A Global Sub-Daily Rainfall dataset

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introduction

GSDR

Newcastle University

Extreme rainfall in 2024…

motivation

Source: Christian Aid Report – Counting the cost

		Fatalities	Economic Cost (USD)
Jan-Dec	**US storms**	88	60+ bn
Oct	**Hurricane Milton**	25	60 bn
Sep	**Hurricane Helene**	232	55 bn
Jun-Jul	**China floods**	315	15.6 bn
Sep	**Typhoon Yagi**	829+	12.6 bn
Jul	**Hurricane Beryl**	70	6.7 bn
Sep	**Storm Boris**	26	5.2 bn
Apr-May	**Rio Grande do Sul floods**	183	5 bn
Jun	**Bavaria floods**	6	4.45 bn
Oct	**Valencia floods**	226	4.22 bn

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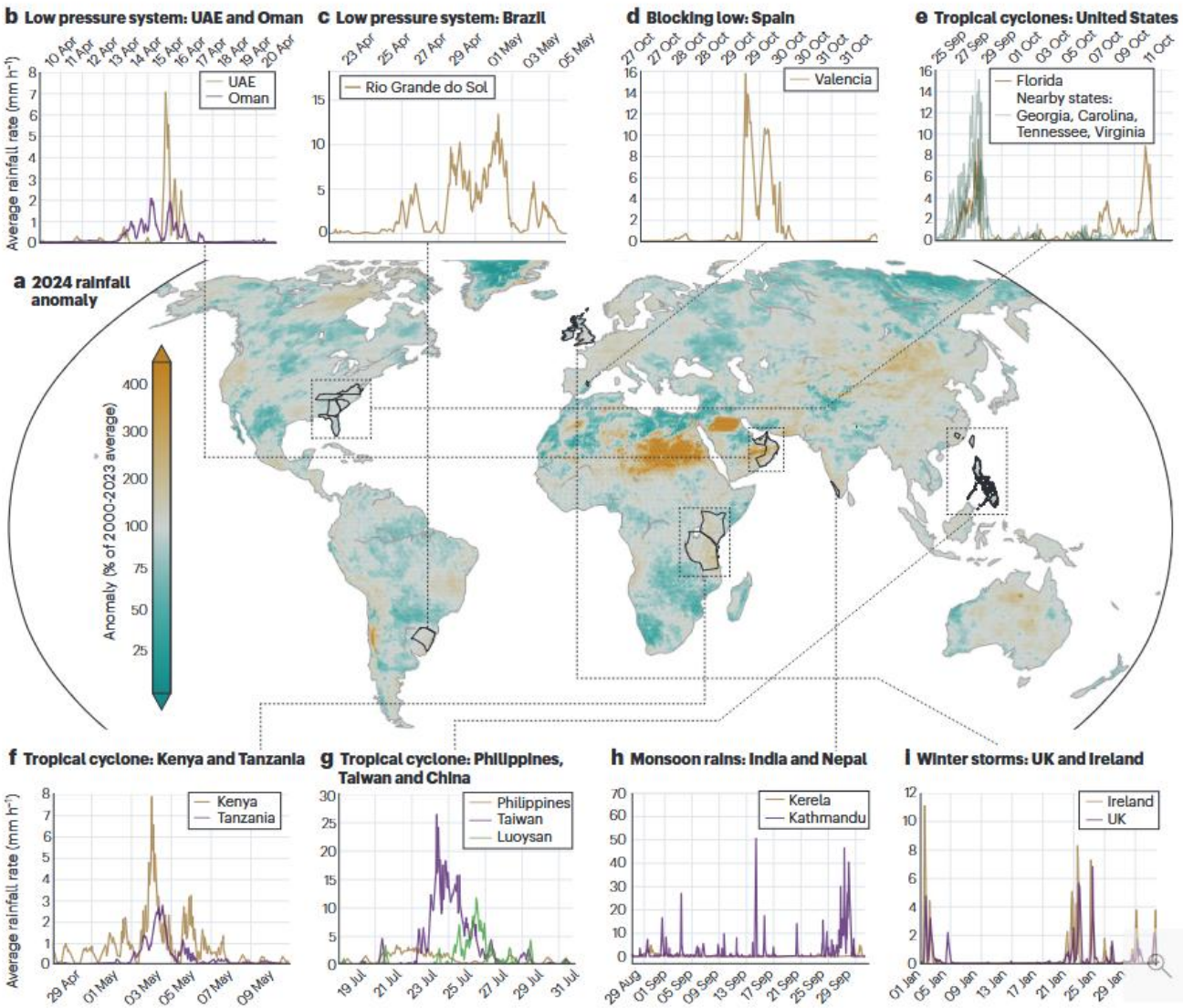
motivation

