Two Black Sea scenarios files REF_Black_Sea_2005_2012.nc and MTFR_Black_Sea_2005_2012.nc contain the upper 10m vertical average of monthly time series from the beginning of 2005 to the end of 2012 of the following variables:

nitrate (mmol N m^{-3}), phosphate (mmol P m^{-3}), chlorophyll a (mg Chla m^{-3}), dissolved oxygen (deviation from the 100% saturation) (mmol O_2 m^{-3}), temperature (°C) and salinity.

They include also vertically integrated monthly time series of the net primary production (mmol N m^{-2} day^{-1}).

Short description of the scenario forcing and results

The model used for producing the above time series consists of a hydrodynamic module (General Estuarine Transport Model (GETM) and GOTM, http://www.getm.eu/) and a low trophic level ecosystem module (Black Sea Ecosystem Model (BSEM),) (Oguz 2017; Miladinova et al., 2016 and 2017a). It is initialised on a high resolution 2 x 2 min latitude–longitude horizontal grid. The model bathymetry grid is produced from ETOPO1 global bathymetric grid with horizontal resolution of 1 min. The maximum depth of the model domain is 2200 m with a 70 levels general vertical grid, which is compressed towards the surface. The meteorological forcing from the European Centre for Medium Range Weather Forecast (ECMWF) available from http://www.ecmwf.int, based on 6-hourly records has been applied (ERA-Interim project). The model is initialized by means of temperature and salinity 3D fields coming from the MEDAR/MEDATLAS II project (http://www.ifremer.fr/medar). The 3D hydrodynamic model has been successfully applied to study the long term (1960-2015) thermohaline structure and circulation in the Black Sea previously (Miladinova et al., 2017b and 2018).

River scenarios (GREEN)

Rivers with discharges greater than 5 m^3/s are considered for scenario simulations. River discharge (runoff>5 m^3/s), total nitrogen (TN) and total phosphorus (TP) of 16 Black Sea rivers are provided by GREEN. The dataset covers the Danube, 11 Turkey’s rivers, 3 Bulgaria’s and 1 Romania’s river. Ukraine’s, Russia’s and Georgia’s rivers are not considered by GREEN.

$NO_3 = 0.6$ TN , $NH_4 = 0.05$ TN and $PO_4 = 0.55$ TP

Two different management scenarios: Reference (REF) and Maximum Technically Feasible Reduction (MTFR) have been considered. Since GREEN dataset includes only annual mean values, an interpolation on the typical seasonal runoff/load distribution is done for the needs of GETM/GOTM/FABM simulations. Runoff used by GREEN is based on the LISFLOOD model. The freshwater runoff does not vary substantially between both scenarios (deviation for a single river is below 2.5%). Thus, the runoff is the same for both scenarios.

REF scenario is based on the river data provided by GREEN for the Danube, 11 Turkey’s rivers, 3 Bulgaria’s and 1 Romania’s river. Climatological mean distributions are applied for the Ukraine’s, Russia’s and Georgia’s rivers. MTFR scenario is based on the river data provided by GREEN for the Danube, 3 Bulgaria’s and 1 Romania’s river. REF values are used for the 11 Turkey’s rivers (no difference between REF and MTFR for the Turkey’s rivers). Climatological mean distributions are applied for the Ukraine's, Russia's and Georgia's rivers. The Danube accounts for 68.2 % of the NO_3 load and 53.57% of the PO_4 load to the Black Sea. Ukraine's, Russia's, Georgia's and Turkey's rivers contribute more to the overall PO_4 load, than to the NO_3 load.

Dataset / Period	BSC		ICPDR		REF GREEN	
	DIN	PO_4	DIN	PO_4	DIN	PO_4
2005	300	10	500	10	303	11
2012			225	7	223	11
Average 2005 - 2012			391	8.08	250	11.04

Table 1. DIN load (kt y^{-1}) from Danube for 2005, 2012 and average over 2005-2012. (BSC, 2006/7, http://www.blacksea-commission.org; ICPDR, http://www.icpdr.org)

DIN load from the Danube in 2005 from GREEN is close to BSC data and far from ICPDR data. In 2005 the NO_3 concentration estimated by GREEN is 89.7 mmol m^{-3} , and NO_3 = 80 mmol m^{-3} is reported in Cociasu et al. (2008). In 2012 DIN value by GREEN matches perfectly ICPDR value. (Note that GREEN is calibrated for 2012). However the mean GREEN DIN value over the simulated period is quite below ICPDR data. Referent phosphate load provided by GREEN (Table 1) is higher than the observations.

