AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
FUNDING CYCLE 2015 – 2017

TITLE: Wireless Sensor Network for "On Farm" Soil Moisture Data Acquisition and Irrigation Scheduling

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Summary

Currently, irrigation scheduling decisions are made based on a combination of three tools: 1) ground truth where field conditions are scouted manually, 2) evapotranspiration calculations, where a "checkbook method" is used to estimate the amount of water used and is subsequently added back through irrigation and 3) the use of soil moisture monitoring sensors. Irrigation scheduling is a key component of efficient water use (Shock et al. 2013b). When properly installed, soil moisture sensors provide a valuable resource for determining what is happening in the field. When soil water tension (SWT) for a crop has been estimated for a soil type, soil sensors provide excellent data to base scheduling decisions on (Shock and Wang 2011; Shock, et al. 2010, 2013a). Granular matrix sensors have been used as a reliable moisture sensing tool (Shock, 2003; Shock and Wang, 2011). One of the primary drawbacks to the use of soil sensors is the need to manually download or review the data onsite at the collection manifold. In recent years, work has been done to provide soil moisture sensor data on a remote platform. This enables sensors to be placed on a strategic basis rather than bound by the logistics of physical access or limited by wiring that complicates cultivation. Proper representation of field conditions can be even more critical when irrigating during drought conditions with very scarce water or when irrigating crops that are very sensitive to over- or under-irrigation (Shock, et al. 2013a).

The collection of SWT data can then be used in conjunction with crop specific guidelines for proper irrigation. By utilizing previously determined parameters for the soil moisture, SWT will provide an objective dataset to base decisions.

Having soil moisture data remotely accessible would enable managers to make decisions by accessing the data on their laptop, tablet, or smart phone. This report discusses a remote monitoring platform that was deployed at the Oregon State University-Malheur Experiment Station near Ontario, OR in 2015 and 2016. This cloud-based platform is the IRROmesh™ system using the SensMit Web™ radio platform. This system was installed in several different fields across the Malheur Experiment Station to determine its monitoring ability. Similar remote monitoring platforms have been developed by other companies with varying radio frequencies and strengths with some using cell phone technology. Many are solar powered while others are battery powered. A very similar system is the Connect™ platform by McCrometer and the WagNet™ system by AgSense. These similar systems utilize cell phone technology to provide data collection that is reported to a website for data interpretation, data storage, and remote access.

Objectives

The goal of this project was to learn more about the capabilities of platforms such as this one and how it can be applied to enable growers to improve irrigation scheduling. This scheduling tool has the opportunity to conserve water and nutrients while enhancing water quality.

Procedures

The IRROmesh™ system (Irrometer Co. Inc., Riverside, CA) was composed of an array of nodes which communicated with each other in a relay fashion using a radio communication vehicle in the Fresnel Zone. The radio waves in the Fresnel Zone bounce from one node to another, transmitting the data to a node referred to as the Base Station. The Base Station was near a personal computer (PC) link which is the first node in the mesh. All data collected at the computer was archived and posted to a website. Data could then be accessed via the internet in real-time or could be exported to a Microsoft Excel file on any internet enabled device.

The array and its sensors was programmed to report every 30 minutes. Three Watermark Soil Moisture Sensors (Irrometer Co. Inc.) and one soil temperature sensor were connected to each node. Some nodes were designated as "relay" nodes and some were "end" nodes. End nodes had only the hardware for collecting soil data and sending out signals while relay nodes were built to collect data from their own sensors and also receive messages from other nodes, then relay the data on across the mesh to the base station.

Significant Accomplishments To Date

The IRROmesh™ monitoring started in May in 2015 and 2016. This continued through the growing seasons. Watermark and soil temperature sensors were installed at predetermined sites in several different fields and crops. The sensors were installed at 8 inch depth using techniques described previously (Shock et al., 2013a) then the sensors were wired to the nodes. The array of nodes installed at the Malheur Experiment Station was representative of a layout that could be implemented by growers wanting to monitor several different crops in different fields around a base station.

