Geophysical Research Abstracts
Vol. 20, EGU2018-8157-1, 2018
EGU General Assembly 2018
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Mechanical and Biophysical Constraints Affecting Soil Bioturbation by Earthworms and Plant Roots

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The structure of many productive soils is marked by earthworm burrows and decaying plant roots voids that span networks of biopores and affect soil hydrological and ecological functioning. We developed a modeling framework for quantifying the mechanical stresses and energetic costs of penetrating the soil at rates characteristic to earthworms and plant roots (200 and 0.2 μm s-1, respectively) and the respective limiting pressures (200 kPa and >1 MPa) for these biological agents. These intrinsic biophysical differences impose strict windows of activity that reflect soil hydration status and mechanical properties. The results delineate temporal windows of activity prescribed by regional soil and climatic conditions that prohibit earthworm burrowing while root growth remains unaffected. We discuss ecological ramifications and geographic implications of such constraints under present and future climates in terms of soil structure generation, carbon consumption, and subterranean biophysical activity.