Carbon storage in soils: Climate vs. Geology

Scientists took a closer look at the much-discussed topic of carbon storage in soils under Climate Change. In a large-scale study across Chile and the Antarctic Peninsula, they show that the role of precipitation and temperature in controlling carbon dynamics in soils is less than currently considered in Global Ecosystem Models.

Soils are important for carbon storage and thus for atmospheric CO_2 concentrations. Whether soils store or release carbon is in general related to **climatic factors,** as they control plant growth (driving the incorporation of carbon into the soil), the activity of soil microorganism (driving the release of C from the soil to the atmosphere), as well as several chemical processes in soils. However, we still do not fully understand the response of soil carbon to Climate Change. An international team of researchers led by Pascal Boeckx and Sebastian Doetterl from Ghent University, Belgium and Erick Zagal from University of Concepcion in Chile, has now examined how the interaction of climate with different types of soil minerals controls how carbon is stored versus released from soils. They studied this interaction by sampling soils from numerous locations representing different vegetation types in Chile and the Antarctic Peninsula.

"Models for predicting the impacts of Climate Change on Nature have generally not sufficiently considered the role of soils in buffering or enhancing the potential impacts of Climate Change" Doetterl says. With their work, the scientists show how important it is to understand what is going on in soils that have developed under different geologic and climatic conditions and how these two aspects are connected. Chile, by its unique geographical position, which crosses many climate zones, and with a very variable geology, offered an ideal natural laboratory to study interactions between climate and geochemistry and their control on carbon storage in soils. For the first time, the close connection of geochemical and climatic controls on soil carbon dynamics could be shown on a large scale.

"Soils in regions with warmer and wetter climate are generally more reactive than soils in dry or very cold regions" Erick Zagal explains, "These more reactive soils can stabilize more carbon by, for example, adsorbing carbon on their mineral surfaces." The adsorption of carbon onto minerals protects the carbon from easy decomposition by microorganism, which would lead to CO_2 production that ultimately ends up in the atmosphere and leads to Climate Change.

So what is the more important factor for carbon storage in soils: climate or geology? The answer is, as expected, complex but can be broken down to a few general statements.

“The interesting thing we saw in our analysis is that climate does not act as the sole control on how much carbon is stored in soils”, Pascal Boeckx explains. Climate acts rather indirectly as a control on those elements in the soil system, such as soil minerals, that directly stabilize carbon. If global models now focus only on climatic variables for predicting soil carbon storage, they are excluding the fundamental interactions and feedbacks of the soil geochemistry on the global C cycle.

“Whether Climate Change can trigger a response in soils to either stabilize or release carbon is, therefore, mostly a question of the geochemical features of a soil and the climatic conditions under which these soils developed.“ Doetterl says. For example, in arctic regions, a temperature increase might enhance the stabilization of carbon in soils with reactive minerals and partly compensate the increased loss of carbon stored currently in the melting permafrost layers. In hot arid areas, soil carbon dynamics will most likely not be affected by a temperature increase, but higher amounts of precipitation might stimulate both soil reactivity and biologic activity. In tropical areas, reactive minerals have been washed out and altered into less reactive forms due to millions of years of weathering. Hence, temperature or precipitation changes in the tropics will likely not lead to significant changes in soil carbon dynamics.

“So, we will see a very diverse response of soils to Climate Change, depending on climatic, biologic, and geologic factors. This makes it so important that we don’t forget that soils are a very important part of all terrestrial ecosystems” co-author Johan Six from ETH Zurich concludes.

The article, “Soil carbon storage controlled by interactions between geochemistry and climate” is published in the September 2015 Volume of Nature Geoscience.

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