

Supplementary Material

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Data	Trend [events yr⁻¹]	p-value	EFC [%]
Sub-daily All	0.0102	0.01	24
Sub-daily Overlap	0.0095	0.04	22
Sub-daily No-Overlap	0.0110	0.01	26
Daily All	0.0066	0.16	15
Daily Overlap	0.0093	0.05	22
Daily No-Overlap	0.0043	0.41	10

Table S1: Trend, statistical significance (OLS p-value) and Exceedance Frequency Change (EFC) for the multi-dataset mean time series of extreme event frequency, computed separately for all selected events, events overlapping between daily and sub-daily timescales (i.e. a daily extreme event occurring on the same calendar day as a sub-daily extreme event) and non-overlapping events.

Dataset	Correlation Coefficient
MSWEP	0.66
CMORPH	0.74
Upscaled CMORPH	0.73
GSMaP	0.64
CHAPTER	0.53
Upscaled CHAPTER	0.70
IMERG	0.44
Multidataset Mean	0.71

Table S2: Spatial correlation between daily and subdaily extreme precipitation frequency trends across different datasets. Upscaled means that original data are upscaled to 0.1° spatial resolution.

Dataset	Version	Resolution	Available period
MSWEP	V2.8	0.1°, 3-hr	1979–2020
CMORPH-CDR	V1.0	8 km, 30-min	1998–2025
GSMaP Gauge RNL	V05A	0.1°, 1-hr	1998–2023
IMERG	V07B	0.1°, 30-min	2000–2025
CHAPTER	–	3 km, 1-hr	1981–2022

Table S3: Summary of the precipitation datasets used in this study, including version, native spatial and temporal resolution and available period.

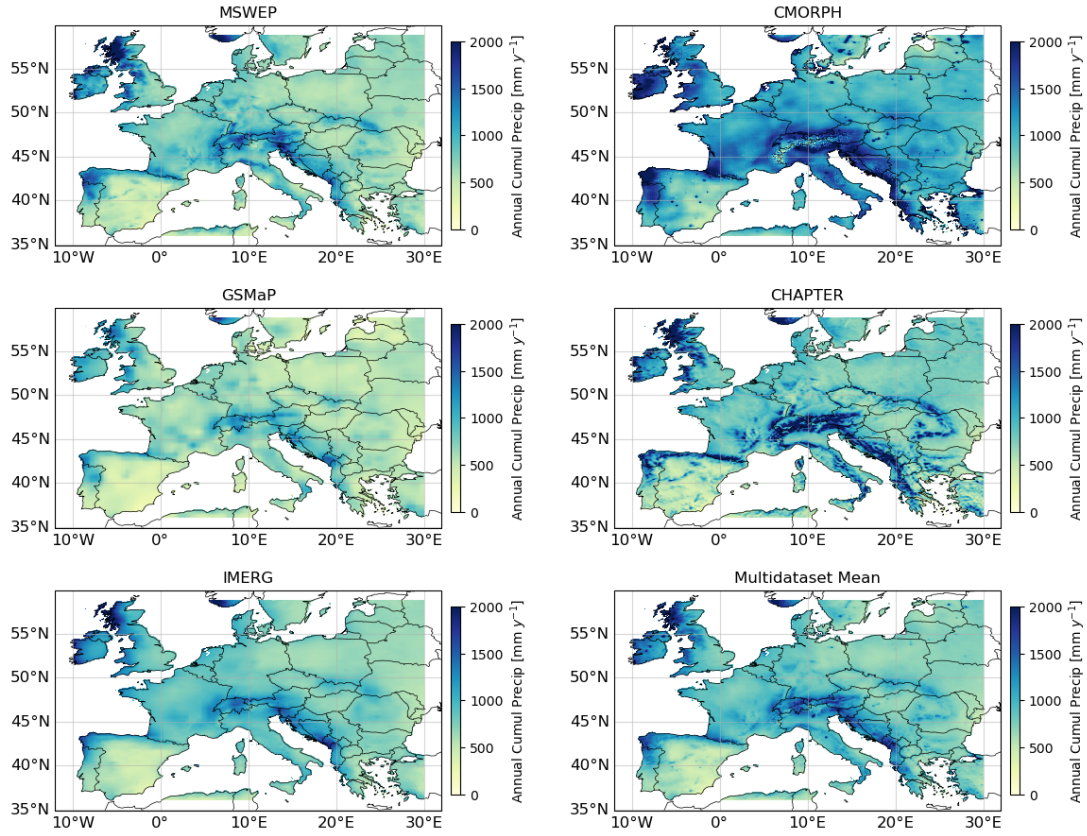


Figure S1: Maps of mean annual cumulative precipitation for each dataset evaluated and for the multidataset case. All dataset are displayed at the resolution of 0.1°.

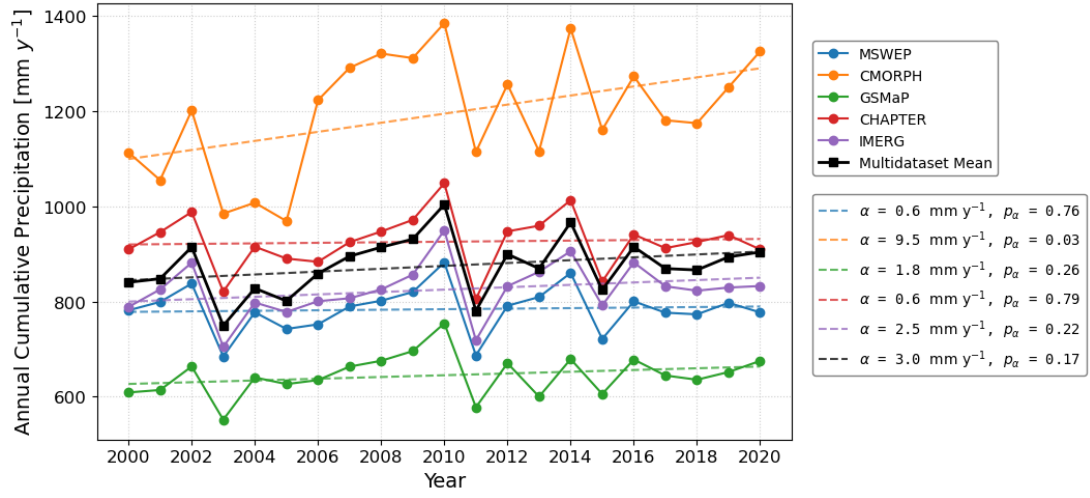


Figure S2: Timeseries and trends for annual cumulative precipitation for each dataset evaluated and for the multidataset case.

