Northern High-Latitude Peat Fires: From Lab to Modelling

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Why Modelling Northern High-Latitude Peat Fires is Important?

- Peat fires are the largest and most persistent fires on Earth
- Northern peatlands are the largest terrestrial carbon store, exerting a net cooling effect on the climate
- Climate warming is occurring most rapidly at high latitudes, heightening the vulnerability of carbon-rich peatlands to fire
- **Feedback loops** of peat fires on climate change can emerge (Figure 1)
- Largely, Earth system models lack peat fire and emissions capabilities
- Therefore, representing peatland fire feedbacks to climate in Earth system models is essential for accurately predicting future climate

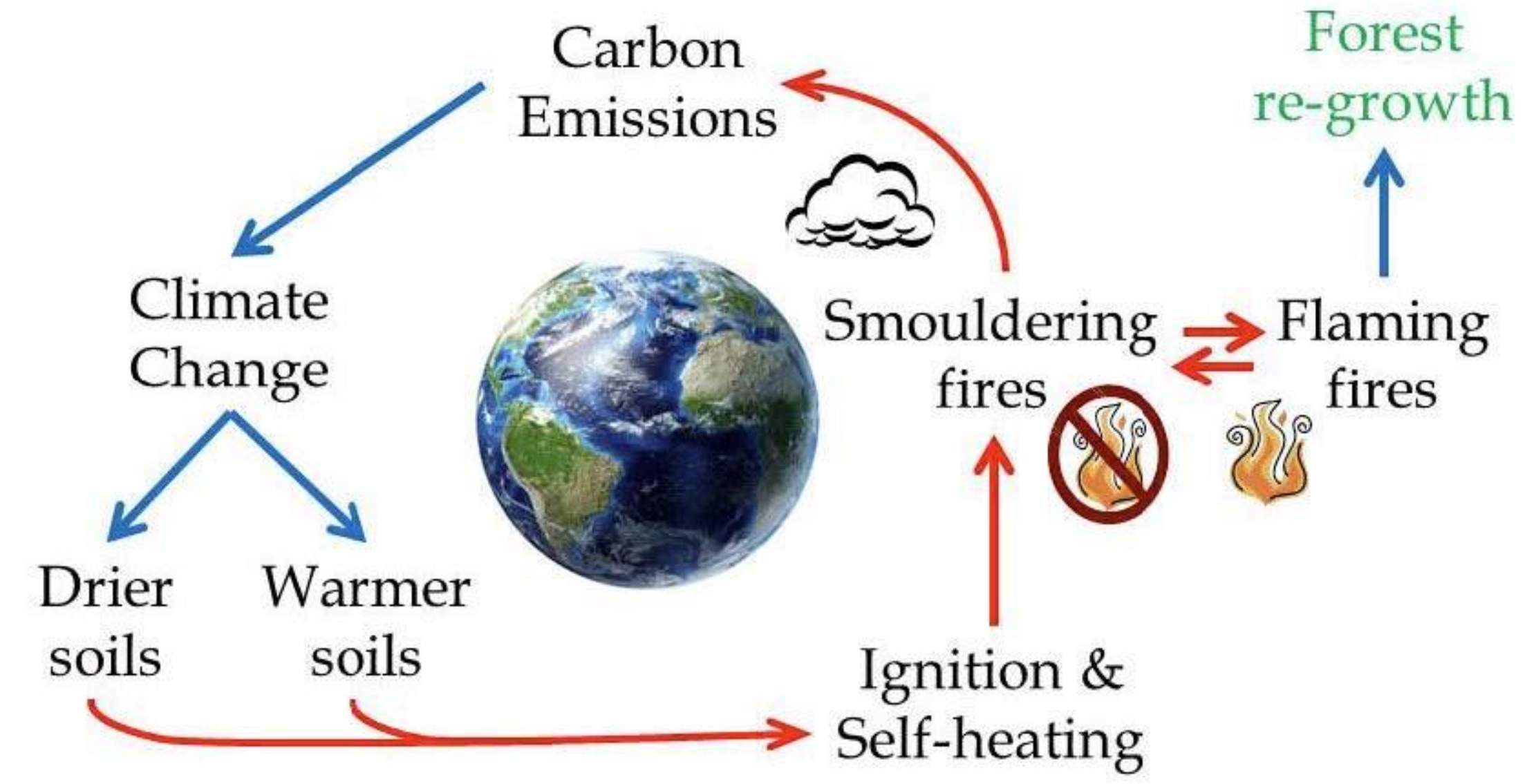

Figure 1: Positive feedback loop between smouldering fires and climate change[a]