Extreme rainfall in 2024…



Rainfall estimation

motivation

Rain gauges

Weather radar

Satellite

Citizen science

Microwave links

Rainfall estimation

motivation

Rain gauges

- Higher accuracy
- Longer records
- Low spatial information

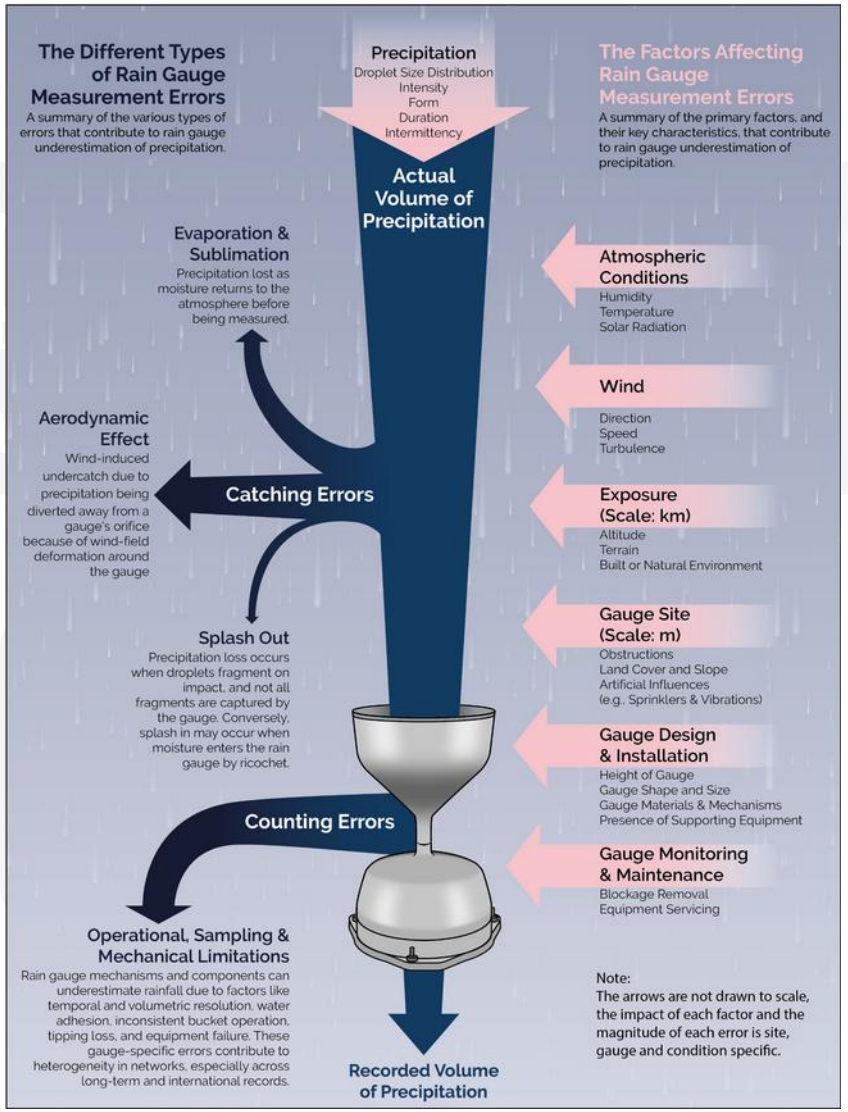


Image source: Ruth Dunn

motivation

Rainfall estimation

Rain gauges

Weather radar

Satellite

- Indirect measurements
- Shorter records
- High spatial information

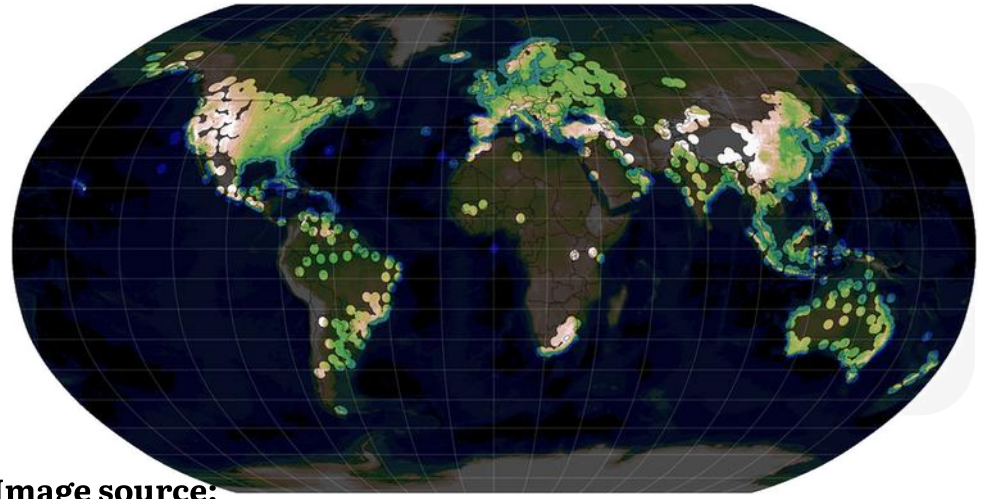
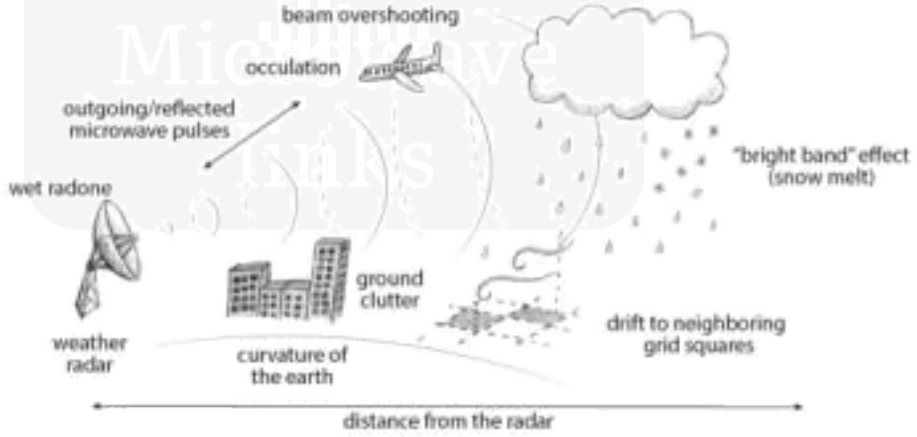


Image source:
Doyle, A. J. (2022) *Use of operational weather radars for understanding Indian monsoon convection and evaluating convection-permitting models*. PhD thesis, University of Reading

Microwave links



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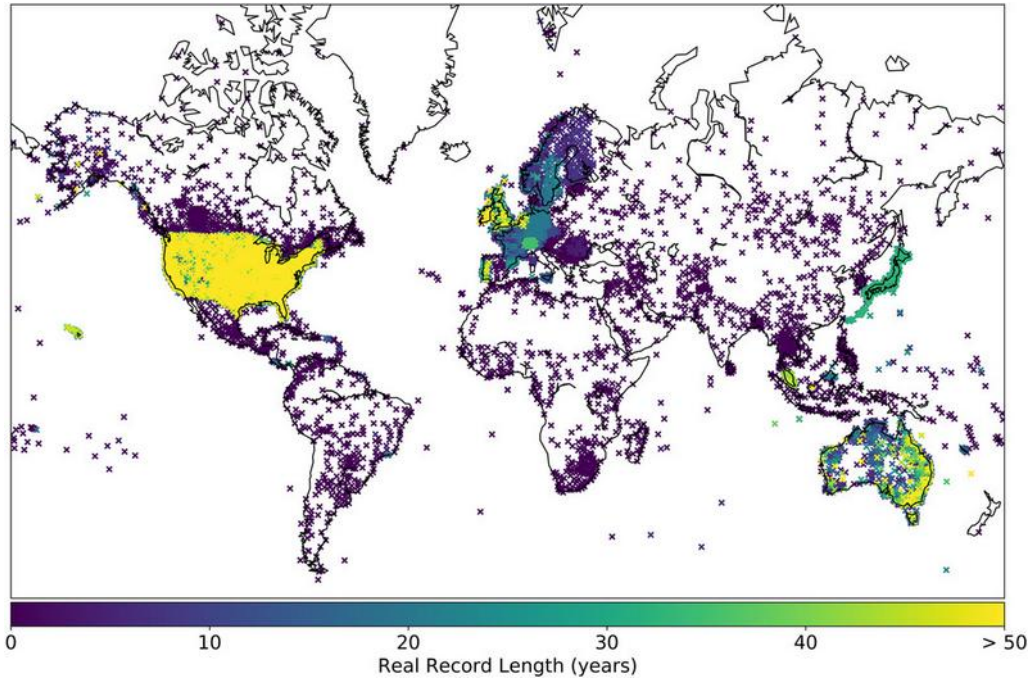
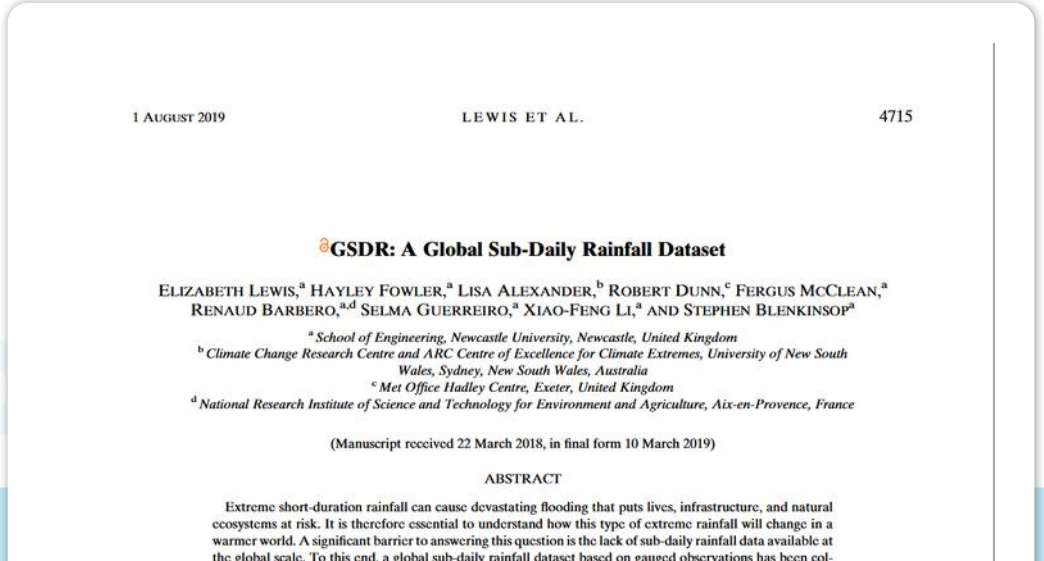
What is the GSDR?

