Soil Moisture Components of the U.S. Climate Reference Network

An Assessment on the Utilization, Value, and Potential Impacts of Downsizing or Discontinuation

NOAA Technical Report OAR-NIDIS-001

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NOAA OAR Climate Program Office National Integrated Drought Information System, NOAA OAR Air Resources Laboratory, & NOAA NESDIS National Centers for Environmental Information
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Cover Photo: U.S. Climate Reference Network stations in Fairbanks, Alaska (top left); Dillon, Montana (top right); Necedah, Wisconsin (bottom left); and Los Alamos, New Mexico (bottom right). Station photos courtesy of the NOAA National Centers for Environmental Information.

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Executive Summary

Understanding the use cases and value of the U.S. Climate Reference Network (USCRN) soil moisture data is essential to inform future directions for the soil moisture network. In 2023-2024, the National Oceanic and Atmospheric Administration (NOAA) conducted extensive outreach both within and external to NOAA to assess the utilization, value, and potential impacts of downsizing or discontinuing the soil moisture network.

Key findings from this stakeholder assessment include the following:

- **For USCRN soil moisture data**, there is a wide variety of users of USCRN soil moisture data and the products they inform. USCRN soil moisture data was most heavily used in the following three areas:
    - validation and calibration for remotely sensed and model dataset development,
    - verification of operational tool development and derived products, and
    - benchmarking and establishment of state mesonet networks against a national network.
- **Many stakeholders emphasized high quality and accuracy of the USCRN soil moisture dataset** as a reason to use this dataset over others. The redundant measurements from USCRN sites were identified as a unique and useful aspect of USCRN soil moisture data, as was their widespread distribution in natural environments.
- **Over half of current users rated the impact of USCRN soil moisture downsizing or discontinuation as having a moderate or major impact.** Participants would pivot to use of state-based mesonets or rely more heavily on the U.S. Department of Agriculture (USDA) Soil Climate Analysis Network (SCAN) network for national coverage, which is currently the only other national network available. A number of potential alternatives for soil moisture information were identified and acceptable for some applications. However, remotely sensed and modeled products require in situ sources with lengthy and continuous time series for validation; alternatives for those activities are limited.

In summary, this assessment documented a wide range of the soil moisture community and their uses of the USCRN soil moisture dataset. Some users could pivot to other sources of soil moisture information, but those users who require in situ soil moisture observations have limited alternatives, particularly on the national scale. The USCRN is considered by the soil moisture community as the highest quality and most trusted authoritative source of soil moisture data. This is the result of this being a tightly configured, stable, and persistent network which is federally-funded and operated across the nation. It provides high value for some important, but unique, uses (e.g., multi-network nationwide cross comparisons and calibration that enable increased accuracy, value, and applicability of all other networks) that directly improve the usefulness of other network applications and applications that rely upon them (e.g., satellite and modeling users). This value cannot be satisfied by state mesonets, sector-focused or academic/research networks. Based on this assessment, the USCRN soil moisture network fills a distinct and critical need for national, high-quality soil moisture data for many important user communities.

Introduction

NOAA's U.S. Climate Reference Network (USCRN) has maintained high-quality climate observing sites since 2004. From 2009-2011, 113 stations in the contiguous U.S. were augmented to include high-quality soil moisture sensors, using triplicate sensor redundancy at five standard soil levels, to create detailed and reliable reference soil moisture profiles. NOAA's USCRN soil moisture network currently is one of two nationwide networks with station records of longer than 15 years, but the only one with triplicate sensors.

NOAA requested a review of the soil moisture component of the USCRN network that will inform a plan for sustainable operations. A cross-line office assessment was completed to better quantify the value of this data for both scientific users and the wider soil moisture user community and potential impacts if the soil moisture network were downsized or discontinued.

Approaches to Solicit and Document Stakeholder Feedback

Understanding the use cases and value of existing USCRN soil moisture data is essential to inform future directions for the soil moisture network. A survey approach was selected as a tool for information gathering because it (1) can reach both the research and user communities broadly; (2) ensures that everyone is asked the same questions; and (3) allows NOAA to easily track and analyze responses.

Survey questions were developed and approved by a team with representatives from the Office of Oceanic and Atmospheric Research (Climate Program Office, National Integrated Drought Information System [NIDIS], Air Resources Lab [ARL]), National Environmental Satellite, Data, and Information Service (National Centers for Environmental Information [NCEI]), and National Weather Service (Climate Services Branch). The survey questions were framed around different themes that are presented here as key takeaways:

- general access and use of soil moisture data,
- how USCRN soil moisture data is utilized, and
- potential impacts of network downsizing or discontinuation.

