

Briefing

Climate change – what the scientists say

This briefing outlines the main findings of the Intergovernmental Panel on Climate Change's report on the latest scientific understanding of climate change¹. The report was produced by over 250 scientists across the globe who reviewed over 9,000 scientific papers. The summary report was agreed by 195 governments.

This briefing report has the following sections:

- Summary of the main findings of the IPCC report
- Global warming
- Extreme weather events
- Sea level rise and melting ice sheets
- Abrupt climate change and tipping points
- Carbon emissions reductions and 'dangerous climate change'
- Friends of the Earth's conclusions

Through-out the briefing Friends of the Earth's view on the findings of the IPCC are in shaded boxes. Detailed references are provided to enable readers to go to the exact source in the IPCC report.

The IPCC report only looked at the physical evidence of climate change and did not consider the likely social, economic, and environmental impacts from different amounts of warming. Their next report – Working Group 2 report – will cover this ground. It is due to be published in March 2014.

For more than 40 years we've seen that the wellbeing of people and planet go hand in hand – and it's been the inspiration for our campaigns. Together with thousands of people like you we've secured safer food and water, defended wildlife and natural habitats, championed the move to clean energy and acted to keep our climate stable. Be a Friend of the Earth – see things differently.

Summary of main findings of IPCC report

- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen and the concentrations of greenhouse gases have increased. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century
- This warming has already increased the occurrence of some types of extreme weather events. Further temperature increases will see the frequency of heavy rainfall events and very hot days increase, with the severity increasing in proportion to warming. In some regions there will be more droughts and floods though a lack of data prevents any firm conclusions on how the frequency will change globally.
- Sea levels will continue to rise throughout the 21st century largely through thermal expansion of the oceans and glacier melt water. Losses from the Greenland ice sheet and Antarctica ice sheet are accelerating. The highest sea level rise will be seen in scenarios with greater warming. Sea level rises are unlikely to exceed one meter in the 21st century, unless there is an unforeseen collapse in parts of the Antarctic ice sheets. Further rises will continue in the 22nd century, although the magnitude will be influenced by rates of loss from the Greenland and Antarctic Ice Sheets.
- Abrupt climate change events are difficult to assess with certainty because of lack of data and unknowns, however under the highest temperature scenarios that the IPCC modelled the Arctic is likely to become nearly ice free by mid-21st century. Whilst the collapse of the Greenland ice sheet is very unlikely in the 21st century the threshold or thresholds to complete loss are thought to be in the region of 1 to 4 degrees C temperature increase. It is possible that permafrost could become a net source of methane in the 21st century. There is low confidence in projections of complete collapse of tropical and boreal forests but still much uncertainty.
- Continued emissions of greenhouse gases will cause further warming. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. The extent of future warming is dependent on future emissions.
- Of 4 future scenarios modelled by the IPCC only in the scenario with the lowest emissions (“RCP 2.6”) is it considered unlikely¹ that warming will exceed the two degrees centigrade target identified by many governments as a threshold to dangerous climate change. The highest emissions scenario (RCP 8.5) considers it as likely as not that temperatures will rise by four degrees centigrade by 2100 compared to pre-industrial levels. The RCP 2.6 scenario had a reduction in emissions from fossil fuel burning of two-thirds by 2050; halving emissions from agriculture, deforestation and other land-use change; and cutting methane emissions by half by 2050.
- Scientists are more confident than ever that the planet is warming largely due to human activities. At least half of the recent slowdown in the warming of surface air temperatures is thought to be due to the solar cycle and volcanic eruptions since 2000. The other half is thought to be due to natural cycles, which have resulted in the oceans continuing to warm over this period. There is high confidence that surface air temperatures will warm more over the next 15 years than they have the previous 15 years.

¹ The IPCC use the following terms in their report to indicate the assessed likelihood of an outcome or a result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely: 95–100%, more likely than not >50–100%, and extremely unlikely 0–5%) are also used.

Friends of the Earth's view is that the magnitude of the risks to humans and the environment from temperature rises, extreme weather and sea level rise means that the lowest emissions IPCC scenario should be followed. Governments should agree on a global carbon budget to keep to this scenario, and immediately implement strategies to stay within this budget. Following this scenario would also reduce the risk of crossing thresholds that lead to the irreversible melting of the Greenland ice sheet, as well as releases of greenhouse gases from permafrost. These types of abrupt climate change pose unacceptable threats to the welfare of future generations in the 22nd century and beyond. Following the lowest emission IPCC scenario would require rapid and radical action to reduce the use of fossil fuels. Carrying out energy efficiency and deploying low carbon technology will have significant benefits.