After the mesh was installed and reporting and the subscription was created, users could navigate to a login page on a smart phone or laptop where they entered their own ID and password to access their account. In the example below, SWT in a quinoa field was shown for five weeks (Figure 1). The time interval of data displayed, the scale of the graph (cb=kPa), or the crop field being examined could easily be adjusted. Figure 1 shows a drying trend starting about 16 August and continuing to dry above the 50 kPa before the next irrigation on 26 August. Accessed in real-time, growers could use the data to increase irrigation duration or frequency to meet plant needs. In addition to seeing a spike of dryness as it is unfolding, there could be a chance to have a post-mortem evaluation at the end of the season. This format enables the grower to see when a field may have become too dry during the growing season. This may help explain crop quality or yield issues and enable the grower to avoid such circumstance in future years. The platform provided a "snapshot" of each node as shown in Figure 2. By holding the mouse over each icon the appropriate data is shown in a pop-up box. When nodes are not reporting on their appointed schedule, the color of the node icon will change as shown in Figure 3. The total span of the mesh deployment example is shown in Figure 4.

When accessing the data, current data was available and users could also create a custom data request and export it to an Excel workbook. Under the conditions at the Malheur Experiment Station trials, the mesh was able to communicate reliably at 1900 feet (580 meters) between relay nodes. For producers who are managing a wide number of crops and fields, remote sensor technology can help ensure that farm employees are following irrigation management guidelines. One significant barrier to adoption is the need to have a base station computer in proximity to the mesh. Platforms that operate on cell phone frequencies could be considered more flexible in their application.

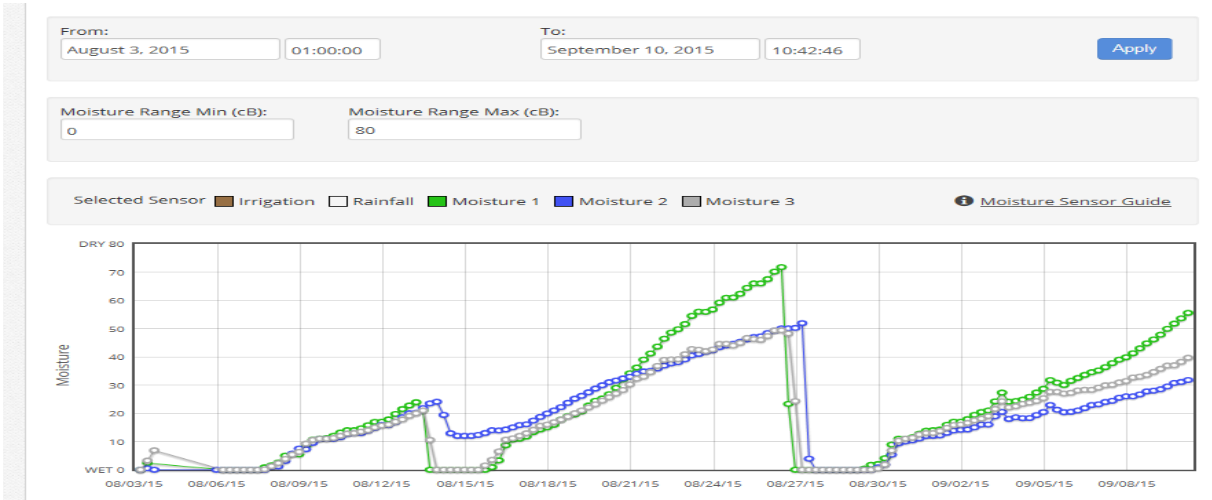


Figure 1. An example of a soil water tension records for three Watermark Soil Moisture Sensors at 8 inch depth in a furrow-irrigated quinoa field for a selected timeframe at the Oregon State University Malheur Experiment Station, Ontario, Oregon in 2015.

