Predicting Net Ecosystem Exchange in European croplands and its response to change in N inputs and climate change

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Overview

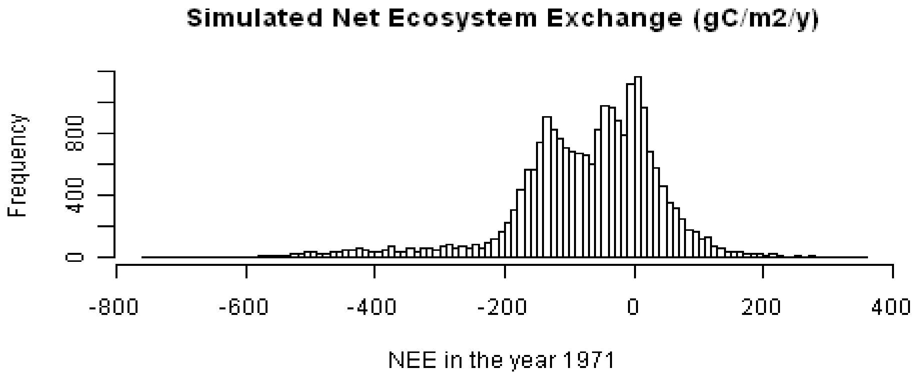
Evaluating the role of agro-ecosystems in the global carbon cycle requires a detailed understanding of carbon (C) exchange between vegetation, soil and the atmosphere, and of the impacts of nitrogen (N) on C exchange . Global climatic change may modify the net carbon balance of terrestrial ecosystems, causing feedbacks on atmospheric CO_2 and climate. We used the DailyDayCent model to investigate the impact of changes in N inputs and climate on Net Ecosystem Exchange from croplands in EU 27 during the period 1970-2030. The total land area in the EU27 was classified into ~41000 homogeneous units (NitroEurope Calculation Units: NCUs). The model was run in each NCU from 1971-2000 (baseline) and 2000-2030 using climate under the IPCC SRES A1B emission scenarios. The results suggest that farm management, like fertilizer N input and crop type are the main drivers of intra-regional differences in Net Ecosystem Exchange (NEE), whereas climatic and edaphic factors are responsible for the regional differences. We aim to investigate the NEE response to climate change in past and future.

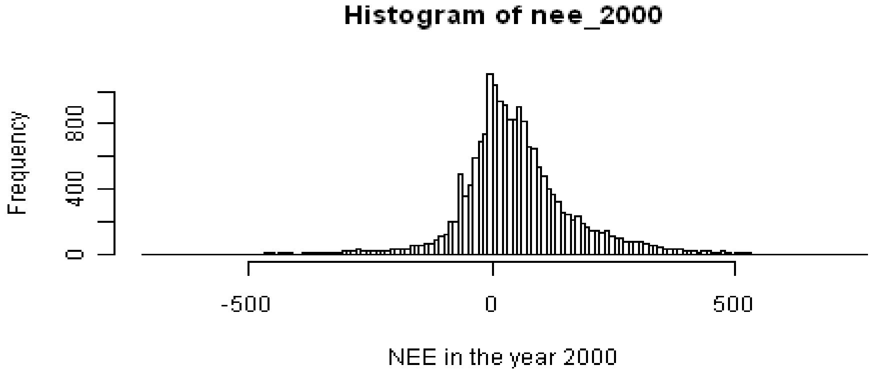
Methods

In this study we used DailyDaycent model to predict the NEE, Net Primary Production (NPP), soil organic carbon (SOC) decomposition, C storage in soil under past and future climate. DailyDayCent simulates fluxes of C and N between the atmosphere, vegetation, and soil. Key sub-models include soil water content and temperature by layer, plant production and allocation NPP, decomposition of litter and SOC, mineralization of nutrients, N gas emissions from nitrification and denitrification, and CH_4 oxidation in non-saturated soils. NPP is allocated to plant components (e.g. roots vs. shoots) based on vegetation type, phenology, and water/nutrient stress. The changes in land use and fertilizer N in response to scenarios were calculated by the GTAP-IMAGE model. To generate crop rotations in each NCU we used a crop rotation optimizer which translates FAO regional crop share information into a mixture of cropping sequences. Crop management information, with timing of ploughing, harrowing, sowing, harvesting and application of mineral fertilizer and manure was generated by a time-line generator model. The model was initialized by spinning up for ten years before 1971 using 1971 climate and management data. Simulated net ecosystem exchange of each NCU was aggregated to regional and country level.

Results and Discussion

Fig 1. shows the variation of carbon exchange (NEE) among different NCUs. Uptake of carbon is presented as a positive number. A large variation is found in NEE among different NCUS (Fig. 1). For the year 1971, there is an average loss of -73.9 gC m^2 y^{-1} with a standard deviation of 117 gC m^2 y^{-1} indicating a large spatial variability in Europe. In the year 2000, for the NCUs and cropping periods considered here, there is an average gain of 47.91 gC m^{-2} y^{-1}. However, a large variation is seen: the standard deviation is 120.5 gC $m^{-2}y^{-1}$. Many recent studies also showed a large variability in NEE across Europe (Smith 2004, Smith et al., 2005, Janssens et al., 2005). The variability was mostly attributed to climate, soil properties and land management. Freibauer et al. (2004) reported NEE simulations using CESAR model for the 2008-2012 commitment period; according to that study a carbon exchange of arable land varying between a source of −293 and a sink of 31 gC m^{-2} $year^{-1}$, resulting in a mean source of −83 gC m^{-2} $year^{-1}$ with a standard deviation of 40 gC m^{-2} $year^{-1}$.Our present study shows that European croplands act as a source or a weak sink of carbon.





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