Flash Drought Webinar #3 Questions for Panelists:

1. Gwen: Are flash drought development tool products archived? I am interested in the early to mid-August 2021 output and what it showed with regard to flash drought development across TX/OK in September 2021.

   Gwen: Yes, I do maintain an archive of flash drought prediction figures. Occasionally, some dates were missing due to data issues or computer problems. The flash drought tool showed some signals over AR and eastern OK in early September. The Week-3 SMP forecasts suggested drought development over OK started on September 6.

   Brad: In addition to Gwen's tools, we have started an archive of the flash drought tool for the Climate Prediction Center's week-2 hazards. It depicted flash drought potential across the southern High Plains but seemed to miss areas to the east. This was an example when using Gwen's tool would be helpful.

2. Gwen: Have you used remotely sensed soil moisture directly, such as SMAP and SMOS data, in Drought Forecasting and Analysis?

   Gwen: No, not yet.

   Trent: The FLASH product uses SMAP L3 (surface) soil moisture (https://vadosezone.tamu.edu/flash/).

3. Gwen: Are these tools (Flash Drought Monitor, Week 1–4 3-Month SPI & Soil Moisture Percentile) computed for just the U.S.? Or are they computed globally? If not yet, can they be computed globally?

   Gwen: Yes, these tools were created for the CONUS domain. The Week 1–4 SPI, SMP, ET anomaly, and runoff anomaly forecasts can be computed globally because CFSv2 is a global model. The flash drought prediction can be computed globally using a global land surface reanalysis data or satellite data.

4. Is it important to also acknowledge when flash drought conditions may develop over existing drought areas, making the existing drought worse?

   Gwen: Yes, I agree. Currently, the drought outlooks provide 4 categories of drought tendency: drought persists, drought remains but improves, drought removal likely, and drought development likely, and the drought development category is for predicting drought onset. There is a possibility that flash drought conditions could develop over existing drought areas. In the Objective Drought Tendency Forecast product, I include an experimental category of drought intensification likely to provide this information. It is not an easy task, but we are aware of it and working on it.

5. Question for all presenters: Should different metrics be used for the flash drought in the Western U.S.? With so much irrigated agriculture and naturally arid/semi-arid landscapes what might be considered a flash drought in the Midwest will not have anywhere near the same impact in the West. Just curious if these ideas have been taken into consideration. Thanks!

   Brad: Although flash drought can occur in the West, it's my experience that drought conditions over the West are typically more long-term after a failed Monsoon (2020) or a lack of precipitation (rain and snow) during the wet season.

   Trent: I think the broader point is well-taken. A majority of flash drought research (globally and in the U.S.) has focused on only a small number of climate regions. I would expect the best indicators for flash drought monitoring or early warning would vary by climate, region, and sector. This is an important area of ongoing and future research—what works best in what region and how to best communicate flash drought based on stakeholder interests.

6. Trent: What do you think about the OpenET tool, and how do you foresee its development in the future?

   Trent: I only knew of OpenET before. After looking into it more, it seems like it could be a good tool to combine with a larger-scale flash drought early warning to support precision ag in irrigated areas. In general, flash drought drivers (lack of precipitation, high VPD or PET, etc.) are regional-scale, but impacts of local scale. So, in theory I like the idea of local-scale water use monitoring.

7. Trent: Do you use SCAN data and/or state mesonet data for soil moisture?

   Trent: I'm assuming this question is in reference to the soil moisture-based flash drought early warning product(s)? If so, we developed the products using model/remote sensing based soil moisture mostly because it is easier to work with across a large area. However, our plan is to bring in *in situ* soil moisture observations from national networks (like SCAN) and mesonet soil moisture.

   When it comes to drought/flash drought monitoring I do specifically in Illinois, our *in situ* network is an important part of weekly updates and monitoring.

8. Trent: How do we address the challenge of model latency in producing products for a time-sensitive flash drought (e.g., EDDI is about 5 days old when produced)?

   Trent: Because there are so many ways to monitor and forewarn drought—each with their strengths and weaknesses—there are many datasets or products on which to base a drought indicator. For traditional (slower-evolving) drought, data latency is less of a concern. A once-a-week updated product can be used to track traditional agricultural drought that intensifies over a period of 6+ weeks. However, data

latency is more of a concern for flash drought monitoring/early warning. So, to me that means that teams that develop flash drought tools must prioritize data latency.

This also comes back to comments and questions about differences in flash drought monitoring between, e.g., the Midwest and West U.S. Products with > 3-day latency are challenging to use in the Midwest and Southeast U.S., where conditions can deteriorate very quickly. But, maybe a 3–5 day latency is sufficient in the West, or in other semi-arid/arid climates?