In accordance with the Paperwork Reduction Act (PRA), a request was made to the NOAA PRA office to include this survey titled ‘‘NOAA Stakeholder Feedback Survey on the Soil Moisture Components of the U.S. Climate Reference Network" under the DOC "Generic Clearance for the Collection of Routine Customer Feedback." NOAA received the Notice of Action approving the survey on May 28, 2024 under OMB Control Number: 0690-0030.

This survey was directly sent to the following groups:

- National Coordinated Soil Moisture Monitoring Network (NCSMMN) coordinating team and listserv,
- participants in National Soil Moisture Network Workshops,
- American Association of State Climatologists (AASC),
- modeling experts working with soil moisture data,
- satellite data experts working with soil moisture data,

- additional researchers and academics working with soil moisture data,
- relevant NOAA experts,
- U.S. Drought Monitor authors, and
- selected NIDIS regional Drought Early Warning Systems partners.

Stakeholder Participation by User Community

The majority of stakeholders reached during this engagement were current users of NOAA's USCRN soil moisture station data, with most working in the research or development areas. The survey generated 87 independent responses. Survey participants were broken into six different groups: Private/Industry, Government - NOAA, Government - External, State Government, Academic/Non-Profit, and Regional Climate Centers/NOAA Affiliated Centers. Governmental participants make up about half of those surveyed. Academic and non-profit organizations were the second highest, at 39%. This included four state climate offices housed at universities. Government partners and state climatologists were the most targeted groups when soliciting feedback for this survey. Of NOAA's six Regional Climate Centers, three are represented in this survey. See Figure 1 for a breakdown of survey responses by groups.

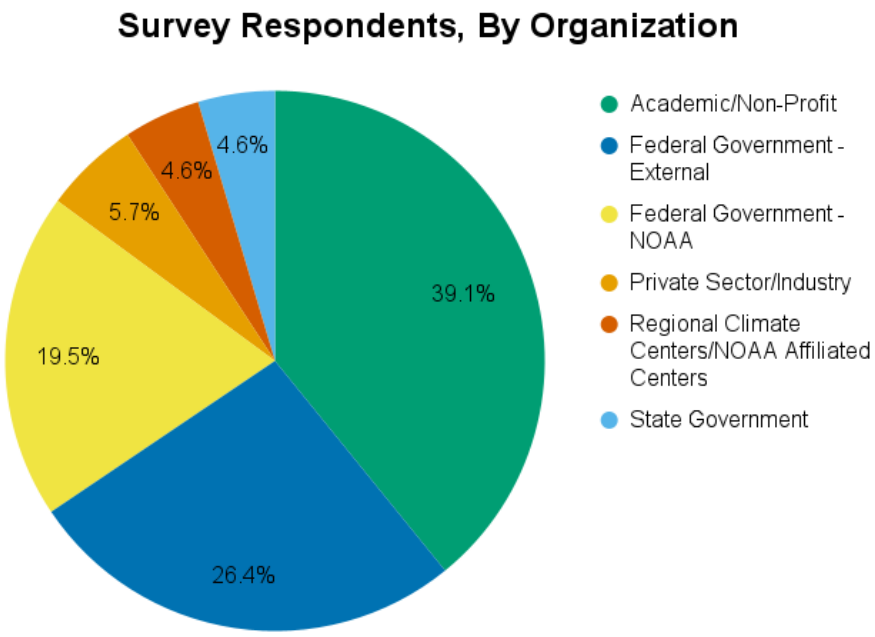

Figure 1. Breakdown of survey respondents by user organization.

Participants from all regions across the contiguous 48 states responded to the survey, coming from more than 50% of the states. There were no participants from Alaska and Hawaii. Additionally, Colorado and Maryland had the highest representation based on research partner and NOAA headquarter participation, respectively.

In addition to the survey, NOAA conducted targeted outreach both internal and external to NOAA to solicit feedback on the USCRN soil moisture network use and value. This included the following:

- Annual National Soil Moisture Network Workshop (July 2024),
- a NOAA-led Town Hall session, “Stakeholder dialogue on NOAA’s USCRN soil moisture network,” at the American Association of State Climatologists Annual Meeting (June 2024),
- Upper Missouri River Basin Project Annual Meeting (February 2024),
- the National Coordinated Soil Moisture Monitoring Network (NCSMMN) Town Hall at the American Meteorological Society Annual Meeting (January 2024),
- outreach to National Weather Service staff (Spring 2023), and
- ongoing dialogues with NOAA researchers and product developers (2021-present).

