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Climate-driven breaching of a deep peat CO_2 reservoir

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The permanently waterlogged and anoxic zone of northern peatlands (i.e. the catotelm), typically holds CO_2 concentrations two orders of magnitude higher than the atmospheric levels, thus representing a vast reservoir of CO_2. Characterization of CO_2 dynamics in the catotelm have so far been restricted to manual sampling, but recent advances in sensor technologies are now opening doors to capture potential temporal dynamics in CO_2 concentrations in these enigmatic environments. Here, we report, to our knowledge, the first continuous measurements of dissolved CO_2 concentrations across different peat depths in a boreal peatland over four consecutive years. We observed rapid sequential drops in CO_2 concentrations from the surface down to 1.5 m depth, which coincides systematically with the thermal destratification, mostly in autumn. Turbulent diffusivity, enhanced during vertical isothermic conditions, was found to be the main driver of these reoccurring annual CO_2 losses. The estimated turbulent diffusive fluxes to the peat surface during these breaching events reached up to 28 g-C m^{-2} d^{-1}, which when sustained over a few days, has the potential to return the equivalent of the entire year net CO_2 uptake from the peatland to the atmosphere. This physical forcing of CO_2 from the catotelm adds a new major component to the complex CO_2 exchange dynamics between peatlands at the atmosphere, which have traditionally been attributed solely to near surface biological processes. Our findings also imply that the shift in seasons will play a decisive role on the sink capacity in northern peatlands, since the magnitude of this breaching of the catotelm CO_2 reservoir, is determined by the duration and depth of the peat profile density destratification during transitional seasons.