Appendix to Chapter 10

Long Term Projections of Sea Level, Temperature and Rainfall Change

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Appendix 10.1 Can we use a pattern scaling approach for regional temperature, rainfall and sea level changes?

In this appendix, we explore the approach of pattern scaling for our projections of temperature, rainfall and sea level rise. As discussed by Collins et al (2013), it relies on the existence of robust geographical patterns of change, emerging at the time when the response to external forcings emerges from the noise (internal variability), and persisting across the length of the simulation and across different scenarios. Pattern scaling was used originally to relate regional temperature and precipitation changes to global surface temperature change (Santer et al., 1990). However, these relationships can be premised on other global and regional climate change variables.

Here, the approach to assessment of pattern scaling is simply to plot regression relationships between regional quantities for Singapore and global basis variable (either global surface temperature, global rainfall, or global thermal expansion). This reduces the 'pattern' we are seeking to a single regression plot. For regional temperature and rainfall, we use rolling 20-year averages (this approach helps to eliminate some of the internal variability) and only the RCP8.5 scenario. For regional sea level change, we analyse annual values of steric/dynamic sea level and global thermal expansion for both the RCP4.5 and RCP8.5 scenarios.

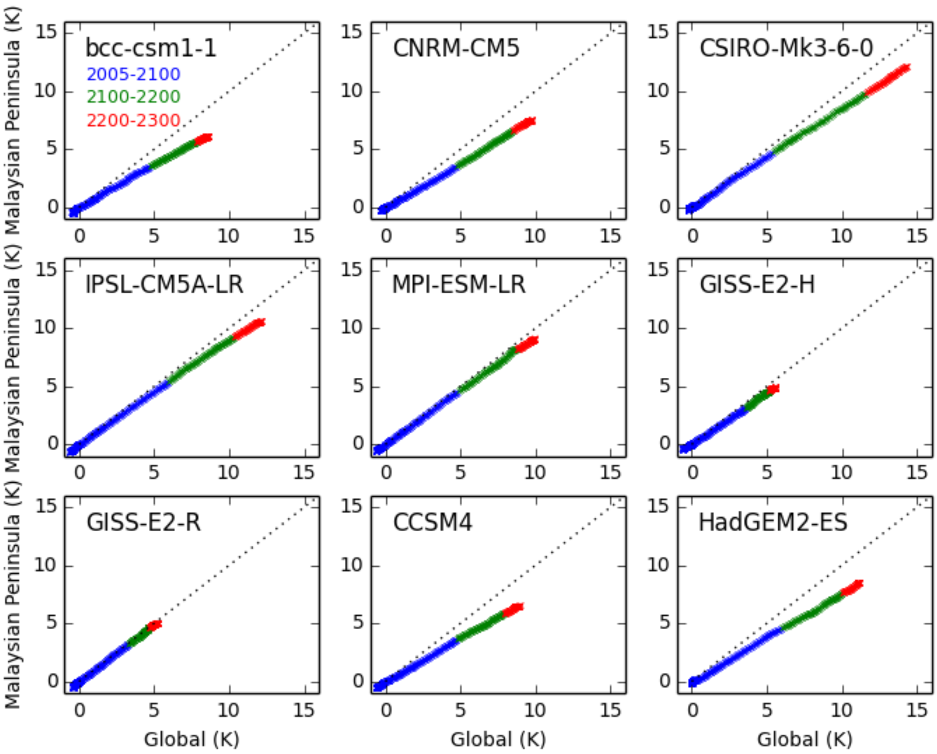

Figure A10.1: Global annual mean temperature anomaly versus temperature anomaly for the Malaysian Peninsula for the RCP8.5 scenario. Points are rolling 20-year running averages.

