CHAPTER 4 RESULTS AND DISCUSSION

4.1 The EdGCM Forecasts

EdGCM is run with the grid size of 8×10 degree latitude-longitude and 9 vertical layers. The model forecasts start on 1st January 1958 and end on 31st December 2100. The selected data for the experiments are surface are temperature on April 2010 to April 2100. The results are shown in Figures 4.1-4.7.

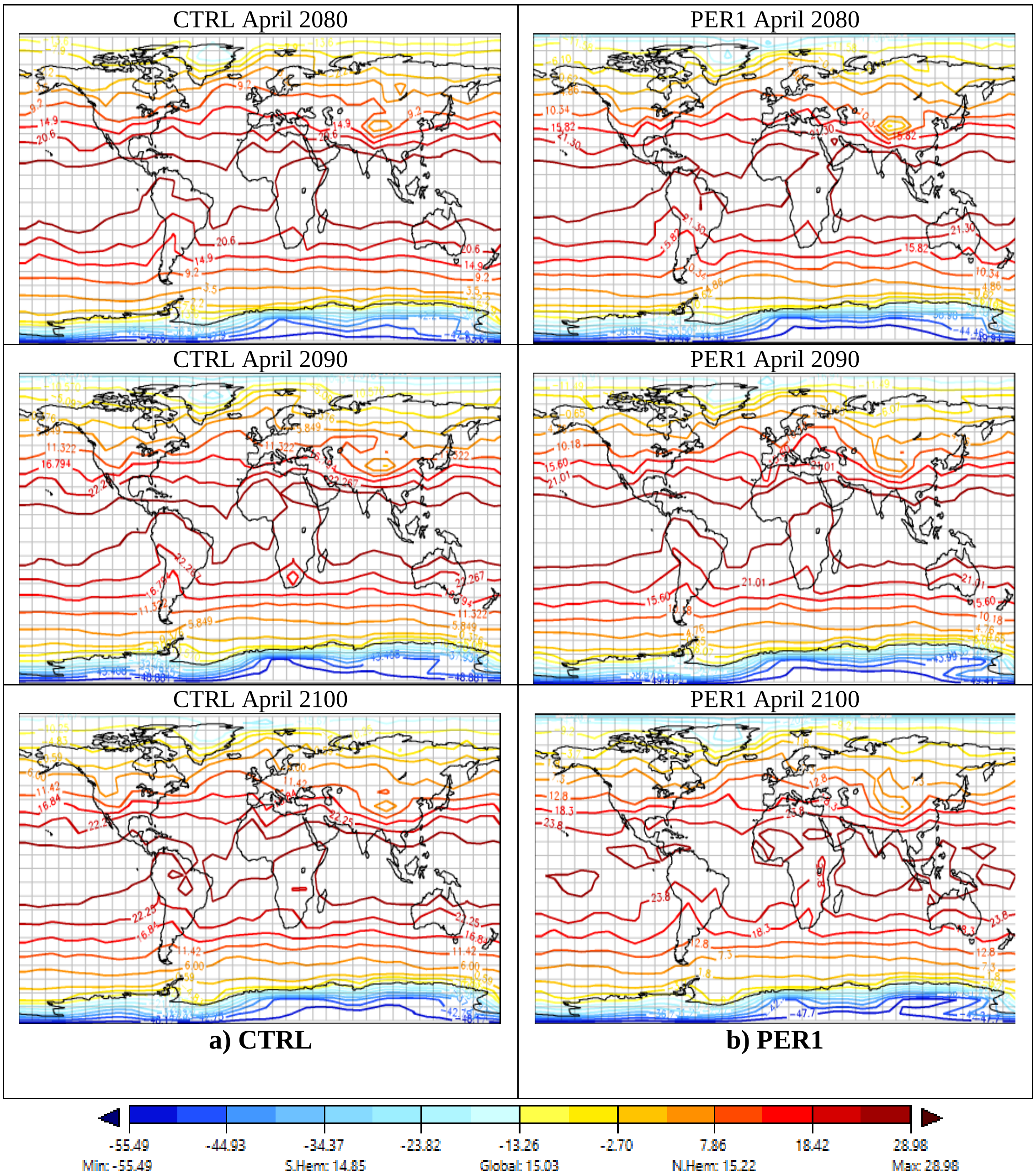

Figure 4.1 Forecast surface air temperature (°C) in April, for the years 2080, 2090 and 2100 from EdGCM model for a) CTRL and b) PER1.

The results in Figure 4.1 show that PER1 has the patterns of surface air temperature close to those of CTRL starting from April 2060. That is, the forecasts from PER1 start to converge to the forecasts of CTRL after about 100 years (the forecast starts from 1958). Appendix A shows the forecasts of surface air temperature for CTRL and PER1 in April, for the years 2010 to 2070 from EdGCM model.

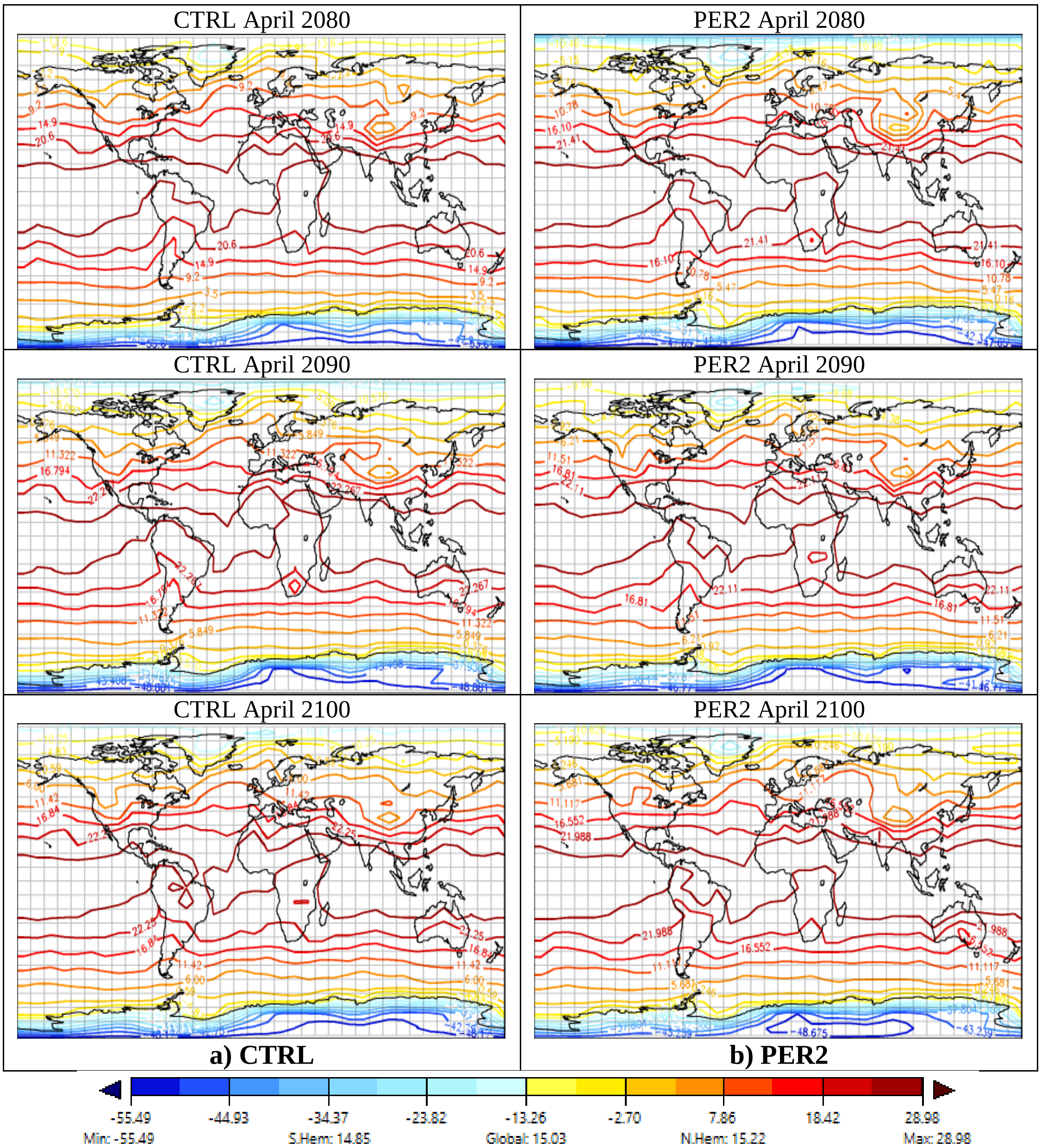

Figure 4.2 Forecast surface air temperature (°C) in April, for the years 2080, 2090 and 2100 from EdGCM model for a) CTRL and b) PER2.

The results in Figure 4.2 show that PER2 has the patterns of surface air temperature close to those of CTRL starting from April 2060. That is, the forecasts from PER2 start to converge to the forecasts of CTRL after about 100 years. Appendix A shows the forecasts of surface air temperature for CTRL and PER2 in April, for the years 2010 to 2070 from EdGCM model.

