AMOC ▪ This is not the first time scientists have warned of an imminent collapse in the North Atlantic ocean currents. It's also not the first time the prediction has met resistance. Have we become any wiser at all?

The climate scientist's dilemma

PETER HARMSEN

It started with a call from The New York Times, and then it went from blow to blow. In a short time, Susanne and Peter Ditlevsen, sister and brother and both researchers at the University of Copenhagen, had spoken to over 70 journalists from near and far. Television stations from Atlanta to Auckland wanted to interview them about the study they published in the prestigious journal Nature Communications last week.

What repeated itself in the vast majority of news articles was the siblings' startling prediction that a system of North Atlantic ocean currents, a crucial element of the globe's climate, could collapse due to global warming as early as 2025.

The ocean currents send warm water masses from the tropics northward, and no one knows exactly what will happen if the system shuts down, but it will be violent: Cold in Europe, drought in Africa, floods in North America are some of the possible consequences.

According to the study, these dramatic and irreversible processes – which in 2004 were given a prominent pop cultural expression in the Hollywood blockbuster The Day After Tomorrow, where a new ice age suddenly hits New York – can therefore begin in just two years. The sensational prediction has gone around the world: If you google "Ditlevsen" and "2025", the results come pouring out.

"We are actually a bit sad about 2025," says Peter Ditlevsen, a climate researcher at the Niels Bohr Institute.

What the article in Nature Communications actually does is outline a time period from 2025 to 2095 in which the ocean current is likely to reach a tipping point of no return. The risk of it happening very early in that period, or for that matter very late, is extremely small.

The year in which, according to the article, the tipping point is most likely to occur, and the globe will round a sharp corner, is 2057. That number has also been thoroughly covered in the world press. But it is also problematic, because it gives the impression of a precision which is basically not there at all:

"It may have been taken a little too literally. You have to understand that these are very uncertain calculations,' says Susanne Ditlevsen, professor of statistics, and points out that in practice there is often a kind of inverse proportionality between how accurate and how interesting a prediction is:

"The closer we are to the tipping point, the easier it is to estimate. But if you get all the way up to the tipping point, then we have observed that it has tipped, and then it is no longer very exciting to estimate when it will tip,' she says.

Sea surface temperatures can [...] literally change with the weather. I'm simplifying a bit, but surface temperatures really depend on much more than circulation in the ocean.

