A generic probability based algorithm to simulate the distribution of dominant crop types in time and space

M. Wattenbach[1,4], T. Schartner[1], J. Hillier[4], F. Hattermann[9], F. Wechsung[9], M. van Oijen[8], W. de Vries[2,3], G. J. Reinds[2], J. Kros[2], J. Yeluripati[4], M. Kuhnert[4], N Hutchings[7], R. Kiese[5], C. Werner[5], K. Butterbach Bahl[5], A. Leip[6], P. Smith[4]

1) Freie Universitaet Berlin, Institute of Meteorology, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany; 2) Alterra, Wageningen University and Research Centre, P.O. Box 47, 6700 AA Wageningen, The Netherlands; 3) Environmental Systems Analysis Group, Wageningen University, PO Box 47, 6700 AA Wageningen, Netherlands; 4) School of Biological Sciences, University of Aberdeen, Cruickshank Building, St. Machar Drive, Aberdeen AB24 3UU, UK; 5) Institute of Meteorology and Climate Research, Atmospheric Environmental Research, Kreuzeckbahnstrasse 19, D-82467 Garmisch-Partenkirchen, Germany; 6) European Commission – Joint Research Centre, Institute for Environment and Sustainability, Climate Change Unit, Via E. Fermi 2749, I-21027 Ispra (VA), Italy; 7) Aarhus University, Department of Agroecology and Environment, Blichers Allé 20, DK-8830 Tjele, Denmark; 8) Centre for Ecology & Hydrology, Bush Estate, Penicuik, EH26 0QB, U.K. 9) Potsdam Institute for Climate Impact Research (PIK), Telegraphenberg A 31, 14473 Potsdam, Germany

martin.wattenbach@fu-berlin

Overview

Croplands are not only the key to human food supply, they also change the physical properties of the land surface and contribute to the amount of greenhouse gases entering the atmosphere. The effects of cropland on the environment depend on the area planted, the type of crop and the associated management. Crop distribution is not random in time and space due to a range of boundary conditions. At a given point of time the pattern of crops in a landscape is not only determined by environmental and socioeconomic conditions but also by the compatibility with the crops which had been grown in the years before. Here we present a crop rotation generator algorithm that is used to calculate the combined and conditional probability for a crop to appear in time and space.

Methods/Approach

The basis for the year to year change in crops as derived by the algorithm is a transition matrix, but we divert from a Markovian approach by imposing additional constraints on year to year change like the return period of crops and temporal changes in crop preferences based on reported European crop statistics available in the Capri-dataset (Capri, 2010) and Eurostat (Eurostat, 2010). To reflect on climate driven changes in crop rotations we employ a bioclimatic envelope approach (Tuck *et al.*, 2006; Bellarby *et al.*, 2010). The conditional probability (p) of a crop (crop) in any year (i) given the crop of the year before (i-1) is defined by the transition matrix as elements of a sequence (seq) for spatial unit k as:

$$p_{k,i}(seq \mid crop_{k,i-1}) = \frac{p_{k,i}(seq \cap crop_{k,i-1})}{p_{k,i}(seq)}$$

Any additional information relevant for a crop to appear is assimilated using probability laws. The crops under consideration are durum wheat (DWHE), fodder maize (MAIF), maize (MAIZ), oats (OATS), other cereals (OCER), rice (PARI), potato (POTA), pulses (PULS), rape seed (RAPE), spring barley (SBAR), soya (SOYA), summer soft wheat (SSWH), sugar beet (SUGB), sun flower (SUNF), winter barley (WBAR), winter rye (WRYE), winter soft wheat (WSWH).

Results

The following maps and tables exemplify the model output over time and space.

