THE ROLE OF FIRE RADIATIVE POWER TO ESTIMATE FIRE RELATED SMOKE POLLUTION

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1. Rationale and Objectives

Smoke production is directly linked to the intensity of a fire, which can be assessed based on released energy, and thus by Fire Radiative Power (FRP) data. Since the FRP is proportional to the amount of burned biomass, higher FRP values are linked to more severe fires [1], with high levels of smoke production and consequently, high emissions of particulate matter and other smoke pollutants. The **objective** of this work **is to explore FRP ability to estimate fire smoke pollution**, namely fire related pollutants, taking advantage of the very high temporal resolution data from geostationary satellites (15 minutes for Meteosat Second Generation, MSG). The rationale is to use a top-down approach to assess smoke emissions from fires [2,3], to derive smoke emissions estimates directly, based on FRP data over study areas within different biomes. Particulate matter (PMx) and carbon monoxide (CO) concentrations emitted during a wildfire over Central Portugal in August 2022 are depicted as an example.

2. Data and Methodology

Serra da Estrela (SE) fire broke out on 6 August 2022, affecting 27,340 hectares of several local municipalities over the Centre Region of Portugal. The SE fire was reported extinguished on 2 September and lasted for 28 days.

Daily Fire Radiative Energy values (GJ) emitted during SE fire result from the temporal integration of FRP data (SEVIRI/MSG disseminated by LSA-SAF), taking into account the formula [4]:

$$FRE_{ph} = 0.9 * \left(\sum_{k=1}^{4} FRP_p\right)_h$$

where the index *k* indicates the sequence of 15 minutes of each hour, *FRPp* is the fire radiative power (in MW) in pixel *p* and 0.9 is a factor that converts the result into GJ.

Estimated daily mass of total particulate matter (TPM) and CO emitted by SE fire are obtained by multiplying daily FRE values by the specific TPM and CO emissions coefficients for European biomes, considering the Fire Radiative Energy Emissions (FERM) top-down approach [2;3,5].

PM_{10} and CO observed concentrations are evaluated through CAMS reanalysis data over SE affected regions, as well as from in-situ data, provided by the local air quality monitoring station, Fundão station, [40.2331ºN; -7.29959ºW]; to check if TPM and CO space-time estimation patterns are captured by the national monitoring station network and by CAMS products, as well.