- INTENSE project
- Global dataset of hourly quality controlled rain gauge observations
- Manual collection
- 23,687 rain gauges

Image source:
Lewis et al (2019) GSDR: A Global Sub-Daily Rainfall Dataset, DOI: 10.1175/JCLI-D-18-0143.1





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GSDR: A Global Sub-Daily Rainfall Dataset

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ABSTRACT

Extreme short-duration rainfall can cause devastating flooding that puts lives, infrastructure, and natural ecosystems at risk. It is therefore essential to understand how this type of extreme rainfall will change in a warmer world. A significant barrier to answering this question is the lack of sub-daily rainfall data available at

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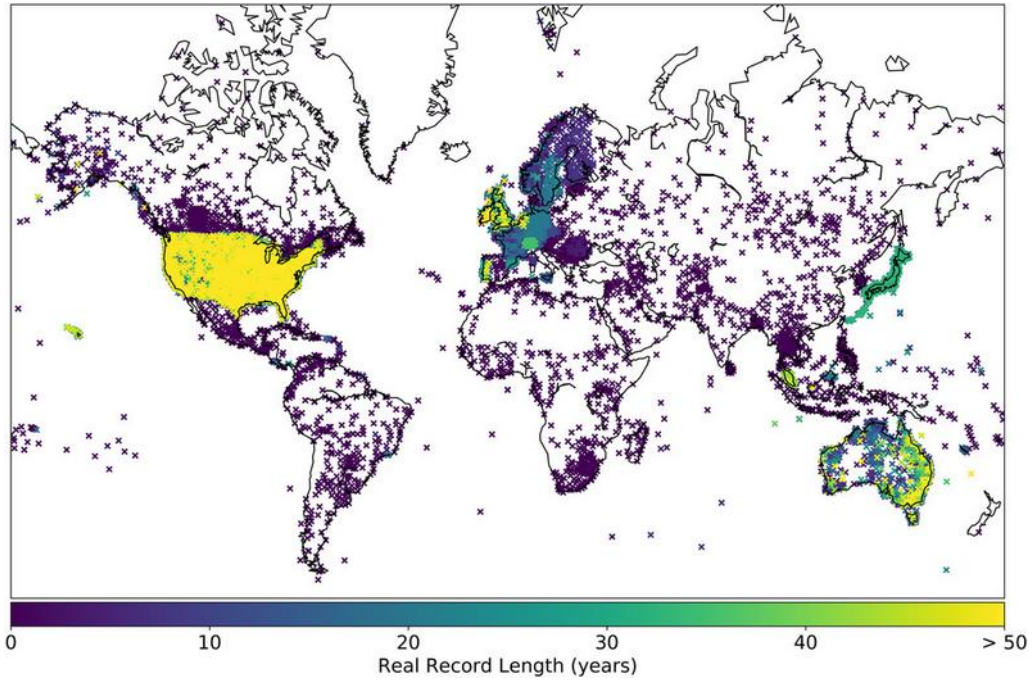
What is the GSDR?

- Quality controlled
  - 25 quality checks and 11 rules
  - excludes suspicious values, improves correspondence with manually quality-controlled GPCC data
  - Flexible level of removal depending on data use
- Variable spatial coverage, record length, completeness, average record length 13 years, earliest records in 1950s.

Image source:
Lewis et al (2019) GSDR: A Global Sub-Daily Rainfall Dataset, DOI: 10.1175/JCLI-D-18-0143.1



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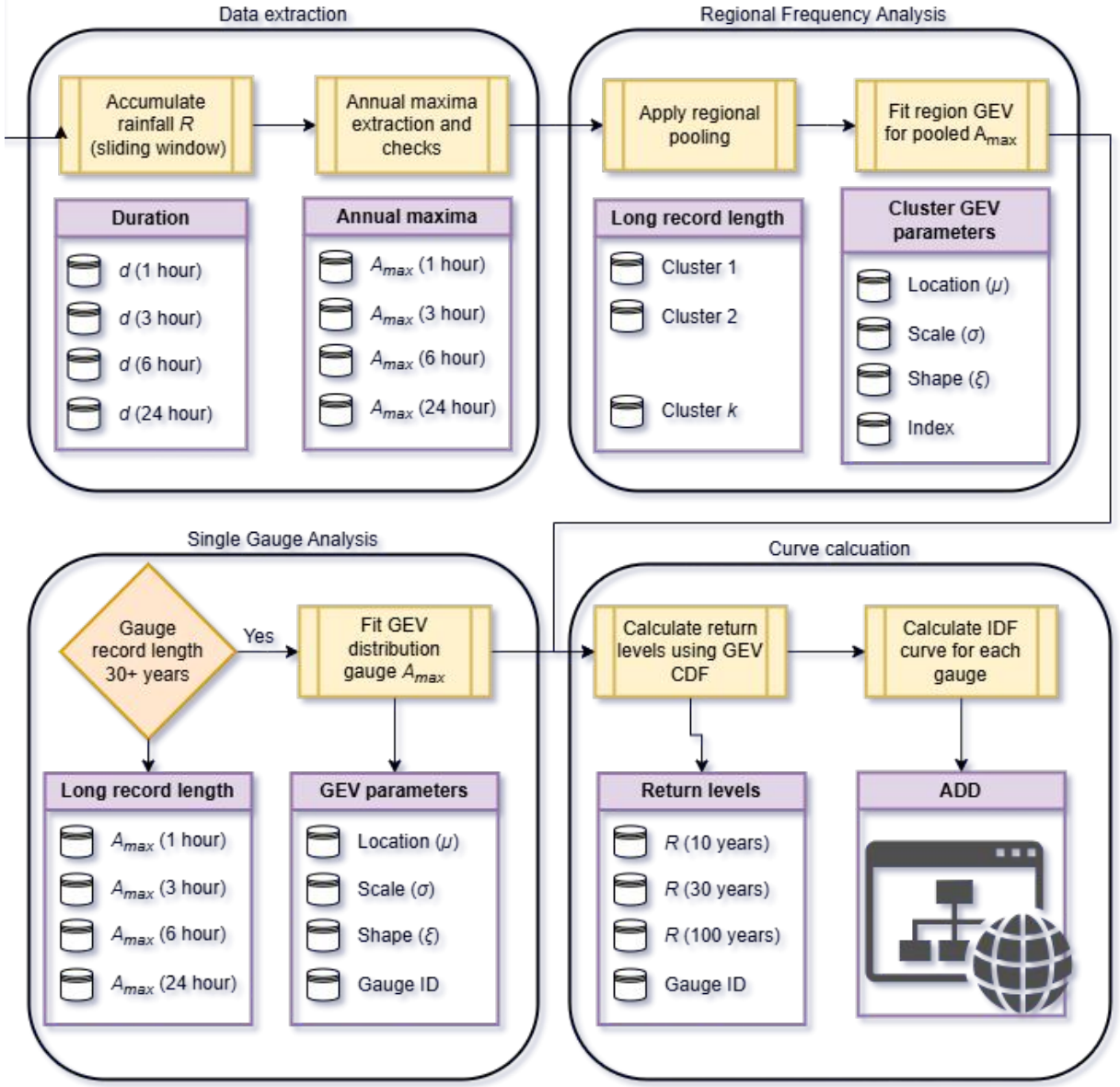
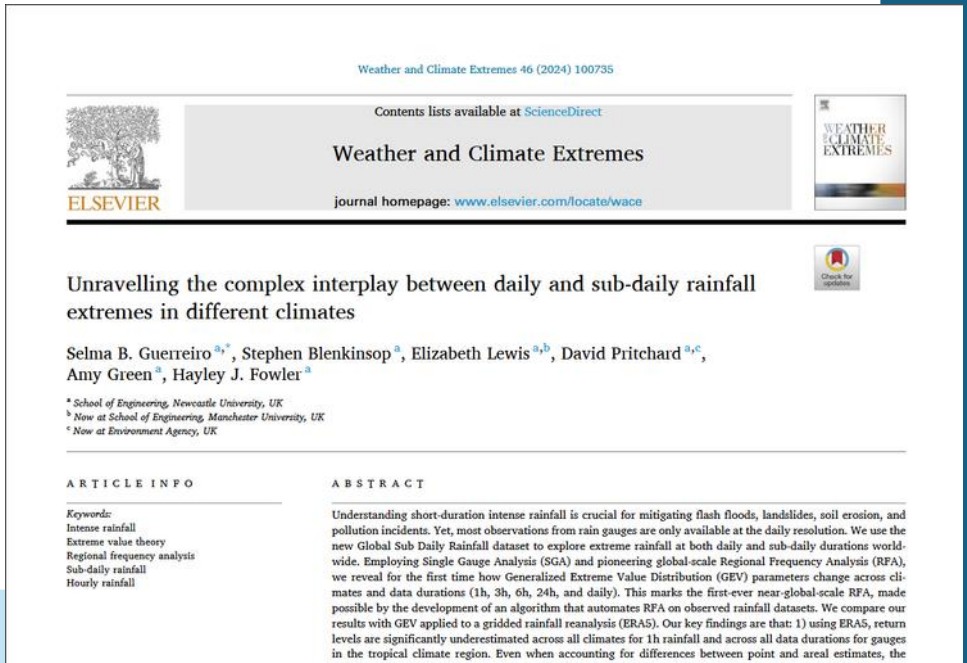
INTENSE

