The INTEGRATOR model: a tool to assess greenhouse gas emissions and nitrogen fluxes in Europe

Reinds G.J.[1], Kros J.[1], Uiterwijk M.[1], de Vries W.[1]

1) *Alterra, Wageningen UR, Netherlands*

gertjan.reinds@wur.nl

Overview

A user-friendly tool was developed to assess land use related emissions of greenhouse gases and nitrogen fluxes including NH_3, and NO_x emission on a high spatial resolution for Europe. This tool, INTEGRATOR, incorporates modified versions of existing modules for estimating N_2O emissions from agriculture (MITERRA) and CO_2 sequestration in forests (EFISCEN) and meta-models based on results from detailed models (such as DNDC). It uses data on, for example, agriculture, land cover changes and climate from various global and European models and from European statistics. The INTEGRATOR model, both core and interface, will be presented including examples of its functionality and of results. A validation based on a comparison of the computed greenhouse gas emissions with results from other European greenhouse gas models, shows that INTEGRATOR produces results that are in line with other assessments.

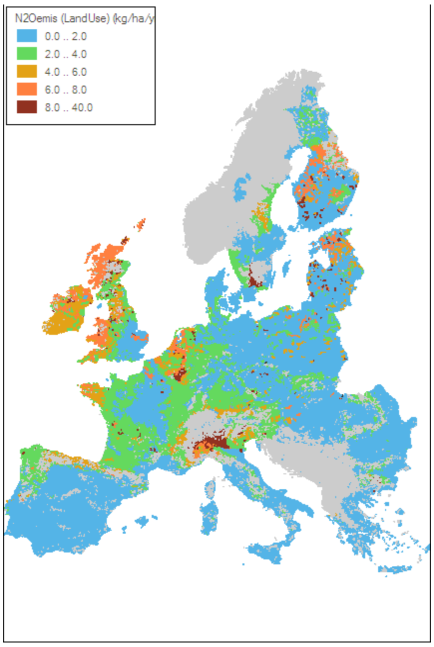
Methods/Approach

The core INTEGRATOR model integrates modules to compute manure input from animal numbers and excretion, a distribution model to distribute the manure over the various land uses within a region, and various models to estimate N fluxes, including N uptake, NH_3, N_2O, NO_x and N_2 emissions and N leaching and runoff to both ground water and surface water and the emissions of the greenhouse gases CO_2 and CH_4. An adapted version of the MITERRA model (Velthof et al, 2007) is used to estimate N_2O emissions from agricultural systems, whereas a regression model based on forest-DNDC results (Kesik, 2005) is used to compute the N_2O emissions in natural ecosystems. CO_2 exchange in forests is computed using data from the EFISCEN model (Schelhaas et al., 2007). Agricultural data (such as crop yields) stem from FAO, RAINS and the trends therein are obtained from IMAGE (Bouwman et al., 2006). Computations are made for about 41000 spatial units in Europe (NCU's), comprising of unique combinations of soil, administrative region, slope and altitude for the period 1970-2030. Within each NCU, land use and the changes therein were obtained by overlaying the NCU map with time series of detailed land use maps from the GTAP/IMAGE/CLUE model chain in response to the A1 and B2 IPCC-SRES scenarios. All data were stored in an RDBMS, that also contains procedures to combine and export data for use with INTEGRATOR. To facilitate the use of INTEGRATOR, a user friendly interface was developed in C#.NET to perform simulations, evaluate mitigation measures and compare scenarios, using graphs, tables and maps. Communication between the interface and the computational core of INTEGRATOR follows the guidelines developed for the software component interface OpenMI..

