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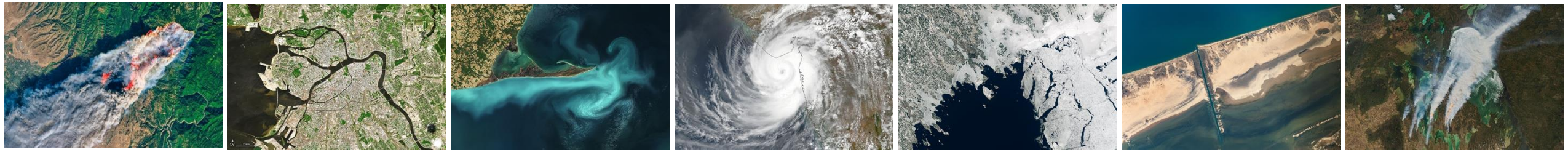

Strengthening Fire Preparedness and Coordination: Quantifying the Persistence and Synchronicity of Extreme Fire Weather

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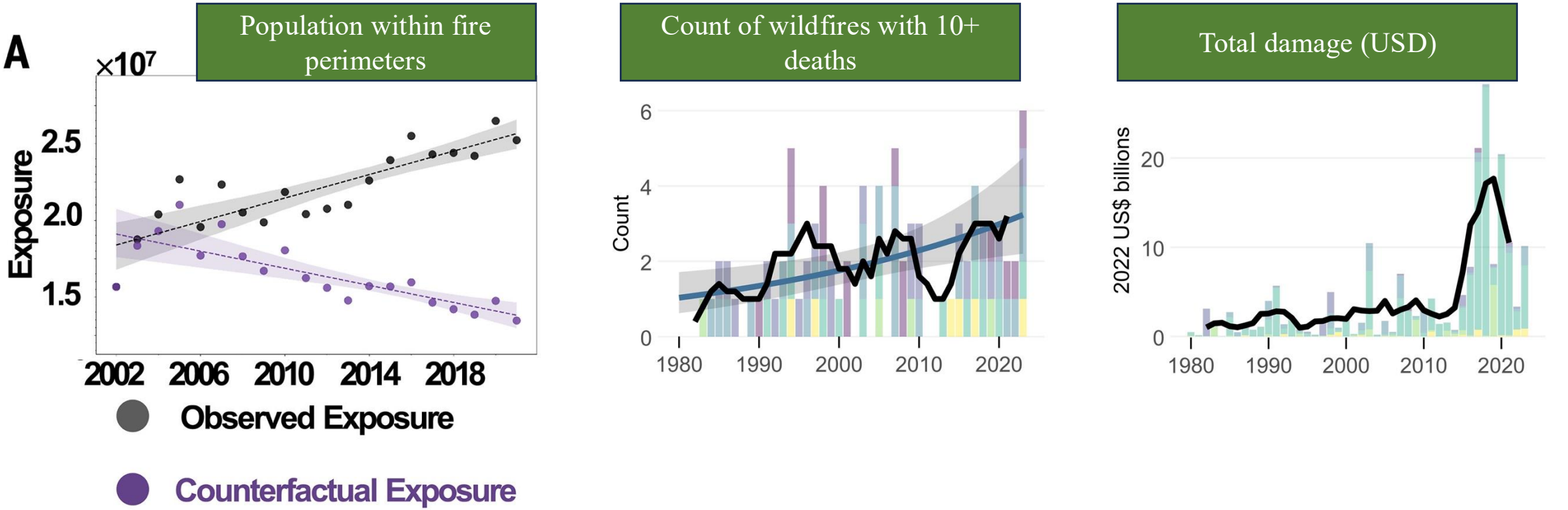
Q1: Why wildfire?

A1: Wildfires cause severe social and ecological consequences

ABC News; Los Angeles Times; NC State; Columbia Magazine

A1: Wildfires cause severe social and ecological consequences

Globally, both the population exposure to wildfires and societally disastrous wildfires are increasing.



Seydi et al., 2025; Cunningham et al., 2025

A1: Wildfires cause severe social and ecological consequences

LA fires, January 2025

- 31 direct deaths
- 16,000 structures damaged

- **440 indirect deaths**
  - Smoke or stress
  - Health systems
  - Mental impacts

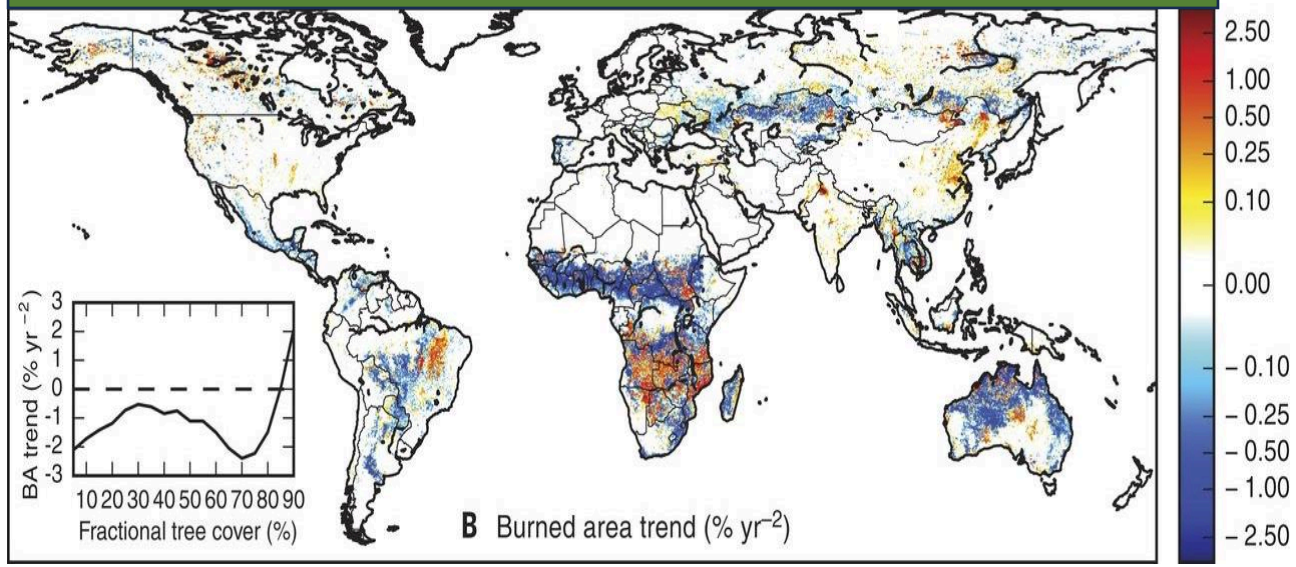
Eaton Fire Jan. 8, 2025. Source: Maxar

Paglino et al., 2025

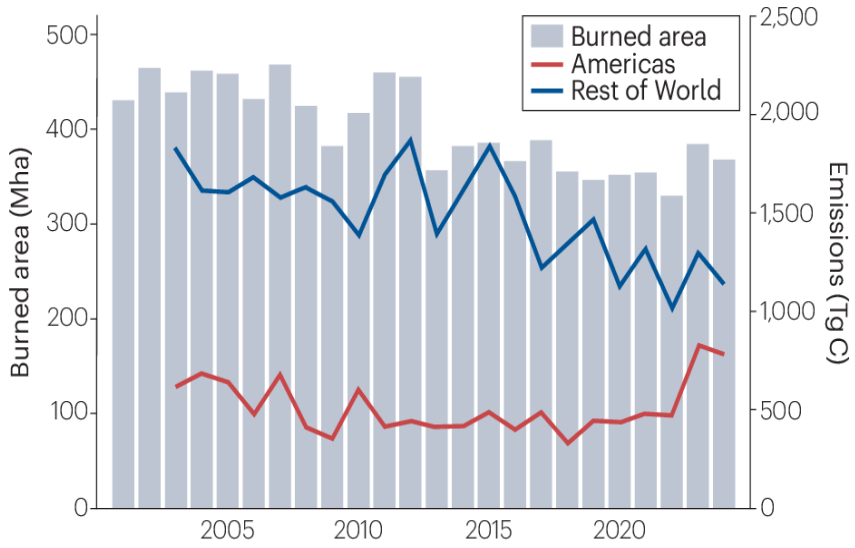
A2: Extreme fires are increasing in some regions

Global burned area is declining over the past two decades, primarily driven by agricultural expansion in fire-prone African savannas.

