Soil Moisture Mini-Workshop #1 Summary

April 16, 2021

Overview

The first US GEWEX Soil Moisture mini-workshop convened around 40 attendees, about half of which were from outside of the typical USGCRP circles. Participants were representing a wide spectrum across climate-weather-water sciences, including researchers and those who relay on information for decision-making.

US GEWEX convened this mini-workshop under the theme of hydroclimate studies. Activities under this theme are focused on enhancing interagency coordination and collaboration, and this workshop initiated on the theme of soil moisture. US GEWEX recognizes that multiple soil moisture observations, modeled products, and metrics/indices exist and are supported across agencies. Better awareness of what they are, how they should/could be used, and how they might work together supports science progress toward GEWEX science goals.

After brief introductions from the NCO (Drew Story) and the SGCR DOE Principal (Gary Geernaert) the US GEWEX members, Jared Entin (NASA) and Jennifer Arrigo (DOE), shared their vision for the hydroclimate workstream and objectives for the mini-workshop series before transitioning to the invited presentations. The April workshop featured speakers from seven different soil moisture groups with a primary focus on in situ observations. In the workshop, speakers delivered successive 10-minute presentations before the meeting transitioned to full group discussion.

Invited Speakers

Soil Moisture Activities: Observational Networks, Data, Products, and Syntheses

National Integrated Drought Information System (NIDIS) – Veva Deheza
The National Integrated Drought Information System (NIDIS) has a connection to soil moisture through drought monitoring. NIDIS utilizes an interagency approach for creating and supporting a national Drought Early Warning Systems (DEWS). This goal is achieved by developing regional DEWS to address information needs that differ across the country. By working regionally to build upon existing networks of federal, tribal, state, local, and academic partners, the ultimate goal is for climate and drought science to become more accessible and useful for decision-makers. So far 9 regional early warning systems across the country have been established. Each of the regional DEWS has elements of 5 components: (1) observations and monitoring; 2) predictions and forecasting; 3) communication and outreach; 4) planning and preparedness; 5) interdisciplinary research and applications. Since soil moisture is a drought indicator for early warning of drought conditions, most of the soil moisture activities are concentrated in the Observations and Monitoring component.

There are several high-level examples where soil moisture has very clear connections to the ongoing NIDIS activities. One of them is in the area of work aiming to expose the links between droughts and wildland fires (e.g., the influence of droughts on the intensity of wildland fires, see Link). Soil moisture is a very important drought indicator that is monitored not only by the drought managers and researchers but also often used by the wildland fire community. Lastly, the newly relaunched Drought.gov website provides public access to regional and nationwide drought data and information.

National Coordinated Soil Moisture Monitoring Network (NCSMMN) – Marina Skumanich

NCSMMN is one of the **NIDIS** initiatives to guide soil moisture network deployment, data integration, and user-focused product development. With a clear recognition that information from soil moisture is important to addressing all ranges of hydrologic extremes (e.g, from droughts to flooding, as well as ongoing agricultural monitoring, forest land management, and wildfire detection), NCSMMN's goal is to build coordinated, high quality, nationwide soil moisture information that could be used in the variety of applications to inform decision making. NCSMMN follows two main directions to achieve this goal: 1) bringing together various networks into one unified and coordinated network, e.g., "network of networks'', and 2) forming partnerships with agencies at federal and state levels, as well as with research and the end-user community. NCSMMN Soil Moisture Information includes: 1) products (real-time, gridded high-resolution soil moisture maps, blending in situ, remote sensing and model data), 2) technical assistance materials (planning guides and tutorials), and 3) standards (e.g., data quality criteria and sensor performance standards).

Over the past year, the 16-member NCSMMN executive committee has worked to formalize key recommendations and a strategy (document) for the NCSMMN that was delivered to NOAA for formal review Possible opportunities for engagement between NCSMMN and USGCRP/US GEWEX could include identifying synergies across the various initiatives, initiating strategic cross-promotion, and making effective connections beyond the federal system.

