Two-decades of GPM IMERG Early and Final Run Products Intercomparison: Similarity and Difference in Climatology, Rates, Extremes and Hydrologic Utilities

Zhi Li[1], Guoqiang Tang[2], Zhen Hong[1], Mengye Chen[3], Shang Gao[4], Pierre-Emmanuel Kirstetter[4], Jonathan Gourley[5], Teshome Yami[1], and Yang Hong[6]

[1]University of Oklahoma Norman Campus
[2]Tsinghua University
[3]The University of Oklahoma
[4]University of Oklahoma
[5]National Severe Storms Lab
[6]School of Civil Engineering and Environmental Sciences, University of Oklahoma

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Abstract

Precipitation is an essential climate and forcing variable for modeling the global water cycle. Particularly, the Integrated Multi-satellitE Retrievals for GPM (IMERG) product retrospectively provides unprecedented two-decades of high-resolution satellite precipitation estimates (0.1-deg, 30-min) globally. The primary goal of this study is to examine the similarities and differences between the two latest and also arguably most popular GPM IMERG Early and Final Run (ER and FR) products systematically over the globe. The results reveal that: (1) ER systematically estimates 13.0% higher annual rainfall than FR, particularly over land (13.8%); (2) ER and FR show less difference with instantaneous rates (Root Mean Squared Difference: RMSD=2.38 mm/h and normalized RMSD: RMSD_norm=1.10), especially in Europe (RMSD=2.16 mm/h) and cold areas (RMSD_norm=0.87); and (3) with similar detectability of extreme events and timely data delivery, ER is favored for use in hydrometeorological applications, especially in early warning of flooding. Throughout this study, large discrepancies between ER and FR are found in inland water bodies, (semi) arid regions, and complex terrains, possibly owing to morphing differences and gauge corrections while magnified by surface emissivity and precipitation dynamics. The exploration of their similarities and differences provides a first-order global assessment of various hydrological utilities: FR is designed to be more suitable for retrospective hydroclimatology and water resource management, while the earliest available ER product, though not bias-corrected by ground gauges, shows suitable applicability in operational modeling setting for early rainfall-triggered hazard alerts.

