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Remote Soil Moisture Sensing Application

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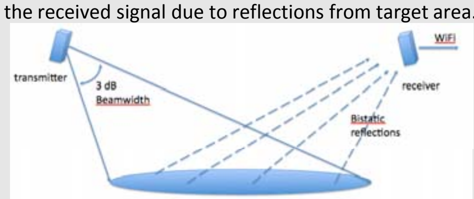
Introduction

A prototype remote radio frequency sensor has been developed at the University of Notre Dame. The sensor, termed CROSSHAIR, characterizes polarization features of RF signals using a patent-pending approach that enables sensing for a broad range of anticipated applications. One promising application involves remote sensing of soil moisture.

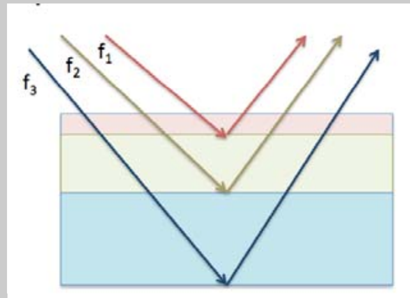
The CROSSHAIR system monitors polarization features of the received signal due to reflections from target area.



The figure above illustrates a bistatic implementation for remotely monitoring the soil moisture of a target area

Depth Profiling

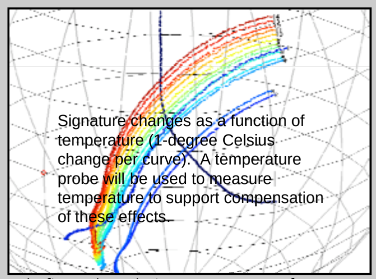
One potential advantage of the remote sensing approach is that multiple frequencies can be employed to obtain a coarse moisture profile. Higher frequencies will have shallow penetration, while lower frequencies will have deeper penetration. The polarimetric responses can potentially be used to profile moisture versus depth



The figure above conceptually illustrates the potential to use multiple frequencies for characterizing soil moisture versus depth

Temperature Sensitivity

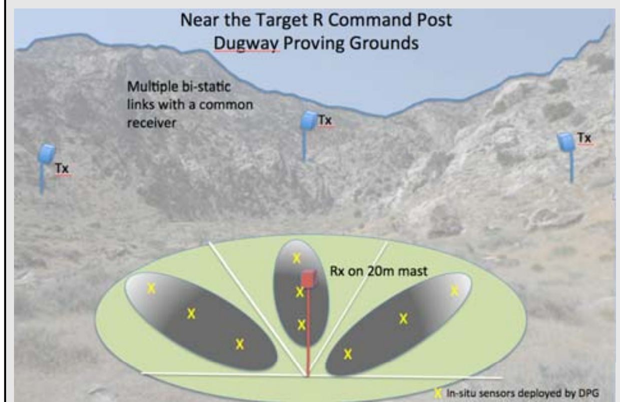
The dielectric properties of water are temperature-dependent, and hence the polarimetric response will change with temperature. Research is underway to learn how to compensate for these effects.



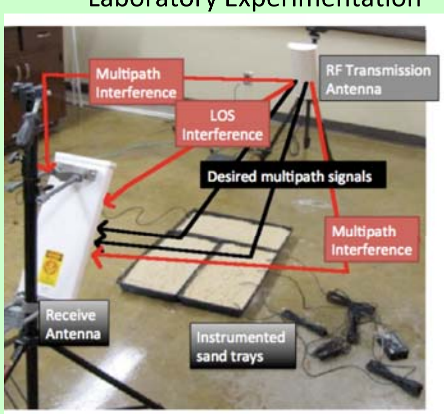
The figure above depicts measurements of PMD signatures at various soil temperatures

System Deployment

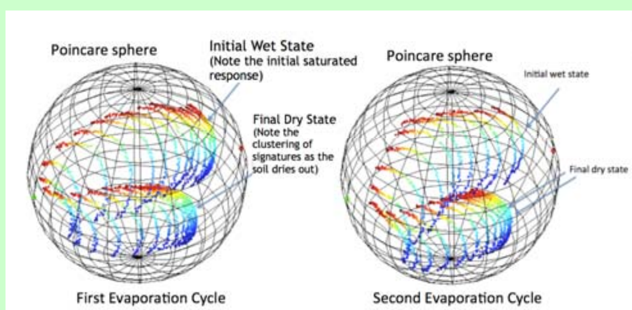
The CROSSHAIR system is to be deployed at Dugway Proving Grounds near Salt Lake City, Utah to monitor soil moisture changes and to potentially detect the formation of fog. The deployment will include three transmitter sites, each transmitting on channels at 2.4 GHz, 900 MHz, and 400 MHz. The receiver will be mounted on a 20m mast.



Laboratory Experimentation



Lab experimentation (see figure on left) has demonstrated the efficacy of measuring PMD changes due to soil moisture, even in the presence of other strong multipath. The results have also confirmed that with calibration, absolute soil moisture measurement is possible.



Summary

- Technology is scalable, i.e., it can operate at different scales
- Remote detection of soil moisture changes is possible, even in the presence of unwanted multipath
- The pattern that the signature follows from wet to dry states is repeatable in both cycles
  - Differences likely due to water distribution in the trays
- The signature is virtually constant in the saturation state, and can potentially be used to detect this state without calibration
- The signature become virtually constant at the dry state, and thus can be used as a "dry state" detector
- Absolute soil moisture estimates is achievable
  - Site-specific calibration required
  - Could potentially be inferred through measured responses