Climate change projections for Eyre Peninsula

Peter Hayman and Bronya Cooper, SARDI Climate Applications.

There are two sources of climate change projections for Eyre Peninsula. The Climate Change in Australia report from CSIRO and BoM and Climate Ready data from the Goyder Institute. Climate Change in Australia is the national provider of climate information and the Goyder Institute data is housed by the state government. CSIRO scientists are the source of both sets of data. There is a high degree of intermodal consistency on temperature but a much wider spread for rainfall. The most worrying projections for rainfall are drying in winter and spring, with the most severe drying in spring. The Climate Change in Australia report provides a range for spring rainfall by 2070 with a high emissions scenario (7 models wetter, 7 about the same +-5%, 10 drying between 5% & 10% and 24 drying more than 15%). Using the same emission scenario, the Climate Ready data has a range from -7% to -60% with the average decline at -33%. As discussed, there are a number of reasons for this difference including the exact region the projections apply to, the choice of models and the downscaling used in the Climate Ready data set.

Definitions: A *prediction* is a probabilistic statement that something will happen in the future based on what is known today. For example, with the oceans in the current pattern, 7 years out of 10 have been above average rainfall and three years have been drier than average.
A *projection is a probabilistic statement that it is possible that something will happen in the future if certain conditions develop*. For example, if greenhouse gasses continue rise to 500ppm CO_2 equivalents, the temperature on EP will rise between X and Y degrees. The set of boundary conditions that is used in conjunction with making a projection is often called a scenario, and each scenario is based on assumptions about how the future will develop. [WeatherZine #26 Guest Editorial (colorado.edu)]

Climate Change in Australia

The Climate change in Australia website is developed by CSIRO and BoM and aims to be the most comprehensive set of climate change projections for Australia. It is based on the CMIP5 (Coupled Model Intercomparison Project). CMIP 5 included 48 models from around the world. CMIP 1 was released in 1995 and CMIP 6 is currently informing the 6th assessment of the Intergovernmental Panel on Climate Change IPCC. CSIRO atmospheric researchers had been involved in all phases of model comparisons and presenting climate change projections for applications such as agriculture since the late 1980s. They acknowledged the frustration in the applications community whereby impacts and adaptation options for one set of projections are developed and communicated just as the next set of projections are announced by climate science. As a solution they proposed "climate futures" which were different levels of warming and changes to rainfall. The spread of models and how this changed through time provided "worst case" and "best case" bookends for planning.

Eyre Peninsula forms a significant area of the region (Figure 1) known as the Southern and SW Flatlands (East) – "SSWFE". Projections from this website are based on downscaled area averages for SSWFE. https://www.climatechangeinaustralia.gov.au/

A common response is that these regions are too broad, however there is debate within the climate science community about the benefits of highly localised information. There is a general expectation of warming across all oceans and land masses with land warming faster than oceans and inland warming faster than the coast. There is a general consensus for drying across the southern half of the continent in the winter and spring period.

Further information on how the plots are produced can be found in section 6.2.2 of the technical report.

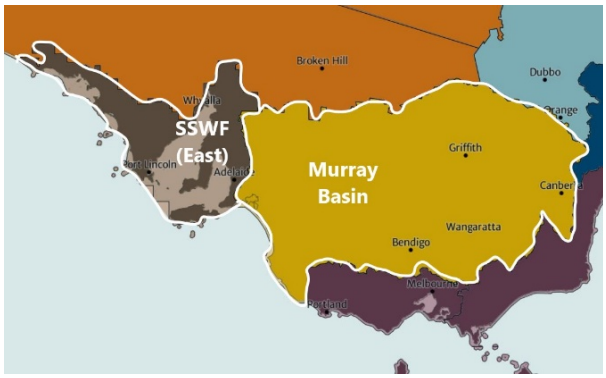


Figure 1: Area forming the Southern and South West Flatlands (East) sub-cluster used for projections in the Climate Change in Australia project https://www.climatechangeinaustralia.gov.au/.

