

Blanco-Alegre et al. reported particulate and gaseous emissions from prescribed fires in two Mediterranean shrubland ecosystems. Through chemical and morphological analyses, they established a link between the fuel characteristics and the emissions. The emission factors of various organic and inorganic species reported will be useful for future assessment of the air quality impacts of prescribed fires in the Mediterranean region. However, in its current form, I feel the manuscript's novelty is mainly about reporting emission factors from these two fuels. It appears better suited for publication as a measurement report rather than a full research article. The authors should try to highlight the novelty of this work beyond reporting emission factors. I also recommend more analysis and discussion on its implication on air quality/fire management policy.

We thank the reviewer for this helpful comment. We have revised the manuscript to better highlight the novelty of the work beyond simply reporting emission factors. We now emphasize the link between fuel characteristics, combustion conditions, and the chemical and morphological properties of the emissions.

We have also expanded the discussion on the implications of our results for air quality assessment, emission inventories, and prescribed-fire management in Mediterranean ecosystems.

Another critical issue is, the authors refer to several tables in the text, including Tables 1-3, but I am not able to find these tables in the submitted manuscript. They should be provided.

We apologize for this oversight. Due to an error during manuscript preparation, Tables 1–3 were not included in the submitted version. These tables have now been added and are available in the revised manuscript.

Specific comments:

Line 101-106: The description about sampling is too brief. More details should be included. For example, what is the sampling duration and flow rate for each filter sample? Where were the filter/bag collection instruments placed? Do they belong to the airborne instruments mentioned at Line 105?

We have revised Sect. 2.1 to include additional details on the sampling duration, flow rate, and positioning of the filter and gas-sampling systems.

"i) a low volume TECORA ECHOPM **sampler operated at a flow rate of 38.3 L min⁻¹ to collect PM_{2.5} onto quartz filters**; ii) TEDLAR bags to sample smoke for further analysis; iii) CO and CO₂ Combo IAQ Meter; and iv) a weather station Geos N11 to record meteorological variables at 1.85 m above the ground, at 10 s intervals; v) an infrared camera type Flir Systems to obtain the characteristics of the fires (mean rate of spread, mean temperatures and residence time). **The sampling duration for each PM_{2.5} filter was adjusted to the duration of the smoke plume generated by each prescribed fire and ranged from 6 to 15 min. Four PM_{2.5} filter samples were collected during *Genista* burning and two during *Calluna* burning. Smoke samples for gaseous analysis were collected in TEDLAR bags during the active combustion period, avoiding the entrainment of background air as far as possible. The PM_{2.5} sampler, TEDLAR bag sampling system, CO/CO₂ monitor, meteorological station, and infrared camera were positioned at ground level approximately 10 m downwind of the fire front.**"

Line 130-131: Gas phase emissions were sampled into Tedlar bags for analyses. Although the analyses were made a few hours after sampling, I am still concerned whether a substantial amount of NH₃ and methanol could have been adsorbed by the surface of the bags. Please check literature or perform QA/QC experiments to provide more quantitative description. Also, this paper talks about the emissions of HF and HCHO, but the measurement methods are not provided.

We have revised Sect. 2.2 to clarify that HF and HCHO were measured using the same Gasetm™ DX-4000 FTIR multicomponent analyser as the other gas-phase species. We have also expanded the discussion of potential storage losses in TEDLAR bags. Specifically, we now state that adsorption onto the bag walls, diffusion through the polymer film, or chemical transformation during storage may affect reactive, soluble, or polar compounds such as NH₃ and methanol. Since no compound-specific storage-stability QA/QC experiment was performed during the campaign, the concentrations

of NH₃, methanol, and other highly reactive or polar compounds are now explicitly interpreted as conservative lower-limit estimates. References on sampling-bag stability have also been added.

“iv) Major gaseous components in the smoke samples were obtained from samples collected in TEDLAR bags, previously flushed with N₂. To avoid secondary reactions, the samples were protected from UV radiation and analysed within a few hours after sampling. Gas-phase species were quantified using a Gasmeter™ DX-4000 multicomponent analyser equipped with a high-resolution Fourier transform infrared (FTIR) spectrometer. The FTIR method identifies and quantifies gases from their compound-specific infrared absorption spectra, allowing simultaneous multi-compound analysis. The analysed species included CO₂, CO, N₂O, NO, NO₂, SO₂, NH₃, CH₄, ethane (C₂H₆), propene (C₃H₆), acetylene (C₂H₂) and methanol (CH₃OH), hydrogen chloride (HCl), hydrogen fluoride (HF), and formaldehyde (CH₂O). A detailed description of the preparation of the TEDLAR bags before and after sampling and of the instrumentation procedure can be found in Alves et al. (2010b).

