1. Response to the editor

We thank the editor for comments and for valuable and constructive suggestions for improving the paper.

General comments (GC)

GC1. "First, in the introduction, I missed an overview on the frequency of occurrence of such cyclones in the Black sea and current knowledge on how they modify the hydrodynamics and chla, RRS dynamics. Here only one year is investigated and I am convinced that the consideration of similar events would considerably strengthen the analysis and conclusions of the work. So my recommendation is to extend the analysis to other similar events".

Answer GC1. Thank You for this suggestion. We have extended the introduction and the discussion according to Your comments. In the Introduction we added the information of similar cyclones over the Black Sea:

"Tropical cyclones mostly are observed at low latitudes (less than 30°). However, in September 2005 the anomalous quasi-tropical atmospheric cyclone was observed over the Black Sea basin at 40°N (Fig. 1a). This cyclone has all the characteristic features of the tropical cyclones: spiral cloud bands, warm core, pronounced eye of the cyclone, and high wind velocity reaching 30 m/s (Efimov et al., 2007, 2008). Similar cyclones was documented rarely in the Mediterranean Sea (Pytharoulis et al., 1995; Homar et al., 2003), but never before over the Black Sea. Later, detailed statistics of cyclones of the basin on the base of the regional atmospheric model showed that eddies with similar intensity were detected over the Black Sea only 3 times over a 30-year period (Efimov et al., 2009). One of the unique characteristics of the cyclone in September 2005 was its quasi-stationarity. It acted on the Black Sea for more than 4 days, which lead to significant change in the state of the Black Sea ecosystem".

Also, we added figures with similar winter bloom of coccolithophores observed in the Black Sea and added information about them in the Discussion:

"Very similar blooms were observed in satellite data in 2014 and 2016 in Fig. 6. These figures demonstrate similar spatial patterns of R_{rs} extending to the east from western cyclonic gyre over the south continental slope. Our analysis shows that these blooms were also triggered by intense western storms over the western cyclonic gyre. Such storms lead to similar changes in the basin dynamics – downwelling and acceleration of the Rim Current over the south part of the basin, upwelling in the western cyclonic gyre. These illustrations show that the discussed in these paper processes may be also important in the evolution of phytoplankton bloom in other years. However, in both of these cases, R_{rs} was significantly smaller than in 2005 and usually does not exceed 0.007, compared to 0.02 in 2005. Also, such blooms in these years was observed later in winter – in December and not in October. This shows that the extremely strong tropical cyclone in 2005 was unique by its impact on the biological processes in the Black Sea because it cause exceptional bloom of coccolithophores in October with estimated cell concentrations exceeding 10 mln cells/l".

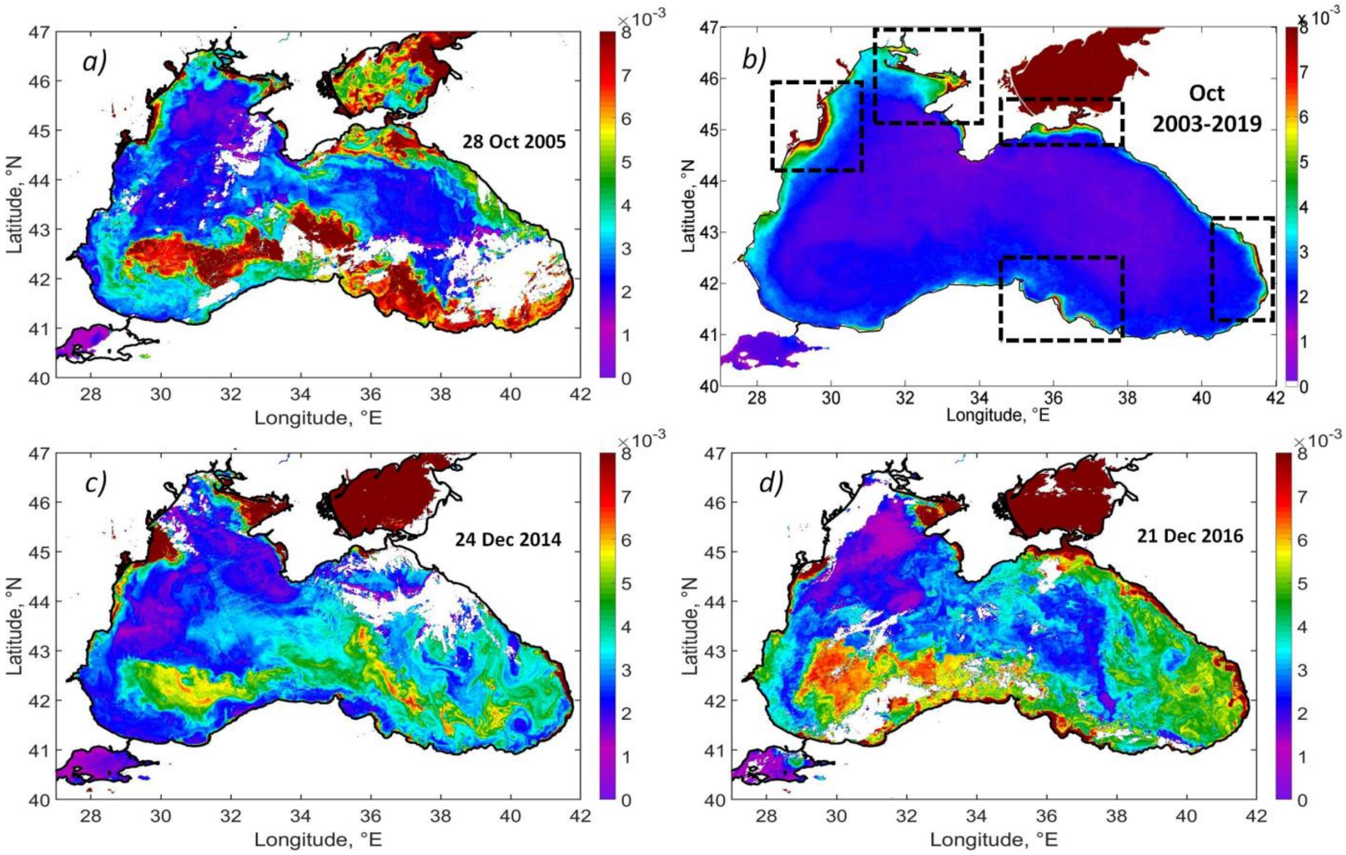

Fig. 6. a) MODIS RRS map on 28 October 2005 showing the intense coccolithophore bloom developed after the action of quasi-tropical cyclone; b) Climatic R_{rs} map for October of 2003-2019 (black rectangles show the main sources of the lithogenous articles in the Black Sea); c,d) Similar to the case of October 2005 coccolithophore blooms observed on the maps of R_{rs} on 24 December 2014 (c) and 21 December 2016 (d).

GC2. "Then, to better highlight the impact of such events I would suggest to compare the state of the system in two situations with and without cyclones (see my detailed comments below). For instance, Sur et al 1996 already evidenced the occurrence of strong coccolithophorids blooms in summer-fall due to baroclinic instabilities that are generated at the end of summer. Please demonstrate that the event induced by cyclones are really exceptional and how their impacts (on chla and RRs) are exceptional (in a quantitative manner)".

Answer GC2. Thank You for this suggestion. We added the corresponded figure and text to the revised version of the paper.

