Measuring soil moisture using COSMOS probes

Intermediate scale between point measurements and satellite sensing

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Stationary

Roving

3rd SMAP cal/val workshop, Oxnard, CA, 16 November 2012
Variations in soil moisture: circle, 400 m diameter

San Pedro, 5 March 2010

Soil moisture, m$^3$/m$^3$

Depth, cm

Soil moisture, m$^3$/m$^3$
Cosmic-ray neutrons above the surface

Neutrons \(10^{-7} \text{ cm}^{-2} \text{ sec}^{-1} \text{ eV}^{-1}\)

Height in air (meters)

Neutrons (10^{-7} cm^{-2} sec^{-1} eV^{-1})

- July - August 1964
- April - May 1965

Dry earth

Water

July - August 1964
April - May 1965
COSMOS probe and its footprint

Rietholzbach, Switzerland
## Pools of hydrogen within COSMOS footprint

<table>
<thead>
<tr>
<th>Pool (in order of importance)</th>
<th>Included in local calibration?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water (snow)</td>
<td>No</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>---</td>
</tr>
<tr>
<td>Mineral (lattice) water</td>
<td>Yes</td>
</tr>
<tr>
<td>Water in organic matter in soil</td>
<td>Yes</td>
</tr>
<tr>
<td>Vegetation (biomass)</td>
<td>Yes (if constant)</td>
</tr>
<tr>
<td>Atmospheric water vapor</td>
<td>Yes</td>
</tr>
</tbody>
</table>
COSMOS is an NSF supported project to measure soil moisture on the horizontal scale of hectometers and depths of decimeters using cosmic-ray neutrons.

Project Summary
People
News
Data Portal
Publications
Mailing List
For more information contact Marek Zreda.

COSMOS is supported by the Atmospheric and Geospace Sciences Division of the National Science Foundation

COSMOS public server: cosmos.hwr.arizona.edu
COSMOS web site: probe data

Silver Sword

The site is co-located with the USDA National Resources Conservation Service ‘Silver Sword’ site. More information regarding the USDA site can be found at http://www.wcc.nrcs.usda.gov/wcc/site?siteId=210&state=HI

Installation Date: 2010-06-15
TimeZone (UTC): -10
Cut-off Rigidity (SV): 12.87
Mean Pressure (mb): 725
Mean Bulk Density (g/cm³): 0.78
Mean Lattice Water (% weight): 9.57
Max Count Rate (/hr): 2633

COSMOS public server: cosmos.hwr.arizona.edu
# COSMOS data levels

<table>
<thead>
<tr>
<th>Current</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Level 4</td>
</tr>
<tr>
<td>Raw count rates</td>
<td>Soil moisture profiles</td>
</tr>
<tr>
<td>basic met data</td>
<td>(DA, LSM)</td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
</tr>
<tr>
<td>Corrected and</td>
<td></td>
</tr>
<tr>
<td>normalized count</td>
<td></td>
</tr>
<tr>
<td>rates</td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
</tr>
<tr>
<td>Soil moisture</td>
<td></td>
</tr>
<tr>
<td>and measurement</td>
<td></td>
</tr>
<tr>
<td>thickness</td>
<td></td>
</tr>
</tbody>
</table>
Considerations for potential use in SMAP cal/val

**Positives**
Area-average soil moisture (integrates small-scale variations)
Each site calibrated locally on moisture form multiple soil samples
Data available in the public domain in real time
Latency: 1 hour

**Negatives**
Measurement thickness larger than SMAP
  - need to produce profiles
Measurement area smaller than SMAP
  - need to upscale

**Possible upscaling solution**
COSMOS rover
Objective and Reasoning:

- Mobile application allows spatial scale matching of satellite pixels
- Compare average of COSMOS rover values to satellite pixels
- Physical up-scaling
- As long as the land is accessible, the rover can match many satellite pixels with varying land cover types!

Challenge:

- Disconnect in vertical depth penetration
Tucson Basin I

University of Arizona

Copper Mine

Pecan Farms
COSMOS rover neutron intensity:
raw data
COSMOS rover neutron intensity: smoothed data
COSMOS rover neutron intensity: processed data
Cal/Val Issues

• Major obstacle
  – Overcoming the depth disconnect between the two methods for direct comparison

• Proposed future work
  – Cal/Val with extrapolated L4 SMAP data
  – Cal/Val with extracted surface value from COSMOS produced SM profile
• Thank you!

• Questions?