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Stepwise embankment of tidal marshes increases landscape-scale soil organic carbon stocks (Scheldt estuary, The Netherlands)

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Tidal marshes are highly productive ecosystems which, as a consequence of the deposition of sediments and organic carbon during tidal inundations, store large amounts of organic carbon. In addition, these ecosystems perform valuable ecosystem services, such as delivering energy and nutrients to estuaries and storing vast amounts of water during storm events. Despite the fact that these ecosystems are highly valued, they have been converted to agricultural, residential and industrial land uses all over the world as a consequence of the increasing population pressure in coastal lowlands. This causes the loss of ecosystem services and the transfer of previously stored organic carbon back to the atmosphere.

Despite the importance of the conversion of tidal marshes on a global scale, research concerning this topic has been limited. Moreover, existing research often focusses exclusively on losses of OC due to the embankment of intertidal regions, while not taking into account the burial of additional organic carbon due to the creation of new tidal wetlands at the coastal site of constructed dikes, which counteracts losses of OC from the converted areas. The balance between both processes will determine the net amount of carbon released to the atmosphere.

Therefore, we studied how stepwise embankments of tidal marshes affect regional soil organic carbon stocks in the Scheldt estuary (southern Netherland). This was done for two chronosequences, from active tidal marshes to converted tidal marshes ranging in age from 50 to 500 years. One chronosequence (10 locations) is located in the brackish portion of the estuary, the other one (15 locations) in the salt portion. In a first step, the decline in SOC stocks after embankment of tidal marshes along both chronosequences was assessed based on the analyses of collected soil depth profiles at every site. Subsequently, this data was combined with well-established characteristics of the geomorphology and biogeochemistry of tidal marshes in the estuary, to construct a 2D model of how SOC stocks vary in the studied landscapes due to stepwise embankments and the resulting initialization of new tidal marshes.

The results show that, despite substantial losses of OC after tidal marshes are embanked, stepwise embankment of tidal marshes results in an increase of the average regional OC stock in both the brackish and salt converted tidal marsh landscapes. Our analyses underpin the importance of accounting for the spatial distribution in both losses and gains of organic carbon when assessing the effect of the embankment of tidal marshes on the resulting emissions of greenhouse gases.