

Evaluation of Remote Sensing and Reanalysis based Precipitation Products for hydrological studies in semi-arid tropics of Tamil Nadu

Supplementary File

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Table 1 General characteristics of selected study regions

Study Locations	Area (km ²)	Average area elevation (m)	Number of stations	Precipitation (mm)				
				North East Monsoon (October to December)	South West Monsoon (June to September)	Winter Season (January to February)	Summer Season (March to May)	Annual
Coimbatore	4732	427	26	343.8	686.8	19.6	164.8	1215.0
Madurai	3710	101	12	418.8	325.2	23.3	146.9	914.2
Tiruchirappalli	4509	74	15	394.2	276.6	18.1	96.7	785.6
Tuticorin	4745	27 to few metres	16	427.7	64.7	41.4	113.9	647.7

Table 2 Daily precipitation characteristics of Coimbatore and Madurai

Scale	Product	Coimbatore						Madurai					
		CC	MAE	RMSE	BIAS	RB	IA	CC	MAE	RMSE	BIAS	RB	IA
Grid	CMORPH	0.19	3.62	8.92	0.58	0.26	0.36	0.24	5.21	10.92	-1.12	-0.25	0.47
	GPM	0.21	3.87	9.00	1.00	0.44	0.38	0.29	4.67	9.20	-1.60	-0.36	0.53
	MSWEP	0.33	2.96	6.07	0.39	0.16	0.55	0.41	4.09	7.87	-1.85	-0.41	0.61
	PERSIANN	0.20	4.25	7.72	0.37	0.16	0.56	0.35	4.52	8.00	-1.95	-0.43	0.62
	TRMM	0.21	3.49	8.76	0.20	0.09	0.30	0.26	5.09	10.13	-1.26	-0.28	0.50
	ERA5Land	0.37	2.86	6.32	0.35	0.15	0.57	0.45	3.86	7.51	-2.04	-0.46	0.63
	MERRA2	0.24	18.95	41.36	18.29	8.04	0.13	0.31	13.0	35.74	10.87	2.43	0.25
	NCEP2	0.05	5.40	15.77	2.59	1.14	0.13	0.07	6.44	14.00	0.45	0.10	0.28
District	CMORPH	0.23	3.39	8.09	0.58	0.26	0.39	0.25	5.12	10.56	-1.12	-0.25	0.48
	GPM	0.25	3.55	8.03	1.00	0.44	0.41	0.31	4.56	8.81	-1.60	-0.36	0.55
	MSWEP	0.38	2.70	5.37	0.39	0.16	0.59	0.43	4.00	7.59	-1.85	-0.41	0.63
	PERSIANN	0.23	4.04	7.15	-0.17	-0.15	0.59	0.36	4.44	7.80	-1.95	-0.43	0.64
	TRMM	0.23	0.17	1.87	1.43	0.63	0.37	0.27	4.99	9.78	-1.26	-0.28	0.52
	ERA5Land	0.39	0.06	0.61	-0.73	-0.45	0.59	0.48	3.79	7.24	-2.04	-0.46	0.65
	MERRA2	0.29	18.7	39.9	18.29	8.04	0.14	0.32	12.9	35.41	10.87	2.43	0.25
	NCEP2	0.06	5.22	15.51	2.59	1.14	0.13	0.07	6.40	13.91	0.45	0.10	0.29

Table 3 Daily precipitation characteristics of Tiruchirappalli and Tuticorin

Scale	Product	Tiruchirappalli						Tuticorin					
		CC	MAE	RMSE	BIAS	RB	IA	CC	MAE	RMSE	BIAS	RB	IA
Grid	CMORPH	0.20	4.19	9.46	-0.97	-0.28	0.42	0.33	3.88	8.50	-1.66	-0.45	0.55
	GPM	0.26	4.19	9.53	-0.55	-0.16	0.47	0.38	3.99	7.94	-1.26	-0.34	0.60
	MSWEP	0.33	3.45	7.23	-1.15	-0.33	0.56	0.46	3.23	6.62	-0.99	-0.29	0.66
	PERSIANN	0.33	3.91	7.32	-1.17	-0.33	0.57	0.43	3.62	6.53	-1.21	-0.34	0.63
	TRMM	0.23	4.27	9.65	-0.67	-0.19	0.44	0.36	3.96	8.47	-1.53	-0.41	0.58
	ERA5Land	0.37	3.24	6.92	-1.19	-0.34	0.59	0.39	3.57	7.23	-1.43	-0.39	0.61
	MERRA2	0.21	11.19	33.08	9.38	2.70	0.18	0.30	11.89	33.27	10.49	2.83	0.23
	NCEP2	0.10	5.50	13.33	1.06	0.31	0.26	0.12	6.16	13.59	1.48	0.40	0.30
District	CMORPH	0.21	4.11	9.16	-0.97	-0.28	0.43	0.37	3.69	7.75	-1.66	-0.45	0.59
	GPM	0.27	4.08	9.10	-0.55	-0.16	0.48	0.43	3.62	7.24	-1.26	-0.34	0.64
	MSWEP	0.35	3.36	6.94	-1.15	-0.33	0.57	0.46	3.19	6.53	-0.99	-0.29	0.66
	PERSIANN	0.35	3.81	7.08	-1.17	-0.33	0.58	0.47	3.38	6.03	-1.21	-0.34	0.66
	TRMM	0.24	4.17	9.30	-0.67	-0.19	0.45	0.40	3.74	7.73	-1.53	-0.41	0.61
	ERA5Land	0.39	3.15	6.66	-1.19	-0.34	0.60	0.46	3.28	6.37	-1.43	-0.39	0.66
	MERRA2	0.22	11.09	32.84	9.38	2.70	0.17	0.33	11.62	32.24	10.49	2.83	0.23
	NCEP2	0.10	5.43	13.21	1.06	0.31	0.26	0.12	6.00	13.36	1.48	0.40	0.29

Table 4 Monthly precipitation characteristics of Coimbatore and Madurai

Scale	Product	Coimbatore						Madurai					
		CC	MAE	RMSE	BIAS	RB	IA	CC	MAE	RMSE	BIAS	RB	IA
Grid	CMORPH	0.54	53.79	72.09	17.60	0.26	0.72	0.16	66.47	91.80	-34.17	-0.25	0.79
	GPM	0.48	61.88	83.12	30.57	0.44	0.67	0.78	65.64	87.07	-48.76	-0.36	0.80
	MSWEP	0.59	45.99	63.01	8.71	0.12	0.83	0.80	67.68	91.04	-58.34	-0.43	0.79
	PERSIANN	0.34	84.50	113.09	54.51	0.79	0.54	0.69	68.06	87.18	-25.84	-0.19	0.79
	TRMM	0.10	80.84	109.78	0.20	0.09	0.30	0.75	63.63	84.70	-38.29	-0.28	0.82
	ERA5Land	0.62	43.63	62.80	5.70	0.08	0.78	0.81	69.98	93.25	-62.09	-0.46	0.78
	MERRA2	-0.15	68.78	96.82	556.73	8.04	0.16	0.71	333.84	459.54	330.96	2.43	0.42
	NCEP2	-0.08	121.22	225.95	78.79	1.14	0.13	-0.02	131.16	190.56	13.65	0.10	0.30
District	CMORPH	0.63	47.69	60.63	17.60	0.26	0.77	0.69	65.44	89.22	-34.17	-0.25	0.79
	GPM	0.56	54.81	73.52	30.57	0.44	0.71	0.80	64.83	85.03	-48.76	-0.36	0.81
	MSWEP	0.69	38.43	50.66	8.71	0.12	0.83	0.81	67.00	89.25	-58.34	-0.43	0.80
	PERSIANN	0.39	78.23	107.45	54.51	0.79	0.54	0.70	67.76	85.39	-25.84	-0.19	0.80
	TRMM	-0.01	2.28	14.08	25.22	0.50	0.30	0.77	62.88	82.40	-38.29	-0.28	0.83
	ERA5Land	0.72	35.84	50.35	5.70	0.08	0.84	0.83	69.45	91.38	-62.09	-0.46	0.78
	MERRA2	0.56	556.6	705.76	556.73	8.04	0.15	0.72	333.68	457.92	330.96	2.43	0.42
	NCEP2	-0.09	117.6	223.0	78.79	1.14	0.12	-0.02	130.84	189.86	13.67	0.10	0.30

