Extreme Peatland Wildfires Exhibit Dynamic Combustion Behaviour & Emission Characteristics

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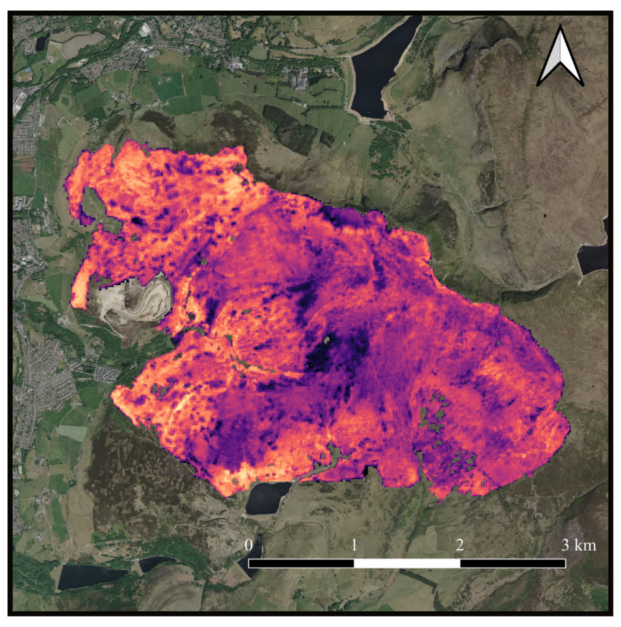
Background

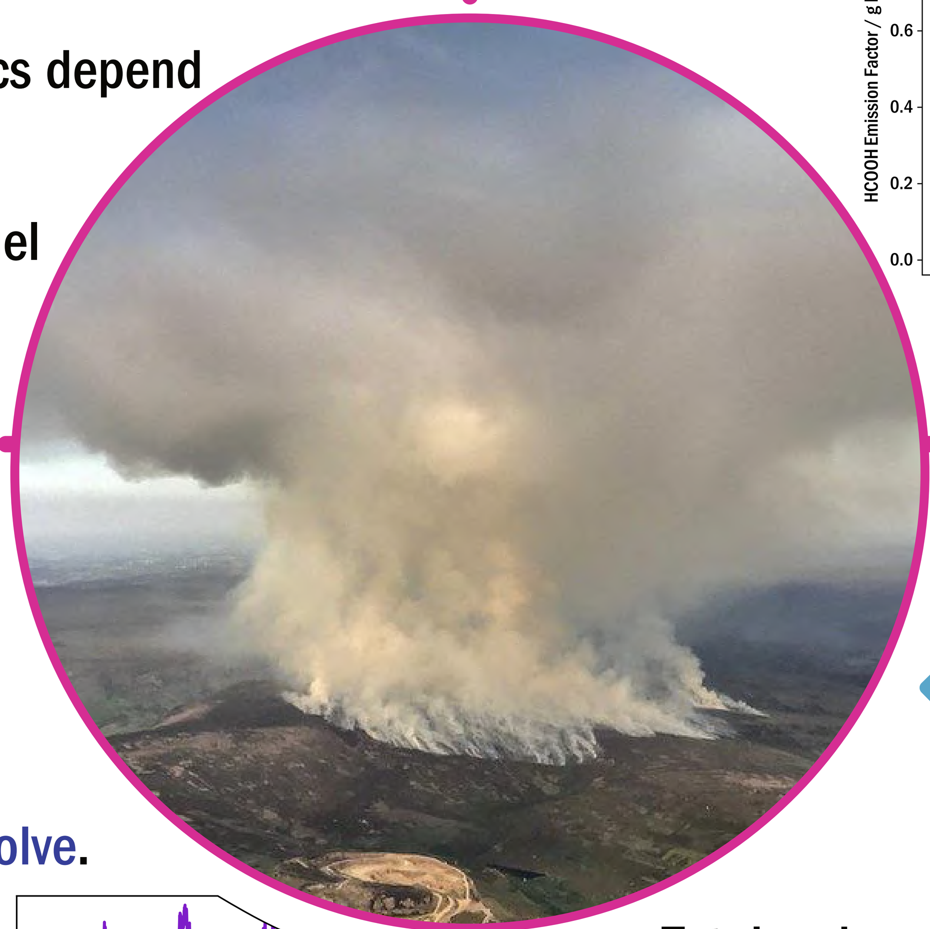
Peatlands store 30% of land-based carbon and are threatened by drying conditions.

