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Effects of wave-induced forcing on a circulation model of the North Sea

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The effect of wind waves on water level and currents during two storms in the North Sea is investigated using a high-resolution NEMO model forced with fluxes and fields from a high-resolution wave model. The additional terms accounting for wave-current interaction that are considered in this study are the Stokes-Coriolis force and the sea-state dependent energy and momentum fluxes. The individual and collective role of these processes is quantified and the results are compared with a control run without wave effects as well as against current and water level measurements from coastal stations. We find a better agreement with observations when the circulation model is forced by sea-state dependent fluxes, especially in extreme events. The two extreme events, the storm Christian (25-27 October 2013), and about a month later, the storm Xaver (5-7 December 2013), induce different wave and surge conditions over the North Sea. Including the wave effects in the circulation model for the storm Xaver raises the modelled surge by more than 40 cm compared with the control run in the German Bight area. For the storm Christian, a difference of 20-30 cm in the surge level between the wave-forced and the stand-alone ocean model is found over the whole southern part of the North Sea. Moreover, the modelled vertical velocity profile fits the observations very well when the wave forcing is accounted for. The contribution of wave-induced forcing has been quantified indicating that this represents an important mechanism for improving water level and current predictions.