**Title**

AMARSS: Identifying meaningful spatial and temporal scales for measuring ecological processes in soil

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# AMARSS: Identifying meaningful spatial and temporal scales for measuring ecological processes in soil.

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## Introduction: Biological process in the soil are scale-dependent.

### "As above, so below …"

*– Tom-Tom Club*

- **Below-ground biomass (i.e., biological/ecological *action*) is comparable to what we see above-ground.**
- **The biogeochemistry of soil processes at local scales are not only affected "top-down" by larger, regional-to-global environmental phenomena but also ramify "bottom-up," with important environmental consequences.**
  - Global warming and carbon cycling: production and storage of $CO_2$.
  - Nutrient cycling: alterations in ecosystem composition and diversity.
  - Community/ecosystem energy budget.

### $10^{14}$-fold range in spatial scales

| Area ($m^2$) | Scale |
|---|---|
| $10^{6}$<br>$10^{0}$ | Remote sensing pixels |
| $10^{-4}$<br>$10^{-8}$ | Soil particles |
| $10^{-12}$<br>$10^{-14}$ | Fungal hyphae, microorganisms |

- **Comparable range in temporal scales, from proton exchange to root growth to erosion of soil "parent material" (i.e., bedrock).**

## Problem Description: How can we determine the most informative scale(s) for measurement?

Human-powered minirhizotron at the James Reserve.

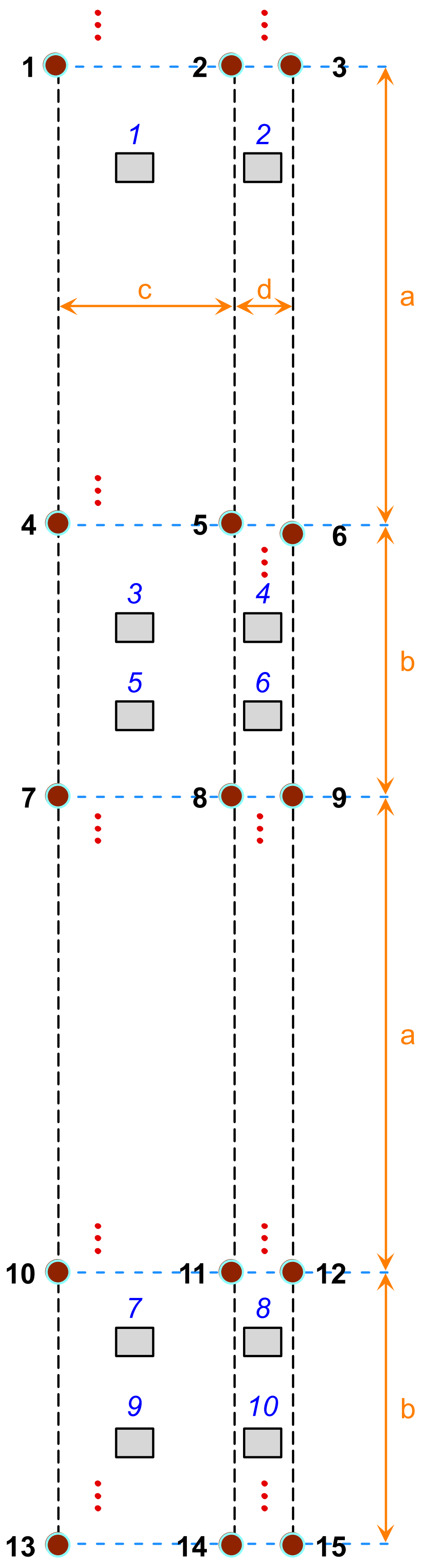
### Automating and networking soil sensing instruments

