We would like to thank both reviewers for their time and for the detailed comments that they have provided. As a result of these comments we have made a number of changes to the paper. The major alterations to the paper have been: a re-written paragraph in the discussion highlighting the methodological differences between our study and others, why it is difficult to compare them and a suggestion of how to tackle this problem; the addition of a sampling plot design figure; and the addition of a schematic of the combustion analysis setup in the supplementary material. We have also added sentences or short passages where the reviewers have suggested they are required and we believe these changes improve the accuracy and readability of the paper. We have sought to address all the individual comments of the reviewers and have made corrections and clarifications where necessary. We have reproduced the reviewers' comments in italics below and our reply to each comment can be found underneath in blue font.

Reviewer One

General comments

This paper presents a study that measured emission factors (EF), fuel load, and carbon content for different fuel types from a temperate forest (Eucalyptus) in south-eastern Australia. The measurements are used to estimate direct carbon emissions due to the application of prescribed fire. The carbon emission estimates derived from the studies measurements are compared to estimates based on less specific input and other methods.

Emission ratios (Table S3) and emission factors (Table 4) for the pooled species (CH4, NMHC and PM) are dramatically at odds all of the biomass burning EF literature of the last 20-30 years!

First, the pooled species are described as the sum of CH4, PM and non-methane hydrocarbons (NMHC), however the in the analysis used the pooled species represent all carbon containing species other than CO2 and CO, organic compounds (volatile and semi-volatile organic compounds) and PM. In biomass smoke a significant fraction of emitted carbon is present in oxygenated organic compounds (e.g. methanol, formaldehyde, furan, …,) that are not hydrocarbons (see Akagi et al., 2013) and the authors should have described the gas portion of the pooled species as VOC or simply organic compounds.

Improper terminology aside, the pooled EF (g-C/g-C) reported in this study are for the most part far higher than that inferred from virtually all previous studies that I am familiar with (e.g. ….).

The median of the EFpooled reported in Table 4 is 0.23 g-C/g-C with maximum of 0.97 gC/g-C. The pooled emissions account for 24% of carbon emitted on average with a maximum of 43% (leaf litter – Oliver). For comparison one may use the laboratory measurements reported in Yokelson et al. (2013). This study combined multiple instruments and methods (open path FTIR spectrometer, proton-transfer-reaction mass spectrometry (MS), proton-transfer ion-trap MS, negative-ion proton-transfer chemical ionization MS, and gas chromatograpghy with MS to measure emissions of over 300 compounds for large scale laboratory burns of forest and chaparral fuels. The supplemental material for Yokelson et al. (2013) supplemental includes EF for CO2, CO, CH4, over 300 organic gases, and PM2.5 for 25 lab burns of forest fuels. Following conversion of these EF from units of g/kg to units g-C/g-C it may be found that the sum of the EF for PM2.5, CH4, and all organic gases (>300 species) has a median of 0.039 g-C/g-C with a range of 0.008 to 0.139 g-C/g-C. The percent of emitted carbon contained in PM2.5, CH4, and all organic gases averaged 3.8% with a range of 0.7% to 13.6%. The EF data from Table 4 of the manuscript and from the supplemental material of Yokelson et al. (2013) are summarized in Table 1 below.

In this manuscript the pooled EF and the fraction of emitted carbon in pooled species are far higher than observed in the comprehensive study of Yokelson et al. (2013). The Yokelson et al. (2013) is consistent with previous and subsequent EF reviews (Andreae & Merlet, 2001; Akagi et al., 2011; Urbanski 2014) and field and laboratory studies (e.g. Burling et al. 2010; Burling et al., 2011; Akagi et al. 2013). For a wide range of biomass burning, the fraction of carbon emitted in species other than CO2 and CO is typically < 5% and rarely greater than 10%. In this manuscript the fraction of emitted carbon attributed to species other than CO2 and CO is on average 24% (with maximum of 43%) and far exceeds what is found the previously

published literature. The fact that the MCE of the burns reported in this study are relatively high (average =0.96) and therefore indicative of high efficiency burns with low PM and VOC emissions makes the pooled EF even less believable. If the authors were to conduct a similar comparison against EF data from other studies / reviews they would arrive at similar results. The authors simply made a comparison versus Hurst et al (1994b) and concluded without any justification that the discrepancies were due to PM. The authors clearly failed in their duty to seriously compare their findings to previously published work. I can only conclude that significant errors were made in the calculation of the pooled EF and this study is therefore seriously flawed and I recommend that is rejected for publication.

