Questions & Answers Part 2

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Jonathan Case: Jonathan.Case-1@nasa.gov, Kevin Fuell (UAH at SPoRT): kevin.fuell@nasa.gov, or Sean McCartney: sean.mccartney@nasa.gov

Question 1: How does the vegetation type and density influence the soil moisture?
Answer 1: Different types of vegetation can extract different amounts of soil moisture depending on the need and availability of water by the vegetation type and the vegetation's rooting depth, so it can vary from type to type and their density across the land surface. For example, corn will extract more soil moisture than say a cotton crop would in similar soil types. Here are a couple of resources from the USGS discussing some of this, although there are others. The 2nd contains links to paper resources.
https://www.usgs.gov/special-topics/water-science-school/science/evapotranspiration-and-water-cycle#overview
https://geochange.er.usgs.gov/sw/changes/natural/et/

Question 2: How would someone differentiate the contribution of each type of drought (soil, hydrological and meteorological) to the general drought occurrence?
Answer 2: Drought indicators are generally grouped into categories along the lines of the drought types: soil moisture indicators, hydrological indicators, meteorological indicators, vegetation-based indicators, etc. The contribution of each drought type is generally determined by the response of the indicators in each category. Use that to assess the type of drought is contributing.

Question 3: To my knowledge, SPoRT-LIS offers the highest resolution, most frequently updated remote sensing soil moisture product (3km). Can you confirm that? And can you talk a bit about whether a person would also want to consider coarser resolution products (e.g., CROP-CASMA (SMAP), NASA-GRACE) and, if so, why?
Answer 3: SPoRT-LIS soil moisture products are updated 4 times per day with hourly output frequency. Some CROP-CASMA products are updated daily and some weekly,

GRACE is updated weekly, and the AAFC SMOS soil moisture product is updated every 2 weeks. (This just considers these indicators; there are other models, such as the Leaky Bucket, NLDAS, and VIC models, that are updated daily.) So, in terms of update frequency and minimum latency, SPoRT-LIS is the choice.

For US Drought Monitor analysis, authors prefer a convergence of evidence approach where consensus among multiple indicators is desired. The USDM decision is not based on any one indicator. So, authors consider all of the above soil moisture indicators; convergence of evidence is more of a factor than just spatial resolution. NOTE: LIS is not a RS product but incorporates and utilizes some remote sensed components and input datasets; it is a land surface modeling product (or solution).

Question 4: What are some of the steps taken to mitigate or reduce the drought in areas once detected?
Answer 4: Drought response (mitigation and reduction of the impact of drought) is in the domain of state and local governments. Several states have drought response plans, which can differ from state to state given the climatology, etc and these can be accessed via the NDMC website (https://drought.unl.edu/Planning/DroughtPlans.aspx). The user is referred to the state plans to learn of the steps taken to mitigate or reduce the impact of drought. Also, the U.S. Department of Agriculture uses USDM classifications to allocate drought relief funds through their Livestock Forage Disaster Program (LFP).

Question 5: Is there a correlation ("conversion") between remotely sensed soil moisture and streamflow statistics? For example, 7Q10 [the 10th Percentile of 7-day total flow] or any other n-Day Flow Statistic.
Answer 5: There is often a lag between soil moisture and streamflow; however, one usually cannot easily convert/relate soil moisture percentile to streamflow in isolation. It depends on many factors including vegetation, soil, terrain, etc. Routing models are typically run on land surface model outputs to relate soil moisture, runoff, and other variables to basin streamflow at specific locations. Streamflow response to a heavy ppt event will be useful for flood forecasting. For drought we measure the base flow (which can be driven by groundwater).

Question 6: Within SPoRT-LIS, can you use historical data to perform a predictive analysis? Just seeing if I can render a report to farmers on potential areas, timeframes, and dates as to when they might experience a drought.