"However, the most significant impact of the cyclone was observed in the field of R_{rs}. Exceptionally high rise of R_{rs} was observed in the western cyclonic gyre and south deep part of the basin (Fig. 6a). The comparison of R_{rs} map on 28 October 2005 with the climatic-averaged map for 2003-2019 (Fig. 6a, b) demonstrates this anomalous event. In the usual year R_{rs} in the Black Sea in October does not exceed 0.001 sr^{-1}, except the area located near Danube mouth, the Kerch strait, the most coastal areas near Caucasian rivers, and shallow north-western shelf (see black rectangles in Fig. 6b). These areas are the source of lithogenous particles in the Black Sea caused by riverine or the Azov Sea inflow, resuspension of bottom sediments, and coastal erosion (see Constantin et al., 2016; Aleskerova et al., 2017, 2019).

After the action of the cyclone, we observed significantly different patterns. R_{rs} was highest not near the coast or river mouths, but in the deep western part of the basin with depths more than 1500m and in the south over the continental slope. In this area, R_{rs} reach very high values (more than 0.01 sr^{-1}), which is 10 times higher than climatic values. In this south part of the basin, there are several small rivers, but their plumes usually do not extend on more than 10 km from their mouth (Kostianoy et al., 2019). In the considered cases in Fig. 6a the width of high R_{rs} values near the south part of the basin was about 100 km and it was not located near a specific river mouth, but extended over the whole periphery of the basin.

An additional possible source of the particles in the Black Sea is deep maximum of suspended matter (Yakushev et al., 2007; Pakhomova et al., 2009; Stanev et al., 2017) which is located on the suboxic boundary in the Black Sea (100-150 m). However, the study based on Bio-Argo data (Kubryakov et al., 2019b) shows that high values of particles backscattering in the surface layers in winter usually occupy only the upper 0-50 m and are not connected to this deep maximum. In-situ data (Oztrovskii, Zatsepin, 2016) show that even during extreme events vertical mixing does not reach the suboxic interface on 100-150 m depth, which may cause the entrainment of anoxic waters to the surface layers of the basin. Therefore the observed rise of R_{rs} should have a biological origin. In the Black Sea, such a rise of R_{rs} is often observed during coccolithophores bloom (Cokacar et al., 2001). The above arguments suggest that in the presented case we observe unusual coccolithophores bloom in October in the Black Sea."

GC3. "In addition, as requested by one of the reviewers, I would appreciate that you better justify why an increase in Rrs is an indication of blooms of coccolithophores and not an increase of particles from deeper waters (e.g. the "suboxic zone") or from the shelf (as mentioned by the authors enhanced horizontal advection stimulates the transport of particles from the shelf to the southern coast)".

Answer GC3. We agree and have added the explanation to the text (Please see the answer to GC2 above).

GC4. "After reading the whole manuscript, I am still puzzled by what is exactly the impact of such storms on the phytoplankton group composition. First, you mention that such events favor blooms of coccolithophorids but at the end of the paper, it is also mentioned that diatoms are stimulated. I would appreciate a clearer justification of the mechanisms at stake that explain why this storm favors the growth of coccolithophores and not diatoms. I also note that reviewer 1 does not clearly capture the mechanisms at stake, in some parts of the text we are told that the bloom is caused by an intensified vertical mixing but later in the text lateral advection from the shelf is evoked. So I really encourage the authors to significantly improve the writing.

Answer GC4. We decided to change completely the structure of the manuscript for clarity. Particularly, we have given a description of the changes in Chl and R_{rs} in two different sections. We also improved the figures and added some new figures for clarity. Also, we rewrite the Discussion to more clearly represent the mechanisms, which may be responsible for the observed anomalous bloom of coccolithophores.

GC5. "Finally, the conclusion needs to be rewritten and more reflect the main messages from this manuscript. As it is now, it is a mixture of introduction (Lines 189-203) and results from the work and this dilutes the main messages".

Answer GC5. We agree and have rewritten the Discussion and Conclusion part of the article.

Detailed comments (DC)

DC1. "Page 2, lines 58-60: please use a dot for a scalar product and bold symbols for vectors for clarity".

Answer. Corrected.

DC2. "Please specify what is meant by "deep waters" e.g; page 4, line 81, line 96)".

Answer DC2. Thank You. We corrected the text for clarity - waters from deep layers, waters from the central part of the sea.

DC3. "Line 85: nitracline? Nitrocline is used everywhere; please correct".

Answer DC3. Corrected.

DC4. "Line 112: I guess that your description mainly relates to surface chla or at least that seen from the satellite".

Answer DC4. We agree and have added the explanation to the text: **"**It should be noted that the Danube plume and shelf waters of the Black sea correspond to turbid Case 2 waters. The determination of the Chl in Case 2 waters is a difficult task and it is likely overestimated mainly due to the presence of CDOM. At the same time, they can be successfully used as a tracer of plume waters (Sur et al., 1994, 1996; Kubryakov et al., 2018)".

DC5. "Legend figure 2: I would say "8-day averaged maps". It would be worth to compare with maps obtained for other years during which there is no cyclone (a climatological average)".

Answer DC5. Corrected.

DC6. "Section 3.1: A figure illustrating how this (these?) tropical cyclones modify the Black Sea hydrodynamics (e.g. SST, Rim Current velocity, SSH, Ekman pumping) compared to climatological situation would be greatly helpful".

Answer DC6. We agree and have added such a figure to the revised version of the manuscript (see below). This figure clearly demonstrates the intensification of cyclonic gyres, strong downwelling in the coastal areas, and exceptional acceleration of the Rim current from 20-30 to 60-75 cm/s.

