In Prof. Eric F Wood's Memory:
What is the role of "Big Data" in water-related disaster mitigation?

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In his memory: Prof. Eric F. Wood

- Passed away on November 3, 2021
- +40 years at Princeton
- AGU/AMS Fellow
- NAE member in 2015
- Contributions: Stochastic Hydrology, Global Hydrology, Remote Sensing, Data Assimilation, Drought Monitoring

We all remember you with warm thoughts and memories, Eric!

Motivation: How to improve community resilience to water-related hazards

Natural System:
Improve prediction skill
(Drought Risk)

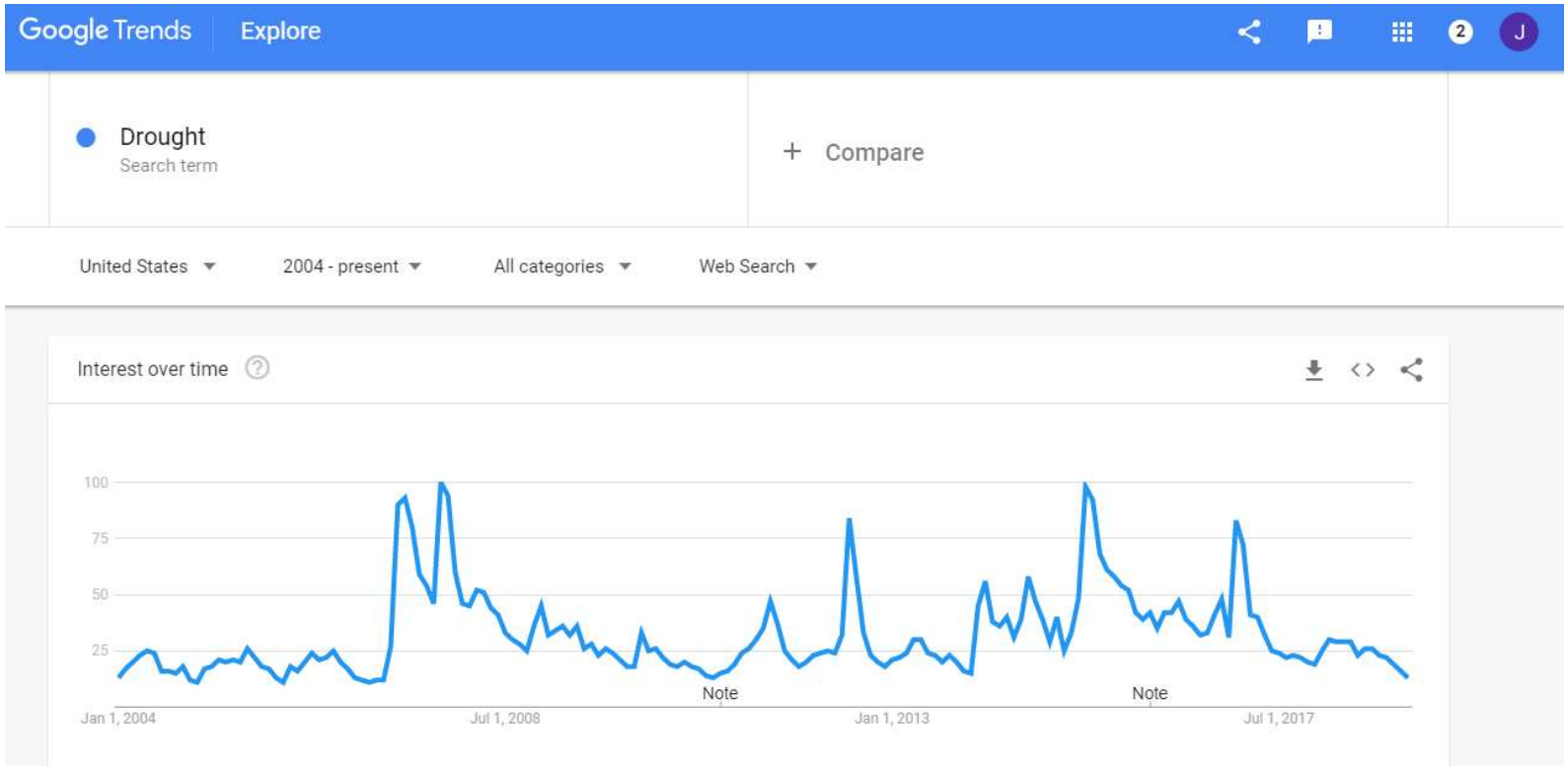
Human System:
Improve social response
(Drought Awareness)

Increase community resilience to water-related hazards

However, the limited data for social system due to costly and slow processes of data collection results in a lack of the studies on the social response to natural hazards.

