Geophysical Research Abstracts
Vol. 20, EGU2018-116, 2018
EGU General Assembly 2018

Large regional potential to enhance carbon uptake by European agricultural land based on remote sensing data and yield statistics

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Agricultural plants, covering large parts of the land surface (globally about 12%) and important for the livelihood of people worldwide, fix carbon seasonally. The carbon (C) uptake of crops, however, remains understudied compared to, for example, forests. Robust information on carbon uptake in croplands can be obtained by integrating remote sensing data and terrestrial yield statistics. Each data source and methodological approach (converting harvested yield from EUROSTAT into productivity, remote sensing based productivity algorithm MOD17 using downscaled European climate data) has limitations, such as assumptions on allocation patterns, carbon content, etc. using conversion factors or the global calibration of crop productivity algorithms. We circumvent biased imputations due to parameter selection by using an ensemble of parameter sets and water content information (n=12). With a climate-sensitive potential productivity model (the Miami model) we can estimate the yield gap, which is the potential to enhance current productivity by improved nutrient management, pest control or cultivar selection.
Country average yield gap in Europe is +123 g C m-2 year-1. The yield gap is higher in Eastern and Southern (for instance Romania +191 g C m-2 year-1, Spain +118 g C m-2 year-1) than in Central-Western countries (e.g. France -108 g C m-2 year-1 , Netherlands -136 g C m-2 year-1). Thus agriculture in some countries even exceeds potential productivity based on climatic limitations. Closing the yield gap in countries with currently lower productivity than the potential would imply an additional carbon uptake of 179 to 194 M t C each year (depending on source of agricultural area information) and thus an increase compared to current carbon uptake by European agriculture of about 45%. The additional carbon uptake could be used for replacing fossil-based products and/or energy.
Management options for closing the yield gap may include improved nutrient management, and/or optimizing pest control. We test this hypothesis using official statistics on fertilizer consumption and pesticide sales. Both the amount of fertilizer and pesticides per hectare agricultural land are correlated with yield gap (more application leads to lower yield gap), which permit identifying best practice examples in agricultural productivity. Optimizing crop management considering resource limitations and legal constraints will be an important task in the future, yet it will take years to decades to see the effect. Considering agriculture in carbon assessments, on the other hand, will have an immediate impact and avoid biased imputations of carbon exchange between the land surface and the atmosphere. We have to aim for optimizing ongoing carbon sequestration efforts considering all vegetation towards a global “carbon-oriented land management”, if we were to meet the current ambitious emission reduction goals.