Biogeosciences Discuss., 9, C1225–C1231, 2012
www.biogeosciences-discuss.net/9/C1225/2012/

Biogeosciences
Discussions

Interactive comment on “How will organic carbon stocks in mineral soils evolve under future climate? Global projections using RothC for a range of climate change scenarios” *by* P. Gottschalk et al.

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Received and published: 15 May 2012

First of all we would like to thank C. Jones for the thorough review and thoughtful comments and suggestions to improve the quality of the manuscript. Please find our detailed responses to individual comments and remarks below.

On the main concern of using MIAMI NPP: MIAMI NPP is not directly used as an input to the simulations with RothC. We are using NPP values from the IMAGE model for which four scenarios are available: A1b, A2, B1 and B2. To account for the different realisations of the A1b scenario of seven AOGCMs in our study, the IMAGE-A1b-NPP-surface is scaled according to temperature and precipitation difference among the different AOGCM realisations. Section 2.5 of the manuscript explains the approach thoroughly and we added an additional explanatory graph (Figure 2) to visualise our approach. To further evaluate the validity of using IMAGE-NPP data we compared IMAGE-NPP to the results of the C4MIP-simulation results. The C4MIP data were kindly provided by the reviewer, Chris Jones, and his contribution to this revision is such that he merits co-authorship of the paper, and has been added as a co-author. The comparison shows that IMAGE-NPP lies well within the spread of C4MIP-NPP data for the 5 global zones representing a medium scenario. We have added the graph showing this relationship as figure 1 in the manuscript, and we have discussed the results in section 2.5. We have therefore resolved doubts about the validity of using IMAGE-NPP data in this study. Our findings are shown to be consistent with state-of-the-art global coupled carbon climate model simulations. Percentage wise, IMAGE-NPP increases much less in the tropics than in the high latitudes (i.e. about 92% in 60-90N and around 43% in 30S-30N). Instead of the suggested overestimation of NPP in the tropics and underestimation in high latitudes, our results rather suggest that differences in the implementation of SOM turnover in RothC and the C4MIP models is more likely than differences in the NPP data. Further, increase of SOC at high latitudes is not a unanimous conclusion from global simulation studies, as explicitly pointed out by Qian et al. (2010) who stated that the “apparent ‘suppression’ of warming-induced increase in SOM decomposition in the C4MIP models still comes as a somewhat surprise”. We now discuss trends of SOC in the northern high latitudes and boreal zones in more detail in section 3.3.

We further note that the use of NPP from the AOGCMs of this study would not be possible, because land use change is not considered in these models but is a strong focus in our study. For this reason, using NPP-data from other AOGCMs would increase inconsistency rather than resolve it. We hope to have assured the reviewer of his concerns about using IMAGE derived NPP data in this study.

Further literature to discuss: We deliberately focused our introductory overview on relevant studies describing simulated SOC trends using off-line studies, and for brevity and clarity have left the introduction as it is. However, we have now included a compilation of results on the range of global studies in section 3.1 “Global mineral SOC dynamics”, including an additional table (Table 4) which presents mean SOC trends and SOC ranges in 2100 in Pg C and %age from across the range of studies. This has strengthened the manuscript and we thank the reviewer for the suggestion.

Responses to minor comments: Abstract, line 19: We have reworded the sentence to remove ambiguity.

p. 414, line 2: We have taken out the sentence on land use change and the reference to 0.7 degree global warming, and added a more focused statement on estimates of historical soil organic carbon losses.

p.420, equations 2+3: the equal-signs on the right hand side of the equation is a typesetting error. Equation 2 is NPPT = 3000*(1+exp(1.315-0.119*T))-1 And equation 3 is NPPP = 3000*(1-exp(-0.000664*P)).

p. 412: RothC simulates only one layer, so no drainage, i.e. bucket hydrology, is simulated. The overall model set-up is internally consistent, including the soil moisture estimation, and has been proven to give reliable results. A more sophisticated approach would not necessarily lead to more accurate simulation, and would require extensive evaluation before being used as an input to RothC.

p. 422(1): NPP is not directly used as the plant inputs, either for natural or for managed systems. RothC generates plant inputs by running in reverse mode to calculate plant inputs to the soil for the given environmental conditions. Once the plant inputs have been established in this way, the year to year changes are changed according to the year to year changes in NPP. The scaling is appropriate as IMAGE-NPP also reflects changes in land cover change (see section 2.5 of the manuscript). Since land use change (amongst other factors) influences NPP changes in IMAGE, RothC uses these

two drivers in a consistent way.

p. 422(2): Changes in land use are simulated stepwise in 5-year intervals. The change from one land use type to the next is mainly reflected by the change in the DPM/RPM ratio of the model, accompanied by a change in the amount of plant inputs according to the NPP change (see section 2.6) . It is true though that we might overestimate C returns under land use change from natural to arable systems as there is no explicit removal of harvested C. The resulting caveat is now discussed in section 3.1 and 3.2..

Fig. 1 (now Fig. 3): Yes, it is true that all panels show results only from simulated cells, which are land-cells for which consistent data were available and which have a SOC concentration lower than 200 t/ha. The Figure caption has been amended to now state this explicitly.

Fig. 2 (now Fig. 4): This graphs show the response of SOC between 1971-2100 as a mean value of all A1b simulations and for the simulations of HadCM3 interpreting the four SRES scenarios separately according to the different land use change type. The underlying land use change pattern is the same for all A1b simulations but the SOC response is different between the mean of all AOGCMs interpreting A1b, and HadCM3 interpreting A1b.