Peat-fire Model

- **INFERNO-peat** is the first representation of peat fires in the JULES – INFERNO fire model[b]
- It models peat burnt area, burn depth and carbon emissions
- Including peat fires **drastically improves** burnt area simulation
- Compared to satellite derived GFED5 product, INFERNO-peat captures **~ 20% more burnt area**, whereas original INFERNO underestimates burning by 50% (Figure 2)

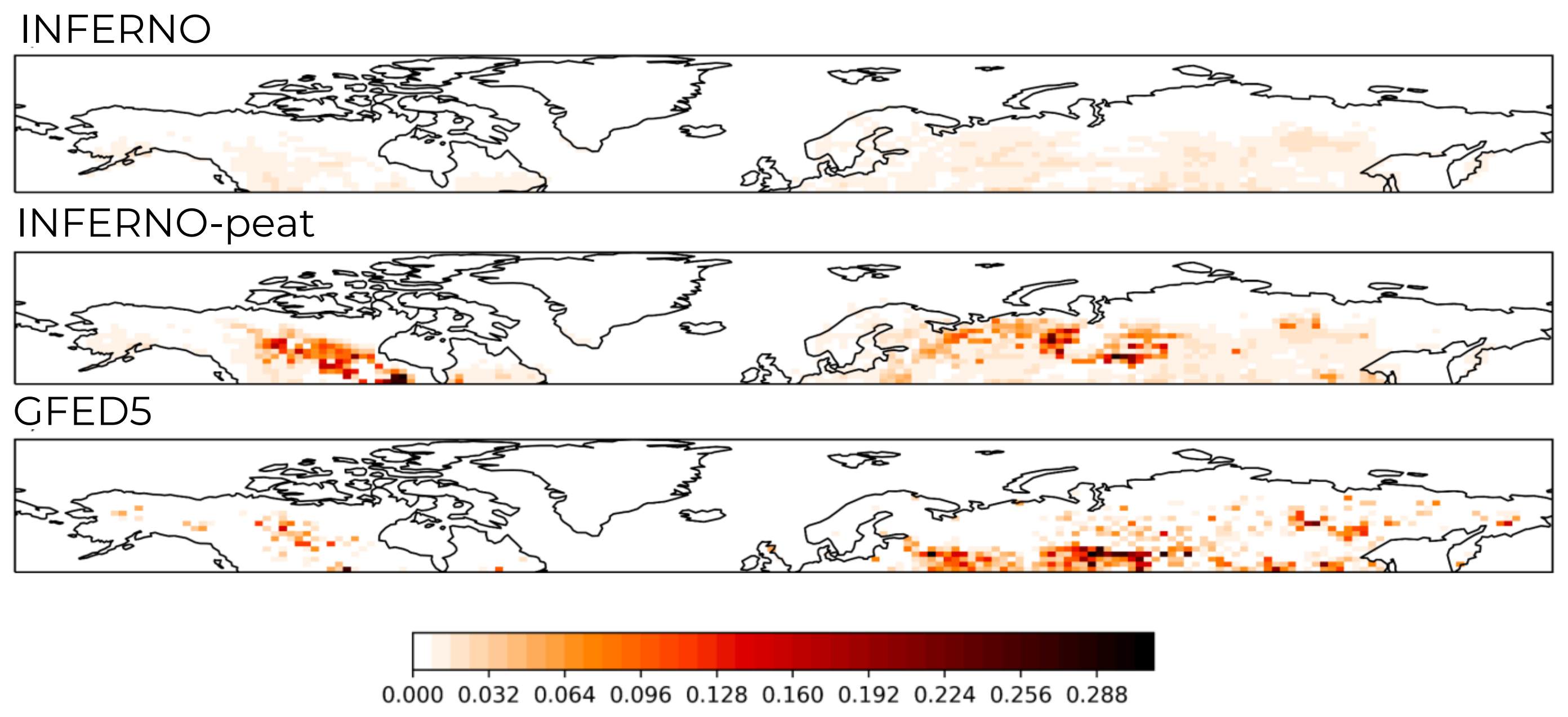

Figure 2: Average annual burnt area fraction (2010 – 2014)[c]

Field Trip (Winterfell II)

Field trip in Thurso, Scotland for peat collection

Figure 3: Collecting peat from a natural peatland

Figure 4: Sample from peatland burnt in 2019

Lab Experiments

- Moisture content (MC) governs the ignition and spread of smouldering fire[a,d]
- Experiments were performed for finding the critical MC for extinction (MC_{ex})
- 2 experiments performed with commercial peat of MC = 120% and MC = 140%
- Use the MC_{ex} value in INFERNO-peat to explicitly calculate the depth of burn

