POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

The regularity of climate-related extreme events under global warming

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ISIMIP Workshop 2024, Potsdam, 26/02/2024

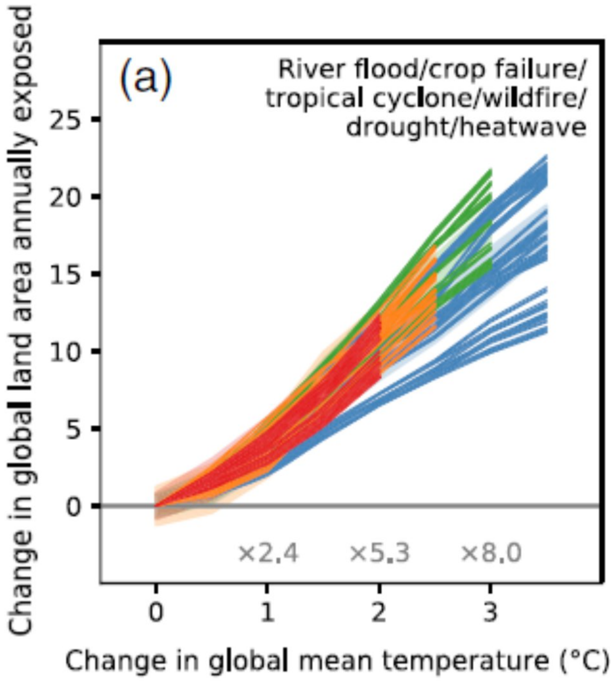
Extreme weather impact

Douris and Kim, WMO (2021)
GRID 2023, IDMC (2023)
B. O'Neill *et al.*, IPCC AR 6 WG II Chap. 16 (2022)

- Observed impacts between 1970-2019:
  - 2 million deaths
  - 3.6 trillion US$ of economic loss

- 32 million new displacements in 2022

- Do impacts occur (quasi-)regularly?
  If so, how can express it?



S. Lange *et al.*, Earth's Future (2020)

- Understanding temporal patterns ☾ improved adaptation

K. Frieler *et al.*, Geoscientific Model Development **17**, 1 (2024)
S. Lange *et al.*, Earth's Future **8**, e2020EF001616 (2020)

Data

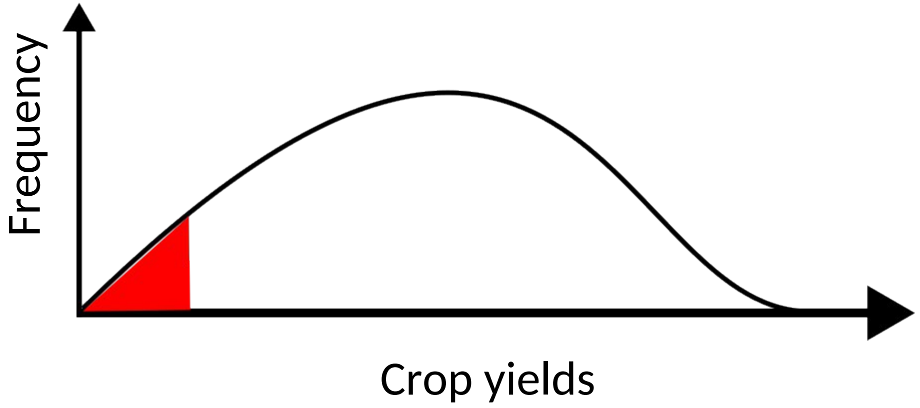
- ISIMIP Phase 3b:
  - Process-based climate impact models
  - Fixed socioeconomic factors

Inter-Sectoral Impact Model Intercomparison Project

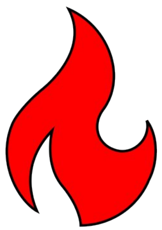
https://www.isimip.org/

Three extreme event types

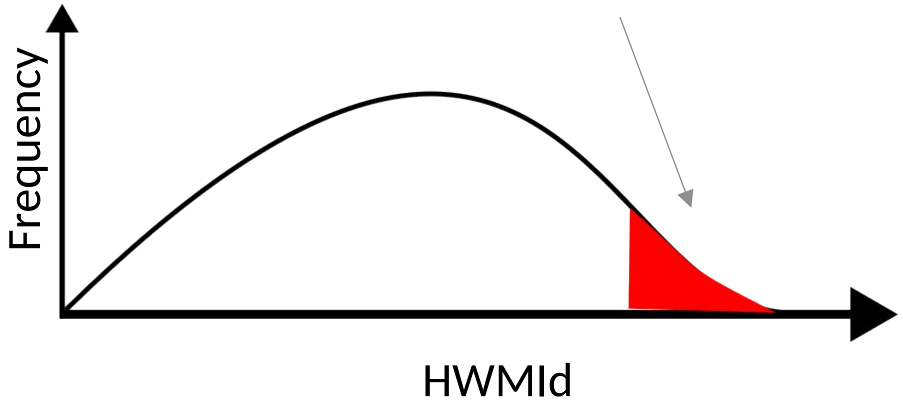
Crop failure
yields below 2.5th percentile of pre-industrial yields



Wildfire
fire model



Heat wave
HWMId (percentile) + Humidex (absolute)



