CLIMATE EMERGENCY INSTITUTE

The Health and Human Rights Approach to Greenhouse Gas Pollution

A review of IPCC global surface temperature increases from the first 1990 assessment to the 2018 1.5°C Report

Peter Carter

Temperatures start with slide 5

The flawed allowable carbon budget supposedly still left to burn: slides 40 and 41

Summary of (current) business-as-usual global average surface temperature increases from the IPCC Assessments

IPCC 1990 1st Assessment	IPCC 1995 2nd Assessment	IPCC 2001 3rd assessment	IPCC 2007 4th assessment	IPCC 2014 5th assessment
6.25°C	5.3°C	+4.8°C up to +6.2°C	4.5°C up to 6.4°C ↑ Accounts for terrestrial carbon feedbacks	4.3°C up to 6°C Possibly as high as 7.8°C
Climate sensitivity 3.8°C	4.5°C	3°C	3°C	3°C

NOTE: These are underestimates

These are all real world underestimates because amplifying greenhouse feedback emissions are not included (apart from a higher top range for IPCC 2001). None of the 'most likely' global warming model projections account for extra global temperature increases from feedback GHG emissions, which are certain. There are multiple enormous sources of feedback emissions.
This omission of extra feedback temperature increase is despite the fact that IPCC 2014 5th Assessment says GHG feedbacks will be positive (more emissions – higher heating) and that permafrost thawing will add substantially more CO2 and methane emissions this century (higher heating) .
On subsea floor methane hydrate emissions IPCC has recognized this as a source of feedbacks (to ocean warming) from the 1st 1990 IPCC Assessment, saying most of released methane hydrate would emit as CO2, as well as methane.
Also excluded is weakening of the currently increased land and ocean carbon sinks

Also, the smooth linear model projections exclude the possibility of sudden high global temperature increases, which is to be expected due to the multiple amplifying feedbacks.

Sources of Greenhouse Gas Radiative Forcing for policy making i.e. Total Global Heating

Note: 93% of the added GHG heat has gone to ocean heating

(Very damaging to ocean function and marine life)

4 Sources of Human Caused Greenhouse Gases

1. Direct industrial age GHG emissions

2. Indirect feedback GHG emissions

3. Failing efficiency of land and ocean carbon sinks (indirect).

4. Extra heat 'unmasking' of air pollution aerosol cooling removal when fossil fuels are no longer burnt for energy

Atmospheric Aerosols	
Acid micro-particles	Cooling
Black carbon micro-particles	heating

Global Surface Warming by 2100: 7.8°C ?

Global surface warming under the current
Business-as-usual fossil fuel world economy scenario
has consistently been shown to be above 4°C
and may be as high as 7.8°C

However, we cannot assume there will be a world for us beyond 2°C

This is clearer than ever with changes happening decades earlier than predicted.
The long standing (now abandoned) 2°C danger limit leads to
the collapse of world agriculture and so civilization's collapse,
and 2°C triggers planetary catastrophe
hot-house Earth runaway heating & climate chaos,
that the human race could not survive.
The EU 2°C policy dating back to 1996 was to
minimize the risk of runaway, but not exclude it.
It was never considered safe.

Since the 2018 IPCC 1.5°C Report, the danger limit is recognized to be 1.5°C

Introduction to
global average temperature increases

2020 Human Race Deadline for Global Emissions to Decline

The only thing that matters today is achieving a rapid decline on global emissions from THIS YEAR 2020. This must happen for both the 1.5°C and 2°C increases. 1.5°C must just be a faster rate of decline. The 1.5°C world will be disastrous- but 2°C leads to total end of world climate and oceans catastrophe. The 2°C limit is no limit because it will trigger feedbacks (inter-reinforcing feed-back loops) that will keep the planet heating – for which there is no known limit.

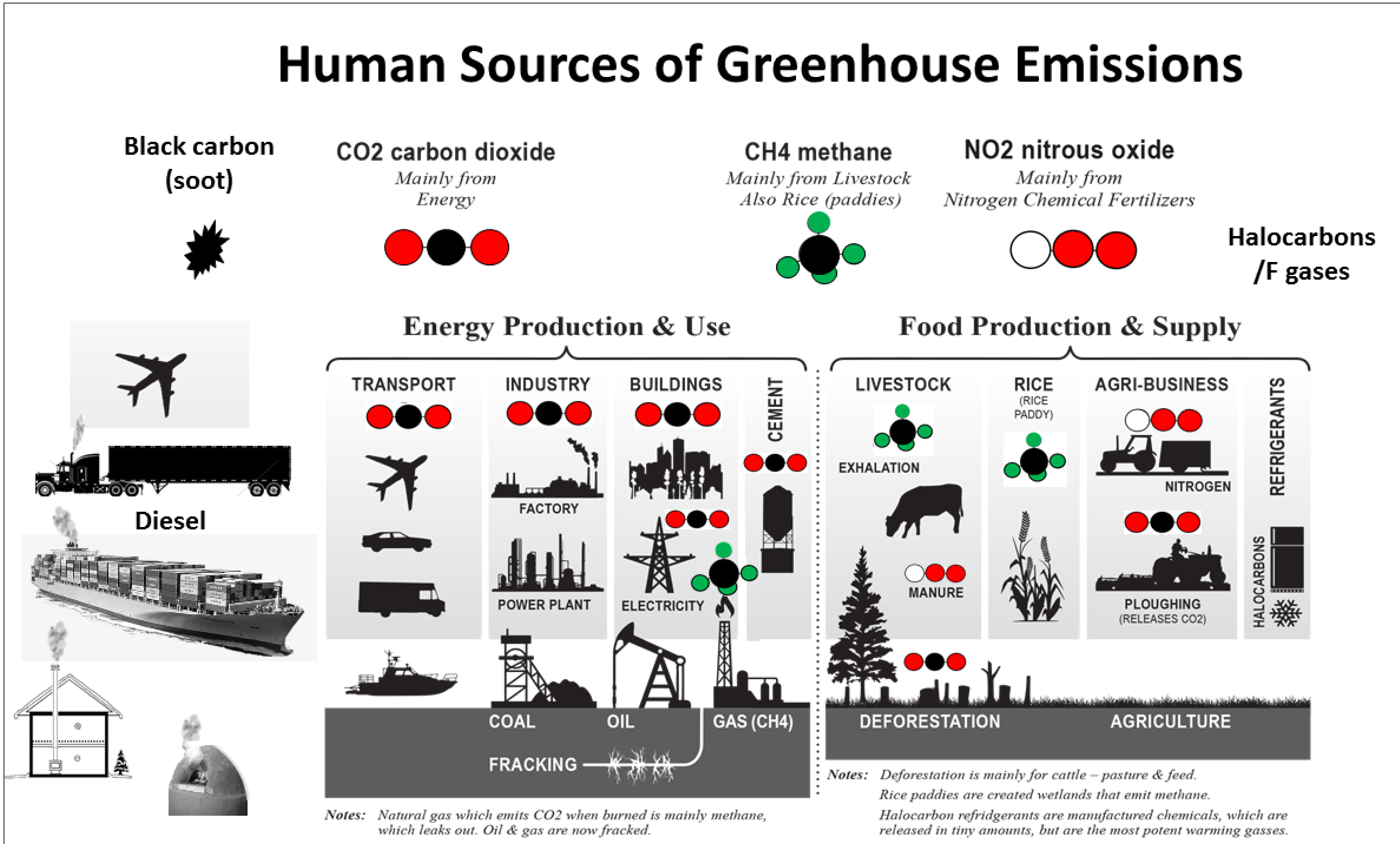
Fossil global CO2 emissions are still increasing and energy projections are to continue the trend. Global energy projections are for continued increases in fossil fuel combustion with nearly a 20% increase in 2050 (Sept 2029, IEA International Energy Outlook). **That is a globally deadly fossil fuel business-as-usual scenario.**

Projections of temperature and impacts above 2°C are exercises in climate computer modelling but highly misleading for policy making and the public.

