Report on Changes in Climate in a South Australian Region in the Period 1961-1990 Compared Against Full Historical Datasets

Abstract

Data is examined to ascertain whether or not climate changed in a particular region over a particular time period. The region in question is the South and South-Western Flatlands East (SSWFE) Natural Resource Management (NRM) zone as identified by the Department of the Environment (2016) and utilized by the CSIRO and Bureau of Meteorology in <http://www.climatechangeinaustralia.gov.au/> (attributed to Hope *et al* 2015). Within this region five locations were chosen as representative and their datasets were examined for the time period 1961-1990 and compared against the full datasets beginning at the point when the meteorological stations were opened. Four parameters were analysed: mean minimum temperatures (T_{MIN}), mean maximum temperatures (T_{MAX}), mean rainfall (P), and mean relative humidity at 9am (RH). It was concluded that mean temperatures (T) rose very slightly, P rose slightly, and RH rose significantly. Further, it was ascertained that T_{MIN} rose at a greater rate than T_{MAX}, that T_{MIN} rose less in winter, and that RH declined in winter. These changes in climate are compared against the extant modelling and known climatological mechanisms to further strengthen the case that climate changed in the SSWFE.

Introduction

This report discusses the climate of a particular region of Australia, comparing full data sets for meteorological recording stations dating back at least to the early twentieth century, against the data for the more recent period 1961-1990. The aim of the exercise is to ascertain whether or not various aspects of climate have changed in line with climate projections for the region, and if so, what mechanisms may have driven the changes. Before the data is discussed, brief explanations will be given as to the reasoning behind the choices of location studied and time periods studied.

Choice of Time Periods

The overall aim of the report is to try to identify climate change in a particular region in a particular time period. One time period (1961-1990) represents the "current" era, and the other represents an "older" era (but incorporating the current era also). As regards the older datasets, care was taken to ensure that only very long datasets were utilised, since they would be more representative of the era before the large-scale use of fossil fuels and thus before the largest increases in greenhouse gas emissions and in climate change. Within the region studied in this report, few datasets exist that extend further back temporally than the mid-twentieth century. The choice of locations therefore had little to do with geography and more to do with the available datasets.

Choice of Locations

The SSWFE region is a sub-zone of the Southern and South-Western Flatlands NRM zone, which incorporates a large swathe of south-western Australia plus part of the state of South Australia. This zone is itself a sub-zone of a Southern Australia NRM zone.

It is acknowledged that the use of a mere five locations for sampling data is not sufficiently representative for an authoritative analysis of climate change in the SSWFE region, but the scope and purpose of this report is limited. Its aim is to provide an introduction to the question of whether climate has changed in the SSWFE region. Great care was taken to ensure that locations were not “cherry-picked” in order to skew the data in favour of a changed climate (or otherwise).

Temperature in the SSWFE

T_{MIN} and T_{MAX} data

Figure 1. (BOM 2016) represents in graph form the monthly T_{MIN} and T_{MAX} data for Roseworthy and Port Lincoln for two time periods. The two locations are at the same latitude but Port Lincoln is distinctly maritime, being at the southern tip of the Eyre Peninsula which juts into the Southern Ocean.

The following conclusions can be reasonably inferred from the graphs:

- **Roseworthy** (less maritime)
  - No visible change in T_{MAX}
  - A slight increase in T_{MIN}
  - A slightly greater increase in T_{MIN} outside of winter as opposed to winter

- **Port Lincoln** (on the coast)
  - A slight increase in T_{MAX} is apparent except in summer
  - There is a noticeable increase year-round in T_{MIN}
  - A slightly greater increase outside of winter in T_{MIN} as opposed to winter

- **Generalisations about the two locations**
  - Overall there is a slight increase in T
  - There is a small but clear increase in T_{MIN}, while there is only a very slight, perhaps negligible increase in T_{MAX}
  - The T_{MIN} increase is slightly greater outside of winter, while T_{MAX} increases are not apparent in summer
  - There is a greater increase in T_{MAX} closer to the coast

Increases in *T*

Radiative forcing is behind global rises in temperature (Meehl et al 2007, p. 749). Emissions of greenhouse gases from human activity allow the atmosphere to absorb excessive amounts of long wave radiation. *T* is projected to increase throughout the 21st century. This applies globally (Meehl et al 2007, p. 749), across Australia (Hughes 2003), and within the SSWFE (Hope et al 2015, *TEMPERATURE PROJECTIONS*).