Trend in burned area



Time series of burned area (bars)

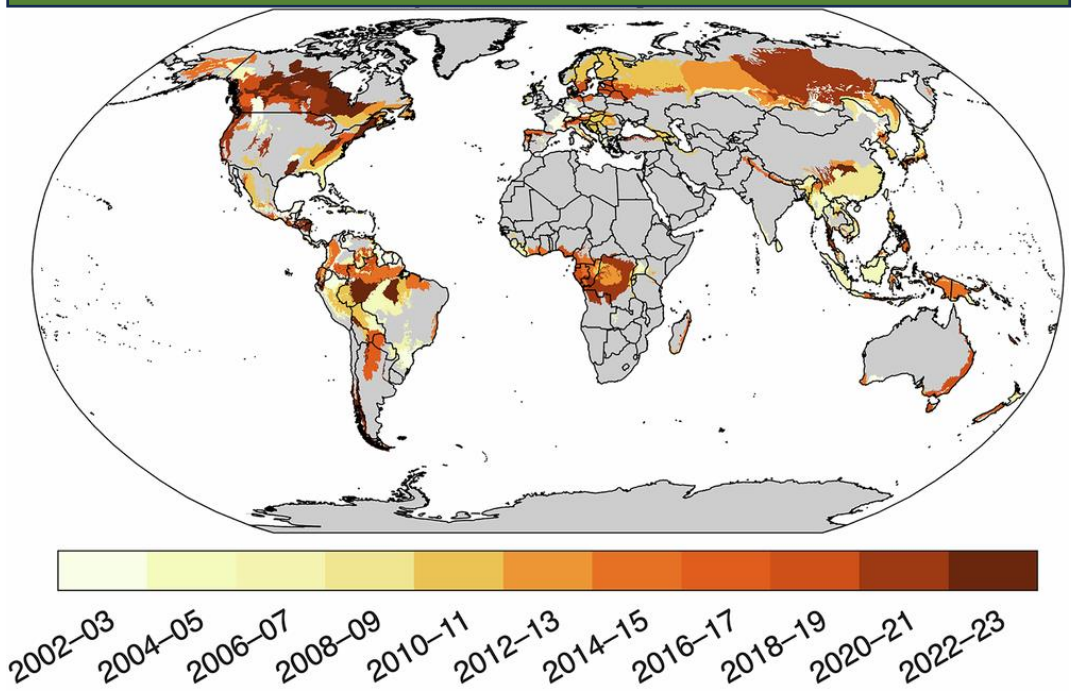


Andela et al., 2017; Kolden et al., 2025

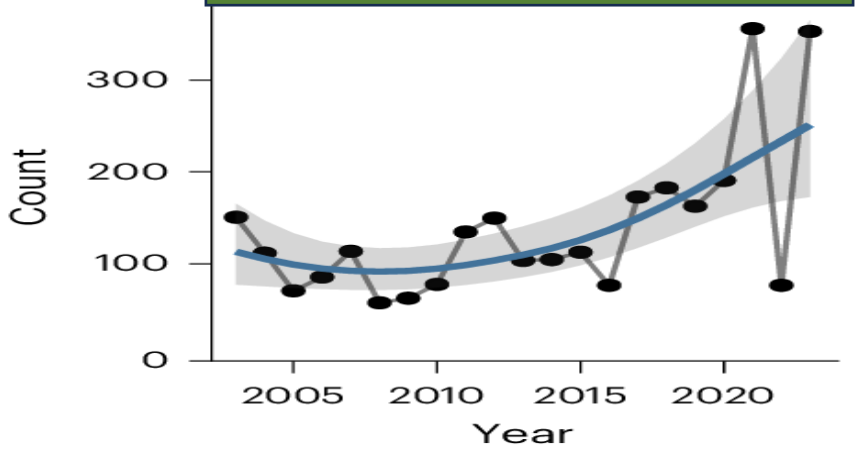
A2: Extreme fires are increasing in some regions

But extreme fires are increasing in some regions, often associated with **the most destructive wildfires**.

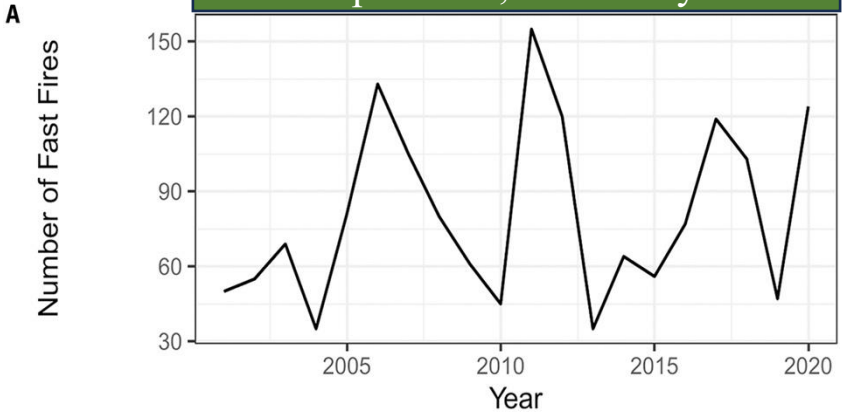
Year of fire season with the largest burned area



Count of wildfires with top 0.01% fire radiative power



Count of wildfires with spread speed > 1,620 ha/day



Balch et al., 2024; Cunningham et al., 2024; Abatzoglou et al., 2025

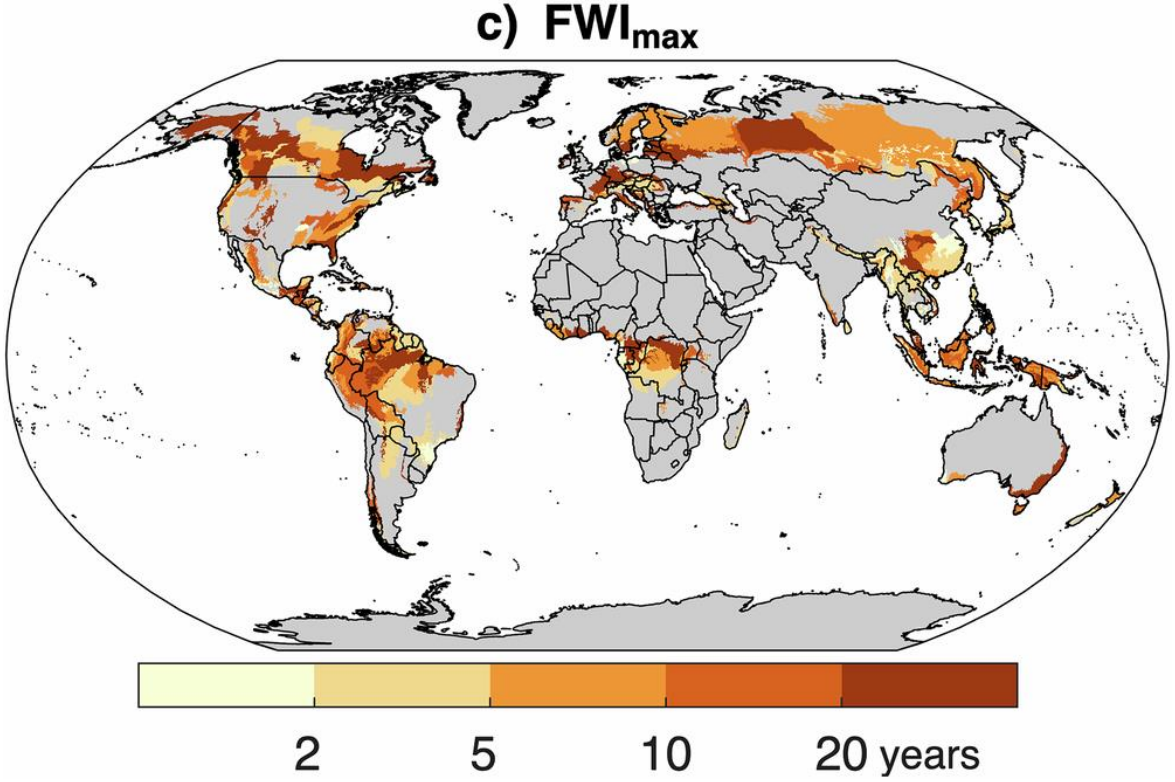
Q2: Why extreme fire weather (EFW)?