Table 5 Monthly precipitation characteristics of Tiruchirappalli and Tuticorin

Scale	Product	Tiruchirapalli						Tuticorin					
		CC	MAE	RMSE	BIAS	RB	IA	CC	MAE	RMSE	BIAS	RB	IA
Grid	CMORPH	0.64	55.51	79.11	-29.57	-0.28	0.77	0.73	60.42	83.80	-50.57	-0.45	0.79
	GPM	0.71	51.08	72.25	-16.67	-0.16	0.83	0.77	55.31	75.04	-38.41	-0.34	0.83
	MSWEP	0.75	50.99	69.96	-36.54	-0.35	0.82	0.80	47.07	66.35	-32.02	-0.31	0.86
	PERSIANN	0.77	43.51	61.65	-7.32	-0.07	0.87	0.73	50.59	69.23	-29.84	-0.26	0.83
	TRMM	0.69	51.99	74.32	-20.43	-0.19	0.82	0.77	57.74	77.44	-46.41	-0.41	0.82
	ERA5Land	0.79	49.01	66.13	-36.16	-0.34	0.83	0.65	62.03	89.45	-43.45	-0.39	0.77
	MERRA2	0.59	17383.95	416.93	285.37	2.70	0.34	0.64	319.79	448.33	319.31	2.83	0.37
	NCEP2	0.17	103.07	160.10	32.27	0.31	0.40	0.11	114.70	169.54	45.12	0.40	0.38
District	CMORPH	0.65	53.66	76.60	-29.57	-0.28	0.78	0.80	57.18	75.62	-50.57	-0.45	0.82
	GPM	0.73	48.52	69.47	-16.67	-0.16	0.84	0.80	51.76	68.40	-38.41	-0.34	0.85
	MSWEP	0.77	49.13	67.24	-36.54	-0.35	0.83	0.80	46.72	65.58	-32.02	-0.31	0.86
	PERSIANN	0.79	41.04	58.07	-7.32	-0.07	0.89	0.82	44.03	61.57	-29.84	-0.26	0.86
	TRMM	0.71	50.09	71.46	-20.43	-0.19	0.83	0.83	55.92	70.34	-46.41	-0.41	0.84
	ERA5Land	0.81	47.53	63.27	-36.16	-0.34	0.84	0.76	55.56	75.15	-43.45	-0.39	0.82
	MERRA2	0.60	287.05	415.75	285.37	2.70	0.34	0.68	319.43	443.23	319.31	2.83	0.37
	NCEP2	0.18	102.69	158.98	32.27	0.31	0.40	0.11	113.03	167.21	45.12	0.40	0.37

Table 6 Yearly precipitation characteristics of Coimbatore and Madurai

Scale	Product	Coimbatore					Madurai				
		CC	MAE	RMSE	RB	IA	CC	MAE	RMSE	RB	IA
Grid	CMORPH	0.21	344.76	423.07	0.24	0.47	0.42	433.69	539.15	-0.26	0.52
	GPM	0.12	454.90	536.78	0.44	0.44	0.64	585.09	644.06	-0.36	0.50
	MSWEP	0.05	317.51	397.89	0.12	0.41	0.45	700.10	767.09	-0.43	0.44
	PERSIANN	0.39	670.97	731.66	0.79	0.44	0.61	330.26	416.82	-0.19	0.60
	TRMM	-0.61	860.22	939.29	0.09	0.07	0.48	462.26	560.14	-0.28	0.54
	ERA5Land	0.33	278.73	346.07	0.08	0.57	0.66	745.05	791.22	-1.00	0.25
	MERRA2	-0.01	6680.71	6878.40	8.04	0.07	0.35	3971.54	4148.24	2.43	0.12
	NCEP2	-0.23	976.94	1145.97	1.14	0.26	-0.75	471.97	609.66	0.10	0.07
District	CMORPH	0.42	9.69	56.92	0.24	0.53	0.44	61.43	200.58	-0.26	0.52
	GPM	0.41	15.95	85.22	0.44	0.40	0.67	83.60	241.07	-0.36	0.51
	MSWEP	0.43	12.50	53.03	0.12	0.58	0.47	100.03	287.87	-0.43	0.45
	PERSIANN	0.47	27.25	138.93	0.79	0.31	0.63	45.61	154.01	-0.19	0.61
	TRMM	0.37	6.53	39.02	0.09	0.57	0.49	65.67	208.98	-0.28	0.54
	ERA5Land	0.69	9.72	41.64	0.08	0.80	0.71	106.46	296.84	-0.46	0.46
	MERRA2	0.30	278.36	1394.66	8.04	0.04	0.36	567.34	1565.42	2.43	0.12
	NCEP2	-0.48	39.40	225.68	1.14	0.12	-0.77	66.67	228.17	0.10	0.07

Table 7 Yearly precipitation characteristics of Tiruchirappalli and Tuticorin

Scale	Product	Tiruchirappalli					Tuticorin				
		CC	MAE	RMSE	RB	IA	CC	MAE	RMSE	RB	IA
Grid	CMORPH	0.32	382.18	468.57	-0.29	0.49	0.46	625.21	693.33	-0.46	0.44
	GPM	0.68	230.68	283.43	-0.16	0.72	0.71	461.92	517.85	-0.34	0.55
	MSWEP	0.68	438.44	481.53	-0.35	0.51	0.77	384.15	425.33	-0.31	0.56
	PERSIANN	0.68	174.31	217.84	-0.07	0.80	0.48	379.93	463.14	-0.26	0.50
	TRMM	0.60	266.01	333.92	-0.19	0.65	0.60	558.37	617.91	-0.41	0.48
	ERA5Land	0.82	434.31	461.09	-0.34	0.57	0.21	521.35	669.71	-0.39	0.41
	MERRA2	0.31	3424.42	3523.97	2.70	0.12	0.30	3831.64	3923.29	2.83	0.13
	NCEP2	-0.23	446.51	567.99	0.31	0.32	-0.54	640.77	746.16	0.40	0.25
District	CMORPH	0.35	45.75	160.87	-0.29	0.49	0.73	51.83	187.02	-0.46	0.44
	GPM	0.74	25.64	92.69	-0.16	0.74	0.88	38.42	138.19	-0.34	0.54
	MSWEP	0.74	54.80	165.86	-0.35	0.51	0.81	192.15	295.53	-0.31	0.57
	PERSIANN	0.79	17.66	62.87	-0.07	0.85	0.85	29.85	113.78	-0.26	0.56
	TRMM	0.67	30.63	110.92	-0.19	0.67	0.90	46.43	164.62	-0.41	0.49
	ERA5Land	0.92	54.21	157.49	-0.34	0.58	0.90	43.44	154.23	-0.39	0.51
	MERRA2	0.33	428.06	1245.12	2.70	0.11	0.44	319.30	1127.75	2.83	0.11
	NCEP2	-0.24	54.81	197.06	0.31	0.31	-0.71	53.25	207.55	0.40	0.20