Table 1.

		EF pooled[1] (g-C/g-C)		
	Average MCE	Median	Minimum	Maximum
Table 4	0.962	0.24	0.00	0.97
Yokelson et al. (2013)[3]	0.935	0.039	0.008	0.139

[1]Labeled as sum of CH4, NMHC, PM in manuscript and is the sum of PMm2.5, CH4, and > 300 organic gases for Yokelson et al. (2013)
[2]MCE = ΔCO2/(ΔCO + ΔCO2) and was calculated from Supplemental Table 3
[3]Derived from EF reported in the Supplemental Material for 25 forest fuel burns

We would like to thank the reviewer for the in-depth comparison of our pooled EF data to that of the literature. However, the primary aim of this manuscript was not to specifically discuss the form that the carbon was lost as (i.e CO_2, CO, VOCs or PM). The aim was to estimate the total carbon lost from south-east Australian forests because of prescribed fire, and how variable they can be when the amount of information you have changes. Specific emission factors for the prescribed burning sites were not available so we had to generate our own. These EFs were then used to create bounds for the random setting of EFs in two of the scenarios in the Monte-Carlo simulations, which are then summed to estimate the total carbon loss (Eqns. 4 and 5). Therefore, what is more important in this study is the total C loss through the sum of the different EFs rather than any one particular EF and we already demonstrate those sums as $\Sigma C_{emit}/C_{fuel}$ in Table 3.

With regard to the pooled data, we acknowledge that, yes, there does appear to be some major differences among the pooled values with those from the literature but the comparison the reviewer has made is a not direct one and not necessarily valid. The EF values for our study relate to different fuel components (twigs, litter, grass, etc.) while many of the published studies, and the reviews that have compiled them, have calculated their EFs based on laboratory studies of complete reconstructed fuel beds (e.g. Burling et al. 2010), and field based studies either on the ground (e.g. Burling et al., 2011) or from aircraft (e.g. Akagi et al., 2013). Therefore, it is entirely plausible that the values recorded for some components of the total fuel may record higher than the aggregated values measured with complete fuel beds, either in the lab or field. Indeed, our values do overlap with the aggregated values but have a different distribution to the Yokelson et al. (2013) study, which is based upon fuels from range of US forest types measured in both the field and laboratory. Hence, we have included in the discussion how the methodological differences of our work make it difficult to compare with other Australian forest studies and that there is a need for measurements from south-east Australia to be made in a similar manner to Yokelson et al. (2013) to reconcile laboratory and field measurements.

With regard to the comparison with Hurst et al. (1996), it was done because, at the time of submission, this was the closest study to ours that was on Australian forests. Indeed, a number of the studies the reviewer cites compare results among the same ecosystems within the United States. The reviews by Akagi et al.

(2011) and Andreae and Merlet (2001) show that there are considerable differences between ecosystems and south-east Australian Eucalypt forests, by extension, are likely to be varied to. Of course, we acknowledge that the environment plays a role in the EF measured, which is why a laboratory bench top study was chosen to control for these environmental effects, as well as to produce some unique, site specific EFs. We have included in the discussion a statement that there is a need for more comprehensive emissions measurements specifically for south-east Australian forests. As previously mentioned, if these measurements are conducted in a manner similar to those for the south-eastern and south-western US (e.g. Yokelson et al., 2013), field and laboratory measurements may be reconciled.

As a minor comment, we would also like to point out a typographical error in the reviewer's table that could potentially be misleading for readers of this discussion because it is reporting incorrect values from our Table 4. The maximum value from Table 4 would be 0.46, producing a median value of 0.22.

The revised paragraph, which also addresses the above comments and the comment regarding P13826, L11 -14 (below), reads as follows:

"Across the four sites, the mean proportion of fuel carbon lost to the atmosphere relative to the total amount of carbon ($\Sigma C_{emit}/C_{fuel}$) was 86%. This is less than the 97% suggested by Hurst et al. (1996) for the one planned burn they measured in a south-east Australian forest. However, a direct comparison of this study with the Hurst et al. (1996) study cannot be made due to the significantly different methodological approaches taken that they may bias either study. These methodological differences include factors such as: the measurement of aggregated emissions from naturally structured fuels taken using an aircraft, compared to individual fuel components measured at a very small scale in the laboratory; and neither study measures the same range of compounds. Indeed, these methodological differences also prevent direct comparison of emission factors, not just with Hurst et al. (1996) but also the recent work of Paton-Walsh et al. (2014) who made ground-based emission measurements from planned fires in temperate south-east Australian fires. There are large variabilities in emission factors for certain compounds among different ecosystems (see reviews by Andreae and Merlet (2001) and Akagi et al. (2011)). This demonstrates the need for more comprehensive emissions measurements for specific ecosystems and regions, including south-east Australian forests. If these measurements are conducted in a manner similar to those for the south-eastern and south-western US (e.g. Yokelson et al., 2013), field and laboratory measurements may be reconciled."

Additional Comments

Combustion analysis method

I find it very uncertain that the combustion analysis employed is a reasonable proxy for the following reasons:

For many of the fuel components (twigs, ground layer, understory, overstory) filling a 10 cm × 10 cm × 3 cm sample holder seems to be a great distortion of the structure and arrangement of the natural fuelbeds which should have a significant impact on the manner in which the fuel burn and the subsequent emissions.

We acknowledge that there will be a distortion of the structure and arrangement of the fuel and this could be a potential source of error in terms of the subsequent emission factors. As mentioned previously, we have added a comment about this to the discussion. The small nature of the laboratory bench top testing equipment precludes us burning multiple components in their original configuration. However, for the purposes of this comparative study, every sample would have been treated and combusted in exactly manner and would carry the same intrinsic error.

The samples were combusted at a fixed irradiance of 25kW/m2 it is unclear how this approach replicates a natural free burning fire. It seems as though this approach could shift the combustion process towards flaming relative to natural fires.

The capacity to alter the flux used during combustion of samples using the MLC is limited. Regardless of this, work by Cruz et al. (2011) and Silvani et al. (2009) indicate that irradiances of 25 kW m^{-2} are achievable during a natural fire at the fire front and can remain that high for some time once the front has passed. This period of time is comparable to the length of time each burn was conducted (300 to 600 seconds).

Cruz, M. G., Butler, B. W., Viegas, D. X., and Palheiro, P.: Characterization of flame radiosity in shrubland fires, Combust. Flame, 158, 1970-1976, 10.1016/j.combustflame.2011.03.002, 2011.

Silvani, X., and Morandini, F.: Fire spread experiments in the field: Temperature and heat fluxes measurements, Fire Saf. J., 44, 279-285, 10.1016/j.firesaf.2008.06.004, 2009.

2.3 Combustion analysis

A diagram of the combustion analysis set-up is needed.

A diagram has been added to the supplementary material (Supplementary Figure 1; see below).

It is stated that the mass of the samples were before burning and the mass of the residue after burning were recorded (P13817, L11-12). Was the carbon content of the fuel and residue also measured? It is unclear, but the laboratory combustion analysis should measure the mass and carbon content of fuel prior to burning and the mass and carbon content of the post fire residue to derive $\Sigma C_{emit}/C_{fuel}$ *for the carbon emission factor calculations (Eq. (1)).*

Yes, it was. This was stated on P13819, L4-6.

Specific Comments

P13811, L26-28: The authors should discuss more broadly factors that affect fuel accumulations such as disturbance history (previous land use, fire, insects, etc.), topography, and soils.

We have added these factors into this paragraph. That part of the paragraph now reads: "Even so, fuel accumulation varies widely in space and time as a result of the interaction of many factors such as topography, soils, disturbance history (e.g. previous land use, insects, fire) and climate (e.g. due to variations in rainfall patterns; Bradstock, 2010); hence, remote sensing techniques will require intensive calibration."

P13814, L14-15: The three fuel sampling plots at each were selected to have "similar slope and aspect". I suspect slope and aspect may have an important influence on the fuel loading as well as burning efficiency and possible fire severity. It seems that randomly locating the plots within the burn units to capture the variability of slope and aspect would have provided a better representation of the natural variability of emissions from prescribed fires in these forest types. Please comment.

This was a mistake on our part. It should have read that the three selected plots had similar slope and aspect due to the narrow elevation change of the general study area (64 m). We have changed the sentence to read:
"Within each study site, three permanent circular plots were established at least 500 m apart in similar vegetation type prior to planned burning. Due to the small elevation change of the of the general study area, all study sites had similar slope and aspect."

