Simulating crop rotations, fertilization and field operations at a European scale for use in complex dynamic models

Hutchings N.[1], Wattenbach M. [2], Reinds G. J.[3], Leip A.[4], Bienkowski J.[5], Dalgaard T.[1], Dragosits U.[6], Drouet J.L.[7], Durand P.[8], Frumau K.F.A.[9], Magliulo V.[10], Maury O.[7] and de Vries W.[3]

1) *Aarhus University, Department of Agroecology and Environment, Blichers Allé 20, DK-8830 Tjele, Denmark.*
2) *Freie Universitaet Berlin, Institute of Meteorology, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany*
3) *Alterra, Wageningen University and Research Centre, P.O. Box 47, 6700 AA Wageningen, The Netherlands.*
4) *European Commission – Joint Research Centre, Institute for Environment and Sustainability, Climate Change Unit, Via E. Fermi 2749, I-21027 Ispra (VA), Italy.*
5) *RCAFE, Poznan, Poland.*
6) *CEH Edinburgh, Bush Estate, Penicuik, Midlothian EH26 0QB, Scotland, UK*
7) *INRA-AgroParisTech, UMR EGC, Thiverval-Grignon, France*
8) *INRA-AgroCampus, UMR SAS, Rennes, France.*
9) *ECN, Petten, The Netherlands.*
10) *CNR-ISAFOM, V Patacca, 85 Ercolano, Napoli, Italy.*

nick.hutchings@agrsci.dk

Overview

Complex dynamic models of carbon and nitrogen can be used to investigate the possible consequences of climate change on greenhouse gas emissions from agriculture. However, these models typically operate with a temporal resolution of one day and require detailed input data concerning field operations (e.g. ploughing, sowing, fertilization, harvesting). Here we describe the development of a model that simulates the effect of historical or predicted daily weather on the timing of field operations associated with a range of spring and winter crops.

Methods

Complex dynamic models of carbon and nitrogen provide an insight into the interactions between agricultural management and the biotic/abiotic processes within agro-ecosystems. This is particularly relevant when investigating the possible consequences of climate change on greenhouse gas emissions from agriculture, since climate impacts at the process scale. Conducting such an investigation at the European scale is relevant because the predicted changes in climate vary across the continent.

Complex dynamic models typically operate with a temporal resolution of one day and require detailed input data concerning field operations (e.g. ploughing, sowing, fertilization, harvesting). Farmers take the weather into account when making decisions concerning field operations, so the timing is likely to vary in response to both year-to-year differences in weather and long-term changes in climate. Researchers wishing to use complex models at the European scale faced a number of problems: determining agricultural management in the past, predicting future management and implementing mitigation measures. Here we describe the development of a model that simulates the effect of historical or predicted daily weather on the timing of field operations associated with a range of spring

and winter crops. This model takes input from a number of other models, as described by De Vries et al (2011).

The timelines model uses the predicted crop-specific dates of sowing and harvesting across Europe that are used in the Crop Growth Modelling System (http://www.marsop.info/marsopdoc/cgms92/) to predict the corresponding dates for the years 1971 to 2030 (using the A1 climate scenario). Agronomic logic is then used to place the timing of ploughing, nitrogen fertilisation and manuring operations relative to these dates. The logic assumes that farmers time fertilisation and manuring operations to maximise the efficiency of nitrogen use efficiency for crop production. For example, for winter cropping, solid animal manure is applied immediately before ploughing and sowing whereas animal slurries and mineral fertiliser are applied at the beginning of the following growing season. For grassland, the timing of cutting and grazing are predicted. The model can implement the following greenhouse gas mitigation measures; zero tillage, cover cropping and (for grass) the avoidance of grazing in the autumn. The model outputs location-specific dates for the field operations, plus operation-specific data (e.g. the amount of ammonium nitrogen, organic nitrogen and carbon in each manure application). The data outputs are suitable for simulations using models such as DNDC-EUROPE (Leip et al., 2008), Mobile DNDC (De Bruijn et al., 2009) and DailyDayCent (Del Grosso et al., 2006).

Results

The NitroEurope project partitioned Europe into nearly 42,000 NitroEurope Compilation Units (relatively homogenous spatial units). The series of models working together has proven capable of producing timelines for field operations for the majority of these NCUs. For this to be achieved, a number of assumptions had to be made. Sowing and harvesting dates for crop species were not always available from the CGMS dataset; data for the nearest equivalent crop was then used. Likewise, these data were not available for every location; in this case, the models searched surrounding areas to find the nearest available data.At the conference, results will be presented comparing model predictions with observed field operation data from a number of the landscape case study areas conducted as part of the NitroEurope project.

References

De Vries, W., Reinds, G.J., Kros, J., Lesschen, J.P, Yeluriparti, J., Kuhnert, M., Smith, P., Kiese, R., Werner, C., Butterbach Bahl, K., Leip, A., Wattenbach, M., Hutchings, N. (2011) Assessing nitrogen fluxes from European agricultural soils in response to changes in nitrogen inputs and climate: a systematic model intercomparison study (this conference).

De Bruijn, A.M.G., K. Butterbach-Bahl, S. Blagodatsky and R. Grote., 2009. Model evaluation of different mechanisms driving freeze-thaw N_2O emissions. Agriculture, Ecosystems and Environment, 133, 196-207.

Del Grosso S.J., W.J. Parton, A.R .Mosier, M.K. Walsh, D.S. Ojima and P.E.Thornton, 2006. DAYCENT national-scale simulations of nitrous oxide emissions from cropped soils in the United States. Journal of Environmental Quality 35, 1451-1460.

Leip, A., G. Marchi, R. Koeble, M. Kempen, W. Britz and C. Li, 2008. Linking an economic model for European agriculture with a mechanistic model to estimate nitrogen and carbon losses from arable soils in Europe. Biogeosciences 5 (1), 73-94.