Fourth International Conference on Climate Change
University of Washington, Seattle, USA
12-13 July 2012

Climate Change Commitment as the Minimum Total Unavoidable Global Warming and Food Security Implications

Rationale for project

20 years after the UN Framework Convention on Climate Change there is no indication that the continued increase in global greenhouse gas emissions will change in the foreseeable future.

The combined national confirmed emissions reduction pledges to the UN (calculated by Climate Interactive) reduce the global temperature increase by 2100, compared to business as usual, by only 0.5°C.

We do not have a practical estimate of the minimum total unavoidable global warming.

Unavoidable global warming and climate change has not been linked to food security.

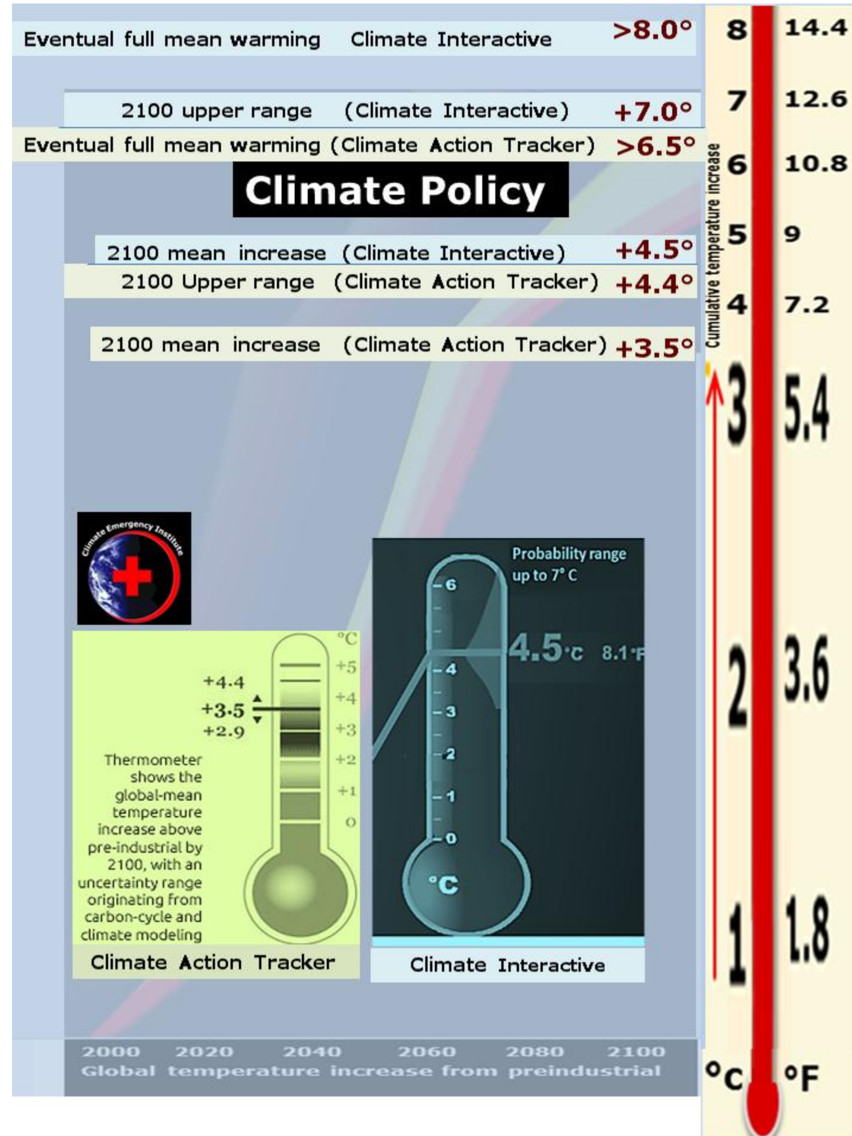
The climate science may be confusing for public and policy makers regarding today's 'committed' or 'unavoidable' global warming.

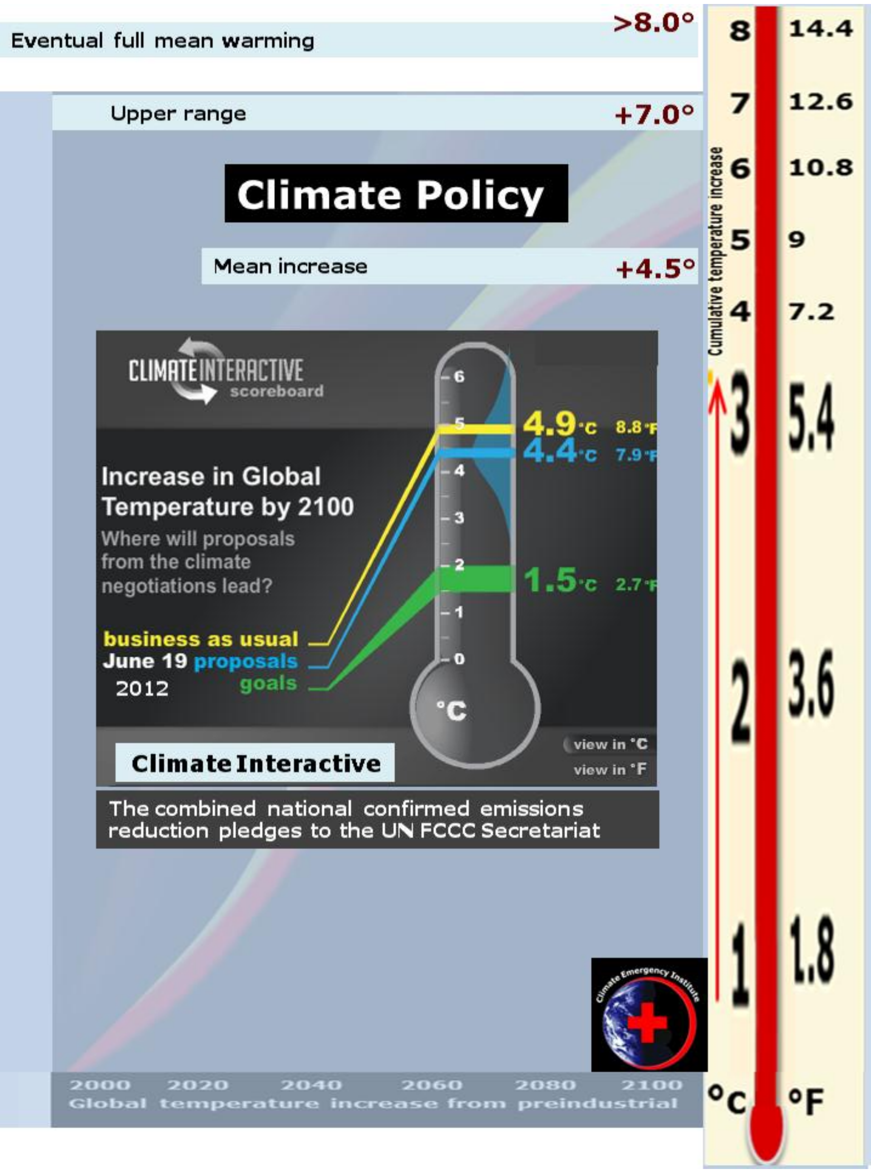
The IPCC 2007 uses *three specific definitions of climate change commitment: (i) the 'constant composition commitment' [...], since the time the composition of the atmosphere, and hence the radiative forcing, has been held at a constant value; (ii) the 'constant emission commitment', [...] since the time the greenhouse gas emissions have been held at a constant value; and (iii) the 'zero emission commitment', since the time the greenhouse gas emissions have been set to zero.*

Climate change commitment as discussed here should not be confused with 'unavoidable climate change' over the next half century, which would surely be greater because forcing cannot be instantly stabilised.

