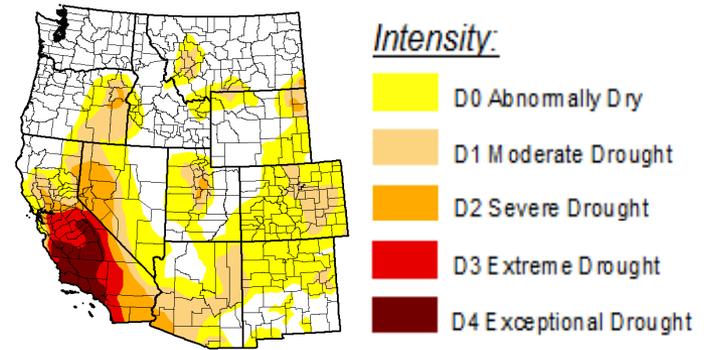
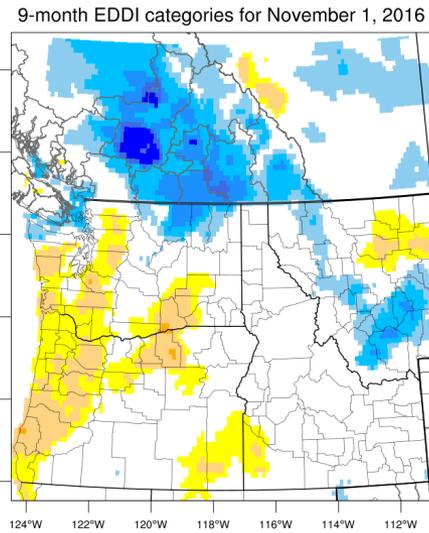
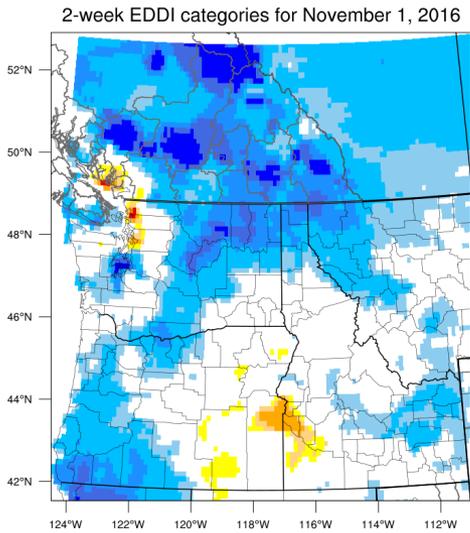
What does EDDI offer?

Current conditions (November 1):

2-week EDDI

9-month EDDI

US Drought Monitor



Drought categories Wetness categories



100% 98% 95% 90% 80% 70% 30% 20% 10% 5% 2% 0%
(EDDI-percentile category breaks: 100% = driest; 0% = wettest)

Generated by NOAA/ESRL/Physical Sciences Division

Drought categories Wetness categories



100% 98% 95% 90% 80% 70% 30% 20% 10% 5% 2% 0%
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Generated by NOAA/ESRL/Physical Sciences Division

Live EDDI maps for PNW DEWS available:

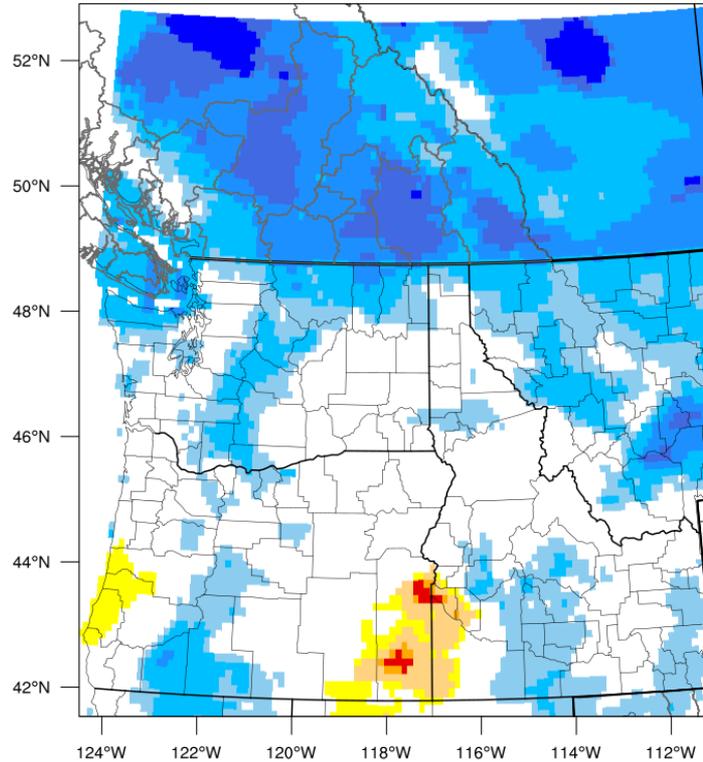
ftp://ftp.cdc.noaa.gov/Public/mhobbins/EDDI/PNW_DEWS/

