Response of the authors to the second round of comments by Bob Yokelson on the manuscript: "Dynamic savanna burning emission factors based on satellite data using a machine learning approach"

Roland Vernooij (corresponding author) on behalf of the authors:

Again, we express our gratitude for the substantial time and effort dedicated to evaluating and improving our manuscript. The insightful and constructive feedback provided greatly contributed to enhancing the quality of this paper. Please find below our comprehensive response addressing each review point. The updated manuscript incorporates the revised text and updated figures, while a separate 'track-changes' document is provided to highlight the modifications made. Additionally, we have appended supplementary explanatory figures referenced in our responses at the bottom of this document.

General comments by Bob Yokelson	**Author's response, reasoning and comments**
1/ The authors are familiar with a large array of products at various spatial and temporal resolution, but the average reader may find this hard to sort out. I think I realized in the second reading that the new product is basically monthly and 0.25 degree resolution? Is that right? If so, maybe highlight that bottom line in the abstract and mention any plans to increase resolution in future in the conclusions.	That is indeed correct, for the sake of this assessment we have computed EFs at a monthly base and 0.25-degree spatial resolution. The future EF files will most likely be made available at 0.25 degree in both monthly and daily resolution to integrate with GFED5. In the abstract, we clarified the text (P1 L34): "We then trained random forest (RF) regressors to estimate EFs for CO_2, CO, CH_4 and N_2O at a spatial resolution of 0.25° and a monthly timestep. Using these modelled EFs, we calculated their spatiotemporal impact on BB emission estimates over the 2002–2016 period using the Global Fire Emissions Database version 4 with small fires (GFED4s)." In the conclusions we changed the last sentence to (P18 L17): "Overall, the model results are a first step towards more dynamic and area specific emission inventories, which we plan to make available in monthly and daily resolution at 0.25° and will further improve as more measurements and better remote sensing products become available."
4a/ Earlier studies targeted a most representative single EF. This led them to attempt conducting random sampling of fires of opportunity using aircraft at the	To structure our reply, we split point 4 into two separate issues.

peak of fire season in the most active areas. There's little opportunity for detailed measurements at the burn in this approach.	We revised the text to (P2 L27): "Earlier studies targeted a most representative single EF. This led them to attempt conducting random sampling of fires of opportunity using aircraft at the peak of fire season in the most active areas. There's little opportunity for detailed measurements at the burn in this approach. Although they quantify overall variability (as summarized in for example Akagi et al., 2011 and Andreae, 2019), to date we cannot quantify how specific factors such as moisture content impact EFs (van Leeuwen and van der Werf, 2011)." Although we agree with the reviewer's statement that "the single representative EF is based on sampling of fires of opportunity using aircraft at the peak of fire season in the most active areas" we believe this applies somewhat less to savannas. In single EF estimates for savannas and grasslands, many of the underlying studies are local (small scale studies), that often include ground measurements and also rely on prescribed fires (e.g. experimental burn plots). Also, the timeframe and diversity in savanna vegetation types that frequently burn is incredibly diverse, making the biome less suited for a single EF. That being said, estimated EFs over the whole savanna (at the time of burning) were not far from previous estimates, resulting in a limited effect on global savanna emission estimates. Therefore, when one is interested in year-on-year estimates, using single EFs may suffice. The added value of our work lies in the spatio-temporal redistribution of these emissions.
4b/ The approach the authors adopted here targets dynamic EFs, but then also relies on fires set by scientists rather than local farmers in order to facilitate collection of data pre and post burn on site. That adds a layer of uncertainty about how faithfully scientists reproduce native practices.	We agree that using prescribed fires raises issues regarding the representativeness of these fires to larger non-prescribed burns. By coupling the estimation of the EFs to the satellite derived local conditions this uncertainty is somewhat mitigated. On top of our own measurements, we also took

