Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-165-AC2, 2020

Interactive comment on "Quasi-tropical cyclone caused anomalous autumn coccolithophore bloom in the Black Sea" *by* Sergey V. Stanichny et al.

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Received and published: 8 August 2020

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 coccolith.

Answer #1. We agree that the rise of Rrs(555) can be caused by both non-algae particles and coccoliths. However, as it has been shown in many previous investigations rapid increase of Rrs values in deep regions is mainly caused by the scattering on coccoliths during the coccolithophore bloom (Hooligan et al., 1983; Balch et al., 1996; Cokacar et al., 2001, 2004; Kopelevich et al., 2014). Particularly Rrs(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 related to the river discharge. Particularly, in the Black Sea, one of the main sources of suspended matter is the large discharge of Danube. At the Fig. 2a, b (in the paper) we can see the local rise of the Rrs near Danube caused probably by the intensification of its discharge. However, suspended matter coming with the riverine waters sink very rapidly (Constantine et al., 2017) and this area is not connected to the significantly larger zone of the bloom situated in the southern Black Sea (Fig. 2 in the paper). At the same time from Fig. 4a, b (in the paper) it is well seen that the riverine waters brought a vast amount of organic matter and increased significantly satellite-derived Chl in the whole western part of the basin, where Rrs was low.

Another source of non-algae particle is coastal erosion or resuspension of bottom sediments in the shallow shelf areas. In this case, Rrs should be the largest near the coast and decrease offshore. However, as we show in Fig. R1 below in the zoomed image for 5 October 2005 the rise of Rrs was observed not near the coast but on the offshore periphery of the high in Chl shelf waters. 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 Rrs(555). We will add this figure to the revised version of the paper.

There are two main difference in the distribution of Chl and Rrs: (1) – a large amount of Chl in the shelf waters affected by river discharge in the western and southwestern part of the sea; (2) – the rapid rise of Chl in the northwestern part of the sea right after the storm on 4 October 2005, which was absent in Rrs signal. We highlight these differences in the paper at lines 110-140 and will extend the description in the revised version of the manuscript.

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 #2. The quasi-tropical cyclone has been acting for three days from 25-29 September, but its impact was observed for more than 1.5 months. 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 hurricaneâĂŘinduced phytoplankton blooms in an oceanic desert. Journal of Geophysical Research: Oceans, 109(C3)) 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).

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 #3. We agree with this comment and have added a graph of time variability of the Rim Current velocity during the study period (see Fig. R2 below). From this graph, it is seen that the maximum current velocity was observed on 5-10 October.

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). That is why we show the map after about ten days from the action of the cyclone. We will extend the description in the text and add the graph of time variability of the velocity of the geostrophic current in the article.

We will add to the manuscript the figure of the sea level and currents before and after the cyclone, which demonstrates the dynamic changes caused by the cyclone (see Fig. R3).

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 #4. This is caused, primarily, by the large amount of cloudiness, which obstructs the optical measurements in 15-30 September, particularly, during the action of the cyclone. We have chosen these maps, as they were obtained in the most uncloudy conditions and allow us to observe the whole basin before and after the cyclone, to highlight the observed changes in the Black Sea.

Please also note the supplement to this comment:
https://bg.copernicus.org/preprints/bg-2020-165/bg-2020-165-AC2-supplement.pdf

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Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-165, 2020.