Extreme rainfall

extremes



- Extreme value analysis
- Duration 1-24hr
- Regional pooling
- Compared to ERA5 with area reduction



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Unravelling the complex interplay between daily and sub-daily rainfall extremes in different climates

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ARTICLE INFO

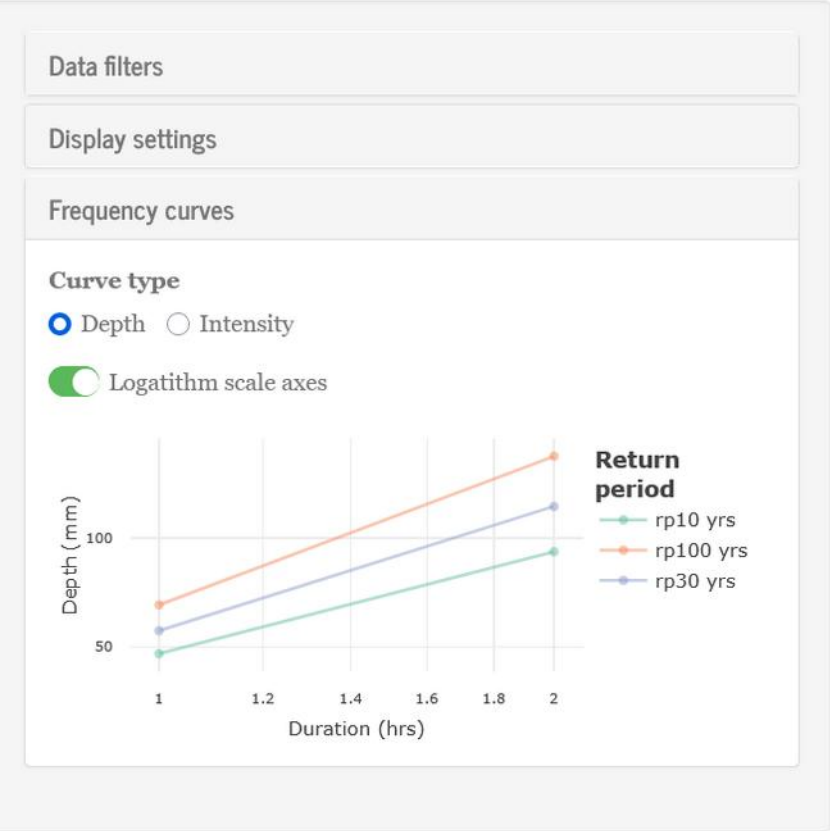
Keywords:
Intense rainfall
Extreme value theory
Regional frequency analysis
Sub-daily rainfall
Hourly rainfall

