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NUMERICAL MODELING OF FLOW CIRCULATION AND SALINITY DISTRIBUTION IN THE SEA OF MARMARA

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ABSTRACT

- Oceanic models are vital for comprehending and forecasting ocean dynamics.
- Numerical models are employed to simulate large-scale ocean processes.
- The resolution of the computational grid used in these models is a crucial factor.
- Two distinct methods of cell grids were evaluated within the simulations.
- This study concentrated on simulating the flow circulation and salinity distribution in the Sea of Marmara.
- The computational grid has a substantial impact on the simulation time, accuracy, and fidelity of the model's results.

1. INTRODUCTION

The Sea of Marmara, located in northwest Turkey, is a unique body of water that plays a crucial role in the hydrodynamics of the region. The Bosporus and Dardanelles Straits play a crucial role in the overall hydrodynamics of the Sea of Marmara (Fig. 1). Understanding their circulation patterns is essential for studying the transport of water, nutrients, pollutants, and marine organisms in the region [1].

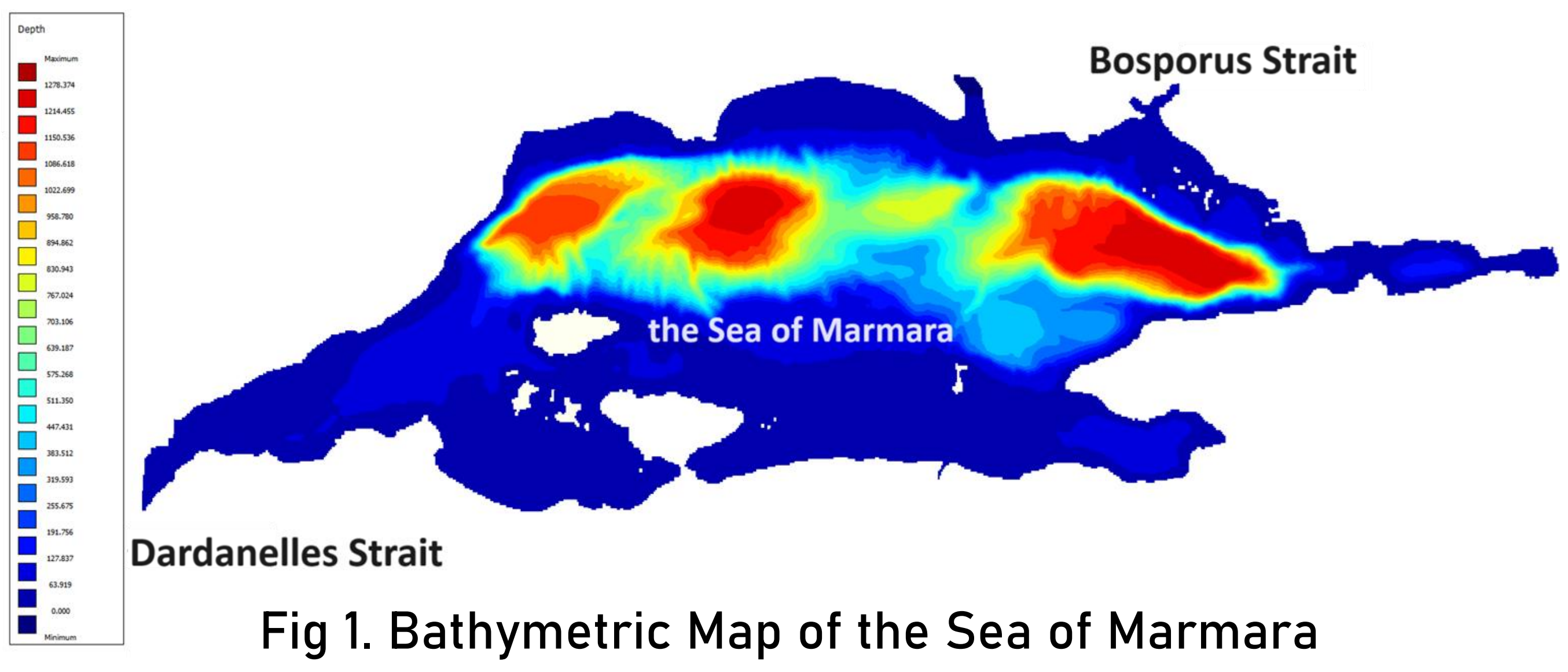


Fig 1. Bathymetric Map of the Sea of Marmara

In the field of hydrodynamic and sediment transport modeling, the accuracy of numerical simulations relies heavily on the appropriate selection of grid size. Different factors influence the choice of grid size. Fine grids require more computational resources and longer simulation times. Practitioners need to balance the desired level of accuracy with the limitations of their computational infrastructure.

