ISSN 1648–6897 print
ISSN 1822–4199 online
JOURNAL OF ENVIRONMENTAL ENGINEERING AND LANDSCAPE MANAGEMENT
http:/www.vtu.lt/english/editions
2006, Vol XIV, No 4, 165–171

EVALUATION OF N_2O EMISSIONS BY DNDC MODEL FOR SANDY LOAM SOILS OF DANUBIAN LOWLAND

Ján Horák, Bernard Šiška

Dept of Biometeorology and Hydrology, Slovak Agricultural University in Nitra,
Hospodárska 7, 949 01 Nitra, Slovak Republic.
E-mail: jan.horak@uniag.sk, bernard.siska@uniag.sk

Submitted 30 Mar 2006; accepted 3 Oct 2006

Abstract. Except for food production the sector of agriculture contribute significantly to emissions of some Greenhouse gases (GHGs), especially N_2O. Agricultural practices (especially increase of N consumption in the sector) are now recognized as a major factor influencing increase of N_2O emissions into the atmosphere. Estimates of greenhouse gas emissions from the agricultural sector both at a local and regional level are necessary to create possible mitigation strategies with respect to environmental efficiency and economic possibility. We used the DNDC (DeNitrification and DeComposition) model that simulates a full carbon (C) and nitrogen (N) balance, including different C and N pools, and the emissions of all relevant trace gases from soils as NH_3, N_2O, NO, NO_2 and N_2. However, for this study only N_2O was considered. Intergovernmental Panel on Climate Change (IPCC, 1997) includes methodologies for calculating both direct and indirect emissions of N_2O related to agricultural production. Finally, the modeled emissions by DNDC were compared with those estimated according to IPCC methodology at a regional level. The rules of a good practice in GHGs inventory in agriculture were taken into account. The N_2O emissions estimated by DNDC model ranged 0,09–0,68 kg N_2O-N/ha yr with an average value of 0,28 kg N_2O-N/ha yr. The N_2O emissions estimated according to IPCC methodology ranged 0,46–2,86 kg N_2O-N/ha yr with an average value of 1,66 kg N_2O-N/ha yr. Simulated N_2O emissions were lower than the N_2O emissions estimated by IPCC methodology (1997). The simulated N_2O emissions ranged 0,04–0,51 % of the total N applied to a field as a mineral N-fertilizer. If DNDC and IPCC emissions are compared in this study, it can be concluded that simulated (DNDC) emissions are in the range of default emission factors (1,25 ±1 %) defined by IPCC methodology (1997), except for 2002.

Keywords: N_2O emissions, DNDC model, climate change, GHGs, IPCC methodology, emission factor.

1. Introduction

With regard to global climate change, soils are of a significant importance as sources for atmospheric trace gas, such as nitrous oxide (N_2O). Total emissions of the primarily active greenhouse gas N_2O from all soils are estimated to be contributing approx. 55–65 % to the total global atmospheric N_2O budget [1]. N_2O emissions from the agricultural sector create about 76 % of the total N_2O emissions in Slovak Republic (*Emissions of Greenhouse Gases in Slovakia 1990–2000*) [2]. N_2O emissions from cultivated soils are of a natural origin from microbial processes – nitrification and denitrification. Therefore, it is important to develop strategies, which efficiently mitigate N_2O emissions from the agricultural sector. Mitigation strategies imply improved management systems related to technical and organizational innovations and political measures capable of directing agricultural practices towards a more sustainable land use. However, to be successful in N_2O emissions mitigation measures strongly rely on farmer acceptance, especially due to unfamiliarity with the issue of climate change [3]. Therefore, next to efficiently reducing N_2O emissions emitted from agricultural systems, mitigation strategies must consider socio-economic factors. In particular, revenues and social constraints, such as regional habits or traditions, are important to obtain acceptance by farmers.

While measurement of N_2O emissions is feasible on the farm scale, on the regional scale only models allow to estimate N_2O emissions from agriculture.

Direct N_2O emissions from cultivated soils depend on nitrogen inputs: synthetic fertilizers, animal excreta, crop residuals and symbiotic fixation of leguminous [1]. During storage of manures some part of nitrogen is lost in dependence on way of storage as well as duration of storage of animal excreta. Indirect N_2O emissions result from processes of atmospheric deposition of ammonia and NO_x, as well as due to transformation of nitrogen from leaching and runoff losses.

