Fire Radiative Power, the potential to be an early smoke indicator

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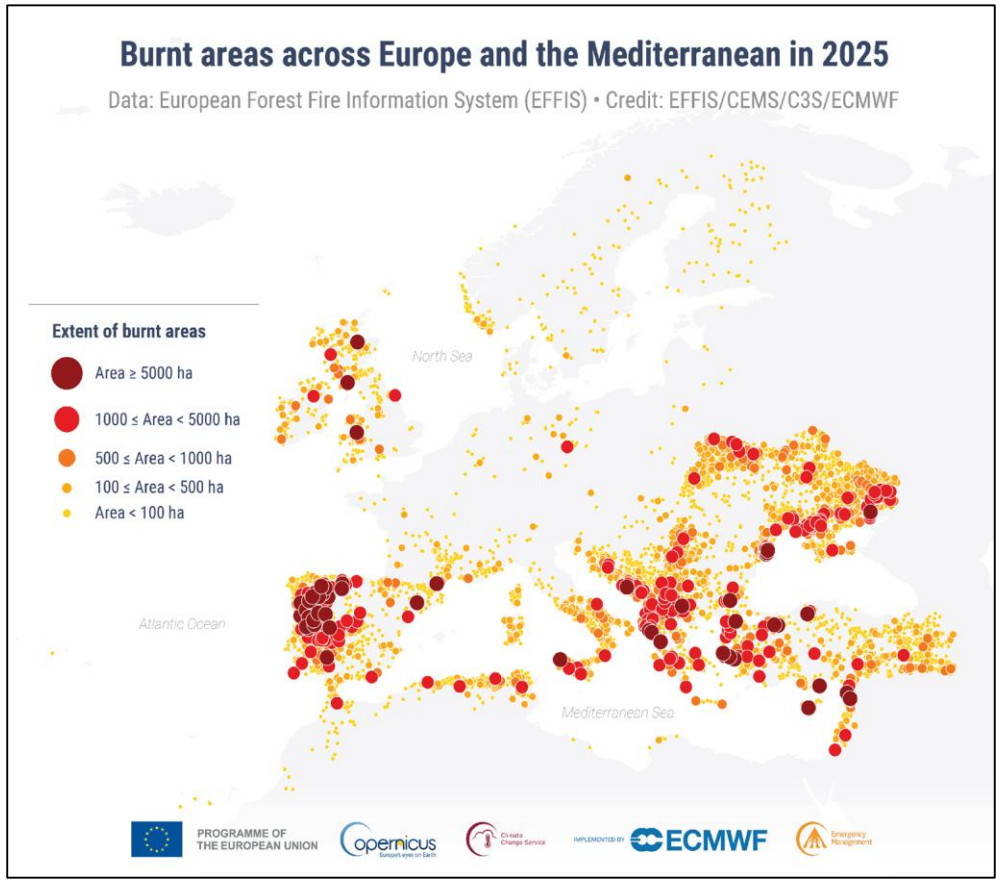
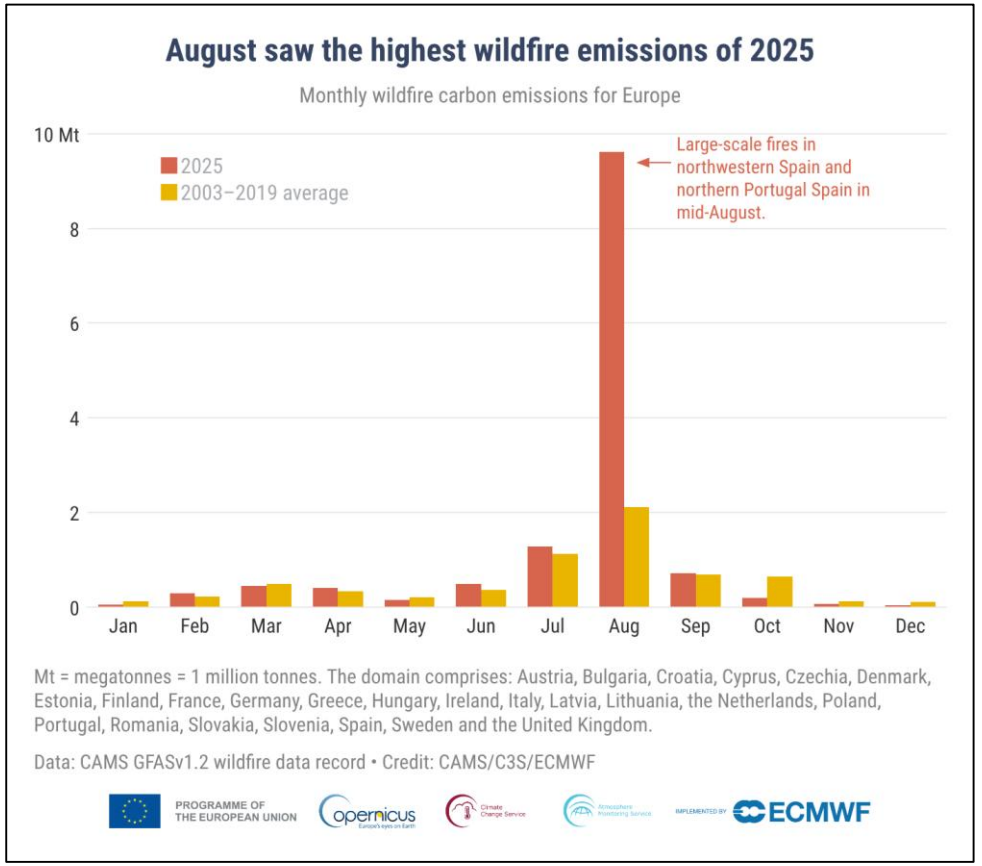
Copernicus | ESOC 2025 | Wildfires



Distribution and extent of burnt areas across Europe and the Mediterranean[2] in 2025.
Data: European Forest Fire Information System (EFFIS). Credit: EFFIS/CEMS/C3S/ECMWF



Mt = megatonnes = 1 million tonnes. The domain comprises: Austria, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.
Data: CAMS GFASv1.2 wildfire data record • Credit: CAMS/C3S/ECMWF

Rationale

FRP's potential to be an early smoke indicator (very high spatial and time resolution MTG data)

- **Fire intensity by integrating fire radiative power (FRP) values over time [1].**
- **FRP is proportional to the amount of burned biomass [1];**
- **High FRP values are linked to more severe fires, higher smoke levels, and thus higher air pollutant emissions. [2,3]**

Copernicus Sentinel data (2025), processed by ESA
ESA Standard Licence

Data & Methodology

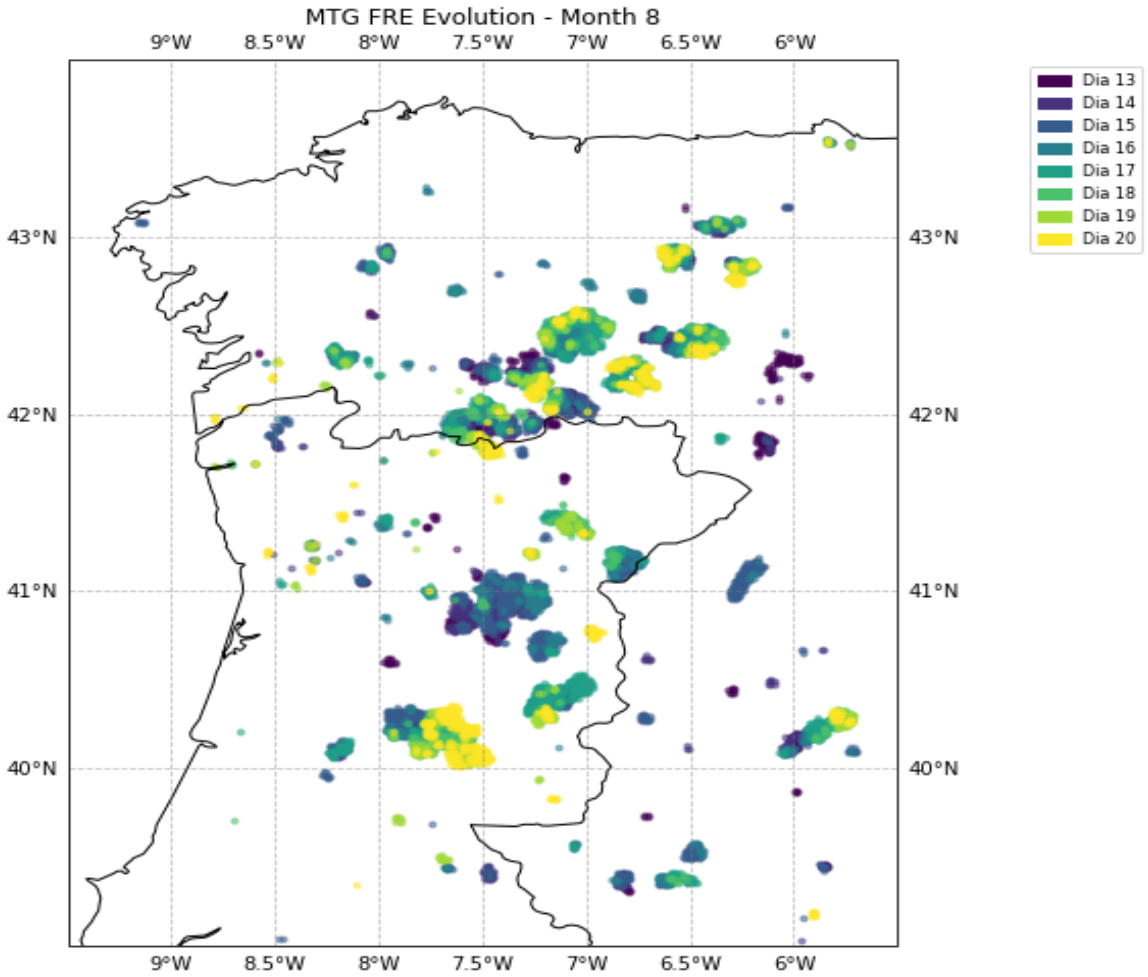
- Daily Fire Radiative Energy (GJ) emitted during a wildfire results from the temporal integration of FRP data (LSA-SAF), taking into account the formula [4]:

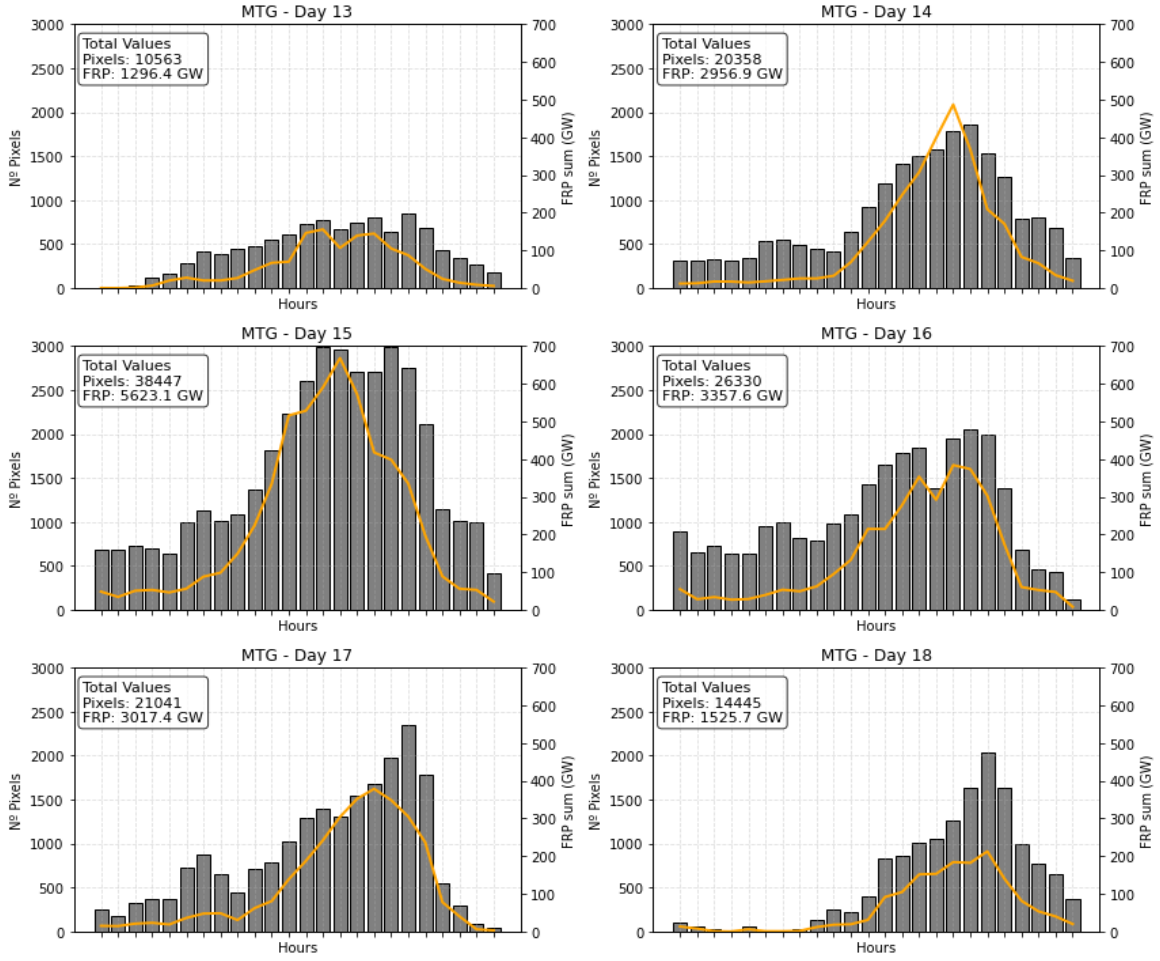
$$FRE_{ph} = 0.9 * \left(\sum_{k=1}^{6} FRP_p\right)_h$$

where the index *k* indicates the sequence of 10 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.

- Daily mass estimates of total particulate matter (TPM) are obtained by multiplying daily FRE values by the TPM emission coefficients for European biomes (ESA CCI Land cover), considering the Fire Radiative Energy Emissions (FERM) top-down approach [2;3,5].

Iberian wildfires, August 2025





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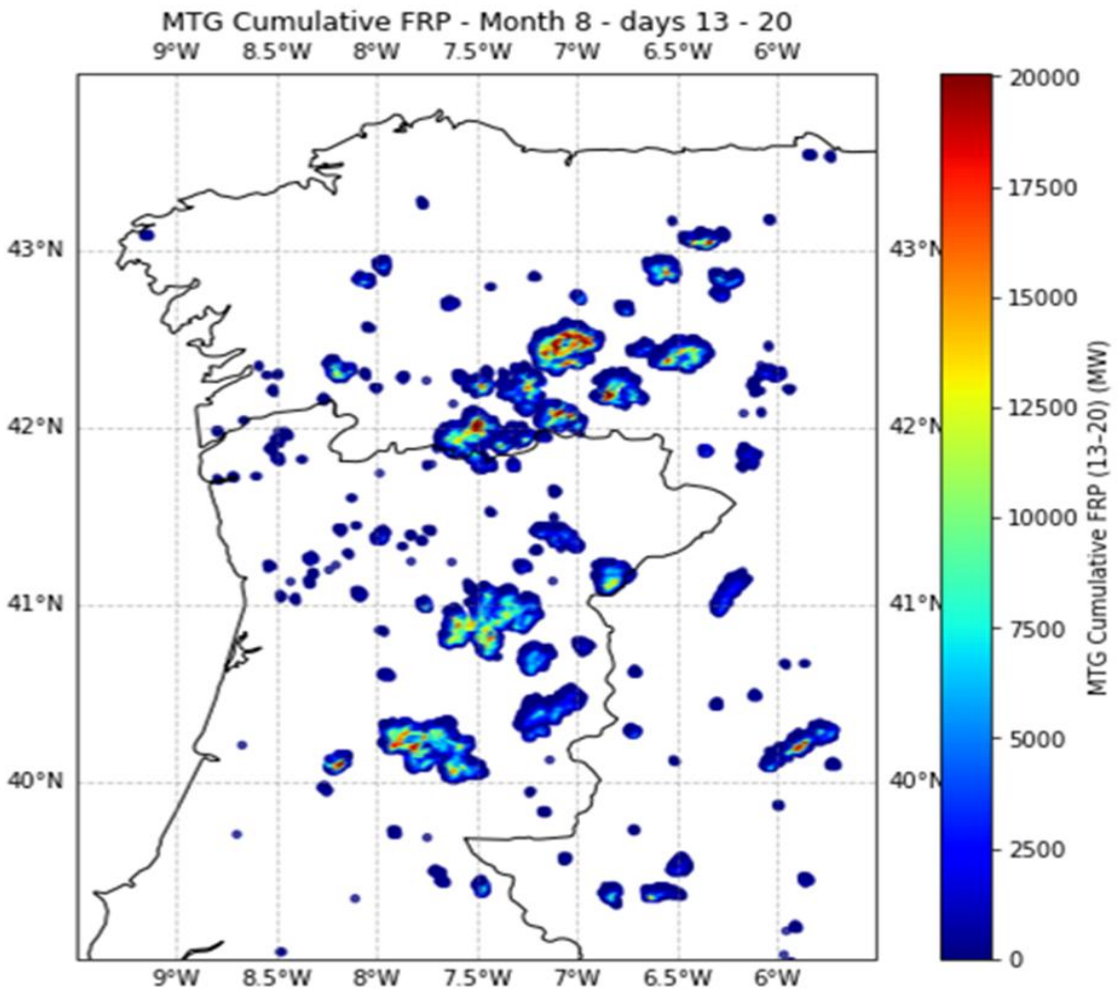
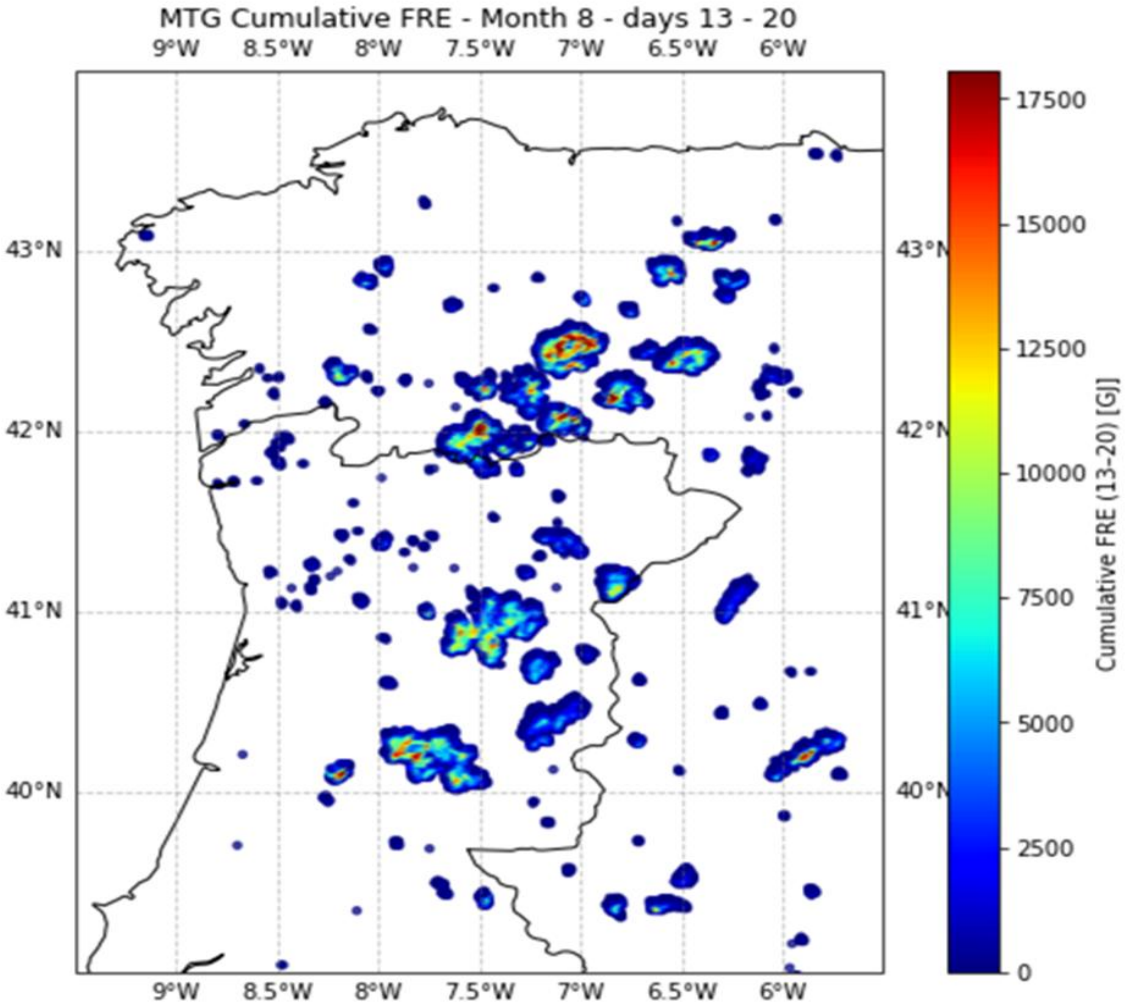
Iberian wildfires, August 2025





