Australian Bush Fires: Is Climate Change to Blame?

Rick Bradford, 27 December 2019

Contents

1. Introduction

The issue of bush fires is currently (in December 2019) topical as many fires rage near populated areas and several people have died. Inevitably there has been a vociferous insistence from some quarters that global warming / climate change is driving Australian bush fires to become worse. There have been calls to shut down Australian coal mines – because carbon is public enemy No.1 as regards global warming. But what are the statistics of Australian bush fires? I have examined the matter in some detail by analysing the raw satellite data, as described below.

2. Essential Background

Before getting into the details of the data analysis, there are some qualitative factors that are very pertinent.

2.1 Australian Bush Fires are Natural (Ecological)

There may be a naïve inclination to assume that all bush fires are damaging to the natural environment. This is untrue, especially in Australia. On the contrary, many native Australian flora have evolved to rely on bushfires as a means of reproduction, and fire events are an essential part of the ecology of the continent. Humans have probably increased the number of bush fires through deliberate action, but this has caused certain fire-loving species, e.g., eucalypts, to spread and prosper thereby.

2.2 Many Bush Fires are Started Deliberately

Depending upon which source you prefer, between 25% and 50% of all Australian bush fires are started deliberately (Romsey says 25%, Dr Janet Stanley says "close to half", and the Australian Productivity Commission says "*It is estimated that 50% of fires are either* *deliberately lit or suspicious in origin*”). Arson appears to figure large in this, though some fires are started for agricultural benefit. That such a large proportion of fires are started deliberately immediately complicates and renders problematic the claims of an increasing incidence of fires due to climate change. If the incidence of fires were increasing, how could an increasing incidence of fire-starting be ruled out as the explanation?

2.3 There Have Always Been a Huge Number of Bush Fires

How many bush fires would you regard as “a huge number”? I was surprised at just how many there are, perhaps around 52,000 per year across Australia. In view of the ecological significance of fires, their prevalence is actually rather fortunate (or do I mean “inevitable”?).

2.4 Risk is Not Prevalence

Figure 1 is a map of risk resulting from bushfires. The unwary may conflate risk with prevalence. But risk is actually the probability of an event (fire, in this case) times a measure of its adverse human impact (e.g., fatalities). Figure 2 shows that the risk map merely follows the population to a good approximation. But the vast majority of bush fires in Australia occur where the population density is extremely sparse or virtually zero (hence little risk).

Figure 3 shows the incidence of bush fires in Australia during 2018. The colour coding relates to month, not severity. Yellow is March, April, May and June; Blue is July, August, September and October; Red is November, December, January and February. The sparsely populated north and west-central Australia have the bulk of the bush fires. Figure 3 therefore bears no resemblance to Figure 1.

Figure 1*: Bushfire Risk Map (reproduced from Romsey)*

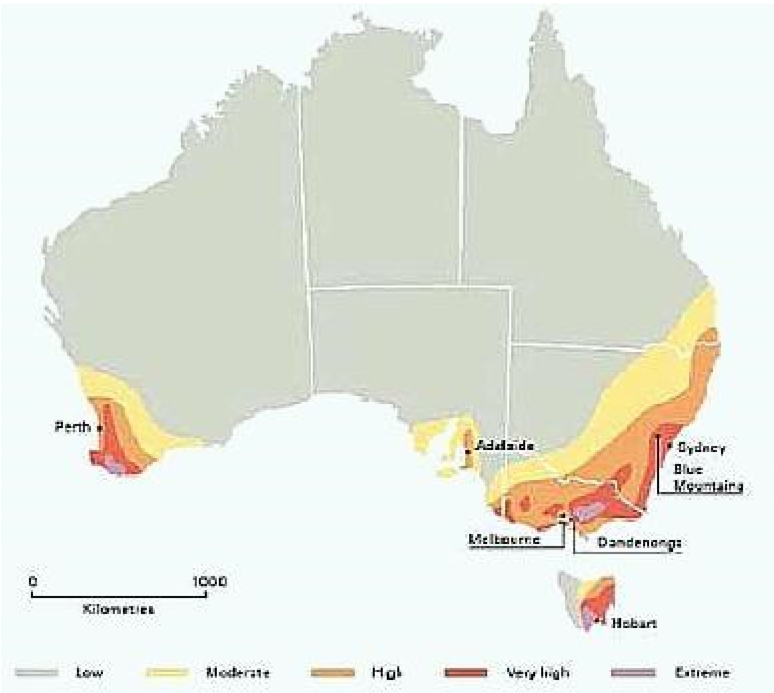
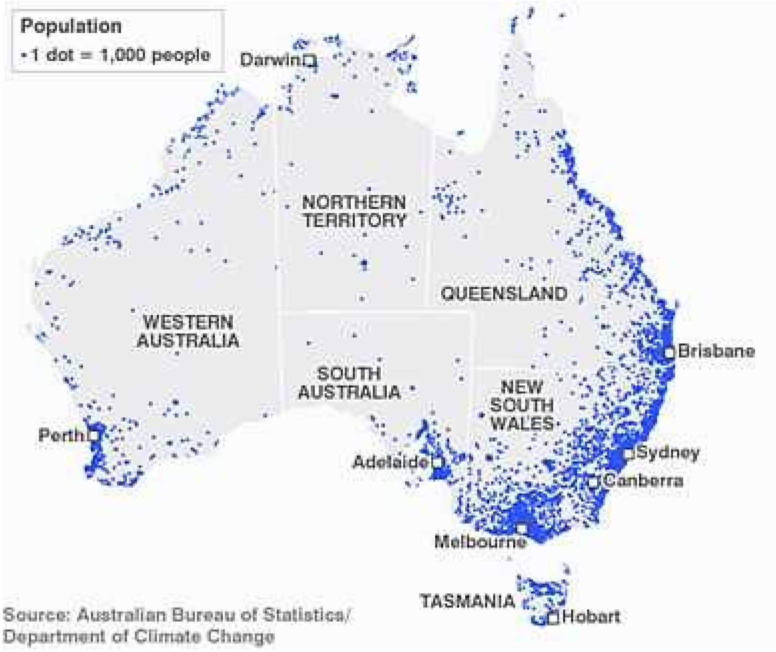


Figure 2: *Population Map*



2.5 Australia is Not the Worst Continent for Bush Fires

It is Africa which is the "fire continent" – see Figure 4 (which uses the same colour coding as Figure 3). The Thai Peninsula also has a high density of bush fires – and many parts of South America also (Figure 5). The rest of the world, other than Australia, will feature in a separate study.

I have created Figures 3, 4 and 5 using NASA's Fire Information for Resource Management System (FIRMS).

