Self-Organising Maps Results for the Upper Komati Domain

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Introduction. Results are presented below for the analyses through self-organising maps (soms) for the Upper Komati Domain.

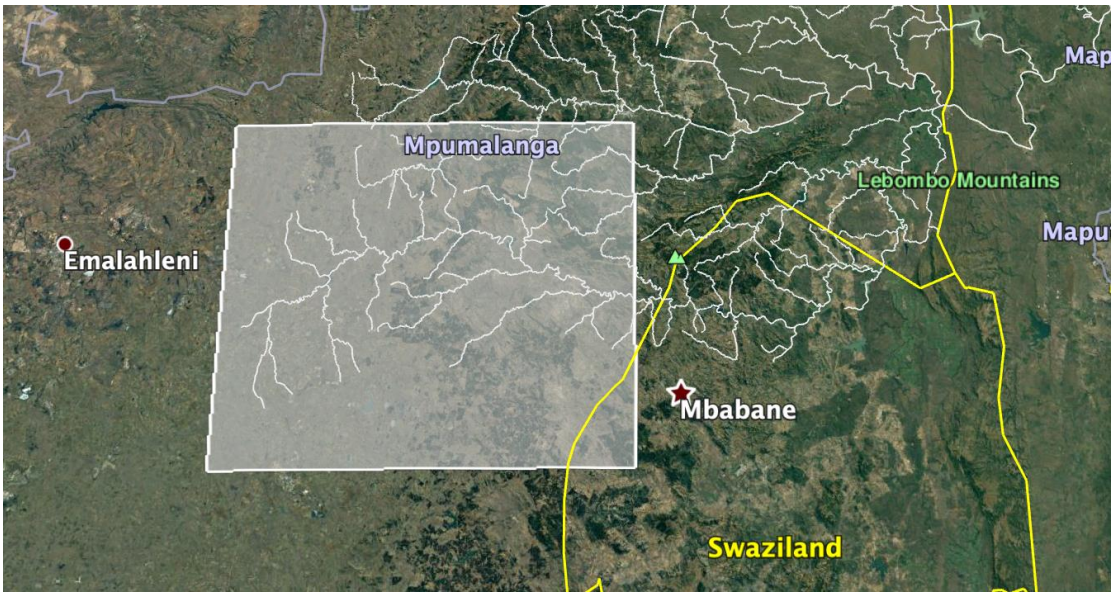

Figure 1: Area over which sims have been calculated, the Upper Komati Domain

The Upper Komati Domain outlined in Figure 1 covers most of the upper parts of the basin within South Africa west of the border with Swaziland.

Assessments of soms analyses for each RCP and temperature vs rainfall or temperature vs rainfall less evaporation are presented in the central section of this document; in these results RCPs start at 2.6 and increase successively, temperature vs rainfall is presented before temperature vs rainfall less evaporation. Results from the soms are charted on each page followed by a table giving suggested scenarios from these particular results; a brief justification for the suggested scenarios is provided below each table.

Immediately preceding the soms results section is a collation of suggested scenarios from both sets of soms analyses for easy reference. Below the collated table for each RCP is a further table giving, for each individual soms analysis, two suggested extreme scenarios, derived entirely subjectively as reasonable external boundaries to the projections. These extreme scenarios focus on changes to rainfall or to rainfall less evaporation as appropriate, and are an attempt to indicate possible scenarios representing greatest increases or decreases in rainfall or in rainfall less evaporation for that particular RCP. Note that had the focus been towards relatively high/low temperature increases different extreme scenarios would have been produced on at least some occasions. Thus the suggested extreme scenarios do not capture necessarily greatest and least changes in temperature projected for that RCP.

The number of projections for a given RCP, listed in the soms charts captions and repeated in the collation tables, may differ between the temperature against rainfall alone analyses and the temperature against rainfall less evaporation analyses; a limited number of rainfall less evaporation projections have been eliminated subjectively from the analyses where over-large changes in rainfall less evaporation results because of near-zero rainfall less evaporation values during the base period of 1979-2005.

Ahead of the suggested scenarios section, and immediately following this introductory section of the document, is a list of the recommended scenarios with estimated likelihoods, and of recommended extreme scenarios for both temperature against rainfall and temperature against rainfall less evaporation. As in earlier work results for RCP8.5 stand somewhat apart from those for the other RCPs. Hence the recommended scenarios, including extreme scenarios, for RCP8.5 are the same as the suggested scenarios. For RCP2.6, RCP4.5 and RCP6.0 a subjective overview has been taken to create single recommended scenarios, including extreme scenarios, representative of all three RCPs.

In a final section of this document, following the results from the soms, are results for inter-annual variability (IAV) calculations based on the suggested scenarios. These are provided successively, first for temperatures, followed by for rainfall and then for rainfall less evaporation. In each case there are time series of appropriate adjustments in each suggested scenario and also decadal probability charts for future successive two- and three-year periods that:

- annual temperatures will exceed +2 and +3 standard deviations
- annual rainfall totals or rainfall less evaporation values will be below the 10th and 25th percentiles
- annual rainfall totals or rainfall less evaporation values will be above the 75th and 90th percentiles

relative to values across the base period of 1979-2005. Temperature results have been given only for the temperature vs rainfall soms as those for the temperature vs rainfall less evaporation soms are equivalent. For all curves, both time series and probabilities, trends across the century have been assessed through the non-parametric Mann-Kendall statistic, with results testing the null hypothesis that there is no trend present at both the 5% and the 10% probability levels. Non-parametric statistics are more conservative than parametric statistics and thus Mann-Kendall is a relatively severe examination of any trends. Some of the probability curves, predominantly for temperatures, plateau at 100% before 2100, a factor taken into consideration in the Mann-Kendall calculations by limiting the calculations to the decade in which the probabilities first reach 95% or more.

It should be noted that while it is reasonable to assess linear temperature trends through the century as a first approximation, although with all RCPs these trends may decline later, it is not necessary that trends in rainfall and rainfall less evaporation should be linear and monotonic. Rainfall dynamics are complex and future rainfall might respond in a number of manners to atmospheric circulation changes associated with increasing temperatures through the century, with periods of opposing trends entirely feasible (something that is seen regularly in historic data). The linear trend values for rainfall and for rainfall less evaporation provided below thus need to be approached appropriately given that issue.

Summary of results from the self-organising maps. There are mixed results from the two sets of soms analyses, with slightly greater likelihood of no change or a small increase in rainfall than for a decrease, but for a rather stronger signal of a decrease in rainfall less evaporation. This result can be contrasted with those from earlier similar analyses for the Vaal Domain and the Mpumalanga Domain. In the former the higher likelihood signal was for an increase in rainfall but for equality in likelihoods for rainfall less evaporation increases/decreases; in the latter likelihoods of rainfall increase/decreases were roughly equally split whereas for rainfall less evaporation decreases gained the higher likelihoods.

Temperature against rainfall. As might be expected, temperatures in the RCP scenarios increase with emissions, a rise that is, in general, greater for the drier scenarios. Throughout most RCPs there is limited differentiation between likelihoods of increased (or remaining roughly the same) or decreased rainfall, viz RCP2.6 55/45, RCP4.5 50/50, RCP6.0 90/10 (the exception, but a relatively low-populated ensemble), RCP8.5 55/45.