It should be noted that the measured concentrations may be underestimates of atmospheric concentrations, since adsorption onto the bag walls, diffusion through the polymer film, or chemical transformation during storage may have occurred. These effects are particularly relevant for reactive, soluble, or polar compounds such as NH₃ and oxygenated VOCs such as methanol, whose stability in polymer sampling bags can be affected by storage time, humidity, concentration, and bag material (Szyłak-Szydłowski, 2015). In addition, some compounds such as SO₂, NH₃, and CH₄ may have been trapped in the air sampling system. Therefore, the concentrations of NH₃, methanol, and other highly reactive or polar compounds reported here should be interpreted as conservative lower-limit estimates.”

Szyłak-Szydłowski, M.: Odour Samples Degradation During Detention in Tedlar® Bags, *Water Air Soil Pollut.*, 226, 227, <https://doi.org/10.1007/s11270-015-2495-2>, 2015.

Line 265 (Figure 2): Since the manuscript focuses on emissions from prescribed fires, it would be helpful to include emission factors from wildfires in the same or closely related Mediterranean shrubland ecosystems. The author should also clarify whether the reference emission factors for savannas/grasslands and temperate forests in Figure 2 are derived from prescribed fires, wildfires, laboratory burns, or a mixture of fire types.

We have revised Figure 2 to include emission factors from Mediterranean shrubland wildfires reported by García-Hurtado et al. (2013), which provide a more regionally relevant comparison for the prescribed fires analysed in this study. We have also expanded the discussion to compare our measured values with those reported by them. In addition, the caption of Figure 2 has been revised to clarify that the savanna/grassland and temperate forest values from Andreae (2019) are literature-average emission factors compiled from multiple biomass-burning studies and therefore represent a mixture of fire types and measurement conditions, including field and laboratory burns.

“A more regionally specific comparison is provided by the experimental Mediterranean shrubland wildfires reported by Garcia-Hurtado et al. (2013), who obtained emission factors of 1257 ± 40 g kg⁻¹ for CO₂, 453 ± 28 g kg⁻¹ for CO, 46 ± 12 g kg⁻¹ for CH₄, 3.4 ± 1.39 g kg⁻¹ for PM_{2.5}, 1.4 ± 0.34 g kg⁻¹ for OC, and 0.051 ± 0.028 g kg⁻¹ for EC. Compared with those values, EFCO₂ in the present study was higher for Calluna (1700 g kg⁻¹) and lower for Genista (592 g kg⁻¹), which is consistent with the different combustion efficiencies observed for the two fuels. In contrast, EFCO and EFCH₄ were substantially lower in both prescribed fires than in Garcia-Hurtado et al. (2013), consistent with the strong smouldering contribution reported in their experiments. Conversely, EFPM_{2.5}, EFOC, and EFEC were markedly higher in the present study, particularly for PM_{2.5} and EC. These differences highlight the influence of fuel type, combustion phase, fire behaviour, and sampling strategy on emission factors, even within Mediterranean shrubland ecosystems.

Garcia-Hurtado, E., Pey, J., Baeza, M. J., Carrara, A., Llovet, J., Querol, X., Alastuey, A., and Vallejo, V. R.: Carbon emissions in Mediterranean shrubland wildfires: An experimental approach, *Atmos. Environ.*, 69, 86–93, <https://doi.org/10.1016/j.atmosenv.2012.11.063>, 2013.

