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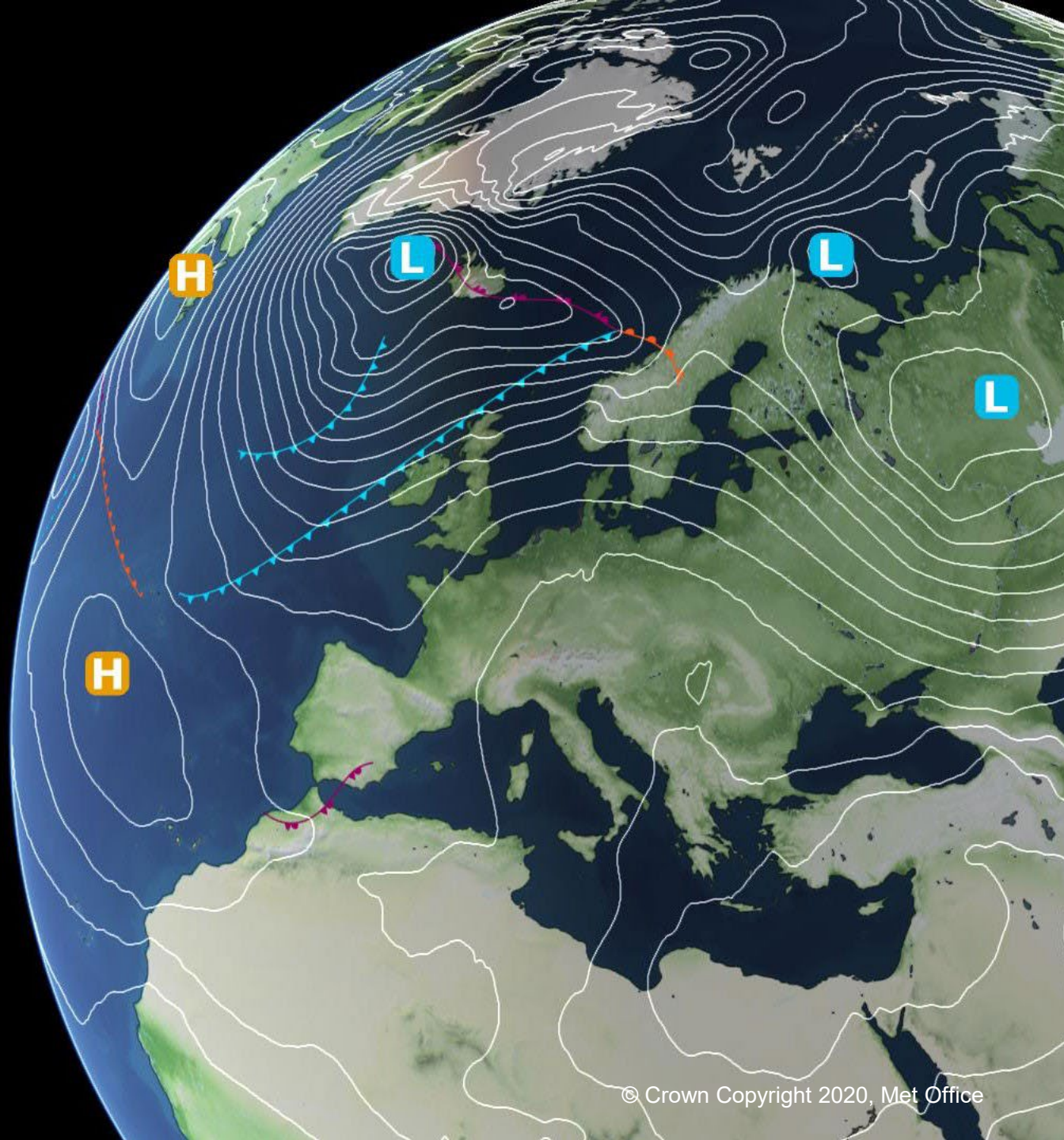
ESM forcing data requirements for CMIP7:

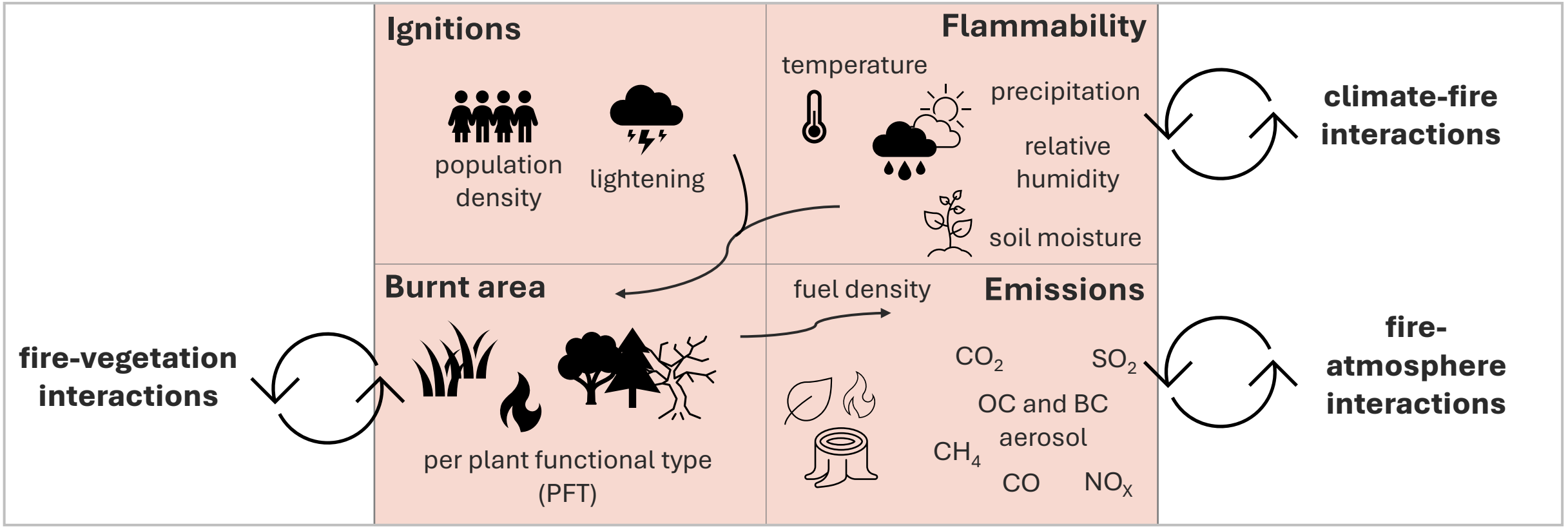
Population Density & Human Development Index (HDI)

Jane Mulcahy & João Teixeira



Interactive fire modelling in ESMs

UKESM + INFERNO



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Fire ignitions and population density

- Ignitions represented by:

Anthropogenic ignitions

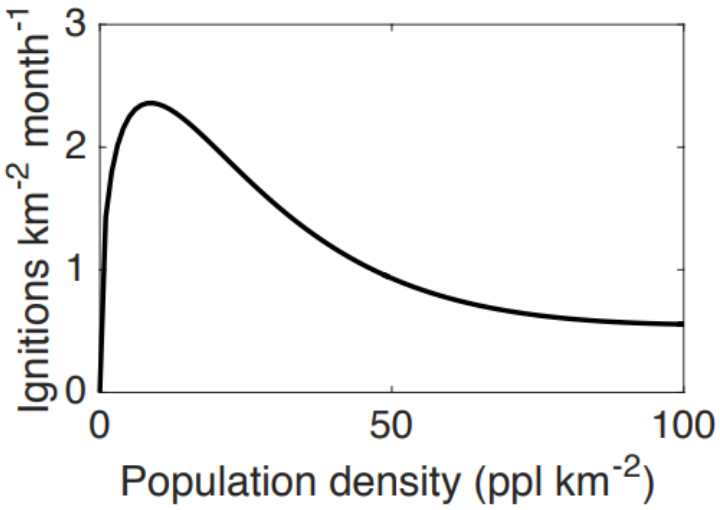
$$I_A = k_{(PD)} PD\ \alpha$$

Suppression due to human activity

$$f_{NS} = 7.7\left(0.05 + 0.9 \times e^{-0.05PD}\right)$$

Total ignitions (Anthro. + Natural)

$$I_T = (I_N + I_A)\frac{f_{NS}}{8.64 \times 10^{10}}$$



$k_{PD} = 6.8 \times PD - 0.6$ *represents the influence on ignitions in rural vs urban environments*

$\alpha = 0.03$ *represents the number of potential ignition sources* $(people\ month^{-1}\ km^{-2})$

