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Modelling the impacts of floating solar structures in a Belgian offshore wind farm

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Marine renewable energies are part of the current energy transition strategy in Europe. Offshore wind farms (OWFs) in the North Sea currently supply around 25.8 GW of power and are aimed to reach at least 117 GW by 2030. Yet, on its own, wind energy supply remains partially unreliable for a consistent energy generation. Offshore photovoltaic (PV) installations are increasingly considered a suitable technology to complement the intermittent energy supply of OWF. In the North Sea, installation of offshore photovoltaics within OWFs offers two significant advantages: (1) space optimization in an already busy North Sea, and (2) the possibility of utilizing and integrating an existing power network.

However, the installation of such systems comes with significant environmental challenges. In particular, solar technologies currently involve more submerged structures per produced energy unit. These floating structures induce hydrographic changes, particularly in terms of current velocity slowdown and turbulence production. Also, the floaters act as artificial hard substrates that are quickly colonized by organisms, potentially altering the biogeochemical dynamics of the water column and, ultimately, affecting the sediments.

This study provides a first assessment of the impact of PV structures on key hydrodynamic variables (e.g. current velocity fields, bottom shear stress, turbulence production), both in the near-field and far-field around an OWF using the 3D hydrodynamic model COHERENS *(https://doi.org/10.5281/zenodo.11654795)*. A 3D computational grid around the Mermaid OWF in the Belgian part of the North Sea was implemented, with a grid resolution of 50m x 50m. We first present the impact of floating solar panels on the surrounding circulation and turbulence field, assessed using a sub-grid scale parameterization. Results from different scenarios will be presented and compared.

Second, we present a first estimate of the enrichment of organic carbon flux to the sediments due to the presence of colonizing organisms (mainly *Mytilus edulis*) on the submerged parts of PV structures. Our aim is to assess the areas of the seabed impacted by the deposition of faecal pellets due to the installation of PV structures within the OWF, considering the hydrodynamic

perturbations presented above. This part uses a 3D Lagrangian particle tracking model *(OSERIT; Dulière et al., 2012)*, faecal pellet characteristics gathered from laboratory experiments (e.g. sinking velocity, production rate and carbon content) and literature data on colonization of wind turbine foundations *(Mavraki et al., 2020)*. In this model, each numerical particle represents a certain quantity of faecal pellets and, consequently, organic carbon.

Maps of faecal pellet deposition patterns will be presented for several scenarios of PV structures distribution in the Mermaid OWF. Our simulations show that the footprint affected by faecal pellet depositions could reach up to 18 times the surface area of the OWF and that the amount of carbon deposited could reach up to 1454 gC.km^{-2} per day (worst-case scenario). These maps illustrate the causal relationship between PV farm design and the surface area of sediment affected by the faecal pellet deposition and thus exposed to organic carbon enrichment.