

# Unexpected long-range transport of glyoxal and formaldehyde observed from the Copernicus Sentinel-5 Precursor satellite during the 2018 Canadian wildfires (A43J-2964)

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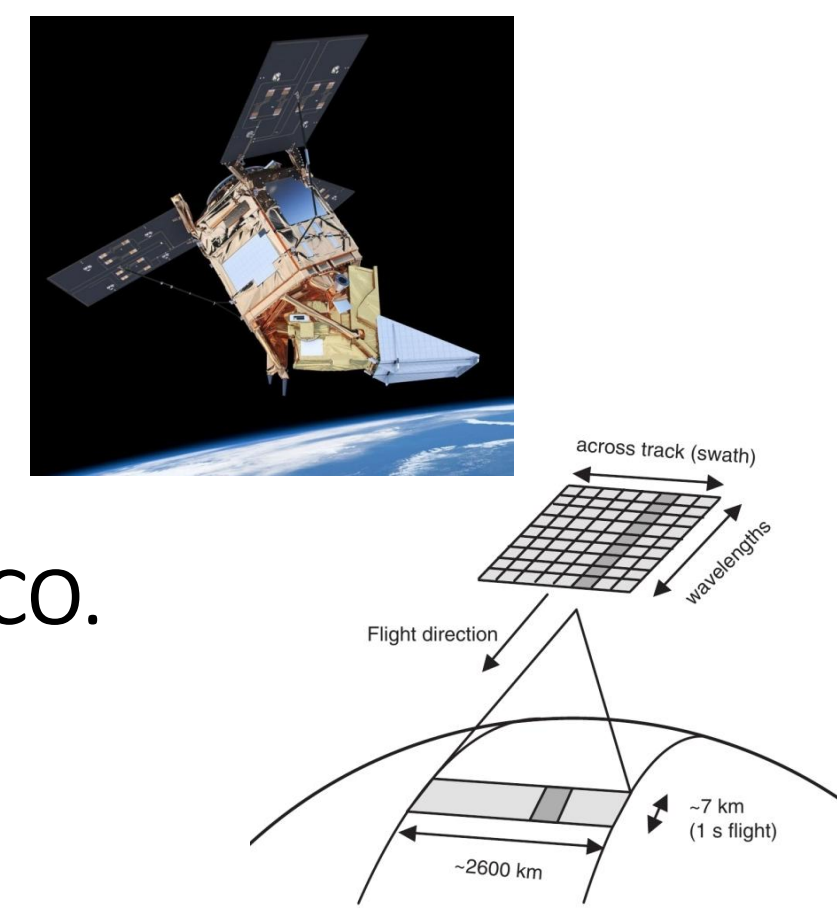


## 1. Introduction

- Glyoxal (CHO.CHO) and formaldehyde (HCHO) are intermediate products in the oxidation of the majority of volatile organic compounds (VOC). These VOCs are released from biogenic, anthropogenic, and pyrogenic sources.
- CHO.CHO and HCHO tropospheric lifetimes are short during the daytime and at mid-latitudes (few hours), as they are rapidly removed from the atmosphere by their photolysis, oxidation by OH, and uptake on particles/deposition.
- Previous studies demonstrated that CHO.CHO and HCHO can be retrieved from space-borne observations using the DOAS method.
- We present CHO.CHO and HCHO columns retrieved from measurements of the TROPOMI instrument, launched recently on the Sentinel-5 Precursor (S5P) platform in October 2017.
- Strongly elevated amounts of CHO.CHO and HCHO are observed during the fire season in British Columbia, Canada, where a large number of fires occurred in August 2018.
- CHO.CHO and HCHO plumes from individual fire hot-spots are observed in air masses travelling over distances of up to 1500 km, i.e. much longer than expected for the short atmospheric lifetime of CHO.CHO and HCHO.

