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Multi-annual model runs for the Mediterranean Sea: the Aegean Sea

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1. Introduction

This study presents the results on the ongoing work of the physical-biogeochemical modeling of the Mediterranean Sea, as a continuation of the work presented in Garcia-Gorriz and Stips (2006a) and Garcia-Gorriz and Stips (2006b). The Mediterranean Sea is a mid-latitude semi-enclosed sea connected to the Atlantic Ocean by the Strait of Gibraltar and to the Black Sea via the Dardanelles Strait, the Sea of Marmara and the Bosporus Strait. It is divided into two main basins: the Western and the Eastern Mediterranean (named hereinafter WM and EM respectively). The WM and the EM are connected by the Strait of Sicily. From west to east, the Alboran, Algerian-Provencal, Tyrrhenian, Adriatic, Ionian, Aegean, and Levantine basins constitute the Mediterranean Sea. More specifically, we present here the multi-annual modeling results for the North Aegean Sea, which is connected to the Sea of Marmara by the Dardanelles Strait (Figure 1). For further details in the geographical distribution of the Mediterranean basins, see Figure 1a in Garcia-Gorriz and Vazquez-Cuervo (1999).

The Mediterranean Sea has an intrinsic physical, ecological, and geo-political importance for the scientific community. During recent years, many efforts have focused on both the observation and the modeling of the Mediterranean Sea. In particular, during the last decade some extensive modeling projects have concentrated on this sea. Some significant ones are EROS2000, EUROMODEL (1995), MERMAIDS (1998), and the ongoing project MFSTEP (Mediterranean Forecasting System- Towards Environmental Predictions). A recent modeling initiative is the Integrated Project ‘Southern European Seas: Assessing and Modeling Ecosystem changes- SESAME’. The general scientific objective of SESAME is to assess and predict changes in the Mediterranean and Black Sea ecosystems. The Mediterranean and Black Seas, representing the Southern European Seas, will be approached as a coupled physical/biogeochemical entity, with links and feedbacks to the world ocean. The JRC/IES-Global Environment Monitoring Unit (Action PROCAS) is one of the scientific partners of SESAME and some results presented in this study will contribute to SESAME’s objectives.

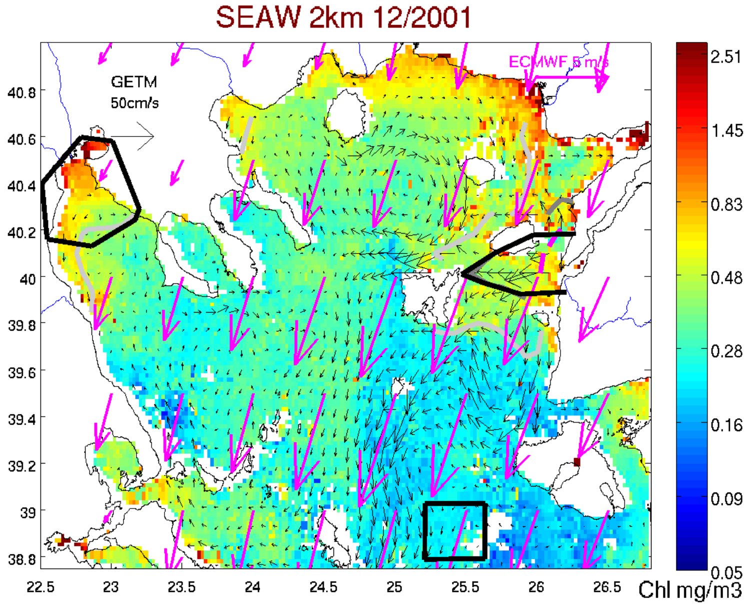
The Aegean Sea has presented and presents great challenges to modeling studies for the oceanographic community. It is a physical domain with complex bottom topography and with numerous islands, islets and straits that can make difficult the selection of the optimal horizontal model resolution in balance with the available computational resources. Additionally, there are limited observations for the Dardanelles inflow and its interannual variability. In recent years, the question of deep water formation has been one of the major scientific questions under active debate in this area, together with the related exchange of waters between the North and the South Aegean. The present study is focused in the North Aegean Sea and on the surface layer.

The Aegean Sea exhibits very strong horizontal gradients along its North-South axis. The archipelago of the Cyclades islands, lying on a relatively shallow shelf (less of 300 m deep) separates the Aegean into two distinc basins, the North and the South Aegean. Whereas the South Aegean basin is filled with warm and highly-saline oligotrophic water, which is characteristic of the Eastern Mediterranean Sea, the North Aegean Sea is directly influenced by the outflow of the Black Sea water masses, through the Dardanelles Strait (Siokou-Frangou et al., 2004). This Black Sea contribution to the North Aegean basin is cold, brackish (salinity about 29), and rather rich in biomass. This North-South contrast can create strong fronts in physical and biogeochemical variables throughout the year within the Aegean Sea.

As pointed out by Zervakis and Georgopoulos (2002), this combination of the brackish water inflow from the Dardanelles and the sea-bottom bathymetry dictate the significant differences between the North and the South Aegean water columns. In the North Aegean, three layers of distinct water masses of very different properties are observed: the 20-50 m thick surface layer is occupied mainly by water with Black Sea origin, modified on its way through the Bosporus, the Sea of Marmara and the Dardanelles. Below the surface layer there is warm and highly saline water originating in the South Aegean and Levantine, extending down to 350-400 m depth. Below this layer, the deeper-than-400 m basins of the North Aegean contain locally formed very dense water with different characteristics at each subbasin.

Figure 1: The Aegean Sea.

Within the North Aegean Sea, we examine three sub-domains that present physical and biogeochemical contrasts and inputs throughout the year (Figure 2). The first sub-domain is close to the mouth of the Dardanelles Strait, where cold, brackish and biomass-rich waters, originally from the Black Sea, enter the Aegean Sea. We simulate and examine the bloom/no-bloom occurrence in this first sub-domain considered an area of direct impact or interaction of the Dardanelles discharge. The second area is located within the Thermaic Gulf (northwest Aegean Sea at the Greek coast) in the same latitude as the Dardanelles Strait but in the opposite (west) Aegean coast, where a number of rivers discharge. The third sub-domain is located offshore in an area with neither rivers nor Dardanelles direct and immediate interaction (Figure 2).