The *T* data for Roseworthy and Port Lincoln show a slight increase in *T* overall. Even though the increase is tiny and no doubt skewed by inadequate data, for the purposes of this report it can be said that *T* in the SSWFE zone has risen, and thus that the data matches predictions in the literature.

Increases in T_{MIN} and T_{MAX}

Generally and globally, T_{MIN} is projected to increase at a noticeably faster rate than T_{MAX} (Pitman and Perkins 2008, p. 41), resulting in increasing diurnal temperature ranges (Meehl et al 2007, p. 750). The T_{MIN} and T_{MAX} lines on the Figure 1. graphs support this hypothesis. Thus it can be said that for the SSWFE, T_{MIN} and T_{MAX} have been rising at different rates.

Seasonality of *T* changes

Hughes (2003, p. 426) states that "the range of warming is projected to be greatest in spring and least in winter." The Figure 1. graphs reflect this, showing smaller T_{MIN} increases in winter than in the other months. The fact that the graphs show T_{MAX} increases in all months outside summer may be related to summer increases in *RH* discussed below.

Maritime effects

Warming over land is projected to be very much greater than warming over sea (Meehl et al 2007, p. 749). Water warms more slowly than soil, thus creating a heat differential between land and sea, and this difference is expected to be accentuated by climate change. The Figure 1. graphs show a greater increase in T_{MAX} at the coast than inland. This does not match predictions in the literature so it could be stated that this particular aspect of climate change has failed to eventuate in the SSWFE.

Rainfall in the SSWFE

Mean monthly rainfall (*P*) data

In Figure 2 (BOM 2016), *P* for the period 1961-1990 for Adelaide, Port Lincoln, and Kingscote on Kangaroo Island, is compared to *P* for datasets that begin in the 19th century.

The following can be concluded from the graphs and data:

- **Adelaide:** Overall reduction in *P* of 3.2%
- **Port Lincoln:** Overall increase in *P* of 5.1%
- **Kingscote:** Overall increase in *P* of 0.5%

- **Generalisations about the three locations overall**
  - Average annual percentage change in *P* is +2.4%
  - Ambiguous changes to winter *P*
  - The coastal locations have an average *P* increase of 2.8%, while the less maritime location (Adelaide) has a decrease of 3.2%

Increase in *P*

Projections for *P* in Australia as climate change progresses are ambiguous in the literature. Pitman and Perkins (2008 p. 28) are confident of continent-wide increases, but Stokes and Howden (2010, p. 16) suggest that for southern Australia *P* will decline. Thus the 2.4% increase in *P* noted here may or may not reflect the predictions in the literature, and may well reflect inter-decadal variability (Stokes and Howden 2010, p. 16).

Winter decrease in *P*

Winter *P* is confidently expected to decrease in southern Australia (Hope et al 2015, *RAINFALL PROJECTIONS*; Hughes 2003, p. 426; Pitman and Perkins 2008, p. 28, 41; Reisinger et al 2014, p. 1379; Stokes and Howden 2010, p. 16). It cannot be said that the SSWFE region has had reduced *P*.

Coastal areas increased *P*

It is anticipated that under climate change, Australia's southern coast will record a greater decline in *P* than more inland areas (Pitman and Perkins 2008, p. 41-3). This does not match the results in this report, the opposite being the case. However it must be acknowledged that categorising Adelaide as less maritime than the other two locations is a tenuous proposition.

More than one theory has been proposed for the expected reduction in rainfall along the southern coast. One is that air pressure at sea level in the mid-latitudes will increase (Pitman and Perkins 2008, p. 45). Since higher pressure air masses can accommodate less moisture, reduced *P* in the mid-latitudes would follow. Low pressure maritime storm systems would correspondingly shift southward and away from the southern coast (Hope et al 2015).

