Chapter 2. Guidance on GHG emissions and removals from organic soils in all land-use categories.

2.1 Introduction

- Line 73: CH_4 emissions and removals from organic soils (it has been proven, and more and more measurable that CH_4 also can be up-taken).
- Line 74: N_2O emissions and removals from organic soils ?
- Line 76: Providing…CH_4 emissions from drainage ditches (and other water bodies? E.g. in the tropics artificial ponds belonging to production mills for palm oil, other human-made lakes or ponds?)

2.2 Land remaining in a LU category

- Line 99: The total change in C stocks: also includes CH_4 which is not mentioned neither in the tekst, nor in the equation. The contribution is low in terms of carbon, however, it should be mentioned.
- Line 104: equation: Lorganic-co2-c(on-site) + Lorganic-co2-C(off-site)
- Line 106: idem. Should say Annual CO_2 and DOC/POC loss, or should change the formula.
- Line 123: what is deeply drained? Please specify since e.g. CO_2 emissions from tropical peat lands are dependent on water table depth.

Table 2.1

- Overall: I think there should be more clarity on separation between peat-CO_2-emissoins and CO_2 emissions from plants: heterotrophic and autotrophic respiration.
- Overall, for the tropical regions a clear relationship between drainage depth (for whatever crop) and CO_2 emissions has been published by Hooijer et al., 2010, 2012; Couwenberg et al., 2010: each 10 cm of drainage depth causes ~ 9 t CO_2 ha^{-1} yr^{-1} emission. E.g. for oil palm a drainage depth of 0.6 – 0.8 m is been practiced: this results in a CO_2 emission of 54 – 72 t CO_2 ha^{-1} yr^{-1}. Why is this not introduced in this new IPCC doc? It is confusing to use ‘old’ numbers.
- An emissions of 5.24 t C ha^{-1} yr^{-1} has been reported for palm oil plantation in this chapter. This is far too low when looking at recent literature for agricultural use. Values between 40 and 80 tons of CO_2 per hectare have been reported in the most recent literature. Needs revision. Also values of 33 t CO_2 for cropland and 47 t CO_2 for acacia are on the conservative side.
- Overall: why not introducing ‘water bodies’ as a category under land use? It’s part of the landscape in ‘drainged organic soils’. CO_2 emissions from water bodies such as drainage ditches are commonly lower that from the surrounding fields, however, they should be considered since they can not be assumed 0.
- Emissions and removals of CO_2 in drained organic soils due to drainage and management include:
    - Losses because of drainage
    - Losses because of reduced photosynthesis and increased respiration in e.g. the case that forest in converted (should be capture in the section 2.3: Land converted to other LU)
    - Direct losses because of biomass removals, and thus C removal in the case that forest is converted (should be capture in the section 2.3: Land converted to other LU)

- (In the tropics) Losses because of fires (increased fire frequency + slash and burn)
- For e.g. oil palm plantations: trees have a 25 years life cycle, after that the forest is been cut and replanted with new plantings. Old palms are burned mostly. Include?

- Forest land EF CO2OrgForestTrop:
  - Hirano et al (2007): NEE 16 t CO_2-eq ha-1 yr-1 (drained sec. forest)
  - Jauhiainen et al (2008): range 24-74 t CO_2 for drained forest sites, respiration only.
- Cropland:
  - acacia plantations in the Sumatra, Indonesia produce 21.8 t C ha-1 yr-1 (heterotrophic respiration only) (Jauhiainen et al., 2012; Biogeosciences 9, 617-630)
  - Hooijer et al (2012) estimates 73 t CO_2, 19,9 t C ha-1 yr-1 for oil palm plantations under current drainage regimes in the 'steady state' (> 5 years after drainage).
- Grassland:
  - Grassland EFCO2GrassTemp: add Veenendaal et al (2007) and Jacobs et al (2007) (all measurements done by eddy covariance): Variability of annual CO_2 exchange from Dutch grasslands, biogeosciences 4, 803-816, 2007. Average of 2,2 (± 0.9) t C ha-1 yr-1 for 4 grassland sites on peat.
- Wetlands:
  - Peatlands drainged for extraction EFCO2PeatTrop: the value 2 t C ha-1 yr-1 is based on the relative difference between temperate and tropical?! Why not using the most recent data on the relation between drainage depth and CO_2 emissions? Each 10 cm of drainage of the peat causes about 9 t CO_2 emission Ha-1 yr-1. Bases on current drainage depth needed for peat extraction one could calculate the emission which will in the case of 40 cm drainage be 9.8 t C ha-1 yr-1. Peatlands used for extraction of the peat are usually cleared/bare soils? That would make this a very conservative estimate since also soil temperature will be increased.