<u>Figure 2</u>: The three sub-domains in the North Aegean Sea selected to carry out coupled physical-biogeochemical model runs are indicated with the black lines.

The three areas present relatively active seasonal cycles and hydrodynamics but display different biogeochemical seasonal regimes. We have selected them to examine the descriptive capability of the coupled physical-ecosystem model to simulate biogeochemical regimes with different occurrence times, nutrient-rich waters inputs, and wind regimes. They are a suitable laboratory for comparison and validation of the coupled model results with sea surface temperatures and chlorophyll-a distributions derived from satellite observations.

Within this general context and continuing our modeling work presented in Garcia-Gorriz and Stips (2006a) and Garcia-Gorriz and Stips (2006b) we use the 3-D General Estuarine Transport Model (GETM model hereinafter) to simulate the hydrodynamics in the Mediterranean Sea. The results from this 3-D model force the 1-D ecosystem model that simulates the biogeochemical regimes in the selected sub-domains mentioned above. We have design and carried out multiannual simulations from January 1985 to December 2006 with horizontal resolution 5’x5’ for the physical model, and from October 1997 to December 2006 for the coupled system. The beginning of this time window corresponds to availability of concurrent satellite-derived chlorophyll-a distributions (Chl hereinafter) used for model validation and discussion at sea surface. In particular, the satellite data are the available monthly fields of the concentration of phytoplankton pigments derived from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the NASA Moderate-resolution Imaging Spectroradiometer Aqua (Modis). We also use the sea surface temperature monthly distributions (SST hereinafter) from the NOAA/NASA Pathfinder Project and from Modis to discuss and validate horizontal dynamical patterns in our study areas.

This report is organized as follows: section 2 describes the methodology and the data sets examined, section 3 presents the results and discussion, and the conclusions and future work are given in section 4.

2. Methodology and data

2.1 Coupled physical-biogeochemical model

The physical model component is the public domain 1-D General Ocean Turbulence Model-GOTM (Burchard et al., 1999), which is currently coupled operatively with three biogeochemical models: a Nutrient- Phytoplankton- Zooplankton- Detritus (NPZD) model, the medium-complexity Fasham et al. (1990) model, and the more complex Neumann (2000) model. The codes for these coupled systems are widely used by the oceanographic community and can be accessed via http://www.gotm.net and http://www.getm.eu.

The coupled physical-biogeochemical system allows forcing the water column in GOTM with the time-series of the physical variables obtained with the 3-D GETM model which simulates the circulation in the Mediterranean Sea. We specifically use the circulation results for the North Aegean Sea. For a detailed description of the GETM equations, see Stips et al. (2004).

The GETM model configuration for the Mediterranean Sea used in this study corresponds to the version 1.4.1 of the model and has horizontal resolution of 5'x5' and 25 vertical layers, within a time window including January 1985 to December 2006. The model domain is extended westward beyond the strict Mediterranean domain to longitude 9°W to allow the mimicking of the Atlantic inflow that enters the model domain through the Strait of Gibraltar, and the Mediterranean water outflow at depth. Also, the current configuration of the GETM model prescribes the Dardanelles inflow to be treated technically in a similar way as a riverine inflow within the basin. The influence of the Dardanelles flow at the surface layer is simulated with an inflow which is prescribed with climatological values of temperature and salinity from the Mediterranean Data Archaeology and Rescue (MEDAR/MEDATLAS) and repeated seasonally. This database is based on in-situ historical hydrographic observations.

The current configuration of the model includes 29 rivers discharging along the Mediterranean coast. The corresponding river discharges are climatological data from Global River Data Center (GRDC, Germany) database. In the current setting of the model, the discharges are repeated seasonally with no interannual variation included. The GETM model runs for the Mediterranean Sea are forced at surface with the European Center for Medium-Range Weather Forecast data (ECMWF data hereinafter), which horizontal resolution is 0.5°. The model is forced every 6-hours, which is the frequency offered by the

ECMWF datasets. ETOPO1, Earth topography on a 1-minute grid, is used to build the bathymetric grid averaging to the corresponding horizontal resolution. The salinity and temperature climatologies required at the start of the model integration are from the MEDAR/MEDATLAS database. No tidal forcing is included in the model results presented here.

We use the model developed by Fasham et al. (1990) [Fasham90 hereinafter] in the present study because it constitutes a compromise between the biologists wish for a sufficiently complex ecosystem model structure and the modelers need to keep the model as simple as possible (Burchard et al., 2006). For this reason it has been and is used and validated widely within the oceanographic community. It uses nitrogen as 'currency' according to the evidence that in most cases nitrogen is the limiting macronutrient (Fasham et al., 1990).

The structure of the model Fasham90 includes the following components: phytoplankton, zooplankton, bacteria, detritus, nitrate, ammonium, and dissolved organic nitrogen. As initial conditions for the components of the ecosystem model, homogeneous conditions are prescribed in the water column. The state variables are represented by their ensemble averaged concentrations, no matter if they are dissolved chemicals (e.g. nitrates) or particles (e.g. zooplankton cells). A two-way coupling between water column physics and biogeochemistry is applied. The dependence of the biogeochemistry on the physics is established via vertical mixing, temperature, and salinity dependence of process rates, light availability, among other mechanisms (Burchard et al., 2006). The feedback from the biogeochemistry to the water column physics is mainly due to modified turbidity changing the light absorption in the water.

2.2 Data

We use the following data to discuss and validate the model results in this study:

- Monthly SST distributions from the NASA/NOAA Pathfinder Project, version 5.0, with 4km of horizontal resolution and covering the entire time window of the model results (January 1985 to December 2006).

- Monthly fields of phytoplankton pigments derived from SeaWiFS and reprocessed within the previous ECOMAR Action with a horizontal resolution of 2km (Melin et al., 2002). The data we use range from October 1997 (first datasets available from the satellite) to December 2004.

