Submission to the Senate Inquiry on recent trends in, and preparedness for, extreme weather events

By Dr Andrew Glikson

Earth and paleo-climate scientist
Visiting Fellow, Australian National University
Honorary Professor, University of Queensland

Summary

Summary

Given the failure of the global community to date to control and mitigate carbon emissions, the frequency and scale of extreme weather events, including droughts, heat waves, fires, floods and hurricanes, can only increase, posing severe existential risks around the globe and in Australia. A rise in the frequency of bushfires and floods is observed in Australia from 2007. Further to emergency measures, this calls for restructuring of elements of Australian agriculture, industrial and transport systems. The Australian continent is in particular danger from: (1) Heat waves and fire-storms affecting gum forests originally adapted to mild Mediterranean conditions; (2) prolonged droughts in agriculturally productive regions; (3) Major floods related to enhancement of the hydrological cycle, in particular along the eastern and southeastern seaboards but also in the interior, and (4) Hurricanes in northeast and northwest Australia. With temperature rise projected toward +4^{o}C later in the 21st century, urgent attempts at mitigation and preparations for rescue and adaptation are imperative. This requires:

Mitigation: Abrupt decrease in carbon emissions coupled with attempts at atmospheric CO2 draw-down, since the present level of 397-400 ppm is generating amplifying feedbacks, including sea ice and land ice melt, methane release and fires.

Emergency measures: Advance preparation for enhancement of rescue services vis-à-vis fire, flood and hurricane events require major increase in the budgets of the SES, fire-fighting, ambulance and hospital emergency services, and training of military personnel in rescue operations..

Adaptation: development of flood and storm retaining walls along rivers and beach fronts, drought-proof agricultural systems, application of ‘water-from-wind’ technology, solar-powered desalination plants, self-sustained drip agriculture and long-range water pipelines from well watered regions for irrigation and water storage.in drought-prone areas, encouragement of small-scale market gardens and domestic food production.

Given the current pace and scale of extreme weather events, time is of the essence;

1. Global warming and extreme weather events

Weather extremes events occur at the high and low ends of the climate variability range, where a limited change in the mean climate parameter, mainly temperature, may ensue in large change in the frequency of events such as drought, fire, flood or hurricane. The rise in land and sea temperature ensues in heat waves, droughts, increased evaporation and thereby precipitation, floods and cyclones.

The rise in mean global temperatures of +0.9°C since 1750 has involved a rise in the mean global land temperatures of +1.5°C [1], as represented by NASA, NOAA, Hadley and Berkeley data sets (Figure 1). Further potential warming is deduced from the mean elevated energy levels of the atmosphere of +3.1 Watt/m2, which translates to +2.3°C, of which about 1.1°C is masked by sulphur aerosols (Figure 2), consistent with the IPCC AR4 values (Figure 3).has led to a shift in temperature distribution (Figure 4) and to a 2 to 3 fold increase in the frequency of extreme weather events (Figures 5 - 7). The linear nature of global warming trends projected by the IPCC since 1990 [2, 3] tended to give the public and policy makers the impression as if sufficient time remains for economies to mitigate climate change through conversion from carbon-emitting industries to non-polluting utilities. However, as is shown below, this impression lulls societies into a false sense of security

Paleo-climate records display abrupt shifts in state of the atmosphere/ocean/cryosphere system, in particular as observed in the ice core records of the last 800,000 years, suggesting high climate sensitivity to changes in radiative forcing, whether triggered by solar insolation or by changes in concentration of greenhouse gases. In some cases marked changes were triggered over periods as short as centuries or decades [4] and in some instances in a few years [5]. Examples of abrupt climate shifts are the 1470 years-long Dansgaard-Oeschger intra-glacial cycles triggered by solar signals amplified by ocean currents and the 'younger dryas' and ~8.5 kyr cold intervals triggered by ice melt water and collapse of the North Atlantic Thermohaline Current [4].

The scale and rate of the rise in atmospheric energy levels, in particular since the 1970s (Figure 1), is expressed by an intensified hydrological cycle, heat waves and hurricanes around the globe [6 - 9], consistent with projections of future tipping point [10]. Between 1900 and 2000 the ratio of observed to expected extremes in monthly mean temperatures have risen from ~1.0 to ~3.5 [6]. From about 1970 the Power Dissipation Index (a parameter which combines storm intensity, duration, and frequency) of North Atlantic storms increased from ~1.0 to ~2.7-5.5, in accord with tropical sea surface temperatures which rose by about 1.0 degree Celsius [6].

Coumou and Rahmstorf [8] state: "*The ostensibly large number of recent extreme weather events has triggered intensive discussions, both in- and outside the scientific community, on whether* *they are related to global warming. Here, we review the evidence and argue that for some types of extreme — notably heat waves, but also precipitation extremes — there is now strong evidence linking specific events or an increase in their numbers to the human influence on climate. For other types of extreme, such as storms, the available evidence is less conclusive, but based on observed trends and basic physical concepts it is nevertheless plausible to expect an increase*."

Hansen et al. (2012) [11] analyzed the distribution of anomalous weather events relative to the 1951–1980 base line, displaying a shift toward extreme heat events (Figure 4). The authors observe: "*hot extreme[s], which covered much less than 1% of Earth's surface during the base period (1951-1980), now typically [cover] about 10% of the land area. It follows that we can state, with a high degree of confidence, that extreme anomalies such as those in Texas and Oklahoma in 2011 and Moscow in 2010 were a consequence of global warming because their likelihood in the absence of global warming was exceedingly small*."

The consequences for the biosphere of accelerating climate change are discussed by Baronsky et al. (2012) [12] in the following terms: "*Localized ecological systems are known to shift abruptly and irreversibly from one state to another when they are forced across critical thresholds. Here we review evidence that the global ecosystem as a whole can react in the same way and is approaching a planetary-scale critical transition as a result of human influence*." and "*Climates found at present on 10–48% of the planet are projected to disappear within a century, and climates that contemporary organisms have never experienced are likely to cover 12–39% of Earth. The mean global temperature by 2070 (or possibly a few decades earlier) will be higher than it has been since the human species evolved*." [12].

At 400 ppm CO2 the committed climate conditions of more than +2^{o}C have reached levels which last existed in the peak Pliocene epoch (5.3-2.6 million years ago), triggering an increase in extreme weather events, as evidenced by reports by the World Meteorological Organization (Figure 5) and Munich Re-Insurance (Figures 6). Current trends in the frequency and intensity of extreme weather events are evident in the USA [14] (Figures 6 and 7). An increase in the

The relatively stable climate conditions which allowed farming and thereby the rise of civilization are being increasingly compromised by the release of more than 560 billion ton of carbon (>560 GtC) into the atmosphere since 1750, when the total original carbon level was ~590 GtC.

2. Perspectives from the USA

The position of much of the USA between the warm pool of the Gulf of Mexico in the south and the Greenland-Labrador sub-Arctic zone in the renders the continent susceptible to extreme weather events, as documented in NOAA's site "Weather-Ready Nation" http://www.nws.noaa.gov/com/weatherreadynation/
http://www.ncdc.noaa.gov/cmb-faq/globalwarming.html
An overall rise in the frequency of meteorological events, hydrological events and climatological events in the US is recorded by Munich Re-Insurance, from a total of less than 60 during 1980-1988 to mostly above 100 during 1987 – 1994 to near-200 from 2006 (Figure 6). A corresponding rise during 1910-2010 in the 5-10 years moving average climate extremes index is shown in Figure 7. An increase in Atlantic Basin hurricane intensity is shown in Figure 8, A list of extreme weather events in the US in 2012 is given in Table 1, including 248 deaths and $119 billion.

