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Impacts of cyclones on the phytoplankton chlorophyll and sea surface temperature spatial and temporal dynamics in the Barents Sea as revealed from space

Anastasiia Fedorova (1,2), Evgeny Morozov (2), Dmitry Kondrik (2), Andrey Rubchenia (1), and Dmitry Pozdnyakov (2)

(1) Saint Petersburg State University, St.Petersburg, Russia, (2) Nansen International Environmental and Remote Sensing Centre, St. Petersburg, Russia

A pilot satellite-based investigation of the modulations exerted upon mixed-layer phytoplankton fields by cyclones is performed for the first time across the northern hemisphere polar region, viz. the Barents Sea. Resorting to a synergetic approach, polar cyclones were first identified from NCEP/NCAR data for the summer time period (April - August) during 2003-2012, and their propagation throughout the Barents Sea were further traced down. The above water wind force was retrieved from QuickSCAT data. These data were further accompanied by ocean color data from SeaWiFS and MODIS(Terra and Aqua) to examine the spatial and temporal distributions of surficial phytoplankton chlorophyll (chl) concentration dynamics along the trajectory of the cyclone's footprint across the sea and sea surface temperature data (obtained from MODIS) were retrieved for the same areas. The cyclone's parameters, bathymetric features and cloud conditions were used to underpin and to further understanding of the actual processes unfolding along the cyclone track.

During the above time period, nearly 70 cyclones passed across the Barents Sea throughout the vegetation period (April- August). Only cyclones (slightly more than 22) passing the sea in less than 3 days, and providing enough cloud-free conditions along the track were further analyzed to detect the cyclone-driven sea surface chl concentration and temperature (SST) space- and time modulations. The chl and SST were collected 5 days prior to the cyclone arrival to the Barents Sea, and then during 5 days following the moment of dissipation of cloud cover over the cyclone's footprint.

Several principal cases were identified in the data thus obtained: the cyclone passage resulted in 1. chl and SST decrease right after the cyclone passage that further switched to their increase on the fourth-eighth day of the cyclone leaving the area of observation, 2. chl and SST increase immediately (on the second day) of the cyclone displacement from the area 3. no recordable changes in SST and chl.

Importantly, the increases in chl concentration were observed not only during the periods of high biological activity of the phytoplankton in the Barents Sea (mid-May- June and mid-August) but even during the periods of low productivity (April-early May and July-late August).

Our analyses of the temporal and spatial modulations of chl and SST fields indicate that they are related to a wealth of factors, first and foremost, the cyclone parameters (baric deepness, wind speed above the water surface, the translation speed), the Atlantic water circulation pathways across the sea, the bottom relief, and cloudiness conditions. The causal mechanisms of the revealed SST and chl modulations have thus been identified for each specific case, and the entire phenomenon general regularities were established.

On balance, the cases of cycle-driven increase in chl proved to be prevalent and thus our findings imply that with the ongoing amplification of climate warming at high northern latitudes, the increase in chlorophyll discussed above is potentially capable of boosting the primary productivity in the Arctic Ocean.