Drivers and implications of recent large fire years in boreal North America

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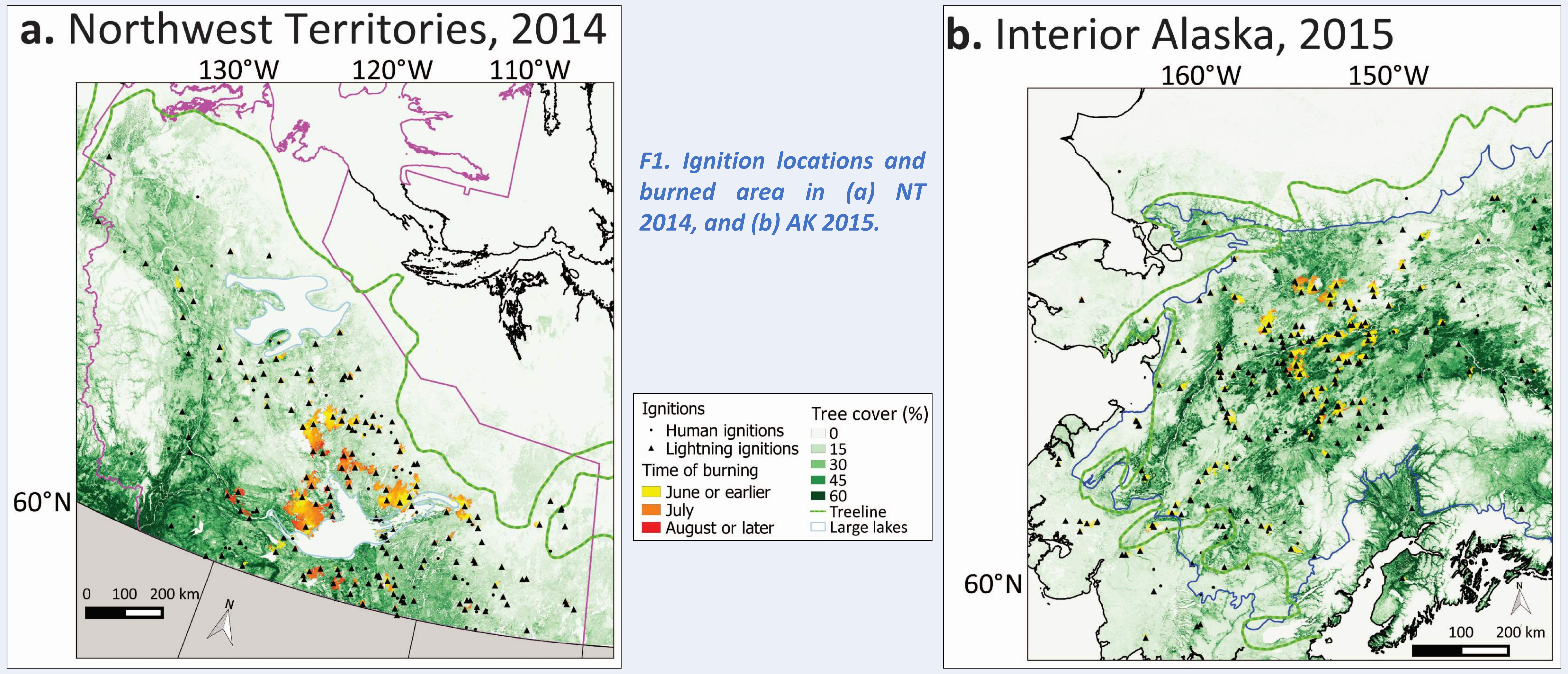
1. Large fire years in 2014 in the Northwest Territories, and in 2015 in Alaska



F1. Ignition locations and burned area in (a) NT 2014, and (b) AK 2015.

