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Regionalization of IDF curves for mainland China: a comparative evaluation of machine learning versus spatial interpolation techniques

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Introduction

Figures S1 and S2 illustrate the spatial context of the study, showing the distribution of the 2,363 hourly observation stations overlaid on elevation and mean annual precipitation maps, respectively. To provide a more granular regional assessment, an alternative regionalization scheme based on the nine major river basins of China is presented in **Figure S3**.

Feature importance analysis using Shapley Additive Explanations (SHAP) for the Gradient Boosting (GB) model is detailed in **Figure S4 which** quantifies the contribution of each input feature to the model's predictions for the four representative Intensity-Duration-Frequency (IDF) cases.

Figure S5 presents the relative errors between observations and predictions for the best-performing interpolation (Kriging with External Drift using mean annual precipitation, KED_AP) and machine learning (GB) methods. The distributions of residuals for both methods are shown in **Figure S6**, which helps assess model bias and error characteristics.

A series of tables provide detailed data and results. **Tables S1 to S12** show the accuracy metrics of ten different machine learning (ML) methods using three distinct gridded precipitation datasets (CGDPP, CHIRPS, and CHM_PRE), demonstrating the rationale for selecting CHM_PRE for the main analysis. A brief description of these ten ML methods is provided in **Table S13**.

Tables S14 to S17 detail the hyperparameter grids used in our grid search for the Random Forest (RF), Gradient Boosting (GB), ExtraTrees (ET), and Multilayer Perceptron (MLP) models. To ensure a more thorough exploration of the parameter space, we subsequently employed a hyperparameter tuning method, Bayesian optimization. The search ranges used for this optimization are detailed in **Tables S18 to S21**. The final performance metrics of the models based on Bayesian optimization are summarized in **Table S22**.

The results of the regional performance evaluation using the nine-major-river-basins scheme are presented in **Tables S23 to S30**. These tables show the accuracy metrics for the KED_AP and GB methods across each basin for all four test cases.

Comprehensive results for the generated regionalized IDF products are provided. **Table S31** lists the optimal regionalization method selected for each of the 243 IDF cases for the 0.1° product based on CHM_PRE. The corresponding performance metrics (NSE, PBIAS, RMSE, and KGE) for this product are detailed in **Tables S32 to S35**. An alternative, lower-resolution (0.5°) IDF product based on the CGDPP dataset is also provided, with its optimal methods and performance metrics shown in **Tables S36 to S40**. To resolve potential crossing phenomena within the generated curves, a bivariate isotonic regression was applied as post-processing. This procedure yielded the final regionalized IDF datasets, ensuring physical consistency with negligible impact on accuracy. The performance metrics for these final datasets are provided in **Tables S41 to S48**. **Table S49** summarizes the statistical characteristics of the station-level IDF data used as the ground truth in this study.

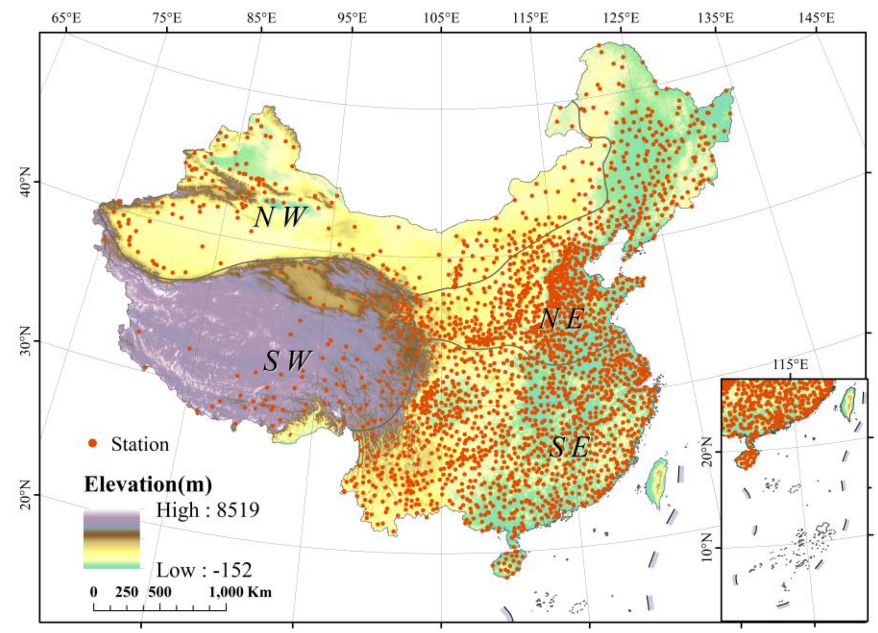

Figure S1. The spatial distribution of 2,122 hourly observation stations and elevation across the study area.

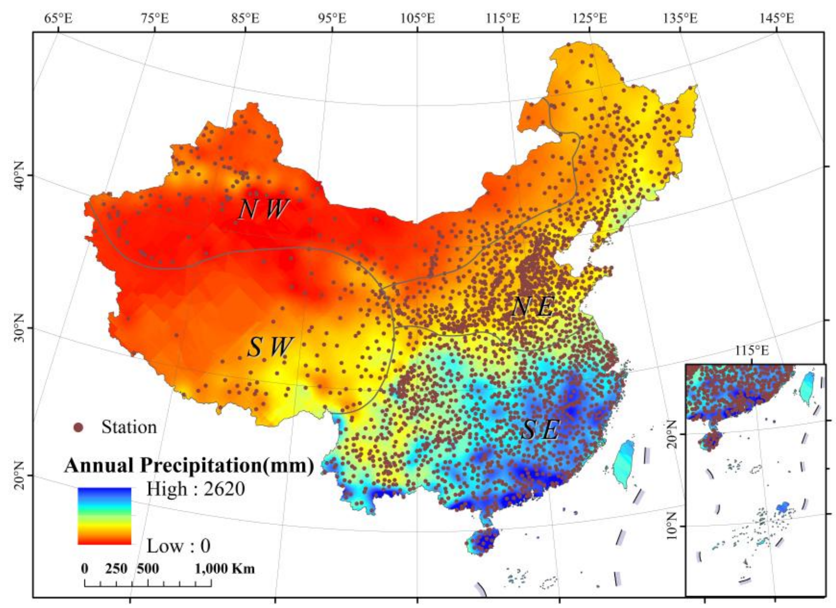

Figure S2. The spatial distribution of 2,122 hourly observation stations and the mean annual precipitation across the study area.

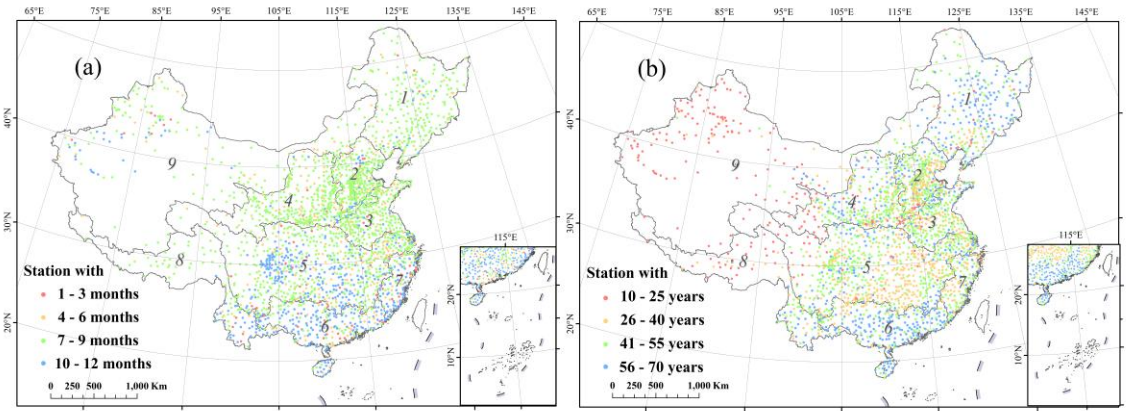

Figure S3. The spatial distribution of the nine major river basins in mainland China, which were used as an alternative regionalization scheme for performance evaluation. The numbered basins are: 1: Songhua and Liaohe River Basin; 2: Haihe River Basin; 3: Huaihe River Basin; 4: Yellow River Basin; 5: Yangtze River Basin; 6: Pearl River Basin; 7: Southeast Basin; 8: Southwest Basin; 9: Continental Basin.

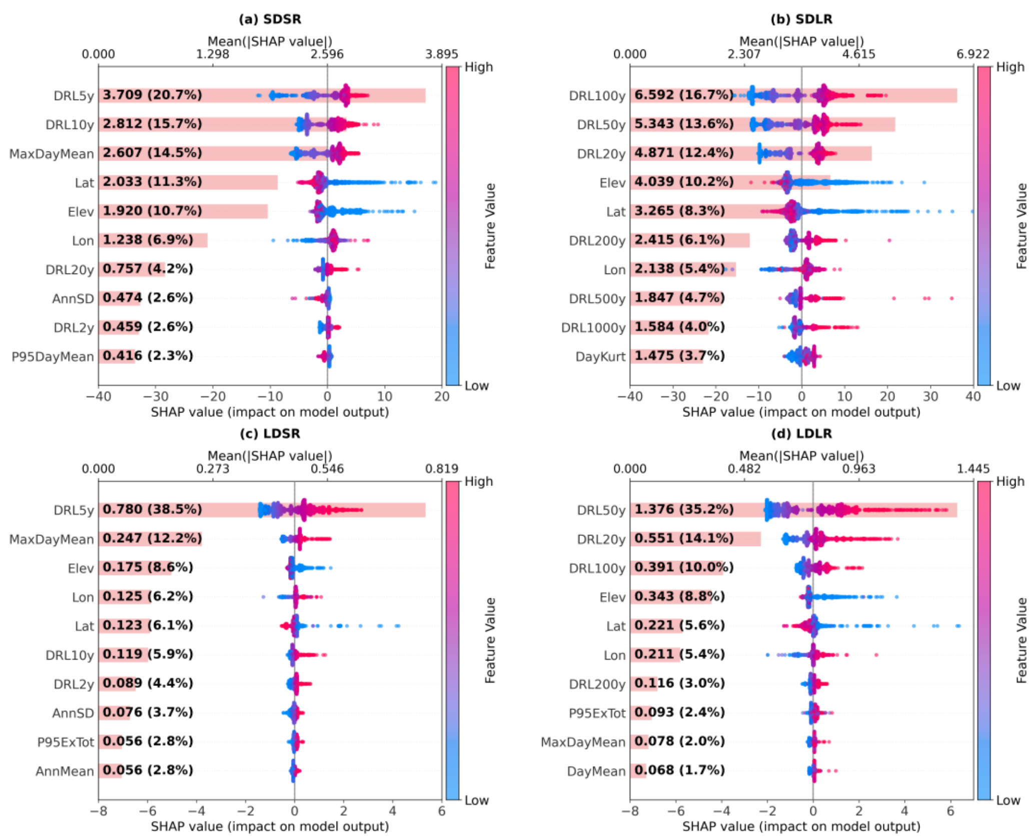

Figure S4. SHAP feature importance for GB-based IDF regionalization for the four considered cases in mainland China. Horizontal bars show global importance as the mean absolute SHAP values (mean|SHAP|) with percentages; beeswarm points show sample-level signed SHAP values; point color encodes the standardized feature value (z-score) from low to high. Abbreviations are Lat: latitude; Lon: longitude; Elev: elevation;

AnnMean: mean annual precipitation; AnnSD: standard deviation of annual precipitation; DayMean: mean daily precipitation; DayKurt: kurtosis of daily precipitation; MaxDayMean: multi-year mean of the annual maximum daily precipitation; P95DayMean: multi-year mean of the annual 95th percentile of daily precipitation; P95ExTot: multi-year mean annual total precipitation from days exceeding the 95th percentile; DRL2y-DRL1000y: daily return level for a 2-1000 year return period.

