

# Where even the earth is melting

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THE world is on the cusp of a "tipping point" into dangerous climate change, according to new data gathered by scientists measuring methane leaking from the Arctic permafrost and a report presented to the United Nations on Tuesday.

"The permafrost carbon feedback is irreversible on human time scales," says the report, *Policy Implications of Warming Permafrost*. "Overall, these observations indicate that large-scale thawing of permafrost may already have started."

While countries the size of Australia tally up their greenhouse emissions in hundreds of millions of tonnes, the Arctic's stores are measured in tens of billions.

## Arctic permafrost

Climate change scientists warn the rate of melting of permafrost in the Arctic could cause significant impact to the environment. Pictures courtesy of an Australian documentary team from Unboxed Media, which is producing a series called Tipping Points, to be aired in 2013.

Human-induced emissions now appear to have warmed the Arctic enough to unlock this vast carbon bank, with stark implications for international efforts to hold global warming to a safe level. Ancient forests locked under ice tens of thousands of years ago are beginning to melt and rot, releasing vast amounts of greenhouse gases into the air.

The report estimates the greenhouse gases leaking from the thawing Arctic will eventually add more to emissions than last year's combined carbon output of the US and Europe – a statistic which means present global plans to hold climate change to an average 2degree temperature rise this century are now likely to be much more difficult.

Until very recently permafrost was thought to have been melting too slowly to make a meaningful difference to temperatures this century, so it was left out of the Kyoto Protocol, and ignored by many climate change models.

"Permafrost emissions could ultimately account for up to 39 per cent of total emissions," said the report's lead author, Kevin Schaefer, of the University of Colorado, who presented it at climate negotiations in Doha, Qatar. "This must be factored in to treaty negotiations expected to replace the Kyoto Protocol."

What isn't known is the precise rate and scale of the melt, and that is being tackled in a remarkable NASA experiment that hardly anyone has heard of, but which could prove to be one of the most crucial pieces of scientific field work undertaken this century.

The findings, for now, are still under wraps. "But I think 'tantalising' is probably the right word," said Charles Miller, the principal investigator in NASA's Carbon in Arctic Reservoirs Vulnerability Experiment, or CARVE.

His office is a rugged little Sherpa passenger aircraft, stripped of seating and packed with electronics and sensors. Each day, the plane criss-crosses the ice fields, forests and tundra of Alaska, skimming along at low altitude, hugging the contours of the ground.

"I've seen the annual migration of the caribou – thousands of animals in a single line stretching for 10kilometres along a ridge, led by a bull with giant antlers," Professor Miller said. "There are grizzly bears in the forests, and moose wallowing in lakes – it's just incredibly beautiful up here."

But it isn't the scenery that brought them to Alaska. What the scientists are searching for is invisible to the human eye – the haze of methane and CO<sub>2</sub> that hovers low over the landscape in summer as the permafrost melts.

"We fly like a rollercoaster, in a flight line that touches the 'boundary layer' [a layer where the air from the ground mingles with higher altitudes] and then we fly down, and come straight back up. We keep doing that repeatedly," Professor Miller said.

The plane dips in and out of the methane plumes, sucking up data that hints at the extent and speed of the permafrost melt.

"We're finding very, very interesting changes, particularly in terms of methane concentrations," he said. "When scientists say 'interesting', it usually means 'not what we expected'. We're seeing biological activity in various places in Alaska that's much more active than I would have expected, and also much more variable from place to place ... There are changes as much as 10 to 12 parts per million for CO<sub>2</sub> – so that's telling us that the local biology is doing something like five or six years worth of change in the space of a few hundred metres."

Methane is not present in the frozen soil, but is instead created as the earth thaws and organic matter is consumed by tiny organisms.

"If the Arctic becomes warmer and drier, we will see it released as carbon dioxide, but if it is warmer and wetter it will be released as methane."

The findings of the first year of the experiment are so complex that Professor Miller and his team at NASA's Jet Propulsion Laboratory are still trying to work out exactly what they have found. The results are being kept secret, which is standard practice while the numbers are crunched and the work is submitted to a peer-review process.

