Sea-level, temperature and salinity change in the Black Sea simulated for period 2000-2100

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Abstract

The Black sea is a deep semi-enclosed dilution basin connected with the Mediterranean Sea by shallow and narrow Turkish Straits with hydraulically controlled two-layer water exchange. The simulation of sea level, temperature and salinity change in the Black Sea in 2000-2100 was carried out using a chain of models, which includes models of the Black and Azov Seas, as well as the Kerch Strait, the Turkish Straits (Bosphorus and Dardanelles) and the Marmara Sea models. The air temperature, wind, evaporation and precipitation for period 2000-2100 over the Black Sea and its catchment area was calculated from regional model CNRM-ALADIN (MED-11) modeling data for RCP4.5 and RCP8.5 scenarios. The neural networks were used to obtain components of freshwater budget from regional model simulations, whereas boundary conditions (sea level, temperature and salinity) in the North Aegean Sea were used from CMIP5 model CNRM CM5.1. The calculated trend of the sea level for period 2000-2100 (3.6 mm/y and 4.6 mm/y for RCP4.5 and RCP8.5, respectively) is close to the corresponding trends in the Mediterranean Sea. The steric correction almost compensates sea-level fall due to the decrease of freshwater influx at 85 km3/y and 99 km3/y in 2100 for RCP4.5 and RCP8.5, respectively. Increasing the air temperature over the sea and reducing the inflow of fresh water are the major factors in changes in the surface layer of the Black Sea. In the period 2000-2100, water temperature of the surface layer of the Black Sea will increase by 2.7 oC, the salinity by 1.7 for the scenario RCP4.5, while the corresponding values will increase by 4.1 oC and by 1.75 for the scenario RCP8.5. These changes in the physical characteristics of the Black and Azov Seas can have a significant impact on the ecosystem of these basins, shores and coastal infrastructure.

OS31D-1778 SEA-LEVEL, TEMPERATURE AND SALINITY CHANGE IN THE BLACK SEA SIMULATED FOR PERIOD 2000-2100

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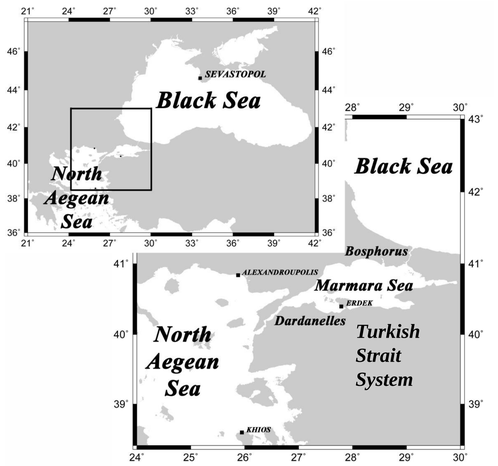
INTRODUCTION

The Black Sea is a fiord-like deep basin with positive freshwater budget connected with Mediterranean Sea by narrow and shallow Turkish Strait System (TSS).

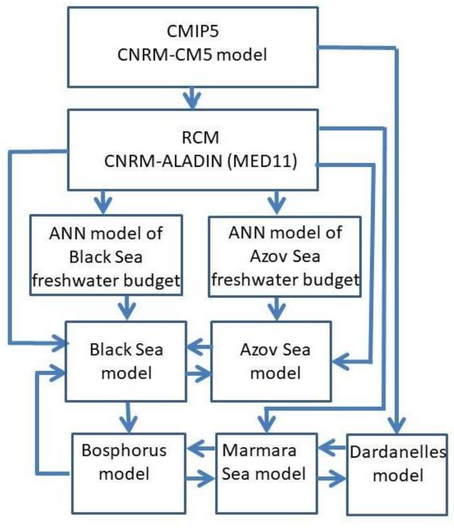
Unlike other seas changes in the Black Sea in period 2000-2100 were not estimated.