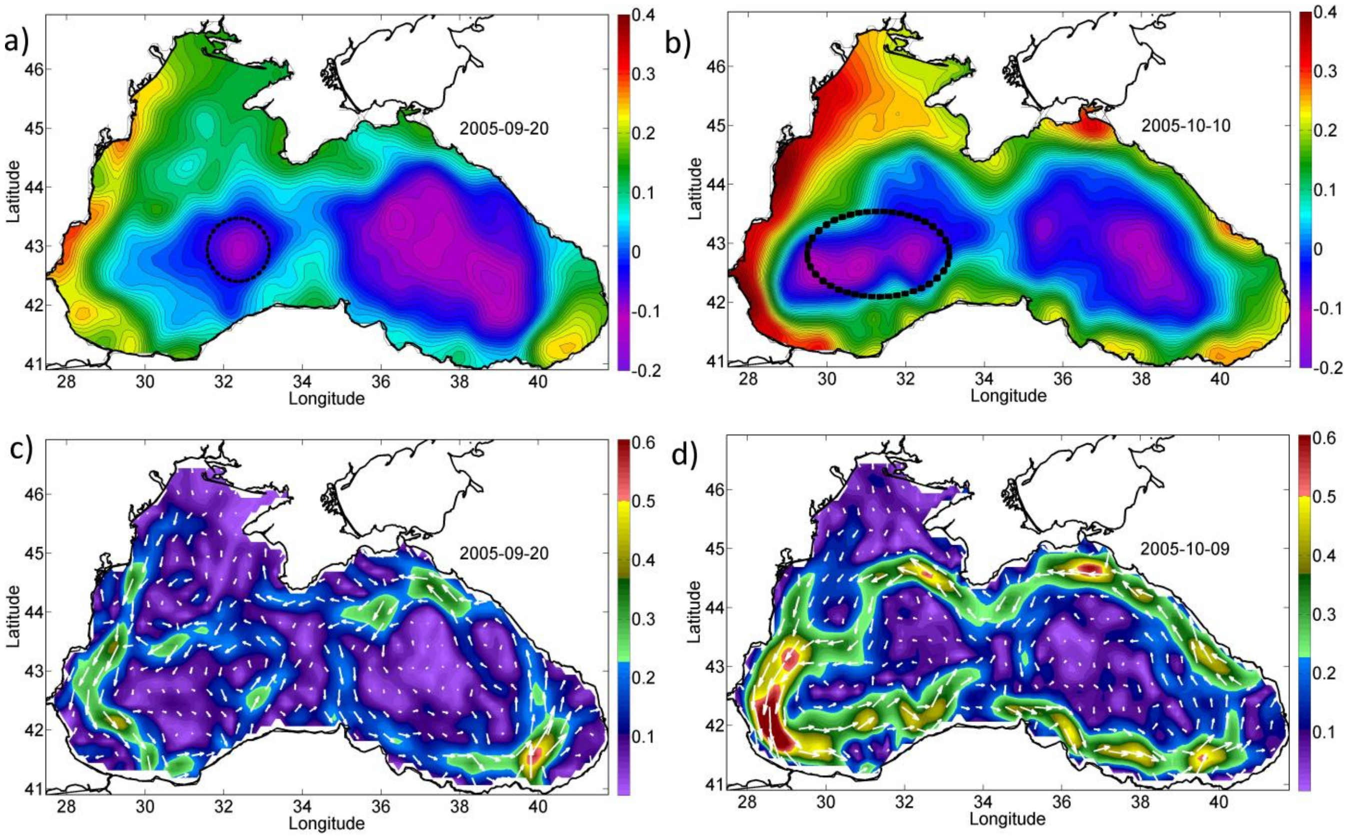

Figure 2. Altimetry-derived map of sea level and geostrophic velocity before (a, c) and after (b, d) the action of the cyclone. Sea level (m) at: *a* – September 20, 2005, *b* – October 10, 2005; Geostrophic velocity (m/s) at : *c* – September 20, 2005, *d* – October 9, 2005. Black circles show the position of the western cyclonic gyre.

DC7. "Section 3.2: Same remark as above: a figure highlighting how tropical cyclones modify the Chla dynamics and RRs compared to climatology would be needed here to convince the reader. For instance, you may add to Figure 3, the climatological average and show as in Figure 2 the spatial pattern in a climatological year".

Answer DC7. Thank You for this suggestion. We added the corresponded figure and text to the revised version of the paper. Please, see the answer on general comment GC2.

DC8. “Lines isobaths and not isobates”.
Answer DC8. Corrected.

DC9. “Line 179: deepening of the nitracline”.
Answer DC8. Corrected.

DC10. “Line 208: a reference is needed after: “..promoting the favorable condition for the coccolithophores bloom”. Why an exec of phosphorus will favor coccolithophores compared to other phytoplankton species?”.

Answer DC10. We have extended and completely rewritten the discussion part in the revised version of the manuscript. We also added several other hypotheses of the reasons for the observed coccolithophores bloom.

DC11. “Lines 205-206: please explain how satellite date can show the development of the two types of phytoplankton blooms simultaneously (i.e. diatoms and coccolithophores). This does not appear in the results neither n the methodology”.

Answer DC11. We excluded this phrase from the text. Instead, we underline that after this anomalous quasi-tropical cyclone the intense coccolithophores bloom developed, which was also accompanied by the rise of Chl.

DC12. “Line 213: Please check the referencing throughout the manuscript: Kubryakov, Zatsepin et al., 2019 should be Kubryakov et al., 2019. You can use ‘a” and “b” if you have two similar references”.

Answer DC8. Corrected.

2. Response to the reviewer #1

We would like to thank the reviewer for comments and for valuable and constructive suggestions for improving the paper.

General comment

"The study is devoted to a very important issue – the response of phytoplankton to meteorological forcing. It is usually very difficult to assess this impact via field observations. The presented study, in which the blooms of diatoms and coccolithophores were traced at the same time after the strong exposure to wind, is a new valuable insight into such processes. The observed sequence of diatom-coccolithophore blooms is also a fairly new knowledge, which was reported for a few places in the oceans, including the Black Sea. At the same time, this is important because it can clarify one of the main causes of coccolithophore blooms – changes in the chemical environment. Of course, coccolithophores are extremely important from the point of view of the global carbon cycle, since these algae export to bottom the largest amount of carbon in paper organic form. Based on these considerations I want to see this paper published in the Biogeoscience".

1. "The structure is illogical. First, the diatom bloom began, but first the figures and text first describes the coccolithophore bloom. The Results already contain a lot of discussion. Because of this, the ultra-small Dissuasion is 1 page. It would be more logical to combine both sections into one "Results and Discussion" section".

Answer. According to Your comment, we decided to change the structure of the manuscript. Particularly, in the revised manuscript we have given the description of the changes in Chl and Rrs in two different sections. We have also improved the figures and added some new figures for clarity. Also, we have rewritten the Discussion to more clearly represent the mechanisms, which may be responsible for the observed anomalous bloom.

2. "The text contains many typos and negligences (see my comment in the text). English needs to be carefully edited".

Answer. Thank You for the detailed comments. We carefully corrected all typos in the text.

3. "The presentation of the material is good. The main problem is commenting on the results and explanations. They are completely unconvincing".

Answer. We have significantly improved the explanations given in the paper. We have also improved the figures and added some new figures for clarity. Please, see the answers given below.

Comment #1

130 "The reason for the initial increase in Rrs values was not vertical, but horizontal advection. . . This flow was well traced in Chl maps (Fig. 4a, b, c)"

This statement was not supported by any evidence. Moreover, from all possible explanations, it seems less realistic.

The distance from the Danube river mouth to the south-western corner of the sea where the Chl bloom began is approximately 500 km along the coast. Fig 4b shows bloom start 4 days (or less) after the cyclone end simultaneously along the 500 km Anatolian coast. Taking the Rim Current velocity (0.3 m/s – 25 km hour) we can understand that these river waters can reach the nearest place of bloom in 20 days, and therefore cannot be the reason for this. In addition, it is obvious that within a 20-day period all ultrahigh nutrients will be consumed by phytoplankton (the graph in Fig. 3 shows well that after 2 weeks such blooms disappear on the surface).

Answer. As it is seen in Fig. 4a (in the paper) and stated on page 5: "At the beginning of September 2005, an area of high Chl (>3 mg/m^3) associated with the spread of a plume of Danube was observed near the western coast to the north of 42°N (28°E) (Fig. 4a)". At that time the south border of the plume (defined here as Chl>3 mg/m^3) was already on 300 km south of the Danube mouth. We marked the plume area by the red rectangle in Fig. 7a.

Further up to 4 October 2005, i.e. one month after the eastern border of the plume displaced in cyclonic direction to the point 34°E (marked as the black arrow in Fig. 4b). This means that in 20 days the plume border moved on about 420 km, which is in good agreement with Your estimates, so there is no contradiction.

To highlight this process we also added a zoomed figure showing a daily MODIS map of Chl on 5 October 2005 (Fig. 5a), where the zone of high Chl extending in the cyclonic direction from the north-western shelf is clearly seen.