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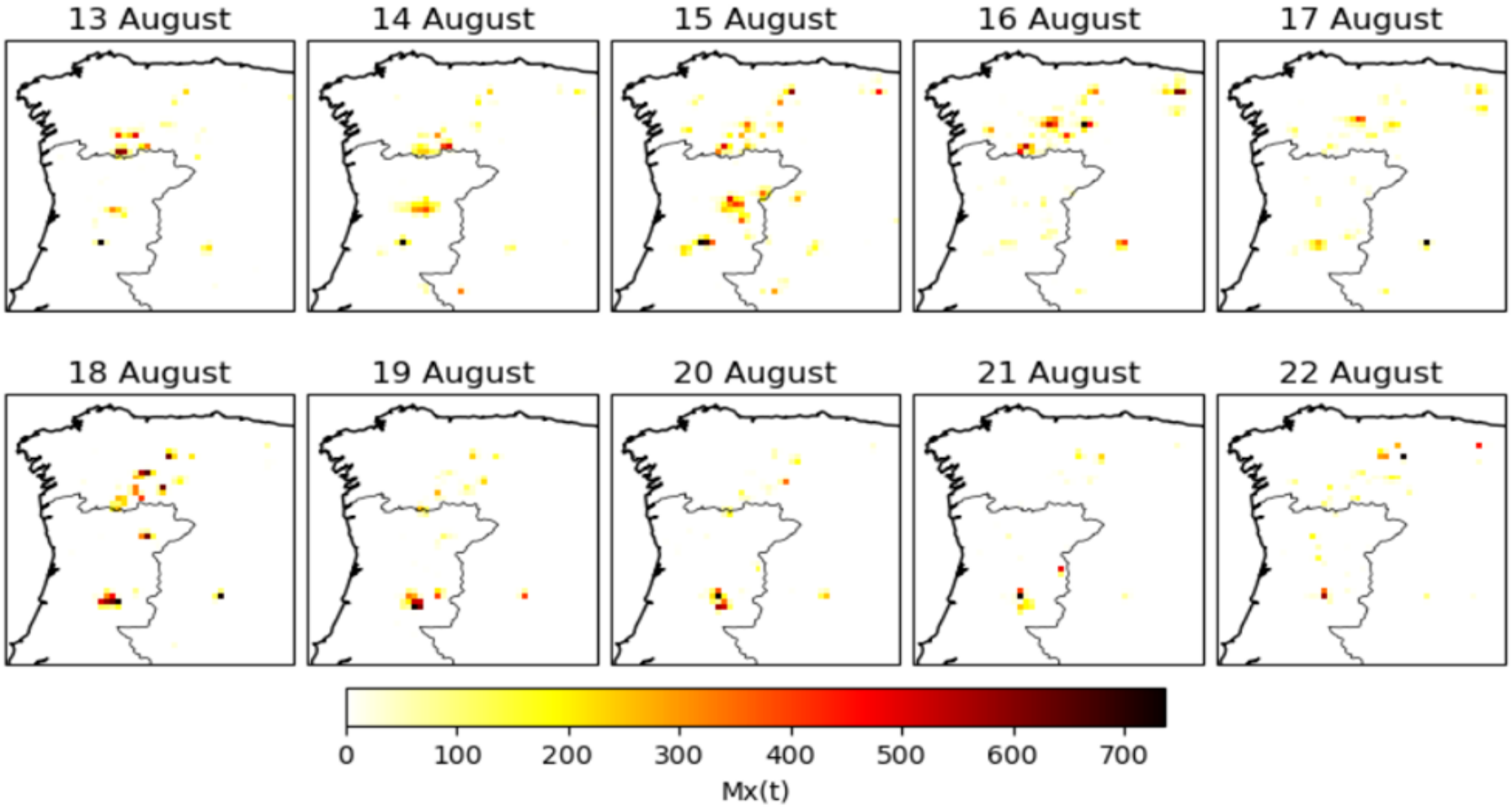
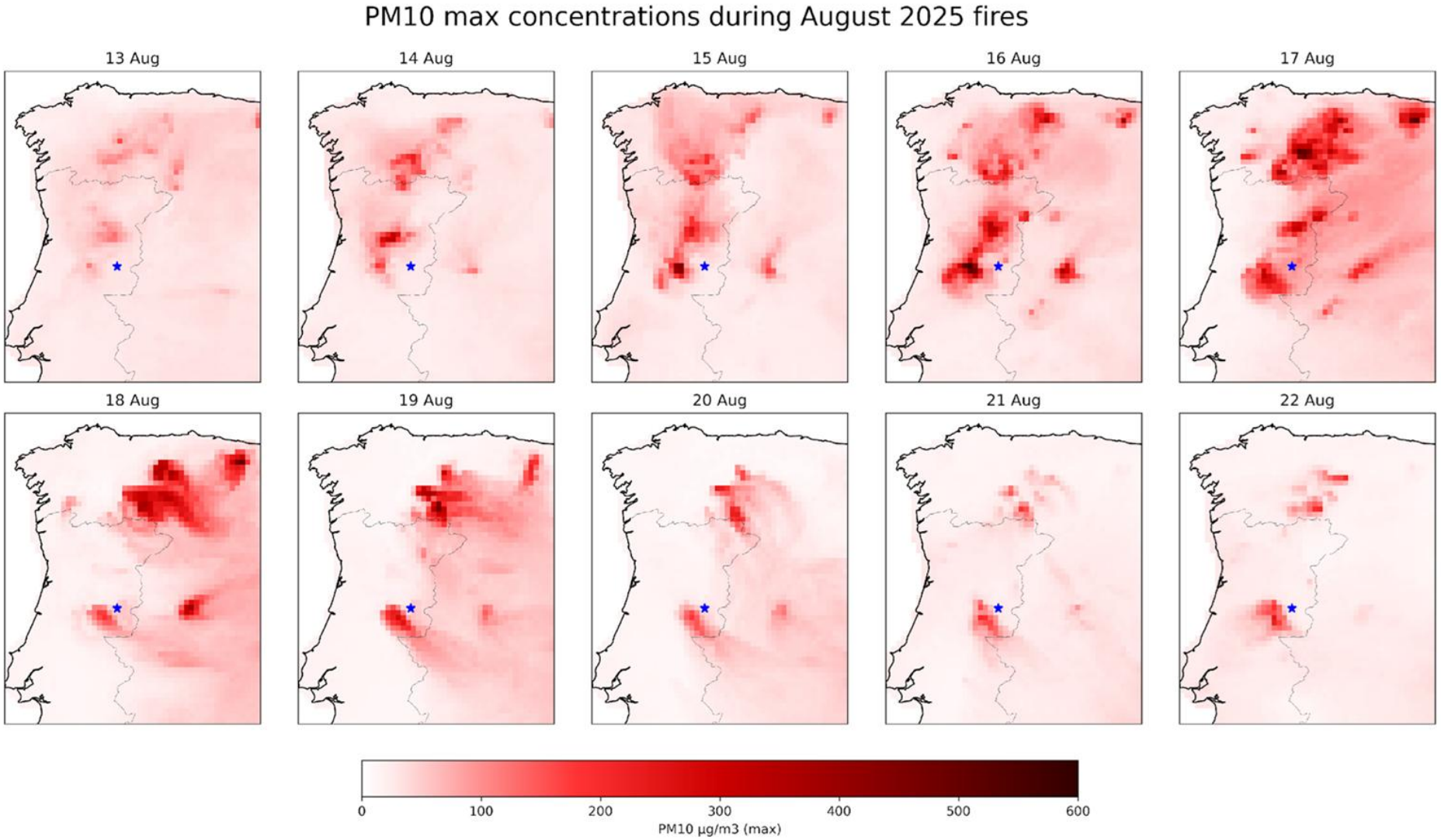
TPM Emissions - Operational (FREM,LSA-SAF)



