CENTRAL AVRA VALLEY STORAGE AND RECOVERY PROJECT (CAVSARP) SITE, TUCSON, ARIZONA: FLOODWATER AND SOIL MOISTURE INVESTIGATIONS WITH EXTRATERRESTRIAL APPLICATIONS.

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Introduction: Planetary geologists, geomorphologists, and hydrologists have hypothesized that Mars is a dynamic, water-enriched planet since the Mariner and Viking missions based on geologic, geomorphic, and topographic information [1,2]. Recent acquisition of Gamma Ray and Neutron Spectrometer information has added further credence to this hypothesis [3,4].

A unique investigation is underway to work towards being able to successfully map the extent and depth of water on Mars. Researchers from the University of Arizona and members of the Autonomous Sciencecraft Experiment (ASE) [5,6] have been compiling multiple layers of information in time and space at the Central Avra Valley Storage and Recovery Project (CAVSARP) site, Tucson, Arizona, for eventual comparative analysis. This information has been acquired from a variety of observational/scientific platforms in controlled conditions.

CAVSARP facility: The site includes more than 10 recharge basins. These basins are aligned parallel to one another with each having the larger dimension in an easterly direction. The dimensions of several of the recharge basins are generally 660 ft by 1,320ft (some basins are smaller). Most of the basins were constructed by excavating two feet of surface soil. The berm heights, which form the margins of the basin, range between approximately 4.5 feet and 7 feet allowing a maximum water level of approximately 6.5 feet along the northern berm.

The CAVSARP site provides controlled conditions of soil moisture, from dry (very low moisture) to inundation. Additionally, the facility is free of vegetation and the excavated regions within the recharge basins are topographically flat with a low surface roughness. These features of the facility allow better correlation of space and airborne data with ground measurements of soil moisture.

Soil Moisture investigation: The data that have been compiled will be used to measure the dielectric permittivity or electrical conductivity of the near surface. Specifically, the dielectric permittivity has been shown to be highly correlated with volumetric water content [7,8]. For example, differences in the backscatter from space-based synthetic aperture radar (SAR) made during two separate overflights could reveal variations in the dielectric permittivity [9]. However, shifting surface features causing a change in surface roughness would also show a variation in backscatter. Verification from a ground-based time domain reflectometer (TDR) or ground penetrating radar (GPR) could help reduce the uncertainty in the interpretation of the SAR image, which is described below.

Data types: Layers of information have been acquired and collected for soil moisture analysis at the CAVSARP site, which can be grouped into three sources: Space (EO-1 Hyperion hyperspectral data), Airborne (AIRSAR in C, L, and P bands at polarizations of HH, VV, and HV), and ground (TDR, gravimetric, and field observations). Other geophysical methods, which can be implemented in the controlled conditions, include ground penetrating radar (GPR) that measures electrical properties of the near surface.

Space-Based Measurements: Hyperion, a hyperspectral imaging spectrometer covering the spectral range of 400-2400 nm with a spectral resolution of 10nm, is one of the sensors onboard EO-1. It yields a 30m/pixel resolution. CAVSARP site is currently an observation target for the preparation of the ASE mission [5]. The ASE software will fly onboard the Earth Observer-1 (EO-1) spacecraft in early 2004 for the purpose of detecting change related to volcanism, flooding, and ice formation and retreat. Up to date, data were acquired on 7/10, 11/6, 11/15, 11/22, 11/24, 12/1 and 12/8/03.

Airborne Measurements: The Jet Propulsion Laboratory (JPL) has operated various airborne radar systems on contract for NASA. The AIRSAR system is a three-band (C, L, P) quad-polarized synthetic aperture radar (SAR). AIRSAR data can be fully calibrated to allow extraction of quantitative measurements of radar backscatter. Spatial resolution of the AIRSAR system is on the order of 12 m in both range and azimuth. Incidence angle ranges from zero degree at nadir to about 70 degrees at the far range. This capability to collect multi-frequency, multi-polarization data over such a diverse range of incidence angles allows a wide variety of specialized research experiments to be carried out. For the CAVSARP site, one of several sites that data was acquired for investigation [10], a 20 MHz bandwidth mode was used with a resulting resolution of ~7.5m/pixel. The resolution was selected because it is comparable to the resolution of proposed SAR instruments for future Mars missions and because unlike higher resolution modes, this allows for simultaneous collection of data in all three bands. AIRSAR data was collected at CAVSARP on March 24, March 31 and July 2, 2003.

Ground Measurements: Ground measurements of soil moisture conditions included TDR measurements and photographs and surveys of ground conditions. The TDR, which consists of a datalogger, pulse generator, and two parallel wave guides, was made portable by placing the electronics in an externally-framed backpack and the wave guides at the end of a staff. The wave guides (10 cm length) were inserted vertically into the soil, and the travel time of a broadband pulse (1-1000 MHz, with a center frequency of 750 MHz) along the wave guides was used to calculate the dielectric permittivity. Measurements were made primarily within one basin during the July 2 AIRSAR flyover, with measurement resolution of 10 m.