To drive the world economy there into the future there is only 1 choice
A continued 80% fossil fuel driven economy with continued fossil fuel extraction and expansion, can only lead to biosphere collapse.

A 100% zero-combustion clean renewable energy economy will lead to a Golden Age for all Humanity.

1. Direct GHG industrial age emissions

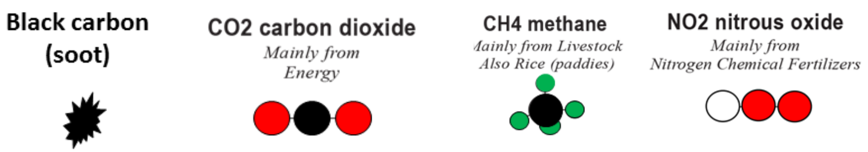


The IPCC Treatment of Amplifying GHG Feed-backs

None of the IPCC assessments account for feedback emissions in their 'most likely global temperature increase projections, so in the real world the global surface warming projections given will be under-estimates, as feedback emissions kick in at about 1.5°C of surface temperature increase.
As the surface temperature increases the added feedback warming will increase

Feed-back emissions

Extra GHG emissions released by the planet caused by our global surface temperature increase of the planet are feedback emissions - which boost our direct global heating even more.
The higher the global surface temperature increase the more the feedback GHG emissions



Feedbacks are classified as 'terrestrial' (carbon cycle) and other (large) sources (forest fires, warming peatlands, thawing permafrost, decomposing subsea floor methane hydrate).

Feedback emissions from forest fires, warming peatlands and thawing permafrost are certain to increase with increasing surface heating. Subsea methane hydrate under ocean warming will release methane, but the effect on global surface warming is unknown.

Only the IPCC 2007 4th assessment provided information of extra surface temperature increase from feedback emissions., which is why the upper range is so high.

PERMAFROST & METHANE HYDRATE IPCC 2019 *The Ocean and Cryosphere in a Changing Climate*.
The RCP8.5 scenario (high emissions) leads to the cumulative release of tens to hundreds of billions of tons (GtC) of permafrost carbon as CO2 and methane to the atmosphere by 2100 with the potential to exacerbate climate change.
Under future global warming, there is risk of increased methane emissions from … sub-sea gas hydrates. The IPCC says this will slowly add emissions to the atmosphere over – mainly as CO2 due to CH4 oxidation in the water column

The Planet Carbon Sinks
Land (terrestrial) **& Ocean**

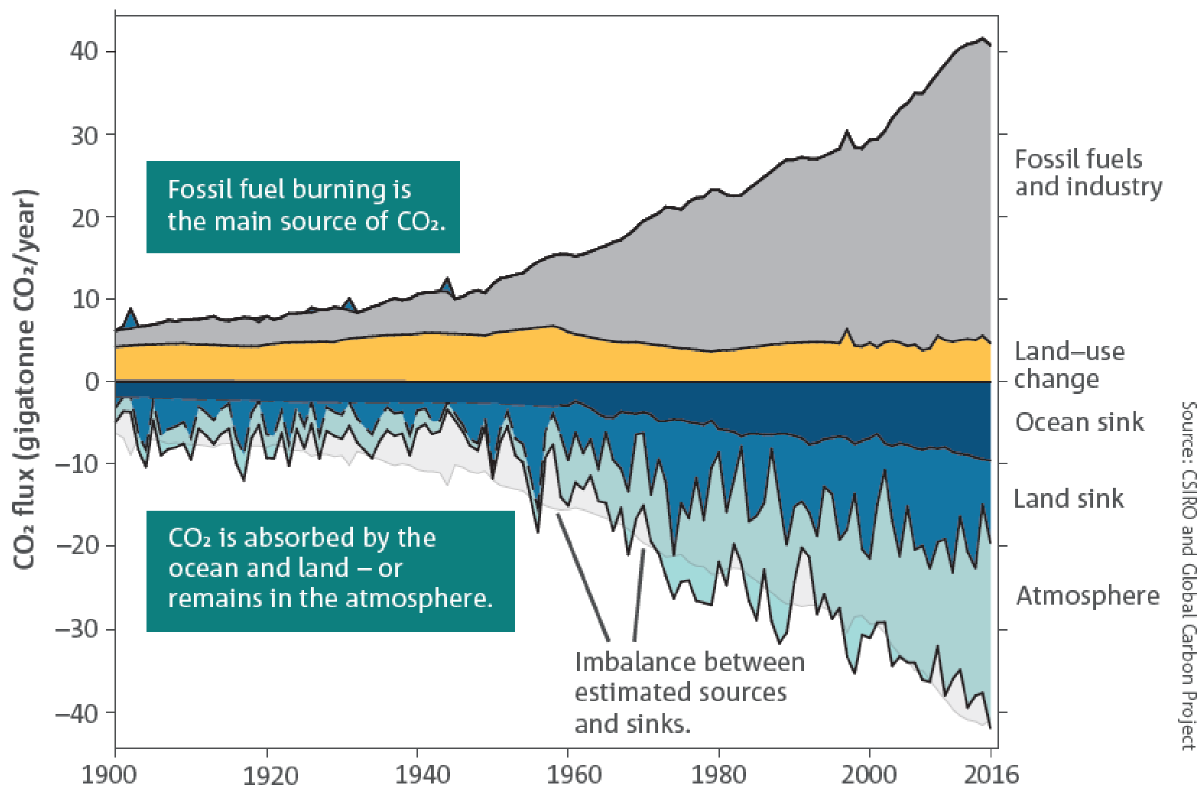
Carbon sink switch to carbon source

It is predicted that the greening effect on the planet of increased atmospheric CO2 will not last. The new forest growth will decay and die returning the increased accumulation of carbon back to the atmosphere as CO2. This will then switch the carbon sink to carbon source with a large boost to global heating.

It looks from this graphic like the land carbon sink is beginning to switch .

The oceans will also inevitably not be able to keep increasing the amount of CO2 dissolved at the ocean surface. This sink will lose efficiency, and as it does the global heating will increase.

About 25 per cent of the CO2 emissions from human activities have been taken up by the ocean through diffusion, and over 30 per cent by the vegetation on land.



The CO_2 fluxes in the global carbon budget over the period 1900–2016.

The IPCC Emissions Scenarios

The IPCC projected surface temperature increases vary widely due to the various socio-economic scenarios used. The IPCC assessments of future effects of emissions are based on invented possible scenarios based essentially on economics and populations.

Different scenario formulations have been used for the different assessments

The scenarios we need are continued high fossil emissions (and other industrial sources) business as usual, and we need best case scenario with climate policies applied.

The 1990 1st assessment included an appendix of a range of T increases that included possible climate policies. The was not in the Summary for Policy Makers (SPM) so the governments were not aware of it.

Up to the 2014 5th IPCC assessment (AR5) the future scenarios did no include any climate policies.

So all temperature projections up to the AR5 were above 2C.

The AR

IPCC Global Temperature Increase Baselines and Horizons

Policy targets are global average temperature increase from the pre-industrial period (1881-1920 average is what I use (like James Hansen), but the T increases in the assessments since the first 1990 assessment have been taken from baselines many years after the pre-industrial, so they have to be converted for policy comparisons.

The corrections here are sourced from NASA GISS. (relative to 1986–2005) from

The 1st (1990) and 2nd (1995) Assessments used a 3 specified climate sensitivities (not the same) that covered the wide range of computer model projections. The subsequent assessments use only one climate sensitivity of 3°C , which was mean of the model projection results.

