Soil Moisture 101 Webinar: Questions & Answers
February 22, 2022

	Questions	Answers
	General Topics	
1	Regarding fire danger and soil moisture, do you have any specific numbers that you have correlated to extreme fire behavior and/or large destructive fires? Is it different in different areas of vegetation? Timber vs. grass vs brush?	See "Soil Moisture Affects Growing-Season Wildfire Size in the Southern Great Plains" at https://digitalcommons.unl.edu/agronomyfacpub/838/
2	Is there any way you measure soil moisture at depth?	All 3 methods for measuring soil moisture (*in situ*, satellite, and model) can provide deeper measurements. Several *in situ* networks install sensors down to 1 meter, so in this case there is an actual measurement at depth. Satellite retrievals are only able to measure near-surface, but NASA and others have methods to take the surface measurements and combine them with models to generated root-zone values. Finally, depending on the sophistication, land surface models can estimate soil moisture at a range of depths. If the question is about even deeper measurements (e.g., multiple meters), that is an active area of research.
3	Do you measure soil moisture accounting for the cone of depression around a well or other anthropogenic water diversion? The point is not surface irrigation but the overdraft from wells.	The soil moisture depths measured are usually limited to the top meter of soil, which is the vadose zone and not the groundwater zone, so the cone of depression of a well is not observed.

4	How do we overcome the differences in spatial resolution between observation types (*in situ*, remotely sensed, modeled) when trying to combine all the different information sources?	Soil moisture is influenced by many variables that are static or near static, like soil texture, hydraulic conductivity, vegetation, etc. Therefore, with a long enough time series and reasonable modeling efforts and calibration/validation efforts, scaling from point to satellite scale is possible to a high accuracy. This accuracy can mean the root mean squared error is as low as 4% volumetric soil moisture, which is more than adequate for most applications.
5	Soil moisture is directly impacted by the overdrafting of the aquifers by agricultural activities, drilling into the aquifers for oil, and draining the aquifers for mining activities (open pit mining), and not allowing the water to infiltrate into the aquifer by surface mining activities, and by activities (such as cattle grazing, road building, deforestation) that inhibit water infiltration. Will this program include monitoring and mapping the groundwater levels where the drought periods have become increasingly longer or is this program only focused on the top 6 inches of soil?	The National Coordinated Soil Moisture Monitoring Network (NCSMMN) initiative is broadly interested in developing and promoting national soil moisture maps and tools, including applications that address depths below 6". In parallel, the U.S. Geological Survey provides nationally integrated groundwater information at the Groundwater Watch website: https://groundwaterwatch.usgs.gov/default.asp. Groundwater connection to soil moisture levels and the effects of different groundwater use scenarios are important research topics, and over time there are likely to be more linkages in products serving these two very inter-related components of the hydrological cycle.
7	I'm looking at http://nationalsoilmoisture.com/About.html. Who all is notified about data? For example, northeast Montana, north of Glasgow, has some stations. There are huge wheat farms up there. Do the farmers get info?	To date, we have not been engaging in public outreach on NationalSoilMoisture.com as it has been in research mode. We are currently transitioning to operational mode and do intend to do outreach to the public on this. Thank you for the suggestion.
8	Hi, first of all, thank you for your presentations. Looking at these presentations, I started thinking, how can	Soil moisture is influenced by many variables that are static or near static, like soil texture, hydraulic conductivity, vegetation, etc. Therefore, with a long enough time series and reasonable modeling efforts and

