ACT CLIMATE CHANGE COUNCIL

CLIMATE CHANGE 2016: A BRIEF SCIENCE UPDATE FOR THE ACT

BY PROFESSOR WILL STEFFEN

The global climate is warming rapidly, primarily due to the emission of carbon dioxide from the burning of coal, oil and gas. Southeast Australia, including the ACT, has warmed by about 1˚C; extreme bushfire weather has increased; and cool season rainfall has declined. Canberra's climate is projected to warm further; even harsher fire weather is expected, and droughts are likely to become more intense and last longer. To meet the Paris target aimed at limiting temperature rise to 2˚C, the ACT should aim for zero emissions by 2050 at the latest, and preferably by 2040.

1. Observations of a changing climate

1.1 Global

Based on the IPCC Fifth Assessment Report (IPCC 2013), the major trends in the climate since the preindustrial baseline are:

Temperature

In terms of global average surface temperature, 2015 was the warmest year on record since reliable temperature records began in the late 1800s (NOAA 2016). The record warm 2015 is the most recent record in a long-term warming trend. Warming of the climate system is unequivocal, and each of the last three decades has been successively warmer than any preceding decade since 1850. In the Northern Hemisphere, 1983-2012 was likely the warmest 30-year period in the last 1400 years.

Precipitation

Averaged over the Northern Hemisphere mid-latitudes, precipitation has increased since 1901. For other latitudes, both positive and negative long-term trends have been observed depending on the location, but with low confidence.

Extreme weather events

It is very likely that the number of warm days and nights has increased, and the number of cold days and nights has decreased. It is likely that heatwaves have increased in large parts of Europe, Asia and Australia. There are likely more land regions where the number of heavy precipitation events has increased than where it has decreased.

Ocean warming

Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010.

Cryosphere

Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent.

Sea-level rise

The rate of sea-level rise since the mid-19th century has been larger than the mean rate during the previous two millennia. Since 1901 global mean sea level rose by 0.19 m.

1.2 Southeast Australia, including the ACT

Information in this section is accessed from the CSIRO/BoM State of the Climate 2016 report and the CSIRO/BoM Projections report (2015).

Temperature and extreme heat

Australia has warmed by around 1˚C since 1910, with most since 1950. The duration, frequency and intensity of extreme heat events have increased across large parts of Australia.

Bushfire weather

There has been an increase in extreme fire weather, and a longer fire season, across Australia since the 1970s, and particularly in the southeast. Over the past 35 years, in southeast Australia seven of eight forest regions experienced a significant increase in the area burned (Bradstock et al. 2013).

Rainfall

Since the 1970s rainfall has increased across parts of northern Australia, while there has been a decline of about 11% since the mid-1990s in April-October rainfall in the continental southeast, which includes the ACT. There is mixed evidence for changes in heavy rainfall.

Drought

There is little evidence for trends in episodic drought in southeast Australia. However, the Millennium Drought of 1996-2010 was larger in spatial extent and was more severe at its depth than previous droughts in the Murray-Darling Basin in the observational record.

Storms

Storms are being influenced by climate change as they are occurring in an atmosphere that is more warmer and moist (Trenberth 2012). However, there are not enough consistent, long-term data to detect trends in the frequency or intensity of thunderstorms and hailstorms in southeast Australia.

In summary, many of the observed changes in the climate system since the 1950s are unprecedented over decades to millennia.

2. Projections of climate change for Southeast Australia and ACT

Information in this section is accessed from the CSIRO/BoM State of the Climate 2016 report and the CSIRO/BoM Projections report (2015).

Temperature and extreme heat

Average temperature is projected to continue to increase through the rest of the century, with the level of increase during the second half of the century dependent on the rate of emissions in the future. For Canberra, the 30-year average (1981-2010) number of days over 35˚C is 7.1 per year. This number is projected to increase to 12 by 2030 and to 13-29 by 2090, depending on the level of emissions between now and the end of the century.