Billion-Dollar U.S. Weather Disasters of 2012 (from AON Benfield)

Location	Dates	Event	Damage	Deaths
Northeast	Oct 29	Hurricane Sandy	*$62 billion*	131
Midwest	Jun - Oct	Drought, heat wave	*$35+ billion*	??
Midwest, Southeast	Mar 2 - 3	Tornadoes, severe weather	*$4 billion*	41
Midwest	Apr 28 - 29	Tornadoes, severe weather	*$4 billion*	1
Midwest, Mid-Atlantic	Jun 28 - Jul 2	Derecho, tornadoes	*$3.75 billion*	28
Midwest, Northeast	May 25 - 30	Tornadoes, severe weather	*$2.5 billion*	0
Gulf Coast	Aug 26 - 31	Hurricane Isaac	*$2 billion*	41
Texas, New Mexico	Jun 11 - 13	Severe weather	*$1.75 billion*	0
Midwest, Plains, SE	Apr 13 - 15	Tornadoes, severe weather	*$1.75 billion*	6
Colorado, Wyoming	Jun 6 - 7	Severe weather	*$1.75 billion*	0
Texas	Apr 2 - Apr 4	Hail, severe weather	*$1.3 billion*	0

Table 1.
Extreme weather events, USA 2012
http://thinkprogress.org/tag/extreme-weather/

3. Effects on Australia

The report “More Extreme Weather” (2008) [13], states: “*Australia is a naturally dry continent, which has been subject to periodic droughts throughout human history. One of the biggest questions for Australia is whether climate change will cause an increase in the severity, duration, frequency or distribution of droughts. CSIRO modeling suggests that the incidence of drought in some areas could triple by 2070, based on scenarios using different levels of carbon dioxide emissions. If accurate, such predictions indicate dire challenges for Australia's agricultural sector. However, CO2 concentrations are not the only factor in determining Australia's climate. The effects of the El Niño-Southern Oscillation (ENSO) on Pacific Ocean circulation and sea surface temperature, and variability in the Southern Annular Mode, which brings the rain-bearing westerly frontal systems across southeastern Australia, are key determinants of rainfall over the continent. Whether and how these phenomena might vary in a warmer world is currently the subject of intense research.*”

Records of droughts, Australian bushfires and floods are given in Appendices I, II and III. The Australian continent has undergone significant warming during 1970-2011, at rates of up to 0.2^{o}C per decade (Figure 9). A list of major bush fires in Australia during 1851 – 2011 (Appendix I) and of major floods during 1806 – 2012 (Appendix II) indicates **a sharp increase in the frequency of major bushfires and major floods from 2007 (**Figure 10), representing an increase in climate variability and extremes at that stage.

Factors driving extreme weather events include:

1. Rising temperatures in central Australian regions, where mean temperatures have increased by up to 1.2^{o}C during 1970-2011 (Figure 9).
2. An intensified hydrological cycle and thereby increased evaporation and precipitation in the southwest Pacific and the ocean off northern Australia, originating floods and cyclones during La-Nina periods.
3. Intense El-Nino periods (positive Indian Ocean Dipole [IOD]) result in droughts, where the drying of vegetation renders the land susceptible for bushfires. http://journals.ametsoc.org/doi/abs/10.1175/JCLI3332.1, http://www.abc.net.au/science/articles/2009/03/25/2525580.htm
4. Subsequent La-Nina events (negative IOD), which involve anti-cyclone wind flow southeastward toward southeast Australia, warm and dry on passage over the continent, leading to events such as the Victorian Black Saturday bushfires, 7 February 2009. http://journals.ametsoc.org/doi/abs/10.1175/JCLI3332.1
5. http://www.abc.net.au/science/articles/2009/03/25/2525580.htm

6. Southward migration of the high-pressure ridge over central and Western Australia associated with the pole-ward migration of climate zones related to global warming, leads to increased droughts and fires in southwest Australia.

In a comprehensive report titled "Australian climate and weather extremes: past, present and future"(Nicholls, 2008) [15] states, among other:

"*Trends in Australian temperature and precipitation extremes have been examined extensively (e.g. Suppiah and Hennessy (1996, 1998); Plummer et al., (1999); Collins et al., (2000); Haylock and Nicholls, (2000); Manton et al., (2001); Griffiths et al., (2005); Nicholls and Collins (2006); Gallant et al., submitted). Nicholls et al., (2000) examined Australian trends in a wide variety of climate extremes and concluded that:*

1. *The number of weak and moderate tropical cyclones observed has decreased since 1969 which, although consistent with changes in the Southern Oscillation Index, may be partly caused by changes in the observational system;*
2. *The number of intense tropical cyclones has increased slightly since 1969;*
3. *Windiness in the eastern Bass Strait has fallen, while it has increased slightly in the western Bass Strait, since the early 1960s;*
4. *There has been a strong decrease, since 1910, in the intensity of rain falling on very wet days, and in the number of very wet days, in the south-west of the continent;*
5. *There has been a strong increase in the proportion of annual rainfall falling on very wet days in the north-east;*
6. *No clear trend has emerged in the percentage of the country in extreme rainfall (drought or wet) conditions, since 1910, although Burke et al., (2006) reported an increase in the Palmer Drought Severity Index in southwestern and eastern Australia from 1952-1998;*
7. *There is a downward trend in frequency of cool nights, with some evidence of an upward shift in frequency of warm nights (since 1957);*
8. *There is some suggestion of an increase in frequency of warm days since the mid-1970s; and*
9. *No clear trend exists in the frequency of cool days.*

Projections of global extreme weather and climate events by Nicholls 2008 are in Table 2.

A rise in Australian insurance costs related to global warming has been reported "Australia's insurance losses to climb as globe warms: Munich Re"[16]. Citation: "*During 1980-2011, there were 820 "loss events" from weather, claiming 1100 lives and costing $US20 billion in insured losses, Munich Re said, citing 2011 dollar values. The increase in damage related to weather was on par with Asia and behind only North America, where they had risen five-fold to account* *for half the $1 trillion in worldwide weather catastrophes between 1980 and 2011, the company said."*

Nicholls (2008) [15] concludes: "*Can we blame climate change for the extreme southern Queensland heat-wave of February 2004, or for other extremes? The attribution of a single event to climate change might never be possible, because almost any weather event might occur by chance, in a climate unmodified by human behavior as well as in a changed climate. However, the risk of specific extreme events occurring (e.g. a heat-wave) may be changed by human influences on climate. Recently, the first attempts to determine whether any changes in extremes could be attributed to human interference with the atmosphere have been reported. Stott et al., (2004) investigated the extent to which climate change could be responsible for the high summer temperatures in Europe during the summer of 2003 over continental Europe and the Mediterranean. They concluded that it is very likely that human influence had more than doubled the risk of a regional scale heat-wave like the 2003 event. This was a study of a regional-average of summer mean temperatures. The first attempts at attributing changes in extremes based on daily data (rather than extremes of seasonal means) have also been undertaken. Christidis et al., (2005) analyzed a new gridded dataset of daily temperature data (Caesar et al., 2006) and detected robust anthropogenic changes in indices of extremely warm nights, although with some indications that the model overestimates the observed warming of warm nights. Human influence on cold days and nights was also detected, although less convincingly."*

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of discernible human influence on observed trend[b]		Likelihood of future trend based on projections for 21st century using SRES scenarios
			D	
Warmer/fewer cold days/ nights over most land areas	Very likely[c]	Likely[e]	*	Virtually certain[d]
Warmer & more frequent hot days/nights over most land areas	Very likely[d]	Likely (nights) [e]	*	Virtually certain[d]
Warm spells / heat waves. Frequency increases over most land areas	Likely	More likely than not[f]		Very likely
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely	More likely than not[f]		Very likely
Area affected by droughts increases	Likely in many regions since 1970s	More likely than not	*	Likely
Intense tropical cyclone activity increases	Likely in some regions since 1970	More likely than not[f]		Likely
Increased incidence of extreme high sea level (excludes tsunamis) g	Likely	More likely than not[f,h]		Likely[i]

Table 2.

