Theme 1: **What controls CZ properties and processes?**

1. *How does the critical zone development depend on lithology and geologic legacy?*
2. *How does critical zone development vary with climate?*
3. *What is the role of microbes deep in the critical zone in mediating solute evolution of runoff water and carbon processing?*
4. *How does hillslope aspect, as it influences local climate, affect critical zone evolution and structure?*

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| Addressing a particular CZO, site, breakout group, or working group: **SOUTHERN SIERRA CZO** | | |
| Questions | Key Findings | Methods & Tools  (infrastructure, measurements, models) |
| Why does soil development not map with regolith?  What controls thickness of deep regolith? (especially vegetation-climate interactions?)  Can we predict from process model? | Found an elevation trend with an optimum zone of thickness at 2000 m  Hyp follows ET trend where:  within sites, topography leads to a pattern of equal thickness on slopes and ridges; Bedrock shows an inverted pattern | Resistivity  Co-located:  Seismic refraction  Geoprobe  Digital Soil Mapping  Ground penetrating radar |

**Theme 2: What is response of CZ structure, stores, and fluxes to climate?**

* 1. *What is the relationship between concentration & discharge?*
  2. *What factors moderate soil-organic carbon relationships in shallow and deep soil?*
  3. *How do material & energy fluxes across boundaries relate to climate?*
  4. *Especially on shorter time scales, what controls biogeochemical stores and fluxes within the CZ?*
  5. *How do microbial communities (activity, composition) influence biogeochemical stores and fluxes?*

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| Questions | Key Findings | Methods & Tools  (infrastructure, measurements, models) |
| What are & what controls spatial and temporal patterns of carbon and nutrients?  - Stocks  - Fluxes  - Turnover time  What drives spatial variation in C, Nutrients at 200 m scales?  At meter scale, what is spatial/temporal variation? (hot spot/hot moments?)  How do nutrients, etc., get to the stream? (flowpaths, meadows, timing)  What controls lateral transport of C and N, and how does that transport influence OM stabilization? | POC related to discharge  Composition is generally constant, with C & N mostly coming from the forest floor, while magnitude has interannual variability  Hydrologic residence time of water exported from meadows varies on diurnal scale (day vs. night)  Very low N-out relative to N-deposition  Soil carbon stabilization is largely under physical control | Point samples:   * isotope, elemental (water, soil, sediment) * density fractionation * lysimeters, resins * spectroscopy |

**Theme 3: What is response of CZ structure, stores and fluxes to land use change?**

1. *How does the CZ respond to climate change & land-use/management effects?*
2. *How does regolith affect vegetation?*
3. *How do (bi-direction) vegetation-regolith dynamics influence CZ structure, stores & fluxes, including water & C?*
4. *How do material and energy fluxes across boundaries relate to land use change?*

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| Addressing a particular CZO, site, breakout group, or working group: **SOUTHERN SIERRA CZO** | | |
| Questions | Key Findings | Methods & Tools  (infrastructure, measurements, models) |
| 1. What is the role of vegetation in controlling water and carbon cycle? 2. What controls distribution of vegetation type and density? 3. How does vegetation influence regolith/soil development? 4. How does regolith modulate Q1 & Q2? | ET is proportional to NPP and reaches a maximum at mid-elevations  Deep regolith allows mid-elevations to continue activity/ET through summer dry period  Significant winter activity at mid-elevation vegetation  Looks like vegetation-regolith are coupled, which could relate over long time scales and in bidirectional manner | Flux tower gradient  Water balance measured at mid-elevation site  (water, snow) |

**Theme 4: How can CZ understanding be used to enhance resilience and sustainability, and restore ecosystem function?**

*How can we apply understanding of the Critical Zone to enhance ecosystem services and patterns such as:*

*water resources, disturbance, ecological indicators, or sustainability?*

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| Addressing a particular CZO, site, breakout group, or working group: **SOUTHERN SIERRA CZO** | | |
| Questions | Key Findings | Methods & Tools  (infrastructure, measurements, models) |
| How does CZ & vegetation combine to affect water yield?  How can we efficiently monitor critical zone services?  How resilient is the ecosystem to drought?  How does disturbance & climate warming affect partitioning of precipitation into ET vs. streamflow?  What is the capacity of this system to sequester carbon & can this be influenced by management? | Water yield under current climate is dominated by high elevations  Moisture storage in deep soils is a key control on drought vulnerability  Snow storage = soil storage  Snow + soil storage = reservoir/dam storage  Peak carbon storage (soil & vegetation) at mid-elevations | Water balance measurements  Flux tower gradient  Remote sensing (LiDAR, HyspIRI)  Point soil cores, geophysics  Modeling |

To be paired with each form, as a breakout group or CZO team fills it out:

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| Cross-CZO Opportunities | | |
| Similar Questions | Comparable Measurements | Synthesis Opportunities |
|  |  | Additional measurements: |
| Funding: |
| Working Group Opportunities |