Table S1 An overview of the currently popular (quasi)global precipitation products. Abbreviations: satellite (S); reanalysis (R); gauge (G). "global" denotes that the precipitation information covers full global coverage, while "land" indicates that the precipitation information only limits in land surface.

Data type	Name	Full name	Data source (s)	Temporal resolution	Spatial resolution	Temporal coverage	Spatial coverage	Reference (s)
Satellite	IMERG-Late	Integrated Multisatellite Retrievals for Global Precipitation Measurement Late Run	S	30 min	0.1°	2000-NRT	60°N/S	Huffman et al. (2019)
	TMPA 3B42RT	TRMM Multi-satellite Precipitation Analysis (TMPA) 3B42RT V7	S	3 hourly	0.25°	2000-2020	50°N/S	Huffman et al. (2007)
	GSMaP-MVK	Global Satellite Mapping of Precipitation Moving Vector with Kalman	S	Hourly	0.1°	2000-NRT	60°N/S	Ushio et al. (2009)
	PERSIANN-CCS	Precipitation Estimation from Remotely Sensed Information using Artificial Neural	S	Hourly	0.04°	2003-NRT	60°N/S	Hong et al. (2004)

		Networks-Cloud Classification System						
	CHIRP	Climate Hazards group Infrared Precipitation	S	Daily	0.05°	1981-present	50°N/S	Funk et al. (2015)
	CMORPH	CPC morphing technique (CMORPH) V1.0 and V0.x	S	30 min	8 km	1998-NRT	60°N/S	Joyce et al. (2004)
	SM2RAIN-ASCAT	Based on ASCAT data	S	Daily	0.5°	2007-2015	Global	Brocca et al. (2014)
	GridSat	Derived from the Gridded Satellite (GridSat) B1 infrared archive V02R01 using CDF matching	S	3 hourly	0.1°	1980-2016	70°N/S	Knapp et al. (2011)
Reanalysis	ERA5	Fifth generation of ECMWF atmospheric reanalyses of the global climate	R	Hourly	0.25°	1959-present	Global	C3S (2017)
	JRA-55	Japanese 55-year Reanalysis	R	3 hourly	~ 60 km	1959-NRT	Global	Kobayashi et al. (2015)
	NCEP-CFSR	National Centers for Environmental Prediction	R	Hourly	0.3125°	1979-2010	Global	Saha et al. (2010)

		(NCEP) Climate Forecast System Reanalysis (CFSR)					
	CPCU	Climate Prediction Center (CPC) Unified	G	Daily	0.5°	1979-present	Global	Xie et al. (2007), Chen et al. (2008)
	CRU	Climatic Research Unit (CRU) Time-Series (TS)	G	Monthly	0.5°	1901-2014	Global	Harris et al. (2013)
Ground	GPCC	Global Precipitation Climatology Centre (GPCC) Full Data Reanalysis	G	Monthly	0.5°	1901-present	Global	Schneider et al. (2014)