(relative to 1986–2005): 0.69°C

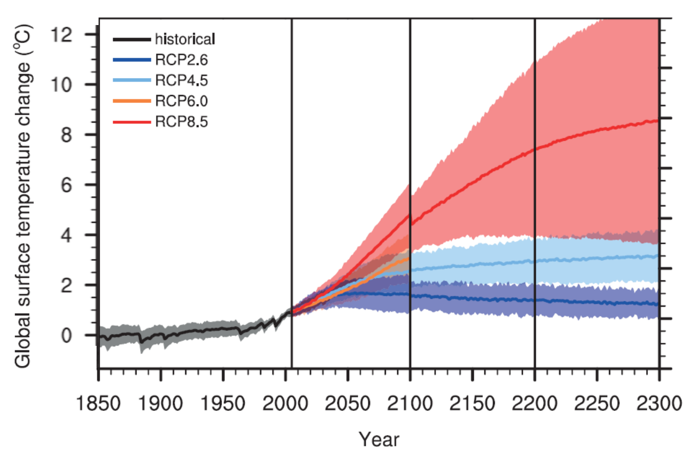
Time horizon

The IPCC assessment horizon is only up to 2100, so the impacts from global climate change are only given up to 2100.

The global heating by 2100 is a commitment for much more heating to continue long after 2100, albeit at a slowing rate.

Global climate change will last over a thousand of years, as will increasing climate change so long as atmospheric GHGs are not stabilized.

T+ from pre-industrial



IPCC AR5 Figure 12.5

IPCC Climate Sensitivity

The climate sensitivity is the basic metric that all assessments are based on.
It is defined as the global surface temperature increase resulting from a doubling of atmospheric CO_2 concentration (preindustrial CO_2).

The 1st (1990) and 2nd (1995) Assessments used a 3 specified climate sensitivities (not the same ones) that covered the wide range of computer model projections.

The subsequent assessments use only one climate sensitivity of 3°C , which was mean of the model projection results.

Except the 2018 IPCC 1.5°C Report used only 2.5°C.

Going back years a few studies have projected a climate sensitivity at the top of the IPCC range (4.5°C). Recent research with more complete climate science in the models projects climate sensitivity as high as 5°C. So here I take the high climate sensitivity for the 1st and 2nd assessments.

Although the IPCC applies the single sensitivity metric of 3°C, which is borne out by global warming to date, sensitivity has to increase with increasing global surface temperatures.
Water vapor (most abundant atmospheric GHG) acts as a powerful amplifying feed-back, about doubling the surface temperature increase caused directly by GHG emissions.
As a multiplier effect this will increase climate sensitivity as global warming increases.
Also global surface heating is melting back land ice and Arctic sea-ice. This loss of albedo cooling will increase climate sensitivity.
GHG feed-back emissions and declining efficiency of the current increased land and ocean carbon sinks, will increase sensitivity.

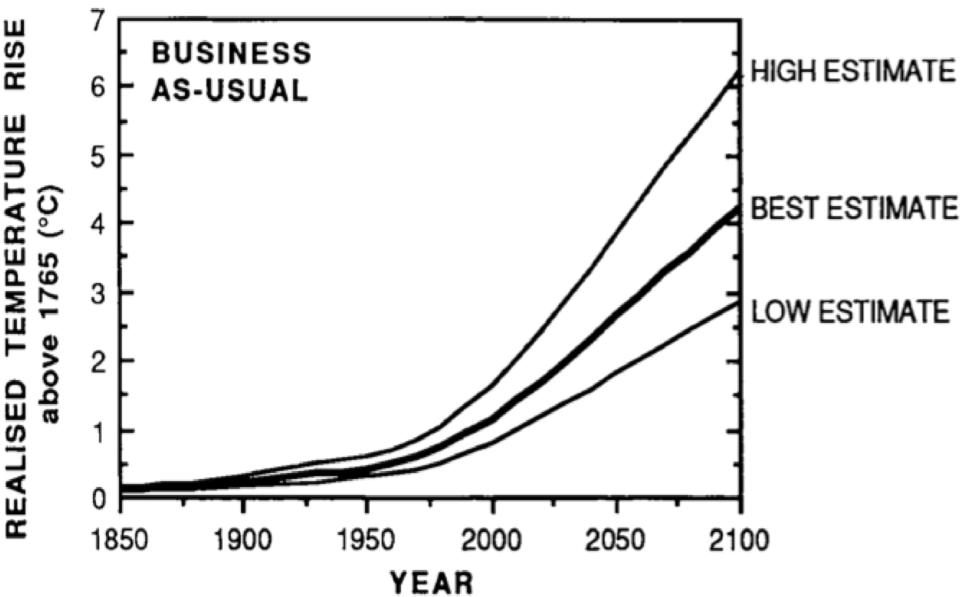
Computer models exclude sudden non-linear heating

Limitation of IPCC computer models excludes abrupt temperature increase

Global temperature increase due to GHG emissions is not a smooth linear curve

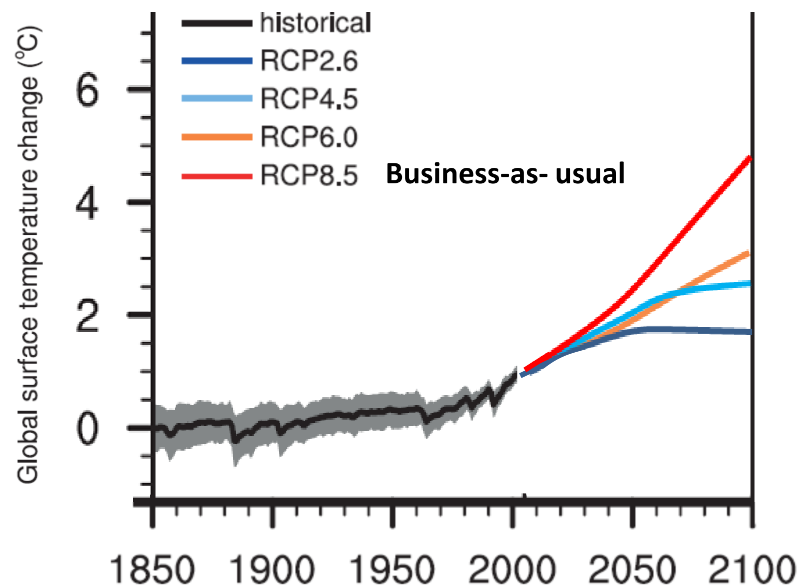
IPCC 1990 1st Assessment

Temperature increases from pre-industrial (1765)



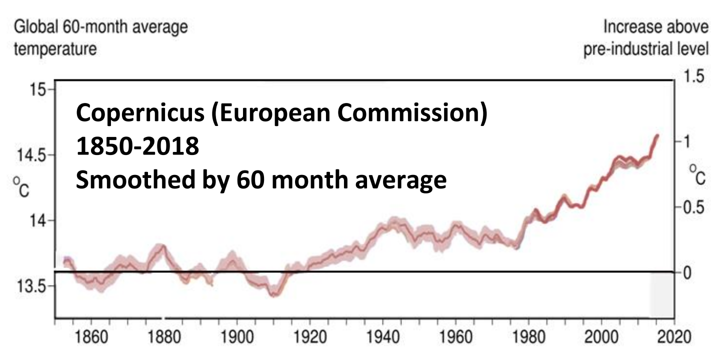
Most recent 2014 IPCC 5th

Temperature increases from pre-industrial (1881-1920)