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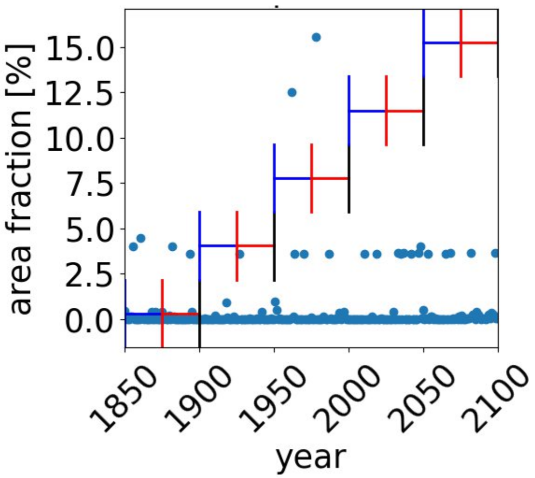
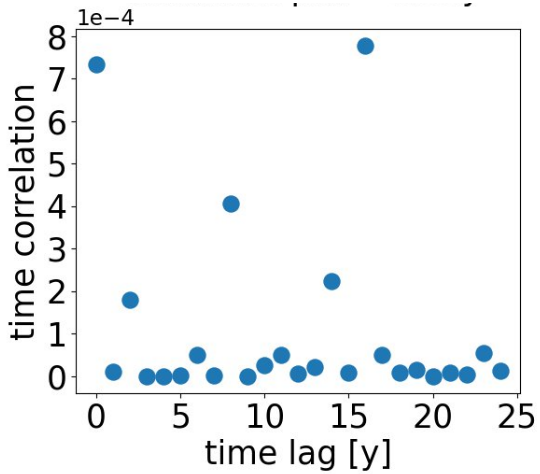
Leibniz Association

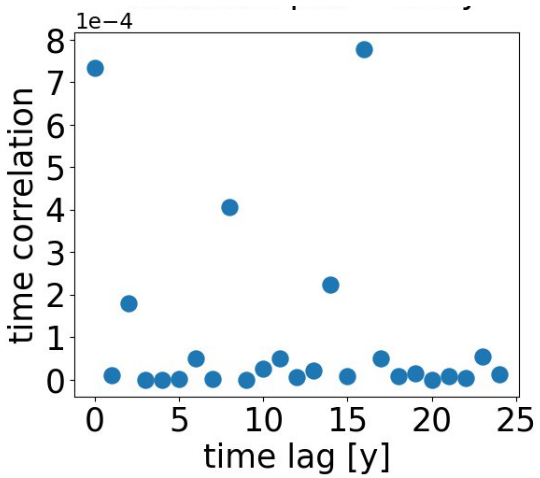
Definition: Dominant period I

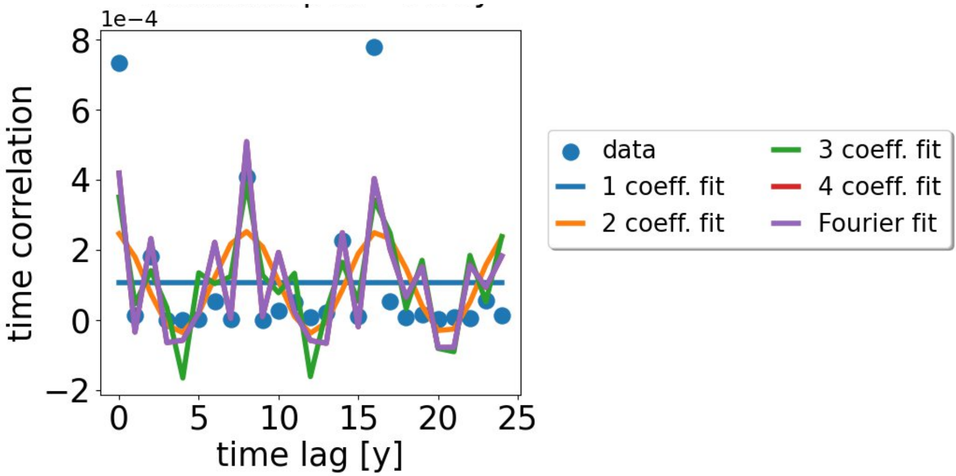
1. Calculate time auto-correlation from time series





