Appendix to Chapter 6

Convective-Scale Modelling

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This Appendix first presents additional details of the convective-scale RCM configuration described in Section 6.2, and then presents a series of additional figures, which are referred to in the main text. These figures compliment the key ones which are embedded in the main text.

Full details of the convective-scale RCM configuration

The configuration used for the convective-scale models is the "version 1" configuration which has been developed and tested over the last fifteen months as part of the SINGV project. This configuration is similar to that used in Kendon et al. (2012), but with the following enhancements. Firstly, the ENDGame dynamical core (Wood et al., 2014) has replaced the New Dynamics dynamical core. ENDGame has been used in Met Office operational global forecast models since July 2014 and is currently being trialled for operational implementation in the UK area 1.5 km model (known as the UKV). Secondly, changes have been made to the model physics to make it more "scale-aware". In particular a "grey zone" blended boundary layer scheme and a revised warm rain microphysics scheme, as described in Boutle et al. (2014)), have been implemented. In addition to the changes described in Boutle et al. (2014), a shallow convection parametrization has also been implemented which represents the effects of convection that remain unresolved at these scales (Adrian Lock, personal communication). The convective-scale model therefore parametrizes shallow convection, and represents explicitly mid- and deep- level convection. These changes enable the same configuration to be used in both the 1.5 km and 4.5 km models. Indeed, the only differences in configuration of these two models are their mesh size and their timestep (50 seconds and 100 seconds respectively).

The third enhancement to the convective-scale configuration is the inclusion of graupel as a prognostic variable, which enables lightning forecasts to be made (see Wilkinson and Bornemann (2014) for more details). The fourth change relative to the UKV configuration is to use an L80 levels set, which has levels distributed more appropriately for the tropics than the UKV L70 levels set. In contrast to the UKV levels set, therefore, the L80 level spacing increases smoothly through the full depth of the model. As a result there are 5 levels in the lowest 100 m of the atmosphere and 20 levels in the lowest 2km. At 16 km above sea level (ASL), which is typically in the upper troposphere in the deep tropics, the level thickness is approximately 500 m, which is three times finer than the UKV levels set at this altitude. The resolution then degrades smoothly up to the model lid, which is at 38.5 km ASL. The final change relative to the UKV configuration is that the mean orography is derived from a 100 m resolution dataset known as the Shuttle Radar Topography Mission (SRTM) dataset.

The nesting procedure requires the 1.5 km RCM to obtain lateral boundary conditions (LBCs) from the 4.5 km RCM, which in turn must obtain LBCs from the 12 km RCM. The 1.5 km model LBCs were updated every 30 minutes and included water vapour, cloud water, cloud ice and also rain and graupel since these water species are prognostic fields in both models. The 4.5 km model LBCs were updated every hour but did not include graupel, since this is not a prognostic field in the 12 km RCM.

Other aspects of the RCM forcing data are now briefly described. First, the soil moisture for each RCM is initialised using the soil moisture of the respective driving model at the initialisation time. Second, all three RCMs derive their sea-surface temperatures (SSTs) from the driving global model, and these are updated daily throughout the simulations.

Finally, ozone concentrations are also derived from the driving global model, and these are updated every month.