	UDEL	University of Delaware (UDEL)	G	Monthly	0.5°	1901-2014	Global	Matsuura and Willmott (2009)
	PREC/L	PRECipitation REConstruction over Land (PREC/L)	G	Monthly	0.5°	1948-present	Global	Chen et al. (2002)
	WorldClim	WorldClim V2.0 monthly climatic dataset,	G	Monthly	~ 1 km	Climatic	Global	Fick and Hijmans

		corrected for gauge-undercatch and orographic effects						(2017)
	IMERG-Final	Integrated Multisatellite Retrievals for Global Precipitation Measurement Final Run	S, G	30 min	0.1°	2000-present	60°N/S	Huffman et al. (2019)
	TMPA 3B42	TRMM Multi-satellite Precipitation Analysis (TMPA) 3B42 V7	S, G	3 hourly	0.25°	2000-2020	50°N/S	Huffman et al. (2007)
Gauge-adjusted products	GSMaP-Gauge	Gauge-adjusted Global Satellite Mapping of Precipitation	S, G	Hourly	0.1°	2000-present	60°N/S	Mega et al. (2019)
	PERSIANN-CDR	Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) Climate Data Record (CDR)	S, G	Daily	0.25°	1983-present	60°N/S	Ashouri et al. (2015)
	CHIRPS	Climate Hazards group Infrared Precipitation	S, G	Daily	0.05°	1981-present	50°N/S	Funk et al. (2015)

	with Station						
CMORPH-CRT	Climate Prediction Center (CPC) MORPHing technique bias corrected	S, G	3 hourly	0.25°	1998-present	60°N/S	Joyce et al. (2004)
GPCP 2.3	Global Precipitation Climatology Project (GPCP) monthly analysis product V2.3	S, G	Monthly	2.5°	1996-NRT	Global	Adler et al. (2003, 2018)
MERRA-2	Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2)	R, G	Hourly	~ 50 km	1980-NRT	Global	Reichle et al. (2017)
MERRA-Land	Modern Era Retrospective-Analysis for Research and Applications (MERRA)-Land	R, G	Hourly	0.5°×0.67°	1979-present	Global	Reichle et al. (2011)
PFD	Princeton global meteorological Forcing Dataset	R, G	3 hourly	0.25°	1948-2012	Global	Sheffield et al. (2006)
WFDEI	WATCH Forcing Data ERA-Interim (WFDEI)	R, G	3 hourly	0.25°	1979-2014	Global	Weedon et al. (2014)

Multi-source merged products	MSWEP V2.8	Multi-Source Weighted Ensemble Precipitation (MSWEP) V2.8	R, G, S	3 hourly	0.1°	1979-present	Global	Beck et al. (2017, 2019)
	MGP	Multi-source Merged Global Precipitation Product (MGP)	R, G, S	Hourly	0.25°	2001-2020	Land	This study
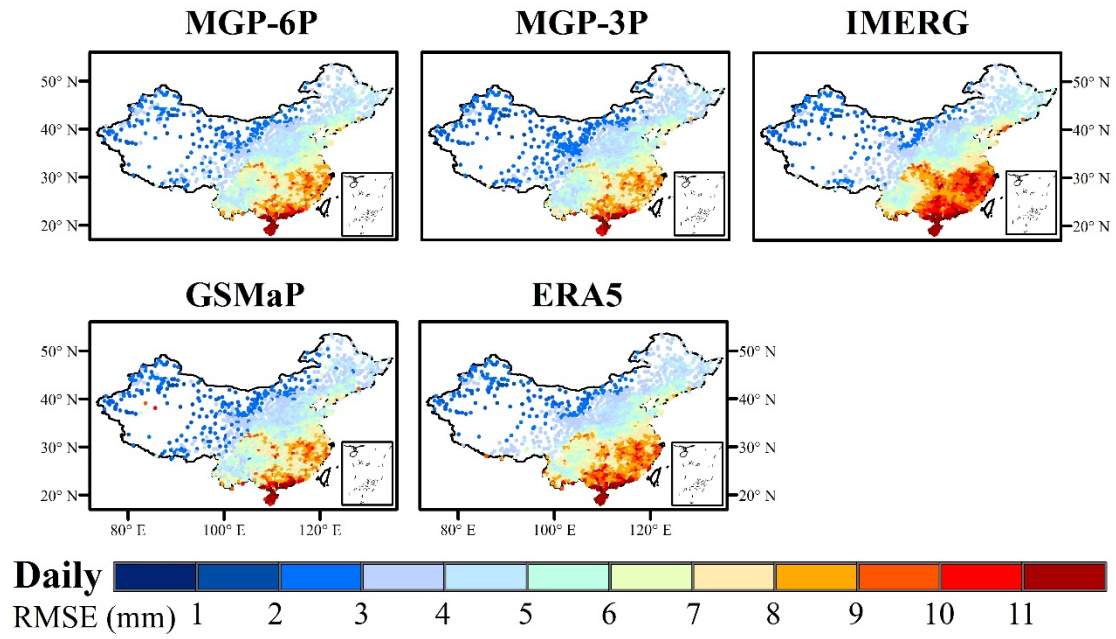
Fig. S1 Spatial maps of RMSE for the five global precipitation products (i.e., MGP-6P, MGP-3P, IMERG, GSMaP, and ERA5) at a daily scale over mainland China.