It's also true that events can derail the accuracy of this higher resolution approach at the single fire level. I.e. if it rains one day in a dry month that will effect DM and EFs with successively less impact over the next few days.	previous savanna studies into account. Some of which were done during larger fires. We took care in selecting widespread, homogenous and representative vegetation types. However, there are many ways in which areas differ (terrain, plant species, soil, grazing patters, fire and rainfall history, human intervention, etc.) that can't all be accounted for at the same time. On top of that, there are the weather conditions during the fire. The only way to remedy this is more measurements. Our model represent a first step in quantifying the broader variability that most studies agree exist. More measurements, indeed preferably in larger fires, will further improve the estimations of these patterns. We added this to the discussion (P15 L1): "Most of the fires used to train the models were prescribed fires set by scientists or park rangers in protected areas in order to facilitate collection of data pre and post burn on site. It is common practice to extrapolate these measurements in relatively undisturbed savanna vegetation to the wider savanna. Even though these protected natural areas tend to burn more frequently, they represent a minority of the area that is currently modelled using savanna and grassland emission factors by global inventories (e.g. Fig.1). Most of this area is to some degree affected by humans though cattle ranging, wood harvesting, slash and burn agriculture, etc. This means fires in this study may not always represent the burning practices by local farmers and thus that representativeness of our work for the larger savanna area remains uncertain. "

Line by line comments by Bob Yokelson	**Author's response, reasoning and comments**
2, 28-9 How about: "Thus current global inventories are not designed to quantify any variation in average emissions at the local or monthly scale." Maybe replace "local" with something more quantitative? In general,	As suggested, we added the text (P2 L27): "Earlier studies targeted a most representative single EF. This led them to attempt conducting random sampling of fires of opportunity using aircraft at the

this region of the paper could be a good place to integrate the first part of overview comment #4 above. The part of that comment about fire authenticity might be part of the fire description text in the methods.	peak of fire season in the most active areas. There's little opportunity for detailed measurements at the burn in this approach." We also added the following sentence (P2 L31): 'Thus, current global inventories are not designed to quantify any variation in emissions at the local scale or at a monthly scale."
2, 31 Add "weather," before "climate change"?	We changed the sentence to (P2 L33): 'Using historic averages also means that EFs do not dynamically change while fire regimes, weather patterns and environmental burning conditions can shift as a result of climate change or human interaction.'
4, 8-12 The same sentence appears twice in a row	Thank you. This appears to be an issue with turning the track changes doc into PDF without comments. "Accepting" the corrections removes the double sentences.
5, 28 I think this was in first set of comments and might have been addressed in response. I wonder why NDVI is normalized to the previous year's range rather than a longer-term average. It seems a wet year could throw off the next year, but maybe that issue is not easy to fix?	The formula for PGREEN was based on equation 2 from Korontzi et al. (2015), who found PGREEN to correlate with EFs for CO and CH_4. In their study they used the NDVI range over the preceding growing season. The reviewer makes a good point that taking the average range over a longer period would even out effects of atypical seasons. In unproductive areas, fuel also builds up over years meaning previous years are likely to contain less biomass than the fire year. On the other hand, including longer periods would make it more likely that fires or other disturbances artificially influence the average. We would like to consider the impact of this in future updates and not change it at this point. Korontzi, S.: Seasonal patterns in biomass burning emissions from southern African vegetation fires for the year 2000, Glob. Chang. Biol., 11(10), 1680–1700, doi:10.1111/j.1365-2486.2005.001024.x, 2005.
6, 27 WA = weighted average? Check if already defined?	That is correct, WA was previously defined in P4 L16.
7, 15 CO EFs at 500 m resolution mentioned here is a bit confusing since the features	You are right that many of the features have native resolutions that are lower than 500