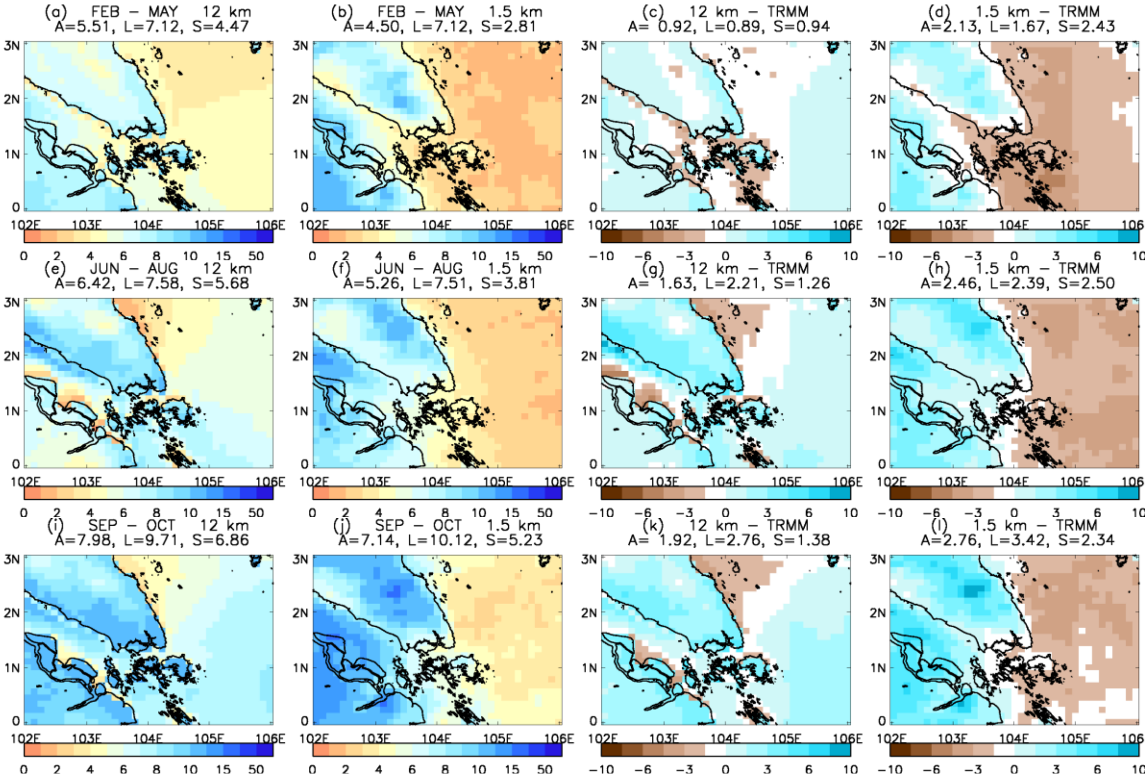

**Figure A6.1. As Figure 6.2, but (a)-(d) for February to May
, (e)-(h) for June to August and (i)-(l) for September and October.**

