Interactive comment on “Constraining global methane emissions and uptake by ecosystems” by R. Spahni et al.

Comment by Frank Keppler
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I would like to draw the authors’ attention to the ongoing debate about methane emissions from plants/vegetation. Although the contribution of vegetation to the global budget remains equivocal, an ever growing body of evidence suggests that plants do produce methane by several different abiotic and biochemical processes (a detailed list of papers on this subject is provided below).

We are aware of the ongoing debate of the aerobic CH4 production and emission from plants and agree that we should have at least mentioned it in our paper – we will do so in our revisions. At the time of conducting our research, we did a simple calculation of the contribution of CH4 emissions from plants to the global CH4 budget and came to the conclusion that those CH4 emissions are negligible (see calculation below). Our simple calculation has now been confirmed by the result of Bloom et al. (2010).

<u>A simple upscaling method of aerobic CH4 emissions from plants:</u>

We based this assumption on some simple extrapolations of CH4 emission rates found by Vigano et al. (2008), who showed CH4 emission rates between 0.1 – 12 ngCH4/gDW/h at naturally occurring UVB radiation in their Fig. 2.

1. *Let's continue with the highest CH4 emission rate of 12 ngCH4/gDW/h.*
2. *Convert it to gC by assuming 50% DW is carbon: 24 ngCH4/gC/h.*
3. *We used a low and a high specific leaf area (SLA) value (e.g. White et al. (2000)) of 20 m2/kgC = 0.02 m2/gC = 1/0.02 gC/m2 and 32 m2/kgC = 0.032 m2/gC = 1/0.032 gC/m2.*
4. *E = 24 ngCH4/gc/h * SLA [gC/m2] = 750-1200 ngCH4/m2 leaf/h*
5. *We assumed that CH4 emissions from leaves happen only when they are exposed to sun, hence we use the leaf area that is exposed to the sun, rather than using total leaf area index (LAI). Under this assumption, we can use the foliar projective cover (FPC) from a model like LPJ to get an approximate global estimate by:*

Global Flux = E * FPC * gridcell area * 12h * 365 days = 0.3 – 0.5 TgCH4/yr

This is a very generous estimate as it allows 12h of light everywhere on the globe and assumes that the emission rate is representative for average annual rates, but all we wanted to find is an upper estimate of CH4 emissions from plants.

Bloom et al. (2010) attributed 0.2 to 1.0 TgCH4/yr to emissions from plants – an estimate that supports our back-of-the-envelope calculation. Based on our calculation we decided not to include aerobic emissions from plants in our current study.

Furthermore, it has recently been shown that leaves of trees growing in wetlands emit methane in substantial quantities (Rice et al., 2010, Gauci et al., 2010). Most likely the methane emitted by the canopy comes from soil-derived CH4 either via internal air spaces or dissolved in the transpiration stream.

This kind of emissions is unrelated to aerobic CH4 emissions from plants. Trees function as conduits for CH4 that is produced anaerobically in wetland soils. We implicitly include this kind of CH4 emissions in our modelling approach because we simply simulate CH4 emissions from wetlands as a fraction of produced CH4 without any assumptions of how the CH4 is transported to the atmosphere. Hence we neither included the CH4 flux through trees explicitly, nor did we exclude it. As our knowledge of how CH4 that is produced in forest soils is transported to the atmosphere is still incomplete – as can be seen by the recent findings of Rice et al. 2010 and Gauci et al. 2010 – we are not at a point where we can mechanistically model CH4 escaping from the soils in wetlands vegetated by trees. Therefore, we see our approach justifiable until we have gained a greater knowledge of CH4 fluxes in forested wetland ecosystems.

Finally, very recently a paper has been published (Martinson et al. 2010) that describes methane fluxes from tank bromeliads; a common group of herbaceous plants in neotropical forests that collect water in tank-like structures. The authors suggested that methane emissions from these plants might differ from the other known vegetation sources as it is produced above ground in a 'canopy wetland' formed by unique structures of the plant.

This is certainly a very interesting study, which we will add to our revised manuscript. However, the rates of CH4 emissions from bromeliads are with 0.36 mgCH4/m2/day or 1.2 TgCH4/yr low and are likely not to have had significant influence of the outcome of our study.

Unfortunately in the current manuscript all information concerning methane emissions from plants/vegetation and the potential contribution of this source to the global methane budget has been neglected even though the paper deals with global biogeochemical process modelling of methane emissions from terrestrial ecosystems. The paper would improve and benefit significantly if the authors were to include a section, e.g. in "3.5 Other sources and sinks", discussing briefly our current understanding of the plant/vegetation sources.

We will follow Dr Keppler's advice here and include a paragraph in our manuscript.

In this context it would be useful to also discuss that many living plants are able to mediate transport of methane from the soil to the atmosphere. Whilst it is clear that this topic is far from being fully understood and that conclusive emission rates are not yet available I would recommend that at the very least the authors should explain why the vegetation sources have not been considered for their global budget calculations.

As explained above, the most important CH4 source from vegetation that has been discovered recently, namely the transport through trees is included implicitly in our study. We will add this explanation to the manuscript.

Moreover, I must point out that the paper by Sanhueza and Donoso (2006), cited in section "3.3. Wet mineral soils", has been misinterpreted. The paper actually deals with emission of methane from dry and green grasses (e.g. *Trachypogon sp.*). In the abstract of the

Sanhueza and Donoso manuscript it is actually stated that “Results support the surprising discovery that vegetation emits methane”. I would request that the outcome of that study be placed into the correct context. To facilitate this it could be included with the section about our current understanding of methane emission from vegetation and discussed as to why it also has not been incorporated into the current global modelling studies.

We don't think that Sanhueza and Donoso (2006) unambiguously show that CH4 emissions measured above savanna soils are due to emissions from plants cf. Keppler et al. (2006). Sanhueza and Donoso (2006) used chamber measurements to detect CH4 emissions from savanna soil-grass complexes. CH4 emissions from unperturbed sites were higher in the wet season (see Fig. 1 in Sanhueza and Donoso (2006)) than in the dry season. Otter and Scholes (2000) showed that Savanna soils switched from being a CH4 sink to a CH4 source when water-filled pore space exceeded 20%. We don't know how the Sanhueza and Donoso (2006) can exclude a potential contribution of anaerobically produced CH4 from the soil. Therefore, we don't agree that we 'misinterpreted' the results, we just interpreted the results differently.

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