Title	Dr
First name	James
Last name	Taylor
I am making this submission as	Academic
Submission type	Personal
Organisation making the submission (if applicable)	
Your position in the organisation (if applicable)	
Consent to make submission public	Public
Your story	On 31 December I came to face the full force of the firestorm as Batemans Bay suffered a direct hit. I am therefore submitting this paper to the NSW Inquiry both as a survivor of the bushfire attack on the New South Wales south coast and as an independent professional engineer and scientist. In addition, as a member of a local bushwalking club, I have spent many years exploring the forested areas around the south coast.
1.1 Causes and contributing factors	In recent months many claims have been made that the severe bushfires in 2019-2020 were caused by climate change resulting in more frequent and worse droughts which have led to this “unprecedented” season. Understandably, many who have been traumatised and suffered catastrophic losses in these bushfires seek to place blame on something or someone. In order to understand this issue, my objective has been to put some facts and evidence together in a common sense way that

	will allow people to better understand the nature and context of climate and bushfires. To do its job, the NSW Inquiry must first seek the answer to this question, which will naturally lead to the recommended solutions. My attached submission addresses this question and provides additional recommendation on how to improve our abilities to cope with future bushfire events.
1.2 Preparation and planning	The community was relatively well prepared to respond to a bushfire threat but the event which transpired was far larger and more destructive than what had been foreseen. The Eurobodalla Council made an outstanding effort to prepare the water and sewage systems which continued throughout to serve the community. The rapid preparation of evacuation centres before the fire hit was a major benefit to many people, both local residents and tourists in a time of desperate need. Our local MP Andrew Constance was incredibly helpful in getting things organised on short notice.
1.3 Response to bushfires	The evacuation centres staffed by RFS, Council staff and volunteers made a huge contribution to the welfare of so many people. But they could not accommodate everyone. Many preferred to stay at home, as I and my wife did, to assist in fighting the fires on our doorstep. As mentioned, the water supply continued to operate at full pressure without fail throughout the firestorm and beyond. Without it we could not have put out the hundreds of spot fires which threatened our home. The toll would have been many times worse without the water system. The sewage system run by pumps which were equipped by council staff with back-up diesel generators continued to operate reliably which allowed most local residents to shelter in place rather than be subject to a mass evacuation. Again, congratulations to the staff. However, the entire power and telecommunication systems failed from the start and were not restored for many days. The RFS with their VHF radio system could not reach their command centre from our neighborhood and the cell phone was completely down. This hampered the ability of the RFS to coordinate. Without power, the cell phone system went into back-up mode on batteries which provided almost no service, probably due to overloading, and completely failed within hours. The NBN internet and telephone system was down and the modems most people had to connect had no battery back-ups. The cell and internet systems are the primary communications services and people had no means to call for help. Nor did authorities have any means of continuing the alerts being sent out before the firestorm arrived. The local radio station also failed as did the TV broadcast service. This combined failure of power and telecommunications throughout was a very poor outcome indicative of a severe lack of emergency planning. Yet these failures could have been addressed through the application of simple fixes and common sense. The power poles were mainly of wood construction and many fell over after being badly burned. Application of a fireproof wrap around the bottom 2-3 metres would be an effective protection. The cell tower specifications need an urgent upgrade to require adequate back-up with full bandwidth capability for at least 48 hours, preferably 72 hours. The NBN system needs to build in power back-ups and network redundancy. None of this requires new technology nor are they hard to do.
1.4 Any other matters	My attached submission details my effort to substantiate the many claims that climate change causing drought was the primary cause of this "unprecedented" bushfire season. After researching BOM climate data and major bushfire records, I could not find any link between climate change and bushfire frequency or severity thus backing up the CSIRO's position and that of Andrew Pitman, head of the UNSW for Climate Extremes. However, I have first hand evidence to substantiate claims of a

	heavy build-up of combustible forest litter in the previous year. As a result of witnessing the extremely rapid spread of the fire front though the forested area along George Bass Drive directly behind my house within a matter of minutes, I have come to support the notion that a great deal of better preparation can be done by enlarging and properly maintaining fire breaks around populated centres. My submission contains photographs to back up this conclusion. Thank you for the opportunity to enable me to have my say.
Upload files	Submission-to-NSW-Independent-Bushfire-Inquiry-James-Taylor.pdf - Download File

Is Climate Change the Primary Cause of Australia's Bushfires?

Submission to the NSW Independent Bushfire Inquiry

By Dr James Taylor
2 April 2020

Introduction

On 31 December I came to face the full force of the firestorm as Batemans Bay suffered a direct hit. I am therefore submitting this paper to the NSW Inquiry both as a survivor of the bushfire attack on the New South Wales south coast and as an independent professional engineer and scientist. In addition, as a member of a local bushwalking club, I have spent many years exploring the forested areas around the south coast.

In recent months many claims have been made that the severe bushfires in 2019-2020 were caused by climate change resulting in more frequent and worse droughts which have led to this "unprecedented" season. Understandably, many who have been traumatised and suffered catastrophic losses in these bushfires seek to place blame on something or someone.

In order to understand this issue, my objective has been to put some facts and evidence together in a common sense way that will allow people to better understand the nature and context of climate and bushfires. To do its job, the NSW Inquiry must first seek the answer to this question, which will naturally lead to the recommended solutions.

I approach this task with a deep background in physics and mathematics (B. Eng Electrical (Hon), MSc Aero and Astro, PhD Aerospace Engineering). Over a long career, I have been heavily involved in both research and systems analysis for which I have used computer modelling extensively. I have no financial interests at stake on either side of the climate change debate other than wishing to see Australia's economy continue to prosper.

