



COSMOS rover: measuring soil moisture using a mobile cosmic-ray probe

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Soil moisture at a horizontal scale of ca. 600 m averaged over depths of 15-70 cm can be inferred from measurements of cosmic-ray fast neutrons above the ground surface. These neutrons are sensitive to water content changes, largely insensitive to soil chemistry, and their intensity is inversely correlated with hydrogen content of the soil. Measurements can be made using stationary or mobile probes. A stationary probe, implemented in the COsmic-ray Soil Moisture Observing System (COSMOS), gives time series of soil moisture averaged over the footprint. A mobile probe, the COSMOS rover, yields soil moisture averaged over swaths that have the width equal to the footprint and the length that depends on the speed of the vehicle and the desired precision of the measurement. Preliminary results obtained with a prototype COSMOS rover are encouraging. On the Island of Hawaii, measurements of soil moisture in a transect between the dry west coast and the wet east coast agree with independent measurements at two nearby SCAN sites, and with both the precipitation and vegetation patterns. Roving measurements over the entire island yielded a map of soil moisture that shows the expected features, such as high moisture on the trade-wind dominated east side of the island and low moisture on the leeward west side, as well as unexpected features, such as wet Mauna Kea, which is due to the presence of secondary minerals containing abundant water. Several short transects near Tucson, Arizona, two areal surveys in Oklahoma, and two multi-state very long linear surveys revealed soil moisture levels that mostly follow expectations. For example, soil moisture decreases with the distance from the west coast; low altitudes are drier than mountain altitudes; they also have less snow in winter; and cities are different than their suburbs. These measurements show that the COSMOS rover is capable of generating soil moisture data quickly and inexpensively. Measurements over an area are suitable for calibration and validation (cal/val) of satellite microwave sensors, such as those in the current SMOS and future SMAP missions. A satellite microwave pixel of 40 km by 40 km can be covered in less than a day of driving. Repeated surveys along the same routes can reveal temporal changes in soil moisture, for example related to seasonal- or longer-term climate change. [Funded by the US National Science Foundation.]