We use the term unavoidable warming for this project.

As a practical guide for protecting food security we include all unavoidable sources of warming.





Inertia, lags, and momentum cause delayed, unavoidable, additional global average temperature increases.
(all are from pre-industrial).

A. Climate and Energy Policy
B. Climate System Science

Climate Science Contributory Factors to Total Minimum Unavoidable Warming

1. Duration of warming 1000s of years
Climate changes that occur because of carbon dioxide increases are expected to persist for thousands of years even if emissions were to be halted at any point in time. (NRC, Climate Stabilization Targets, 2010)

2. Lifetime of GHG emissions in the atmosphere

3. Today's global emissions scenario Highest emissions

4. Time from rapid reduction of emissions to atmospheric GHG stabilization
(we assume an emergency response to a zero carbon emissions target)

5. Delayed warming from ocean heat lag
Warming that occurs in response to a given increase in CO_2 is only about half the eventual total warming. (NRC, 2010)

6. Deferred warming due to air pollution aerosol cooling
(we apply to 2100)

7. Additional incurred warming from +ve feedbacks

Food Security

Warming by 2050 is the crucial time- frame
Several major crops and regions reveal consistently negative temperature sensitivities with between 5 to10% yield loss per degree C of warming
(NRC Climate Stabilization Targets 2010)

Inertia, lags, and momentum causing delayed, unavoidable, additional global average temperature increases
(all are from pre-industrial)

Climate Science Contributory Factors to Total Minimum Unavoidable Warming

1. **Duration of warming**
2. **Lifetime of GHG emissions in the atmosphere**
3. **Today's global emissions scenario**
4. **Time from rapid reduction of emissions to atmospheric GHG stabilization**
   (we assume an emergency response to a zero carbon emissions target)
5. **Delayed warming from ocean heat lag**
6. **Deferred warming due to air pollution aerosol cooling**
   (we apply to 2100)
7. **Additional incurred warming from +ve feedbacks**

1. The Duration of Warming

is practically unlimited -1000s of years

- **Ocean thermal inertia lasts 100s of years**
- **20% of CO2 emissions last 1000 years in the atmosphere**

2. Atmospheric Lifetime of GHG Emissions

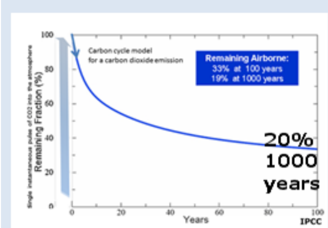
Very long lasting atmospheric GHGs are cumulative in the atmosphere, so long as they are being constantly emitted.

As a result, if the emissions reduction target is not zero carbon emissions, unavoidable warming is unlimited.

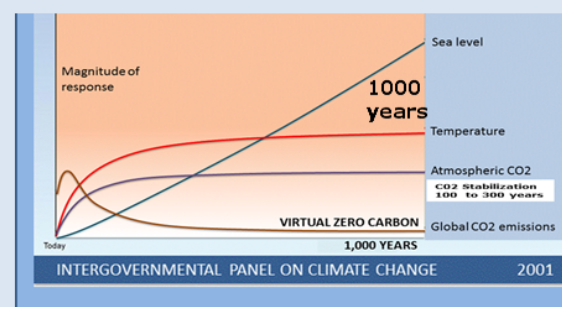
For zero carbon the lower carbon intensity policy is not the same as a zero carbon energy conversion policy.

The same approach applies to nitrous oxide - atmospheric lifetime 114 years (pointed out in the 1990 IPCC FAR)

Zero carbon is the bottom line for limiting unavoidable irreversible temperature increases



20% of a CO2 emission remains in the atmosphere after 1000 years



3. The Current Emissions Scenario

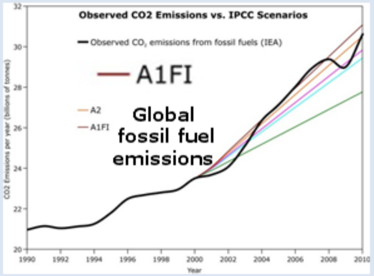
Worst case IPCC A1FI

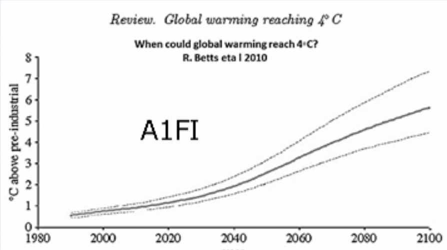
Significance:

- Unavoidable potentially irreversible greater degree of warming by locking in fossil fuel energy dependency
- Continued deferred warming from aerosol cooling
- Higher unavoidable warming from larger incurred feedbacks

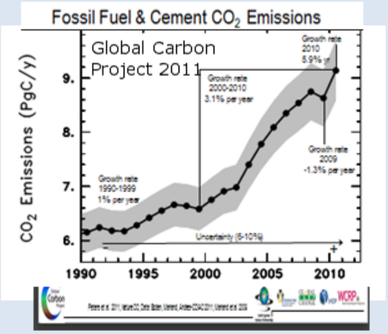
Today's world economy is fixed on the worst case IPCC fossil fuel intensive emissions scenario of A1FI, with no agreement or plan to be changed.

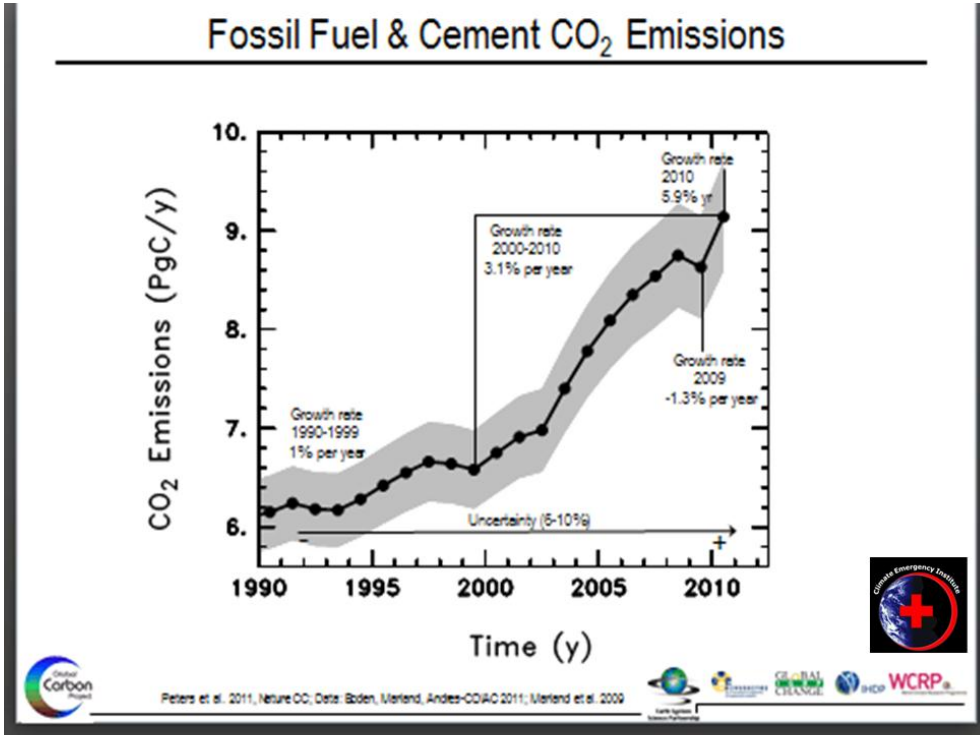
For A1FI the UK Met Office and Betts (2010) project a mean warming of 5.5°C (1 in 10 chance of over 7.2°C) by 2100, including terrestrial carbon feedback. That is a full eventual mean warming after 2100 of over 9.0°C.