EFW drives extreme fires and is increasing

EFW

- Characterized by **exceptionally dry, warm, and often windy** conditions.
- Enhance fuel dryness and promote fire spread
- Serve as an important driver of extreme fires.

- Defined as days with **extreme fire weather index** (e.g., FWI95).



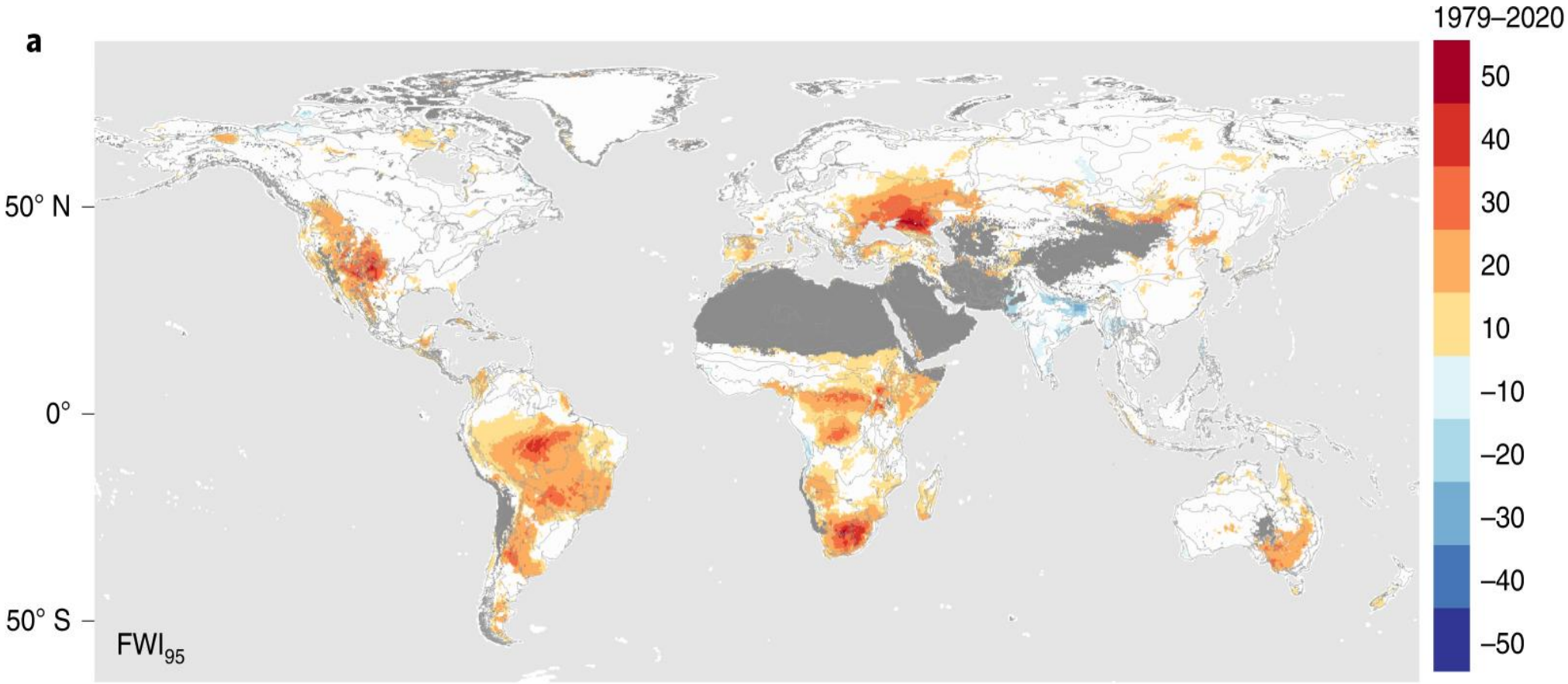
The year with the largest burned area often coincides with the year of very rare extreme fire weather (e.g., 1-in-20 years).

Strong connection between EFW and extreme fire activity

Abatzoglou et al., 2025

EFW drives extreme fires and is increasing

EFW (FWI95) is increasing in almost half of the burned lands globally.