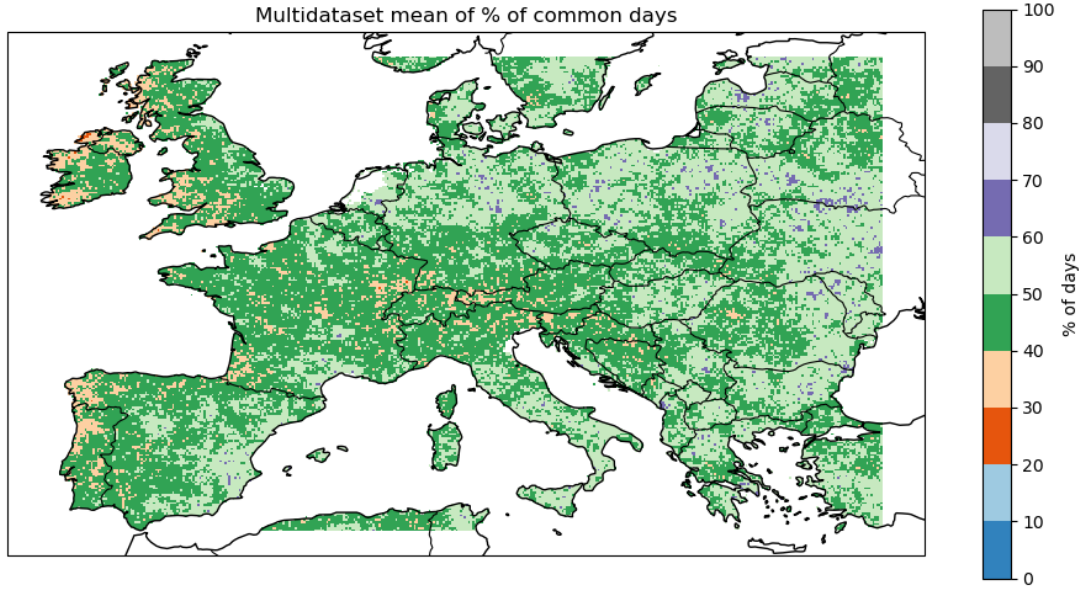


Figure S3: Co-occurrence of daily and sub-daily independent extreme precipitation events. Spatial mapping of locations where a daily extreme event and a 3-hour extreme event occur concurrently on the same calendar day over the study period.

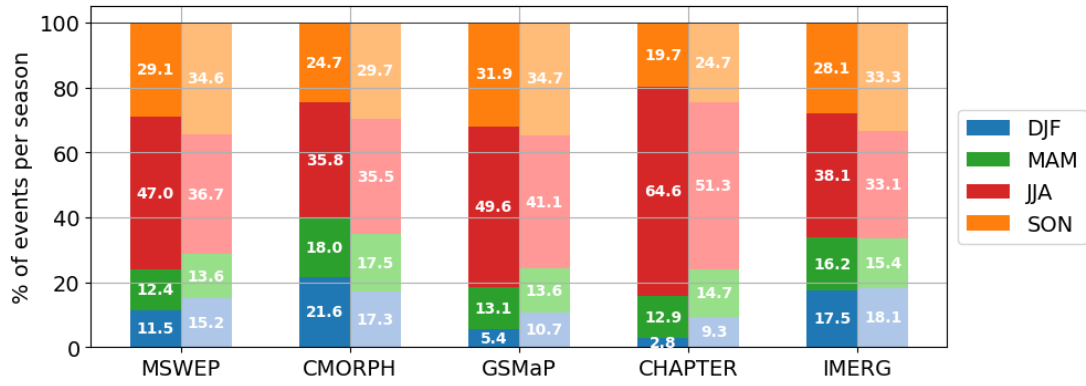


Figure S4: Percentage of selected extreme independent events per season (different colors). Solid color and transparent color represent the sub-daily and daily cases, respectively.

