Characterization of the New Systems for Soil Carbon Analysis

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Introduction

A new generation of analytical instruments for analyzing soil composition is being deployed at various centers. These include;
IR- Mid- and Near-infrared,
LIBS- laser breakdown spectroscopy and
INS- inelastic neutron scattering.
These technologies operate *in situ,* are less labor intensive and provide a higher sample throughput than the standard method of dry combustion. Some of them are non-destructive and can be used in either static or scanning modes. In general these systems provide more detailed information on the chemical- and elemental-speciation of the belowground carbon, a features currently not available. Since NOT A SINGLE MODALITY CAN RESOLVE ALL THE ISSUES AT HAND a combination of them should provide an ideal situation for studying the belowground processes.

Table 1 Basic Characteristics of the Emerging Technologies

Instrument	Process	Methodology	Radiation Type Detected	Penetration Depth (cm)	Sampled Volume (cm^3)	Measurement Type
LIBS	Atomic	Plasma Induced Emission	Visible	~ 0.1	10^{-2}	Point, Depth Profile, Destructive
NIR	Molecular	Diffuse Reflectance	Near-Infrared	~ 0.2	10^{0}	Surface, Scanning, Destructive
MIR	Molecular	Diffuse Reflectance	Infrared	~ 1	10^{1}	Surface, Destructive
INS	Nuclear	Neutron Induced Nuclear Reactions	Gamma Rays	~ 30	10^{5}	Volume, Scanning, Non-Destructive

Table 2 Comparison between INS and Dry Combustion

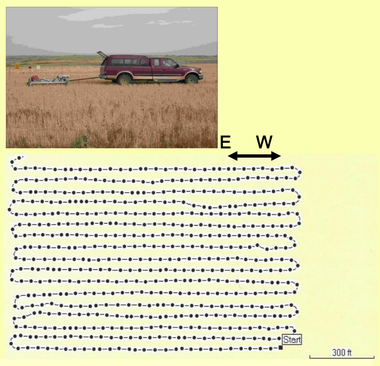
Dry Combustion	INS
Sampling	
Cores, Excavations Sample size Small (<1 g) No scanning capability	None In Situ, Large (>200 kg) static and scanning capabilities (for an arbitrarily large area)
Sample Preparation	
Labor and resource intensive, time consuming; weighing, drying, weighing, grinding, sieving, milling, homogenized, sampling	None, occasional litter removal for static counting (if needed)
Single Run Measurement	
C (Total; OC+IC) %C IC requires separate analysis Requires bulk density determination	Elemental C (Total), N, K, Si, O, H, Ca IC through calibration with Ca Moisture through calibration with H Calibrated in gC/cm^2
Analysis	
Direct C reading Gaostatistical or simple mean of discrete points	Instantaneous spectral peak analysis and conversion to elemental concentrations based on calibrations together with moisture A true physical mean
Assumptions	
That the number of selected coring sites in a field is chosen to adequately represent the field That the lateral C distribution is fairly uniform without hot or cold spots No major C contribution exist Beyond a depth of about 30 cm	At most single static measurement for counts conversion to gC/sm^2 (None once the INS simulation is finalized) No drastic changes in the carbon depth profile exist

Summary

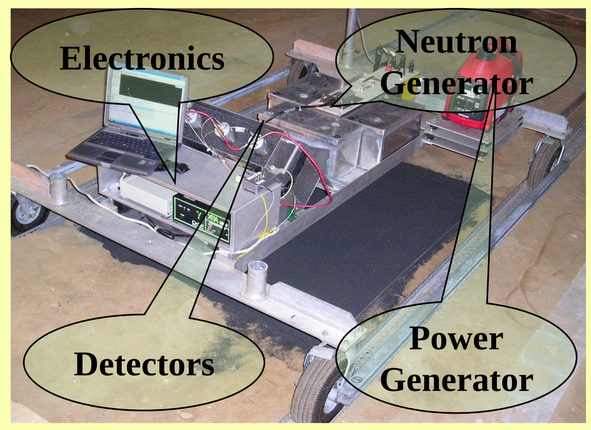
INS method is a non-destructive method for C analysis in large volumes and for scanning entire fields. Thus it differs fundamentally from the standard practice based on measurements performed at discrete points for assessing burdens of soil C locally and on a large scale.

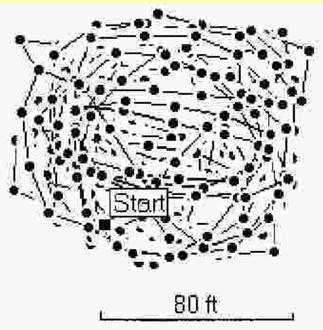
Consequently, when the INS results agree with the chemical analysis by dry combustion basic uniformity in the field can be assumed. However, when the results disagree it is possible that the INS continuous scanning provides a better measure of the field true mean value than a predicted one based on discrete points. To validate this hypothesis , which challenge the conventional wisdom, special protocols are being developed.

Field INS Scans and GPS Traces

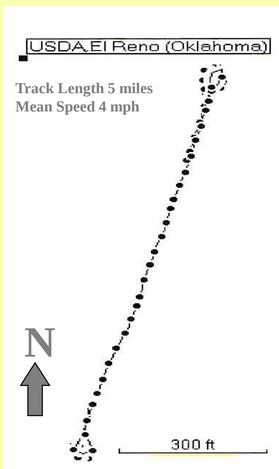


Track Length – 4.38 miles
Mean Speed – 3.6 mph

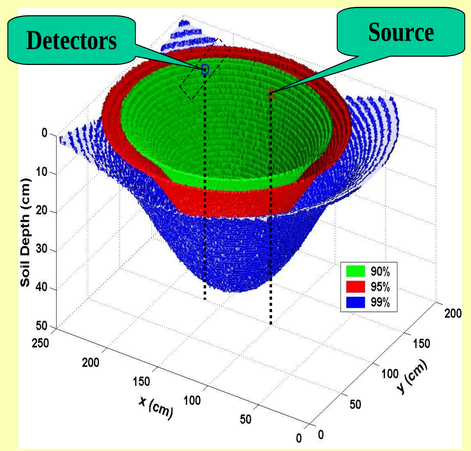




Track Length – 3.06 miles
Mean Speed – 2.4 mph



Monte Carlo Simulations of the INS's Large Volume and Footprint



Surfaces describing the volumes from which a 90, 95 and 99% of the carbon gamma rays signal intercepts the detectors and the resulting sampled depth, footprint and volume.

% of Total Response	Dept (cm)	Footprint (m^2)	Volume (m^3)	Mass (kg)
90	25	2.4	0.23	326
95	31	3.3	0.37	522
99	44	7.1	0.79	1105