- Monthly fields of phytoplankton pigments derived from the NASA Moderate-resolution Imaging Spectroradiometer Aqua (Modis). The data we use range from July 2002 (first datasets available from the satellite) to December 2006.

3. Results and discussion

We carry out multi-annual simulation of the hydrodynamics of the Mediterranean Sea from January 1985 to December 2006. When we examine the sea surface temperatures for the whole basin, the model results present a good agreement with the satellite-derived SST formed with NASA/NOAA Pathfinder SST (from January 1985 to December 2006). We obtain that including 94% of the monthly SST fields from January 1985 to December 2006, the differences between monthly averages of SST are within ±0.5°C, which is the accuracy provided by NASA for the Pathfinder dataset.

Within the North Aegean Sea, the area close to the Dardanelles mouth is the first selected sub-basin that we use in the present study to couple the physical and ecosystem models and to discuss realistic biogeochemical scenarios (Figure 2). The North Aegean Sea is directly impacted by the surface outflow of the Black Sea water masses (BSW hereinafter), through the Bosporus, the Sea of Marmara, and the Dardanelles Strait (Siokou-Frangou et al., 2004). This Black Sea contribution to the North Aegean basin is cold, brackish and rather rich in biomass. The grey and pink isolines in the maps of Figure 3 indicate qualitatively the progression of the Dardanelles contribution at surface within the Aegean basin. At the Dardanelles there is a two-layer flow, with light waters of low salinity (less than 29 psu) forming a 20 m-thick surface layer flowing towards the North Aegean Sea, and highly saline countercurrent waters at the bottom, flowing north-eastward towards the Black Sea (Siokou-Frangou et al., 2004). As pointed out by Zervakis and Georgopoulos (2002), the salinity gradient observed between the Aegean Sea and Black Sea is too strong to be extinguished by evaporation or vertical mixing during the journey of BSW through the Turkish Straits and the Sea of Marmara.

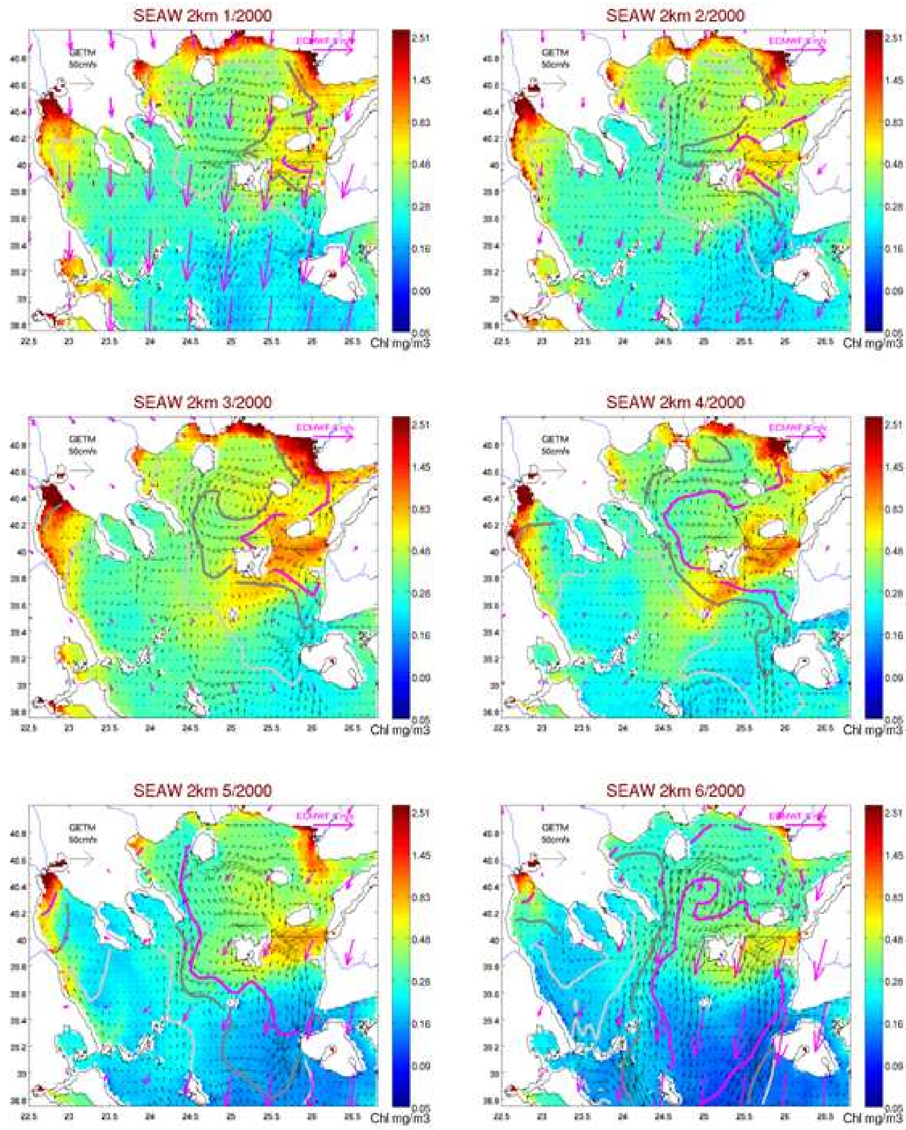
The black arrows in the plots of Figure 3 are the surface currents computed with the GETM model and, in the vicinity of the Dardanelles Strait, they represent the progression of the BSW inflow within the North Aegean Sea. The surface currents computed with GETM show the direction seasonality reported in Zervakis and Georgopoulos (2002). In winter the BSW surface layer, after exiting the Dardanelles, follows a north-westward path through the strait between the islands of Imbros and Limnos and can form an anticyclonic structure in the North Aegean (Figure 3, winter plots). In contrast, the BSW surface inflow follows in summer a south-westward route to reach the western coast of the Aegean and move cyclonically towards the South, in agreement with the surface currents computed with the circulation model and plotted in Figure 3. This south-west shift in summer has been attributed mostly to the forcing by the northerly Etesian winds that apply in late summer on the BSW jet (Zervakis and Georpoulos, 2002). For the years 2000 and 2001 in Figure 3, these strong seasonal winds can be obtained from the ECMWF monthly fields and they are overlapping the concurrent maps of surface currents computed with the circulation model. Also in good agreement with the model surface currents in Figure 3, Zervakis and Georgopoulos (2002) observed that the currents in the North Aegean were stronger in summer. They considered it was due to the strong baroclinicity induced by the increased summer stratification.