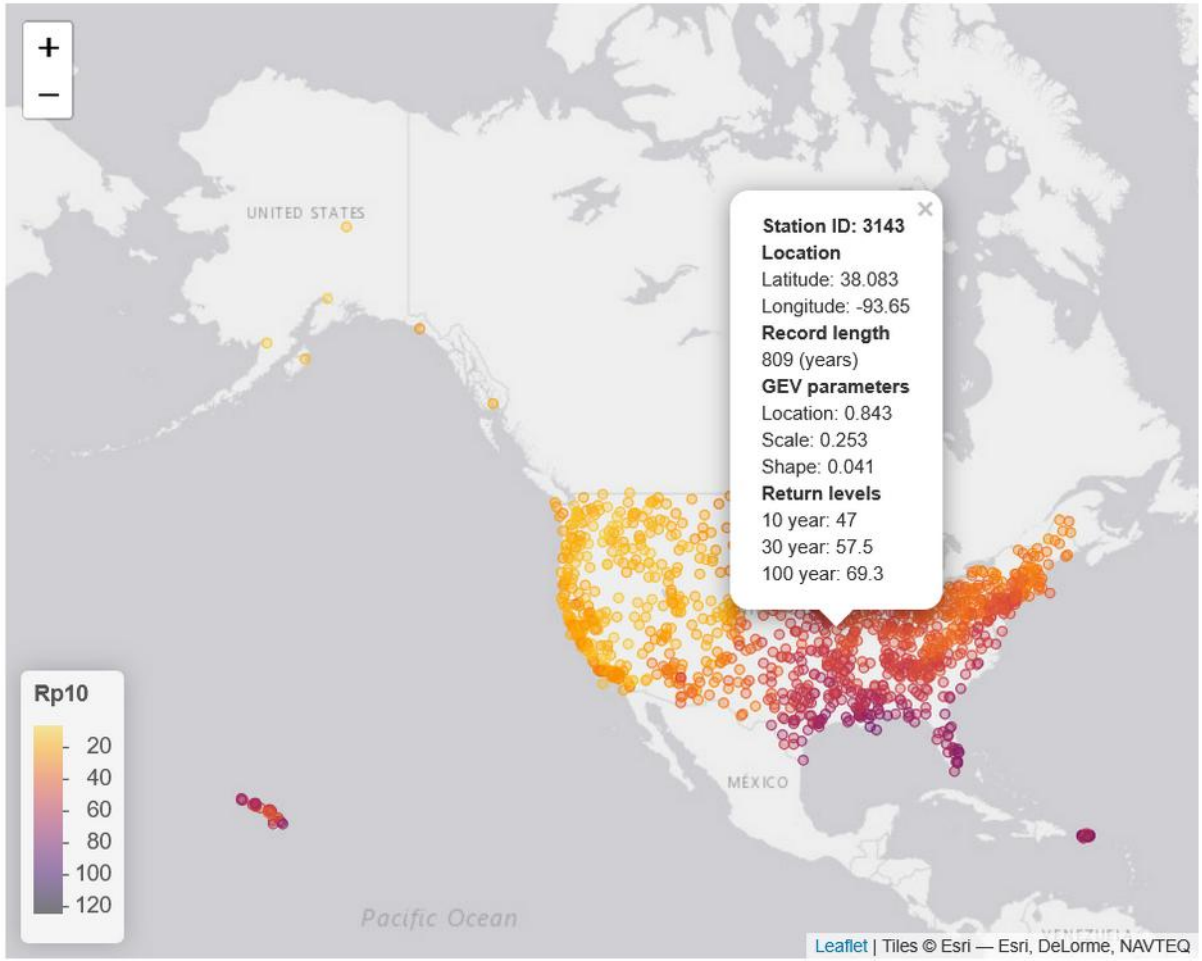
ABSTRACT

Understanding short-duration intense rainfall is crucial for mitigating flash floods, landslides, soil erosion, and pollution incidents. Yet, most observations from rain gauges are only available at the daily resolution. We use the new Global Sub Daily Rainfall dataset to explore extreme rainfall at both daily and sub-daily durations worldwide. Employing Single Gauge Analysis (SGA) and pioneering global-scale Regional Frequency Analysis (RFA), we reveal for the first time how Generalized Extreme Value Distribution (GEV) parameters change across climates and data durations (1h, 3h, 6h, 24h, and daily). This marks the first-ever near-global-scale RFA, made possible by the development of an algorithm that automates RFA on observed rainfall datasets. We compare our results with GEV applied to a gridded rainfall reanalysis (ERA5). Our key findings are that: 1) using ERA5, return levels are significantly underestimated across all climates for 1h rainfall and across all data durations for gauges in the tropical climate region. Even when accounting for differences between point and areal estimates, the

Climatology

- Intensity-duration-frequency curves





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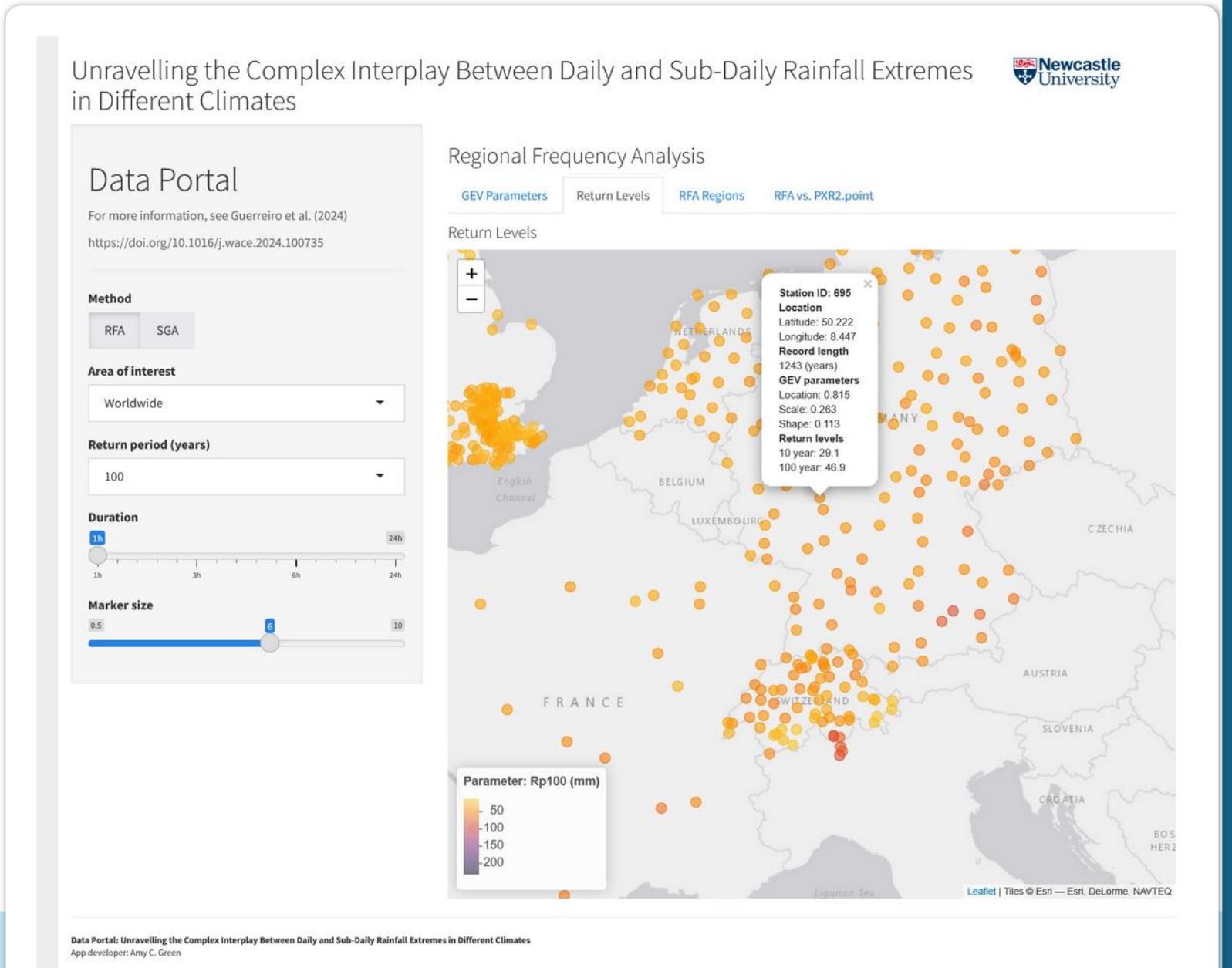
Extreme rainfall

extremes

- ERA5 significantly underestimates return levels (40% lower) across all climates (1hr), and all durations (tropical

