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# Towards multi-method and multi-scale attribution of global wildfire danger

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# Attributing extreme fire weather events

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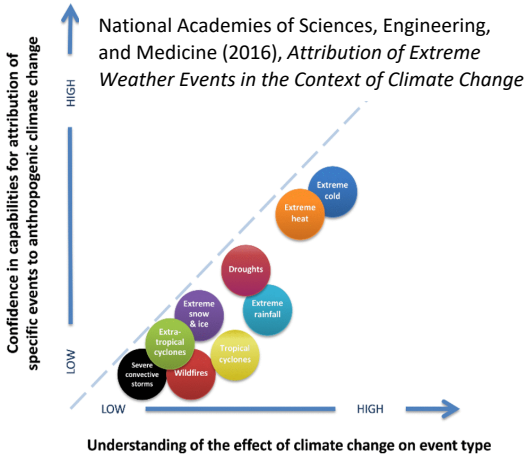
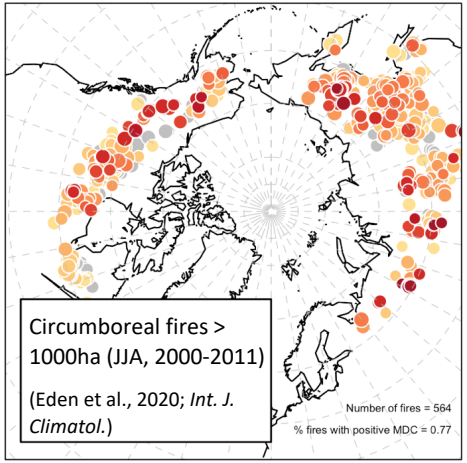
- Large fires across both hemispheres in recent years have led to inevitable questions about how human-induced climate change may be altering the character of such events.
- Providing answers to these questions is a crucial step to increasing resilience to major wildfires.
- The link with climate change remains poorly understood (right) and wildfires are not a consistent focus for attribution studies.




National Academies of Sciences, Engineering, and Medicine (2016), *Attribution of Extreme Weather Events in the Context of Climate Change*




Here, we take a first step toward a global framework for assessing risk in wildfire danger:

(a) Attribution of observed trends in fire weather, with initial focus on the **circumboreal region**.

(b) Towards tailoring attribution information to meet the needs of forest management activities.

# Preliminary methods and analysis

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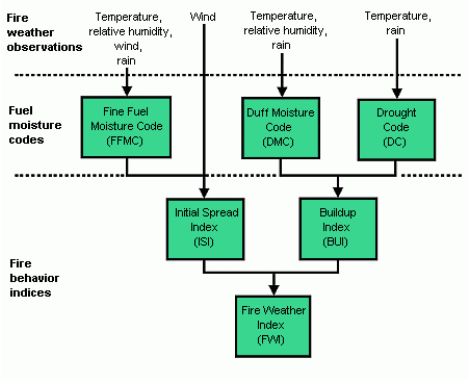
**Approach**

Pointwise empirical attribution approach to assess trends in annual maxima in summertime fire weather

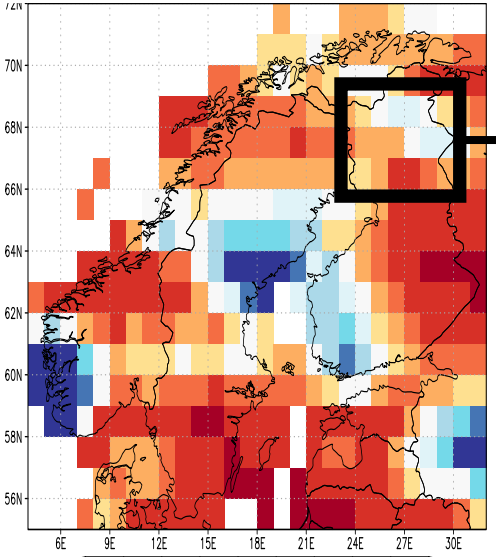
**Input data: Fire danger re-analysis**

- Canadian Fire Weather Indices for 1980-2018; weather forcings from ERA-Interim (Vitolo et al., 2019; *Sci. Data*).
- Includes the Daily Severity Rating (DSR), a non-linear transformation of FWI.




