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Discussions

Interactive comment on "Quantifying nitrous oxide emissions from Chinese grasslands with a process-based model" *by* F. Zhang et al.

F. Zhang et al.

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We thank the reviewer for her/his very careful reading of the manuscript and the resulting constructive comments! All reviewer comments are in italics, whereas our response/ [action] is described in Times New Roman font.

(A) Management. The only management option considered for the application is grazing, which is probably a realistic assumption for China, as (I imagine) hay production plays a minor role. The authors assume a constant grazing intensity across all of China, with stocking density estimated as total livestock divided by total area (Section 2.1.4) and number of grazing days per year and grazing hours per day as given in Tab.2. Although there is a necessity, in this type of studies, for simplified approaches, the latter assumptions can be questioned as (likely) not all of the Chinese grasslands can

sustain the same animal population. In this sense, an alternative and somehow more realistic solution would be to relate the grazing intensity to the potential productivity of the different grassland types. The latter could be estimated from climate data using empirical relations (e.g. as done in Sala et al., 1988 or Lauenroth and Sala, 1992) or running a model like DNDC without grazing. As I am aware of the required working load, I am not asking for a re-evaluation of the inventory. On the other hand, I'd like to encourage the authors to more thoroughly comment the assumptions on management in Section 2.1.4. and again in the Conclusions (things that could be improved).

[Answer]: All the time, in China, the dominated grazing regime was only use the natural grassland, and people seldom planting grass or produces hay. Although Chinese government has been encouraging herdsmen planting oats (Avena sativa L.) in Qinghai-Tibet region, alfalfa (medicago sativa L.) and Chinese wildrye (Aneurolepidium chinense) in inner-Mongolia region from 2005, the grass-planting area was far smaller than the natural grassland. In Chinese natural grassland regions, the rotation grazing method is usually adopted, which requires transferring the livestocks from one pasture to another in different seasons and staying in same pasture during the whole season. For example, in Qinghai-Tibet grassland region, there are three types of pastures, namely spring-winter, summer, and autumn pasture. Every pasture will be grazed in tune. This grassland management was simplified in this research. China as a developing country is weak in basic statistical data, especially in the grazing observation. We can not find more detail grazing data. So we assumed that livestocks stay in the same pasture whole year with 12 hours grazing time per day and the stocking rates are same throughout the country. Furthermore, we assumed all grasslands are useable. These assumptions could induce some uncertainties in the simulation result. The average grazing rate may be underestimated compare to the real since not all grasslands can be grazed. As Fig3 (d, e) shown, the higher grazing rate is, the more N2O is emitted. The underestimation of stocking rate could underestimate the N2O emission

(B) Model validation. As explained in Section 2.3 the model performance is tested

with reference to ten grassland sites in China and United States, but the authors do not report the management at these sites, in particular whether they are grazed or not. Results of the sensitivity analysis suggest that stocking rates and grazing time are relevant for explaining N2O emission. In view of the importance of grazing for the overall assessment of N2O from Chinese grasslands, commenting on the management at the validation sites would help understanding whether DNDC performs properly with respect to the specific settings of the study.

[Answer]: All validation points were selected from natural grassland, where no grazing and fertilizer. For more reasonable, authors redrawn Fig 2, which was comparison of non-grazing N2O emission simulation with literature points. The suggestion was accepted, new statements of validation points were add to manuscript. [The sites were natural grasslands as defined by Coupland (1992) without any fertilizer and grazing applied] and see Fig. 2

(C) Sensitivity analysis. While the results presented in Fig. 3 are per se instructive, I am missing the motivation for a sensitivity analysis in the context of the preparation of national inventory. One logical reason could be the necessity to quantify uncertainties in the output (e.g. average annual emissions are 76.5 Gg N2O-N +/- what?) given uncertainties in the inputs. Apart from the assumptions on management, these could arise from uncertainties in original data (e.g. soil data, climate data), the preprocessing of inputs (e.g. spatial interpolation), and of course model uncertainties. A second reason could be the need to explain inter-annual variations in N2O emissions. Yet another reason could be a discussion of the implications of changes in the management regime, e.g. intensification of grazing. In any case, it is desirable that the authors provide a rationale for the sensitivity analysis and discuss the results shown in Fig. 3 from a broader perspective.