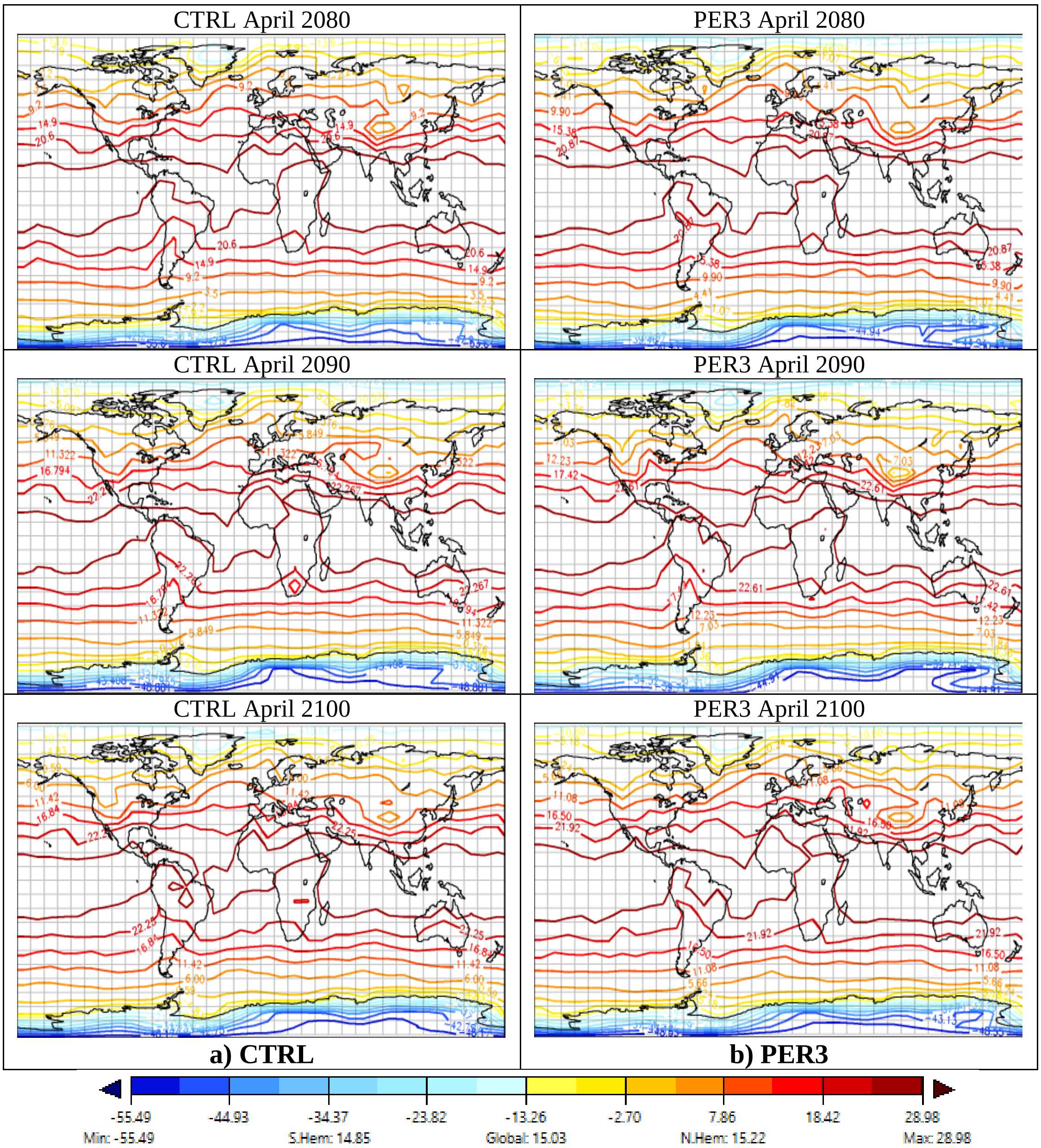

Figure 4.3 Forecast surface air temperature (° C) in April, for the years 2080, 2090 and 2100 from EdGCM model for a) CTRL and b) PER3.

The results in Figure 4.3 show that PER3 has the patterns of surface air temperature close to those of CTRL starting from April 2050. That is, the forecasts from PER3 start to converge to the forecasts of CTRL after about 90 years. Appendix A shows the forecasts of surface air temperature for CTRL and PER3 in April, for the years 2010 to 2070 from EdGCM model.

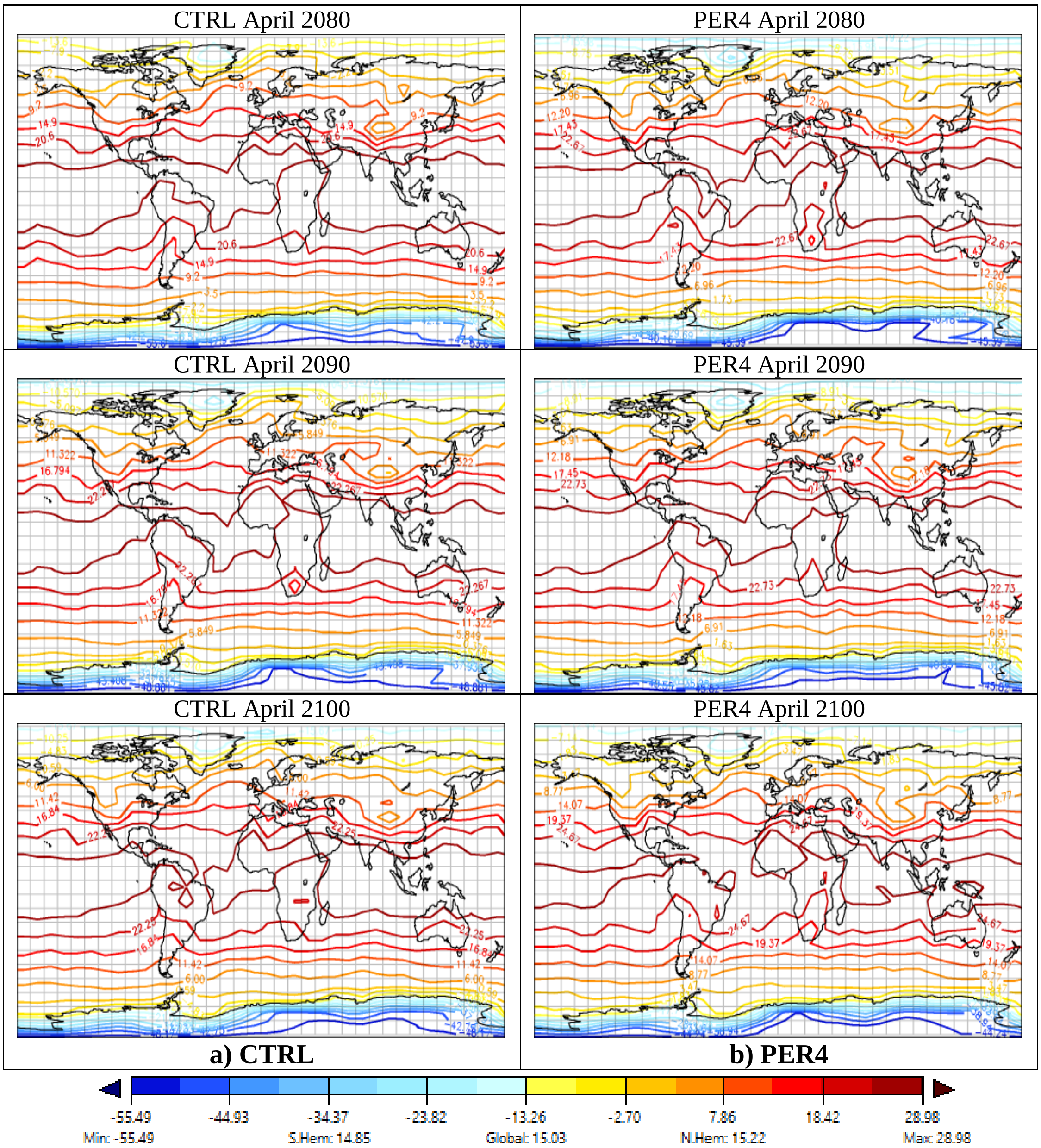

Figure 4.4 Forecast surface air temperature (° C) in April, for the years 2080, 2090 and 2100 from EdGCM model for a) CTRL and b) PER4.

The results in Figure 4.4 show that PER4 has the patterns of surface air temperature close to those of CTRL starting from April 2040. That is, the forecasts from PER4 start to converge to the forecasts of CTRL after about 80 years. Appendix A shows the forecasts of surface air temperature for CTRL and PER4 in April, for the years 2010 to 2070 from EdGCM model.

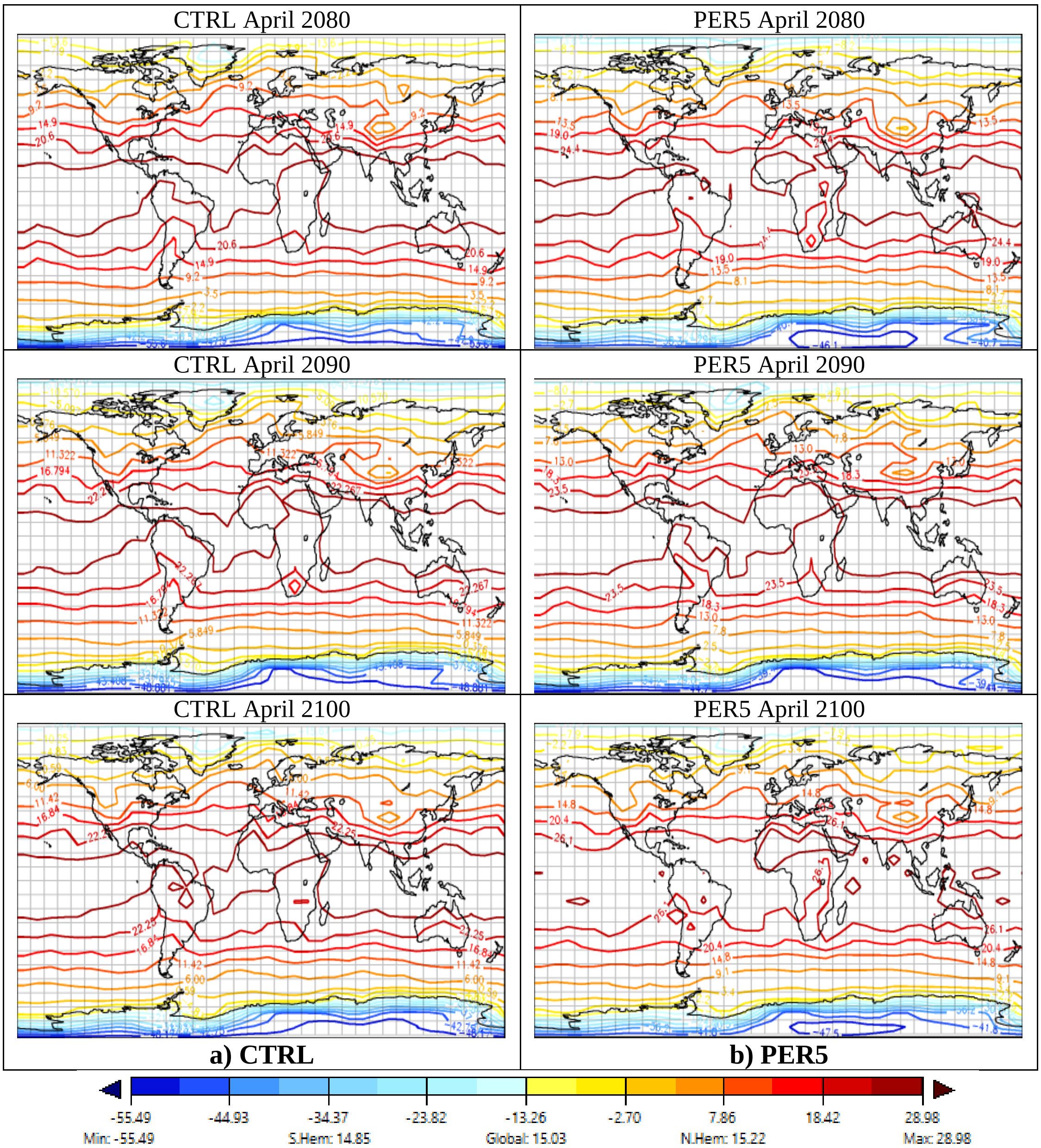

Figure 4.5 Forecast surface air temperature (°C) in April, for the years 2080, 2090 and 2100 from EdGCM model for a) CTRL and b) PER5.

The results in Figure 4.5 show that PER2 has the patterns of surface air temperature close to those of CTRL starting from April 2030. That is, the forecasts from PER5 start to converge to the forecasts of CTRL after about 70 years. Appendix A shows the forecasts of surface air temperature for CTRL and PER5 in April, for the years 2010 to 2070 from EdGCM model.

