

Bugs, bogs and gravity: *a new look at methane*



A peat bog on Fairfield in the Lake District National Park.

Wetlands are the largest source of methane but until now we have not understood how changes in these natural emissions affect concentrations of methane in the atmosphere. Paul Palmer and Anthony Bloom describe how they used satellite observations to reveal new insights into this greenhouse gas.

Methane is the poor cousin of carbon dioxide (CO₂), often mentioned in passing when the subject of greenhouse gases is raised but rarely the focus of discussion. But should it be? Sure, there is roughly 200 times more CO₂ in the atmosphere than methane, largely because methane is removed from the atmosphere relatively quickly, with an ‘atmospheric lifetime’ of 9 years. But as a greenhouse gas methane is about 25 times more potent than the same amount of CO₂. Calculations from the 2007 Intergovernmental Panel on Climate Change (IPCC) report showed that over a 20-year period methane has as much impact on the climate as CO₂. The oxidation of methane in the atmosphere also helps to determine the concentration of ozone in the lower levels of the atmosphere, so methane has a significant indirect effect on climate too. Elevated levels of ozone are linked to human respiratory illnesses and falling agricultural crop yields, both of which have measurable economic consequences. So it is clear that controlling emissions of methane is important for mitigating global warming in the short term and as part of a more comprehensive strategy to reduce greenhouse gas emissions.

Between 1984 and 2009, the amount of methane in the atmosphere increased by 10 per cent – 165 parts per billion (ppb). While this increase was fairly steady up until 2006,

in 2007 methane concentrations started to rise almost simultaneously at all latitudes. What changed over this period? Scientists have suggested a number of hypotheses based on sparse surface data but did not reach any firm conclusions.

Our project went into space for a closer look. We used methane observations from the SCIAMACHY satellite instrument, which measures how solar radiation is absorbed by the atmosphere. These observations contain information about the processes that release and destroy methane and about the winds that blow the gas around the atmosphere. But there is nothing in the satellite measurement that can tell us which surface processes cause the atmospheric variations. Other gases showed no evidence of large changes in the man-made sources of methane or in the surface or atmospheric processes that consume methane (known as ‘sinks’). This led us to study changes in the wetland source of methane.

Wetlands – bogs, fens and swamps for example – are the single largest source of methane. Methane is produced by microbes under anaerobic conditions and is consumed by other microbes under aerobic conditions – a wonderful example of how some of the smallest components of the climate system help determine the evolution of the Earth’s climate. The net amount of methane emitted by wetlands is determined by temperature,

water level and organic carbon content, with temperature generally playing a larger role at high latitudes and water availability being more significant at low latitudes. We used output from a numerical weather model for surface temperature changes, but for changes in water level we once again looked to space, this time the GRACE satellites. These can measure very small changes in gravity, some of which can be related to changes in groundwater level.

Our next step was to develop a mathematical model to investigate how atmospheric methane changed with temperature and water levels between 2003 and 2005, combining the weather model output and satellite data with information on global wetland emissions from the IPCC report. When we tested our model over the period 2003-2007 we found that global wetland emissions increased steadily, peaking in 2007. This was mainly due to increased emissions at mid-high northern latitudes, with the large increase in 2007 due to warming at high northern latitudes and increased precipitation in the tropics – a result that agreed with the analysis of the surface data.

So, what next? Our analysis has shown that even moderate changes in warming at high northern latitudes or precipitation at low latitudes can lead to a substantial release of methane into the atmosphere. Other (unpublished) work suggests that currently emissions of methane from wetlands are not growing, which means we have not yet reached the warming necessary for a self-sustained runaway increase in emissions. Reaching this level of warming would eventually result in the release of a huge amount of methane currently trapped underneath the permafrost.

How close we are to this point, or indeed whether it exists, is uncertain. But the combination of surface and satellite

measurements has been important. Detailed surface data can be used to advance our understanding of how individual wetlands respond to changes in climate. Satellite data can be used to relate this information to the globe, effectively mapping these large vulnerable regions to help develop and monitor land-use policy. Such policy lies at the centre of managing wetland emissions but there is currently no consensus as to what an effective long-term strategy would be. What is clear is that integrated research activities like these are fundamental to the development of sensible approaches to limiting climate change caused by methane.

MORE INFORMATION

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The NERC-funded MethaneNet project promotes integrative research activities. www.methanenet.org.uk

FURTHER READING

Bloom, AA, Palmer, PI, Fraser, A, Reay, DS and Frankenberg, C (2010) Large-scale controls of methanogenesis inferred from methane and gravity spaceborne data. *Science* 327, 322-5.

GLOBAL BUDGET ESTIMATES FOR ATMOSPHERIC METHANE IN RECENT YEARS (Terragram/year)

A terragram (Tg) is 10^{12} grams.

