Short-term Monitoring and Forecasting of Flash Drought Conditions

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Introduction

Flash droughts are droughts that develop over rapid time scales (∼ 1 month) and have high impact on vegetation and agriculture. As such, being able to properly identify and predict flash droughts is important, though there has been some debate on how to identify and classify flash droughts (Otkin et al. 2018). A method to identify and quantify flash drought has recently been developed by Christian et al. (2019). This method was developed for the NARR, so it can only identify flash droughts retrospectively, though it should work for any gridded system. Hence, this study takes the method developed in Christian et al. (2019) and attempts to apply it to the GFS to identify flash droughts in real time and obtain short-term forecasts. Early focus has been given to the flash drought in 2012 to develop and test the algorithm for the GFS as 2012 drought conditions are known (e.g., Christian et al. 2019 and Basara et al. 2019).

Data and Methods

Data was collected from:

- GFS $1^\circ \times 1^\circ$ data. Temporal resolution of 3 hours out to 192 hours (8 days).
  - A minimum of 30 day dataset of 3 hour forecasts was constructed and combined with a full model run
  - The 0 hour forecast is the beginning of the full model run
- NARR 32km × 32km data. Daily mean ESR values provided from Jan. 1 1979 to Dec. 31 2016.

Data extracted from the GFS included:

- Surface latent heat flux (LE)
- Potential evaporation rate (PET)

The following variables were calculated obatined from both datasets:

- Standardized evaporative stress ratio ($SESR = \frac{ESR - \overline{ESR}}{\sigma_{ESR}}$; $ESR = \frac{LE}{PET}$)
  - Daily averaged SESR was used for criteria 2
  - Pentad (5 day average) SESR was used to calculate ΔSESR for criteria 3 and 4 as they better represent the trend
- $\Delta SESR = SESR_t - SESR_{t-1}$
- ΔSESR was also standardized
- Means and standard deviations were obtained from the daily NARR dataset

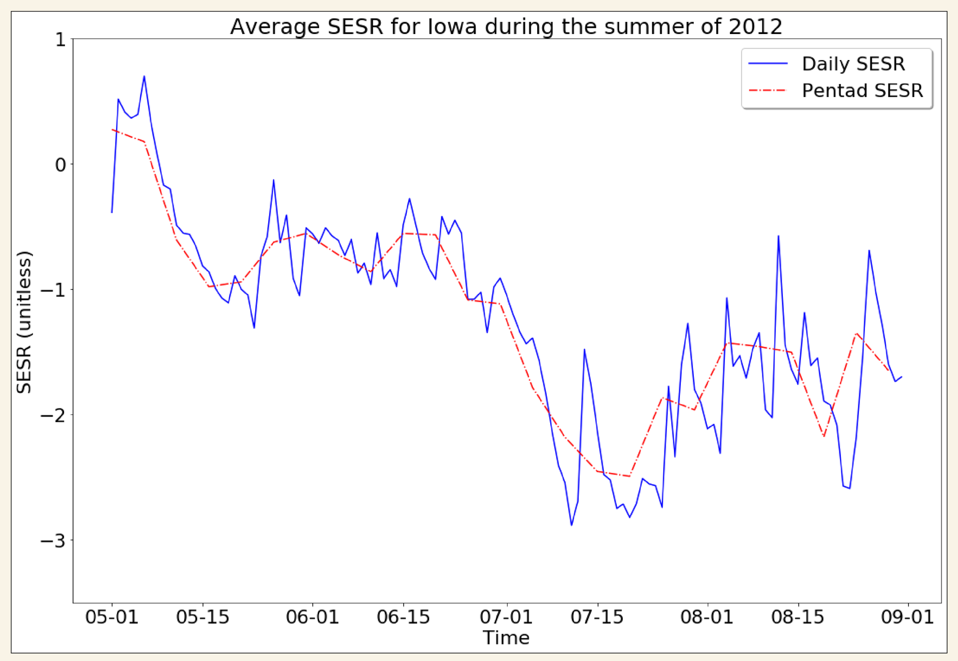

Figure: Daily and Pentad SESR for Iowa during the summer of 2012, calculated from the NARR.