What does EDDI offer?

ftp://ftp.cdc.noaa.gov/Public/mhobbins/EDDI/PNW_DEWS/

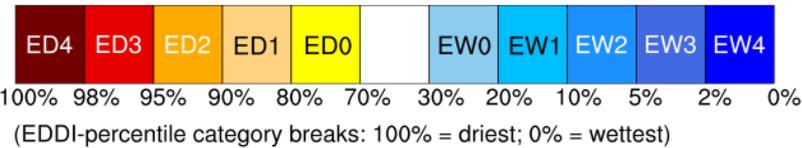
*3-month EDDI
development,
since WY 2016*

3-month EDDI categories for November 4, 2016



Drought categories

Wetness categories



Generated by NOAA/ESRL/Physical Sciences Division

What's next for EDDI?

User outreach, operationalizing, research

Two-pager:

EDDI
A Powerful Tool for Early Drought Warning

Green River, Wyoming. Photo: K. Miller, USGS.

What is EDDI?
EDDI, which stands for Evaporative Demand Drought Index, is a drought index that can serve as an indicator of both rapidly evolving "flash" droughts (developing over a few weeks) and sustained droughts (developing over months but lasting up to years).

Why use EDDI?
EDDI has been shown to offer early warning of drought stress relative to current operational drought indicators, such as the US Drought Monitor (USDM) (see Figure 1). A particular strength of EDDI is in capturing the precursor signals of water stress at weekly to monthly timescales, which makes EDDI a potent tool for drought preparedness at those timescales. EDDI also uses the same classification scheme as the USDM to define drought conditions, so it is easy to read EDDI maps.

Does EDDI work in real time?
Yes. At present, EDDI is generated every week by analyzing a real-time atmospheric dataset. There is also an ongoing effort to forecast EDDI based on seasonal climate-forecast information.

What is the physical basis for EDDI?
EDDI exploits the strong physical relationship between evaporative demand (E_e) and actual loss of water from the land surface through evapotranspiration. E_e is the "thirst of the atmosphere," estimated by the amount of water that would evaporate from the soil and be transpired by plants if the soil were well watered. EDDI measures the signal of drought using information on the rapidly evolving (daily) conditions of the atmosphere to estimate their impact on land-surface moisture, and vice versa. EDDI's effectiveness in reflecting the moisture conditions on the land surface is based on feedbacks between the atmosphere and land that are particularly strong during the warm season, when drought is of greatest concern.

EDDI is sensitive to two distinct land-surface atmosphere interactions: (i) increased E_e drives increased evapotranspiration until the available soil moisture becomes limiting, potentially leading to flash droughts; and (ii) as surface water becomes increasingly scarce in sustained droughts, evapotranspiration declines, which leads to higher air temperature and lower humidity, and thereby increases E_e .

Figure 1
Development of a flash drought in the Midwest in 2012. The 2-week EDDI (right) is compared at 5-week intervals to the US Drought Monitor (USDM) (left). EDDI captures the severe drought condition two months ahead of the USDM. Image: Mike Hobbins.

Logos: Western Water Assessment, CIRES, Western Regional Climate Center, NOAA, and NOAA Cooperative Climate Science Center.

