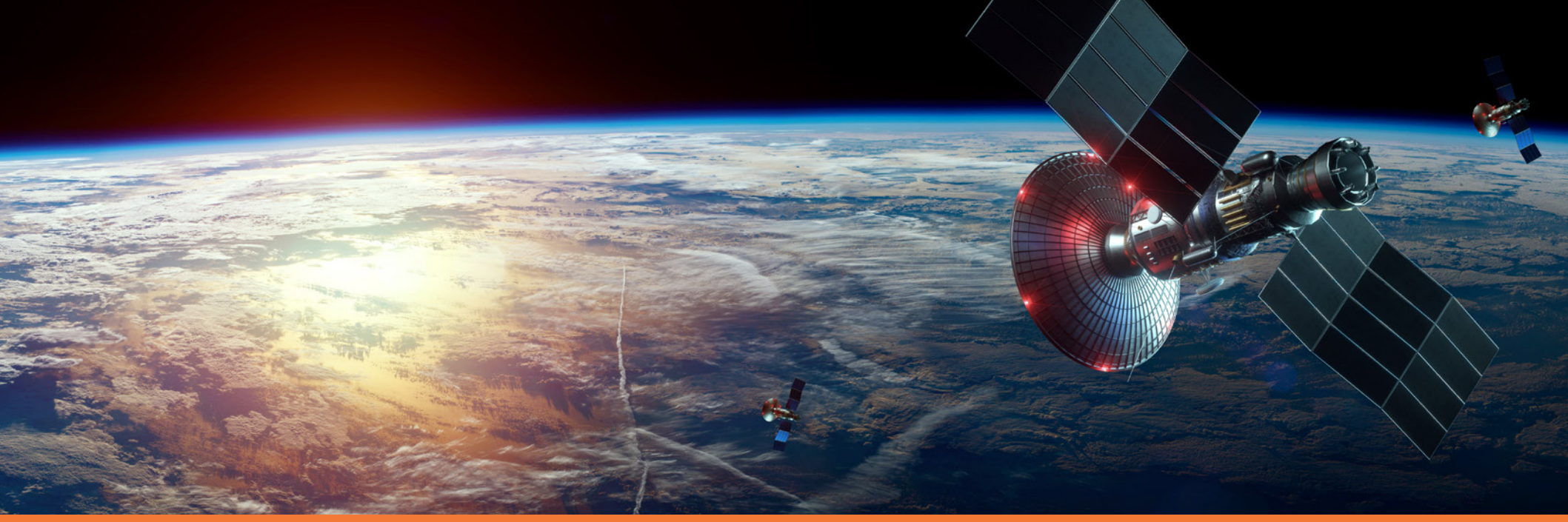


HOW THE NPL 'STAR' FACILITY CAN SUPPORT BETTER CLIMATE MONITORING FROM SPACE

Climate change is one of the biggest challenges of our time. Domestic policy commits the UK to achieving net-zero emissions by 2050, and internationally, the Paris Agreement requires significant decarbonisation to keep average global temperature increases well below 2°C. Meeting these challenging goals requires immediate, sustained and significant annual drops in greenhouse gas emissions.

Policy makers and environmental experts need high quality trustworthy information to make sound decisions to protect the planet and meet the ambitious climate targets.

Whilst there is no doubt that the Earth's climate is changing and near-global consensus that mankind is playing a major role, the timescale and nature of our impact remains uncertain. Detecting a climate trend for key observable parameters of the Earth system requires observations over decades, so that small, often subtle, changes can be reliably detected.

Space based sensors offer a unique opportunity to capture global data on climate over time. However, as we generate more and more data, we also need to ensure that the data collected is trusted and reliable. Having reliable data from Earth observation systems is critical to achieving UK and international targets.

These observations need to be stable and accurate, often within a few tenths of a percent per decade. In many cases, this requires measurement uncertainties that are normally only realisable in the laboratories of National Metrology Institutes (NMIs) such as the National Physical Laboratory (NPL).

There are hundreds of Earth observation satellites orbiting our Earth and recording data, a lot of which is used to monitor the current environment and climate change. Using satellites, we can look at the health of oceans and forests. Whilst we understand that climate change is happening there are still uncertainties around how the natural world is reacting to changes in the levels of greenhouse gases in the atmosphere.

Understanding the end-to-end performance of a satellite instrument under operational conditions before it is launched is a critical task for any space missions. NPL has decades of experience in providing specialised transfer standards and developing novel methods and instrumentation to ensure that fit-for-purpose solutions can be optimally employed in clean rooms across the globe.

As the UK's National Metrology Institute, NPL is leading international activities to improve the quality and reliability of Earth observation data and developing new measurement techniques and instrumentation to reduce the associated measurement uncertainties.

NPL's STAR facility is a vital piece in the climate monitoring puzzle by providing innovative solutions to the pre-flight calibration of satellite instruments. STAR-cc-OGSE, which stands for Spectroscopically Tuneable Absolute Radiometric, calibration and characterisation, Optical Ground Support Equipment, will aid UK and global Earth Observation missions, providing calibrated and characterised climate quality missions.