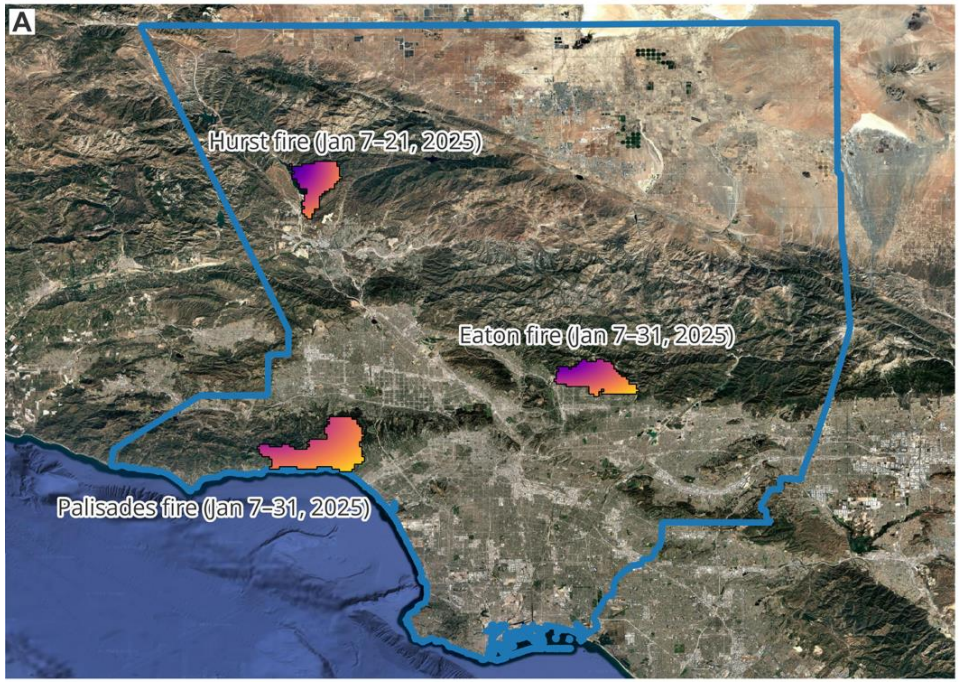
Jain et al., 2021

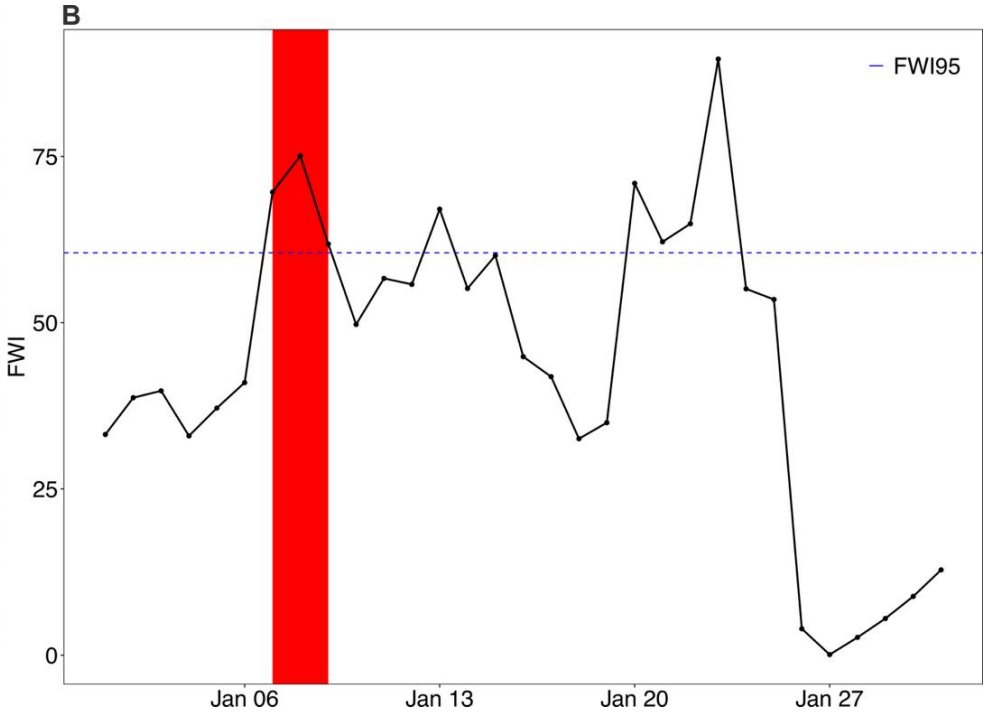
Q3: Why the persistence and synchronicity of EFW?

H1: Persistent EFW (FWW) further elevates extreme fire danger

FWW → **Maintain favorable conditions for fire ignition and spread** → **Elevate extreme fire danger**

A FWW event coincided with the ignition of three major fires on 7th Jan.





H2: Synchronous EFW (SFW) complicates firefighting coordination

SFW

Widespread large fires

Greater fire suppression pressure

Degrade regional air quality

Coordination of firefighting resources

Part 1: Fire weather waves (FWW)

- **RQ1: How do FWWs impact fire activity?**
- **RQ2: What are the patterns and trends of FWWs?**

Yin et al., 2025, submitted

Part 2: Synchronous fire weather (SFW)

- **RQ1: Patterns, trends, and seasonality of SFW**
- **RQ2: Links between SFW and climate variability**
- **RQ3: Relationship between SFW and air quality**

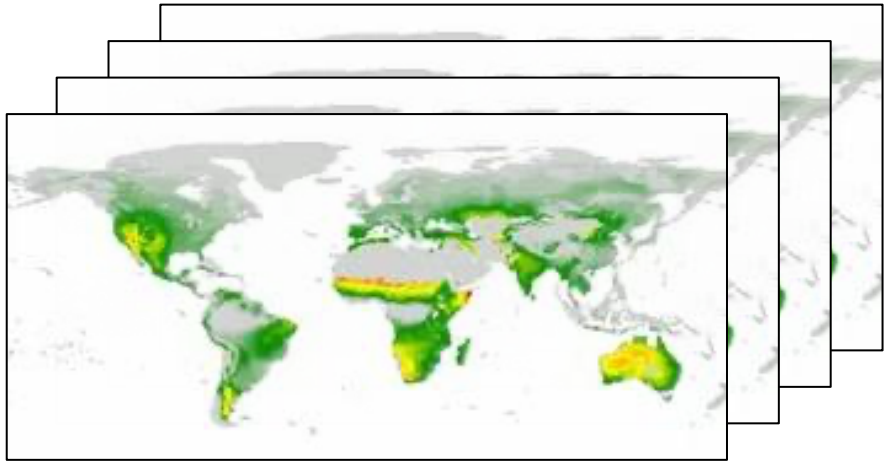
Yin et al., 2025, under review

Quantify synchronicity

GFED (Global Fire Emissions Database) regions

BONA	Boreal North America	NHAF	Northern Hemisphere Africa
TENA	Temperate North America	SHAF	Southern Hemisphere Africa
CEAM	Central America	BOAS	Boreal Asia
NHSA	Northern Hemisphere South America	CEAS	Central Asia
SHSA	Southern Hemisphere South America	SEAS	Southeast Asia
EURO	Europe	EQAS	Equatorial Asia
MIDE	Middle East	AUST	Australia and New Zealand

ERA5-drived daily gridded FWI (1979-2024)



N = 167802 days

Quantify synchronicity

Intra-regional

Inter-regional

Quantify synchronicity

Intra-regional

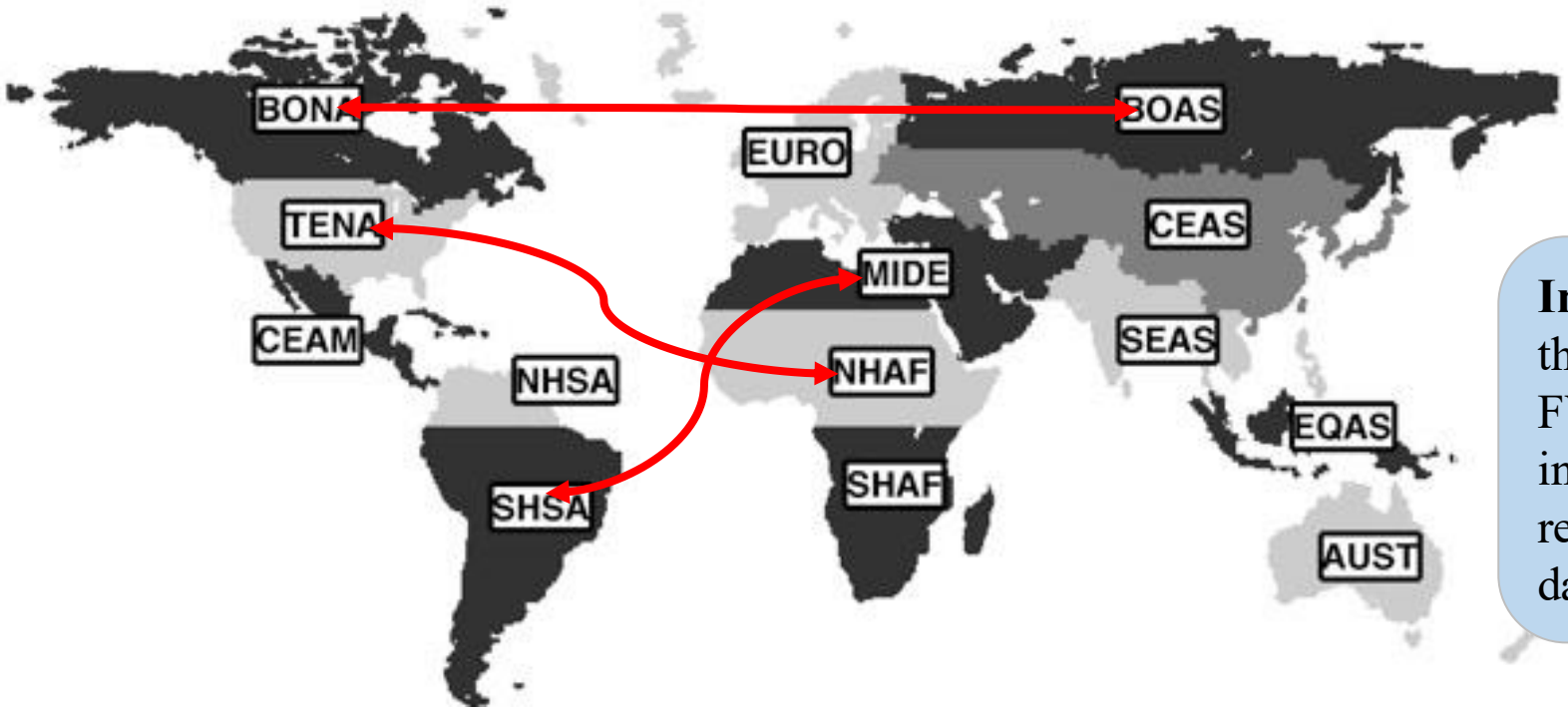
Inter-regional

IntraD: days when FWI exceeds **FWI90** across at least **30%** of the burnable area within a GFED region.