In this regard, we have simulated flow circulation in the Sea of Marmara by considering salinity stratifications using two kinds of meshing; then compared the results. For both simulations, input data were the same. For the first simulation, Decomposition Domain Boundary (DDB) was applied, and for the other whole domain was divided into three separate subdomains and exported a polygon for each one. This is in preparation for applying different initial conditions to each subdomain. The simulations were performed using a computer with processor 13th Gen Intel(R) Core i 9- RAM 32 GB.

2. MATERIALS AND METHODS

Delft-3D software was used to analyze the flow circulation in the area of interest. It uses structured orthogonal curvilinear grid system [3]. Using delft dashboard, the grid was generated, and the bathymetry data was extracted from Emodnet. Two open boundaries were applied "Bosphorus in North-east and Dardanelles in South-West". The boundary conditions applied was imposed as data from [2] and forcing applied on the boundary was net flux discharge as Time-Series from the Mediterrenian towards the Black Sea. The physical parameter considered was uniform North-East wind (60°) reaching constant speed of 25 km/h after 24 hrs. In order to get the proper salinity distribution in the domain, 15 vertical sigma layers were considered.
It should be noted that in this study salinity data were considered until depth of 40m, 70m, and 1280m for Bosphorus Strait, and Dardanelles Strait, and Marmara Sea, respectively.

3. RESULTS AND DISCUSSIONS

Fig 2 shows the domain with three parts and assigned initial salinity values for each subdomain. Mesh characteristics for each simulation was presented in Table 1.