***RH* in the SSWFE**

Mean Relative Humidity at 9am (*RH*) Data

Figure 3 (BOM 2016) shows *RH* for one coastal location (Kingscote) and two less maritime locations for a "recent" time period that can be roughly categorised as "the 1980s and 1990s", compared against an "older" time frame dating to the early twentieth century. Kingscote shows minimal change in *RH* (a 1.4% drop) and it must be noted for Kingscote only, that the *x* axis cuts off the graph up to 65%, giving a false impression of a major reduction in *RH.* Roseworthy exhibits a noteworthy 7.2% increase in *RH* and a quite remarkable increase in *RH* for summer of 19.2%. Snowtown's results are less dramatic but still significant, with a 4.4% annual *RH* increase and an 8.2% summer *RH* increase.

Increased annual *RH*

The three locations studied here display a combined average increase in *RH* of 8.8%. Meehl et al (2007, p. 750) state that on a global level, "mean water vapour, evaporation and precipitation are projected to increase." This is because warmer air can hold more water vapour and under climate change air is generally warmer than otherwise. Increased *RH* relates to this fact because for a given temperature, the higher the *RH,* the closer T is to the dewpoint (T_d) and thus the greater the likelihood of condensation occurring.

Another projection is that with climate change there is a decline in winter *RH* (Hope et al 2015, *HUMIDITY*). The graphs show a huge 10.2% rise in the summer months. This could also be interpreted as a huge *decrease* in winter, if it is assumed that a huge increase in winter would have occurred (as it did in summer) if not for the winter decline supposed by the models. Thus it can be said that in the SSWFE, *RH* has increased annually, but with a decline in winter (as a proportion of the total rise), as expected by modelling.

Conclusion

By examining the extant meteorological datasets for five locations in the SSWFE region, it has been determined that climate changed in the region throughout the twentieth century. The base period of 1961-1990 was compared with full datasets dating back to roughly the turn of the 20^{th} century. Broadly speaking it was concluded that *T* rose very slightly, *P* rose slightly, and *RH* rose significantly. Further, it was ascertained that T_{MIN} rose at a greater rate than T_{MAX}, that T_{MIN} rose less in winter, and that *RH* has declined in winter. However the results also show some discrepancies compared to the predictions of the literature, and it must be noted that the locations and time periods used here have been basic and based upon limited availability of data, with the overall intention being a snapshot of climate change in the SSWFE.

References

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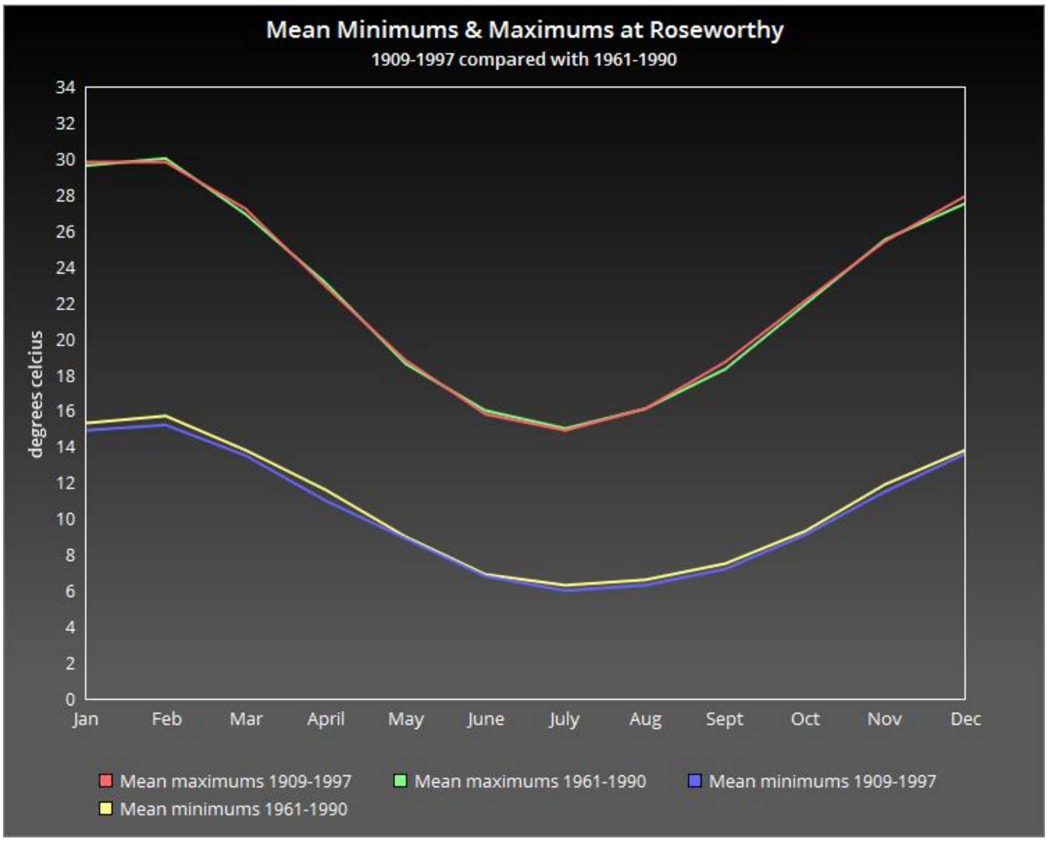
Stokes, Chris and Howden, Mark, eds. 2010. *Adapting Agriculture to Climate Change: Preparing Australian Agriculture, Forestry and Fisheries for the Future.* Collingwood, VIC: CSIRO Publishing.