In this submission I aim to answer three key questions with research into Bureau of Meteorology (BOM) data and records of major bushfires. Below, I first present a summary of my conclusions followed by some background on climate and weather. Then I present the evidence that concerns both drought and bushfire occurrence followed by some recommendations of how we can better prepare to cope with future bushfire attacks.

Summary

1. Has climate change caused drought conditions to be more frequent or severe?
    - My review of 120 years of BOM records shows that rainfall, the most reliable indicator of drought, has in fact clearly increased since 1960, both for Australia in total and most states.
    - Very high year-to-year rainfall volatility dwarfs any effects that long term climate change, which involves only a few tenths of a degree every decade, could reasonably be expected to influence.
    - Furthermore, annual average temperatures along Australia's east coast, where much of our forest resources are located, vary as a function of latitude by more than the highest UNIPCC predictions for future warming. This happens without any catastrophic consequences for the population in the warmer, more northerly regions.

- BOM's excellent descriptions of the nature of various weather patterns, such as El Nino and the Indian Ocean Dipole, provide a far more credible explanation of highly variable rainfall patterns.

2. Are major bushfires caused primarily by drought?
   - While bushfires occur every year, major bushfires in terms of extent (hectares burned) and loss of life have occurred in 32 years out of the last 94 years.
   - At the national level, 10 years experienced extreme severity while 22 were rated as severe and no trends appear to sustain the claim that major bushfires are more frequent. The 2019/2020 season, rated as an extreme year at 8th out of 10, was not unprecedented.
   - It is noteworthy that 73% of extreme and severe bushfire years occurred at times of normal or above average rainfall. And 9 out of 15 years with below average rainfall did not experience major bushfires.
   - The data for NSW/ACT is very similar to the national figures. Only 7 of 18 major bushfires occurred in years of lower than average rainfall.

3. Are we in fact facing a catastrophe?
   - The BOM and bushfire data provides no evidence of change in Australian conditions and history which can be blamed on global climate change.
   - The severity of bushfires in some years and not others makes it necessary to look beyond a simple explanation of climate change causation. The amount of combustible vegetative litter accumulating in forested areas combined with cycles of wet and dry conditions has been identified by many as being associated with a higher risk of major bushfires.
   - My own first-hand observations of south coast forests in the last few years supports this notion. The rapid ignition through forest litter of the fire next to my own property certainly provided a lasting impression.
   - A focus on adaptation and precautions near populated areas to create adequate fire breaks appears to be the best approach to mitigating future risks. Combustible forest litter needs to be regularly and effectively controlled.
   - A lot can be done to create more resilient infrastructure. The fact that the Eurobodalla water system continued to provide full supply throughout the crisis was the key to avoiding a far larger loss in the community. The fact that the telecommunications infrastructure failed at the outset and continued non-operational for several days was a substantial factor hindering the RFS and public safety authorities in their efforts to safeguard the well-being of the public.

We are frequently told to "listen to the experts".
Andrew Pitman, head of the Centre for Climate Extremes at the University of New South Wales, stated in June last year that 'as far as the climate scientists know, there is no (direct) link between climate change and drought'.
In March at Senate Estimates, CSIRO scientists confirmed that "no studies explicitly attributing the Australian increase in fire weather to climate change" have been done.

The Nature of Climate Change and Weather

First, it is useful to review some of the features which define climate and weather. Climate is commonly defined as average weather conditions over a longer period, usually 30 years. The effect of rising CO2 in the atmosphere is predicted to be a long term increase in global temperature due to the greenhouse effect. However, other causes of global warming and cooling such as oscillations in the earth's orbit around the sun, solar output variations and long term geological shifts due to continental drift have been the subjects of research yet not included in the mandate of the UNIPCC which was restricted only to manmade causes.

Satellite-based measurements of the lower atmosphere, available since 1979, is the most reliable and accurate source for global temperature measurements due to its daily and uniform coverage across the entire planet with highly calibrated sensors. It indicates that over the last 40 years, global average temperature of the lower atmosphere is increasing by about 0.13 degrees C per decade.

UNIPCC reports issued since the early 1990s are based on many different computer models which have predicted ***future*** rises 2-4 times as much as actual satellite data – a difference that has led to much debate. Despite past over-estimations of global temperature increases, the UNIPCC continues to provide computer modelling predictions that outstrip the evidence. This is despite the fact that its own 2001 Third Assessment scientific report stated that "The climate system is a coupled non-linear chaotic system, and therefore the long term prediction of future climate states is not possible".

The issue of what is causing the rise in global average temperature has not been addressed satisfactorily. Climate change advocates tend to ascribe all global temperature increase solely to increasing CO2 in the atmosphere whereas others point to naturally occurring processes since the Little Ice Age ended in approximately 1850 as potential causes. Since the mandate of the UNIPCC was restricted to researching only anthropogenic causes, in this respect alone, it can be said "the science is definitely **not** settled".

It should be far better known in the media and political worlds that CO2's physical properties prevent it from occurring as anything except a gas on earth (liquid CO2 requires at least five times the atmospheric pressure at sea level and the solid form exists only at temperatures below -78.5 degree C). Hence CO2 emissions become well mixed within the atmosphere through gas diffusion to provide a fairly uniform concentration around the world. This is why ***CO2 is a global issue*** – no amount of emission control by one country will have any significant effect locally.