Quantify synchronicity

Intra-regional

Inter-regional

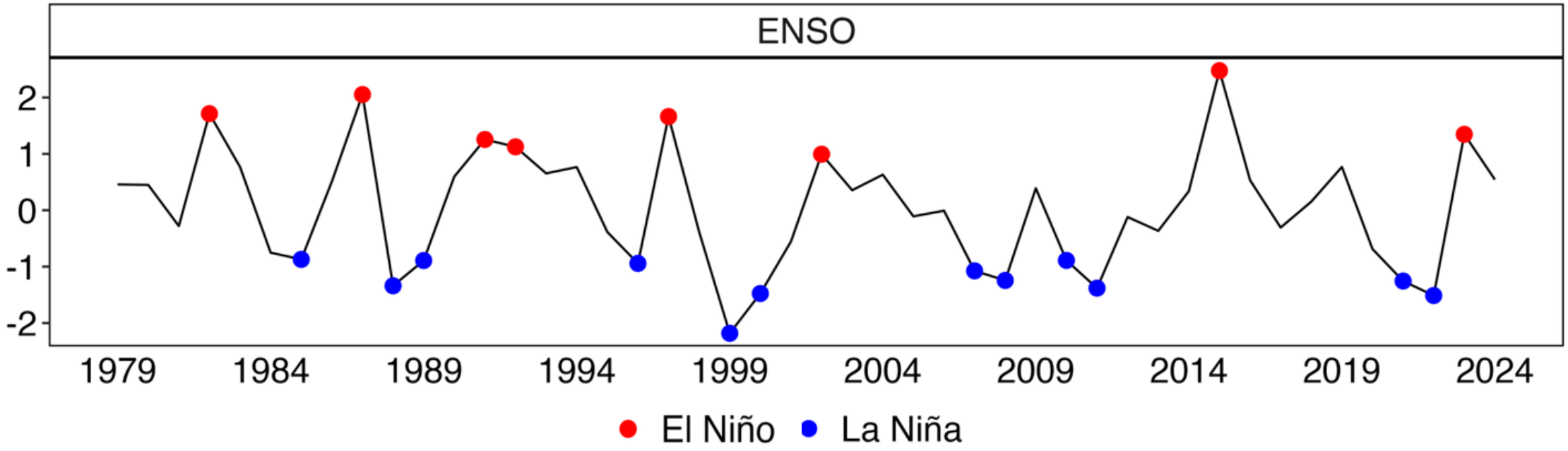


InterD: days when the regional average FWI exceeds **FWI90** in at least **two** GFED regions on the **same** day.

Identify El Niño and La Niña years

Detrended sea surface temperature (SST) in the Niño 3.4 region (170°W–120°W, 5°S–5°N):