Figure 3: *Incidence of Bush Fires in 2018*

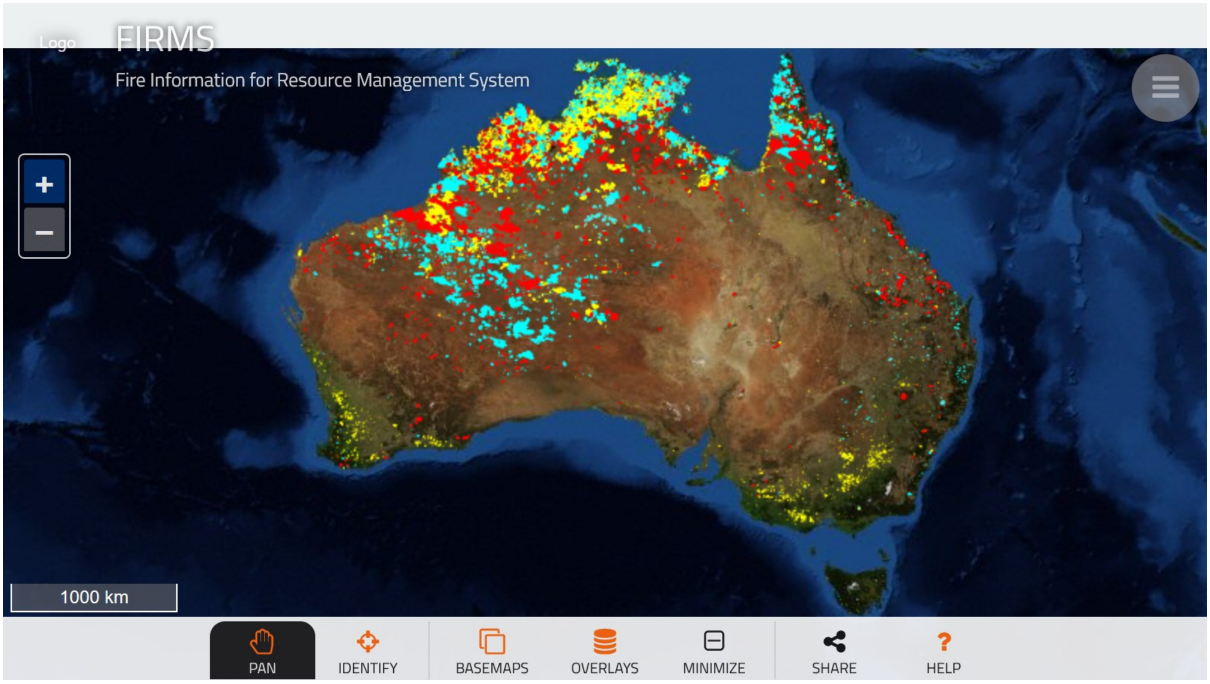


Figure 4*: Bush Fire Incidence, 2018, Africa, India, Thai Peninsula*

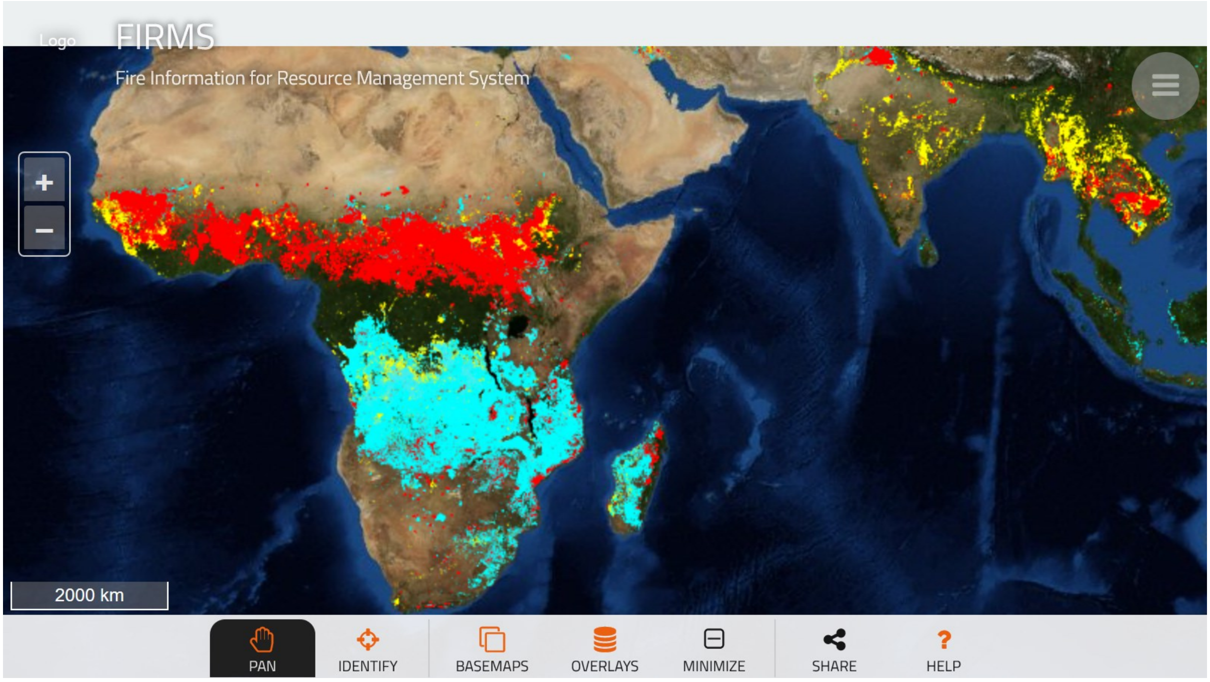
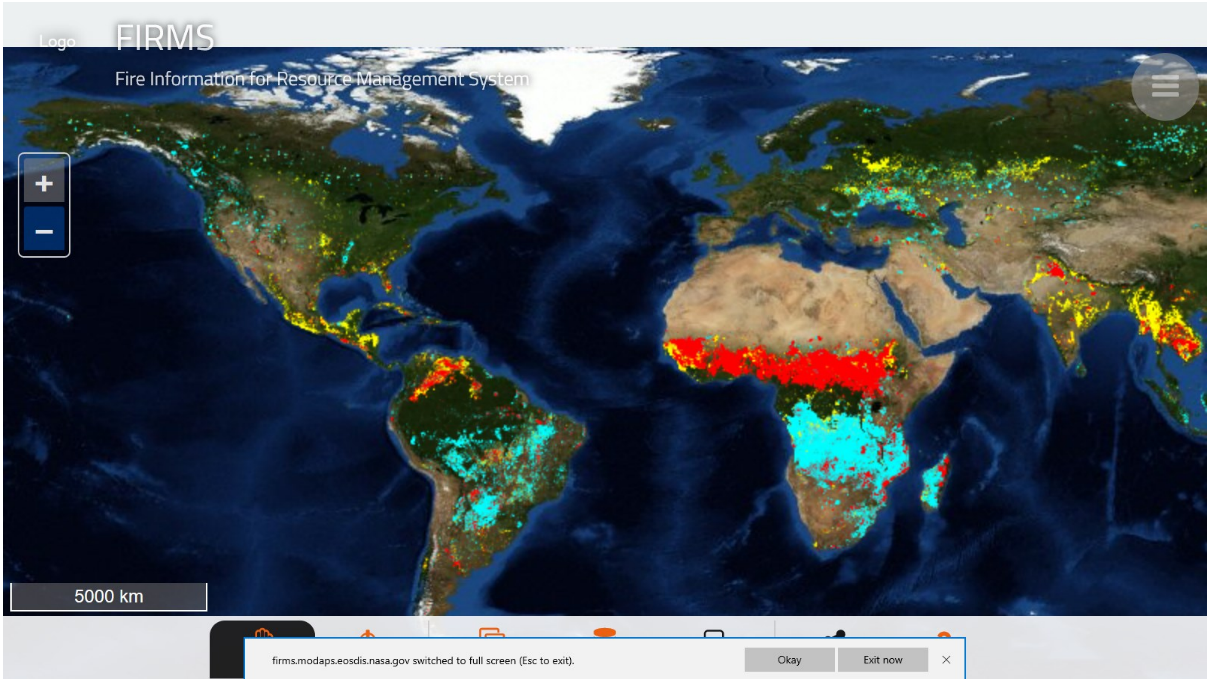


Figure 5*: Bush Fire Incidence, 2018, Including the American Continent and Europe*



3. Published Analysis of Australian Bush Fires

I will not attempt a literature review. However I came across this publication,

"*Big data integration shows Australian bush-fire frequency is increasing significantly*" by Dutta , Das and Aryal, February 2016, Royal Society Open Science,**3**:150241, https://doi.org/10.1098/rsos.150241.

