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Interactive comment on “N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels” *by* P. J. Crutzen et al.

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The manuscript shows once more that policy has to be very careful before jumping on the bio-fuel train and that there are large differences in the environmental impact of various options that use modern rather than fossil photosynthetic energy to satisfy our energy-hunger.

What this paper distinguishes from other studies on this topic is the recognition that N2O emissions are more than just direct emissions; or even direct and indirect emissions if not carefully assessed. A life cycle analysis for biofuel, be it even more complete than the present study, will not be able to grasp the environmental impact of

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biofuels if based on a biased N2O yield. However, I believe that the approach should be complemented by two additional factors

1. The manuscript adopts a globally averaged N2O yield that is 3-5 times higher than the in-situ fertilizer-related contribution from agricultural fields to the N2O flux. The discrepancy is related to 'background' N2O production from various sources that are listed in the paper. These sources include also animal husbandry and thus also emissions from manure management systems and the application of manure nitrogen to arable soils. This has major implication on the assumption that the newly fixed nitrogen can be estimated from the harvested biomass. As the emissions from applied manure are included in the N2O yield y, its nitrogen can not be treated as new nitrogen. FAO (2006) estimate that 30% of the applied nitrogen comes from the livestock sector. For arable crops this ratio is somewhat smaller, about 20%. To avoid double counting, the factor fnew=0.8 should be added in equation (2). The factor fnew could in principle be varying with the type of bio-crop.

2. The interactive comment from David Reay already shows that the energy density of biofuel and replaced fossil must be accounted for to estimate the final GHG 'savings'. I believe that this must be done already at an early stage of the calculations. Crutzen et al. state that equation (1) calculates the 'saved CO2'. Let's take the example of corn given also in the paper. With rc=0.44 (g Carbon)/(g dry matter in used biomass of corn) and cv=0.37 (kg ethanol)/(kg corn) (kg Carbon burned per kg ethanol)/(kg Carbon per kg corn), the equation yields 0.6 kg CO2 from burned biofuel/kg dry matter. This is the amount of CO2 emitted, molecules that were photosynthesized just a vegetation period earlier. The relation of the energy density per mass unit of 1.8 for gasoline:ethanol implies that for each kg of bio-ethanol produced 540 g of gasoline can be saved. Accounting for a higher carbon content in gasoline with respect to ethanol, we get a saving of CO2 which is 89% of the one suggested by equation (1). Considering further that only 83% of the extracted gasoline can be used to gain energy, we propose to add the factor fenergy=1.07 (kg CO2 from saved gasoline)/(kg CO2 from burned biofuel).

This gives 0.64 kg saved CO2 from gasoline/kg dry matter of corn. For bio-diesel, the relation of the energy density is more favourable (1.2) but this is compensated by the lower carbon content, so that the same fenergy can be used.

Both adjustments make biofuels less harmful than the paper suggests. Overall, this would lead to a correction of the relative warming given in Table 1 downwards by 25%.

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FAO, livestock's long shadow - environmental issues and options. (Food and Agriculture Organization of the United Nations, Rome, 2006).

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 11191, 2007.

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