Emissions of nitroux oxide N_2O from soils result primarily from microbially driven nitrification and denitrification processes. Nitrification is the aerobic microbial oxidation of ammonium ions to nitrite via NH_2OH, and then to nitrate:

$$NH_4^+ \rightarrow NH_2OH \rightarrow NO_2^- \rightarrow NO_3^- . \qquad (1)$$

When oxygen is limiting, ammonium oxidizers can use NO_2.

N_2O is also formed in the course of denitrification, the anaerobic microbial (mainly bacterial) reduction of nitrate successively to nitrite and then to the gases NO, N_2O and N_2 (Fig 1):

$$NO_3^- \to NO_2^- \to NO \to N_2O \to N_2 . \qquad (2)$$

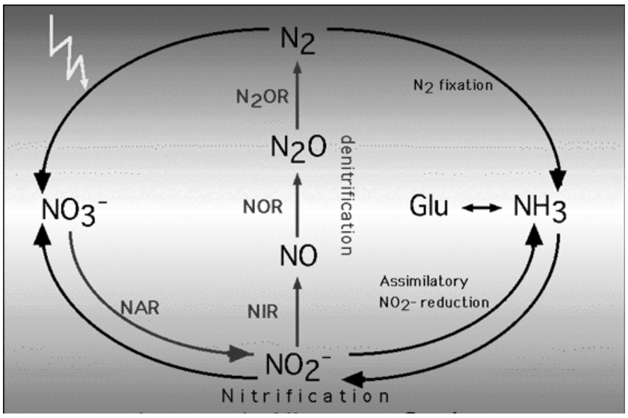


Fig 1. Inorganic nitrogen cycle

Both processes can simultaneously occur in soils, although the rate of the two processes depends on the soil aeration and the microsite availability. At low soil pH-values (< 4,0) the physico-chemical process of chemodenitrification has to be considered as an additional process of NO-production in soils [4].

Microbial production of N_2O is dependent on the presence of suitable mineral N substrates in the soil, i e ammonium and nitrate. Thus additions of mineral N-fertilizers, and N from other sources, such as animal manures, crop residues, N_2-fixing crops, and sewage sludge (from which ammonium is released by mineralization) to agricultural soils are recognized as major drivers of N_2O emissions [5]. Additionally, there is an additional "Background" source due to the mineralization of soil organic matter (humus), and where soils have only relatively recently been brought into cultivation, the accelerated decomposition of OM that may have slowly accumulated over thousands of years under natural forest or grassland vegetation will enhance this "Background" source. Organic (peat) soils that have been drained and cultivated can give rise to particularly high N_2O fluxes [6].

In view of the complexity of processes underlying the N-trace gas exchange between soils and the atmosphere, it is necessary to estimate GHGs from soils on a regional and global scale.

Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. It is open to all members of the UN and WMO.

The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate-related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific-technical literature.

Table 1. Current IPCC default emission factors for N_2O

Source	N content	Emission factor
Crop production[1] Synthetic N fertilizer	Amount of N applied – 10 % $NH_3 + NO_x$ loss	
Animal excreta used as fertilizer & other organic fertilizers	Amount of N applied – 20 % $NH_3 + NO_x$ loss	1,25 %
Biological nitrogen fixation	Amount of N is 2 x harvested crop biomass x N content (3 %) for pulses and soybeans	1,25 %
Crop residues[2]	Amount of N is 2 x harvested crop x N content minus harvested parts (45 %) minus fraction of crop residue that is burnt in field (25 % in developing countries, <10 % developed countries) minus fractions used as biofuel and in construction	1,25 %
Cultivation of organic soils	Area of cultivated organic soils	Temperate regions: 5 kg N_2O-N/ha yr Tropical regions: 10 kg N_2O-N/ha yr
Livestock production[3]	N in animal excreta dropped during grazing	2,0 %

[1] Excluding glasshouse farming.
[2] Excluding root biomass.
[3] Excluding direct emissions of N_2O from animals through nitrate reduction in the gut of animals.

There is an Intergovernmental Panel on Climate Change (IPCC) methodology for estimating N_2O emissions, which relies on emission factors specifying the fraction of N_2O emitted to the atmosphere if N-fertilizers, manure or crop residues are applied to soils (Table 1). In spite of the difficulties associated with making emission estimates, it is worth noting that the latest revision to the IPCC Guidelines [7] has been used to make an estimate of N_2O emissions at a global level, and when this estimate was used as input to a simple atmospheric box model, the observed increase in atmospheric N_2O with time could be explained reasonably well [8].