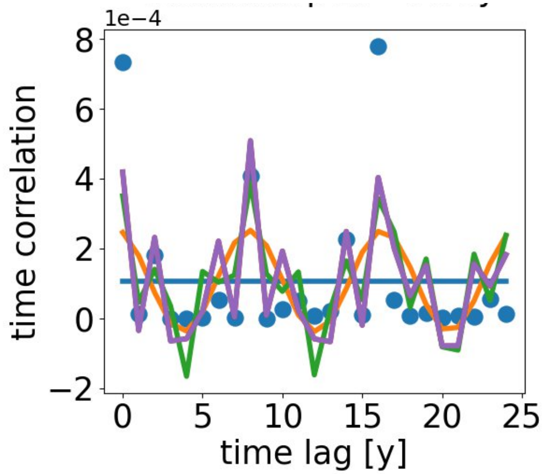
2. Compute Fourier components





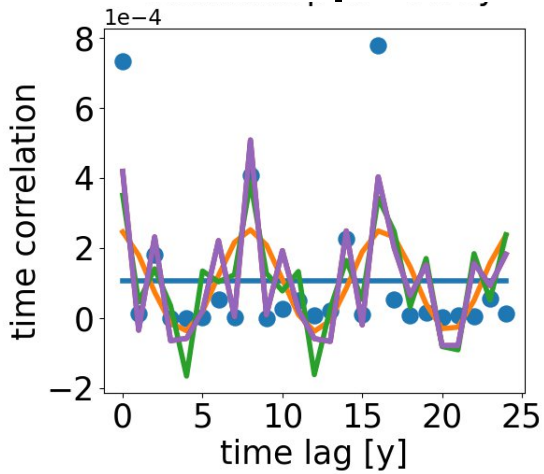
Definition: Dominant period II

3. Calculate adjusted R^2 for base frequency and higher harmonics



R^2= 0.52

4. If $R^2 > 0.5$
   we define the base period to be the ***dominant period***



Dominant period = 8.33y

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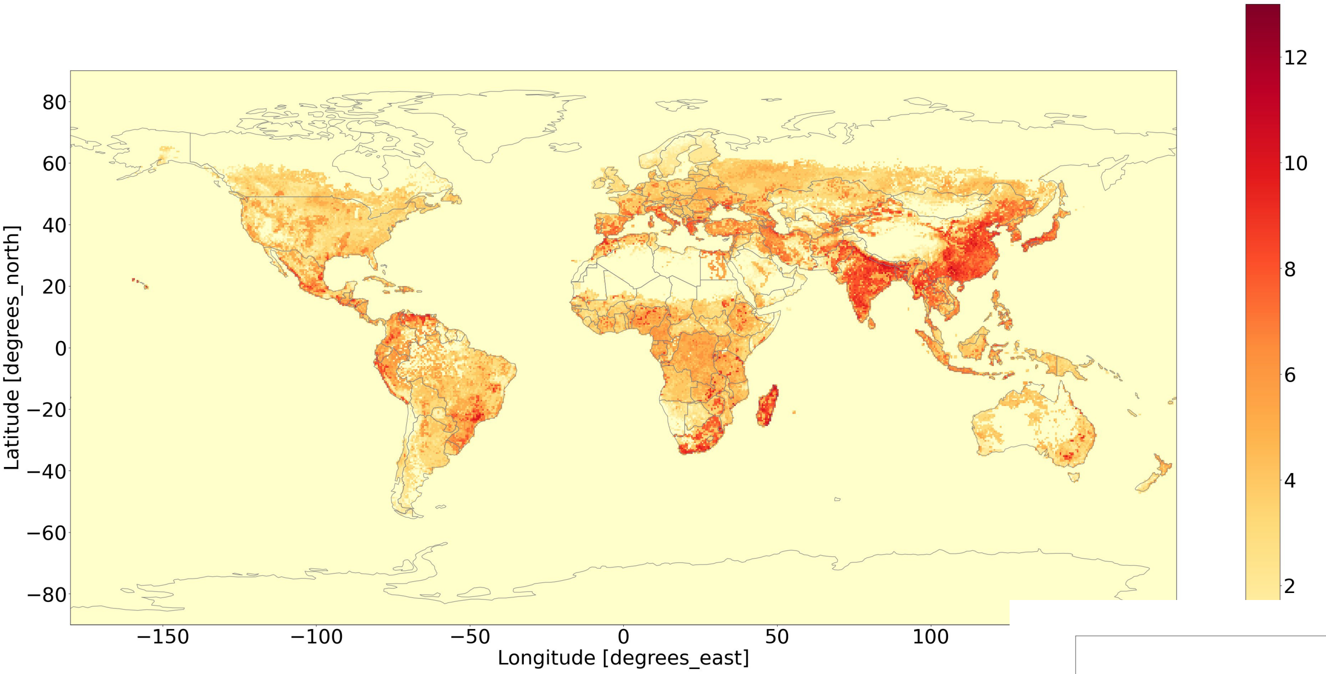
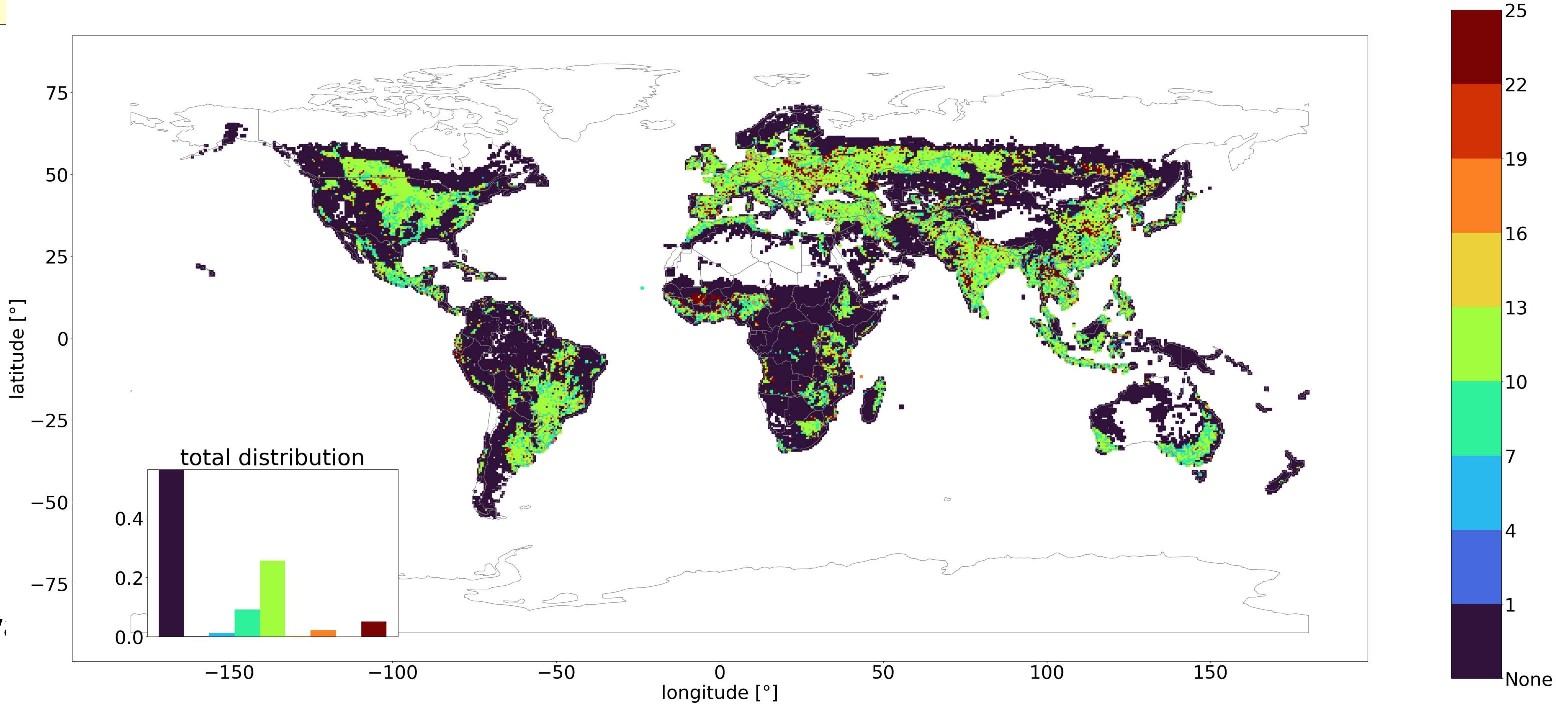
Crop failure – pre-industrial climate



