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Iceberg Drift Simulations Using Inferred, Measured, and Ocean Model Currents

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An iceberg drift model was developed for offshore oil and gas operations. Increasing forecasting accuracy is critical for making appropriate downtime decisions. Three sources of ocean current data were used to run test simulations of the model: estimates from observed iceberg drift and wind, measurements from a drifting buoy, and a three-dimensional (3D) ocean model. The average simulated iceberg position errors at 24 hours were 12% smaller for the estimated current drift simulations compared with the 3D modelled current simulations. The 17-hour iceberg position errors were 21% smaller for the buoy current drift simulation compared with the 3D modelled current simulation.

INTRODUCTION

Iceberg drift prediction is an important component of ice management decision support for offshore oil and gas exploration and drilling operations. Improving the accuracy of iceberg drift trajectory forecasts can help to increase ice management efficiency in terms of allocating ice management vessels, prioritizing tow targets when multiple icebergs are present, and ensuring operational shutdown decisions are appropriate. Inaccurate iceberg drift trajectory predictions can lead to unnecessary downtime and result in financial losses on the order of tens of millions of dollars. The Grand Banks offshore Newfoundland and Labrador, Canada, for example, have historically been the site of significant oil and gas exploration and drilling activities, with production, construction, and exploration facilities threatened during iceberg incursion events occurring on a near-annual basis, typically during the months of March to June.

Previous models have typically operated on temporal integration of the momentum balance of the primary metocean forcings on iceberg drift: wind, current, and Coriolis force. In most of the existing literature on iceberg drift modelling, iceberg drift simulations were run in a hindcast mode. Some of these models used wind and ocean current data from regional atmospheric and ocean prediction models, respectively, whereas others used site-specific measured wind and ocean current data. Some of the earliest iceberg drift modelling was performed offshore Labrador in the 1980s using locally measured winds and currents (Sodhi and El-Tahan, 1980; Smith and Banke, 1983; Smith and Donaldson, 1987). Subsequent work used atmospheric and ocean circulation models to run iceberg drift simulations (Carrieres et al., 2001; Lichey and Hellmer, 2001; Kubat et al., 2005; Eik, 2009).

Turnbull et al. (2015) presented the results of an iceberg drift prediction model specifically designed to provide ice management decision support to a seabed coring operation offshore northwest Greenland. This model employed a hindcast-forecast approach, in which the model was initially calibrated during a hindcast period. During the hindcast period, typically 4 to 24 hours, the observed iceberg drift was simulated using locally measured winds to optimize the air and water form drag coefficients, and these coefficients were subsequently used in the forecast. The air and water form drag coefficients were optimized by choosing coefficients that minimized the root-mean-square (RMS) position errors between the observed and hindcast drift. The model presented in Turnbull et al. (2015) estimated the nontidal ocean current from the observed iceberg drift during the hindcast period and subsequently estimated the current during the forecast period as the sum of the inferred nontidal current and the locally predicted tidal current.

Andersson et al. (2016) employed a similar hindcast-forecast approach to iceberg drift prediction as did Turnbull et al. (2015), but they introduced the concept of an "ancillary" current, which could be added to the locally measured or inferred current during the hindcast period to reduce the positional error between the observed and hindcast simulated drift. Andersson et al. (2016) showed that the introduction of the ancillary current improved the subsequent forecast drift.

Turnbull et al. (2018) used the hindcast-forecast approach of Turnbull et al. (2015) for simulations of iceberg drift offshore northern Newfoundland and southern Labrador, and they utilized the ancillary current according to Andersson et al. (2016), as well as an inferred ocean current from the observed iceberg drift during the hindcast period to calibrate the subsequent drift forecast. Turnbull et al. (2018) additionally incorporated three-dimensional (3D) profiles of the icebergs into the drift model to reduce uncertainties as a result of iceberg shape, dimension, and mass estimation. The 3D profiles were generated with a rapid iceberg profiling system consisting of multibeam sonar for the underwater portion (keel) of the iceberg and LiDAR (light detection and ranging) for the iceberg freeboard (sail). The incorporation of the 3D iceberg profiles in the Turnbull et al. (2018) model resulted in an average 18% reduction in observed versus predicted iceberg position errors at 24 hours, based on the drift simulations of 14 icebergs.

During April to August 2019, four voyages were conducted offshore Newfoundland and Labrador to deploy GPS trackers on icebergs from UAVs. The main goal of this "iceberg tagging" project was to provide the International Ice Patrol (IIP) with ground-truth iceberg positional data for verification in satellite imagery. The four voyages were each 10 to 15 days, with the first one conducted aboard the United States Coast Guard (USCG) cutter *Juniper* and the last three aboard the Canadian fishing vessel (FV) *Patrick & William* (Fig. 1). Tracking beacons were secured to rubber mats with nail beds to increase the chances the mat would adhere to the

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