[Answer]: 76.5 was eight years average value while 12.8 was the standard variation of eight years . So the result was 76.5 +/- 12.8 Gg N2O-N. As the referee mentioned, there could exist uncertainty in the input data. Specifically, when we interpolated point

data to raster format, which will induce uncertainty on the final data. As the climate data is daily scale, it's hard to give a comprehensive accuracy report. We randomly selected 10 datasets from the climate data, and used the cross-validation method to validate the interpolated result. The calculated root mean square errors (RMSE) of minimum temperature, maximum temperature and precipitation were 1.58, 15.8, and 1.48, respectively. In our simulation, we keep all variables constant except the climate factors (temperature and precipitation).Hence, the inter-annual variations in N2O emission only linked with the climate change. A new paragraph [3.5] was added to conduct the uncertainty analysis.

(D) National inventory. The results of this study are discussed in Section 3.7 in relation to emission estimates for other areas of the world. However, it is also important to set the work also in the context of the worldwide efforts to establish national greenhouse gas inventories. In most cases these are based on the IPCC methodology (http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html, accessed 31.02.2010). I couldn't find anything specific in this direction in the Introduction. Two aspects could be of interest. On the one hand, the authors could provide their point of view on the advantages of a spatial application of DNDC (with the specific setup of the study) as opposed to the IPCC methodology. On the other hand, they could discuss the estimated total emissions from grasslands (76.5 Gg N2O-N per year) in relation to the figures (in particular N2O and GHG emissions for the agricultural sector) reported in the Initial National Communication on Climate Change by the People's Republic of China (available under http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php, accessed 31.03.2010).

[Answer]: Li had compared DNDC method with IPCC model to evaluate N2O emission in China agriculture system, and found that estimations of direct N2O emissions from cropland soils from the process-based DNDC simulation and the strictly empirical IPCC methodology were similar in 1990. However, DNDC can capture the spatial pattern of N2O emission(Li et al. 2001) which is critical important for the management

optimization in the our next work. As part of United Nations Framework Convention on Climate Change, chinese government provided a 1994 national greenhouse gas inventory(China 2004), which was estimated through IPCC method tier 1. But it had not reported the direct N2O emission from grassland and it only took the directed N2O emission from cropland (474 Gg N2O-N) into account. Our estimated grassland N2O emission was roughly 1/6 of the N2O emission of cropland reported by The People's Republic of China Initial National Communication on Climate Change throughout the country. So, in the further national N2O inventory, the grassland direct N2O emission should be accounted. Therefore, our work could be a good complement for the national N2O inventory. The suggestion was accept. [As part of United Nations Framework Convention on Climate Change, chinese government provided a 1994 national greenhouse gas inventory (China 2004), which was estimated through IPCC method tier 1. But it had not reported the direct N2O emission from grassland and it only took the directed N2O emission from cropland (474 Gg N2O-N) into account. Our estimated grassland N2O emission was roughly 1/6 of the N2O emission of cropland reported by The People's Republic of China Initial National Communication on Climate Change throughout the country. So, in the further national N2O inventory, the grassland direct N2O emission should be accounted. Therefore, our work could be a good complement for the national N2O inventory.]

(E) Climate change and N2O emissions. In section 3.6 and again in the Conclusions, the authors emphasise the positive trend in N2O emissions over 2000 to 2007 and propose a possible link to climate change. In view of the (not quantified) uncertainties in the emission estimates and the shortness of the time period considered, I would be more cautious in speaking about trends in N2O emissions in response to trends in climate

[Answer]: There are uncertainties existing in the results. However, in the simulation, we controlled other variables except precipitation and temperature from 2000 to 2007. As a result, the change of the climate led to differences in the modeled N2O emissions

between 2001 and 2007. As the referee suggested, we used more cautious statements to describe relationship between climate change and N2O emission. The suggestion was accept.

