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1 **Capturing glacier calving using time-lapse camera arrays**

2

3 *Connie Harpur*

4 *School of Geography, University of Leeds, Leeds, UK*

5 *e-mail: gycmh@leeds.ac.uk*

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7 **Main text**

8 Glaciers worldwide are losing mass more rapidly due to climate change. Much of this loss
9 happens at their lake and marine margins, where chunks of ice break away through a process
10 termed calving. Assessing the timing, style and volume of individual calving events is important
11 for glaciologists seeking to understand the mechanisms driving glacier retreat, measure ice
12 loss, and predict how glaciers might respond to lake and ocean warming. Although satellite
13 and drone imagery can be used to document calving activity, limitations related to image
14 resolution, cloud cover and constraints on field season lengths mean they are less suited to
15 capturing dense, long-term calving records.

16 The application of Structure-from-Motion (SfM) photogrammetry to time-lapse camera imagery
17 addresses these challenges. This approach uses an array of automated trail cameras
18 (typically 12 to 15) positioned to photograph a calving front from multiple angles at intervals of
19 several hours. The resulting images, taken over weeks, months, or even years, are processed
20 with SfM techniques to generate detailed 3D models of the glacier front at each timestep.
21 Differencing successive models reveals the precise locations and volumes of individual calving
22 events. Since trail cameras have the durability to withstand deployment over timescales much
23 longer than typical field campaigns, this method can produce records of calving activity
24 spanning both summer and winter months.

25 The capability of time-lapse SfM photogrammetry is allowing novel insights into the seasonality
26 of calving processes. For example, this technique was used to generate the first year-round
27 volumetric record of calving at a lake-terminating glacier in Greenland, which showed how
28 calving volumes and mechanisms evolved in response to lake conditions. Given likely
29 increases in lake and ocean temperatures, and reduced lake and sea ice-cover, an
30 understanding of the associated implications for ice loss is set to become increasingly critical.
31 Consequently, the combined time-lapse and SfM approach offers an affordable means to
32 unravel the complexities of glacier calving.

33

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37 Grant NE/S007458/1).

38

39 **Image**



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41 Image credit: Alex Scoffield