

## Reviewer comments for esd-2023-26

### Title: Regionally optimized fire parameterizations using feed-forward neural networks

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In this manuscript, the authors have proposed a neural network based method to simulate Fire Radiative Power (FRP). The inputs to this network are 4 meteorological parameters. This new method to estimate FRP can be useful to scientists involved in understanding the fire intensity and weather/climate relationships, especially with less access to various fire-related datasets like ignition etc. However, there are some serious issues in the methods and interpretation of the results obtained. I recommend addressing the methodological issues and rethinking the interpretations of the results before proceeding with publication. Also, the composition of the paper needs to be changed significantly. I have segregated my comments into three sections, major, minor and language-related. Following are the points in the order of seriousness.

#### Major comments:

##### 1. Methodological improvement with FFNN

I found several instances which do not strongly support the opinion of the authors, i.e., FFNN-based FRP estimates are indeed better than the FWI-based ones.

- A. The whole argument is based on the comparison of FFNN-based FRP estimates with the FWI-based linear regression model. Why linear regression? The relationship between FWI and FRP is not at all linear. The correct approach would be to use various non-linear regression techniques, take the best of them and then compare them with the FFNNs. Only then can we compare the predictive abilities between FWI-based and FFNN-based methods. I expect significant changes in results and conclusion if instead of the linear method some other non-linear method is used.
- B. Though FWI was originally developed for Canada, a large number of studies have used the system successfully to ascertain fire weather. It is true that the equations do not take into account some factors like species distribution etc. (lines 57-59). Even FFNN or in fact, any machine-learning-based model also does not take these into account.
- C. Inferences in lines 60-62 such as which variable contributes most to Arctic or Amazon fire activity can be determined by FWI-based studies too.
- D. Lines 156-158 and Figure 1.b: Even if this approach of linear regression is considered, from the figure it seems that the FWI-based model is statistically significant at all points as FFNNs. How is that an improvement?

- E. Line 249: Since a linear regression method was used to map FWI into FRP, of course, the FRP estimates would not be able to capture the non-linear RH2m-FRP and PRCP-FRP relationships. The argument in section 4 needs to be rewritten after considering some non-linear regression of FWI and FRP.
- F. Methods like FFNNs need extensive validation. Though it is a common practice to train and validate ML models using the same datasets, if additional validation can be done with any station data or ground observations, then the FRP estimates will be more reliable.

## 2. Incomplete information in the methods

- A. Methods should include all the calculations and steps taken for complete analysis leading to figures and also stating the reasons for conducting that particular analysis. The sensitivity experiments are not explained elaborately. A flowchart or graphical representation of these steps or at least a detailed explanation would be appropriate. Otherwise, it is very cumbersome for readers to understand the inferences discussed in the subsequent sections.
- B. Input variables for the FFNN model as well as for computing FWI are discussed in lines 95-96. Are these taken at 12 Noon local time? Or daily averages? For precipitation, was it the 24-hour sum or average? Ideally, 12 Noon UTC values or daily maximum temperature, minimum relative humidity, average wind speed and 24-hour accumulated precipitation should be used. Please specify in the manuscript.
- C. In lines 118-121, some techniques related to the neural networks are just mentioned. Please explain the terms or provide citations which explain the terms like dropout rate, batch normalization, and ReLU function for readers not familiar with these. Also, what does a dropout rate of 0.2 physically signify? Please explain these in the text.

## 3. Miscellaneous

- A. An anomalous behaviour of increasing FRP with increasing RH when humidity is less than 30% has been reported in section 4 (lines 237-241). This is supported by an argument reported by Abatzoglu and Kolden (2013). However, I could not find any such observation in the cited article. Can the authors clarify exactly where in the paper this is mentioned? Also, fire activity usually translates to fire frequency. FRP gives us more information about fire intensity. It is unusual that fire intensity at 20% RH will be lesser than at 30% RH.
- B. In supplementary figure S5, the result of precipitation and temperature values are almost similar. Line 182 in the main text contradicts this.