IPCC default approach assumes the emission to be a fixed proportion of the unvolatilized portion of N applied. The default values for this portion are 90 % for synthetic fertilizers, 80 % – for organic fertilizers and animal waste, and 100 % – for all other categories. The default values for emissions from cultivated histosols are 5 and 10 kg N_2O-N/ha y for temperate and tropical climate, respectively. That for N deposition by grazing animals is 2 % of the unvolatilized N.

The emission factor for inorganic N-fertilizer applied to soils is 0,0125, i e one assumes that 1, 25 %±1 % of the total N applied to a field as a mineral N-fertilizer is lost in the form of N_2O to the atmosphere (Table 2).

Table 2. Activity data required for estimation of direct N_2O emissions from agricultural soils

Type of activity data	Units
Commercial synthetic fertilizer consumption[1]	Kg N/yr
Commercial organic fertilizer consumption[1,2]	Kg N/yr
Livestock and poultry waste that is applied to soils	Kg N/yr
Crop product and residues of nitrogen-fixing crops	Kg N/yr
Crop residue returned to soils	Kg N/yr
Histosol area cultivated (by climatic zone)	Ha/yr

[1] It is desirable to collect disaggregated data on individual crops.

[2] This value should not include animal waste nitrogen used as commercial fertilizer if the “livestock and poultry waste that is applied to soils” data include this nitrogen.

Since the emission factors were derived from a limited number of measurements in different countries, the factors themselves are still uncertain [9]. In many countries it is difficult to obtain data on the amount and composition (mineral N, organic N, recalcitrant N) of animal waste for different age classes within animal categories. Therefore, these data have to be estimated from an “average” animal in a particular country or production system. Geographic data on the application rate and timing of manure application, soil conditions and weather conditions during application are not available. In addition to spatial variability, manure application, and mode and timing of application, show a strong interannual variability, which is not easy to include in scaling exercises. Data on crop production systems that are essential for estimating trace gas fluxes include fertilizer use (including animal manure and other organic inputs) and the mass of residues which is ploughed into the soil (in units of N), or the amount produced of the crop(s) whose residues are ploughed in (in units of biomass). In summary, the economic and attribute data generally have to be inferred from aggregated country totals for different land-use systems. Data on mineral fertilizer production and consumption are probably more reliable than any other data needed for emission estimation.

There are other improvements of current estimates of N-trace gas fluxes from soils through the models, which are able to simulate N-trace gas emissions based on the processes involved in N-trace gas production, consumption and emission. DNDC (DeNitrification and DeComposition) model, which has been applied to calculate regional inventories of N_2O emissions across agricultural ecosystem, is one of them.

Finally, the modeled regional results were compared with those estimated from the IPCC methodology.

Evaluation of GHGs and ammonia emissions results from protocols accepted by the Slovak Republic during the last decade. On the basis of inventory of emission sources it will be possible to prepare efficient measures for reduction of greenhouse gases in ammonia emissions what consequently influence landscape protection too. Therefore, possible adaptive measures to reduce emissions are mentioned in the study. Because of shortage of recent data on storage of animal waste in Slovakia all emission balances are evaluated on level business as usual.

2. Investigation object and methodology

The area of interest for this study is situated northeast from the town of Nitra, which is a part of Danubian Lowland, 160–180 m above the see level. From the point of view of areal geology the investigation area is located on the geological dividing line of Tribeč and Žitavská upland.

The DNDC (DeNitrification and DeComposition) model for estimating N_2O emissions was used. The DNDC model is a process-oriented computer simulation model of soil carbon and nitrogen biogeochemistry.

The model consists of two components. The first component, consisting of the soil climate, crop growth and decomposition sub-models, predicts soil temperature, moisture, pH, redox potential (Eh) and substrate concentration profiles driven by ecological driver (e g, climate, soil, vegetation and anthropogenic activity). The soil climate submodel calculates vertical profiles of soil temperature, moisture and soil redox potential driven by meteorological data and soil properties. The crop growth submodel calculates crop growth and its influence on soil environmental factors, such as soil moisture, dissolved organic carbon (DOC) and available nitrogen concentrations. The decomposition submodel then generates vertical concentration profiles of substrates (e g, DOC, NH_4^+, NO_3^-) The second component, consisting of the nitrification, denitrification and fermentation sub-models, predicts NO, N_2O, N_2, CH_4 and NH_3 fluxes based on the modeled soil environmental factors [10]. DNDC adopts biogeochemical and empirical equations to simulate the carbon and nitrogen biogeochemical cycles including soil trace gas emissions [11].