- Why are CO_2 fluxes from water bodies in peatlands not mentioned? See e.g. Schier-Uijl et al., 2011 for CO_2 fluxes from lakes and drainage ditches in temperate peatlands. Maybe add in table the category 'water bodies' consisting of 1) drainage ditches and 2) lakes and ponds 3) rivers (?).

- Table 2.2: The default values for EFDOC_drained (t C ha-1 yr-1) for the tropics is now reported at 0.78 (0.44-1.46). Oechel et al (2011 (AGU conference proceedings), 2012 in prep) have done a very extensive study in the Kapuas river in Sumatra, Indonesia (very large area) and they found the CO_2 emissions to be 12.4 t C ha-1 yr-1 (or 1240 g C m-2 yr-1). Should be taken into account.
- Line 421: In general…reduced. Not only production is reduced, also the transport route of CH_4 through the soil is increased and therefore the oxidation of CH_4 tot CO_2 will increase.

- Line 425: see also earlier comment. Not only drainage ditches emit because of the surrounding land use, also lakes and ponds that are located in the peat area and where the drainage ditches drain to.
- Same here: why not making a separate LU category in table 2.3 for ‘water bodies’ which are part of the ‘drained-peat-landscape’.
- Line 491: on substrate…ditches: should maybe add length of transport route through water and the oxygen status of the water since this is related to the oxidation of CH4 to CO2.

Table 2.3

- Overall, below is listed the research that has been performed in SE Asia on CH4 in different LU types with Couwenberg et al., 2012 giving a summary of the available research.

Annual terrestrial (land based) methane emissions from peatlands in tropical Southeast Asia from available scientific literature and calculated in different ways. Not included are the fluxes related to open water or to management activities.

Reference	Land use	Chamber measurements frequency	Mean CH_4 emissions (g CH_4 m^{-2} yr^{-1})	Min CH_4 emissions (g CH_4 m^{-2} yr^{-1})	Max CH_4 emissions (g CH_4 m^{-2} yr^{-1})	Mean CO_2-eq (t CO_2 ha^{-1} yr^{-1})	Min CO_2-eq (t CO_2 ha^{-1} yr^{-1})	Max CO_2-eq (t CO_2 ha^{-1} yr^{-1})
Ueda *et al*, 2000	Fresh water swamp			4.38	109.5		1.05	26.28
Hadi *et al*, 2005	Rice	1 year, monthly		3.5	14.0		0.3	1.22
	Sec. forest	1 year, monthly	5.87			1.41		
	Paddy field	1 year, monthly	26.13			6.28		
	Rice-soybean	1 year, monthly	3.47			0.83		
Couwenberg *et al*, 2010*	Swamp forest	1 year, monthly on average		-0.37	5.87		-0.9	1.41
	Agriculture	1 year, monthly on average		0.025	3.4		0.006	0.816
	Rice	1 year, monthly on average		3.26	49.5		0.87	11.88
Melling *et al*, 2005	Sec. forest	1 year, monthly	0.02			0.006		
	Sago	1 year, monthly	0.24			0.06		
	Oil palm	1 year, monthly	-0.02			-0.006		
Furukawa *et al*, 2005	Drained forest	1-2 years, monthly	1.17			0.28		
	Cassava	1-2 years, monthly	3.39			0.81		
	Paddy field upland	1-2 years, monthly	3.62			0.87		

	Paddy field lowland	1-2 years, monthly	49.52			11.89		
	3 Swamp forests	2 months	6.15			2.02		

* Combined research adapted from Couwenberg *et al*., 2010: Inubushi *et al*., 2003; Furukawa *et al*., 2005; Hadi *et al*., 2005; Jauhainen *et al*., 2005; Melling *et al*., 2005; Takakai *et al*., 2005; Hirano *et al*., 2009.

