The tundra—a dark horse in planet Earth's greenhouse gas budget

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Zackenberg Research Station in Northeast Greenland was established in 1995 and has since become one of the best platforms for research and monitoring in the Arctic thanks to the ongoing monitoring programs. The buildings in Zackenberg are owned by Greenland's Self Government, whereas operation and maintenance are undertaken by Aarhus University. Credit: Henrik Spanggård Munch, Aarhus University

There are huge amounts of organic carbon in the soil beneath the tundra that covers the northernmost woodless areas of the planet. New research findings from Aarhus University show that the tundra may become a source of CO2 as the climate becomes warmer.

Vast areas on the Northern Hemisphere are covered by tundra. Here,

dwarf shrubs, sedges, mosses etc. thrive on top of permafrost in areas where only the uppermost soil layer thaws during the short Arctic summer.

New studies show that the tundra may become a source of CO2 in the future. Researcher Magnus Lund from Aarhus University explains: "The soil below the tundra contains very large quantities of carbon – more than twice as much as is present in the planet's entire atmosphere. Therefore, we would like to know if the carbon will stay put – or if it will be released into the atmosphere as CO2 or methane as the climate warms."

Since 2000, researchers in Zackenberg in Northeast Greenland have therefore studied the carbon balance by exploring the following two figures:

1. The amount of carbon released in the form of CO2 as living organisms respire

2. The amount of carbon being stored in plants owing to photosynthesis.

Once you have established the two figures, it is possible to calculate if the tundra is a source of CO2 or if it acts as a sink absorbing carbon and storing it in living plants or in the peat layer.

"We can see that the annual release of CO2 from living organisms increases linearly as the temperature increases, measured as the average temperature in July. However, it seems that the ability of the photosynthesis to assimilate carbon stops increasing when the temperature in July rises above approx. seven degrees Celsius, which has occurred several times in past years. This means that the tundra may become a CO2 source if the current strong climate warming continues as expected," says Magnus Lund, before pointing out that the fear that the

tundra can develop into a source of CO2 is based on a very limited number of measurements.

This image shows measuring equipment in Rylekæret fen, Zackenberg. The lawn-chair-like devices at the end of the boardwalk measure the exchange of methane and CO2 between the fen and the atmosphere. To the left is: a gradient system for measurement of the exchange of methane between the tundra and the atmosphere. Even though many of the measurements can now be made automatically, it is necessary to check the equipment regularly to ensure that everything is in good working order. Credit: Photo: Laura Helene Rasmussen, Aarhus University

"It's a problem in the Arctic that we don't perform measurements at enough locations. The variation between locations is substantial both for CO2 and not least for methane. In Greenland, we measure near Nuuk and in Zackenberg, where we collect measurements from a relatively dry heath and from a moist fen area. A new station is also being established at Station Nord in the northernmost part of Greenland."

Methane remains more important

Magnus Lund emphasises that, in decades to come, from an Arctic

perspective, methane will remain the primary contributor to Earth's greenhouse gas budget. In 2007, researchers from the Zackenberg research station in Northeast Greenland made a surprising discovery: In autumn, when the surface of the tundra freezes and ice is formed, large quantities of the powerful greenhouse gas methane are released. In fact, the quantities released were so large, that the annual methane emissions had to be doubled in the calculation of the tundra's methane budget.

Methane is a powerful greenhouse gas, its effect is 20-25 times as strong as that of CO2. Methane, therefore, still plays a central role for the research performed at Zackenberg.

Soil moisture crucial

Recent studies have shown that the formation of methane is closely linked to the tundra's water content - as implied by the term "swamp gas". The more water is present in the tundra, the more methane is formed. And vice versa, where there is less water, the presence of oxygen will provide the basis for formation of CO2. In this way, the soil's water content plays an important role in determining what will happen with the carbon below the tundra.

Areas that become drier will give rise to increased CO2 emissions, whereas areas that become more moist will cause the emissions of methane to increase. The water balance is affected by the temperature and precipitation, but also by the soil's content of ice.

Among other things, researchers are now working to establish how and when the methane released in autumn is formed, and if this involves new or old carbon.

More information: Trends in CO2 exchange in a high Arctic tundra heath, 2000–2010. M. Lund et al. 2012, *Journal of Geophysical*

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