9. Trent, how is the progression Eastward tracked and timed?

   Trent: I don't think any of the products explicitly track or time the geographic progression of flash drought. Most of the flash drought products highlighted focus on emerging or potential areas of flash drought, with less emphasis on where there is currently drought.

   This is why tools built specifically for flash drought will not do well as standalone drought monitors, but should be used in tandem with products like the U.S. Drought Monitor to understand current drought status and emerging drought conditions.

10. This has been very interesting with a lot of great information. It's obvious you have learned a lot about flash droughts in recent years. What don't you know about this topic that needs more research in the future?

    Brad: As a forecaster, I would like to see more research devoted to what background climate states such as ENSO are associated with a higher risk of flash drought during the warm season. Are greater chances of above-normal temperatures on the seasonal time scale typically consistent with more flash drought events? That could help communication efforts heading into the growing season and aid preparation. Also, it seems that flash droughts are becoming more frequent during the spring and fall. Is that true?

    Trent: Three things stand out to me:

    (1) As Brad mentioned, linking flash drought risk/occurrence with background climate states and large-scale patterns. This would get us closer to medium-range prediction of flash drought likelihood.

    (2) Flash drought impact research has lagged behind flash drought science. Who (or what sectors) are being impacted by flash drought, in what regions, how quickly, and when? Here in the Midwest we may see crop conditions deteriorate rapidly with (for example) late-season flash drought, but even if we forewarn this 1–2 weeks ahead of time, it's arguable whether producers could actually do anything about it… at least in rainfed areas. But, if flash drought results in streamflow declines that threaten municipal or power

plant water supplies—which can happen in many places—there may be actionable information that can be provided 1–2 weeks ahead of time… or maybe 3–4 weeks ahead of time. This goes back to the point I made in the webinar that continued flash drought tool/product development has to include significant stakeholder input. Otherwise we may be (a) providing a solution to a problem that doesn't exist or (b) missing the problem entirely.

(3) What do flash droughts look like in a changing climate? In particular, how do regionally-variable changes in precipitation (total, seasonality, intensity) & evaporative demand combine to affect flash droughts? I suspect the "answers" to this question are going to be highly regionally variable. For example, model projections indicate total precipitation in the Midwest will continue to increase, but summer precipitation will become more intense and variable. Combined with higher evaporative demand and VPD, does this mean more flash droughts, more intense flash droughts, fewer flash droughts, no real change? A sort of offshoot to this question is if we can induce drought-like stress in an agricultural or naturalized system if soil moisture is adequate but atmospheric demand (like, VPD) is very, very high?

11. Regardless of any given geographical variability what level of *in situ* monitoring coverage in general is necessary to be representatively useful?

    Trent: The problem is that the answer to this question is going to be highly dependent on geography. Topography, soil texture variability, climatic variability, land use/land cover, urban development, and about a hundred other geographically-varying factors affect how representative an *in situ* soil moisture or temperature observation is. There are ways to try to boost representativeness, like calculating anomalies instead of absolute values, or using auxiliary information like precipitation or soil texture in between your point observations. But, for *in situ* monitoring, the more the better. To put a number on it (which is really generalizing), at least one observation per 1,000 square miles is a good start in a topographically homogenous area like Illinois.

12. How well is geospatial technology being utilized to overlay, analyze, and evaluate the myriad of datasets? How good is the access to the myriad of datasets for Drought Monitor authors?

    <No replies>

13. What data sources are going into the Rapid Change Index? Is that information contained on the website?

    Gwen: The Rapid Change Index is calculated using NLDAS-2 data. Please see Section 2 in this paper (https://www.mdpi.com/2073-4433/11/10/1114/htm) for a description. The NLDAS-2 data are available at https://ldas.gsfc.nasa.gov/nldas.

14. Do the current flash drought products consider the stationarity vs. non-stationarity assumptions? And if so, how is the non-stationarity is considered, or any comments or suggestions on how these kind of assumptions may affect the effectiveness of the indicators?

    Gwen: No, the current flash drought products do not consider non-stationarity. The flash drought tool uses the 1981–2010 base period to calculate RCI. 30-year climatology is recommended by WMO for operational forecasts to avoid non-stationarity.

15. Research needs—with respect to ecological flash drought, what indicators need more research? An index that relates precipitation, flow, temperatures (stream and air), other?

    Trent: Yes, all the above are good landscape-scale information to include. For ecological drought, it is also important to link drought indicators like precipitation deficits, ET or PET, soil moisture, and temperature to species-specific conditions and triggers. A mixed maple-beech stand is going to respond to the same flash drought conditions differently than oak savannah or wetlands. And on the fauna side, aquatic species will respond differently than terrestrial species. This sort of translational work from flash drought product to ecosystem response is a critical research need.

16. Where are we in terms of modeling efforts to capture the onset and progression of flash droughts? Are the current LSMs skillful enough to capture those processes?

    <No replies>