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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "New experimental diagnostics in combustion of forest fuels: Microscale appreciation for a Macroscale approach" *by* Dominique Cancellieri et al.

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(1) Overall, I think that this study is very valuable for the community but it needs more elaboration, especially since it has already been published in 2014, with the exact figures, methodology and results, under the following: D. Cancellieri, V. Leroy- Cancellieri, E. Leoni, Multi-scale kinetic model for forest fuel degradation, in Advances in Forest Fire Research, 2014. In order to avoid repetition of what is already published, I propose that the authors include novel elements, such as more in depth analysis on the differences between laboratory scale and field scale measurements, or perhaps testing the proposed kinetic model in a CFD code, as it is already suggested by the

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authors. Other elements can also be added, if they are novel. Only for that reason I consider that major revisions are necessary. Please consider my recommendation in a positive light.

Reply : The work presented at the Conference of Coimbra was focused on prototype design. It aimed at presenting our approach and our intents regarding the measurement of mass loss in real fire conditions. The results published in the proceeding of the conference only came from a single experiment. Since we have tripled the experiments to provide reproducible data which have been included in the revised version of this paper. In order to take into account the reviewer comment, new elements, such as the chemical composition, the heat flux measurement and the confidence levels, have been added. It is well known that the chemical and physiological properties play a significant role on thermal decomposition of fuel, so we proposed in the revised paper a deeper characterization of studied species including elemental and lignocellulosic composition, and physiologic properties (table 1). Moreover, as underline by the reviewer in its comments (n°6), the heat flux is a great of importance in modelling wildland fire, so we have included a large part devoted to the heat flux measurement carry out during our tests campaign. These data, in part, will fill the lack of information on heat transfer and physiological parameters. All these elements are new and are discussed and correlated to the thermal behaviour of each species.

(2) Page 2 (line 8-10): Wind and heat flux conditions can be very similar in FPA and cone calorimeter than in real scale conditions, could you elaborate on how the gap between real scale and laboratory scale tests is significant?

Reply: For our point of view, FPA and cone calorimeter experiments are still far from conditions obtained at field scale. Indeed, the samples studied are not kept intact, since it must be placed in a basket about 12-13 cm in diameter by 3-5 cm high. On the other hand, during the laboratory experiments, the samples are suddenly submitted to a constant heat flux, while during field tests the samples are subjected to a fire front. The samples are heated by a real flame not by infrared heater unlike using FPA or with a radiant panel when using a calorimeter cone. The whole heating conditions ensure the conditions of preheating and the variations of fluxes (with increasing fire intensity) encountered in real conditions.

(3) Page 2 (line 15): It is worth mentioning that Dupuy in international journal of wildland fire (1995) measured the mass loss for an intermediate scale fire spread on a tilted table and Mell et al. measured the mass loss for a single Douglas fir tree in Combustion and Flame (2009).

Reply: This oversight has been rectified.

(4) Page 2 (line 28): The last sentence is incorrect as numerous publications by Morvan, Mell, Rochoux and others reported back on the use of kinetics models implemented in physical models and compared to field data.

Reply: This sentence has been deleted.

(5) Page 3 (2.1 samples): In the field experiments, were the samples living fuels? Is there an estimation of their fuel moisture content? It would be valuable to at least mention it, since, the evaporation process is not included in the model.

Reply: In order to focus on oxidative pyrolysis and combustion processes, samples were oven-dried even at field scale. Because the fuel moisture content is more impacting the burning rate than the type of fuel, the fact of getting rid of the moisture content let us concentrate on the influence of the physicochemical parameters of the plants on the mass-loss rate. For more clarity, this part (2.1. samples) has been rewritten and more details on the sampling process have been done.

(6) Page 5 (2.3.2 experimental and meteorological conditions): Was there any measurement of the flame height or of the heat flux received by the sample? This is important in order to relate to real scale and laboratory scale fire conditions.

Reply: In order to characterize the heat flux impacting the sample, we have also deployed a flux meter on the experimental site (cf. figure 3). A part dedicated to the description (cf. section 2.3.2) and to the results (cf section 3.2) of these measures has been added in the text.