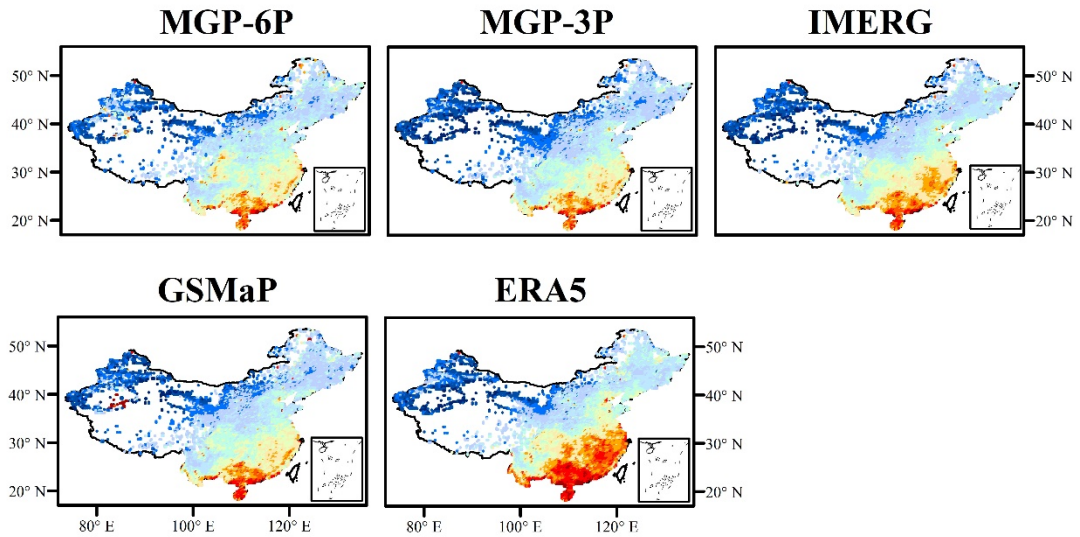
Fig. S2 Spatial maps of RMSE for the five global precipitation products (i.e., MGP-6P, MGP-3P, IMERG, GSMaP, and ERA5) at an hourly scale over mainland China.
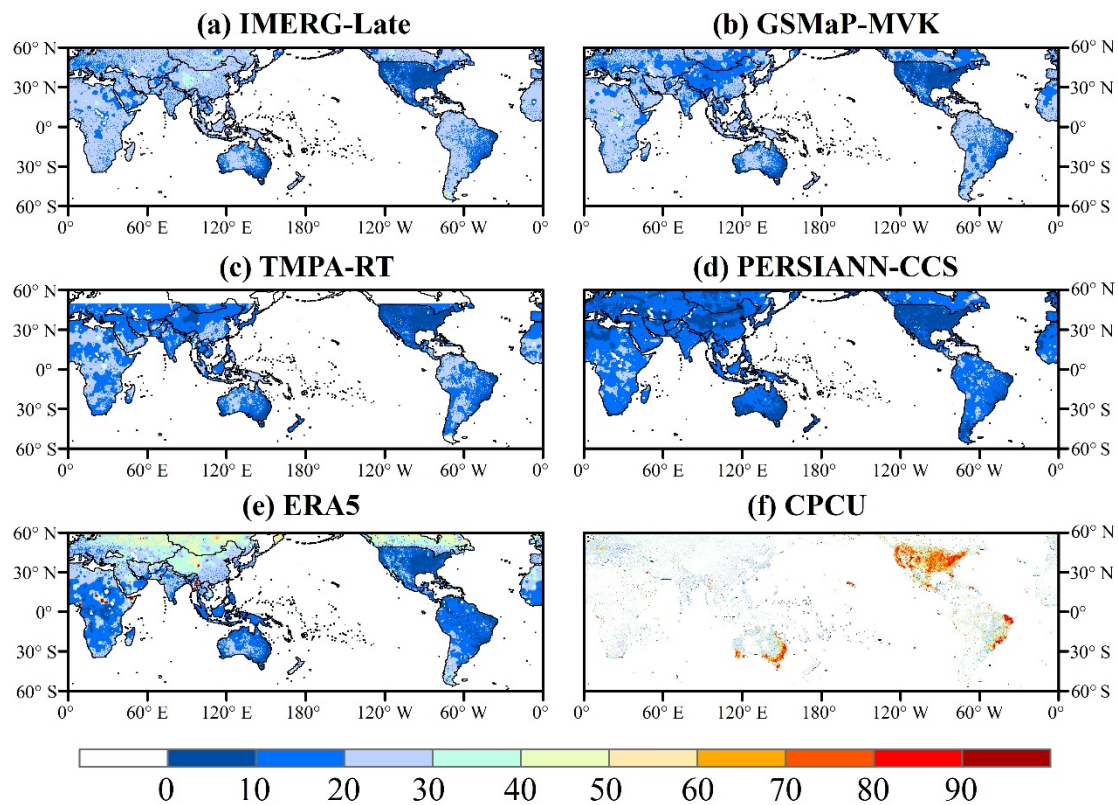
Fig. S3 Global land maps of the weights designed