Source: IPCC 2014 5th Assessment

Actual global temperature increase



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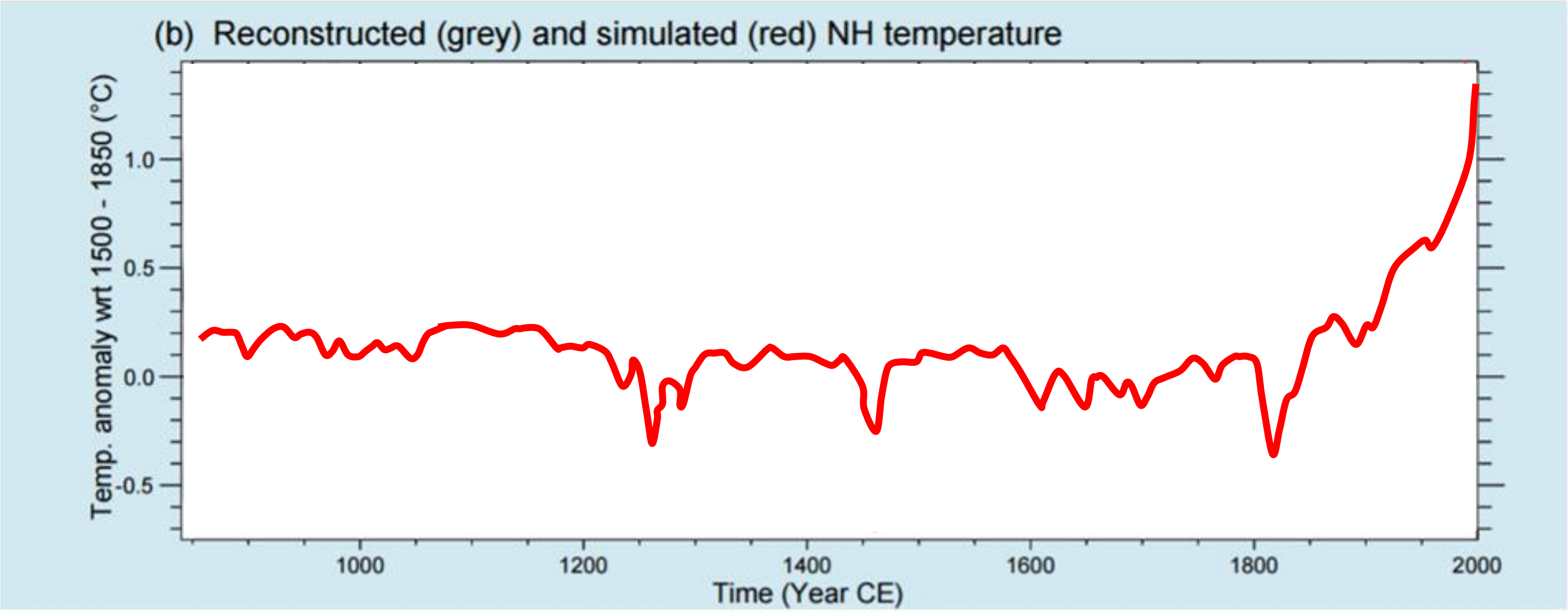
Northern hemisphere temperature change over the past 2000 years (IPCC AR5)

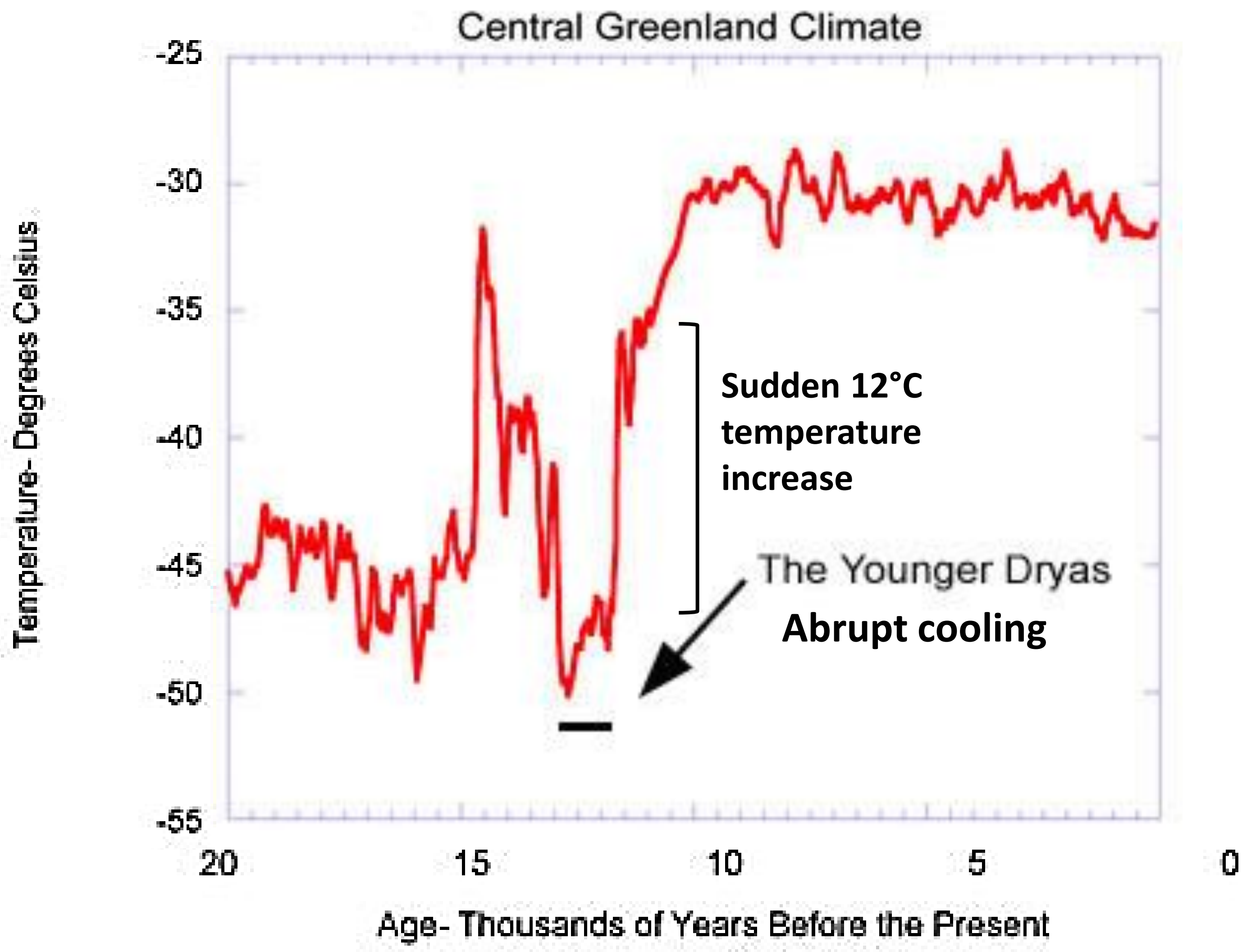
Temperature does not change in a smooth linear fashion



IPCC AR5 WG1 Box TS.5, Figure 1 | Last-millennium simulations and reconstructions. Paleoclimate Modelling Intercomparison Project

Non-linear abrupt surface cooling followed by abrupt warming just from 12,000 to 15,000 years ago

(Northern hemisphere ice core record)



Central Greenland temperature over the past 20,000 years from NOAA The Younger Dryas