(7) Page 5 (2.3.2 experimental and meteorological conditions): I understand the purpose of placing the samples at the edge of the fuel bed. However, placing the samples in the middle of the fuel bed would have provided more realistic fire conditions, such as more radiation from the back of the flame front and more induced wind. This could have significant impact on the temperature and mass loss curves at t>550s. What there any other technical limitations for choosing this configuration?

Reply: We have tested different configurations: in the middle of the fuel bed (as shown the picture of the figure 4) and at the end. The configuration where the prototype was positioned in the middle only allowed a 5m propagation which did not ensure the quasi-stationary conditions that we were looking for. It would have been interesting to work on a longer fuel bed and position the prototype at around 10m but the site of the UICS n°5 did not allow it.

(8) Page 7 (Figure 5): Could you add more explanation on the significance of the first small peaks that are reached around 480-510sec? Do they represent local ignitions? Are these small peaks included in the "straight line" described line 7? Is this simplification overlooking the influence of evaporation process on the mass loss, especially for pine? Reply: In order to have any disturbances of the thermocouple on the sample and in return, we have placed the thermocouple on the side of each sample. Moreover, we have selected K-type thermocouples (diameter: 25μm) for their high sensibility and their temperature range, with an upper limit of 1300 $\pm$ 0.5°C. With this configuration and the high sensibility of thermocouples, we detect the fluctuations due to the eddy of the flames approaching the target samples. This is what is visualizing around 480-510 s.

(9) Page 8 (line 18), There is a typographical error in the equation. Apostrophe to be removed.

Reply: The apostrophe has been removed.

(10) Page 9 (line 25): The authors highlight the importance of taking into account the physiological nature of species and to integrate them in CFD models. This is the exact same conclusion from the authors study in 2014. Could the author provide results or even guidelines on of the implementation of this model in a CFD code?

Reply: We do agree with the reviewer that we have to provide guidelines for modelling mass-loss rate. With this aim, we have graphically determined which chemical or structural parameters is most impacting the mass-loss rate. For coherence reasons with the target element (m ÌĞ) we have focused on the parameters directly linked with the mass-loss: cellulose, lignin, holocellose and fuel density. For more visibility, we have dimensionless all the parameters. This graphic (figure 11) reveals that the holocellulose is the main impacting parameter on the mass-loss rate. Conversly, extractive is inversely proportional to mass-loss rate. Usually, CFD models take into account fuel density, well it seems that the chemical composition and the structure of the plants are of primary interest when modelling wildland fire.

(11) Page 9-10 (Conclusion): What it the conclusion on the similarities and the differences between laboratory and field experiments? Mass loss and temperature can be measured in laboratory as well, why aren't they compared?

Reply: In TGA, experiments are carried out under dynamic conditions, ie at a pre-set heating rate. We have worked at 30 K/min which represents the maximum heating rate for which there is no temperature gradient between the order and the measurement. Whereas in field experiments, we have measured heating rates upper than 10 K/s. So in order to compare mass-loss rate, we have used the kinetic model describe by the eq. 3 and 4, and simulated the mass-loss rate at the same heating rates that the one observed on field (i.e 12.7 K/s). For our point of view, it is the only way to compare mass-loss rates. Nevertheless, due to the stochastic and uncontrolled conditions of field experiment the confidence level are more important with 16% vs. 0.0.3% of error for TGA. With regard to the measurement of heat flux, it should be noted that, even if the high levels of radiation are of the same order of magnitude as those obtained in the laboratory, the heating rates are not representative of an ambient fire front since the samples are subjected to a constant heat flux.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-451/nhess-2017-451-AC1-supplement.pdf

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2017-451, 2018.

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(a) Rockrose (b) Heather (c) Pine