- C. In lines 167-170. Supplementary figures S2 and S3 have been discussed. These figures refer to Fig.2 in the main article which has not been discussed yet. Such issues in the chronology of the paper disrupt the course of reading. The whole of the result sections need to be reorganised.
- D. Lines 186-194: Inferences related to FFNNs are discussed here, however, the inferences from the FWI-based method (Figure 2d-f) are in lines 201-208. These inferences related to the same figure should be kept together. Also, between Fig 2c and Fig 2f, how do we conclude which is more correct?
- E. Line 195: Explain the physical interpretation of the LRP method for unfamiliar readers. How is the result obtained from this analysis different from the sensitivity study with FFNNs? It is still unclear which method gives a more accurate estimate of the major factors influencing FRP. Also, explain supplementary figure S7 in the supplementary or main text.
- F. Line 221: Why was this particular 0.05 number chosen? The sentence in lines 223-225 is unclear. Please rephrase. Also, figure S8 can be moved to the main article.
- G. Line 233: What is the relevance of this reference here?
- H. Line 257 onwards: Is the precipitation considered here the daily average or the daily sum? The ideal approach would be to use daily sum. Clarify.
- I. Line 285-289: Is quadratic the best fit? Also, please explain why the heightened sensitivity of FRP to precip is incorrect. That very well might be the case.
- J. ERA5 has been used in this study. What will be the scenario if we use some other weather data/ observation? How sensitive is the FFNN model to the kind of dataset used?
- K. In line 136, it is said that the entire period is divided into three-year periods. But if the test period is 1st Jan 2001- 31st Dec 2004, it is actually a four-year period. Such confusion should be removed.
- L. Supplementary figure S4: Why these particular stations and years? This is nowhere mentioned in the methods/ results/ supplementary text. Please elaborate.
- M. In Line 300, FRP behaviour or rather correlation of FFNN estimated FRP and observations over certain regions are discussed. However, why certain regions show high/low correlation has not been discussed anywhere.

#### 4. Regarding figures:

- A. What does except 0 mean in supplementary figure S2? Mention in the text/ supplementary the methodology of how these figures were obtained, their necessity and inferences.
- B. A reader has to constantly toggle between main article figures and supplementary figures. The order in which figures are discussed is random

**Minor comments:**

1. Lines 26-27: This sentence requires rephrasing. The FFNNs captured the 'relationship' accurately. Correlation is a method by which we can ascertain this relationship. Also, what do the authors mean by 'as well as precipitation'? Is precipitation well correlated or not? Please clarify.
2. Line 28: Ideally, we expect an inverse relationship between FRP and precipitation. How is this 'excessive' relationship a concern in this context?
3. Line 34: What kind of fires? Wildfires or agricultural fires? Not all fires cause ecological and socio-economic impacts. Please specify.
4. Lines 36-37: I see no relevance of this statement here, as the authors have not discussed the ignition factor anywhere in the manuscript.
5. Line 49: Moisture codes provide no exclusive information about any deceased organic matter.
6. Line 63: It is unclear what the authors are trying to convey here. Also, how is it relevant to the rest of the paragraph?
7. Line 65: How can we 'calibrate' sensitivity? Consider changing it to 'estimate/ calculate'.
8. Line 70: I guess there is a typo. It should be 'fuel' moisture code instead of fire.
9. Line 116: consider changing 'responsible for' with 'representing'
10. Line 127: there is a typo in the equation. It should be  $y_i$  instead of  $y_1$ .
11. Line 132: Is the title 'Experimental design' for section 2.3 suitable? It is rather an explanation of the cross-validation strategy only.
12. Line 143-145: Rephrase the sentence. Anomalies were compared and assessed for accuracy.
13. Line 161: Please provide a map of FRP climatology in the main or supplementary article. What does the citation here convey?

14. Line 196: To support which findings? Please specify.
15. Line 213, 217: The ideal course for this kind of study should be first to identify which is a better method, gather sufficient evidence and then put forth the result as to which is a better method. Also, try to avoid phrases like 'confirm the superior performance'.
16. Line 216: What does 'Physical' explanation mean? Consider changing the title of this section.

**Language suggestions:**

1. The tense of the entire article needs to be rechecked. For example, in line 228 the authors have used present tense, but in line 229, 'indicated' is past tense.
2. Avoid using unnecessary adjectives and adverbs. For example, in line 21, 'marked' enhancement is obsolete. Similarly, in line 209, 'dramatic' disparity is unnecessary. Consider removing all such adjectives and adverbs unless absolutely necessary as they do not add any additional merit to the manuscript.
3. Paragraphing should be rechecked. Ensure that all sentences within a paragraph are related to the main idea expressed in it. For example, the information in the paragraph starting at line 313 is related to the previous paragraph. In such a case a paragraph break is not required. The authors should review the whole article for appropriate paragraphing.
4. Line 44: 'holds a prominent status' is not suitable here. There are other indices also which are used in various countries for operational purposes. FWI is one of the popular ones. Please rephrase the sentence.
5. Line 175: Consider changing 'exploring' to 'simulating/ calculating/ estimating'. The relationship is known and already established. The models are just simulating them.
6. Line 179: 'alteration' is not suitable here
7. Line 232: A sentence break is required before 'as oxygen...'