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

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<th>DEVICE</th>
<th>STATE</th>
<th>LAST ACTIVE</th>
<th>USAGE</th>
<th>PLAN &amp; COVERAGE</th>
<th>PHONE #</th>
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Gateway in Jordan – Adding Tag for Evett J1
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

30-cm deep in basin

Plants in basin shade soil, reducing temperature
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.
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Thank you – Questions?

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