P13814 – 13815: Sampling Protocol.
The ground layer and forest floor (decomposing litter, twigs, leaf litter) was sampled using destructive / disruptive methods and separate post-fire quadrants would be required to estimate fuel consumption. Please describe where the post-fire quadrants were located relative to the pre-fire quadrants. I recommend including a diagram showing the sampling design.

We have included a diagram showing the sample design. This is now Figure 1 (see below). The position of the post-fire quadrats is now addressed with the following sentence added to section 2.2.1: "The mass of ground layer vegetation, twigs and litter (see below) remaining after prescribed burning was measured in the same way using quadrats positioned 2-3 m from the position of the original quadrat to avoid the influence of biomass removal prior to prescribed burning."

Please note if the "decomposing litter" included unidentifiable decomposing organic matter in the upper layer of soil that could be consumed by fire? I'm thinking of the 'duff' layer or organic soil layer typically found in Northern Hemisphere temperate and boreal forests. Is such a layer present and important in the forest examined in this study or Australian temperate forest in general? Please comment.

No observable duff layer was present in these forests, therefore explaining its absence from this study.

P13818: Define DeltaCO2, DeltaCO, etc. including units. Presumably these are molar mixing ratios as in Hurst et al. (1994b) but this must still be defined.

Yes, they are mixing ratios and a definition has been added.

P13818: NMHC should be VOC (volatile organic compounds) as a significant fraction of emitted carbon is present in oxygenated organic compounds (e.g. methanol, formaldehyde, furan, …,) that are not hydrocarbons (see Akagi et al., 2013).

NMHC has been changed to VOC throughout the manuscript and the supplementary material.

P13826, L11 -14: "Across the four sites, the mean proportion of fuel carbon lost to the atmosphere relative to the total amount of carbon (ΣCemit/Cfuel) was 86 %. This is significantly less than the 97% suggested by Hurst et al. (1996). Hurst et al. (1996) based their analysis on the assumption that the carbon content of ash was constant at 6 %."
It seems that this is an invalid comparison as the Hurst et al. (1996) numbers alluded include forest fires of all types – clearing, prescribed, and wild while the current study examines only prescribed fires.

With hindsight, the comparison with Hurst et al. (1996) and the very recently published Paton-Walsh et al. (2014) values cannot be directly compared because of the different methodologies. The Hurst et al. (1996) study was an aircraft study and the Paton-Walsh et al. (2014) study was a series of ground based measurements. Therefore, both studies have measurements made on aggregated fuels rather than individual components. We have changed this paragraph to reflect this caveat and to also highlight the need for work similar to that of Yokelson et al. (2013) for south-east Australian forests. These revisions also address the reviewer's general comments and the revised paragraph can be read towards the end of that section (above).

Technical Corrections

P13812, L2: Volkova and Weston (2013) reference missing from bibliography
Missing reference added. (Volkova, L., and Weston, C.: Redistribution and emission of forest carbon by planned burning in *Eucalyptus obliqua* (L. Herit.) forest of south-eastern Australia, Forest Ecology and Management, 304, 383-390, 10.1016/j.foreco.2013.05.019, 2013.)

P13812, L19: change "whether" to "demonstration that"
Change made.

P13812, L23: change "shorter" to "longer"
Change made.

P13812, L27 insert "that" between "burning" and "reduces"
Change made.

P13815, L26-28: The sentence beginning with "sample" does not makes sense the text "and a subsample of pre-fire fraction ground" seems out of place. Insert "were" between "fraction" and "ground"?
Change made.

P13862, L22: Eq. (4) predicts emissions not emission factors. Is this a typo? Should it cite Eq. (1)?
This is a typographical mistake and Eq. 1 is now cited

Reviewer 2

General comments

This manuscript presents a study of carbon (C) emissions from prescribed fire from a temperate forest in south-eastern Australia. The authors measured emission factors, fuel load, and carbon content for different fuel types from four field sites to estimate direct C emissions after a prescribed fire. They used Monte-Carlo simulations to generate probability density functions of the parameters to account for low quality of data when calculating C emissions. Their results show that the uncertainty in their estimates of C emission declines with declining information quantity and coarse woody debris' inclusion in estimates increases the median C emissions and overall uncertainty in C emissions.

Specific Comments:
Abstract
L1: remove "of" before emissions

Removed.

L10: effect of what on what? Please rephrase.

This has been rephrased to: "In order to assess the effect of declining information quantity and the inclusion of coarse woody debris when estimating emissions, Monte-Carlo simulations were used to create seven scenarios where input parameters values were replaced by probability density functions."