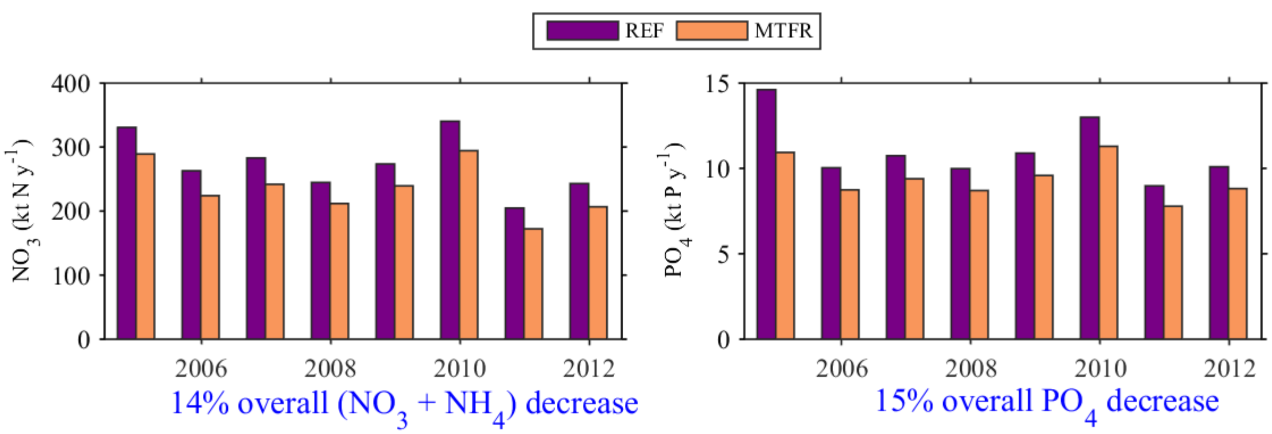

Figure 1. The Danube NO_3 (kt N y^{-1}) and PO_4 (kt P y^{-1}) load over the simulation period for both REF and MTFR scenarios.

Scenario results

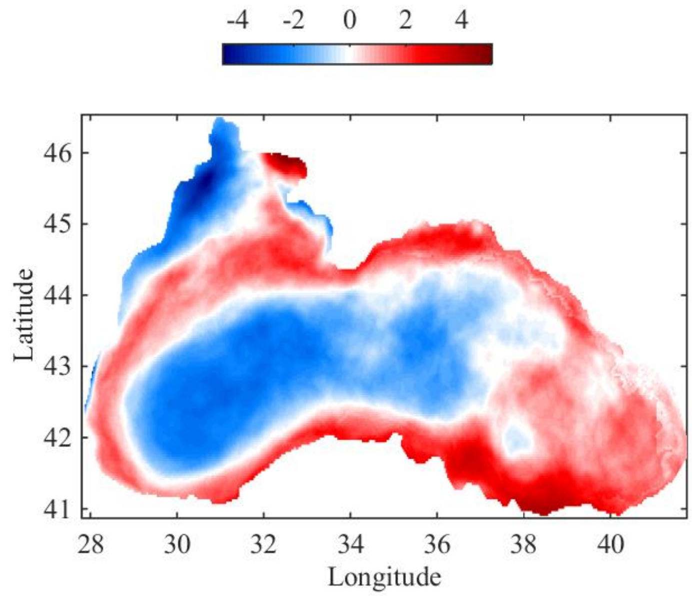

Figure 2. Chlorophyll a relative difference (%) (MTFR – REF)x100/REF. There is no area, where the difference between two time series is significant (95%).