https://www.climatechangeinaustralia.gov.au/en/communication-resources/reports/ and timeseries https://www.climatechangeinaustralia.gov.au/en/projections-tools/time-series-explorer/

Figure 2a shows the range in annual temperature projections from all 48 models summarized in grey for the 10th, 50th and 90th percentiles, using RCP8.5 for SSWFE. Superimposed in blue is the historic AWAP data. Figure 2b shows the projected percent change in annual rainfall. Figure 2a shows that not only is the projection for temperature clear, a cool year after 2000 would have been a warm year in the 1960s. Although there is a general drying in the projections, the trends and projections are less clear, especially in the planning horizon of the coming decades. Figure 3 shows the seasonal rainfall projections.

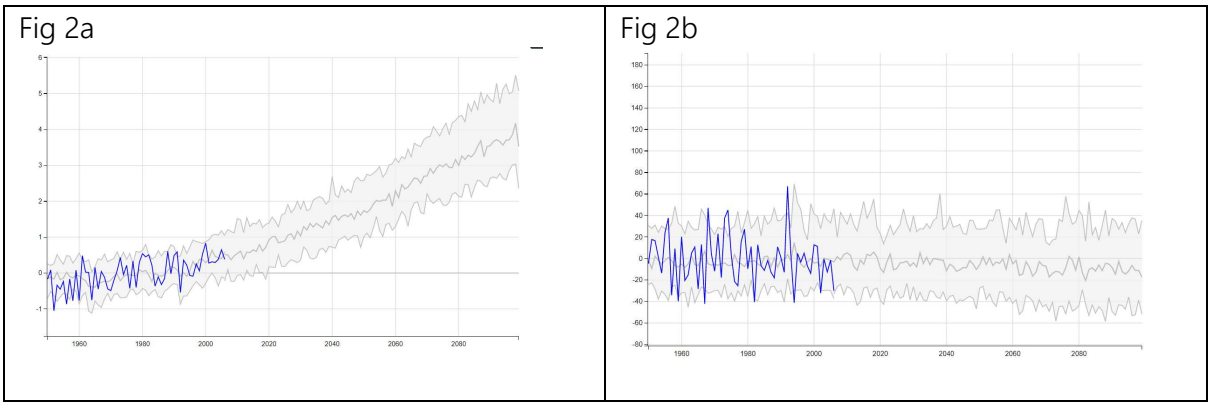


Figure 2: The range in annual temperature (Fig 2a) and rainfall (Fig 2b) projections from 48 models summarized in grey for the 10th, 50th and 90th percentiles, using RCP8.5 for SSWFE. Superimposed in blue is the historic AWAP data. The y-axis is the change from 1950-2005 mean in degrees Celsius (Fig 2a) or % change in rainfall (Fig 2b). From https://www.climatechangeinaustralia.gov.au/en/projections-tools/time-series-explorer/