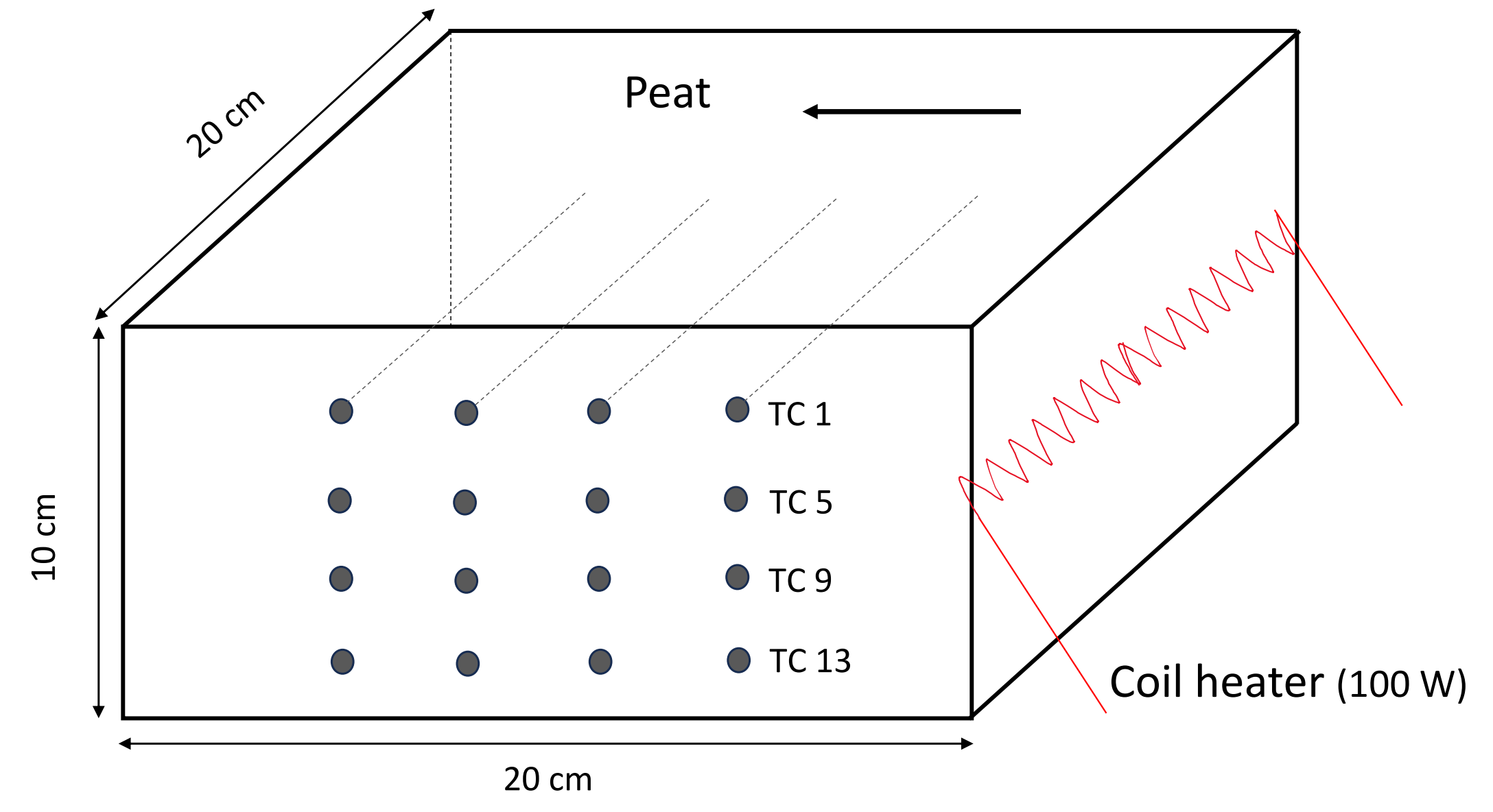

Figure 5: Experimental set-up

Preliminary Lab Results

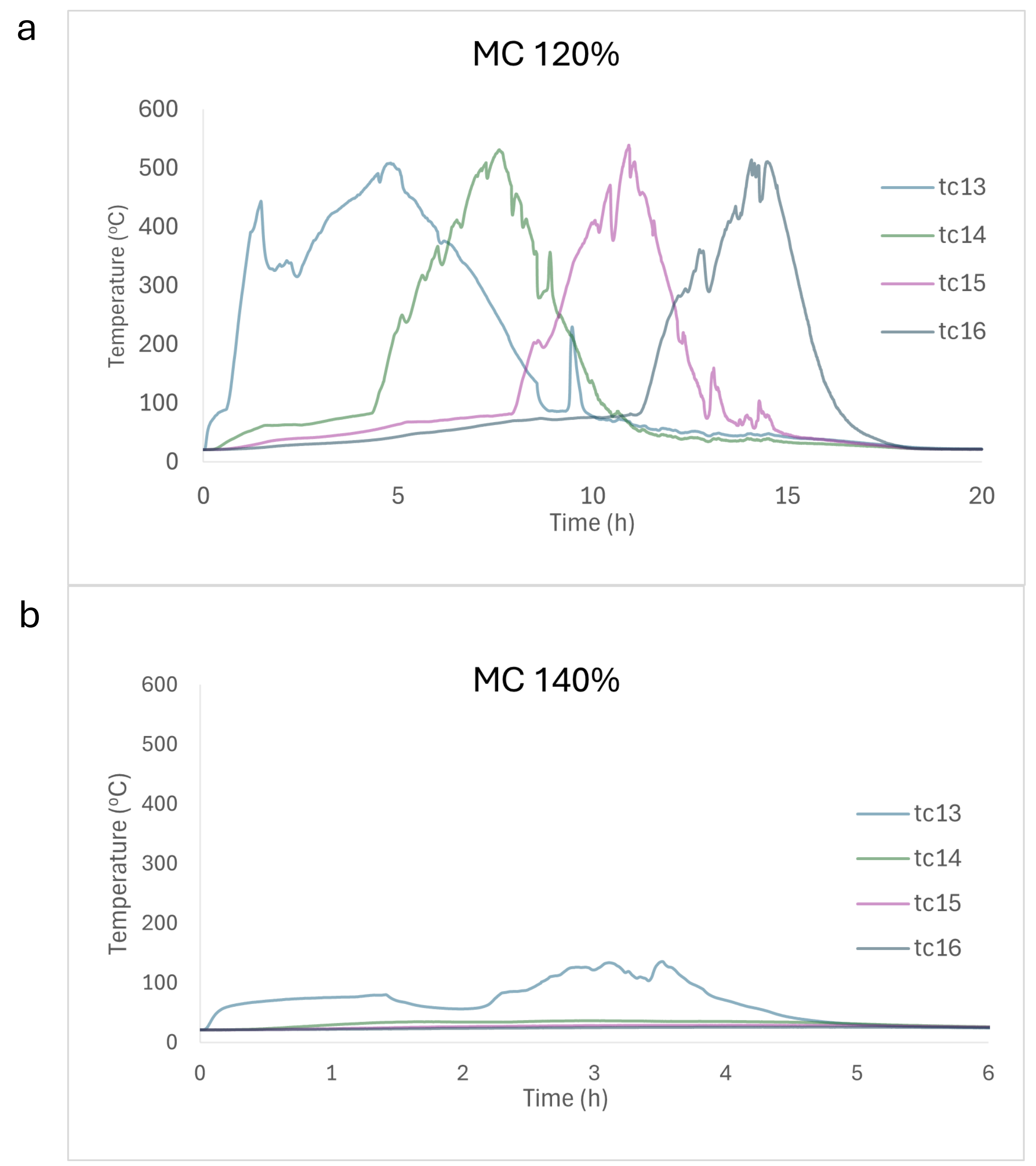

Figure 6: Temperature measurements of thermocouples for peat of (a) 120% MC and (b) 140% MC

- **MC = 120%** : Peak temperatures range from 450 to 550 °C, indicating a burning smouldering front (Figure 6a)
- **MC = 140%** : Thermocouples do not reach 200 °C, which is a typical temperature for peat pyrolysis onset (Figure 6b)
- Therefore, 120% < MC_{ex} < 140%

Future Work

- Perform lab experiments with commercial peat to find the MC_{ex}
- Repeat the experiments with the collected natural samples and compare the results with the commercial ones
- Update INFERNO-peat incorporating the experimental results and a new depth of burn calculation method
- Perform simulations for the period 1990-2014 and compare with the previous version of INFERNO-peat

References

[a]Rein, 2013, “Smouldering fires and natural fuels”, Phenomena and the Earth System, Belcher (Ed.), Wiley and Sons, 15–33
[b]Mangeon et al., 2016, “Inferno: A fire and emissions scheme for the UK Met Office’s unified model”, Geosci. Model Dev., 9(8), 2685–2700
[c]Blackford et al., 2023, “INFERNO-peat v1.0.0: A representation of northern high latitude peat fires in the JULES-INFERNO global fire model”, EGUsphere [preprint]
[d]Huang and Rein, 2017, “Downward spread of smouldering peat fire: the role of moisture, density and oxygen supply”, Int. J. Wildland Fire, 26(11), 907-918

Acknowledgements

This research work was supported by the AXA Research Fund (project ‘AXA Chair in Wildfires and Climate’) and the Hellenic Foundation for Research & Innovation (H.F.R.I.) under the project ‘Fire-emitted Pollution and Climate Change: Linkages in the Past, Present and Future’ (Fire-PC) (Grant No. 03453). In addition, it was partially funded by the Leverhulme Centre for Wildfires, Environment, and Society through the Leverhulme Trust, Grant No. RC-2018-023.