

Modeling new scenarios of ocean dynamics during deglaciation over Southern European Seas (Mediterranean and Black Seas)



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INTRODUCTION

During quaternary, sapropels are not only driven by African monsoon modulation. Superimposed to the main pacing associated with precession cycles, many sapropels are also impacted by the glacial-interglacial cycles, such as the last sapropel, S1[1]. Previous modelling studies shown that North Atlantic Ocean freshening is required to drive Eastern Mediterranean sea (EMS) deep water anoxia[2]. Here, we investigate another important source of freshwater induced by the melting of Fennoscandian ice sheet (FIS). Indeed, FIS melting has been documented as a consequent source of freshwater running off to the Caspian and Black Seas during the last deglaciation[3–7]. This inflow has been documented from the LGM to the Yungler-drias in the Marmara Sea[8,9], and it is likely that it ended in the Aegean Sea. However, marine proxy-based data studies in the EMS are far from attesting this northern freshwater influence.

AIM OF THE STUDY

For this purpose, continental hydrologic perturbation scenarios have been developed to drive an Oceanic Regional Circulation Model (ORCM) with 1/8° horizontal resolution. Through mean and extreme cases, we demonstrate that effect of freshwater from the melting of FIS during the deglaciation leads to the shutdown of the ventilation and the Eastern Mediterranean Thermohaline Circulation. We suggest these results from this range of scenarios can conciliate with data and likely contribute to the S1 preconditioning.

MATERIAL (1)

Flux reconstruction: ICE-6G (isostatic adjustment)[10], 3d-thermomechanical model output[11].