Answer 6: Perhaps, but it may be more appropriate to relate the soil moisture values to agricultural impacts specifically, rather than to drought. Since “drought” implies a broader lack of water in the hydrologic system, other metrics would need to be analyzed. Nevertheless, having important information about crop impacts due to soil moisture availability could help to inform about those impacts in the short term. It sounds like this sort of analysis and any forecasts could benefit from a machine-learning effort.

(Follow-on from Jonathan Case): SPoRT began generating experimental 14-day forecasts of SPoRT-LIS soil moisture percentiles last year, updated daily and driven by GFS forecasts. We would also like to enhance these predictions with ensemble approaches (driven by GEFS members) to depict the probability that soil moisture percentiles could drop below drought thresholds over the next 2 weeks or longer. For now, we are making daily animated GIFs of these daily forecast percentiles at https://geo.nsstc.nasa.gov/SPoRT/modeling/lis/conus3km/forecasts/, with a rolling real time archive. However, we plan to generate geotiffs of CONUS-scale forecast soil moisture percentiles in the near future as well.

Question 7: Can you share a published research article about this product generation (NC DMAC)?

Answer 7: We have several publications related to the SPoRT-LIS going back several years, listed below:

Case, J. L., 2016: From drought to flooding in less than a week over South Carolina. *Results Phys.,* **6,** 1183-1184, doi: 10.1016/j.rinp.2016.11.012.

Case, J. L., W. L. Crosson, S. V. Kumar, W. M. Lapenta, and C. D. Peters-Lidard, 2008: Impacts of high-resolution land surface initialization on regional sensible weather forecasts from the WRF model. *J. Hydrometeor.,* **9,** 1249-1266, doi:10.1175/2008JHM990.1.

Case, J. L., S. V. Kumar, J. Srikishen, and G. J. Jedlovec, 2011: Improving numerical weather predictions of summertime precipitation over the Southeastern United States through a high-resolution initialization of the surface state. *Wea. Forecasting,* **26,** 785-807, doi:10.1175/2011WAF2222455.1.

Case, J. L., L. T. Wood, J. L. Blaes, K. D. White, C. R. Hain, and C. J. Schultz, 2021: Soil moisture responses associated with significant tropical cyclone flooding events. *J. Operational Meteor*., **9** (1), 1-17, doi:10.15191/nwajom.2021.0901.

Case, J. L., and B. T. Zavodsky, 2018: Evolution of 2016 drought in the Southeastern United States from a land surface modeling perspective. *Results Phys.,* **8,** 654-656, doi:10.1016/j.rinp.2017.12.029.

Kotikot, S. M., A. Flores, R. E. Griffin, J. Nyaga, J. L. Case, R. Mugo, A. Sedah, E. Adams, A. Limaye, and D. E. Irwin, 2020: Statistical characterization of frost zones: Case of tea freeze damage in the Kenyan highlands. *Int. J. Appl. Earth Obs. Geoinformation,* **84,** 101971, doi:10.1016/j.jag.2019.101971.

McDonough, K. R., S. L. Hutchinson, J. M. Hutchinson, J. L. Case, and V. Rahmani, 2018: Validation and assessment of SPoRT-LIS surface soil moisture estimates for water resources management applications. *J. Hydrology,* **566,** 43-54, doi:10.1016/j.jhydrol.2018.09.007.

Zavodsky, B. T., J. L. Case, C. B. Blankenship, W. L. Crosson, K. D. White, 2013: Application of next-generation satellite data to a high-resolution, real-time land surface model. *Earthzine,* J. Kart, editor, Institute of Electrical and Electronics Engineers, available at https://earthzine.org/application-of-next-generation-satellite-data-to-a-high-resolution-real-time-land-surface-model/.