Trends, attribution and projections of extreme weather and climate events. Only extremes for which there is evidence of an observed late 20th century trend are included. Thus, cold spells and small-scale weather phenomena for which there are insufficient studies for assessment of observed changes are not included in the Table. Asterisk in column headed "D" indicates that formal detection and attribution studies were used, along with expert judgment, to assess the likelihood of a discernible human influence. Where this is not available, assessments of likelihood of human influence are based on attribution results for changes in the mean of a variable or in physically related variables, on qualitative similarity of observed and simulated changes, combined with expert judgment. Likelihood terminology: "very likely" means >90% probability, but <99%; "likely" means >66% but <90%; "more likely than not" means >50% (from Solomon *et al*., 2007). Nicholls, N., 2008. Australian climate and weather extremes: past, present and future. Report for the Department of Climate Change.
www.climatechange.gov.au/~/media/.../science/weather-extremes.pdf

4. Mitigation and adaptation

Given the failure of the global community to date to control and mitigate carbon emissions, the frequency and scale of extreme weather events, including droughts, heat waves, fires, floods and hurricanes can only increase, posing severe existential risks. Further to emergency measures, this calls for restructuring of elements of Australian agriculture, industrial and transport systems, including the following:

A. Construction of levies along rivers flowing through major population centers, such as the Brisbane, Yarra, Torrens and Swan rivers.

B. Construction of retaining storm walls along vulnerable beach-front sections.

C. Further development of Australia's Special Emergency Service and Fire brigade capabilities, including training of army and police forces for disaster relief.

D. Construction of long-range conduit and pipe systems for channeling water from well-watered and flooded regions to drought-stricken regions, such as from northeast Queensland to the Murray-Darling Basin and from the Kimberley to southwestern Australia.

E. Construction of solar-powered water desalination plants along coastal regions.

F. Application of 'water-from-wind' plants in agricultural areas and around small towns http://en.wikipedia.org/wiki/Atmospheric_water_generator, and 'air well' structures http://en.wikipedia.org/wiki/Air_well_(condenser) allowing water for domestic use and for drip irrigation.

G. Enhanced development of drip irrigation such as has been, and continues to be used, in the Middle East and other desert regions for growing vegetables http://en.wikipedia.org/wiki/Drip_irrigation

H. Encouragement of and subsidies (such as in the form of reduced rates) of small-scale domestic gardens for vegetable and fowl cultivation to allow a degree of self-sufficiency in food production.

References

[1] Berkley Earth surface temperature http://berkeleyearth.org/
[2] http://www.grida.no/publications/
[3] www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf
[4] Broecker, W., 2006. Global and Planetary Change 54, 211–215
[5] Steffensen et al., 2008. http://www.sciencemag.org/content/321/5889/680.abstract
[6] Coumou and Rahmstorf 2012.
http://www.nature.com/nclimate/journal/v2/n7/full/nclimate1452.html
[7] http://www.pnas.org/content/early/2012/07/30/1205276109.abstract
http://www.climatecentral.org/news/hansen-study-extreme-weather-tied-to-climate-change-14760/
[8] http://www.realclimate.org/index.php/archives/2012/08/extreme-metrics/
[9] http://www.csiro.au/science/adapt-extreme-weather
[10] http://www.pnas.org/content/105/6/1786.abstract
[11] Hansen et al. (2012) http://www.pnas.org/content/early/2012/07/30/1205276109.abstract
[12] Approaching a state shift in Earth's Biosphere.
http://www.nature.com/nature/journal/v486/n7401/full/nature11018.html
[13] More Extreme Weather
http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/Browse_by_Topic/ClimateChange/theClimate/moreExtreme
[14] Natural Disasters in the United States, 1980 – 2011.
http://www.ritholtz.com/blog/2011/10/natural-disasters-in-the-united-states-1980-%E2%80%93-2011/
[15] Nicholls, N., 2008. Australian climate and weather extremes: past, present and future. A report for the Department of Climate Change.
www.climatechange.gov.au/~/media/.../science/weather-extremes.pdf
[16] http://www.smh.com.au/business/carbon-economy/australias-insurance-losses-to-climb-as-globe-warms-munich-re-20121027-28bxa.html

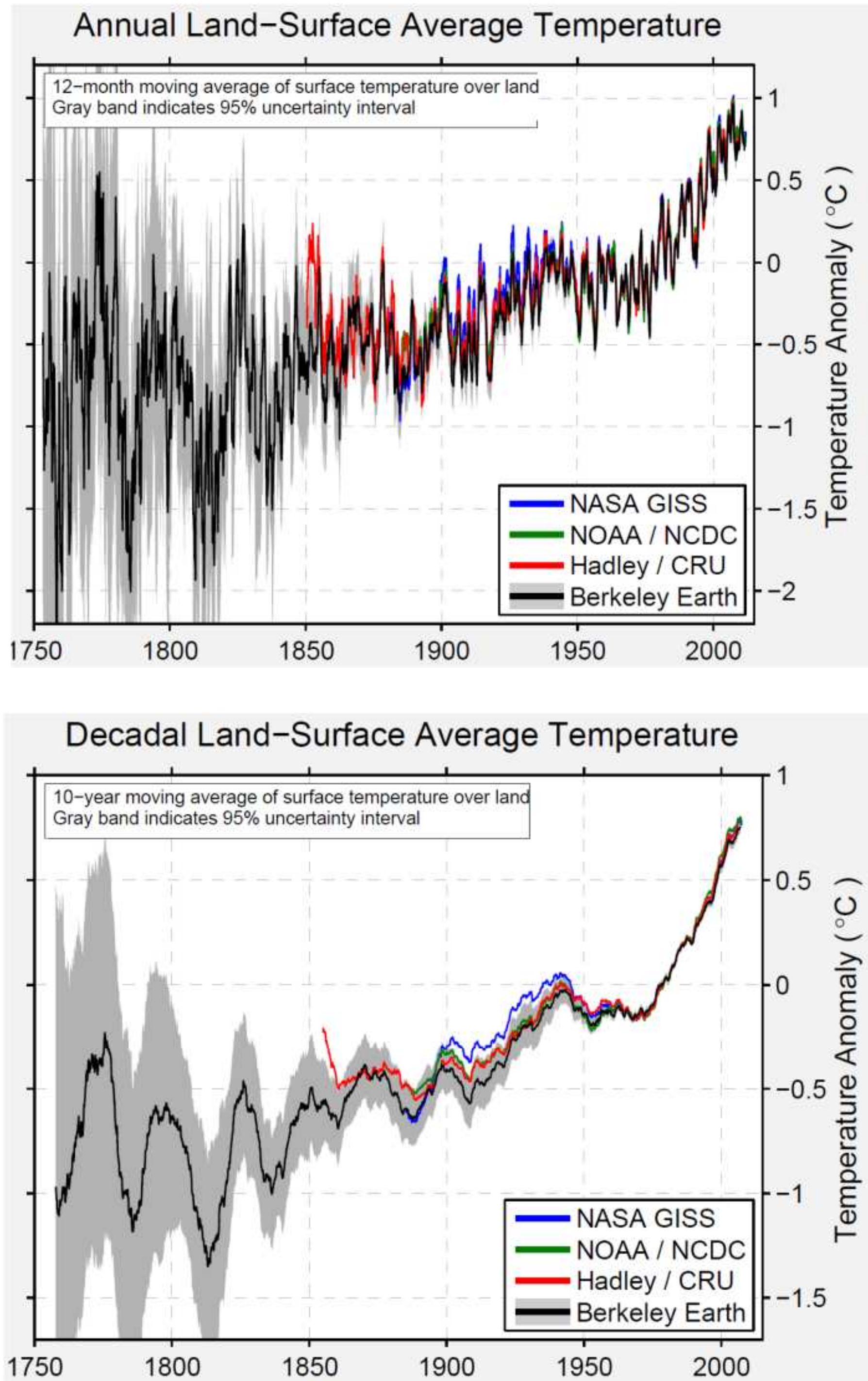


Figure 1. Land temperature with 1- and 10-year running averages. The shaded regions are the one- and two-standard deviation uncertainties calculated including both statistical and spatial sampling errors. Prior land results from the other groups are also plotted. Berkley Earth surface temperature http://berkeleyearth.org/