1. Global warming

The IPCC says that warming of the climate system is unequivocal and that since the 1950s, many of the observed changes are unprecedented. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen and the concentrations of greenhouse gases have increased. They say that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

It also says that, despite a recent hiatus in surface air temperatures, the planet continues to absorb extra energy due to man-made global warming with continued warming of oceans and melting of ice. The oceans absorb 93 per cent of this energy².

The recent hiatus in air surface temperature is thought to be due in part to the solar radiation eleven -year cycle which went from relative maximum in 2000 to relative minimum in 2009, together with a series of volcanic eruptions since 2000, and natural fluctuations in the climate system, which includes a redistribution of warming within the oceans³. Surface air warming over the next 15 years will be greater than the last 15 years says the IPCC with high confidence⁴. Longer-term trends for warming are very clear they say⁵.

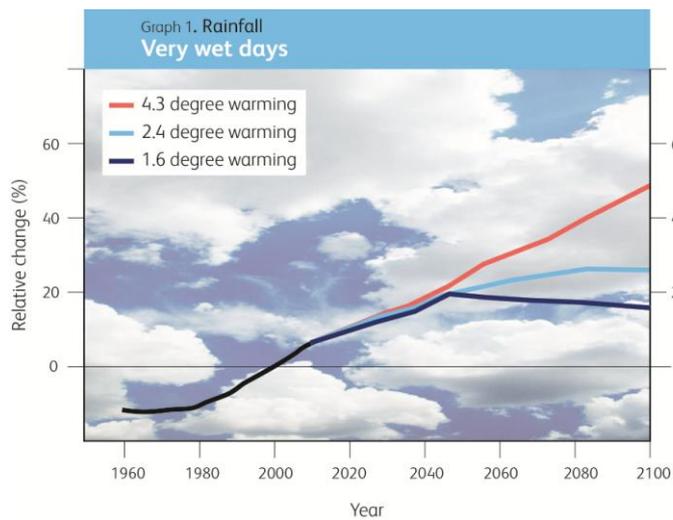
This increase in energy is largely the result of atmospheric concentrations of carbon dioxide (CO₂), methane, and nitrous oxide at levels unprecedented in at least the last 800,000 years⁶.

2. Extreme weather

Extreme rainfall

The IPCC has high confidence that there has been increased precipitation in northern hemisphere since the 1950s, although they cannot say the same in the southern hemisphere due to lack of available data⁷. As a rule of thumb, it is expected that in the future under climate change wetter regions will get wetter and drier regions drier⁸.

For example, the IPCC has high confidence that the frequency and intensity of extreme precipitation events will increase with warming⁹. Each degree of warming will increase rainfall intensity by 5-10%¹⁰.



Graph 1 – increase in rainfall projected for different scenarios of warming (compared to pre-industrial times), adapted from from IPCC CH11, figure 11.17

Future increases in heavy rainfall events are very likely in South America, Africa, East Asia, South Asia, Southeast Asia and Australia under all scenarios the IPCC modelled, but with greater extremes for the highest temperature rises.¹¹

Extreme heat

It is very likely that human influence has contributed to observed global scale changes in the frequency and intensity of daily temperature extremes since the mid-20th century¹². It is likely that human influence has more than doubled the probability of occurrence of heat waves in some locations¹³.

It is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales as global mean temperatures increase. It is very likely that heat waves will occur with a higher frequency and duration. Occasional cold winter extremes will continue to occur¹⁴. Extreme heat days are expected to be at least twice as common in the long-term¹⁵.

Floods and droughts

Floods larger than the 20th century floods in northern, western Europe, western Mediterranean and eastern Asia have happened in the past within the last five centuries. The recent floods in India and Central America are comparable or have surpassed historical floods in magnitude and/or frequency¹⁶.

Global monsoon areas and precipitation are likely to increase and have longer seasons¹⁷. El Nino rainfall is also likely to intensify¹⁸.

Although there is low confidence in a global trend to greater floods and droughts increased flooding in particular regions will result from climate change¹⁹, as well as increased droughts in some regions. For example, the Mediterranean, south western USA and southern Africa regions are likely to get drier for several degrees warming²⁰.

Friends of the Earth's view on extreme weather

Extreme weather causes large-scale human suffering, economic losses and environmental damage. Allowing temperatures to increase much further would in the future lead to much more severe rainfall, as well as heat-waves, floods and droughts in some areas.

