Workshop to Promote and Define Cross CZO Science on Organic Matter Dynamics

Organized by the Cross Critical Zone Observatory Working Group on Organic Matter Dynamics and held at the **Conference on Critical Zone Science, Sustainability, and Services in a Changing World.** Oct 22-24, 2015. Purdue University.

The Cross CZO Working Group on Organic Matter Dynamics has convened this workshop to support its overarching mission to define the controls on organic matter storage and reactivity in the critical zone.

Background on the U.S. NSF Critical Zone Observatory Network: The critical zone is defined as the portion of the Earth's land surface that extends from the top of the vegetation canopy to the lowest limit of circulating groundwater. Critical zone science views the ecological, geological, and hydrological processes taking place in this zone as an integrated and interconnected system that acts over broad spatial (primarily at the catchment level) and temporal scales. The U.S. National Science Foundation (NSF) has created and supports a network of Critical Zone Observatories (CZOs) in the United States. Each CZO has attributes in climate, lithology, land use, biology, and topography that makes its character unique for studying a range of Critical Zone processes. The CZO network, which began in 2007, currently consists of 10 sites. Collaborative research within each CZO, as well as across the CZO network, leverages a diverse and growing scientific community that now has the platform for novel and fundamental advances in knowledge of our Earth system and the study of how Critical Zone processes, like soil formation, stream flow generation, landscape evolution, and the biogeochemical cycling of essential elements benefit society.

Workshop Aims: Our intent is to develop recommendations to the CZO community for common questions, common measurements, common methods, common laboratories, and common experiments to support cross-U.S. CZO and international CZ science in the area of organic matter dynamics. We will take advantage of the participation of the large cohort of scientists from China who are either already engaged in China CZO development or directly working in CZ-related science to help advance CZO efforts toward the implementation of a China-U.S. bi-laterally coordinated and funded CZO program. The conference and workshop will further the on-going efforts to educate future leaders in global CZ science and policy, and address major societal challenges related to CZ functions by leveraging diverse scientific perspectives and unique institutional resources afforded by an integrated U.S.-China perspective.

At this workshop three topics will be discussed in parallel sessions starting in the afternoon on Oct 23 and concluding by 2pm on Oct 24. These topics are a) multivariate/chemometric methods for large and complex data set analysis in CZ science, b) organic matter dynamics as controlled by erosion and deposition, c) mineralogical and microbial controls on soil and sediment organic matter reactivity and persistence. We ask that the conversations be directed toward establishing the appropriate networked science, e.g. common questions, new and existing analytical techniques, statistical approaches, and common lab and field experiments, to allow the scientists in the CZO Network to

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take advantage of the full spectrum of biogeochemical, topographic, land use, climatic, and hydrological variability across the CZO to identify fundamental drivers for organic matter dynamics through the entire CZ profile through time. Discussions concerning establishing an overarching conceptual framework that controls organic matter persistence and vulnerability across the network may also be fruitful.

Guiding questions to assist in discussion direction for each of the three topic areas may include:

- What are the needed (and current) cross CZO organic matter-related hypothesis to be tested?
- What are the major opportunities and knowledge gaps in this area and are they the same for the US and China?
- What are the "low hanging fruit" science questions that can be addressed with common experiments or common measurements?
- Should there be minimal measurements required/suggested for each observatory across the network?
- What are the opportunities and challenges of creating nationally/internationally networked CZO program in this area
- What plan of action and a schedule of steps is needed to develop a coordinated national and international program of CZO research in this area?
- What makes a CZO a "CZO" in this area?

Suggested Outcomes for Workshop and post workshop synthesis: This workshop will result in a platform of recommended common questions, experiments, measures, metrics, and data treatment for cross CZO science on OM dynamics do be provided to the NSF CZO national office for distribution to the US and International CZ community. The hope is that the outcome of each of the workshops shall be distilled for publication in an appropriate journal or book.

Detailed Workshop Topic Descriptions

A. Multivariate/chemometric methods for large and complex data set analysis in CZ science: Rationale-Faster and less expensive methods to assess biogeochemical, geomorphic, and environmental drivers of organic matter dynamics in the CZ are needed particularly considering the opportunities to work across large sample sets and locations in networked research such as in Ameriflux, Chinaflux, CERN, CZO, LTAR, LTER, and NEON. Statistical approaches calibrating high throughput spectral measures with higher resolution and sensitivity tools that are often costlier and more labor intensive offer

strong predictive potential. Contributions and discussions will focus on the use of statistical methods to correlate organic geochemical (e.g. Diffuse reflectance FT-IR spectroscopy (DRIFT), solid and liquid state NMR, thermal analysis, complex biomarker assemblages from gas and liquid chromatography analysis, and stable isotopic and other geochemical properties) across large data sets.

B. Organic Matter Dynamics As Controlled by Erosion and Deposition: Rationale-Over a broad range of time scales, soil organic matter (SOM) processes are strongly influenced by soil erosion, deposition and the development of landscape macro/microtopography. Through the natural coevolution of geomorphic, pedogenic, and ecological processes in the critical zone or by punctual changes in these processes as a result of intensive management, dynamic landscapes establish characteristic hierarchies of physicochemical controls on organic matter stability. These mechanisms include physical isolation of organic matter (OM) inside aggregates, the chemical interaction of OM with soil minerals, and the molecular structure of primary or altered soil organic matter that defines the state of SOM persistence/resilience. Contributions and discussions will focus on addressing soil organic matter dynamics as controlled by runoff, erosion, deposition and macro/microtopography.

C. Mineralogical and Microbial controls on soil and sediment OM reactivity and persistence: Rationale-Strong organo-mineral interactions are arguably the most important mechanisms governing long-term C stabilization in shallow and, in particular, deep soil and sediments horizons. Such physico-chemical interactions have a fundamental control on the microbial decomposition of soil and dissolved OM and also control the subsequent stabilization of microbial necromass. While the main contributions to soil organic matter include plant residues (i.e. above and belowground litter, rhizodeposits), microbial necromass, and pyrogenic organic matter a finite range of organo-mineral interactions, including ion exchange, ligand exchange, hydrophobic interactions, or weak electrostatic interactions, control the accessibility of OM to microbes regardless of the availability of other required nutrients and moisture needed for anabolic and catabolic processes.