Geophysical Research Abstracts
Vol. 21, EGU2019-4551, 2019
EGU General Assembly 2019

A comprehensive understanding of how inundation changes ecosystem CO_2 exchange in a coastal freshwater wetland

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Wetlands are among the ecosystems that are most sensitive to hydrological changes as induced by climate change or human activities. Many regions have experienced increased frequency of intensive flooding. With the impact of inundation pattern shifts, such as deeper water levels and longer inundation periods, on ecosystem carbon dioxide (CO_2) sequestration capacity, the fate of the wetland carbon storage becomes uncertain. While inundation was mostly considered as a binary factor (e.g. inundated vs non-inundated), a comprehensive understanding of how the ecosystem CO_2 exchange would respond to continuous changes in water level and inundation duration is still needed. In this study, we evaluated the effect of water level and inundation duration on CO_2 fluxes by analyzing a 10-year (2008-2017) eddy covariance dataset from a seasonally inundated freshwater marsh in the Everglades National Park. Both gross primary production (GPP) and ecosystem respiration (ER) rates showed declines under inundation. While GPP rates decreased linearly as water level increased, ER rates were less responsive to water level increase beyond 30 cm. The unequal responses between GPP and ER has led to a weaker net ecosystem CO_2 sink strength as water level increases. Eventually, the ecosystem tended to become a net CO_2 source when either water level exceeded $\sim$40 cm or inundation lasted longer than 8 months. With an extended period of high water levels in 2016, the ecosystem became a CO_2 source, as opposed to being a sink or neutral for CO_2 in other years. Furthermore, extreme inundation in 2016 was followed by a 3-month period of lower net ecosystem CO_2 uptake compared to other years. Overall, this study revealed a comprehensive relationship between CO_2 fluxes and different levels of inundation intensity, which was never reported before. Given that inundation plays a key role in controlling ecosystem CO_2 balance, we suggest that a future with more intensive inundation caused by climate change or water management activities will weaken the CO_2 sink strength of the Everglades freshwater marshes and similar wetlands globally, creating a positive feedback to climate change.