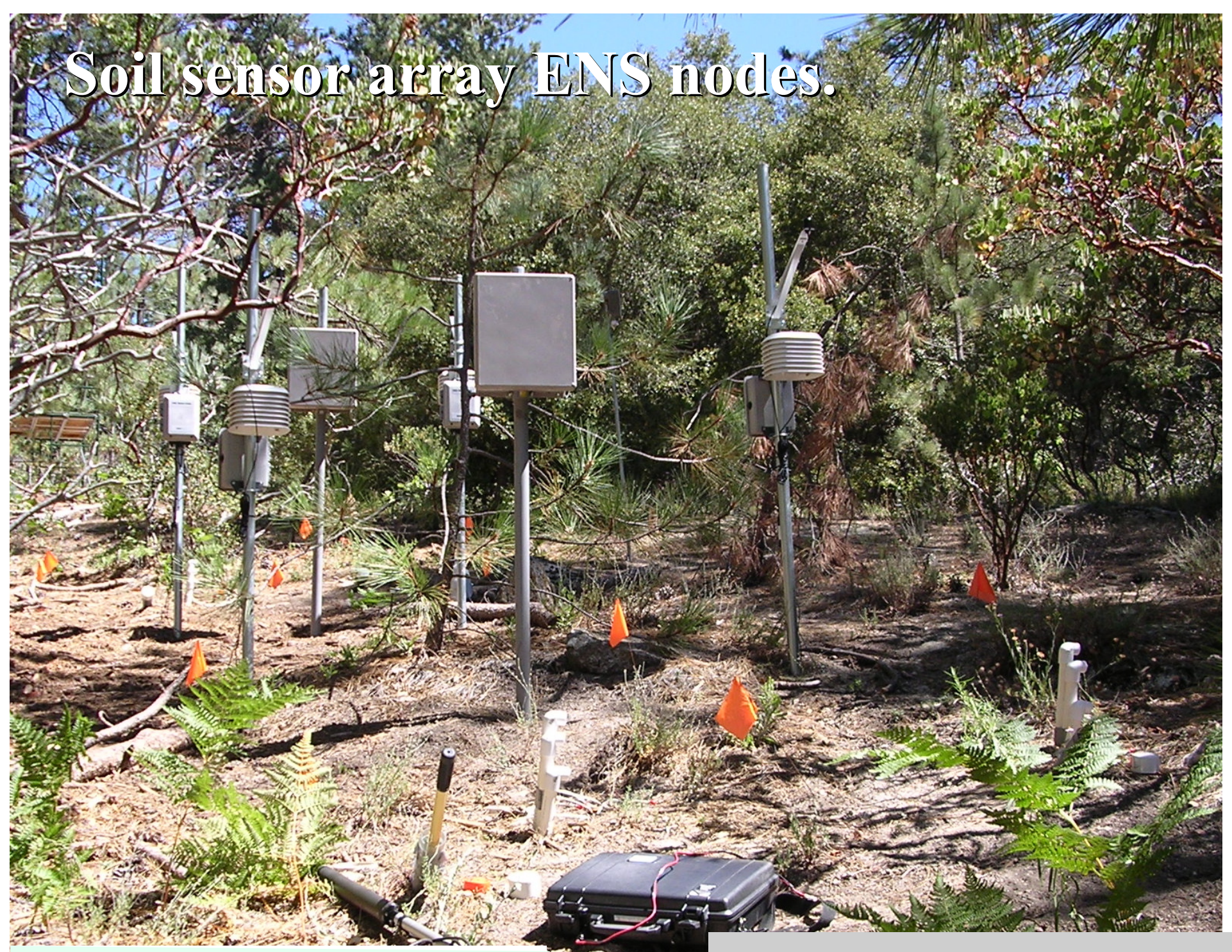
- Until now, measurements of belowground ecological processes have largely been collected as "snapshots" of conditions at isolated points in space and time. This data has been essential for describing soil biogeochemistry but has provided little insight into the extent or rates of soil patterns and processes.
- By collecting multiple data streams at varying intervals, AMARSS will enable us to compare discontinuities in variance across multiple spatial and temporal measurement scales, providing essential information for identifying the scales) of measurement necessary for a far more complete understanding of many soil processes.