- #number of extreme events in 50y time window
- inhomogeneous global impact distribution

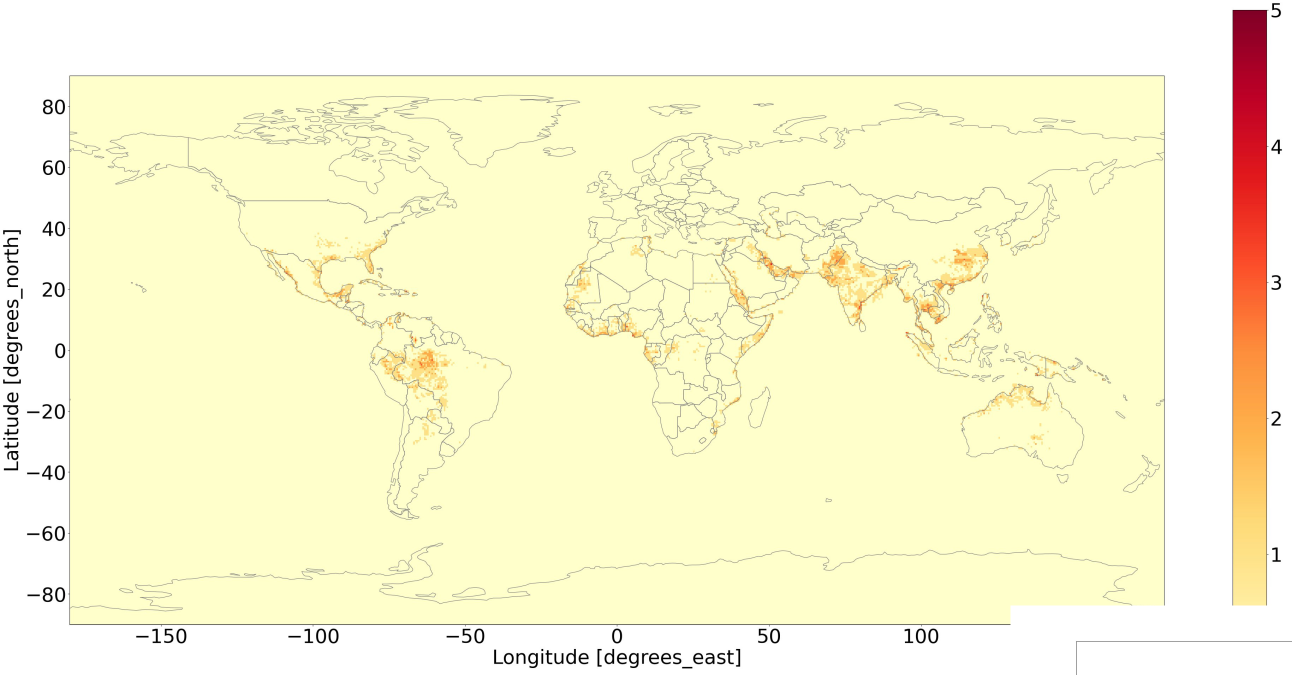


- Dominant periods concentrated at 10-13y
- ENSO + local climate modes imprint on crop yields

