Introduction
Scotland’s vast blanket bogs might not look very special at first glance, but the health of this unique ecosystem is crucial in our efforts to curb climate change. Peat holds approximately one third of the world’s soil-based stores of carbon – a quantity roughly equivalent to all the carbon currently present in the atmosphere. The UK’s peatlands also play an important role in preventing flooding and providing local communities with clean water. However, these natural services are lost as peat soils degrade due to draining, grazing livestock and forestry.

The Basics
Peat is formed in waterlogged soils, where the lack of oxygen prevents microbes from decomposing dead plants and animals. This means that peatland soils are 95% water and incredibly rich in organic matter, making them an important store of carbon.

Waterlogged, healthy peat bogs tend to grow at a rate of about 1 - 2mm per year. When water is drained from the peatland, microbes start eating away at the bog, reducing the height of the bog and releasing carbon into the atmosphere in the process.

As spongy peat soils gain and lose water, gases or organic matter, they can gradually rise and fall, like slow-motion waves on the ocean.

Because of the sheer scale of peatlands – they cover 23,000 square kilometres in the UK alone – it is challenging to monitor their health, especially over long time periods. David Large (University of Nottingham) and his team tested a novel radar imaging technique for visualising the motion of the peat soil surface to remotely monitor peatland health – a task that would otherwise be laborious and extremely expensive.

Counter-intuitively, “it’s easier to measure that motion by satellite rather than measuring in the field with a pole”, said Large.

Key Findings
- Satellite-based radar can accurately estimate the surface motion of peatland soils across large areas.
- The annual ebb and flow of peat depends on the type of vegetation, which can tell us about the health of the soil below.
- Severe drought flattened the normally domed shape of peat bogs and these effects could take decades to recover.
Methodology
The researchers used a novel satellite-based imaging technique known as ‘interferometric synthetic aperture radar’ (InSAR) to visualise the movement of the surface of Scottish peat bogs. They used field tests to validate the results and evaluate how well this remote sensing technique is able to detect changes in peat height. The team produced a near-continuous 4-year map of the surface motion of two peatlands sites in Scotland’s Flow Country, with measurements taken by satellite every 6 days.

Results
They found that the InSAR results agreed with their ground measurements over three quarters of the time, suggesting that the technique could be widely used to monitor the motion of peatland surfaces. “This is giving you a view of the hydrology of huge areas simultaneously in a way that scientists have never seen it before”, said Large. “It’s like having a new view … of the dynamic movement of peatland”.

However, around one third of ground samples differed substantially from the radar-based estimates. These were all taken in the wettest areas during a severe drought, when peat surface moved faster than the detection limit of the technique. Just like radar navigation devices, InSAR bounces microwaves off the surface of the ground to calculate its distance, meaning that the technique cannot accurately measure very abrupt changes in surface height.

During severe droughts in 2018, the soil dropped by an average of 3cm in just 6 days, meaning that InSAR was unable to accurately estimate the change in height.

The team found that the annual pattern of surface height depends on the type of vegetation present. Wet, healthy peatlands tend to be dominated by mosses and reach their peak height in mid-winter, whereas drier peatlands are often dominated by heather and reach peak height in early spring. Large says this probably relates to the way the different plants regulate water – mosses cannot actively move water out of their leaves, whereas heathers will keep pumping moisture into the atmosphere even as the bog starts to dry out.

The signature of annual oscillations can therefore tell us a lot about the health of a peat bog. “If it has a signal that’s indicative of mosses, then that’s good, because mosses will tend to dominate areas of wet peatland, and if it’s wet, it will tend to be accumulating carbon in the long-term”, said Large.

The researchers discovered that drought can have a long-term impact on the shape and characteristics of a peat bog. Peatlands tend to have a domed shaped, with higher, wetter soils in the centre. Satellite radar measurements showed that during the 2018 drought the centre of bogs collapsed, flattening the domed shape.

After the drought, the centre was much slower to recover and remained water logged for longer. “Ironically from a scientific point of view, the consequence of drought was that the bog became wetter”, said Large.

Contact Details: Dr David Large (David.Large@nottingham.ac.uk)

Broader Implications
- InSAR could be used as a cheap, large-scale surveying method to identify degraded areas of peatland for targeted restoration programmes, as well as being a useful tool to monitor changes in peat soil health over time.
- The technique could also be a useful tool to monitor the resilience of peatland to climate change.
- Agencies that are investing in peatland restoration often have no affordable way to monitor the success of their interventions on a large scale.

InSAR is new a tool that can be used to “cost-effectively validate the success of their investments” - David Large

A representation of the InSAR method. InSAR uses radar waves to create a map of the changing soil height.