The influence of hydroclimate on the hydrological impact of bushfires in southeast Australia

Notes prepared by Francis Chiew, University of Melbourne, CRC for Catchment Hydrology

Hydroclimate variability

The considerable variation in rainfall and runoff from year to year is part of the natural variability in the climate system. The management of land and water resources involves designing and operating to cope with this variability. The management challenges in Australia are compounded by Australian streamflow (and to a lesser extent climate) being more variable that elsewhere in the world. As a result of the higher streamflow variability, temperate southeast Australia is more vulnerable to river flow related droughts and floods than elsewhere in the world.

Medium-term rainfall and runoff

The immediate to medium-term hydrological impacts of bushfires depend on various factors including climate. High rainfall intensities will lead to more soil erosion and sediment and pollutant transport. High rainfall amounts and intensities will also result in higher catchment runoff yields that are required to replenish water storages.

Rainfall in southeast Australia in the last few months was significantly below average (see www.bom.gov.au/climate/current).

There is a teleconnection between El Niño/Southern Oscillation (ENSO) and Australian rainfall and runoff. El Niño is generally described by very warm sea surface temperatures in the tropical Pacific Ocean and/or very negative SOI values (standardised difference of Tahiti minus Darwin sea level pressure). El Niño typically results in dry conditions in southeast Australia. There is currently a weak to moderate El Niño, but the key ENSO indices suggest a weakening of El Niño and most climate models predict neutral conditions by the middle of the year (see www.bom.gov.au/climate).

The ENSO-rainfall teleconnection can be exploited to forecast rainfall several months ahead. The teleconnection is strongest in late spring and summer, but is relatively weak after February/March. The Bureau of Meteorology seasonal climate outlook (which uses ENSO-rainfall teleconnection and other information) is for average rainfall conditions in southeast Australia in the coming months (see www.bom.gov.au/climate/ahead).

The plots in Figure 1 show exceedance probabilities for February to May four-month rainfall totals in Sydney, Canberra and Melbourne. The two curves show values based on climatology (derived solely from the historical data) and values estimated by the CRCCH seasonal forecasting model (the SOI is used here to forecast rainfall). The two curves are similar because the rainfall-SOI relationship is weak over this period, and there is little to no skill in the forecasting model. This is consistent with the Bureau's outlook of average rainfall in the coming months.

Figure 2 shows plots of daily rainfall versus percentage time that they are exceeded in February to May. The daily rainfall intensity frequency curves are derived from climatology and can be used as inputs into pollutant transport models to provide probabilistic estimates of medium-term hydrological impact of bushfires. Like the rainfall totals in Figure 1, the use of ENSO information (not shown here) does not significantly change the climatologically derived frequency curves for daily rainfall intensity in Figure 2 for these locations at this time of the year.

The CRCCH nonparametric seasonal forecasting model was developed mainly for forecasting streamflow or reservoir inflows. The forecasts provide invaluable information, particularly now because of depleting water resources resulting from the drought and bushfires in southeast Australia. The forecasts are expressed as exceedance probabilities so that they can be used to assess the operation of conservative low risk water resources systems. The forecasts can be used to help make decisions on water allocation for competing users, and to provide a probabilistic indication of likely water allocation in the coming months.

There is generally more skill in forecasting streamflow than rainfall because the model can also make use of the serial correlation in streamflow. The persistence in streamflow results from the delayed response in the rainfall-runoff process due to soil and subsurface water storage, giving the streamflow data a memory of conditions over several months. Figure 3 shows as an example the streamflow forecast for a catchment in southeast Australia that experienced low streamflow in the previous months. Unlike the plots in Figure 1, the CRCCH model forecast much lower streamflow compared to the historical based values (particularly at the high exceedance probabilities) because of the persistence in low streamflow conditions.