Temperatures in the suggested extreme scenarios increase in general with RCP; rainfall changes in the scenarios with increases tend to be of the order of +5% whereas those with decreases are around 10-15%, and a little more for RCP8.5.

Temperature against rainfall less evaporation. The picture is a little more straightforward for rainfall less evaporation, with reduced future water resources the main likelihood, but again with the exception of RCP6.0. Indeed, for RCP4.5 the split in terms of likelihoods is 80/20, and for both RCP2.6 and RCP8.5 it is 60/40.

Temperatures in the suggested extreme scenarios increase in general with RCP; increases in water resources according to these scenarios tend to remain around 10-20% whereas there is a trend for increasing losses with RCP, reaching about 60% under RCP8.5.

Summary of results from the study of future interannual variability.

To aid interpretation of the following below shows the likelihoods of all suggested scenarios in %, with the terminology used in the tables following in each first column. These are for the temperature against rainfall scenarios:

Scenario	RCP2.6	RCP4.5	RCP6.0	RCP8.5
High	45	50	50	55
Medium	35		40	
Lowest	20	50	10	45

and for the temperature against rainfall less evaporation scenarios:

Scenario	RCP2.6	RCP4.5	RCP6.0	RCP8.5
High	45	80	80	60
Medium	40			
Low	15	20	20	40

Inter-annual variability of temperatures for the suggested scenarios.

Later in the document there are time series curves for temperatures for each complete ensemble set for each RCP, designated 'Full' in the first part of the following table, together with curves for each of the scenarios derived through the soms analyses. These are designated appropriately in the following table as 'Highest', 'Medium, and 'Lowest' in references to the likelihoods assigned to each of these scenarios. See table above for attached likelihoods – results are for the temperature against rainfall soms only as those against rainfall less evaporation are equivalent.

In the table below the orange-shaded part provides a summary of the trends throughout the projected period according to Mann-Kendall in degrees Centigrade per decade; values in **bold** are significant at the 5% level. In fact, all are significant at the 5% level and hence tests at the 10% level are not included.

In the green-shaded section are trends for changes in probabilities of two successive years with temperatures exceeding two standard deviations, and in the blue-shaded section for three standard deviations, in % per decade, again with results significant at the 5% level in **bold**. In fact all are significant at the 5% level with the

single exception of the three standard deviation RCP2.6 medium likelihood scenario, for which there is no significance at the 10% level either. Results across three-year periods are not tabulated here. **NOTE** that trends have been calculated across only those parts of the curves in which probabilities increase; many of the curves plateau at 100% before the end of the century and to provide a meaningful estimate of changes prior to any plateauing calculations have been terminated at the final decade in which the likelihoods reach 95% or more.

Scenario	RCP2.6	RCP4.5	RCP6.0	RCP8.5
Time series				
Full	**0.08**	**0.22**	**0.26**	**0.49**
Highest	**0.10**	**0.24**	**0.29**	**0.53**
Medium	**0.05**		**0.27**	
Lowest	**0.11**	**0.21**	**0.27**	**0.47**
2 standard deviations				
Highest	**7.3**	**19.6**	**13.8**	**30.7**
Medium	**4.5**		**16.2**	
Lowest	**4.2**	**14.1**	**18.4**	**25.9**
3 standard deviations				
Highest	**4.7**	**14.9**	**12.0**	**16.0**
Medium	1.1		**13.3**	
Lowest	**3.5**	**10.3**	**11.8**	**22.3**

Time series for all RCPs and for all suggested scenarios have trends that are significant at the 5% level and that increase with emissions. There appears to be little difference in magnitudes of trends between RCP4.5 and RCP6.0, whereas those for RCP2.6 and RCP8.5 are substantially lower and greater respectively

Trends for all probabilities for both 2 and 3 standard deviations for RCP4.5 and above are significant at the 5% level**,** with the single exception of the medium likelihood scenario for RCP2.6 for three standard deviations. Trends increase progressively with RCP in the pre-plateauing period, confirming that greater temperature extremes will be reached the more quickly the higher the emissions.

Interannual variability of rainfall for the suggested scenarios

The table below is similar to that for temperatures above but provides rainfall trends for time series in the orange section and for trends in probabilities of two-year rainfall totals falling below the 10th and 25th and above the 75th and 90th percentiles in the green, blue, purple and yellow sections respectively. Values according to Mann-Kendall statistics are in % per decade in all cases and trends significant at the 5% level are in **bold**. Values significant at the 10% level but not at the 5% level are indicated by *. Negative trends are indicated by underlining.

Scenario	RCP2.6	RCP4.5	RCP6.0	RCP8.5
Time series				
Full	0.3	0.0	0.0	**0.4**
Highest	0.5	0.3	0.1	**0.4**
Medium	0.2		0.4	
Lowest	0.1	**1.0**	**1.6**	**1.7**
<10th percentile				
Highest	0.1*	0.0	0.0	0.0
Medium	0.1		0.0	
Lowest	0.2*	0.0	0.1	1.0
<25th percentile				
Highest	0.6	0.1	0.1	0.3
Medium	0.5		0.0	
Lowest	**0.4**	**2.1**	**5.5**	**3.1**
>75th percentile				
Highest	0.1	0.1	0.2	0.4
Medium	**0.7**		1.2	
Lowest	0.1	0.0	0.0	0.3
>90th percentile				
Highest	0.0	0.0	0.2	0.1
Medium	0.1		**0.7**	
Lowest	0.0	0.0	0.0	0.0

In the majority of cases the time series trends are negative, although several are close to zero, and there may be a possible increase in the negative trends with successive RCP, but certainly with RCP8.5. Nevertheless, few time series for either the full ensemble or the suggested scenarios are significant at the 5% level except for the lowest likelihood scenarios for RCP4.5 and above and for all time series for RCP8.5.

Some of the trends in probabilities of two successive years with rainfall totals below the 10th and the 25th percentiles are positive, but mainly weakly so, indicating increasing frequencies of dry events, although few are statistically significant at the 5% level except for all of the lowest likelihood scenarios for the 25th percentile. It seems reasonable to suggest that these significant positive trends may increase with RCP.

Trends for adjustments in rainfall events above the 75th and 90th percentiles are of variable sign, and most of those for the 90th percentile are close to zero. Few reach statistical significance. Perhaps there is an overall positive signal for the 75th percentile indicating an increase (weak) in frequencies of these wetter events.

Interannual variability of rainfall less evaporation for the suggested scenarios

The table following is similar to the one preceding for rainfall alone except it is for rainfall less evaporation.

