

The Danube River role in the Black Sea dynamics

Caterina Gianolla^{1,2}, Giorgia Verri¹, Eric Jansen¹, Francesco Trotta²

¹Centro Euro-Mediterraneo sui Cambiamenti Climatici, CMCC, Lecce, Italy, ²Department of Physics and Astronomy, University of Bologna, Bologna, Italy

AIM: study how the Danube River discharge (in terms of volume, temperature and salinity) affects the Black Sea circulation and dynamics

MAIN TARGETS:

1. Run a 1D estuarine box model, which currently solves the estuary water exchange in terms of volume flux and salt flux (CMCC EBM - Verri et al. 2020, 2021, <https://www.estuaryboxmodel.org/>)
2. Evaluate the effect of **coupling** the EBM with a mesoscale regional ocean model for the Black Sea (NEMO code, Ciliberti et al. 2021) in **2way** mode

METHOD and EXPERIMENTS:

BS-NEMO_EXP1

- Run of the NEMO 4.0.2 Ocean Model
 - **When:** from 2019 to 2021
 - **Grid:** 591 x 261 grid points, 1/40° x 1/40° resolution, z* coordinates
 - **IC:** climatology for SST and SSS
 - **Surface SB:** ECMWF analyses for atmospheric forcing at 6 hours frequency, MFS bulk formulae
 - **River runoff:** 72 rivers considered – for Danube: **monthly climatological discharge** (for 2019 and 2020) and **observations** (for 2021) provided by NIHWM at daily frequency
 - **River salinity:** **zero-salinity at the river mouths** except for the major rivers (like Danube) where **monthly climatological salinity data** from SeaDataNet is used

EBM_EXP1

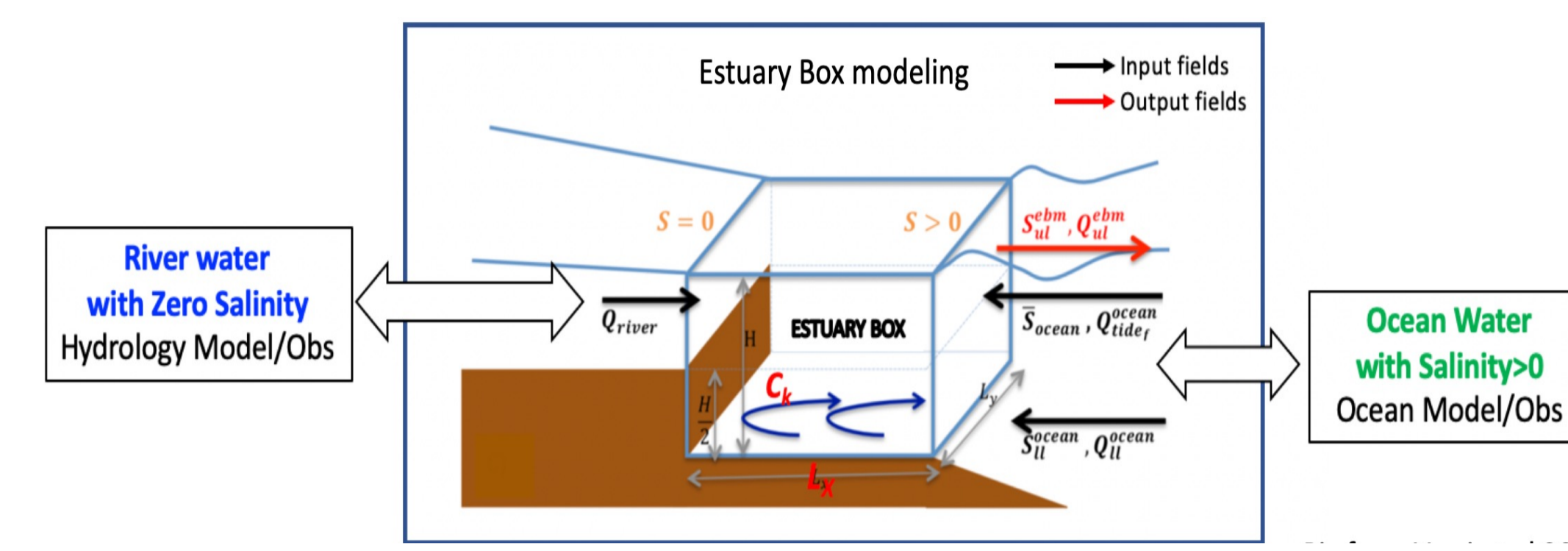
- Run of the Estuary Box Model
 - **Where:** 5 branches of Danube River
 - **When:** from 2019 to 2021
 - **Two conservation equations** for volume and salt fluxes + **two dimensional equations** for horizontal mixing and salt wedge intrusion length
 - **River runoff at estuary heads:** for Danube **monthly climatological discharge** (for 2019 and 2020) and **observations** (for 2021) provided by NIHWM at daily frequency
 - **River salinity at estuary heads set to zero**
 - **Ocean inflow at estuary mouths taken from BS-NEMO_EXP1**