Friends of the Earth has produced a short briefing on extreme weather events²¹. It reported on research which demonstrated that half of twelve extreme weather events of 2012 could be linked to climate change. The US heat-waves, Superstorm Sandy, shrinking Arctic sea ice, drought in Europe's Iberian Peninsula and extreme rainfall in Australia and New Zealand were given as examples. It also reported on a 2011 study that found that man-made climate change may have almost doubled the risk of the extremely wet weather that caused the big UK floods in the year 2000.

3. Sea level rise and melting ice sheets

Over the last two decades the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink with very few exceptions worldwide and Arctic sea ice is retreating²².

Arctic sea ice

It is likely that the annual period of melting has increased by around 6 days per decade and there is high confidence that the sea ice is getting thinner, and is now between 1-2 meters thinner than in 1980s. There amount of older multi-year ice has decreased by around 40 per cent over the last three decades. The Arctic is losing around 11% of summer sea ice extent per decade²³ Most models continue to underestimate ice loss.²⁴.

In the highest temperature scenario the IPCC modelled a nearly ice-free arctic in summer by mid-century is predicted. In the lowest temperature scenario some of the Arctic summer sea ice is maintained beyond 2100²⁵.

Greenland ice sheet

The average rate of ice loss from the Greenland ice sheet has increased six-fold over the period 1992–2001 to 2002–2011²⁶.

There is high confidence that sustained warming greater than some threshold would lead to the near-complete loss of the Greenland ice sheet over a millennium or more, causing a global mean sea level rise of up to 7 m over millennia. Current estimates indicate that the threshold is greater than about 1°C but less than about 4°C global mean warming with respect to pre-industrial temperatures²⁷.

Antarctica

The IPCC say they have high confidence that the ice-shelves around the Antarctica Peninsula are undergoing a long-term retreat and partial collapse²⁸. Losses from the ice shelves have increased fivefold over the period over the period 1992–2001 to 2002–2011²⁹.

Some parts of the Antarctic sea ice are expanding, probably due to shifting wind patterns, whereas other areas are reduced. Overall there is a net gain in sea ice³⁰.

Sea level rise

Sea level rise is accelerating, increasing by around 3.2 mm per year currently³¹. Three-quarters of this is driven by thermal expansion of the water as the oceans heat up, and losses from glaciers. Losses from the Greenland ice sheet, Antarctic ice sheet and losses from land (e.g. draining of underground aquifers) contribute the rest³².

Sea levels increases are not expected to exceed one meter by 2100 even in the high temperature scenario modelled³³, although higher rises cannot be ruled out if there is a collapse of some of the Antarctic ice sheet³⁴.

After 2100 sea level rises will continue to increase, although proportional to the degree of warming³⁵. For each degree of warming a sea level rise of 1-3 meters is expected if the warming persists for several millenia³⁶.

Friends of the Earth view on sea level rise

Up to one meter of sea level rise will be extremely difficult to cope with for many nations, especially poorer low-lying nations. The costs of adaptation will be very high. It is prudent to keep sea level rises as low as possible by following the lowest temperature scenario modelled by the IPCC.

All the scenarios modelled by the IPCC risk crossing the threshold or thresholds for the loss of the Greenland Ice sheet, particularly the higher temperature scenarios. The loss of the Greenland ice sheet, although not rapid, would result sea level rises of 7 meters, very significant loss of land and assets for future generations and, in Friends of the Earth's eyes, represent a grave injustice to future generations. This is further evidence for the need to follow the lowest temperature scenario modelled by the IPCC.

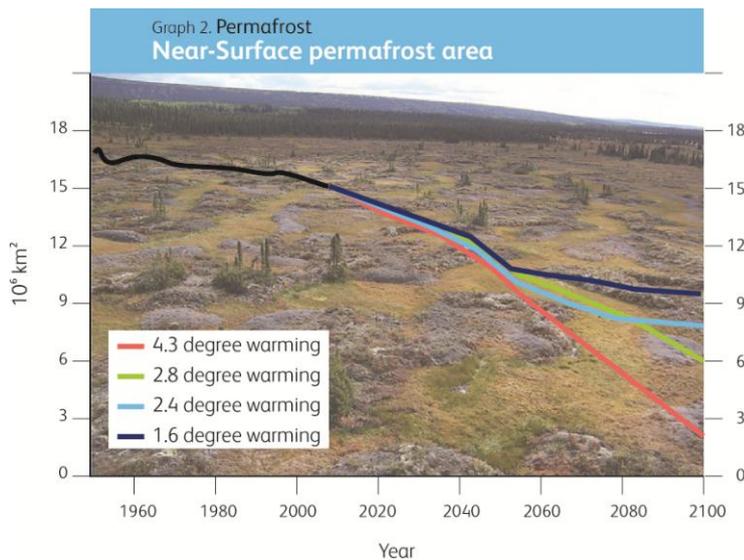
4. Abrupt climate change

The IPCC report assessed the likelihood of a number of abrupt climate change events occurring during the 21st century³⁷. These are extremely high impact but low probability events.