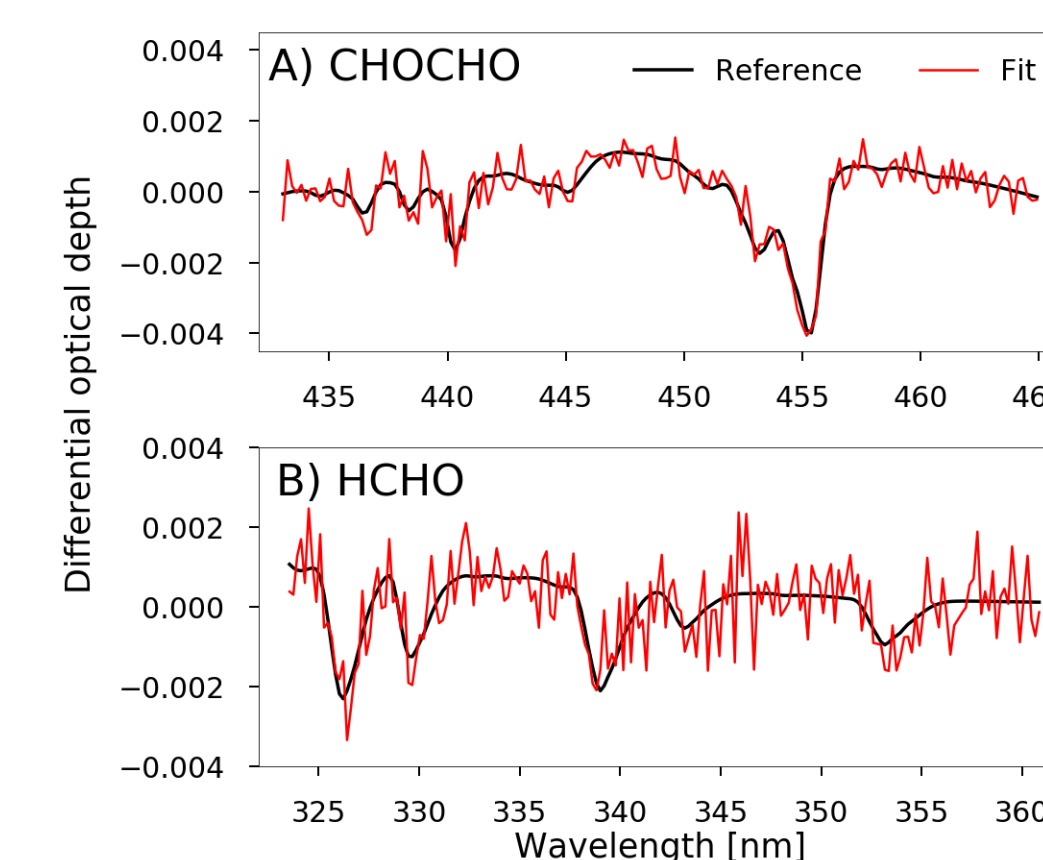
## 2. TROPOMI on Sentinel-5 Precursor (S5P)

- The TROPospheric Monitoring Instrument (TROPOMI) onboard the Copernicus Sentinel-5 Precursor satellite.
- TROPOMI is a nadir-viewing imaging spectrograph with a 2-Dimensional CCD.
- Spectral range from 270 to 500 nm in the UV- VIS, from 675 to 775 nm in the NIR and in a SWIR band from 2305 to 2385 nm.
- Observation of several relevant atmospheric species including CHO.CHO, HCHO, NO<sub>2</sub> and CO.
- Global daily coverage at a spatial resolution of 3.5 km×7 km (7 km×7 km in the SWIR) and equatorial crossing time at 13:30 LT (ascending node).