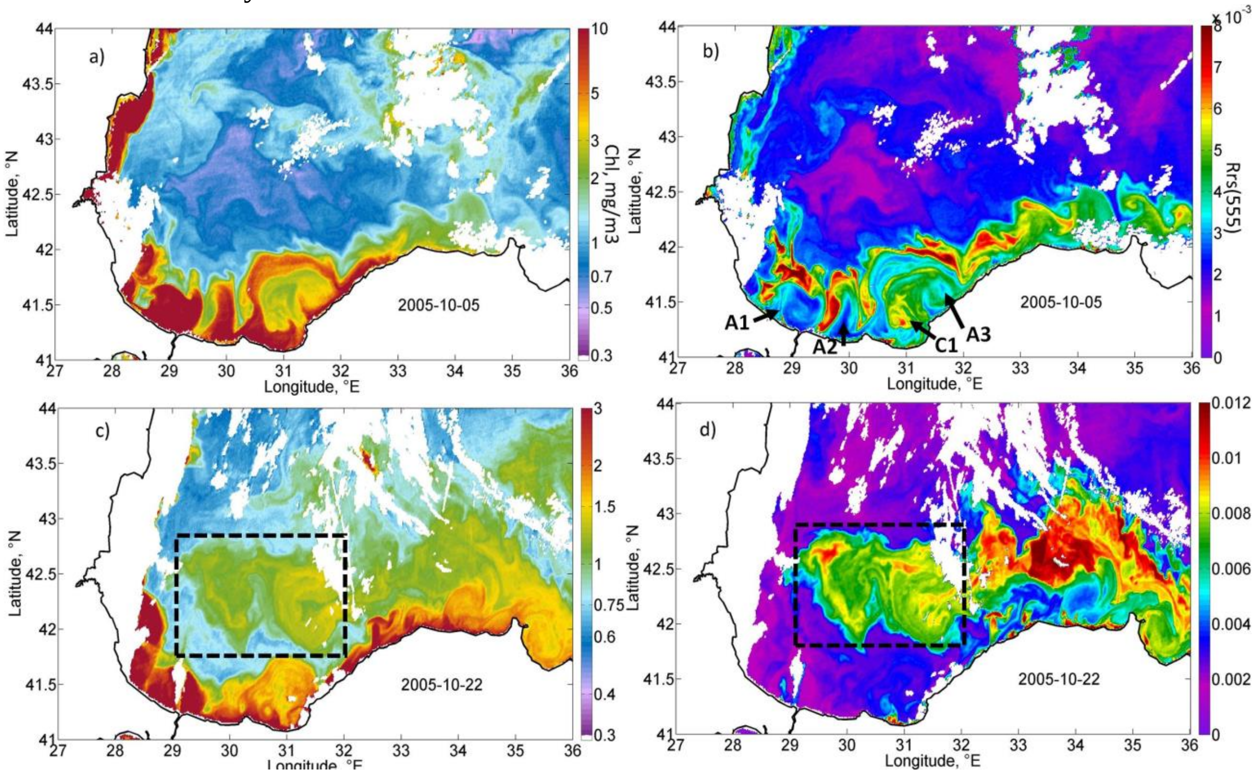

Figure 5. Zoomed daily MODIS maps demonstrating two stages of coccolithophores bloom development: a, b) MODIS daily map of Chl **(a)** and RRS (b) on 5 October 2005 demonstrating the initial rise of RRS on the offshore periphery of the Danube plume; c, d) MODIS daily map of Chl **(c)** and RRS (d) on 22 October 2005 demonstrating the strong rise of RRS in the central-western gyre of the Black Sea (black dashed circles).

An important fact is that before the action of the cyclone the Rim Current was weak (please, see the Fig. 2c). The Ekman pumping caused strong onshore Ekman transport and importantly downwelling in the coastal areas, which increased the sea level gradients over the continental slope and intensified the velocity of the Rim Current up to anomalous values of 0.75 m/s (Fig. 2d, 3). Taking into account the additional impact of strong-wind driven currents on surface transport, which may be estimated as $k_{wd} \cdot V_{wind} = 0.03 \cdot 15 = 0.45$ m/s the total velocity will be more than 1 m/s which is more than enough to cause the observed displacement of the plume (k_{wd} – wind drift coefficient, V_{wind} – wind velocity).

The impact of the Rim Current on the transport of Danube waters in the southern part of the sea was shown in several previous studies (see Oszoy, Unluata, 1997; Yankovsky et al., 2004; Kubryakov et al., 2018).

Comment #2

From Fig.4 it also is not follows that the high Chl from the west coast (panel a) was shifted to the east (panel b). This is just the authors' assumptions. It is strange that earlier they showed how the cyclone involved the nutrient-rich deep water to the sea surface and now they say that it is not the reason for bloom. The same mixing processes most probably entrained deep nutrients into the mixed layer on the western and south shelfs, causing an Chl increase. The most obvious explanation for the bloom in the western center is the growth of phytoplankton. At least, it is proved by uplifted deep water (Fig. 1).

Answer. We do not state that Chl from the west coast shifted to the east. We write that "Immediately after the action of an atmospheric cyclone in late September, Chl increased significantly throughout the western part of the sea and on 4 October Chl reached its maximum values (1.3 mg/m^3) in the western central part of the basin (green line in Fig. 3). This fast rise of the Chl in the zone of the cyclone action was partly caused by the entrainment of phytoplankton from the layer of its subsurface maximum". We marked this zone of fast increase of Chl in the north and central-western part of the sea by a red ellipse in Fig. 4b. Further on the next 8-daily map (Fig. 4c) Chl in this zone decreased to the background values. This bloom can be related both to the entrainment of Chl from the subsurface maximum and also the growth of phytoplankton, which rapidly ended on 12 October.

Another feature well-seen in the Chl maps after the cyclone is the transport of the Danube plume waters in the cyclonic direction (see black arrow in Fig. 4b). The intense Rim Current accelerated after the cyclone action and transported the plume water along the sea coast from the south-western part to the south-central coast (marked as the black arrow in Fig. 4b). On 5 October (Fig. 4b) the zone with high Chl (>3 mg/m^3) reaches 34°E. At this time this zone looks like a band with about 50 km width extending from the Danube mouth in the cyclonic direction. This zone is well seen in Fig. 5a.

We have added a more detailed explanation to this part of the text in the paper.

Comment #3

145 "Part of the turbid Danube waters during this period moved across the isobates and penetrated a considerable distance into the central part of the sea (Fig. 2c, 4c)". Again, no evidence for such a claim. The authors look at the green color in the center of the sea, which joins the shelf waters, and concludes that it came from the shelf. Why are they sure that this is not the growth of phytoplankton in the western center after the action of the cyclone?

Answer. The zone of the intense horizontal mixing is marked by the red dashed rectangle in Fig. 4c.The observed difference between the Chl map in Fig. 4b, c shows that near the coast (in the area of the red dashed rectangle) Chl decreased, while to the north increased. This evidence about the dilution of the plume due to its horizontal mixing with offshore waters with relatively low values of Chl (Chl<0.75 mg/m^3). Significant intensification of the Rim Current in the southwest Black Sea up to extreme values of 0.75 m/s causes its baroclinic instability related to strong horizontal shear. The offshore boundary of the front of turbid waters was characterized by several mesoscale features – eddies and filaments, well-seen on the zoomed image in Fig. 5a), which intensifies the horizontal exchange in this part of the basin. As a result, on 12 October 2005, the area of the high Chl values in the south eastern part of the sea significantly widens and reaches a width of 100-150 km (see red dashed rectangle in Fig. 4c).