## Proposed Solution: Comparing variation across multiple scales.

### Soil Space-Time

Layout of the AMARSS transect at the San Jacinto Mountains James Reserve. Located directly beneath a Networked Info-Mechanical Systems (NIMS) cable, the arrangement and dimensions of the AMARSS sensor array was designed to compare variance in measurements at multiple scales. Distances between minirhizotron tubes follow a scale-invariant power law: $y = 1.1413x^{2.1}$, with parameters chosen to fit the study area.





1 **Tube** ●

*1* Data node ☐

Soil sensor array ⋮

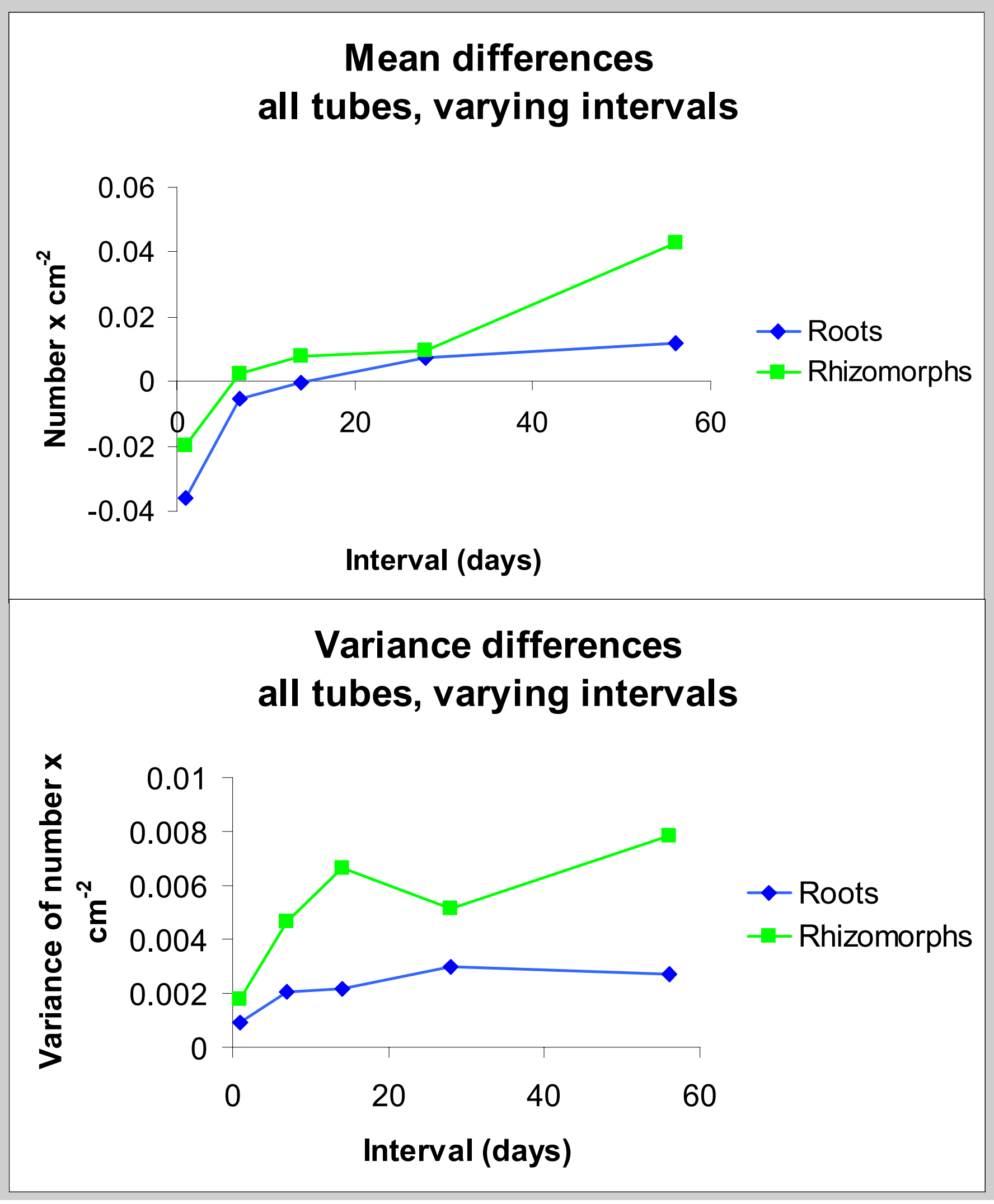
Dimensions (m)