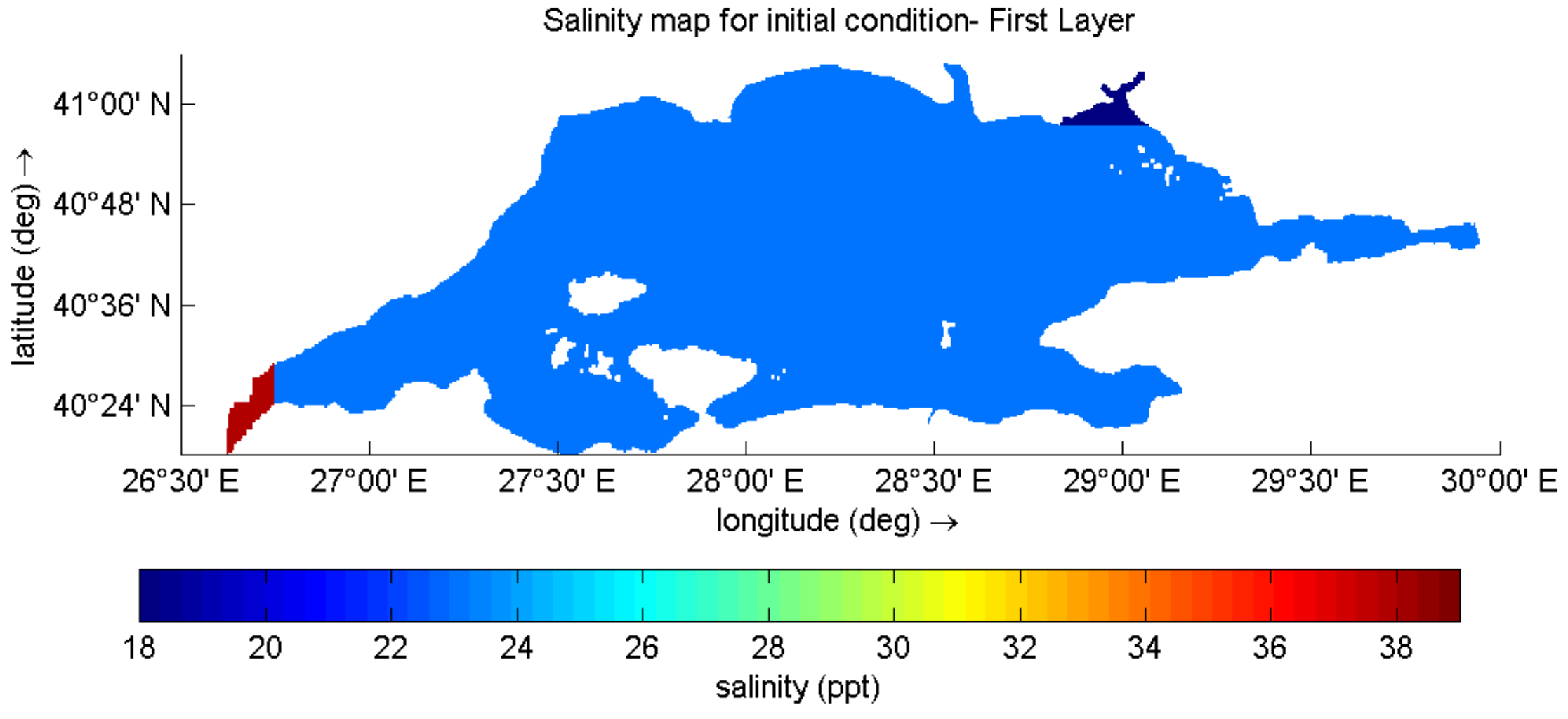


Fig 2. Salinity Map for Initial Condition- First Layer

Table 1. Mesh characteristics

Mesh Characteristics	DDB Simulation	Space varying Simulation
Grid Resolution (M*N)	1729*428 (Marmara Domain) 209*308 (Bosphorus Strait) 386*173 (Dardanelles Strait)	3594*854
Cell Size (X*Y) [m]	156*206 (Marmara Domain) 52*68 (Bosphorus Strait) 52*68 (Dardanelles Strait)	78*102

3.1. Flow Circulation

The flow patterns in the Marmara Sea are influenced by the two-layer flow system in the Bosporus and Dardanelles Straits. This circulation pattern creates a cyclonic gyre in the Marmara Sea. In the present study, although the simulation time is shorter compared to the reference [2], there is still a noticeable similarity in the flow circulation.