The use cases and information reflected in this report are largely from the 2024 survey, but also reflect feedback received in the above engagements.

Key Takeaways: General Access and Use of Soil Moisture Data

Stakeholders identified many different use cases for soil moisture data in general (not specific to the USCRN network). The main categories were operational, developmental, and research product delivery.

Operational Activities

Operational activities that use soil moisture data include drought monitoring (e.g., providing input into the weekly U.S. Drought Monitor, which informs USDA disaster relief program decisions, among other outcomes). Additional use cases include the application of soil moisture data for fire suppression reconnaissance, determining areas of landslide susceptibility, forestry management decisions (such as determining when the soil is dry enough to use heavy equipment to avoid long-term soil impacts), and identifying if the soil is too wet or dry to conduct a prescribed burn.

Development Applications

Development applications incorporate a range of research to operations activities such as tool development and evaluation of tools, datasets, and models for operational use. Specific examples include the following: utilizing soil moisture for initial conditions for hydrologic modeling, evaluating model simulation accuracy, calculating inputs to crop growth and crop disease models, using soil moisture for specific soil physical property measurements, calibrating and validating remotely sensed soil moisture retrieval algorithms, and evaluating land surface model (LSM) performance for terrain-based research and development activities.

Research Applications

Research applications were the most common use of soil moisture. This included a wide range of research needs, such as: sector-specific impacts (e.g., estimating crop yields, irrigation research), impacts of soil moisture on other parameters (e.g., soil physical properties, surface energy balance, downstream water quality), climate research (e.g., how changes in climate and land cover affect water balances), and methodology development (e.g., calibrating methods for remote sensing of soil moisture validation).

Stakeholders identified a wide variety of sources for soil moisture information, with most utilizing a combination of sources in their work. Key sources include the following:

- ***State and Local Networks*:** neutron probes and other on-site field measurements, various mesonets, condition reports, e.g., Farm Bureau, Community Collaborative Rain, Hail and Snow (CoCoRaHS) Network;
- ***Global and National in situ Networks with Sensor-Based Data*:** National Soil Moisture Network, NOAA's U.S. Climate Reference Network (USCRN), the USDA Soil Climate Analysis Network, the International Soil Moisture Network (ISMN), the National Science Foundation National Ecological Observatory Network (NEON), AmeriFlux, USDA's Snow Telemetry (SNOTEL);
- ***Remote Sensed*:** National Aeronautics and Space Administration's (NASA) Soil Moisture Active Passive (SMAP), European Space Agency (ESA) Climate Change Initiative, Soil Moisture and Ocean Salinity (SMOS), Advanced Scatterometer (ASCAT)

Data Products, Advanced Microwave Scanning Radiometer Earth Observing System (AMSR-E), Advanced Microwave Scanning Radiometer 2 Version 3 (AMSR2/3), and Cyclone Global Navigation Satellite System (CyGNSS); and

- ***Modeled*:** NASA Short-term Prediction Research and Transition Land Information System (SPoRT-LIS), Topofire, Soil Moisture Active Passive Level 4 (SMAP-L4), Noah-Multiparameterization Land Surface Model (Noah-MP), Global Land Data Assimilation System (GLDAS), North American Land Data Assimilation System (NLDAS), NOAA Climate Prediction Center and National Weather Service Forecast Centers model-based products, modeled values from National Severe Storms Laboratory Flooded Locations and Simulated Hydrographs (FLASH), Sacramento Soil Moisture Accounting Model (SAC SMA) from the Colorado Basin River Forecast Center, North American Regional Reanalysis (NARR), Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2), and the fifth-generation European Centre for Medium-Range Weather Forecasts atmospheric reanalysis of the global climate (ERA-5).

