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Biological soil crusts emit large amounts of NO and HONO affecting the nitrogen cycle in drylands

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Dryland systems currently cover ∼40% of the world´s land surface and are still expanding as a consequence of human impact and global change. In contrast to that, information on their role in global biochemical processes is limited, probably induced by the presumption that their sparse vegetation cover plays a negligible role in global balances. However, spaces between the sparse shrubs are not bare, but soils are mostly covered by biological soil crusts (biocrusts). These biocrust communities belong to the oldest life forms, resulting from an assembly between soil particles and cyanobacteria, lichens, bryophytes, and algae plus heterotrophic organisms in varying proportions. Depending on the dominating organism group, cyanobacteria-, lichen-, and bryophyte-dominated biocrusts are distinguished. Besides their ability to restrict soil erosion they fix atmospheric carbon and nitrogen, and by doing this they serve as a nutrient source in strongly depleted dryland ecosystems. In this study we show that a fraction of the nitrogen fixed by biocrusts is metabolized and subsequently returned to the atmosphere in the form of nitric oxide (NO) and nitrous acid (HONO). These gases affect the radical formation and oxidizing capacity within the troposphere, thus being of particular interest to atmospheric chemistry. Laboratory measurements using dynamic chamber systems showed that dark cyanobacteria-dominated crusts emitted the largest amounts of NO and HONO, being ∼20 times higher than trace gas fluxes of nearby bare soil. We showed that these nitrogen emissions have a biogenic origin, as emissions of formerly strongly emitting samples almost completely ceased after sterilization. By combining laboratory, field, and satellite measurement data we made a best estimate of global annual emissions amounting to ∼1.1 Tg of NO-N and ∼0.6 Tg of HONO-N from biocrusts. This sum of 1.7 Tg of reactive nitrogen emissions equals ∼20% of the soil release under natural vegetation according to the latest IPCC report. In summary, our measurements show that dryland emissions of nitrogen oxides are largely driven by biocrusts and not by the underlying soil. As precipitation patterns, which influence biocrust activity, are affected by climate change, alterations in global nitrogen oxide emissions are to be expected. Thus, the role of biocrusts in the global cycling of reactive nitrogen needs to be followed and also implemented in regional and global models of biogeochemistry, air chemistry and climate.