- Grasslands:
  - GrasslandsEFCH4GrassTemp: References:
    - Kroon et al., 2010; Annual balances of CH4 and N2O from a managed fen meadow using eddy covariance flux measurements. Eur. J. Soil Sc., 61. This is a three years EC study (the first very reliable, long term EC study for CH4!): 0.124 (± 17%) t C ha-1 yr-1 in a Dutch temperate grassland.
    - Schrier-Uijl et al 2009: Methane emissions in two drained peat agro-ecosystems with high and low agricultural intensity. Plant Soil, doi:10.1007/s11104-009-0180-1. Long term (3 years chamber based) study in grasslands on peat: 0.128 ((± 50%) in intensively manged grass, 0.125 t C ha-1 yr-1 (((± 50%) for extensively managed grass.

CH4

Suggestion:
Merge tables 2.3 and 2.4 and broaden ‘drainage ditches’ of table 2.4 to ‘water bodies’ (which includes also (shallow) lakes, ponds and other water bodies). Water bodies are part of the ‘wetlands-peatlands-landscape, so why separating it from the lands use categories in table 2.3?

Suggestions for categorizing ‘water bodies’ + literature:

- Lake or pond
  - Boreal (Juutinen et al., 2009; Huttunen et al, 2002; Bastviken et al., 2004; Repo et al., 2007)
  - Temperate (Schrier-Uijl et al., 2011; Stadmark and Leonardson, 2005)
  - Tropics (Guerin et al., 2007; Jauhiainen et al., in prep)
- Drainage ditch
  - Boreal (..)
  - Temperate (Schrier-Uijl et al., 2011; Vermaat et al., 2011)
  - Tropics (Jauhianen et al., in prep; guerin and abril, 2007)

Reference	System	Location	Sampling period	Flux CH_4 (mg m^{-2} h^{-1})
Guerin and Abril 2007	Tropical lake	French Guiana	Late spring	4 ± 4.7
Juutinen et al. 2009	30 Eutrophic Boreal lakes	Finland	All seasons	Median of 0.137
Stadmark and Leonardson 2005	3 Ponds	South Sweden	Summer	10
Huttunen et al. 2002	Boreal lakes	Finland	Summer	1.0
Bastviken et al. 2004	11 Lakes	North America	Summer 2000	Range 0.15–3.2
Repo et al. 2007	3 Boreal lakes	Siberia	Summer	0.34
Present research	5 Temperate lakes	Netherlands	Early summer 2009	1.4–18.1, mean 5.0
Present research	7 Drainage ditches	Netherlands	Early summer 2009	1.2–39.3, mean 18.8

Mean CH_4 emission rates are in mg CH_4 m^{-2} h^{-1}. The period of sampling and the location are given
For units: mg CH_4 m^{-2} h^{-1} refer to mg CH_4 emitted per m^2 of water area per hour

o

N2O

Equation 2.6

Categories in eq. 2.6: Temperate grass/cropland, Tropical grass/cropland, Temperate forest (nutrient poor and rich), Tropical forest. With 'N2O emissions from organic soils' being the title, this is not complete. Perhaps, either change the title, or make categories complete.

Table 2.5 (all categories):

Use CG or GC, but consistently

References missing. See below for more references for the tropical regions (note that all research is very short term. There is a very high need for long term data, preferably a combination of eddy covariance (to capture temporal variability) and chamber measurements):

Table. References and N2O emissions values for tropical organic soils under different LU.

Reference	**Land use on peat**	**Chamber measurement frequency**	**Emission (kg CO_2-eq ha^{-1} yr^{-1})**
Hadi *et al* (2005)	Rice paddy field	3 measurement days	0-5781
Furukawa *et al* (2005)	Rice paddy field	1 year, monthly	0.016
Hadi *et al* (2005)	Cultivated upland field	3 measurement days	6608-36754
Furukawa *et al* (2005)	Upland cassava field	1 year, monthly	0.257
Melling *et al* (2005)	Sago	10 months, monthly	1556
Hadi *et al* (2005)	Soya	3 measurement days	4543
Hadi *et al* (2005)	Forest, not primary	3 measurement days	6600
Melling *et al* (2005)	Forest, not primary	10 months, monthly	330
Furukawa *et al* (2005)	Forest, not primary	1 year, monthly	0.101
Inubushi *et al* (2003)	Forest, not primary Abandoned upland field Rice	1 year, monthly	range -664 - +498
Melling *et al* (2005)	Oil palm	10 months, monthly	566
Furukawa *et al* (2005)	Pine apple	1-2 months	132-1017

Table 2.5 (Grasslands):

- Perhaps split temperature grasslands on organic soils in ‘nutrient rich’ and ‘nutrient poor’. Enough literature on that.

