Soil water sensing from afar: How the Cloud is enabling remote data collection

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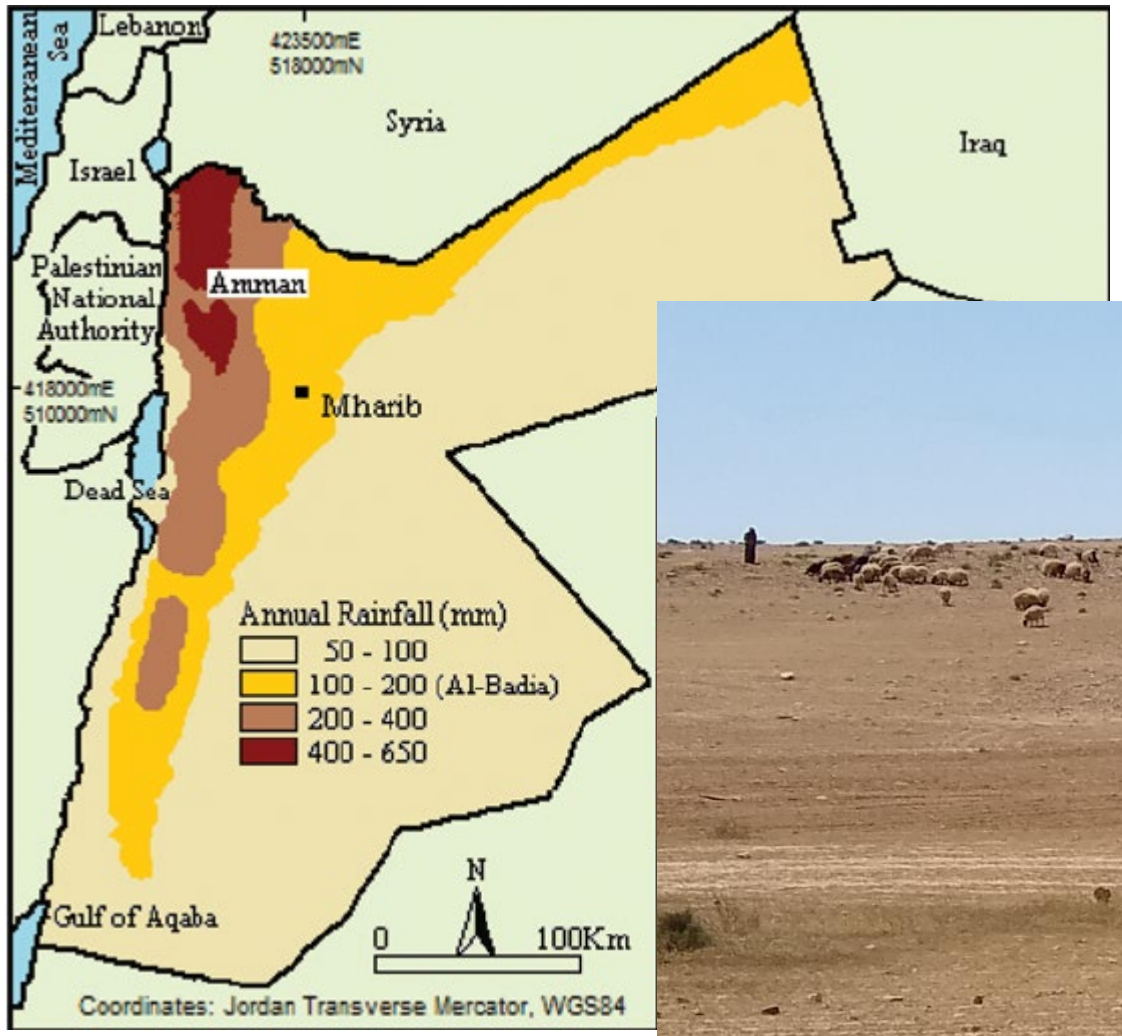
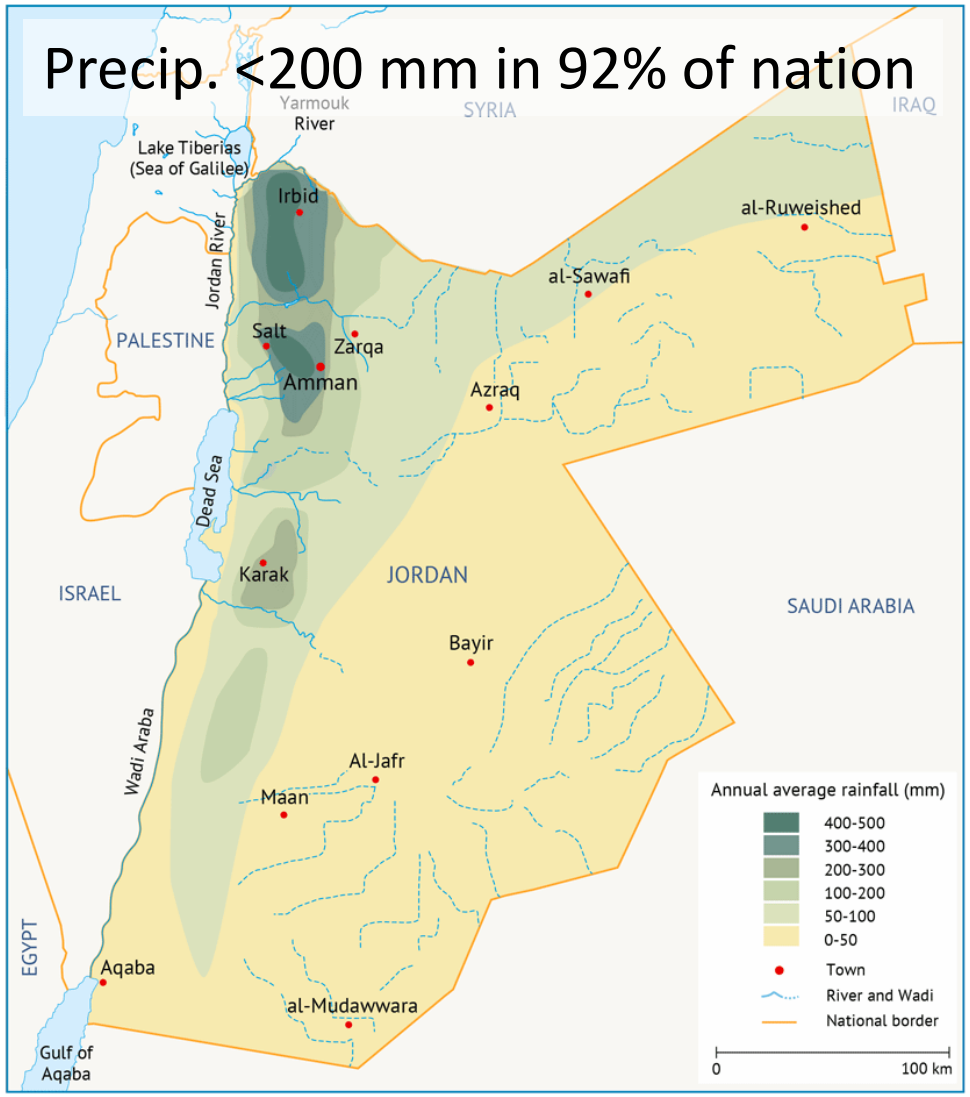
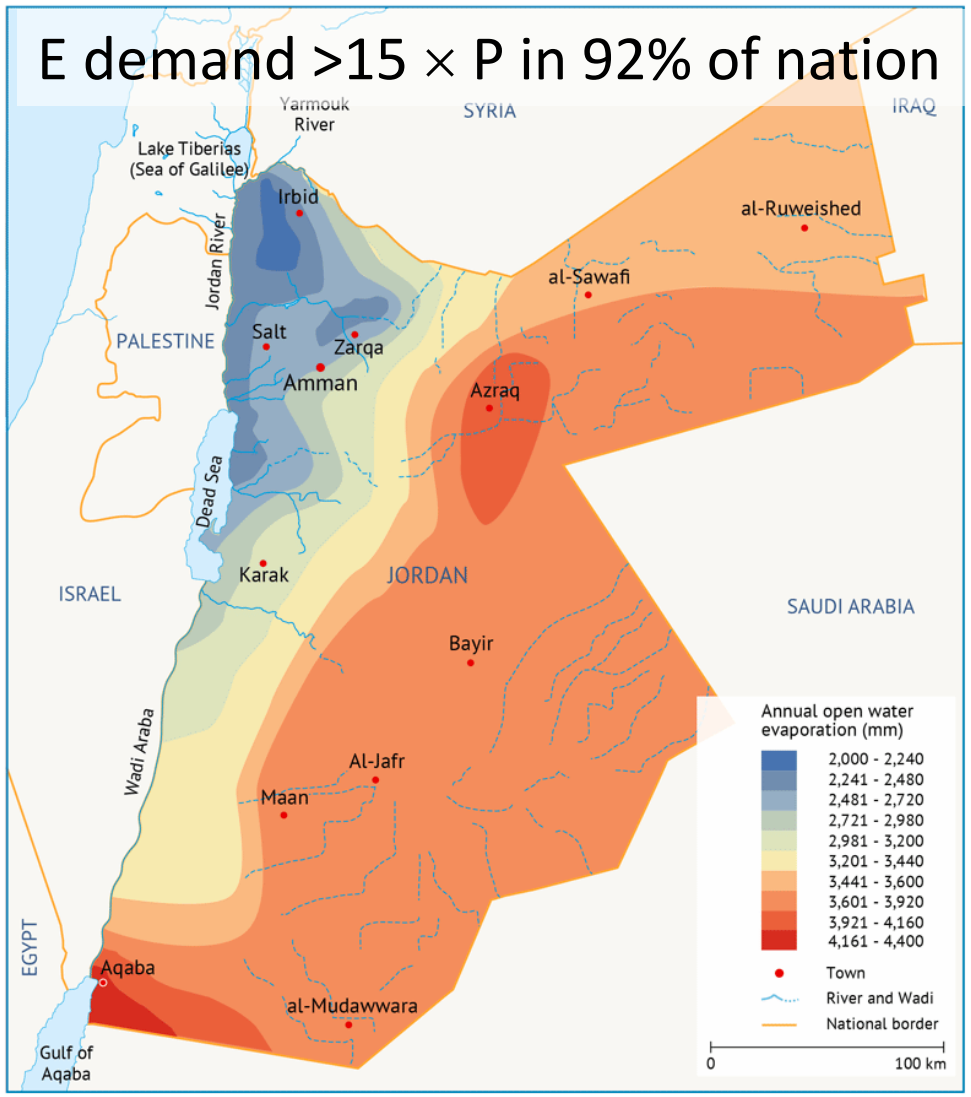
Jordan Rangeland Restoration