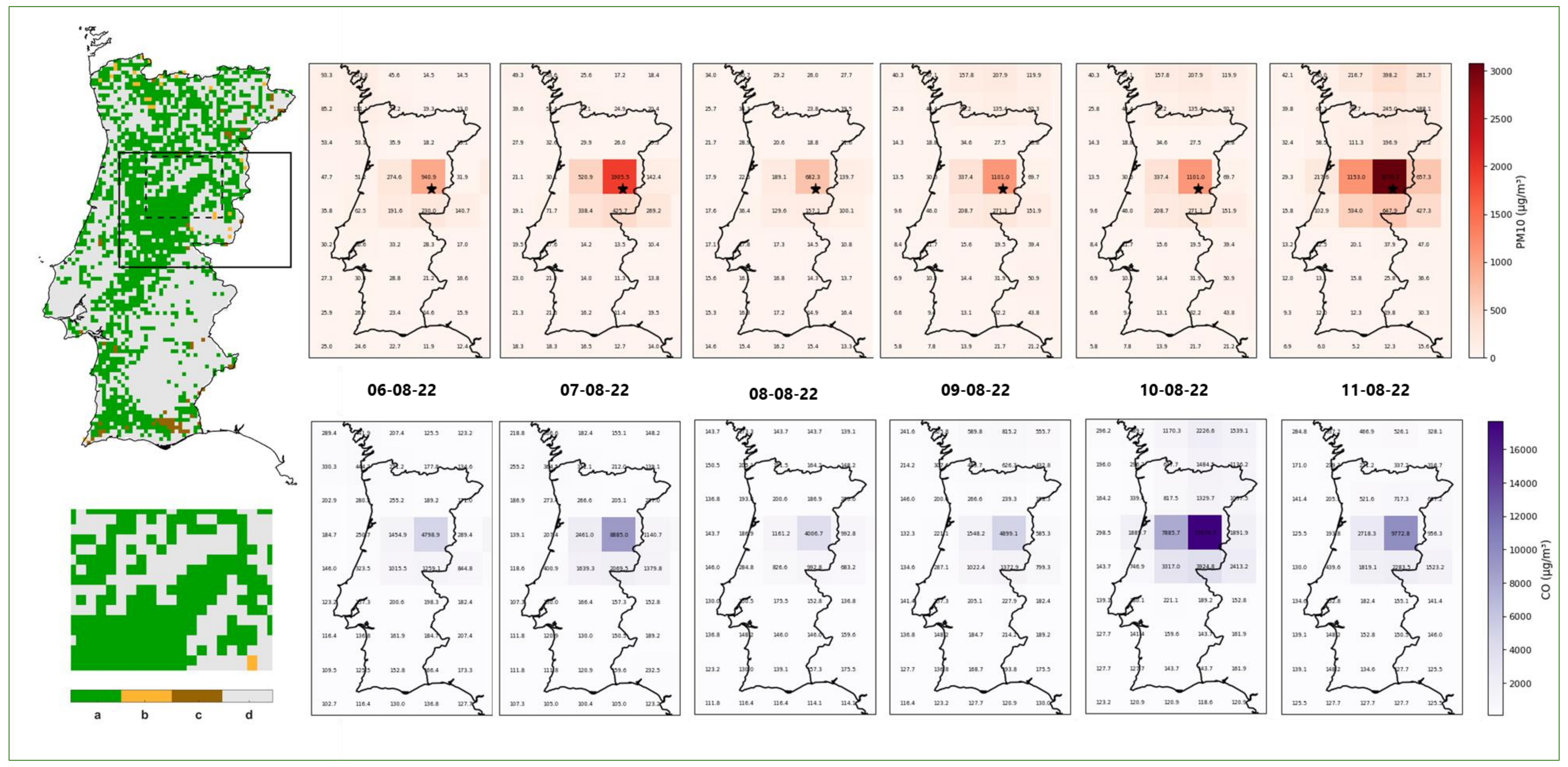

Fig.1 (Left): SE land cover types (a-forest, b-grassland, c-shrubland and d-sparse vegetation) over fire-affected areas, according to the ESA CCI (2020); **(Right):** PM_{10} and CO maximum daily values from 6 to 11 of August 2022 (CAMS reanalysis data), with Fundão air quality monitoring station represented by a star marker.