Question 8: Is there something wrong with the SPoRT-LIS data? I haven't been able to access the current data since late last week. I keep getting an error message that says "Sorry, no data found for this product."
Answer 8: There has been a computer storage failure - this is actively being worked on. We hope to be back up to the most current data ASAP. You can see a banner with updates at:
https://weather.ndc.nasa.gov/sport/viewer/?dataset=lis_conus&product=rsoim0-100, or for users who download from the FTP server: https://geo.nsstc.nasa.gov/SPoRT/

Question 9: What are the kinds of data that you obtain from the citizen science reports and how are they integrated into the drought assessment?
Answer 9: Two types of citizen science data are available to USDM authors. The first is daily precipitation measured from rain gauge reports available through the CoCoRaHS network (https://www.cocorahs.org/). The second is drought impacts information provided through the NDMC Drought Impacts Reporter (https://droughtreporter.unl.edu/map/) and Condition Monitor Reports (https://droughtimpacts.unl.edu/Tools/ConditionMonitoringObservations.aspx).

Subjective indicators (the person observes that the ground is cracking, this stream has never been dry in the last 30 years, etc.) are helpful by backing up the objective measures.

Question 10: Is it possible to downscale the soil moisture product to be < 1km?
Answer 10: There are methods to do so, using higher resolution datasets. SMAP products are ~30 km, and some downscaling methods have been applied to downscale the retrievals to a higher resolution solution – which is typically done over smaller footprints and regions. Some higher res, regional products can be used.

Question 11: You mentioned SPoRT-LIS has characteristics associated with different areas and how it can make some areas more prone to errors. How is that so?
Answer 11: There have been some problems with precipitation analysis inputs to the SPoRT-LIS in the recent past, with the use of the NLDAS data set. However, for the mean-time we have switched to GDAS analyses because of this. Also, in the short-term especially, since the MRMS data suite serves as the precipitation data forcing, those areas with less accurate MRMS analysis (radar analysis) will have less accurate soil moisture data. Think of the Western U.S., where this may be a problem compared to locations in the Eastern US that have a better radar network and precipitation analysis. Future solution would be a multivariable data assimilation system.

Additionally, soil moisture may have errors due to variations in actual soil type compared to the static dataset of soil types defined in LIS, as well as the fact that the entire column of soil may not be uniform in type. Related to this is the issue of a duff layer that sits on top of the soil column in heavily forested areas of colder climate regimes. This duff layer can hold water that the SPoRT-LIS LSM allows to infiltrate to subsurface layers. Implementation of a duff layer or parameter has not been implemented to date.

Depending on the area of interest, sharp changes in actual topography may not be exactly represented in the LSM within SPoRT-LIS. This may cause less runoff of precipitation or it may impact snow retention and melt. It also may cause erroneous warmer/colder surface temperatures in the LSM if the topography is higher or lower than reality.

Question 12: Can you post a link to the soil layers (i.e., a map) used as an input to SPoRT-LIS?
Answer 12: We have an image of the STATSGO input soil classes that are used in the SPoRT-LIS. That is shown in the Session 1 recording, but it's also included in the microlesson training materials (SPoRT-LIS Starter Package). Recommendation is to refer back to the material in the micro-lesson for Session 1.

Question 13: Is there any process to predict a drought prior to occurring? Specifically, can you precede the query as knowing the probability of a drought happening before it takes place? Hence, we can take steps to mitigate the aftermath.
Answer 13: There are a few different efforts to provide outlooks for drought development and early warning, including seasonal drought outlooks from the NOAA Climate Prediction Center (https://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php) and NIDIS Drought Early Warning Systems (https://www.drought.gov/dews). There is also a rapid onset drought product from CPC in experimental phase (https://www.cpc.ncep.noaa.gov/products/predictions/threats/threats.php)
NC DMAC does not use forecasts for recommendations. But we are trying to find ways to predict drought that is separate from the Drought Monitor. Drought monitor is a map of the current state of drought.

SPoRT began generating experimental 14-day forecasts of SPoRT-LIS soil moisture percentiles last year, updated daily and driven by GFS forecasts. We would also like to enhance these predictions with ensemble approaches (driven by GEFS members) to depict the probability that soil moisture percentiles could drop below drought thresholds over the next 2 weeks or longer. For now, we are making daily animated GIFs of these daily forecast percentiles at https://geo.nsstc.nasa.gov/SPoRT/modeling/lis/conus3km/forecasts/, with a rolling real time archive. However, we plan to generate geotiffs of CONUS-scale forecast soil moisture percentiles in the near future as well. Research/Development toward quantification or analysis of these forecast percentiles could lead to a forecast indicator for a specific type of drought. This is a topic for discussion and further collaboration. There are also large-scale (i.e. global) efforts to look at season-to-subseasonal trends as well as long term future predictions of drought. Some of these datasets are less open to the public and they are part of specific funding tasks for a given organization.