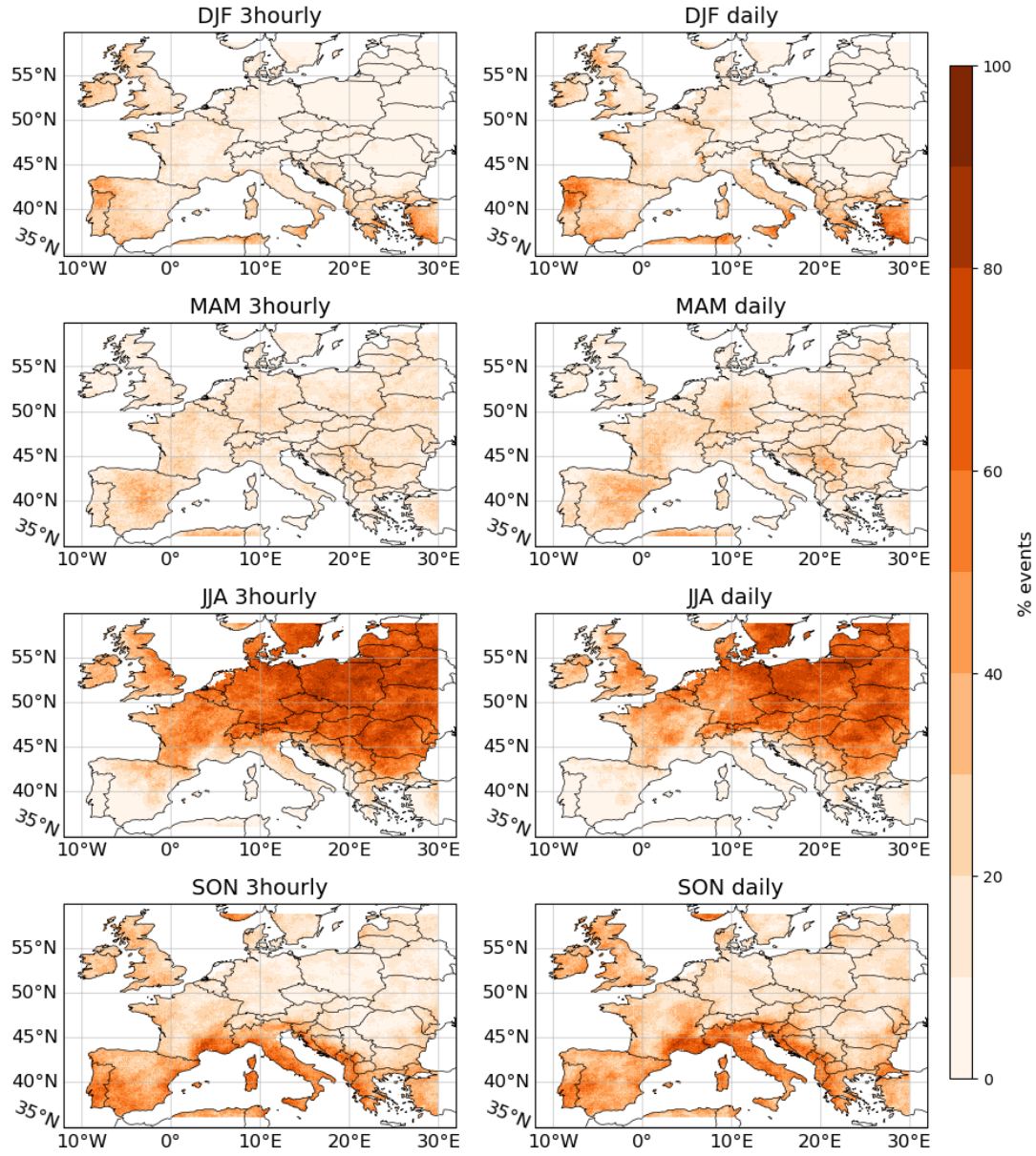


Figure S5: Multidatasets percentage of selected subdaily independent (left column) and daily (right column) extreme events per season.

