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Trans-Boundary Transport of Nutrients in the North Sea: a model study

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Rivers are important sources of anthropogenic nutrients for shelf seas, originating from agriculture, sewage treatment plants and industry. After discharge into coastal and shelf seas, these nutrients are transported by marine currents, and can under certain conditions lead to eutrophication in certain maritime areas. The North Sea is surrounded by a number of highly industrialised countries, each of which contributes to the riverine nutrient load of specific rivers. In the Oslo-Paris convention (OSPAR), agreement was reached to reduce riverine nutrient loads to 50% of the levels in the year 1985 in areas where eutrophication has been diagnosed. As a contribution to the 2009 international workshop for the OSPAR Intersessional Correspondence Group for Eutrophication Modelling (ICG-EMO) in Brussels, model runs were carried out using the three-dimensional physical-biogeochemical model GETM-BFM to trace the contributions of Nitrogen from their source in prescribed groups of rivers to the maritime areas of the countries surrounding the North Sea, and to specific, smaller, target areas that are also used for eutrophication assessment. The model runs covered the period 1985 to 2002, where 1985-1996 were used for spin-up of the biogeochemistry, and 1997-2002 to track the Nitrogen discharged at the river mouths through the 3D physical space and through the biogeochemical cycles, including the sea bed. Results were analysed in terms of the contribution of the discharged Nitrogen from the specified groups of riverine sources to the total Nitrogen content within each grid cell of the model, and also within the specified maritime and target areas. The results showed that the dispersal of Nitrogen mainly followed the general circulation and known water masses in the North Sea. The result was an overlapping banded structure with Netherlands and German rivers contributing mainly to continental coastal waters, French rivers contributing to offshore waters and UK coastal waters typically originating from the English Channel, and UK rivers contributing to UK coastal waters and waters described elsewhere as the East Anglian Plume. For coastal areas, anthropogenic Nitrogen contribute up to 70% to the total Nitrogen content, whereas for offshore areas the anthropogenic Nitrogen contribution was typically less than 30%. The results address a specific request of OSPAR to quantify the level of transboundary nutrient transport required in order to develop robust mitigation strategies required to eliminate eutrophication where it is has been detected.