Figure 1. Map of Tamil Nadu and study regions (Coimbatore, Madurai, Tiruchirappalli, Tuticorin) with ground stations

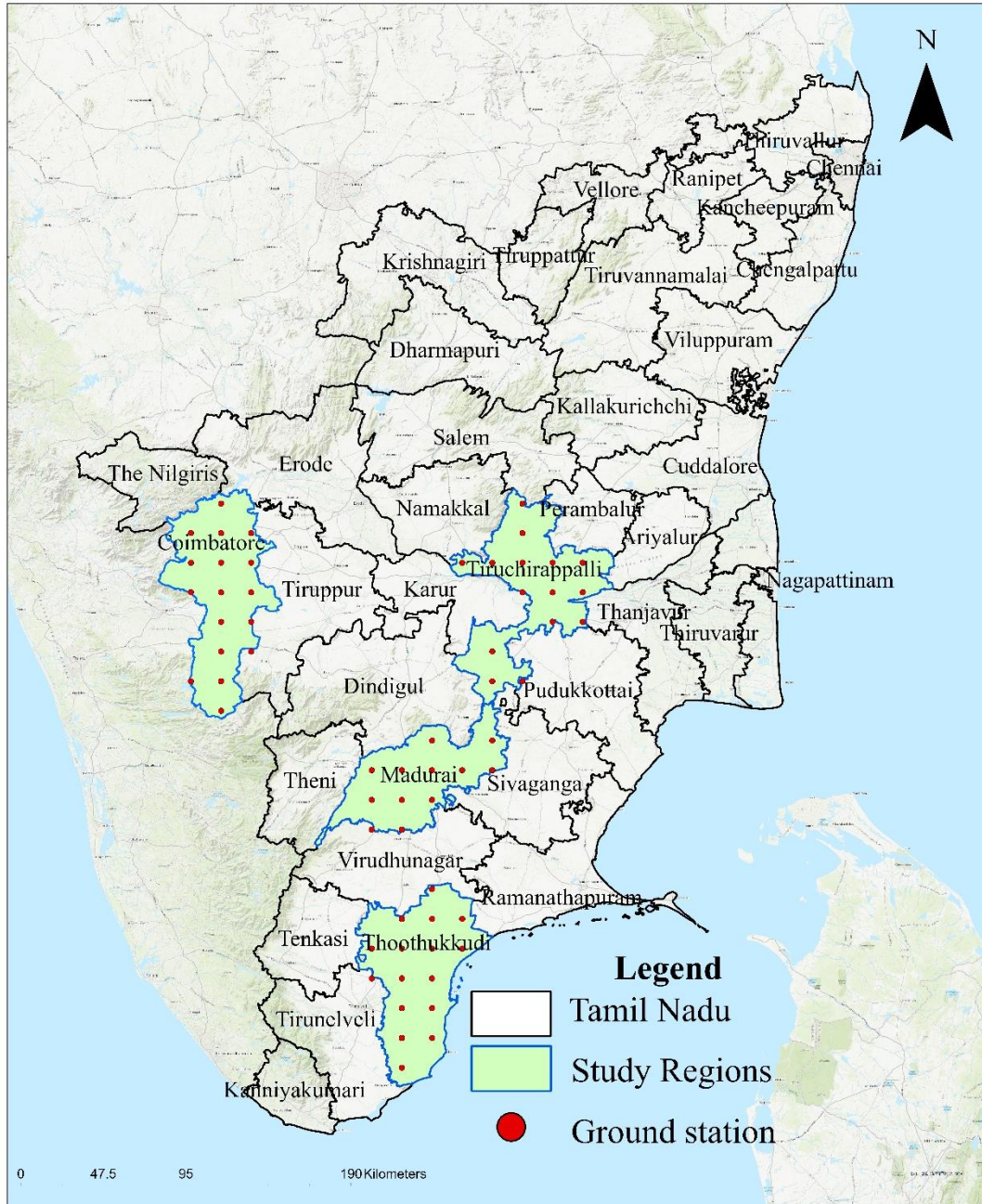


Figure 2 Occurrence frequency of precipitation (0-1 mm) for (a) Coimbatore, (b) Madurai, (c) Tiruchirapalli and (d) Tuticorin

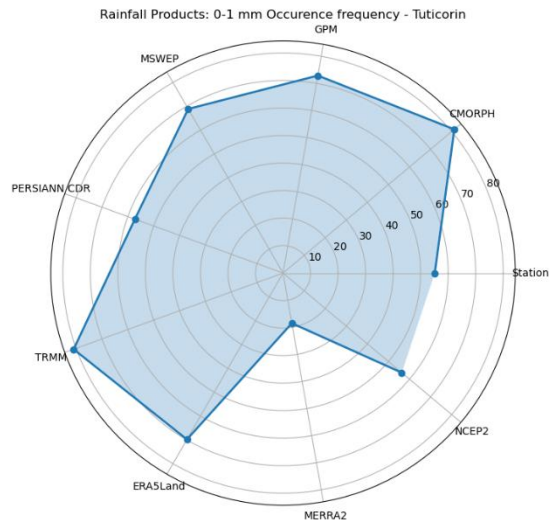
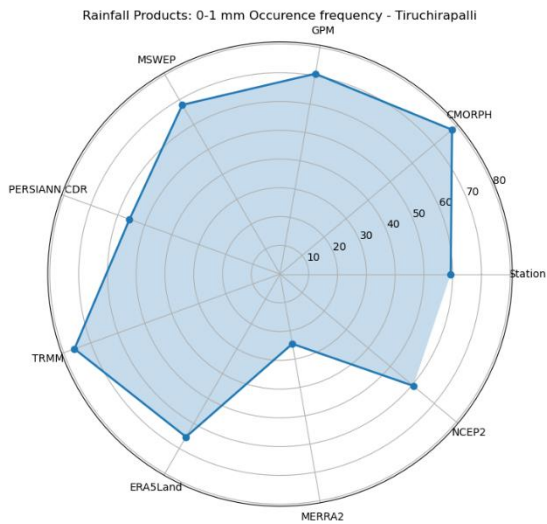
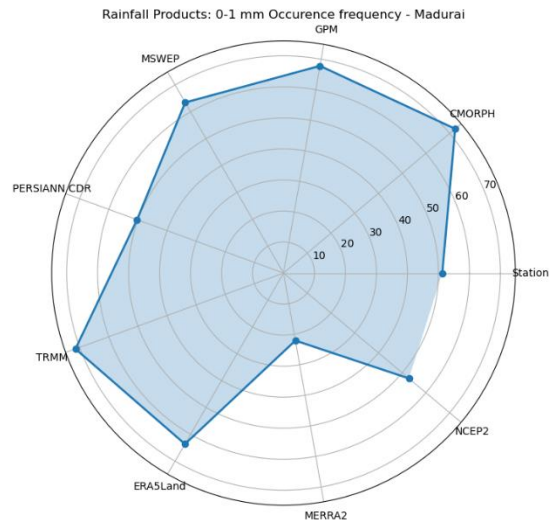
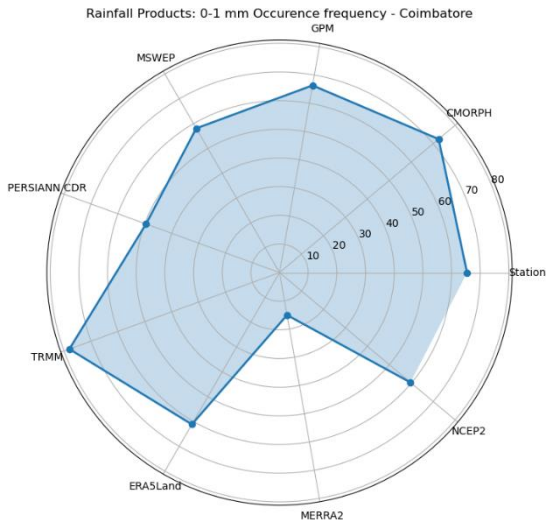