T. Iizumi *et al.*, Nat. Comm. (2014)
D.K. Ray *et al.*, Nat. Comm. (2015)
M. Heino *et al.*, Nat. Comm. (2018)

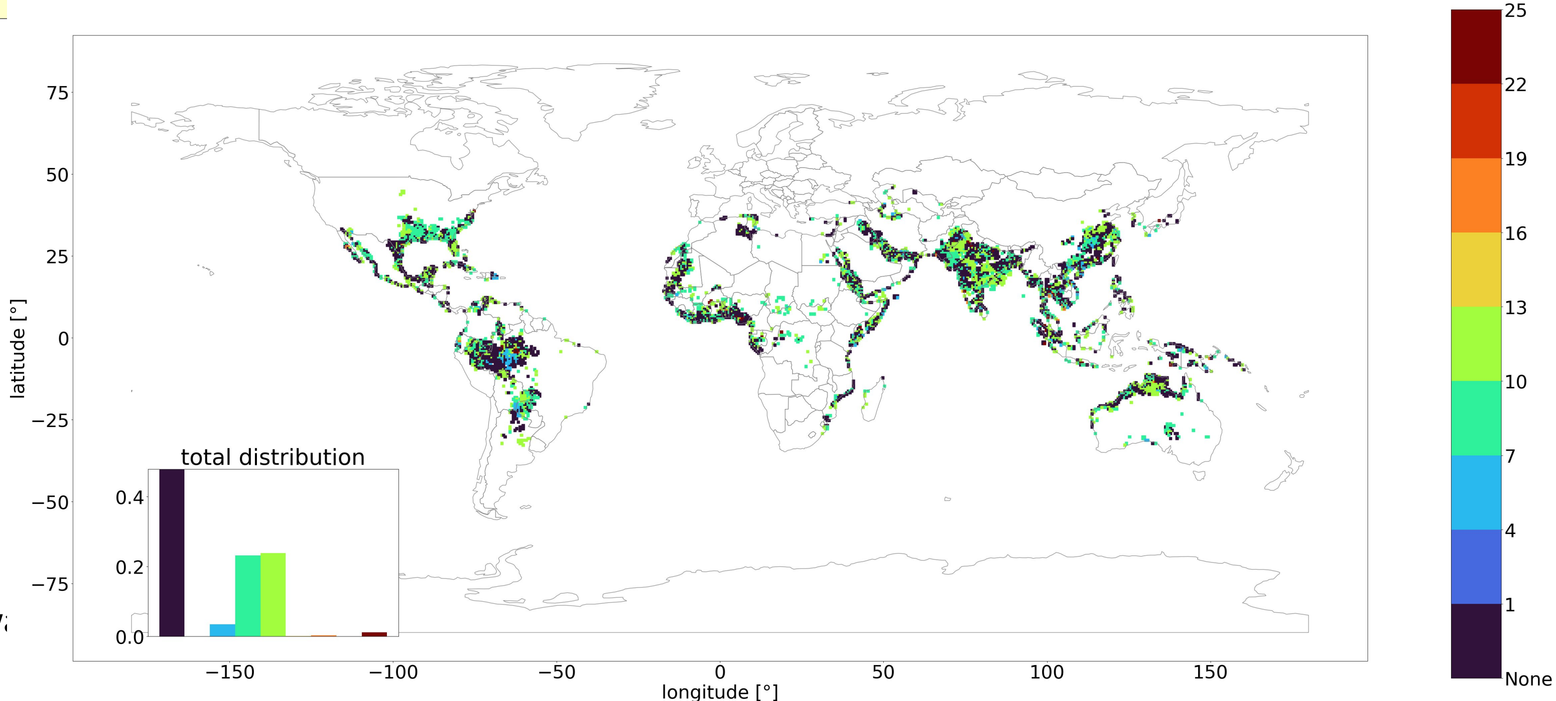
K. Zantout *et al*. (in preparation)

Heatwave – pre-industrial climate



- Much fewer impacts in 50y window
- Concentration at low latitudes with large humidity

- Dominant periods concentrated at 7-13y
- Direct effect from ENSO + local climate modes