Flash drought was identified using the same 4 criteria in Christian et al. (2019)

1. There must be a minimum of 30 days between 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 date 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 start and end dates must be below the 25th percentile

For purposes of identification and forecasts, every day in the GFS forecast were treated as end dates.

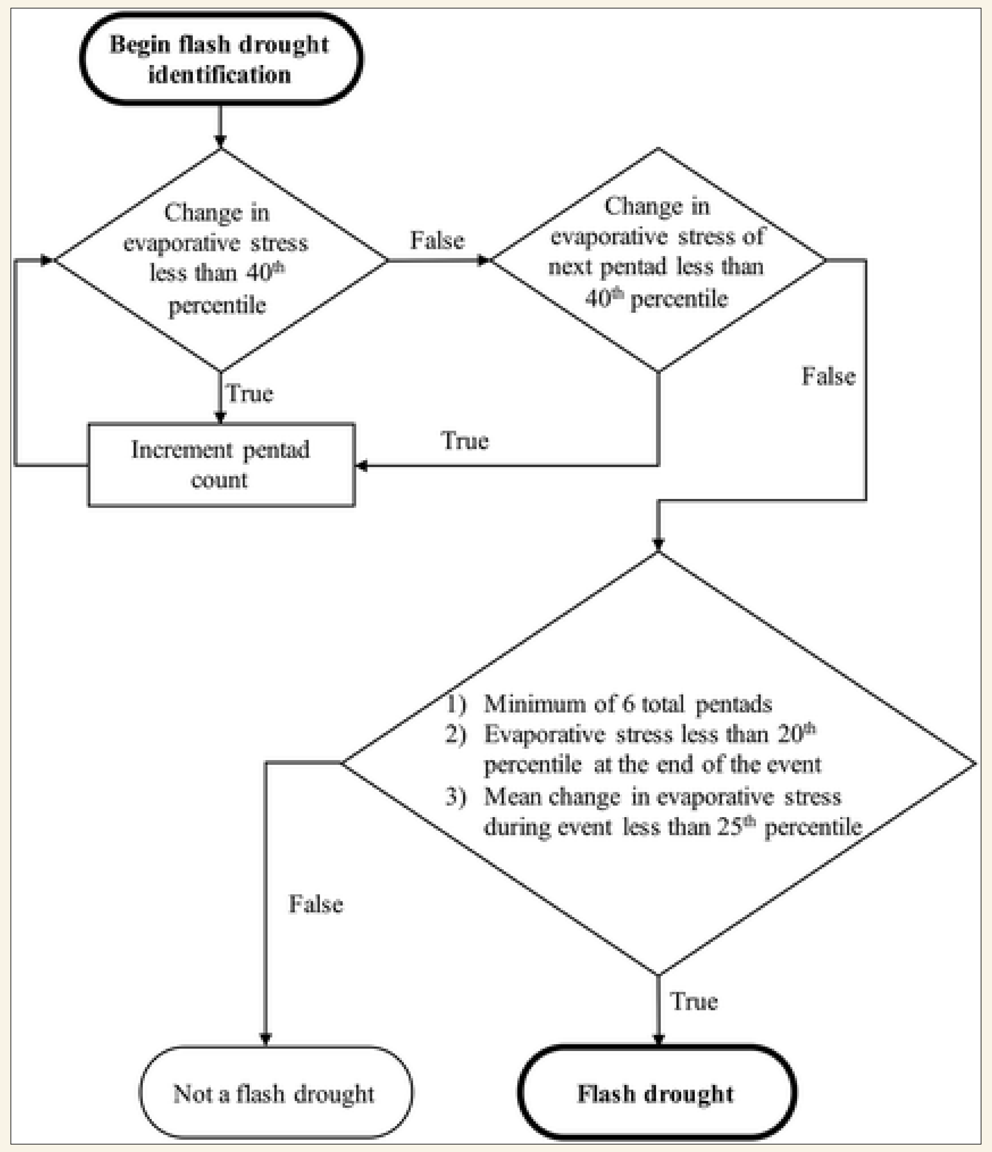

Figure: Algorithm used to identify flash drought using SESR and ΔSESR. Figure 3 in Christian et al. (2019).