Scenario	RCP2.6	RCP4.5	RCP6.0	RCP8.5
Time series				
Full	0.4	1.3*	0.7	**1.5**
Highest	1.2	0.9	0.7	**2.4**
Medium	0.0			
Lowest	2.1	4.4*	**2.6**	0.1
<10th percentile				
Highest	0.1	**0.2**	0.0	0.3
Medium	0.2*			
Lowest	0.0	0.0	**1.2**	0.0
<25th percentile				
Highest	**1.2**	**1.5**	0.5*	1.0
Medium	**0.4**			
Lowest	0.7	0.0	**8.0**	0.0
>75th percentile				
Highest	0.4	0.1	0.2	0.2
Medium	0.5			
Lowest	0.3	1.1*	0.0	0.6
>90th percentile				
Highest	0.0	0.0	0.2	0.0
Medium	0.0			
Lowest	0.2	**0.6**	0.0	0.0

Almost all time series trends are negative but reach significance at the 5% level only for some of the series for the two higher RCPs. For the full time series, the trend may strengthen with RCP. Decreases in water availability seem reasonably certain according to this measure.

The probability curves for rainfall less evaporation are noisy (see the diagrams later in the report), with the result that many of the trends listed in the table above are close to zero, with few significant at either the 5% or the 10% levels. If there is a signal then it is that in general most trends are positive. In other words the tentative conclusion is that drier events may increase in frequency, in terms of water resources as represented by rainfall less evaporation, while at the same time wetter events may similarly increase, suggesting overall a broadening of the annual rainfall less evaporation distribution.

Return Periods

Return periods for warmer years and for wetter and drier years have been estimated through fitting the Gumbel Distribution, first to values across the base period of 1979 to 2005, and then reassessing across the projections for each RCP over the years 2005 to 2100. The green section of the table below provides average annual temperatures expected to be exceeded once every 100, 50 or 25 years. Similarly the blue section indicates total annual rainfall amounts expected to be exceeded as a percentage of the average across the base period of 1979 to 2005. Finally the orange section provides details for dry periods, with total annual rainfall amounts not to be reached once in each period. Note that the approach used is consistent with numerous similar approaches elsewhere but nevertheless is subject to uncertainties within the estimates.

Data set	100 year	50 year	25 year
Annual Temperature ºC			
Base	18.7	18.4	18.1
RCP2.6	20.5	20.2	19.8
RCP4.5	21.6	21.1	20.6
RCP6.0	22.2	21.7	21.1
RCP8.5	24.5	23.6	22.7
High Rainfall (% of base average)			
Base	161	151	142
RCP2.6	173	162	151
RCP4.5	163	153	143
RCP6.0	174	163	153
RCP8.5	163	153	143
Low Rainfall (% of base average)			
Base	39	50	62
RCP2.6	38	51	63

RCP4.5	28	41	54
RCP6.0	35	48	61
RCP8.5	29	42	54

Temperatures.

Historically the annual average temperature is above 18ºC for all return periods, but increases to above 20ºC for all RCPs (except RCP2.6 25-year). Naturally values increase with RCP, the highest being the 100-year return period value of 24.5ºC under RCP8.5, an increase of 5.8ºC above the equivalent for the historical base period. The minimum increase of the 100-year value, RCP2.6, represents a 1.8ºC rise, a 4ºC difference with that for RCP8.5.

High Rainfall.

Overall there appears to be limited change to the return periods for high rainfall that might be expected in the future as compared to the base period, largely independent of RCP. For the 100-year values, those for RCP4.5 and RCP8.5 are similar to the 161% of the recent average over the base period, although the lesser populated RCP2.6 and RCP6.0 do suggest increases of a little over 10%. The pattern is similar for the 50-year and 25-year values.

Low Rainfall.

There is a distinct decrease in the 100-year low rainfall expected value for RCP4.5 and RCP8.5 a compared to the base period (28% and 29% against 39% respectively), whereas little change is suggested for RCP2.6 and RCP6.0. And similarly, for the 50-year and 25-year values.

Conclusions. The Upper Komati sits at a location perhaps just a little north of the area over the upper Vaal catchment, Lesotho and northern KwaZulu where the IPCC AR5 broadly indicates future increase in rainfall according to the CMIP5 ensemble means, and south of an extensive region, including eastern Mpumalanga, similarly with rainfall decreases. By comparison with earlier results from Domains north and south of the Upper Komati the current results are intermediate, those for rainfall reflecting more those from the Vaal Domain to the south and those for rainfall less evaporation reflecting those more from the Mpumalanga Domain to the north, thus confirming the cusp positioning of the Upper Komati Domain with regards to the CMIP5 projections.

As found in most other areas for which the soms technique has been applied RCP8.5 stands out somewhat, both in terms of higher temperature increases as well as in adjustments to rainfall/rainfall less evaporation. Hence the recommendations below are weighted away from RCP8.5. It suggests according to the temperature against rainfall analyses that the more likely future is for limited, about 5%, change in current rainfall conditions, with an alternate of decreases of perhaps 5%, with likelihoods slightly weighted towards the former. For the recommended scenarios based on the temperature against rainfall analyses the higher likelihood is towards decreases of around 15% contrasted with increases up to about 20%.

If there is a requirement to examine projected changes under RCP8.5 then use the recommended and extreme scenarios repeated from the appropriate collated tables below.

The IAV calculations have been split into three sections, one with time series. A second with changes in probabilities of two- and three-year spells of high temperatures and extended wetter and drier periods, and a third with return periods for high temperature and rainfall as well as low rainfall events. The results for temperatures are all clear, with increasing future temperature and more extended hot periods, under all RCPs.

Temperatures increase also for specific return periods. Not unexpectedly changes are greatest under RCP8.5 and least were the Paris Agreement achieved as represented by RCP2.6.

Time series for both rainfall and rainfall less evaporation have downward trends in general, tending to increase with RCP. In the analysis for the periods of extended wetter and drier spells perhaps the strongest signal is for an increase in future extended drier spells, but there is also a possibility of compensation (if that is the correct term) in the form of extended wetter spells. Return periods have been calculated only for rainfall, with mixed results. Annual rainfall during heavier events increases by some 10% of the recent average for RCP2.6 and RCP6.0, with little change otherwise, but during the drier events declines by some 10% for RCP4.5 and RCP8.5, with little change otherwise.

1. Results from the Self-Organising Maps

Recommended Scenarios for the Upper Komati Domain based on RCP2.6, RCP4.5 and RCP6.0

Recommended scenarios based on temperature against rainfall analyses

%	2040	2065	2080
55	1.00ºC/1.05	1.75ºC/1.05	2.25ºC/1.05
45	1.25ºC/0.95	1.75ºC/0.95	2.00ºC/0.95

Extreme scenarios based on temperature against rainfall analyses (focussed primarily on rainfall changes)

	2040	2065	2080
Increased	1.00ºC/1.10	2.00ºC/1.10	2.25ºC/1.10
Decreased	1.25ºC/0.85	2.00ºC/0.80	2.25ºC/0.80

Recommended scenarios based on temperature against rainfall less evaporation analyses

%	2040	2065	2080
60	1.25ºC/0.90	1.50ºC/0.85	2.00ºC/0.85
40	1.25ºC/1.25	1.75ºC/1.20	2.00ºC/1.20

Extreme scenarios based on temperature against rainfall less evaporation analyses (focussed primarily on rainfall less evaporation changes)

	2040	2065	2080
Increased	1.00ºC/1.50	1.75ºC/1.40	2.50ºC/1.50
Decreased	1.00ºC/0.60	1.75ºC/0.50	2.50ºC/0.60