As far as toxicity is concerned, CO2 is a colourless and odourless trace gas which currently comprises just 0.04% of the atmosphere. CO2 is not toxic, quite the opposite. CO2 occurs at up to 10 times the current atmospheric concentration in enclosed spaces such as buildings, offices, subways and submarines without harmful effects. In fact, on the international space station NASA sets the level at 0.52%, about 13 times higher than in the atmosphere on earth.

Today's 0.04% concentration is just 4 molecules of CO2 for every 10,000 thousand molecules of air. Yet this 'trace' gas is the critical element of the carbon cycle which supports all life on earth. At CO2 concentration less than about 0.02% plants cannot perform photosynthesis to grow and animals cannot survive without plant life.

At the start of the Industrial Revolution in the early 1800s, CO2 was at about 280 ppm (0.028%) in the atmosphere, close to the level at which plant growth would cease. Yet large monetary prizes have been offered by uninformed billionaires to motivate inventors of machines capable of directly removing CO2 from the atmosphere – a doomsday weapon if ever there could be one!

In fact, augmentation of CO2 is widely used in greenhouses to aid plant health and growth. Using satellite imagery it has been estimated that increased concentrations of atmospheric CO2 in the last century (now at about 0.04%) has led up to a 15% increase in planetary biomass in the last 30 years, surely a benefit for life on the planet.

On the other hand, weather is primarily influenced by another potent greenhouse gas that is far more abundant in the atmosphere than CO2 – water vapour. Without it our weather would be rather boring, much like planet Mars, which has little free water, and our world would be very cold. An application of the Stefan-Boltzmann radiation equation indicates that without greenhouse gases earth's average temperature would be a freezing -18 degrees C instead of a much more pleasant +15 degrees C currently.

Unlike CO2, water vapour concentrations in the atmosphere vary from almost zero (in deserts) up to about 4% of the atmosphere when it becomes saturated and rain starts falling. On average it is estimated that global water vapour is about 1.5 – 2% of the atmosphere. Hence the concentration of water vapour is 50-75 times higher than CO2 at 0.04%.

With water vapour accounting for more than 98% of significant greenhouse gases (methane is present in far less quantities than CO2), it is by far the dominant effect on temperatures. If CO2 and water vapour had the same properties of greenhouse warming, it could be inferred that CO2's effect was at most about 0.66 degrees C. But water vapour is in fact a stronger greenhouse gas than CO2 making its contribution even less.

Water, unlike CO2, exists in the atmosphere in all three phases – liquid, solid and gas. It is constantly changing from one form to another absorbing and releasing huge energy differences due to its unusually large heat of vaporization (the amount of energy it takes to turn liquid to vapour – 2453 kJ/kg) and latent heat of fusion (the amount of energy it takes to turn ice into liquid – 333.5 kJ/kg). Only ammonia is larger.

Water vapour is massively generated all the time through evaporation from lakes and oceans – 71% of the earth's surface is water. Most importantly, it forms clouds composed of tiny water droplets (and sometimes crystals) which are highly reflective of solar energy and provide a negative feedback for surface temperatures. Cloud cover, particularly in the tropics, is what many scientists think plays a major role in regulating temperatures on earth.

Clouds also provide rainfalls which on a global scale exactly balance out the amount of evaporation. Failing to do so, the earth's global atmosphere would soon become fully saturated and completely cloud covered. But of course it does not. As a result of this massive evaporation/condensation process and global scale movements of clouds and air, water vapour never has the chance to become permanently diffused into the atmosphere. Hence it is a local and regional phenomenon that constitutes what we know as weather.

Water's unique physical properties drive the dynamics of weather, moving vast amounts of water and energy from place to place and creating employment for armies of meteorologists whose job is to help all parts of society with accurate forecasts of weather conditions. But what a challenge! The complexities of water behaviour in the atmosphere are so great that even supercomputers have difficulty forecasting detailed weather conditions for more than a few days in time. Here again is where the science most definitely is **not** settled.

The bottom line is that weather with all its complexities is what brings water to most places on earth to sustain life. It drives daily, monthly and yearly variations in temperature that are many times larger than those associated with long term climate warming, which includes the possible effects of CO2 increases.

Is drought becoming more common or severe?

Common sense indicates that higher temperatures and drought cause bushfire risks to increase. That is behind much of the media discussion in the last few months. But is climate change causing more frequent and more severe droughts?

Certainly a lack of rainfall, by definition, leads to drought. But temperature by itself does not do so. While the two parameters are often coincident, drought just does not occur when rainfall is plentiful, regardless of the temperature. Nevertheless, high temperatures hasten the drying process which leads to more flammable fuels on the ground when rain is absent.

The BOM's Climate 2019 report states that Australia's 2019 average annual mean temperature was 1.52 degree C above average – a record. Furthermore, 2019 national average rainfall was 40% below average (except for Queensland's northwest and northern tropics) – another record. Much of Australia was affected by drought last year which was especially severe in New South Wales, southern Queensland and parts of Victoria, South Australia and Western Australia.

On this basis, the key is to examine rainfall data while keeping in mind that temperature is a secondary aggravating factor. Science usually depends on laboratory experiments to confirm or disprove new hypotheses. With environmental science, it is not easy to create alternative environments on a scale to answer global climate change questions. Instead it is instructive to look at various locations on earth where conditions differ. Note that average temperatures are substantially warmer in locations closer to the equator. In fact, examination of the annual mean temperatures for seven coastal locations along the east coast of Australia where much of our forest resources are located provides an indication of how average temperature varies with latitude. Table 1 provides some BOM data for cities with low elevations above sea level.