Their conclusion was,

"*Our analysis also indicates that Australian weekly bush-fire frequencies increased by 40% over the last 5 years, particularly during summer months, implicating a serious climatic shift*."

A glance at the paper suggests a very sophisticated analysis. Yet the claim is that a huge increase in fire incidence has occurred in a very short time period. In fact, the authors only analyse fire data from 2007 to 2013, a seven year period. They do not state why they chose this period. Charitably one might assume that 2013 was the last complete year of data available when they started their analysis. But that does not explain why they started their analysis in 2007. The NASA dataset they deploy starts at November 2000.

I shall claim below that the very short (7 year) period analysed by Dutta et al is the reason for their result which I shall claim is incorrect – by using the same data source but over a longer time period (just over 19 years).

4. NASA Data to be Analysed

The data has been taken from NASA's MODIS system (MODerate resolution Imaging Spectroradiometer): https://modis.gsfc.nasa.gov/

The MODIS system employs two satellites: Terra and Aqua, which together map the entire globe "almost once per day". I have used the data release "MODIS C6 (Collection 6)" which is the most recent as of December 2019. Data has been collected from this system since November 2000 to the present on a consistent basis and hence this period of just over 19 years provides a good basis to examine trends. (An even longer time period would be preferable, of course, but the use of earlier data would involve a completely different hardware source with differing reliability and hence risk introducing apparent changes due to detector efficiency).

[NASA also have a higher resolution system, VIIRS, but this has provided data only since January 2012, so I have opted for the lower resolution system with the longer consistent period of data collection. I have not attempted to combine the two as the different resolutions would prejudice the consistency over the whole period since 2000].

The average pixel size within which fires are reported by MODIS is 1.71 km x 1.24 km (2.1 km^2) – this being specific to Australian latitude/longitude.

The size of fire that will be detected depends upon observing conditions. Fires of size 32m x 32m (i.e., 1000 m^2) will generally be detected, subject to cloud cover, but in ideal conditions fires as small as 7m x 7m (i.e., 50 m^2) might be detected.

Each line of the downloaded archive datafile represents an observation of a suspect fire in a given geographical pixel (identified by latitude & longitude). The datafiles include a confidence level for every potential fire observation between 0 and 100%, i.e., where the confidence is greater than 50% the observation is more likely than not to be a real fire.

The files I downloaded were specific to Australia alone.

The datafiles consist of 15 columns of data, and the whole dataset from November 2000 to December 2019 consists of roughly 5 million lines of such data. To reduce this to something manageable I have summed the fire observations and the fire powers by month. I have done this separately for (a) all recorded observations, (b) only observations with confidence >25%, and finally, (c) only observations with confidence >50%. I will report only (a) and (c) here as they turn out to be qualitatively very similar.

The last data entry was dated 26th December 2019, so the bush fires which have featured on media news programmes recently are included (up to that date).

Note that fires can be missed. This will happen if they start and burn out between passages of the satellites. Fires will also be missed if cloud cover, or foggy conditions, prevent them being seen by the satellite. Fires obscured by a non-burning forest canopy will also be missed. Consequently it cannot be assumed that the data derived from summing the fire observations at confidence levels >50% are necessary the most accurate. Actually, these will probably be lower bounds.

The total number of fire observations (i.e., the number of lines of data) is ***not*** the number of separate fires. This is because fire observations in adjacent pixels may be the same fire, which might extend over many pixels. Similarly, fire observations made on consecutive days may be the same fire. Consequently, each fire observation is best regarded as a "pixel-fire-instance" and relates to a particular ~2 km^2 of land and a particular day & time. Actually, this is a better measure of fire severity than merely the number of separate fires since the latter would fail to distinguish between large and small fires, and would also fail to distinguish between brief fires and fires persisting over many days or weeks. Consequently the total number of fire observations within a given month (i.e., the number of lines of data or "pixel-fire-instances") is a good measure of the severity of fires in that period, accounting for both spatial extent and duration.

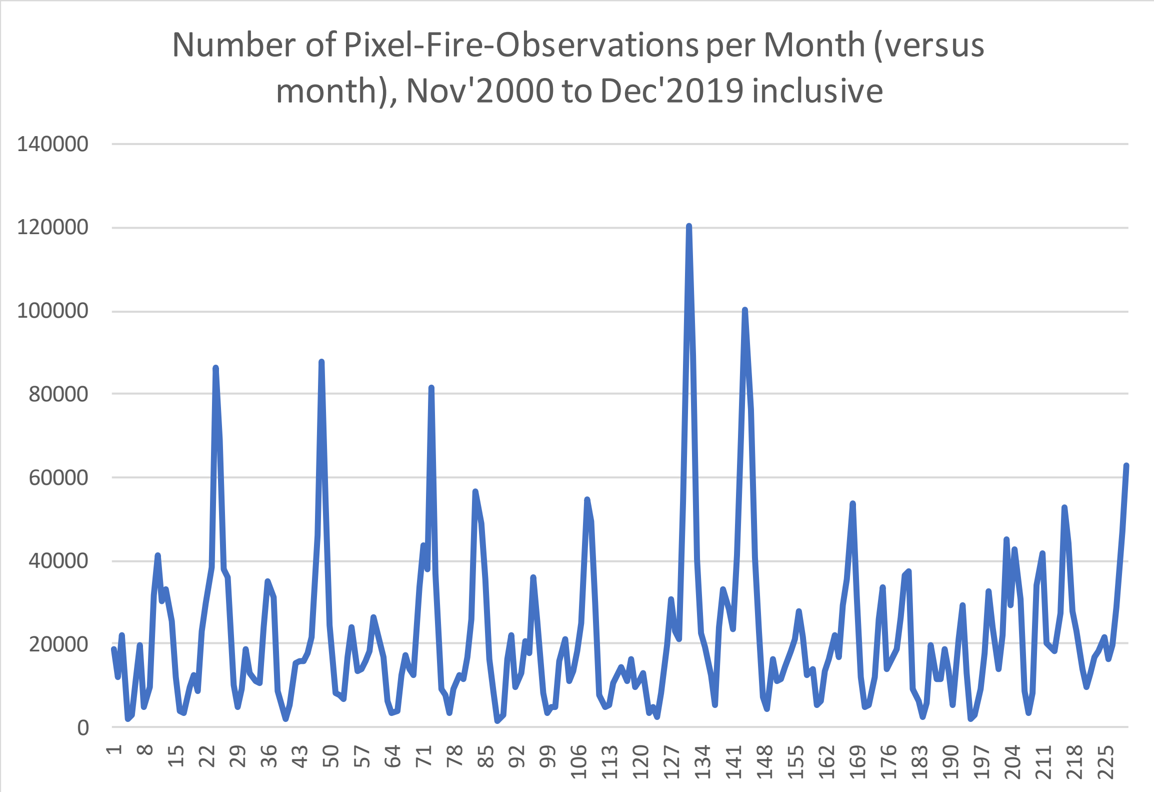
An even better measure is available as the datasets include an estimate of the power of each fire in MW, so the total MW of all fire observations in a given month can also be used as an indication of severity. Crudely, multiplying this total by 86,400 seconds (i.e., 1 day) will give the total heat energy released over the month in MJ. Since the total monthly power figure is of the order of millions of MW, the energy released over the whole of Australia will be of the order of hundreds of petajoules (~10^{17} J) per month.