Advise against using gridded reanalysis rainfall data for extreme studies

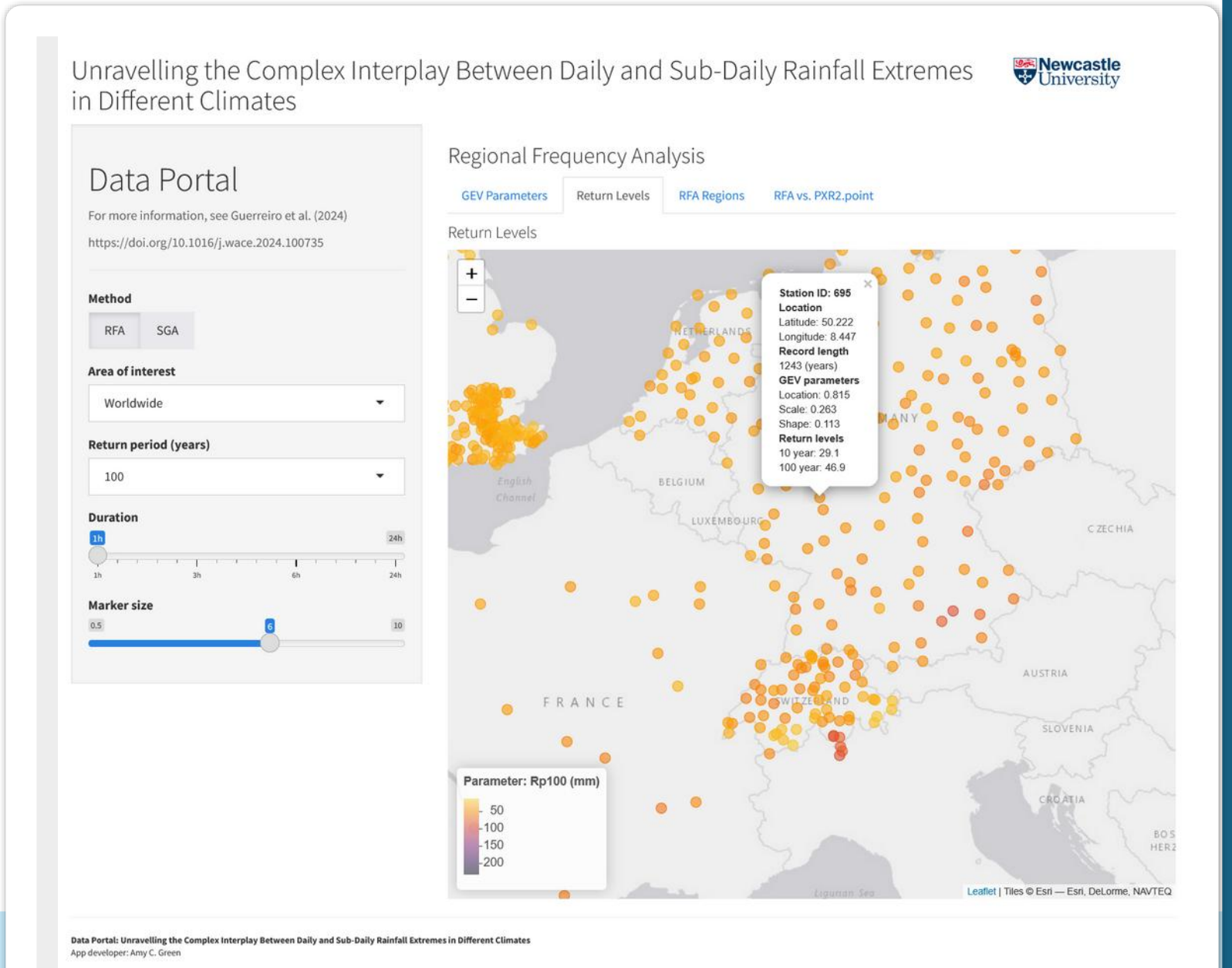


Extreme rainfall

extremes

- Mostly similar return levels for regional/single-gauge, some differ significantly (no bias either way)

Apply single-gauge and regional frequency for return levels, for a robust risk assessment for flood design infrastructure



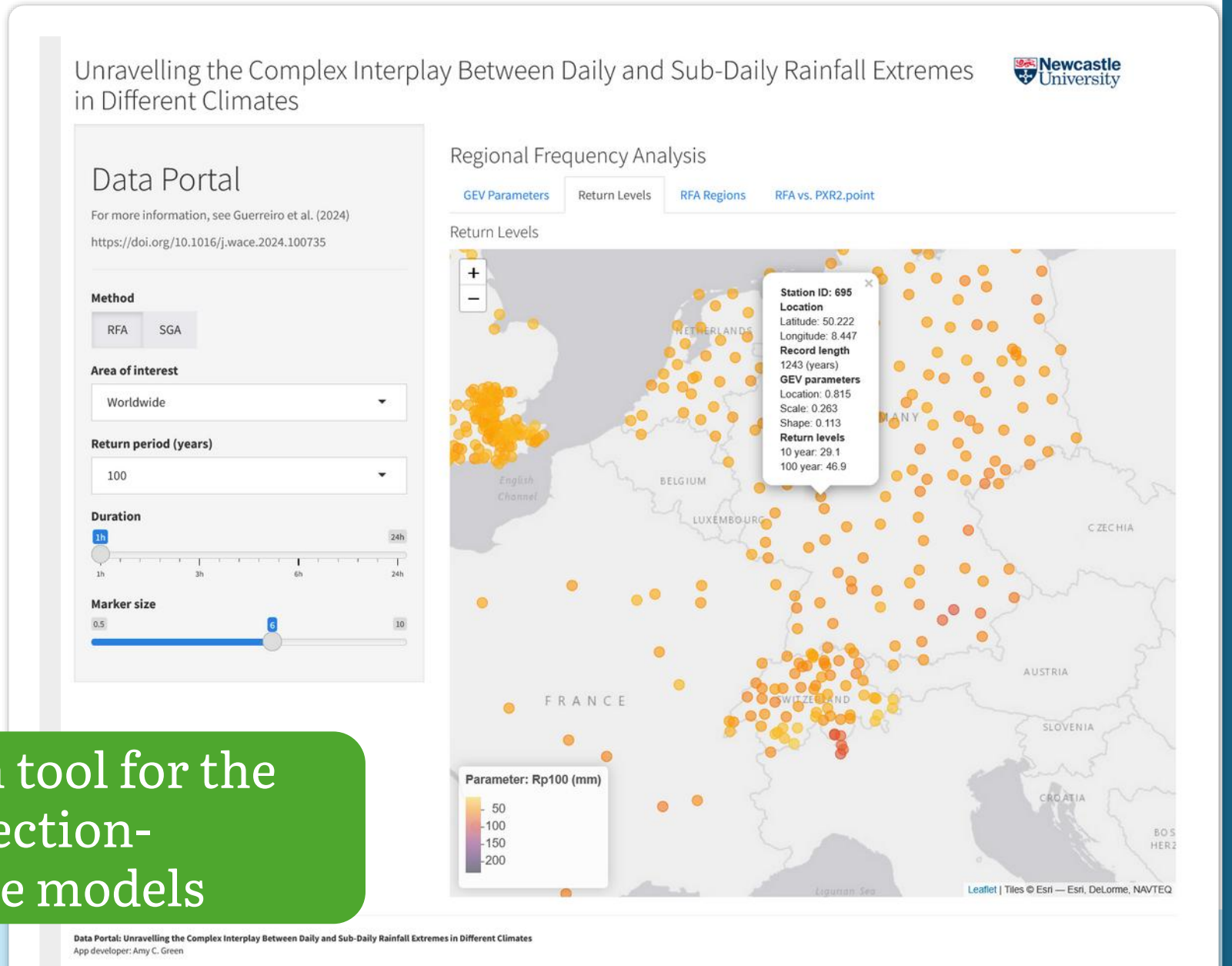
Extreme rainfall

extremes

- Daily and sub-daily interactions for GEV shape parameter varies across climate regions

Universal method for inferring sub-daily from daily (e.g. IDF curves)

Crucial validation tool for the rising no. of convection-permitting climate models worldwide.