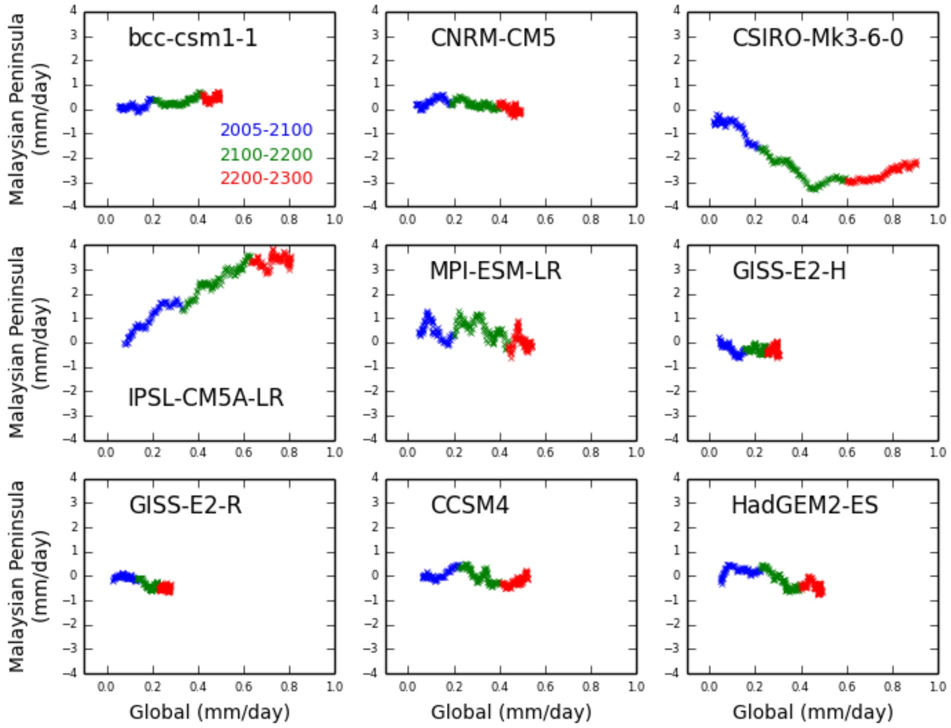

Figure A10.2: Global annual mean temperature anomaly versus rainfall anomaly for the Malaysian Peninsula for the RCP8.5 scenario. Points are rolling 20-year running averages.

As expected, we find a good relationship between global surface temperature rise and the regional average for the Malaysian Peninsular under RCP8.5 (Figure A10.1). In general, the amount of regional surface temperature rise is less than the global average, by up to about 30% – this is also apparent in the comparison between Figure 10.5 and Figure 10.1. However, the regressions against regional rainfall show less favourable results (Figure A10.2). While it might be reasonable to apply a pattern scaling relationship over the 21st Century, it is not clear that this relationship will hold over the following two centuries. The change is the relationship for rainfall in some models is likely related to the stabilisation of temperature late in the RCP8.5 scenario. This phenomenon has been documented previously by Wu et al (2010) and Caesar et al (2013).

Similar to the results for regional temperature, we find an approximately linear relationship between local steric/dynamic sea level change and global thermal expansion for both RCP4.5 and RCP8.5 (Figures A10.3, A10.4). This means that we can estimate the relationship even for all available CMIP5 models over the period 2006-2100. When we do this we see that, to first-order, all models show a linear relationship that is largely independent of the climate change scenario (Figure A10.5). On average, the local sea level change from CMIP5 models is larger in the Singapore region than the global thermal expansion by about 11%. This amplification of the global signal may simply reflect the greater thermal expansion associated with the warm tropical waters in this part of the World (systematic response in circulation?).