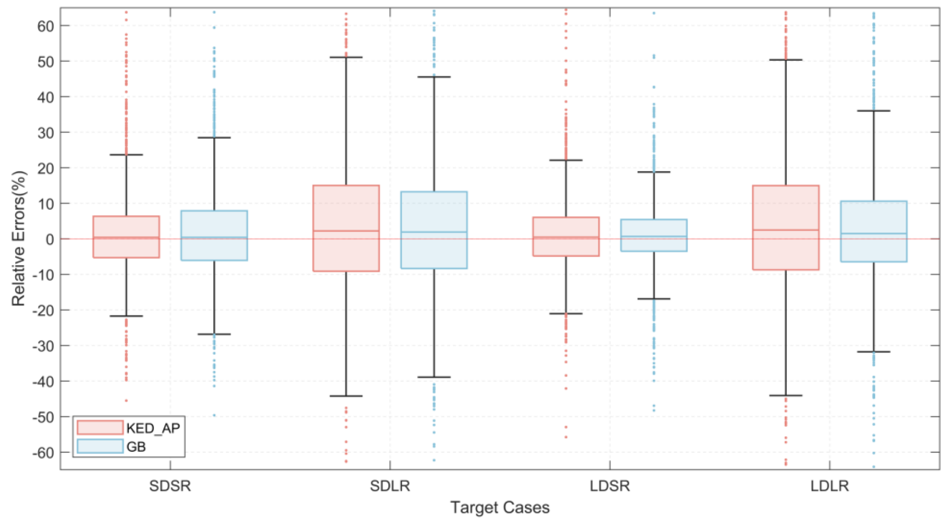

Figure S5. Relative errors of predicted intensities for KED_AP (the best interpolation method) and GB (the best machine learning method).

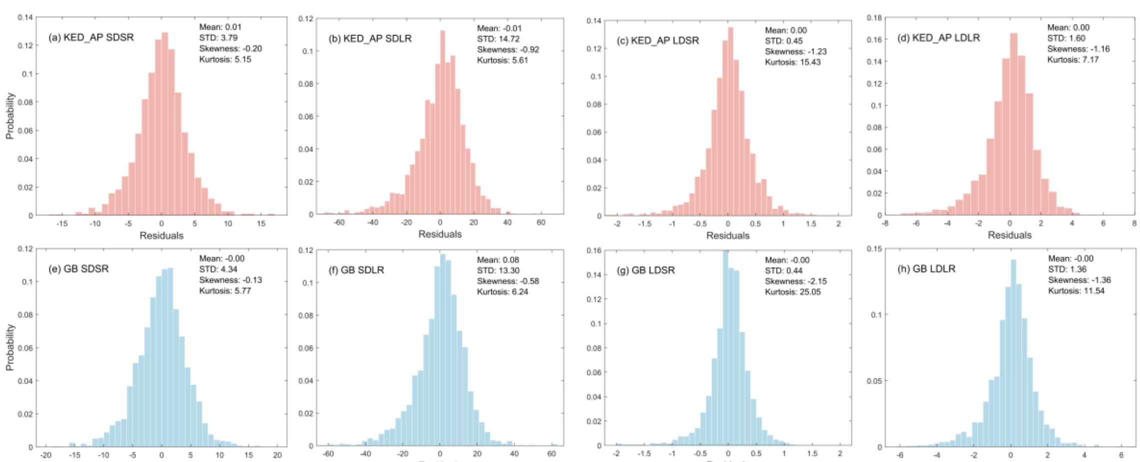

Figure S6. Residual histograms for KED_AP (the best interpolation method, (a)-(d)) and GB (the best machine learning method, (e)-(h)). Skewness of 0 and kurtosis of 3 are expected of the normal distribution.

Table S1. Accuracy metrics of machine learning methods for SDSR (1-hour rainfall intensity for a 5-year return period) using CGDPP.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.88	1.24	5.36	0.87
Bayesian Ridge Regression	0.87	0.03	5.69	0.90
ExtraTrees Regression	0.91	0.43	4.61	0.94
Gradient Boosting	0.91	0.05	4.60	0.93
K-Nearest Neighbors Regression	0.89	0.92	5.10	0.92
Linear Regression	0.84	0.16	6.24	0.90
Multilayer Perceptron	0.86	-0.30	5.85	0.92
Random Forest	0.92	0.33	4.32	0.94
Ridge Regression	0.87	0.02	5.70	0.90
Support Vector Regression	0.83	-0.44	6.39	0.83

Table S2. Accuracy metrics of machine learning methods for SDLR (1-hour rainfall intensity for a 100-year return period) using CGDPP.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.70	8.13	17.86	0.74
Bayesian Ridge Regression	0.73	0.03	16.84	0.80
ExtraTrees Regression	0.73	0.75	17.04	0.84
Gradient Boosting	0.78	0.02	15.38	0.83
K-Nearest Neighbors Regression	0.75	0.90	16.38	0.82
Linear Regression	0.63	0.27	19.69	0.78
Multilayer Perceptron	0.71	-0.97	17.50	0.82
Random Forest	0.76	0.74	15.89	0.84
Ridge Regression	0.73	0.03	16.83	0.80
Support Vector Regression	0.66	-3.29	18.89	0.68

Table S3. Accuracy metrics of machine learning methods for LDSR (24-hour rainfall intensity for a 5-year return period) using CGDPP.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.91	2.82	0.59	0.88
Bayesian Ridge Regression	0.93	0.00	0.51	0.95
ExtraTrees Regression	0.92	0.17	0.54	0.95
Gradient Boosting	0.93	-0.07	0.50	0.95
K-Nearest Neighbors Regression	0.92	0.37	0.54	0.94
Linear Regression	0.89	0.19	0.66	0.94
Multilayer Perceptron	0.92	0.28	0.55	0.95
Random Forest	0.93	0.09	0.51	0.95
Ridge Regression	0.93	0.00	0.51	0.95

Support Vector Regression	0.92	-0.40	0.55	0.93

Table S4. Accuracy metrics of machine learning methods for LDLR (24-hour rainfall intensity for a 100-year return period) using CGDPP.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.75	9.93	1.96	0.74
Bayesian Ridge Regression	0.82	0.01	1.63	0.87
ExtraTrees Regression	0.77	0.53	1.86	0.87
Gradient Boosting	0.82	0.16	1.63	0.87
K-Nearest Neighbors Regression	0.81	0.38	1.70	0.86
Linear Regression	0.68	0.33	2.22	0.83
Multilayer Perceptron	0.82	0.09	1.65	0.88
Random Forest	0.80	0.51	1.72	0.87
Ridge Regression	0.83	0.00	1.63	0.87
Support Vector Regression	0.80	-2.40	1.74	0.84

Table S5. Accuracy metrics of machine learning methods for SDSR (1-hour rainfall intensity for a 5-year return period) using CHIRPS.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.87	3.36	5.60	0.85
Bayesian Ridge Regression	0.80	-0.01	6.93	0.85
ExtraTrees Regression	0.92	0.26	4.45	0.93
Gradient Boosting	0.90	0.10	4.86	0.92
K-Nearest Neighbors Regression	0.86	0.62	5.83	0.88
Linear Regression	0.80	-0.12	7.02	0.86
Multilayer Perceptron	0.84	-0.17	6.15	0.90
Random Forest	0.92	0.12	4.43	0.93
Ridge Regression	0.80	0.00	6.99	0.85
Support Vector Regression	0.80	-0.85	7.02	0.78

Table S6. Accuracy metrics of machine learning methods for SDLR (1-hour rainfall intensity for a 100-year return period) using CHIRPS.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.65	9.89	19.22	0.68
Bayesian Ridge Regression	0.63	0.01	19.87	0.71

ExtraTrees Regression	0.76	0.95	15.78	0.82
Gradient Boosting	0.74	0.33	16.54	0.80
K-Nearest Neighbors Regression	0.68	1.10	18.46	0.77
Linear Regression	0.63	-0.03	19.87	0.71
Multilayer Perceptron	0.67	-0.59	18.67	0.77
Random Forest	0.76	0.63	15.93	0.82
Ridge Regression	0.62	0.03	19.91	0.70
Support Vector Regression	0.57	-4.68	21.28	0.60

Table S7. Accuracy metrics of machine learning methods for LDSR (24-hour rainfall intensity for a 5-year return period) using CHIRPS.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.83	6.55	0.81	0.80
Bayesian Ridge Regression	0.81	0.00	0.85	0.86
ExtraTrees Regression	0.91	0.09	0.57	0.92
Gradient Boosting	0.89	-0.01	0.64	0.92
K-Nearest Neighbors Regression	0.85	-0.44	0.76	0.87
Linear Regression	0.81	-0.08	0.85	0.86
Multilayer Perceptron	0.87	0.04	0.71	0.90
Random Forest	0.91	-0.02	0.58	0.92
Ridge Regression	0.81	0.01	0.84	0.86
Support Vector Regression	0.84	-1.83	0.78	0.85

Table S8. Accuracy metrics of machine learning methods for LDLR (24-hour rainfall intensity for a 100-year return period) using CHIRPS.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.64	12.29	2.34	0.65
Bayesian Ridge Regression	0.67	0.05	2.25	0.74
ExtraTrees Regression	0.79	0.65	1.78	0.84
Gradient Boosting	0.76	0.28	1.89	0.82
K-Nearest Neighbors Regression	0.71	0.02	2.11	0.78
Linear Regression	0.66	0.02	2.25	0.74
Multilayer Perceptron	0.72	-0.21	2.05	0.79
Random Forest	0.79	0.29	1.79	0.84
Ridge Regression	0.67	0.05	2.25	0.74
Support Vector Regression	0.69	-3.78	2.18	0.73

Table S9. Accuracy metrics of machine learning methods for SDSR (1-hour rainfall intensity for a 5-year return period) using CHM_PRE.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.89	2.04	5.09	0.87
Bayesian Ridge Regression	0.89	0.00	5.23	0.92

