Science for Environment Policy
DG Environment News Alert Service
European Commission

1 December 2011

Thawing permafrost could lead to higher carbon emissions

Permafrost and wetlands in high latitudes could switch from carbon sink to carbon source by the end of the century, according to a recent study. Using a model of terrestrial ecosystems that showed how carbon is stored and released in soils at high latitudes, researchers revealed that climate change could cause these soils to release much more carbon than previously predicted.

Many climate change policies are based on the IPCC's Fourth Assessment Report, published in 2007. In this assessment, the terrestrial biosphere models predicted that warmer northern regions would act as carbon sinks, locking more carbon away in soils as plant growing seasons lengthened. However, the models did not include a detailed description of the carbon in permafrost (frozen soil). The permafrost regions concerned are fully covered by the Soil Atlas of the Northern Circumpolar Region[1], published by the European Commission in 2010. For policymakers, the results of this new study suggest that earlier predictions of the rate of climate change may be underestimates. Future policy decisions need to recognise that northern ecosystems could shift from being a sink to a source, exacerbating the problems caused by CH_4 and CO_2 emissions from human activities. The issue of greenhouse emissions in northern soils is controlled by soil moisture. Wet ground conditions will cause methane emissions, but little CO_2 and the accumulation of peat. Drier conditions lead to the oxidsation of the peat, thus emitting CO_2. Thawing permafrost is expected initially to provide wet ground as the ice content melts. But the lack of water-logging in warmer, drier conditions will eventually lead to soils with significantly lower carbon content.

The researchers, with support from the EU-funded COMBINE project[1], developed a terrestrial ecosystem model, based on the ORCHIDEE model, which included a detailed description of soil carbon. Unlike the models used by the IPCC's 2007 assessment, the researchers' model featured discrete vertical layers of soil carbon and better soil physics. Using this, the researchers ran four different simulations. The first, the control, used just the detailed soil carbon layers. In the second, called 'freeze', winter temperatures inhibit the decomposition of carbon in soils. The third, 'permafrost', added permafrost layers and the fourth, 'heat', added the heat generated by microbial activity in the soil. As well as looking at CO2 emissions from permafrost, the researchers also looked at the effects of climate change on the release of methane from wetlands, a potent greenhouse gas, with a warming potential about 25 times stronger than CO_2.

Running the modified ORCHIDEE model through a climate change scenario between 1860 and 2100 suggested that high latitude soil temperatures would increase by around 8ºC (the global temperature rise of the scenario) and the area covered by permafrost would shrink by around 30%. In the control experiment, the higher temperatures increased the amount of plant growth as the growing season increased by 37 days between 1990 and 2100. This sequestered more carbon in soils and counterbalanced the associated increase in CO_2 emissions from respiration. The result was a small net release of CO_2. However, the other three experiments all found that increased productivity and carbon sequestration was countered by a greater release of carbon already stored in soils.

The 'freeze' experiment found that higher starting levels of carbon in the soils and greater heat sensitivity led to a net release of around 25 petagrams (Pg) of carbon (1 petagram = 1 billion tons). The permafrost experiment suggested a greater release, 62Pg, as the old carbon stored in permafrost decomposed over the warmer summer months. Finally, the microbial heat accelerated the thawing of the permafrost, leading to a loss of 85Pg. In these final two experiments, the greatest loss of carbon from permafrost occurs in central Canada, and the effect of microbial heating is particularly strong in Eastern Siberia. Rising atmospheric CO_2 levels also lead to increased productivity in wetlands, while temperature rises lead to shrinking wetland areas; the net result is a release of 41 to 57 teragrams of methane (1 teragram = 1 million tons). But the researchers caution that there are uncertainties around their results, as high latitude ecosystems are complex and their model simplifies the processes involved.

1. Jones, A., V. Stolbovoy, C. Tarnocai, G. Broll, O. Spaargaren and L. Montanarella (eds.), 2010, Soil Atlas of the Northern Circumpolar Region. European Commission, Office for Official Publications of the European Communities, Luxembourg. 142 pp

2. Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection (COMBINE) was supported by the European Commission under the Seventh Framework Programme. See: www.combine-project.eu

Source: Koven, CD, Ringeval, B., Friedlingstein, P., *et al.* (2011) Permafrost carbon-climate feedbacks accelerate global warming. *Proceedings of the National Academy of Sciences*. 108(36): 14769-14774. **Contact:** cdkoven@lbl.gov **Theme(s):** Climate change & energy, Soil