Bushfire weather

An increase in the number of days with weather conducive to fire is projected for southern and eastern Australia, including the ACT. That is, harsher fire weather is projected for our region.

Rainfall

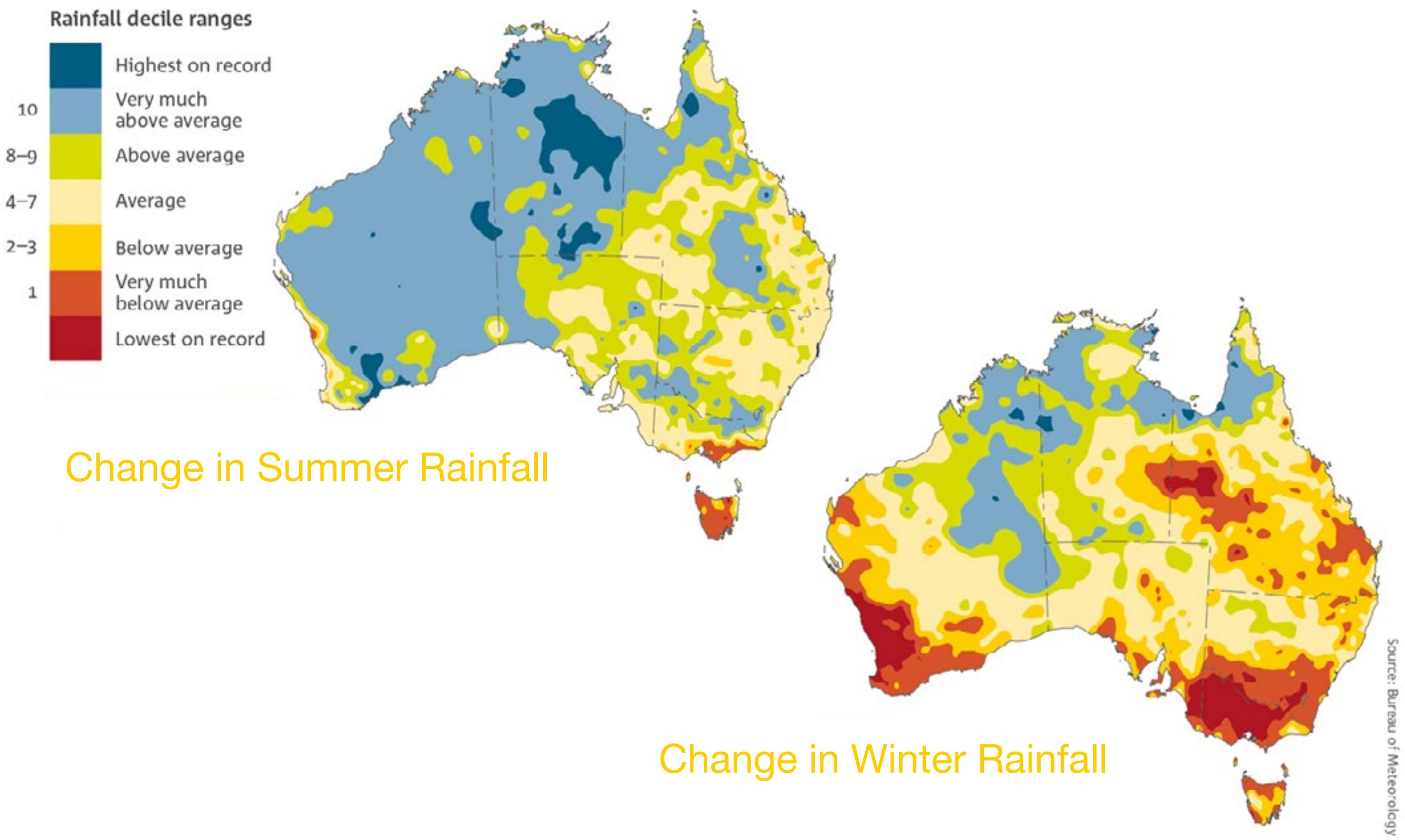
Winter and spring rainfall is projected to continue to decrease across southern continental Australia, including the ACT. Changes in summer rainfall, even the direction of change (increase or decrease) cannot yet be projected with any confidence. Overall annual rainfall is likely to decrease. Extreme rainfall events are very likely to increase in intensity.