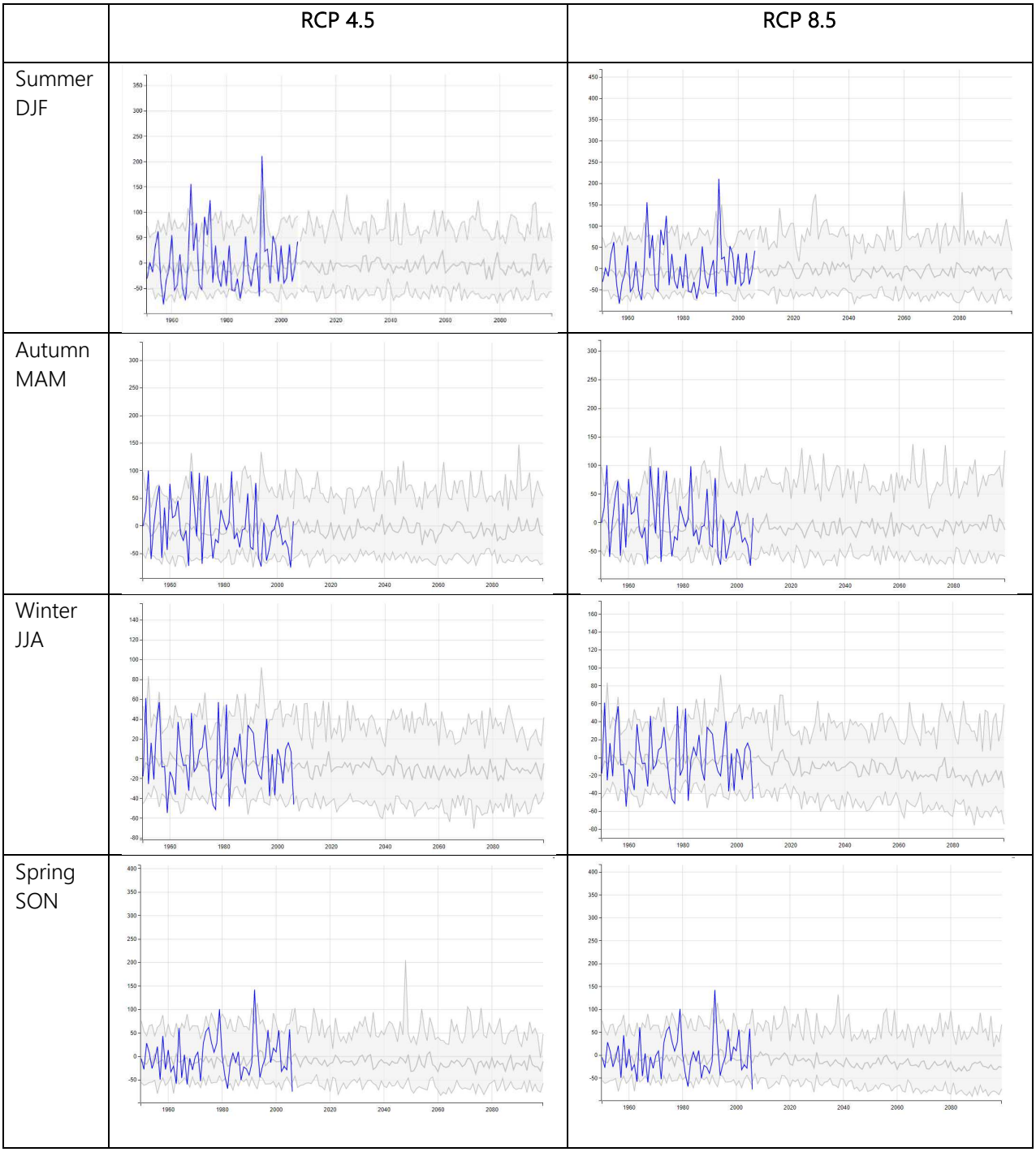


Figure 3: The range in seasonal rainfall (% change) projections from all available CMIP5 simulations summarized in grey for the 10th, 50th and 90th percentiles, using RCP4.5 and RCP8.5 for SSWFE. Superimposed in blue is the historic AWAP data. The y-axis is the rainfall anomalies in % of 1950-2005. From https://www.climatechangeinaustralia.gov.au/en/projections-tools/time-series-explorer/.

Climate Futures matrices are available for temperature and rainfall changes for SSWFE, and the number (and %) of the 48 GCMs that fall into each category indicating model consensus in the projections. Figure 5 shows the matrices using RCP 8.5 for four outlook periods: 2030, 2050, 2070 and 2090. Figure 6 shows the seasonal (summer, autumn, winter and spring) projections for 2070, and Figure 7 shows seasonal projections for 2070. The key for Figures 5-7 is found in Figure 4.

Annual temperature projections for SSWFE (Figure 5) show a progression in model consensus from being in the "warmer" (0.5 to 1.5degreesC) category for 2030, through to the "hotter" (1.5 to 3C) category for 2070, and 52% of the 48 models falling in the "much hotter" (>3C) category by 2090. Annual rainfall projections more consistently fall in the "Little change" (-5 to +5%) category for 2030. 2050 projections are roughly split between the "little change" and "Drier" (-15 to -5%) categories. By 2090, 29% of models are in the "little change" or "wetter" categories, 30% fall into the "Drier" category, and 41% fall into the "Much drier" (<-15%) category. While "Much drier" is the most likely single category, there are still 59% of models NOT in this category, so the model consensus is much weaker for rainfall than temperature.