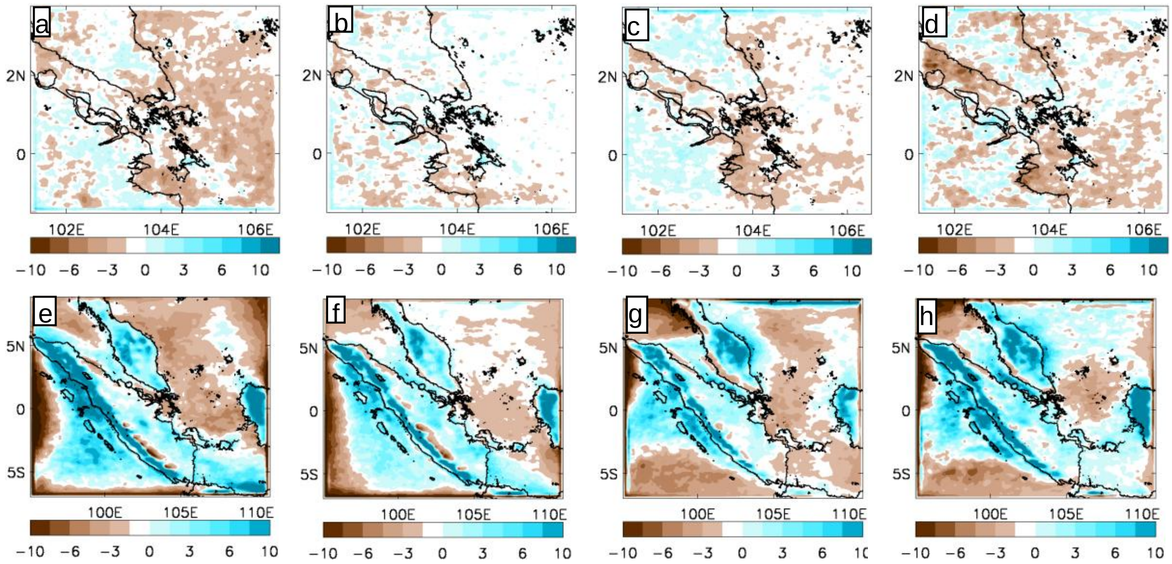

Figure A6.2. (a) The November to January mean rainfall difference in mm d^{-1} for the 1.5 km RCM minus the 4.5 km RCM. (b), as (a) but for February to May, (c) as (a) but for June to August and (d), as (a) but for September and October. (e)-(h), as (a)-(d) but showing the 4.5 km minus 12 km RCM difference. The region shown in (a)-(d) spans the full 1.5 km domain (including its rim), whilst for (e)-(h) the region shown spans the full 4.5 km RCM domain.