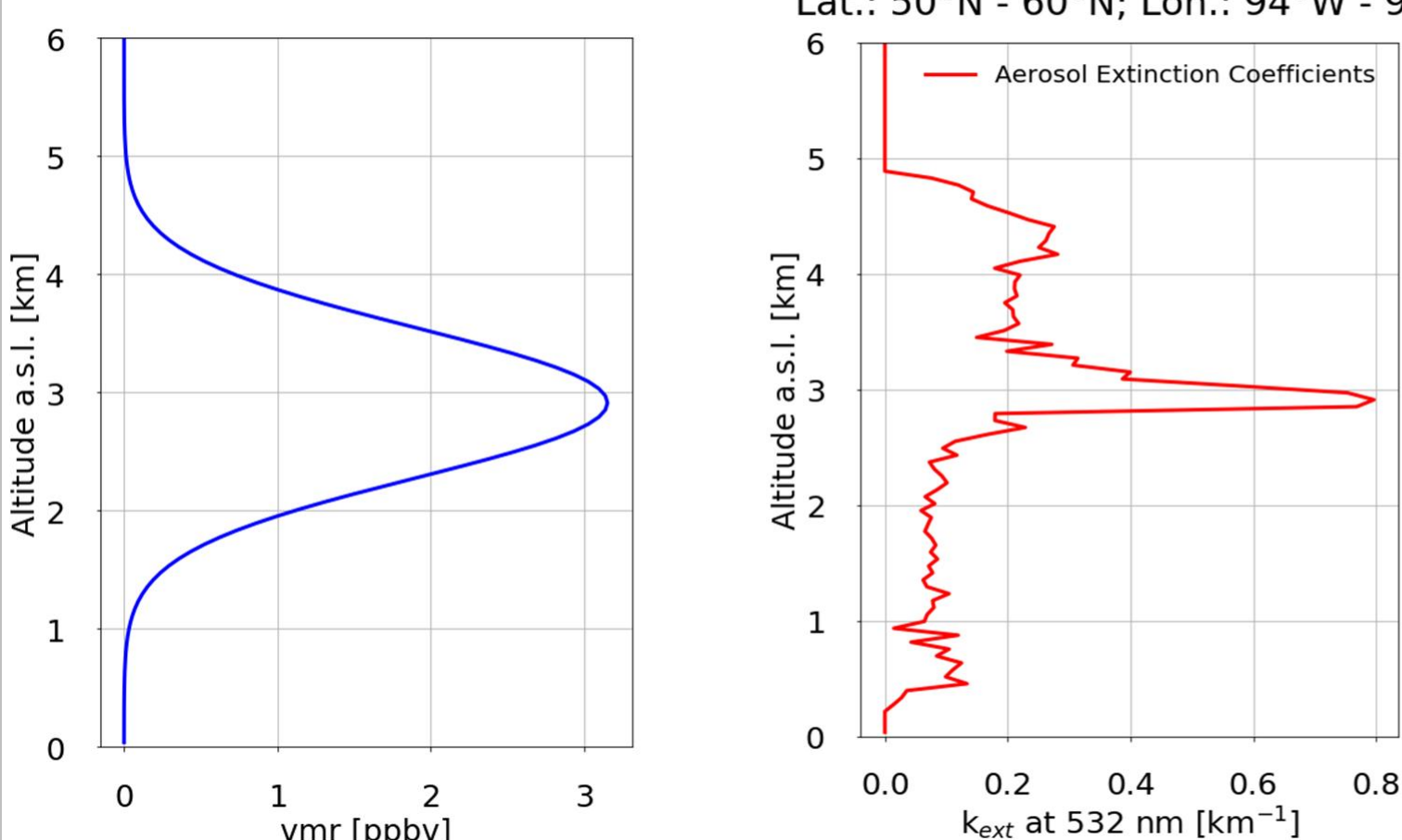
## 3. CHO.CHO and HCHO observations

- The retrieval algorithm for CHO.CHO and HCHO uses the Differential Optical Absorption Spectroscopy (DOAS) technique in the UV and VIS spectral ranges.
- A simple profile with a Gaussian distribution having its maximum peak at the altitude of the aerosol layer is used.
- The altitude of the aerosol layer was estimated from profiles retrieved by the CALIPSO and also used in the calculation of the AMFs by the radiative transfer model SCIATRAN.