ExtraTrees Regression	0.92	0.10	4.50	0.93
Gradient Boosting	0.92	-0.02	4.34	0.94
K-Nearest Neighbors Regression	0.90	0.13	5.00	0.92
Linear Regression	0.89	0.00	5.24	0.92
Multilayer Perceptron	0.88	-0.50	5.36	0.93
Random Forest	0.92	0.16	4.34	0.94
Ridge Regression	0.89	0.00	5.25	0.92
Support Vector Regression	0.85	-0.89	6.12	0.85

Table S10. Accuracy metrics of machine learning methods for SDLR (1-hour rainfall intensity for a 100-year return period) using CHM_PRE.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.76	6.48	15.76	0.74
Bayesian Ridge Regression	0.81	-0.01	14.33	0.86
ExtraTrees Regression	0.82	0.41	13.93	0.87
Gradient Boosting	0.83	0.11	13.29	0.87
K-Nearest Neighbors Regression	0.80	0.00	14.69	0.85
Linear Regression	0.80	0.05	14.56	0.86
Multilayer Perceptron	0.78	-1.21	15.10	0.87
Random Forest	0.83	0.37	13.49	0.87
Ridge Regression	0.81	-0.01	14.33	0.86
Support Vector Regression	0.72	-3.36	17.24	0.73

Table S11. Accuracy metrics of machine learning methods for LDSR (24-hour rainfall intensity for a 5-year return period) using CHM_PRE.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.88	8.06	0.68	0.82
Bayesian Ridge Regression	0.93	-0.02	0.50	0.95
ExtraTrees Regression	0.93	0.01	0.50	0.95
Gradient Boosting	0.95	-0.07	0.44	0.96
K-Nearest Neighbors Regression	0.93	-0.60	0.53	0.94
Linear Regression	0.93	-0.04	0.50	0.95
Multilayer Perceptron	0.95	-0.14	0.45	0.97
Random Forest	0.94	-0.03	0.47	0.96
Ridge Regression	0.93	-0.02	0.50	0.95
Support Vector Regression	0.92	-1.36	0.55	0.93

Table S12. Accuracy metrics of machine learning methods for LDLR (24-hour rainfall intensity for a 100-year return period) using CHM_PRE.

	NSE	PBIAS(%)	RMSE(mm/hr)	KGE
AdaBoost Regression	0.78	10.97	1.83	0.72
Bayesian Ridge Regression	0.87	-0.03	1.40	0.90
ExtraTrees Regression	0.86	0.18	1.45	0.90
Gradient Boosting	0.88	-0.05	1.36	0.91
K-Nearest Neighbors Regression	0.85	-0.72	1.50	0.89
Linear Regression	0.87	0.00	1.41	0.91
Multilayer Perceptron	0.87	0.18	1.37	0.91
Random Forest	0.87	0.22	1.37	0.91
Ridge Regression	0.87	-0.03	1.40	0.90
Support Vector Regression	0.84	-2.06	1.55	0.87

Table S13. Ten different Machine learning methods used for the 4 test intensities. The details can be found in the user guide of scikit-learn (https://scikit-learn.org/stable/user_guide.html).

Machine Learning Method	Description
AdaBoost Regression	A boosting technique that adjusts the weights of training samples based on previous errors, focusing more on difficult-to-predict instances in subsequent weak learners.
Bayesian Ridge Regression	A Bayesian approach to linear regression that includes a probabilistic model and regularization, offering a distribution over model parameters rather than point estimates.
ExtraTrees Regression	Similar to Random Forest, but with more randomization in selecting splits, leading to reduced variance and often faster computation.
Gradient Boosting	An ensemble technique that builds decision trees sequentially, with each tree trying to correct the residual errors of the previous trees, optimizing the overall loss function. At each stage a regression tree is fitted to the negative gradient of the given loss function.
K-Nearest Neighbors Regression	A non-parametric method that predicts the target value based on the average or weighted average of the k-nearest data points in the feature space.
Linear Regression	A basic linear approach that models the relationship between input features and the target as a linear combination of the input variables.

Multilayer Perceptron	A type of feedforward neural network with one or more hidden layers, capable of learning complex non-linear relationships between inputs and outputs.
Random Forest	A bagging-based ensemble method that builds multiple decision trees and merges their results to improve accuracy and prevent overfitting.
Ridge Regression	A variant of linear regression that includes a regularization term (L2 penalty) to prevent overfitting by shrinking the coefficients of less important features.
Support Vector Regression	A regression variant of support vector machine that attempts to find a hyperplane that best fits the data within a certain margin of tolerance, used for both linear and non-linear regression.

Table S14. Hyperparameter grid for random forest (RF). The default hyperparameters in the scikit-learn library are highlighted in red. (Grid Search)

Hyperparameter	Values
n_estimators	50, 100, 150, 200, 500
min_samples_split	2, 5, 10, 20, 30
max_features	0.3, 0.5, None, "sqrt", "log2"

Table S15. Hyperparameter grid for gradient boosting (GB). The default hyperparameters in the scikit-learn library are highlighted in red. (Grid Search)

Hyperparameter	Values
n_estimators	50, 100, 150, 200, 500
max_depth	3, 4, 5, 10
max_features	0.3, 0.5, None, "sqrt", "log2"
subsample	0.2, 0.5, 1
learning_rate	0.05, 0.1, 0.2, 0.5

Table S16. Hyperparameter grid for ExtraTrees (ET). The default hyperparameters in the scikit-learn library are highlighted in red. (Grid Search)

Hyperparameter	Values
n_estimators	50, 100, 150, 200, 500
min_samples_split	2, 5, 10, 20, 30
max_features	0.3, 0.5, None, "sqrt", "log2"

Table S17. Hyperparameter grid for multilayer perceptron (MLP). The default hyperparameters in the scikit-learn library are highlighted in red. (Grid Search)

Hyperparameter	Values
hidden_layer_sizes	(50), (100), (500), (750), (1000), (150, 150), (200, 200), (250, 250), (15, 30, 45), (30, 45, 30), (45, 30, 15), (10, 10, 10, 10), (15, 15, 15, 15)
activation	'logistic', 'tanh', 'relu', 'identity'
alpha	0.0001, 0.001, 0.01, 0.1

Table S18. Hyperparameter search ranges for the Random Forest model using Bayesian optimization.

Hyperparameter	Search range for Bayesian optimization	SDSR	SDLR	LDSR	LDLR
n_estimators	50 - 1000	914	173	943	1000
min_samples_split	2 - 50	2	2	2	2
max_features	0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, None, “sqrt”, “log2”	None	None	0.90	None

Table S19. Hyperparameter search ranges for the Gradient Boosting model using Bayesian optimization.

Hyperparameter	Search range for Bayesian optimization	SDSR	SDLR	LDSR	LDLR
n_estimators	50 - 1000	826	1000	640	607
max_depth	2 - 50	4	2	2	6

max_features	0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, None, “sqrt”, “log2”	0.90	0.40	0.20	0.10
subsample	0.10 - 1.00	0.3771	0.8657	0.9867	0.2546
learning_rate	0.01 - 0.50	0.0791	0.1145	0.2807	0.0100

Table S20. Hyperparameter search ranges for the Extremely Randomized Trees model using Bayesian optimization.

Hyperparameter	Search range for Bayesian optimization	SDSR	SDLR	LDSR	LDLR
n_estimators	50 - 1000	938	899	72	1000
min_samples_split	2 - 50	2	12	4	11
max_features	0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, None, “sqrt”, “log2”	None	None	None	0.10

Table S21. Hyperparameter search ranges for the Multilayer Perceptron model using Bayesian optimization.

Hyperparameter	Search range for Bayesian optimization	SDSR	SDLR	LDSR	LDLR
hidden_layer_sizes	(50,), (64,), (100,), (128,), (256,), (500,), (750,), (1000,), (64, 64), (128, 64), (64, 128), (150, 150), (200, 200), (250, 250),	(128,64)	(150,150)	(150,150)	(30,45,30)

	(15, 30, 45), (30, 45, 30), (45, 30, 15), (10, 10, 10, 10), (15, 15, 15, 15)				
activation	“logistic”, “tanh”, “relu”, “identity”	“tanh”	“relu”	“relu”	“relu”
alpha	(1e-6) - 1	0.7277	0.01525	(1e-6)	0.7825

Table S22. Accuracy metrics of machine learning methods after hyperparameter tuning via Bayesian optimization.

	SDSR				SDLR				LDSR				LDLR			
	NSE	PBIAS (%)	RMSE(mm/hr) (mm/hr)	KGE	NSE	PBIAS (%)	RMSE	KGE	NSE	PBIAS (%)	RMSE (mm/hr)	KGE	NSE	PBIAS (%)	RMSE (mm/hr)	KGE
RF	0.92	0.11	4.30	0.94	0.83	0.33	13.40	0.87	0.94	0.00	0.47	0.96	0.88	0.18	1.37	0.91
GB	0.93	0.19	4.18	0.95	0.84	-0.06	13.16	0.89	0.95	0.00	0.44	0.97	0.88	0.07	1.36	0.90
ET	0.92	0.08	4.48	0.93	0.82	0.24	13.82	0.86	0.94	0.01	0.49	0.95	0.86	0.02	1.42	0.89
MLP	0.92	-0.35	4.33	0.93	0.83	-0.16	13.38	0.88	0.95	-0.15	0.43	0.97	0.88	-0.61	1.34	0.92

Table S23. Accuracy metrics for the KED_AP interpolation method across the nine major river basins for the SDSR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.85	0.38	2.68	0.88
2.Haihe River Basin	0.9	-0.41	3.19	0.93
3.Huaihe River Basin	0.96	-0.17	3.9	0.97
4.Yellow River Basin	0.89	-0.03	3.28	0.92

5.Yangtze River Basin	0.82	0.13	4.03	0.86
6.Pearl River Basin	0.72	-0.02	5.25	0.8
7.Southeast Basin	0.58	0.36	3.62	0.7
8.Southwest Basin	0.09	-0.72	3.44	0.25
9.Continental Basin	0.72	-0.06	3	0.83
Mainland China	0.94	0.03	3.79	0.96

Table S24. Accuracy metrics for the KED_AP interpolation method across the nine major river basins for the SDLR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.66	0.64	8.24	0.73
2.Haihe River Basin	0.73	-0.4	14.99	0.78
3.Huaihe River Basin	0.91	0.49	12.27	0.92
4.Yellow River Basin	0.65	-0.27	15.26	0.72
5.Yangtze River Basin	0.57	0.09	15.22	0.65
6.Pearl River Basin	0.52	-0.07	18.33	0.62
7.Southeast Basin	0.43	0.68	15.53	0.48
	-			-
8.Southwest Basin	0.22	-2.5	14.42	0.25
9.Continental Basin	0.27	-0.48	11	0.46
Mainland China	0.79	-0.01	14.72	0.84