The USDA's SCAN is similar to the USCRN soil moisture network in that it is both national in scope and used in similar ways by the soil moisture community. Differences identified between USCRN and SCAN soil moisture data are primarily around coverage and quality control. In terms of coverage, respondents describe the USCRN as having a more balanced and homogeneous distribution of stations across the country compared to SCAN. Specifically, they mentioned the SCAN coverage is often skewed toward agricultural areas; SCAN lacks stations in the U.S. Great Plains; SCAN sites are not evenly distributed throughout the U.S.; and SCAN sites are heavily weighted toward the West and mountainous regions. Respondents considered the USCRN network to have higher data quality and maintenance compared to SCAN (partially because of its triplicate sensors), and USCRN data seems to be easier to access. Despite any differences, stakeholders view SCAN and USCRN as complimentary given the relative paucity of soil moisture measurements in relation to the vast national land extent and diversity. The stations in these networks are not co-located, so they can complement each other. Users working on model and satellite validation or product development also find more confidence when more, versus less, data is available.

National and international data portals that include USCRN soil moisture data are commonly accessed. The National Soil Moisture Network website supports operational monitoring of soil moisture conditions in the contiguous United States. It utilizes in situ measurements of soil moisture as well as model-derived and satellite-derived soil moisture to develop high-resolution (4 km) gridded soil moisture products for the contiguous United States. The International Soil Moisture Network (ISMN) is an international cooperation to establish and maintain a global in situ soil moisture database. For some, these portals are their primary means of access to USCRN data, as the portals provide access to many in situ soil moisture networks, and some may reference these portals as their source of USCRN data instead of NOAA. Others prefer to get their USCRN data directly from NOAA. In the ISMN, 80% of the soil moisture data is from the U.S., and USCRN accounts for 33% of the U.S. data.

Key Takeaways: Use Cases of USCRN Soil Moisture Data

There is a wide variety of users of USCRN soil moisture data and the products they inform. Academics, water managers, and the general public largely use products and services derived from USCRN soil moisture data. Other communities utilizing USCRN soil moisture data include environmental managers, farmers, emergency managers, and federal, state, and local agencies.

The most common use of USCRN soil moisture data identified was in the development space, which includes research to operations activities; tool development; evaluating tools, datasets, or models for operational use; and the validation and calibration of remote sensed and modeled data**.** Respondents frequently highlighted the use of USCRN soil moisture data for model validation, particularly in remote sensing modeling. These models require high-quality, in situ datasets for training or accuracy evaluation. Respondents also identified USCRN soil moisture data as an important source of CONUS-based station-based observations useful in assessing model performance. Specific operational, developmental, and research activities respondents named in the survey responses are listed in Appendix A.

Stakeholders that operate a state mesonet highlighted the value of using the USCRN soil moisture methodologies to inform protocols to establish and operate their state monitoring networks. The following states use USCRN protocols when installing soil moisture sensors at their state stations: Alabama, Delaware, Georgia, Kansas, Minnesota, Montana, and New Mexico. Indiana mesonet operators use the USCRN soil moisture data to help fill gaps. Several states that operate their own mesonsets do not have soil moisture sensors. In these cases, they must rely on USCRN soil moisture data or SCAN data. These states highlighted the criticality of these sensors due to the sparseness of existing soil moisture data to support their responsibilities to monitor climate and characterize drought.

Modelers and developers use USCRN soil moisture data in a wide variety of ways. The survey had a few tailored questions aimed at participants who identified as modelers or researchers. The goal was to target use of USCRN soil moisture data in analysis and validation activities related to satellite data streams and models. About 60 respondents self-identified as modelers or researchers. Use cases included satellite calibration and validation, model verification, downscaling of remotely sensed data, and training data for models. Respondents identified many applications of their activities, with the most popular being for agricultural study and monitoring, drought analysis and monitoring, and land surface modeling.

They were also asked what other data sources they use for calibration and validation, if any, and how that compared with the USCRN soil moisture observations. Many respondents used remotely sensed sources in conjunction with in situ sources. Responses came from internal NOAA offices, other government agencies (USDA, Bureau of Land Management, National Science Foundation, U.S. Army Corps of Engineers), academia, and private industry. Over a dozen other sources were identified, though only a few are also in situ sources. The most popular in situ networks that were used were SCAN, SNOTEL, and the United Kingdom's Cosmic-ray Soil Moisture Monitoring Network (COSMOS).

When asked to compare USCRN soil moisture data with the other soil moisture data sources for calibration & validation, reliability and data quality was a common theme. The USCRN soil moisture data was considered one of the most reliable and highest quality continental-scale soil moisture measurements and was a preferred source for validation. Respondents preferred USCRN data for the following reasons: it is the only network with in situ redundancy, which is important for the proper characterization of the spatial and temporal uncertainties; the observations are more representative of actual soil moisture; their quality is higher than either SCAN or SNOTEL; and USCRN reporting and geographic coverage is more consistent than the other networks.