5. My Analysis of the NASA Data

There is nothing sophisticated about my analysis. "Sophistication" can too often provide an opportunity for obfuscation and manipulation, rather than clarification. My analysis consists simply of linear regression to identify trends over the period covered, i.e., November 2000 to December 2019. Regression provides both a best estimate gradient for the data, and also the lower and upper bounds to this gradient at the 95% confidence level. The range of gradients between the lower and upper 95%CL levels defines the 90% confidence interval. If this confidence interval includes zero then there is no statistically significant trend at the 90% confidence level.

Figure 6 plots the total number of fire observations per month, against month, from November 2000 (month 1) to December 2019 (month 230). No overall trend is immediately discernible. However, fire incidence is clearly seasonal as the peaks and troughs in the graph occur at 12 month spacings.

Figure 6: *All Fire Observations per Month, All Data, Nov'2000 to Dec '2019*



Due to seasonal variations, in order to analyse trends it is necessary either, (i) to focus on a given calendar month, or, (ii) to sum the data over the whole year. Figures 7a-d plot the trend data on a month specific basis. Thus, Figure 7a plots separate curves for August, September and October, Figure 7b plots separate curves for November, December and January, etc. The Figures are plotted on the same scale so they are directly comparable. These graphs are based on the data for which the confidence of the fires is 50% or greater. It is clear that there are fewer fires in the six months February to July (Figures 7c,d) than the other half of the year.

At the best estimate level, four months have a downward trend (August, September, October and January), one is essentially flat (November), whilst the other months trend upwards. However, the months with the largest number of fires appear to be trending downwards. Because the trends for the individual months vary, this throws us back onto the annual data. Thus Figure 8 plots the fire observations per year, including only those at or above the 50% confidence level. The best estimate trend line has almost zero gradient.

Figure 8 also shows the lower and upper 95%CL gradient trends. **It is clear that the data do not display a statistically significant trend in fire observation incidence**.

Figure 7a: *Number of Fire Observations in August, September and October versus Year (>50%CL data)*

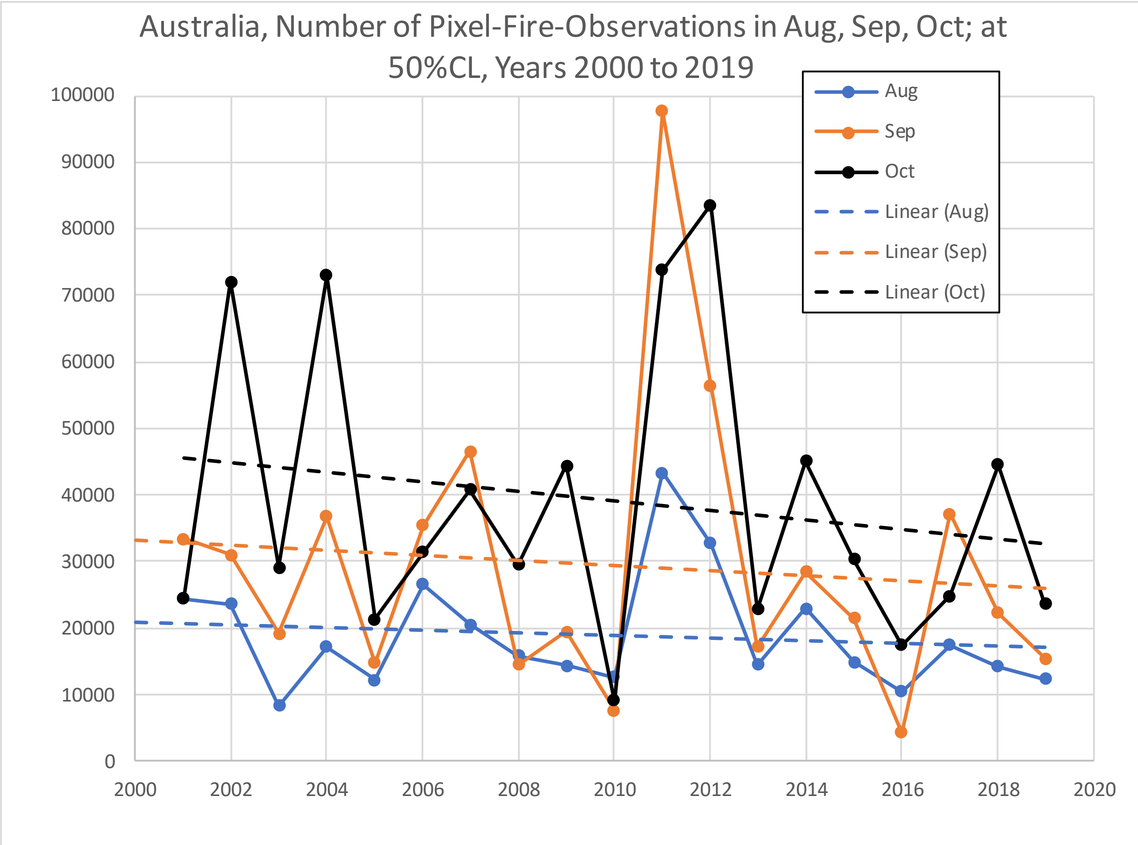


Figure 7b: *Number of Fire Observations in November, December and January versus Year (>50%CL data)*

