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Discussions

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Interactive comment on "Modeling the biogeochemical effects of rotation pattern and field management practices in a multi-crop (cotton, wheat, maize) rotation system: a case study in northern China" *by* Wei Zhang et al.

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RC1 The manuscript entitled "Modeling the biogeochemical effects of rotation pattern and field management practices in a multi-crop (cotton, wheat, maize) rotation system: a case study in northern China" is within the scope of BG. To ensure reliability, models should be tested and improved as part of their development and application. The manuscript is important in that context (though it is poor- it lacks for a 6 years validation that includes a rotation of all three commodity crops as well as all management practices studied in question) but the novelty of this manuscript lies with the optimization of

different rotation patterns (of three cultivars: cotton, wheat, maize) and management practices which is very complex. Overall, the manuscript lacks of structure and the English language in the manuscript needs to be improved. The manuscripts need major revisions to be acceptable for the publication. In the current state should be rejected.

Revised. We have revised the manuscript one by one as the reviewer suggested. The manuscript has been new structured, especially for the Introduction, and the English language has been revised by AJE. Please see the detailed revision notes below.

For more details please see my comments below: In the site simulation NEE and NO emission are predicted with lower accuracy by the model, then how this impacted the optimization of mitigation options?

Revised. "The simulated NEE flux is one of component of âŰşSOC, which is key factor considered in BMP selection." (Please see lines 233-234). âŰşSOC and NO are all the decision variables for NIP, which is applied for screening the BMP. "the NEGE was the residual of the annual sum of CH4 and N2O emissions minus the âŰşSOC" and "NEGE, NH3, NO, N2OODM, and NL represent the multi-goal decision variables" (Please see lines 183-185 and lines 189-192). The relative uncertainty of the model validation was evaluated, and then we provided the uncertainty of the BMP, which reflect the impacts of validation on BMP. "In this study, the MRB of simulated variables were regarded as the relative uncertainty of the model validation, which were further used for estimating the relative uncertainty of each scenario based on the error transfer formula (Eqs. (S1-4))." (Please see lines 210-212) and section "3.4 The uncertainty of the best management practice". (Please see lines 309-321)

The novelty of this manuscript lies with optimization of mitigation options at site level but authors exploited this inadequately in this manuscript. Elaborating and extending optimization analysis will add substantial knowledge and value to the manuscript. What about using i.e. Monte Carlo optimization technique to screen different set of possible agricultural management practices (a multiple optimization criteria that includes crop

rotation in interaction with all studied management practices) which maximize yields while minimizing environmental effects.

Revised. The Monte Carlo technique has been applied for identifying the BMP. "To screen the BMP of six rotation patterns in interaction with all considered management practices, the variation of fertilizer amount, irrigation amount and residue incorporation rate was set as 40% of baseline to baseline (N44/172 to N110/430), 40% of baseline to baseline (I40 to I100) and 0 to 100% (RI0 to RI100). The factors of irrigated method and tillage consisted of flood (IF) and sprinkle (IS) irrigation, and no-tillage (T0), reduced tillage (5 cm and 10 cm, T5 and T10) and conventional tillage (20 cm, T20), respectively. We assumed the frequency distribution of all the factors were uniform. Monte Carlo simulations, 1000 combination scenarios of field managements, were used to screen the BMP for each rotation pattern, and the final BMP for the system were selected from the BMPs of six rotation patterns in light of 6000 combination scenarios." (Please see lines 161-170)

Uncertainty quantification is a critical challenge in both validation and calibration. There is NO mention of model uncertainty in the manuscript. I suggest adding one section on model uncertainty and discussing uncertainties and how that might propagate to model outputs in this study. Authors should also focus on potential applications of optimization considering uncertainty. Otherwise these mitigation options have only academic interest and not much real-world value. Please, see the specific comments below.

Revised. The section on model relative uncertainty of the validation was added, and then we provided the uncertainty of the BMP, which reflect the impacts of validation on BMP. "In this study, the MRB of simulated variables were regarded as the relative uncertainty of the model validation, which were further used for estimating the relative uncertainty of each scenario based on the error transfer formula (Eqs. (S1-4))." (Please see lines 210-212) and section 3.4"The relative uncertainty resulted from the model validation was calculated based on MRB and error transfer formula (Eqs. (S1-4)). The MRB of cumulated N_2O, NO, NEE and CH_4 were 3%, 6%, 2% and 8%,

C3

respectively, which were used for calculating the relative uncertainty of NIP for all 6000 scenarios. For the BMP of each rotation pattern, the scenarios, whose uncertainty ranges had some overlap as that of the BMP, showed no significant differences from each other. Thus, 7, 8, 4, 2 and 2 alternative scenarios were selected for the BMP of R0, R1, R2, R3 and R4, respectively, with the average relative uncertainty of 5.1%. For the final identified BMP of N90/353_I82_IS_RI90_T10 involved in R3 rotation pattern, the relative uncertainty of the NIP was 4.7%, ranged from 314 to 345 USD ha−1 yr−1. There were another two alternative scenarios (N94/366_I91_IS_RI95_T10 and N97/378_I88_IS_RI70_T5) in R3, which indicated the trade-off effects of different field managements, such as the opposite effect of reduced residue incorporation (decrease âŰşSOC) and tillage depth (increase âŰşSOC) on âŰşSOC. They were also regarded as alternative BMP for the system." (Please see lines 309-321)

