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Will rainfall decrease in SW Western Australia recover in the future? –CSIRO Mk3.6 Large Ensemble

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Introduction and Methodology

CSIRO Mk3.6 model (Jeffrey et al., 2013 AMOJ) was used to extend CMIP5 historical and RCPs simulations to form Large Ensemble of simulations. A 30 member ensemble of historical and each of four RCPs were completed for period 1850-2115. A number of large population centres in Australia and in South Africa have experienced issues with water supply security in recent past. Focus of this poster is to explore historical and projected rainfall changes in the Southern Hemisphere mid-latitudes. Since the mid-1970s the SW Western Australia experienced a change in climate state resulting in step decline in winter rainfall and an associated decrease in streamflow (Fig 1). Key synoptic features associated with rainfall reduction were increase in frequency of dry days and reduction in heavy precipitation days. In late 1990s SE Eastern Australia experienced similar rainfall decrease. More recently Cape Town in South Africa experienced significant rainfall reduction.

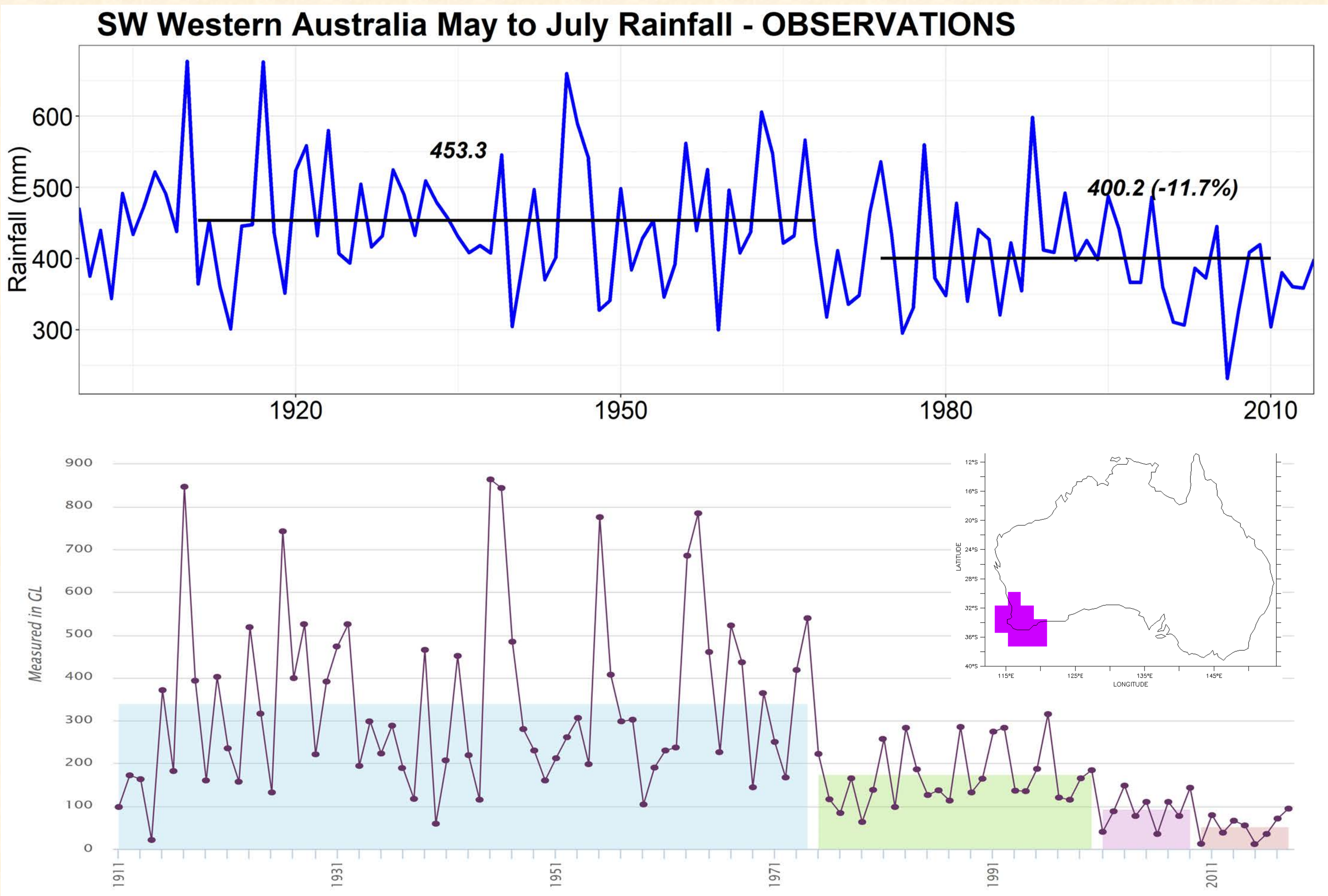

Figure 1. Historical May to July rainfall (upper panel) and streamflow (lower panel) for SW Western Australia. Insert show region of SW WA used in the analysis.