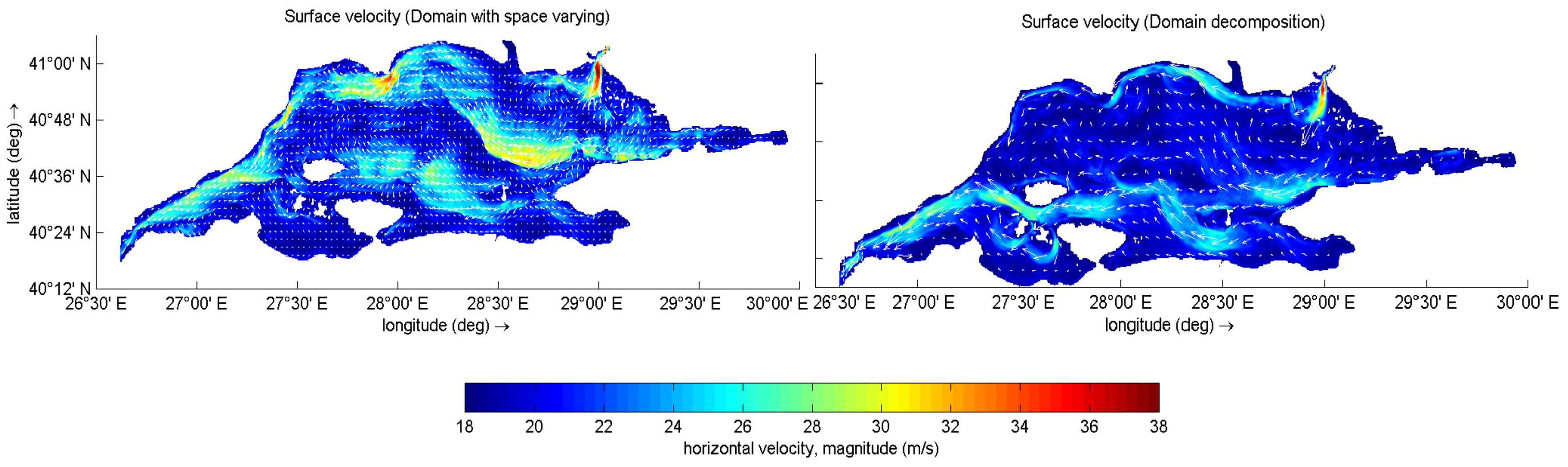
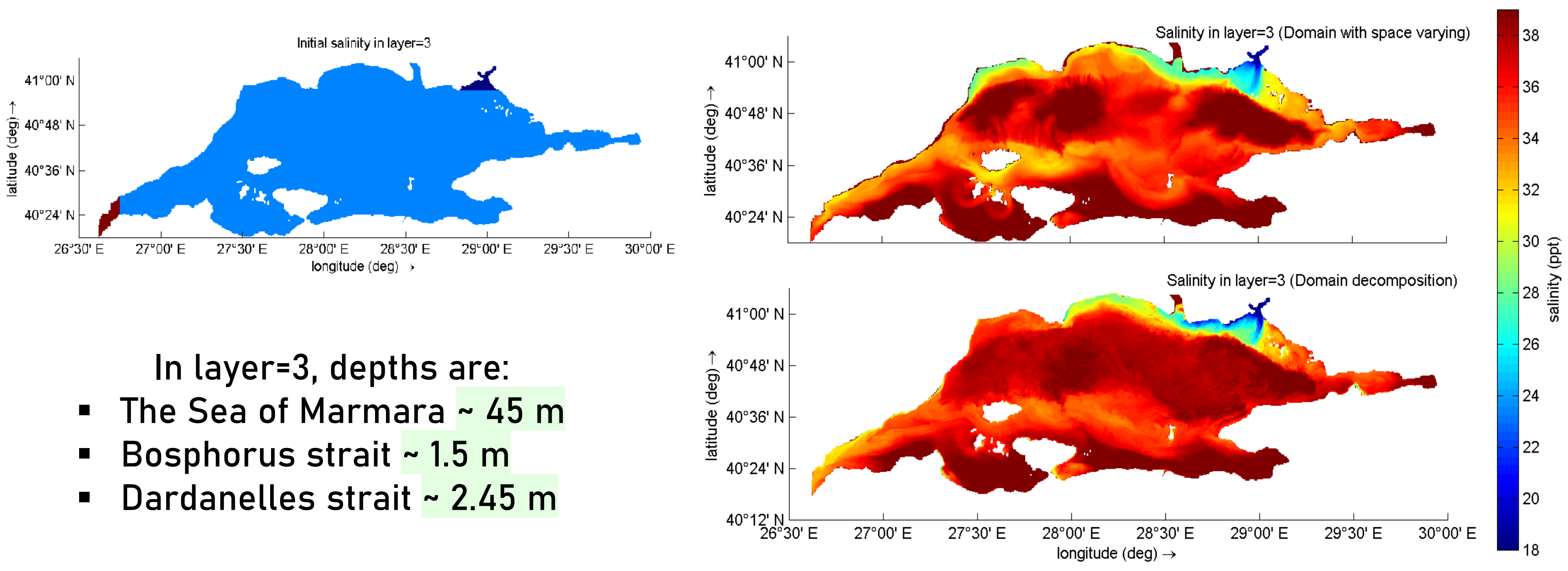


Fig 3. Flow Circulation in the Sea of Marmara

3.2. Salinity Distribution

Due to this two-layer flow, the salinity distribution in the Marmara Sea generally shows a vertical stratification. Due to the influx of low-salinity water from the Black Sea through the Bosporus Strait, the surface layer has a lower salinity (around 22-26 PSU). While the deeper layers have a higher salinity (around 38-39 PSU) due to the inflow of higher-salinity water from the Aegean Sea through the Dardanelles Strait (Fig.4).



In layer=3, depths are:
- The Sea of Marmara ~ 45 m
- Bosphorus strait ~ 1.5 m
- Dardanelles strait ~ 2.45 m

Fig 4. Salinity Distribution in the Sea of Marmara

In future studies, we will conduct extended simulations over a longer period and incorporate temperature data and realistic wind patterns.

4. CONCLUSIONS

- DDB technique facilitates the local grid refinement in multiple directions which improves computational efficiency.
- The whole number of cells employed in the DDB technique are approximately one quarter of those used in a single space varying domain approach.
- Time simulation in DDB technique took two days, while using single domain with space varying took about five days.
- In terms of result quality, simulations using the DDB technique exhibit a more distinct salinity flow compared to the domain with space variation. In addition, DDB technique employed in the simulations allows for a more precise representation of the circulation flow.

5. REFERENCES

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