Introduction
P13812 L21-24: Check to make sure this is correct, "Return frequencies of wildfires in extra-tropical (temperate) forests in Australia are typically shorter than that of tropical grassland and savanna and are often decadal compared to annual and biannual (Russell-Smith et al., 2007)." I could not find this claim in Russell-Smith et al 2007.

We have used an incorrect reference here and have changed the citation to Bradstock (2010) and Adams (2013). Both citations are already in the reference list. Also, the return frequency has been changed to 'longer' (see Reviewer one's comment).

P13812 L24-25: Strange sentence structure, "In addition, and on an annual basis,"please rephrase, doesn't make sense.

We changed the sentence to: "In addition, the total area of temperate forest burnt on an annual basis is considerably smaller (Russell-Smith et al., 2007), notwithstanding large single fire events (Adams, 2013)."

P13812 L26-28: "On the other hand, planned or prescribed burning reduces fuel loads in temperate forests is used at moderate return frequencies (e.g. 7–10 years) to mitigate risks to life and property from wildfires (Penman et al., 2007; McCaw, 2013)." Rephrase and look at multiple verbs in this sentence.

We have rephrased the sentence so it now reads: "Planned or prescribed burning in temperate forests to mitigate risks to life and property from wildfires is used at moderate return frequencies (e.g. 7 – 10 years) (Penman et al., 2007; McCaw, 2013)."

What is TC, Tons of C?
It is metric tonnes of carbon but we have changed the units to megagrams (Mg) where one Mg equals one metric tonne.

P13812, L2: Volkova and Weston (2013) reference is missing from the references.
The reference has been added (see Reviewer one's comment for citation)

Materials and Methods

Study sites
P13818, L5: Cfuel is defined as "the total mass of carbon contained in fuel that is burnt", this does not corresponds to the caption of table 3, "Cfuel is the initial carbon content of fuel".

The definitions have been changed to match (initial C content of the fuel).

P13818 L1-8: Define DeltaCO2, DeltaCO, DeltaCH4, Delta PM and DeltaSigmaNHMC and give units.
As per Reviewer One's comments the definition has been added.

P13818 L10-13: Define DeltaX and give units.
As per Reviewer One's comments the definition has been added.

P13862, L22: Eq. (4) predicts emissions not emission factors. Is this a typo? Should it cite Eq. (1)?
The typo has been corrected.

Results

Table 1 and 2 both have Carbon Content listed but different values and unit. Table 1 shows carbon content varying from 0-1 and it is a unitless number. Table 2 has unit in % dry weight and value is mostly >1. Are you referring to different things?

The definition in Table 1 has been changed to match that of Table 2

Table 3-What is the rationale for assuming the same ΣCemit/Cfuel for twigs and CWD?
CWD was defined as woody material greater than 25 mm in diameter. 'Twigs' was the term given to woody material (twigs, wood and bark) that was between 10-25 mm in diameter. Both are effectively the same material, just different sizes.

Figure 1 – Change the y axis label to "Proportion of total biomass (%)" because you are showing both pre and post burn measurements. Correct the legend as well.
Changes have been made to now read 'proportion of total biomass (%)'.

Figure 2-Describe 7 scenarios, all figures and tables should be stand alone.

The scenarios were original described in the legend but during the technical review the Editor asked us to reduce the length of caption and describe them in a Table.