- **3.41 ± 0.21 Mha burned** in the **Northwest Territories** (NT) in **2014**
- This resulted in **164 ± 32 Tg carbon emissions** (*F1a*)
- **NT 2014** was the **largest fire year** since 1975

- **1.77 ± 0.23 Mha burned** in Interior **Alaska** (AK) in **2015**
- This resulted in **65 ± 13 Tg carbon emissions** (*F1b*)
- **AK 2015** was the **second largest fire year** since 1975

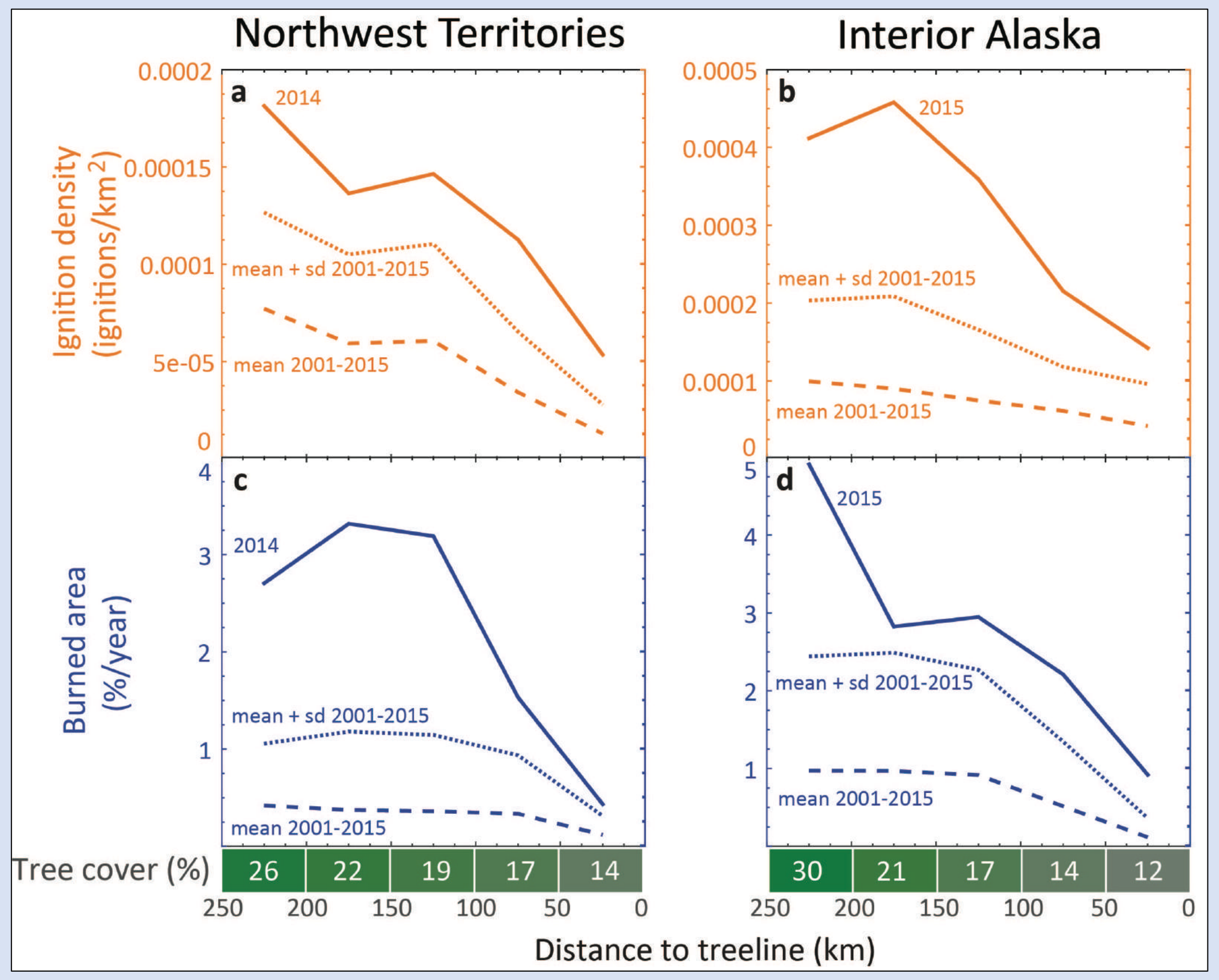
Science questions

- What were the drivers of the large fire years in NT 2014 and AK 2015?
- Were there similarities between these two events?
- How are these drivers expected to change in the future?
- How will this impact future fire regimes and vegetation composition?