often only have 0.25 res or in any case are not available at 500m	meter. When computing the 500-meter EFs this means that only the higher resolution (MODIS based) features vary from pixel to pixel, while the temperature estimate (which is ERA5-Land derived at 0.10°) may be the same in many adjacent 500-meter pixels. As some of the features (like FTC) are different, the EF estimate will still be different between 500-meter pixels. The temporal resolution in the models on the other hand is mostly driven by the ERA5-land-derived variations. The FTC retrievals will be the same the entire year while differences in for instance VPD, temperature and FWI make the EF estimate vary each day. We added the following text (P7 L18): "When computing to a higher resolution e.g. 500-meter EFs, only the higher resolution (MODIS-based) features exhibit pixel-to-pixel variability, while meteorological conditions (derived from ERA5-Land at 0.10°) may remain consistent across many adjacent 500-meter pixels. The presence of Modis-derived features like FTC ensures that EF estimates remain distinct between the grid cells. In contrast, temporal resolution within the models is more influenced by ERA5-Land-derived fluctuations. While FTC retrievals remain constant throughout the year, variations in factors like VPD, temperature, and FWI cause EF estimates to fluctuate on a daily basis."
7, 18-24 It's still not explicitly clear how fine fuel moisture was computed. For instance, the daily cycle in fuel moisture could be important https://www.nwcg.gov/publications/pms425-1/weather-and-fuel-moisture. Typically fine fuel moisture could range from 15% in early AM to 5% in late afternoon. Is FFMC an average near 10%? If active fire products suggest burning peaks in afternoon, is the fine fuel moisture adjusted to assume afternoon conditions for every fire in a 0.25 degree grid box?	If understood correctly, you refer to the Fine Fuel Moisture Code (FFMC), which is included as a part of the FWI but as a standalone variable is not a feature in figure 2. This code is a numeric rating of the moisture content of litter and other cured fine fuels occupying the first fuel bed layers (surface layer, 1-2 cm deep) and ranges from 2-101. It is based on Vitolo et al (2019) who use the equations from van Wagner and Picket (1987) combined with ECMWF model inputs. As this product is available daily, we did not consider the diurnal cycle of this parameter.

	Vitolo, C., Di Giuseppe, F., Krzeminski, B. and San-Miguel-ayanz, J.: Data descriptor: A 1980–2018 global fire danger re-analysis dataset for the Canadian fire weather indices, Sci. Data, 6, 1–10, doi:10.1038/sdata.2019.32, 2019. Van Wagner, C. E. & Forest, P. Development and structure of the canadian forest fire weather index system. Can. For. Serv. Forestry Tech. Rep. 35, (1987). It should be noted that this code did exhibit strong correlation with the fine fuel moisture contents we measured in the fuel (Table 4).
7, 24 So here is where we learn that this study is taking us from one static EF or an assigned EF for EDS and LDS to monthly EFs, but not higher?	For this global assessment over the 2002-2016 period, we indeed calculated EFs on a monthly basis. We have more recently calculated global EFs on a daily basis which will be made publicly available alongside GFED5. The main temporal patterns however will most likely be very similar to those presented here. As mentioned in the response to point 1, this is now mentioned in the conclusions section.
7, 25 EFs, MCE, and DM consumed are all impacted by the environment. Does DM consumed vary based on these features or is that built in to GFED already?	In GFED the combustion completeness is directly scaled (between set minimum and maximum values and for different fuel types) based on moisture. Other environmental influences are assumed to be accounted for by NDVI which is used in the light-use efficiency model to compute carbon uptake. In future GFED values we aim to build-in MCE and EFs based on this work.
8, 11 Not required but possible that this section could be a place to remind less experienced readers of the historical "one EF" motivation for simply reporting a study average measured on a big plane with lots of instruments and a fast speed to access a lot of fires and operating from a base at the peak season/area.	We are very sorry if the reviewer feels that we underrated the numerous previous airplane and field measurements. That was not our intention, we fully realize how complicated and laborious these campaigns are which yield information on a much larger range of species and insights into atmospheric chemistry than our work can ever do. In the introduction we added (P3 L9): "While lacking the extensive species coverage and precision instruments found