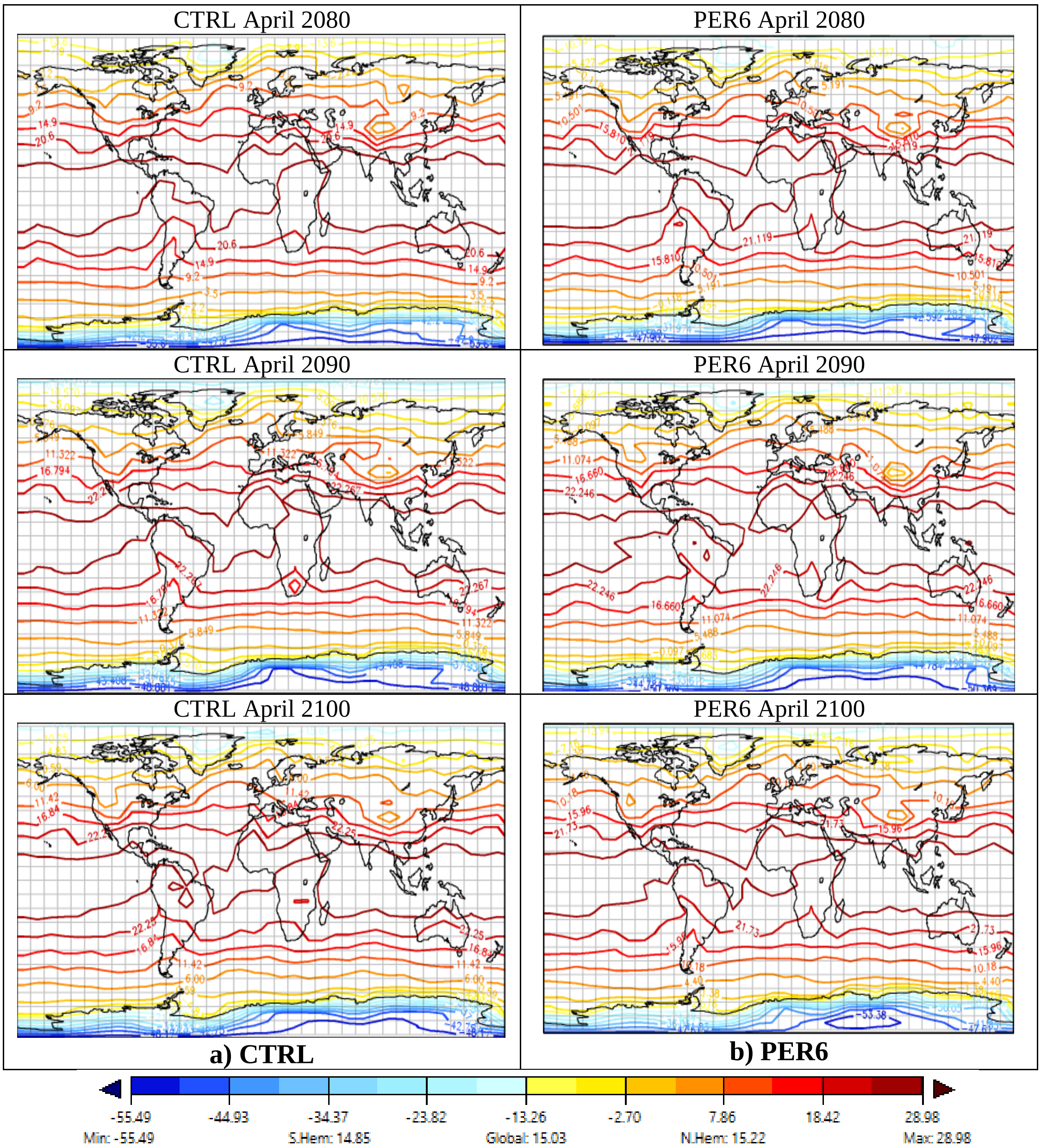

Figure 4.6 Forecast surface air temperature (° C) in April, for the years 2080, 2090 and 2100 from EdGCM model for a) CTRL and b) PER6.

The results in Figure 4.6 show that PER6 has the patterns of surface air temperature close to those of CTRL starting from April 2050. That is, the forecasts from PER6 start to converge to the forecasts of CTRL after about 90 years. Appendix A shows the forecasts of surface air temperature for CTRL and PER6 in April, for the years 2010 to 2070 from EdGCM model.

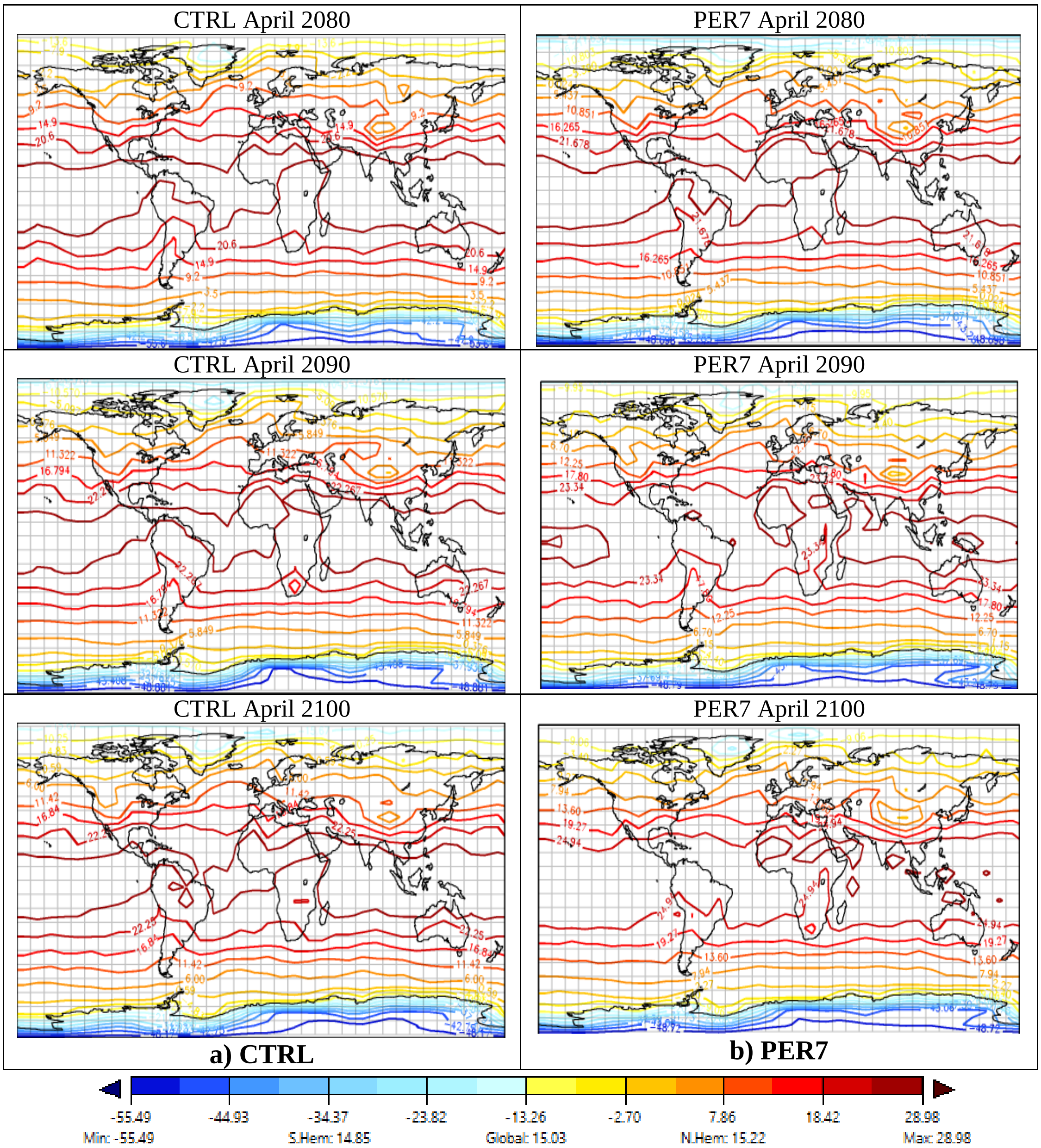

Figure 4.7 Forecast surface air temperature (°C) in April, for the years 2080, 2090 and 2100 from EdGCM model for a) CTRL and b) PER7.

The results in Figure 4.7 show that PER7 has the patterns of surface air temperature close to those of CTRL starting from April 2040. That is, the forecasts from PER7 start to converge to the forecasts of CTRL after about 80 years. Appendix A shows the forecasts of surface air temperature for CTRL and PER7 in April, for the years 2010 to 2070 from EdGCM model.

4.2 Difference in Surface Air Temperature Forecast for EdGCM

In this study, the differences of surface air temperature between the control runs and the corresponding perturbed runs are calculated for each grid point in the study domain. This is done to see sensitivity of the model to perturbations in the initial conditions. The results are shown in Figures 4.8 - 4.14. More results are shown in Appendix B.

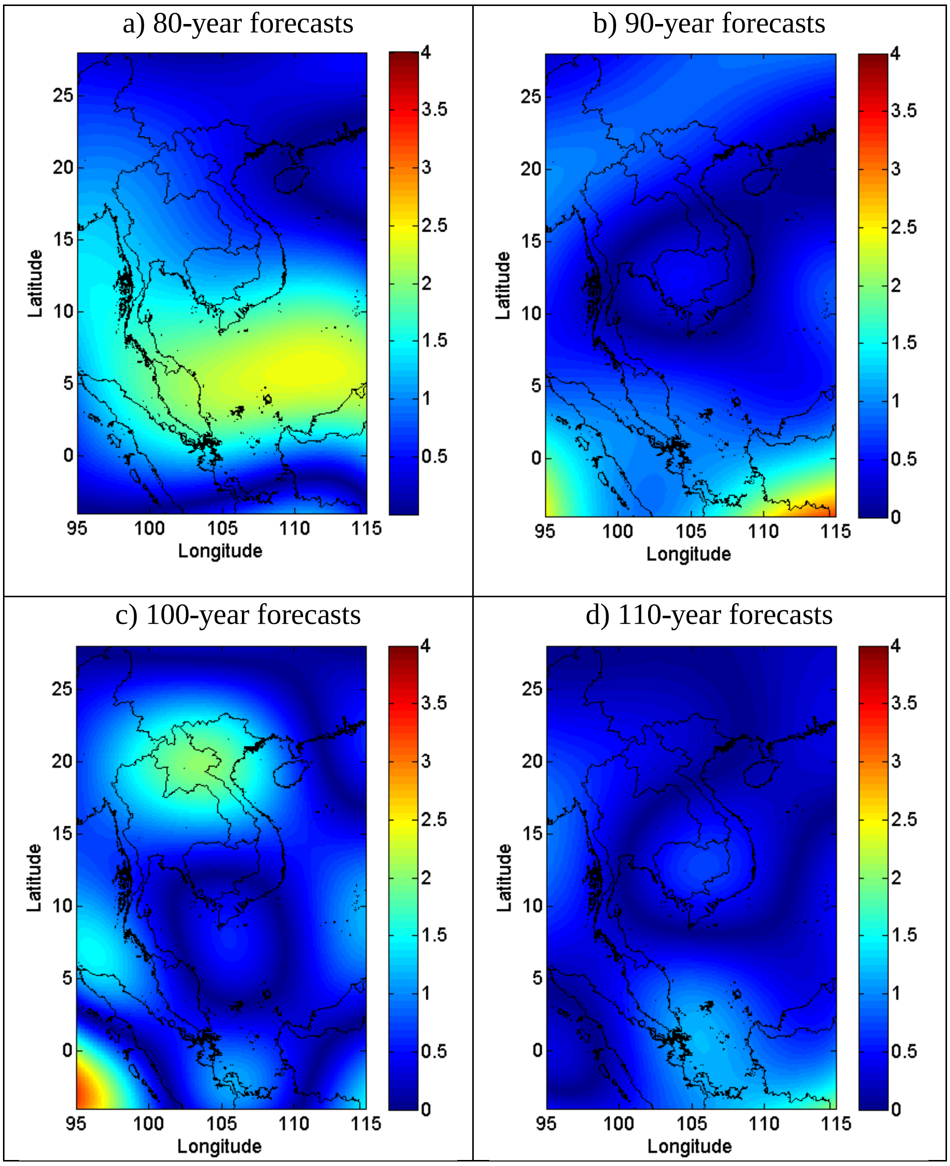

Figure 4.8 The differences of the forecast values of surface air temperature (°C) between PER1 and CTRL (PER1-CTRL).