Consensus	Proportion of models
Not projected	No models
Very Low	< 10%
Low	10% - 33%
Moderate	33% - 66%
High	66% - 90%
Very High	> 90%

Figure 4: Key for Figures 5-7.

The projected warming over time is clear (the consensus moves to the right from mild to severe warming). There is a wider spread for rainfall but severe drying (<15%) is projected by only 4 models in 2030 but 20 of the 48 models by 2090. The projected warming is broadly similar for each season of the year (Figure 6) but there is stronger model consensus for a severe rainfall decline in winter and spring.

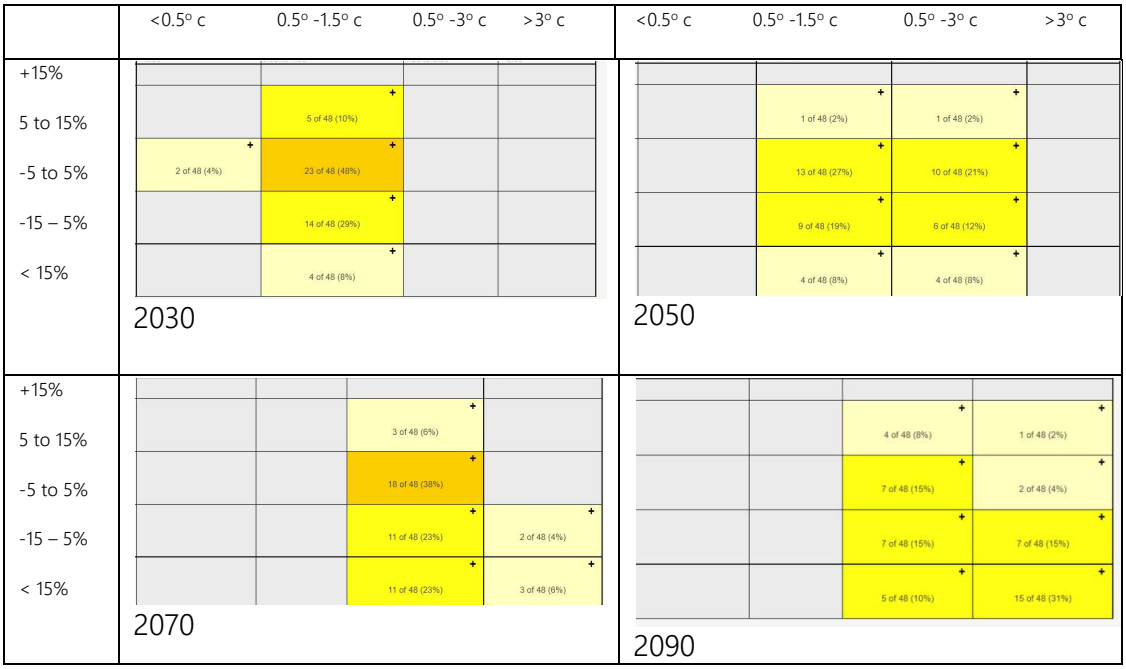


Figure 5: Annual temperature and rainfall projections for SSWFE region using RCP8.5, for 2030 (top left), 2050 (top right), 2070 and 2090.

