FieldNET Advisor: Remote Sensing Performance and Opportunity for Full-Farm Adoption

Abstract

In many geographies, on-farm water management tools can be used to increase irrigation efficiency returning value to growers in yield or energy savings. A barrier to the adoption of these tools stems from 1) challenging installation/setup and 2) effort on the grower's part related to carrying out the recommendation. In this work we investigate updating a digital irrigation recommendation tool, FieldNET Advisor, with a remote sensing algorithm. We test how this update performs relative to sensors installed in-field and contextualize that performance with the performance of the current FieldNET Advisor product. Results show a decrease of nearly 45% in daily evapotranspiration error (RMSE) relative to the current version of FieldNET Advisor. This update will enhance confidence in the tool as well as enable easy adoption of FieldNET Advisor at the full-farm level.

Introduction

Currently a wide range of approaches are used on-farm to decide when to irrigate. The approaches that growers use can be separated into two categories: qualitative and quantitative. Examples of qualitative approaches include things like visually inspecting the crop (looking for leaf rolling) or feeling the moisture of the soil. Quantitative approaches include measuring soil moisture using a soil moisture probe or calculating crop water use (evapotranspiration; ET) based on weather station information and crop development. A gap exists between established science-based quantitative approaches and use in-field; the USDA IWMS 2018 survey estimates about 1/3rd of growers in the United States use a quantitative approach when deciding when to irrigate [1]. While qualitative approaches can perform well, they often require trips to the field which can be inefficient as farms increase in size and as growing seasons become hectic.

As an irrigation company, we are well-suited to help growers make irrigation decisions as we can provide valuable information relevant to irrigation (rainfall, previous irrigation application, soil information, crop development) to the grower via software solutions as well as create tools that allow growers to easily carry out irrigation recommendations. Currently we offer an irrigation recommendation tool called FieldNET Advisor that tracks weather conditions, irrigation application, and crop development. Figure 1 below highlights how FieldNET Advisor tracks the inputs and outputs of water on a daily basis in a field and predicts how soil moisture is changing over time.

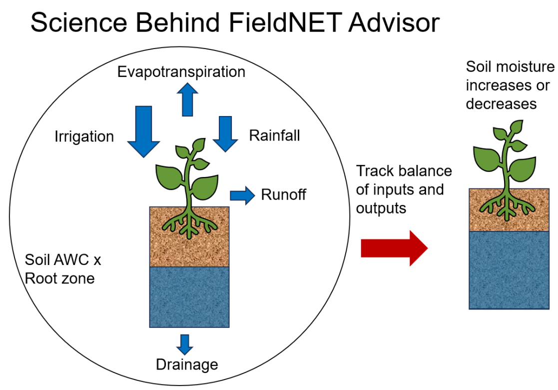


Figure 1. Daily calculation of inputs and outputs of water in FieldNET Advisor.

Continuous Improvement and User Feedback

Common feedback from users of FieldNET Advisor is that while it often returns value back to the grower, it can take too much time and effort to set up many fields. One of the most data-intense steps for users is entering crop type, variety, and planting data for every field. This information primarily is used to calculate crop growth over the season which is used to calculate evapotranspiration. We can substantially reduce the amount of effort for a user when enrolling FieldNET Advisor fields if we integrate a remote sensing algorithm to calculate evapotranspiration for growers. This is due to the use of imagery updating the model with observed crop development instead of simulating with a crop growth model. Prior to releasing this update for our users, field trials were carried out to validate and test that this change leads to as-good or better performance relative to in-field sensors measuring ground-truth data.

Methods

To validate and test the new remote sensing-based evapotranspiration algorithm, field trials were conducted in 2023 in Washington, Nebraska, Wisconsin, and Georgia within corn, soybean, potato, and cotton fields. The field trials included the collection of data pertinent to assessing the accuracy of the new remote sensing-based evapotranspiration as well as the difference of this new approach relative to the current version of FieldNET Advisor. To collect in-field data, Arable Mark 3 weather stations [2] and Sentek Drill and Drop probes [3] were deployed in each field which provided measurement of rainfall, evapotranspiration, canopy development, and soil moisture.

