The transferability of Regional Climate Models through an assessment of the diurnal cycle

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1. Introduction

Three Regional Climate Models (RCMs) were implemented over seven different regions of the globe with the objective of assessing their *transferability* to different climate regimes. This can be explained as the ability of RCMs to simulate the variability of continental scale climates over different regions of the world with minimal parameter changes [4]. The models are: the Rossby Centre Regional Atmospheric Climate Model (RCA3) from Sweden [3]; the Canadian Regional Climate Model (MRCC) [1]; and the climate version of the operational forecast model of Environment Canada (GEM) [2]. The RCMs were piloted by ERA-40 and NCEP boundary conditions for a five year period spanning from 2000 to 2004. To fully assess the ability of the RCMs to represent the observed variability, field observations collected as part of the Coordinated Enhanced Observation Period (CEOP) program over the same period, were used as a baseline. The variability of surface temperature, precipitation, humidity, wind speed, sensible heat, latent heat, and the surface radiation fields were examined. A succinct description of the analysis of the diurnal cycle of precipitation and temperature with three RCMs is presented for a site at a non-native domain spanning July to September 2001.

2. Analyses

Table 1 lists the observed average temperature and the difference from this value that was simulated by the RCA3, GEM, and MRCC models. In order to highlight the scope of the project, values from five sites in five different model domains are presented. These sites highlight different climate regimes and a different land surface characteristics. The Cabauw and Mongolia sites are grasslands situated in maritime and continental climates respectively. The BERMS site is over the boreal forest with Old Black Spruce vegetation. The Rondonia site covers a tropical rain forest in the Amazon. The site at Manus, is located on an island in the tropical western Pacific ocean.

For simplicity, one could regard an anomaly value close to ± 1 K to signify that the model simulations are similar to the observations. By this measure, RCA3 simulates temperature closest to the observations for four of the five sites in Table 1. GEM simulates temperature closest to the observed at Manus in the tropical western Pacific and is furthest from the observed at the BERMS boreal forest site. MRCC is closest to the observed over the tropical rain forest and is furthest from the observed over the boreal Black Spruce forest. To explain these differences, an examination of the diurnal cycle helps yield insight into the underlying model variability.

Site	lon	lat	CEOP Obs (K)	Model - Obs RCA3 GEM MRCC
1	4.93	51.97	289.94	-0.08, 1.69, -1.19
2	-105.1	53.99	289.77	-1.11, 2.11, -3.17
3	106.26	45.74	291.76	-0.75, -1.10, 2.73
4	-61.93	-10.08	299.01	4.17, 2.00, -0.93
5	147.43	-2.06	300.69	0.23, 0.19, -1.21

Table 1: Average July August and September 2001 2-meter temperature: 1. Cabauw; 2. BERMS Old Black Spruce; 3. Mongolia; 4. Rondonia; 5. Tropical Western Pacific (Manus). Negative anomaly values imply that the model is colder than observations.

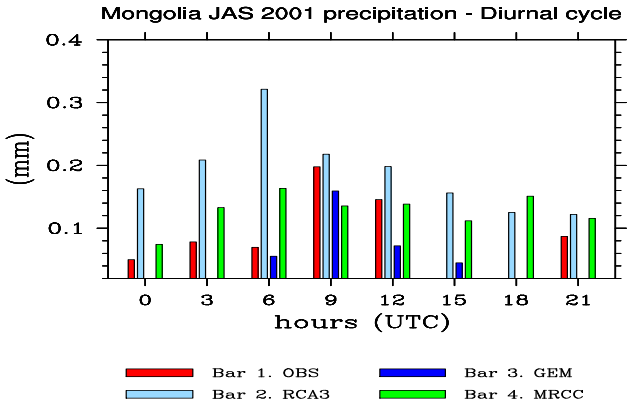

Figure 1: Diurnal cycle of JAS 2001 precipitation.

Figure 1 shows the diurnal cycle of precipitation of the three RCMs compared to the observations for Mongolia (local time = UTC + 8 hours). The precipitation accumulated over three-hour intervals were averaged over the 92 days from July to September 2001. The site experiences a dry continental climate. The CEOP observations show that the time of the day with the maximum precipitation is at 9 hours UTC. This implies that during the northern hemisphere summer, the site received most of

the daily precipitation in the late afternoon. The three RCMs simulate precipitation at night, unlike the observations. RCA3 simulates more than twice the total amount of precipitation observed during this period at this site, while GEM simulates less than half the amount observed.