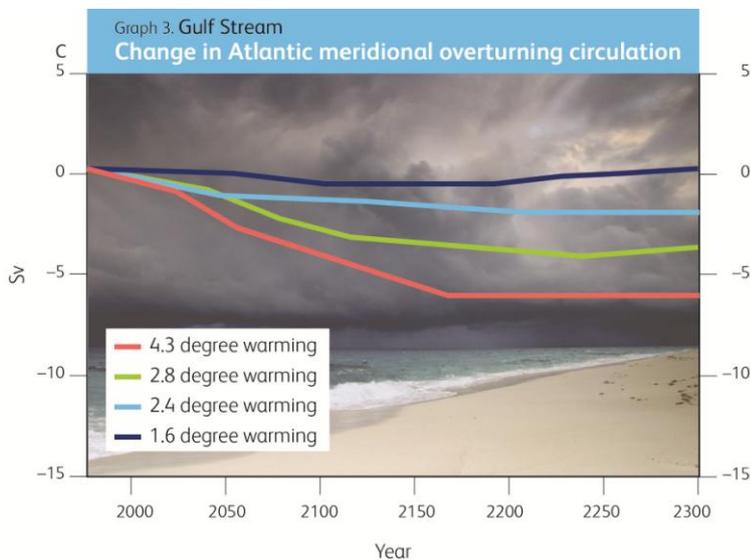
They found³⁸ that the collapse of the Gulf Stream was very unlikely – less than 10 per cent probability - although it would weaken, dependent on the amount of warming (see graph 3) . It is also very unlikely that that methane from clathrates – underwater methane deposits -

will undergo catastrophic releases. It is exceptionally unlikely – less than 1 per cent probability - that either the Greenland or West Antarctic ice sheets will suffer near-complete disintegration.

However they found it is possible that permafrost could become a net source of greenhouse gases during the 21st century. And under higher levels of warming it was likely that the Arctic would be near ice-free before 2050.



Graph 2 – projected reduction in near-surface permafrost area under different warming scenarios, adapted from IPCC, CH12, figure 12.33



Graph 3 – projected weakening of the Gulf Stream under different warming scenarios, adapted from IPCC, CH12, figure 12.42

The IPCC say they have low confidence in projections of the collapse of tropical or boreal forests, or of the collapse of the monsoon circulation, in the 21st century. Low confidence means that the event is not impossible but that the research to date is limited and there is a lack of agreement between studies.

Friends of the Earth's view on abrupt climate change

Whilst the conclusions in the table may appear somewhat reassuring it is important to bear three things in mind:

- These are expert assessments of events happening in the 21st century. It is very possible - and indeed likely in some cases such as the loss of the Greenland ice Sheet - that in the higher temperature scenarios these changes will have been committed to in the 21st century even if the impact is felt in later centuries.
- The higher temperature scenarios increase the likelihood of some of these abrupt changes, although not all.
- Low confidence does not imply that the events will not happen but are reflections of the need for further research.

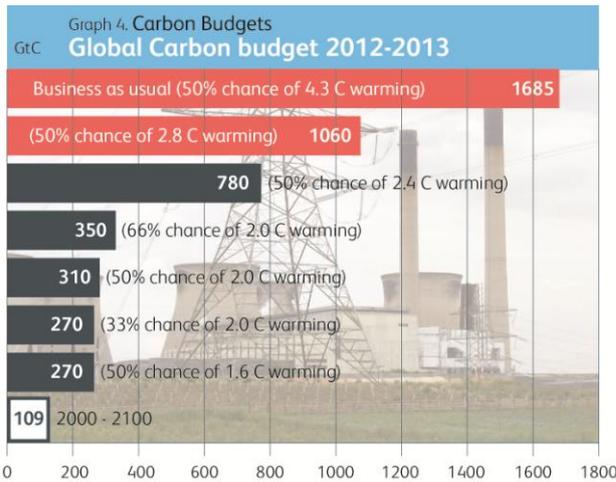
These abrupt changes, if they occur, are extremely high impact events. In other policy areas, such as terrorism or military planning, low probability but high impacts events result in considerable investment to avoid or prepare for them. In Friends of the Earth's view these climate change extremely high impact events should be avoided with high certainty. With such uncertainty surrounding many of the abrupt changes it is prudent to reduce the risk by following the lowest temperature scenario modelled by the IPCC.