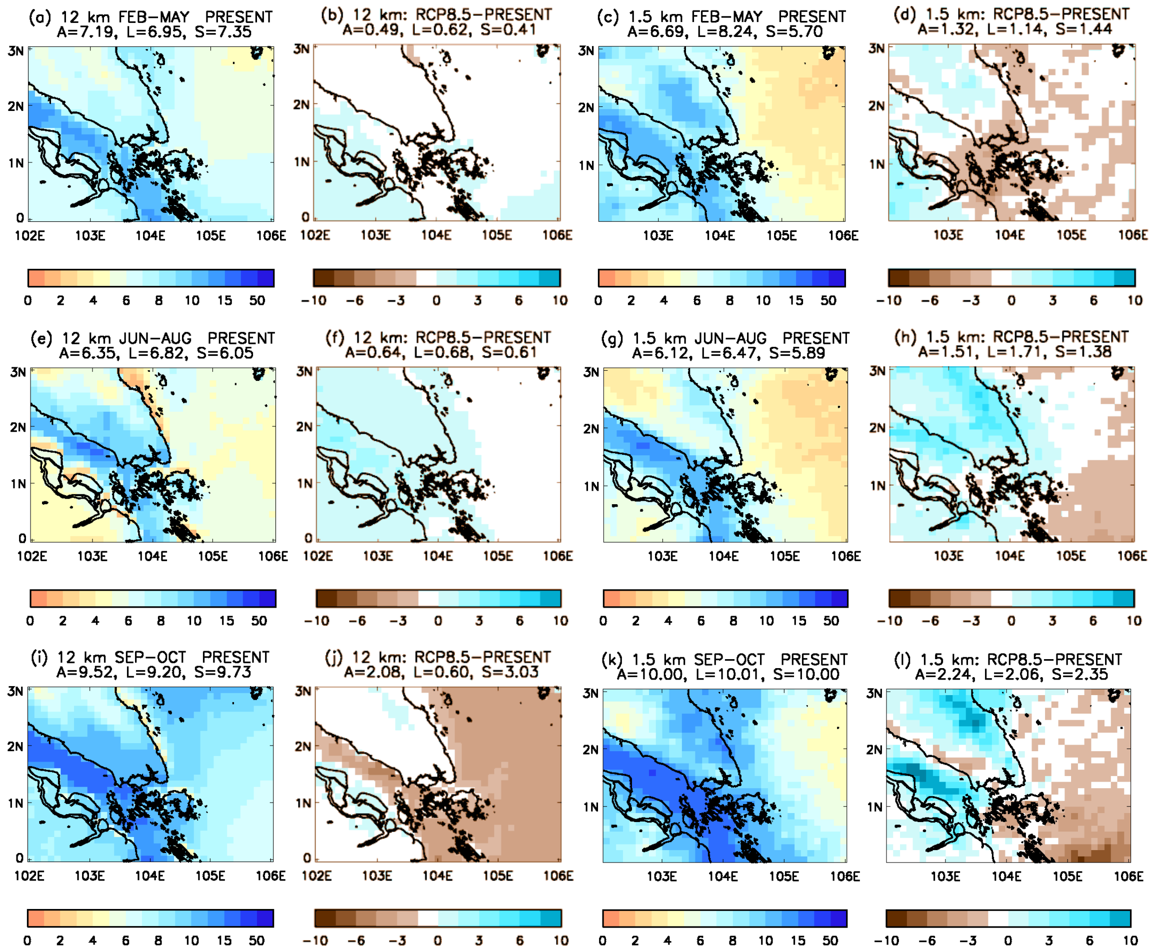

Figure A6.3. As Figure 6.7, but (a)-(d) for February to May, (e)-(h) for June to August and (i)-(l) for September and October.

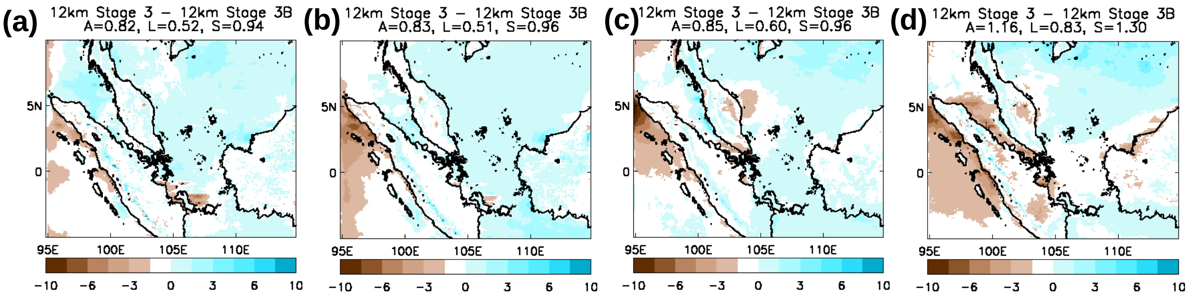

Figure A6.4. Seasonal mean rainfall differences for the Stage 3 minus Stage 3b 12 km present day (1995-2005) RCM simulations for (a) NDJ, (b) FMAM, (c) JJA and (d) Sep-Oct. Note that the area shown here is larger than in any other figure and extends westwards to the edge of the Stage 3 domain rim. Units are mm day^{-1}.