3. Results

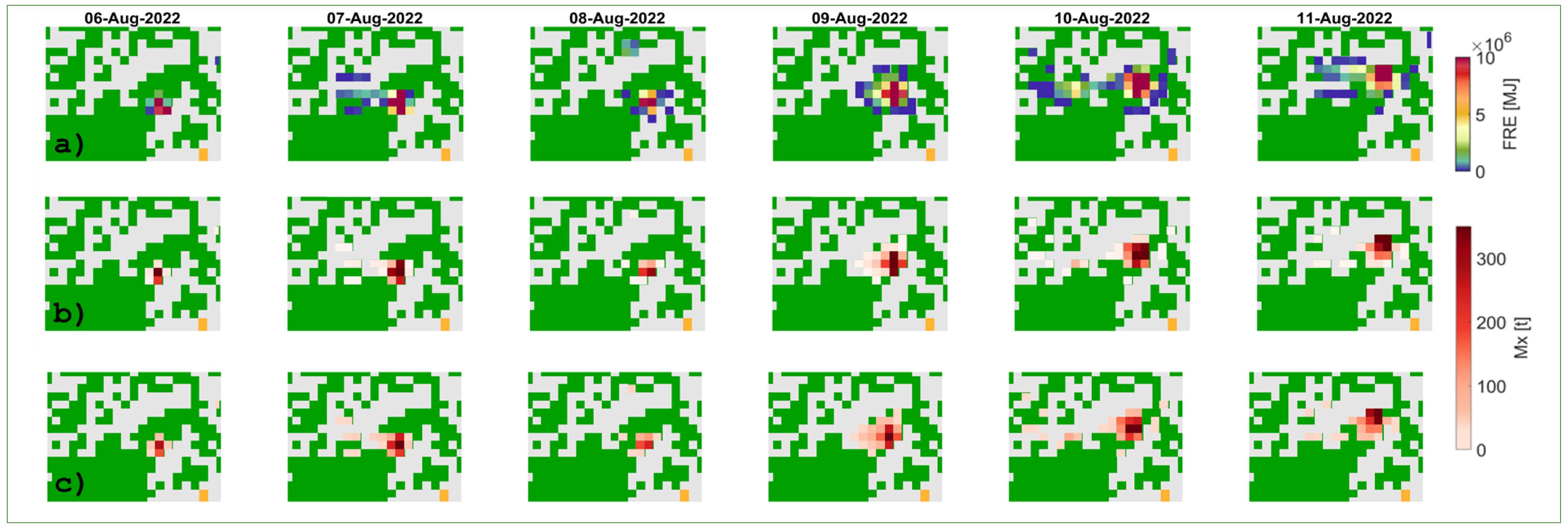

Fig.2 a) Daily FRE emitted from 6 to 11 of August 2022; **b)** estimated TPM daily mass values based on FERM coefficients; **c)** as in **b)** but for estimated CO daily mass values.

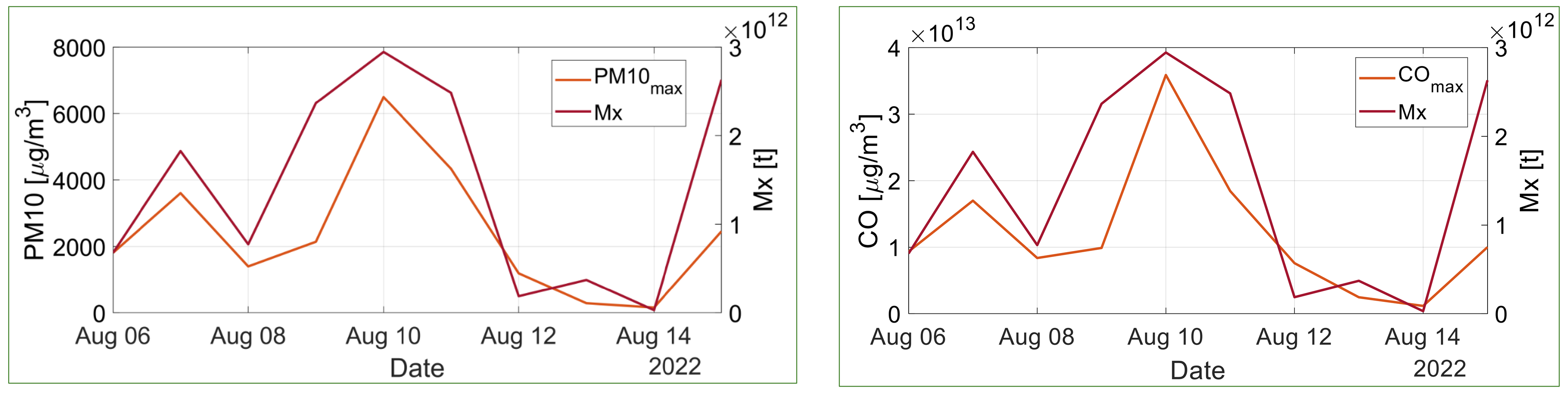

Fig.3 (**Left):** Daily evolution of maximum PM_{10} values (CAMS reanalysis), and TPM estimated mass emitted over the fire days considering the FERM coefficients for SE land cover classes; **(Right)**: as in left, but for estimated CO daily mass values..