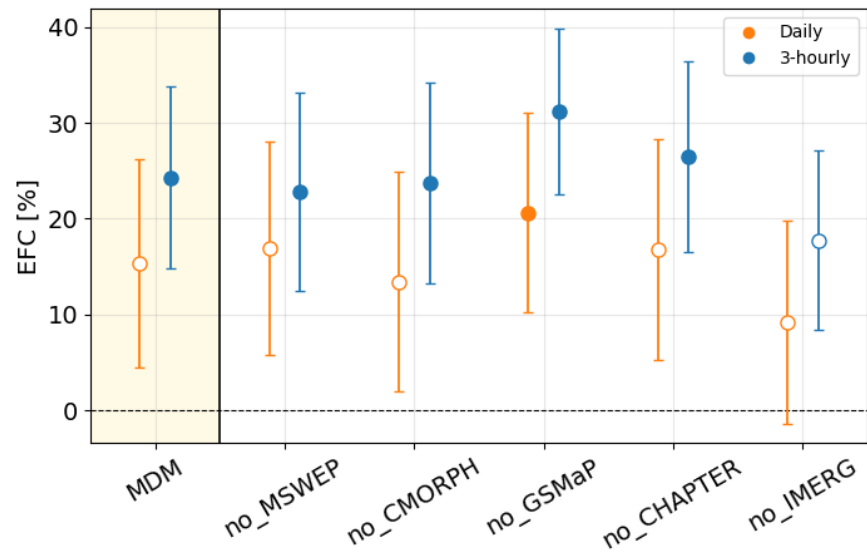


Figure S6: Leave-one-dataset-out sensitivity analysis

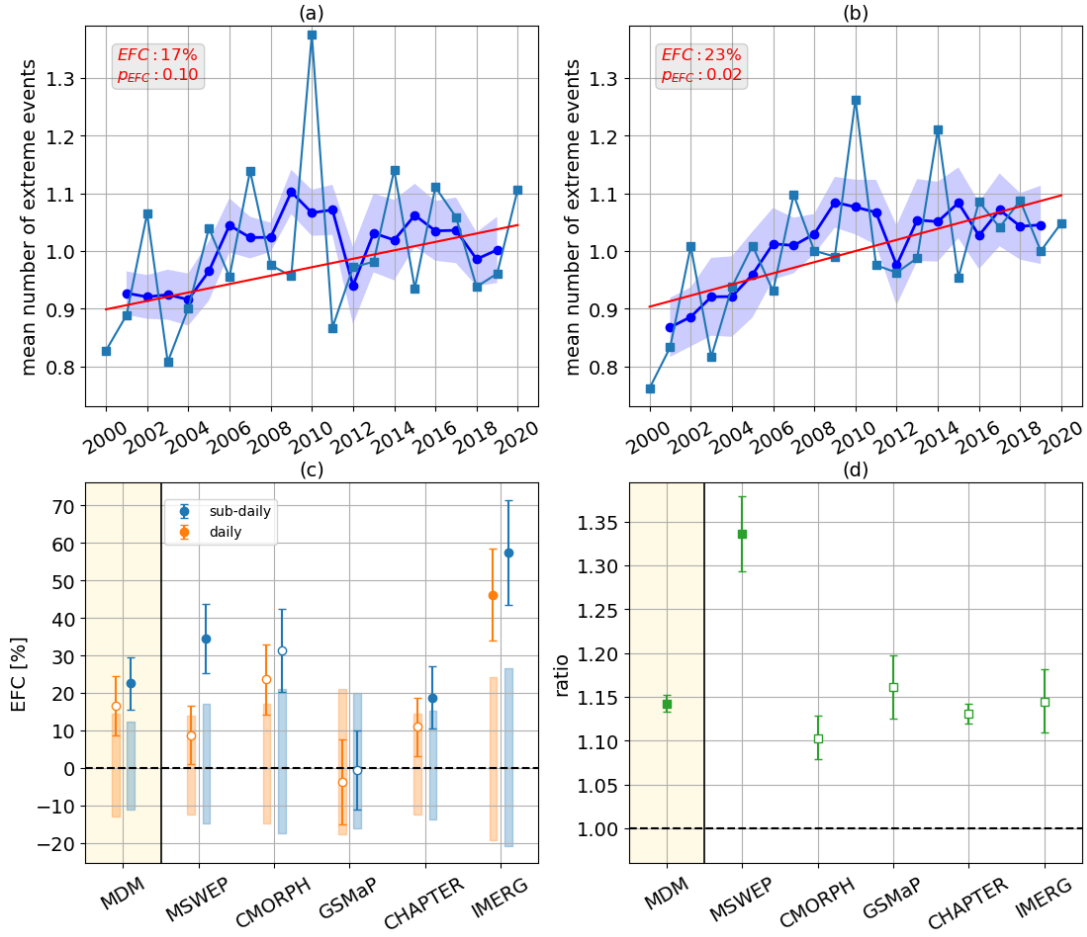


Figure S7: Same as Figure 4 but with trend estimation performed using Theil-Sen's slope estimator; statistical significance is assessed using Mann-Kendall test.

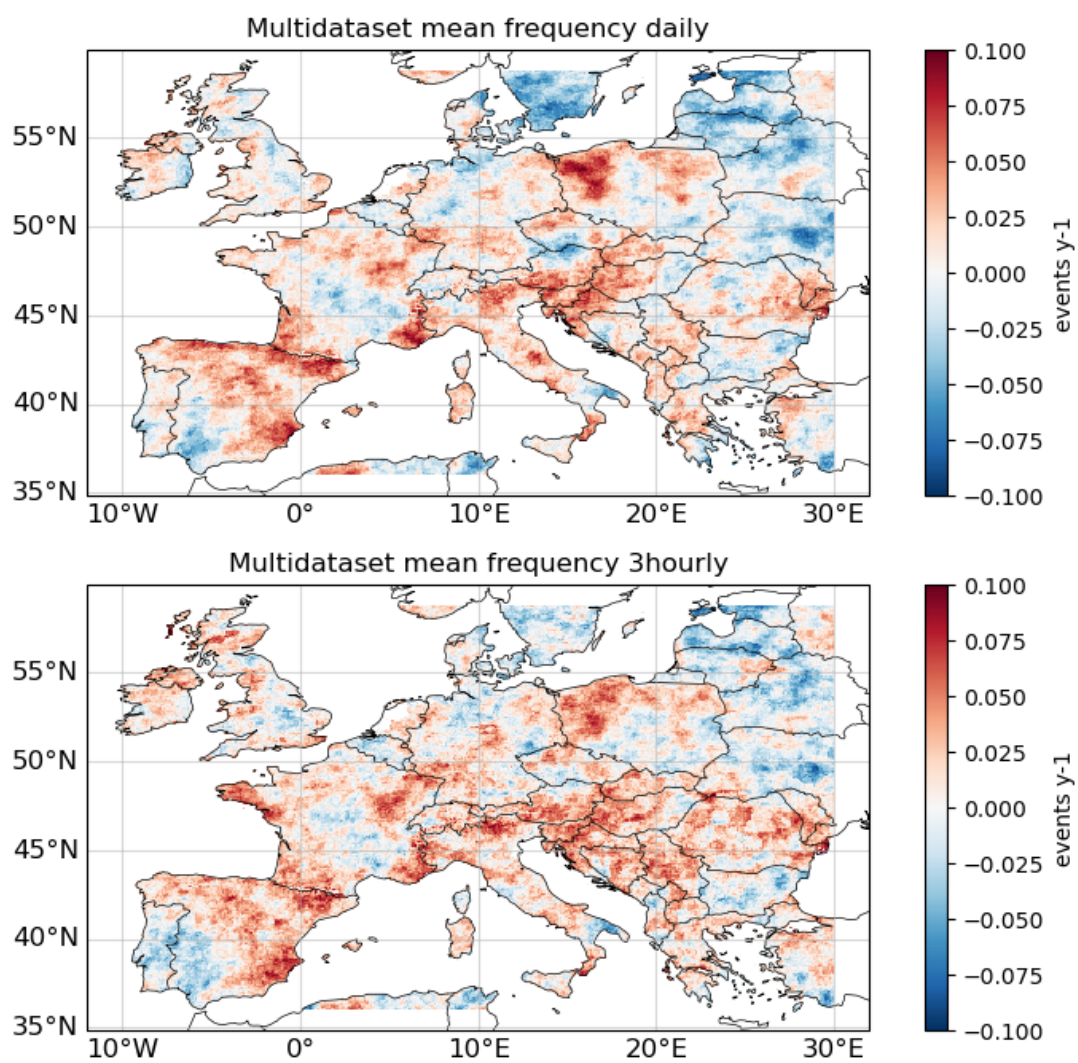


Figure S8: Multidatasets mean of daily subdaily trends (top and bottom panel respectively).

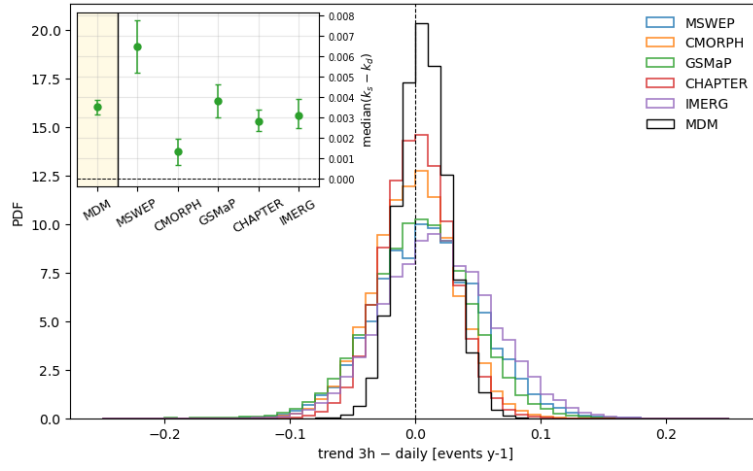


Figure S9: Pdf of the trends difference $k_s - k_d$ for all datasets and multi-dataset case. Inset: median of the trends difference $k_s - k_d$ for the all datasets and multi-dataset case.