PD = Population density

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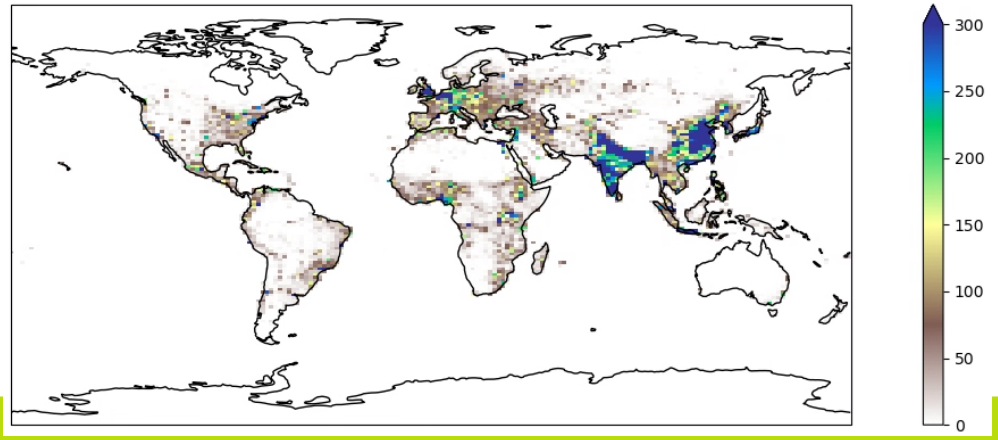
Data sources: HYDE

PI & Historical

- Suitable gridded data for the preindustrial and Historical periods → Supports the IMAGE IAM
- Temporal resolution:
  - decadal 1850 to 1950
  - annual 1951 to 2023

Population density ppl/km^2 (2010)



Future scenarios

- Should be available from IAMs (eg: IMAGE), but isn't openly available
- Require harmonised, gridded data for the SSPs
- Ensures consistency between modelling centres using population density data

Data Requirement!

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Representing socio-economic factors via HDI