Figure 1: Picture of samples

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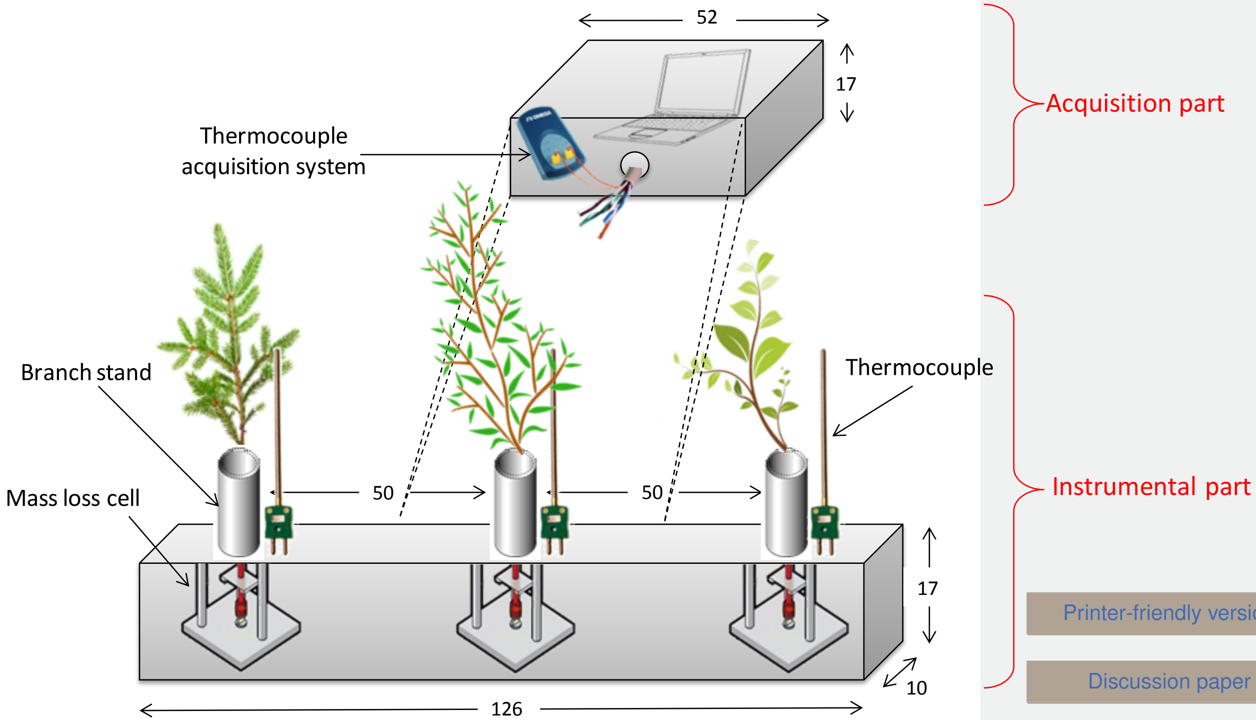