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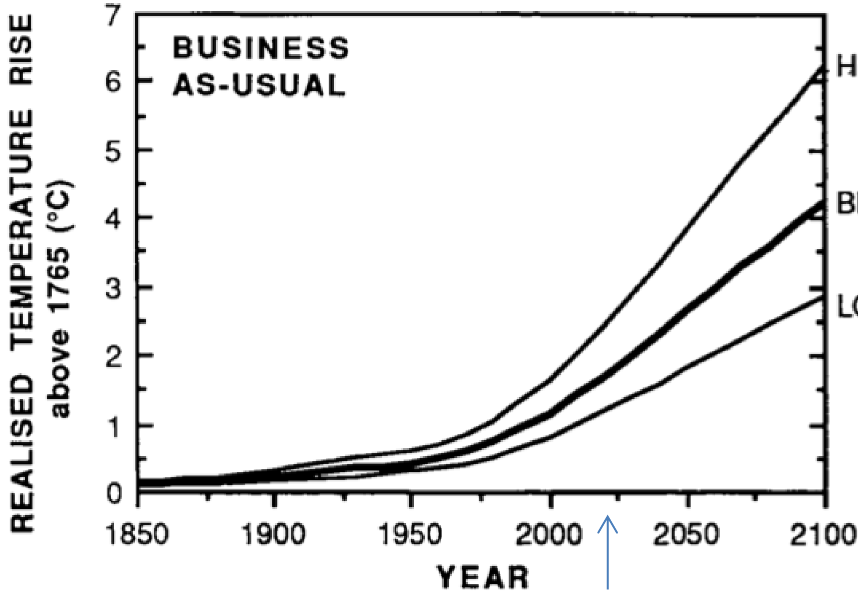
IPCC 1990 1st Assessment (FAR)

IPCC 1990 1st Assessment (FAR)

Usual business emissions scenario with higher climate sensitivity **+6.25°C**

Temperature increases from pre-industrial (1765)



	2100 T+	Climate sensitivities
HIGH ESTIMATE	+6.25°C	3.8°C
BEST ESTIMATE	+4.25°C	2.1°C
LOW ESTIMATE	+2.8°C	1.3°C

No amplifying feedback emissions

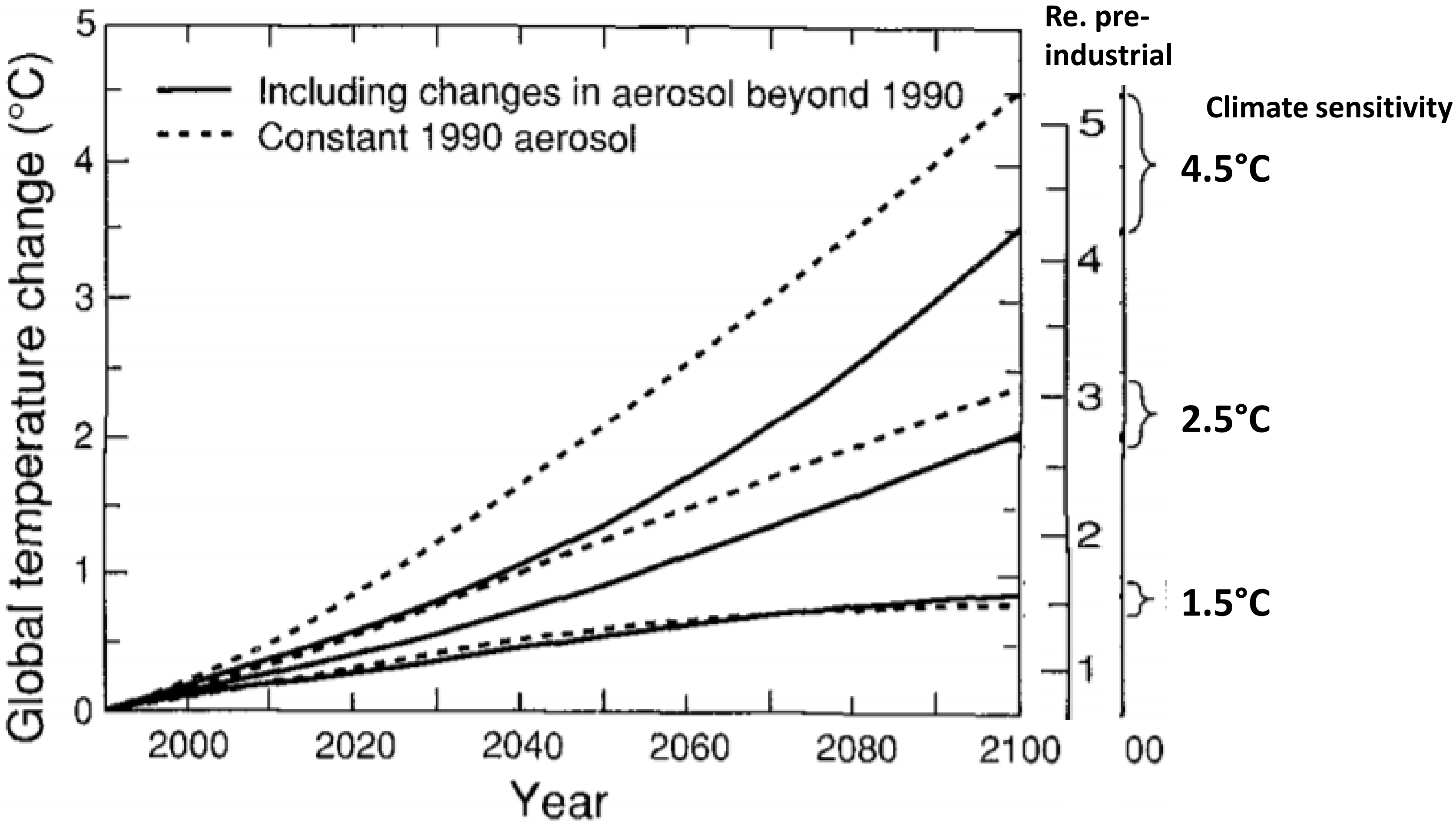
Figure 8: Simulation of the increase in global mean temperature from 1850-1990 due to observed increases in greenhouse gases, and predictions of the rise between 1990 and 2100 resulting from the Business-as-Usual emissions

Figure 1: IPCC FAR projected global warming in the BAU emissions scenario using climate models with equilibrium climate sensitivities of 1.3°C (low), 2.1°C (best), and 3.8°C (high) for doubled atmospheric CO2

IPCC 1995, 2nd Assessment Report

IPCC 1990 2nd Assessment (SAR)

Usual business emissions scenario with higher climate sensitivity **T+ 5.3°C**



The solid curves include the effect of changing aerosol;
the dashed curves assume aerosol emissions remain constant at their 1990 levels.

