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Overview of the South American Biomass Burning Analysis (SAMBBA) Field Experiment

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Abstract. Biomass burning represents one of the largest sources of particulate matter to the atmosphere, which results in a significant perturbation to the Earth's radiative balance coupled with serious negative impacts on public health. Globally, biomass burning aerosols are thought to exert a small warming effect of 0.03 Wm^{-2}, however the uncertainty is 4 times greater than the central estimate. On regional scales, the impact is substantially greater, particularly in areas such as the Amazon Basin where large, intense and frequent burning occurs on an annual basis for several months (usually from August-October). Furthermore, a growing number of people live within the Amazon region, which means that they are subject to the deleterious effects on their health from exposure to substantial volumes of polluted air. Initial results from the South American Biomass Burning Analysis (SAMBBA) field experiment, which took place during September and October 2012 over Brazil, are presented here. A suite of instrumentation was flown on-board the UK Facility for Airborne Atmospheric Measurement (FAAM) BAe-146 research aircraft and was supported by ground based measurements, with extensive measurements made in Porto Velho, Rondonia. The aircraft sampled a range of conditions with sampling of fresh biomass burning plumes, regional haze and elevated biomass burning layers within the free troposphere. The physical, chemical and optical properties of the aerosols across the region will be characterized in order to establish the impact of biomass burning on regional air quality, weather and climate.

Keywords: Biomass burning, Amazon, Aerosol Composition, Organic Aerosol, Black Carbon

INTRODUCTION

The South American Biomass Burning Analysis (SAMBBA) field experiment took place during September/October 2012 across a wide range of environments in the Amazon region of Brazil. The aim of the project was to characterize the impacts of biomass burning emissions on air quality, numerical weather prediction and climate in the region. Characterisation of the background, pristine environment away from the biomass burning regions was also conducted. SAMBBA represents an international collaboration which is led by a partnership between the Met Office in the UK, the Brazilian National Institute for Space Research (INPE), the University of Sao Paulo

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and a group of UK Universities. The field experiment encompassed a ground based deployment alongside airborne measurements on the UK Facility for Airborne Atmospheric Measurement (FAAM) BAe-146 research aircraft. A large suite of instrumentation was flown onboard the aircraft, which measured the gas and particle phase properties of the biomass burning emissions in the region.

Preliminary results highlight the range of conditions encountered across the study, with sampling of fresh biomass burning plumes, regional haze and elevated biomass burning layers within the free troposphere. The physical, chemical and optical properties of these environments will be assessed using both in-situ and remote sensing instrumentation.

PRELIMINARY RESULTS

Preliminary results are presented here focusing upon aerosol chemical composition measurements made by the Single Particle Soot Photometer (SP2) and Aerosol Mass Spectrometer (AMS).

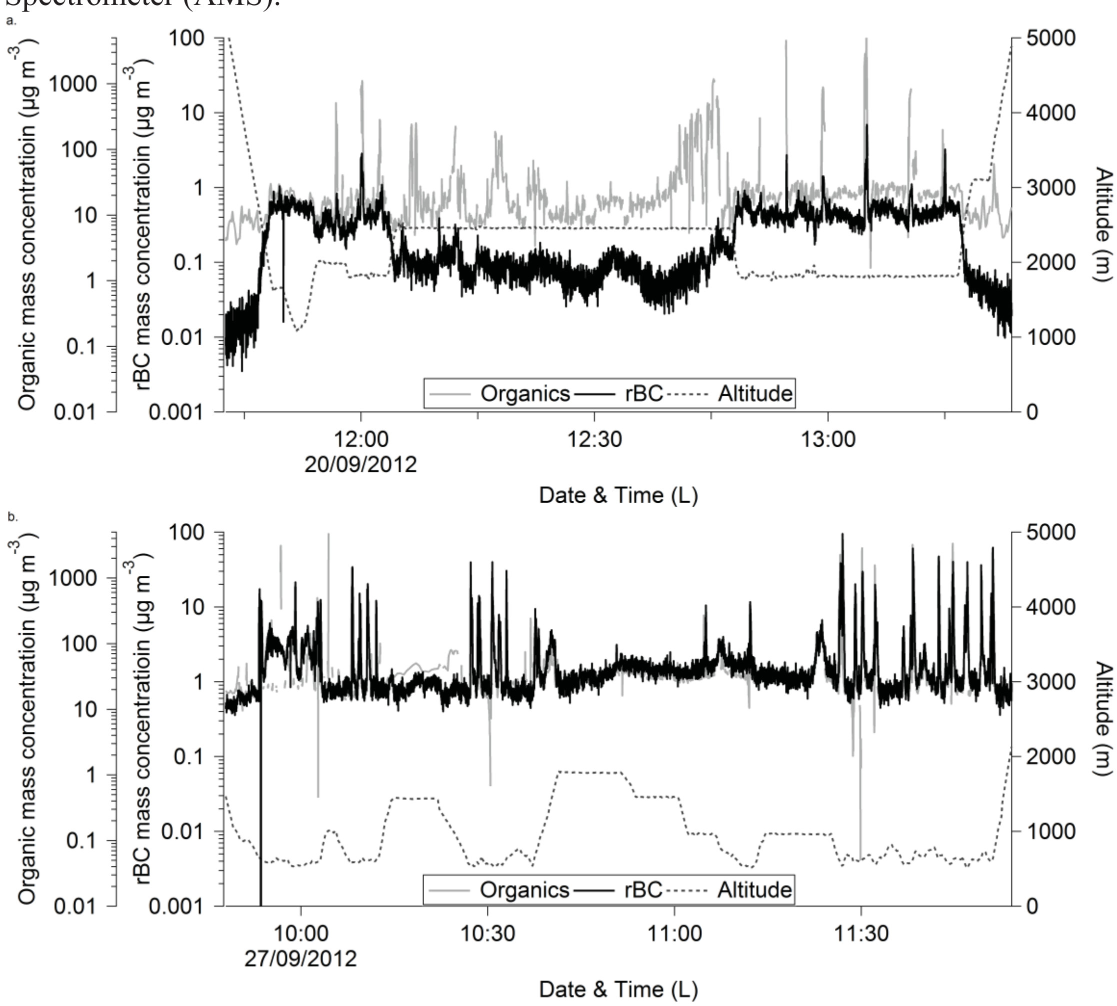

FIGURE 1. Time series of refractory Black Carbon (rBC) and organic aerosol for flight B737 (a) and B742 (b). The altitude of the aircraft is also shown. Note the logarithmic scales for both rBC and organic mass concentrations.