- 93% of Jordan is rangelands or desert – mostly degraded – overgrazing, climate change
- $Millions spent with little result due to:
- Poor siting of restoration practices – a major gap in knowledge
- Precipitation <200 mm in 92% of nation

Small precipitation – Large evaporative demand → Store water in soil and aquifer

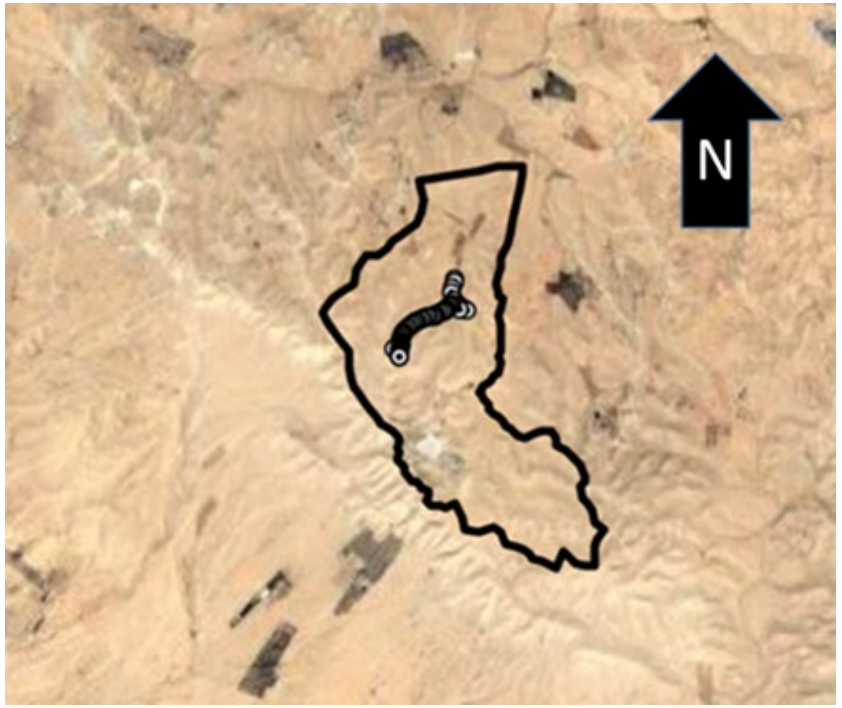




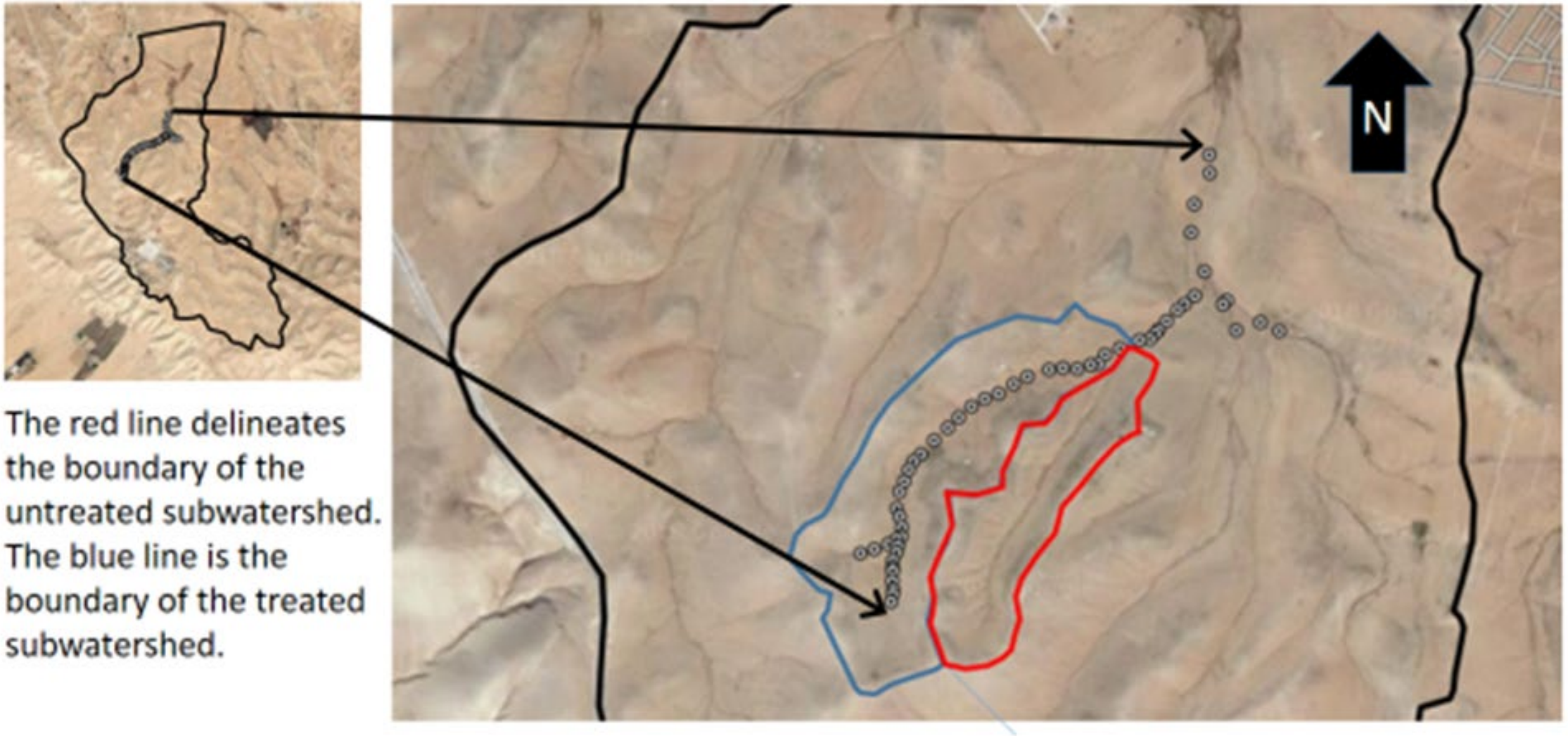
FAO (2018)
An assessment of policies, institutions and regulations for water harvesting, solar energy, and groundwater in Jordan: A review and gap analysis.
Maher Salman, Claudia Casarotto, Maria Bucciarelli and Maria Losacco