Figure 3 Occurrence frequency of precipitation (1-> 50 mm) for (a) Coimbatore, (b) Madurai, (c) Tiruchirapalli and (d) Tuticorin

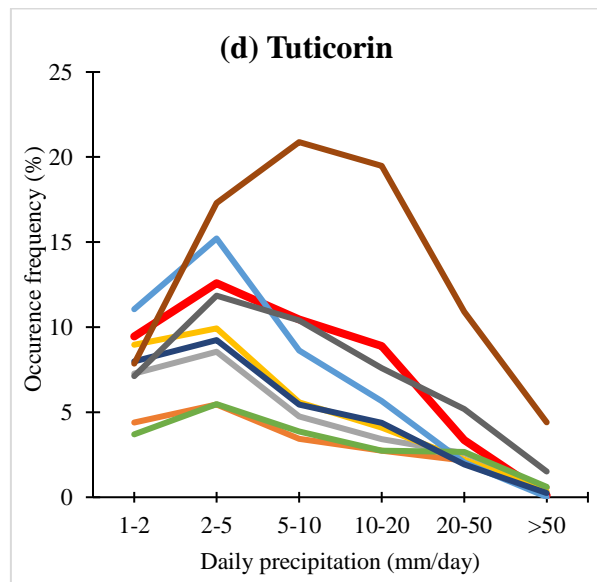
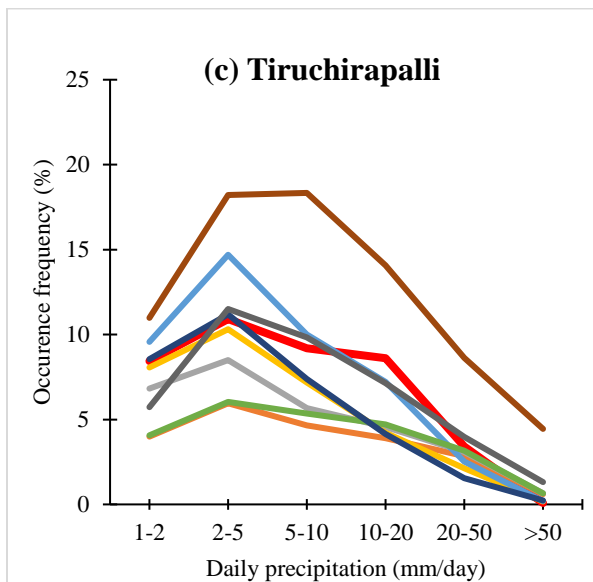
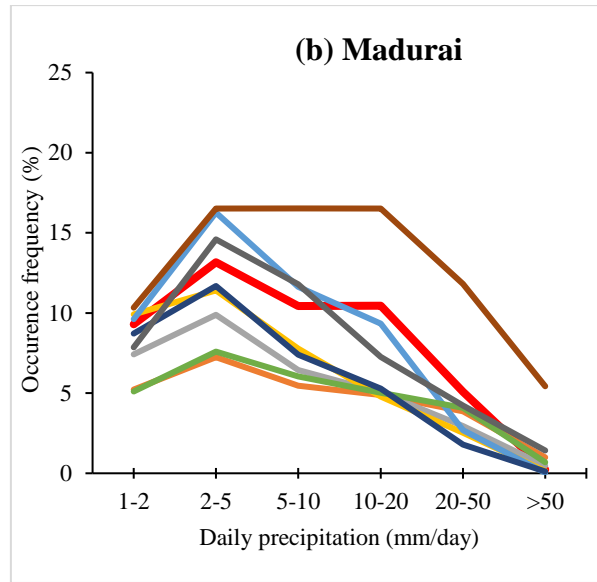
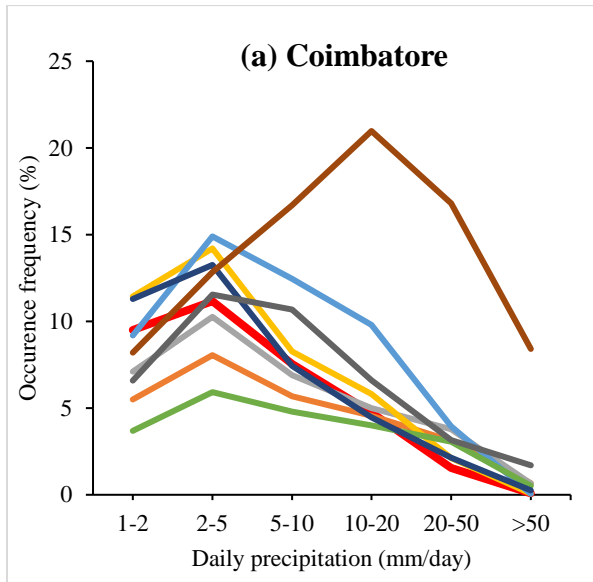


Figure 4 Monthly Mean (a) and %MAE (b) of different precipitation products with respect to Station data in Coimbatore

