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 |  ResistivityCo-located: Seismic refractionGeoprobeDigital Soil MappingGround 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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| Addressing a particular CZO, site, breakout group, or working group: **SOUTHERN SIERRA CZO** |
| Questions | Key Findings | Methods & Tools (infrastructure, measurements, models) |
|  What are & what controls spatial and temporal patterns of carbon and nutrients? - Stocks- Fluxes- Turnover timeWhat 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 dischargeComposition is generally constant, with C & N mostly coming from the forest floor, while magnitude has interannual variabilityHydrologic residence time of water exported from meadows varies on diurnal scale (day vs. night)Very low N-out relative to N-depositionSoil carbon stabilization is largely under physical control |  Point samples: * isotope, elemental (water, soil, sediment)
* density fractionation
* lysimeters, resins
* spectroscopy
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**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-elevationsDeep regolith allows mid-elevations to continue activity/ET through summer dry periodSignificant winter activity at mid-elevation vegetationLooks like vegetation-regolith are coupled, which could relate over long time scales and in bidirectional manner |  Flux tower gradientWater 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 vulnerabilitySnow storage = soil storageSnow + soil storage = reservoir/dam storagePeak carbon storage (soil & vegetation) at mid-elevations |  Water balance measurementsFlux tower gradientRemote sensing (LiDAR, HyspIRI)Point soil cores, geophysicsModeling |

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 |