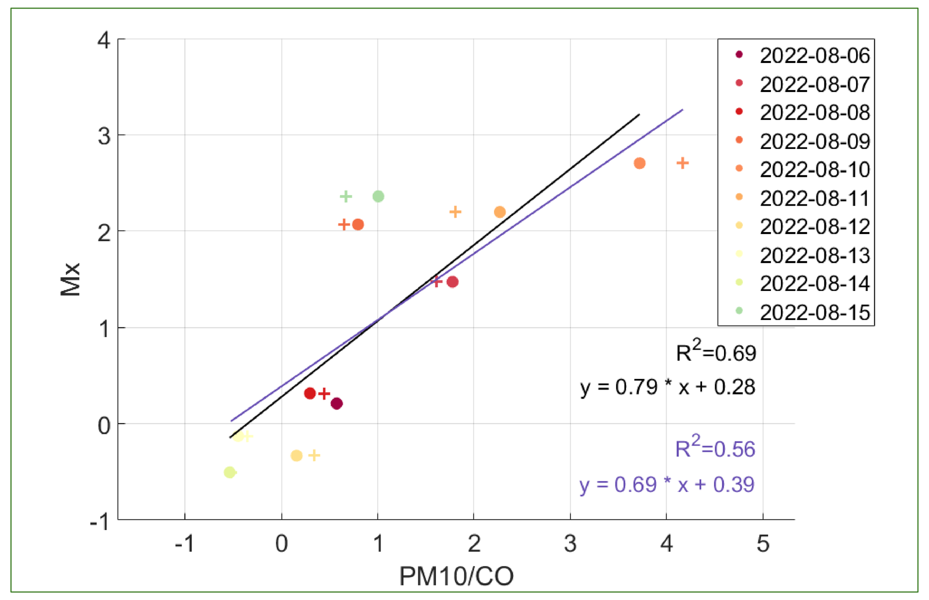

Fig.4 Scatter plot of TPM and CO mass emitted over the selected SE fire days, from 6 to 15 of August 2022 (represented by colors) computed taking into account FERM coefficients, where TPM is represented by (**o**); and CO is represented by (**+**); and maximum observed PM_{10} and CO values (CAMS reanalysis).

4. Conclusions: The fire FRE values align with the known severity of this event, which consistent with the observed concentrations of air pollutants, being demonstrated that the **FRP can be associated with smoke production**, namely TPM and CO emissions during SE fire. **The proposed methodology has potential to use FRP data as an indicator of air pollution and smoke dispersion over fire-affected regions**. However, further detailed comparisons and validations, between other fire-based pollutants must be accomplished, considering also other recent fire events.

References: 1. Wooster, M.J.; Roberts, G.; Freeborn, P.H.; Xu, W.; Govaerts, Y.; Beeby, R.; He, J.; Lattanzio, A.; Fisher, D.; Mullen, R. LSA-SAF Meteosat FRP Products—Part 1: Algorithms, Product Contents, and Analysis. Atmos. Chem. Phys. 2015, 15, 13217–13239; **2.** Mota, B., & Wooster, M. J. (2018). A new top-down approach for directly estimating biomass burning emissions and fuel consumption rates and totals from geostationary satellite fire radiative power (FRP). Remote sensing of environment, 206, 45-62; **3.** Nguyen, H. M. and M. J. Wooster, 2020: Advances in the estimation of high Spatio-temporal resolution pan-African top-down biomass burning emissions made using geostationary fire radiative power (FRP) and MAIAC aerosol optical depth (AOD) data, Remote Sens. Environ. 248, doi: 10.1016/j.rse.2020.111971; **4.** Pinto, M. M., DaCamara, C. C., Trigo, I. F., Trigo, R. M., and Turkman, K. F.: Fire danger rating over Mediterranean Europe based on fire radiative power derived from Meteosat, Nat. Hazards Earth Syst. Sci., 18, 515–529, https://doi.org/10.5194/nhess-18-515-2018, 2018. 5**.** Nguyen, H. M., He, J., and Wooster, M. J.: Biomass burning CO, PM and fuel consumption per unit burned area estimates derived across Africa using geostationary SEVIRI fire radiative power and Sentinel-5P CO data, Atmos. Chem. Phys., 23, 2089–2118, https://doi.org/10.5194/acp-23-2089-2023, 2023;.

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