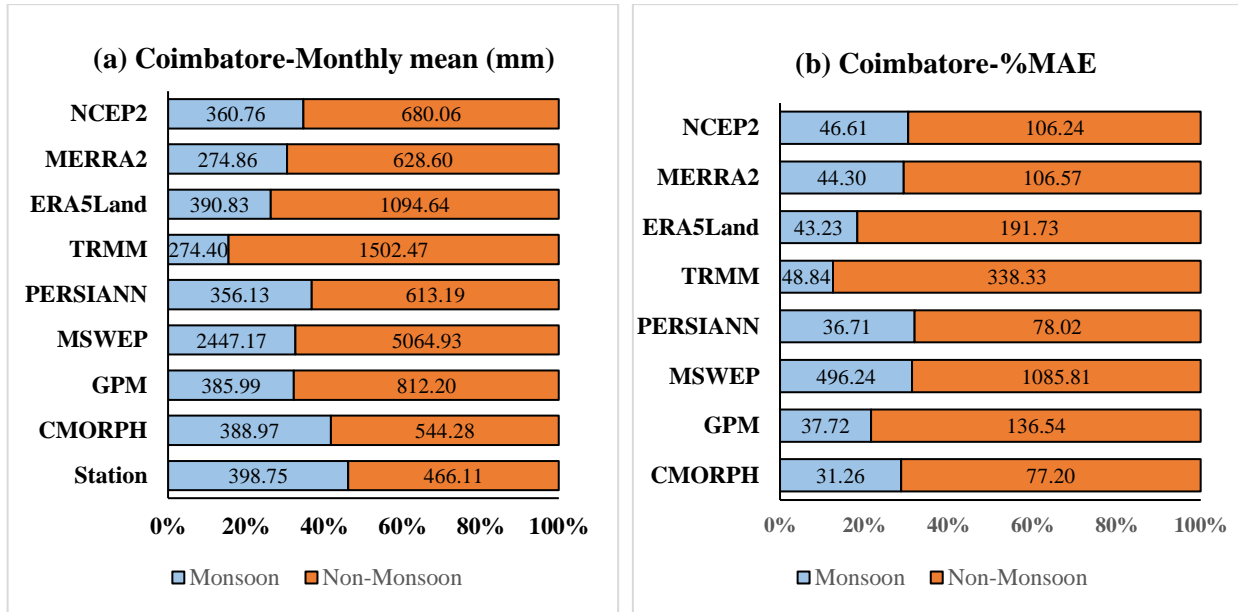


Figure 5 Monthly Mean (a) and %MAE (b) of different precipitation products with respect to Station data in Madurai

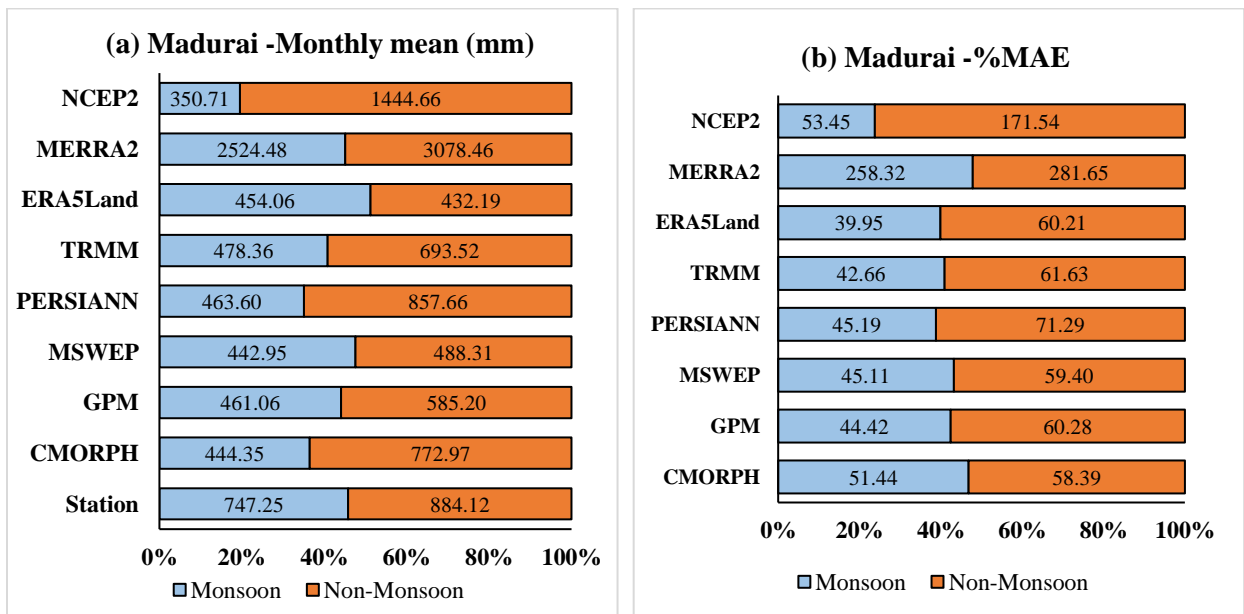


Figure 6 Monthly Mean (a) and %MAE (b) of different precipitation products with respect to Station data in Tiruchirapalli

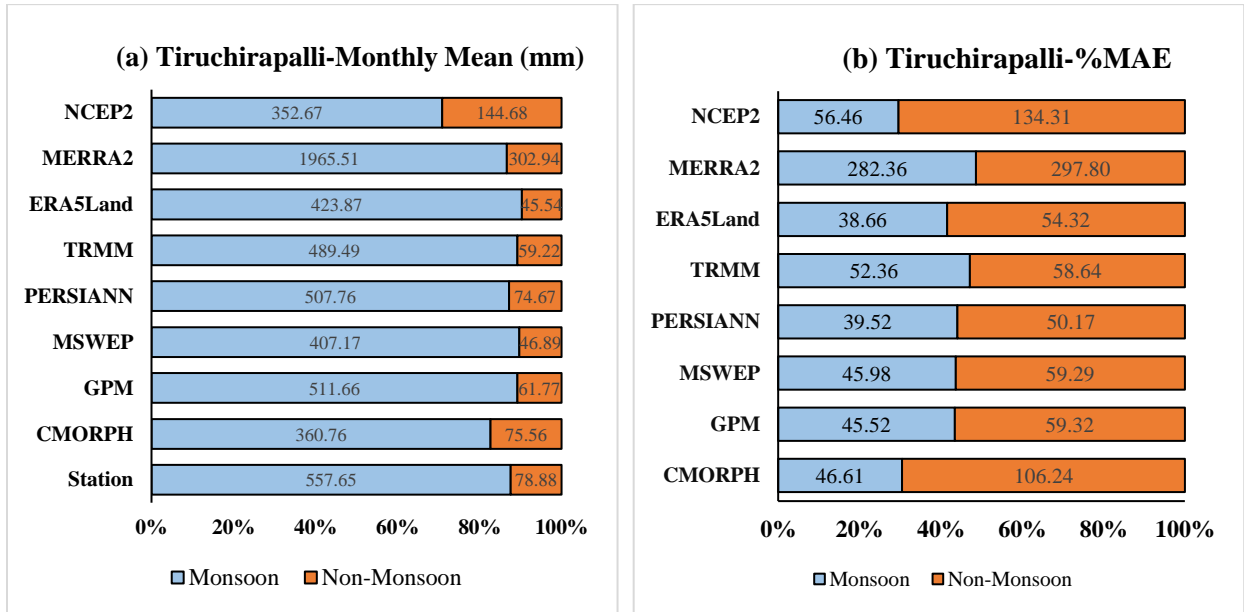


Figure 7 Monthly Mean (a) and %MAE (b) of different precipitation products with respect to Station data in Tuticorin