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Zhi Li

Hydrology and Water Security Program

Civil Engineering and Environmental Science

University of Oklahoma

Advisor: Prof. Yang Hong

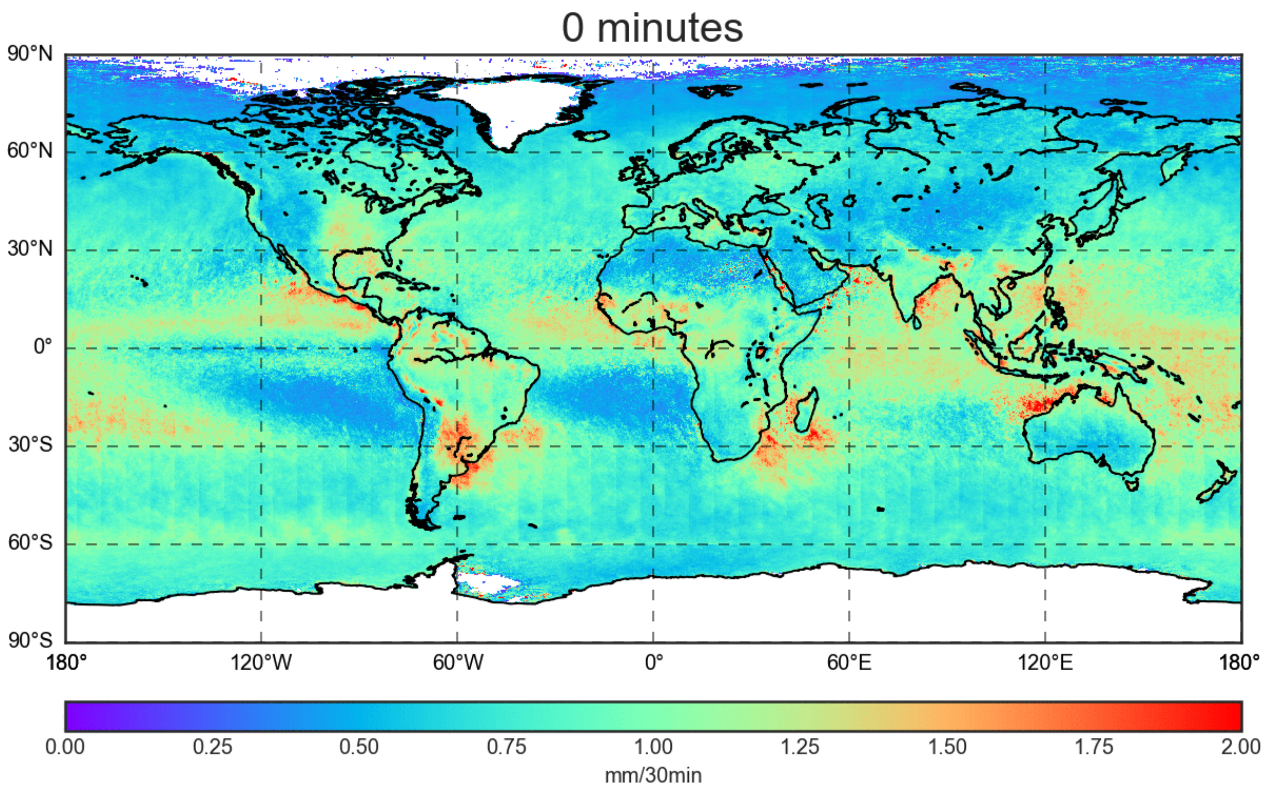
HYDROLOGY & WATER SECURITY PROGRAM
The UNIVERSITY of OKLAHOMA

Background

Satellite precipitation products are vital for:

1) Providing global observations
2) Developing precipitation climatology
3) Hydrometeorological applications

This year marks the two-decades satellite precipitation measurements over the globe



Background

IMERG (Integrated Multi-satellitE Retrievals for Global Precipitation Measurement)

Early (~4 hours latency): operational products for flash flooding.

Late (~12 hours latency): refined products for crop forecasting.

Final (~3 months latency): research-basis products.

Temporal resolution: 30min/day/month (2000-)

Spatial resolution: 0.1° (90° N-S/180° W-E)

Ref: Huffman, G. J., E.F. Stocker, D.T. Bolvin, E.J. Nelkin, Jackson Tan (2019). GPM IMERG Final Precipitation L3 Half Hourly 0.1 degree x 0.1 degree V06. Greenbelt, MD, Goddard Earth Sciences Data and Information Services Center (GES DISC).

Objectives and Methodology

Systematically investigate the **similarity and difference** between the GPM **IMERG Early and Final Run products** over the globe for the last two decades (from 2000.06 to 2019.06)

Why Early and Final are selected?

1. Early: operational product to monitor water-related natural hazards
2. Final: high accuracy and research based (with gauge justification)
3. Late: only marginal improvement compared to Early (Mazzoglio et al.,2019; O et al., 2017)

Comparisons from three aspects:

1) Precipitation climatology (long timescale – mm/year)
2) Instantaneous rates (short timescale – mm/hour)
3) Extreme precipitation events

Objectives and Methodology

The main differences between Early and Final includes:

	Early run	Final run
Latency	~4 hours	~3 months (more PMW data)
Morphing algorithm	Forward morphing	Forward and backward morphing
Motion vector	GEOS-FP	MERRA-2
Rotation calibration with CORRA	Trailing approach	Centered approach
Calibration	Climatological coefficients (vary by month and location)	Monthly gauge adjustments

Results: General assessment

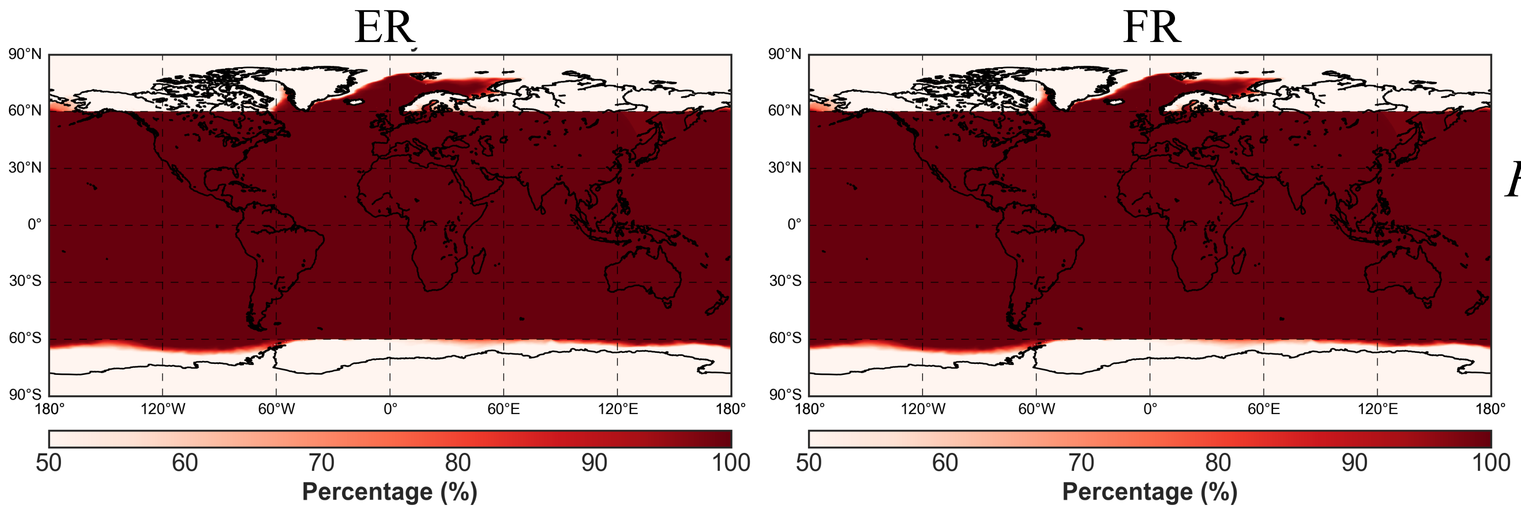


Fig.1 Data availability for Early Run (ER) and Final Run (FR)