RESEARCH QUESTIONS

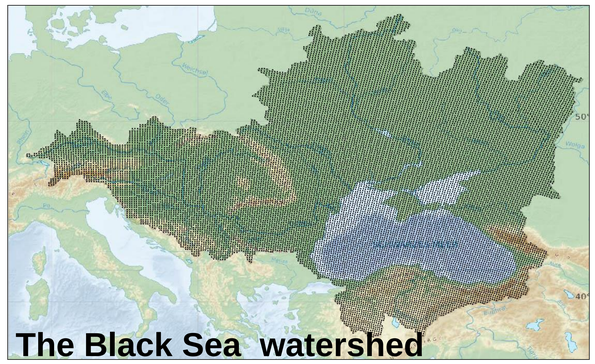
1. How climate change of fresh water budget will affect sea level and stratification in semi-closed Black Sea?
2. How climate change will affect two-way exchange through TSS?
3. Do climate changes in level, temperature and salinity in the Black Sea differ from other seas?

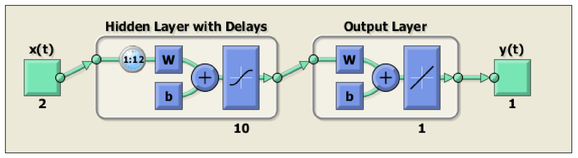
DATA FLOW IN MODEL CHAIN



The chain of 1.5 dimension models of seas and internal hydraulics models for Turkish straits is described in: Maderich V., Ilyin Yu., Lemeshko E. (2015). *Mediterranean Marine Science,* **16** (2)

BLACK SEA FRESHWATER BUDGET IN 2000-2100



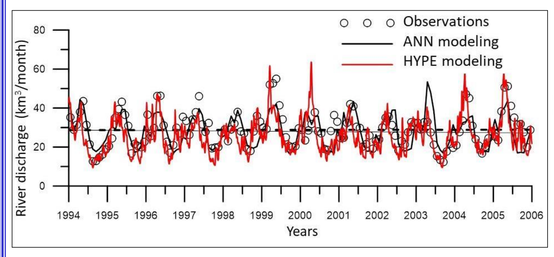


The Black Sea river runoff and evaporation-precipitation difference were calculated) using artificial neural network (ANN) to the projections by RCM CNRM-ALADIN (MED-11 projections for 2010-2100.

The vector of predictors x consisted of the values of the difference evaporation - precipitation, integrated over the catchment area and 1 month in time, as well as the average monthly air temperature averaged over the catchment area.

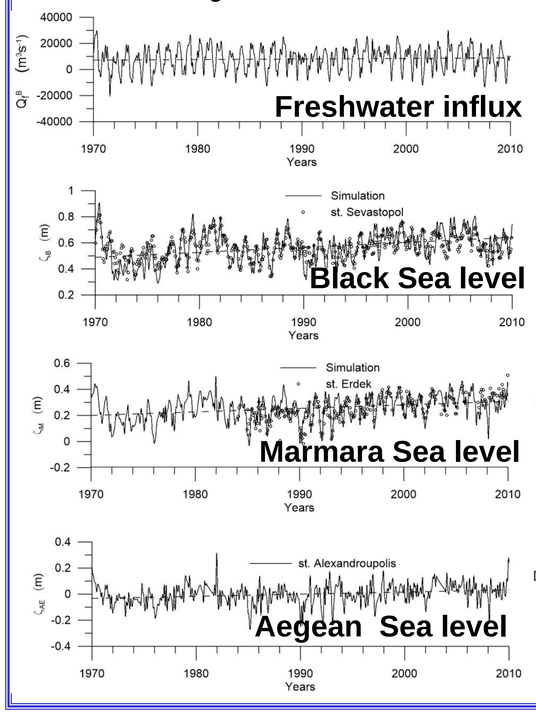
The Neural Network Toolbox neural network consisted of two layers of neurons

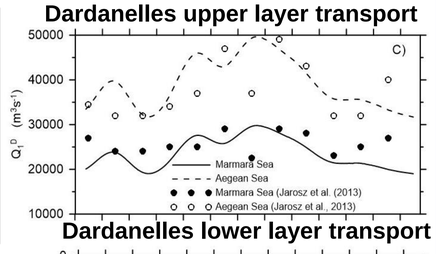
MODEL CHAIN VERIFICATION USING DATA 1970-2010