Another evidence, which is more important to the goal of the paper is that the maximum R_{rs} indicating coccolithophore bloom in Fig. 5a was situated not in the area of maximum upwelling, but to the south of it in the area of downwelling. Such inconsistency can not be described by the impact of cyclone-induced vertical upwelling and also supports the importance of horizontal exchange. To highlight this effect we added a Fig. 5b of daily R_{rs} map on 5 October 2005. In this figure, it is seen that the maximum R_{rs} was observed in the thin zone on the offshore periphery of the plume, which evidence about the importance of frontal mixing on the plume periphery on the growth of coccolithophores.

However, thank You for the comments. We agree that another probable reason for the initial growth of coccolithophores is vertical motions caused by submesoscale instabilities in the frontal zone. We have added this suggestion n to the text: "Detailed daily map of R_{rs} for 5 October 2005 (Fig. 5b) shows that the maximum R_{rs} was observed in the thin zone on the offshore periphery of the Danube plume. At the same time near the coast and in the western central part in the epicenter of cyclone action R_{rs} rise was absent. This frontal zone is a subject of the intense horizontal mixing between brackish nutrient-rich plume waters and saline waters of the central part, which may be one of the possible triggers of coccolithophore bloom. High R_{rs} values were located mainly in the frontal instabilities formed on the boundary of the plume, possibly due to the impact of strong horizontal shear on the periphery of the intensified Rim Current. Mixing between plume and saline waters can significantly intensify buoyancy gradients, which possibly cause the rise of baroclinic submesoscale instabilities observed in Fig. 5a, 5b. Submesoscale motions can induce very strong vertical velocities reaching more than 10-100 cm/s (McWilliams, 2016), which can provide upward nutrient fluxes for coccolithophores. For example, we can observe a strong rise of R_{rs} on the periphery of anticyclones A1 and A2 (Fig. 5b), where vertical velocities are probably directed upward. At the same time in the center of anticyclones, where vertical motions are downward R_{rs} is low. Another prominent feature in Fig. 5b is the mushroom structure consist of cyclone C1 and anticyclone A3. The cyclonic part of this structure have significantly higher R_{rs} than its anticyclonic part. These observations suggest the important impact of submesoscale vertical fluxes on the initial rise of R_{rs}. Analysis of MODIS daily maps shows that in this area from 5 to 7 October of 2005 R_{rs} valued almost doubled. We note that R_{rs} was lower near the coast, which indicates that its rise was not related to the terrigenous particles caused by river discharge or storm-driven coastal erosion".

Comment #4

170 At the velocity of 0.45 m s-1 (Fig. 1e), the particles will be transported on 1000 km in 3 weeks, which coincides well with satellite optical measurements (Fig. 2) The Fig.1f (not 1e) shows that the velocity of 0.45 m s-1 is the maximal on some areas along the western coast. 0.4 m s-1 will be a very optimistic estimate of the average current velocity. In this case 1 month is needed to distribute a bloom to the eastern part. Simultaneously, fig 2c shows that bloom occupy the eastern part of Turkish shelf after 10 days after bloom 600 km eastward. Plus, fig 2c demonstrates that from approximately (because the 8-day centering) from 10 to 30 October occupy the same area, without any shifting. It is even approximately not look like as a spot of high concentration moving among poor waters in eastward direction. Moreover, the spots of high concentration are stable and only slightly shifting to the east. For example, spot of bloom at 33 longitude moved to 34 longitude, which is much more seems to be truth. Such pattern points on local slope upwelling which was intensified under action of cyclone and Rim Current activation. In any case, the explanation, that the current bears the bloom to the east is not supported by presented material.

Answer. As it is shown in Fig. 7b the initial bloom was started on the whole south coast of the western part of the Black Sea in longitudes 30-37°E, which corresponds to the zone of the plume mixing seen in Fig. 5a. Further, the eastern boundary of the bloom moves in the cyclonic direction due to its advection by the Rim Current. To underline this displacement we mark this boundary with a black arrow in Fig. 7. The east border of the bloom move from 36°E in Fig. 7b, to 38°E in Fig. 7c, then to 42°E in Fig. 7d. This gives a velocity of the transport 150 km/8 days=0.2 m/s and 300 km/8 days. This well agrees with Your estimates of the Rim Current velocity given on the base of Fig. 1f. We should note that altimetry-derived velocities are somewhat underestimated, especially near the coast due to the mapping procedure (Fu, Cazenave, 2001). That is why, both satellite altimetry and optical data confirm the displacement of the bloom to the east caused by the Rim current We extended the explanation in the text.

At the same time, we note that the western border of the bloom did not move and was located in western cyclonic gyre exactly in the zone of the maximum upwelling (see answer below).