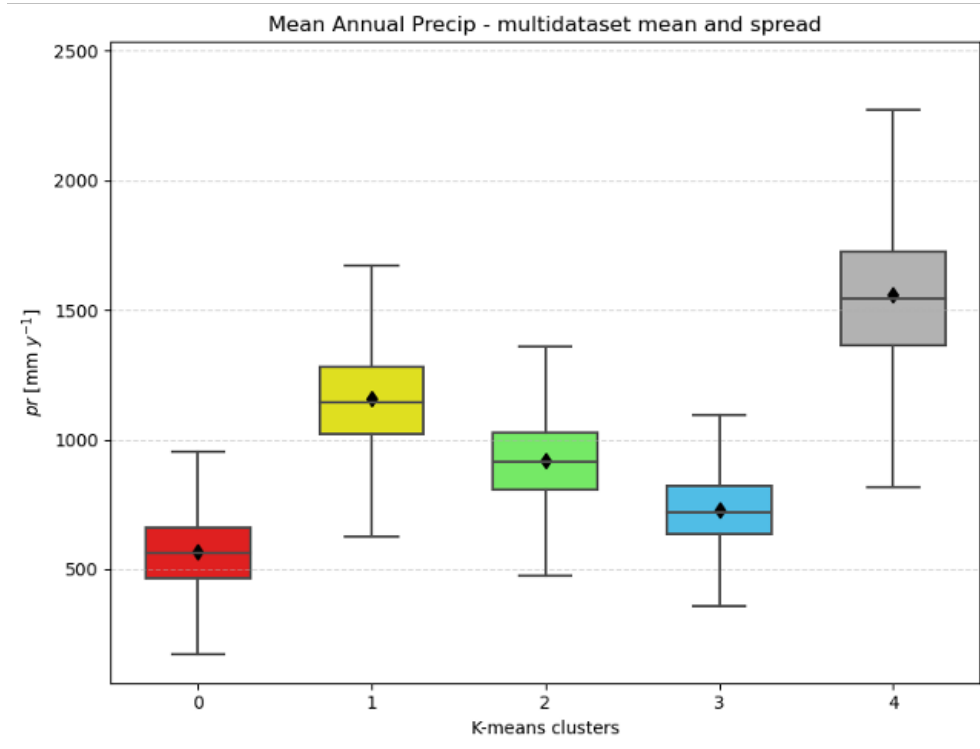


Figure S10: Boxplot of multidatasets mean of precipitation climatology for each cluster identified by K-means.

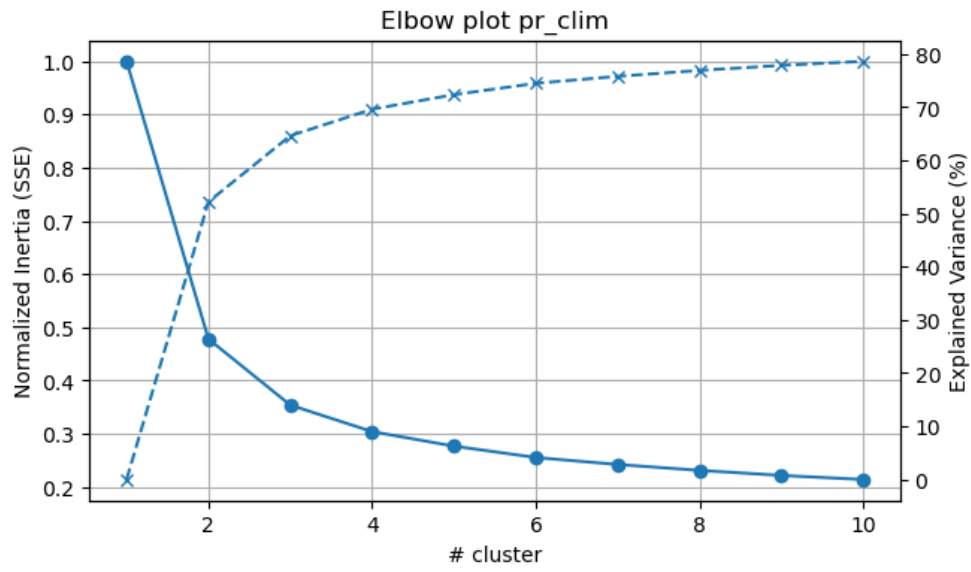


Figure S11: Elbow plot of multidatasets mean of precipitation climatology.

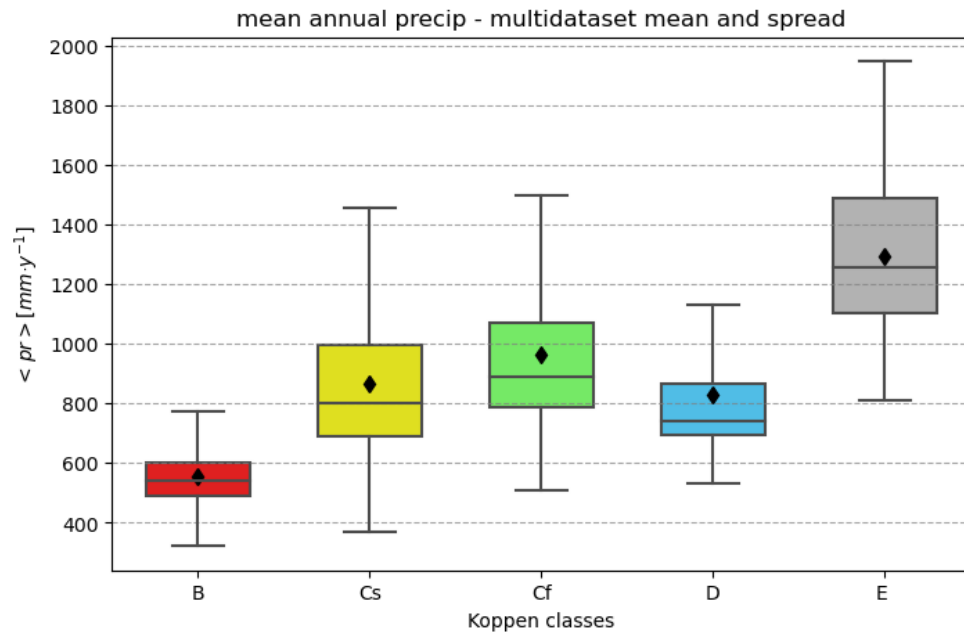


Figure S12: Boxplot of multidatasets mean of precipitation climatology for each Koppen-Geiger area.

