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Supplement of

Adaptation of water resource systems to an uncertain future

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Weather generator validation

The NSRP rainfall model and CRU weather generator have been extensively validated for the UK; details for the single site stochastic rainfall model are provided by Kilsby et al. (2007), Burton et al. (2008) and Jones et al. (2009). Validation of the multi-site STNSRP model is provided by Burton et al. (2008), for an application in the Netherlands by van Vliet et al. (2012) and spatially by Burton et al (2010). Validation of additional weather generator variables may also be found in Jones et al. (2009).

In this study, ten 100-year BSL simulations of daily rainfall across the catchment were assessed for 10 grid cells across the catchment by comparison with the daily 5 km gridded precipitation dataset developed by Perry and Hollis (2005a, b). For brevity, representative grid cells are shown in Figure S1 for each of the 3 sub-catchments. The model reproduces the five rainfall statistics very well and captures the spatially varying properties of the observed rainfall across the Thames basin, in particular for the mean and PDD. There is a tendency to slightly under-estimate variance in summer months although the ensemble generally encompasses the gridded dataset variance, whilst skewness, although generally reasonably well reproduced, is substantially underestimated at some locations due to the highly sensitive nature of this statistic and the influence of rare extreme daily totals.

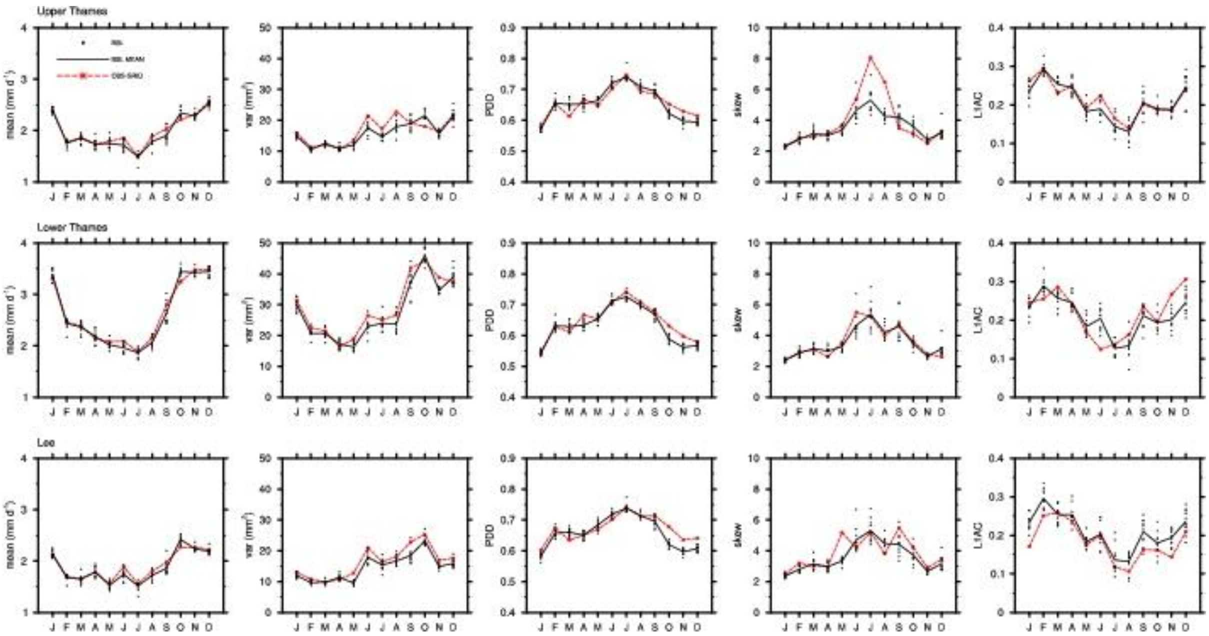

Figure S1. Validation of the STNSRP rainfall model for the Thames catchment. Representative 5 km grid cells are show for the Upper Thames (top row). Lower Thames (middle row) and Lee (bottom row). For the BSL rainfall simulations results are shown for each of the 10 simulations (dots) which are summarised by the mean (solid line).

Selection and application of UKCP09 change factors

The ensemble provided by UKCP09 comprises 10,000 sets of change factors and so a significant challenge for the application of UKCP09 projections is the use of an appropriate means of sampling this dataset to make the modelling of future climate impacts feasible whilst still preserving probabilistic information. This is particularly important if consideration is to be made of multiple future time periods and/or emissions scenarios. For example, Christierson et al. (2012) outline an alternative approach using Latin Hypercube Sampling to obtain 20 samples for use with hydrological models to assess changes in river flows at the UK national scale within the context of water resource planning. However, UKCP09 guidance recommends that a minimum of n = 100 random samples are required to maintain the representativeness of the sampled dataset and we take this approach here for each of the selected periods. Supplementary resource presents a brief assessment of the robustness of the random sample of CFs used in this study.

Murphy et al. (2009) indicate that smaller values of CF samples n may lead to the resultant distribution diverging from that of the full, sampled population of 10,000. The single-site UKCP09 weather generator was used to generate an additional n=1,000 future rainfall series for both SCN20 and SCN50 for the 5km grid cell at the catchment centroid. For each time period the monthly CFs for mean daily precipitation were examined and the median and 10th and 90th percentiles were calculated for each and compared with those of the original 100 samples for the same grid cell. Figure S2 shows a comparison between the two random samples for SCN20 and SCN50. The mean absolute monthly difference between the samples is ~3 %, although for individual months it is higher (up to 7 % for August SCN50). The mean difference for the 10th and 90th percentiles is in the range of 4-6%, with a maximum monthly difference of ~10 %. An examination of the distribution of CFs for individual months shows that there may be a tendency for random sampling to insufficiently sample the range of CFs in some months when n is smaller (e.g. Figure S2c), although in most months the differences are relatively small (for example, Figure S2d). Given the nature of the subsequent hydrological and water resources modelling it was not feasible to increase n above 100 and as the differences between the two samples are relatively small we considered it appropriate to proceed with the sample while noting the caveats provided above. A future study might consider examining the sensitivity of modelling results to different sampling strategies. This might usefully assess whether any gains provided by a more sophisticated sampling strategy outweigh the pragmatism and relative robustness provided by random sampling.