Social Monitoring Data: Google Trends

Google Trends is a public web facility of Google Inc., based on Google Search, showing how popular a particular search-term is over the specific time relative to the maximum volume of search activities given the chosen time.



Social Media Data: Twitter

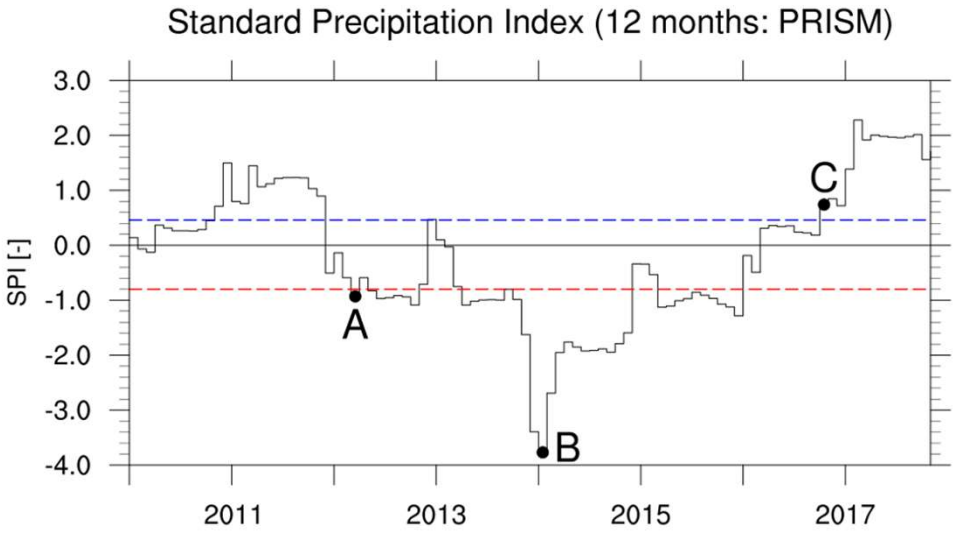
Available information from Twitter:

- Title
- Pictures
- Retweets
- Likes
- Comments
- Posting Date and Time

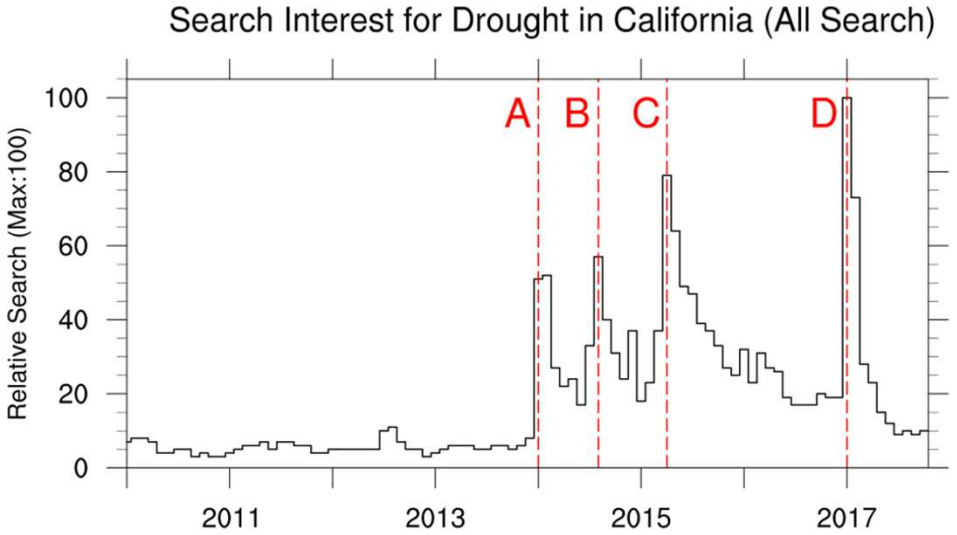
Social Responses to the 2011-17 California Drought