The Chl-rich waters related to the Dardanelles inflow can be considered as tracers of surface currents, especially in the vicinity of the islands of Limnos and Imbros (Figure 1 and Figure 3). Throughout the year, the model currents in that area agree well with the progression path and seasonality indicated by satellite-derived pigment distributions.

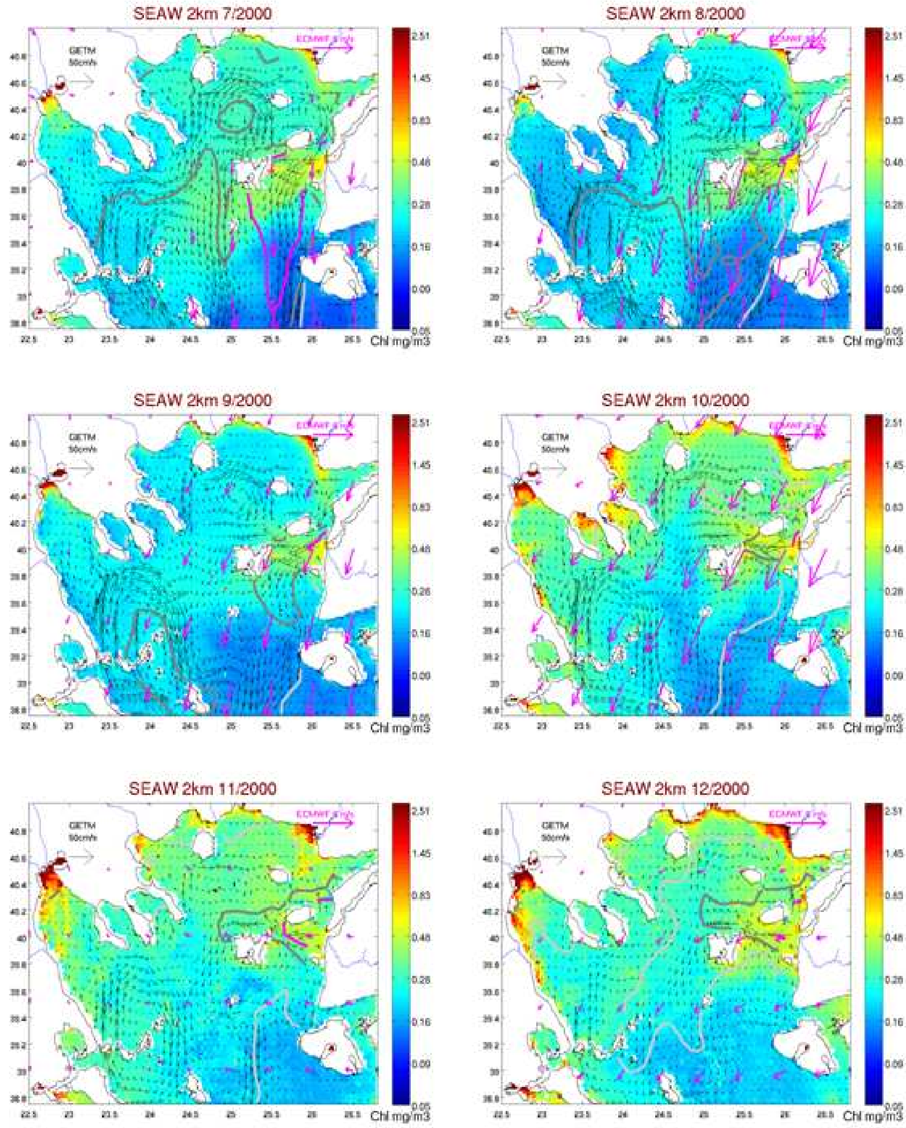
The Black Sea is the major, buth not the only source of brackish nutrient-rich water for the Aegean Sea. Several rivers along the Greek and Turkish coasts also contribute. The annual contribution of the Dardanelles to the North Aegean water balance is of the order of 300-1000 km^3/year, while the rivers do not exceed 10 km^3/year. In addition, the inflow from the Dardanelles reaches its maximum in summer, while that of the rivers does in late winter (Zervakis and Georgopoulos, 2002). The second sub-domain to be examined is located within the Thermaic Gulf (northwest Aegean Sea at the Greek coast), where a number of rivers discharge (Figure 2). The main rivers discharging within this western sub-domain are the Aliakmon and Axios rivers, which are as well included in the computations of the GETM model.

The third sub-domain is located offshore in an area with neither rivers nor Dardanelles direct and immediate inflow interaction (Figure 2). As displayed in Figure 3 and 4 (bottom panel), the seasonality of the wind fields on that area are very similar to those on Dardanelles, and much more active than in the west-rivers area.