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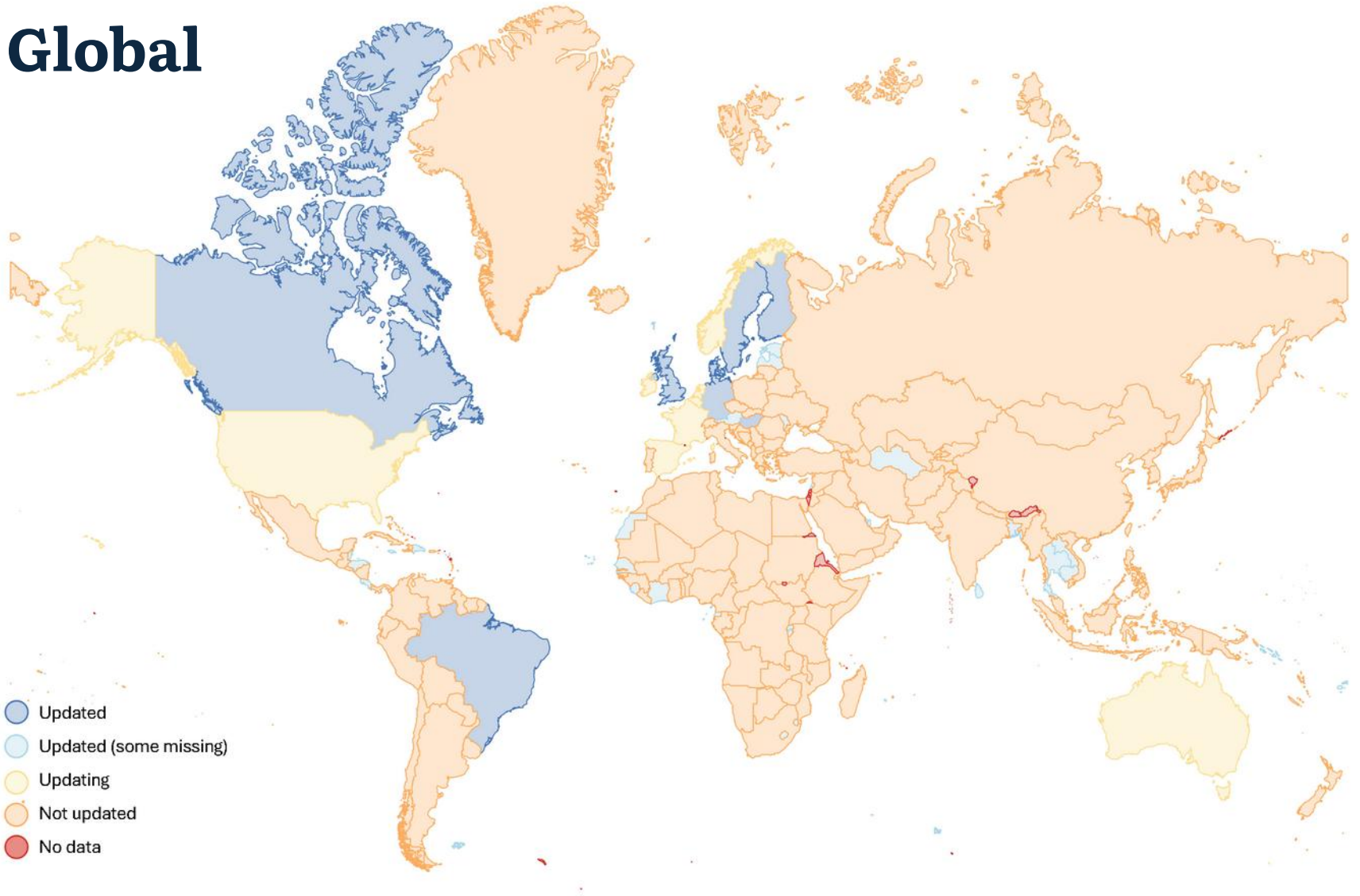
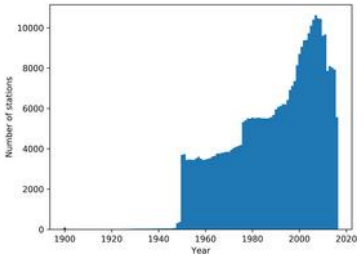
GSDR updates

Global





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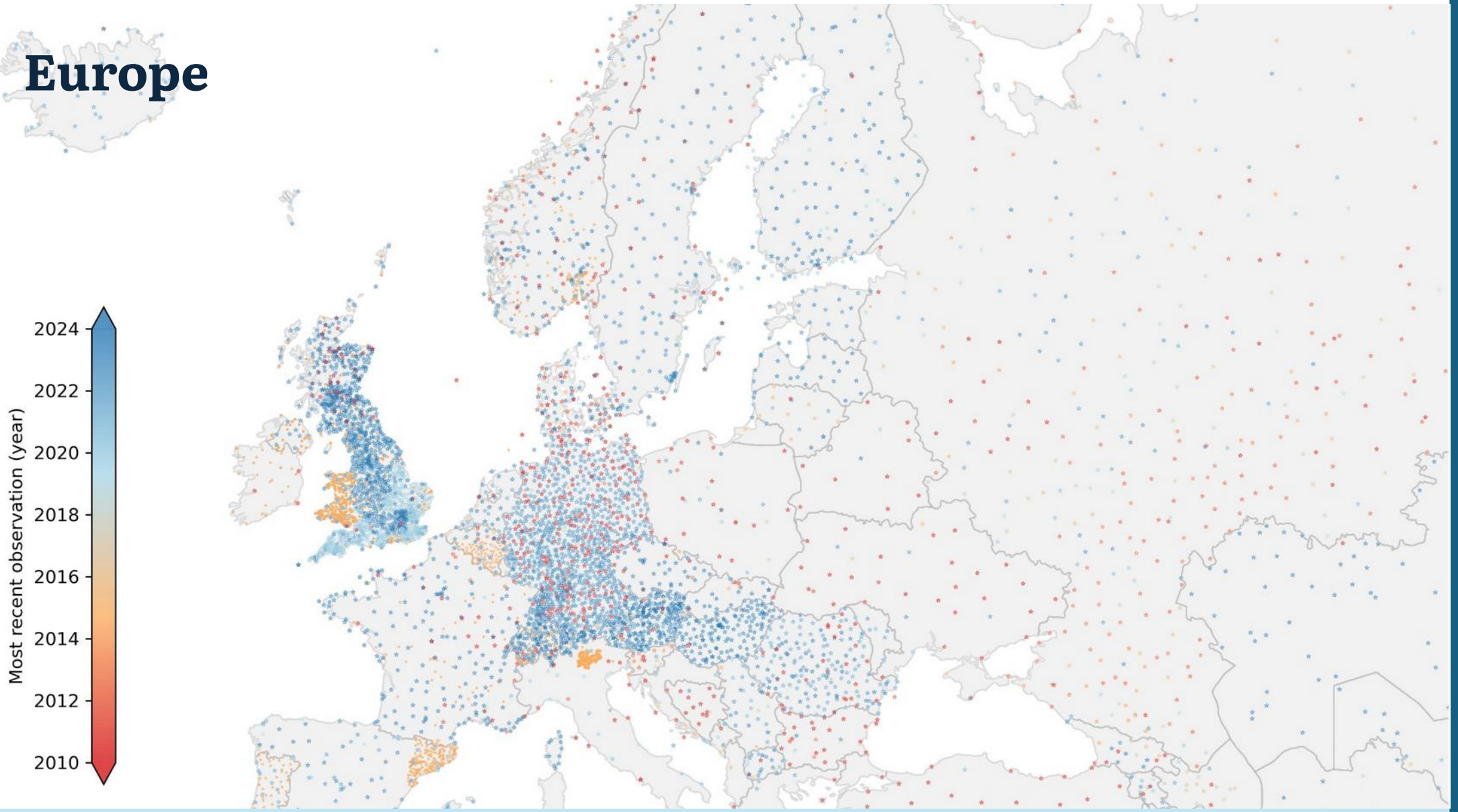
GSDR updates