Input parameters required by the model include daily climate data, soil properties (e g, texture, pH, bulk density), vegetation (e g, crop type) and management (e g, tillage, fertilization, manure amendment, planting, harvest, etc). The DNDC model has been used in national or regional N-trace gas emission inventories in North America, Europe, Oceania and Asia [12, 13] with robust results based on reasonable input data requirements.

Soil. The database includes detailed information on soil type, texture, soil pH, SOC, bulk density, etc. An observed area is an upland crop field with sandy loam soils with parameters that are given in Table 3.

Table 3. DNDC model inputs of soil properties [14]

Bulk density (g/cm^3)	1,4000
Soil pH	4,9900
Initial organic C content at surface soil (kg C/kg)	0,0135
Clay fraction	0,0900
Litter SOC	0,0250
Humads SOC	0,0250
Humus SOC	0,9500
Initial NO_3^- concentration at soil surface (mg N/kg)	4,0500
Initial NH_4^+ concentration at soil surface (mg N/kg)	0,4050
Moisture (water-filled porosity)(%)	0,3200
Initial soil temperature (°C)	–10,40

Farming management. The timing for ploughing, planting day, harvest and application of N-fertilizers was set in coordination with the individual needs of different crops and actual weather conditions in 2000, 2001, 2002 and 2003. Management practices were applied in days when no or low rainfall occurred. Table 4 shows the cropping practices, its timing and average rates of N-fertilizer applied to each crop.

Climate. Daily maximum and minimum temperatures as well as daily precipitation for 2000, 2001, 2002 and 2003 [15, 16, 17, 18] were obtained from a climatic station located in the study area (Nitra, latitude 48°, 160–180 m above the see level). Normal characteristics (1951–1980) of mean air temperature and precipitation are given in Figs 2, 3.

Climatic data were measured at the weather station of the Department of Biometeorology and Hydrology in an experimental area of Slovak Agricultural University in Nitra.

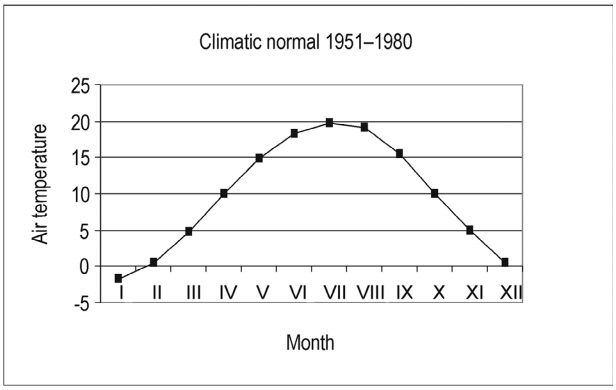


Fig 2. Mean air temperature in Nitra (1951–1980)

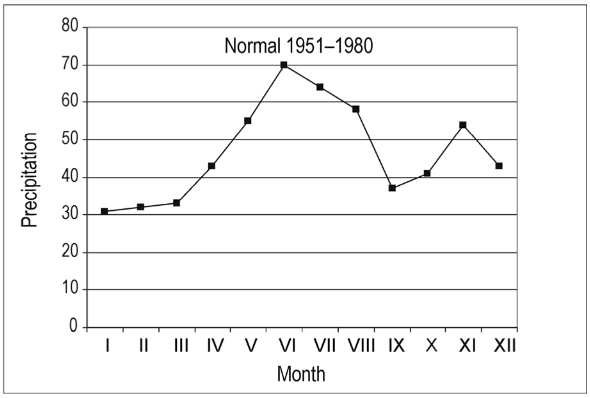
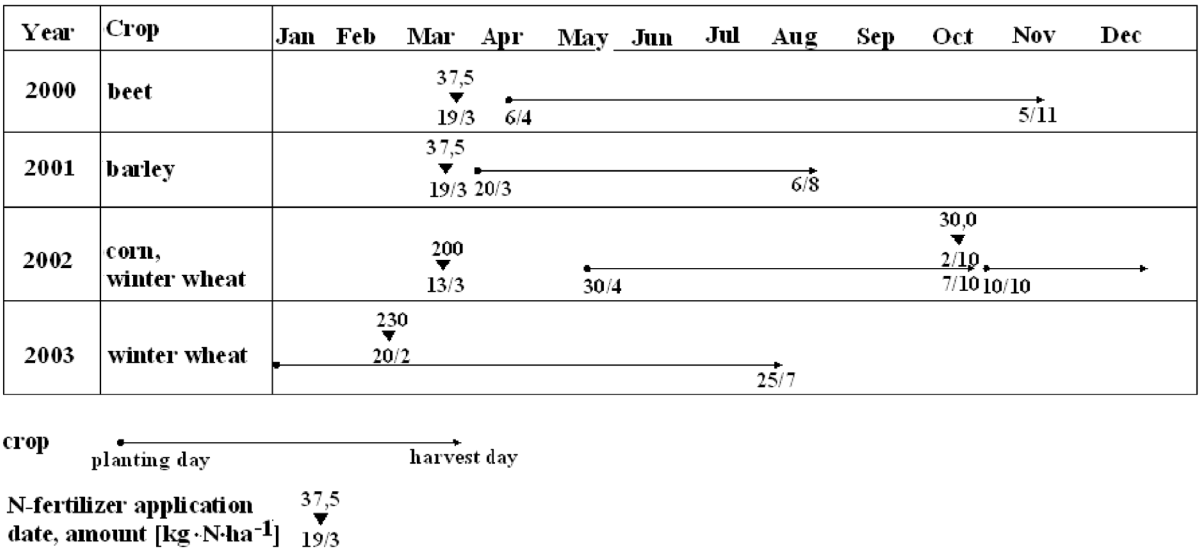


