**Common Critical Zone Observatory (CZO) Infrastructure and Measurements**

***Conceptual framework and goals:***

The CZOs are sites where new and innovative techniques for quantifying the Critical Zone (CZ) are developed and tested. While each site develops and shares novel approaches to quantifying the CZ, all sites aim to make a set of cross-CZO comparable measurements. The data collected are also comparable with local, regional, and global monitoring efforts.

The site-specific approach is based on the principal of “best technique and sampling design” for the individual CZO - the target set of focal areas of measurements for all sites is described below. The goal of each site and the network is to fully develop the infrastructure and personnel needed to:

(i) resolve the evolution and formation of the CZ and its attributes;

(ii) measure the properties and structure of the present-day CZ;

(iii) construct mass and energy balances (event- to long-time scales) that can be used for cross- site comparisons at multiple scales and to characterize the state of the CZ, and changes in the CZ through space and time.

**All CZOs seek to develop a common set of measurements to quantify:**

**1. CZ architecture and evolution;** including structural change with time; regolith and drainage valley evolution; rates of soil production, differentiation, and erosion; 3D spatial distribution and character of bedrock, soil, vegetation, and topography.

**2. Fluxes across the CZ boundaries;** including the vegetation-atmospheric boundaries; terrestrial-aquatic boundaries; soil-atmospheric boundaries; soil-plant boundaries; and bedrock-soil boundaries.

a. *Energy*: Measurements of incoming and outgoing visible and infrared radiation, plus latent and sensible heat exchange, supported by sufficient characterization to distribute these quantities across a watershed.

b. *Water*: Measurements of catchment-scale hydrologic cycles and pathways, including precipitation amount and type, evapotranspiration (ET) and its components, subsurface flows, and stream discharge.

c. *Solutes and Sediment:* Gaseous, aqueous and solid inputs and exports of elements (carbon, metal(loid)s, nutrients) are quantified with sufficient characterization to distribute these quantities across a catchment and landscape.

**3. Fluxes and changes in storage of the major CZ reservoirs at the catchment scale**

a. *Energy*: Changes in the thermal state of the near-surface realm.

b. *Water*: Amounts of and changes in snowpack, soil water and groundwater storage

c. *Mass transfer:* Using known water fluxes and measured concentrations to provide solute and sediment mass fluxes and changes in the major reservoirs of the CZ. These measurements are of sufficient detail that they can describe changes as a function of depth and watershed location.

***CZO Common Measurement Protocols***

The CZO network uses both CZO specific instrumentation and campaign-style measurements to quantify the composition and fluxes across the (i) land-atmosphere boundary (upper boundary) through (ii) vegetation (iii) regolith and (iv) stream water through space and time. A representative set of measurements/approaches (not all of which may be feasible in all CZOs) is discussed below.

**1. Land-Atmosphere**

* LiDAR datasets
* Eddy flux for momentum, heat, water vapor, CO2
* Wind speed and direction sensors
* Solar radiation and temperature sensors
* Precipitation and through-fall samplers
* Wet and dry deposition samplers

**2.**  **Vegetation and associated microbiota**

* Structure and composition of above and below biomass
* Above and below ground microbial composition
* Relations between ET and species composition and structure

**3.** **Soil (vadose zone)**

* Solid phase (campaign sampling for spatial characterization)
  + Elemental composition and Mineralogy
  + Texture and physical characterization
  + Organic matter content
  + Radiogenic isotope composition
* Fluid phase (sensors and samplers for time series)
  + Soil moisture (sensors)
  + Soil temperature (sensors)
  + Soil solution chemistry (samplers)
  + Soil gas chemistry (samplers/sensors)

**4.** **Saprolite and bedrock (saturated zone)**

* Solid phase (campaign sampling for spatial characterization)
  + Petrology and mineralogy
  + Elemental composition and organic matter content
  + Texture and other physical and architectural traits
* Fluid phase (sensors and samplers for time series)
  + Potentiometric head and temperature (sensors)
  + Groundwater chemistry (samplers/sensors)

**5. Surface water**

* Instantaneous discharge (flumes, weirs, with water quality sensors)
* Stream water chemistry, dissolved and suspended (samplers/sensors)
* Sediments (samplers/sensors)