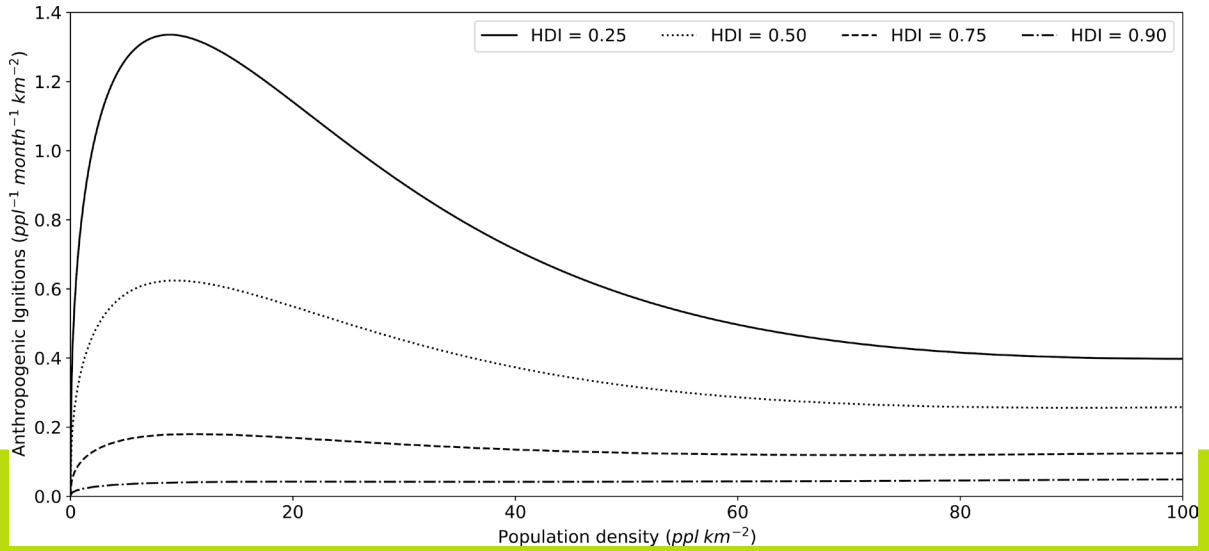
Anthropogenic ignitions

$$I_A = k_{(PD)} PD\ \alpha \times (\mathbf{1} - \boldsymbol{HDI})$$

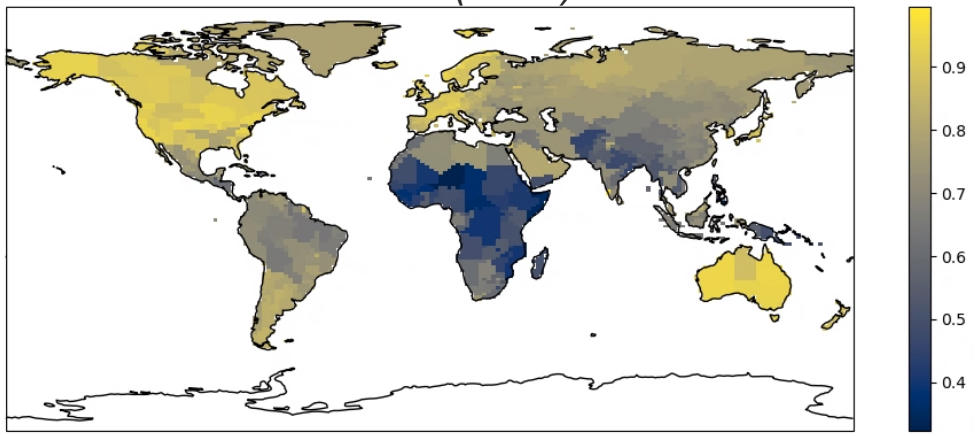
Suppression due to human activity

$$f_{NS} = 7.7\left(0.05 + 0.9 \times e^{-0.05PD}\right) \times (\mathbf{1} - \boldsymbol{HDI})$$

Anthropogenic ignitions



HDI (2010)



Lack of consistent data

- *Kummu et al. (2019)*: gridded dataset covering 1990 to 2015
- *Leandro Prados de la Escosura* provides temporal cover for 1870-2020, but data provided by country (xls format)
- No published dataset for future scenarios (SSPs)

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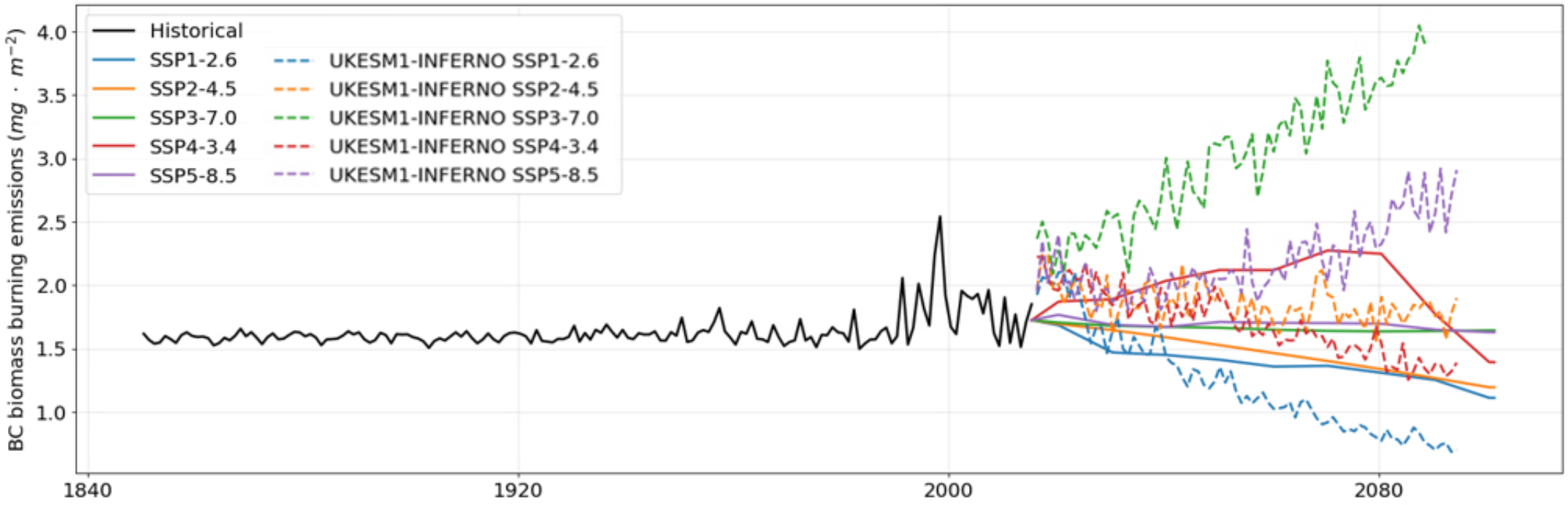
Impact of INFERNO on future fire emissions



Summary of key requirements

ESMs are moving towards modelling fires interactively, thereby simulating the feedbacks on both terrestrial vegetation, carbon cycle as well as atmospheric composition.

This presents some new forcing data requirements:

Priority 1: **Population Density**

Required for: Fire ignitions

Historical gridded data available from HYDE.
Scenario data currently not as easily available.

Requirement: Gridded data for all CMIP7 future scenarios, harmonized with historical record.

Priority 2: **HDI**

Required for: Fire ignitions incl. socio-economic information

Historical gridded data available for a limited time period.
Gridded scenario data currently not as easily available – but should be available from IAMs.

Requirement: Gridded data for historical + future scenarios

Timescales (UKESM only): not needed for FT but needed for UKESM2 DECK/scenario simulations mid-2026