Long-term rainfall and runoff

The impact of bushfires on long-term catchment yield depends on the change in the hydrological processes (mainly due to the clearing and re-growth of vegetation) and potentially the change in climate. There is now strong evidence that global warming is occurring and will continue in the foreseeable future. This will lead to changes in rainfall pattern and other climate variables, which will in turn impact on the hydrological cycle. There is a need to consider climate change, in particular rainfall and potential evapotranspiration inputs into hydrological models that assess the recovery of catchments following a bushfire.

The historical hydroclimate data series are probably too short to confirm statistically whether there is a climate change trend. Nevertheless, the persistent dry conditions in southeast Australia over the last decade are consistent with most global climate model predictions of reduced rainfall in the region in a climate-changed environment. The CSIRO Atmospheric Research climate change projections (www.dar.csiro.au/publications/projections2001.pdf) indicate changes in annual rainfall of –15% to +10% in southeast Australia by 2030, with the higher decreases estimated for the southern parts of southeast Australia. Rainfall-runoff modelling studies carried out by the CRCCH indicate that this translates to a change in runoff of –25% to +15% in catchments in the central coast of New South Wales to a decrease of up to 35% in catchments in southern Victoria. This is because the change in rainfall is amplified in runoff and the higher temperatures (and therefore potential evapotranspiration) enhance the effect of

reduced runoff and moderates the effect of increased runoff (although the temperature impact is a lot smaller than the rainfall impact).

Climate variability should also be quantified to properly assess the influence of rainfall and runoff on the long-term hydrological impact of bushfires (like the estimation of catchment yield to replenish the reservoirs). Running models with alternative sets/replicates of stochastic data provide a method for quantifying uncertainty in hydrologic systems caused by climate variability. The CRCCH has a research project on developing and testing stochastic models that generate time-series rainfall and climate data.

General References

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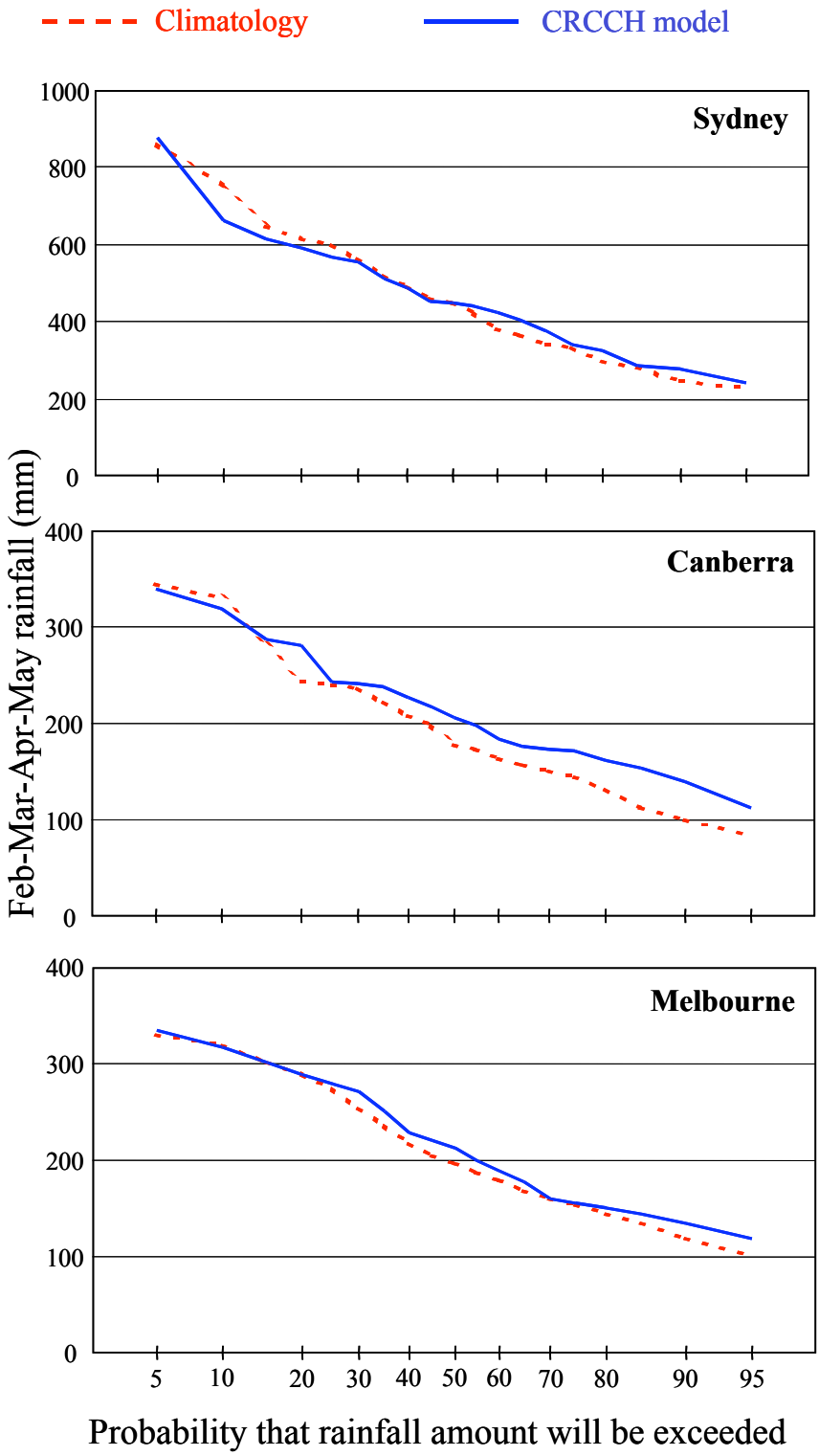