(a)



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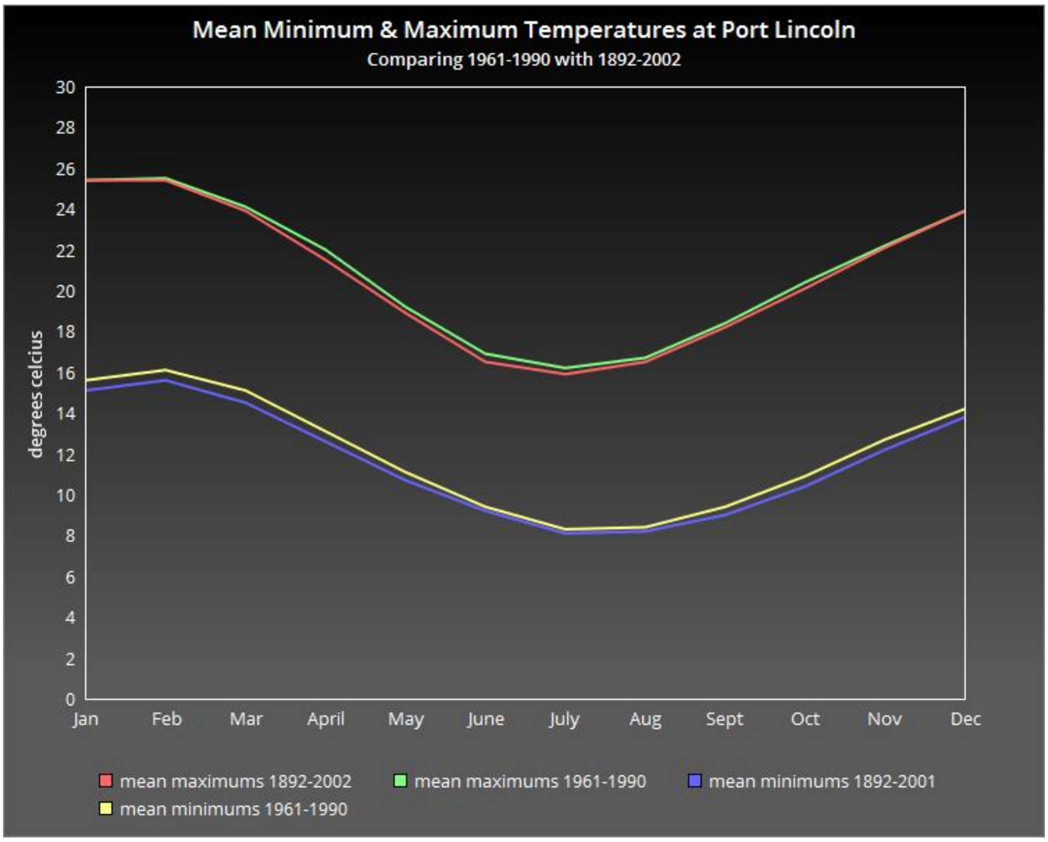
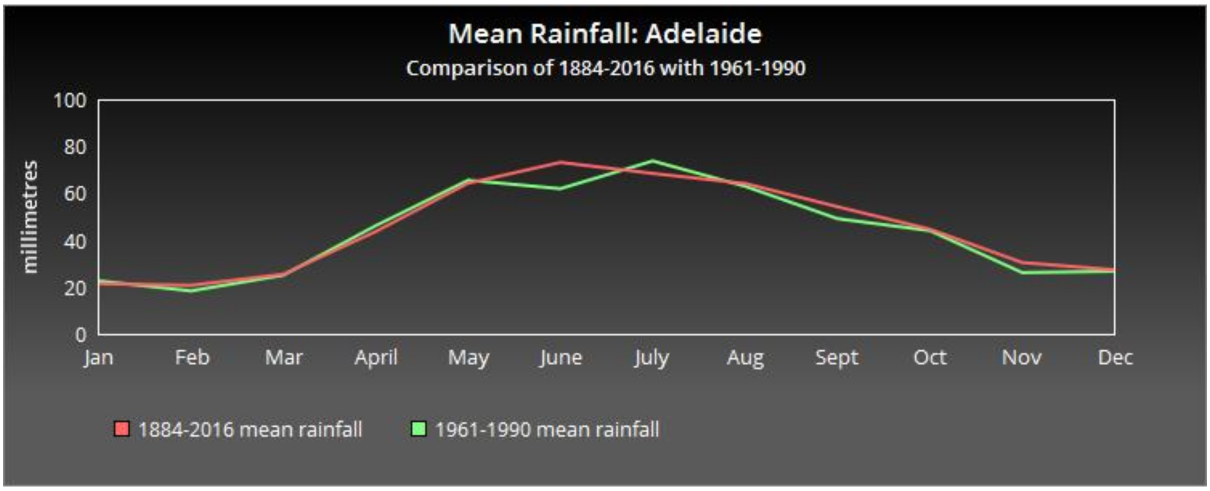