In June 2018, Saddleworth Moor experienced "the worst wildfire in living memory" in the UK. Consuming 10 km^2 of land, the fire is our main case study.



Key uncertainties surround peatland wildfires:

- To what extent is a peatland wildfire just the surface vegetation burning?
- Do the emission characteristics depend on the stage of the burn?
- Are emissions dependent on fuel properties, such as moisture?

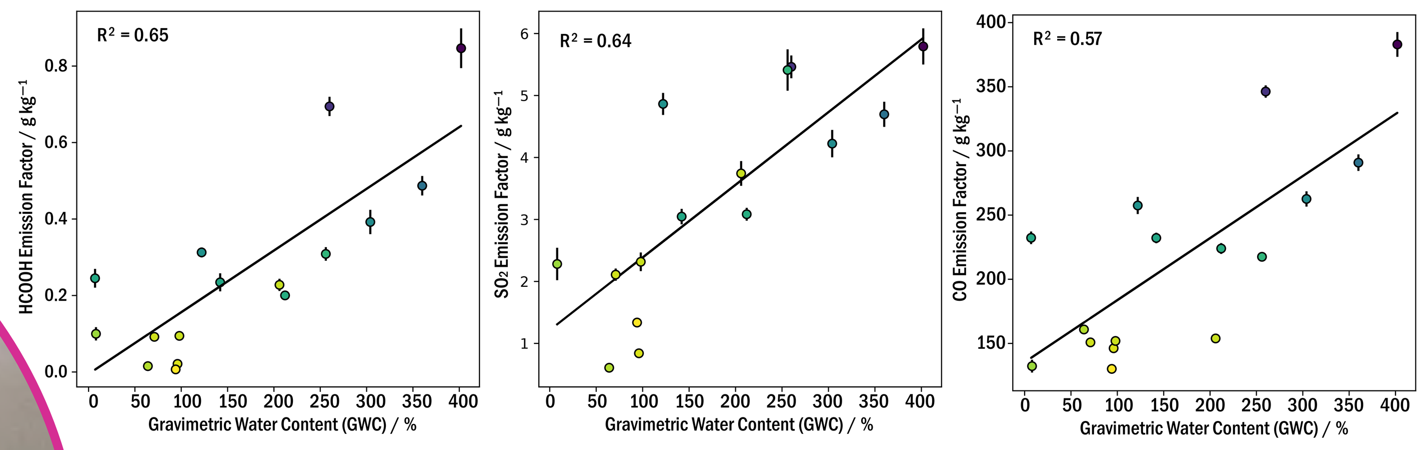


Peat Condition Regulates Fire Emissions

Peat fires behave differently depending on initial moisture conditions.

A greater fraction of carbon monoxide and toxic 'trace' gases are released when the peat is more moist. This is currently unrepresented in global emission models.

A series of labaratory burns measured the impact of moisture on trace gas emissions.