Figure 4.8 shows the differences of forecast values of surface air temperature between PER1 and CTRL. It is found that for 80-year forecast the largest difference in surface air temperature on the study domain is about 2.4°C. For 90-year, 100-year and 110-year forecasts, the largest absolute differences are about 3.3°C, 3.3°C, and 2.1°C, respectively.

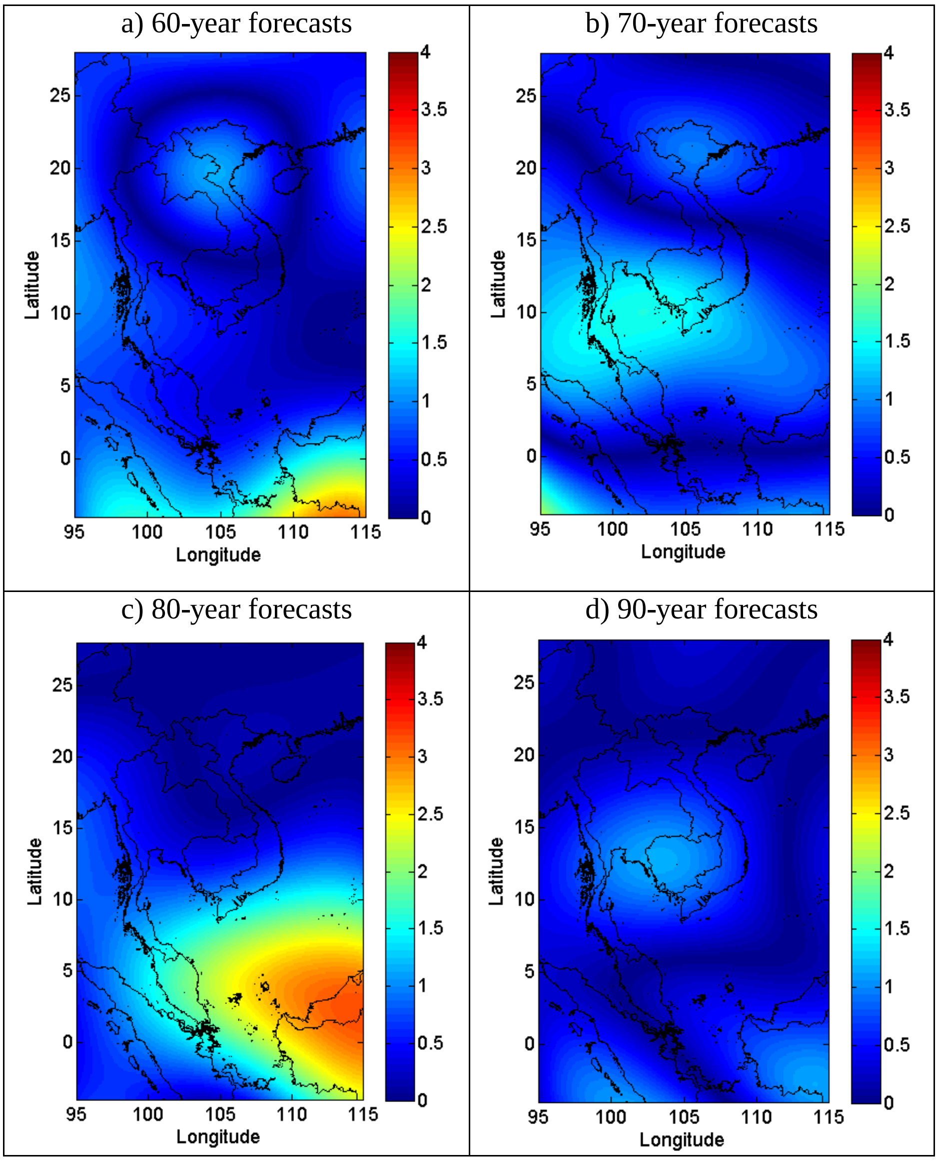

Figure 4.9 The differences of the forecast values of surface air temperature (°C) between PER2 and CTRL (PER2-CTRL).

Figure 4.9 shows that the differences of forecast values of surface air temperature between PER2 and CTRL decreases with forecast period. It is found that for 60-year forecast the largest difference in surface air temperature on the study domain is about 3.0°C. For 70-year, 80-year and 90-year forecasts, the largest absolute differences are about 2.2°C, 3.2°C, and 1.2°C, respectively.

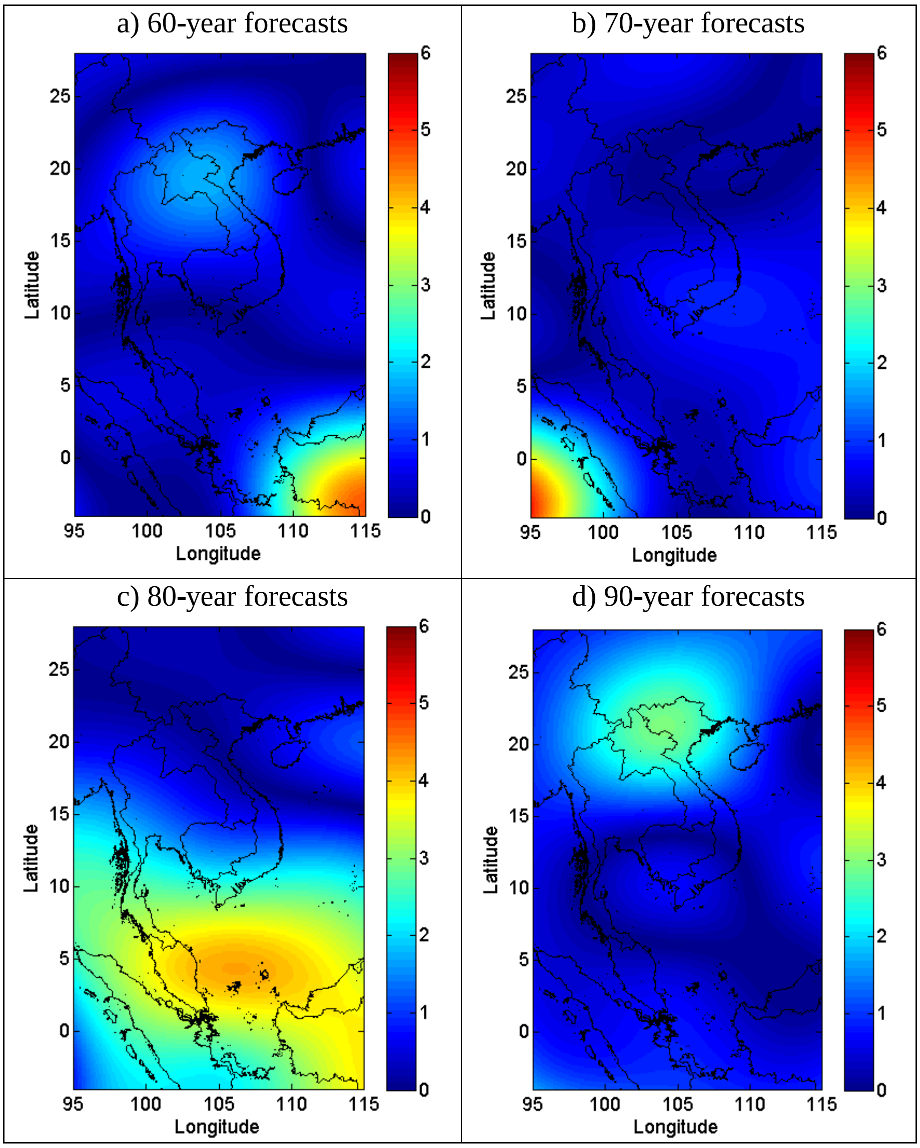

Figure 4.10 The differences of the forecast values of surface air temperature (°C) between PER3 and CTRL (PER3-CTRL).

Figure 4.10 shows the differences of forecast values of surface air temperature between PER3 and CTRL. It is found that for 60-year forecast the largest difference in surface air temperature on the study domain is about 4.7°C. For 70-year, 80-year and 90-year forecasts, the largest absolute differences are about 5.1°C, 4.2°C, and 2.9°C, respectively.

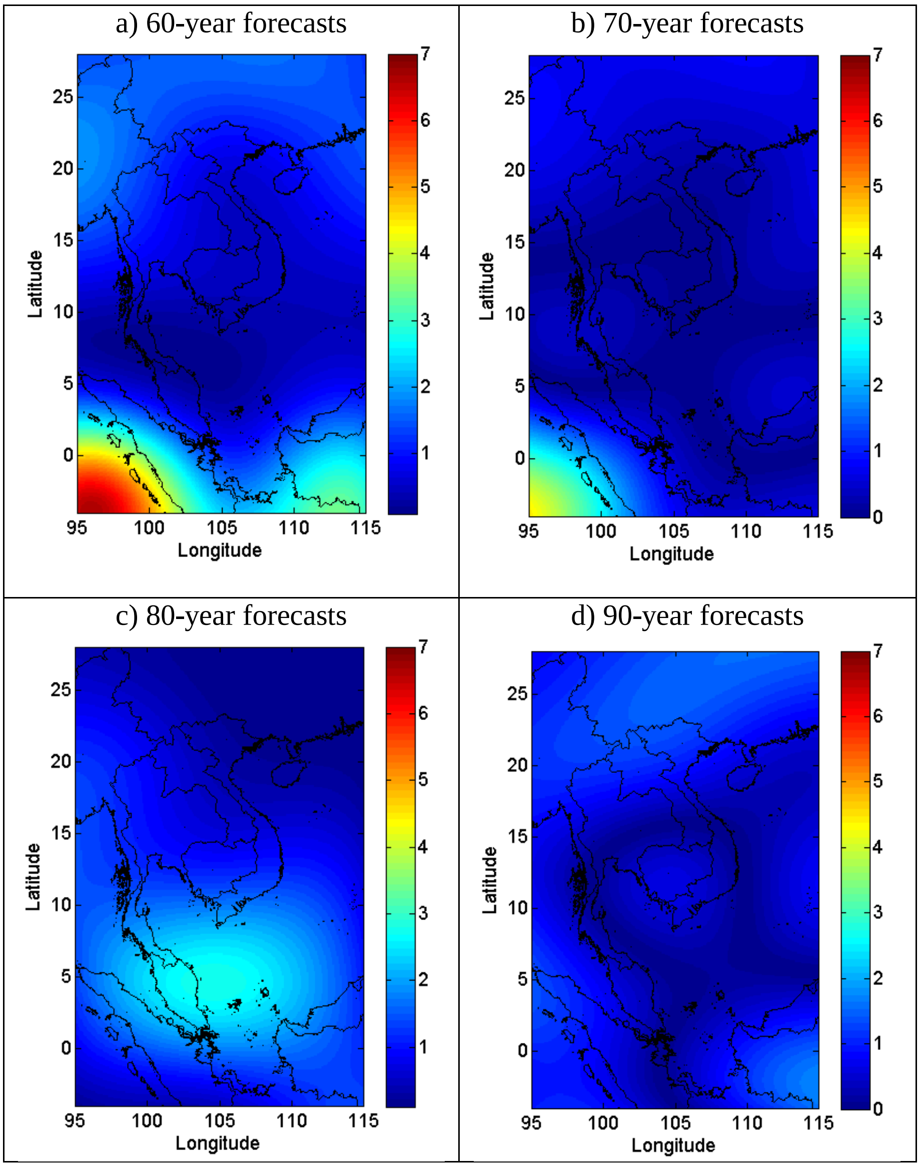

Figure 4.11 The differences of the forecast values of surface air temperature (°C) between PER4 and CTRL (PER4-CTRL).