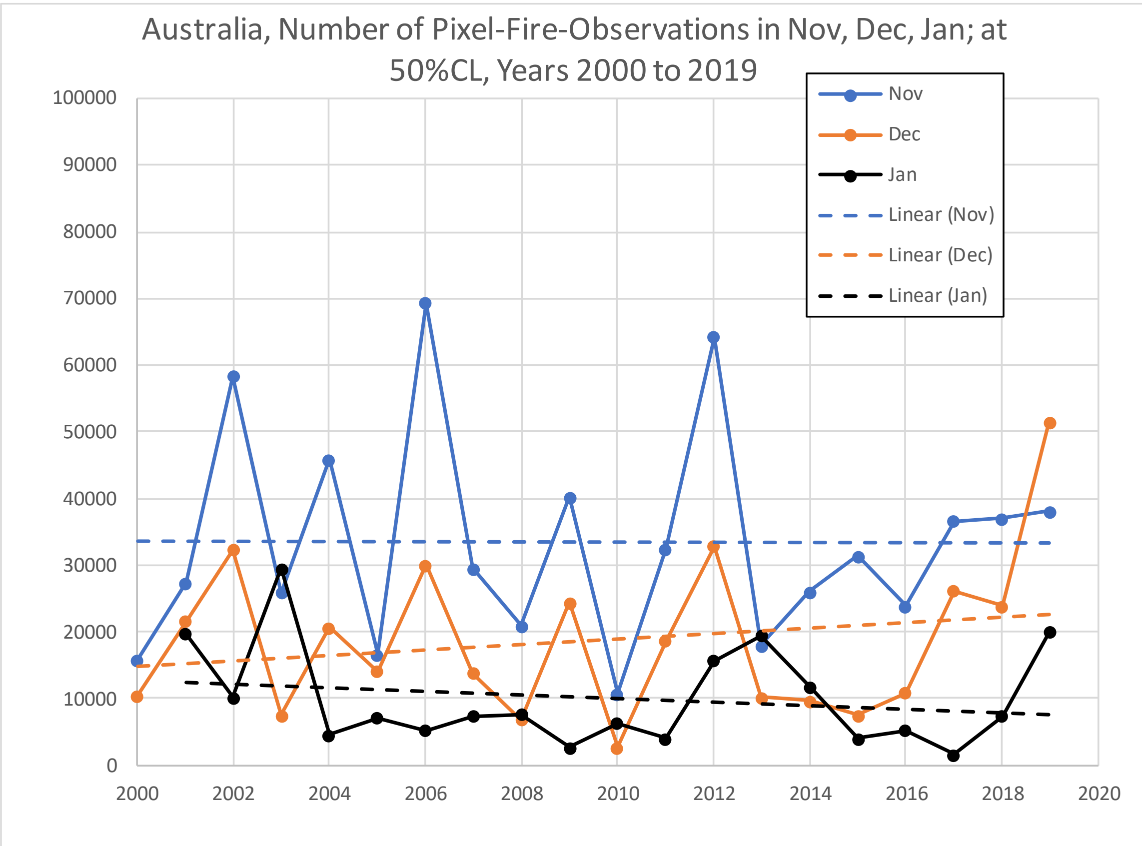


Figure 7c*: Number of Fire Observations in February, March and April versus Year (>50%CL data)*

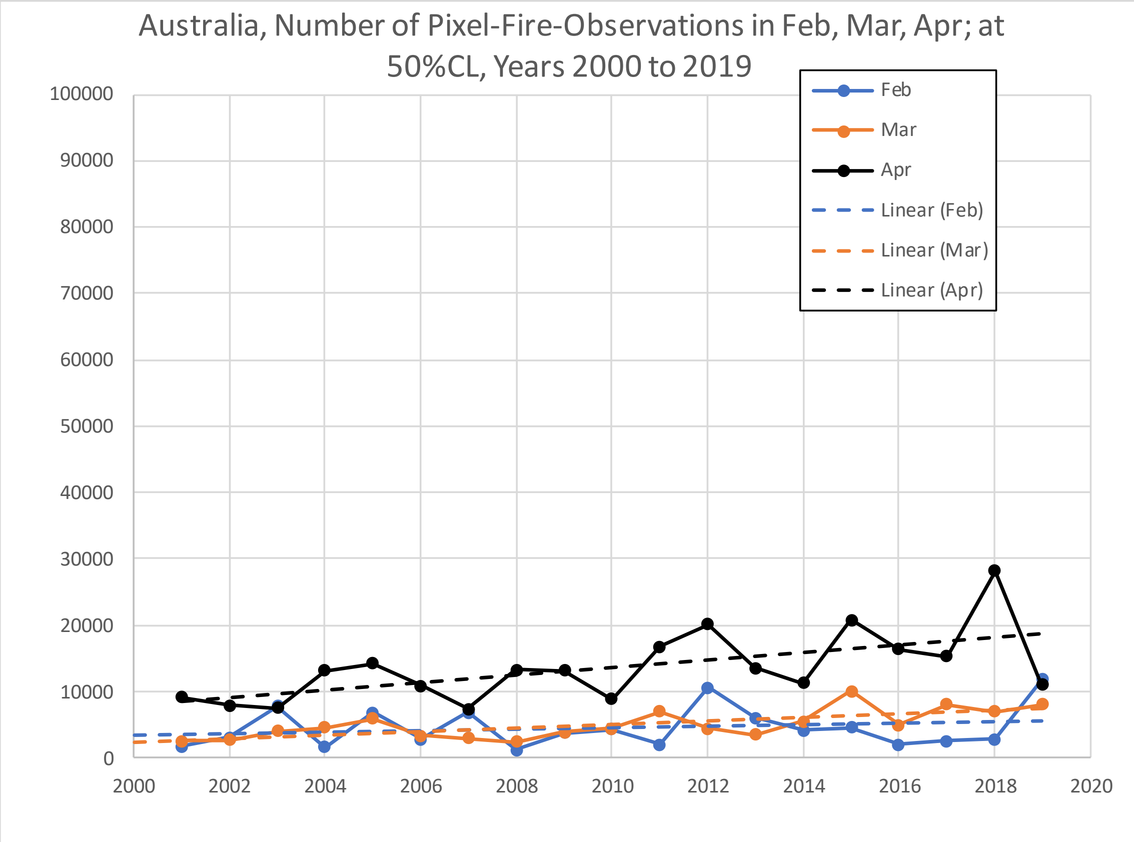


Figure 7d*: Number of Fire Observations in May, June and July versus Year (>50%CL data)*