5. Carbon emissions reductions and 'dangerous climate change'

The IPCC produced four scenarios, called Representative Concentration Pathways (RCPs). These model what the temperature, sea level rise, ocean acidification, etc will result from different carbon budgets, i.e. the different cumulative emissions between now and 2100³⁹.

Of these four scenarios only one scenario (called RCP 2.6) unlikely to exceed two degrees warming by 2100 compared to pre-industrial levels⁴⁰. This scenario has the smallest carbon budget. This scenario is also the only scenario which avoids extensive ocean acidification threatening the health of marine micro-organisms, such as plankton at the base of the marine food-chain, through corrosive impacts on aragonite (a form of calcium carbonate)⁴¹. All scenarios will create unhealthy environments for these marine micro-organisms in some locations, such as parts of the arctic⁴².

Graph 4 below shows the different size global carbon budgets between 2012 and 2100 for the scenarios modelled by the IPCC, plus the different size carbon budgets for chances of 2 degrees warming. For comparison purposes size of the carbon budget released between 2000 and 2010 is also given⁴³.



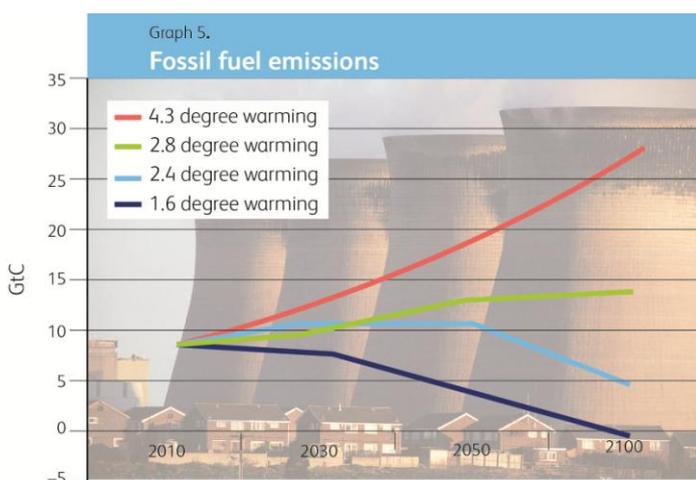
Graph 4 –The size of the carbon dioxide global carbon budgets in GtC. Numbers from IPCC SPM and IPCC Annex 2. Note: The IPCC report makes clear that these carbon budgets could be smaller if cooling aerosols are cut faster than assumed by the different scenarios, or if more ‘natural’ emissions of carbon result from changes in permafrost or soils⁴⁴.

Pathways

The IPCC report identified pathways of emissions for the different scenarios. Below are the pathways for carbon dioxide emissions from fossil fuel burning. Currently around 90 per cent of total carbon dioxide emissions are from fossil fuel burning⁴⁵.

By 2040 all the pathways require emissions from land-use changes - such as deforestation and agriculture – to be by at least half of current levels. Failure to do so would lead to higher temperatures. All the pathways also require emissions from aerosol pollutants – some which warm the planet and some which cool it – to be significantly reduced over coming decades⁴⁶.

It is worth noting that in the 1.6 degree pathway (RCP2.6) it is as likely as not that after 2070 significantly more carbon dioxide emissions can be removed from the atmosphere than is released into it, giving overall negative emissions.⁴⁷



Graph 5 – Reductions required in fossil fuel emissions to achieve different levels of warming. Adapted from figures in IPCC Annex 2.

Friends of the Earth's view carbon emissions reductions and dangerous climate change

Two degrees warming is the level that many developed country governments have said is the threshold to dangerous climate change. Many developing country governments have suggested that 1.5 degrees warming is the threshold to dangerous climate change. In Friends of the Earth's view the scientific understanding of the impacts of climate change is more consistent with the view of developing countries.

Given the global political commitment to avoid a 2 degree C increase in global temperatures above pre-industrial temperatures it is necessary for politicians to adopt a global carbon budget and pathway similar to the pathway outlined by the lowest temperature IPCC scenario (RCP 2.6), which gives a high probability of avoiding a 2 degree rise in this and subsequent centuries. Other pathways do not provide even a 50:50 chance of avoiding a 2 degree rise.

