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Comment on "Carbon budget of mature no-till ecosystem in North Central Region of the United States"

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Letter to the Editor

Comment on ''Carbon budget of mature no-till ecosystem in North Central Region of the United States''☆

Following a 6-year study of net ecosystem exchange of carbon (NEE) in a maize–soybean system, Hollinger et al. (2005) concluded that the system was a net sink of 90 g C m^{-2} $year^{-1}$. This estimate was erroneous because a wrong equation for computing grain carbon removal (Eq. 1) was used and because the authors computed average annual values for each of the two crops (average C gain under maize: 184 g C m^{-2}; average C loss under soybean: −94 g C m^{-2}), then added them together, as if both crops were present each year. Hollinger et al. (2006) have recently corrected those calculation errors, now suggesting that (1) maize acted as a C-sink of 184 g C m^{-2}, (2) soybean was a C-source of 124 g C m^{-2}, and (3) the system was a net sink of 30 g C m^{-2} $year^{-1}$. Although we agree with the corrections of the major calculation errors, we disagree with the authors' conclusions about the carbon sequestration potential of the maize–soybean rotation.

Even the corrected value of 30 g C m^{-2} $year^{-1}$ may paint a picture that is too rosy because it was heavily affected by 1 year of anomalous data. In 2002, a soybean year, they reported the NEE—grain C was −52.1 g C m^{-2} (Hollinger et al., 2006), indicating net sequestration. This is in stark contrast to the 1998 and 2000 soybean years, which were net sources of CO_2 (171–254 g C m^{-2}), as has also been measured in other studies (Baker and Griffis, 2005; Verma et al., 2005). They acknowledge this in the text, stating that it was due to a severe weed infestation in the spring of the year that evidently fixed additional C and suppressed decomposition of the maize residue from the previous year. The difference is most evident in the final column of their Table 1, fallow season NEE. In 1998 and 2000, the totals were 376 and 338 g C m^{-2}, an average of 357 g C m^{-2}, while in 2002 the value was only 129 g C m^{-2}. Since maize production during the previous year was roughly equal to the average of the years preceding 1998 and 2000, it is reasonable to expect that in the absence of the weed infestation the fallow NEE would have been similar as well. If that substitution is made, the net carbon change during the whole 6-year period becomes +45 g C m^{-2}, i.e., the system has in fact been a carbon source at an annual rate of 7.9 g C m^{-2} $year^{-1}$. Since estimates of annual NEE derived from long-term eddy covariance flux measurements are associated with many uncertainties, even under good measurement conditions the error is typically ±30 to 50 g C m^{-2} $year^{-1}$ (Anthoni et al., 2004; Baldocchi, 2003; Knohl et al., 2003). Consequently, both the revised estimate by Hollinger et al. (2006) and the estimate resulting from substituting for the anomalous soybean year are sufficiently close to zero that the designation of this system as a C-sink is not supported.

The authors also made an attempt to extrapolate their field-level results to the whole North Central region (NCR), but the equations used to do so contain additional errors. In Eq. (2), the total C in plant biomass (C_p) is calculated as $C_p = C_{gr}W_g$/EHI. The authors define a term 'ecosystem harvest index' (EHI) as EHI = C_{gr}/growing season NEE. However, Eq. (2) cannot be used to estimate C_p without an explicit accounting of growing season heterotrophic soil respiration, r_h. The correct calculation for this purpose is EHI = C_{gr}/(NEE + r_h) or, consequently, C_p = NEE + r_h (Biscoe et al., 1975; Verma et al., 2005). Since Eq. (2) was used to estimate NEE for the whole North Central Region of the U.S. (see p. 62 in Hollinger et al., 2005) and the EHI was also used in Eq. (3) to calculate the regional total uptake of C during the growing season, the resulting regional estimates of C sequestration potential remain questionable.

The study by Hollinger et al. (2005) is the longest-running eddy covariance experiment in a maize–soybean rotation and is a valuable contribution to carbon cycle science. However, we believe that analytical errors have led them to mistaken conclusions

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regarding C sequestration in this system, both locally and regionally, and that their system was essentially C-neutral, similar to initial findings reported from other sites (Baker and Griffis, 2005; Verma et al., 2005).

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