https://lsa-saf.eumetsat.int/en/data/products/fire-products/

PM_{10} "Observations" | CAMS data



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https://ads.atmosphere.copernicus.eu/datasets/cams-europe-air-quality-reanalyses?tab=overview

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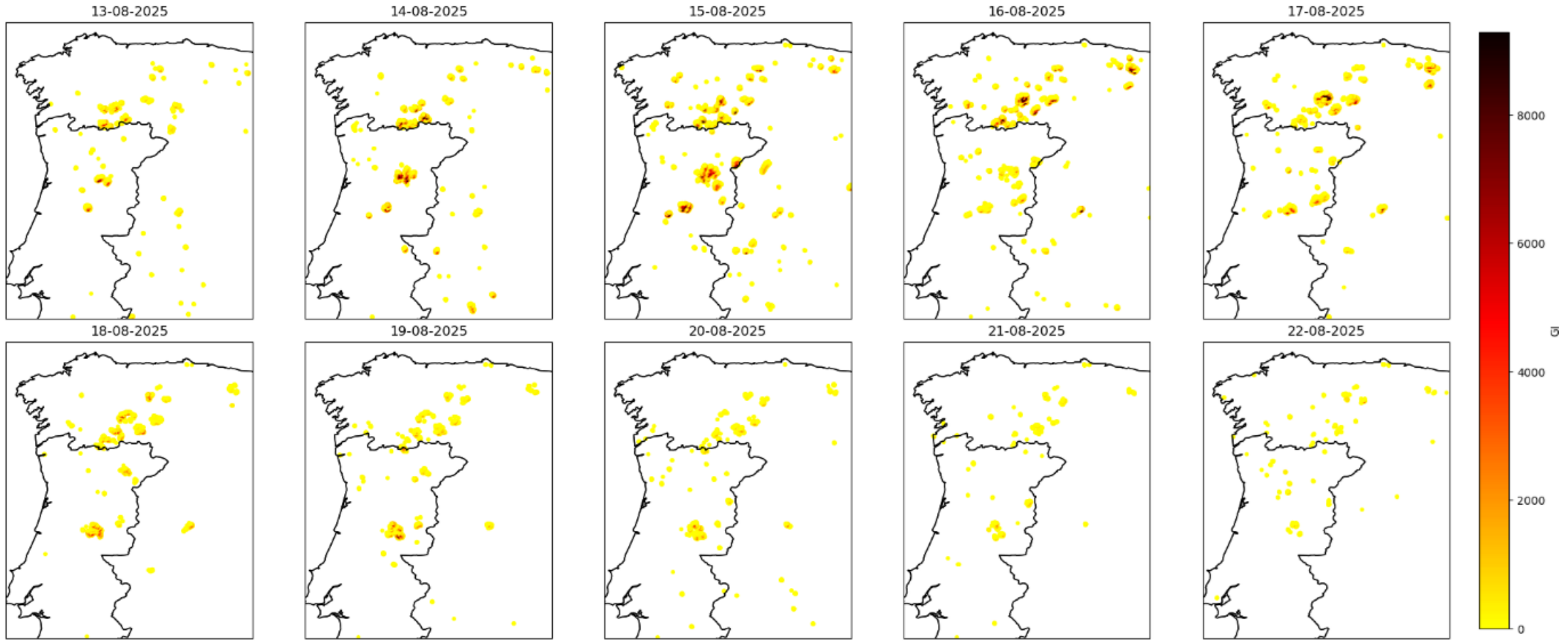
FRE | MTG



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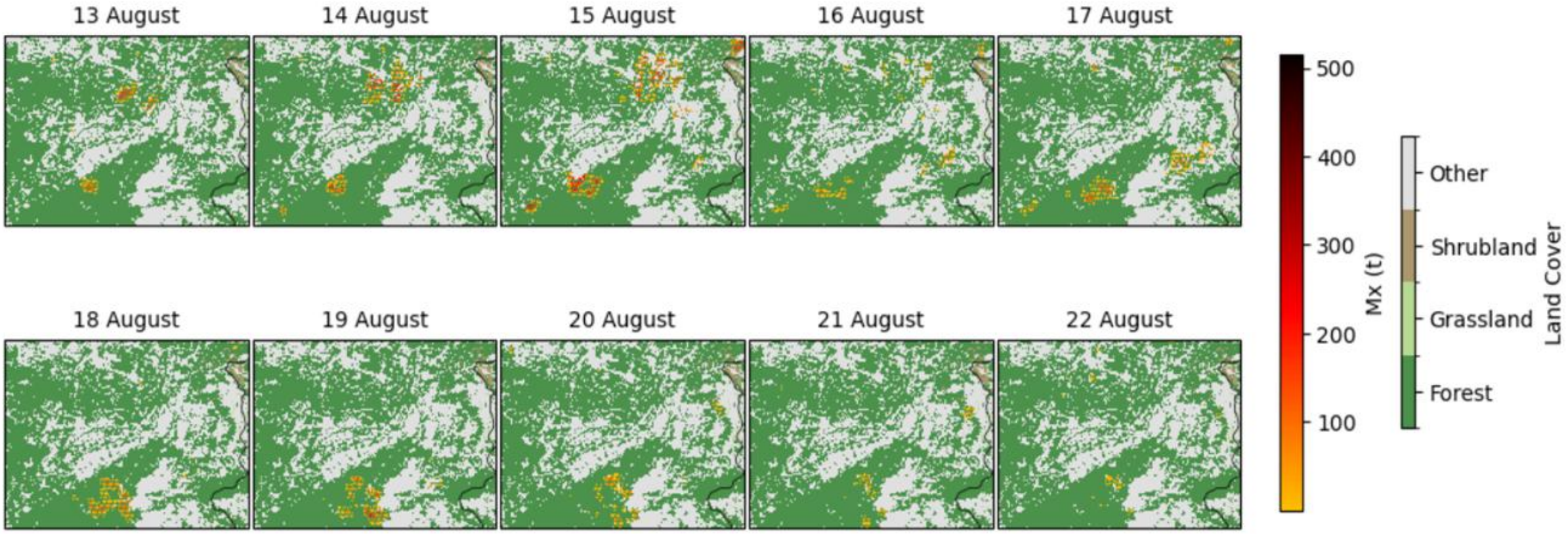
TPM Emissions | ESA CCI Land Cover