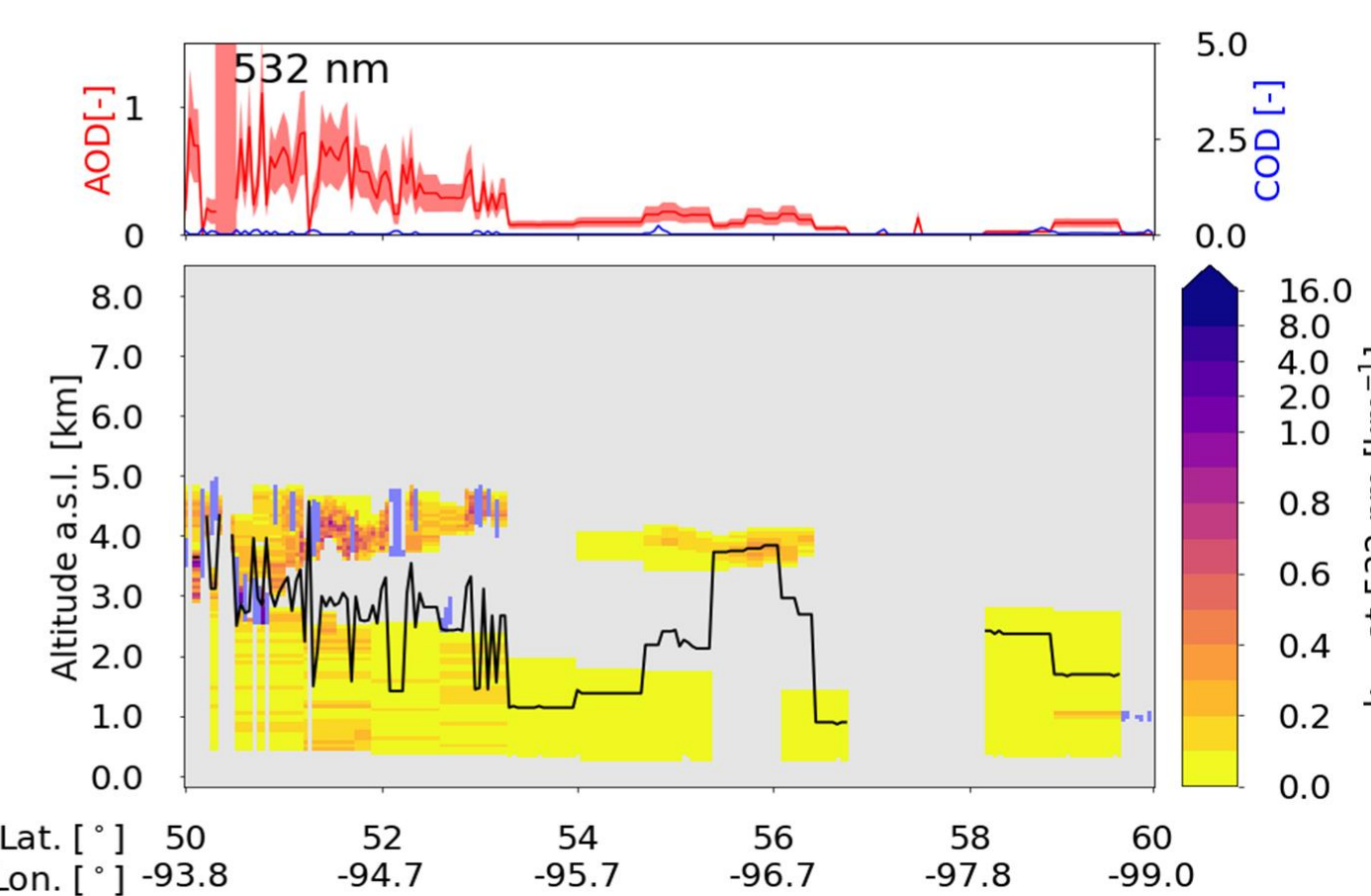


**Figure 1.** Example fit for CHO.CHO (A) and HCHO (B) from a single measurement of S5P taken on 10 August 2018. The black line depicts the scaled differential cross-section and the red line the fit.