1. Search Activity Volumes from Google Trends:

Physical system



Cyber system



Kam et al. 2019

2. Network Analysis from Twitter

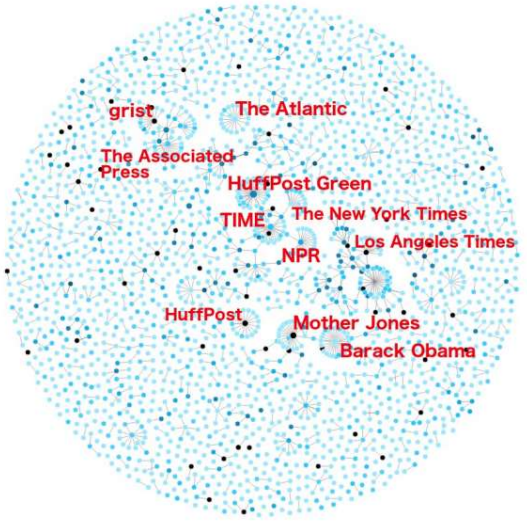


Figure 5. User ranking based on reply relationships

Musaev et al. 2018

3. Word cloud from Twitter

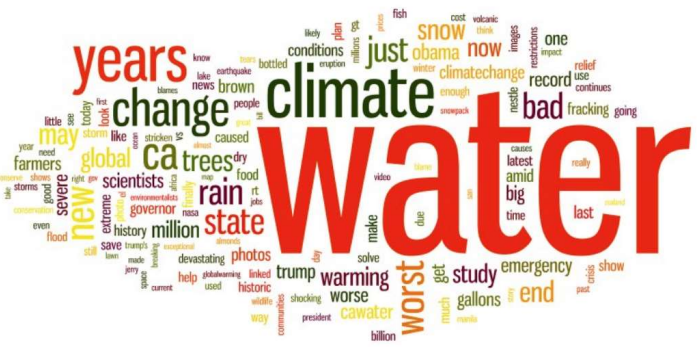


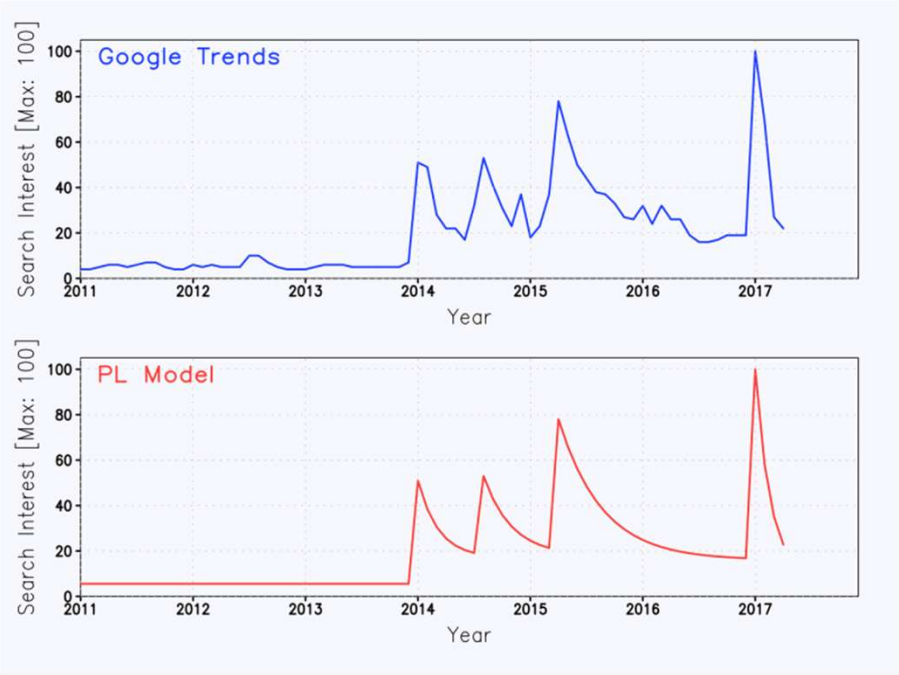
Figure 4. Word cloud generated using the top 2,000 most retweeted tweets on California drought

