

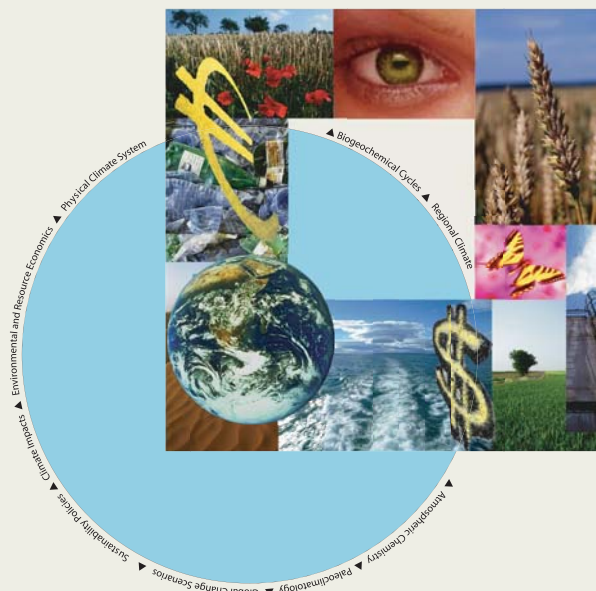


International Max Planck Research School on EARTH SYSTEM MODELLING

Assessing the Agricultural System and the Carbon Cycle under Climate Change in Europe using a Dynamic Global Vegetation Model

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Abstract

Several recent studies predicted changes in the climatic conditions in Europe driven by the increased atmospheric CO₂ concentration due anthropogenic activities. The climate change can affect the agriculture through many aspects of crop production over the European continent. Not only plant productivity, but also geographical shifts of cultivation areas, changes in crop phenology, in land use, and in soil carbon stocks have to be taken into account for assessments of the next future. This study provides a potentially powerful baseline to perform integrated assessments on the impacts of the changing climate by assessing crop production with a single integrated framework for large-scale studies. Not only crops and natural vegetation in a single Dynamic Global Vegetation Model, the LPJ-C, but also potential and water-limited crop production are included within the same biosphere scheme.

The LPJ-C is extended to simulate not only natural biomes, but also crops. We perform an optimization procedure, which provides a set of crop parameters used in the regional assessment over Europe. Further, we used the resulting modelling framework to study the changes of potential production of maize and wheat together with the shift in their potential growing area. The results show that wheat yield will suffer from a decline, but fertilization due to the CO₂ enriched atmosphere will compensate this effect. For maize, cultivation will clearly expand towards north and east. Since maize, as a C₄ plant, is mostly unaffected by the CO₂ fertilization effect, the shorter growing season will lead to a lower net primary productivity, while the mean over the continent will increase according to the large geographical spread.

Furthermore, LPJ-C is able to reproduce the observed relative increase of water use efficiency under water-limited conditions and a CO₂ fertilization effect. The improved water use efficiency of wheat leads to a relatively smaller transpiration per unit of biomass, so that precipitation will partially satisfy the

transpiration demand. On the other hand, wheat will suffer from an increase of yield variability and a higher frequency of extreme crop failures. Even though maize potential distribution will be enlarged, the yield will be affected by strong losses, unless largely improved irrigation will satisfy the increased water demand.

We perform also the coupling of LPJ-C with the land-use model KLUM, as a connection between a profit maximization procedure for land allocation and a process-based description of crop production. The coupled system showed that temperature would play a major role in the soil carbon dynamics over the expected northward shift of crops. However, important changes have to be expected for distribution of “warm” cereals as rice and maize.