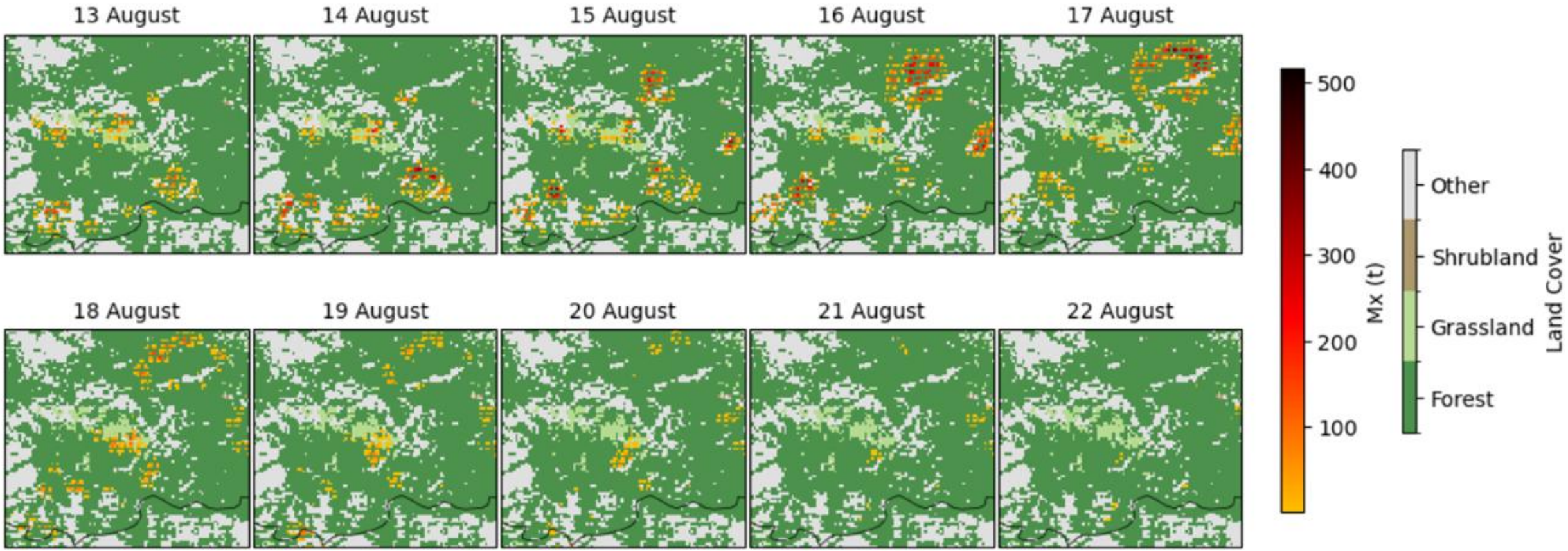
Central Portugal



TPM coefficient values FOR local land cover classes is a coefficient average of the given three Forest classes (broadleaved, evergreen-broadleaved, deciduous); (23.3 $g.MJ^{-1}$); a single value for the Grassland class (20.6 $g.MJ^{-1}$); and a coefficient average of the given two Shrubs and Sparse Vegetation classes (11.2 gMJ^{-1}) - Land cover classification gridded maps from 1992 to present derived from satellite observation. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.006f2c9a

TPM Emissions | ESA CCI Land Cover

GALIZA



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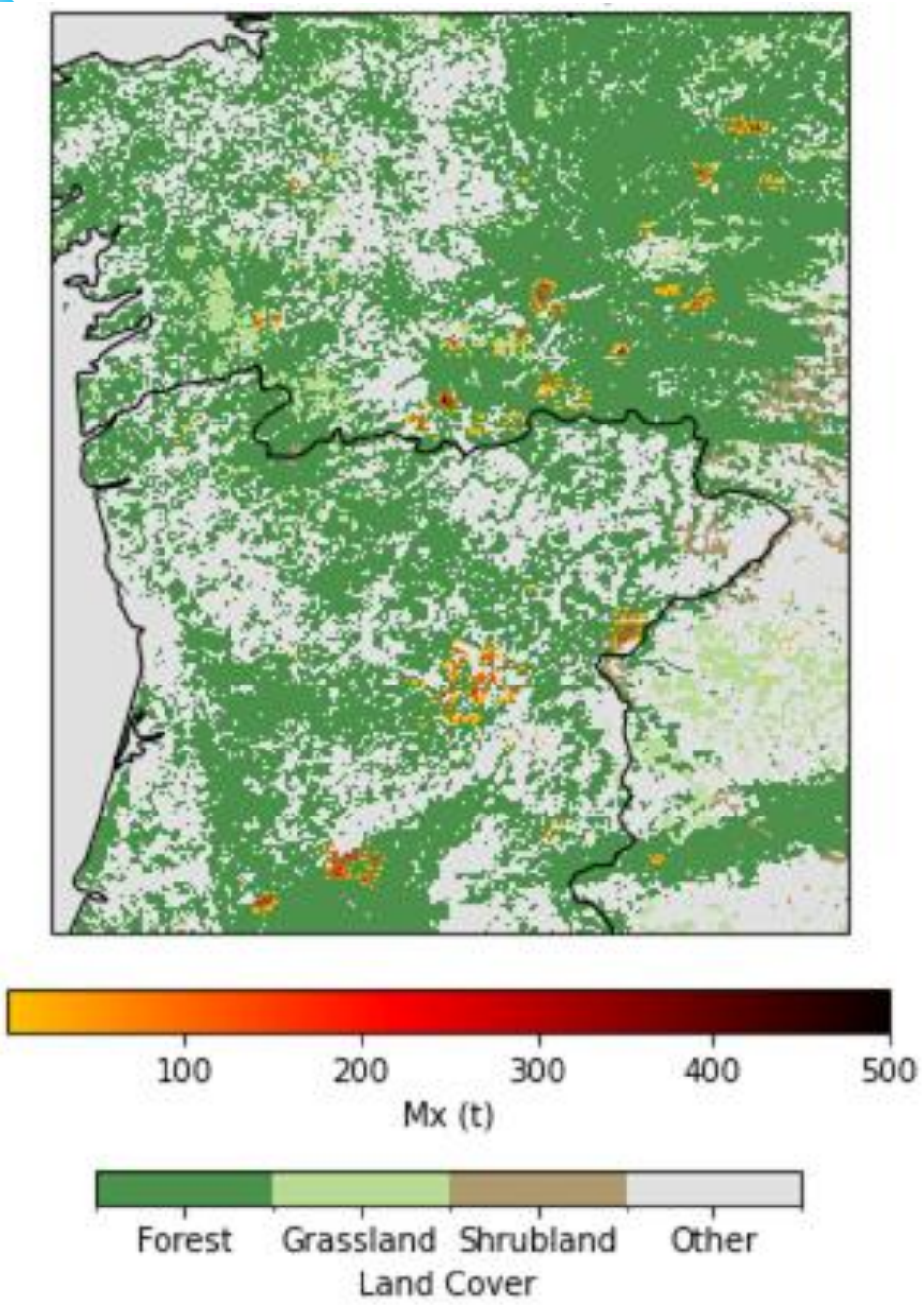
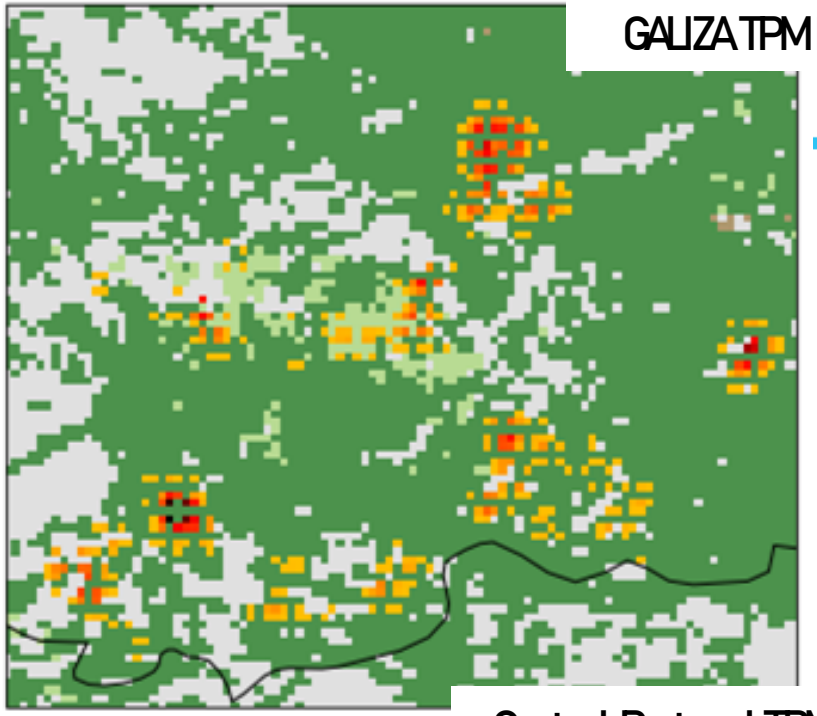
Copernicus Climate Change Service, Climate Data Store, (2019): Land cover classification gridded maps from 1992 to present derived from satellite observation. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.006f2c9a