Figure 2 shows the box-whisker diagrams of 3-hourly surface temperature for the observations and the RCMs at the same site and for the same period. The box shows the inter-quartile range and the whiskers show the 5% and 95% values. The CEOP observations show the maximum temperature of the day at 9 hours UTC (1700 hours local). This corresponds to the time of maximum precipitation in the afternoon. On the other hand, the three RCMs show the maximum temperature at 6 hours UTC. The excessive warm temperatures simulated by GEM causes greater dryness due to evaporation and subsequently the least precipitation. Interestingly, although RCA3 has an average temperature close to the CEOP observations, the range of temperatures is larger at all hours of the diurnal cycle. MRCC has the coldest temperatures at 18 and 21 hours UTC i.e. the early hours of the morning at this site.

3. Summary

Only two variables at one reference site and one season are examined here due to space limitations. It should be stressed that transferability is not an inter-comparison exercise. The understanding of the response of RCMs to different continental forcings have profound implications for the hydrologic cycle and associated feedbacks, which are vital to the study of present and future climates. The analyses of these processes are currently being assessed.

References

[1] D. Caya and R. Laprise. A semi-implicit semi-Lagrangian regional climate model: The Canadian RCM. *Monthly Weather Review*, 127:341–362, 1999.

[2] J. Côté, S. Gravel, A. Methot, A. Patoine, M. Roch, and A. Staniforth. The operational CMC-MRB Global Environmental Multiscale (GEM) model. Part I: Design considerations and formulation. *Monthly Weather Review*, 126:1373–1395, 1998.

[3] C.G. Jones, U. Willen, A. Ullerstig, and U. Hansson. The Rossby Centre regional atmospheric climate model Part 1: Model climatology and performance for the present climate over Europe. *Ambio*, 33:199–210, 2004.

[4] E.S. Tackle, J. Roads, B. Rockel, W.J. Gutowski Jr, R.W. Arritt, I. Meinke, C.G. Jones, and A. Zadra. Transferability Intercomparison: An opportunity for new insight on the global water cycle and energy budget. *Bulletin of the American Meteorological Society*, 88:In Press, 2007.

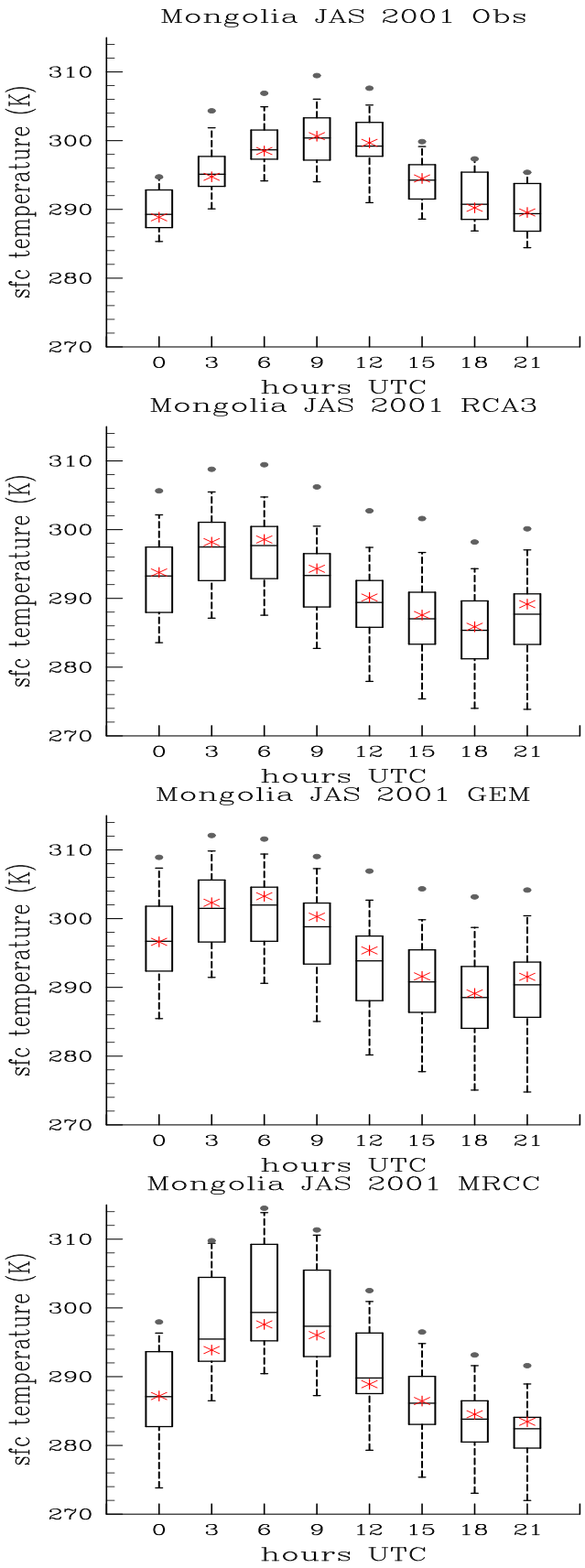

Figure 2: Box-whisker diagrams of 3-hourly surface temperature during July to September 2001 (⋆=mean).