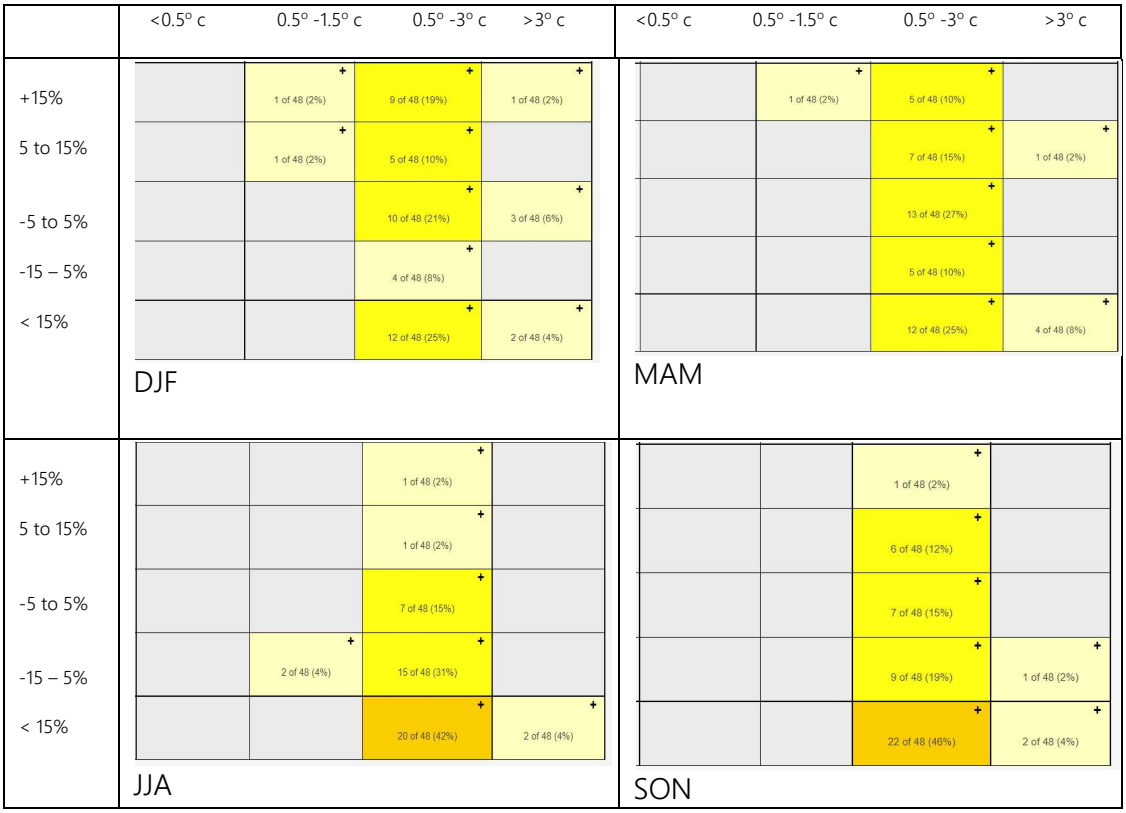


Figure 6: Seasonal temperature and rainfall projections for SSWFE region for 2070 using RCP8.5, for summer (DJF) (top left), autumn (MAM) (top right), winter (JJA) and spring (SON).

Pie charts have been effective in communicating shifts in probability for seasonal forecasts. In a presentation at GRDC updates we used a pie chart to communicate the confidence/uncertainty in model spread. If there was no change in outlook for rainfall it might be reasonable to expect 70% chance of no change, 10% chance of a mild swing to wetter or drier and 5% chance of severe swing to wetter or drier (Figure 7). Figures 8 and 9 represent the proportion of the 48 models that fall in each of the categories of either rainfall or temperature, and enable quick comparisons between 2030 and 2070 changes annually and seasonally. For rainfall (Figure 8), annually there is a shift toward drier conditions in 2070. However, for summer and autumn there are still many models falling into the wetter and much wetter categories for both 2030 and 2070, but the driest category has increased in size as well. So we can't conclude much on rainfall changes for summer and autumn based on this data. Winter already shows model consensus for drier conditions for 2030, with a shift to even more models in the much drier category for 2070. Spring is similar, with many models projecting drier conditions in 2030 and even more models projecting much drier by 2070. For temperature (Figure 9) the messages are much clearer and consistent across all seasons. While model consensus is for a 0.5 to 1.5dC increase by 2030, by 2070 the majority of models suggest hotter conditions of 1.5 to 3dC increase for SSWF (East).

