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Nitrous oxide emissions from organic soils of the world explained by soil nitrate and moisture

Jaan Pärn (1,2), Ülo Mander (1,3), and the 35 international collaborators Team

(1) Department of Geography, Institute of Ecology and Earth Sciences, University of Tartu, Estonia, (2) School of Geography, Geology and the Environment, Keele University, Keele, United Kingdom, (3) Hydrosystems and Bioprocesses Research Unit, National Research Institute of Science and Technology for Environment and Agriculture (IRSTEA), Antony, France

Human activity has increased the atmospheric concentration of nitrous oxide (N2O), a powerful greenhouse gas and the main stratospheric-ozone depleting agent. Organic soils are considered a minor N2O source but that may be changing due to human activities, particularly drainage and fertilisation for agriculture. Predicting global N2O emission is a challenge owing to high temporal and spatial variability, and in view of the paucity of data from the tropics. We conducted a global soil- and gas-sampling campaign between August 2011 and January 2016, following a standard protocol. We sampled 61 organic-soil sites (>10% soil carbon content in the upper 0.1m at all locations) in 25 regions covering moist tropical, temperate and boreal climates. Of all parameters assessed for the variability in site-mean N2O emission, the logarithm of soil carbon-to-nitrate ratio (log (C/NO_3-N)) was the strongest predictor, explaining 68% of the variation in log N2O fluxes. Inclusion of site-mean soil moisture raised the explanatory power of the multiple-regression GAM to R2=0.71. The paraboloid regression surface had a humped shape with large N2O fluxes above 80% soil moisture. Likewise, in an independent test of the model on published data, annual time scales of N2O emission were represented well. The relationship between the mean relative N2O fluxes (scaled to the maximum value in the data set) and soil moisture was best described by a humped log GAM regression with a maximum at 50 to 60% soil moisture (R2=0.66; p= 0.0114). Soil temperature, another factor that has often been used to explain variability in N2O emissions, showed only a weak relationship with both the N2O fluxes measured in our study and published in the analysed papers. We conclude that loss of moisture increases N2O emissions from nitrogen-rich organic soils by two orders of magnitude. Wetland conservation and restoration, and appropriate soil management, are thus essential for climate-change mitigation and protecting the stratospheric ozone layer.