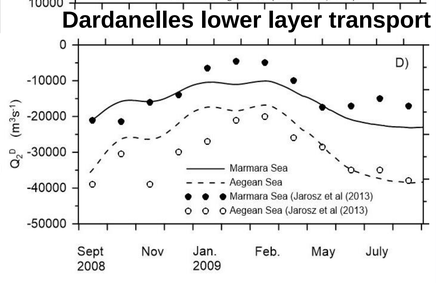


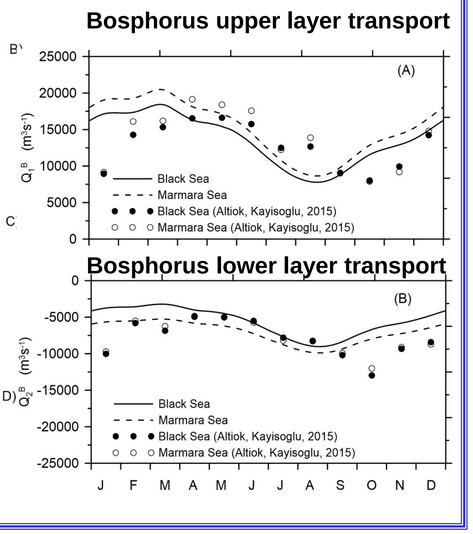
Black Sea river runoff

Sea level modeling vs. measurements in 1970-20









TRENDS OF THE BLACK SEA PROJECTION 2000-2100

Temperature and salinity

Parameter	RCP 4.5	RCP8.5
Air temperature over the Black Sea (°C/y)	+0.027	+0.042
Black Sea surface temperature (°C/y)	+0.027	+0.041
Black Sea surface salinity (1/y)	+0.017	+0.018
Azov Sea surface temperature (°C/y)	+0.030	+0.048
Azov Sea surface salinity (1/y)	+0.012	+0.022

Sea level

Parameter	RCP 4.5	RCP8.5
Black Sea freshwater budget (κm³/y)	-0.85	-0.99
Black Sea elevation (mm/y)	+3.2	+4.2
Sea level difference Black - Aegean Seas (mm/y)	-0.6	-0.6
Thermohalosteric correction (mm/y)	+0.4	+0.4
Black Sea elevation with steric correction (mm/y)	+3.6	+4.6

Turkish Straits transport

Parameter	RCP 4.5	RCP8.5
Bosphorus upper layer transport (κm³/y)	-0.65	-0.75
Bosphorus lower layer transport (κm³/y)	-0.19	-0.27
Dardanelles upper layer transport (κm³/y)	-0.74	-0.87
Dardanelles lower layer transport (κm³/y)	-0.11	-0.14

CONCLUSIONS

RCM projected reduction in runoff and increase in evaporation reduces river runoff and increases the evaporation resulting in decrease of sea level difference between Black and Aegean Sea and decreasing transport through TSS.

The effect of reducing river runoff and increasing evaporation resulting in increase of salinity is offset by rising water temperature in upper layer of sea, which will not lead to the deep convection in the Black Sea and the appearance of hydrogen sulfide in the upper layers of the Black Sea.

The calculated changes in the physical characteristics of the Black and Azov seas can have a significant impact on the state of the ecosystems of these basins, coasts and coastal infrastructure.

A sea level rise of 0.36 and 0.46 m according to the RCP4.5 and RCP8.5 scenarios will lead to a flooding in the lowland coast (for example, the Arabat Spit in Crimea) and to intensification of coastal erosion.

Increasing the air temperature (by 3 and 4.8 °C) and SST of the Black Sea (by 2.7 and 4.1 °C) will worsen the ecosystems of the sea, increase the likelihood of algae blooms and deteriorate water quality in the coastal zone.

Even higher temperature rise (by 3 and 4.8 °C) results in corresponding environmental change in the shallow Azov Sea.