Networked Sensing of Nitrate in Support of Groundwater Quality Protection

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Introduction: Soil Sensor networks in a real-world application: wastewater irrigation

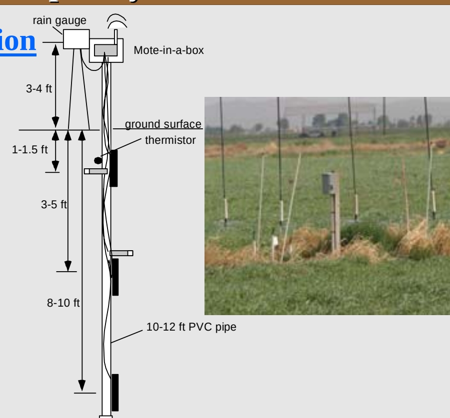
Municipal wastewater flows in a megapolis like Los Angeles exceed 100s of millions of gallons per day. In land-locked areas, prudent watershed management demands that we monitor and control the release of treated wastewater, and the associated contaminants and nutrients, into the environment. If the release is into the soil, such as for irrigation or artificial recharge of aquifers, monitoring well networks are currently sparse due to costs of deployment (well drilling and construction).

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: How to adequately monitor nitrate in soils using sensor networks

Model Development and Calibration

- **The fate and transport of nitrate in the unsaturated zone is described by *flow, temperature, and nitrate simulation models*.**
- **Due to the *spatial variability* of soil properties, parameter estimation for the simulation models requires *geostatistical treatment* (e.g., semivariogram and kriging)**

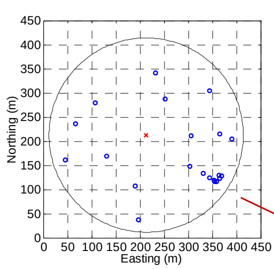


Sensor Network System

- **Novel *multi-level sensing stations (pylons)* for temperature, moisture and nitrate to be deployed at varying spatial densities over a portion of a 30 acre test plot in Palmdale, CA.**
- **Each *pylon monitors conditions* (temperature, moisture and nitrate distributions) in its own 1-D setting**
- **Pylons *communicate with other nearby pylons* to delineate dissolved nitrate distribution in time and space**

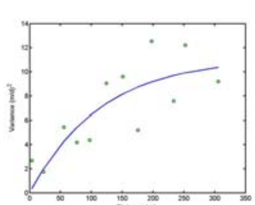
Proposed Solution: System identification and optimization of irrigation scheduling

Parameter estimation



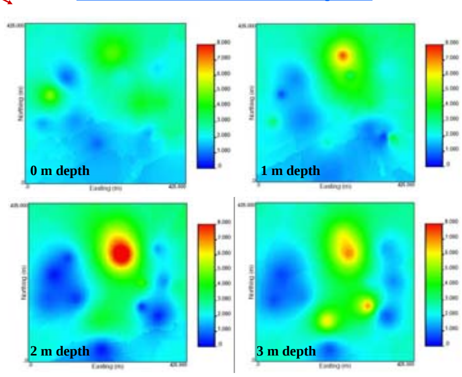
30 acre Palmdale Site Sampling Locations

- **Soil samples have been collected *to observe spatial variability* throughout the research site.**
- **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.**



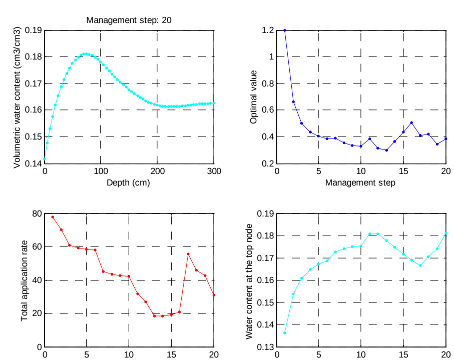
***Semivariogram* of hydraulic conductivity: a measure of spatial variability**

Geostatistical Analysis



- **Spatial distribution of hydraulic conductivity is visualized in contour maps created by *kriging* methods.**
- **We can then estimate soil properties at unsampled locations with geostatistical realizations.**

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.**

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