- **> 0.8σ: El Niño**
- **< -0.8σ: La Niña**

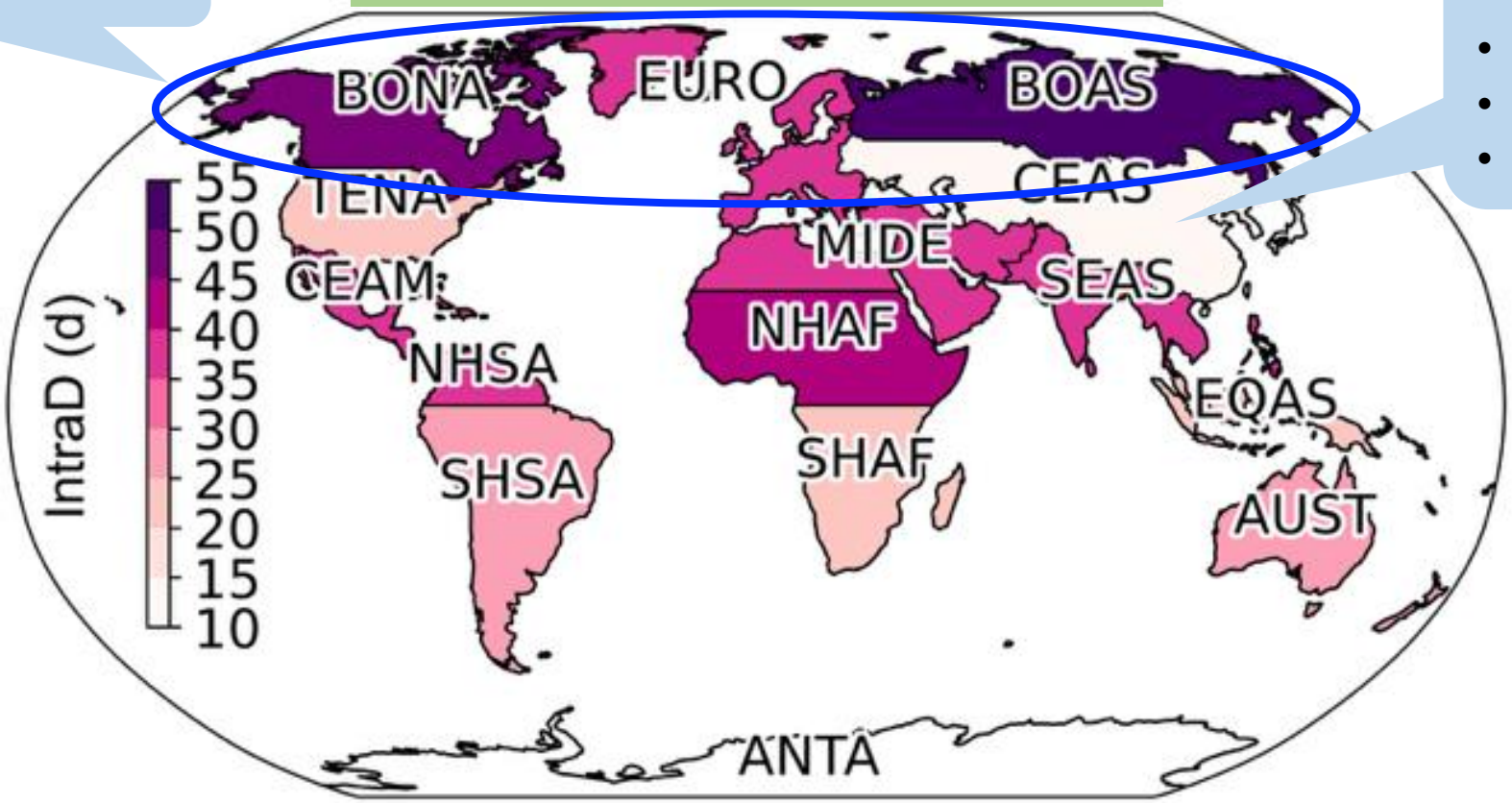


RQ1: Patterns, trends, and seasonality of SFW

Finding 1: Patterns of IntraD

- Extensive Subarctic climate
- Short warm season

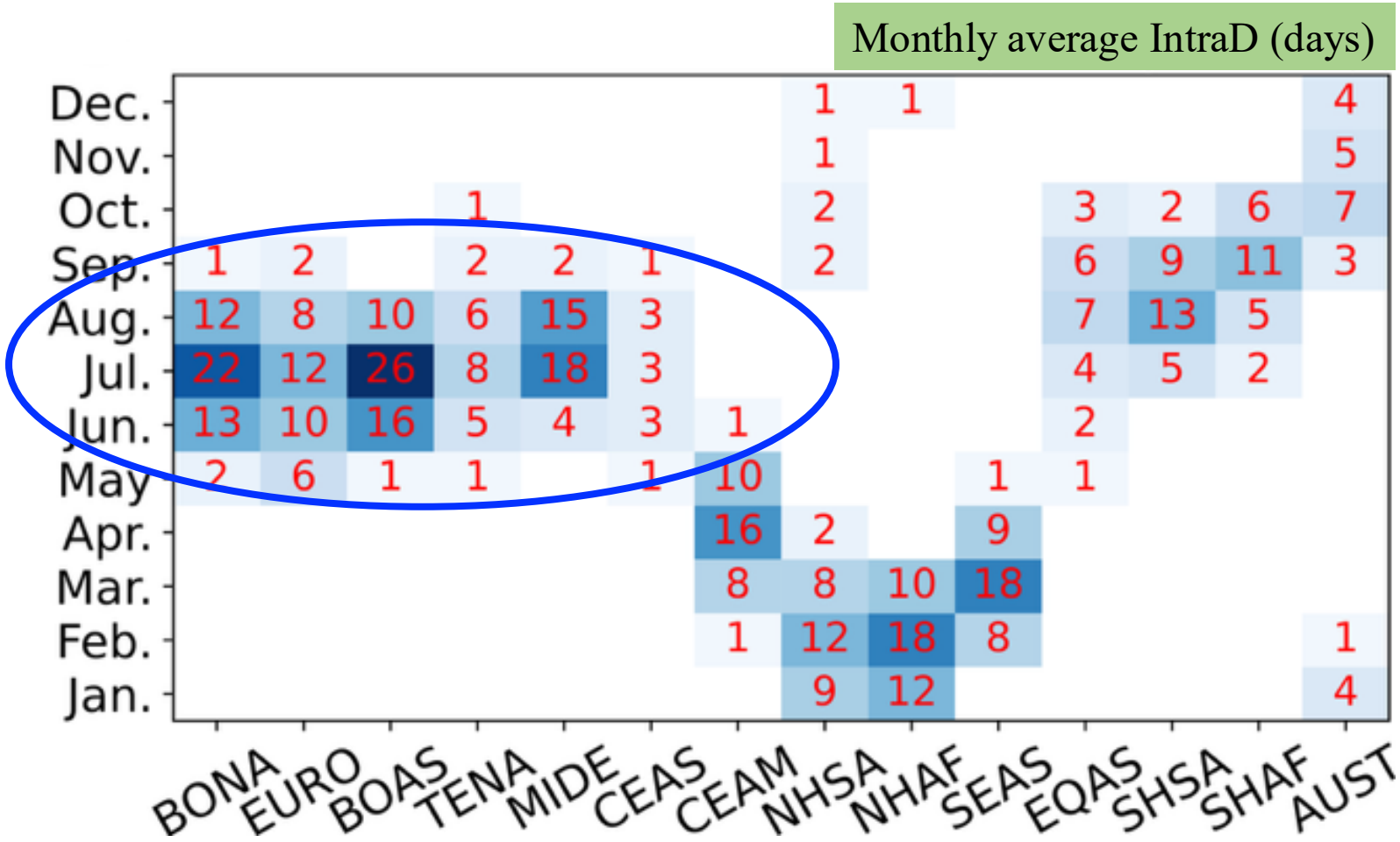
Average IntraD from 1979 to 2024 (days)



- Humid subtropical
- Temperate
- Continental
- Arid

Finding 1: Patterns of IntraD

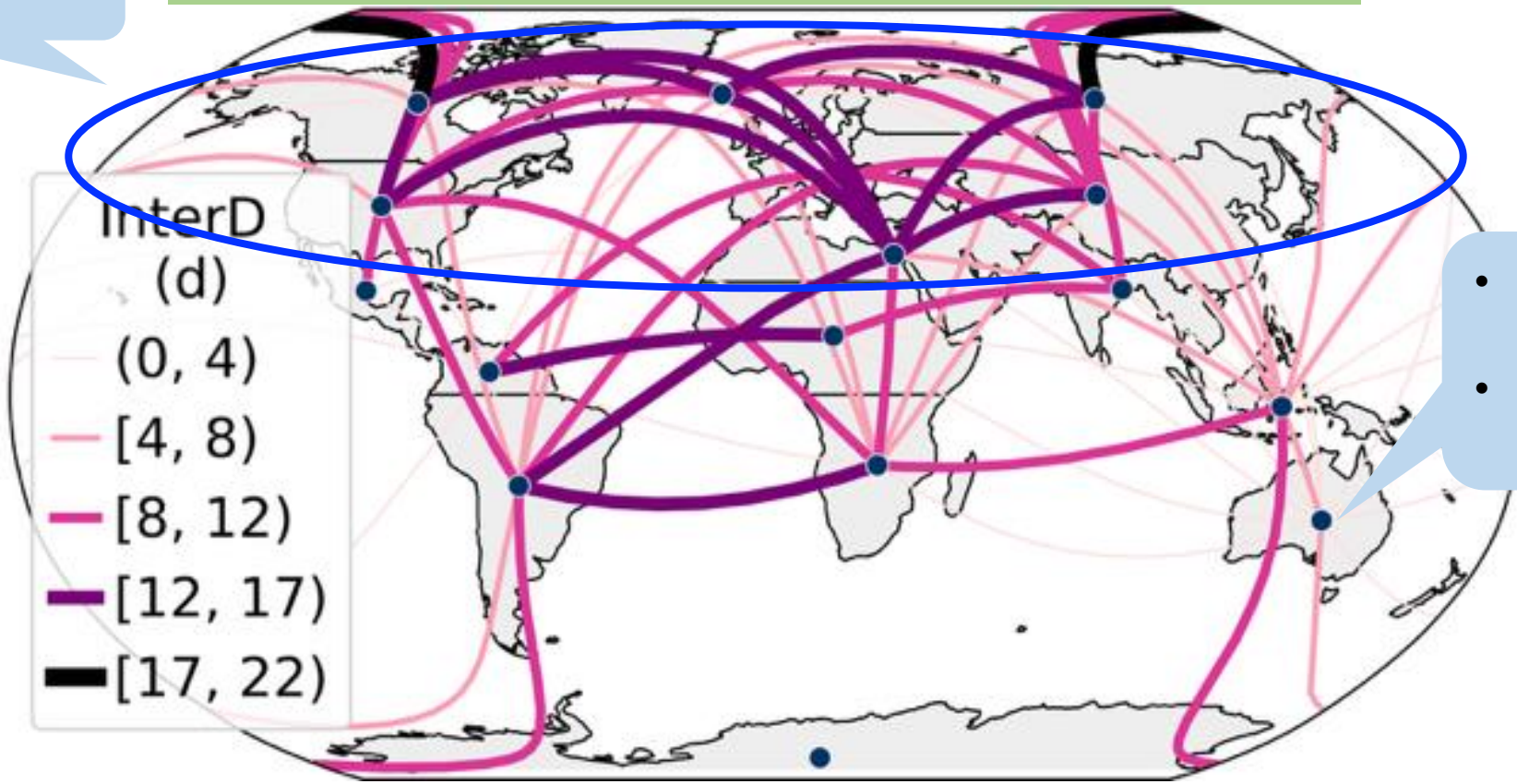
High synchronicity among regions in northern hemisphere.