Table S25. Accuracy metrics for the KED_AP interpolation method across the nine major river basins for the LDSR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.9	0.14	0.19	0.92
2.Haihe River Basin	0.88	0.11	0.27	0.92
3.Huaihe River Basin	0.96	0.15	0.42	0.96
4.Yellow River Basin	0.87	-0.19	0.34	0.89
5.Yangtze River Basin	0.86	-0.1	0.44	0.89

6.Pearl River Basin	0.86	-0.02	0.67	0.89
7.Southeast Basin	0.61	0.93	0.73	0.69
8.Southwest Basin	0.42	0.84	0.55	0.56
9.Continental Basin	0.78	0.18	0.28	0.85
Mainland China	0.95	0.07	0.45	0.96

Table S26. Accuracy metrics for the KED_AP interpolation method across the nine major river basins for the LDLR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.71	0.97	0.66	0.77
2.Haihe River Basin	0.67	-0.56	1.41	0.73
3.Huaihe River Basin	0.9	0.35	1.36	0.9
4.Yellow River Basin	0.56	-0.15	1.58	0.65
5.Yangtze River Basin	0.64	-0.04	1.64	0.71
6.Pearl River Basin	0.72	0.37	2.12	0.77
7.Southeast Basin	0.48	0.75	2.16	0.52
8.Southwest Basin	0.2	-0.69	1.48	0.21
9.Continental Basin	0.31	-0.63	1.09	0.48
Mainland China	0.82	0.05	1.6	0.87

Table S27. Accuracy metrics for the GB machine learning method across the nine major river basins for the SDSR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.77	-0.78	3.26	0.8
2.Haihe River Basin	0.87	-0.23	3.52	0.91
3.Huaihe River Basin	0.94	-1.36	4.74	0.94
4.Yellow River Basin	0.82	-0.14	4.26	0.86
5.Yangtze River Basin	0.78	0.51	4.55	0.82

6.Pearl River Basin	0.69	-1.02	5.72	0.81
7.Southeast Basin	0.39	0.86	4.33	0.49
8.Southwest Basin	-0.23	-1.72	3.99	0.18
9.Continental Basin	0.75	1.43	2.86	0.82
Mainland China	0.92	-0.01	4.34	0.94

Table S28. Accuracy metrics for the GB machine learning method across the nine major river basins for the SDLR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.68	-1.18	7.9	0.71
2.Haihe River Basin	0.79	0.48	13.18	0.82
3.Huaihe River Basin	0.91	-0.45	12.24	0.91
4.Yellow River Basin	0.67	-0.36	14.87	0.74
5.Yangtze River Basin	0.66	1.07	13.57	0.75
6.Pearl River Basin	0.68	-1.54	15.23	0.77
7.Southeast Basin	0.57	0.66	13.51	0.63
8.Southwest Basin	- 0.27	-4.19	14.7	0.12
9.Continental Basin	0.4	0.49	9.93	0.52
Mainland China	0.83	0.1	13.3	0.87

Table S29. Accuracy metrics for the GB machine learning method across the nine major river basins for the LDSR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.87	2.39	0.22	0.92
2.Haihe River Basin	0.92	-0.07	0.22	0.96
3.Huaihe River Basin	0.96	-0.7	0.39	0.94
4.Yellow River Basin	0.83	0.28	0.39	0.91

5.Yangtze River Basin	0.88	0.08	0.42	0.93
6.Pearl River Basin	0.83	-0.83	0.77	0.89
7.Southeast Basin	0.7	-0.39	0.63	0.75
8.Southwest Basin	0.46	-1.64	0.53	0.74
9.Continental Basin	0.86	0.74	0.23	0.9
Mainland China	0.95	-0.08	0.44	0.96

Table S30. Accuracy metrics for the GB machine learning method across the nine major river basins for the LDLR

Region	NSE	PBIAS (%)	RMSE(mm/hr)	KGE
1.Songhua and Liaohe River Basin	0.68	3.94	0.69	0.81
2.Haihe River Basin	0.77	-0.17	1.16	0.82
3.Huaihe River Basin	0.92	-0.09	1.23	0.91
4.Yellow River Basin	0.61	-0.06	1.48	0.73
5.Yangtze River Basin	0.77	0.47	1.3	0.85
6.Pearl River Basin	0.79	-1.11	1.88	0.85
7.Southeast Basin	0.68	-0.85	1.7	0.75
8.Southwest Basin	-0.08	-3.37	1.72	0.39
9.Continental Basin	0.5	-0.31	0.93	0.63
Mainland China	0.88	-0.05	1.36	0.91

Table S31. Optimal regionalization methods for developed IDF curves with a spatial resolution of 0.1°×0.1° based on CHM_PRE.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	KED_AP	KED_AP	KED_DEM+AP	KED_AP	GB	GB	GB	GB	GB
2h	KED_AP	KED_AP	KED_AP	GB	GB	GB	GB	GB	GB
3h	KED_DEM+AP	KED_AP	KED_AP	GB	GB	GB	GB	GB	GB
4h	KED_DEM+AP	KED_AP	GB	GB	GB	GB	GB	GB	GB
5h	KED_AP	GB	GB	GB	GB	GB	GB	GB	LR
6h	KED_AP	KED_AP	GB	GB	GB	GB	GB	GB	LR

7h	KED_AP	GB	GB	GB	GB	GB	GB	GB	GB
8h	KED_AP	GB	GB	GB	GB	GB	GB	LR	LR
9h	KED_AP	GB	GB	GB	GB	GB	GB	LR	MLP
10h	KED_AP	KED_AP	GB	GB	GB	GB	GB	GB	LR
11h	GB	GB	GB	GB	GB	GB	LR	LR	GB
12h	KED_AP	KED_AP	GB	GB	GB	GB	GB	LR	GB
13h	KED_AP	GB	GB	GB	GB	GB	LR	LR	MLP
14h	GB	GB	GB	GB	GB	GB	GB	MLP	LR
15h	KED_AP	GB	GB	GB	GB	GB	GB	GB	GB
16h	GB	GB	GB	GB	GB	GB	MLP	GB	MLP
17h	GB	GB	GB	GB	GB	GB	GB	LR	MLP
18h	GB	GB	GB	GB	GB	GB	GB	GB	MLP
19h	GB	KED_AP	GB	MLP	GB	GB	LR	GB	MLP
20h	KED_AP	GB	GB	GB	GB	GB	GB	MLP	GB
21h	KED_AP	KED_AP	GB	GB	GB	GB	GB	LR	MLP
22h	KED_DEM+AP	GB	GB	GB	GB	GB	MLP	GB	GB
23h	KED_DEM+AP	GB	MLP	MLP	GB	GB	GB	MLP	GB
24h	KED_AP	GB	MLP	MLP	GB	GB	GB	GB	MLP
36h	KED_AP	MLP	GB	MLP	GB	GB	MLP	MLP	MLP
48h	KED_AP	RF	MLP	MLP	GB	GB	GB	MLP	MLP
72h	KED_AP	KED_AP	RF	MLP	MLP	GB	MLP	GB	MLP

Table S32. Nash-Sutcliffe Efficiency for developed IDF curves with a spatial resolution of 0.1°×0.1° based on CHM_PRE.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	0.95	0.94	0.93	0.90	0.87	0.83	0.79	0.71	0.66
2h	0.95	0.94	0.94	0.91	0.88	0.85	0.81	0.74	0.67
3h	0.95	0.94	0.93	0.92	0.89	0.86	0.81	0.74	0.68
4h	0.95	0.94	0.93	0.92	0.89	0.86	0.82	0.75	0.68
5h	0.95	0.95	0.94	0.93	0.90	0.86	0.82	0.75	0.67
6h	0.95	0.94	0.94	0.93	0.90	0.86	0.82	0.75	0.67
7h	0.95	0.95	0.94	0.93	0.90	0.86	0.82	0.75	0.68
8h	0.95	0.95	0.94	0.93	0.90	0.86	0.82	0.74	0.68
9h	0.95	0.95	0.94	0.93	0.90	0.87	0.82	0.75	0.70
10h	0.95	0.95	0.94	0.93	0.90	0.87	0.82	0.75	0.68
11h	0.95	0.95	0.94	0.93	0.90	0.87	0.82	0.75	0.69
12h	0.95	0.95	0.94	0.93	0.90	0.87	0.83	0.75	0.69
13h	0.95	0.95	0.94	0.93	0.90	0.87	0.82	0.75	0.71
14h	0.96	0.95	0.94	0.93	0.90	0.87	0.83	0.76	0.69
15h	0.95	0.95	0.94	0.93	0.90	0.87	0.83	0.76	0.69
16h	0.96	0.95	0.94	0.93	0.91	0.87	0.83	0.76	0.71
17h	0.95	0.95	0.94	0.93	0.91	0.87	0.83	0.75	0.71
18h	0.96	0.95	0.94	0.93	0.91	0.87	0.83	0.76	0.71
19h	0.95	0.95	0.94	0.93	0.91	0.87	0.83	0.76	0.71
20h	0.95	0.95	0.94	0.93	0.91	0.87	0.83	0.77	0.69

21h	0.95	0.95	0.94	0.93	0.91	0.87	0.83	0.76	0.71
22h	0.95	0.95	0.94	0.93	0.91	0.87	0.84	0.76	0.69
23h	0.95	0.95	0.94	0.93	0.91	0.88	0.83	0.77	0.69
24h	0.95	0.95	0.94	0.93	0.90	0.88	0.83	0.76	0.71
36h	0.95	0.95	0.94	0.93	0.91	0.88	0.84	0.78	0.72
48h	0.95	0.95	0.94	0.93	0.91	0.87	0.84	0.78	0.72
72h	0.95	0.94	0.94	0.93	0.91	0.88	0.85	0.77	0.73

Table S33. Percent Bias (%) for developed IDF curves with a spatial resolution of 0.1°×0.1° based on CHM_PRE.