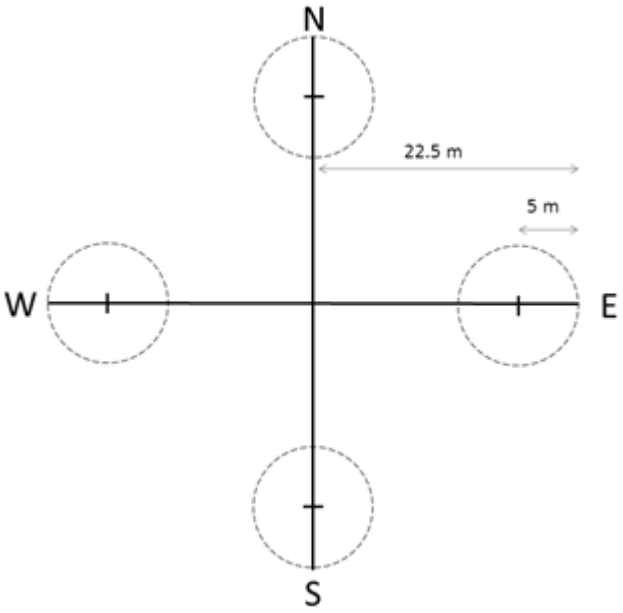
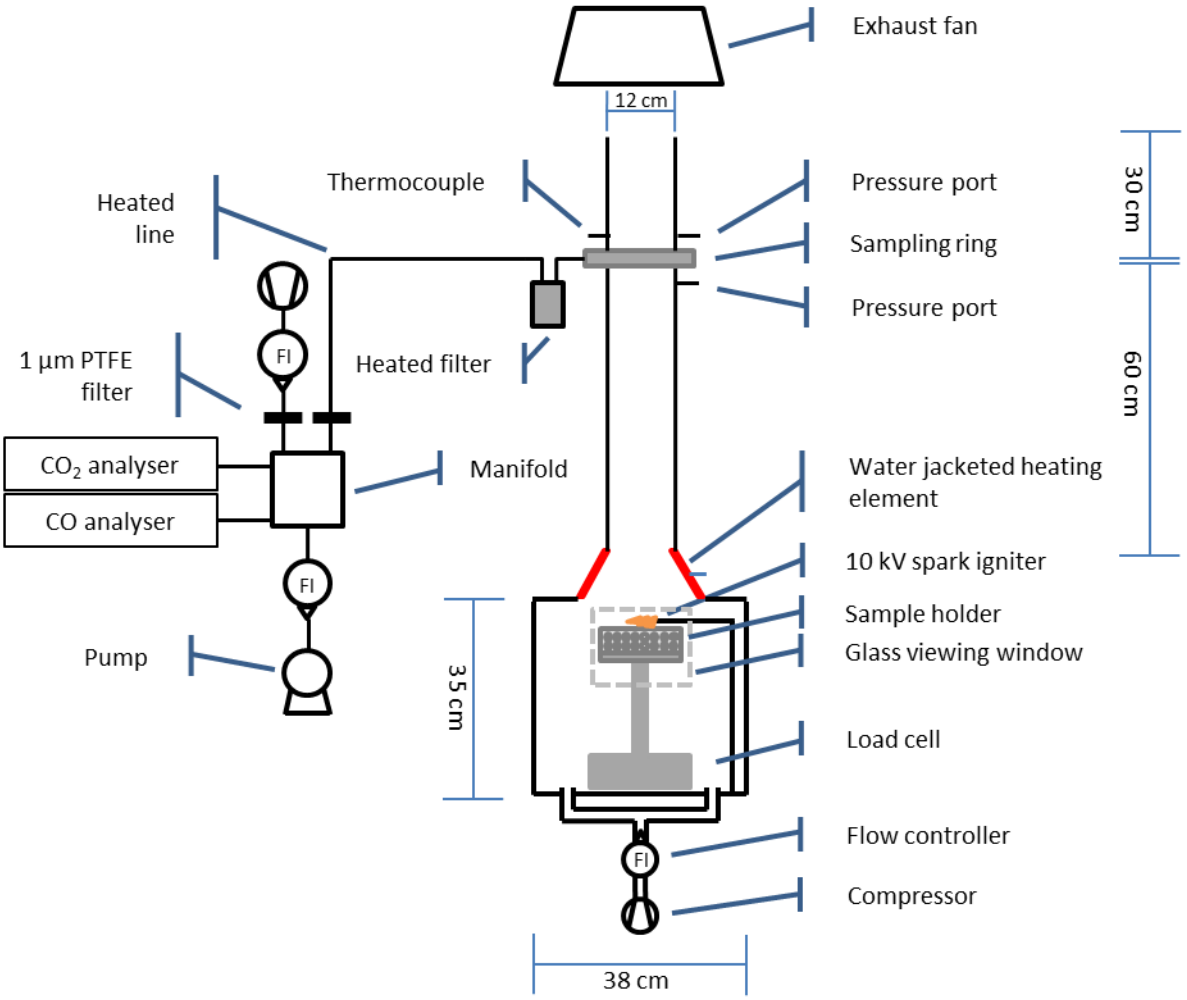


Figure 1: Plot layout for data and sample collection.



Supplementary Figure 1: Schematic of experimental set-up used for the combustion analysis. Dimensions of certain components are provided but the figure is not drawn to scale.