USCRN soil moisture data is frequently used in various research endeavors in government, academia, and private industry. Research focused in areas of agriculture, drought, wildfire, water balance and water usage, modeling soil moisture, and others. A full list of examples is included in Appendix A. Many use cases involved independently evaluating model or satellite product performance that were also listed in the operational and development activities for different areas of interest.

Reasons identified for not using USCRN soil moisture data were primarily around coverage or lack of knowledge about the data. Specific reasons mentioned include the following: not enough granular coverage; data not available at their location; the need for measurements at specific locations; not aware of the data and network; and not aware of how to access the data.

In addition to its primary mission of providing a national indicator of soil moisture, there are particular locations where USCRN soil moisture data stations provide value. Specific regions mentioned included the Mid-Atlantic, Southeast, Northeast, High Plains, Great Plains, and the Western U.S., as well as particular states within these regions. Additionally, respondents highlighted the Upper Colorado River Basin, where stakeholders and water managers are eagerly seeking more soil moisture data due to the large land area covered by forests and complex topography, where there is high uncertainty around representativeness of modeled and satellite data for this region, and where there is a need to better understand both current and potential future water supplies.

The USCRN enables comparison across other soil moisture networks. Respondents placed particular value on stations that are either co-located or nearby stations from other large networks (SCAN, SNOTEL, NEON, and state mesonets) since that allows for cross-network comparisons. Also, USCRN sites that are far from any other monitoring network sites are valuable because they fill in spatial gaps. Respondents highlighted eastern Oregon and Washington, as well as Texas, in this regard: USCRN station data support drought characterization and agricultural interests, respectively, in these states. A recurring theme among those responding was that the current network would be of even greater value if it were more dense and had a longer period of record.

Key Takeaways: Potential Impacts of USCRN Soil Moisture Downsizing or Discontinuation

In the survey, participants were asked to rate their level of impact on a 1–5 scale if there were (1) a full discontinuation and (2) a partial discontinuation of the USCRN soil moisture network. The impact scale was described as follows:

1 - alternative source identified and available; minor work required to adjust
2 - alternatives available; moderate work required
3 - partial alternative coverage available; moderate work required
4 - minimal alternative (less than 50%) coverage available; moderate to major work required
5 - no alternative available; likely discontinuation of product or service

For summary purposes, impact levels of 4 and 5 were combined as a major impact (described as majorly disruptive to their activities, no or minimal alternative available), level 3 represented moderate impact, and levels 1 and 2 as low impact (described as minimally impactful, some adjustments to activities).

Figure 2 quantifies the results about a *full discontinuation* of the network. Nearly half (47.7%) of the participants describe a discontinuation of the network as having a major impact on their activities. Twenty percent noted a moderate impact, about a quarter had a low impact, and five respondents did not answer this question. Comments on this question noted that alternatives would rely heavily on the SCAN network or state-based mesonets that are difficult to standardize. Several participants noted SCAN does not have the redundancy in its measurements that USCRN does. In the group that noted major impacts, the types of organizations had a similar breakdown to that of the whole sample outlined in Figure 1.