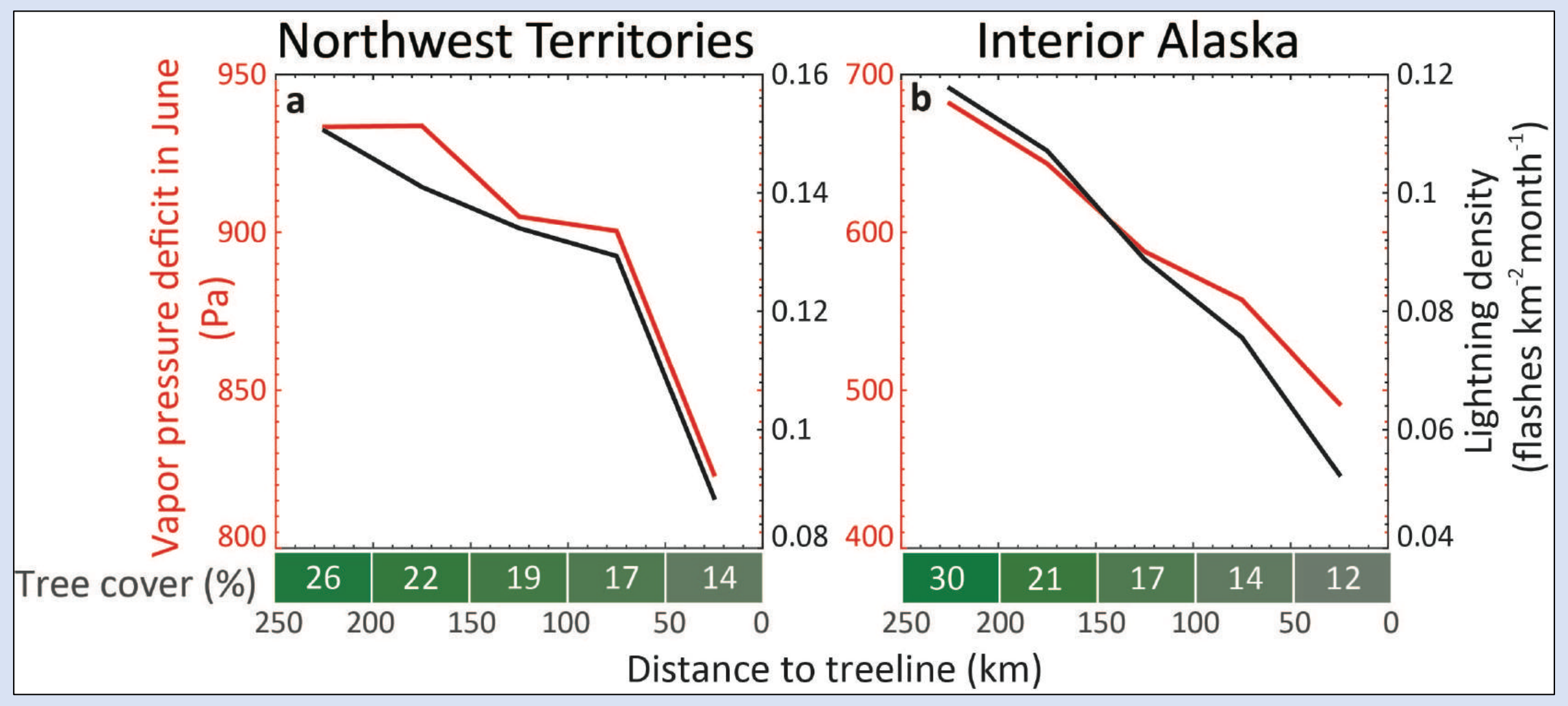
2. Proximity of burning to the treeline

- Unusually **high levels of ignitions** in the forest-to-tundra ecotone (*F2ab*)
- This also lead to exceptionally **high levels of burning** in the **ecotone** (*F2cd*)
- Fire has historically been less frequent in these areas

- Meteorological properties conducive to lightning, and **lightning decrease across** the forest-to-tundra **ecotone** (*F3*)
- **Increases in lightning** occurrence across the forest-to-tundra ecotone caused the higher levels of ignitions and burning across the treeline ectone in NT 2014 and AK 2015



F2. Ignitions and burned area were considerably higher than the longer-term mean near the treeline in (a, c) the NT 2014, and (b, d) AK 2015.



F3. Decreases in vapor pressure deficit (VPD) in June and lightning in the treeline ecotone for (a) the Northwest Territories, and (b) Interior Alaska.