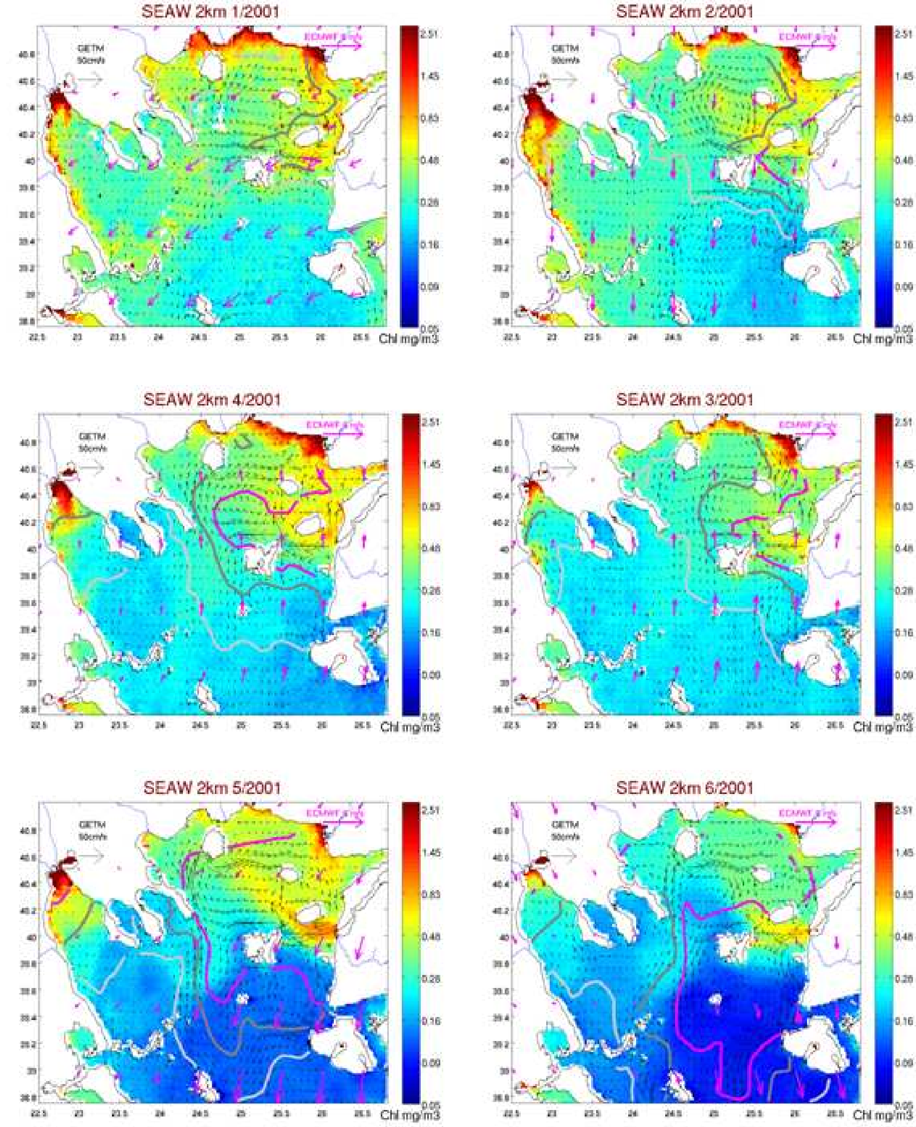
<u>Figure 3:</u> Monthly SeaWiFS-derived chlorophyll-a maps from January 2000 to December 2001 in the North Aegean Sea. The black arrows are the concurrent horizontal currents at surface from the GETM circulation model, averaged over the same period of time. The pink arrows are the corresponding ECMWF wind fields. The grey and pink isolines indicate the progression of the Dardanelles discharge at surface within the basin. The remaining panels are in following pages.



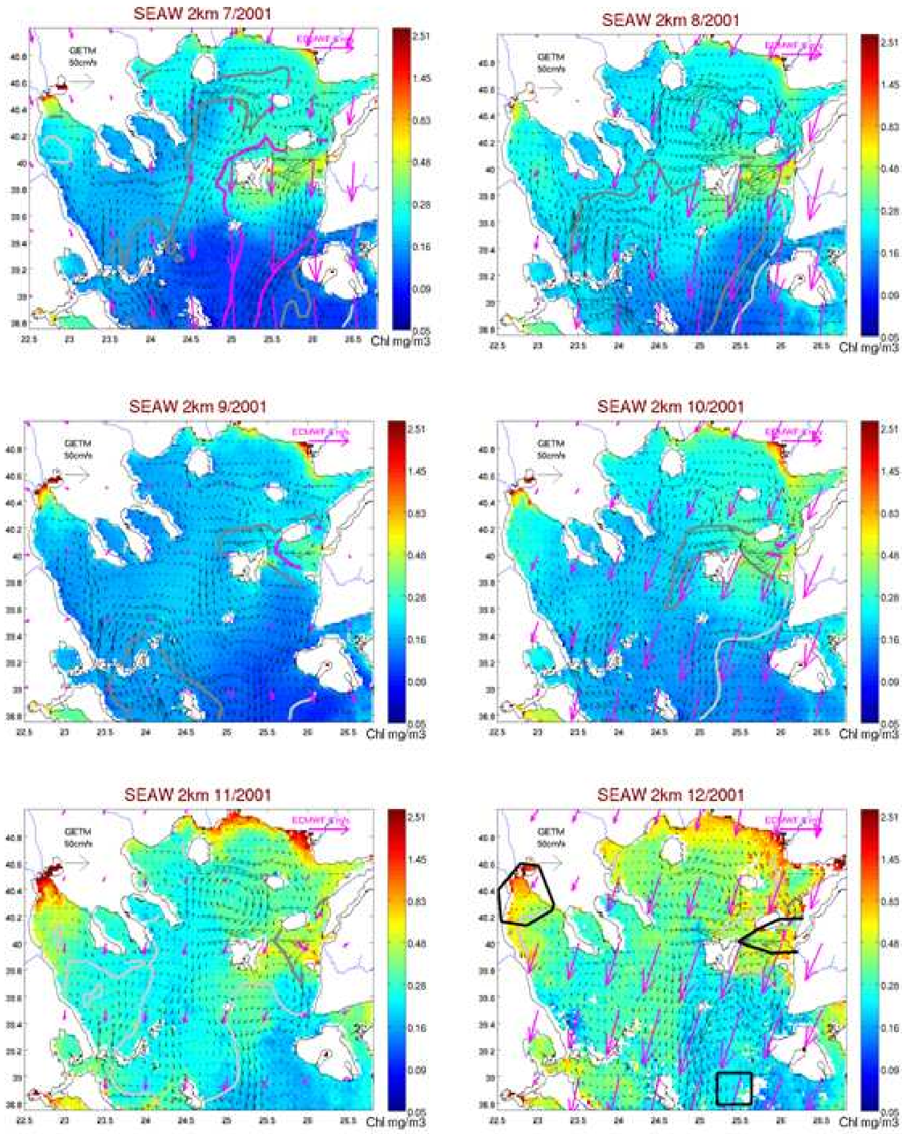
<u>Figure 3</u>: Following monthly distributions from 7/2000 to 12/2000.



