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Ensemble simulation of sea water temperature and salinity and their seasonal variations in vertical gradient – An application to aquaculture operations in Southern Aegean Sea, Greece

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During the past decades, aquaculture industry has developed rapidly and, due to a continuously growing market, a high demand for new installations, both near and off-shore, is already observed. Various studies show direct correlations between fish growth parameters and water quality variables, among which the most important are temperature, salinity and dissolved oxygen concentration. Those variables can directly impact planning and farming operations such as location, height and depth of cages, stocking density, or fish feeding rate. Moreover, for a sustainable seafood production, necessary management practices should be in place aiming to reduce food waste and spread of diseases.

At present, large section of the farming sector depends on ad-hoc measurements of water quality without a forecast mechanism. With availability of ocean hydrodynamic and water quality data from various sources such as Copernicus Marine Environmental Monitoring Service (CMEMS), atmospheric data from European Centre for Medium-Range Weather Forecasts (ECMWF), water quality variables can be simulated and forecasted well in advance with the use of numerical modelling tools.

Within the framework of the EU H2020 funded HiSea Project, a new high-resolution coastal 3D hydrodynamic model aiming at describing the vertical gradients of temperature and salinity and their seasonal variations is developed for southern Aegean Sea of Greece. The Delft3D Flexible Mesh modelling tool is used which allows for computationally economic grid development. Data from CMEMS are utilized to setup the model boundary conditions. A complex heat flux model of temperature computations is employed, which means that the model needs to be provided with several atmospheric forcing data such as wind speed, air temperature, dew point temperature, and mean sea level pressure. These data are derived from ERA5 single level reanalysis data of ECMWF. The output variables show a seasonal trend due to changes in atmospheric forces. Therefore, the developed model simulates seasonal water quality conditions and gives important insights into the vertical gradient of temperature and salinity. Validation of the model outputs is carried out at multiple levels. The water level simulation is verified against Intergovernmental

Oceanographic Commission (IOC) mean sea level measurements while the simulated temperature at the two aquaculture sites is verified against the daily in-situ measurements.

The uncertainties in the model outputs (temperature and salinity) are estimated through ensemble simulation using different atmospheric forcing from ERA5 and perturbed model process parameters as source of uncertainty. The application of ensemble simulations to understand the vertical gradients of the water quality parameters is a unique approach. Moreover, the application of the numerical model simulations to optimize the aquaculture planning and operation is innovative. The research could be replicated for other marine sectors where water quality variables are of paramount importance.

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