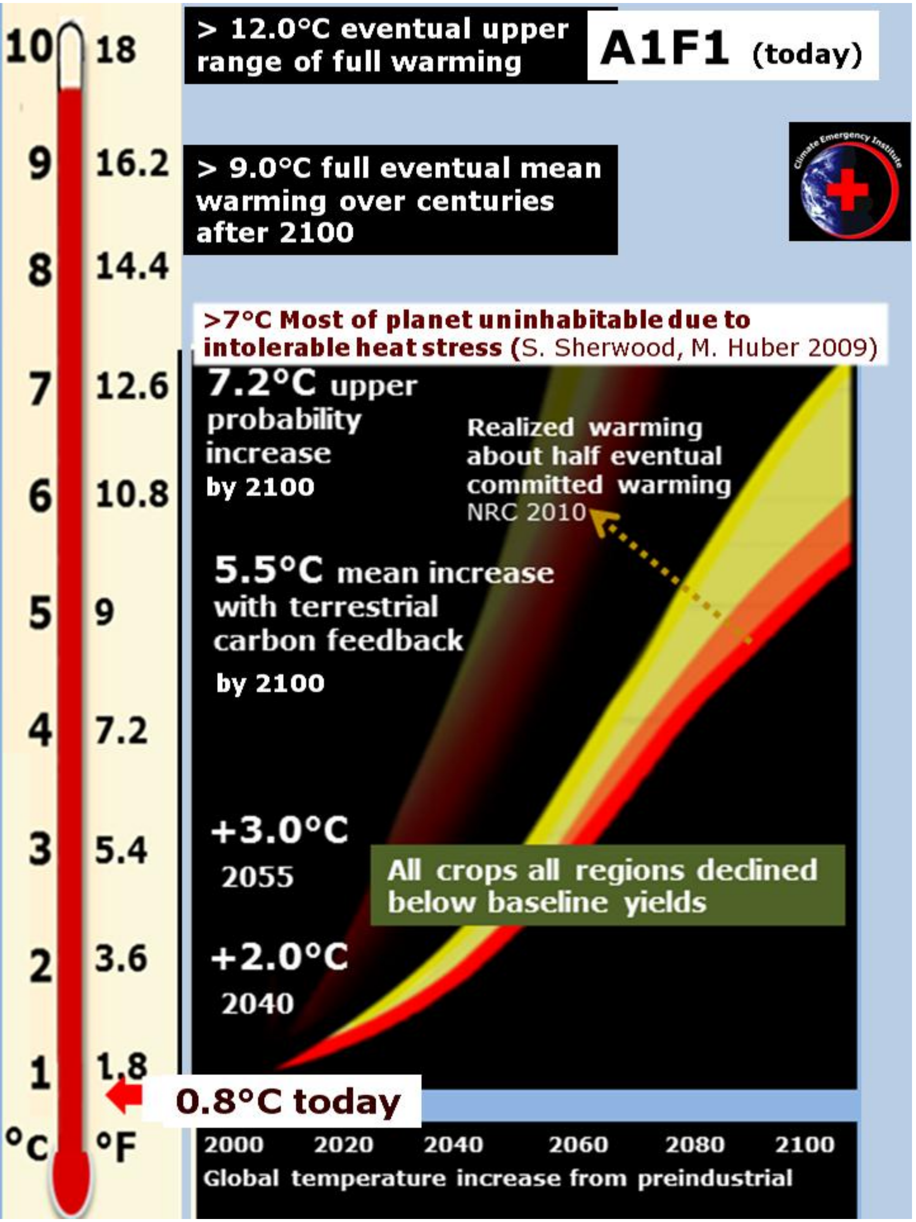




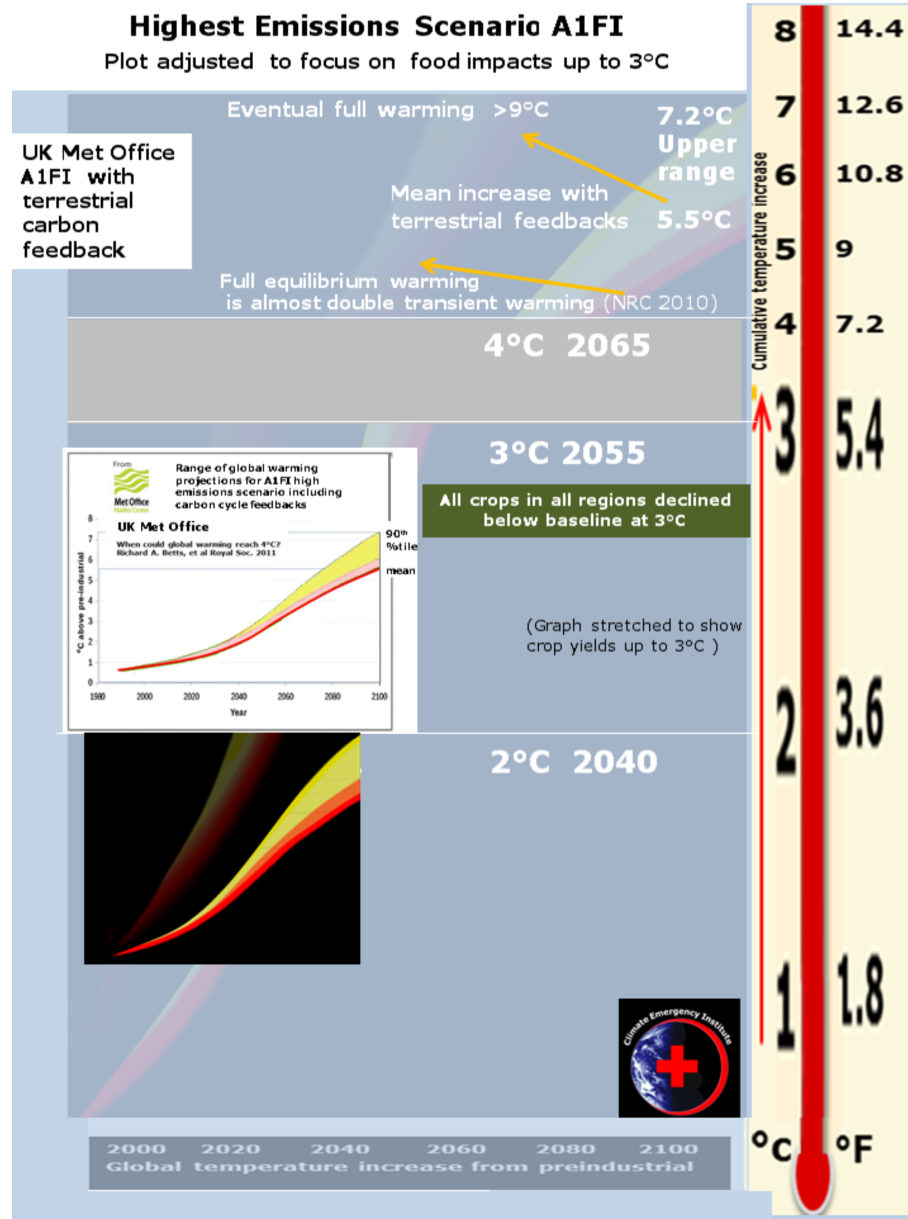
Global mean temperature change over the twenty-first century relative to pre-industrial, under the A1FI emissions scenario, ...The central thick line shows the median projection, and the two dashed lines show the 10th and 90th percentiles of the frequency distribution of the 729 MAGICC experiments.







