MONITORING GREENHOUSE GASES FROM SPACE

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List of Principal Investigators (PIs)

Topic Nr.	PIs	Title
32301_1	*Dr. Hartmut Boesch,* *Prof. Yang Dongxu*	***Monitoring greenhouse gases from space: retrieval algorithm development and CO2 and CH4 flux inversion***
32301_2	*Dr. Johanna Tamminen,* *Prof. Liu Yi*	***Monitoring greenhouse gases from space: validation and uncertainties with focus in China and high latitudes***

EXECUTIVE SUMMARY

Carbon dioxide (CO2) is the major anthropogenic greenhouse gas, but substantial uncertainties remain about the magnitude, location, and durability of natural fluxes. Atmospheric CO2 has increased from a pre-industrial value of about 280 parts per million (ppm) to more than 398 ppm today. The fossil fuel combustion has increased with the faster growth of global economy leading to sharp increases in the emission of CO2. In the last 100 years, Earth's average surface temperature increased by about 0.8 C with about two thirds of the increase occurring over just the last three decades. This increase in the global mean temperature has far-reaching humanitarian and economic implications.

ABSTRACT 32301_1: "Monitoring greenhouse gases from space: retrieval algorithm development and CO2 and CH4 flux inversion"

European Principal Investigator	***Chinese Principal Investigator***
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Carbon dioxide (CO2) is the major anthropogenic greenhouse gas, but substantial uncertainties remain about the magnitude, location, and durability of natural fluxes. Atmospheric CO2 has increased from a pre-industrial value of about 280 parts per million (ppm) to more than 398 ppm today. The fossil fuel combustion has increased with the faster growth of global economy leading to sharp increases in the emission of CO2.
Our current understanding of the temporal and spatial distribution of atmosphere CO2 is largely informed by a sparse network of in situ high precision/accuracy measurements of CO2 concentration at the surface. The sparseness of this network compromises our ability to quantify regional fluxes of CO2, particularly at low and high northern latitudes where there are only a few measurement sites. Detailed computer model studies indicate that uncertainties in the atmospheric CO2 balance could be significantly reduced with global, unbiased, precise space-borne measurements of column-average CO2 dry-air mixing ratio (XCO2)
Short-wave infrared (SWIR) wavelengths are sensitive to CO2 changes in the lower troposphere and are therefore suitable for estimating the magnitude and geographical distribution of surface fluxes. TANSO/GOSAT is the first high spectra resolution Fourier Transform Spectrometer (FTS) which was successful launched in 2009. Since its launch, TANSO has improved greatly in the calibration, XCO2 retrieval algorithm, CO2 flux inversion and validation. Successful launched in 2014, the OCO-2 provides higher precision XCO2 products over global scale.
The Chinese Carbon Satellite (TanSat, Tan - carbon in Chinese) Mission has been proposed by MOST and CAS. TanSat will be launched into ~700 km Sun-Synchronous orbit in the Aug. 2016 time frame with a hyper-spectral Carbon Dioxide Spectrameter (CDS) and a Clouds and Aerosols Polarization Imager (CAPI) on board. The Carbon Dioxide Spectrameter (CDS) incorporates three high resolution grating spectrometer to make coincident measurements in the O2 A-band and SWIR CO2 absorption bands from reflected sunlight. CAPI is a wide field of view moderate resolution imaging spectrometer. It covers ultraviolet, visible, and near infrared bands and two polarization channels. Column-averaged CO2 dry air mole fraction (XCO2) will be estimated from measured spectra and the cloud and aerosol interference will be corrected by the measurements from CAPI.
The overall goal of this proposal is to harmonize, characterize and improve the retrieval and forward models used for the CO2 retrieval and to validate and interpret results from TanSat. We will carry out retrieval experiments initially using GOSAT data, compare and interpret retrieval results from subsequent validation with TCCON and Chinese ground-based measurements. This will be expanded to include also NASA OCO-2 and, once consolidated, TanSat data.
The CO2 retrieval results will be compared to CO2 model calculation and we will carry out tests using inverse modeling to obtain sources and sinks. The focus of this sub-project is global but we will give some emphasis on China.
This sub-project is a joint project of Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS), Earth Observation Science, Department of Physics & Astronomy, University of Leicester and the School of GeoSciences at University of Edinburgh. No extra funding for this project is presently available. Work by both teams will be part of the normal scientific research. Chinese team is funded by MOST and CAS, from which a limited amount of funding could be used to support international cooperation research. University of Leicester and University of Edinburgh will carry out the work using existing resources and by synergies with ongoing research projects funded by the National Centre for Earth Observations NCEO, NERC, ESA and the EU

ABSTRACT 32301_2: "Monitoring greenhouse gases from space: validation and uncertainties with focus in China and high latitudes"

European Principal Investigator	***Chinese Principal Investigator***
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Due to the anthropogenic greenhouse gas emissions our climate is changing. Climate forecasts are needed so that we can prepare, mitigate and adapt to the changing climate. The forecasts require accurate information about the sources and sinks of natural and anthropogenic greenhouse gases, in particular, carbon dioxide (CO2) and methane (CH4). Presently greenhouse gas concentrations are observed using ground-based and satellite observations. While local sources can be observed using accurate in-situ measurements, remote sensing methods from satellites are needed to obtain global and regional coverage, which are important for climate research.

The accuracy requirements of satellite remote sensing of atmospheric composition and, in particular, greenhouse gases are challenging. The validation of the measurements is an important in the development of satellite remote sensing systems. In addition to ground-based validation, also algorithm validation including proper quantification of retrieval uncertainties forms the basis for reliable satellite observations. In this research plan, the ground-based measurements of carbon dioxide (XCO2) over China and Europe will be used to validate satellite products of TanSat, OCO-2 and GOSAT. In addition, methane (XCH4) observations of GOSAT and Sentinel 5 Precursor will be analysed to support forming the overall picture of monitoring carbon cycle from space.

The experience obtained after launching GOSAT and OCO-2, has emphasized the importance to utilise ground-based measurement to validate the satellite products, especially to improve the accuracy of satellite retrievals to reduce the interference by many other factors, such as aerosols, clouds, ground surface properties, and instrument noise. In particular, the ground-based Fourier transform spectrometer (FTS) observations have been found crucial.

The overall goal of this proposal is to characterize and improve the TanSat XCO2 observations and their uncertainty quantification. We will use TCCON and Chinese ground-based measurements and extend the validation previously applied for GOSAT and OCO-2 data to TanSat XCO2 and also analyse Sentinel 5 Precursor XCH4 observations. AirCore profile observations of greenhouse gases at Sodankylä will be used to support the validation at high latitudes.

This project is a joint project of Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS), Earth Observation Science, Finnish Meteorological Institute, Earth Observation and Arctic Research Units, Department of Physics & Astronomy, University of Leicester, and the School of GeoSciences at University of Edinburgh.

No extra funding for this project is presently available. Work by both Chinese and European teams will be part of the normal scientific research. Chinese team is funded by MOST and CAS, from which a limited amount of funding could be used to support international cooperation research. Finnish Meteorological Institute and University of Leicester will carry out the work using existing resources and by synergies with on-going research projects funded by the Finnish Academy, UK National Centre for Earth Observations NCEO, NERC, ESA and the EU.