Figure 1. Comparison of mean minimum and maximum temperatures at (a) Roseworthy and (b) Port Lincoln. In each case the full available data set is compared with the period 1961-1990. Regarding maximums, no trend can be seen at Roseworthy while a warming trend can possibly be seen at Port Lincoln. Regarding minimums, a warming trend, though slight, can be fairly clearly seen at both sites.

Source: Bureau of Meteorology 2016

(a)



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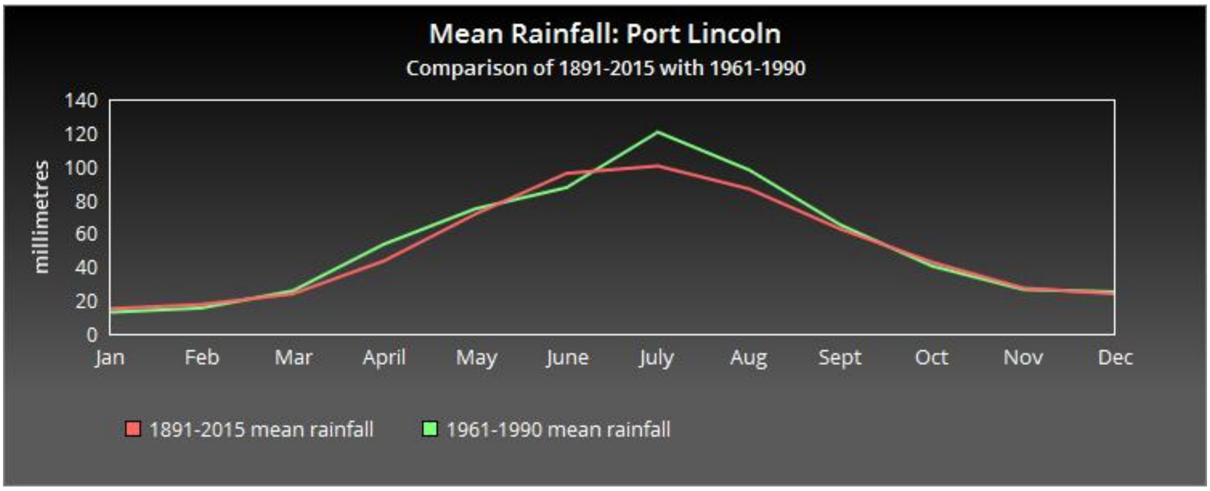