<u>Figure 3</u>: Following monthly distributions from 1/2001 to 6/2001



<u>Figure 3</u>: Following monthly distributions from 7/2001 to 12/2001.



In contrast with the other two sub-domains, the west-rivers area present smaller surface currents and much weaker wind fields throughout the year (Figure 3 and Figure 4, bottom panel).

From the monthly SST distributions derived from satellite, the three sub-domains present an analogous SST seasonality. The middle panel in Figure 4 reveals that the west-rivers area reaches warmest temperatures at surface in summer than the Dardanelles sub-domain. The south-area monthly temperatures indicate a narrower range of variation of SST values offshore.

Regarding pigments distribution, the west-rivers sub-domain shows the highest concentrations of Chl. The lowest concentrations correspond to the south sub-basin, which is mainly oligotrophic throughout the years (Figure 3 and Figure 4, top panel). According to the satellite-derived Chl distributions, the main seasonal bloom generally occurs in spring for the three areas, with eventual secondary blooms in fall-winter. The monthly values of Chl for the south sub-basin remain very low in general. With different ranges of variation for the three sub-basins, the top panel in Figure 4 indicates the presence of a strong interannual variability in pigments concentrations from October 1997 to December 2006.

In Garcia-Gorriz and Stips (2006b), we examined and assessed the descriptive capability of the Fasham90 model coupled to the physical model to simulate biogeochemical regimes with different occurrence times in the Alboran Sea and the Gulf of Lions. We obtained a good agreement in bloom/no-bloom timing and Chl concentrations between model results and satellite-derived observations from 1997 to 2003. In the present study, the three sub-domains in the North Aegean Sea mainly differ in occurrence (or not) of close nutrient-rich inputs, origin of these nutrient inputs, and wind regime throughout the year. We validate the coupled model results with the concurrent chlorophyll-a distributions derived from available satellite observations from 1997 to 2006.

Figure 5 displays the phytoplankton concentration resulting computed with the coupled model from October 1997 to December 2006 for the three sub-domains in the North Aegean Sea. We obtain that, for the Dardanelles and south sub-domain, there is a general good agreement of the model results with the satellite-derived Chl observations both in bloom timing and interannual variation. For those two areas, the bloom maximums are in general concurrent to the maximum rivers discharge time, which is displayed periodically in Figure 5 (thin and dashed vertical lines), even in the area of direct interaction of the Dardanelles discharge. There are some secondary blooms that are concurrent to the Dardanelles maximum inflow input (thick and dashed vertical lines). Furthermore, the bloom timing and magnitude can be correlated with the magnitude and timing of the maximum wind-stress over those areas which might be considered as one of the main bloom drivers (Figure 5, top and bottom panels).

In contrast, the west-rivers sub-domain presents a non-easy correlation between the bloom timing and magnitude from satellite-derived observations and wind-stress fields. The winds are generally low throughout the year over that area. In fact, the timing and magnitude of the bloom maximum is very variable both seasonally and interannually. The monthly sequence of the phytoplankton concentrations in the middle panel of Figure 5 is noise-like and it is not simulated with the coupled model. The discharges of the rivers in the west sub-domain may be controlling the phytoplankton concentration in the area. Those discharges from 1997 to 2006 might have suffered variations of anthropogenic origin, with different nutrient-rich riverine discharges year after year. Those year-dependent input values might have caused the noise-like pattern of the phytoplankton concentration sequence in that period of time.

