Geophysical Research Abstracts
Vol. 17, EGU2015-1775-1, 2015
EGU General Assembly 2015

Uncovering stability mechanisms in microbial ecosystems – combining microcosm experiments, computational modelling and ecological theory in a multidisciplinary approach

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Although bacterial degraders in soil are commonly exposed to fluctuating environmental conditions, the functional performance of the biodegradation processes can often be maintained by resistance and resilience mechanisms. However, there is still a gap in the mechanistic understanding of key factors contributing to the stability of such an ecosystem service. Therefore we developed an integrated approach combining microcosm experiments, simulation models and ecological theory to directly make use of the strengths of these disciplines. In a continuous interplay process, data, hypotheses, and central questions are exchanged between disciplines to initiate new experiments and models to ultimately identify buffer mechanisms and factors providing functional stability. We focus on drying and rewetting-cycles in soil ecosystems, which are a major abiotic driver for bacterial activity. Functional recovery of the system was found to depend on different spatial processes in the computational model. In particular, bacterial motility is a prerequisite for biodegradation if either bacteria or substrate are heterogeneously distributed. Hence, laboratory experiments focussing on bacterial dispersal processes were conducted and confirmed this finding also for functional resistance. Obtained results will be incorporated into the model in the next step. Overall, the combination of computational modelling and laboratory experiments identified spatial processes as the main driving force for functional stability in the considered system, and has proved a powerful methodological approach.