- Include the study of Kroon et al., 2010: Eddy covariance measurements (three years!, first study with half hourly temporal coverage, reliable data): 15 kg N ha-1 yr-1 for heavily managed grasslands (which is a very common practice, at least in Europe). Kroon et al split background emissions (natural) from N input related emissions (human induced).

- Also studies in Denmark, Germany have been performed on N2O from heavily managed grasslands that have much higher N2O emissions than the numbers mentioned in the table. The values of Langeveld and van Beek were on grasslands with less fertiliser and manure inputs.

- Table 2.5 (Wetlands):
- To the reader it is not clear what this includes. Only peatlands drained for extraction, why? But what about e.g. undrained peatlands, abandoned peatland, wetlands with vegetation other than forest?

Line 647: non-CO2 <-> CO2? CH4, N2O?

Line 651: does that make sense? Secondary forest is usually affected by drainage. Is meant primary forest?

Lines 683-685: changes in GHG sinks and sources related to LUC are:
- Direct losses/gains because of biomass clearance/(re)planting (direct loss of carbon)
- Indirect losses/gains because of biomass clearance/(re)planting (indirect losses because of reduced photosynthesis and increased respiration because increased soil temp)
- Losses/gains because of drainage/rewetting (oxidation of peat)
- Losses/gains because of increased fire frequency/dercreased fire frequency after drainage/rewetting

These sources and sinks have to be capture somewhere in the IPCC guidelines.

Annex 2A.2
Table 2A.2:
- To be consistent use t C ha-1 yr-1.

- Because this is an IPCC report, I would again translate this also in CO2 (equivalents), assuming a certain fraction of C released to drainage ditches and rivers converted into CO2 before it enters the ocean.

- Oechel et al., 2012 (in preparation, see conference proceedings) did a very extensive study in Kalimantan, Indonesia, Kapuas river: upto 13.200 ppm p CO2, CO2 flux = 3.4 g C m-2 d-1 (range 1-6.5), DOC concentration of 30 g m-3 (range 5.38-60.3).

Review Chapter 3 of Draft 2013 Wetlands Supplement

Cross-cutting guidance on rewetted peatlands and organic soils

Line 50: suggestion: add clear definitions of 1) peatlands 2) organic soils and 3) wetlands. Now, throughout the different chapters of the guidance it is confusing what is meant it.

Line 53: remove 'and how they affect GHG', there is nothing on GHG in this section. Or add a paragraph on the influence of these measures on GHG.

Line 55: 'Wetlands are…'; Does this exclude wetlands that are not saturated part of the year because of dry summers?

Line 59: remove 'processes'

Line 59: 'pre-dated' – original? Perhaps say: recovery of vegetation.

Line 70/71: Personally, I do not really see the advantage of expressing fluxes in terms of C. When we talk about the IPCC I would expect that we express things in terms of 'climate change', and so in 'warming potentials'; for CH4 in CO2-equivalent (warming potential 23) and for N2O in CO2-equivalents (warming potential 310?). You want to know the effect on the climate, not in terms of carbon losses. Is it because DOC can not directly be translated in CO2-eq because the conversion factor of DOC-> CO2 is quite uncertain?

Line 87: 'have been re-wetted should be encouraged…'.

Table 3.1: 4th column should be deleted and shifted into the 'bog' and 'fen' column? Tropical peat is either 'bog' or 'fen', its not a separate peat type. Or if it is considered as separate peat type explain why: e.g. because of the 'nature' of the peat: forest remains (lignin), compared to low vegetation remains in the temperate and boreal zones.

Equation 3.1: why not implementing the biomass burning component here such as has been done in eq. 3.4 (methane) and 3.6 (n2o)? consistency needed…. Perhaps just say that on rewetted soils the GHG emissions as a result of fire is approximately zero (with references)? And then also remove it from eq. 3.4 and 3.6?. Natural, wet, peat- and organic soils usually do not burn.