To fulfil this pathway will particularly require significant reductions in fossil fuel, reductions of at least two-thirds by 2050. Current reserves of proven fossil fuels, if burnt would release 760 GtC. This compares with 270 GtC IPCC global carbon budget which is consistent with a 50% chance of avoiding warming higher than the 2 degrees target.

The IPCC report does not identify emissions pathways for particular countries as this is a political and ethical decision rather than scientific. In Friends of the Earth's view developed countries will need to reduce fossil fuels use much more rapidly than the two-thirds by 2050 in the IPCC RCP 2.6 scenario because of their historic responsibility for the majority of greenhouse gases already emitted, the need for developing countries to use more energy, and the differentiated responsibility principles enshrined in the UNFCCC convention text. Friends of the Earth's 2010 report 'Reckless Gamblers' identifies results from an equity-based approach to dividing global carbon budgets⁴⁸.

6. Friends of the Earth overall conclusions

The three IPCC scenarios that result in global temperatures above 2 degrees by 2100 are high risk scenarios. They will lead to more extreme weather events, high sea levels and increase the chance of crossing thresholds - such as irreversible melting of the Greenland ice sheet and some other abrupt climatic changes. The costs of these scenarios will be high for everybody, but particularly for developing countries and the poorest people in rich and poor countries alike.

The lowest temperature IPCC scenario (RCP2.6) which provides a 50:50 chance of only 1.6 degree warming by 2100 and a two-thirds chance of avoiding 2 degrees warming is the scenario that should be followed. The worst impacts of climate change can still be averted, and risks can be kept low. It is still possible if immediate and radical action to taken to reduce all greenhouse gas emissions, particularly from the majority source - the use of fossil fuels.

Doing this requires a four-fold global focus: i) keeping the majority of fossil fuel reserves in the ground, ii) rapid deployment of low-carbon energy technologies iii) concerted action to reduce energy waste, iv) reversing deforestation and action on agricultural emissions

In addition, due to the warming that is already happening and the further warming that will happen even if carbon emissions are reduced dramatically, it will be necessary to invest in climate adaptation. Developing countries will require significant assistance in this from developed countries..

References

In the following references :

SPM-X refers to the appropriate page in the Summary for Policy Makers of the IPCC AR5 Working Group 1 report, available at: http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf,

TS-X refers to the appropriate page in the Technical Summary of the IPCC AR5 Working Group 1 report, available at: http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_TechnicalSummary.pdf

CHX-X refers to the appropriate chapter and page in the full IPCC AR5 Working Group 1 report, available at: http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_All.pdf

¹ IPCC (2013), Working Group 1 contribution to the IPCC Fifth Assessment Report, the physical science basis

² SPM - 4

³ SPM -10

⁴ TS-29

⁵ SPM -15

⁶ SPM -7

⁷ TS-36

⁸ SPM -16

⁹ SPM -16

¹⁰ CH7 - 4

¹¹ TS -66

¹² SPM -13

¹³ SPM -13

¹⁴ SPM -15

¹⁵ TS -51

¹⁶ TS -71

¹⁷ SPM -16

¹⁸ SPM -16

¹⁹ CH3-49

²⁰ TS-11

²¹ Friends of the Earth (2013), Extreme weather and climate change,
http://www.foe.co.uk/resource/briefing_notes/extreme_weather_cc.pdf

²² SPM - 5

²³ CH4 -3

²⁴ SPM -11

²⁵ TS -52

²⁶ TS-9

²⁷ TS-37

²⁸ TS-10

²⁹ TS9 & 10

³⁰ TS-9

³¹ SPM -6

³² SPM -7

³³ SPM, Table SPM 2

³⁴ SPM -18

³⁵ TS-14

³⁶ CH13-4

³⁷ CH12

³⁸ CH12, table 12.4

³⁹ SPM, Box SPM 1

⁴⁰ SPM Table SPM 2

⁴¹ TS -57 and SPM -22 for concentrations of CO₂ associated with RCP scenarios

⁴² TS -57

⁴³ Data from SPM -20 and SPM table SPM3

⁴⁴ SPM -10,

⁴⁵ SPM -7

⁴⁶ Annex 2 of full report, http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_AnnexII.pdf

⁴⁷ TS -57

⁴⁸ Friends of the Earth (2010), Reckless gamblers, how politicians' inaction is ramping up the risk of dangerous climate change, http://www.foe.co.uk/resource/reports/reckless_gamblers.pdf