Implications: The controlled conditions at the CAVSARP site provides a unique opportunity to develop and improve upon complementary techniques that can be used to identify, characterize, and determine the extent of soil moisture conditions in both terrestrial and extraterrestrial environments. We will present preliminary findings during the meeting.

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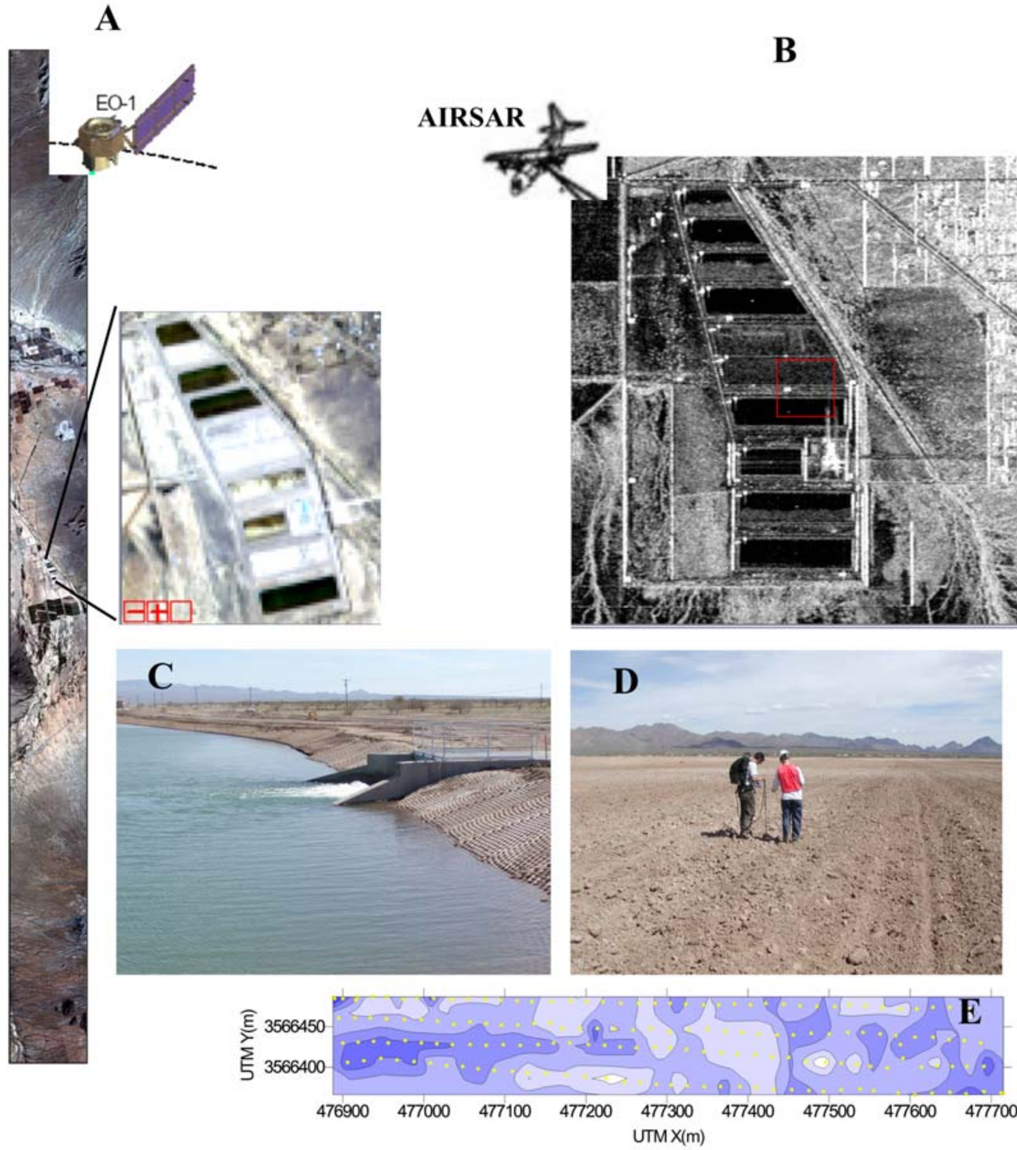

Figure 1. Layers of information to discern soil moisture characteristics at the CAVSARP. A) EO-1 (true-color composite) of Avra Valley, AZ with expanded view of CAVSARP facility (July 10, 2003). B) C-band, HH polarization of CAVSARP (July 2, 2003). C) Picture of inundated basin (March 24, 2003). D) Picture of dry basin during TDR measurement campaign (March 24, 2003). E) Contour of kriged soil moisture data from discrete TDR measurements (white=0.26 cm^3 cm^{-3}, dark blue=0.46 cm^3 cm^{-3}).