Estimating CO_2 Flux Distributions from Space-Based Observations of CO_2

Supervisors: Mat Williams and Paul Palmer (Univ. of Leeds)

Project Background

Recent studies have shown the considerable potential of satellite observations of CO_2 to characterize sources and sinks of CO_2 on regional scales. We propose to explore some new ideas that will improve CO_2 fluxes estimated from such data. The Orbiting Carbon Observatory (OCO, to be launched towards the end of this studentship) will provide the first global, space-based CO_2 observations with the accuracy and precision necessary to improve upon CO_2 flux estimation using the global surface flux network. In preparation for the OCO data, we will conduct observing system simulation experiments (OSSE) in which "true" CO_2 flux distributions are used to generate realistic OCO observations, including estimated instrument noise. The idea, at its simplest, is to test whether the "true" flux distribution can be retrieved using the OCO observations and some independent CO_2 flux distribution.

Techniques

The research involves using a coupled biosphere-atmosphere model of C exchanges and transport to investigate methods to reduce uncertainty in regional CO_2 flux estimates. The work will use existing data and models, and will not rely on OCO data. To achieve the project goals, the student must:

1. Develop the coupling between the DALEC biospheric C model and the TOMCAT atmospheric transport model. Anthropogenic CO_2 emissions will be taken from recent work by the supervisors. The student will evaluate the coupled model with available surface and atmospheric CO_2 observations.
2. Develop existing inverse models for OCO OSSEs. The student will apply several inverse model approaches, e.g. Markov chain Monte Carlo, to the OCO OSSEs to assess which one is most suitable for the OCO project.
3. Identify, using the OSSEs, the limitations of OCO to distinguish between different viable CO_2 flux distributions. The student will quantify the uncertainty in regional and global CO_2 flux estimates from OCO for different seasons and different instrument noise estimates.
4. Quantify the benefits of assimilating observed CO_2 radiances versus retrieved CO_2 products. Using existing an radiative transfer model, the student will address the balance between easier error characterization versus computationally intensive forward modelling.

Training

The student will attend courses on computer programming, atmospheric dynamics, remote sensing techniques and the global C cycle (offered by the computing service and masters' programmes within the School of GeoSciences). The student will then become familiar with the DALEC biospheric C model (M Williams), and the TOMCAT atmospheric transport model, and several inversion techniques (P Palmer).

Existing Facilities

The necessary computing resources and model codes are available within the School, and to the supervisors. OCO instrument characteristics will be provided directly by the OCO science team at the Jet Propulsion Laboratory.

Project summary:

Understanding of the global C cycle will be enhanced by the launch of several new satellite instruments that can measure atmospheric CO_2. This PhD project will explore how these data can best be used to improve our understanding of the global C cycle, through modelling the interactions of the biosphere with atmospheric transport processes.