# Variability of CO and aerosols plumes from wildfires in the Northern Hemisphere using satellite observations (2008-2022)

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## Context

- Wildfires are a significant source of pollutants (*Andreae, 2019*).
- The fire risk is increasing and fire seasons are lengthening as a result of climate change in the mid and high latitudes of the Northern Hemisphere (*Smith, 2020*).
- Pollution plumes produced during extreme fires can be transported over thousands of kilometers, impacting background pollutant levels on a hemispheric scale.
- In this poster, wildfires variability, the link between wildfires and extreme fire weather and the impact of wildfires on CO and AOD variability are analyzed based on satellite observations.

## Tools

- Fire data from MODIS produced using the APIFLAME tool (*Turquety, 2020*).
- Fire risks : Canadian Fire Weather Index (CFWI) (*McElhinny, 2020*).
- AOD observations from MODIS : MOD04_L2, MYD04_L2.
- CO observations : IASI/METOP CDR CO L2 products (ULB-LATMOS) (Hurtmans et al., 2012)
- Observations are gridded on a 0.5°x0.5° grid.

## Wildfires variability

FIGURE 1

### Yearly averaged area burned, 2008-2022

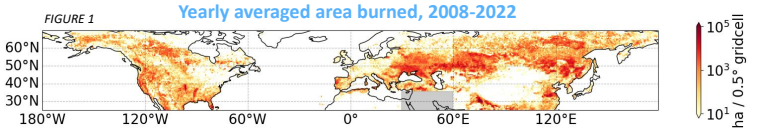



FIGURE 2

### Number of years with at least one fire, 2008-2022

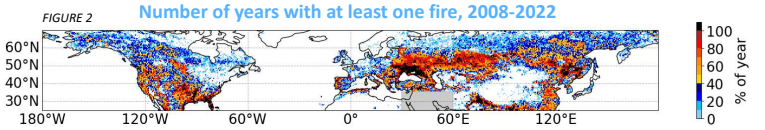
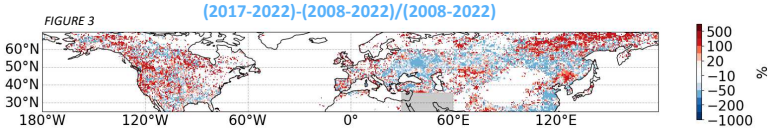



FIGURE 3

### Yearly averaged area burned relative difference (2017-2022)-(2008-2022)/(2008-2022)

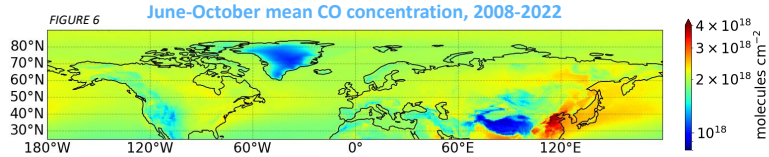



- Larger burnt areas, e.g.: Eastern Europe, Portugal, Boreal Asia or North America (Fig. 1).
- Eastern Europe : high frequency suggests agricultural fires (Fig. 2).
- Decreasing trends in number of events in Europe and Asia except Southeast Asia (increasing). Non significant trends elsewhere.
- Comparing last 6 years 2017-2022, with 2008-2022, a significant increase is obtained in : number of fire events, duration and resulting burned area (Fig. 3).

## Long-range transport

FIGURE 6

### June-October mean CO concentration, 2008-2022




### June-October mean CO concentration relative difference (2017-2022)-(2008-2022)/(2008-2022)

FIGURE 7

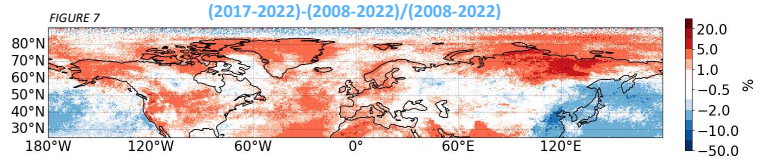
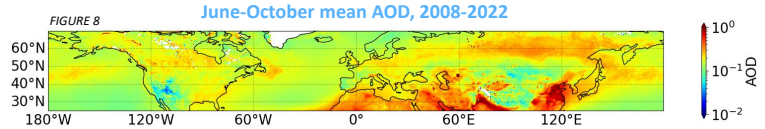


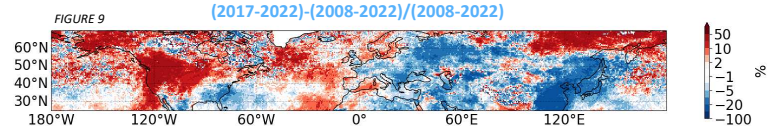

FIGURE 8

### June-October mean AOD, 2008-2022




### June-October mean AOD relative difference (2017-2022)-(2008-2022)/(2008-2022)

FIGURE 9




- Increase in CO concentration and AOD in regions experiencing an increase in burned area in recent years (Fig. 7 & 9).
- Increase in CO concentration and AOD in Atlantic (Fig. 7 & 9).
- Low difference in regional average CO concentration (2017-2022 compared to 2008-2022) except for the late fire season (Summary table).
- Regional average AOD increases except for the early fire season and Europe.