Finding 1: Patterns of InterD

- Concurrent heat extremes in NH

Annual average InterD between connected GFED regions (days)



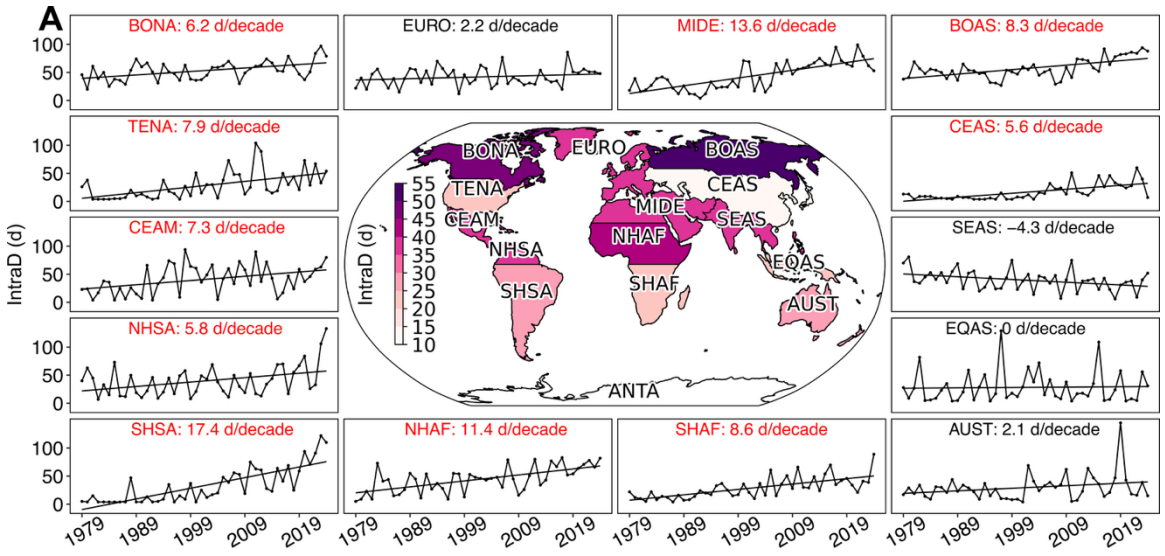
- Distinct fire seasonality
- Firefighting resource allocation

Finding2: Increasing trends in SFW

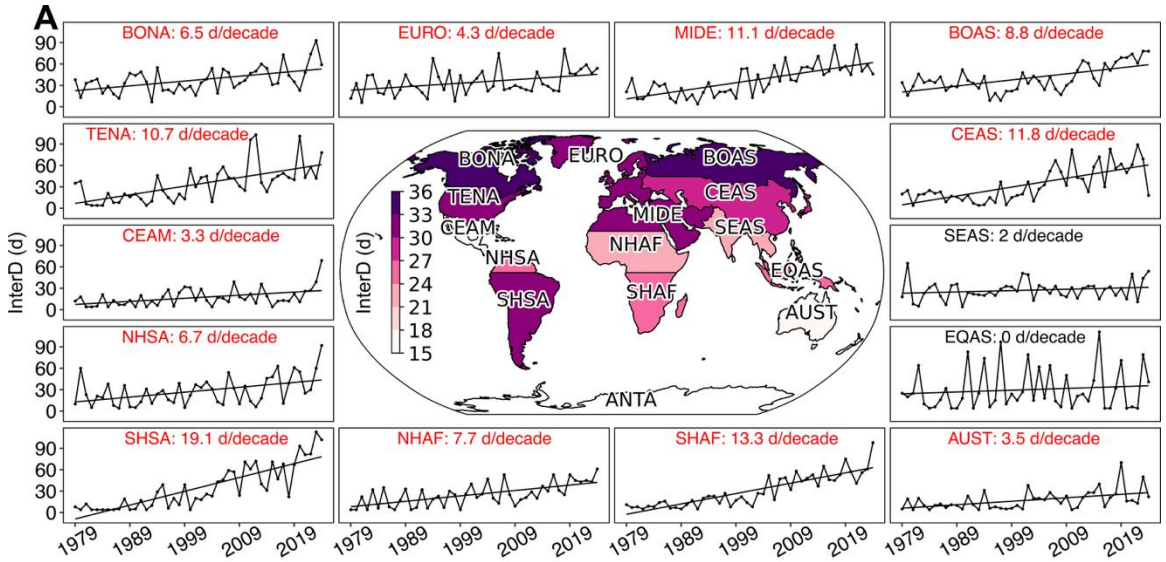
- Significant increase across most regions.
- South America experiencing the most pronounced.

→ Restrict firefighting cooperation

Annual IntraD



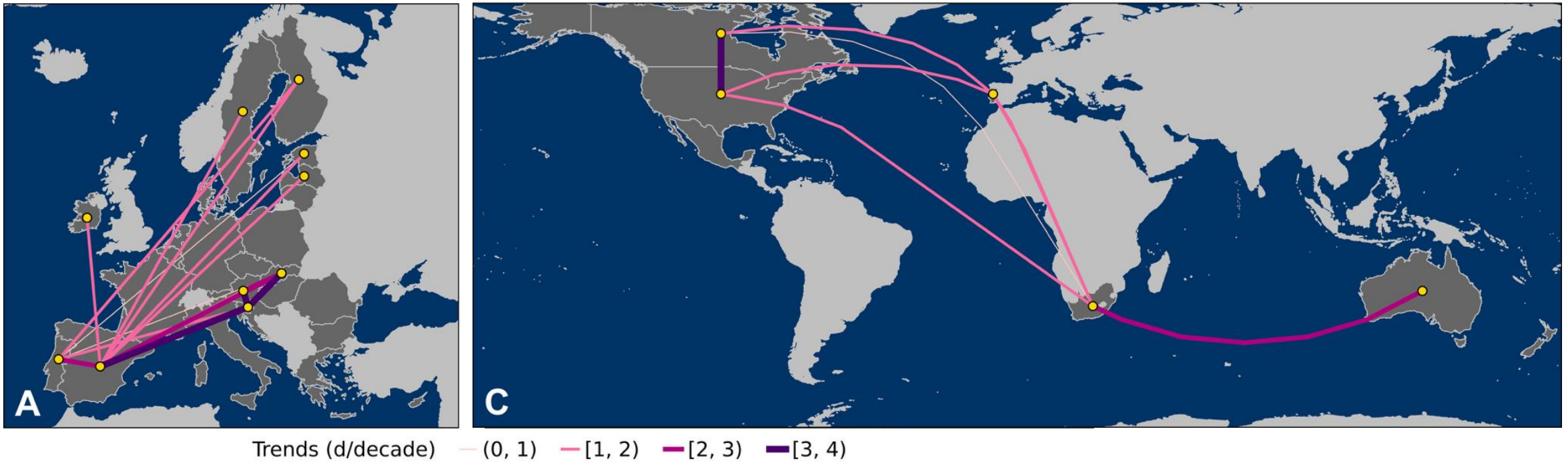
Annual InterD



Finding2: Increasing trends in SFW

The increase in SFW poses challenges for firefighting cooperation networks across the European Union (EU), and fire-prone countries such as the US, Canada, and Australia.

