Large-scale dynamics of black carbon in tropical river basins in South America.

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Description of the project: Black carbon (BC) is a product of the incomplete combustion of biomass and fossil fuel. Due to its recalcitrant characteristics, BC is thought to be an important sink in the short-term carbon cycle (Forbes et al. 2006). Also, the absorptive optical properties of BC aerosol result in a positive surface radiative forcing that is exceeded only by that caused by rising atmospheric carbon dioxide concentration (Bond et al. 2013). Quantifying the rates of BC production and transport (both as an aerosol and by river systems) therefore represents an opportunity to refine the terrestrial carbon budget whilst also building the foundations for higher-resolution analyses of its local and regional effects on climate. The contribution of black carbon to the carbon cycle is critical in tropical regions because biomass burning, which produces the majority of BC globally, is commonly employed for agricultural land management and for removing tropical forest cover. This PhD aims to apply a multidisciplinary approach combining remote sensing, atmospheric modelling and field-based surveys to quantify the atmospheric BC inputs, the BC stocks in soils and the export rates in the Paraíba do Sul River basin, Brazil. Specifically, the successful candidate will:

1. Develop a spatially explicit approach to quantify emissions of BC aerosol by land management and fossil fuel burning and calibrate an atmospheric transport and deposition model using data from satellites and fieldwork.

2. Quantify BC stocks in soils and map the spatial configuration of these stocks to understand the influences of recent atmospheric inputs and historical forest clearing.

3. Quantify the export rates of dissolved and particulate BC along the river and analyse the links with stocks and river discharge.

4. Produce a BC budget for the basin, identifying the major sources of BC to the Paraíba do Sul River and quantifying the magnitude of the carbon sink.

The ultimate goal of this PhD is to develop a detailed understanding of large scale dynamics of BC in tropical regions to produce a general spatial model of BC transport for application in other river basins, to include the Amazon. Published work that has applied a simple aerosol transport model provides indicative preliminary evidence that recent regional burning represents a significant contribution towards the BC stock present in the river basin and complements high-impact research into historical local sources. The successful candidate will have the opportunity to work with collaborators at the Met Office and in Brazil and Germany.

Bond, T. C., Doherty, S. J., Fahey, D. W., Forster, P. M., Berntsen, T., DeAngelo, B. J., ... & Zender, C. S. (2013). Bounding the role of black carbon in the climate system: A scientific assessment. Journal of Geophysical Research: Atmospheres.

Forbes, M. S., Raison, R. J., & Skjemstad, J. O. (2006). Formation, transformation and transport of black carbon (charcoal) in terrestrial and aquatic ecosystems. Science of the Total Environment, 370(1), 190-206.

Training opportunities:

Exeter - Sediment fingerprinting (gamma radionuclide laboratory); Land use modelling.

MetOffice – Black Carbon transport modelling

INPE – Remote Sensing

Max Planck, Germany - Geochemistry