Drought

Time in drought is projected to increase, with a greater frequency of severe droughts.

Storms

Weather conducive for the formation of thunderstorms is projected to increase. The annual frequency of potential severe thunderstorm days is likely to increase by 22% in Melbourne and 30% in Sydney by 2100 (Allen 2014). It is thus reasonable to expect that potential severe thunderstorm days are likely to increase in Canberra as well towards the end of the century.



3. The carbon budget approach: implications for the ACT

The carbon budget approach

The carbon budget approach (also called the "cumulative emissions" approach) is based on the linear relationship between (i) the cumulative amount of CO_2 that has been emitted to the atmosphere by all human sources (mainly fossil fuel combustion and land-use change) since the beginning of the industrial revolution and (ii) the increase in global mean surface temperature (IPCC 2013). This approach allows the calculation of a carbon budget – that is, the amount of carbon that can still be emitted in the future for a given temperature target, for example, the Paris agreement 1.5 and 2.0˚C targets. Apportioning a global budget to individual countries is not straightforward, but a common assumption is that it be calculated on a per capita basis.

To have a 66% chance of meeting the 2˚C Paris target, total human emissions of CO_2 cannot exceed 1,000 Gt (billion tonnes) C. Note that the carbon budget is often measured in mass of C, not CO_2 (there is a conversion factor of 3.664 between the mass of C and of CO2). Warming is also driven by non-CO_2 greenhouse gases such as CH_4, N_2O and hydrofluorocarbons (HFCs), and when the warming effect of these gases is considered, the budget for CO_2 emissions must be reduced by 210 Gt C equivalent, giving a revised budget of 790 Gt C for the 2˚C target.

Cumulative human emissions of CO_2 since the industrial revolution are approximately 565 Gt C, leaving a budget of only 225 Gt C for the world as a whole from now until zero net emissions of carbon are achieved globally. Current global human emissions of CO_2 are about 10 Gt C annually, so at present rates the entire remaining budget will be consumed in about 22-23 years.

Based on the carbon budget for a 2˚C target, an economic analysis shows that the percentages of the reserves (commercially viable deposits) of the three major fossils that can still be burned to be compatible with the budget are: coal 12%, gas 48% and oil 65% (McGlade and Ekins 2015). This result has important implications for Australia. Over 90% of Australia's existing coal reserves are unburnable, more than the global percentage. Development of any new coal deposits, including those of Galilee Basin, are incompatible with the action needed to meet a 2˚C target.

The Paris climate agreement aims to keep the temperature increase to well below 2˚C and to make strong efforts to limit the temperature rise to 1.5˚C. What does a 1.5˚C carbon budget look like?

The budget for the 1.5˚C target is about 650 Gt C from preindustrial, ignoring the further decrease to account for non-CO_2 greenhouse gases. With current emissions of 565 Gt C, the remaining budget is about 85 Gt C, less than decade of emissions at current rates. If non-CO_2 greenhouse gas emissions are included, the 1.5˚C budget has already been consumed. To meet either the 1.5 or 2.0˚C budgets, it is highly likely that "negative emission technologies" (removing CO_2 from the atmosphere and storing it securely underground) will be required at large scale.

