Atmos. Chem. Phys. Discuss., 7, S4684–S4687, 2007
www.atmos-chem-phys-discuss.net/7/S4684/2007/

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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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Received and published: 5 September 2007

This study uses a clever budget analysis to contrast the CO_2 emissions savings from using biofuels with the N_2O emissions from cultivating the biofuel crops in terms of global warming potential. The conclusion that the “warming” from fertilizer N_2O emissions alone could more than counteract the CO_2 “cooling” is somewhat surprising given the results of other life cycle analyses of biofuel production.

The authors conclude that 3-5% of newly fixed agricultural nitrogen (i.e. fertilizer + legume fixation) is emitted as N_2O. As the authors note, the IPCC and other studies

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have concluded that this N_2O yield (y) is 1% of fertilizer application. The difference in accounting is thought to be the result of the background or indirect emissions, those emissions, for example, from aquatic systems after nitrogen leaches from the field or from animals that been have fed the fertilized crops.

This indirect N_2O yield varies widely in time and space and hence is difficult to characterize. The IPCC currently assumes a value of 1% for the direct agricultural emissions and has a complicated accounting system for the indirect or background emissions. The 2001 IPCC report used a total yield of 2%, based on a value of 1.25% for the direct emissions and 0.75% for the indirect emissions. For the sake of argument, if y=0.02, as in the earlier IPCC report, the reported relative climate warming for rapeseed (0.7) and corn ethanol (0.58) become relative climate cooling.

The conclusions of this study hinge on the value of y. In this study, the value was determined from an estimated global N_2O budget. An alternative approach may be to review studies of denitrification, the reductive process responsible for returning almost all fixed nitrogen to the atmosphere, largely as N_2 or N_2O. The N_2O:N_2 emission factor (EF) in denitrification should therefore be on the same order as the N_2O yield (y). However, mean values in the literature tend to be much lower than the 3-5% reported used in this study. For example, in a survey of N_2O emissions from the world's rivers, estuaries and continental shelves, Seitzinger et al. (2005) reports a mean EF of 0.1-0.5% for aquatic sediments in the literature, with some studies reporting values up to 6%. That study settled on a mean EF of 0.3% in waterways subject low N loading (<10 kg/ha/yr) and a mean EF of 3% in areas of high N loading; the rationale is that the N_2O produced by denitrification may be less likely to be further reduced to N_2 when excess NO_3 is available as an electron acceptor.

There are three likely sources for the discrepancy between observed EF and the estimates of y in this study: i) significant N_2O losses from nitrification, ii) a sampling bias towards regions with low EF or low N loading, and iii) a problem with the global N_2O budget analysis used in this study. While issues of the nitrification source and the limited extent of denitrification field data are important, it could be that the simple N_2O budget is confusing the source of some of the nitrogen in the crop production.

The anthropogenic contribution is assumed to be the difference between the total atmospheric source and the pre-industrial source (minus a decreased source from denitrification). The agricultural contribution, estimated as the difference between the total anthropogenic source and the industrial source, is assumed to originate entirely as newly fixed nitrogen. The world's prime agricultural regions, like the central and upper Midwestern U.S, are such because of soils that are or were rich with carbon and nitrogen. Intensively farming regions has mobilized and harvested this pre-existing soil nitrogen, very possibly increasing the fraction emitted as N_2O, both directly from the soils and indirectly, by eroding and leaching nitrogen into waterways where denitrification may occur. It is the possible that we are drawing down soil nitrogen in the world's agricultural regions and indirectly increased the “natural” source of N_2O via introduction of previously fixed nitrogen to the mobile agricultural nitrogen pool. Unfortunately, few long-term soil nitrogen records exists to test this contention.

This study does raise a crucial question about the net climate effect of biofuel cultivation. The largest obstacle in answering that question may be our limited understanding of long-term changes in the terrestrial nitrogen cycle.

References:

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

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