Jordan Watershed Rehabilitation

- ICARDA Benchmark Watershed at Majdiyyah near Amman, Jordan
  - Water and Livelihoods Initiative-ICARDA
- Joint with ICARDA, U.S. Forest Service, USDA ARS, National Centre for Agricultural Research, Jordan
- 953 ha, semi-arid to arid, 260 mm mean precip.
- Severely degraded rangeland
- Goal: Enhance sustainability. Objectives:
  - Determine how, where and why given restoration practices work or don't work
  - Develop modeling framework for predicting regions where given practices have a likelihood of working



Paired watershed research approach



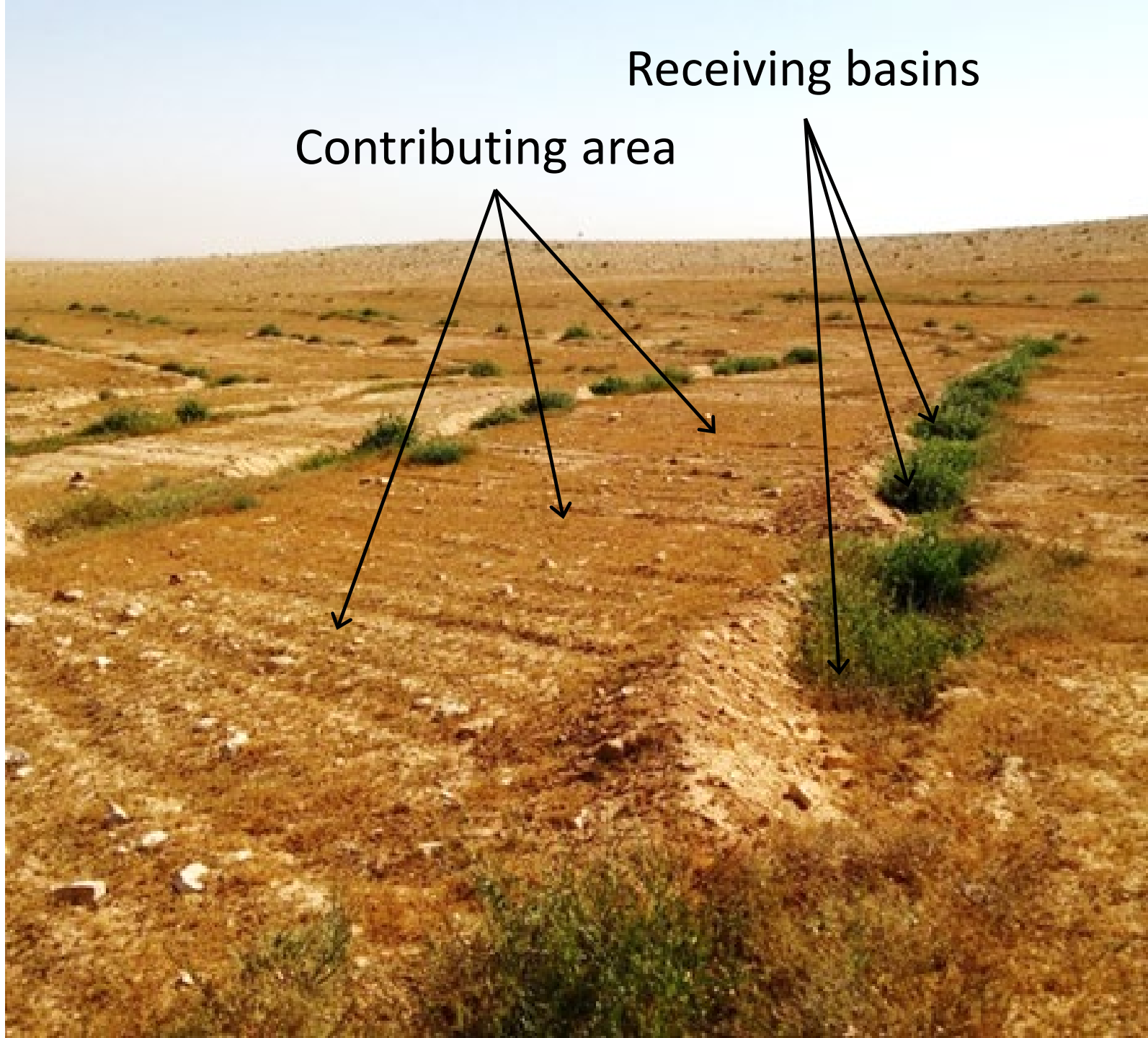
The red line delineates the boundary of the untreated subwatershed. The blue line is the boundary of the treated subwatershed.

Contour basins

- Made with Vallerani plow
- Spacing between contours maintains runoff in sheet flow mode – no rilling detected
- Discontinuous basins allow safe exit of water if filled

Vallerani basins

- Planted to atriplex and other species in 2016
- Note furrows up- and down-slope from previous barley planting



Gully plugs

- 55 rock gully plugs
- 37 in treated watershed

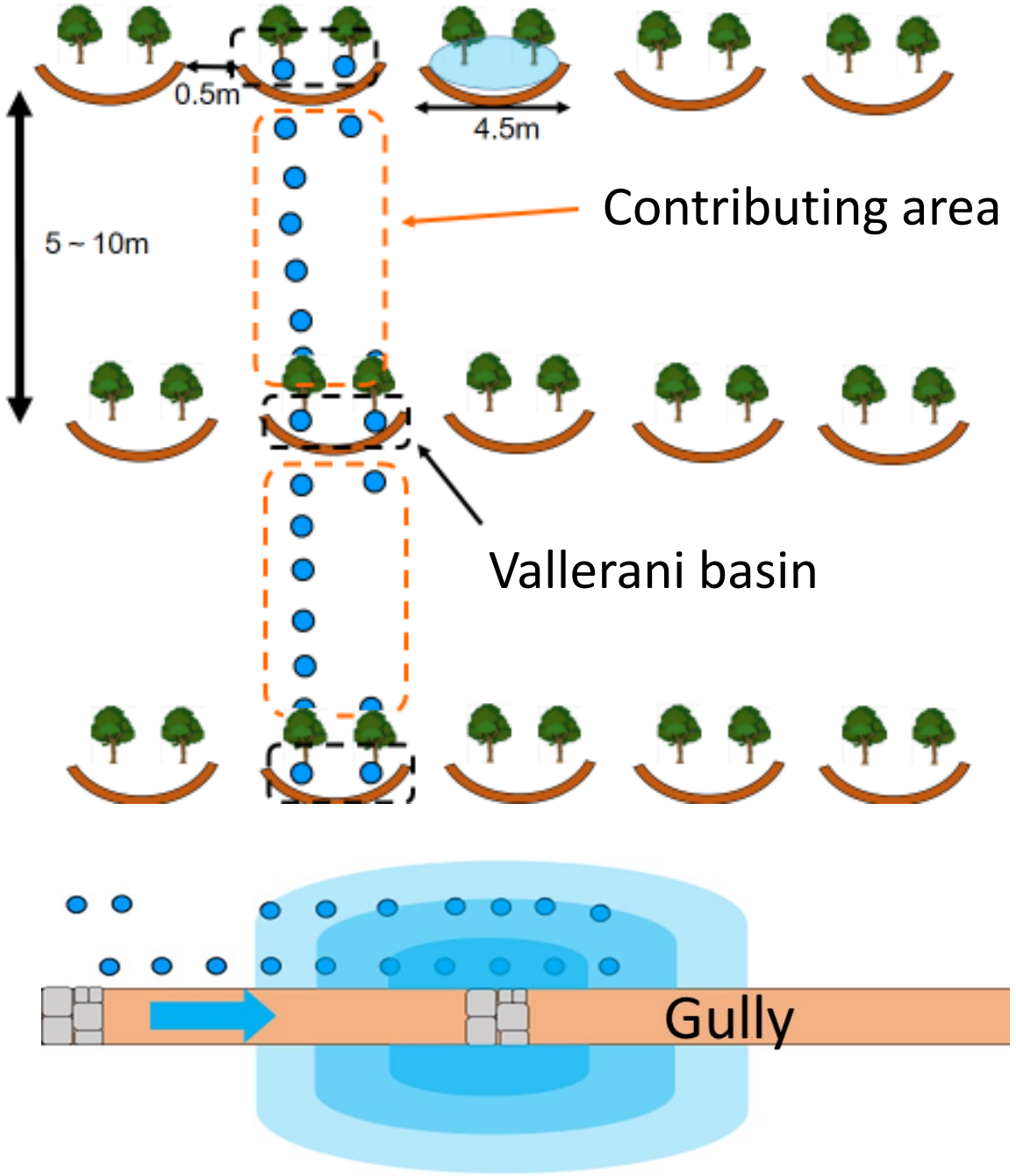
Designed to

1. Trap sediment,
2. Increase retention time and infiltration
3. Allow vegetation to take root

Gully plug effects

Extant measurements

- Trime access tubes in basins and interspaces
- Trime access tubes along gully
- Trapezoidal weir in gully
- Manual Trime readings done intermittently
- Weir readings on 5-min basis
- **But, data gaps limit usefulness**