Fig. 1 shows the time series of refractory Black Carbon (rBC) and organic aerosol during two flights on 20 September 2012 (B737) and 27 September 2012 (B742). B737 took place within Rondonia state, while B742 was conducted in Tocantins state. Both flights concentrated upon measuring intensive biomass burning plumes in these regions, coupled with regional haze sampling. The Rondonia fire was largely dominated by smouldering combustion of a huge single area of rainforest with a visible plume of smoke extending approximately 80km downwind. The Tocantins example contrasted with this as it was a collection of a large number of smaller fires, with flaming combustion being more prevalent. Furthermore, the burned area was largely made up of agricultural land in a cerrado (savannah-like) region of Brazil.

The chemical nature of these fires differed markedly, with BC concentrations being an order of magnitude greater in the Tocantins case (up to 50 μg sm^{-3} of rBC) compared with the Rondonia case (up to 5 μg sm^{-3} of rBC). Organic aerosol concentrations were similar in both cases, with maximum concentrations peaking between 4-5 mg sm^{-3}. Such concentrations are approximately 100 times greater than those sampled in the "background" regional haze.

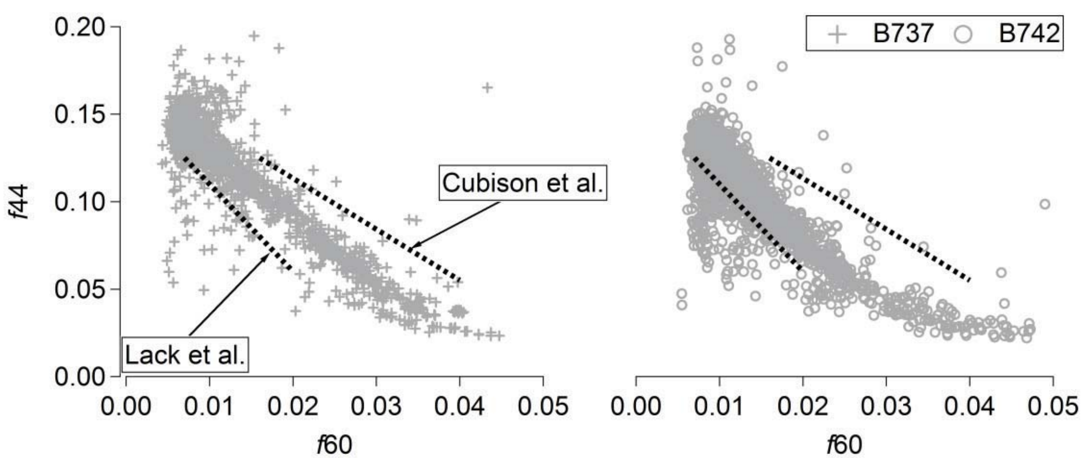

FIGURE 2. Relationship between *f44* and *f60* (defined below) for flights B737 and B742. The dotted lines correspond to the approximate slopes observed in Cubison et al. [1] and Lack et al. [2].

Fig. 2 shows the relationship between the ratio of organic mass at *m/*z 44 to the total organic mass (*f44*) against the ratio of organic mass at *m/*z 60 to the total organic mass (*f60*). The *f44* ratio represents a proxy for the degree of oxidation of the organic material, which is related to the photochemical age of the air mass sampled. The *f60* ratio represents a marker for biomass burning, as organic mass at *m/z* 60 is related to a range of anhydrous sugars such as levoglucosan in the AMS. There is a general progression from fresh organic matter that is sampled directly above the fires, that is relatively un-oxidised, through to more aged material away from the direct source. This is consistent with previous measurements of biomass burning plumes in high latitude environments [1] and in Colorado [2]. The SAMBBA measurements fall between the slopes observed in these two environments, while the two case studies themselves exhibit different slopes closer to source.

DISCUSSION

The variation of BC to OM ratio has potentially large implications for the radiative balance in the respective regions, as BC represents the major absorbing component of biomass burning aerosol. Further analysis will compare the mixing state of the particles in this environment and probe its progression as it ages into regional air masses. The impact of such changes upon the optical properties of the aerosol will be investigated, which will ultimately determine their climate impact.

The aging and cycling of the organic matter component will also be investigated further. The examples shown here suggest that the organic aerosol is progressively oxidized as it advects away from the main fire source. These examples will be combined with the more regional studies to examine how this evolves further downwind. Further analysis will compare the aerosol mass concentrations with gas phase species, which will provide a photochemical basis for the chemical and physical evolution of the aerosol as it advects downwind and is diluted with regional air.

The vertical distribution of the aerosol will also be investigated, as the regional measurements that were conducted demonstrated significant lofting of biomass burning layers into the free troposphere as a result of convective uplift in the region. Such layers were at times persistent and extensive, which has implications for the hydrological cycle and direct radiative forcing in the region.

These properties have important implications for the life cycle and formation of particulate material, which governs its subsequent impacts.

ACKNOWLEDGMENTS

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