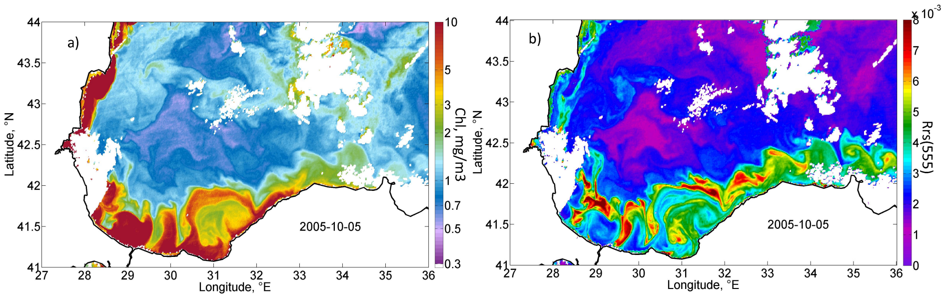

Fig. 1. R1. MODIS daily map of Chl (a) and Rrs (b) for 5 October 2005 illustrating the initial growth of coccolithophores on the front of the rich in Chl plume waters

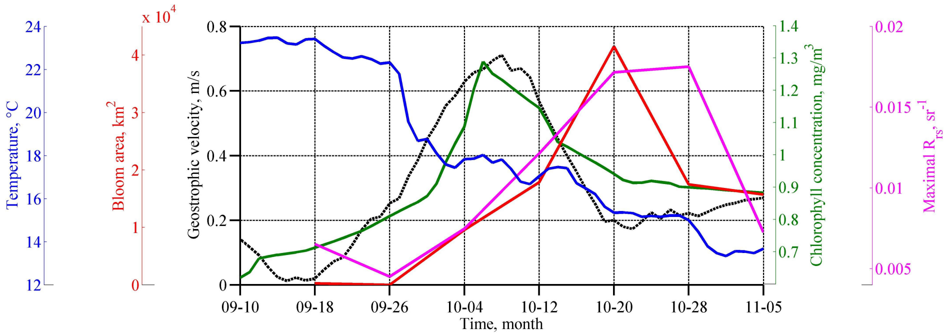

Fig. 2. R2. Average variability of SST (blue line), Rrs (purple), Chl (green) in the center of the western cyclonic cycle area of coccolithophore bloom (red) in the sea, geostrophic velocity, m/s

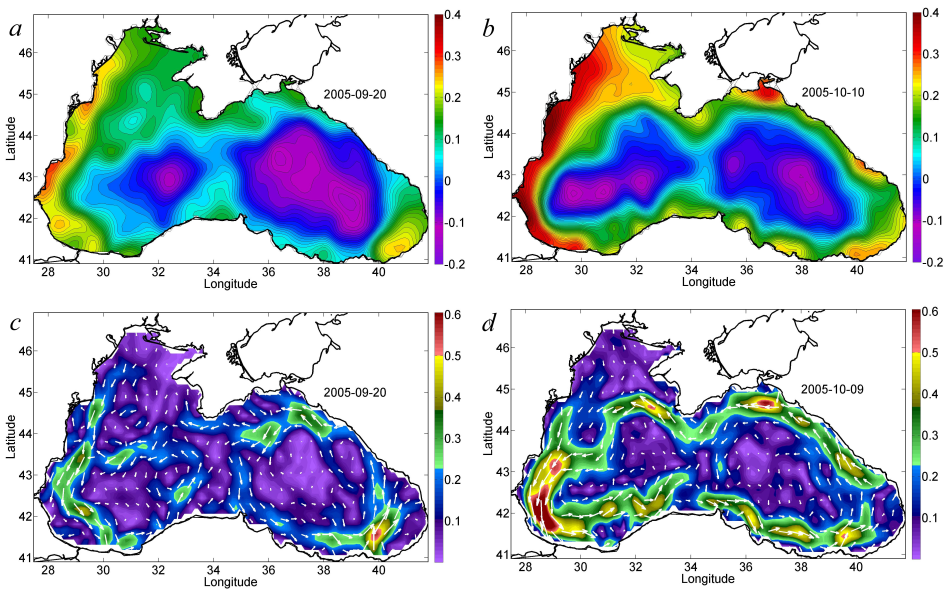

Fig. 3. R3. Attinetry-derived sea level, m: Đř – 20 September 2005, b – 10 October 2005; geostrophic current, m/s: c – 20 September 2005, d – 9 October 2005