Towards Reliable Performance Predictions for Stommel's Perpetual Salt Fountain

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ABSTRACT

Artificial Upwelling (AU) of nutrient-rich Deep Ocean Water (DOW) to the ocean's sunlit surface layer is currently being investigated as a way of increasing productivity and enhancing the natural CO_2 uptake of the ocean. AU is thus considered a marine Carbon Dioxide Removal (CDR) option [1] in addition to its potential in the context of open ocean fish and macroalgae farming [2, 3].

A promising technical concept for AU was described by the oceanographer Stommel in 1956 [4]. Stommel proposed that the counteracting effects of typical open ocean temperature and salinity depth profiles on density can be utilized to drive a self-sustaining upwelling flow in a vertical ocean pipe. He termed this effect the "perpetual salt fountain".

Despite several research efforts, none of the previous studies were able to reliably predict or demonstrate the potential of Stommel Upwelling Pipes (SUP)s. The growing interest in AU in light of current CDR research poses the need for reliable performance prediction methods and further development of Stommel's concept.

To fill this gap, two models have been developed in the present work. A Reynolds-Averaged Navier-Stokes (RANS) model and a one-dimensional numerical model. While the RANS model enables detailed modeling of the heat transfer and flow phenomena, the one-dimensional numerical model allows for fast evaluation of simplified geometries for optimization and large-scale studies. This twofold approach allows for effective performance predictions while ensuring good reliability of the results.

The present work shows the results of a number of studies, performed for different geometries and environmental conditions. The results of both models are compared and analyzed, and the respective potential is demonstrated. The presented results provide insight into some key aspects of the performance of SUPs and their potential for AU.

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