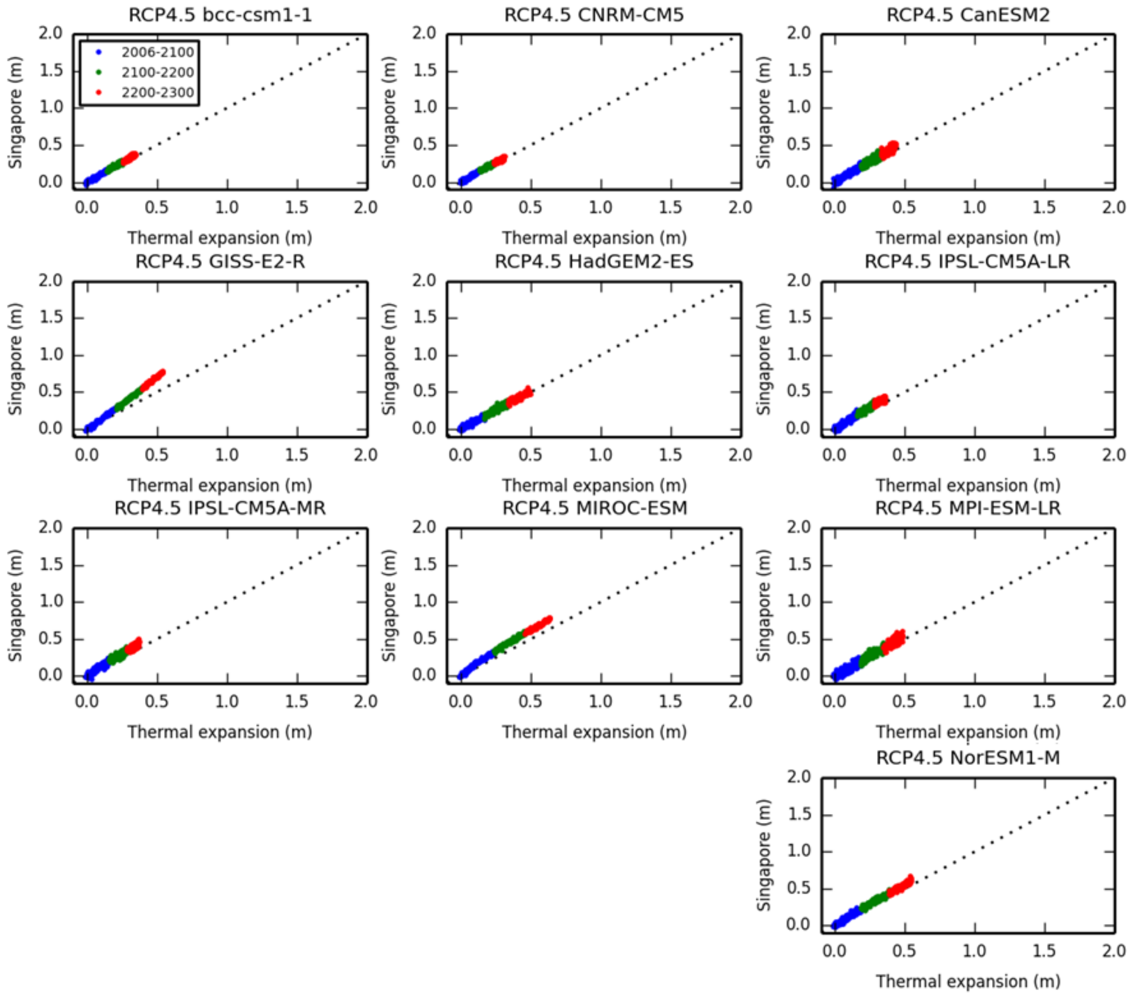

Figure A10.3: Regional steric/dynamic sea level change at Singapore versus global thermal expansion for the RCP4.5 scenario over the period 2006-2300. All points are annual-mean values of the change relative to a baseline of 2006-2015 .

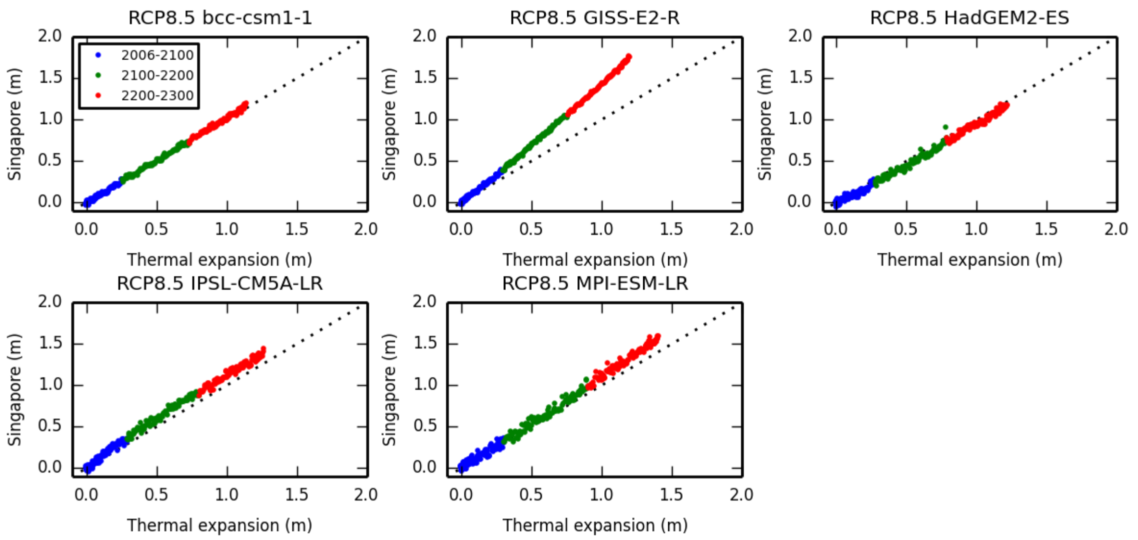

Figure A10.4: Regional steric/dynamic sea level change at Singapore versus global thermal expansion for the RCP8.5 scenario over the period 2006-2300. All points are annual-mean values of the change relative to a baseline of 2006-2015.