Location	Latitude	Elevation	Min Temp	Max Temp	Mean Temp
	degree S	meters asl	degree C	degree C	degree C
Melbourne	37.8	31	10.2	19.9	15.05
Batemans Bay	35.8	11	10	21.8	15.9
Sydney	33.9	39	13.8	21.8	17.8
Coffs Harbour	30.3	5	14	23.4	18.7
Brisbane	27.5	38	15.7	25.5	20.6
Gladstone	23.9	17	18.1	27.4	22.75
Cairns	16.9	2	20.8	29.1	25.95

Table 1 BOM Mean Annual Temperatures Along the East Coast

Over a span of latitude equal to 20.9 degrees, the mean annual temperatures vary by 9.9C – substantially larger than any estimate predicted by the UNIPCC for the doubling of CO2 in earth's atmosphere. Between Melbourne and Brisbane the difference is 5.55C.

Are these differences indicative of a conclusion that bushfire risk in Queensland is catastrophically higher than Victoria? Are the bushfire seasons longer and more severe in Queensland? These differences dwarf the slow annual changes in global temperatures of a few hundredths of a degree C. What can be deduced from these observations?

The BOM, Australia's most respected environmental institution, is responsible for recording weather and climate data. It employs many scientists who provide excellent interpretations of weather related patterns and many of its scientists are also supporters of the global climate change narrative. Its website provides hard scientific data in many different forms and a wealth of information.

In Figure 1 from the BOM is Australia's national rainfall record for the last 120 years. The solid black line is BOM's running 11 year average to show the trend. Clearly, the national climate rainfall trend is higher, not lower. This directly contradicts the many claims that climate change is causing lower rainfall and more drought. But there is much more to this issue that requires understanding.

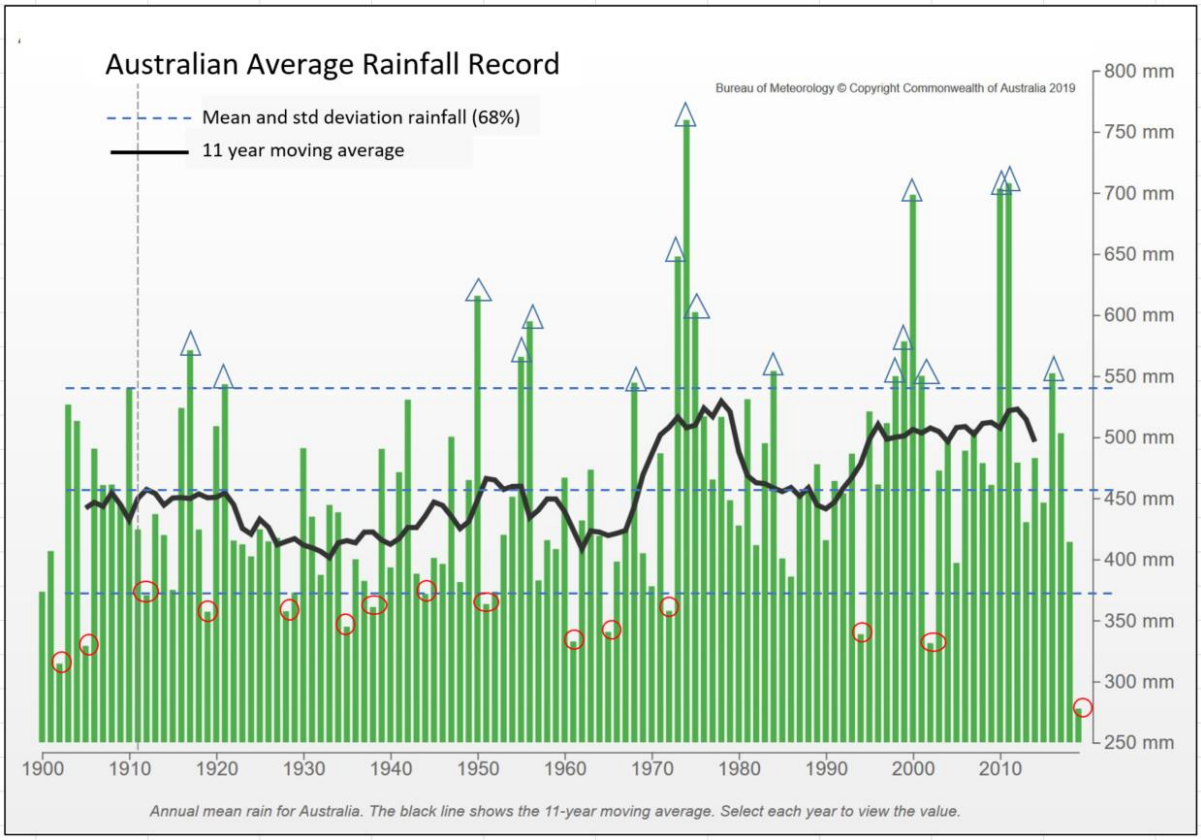

Figure 1 BOM Australian National Rainfall Record (Annotations added.)

The dotted lines added to the chart indicate the average over the last 120 years and the standard deviation, plus and minus, which is the most common indication of the variability in the data. (A standard deviation encompasses 68% of the data in a normal Gaussian probability distribution.) This defined band can be considered the "normal" fluctuations of year-to-year rainfall.

Some observations from looking at this chart are:

- BOM data over the last 120 years shows clearly that national annual rainfall is on an increasing trend; about 13% increase over the 120 year period indicated by the 11 year moving average.
- The frequency of lower than normal rainfall years was higher prior to 1960. Nine out of 15 very low rainfall years occurred prior to 1960; 6 occurred subsequently.
- In the last 60 years, higher than normal rainfall years have been more frequent. Twelve out of 17 very high rainfall years occurred since 1960; only 5 occurred previously.
- Although 2019 rainfall at -39% was exceptionally low, the second lowest year was 117 years ago in 1902 at -31%.