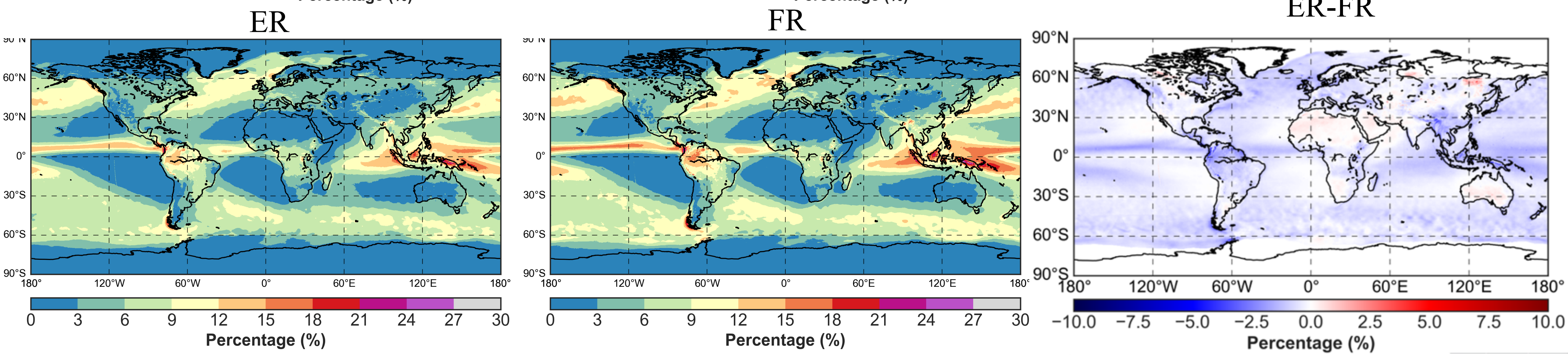


Fig.2 Global rainy probabilities (occurrence percent) for ER and FR at hourly scale

