Drought Prediction and Water Availability National Listening Session Series: Introductory Webinar – February 9, 2022

Questions and Answers

	Question	Answer
1	Are you working with the National Weather Service (NWS) River Forecast Centers (RFCs) and the National Water Center (NWC) and their modeling efforts?	Answered during the webinar. We are still working to finalize methodologies for the first test basin and looking at ways to extend this approach to another test basin. Those connections to the RFCs and NWC are within the plan, though we're very early in the process.
2	Have you experienced disparate end point user needs that would require a shift in the model structure/products to satisfy those needs? If so, what have been examples of those disparate needs? How do you anticipate reconciling which needs get satisfied first?	Part of the goal of the upcoming listening sessions is to better understand this exact question. Through stakeholder input, we hope to inform the development of tools and resulting information to the extent possible.
3	Given that you are using undisturbed streamflow points for this work, roughly what stream order or HUCS are the streams you have analyzed?	Answered during the webinar. There is a large range in size of watersheds used as inputs to the models, and different types of model approaches will work better in different sizes of watersheds. The first approach is developing models for ungaged areas, starting with headwater areas. For larger downstream areas we would look at adding another tier to assimilate additional information to hopefully lead to more accurate predictions.

4	Does the national drought prediction project have a website?	Not yet, but watch for updates in the coming months under the Water Availability and Use Program site: https://www.usgs.gov/programs/water-availability-and-use-science-program
5	How can these tools be expanded to incorporate additional gage data, for example from state agency partners?	Currently we are focused on U.S. Geological Survey (USGS) streamgages, but as the project continues we will look at the opportunity to add additional datasets and resources. Thanks for this input. If there are specific suggestions we would encourage you to bring them up during the listening sessions, or via email.
6	How does this work handle intermittent vs. perennial streams?	We use an approach that computes streamflow percentiles in intermittent streams by accounting for the consecutive number of zero flow days prior to any given day as a way to remove ties when calculating streamflow percentiles.
7	How do you separate "drought" from what is becoming the norm? The problem is that droughts end; this new norm won't. How do we encourage the public to understand the difference and modify our practices to live with this new norm?	Answered during the webinar. This is an excellent question. Initial characterization efforts are at the national level, which show that drought has increased in the southeast and southwest United States in the past decades. Characterization of drought for this project considers recent drought as well as paleodrought, recognizing the critical importance to contextualize drought and changes to drought. We look forward to input from the listening sessions about potential ways to communicate drought change.

8	What are the limitations of the current state of the art models (especially those developed by USGS) in predicting streamflow droughts for an extended period into the future, let's say 1–2 years?	Answered during the webinar. Some of the biggest uncertainties are in how humans store and use water, and increasing uncertainty as the forecast horizon increases. This is how we see the national project, which focuses on characterization and prediction of drought duration, severity, occurrence, and frequency linking to the regional drought prediction project. It is our hope that these stakeholder sessions can provide insight into the planning periods which are most relevant for us, so that we can reduce uncertainties for these horizons.
9	How do you anticipate drought predictions to be used by water managers? Proactive water conservation, reduction in reservoir releases, change in planting guidelines to less water needy crops?	Part of the goal of the upcoming listening sessions is to better understand this exact question. Through stakeholder input, we hope to inform the development of tools and resulting information to the extent possible.
10	What is the status of the White House Drought Relief Working Group established back in April 2021? Who are the contacts? How many meetings have been held? What is the process for public input?	It is our understanding that some communication is happening to collaborate between the White House Drought Group (IWG) and National Drought Resilience Partnership (NDRP), which is focused on mid- to long-term strategies for resilience. The Drought IWG's focus is on addressing and responding to current worsening drought, co-chaired by the U.S. Department of Agriculture and the U.S. Department of the Interior.
11	Here in north-central Montana, we are going into the new year with very little/no precipitation and still in D3–D4 drought status. This coming summer does not look good, and our tribal community will continue developing resiliency methods to capture water resources and vegetation problems that arise.	Thanks for the information on the status of the drought conditions in north-central Montana. If there are specific scientific resources or information the USGS can provide to support your planning, please reach out to the session organizers and we will put you in touch with our local USGS office.