Introduction: In general I would say that the introduction is too long and not enough focused on the task. There are plenty of paragraphs which must be shortened and better structured. This will improve the content and impact of the current manuscript. Please skip unnecessary things. i.e. frequent applications of pesticides and/or herbicides. My suggestion is to reduce the introduction section to max. 2 pages. I will start with one example: Globally, fiber crops (i.e. cotton) and cereals such as wheat and maize have been playing a relevant role in humanity as they are a primary source for the textile and food industry. In China, while the cultivation of cotton only covers between 2.0−3.9% of the annual crop harvest areas (cotton lint production of 5.3−7.6 million metric tons during 2007−2016), the cultivation of cereals is significantly large. Wheat and maize account for 39% and 26% of the harvest area and represent 129 and 220 million metric tons of grain in 2016, respectively (China Statistical Yearbook, 2017). Northern China is not only the second most important area of cotton production but the largest region of the winter wheat−summer maize double-cropping system (i.e., both crops harvested within a year, hereinafter referred to as W-M) in the country (e.g., Cui et al., 2014). Crop rotations of cotton and the W-M have been commonly applied in this region (e.g., Liu et al., 2010, 2014) and are typically alternated every 3−5 years.

C4

During the last decades, cotton, wheat and maize's yields have increased by means of intensified agricultural management practices such as: increased fertilizer inputs, advanced irrigation methods (Han, 2010). A recent study (Liu et al., 2019) indicated that the cotton cropping system in northern China persistently functioned as an intensive carbon or net greenhouse gas (GHG) source compared to the W-M because of strong carbon dioxide (CO_2) emissions during the long non-growing periods. Add Reference. revealed that the change in storage of soil organic carbon (ăŰşSOC), net ecosystem GHG emission (NEGE) and other biogeochemical processes of the multiple-cropping systems in northern China likely are closely related to the rotation pattern of cotton and the W-M. Thus, one can hypothesize that identifying and adopting optimal rotation pattern of cotton and the W-M are beneficial for soil carbon sequestration and mitigation of GHG emissions in the region...... Please see general comment of this section!

Revised. The Introduction has been structured and revised based on reviewer's comments, and the length has been reduced to less than 2 pages, with words reduction from 1400 to 800. For instance, "The objective method is applied for identifying the best management practice (BMP), which evaluates each decision variable with price-based proxies or other measures and screens the best option with minimal negative impact potential (NIP) under the given constraints (e.g., Cui et al., 2014; Xu et al., 2017). To screen the BMP using the multi-goal approach, it is essential to quantify the biogeochemical effects of management practices. As field experiments often focus only on the decision variables of very few management practices during short periods (e.g., Ding et al., 2007; Liu et al., 2010, 2015; Wang et al., 2013a, b), the process-oriented biogeochemical models have the potential to overcome this limitation, such as the DNDC (e.g., Chen et al., 2016; Giltrap et al., 2010; Li, 1992, 2000; Zhang et al., 2017a), DAYCENT (e.g., Delgrosso et al., 2005) and LandscapeDNDC (e.g., Haas et al., 2012; Molina-Herrera et al., 2016) models." (Please see lines 33-86)

Material and Methods General comment: Same as above, please shorten and restructure this section Put sections 2.1 and 2.3 together (short and concise)

Revised. We shorten and revised the content of Materials and methods as the reviewer suggested. Put the sections 2.1 and 2.3 together as section 2.2 and reconstructed. For instance, "Based on the model validation of Cui et al. (2014) for the W-M, the authors were able to further validate this model in the adjacent land cultivated with cotton. The daily meteorological data of 2004−2010 were directly obtained from Cui et al. (2014). Measured data were directly used for the least required soil properties. The input data of field capacity and wilting point in water-filled pore space (WFPS), being 0.65 and 0.2, respectively, were cited from Cui et al. (2014). The crop parameters for cotton were directly determined by the field measurements, which were 1900 kg C ha−1 for potential grain (1.2 times the mean of the measured values), 0.41 and 25, 0.16 and 40, and 0.43 and 40 for mass fractions and C/N ratios of grain, root and leaf plus stem, respectively, and 3600 °C for TDD. The detailed management practices (Table S1) were obtained from Li et al. (2009) and Liu et al. (2014). Compared with the conventional fertilizer application rate of 110−140 kg N ha−1 yr−1 for the cotton, the fertilizer doses of 2007 and 2008 were reduced to 66−75 kg N ha−1 yr−1 by local farmers to avoid the overgrowth of leaves instead of seeds or lint. The measured data used for validation were available for soil (5 cm depth) temperature, topsoil (0−6 cm) moisture and N_2O and NO emissions in 2007−2009 (Liu et al., 2010, 2014), CH_4 uptake fluxes during the period from March to November 2010 (unpublished data of the authors), grain yields, and NEE during the period from November 2008 to November 2009 (Wang et al., 2013a). For the W-M, the crop parameters and other inputs used by Cui et al. (2014) were directly adopted in this study." (Please see lines 110-138, lines 150-179 and lines 200-215)

Lines 222-226 what do you want to say? It is not clear to me. Please keep in mind that you are not studying the environmental impacts of using pesticides.