Figure 1 Exceedance probabilities for Feb-Mar-Apr-May total rainfall for Sydney, Canberra and Melbourne estimated from climatology (dotted lines) and by the CRCCH seasonal forecasting model (full lines)
(the two curves are similar because there is no skill in the forecasting model because of the low lag rainfall-SOI correlation over this period - about 0.1 at the three locations)

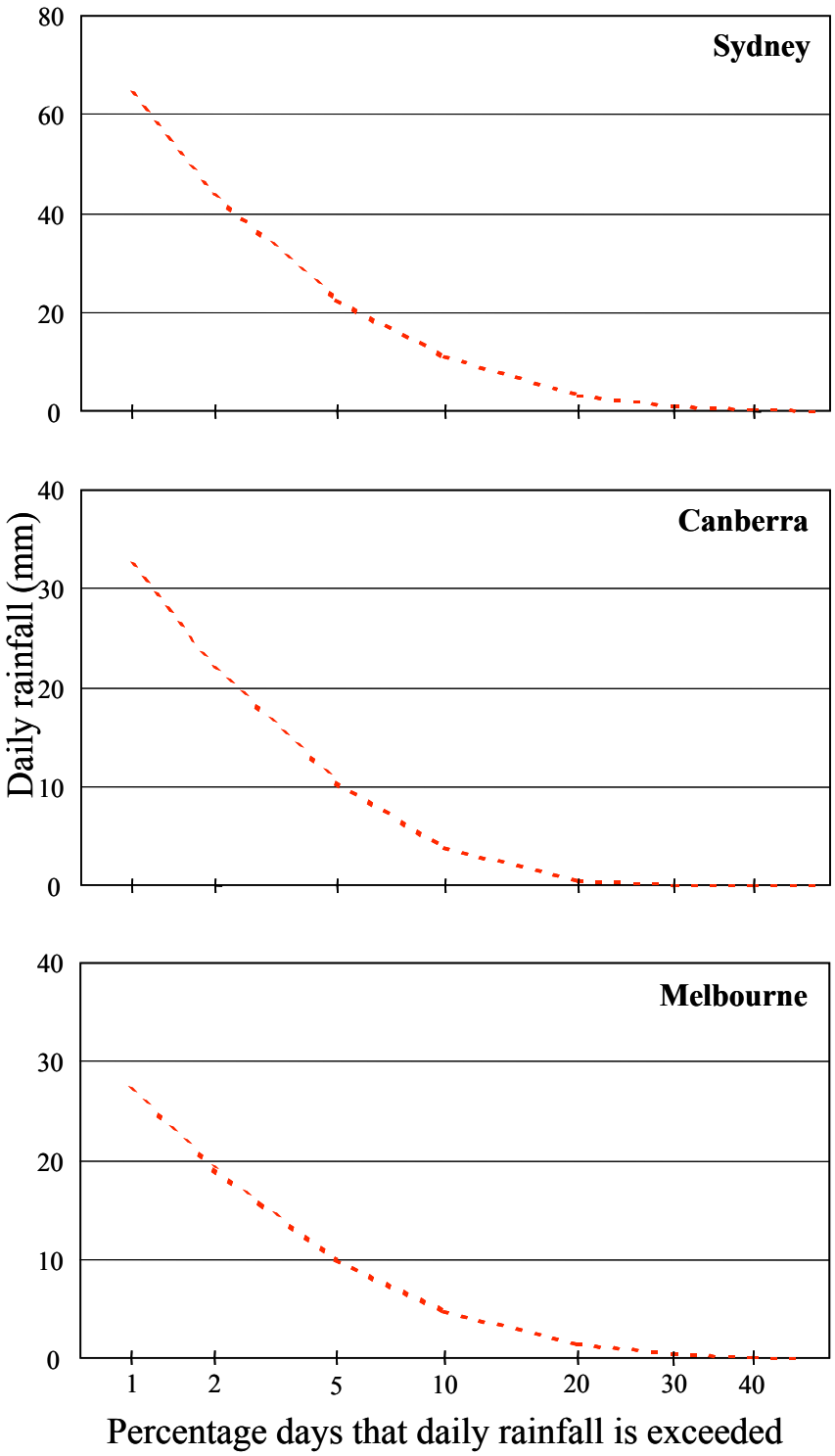

Figure 2 Frequency curves of daily rainfall intensities in February to May in Sydney, Canberra and Melbourne

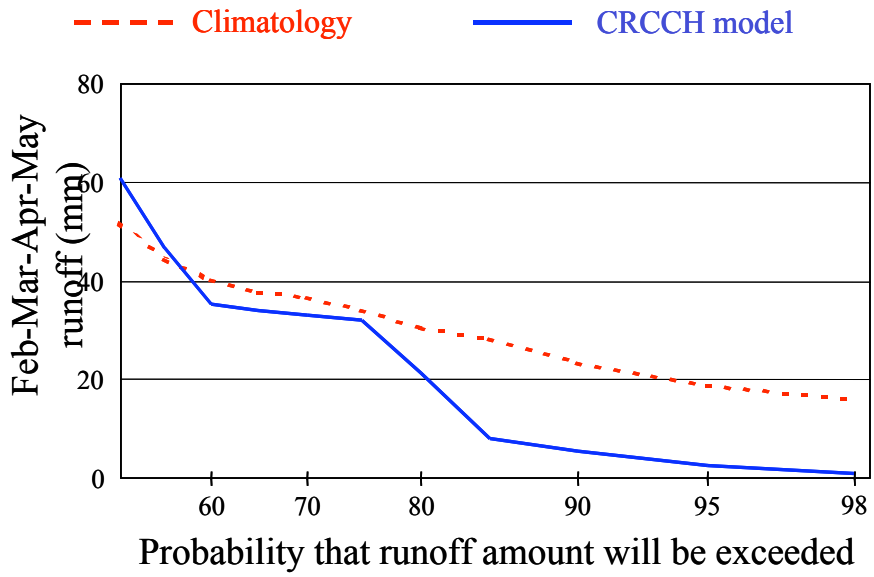

Figure 3 Exceedance probabilities for Feb-Mar-Apr-May total runoff for a catchment in southeast Australia estimated from climatology (dotted lines) and by the CRCCH seasonal forecasting model (full lines)