	in advanced aircraft campaigns, these UAS measurements can effectively focus on particular vegetation types, facilitating the connection between ground conditions and emissions.”
8, 15 add any impact on MCE?	We changed the sentence to (P8 L21): “EFs of CO and CH_4 were lower (i.e. higher MCE) in xeric open savannas compared to woodland savannas.”
8, 18-19 isn’t DM-consumed more important than burned area here?	That’s correct. In relation to the DM consumed, this sample bias would be even larger. We have changed the sentence to (P8 L23): “However, this may be largely attributable to the fact that xeric savannas were overly represented in our measurements in terms of annual biomass consumption (i.e. sample bias)”
8, 28 May have asked in round one, but how does measured fuel consumption compare to the fuel consumption predicted by GFED FC?	We did not use these plots yet to compare against the GFED4s modelled combustion completeness. However, many of these field measurements were used for the calibration of the GFED 500-meter model by van Wees et al. (2022). Figure 3 of that paper shows a comparison of the fuel consumption (and combustion completeness) range found in our plots and predicted by the GFED 500-meter model. As mentioned, this is more a calibration exercise rather than an independent comparison. Van Wees, D., Van Der Werf, G. R., Randerson, J. T., Rogers, B. M., Chen, Y., Veraverbeke, S., Giglio, L. and Morton, D. C.: Global biomass burning fuel consumption and emissions at 500 m spatial resolution based on the Global Fire Emissions Database (GFED), Geosci. Model Dev., 15(22), 8411–8437, doi:10.5194/gmd-15-8411-2022, 2022.
8, 30 “corresponding mixtures of fuel age” is a bit nebulous unless you define fuel age. Do you mean time since last burn, or something else? This fuel age concept comes up again on page 9, line 3.	We changed the sentence to (P9 L10): “For some characteristics (e.g., the total fuel load), it is important to note that the average time since the last fire was not necessarily equal between the listed vegetation types. The higher fuel loads we found in open savannas in Australia compared to Botswana, may be partially attributed to the longer fuel build-up.”

8, 35-38 Here you seem to clearly indicate there was more RSC late in dry season, at least in the humid savanna. On line 38, I would move live foliage before the list of RSC-prone fuels. Have you defined RSC? You might find the Bertschi et al 2003 JGR paper useful for that. Or one could term this phenomenon as "post-frontal combustion."	We changed the text to (P9 L3): "As the dry season progressed, there was a clear shift towards the combustion of more live foliage and Residual Smouldering Combustion (RSC)-prone fuels like coarse woody debris, stems and densely packed litter, which after months of drought have become more receptive to combustion. RSC occurs after the passage of a flame front and its emissions are not lofted by strong fire-induced convection (Bertschi et al., 2003). The late-LDS increase in the consumption of live and course fuels coincided with higher EFs for CO and CH_4 in the LDS."
9, 8 The dry Australian savannas had lower EFs, but was DM-consumed also lower or was that offset by longer fire-return intervals?	As is listed in Table 3, both the fine fuel load and the combustion completeness were very high while these locations did not contain much in terms of trees. Indeed, the average time since last fire was also much higher. This combination of infrequent but intense fires is related to the typical (hummock style) growth pattern of the spinifex grasses (e.g. Figure 2 below) that predominantly carry the fire. They burn extremely hot and at high MCE. However, it takes some years for the fuel to become continuous enough to carry.
9, 9 One thing was obvious during our field work in Zambia. Within a radius of settlements, much of the woody debris is collected for household firewood. On the outskirts of Kaoma we saw people pushing bicycles with logs tied to the seat and handlebars headed to a local sawmill. The landscape was clearly managed differently within say 50 miles of Lusaka compared to more remote areas.	Our measurements took place in the Kafue national park where these practices are not allowed. We have added the following text to the discussion (P15 L1): "Most of the fires used to train the models were prescribed fires set by scientists or park rangers in protected areas in order to facilitate collection of data pre and post burn on site. It is common practice to extrapolate these measurements in relatively undisturbed savanna vegetation to the wider savanna. Even though these protected natural areas tend to burn more frequently, they represent a minority of the area that is currently modelled using savanna and grassland emission factors by global inventories (e.g. Fig.1). Most of this area is to some degree affected by humans though cattle ranging,