Recommended Scenarios for the Upper Komati Domain based on RCP8.5

Recommended scenarios based on temperature against rainfall analyses

%	2040	2065	2080
55	1.50ºC/1.05	2.75ºC/1.05	4.25ºC/1.00
45	1.00ºC/0.95	2.50ºC/0.95	4.25ºC/0.85

Extreme scenarios based on temperature against rainfall analyses (focussed primarily on rainfall changes)

	2040	2065	2080
Increased	1.25ºC/1.10	3.00ºC/1.10	3.50ºC/1.15
Decreased	1.25ºC/0.85	2.25ºC/0.85	4.00ºC/0.80

Recommended scenarios based on temperature against rainfall less evaporation analyses

%	2040	2065	2080
60	1.50ºC/0.80	2.75ºC/0.80	4.25ºC/0.80
40	1.50ºC/1.20	2.75ºC/1.25	4.00ºC/1.45

Extreme scenarios based on temperature against rainfall less evaporation analyses (focussed primarily on rainfall less evaporation changes)

	2040	2065	2080
Increased	1.50ºC/1.40	2.50ºC/1.50	3.25ºC/1.70
Decreased	1.25ºC/0.50	2.50ºC/0.50	4.00ºC/0.50

Scenarios from each RCP for the Upper Komati Domain based on analyses of temperature against rainfall to the left and on analyses of temperature against rainfall less evaporation to the right. In the summaries following each table TR refers to the temperature/rainfall table to the left and TRLE to the temperature/rainfall less evaporation table to the right. Following the RCP header are the numbers of projections available to produce TR and TRLE respectively. Note that the soms numbers in the second columns of each individual table are arbitrary and should not be used to inter-compare TR and TRLE.

RCP2.6 – 20 and 18 projections

	%		2040	2065	2080	%		2040	2065	2080
1	45	1→2	1.25ºC/0.95	1.50ºC/0.95	1.50ºC/0.95	45	1	1.25ºC/0.85	1.25ºC/0.85	1.25ºC/0.85
2	35	3	0.75ºC/1.00	1.00ºC/1.00	0.75ºC/1.00	40	3	1.00ºC/1.15	1.00ºC/1.15	0.80ºC/1.10
3	20	4	1.00ºC/1.00	1.25ºC/1.10	1.25ºC/1.10	15	2	1.75ºC/1.00	1.75ºC/0.70	1.00ºC/0.95

Summary: For both TR and TRLE the highest likelihood scenarios suggest future decreases in water availability, but overall in TR the combined higher likelihood is towards no change or an increase and in TRLE to a decrease. Note that som4 in TRLE contained only a single point and has been ignored.

Suggested extreme scenarios for RCP2.6 determined primarily in terms of changes in water availability – changes in water availability indicated appropriately by "increased" and "decreased" – no indication of relative likelihoods may be given – TR to left, TRLE to right

	2040	2065	2080	2040	2065	2080
Increased	1.50ºC/1.05	1.50ºC/1.05	1.00ºC/1.05	1.50ºC/1.20	2.00ºC/1.10	2.00ºC/1.10
Decreased	1.25ºC/0.90	1.25ºC/0.90	1.75ºC/0.90	2.00ºC/0.80	2.25ºC/0.80	2.50ºC/0.70

RCP4.5 – 38 and 32 projections

	%		2040	2065	2080	%		2040	2065	2080
1	50	2→4	1.25ºC/1.05	2.00ºC/1.05	2.50ºC/1.05	80	1→3→4	1.25ºC/1.00	1.75ºC/0.85	2.25ºC/0.90
2	50	1→3	1.25ºC/0.95	1.75ºC/0.95	2.00ºC/0.95	20	2	1.25ºC/1.40	2.00ºC/1.30	2.00ºC/1.35

Summary: RCP4.5 is a relatively well-populated emissions scenario, but TR and TRLE offer different views. In TR there are roughly equal likelihoods of increases and decreases in rainfall whereas in TRLE by far the higher likelihood is for a decrease in water resources.

Suggested extreme scenarios for RCP4.5 determined primarily in terms of changes in water availability – changes in water availability indicated appropriately by "increased" and "decreased" – no indication of relative likelihoods may be given – TR to left, TRLE to right

	2040	2065	2080	2040	2065	2080
Increased	1.00ºC/1.05	2.00ºC/1.05	2.75ºC/1.05	1.00ºC/1.10	1.50ºC/1.20	2.50ºC/1.20
Decreased	1.50ºC/0.90	2.25ºC/0.90	3.00ºC/0.85	1.50ºC/0.40	2.50ºC/0.40	3.00ºC/0.50

RCP6.0 – 15 and 12 projections

	%		2040	2065	2080	%		2040	2065	2080
1	50	1→4	1.00ºC/1.05	1.75ºC/1.00	2.50ºC/1.00	80	1→3→4	1.00ºC/1.05	1.75ºC/1.20	2.00ºC/1.00
2	40	1→3	1.00ºC/1.05	1.50ºC/1.05	2.00ºC/1.10	20	2	0.75ºC/0.60	1.50ºC/0.60	2.25ºC/0.40

3	10	2		0.75ºC/0.90	1.50ºC/0.85	2.00ºC/0.80						

Summary: In both cases the predominant signal is for little change or for an increase in water resources. Again in both cases the likelihoods of any reductions are low.

Suggested extreme scenarios for RCP6.0 determined primarily in terms of changes in water availability – changes in water availability indicated appropriately by "increased" and "decreased" – no indication of relative likelihoods may be given – TR to left, TRLE to right

	2040	2065	2080		2040	2065	2080
Increased	1.00ºC/1.05	1.50ºC/1.05	2.75ºC/1.05		1.00ºC/1.20	2.00ºC/1.10	3.00ºC/1.10
Decreased	1.50ºC/0.90	2.25ºC/0.90	3.25ºC/0.90		1.00ºC/0.75	2.50ºC/0.70	3.00ºC/0.60

RCP8.5 – 39 and 32 projections

	%		2040	2065	2080	%		2040	2065	2080
1	55	1→3	1.50ºC/1.05	2.75ºC/1.05	4.25ºC/1.00	60	2→4	1.50ºC/0.80	2.75ºC/0.80	4.25ºC/0.80
2	45	2→4	1.00ºC/0.95	2.50ºC/0.95	4.25ºC/0.85	40	1→3	1.50ºC/1.20	2.75ºC/1.25	4.00ºC/1.45

Summary: In TR the higher likelihoods are towards increases in water resources, in TRLE they are towards decreases, but in both cases the differences in likelihoods between the two scenarios suggested is limited.

