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COsmic-ray Soil Moisture Observing System (COSMOS): soil moisture and beyond

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COSMOS, a project funded by the US National Science Foundation, was designed to measure average soil moisture in the top 10-70 cm of soil over the horizontal footprint of approximately 700 m by measuring cosmic-ray neutrons in air above the ground surface. It is in its fourth, final, year of the feasibility phase in which 60 neutron probes have been installed in the USA to provide continental-scale soil moisture data. The cosmic-ray neutron probe responds to all sources of hydrogen present within the footprint. Therefore, in addition to soil moisture, other pools of hydrogen can be measured; these include atmospheric water vapor, organic matter in soil, water in soil minerals, biomass water (including hydrogen bound in cellulose), and snow on the ground and on the canopy. All these pools of hydrogen form the “total surface moisture” that is measured by COSMOS probes. The first four pools are measured independently (water vapor) or are implicitly included in the probe calibration (water in minerals and organic matter, biomass water). The other two can be separated from one another to produce time series of soil moisture and snow water equivalent. Work is in progress to assimilate neutron data into land-surface models, to produce soil moisture profiles, to validate satellite soil moisture products (the current SMOS mission and the future SMAP mission), to measure temporal variations in biomass, and to measure area-average unsaturated hydraulic properties of soils. Separately, mobile COSMOS probe, called COSMOS rover, is being developed. COSMOS rover can be used to map soil moisture over large areas or along long transects.

Cosmic-ray sensing of moisture at the land surface has gained popularity outside of the USA. Approximately 60 probes have been purchased in addition to the 60 probes in the COSMOS project. Funds for additional 80 probes, most of them in Germany, have been secured, and large new proposals will be submitted in the USA and Australia in 2013. These probes form an embryonic global COSMOS network, and an international community of scientists interested in cosmic-ray sensing is emerging.

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