*Summary: Difference between the regional average during 2017-2022 compared to 2008-2022 for several key variables and 3 time periods: June-October (fire season, top value), June-July (early season, bottom left), September-October (late season, bottom right). The relative difference (%) is calculated as* $\frac{(2017-2022)-(2008-2022)}{(2008-2022)} \times 100$

| Regions | ΔAB | | ΔCFWI | | Δlength fire events | | Δ[CO] | | Δ[CO] in plumes | | Δnbr of day CO plumes | | ΔAOD | | ΔAOD in plumes | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boreal North America | 7 | | 2 | | 1 | | 1 | | 2 | | 31 | | 7 | | -4 | |
| | -8 | 24 | 3 | -4 | 0 | 18 | -2 | 4 | -3 | 3 | 13 | 97 | 1 | 11 | -5 | -6 |
| Temperate North America | 28 | | 1 | | 5 | | 1 | | 1 | | 61 | | 9 | | 3 | |
| | 23 | 45 | 2 | 0 | -1 | 11 | -2 | 6 | -3 | 1 | 3 | 140 | -4 | 20 | -1 | 3 |
| Atlantic | x | | x | | x | | 2 | | 0 | | 50 | | 4 | | -19 | |
| | x | x | x | x | x | x | -2 | 5 | -3 | 0 | -19 | 120 | -2 | 6 | -27 | 6 |
| Europe | -10 | | 7 | | 4 | | 1 | | 0 | | 25 | | -2 | | -6 | |
| | -3 | -4 | 9 | 7 | 2 | 11 | -2 | 4 | 0 | 0 | -39 | 105 | -4 | 0 | -4 | 13 |

## CFWI

FIGURE 4

### June-October mean CFWI, 2008-2021

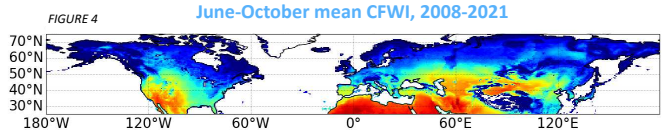
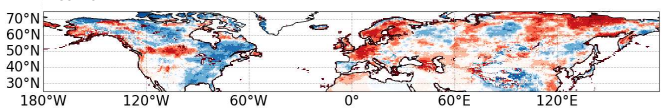



FIGURE 5

### Yearly averaged CFWI relative difference (2017-2021)-(2008-2021)/(2008-2021)




- Increasing risk : Boreal Asia, Western North America, Europe (Fig. 5).
- No correlation between CFWI and area burned.
- Distributions of burned areas according to the CFWI are consistent : lowest burned areas corresponding to days with low risk and vice versa.
- 56% of the burned areas (2003-2021) of more than 500 ha were burned on a day with a high to very extreme risk.

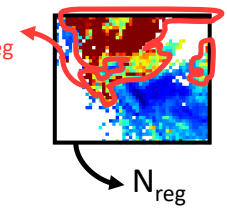
## Plume detection

### Plume detection algorithm :

1) In a region with $N_{Reg}$ pixels the number $n_{Reg}$ of pixels k in a plume is calculated as the number of pixels satisfying : $TCO_k > Q97$

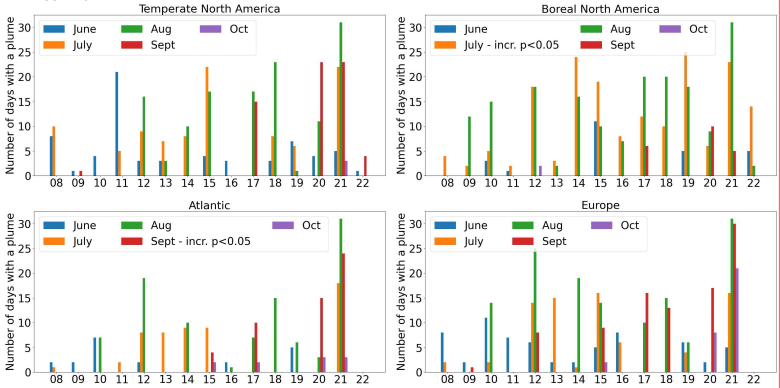
*with : Q97 = percentile 97 of the 2008-2022 June-Oct distrib.*
*$TCO_k$ = CO total column concentration in the pixel k*

2) A plume is detected if $n_{Reg} > 5\% N_{Reg}$ for 2 consecutive days




### Number of days with a plume detected

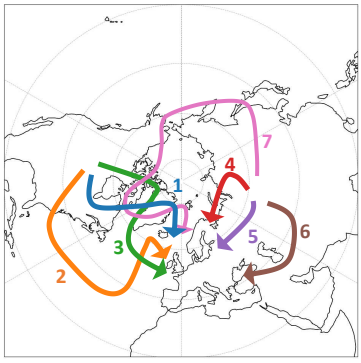
FIGURE 10




- No significant trend of the number of days with a plume over the period 2008-2022. NB : increasing trend in Western Temperate North America in August and September.
- Average number of days with a plume increases over 2017-2022 compared to 2008-2022 except for the early fire season in Atlantic and Europe.

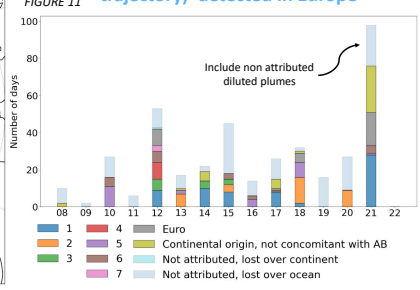
## Back trajectories

### Trajectories of the plumes arriving in Europe




### Number of days with a plume (grouped by trajectory) detected in Europe

FIGURE 11

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