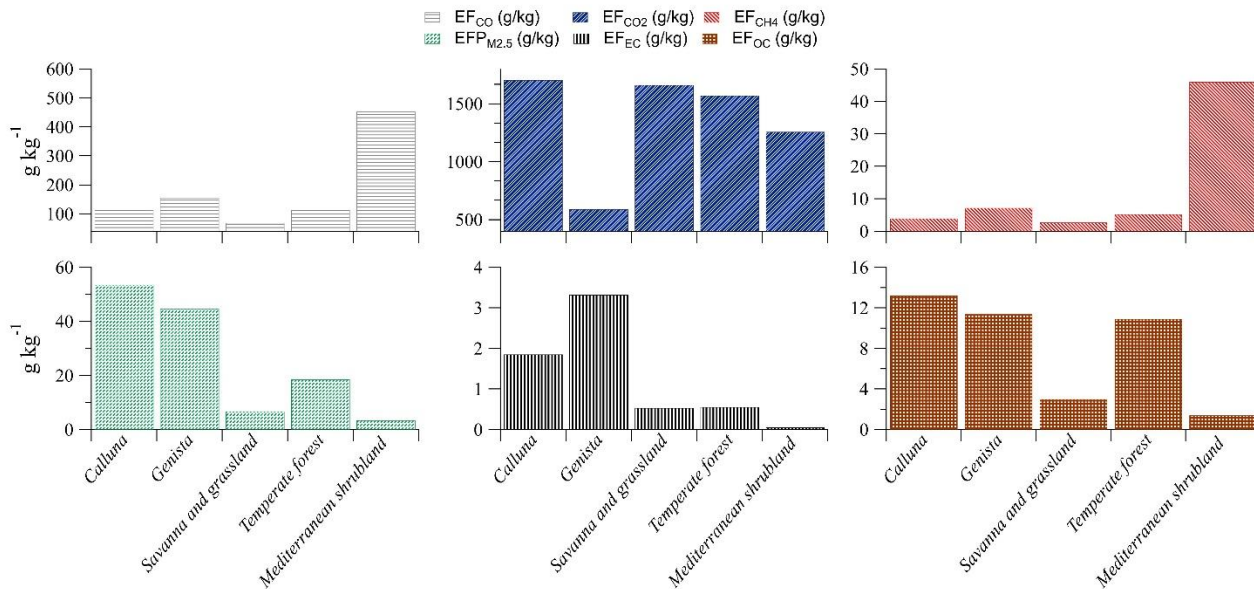


Figure 2. Comparison of emission factors (EF) for CO, CO₂, CH₄, PM_{2.5}, organic carbon (OC) and elemental carbon (EC) during Calluna and Genista prescribed fires with Mediterranean shrubland wildfire values from Garcia-Hurtado et al. (2013) and literature-average values for savannas/grasslands and temperate forests from (Andreae, 2019). The Andreae (2019) values are compiled averages from multiple biomass-burning studies and represent a mixture of fire types and measurement conditions, including field and laboratory burns.”

Minor comments:

Line 18 and Lines 141-145: Please use consistent units for MCE throughout the manuscript. In some places, MCE is reported as a percentage, whereas in others it is reported as a dimensionless value. Please standardize the format.

We have corrected the MCE notation throughout the manuscript so that it is consistently expressed as a percentage.

- Line 53-55: Please give a citation for this statement. Organic Carbon, especially biomass burning OC also contains BrC which can absorb solar radiation as well. Are there papers about the net radiative effect of OC?

We agree that the original statement was oversimplified. Organic carbon generally contributes to light scattering, but biomass-burning organic aerosol may contain brown carbon (BrC), which absorbs solar radiation, particularly at near-UV and short visible wavelengths. We have revised the sentence accordingly and added references addressing the radiative effects of light-absorbing organic carbon and the net direct radiative effect of carbonaceous aerosols from biomass burning.

“Combustion produces large amounts of carbonaceous material in the atmosphere, especially elemental carbon (EC) and organic carbon (OC), which alter the Earth’s radiative balance (Bond et al., 2013). EC is an important absorber of solar radiation, playing an important role in climate change, while OC primarily scatters solar radiation opposing the heating effect of EC. However, biomass-burning OC can contain light-absorbing brown carbon (BrC), which absorbs radiation mainly at near-UV and short visible wavelengths and can partly offset the cooling effect of scattering organic aerosol (Saleh et al., 2015).”

Saleh, R., Marks, M., Heo, J., Adams, P. J., Donahue, N. M., and Robinson, A. L.: Contribution of brown carbon and lensing to the direct radiative effect of carbonaceous aerosols from biomass and biofuel burning emissions, *Journal of Geophysical Research: Atmospheres*, 120, <https://doi.org/10.1002/2015JD023697>, 2015.

- Line 78-79: This sentence is hard to understand. What does “heatlands” mean?

The term “heatlands” was a typographical error and has been corrected to “heathlands”. We have also revised the sentence to improve clarity.

“European **heathlands** dominated by the ericaceous shrub *Calluna vulgaris* are ecosystems of high ecological, cultural, and carbon-storage value (Fagúndez, 2013), but they are also affected by both wildfires and prescribed fires (Grau-Andrés et al., 2019; McMorrow, 2011)”

- Line 154: Are these fuel carbon fraction values measured or from literature?

These fuel carbon fraction values were measured, not taken from the literature. They correspond to the carbon mass fraction of the dry fuel for *Calluna* and *Genista*, respectively, obtained from the elemental analysis described in Sect. 2.2 and reported in Table 2. This has now been clarified in the revised manuscript.

“The carbon mass fraction of the dry fuel used in Eq. (2) was obtained from the elemental analysis described in Sect. 2.2 and reported in Table 2. The $\%C_{fuel}$ values were 53.3 % for *Calluna* and 53.2 % for *Genista*.”

- Line 300 (Figure 3): Subscript for nitrate ion

The ion labels in Figure 3 have been corrected to include the appropriate subscripts and superscripts, including NO_3^- .