Figure 2. Installation of Arable Mark 3 in field in Nebraska

Results

The 2023 field trials provided insight on the accuracy of the remote sensing-based ET approach in relation to the Arable Mark sensor and the original FieldNET Advisor model. Figures 2 and 3 display the time series daily and cumulative ET from all three approaches for Sites 1 (corn) and Site 7 (potato).

Relative to the ET measurements from the Arable Mark 3, daily ET from the remote sensing-based approach had lower error than the original FieldNET Advisor model (RMSE reduced by 45%). Table 1 summarizes these results using the mean bias error and root mean squared error metrics (RMSE), where values closer to zero represent a better comparison.

Discussion and Conclusion

The results from 2023 field trials indicate that the remote sensing-based ET approach is providing better estimates of daily ET than the original FieldNET Advisor model when compared to ET provided by the Arable Mark 3 sensor. One reason for the improved accuracy may be due to the overall workings of the three methods. The Arable Mark 3 sensor and remote sensing-based ET approaches both use a reflectance-based method to measure and track the development of the crop. This feature provides real-time insight on the development of the crop.

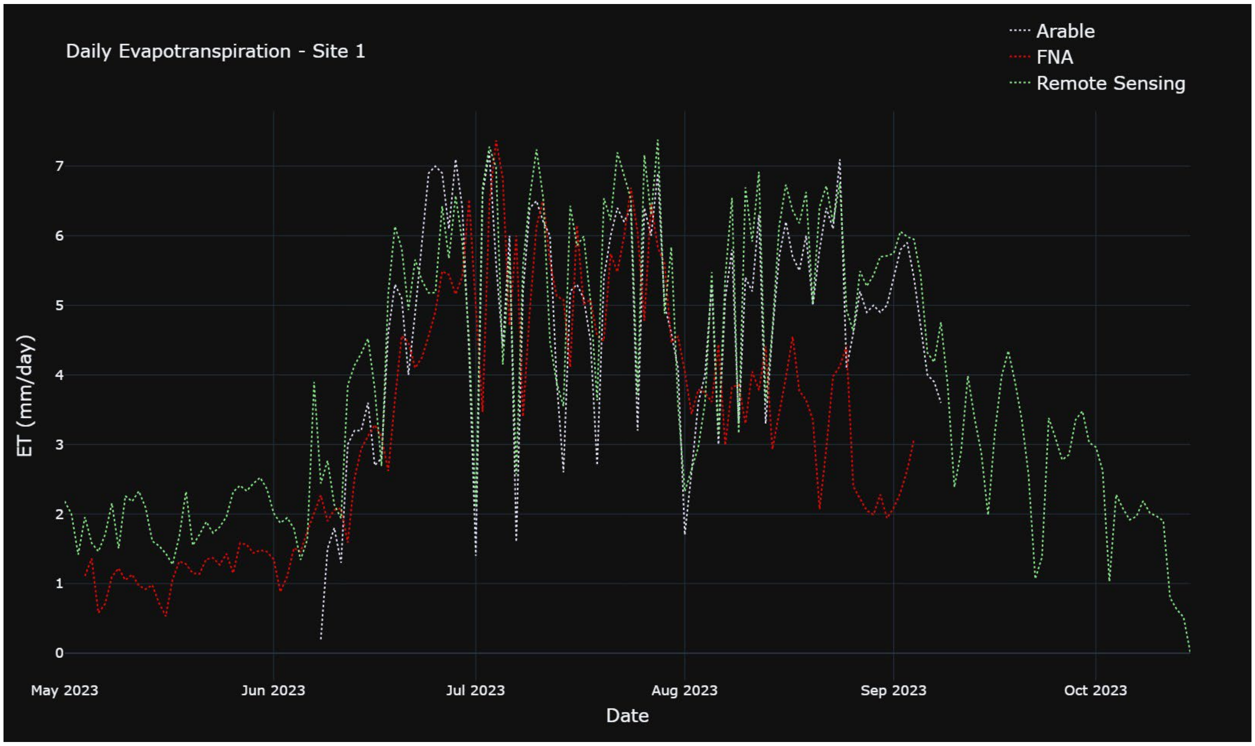
Future field trials will continue to build on this analysis, further testing the accuracy and confidence in the remote sensing-based ET approach. One notable addition to future field trials will be the use of eddy covariance systems to measure ET. These systems are seen as one of the leading sensors in research and industry for measuring ET and will help provide data needed to continue to refine and improve FieldNET Advisor.

