

# Heavy summer rain in Greenland speeds up ice melt

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Rapid ice melt in Greenland is driven by intense late summer rainfall, making the vast ice sheet even more vulnerable as the earth warms, new research shows.

You may think that warmer temperatures alone were enough to drive the melting of the Greenland Ice Sheet, and you would not be alone -- Many glaciologists thought roughly the same.

But a new study shows for the first time that the Greenland Ice Sheet melts rapidly, not just with warm summer temperatures, but also after intense late-summer rain.

The new study shows that these heavy rain events have occurred frequently due to the warmer, wetter weather of the last 20 years, penetrating deeper into the ice sheet, making it move and melt faster.

“We saw 10 to 15 % of the total annual surface melt occur in this unusual week of warm, wet weather in late summer 2011. When this water reached the bed, the ice sheet lifted up and moved faster,” says Sam Doyle, from Aberystwyth University, UK, lead author of the new study, which has just been published in *Nature Geoscience*.

According to his colleague and co-author, professor Jason Box of the Geological Survey of Denmark and Greenland, their results add more weight to scientists’ concerns of the sensitivity of the entire Greenland Ice Sheet to melting.

“We’re seeing that warm wet weather, that is increasing with climate change, is driving more melt of the Greenland Ice Sheet than we thought. And worryingly, this melt is reaching further into the ice sheet,” says Box, speaking via satellite phone, along with Doyle, as they work together on another fieldtrip in Greenland.

## **Scientist: An interesting, thorough, and novel study**

Edward Hanna, professor in climate change with the University of Sheffield, UK, is impressed with the new study.

“This is an interesting, thorough and novel study based on a wealth of robust meteorological and glaciological datasets, and is based on meteorological models as well as observations,” says Hanna, who was not involved in the research.

“The study adds to an already complex story of how Greenland Ice Sheet dynamics appear to be influenced by changes in weather conditions, sometimes on a daily timescale,” he says.

## **Heavy rain makes the Greenland Ice Sheet move**

The study began after observing exceptionally warm wet weather in late summer 2011, causing huge amounts of melt at the ice surface. At this time of the year, there was no snow on the surface of the ice to absorb and act as a buffer for all this rain and melt water, which then moved very quickly through the ice sheet.

“At first our observations of this late-August intense rainfall and melt event were met with the attitude of “hey big deal, it’s summer, it melts”,” says professor Alun Hubbard from the Center for Arctic Gas Hydrate, Environment and Climate at The Arctic University of Norway, and principle investigator of the project that led to the study.

“But this new data, shows these periods of rapid movement of the ice are in fact tied to a particular type of rainfall event, the kind of storm you would expect to see in the mid-latitudes -- UK or Scandinavia -- and not so much in Greenland where high pressure systems are more common.”

“We can now reinterpret these big late summer melt events to get a much better understanding of what is going on -- what is affecting the ice sheet system and how it is responding” he says.

#### **Imagine a storm drainage system after heavy rain**

Hubbard uses the analogy of a storm drainage system, to explain how the rain and melted ice moves through the ice sheet so quickly.

“Imagine a big downpour in a city. You get so much rain so quickly, on to an impermeable concrete surface that the water is immediately shunted into the city's drainage system -- which due to the huge volumes of water -- can't cope. Drains back up and it floods. Basically, the same thing happens on the bare ice sheet surface, which like the city is literally comprised of pipes, conduits and cavities,” he says.

According to him, when these pipes back up the hydraulic pressure lifts the ice sheet up, like a gigantic iceberg. There is less friction at the bed and so it moves faster.

#### **Melting extends far into glacier interior**

But observing one event was not enough to convince some glaciologists that this process is important over longer periods of time, or that rain could cause melting over such a wide area.

Doyle and his team analysed the strange event in more detail.

They monitored the ice-movement by GPS, set up their own weather stations on the ice, and measured how much water was being discharged from the ice sheet.

According to Hubbard, the rain event covered a huge area, and melting extended deep into the interior of the ice sheet, by about 140 km. This is where you would expect it to be frozen, and for rain to fall as snow.

They also gathered rainfall data for the last 20 years and compared it with other known melt events across Greenland.

“We saw these August rainfall events were in fact quite common, a major one occurring once every couple of years, and hence could explain some of the other rapid flow acceleration events recorded by other research groups working on the ice sheet,” says Hubbard.

#### **Timely rainfall catches the ice sheet off guard**

According to Doyle, it is not only the amount of rainfall that is important, but also the precise timing of this rain.

“The late-summer timing was critical. The event occurred after the end of the melt season and the ice sheet's drainage system had started to close down,” he says.

“In this closed-down state the ice sheet's drainage system just couldn't cope with the exceptional water inputs from melt and rain, and this is why the ice sheet reacted so dramatically, lifting off its bed and accelerating the flow of the ice towards the sea,” he says.

#### **Scientists expect more melt due to rain**

Box emphasises how climate change will continue to drive this process in the future.

“It is rain and warmer temperatures that cause melt, and we show that this melting trend has been underway for the last two decades as the atmosphere has warmed,” he says.

According to Hubbard a succession of these rain events would have a big impact on the ice sheet -- allowing it to melt more and move faster.

“By speeding up the ice sheet, we are effectively turning up the tap -- opening the sluice gate and hastening the speed at which the ice moves and melts and hence ends up in the ocean. But we don't yet know for sure how frequent or how intense these late-season rainfall events will be in the future,” he says.

Hanna echoes this caution.

“The trouble is we don't really have a clear prediction of how such events will change in frequency and intensity over Greenland with on-going climate change,” he says.

“But certainly this is another, now well-evidenced potential feedback that should be included in studies of ice sheet change during the rest of this century,” says Hanna.

 [Formation of lakes on the Greenland Ice Sheet after the main melt-season due to warm wet weather and heavy rain. Later this water drains to the bottom of the ice sheet enabling it to move and melt faster. This makes the ice sheet more vulnerable to such rapid melt events as the climate warms, scientists say in a new study. \(Photo: Sam Doyle\) \[6\]](#)

 [A monster moulin on the Russell Glacier, Greenland. You can see a helicopter for scale. These large gaping holes allow rain and melt water to drain quickly into the ice sheet. \(Photo: Alun Hubbard\) \[7\]](#)

 [A scientist watches melt water drain from the Russell glacier catchment in Greenland. Scientists do not yet know just how often these rapid melt events may occur in the future as the earth warms and Greenland receives more rain. \(Photo: Sam Doyle\) \[8\]](#)

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[Amplified melt and flow of the Greenland ice sheet driven by late-summer cyclonic rainfall. DOI 10.1038/ngeo2482 \[19\]](#)

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