	wood harvesting, slash and burn agriculture, etc. This means fires in this study may not always represent the burning practices by local farmers and thus that representativeness of our work for the larger savanna area remains uncertain." In the conclusions we also added the following sentence (P17 L22): "The measured fires were predominantly intentional burns conducted by scientists or park rangers in protected areas for data collection, and while these measurements are extended to undisturbed savanna, the majority of the broader savanna used in emission models is influenced by human activities like cattle grazing and agriculture, raising uncertainty about the representativeness of the study's findings."
10, 4 So to me, this means the MAE in MCE using static MCE is ~1.60*0.006 = 0.010. If that's not right, maybe explain more?	Not exactly, that would be 60% compared to the new MAE. Instead, the reduction is given compared to the old value. Therefore, the MAE in MCE using static MCE is ~ 0.006 / (1-0.6) = 0.015 We changed the text to (P10 L9): "Overall, we found that using only globally available features covering a large (>20 year) timespan, we could estimate the field-measured MCE of the fires in the validation set with a mean absolute error (MAE) of 0.006. Using the static MCE in GFED4 (MAE of 0.015 compared to the measurements) as a baseline, this meant a MAE reduction of 60%."
10, 24 Soil moisture may act more like a "long time-lag" (1000 hour) fuel?	You are right that a time lag is to be expected between soil and fuel moisture. however, we also found that the soil moisture variability was more spatial rather than temporal in nature. This resulted in it still being a strong predictor, even though being a mediocre indicator of seasonality.
10, 30 Again one wonders how common are grid cells that are a mixture of savanna and non-savanna? This may have been partly addressed in the added text about misclassification of savannas as cropland.	Given the fact that our measurements were mostly taken in protected areas, the impact of actual cropland on our measurements is limited ("Cropland/Natural vegetation mosaic" (6%) and "Croplands" (1%)).

	The IGBP classification classifies savannas as “Lands covered with temporary crops followed by harvest and a bare soil period (e.g., single and multiple cropping systems). Note that perennial woody crops will be classified as the appropriate forest or shrub land cover type.” We appreciate that in some savanna areas with very distinct seasonal signals, this distinction may be problematic. It would be very interesting to see to what extent possible misclassifications affect our emission estimations, albeit somewhat out of the scope of this study. In addition to the previously added classes and the classes in the Excel file, we added the previously mentioned section about the representativeness of protected areas to the discussion (P15 L1).
11, 7&10 I think it was decided in response to another reviewer that there’s no such thing as “typical savanna”?	We have removed all references to “typical savanna” from the manuscript.
11, 25-26 There are no parentheses and two EFs have stdev of zero? The interannual variability seems low at < 1% maybe?, and certainly lower than real accuracy?	We added parentheses. We found that giving the numbers in 2 decimal precision suggests the models to be more accurate than they are. However, rounding to a single decimal means the standard deviation becomes zero. We agree that the interannual variability is lower than one would expect. This may partially be because the interannual variability in some features like FTC and FBC is also low. Also, looking at a global perspective some regional effects even out. If we look at the regional interannual variability, this is more pronounced. Below we have added figure 3 below (not in the paper), in which we show the variability for different GFED regions.
12, 16 As an alternative to saying fires get more intense, or as the probable cause, is the concept that “the fuels get more receptive.”	We changed the sentence to (P12 L23): “On the other hand, as fuels get more receptive over the dry season, fires consume increasingly more litter, coarse fuels and live foliage, provided these fuels are available (Table 3).”
12, 37-40 choose one version of sentence. I boycott the concept of “fires getting “hotter”” since no-one has ever defined how	This additional explanation was added on the suggestion of one of the other reviewers but we agree with you.