	2 years	5 years	10 years	20 years	50 years	100 years	200 years	500 years	1000 years
1h	0.06	0.03	-0.07	-0.02	0.10	0.11	0.06	0.20	0.05
2h	-0.02	0.05	-0.07	-0.01	0.04	0.00	0.04	0.23	0.36
3h	0.07	0.05	0.01	-0.01	0.01	-0.02	0.01	0.12	0.22
4h	0.09	0.07	-0.04	-0.06	-0.02	-0.03	-0.02	0.11	0.20
5h	-0.05	-0.09	-0.09	-0.05	-0.02	-0.01	-0.04	0.12	0.12
6h	0.00	0.03	-0.10	-0.09	-0.03	-0.01	0.07	0.05	0.12
7h	-0.01	-0.09	-0.04	-0.08	-0.05	-0.03	0.03	0.04	0.12
8h	0.03	-0.12	-0.01	-0.05	-0.02	-0.04	0.02	0.07	0.11
9h	0.02	-0.03	-0.10	-0.07	-0.03	0.04	-0.01	0.07	-0.24
10h	-0.03	-0.01	-0.07	-0.07	-0.02	-0.01	0.06	0.10	0.11
11h	-0.11	-0.07	-0.10	-0.08	-0.08	0.03	0.03	0.07	0.09
12h	0.02	0.00	-0.09	-0.07	-0.08	-0.01	0.03	0.07	0.03
13h	0.01	-0.10	-0.12	-0.10	-0.06	0.04	0.03	0.06	-0.06
14h	-0.07	-0.04	-0.14	-0.06	-0.06	0.04	-0.03	-0.06	0.10
15h	0.03	-0.05	-0.13	-0.10	-0.07	0.03	0.04	0.01	-0.01
16h	-0.05	-0.05	-0.15	-0.12	-0.05	-0.01	-0.08	0.05	-0.24
17h	-0.08	-0.08	-0.07	-0.09	0.00	-0.01	0.03	0.06	-0.27
18h	-0.06	-0.08	-0.14	-0.10	-0.09	-0.01	0.00	0.05	-0.12
19h	-0.07	0.00	-0.11	0.01	-0.03	-0.05	0.02	-0.02	0.16
20h	0.05	-0.10	-0.07	-0.07	-0.07	-0.03	0.04	-0.01	-0.02
21h	0.03	0.02	-0.10	-0.08	-0.04	0.00	0.03	0.05	-0.11
22h	-0.03	-0.07	-0.06	-0.10	0.01	-0.02	0.09	-0.01	0.04
23h	0.01	-0.07	0.04	-0.03	-0.03	0.00	-0.03	-0.10	0.02
24h	0.01	-0.07	0.02	0.02	-0.02	-0.05	-0.01	-0.03	-0.23
36h	0.02	0.02	-0.10	0.12	-0.04	-0.04	-0.10	-0.23	-0.12
48h	0.08	0.01	-0.25	-0.35	-0.04	-0.06	-0.04	-0.16	-0.24
72h	0.05	0.06	0.00	0.00	-0.08	-0.02	-0.14	-0.05	0.12

Table S34. Root Mean Square Error for developed IDF curves with a spatial resolution of 0.1°×0.1° based on CHM_PRE.

	2 years	5 years	10 years	20 years	50 years	100 years	200 years	500 years	1000 years

1h	2.57	3.79	4.99	6.94	10.02	13.29	17.71	26.10	34.68
2h	1.68	2.46	3.22	4.39	6.32	8.49	11.32	16.79	22.71
3h	1.36	1.92	2.53	3.30	4.79	6.43	8.62	12.76	17.20
4h	1.10	1.60	2.09	2.70	3.91	5.25	7.05	10.43	14.06
5h	0.94	1.38	1.76	2.27	3.31	4.47	6.04	8.91	12.27
6h	0.84	1.22	1.54	1.98	2.90	3.91	5.30	7.82	10.71
7h	0.75	1.07	1.36	1.76	2.59	3.50	4.70	6.98	9.41
8h	0.68	0.97	1.24	1.59	2.35	3.17	4.25	6.40	8.61
9h	0.62	0.89	1.13	1.45	2.13	2.90	3.91	5.85	7.62
10h	0.58	0.83	1.05	1.34	1.99	2.69	3.62	5.32	7.26
11h	0.53	0.77	0.97	1.24	1.85	2.49	3.40	5.01	6.69
12h	0.50	0.74	0.91	1.17	1.72	2.33	3.14	4.69	6.27
13h	0.47	0.68	0.85	1.11	1.62	2.19	2.99	4.41	5.73
14h	0.44	0.64	0.81	1.05	1.54	2.06	2.79	4.07	5.61
15h	0.42	0.61	0.77	1.00	1.47	1.96	2.65	3.92	5.26
16h	0.40	0.59	0.73	0.96	1.38	1.87	2.52	3.72	4.88
17h	0.39	0.56	0.70	0.90	1.31	1.79	2.41	3.59	4.67
18h	0.37	0.54	0.67	0.87	1.26	1.70	2.30	3.42	4.45
19h	0.36	0.52	0.65	0.87	1.21	1.63	2.24	3.27	4.28
20h	0.35	0.50	0.63	0.81	1.16	1.59	2.12	3.07	4.23
21h	0.34	0.49	0.61	0.78	1.13	1.52	2.04	3.05	3.96
22h	0.33	0.47	0.59	0.75	1.08	1.46	1.95	2.93	3.95
23h	0.32	0.46	0.59	0.74	1.05	1.41	1.91	2.77	3.82
24h	0.31	0.44	0.56	0.72	1.03	1.36	1.85	2.74	3.56
36h	0.23	0.33	0.42	0.53	0.75	1.01	1.34	1.96	2.61
48h	0.19	0.28	0.33	0.43	0.61	0.82	1.09	1.56	2.09
72h	0.14	0.21	0.26	0.32	0.45	0.61	0.78	1.18	1.53

Table S35. Kling-Gupta Efficiency for developed IDF curves with a spatial resolution of 0.1°×0.1° based on CHM_PRE.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	0.96	0.96	0.95	0.93	0.90	0.87	0.84	0.78	0.73
2h	0.97	0.96	0.95	0.93	0.91	0.89	0.85	0.80	0.75
3h	0.97	0.96	0.95	0.94	0.92	0.89	0.86	0.81	0.76
4h	0.96	0.96	0.95	0.94	0.92	0.90	0.86	0.81	0.76
5h	0.97	0.96	0.95	0.94	0.92	0.90	0.86	0.81	0.76
6h	0.96	0.96	0.95	0.94	0.92	0.90	0.87	0.81	0.77
7h	0.96	0.96	0.95	0.94	0.92	0.90	0.87	0.82	0.77
8h	0.97	0.96	0.96	0.95	0.92	0.90	0.87	0.82	0.77
9h	0.96	0.96	0.96	0.95	0.93	0.90	0.87	0.82	0.78
10h	0.96	0.96	0.96	0.95	0.93	0.90	0.87	0.82	0.77
11h	0.97	0.96	0.96	0.95	0.93	0.90	0.87	0.82	0.77
12h	0.97	0.96	0.96	0.95	0.93	0.91	0.87	0.82	0.77

13h	0.97	0.96	0.96	0.95	0.93	0.91	0.87	0.82	0.78
14h	0.97	0.96	0.96	0.95	0.93	0.91	0.87	0.84	0.78
15h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.82	0.77
16h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.82	0.79
17h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.79
18h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.82	0.79
19h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.82	0.79
20h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.78
21h	0.96	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.79
22h	0.96	0.96	0.96	0.95	0.93	0.91	0.89	0.83	0.78
23h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.84	0.78
24h	0.96	0.96	0.96	0.94	0.93	0.91	0.88	0.83	0.79
36h	0.97	0.96	0.96	0.95	0.93	0.91	0.89	0.85	0.79
48h	0.97	0.96	0.97	0.96	0.93	0.91	0.88	0.84	0.79
72h	0.96	0.96	0.95	0.94	0.93	0.91	0.90	0.83	0.80

Table S36. Optimal regionalization methods for developed IDF curves with a spatial resolution of 0.5°×0.5° based on CGDPP.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	KED_AP	KED_AP	KED_DEM+AP	KED_AP	KED_AP	KED_AP	KED_DEM+AP	KED_DEM+AP	GB
2h	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	KED_DEM+AP	GB	GB
3h	KED_DEM+AP	KED_AP	KED_AP	KED_DEM+AP	KED_AP	KED_AP	KED_DEM+AP	GB	GB
4h	KED_DEM+AP	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	GB	GB	GB
5h	KED_AP	KED_DEM+AP	KED_DEM+AP	KED_AP	KED_AP	KED_AP	GB	GB	GB
6h	KED_AP	KED_AP	KED_DEM+AP	KED_DEM+AP	KED_AP	GB	GB	GB	GB
7h	KED_AP	KED_AP	KED_DEM+AP	KED_AP	KED_AP	GB	GB	MLP	MLP
8h	KED_AP	KED_AP	KED_DEM+AP	KED_DEM+AP	KED_AP	KED_AP	GB	MLP	MLP
9h	KED_AP	KED_DEM+AP	KED_AP	KED_AP	KED_AP	KED_DEM+AP	GB	MLP	GB
10h	KED_AP	KED_AP	KED_AP	KED_DEM+AP	KED_AP	GB	GB	MLP	MLP
11h	KED_DEM+AP	KED_DEM+AP	KED_AP	KED_DEM+AP	GB	KED_AP	MLP	MLP	MLP
12h	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	MLP	MLP	MLP
13h	KED_AP	KED_DEM+AP	KED_AP	KED_AP	KED_AP	KED_AP	GB	MLP	GB
14h	KED_AP	KED_AP	KED_DEM+AP	KED_DEM+AP	KED_AP	KED_AP	MLP	MLP	MLP
15h	KED_AP	KED_DEM+AP	KED_AP	KED_AP	KED_DEM+AP	GB	MLP	MLP	MLP
16h	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	GB	MLP	MLP	MLP
17h	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	MLP	MLP	MLP
18h	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	MLP	MLP	MLP
19h	KED_AP	KED_AP	KED_AP	KED_DEM+AP	MLP	GB	MLP	MLP	MLP
20h	KED_AP	KED_AP	KED_AP	KED_AP	MLP	MLP	GB	MLP	MLP
21h	KED_AP	KED_AP	KED_AP	KED_DEM+AP	KED_DEM+AP	MLP	MLP	MLP	MLP
22h	KED_DEM+AP	KED_DEM+AP	KED_AP	KED_AP	KED_AP	GB	MLP	MLP	MLP
23h	KED_DEM+AP	KED_DEM+AP	KED_AP	KED_AP	MLP	MLP	GB	MLP	MLP
24h	KED_AP	KED_AP	KED_DEM+AP	KED_AP	KED_AP	GB	MLP	MLP	MLP
36h	KED_AP	KED_DEM+AP	KED_DEM+AP	KED_AP	MLP	MLP	MLP	MLP	MLP
48h	KED_AP	KED_AP	KED_AP	KED_AP	KED_AP	GB	GB	MLP	MLP