a: 30.8
b: 7.2
c: 1.7
d: 0.4

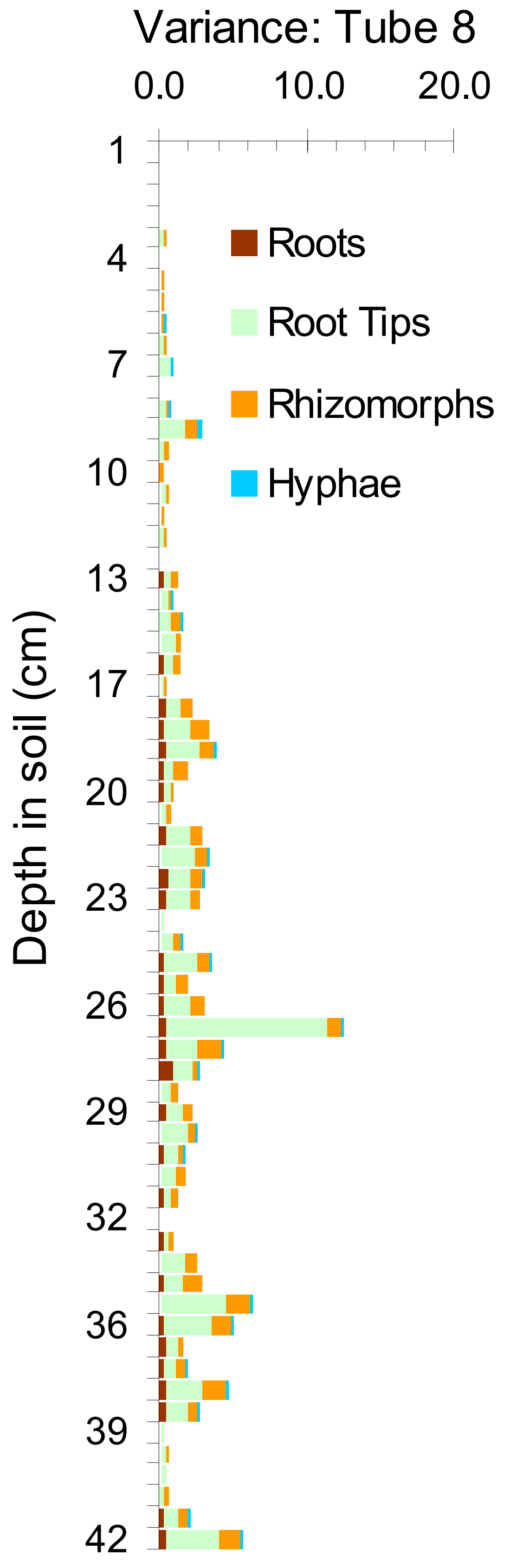
Total length = 76 m

Bar graph of variance by depth over time in counts of mycorrhizosphere components: plant roots, mycorrhizal root tips, fungal rhizomorphs and hyphae. Counts are per 9 x 12 mm minirhizotron image tube #8 and are based on averaging across all sessions from 3/17/2005-9/16/2005 (183 days).

Image data alone are inadequate to understand ecologically significant biogeochemical processes in the soil. Integral to AMARSS, soil physical- and chemical-state sensors are buried in close proximity to each minirhizotron camera, allowing us to correlate visual observations with changing environmental conditions such as occurs during spring snow-melt or with increasing temperature during the summer.



By collecting data frequently and comparing discontinuities in variation across multiple spatial and temporal intervals, AMARSS will yield essential information regarding the scale's) of measurement necessary for understanding soil ecosystems. Further refinement of the analysis will involve semivariance, geospatial, and related statistical techniques.



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