The wind sublimates snowflakes in Antarctica

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The Dumont d'Urville French research station on the coast of East Antarctica. Credit: @LTE/EPFL

Researchers have observed and characterized a weather process that was not previously known to occur in Antarctica's coastal regions. It turns out that the katabatic winds that blow from the interior to the margins of the continent reduce the amount of precipitation (mainly snowfall)—which is a key factor in the formation of the ice cap. By forming a very dry

layer of air in the first kilometer or so of atmosphere, the winds turn the falling snowflakes during their fall directly from their solid state into water vapor in a process known as sublimation.

The authors of this study used new data collected at the coast of Adélie Land over a yearlong period, together with simulations carried out using atmospheric models. They estimated that, across the continent, cumulative precipitation near the ground was 17% lower than its maximum level higher in altitude. Their measurements indicate that precipitation may be as much as 35% lower in the region around East Antarctica. The researchers believe that this phenomenon could be further aggravated by climate change. Their study has been published in *Proceedings of the National Academy of Sciences*.

"Until now, the extent of this important process, which is largely undetectable by satellite, was not fully appreciated," explains Alexis Berne, corresponding author of the study and head of EPFL's Environmental Remote Sensing Laboratory (LTE). Berne worked with a team of Swiss, French and British researchers in 2015 and 2016, using a new combination of instruments to take measurements at the Dumont d"Urville French research station on the coast of East Antarctica. The team used three instruments: a Doppler dual-polarization weather radar, a weighing precipitation gauge and a radar profiler. The polarization radar collected information on the type and intensity of precipitation, while the precipitation gauge weighed the accumulated snowfall every minute and helped calibrate the two radars' estimates. These two instruments were used to collect data from November 2015 to January 2016. The third instrument—the radar profiler—has been continuously collecting vertical profiles of the intensity of precipitation up to three kilometers in altitude since November 2015 at Dumont d"Urville.

At first, the researchers were surprised by the results they obtained. The sharp decline in precipitation recorded near the ground was not

consistent with their usual observations. "We therefore worked off the hypothesis that the reduction in precipitation in the lower atmospheric levels was caused by snow crystals sublimating as a result of the katabatic winds," explains Christophe Genthon, CNRS Senior Scientist at the Institute of Geosciences of the Environment, based in Grenoble. These frequent, strong winds come from the continent's high plateaus. The Antarctic ice sheet is quite flat, so the winds can gain in strength and reach as far as the coast. This creates a thin bottom layer of air (up to 300 m) that is saturated with uplifted snow crystals. Above this, there is a second layer of air that is much dryer. Snowflakes formed in the cloud layer aloft, sublimate when they pass through this second layer, turning straight into water vapor. Over time, this reduces the contribution from precipitation to the ice sheet's mass balance. "This layer is in a blind zone for satellites because of the echoes from the surface, which explains why this phenomenon had not been detected by satellites," says Berne.

The researchers then found evidence of katabatic winds capable of triggering sublimation in most of the data collected by radiosonde at permanent research stations across East Antarctica. Using a series of numerical atmospheric models and comparing the results with the measurements taken in Adélie Land, they were able to quantify the impact over the entire continent. And they discovered that the process of sublimation has a huge influence on the accumulation of precipitation.

Data on the ice sheet's mass balance is essential for predicting how sea levels will rise or fall. Researchers generally expect global warming to result in higher levels of precipitation in Antarctica. But the impact of the katabatic winds on precipitation could challenge these forecasts and make them far more complicated. The team therefore plans to continue analyzing the continent. "We'd like to keep collecting data on coastal areas and look more closely at areas where the terrain is more complex. We also plan to use different types of atmospheric models for

comparison purposes. Broadly speaking, we hope our work will help increase our understanding of how climate change will affect precipitation in Antarctica," explains Alexis Berne.

More information: Jacopo Grazioli, Jean-Baptiste Madeleine, Hubert Gallée, Richard M. Forbes, Christophe Genthon, Gerhard Krinner and Alexis Berne, "Katabatic Winds Diminish Precipitation Contribution to the Antarctic Ice Mass Balance", *Proceedings of the National Academy of Sciences*, 25 September 2017.

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