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Are catchment-scale nitrogen and phosphorous use efficiencies controlled by climate?

Anna Scaini[1,2] and Stefano Manzoni[1,2]
[1]Department of Physical Geography, Stockholm University, Stockholm, Sweden
[2]Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden

Nutrient loss from agricultural fields imparts increased fertilizer costs as well as negative consequences for the natural environment. Given that water availability mediates both nutrient uptake by plants as well as nutrient leaching, we hypothesize that hydrologic conditions can explain variations in nutrient use efficiencies, defined as ratios of the nutrient amounts in harvested yield and in inputs. We analyze data from 110 US catchments with agricultural area comprising more than 10% of the watershed and compute nitrogen and phosphorus use efficiencies (NUE and PUE) over the period 1988-2007. To assess if NUE and PUE are related to hydrologic conditions, we consider the evaporative ratio ET/P (calculated as evapotranspiration divided by precipitation) as a predictor in a linear mixed effect model. We test the hypotheses that the nutrient use efficiencies increase with ET/P, through increased water and nutrient retention, and that the nutrient efficiencies increase through time. We found that both nutrient use efficiencies increased through time: NUE increased in the period analyzed in 88% of catchments, while PUE in 90% of catchments. Both NUE and PUE were largely driven by significant increases in N and P amounts in yield. The evaporative ratio was positively related to NUE. Moreover, we found an interaction between ET/P and time, such that the ET/P effect on NUE decreased in the period 1998–2007. The evaporative ratio was also positively related to PUE. Other potential drivers were assessed, including interaction between ET/P and time, as well as the percentage of agricultural area in each catchment. Our results show that changes in climate that include increased evaporation and decreased precipitation can lead to increase N use efficiencies without decreasing yields. The implications of our findings in terms of the release of N and P to water bodies has particular relevance in terms of climate change, as higher temperatures and lower precipitation (i.e. increasing evaporative ratios) will potentially lead to increased nutrient retention and therefore decreased nutrient leaching from agricultural fields.