Rationale for automated, wireless soil water sensing

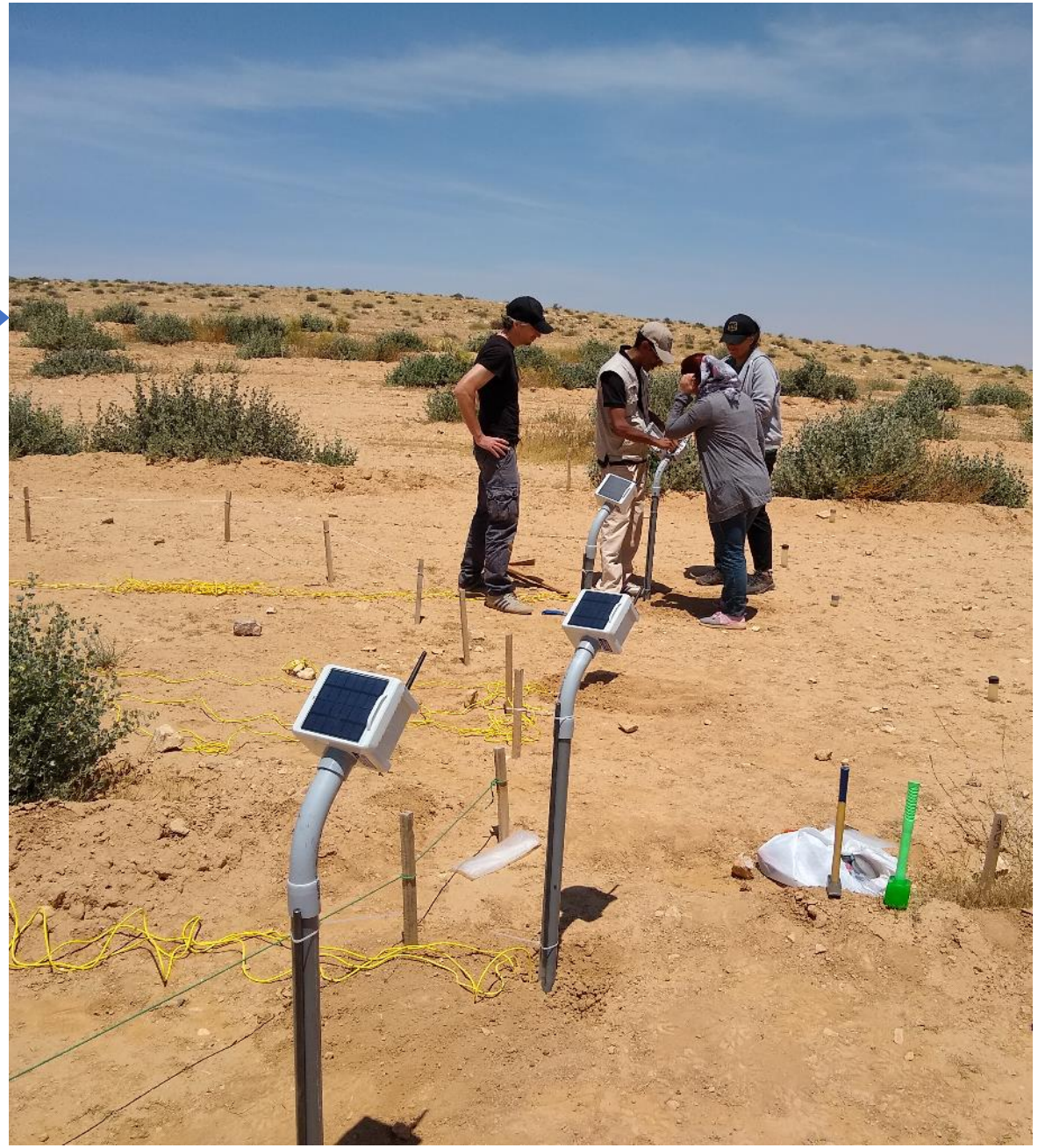
- NEED: Spatiotemporal water content data on smaller time and space increments without large labor costs in site visitation and with remote access and support
- WHY:
  - Data for inverse modeling of soil hydraulic characteristics
  - Data to document volumes of water stored in the soil, depths of water movement, possible aquifer recharge through the karstic bedrock
  - Data to verify model predictions
  - Need to build local expertise
- MODELS:
  - Hydrus, RHEM, SWAT

Spatiotemporal water content monitoring

- Vertical profiles of TDR sensors installed horizontally in basins and interspaces
- Wireless nodes and gateway designed by ARS Beltsville
- Sensors checked with Sensor Reader. Sensor addresses assigned using node
- Wired (SDI-12) sensors to four nodes
- One gateway receives data from the four nodes on an hourly basis and transmits data to Hologram web site via cellular network using Hologram SIM and local (Zain) cellular service
- Identical system installed at Bushland, TX

