Linking hydrology and biogeosciences towards better understanding of soil and critical zone processes

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The growing recognition of the centrality of soil and the critical zone (SCZ) as a key biogeochemical-hydrological compartment of the biosphere and as a scientific arena is driven by pressing global challenges that range from climate change to food security and from energy and water resources to understanding of ecosystem functioning. The evolving SCZ community is expanding beyond traditional links with agriculture and pedogenic processes. The importance of strengthening ties across disciplines including atmospheric sciences; biogeosciences; ecology; hydrology; and geochemistry are not only critical for the relevance of the SCZ community, but are mandated by the scientific challenges such as water quality and quantity, carbon cycling, and nutrient availability. A more strongly interdisciplinary community will offer numerous advantages for the professional preparation of broadly-trained current and future students, and will undoubtedly contribute to the flourishing of a vibrant SCZ discipline.

The US National Academy of Sciences (2001) defined the critical zone as the Earth's outer layer from vegetation canopy to the soil and groundwater that sustains life on earth. The evolving and broader context of soil science is derived from the array of functions and critical services provided by soils that both include and transcend food production (Figure 1):

- Soil within the critical zone is probably the most biologically active compartment of the biosphere, hosting the largest pool of biodiversity on Earth;
- Soil functions as Earths' life support body, a thin film of life covering much of the terrestrial surface;
- Soil is a giant recycling system, providing most of our needs for food, feed, fiber, and increasingly for renewable energy production through biofuels.
- Soil supports global biogeochemical cycles (C, N, P), representing the largest terrestrial stock of organic carbon;
- Soil provides important ecosystem services essential for human primary needs including drinking water and food provision, and carbon storage and flood regulation;
- Soil is a functioning complex natural body with unique characteristics and emergent behaviors that cannot be deduced from a collection of its constituents or individual processes; soil is an integrator of the Earth processes for which it is intrinsically linked.

Translating these general ideas into a coherent plan of action requires formulation of SCZ-relevant science questions that frame grand challenges to the community. Questions such as the following will provide more specific context for the evolution of the field:

a. How will improved understanding of SCZ processes lead to a more complete description of land surface-climate interactions in the context of climate modeling and assessment of changing climate impacts? For example, how can surface soil moisture dynamics and remotely-sensed fluxes be better linked? How is soil water storage manifested in hydro-climatic memory, or in mediating precipitation patterns and extreme heat waves? How can the contribution of SCZ better constrain estimates of carbon storage and greenhouse gas emissions?
b. What are the gaps in fundamental understanding of SCZ processes that must be addressed to sustain and increase food production with limited natural resources (land, water) and in a changing climate? How can we leverage SCZ knowledge to refine crop selection and improve agricultural production? How can modern theories of hydro-mechanical process be implemented to support sustainable land use under increasingly intensive practices? How do land use patterns vary with climatic and SCZ processes? What are the ramification of climate change trends on SCZ process and land use?

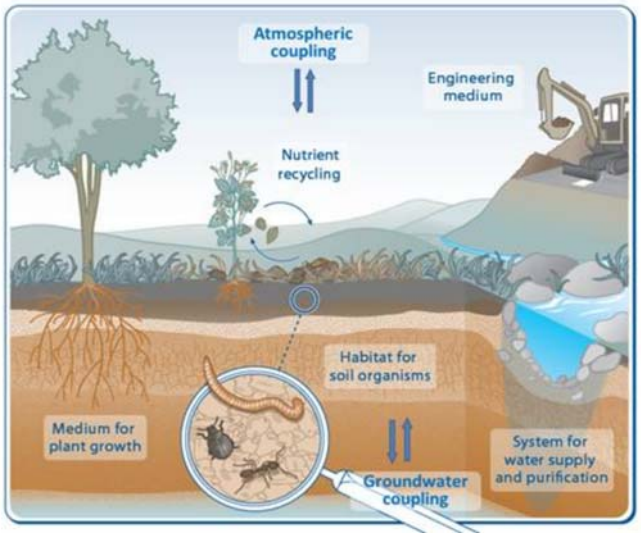

Figure 1: An overview of some of key ecological functions and services provided by soil and the critical zone (visual courtesy D. Or, ETH Zurich).

c. Considering the central role of soil as the most biologically active part of the Earth's terrestrial biosphere, how can SCZ processes be managed to assure sustainability of ecosystem functions of natural and man-made (agro) ecosystems? How do SCZ conditions affect global biogeochemical cycles? What are the most pressing gaps in understanding of plant-soil interactions? What are relationships between structure and function in soils? How do we define and assess soil quality and functionality to detect trends and thus mitigate degradation processes?
d. Can the potential of remote and terrestrial land observing systems (targeting primarily soil surfaces) be better exploited to understand connections between observable above land surface SCZ elements (vegetation, atmosphere) and unobservable elements (groundwater, deep vadose zone)?How can observations of hydrological, climatic and ecological elements of the critical zone be acquired and linked for synergistic assessment of processes and state of ecosystems? How can SCZ information best be communicated to decision makers and the public?

These are only few examples of overarching issues facing the SCZ community. Most of them point to intricate connections between many disciplines, most prominent of which in the context of AGU are links between hydrology and biogeosciences. The newly-formed Technical Committee on Soil Systems and Critical Zone Processes creates a natural bridge between the Biogeosciences and Hydrology Sections of AGU, and provides the SCZ community with opportunities to strengthen links with the Soil Science Society of America (SSSA), the Ecological Society of America (ESA), and others. We hope that the TC will promote the scientific study of soil and critical zone by increasing visibility of soil and critical zone processes at AGU meetings, engaging in joint activities with other societies, and fostering publication on these topics in AGU journals.

Among the short-term goals for the TC will be to solicit reviews and/or position papers on some of the cross-cutting research questions above. The new TC will also be developing ideas for sessions at AGU meetings that will capitalize on natural SCZ links in the context of AGU Earth System Science. It may also organize Chapman or Gordon Research Conferences, and other topical conferences on the role of SCZ in some of the themes listed above. We expect that an important, but less specific role of the TC will be to promote teaching of SCZ science, and to encourage young scientists in the area. We have launched a new web page for the SCZ TC (http://www.soils-agu.ethz.ch/index.php) where such initiatives can be announced, and we encourage members to contact us as co-chairs of the TC regarding proposals and promotion of new ideas. An inaugural TC meeting will be held during the AGU Fall 2011 meeting (*12/7/2011; 6:45-7:45AM at Moscone North, Room 114*) and will be devoted to establishing activities and operating rules for the TC. We encourage you to become involved, express your views and share your ideas for future activities!

References

National Research Council (NRC), 2001. Basic research opportunities in earth science. National Academy Press, Washington, DC.