BS-NEMO_EXP2

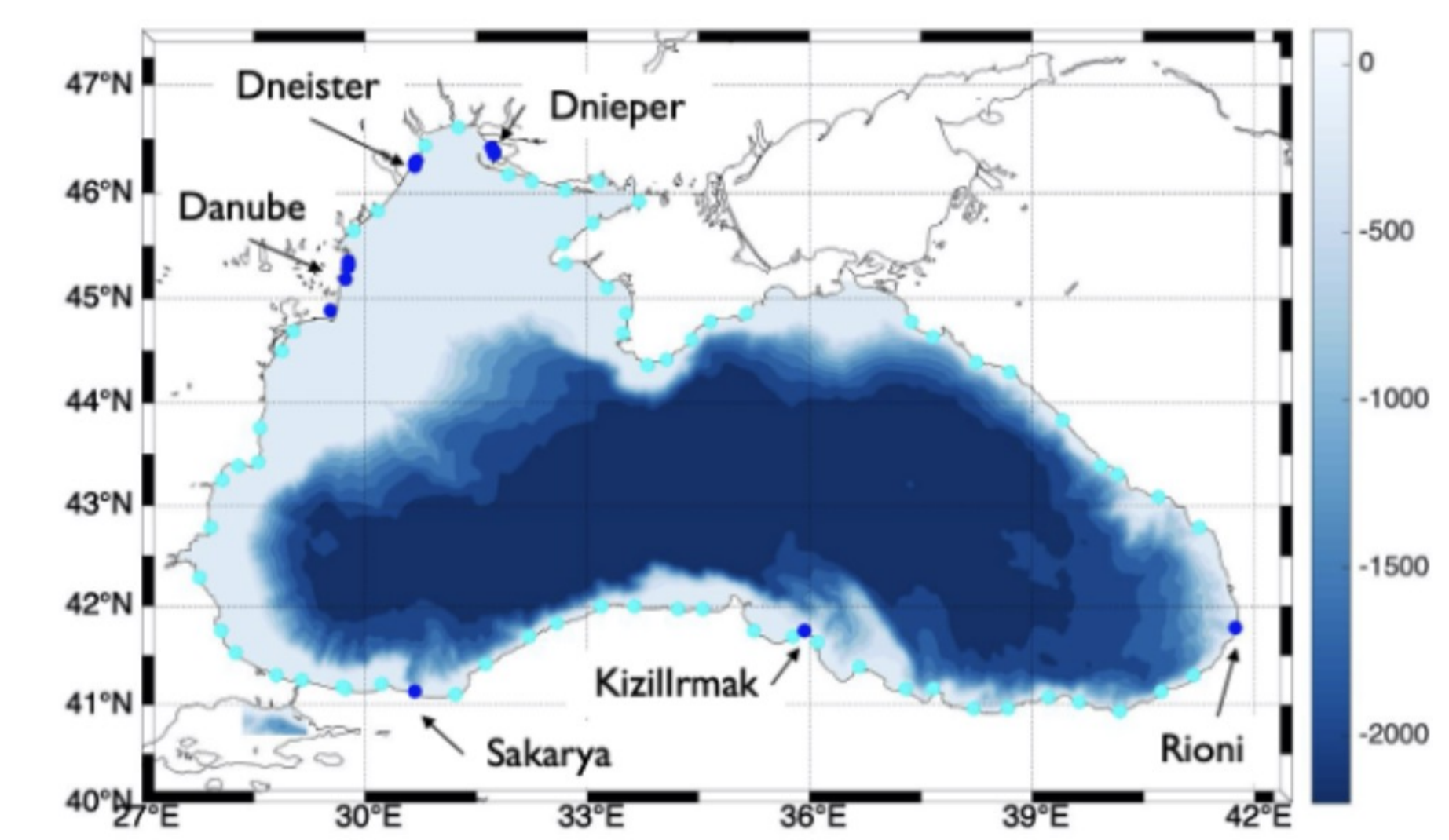
- Second run of the NEMO 4.0.2 Ocean Model (Twin Experiment)
 - **When:** from 2019 to 2021
 - **Grid:** 591 x 261 grid points, 1/40° x 1/40° resolution, z* coordinates
 - **IC:** climatology for SST and SSS
 - **Surface SB:** ECMWF analyses for atmospheric forcing at 6 hours frequency, MFS bulk formulae
 - **River runoff:** **Outflowing river runoff taken from EBM_EXP1**
 - **River salinity:** **Outflowing river salinity taken from EBM_EXP1**