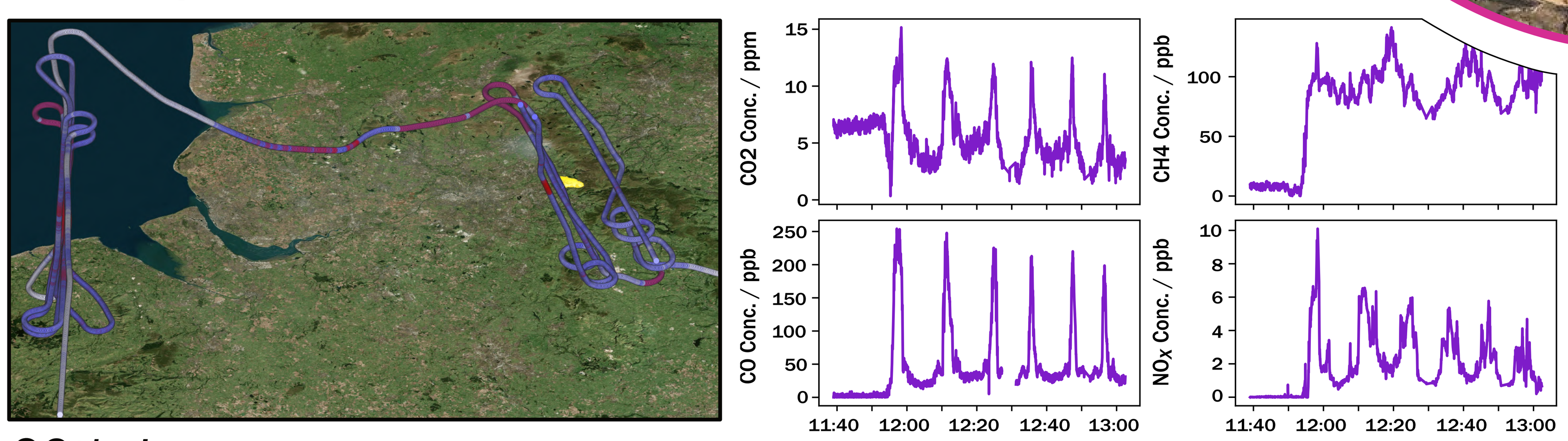


Formic Acid — Sulphur Dioxide — Carbon Monoxide

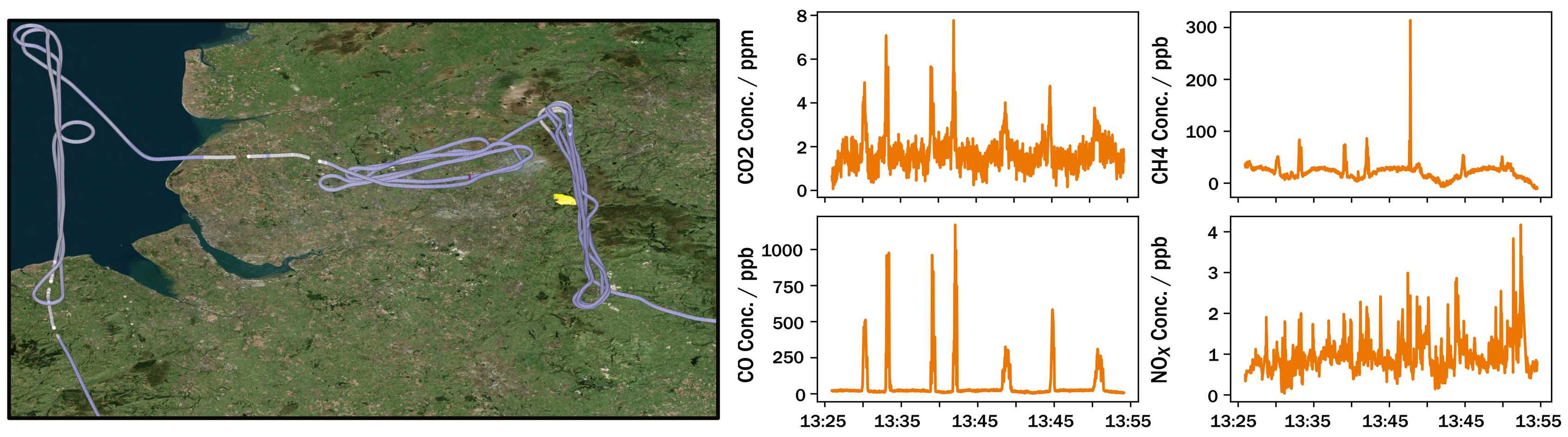
Wildfire Plume Sampling

During the wildfire, the FAAM airborne laboratory sampled the plume with a gas analysis suite.

Sampling on two dates, we observe emission characteristics evolve.