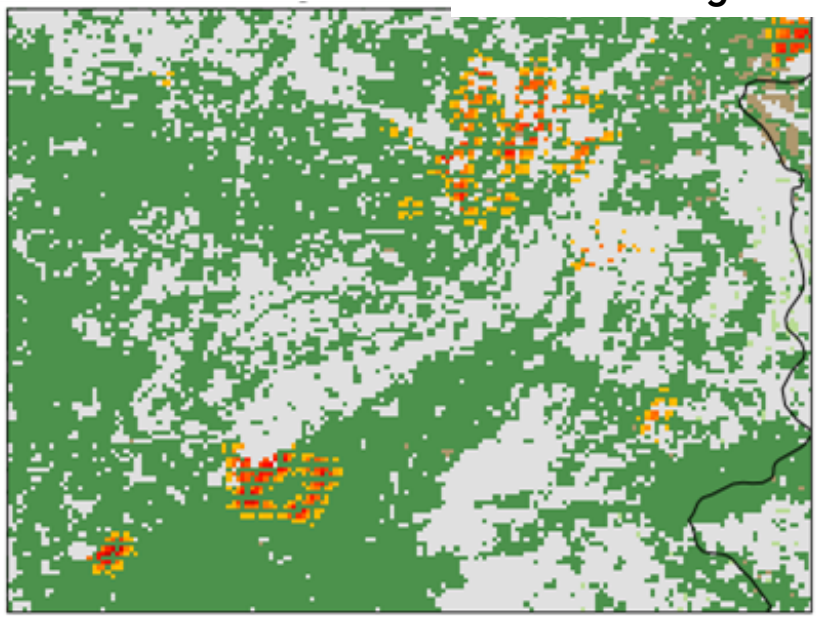
TPM Emissions (MTG) | 15-08



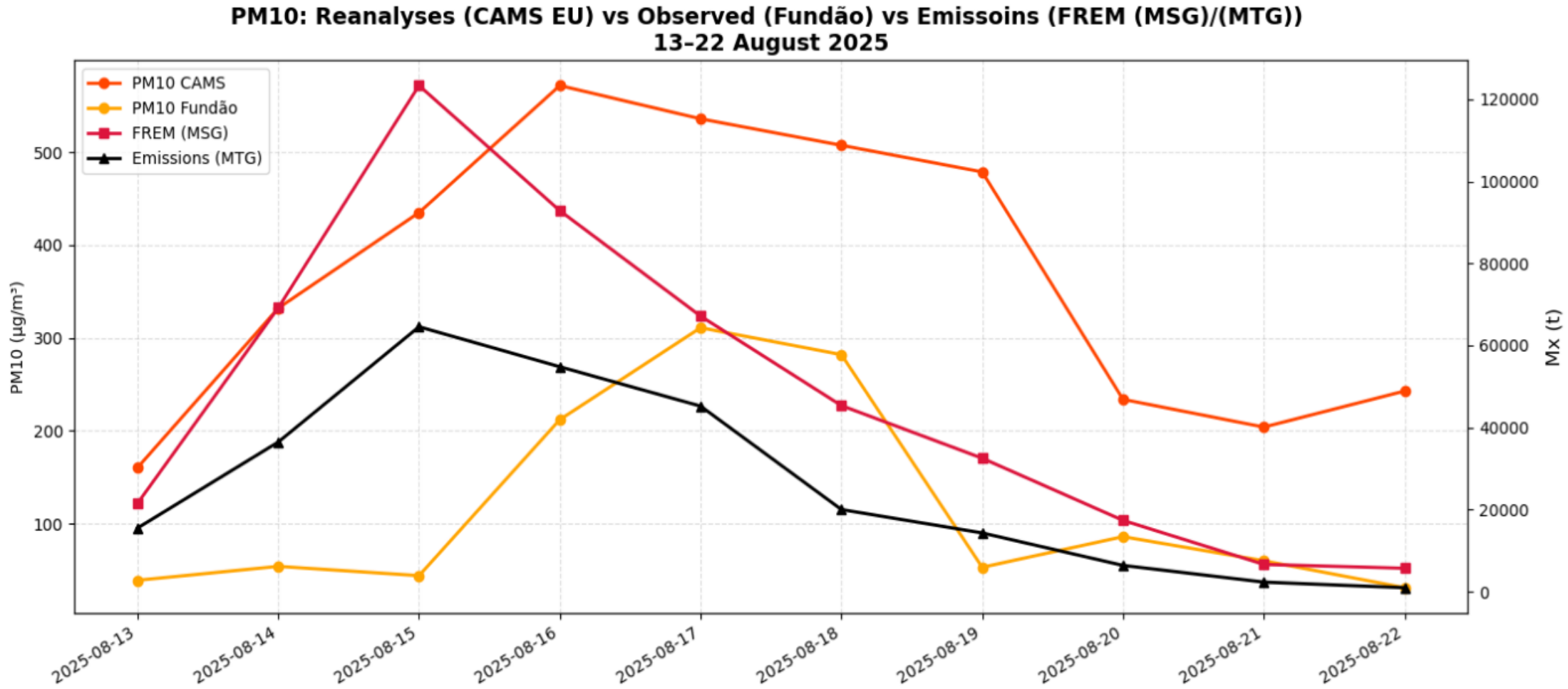
GALIZA TPM Emissions | 15-08



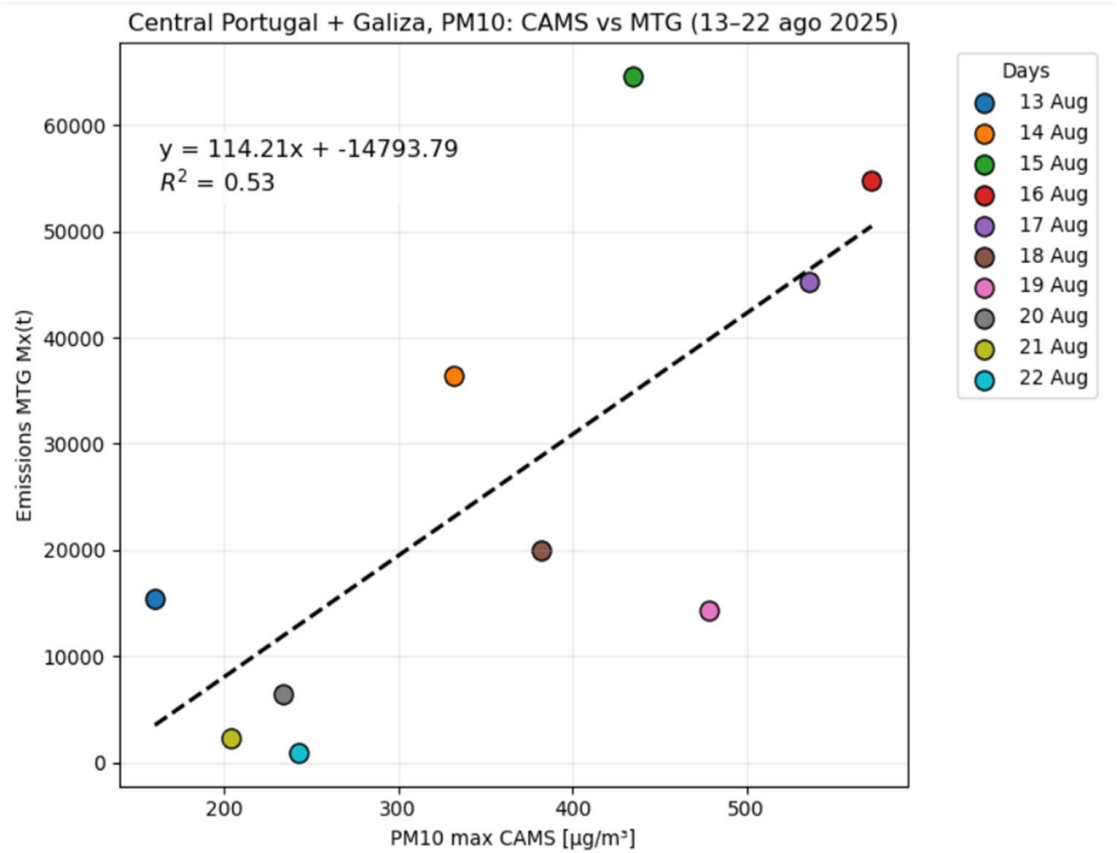
Central Portugal TPM Emissions | 15-08



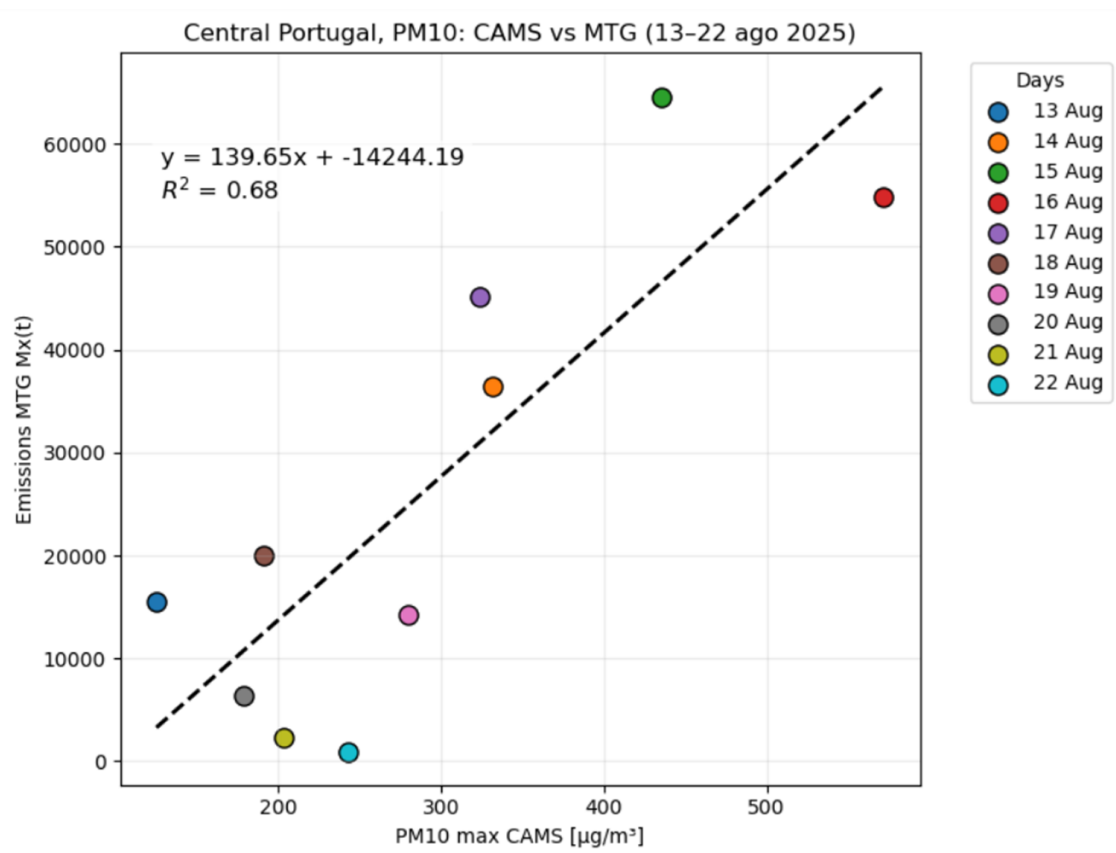
TPM Emissions | PM_{10} "Observations" Evolution



TPM Emissions | PM_{10} "Observations"



Pearson r = 0.731
p-value = 0.0163
Spearman ρ = 0.661
p-value = 0.0376