Line 115: '..strongly by oxygen availability within the soil.': and thus water table. In the rest of the chapter, often WT is reported as a control of CO2 (which of course indirectly controls O2 availablity), I would say 'water table' and also 'temperature' (even within climate zones, often temperature is the dominating factor for CO2 emissions of soils and water).

Line 117: 'decomposition of dead organic matter such as…'. The litter and root excudates are included in the CO2 measurements where the EF's are based on I guess? (included in the CO2-Csoil component?). In the definition of 'organic soil' the litter layer is included?
Line 128: explanation on what exactly particulate organic carbon is?

Lines 127/135. Perhaps report in 'broad lines' what happens to all components (CO2-C soil, CO2-Cveg, CO2-Cwoosy biomass, CO2-CDOM, DOC, DIC and POC) of the total balance, and why, if peatlands are rewetted.

Line 150: because DOC and related CO2 fluxes are from ditches and other open water bodies, it has to be noted that double counting must be avoided. I could be that people use EF's for 'water fluxes' from chapter 2, and on top of that use DOC values and their EF's to estimated CO2 emissions from DOC.

Line 159: 'use of 5 years transition zone': references?

Lines 163/171: also differences because of LU history & increased fertility of soils because of management, maybe more factors that control the differences: decreased erosion upon rewetting (because of the combination heavy rainfall and vulnerable peat soils in the case of drainage).

Table 3.2: would add (as has been done for methane) a list of references where the EF's are based on (in Annex 3.1).

Table 3.2: consistency between the different table in using capitals or not for ha-1 yr-1.

Equation 3.3: is nothing know about a 'DOC peek' after rewetting? No need for a temporal dynamic equation for the first 5 years after drainage?

Table 3.3: 3rd column: add uncertainties as reported in table 2.2 of chapter 2.

Table 3.3: add units in 4th column and perhaps remove it from the top of the table.

Line 238: '….default value of 90% is proposed..'. based on? 10% is stored elsewhere? Mangroves in tropical regions? Released as CH4? In this case it should perhaps be accounted for?

Line 271: '..oxidation in the soil column…'. And water column should be added.

Line 271/272: should biomass burning and peat burning be mentioned in re-wetted areas? This is not a significant contributor to th GHG balance in re-wetted areas. If so..also for CO2, because this is the most important contributor in case of fire.

Lines 287/292 and 293/298 are the same.

Lines 331/337: Except for prior land use, in temperate organic soils also the in-flux of nutrient rich ground water (through underlying mineral soil layers) from the surrounding heavily managed areas has a large impact on methane fluxes (see e.g. Hendriks et al., 2007). Eventhough the area is already 20 years abandoned after rewetting, the water in the area is still very eutrophic.

Line 374: it would be interesting to see a number for this; what is 'much lower', The reader will be curious eventhough it can not be used as EF. No number are given in annex 3.3.

Equation 3.6: remove biomass burn and soil burn components?

Lines 408/412: if CH_4 and CO_2 are expressed as CO_2-C and CH_4-C, then I would recommend to express N_2O as N_2O-N. Add ha^{-1}.

Annex 3.1:

Suggestion: Refer to studies where EF's are based on (e.g. as in annex 3.3 for CH_4).

Line 613: 'studies that report daily CO_2 flux……used'. Why not? What is the reason to exclude them? Uspcaling reasons?

Line 641/642: While a total of 142….factors. Why are 12 studies not included? Because they were outliers? Because they were judged as unreliable? Explain.

Lines 647/652: perhaps short explanation on why rewetted temperate fens differ from undrained natural temperate fens in terms of CO_2 emissions.

Annex 3.2:

Line 664: explain what is 'soon after rewetting'.

Table 3.A1: Last two rows: numbers have to be shifted between columns 4 and 5 I think. See also table 2A. 3 in Chapter 2 where DOC values in drained sites are always higher than in undrained sites. Maybe also add the references from chapter 2, table 2A.3 to this table.

Lines 679/685: It is interesting to see that methane fluxes from rewetted sites are overall lower than from undrained pristine sites. This is probably because of the redox conditions (soils more eutrophic after certain LU history). Would be interesting to report if after a certain period an equilibrium is expected, that rewetted peatlands have the same emissions than undrained peatlands. Or will this equilibrium never be reached?