29th June



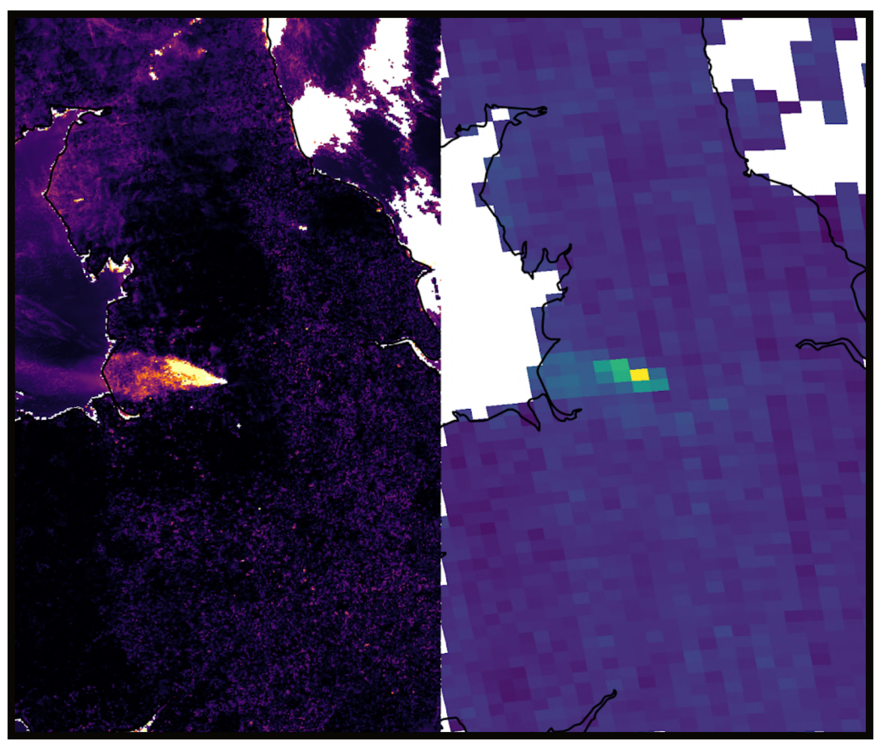
3rd July

Emission Estimation

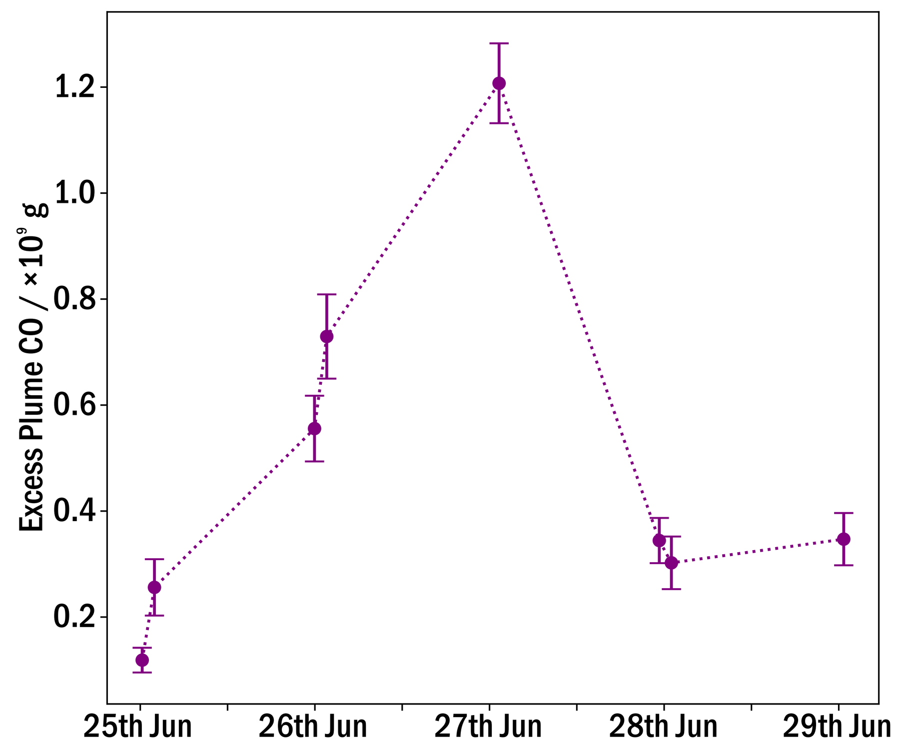
The plumes were monitored overtime using VIIRS.