to measure the temperature or, much less, the extent of a "whole fire." This is in contrast to concepts like "flame temperature" or "combustion completeness", which have straightforward definitions. Also, you have already said there was more RSC in the wooded savanna in the LDS, which would lower the MCE.	We changed the text to (P13 L1): "Contrary to previous research which indicated that dryer conditions in the LDS would lead to higher-MCE fires in both grasslands and savanna woodlands (Korontzi, 2005), we found lower MCE in these regions under late-LDS conditions (Fig. 3). One potential explanation is that although the LDS fires were more intense, they consumed much more RSC-prone fuels (Table 3), which may explain the higher CH_4 and CO EFs. An alternative explanation to this fuel-driven MCE reduction is that in certain areas our measurement campaigns missed the peak-season when fires are driven by stronger winds (Laris et al., 2021; N'Dri et al., 2018), and that fire intensity and MCE in these areas would already be on the decline."
13, 6-8 Standing alone this sentence could be interpreted to mean RSC is not a factor across the whole savanna biome. The previous sentence tries to qualify it, but with a new term "open savannas" Thus, I would qualify this sentence as follows: "We found that, in the xeric savannas, the composition …"	We revised the text to (P13 L11): "We found that, in the xeric savannas, the composition of the fuel in LDS fires did not significantly differ from EDS fires, as most of the available fuel was consumed in both the EDS and LDS fires. In these areas, we did observe a slight seasonal decline in CO and CH_4 EFs."
The version of Fig 9 in track-changes is not the same as the revised Figure in the response showing the fit to both spot samples and fire-average data. I like the new version with two fits better and thought the authors intended to upgrade?	We have replaced figure 9 with the version shown in the response to your previous comments (also shown below).
13, 22-25 Indicate if this applies only to mesic or wooded savannas. 13, 25-27 This is a lot in a short sentence. How do you know if studies are skewed, how would that effect slopes based on first principles, how does FTC fit in? I'd either explain all these things in full or just delete the sentence since it may not be that important.	We changed the sentence to (P13 L32): "Mainly within wooded savannas, this clarifies why studies focused on either smouldering or flaming phase emissions exhibit diverse slopes for CH4 EF to MCE when employing linear regressions. Additionally, this phenomenon accounts for the inclination of the slope to intensify in fueltypes characterized by higher lignin content."
13, 29-33 Should this summary of analytical uncertainty go in the methods section?	We moved the section to the methodology (P5 L8).
13, 36 EESGT defined?	We changed EESGT to "Estação Ecológica Serra Geral do Tocantins (EESGT)"

13, 35-37 could a higher elevation of African sites mean cooler temps and less evaporation than in Brazil?	While the African sites in Kafue national park (Zambia) where indeed higher (1000-1200 MSL) compared to the Brazilian samples (450-550 MSL), the fires in Niassa, Mozambique where at lower elevations (400-450 MSL). Another possible explanation may be the nutrient availability: The soil in the Cerrado tends to be nutrient-poor and acidic, which can limit the growth of trees. The nutrient availability in the soil plays a crucial role in determining the density of trees. In more nutrient-rich soils, trees can thrive and outcompete grasses, whereas in nutrient-poor soils, grasses may have an advantage. Given that this is all speculative and the paper is already very dense we refrain from modifying the text
14, 8-17 is Mg/ha better than tonne/ha? Line 17 missing word, add "was" before "grass"?	In our experience Tonne is more often used, however we understand confusion with the imperial Ton.
14, 19 Is grazing taken into account in GFED or IGBP cover types?	No not directly. IGBP landcover classifications are derived from fuel structure (tree cover (>2m), non-tree vegetation cover and bare soil) and their seasonal properties (E.g. evergreen vs deciduous forests). Croplands are classified as "areas covered with temporary crops followed by harvest and a bare soil period". Therefore, perennial crops will not be classified as cropland and frequently burning or cleared areas may be. Although grazing is not directly included in the definitions it may of course alter the vegetation structure.
14, 32 and throughout. Technically there is no such thing as a "head fire"; it's "shorthand." Based on my four years as a wildland firefighter and with some back-up on terminology from: NWCG Glossary of Wildland Fire Terminology PMS 206 https://www.nwcg.gov/publications/pms205 I think it's best to encourage using the following terms clearly and consistently among fire professionals.	Many thanks for this glossary. We fully agree we should aim for consistent terminology and will strive to use and promote the use of these terms in our future work. We changed all instances of headfires and backfires in the text.
36-37 RSC can be increased in a heading fire because the high rate of spread and	We changed the text accord to the suggested terminology to (P15 L14): "The