For a peaking of global emissions around 2020, which now seems feasible, emissions would have to reduce to net zero by ca. 2050 for a 2˚C target and by ca. 2035 for a 1.5˚C target. In both cases, the emission reduction is exceedingly steep in the post-2020 period, implying a massive, focused effort of the type seen only in wartime periods in the past. There is absolutely no time for delay; each year of delay simply consumes more of an extremely limited carbon budget.

What does the carbon budget approach imply for the ACT?

We can make a number of observations (assuming a budget allocated on a per capita basis):

» Assuming an ACT population of ca. 500,000 and a global population of ca. 8.5 billion for the 2030-e40 period, and a carbon budget of ca. 225 Gt C (2˚C target), the budget for the ACT would be about 13 Mt C (48 Mt CO_2) from now until we reach zero net emissions.

» Aiming for zero net emissions for the Territory by 2035 or 2040 would be much more effective than a 2050 target date.

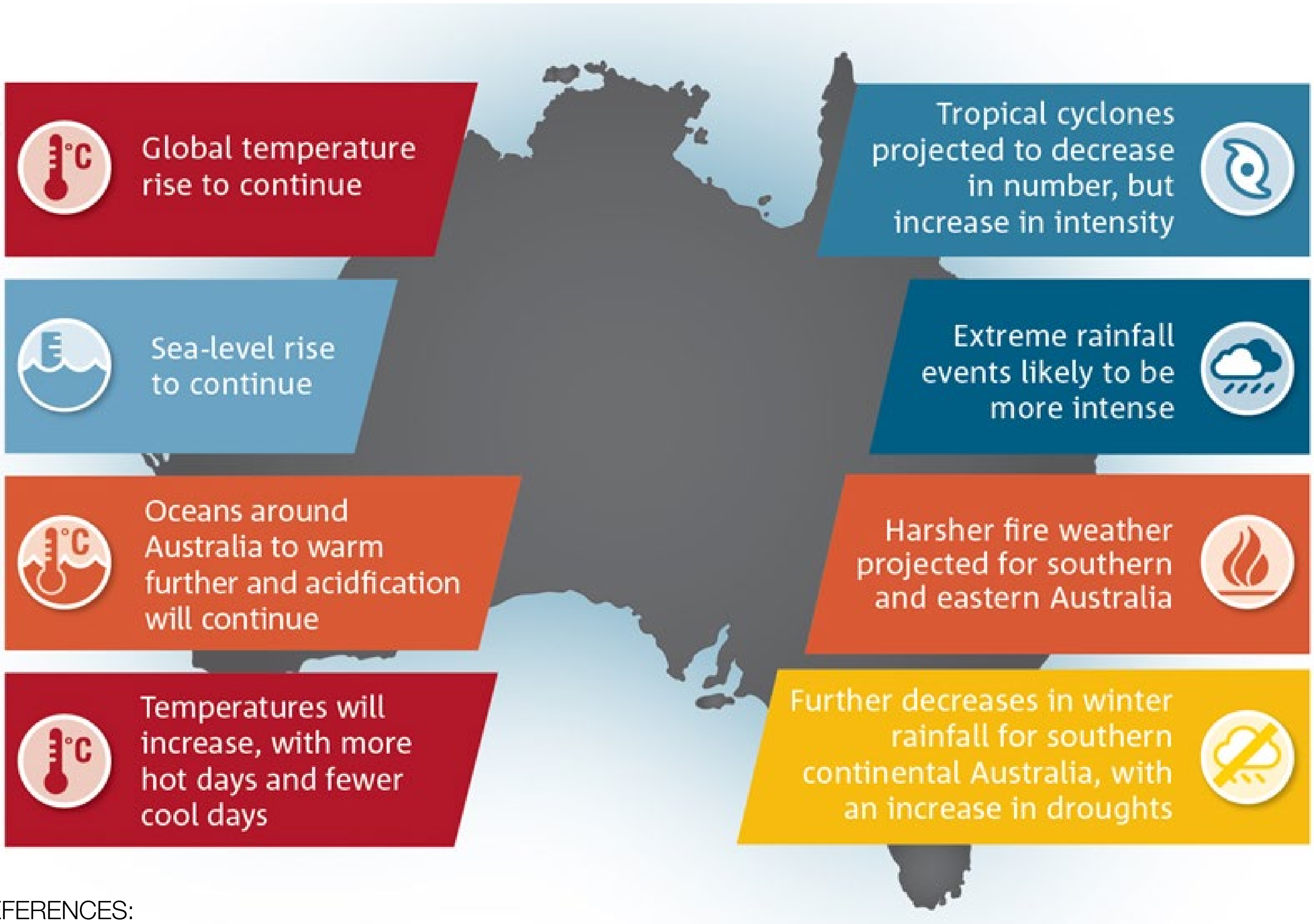
» The carbon budget approach requires deep emission reductions early on, with a slower rate towards the end of the emission reduction period, rather than a slow rate early, followed by deep reductions later. The budget is determined by the area under the emissions reductions curve so the trajectory is very important.