> 12.0°C eventual upper range of full warming
A1F1 (today)
> 9.0°C full eventual mean warming over centuries after 2100
>7°C Most of planet uninhabitable due to intolerable heat stress (S. Sherwood, M. Huber 2009)
7.2°C upper probability increase by 2100
Realized warming about half eventual committed warming NRC 2010
5.5°C mean increase with terrestrial carbon feedback by 2100
+3.0°C 2055
All crops all regions declined below baseline yields
+2.0°C 2040
0.8°C today
°C
°F
10 9 8 7 6 5 4 3 2 1
18 16.2 14.4 12.6 10.8 9 7.2 5.4 3.6 1.8
2000 2020 2040 2060 2080 2100
Global temperature increase from preindustrial



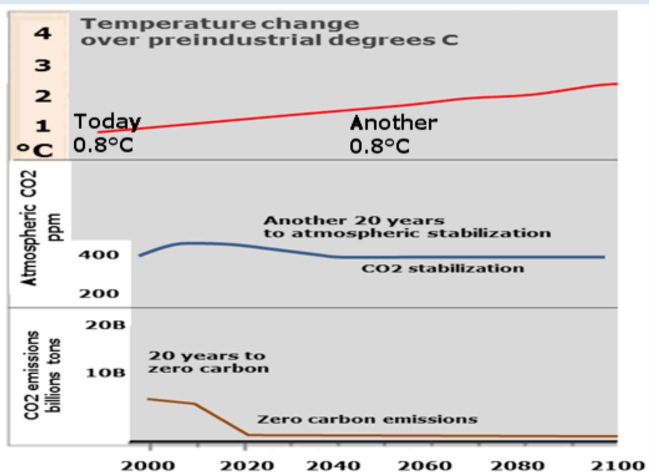
Highest Emissions Scenario A1FI
Plot adjusted to focus on food impacts up to 3°C
UK Met Office A1FI with terrestrial carbon feedback
Eventual full warming >9°C
7.2°C Upper range
Mean increase with terrestrial feedbacks
5.5°C
Full equilibrium warming is almost double transient warming (NRC 2010)
4°C 2065
3°C 2055
All crops in all regions declined below baseline at 3°C
Range of global warming projections for A1FI high emissions scenario including carbon cycle feedbacks
UK Met Office
When could global warming reach 4°C? Richard A. Betts, et al Royal Soc. 2011
90th %tile
mean
°C above pre-industrial
Year
(Graph stretched to show crop yields up to 3°C)
2°C 2040
Cumulative temperature increase
°C
°F
8 7 6 5 4 3 2 1
14.4 12.6 10.8 9 7.2 5.4 3.6 1.8
2000 2020 2040 2060 2080 2100
Global temperature increase from preindustrial

4. Shortest Possible Time from Emergency Emissions Reduction to Atmospheric GHG Stabilization

1. **Emissions reduction to virtual zero carbon**
   - **minimum 20 years** (Climate Interactive)

2. **Time from virtual zero carbon to atmospheric stabilization**
   - could be decades, according to the IPCC
   - **minimum 20 years** (Climate Interactive) – **totals an optimistic minimum of 40 years**
   - **adds another 0.8°C**

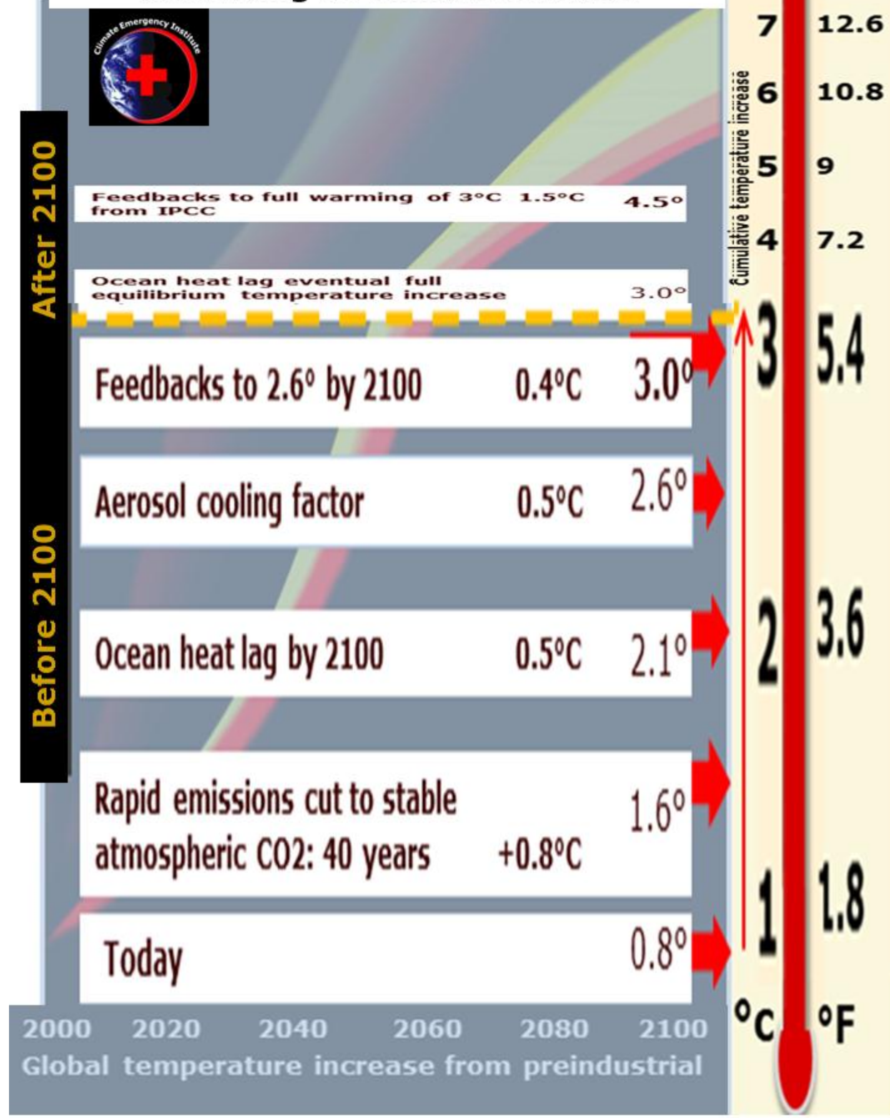
   - Assumes other long lasting GHGs are also stabilized