Fig 3. Precipitation totals in Nitra (1951–1980)

Table 4. Scheme for cropping practices



Year	Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	beet			37,5 ▼ 19/3	6/4							5/11	
2001	barley			37,5 ▼ 19/3 20/3					6/8				
2002	corn, winter wheat			200 ▼ 13/3		30/4					30,0 ▼ 2/10 7/10 10/10		
2003	winter wheat		230 ▼ 20/2					25/7					

crop ●——→ planting day harvest day

N-fertilizer application date, amount [kg·N·ha^{-1}] 37,5 ▼ 19/3

The nitrification submodel predicts the production, consumption, and diffusion of NO and N_2O under aerobic conditions. Integrated soil and environmental factors calculated from the soil, climate, development stage and decomposition submodels are taken into account (Table 5). The denitrification submodels predict emissions of NO and N_2O under anaerobic conditions. The final model outputs are daily emissions of NO and N_2O, N_2 and NH_3. However, for this study we considered only N_2O.

Table 5. DNDC model inputs of climate

Latitude (degree)	48°
N concentration in rainfall (mg N/l or ppm)	0,0560
Atmospheric background NH_3 concentration (ug N/m^3)	0,0600
Atmospheric background CO_2 concentration (ppm)	350,000

After estimating N_2O emissions by the DNDC (DeNitrification and DeComposition) model, estimate of N_2O emissions according to IPCC methodology was made. This methodology relies on emission factors specifying the fraction of N_2O emitted to the atmosphere if N-fertilizers, manure or crop residues are applied to soils [1].

L. Bowman (1996) published a new variant of estimate, especially a new emission factor of N_2O emissions from the soil. This system was accepted by IPCC/OECD-IEA document in 1997, and in May of the same year it was recommended by an expert group in Oslo as definite for the following period [19]. The emission factor for inorganic N-fertilizer applied to soils is 0,0125, i e one assumes that 1,25 ±1 % [9] of the total N applied to a field as a mineral N-fertilizer is lost in the form of N_2O to the atmosphere.

3. Results and discussion

The total N input ranged from 37,5 kg N/ha for sugar beet and barley (for 2000, 2001) to 230 kg N/ha (for 2002, 2003).

N input levels were based on crop requirements. N_2O emissions from an agricultural ecosystem estimated by the DNDC (DeNitrification and DeComposition) model ranged from 0,09 to 0,68 kg N_2O-N/ha yr with an average value of 0,28 kg N_2O-N/ha yr. Among all the simulated crops (sugar beet, barley, corn and winter wheat), the highest loss of N_2O (0,68 N_2O-N/ha yr) was simulated for winter wheat in 2003.

N_2O emissions estimated by IPCC methodology ranged from 0,46 to 2,86 kg N_2O-N/ha yr with an average value of 1,66 kg N_2O-N/ha yr. Fig 4 shows the comparison of simulated N_2O emissions with IPCC estimate (1,25 ±1 %).

Fig 4 shows that the simulated N_2O emissions were lower than the N_2O emissions estimated by IPCC methodology (1997). The simulated N_2O emissions ranged 0,04–0,51 % of the total N applied to a field as a mineral N-fertilizer. We can also say that simulated values are in the range of (1,25 ±1 %) of the total N applied according to default emission factors of IPCC methodology (1997), except one in 2002.