FRESHWATER FLUX RECONSTRUCTION FROM FENNOSCANDIA TO THE BOSPHORUS STRAIT

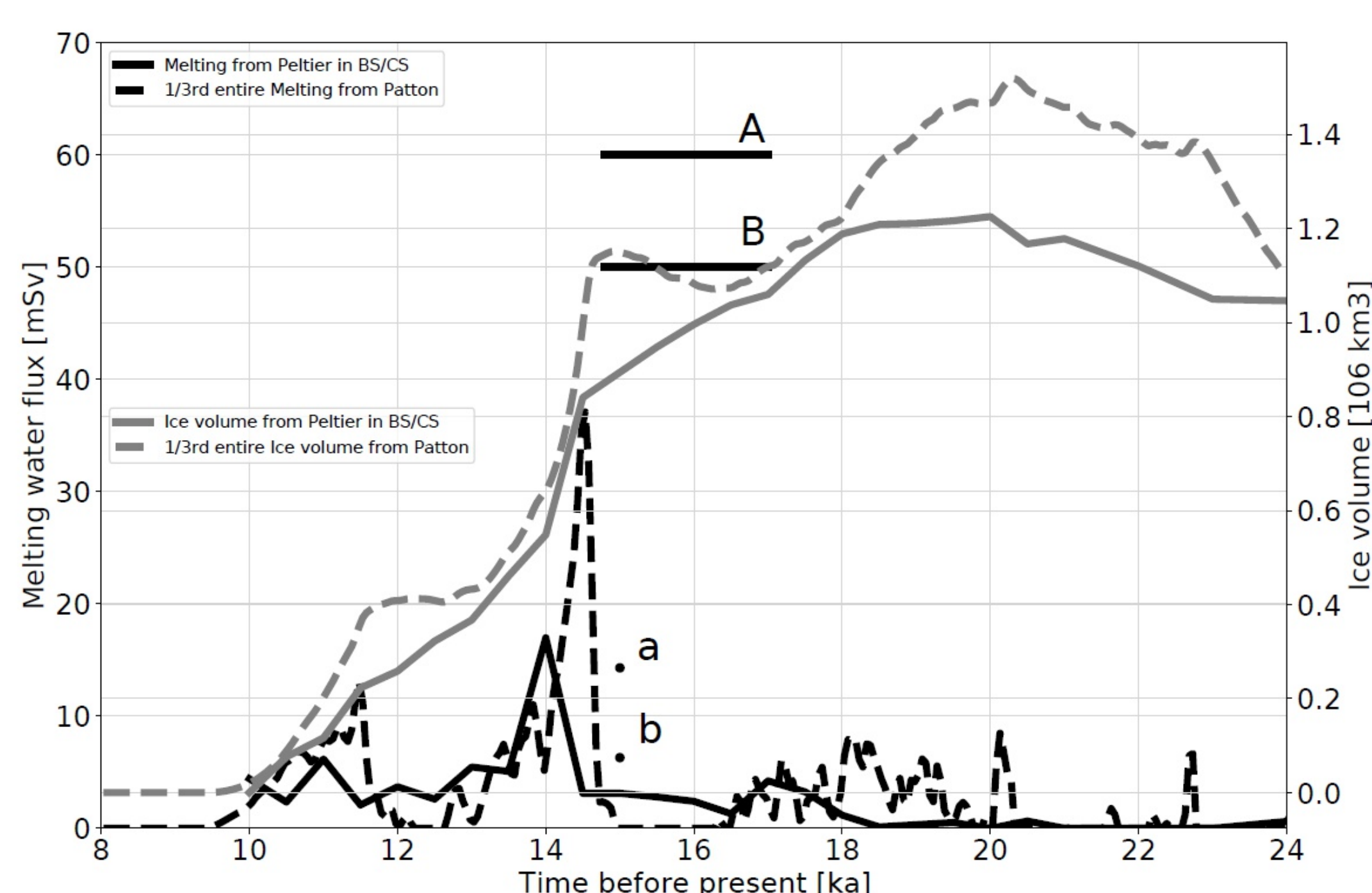


Fig1: Ice sheet volume potentially flowing in the BS and CS catchment (grey lines) and its associated melting water flux (black lines), according to the isostatic reconstruction of Peltier et al (2015)[10] and the estimation from Patton et al., (2017)[11]. Black straight plain lines represent the outflow estimation during the so-called “Great Flood” from Chepalyga (2007)[7] in B) Caspian Sea and A) in Black Sea and Marmara Sea. Black dots a) and b) represent the outflow maximum from Black Sea at the Strait of Bosphorus occurring at 15 ka modelled by Georgievski and Stanev (2006)[12].

From that estimation we extract regimes: 4 mSv (1 mSv = 1000000 m³.s⁻¹), mean flux over the deglaciation, and 17 mSv, pulse likely associated to the Bølling-Allerød warming) to force the regional model with simplified scenarios because a transient simulation would be too much time-consuming.

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MATERIAL (2)

ORCM: NEMOMED8, 1/8° horizontal resolution (9-12km)

Atmospheric forcing: Early Holocene fields from atmospheric regional model[13]

Freshwater forcing:

Simulations: 9kStd, 9kNile, 4mSv, 17mSv, 4mSv+9kNile. “9kNile” is a simulation using the Early Holocene Nile enhancement[13], as an additional reference experiment. “4mSv+9kNile” is the combination of the flux from Bosphorus and Nile, at a time the two freshwater input could coexist (at the very end of the deglaciation / Early Holocene)