Pearson r = 0.824
p-value = 0.00335
Spearman ρ = 0.673
p-value = 0.033

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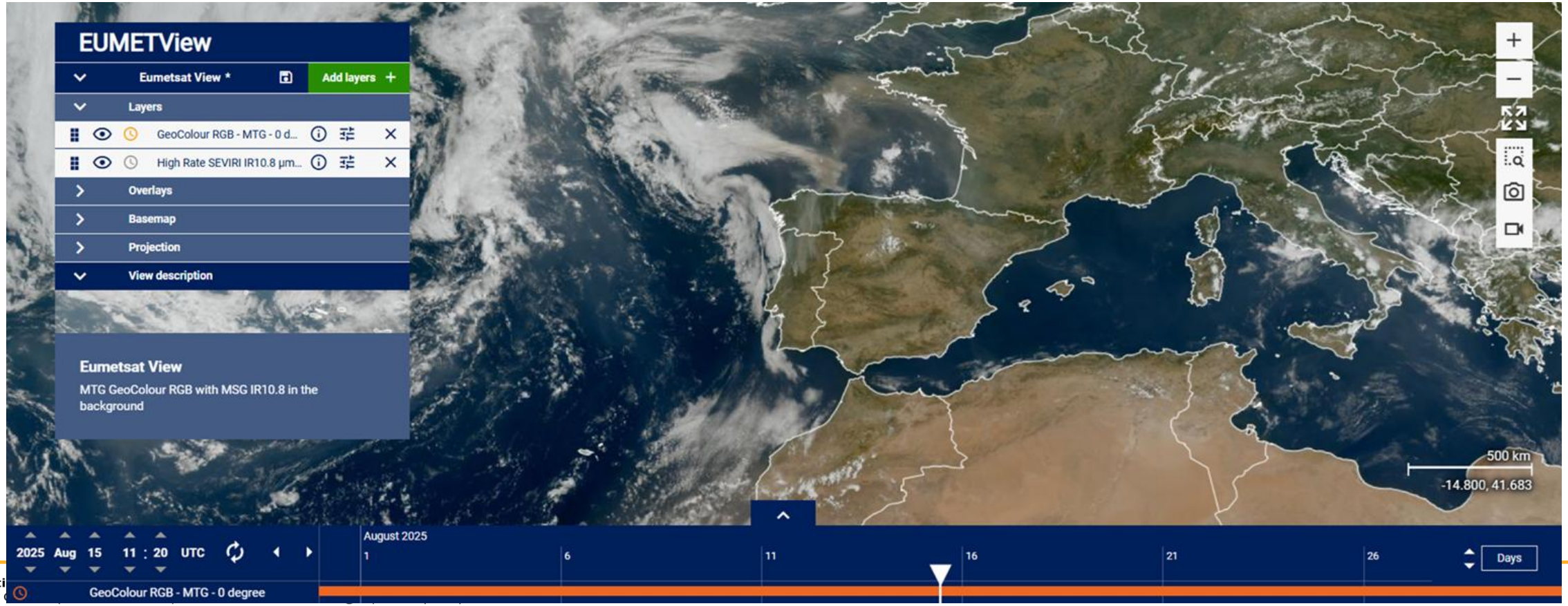
Thank you!

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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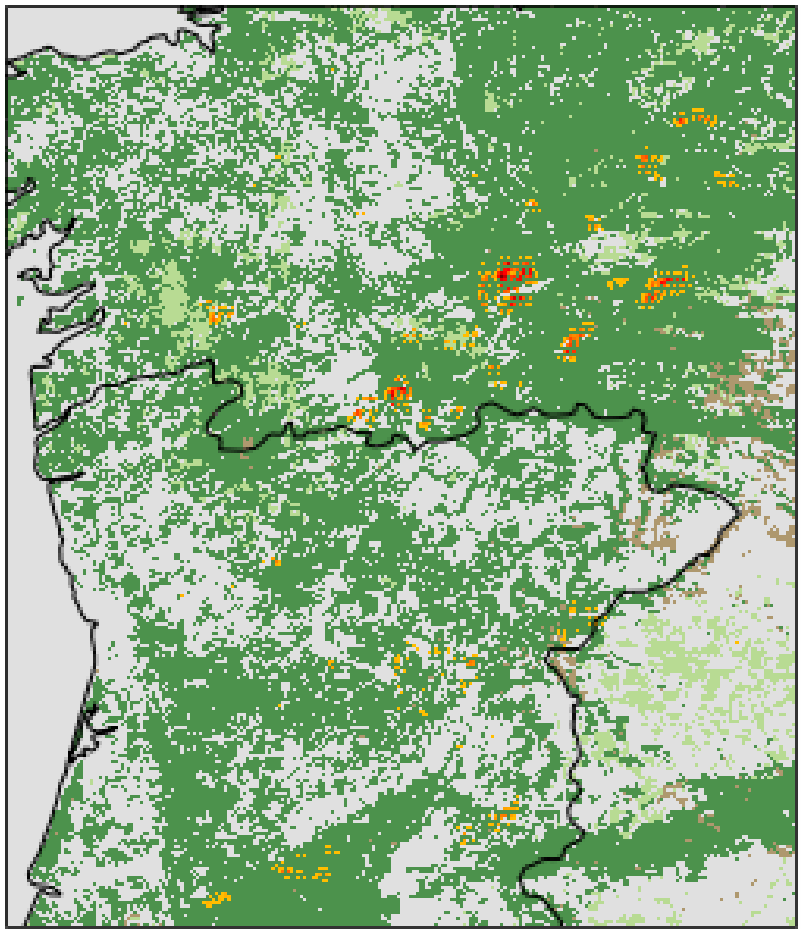
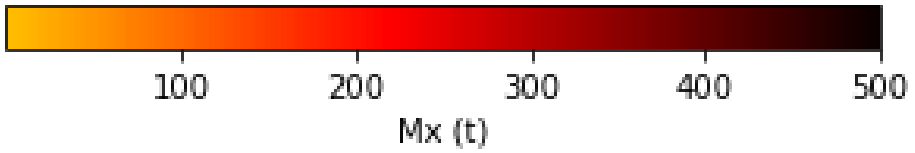
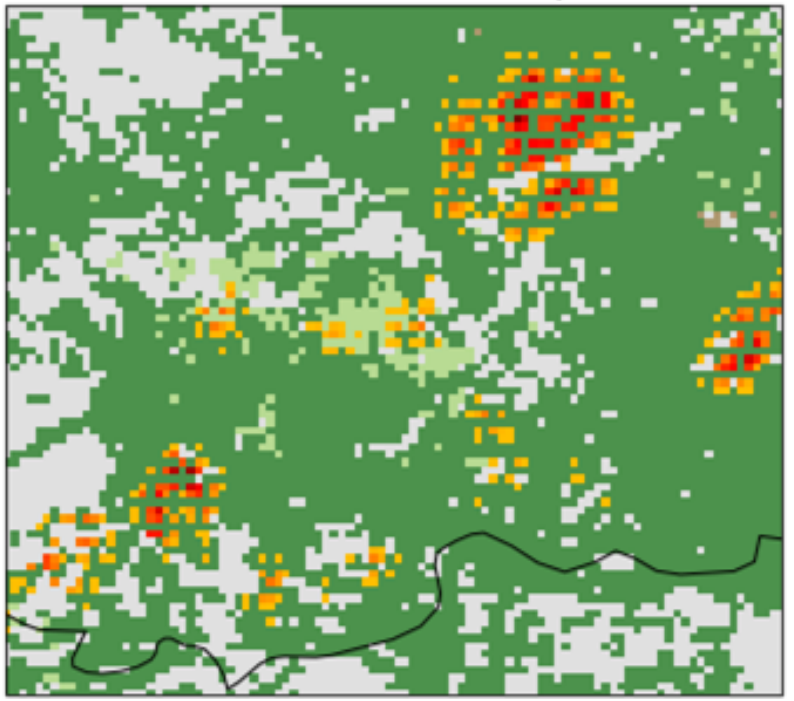
PM10 emissions MTG | 16-8