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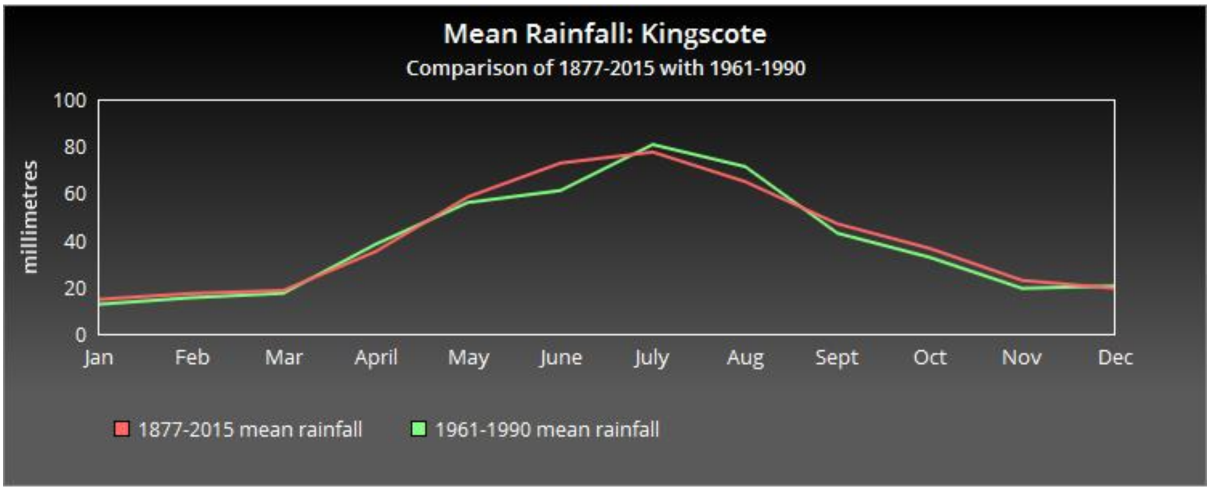
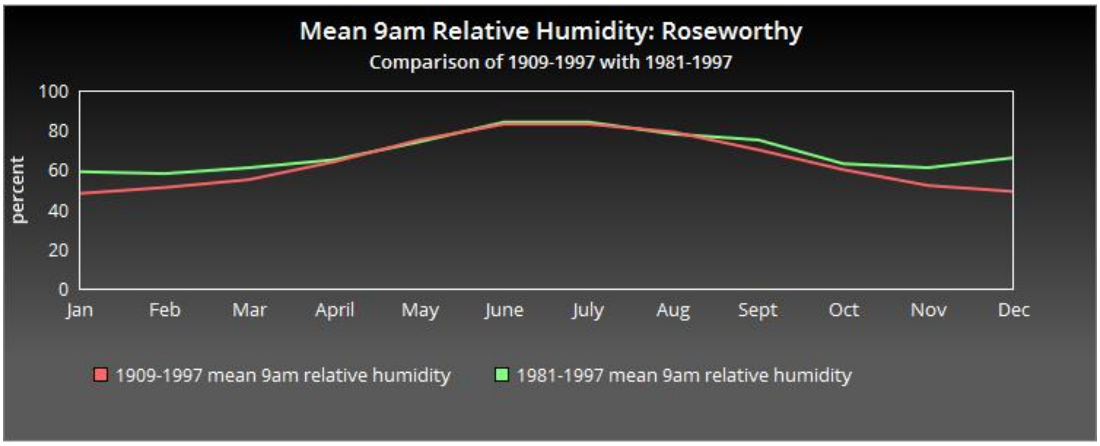


Figure 2. Mean rainfall at three locations in the Southern and Southwest Flatlands (East) Region. Here the period 1961-1990 is compared with the full data set for (a) Adelaide, (b) Port Lincoln and (c) Kingscote. No discernible trend is evident except perhaps a change in the winter rainfall distribution, but not total volume. Combined, the three graphs may well be indicating a decline in early winter rainfall and an increase in late winter rainfall.