**A) Gaussian profile: 10 Aug. 2018** **B) Average aerosol profile: 10 Aug. 2018** Lat.: 50°N - 60°N; Lon.: 94°W - 99°W



**C) CALIPSO Aerosol profiles: 10 Aug. 2018**



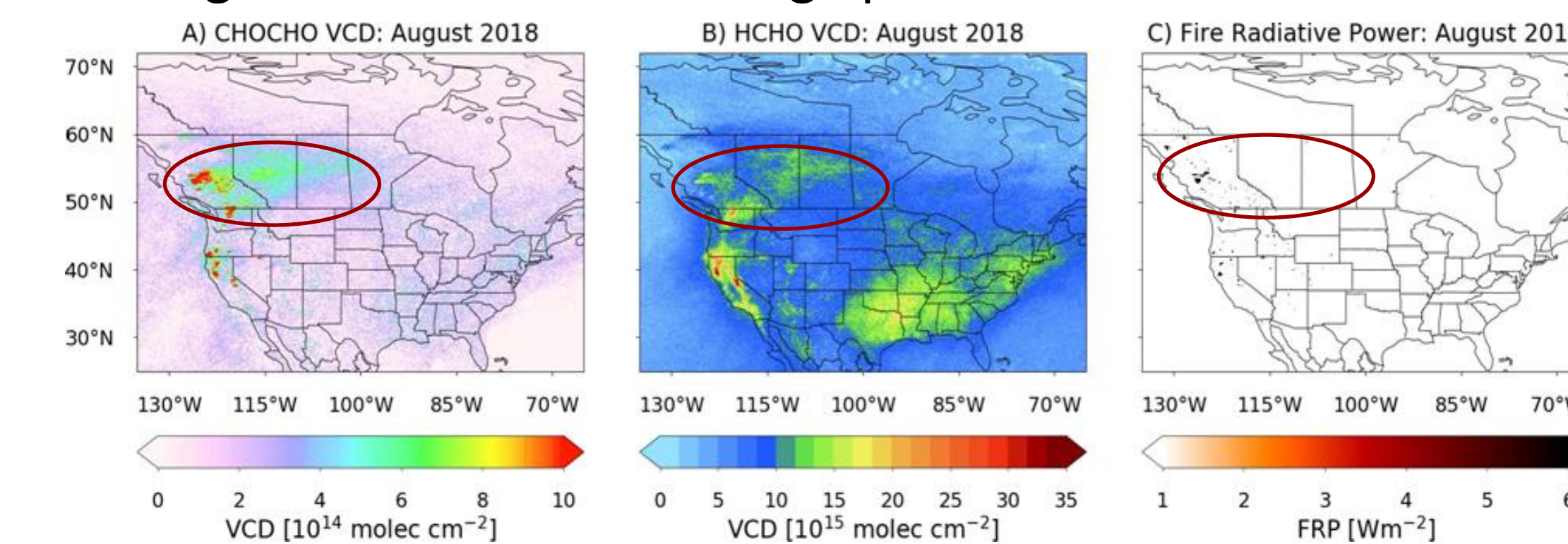
**Figure 2.** A) CHO.CHO and HCHO profiles assumed in the computation of AMFs. B) CALIPSO average profile of aerosol extinction coefficients ( $k_{ext}$ ) for all latitudes and longitudes of Figure 2-C, excluding cloudy scenes. C) Top panel: Example of CALIPSO Aerosol profile extinction coefficients retrieved at a wavelength of 532 nm. Aerosol and cloud optical depth are shown as a function of latitude and longitude for every single profile. Bottom panel: Colour-coded  $k_{ext}$  for every latitude and longitude in the selected region. Purple spots represent cloudy scenes. The black line depicts the aerosol layer height.

## 5. Summary and Conclusions

- The retrieval of CHO.CHO and HCHO total column amounts from measurements of the TROPOMI instrument onboard the Sentinel-5P satellite is reported from pyrogenic emissions during the wildfire season in summer 2018 in British Columbia.
- The spatial and temporal pattern of the highest retrieved CHO.CHO and HCHO VCDs are associated with areas having high FRP.
- Extended plumes of elevated CHO.CHO and HCHO amounts are observed on some days downwind of the fires.
- Enhanced CHO.CHO and HCHO columns were found in the S5P data up to 1500 km from their sources.
- An effective tracer lifetime of 28.9 hours needs to be assumed in FLEXPART dispersion simulations to explain these observations.
- The long apparent lifetime of CHO.CHO and HCHO could either be a real increase in atmospheric lifetime due to the specific photochemical conditions in the biomass burning plume or, as we attribute, the presence of longer-lived precursors, which are oxidized to form CHO.CHO and HCHO during transport.