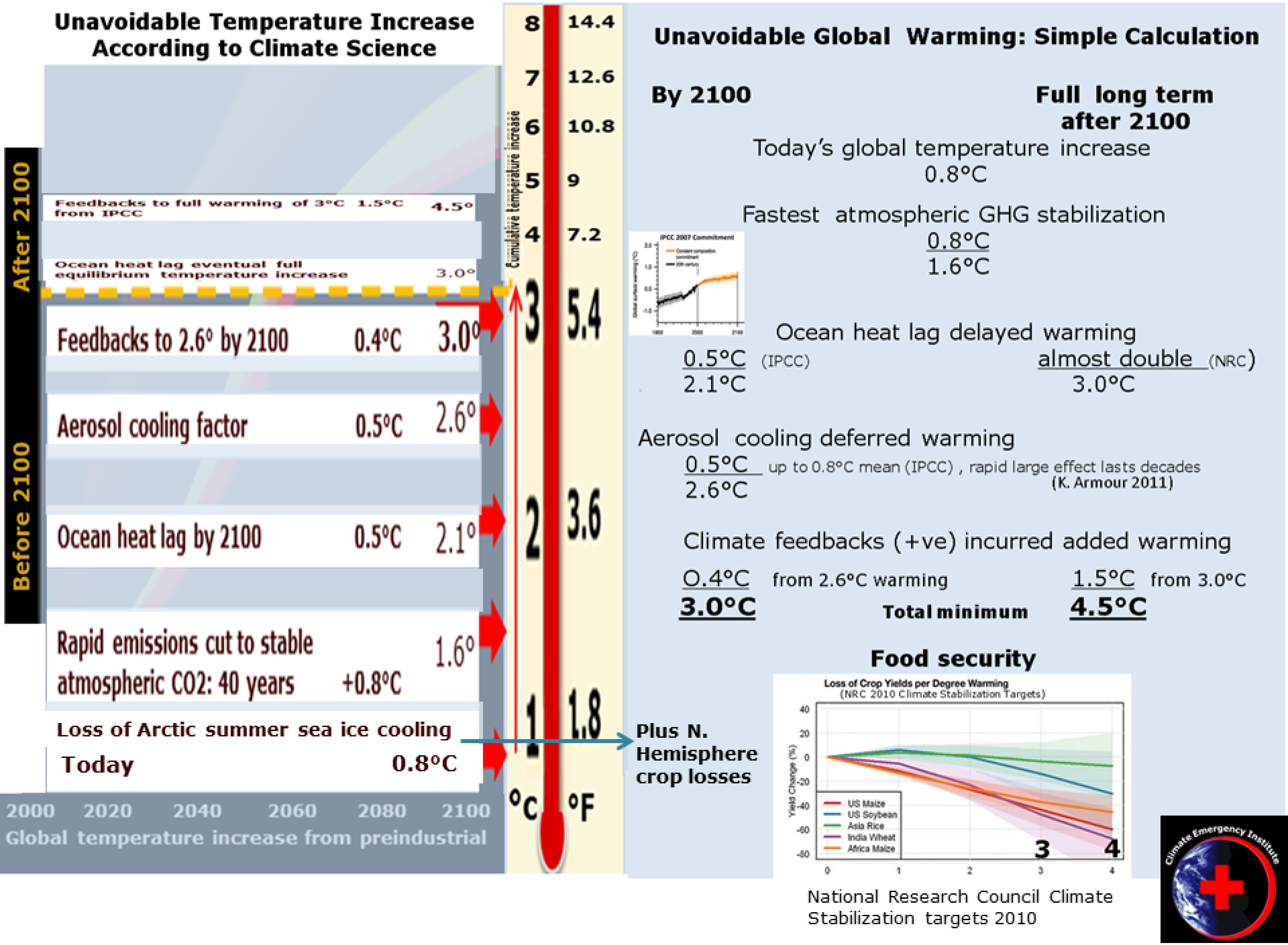


95% reduction of emissions in 20 years

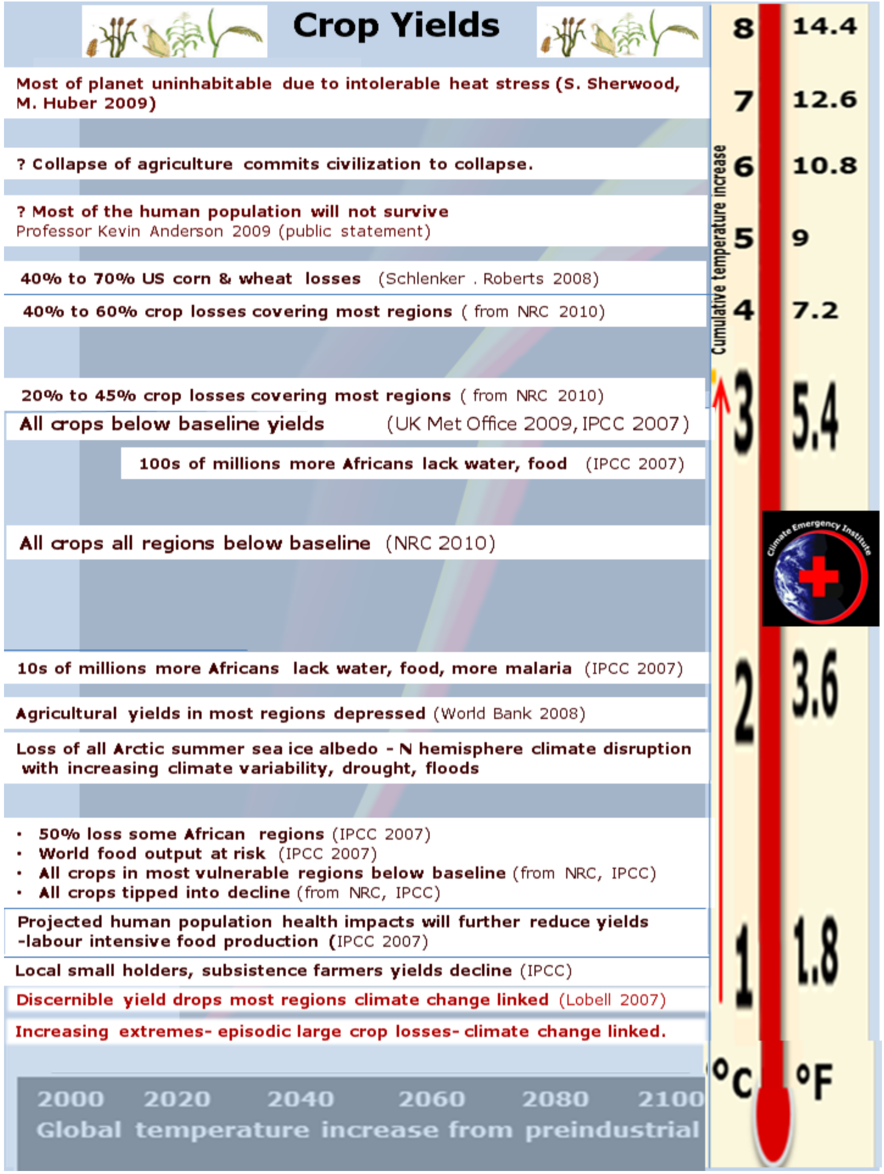
Source: Climate Interactive

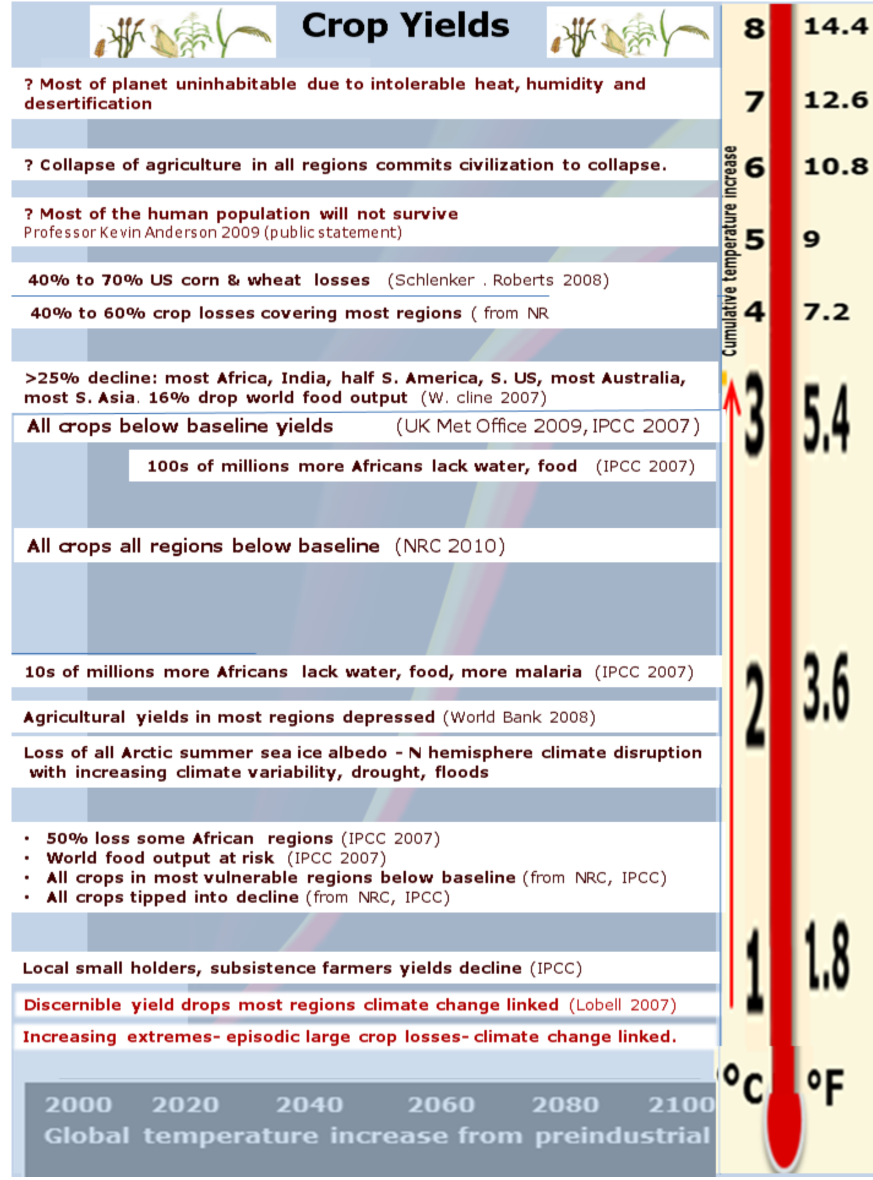
Unavoidable Temperature Increase According to Climate Science





Unavoidable Temperature Increase According to Climate Science
After 2100
Before 2100
Feedbacks to full warming of 3°C from IPCC 1.5°C 4.5°
Ocean heat lag eventual full equilibrium temperature increase 3.0°
Feedbacks to 2.6° by 2100 0.4°C 3.0°
Aerosol cooling factor 0.5°C 2.6°
Ocean heat lag by 2100 0.5°C 2.1°
Rapid emissions cut to stable atmospheric CO2: 40 years +0.8°C 1.6°
Loss of Arctic summer sea ice cooling
Today 0.8°C
2000 2020 2040 2060 2080 2100
Global temperature increase from preindustrial
Cumulative temperature increase
°C 8 7 6 5 4 3 2 1
°F 14.4 12.6 10.8 9 7.2 5.4 3.6 1.8
Unavoidable Global Warming: Simple Calculation
By 2100
Full long term after 2100
Today's global temperature increase
0.8°C
Fastest atmospheric GHG stabilization
0.8°C
1.6°C
IPCC 2007 Commitment
Ocean heat lag delayed warming
0.5°C (IPCC)
2.1°C
almost double (NRC)
3.0°C
Aerosol cooling deferred warming
0.5°C up to 0.8°C mean (IPCC), rapid large effect lasts decades (K. Armour 2011)
2.6°C
Climate feedbacks (+ve) incurred added warming
0.4°C from 2.6°C warming
3.0°C
1.5°C from 3.0°C
4.5°C
Total minimum
Plus N. Hemisphere crop losses
Food security
Loss of Crop Yields per Degree Warming
(NRC 2010 Climate Stabilization Targets)
Yield Change (%)
US Maize
US Soybean
Asia Rice
India Wheat
Africa Maize
National Research Council Climate Stabilization targets 2010
