Climate change in Arctic and sea wave activity in the 21st century from model simulations

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Rapid climate change in the Arctic during the last decades is one of the most noticeable manifestations of global warming (Arctic Climate Impact Assessment; ACIA, 2005). Therefore, prognostic assessments of dangerous storm events and associated wave activity have very important implication for the potential planning the shelf exploration and marine navigation in Arctic basin, including the Northern Sea Route (Khon et al., 2010).

Two dimensional spectral numerical model for ocean surface waves (Polnikov, 2005) has been applied to analyze sea wave activity in Arctic basin using simulations with climate general circulation model CCSM3 (Collins et al., 2006) forced by SRES-A1B anthropogenic scenario for the 21st century. Figure 1 shows the histograms of the mean significant wave height distribution for five Russian Arctic seas. The horizontal axis represents ranges (according to Beaufort scale) of wave heights in meters for a developed wind waves on the high seas. The vertical axis is the percentage frequency (with respect to the total amount of events) of the different wave heights over the entire ice-free sea area for three decades: 1990-1999, 2040-2049 and 2090-2099.

For all analyzed seas except the Barents Sea, the model results show considerable increase in frequency of high waves (up to 2 m) in the 21st century with the strongest changes for the Laptev (~45% in the end of 21st century) and East-Siberian (more than 2 times in the middle of 21st century) Seas. This tendency is a result of the projected significant increase in ice-free water areas which is in favor of developing wave activity. For the Barents Sea model does not reveal significant changes in sea wave activity for the 21st century. For the frequency of very high (more than 5 meters) waves model simulations show a growth of activity in the middle and end of 21st century.

Similar analysis has been performed with WAVEWATCH III ocean surface waves model (Tolman, 2009) using simulations with the regional climate model HIRHAM (Rinke and Dethloff, 2008) forced by SRES-A1B anthropogenic scenario, in particular. There is a general agreement for sea wave activity estimates based on HIRHAM and CCSM3 climate simulations with remarkable differences for very high waves.

Despite very small frequency of extremely high sea waves (of the order of 1% for the Barents Sea, in particular) these waves are especially dangerous for shipping and offshore construction.

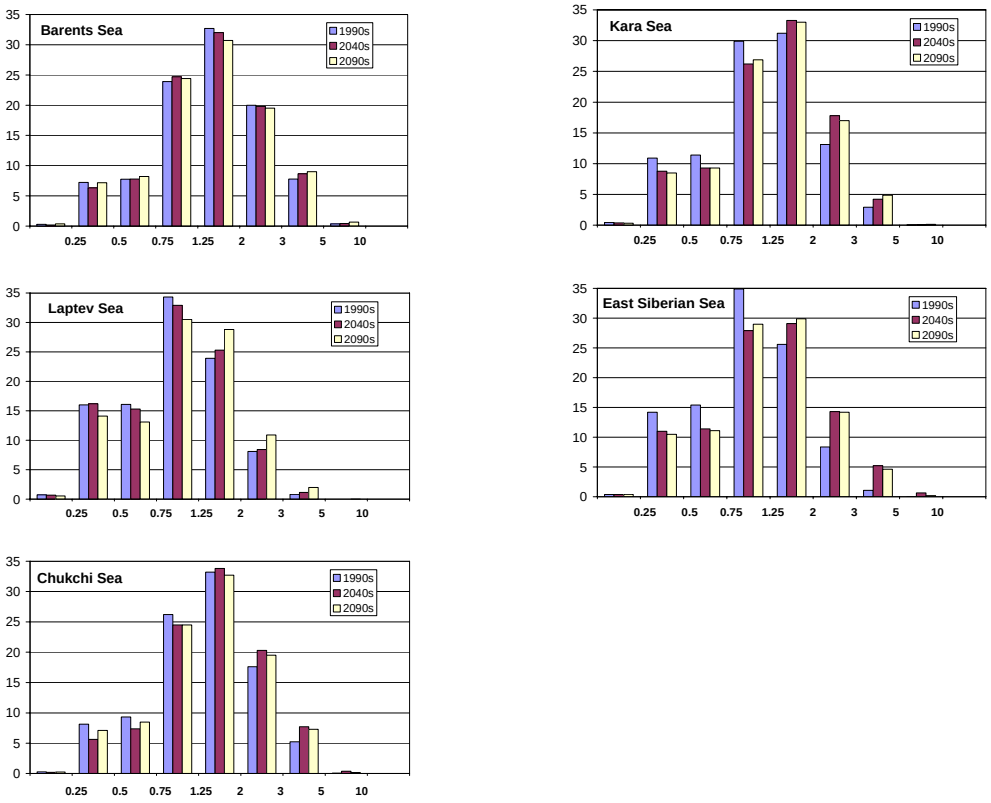

Figure 1. Histograms of the mean sea wave height (m) from model simulations for different Arctic Seas for three decades: 1990-1999, 2040-2049 and 2090-2099.

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