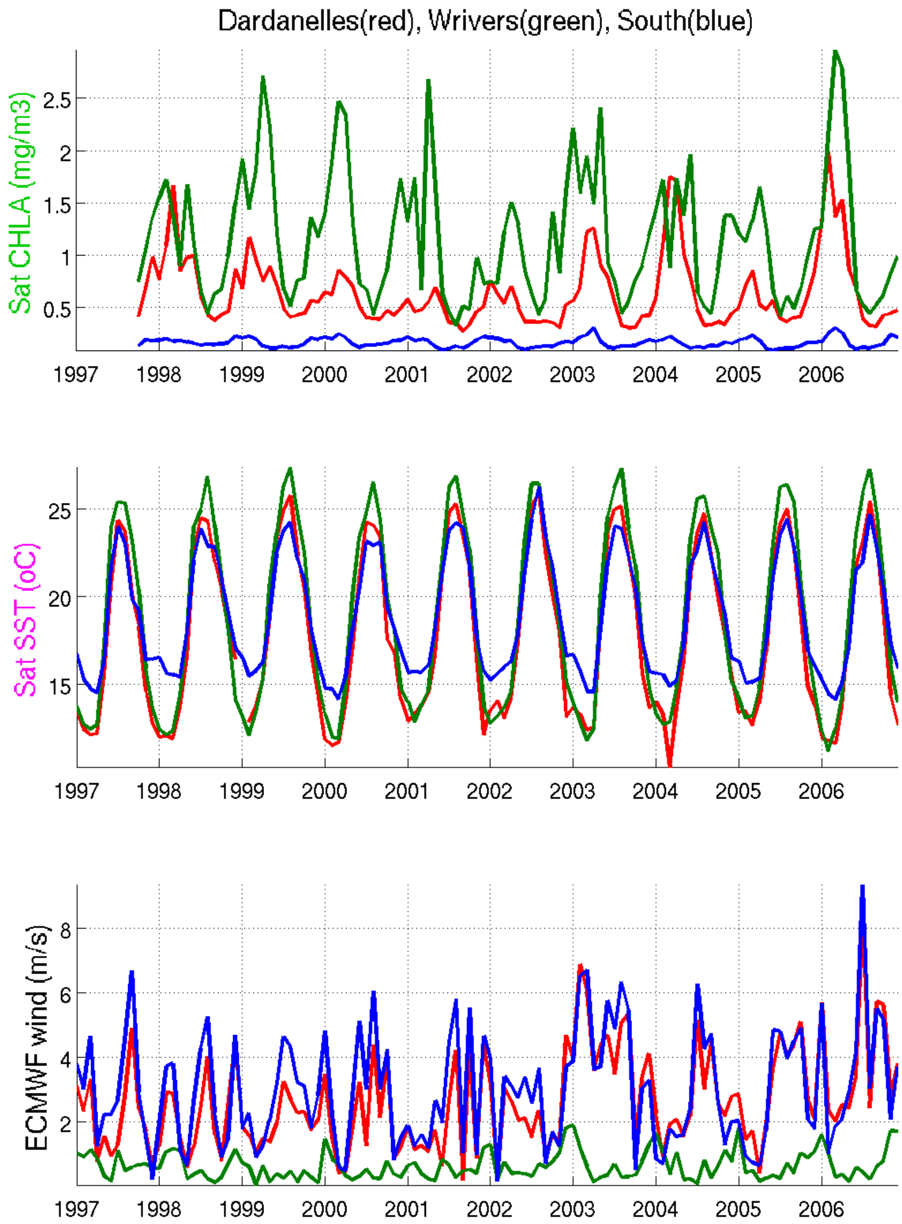


Figure 4: <u>Top panel</u>: satellite-derived monthly values of Chl averaged for the Dardanelles, west rivers and south sub-domains in the North Aegean Sea from 1997 to 2006. <u>Middle panel</u>: satellite-derived monthly SSTs for the same areas and times. <u>Bottom panel</u>: corresponding ECMWF winds.

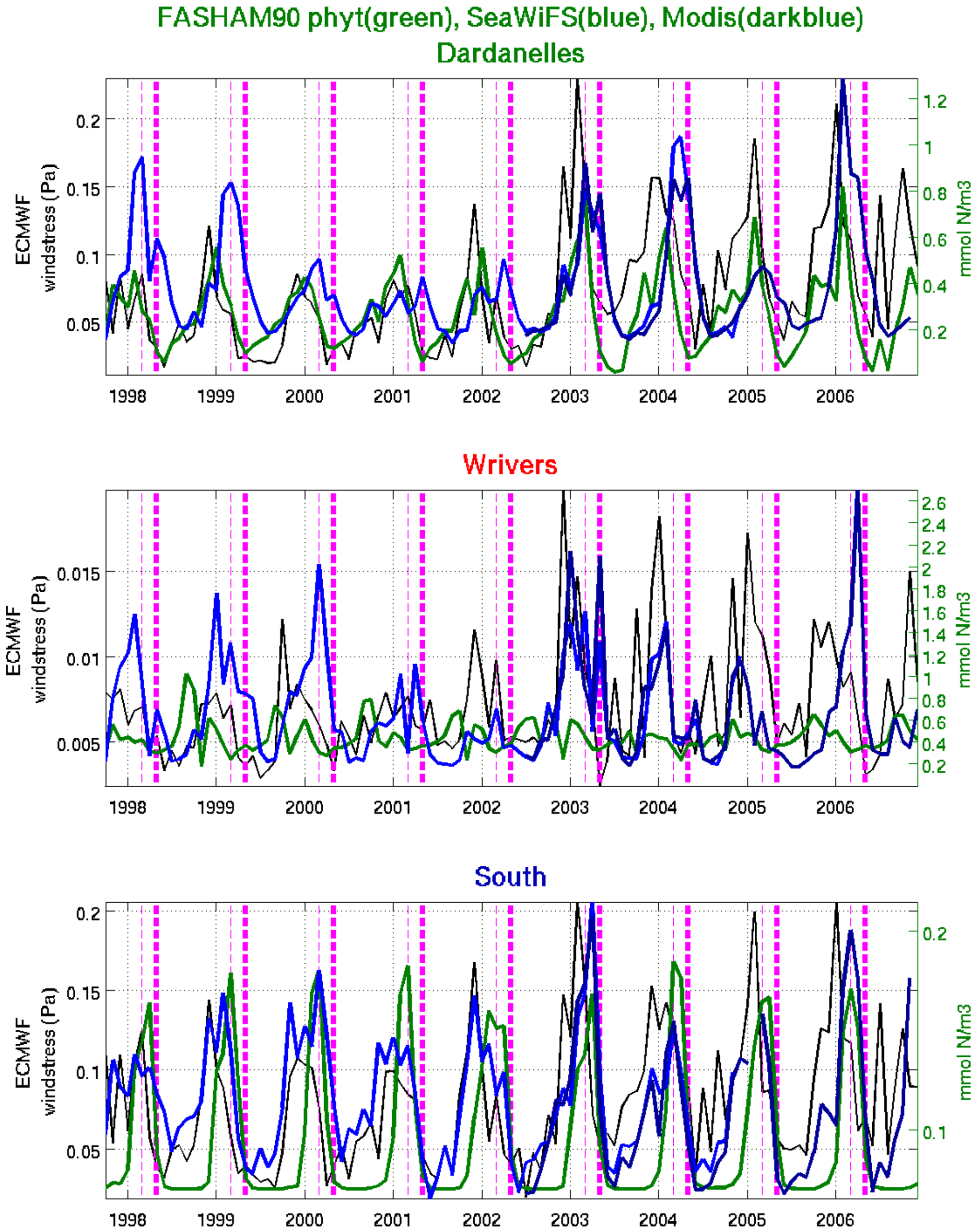


Figure 5: Multiannual monthly results of model-computed phytoplankton concentration at surface (green lines) from October 1997 to December 2006 for the Dardanelles, west-rivers and south sub-domains in the North Aegean Sea. The concurrent monthly satellite-derived phytoplankton values are in blue for both SeaWiFS and Modis. The black lines correspond to the multi-annual wind stresses from ECMWF for the same period. The thick vertical lines (dashed) in purple indicate the month of maximum discharge through Dardanelles Strait as computed

from climatological data. The thin vertical lines (dashed) in purple indicate the month of maximum discharge for the North Aegean rivers.

4. Conclusions and future work

From the comparison of the GETM model multiannual results with NASA/NOAA Pathfinder SSTs for the whole Mediterranean Sea, we obtain that including 94% of the monthly SST fields from January 1985 to December 2006, the differences between monthly averages of SST are within ±0.5^{o}C.