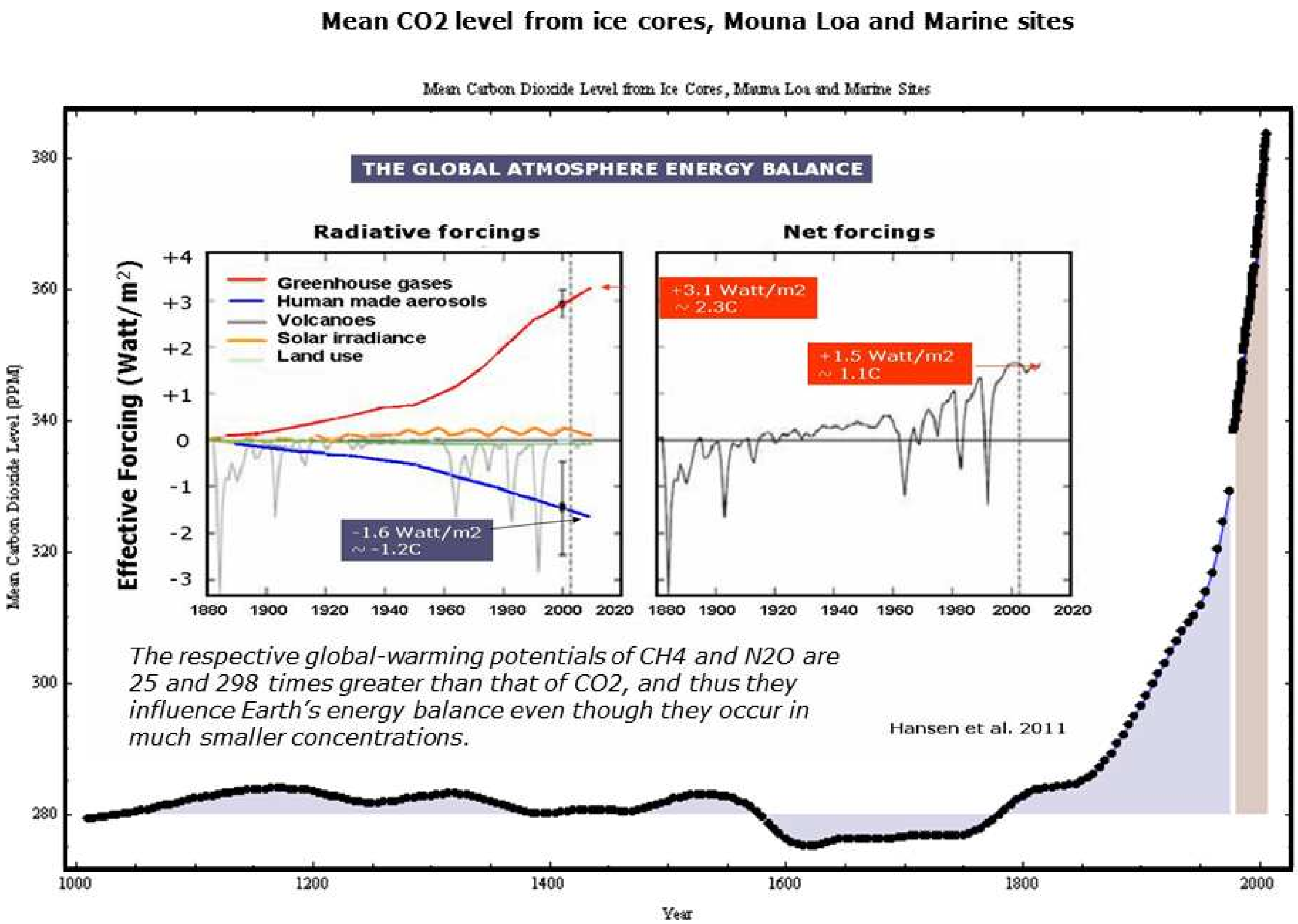


Figure 2. Global rise in CO2 levels and changes in radiative forcing including greehnouse gases (GHG) (including O3 and stratospheric H2O, in addition to well-mixed GHG), human made aerosols (mainly SO2), volcanoes, solar irradiance and land use). Total radiative GHG of 3.1 Watt/m2 translate to ~ +2.3^{o}C above pre-industrial tempratures, transiently mitigated by SO2 and other aerosols by ~1.6 Watt/m2 which translate to ~1.2 ^{o}C. From Hansen et al. 2011

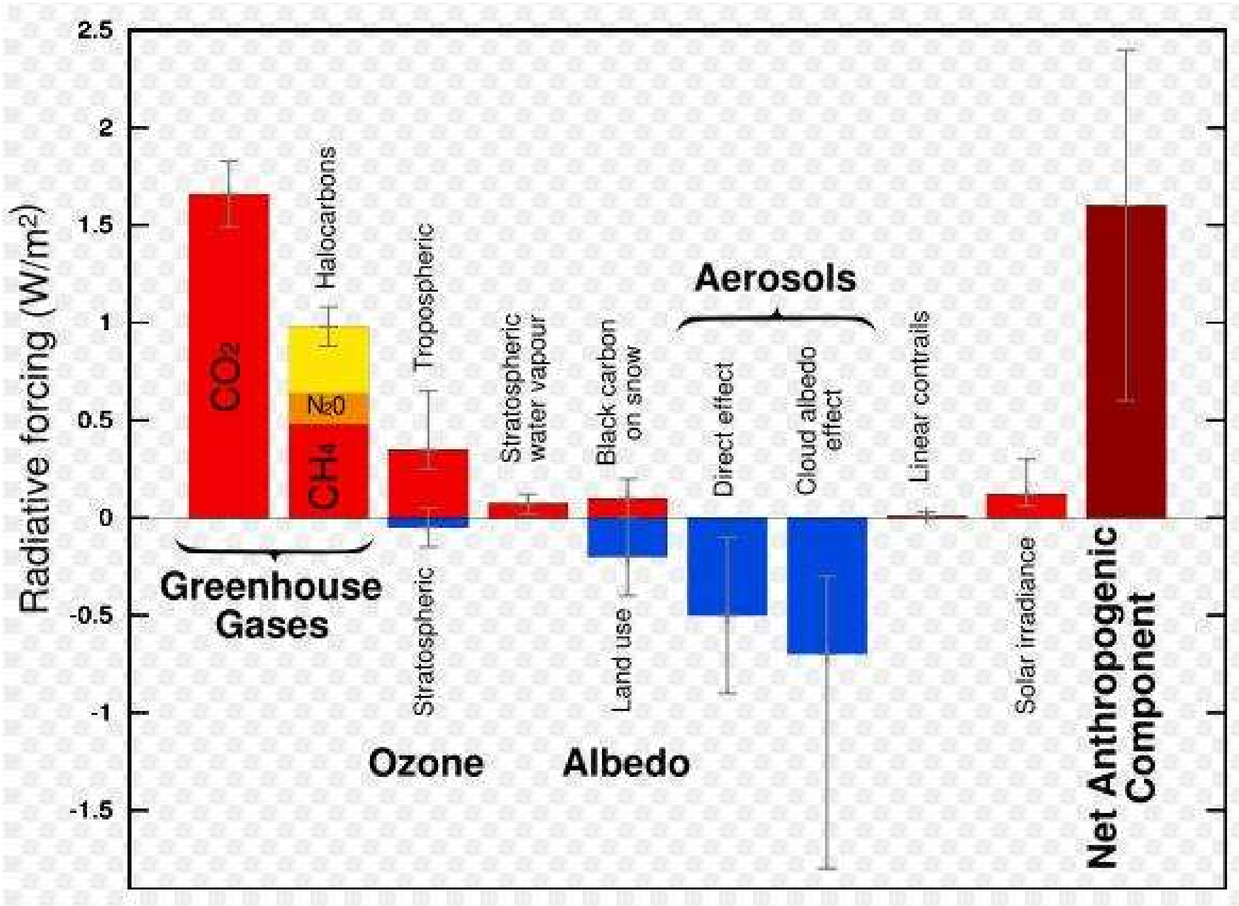


Figure 3.