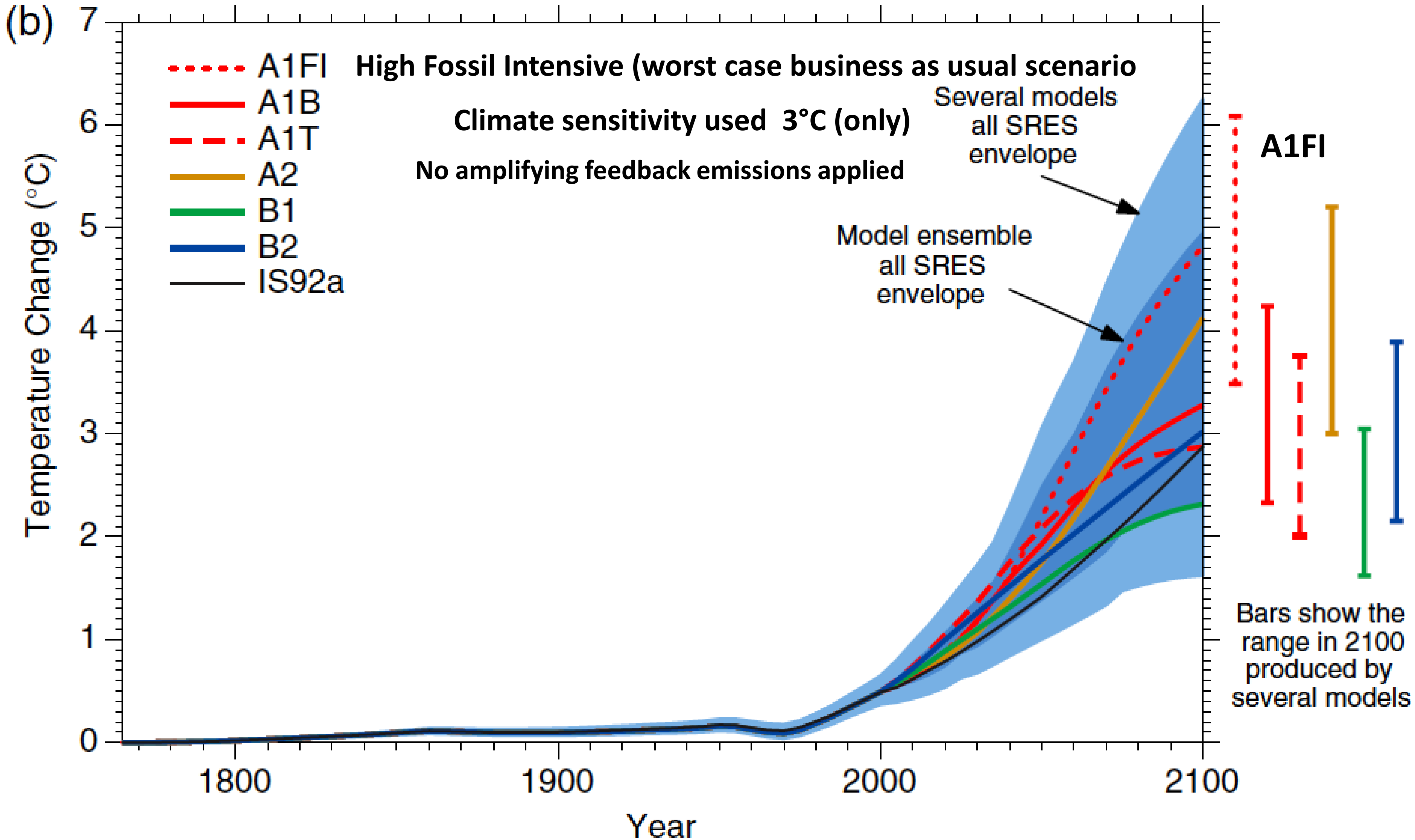
Global T increase from 1990 Correction for pre-industrial is 0.72°C

Annual J-D 1990	L-OTI(°C) Anomaly vs 1881-1920	0.72

IPCC 2001, 3rd Assessment Report

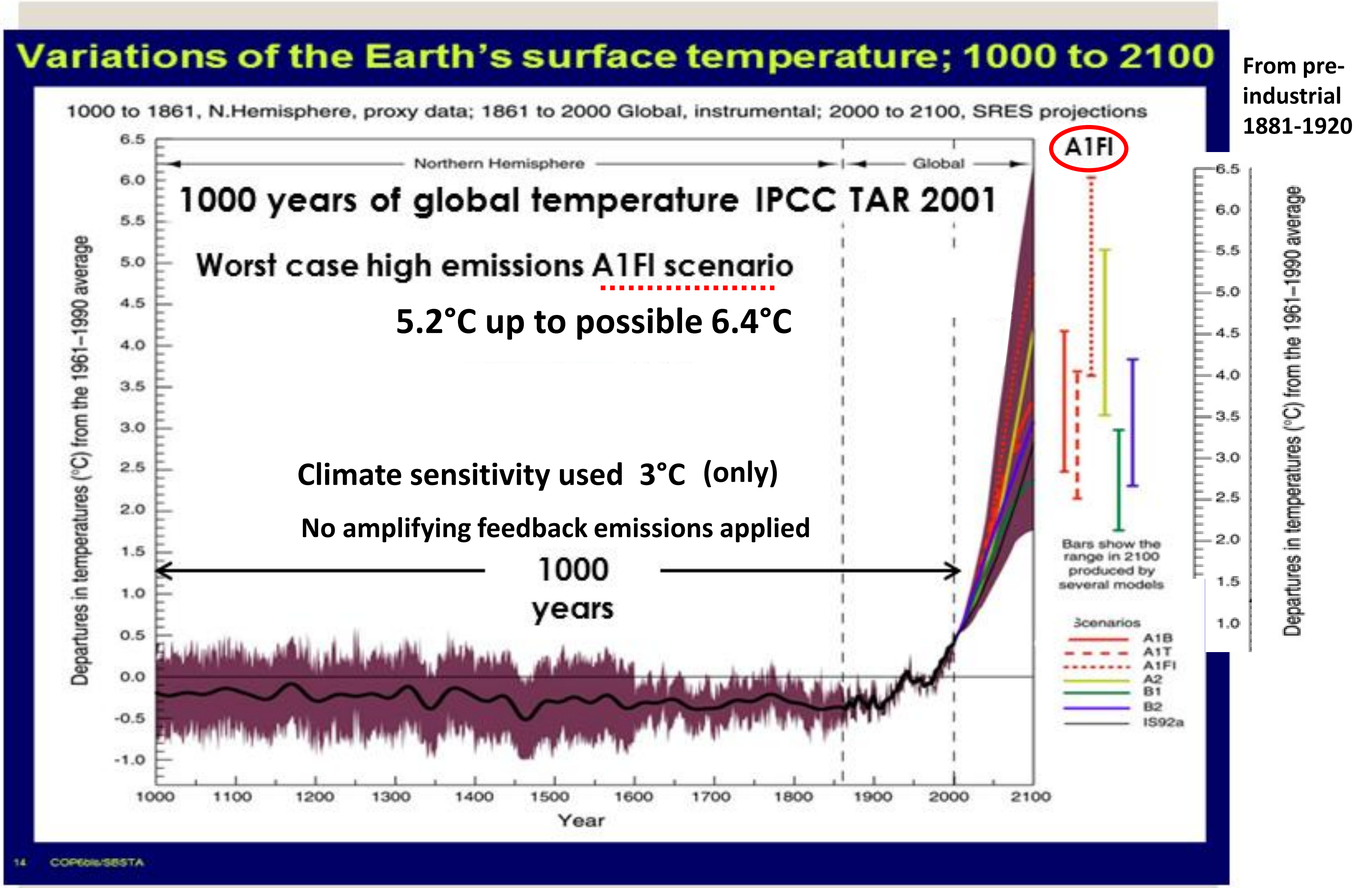
IPCC 2001 3st Assessment (TAR)