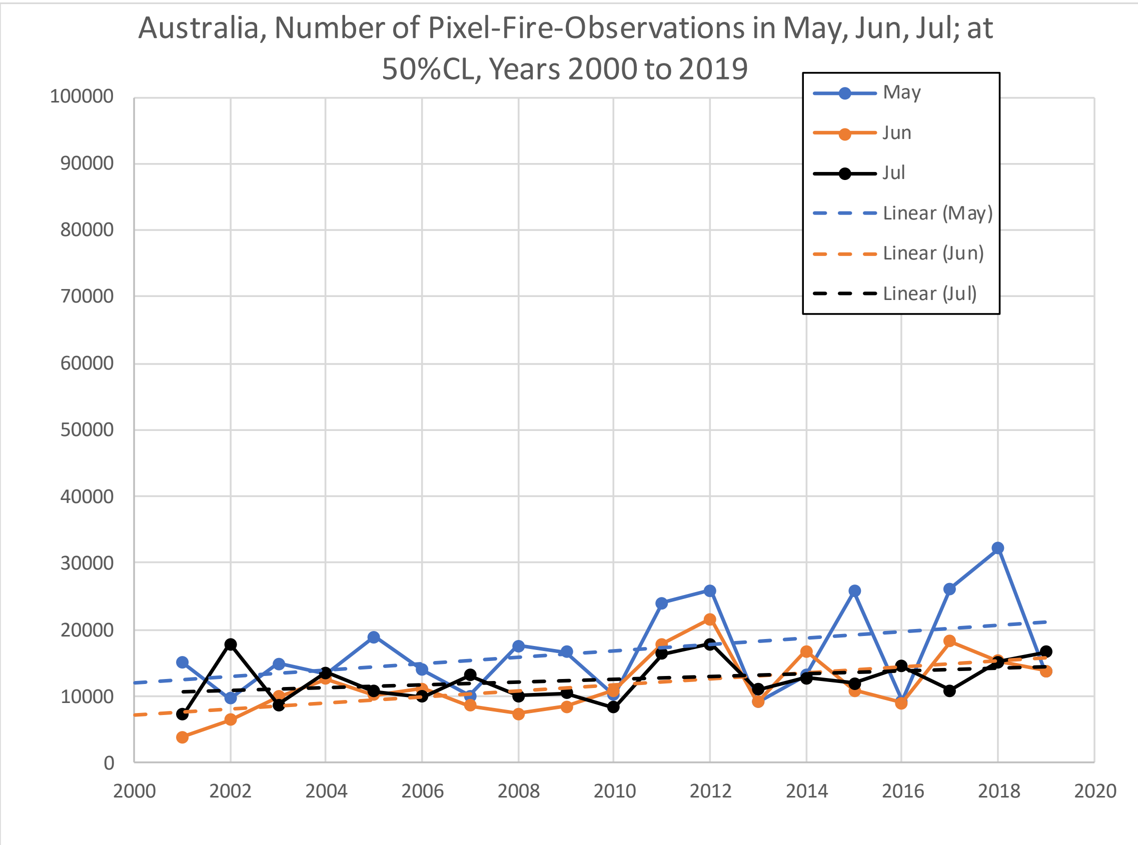


Figure 8*: Number of Fire Observations per Year (>50%CL data), Nov'2000 to Dec'2019*

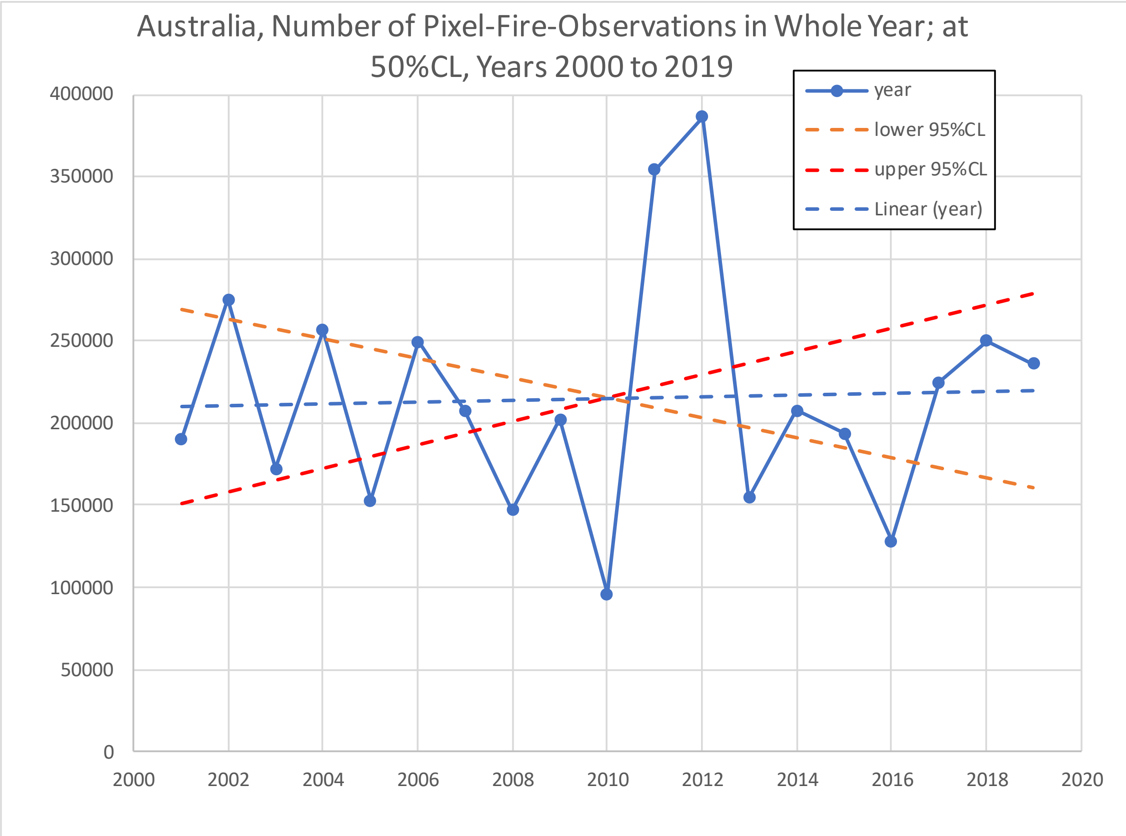
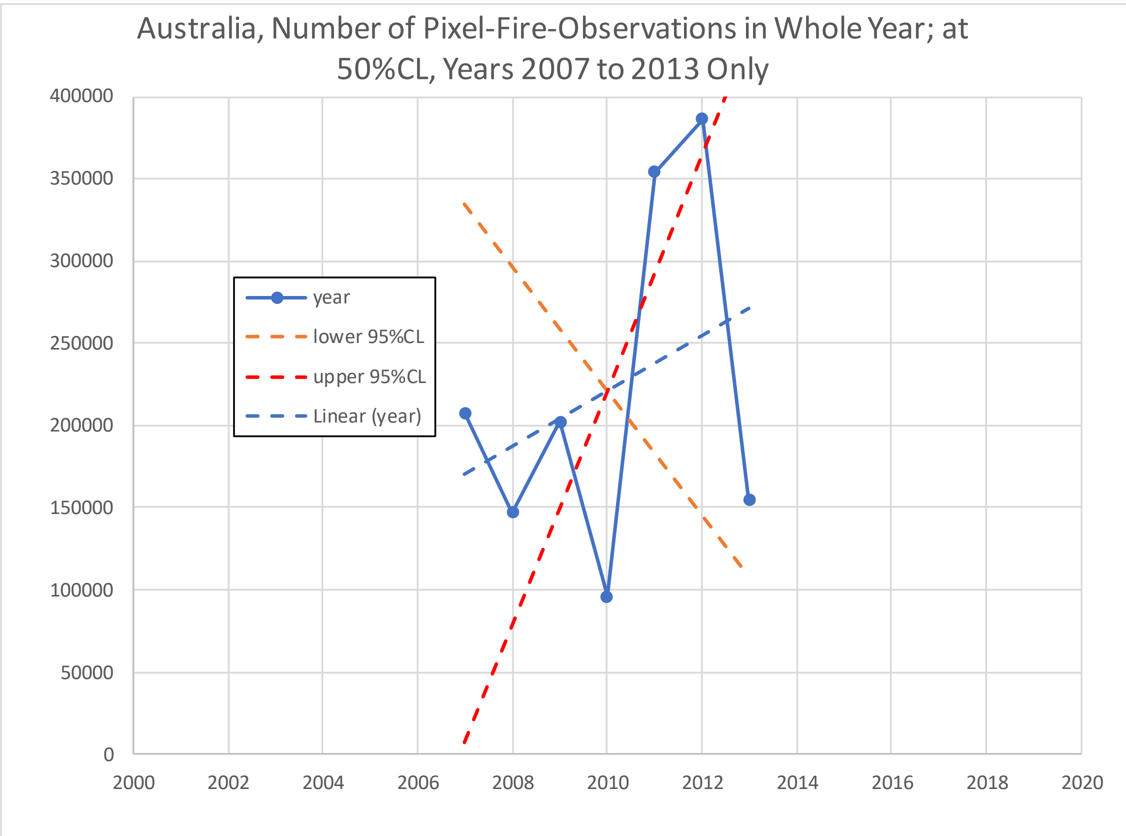


Figure 9: *Number of Fire Observations per Year (>50%CL data), Jan'2007 to Dec'2013*



5.1 Dutta et al's Error?

Figure 9 is exactly as Figure 8 except that the data has been confined to the seven years 2007 to 2013, inclusive. This is the same data range (and the same dataset!) as used by Dutta et al. This restricted dataset now displays an apparent large upward trend (blue dashed line). It is clear that the reason for this is that the restricted dataset happens to have some typical data followed by the two years 2011 and 2012 with larger than usual numbers of fire observations. This gives Figure 9 the appearance of a steep upward trend, but this is purely an artefact of the time period analysed. Figure 8 shows this spurious "trend" disappears when all 19 years of data are used. This explains, I believe, Dutta et al's result.

