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On extreme atmospheric and marine nitrogen fluxes and chlorophyll-a levels in the Kattegat Strait

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Abstract. A retrospective analysis is carried out to investigate the importance of the vertical fluxes of nitrogen to the marine sea surface layer in which high chlorophyll a levels may cause blooms of harmful algae and subsequent turn over and oxygen depletion at the bottom of the sea. Typically nitrogen is the limiting factor for phytoplankton in the Kattegat Strait during summer periods (May to August) and the major nitrogen inputs come from the atmosphere and deep-water entrainment. The extreme reoccurrence values of nitrogen from atmospheric wet and dry deposition and deep-water flux entrainments are calculated by the periodic maximum method and the results are successfully compared to a map of chlorophyll return periods based on in-situ observations. The one-year return of extreme atmospheric wet deposition is around 60 mg N m^{-2} day^{-1} and 30 mg N m^{-2} day^{-1} for deep-water entrainment. Atmospheric nitrogen dry deposition is insignificant in the context of algal blooms. At longer time-scales e.g. at 10-year return, the nitrogen deep-water entrainment is larger than the extreme of atmospheric wet deposition. This indicates that the pool of nitrogen released from the sea bottom by deep-water entrainment forced by high winds greatly exceeds the atmospheric pool of nitrogen washed out by precipitation. At the frontal zone of the Kattegat Strait and Skagerrak, the nitrogen deep-water entrainment is very high and this explains the high 10-year return chlorophyll level at 8 mg m^{-3} in the Kattegat Strait. In the southern part, the extreme chlorophyll level is only 4 mg m^{-3} according to the statistics of a multi-year time-series of water samples. The chlorophyll level varies greatly in time and space as documented by a series of SeaWiFS satellite maps (OC4*v*4 algorithm) of chlorophyll ScanFish and buoy observations from an experimental period in the Kattegat Strait. It is recommended to sample in-situ chlorophyll observation collocated in time to the satellite overpasses of e.g. SeaWiFS and ENVISAT MERIS to ensure improved mapping of the chlorophyll levels in the Danish waters.

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