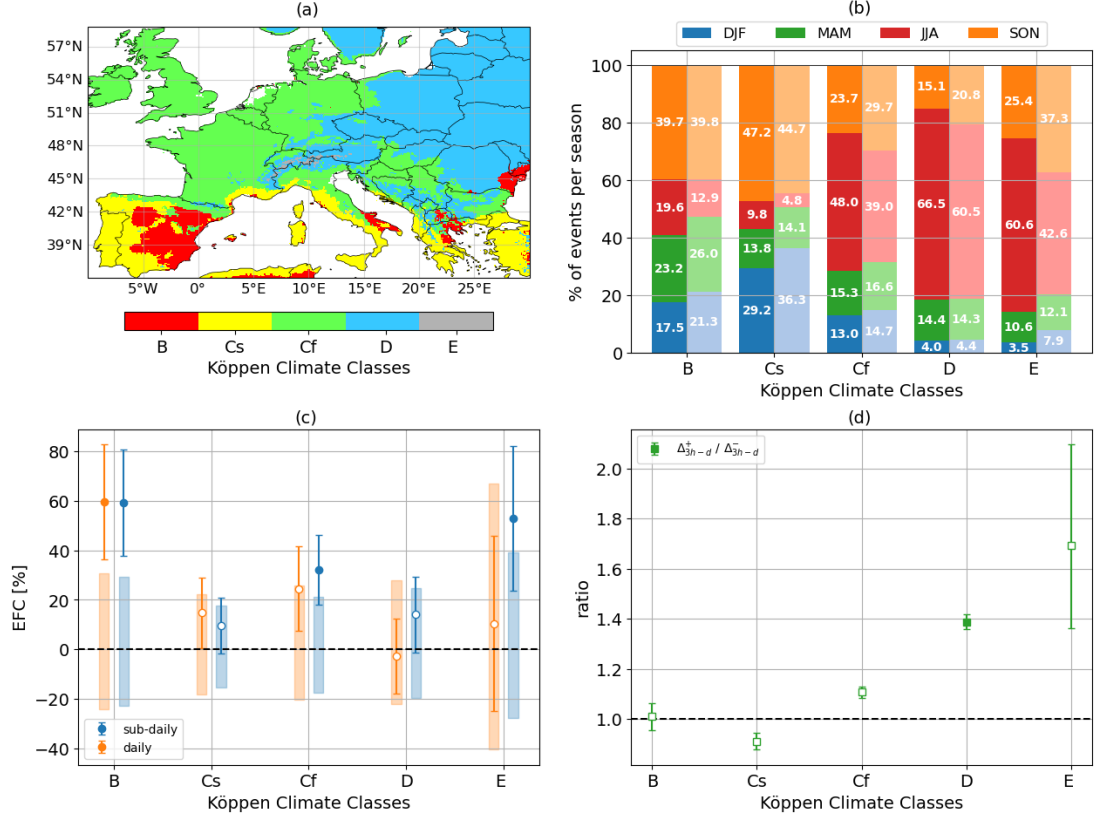


Figure S13: (a) Map of Köppen-Geiger classes. (b) Percentage of selected events per season (different colors) for each Köppen-Geiger class; solid and transparent color represent the sub-daily and daily cases, respectively. Summary of multidataset relative trends (c) and ratios (d) for each Köppen-Geiger class. Empty points are not statistically significant. Shaded bars around the zero lines (c) indicate the 95% confidence band of changes expected from internal variability alone, obtained applying a bootstrap technique using a Monte Carlo algorithm.

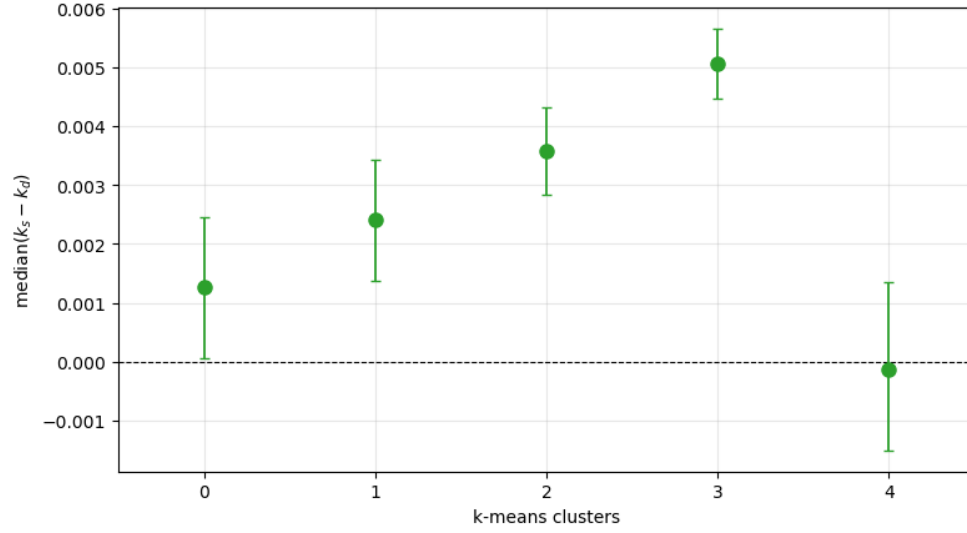


Figure S14: Regional median of the trends difference $k_s - k_d$ for the multi-dataset case.