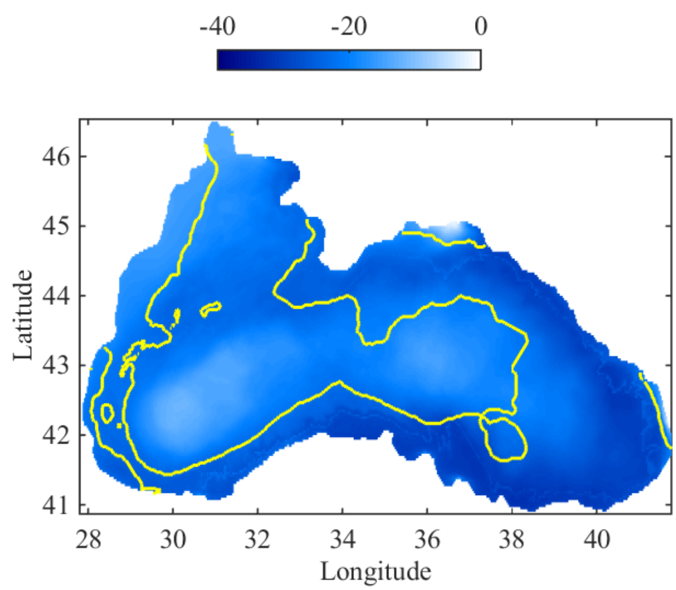

Figure 3. Nitrate relative difference (%) (MTFR – REF) x 100 / REF. The areas, where the differences between two time series are significant (95%) are outlined by yellow lines.

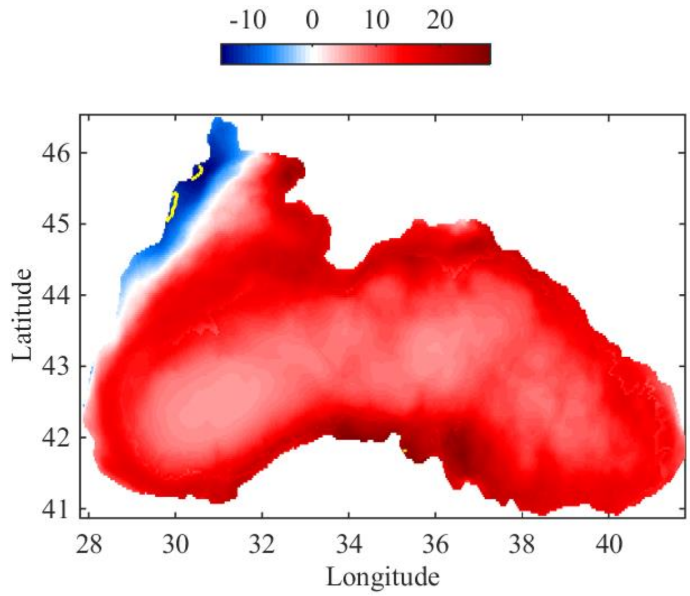

Figure 4. Phosphate relative difference (%) (MTFR – REF) x 100 / REF. The areas, where the differences between two time series are significant (95%) are outlined by yellow lines.

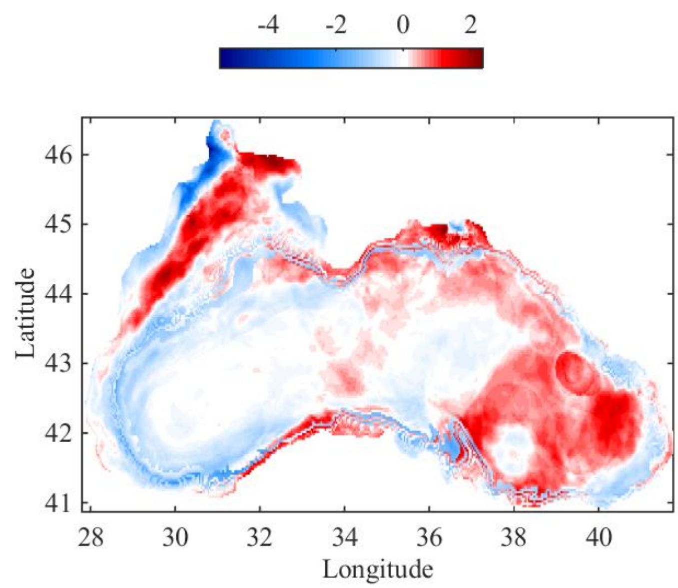

Figure 5. Oxygen (deviation from the 100% saturation) relative difference (%) (MTFR – REF)x100/REF. There are not areas, where the differences between two time series are significant (95%).

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