References:

[1] USDA: Farm and Ranch Irrigation Survey (2018), Washington, D.C., available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Farm_and_Ranch_Irrigation_Survey/fris_1_0023_0023.pdf/ (last access: 05 January 2023)

[2] Arable Mark 3. 06 Dec 2022, https://www.arable.com/mark3/

[3] Sentek Drill and Drop (n.d.) https://sentektechnologies.com/products/soil-data-probes/drill-drop/



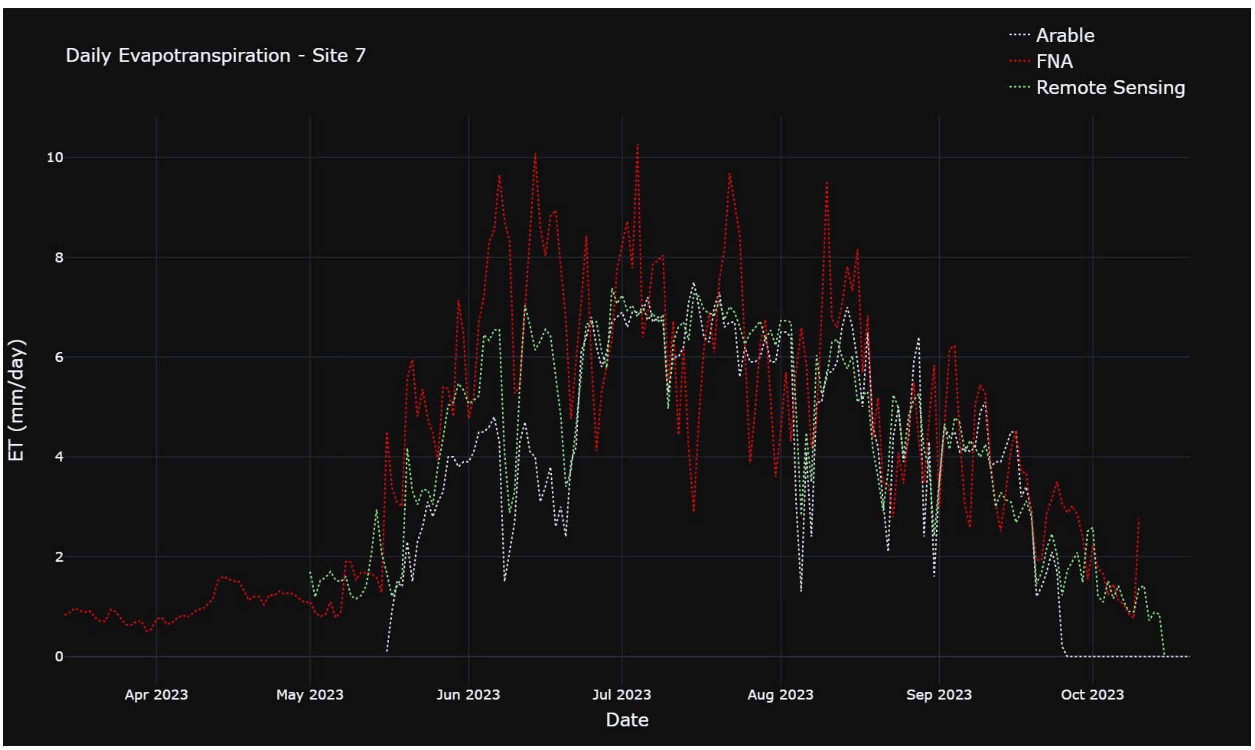
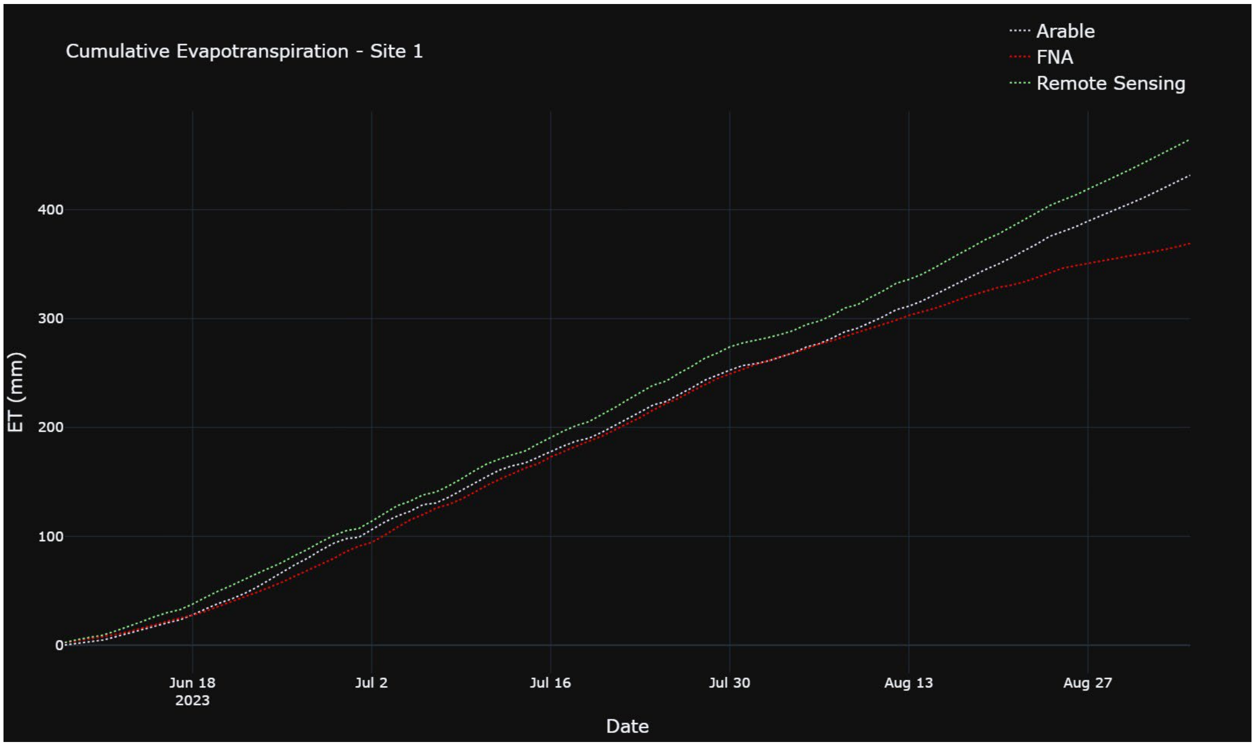


Figure 2. Daily evapotranspiration (ET) calculated using the Arable sensor, FieldNet Advisor model (FNA), and the remote sensing-based approach (Remote Sensing) for Site 1 (corn) and Site 7 (potato).