"What we can say is that methane is significantly elevated in places – about 2000 parts per billion, against a normal background of about 1850 parts per billion," he said. "It's interesting because the models are predicting one thing and what we are observing is something fairly different."

The rate of melt was "deeply concerning", said Andy Pitman, the director of Australia's Centre of Excellence for Climate System Science, an adviser to the Climate Commission, and a lead author of the Intergovernmental Panel on Climate Change's reports.

"It had been assumed that on the timescale of the 21st century, that the effects of methane release would be relatively small compared to other effects – that's why it has been largely left out of the climate models," Professor Pitman said.

"I think it's fair to say that until recently climate scientists underrated the rate at which permafrost melt could release methane. I think we've been shown to be over-conservative. It's happening faster than we had thought ... This is not good news."

The report presented to the UN said a tipping point could still be averted if the world moved to cut emissions from fossil fuels fast.

"The target climate for the climate change treaty is not out of date," Professor Schaefer told Fairfax Media. "However, negotiation of anthropogenic emissions targets to meet the 2 degree warming target must account for emissions from thawing permafrost. Otherwise, we risk overshooting the target climate."

The report pointed out that permafrost carbon feedback had not been included in the Fourth IPCC report, the most recent update from the UN's climate body, published in 2007.

"Participating modelling teams have completed their climate projections in support of the Fifth Assessment Report, but these projections do not include the permafrost carbon feedback," the report said. "Consequently, the IPCC Fifth Assessment Report, due for release in stages between September 2013 and October 2014, will not include the potential effects of the permafrost carbon feedback on global climate."

The cost of this omission could be high if measured in financial terms, according to Pep Canadell, a CSIRO scientist and executive director of the Global Carbon Project, which tallies how much CO<sub>2</sub> humans can release before the climate can be expected to warm to dangerous levels.

"If you were to take the price of a tonne of carbon to be \$23 like Australia does, you are looking at an extra cost of about \$35 billion for the permafrost," Dr Canadell said. "That's on top of the hundreds of billions we already know it will cost to slow emissions to reach a 2degree level. It's a significant problem in the carbon budget."

The evidence that major change is already happening is trickling in not just from the NASA measurements, but from ground-based tests.

"There is compelling evidence, not just that permafrost will thaw, but that it is already rapidly thawing," said Ben Abbott, a researcher at the Institute of Arctic Biology at the University of Alaska, Fairbanks.

"Borehole measurements, where temperature readings are taken at multiple depths within the soil, show more than 2 degree soil warming in some areas of Alaska. While that may not sound like much, a lot of permafrost is at or just below freezing. The difference between minus 1degree and 1degree is the difference between a fresh frozen meal and a rotten mess."

In a piece in the journal *Nature*, Mr Abbott and fellow researcher Edward Schuur from the University of Florida summarised recent findings from experts in the field.

About 1700 billion tonnes of organic carbon is held in frozen northern soils, they said – about four times more than all the carbon emitted by human activity in modern times and twice as much as is present in the atmosphere now. The impact of thawing soil on the speed of climate change will be similar to the total rate of logging in all forests around the world, they calculated.

"Our collective estimate is that carbon will be released more quickly than models suggest, and at levels that are cause for serious concern," they wrote. "We calculate that permafrost thaw will release the same order of magnitude of carbon as deforestation if current rates of deforestation continue."

Like Professor Miller, Mr Abbott's job involves long expeditions into the Alaskan tundra.

"I think it's easy for people to feel that the Arctic is just a far away place that will never have any direct effect on their life," he said. "[But] the last time a majority of permafrost carbon was thawed and lost to the atmosphere, temperatures increased by 6degrees. That's a different world. Too often climate change is depicted as a story of drowning polar bears and third world countries. Human-caused climate change has the potential to change our way of life. Mix in the potent feedbacks from the permafrost system and it becomes clear that we need to act now."