IPCC AR4 estimates of radiative forcings since 1750.

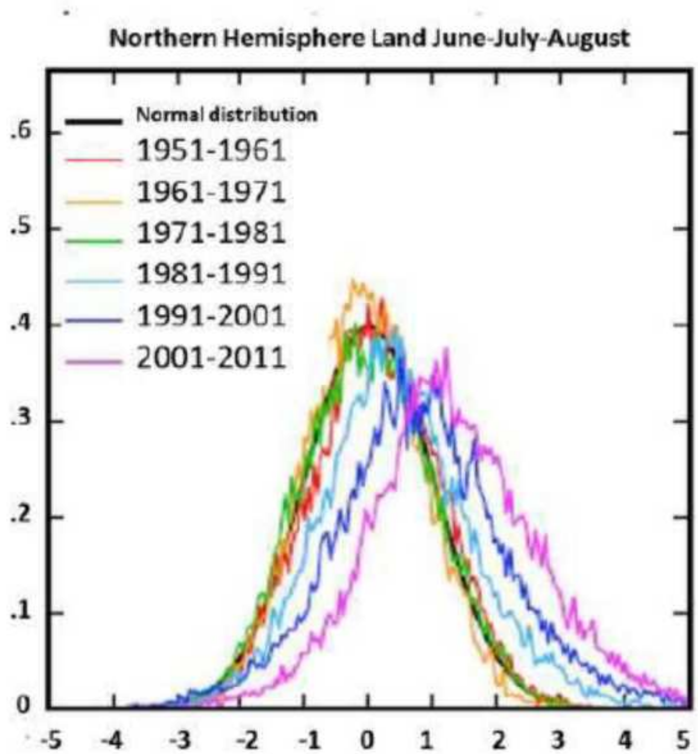


Figure 4.

Distribution of anomalous weather events relative to the 1951–1980 base line (Hansen et al., 2012). The plots represent calculations of the seasonal mean and standard deviation at each grid point for this period, and then normalize the departures from the mean, obtaining a Gaussian bell-shaped distribution. Histogram of the values from successive decades indicate by how much the climate of each decade departed from that of the initial baseline period.

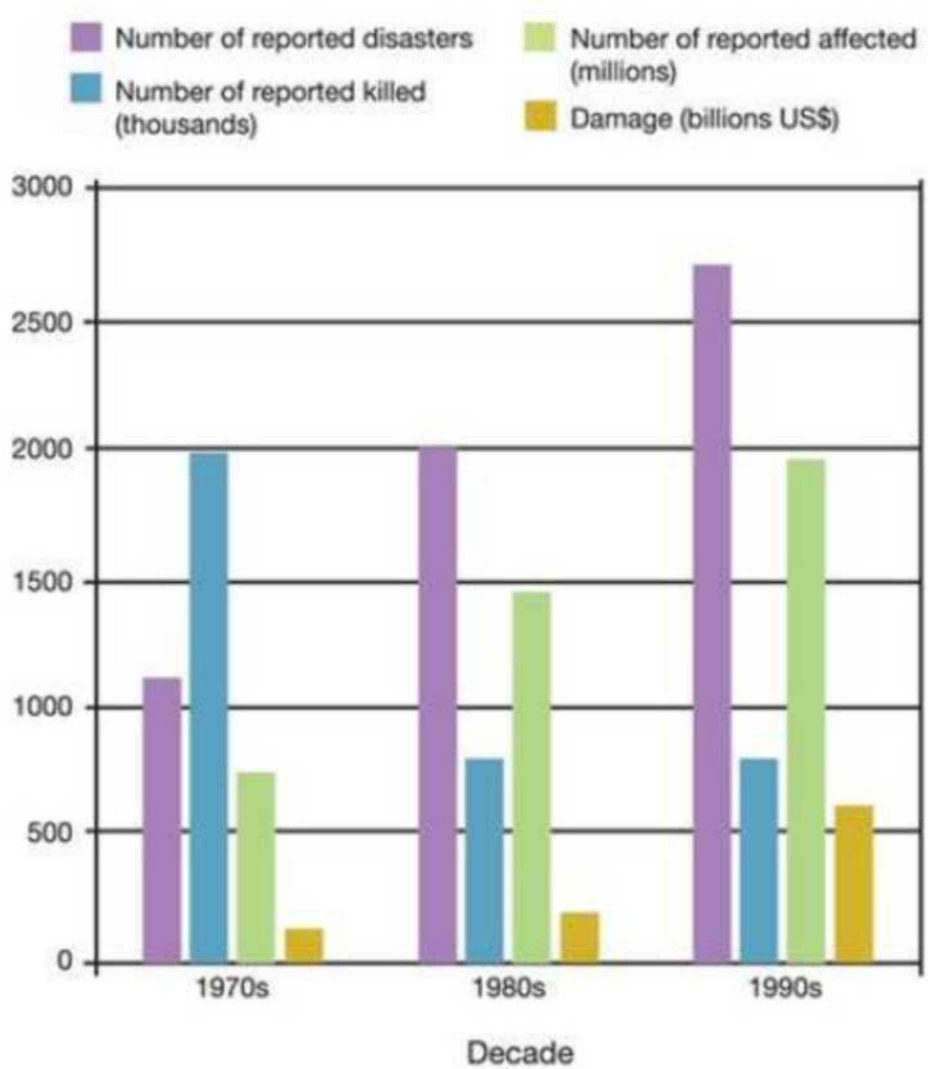


Figure 5. Global frequency of natural disaster impacts and associated human and economic losses from the 1970s to 1990s. World Meteorological Organization, 2006 http://www.nrcan.gc.ca/earth-sciences/climate-change/communityadaptation/assessments/378

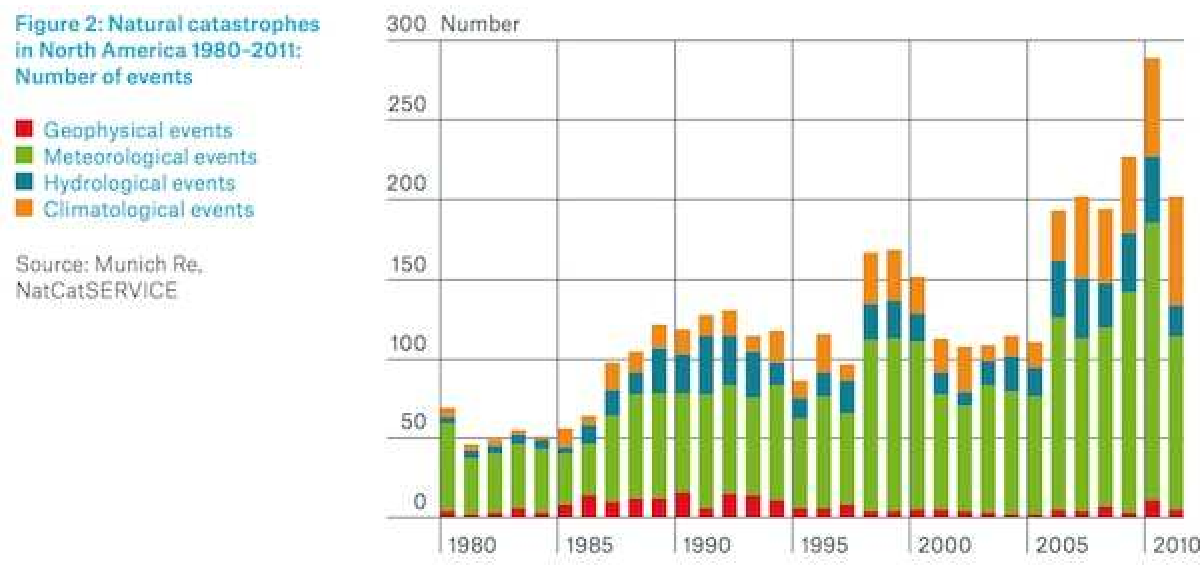


Figure 6. Frequency of global extreme weather events and geophysical events, 1980 - 2011. Munich ReInsurance. http://thinkprogress.org/climate/2012/12/19/1359461/from-sandy-to-sandy-hook-the-moral-urgency-for-action-even-when-it-appears-the-politics-are-too-hard/