Acknowledgements

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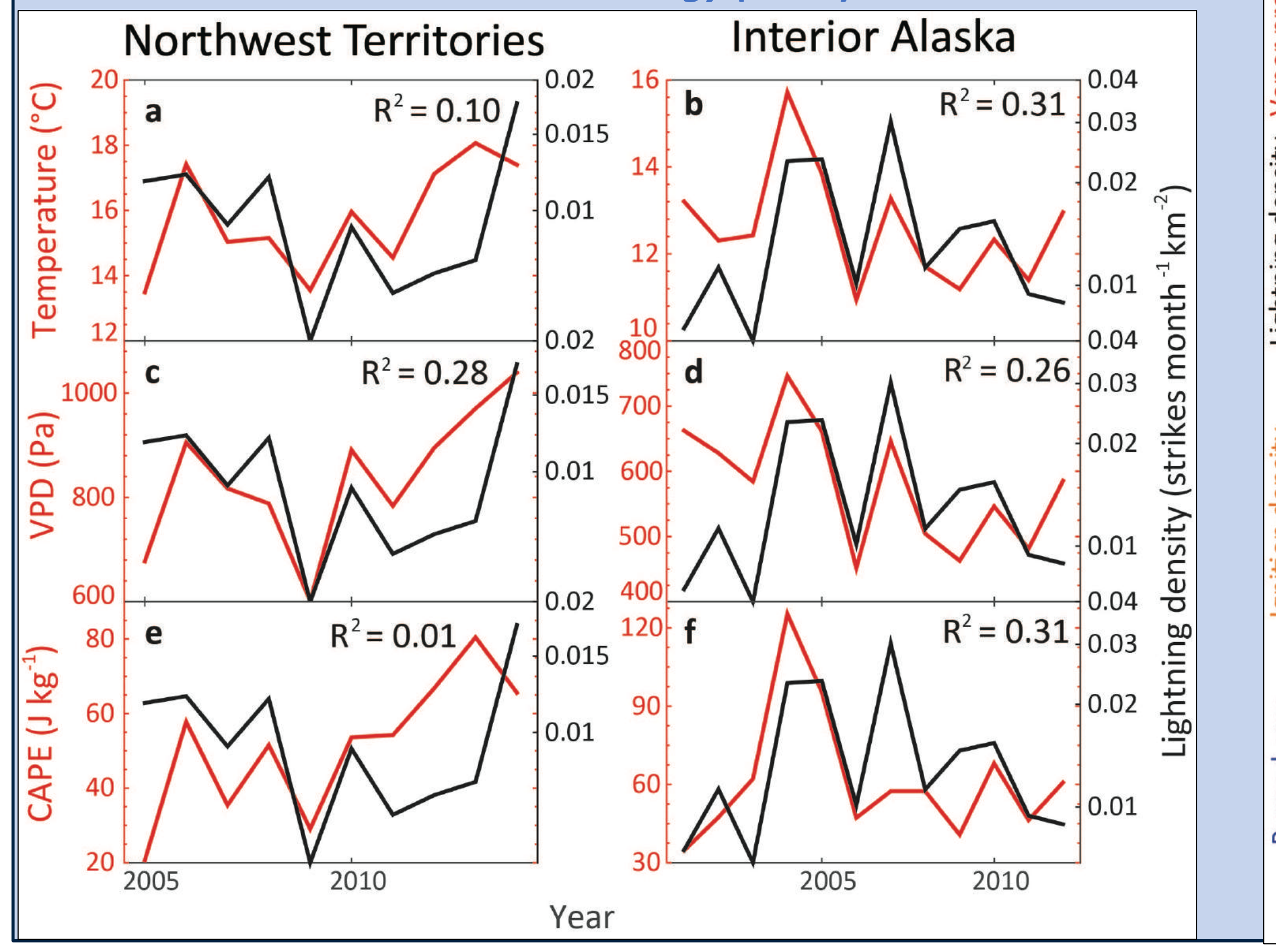
3. Lightning as driver