Climate Emergency Institute


Crop Yields
Most of planet uninhabitable due to intolerable heat stress (S. Sherwood, M. Huber 2009)
? Collapse of agriculture commits civilization to collapse.
? Most of the human population will not survive
Professor Kevin Anderson 2009 (public statement)
40% to 70% US corn & wheat losses (Schlenker . Roberts 2008)
40% to 60% crop losses covering most regions (from NRC 2010)
20% to 45% crop losses covering most regions (from NRC 2010)
All crops below baseline yields (UK Met Office 2009, IPCC 2007)
100s of millions more Africans lack water, food (IPCC 2007)
All crops all regions below baseline (NRC 2010)
10s of millions more Africans lack water, food, more malaria (IPCC 2007)
Agricultural yields in most regions depressed (World Bank 2008)
Loss of all Arctic summer sea ice albedo - N hemisphere climate disruption with increasing climate variability, drought, floods
50% loss some African regions (IPCC 2007)
World food output at risk (IPCC 2007)
All crops in most vulnerable regions below baseline (from NRC, IPCC)
All crops tipped into decline (from NRC, IPCC)
Projected human population health impacts will further reduce yields -labour intensive food production (IPCC 2007)
Local small holders, subsistence farmers yields decline (IPCC)
Discernible yield drops most regions climate change linked (Lobell 2007)
Increasing extremes- episodic large crop losses- climate change linked.
2000 2020 2040 2060 2080 2100
Global temperature increase from preindustrial
Cumulative temperature increase
8 14.4
7 12.6
6 10.8
5 9
4 7.2
3 5.4
2 3.6
1 1.8
°C °F
Climate Emergency Institute