Suggested extreme scenarios for RCP8.5 determined primarily in terms of changes in water availability – changes in water availability indicated appropriately by "increased" and "decreased" – no indication of relative likelihoods may be given – TR to left, TRLE to right

	2040	2065	2080	2040	2065	2080
Increased	1.50ºC/1.05	3.00ºC/1.05	4.50ºC/1.05	1.50ºC/1.40	3.00ºC/1.20	3.75ºC/1.10
Decreased	2.00ºC/0.90	3.00ºC/0.85	5.00ºC/0.80	1.75ºC/0.70	3.25ºC/0.50	5.00ºC/0.40

RCP2.6; temperature vs rainfall

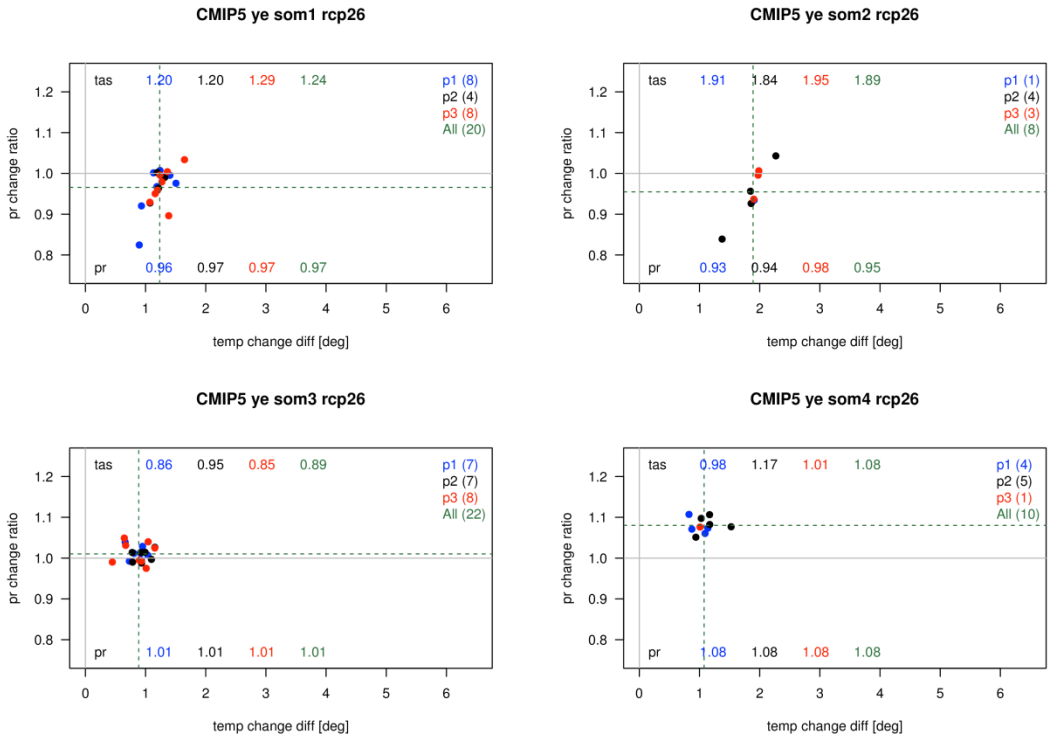

Figure UKD1. Self-organising maps charts for rainfall (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP2.6; charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall vs temperature projection relative to the base period of 1986-2005 from that single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 20 projections available in CMIP5 for RCP2.6.

Table UKD1a. Scenarios for the year over the Upper Komati Domain under RCP2.6 based on Figure UKD1 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
45	1→2	1.25ºC/0.95	1.50ºC/0.95	1.50ºC/0.95
35	3	0.75ºC/1.00	1.00ºC/1.00	0.75ºC/1.00
20	4	1.00ºC/1.00	1.25ºC/1.10	1.25ºC/1.10

Summary: Two of the soms, 3 and 4, form individual scenarios, with 1 and 2 combining. The highest likelihood overall is towards little change in rainfall, or perhaps a 10% increase, although the individual highest likelihood scenario suggests a decrease of around 5%.

RCP2.6; temperature vs rainfall less evaporation

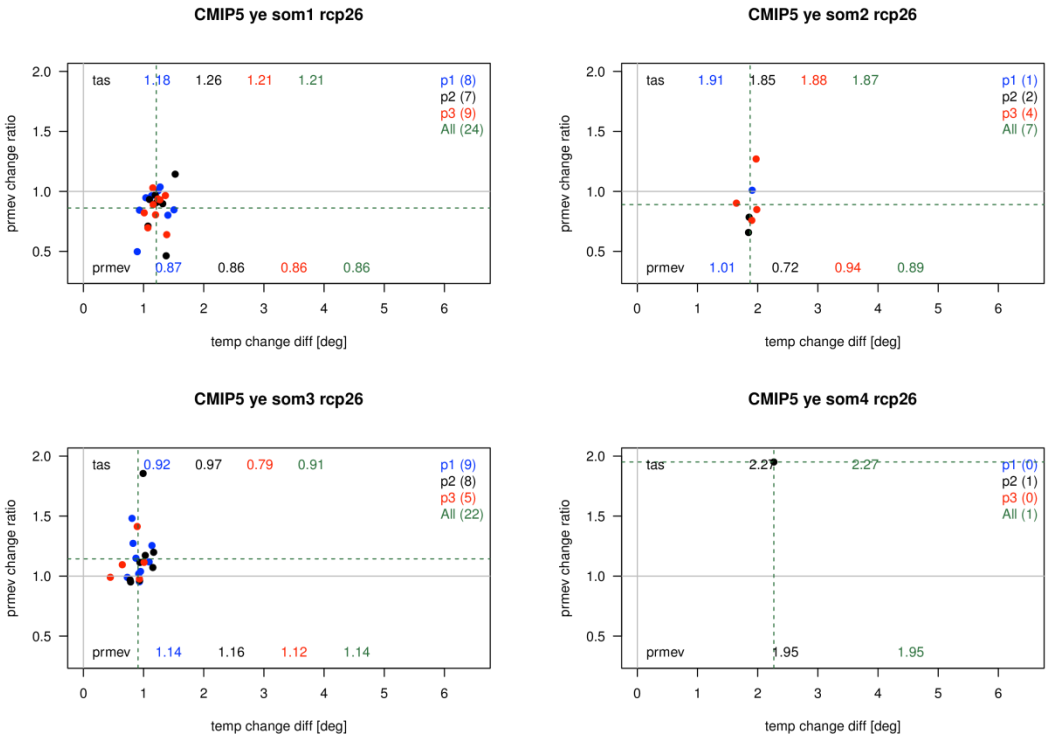

Figure UKD2. Self-organising maps charts for rainfall less evaporation (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP2.6; charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall less evaporation (prmev)/temperature projection relative to the base period of 1986-2005 from that single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall less evaporation (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 18 projections available in CMIP5 for RCP2.6.

Table UKD2a. Scenarios for the year over the Upper Komati Domain under RCP2.6 based on Figure UKD2 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall less evaporation changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall less evaporation changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
45	1	1.25ºC/0.85	1.25ºC/0.85	1.25ºC/0.85
40	3	1.00ºC/1.15	1.00ºC/1.15	0.80ºC/1.10
15	2	1.75ºC/1.00	1.75ºC/0.70	1.00ºC/0.95

Summary: Results suggesting issues with this analysis, with som4 containing a single point. Two p2 points, one in som3 and that in som4, also appear well outside the normal range in terms of rainfall less evaporation. Both points, and the entire som4, have been ignored in determining the recommended scenarios. The lowest likelihood recommended scenario, from som2, also appears to require caution in its use. Thus the main signals, of roughly equal likelihoods, and for decreases and increases of the order of ±15% in terms of water availability.