Business as usual scenario +4.8°C up to +6.2°C



IPCC 2001 3st Assessment (TAR) 1000 years of temperature

High Fossil Intensive (business-as usual-scenario) 4.9°C to 6.5°C



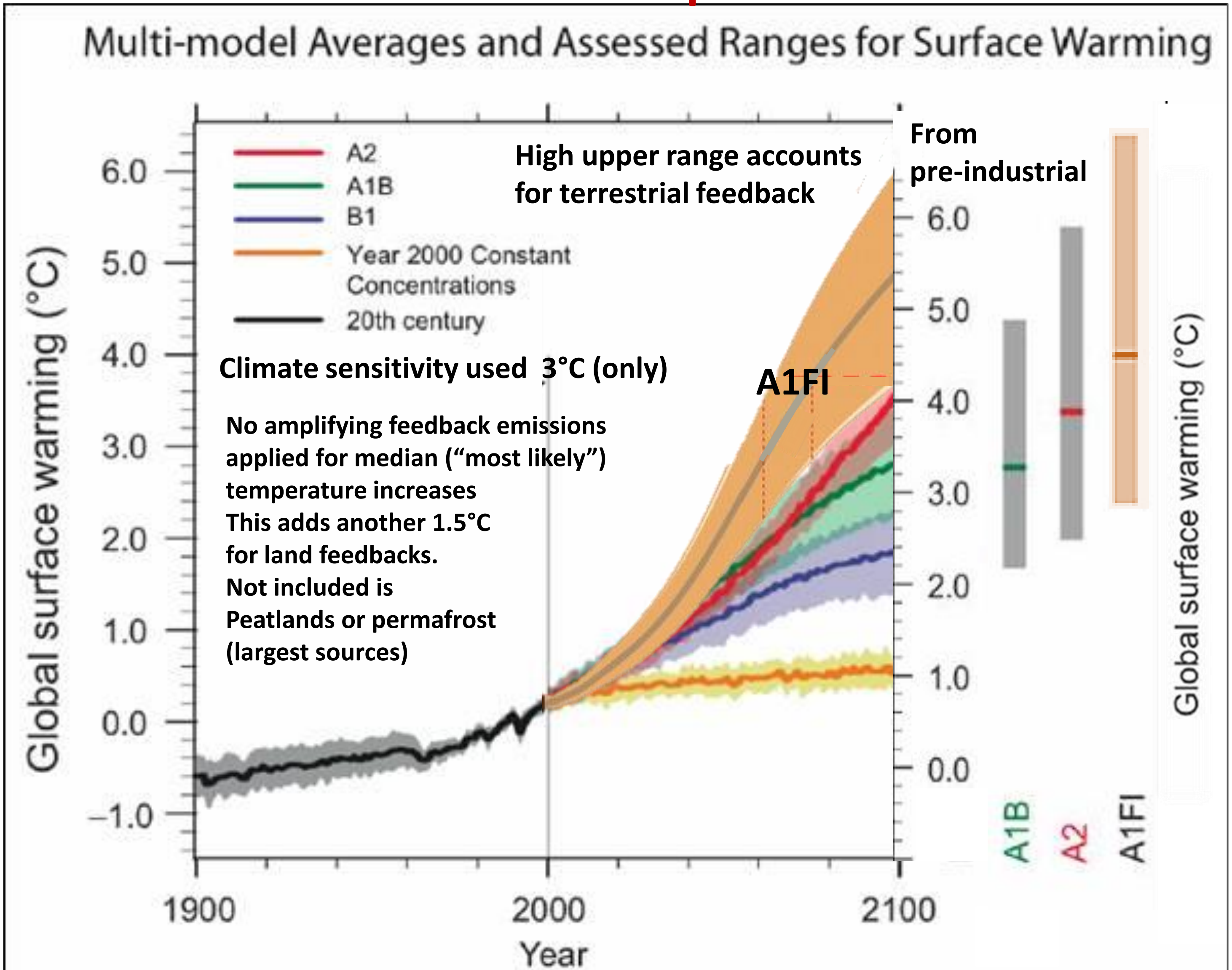
Pre-industrial conversion +0.37°C (NASA GISS)

Annual J-D 1961-1990 L-OTI(°C) Anomaly vs 1881-1920 NASA GISS 0.37

IPCC 2007, 4th Assessment Report

IPCC 2007 4th Assessment (AR4) Worst-case scenario

4.5°C up to 6.4°C



Pre-industrial conversion +0.5°C (IPCC AR4)

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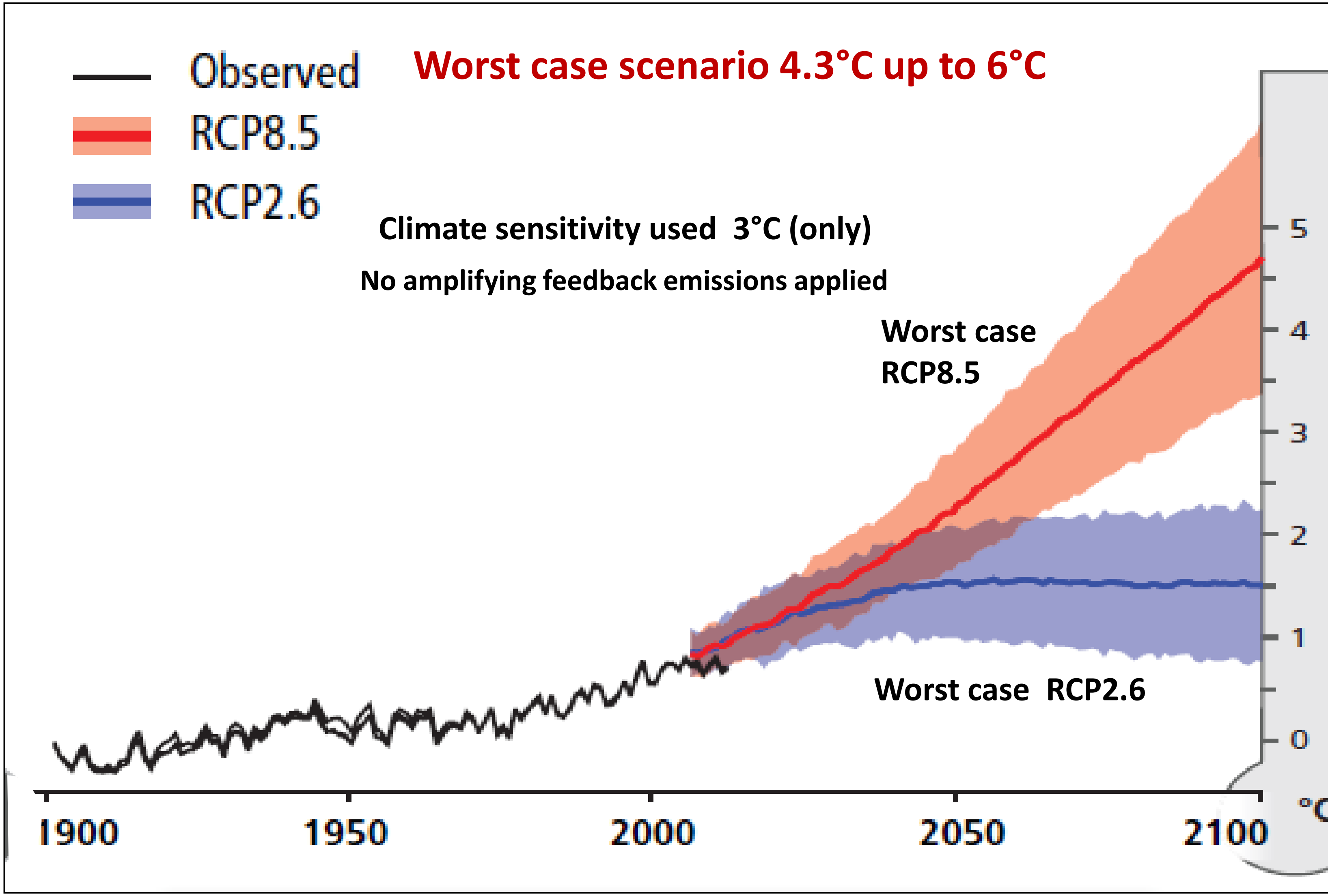
IPCC 2014, 5th Assessment Report