Figure 4.11 shows the differences of forecast values of surface air temperature between PER4 and CTRL. It is found that for 60-year forecast the largest difference in surface air temperature on the study domain is about 6.7°C. For 70-year, 80-year and 90-year forecasts, the largest absolute differences are about 4.5°C, 2.8°C, and 1.8°C, respectively.

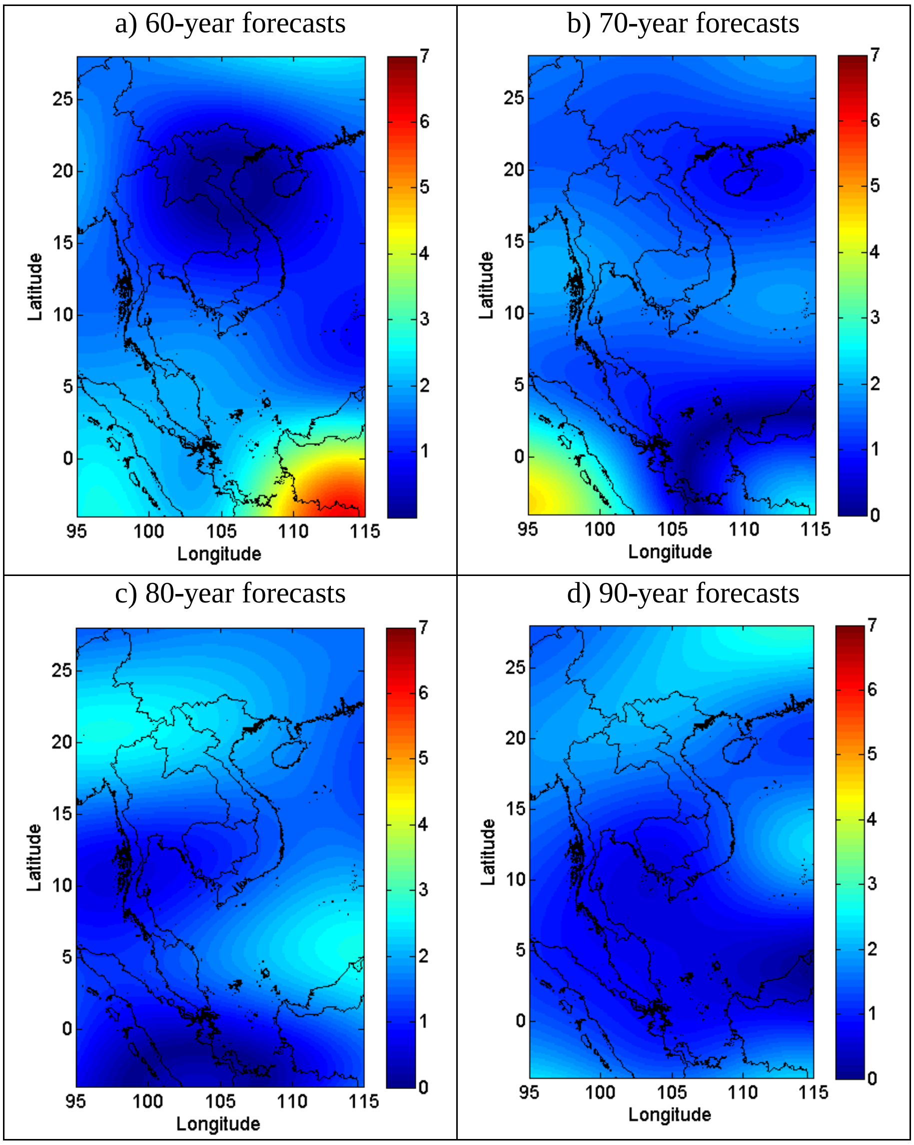

Figure 4.12 The differences of the forecast values of surface air temperature (°C) between PER5 and CTRL (PER5-CTRL).

Figure 4.12 shows the differences of forecast values of surface air temperature between PER5 and CTRL. It is found that for 60-year forecast the largest difference in surface air temperature on the study domain is about 6.2°C. For 70-year, 80-year and 90-year forecasts, the largest absolute differences are about 4.6°C, 2.7°C and 2.9°C, respectively.

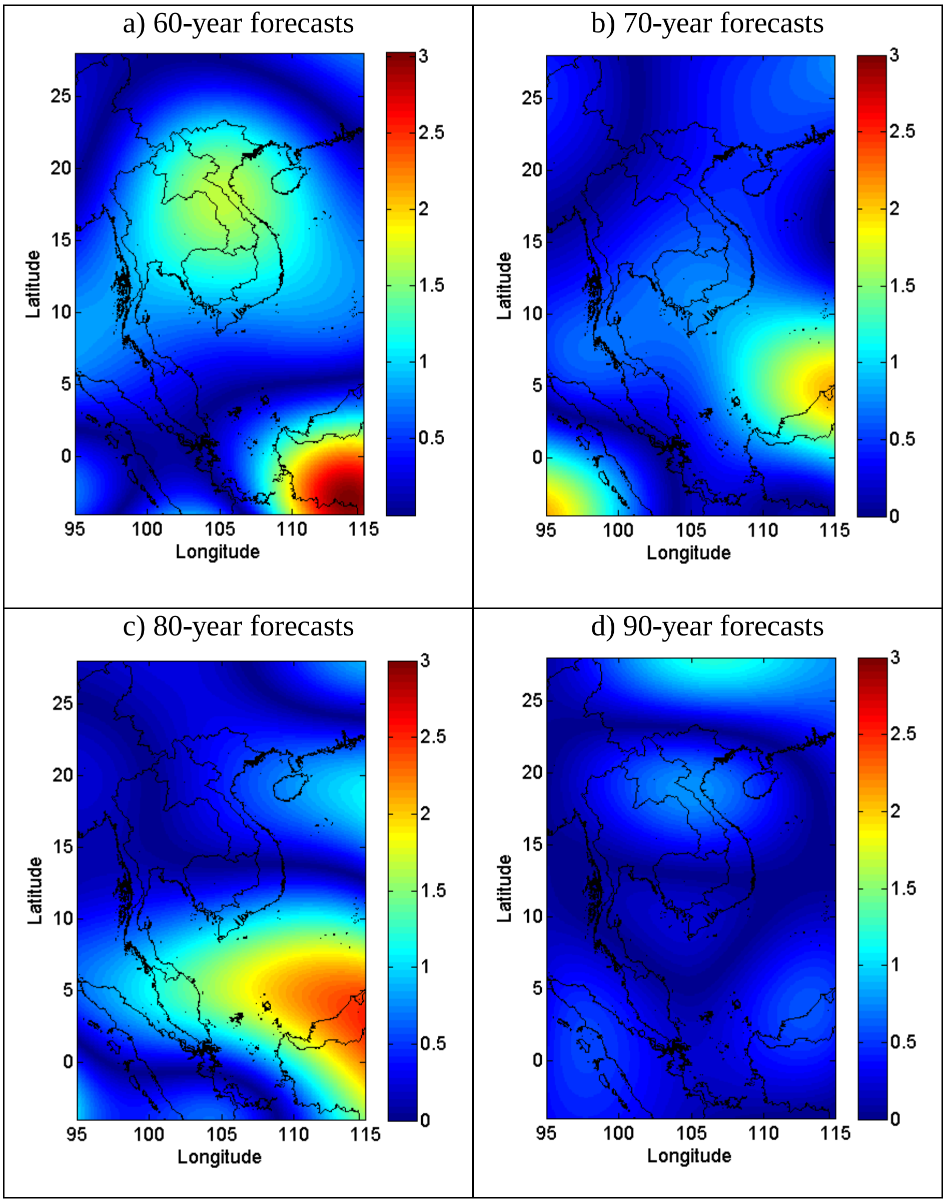

Figure 4.13 The differences of the forecast values of surface air temperature (°C) between PER6 and CTRL (PER6-CTRL).

Figure 4.13 shows the differences of forecast values of surface air temperature between PER6 and CTRL. It is found that for 60-year forecast the largest difference in surface air temperature on the study domain is about 3.0°C. For 70-year, 80-year and 90-year forecasts, the largest absolute differences are about 2.1°C, 2.5°C, and 1.2°C, respectively.

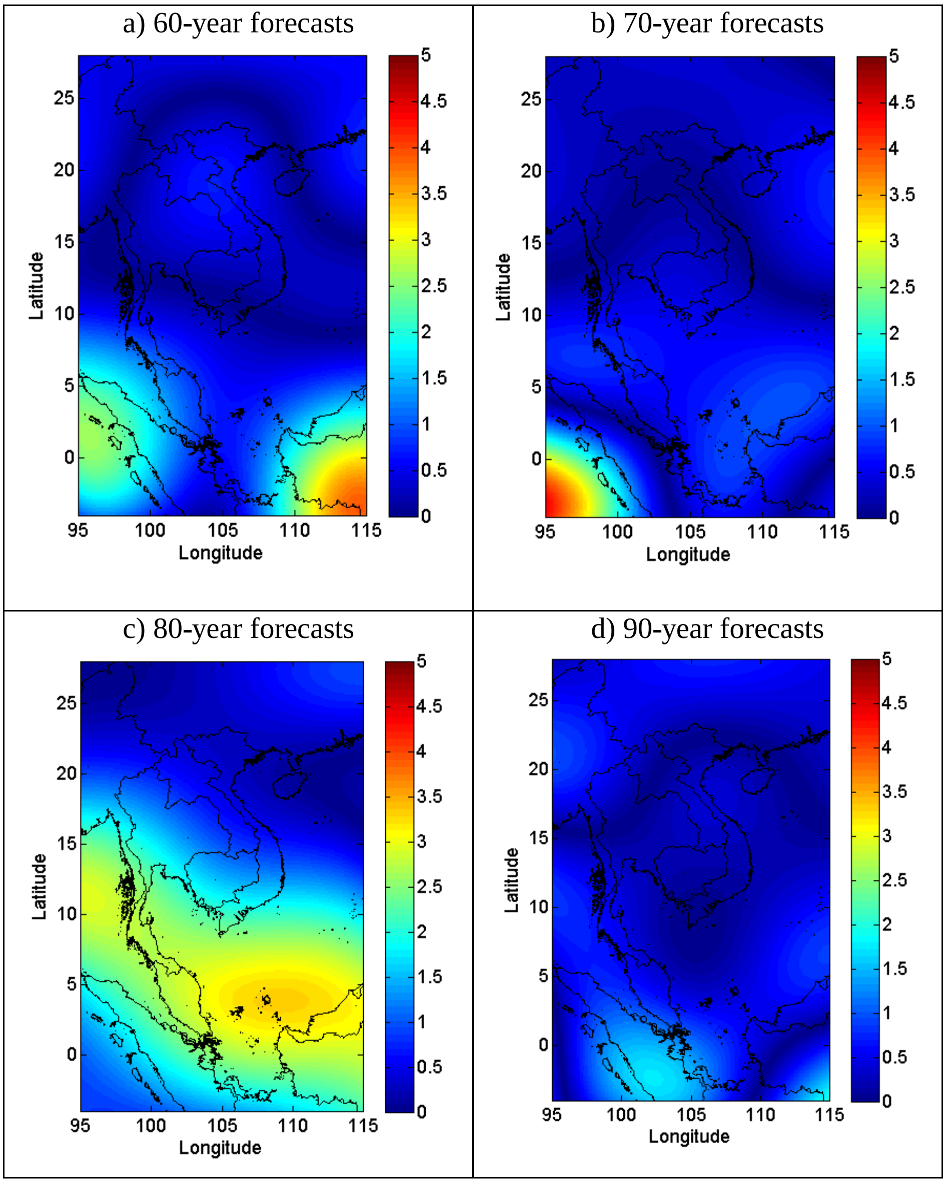

Figure 4.14 The difference of the forecast values of surface air temperature (°C) between PER7 and CTRL (PER7-CTRL).