Musaev et al. 2018

How can we investigate drought awareness?

$$\mathrm{E}(Y_t \mid Y_{t-1}) = Y_{t-1} \frac{1}{\left((t-(t-1))+1\right)^{\alpha}} \quad (t \geq 1)$$

$$= Y_{t-1} \frac{1}{2^{\alpha}} \quad (t \geq 1)$$

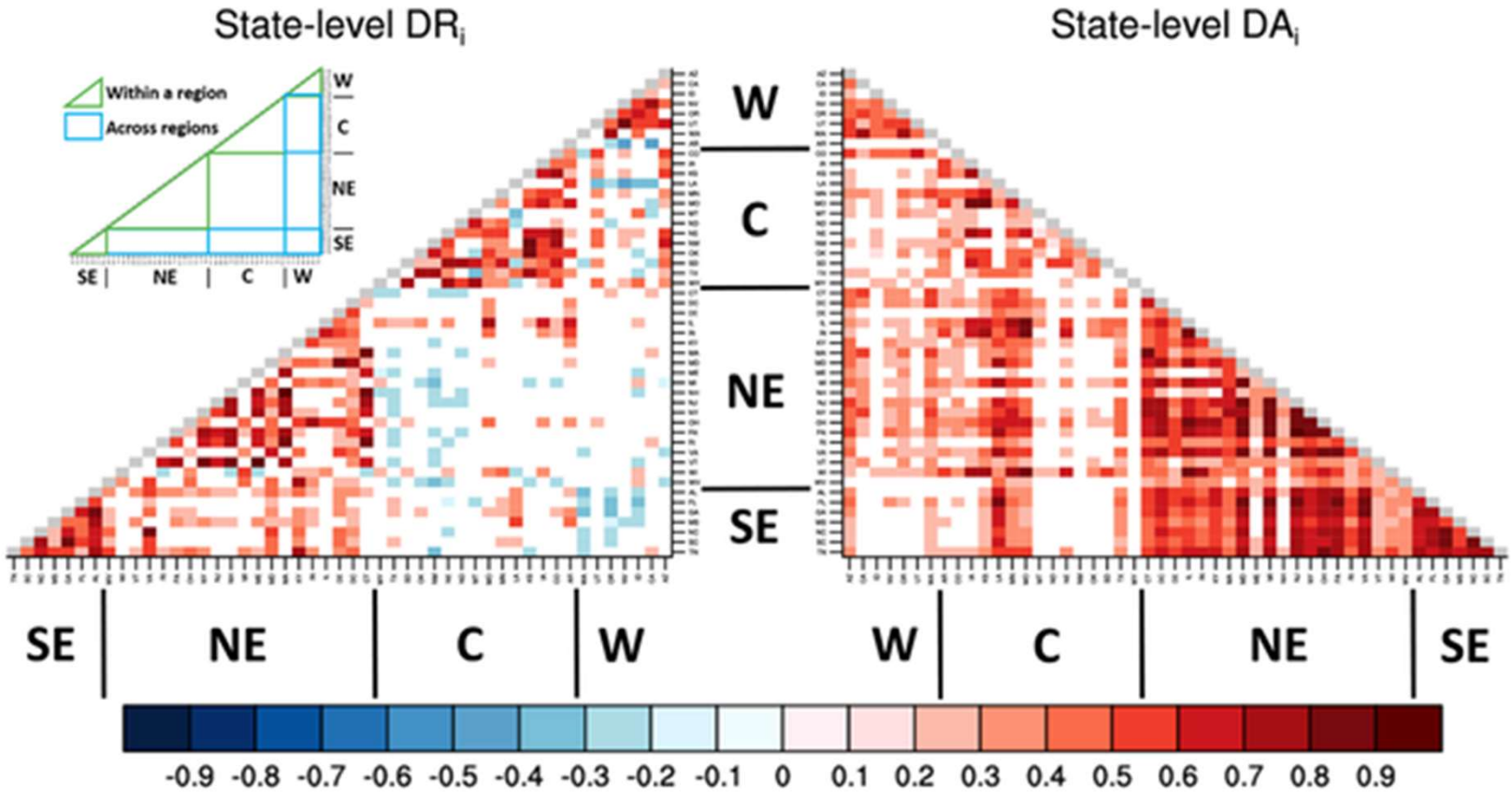


The alpha parameter (α) show how rapidly society forgets the event.

