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Assessing the impact of exceptional inter-annual climatic variability on rates of net ecosystem carbon dioxide exchange at Clara bog.

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Peatland ecosystems are integral to the mitigation of climate change as they represent significant terrestrial carbon sinks. In Ireland, peatlands cover ~20% of the land area but hold up to 75% of the soil organic carbon stock however many of these ecosystems (~85% of the total area) have been degraded due to anthropogenic activities such as agriculture, forestry and extraction for horticulture or energy. Furthermore, the carbon stocks that remain in these systems are vulnerable to inter-annual variation in climate, such as changes in precipitation and temperature, which can alter the hydrological status of these systems leading to changes in key biogeochemical processes and carbon and greenhouse gas exchange. During 2018 exceptional drought and heatwave conditions were reported across Northwestern Europe, where reductions in precipitation coupled with elevated temperatures were observed. Exceptional inter-annual climatic variability was also observed at Clara bog, a near natural raised bog in the Irish midlands when data from 2018 and 2019 were compared. Precipitation in 2018 was ~300 mm lower than 2019 while the average mean annual temperature was 0.5°C higher. The reduction in precipitation, particularly during the growing season in 2018, consistently lowered the water table where ~150 consecutive days where the water table was >5cm below the surface of the bog were observed at the central ecotope location. The differing hydrological conditions between years resulted in the study area, as determined by the flux footprint of the eddy covariance tower, acting as a net source of carbon of 53.5 g C m^{-2} in 2018 and a net sink of 125.2 g C m^{-2} in 2019. The differences in the carbon dynamics between years were primarily driven by enhanced ecosystem respiration (R_{eco}) and lower rates of Gross Primary Productivity (GPP) in the drier year, where the maximum monthly ratio of GPP:R_{eco} during the growing season was 0.96 g C m^{-2} month in 2018 and 1.14 g C m^{-2} month in 2019. This study highlights both the vulnerability and resilience of these ecosystems to exceptional inter-annual climatic variability and emphasises the need for long-term monitoring networks to enhance our understanding of the impacts of these events when they occur.