to satellites (i.e., IMERG-Late, GSMaP-MVK, TMPA-RT, and PERSIANN-CCS), reanalysis (i.e., ERA5), and CPCU for scheme 1 during MAM.
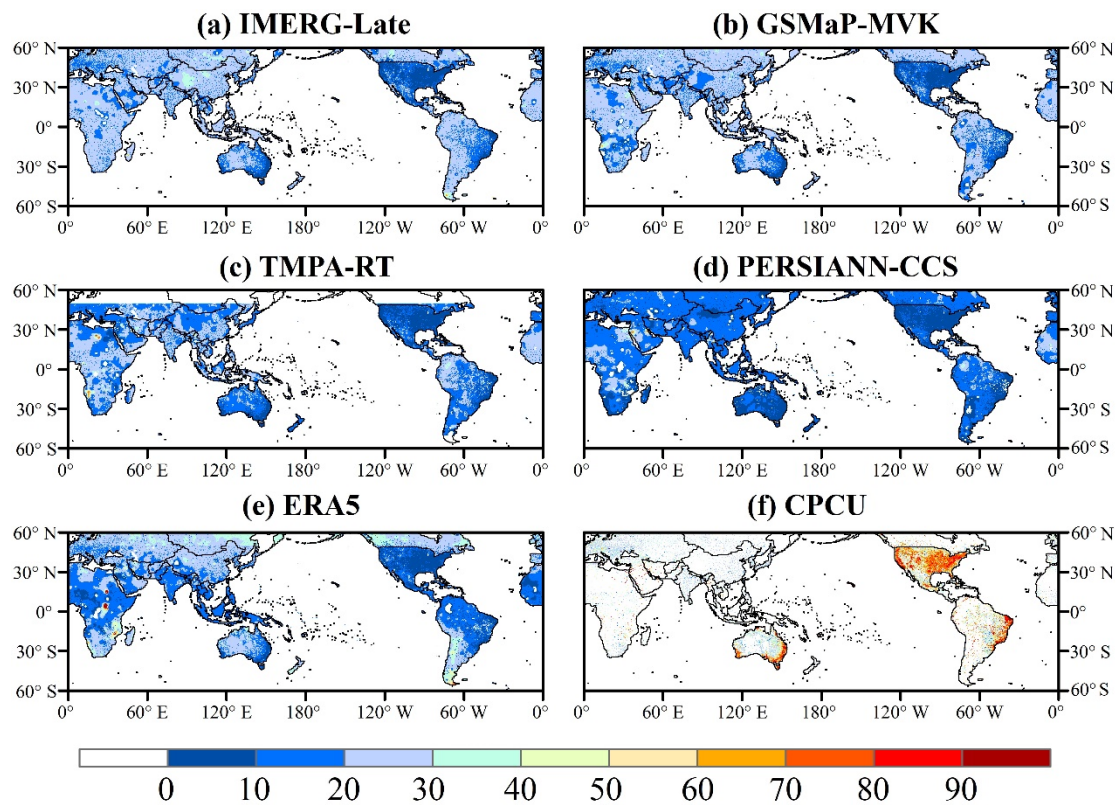
Fig. S4 Global land maps of the weights designed to satellites (i.e., IMERG-Late, GSMaP-MVK, TMPA-RT, and