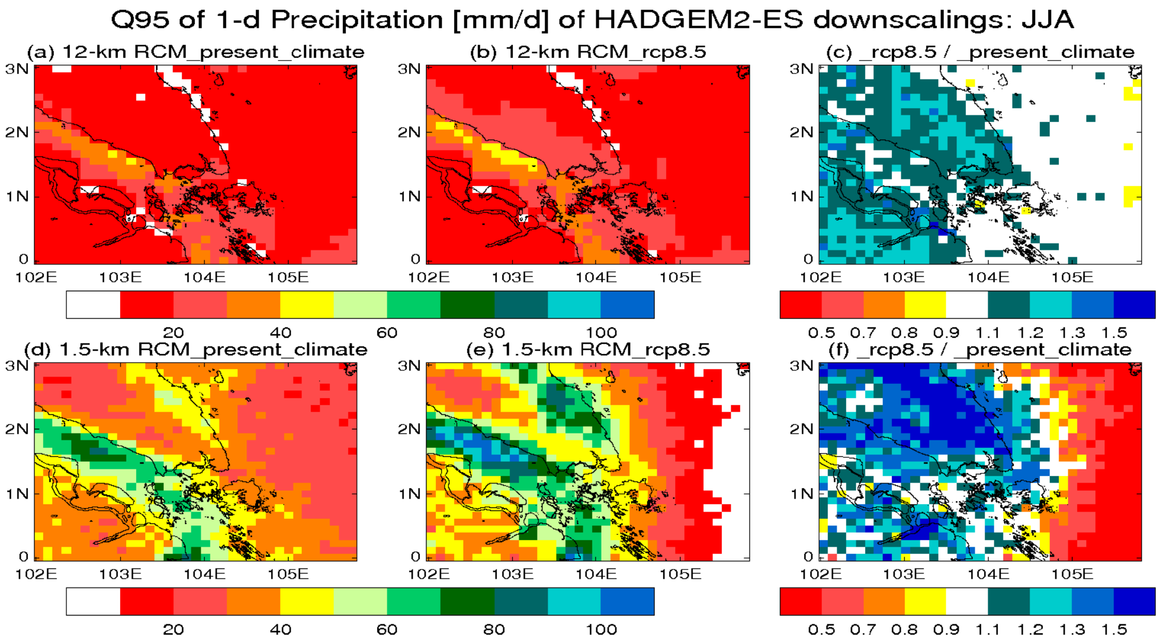

Figure A6.5. As Figure 6.8, but for June to August.

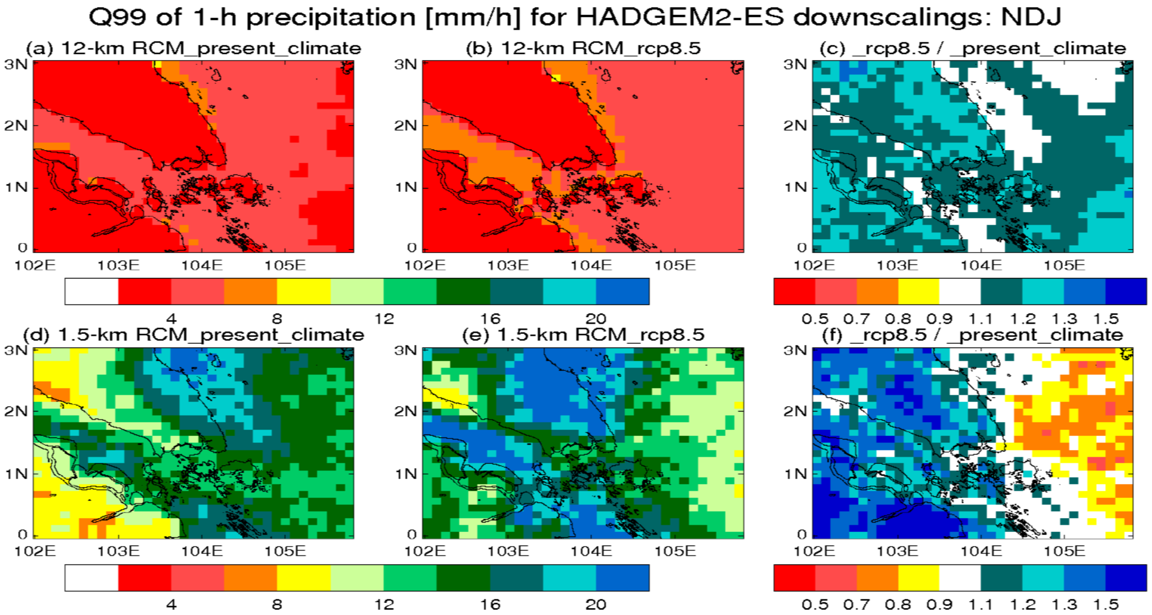

Figure A6.6. The 99th percentile of the daily precipitation totals for NDJ of the HadGEM2-ES driven simulations. (a) The 12 km RCM present day simulation, (b) the 12 km RCM RCP8.5 simulation and (c) the ratio of the future and present day climates. (d) - (f), as (a) –(c), but for the 1.5 km RCM.

