Evaluation of Flash Drought Criteria Components

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Introduction

Flash droughts are droughts that develop over rapid time scales (~ 1 month), and have known ecological, agricultural, and socioeconomic impacts. As such, there have been several studies to identify flash drought using variables such as evapotranspiration (ET) and potential ET (PET) to study flash drought. Recently, Christian et al. (2019) was able to design a method to identify flash drought using the standardized evaporative stress ratio (SESR). This method was used to split flash drought into flash (i.e., rapid intensification) and drought components to examine their climatology and how well SESR represents drought. This can help improve our understanding of flash drought drivers and identify areas that need improvement in flash drought predictability.

Data

North American Regional Reanalysis

- 32km × 32km spatial resolution
- Pentad temporal resolution
  - 5 day, non-overlapping means
- Data collected from 1979 - 2019

U.S. Drought Monitor

- Rasterized data from 2010 – 2019
- Weekly timescale
- Used to verify drought component

Methods

- Method uses the standardized evaporative stress ratio (SESR) and standardized changes in SESR (ΔSESR; see Christian et al. (2019))
- Correlation coefficient and composite mean difference were calculated between
  - SESR drought component and USDM identified drought
  - Rapid intensification and flash drought events
- Statistical significance to the 95% level was calculated via the Monte-Carlo method

Flash drought criteria:

1. There must be a minimum of 30 days between the start and end dates
2. The final SESR value must be below the 20th percentile
3. The following must be true:

a) ΔSESR for each pentad in the flash drought must be below the 40th percentile

b) No more than 1 exception is allowed for Criteria 3a

4. The mean ΔSESR between the start and end dates must be below the 25th percentile

- Drought component was defined as Criteria 2
  - Drought intensity was calculated using percentile scores found in the USDM
- Flash component or rapid intensification was defined as Criteria 4
  - Criteria 4 incorporates aspects of

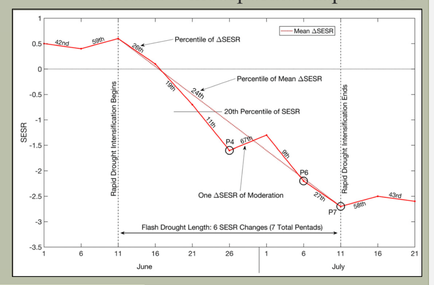

Figure 1 (right). A time series schematic illustrating the four criteria used in the flash drought identification method. [Figure and caption from Figure 2 in Christian et al. 2019.]

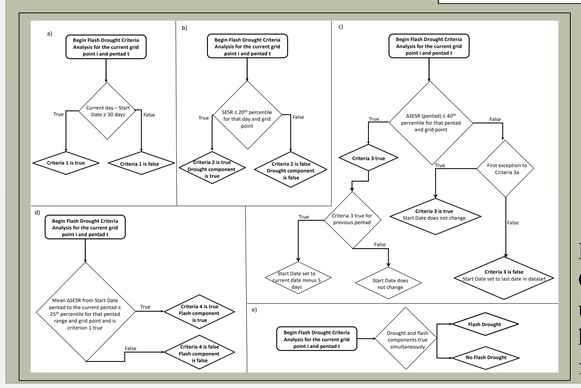

Figure 2 (left). Flow Chart showing algorithm used for this study and how it calculated the flash drought criteria.

Case Studies

2011

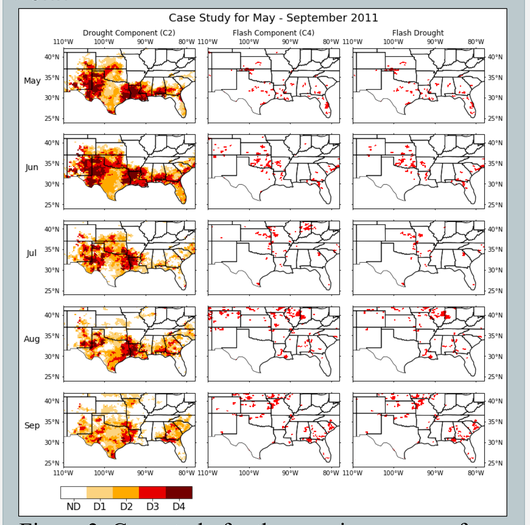

Figure 3. Case study for the growing season of 2011. (left) Monthly average drought component, (center) SESR flash component, and (right) flash drought. Red color indicates SESR flash component/drought was newly identified for at least 1 pentad in that month.

