Southeast Australian Rainfall Workshop – Summary

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A workshop on Southeast Australian (SEA) rainfall was held at the UNSW Climate Change Research Centre on 8-9 September 2009, bringing together about 30 scientists. The workshop was motivated by the ongoing SEA drought and associated scientific debate as to its causes and likelihood for continuance in the future in the face of global warming. The goals of the workshop were to identify areas of broad consensus, important open questions, and promising research strategies. The format was organised to maximise discussion while allowing participants to present their most recent work. Key problems include the relative roles of specific natural and anthropogenic causes in causing past rainfall variations – which bears critically on longer-term prediction – and the extent to which decadal variations are predictable.

It was recognised by the end of the workshop that much progress has been made very recently and that more is likely in the near future. Consensus was reached on several matters. Most of the southern half of Australia has seen low rainfall for the last 1-3 decades, whilst the northwest has become wetter. The rainfall reduction in SEA, underway for roughly the last decade and most pronounced in autumn and winter, appears to be comparable to the so-called “World War II” and “Federation” droughts of the 1940’s and circa 1900, respectively, when measured by annual rainfall in the Murray-Darling Basin. However the rainfall in southern Victoria appears to have declined more than in either of those droughts. It has also declined more in autumn, which along with higher temperatures, has produced streamflow levels lower than any in the available record. A number of rainfall records show evidence of a steady downward trend going back several decades that may be a climate-change signal independent of the usual drought cycle. This and other evidence suggests that the current drought is due to a temporary fluctuation and an underlying climate-change signal, both contributing non-negligibly. Work is currently underway to extend drought records back further in time so as to help clarify how unusual the current drought is.

The search for proximate, atmospheric causes (or correlates) of rainfall variations has shown that average surface pressure is closely related to average rainfall south of 30°S, and that this relationship holds both for year-to-year variations and trends. Rainfall in SEA is also well correlated with the appearance of atmospheric blocking highs and with the location and (especially) strength of a subtropical ridge over eastern Australia. These relationships hold in most seasons, but evidently not summer when precipitation is mainly convective. Intriguingly, the changes over the 20th century in the strength of the subtropical ridge closely mirror those of global temperature, although there is no obvious reason for this. Recent decreases in rainfall are due to a slightly decreased number of synoptic rain-bearing systems and a larger decrease in rainfall per system. Further work is needed to better relate rainfall to system characteristics, to relate local flow characteristics to climatic drivers, and to evaluate simulations of these processes in
Another open question is what controls rainfall along the eastern seaboard, which does not seem to follow that west of the ranges.

Atmospheric flow patterns may be organised and driven by events in the oceans and on the land surface, especially on longer time scales. Several studies show that the “Indian Ocean Dipole” (IOD, a combination of cool water in the eastern Indian ocean and warmer water farther west), or a similar tri-polar pattern, are strongly linked to interannual variation in SEA rainfall during some parts of the year via atmospheric flow patterns. Water temperatures north of Australia are also very highly (positively) correlated with mean rainfall south of 30°S – but it is not clear whether this relationship is causal, or whether the oceans and rainfall are each symptoms of varying atmospheric flow patterns. The El Niño-Southern Oscillation has long been seen as having a dominant influence on Australian rainfall, but the impact of an individual El Niño seems sensitive to how far west it reaches, associated with a so-called “Modoki” warming pattern variation. The various ocean predictors that have been identified tend to be correlated in time and space, making it difficult to discern exactly which sea (or possibly land) surface temperature characteristics are most important. Participants noted the need to bring dynamically grounded theories to bear on this question, and offered some suggestions.

Statistical relationships between rainfall and tropical ocean temperature often fail to explain observed trends even when the relationships appear strong year-to-year. For example, years when oceans north of Australia are warm normally coincide with those of more southern rains, but the upward trend in ocean temperatures associated with global warming is in the wrong direction compared to the decreasing SEA rainfall. Trends in the IOD pattern predict decreasing springtime SEA rainfall, but do not work in other seasons or regions. These conundrums imply that the rainfall trends are dominated by slowly-evolving factors that are not obvious in the interannual variability, again suggesting a link to climate change (driven largely by greenhouse gases), land use or land-atmosphere feedbacks or aerosols—although more subtle natural variations, separate from those most evident on a year-to-year basis, cannot yet be ruled out. Further model studies are needed to clarify these matters, and to identify what makes Australian rainfall anomalies so persistent.

Climate models driven by anthropogenic and natural influences fall somewhat short in explaining the drought. Nearly all atmospheric models, when driven by estimated sea surface temperatures since the 1950s, predict wintertime moistening during recent decades rather than drying. Most coupled models do predict that greenhouse-induced warming will eventually produce a drier SEA, making these gases likely contributors to the drought. At least one coupled ocean-atmosphere model is able to reproduce the recent changes to circulation and rainfall when increasing greenhouse gases are taken into account, although predicted trends are 2-3 times too weak. Intriguingly, global climate studies have also shown that models underestimate the observed poleward expansion of the tropical boundaries over the last three decades by a similar factor. The possibility that this or other global phenomena are responsible for Australian
drought, and the links of these to the more local flow characteristics emphasised in the workshop, should be further explored.

Participants agreed that this tightly focused workshop allowing a great deal of time for discussion and debate, was very worthwhile, and allowed us to reach consensus on several aspects of the drought and on what issues still need to be resolved.