Evaluation of CORDEX regional climate models (RCMs) for future climate extreme projection in Bangkok and its vicinity, Thailand

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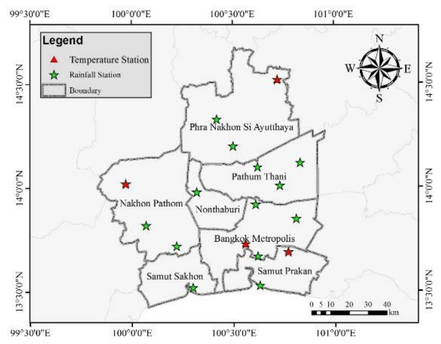
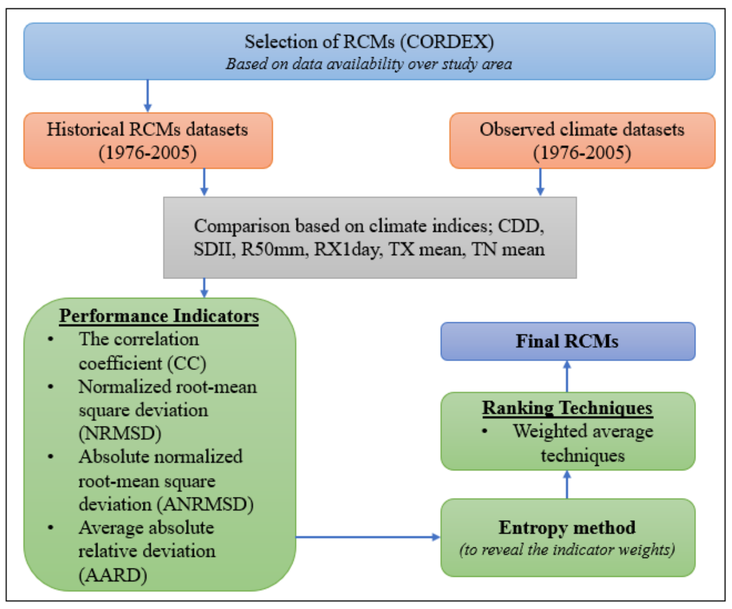
Abstract

This study focusses on evaluating a set of Regional Climate Models (RCMs) for future climate extreme projection in Bangkok and its vicinity, Thailand. Although a large number of RCMs are available nowadays in the CORDEX archive, the issue of their reliability for specific regions must still be confronted. This situation makes it imperative to sort out the most appropriate set of RCMs for the assessment of climate change impacts in the region. To this end, twenty-one RCMs with gridded resolution of 0.44°*044° from the CORDEX data portal were assessed for six climate indices; Consecutive Dry Days (CDD), Simple Daily Intensity Index (SDII), Number of extremely heavy precipitation days (R50mm), Maximum 1-day precipitation amount (RX1day), Mean of daily maximum temperature (TX mean) and Mean of daily minimum temperature (TN mean) using four performance indicators. The performance indicators used were correlation coefficient (CC), normalized root mean square deviation (NRMSD), absolute normalized root mean square deviation (ANRMSD) and average absolute relative deviation (AARD). The Entropy method was endorsed to acquire weights of these 4 indicators and weightage average techniques was used for ranking of 21 RCMs. The result demonstrated that the best model for one climate indices is not the same best model for other climate indices. In addition, the RCMs; WAS44_SMHI_RCA4_IPSL_CM5A_MR, WAS44_SMHI_RCA4_NCC_NorESM1_M, WAS44_SMHI_RCA4_CCCma_CanESM2, WAS44_SMHI_RCA4_ICHE_EC_EARTH and, WAS44_SMHI_RCA4_MPI_ESM_LR are the top five best performing RCMs in Bangkok and its vicinity, Thailand, respectively. Therefore, they are recommended for the further investigation.