Observations and projections show reduction in rainfall in mid-latitudes of Southern Hemisphere. Model attribution show that the ozone depletion and CO_2 increase resulted in atmospheric circulation changes in the mid-latitudes of Southern Hemisphere (Fig 2).

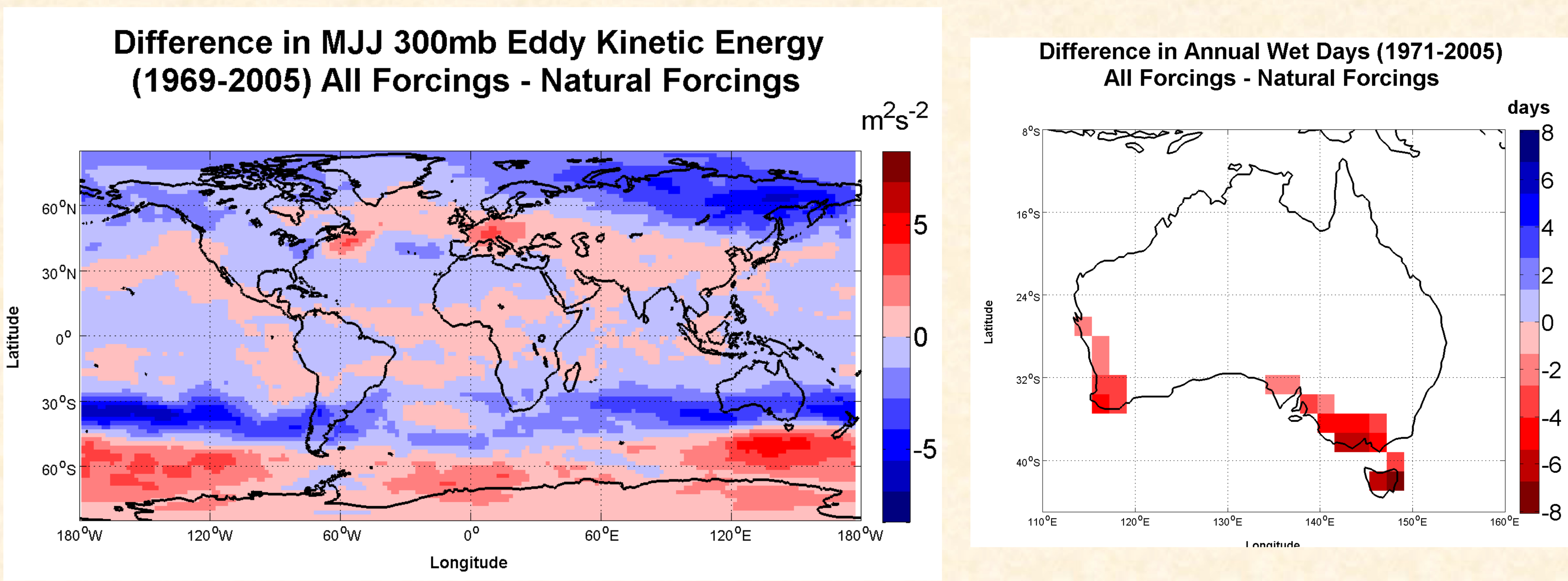

Figure 2. Changes in storm track (left panel) between anthropogenic and natural only forcing during the 1969-2005 period (ensemble average). A significant reduction in storm tracks along southern margin of Australian continent and corresponding increase further to the high-latitude is simulated. Simulated changes in number of wet days (right panel) show decrease in SW Western Australia and SE Eastern Australia attributed to change in anthropogenic forcing during late part of 20th century. Results are from CSIRO Mk3.6 ensemble.