Figure 2: The differential mass-loss prototype

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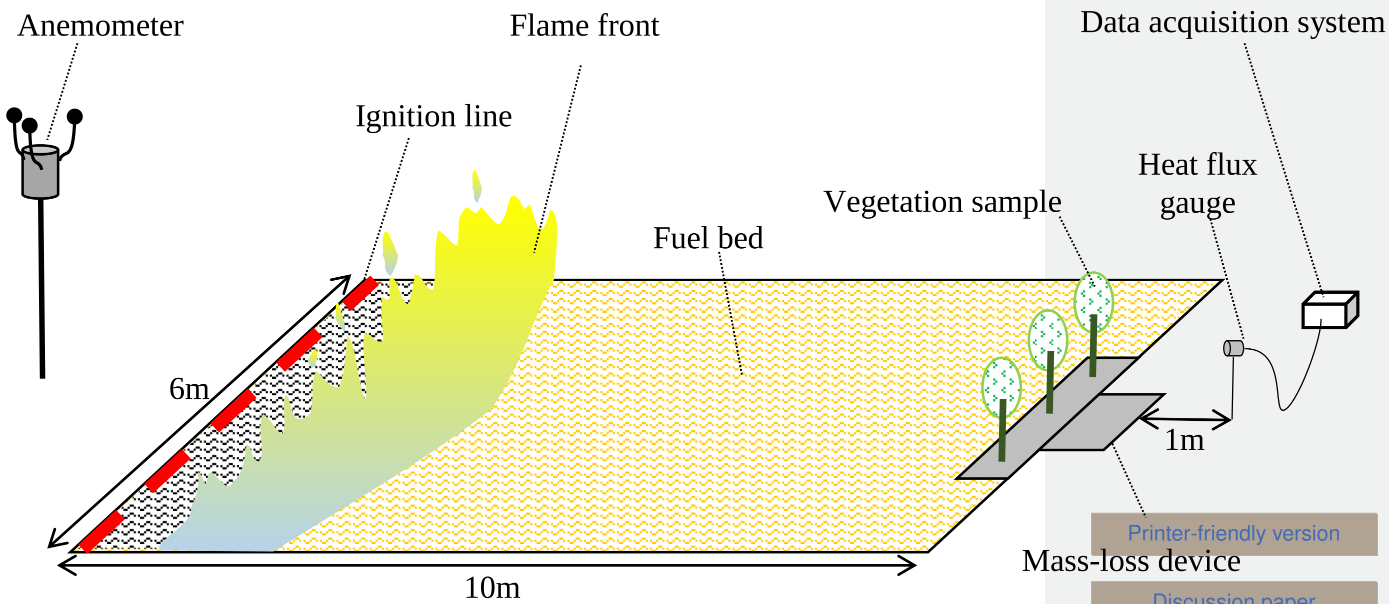
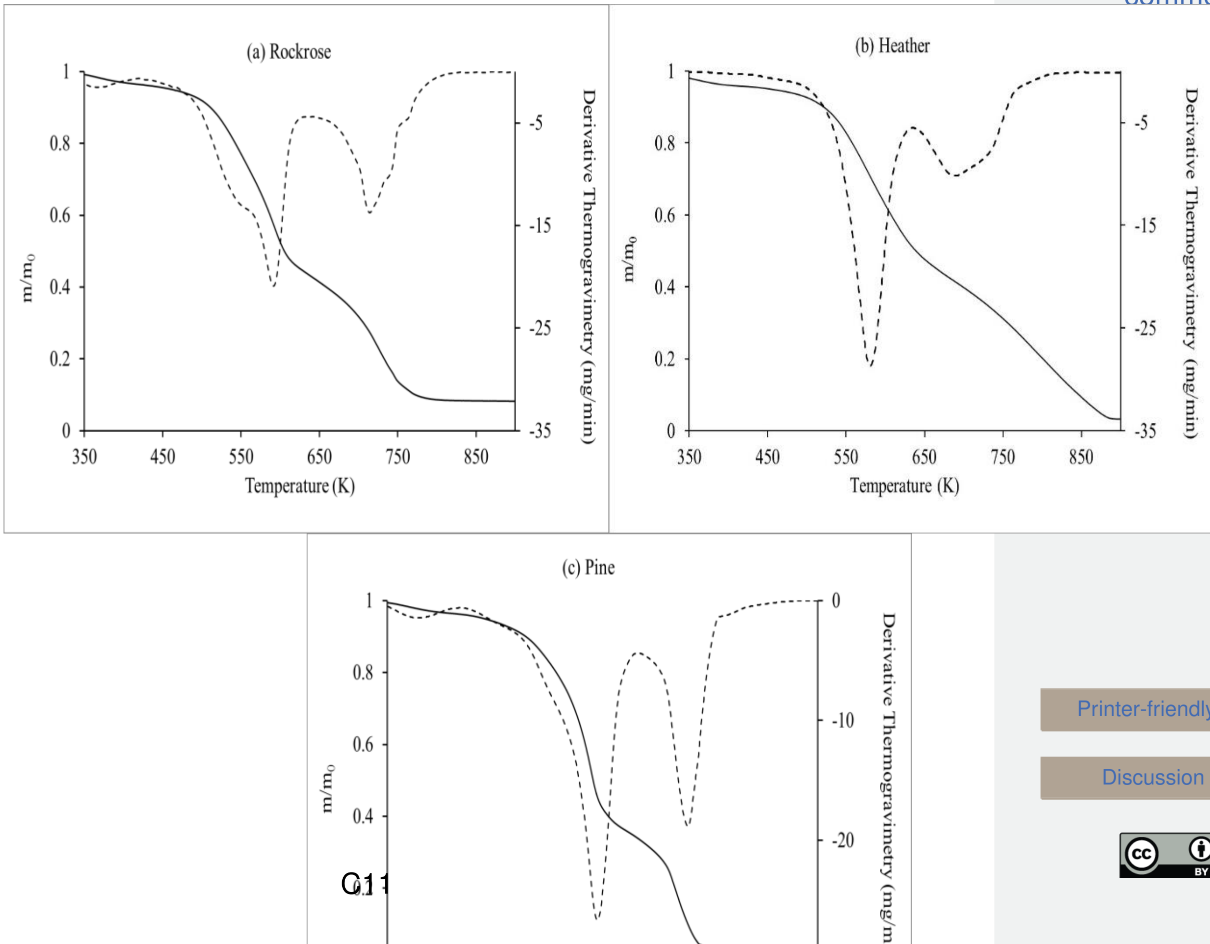