**Model fitting: GEV scaled with global mean surface temperature**

- Attribution statistics are produced at each grid point.
- Annual 5-day maxima in seven fire danger indices within a surrounding spatial grid fitted to a GEV.




$$F(x) = exp[-(1 + \xi \frac{x-\mu}{\sigma})^{\frac{1}{\xi}}]$$

$$\mu = \mu_0 \cdot exp\ \frac{\alpha T}{\mu}$$

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- Distribution assumed to scale with global mean temperature *T*.
- Uncertainty margins estimated using non-parametric bootstrapping with moving-block approach.

# Risk ratios in the circumboreal region

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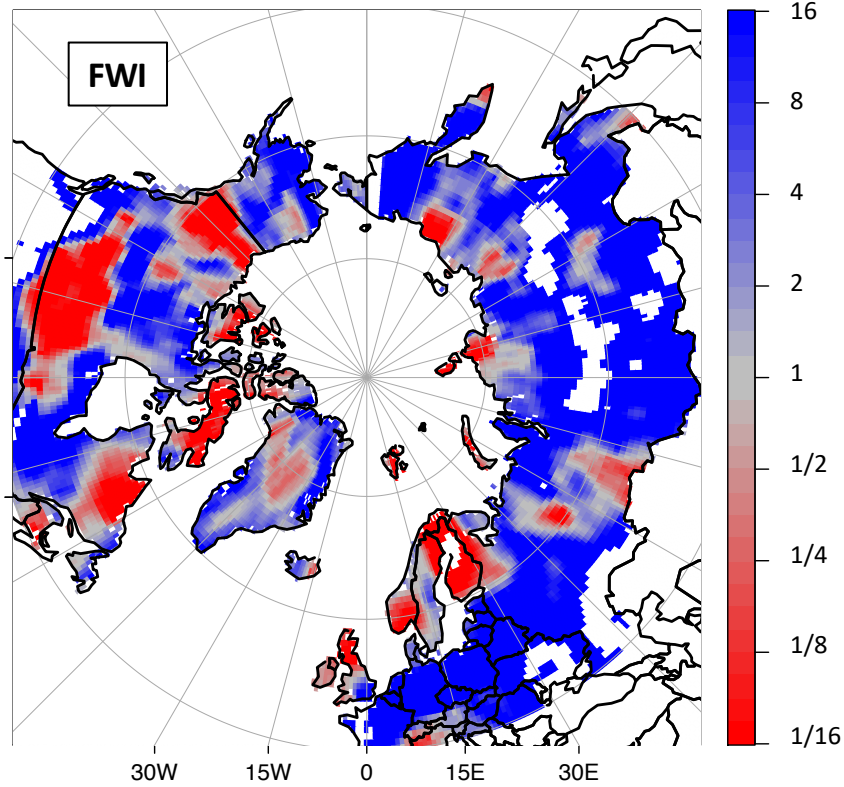
**Risk ratio**: probability of the event occurring in present vs past climates.

$RR = P_1/P_0$

Risk ratios produced at each grid point for each index (only FWI shown here) to represent the 1961-2019 change in likelihood of an annual JJA maximum exceeding the observed 99$^{th}$ percentile.

**Two key points**:

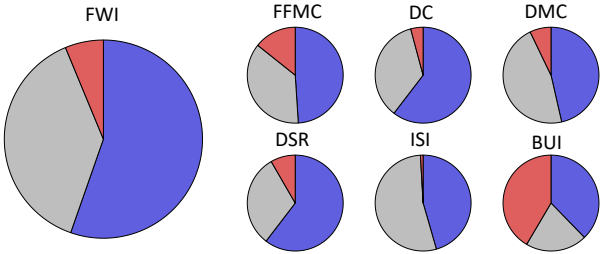
- The variability illustrates the implications of choosing an arbitrary event definition; for instance, risk ratios vary considerably across Fennoscandia.
- Risk ratio maps are not consistent for all indices. These differences should be understood and communicated.