Priliminary Results

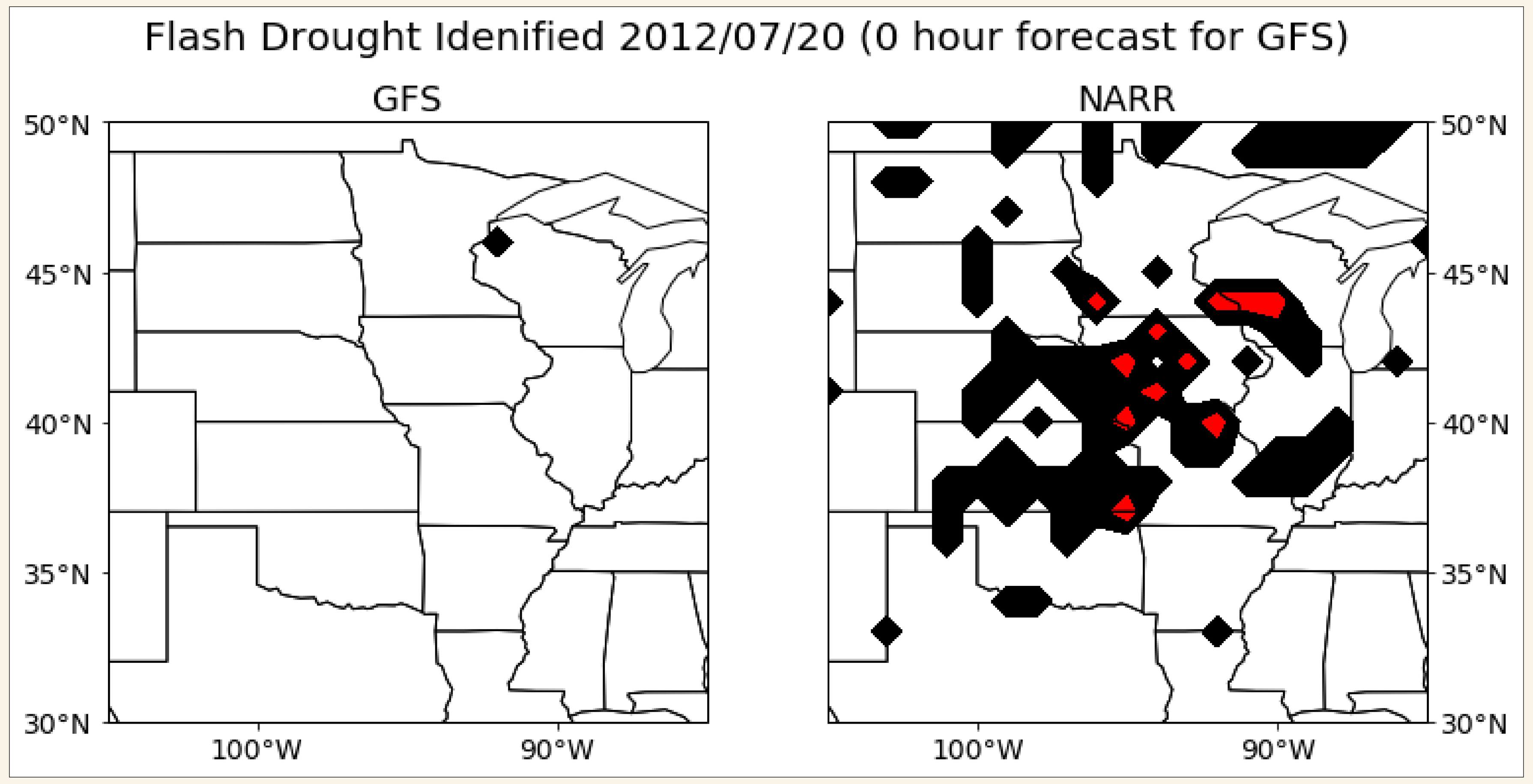

Figure: Flash drought identified by GFS (left) and NARR (right) for the Great Plains on July 20, 2012. Red indicates what the GFS would have identified with 1 month of data.

