Title
Embedded Network Sensing of Moisture and Nitrate Propagation During Irrigation with Reclaimed Wastewater

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Embedded Network Sensing of Moisture and Nitrate Propagation During Irrigation with Reclaimed Wastewater

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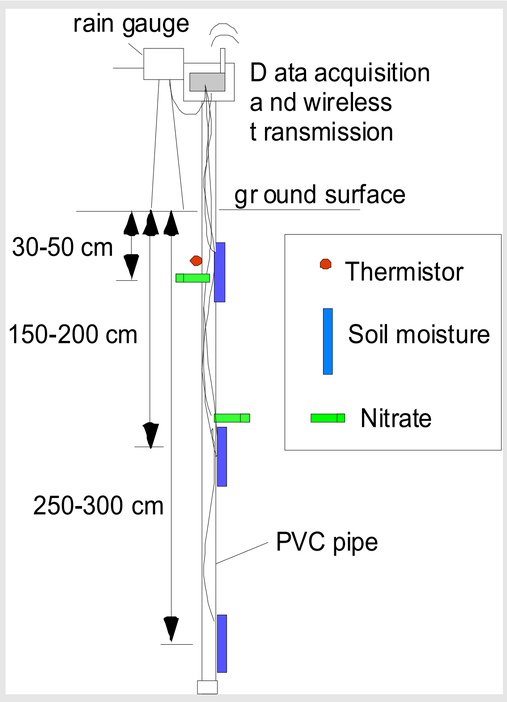
Overview: A real-world application of sensor networks in soil and irrigation with wastewater

A wireless sensor network monitors soil moisture and nitrates in an agricultural plot irrigated with reclaimed wastewater. An embedded sensor network that operates *in situ* over large scales in time and space is advantageous as it increases data acquisition rates, distributes the computation and analysis process, improves the modeling and prediction of nitrates, and reduces human intervention -- all in real-time. Once established, the automated network can optimally control nitrate and moisture inputs. The objective of this project is *to systematically develop sensor networks and design a control system to monitor and respond to nitrate propagation in soil* being irrigated with reclaimed wastewater.

Problem Description: Simulation and Control model development using sensor networks

Simulation and Control Models

- **Description of the transport and fate of nitrate in the unsaturated zone requires *flow, temperature, and nitrate simulation models*.**
- **Soil is homogenous fine to medium sand; Flow expected to be mainly vertical (one dimension).**
- **Irrigation must be scheduled with simulation models and *data feedback from the pylons* to control pivot operation, thus optimizing discharge of nitrate-laden wastewater.**

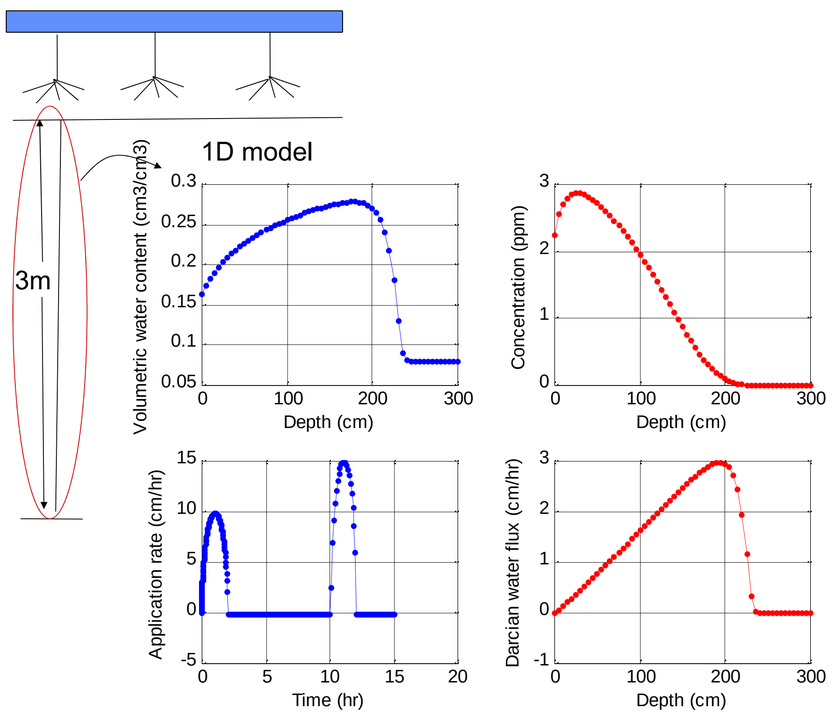


Sensor Network System

- **A *Multi-level sensing station (pylon)* for temperature, moisture, and nitrate was deployed at a test site in Palmdale, CA.**
- **The *pylon measures temperature, moisture, and nitrate* in its one-dimensional setting.**
- **Pylons will *communicate with other nearby pylons* to delineate nitrate concentration distribution in time and space.**
- **Data is captured at a base-station and relayed to a database.**

Proposed Solution: System characterization and optimization of irrigation scheduling

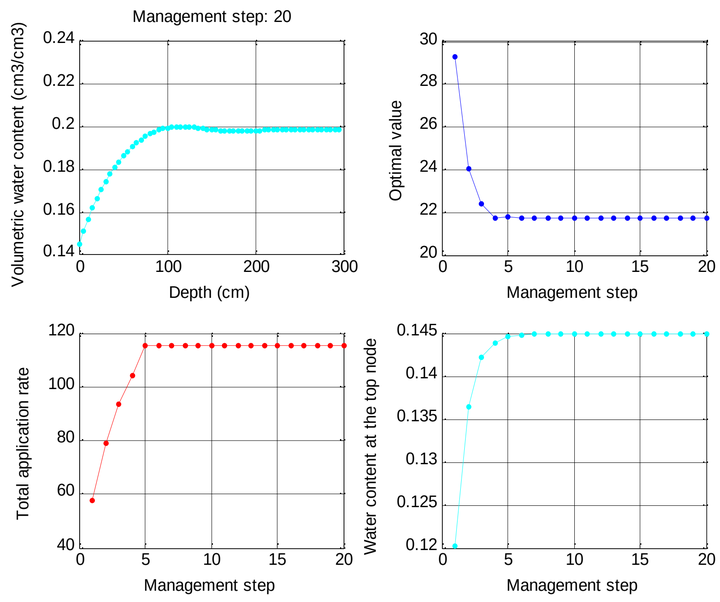
1D simulation results



- **Flow and nitrate simulation is performed with *1D Richards equation and 1D advection-dispersion equation* using a finite difference method.**
- **Application rate is assigned as *sine function* to imitate the irrigation pattern when the pivot passes.**
- **The simulation *will be extended to 2D* to examine settings in which horizontal flow is significant.**

- **Pylon installation (above).**
- **The irrigation pivot (right).**

Irrigation Control



- **The objective of irrigation control is *to determine the application rate* such that wastewater usage is maximized and the nitrate regulatory level is not violated.**
- **The control scheme (measurement, decision, and action) is executed by using the *on-line data feedback* from the pylons and providing control to the watering pivot.**

Parameter estimation

- **Parameter estimation for the simulation model is an important part of sensor network calibration.**
- **Soil samples are collected to measure hydraulic conductivity and moisture retention and their spatial variability.**
- **Each pylon provides real-time sensor data for local network node calibration.**
- **Deterministic and geostatistical algorithms for scaling up toward sensor network error resiliency will then be tested.**