	we be more confident about using the small footprint of a sensor in the process of data assimilation with remote sensing or model data? Do you know any method that considers this variability of scenarios when merging information, for instance we should not consider all the *in situ* locations equally valuable when doing this process?	calibration/validation efforts, scaling from point to broader scale is possible to a high accuracy. This accuracy can mean the root mean squared error is as low as 4% volumetric soil moisture, which is more than adequate for most applications. Having said that, there is a recognition by the National Coordinated Soil Moisture Monitoring Network of the need to accommodate different "quality" data, including possibly providing users the option to select out stations/networks that might not meet their particular performance requirements.
9	Are the soil moisture, air quality, and conditions being monitored with respect to USDA Agricultural Research Service regarding the H5N1 outbreak in the poultry farms with collaboration of NIH, CDC for Health and Human Services?	This is a great suggestion, but not something the National Coordinated Soil Moisture Monitoring Network is aware of.
10	Are there any average volumetric 1 m-integrated soil moisture data products for the HUC 8 or HUC 10 scale?	We are not aware of any at this time, but this could be developed if desired. Thank you for the suggestion.
11	To get the best picture of soil moisture what combination of tools and products would you recommend? Currently there are many places lacking some basic monitoring on the ground like mesonet stations across ND, MT, and SD, for example, so just wondering what is needed to get the best picture of soil moisture in those places in the future using best available technology.	It is hard to define a best "one-size-fits-all" tool or combination of tools, as this varies by use, level of resolution needed, etc. One of the 2022 priorities of the National Coordinated Soil Moisture Monitoring Network initiative is to developed a "curated" kiosk of soil moisture maps, datasets, and other tools, which would include information for users on what might be good sources of data for their particular purpose. One suggestion in the meantime is to consult with your state climatologist (see the American Association of State Climatologists for contact info), as many have experience for what works best in their state. There are also a number of tools currently featured on the Soil Moisture Data and Maps page at drought.gov.
12	How is this coordinated with the USGS drought monitoring and prediction program?	The U.S. Geological Survey is a partner and on the planning committee of the National Coordinated Soil Moisture Monitoring effort. They are also engaged in a series of soil moisture activities, including as part of the Next-

		General Water Observing Systems (NGWOS) effort—currently focused on the Colorado River Basin. Finally, NIDIS works directly with the USGS drought monitoring and prediction program.
13	About climatology, the pure scientist requests at least 30-year time series. Climate change dynamics are running fast. Do you think that this period should be shorter? I mean for short-term climate forecasts.	There is growing recognition among climatologists, hydrologists, and others that a changing climate requires rethinking what are appropriate periods of record to use in different applications. NOAA's National Centers for Environmental Information (NCEI) is now publishing a number of shorter normals (10-year, 15-year, etc.) since the typical 30-year normals are not quite as relevant for all sectors. A good reference is: https://www.jstor.org/stable/26218540?seq=1#metadata_info_tab_contents
	***In Situ* Measurement of Soil Moisture**	
14	MESO Net no longer uses Personal Weather Station data. Is there a way to connect a PWS to MESO Net?	Many state and regional networks require that all stations within the network adhere to common sensor calibrations, sensor makes/models, sensor rotations, sensor heights, and maintenance protocols. Therefore, Personal Weather Stations may not be easily integrated into their network. We do know of several data integrators (e.g., Weather Underground) that ingest various personal weather station data. On the general point about folding in Personal Weather Station data, there is active discussion within NOAA about how to better involve citizen science both in atmospheric monitoring and in soil moisture monitoring specifically.
15	At OK Mesonet, do you have a preferred soil moisture sensor you use within your networks? We've tried Stevens and found them highly accurate below 25% vwc but skewed very high above those moistures (in a loam soil).	We have used the matric potential sensor from Campbell Scientific (229-L) since 1996. Since the sensors basically operate in a range from wilting point (low end) to field capacity (high end), we have found those observations useful to the ag community. However, we realize that many soil moisture scientists and those in the modeling community want volumetric water content. We are exploring volumetric water sensors. We have operated and maintained the Stevens Hydraprobe in two USDA Agricultural Research Service micronets for the past ten years. We collect the raw voltages and then use the appropriate soil type equation (rather than letting the sensor automatically calculate it). In some cases, we have to tweak the soil type category in order to get the data to stay in range. I

		don't believe the new sensors have an equation for loam soil type, but I'm not certain. That's my experience purely as an operator. I'm not a soil scientist.
16	RE: OK Mesonet. Approximately when do records from the *in situ* monitoring network begin? Are there multiple decades of data available from this network?	For Oklahoma, our archive of soil moisture data goes back to 1996 at ~60 stations. That increased to about ~100 stations in 1999 and then at all 120 stations in about 2013.
17	How often are mesonet sites visited by technicians for inspection, troubleshooting, etc.?	OK Mesonet sites are visited on average 4–5 times per year for either routine vegetation maintenance, sensor rotations, or emergency troubleshooting.
18	What is the time interval of mesonet data? Is it available to public?	Most state and all federal mesonets are available to the public. And the time interval varies by network. You would have to check with individual mesonets to determine their particular time interval and access requirements. Also, a gridded map based on over 20 state and national mesonets' point data is available at NationalSoilMoisture.com.
19	Do you have runoff at the mesonet sites if someone wants to account in soil water balance models?	Ideally, no. We have had a site or two in our history get inundated with floodwaters. The siting criteria excludes any locations that would have standing water or regular runoff. We have had some sites report greater plant available water increases than the rainfall amount. This could indicate water has drained into the site from elsewhere.
20	How many of these stations do we have around the country?	There are about 2,000 stations that estimate soil moisture in public (federal and state) networks around the country. One of the priorities of the National Coordinated Soil Moisture Monitoring Network is to support build-outs for additional stations, and important build-out projects are happening currently in the Upper Missouri River Basin and in the Southeastern U.S. (AL, GA, FL). As of 2022, priority areas for build-out include forested lands and tribal lands— both currently underserved land areas.

