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Morphometry and Mass of Icebergs in the Russian Arctic Seas

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In this paper, empirical relationships are derived to determine the mass and geometry of icebergs based on instrumental measurements and airborne data in the Barents, Kara and Laptev Seas. The authors give regression dependencies between 1D parameters of icebergs (length, width, height, draft); linear and area parameters of icebergs (cross-section area of the above and underwater parts of icebergs); linear iceberg parameters and its volume and mass. One can use the obtained empirical relations for the iceberg geometry and mass to simulate the drift of icebergs and to estimate their impact on offshore structures and vessels.

INTRODUCTION

Icebergs present a serious danger for navigation, production, and transportation of minerals in the offshore area. It is necessary to develop a complex system of measures for detecting, monitoring, and forecasting the drift of icebergs and risk assessment, in order to ensure safe man activity on the shelf of the Arctic Seas. The numerical model of the drift of icebergs is the base for the systems of forecasting and monitoring of the motion of dangerous ice features. The modern numerical model of the drift of icebergs presents a system of motion equations, taking into account the impact on icebergs of wind, currents, water resistance, sea level tilt, sea ice impact, wind wave, soil, and the Coriolis force (Klyachkin and May, 2012).

The wind impact force comprises tangential and normal stresses. Hence, to calculate this force, it is necessary to know the area of cross-(vertical) section S_{va} and the area of horizontal section S_{ha} (iceberg area by waterline) of the iceberg's above-water part. To determine the water resistance force, it is necessary to know the area of a vertical cross-section of the iceberg's underwater part S_{vw}. Forces determined by the ice cover and wind wave impact are calculated depending on the iceberg's linear dimensions (length L or width W). Finally, the force of soil impact on the iceberg depends on the sea depth and iceberg draft (D). So, for prognostic or diagnostic iceberg drift calculation, one has to know the iceberg mass (M) and its following geometric parameters: L, W, D, S_{va}, S_{vw}, and S_{hw}.

At present, one uses satellite images at different electromagnetic spectrum ranges to detect the ice targets more frequently. It instantaneously allows one to cover a large area that is inaccessible for ship surveys. However, from high-resolution satellite images, one can estimate only horizontal iceberg dimensions. For iceberg management objectives (including online use of the iceberg drift model), it is necessary to have the statistical regularities connecting the linear size of the above-water part with other iceberg parameters (normal and tangential drag, draft depth and mass).

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KEY WORDS: Iceberg forecasting, iceberg geometry, iceberg draft, iceberg length, iceberg cross-section area, iceberg mass.

MEASUREMENTS OF GEOMETRIC PARAMETERS OF ICEBERGS

As commissioned by the Rosneft Oil Company, the AARI made 12 comprehensive expeditions from 2012 to 2017 in the Russian Arctic Seas. One of the expedition goals was to study the spatial distribution of icebergs, drift characteristics, and assessment of their geometric size.

The expeditions were carried out onboard special research vessels. They were equipped with a helipad, small craft and ship radars. In the course of these expeditions, a search of icebergs was based on satellite information reported to the ships, helicopter reconnaissance flights, and ship radar and visual observations from the bridge. After iceberg detection, its coordinates and detection time were recorded and the iceberg size and type were assessed visually. Researchers determined the detected iceberg's type visually according to the national sea ice nomenclature (Gidrometeoizdat, 1974; Kazanskiy and Egorova, 1988). This nomenclature represents the following types of iceberg shapes: tabular, wedged, dome, dry dock, pinnacle, weathered, bergy bit and growler. This classification of icebergs coincides to some extent with the international classification of icebergs adopted by the World Meteorological Organization (WMO, 2014). The only important difference in the national sea-ice nomenclature is that in it tabular and blocky bergs belong to the same type.

After determining the iceberg coordinates and visually assessing its size and type, researchers performed the instrumental mea-