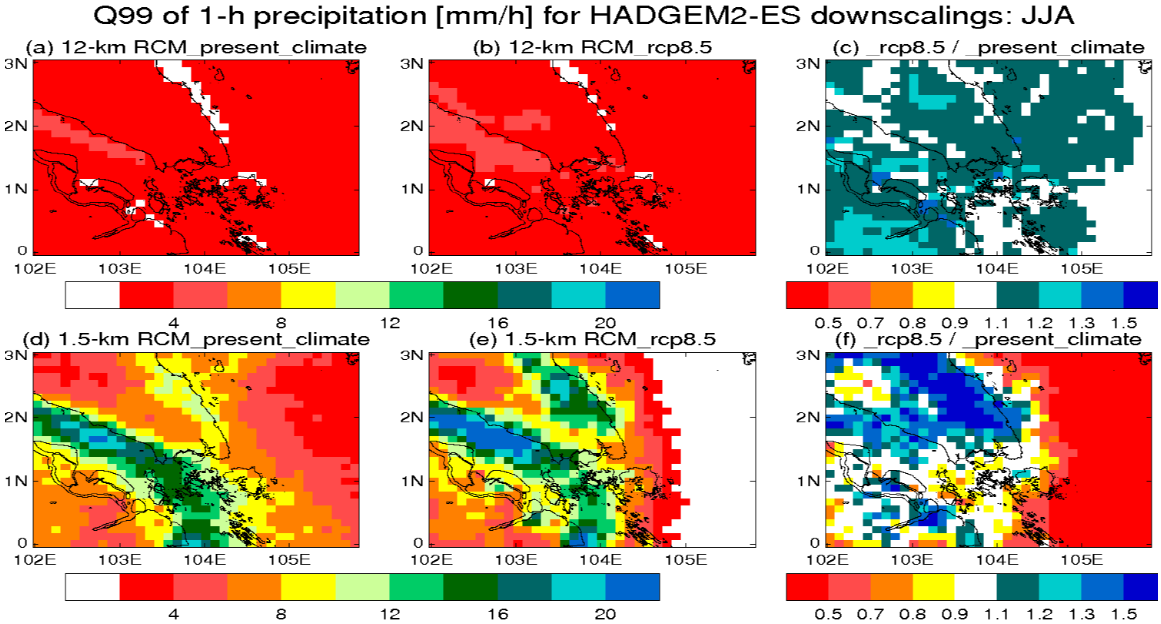

Figure A6.7. As Figure A6.6, but for June to August.