Results

In recent paper Snidernam et. al. (2019, NCC) suggest that Southern Hemisphere subtropical drying may be a transient response to rapid warming and as greenhouse emission stabilise the rainfall reduction may be reversed. CMIP5 projections for RCP4.5 and RCP8.5 to 2300 were considered and results were presented for zonal mean of 25-35°S, including both land and ocean. We used 3 member ensemble simulations with CSIRO Mk3.6 model, which were extended to 2300 for both RCP4.5 and RCP8.5 to assess the rainfall changes in SW Western Australia. Results show steady decrease up to 2100 and then slow recovery, however by the 2300 the rainfall is still reduced by 35% for the RCP8.5 and by 17% for RCP4.5 compared to 1911-1968 average for the May to July period. Our results are more pessimistic than results by Sniderman, which show some recovery for winter rainfall and increase for summer rainfall, with annual average by 2300 close to historical levels. In this poster we use CSIRO 30 member ensemble to explore the role of different emissions in rainfall decline and recovery. Specifically we assess the projected rainfall changes for RCP2.6 which is characterised by strong emission mitigation effort and recovery of ozone depletion.

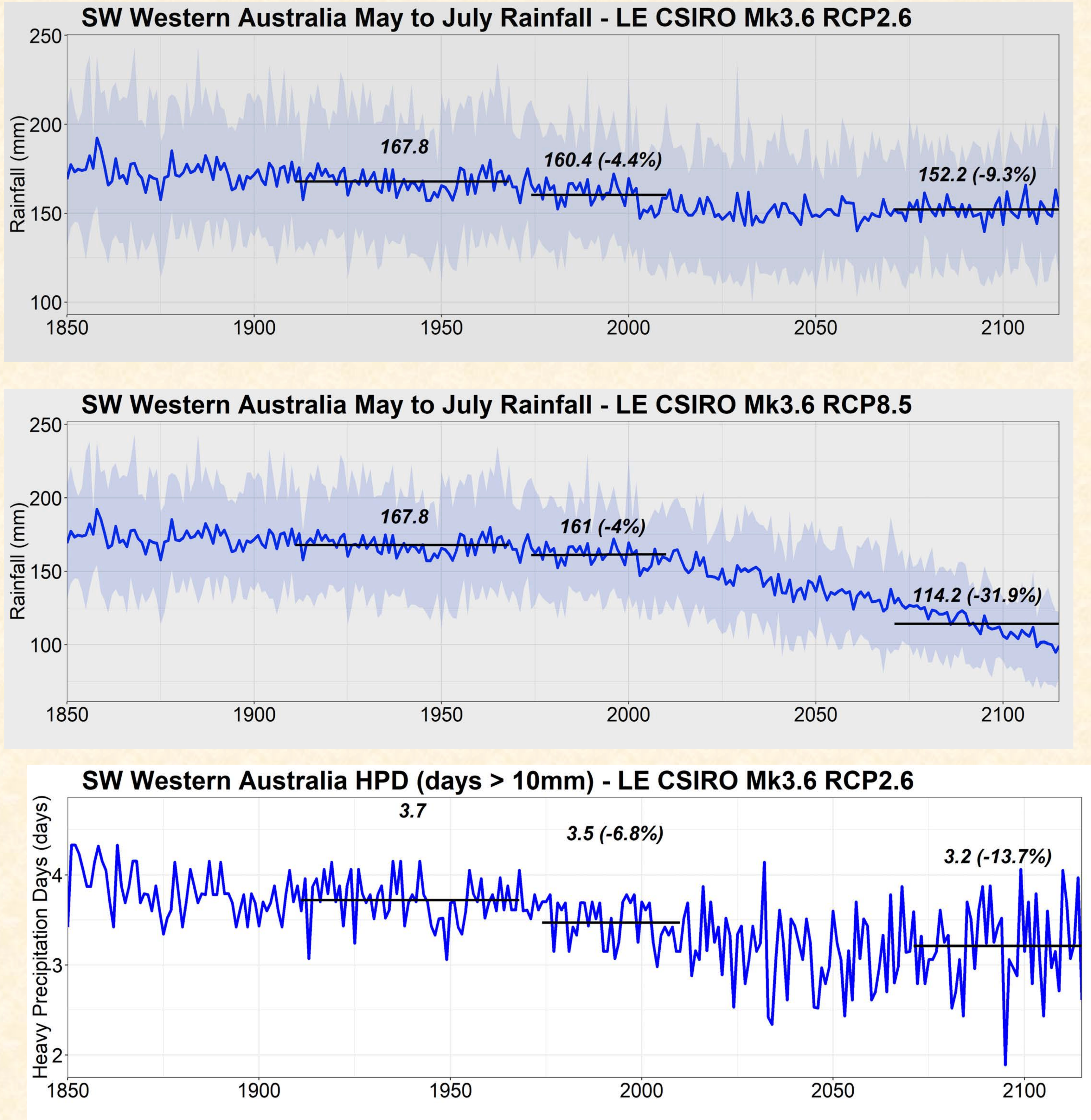

Figure 3. Projected changes MJJ rainfall in SW Western Australia for RCP2.6 & RCP8.5 from 30 member ensemble of CSIRO Mk3.6. Ensemble average and 10 & 90 percentile are shown. Projected changes in number of heavy precipitation days (lower panel) for SW Australia.