Fig. 9 (now Fig. 11): We cannot shift the projection as it runs from -180 to +180° which is the standard global projection, as also found in many of the global studies cited in this manuscript.

Interactive comment on Biogeosciences Discuss., 9, 411, 2012.

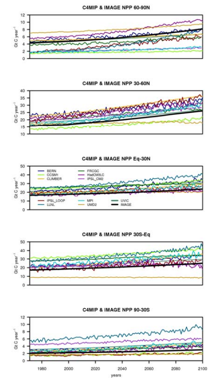

Fig. 1. Comparison of zonal NPP of IMAGE and C4MIP-simulations (Friedlingstein et al., 2006) for the SRES A2 emission scenario. Please refer to respective study for details on model abbreviations.

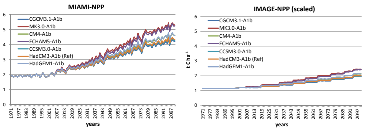

Fig. 2. Example of the NPP-scaling approach for an arbitrary grid cell. The panel on the left depicts NPP values calculated based on mean yearly temperature and precipitation for the seven AOGCMs. The panel o

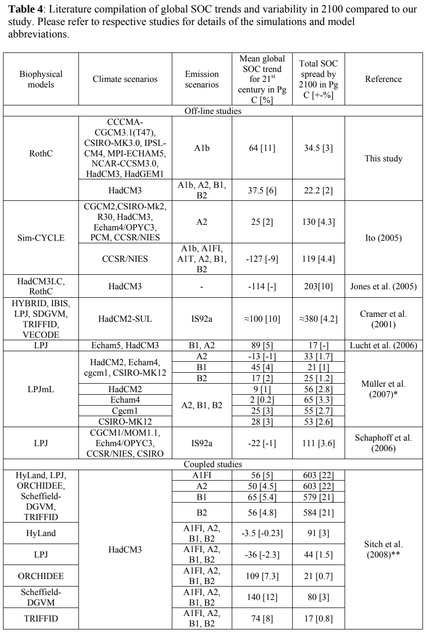

Table 4: Literature compilation of global SOC trends and variability in 2100 compared to our study. Please refer to respective studies for details of the simulations and model abbreviations.

Biophysical models	Climate scenarios	Emission scenarios	Mean global SOC trend for 21st century in Pg C [%]	Total SOC spread by 2100 in Pg C [+-%]	Reference
Off-line studies					
RothC	CCCMA-CGCM3.1(T47), CSIRO-MK3.0, IPSL-CM4, MPI-ECHAM5, NCAR-CCSM3.0, HadCM3, HadGEM1	A1b	64 [11]	34.5 [3]	This study
	HadCM3	A1b, A2, B1, B2	37.5 [6]	22.2 [2]	
Sim-CYCLE	CGCM2,CSIRO-Mk2, R30, HadCM3, Echam4/OPYC3, PCM, CCSR/NIES	A2	25 [2]	130 [4.3]	Ito (2005)
	CCSR/NIES	A1b, A1FI, A1T, A2, B1, B2	-127 [-9]	119 [4.4]	
HadCM3LC, RothC	HadCM3	-	-114 [-]	203[10]	Jones et al. (2005)
HYBRID, IBIS, LPJ, SDGVM, TRIFFID, VECODE	HadCM2-SUL	IS92a	≈100 [10]	≈380 [4.2]	Cramer et al. (2001)
LPJ	Echam5, HadCM3	B1, A2	89 [5]	17 [-]	Lucht et al. (2006)
LPJmL	HadCM2, Echam4, cgcm1, CSIRO-MK12	A2	-13 [-1]	33 [1.7]	Müller et al. (2007)*
		B1	45 [4]	21 [1]	
		B2	17 [2]	25 [1.2]	
	HadCM2	A2, B1, B2	9 [1]	56 [2.8]	
	Echam4		2 [0.2]	65 [3.3]	
	Cgcm1		25 [3]	55 [2.7]	
	CSIRO-MK12		28 [3]	53 [2.6]	
LPJ	CGCM1/MOM1.1, Echm4/OPYC3, CCSR/NIES, CSIRO	IS92a	-22 [-1]	111 [3.6]	Schaphoff et al. (2006)
Coupled studies					
HyLand, LPJ, ORCHIDEE, Scheffield-DGVM, TRIFFID	HadCM3	A1FI	56 [5]	603 [22]	Sitch et al. (2008)**
		A2	50 [4.5]	603 [22]	
		B1	65 [5.4]	579 [21]	
		B2	56 [4.8]	584 [21]	
HyLand		A1FI, A2, B1, B2	-3.5 [-0.23]	91 [3]	
LPJ		A1FI, A2, B1, B2	-36 [-2.3]	44 [1.5]	
ORCHIDEE		A1FI, A2, B1, B2	109 [7.3]	21 [0.7]	
Scheffield-DGVM		A1FI, A2, B1, B2	140 [12]	80 [3]	
TRIFFID		A1FI, A2, B1, B2	74 [8]	17 [0.8]	

Fig. 3. Table 4: Literature compilation of global SOC trends and variability in 2100 compared to our study. Please refer to respective studies for details of the simulations and model abbreviations.