Regularity of climate-related extreme events under global wa

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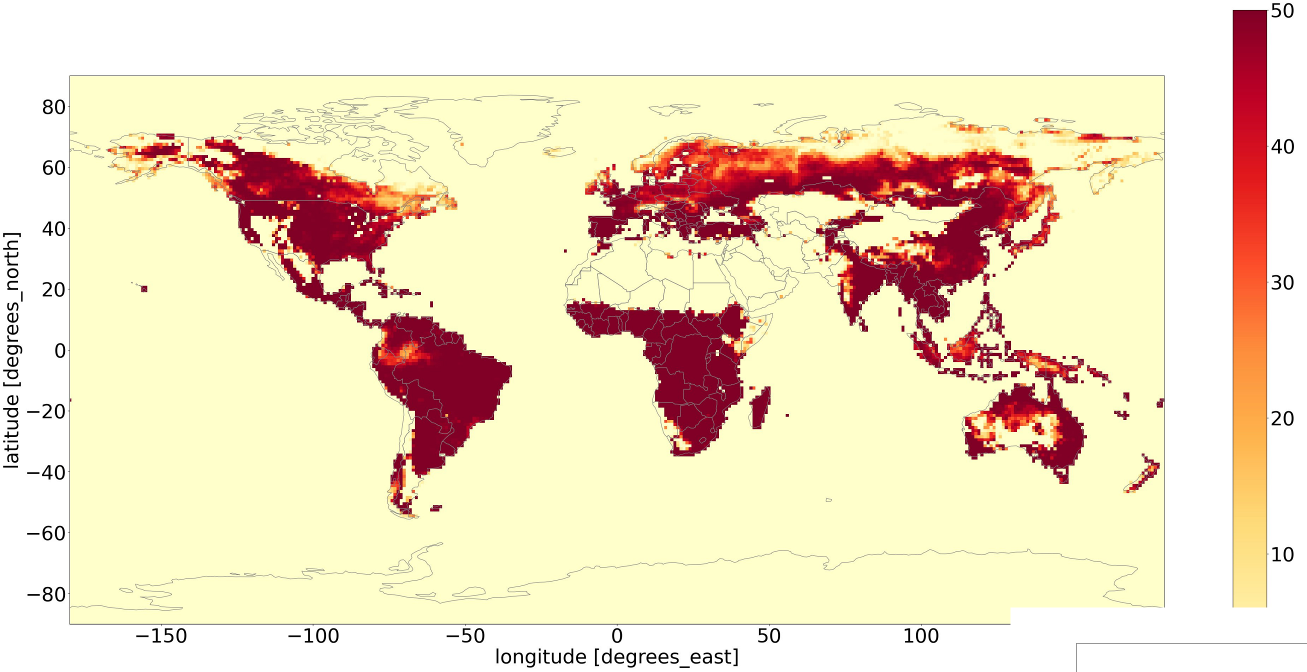
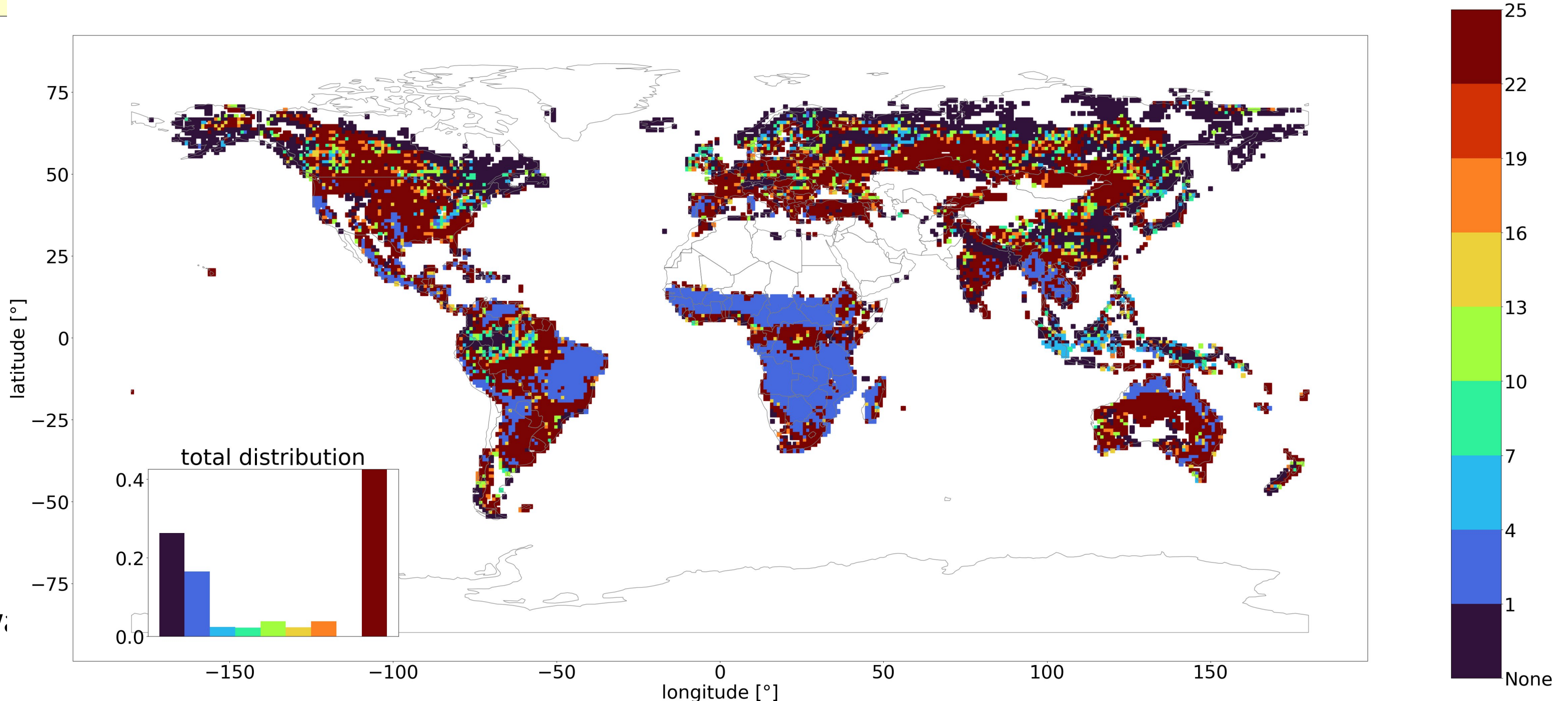
Wildfire – pre-industrial climate



- Wildfire (at least small fractions) very common

- Dominant periods concentrated at 1-3 and 22-25y
- Dynamics determined by fire regimes
  S. Archibald *et al.*, PNAS (2013)