The bigger value of the alpha parameter means that society forget the event more quickly.

The alpha parameter is estimated by the least square method.

Social Responses to U.S. Droughts



Kim et al. 2019

Drought risk is limited by the affected geographical boundaries (triangles) however drought awareness is beyond the affected areas.

Drought Awareness occurred at the national scale via information search activities in cyberspace.

Lesson from "Big Data" to Socio-Hydrology: Modeling of Social Memory/Awareness

Flood Intensity:

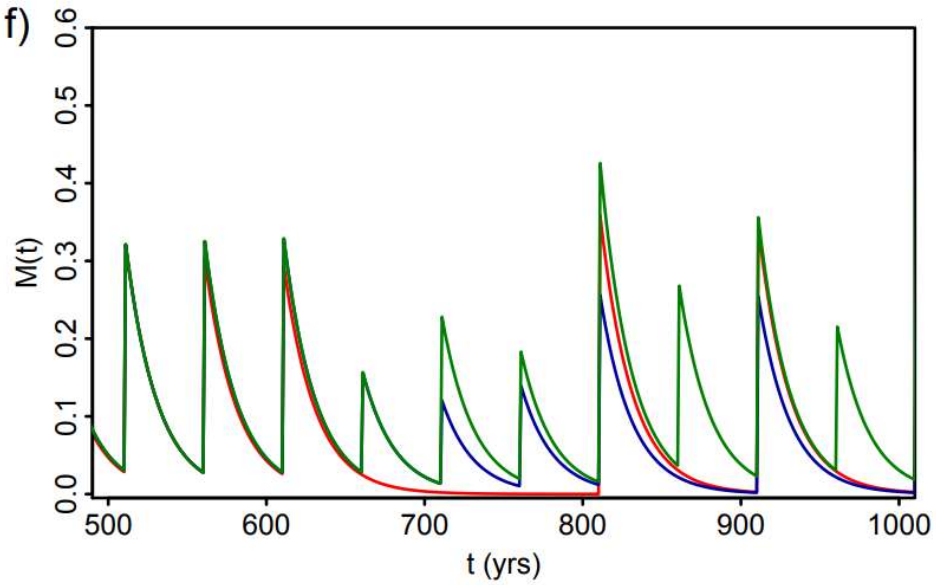
$$R = \begin{cases} \varepsilon_T (W + \xi_H H_- - H_-) & \text{if } (F > 0) \\ & \text{and } (F G_- > \gamma_E R \sqrt{G_-}) \\ & \text{and } (G_- - F G_- > \gamma_E R \sqrt{G_-}) \\ 0 & \text{otherwise,} \end{cases} \quad (2)$$

Shock Magnitude:

$$S = \begin{cases} \alpha_S F & \text{if } (R > 0) \\ F & \text{otherwise,} \end{cases}$$

Social Memory/Awareness:

$$\frac{dM}{dt} = \Delta(\Upsilon(t))\, S - \mu_S M$$



(Di Baldassarre et al., 2013)

The proposed social memory/awareness model depends only on flood intensity (R).

In reality, Social Dynamics is Far More Complex!