For RCP2.6 ensemble average rainfall reduction for the 2071-2015 is ~9%, which is only 5% reduction from late 20th century average, whereas for the RCP8.5 & RCP4.5 reduction is 32% and 17%. (Fig 3). Ensemble changes for the RCP2.6 vary from -2.5 to -14% compared to 1911-1969 period. Changes simulated by the CSIRO Mk3.6 30 member ensemble are very similar to the CMIP5 multi-model ensemble which show 10% reduction by the end of 21st Century. Both ensembles show steady rainfall reduction up to 2050 and levelling off after 2050. These changes follow closely the radiative forcing. Change in mean rainfall are strongly influenced by the reduction (-11.5%) in wet day precipitation (>1 mm) and reduction (-14%) in number of heavy precipitation days (Fig 3).

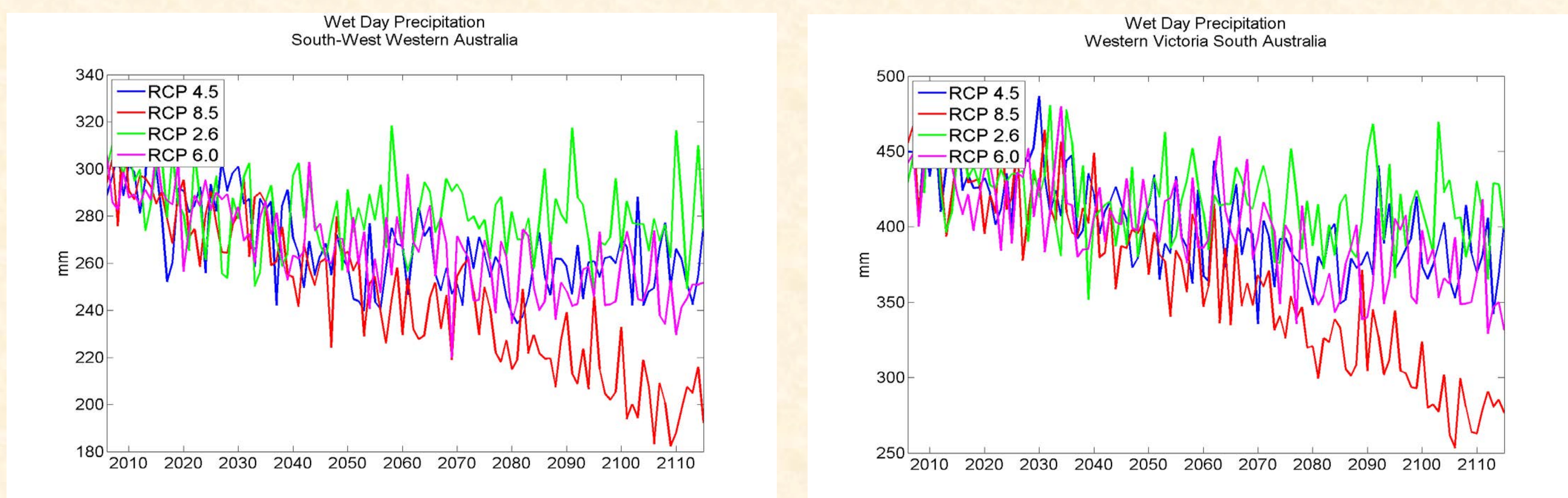

Figure 4. Projected changes in wet day precipitation totals for SW Western Australia and SE Australia for four RCPs from CSIRO Mk3.6 ensemble.

Results show modest decrease for the RCP2.6 during the 21st Century compared to higher emission scenarios and relatively high frequency of high precipitation days comparable to historical period in both regions (Fig 4).

Conclusion

- Large Ensemble of CSIRO Mk3.6 model show that rainfall reduction in subtropical regions of Southern Hemisphere is likely to stay below historical averages.
- Simulations up to 2300 show some recovery once radiative forcing levels off from rapid increase during the transient phase.
- Simulations with strong emission mitigation measures represented by RCP2.6 show modest (~9%) rainfall reduction by the end of 21st Century compared to high-emission RCPs. Frequency and amount of wet day (>10mm) precipitation (which is critical for streamflow) during the second part of 21st Century is similar to historical period.
- Results show that emission reduction are critical in maintaining rainfall regime conductive to security of water supply in major population centres of Southern Hemisphere subtropics.

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