

Antarctic ice shelves are prone to slush

A new analysis suggests that researchers have been underestimating the amount of meltwater sitting atop Antarctica's floating glacial ice.

More than a tenth of Antarctica's surface overhangs the ocean. The continent's floating ice shelves preserve flowing glacial ice that would otherwise slip into the Southern Ocean and cause global sea levels to rise. Without the benefit of underlying bedrock, however, ice shelves are vulnerable to weakening and even calving when liquid water seeps through them (see the Quick Study by Kristin Poinar, *PHYSICS TODAY*, October 2023, page 70). Researchers have blamed the 2002 collapse of Larsen B, an Antarctic ice shelf roughly the size of Rhode Island, in part on the effects of pooled meltwater.

The Larsen B event underscores the importance of tracking ice shelf meltwater, particularly as the poles warm faster than the rest of the planet (see the article

by Sammie Buzzard, *PHYSICS TODAY*, January 2022, page 28). Although the vivid blue of meltwater lakes stands out in aerial and satellite imagery, liquid water can also subsist in forms that are harder to detect. Now, with the help of an image-scouring machine-learning algorithm, Rebecca Dell at the University of Cambridge in the UK and colleagues have compiled a multiyear inventory of meltwater on dozens of Antarctic ice shelves. They find that most of the water that collects during the summer months comes in the form of saturated snow: slush.

After training their algorithm on prescreened images from the Earth-observing *Landsat 8*, Dell and colleagues fed it every Antarctic ice shelf shot acquired by the satellite during the continent's summers from 2013 to 2021 and compiled monthly meltwater inventories. At any one time, as much as 6000 km² of the shelves' surfaces—larger than the size of Delaware—contained lakes, slush, or both. Slush accounted for an average of 57% of the meltwater. Roughly 17 000 km² of surface area hosted meltwater at some point during the nine years. Although the figures represent small percentages of the shelves' total area, they exceed those reported in earlier studies that

had focused only on ponded water.

The measured meltwater abundance has implications for the future of Antarctica's ice shelves. Whether originating in ponds or as slush, liquid water percolates into the firm, the porous boundary layer that buffers a shelf's deep, compressed ice from its snowy surface, and can exacerbate fractures in the ice. Meltwater also causes problems when it resolidifies: Freezing water releases latent heat, which warms the surrounding snow and ice, and then forms less permeable ice that promotes the ponding of future meltwater.

Slush is also darker than pure snow, so it absorbs more sunlight. Dell and colleagues measured the albedo values for the waterlogged regions of five ice shelves and compared them with estimates derived from a leading polar climate model. The researchers found that the model overestimated the surface reflectance for both lake-filled and slushy regions and thus underestimated how much those surfaces would melt. Correcting models and further improving meltwater detection should improve researchers' predictions of how Antarctic ice shelves will fare as global temperatures continue to rise. (R. L. Dell et al., *Nat. Geosci.* **17**, 624, 2024.)

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MELTwater SLUSH AND LAKES are shown covering a portion of the surface of Antarctica's Bach Ice Shelf in a satellite photo last year. (Image contains modified Copernicus Sentinel data (2023), processed by Rebecca Dell.)