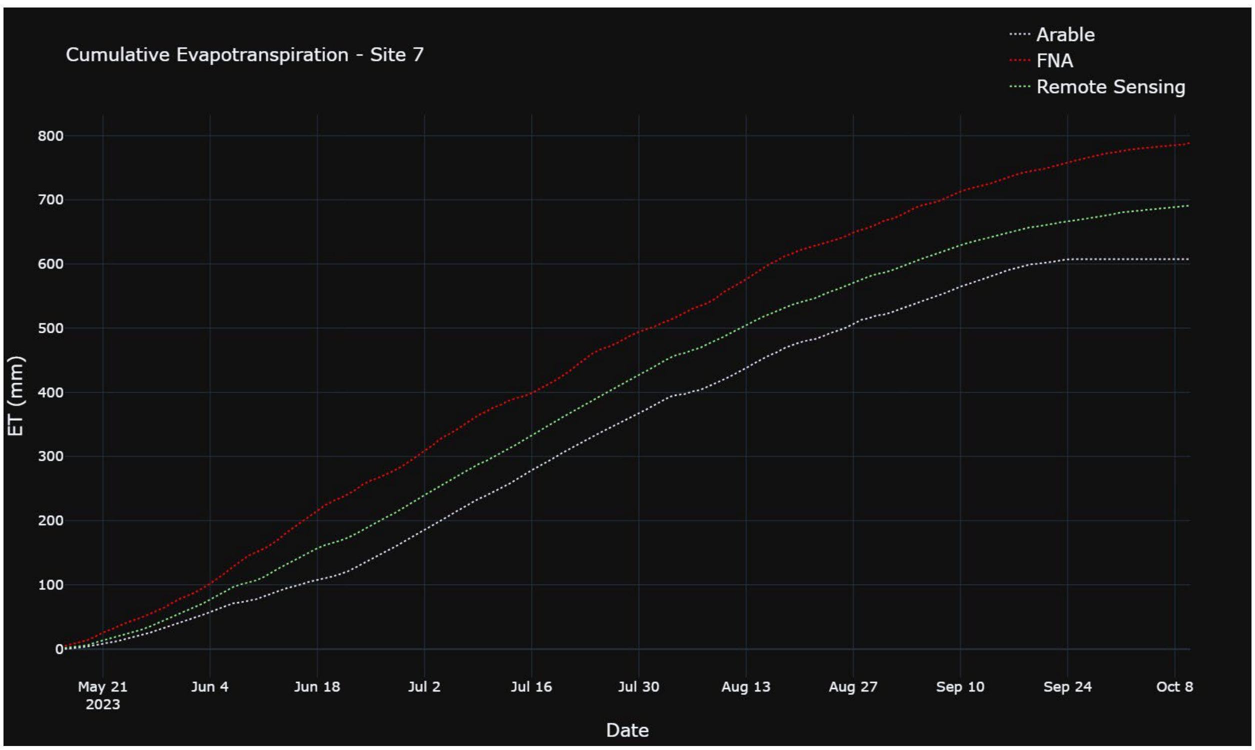


Figure 3. Cumulative evapotranspiration (ET) calculated using the Arable sensor, FieldNet Advisor model (FNA), and the remote sensing-based approach (Remote Sensing) for Site 1 (corn) and Site 7 (potato).

Table 1. Comparison of evapotranspiration from the remote sensing-based approach and the original FieldNET Advisor model to the Arable Mark 3 sensor.

		Mean Bias Error[1] (mm/day)		Root Mean Squared Error[2] (mm/day)	
Site	**Crop**	Arable vs FNA[3]	Arable vs RS[4]	Arable vs FNA	Arable vs RS
Site 1	Corn	-0.70	0.37	1.87	0.74
Site 2	Corn	-0.57	0.50	2.01	1.10
Site 3	Cotton	0.84	0.49	1.91	1.08
Site 4	Cotton	-0.12	0.03	1.81	0.61
Site 5	Cotton	0.39	-0.34	1.82	1.65
Site 6	Potato	3.93	1.76	4.34	2.25
Site 7	Potato	1.23	0.57	2.33	1.12
Crop					
Corn		-0.64	0.44	1.89	1.16
Cotton		0.37	0.06	1.84	1.11
Potato		2.58	1.16	3.34	1.68
All Sites		0.88	0.47	2.40	1.32

[1]*Mean Bias Error: represents the average difference between predicted and true values, indicating the overall bias high or low.*
[2]*Root Mean Squared Error: represents average magnitude of the differences between predicted and true values, providing a comprehensive measure of overall prediction accuracy.*
[3]*FNA: Original FieldNet Advisor model evapotranspiration.*
[4]*RS: Remote sensing-based evapotranspiration.*