The inadequacy of using only 7 years of data is obvious from Figure 9 without the need for sophisticated analysis. However, regression bears this out. The lower and upper trend gradients indicate an enormously wide 90% confidence interval, easily encompassing zero despite the apparently large best estimate trend. So my simplistic analysis would have rejected Dutta et al's claims even if I had used the same, limited, 7 year dataset.

Remarkably, Dutta et al seem to have carried out no statistical significance checks on their claimed "40% increase in bush fire frequencies" over 5 (or 7?) years. This is despite the word "significant" appearing in the title of their paper. The title of their paper would appear to be the opposite of the truth: bush fire frequency is not indicated to be increasing significantly, even based on their short 7 year dataset.

5.2 Further Analyses

Rather than confining attention to data where the fire-confidence is at least 50% we may simply use all the recorded data. Doing so results in graphs which are qualitatively very similar to Figures 7a-d and Figure 8, merely being displaced to slightly larger numbers.

We can also use the fire energy data. Hence, Figures 10a-d plot, for each calendar month, the total MWdays per month against year. They are qualitatively very similar to Figures 7a-d. Figure 11 plots the annual total MWdays against year. Like Figure 8 the best estimate trend is essentially zero. The lower and upper bounds on the gradient easily encompass zero. Hence the conclusion using the energy data is the same: **the data does not display a statistically significant trend.**

6. Conclusion

Australian bush fire data does not indicate a statistically significant trend over the last 19 years and hence provides no evidence for a climate change effect, contrary to repeated claims.

The analysis of Dutta et al appears to be incorrect due to elementary failings of significance.

Figure 10a: *Total Fire Energy in August, September and October versus Year (All Data)*

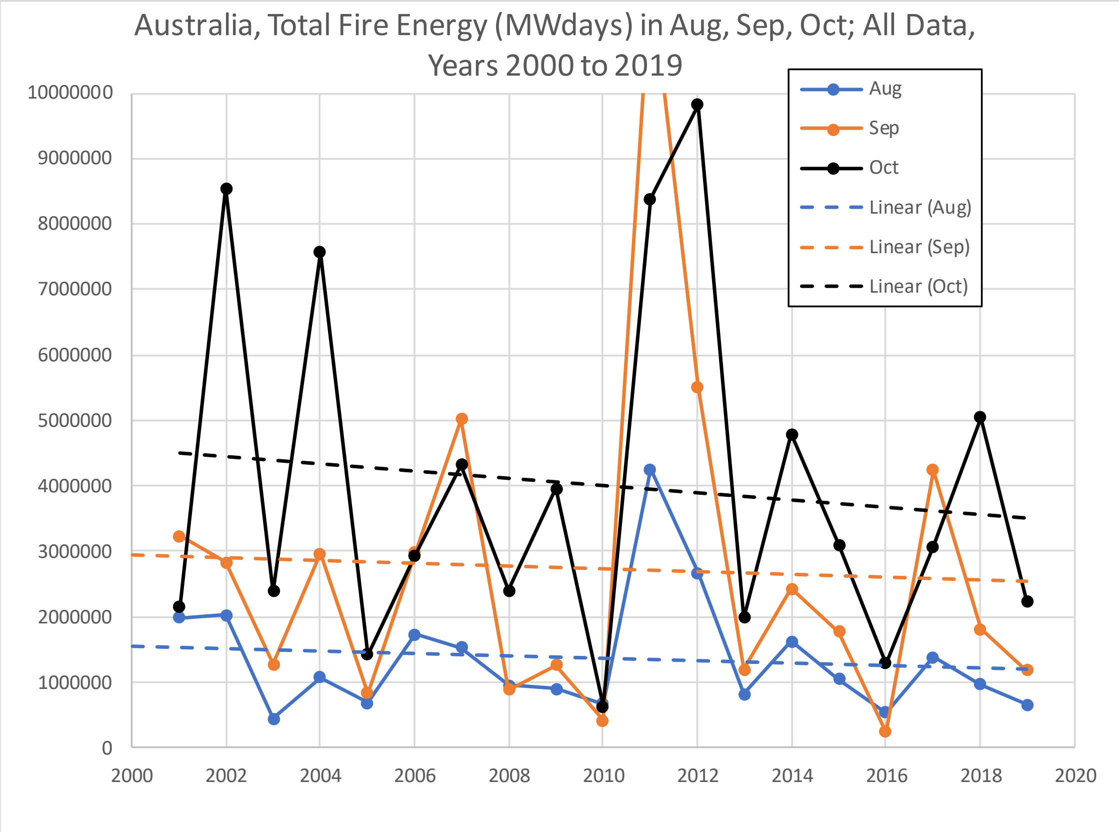


Figure 10b: *Total Fire Energy in November, December and January versus Year (All Data)*