Plume outlines were hand-drawn and total plume carbon monoxide was derived using Sentinel-5P.

Total carbon emissions can then be from emission factors characteristic of the fire type (i.e. peat fires, grassland fires, etc.) This is the 'aFREM' method.



VIIRS AOD — S5P TCCO



Carbon Monoxide Emissions

Variability in Total Carbon Estimation

To calculate total carbon emissions, we need the carbon monoxide emission factor for peat. So what is it, exactly?

Literature Values

Reported values for 'boreal peat' fires vary:

105.5 - 291 g kg^{-1}

GFED uses:

182 ± 60 g kg^{-1}

Aircraft Observations

Wildfire plume sampling observed different emission factors on the two dates:

29th June: 89.1 ± 6.4 g kg^{-1}

3rd July: 121.3 ± 9.5 g kg^{-1}

Moisture Dependency

Moisture will vary across the site and and overtime.

Lab-measured emission factors range across:

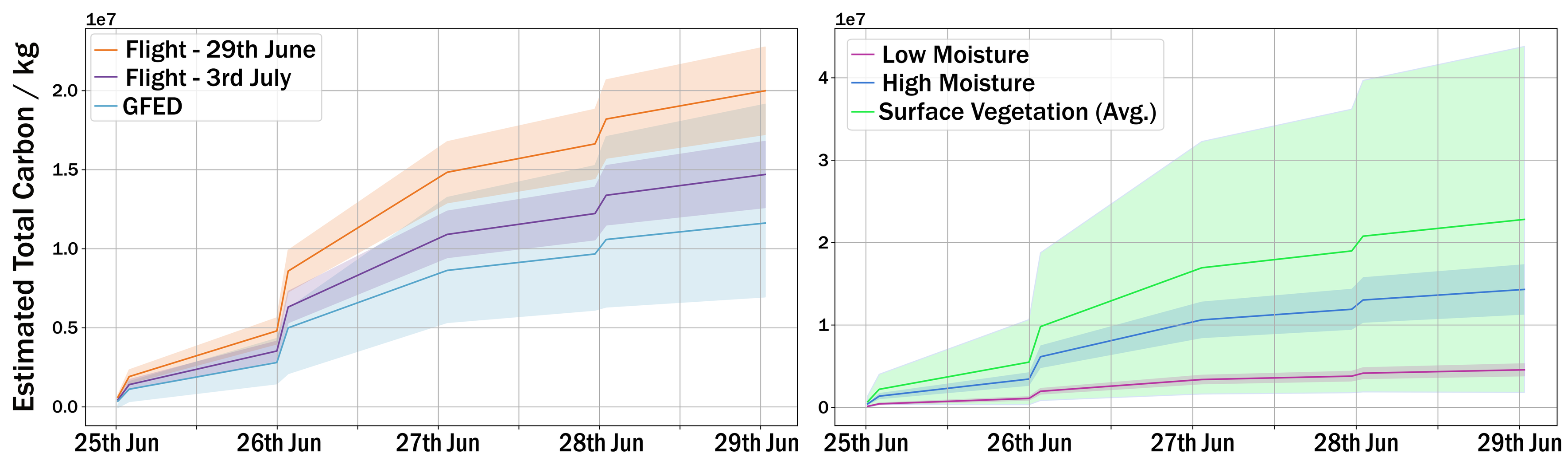
127 - 392 g kg^{-1}

Fuel Variation

Peat fires burn more than just peat, they typically burn the surface vegetation too:

Sedges: 61 - 105 g kg^{-1}

Mosses: 58 - 156 g kg^{-1}



- Estimates of total released carbon vary by ~4.11 · 10^7 kg depending on the pescribed emission factor.
- The sampled plumes shows some evidence the fire initially was dominated by surface flaming, before smouldering the peat below.

References

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Hu, Y, et al. "Review of Emissions from Smouldering Peat Fires and Their Contribution to Regional Haze Episodes." International Journal of Wildland Fire, vol. 27, no. 5, 2018.

Davies, G.M., et al., 2016. The role of fire in UK peatland and moorland management: the need for informed, unbiased debate. Philosophical Transactions of the Royal Society B: Biological Sciences 371, 20150342.

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