Overall Methodological Framework





Entropy Method

Step 1: Formation of decision matrix which shows the performances of different alternatives (RCMs) with respect to various evaluation criteria (Performance indicators)

$$X = [X_{ij}]_{matrix} = \begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{bmatrix} \quad \text{where, i = 1, 2...., m; j = 1, 2..., n}$$

Step 2: Normalization of the decision matrix

$$r_{ij} = \frac{X_{ij} - min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \quad \text{where, i = 1, 2...., m; j = 1, 2..., n}$$

$$r_{ij} = \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} \quad \text{where, i = 1, 2...., m; j = 1, 2..., n}$$

Step 3: Determination of Entropy value (ej) for each evaluation criteria (performance indicators)

$$e_j = \frac{-1}{\ln(m)} \sum_{i=1}^{m} f_{ij} * \ln(f_{ij}) \quad \text{where, i = 1, 2...., m; j = 1, 2..., n}$$

$$f_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad \text{where, i = 1, 2...., m; j = 1, 2..., n and 0<ej<1}$$

Step 4: Calculation of Entropy weights (Wj) based on degree of diversification (Dj)

$$D_j = 1 - e_j$$

$$W_j = \frac{D_j}{\sum_{j=1}^{n} D_j} \quad \text{where, } \sum_{j=1}^{n} W_j = 1$$

Weightage Average Technique

$$V_j = \sum_{j=1}^{n} r_{ij} W_j \text{ where, j = 1, 2..., n; } \sum_{j=1}^{n} W_j = 1 \text{ ; Wj>=0}$$

Conclusions

- *Each indicator responds differently for various RCMs and climate indices and the best model for one climate indices is not the same best model for other climate indices.*
- *RCMs; WAS44_SMHI_RCA4_IPSL_CM5A_MR, WAS44_SMHI_RCA4_NCC_NorESM1_M, WAS44_SMHI_RCA4_CCCma_CanESM2, WAS44_SMHI_RCA4_ICHE_EC_EARTH and, WAS44_SMHI_RCA4_MPI_ESM_LR are the top five best performing RCMs in Bangkok and its vicinity, Thailand, respectively.*

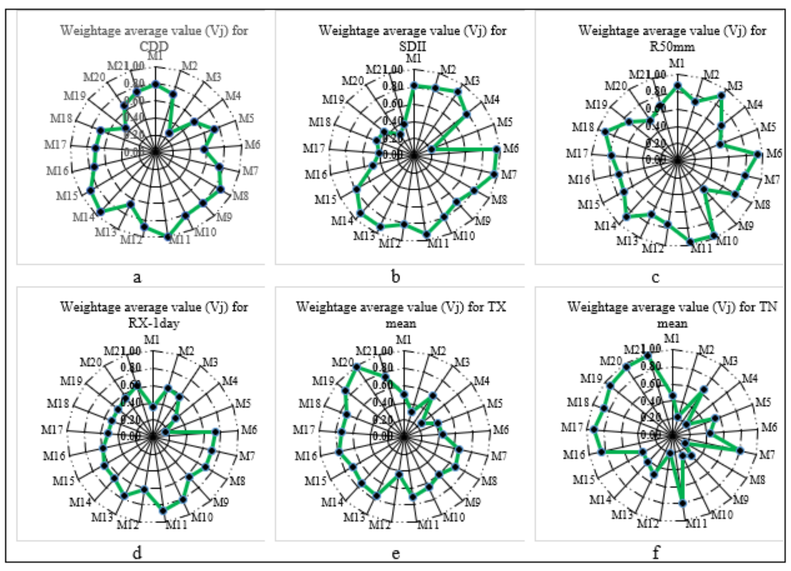
Analysis of Performance Indicators for CDD