12	Drought is a multi-year event. It would be helpful to be able to place present conditions in context for members of the general public. E.g., Last year was dry. So far this year we are dry.	Agree. Place-based science communication is a key part of the science the USGS produces. Thank you for sharing this consideration. We will record this comment as part of the listening session feedback.
13	Has there been communication with the Colorado River Salinity project? It might help to improve the output for potential model users. The salinity program is also working on models.	Yes, the USGS is a partner in the Colorado River Basin Salinity Control Program.
14	Are there any state funds out there that industries can utilize to implement water reduction projects?	This is a great question, but unfortunately not something the USGS can comment on. The USGS is mainly focused on providing science, developing new methods, and creating tools to enable timely, relevant, and useful information about the Earth and its processes for decision makers and resource managers to use for implementing drought planning, management, and mitigation projects.
15	I didn't see any mention of conditions such as beaver activity on drought—with increasing interest in reintroduction of beavers, how do your models take this into account? And beavers are only one example; land management practices, such as those pertaining to forestry or ag, can also affect flows and quality. How are these accounted for?	Thank you for this important point. There is a unique and developing literature on the effects of beaver dams—they are certainly important to the hydrologic budget in areas. Our current models do not include site scale features like beaver dams, but we do include time-varying land cover, dam storage, irrigated area, etc. as way to account for changes in human landscape and flow modifications within the models. We would welcome additional stakeholder input on these topics through future listening sessions.
16	Can someone speak to whether changes in atmospheric and ocean currents projected under global change are being taken into account?	Our models are currently using daily meteorological forcings in addition to climatic teleconnections that relate to atmospheric and oceanic circulation, but the models do not include multidecadal accounting for shifts in these circulations.

17	Main needs are for tools that are more predictive, accounting for changes in management practices and climate change. Tools built on historical gauge flow data are not useful.	Thank you for sharing this consideration. We will record this comment as part of the listening session feedback.
18	I know all of the reference sites are relatively undisturbed. Do you expect forest regeneration in some of these young forests will impact your drought severity metrics? If so is there any way to account for this?	Answered during the webinar. Various types of input including temporally variable and static are considered—starting with static estimates of land cover. Once the initial models are generated it may be possible to include estimates of time-varying forest cover from satellite information to include as predictor—if it is identified as an important variable in the model. The project is not quite at a point to answer this fully. Another way we are considering forest generation is in our modeling of the linkage between drought and wildfire in the national project
19	Are you factoring in ENSO or PDO into longer term hydrologic drought predictions?	We are using these time series as input variables for our models.
20	Is there data from state, private, and other federal agencies that you can use to help develop predictive models, even if it may not be of as long of duration as USGS data?	Answered during the webinar. Currently we are focused on USGS streamgages, but as the project continues we will look at the opportunity to add additional datasets and resources. Thanks for this input, and please share any additional network suggestions during the upcoming listening sessions.
21	Will this project (or subsequent work) look at trends/variability in stream temperature?	Answered during the webinar. The primary focus of the drought projects is to examine linkages between drought and water quantity metrics; however, as we get further along we would like to make more connections between drought and other factors, such as water quality (including stream temperature).

22	Will specific drought/water availability questions or topics, for which your team is most interested in soliciting stakeholder feedback on, be provided in advance of each of the listening sessions?	Answered during the webinar. This is an excellent question and suggestion for how to structure our future listening sessions. We agree that asking for stakeholder feedback on the questions and topics we are currently pursuing will help in shaping focus and prioritizing research and outcomes. For example, we are working on and interested in feedback on at what point drought starts to impact the users, i.e., thresholds that define drought and discussions about challenges across different landscapes and local areas. This feedback can help us define the best metrics to track and report in our drought tools.
23	Is there any accounting for changes in runoff efficiency?	Answered during the webinar. From year to year the effects of drought compound and can deplete water stored in groundwater and the soil. The national project is working to understand the processes that control the propagation of drought and how that affects runoff. Runoff efficiency is not explicitly considered as a metric in the current project scope.
24	Has modeling been performed forecasting the impact of 100% adoption of cover crop practice on restocking groundwater and managing impact of low rain anomaly?	This has not currently been a focus of our work, but we welcome input if this is a critical need for our stakeholders.
25	In the maps of streamflow drought over time, how do you determine natural vs. human influenced?	Initial analyses have focused on tracking drought duration and severity through time, and ongoing analyses are looking at drought frequency. Thus far, we have been looking at the trends in these drought metrics related to climate, and continuing work focuses on attribution of trends to other potential causes, such as land cover change, reservoirs, and water use.