4. Conclusions

Direct emissions of N_2O from agricultural soils have increased substantially over the last few decades, in parallel with increasing use of N-fertilizers. The present IPCC default emission factor for N_2O of 1,25 ±1 % of the N applied must necessarily stand for the time being, but there is considerable scope for more data analysis to see

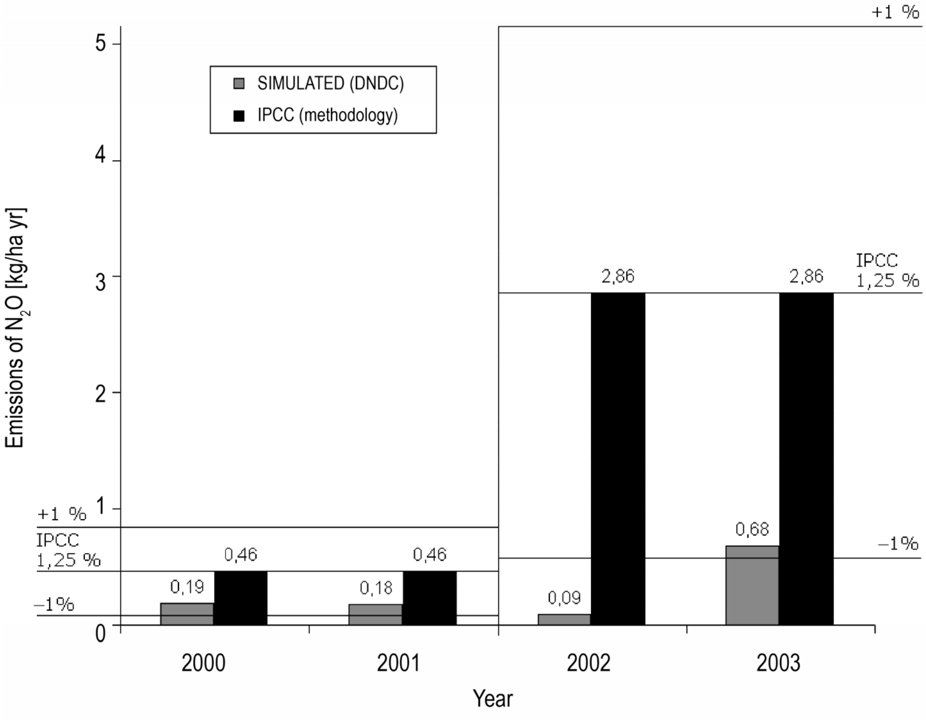


Fig 4. Comparison of simulated N_2O emissions with IPCC estimate (1,25 ±1 %)

whether significant differences between crop types and/or between regions and climatic zones are now discernible. In some variable environment, several years of study will be needed to derive robust mean emission values. In compiling national GHG inventories, it is good practice to use country/specific data, where available, for the activity data and N_2O emission factors. There is a potential for reducing the present high uncertainty in emission estimates through the development of predictive flux models.

Estimates of regional N-trace gas emissions from soils cannot currently be validated per se. This problem cannot be thoroughly solved by comparison with the IPCC methodology because of diverse land use and management at the regions and field scales. It is obvious from Fig 4 that the simulated N_2O emissions are within a range (1,25 ±1 %) of total N applied according to default emission factors of IPCC methodology (1997), except one in 2002. It is assumed that the reasonable results should attribute to incorporation of the fundamental biogeochemical processes in DNDC that enables the model to be applicable across climate zones, soil types, and management regimes.

Advantages of using models for calculating N-trace gas emission inventories or for developing mitigation strategies are obvious and necessary. Models can be also used for policy-making analysis by comparing alternative farming management and their effects on greenhouse gas emissions on a regional or national scale. The models can be also used for predicting the influence of future climate changes on trace gas emissions.

On the other hand, there might be some problems with models (e g underestimating and overestimating the results). In this study it was found out that the DNDC model generally underestimates simulated N_2O emissions.

Sandy loam soils represent 20 % of total agricultural acreage of the Slovak Republic. It seems that N_2O emissions from these soils are overestimated according to IPCC methodology.

Acknowledgement

The project was supported by the Grant Agency of the Slovak Republic – VEGA 1/1313/04.