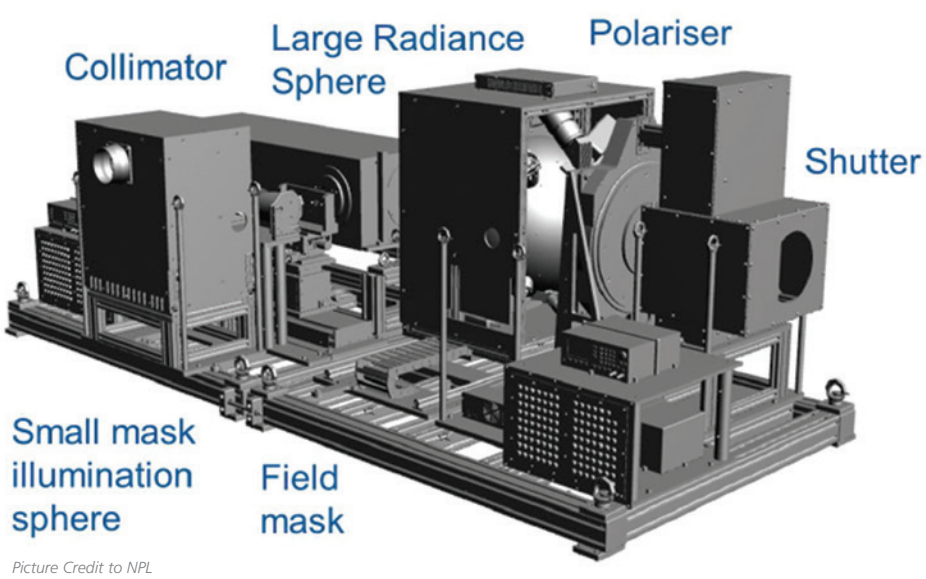
The facility provides a state-of-the-art solution to instrument calibration and characterisation, ensuring the needed performance is achieved while also minimising the time and effort involved in the pre-launch vacuum test environment. In essence, the facility combines together in a single transportable package, the contents of NPL radiometric calibration capabilities which normally occupy three laboratories at the Teddington site.

The STAR facility is the result of a partnership between NPL and the Scottish Laser company M-squared lasers. The concepts embedded in the STAR facility were established more than three decades ago and have in part been exploited for some time in the US space sector. However, until recent innovations by M-squared lasers, it has not been possible to create a transportable turn-key facility such as STAR that can deliver SI-traceability at unprecedented accuracies in space representative environment at customer facilities.

The STAR-cc-OGSE is fully traceable to NPL's primary radiometric standard, the cryogenic radiometer, and can provide unprecedented uncertainties well below 0.5% across a wide spectral region. The first mission that will utilise the STAR-cc-OGSE is the CNES/UKSA microsatellite – MicroCarb, a mission designed to measure greenhouse gases.

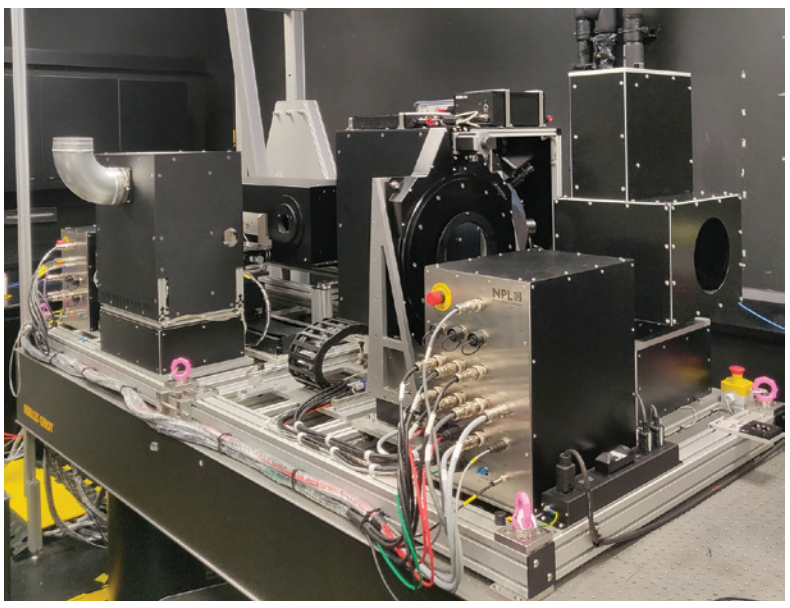
This mission's scientific objective is to monitor and characterise carbon dioxide (CO_2) surface fluxes, that is the exchanges between the sources (natural or anthropogenic) and the sinks (the ocean, the land and the vegetation). CO_2 is the greenhouse gas with the highest contribution to climate change. As its concentration in the atmosphere has increased, the mean temperature at Earth surface has increased by nearly 1°C in the last 100 years. Although this may seem small, it is important to note this is the mean temperature and its continued increase is rising sea levels resulting in coastal and low-level land loss and is likely to lead to ever more unusual weather events.

Being able to accurately quantify the global carbon cycle, the anthropogenic contribution to it and the response of the natural environment is crucial to international efforts to manage a sustainable planet. Missions like MicroCarb provide the data needed to understand these complex interactions and the efficacy of implemented policy. NPL is underpinning the measurements provided by Microcarb, providing traceability and confidence in the outputs of the mission – a vital tool in the UK's efforts towards greenhouse gas monitoring.



Picture Credit to NPL

The schematic representation of STAR-cc-OGSE



Picture Credit to NPL

The complete on-table system

Author Contact Details

Nigel Fox, NPL Fellow in Optical Radiometry and Earth Observation • Email: Nigel.fox@npl.co.uk

Paul Green, Science Area Leader, Climate and Earth Observation • Email: Paul.green@npl.co.uk

• National Physical Laboratory (NPL). **Web: www.npl.co.uk**

Nigel Fox

Paul Green