Northumbria University NEWCASTLE

Taken from Rothera Research Station, Antarctic Peninsula by Dr Jan De Rydt.

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Scientists reveal the best and worst-case scenarios for a warming Antarctica

A new analysis of decades of research on the Antarctic Peninsula, involving experts from Northumbria University, concludes that the next ten years of climate action will decide Antarctica's future for centuries to come.

Pale expanses of ice keep water locked up and reflect heat from the planet in Antarctica — but the climate crisis is putting these safeguards under increasing pressure. Rising temperatures could destroy its ecosystems and put other parts of the planet at risk by driving sea level rise and damaging

food chains.

An international group of scientists modelling possible outcomes for the Antarctic Peninsula have outlined the best and worst-case scenarios for climate change in a new paper published in the scientific journal *Frontiers in Environmental Science*. The results demonstrate just how high the stakes are — but also how much harm can still be prevented.

“The Antarctic Peninsula is a special place,” said Professor Bethan Davies of Newcastle University, lead author on the paper published today. “Its future depends on the choices that we make today. Under a low emissions future, we can avoid the most important and detrimental impacts. However, under a higher emissions scenario, we risk the loss of sea ice, ice shelves, glaciers, and iconic species such as penguins.

“Though Antarctica is far away, changes here will impact the rest of the world through changes in sea level, oceanic and atmospheric connections and circulation changes. Changes in the Antarctic do not stay in the Antarctic.”

The scientists focused on the Antarctic Peninsula as a centre for research, tourism, and fishing which is very well-studied and vulnerable to anthropogenic changes, allowing them to track the effects of global warming on its ecosystem.

Using scenarios which estimate future emissions to model outcomes for the Antarctic Peninsula: low emissions (1.8°C temperature rise compared to preindustrial levels by 2100), medium-high emissions (3.6°C), and very high emissions (4.4°C), they looked at eight different aspects of the Peninsula’s environment affected by climate change. This included marine and terrestrial ecosystems, land and sea ice, ice shelves, the Southern Ocean, the atmosphere, and extreme events like heatwaves.

In higher emissions scenarios, the Southern Ocean will get warmer faster and accelerate the erosion of ice on land and at sea. The higher temperatures get, the more likely ice shelves are to collapse, driving sea level rise.

Professor Alison Banwell, a co-author on the paper from the Centre for Polar Observation and Modelling (CPOM) based at Northumbria University, carried out analysis of the impact on the Peninsula’s ice shelves.

She explained: “Ice shelves act as critical buffers against sea-level rise, holding back Antarctica’s land ice, yet their future remains highly uncertain.

They can appear stable for decades before collapsing rapidly once key structural or climatic thresholds are crossed, making these events difficult to capture in models.

“What this study shows is that the future of the Antarctic Peninsula — including its ice shelves — depends strongly on the emissions pathway we follow. Under lower emissions, many of these systems remain stressed but largely intact; under higher emissions, we cross thresholds that lead to irreversible change.

“The Antarctic Peninsula is already responding to climate change, but our study shows that decisions made in the coming decades will be crucial in terms of shaping its ice, ecosystems, and contribution to sea-level rise for centuries to come.”

Under the highest emissions scenario, sea ice coverage could fall by 20 per cent, devastating species that rely on it — such as krill, an important prey for whales and penguins — and amplifying ocean warming worldwide. Higher ocean warming would also stress ecosystems and contribute to extreme weather.

Although it’s difficult to predict how these environmental changes would combine to affect animals, the scientists expect that under very high emissions scenarios, many species will move south to escape higher temperatures. Warm-blooded predators may cope with temperature changes, but if their prey can’t, they will starve.

Chinstrap penguins on the Antarctic Peninsula taken by Professor Alison Banwell.

Dr Jan De Rydt, a co-author and researcher in polar glaciology and oceanography from Northumbria University's School of Geography and Natural Sciences, worked on modelling the impacts on land ice. He added: "It is clear that glaciers along the Antarctic Peninsula will continue to change rapidly in a warming world.

"Exactly how much ice will be lost, and the consequences for oceans and ecosystems, remains an active area of research, requiring integrated oceanographic, atmospheric and glaciological observations and modelling. The UK plays a leading role in this effort, with Northumbria University researchers at the forefront of developing numerical models that advance our understanding of Antarctica's future."

Researchers aren't safe from the consequences of climate change either: damage to infrastructure is making it more dangerous to carry out research, so it's harder to collect the data needed to forecast the future effects of climate change. Although numerical models simplify reality, more data makes them more accurate. However, the scientists emphasise that we must act now to avoid the worst-case scenarios.

"At the moment, we're on track for a medium to medium-high emissions

future," added Professor Davies. "A lower emissions scenario would mean that although the current trends of ice loss and extreme events would continue, they would be much more muted than under a higher scenario. Winter sea ice would be only slightly smaller than today, and sea level contributions from the Peninsula would be limited to a few millimeters. Most of the glaciers would be recognisable and we would retain the supporting ice shelves.

"What concerns me most about the higher emissions scenario is just how permanent the changes could be. These changes would be irreversible on any human timescale. It would be very hard to regrow the glaciers and bring back the wildlife that makes Antarctica special. If we don't make changes now, our great-grandchildren will have to live with the consequences."

Northumbria University is home to one of the world's leading research groups studying interactions between ice sheets and oceans. The team of researchers are working to explore the future of ice sheets and glaciers in a warming world. This involves understanding the causes of ongoing changes in Antarctica, Greenland and alpine areas, as well as assessing future changes and resulting impacts on human environments globally.

FURTHER INFORMATION:

B. Davies et al. The Antarctic Peninsula under present day climate and future low, medium-high and very high emissions scenarios was published in Frontiers in Environmental Science.

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