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Results: General assessment

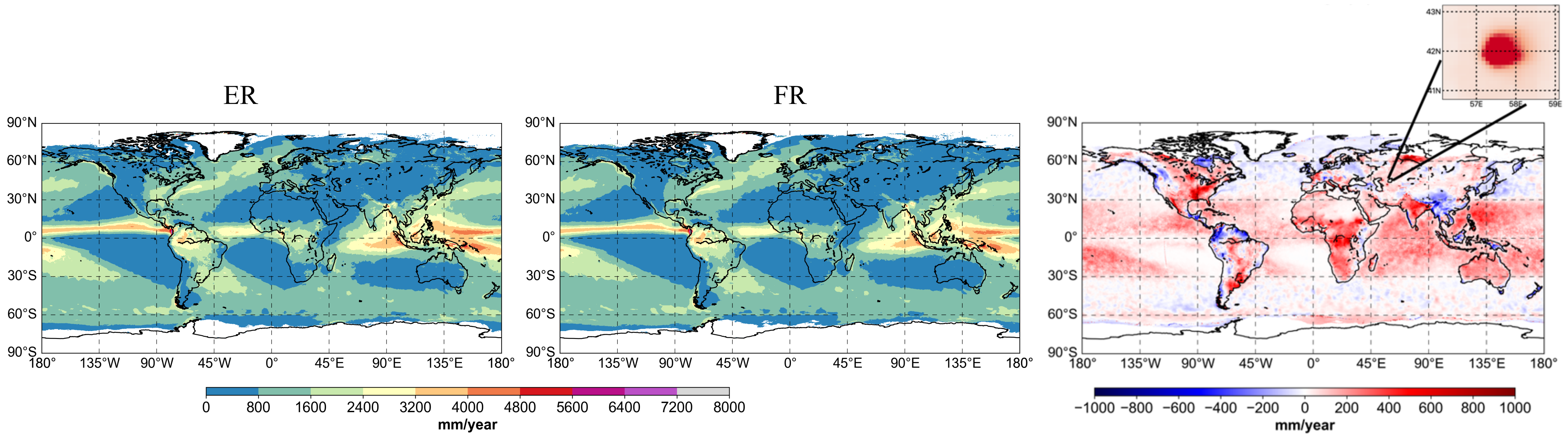

Fig.3 Annual rainfall amount for ER and FR, and ER-FR

Results: General assessment

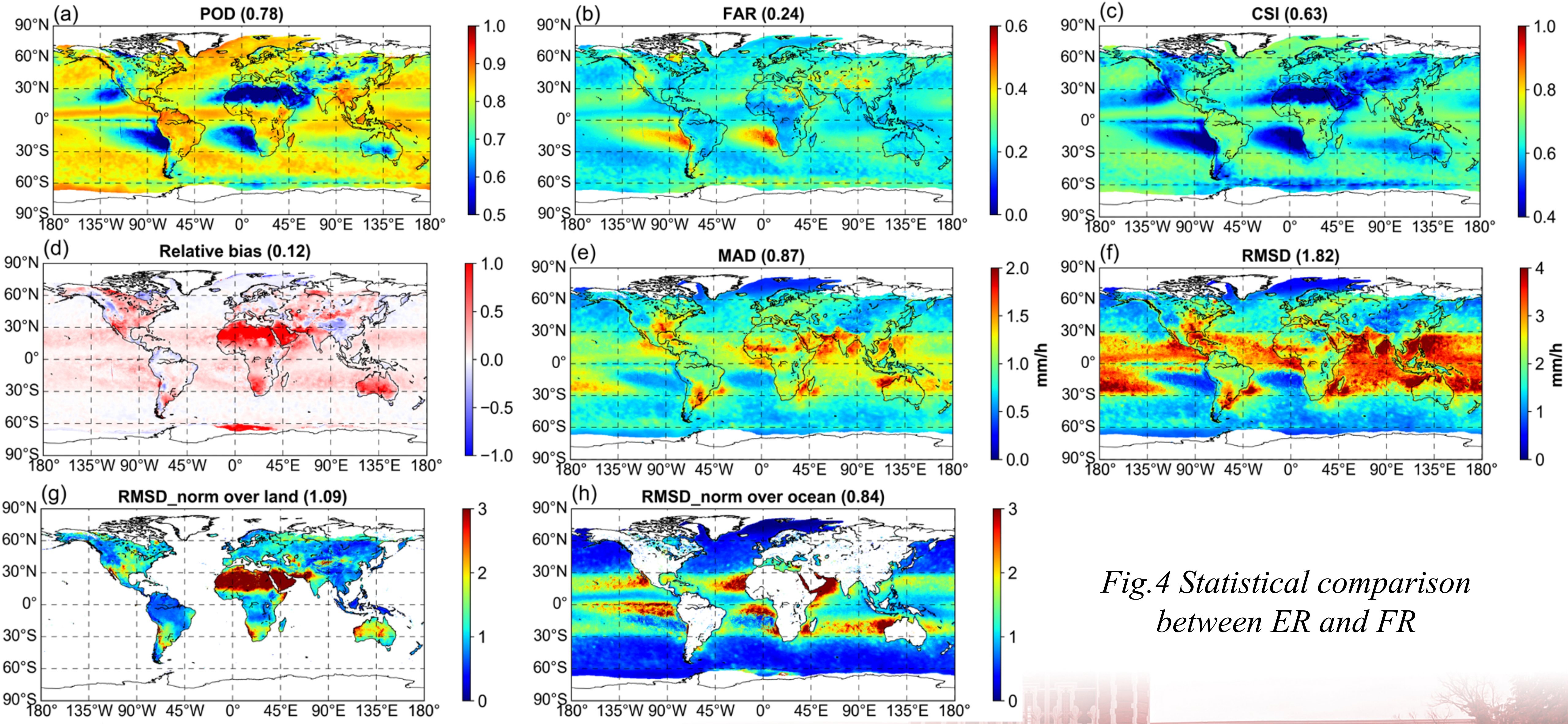