Europe



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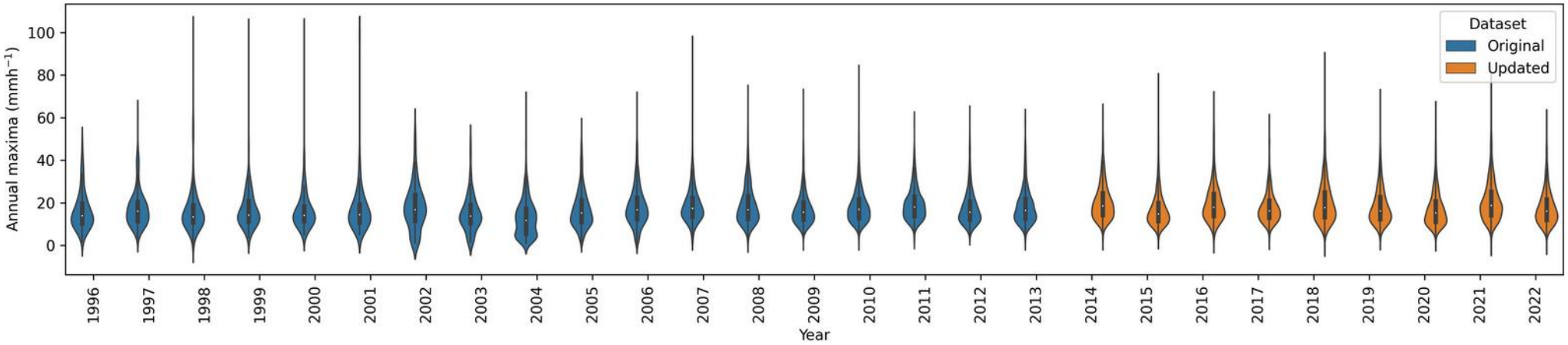
Germany


Annual maxima (mmh⁻¹)
Year
Dataset
Original
Updated
1996
1997
1998
1999
2000
2001
2002
2003
2004
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2007
2008
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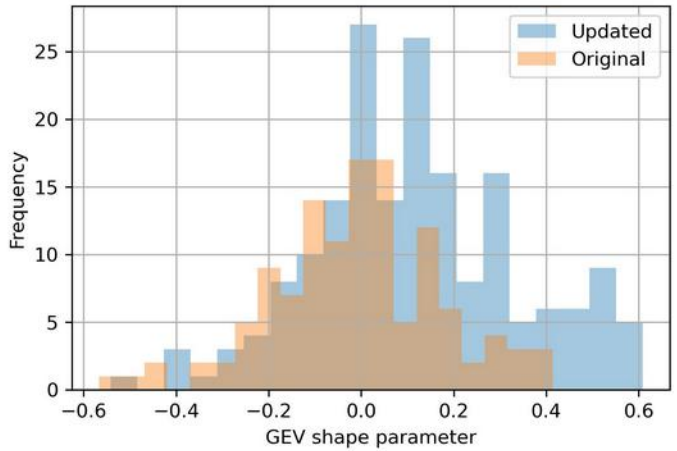
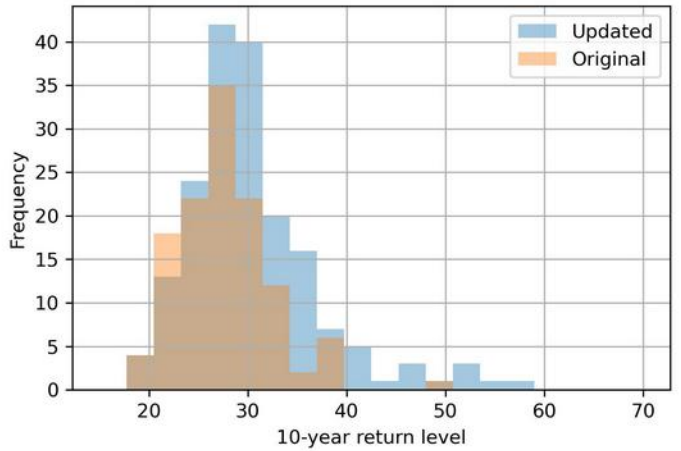
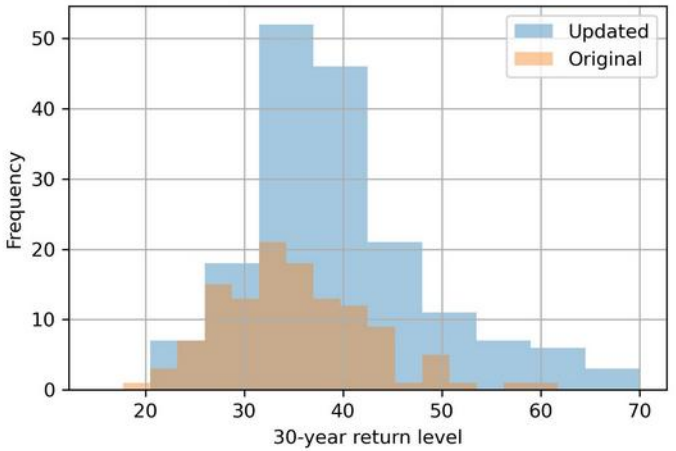
2019
2020
2021
2022


Frequency
GEV shape parameter
Updated
Original


Frequency
10-year return level
Updated
Original


Frequency
30-year return level
Updated
Original

Moving forward

next steps

- Additional quality control checks where available (e.g. nearest radar pixels), machine learning.
- GSDR-I: Precipitation indices
- Better understanding how extreme precipitation will change in the future
  - Compare with climate projections and other observations (e.g. satellite) – Indices for EUROCORDEX/Convection permitting as part of IMPETUS4CHANGE
  - Verification of reference periods
  - Assessment of performance
  - Adjustment factors for better understand
- Better connectivity between GSDR datasets

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GSDR: A Global Sub-Daily Rainfall

Summary

- What it is and why we need it
- Applications for extreme rainfall
  - Crucial validation tool for convective permitting models
- Additional datasets within the GSDR
  - Extreme indices
  - Quality control
  - Updated dataset
- Future plans

Image sources

https://mediacentre.christianaid.org.uk/new-study-top-10-climate-disasters-cost-the-world-billions-in-2024/

https://edition.cnn.com/2024/06/14/india/india-sikkim-landslide-deaths-tourists-stranded-intl-hnk/indehttps://www.theguardian.com/world/2024/apr/23/china-floods-death-toll-guangdong-province-pearl-river-deltax.html

https://www.opb.org/article/2024/10/30/spain-flooding-photos-show-the-devastation-in-valencia/

A Global Sub-Daily Rainfall

thank you

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