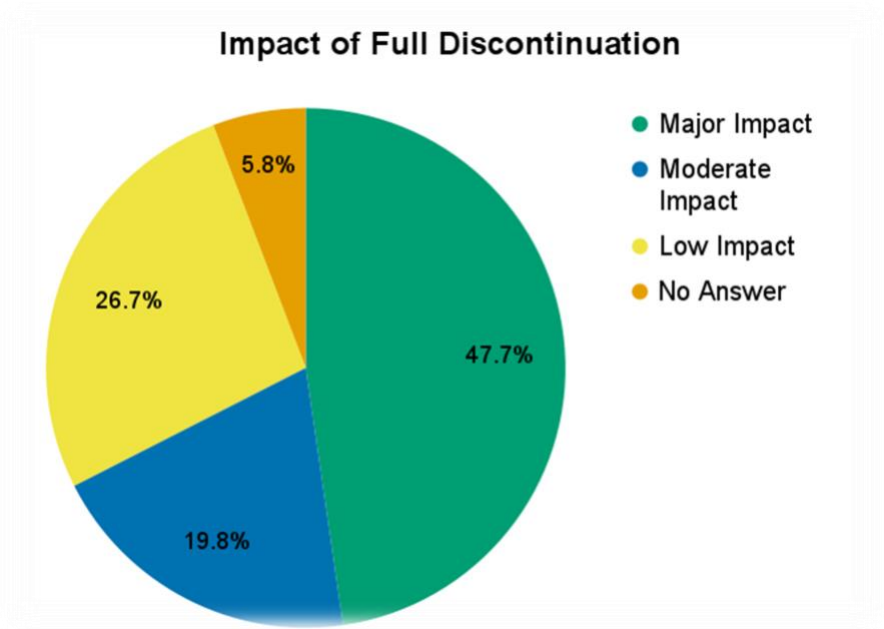

Figure 2. Breakdown of responses to a full discontinuation of the USCRN soil moisture network.

The results for *partial discontinuation* (Figure 3) indicate that fewer participants would have a major impact (37.5%) based on a theoretical reduction of the network (participants based their answer on a notional 30% reduction of stations spread across the contiguous U.S.). The comments for this question are similar to those discussed in the previous result. Participants would pivot to use of mesonets or rely more heavily on the SCAN network for national coverage. Many said the impact would depend on which areas saw reductions or loss of their stations. Several comments stated concern that a reduction in the redundant measurements from USCRN could impact the quality of the data, which is unique and useful for their activities.

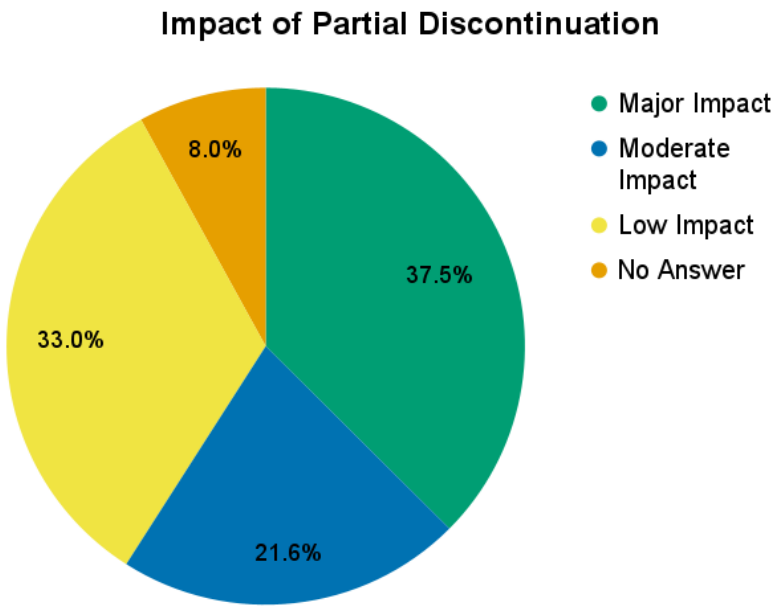

Figure 3. Breakdown of responses to a partial discontinuation of the USCRN soil moisture network.

Additional Sources of Soil Moisture Information

Other sources of soil moisture information were identified and discussed in the survey and the in-person engagements. Table 1 provides a list of other sources of soil moisture information the community relies on, whether that is in addition to or instead of the USCRN soil moisture network. It is split into in situ (most similar to the USCRN soil moisture network), remotely sensed, and modeled sources. For some users, remotely sensed or modeled soil moisture information is acceptable for their applications. However, as discussed previously, **remotely sensed and modeled products typically use in situ sources for validation**. Alternatives for those activities are more limited.

Table 1. Other sources of soil moisture information utilized by the community

In situ
U.S. Geological Survey National Groundwater Climate Response Network (CRN)
California Irrigation Management Information System (CIMIS)
United Kingdom Cosmic-ray Soil Moisture Monitoring Network (COSMOS)
U.S. Department of Agriculture (USDA) Soil Climate Analysis Network (SCAN)
International Soil Moisture Network (ISMN)
Natural Resources Conservation Service (NRCS) Soil Survey
USDA Snow Telemetry (SNOTEL)
Remotely Sensed
National Aeronautics and Space Administration (NASA) Soil Moisture Active Passive (SMAP)
Soil Moisture Spatial Inference Engine (SOMOSPIE)
Modeled
Sacramento Soil Moisture Accounting Model
National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center Modeled Soil Moisture
NOAA National Severe Storms Laboratory Flooded Locations and Simulated Hydrographs
NOAA National Weather Service River Forecast Centers Soil Moisture
NASA Short-term Prediction Research and Transition Land Information System (SPoRT-LIS) Soil Moisture
North American Land Data Assimilation System-2 Reanalysis (NLDAS-2)
Soil Moisture Spatial Inference Engine (SOMOSPIE)

