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Operational iceberg drift forecasting in Northwest Greenland

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ABSTRACT

An operational iceberg drift forecast model was developed and used in 2012 to support Shell Greenland A/S, which was leading a consortium of companies to conduct a scientific coring campaign offshore northwest Greenland. The nine-week program took place in August–October 2012 in Melville Bay where there is a very high spatial density of icebergs. In order to increase operational safety and efficiency, the iceberg drift model presented here was fully integrated within the ice management strategy and its decision protocols. The model was optimized to fulfill the operational requirements in terms of (1) the format and content of the input/output, (2) the calculation of the iceberg alert zones, and (3) the derivation of the associated Closest Point of Approach (CPA) and time to CPA (T-CPA). To achieve this, the iceberg drift forecast model used as near real-time input: in-situ measured metocean parameters, observed iceberg drift and size data, tidal currents, and weather forecasts. The model forecast the 24-hour iceberg drift trajectory including the CPA and T-CPA. It also derived the T-Time (e.g., Total Time, or the time necessary to lift the coring pipe to 50 m below the seabed) alert zones based on the observed mean iceberg drift speed. The iceberg trajectory forecast was optimized by running a hindcast simulation of the observed iceberg trajectory. In this simulation, the air and water iceberg form drag coefficients were tuned to minimize the difference between the hindcast and the observed iceberg drift trajectories. The forecast iceberg track, beginning at the end of the observed iceberg record, was subsequently generated using the air and water form drag coefficients derived from the hindcast simulation. The model also incorporated a method to correct for the lack of robust near real-time in-situ ocean current measurements. During this campaign, the model was used to forecast the drift of 73 icebergs and exhibited good performances in locations with strong and persistent non-tidal currents. However, further offshore where the ocean currents were dominated by tidal and inertial forcings, the model exhibited poorer performance. Nevertheless, as shown for two icebergs in this paper whose drift was dominated by tidal and inertial oscillations, model performance could be significantly improved in the hindcast mode by using the vessel's wind data and the ocean current data retrieved from a mooring deployed in the area. This illustrated the importance of using adequate near real-time ocean current and wind measured and forecast input data.

1. Introduction

In August–October 2012, Shell Kanumas A/S (Shell), acted as an operator on behalf of the Baffin Bay Operators & Licensee Consortium (ConocoPhillips, Maersk Oil, Cairn Energy, Nunaoil, GDF SUEZ, Dong Energy and Statoil), to conduct a scientific coring program offshore northwest Greenland (Fig. 1). Overseas Drilling Limited provided the scientific coring vessel RV JOIDES Resolution to undertake the 63-day coring program. The primary objective of the campaign was to obtain samples of the sediments and rocks beneath the seabed to improve the understanding of the lithology and age of the sedimentary sequences.

The ubiquitous presence of icebergs in the vicinity of the coring sites (Figs. 2–3) necessitated the development of an adequate iceberg management plan including robust iceberg detection, monitoring, and forecasting systems as well as consistent ice alert zones and decision protocols. During the campaign, 447 icebergs were recorded (Figs. 2–3) with 316 and 61 drifting within 5 nautical miles (nmi) and 1 nmi of a coring site, respectively (Fournier et al., 2013). The 447 icebergs were observed on the ship's marine radar, and their locations were

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Fig. 1. Predominant ocean currents of Baffin Bay, in knots (kts). The coring expedition took place in the NE corner where the West Greenland current flows north along the West Greenland coastline and turns west toward Cape York (image from Valeur et al., 1996).

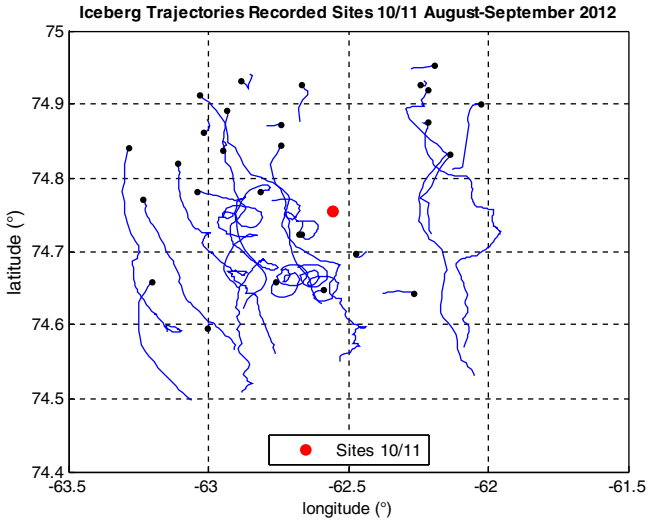

Fig. 2. Drift trajectories of all icebergs recorded at coring sites 10/11. Icebergs at this location tended to drift northward and displayed looping patterns due to tidal and inertial oscillations in the currents. The small black dots mark the last recorded locations of the icebergs.

recorded every hour in an Excel spreadsheet by the ice management team. A Kelvin Hughes marine radar system with Enhanced Target Detection (ETD) capability was used to monitor icebergs, and had both X- and S-band modes available. A Sperry marine radar was also available, but icebergs were only recorded on the Kelvin Hughes system. Icebergs at coring locations were recorded for periods of time ranging from one hour to several days, while icebergs observed while the vessel was in transit had only their first known locations recorded. In addition, 208 drift forecasts were issued for 73 icebergs throughout the campaign.

1.1. Regional environment

The coring campaign was conducted in the NE region of Baffin Bay, in an area known as Melville Bay. This region is dominated by the West Greenland current (Fig. 1), a surface ocean current flowing north along the West Greenland coast, and then turning west at the NE corner of Melville Bay (Tang et al., 2004; Valeur et al., 1996). The icebergs calving from the Greenland ice sheet in this region tend to drift with the West Greenland current, with some drifting across Baffin Bay in the current connecting the West Greenland current with the Baffin Island current on the east side of the bay.

Fig. 4 shows the bathymetry of the NW Greenland region of Baffin Bay, according to the General Bathymetric Chart of the Oceans (GEBCO), (2008) 30-second dataset. Water depths up to about 200 m