Measuring Critical Zone Co-evolution in Real time

JON CHOROVER[1], YANIV OLSHANSKY[1], JON PELLETIER[2], CRAIG RASMUSSEN[1], GREG BARRON-GAFFORD[3], AND NATE ABRAMSON[1]

[1]Department of Soil, Water and Environmental Science, University of Arizona, Tucson, AZ 85721
[2]Department of Geosciences, University of Arizona, Tucson, AZ 85721
[3]School of Geography and Development, University of Arizona, Tucson, AZ 85721

Critical zone (CZ) co-evolution depends on the coupled changes in biota, regolith and landscape structure that are most commonly observed to occur over pedogenic and geologic time scales (through space for time substitution). The sky islands of southern Arizona represent a well-defined natural experiment involving such feedbacks because mean annual precipitation varies five-fold over distances of ca. 10 km in areas of similar rock type and tectonic history. Pelletier et al. (2013) showed that, in the Santa Catalina Mountains (AZ, USA), strong correlations exist among vegetation-soil-topography variables that vary non-linearly with elevation, and that these trends could be reproduced in a landscape evolution model that includes eco-pedo-geomorphic feedbacks. Feedbacks between above ground biomass, soil thickness, clay content and geochemical weathering indices have been observed, highlighting the influence of climate on CZ structure. To resolve the real-time impacts of ecosystem metabolism on soil geochemical reactions, we installed a set of *instrumented pedons*, containing multiple co-located sensors and samplers as a function of depth, in close proximity to an eddy covariance tower at a high elevation (mixed conifer forest) site. Apparent respiratory quotients, calculated from CO_2 and O_2 flux data, deviated from expected oxidative ratios particularly during soil wetting events. These deviations were correlated in time with pore water geochemical responses, revealing that a significant fraction of respired CO_2 (and dissolved O_2) was consumed in pulsed silicate weathering events that accompanied wetting-front propagation through the soil. The timing and nature of the moisture-CO_2-weathering response was dependent on intial conditions, landscape position and season. The results highlight the tight coupling that exists between physical, biological and chemical processes, on event time scales, during incremental co-evolution of the CZ, particularly in water-limited systems.