Released December 2015

Next steps:

- 3-year NOAA-RTAP grant to operationalize EDDI at NOAA National Water Center
- Enlarge and engage user-base
- 2-year NOAA-SARP grant for wildfire prediction
- Continued collaboration with DRI
 - research & development
 - add forecast component
- EDDI User's Manual

(2-pager: Rangwala et al., NOAA 2015)

Drivers of drought

$$E_0 = f(T, R_d, q, U_2), \text{ so}$$

$$\Delta E_0 = \frac{\partial E_0}{\partial T} \Delta T + \frac{\partial E_0}{\partial R_d} \Delta R_d + \frac{\partial E_0}{\partial q} \Delta q + \frac{\partial E_0}{\partial U_2} \Delta U_2$$

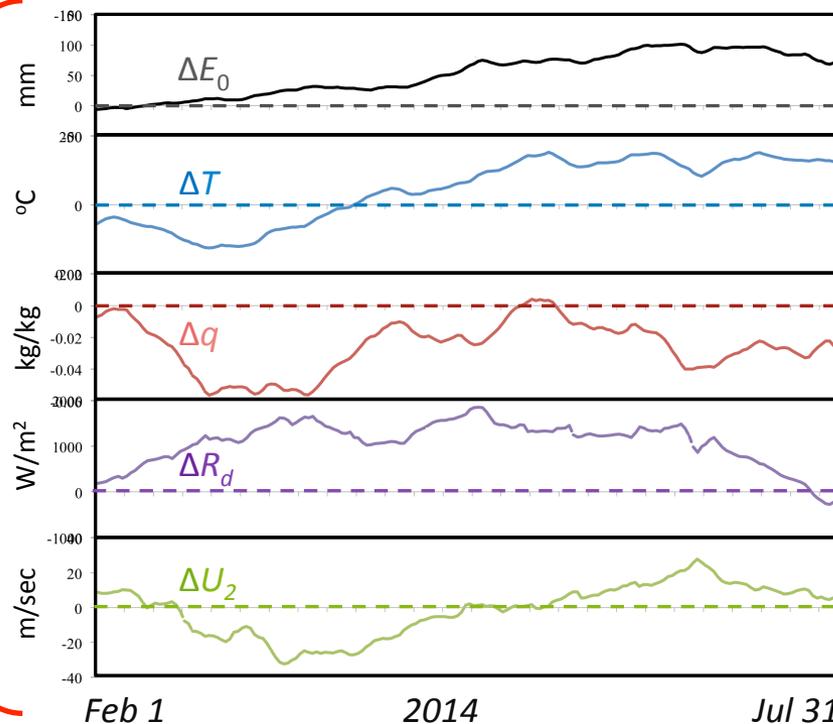
anomalies
observed in
reanalyses

derived
analytically
(Hobbins, 2016)

E_0 changes due to changes in:

- T , temperature
- R_d , solar radiation
- q , humidity
- U_2 , wind speed

Sacramento River basin, CA



(Hobbins et al., JHM 2016)