References

1. IPCC (Intergovernmental Panel on Climate Change) 1996, Climate Change 1995. The science of climate change.
2. The third national communication on climate change, Slovakl Republic, 2001.
3. Oenema, O. et al. Technical and policy aspects of strategies to decrease greenhouse gas emissions from agriculture. *Nutrient Cycle Agroecosystem*, 60, 2001, p 301–315.
4. Van Cleemput, O.; Baert, L. A key compound in N loss processes under acid conditions. *Plant Soil*, 76, 2005, p 233–241.
5. Bøckman, O. Chr.; Olfs, H. W. Fertilizes, agronomy and N_2O. *Nutrient Cycling in Agroecosystems*, 52, 1998, p 165–170.
6. Kasimir-Klemedtsson, A. et al. Greenhouse gas emissions from farmed organic soils: a review. *Soil Use & Management*, 13, 1997, p 245–250.
7. Mosier, A.R. et al. Closing the global N_2O budget: nitrous oxide emissions through the agricultural nitrogen cycle. OECD/IPCC/IEA phase II development of IPCC guidelines for national greenhouse gas inventory methodology. *Nutrient Cycling in Agroecosystems*, 52, 1998, p 225–248.
8. Kroeze, C.; Mosier, A.; Bouwman, L. Closing the global N_2O budget: a retrospective analysis 1500–1994. *Global Biogeochemical Cycles*, 13, 999, p 1–8.
9. IPCC, 1997 Revised 1996 IPCC guidelines for national greenhouse gas emissions inventories: Reference Manual.
10. User´s Guide for the DNDC Model, 2003. 39 p.
11. Li, C. Modeling trace gas emissions from agricultural ecosystems. *Nutrient Cycle Agroecosystem*, 58, 2000, p 259–276.
12. Li, C.; Narayan, V.; Harris, R. Model estimates of nitrous oxide emissions from agricultural lands in the United States. *Global Biogeochemical Cycle*, 10, 1996, p 297–306.
13. Li, C. et al. Comparing process-based agro-ecosystem model with IPCC methodology for developing national inventory of N_2O emissions from arable lands in China. *Nutrient Cycle Agroecosystem*, 60, 2001, p 159–175.
14. Chlpík, J.; Pospíšil, R. Spatial characteristic of mechanical and chemical soil properties at experimental base of Slovak Agricultural Univesity in Nitra, Kolinany. In: *Acta fytotechnica at zootechnica*, 7, 1, 2004, p 8–10 (in Slovak). ISSN 1335-258-X.
15. Repa, Š.; Šiška, B. Climatic characteristics of 2001 in Nitra. 11, VES SPU Nitra, 2002. 30 p. ISBN 80-8069-043-X.
16. Repa, Š.; Šiška, B.; Climatic characteristics of year 2003 in Nitra. 13 SPU Nitra, 2004. 24 p. ISBN 80-8069-384-6.
17. Šiška, B.; Repa, Š. Climatic characteristics of 2000 in Nitra. VES SPU Nitra, 2001. 30 p. ISBN 80-7137-833-X.
18. Šiška, B.; Repa, Š. Climatic characteristics of 2002 in Nitra. VES SPU, 2003. 32 p. ISBN 80-8069-219-X.
19. Bielek, P. Nitrogen in agricultural soils of Slovakia, Bratislava, 1998. 256 p. (in Slovak).

N_2O EMISIJŲ IŠ PRIESMĖLIO DIRVOŽEMIŲ DUNOJAUS ŽEMUMOJE ĮVERTINIMAS, TAIKANT *DNDC* MODELĮ

J. Horák, B. Šiška

Santrauka

Dėl žemės ūkio sektoriaus, išskyrus maisto gamybą, kai kurių šiltnamio efektą sukeliančių dujų (ŠED), ypač N_2O, emisijos labai padidėja. Žemės ūkis (ypač sektoriuje didinant naudojamo N kiekius) dabar laikomas pagrindiniu veiksniu, turinčiu įtakos didėjančiai N_2O emisijai atmosferoje. Atsižvelgiant į ekonomines galimybes ir aplinkos apsaugos efektyvumą vietiniu ir regioniniu lygiais būtina sukurti ŠED mažinimo strategiją. Taikytas *DNDS* (denitrifikacijos ir destruktūrizacijos) modelis, imituojantis anglies (C) ir azoto (N) balansą, įskaitant skirtingas C ir N sankaupas, ir visų tiesiogiai susijusių dujų, tokių, kaip: NH_3, N_2O, NO, NO_2 ir N_2 pėdsakų iš grunto emisijas. Tačiau šiame tyrime buvo atsižvelgta tik į N_2O. Tarpvyriausybinė klimato kaitos tyrimų specialistų grupė (IPCC, 1997) parengė tiesioginės ir netiesioginės N_2O emisijos, susijusios su žemės ūkio gamyba, apskaičiavimo metodikas. Galiausiai pagal *DNDS* modeliuotos emisijos buvo palygintos su įvertintomis pagal *IPCC* metodiką regioniniu lygiu. N_2O emisija, nustatyta pagal *DNDS* modelį, kito nuo 0,09 iki 0,68 kg N_2O–N/ha m, vidutinė vertė – 0,28 kg N_2O–N/ha m. N_2O emisija, nustatyta pagal *IPCC* metodiką, kito nuo 0,46 iki 2,86 kg N_2O–N/ha m, vidutinė vertė – 1,66 kg N_2O–N/ha m. Sumodeliuotoji N_2O emisija buvo mažesnė nei N_2O emisija, įvertinta pagal *IPCC* metodiką (1997), ir kito 0,04–0,51 % nuo bendrojo N, naudoto lauke kaip mineralinė N trąša. *DNDS* ir *IPCC* emisijų palyginimas leidžia teigti, kad sumodeliuotųjų (*DNDS*) emisijų kitimas atitinka pagal *IPCC* metodiką (1997) nustatytųjų emisijų ribas (1,25 ± 1 %), išskyrus 2002 metus.