4. Climate change in an Earth System perspective

Earth's climate, using global average surface temperature as an indicator, has been relatively stable for the past 12,000 years (the Holocene epoch), varying slowly by about =/- 0.5˚C around the long-term average. It was only during this relatively stable 12,000-year period that humans developed agriculture, villages, cities and the complex societies we live in today. The Holocene was preceded the most recent ice age, which was, on average, about 4˚C colder than the Holocene. The peak of the last ice age occurred about 20,000 years ago, and the ca. 8,000-year transition between the ice age and the Holocene is called the deglaciation period.

The rate of human-driven climate change since the mid-20th century is striking when compared to background rates. For example, the rate of increase of atmospheric CO_2 concentration over the past two decades is about 100 times the maximum rate during the last deglaciation (Wolff 2011). Since 1970 the global mean temperature has risen at a rate about 170 times the background rate over the past 7,000 years (Marcott et al. 2013; NOAA 2016).

Source: Bureau of Meteorology and CSIRO



REFERENCES:

Allen, J.T., Karoly, D.J. and Walsh, K.J. (2014) Future Australian severe thunderstorm environments Part B: The influence of a strongly warming climate on convective environments. *Journal of Climate* 27: 3848-3868. DOI: 10.1175/JCLI-D-13-00426.1

Bradstock, R.A., Penman, T., Boer, M., Price, O. and Clarke, H. (2013) Divergent responses of fire to recent warming and drying across south-eastern Australia. *Global Change Biology*. doi: 10.1111/gcb.12449

CSIRO and BoM (2016). State of the Climate 2016, 23pp.

CSIRO and BoM (2015) Climate change in Australia: Projections for Australia's NRM regions. Technical Report, 216pp.

IPCC (2013) Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis*, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M. Allen, S.K., Boschung, J. Nauels, A., Xia, Y., Bex, V. and Midgley, P.M, Cambridge and New York, Cambridge University Press, pp. 3-29.

Marcott, S.A., J.D. Shakun, P.U. Clark and A. Mix (2013) A reconstruction of regional and global temperature for the past 11,300 years, *Science* 339(6124), 1198-1201.

McGlade, C. and Ekins, P. (2015) The geographical distribution of fossil fuels unused when limiting global warming to 2˚C. *Nature* 517(7533): 187-190.

NOAA (2016), State of the Climate: Global Analysis for Annual 2015, National Centers for Environmental Information, available at http://www.ncdc.noaa.gov/sotc/global/201513

Trenberth, K.E. (2012) Framing the way to relate climate extremes to climate change. *Climatic Change* 115: 283-290. DOI: 10.1007/s10584-012-0441-5

Wolff, E.W. (2011), Greenhouse gases in the Earth system: A palaeoclimate perspective, *Phil. Trans. Royal Soc*. A 369: 2133–2147, doi: 10.1098/rsta.2010.0225;pmid: 21502180