Length: 100 years

HIGH RESOLUTION MODELING IMPACT ON THE EASTERN MEDITERRANEAN SEA

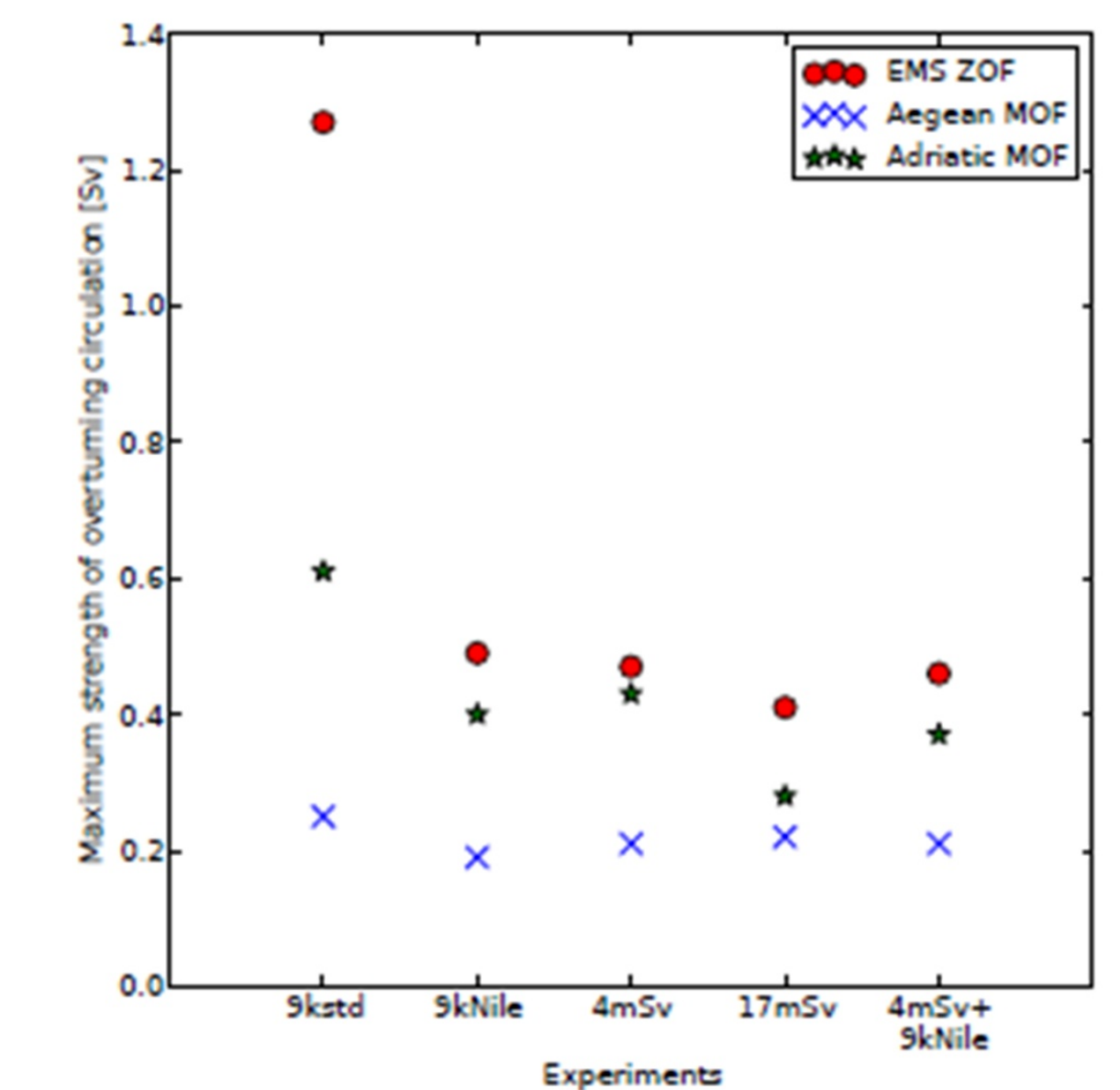
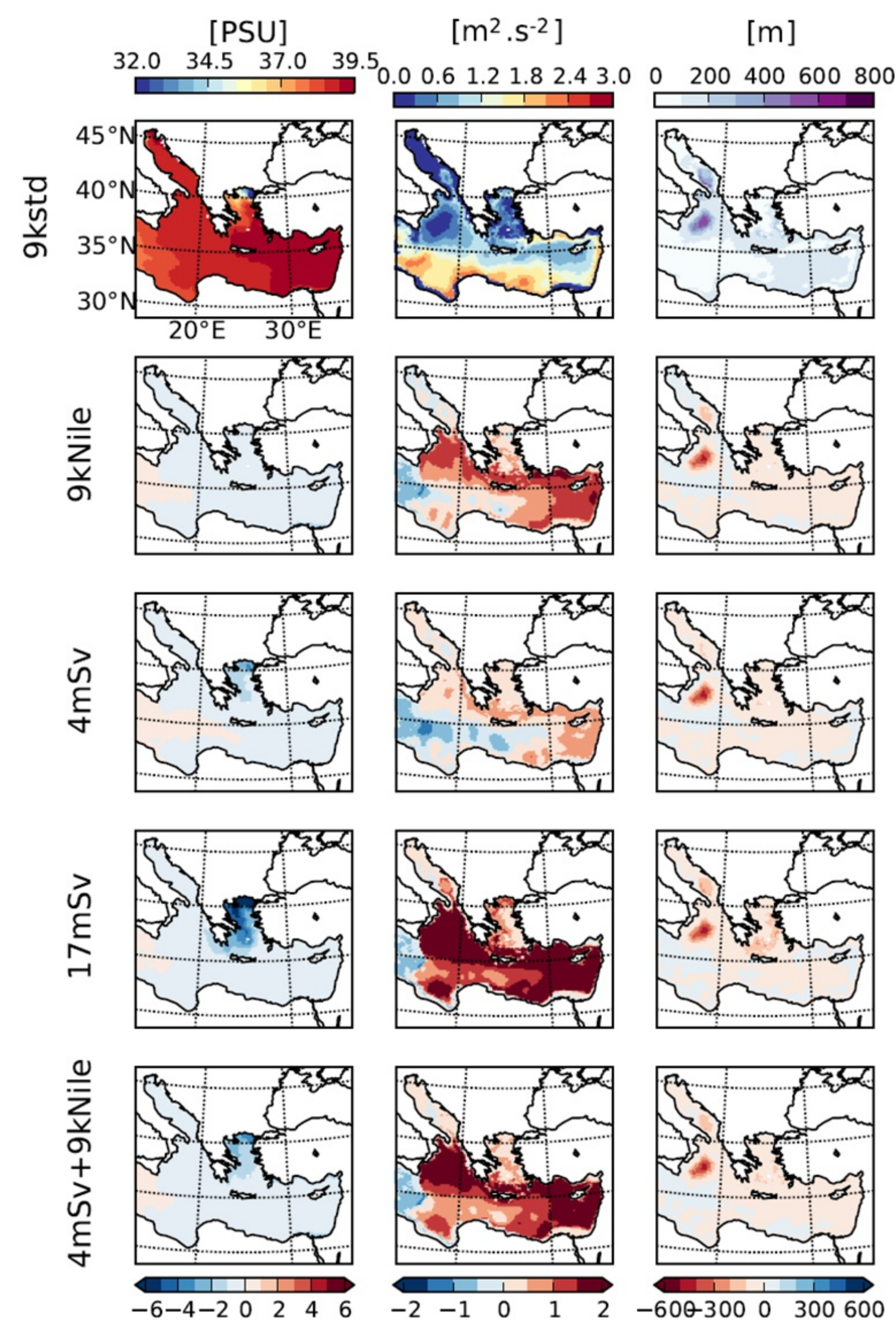