Reikšminiai žodžiai: N_2O emisija, *DNDS* modelis, klimato kaita, šiltnamio efektą sukeliančios dujos (ŠED), *IPCC* metodika, emisijos veiksniai.

ОЦЕНКА С ИСПОЛЬЗОВАНИЕМ МОДЕЛИ ДНДС ЭМИССИЙ N_2O ИЗ ПОЧВЫ В НИЗМЕННОСТИ ДУНАЯ

Я. Горак, Б. Шишка

Резюме

Сектор сельского хозяйства в значительной мере способствует эмиссии газа, в особенности N_2O, вызывающего парниковый эффект. Для оценки эмиссии этого газа из сектора сельского хозяйства на местном и региональном уровнях необходимо создать возможную стратегию уменьшения эмиссий, обращая внимание на эффективность охраны окружающей среды и экономические возможности. Нами использована модель ДНДС (денитрификации и деструктуризации), которая имитирует полный баланс углерода (C) и азота (N), включая различные скопления C и N и других газов, таких как NH_3, N_2O, NO, NO_2 и N_2, а также следы эмиссий из грунта. В этом исследовании внимание уделялось лишь N_2O. Межправительственная группа по изменению климата (IPCC, 1997) подготовила методики для расчета прямой и косвенной эмиссии N_2O, связанной с сельскохозяйственным производством. Эмиссии, смоделированные с использованием ДНДС, были сравнены с эмиссиями, оцененными по методике IPCC, на региональном уровне. При этом основывались на правилах удачной практики, применявшейся во время инвентаризации газа парникового эффекта в сельском хозяйстве. Эмиссия N_2O, установленная с использованием модели ДНДС, изменялась в пределах от 0,09 до 0,68 кг N_2O-N/га м, ее среднее значение было 0,28 кг N_2O-N/га м. Эмиссия N_2O, установленная по методике IPCC, изменялась в пределах от 0,46 до 2,86 кг N_2O-N/га м, среднее значение было 1,66 кг N_2O-N/га м. Смоделированная эмиссия N_2O была меньше, чем эмиссия N_2O, рассчитанная по методике IPCC. Смоделированная эмиссия N_2O менялась в пределах от 0,04 до 0,51 % от общего N, который использовался как минеральное удобрение. Сравнение эмиссий, полученных по методикам ДНДС и IPCC, позволяет утверждать, что смоделированные эмиссии (ДНДС) изменяются в пределах факторов эмиссии, указанных по методике (1,25 ± 1 %) IPCC (1997), за исключением 2002 года.

Ключевые слова: эмиссия N_2O, модель ДНДС, потепление климата, газ, способствующий парниковому эффекту, методика IPCC, факторы эмиссии.

Ján HORÁK. Master, doctoral student, Dept of Biometeorology and Hydrology, Slovak Agricultural University (SAU). Master of Landscape Engineering, SAU, 2005. Research interests: greenhouse gas emissions (modeling), GIS.

Bernard ŠIŠKA. PhD, Assoc Prof, Dept of Biometeorology and Hydrology, Slovak Agricultural University (SAU).

PhD, SAU, 1992. Assoc Prof since 1999. Publications: author or co-author of more than 80 research papers and 8 monographs. Research interests: crop-weather modeling, climate change impacts. Membership: member of Editorial Board of Acta Scientiarum Polonorum, vice chairman of Slovak Bioclimatological Society of Academy of Sciences of Slovak Republic.