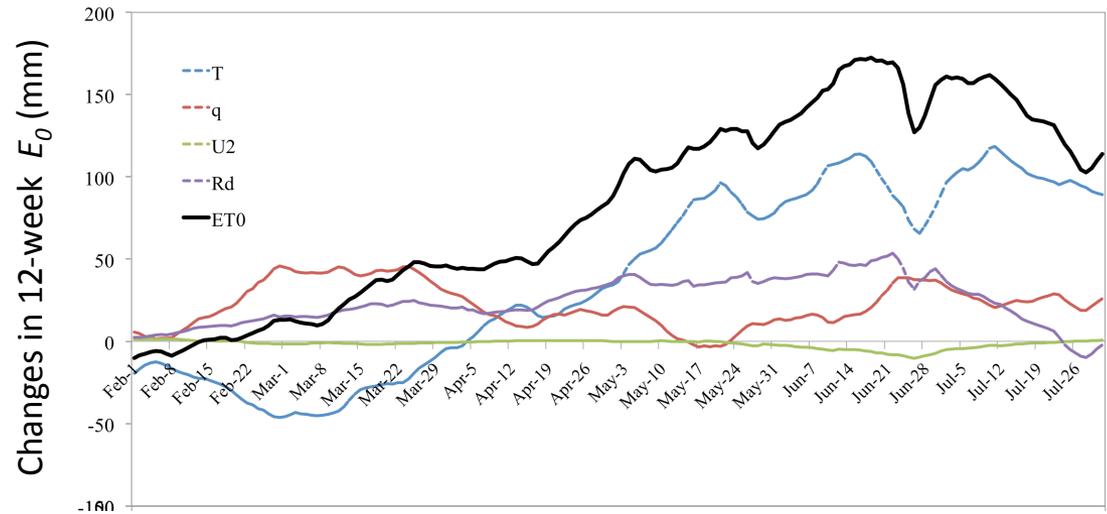
Drivers of drought

Drought intensification
(increasing E_0) forced by

- first, below-normal q
(while T falling)
- then, increasing T and,
to a lesser degree, R_d
- U_2 plays little role

T = air temperature
 R_d = downwelling SW
 q = specific humidity
 U_2 = wind speed

Sacramento River basin, CA



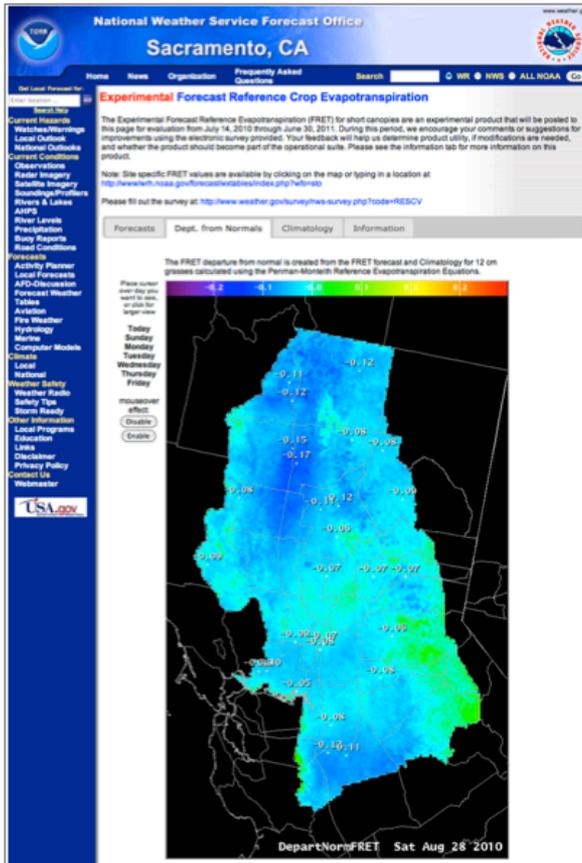
(Hobbins et al., JHM 2016)

OPERATIONAL ATTRIBUTION
COMING SOON!

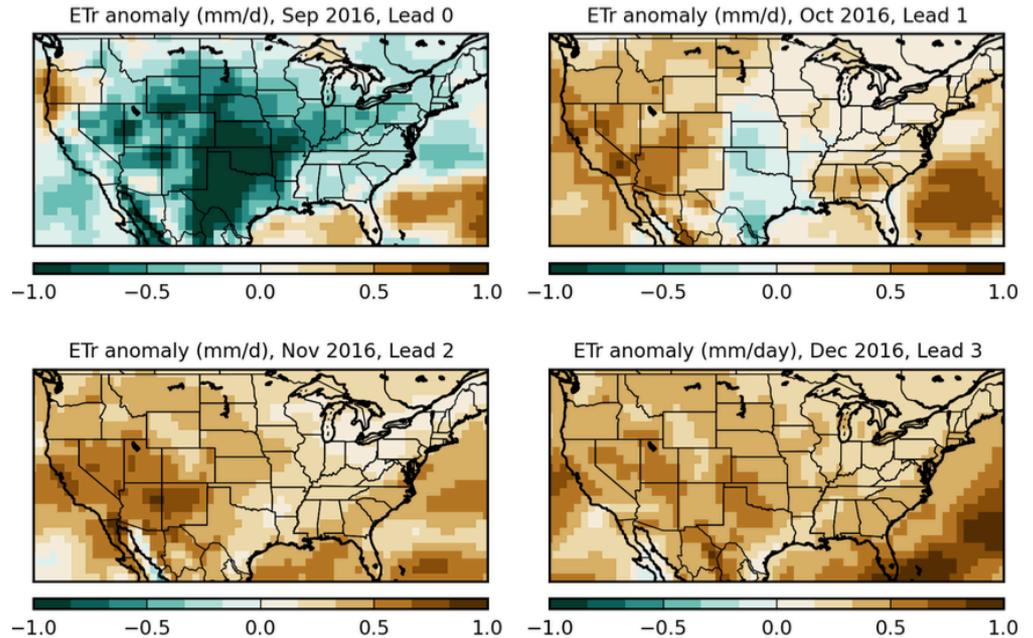
Forecasting of E_0 (and drought)