26	Can you predict drought a year in advance, beyond a week/month? In the Pacific Northwest, we experienced exceptional drought in 2021 that will require exceptionally high precipitation to turn it around to near normal. Given global forecasts and chances of La Niña, there could be an evaluation of chance of certain conditions.	Thank you for sharing this observation, as it highlights that short-term predictive models may not fully meet stakeholder needs. Our planned model forecasts are focused on weeks to months out, though we may further test the limit of the predictive capacity by looking out 12 to 18 months.
27	How do you relate groundwater declines with a reduction in streamflow/baseflow?	We are working to assess the propagation of reductions in streamflow to groundwater as they pertain to drought.
28	Do you predict long-term impacts of prolonged drought on groundwater levels?	Prediction of groundwater metrics associated with drought is a focus of the national project. Groundwater levels are one metric we are assessing. We are also examining the propagation of meteorological drought conditions from soil moisture to streamflow and groundwater drought conditions.
29	How do we get water from where there is more to where more is needed (e.g., from E to W?)	The intent of this program is to provide tools and information to help plan for variation in water availability by delivering actionable intelligence at scales and timeframes relevant to decision makers.
30	Are you using neural networks to forward predict or predict in areas you have no data?	Initial models are retrospective and at gaged sites, but regional models are being built to predict for ungaged areas and for future time periods. We are considering a full range of possible approaches, including neural networks to accomplish this task.
31	What about the Caribbean? Are you addressing the Caribbean as well when it comes to drought prediction?	Answered during the webinar. The scope of the current drought projects is limited to CONUS, though other USGS programs such as the Integrated Water Availability

		Assessments are looking at applying what we learn in water prediction to the United States outside of CONUS.
32	Can you explain a bit more on how are you approaching incorporating baseflow as soil moisture is depleted over periods of time (longer durations) in the prediction of drought? Also, thinking this might be variable from headwaters and larger watersheds as we move downstream.	Answered during the webinar. From year-to-year, the effects of drought compound and can deplete water stored in groundwater and the soil. The national project is working to understand the processes that control the propagation of drought and how that affects runoff. We appreciate this comment, and we need to reflect more on this point. The project does have the involvement of remote sensing research staff and soil moisture researchers to help understand these aspects.
33	Has there been testing on sensitivity to inputs relating to streamflow (i.e., soil moisture, snowpack, etc.), and where do you think better observational data should be focused to improve predictability beyond streamflow data?	Answered during the webinar. We are testing this sensitivity now. The regional project has completed a set of initial models, and we are analyzing how much predictive capacity are available from various variables in order to determine if any variables can be removed from the models. Reducing the number of variables used for prediction is especially important for scaling up nationally because not all variables available at the region will be available nationally. Regarding the Colorado River Basin, information on snowpack distribution and soil water content would be helpful datasets; if there are other products out there not currently in use, we would certainly be interested in hearing about them.

34	There is an interagency Tribal Water Subcabinet Team, and it will be focusing on the Middle Rio Grande Basin and the Upper Missouri River Basin. When will the study on the Colorado River Basin grow to include other basins? Has the next basin of interest been identified? Would these rivers possibly be targets?	The USGS works across the U.S. landscape, including the Middle Rio Grande Basin and Upper Missouri Basin. With regards to this specific methodology the USGS has just begun the project in the Colorado River Basin, and based on long-standing partnerships with the Bureau of Reclamation, NIDIS, and tribal organizations there are opportunities to work with the Tribal Water Subcabinet Team.
35	Do you anticipate streamflow drought prediction being more or less skillful for small-scale, snowmelt-driven watersheds (headwater basins) than for your large-scale (e.g., HUC-2) watersheds? Is there a trade-off between the extra data provided by snowpack and the inherently larger skill of predicting at large spatial scales?	We initially anticipate predictions being more skillful in smaller headwater areas than in larger downstream areas that have many human modifications of flow. However, our data assimilation approach to pull in streamflow data from upstream gages and reservoirs should help to generate more skillful predictions in the larger downstream watersheds.
36	What models are being used for drought prediction? Are they primarily AI-based models? Or are you incorporating seasonal forecasts from, for example, the NMME suite?	Currently, random forest and long short-term memory neural network models are being developed for individual sites as well as for the entire region. Models are being trained to predict daily streamflow percentiles using static and variable threshold approaches. In post processing, drought onset, duration, and severity are being calculated for several n-day periods looking forward from the last day of data used for inputting to the models.
37	What lead times do the predictions cover?	Our planned model forecasts are focused on weeks to months out, though we may further test the limit of the predictive capacity by looking out 12 to 18 months.