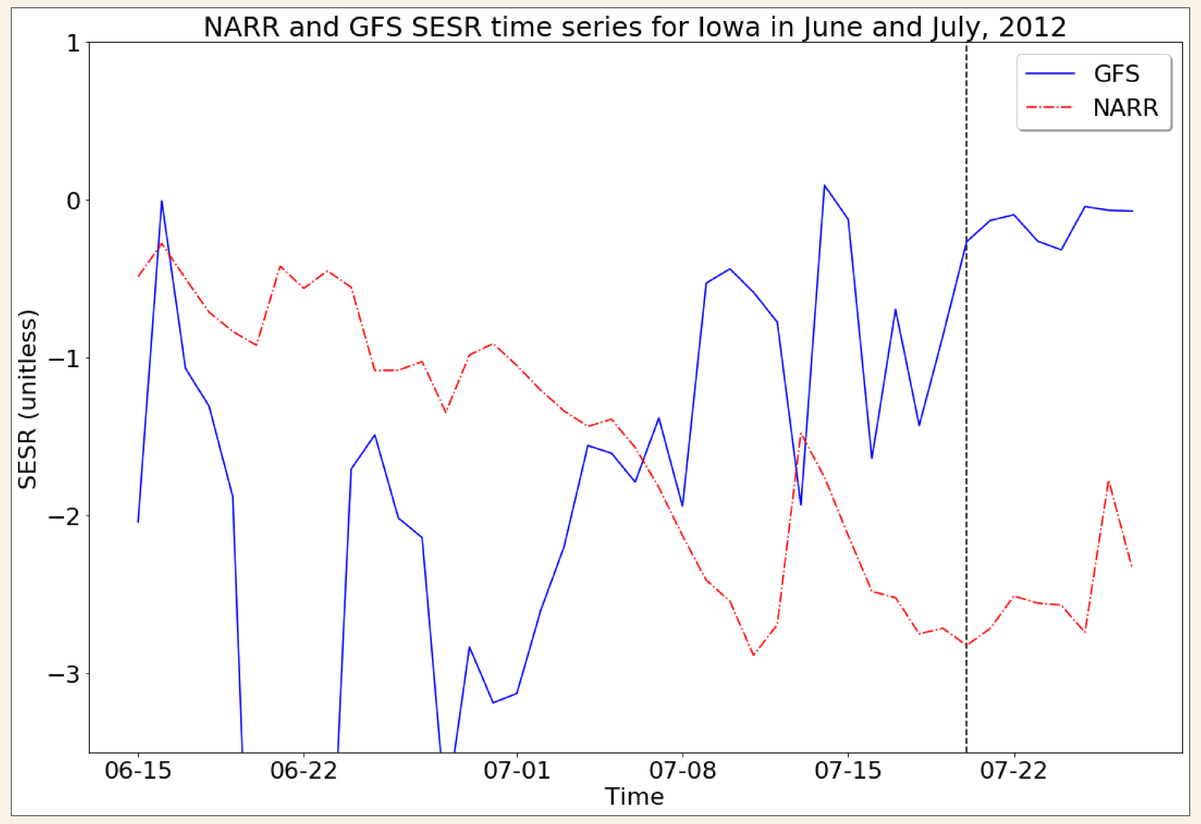

Figure: SESR time series in Iowa during the 2012 flash drought for the GFS (solid blue line) and NARR (dashed red line). The black dashed line indicates the 0 hour forecast.