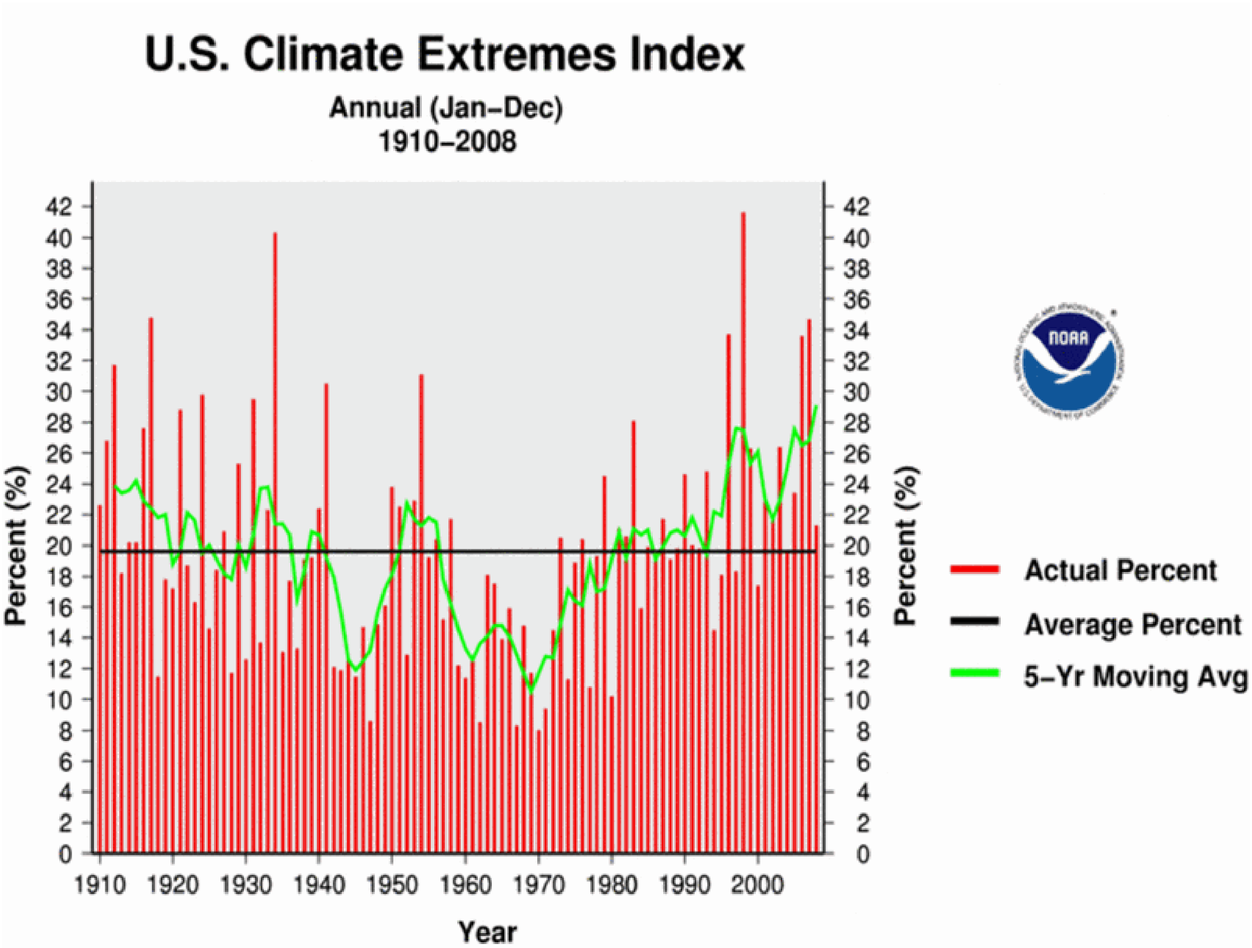


Figure 7. Annual Climate Extremes Index (CEI) value for the contiguous United States. Larger numbers indicate more acive climate extremes for a year. http://www.ncdc.noaa.gov/cmb-faq/globalwarming.html . The CEI indicator documents trends in tropical system activity based on the wind velocity of landfalling tropical storm and hurricanes http://www.ncdc.noaa.gov/extremes/cei/