Similarly, Figure 4.14 shows that the differences of forecast values of surface air temperature between PER7 and CTRL decreases with forecast period. It is found that for 60-year forecast the largest difference in surface air temperature on the study domain is about 3.9°C. For 70-year, 80-year and 90-year forecasts, the largest absolute differences are about 4.4°C, 3.3°C, and 2.0°C, respectively.

4.3 Predictability of EdGCM

4.3.1 Case I : Pertubed CO_2

The predictability values (separation rate, λ) from LE, FSLE, FTLE, LLE, MLE, SLE and MoLE of EdGCM for Case I which consist of PER1 (1% increase of CO_2), PER2 (5% increase of CO_2), PER3 (10% increase of CO_2), PER4 (20% increase of CO_2) and PER5 (50% increase of CO_2) in Southeast Asia (longitude 95^{o}E to 115^{o}E and latitude 4^{o}S to 28^{o}N) are shown in Table 4.1 with bold numbers represent negative values.

Table 4.1 Values of predictability of EdGCM for Case I.

Forecast (year)	Method	PER1	PER2	PER3	PER4	PER5
50	LE	0.066	0.1131	0.074	**-0.0314**	**-0.0559**
	FSLE	0.1229	0.1291	0.1573	0.1703	0.2381
	FTLE	0.0168	0.0491	0.0321	**-0.0137**	**-0.0243**
	LLE	0.113	0.1667	0.1301	0.0831	0.0135
	MLE	0.4382	0.3839	0.148	**-0.1946**	**-0.1187**
	SLE	0.2603	0.439	0.2996	0.1912	0.0387
	MoLE	0.2036	**-0.1509**	0.0557	0.0504	0.0172
60	LE	0.0141	0.0858	0.0317	0.0232	**-0.0078**
	FSLE	0.0425	0.0938	0.0734	0.1241	0.1392
	FTLE	**-0.0164**	0.0254	**-0.0046**	0.0338	0.0175
	LLE	0.182	0.1296	0.049	0.1415	0.0676
	MLE	0.1717	0.1337	**-0.0031**	**-0.0021**	**-0.0373**
	SLE	0.1422	0.1643	0.2039	0.1025	0.0375
	MoLE	0.0734	0.0349	**-0.0092**	0.045	**-0.0026**
70	LE	0.0318	0.0442	0.0232	**-0.0169**	**-0.0088**
	FSLE	0.0508	0.0547	0.0509	0.0504	0.0892
	FTLE	0.0292	**-0.0169**	0.0026	**-0.0421**	**-0.0046**
	LLE	0.2037	0.0322	0.1447	**-0.0301**	0.0821
	MLE	0.1015	0.1402	0.0291	**-0.0565**	**-0.0137**
	SLE	0.0981	0.1402	0.1099	0.0358	0.023
	MoLE	**-0.0067**	**-0.004**	**-0.0083**	**-0.0307**	**-0.0015**
80	LE	0.03	0.0299	0.0357	**-0.0066**	**-0.009**
	FSLE	0.0442	0.0339	0.0565	0.0439	0.0645
	FTLE	0.0107	**-0.018**	0.0318	0.0106	**-0.0042**
	LLE	0.0352	**-0.0262**	**-0.0512**	0.1121	0.0806
	MLE	0.1199	0.0858	0.0404	0.0222	**-0.0228**
	SLE	0.0817	0.1156	0.0913	0.0532	0.0128
	MoLE	0.0698	0.0087	0.0209	0.0024	**-0.0088**
90	LE	0.0281	0.0127	0.021	**-0.0034**	**-0.0093**
	FSLE	0.0395	0.0159	0.0376	0.0369	0.0495
	FTLE	0.009	**-0.0244**	**-0.0164**	0.0039	**-0.0045**
	LLE	0.0949	5.14E-15	0.184	0.0442	0.0688
	MLE	0.0757	0.0798	0.0095	0.0044	**-0.0254**
	SLE	0.0594	0.0798	0.0855	0.0257	0.0091
	MoLE	0.0549	**-0.0438**	0.0157	0.0072	0.0074
100	LE	0.0129	0.0211	0.005	0.0014	**-7.41E-05**
	FSLE	0.0224	0.0238	0.0214	0.035	0.0489
	FTLE	**-0.0274**	0.0274	**-3.86E-15**	0.0111	0.0200
	LLE	0.0821	0.0398	**-4.88E-03**	0.0434	0.2044
	MLE	0.0299	0.044	0.0076	0.0124	0.0063
	SLE	0.0538	0.0636	0.0543	0.0384	0.0151
	MoLE	0.0355	**-0.0328**	**-0.0068**	**-0.0018**	0.0039

Table 4.1 (Cont.).

Forecast (year)	Method	PER1	PER2	PER3	PER4	PER5
110	LE	0.0046	0.0167	0.0104	**-0.0065**	**-0.0060**
	FSLE	0.0149	0.0189	0.0223	0.0224	0.0360
	FTLE	**-0.0198**	**-0.0044**	0.0018	**-0.0232**	**-0.018**
	LLE	0.0699	0.1161	0.1574	0.0782	0.0489
	MLE	0.0603	0.0372	0.0092	**-0.0128**	**-1.75E-02**
	SLE	0.0349	0.0462	0.0552	0.0215	0.0115
	MoLE	0.0125	**-0.0233**	**-0.0065**	**-0.0132**	0.0011
120	LE	0.0053	0.0221	0.0114	**-0.0124**	**-0.0012**
	FSLE	0.0144	0.0241	0.0218	0.0128	0.0356
	FTLE	0.0045	0.0262	0.0079	**-0.0234**	0.0141
	LLE	0.1204	0.1079	0.1308	0.1597	0.0621
	MLE	0.0552	0.0224	0.0149	**-0.0186**	**-0.0133**
	SLE	0.0183	0.0499	0.0577	0.0225	0.0111
	MoLE	0.0221	**-0.0040**	0.0016	0.0025	0.0014
130	LE	0.0136	0.0161	0.0046	5.62E-04	**-5.94E-05**
	FSLE	0.0199	0.0179	0.0138	0.0230	0.0326
	FTLE	0.0176	**-0.0139**	**-0.0217**	0.0453	0.0039
	LLE	0.0921	0.0753	0.0041	0.1716	0.0477
	MLE	0.0528	0.0392	0.0055	6.60E-04	**-0.0012**
	SLE	0.036	0.0392	0.0423	0.0320	0.0116
	MoLE	0.0276	**-0.0200**	**-0.0098**	0.0027	0.0030
140	LE	0.0144	0.0171	0.0145	0.0074	0.0032
	FSLE	0.0201	0.0187	0.0229	0.0275	0.0326
	FTLE	0.0096	0.0111	0.0452	0.0298	0.0141
	LLE	0.2042	0.0783	0.0758	0.0851	0.0926
	MLE	0.0569	0.0225	0.0221	0.0069	**-0.0033**
	SLE	0.0301	0.0492	0.0376	0.0359	0.0141
	MoLE	0.0258	0.0051	0.0116	0.0113	0.0067

The plots of λ for all methods in Table 4.4 are shown in Figures 4.15-4.19.

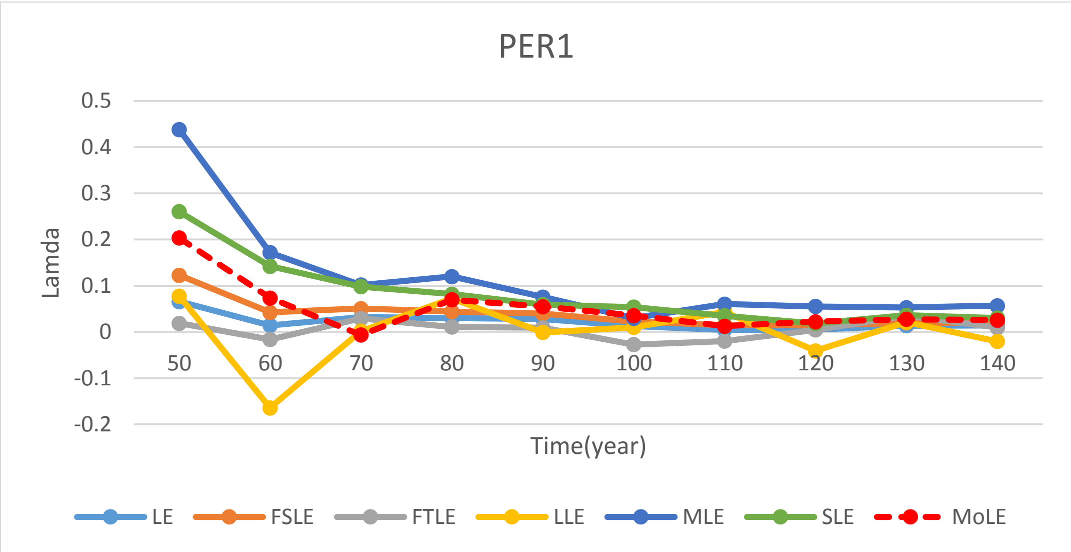

Figure 4.15 Time evolution of λ for PER1 for all methods.

Figure 4.15 shows that from 50-year to 100-year forecasts, λ of almost all methods decrease monotonously. FTLE shows slight oscillation while LLE displays dramatic fluctuation. In other word, both of them do not show definite trend for convergence or divergence of two nearby trajectories. The results also clearly show that LE, FSLE, MLE and SLE values from 100-year forecast do not level off until approximately 140-year forecast. The measurement by the new method, MoLE, agrees with most of the existing measurement methods. It is quite possible that by 140-year forecast, most of λ values are reaching equilibrium rather than decreasing. Thus the predictability of EdGCM for PER1 is about 100 years.

