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Changes in sea wave activity and their consequences for the Arctic marine navigation in the 21st century from model simulations

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Climate change in the Arctic region and rapid decline of sea ice cover during the last decades are important factors effecting the development of Arctic marine transport systems and shelf deposit exploration. At the same time, this region is influenced by extreme weather events, such as heavy storms with strong wind and sea waves enhancing a hazard for shipping, fishing and for the objects on the shelf seas. Therefore, the model assessments of extreme storm events and associated sea wave activity have imperative importance for estimations of possible consequences for the shelf exploration and marine navigation along the Northern Sea Route.
In the present study we use two-dimensional spectral numerical model of sea waves (WAVEWATCH III) has been applied to analyze sea wave activity in the Arctic basin in the 21st century using the regional climate model HIRHAM forced by anthropogenic scenario SRES-A1B. The significant wave heights in the Arctic basin for the 1980-1999 are compared to that simulated for the middle (2045-2064) and the end (2080-2099) of the 21st century. Our model results show an enhanced fraction of waves with height more than 2 m in different areas of the Arctic basin, which is related with increasing the length of the wave run-up (due to the expansion of open water) and strengthening the surface winds in the middle of the 21st century. The frequency of days with strong winds ($U > 8$ m/s) and vigorous waves ($Hs > 2$ m) increases for the Russian Arctic seas, with the largest growth simulated for the Kara Sea region during October-December. In general, the Arctic sea ice reduction should facilitate strengthening the sea wave activity in the 21st century. However, for the areas with the predominant ice-free conditions for the present-day climate (the Barents Sea) the model simulates a weakening of wave activity in the 21st century mainly due to reduction in the surface wind speed. In particular, by middle of the 21st century, the model simulates the strongest increase of extreme waves (with significant wave height above 3 m) frequency for the Kara and Chukchi Seas during October-December.