[As climate could be play an important role in N2O emission, further climate change may have some impact on the N2O emission pattern. However, it still needs more quantified research and long time-scale simulation to verify]

(F) Minor issues. (1) Please specify whether grassland and soil data were interpolated to the same grid as used for the climatic data. (2) There is an inconsistency between the number of 10 validation sites mentioned in Section 2.3 and the 11 sites listed in Table 1. (3) Please refer to all of the panels of Fig. 3 in discussing the results of the sensitivity analysis in Section 3

[Answer]: (1) both grassland and soil data were interpolated to the same grid as climate data, the authors accepted suggestion. [. . .The final grassland area of our new database was 336.98 million ha and the database has 10 km-resolution. . ..; . . .the upper 0–10-cm soil profile as the soil surface properties for model simulations and for assimilation data, it was resample to 10 km-resolution.] (2) There are 11 points, the authors accepted suggestion.[Eleven grassland sites, including nine in China and two in the United States. . ...] (3) the authors accepted suggestion

References

China, T. P. s. R. o. 2004. Initial National Communication on Climate Change by the People's Republic of China. Beijing. Li, C., Y. Zhuang, M. Cao, P. Crill, Z. Dai, S. Frolking, B. Moore, W. Salas, W. Song, and X. Wang. 2001. Comparing a process-based agro-ecosystem model to the IPCC methodology for developing a national inventory of N2O emissions from arable lands in China. Nutrient Cycling In Agroecosystems 60:159-175.

3.5 Uncertainty analysis This study has made great efforts to reduce the uncertainties

in the estimation of N2O inventory, especially in the input data. All input datasets are from official statistical data of China and the national survey in order to simulate as precisely as possible. However, there are still uncertainties associated with the climate data, grazing and soil data. As Fig3 shown, climate is a key parameter of DNDC model. In this research, we interpolated precipitation, which produces larger number of rainfall events with less rainfall per event, but the total precipitation is similar with the observed value. This can be source of the uncertainty of simulated results. In Chinese natural grassland regions, the rotation grazing method is usually adopted, which requires transferring live stocks from one pasture to another in different seasons and staying in same pasture during the whole season. For example, in Qinghai-Tibet grassland region, there are three types of pastures, namely spring-winter, summer, and autumn pasture. In real, every pasture will be grazed in turn according to the seasons. This grassland management, however, was simplified in this research as we could not find any specific data about it. We assumed that live stocks stay in the same pasture whole year with 12 hours grazing time per day and the stocking rates are same throughout the country. Furthermore, we assumed all grasslands are useable. These assumptions could induce some uncertainties in the simulation results. The average stocking density rate may be underestimated compare to the real since not all grasslands usable or be grazed in same time. As Fig3 (d,e) shown, this simplified grazing assumption could induce underestimated N2O emission. Accurate soil properties can help to reduce uncertainties. This research, we used the second national soil survey data conducted from 1979-1994 as initial model input value. This value should have some changes since then. As Fig3 shown, soil properties was one of most sensitive factors, the outdate soil value will increase uncertainties.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/7/C887/2010/bgd-7-C887-2010-supplement.pdf

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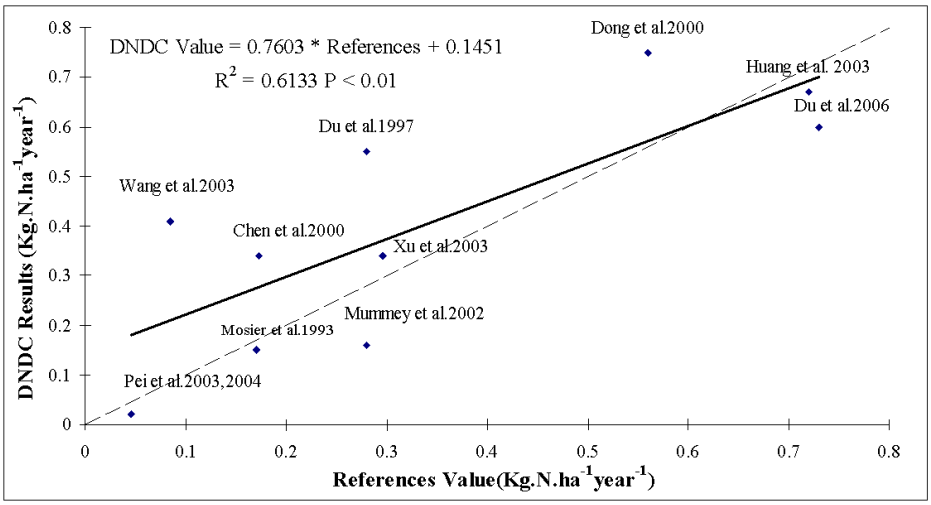

Fig. 1. Fig. 2 DNDC results compared with literature reports. Dashed line is 1:1 line (Du et al. 2008 was excluded).