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Submarine groundwater discharge from coastal peatlands of northeast Germany

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Submarine groundwater discharge (SGD) is an important pathway for water and compounds within the land-ocean transition zone that can impact coastal environments and marine life. Although SGD research from sandy shorelines has rapidly advanced in recent years, there is very little understanding of coastal areas dominated by coastal peatlands, where the prevailing soils are characterized by a low hydraulic conductivity. Peatlands, the world's most efficient carbon storage, could be a potential source of carbon, nutrients, and trace metals via the SGD pathway. The objective of this study was to determine the magnitude and location of SGD in a coastal peatland in northeast Germany. We wanted to understand the factors controlling terrestrial SGD from coastal peatlands through numerical modelling employing the HYDRUS-2D modeling package. Steady-state scenarios were simulated based on soil physical properties, hydraulic heads, and geological stratifications and structure. In the model set-up, emphasis was laid upon peat layers extending from land into the sea. Our results show that terrestrial SGD occurs at a net discharge volume flux of 0.0803 m^3 m^{-1} d^{-1} with seepage rates of 1.05 cm d^{-1} near the shore and 0.16 cm d^{-1} at a second discharge region above the submerged peat layer. Calculated seepage rates compare to observations from other SGD sites in the Baltic Sea region and other wetland environments. The upscaled SGD estimate for the 3-km coastal peatland is 240 m^3 d^{-1}, which is in correspondence to earlier estimates from the same site. Analysis of the model output reveals that magnitude and location of terrestrial SGD are mainly driven by the magnitude of hydraulic gradient and the hydraulic conductivity of both peat and mineral soils. Additional influencing factors are peat anisotropy, thickness of aquifer sands and peat layers, and peat elevation. Submerged peat layers extending into the sea can restrict SGD flow in deeper discharge regions but may be less critical in terms of volume flux as most SGD occurs near the shoreline. We conclude that coastal peatlands could be an essential source of carbon, nutrients, and other compounds via SGD and may influence local geochemistry budgets and marine ecosystems.