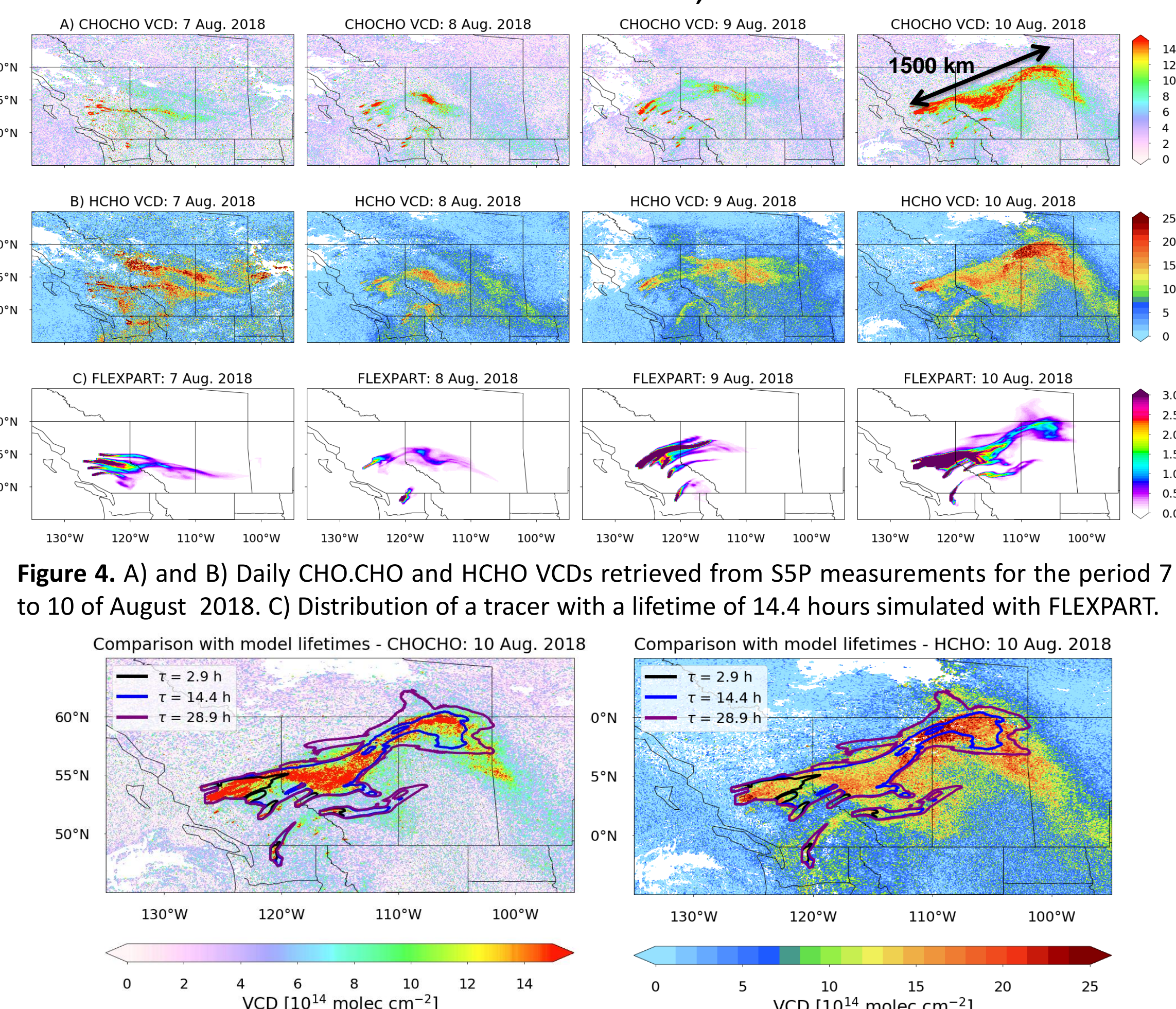
## 4. Results and discussion

- CHO.CHO and HCHO** enhancements are not limited to the main fire region but extend over large parts of Canada.