When the GETM velocity fields at surface overlay the phytoplankton distributions in the North Aegean Sea, the surface currents can be traced in most of the Chl distributions throughout the year. Especially, the direction seasonality of the surface currents is simulated well by the model currents in the vicinity of the Dardanelles Strait.

The multiannual runs with the coupled physical-biogeochemical model in the Dardanelles and south sub-basins predict successfully the timing of the bloom/non-bloom sequences from 1997 to 2006, as validated with SeaWiFs and Modis pigment observations. The magnitude and timing of the bloom maximum is concurrent with the timing and maximum of wind-stress over the areas. The bloom maximum is in general good agreement with the time of maximum riverine discharge in North Aegean Sea, even for the Dardanelles sub-domain. Some secondary blooms are concurrent with the maximum of Dardanelles inflow.

In contrast, the west-rivers sub-domain presents a non-easy correlation between the bloom timing and magnitude from satellite-derived observations and wind-stress fields. In fact, the timing and magnitude of the bloom maximum is very variable both seasonally and interannually. The discharges of the rivers in the west sub-domain may be controlling the phytoplankton concentration in the area. Those discharges from 1997 to 2006 might have suffered variations of anthropogenic origin, with different nutrient-rich riverine discharges year after year, than might have caused the noise-like pattern of the phytoplankton concentration sequence in that period of time. Within the frame of the integrated project SESAME we expect to get access to detailed river run-off and riverine nutrient input data, which are expected to improve specifically the simulation in the west-rivers area.

This is an ongoing work and we expect to perform numerical experiments with the coupled physical-ecosystem model systems that may include other locations and sources of nutrients in the Mediterranean Sea, including more complexity in the ecosystem model.

5. Bibliography

Burchard, H., K. Bolding,, and M. R. Villarreal (1999) ‘GOTM- a general ocean turbulence model. Theory, applications and test cases’. JRC EUR Report 18745 EN.

Burchard H. and K. Bolding (2002) ‘GETM. A general estuarine transport model. Scientific documentation’. JRC EUR Report 20253 EN.

Burchard, H., K. Bolding, W. Kuhn, A. Meister, T. Neumann, and L. Umlauf (2006) ‘Description of a flexible and extendable physical-biogeochemical model system for the water column’. Journal of Marine Systems, 61, 180-221.

Fasham, J. M. R., Ducklow, H. W., and McKelvie, S. M. (1990) ‘A nitrogen-based model of plankton dynamics in the oceanic mixed layer’. Journal of Marine Systems, 48, 591-639.

Garcia-Gorriz, E. and J. Vazquez-Cuervo (1999), ‘Ocean-atmosphere coupling in the Mediterranean Sea from TOPEX/POSEIDON, ERS1 and AVHRR data’. International Journal of Remote Sensing, 20(11), 2127-2147.

Garcia-Gorriz, E. and A. K. Stips (2006a) ‘Report on the first results from the Mediterranean Sea model’. JRC EUR Report 22141 EN.

Garcia-Gorriz, E. and A. K. Stips (2006b) ‘Physical and ecosystem model results for selected sub-basins of the Mediterranean Sea’. JRC EUR Report 22620 EN.

Neumann, T. (2000) ‘Towards a 3D-ecosystem model of the Baltic Sea’. Journal of Marine Systems, 25, 405-419.

Siokou-Frangou, I., T. Shiganova, E. D. Christou, L. Kamburska, A. Gubanova, A. Konsulov, E. Musaeva, V. Skryabin, and V. Khoroshilow (2004), 'Mesozooplankton communities in the Aegean and Black Seas: a comparative study', Marine Biology, 144, 1111-1126, doi: 10.1007/s00227-003-1277-3.

Stips, A., K. Bolding, T. Pohlmann, and H. Burchard (2004) 'Simulating the temporal and spatial dynamics of the North Sea using the new model GETM (General Estuarine Transport Model)', Ocean Dynamics, 54, 266-283.

Zervakis V. and D. Georgopoulos (2002) 'Hydrology and circulation in the North Aegean (eastern Mediterranean) through 1997 and 1998', Medit. Mar. Sci., 3.1, 5-19.

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Abstract

This study presents the results on the ongoing work of the physical-biogeochemical modeling of the Mediterranean Sea. In particular, we examine three sub-domains of the Aegean Sea (eastern Mediterranean Sea). These three areas within the North Aegean Sea present physical and biogeochemical contrasts throughout the year. The first sub-domain is close to the mouth of the Dardanelles Strait, where cold, brackish and biomass-rich waters, originally from the Black Sea, enter the Aegean Sea. The second area is located within the Thermaic Gulf (northwest Aegean Sea at the Greek coast) at the same latitude as the Dardanelles Strait but in the opposite (west) Aegean coast, where a number of rivers discharge. The third sub-domain is located offshore in an area with neither rivers nor Dardanelles direct and immediate interaction. The three areas present relatively active seasonal cycles and hydrodynamics but they display different biogeochemical seasonal regimes. We have selected them to examine the descriptive capability of the coupled physical-ecosystem model to simulate biogeochemical regimes with different occurrence times, nutrient-rich waters inputs, and wind regimes. They constitute, therefore, a suitable laboratory for comparison and validation of the coupled model results with sea surface temperatures and chlorophyll-a distributions derived from satellite observations. We use the 3-D General Estuarine Transport Model (GETM model) to simulate the hydrodynamics in the Mediterranean Sea. The results from this 3-D model force the 1-D ecosystem model that simulates the biogeochemical regimes in the selected sub-basins. We have designed and carried out multiannual simulations from January 1985 to December 2006 with a horizontal resolution of 5'x5' for the physical model, and from October 1997 to December 2006 for the coupled system. The beginning of this time window corresponds to availability of the SeaWiFS and MODIS chlorophyll-a distributions used for model validation and discussion at sea surface. This report is organized as follows: section 2 describes the methodology and the data sets examined, section 3 presents the results and discussion on their validation, and the conclusions and future work are given in section 4.

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