PERSIANN-CCS), reanalysis (i.e., ERA5), and CPCU for scheme 1 during JJA.
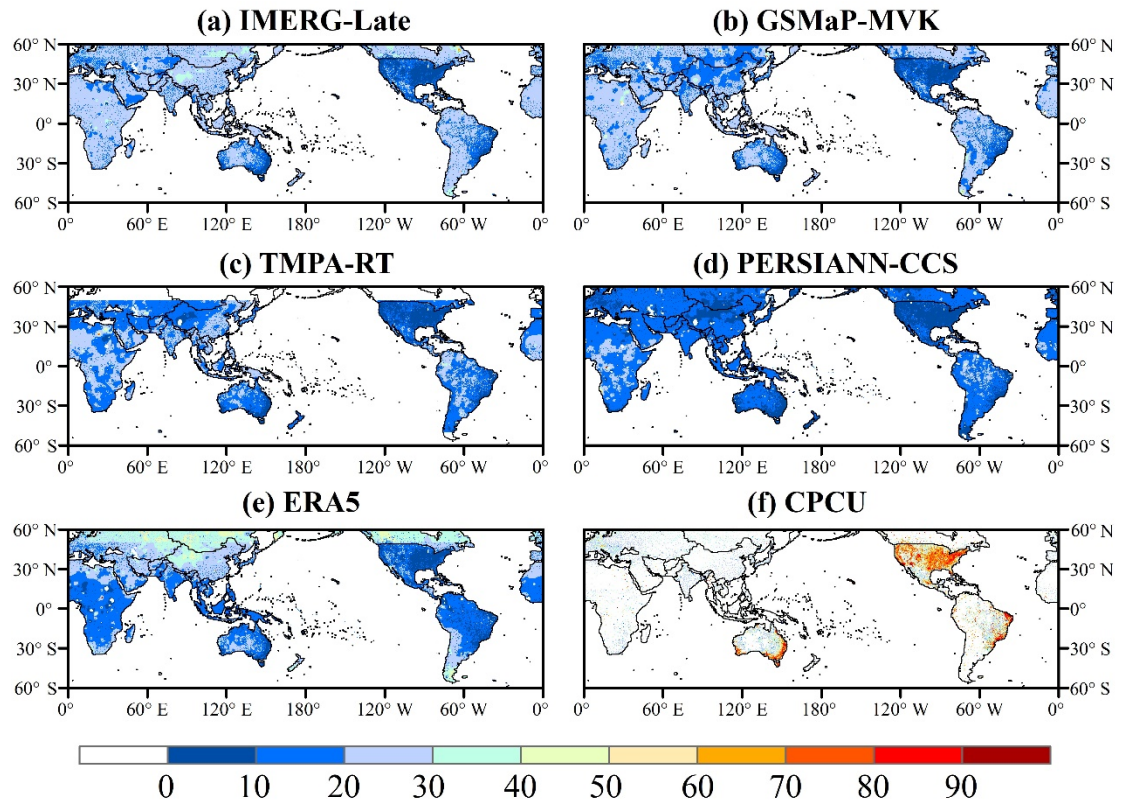
Fig. S5 Global land maps of the weights designed to satellites (i.e., IMERG-Late, GSMaP-MVK, TMPA-RT, and PERSIANN-CCS), reanalysis (i.e., ERA5), and CPCU for scheme 1 during SON.