Model Serial	CC	NRMSD	ANRMSD	AARD
M1	0.029	0.593	0.166	0.547
M2	0.014	0.626	0.257	0.642
M3	0.174	0.968	0.795	1.193
M4	0.059	0.764	0.378	0.810
M5	0.001	0.618	0.198	0.601
M6	0.008	0.718	0.371	0.792
M7	0.090	0.632	0.407	0.447
M8	0.151	0.582	0.317	0.423
M9	0.029	0.553	0.147	0.571
M10	0.187	0.631	0.429	0.452
M11	0.206	0.526	0.139	0.429
M12	0.138	0.584	0.217	0.471
M13	-0.054	0.634	0.352	0.460
M14	0.138	0.537	0.156	0.425
M15	0.158	0.589	0.249	0.450
M16	0.044	0.625	0.378	0.432
M17	0.081	0.675	0.420	0.512
M18	0.018	0.650	0.372	0.499
M19	-0.203	0.719	0.427	0.584
M20	0.000	0.667	0.414	0.487
M21	0.039	0.624	0.356	0.459
Max	0.206	0.968	0.795	1.193
Min	-0.203	0.526	0.139	0.423
Max-Min	0.408	0.441	0.656	0.771

Application of Entropy Method and Weightage Average Technique for CDD

Model Serial	CC	NRMSD	ANRMSD	AARD	Weighted Average Value (Vj)	Rank
M1	0.566	0.848	0.958	0.838	0.790	8
M2	0.529	0.774	0.820	0.716	0.700	13
M3	0.923	0.000	0.000	0.000	0.272	21
M4	0.641	0.461	0.635	0.498	0.566	18
M5	0.498	0.794	0.909	0.769	0.730	12
M6	0.515	0.566	0.645	0.520	0.560	19
M7	0.716	0.761	0.591	0.968	0.752	9
M8	0.865	0.874	0.728	1.000	0.863	5
M9	0.568	0.940	0.988	0.808	0.813	7
M10	0.953	0.764	0.557	0.962	0.813	6
M11	1.000	1.000	1.000	0.992	0.998	1
M12	0.834	0.869	0.881	0.937	0.877	4
M13	0.364	0.755	0.675	0.951	0.665	16
M14	0.835	0.977	0.974	0.997	0.939	2
M15	0.883	0.858	0.831	0.965	0.883	3
M16	0.604	0.776	0.635	0.988	0.738	10
M17	0.694	0.664	0.571	0.884	0.699	14
M18	0.539	0.721	0.644	0.901	0.689	15
M19	0.000	0.564	0.561	0.791	0.449	20
M20	0.497	0.680	0.581	0.917	0.655	17
M21	0.593	0.779	0.669	0.953	0.736	11
ej	0.973	0.979	0.977	0.979	-	-
Dj	0.027	0.021	0.023	0.021	-	-
Wj	0.295	0.229	0.249	0.227	-	-

Weightage Average Value for all Climate Indices



Final Selection of RCMs in Bangkok and its Vicinity, Thailand

Modal Serial	Rank in Bangkok and its vicinity						
	CDD	SDII	R50mm	Rx 1day	TX mean	TN mean	Rank Sum
M1	8	8	7	19	16	12	70
M2	13	7	13	12	20	18	83
M3	21	6	4	14	15	9	69
M4	18	13	18	20	21	20	110
M5	12	21	20	21	19	10	103
M6	19	1	3	4	17	13	57
M7	9	2	8	5	12	7	43
M8	5	10	9	6	11	21	62
M9	7	14	21	9	14	16	81
M10	6	11	1	2	13	17	50
M11	1	3	2	1	9	8	24
M12	4	9	11	11	18	19	72
M13	16	4	16	3	4	11	54
M14	2	5	6	7	6	14	40
M15	3	12	14	8	10	15	62
M16	10	15	15	13	3	6	62
M17	14	18	10	16	7	4	69
M18	15	16	5	17	8	5	66
M19	20	17	12	18	2	3	72
M20	17	20	19	15	1	2	74
M21	11	19	17	10	5	1	63

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