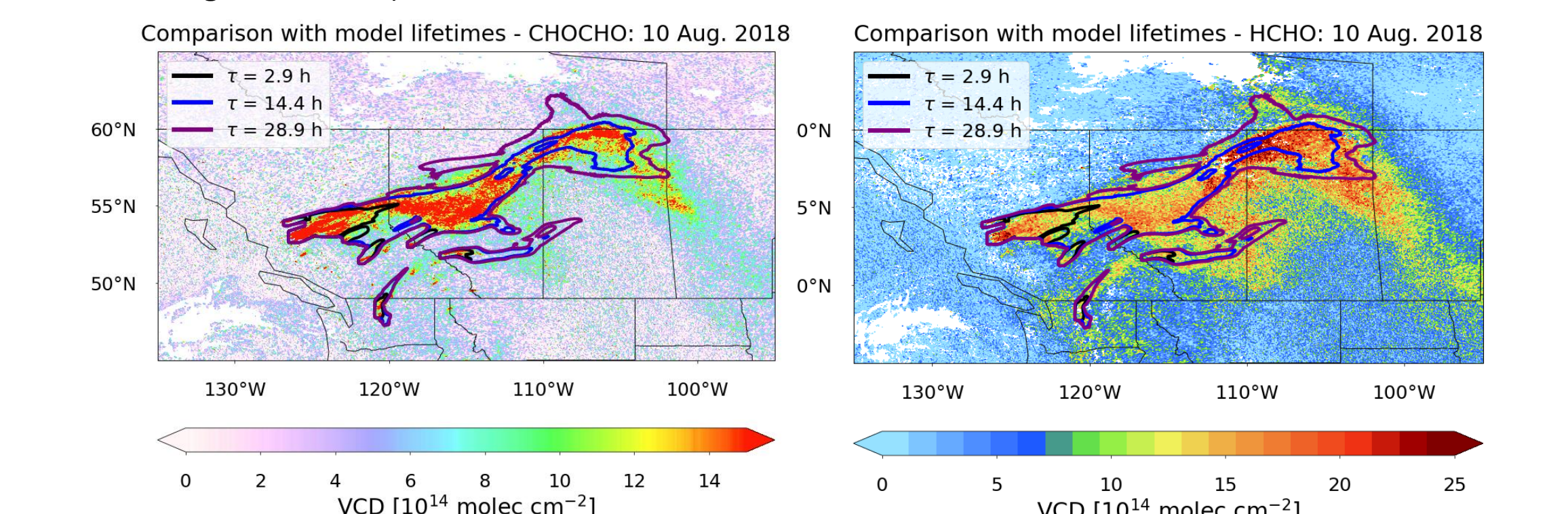


**Figure 3.** Monthly average of CHO.CHO (A) and HCHO (B) VCDs retrieved from the TROPOMI instrument for August 2018, and over North America. C) shows the integrated FRP from MODIS.

- A passive tracer simulated with FLEXPART spreads over the same area as CHO.CHO and HCHO.
- Plumes cover a distance of about ~1,500 km from the fires.



**Figure 4.** A) and B) Daily CHO.CHO and HCHO VCDs retrieved from S5P measurements for the period 7 to 10 of August 2018. C) Distribution of a tracer with a lifetime of 14.4 hours simulated with FLEXPART.