Figure 3: Experimental configuration

Figure 4: Differential mass loss prototype in field conditions



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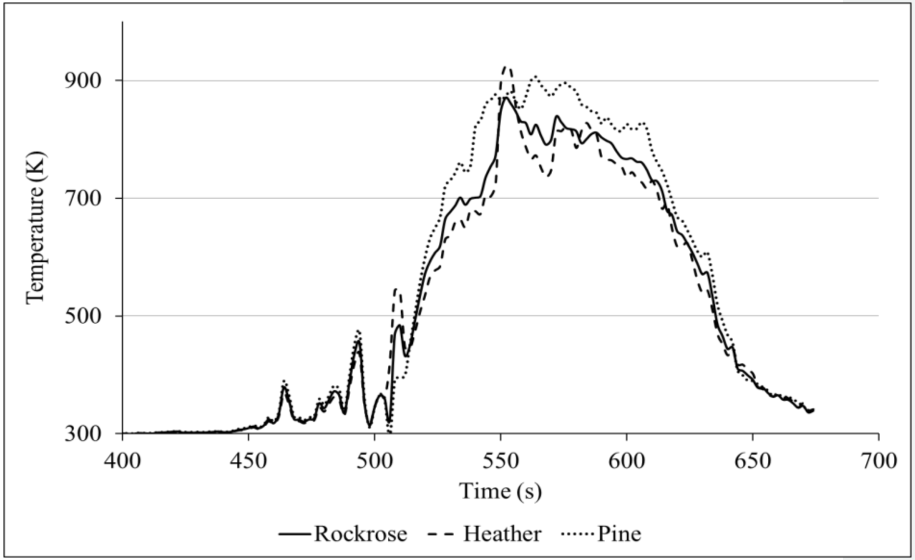

Figure 6: Temperature *vs*. Time obtained during a field experiment.

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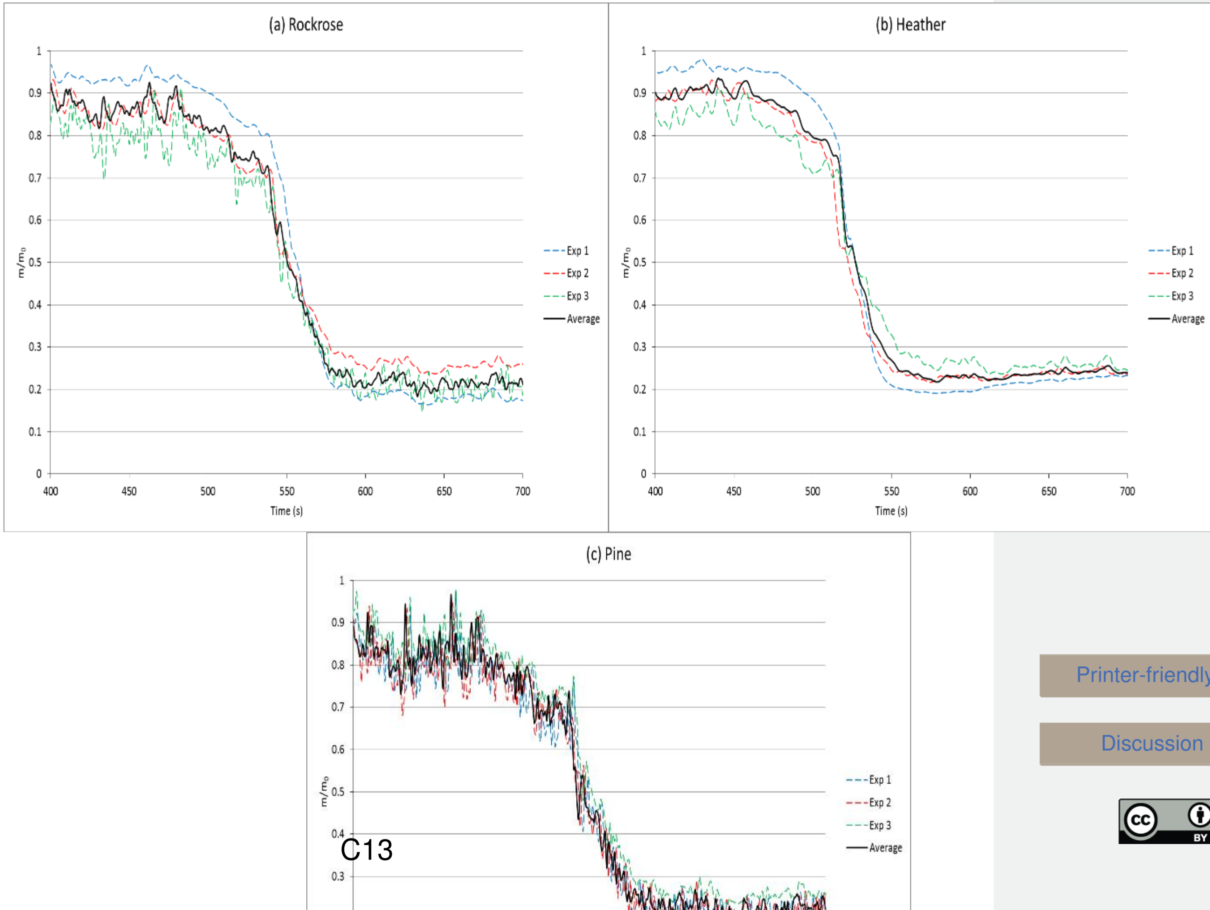