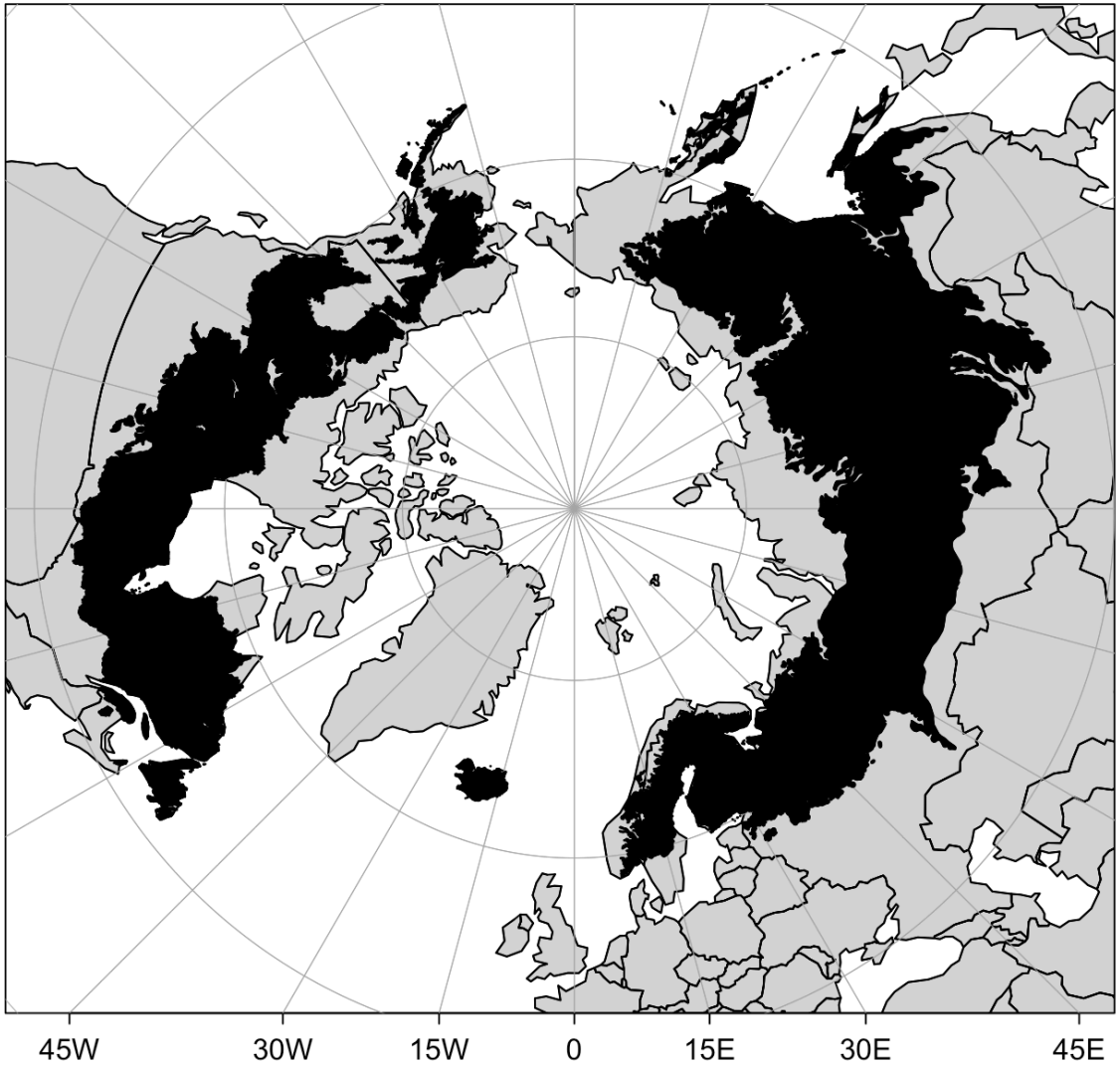
# Circumboreal overview

Proportion of extremes attributable to global temperature change across the boreal biome:

Blue: significant increase
Red: significant decrease
Grey: no change




The differences between the indices is of note, particularly given their relative importance to different stakeholders.