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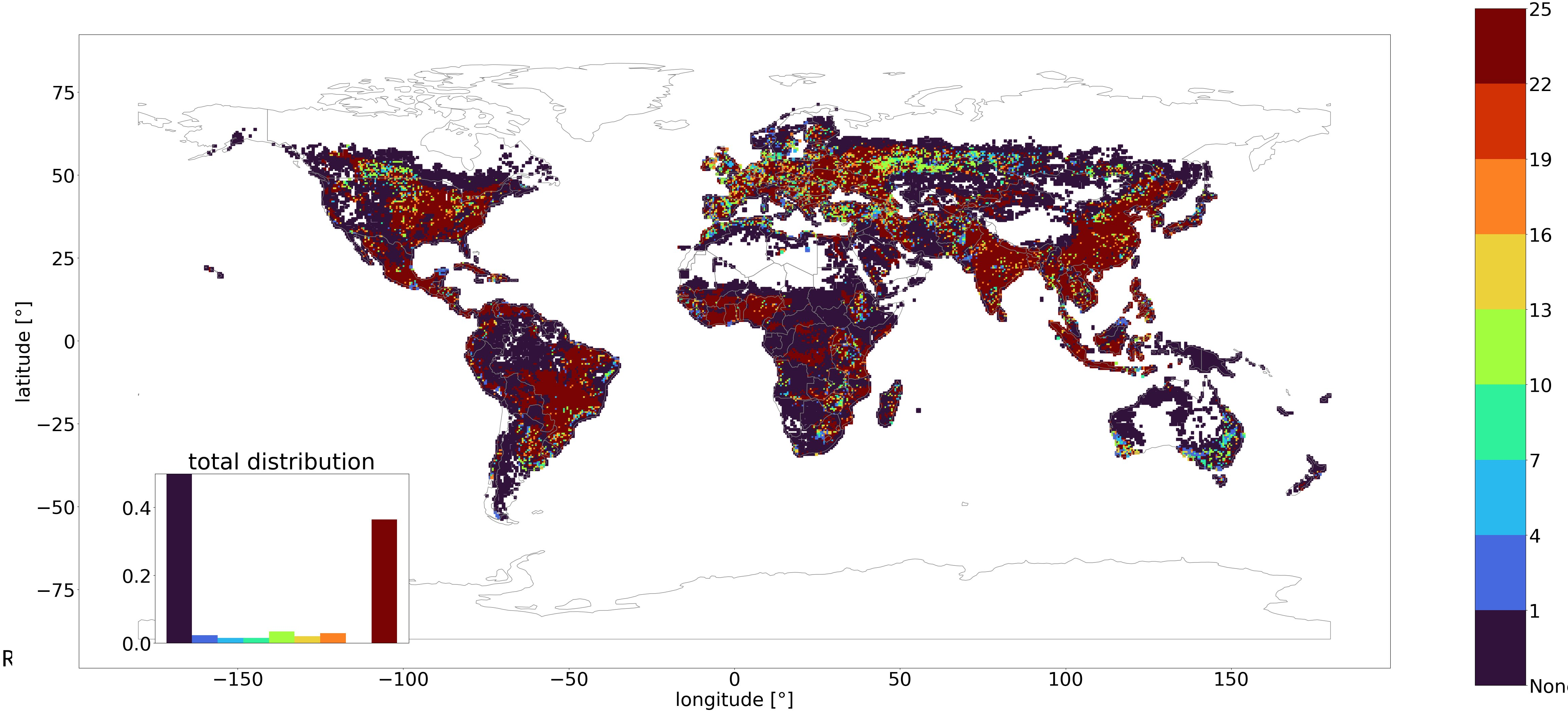
Crop failure – linearly detrended, SSP5-8.5

- Dominant period strongly dominated by warming trend
- Small trend towards higher frequencies



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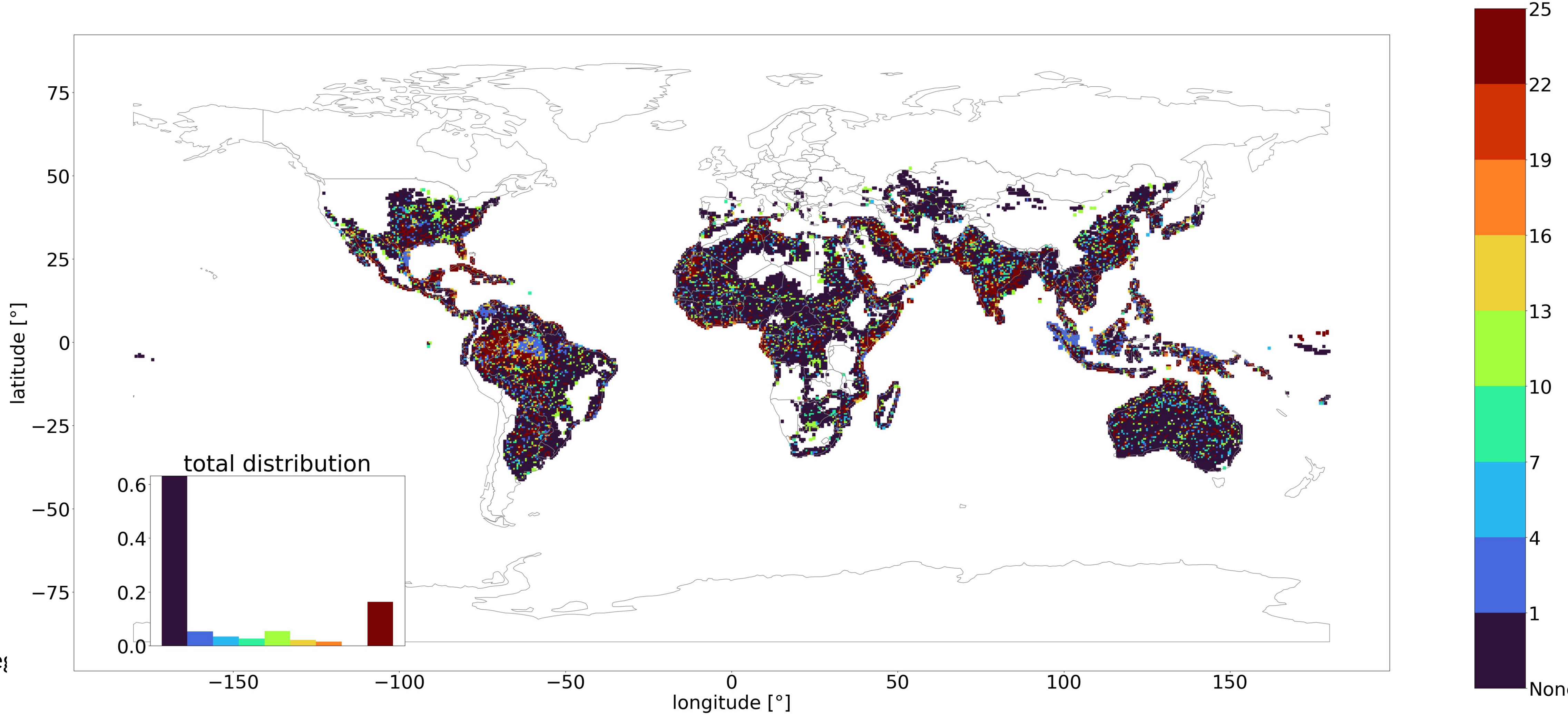
Heat wave – linearly detrended, SSP5-8.5