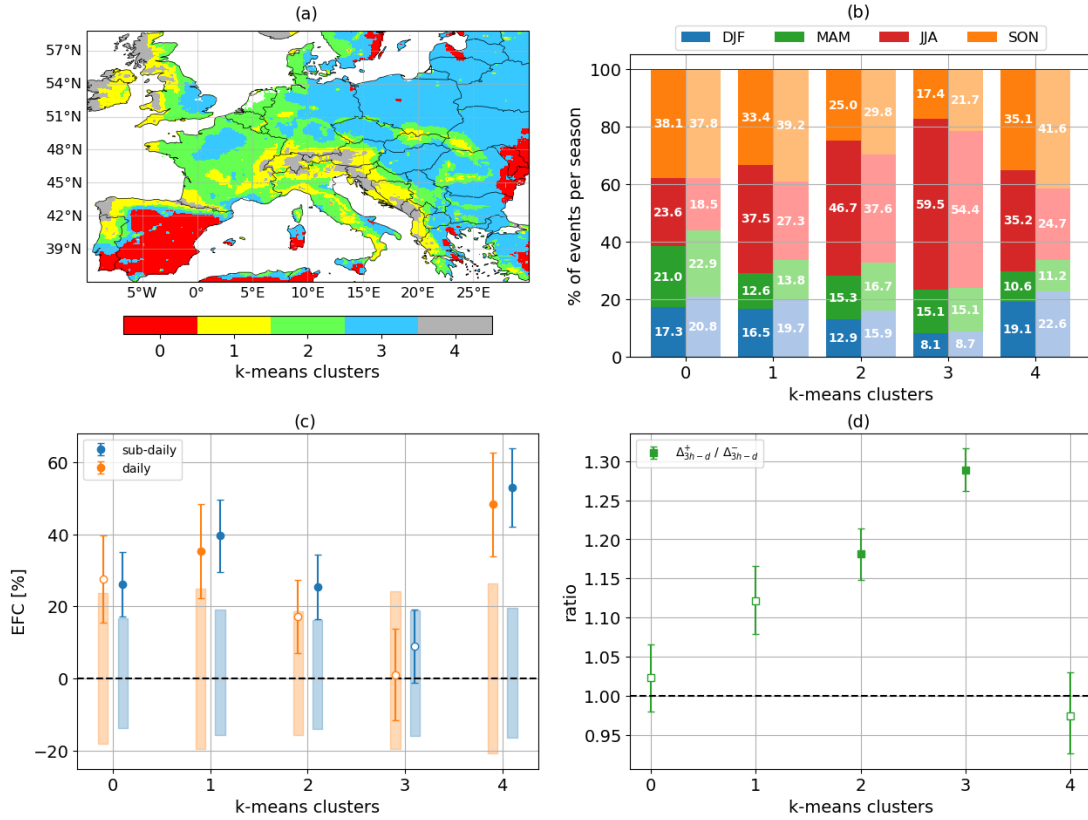


Figure S15: Same as Figure 4 but with trend estimation performed using Theil-Sen's slope estimator; statistical significance is assessed using Mann-Kendall test.

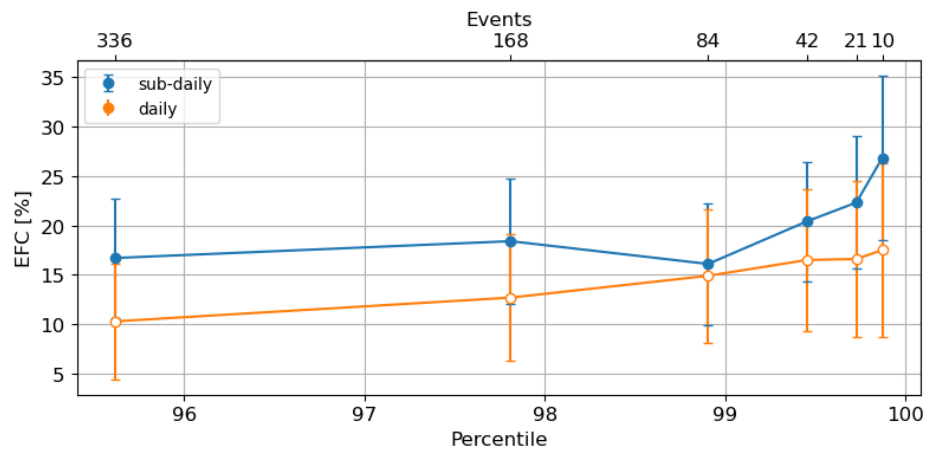


Figure S16: Same as Figure 5 but with trend estimation performed using Theil-Sen's slope estimator; statistical significance is assessed using Mann-Kendall test.