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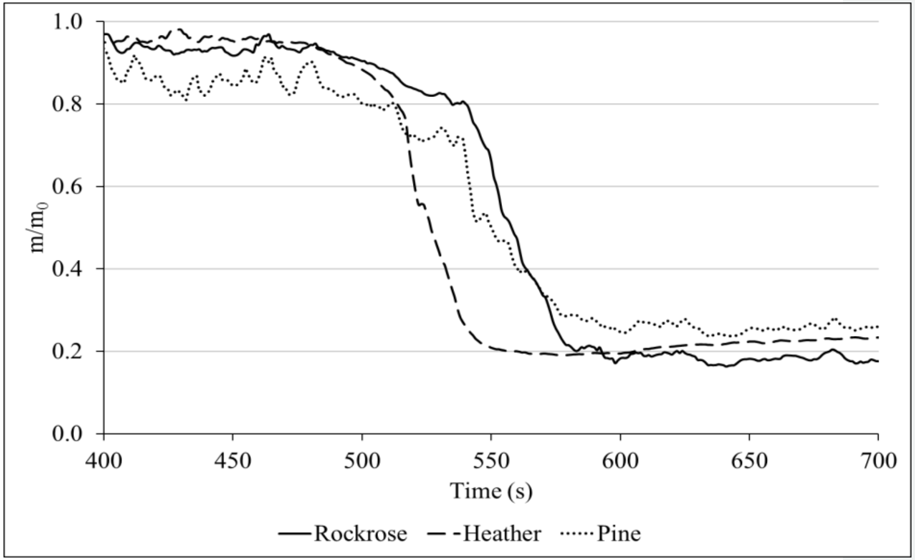
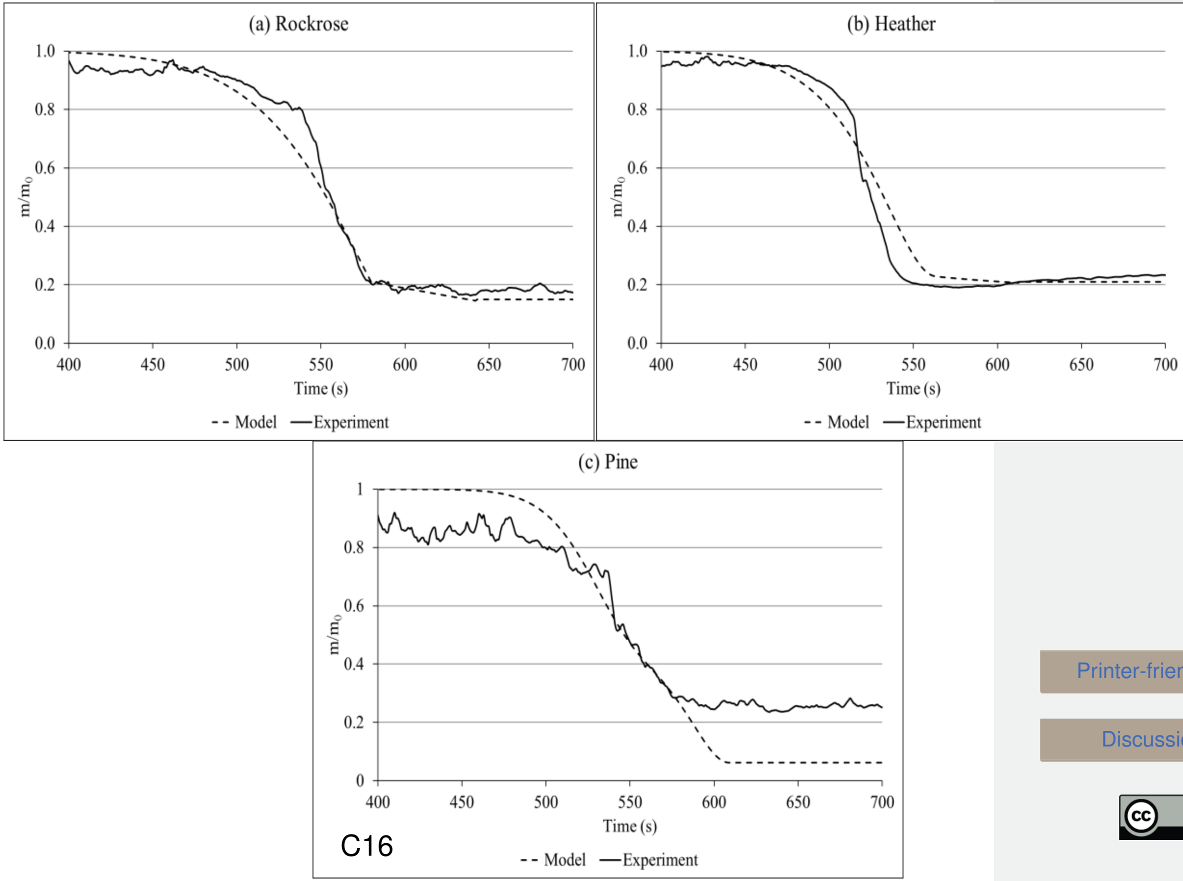