Source: Bureau of Meteorology 2016.

(a)



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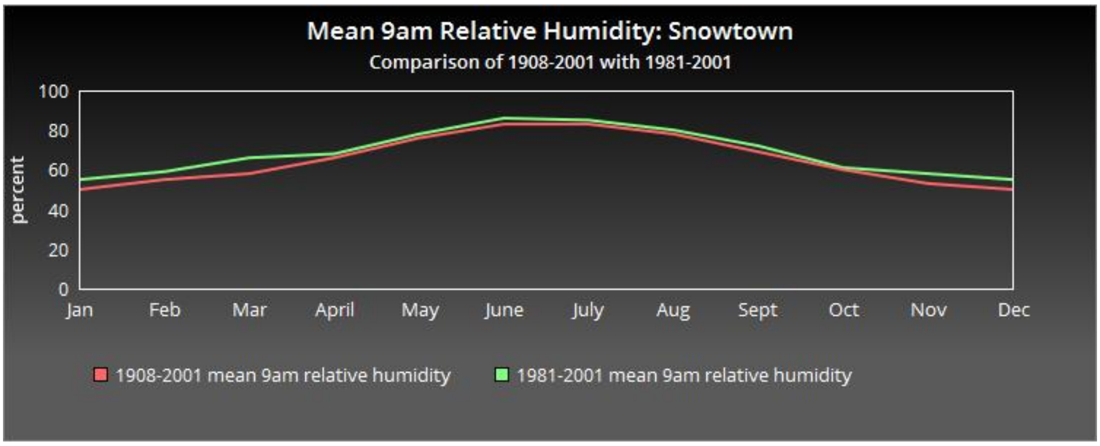

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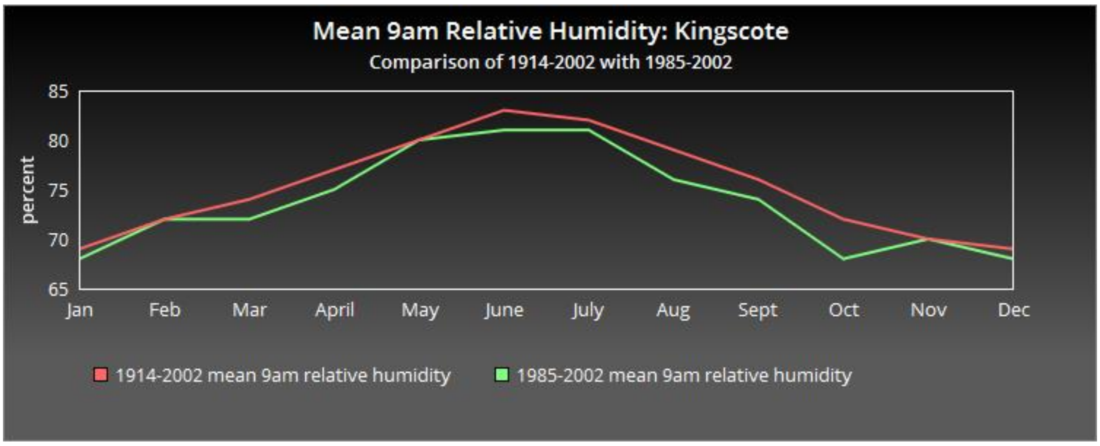

Figure 3. Mean 9am relative humidity at 3 locations in the Southern and South-western Flatlands (East) Region. At Roseworthy (a) and Snowtown (b) there is a noticeable increase in 9am relative humidity in the more recent era, but at Kingscote (c) there is a decline more or less throughout the year. It should be noted in relation to the Kingscote graph that only the relevant part of the Y axis has been included to save space. This has the effect of exaggerating the change in relative humidity. It is regrettable that the period 1961-1990 could not be accommodated due to limitations in BOM's data sets, however this is perhaps compensated for by the fact that the recent data sets that appear here are more up-to-date than 1961-1990.

Source: Bureau of Meteorology 2016