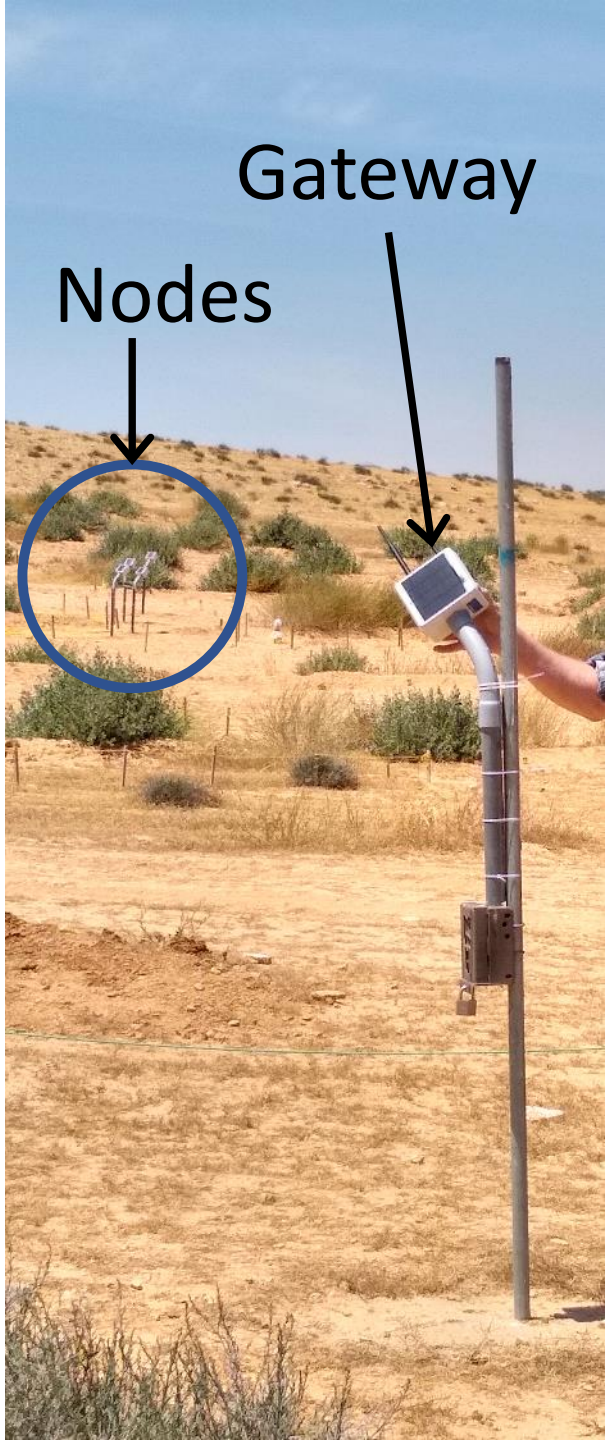
System installation

- Finishing the 4th node
- Running wires into a node



Completed installation

The team! 10 May 2019, Majdiyya, Jordan



World Wide Coverage - Hologram

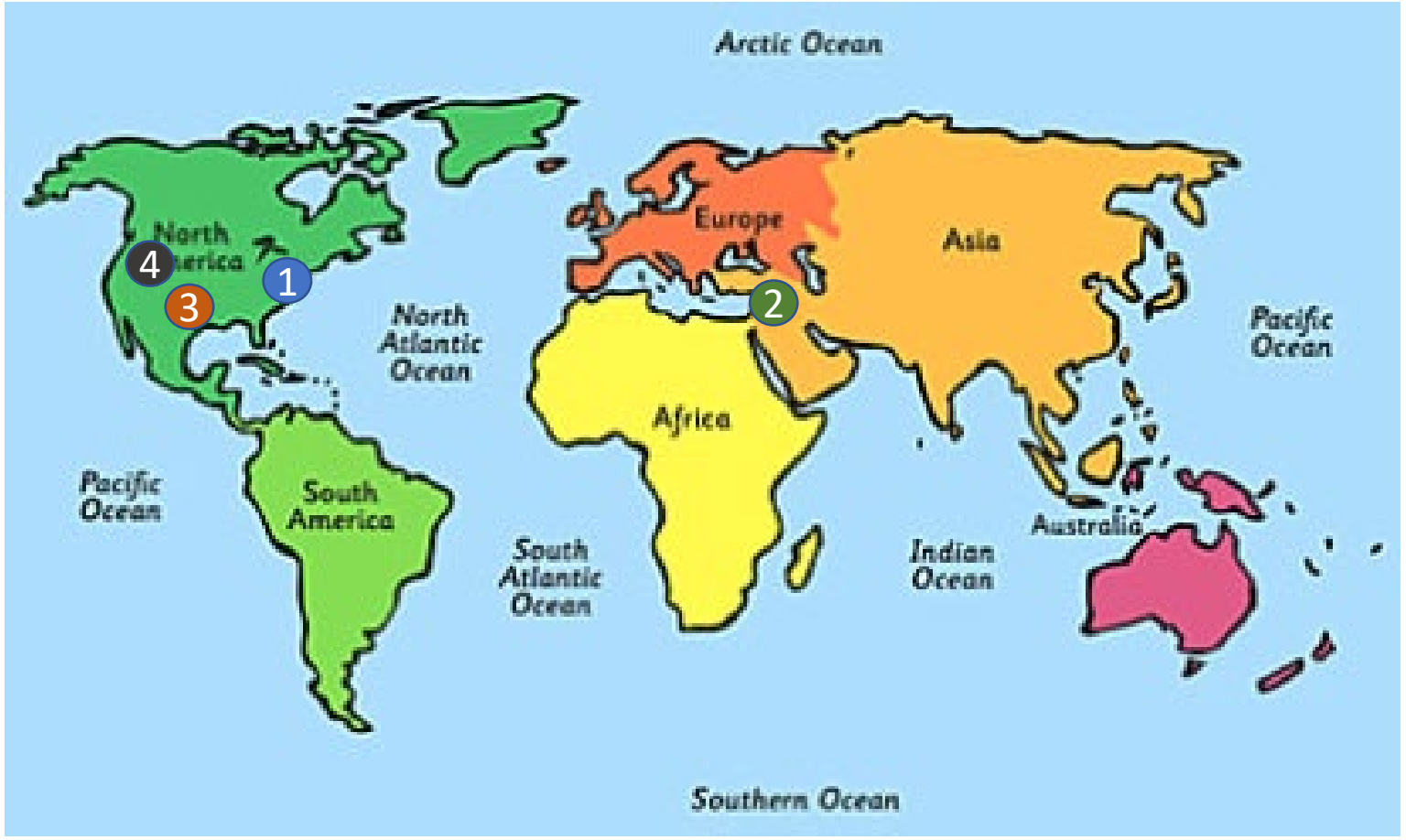
1 – Beltsville, MD

2 – Amman, Jordan

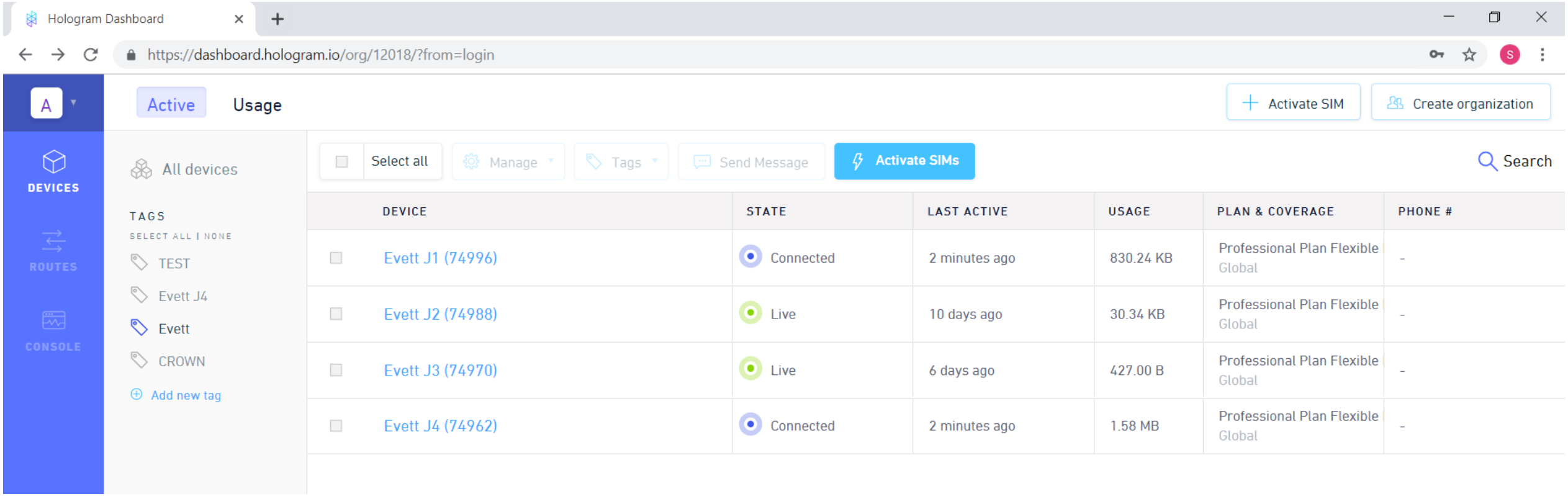
3 – Bushland, TX

4 – Meridian, ID

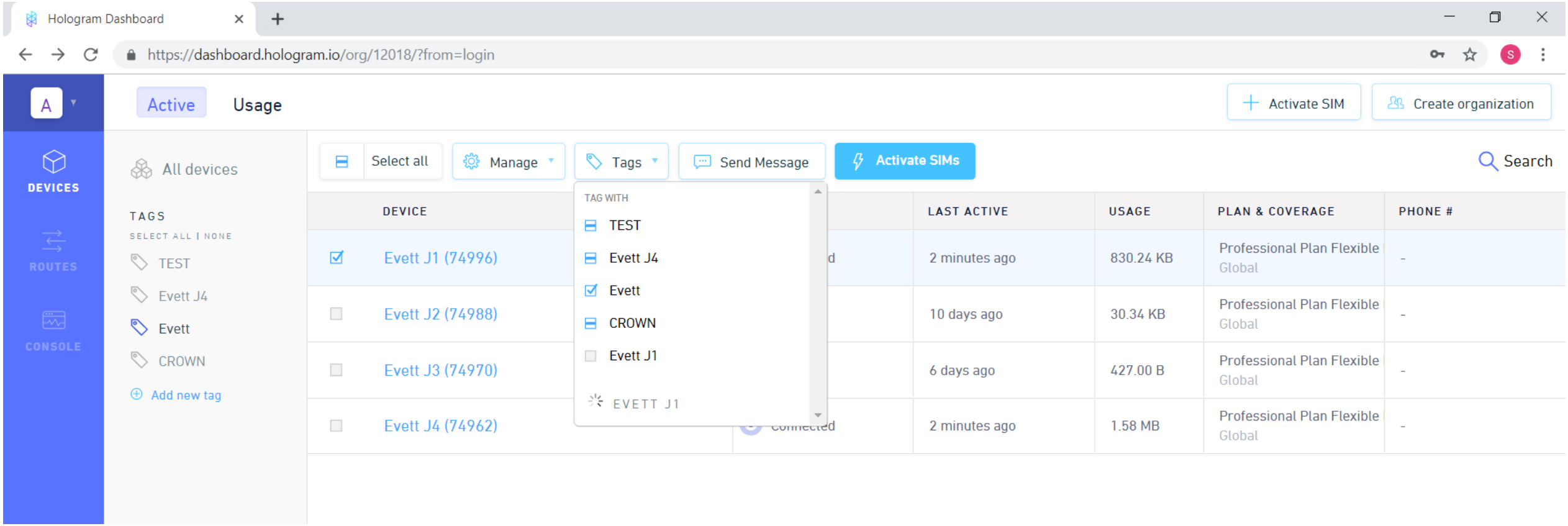
global access to 196+ countries and 550 carriers