HALI KILBOURNE
Climate scientist

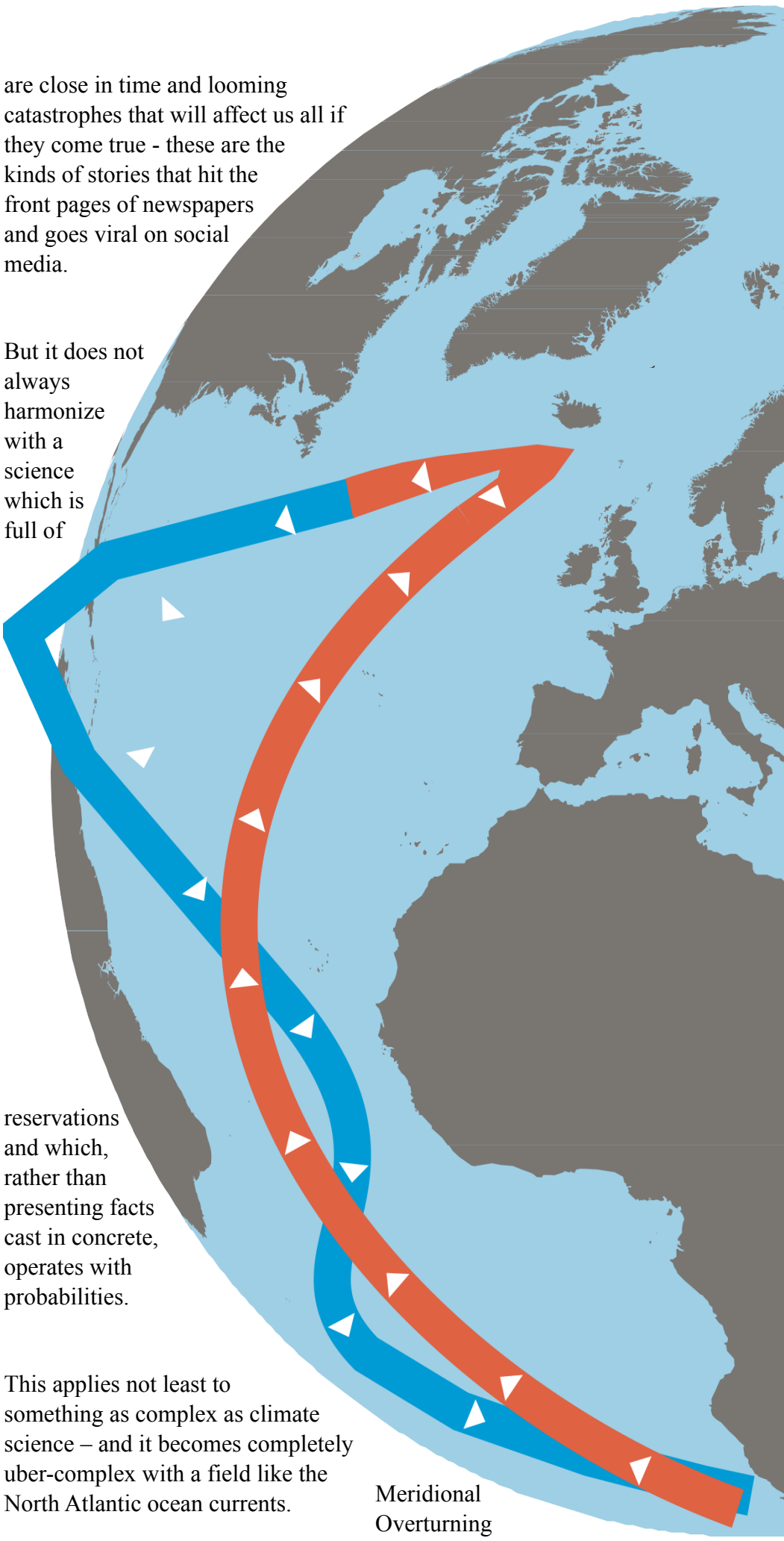
A sick body

Points like that tend to get lost in the news stream. In that sense, the case illustrates one of climate research's central dilemmas: concrete years that are close in time and looming catastrophes that will affect us all if they come true - these are the kinds of stories that hit the front pages of newspapers and goes viral on social media.

But it does not always harmonize with a science which is full of reservations and which, rather than presenting facts cast in concrete, operates with probabilities.

This applies not least to something as complex as climate science – and it becomes completely uber-complex with a field like the North Atlantic ocean currents.

Several of the early news articles mistakenly spoke of a collapse in the Gulf Stream - which is driven by the wind and therefore not on the way to a standstill - but in reality the study is about a more extensive system of ocean currents known as the Atlantic Meridional Overturning Circulation, which very painting is abbreviated AMOC.



The AMOC is a large system of ocean currents in the Atlantic Ocean, which is driven by differences in temperature and salinity. It works a

bit like a conveyor belt that transports hot water to the north and cold water to the south. Graphics: Andreas Peretti

In their study, Susanne and Peter Ditlevsen have looked at surface measurements of the temperature in the Atlantic Ocean, which go back to 1870. The intention has been to establish a picture of what was the "normal" state, before the greenhouse gases really started to make a difference, and temperatures became more extreme.

They have analyzed the 150-year time series based on a universal experience that a system approaching a tipping point becomes more and more unstable and makes larger and larger fluctuations.

Peter Ditlevsen compares it to the difference between a healthy and a sick body: If you do nothing wrong and it gets hot, you sweat. If it gets cold, you burn off sugar. In this way, the body keeps its temperature in place at around the vital 37 degrees. But if the fluctuations start to get bigger, it's a sign that something is wrong:

"If you get sick and the system becomes unstable, the fluctuations will be greater. Then you can become hypothermic or get a fever. It's the same thing we see here,' says Peter Ditlevsen.

He and his sister have therefore looked at how the fluctuations in temperature have developed:

"And here it is that, to our great horror, it has turned out that the tipping point is much, much closer than we had actually imagined. We really had to do the math and actually subsequently do much more advanced statistical calculations to substantiate it.'

Faster or slower?

The AMOC has been in the scientific spotlight for decades, and the potential collapse has been described in report after report by the UN Climate Panel, which so far does not see it happening this century.

Scientists are still debating what exactly weakens the AMOC and causes it to move towards a tipping point – if that is what it does, says Feng He, a climate scientist at the University of Wisconsin-Madison.

"If there is anything at all that can resemble a consensus in the area, it is that the melting of ice from, among other things, Greenland will lead to the AMOC flowing more slowly. But my own research suggests that even that is not necessarily consistent with the data,' he says.