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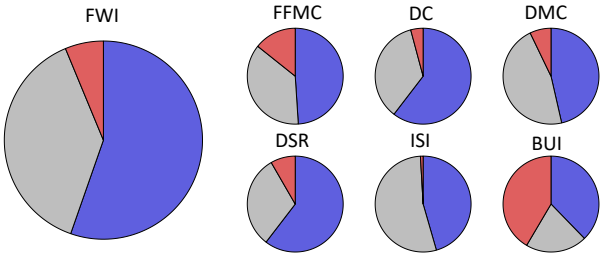
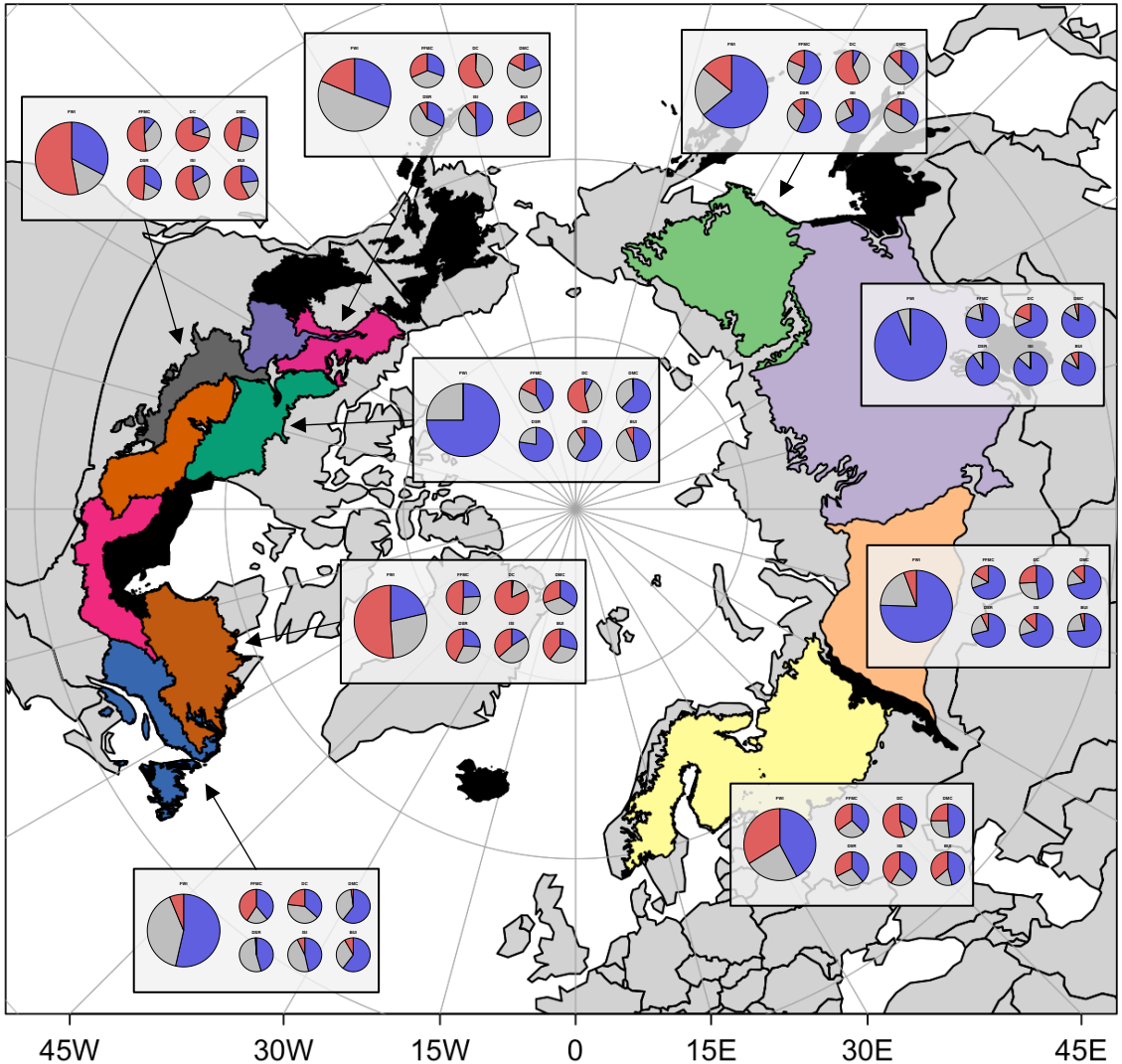



Further distinction is made between several boreal ‘ecoregions’ (regions of homogeneous vegetation and ecological characteristics).



# Summary and outlook

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- Preliminary steps towards a framework for assessing fire risk at continental and global scales demonstrate the flexibility of a pointwise approach to empirical attribution.
- Effective forest management should consider the **response of the natural environment** to fire activity and can be supported by provision of fire weather attribution information at the **ecoregion-scale.**
- Inter-index differences will be a target of further study; stakeholder engagement will inform how different indices are understood and interpreted by the end user.

**Next steps:**

- Application to additional global and regional model ensembles, including establishing a robust model evaluation and bias correction approach.
- Attribution of fire weather associated with a collective of recent fire events, initially throughout the boreal region.
- Potential expansion to other fire-prone regions of the world.