The good news is that almost every year of very low rainfall was followed by a year of normal or above average rainfall. Hopefully 2020, which has started off well, will continue to accumulate good rainfall. The previous very low rainfall year was in 2002, a 17 year gap before 2019's record low rainfall occurred.

However, these are national annual statistics. Australia is a large continent and the national pattern of rainfall does not apply equally to all regions. Figure 2 based on BOM data shows

the rainfall record for NSW and ACT where bushfire activity was especially severe in 2019/2020.

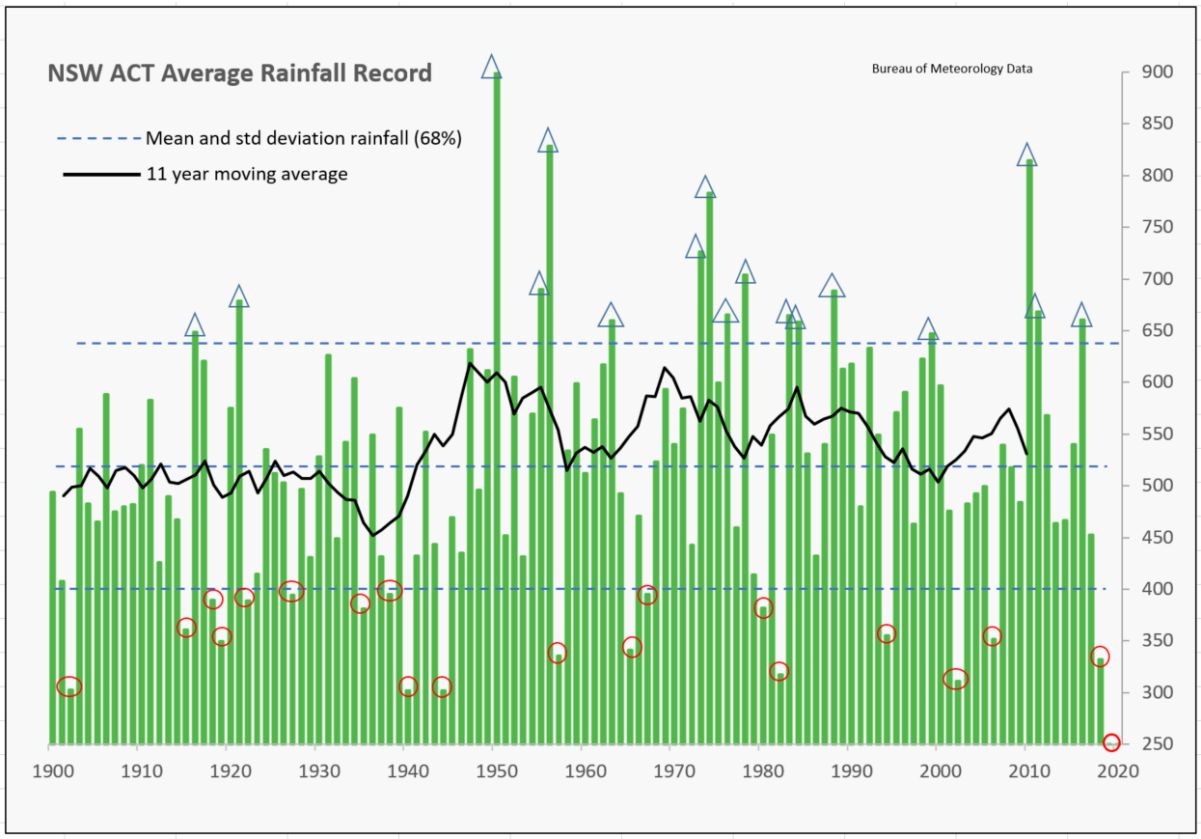

Figure 2 BOM NSW and ACT Rainfall Record (Annotations added.)

The standard deviation was 118 mm or about 22% of the average rainfall.

The NSW/ACT observations from this chart are similar to the national data:

- BOM data over the last 120 years shows clearly that NSW/ACT rainfall is on an increasing trend, about 10% over the 120 year period.
- The frequency of lower than normal rainfall years was only slightly higher prior to 1960. 11 out of 20 very low rainfall years occurred prior to 1960; 9 occurred subsequently.
- In the last 60 years, higher than normal rainfall years have been more frequent. 12 out of 17 very high rainfall years occurred since 1960; 5 occurred previously.
- Although NSW/ACT 2019 rainfall at -52% was a record low, the second lowest years were 1902, 1940 and 1944 at -42%. 1982 and 2002 were close to -40%.
- Furthermore 2018 was also a very low year at -36% which created an unusual two year record of very low rainfall which worsened NSW drought conditions.

To compare the variation of state data with variability in the national rainfall data over 120 years, a mathematical correlation process was performed on the rainfall data (a normalized cross correlation technique which produces 100% for identical variations and 0% for no similarity). The correlation results are in Table 2. NSW/ACT is about 70% similar to the national rainfall record while NT, QLD and SA are at or above 80%. All are very high scores. Tasmania is quite dissimilar, probably due to its location in the Southern Ocean which exposes it to a

significantly different pattern of weather. Victoria and Western Australia have moderately good similarity with the national rainfall data.