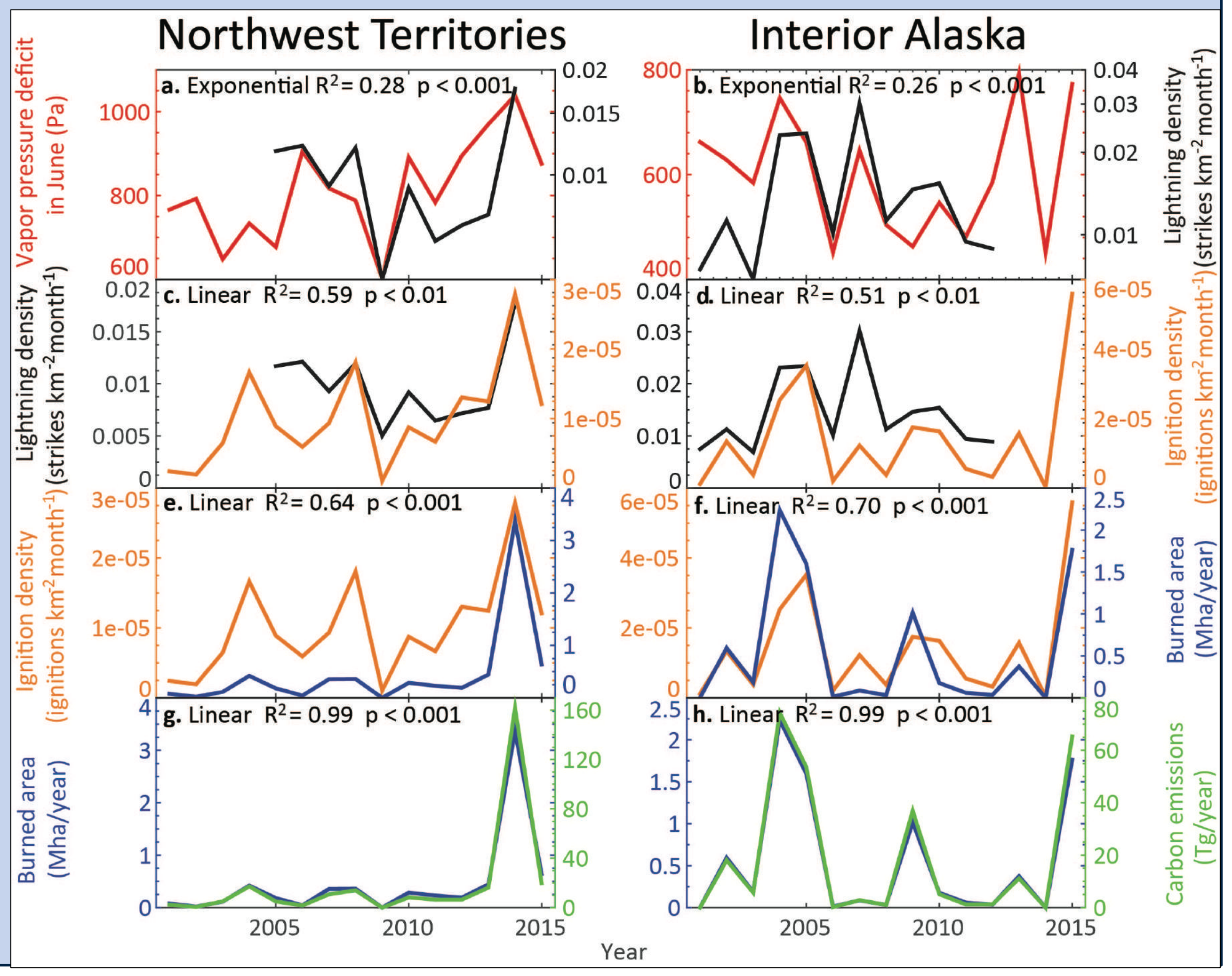
- Meteorological variables sensitive to **thermal convection explained** part of interannual variability in **lightning** (*F4*)
- There is a **cascade** of relationships from climate-induced **lightning to carbon emissions** from fires (*F5*)

1) Vapor pressure deficit → Lightning (*F5ab*)
2) Lightning → Ignitions (*F5cd*)
3) Ignitions → Burned area (*F5ef*)
4) Burned area → Carbon emissions (*F5gh*)

F4. Relationships between lightning density and (a, b) temperature, (c, d) vapor pressure deficit (VPD), and (e, f) Convective Available Potential Energy (CAPE).

