

## The Tropical Carbon Mission (TCM): quantifying tropical carbon fluxes from space

The Tropical Carbon Mission (TCM) is a proposed bilateral Earth Observation mission between the UK and US space agencies for launch in 2015/2016. TCM will measure columns of CO<sub>2</sub>, CH<sub>4</sub> and CO over the tropics to a precision sufficient to infer the underlying emission and uptake of CO<sub>2</sub> from natural and anthropogenic activities to help inform science and policy inquiries.

### Why is TCM needed by scientists and policy makers?

The importance of CO<sub>2</sub> and CH<sub>4</sub> in climate is well established. There is broad scientific consensus that human activities are the main driver for increasing concentrations of these greenhouse gases (GHG), particularly over the past century. On average less than half of the CO<sub>2</sub> emitted by human activities stays in the atmosphere, with the remaining balance taken up by global oceans, terrestrial vegetation and soils. However, there are substantial uncertainties associated with the location, strength and durability of these natural components of the carbon cycle. The tropics and sub-tropics are regions of key importance for the global carbon cycle. These diverse and productive ecosystems are subject to rapid environmental change due to extensive deforestation and urbanisation, with consequent changes in hydrology and regional carbon balance. However, GHG fluxes in the tropics and southern-hemispheric sub-tropics are poorly constrained by the existing network of surface measurements. Consequently, the tropics and sub-tropics remain poorly characterized compared to other ecosystems on the planet and dense and frequent observations are urgently needed to improve our understanding of the tropical carbon cycle. Anthropogenic GHG emissions are receiving increased attention from the international policy communities, such as the United Nations Framework Convention on Climate Change, and from the financial sector, as carbon trading becomes more prevalent. A key challenge for monitoring anthropogenic emissions is that they are embedded within a dynamic, natural carbon cycle with much larger fluxes into and out of the atmosphere and thus require a better understanding of the processes involved in this global carbon cycle. Observations of CO<sub>2</sub> and CH<sub>4</sub> over the tropics with the precision and frequency that are required by scientists, policy makers and carbon markets is an unmet technical challenge, which will be addressed by the TCM mission. Without such observations we cannot obtain the required step-wise change in current understanding of the tropical and global carbon cycle as needed for improved predictions of the future climate and it will be impossible to move far forward with establishing a robust emission verification scheme that is critical in reducing global GHG emissions.

### Science Objectives

The primary science and economic objectives of TCM are to reduce overall uncertainties in the magnitude and distribution of tropical CO<sub>2</sub> fluxes, and to improve our understanding of the tropical carbon cycle. These will result in more reliable climate change forecasts and contribute to the verification of anthropogenic emissions as part of international treaty agreements. By better estimating tropical fluxes, we also improve the efficacy of existing surface measurement networks to help estimate extra-tropical CO<sub>2</sub> fluxes.

The secondary science objectives of TCM are: 1) to reduce the uncertainties in the magnitude and distribution of CO and CH<sub>4</sub>; and 2) use concurrent measurements of CO and CH<sub>4</sub> to improve source attribution of observed variations in CO<sub>2</sub>. (NB. CO is an excellent atmospheric tracer of incomplete combustion, which will be used to help distinguish between the release and uptake of CO<sub>2</sub> from combustion and natural sources.)

The tertiary science objective of TCM is to complement global survey CO<sub>2</sub> measurements from the NASA OCO-2 instrument, which will be launched in a sun-synchronous orbit in 2013.

### Mission Overview

TCM will be launched in a low Earth orbit at an inclination of 35° to enhance coverage over the tropics. TCM will carry two mature instruments: (1) a copy of the visible/short-wave IR (SWIR) spectrometer that the NASA/Jet Propulsion Laboratory (JPL) has developed for the Orbiting Carbon Observatory (OCO) missions; and (2) a version of the SWIR instrument developed by Surrey Space Technologies Limited (SSTL) for the ESA Sentinel-5 precursor, the Carbon Monoxide and Methane Spectrometer (CMS). The maturity of the instruments minimises the overall risks and costs to the mission. The combined instrumentation will measure atmospheric concentrations of CO<sub>2</sub>, CH<sub>4</sub> and CO. TCM will use a spacecraft bus developed by SSTL. Data processing operations will be shared between UK and US collaborators. TCM is a focused mission concept with low risk that uses technology that already exists.

### Contact

Paul Palmer, School of GeoSciences, University of Edinburgh, UK; Email: pip@ed.ac.uk

Hartmut Bösch, Space Research Centre, University of Leicester, UK

Mike Cutter, Surrey Satellite Technology Limited, Guildford, UK

Alan O'Neil and Andy Shaw, National Centre for Earth Observation, UK