Figure 8: Comparison of experimental mass losses of the 3 species.

Figure 9: Heat flux measurement according to the distance from the fire front.



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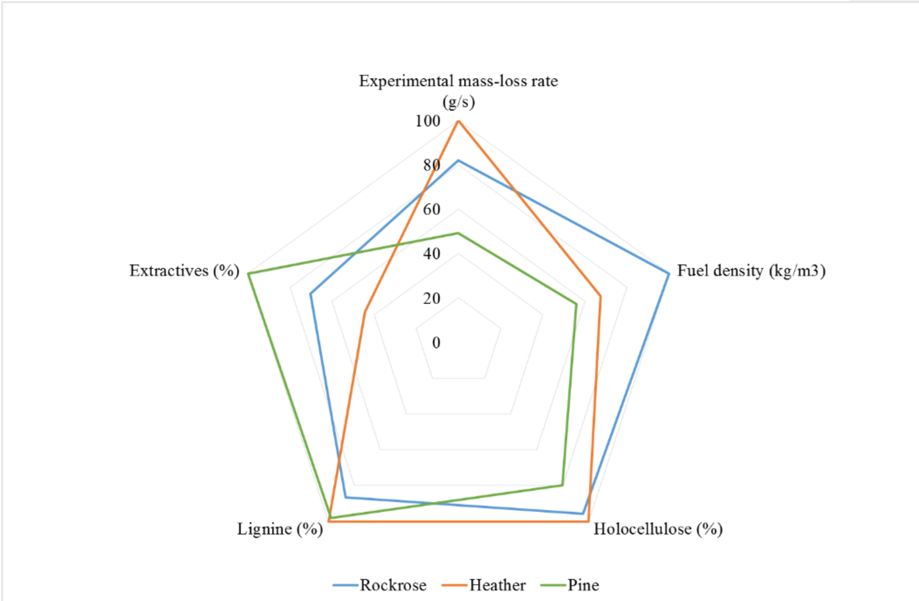

Figure 11 : Radar chart of the experimental mass-loss rate and the chemical and structural parameters.