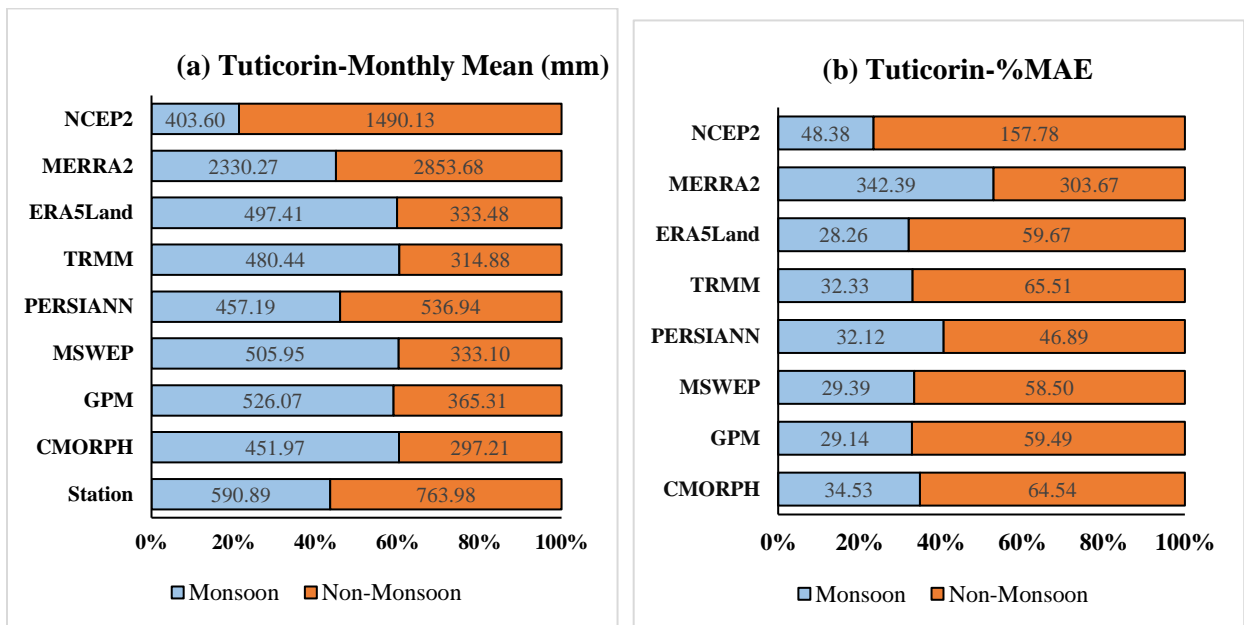


Figure 8 Taylor diagram depicting the agreement between station data and precipitation products at a yearly grid scale.

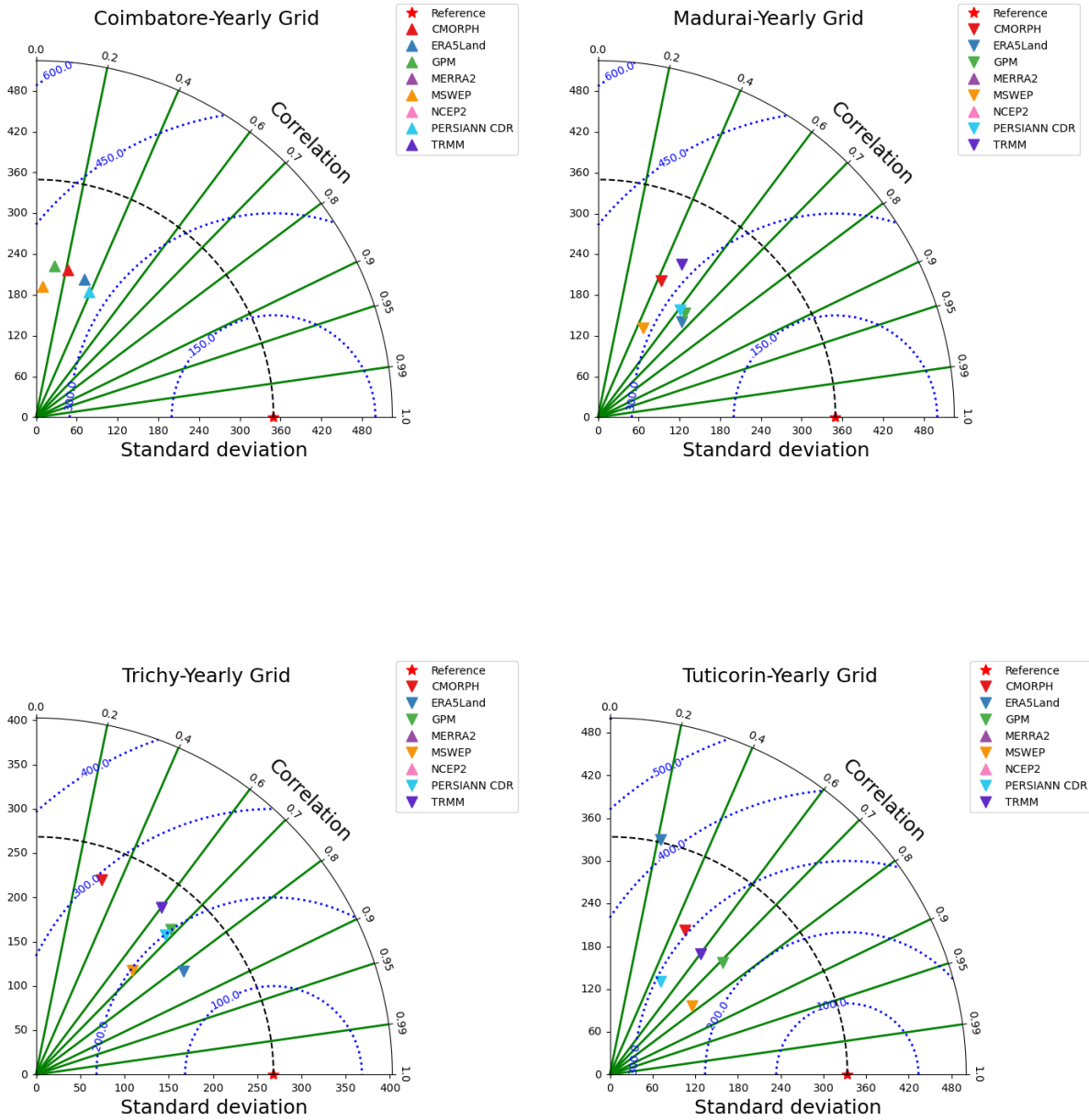


Figure 9 Taylor diagram depicting the agreement between station data and precipitation products at a yearly district scale.

