

Methane Bubbles – what they can tell us about the impacts of global temperature changes

The arctic regions are expected to suffer the brunt of any temperature increases associated with global warming. A major change concomitant with warming is the release of carbon in the form of methane through the thawing of ice.

The thawing of permafrost (soil that is at or below the freezing point of water), threatens to release carbon into the atmosphere in the form of vast amounts of methane, a greenhouse gas some 23 times more potent in terms of warming than CO₂. The primary natural source of methane (CH₄) is microbial decay of organic matter under oxygen-free conditions in wetlands. As permafrost melts, it forms lakes which account for the majority of permafrost-derived methane emitted to the atmosphere via ebullition (bubbling). Previous studies appear to have grossly under-estimated the true rate of methane emission because random-sampling techniques can miss the ebullition sources, which occur in hotspots with little background emission. Permafrost degradation has already been linked to changes in vegetation composition, ecosystem functioning and the damaging impacts of permafrost degradation-induced subsidence on civil infrastructure.

Because there are significant uncertainties about the amounts of atmospheric methane, better measurements of this gas are needed to improve the accuracy of climate change estimates. A new research project aims to address these issues by pioneering a novel technique for measuring methane ice bubbles trapped within lake ice. As ice forms in autumn, bubbles released from lake sediments are trapped, resulting in stacks of ice bubbles separated by thin films of ice. With seed-corn funding provided through the Centre for Earth Observation Instrumentation (CEOI), the University of Cranfield is currently investigating this.

Environmental Measurements from Space

The work uses the Synthetic Aperture Radar (SAR) backscattering technique to show the characteristics of ice-bubble mixtures. This is based on laboratory measurements of simulated ice-bubble mixtures made from artificial materials. If satellite-based SAR can provide quantitative measurements of the presence of methane bubbles, it will provide a much needed observation technique for constructing regional and pan-arctic estimates of current and future methane fluxes. Many recent pan-arctic studies show that permafrost extent is shrinking and that the upper portion of soil that thaws each summer



(Photo by Michael Runtz)

is increasing. Some projections of permafrost melt forecast the current 10.5 million km² extent of near-surface permafrost will shrink to as little as 1.0 million km² by 2100.

An indoor measurement facility has been created at Cranfield University within the Department of Informatics and Systems Engineering, in order to simulate the radar properties of ice containing methane bubbles. Dry sand is used in place of ice, as it has a very similar response to a radar wave. Voids simulating gas bubbles are created using expanded polystyrene within the sand. The work will provide an understanding of how the reflections are dependent on the size, shape and density of the bubbles. It also seeks to identify what effect the radar frequency and the angle the bubbles are viewed from has on the signal returns. A new in-house imaging technique known as tomographic profiling provides vertical slices of the radar returns through the ice volume, allowing separation of the ice and bubble signals.

Not just for bubbles

The main aim of this CEOI project is to establish optimum techniques for bubble identification and characterisation, with consideration to existing and future space SAR platforms. Because methane bubbles can range in size from centimetres to metres in diameter, a combination of imagery from multiple satellites working in different parts of the frequency spectrum may offer the best prospect for providing the required measurements. Knowledge of methane emissions is important in its own right, but also provides essential information on the degradation of permafrost, snow cover and freeze-thaw processes, and therefore is likely a strong indicator of climate change. As well as being of great interest to climate modelers, and to those interested in land/atmosphere interaction and exchange, this novel technique could also be applicable to other environmental applications. In addition, because it can measure scattering structure, it could also provide information on forestry canopy and layering in soil.

Further information about this technology and others funded by the CEOI can be found at www.ceoi.ac.uk. You can also contact the Project Lead - Dr Keith Morrison tel: +44 (0) 1793 785473, email:k.morrison@cranfield.ac.uk or the CEOI Director, Professor Mick Johnson: Tel: +44(0)1438 774421, email: mick.johnson@astrium.eads.net.

Notes to Editors:

The Centre for Earth Observation Instrumentation (CEOI) is a catalyst for the development of technologies for environmental and security monitoring from space. The CEOI was created in 2007 and is jointly funded by the Natural Environment Research Council (NERC), the Technology Strategy Board, and industry. The Centre has a key aim to develop the next generation of Earth observation instrumentation through the teaming of scientists and industrialists and the funding of leading edge projects. These projects reflect the imperatives associated with monitoring of climate change and the environment - investing in clearly identified gaps in instrumentation requirements, thus maximizing impacts of UK developed technologies in European programmes. The CEOI is led by Astrium Ltd, in partnership with the University of Leicester, Science and Technology Facilities Council / Rutherford Appleton Laboratory and QinetiQ Ltd.