72h	KED_AP	KED_AP	KED_DEM+AP	KED_AP	MLP	MLP	MLP	MLP	MLP

Table S37. Nash-Sutcliffe Efficiency for developed IDF curves with a spatial resolution of 0.5°×0.5° based on CGDPP.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	0.95	0.94	0.93	0.90	0.85	0.79	0.71	0.61	0.54
2h	0.95	0.94	0.94	0.91	0.86	0.80	0.73	0.64	0.55
3h	0.95	0.94	0.93	0.91	0.86	0.80	0.73	0.65	0.56
4h	0.95	0.94	0.93	0.91	0.86	0.81	0.74	0.65	0.57
5h	0.95	0.94	0.93	0.91	0.86	0.81	0.75	0.65	0.57
6h	0.95	0.94	0.93	0.91	0.87	0.81	0.75	0.65	0.58
7h	0.95	0.94	0.93	0.91	0.87	0.81	0.75	0.65	0.57
8h	0.95	0.94	0.93	0.91	0.86	0.82	0.75	0.65	0.57
9h	0.95	0.94	0.93	0.91	0.87	0.81	0.75	0.65	0.59
10h	0.95	0.95	0.93	0.91	0.87	0.81	0.75	0.65	0.58
11h	0.95	0.94	0.93	0.91	0.86	0.82	0.75	0.66	0.58
12h	0.95	0.95	0.93	0.91	0.87	0.82	0.75	0.66	0.59
13h	0.95	0.94	0.93	0.91	0.87	0.82	0.76	0.66	0.59
14h	0.95	0.95	0.93	0.91	0.87	0.82	0.75	0.66	0.59
15h	0.95	0.94	0.94	0.92	0.86	0.82	0.76	0.66	0.59
16h	0.95	0.95	0.93	0.92	0.87	0.82	0.76	0.67	0.59
17h	0.95	0.95	0.94	0.92	0.87	0.82	0.76	0.67	0.59
18h	0.95	0.95	0.93	0.92	0.87	0.82	0.76	0.67	0.60
19h	0.95	0.95	0.94	0.91	0.86	0.82	0.76	0.67	0.60
20h	0.95	0.94	0.94	0.92	0.86	0.82	0.76	0.67	0.60
21h	0.95	0.95	0.93	0.91	0.87	0.82	0.76	0.68	0.60
22h	0.95	0.94	0.94	0.92	0.87	0.82	0.76	0.67	0.60
23h	0.95	0.94	0.93	0.92	0.86	0.82	0.77	0.68	0.60
24h	0.95	0.95	0.93	0.92	0.87	0.82	0.77	0.68	0.60
36h	0.95	0.94	0.93	0.92	0.87	0.83	0.78	0.69	0.61
48h	0.95	0.94	0.94	0.92	0.87	0.83	0.78	0.69	0.62
72h	0.95	0.94	0.92	0.92	0.88	0.83	0.78	0.70	0.62

Table S38. Percent Bias (%) for developed IDF curves with a spatial resolution of 0.5°×0.5° based on CGDPP.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	0.06	0.03	-0.07	-0.02	0.09	-0.01	0.18	0.19	0.49
2h	-0.02	0.05	-0.07	0.07	-0.02	-0.04	0.17	0.32	0.45
3h	0.07	0.05	0.01	0.06	0.07	-0.01	0.11	0.27	0.32
4h	0.09	0.07	-0.02	0.05	0.02	-0.01	0.18	0.28	0.31
5h	-0.05	0.05	0.02	0.01	0.04	0.08	0.12	0.24	0.33
6h	0.00	0.03	0.00	-0.04	-0.04	0.02	0.14	0.28	0.37

7h	-0.01	0.06	0.02	0.04	0.02	0.08	0.17	-0.21	-0.37
8h	0.03	-0.01	0.05	0.07	0.05	-0.04	0.20	-0.45	-0.26
9h	0.02	0.05	-0.06	-0.03	-0.09	-0.01	0.26	-0.29	0.43
10h	-0.03	-0.01	0.01	-0.01	0.06	0.15	0.23	-0.29	-0.29
11h	0.06	-0.02	0.09	-0.04	0.05	0.02	-0.18	0.04	-0.35
12h	0.02	0.00	0.05	0.09	-0.05	0.00	0.06	-0.23	-0.44
13h	0.01	0.02	0.01	0.13	0.07	-0.03	0.28	-0.45	0.51
14h	0.06	0.07	-0.02	0.04	0.00	0.00	0.04	-0.10	-0.21
15h	0.03	0.06	0.06	0.04	0.04	0.13	-0.21	0.03	-0.13
16h	0.00	-0.06	-0.03	-0.03	0.09	0.15	-0.10	-0.12	-0.23
17h	0.10	0.13	-0.02	0.05	-0.03	-0.02	-0.14	-0.38	-0.19
18h	0.04	-0.02	0.07	0.03	-0.01	-0.03	-0.01	0.09	-0.23
19h	0.04	0.00	0.09	0.05	-0.12	0.14	-0.08	-0.19	-0.08
20h	0.05	0.00	-0.03	0.11	-0.07	-0.11	0.30	-0.23	-0.27
21h	0.03	0.02	-0.02	0.02	0.01	0.14	-0.11	-0.03	-0.37
22h	-0.03	0.01	0.02	0.06	0.11	0.19	-0.12	-0.19	0.11
23h	0.01	0.00	0.06	0.07	-0.04	0.03	0.30	-0.20	-0.21
24h	0.01	0.07	-0.02	0.05	0.04	0.15	0.05	-0.15	0.17
36h	0.02	0.01	0.09	-0.03	-0.08	0.10	-0.15	0.24	0.11
48h	0.08	0.10	0.06	0.05	0.01	0.19	0.27	0.00	-0.25
72h	0.05	0.06	0.02	0.08	0.01	-0.12	0.09	0.23	-0.27

Table S39. Root Mean Square Error for developed IDF curves with a spatial resolution of 0.5°×0.5° based on CGDPP.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	2.57	3.79	4.99	6.94	10.58	14.72	20.61	30.20	40.07
2h	1.68	2.46	3.22	4.53	6.92	9.62	13.27	19.73	26.34
3h	1.36	1.92	2.53	3.47	5.28	7.42	10.30	14.99	20.03
4h	1.10	1.60	2.12	2.83	4.36	6.06	8.39	12.31	16.39
5h	0.94	1.41	1.84	2.50	3.76	5.13	7.13	10.47	13.97
6h	0.84	1.22	1.62	2.18	3.26	4.64	6.27	9.20	12.16
7h	0.75	1.10	1.47	1.91	2.93	4.16	5.58	8.30	10.94
8h	0.68	1.00	1.31	1.76	2.68	3.63	5.03	7.47	9.92
9h	0.62	0.94	1.19	1.63	2.45	3.44	4.63	6.86	8.96
10h	0.58	0.83	1.11	1.55	2.27	3.18	4.28	6.33	8.30
11h	0.54	0.80	1.03	1.42	2.21	2.88	4.02	5.86	7.76
12h	0.50	0.74	0.96	1.31	1.96	2.69	3.81	5.45	7.23
13h	0.47	0.71	0.92	1.24	1.85	2.53	3.51	5.15	6.81
14h	0.45	0.66	0.86	1.19	1.75	2.41	3.35	4.89	6.45
15h	0.42	0.63	0.81	1.10	1.71	2.35	3.17	4.62	6.08
16h	0.41	0.60	0.79	1.05	1.58	2.23	3.00	4.37	5.79
17h	0.39	0.57	0.74	1.00	1.52	2.08	2.90	4.20	5.52
18h	0.37	0.55	0.72	0.96	1.46	1.99	2.75	4.01	5.29

19h	0.36	0.52	0.68	0.95	1.47	1.96	2.64	3.87	5.08
20h	0.35	0.51	0.67	0.89	1.42	1.89	2.52	3.70	4.88
21h	0.34	0.49	0.65	0.87	1.33	1.84	2.44	3.54	4.66
22h	0.33	0.48	0.62	0.82	1.25	1.74	2.37	3.43	4.54
23h	0.32	0.48	0.61	0.79	1.29	1.70	2.25	3.30	4.39
24h	0.31	0.45	0.59	0.77	1.16	1.63	2.19	3.18	4.24
36h	0.23	0.35	0.45	0.58	0.89	1.20	1.59	2.32	3.08
48h	0.19	0.28	0.35	0.47	0.70	0.96	1.29	1.86	2.46
72h	0.14	0.21	0.29	0.36	0.53	0.71	0.94	1.36	1.81

Table S40. Kling-Gupta Efficiency for developed IDF curves with a spatial resolution of 0.5°×0.5° based on CGDPP.

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	0.96	0.96	0.95	0.93	0.89	0.84	0.80	0.71	0.64
2h	0.97	0.96	0.95	0.93	0.89	0.85	0.81	0.72	0.66
3h	0.97	0.96	0.95	0.93	0.90	0.85	0.81	0.73	0.66
4h	0.96	0.96	0.95	0.93	0.90	0.85	0.81	0.73	0.67
5h	0.97	0.96	0.95	0.93	0.90	0.86	0.81	0.74	0.67
6h	0.96	0.96	0.95	0.93	0.90	0.86	0.81	0.74	0.68
7h	0.96	0.96	0.95	0.93	0.90	0.86	0.82	0.75	0.68
8h	0.97	0.96	0.95	0.93	0.90	0.86	0.82	0.75	0.69
9h	0.96	0.96	0.95	0.93	0.90	0.86	0.82	0.75	0.69
10h	0.96	0.96	0.95	0.93	0.90	0.87	0.82	0.75	0.68
11h	0.96	0.96	0.95	0.94	0.90	0.86	0.82	0.75	0.69
12h	0.97	0.96	0.95	0.93	0.90	0.86	0.83	0.76	0.69
13h	0.97	0.96	0.95	0.94	0.90	0.86	0.83	0.75	0.69
14h	0.96	0.96	0.95	0.93	0.90	0.86	0.83	0.76	0.69
15h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.76	0.69
16h	0.96	0.96	0.95	0.93	0.90	0.87	0.83	0.76	0.69
17h	0.97	0.96	0.95	0.94	0.90	0.86	0.83	0.76	0.70
18h	0.96	0.96	0.95	0.93	0.90	0.86	0.83	0.76	0.69
19h	0.97	0.96	0.95	0.94	0.91	0.87	0.84	0.76	0.70
20h	0.97	0.96	0.95	0.94	0.91	0.88	0.83	0.76	0.70
21h	0.96	0.96	0.95	0.94	0.91	0.88	0.84	0.77	0.70
22h	0.96	0.96	0.95	0.94	0.90	0.87	0.84	0.76	0.70
23h	0.97	0.96	0.95	0.93	0.91	0.87	0.83	0.76	0.70
24h	0.96	0.96	0.95	0.94	0.90	0.87	0.84	0.77	0.70
36h	0.97	0.96	0.95	0.93	0.91	0.88	0.84	0.76	0.71
48h	0.97	0.96	0.95	0.94	0.90	0.88	0.84	0.77	0.71
72h	0.96	0.96	0.95	0.93	0.92	0.90	0.85	0.77	0.73

Table S41. Nash-Sutcliffe Efficiency for the final regionalized IDF datasets with a spatial resolution of 0.1°×0.1° based on CHM_PRE (post-processed using bivariate isotonic regression).