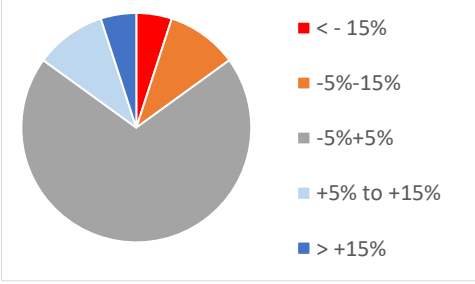


Figure 7: Example of the make-up of a change in rainfall across multiple models, showing 70% chance of no change, 10% chance of a mild swing to wetter or drier and 5% chance of severe swing to wetter or drier.

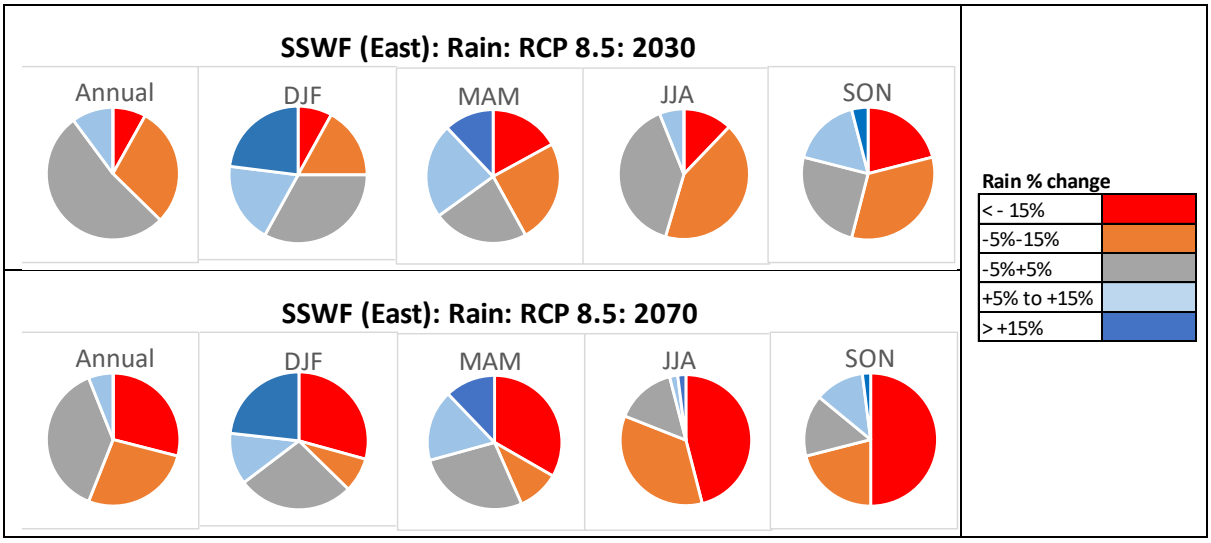


Figure 8: Proportion of the 48 CMIP5 GCMs that fall in each of the 5 categories of percent change in rainfall for the Southern and South West Flatlands East (SSWF (East)) using RCP8.5 projections for 2030 (top) and 2070.