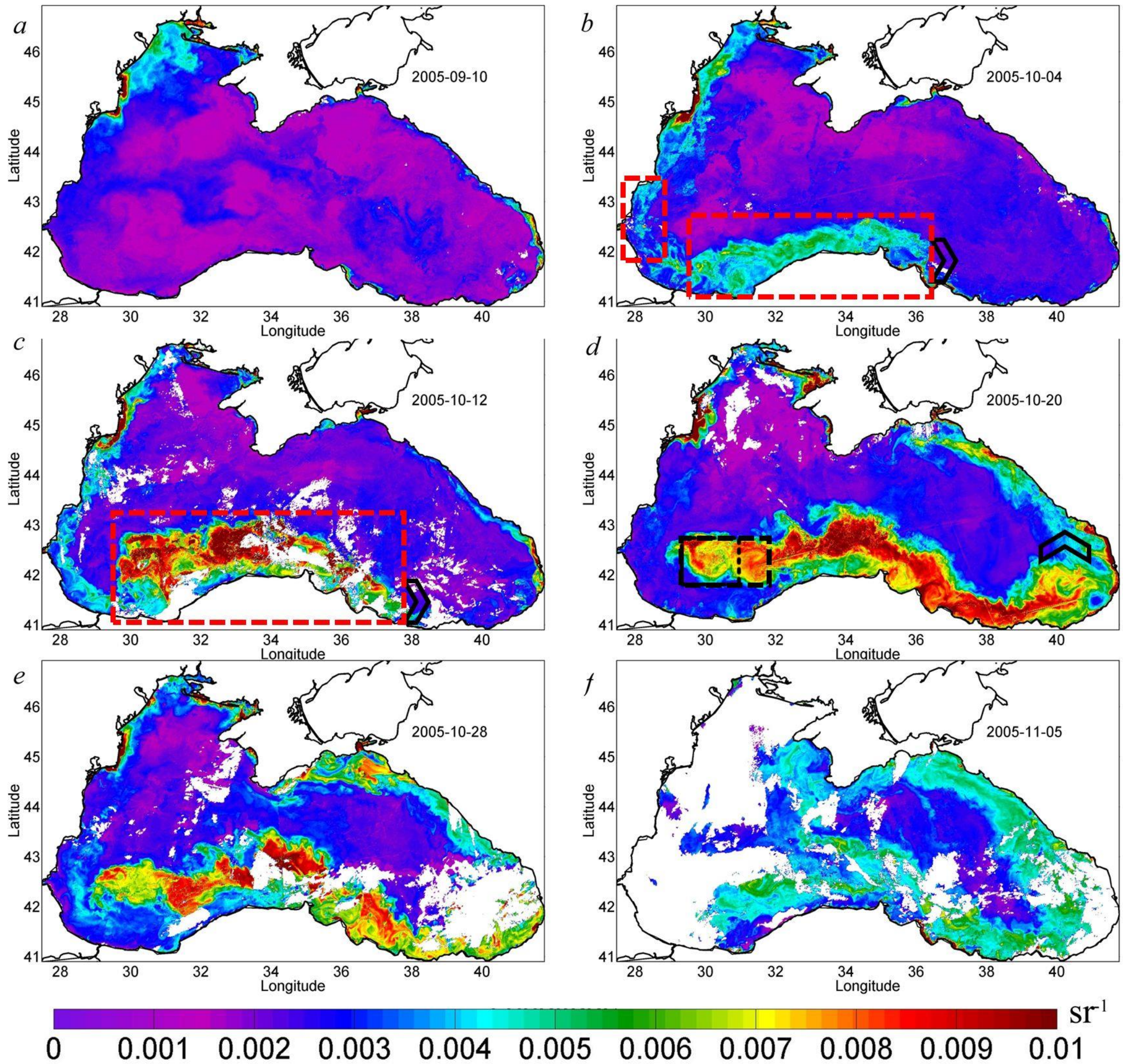

Figure 7: 8-day maps of remote sensing reflectance R_{rs}, sr^{-1}, centered at **(a)** 10 September 2005; **(b)** 4 October 2005 the red rectangle shows the area of the initial start of the bloom; **(c)** 12 October 2005, the red rectangle shows a mixing area; **(d)** 20 October 2005, the black rectangle shows the center of the deep bloom in the western cyclonic gyre **(e)** 28 October 2005, **(f)** – 5 November 2005. The black arrow shows the position of the eastern boundary of the bloom.

Comment #5

175 "The upwelling in the center of the west cyclonic gyre was a permanent source of nutrients and phytoplankton growth, from which the bloom stretched to the eastern shore "What drives this constant source of nutrients? Pure guess!

Answer. This statement is supported by the fact that the western border of the bloom (Fig. 7d, black dashed rectangle) did not move and was located exactly in the zone of the maximum upwelling, despite its eastern part moved in a cyclonic direction with the Rim Current (see comment above). This shows that the western part of the bloom with a shape well corresponded to the upwelling area was quasi-stationary, despite the Rim Current constantly transported coccolithophores from it to the east. If this source was not permanent, the process of advection would cause a decrease of R_{rs} in the west cyclonic gyre (advection cause losses of coccolithophores in this local zone). Therefore, there should be some process that causes the gain of coccolithophores compensating these losses. The position of this spot of bloom coincides with the area of maximal entrainment. So, the most probable source of this gain is the vertical transport of nutrients, which is maximal in the zone of upwelling in the west cyclonic gyre. The prolonged action of upwelling can be related to, first, the delay between the action of Ekman pumping and upwelling and, second, the time needed for the relaxation of the upwelling after the wind action. We added a more detailed explanation in the text of the paper.

So two evidences are supporting this hypothesis:

1) The stability of the bloom in the western cyclonic gyre over more than 3 weeks despite intense cyclonic currents;

2) The coincidence of this stable bloom with the area of maximal cooling.

Comment #6

And how does this coincide with the statement that “The reason for the initial increase in Rrs was not vertical, but horizontal advection”?

Answer. There were two stages of the bloom. The initial growth of coccolithophores in the south coastal part was triggered by the mixing of the Danube plume with open sea waters. To underline this process we added a Fig. 5 showing the initial rise of R_{rs} growth. Such a mixing may the intense grow of coccolithophores due to several reasons: (1) rise of stratification caused by the overflow of brackish waters on saline waters; (2) vertical fluxes of nutrients caused by baroclinic submesoscale instabilities; (3) penetration of nutrient from brackish plume waters in the deep saline part of the basin, which can cause the growth of coccolithophores preferring more saline waters (see Brand, 1984).

Further, the bloom started in the center of the western cyclonic gyre due to vertical entrainment of nutrients and its maximum displaced offshore from the coast (see Fig. 7c).

To highlight these stages we extend the Discussion part in the revised version of the manuscript.

Additional questions in the text

#7

“What is Rim Current explanation (in abstract)?”

Answer. We have expanded the explanation of “the Rim Current” in the text.

#8

“types” for phytoplankton means the particular systematic information, like “genera”, ‘families’, etc. If you don’t mean this, use term “group”

Answer. Thank You, corrected.

#9

“no such references in the list”

Answer. The reference was incorrect – changed on (Kubryakov, et al., 2019).

#10

line 54: “Who and where compared these two approaches?”

Answer. We exclude this part in the revised version of the manuscript.

#11

Line 98: Why is this phrase here?

Answer. It is here to highlight that the shallowness of the Black Sea nitrocline. We have corrected this part of the text for clarity. Nitroclyne in the Black Sea is relatively shallow and its upper border is located at the depth of 40-50 m (Konovalov and Murray, 2001; Turgul et l., 2015). The upwelling and mixing during such a strong vorticity in the Black Sea may cause significant entrainment of the nutrients in the upper layers, and occasionally trigger intense blooms of phytoplankton in the warm period of a year (Kubryakov et al., 2019).

#12

line 115: “Fig. 3 shows that until 30 October the increase of Chl was very gradual. Therefore, during the wind-induced mixing from 25 to 29 Oct NO "fast" increase was observed, and hence, only small, not significant, addition of Chl from deep chlorophyll maximum can be expected. The fast growth started immediatelly after cyclone and was provided by phytoplankton division”.

Answer. The fast increase of Chl to the values of more than 1.3 mg/m^3 was observed in the northern and western deep part of the basin after the cyclone action on 4 October. We marked this zone as a red ellipse in Fig. 4b for clarity. Further on 12 October Chl in this part declined again to 0.6 mg/m^3 (Fig. 4c).

#13

line 135: Why maximum?

Answer. It is a misprint. Should be “area of coccolithophore bloom”. Corrected. Thank You.

3. Response to the reviewer #2

"There are quite a few studies on the changes of phytoplankton caused by tropical cyclone. The innovation of this research is the coccolith bloom induced by the tropical cyclone, which will be very interesting to the readers. I went through the paper and I have the following main questions".

Comment #1

"The change of phytoplankton in the article is shown in Figure 4, which looks not consistent to Figure 2 (representing coccolith). The authors believe that the change of the Rrs555 represents the change of coccolith. But in my opinion, the change of Rrs555 may also be caused by non-algae particles. I didn't see how the authors excluded the high Rrs555 in the high value area (southern area) in Figure 2 because it was caused by non-algae particles. I also didn't see the detailed explanation on the spatial and temporal difference of phytoplankton and coccoliths".

Answer. We agree that the rise of $R_{rs}(555)$ can be caused by both non-algae particles and coccoliths. However, as it has been shown in many previous investigations rapid increase of R_{rs} values in deep regions is mainly caused by the scattering on coccoliths during the coccolithophore bloom (Holligan et al., 1983; Balch et al., 1996; Cokacar et al., 2001, 2004; Kopelevich et al., 2014). Particularly $R_{rs}(555)$ was used to study the coccolithophore blooms in the Black Sea (Cokacar et al., 2001, 2004). Several authors also show previously that the bloom can occupy both coastal and deep areas of the Black Sea (Kopelevich et al., 2014; Mikaelyan et al., 2011, 2015).

