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Wind waves as the environmental forcing factor for Arctic Coastal Dynamics

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Waves are an important force of the environment, which determines the state of arctic coasts. In the Arctic, where substantial part of coastline extension is made up by frozen ground, waves play significant role along with temperature conditions and precipitation. The investigations showed that in general their role is the more important the lower ice content in permafrost is, and it becomes less essential with ice content increasing in the ground. In arctic seas the wind-induces waves are predominate. Ocean swell is important only in Barents and less in the Chuckchee Seas.

The evolution of arctic coasts over the coming decades will be governed by changes in the natural environment caused by the effects of climate warming. Rising temperatures are altering the arctic coastline by reducing sea ice and larger changes are projected to occur as this trend continues. Less extensive sea ice creates more open water, allowing stronger wave generation by winds. The wave-energy factor acts via the direct mechanical impact of sea waves on the shore, thus increasing wave- induced erosion along arctic coasts. Correspondingly, the effectiveness of this factor is determined by storm-driven sea surge intensity as well as by the length of the stormiest period. Conversely, surge intensity substantially depends on the fetch, which is intrinsically linked to sea-ice extent since less extensive sea ice creates more open water, allowing stronger wave generation by wind.

To understand how wind waves development would change in conditions of decreasing ice coverage in the Arctic Ocean we should turn to conditions of 2007 year, when the lowest ice coverage during all the history of instrumental observations from satellites since 1978 has been fixed. In 2007 anomalously wide clearance of arctic seas' water area from ice caused forming of unique conditions for wind waves' development due to remarkable increasing of wave fetch. In its turn the duration of dynamically active ice-free period essentially increased and also reached the highest values over the observation period.

Near the shore waves undergo considerable transformation and refraction, which are most pronounced in arctic seas because of their shallowness. As a result the observations on coastal hydrometeorological stations are not representative for determination of wave parameters on the open sea. The results of observations on automatic buoy station are local and this information is closed for general use. Thus considering lack or low representativeness of long instrumental wave measurements in arctic seas the estimations of wave parameters can be received only on basis of model calculations and forecasts.

For the estimation of wave parameters in 2007 the spectral-parametric model of State Oceanographic Institute (Russia) in modification of Arctic and Antarctic Research Institute (Russia), which had been approved on North-European basin of the Arctic Ocean, has been used. Wind – the main driving force – is calculated based on the atmospheric pressure fields at the sea level. The location of sea ice margin, as it was already mentioned, is available with 1 day periodicity in the Internet. The quality of diagnostic calculations carried out using this model for North-European basin of the Arctic Ocean stands on the high level: mean absolute error of calculations of the mean wave height is 0.22 m, mean square error – 0.89 m, with correlation coefficient 0.82 between observed and design values. Based on the results of model calculations for ice-free water areas of the Barents and Kara seas the estimation of significant wave heights recurrence (Hs – 13% exceedance level) for separate months of the year has been made.

From the analysis of wave heights distribution for months of 2007 in Barents and Kara seas the regularities which are also typical for the rest seas of Arctic Ocean are clearly traced. Along with the intensity of atmospheric circulation that determines the wind speed, wave heights are the function of wave fetch which is in turn is determined by ice coverage of the sea. From the table 1 it is well seen that in mostly ice-free Barents Sea the maximum intensity of

atmospheric activity falls on cold period of year (October-April), during which the local minimum of wave heights coincident to ice coverage maximum in February is evident. In Kara Sea the highest wave heights are observed in September-October, in the period while this sea is totally free of ice and wave fetch is maximal, and atmospheric circulation intensity begin to growth with approach of winter. Hence in the case of climate warming and increase of ice-free period duration due to November and December in Kara Sea as for in other arctic seas the noticeable growth of both wave parameters and total values of wave energy would certainty take place. As a result the wave influence on the coasts will increase that will lead to significant growth of erosion rates of arctic coasts.