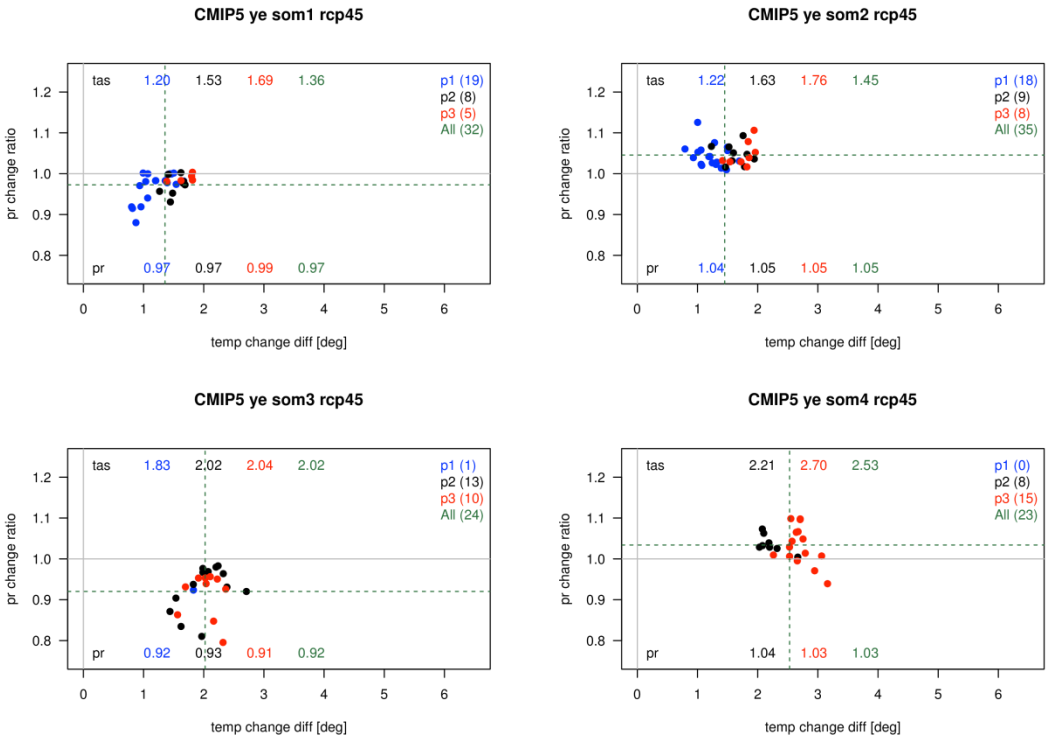

Figure UKD3. Self-organising maps charts for rainfall (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP4.5 charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall vs temperature projection relative to the base period of 1986-2005 from that single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 38 projections available in CMIP5 for RCP4.5.

Table UKD3a. Scenarios for the year over the Upper Komati Domain under RCP4.5 based on Figure UKD3 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
50	2→4	1.25ºC/1.05	2.00ºC/1.05	2.50ºC/1.05
50	1→3	1.25ºC/0.95	1.75ºC/0.95	2.00ºC/0.95

Summary: Two recommended scenarios of closely similar likelihoods, unusually with the warmer scenario associated with increases in water availability.

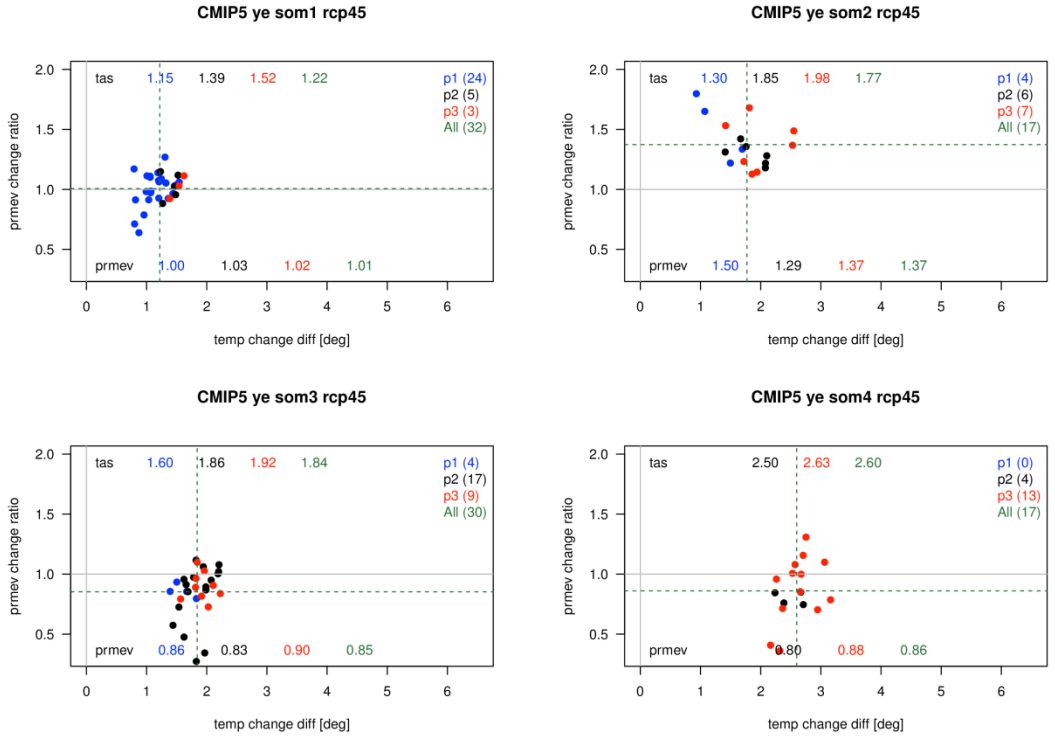

Figure UKD4. Self-organising maps charts for rainfall less evaporation (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP4.5; charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall less evaporation (prmev)/temperature projection relative to the base period of 1986-2005 from a single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall less evaporation (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 32 projections available in CMIP5 for RCP4.5.

Table UKD4a. Scenarios for the year over the Upper Komati Domain under RCP4.5 based on Figure UKD4 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall less evaporation changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall less evaporation changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
80	1→3→4	1.25ºC/1.00	1.75ºC/0.85	2.25ºC/0.90
20	2	1.25ºC/1.40	2.00ºC/1.30	2.00ºC/1.35

Summary: The majority signal is decidedly towards future decreases in water availability, although there is some diversity amongst soms 1, 3 and 4 as to the magnitude of the temperature increase. The lesser likelihood alternative is for an increase.