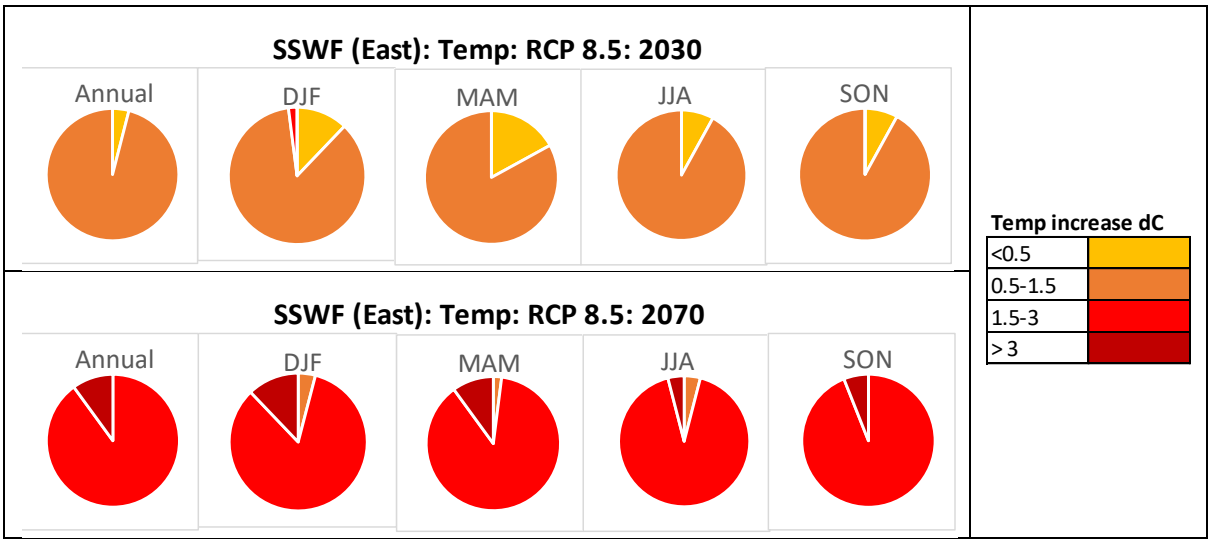


Figure 9: Proportion of the 48 CMIP5 GCMs that fall in each of the 4 categories of increase in temperature (degrees Celsius) for the Southern and South West Flatlands East (SSWF (East)) using RCP8.5 projections for 2030 (top) and 2070. Data from https://www.climatechangeinaustralia.gov.au/en/projections-tools/climate-futures-tool/projections/.

SA Climate Ready aims to provide a common basis on which Government, business and the community in South Australia can develop solutions to climate change adaptation challenges. http://www.goyderinstitute.org/research/foundation-research/climate-change/

The Climate Ready data focused on downscaled projections from 6 GCMs which were chosen to better represent the main climate drivers for South Australia. Within climate science, views differ on the benefits of subsampling from the fuller model set. The Goyder Institute data is statistically downscaled at the station level and then summarised for EP.

The key rainfall figure from the EP summary is shown in Figure 10. This shows the average annual rainfall change for 2070 at -16% using RCP 8.5. The most worrying change for 2070 is in the spring rainfall, where the average of downscaled models is -33.5%.

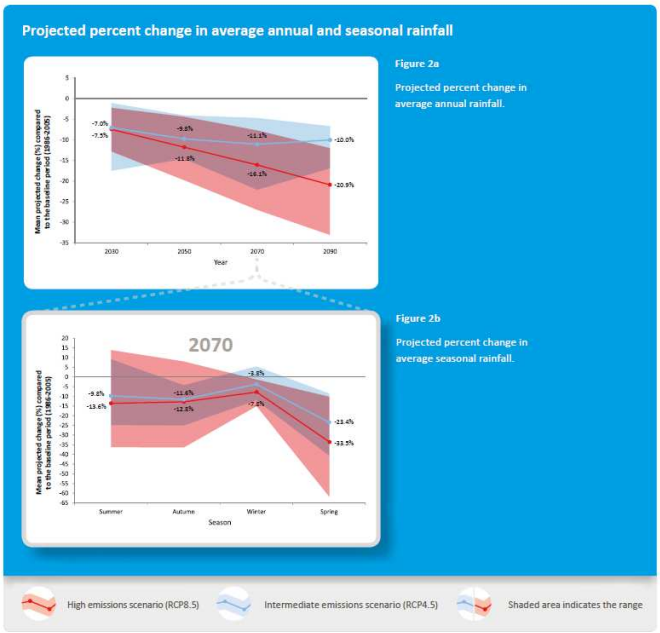


Figure 10: Rainfall projections from the EP regional summary from Goyder Institute.

