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A state-of-the-art parameterization of atmospheric nutrient deposition fluxes in the global ocean

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Atmospheric deposition of trace constituents of natural and anthropogenic origin act as a nutrient source into the open ocean, affecting the marine ecosystem functioning and subsequently the exchange of CO_2 between the atmosphere and the global ocean. Among other species that are deposited into the open ocean, nitrogen (N), iron (Fe), and phosphorus (P) are considered as highly significant nutrients that can limit marine phytoplankton growth and thus directly impact on ocean carbon fluxes in the ocean, particularly where the nutrient availability is the limiting factor for productivity. For this work, we take into account the up-to-date understanding of the effects of air quality on the atmospheric aerosol cycles to investigate the potential ocean biogeochemistry perturbations via the atmospheric input with the European Community Earth System Model EC-Earth (http://www.ec-earth.org/), which is jointly developed by several European institutes. In more detail, state-of-the-art N, Fe, and P atmospheric deposition fields are coupled to the embedded marine biogeochemistry model and the response of oceanic biogeochemistry to natural and anthropogenic atmospheric aerosols deposition changes is demonstrated and quantified. Model calculations show that compared to the present day, the preindustrial atmospheric deposition fluxes are calculated lower (~1.7, ~1.5, and ~1.4 times for N, Fe, and P, respectively) corresponding to a respective lower marine primary production. On the other hand, future changes in air pollutants under the RCP8.5 scenario result in a modest decrease of the bioaccessible nutrients input into the global ocean (~ -15%, ~ -16% and ~ -22% for N, Fe and P, respectively) and overall to a slightly lower projected export production compared to present day. Although the impact of atmospheric processing on atmospheric inputs to the ocean results in a relatively weak response in total global-scale simulated marine productivity estimates, strong regional changes up to 40-60% are calculated in the subtropical gyres. Overall, this study indicates that both the atmospheric processing and the speciation of the atmospheric nutrients deposited in the ocean should be considered in detail in carbon-cycling studies, since they may significantly affect the marine ecosystems and thus the current estimates of the carbon cycle feedbacks to climate.

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