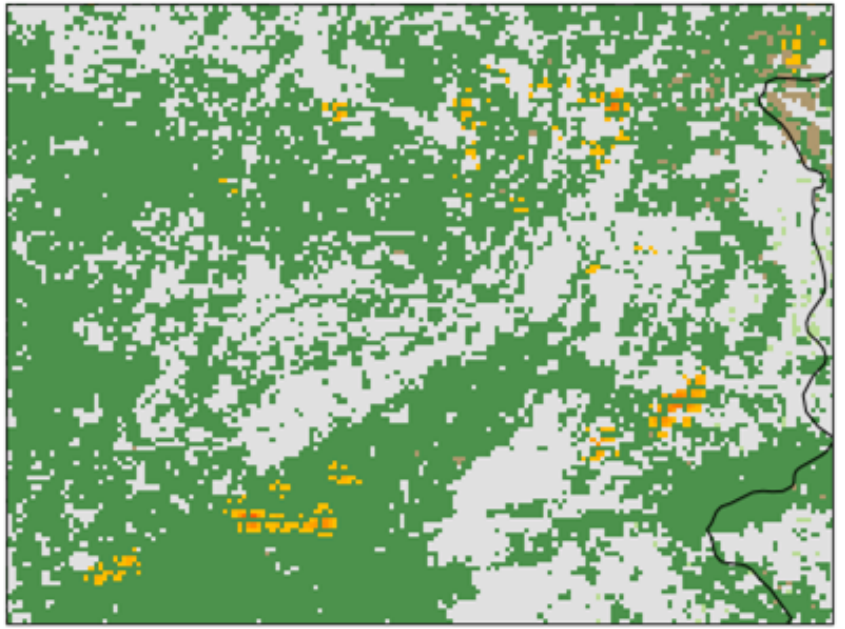


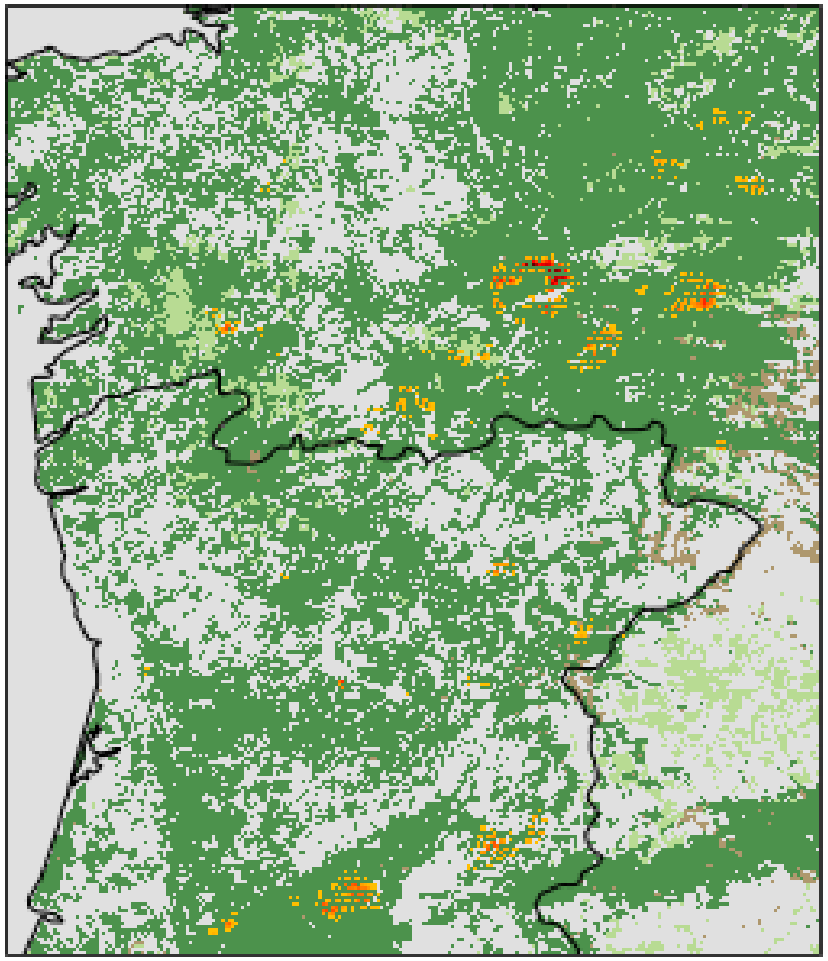


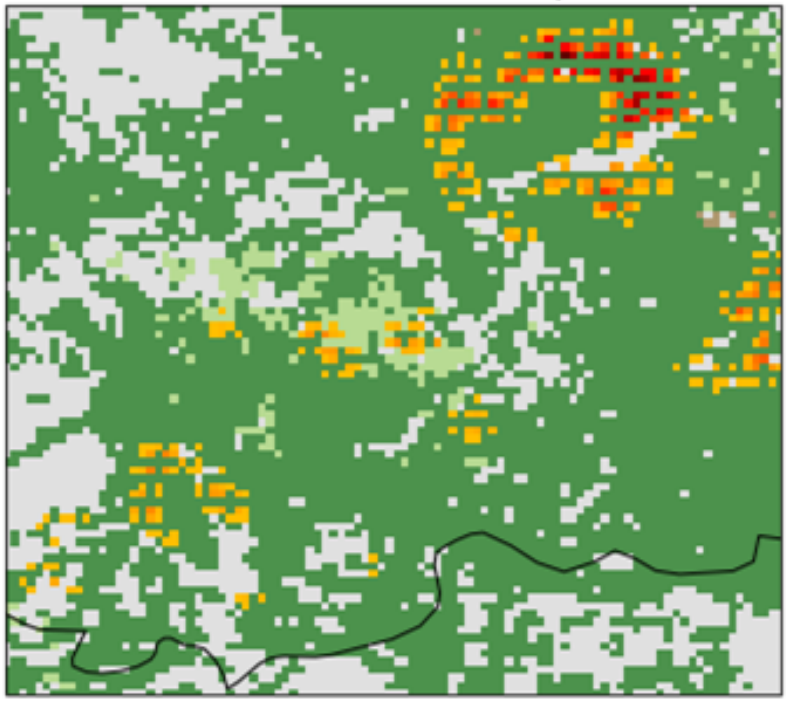
Galiza PM10 emissions MTG | 16-8

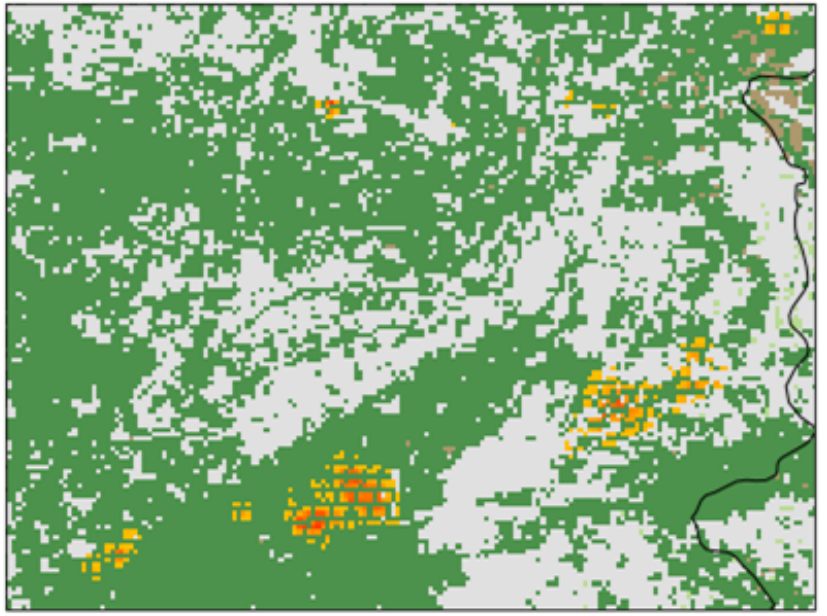


Central Portugal PM10 emissions MTG | 16-8









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