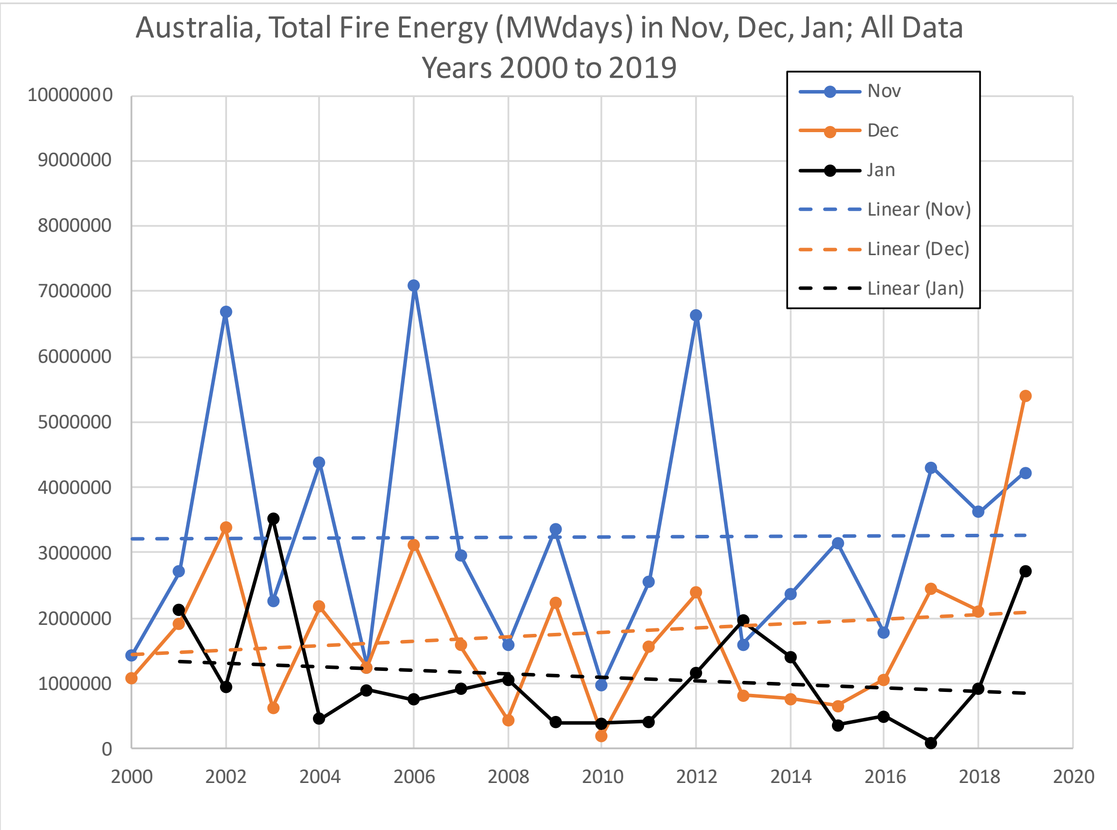


__Figure 10c__: Total Fire Energy in February, March and April versus Year (All Data)

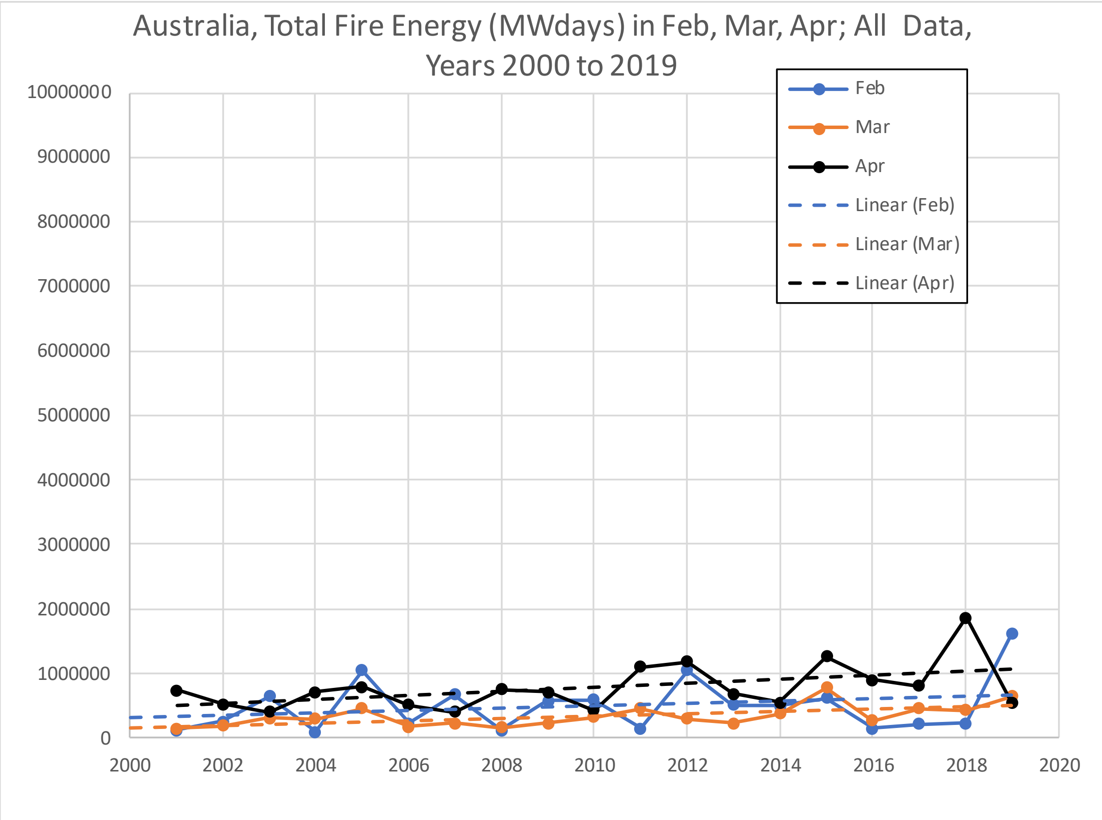


__Figure 10d__: Total Fire Energy in May, June and July versus Year (All Data)

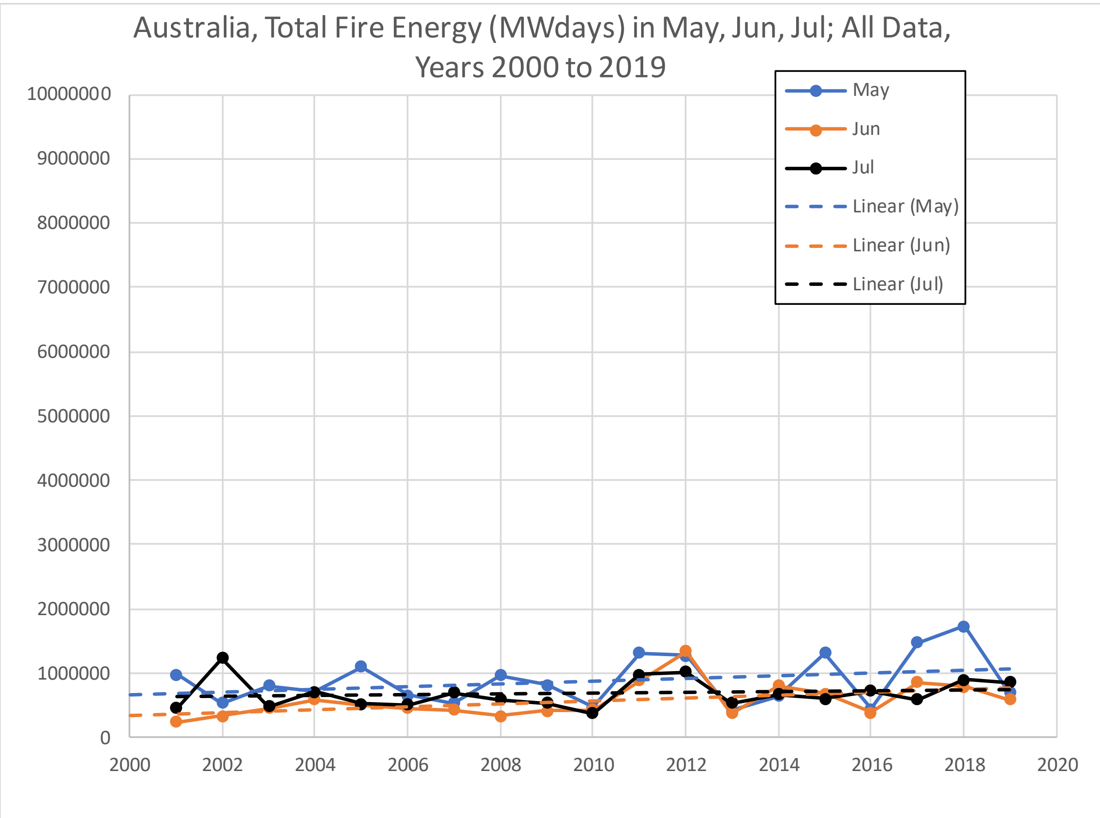


Figure 11: *Total Fire Energy in Each Year (All Data)*