The non-algae particles are mainly of terrigenous origin and are mainly related to the river discharge, coastal erosion, and resuspension of bottom sediments. To highlight the impact of these sources on the R_{rs} in the Black Sea and underline the biological origin of R_{rs} discussed in the paper we have added the comparison of R_{rs} map on 28 October 2005 with the climatic-averaged map for 2003-2019 (Fig. 6a, b). In the usual year R_{rs} in the Black Sea in October does not exceed 0.001 sr^{-1}, except the area located near Danube mouth, the Kerch strait, the most coastal areas near Caucasian rivers, and shallow north-western shelf (see black rectangles in Fig. 6b). These areas are the source of lithogenous particles in the Black Sea caused by riverine or the Azov Sea inflow, resuspension of bottom sediments, and coastal erosion (see Constantine et al., 2016; Aleskerova et al., 2018, 2020).

After the action of the cyclone, we observed significantly different patterns. R_{rs} was highest not near the coast or river mouths, but in the deep western part of the basin with depths more than 1500 m and the south over the continental slope. In this area, R_{rs} reach very high values (more than 0.01 sr^{-1}), which is 10 times higher than climatic values. In this south part of the basin, there are several small rivers, but their plumes usually do not extend on more than 10 km from their mouth (Kostianoy et al., 2019). In the considered cases in Fig. 6a the width of high R_{rs} values near the south part of the basin was about 100 km and it was not located near a specific river mouth, but extended over the whole periphery of the basin.

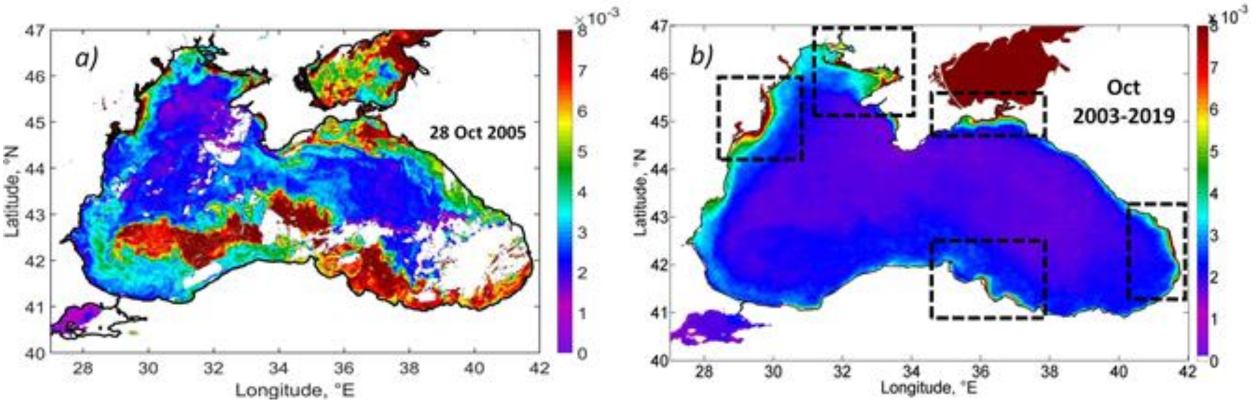

Fig. 6. a) MODIS R_{rs} map on 28 October 2005 showing the intense coccolithophore bloom developed after the action of quasi-tropical cyclone; b) Climatic R_{rs} map for October of 2003-2019 (black rectangles show the main sources of the lithogenous articles in the Black Sea).

Another source of non-algae particle is coastal erosion or resuspension of bottom sediments in the shallow shelf areas. In this case, R_{rs} should be the largest near the coast and decrease offshore. However, as we show in Fig. 5 below in the zoomed daily image for 5 October 2005 the rise of R_{rs} was observed not near the coast but on the offshore periphery of the Danube plume with high values of Chl. At this location of the Black Sea, the continental slope is very steep and depths are already more than 500 m, so bottom resuspension can not take place. This also evidence about the biological origin of the observed patterns of $R_{rs}(555)$. We have added this figure and extended the description in the text for clarity.

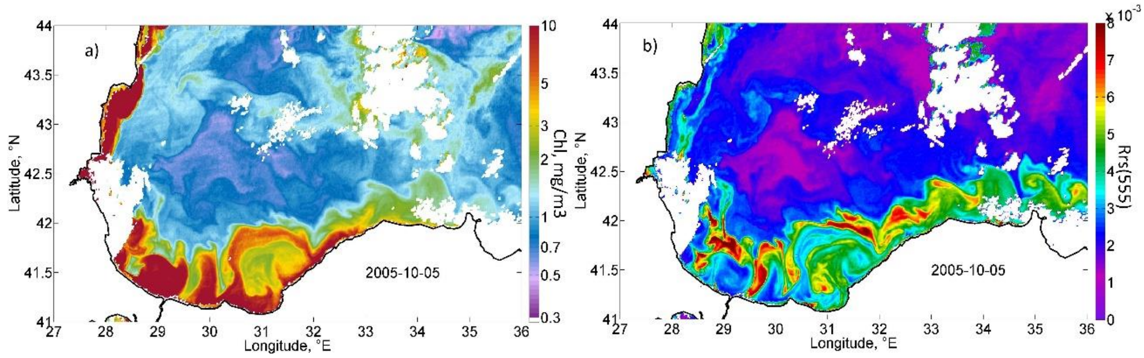

Fig. 5. MODIS daily map of Chl **(a)** and R_{rs} **(b)** for 5 October 2005 illustrating the initial growth of coccolithophores on the front of the rich in Chl plume waters.

An additional possible source of the particles in the Black Sea is a deep maximum of suspended matter (Yakushev et al., 2007; Pakhomova et al., 2009; Stanev et al., 2017) which is located on the suboxic boundary in the Black Sea (100-150 m). However, the study based on Bio-Argo data (Kubryakov, Mikaelyan, et al., 2019; Kubryakova et al., 2020) shows that high values of particles backscattering in the surface layers in winter usually occupy only the upper 0-50 m and are not connected to this deep maximum. This also corresponds to the estimates of the mixing depth during the action of the cyclone (40-50 m) based on SST data. Historical data analysis shows that vertical mixing unlikely may reach the suboxic interface on 100-150 m depth, which may cause the entrainment of anoxic waters to the surface layers of the basin. Therefore the observed rise of R_{rs} should have a biological origin. of bottom sediments and coastal erosion (see Constantine et al., 2016; Aleskerova et al., 2018, 2020).

In the revised version of the manuscript, we have also separated the description of the changes of Chl and R_{rs} to underline their differences.

Comment #2

The author believes that this quasi-tropical cyclone caused coccolith to increase for 1.5 months. How long did this quasi-tropical cyclone last in the Black Sea area?

Answer. The quasi-tropical cyclone has been acting for four days from 25-29 September, but its impact was observed for more than 1.5 months. We added this information to the text. Such prolonged action of the cyclone was probably related to the huge amount of nutrients, which were entrained in the upper layer during the cyclone. Similar long-lasted bloom of non-calcified algae after the cyclones were documented in several previous studies (*e.g. Babin, S. M., Carton, J. A., Dickey, T. D., & Wiggert, J. D. 2004. Satellite evidence of hurricane-induced phytoplankton blooms in an oceanic desert. Journal of Geophysical Research: Oceans, 109(C3). https://doi.org/10.1029/2003JC001938)* and in a recent study in the Black Sea (*Kubryakov, A. A., Zatsepin, A. G., & Stanichny, S. V. 2019. Anomalous summer-autumn phytoplankton bloom in 2015 in the Black Sea caused by several strong wind events. Journal of Marine Systems, 194, 11-24. https://doi.org/10.1016/j.jmarsys.2019.02.004*).