In-Person Stakeholder Engagement

American Association of State Climatologists (AASC): 2024 Town Hall Summary

A town hall discussion was held as part of the AASC 2024 Annual Meeting to gather feedback regarding how this community uses USCRN soil moisture observations. Attendees were also invited to complete the survey to further collect use cases. Town hall feedback aligned with survey input, but also provided some additional discussion and perspectives from individual states.

Value and Use of the Data

State climate offices identified a wide variety of operational, development, and research uses of soil moisture data in general, and USCRN soil moisture data specifically. This includes using the national reference network to set up and install state networks, characterizing drought conditions, calibrating existing networks, validating models, and creating gridded products. While the USCRN data is often used alongside other soil moisture data sources, these users emphasized the value of USCRN as a robust, high-resolution sensor network. They recognized satellite observations as a valuable resource, especially for data sparse areas, but that soil moisture sensors are important for validation and ground-truthing of remote-sensed information. One state identified that existing data is not easy to access, and this should be considered.

Coverage

There is a huge variability among states related to soil moisture data collection, including USCRN soil moisture data. Many states noted the need for more soil moisture stations, with specific examples and reports documenting this need. Several states do not have any USCRN sites (e.g., Delaware) but still recognize the value of long-term reference quality data for the greater good. States such as Utah have over 130 mesonet stations, but these do not include soil moisture sensors. Georgia has many soil moisture stations, but still relies on the USCRN soil moisture data to validate their networks. Because there are so few stations that report soil moisture, state climate offices noted that losing even one station could have a big impact on climate monitoring and research applications. State climate offices emphasized that observations are needed, especially in data sparse areas, to provide adequate information on soil moisture conditions, particularly across states with widely differing soil types. Soil moisture sensor depth was also cited as a key value of the USCRN network.

Period of Record

From a climatological perspective, participants highlighted that the USCRN soil moisture observations are just beginning to reach the period of record needed to produce a soil moisture climatology, and that the community has not yet realized the full value of the data. Uninstalling and potentially reinstalling at a later time would interrupt or break the climatology in a given area. Removing existing sites was deemed a poor choice due to difficulty in establishing new sites. The co-location of sites with an existing USCRN station was identified as critical.

Sustaining Networks

The town hall discussed sustaining a national reference network that can be cooperatively managed with high-quality data. State climate offices highlighted the National Mesonet Program as an example of how the federal government can access data at a reasonable cost. They also suggested other federal-state partnership models for observing networks for consideration to support the operations and maintenance of the USCRN soil moisture network; however, these would vary from state to state, and each carried their own challenges to implement.

Upper Missouri River Basin (UMRB) Annual Meeting, February 8, 2024

A dialogue on the value of USCRN soil moisture data was held as part of the 2024 Annual Meeting. Input collected from meeting participants largely aligned with input received in the stakeholder survey and at the AASC Town Hall. Examples of use cases attendees identified include use in modeling (with regional modeling highlighted), research into sensor performance and comparison, and bias correction of models and filling in missing data. The value of the data mentioned included the ability of a longer period of record to better capture climate dynamics, reliability of data, and that the location of sites are in good locations. Also mentioned was (1) that the full set of USCRN data (soil moisture, relative humidity, along with temperature and precipitation) can determine evapotranspiration (ET) and total water, which was identified as a valuable indicator and (2) that the USCRN soil moisture data may not have high value on its own, but there is high value when combined with other data and resources.

National Professional Association Meetings

Town halls related to soil moisture at the 2024 American Meteorological Society (AMS) Annual Meeting and the 2023 American Geophysical Union (AGU) Annual Meeting referred to the USCRN soil moisture network for awareness purposes, but no specific use cases were documented.