38	Are you using non-USGS gaging stations in your datasets? In Colorado, the Colorado Division of Water Resources has a very large long-term streamgage network that would enhance the streamgaging network.	Currently we are focused on USGS streamgages, but as the project continues we will look at the opportunity to add additional datasets and resources. Thanks for this input, and please share any additional network suggestions during the upcoming listening sessions.
39	How does the team envision an "early warning" drought prediction model will be used by Colorado River Basin land and resource managers and other stakeholders? And how will this be used in conjunction with or to enhance other prediction models that already exist?	Part of the goal of the upcoming listening sessions is to better understand this exact question. Through stakeholder input, we hope to inform the development of tools and resulting information to the extent possible.
40	Question to the NIDIS staff on this webinar: Are there plans for a Mid-Atlantic DEWS region?	A Mid-Atlantic Drought Early Warning System (DEWS) is under consideration by NIDIS. The important thing to note is that if someone in the mid-Atlantic states needs assistance on a drought issue, they are invited to reach out to either the Northeast DEWS coordinator (Sylvia Reeves, sylvia.reeves@noaa.gov) or the Southeast DEWS coordinator (Meredith Muth, meredith.f.muth@noaa.gov).
41	Have you tried to relate drought levels to sunspot cycles?	This has not currently been a focus of our work, but we welcome input if this is a critical need for our stakeholders.
42	Two questions: (1) What is the lead time for the drought prediction, and (2) how does the USGS forecast compare with the NOAA National Water Model forecast... can both be combined to develop a better forecast?	Ongoing work is assessing differences in model accuracy between multiple physically based models (including NWM 2.1) and the AIML models being developed as a part of current USGS drought projects. Our planned model forecasts are focused on weeks to months out, though we may further test the limit of the predictive capacity by looking out 12 to 18 months.

43	Hydrological drought can be manifested in one or more forms of frequency, intensity, and duration. Is there any statistically significant evidence which part of drought increased? How do separate the effect of anthropogenic effect in your analysis?	This is an excellent point, and the national project is examining trends in all aspects of drought—frequency, intensity, duration, magnitude, as well as seasonal occurrence of drought and paleodroughts. We will be using a range of approaches to understand and attribute the causes of changes in drought, including panel regression and formal causal attribution techniques.
44	The comment was made that "when scientists are left to their own devices, they may produce solutions that are unusable," but I would counter that—through the second presenter's work that drought is a complex, slow-moving process with many factors affecting its development, duration, severity, and frequency. It is important to appreciate the complexity of research needed to arrive at useful solutions.	The intent of the example was to focus on the need for stakeholder input so that any tools and information developed are the most usable that they can be. We recognize that complex research is needed, and distilling highly complex science, such as drought prediction, to a point that is easily consumable by many different interests is an extremely difficult task and should rely on information from many sources.
45	What type of droughts will you focus on predicting? Meteorological and hydrologic drought are basically statistical anomalies, but agricultural and water supply droughts are DEFICITS between supply and demand.	We are focused on hydrological drought predictions of streamflow, groundwater levels, and reservoir levels. We aim to predict the onset, duration, and severity (one potential metric being drought deficit) of drought in each of these categories.
46	How will USGS drought prediction complement or differ from the very significant investment in ensemble prediction by NOAA/NWS and the National Water Model?	USGS works closely with NOAA and other Federal science organizations to collaborate and provide complimentary science. Although the USGS national and regional projects have just gotten underway, they will leverage the long-standing partnership with NOAA/NWS and the National Water Model to create complimentary hydrologic drought prediction products to support the meteorological and climate products produced

		by NOAA to improve the overall understanding of drought on the landscape.
47	You mentioned using the Random Forest and ANN in your modeling. Could you briefly explain how you are using these models?	Currently, random forest and long short-term memory neural network models are being developed for individual sites as well as for the entire region. Models are being trained to predict daily streamflow percentiles using static and variable threshold approaches. In post processing, drought onset, duration, and severity are being calculated for several n-day periods looking forward from the last day of data used for inputting to the models.
48	What are your thoughts on why the predictive capabilities are weaker in the Intermountain West and Southwest compared to the eastern U.S.?	We are still in the process of understanding this question. This is a general result, that goes beyond only our predictive models, and is observed for national models by other federal and non-federal researchers. A number of hypotheses have been proposed: the aridity index, streamgage density, hydroclimatology, and groundwater-surface water contributions. However, this remains an ongoing question.
49	Will groundwater level trends be predicted as a part of this effort (or a future related effort)?	Groundwater level prediction relevant to drought is currently part of the National Drought Prediction project, and we hope to share more on this in the upcoming listening sessions.

50	Can these metrics be used to assist island areas that have been having a rise in well usages that are not currently being actively monitored? How do we inform the stakeholders of the importance when they seem to be unaware?	We are looking forward to input during the listening sessions for a diverse group of perspectives, including island areas with increased well usages. If there are specific scientific resources or information the USGS can provide to support your question please reach out to the session organizers, and we will put you in touch with our local USGS office to discuss in more detail.
51	Is the impact of increased human uses excluded in your low flows?	Several of the input datasets to our models quantify changes in dam storage, water use, irrigated area, and other human water uses that impact the flows we aim to predict.