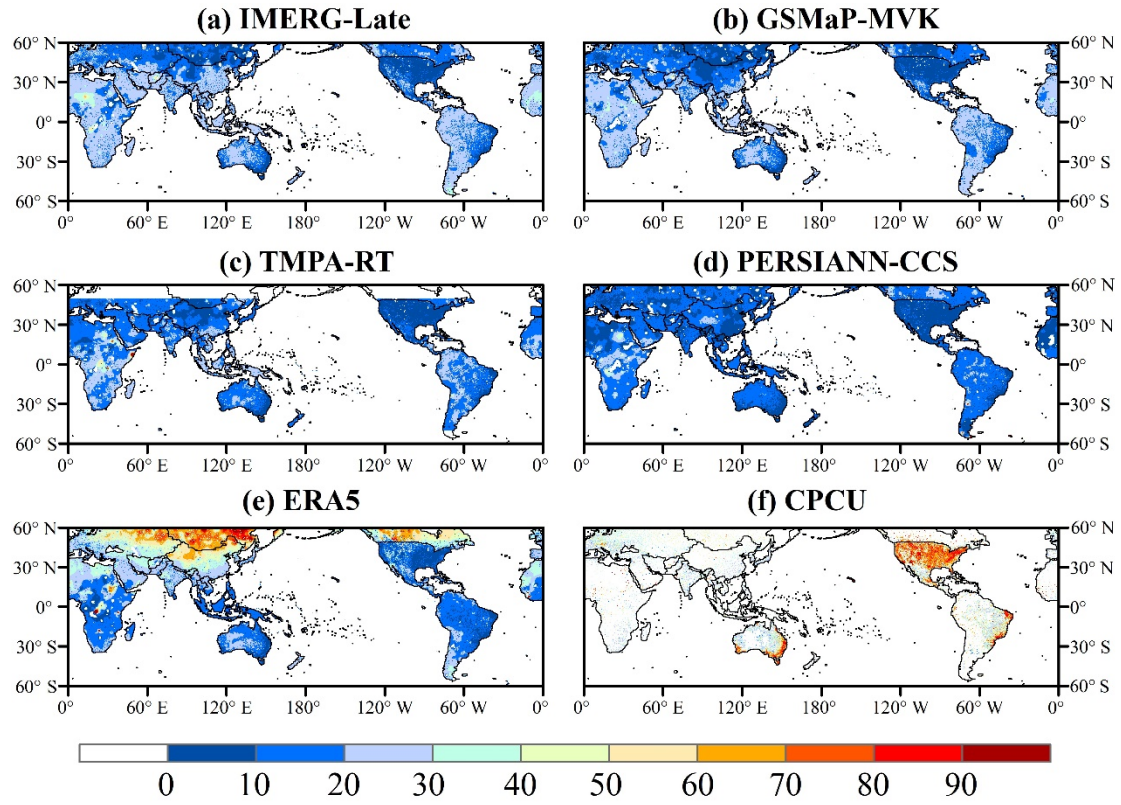
Fig. S6 Global land maps of the weights designed to satellites (i.e., IMERG-Late, GSMaP-MVK, TMPA-RT, and PERSIANN-CCS), reanalysis (i.e., ERA5), and CPCU for scheme 1 during DJF.

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