Revised. The statements of pesticides throughout the full manuscript have been deleted so as to keep concentrated as the reviewer suggested.

Discussion Please delete lines 526-527. I do not see that such statement helps to

your work. Unfortunately– your model validation is poor as it evaluates only one site and does not include a rotation of all three commodity crops together. Remember that optimization studies rely on robust site validations. These validation studies should be done using several pilot areas with different geographical, climatic and soil conditions; different types of reference data (long term datasets) used for model calibration. I am not sure that you will get the same results if you apply your best rotation and management practices across different geographical, climatic and soil conditions. A regional simulation will help you to clarify this. I would start with this: The scenario analysis relying on model simulations in this study showed that environmental contamination can be reduced while a) sustaining crop yields and b) increasing carbon sequestration in the soil. Reductions of environmental i.e. N losses are attributed to the better synchronization of crop N requirements and soil N availability......

Revised. The Discussion has been revised as the reviewer suggested so as making it more concise and focused. For instance, "The simulated positive annual changes in SOC for the W-M were mainly attributed to the incorporation of full aboveground residues (at rates of $5.1-7.0$ Mg C ha-1 yr-1), which were favorable for carbon sequestration (Han et al., 2016). However, the negative annual changes in SOC for the cotton cropping system resulted from a notable CO_2 emission in long fallow season relative to that of the W-M (Liu et al., 2019). As a remarkable carbon sink, the W-M with incorporation of full crop residues could even totally compensate for the SOC lost during the first cotton-planting year following cultivation of the W-M. Thus, the annual change in SOC was generally positive in the first cotton-cultivation year. The rotation patterns of R0 and R1 acted as net GHG sinks since the increased SOC exceeds the increased N2O emission related to the W-M cultivation, while the others all functioned as net GHG sources. The higher application rate of fertilizer for the W-M than for cotton resulted in more reactive nitrogen remained in the soil (Chen et al., 2014; Ju et al., 2009), thereby stimulating more emissions of the nitrogenous air pollutants and N2O under the scenarios with fewer cotton planting years. Therefore, the appropriate rotation pattern of cotton and the W-M can allow the sustainable intensification

C7

with maximal yield and economic benefits, balanced soil organic carbon budget and minimal negative impacts on the environment." (Please see lines 363-461)

Lines 531-532 Why do you discuss about pesticides when the DNDC model does not account for?. Please state that DNDC model assumes balanced nutrient supplies for any crops as well as optimum phytosanitary conditions. Hence negative effects of monoculture are not accounted for.

Revised. The statement has been revised based on the reviewer's suggestion. "For the cotton, period of 5 consecutive years is usually applied for the longest cotton monoculture to stabilize its yields. Meanwhile, balanced elemental nutrients have been applied in cotton cultivation, and thus the negative effect of monoculture on cotton yields can be offset in practice (Han, 2010). As DNDC model assumes balanced nutrient supplies for any crops as well as optimum phytosanitary conditions, the negative effects of monoculture are not accounted for. (e.g., Li, 2017)." (Please see lines 368-372)

suggest you to add an uncertainty section as requested before.

Revised. The section on model relative uncertainty of the validation was added, and then we provided the uncertainty of the BMP, which reflect the impacts of validation on BMP. "In this study, the MRB of simulated variables were regarded as the relative uncertainty of the model validation, which were further used for estimating the relative uncertainty of each scenario based on the error transfer formula (Eqs. (S1-4))." (Please see lines 210-212) and section 3.4 "The relative uncertainty resulted from the model validation was calculated based on MRB and error transfer formula (Eqs. (S1-4)). The MRB of cumulated N2O, NO, NEE and CH4 were 3%, 6%, 2% and 8%, respectively, which were used for calculating the relative uncertainty of NIP for all 6000 scenarios. For the BMP of each rotation pattern, the scenarios, whose uncertainty ranges had some overlap as that of the BMP, showed no significant differences from each other. Thus, 7, 8, 4, 2 and 2 alternative scenarios were selected for the BMP of R0, R1, R2, R3 and R4, respectively, with the average relative uncertainty of 5.1%. For

C8

the final identified BMP of N90/353_I82_IS_RI90_T10 involved in R3 rotation pattern, the relative uncertainty of the NIP was 4.7%, ranged from 314 to 345 USD ha−1 yr−1. There were another two alternative scenarios (N94/366_I91_IS_RI95_T10 and N97/378_I88_IS_RI70_T5) in R3, which indicated the trade-off effects of different field managements, such as the opposite effect of reduced residue incorporation (decrease âŰşSOC) and tillage depth (increase âŰşSOC) on âŰşSOC. They were also regarded as alternative BMP for the system." (Please see lines 309-321)

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2018-401/bg-2018-401-AC1-supplement.zip

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