Appendix A

Table A-1. Specific use case examples of USCRN soil moisture data from the survey

Operational
Assimilating satellite soil moisture data products into the National Oceanic and Atmospheric Administration (NOAA) Numerical Weather Prediction and water models
Provide state level recommendation to the U.S. Drought Monitor and in state drought monitoring group discussions
Provide drought and water availability information to farmers and farmer groups from state level
Operating the Level 1 operational systems for receiving, quality controlling, archiving, and providing access to USCRN Soil Moisture and Temperature Observations
Contribution of operational products that are part of NationalSoilMoisture.com
The development of Soil Moisture Active-Passive(SMAP)-Hydroblocks dataset
Critical inputs for local scale (30m) forecasts of soil moisture profile conditions affecting rangeland, forest and agricultural productivity, and drought and fire risk across Montana and the western U.S.
Produce value added products, including daily and hourly (daily01 and hourly02) layer-averaged soil data, soil moisture climatology, standardized soil moisture, and drought indices products
Downscaling satellite-derived soil moisture using Soil Moisture Spatial Inference Engine (SOMOSPIE)
Development - Satellite calibration/validation and model verification
Development and evaluation of Land Surface Models (e.g., models from National Corporation for Atmospheric Research [NCAR], U.S. Army Corps of Engineers [USACE])
Calibration and validation of the European Organisation for the Exploitation of Meteorological Satellites Satellite Application Facility (EUMETSAT H SAF) Surface Soil Moisture products
Validation of National Water Model modeled soil moisture output during development of model upgrades
Calibration and validation of NOAA National Environmental Satellite and Data Information Service (NESDIS) Soil Moisture Products System (SMOPS) Daily Blended Products
Evaluation of NOAA Climate Prediction Center land surface model products (e.g., CPC Leaky Bucket model)
Verification and validation of the SOILWAT2 ecosystem water balance model
Calibration and validation of the Global Navigation Satellite Systems-Reflectometry (GNSS-R) satellite soil moisture retrievals
Validation of global soil moisture retrievals from Soil Moisture Active Passive mission (SMAP)
Validate Soil Moisture Active Passive (SMAP) satellite soil moisture data

Downscale satellite soil moisture data, validate algorithms, and in near future for calibration/validation of NASA-Indian Space Research Organization (NISAR) satellite data
Validation of the Rapid Refresh/Rapid Update Cycle of the High-Resolution Rapid Refresh model (RAP/HRRR) soil-atmosphere interactions
Development - Product development
Development of simple models that can be used to better characterize plant and soil responses in land simulation models
Calibrate and adjust modeled and remote sensed values to inform river/flash flooding forecasts
NOAA NESDIS satellite soil moisture operational product system development, validation, and applications
Evaluate flash droughts and evaluate our low-cost soil moisture sensors performance
Used in downscaled remotely sensed soil moisture products
Developed a multi-year retrospective global land surface analysis (using the National Aeronautics and Space Administration Land Information System)
Produce a suite of products based on USCRN soil moisture observations
Data assimilation in gridded and operational soil moisture products
Calibration and validation for satellite-derived soil moisture products (e.g., NASA Signals of Opportunity P-band Investigation [SNOOPI])
Development of operational national and regional soil moisture maps
Standards development for Kansas mesonet network
Set community best practices to inform National Science Foundation National Ecological Observatory Network (NEON) operations
Calibration and validation of high-resolution soil moisture products derived from remotely sensed data sources
Research
In situ validation studies on several models and European Space Agency (ESA) and NASA satellite soil moisture products
Use soil moisture to characterize/define, monitor, and predict flash droughts in the Southeast U.S.
Use soil moisture data in developing research on low flow and ecological system
Understanding soil moisture conditions before wildfire
Research activities in regards to wetland and water quality studies
Artificial intelligence and machine learning model development for research
Developing insights into drought propagation dynamics and soil hydraulic characterization

Evaluating a temperature-vegetation-shortwave infrared reflectance dryness index (TVSDI) in the continental United States
Assessing long-term sensor performance for the U.S. Geological Survey
Calibration and validation for remotely sensed sources to study thermal inertia methods
Better understand regional water demands and crop water use in arid climates
Evaluating soil moisture models to determine their relative strengths and weaknesses for use in national drought monitoring and wildfire danger ratings
Validate new methods of indirect estimation of rootzone soil moisture dynamics based satellite datasets
Validation of Cosmic-Ray Neutron Technology (CRNS) and Geosynthetic-reinforced soil (GRS) research
Produce land-atmosphere coupling indices
Validate operational soil moisture products and remote sensing products
Evaluate soil moisture models nationwide and to develop better ways of estimating soil hydraulic properties which are critical to hydrologic modeling