State	Normalised Cross Correlation
NSW/ACT	70.9%
Northern Territory	82.9%
Queensland	82.0%
South Australia	80.1%
Tasmania	13.7%
Victoria	48.3%
Western Australia	68.1%

Table 2 State Rainfall Similarity to National Rainfall

Some of our states are large enough on their own to have regions experiencing drought when the rest of the state may be receiving adequate rainfall. Western NSW is an example when compared to the state's coastal regions where most of the state's forested areas are located.

Conclusions: Climate warming due to CO2 would have longer term rather than shorter term patterns in the data. In fact it is plain to see from BOM 120 year data that the long term effect is increasing rainfall which should decrease the risk of droughts. Furthermore, short to medium term variations are very large and can only be related to the volatility caused by weather patterns.

BOM's website provides excellent explanations for several weather cycle patterns which are most probably driven by ocean current cycles. The well-known El Nino – La Nina cycle (the Southern Oscillation Index) over the Pacific is well correlated with droughts in Australia and typically last 1-3 years. The lesser known Indian Ocean Dipole is also described by BOM as having a major impact on our droughts. Another pattern is the Southern Annular Mode. More rarely, upper stratosphere warming above Antarctica (temperatures still well below 0 degrees C) has an effect on weather patterns in the Southern Hemisphere. BOM describes these weather patterns as subject to further research studies.

It is noteworthy to consider that in 2019 the Indian Ocean Dipole peaked at the same time as stratospheric warming over Antarctica occurred. And perhaps it is no coincidence that as soon as the IOD collapsed in early January, as announced by the BOM, the monsoonal rains started and we saw a major and sudden shift in weather patterns bringing welcome rains which ended most bushfires.

Are major bushfires caused by drought conditions?

The popular contention that drought results in bushfires is almost a truism that needs no discussion. But every year has localities with drought conditions for at least part of the year and some bushfires occur every year. The relevant question is what drives our major bushfire seasons where losses of life and property are tragically on a high scale.

In Figure 3, the BOM rainfall data for the nation, which is the primary indicator of the extent of overall drought conditions, is over-printed with a chart of major bushfire events over the last 94 years (since 1926) as documented in Wikipedia. Two factors, the total hectares burned and the number of lives lost were combined in a single index of severity, as expressed in the chart scale on the left, to make a comparison between years.

Major bushfires are broken into two categories, severe and extreme, depending on the severity index which shows the clustering of severe years towards the bottom of the scale.

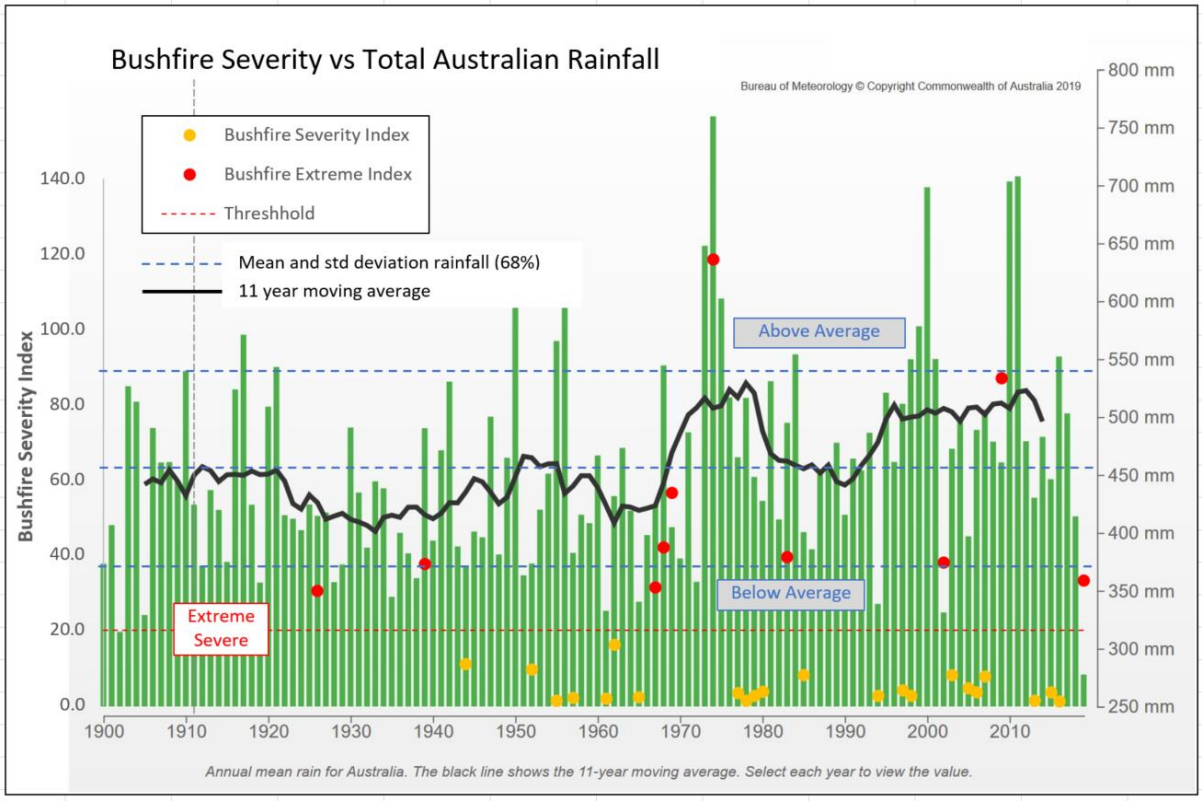

Figure 3 Australian Bushfire Severity since 1926 Related to Total Rainfall

Once again, expectations appear to be contradicted by the data. Some observations are as follows:

- Overall 73% of severe and extreme bushfire seasons occurred when rainfall that year was within normal or above conditions.
- In 15 years with significantly lower rainfall, 9 did not record major bushfire events.
- Of 10 extreme years since 1926, only two (2003 and 2019) occurred during years with lower rainfall than normal.
- With 1973 marking the halfway point in the bushfire data, half of the 10 extreme events occurred before that point and half since then.
- Of 22 severe bushfire years, only 4 occurred in years of below normal rains.
- Before 1973, 7 severe bushfire years were recorded; 15 happened afterwards.