patchiness leaves fuels smoldering further from the convection associated with the advancing flame front.	samples were predominantly collected over heading fires, which in the measured fires typically represented most of the burned area. A common approach for prescribed fires is burning against the wind (backing fire), to minimise both the impact on vegetation and risk of spread. In a heading fire, RSC can be increased because the high rate of spread and patchiness leaves fuels smouldering further from the convection associated with the advancing flame front. In accordance with Wooster et al. (2011) and Laris et al. (2021), we found higher MCE in samples from backing fires, indicating less RSC and thus CH_4 and CO emissions in these types of fires. Another possible explanation for the higher MCE in the backing fire samples is that slower lofting RSC smoke does not mix with the flaming combustion emissions in these measurements, like it does in heading fires."
15, 4 Higher resolution weather might be even more important than increased spatial resolution. If it rains before your fire, that changes a lot for a few days at least. And the duration of the rain is more important than total amount in terms of soaking the fuels.	We added the following sentence (P15 L24): "Enhancing the resolution of meteorological data would further amplify the precision of these models."
15, 11-13 Is this topic out of place here and maybe fits better elsewhere?	We decided to remove the sentence as it was indeed of little relevance in this discussion.
15, 23-24 I don't think you mean these predictors worked better 20 years ago, but the sentence kind of gives that impression?	We changed the sentence to (P16 L19): "Along with inconsistent retrievals related to cloud cover, this may contribute to these features being deemed poor predictors by the models."
15, 28 can be, but were not, correct?	Correct. In this study we chose aggregate to 0.25° resolution to study the global impacts of the model using GFED4s which uses that spatial resolution. In an upcoming study however, we do use 500-meter resolution EFs combined with the 500-meter resolution emission model by van wees et al. (2022) to calculate emissions over Africa. Van Wees, D., Van Der Werf, G. R., Randerson, J. T., Rogers, B. M., Chen, Y., Veraverbeke, S., Giglio, L. and Morton, D.

	C.: Global biomass burning fuel consumption and emissions at 500 m spatial resolution based on the Global Fire Emissions Database (GFED), Geosci. Model Dev., 15(22), 8411–8437, doi:10.5194/gmd-15-8411-2022, 2022.
16, 10 It's a good discussion, but one starts to wonder if the discussion jumps around a bit and might be better organized. Maybe worth a small effort to improve, but okay.	We have reorganized the discussion while preserving the core ideas. Please refer to the track changes document for the revised text.
16, 18-19 You might want to say "have high confidence in" rather than "be sure about." The part of the sentence after the comma doesn't add much.	We changed the sentence to (P16 L34): "Although all satellite data comes with some uncertainty, we feel the errors are small enough to have high confidence in the key findings such as lower EFs in dry regions and higher in wetter regions."
17, 9 could acknowledge impact of fuel receptiveness on fire intensity	We changed the sentence to (P17 L27): "Measurements of the pre-and postfire fuel load and the fuel conditions during the fire indicated significant changes in fuel receptiveness resulting in increased fire intensity over the dry season."