Significant trends ($p < 0.05$) in InterD between connected countries



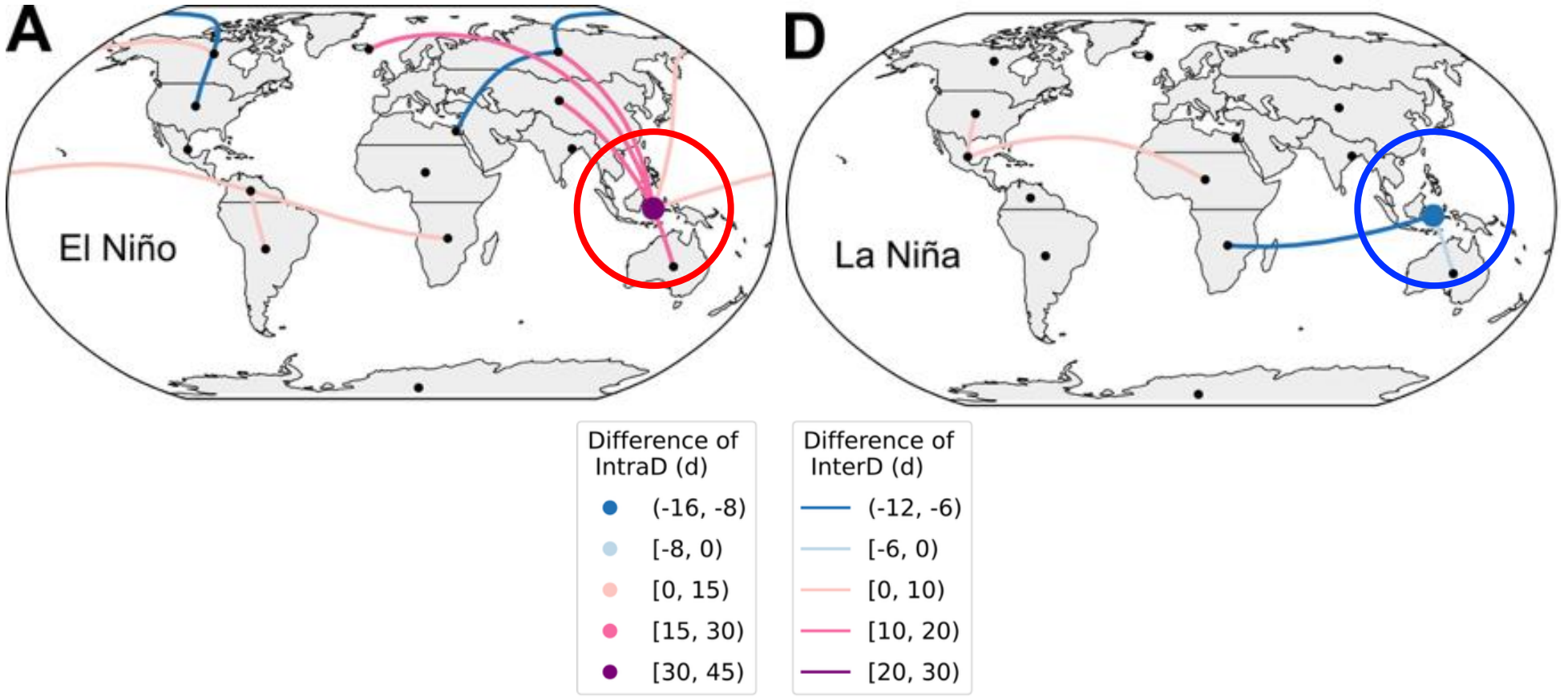
RQ2: Links between SFW and climate variability

Finding 3: SFW strongly linked to climate variability

43 additional IntraD during El Niño years compared to neutral years in Equatorial Asia.

- Elevated temperatures and pronounced rainfall deficits during El Niño.

Differences in IntraD (colored points) and InterD (colored lines) between El Niño years and neutral years



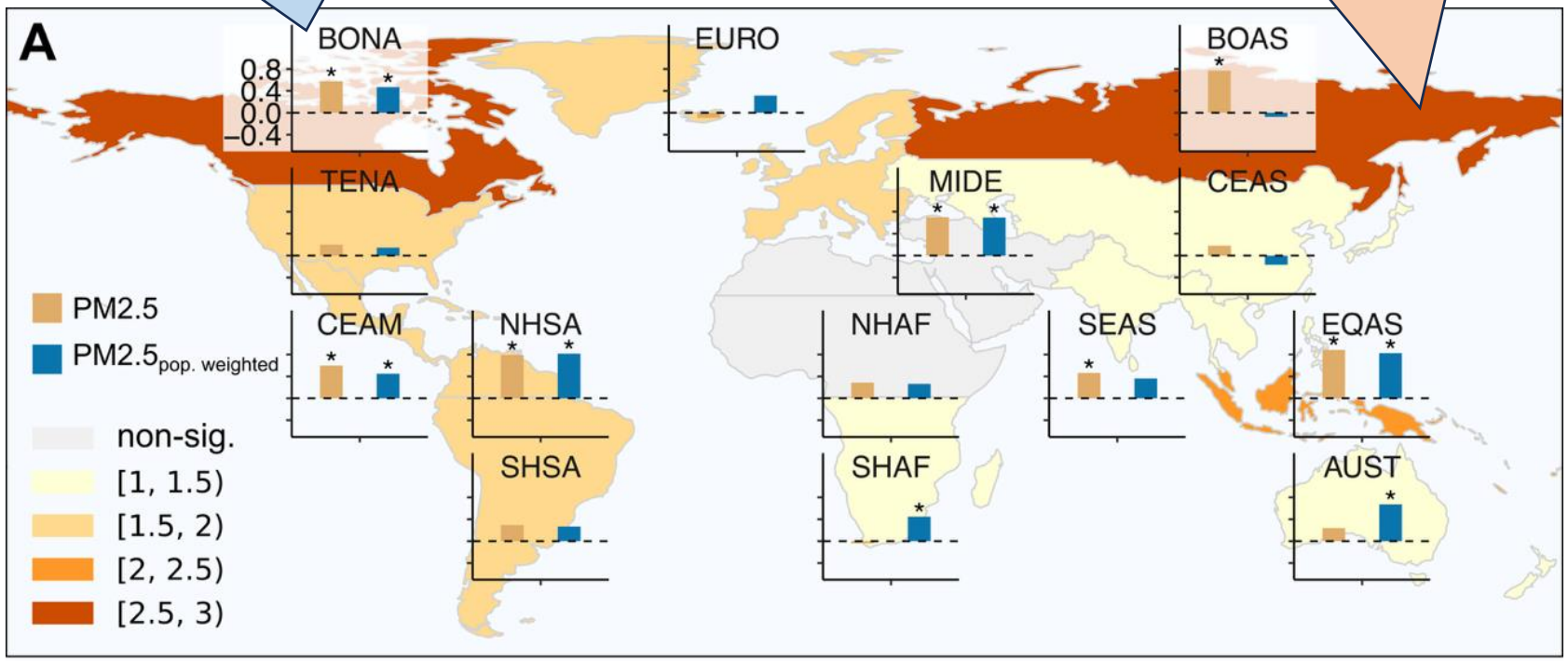
RQ3: Relationship between SFW and air quality

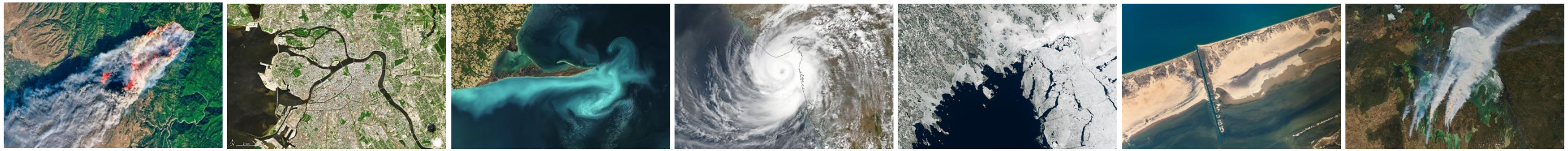
Finding 4: SFW adversely affects air quality

Intra-regional SFW degrades air quality due to elevated burned area during SFW.

Bars: interannual correlation between IntraD and fire-sourced PM2.5

Colored regions: ratio of daily average burned area on IntraD to preceding five days





Thanks for your attention!

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