	2 years	5 years	10 years	20 years	50 years	100 years	200 years	500 years	1000 years
1h	0.95	0.94	0.93	0.91	0.87	0.83	0.79	0.72	0.65
2h	0.95	0.95	0.94	0.92	0.88	0.85	0.81	0.74	0.67
3h	0.95	0.94	0.94	0.92	0.89	0.86	0.81	0.74	0.67
4h	0.95	0.95	0.94	0.92	0.89	0.86	0.82	0.75	0.68
5h	0.95	0.95	0.94	0.93	0.89	0.86	0.82	0.75	0.68
6h	0.95	0.95	0.94	0.93	0.90	0.86	0.82	0.75	0.67
7h	0.95	0.95	0.94	0.93	0.90	0.86	0.82	0.75	0.69
8h	0.95	0.95	0.94	0.93	0.90	0.86	0.82	0.75	0.68
9h	0.95	0.95	0.94	0.93	0.90	0.86	0.82	0.75	0.70
10h	0.96	0.95	0.94	0.93	0.90	0.87	0.82	0.76	0.70
11h	0.96	0.96	0.94	0.93	0.90	0.87	0.83	0.76	0.70
12h	0.96	0.96	0.94	0.93	0.90	0.87	0.83	0.76	0.70
13h	0.96	0.95	0.94	0.93	0.90	0.87	0.83	0.76	0.70
14h	0.96	0.95	0.94	0.93	0.90	0.87	0.83	0.77	0.70
15h	0.96	0.95	0.94	0.93	0.90	0.87	0.83	0.76	0.71
16h	0.96	0.95	0.94	0.93	0.90	0.87	0.84	0.77	0.71
17h	0.96	0.95	0.94	0.93	0.91	0.87	0.83	0.77	0.71
18h	0.96	0.95	0.94	0.93	0.91	0.87	0.83	0.77	0.71
19h	0.96	0.96	0.94	0.93	0.91	0.87	0.84	0.77	0.71
20h	0.96	0.96	0.94	0.93	0.91	0.87	0.84	0.77	0.71
21h	0.96	0.96	0.94	0.93	0.91	0.87	0.84	0.77	0.71
22h	0.95	0.95	0.95	0.94	0.91	0.88	0.84	0.77	0.71
23h	0.95	0.95	0.94	0.93	0.91	0.88	0.84	0.77	0.71
24h	0.95	0.95	0.94	0.93	0.90	0.88	0.83	0.77	0.71
36h	0.95	0.95	0.94	0.93	0.91	0.88	0.84	0.78	0.72
48h	0.95	0.95	0.94	0.93	0.91	0.88	0.84	0.78	0.73
72h	0.95	0.95	0.94	0.93	0.91	0.88	0.85	0.78	0.73

Table S42. Percent Bias (%) for the final regionalized IDF datasets with a spatial resolution of 0.1°×0.1° based on CHM_PRE (post-processed using bivariate isotonic regression).

	2 years	5 years	10 years	20 years	50 years	100 years	200 years	500 years	1000 years
1h	0.00	-0.02	0.06	-0.13	0.26	0.10	0.06	0.20	0.11
2h	-0.01	0.00	-0.18	0.11	0.03	0.01	0.02	0.20	0.34
3h	0.00	0.00	-0.11	0.14	0.01	-0.03	0.04	0.08	0.32
4h	0.01	0.00	-0.06	-0.08	-0.03	-0.02	-0.03	0.07	0.36
5h	-0.04	-0.13	-0.14	-0.05	-0.04	-0.06	-0.10	-0.38	0.34
6h	-0.02	0.03	-0.05	-0.08	-0.02	-0.03	0.02	-0.32	0.74

7h	-0.03	-0.36	-0.07	-0.08	-0.07	-0.04	-0.04	0.30	0.20
8h	-0.02	-0.14	-0.01	-0.05	-0.04	-0.09	-0.25	-0.07	-0.04
9h	0.01	0.28	-0.09	-0.08	-0.05	-0.01	-0.15	0.43	-0.35
10h	0.35	0.00	-0.06	-0.08	-0.04	-0.01	0.36	-0.13	0.36
11h	-0.13	-0.14	-0.10	-0.08	-0.11	-0.14	0.15	-0.48	-0.48
12h	-0.40	0.04	-0.07	-0.09	-0.08	-0.04	-0.10	0.04	0.47
13h	0.42	-0.66	-0.13	-0.09	-0.06	-0.08	0.20	0.51	-0.16
14h	-0.13	-0.14	-0.14	-0.07	-0.09	0.03	-0.50	-0.05	0.21
15h	0.03	-0.10	-0.13	-0.10	-0.06	0.02	0.33	-0.86	-0.25
16h	-0.62	-0.04	-0.18	-0.12	-0.09	-0.08	-0.07	0.05	-0.56
17h	-0.12	-0.01	-0.07	-0.07	-0.02	-0.04	-0.56	-0.12	-0.34
18h	0.08	0.59	-0.14	0.23	-0.10	-0.01	0.41	-0.73	0.01
19h	0.58	-0.10	-0.13	-0.06	-0.04	-0.14	0.13	0.36	0.42
20h	-0.72	-0.18	-0.04	-0.49	-0.08	-0.08	-0.51	-0.13	-0.36
21h	-0.14	0.07	-0.01	-0.10	-0.04	-0.02	0.32	0.13	0.12
22h	-0.15	-0.89	0.34	0.30	0.00	-0.07	-0.13	-0.32	-0.77
23h	0.00	-0.31	-0.39	-0.64	-0.05	-0.04	-0.74	-0.47	0.41
24h	-0.13	-0.21	-0.26	-0.34	-0.04	-0.08	-0.28	-1.22	-1.26
36h	0.01	-0.02	-0.19	-0.10	-0.05	-0.28	0.02	0.09	-0.16
48h	0.01	-0.07	-0.02	0.24	0.00	-0.05	-0.21	0.14	0.06
72h	0.07	-0.14	0.06	-0.21	-0.04	-0.14	0.06	-0.43	0.25

Table S43. Root Mean Square Error for the final regionalized IDF datasets with a spatial resolution of 0.1°×0.1° based on CHM_PRE (post-processed using bivariate isotonic regression).

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	2.61	3.76	4.98	6.73	9.98	13.28	17.72	26.05	34.73
2h	1.69	2.46	3.20	4.29	6.32	8.47	11.35	16.78	22.71
3h	1.31	1.93	2.47	3.24	4.78	6.41	8.61	12.74	17.24
4h	1.10	1.56	2.02	2.70	3.92	5.25	7.05	10.39	14.12
5h	0.95	1.32	1.74	2.27	3.33	4.47	6.03	8.84	12.06
6h	0.84	1.16	1.52	1.98	2.89	3.90	5.30	7.77	10.65
7h	0.75	1.03	1.35	1.76	2.60	3.50	4.70	6.95	9.34
8h	0.68	0.95	1.23	1.59	2.35	3.17	4.24	6.28	8.48
9h	0.62	0.86	1.13	1.45	2.13	2.91	3.90	5.76	7.64
10h	0.55	0.77	1.04	1.34	1.98	2.68	3.60	5.28	7.04
11h	0.49	0.71	0.97	1.24	1.85	2.49	3.32	4.94	6.57
12h	0.48	0.66	0.90	1.17	1.72	2.32	3.11	4.64	6.15
13h	0.45	0.65	0.85	1.11	1.62	2.19	2.92	4.36	5.76
14h	0.41	0.63	0.81	1.05	1.53	2.06	2.76	4.04	5.44
15h	0.38	0.60	0.77	1.00	1.46	1.96	2.62	3.86	5.14
16h	0.39	0.58	0.73	0.95	1.38	1.87	2.47	3.65	4.86
17h	0.37	0.55	0.70	0.90	1.31	1.79	2.38	3.48	4.65

18h	0.35	0.52	0.67	0.86	1.26	1.71	2.28	3.36	4.45
19h	0.34	0.46	0.65	0.83	1.21	1.63	2.17	3.22	4.25
20h	0.33	0.46	0.63	0.80	1.16	1.58	2.10	3.08	4.10
21h	0.33	0.42	0.60	0.77	1.12	1.52	2.01	2.96	3.95
22h	0.33	0.45	0.58	0.73	1.08	1.46	1.92	2.86	3.86
23h	0.32	0.45	0.57	0.74	1.04	1.41	1.88	2.76	3.72
24h	0.31	0.43	0.56	0.72	1.02	1.36	1.84	2.69	3.57
36h	0.23	0.33	0.41	0.53	0.75	1.01	1.32	1.95	2.61
48h	0.19	0.27	0.33	0.43	0.61	0.82	1.09	1.56	2.08
72h	0.14	0.21	0.26	0.32	0.45	0.60	0.78	1.17	1.52

Table S44. Kling-Gupta Efficiency for the final regionalized IDF datasets with a spatial resolution of 0.1°×0.1° based on CHM_PRE (post-processed using bivariate isotonic regression).

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	0.96	0.96	0.95	0.93	0.89	0.87	0.84	0.78	0.73
2h	0.97	0.96	0.95	0.93	0.91	0.89	0.85	0.80	0.75
3h	0.97	0.96	0.95	0.94	0.92	0.89	0.86	0.80	0.76
4h	0.96	0.96	0.95	0.94	0.92	0.90	0.86	0.81	0.76
5h	0.97	0.96	0.95	0.94	0.92	0.90	0.87	0.82	0.76
6h	0.96	0.96	0.95	0.95	0.93	0.90	0.87	0.82	0.76
7h	0.96	0.96	0.96	0.95	0.92	0.90	0.87	0.82	0.77
8h	0.96	0.96	0.96	0.95	0.93	0.90	0.88	0.82	0.77
9h	0.96	0.96	0.96	0.95	0.93	0.90	0.87	0.82	0.78
10h	0.96	0.96	0.96	0.95	0.93	0.90	0.87	0.82	0.77
11h	0.96	0.96	0.96	0.95	0.93	0.91	0.87	0.82	0.78
12h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.82	0.77
13h	0.97	0.96	0.96	0.95	0.93	0.91	0.87	0.82	0.78
14h	0.96	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.78
15h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.78
16h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.79
17h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.79
18h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.79
19h	0.97	0.96	0.96	0.95	0.93	0.91	0.87	0.83	0.78
20h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.78
21h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.83	0.78
22h	0.97	0.96	0.96	0.95	0.93	0.91	0.89	0.83	0.78
23h	0.97	0.96	0.97	0.95	0.93	0.91	0.88	0.84	0.78
24h	0.97	0.96	0.96	0.96	0.93	0.91	0.88	0.84	0.79
36h	0.97	0.97	0.96	0.96	0.93	0.91	0.89	0.84	0.79
48h	0.97	0.96	0.96	0.95	0.93	0.91	0.88	0.84	0.80
72h	0.96	0.96	0.95	0.96	0.94	0.91	0.90	0.84	0.80

Table S45. Nash-Sutcliffe Efficiency for the final regionalized IDF datasets with a spatial resolution of 0.5°×0.5° based on CGDPP (post-processed using bivariate isotonic regression).

