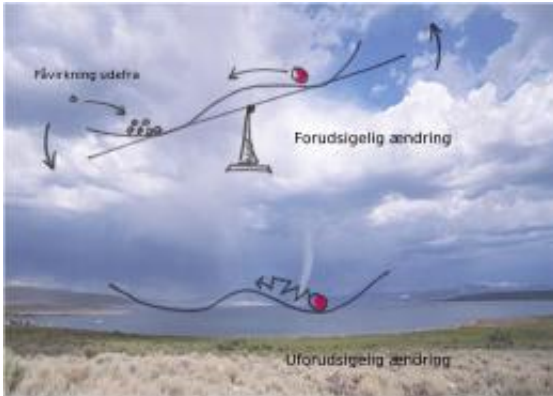


# Dramatic climate change is unpredictable

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This is a schematic picture of the climate represented by the red ball. The climate can be located in two different states, the two valleys on each side of a hill. In the first scenario the climate is like a seesaw. If the outside influences increase or, for example, increased CO<sub>2</sub> makes the weight heavier on the other side, the seesaw will tip forcing the climate over into the other state. The climate change would be predictable. In the second scenario, the hill is fixed and a series of small chaotic kicks from wind and weather could cause it to roll over into the other state. This climate change is unpredictable. Mathematically speaking, the first scenario is a "bifurcation" and the second scenario "noise-induced transition". Credit: Peter Ditlevsen

The fear that global temperature can change very quickly and cause dramatic climate changes that may have a disastrous impact on many countries and populations is great around the world. But what causes climate change and is it possible to predict future climate change? New research from the Niels Bohr Institute at the University of Copenhagen

shows that it may be due to an accumulation of different chaotic influences and as a result would be difficult to predict. The results have just been published in *Geophysical Research Letters*.

For millions of years the Earth's climate has alternated between about 100,000 years of [ice age](#) and approximately 10-15,000 years of a warm climate like we have today. The climate change is controlled by the Earth's orbit in space, that is to say the Earth's tilt and distance from the sun. But there are also other [climatic shifts](#) in the Earth's history and what caused those?

## **Dramatic climate change of the past**

By analysing the ice cores that are drilled through the more than three kilometer thick ice sheet in Greenland, scientists can obtain information about the temperature and climate going back around 140,000 years.

The most pronounced climate shifts besides the end of the ice age is a series of climate changes during the ice age where the temperature suddenly rose 10-15 degrees in less than 10 years. The climate change lasted perhaps 1000 years, then - bang - the temperature fell drastically and the climate changed again. This happened several times during the ice age and these climate shifts are called the Dansgaard-Oeschger events after the researchers who discovered and described them. Such a sudden, dramatic shift in climate from one state to another is called a tipping point. However, the cause of the rapid climate change is not known and researchers have been unable to reproduce them in modern [climate models](#).

## **The climate in the balance**

"We have made a theoretical modelling of two different scenarios that

might trigger climate change. We wanted to investigate if it could be determined whether there was an external factor which caused the climate change or whether the shift was due to an accumulation of small, chaotic fluctuations", explains Peter Ditlevsen, a climate researcher at the Niels Bohr Institute.

He explains that in one scenario the climate is like a seesaw that has tipped to one side. If sufficient weight is placed on the other side the seesaw will tip - the climate will change from one state to another. This could be, for example, an increase in the atmospheric content of CO<sub>2</sub> triggering a shift in the climate.

In the second scenario the climate is like a ball in a trench, which represents one climate state. The ball will be continuously pushed by chaos-dynamical fluctuations such as storms, heat waves, heavy rainfall and the melting of ice sheets, which affect ocean currents and so on. The turmoil in the climate system may finally push the ball over into the other trench, which represents a different climate state.

Peter Ditlevsen's research shows that you can actually distinguish between the two scenarios and it was the chaos-dynamical fluctuations that were the triggering cause of the dramatic climate changes during the ice age. This means that they are very difficult to predict.

## **Warm future climate**

But what about today - what can happen to the climate of the future? "Today we have a different situation than during the ice age. The Earth has not had such a high CO<sub>2</sub> content in the atmosphere since more than 15 million years ago, when the climate was very warm and alligators lived in England. So we have already started tilting the seesaw and at the same time the ball is perhaps getting kicked more and could jump over into the other trench. This could mean that the climate might not just

slowly gets warmer over the next 1000 years, but that major climate changes theoretically could happen within a few decades", estimates Peter Ditlevsen, but stresses that his research only deals with investigating the climate of the past and not predictions of the future climate.

**More information:** *Geophysical Research Letters* article:  
[www.agu.org/journals/gl/papers ... shtml#id2010GL044486](http://www.agu.org/journals/gl/papers ... shtml#id2010GL044486)

Provided by University of Copenhagen

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