Federal Soil Moisture Working Group (FSMWG) – Mike Cosh

The roots of the FSMWG began in 2015 with a launch of the NASA Soil Moisture Active Passive (SMAP) Mission with a NASA SMAP Early Adopter Program, led by Susan Morgan (USDA-ARS). A USDA Soil Moisture Working Group was formed in 2017 as one of the major milestones from the activities in the 2015-2020 Memorandum of Understanding between USDA and NASA, with a goal to coordinate USDA cooperation with soil moisture projects and missions. Since its formation in 2017, the USDA Soil Moisture Working Group has grown over time into the Federal Soil Moisture Working Group by including dozens of Federal agencies and groups. FSMWG provides a forum for the federal soil moisture community, serving as an integrator and networking location and promoting discussion and collaboration. Members meet regularly to discuss a range of topics related to the use of soil moisture information and data challenges, needs, and future direction. The FSMWG is currently focusing on understanding the landscape of identifying those stakeholders or groups that need the various soil moisture data and information that the FSMWG members provide, to better understand how to meet their needs.

AmeriFlux Network – Russ Scott and Marcy Litvak

AmeriFlux is a network of land-atmosphere monitoring stations/sites that measure ecosystem CO_2, water, and energy fluxes in North, Central, and South America. The network launched in 1996, and there are currently 523 sites and 8000 scientists registered with AmeriFlux, with 3466 unique data users in the last 5 years. About 80% of North American AmeriFlux sites have soil moisture data measurements. While AmeriFlux is a "coalition of the willing" - a network of sites managed by individual PIs - the AmeriFlux Management Project is a DOE-supported activity that provides network support for data, technology, core sites, and outreach activities.

In March 2021, AmeriFlux started a new theme for network action, "Year of Water". While traditionally AmeriFlux concentrated on the CO_2 fluxes, this effort is designed to highlight the water flux component of the hydrological cycle. Some of the applications that are related to water in the AmeriFlux network include: coupled carbon and water cycles in regions such as the southwest; land and water management in agroecosystems communities and research; remote sensing (ET, soil moisture); boundary layer dynamics, among others. NASA, DOE ASR and ARM, NOAA, Integrated Interagency Water Cycle Group, GEWEX, USDA, USGS, as well as OpenET are all identified as AmeriFlux's potential partners and audiences.

National Ecological Observatory Network (NEON) – Ed Ayres

. NEON is a continental-scale ecological observation network funded by the NSF. NEON consists of 47 terrestrial and 34 aquatic sites that span major US biomes. Soil moisture is among the ~180 unique data products that are generated via In-situ sensors, remote sensing, field and aircraft campaigns at the research sites. All data and archived samples are available online (www.neonscience.org). A typical sensor component of the terrestrial site consists of the 1) one instrumented tower that measures meteorology, eddy covariance, phenocams along with other variables; 2) five soil plots per site located 25-40 m apart in the locally dominant soil type and each soil plot produces one moisture profile. Soil water content is measured in vertical profiles up to 2 m deep. Data is available as 1-min and 30- min averages. All soil water content undergoes a range of automated QA/QC tests with an option for manual flagging as necessary. Data is published with a final quality flag on NEON Data Portal. In addition to the soil moisture data, NEON also produces many other co-located measurements (e.g., soil temperature, heat flux, and CO_2, as well as soil microbial and meteorological conditions) that could potentially be very useful to the US GEWEX community.

Despite being a very new network, NEON has already established many partnerships around monitoring, research, and validation. For example, NEON participated in the National Coordinated Soil Moisture Monitoring Network, National Soil Moisture Workshop, Critical Zone Collaborative Network Advisory Committee. NCAR incorporates NEON data into Community Land Model and NEON has been collaborating with NASA SMAP validation and expansion to forest ecosystems.

Consortium of Universities for the Advancement of Hydrologic Science, Inc (CUAHSI) – Jerad Bales

CUAHSI provides water data and community services to a broad water science community. CUAHSI started about 20 years ago to support the discovery, publication, storage, re-use of water data and models, as well as tools for collaboration among members of the academic community. Over the last 20 years, CUAHSI has evolved to serve a broader community including federal agencies. They now have partnerships with NASA, NOAA, Homeland Security, and working relationships with many others.