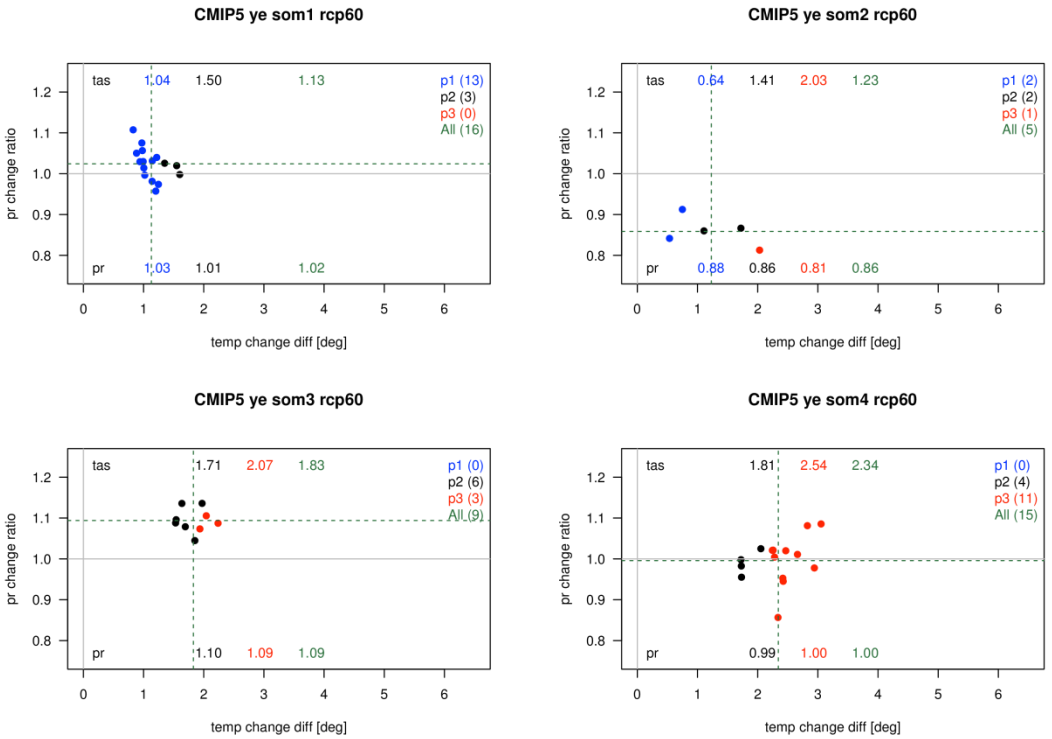

Figure UKD5. Self-organising maps charts for rainfall (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP6.0 charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall vs temperature projection relative to the base period of 1986-2005 from that single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 15 projections available in CMIP5 for RCP6.0.

Table UKD5a. Scenarios for the year over the Upper Komati Domain under RCP6.0 based on Figure UKD5 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
50	1→4	1.00ºC/1.05	1.75ºC/1.00	2.50ºC/1.00
40	1→3	1.00ºC/1.05	1.50ºC/1.05	2.00ºC/1.10
10	2	0.75ºC/0.90	1.50ºC/0.85	2.00ºC/0.80

Summary: The majority of p1 points lie in som1 (the other 2 are in som2 which treated as a separate scenario), and hence two recommended scenarios originate there. The weight is clearly towards little change or an increase in rainfall in this low-populated som, the alternative of a decrease receiving only about 10% likelihood.

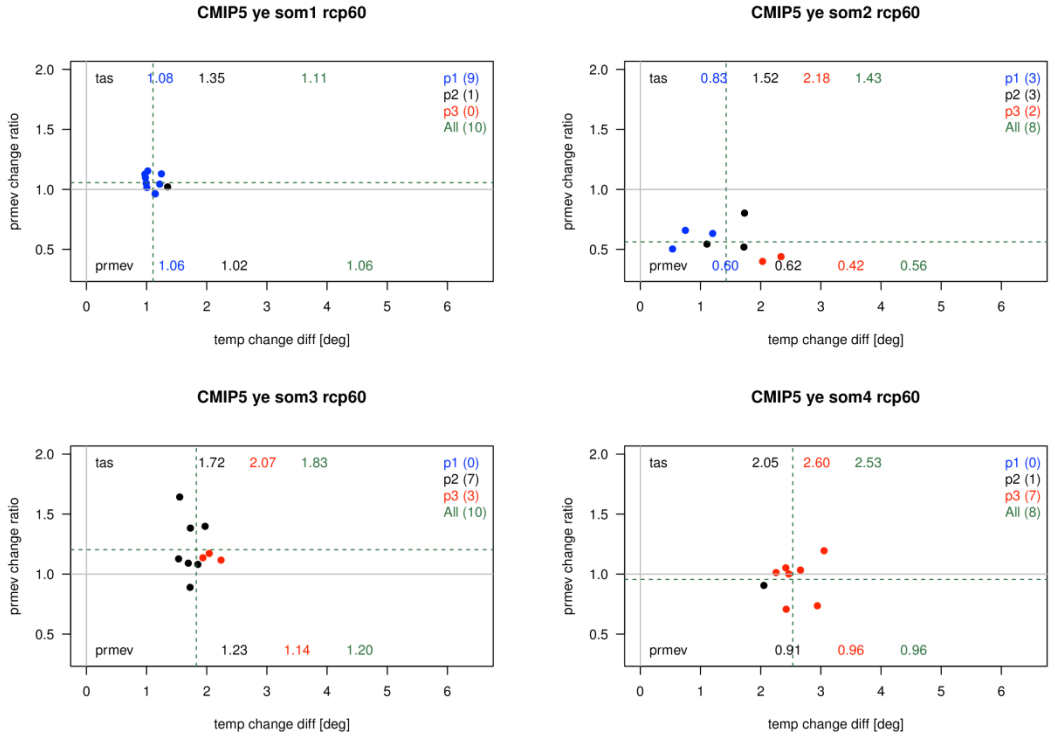

Figure UKD6. Self-organising maps charts for rainfall less evaporation (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP6.0; charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall less evaporation (prmev)/temperature projection relative to the base period of 1986-2005 from a single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall less evaporation (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 12 projections in CMIP5 for RCP6.0.

Table UKD6a. Scenarios for the year over the Upper Komati Domain under RCP6.0 based on Figure UKD6 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall less evaporation changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall less evaporation changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
80	1→3→4	1.00ºC/1.05	1.75ºC/1.20	2.05ºC/1.00
20	2	0.75ºC/0.60	1.50ºC/0.60	2.25ºC/0.40

Summary: With almost all p1 points in som1 the main scenario begins there; perhaps because of the limited numbers of projections available this scenario includes unusually large vacillations in the change in water resources, all positive. The low-likelihood alternative is a reduction in resources.