Crop Yields
? Most of planet uninhabitable due to intolerable heat, humidity and desertification
? Collapse of agriculture in all regions commits civilization to collapse.
? Most of the human population will not survive
Professor Kevin Anderson 2009 (public statement)
40% to 70% US corn & wheat losses (Schlenker . Roberts 2008)
40% to 60% crop losses covering most regions (from NR
>25% decline: most Africa, India, half S. America, S. US, most Australia, most S. Asia. 16% drop world food output (W. cline 2007)
All crops below baseline yields (UK Met Office 2009, IPCC 2007)
100s of millions more Africans lack water, food (IPCC 2007)
All crops all regions below baseline (NRC 2010)
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Cumulative temperature increase
8 14.4
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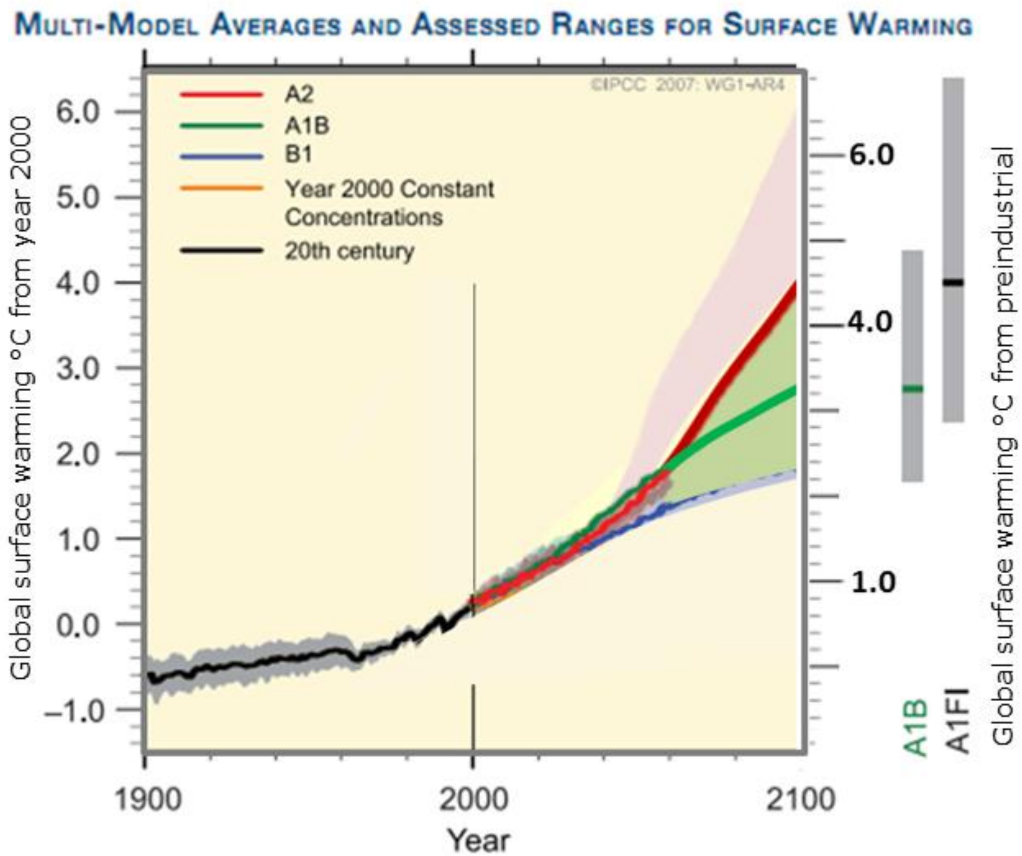
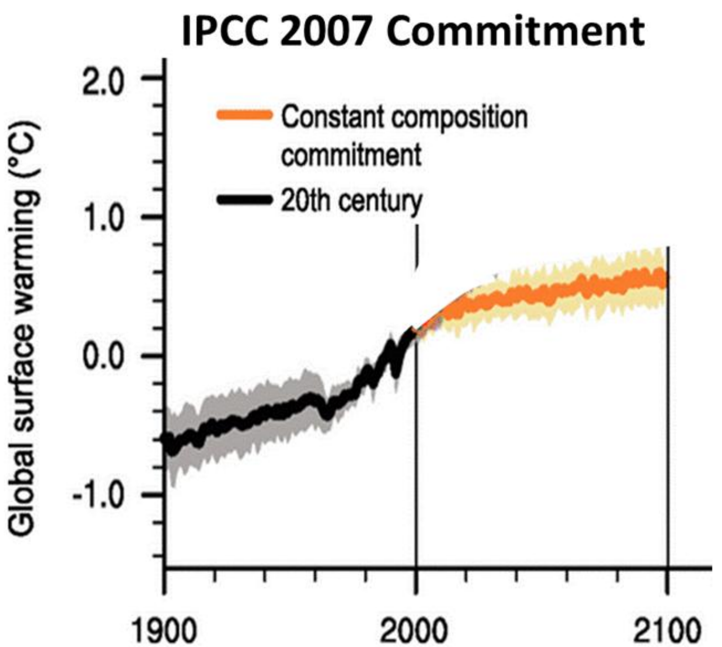
2 3.6
1 1.8
°C °F

IPCC AR4 2007 temperature increase projections showing worst case current scenario A1FI and A1B (often the base for research papers).

IPCC AR4 2007 showing the IPCC commitment to 2100 due to just the ocean heat lag

IPCC 2007 global average temperature increase projections (including from preindustrial) showing only A1B (the previously assumed business as usual scenario) and A1F1 and worst case global emissions scenario that we have been tracking for years and are fixed on.





Global temperature increases with crop losses AFRICA

Wolfram Schlenker, David Lobell 2010

Maize	sorghum	millet	groundnut	cassava

100s of millions more Africans lack water, food more malaria (IPCC 2007)

