

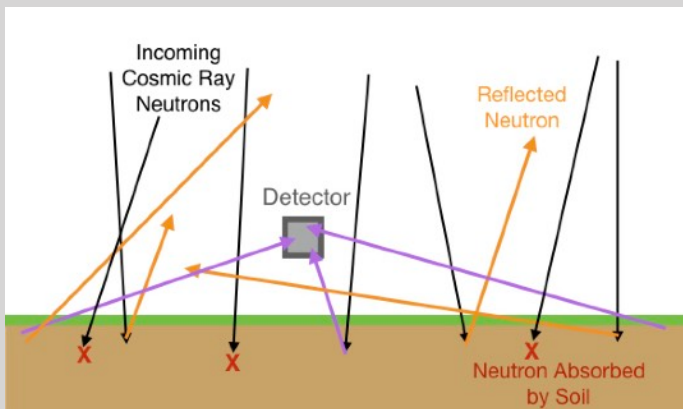
Measuring Soil Moisture with Cosmic Ray Neutrons

Methodology

Cosmic Ray Neutron Sensing (CRNS) infers water content near the land surface from measurement of cosmic ray neutrons reflected by the ground.

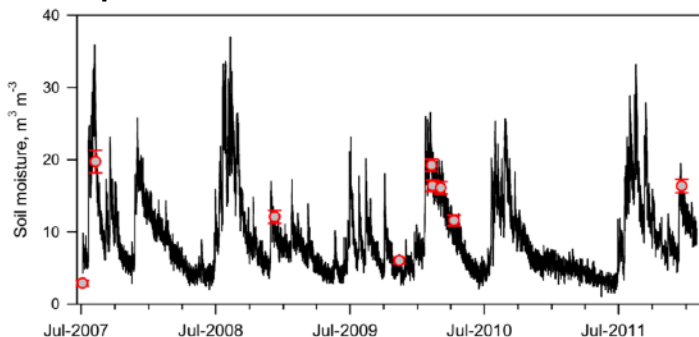
Science

Cosmic ray neutrons are generated when high energy particles from outer space collide with molecules in the atmosphere. These neutrons lose energy through collisions with hydrogen atoms in the air and ground. Water contains a high amount of hydrogen, so wetter soil and snowpack slow down and absorb, rather than reflect, more neutrons. The CRNS methodology uses a neutron detector located above the ground to measure the intensity of reflected neutrons, which is inversely proportional to water content.



Simplified neutron interaction with soil and detector. Incoming cosmic-ray neutrons can be absorbed by the soil, or reflected.

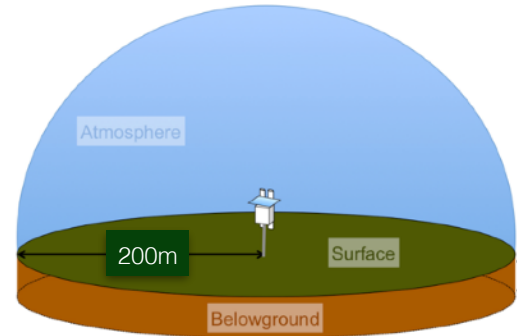
Sample Data



Soil moisture from cosmic-ray neutron measurements (black line) compared with soil samples (red symbols) (Zreda, 2012)

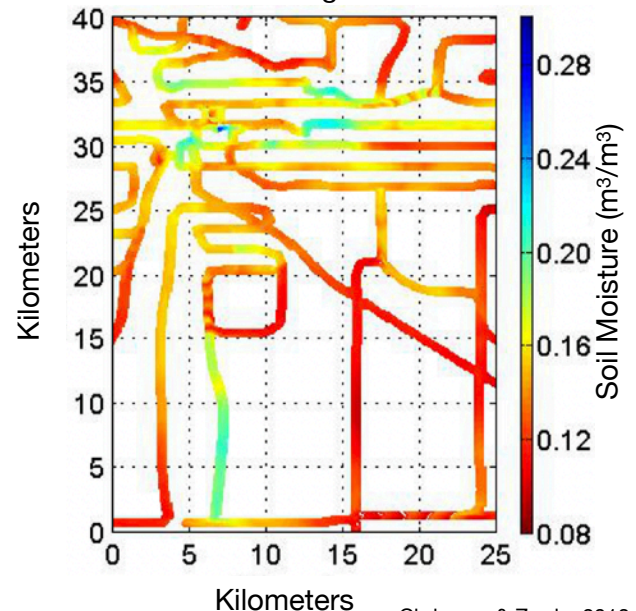
Versatile Modes of Use

Stationary soil moisture sensing over a field-scale area



Modified from Rosolem et al., 2014

Mobile sensing to map soil moisture over a larger area



Chrisman & Zreda, 2013

Applications

- Cosmic ray neutron sensors provide non-invasive soil moisture data at an intermediate scale between point measurements and satellite data.
- Potential applications include precision agriculture, irrigation management, weather and drought forecasting, and climate modeling.
- CRNS can also be used to measure snow water equivalent (SWE) to a depth of approximately 100mm.