Last year he co-authored a paper in Nature Climate Change which showed that at the end of the last ice age, when melting ice masses in the Northern Hemisphere sent enormous amounts of fresh water into the North Atlantic – so much so that the sea level rose by 50 meters – AMOC not weakened. It was actually strengthened:

"It is always difficult to make predictions, but when you also have to make predictions about something that we do not yet fully understand, it becomes even more difficult," notes Feng He.

So what are we going to do? We cannot go back in time and measure. We would like to have some direct measurements. We cannot have that. So must We take the measurements that are available.

SUSANNE DITLEVSEN
Statistician

In a situation where the fundamental dynamics surrounding the AMOC are the subject of discussion, researchers can instead be driven by data. If they have abundant amounts distributed over long periods of time, they can use them to extrapolate from the past into the future, as Susanne and Peter Ditlevsen have done.

But when it comes to the AMOC, researchers find it difficult to agree on what can fundamentally be accepted as relevant data.

It is only within the last two decades that precise measurements have been made. This has happened, among other things, with an ambitious project called RAPID, where moored instruments, submarine cables and satellites have been used to form a detailed picture of the situation in the Atlantic.

If you want to understand how the ocean current develops over the very long run, you have to go further back in time. And that requires the use of proxies – data that does not directly measure the AMOC, but which is expected to indirectly say something about the AMOC.

Two steps forward and one back

Susanne and Peter Ditlevsen's results have aroused both interest and skepticism in academic circles, and it is not the first time that a controversial announcement about AMOC has been met with criticism.

In 2005, a group of climate scientists at the UK's National Oceanography Center published an article in the journal Nature in which they claimed that over half a century, ocean currents had been reduced by 30 percent. They based this on a series of snapshot-like measurements of the temperature in the Atlantic Ocean made in 1957, 1981, 1992, 1998 and 2004.

Just two years later, an answer came in the form of an article in the journal Science, which was based on measurements from the RAPID project along the 26th north latitude. The figures showed that temperatures in the AMOC fluctuated significantly over very short periods of time, and the article's authors suggested that the values used in the 2005 study could be an expression of "fluctuations within individual years rather than a long-term trend".

In 2015, a new alarming study about the AMOC was published. Again, it was based on measurements along the 26th north latitude, where by now there were precise figures for a period of approximately ten years. The message was that the ocean current was decreasing every year by 0.5 sverdrup – a measure of flow speed – ten times faster than predicted by the climate models.

But already the following year a new paper was published which, using proxy data on the height of the sea level along the 26th parallel, was able to look back another decade, to the early 1990s, and then the average annual reduction in the AMOC was suddenly down to 0, 13 sverdrup – no longer significant enough for one to conclude that there was an actual decrease in sea currents over the long run.

At first glance, it may look like a series of false alarms: scary projections that attract a lot of attention for a short time, only to be shot down again without anyone being much the wiser. But you shouldn't see it that way, believes Levke Caesar, climate researcher at the University of Bremen, because there is a difference between a newspaper article and a scientific exchange:

"The new study itself mentions some of the caveats and should therefore not be read as a claim that the AMOC will collapse by 2095 at the latest," she says.

"Rather, it says that an interesting new method has been developed to determine a time period within which the AMOC will reach a tipping point, but so far it is based on indirect observations of the AMOC. It should inspire other researchers to improve their observed data.'

The principle of existing nails

It was only in the early 21st century that science, including the RAPID project, began to make extensive measurements of ocean currents. This is why researchers like Susanne and Peter Ditlevsen have to use surface temperatures when they want to look further back. But it is problematic, warns Hali Kilbourne, a climate scientist at the University of Maryland:

"It's quite controversial among scientists, and there's a good reason for that, because it's based on sea surface temperatures, and they can indeed be influenced by the AMOC, but they can also be influenced by what we call interaction between air and sea,' she says.

"The temperatures at the sea surface can therefore reflect an exchange of heat, which can literally change with the weather. I'm simplifying a bit, but surface temperatures really depend on a lot more than circulation in the ocean.'

Susanne Ditlevsen agrees that in an ideal world data could be better. But in the real world, you sometimes have to make use of the principle of existing nails.

"So what should we do? We cannot go back in time and measure. We would like some direct measurements. We can't have that. Then we have to take the measurements that are now available. It's the best we have,' she says.

It may remind a little of the pressure scientists were under in connection with covid-19, where they had to get to the bottom of the understanding of the coronavirus as quickly as possible, and the scientific process was accelerated to save lives.

"The issue is just so big and so important that I don't think we can afford to say that we're going to have to wait until we only have really, really high-quality measurements to say anything," says Susanne Ditlevsen.