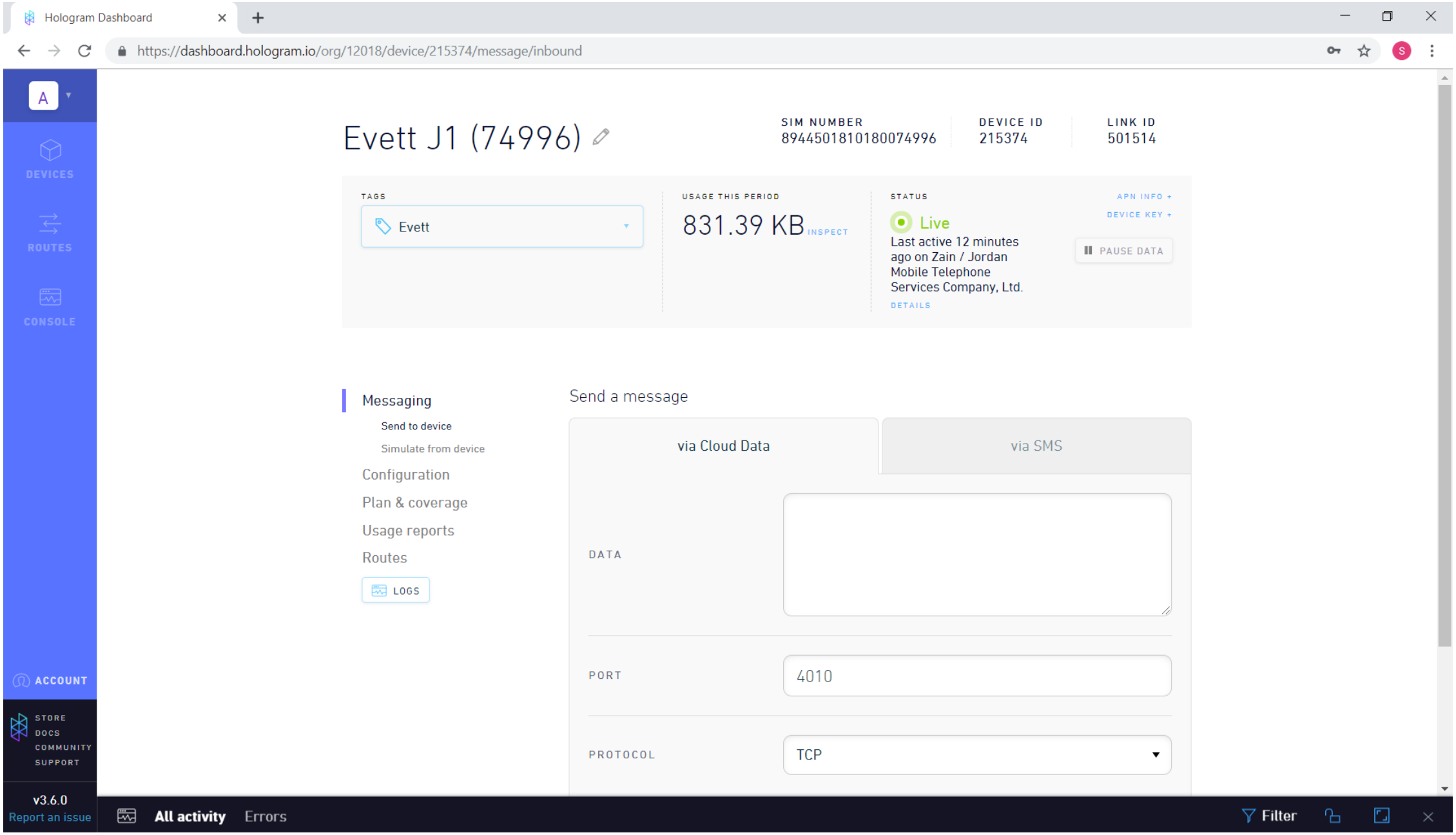


Data in the Cloud – Hologram Dashboard



Gateway in Jordan – Adding Tag for Evett J1




Hologram Dashboard
https://dashboard.hologram.io/org/12018/device/215374/message/inbound
DEVICES
ROUTES
CONSOLE
ACCOUNT
STORE
DOCS
COMMUNITY
SUPPORT
v3.6.0
Report an issue
Evett J1 (74996)
SIM NUMBER
8944501810180074996
DEVICE ID
215374
LINK ID
501514
TAGS
Evett
USAGE THIS PERIOD
831.39 KB
INSPECT
STATUS
Live
Last active 12 minutes ago on Zain / Jordan Mobile Telephone Services Company, Ltd.
DETAILS
APN INFO
DEVICE KEY
PAUSE DATA
Messaging
Send to device
Simulate from device
Configuration
Plan & coverage
Usage reports
Routes
LOGS
Send a message
via Cloud Data
via SMS
DATA
PORT
4010
PROTOCOL
TCP
All activity
Errors
Filter

Hologram Dashboard

https://dashboard.hologram.io/org/12018/?drawer=full&from=login

A

DEVICES

ROUTES

CONSOLE

ACCOUNT

STORE
DOCS
COMMUNITY
SUPPORT

v3.6.0
Report an issue

All activity | Errors

Filter

Evett J4

Most recent logs

Search by topics published

	DATA	TOPICS	
Message sent from Evett J4 (74962) KEY	NEL04~4.09~17.25~12~6.59~2019-5-19_15:00:00_UTC~0~31.7~26.6~17.9~478~2760~1~28.9~22.3~15.9~443~2983~2~36.3~28.1~21.5~586~2681~3~35.7~26.7~21.0~586~2761	NE1 DATA 6 more...	May 19 2019, 10:05:45 SIMULATE VIEW RAW
Message sent from Evett J4 (74962) KEY	NEL03~4.07~18.75~70~6.59~2019-5-19_15:00:00_UTC~4~32.0~26.6~18.1~474~2696~a~36.5~24.7~21.7~599~2712	NE1 DATA 6 more...	May 19 2019, 10:05:42 SIMULATE VIEW RAW
Message sent from Evett J4 (74962) KEY	NEL02~4.18~17.75~12~6.59~2019-5-19_15:00:00_UTC~5~40.6~31.7~25.4~796~2982~6~40.5~26.4~25.3~773~2903~7~40.8~24.9~25.5~814~3028~8~40.3~30.2~25.2~816~3079	NE1 DATA 6 more...	May 19 2019, 10:05:39 SIMULATE VIEW RAW
Message sent from Evett J4 (74962) KEY	NEL01~4.08~18.00~6~6.58~2019-5-19_15:00:00_UTC~4~42.9~20.9~26.9~808~2824	NE1 DATA 6 more...	May 19 2019, 10:05:36 SIMULATE VIEW RAW
Message sent from Evett J4 (74962) KEY	NEL04~4.09~16.25~6~6.59~2019-5-19_14:45:00_UTC~0~31.5~24.6~17.7~468~2736~1~29.0~20.6~15.9~439~2946~2~36.3~26.3~21.5~588~2690~3~36.4~24.9~21.6~586~2667	NE1 DATA 6 more...	May 19 2019, 10:05:33 SIMULATE VIEW RAW
	DATA	TOPICS	May 19 2019, 10:05:30