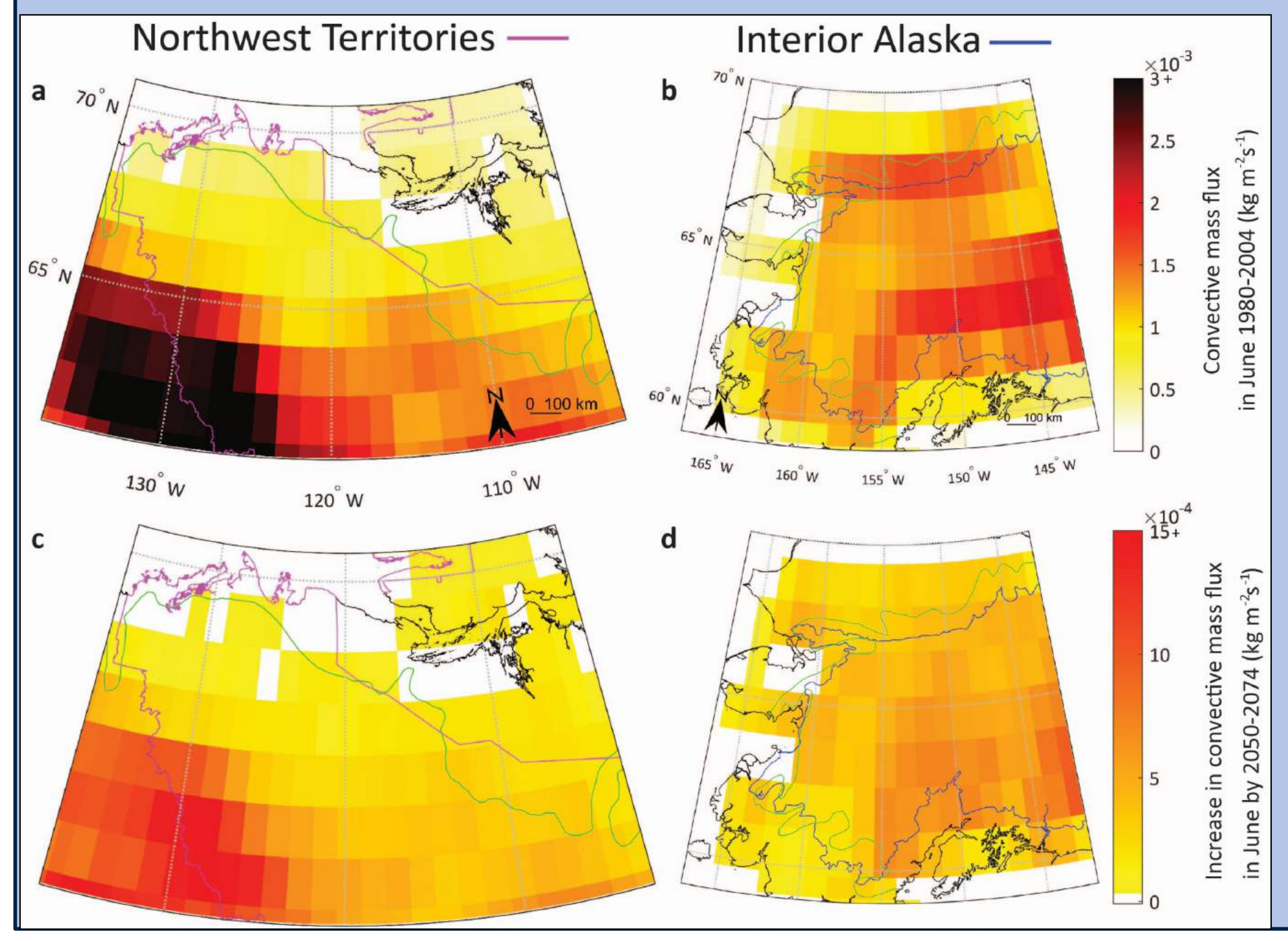


F5. Interannual relationships from 2001 to 2015 between (a, b) June vapor pressure deficit (VPD) and lightning density, (c, d) lightning density and ignition density, (e, f) ignition density and burned area, and (g, h) burned area and carbon emissions.