Location of the 5 branches of the Danube River

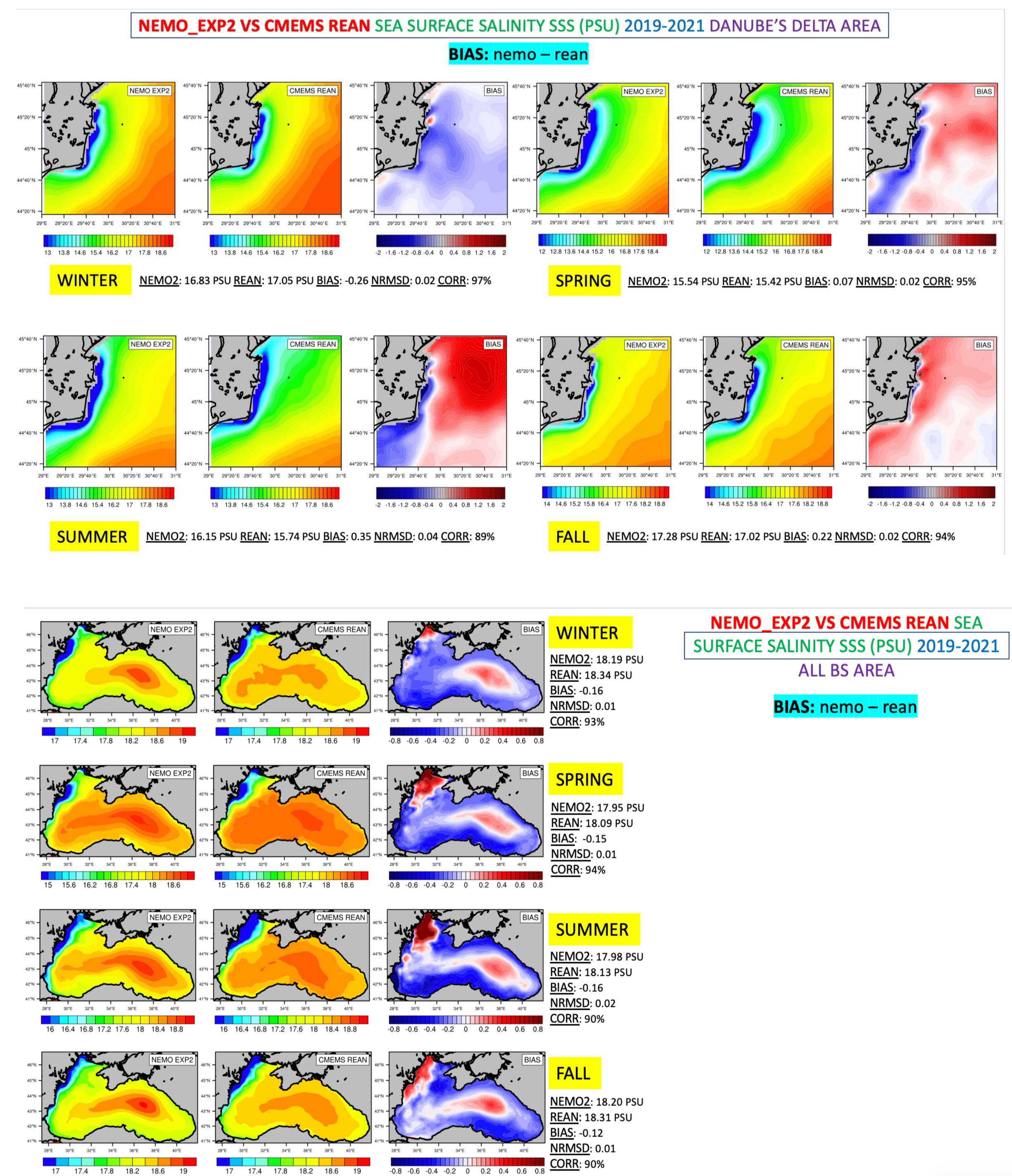
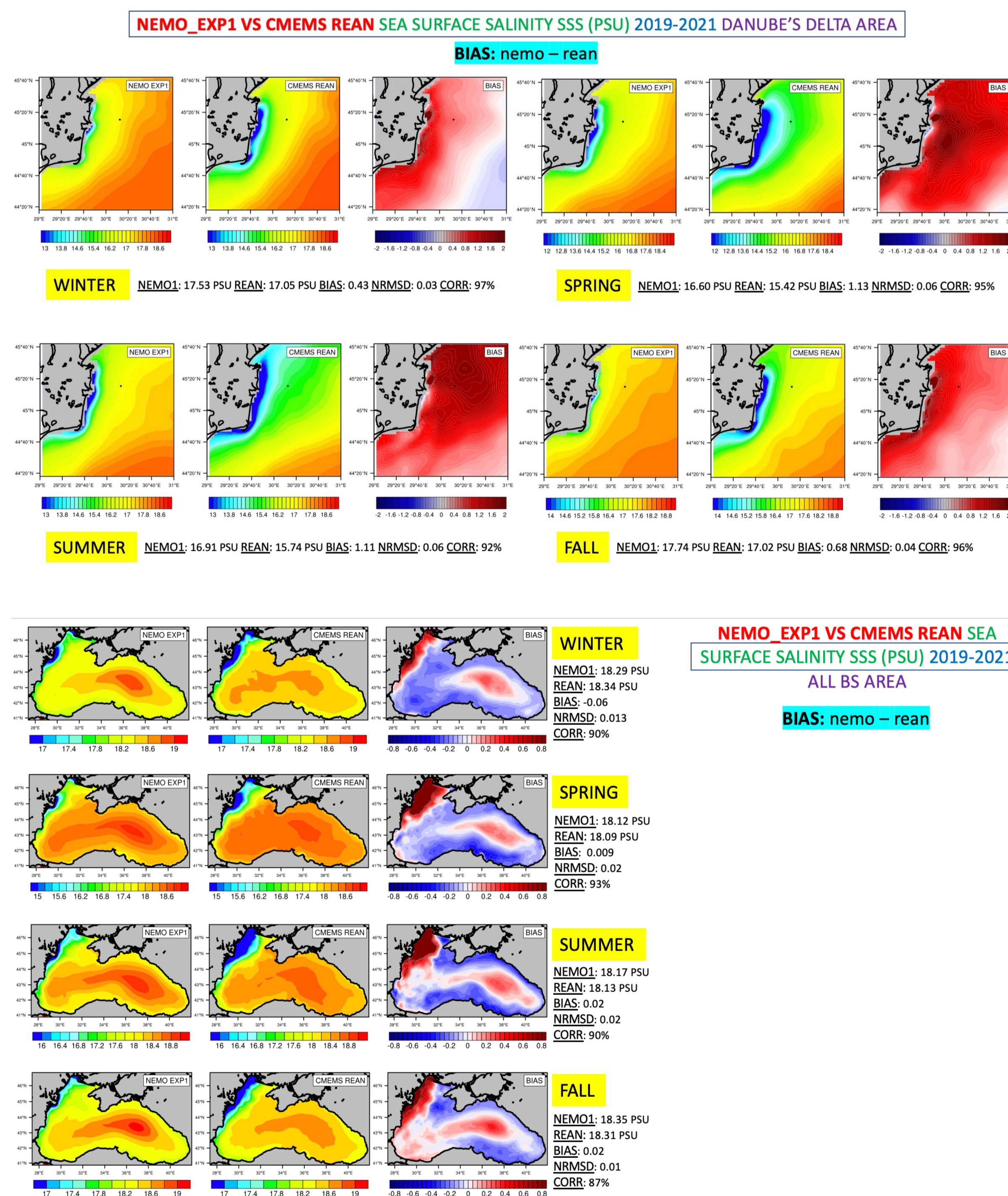


EBM scheme



The Black Sea spatial domain for NEMO 4.0.2 and the distribution of the main rivers

DOES THE REPRESENTATION OF THE SEA SURFACE SALINITY AND TEMPERATURE IMPROVE WITH RIVER SALINITY AND RUNOFF COMING FROM AN ESTUARINE MODEL INSTEAD OF CLIMATOLOGIES?



CONCLUSIONS:

- ✓ **Improvement of the bias in the ROFI** by using the output from BS-NEMO_EXP2 for all seasons
- ✓ **Better representation of the river plume** in BS-NEMO_EXP2
- ✓ NEMO BIAS with respect to reanalysis on basin scale to be investigated

FUTURE STEPS:

1. Use of a 3D hydrodynamic model (SHYFEM) as a Digital Twin to calibrate EBM
2. Add the heat flux conservation equation to the EBM in order to evaluate the effect of providing temperature release to the Black Sea regional ocean model