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Flash Droughts over the United States

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Flash drought refers to relatively short periods of warm surface temperature and anomalously low and rapid decreasing soil moisture (SM). Based on the physical mechanisms associated with flash droughts, we classify these events into two categories: heat wave and precipitation (P) deficit flash droughts. We analyze flash droughts based on observations of P, temperature (T_{air}), SM and evapotranspiration (ET) reconstructed using four land surface models (VIC, Noah, Catchment and SAC) for the period 1916 to 2013. Both types of flash droughts are manifested by SM deficits which cause damage to crops. Therefore, both are agricultural droughts.

To determine the preferred regions for flash drought occurrence, we computed the frequency of occurrence (FOC) by using a threshold method. We processed each model separately. For a given pentad T and grid point x , we identified a flash drought event when a given definition of flash drought was met. That pentad was defined as the onset. For each grid point, we computed the total number of pentads N under flash drought of either type for the entire record for a given model. We defined the FOC as the percentage of pentads under heat wave or P deficit flash droughts.

$$\text{FOC (model)} = \frac{N}{N_{total}} \times 100\%$$

where N_{total} is the total pentads.

The requirements for heat wave flash droughts are T_{air} anomalies greater than one standard deviation (SD), ET > 0 and SM% less than 40%. Figure 1a shows the FOC for heat wave flash droughts. They occur most often in the North Central, the Ohio Valley and the Pacific Northwest. Heat wave flash droughts are resulted from the confluence of severe warm air temperature and low SM. The heat waves increase ET, and decrease SM. Therefore, they tend to occur in the vegetation dense areas.

The second type of flash droughts is caused by precipitation deficits. We associate with lack of P, which causes ET to decrease and temperature to increase. The requirements for P deficit flash droughts are T_{air} > 1SD, ET<0 and P <40%. Fig. 1b shows the FOC for P deficit flash droughts. P deficit flash droughts are more common than heat wave flash droughts. We find that P deficit flash droughts are about twice as likely to occur as heat wave flash droughts averaged over the conterminous U.S. (CONUS). They are most prevalent over the southern United States with maxima over the Southern Great Plains and the Southwest, in contrast to heat wave flash

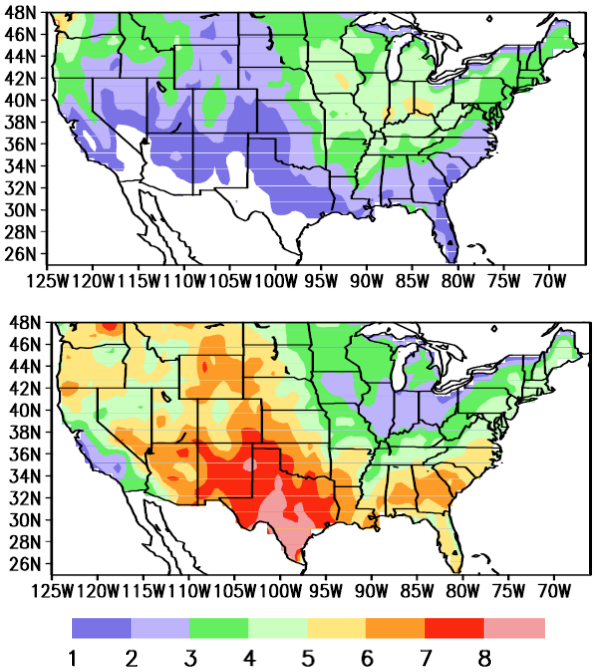

Fig. 1 FOC for (upper) the heat wave flash droughts and (lower) the P deficit flash droughts. The units are percentiles. Shadings are given by the color bar. (Mo and Lettenmaier 2015)

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droughts which are mostly likely to occur over the Midwest and the Pacific Northwest where the vegetation cover is denser.

The P deficit drought is initialized by P deficits. The lack of P decreases SM. In the areas where SM and ET anomalies have linear relationship, ET decreases. That leads to the increase of sensible heat and high temperature. In this sense, high temperatures are the consequence of P deficits.

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References

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