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Method Article

Adapting open-source drone autopilots for real-time iceberg observations

Daniel F. Carlson[a,b,*], Søren Rysgaard[a,c]

[a] Arctic Research Centre, Department of Bioscience, Aarhus University, 8000 Aarhus C, Denmark
[b] Department of Earth, Ocean, and Atmospheric Science, Florida State University, Tallahassee, FL 32306, USA
[c] Centre for Earth Observation Science, University of Manitoba, Winnipeg, MB R3T 2N2, Canada

A B S T R A C T

Drone autopilots are naturally suited for real-time iceberg tracking as they measure position and orientation (pitch, roll, and heading) and they transmit these data to a ground station. We powered an ArduPilot Mega (APM) 2.6 with a 5V 11 Ah lithium ion battery (a smartphone power bank), placed the APM and battery in a waterproof sportsman's box, and tossed the box and its contents by hand onto an 80 m-long iceberg from an 8 m boat. The data stream could be viewed on a laptop, which greatly enhanced safety while collecting conductivity/temperature/depth (CTD) profiles from the small boat in the iceberg's vicinity. The 10 s position data allowed us to compute the distance of each CTD profile to the iceberg, which is necessary to determine if a given CTD profile was collected within the iceberg's meltwater plume. The APM position data greatly reduced position uncertainty when compared to 5 min position data obtained from a Spot Trace unit. The APM functioned for over 10 h without depleting the battery. We describe the specific hardware used and the software settings necessary to use the APM as a real-time iceberg tracker. Furthermore, the methods described here apply to all Ardupilot-compatible autopilots. Given the low cost ($90) and ease of use, drone autopilots like the APM should be included as another tool for studying iceberg motion and for enhancing safety of marine operations.

- Commercial off-the-shelf iceberg trackers are typically configured to record positions over relatively long intervals (months to years) and are not well-suited for short-term (hours to few days), high-frequency monitoring
- Drone autopilots are cheap and provide high-frequency (>1 Hz) and real-time information about iceberg drift and orientation
- Drone autopilots and ground control software can be easily adapted to studies of iceberg-ocean interactions and operational iceberg management

* Corresponding author at: Arctic Research Centre, Department of Bioscience, Aarhus University, 8000 Aarhus C, Denmark.
E-mail address: danfcarlson@bios.au.dk (D.F. Carlson).

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A R T I C L E I N F O
Method name: Low-cost, Real-time iceberg drift and orientation observations
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Specifications Table

Subject area	• *Earth and Planetary Sciences* • *Energy* • *Engineering* • *Environmental Science*
More specific subject area	*Cryosphere, Oceanography, Ice Hazards, Oil and Gas*
Method name	*Low-cost, real-time iceberg drift and orientation observations*
Name and reference of original method	*Iceberg tracking was first pioneered by the International Ice Patrol -* https://cgaviationhistory.org/1946-international-ice-patrol/ *and also summarized in – Icebergs: Their Science and Links to Global Change by G.R. Bigg* [7]. *Cambridge University Press*
Resource availability	*All required documentation to use an open source autopilot as an iceberg tracker can be found here:* http://ardupilot.org/

Method details

Background

Icebergs play an important role in Polar ocean environments [1–3], and can also threaten marine infrastructure [4–6]. Observations of iceberg translation and rotation are relatively rare, as are oceanographic observations in the vicinity of drifting icebergs. These observations are necessary, however, to improve our understanding of iceberg-ocean interactions and to develop reliable models of iceberg drift and deterioration. For a review of iceberg science we refer the reader to Bigg [7].

Oceanographic observations around icebergs typically attempt to capture the signature of the iceberg's melt water plume in water temperature and salinity [2,8,9]. The structure of an iceberg's melt water plume depends on the relative velocity between the iceberg and ocean currents [10] and in stratified waters the plume behavior also depends on the density difference between the plume and the saltier water below [8,9]. Attached (detached) iceberg plumes generally occur when the relative velocity is small (large; [9]) and strong vertical velocity shear can result in more complicated plume behavior [10]. In some cases, particularly during very calm conditions, the surface signature of the melt water plume may be clearly visible (Fig. 1). During windy and wavy conditions, however, the location of the meltwater plume may not be immediately apparent to the eye. Similarly, real-time information about oceanographic conditions (e.g., stratification and velocity shear) and iceberg drift may not be available to researchers, which makes field assessments of plume structure difficult, if not impossible. Instead, plume behavior is usually assessed from field or laboratory data. Observations of the direction and speed of the iceberg's drift can aid, therefore, in the interpretation of oceanographic measurements.

Oceanographic observations of iceberg meltwater plumes consist of conductivity/temperature/depth (CTD) profiles, at a minimum, and can include many other variables, including water velocity profiles, fluorescence, photosynthetically available radiation (PAR), dissolved oxygen (DO), turbidity, and nutrients, for example. The micro-scale mixing due to the buoyant meltwater plume and the displacement of water by the iceberg keel may also be inferred using a turbulence profiler. Ocean profile measurements are typically geolocated using data from a global positioning system (GPS) or a