21	For *in situ* measurements, how large a volume of soil is being measured?	Most *in situ* sensors are only measuring a fairly small volume of soil (i.e., the soil directly in contact with the sensor). The COSMOS sensor (which is on a mobile unit on-site but above ground, so not strictly "in situ") counts slow neutrinos to estimate soil water content across an area around 100 yards. It should be noted though that with good soil characterization information and modeling, scaling from point to broader scale is possible at a fair level of accuracy.
22	Can the *in situ* sensors be left in frozen ground? Is it best to leave them in year-round?	I think definitely leave them in year-round. Each time we install or re-install a soil moisture sensor, there can be a long heal time for the sensor to come in good contact with the soil. We generally flag all data as erroneous for 21 days after install as we wait for the soil to heal around the sensor. However, this can be even longer during drought conditions. I don't know of any sensors that can't withstand frozen soil conditions (although the data may likely be erroneous during the frozen soil conditions).
23	How does the horizontal movement of water affect the temporal resolution of the dataset?	In the OK Mesonet, we once experienced lateral water flow from an irrigation ditch nearby. Namely, we noticed deeper depths increasing in soil moisture in the absence of shallow soil moisture and/or rainfall. We had to flag all of the associated data as erroneous.
24	Our neighborhood here in Portland, Oregon is seeking to harness as much soil moisture as possible for our tree canopy and to reduce wildfire hazards during this extended drought. What are the best sensors we can use at a local level to track soil moisture throughout our community?	Research grade soil moisture sensors, which are used by national and state mesonets, are all of equivalent value and they can be expensive. There are specific lower-cost options that might be better for your situation depending on soil texture, organic matter, etc. Sticking with 'tined' probes or heat dissipation-based sensors is probably optimal over capacitance borehole technologies (though this is not an endorsement).

25	How are sites acquired for the Mesonet network? Wondering about potential sites in Oregon.	Our Oklahoma Mesonet is largely state funded. Initially, we worked with each county extension agent (now termed County Educators) to find a long-term, stable site location in each county. We are about half on privately owned property (local farmer/rancher) and half on public lands (university/federal/airport/etc.).
	Satellite Retrieval of Soil Moisture	
26	Do you use LIDAR to measure soil moisture? How does the soil profile affect soil moisture?	Some have explored LIDAR, but there are many limitations, including many better alternatives, such as L-band. Visual (LIDAR) systems are especially limited by needing a clear line of sight of the soil.
27	How does snow cover affect the remote sensing soil moisture?	Soil moisture cannot be observed below snow from most remote sensing, except for potential future missions like a P-band mission, but the snow would have to be quite thin and practically non-existent. Since most instances of snow occur on frozen soil, soil moisture is often assumed to be static while under a snowpack. This is not always true, but practical and reasonable in many cases.
28	Can you share a little bit about recent 30-m downscaled SMAP HYDRO-Block (mentioned earlier)?	The SMAP HB product is currently only available for a 5-year period and is a downscaled SMAP product using soil texture as a one-dimensional model. There are many assumptions in the model, and precise validation has not been extensively conducted. This is also 'fed' by a 4 km precipitation map, which is another limitation of the product as precipitation still has some variability within those 4 km.
29	How does NASA SPoRT estimate soil moisture content?	NASA SPoRT hosts SMAP data, SMAP enhanced data, as well as modeled soil moisture from the NASA Land Information System (LIS).
30	What soil moisture products are available in the U.S. Caribbean islands?	The SMAP products are available over the U.S. Caribbean islands. As well, the NASA USDA Data Assimilation System and the NASA LIS products include this domain.
31	SMAP ended in 2015 to be replaced by SMAP Modis? Didn't quite catch that—is this level 4?	The SMAP radar product prematurely expired, but the SMAP Passive product has continued, and then a new product which combines information from a European satellite system (Sentinel) is now available