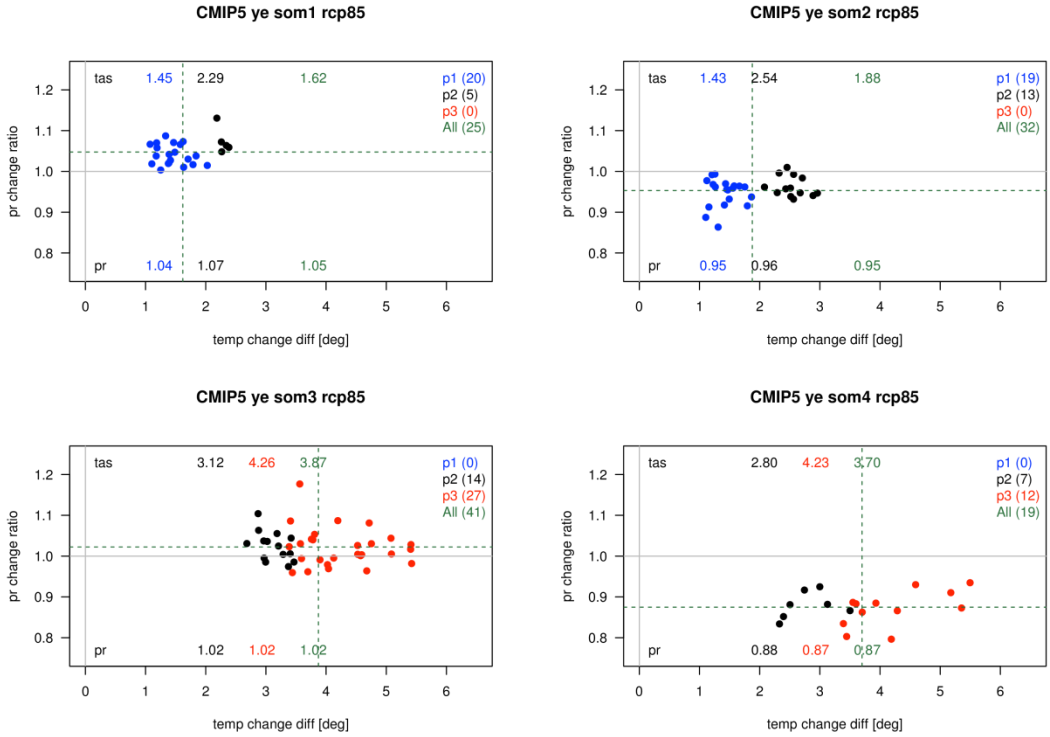

Figure UKD7. Self-organising maps charts for rainfall (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP8.5 charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall vs temperature projection relative to the base period of 1986-2005 from that single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 39 projections available in CMIP5 for RCP8.5.

Table UKD7a. Scenarios for the year over the Upper Komati Domain under RCP8.5 based on Figure UKD7 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
55	1→3	1.50ºC/1.05	2.75ºC/1.05	4.25ºC/1.00
45	2→4	1.00ºC/0.95	2.50ºC/0.95	4.25ºC/0.85

Summary: Two similar recommended scenarios with similar likelihoods suggesting changes in rainfall of about ±5%.

RCP8.5; temperature vs rainfall less evaporation

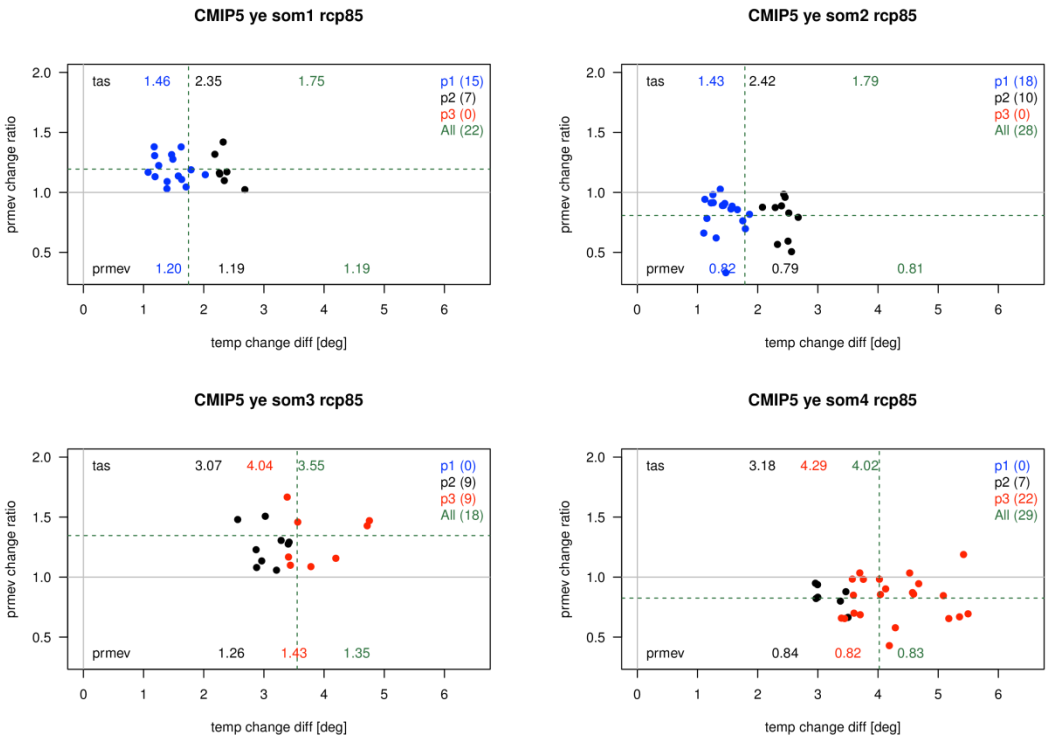

Figure UKD8. Self-organising maps charts for rainfall less evaporation (along vertical axis) against temperature (along horizontal axis) for the year over the Upper Komati Domain under RCP8.5; charts are numbered entirely arbitrarily 1 (top left), 2 (top right), 3 (bottom left) and 4 (bottom right). Each point represents a rainfall less evaporation (prmev)/temperature projection relative to the base period of 1986-2005 from a single model, with projections for 2025 to 2049 in blue (p1), 2050 to 2074 in black (p2), and 2075 to 2099 in red (p3). Numbers of projections in each time slot are listed colour-coded in the top right-hand of each chart, with overall totals given in green (it is assumed, tentatively, that these values provide an indication of likelihood). Solid grey lines indicate zero change; dotted green lines indicate average changes across all time slots for all projections within a single som chart. Average values of changes are listed colour-coded at the top for temperature (ºC) and at the bottom for rainfall less evaporation (as a ratio - %); these are omitted in cases of charts with no projections within a particular time slot. There are 32 projections in CMIP5 for RCP8.5.

Table UKD8a. Scenarios for the year over the Upper Komati Domain under RCP8.5 based on Figure UKD8 above. The first column provides a *suggestion* of relative likelihood of each scenario presented along the rows based on the tentative assumption that likelihood is indicated by the number of projections within each scenario. The second column indicates the chart numbers (see Figure caption) for each scenario. Remaining columns give temperature/rainfall less evaporation changes for each scenario and time slot; temperature changes (all positive) are estimated to 0.25ºC, and rainfall less evaporation changes to 5% - values above 1.00 represent increases, below 1.00 decreases.

%		2040	2065	2080
60	2→4	1.50ºC/0.80	2.75ºC/0.80	4.25ºC/0.80
40	1→3	1.50ºC/1.20	2.75ºC/1.25	4.00ºC/1.45

Summary: Water resources changes by ±20%, with higher likelihoods towards the decreases.

2. Results for timelines and inter-annual variability based on the scenarios from the self-organising maps for the individual RCPs