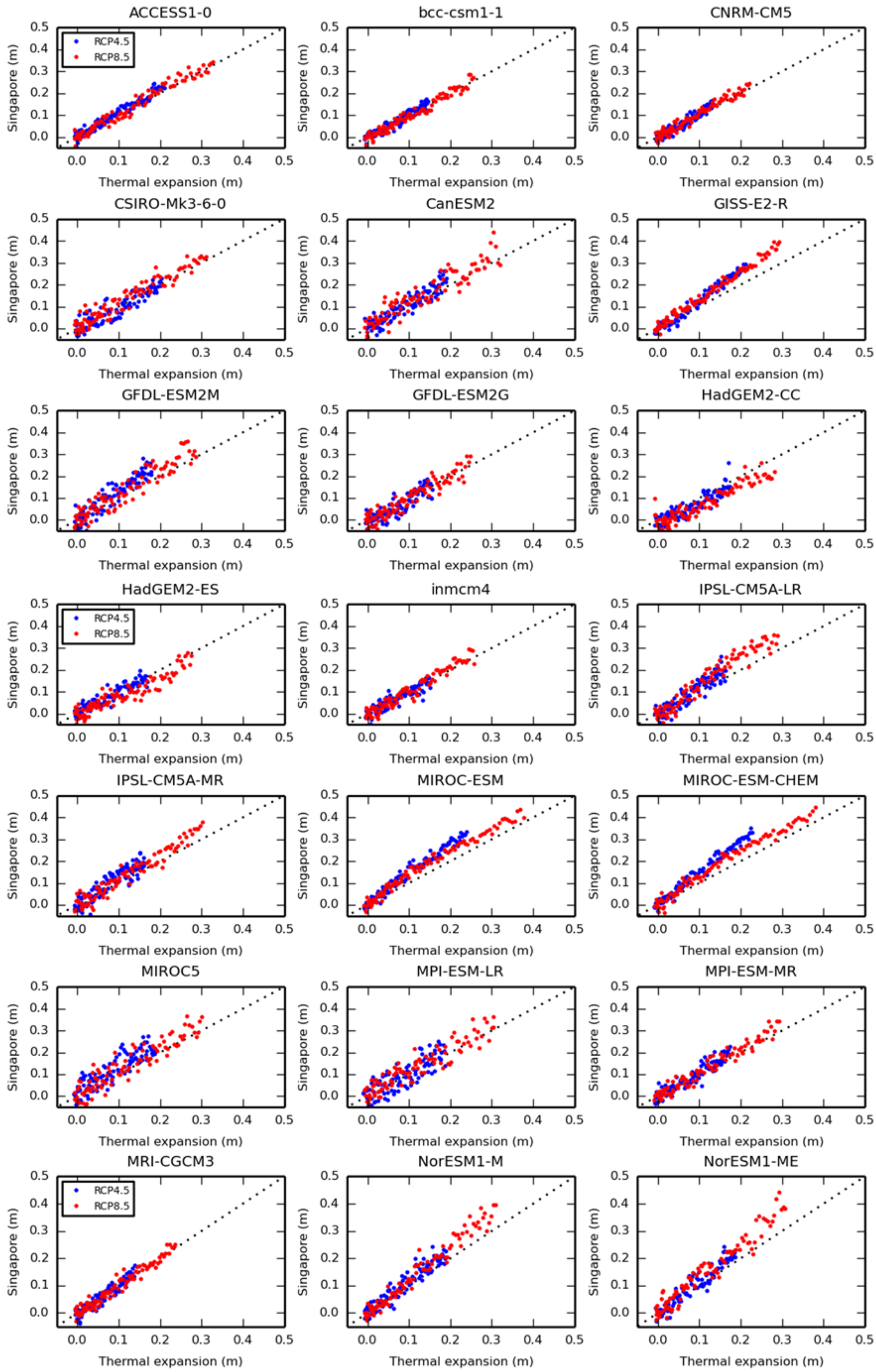

Figure A10.5: Regional steric/dynamic sea level change at Singapore versus global thermal expansion for the RCP8.5 scenario over the period 2006-2300. All points are annual-mean values of the change relative to a baseline of 2006-2015 .