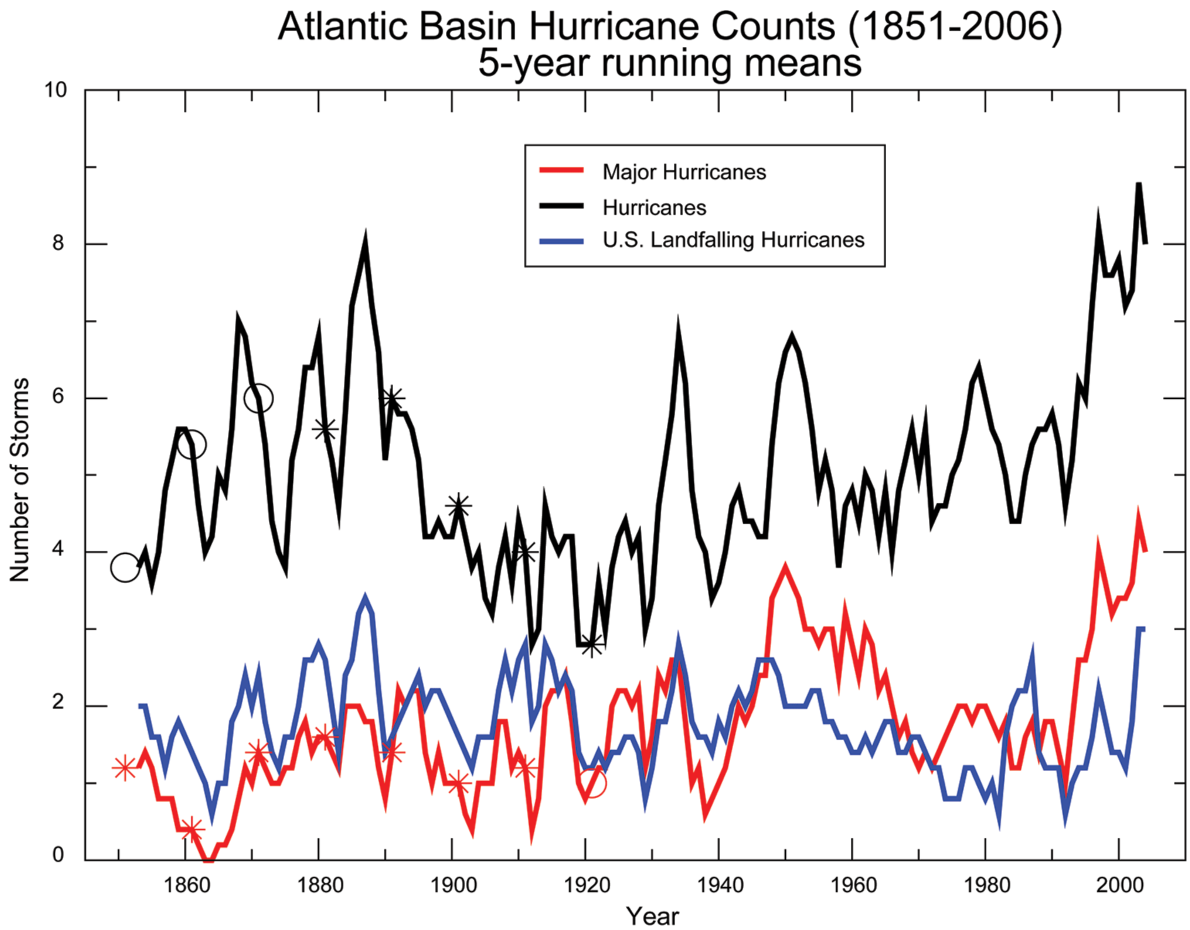


Figure 8

Atlantic Basin hurricane counts 1851-2006, 5-year running means

http://www.ncdc.noaa.gov/cmb-faq/globalwarming.html

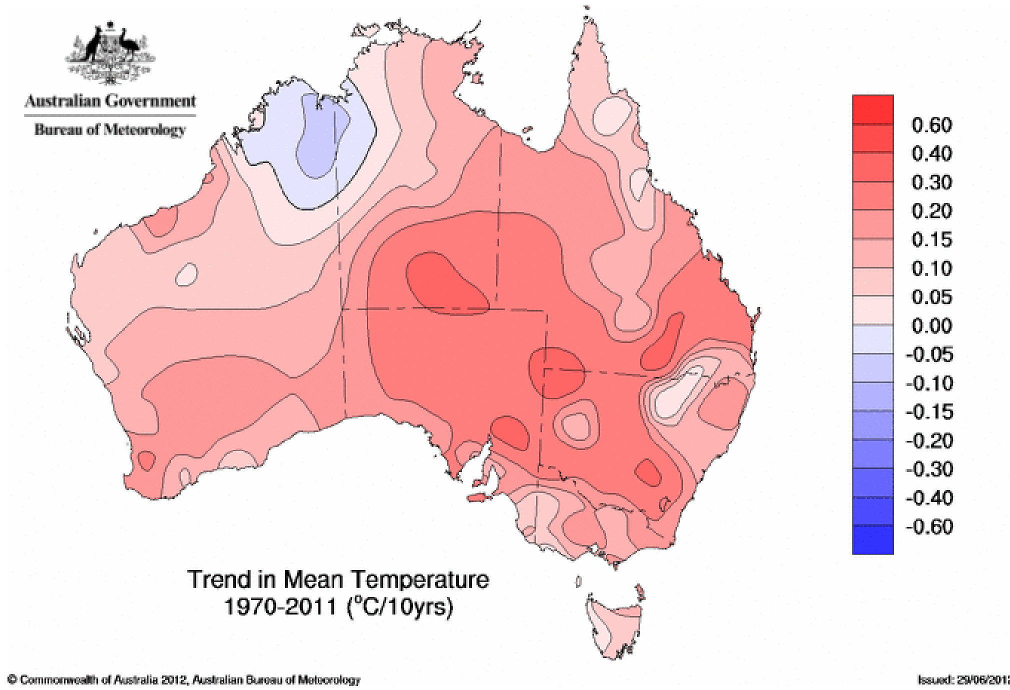
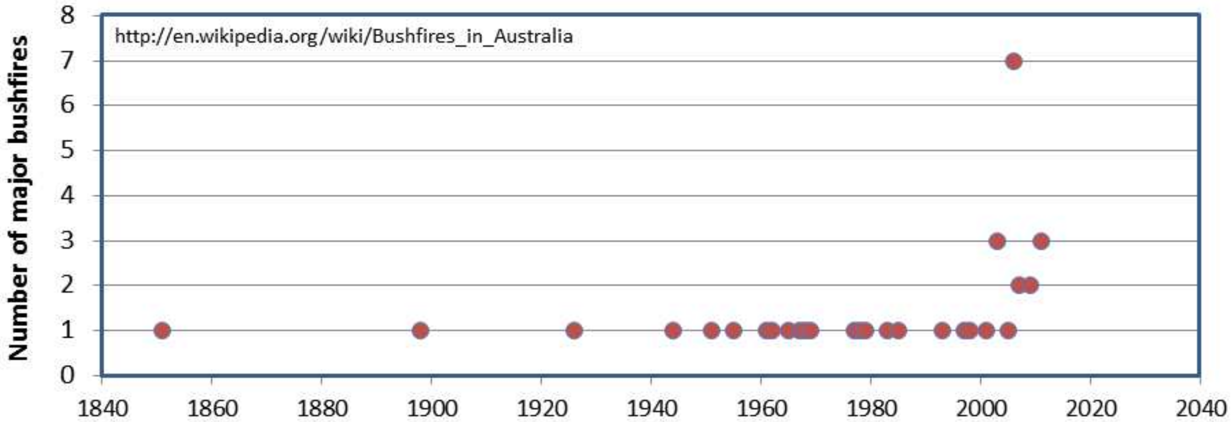
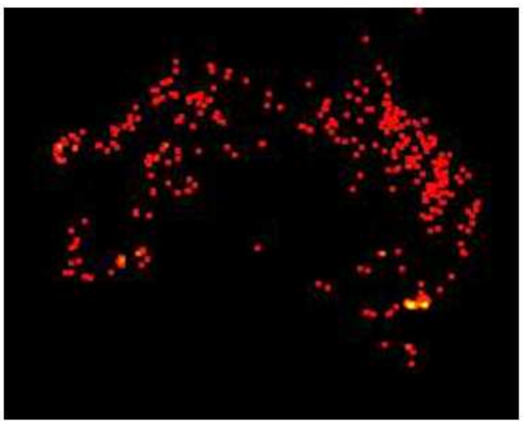


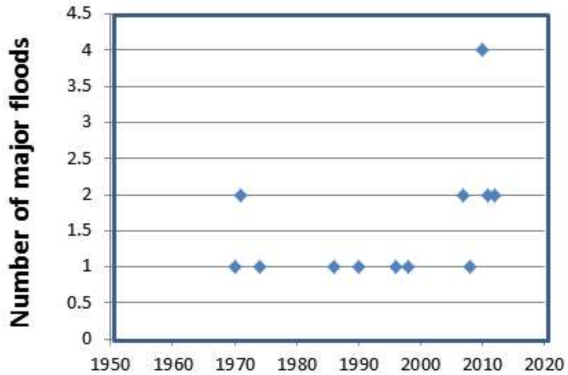
Figure 9

Trends in mean tempeature in Australia in degrees per decade 1970-2011. Bureau of Meteorology (http://www.bom.gov.au/cgi-bin/climate/change/trendmaps.cgi)





Satellite image of active bushfires in Australia. 18-1-2003



http://en.wikipedia.org/wiki/Floods_in_Australia

Figure 10

Frequency of fires and floods in Australia (based on Appendices I and II).
http://en.wikipedia.org/wiki/Bushfires_in_Australia
http://en.wikipedia.org/wiki/Floods_in_Australia

Appendix I - Australian droughts

http://en.wikipedia.org/wiki/2000s_Australian_drought

Time	**Region**	**Consequences**
1902 'Federation Drought'	Australia-wide	Total sheep dropped to <54,000,000 from a total of 106,000,000 in 1891; cattle fell by more than 40%; Wheat crop lost.
1911-1915 major drought	Australia-wide	Failure of the 1914 wheat crop
1918 - 1920	Australia-wide	severe drought
1937-1947	eastern Australia	dry conditions
1965-1968	eastern Australia	Drought; 1967 Tasmanian fires, 62 people died in one day and 1,400 homes were lost.
1982-1983	southeast Australia	Severe dust storms in NW Victoria; severe bushfires in SE Australia in February 1983, with 75 people killed.
1991-1995	Queensland	very severe drought; more than 10 towns lost irrigation systems more than 13,000 properties were drought declared.
1995-2007	southern Australia	2003 drought worst on record; 2006 annual rainfall 40-60% below normal; average rainfall in South Australia lowest since 1900; Across Victoria and the Murray-Darling Basin the season was the second driest since 1900; NSW state average rainfall for the season the third lowest since 1900; temperatures the highest on record since the 1950s.

Appendix II – Major bushfires in Australia

http://en.wikipedia.org/wiki/Bushfires_in_Australia
http://home.iprimus.com.au/foo7/firesum.html

Bushfires have accounted for over 800 deaths in Australia since 1851 and the total accumulated cost is estimated at $1.6 billion.[14] In terms of monetary cost however, they rate behind the damage caused by drought, severe storms, hail, and cyclones,[15] perhaps because they most commonly occur outside highly populated urban areas.