Fig.4 Statistical comparison between ER and FR

Results: Latitude

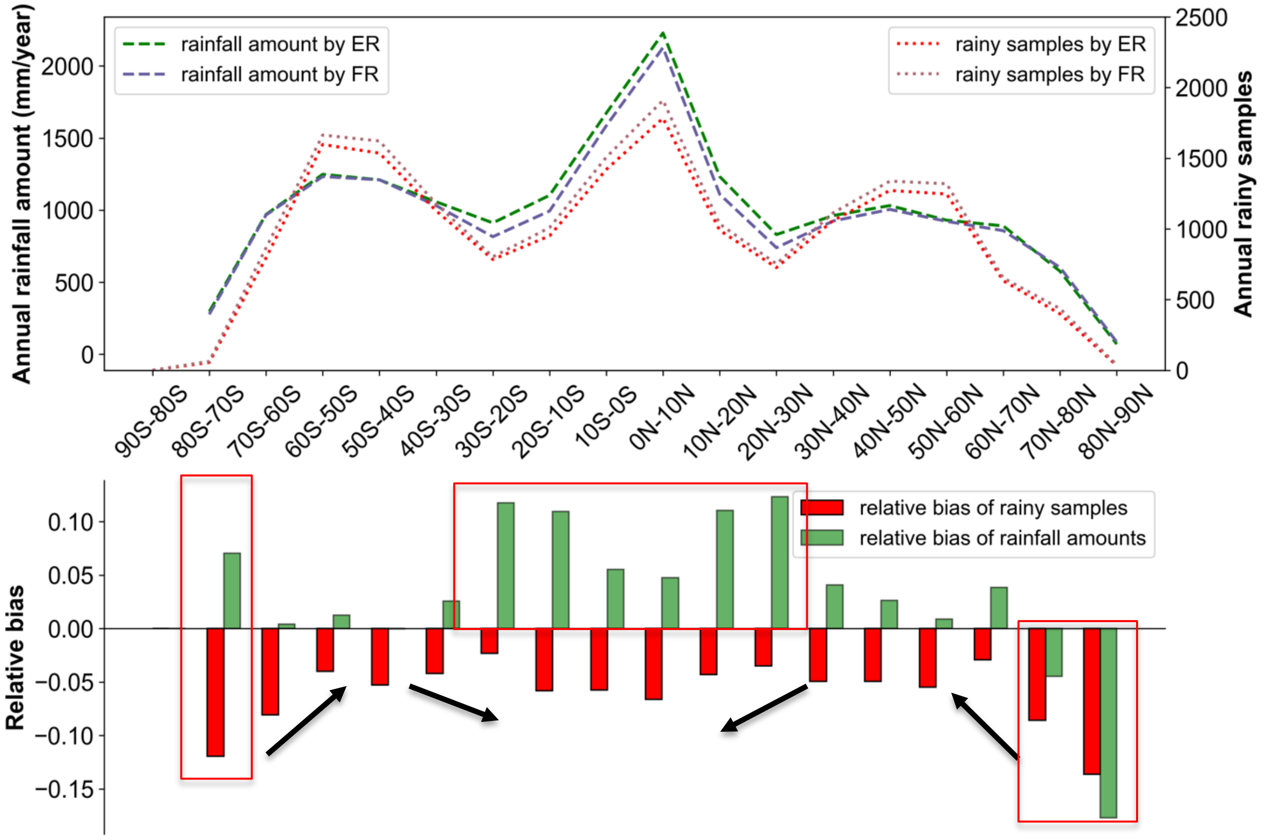

Fig.5 Annual rainfall and rainy samples across latitudes.
The upper panel is the absolute values and lower panel is the relative bias