- Wide extension of heat wave affected areas
- Shift towards irregularity and higher dominant frequencies



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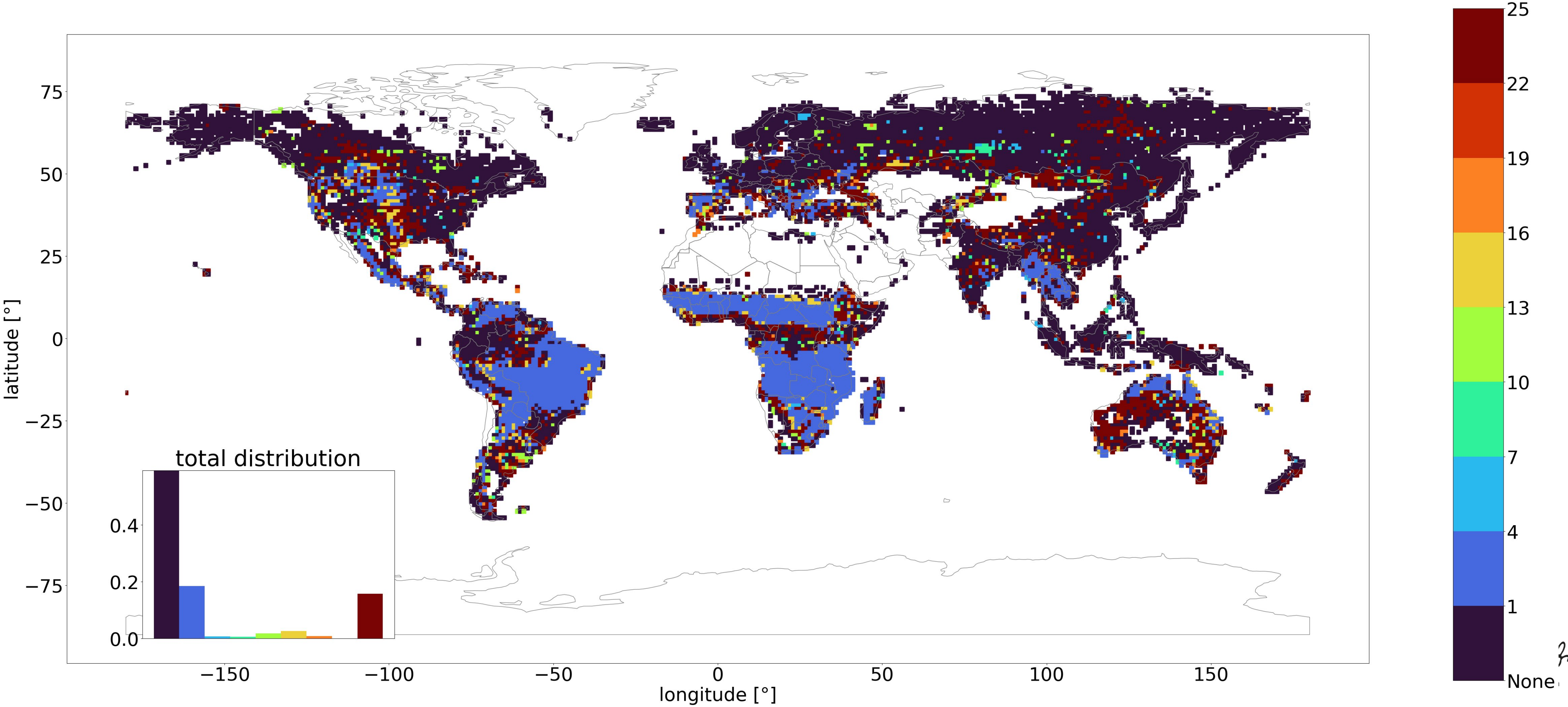
Wildfire – linearly detrended, SSP5-8.5

- Overall decrease in regularity
- Strong increase in high frequency regularities (1-3y)



Thank you for your attention!

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