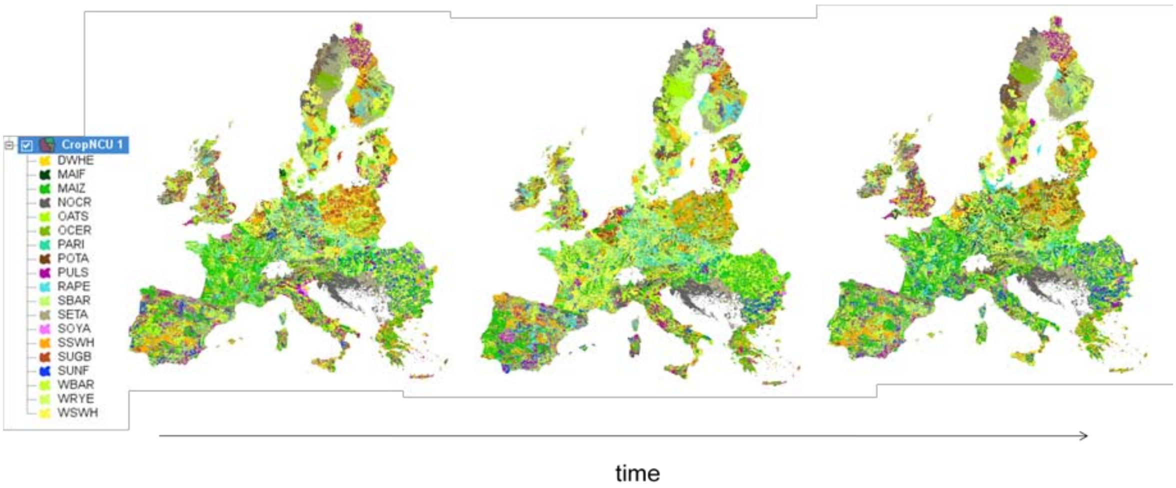
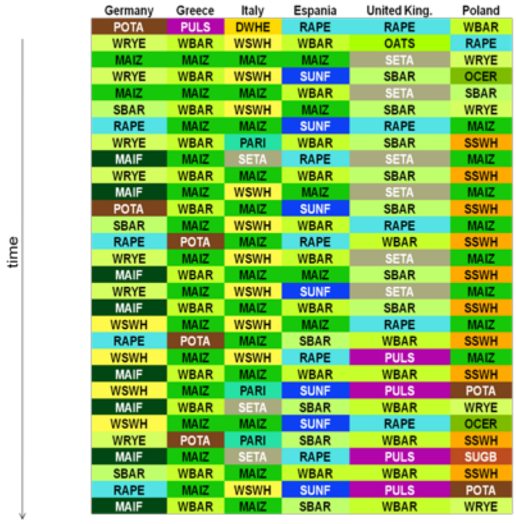


Fig. 1. Crop rotations over a sequence of three consecutive years. The colours illustrate the dominant rotation per NCU. The figure illustrates the change in pattern at country borders due to changes in crop preferences



Germany	Greece	Italy	Espania	United King.	Poland
POTA	PULS	DWHE	RAPE	RAPE	WBAR
WRYE	WBAR	WSWH	WBAR	OATS	RAPE
MAIZ	MAIZ	MAIZ	MAIZ	SETA	WRYE
WRYE	WBAR	WSWH	SUNF	SBAR	OCER
MAIZ	MAIZ	MAIZ	WBAR	SETA	SBAR
SBAR	WBAR	WSWH	MAIZ	SBAR	WRYE
RAPE	MAIZ	MAIZ	SUNF	RAPE	MAIZ
WRYE	WBAR	PARI	WBAR	SBAR	SSWH
MAIF	MAIZ	SETA	RAPE	SETA	MAIZ
WRYE	WBAR	MAIZ	WBAR	SBAR	SSWH
MAIF	MAIZ	WSWH	MAIZ	SETA	MAIZ
POTA	WBAR	MAIZ	SUNF	SBAR	SSWH
SBAR	MAIZ	WSWH	WBAR	RAPE	MAIZ
RAPE	POTA	MAIZ	RAPE	WBAR	SSWH
WRYE	MAIZ	WSWH	WBAR	SETA	MAIZ
MAIF	WBAR	MAIZ	MAIZ	SBAR	SSWH
WRYE	MAIZ	WSWH	SUNF	SETA	MAIZ
MAIF	WBAR	MAIZ	WBAR	SBAR	SSWH
WSWH	MAIZ	WSWH	MAIZ	RAPE	MAIZ
RAPE	POTA	MAIZ	SBAR	WBAR	SSWH
WSWH	MAIZ	WSWH	RAPE	PULS	MAIZ
MAIF	WBAR	MAIZ	WBAR	WBAR	SSWH
WSWH	MAIZ	PARI	SUNF	PULS	POTA
MAIF	WBAR	SETA	SBAR	WBAR	WRYE
WSWH	MAIZ	MAIZ	SUNF	RAPE	OCER
WRYE	POTA	PARI	SBAR	WBAR	SSWH
MAIF	MAIZ	SETA	RAPE	PULS	SUGB
SBAR	WBAR	MAIZ	WBAR	WBAR	SSWH
RAPE	MAIZ	WSWH	SUNF	PULS	POTA
MAIF	WBAR	MAIZ	SBAR	WBAR	WRYE

Fig. 2. Crop sequences for different countries. The sequence clearly shows the effect of crop preferences and return probability.

The generator output is then used as input in a crop management generator to produce times lines as input for biogeochemical process models (Hutchings et al. 2011).

References

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