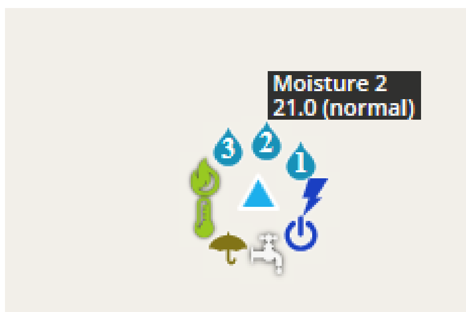


Figure 2. An schematic example of a reporting node at the Oregon State University, Malheur Experiment Station, Ontario, Oregon in 2016. The blue triangle indicates the node is reporting correctly while holding the mouse over each icon reports the current reading.

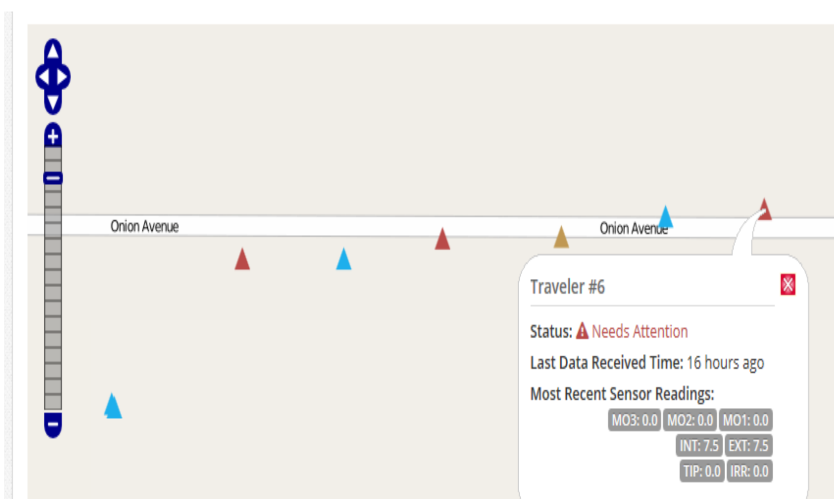
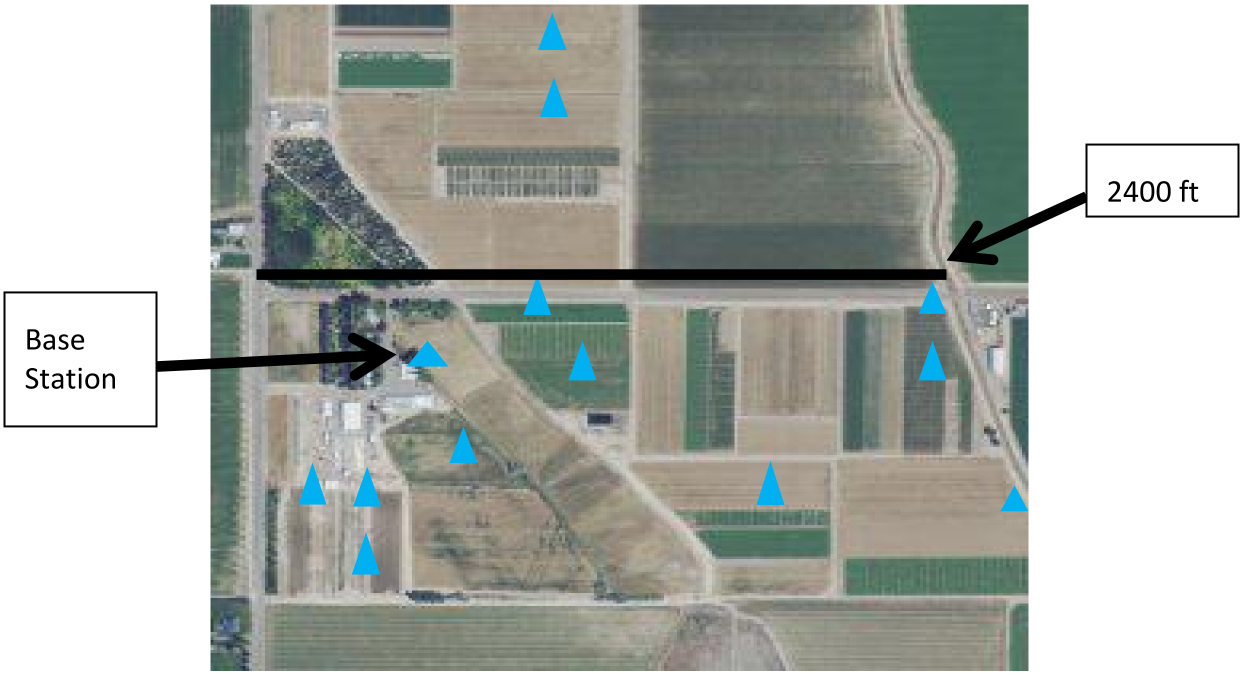