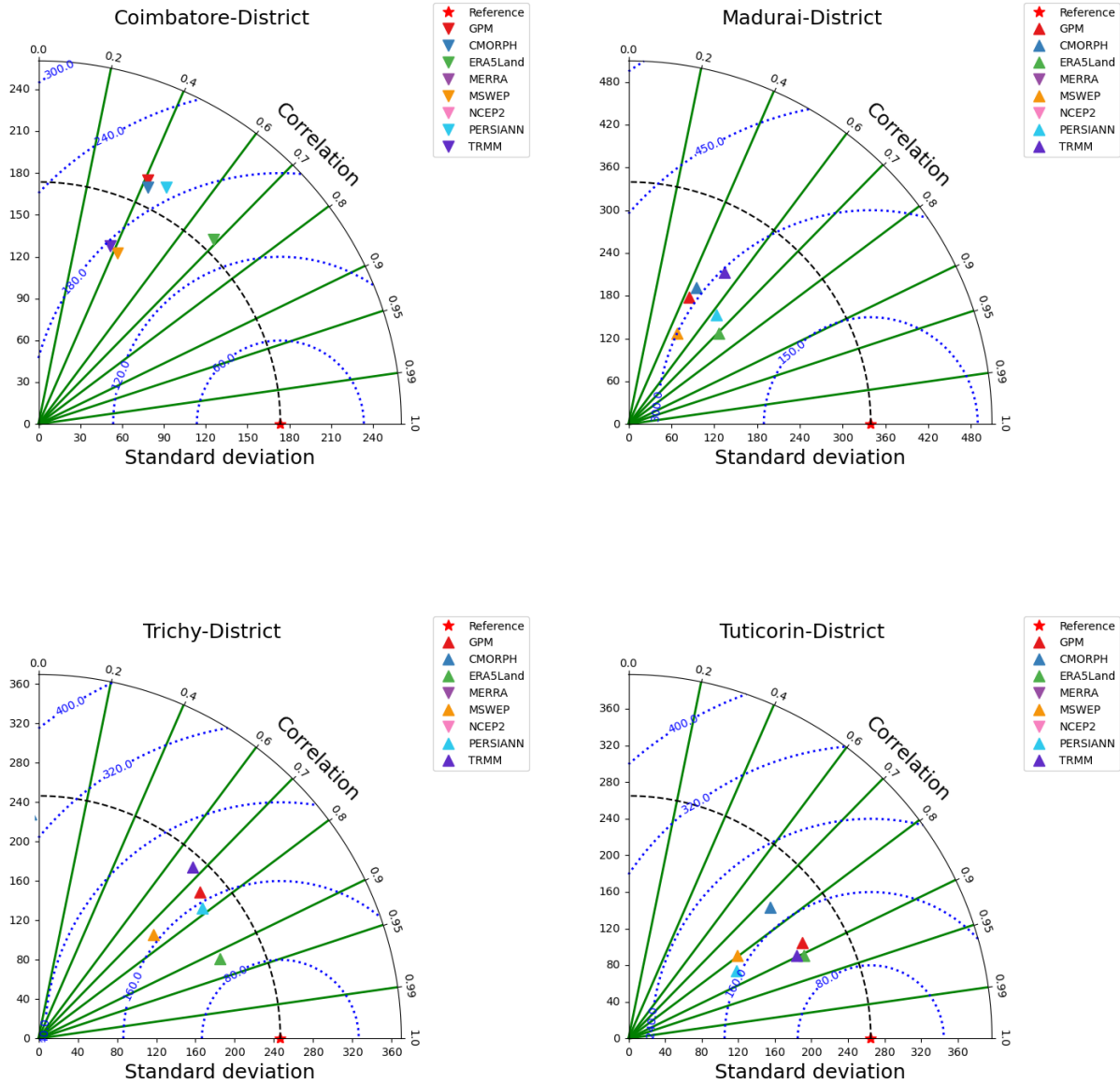


Figure 10 Mean annual precipitation for the Station data and different precipitation products at Coimbatore

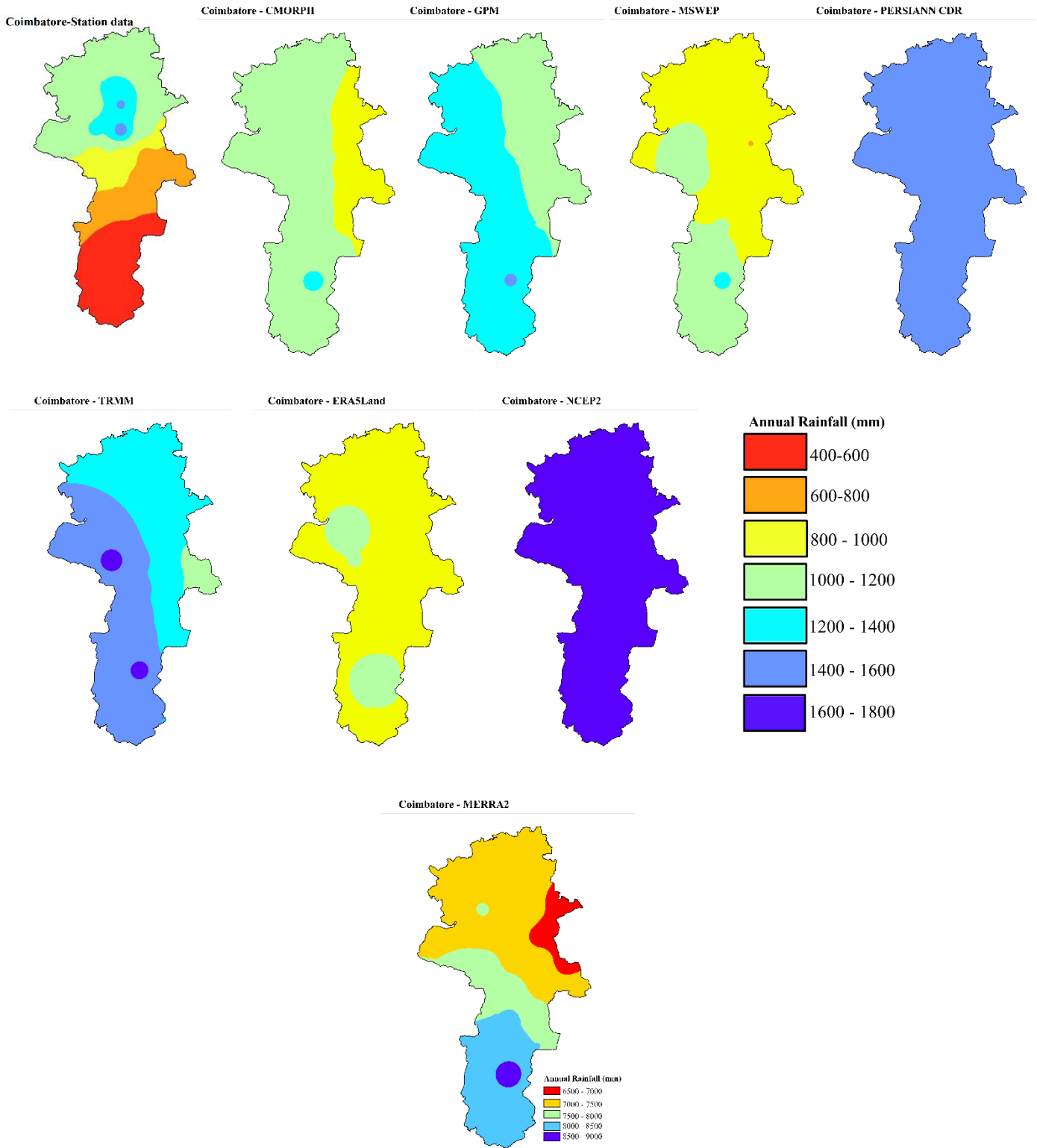


Figure 11 Mean annual precipitation for the Station data and different precipitation products at Madurai