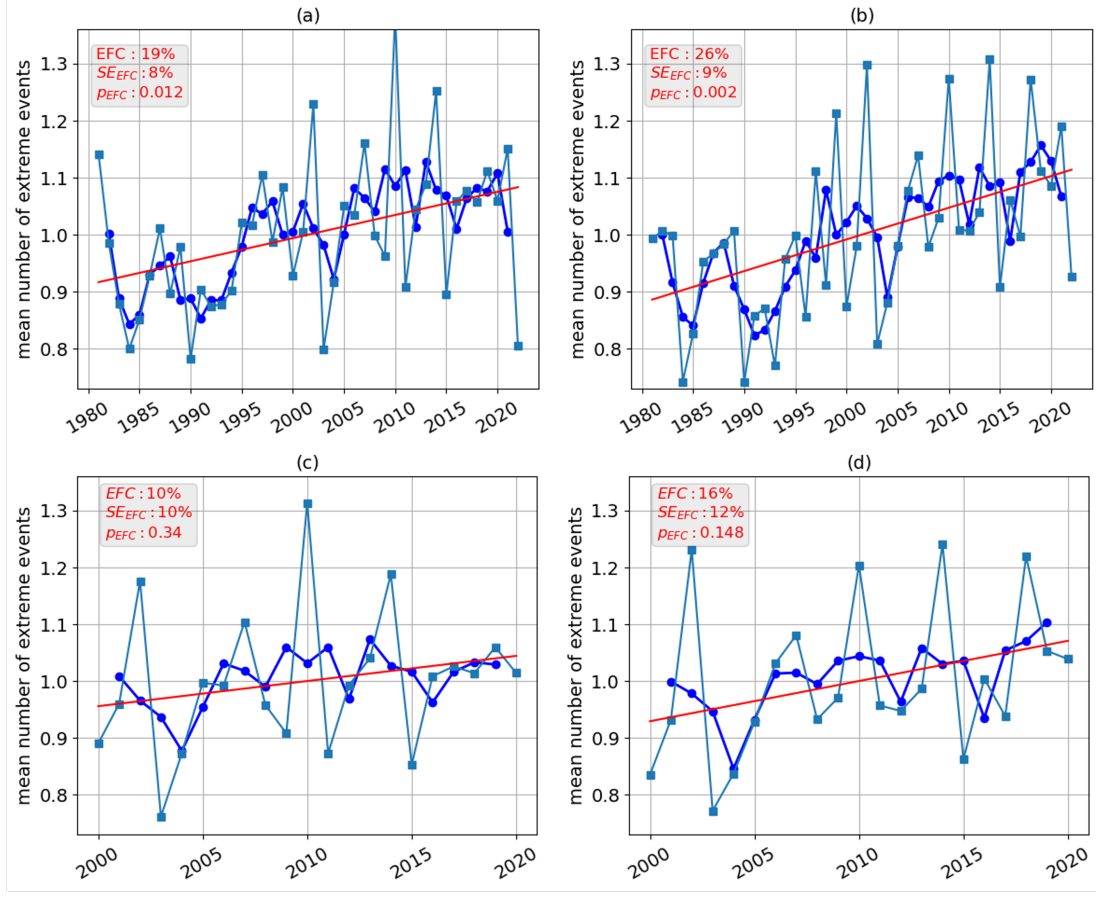


Figure S17: CHAPTER timeseries of the frequency of extreme events (light blue) and its 3-years running mean (blue) for daily (a) and sub-daily (b) in the longer period 1981-2022 and daily (c) and sub-daily (d) in the shorter period 2000-2020. Red line is the linear regression fitted directly to the raw annual timeseries.

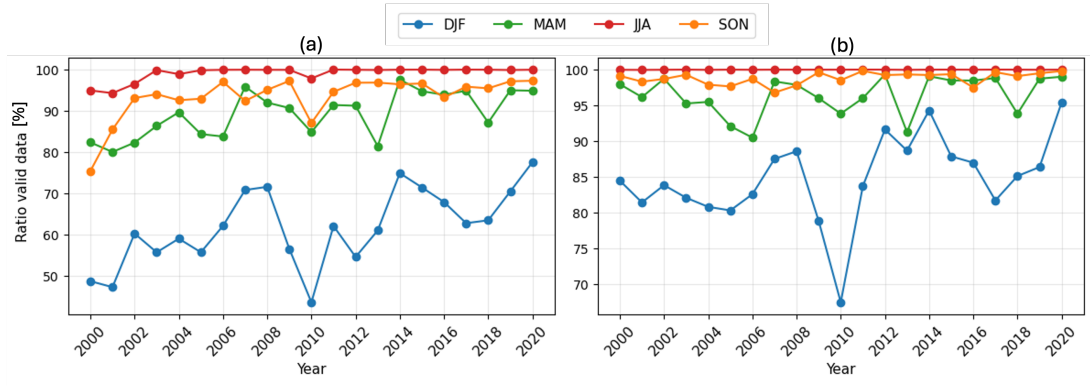


Figure S18: Seasonal ratio of valid data ($N_{valid}/N_{tot} \times 100$) for GSMaP (a) and IMERG (b).

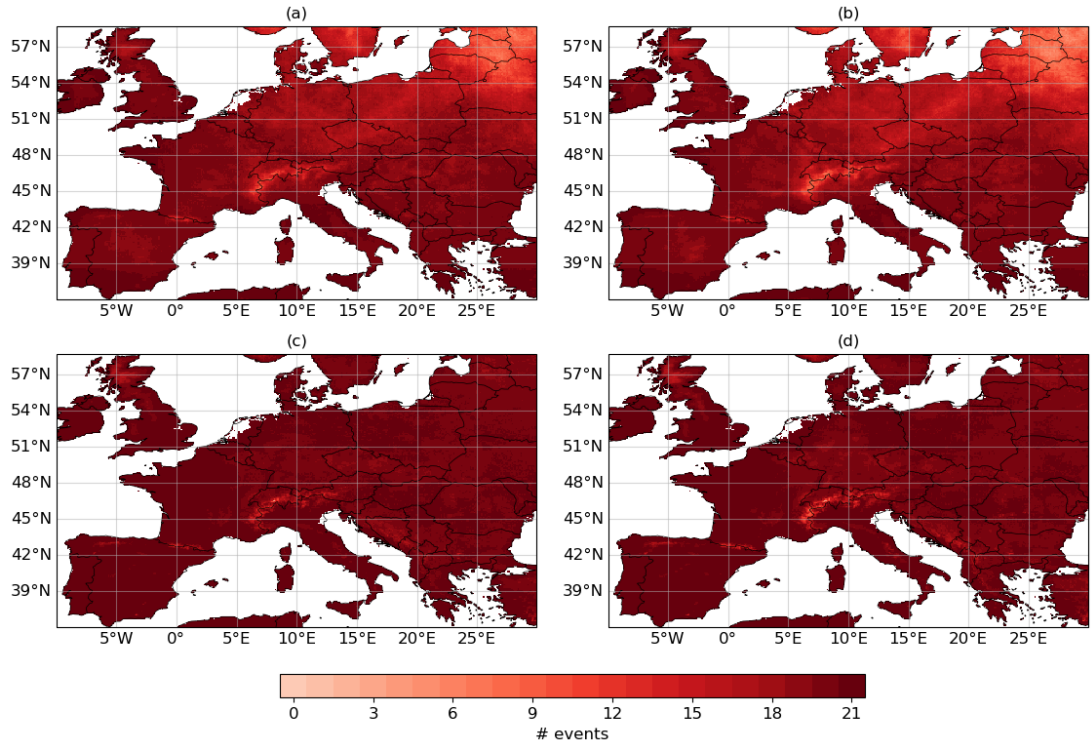


Figure S19: Maps of $N_{ev} \cdot \langle cf \rangle$ for GSMaP sub-daily (a) and daily (b), and for IMERG sub-daily (c) and daily (d).