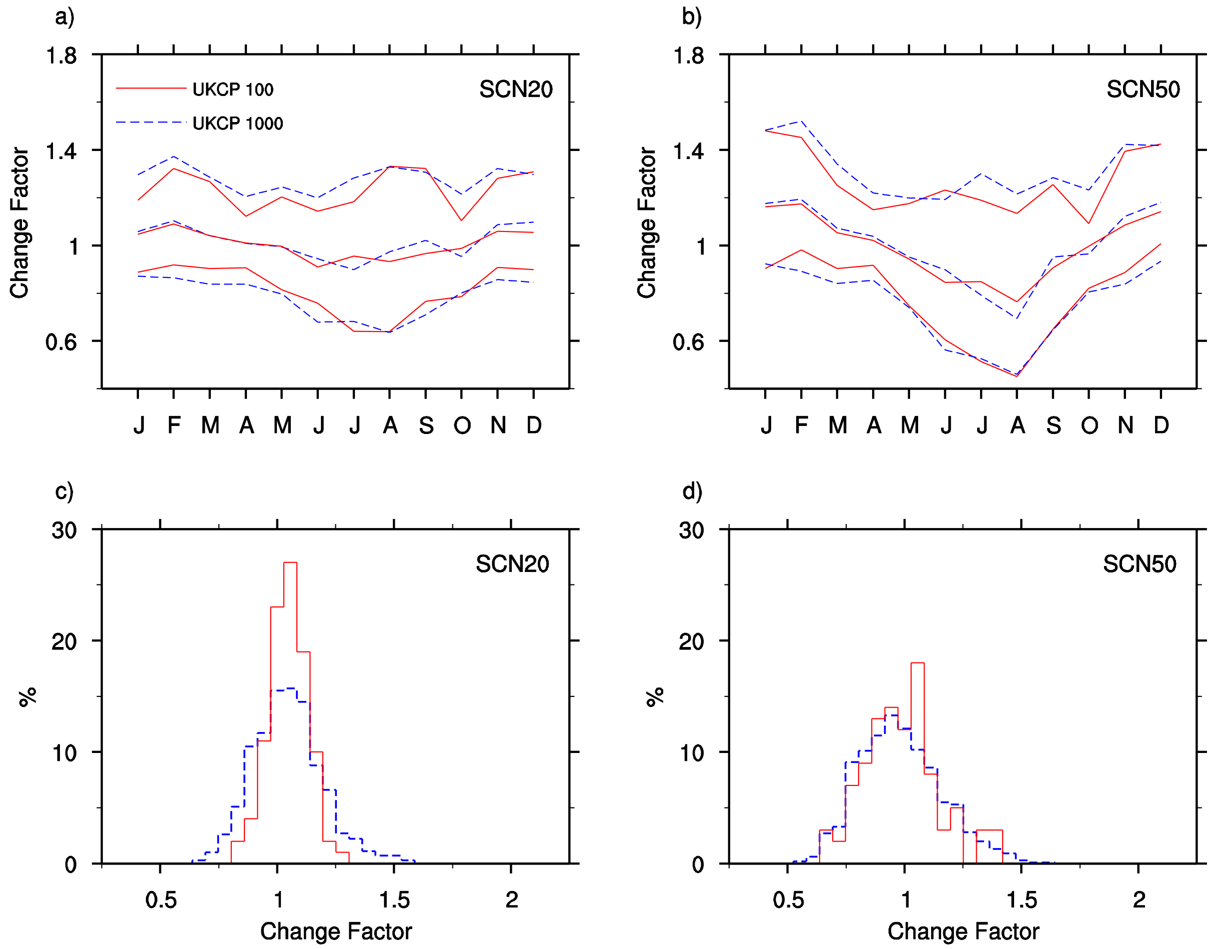

Figure S2: Ensemble change factors for mean daily precipitation for a) SCN20 and b) SCN50. Change factors are shown for the 100 member ensemble (UKCP 100) used here and a comparative 1000 member ensemble (UKCP 1000) for the catchment's centroid grid cell. In both cases the central lines denote the ensemble median and the upper and lower lines denote the 90th and 10th percentiles respectively. Ensemble change factor distributions are shown as the percentage of the 100 and 1000 ensemble c) SCN20 (April) and d) SCN50 (May).

Water resource model: demand saving measures

Reservoir trigger thresholds for demand saving measures are dynamic and vary monthly (see Table S1)

Table S1: Percentage of reservoir total storage capacity that invokes the different levels of restrictions (Source: Thames Water, 2014).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Level 1	69.5	82.0	89.5	92.1	92.1	90.9	86.0	74.9	64.8	61.0	59.8	61.0
Level 2	42.2	47.8	55.3	65.2	74.0	76.5	74.7	67.7	55.7	46.2	41.1	39.8
Level 3	33.6	37.3	43.4	52.1	60.9	65.9	67.2	62.4	51.2	41.2	34.9	32.4
Level 4	17.4	19.8	24.8	29.8	34.8	38.6	39.8	39.8	37.4	31.2	25.0	20.0

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