FRET = Forecast Reference Evapotranspiration
Prctp = precipitation

Daily, weekly - FRET



Seasonally (with greater skill than *Prctp*)

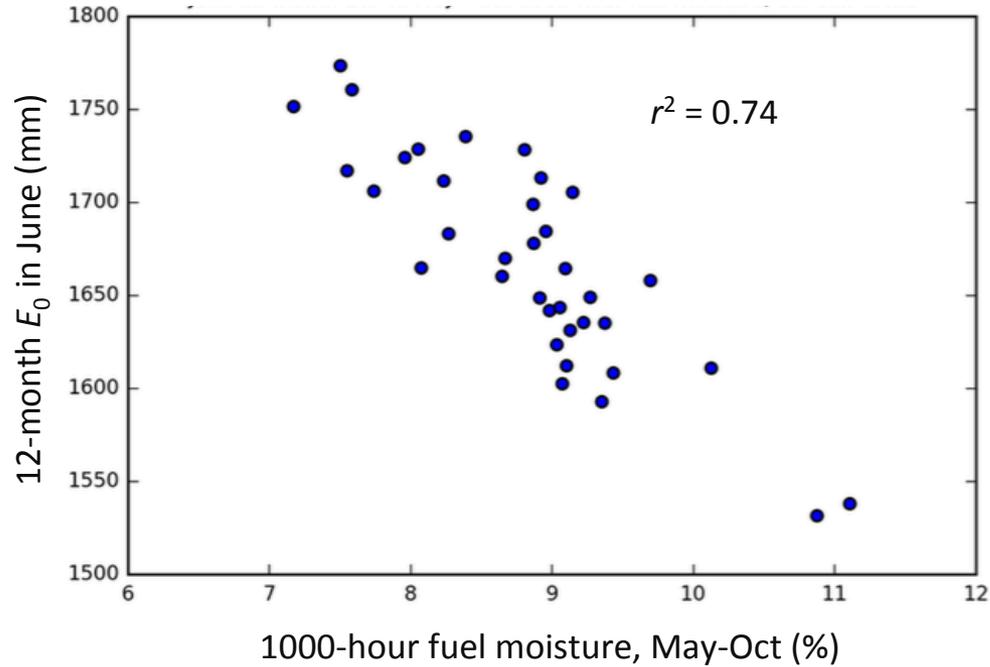


CFSv2 4-member ensemble mean initialized Sept 8 (00Z, 06Z, 12Z, and 18Z) – Dan McEvoy, DRI

Predicting wildfire risk

COMING SOON!

*E_0 -fuel load
relationship across
S. California GACC*



2-year NOAA-SARP grant: *Developing a wildfire component for the NIDIS CA DEWS – DRI*

Summary

E_0 and drought:

Physically rational relationship to drought

More readily available than ET (than $Prcp$, often)

- latency can be significant

Permits decomposition of evaporative drought drivers

E_0 is forecastable (*McEvoy et al.*, GRL 2016)

mike.hobbins@noaa.gov

303-497-3092

ftp://ftp.cdc.noaa.gov/Public/mhobbins/EDDI/PNW_DEWS/