Results: Surface type and elevation

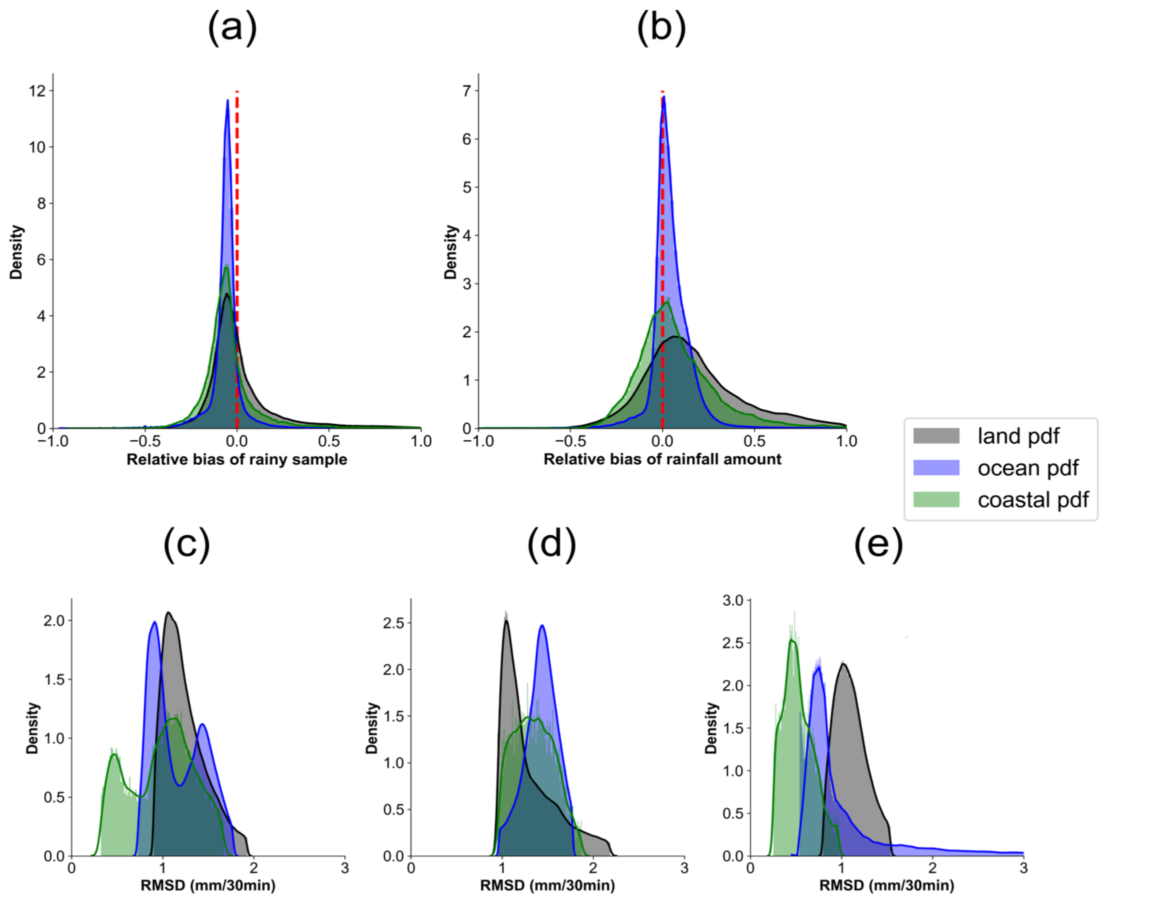

Fig.6 The probability density function of relative bias and RMSD for three earth surface types: (a) and (b) are the relative bias of rainy samples and annual rainfall; (c) is the RMSD distributed in the globe; (d) and (e) are the RMSD within 30NS and outside 60NS.

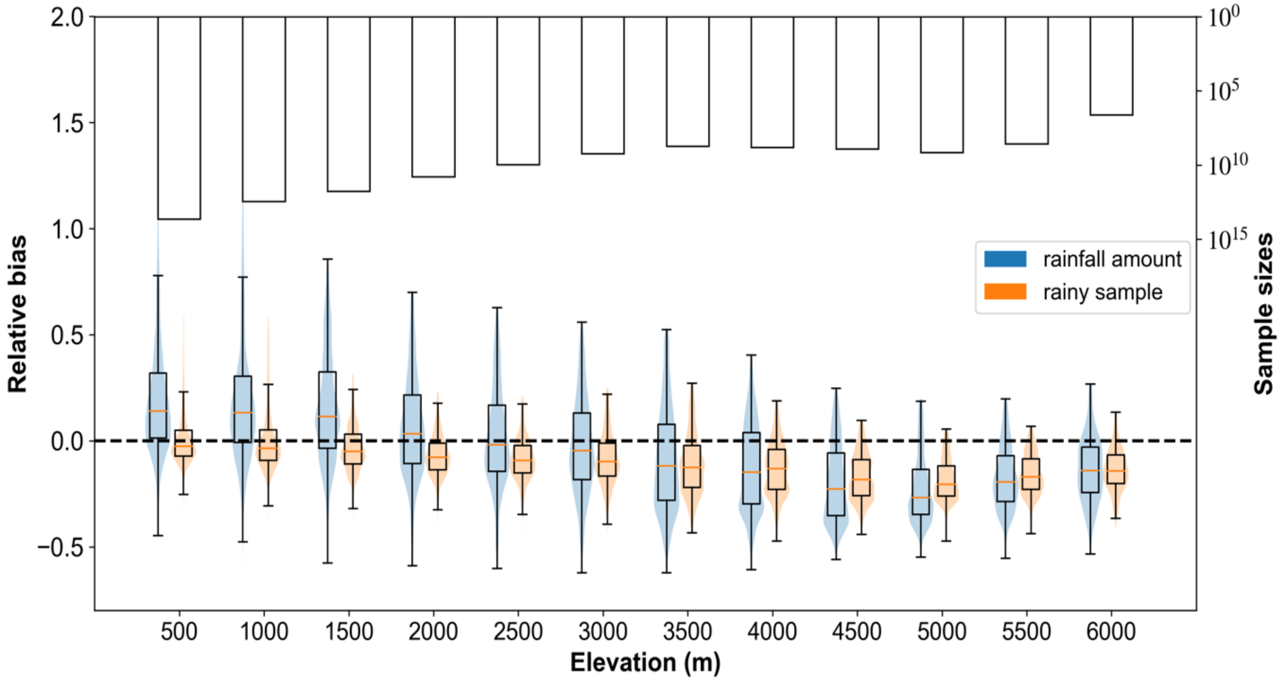

Fig.7 Relative bias of rainy samples and annual rainfall at different elevations. The respective sample sizes within each elevation bin in the upper x-axis corresponds to the right y-axis in the logarithmic scale.

