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Interactive Comment

Interactive comment on “Methane production from mixed tropical savanna and forest vegetation in Venezuela” *by* P. J. Crutzen et al.

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Crutzen et al. have reinterpreted a 1988 data set of measurements of methane mixing ratios in the boundary layer of Venezuelan savanna in light of our recently published paper (Keppler et al., 2006). Their extrapolations suggest that around 30-60 Tg/yr of methane arise from savanna areas: vegetation is considered the most likely source. It is indeed impressive that the emissions calculated by Crutzen et al. are similar to those postulated from our lab measurements for tropical savannas and grasslands (range 12-46 Tg/yr, mean 29 Tg/yr, Keppler et al., 2006). In our opinion these field observations provide independent evidence that vegetation is a significant source of atmospheric methane.

We would also like to take this opportunity to add a few thoughts regarding the up-scaling of our laboratory experiments. As mentioned in the interactive comment of Jürgen Kesselmeier the current "hot discussion" is about the best approach the best approach for up-scaling our emission rates to the global scale. Since our paper was published in January 2006 we have received numerous comments on this subject.

As most scientists are aware scaling of laboratory experiments to the global atmosphere is extremely difficult and thus has large associated errors. Whilst in our work we show that plant methane emissions were dependent on both light and temperature (for plant litter), we believe that other factors, for example humidity or atmospheric CO2 levels, will also effect these emissions. It is, therefore, essential that further studies, both in the laboratory and in the field (i.e. in the atmosphere itself), be undertaken, firstly to verify our observations and then to measure the emissions under the many different normal environmental conditions. It is only when these data are available that it will be possible to refine the budget and significantly reduce the errors of uncertainty. However, Crutzen et al. is one of the first studies that provide new estimates from independent data.

We welcome any attempt to provide alternative estimates of the global CH4 emissions from vegetation. In our paper we restricted our estimates to biomass related to NPP. We would agree that there are difficulties when using NPP for scaling our emission rate on a global scale. An alternative approach, and we can see the merit, is using leafy biomass (LAI) as the scaling factor for recalculating our global estimations, and in fact we are now also using this approach in a follow-up study (Houweling et al. 2006). Nevertheless, we note that since the underlying process has not yet been identified, also with other approaches like the LAI approach many questions remain unanswered: for example, are we certain that other parts of the plants, such as roots, trunks and stems are not emitting methane? In our paper we restricted our estimate to short-lived biomass, but this also has drawbacks since even tiny emissions from long-lived biomass would be important when scaled up with global biomass.

Overall, we agree with the comments of other scientists that forests and agro-ecosystems are very complex, and now it is much too early to derive final conclusions about the relative contribution of each ecosystem. In our paper we highlighted the fact that our 'simple approach neglects the complexity of terrestrial ecosystems'. Therefore, and we have suggested this before, we really need to get more basic information before the full impact of our discovery, of in-situ formation of methane in plants, can be reliable assessed. Unless a wide range of emission rates of methane from numerous plant species becomes available it may be better that we use field observations such as those of Crutzen et al., to evaluate the importance of the newly discovered vegetation source.

In addition to the observations of Crutzen et al. several other field studies providing supporting evidence of a plant source have been published during the last year that we would like to highlight. Firstly, Frankenberg et al. (2005, 2006) presented comparisons of SCIAMACHY CH4 retrievals and transport model calculations pointing not only to a major missing source over tropical forests but also to lower methane emissions from rice paddies. Secondly, Ferretti et al. (2005) reported a surprising variation in the stable carbon isotope values of CH4 in Antarctic ice cores. Unexpectedly enriched d13C values of around -47 per mill were shown to persist over the time period 0 to 1200 AD. In our opinion, this is difficult to reconcile with a pre-industrial methane budget dominated by isotopically depleted wetland emissions (d13C around -60 per mill) which would lead to atmospheric d13C values in the region of -54 to -49 per mill during the late pre-industrial Holocene period (for detailed information please see Houweling et al. 2000). However, direct plant emissions are enriched in 13C compared to wetland emissions, and from our measurements we derive a d13C value of around -50 per mill based on a 60:40 ratio of C3 and C4 plants. Thus, the isotope mass balance for the pre-industrial atmosphere can be closed if 50% or more of the source strength that was previously assigned to wetlands (130-194 Tg/year, (Houweling et al. 2000))

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actually comes from direct plant emissions. This independent approach leads to a source strength of at least 65-97 Tg/year for direct plant emissions with a corresponding reduction in the wetland emissions ($<$ 65-97 Tg/year). The pre-industrial budget is considered to be a tight constraint for natural sources, as shown by Houweling et al. (2006). This can provide independent information to constrain our initial range, which was a simple bottom-up estimate. Finally, Carmo et al. (2006) shows methane emissions from upland forests in the Brazilian Amazon in the range of 4-38 Tg/year. These very recent findings together with the reinterpret field data from the Venezuelan savanna region by Crutzen et al. strongly support our recent observations that vegetation is a significant source of atmospheric methane Keppler et al. (2006) and most certainly call for a re-evaluation of the present and past global methane budgets. In our opinion, the recently published papers suggest that uncertainties in the global methane budget maybe more questionable than previously thought.

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