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Effect of Iceberg Shape on Wind-force Parameters

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This article examines iceberg movement under the influence of wind-force, with detailed analysis of the influence of iceberg shape (both keel and sail) on the parameters of this movement. For four icebergs, studied during trials in 2016–2017, hydrodynamic characteristics of keels and sails were determined by means of numerical and basin modeling. For these icebergs, orientation, direction, and speed of movement were calculated for different wind speeds and directions. Regression between the maximum value of the hydrodynamic drag coefficient and the geometric parameters is built based on the studied shape of sails of 10 icebergs. A formula for calculating the wind load on an iceberg depending on the parameters of its topside and a formula for calculating the drift speed of icebergs less than 75 meters long are proposed. The formulas are applied to icebergs of the southwestern part of the Kara Sea, which made it possible to estimate their drift speed and wind load under the influence of wind. The obtained results can be used in the modeling of the iceberg drift, as well as for assessing the wind impact during iceberg towing.

INTRODUCTION

Wind and sea currents are the main driving forces behind the iceberg movement in the waters of the world ocean. Wind impact is considered in all existing iceberg drift models; results of the modeling are usually verified instrumentally. To our knowledge, the most recent work on this topic is that described in Turnbull et al. (2021). At the same time, wind also significantly affects the process of iceberg towing from offshore oil and gas facilities; it is critical to determine the vector and moment of the wind-force when wind speed and direction are known. Correct calculation of the wind-force is impossible without knowledge of the geometry of the iceberg surface; the most advanced calculation method is the numerical simulation of aerodynamic characteristics.

For this research, it is useful to refer to previously studied icebergs with known shapes of sail and keel. Informative data on the Russian Arctic icebergs have been published in May et al. (2019) and Buzin et al. (2016, 2019) and on the derived correlations of the iceberg's sail shape in papers

- on iceberg stability (Kornishin et al., 2020),
- on towing load (Pashali et al., 2018; Efimov et al., 2019; Kornishin et al., 2019), and
- on iceberg detection distance (Pavlov et al., 2018).

The same philosophy of research was chosen to study the wind impact on icebergs, including iceberg drift speed and its behavior under tow: during trials performed in 2016–2017, aerial photography and a sonar survey of icebergs were taken, then three-dimensional (3D) models of icebergs were constructed, and the numerical modeling described in this work was carried out. Analysis of the numerical modeling results made it possible to divide regression dependences as well as to clarify the behavior of a drifting iceberg under wind load. Previously published works on the topic include Bigg et al. (1997), Wagner et al. (2017), Smith and Donaldson (1987), Mauviel (1980), and Marchenko et al. (2010).

METHODOLOGY OF NUMERICAL MODELING

The purpose of numerical modeling is to determine the positional components of the hydrodynamic characteristics of the iceberg's keels and sails in the case of uniform motion at different heading angles.

The turbulent flow of a viscous incompressible ponderable fluid can be described by the averaged equations of continuity and Reynolds, as in Eqs. 1 and 2:

$$\frac{\partial \langle u_i \rangle}{\partial x_i} = 0 \tag{1}$$

$$\frac{\partial \langle u_i \rangle}{\partial t} + \langle u_j \rangle \frac{\partial \langle u_i \rangle}{\partial x_j} = -\frac{1}{\rho}\frac{\partial \langle p \rangle}{\partial x_i} + \nu \frac{\partial^2 \langle u_i \rangle}{\partial x_j \partial x_j} - \frac{\partial \langle u_i' u_j' \rangle}{\partial x_j} \tag{2}$$

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KEY WORDS: Ice management, iceberg, towing, drift, wind, shape.