There are two primary platforms/technologies that CUAHSI currently operates for its data services: HIS/Hydroclient and HydroShare, both developed through NSF research projects. These two platforms are used for data discovery, access, publishing (getting DOI so it can be cited), sharing, and analyses. Hydroclient is used for the discovery and publication of time series data (http://data.cuahsi.org/). There are approximately 110,000 soil moisture time series in the U.S. and 112,756 soil moisture time series globally available through Hydroclient. HydroShare supports a broader set of hydrologic data types (datasets in different formats, images, etc.; https://www.hydroshare.org/); thus, enabling the community to more easily and freely share products resulting from their research. In addition, CUAHSI provides community services with a goal to advance education, and extend existing water-science

research capacity. Among CUAHSI services are educational opportunities, trainings, multi-organizational workshops, community meetings, and various grants.

Reducing Uncertainty in Biogeochemical Interactions through Synthesis and COmputation (RUBISCO) – Jiafu Mao, Trevor Keenan, and Forrest Hoffman.
Based on several moisture datasets (e.g., in situ, remote sensing, land surface models, reanalysis, and Earth system models), RUBISCO has developed new merged soil moisture products to highlight and address uncertainties in biogeochemical interactions. Merging multiple data sources led to overcoming the limitations of individual datasets, resulting in long-term, global, gap-free soil moisture products for research purposes. The RUBISCO team applied three merging methods to produce 7 hybrid soil moisture products with global coverage from 1970 to 2016, a spatial resolution of 0.5 degrees, monthly temporal resolution, and several vertical layers (0-10cm, 10-30cm, 30-50cm, 50-100cm). They also performed a systematic and comprehensive evaluation of the soil moisture products against the validation set of In situ observations and semi-independent gridded soil moisture data. The quantification of significant anthropogenic signals in different soil layers (see Wang et al. (2021) for more details) and improvement of the International Land-Atmosphere Model Benchmarking (ILAMB) package are two highlighted applications for soil moisture merged products. In addition, the RUBISCO team anticipates including further applications and development (e.g., analyzing the impacts of long-term soil moisture changes on C dynamics, providing initial and boundary conditions for climate modeling, assembling more in situ soil moisture datasets, and implementing other advanced fusion algorithms) and creating a new Soil Moisture Working Group.

Discussion Points

Participants in the April workshop found it useful to be able to hear from and talk to groups doing similar work. Many participants expressed that there is existing overlap and connections among many of these programs, since the in-situ soil moisture network community is rather small, but that more regular periodic inter-group updates could be helpful for coordination.

The discussion highlighted the value of soil moisture data to both water cycle research and decision makers, and showed that enhancing integration and reducing fragmentation of the various in-situ soil moisture efforts could make the data more useful to the scientific community and various other stakeholders. Agencies, researchers, and stakeholders would benefit if there were ways to better map, access, and share information on existing networks and their products and characteristics (e.g. frequency of collection, instruments, quality, length of the datasets, etc.).

Because soil moisture data is often collected and used for different purposes, there was a discussion around the relative value of historical data versus new data, the latency of data collection and reporting (including homogenization of that latency), and geographic placement of data collection, as different potential users may have different needs.

Low latency (e.g. 1-3 days, with ~1 day being ideal) is often key for decision makers and becomes critical for operational networks. Many research networks or efforts may collect data at the same or higher frequency, but they may have latency of 1 week or longer, limiting the utility to certain stakeholders.

For research users, the ability to ingest soil moisture data readily into computational frameworks, which requires standardization and formatting of both data and metadata, is seen as a key need. The in-situ soil moisture community sees strong benefits in connecting with soil moisture modeling and satellite soil moisture efforts, to understand their needs and efforts, and to make connections to these strong potential partners and users.

The workshop participants recognized that collaboration and efforts to standardized reporting, latency and metadata requirements and metadata enhancements across networks will be important to both research and application users.

Workshop participants noted the expense of in-situ network upkeep; maintaining low-latency monitoring and long term observational networks will require funds and attention.

Key Takeaways

Invited speakers described the following topics/themes as areas where additional research or coordination would be helpful:

- Standardize data reporting latency to ~1 day
- Funds are needed for in situ network upkeep; it was expressed that this is more difficult for universities to do than it would be for governments
- Periodic correspondence between various groups
- Mapping of agencies/stakeholders to their respective networks/products (getting information out in terms of frequency of collection, instruments, quality, length of the datasets, etc).
- Metadata creation or enhancement
- Computational frameworks
- Know more about and seek connections with other ongoing modeling and satellite soil moisture efforts.