Comment #3

The MODIS true-color composite picture in Figure 1 was on September 27. The temperature, wind field, and Ekman velocity were also within two days of the typhoon. But why should Sea level and flow velocity be on October 10 and 9? Why not choose sea level or flow velocity on a certain day at the end of September? If the authors want to use flow velocity to show that current transfers nutrients and phytoplankton to the east. The author should add the average flow rate during this period, but not a certain day.

Answer. We agree with this comment. We added to the manuscript the figure of the sea level and geostrophic currents before and after the cyclone, which demonstrates the dynamic changes caused by the cyclone (see Fig. 2). We also added a graph of time variability of the Rim Current velocity during the study period (see Fig. 3 below). From this graph, it is seen that the maximum current velocity was observed on 5-10 October.

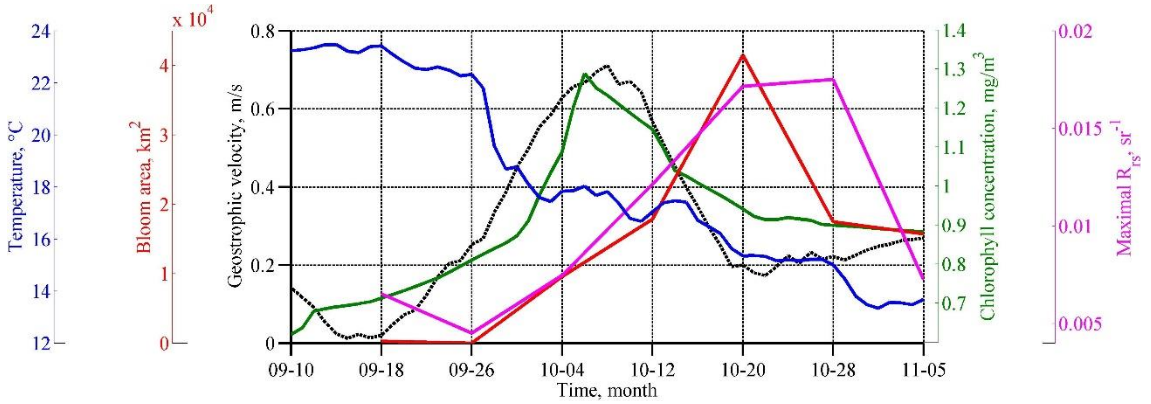

Fig. 3. Time variability of SST (blue line), R_{rs} (purple), Chl (green) averaged in the center of the western cyclonic cycle; area of coccolithophore bloom (red); geostrophic velocity over the south continental slope (black), m/s

The currents response on the rise of the wind curl in the Black Sea is delayed, as it is shown (Grayek et al., 2010; Kubryakov et al., 2016). This delay is related to the mechanism of the intensification of the Black Sea geostrophic circulation. Wind curl cause induces the onshore Ekman transport to the coast of the Black Sea. This transport further causes an increase in sea level and downwelling near the coast. Rising gradients drive the Black Sea cyclonic geostrophic circulation. The time needed for the sea level and currents to adjust to the changes in the wind curl is estimated on the base of altimetry data in several previous studies as about 1-2 weeks (Grayek et al., 2010; Kubryakov et al., 2016).

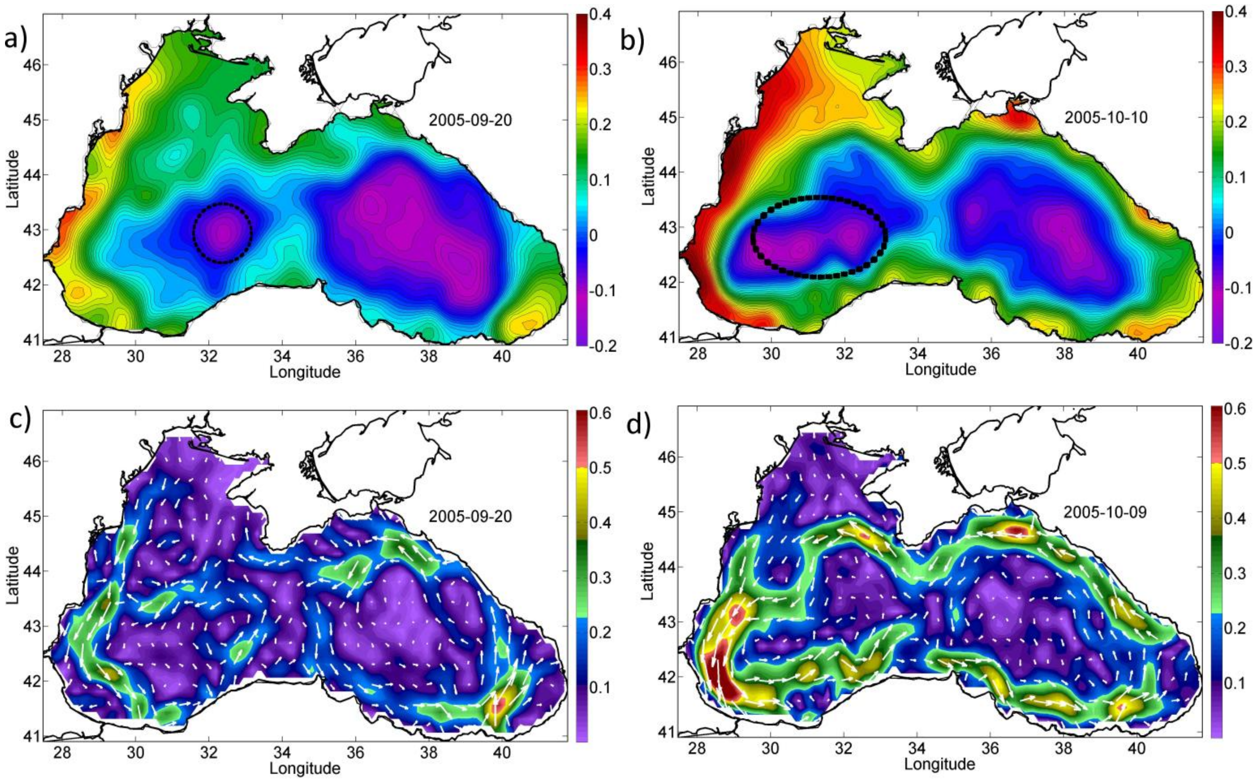

Figure 2. Altimetry-derived map of sea level and geostrophic velocity before (a, c) and after (b, d) the action of the cyclone. Sea level (m) at: *a* – September 20, 2005, *b* – October 10, 2005; Geostrophic velocity (m/s) at : *c* – September 20, 2005, *d* – October 9, 2005. Black circles show the position of the western cyclonic gyre.

Grayek, S., Stanev, E. V., & Kandilarov, R. (2010). On the response of Black Sea level to external forcing: altimeter data and numerical modelling. Ocean dynamics, 60(1), 123-140.

Kubryakov, A. A., Stanichny, S. V., Zatsepin, A. G., & Kremenetskiy, V. V. (2016). Long-term variations of the Black Sea dynamics and their impact on the marine ecosystem. *Journal of Marine Systems*, *163*, 80-94.

Comment #4

In Figure 4, the author chooses the images on September 10th, October 4th, why not September 18th and September 26th? What is the principle for the authors choosing the image?

Answer. This primary reason is the large amount of cloudiness, which obstructs the optical measurements in 15-30 September, and particularly, during the action of the cyclone. We have chosen these maps, as they were obtained in the most uncloudy conditions. This allows us to observe the whole basin before and after the cyclone, which helps to highlight the observed changes in the optical properties of the Black Sea.