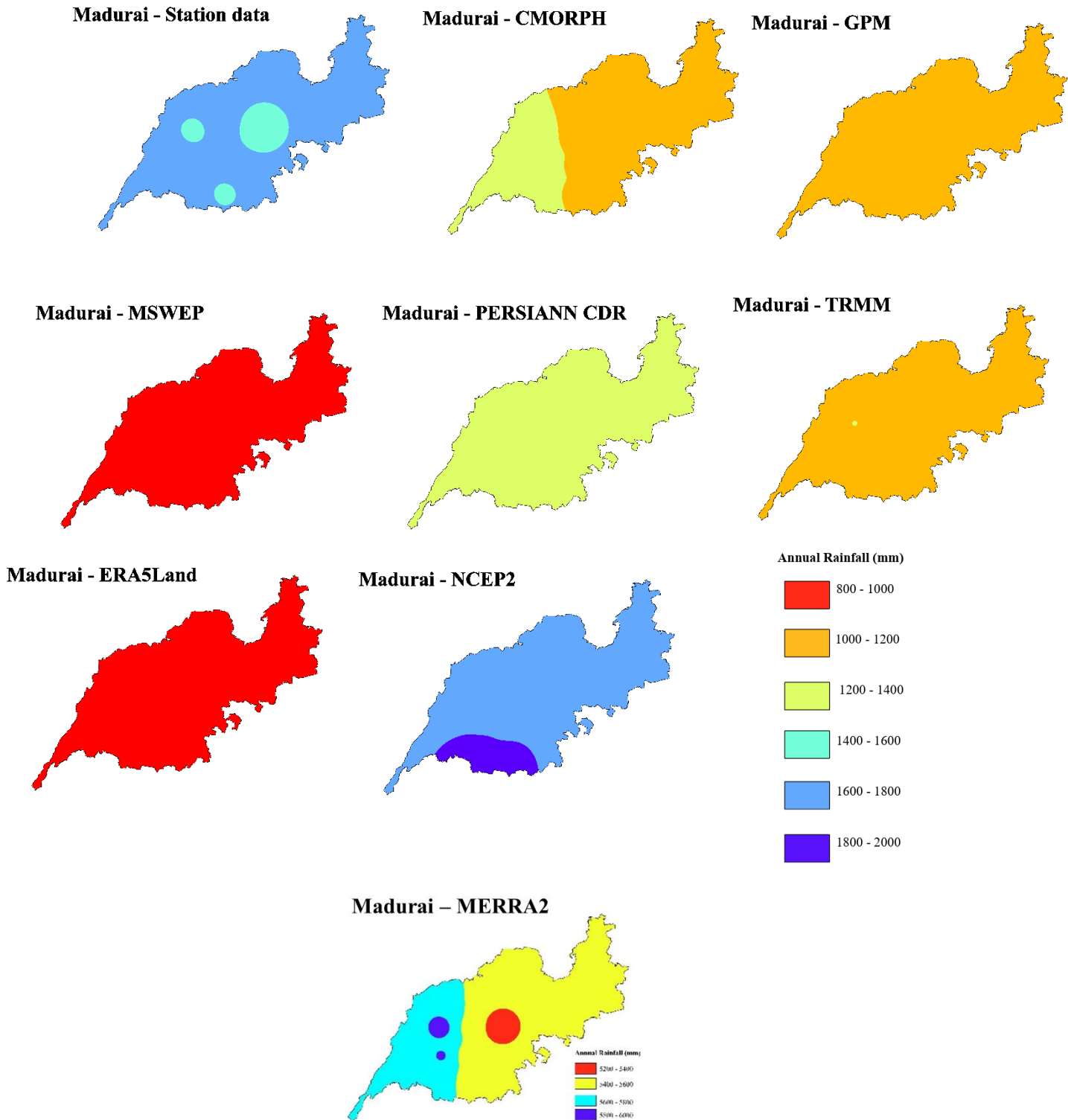


Figure 12 Mean annual precipitation for the Station data and different precipitation products at Tiruchirappalli

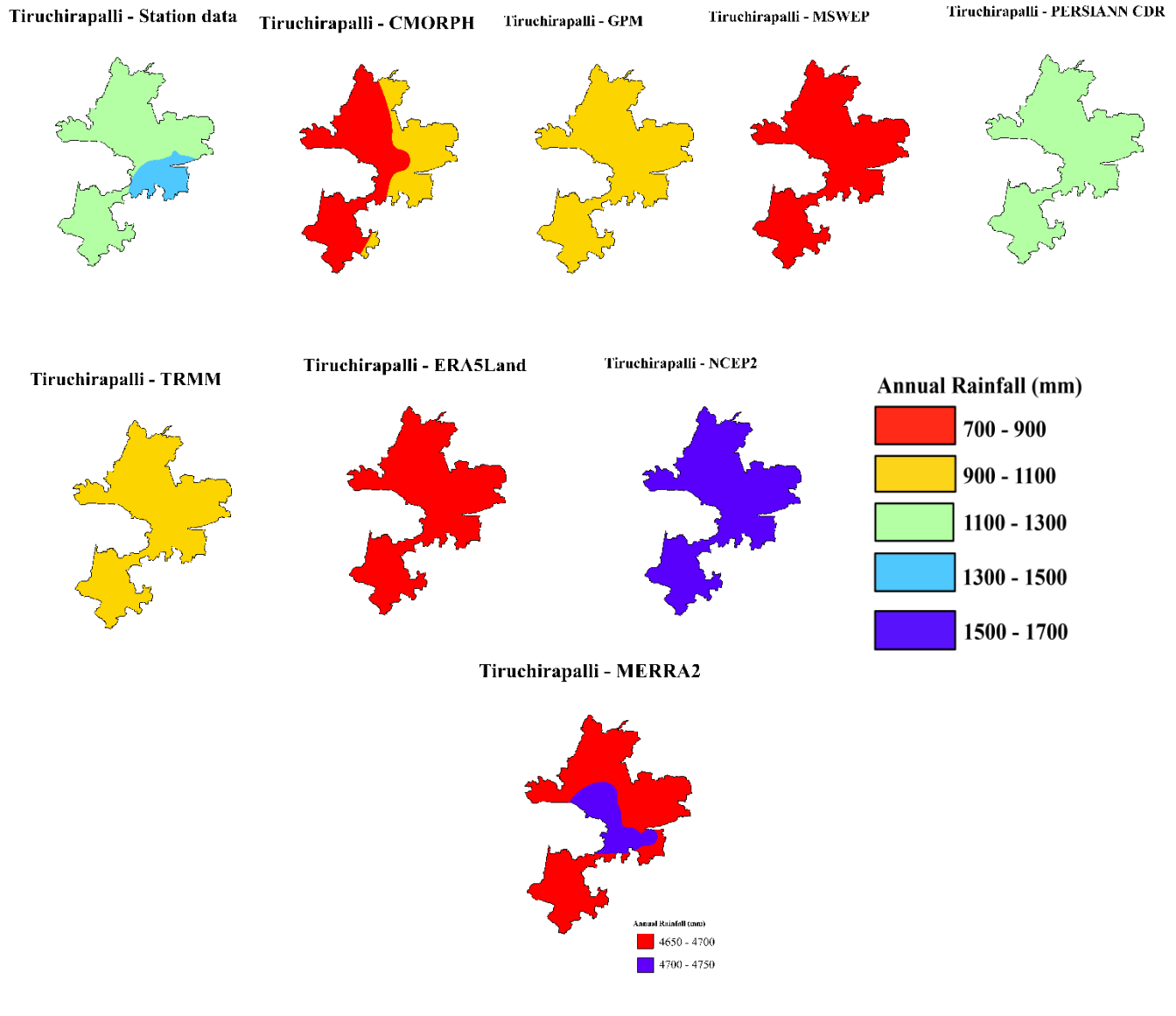


Figure 13 Mean annual precipitation for the Station data and different precipitation products at Tuticorin