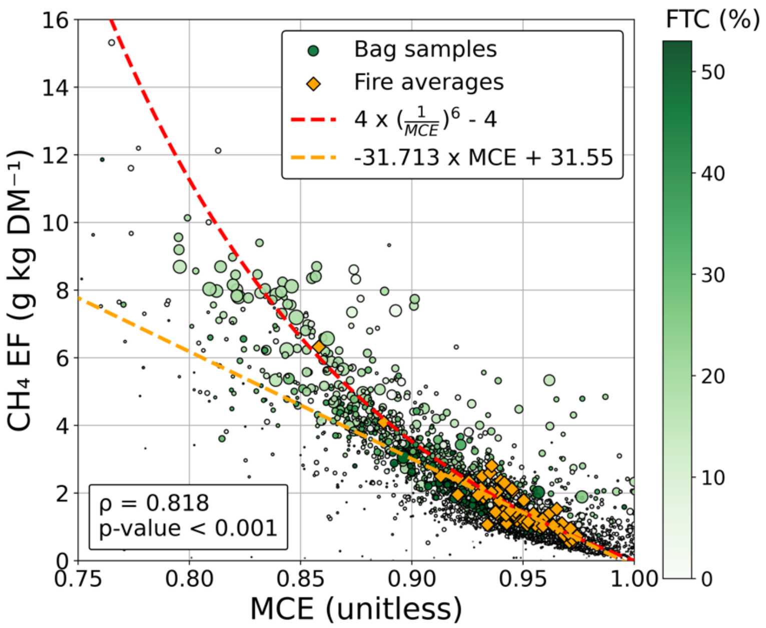

Figure 1. The non-linear regression between the CH_4 EF and the MCE for the individual bag samples (green circles) and the fire averaged values (orange Diamonds). In the box on the bottom left, ρ refers to Spearman's rank correlation coefficient for the bag samples.

Figure 2. Example of a "Spinifex" grassland in the Northern Territory. The fire needs to jump from hummock to hummock and therefore only carries when the hummocks become close to continuous, or the wind carries it far enough.

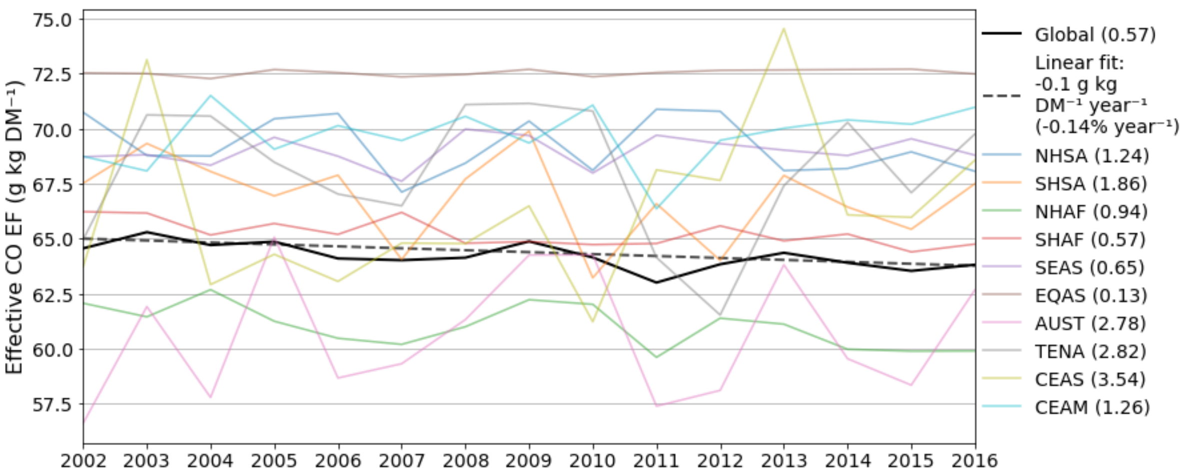

Figure 3: Interannual variability in the effective EF of CO over the time period 2002-2016. The dotted line represents a linear fit of the global trend. The lines represent the interannual variability within the individual GFED regions that represent a significant portion of "savanna and grassland" fires. The number in the parentheses is the standard deviation of the annual mean effective CO EFs over the given timeframe.