Earth's upper mantle related to large-scale convective processes.


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**Supporting Online Material**
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Materials and Methods
Figs. S1 to S18
References


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# The Impact of Agricultural Soil Erosion on the Global Carbon Cycle


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Agricultural soil erosion is thought to perturb the global carbon cycle, but estimates of its effect range from a source of 1 petagram per year$^{-1}$ to a sink of the same magnitude. By using caesium-137 and carbon inventory measurements from a large-scale survey, we found consistent evidence for an erosion-induced sink of atmospheric carbon equivalent to approximately 26% of the carbon transported by erosion. Based on this relationship, we estimated a global carbon sink of 0.12 (range 0.06 to 0.27) petagrams of carbon per year$^{-1}$ resulting from erosion in the world's agricultural landscapes. Our analysis directly challenges the view that agricultural erosion represents an important source or sink for atmospheric $CO_2$.


Humans have drastically altered the global carbon cycle, mostly through increased use of fossil fuels and land use change (*1*). Global earth system models (*2*, *3*) represent well the changes in carbon flux between soil and atmosphere resulting from the reduced carbon inputs to soil and the accelerated decomposition of soil organic carbon (SOC) that accompany conversion of land from an undisturbed state to agricultural use (*4*, *5*). In contrast, the carbon dynamics of the well-documented acceleration of soil erosion and deposition (and resultant lateral fluxes of SOC) associated with conversion of land to agricultural use are poorly understood (*6*).

Soil erosion removes SOC from the site of formation and results in its burial in depositional environments. Recent analyses have identified three key mechanisms whereby these geomorphic processes, together or separately, may result in a change in the net flux of carbon between the soil and atmosphere (fig. S1). Mechanism M1 involves replacement of SOC at eroding sites as a result of continued inputs from plants and decrease in SOC available for decomposition (*6*, *7*); mechanism M2 is the deep burial of allochthonous and autochthonous carbon (*8*) and inhibited decomposition upon burial (*6*, *9*, *10*); and mechanism M3 is the enhanced decomposition of SOC as a result of the chemical or physical breakdown of soil during detachment and transport (*11*). The fundamental controls on the magnitude of the erosion-induced sink or source are then the rate at which SOC is replaced at sites of erosion, changes in the reactivity of SOC as a result of transport and burial, and the rates of soil erosion and deposition. Previous global assessments of the influence of erosion and deposition on carbon dynamics have made markedly different assumptions about these controls, resulting in the diametrically opposed assertions of a global net release or source of 0.37 to 1 Pg C year$^{-1}$ (*12*, *13*) versus a net uptake or sink of 0.56 to 1 Pg C year$^{-1}$ (*6*, *9*, *10*) as a consequence of erosion on agricultural lands.

The controversy about the role of erosion in the global carbon cycle reflects the inherent difficulty of quantifying a net flux controlled by interacting processes that are most often studied in isolation. We examined the integrated effect of the interacting processes using evidence for (i) the rate of SOC replacement at sites of erosion, (ii) the fate of the eroded and buried SOC within agricultural watersheds, and (iii) global soil erosion and soil carbon erosion rates (*14*). The first two lines of evidence were derived from a comprehensive large-scale survey of the SOC and caesium-137 ($^{137}Cs$) inventories (mass per unit area to given depth) of agricultural soils in Europe and the United States (table S1) that allows us to assess quantitatively the relationships between lateral and vertical SOC fluxes. We examined 1400 soil profiles from 10 watersheds (1 to 14 ha), including noneroded soils and eroding hill slopes as well as colluvial soils where sediment and SOC are buried. The artificial fallout radioisotope


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