These counter-intuitive results need some careful thinking about the nature of bushfires causation. There appears no trend in extreme bushfires occurring more frequently. Notably the extreme 2019 bushfire season ranked 8th out of 10th on the bushfire severity index. Yes, this was an extreme year; but it does not appear "unprecedented".

If there is any trend to the data, it is that severe bushfires may be occurring more frequently since about 1950 but records before that time may be incomplete. Since 1950 the data on severe bushfires appears fairly evenly spread out but that there does appear some clumping in the data since the mid-1970s on a 10 year repeat cycle.

Since global climate change is said to cause global scale disruptions it is curious that no indication of this is observed in annual Australian rainfall data which covers a large continental area. It is therefore difficult to support claims that climate change causes drought which leads to major bushfires.

Looking at New South Wales and ACT, a smaller area, similar data is presented in the chart in Figure 4.

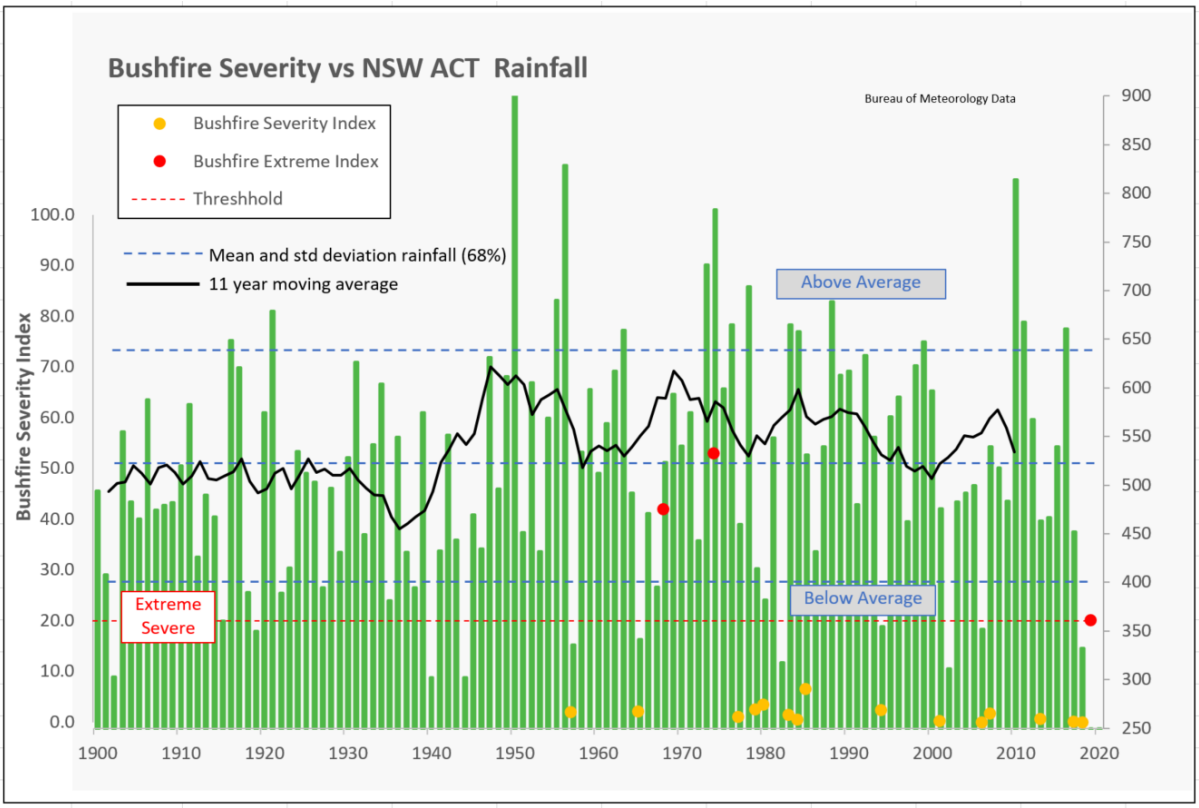

Figure 4 NSW/ACT Bushfire Severity since 1926 Related to Total Rainfall

Some observations are as follows:

- Of 18 years since 1926 when major bushfires occurred in NSW/ACT, only 7 coincided with below average rainfall.

- In 3 years of extreme bushfires (1968, 1974 and 2019), only 2019 occurred in years of below average rainfall and the other two occurred more than 46 years ago and were more severe in terms of the Bushfire Severity Index
- In 15 years of severe bushfires only 6 occurred in years of below average rainfall
- Eight of them occurred more than 33 years ago (1957 to 1985)
- There are no NSW/ACT major bushfires prior to 1950, perhaps due to incomplete records. The frequency of major bushfire years does not appear to have changed since 1950.

Clearly, severe and extreme bushfire seasons have occurred during years with rainfall anomalies below, within and above average in NSW/ACT. In fact 61% of severe and extreme bushfire years occurred during normal and above average rainfall. And 8 years out of 15 years with below average rainfall did not coincide with a major bushfire season.