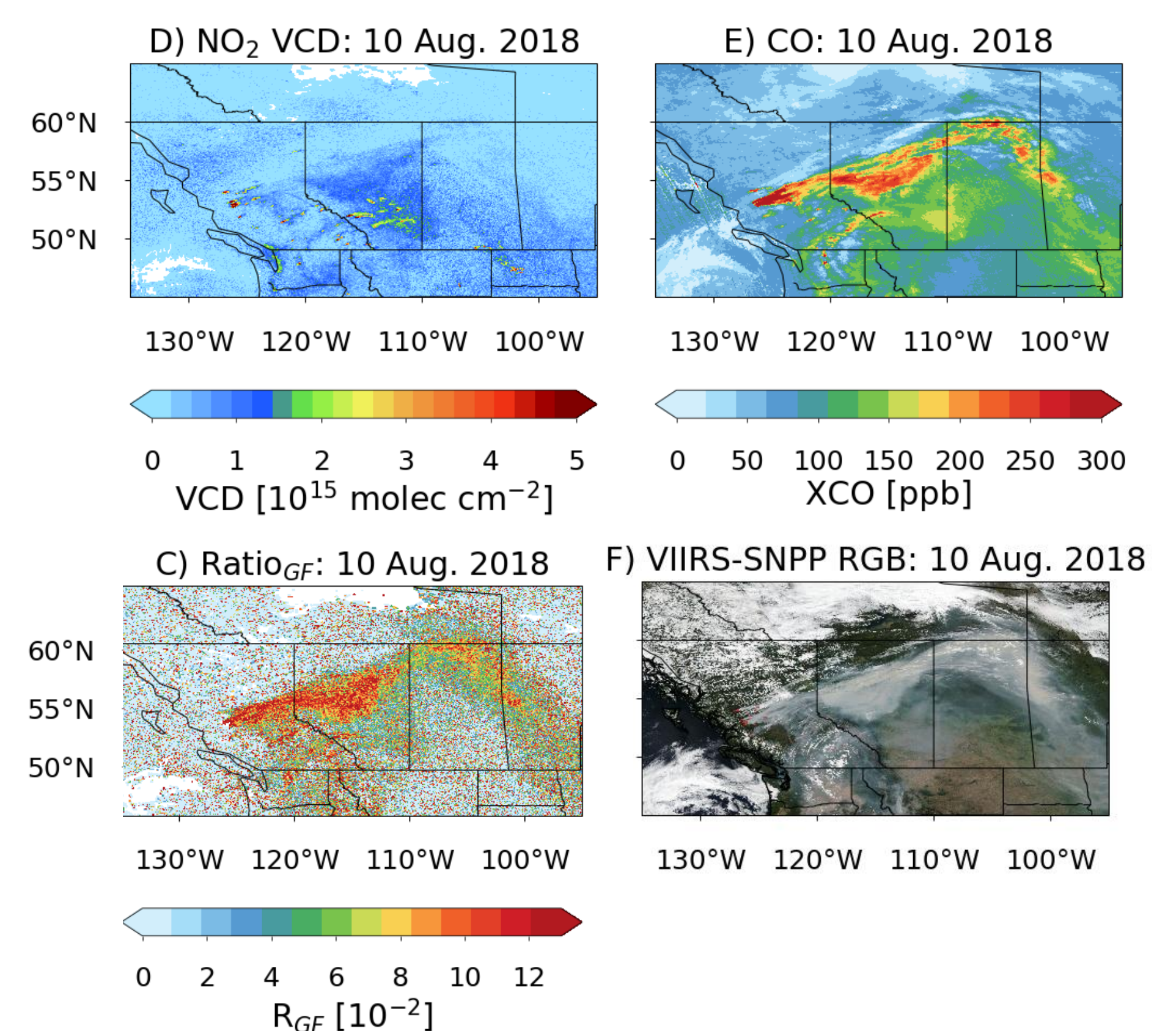
**Figure 5.** Daily maps CHO.CHO and HCHO VCD retrieved from S5P for 10 August 2018 compared with FLEXPART tracer simulations having three different effective lifetimes (~2.9, 14.4, and 28.9 hours).

## 6. Selected references and Acknowledgements

- Alvarado, L. M. A., Richter, A., Vrekoussis, M., Hilboll, A., Kalisz Hedegaard, A. B., Schneising, O., and Burrows, J. P.: Unexpected long-range transport of glyoxal and formaldehyde observed from the Copernicus Sentinel-5 Precursor satellite during the 2018 Canadian wildfires, Atmos. Chem. Phys. Discuss., 2019.
- Veeckind, J. P., Aben, I., McMullan, K., Förster, H., de Vries, J., Otter, G., Claas, J., Eskes, H. J., de Haan, J. F., Kleipool, Q., van Weele, M., Hasekamp, O., Hoogeveen, R., Landgraf, J., Snel, R., Tol, P., Ingmann, P., Voors, R., Kruizinga, B., Vink, R., Visser, H., and Levelt, P. F.: TROPOMI on the ESA Sentinel-5 Precursor: A GEMS mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications, Remote Sensing of Environment, 2012.

- Potential explanation for enhanced effective lifetimes**

- Reason 1:** The lifetimes of CHO.CHO and HCHO could be significantly longer than expected in these biomass burning plumes.
- Reason 2:** There could be an efficient recycling process between the gas and aerosol phase, resulting in the observed extended effective lifetimes of CHO.CHO and HCHO.
- Reason 3:** The plume could contain glyoxal and formaldehyde precursors which slowly produce additional VOCs along the trajectory, resulting in an apparent increase in lifetimes.



**Figure 6.** Panels D and E show the NO<sub>2</sub> and CO columns retrieved from S5P measurements for the 10 August 2018. Panel C depicts the calculated ratio of CHO.CHO to HCHO (RGF) for the same day. Panel F shows a true color image of the aerosol distribution from VIIRS for 10 August 2018.

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