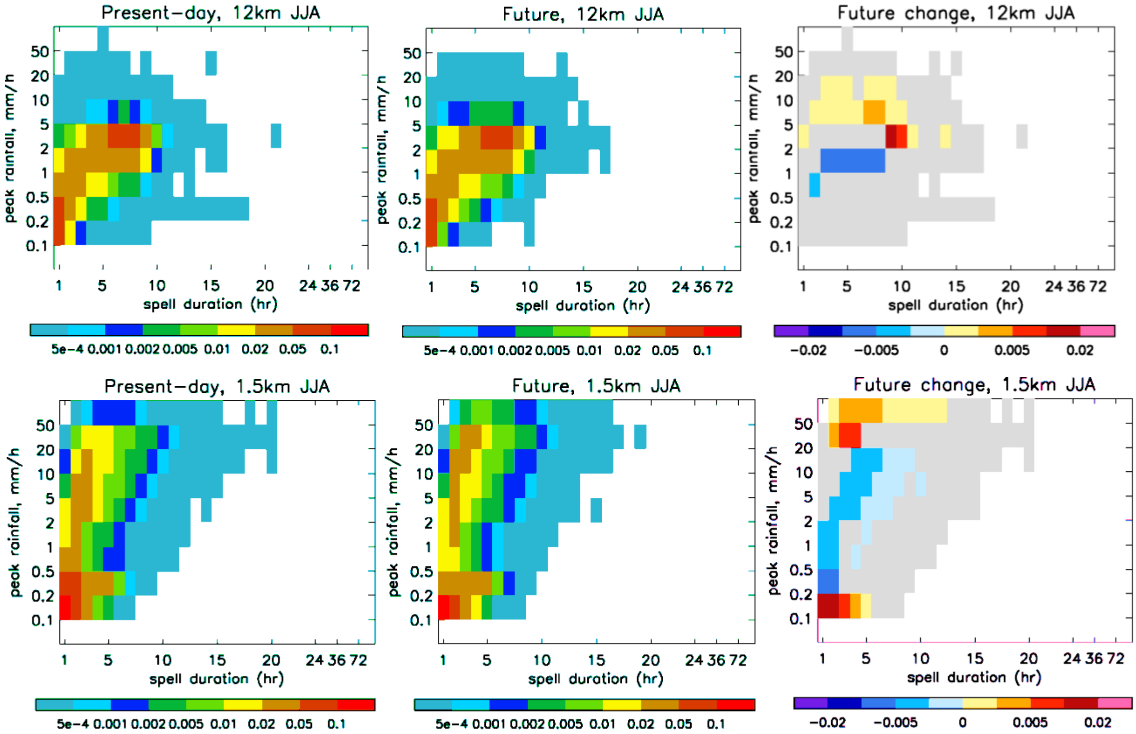

Figure A6.8. As Figure 6.10, but for June to August.

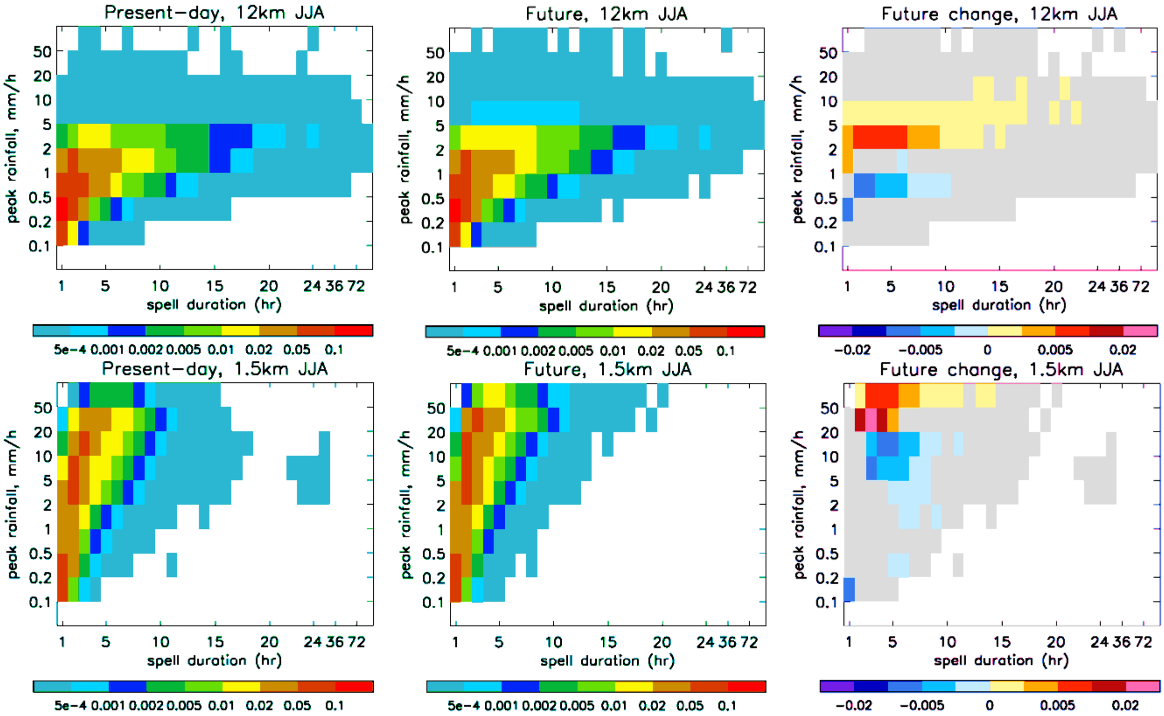

Figure A6.9. As Figure 6.11, but for June to August.