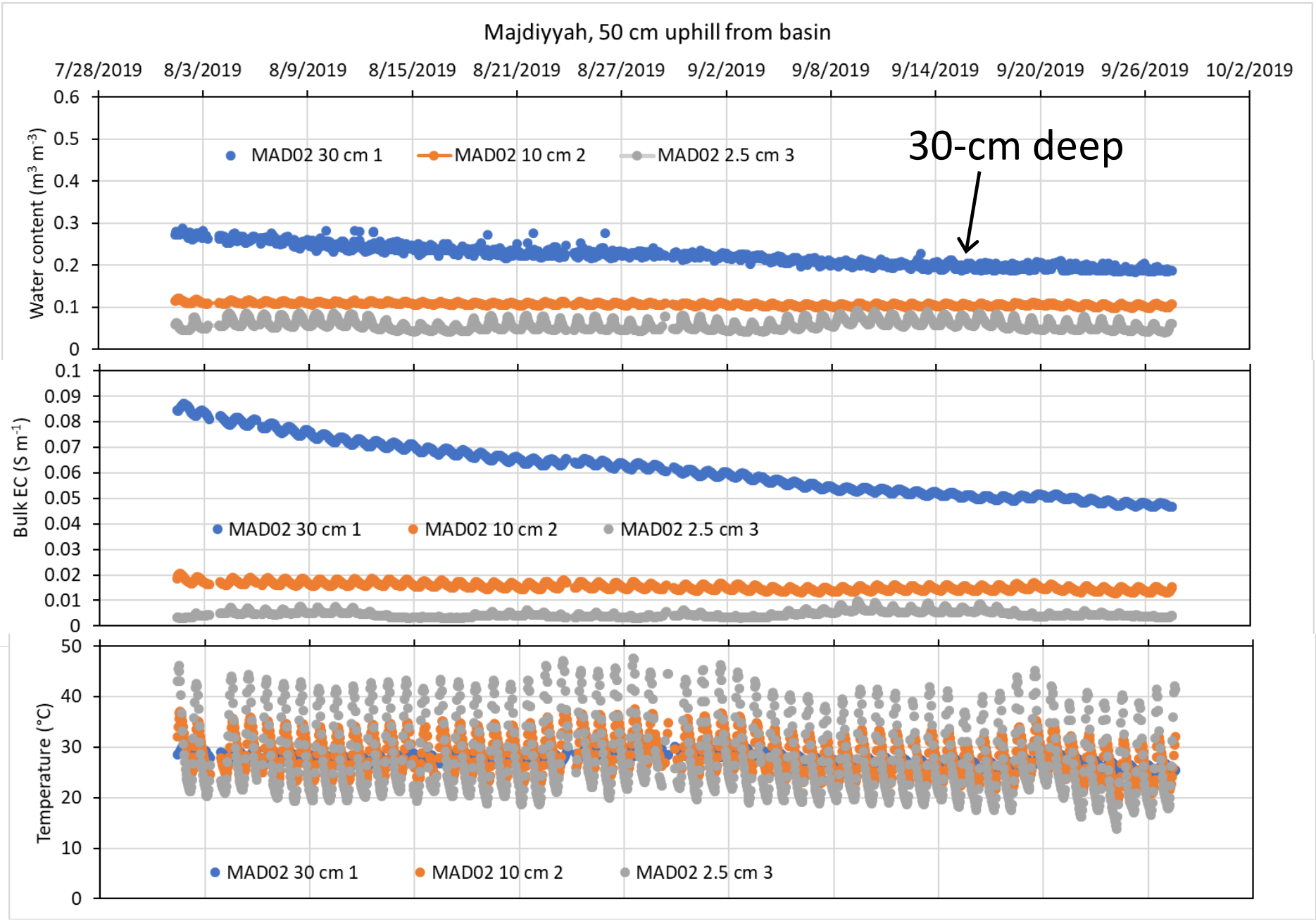
Data from the Cloud Aug-Sep

Node MAD02 at Majdiyyah, Jordan

TDR sensors installed horizontally

One sensor near the soil surface (2.5 cm depth)