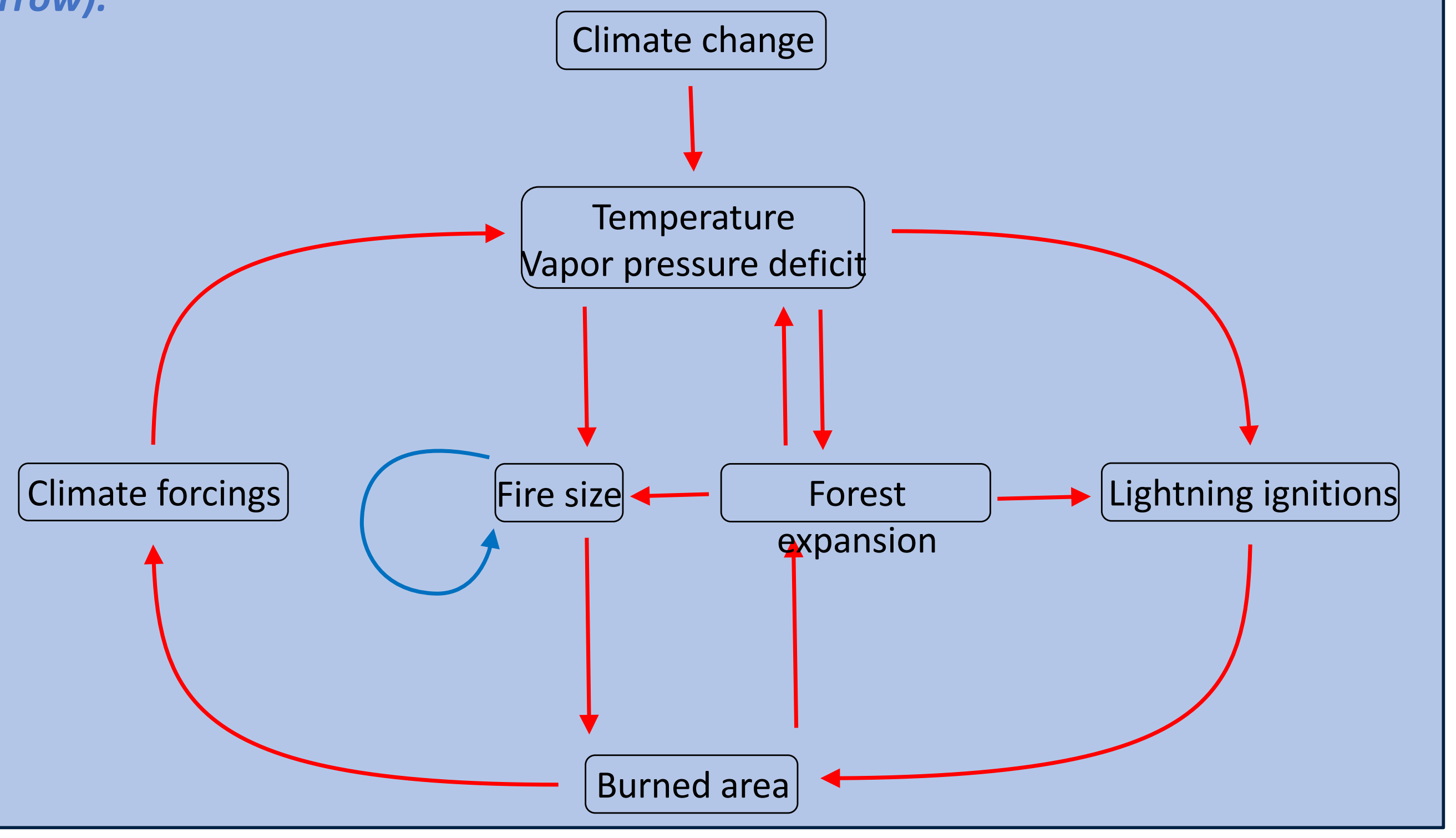
4. Future change and implications

- **Lightning** is predicted to **increase with climate warming** (*F6*)
- This may lead to a **positive feedback loop** (*F7*). **Warming** may increase treeline lightning and **fires**; increased treeline **fires** may facilitate northward **expansion of forest**; increased high latitude **forest** may feedback to further increase local **lightning**.



F6. Convective mass flux, a strong lightning predictor, in June in 1980-2004 (ab), and increase in convective mass flux by 2050-2074 (cd).

F7. A positive feedback loop (red arrows) between climate, lightning, fires and northward forest expansion partly mitigated by a negative fuel feedback (blue arrow).



5. Conclusions

- The **large fire years** in the **Northwest Territories in 2014** and in **Alaska in 2015** were associated with unusually large number of **lightning** ignitions and high **burned area in** the northern treeline **ecotone**
- **Lightning** incidence is projected to **increase** in the **future**, which may **increase ignition** and carbon loss while **accelerating** the northward **expansion** of boreal **forest**