Results: impact due to gauge density

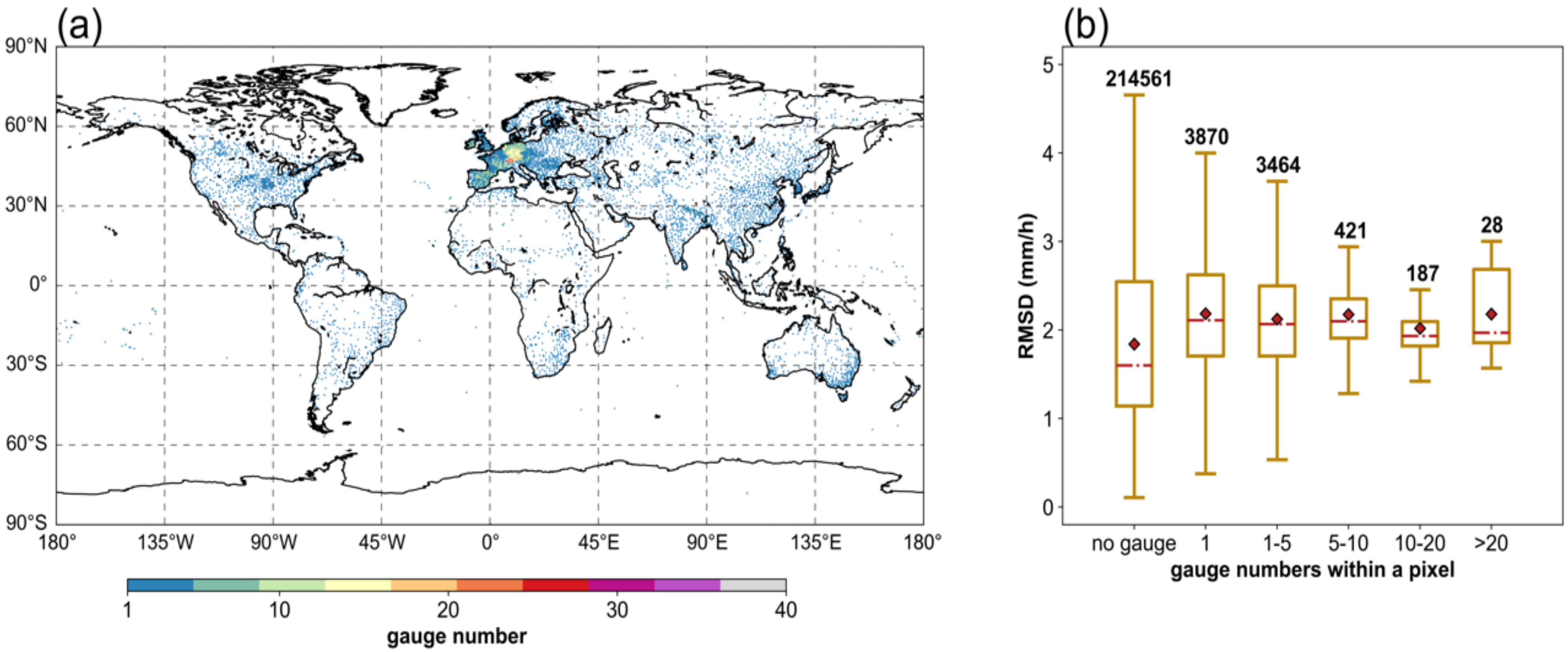

Fig.8 Spatial distribution of GPCC gauge numbers (applied to 2016-12) (a), and the Root Mean Square Difference (RMSD) as a function of gauge number within a grid box (b). The marker in (b) shows the mean value of the RMSD; the number in the above of each box indicates the number of pixels.