Time is UTC



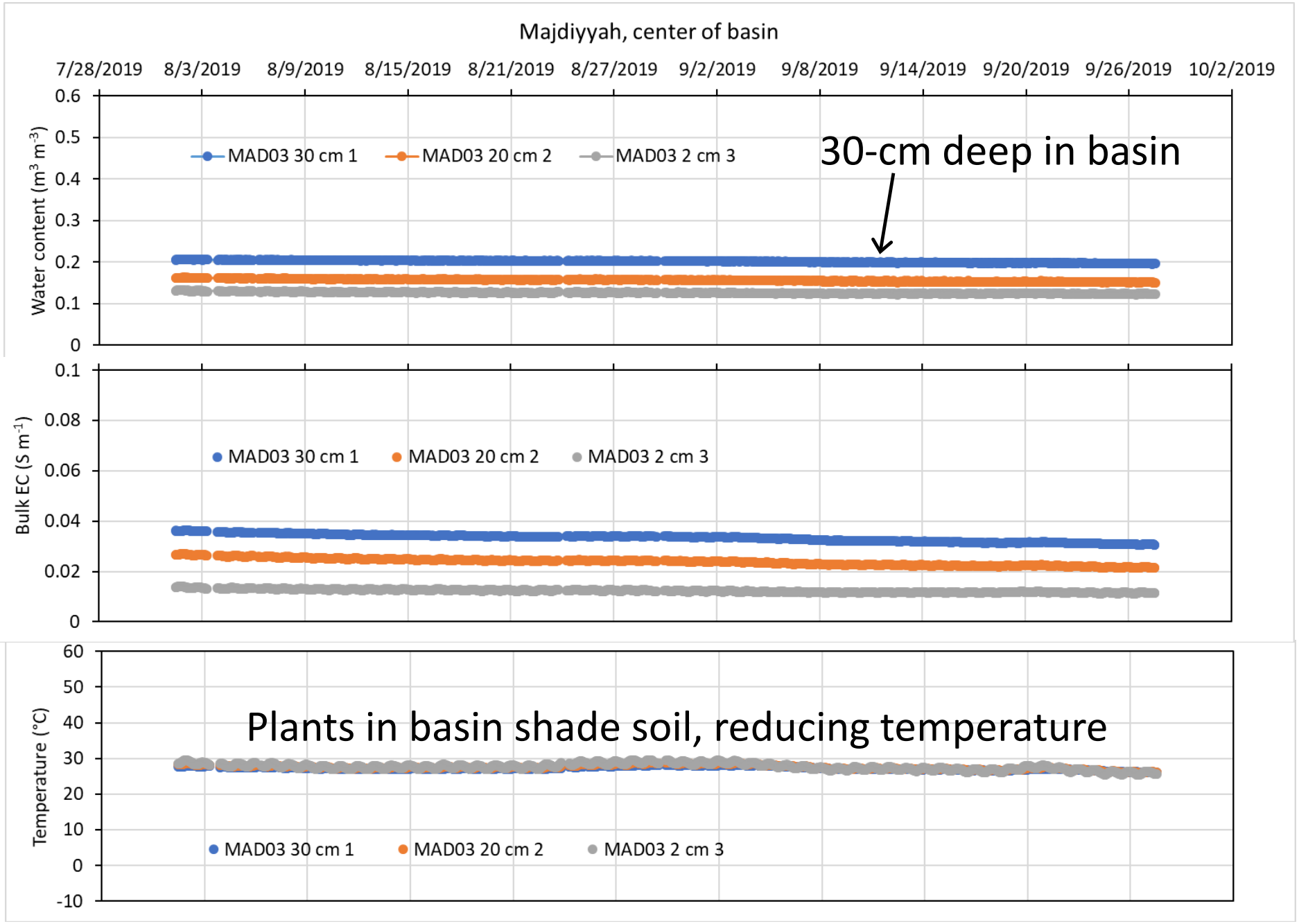
Data from the Cloud Aug-Sep

Node MAD03 at Majdiyyah, Jordan

TDR sensors installed horizontally

All sensors at depth

Time is UTC

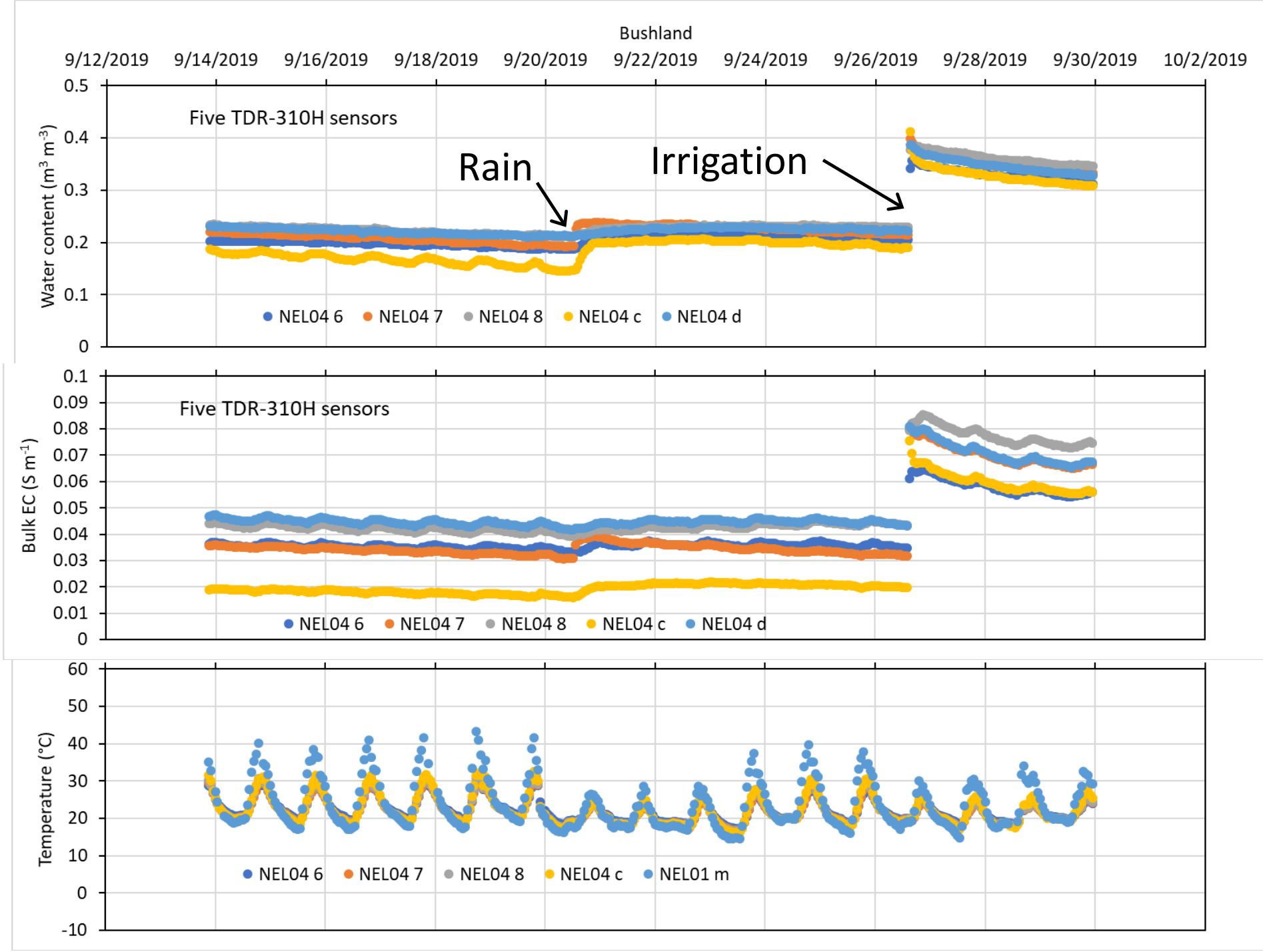


Data from the Cloud

Node NEL04 at Bushland, TX

TDR-310H sensors installed vertically into surface

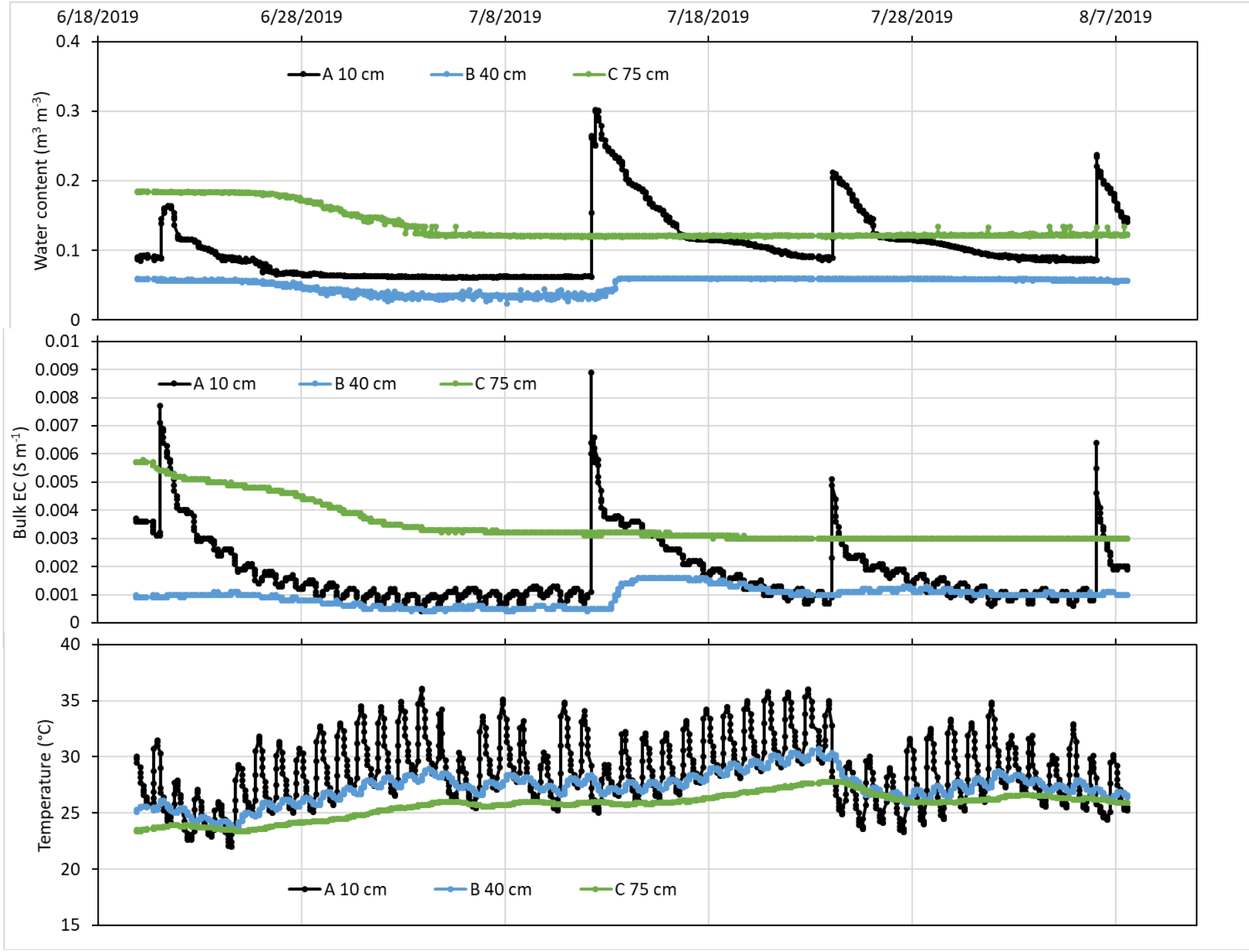
Time is UTC



Data from the Cloud

Node in North Carolina

Sensors installed at 0.1, 0.4 and 0.75 m depths



Summary

- The Internet-of-Things (IoT) approach to sensor systems is already being applied in many industrial settings and increasingly for agricultural field operations (e.g., Kohanbash et al., 2013).
- The LoRa based node and gateway system for soil water sensor data acquisition and wireless telemetry described here provides an effective, low-cost, solar-powered solution for delivering data to the Internet Cloud.
- Anyone with access rights can access the URL.
- For our irrigation decision support systems this provides a data access solution that fits well with the underlying wireless in-field and multiple field communications concept.
- This allows user interaction with a data-laden interface on a remote cellular telephone, tablet or other computer that communicates with a single or with multiple systems for both control and data acquisition.

Acknowledgments & Disclosures

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  - USDA NIFA award number 2016-67021-24420, “Increasing Crop Water Use Efficiency Through SCADA Control of Variable Rate Irrigation Systems Using Plant and Soil Sensor Feedback”
  - CRADA #: 58-3090-5-011, “Affordable Profiling Soil Water Content Measurement System”, with Acclima, Inc., Meridian ID
  - CRADA #: 58-3K95-0-1455-M, “A Sensor-Feedback-Based Supervisory Control and Data Acquisition System for Variable Rate Irrigation Decision Support”, with Valmont Industries, Inc., Valley NE
  - The Ogallala Aquifer Program, a consortium between USDA-Agricultural Research Service, Kansas State University, Texas AgriLife Research, Texas AgriLife Extension Service, Texas Tech University, and West Texas A&M University.

Thank you – Questions?

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