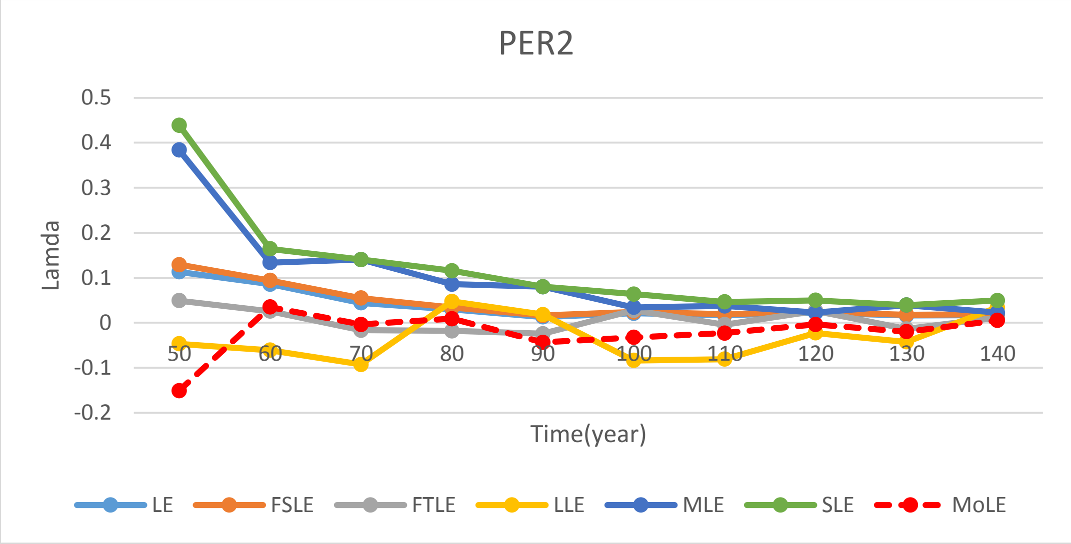

Figure 4.16 Time evolution of λ for PER2 of all methods.

Similarly, Figure 4.16 shows that from 50-year to 90-year forecasts, λ of almost all methods decrease monotonously. FTLE and MoLE shows slight oscillation from 50-year to 90-year forecasts while LLE displays significant fluctuation throughout the period of forecast. The results also clearly show that LE and FSLE values from 90-year forecast do not level off until approximately 140-year forecast while MLE, SLE and MoLE values from 110-year forecast do not level off until approximately 140-year forecast. It is quite possible that by 140-year forecast, most of λ values are reaching equilibrium rather than decreasing. Thus the predictability of EdGCM for PER2 is about 90 years.

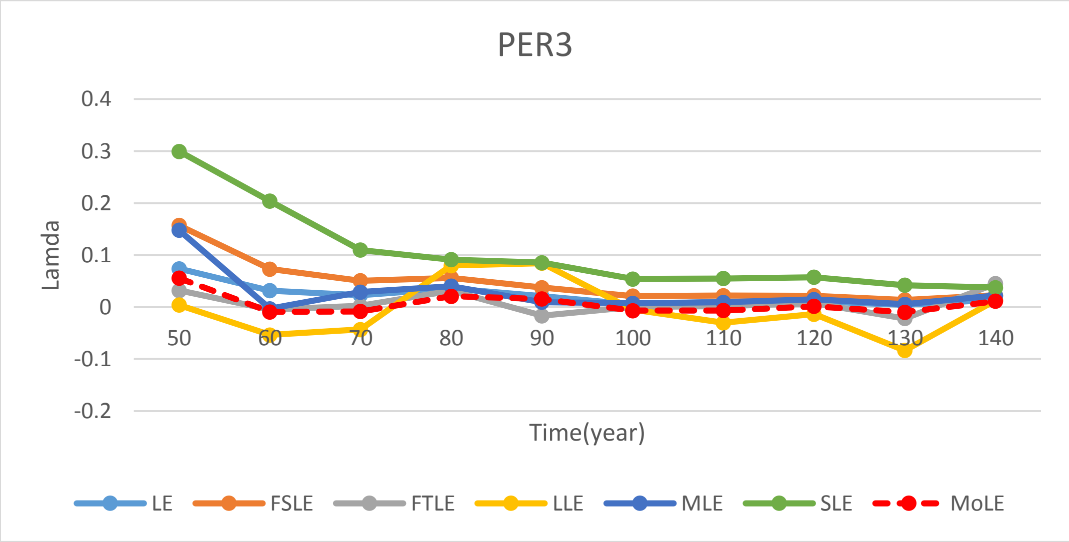

Figure 4.17 Time evolution of λ for PER3 of all methods.

Figure 4.17 shows that from 50-year to 90-year forecasts, λ of almost all methods decrease monotonously except LLE method. LLE displays dramatic fluctuation, in other word it does not show definite trend for convergence or divergence of two nearby trajectories. The results also clearly show that LE, FSLE, MLE and SLE values from 90-year forecast do not level off until approximately 140-year forecast. The measurement by MoLE agrees with most of the existing measurement methods. It is quite possible that by 140-year forecast most of λ values are reaching equilibrium rather than decreasing. Thus the predictability of EdGCM forecasting for PER3 is about 90 years.

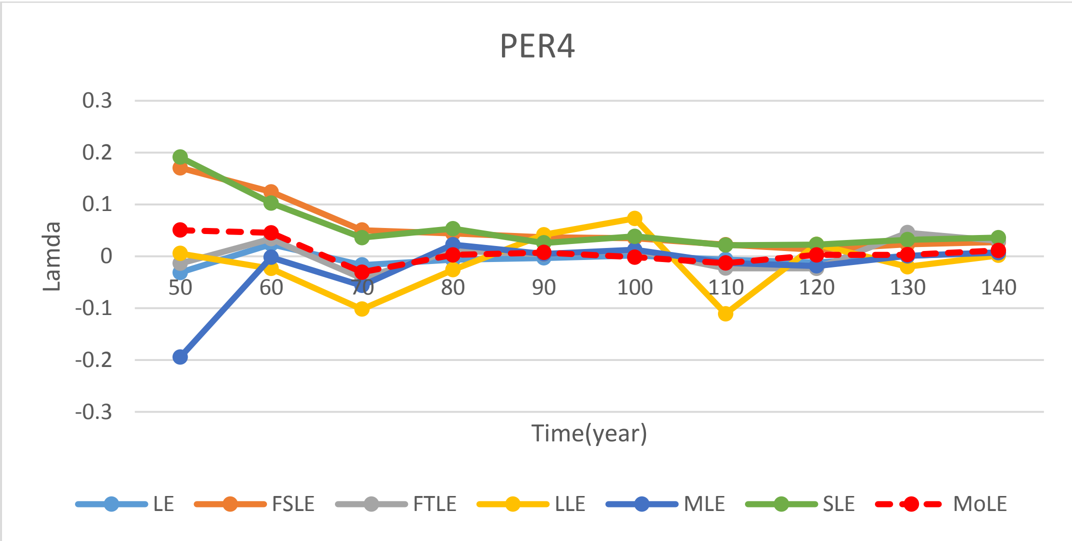

Figure 4.18 Time evolution of λ for PER4 of all methods.

Figure 4.18 shows that the λ values of FSLE and SLE from 50-year to 80-year forecasts decrease monotonously while LE, MLE and MoLE shows slight oscillation. After 80-year forecast they do not level off until approximately 140-year forecast. FTLE shows slight oscillation throughout the period of forecast while LLE displays significant fluctuation, which implied that both of them do not show definite trend for convergence or divergence of two nearby trajectories. Thus the predictability of EdGCM for PER4 is about 80 years.

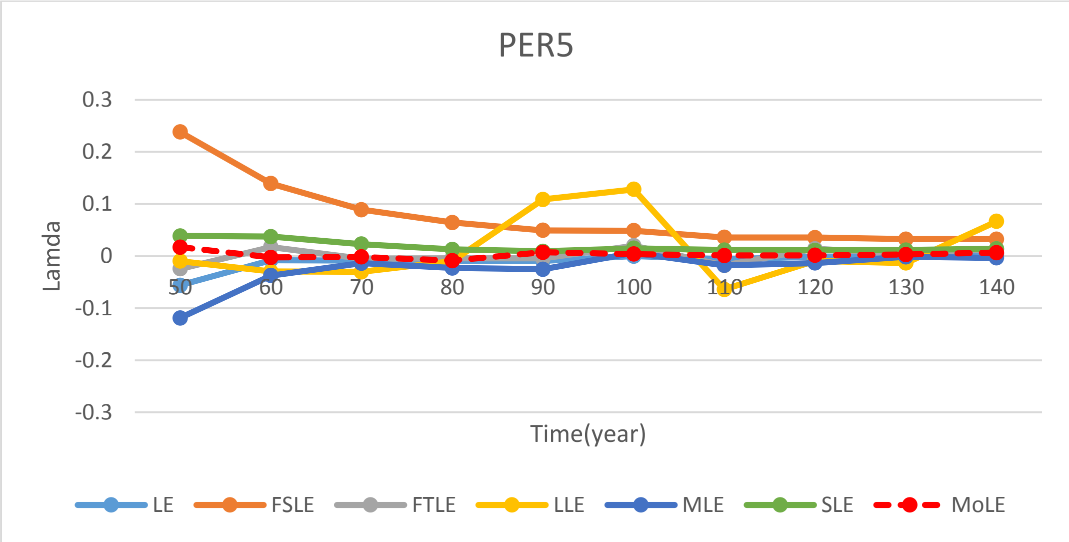

Figure 4.19 Time evolution of λ for PER5 of all methods.

Figure 4.19 shows that from 50-year to 100-year forecasts, λ of FSLE increases while that of MLE decreases monotonously and after 100-year forecast they do not level off until approximately 140-year forecast. LE, SLE and MoLE show stability trend and after about 60-, 90- and 60-year forecast, respectively, they do not level off until 140-year forecast. It is quite possible that by 140-year forecast the λ values are reaching equilibrium. FTLE and LLE do not show definite trend for convergence or divergence of two nearby trajectories. Again, MoLE agrees with most of the existing measurement methods. Thus the predictability of EdGCM for PER5 is about 60 years.

4.3.2 Case II : Perturbed CO_2 and CH_4

The predictability value λ from all measurements of EdGCM for Case II which consist of PER2 (5% increase of CO_2), PER6 (5% increase of CH_4) and PER7 (50% increase of CO_2+5% increase of CH_4) in Southeast Asia (longitude 95°E to 115°E and latitude 4°S to 28°N) are shown in Table 4.2 with bold numbers represent negative values.

Table 4.2 Values of predictability of EdGCM for Case II.

Forecast (year)	Method	PER2	PER6	PER7
50	LE	0.1131	0.0346	0.1211
	FSLE	0.1291	0.1252	0.1916
	FTLE	0.0491	0.015	0.033
	LLE	0.1667	0.01946	0.05868
	MLE	0.3839	**-0.1025**	0.0318
	SLE	0.439	0.2079	0.3232
	MoLE	**-0.1509**	0.0572	0.1114
60	LE	0.0858	0.0215	0.0537
	FSLE	0.0938	0.0668	0.0889
	FTLE	0.0254	0.0036	**-0.006**
	LLE	0.1296	**-0.00678**	0.00492
	MLE	0.1337	0.0514	0.0059
	SLE	0.1643	0.1073	0.1538
	MoLE	0.0349	0.0193	0.0298

Table 4.2 (Cont.).

