Evaluating the relationship among energy, water and carbon in soil by using multi-layered land surface model, BEAMS

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The amount of carbon released from the soil to the atmosphere is recently increasing along with climate change. One of the most focusing point is a response of soil carbon dynamics on global warming. However, since the complexity of the relationship among soil energy, water and carbon processes, we have not still understood the scientific understanding relevant to soil carbon dynamics, leading a need to more accurately develop the land surface model. Particularly, the quantitative understanding of the role of soil carbon in the subsurface layer is lacking because the importance of the surface processes has only been recognized recently. The existing models cannot sufficiently reproduce the soil carbon processes in the subsurface layer. Only few studies have focused on the response of the subsurface soil carbon to the changes in soil temperature, soil water content and freezing rate that are the key elements of soil heat and water environment. In this study, we aim to estimate the response of the soil carbon decomposition rate to the changes in soil heat and water environment of the vertically multilayered soil. By integrating an elaborate hydrological model into the existing Biosphere model integrating Eco-physiological And Mechanistic approaches using Satellite data (BEAMS) (Sasai et al., 2016), we developed a new land surface model, and estimated the 1° grid terrestrial carbon fluxes from 1982 to 2011.

As a result, the global average soil carbon decomposition rate increased throughout the model experiment period. The sensitivity experiments showed that 16% of the increasing trend resulted from the changes of the soil heat and water environment. The soil heat and water environment in the top layer (0.00m ~ 0.05m) explained 8.1%, in the middle layer (0.05m ~ 0.30m) explained 5.7%, and in the bottom layer (0.30m ~ 1.00m) explained 2.2% of the increasing trend. These results suggest that the response of the soil decomposition rate on the changes of soil heat and water environment decreases with the soil depth, so that the soil carbon below the surface layer is less affected by the changes in the soil heat and water environment than the soil carbon in the surface layer.

However, this pattern is not universal. In several regions, such as cold regions in the northern hemisphere and grassland in the southern part of Africa, the response of the bottom layer is large. We emphasize that in these regions, the role of the subsurface soil carbon is particularly important.

Keywords: terrestrial carbon cycle, land surface model, soil carbon dynamics