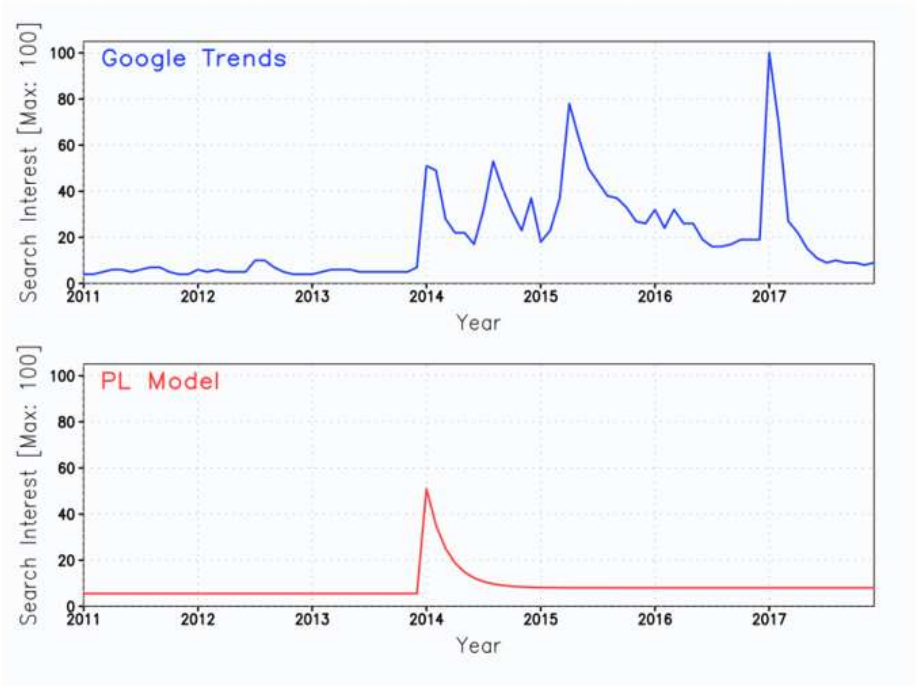
Hypothetical society:

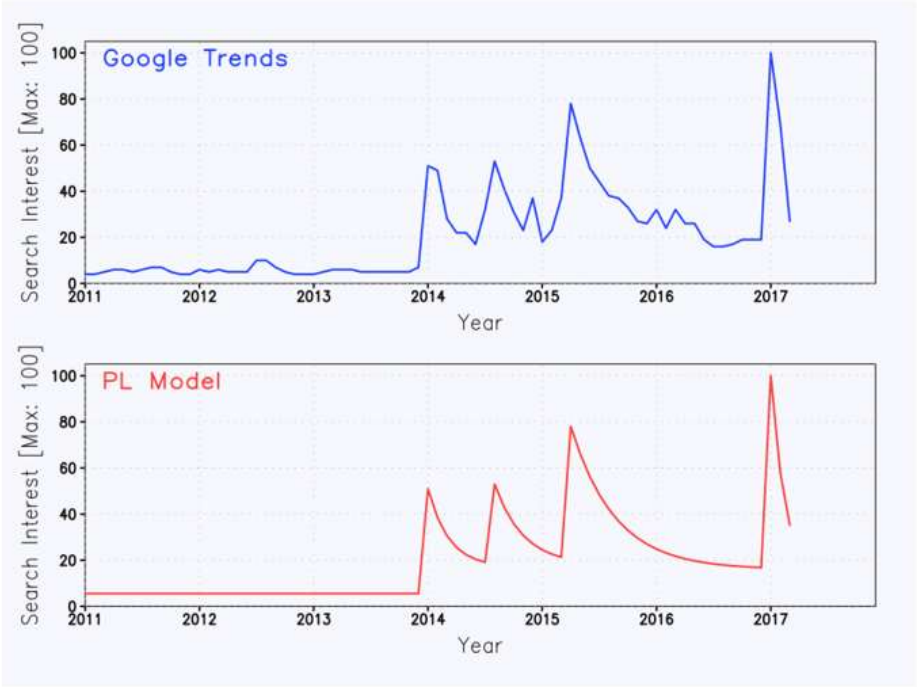
$$M_{ideal}(t) \cong f(R(t-1))$$

Real society:

$$M_{\text{data}}(t) \cong f(R(t-1), P, I, F)$$

where, R is Drought Risk, P is Political Action, I is Forecast Information, and F is Flood risk





How can we model our social systems?

- **Big Data and Artificial Intelligence are a Key!**
- **New Education Programs are needed for Next-Generation Hydrologists**
- **We need more active inter/multi/transdisciplinary collaborations across nations!**

References:

1. Musaev, A., J. Kam, K. Stowers, 2018, Harnessing Data to Create an Effective Drought Management System, Proceedings of the 15th International Conference on Information Systems for Crisis Response and Management, May 20-23, 2018, Rochester NY, USA.
2. Kam, J., K. Stowers, and S. Kim, 2019, Monitoring of Drought Awareness from Google Trends: A Case Study of the 2011–17 California Drought, Weather Clim Soc., 11, 419-429.
3. Kim, S., W. Shao, and J. Kam, 2019, Spatiotemporal Patterns of US Drought Awareness, Palgrave Comm., 5, 107.

Questions?

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