How it works: The Meltstake!

Tidewater glaciers — those that flow directly into the ocean — are a key piece of the climate change puzzle. They are in rapid retreat, contributing to sea-level rise and even changing ocean currents. Yet, understanding how much and how fast these glaciers will melt remains a stubborn challenge for scientists, mostly because dangerous conditions make direct measurements impossible. (Imagine being on a small boat at the glacier face just as a house-sized piece of ice detaches and falls into the ocean!) One important step in measuring melt is observing the small-scale physics that will help improve big-picture climate projections. Nobody has ever done this before!

A team of scientists, technicians, engineers, glaciologists, students and physical oceanographers at Oregon State University has invented an innovative system to obtain direct observations at the ice-ocean boundary, without putting humans in harm’s way: the Meltstake. The entire setup includes several components: an autonomous motorboat that ferries the system to the glacier face (not shown in these diagrams), an underwater robot that dives below the surface to deploy the Meltstake, and the Meltstake itself, which drills itself into the ice to begin collecting all kinds of data on currents, temperature and more. Together these data provide scientists with a better picture of melt rate and potential sea-level rise.

Dive in, and learn more about the Meltstake!

1. Motor and gears: An underwater drill is unfortunately not an off-the-shelf item at your local hardware store. So, the Meltstake team built a custom gear box that drills the ice screws into the glacier.

2. Ice screws: Snug within carbon fiber tubes, the ice screws get drilled into the glacier face. Scientists can communicate with the Meltstake to tell it to drill in deeper, as melting occurs. When finished, the instrument unscrews itself from the ice and floats to the surface, transmitting its location so scientists can retrieve Meltstake and the data.

3. Acoustic modem: Since there’s no Wi-Fi underwater, the acoustic modem serves as a pathway for all communications. It enables the scientists to “talk” to the instrument in real time and tell it to drill in 10 turns, for instance. When the Meltstake is initially attached to the ice face, all the drilling commands are delivered via acoustic signals. It’s like battleship: D4 means “please drill in 4 inches.” After the Meltstake has drilled itself into the ice, scientists tell the underwater robot (which delivers the instrument) to release and drive away.

4. Underwater cameras: These cameras enable scientists to see the ice face structure and monitor how the Meltstake is performing. They also film tiny air bubbles trapped in the ice, which may accelerate melt when they burst.

5. Remotely operated vehicle: The underwater robot (transparent in the figure) delivers the Meltstake to the glacier face and then swims away.
**Hydrophone:** The hydrophone listens to the sounds of ice and bursting bubbles, which may be accelerating ice melt.

**Acoustic Doppler Current Profiler:** As ice melts, the collision of freshwater with the denser ocean water creates currents, which flow up over the ice to create even more melt. The ADCP measures these nearby currents by sending out a sound pulse that bounces back and tells scientists how the water is moving — an important step in understanding the overall melt rate.

**Acoustic Doppler Velocimeter:** The ADV is also an acoustic instrument that measures current. But unlike the ACDP that surveys a broad swath of ocean, the ADV gets up close and personal. It measures tiny currents in a tiny volume very close to the glacier face and fills in a gap that the ADCP cannot capture.

**Thermistor rake:** Temperature varies exponentially near the glacier ice face, sometimes as much as 4 degrees Celsius in a span of a few centimeters. This temperature gradient can make a huge difference in melt dynamics. The thermistor rake, with a row of eight precisely placed sensors, measures the change in temperature at the ice face to understand how heat moves and is contributing to ice melt.

*Meltstake drilled into glacier face*