Results

As an example, Fig. 1. shows that the European pattern in N_2O fluxes in the year 2030 in response to the A1 IPCC-SRES scenario is strongly determined by the N inputs from manure and fertilizers. High

N_2O fluxes are thus found in regions with intensive husbandry (Netherlands, Western France, Po valley). High emissions also occur from wet soils, located in for example Scotland and Finland. In general the results from INTEGRATOR compare well with results from other European greenhouse gas model models (De Vries et al., 2011.). Some of the hotspots in N_2O emission in for example Finland are due to a mismatch between the manure produced and the modelled land use distribution in the region; improvements are needed. As a second example the calculated change in NH3 emissions from agriculture by INTEGRATOR in response to the A1 and B2 scenario is given in Figure 2, showing that the A1 scenario leads to higher emissions of NH_3 in the future than the B2 scenario. This is mainly caused by the increase in animal numbers and the lack of emission mitigation in this scenario aiming at economic growth and a liberal market. INTEGRATOR can also compute the effects of mitigation measures. Results show that balanced fertilization and setting limits to the maximum amount of fertilizer that can be applied, can significantly reduce the emissions of greenhouse gases from European agriculture.



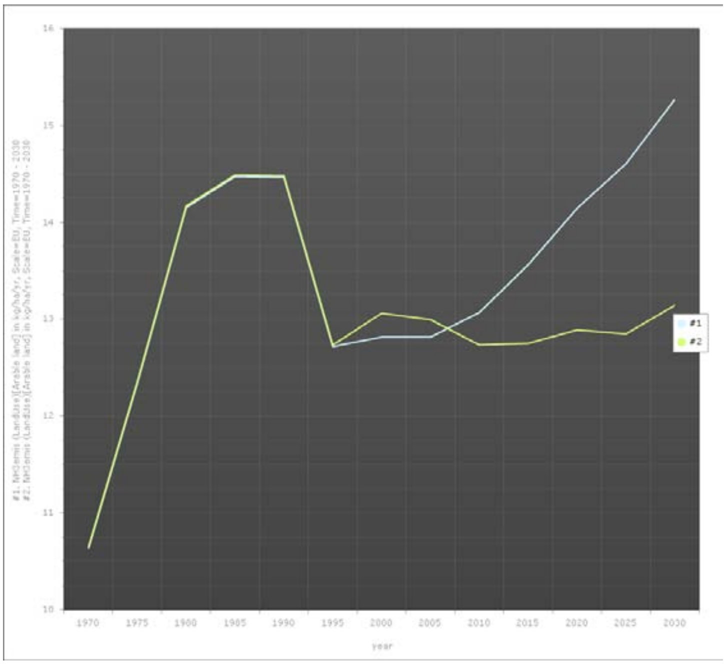


Fig. 1. N_2O emission from agriculture in 2030, A1 scenario.

Fig. 2. Time trend in NH_3 emission from agriculture for A1(green line) and B2 (blue line) scenario for 1970-2030.

References

Bouwman, A.F., Kram, T., Klein Goldewijk, K. (Eds.), 2006. Integrated modelling of global environmental change. An Overview of IMAGE 2.4. Netherlands Environmental Assessment Agency (MNP), Bilthoven, The Netherlands.

De Vries, W., A. Leip, G. J. Reinds, J. Kros, J. P. Lesschen and A.F. Bouwman, 2011. Comparison of land nitrogen budgets for European agriculture by various modeling approaches. Environmental Pollution (Accepted).

Kesik, M., et al. (2005), Inventories of N2O and NO emissions from European forest soils, Biogeosciences, 2, 353–375.Schelhaas, M.J., Eggers, J., Lindner, M., Nabuurs, G.J., Pussinen, A., Päivinen, R., Schuck, A., Verkerk, P.J., van der Werf, D.C., Zudin, S. 2007. Model documentation for the European Forest Information Scenario model (EFISCEN 3.1.3). Alterra rapport 1559. EFI Technical Report 26

Velthof, G. et al. Integrated assessment of nitrogen losses from agriculture in EU-27 using MITERRA-EUROPE. J. Env. Qual. 2009 Feb 6;38(2):402-17