Some of the most severe Australian bushfires, in chronological order, have included:

Fire	Location	Area burned	Date	Deaths	Properties damaged
Black Thursday bushfires	Victoria, Australia	approximately 5 million ha	6 February 1851	about 12	1 million sheep; thousands of cattle[16]
Red Tuesday bushfires	Victoria	260,000 ha	1 February 1898	12	2,000 buildings[17]
1926 bushfires	Victoria		February – March 1926	60[18]	1000
Black Friday bushfires	Victoria	2,000,000 ha	December 1938 – January 1939, peaking 13 January 1939	71	3,700
1944 Bushfires	Victoria	estimated 1 million ha	14 January – 14 February 1944	15–20	more than 500 houses[17]
1951-2 Bushfires	Victoria		Summer 1951–52	at least 10[19]	
Black Sunday Bushfires	South Australia		2 January 1955	2	
1961 Western Australian bushfires [20]	Western Australia	1,800,000 ha	January–March 1961	0	160 homes
1962 bushfires	Victoria		14–16 January 1962	32	450 houses[18]
Southern Highlands bushfires	New South Wales		5–14 March 1965	3	59 homes
Tasmanian "Black Tuesday" bushfires	Tasmania	Approximately 264,000 ha	1967	62	1,293 homes

Dandenong Ranges Bushfire	Victoria	1,920 ha	19 February 1968		53 homes 10 other buildings
1969 bushfires	Victoria		8 January 1969	23	230 houses[18]
Western Districts Bushfires	Victoria	103,000 ha	12 February 1977	4	116 houses 340 Buildings
1978 Western Australian Bushfires	Western Australia	114,000 ha	4 April 1978	2	6 buildings (drop in wind in early evening is said to have saved the towns of Donnybrook, Boyup Brook, Manjimup, and Bridgetown.)
Northern Sydney bushfires	Sydney, NSW		1979		
Ash Wednesday bushfires	South Australia and Victoria	418,000 ha	16 February 1983	75	about 2,400 houses
Central Victoria Bushfires	Victoria	50,800 ha	14 January 1985	3	180+ houses
1994 Eastern seaboard fires	New South Wales		27 December 1993 – 16 January 1994	4	225 homes
Wooroloo Bushfire	Western Australia	10,500 ha	8 January 1997	0	16 homes
Dandenongs bushfire	Victoria	400	21 January 1997	3	41 homes[21]
Lithgow bushfire	New South Wales		2 December 1997	2[21]	
Perth and SW Region bushfires	West Australia	23,000 ha	2 December 1997	2 (21 injuries)	1 home lost
Linton bushfire	Victoria		1998	5	
Black Christmas (bushfires)	New South Wales	740,000 acres (3,000 km^2)	2001–02	0	121 homes
2003 Canberra	Canberra, Australian		2003	4	almost 500 homes[21]

bushfires	Capital Territory				
2003 Eastern Victorian alpine bushfires	Victoria	over 1.3 million ha	8 January – 8 March 2003		41 homes
Tenterden	Western Australia		December 2003	2	(2,110,000 ha of forest burnt during the 2002-2003 bushfire season in the S/W of WA)
Eyre Peninsula bushfire	South Australia	145,000 ha	2005	9	93 homes
2006 Central Coast bushfire	Central Coast, New South Wales		New Years Day, 2006		
Jail Break Inn Fire	Junee, New South Wales	30,000 ha[22]	New Years Day 2006	0	Livestock losses estimated to be over 20,000. Seven homes, seven headers and four shearing sheds destroyed. 1,500 kilometres (930 mi) of fencing damaged.[23]
2005 Victorian bushires	Victoria	160,000 ha	December 2005 – January 2006	4	57 houses, 359 farm buildings, 65,000 stock losses, fires occurred in the Stawell, Moondarra, Anakie, Yea, and Kinglake regions[24]
Grampians Bushfire	Victoria	184,000	January 2006	2	
Pulletop bushfire	Wagga Wagga, New South Wales	9,000	6 February 2006	0	2,500 sheep and 6 cattle killed, 3 vehicles and 2 hay sheds destroyed as well as 50 km of fencing.
The Great Divides Fire	Victoria	1,048,000 ha	1 Dec 2006 - March 2007	1	51 homes
2006-07 Australian bushfire season			September 2006 – January 2007		
Dwellingup	Western	12,000 ha	4 February	0	16

bushfire	Australia		2007		
Kangaroo Island Bushfires	South Australia	95,000 ha	6–14 December 2007	1	
Boorabbin National Park	Western Australia	40,000 ha	30 December 2007	3	Powerlines and Great Eastern Highway, forced to close for 2 weeks
Black Saturday bushfires	Victoria	450,000+ ha	7 February 2009 – 14 March 2009	173	2,029+ houses, 2,000 other structures
Toodyay Bushfire	Western Australia	3,000+ ha	29 December 2009	0	38
Lake Clifton Bushfire	Western Australia	2,000+ ha	11 January 2011	0	10 homes destroyed
Roleystone Kelmscott Bushfire	Western Australia	1500+ ha	6-8 February 2011	0	72 homes destroyed, 32 damaged, Buckingham Bridge on Brookton Highway collapsed and closed for 3 weeks whilst a temporary bridge was constructed and opened a month after the fires
Margaret River Bushfire	Western Australia	4000 ha	24 November 2011	0	31 homes destroyed including the historic Wallcliffe House

Appendix III - Floods in Australia

http://en.wikipedia.org/wiki/Floods_in_Australia

Date	Location	State(s)	Fatalities
1806	Maitland	NSW	
1820	Maitland	NSW	
1852	Gundagai	NSW	89[citation needed]
1863	Melbourne (December)	VIC	1[1]
1869	Ballarat	VIC	2[2]
1891	Melbourne (July)	VIC	1[3]
1893	Brisbane flood	QLD	11[4][5]
1893	Maitland	NSW	9[citation needed]
1900	Western Australian floods	WA	
1909	Western Victorian floods	VIC	4[citation needed]
1913	Maitland	NSW	
1916	Clermont	QLD	65[citation needed]
1923	Adelaide	SA	3[citation needed]
1926	Southwestern Australia	WA	
1927	Wollombi	NSW	
1929	Tasmanian Floods	TAS	22[citation needed]
1930	Maitland	NSW	
1931	Maitland	NSW	
1934	Yarra River	VIC	35[citation needed]
1947	June 1947 Tasmanian floods	TAS	
1949	Maitland	NSW	
1950	Maitland, Gippsland, West Queensland	NSW, VIC, QLD	1[6]
1951	Maitland	NSW	
1952	Maitland	NSW	
1955	Maitland flood	NSW	14[citation needed]
1955	All southern states (August)	WA, SA, VIC, NSW, TAS	2[citation needed]
1956	Murray River flood	NSW, VIC, SA	
1970	All eastern states (December)	QLD, NSW, VIC, TAS	16[citation needed]
1971	Canberra flood	ACT	7[citation needed]
1971	Maitland	NSW	
1974	Brisbane flood	QLD	16[citation needed]
1986	Sydney	NSW	6[citation needed]
1990	East Coast	NSW	7[citation needed]

Date	Location	State(s)	Fatalities
1996	Queensland and New South Wales	NSW & QLD	4[citation needed]
1998	Katherine Townsville	NT, QLD	3[7]
2007	Hunter Valley/Maitland floods (June)	NSW	10[citation needed]
2007	Gippsland Floods (June)	VIC	
2008	Mackay floods (February)	QLD	
2010	Victorian floods (Sept)	VIC	
2010	Queensland floods (March)	QLD	
2010	Carnarvon/Gascoyne (December)	WA	
2010-11	Queensland floods (Dec–Jan)	QLD	35[8]
2011	2011 Victorian Floods (Jan)	VIC	2[9][10]
2011	Gippsland (August)	VIC	1[11]
2012	Eastern Australia (Feb-Mar)	NSW, VIC, QLD	2[12][13]
2012	Gippsland and Melbourne (June)	VIC	