

## **An Operational Iceberg Deterioration Model**

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### **ABSTRACT**

This paper describes the iceberg deterioration component of an iceberg forecasting model. The model is intended for operational use by the Canadian Ice Service, and locally by offshore operators. The paper describes the formulation used to account for the various deterioration mechanisms, which consist of melting due to solar radiation, buoyant convection, and forced convection, as well as wave erosion and calving. The work also includes a sensitivity study that examines the role of the environmental input variables and model parameters. Tests examine the influence of water temperature, wind and current velocities, iceberg size, and wave height. The results indicate that wave height plays a major role in iceberg deterioration. Wind velocity and water temperature also play significant roles. In contrast, water current had little influence on iceberg deterioration. Finally, predicted calving intervals are found to be in reasonable agreement with field observations.

**KEY WORDS:** Iceberg forecasting, iceberg deterioration, iceberg calving.

### **INTRODUCTION**

An iceberg forecasting model has been under development by the Canadian Ice Service (CIS). The development addresses iceberg drift, deterioration and calving, as well as the fate of the calved small ice masses. The model is intended for operational use by CIS to forecast iceberg conditions along the East Coast of Canada. Versions of the model are also adapted for local use by offshore operators over the Grand Banks. For example, the model is currently in use to provide information for iceberg management operations. Previous papers have described the drift component (Kubat et al. 2005), and the modeling of the size distribution and fate of calved ice (Savage et al. 2000, and

2001). The present paper concerns modeling of the deterioration of icebergs.

Knowledge of the deterioration of iceberg size is essential for forecasting the drift. Moreover, iceberg size is also an important factor in making decisions concerning iceberg management (e.g. towing) and evaluating the risks to offshore installations. Calving of small ice pieces presents an additional hazard to shipping. The small pieces are difficult to detect, and can inflict considerable damage if collisions occur. For these reasons, an operational iceberg forecasting model requires reliable modeling of deterioration processes. The model has to address several issues that complicate modeling of those processes. Difficulties arise, for example, from the irregular shapes of icebergs and the continuous changes due to calving and occasional rolling. There are also many environmental conditions (forcing) that influence iceberg deterioration, such as wind, water currents, waves, air and water temperatures, and solar and ocean heat fluxes. In view of such complexities, deterioration processes are usually modeled through semi-empirical parameterizations that capture the salient features of iceberg size evolution.

Josberger (1977) reported on detailed laboratory and field studies of the melting of icebergs. Another early study by White et al. (1980) gave estimates of the deterioration rates due to various processes. Their analysis became the basis for many of the subsequent modeling of iceberg deterioration. El-Tahan et al. (1987) also provided several empirical relations to describe iceberg deterioration, and verified their performance using field observations. In addition to the empirical formulas for iceberg deterioration, other studies addressed details of temperature distributions in icebergs. Loset (1993) gave a detailed analysis of temperature distributions, melt, refreezing and run-off in icebergs.