2012

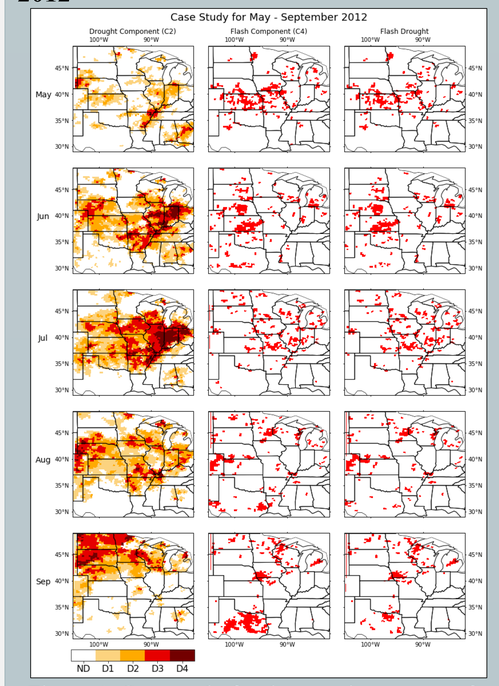

Figure 4. Case study for the growing season of 2012. (left) Monthly average drought component, (center) SESR flash component, and (right) flash drought. Red color indicates SESR flash component/drought was newly identified for at least 1 pentad in that month.

Climatology

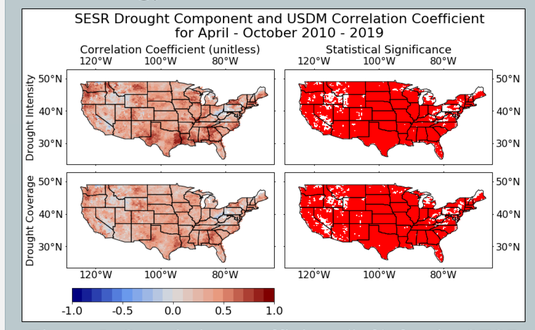

Figure 5. Correlation coefficient (left) for the SESR drought component and USDM and statistical significance (right) for the corresponding correlation coefficients for coverage and intensity (top) and just drought coverage (bottom) for growing season of 2010 – 2019.

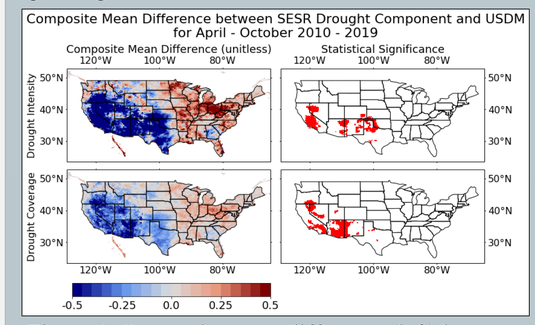

Figure 6. Composite mean difference (left) between the SESR drought component and USDM and statistical significance (right) for the corresponding composite difference for coverage and intensity (top) and just drought coverage (bottom) for growing season of 2010 – 2019.

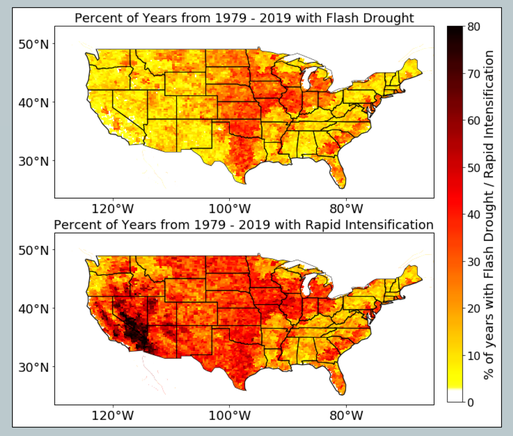

Figure 7. Climatological average (from 1979 – 2019) of flash drought (top) and the flash component (bottom).

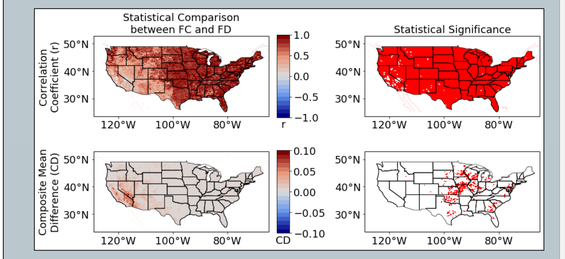

Figure 8. Correlation coefficient between the SESR flash component and flash drought (top) and the composite mean difference between the flash component and flash drought (bottom) for all years (1979 – 2019; left) and statistical significance for the corresponding statistical comparison (right).

Conclusion

- Overall SESR showed strong potential in being able to describe drought as a solo metric
  - However it showed some problems with extremes
  - Poor performance in the Intermountain West (different hydrology)
- SESR was able to effectively describe the rapid intensification of flash drought events
- Rapid Intensification climatology showed similar hotspots to flash drought, as well as highlighting most of the Great Plains and the Desert Southwest
- Suggested future work:
  - SESR should be paired with another metric (a precipitation metric would be most useful) for general drought identification
  - Further investigation into rapid intensification climatology of the Western U.S. is needed to determine physical characteristics
  - Further investigation into physical mechanisms that allow rapid intensification but not drought to occur is recommended

Acknowledgements

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References

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