Question 14: Can we spatially correlate the drought indices and obtain a map that indicates the areas with high and low correlation to demonstrate the effectiveness of these indices?
Answer 14: (I'm assuming that the question is asking about the SPoRT-LIS percentiles correlating to the USDM drought categories? That is how I'm phrasing the response). In the Session 1 presentation by Jonathan Case and in SPoRT-LIS: Soil Moisture Percentile microlesson training (supporting Session 1 and as a reference to attendees) prepared by SPoRT, we have validation statistics of SPoRT-LIS 0-200 cm RSM percentiles compared to the USDM drought categories, weekly from 2000-2022 (23 years total). We found that the SPoRT-LIS soil moisture percentiles correlated the best with the USDM categories over the Southeast U.S., Southern Plains, and Northern Plains regions. The correspondence was lower in the western U.S. regions and northeastern U.S. for higher-intensity drought categories.

Keep in mind, however, that many other indicators play a role in determining the weekly USDM classifications, so these correlations mostly show the areas where soil moisture deficits have important contributions to drought determination.

Correlation and bias is seeing the correspondence between percentiles and the Drought Monitor (DM).

In California US in late winter/early spring, dry conditions remained for 3 years. A deficit had built up. Groundwater was depleted. CA experiences atm rivers. The DM was showing a slow recovery. Because in the west soil moisture is indeed important but more important are reservoir levels, snowpack, and groundwater, which took several weeks to a few months to respond to the heavy rainfall and snowfall events.

Therefore, we would expect lower correlation and less correspondence between SPoRT-LIS soil moisture percentiles and the US Drought Monitor product in regions that are highly dependent upon the other drought indicators mentioned above, like California.

Comments:

Know what your primary sources of water are, the storage within the hydro system. Environmental conditions such as the type of vegetation (root depth, etc) will also contribute to drought analysis.

E. Africa is in a severe drought (2023) for the past 3 years. Soil moisture (SM) is crucial for crops, so the more SM products we have the better we can monitor. SPoRT products were very useful in Arkansas and N. Dakota captured rapid drying (flash drought).

Question 15: Does SPoRT Land Information System (SPoRT-LIS) soil moisture data exist for Africa? Is it freely available?
Answer 15: We do have a regional LIS run over eastern Africa that has been running since about 2016. It is one of the regional zoom regions on the SPoRT-LIS Viewer. See https://weather.ndc.nasa.gov/sport/viewer/?dataset=lis_africa&product=rsoim0-10
There is also a regional zoom of graphics over Kenya and Tanzania at https://weather.ndc.nasa.gov/sport/viewer/?dataset=lis_kenya&product=rsoim0-10.

All SPoRT-LIS data are publicly-available and specific data requests can be made on a one-on-one basis. The SPoRT-LIS over CONUS (historical and real-time) will eventually be made publicly available on a Distributed Active Archive Center forthcoming, with a goal of late 2023.

LIS runs have been made over Africa and parts of Asia. An application includes connecting SM with locust invasions in parts of Eastern Africa. In part 3, we will be using Google Colab to look at the LIS runs over Africa. The period of record is not as extensive as over CONUS.

Question 16: How does SPoRT-LIS data compare to the SMAP data?
Answer 16: SMAP retrievals are only valid for ~0-5 cm unlike the SPoRT-LIS products which will characterize conditions deeper in the soil through 0-200 cm. SMAP is only available 2x daily. The best way to compare SMAP to SPoRT-LIS is to compare only the top layer of SPoRT-LIS (0-10 cm) to the SMAP soil moisture retrievals.