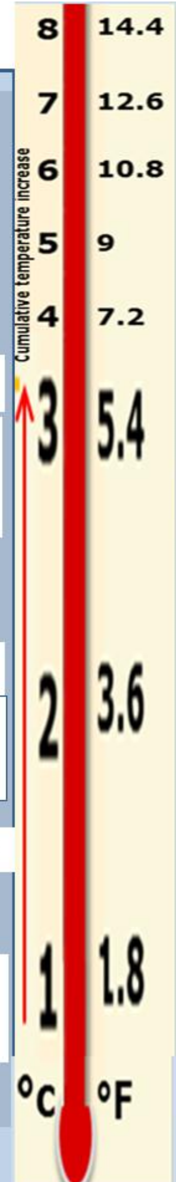
-30	-25	-25	-35	-13

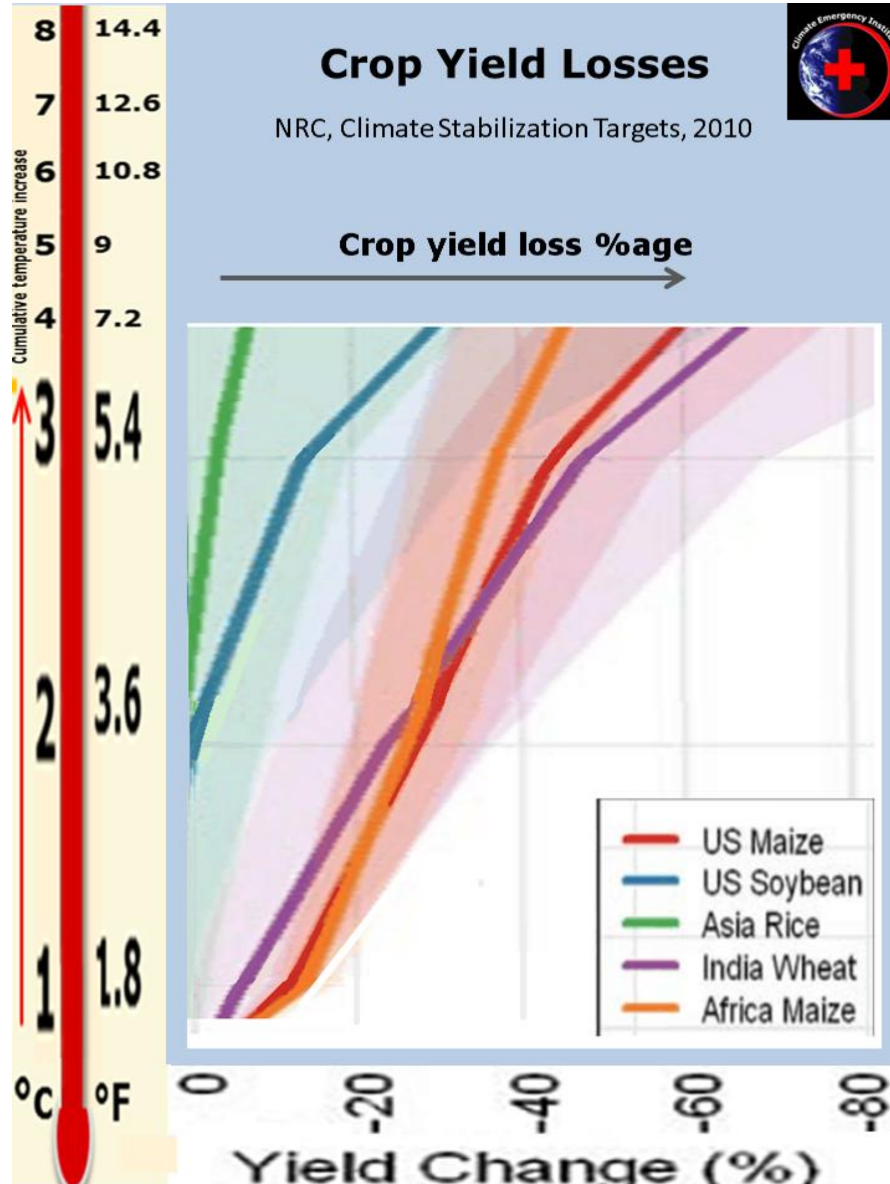
10s of millions more Africans lack water, food , more malaria (IPCC 2007)

−22,	−17,	−17,	−18,	−8%

50% loss some African regions (IPCC 2007)

Low latitude yields decline (IPCCP 07)
Local small holders, subsistence farmers yields decline (IPCC 07)



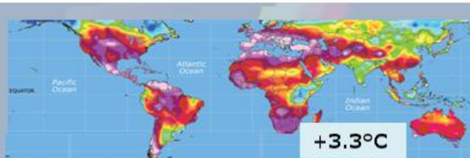


Drought

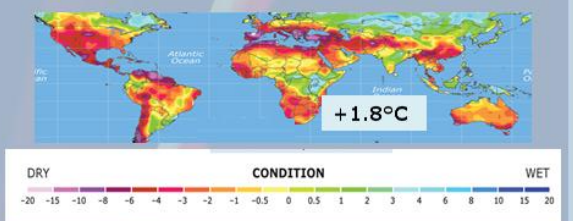
The impact of sudden or prolonged drought is not captured by the climate crop models

There is now higher confidence in the projected increases in droughts, heat waves and floods, as well as their adverse impacts. Increases in drought, heat waves and floods are projected in many regions IPCC 2007

Drought under global warming: a review
Aiguo Dai, Wiley Interdisciplinary Reviews: Climate Change, 2011



Climate models project increased aridity in the 21st century over most of Africa, southern Europe and the Middle East, most of the Americas, Australia, and Southeast Asia. (A Dai 2011)



Moreover, most crop modeling studies have not considered changes in sustained droughts, which are likely to increase in many regions (NRC 2010)

[...] This leads to an underestimation of future floods, droughts and irrigation water requirements. (IPCC Climate Change and Water Technical 2008

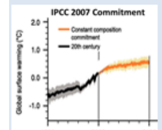
2000 2020 2040 2060 2080 2100
Global temperature increase from preindustrial

Unavoidable Global Warming: Simple Calculation

By 2100 | **Full long term after 2100**

Today's global temperature increase
0.8°C

Fastest atmospheric GHG stabilization
<u>0.8°C</u>
1.6°C

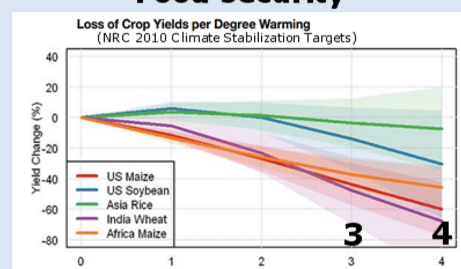


Ocean heat lag delayed warming
<u>0.5°C</u> (IPCC) | <u>almost double</u> (NRC)
2.1°C | 3.0°C

Aerosol cooling deferred warming
<u>0.5°C</u> up to 0.8°C mean (IPCC), rapid large effect lasts decades (K. Armour 2011)
2.6°C

Climate feedbacks (+ve) incurred added warming
<u>0.4°C</u> from 2.6°C warming | <u>1.5°C</u> from 3.0°C
<u>3.0°C</u> **Total minimum** **<u>4.5°C</u>**

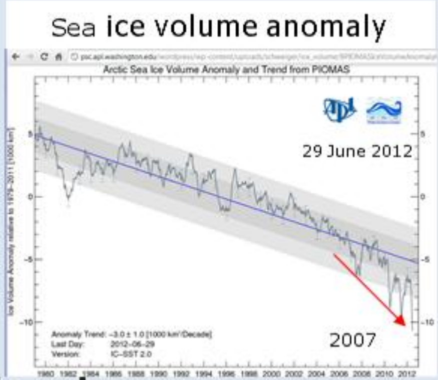
Food security



Loss of Arctic Snow and Summer Sea Ice Albedo Cooling

Unavoidable loss of Arctic albedo – feedback affecting the temperate N hemisphere.

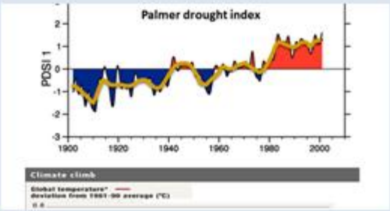
All sea ice models project virtual total loss of Arctic summer ice, >50% project possible abrupt loss. Most experts, based on sea ice extent models, say it is decades away. A few say it is years away, by accounting for the very rapid loss of sea ice volume.

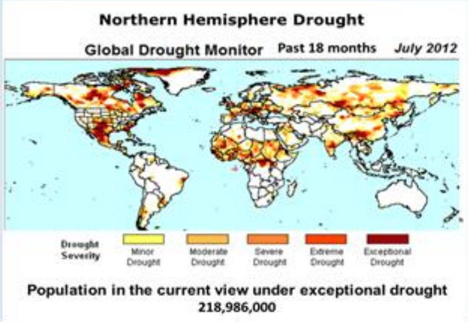


Impact on N.H. crop productivity is unknown.

Expected effects are increasing:

- **climate variability**
- **severe storms**
- **heat waves**
- **drought**
- **floods**





Global drought (PDSI) has been steadily increasing for the past 30 years. There is a recent trend of increasing N. hemisphere drought .