Forecast (year)	Method	PER2	PER6	PER7
70	**LE**	0.0442	0.0099	0.0167
	FSLE	0.0547	0.0401	0.0402
	FTLE	**-0.0169**	**-0.0058**	**-0.0249**
	LLE	0.0322	**-0.0448**	**-0.08751**
	MLE	0.1402	0.0218	0.0553
	SLE	0.1402	0.0876	0.102
	MoLE	**-0.004**	0.0422	**-0.0305**
80	**LE**	0.0299	0.0186	0.0353
	FSLE	0.0339	0.0413	0.0529
	FTLE	**-0.018**	0.0195	0.0395
	LLE	**-0.0262**	**-0.01703**	0.01236
	MLE	0.0858	**-0.0027**	0.0752
	SLE	0.1156	0.0702	0.1163
	MoLE	0.0087	0.0162	0.033
90	**LE**	0.0127	**-0.008**	0.0142
	FSLE	0.0159	0.0101	0.0283
	FTLE	**-0.0244**	**-0.0498**	**-0.0304**
	LLE	5.14E-15	**-0.0243**	**-0.01761**
	MLE	0.0798	**-0.0253**	0.0064
	SLE	0.0798	0.0565	0.048
	MoLE	**-0.0438**	0.024	**-0.0139**
100	**LE**	0.0211	1.06E-02	2.08E-02
	FSLE	0.0238	0.0257	0.0325
	FTLE	0.0274	0.0451	0.0233
	LLE	0.0398	**-0.1028**	**-0.00669**
	MLE	0.044	0.0102	0.0396
	SLE	0.0636	0.0255	0.0419
	MoLE	**-0.0328**	**-0.0025**	0.0055
110	**LE**	0.0167	0.0084	0.0119
	FSLE	0.0189	0.0213	0.022
	FTLE	**-0.0044**	**-0.0022**	**-0.0179**
	LLE	0.1161	**-0.04372**	**-0.0573**
	MLE	0.0372	**-4.20E-03**	2.70E-02
	SLE	0.0462	0.0284	0.0334
	MoLE	**-0.0233**	0.0216	0.0014
120	**LE**	0.0221	0.009	0.01
	FSLE	0.0241	0.0203	0.0188
	FTLE	0.0262	0.0057	**-0.0013**
	LLE	0.1079	0.07061	0.00565
	MLE	0.0224	**-0.0037**	0.015
	SLE	0.0499	0.0345	0.0314
	MoLE	**-0.004**	0.0055	**-0.0024**
130	**LE**	0.0161	5.20E-03	1.24E-02
	FSLE	0.0179	0.0152	0.0202
	FTLE	**-0.0139**	**-0.011**	0.0136
	LLE	0.0753	**-0.04879**	0.0727
	MLE	0.0392	**-2.28E-02**	0.0252
	SLE	0.0392	0.0277	0.0296
	MoLE	**-0.0200**	0.0093	**-0.0171**

Table 4.2 (Cont.).

Forecast (year)	Method	PER2	PER6	PER7
140	**LE**	0.0171	0.0138	0.0164
	FSLE	0.0187	0.0228	0.0234
	FTLE	0.0111	0.0396	0.0228
	LLE	0.0783	0.09409	0.08321
	MLE	0.0225	**-0.003**	0.0161
	SLE	0.0492	0.0366	0.0422
	MoLE	0.0051	0.0195	0.0173

Figures 4.20 and 4.21 show the plots which corresponded to the values in Table 4.2.

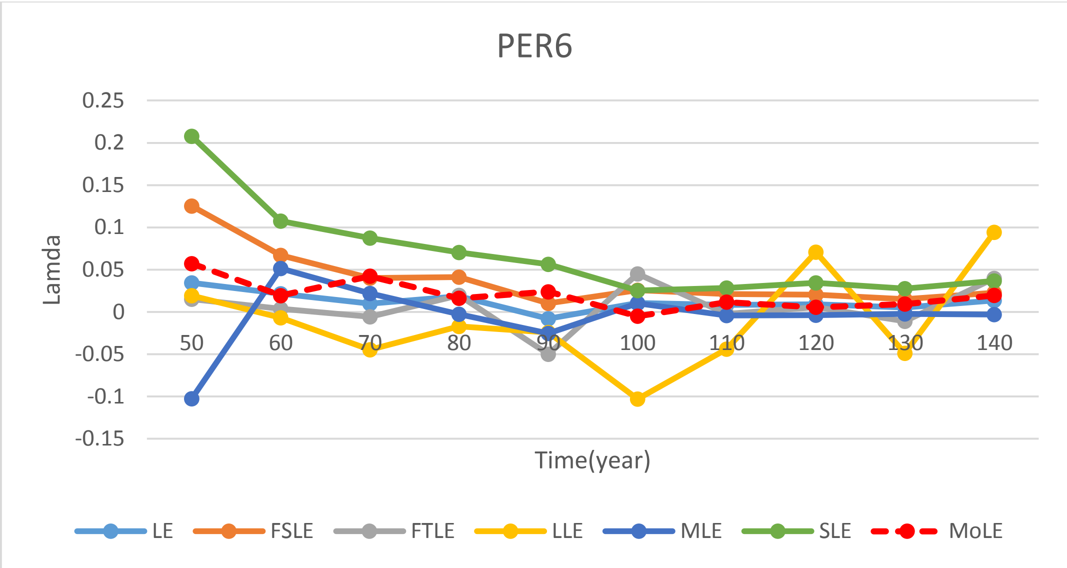

Figure 4.20 Time evolution of λ for PER6 of all methods.

Figure 4.20 shows that from 50-year to 100-year forecasts of FSLE and SLE, λ decreases monotonously after that they remain stable. FTLE and LLE display significant fluctuation throughout the period of forecast. In other word both of them do not show definite trend for convergence or divergence of two nearby trajectories. LE, MLE and MoLE show slight fluctuation of λ from 50-year to 100-year forecasts after that λ remains stable. The results clearly show that LE, FSLE and SLE values after 90-year forecast do not level off until approximately 140-year forecast. Thus the predictability of EdGCM for PER6 is about 90 years.

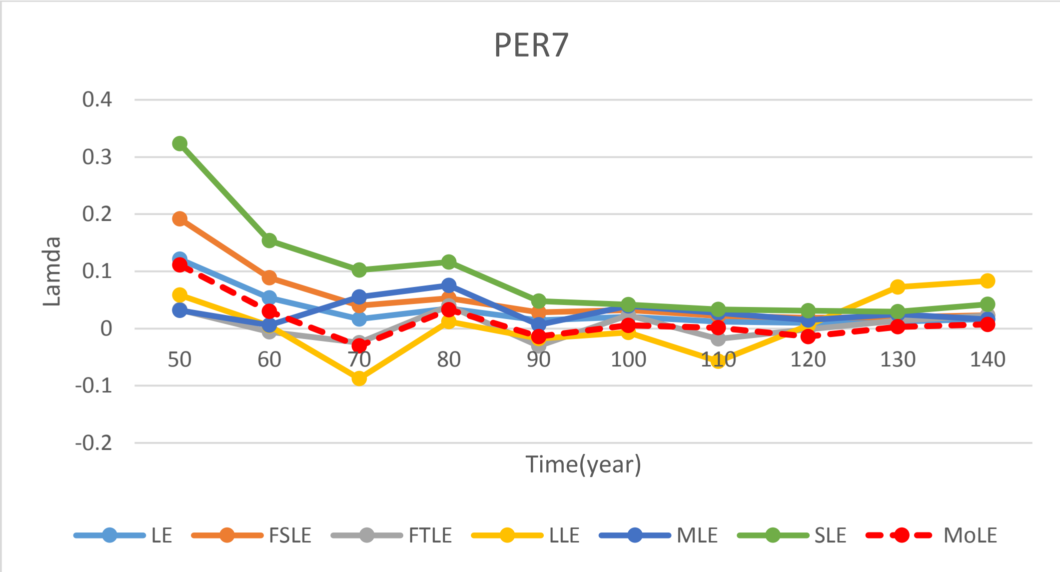

Figure 4.21 Time evolution of λ for PER7 of all methods.

Figure 4.21 shows that from 50-year to 100-year forecasts, λ of almost all methods decrease monotonously. FTLE and LLE display significant fluctuation throughout the period of forecast. In other word both of them do not show definite trend for convergence or divergence of two nearby trajectories. The results also clearly show that MLE value after 100-year forecast does not level off until approximately 140-year forecast while LE, FSLE, SLE and MoLE start to remain stable after 90-year forecast. Thus the predictability of EdGCM for PER7 is about 90 years.

To summarize the results of predictability measurement of surface air temperature prediction by EdGCM, Table 4.3 is presented.

Table 4.3 Summary of predictability measurements.

Method	Description
LE	Can measure convergence or divergence of two nearby trajectories.
FSLE	Can measure convergence or divergence of two nearby trajectories.
FTLE	No definite trend for convergence or divergence of two nearby trajectories.
LLE	No definite trend for convergence or divergence of two nearby trajectories.
MLE	Can measure convergence or divergence of two nearby trajectories.
SLE	Can measure convergence or divergence of two nearby trajectories.
MoLE	Can measure convergence or divergence of two nearby trajectories.

4.4 Summary of the Experiments

The predictability of EdGCM is assessed from predictability of surface air temperature under climate change scenarios over Southeast Asian region. It is measured by various methods from all experiments discussed above. It can be summarized in Tables 4.4 and 4.5.

Table 4.4 Summary of predictability measurement of surface air temperature from EdGCM for Case I.

Method	Predictability (years)				
	PER1	**PER2**	**PER3**	**PER4**	**PER5**
LE	100	90	100	80	60
FSLE	100	90	100	110	100
MLE	110	100	90	90	80
SLE	110	110	110	90	70
MoLE	110	110	90	80	60
Time period	100-110	90-110	90-110	80-110	60-100

From Table 4.4, it can be seen that different level of CO_2 have different predictability. LE and FSLE do not show relation between predictability and the level of CO_2. However, it can be notice that predictability by MLE, SLE and MoLE fall from 110 to 80, 70 and 60 years, respectively, while the level of CO_2 increases from PER1-PER5 which point out that the levels of CO_2 seem to have an effect on predictability. As for time periods, it also shows that as the level of CO_2 increase the less predictability it is. In summary, predictability of surface air temperature under different level of CO_2 is at least about 60 years and reaches the maximum about 110 years. This results imply a good performance of EdGCM.

In addition, to check more impact of other greenhouse gases on predictability, CH_4 is explored as Case Study II. Summary of results are shown in Table 4.5.

Table 4.5 Summary of predictability measurement of surface air temperature from EdGCM for Case II.

Method	Predictability (years)		
	PER2	**PER6**	**PER7**
LE	90	100	90
FSLE	90	90	90
MLE	100	100	100
SLE	110	100	90
MoLE	110	100	90
Time period	90-110	90-100	90-100

As shown in Table 4.5, predictabilities of different scenarios do not show much differences. Moreover, FSLE and MLE show that even if levels of CO_2 and CH_4 are increasing at the same time (PER7), predictability remains unchanged as well. It may be possible that the level of CO_2 and CH_4 are not enough to have effect on predictability. However, it may be deduced that CH_4 has more effect on predictability than CO_2 as it cannot be predicted longer than 100 years while predictability limit of CO_2 is 110 years. EdGCM again shows a good performance of at least about 90 years.