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2D visualization captures the local heterogeneity of oxidative metabolism across soils from diverse land-use

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Abstract:

Fine-scale processes in soils affect large-scale phenomena by controlling mixing and reaction rates, yet technological constraints have hampered the collection of micro-scale kinetic data. As a result, limited information is available on the magnitude of fine-scale biogeochemical rates and their temporal and spatial pattern in response to environmental perturbations. In this work we investigate the spatio-temporal dynamics in oxidative microbial activity and the development of anoxic micro zones (i.e., anoxic hot-spots) at the microscopic level (μm – cm). These analyses rely on novel non-invasive & non-destructive optodes, which are able to capture real-time imaging of oxygen concentrations over time at an interval of twenty seconds. Results showed that labile carbon addition resulted in maximum rates of local metabolic activity within a few minutes (5 to 15) and led to the subsequent formation of anoxic hot-spots. Different areas within a given soil sample presented up to one order of magnitude variation in metabolic rate values. As a result, oxic and anoxic micro-zones coexisted closely. The relationship between oxygen concentrations and heterogeneity of oxidative metabolism resulted in an initial increase in metabolic heterogeneity over time followed by a decrease when anoxic conditions dominated. A similar link was found by comparing metabolic activity and its heterogeneity across a range of soil types. These results demonstrate that the microbial activity and hot-spot development can be monitored by using a non-invasive quantitative imaging system that allows real-time monitoring of spatial oxygen distribution. We conclude that local dynamics of heterogeneity in space and time at the fine/scale present the same functional behaviour encountered in most ecosystems at the landscape-scale.

Keywords: Real-time oxygen imaging, interspersion, planar optode, microbial activity, micro-habitats, labile substrate addition