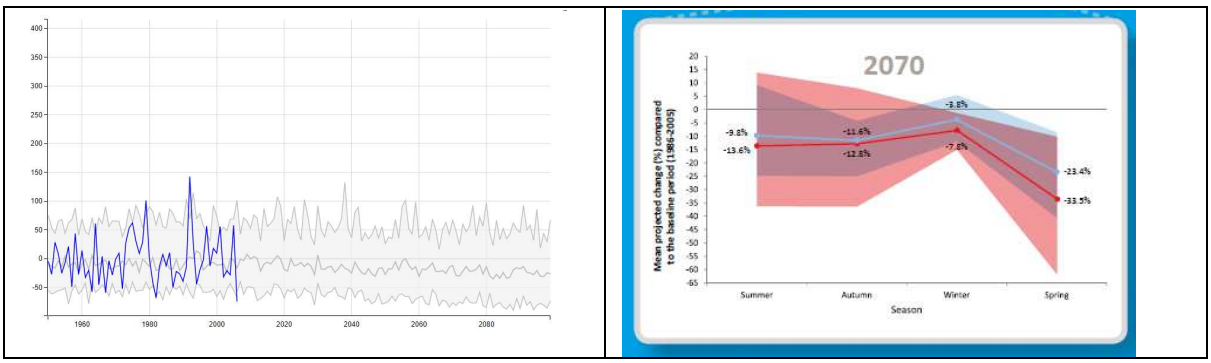
The Climate Futures Matrices use all 48 CMIP5 GCMs. The subset of 6 GCMS used by the Goyder Institute are spread across wetter to much drier categories. The average annual rainfall change using just the 6 models ranges from +9.3 to -31.4, with a mean of -6% (not as dry as the Goyder data at -16). It's also worth noting that 2 of the 6 models have averages in the wetter category, whereas in the Goyder Figure 10 the range of models for 2070 (red shading) is all for drying. The climate futures data for the 6 models for spring gives an average of -17% drying. Goyder gives spring average of -33.5% for the same 6 models.

Concluding remarks on climate change projections for EP

It is naïve to assume that a topic as controversial, multifaceted and complex as climate change won't be confusing and subjected to mixed messaging. Rather than referring to people who believe or don't believe in climate change, or climate change deniers a more useful term is those who follow the conventional and a contrarian view. Some farmers have a suspicion of what they see as city-based press articles on climate change, especially when climate change is being promoted by environmental groups and political parties that are opposed to conservative politics. The internet has numerous outlets for conspiracy of mainstream science, some of these are discussed in 13 Misconceptions About Global Warming - YouTube.

At the risk of falling for another conspiracy, historians of science Naomi Oreskes and Erik M. Conway wrote a book titled "Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming" They detail parallels between the global warming controversy and earlier controversies over tobacco smoking, acid rain, DDT, and the hole in the ozone layer. In each case they argue that there has been a vested interest in "keeping the controversy alive" by spreading doubt and confusion after a scientific consensus had been reached. For example with tobacco smoke, rather than rebut the links to cancer, the strategy was to point to the many other sources of cancer. In a similar way, rather than rebut the impact of burning fossil fuels, there can be a strategy of referring to emissions from volcanos or water as a greenhouse gas.

There is a large amount of excellent material on the science of climate change and the impacts on Eyre Peninsula. Recent presentations at the Ag Excellence Alliance forum by Mark Howden and Richard Eckard provided further guidance. Climate Change in Australia and the Climate Ready data sets also provide clear information with suitable caveats. It is not surprising that approaches to downscaling and model choice lead to different projections between these etwo sources. Given the importance of spring rainfall to Eyre Peninsula it is noteworthy that, as far as we are aware, this report is the first time that attention has been drawn to the differences in severity of projected spring drying. The figures below from Climate change in Australia (left) and Climate Ready SA (red section in the figure on the right) show different outlooks for spring.



We are not expecting many farmers to read these reports, although they are making multi-million dollar land purchases based on an optimistic future for multi-generational farms. However, there are many NRM and Regional Development professionals that are the target audience for these reports. It is possible that these differences have been noted and then dismissed along with the many caveats. It seems more likely that limited attention is paid to quantification of changes to rainfall in the distant future. It is important that farmers and advisers are given the latest information from the next round of climate models. It is however sobering that there is limited evidence that the reports are closely read.