	2 years	5 years	10 years	20 years	50 years	100 years	200 years	500 years	1000 years
1h	0.95	0.94	0.93	0.90	0.83	0.78	0.72	0.62	0.54
2h	0.95	0.94	0.93	0.91	0.84	0.79	0.73	0.64	0.55
3h	0.95	0.94	0.93	0.91	0.85	0.80	0.74	0.64	0.56
4h	0.95	0.94	0.93	0.91	0.85	0.80	0.74	0.65	0.57
5h	0.95	0.94	0.93	0.91	0.85	0.80	0.75	0.65	0.57
6h	0.95	0.94	0.93	0.91	0.86	0.81	0.75	0.65	0.58
7h	0.95	0.94	0.92	0.91	0.86	0.81	0.75	0.66	0.58
8h	0.95	0.94	0.94	0.90	0.86	0.81	0.75	0.66	0.58
9h	0.95	0.94	0.93	0.91	0.86	0.81	0.75	0.66	0.59
10h	0.95	0.94	0.94	0.92	0.86	0.81	0.76	0.66	0.59
11h	0.95	0.94	0.94	0.91	0.86	0.81	0.76	0.66	0.59
12h	0.95	0.94	0.94	0.91	0.86	0.82	0.76	0.66	0.59
13h	0.95	0.94	0.94	0.91	0.86	0.82	0.76	0.67	0.59
14h	0.95	0.94	0.94	0.91	0.86	0.81	0.76	0.66	0.59
15h	0.95	0.95	0.93	0.90	0.86	0.81	0.76	0.67	0.59
16h	0.95	0.95	0.93	0.91	0.86	0.82	0.77	0.67	0.60
17h	0.95	0.95	0.94	0.90	0.86	0.82	0.77	0.67	0.60
18h	0.95	0.95	0.94	0.91	0.87	0.82	0.77	0.68	0.60
19h	0.95	0.95	0.94	0.91	0.86	0.82	0.77	0.68	0.60
20h	0.95	0.95	0.94	0.92	0.87	0.82	0.77	0.68	0.60
21h	0.95	0.95	0.94	0.92	0.87	0.82	0.77	0.68	0.60
22h	0.95	0.95	0.94	0.91	0.87	0.82	0.77	0.68	0.60
23h	0.95	0.95	0.94	0.91	0.87	0.82	0.77	0.68	0.61
24h	0.95	0.95	0.94	0.91	0.87	0.82	0.77	0.68	0.61
36h	0.95	0.95	0.94	0.91	0.87	0.83	0.78	0.68	0.61
48h	0.95	0.95	0.93	0.91	0.87	0.83	0.78	0.69	0.62
72h	0.95	0.94	0.94	0.91	0.87	0.84	0.79	0.71	0.63

Table S46. Percent Bias (%) for the final regionalized IDF datasets with a spatial resolution of 0.5°×0.5° based on CGDPP (post-processed using bivariate isotonic regression).

	2 years	5 years	10 years	20 years	50 years	100 years	200 years	500 years	1000 years
1h	-0.01	0.00	-0.06	0.01	0.14	0.05	0.19	0.25	0.51
2h	-0.02	0.00	0.00	-0.10	0.13	0.12	0.25	0.29	0.43
3h	-0.02	-0.03	0.03	-0.06	0.15	0.09	0.19	0.26	0.33
4h	0.00	0.00	0.02	0.08	0.06	0.06	0.19	0.29	0.34
5h	0.00	0.00	0.11	-0.12	0.07	0.12	0.10	0.23	0.39
6h	-0.03	-0.05	-0.19	0.18	0.08	0.03	0.14	0.29	0.42

7h	-0.02	-0.05	0.11	-0.33	0.10	0.07	0.18	0.26	0.49
8h	-0.01	0.04	0.09	0.02	-0.01	0.08	0.21	0.33	0.45
9h	0.00	-0.05	-0.11	0.32	0.04	0.11	0.25	0.63	0.53
10h	-0.01	0.04	-0.33	0.11	0.05	0.13	-0.02	-0.66	0.92
11h	-0.01	0.02	0.02	-0.45	0.03	0.15	0.03	-0.19	-0.81
12h	0.00	-0.06	0.35	-0.03	0.01	0.12	0.13	-0.08	-0.41
13h	-0.01	-0.03	-0.17	-0.08	0.04	0.49	0.49	-0.06	-0.26
14h	0.00	0.00	0.05	0.02	-0.04	-0.30	-0.32	-0.21	-0.33
15h	0.01	-0.05	-0.61	-0.01	-0.07	0.10	0.40	-0.13	-0.03
16h	0.05	0.00	0.44	-0.04	0.02	0.34	-0.36	-0.25	0.01
17h	0.00	0.01	-0.68	-0.01	0.06	0.01	0.50	0.04	-0.11
18h	-0.07	0.02	-0.04	0.09	0.02	0.00	0.19	-0.11	0.06
19h	0.00	0.02	0.02	0.74	0.07	0.08	0.16	-0.33	-0.08
20h	0.01	0.02	-0.11	0.04	0.01	-0.46	-0.41	-0.15	-0.40
21h	0.01	0.02	-0.11	-0.73	0.35	-0.05	-0.09	0.25	-0.40
22h	0.03	0.03	-0.09	-0.19	-0.08	0.12	-0.15	-0.27	-0.17
23h	0.08	0.02	-0.09	-0.03	-0.42	0.04	0.18	-0.29	0.70
24h	-0.10	0.03	-0.08	0.00	-0.15	-0.17	-0.11	-0.30	-1.15
36h	-0.01	0.05	-0.01	0.02	0.02	-0.19	0.21	-0.06	-0.02
48h	0.04	-0.04	-0.13	-0.15	0.17	-0.01	0.00	0.18	-0.15
72h	0.05	-0.04	-0.05	0.04	-0.12	-0.10	-0.21	-0.17	0.21

Table S47. Root Mean Square Error for the final regionalized IDF datasets with a spatial resolution of 0.5°×0.5° based on CGDPP (post-processed using bivariate isotonic regression).

	2 years	5 years	10 years	20 years	50 years	100 years	200 years	500 years	1000 years
1h	2.60	3.76	4.97	6.86	11.39	15.37	20.58	30.17	40.15
2h	1.69	2.46	3.26	4.42	7.38	9.96	13.42	19.71	26.33
3h	1.32	1.92	2.54	3.41	5.62	7.59	10.20	15.01	20.02
4h	1.10	1.61	2.10	2.82	4.57	6.22	8.38	12.32	16.39
5h	0.95	1.39	1.79	2.57	3.93	5.32	7.13	10.47	13.98
6h	0.84	1.21	1.71	2.12	3.45	4.65	6.26	9.21	12.18
7h	0.75	1.10	1.55	2.02	3.09	4.17	5.57	8.18	10.87
8h	0.68	1.00	1.27	1.87	2.79	3.77	5.03	7.40	9.82
9h	0.63	0.91	1.23	1.70	2.57	3.45	4.63	6.76	8.95
10h	0.58	0.84	1.08	1.45	2.36	3.18	4.25	6.27	8.29
11h	0.54	0.79	1.02	1.42	2.21	2.97	3.95	5.85	7.69
12h	0.51	0.74	0.96	1.37	2.06	2.77	3.71	5.47	7.21
13h	0.48	0.70	0.92	1.31	1.94	2.60	3.48	5.13	6.78
14h	0.45	0.66	0.84	1.24	1.82	2.49	3.31	4.87	6.41
15h	0.43	0.63	0.85	1.18	1.73	2.37	3.14	4.59	6.08
16h	0.41	0.60	0.81	1.13	1.66	2.24	2.96	4.37	5.77
17h	0.39	0.58	0.73	1.08	1.58	2.11	2.82	4.18	5.51

18h	0.38	0.55	0.71	1.03	1.51	2.03	2.70	3.98	5.27
19h	0.36	0.53	0.69	0.97	1.46	1.94	2.58	3.82	5.05
20h	0.35	0.51	0.66	0.86	1.40	1.89	2.51	3.67	4.85
21h	0.34	0.49	0.64	0.87	1.34	1.83	2.42	3.53	4.67
22h	0.32	0.48	0.61	0.86	1.30	1.77	2.34	3.39	4.50
23h	0.31	0.46	0.60	0.85	1.24	1.69	2.26	3.28	4.33
24h	0.31	0.45	0.58	0.82	1.21	1.64	2.19	3.18	4.17
36h	0.23	0.33	0.43	0.62	0.90	1.20	1.59	2.34	3.07
48h	0.19	0.27	0.38	0.50	0.73	0.96	1.28	1.86	2.45
72h	0.14	0.21	0.26	0.38	0.54	0.71	0.94	1.35	1.79

Table S48. Kling-Gupta Efficiency for the final regionalized IDF datasets with a spatial resolution of 0.5°×0.5° based on CGDPP (post-processed using bivariate isotonic regression).

	2 years	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**	**200 years**	**500 years**	**1000 years**
1h	0.96	0.96	0.95	0.93	0.87	0.83	0.78	0.71	0.64
2h	0.97	0.96	0.95	0.94	0.88	0.85	0.80	0.72	0.66
3h	0.96	0.96	0.95	0.93	0.89	0.85	0.81	0.73	0.66
4h	0.96	0.96	0.95	0.93	0.89	0.85	0.81	0.74	0.67
5h	0.96	0.96	0.95	0.93	0.89	0.86	0.81	0.74	0.67
6h	0.96	0.96	0.94	0.93	0.89	0.86	0.81	0.74	0.68
7h	0.96	0.96	0.94	0.93	0.90	0.86	0.82	0.74	0.68
8h	0.96	0.96	0.95	0.93	0.90	0.86	0.82	0.74	0.68
9h	0.96	0.96	0.95	0.93	0.90	0.86	0.82	0.74	0.69
10h	0.96	0.96	0.95	0.93	0.90	0.87	0.82	0.75	0.68
11h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.75	0.69
12h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.75	0.69
13h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.75	0.69
14h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.76	0.69
15h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.76	0.69
16h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.76	0.69
17h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.76	0.69
18h	0.97	0.96	0.95	0.93	0.90	0.88	0.83	0.76	0.69
19h	0.97	0.96	0.95	0.93	0.90	0.87	0.83	0.76	0.70
20h	0.97	0.96	0.95	0.93	0.91	0.88	0.83	0.76	0.70
21h	0.97	0.96	0.95	0.94	0.91	0.87	0.83	0.76	0.70
22h	0.97	0.96	0.95	0.94	0.91	0.88	0.84	0.76	0.70
23h	0.97	0.96	0.95	0.93	0.91	0.88	0.83	0.77	0.70
24h	0.97	0.96	0.95	0.93	0.91	0.88	0.84	0.77	0.70
36h	0.97	0.96	0.95	0.93	0.91	0.88	0.84	0.77	0.70
48h	0.97	0.96	0.95	0.94	0.92	0.88	0.84	0.77	0.72
72h	0.96	0.96	0.95	0.94	0.92	0.90	0.85	0.78	0.71

Table S49. Statistical characteristics of 4 representative observed station-level IDF cases(mm/h).

	Mean	Median	STD*	Minimum	5th Percentile	95th Percentile	Maximum
SDSR	40.68	44.37	15.59	2.63	12.19	61.92	94.54
SDLR	76.38	77.05	32.49	4.52	21.5	129.03	221.95
LDSR	4.5	4.62	1.94	0.17	1.39	7.61	13.34
LDLR	8.42	8.31	3.87	0.36	2.42	14.78	27.17

*STD represents the standard deviation.