Figure 3. An schematic of a mesh deployment at the Oregon State University, Malheur Experiment Station, Ontario, Oregon. The blue indicates the node is reporting correctly, while the yellow icon indicates it has not reported recently. The red icon shows that it the node is not reporting at all.



The data that remote moisture sensors can provide for growers will be valuable and easily accessible with the Irromesh Platform. Rapid access to soil moisture data is a great aid for efficient irrigation scheduling. While an attractive irrigation scheduling tool, it should not be considered a total replacement for spending time in the field assessing conditions in person. Disease or insect pressures are still factors that need to be monitored in person as part of an integrated pest management program. The ability to access data in real-time and review the archive at the end of the season will provide quality insight into irrigation scheduling. It is important to note that optimal SWT levels for many crops are known (Shock et al. 2013a) but the levels for others like quinoa have not been determined. For crops such as the quinoa, the utility of the results is to watch the trend in soil moisture in the absence of definitive results to indicate what SWT criteria its irrigations should be scheduled by. In addition to the initial cost of the equipment, there is an annual subscription that is required to access the data.

Benefits & Impact

Greater attention by growers toward technological improvements to traditional operations continues to increase. Operators can control irrigation equipment such as center pivots with their smart phones and can add this monitoring platform as complementary information. With a continued push toward increasing water quality and water conservation, the readily available data this platform generates helpful information with little effort for equipment set-up and removal. As adoption of soil monitoring increases, this remote monitoring platform is ready for implementation as well. The following is a list of grower presentations where this technology was presented and/or discussed:

1. Grower tours of the deployed equipment in the mesh were held in conjunction with the annual Malheur Experiment Station Farm Fest on July 9, 2015 and July 13, 2016.
2. Presentation on the 2015 field results was given at the ASABE Irrigation Symposium in Long

Beach, CA on November 10, 2015.

3. A presentation on the 2015 field results was given at the Treasure Valley Irrigation Conference in Ontario, OR on December 17, 2015.
4. A draft extension bulletin has been written with the goal of making this a deliverable of the project.

Additional Funding Received During Project Term

We would like to thank Tom Penning and Jeremy Sullivan of Irrometer for their support of this trial. They have supplied much of the equipment and technical support for this project.

Future Funding Possibilities

As this work continues forward, more platforms are available to be tested and demonstrated. The Amalgamated Sugar Company has indicated they feel one of their future priorities is to better schedule irrigations and manage deep soil (3rd foot) moisture. In 2016, a separate demonstration of the McCrometer Connect platform was held in conjunction with University of Idaho extension agent Jerry Neufeld for Canyon County. This work, coupled with the work done at the Malheur Experiment Station, should lead to continued demonstrations to help with grower adoption.

Literature Cited

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