These counter-intuitive results demonstrate that knee-jerk reactions in the media to blame bushfires primarily on CO2 driven climate change are quite dubious. A more nuanced approach to assessing bushfire risks is needed.

Are we in fact facing a catastrophe?

It is realistic to postulate that normal and above average rainfalls, which BOM records indicate have occurred more frequently since 1960, promote the growth of abundant vegetation in forested areas during successive seasons until combustible forest litter accumulates to hazardous levels.

When dry periods occur, low humidity conditions are set so that once a bushfire is ignited (for any reason) it results in a rapid spread and buildup to levels where firestorms form. Fires are sometimes driven by winds (often self-generated) to form fire fronts which can spread several kilometers through the air by burning embers to overwhelm most fire breaks which have been constructed.

While low rainfall years certainly contribute to overall drier conditions, it is also true that variations of weather patterns can also lead to periods of significant drying within almost any year and locally in some regions for longer periods. There is, therefore, the potential for major bushfires to occur in almost any year.

It is also realistic to say that elevated temperatures (often aided by high winds), which occur every summer, hasten the drying processes which lead to a more combustible fuel load in areas affected by low rainfall. Hence it is unsurprising that bushfires are a constant occurrence every year. Figure 5 shows some photos taken in February of typical forest litter in the unburnt Eurobodalla National Park in the NSW south coast; conditions which were common across the south coast in 2019.

However, major bushfire seasons imply extraordinarily large areas affected by fire and a severity which claims many lives. The slow rise in global temperatures, year-to-year, are miniscule compared to variations caused by weather patterns and by the effect of latitude.

Figure 5 Dry litter abounds in unburnt forest on NSW south coast

There is simply no data in BOM records at the national and state levels to indicate a gradual worsening of bushfire occurrence and severity that would be consistent with a gradually warming climate, regardless of its cause.

The conclusions indicated by this analysis are:

- Dry bushfire conditions are a regular annual feature of Australian weather patterns in the past and will be in the future.
- No evidence for increasing frequency or severity of major bushfires consistent with global warming has been found.
- The key determinant of whether a major bushfire event breaks out is most likely the buildup of heavy loads of combustible forest litter prior to the outbreak of a bushfire.

The abundance of combustible fuel combined with dry conditions in 2019 along the east coast of NSW, Victoria and parts of Queensland during the summer season, created dangerous conditions over a very large area. Once ignited, the bushfires were extremely active, often generating their own firestorm winds. In Batemans Bay the arrival of the firestorm on 31 December 2019 brought with it gusty winds several times stronger than those preceding it.

In Figure 6 the photos show the progress of the fire along George Bass Drive on the morning of the attack over a period of just 15 minutes. The movement of the fire front through the undergrowth was faster than the speed any person could run. Once the litter started burning, it was only a matter of minutes before it reached up into the trees.

Bushfires will continue to occur every year and occasionally some seasons will witness severe or extreme conditions. In the future, we will have to improve many ways of coping with and

abating the risks regardless of what Australia or the world does with respect to controlling CO2 emissions.

Figure 6 Firestorm progression on 31 December 2019 at Surf Beach, NSW

The one thing that saved countless properties from being destroyed was the reliability of the Eurobodalla water supply system, which continued functioning throughout the period without fail. Small teams of residents worked tirelessly for many hours putting out spot fires which could have ignited buildings. Without water this effort could not have been made.

Similarly, the council staff made extraordinary efforts to keep the sewage system running with back-up diesel generators installed on pumps and kept fueled. With a functioning sewage system the region was able to continue to shelter in place instead of requiring a mass evacuation.

The telecommunications and electrical power infrastructure was a different story. By 8 am on the morning of 31st December, all electrical power was cut and remained out for days. The cell phone system quickly degraded until it was a struggle to get even a short SMS message out. Telephones and the NBN collapsed as soon as the power went out. TV station broadcasts ceased. Only with an old battery powered AM/FM radio was it possible to pick up an ABC station in Shoalhaven Shire, a long distance to the north.

This is clearly inadequate at a time of emergency since the general population had no means to call for help or be informed by instructions from authorities. While the various evacuation centres provided extraordinary help to many thousands, they could not reach out to many more left in their homes.

The RFS units, when they arrived in the neighborhood, were unable to communicate with their headquarters either by their own VHF radio network or the cell phone system, thereby making coordination difficult.

These failures need to be addressed quickly.

- The power grid being reliant on wooden poles could be better protected by some form of insulation or fire shielding around the lower 2 meters of the poles.
- The battery back-up systems on cell phone towers need upgrading to specify a minimum period of at least 48 hours, preferably longer.
- The NBN system, being the primary core of the entire internet, is in need of power back-up for a similar period as the cell phone system. Individual modems need to be designed with built-in battery backup.
- Emergency radio broadcast facilities need strengthening.

Strong action needs to be taken with respect to the buildup of combustible forest litter that fuels major bushfires. It is clearly impossible in terms of person power and costs to regularly burn off the entire forested area of the country every few years. However, a strategy needs to be formulated, based on recommendations which have been made many times after similar bushfire events, to provide properly maintained fire break buffer zones.

- Restrictions placed by many governments on vegetation clearing of properties have hampered people from maintaining safe environments and need to be revised.
- Appropriate areas need to be identified as fire breaks around population centres and regular operations conducted to control forest litter buildup in them.

Through better preparedness and adaptation, we can improve our capability to cope with bushfire threats in the future.