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The efficiency of E. huxleyi blooms in dissolved CO_2 and particulate inorganic carbon production in the northern hemisphere: a 1998-2016 satellite study

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Blooms of a coccolithophore E. huxleyi are known to (i) release in the ambient water inorganic carbon in the form of calcite scales/coccoliths, and (ii) production of CO_2 that causes lessening of the atmospheric CO_2 flux into the ocean. Both processes are highly consequential in terms of atmospheric and oceanic chemistry, and eventually can affect the state of climate and aquatic ecology. Being generally huge, E. huxleyi blooms are a challenge for shipborne studies, and prone to investigations by means of satellite remote sensing. We used Ocean Colour Satellite time series data for a 19-year period (1998-2016) to quantify both the CO_2 partial pressure increase (ΔpCO_2) and inorganic carbon content (PIC) within E. huxleyi blooms in the North, Norwegian, Greenland, Barents, and Bering Seas. To do that, we developed special retrieval algorithms based on extensive databases of both in situ determinations and climatology. We also utilized OCO_2 data (2014-present) to retrieve the concentration of atmospheric columnar CO_2 over E. huxleyi blooms and immediately beyond them.
We found that E. huxleyi outbursts in the North Atlantic and Arctic Seas occur annually, but their extent vary interannually. In the Bering Sea, during 1998-2001 there was a splash in blooming activity followed by a drastic drop. The bloom duration in the Bering Sea in 1997/98-2001 reached 10 months, in the North Atlantic seas it was $\sim$ 1 month. The maximum inorganic carbon content in E. huxleyi blooms in all seas varied over the 19 years between $\sim$ 15 and 70 Kt. When normalized to pCO_2 in the absence of bloom, the mean and maximum ΔpCO_2 values within the bloom areas varied in percent between 21.0 – 43.3 and 31.6 - 62.5, respectively. Processing OCO_2 spaceborne data on columnar pCO_2, revealed appreciable changes in atmospheric columnar CO_2 over E. huxleyi blooms in the target seas and documented a reversion of CO_2 flux from ocean to atmosphere. The reversion flux was found to be sea and year specific as being conditioned by the both the bloom extent, and concentration of E. huxleyi cells. For instance in the Barents Sea on 13.08.2015 the CO_2 concentration in the atmospheric column over the E. huxleyi bloom increased by ca 4 ppm with regard to the adjacent bloom-free area. As huge outbursts of E. huxleyi also occur in the southern hemisphere, such blooms unfold in the world oceans across the entire year. Our data can serve as a baseline for assessing the importance of the phenomenon for climatology, marine chemistry and ecology on a global scale.