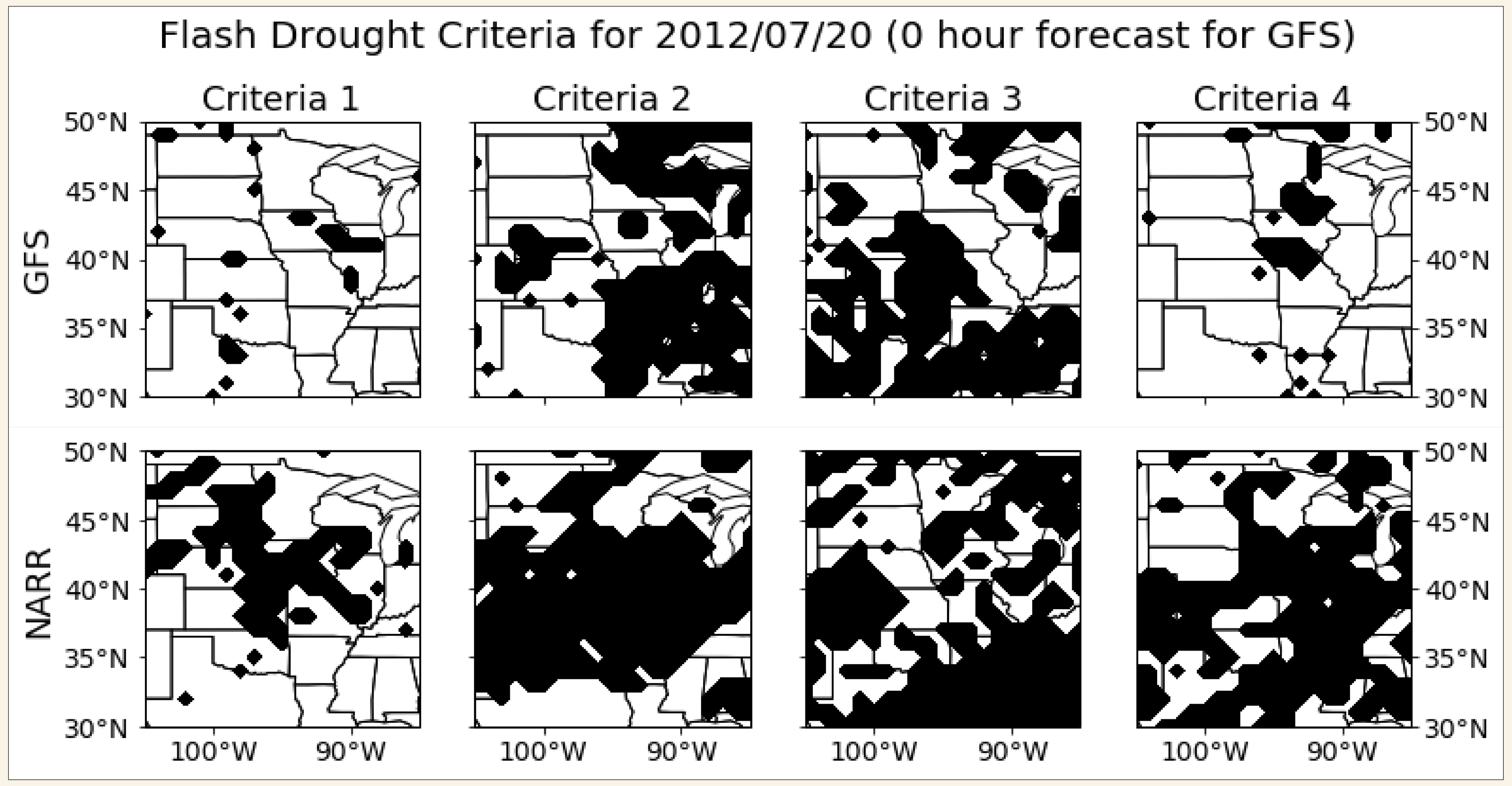

Figure: Each flash drought criteria for the GFS (top) and NARR (bottom) for the Great Plains in July 20, 2012.

- GFS seems to have trouble reproducing SESR and associated trends
  - It is currently unknown if this may be due to calculation errors or errors in the GFS
- This results in the GFS not having a rapid enough drying period
  - Criteria 3 fails quickly, resulting in a small area where criteria 1 is true
  - The overall trend is also heavily underestimated, resulting in a failed criteria 4
- As an interesting note, the GFS will not see the entire drought
  - The GFS only identify flash drought that began at the start of its 30 day dataset. If the drought began before that dataset, the GFS will not identify it.
  - E.g., the figures identifying flash also show flash drought identified at earlier times. For the NARR, this includes May and June (before the GFS dataset starts). What the GFS would have seen with its 1 month dataset is indicated in red.

Future Work

- There is notable difference in SESR between the GFS and NARR models.
- Currently, the forecast only goes until the GFS resolution changes. This is being worked on to obtain a flash drought forecast for the entire GFS run.
- The efficiency of the current algorithm needs to be improved.
- Flash drought that develops before or during the GFS dataset needs to be addressed.
- Once refined, the algorithm will be applied to other flash drought events to quantify the GFS's skill in identifying and forecasting flash drought.

Acknowledgements

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