		and currently running. Level 4 is a modeled product that uses remote sensing and a soil column model to estimate the top 1 meter of soil moisture.
32	Is SMAP correlated with GRACE?	GRACE operates on a monthly time scale, and there is some large-scale correspondence between SMAP and GRACE with respect to seasonal scales. However, short timescales are not observable by GRACE.
33	Are there any solutions in using UAS with collaboration of Governmental Agencies for Air Space with respect to USDA, USGS, NASA, NOAA EOD, GOES-T Satellite Services?	UAS platforms for soil moisture are not yet fully tested (soon), but the satellite products are also becoming more omnipresent and approaching the spatial and temporal resolutions of a UAS system.
34	Is the parallel LIS that assimilates SMAP data available to the public?	Yes, it is available at: https://weather.msfc.nasa.gov/sport/case_studies/lissmapda_CONUS.html. You can find all the LIS displays and zooms on our website: SPoRT web page. To navigate to any of the LIS pages, go to: Real-Time Data -> Land Information System -> SPoRT-LIS or SPoRT-LIS + SMAP DA. Below that menu are the various zoom domains we post.
35	My query is regarding the coverage and temporal resolution. I see that the temporal resolution of SMAP is not 3 days but higher than that for covering entire U.S. I need a daily soil moisture product but we are ok with using the data at 3-day resolution as well. Which is a better product in terms of better spatial resolution and at daily temporal resolution?	The best available product is the SMAP Enhanced 9km gridded product if you can handle the 3 day, which is going to be reasonable. Anything daily will be modeled and probably of less accuracy.

36	It is amazing what the researchers can do with data. I am connected from Mexico. In the proximate future, how do we can reach SMAP data in near real time? As the NW coast of USA Mexico is severely affected by drought, and these satellite images would be very useful for policymaking.	You should reach out to NASA directly or SERVIR, or SPoRT-LIS for options. Low-latency comes at a cost, but there may be some options available to you.
37	Can you mention how these satellite products might boost smart farming agriculture? I think it is relevant, but I would like to hear from you, the experts.	Smart farming usually requires higher resolution than available currently, but the VISIR (visible and infrared products) do exist at the field scale and are able to be used in a synthesized way to help understand drought or ponding conditions in reasonable time frames. Future remote sensing products for soil moisture include NISAR (Radar) which will have a field level resolution. A better option for field decisions is still *in situ* monitoring.
38	With respect to NASA satellites sensing (active and passive) soil moisture at different soil depths where *in situ* measurements are not available?	Remote sensing is most useful for places where we don't have *in situ* data. Calibration/validation at locations with in situ data provides us with the confidence for places without *in situ* data.
	Model-Output Soil Moisture	
39	Are there plans to develop soil moisture models that relate land use types?	Land use and soil moisture are often 'convoluted' together, meaning one land use can cause a soil moisture predominance, but a soil moisture predominance (it's always dry for instance) can influence land use. Cropland is not usually very dry or very wet, unless irrigation is available.
40	With regards to the root zones, is the model only including the root zones of plants? Are there models that include root zones of the trees that have roots that reach 20 to 100 feet beneath the ground surface?	This depends on the model being applied. The Palmer model, used by NASA USDA Data Assimilation System, uses available water content, which is a combined variable of soil type and depth to bedrock. Other layered hydrologic models have rooting depths assigned typically for agriculture. There are some models with dynamic rooting depths based on agricultural growth. Typically soil moisture models do not consider deep tree roots.

41	I am aware of an ongoing modeling effort associated with the Colorado River Salinity reduction efforts. I can see a potential cross-over between that project and soil moisture. Has there been communication between your group and theirs that you are aware of?	To date there has not been communication between the National Coordinated Soil Moisture Monitoring Network effort and the Bureau of Reclamation (USBR) Colorado River Salinity project, but thank you for the suggestion. We are in the process of beginning engagement with the USBR and will raise this opportunity.
42	If we want to evaluate how well our regional atmosphere model performs on soil moisture, which datasets do you recommend to use?	The SMAP Enhanced product is probably the most accurate and most applicable.
43	To test a new hydro model, would it be wise to test it as a column model at an *in situ site* to check the physics? Or would lateral flow in to the 'column' affect the results?	For most situations, there is little lateral flow in the soil column, and lateral distribution occurs from overland flow. I would suggest 'well behaved' or typical-appearing *in situ* soil data from SCAN, CRN, or a mesonet to be used as part of a population of data to assess accuracy. Satellite products for the top column are also models, so that would be less physics-based.