Fig2. 9kStd simulation and anomalies for each freshwater perturbation simulations. First column, sea surface salinity. Second column, index of stratification (IS). Third column, mixed layer depth (each simulation is averaged over the last 10 years). Maximum values of the overturning stream function revealing the strength of the overturning circulation in the EMS (Levantine), the Aegean Sea, and the Adriatic Sea for each simulation (averaged over the last 10 years).

9kStd: Sea Surface Salinity (SSS), IS and MLD characteristics of the present-day EMS (west-east salinity gradient and well depicted convection area).

4mSv: SSS anomaly propagates over the Aegean Sea with a strong southward dilution, leading to a similar pattern up to -1 PSU. Convection spots are also disturbed as depicted by the IS anomalies. MLD are almost equally impacted, being shallower in “17mSv” compared to “4mSv” over the southern Aegean Sea but equal in the Northern Ionian Sea and the Levantine basin.

9kNile: Negative SSS anomaly spreading westward following the coastline (-1 PSU). increasing IS area pattern is “between” “4mSv” and “17mSv” with an averaged value of about + 1 m².s⁻². MLD reduction pattern and values are very similar to “4mSv” and “17mSv” but more propagated over the easternmost coast.

9kStd: most ventilated simulation with 1.3 Sv in the EMS (Levantine cell), 0.6 Sv in the Adriatic and 0.25 Sv in the Aegean Sea. When disturbed, the EMS ZOF (related to the intermediation and deep convection in Ionian and Levantine) is the most impacted, with its strength dropping from 0.85 Sv to 0.25/0.3 Sv. Adriatic/Ionian cell (intermediate and deep) falls from 0.6 to 0.4 Sv in all experiments except in “17 mSv” (0.3 Sv). Relatively, the Aegean cell is the less disturbed, from a ventilated state of 0.25 Sv to the perturbed state of about 0.2 – 0.23 Sv.

In an upcoming paper, we will discuss the plausibility of these modeling scenarios, regarding the δ¹³C and δ¹⁸O marine proxies especially over the Aegean Sea.

REFERENCES

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