Results: Köppen-Geiger climate classification

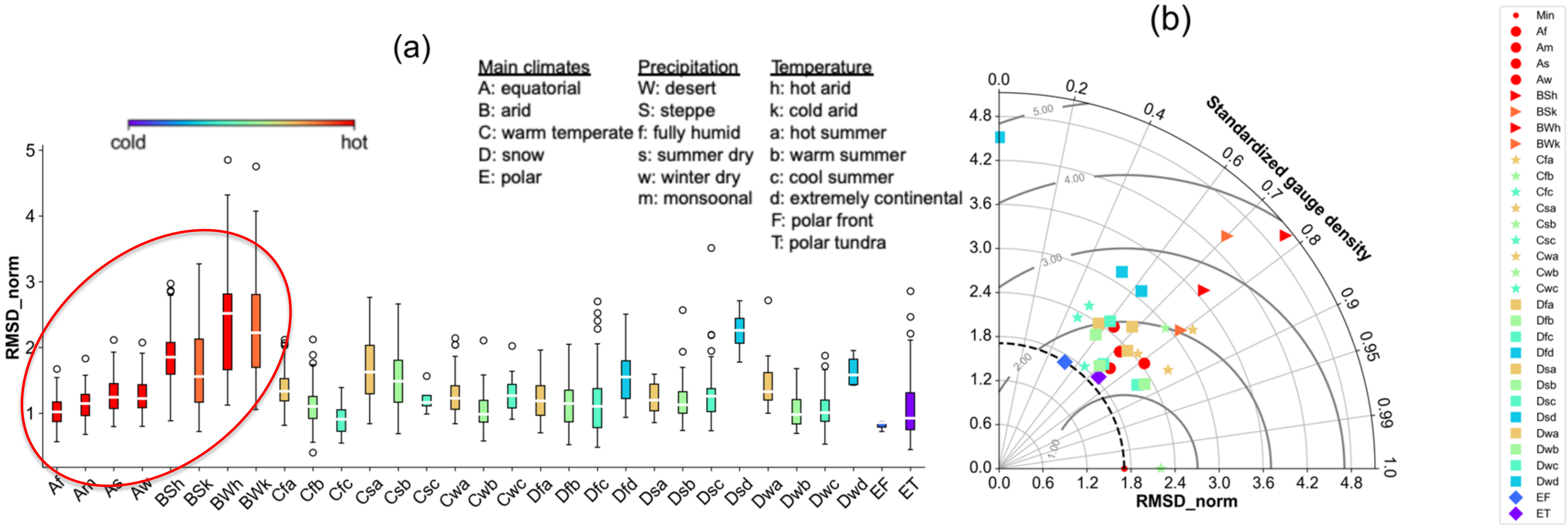

Fig.10 Distribution of the normalized RMSD in different climate zones by Köppen-Geiger classification: (a) Boxplot of RMSD_norm; (b) Taylor plot of the mean RMSD and complementary standardized gauge density (standardized by Cwb). All the boxes/markers are color-coded from cold to hot temperature.

Results: Extreme events at 99th percentile

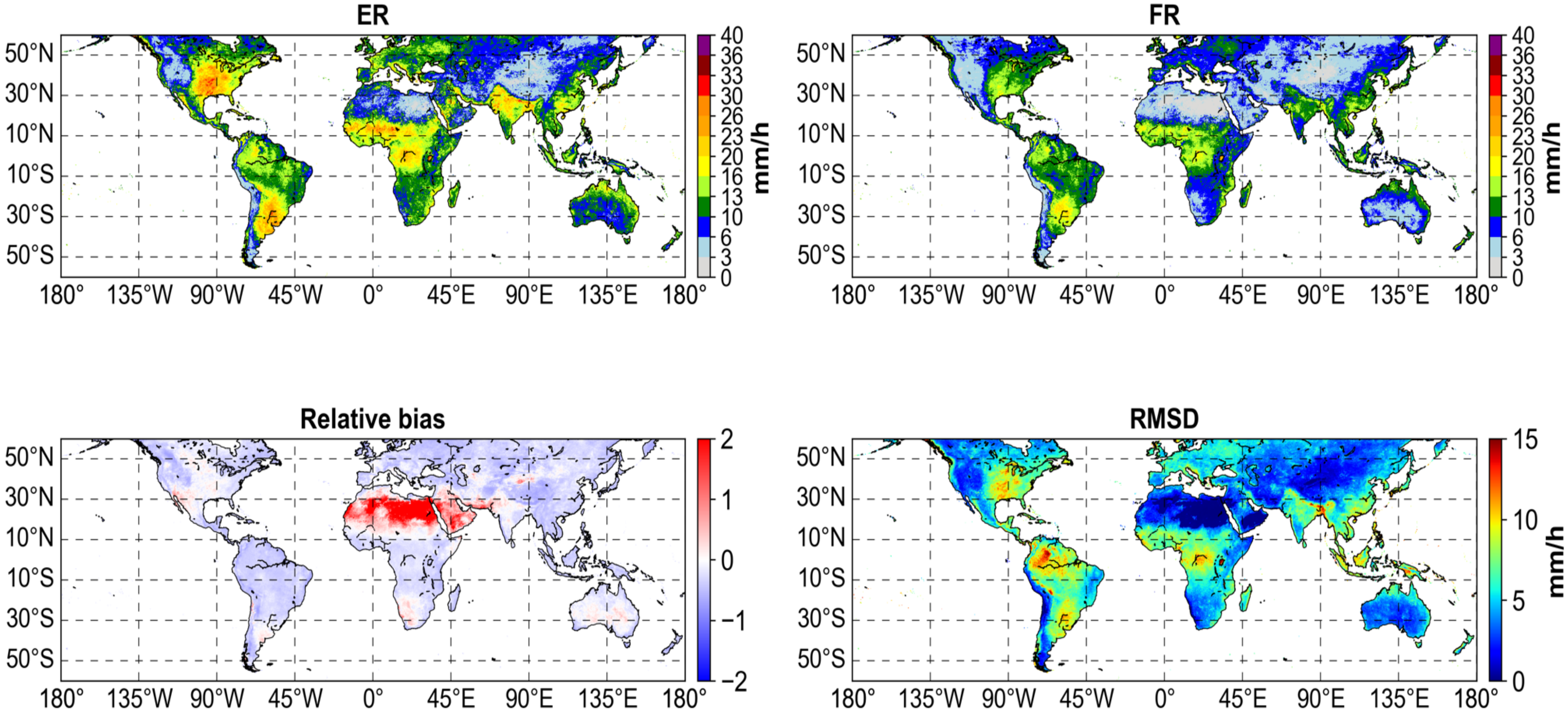

Fig.11 The global map of extreme rainfall rate (ER and FR) and the conditioned relative bias and RMSD.

Conclusions

1. *ER* systematically estimates 12.0% **higher** annual rainfall than *FR*, particularly over land surface (16.7%)
2. *ER* and *FR* show significant differences in instantaneous rates, especially in **Africa** and **hot, arid** regions
3. *ER* measures 33.0% **higher** extreme rainfall rates than *FR* over the globe, which needs special care for near-real-time rainfall monitoring

Thanks for your attention!