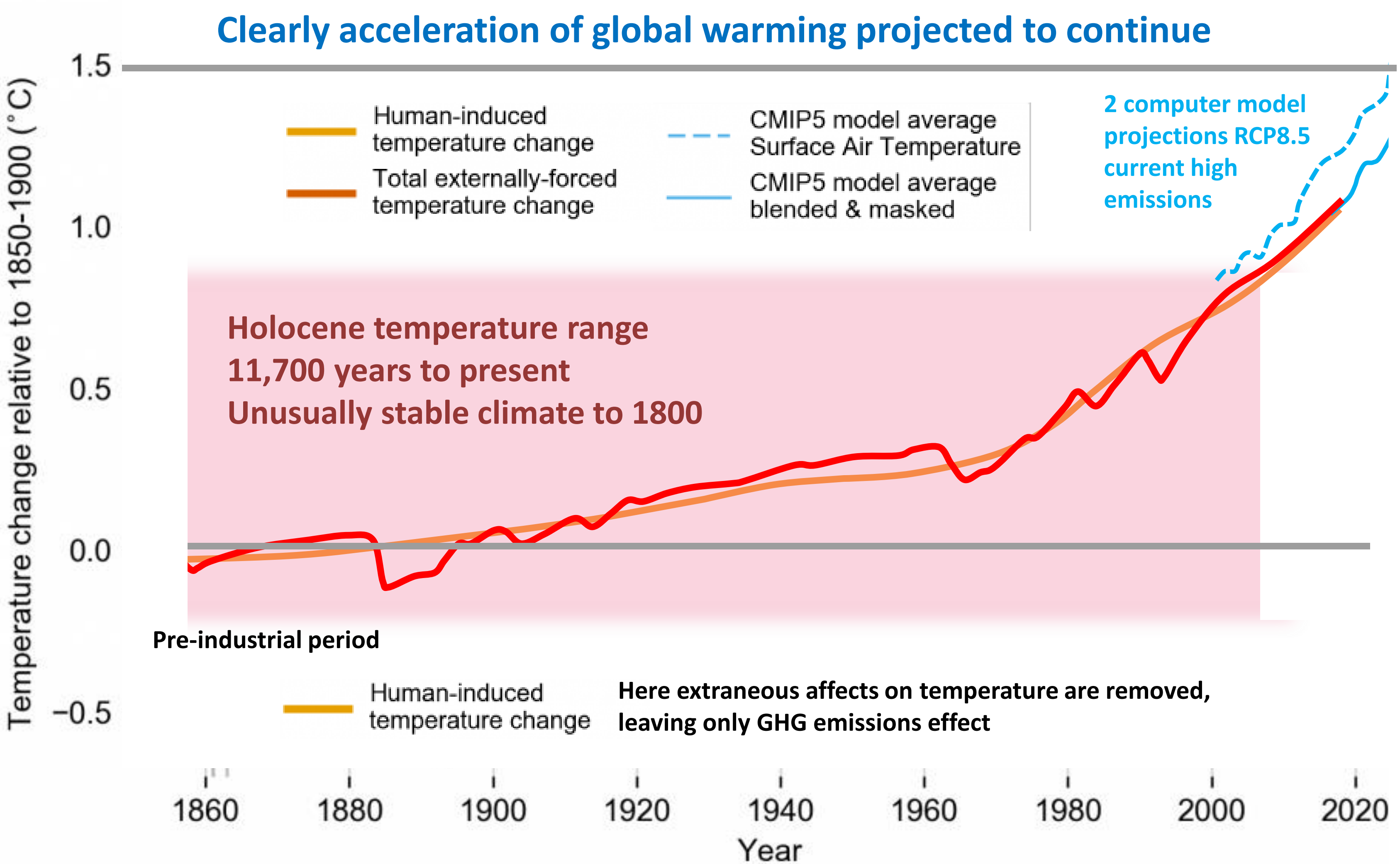
IPCC 5th Assessment (AR5)
worst & best-case emissions scenarios global warming



IPCC AR5 WG2 SPM Assessment Box SPM.1 Figure 1

IPCC 2018 1.5°C Report

Recorded global mean surface temperature change compared to the pre-industrial



IPCC 2018 1.5C REPORT FIGURE 1.2

Evolution of global mean surface temperature (GMST) over the period of instrumental observations.

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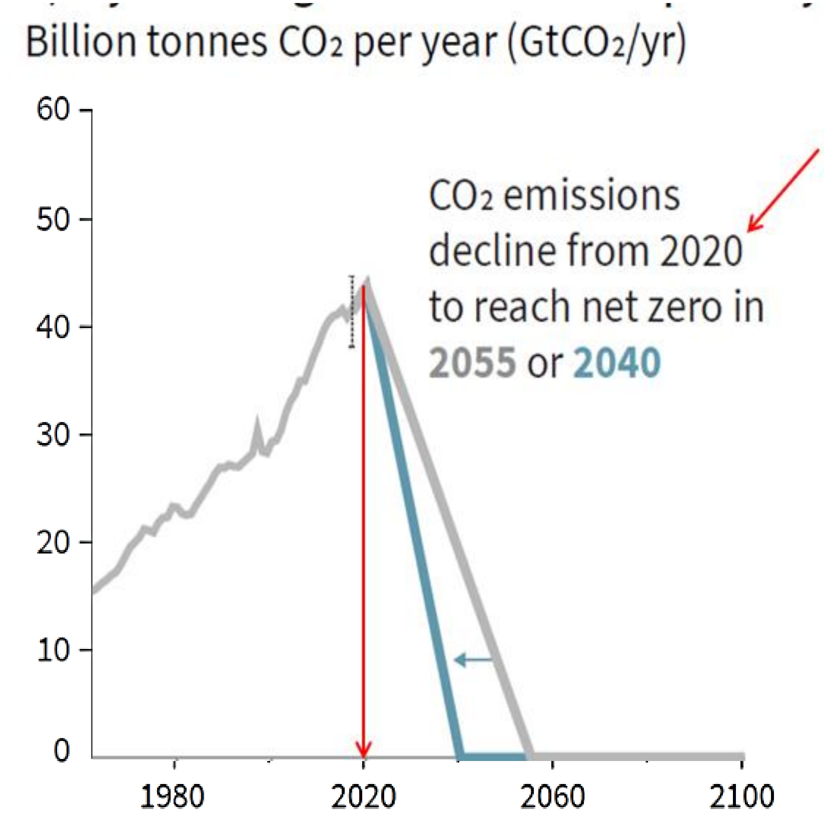
For 1.5°C limit global CO2 emissions decline rapidly from 2020
50% reduction by 2030
Virtual zero by 2050



IPCC 2018 1.5°C Report Figure SPM.1 (b)

Global CO2 emissions decline rapidly from 2020

50% reduction in CO2 emissions from 2020 by 2030

Virtual zero globalCO2 emissions by 2050

Natural CO2 removal by land management

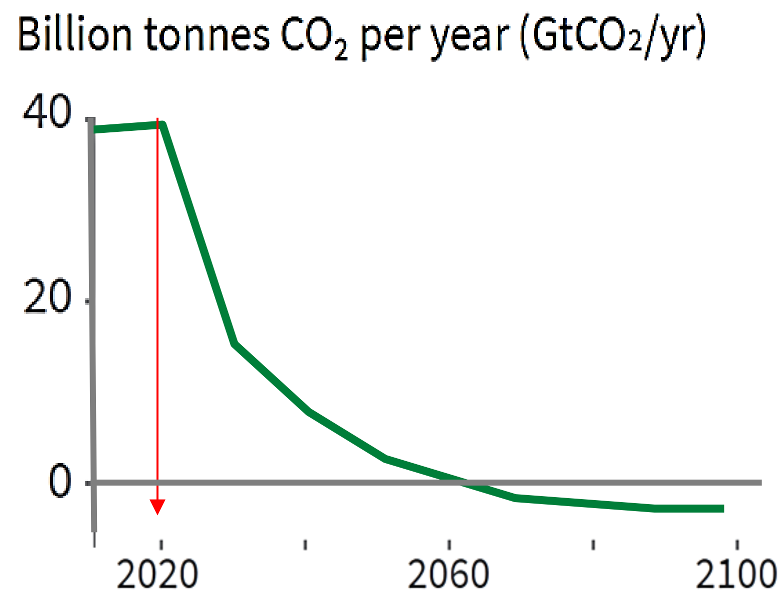


Figure SPM. 3 (b)

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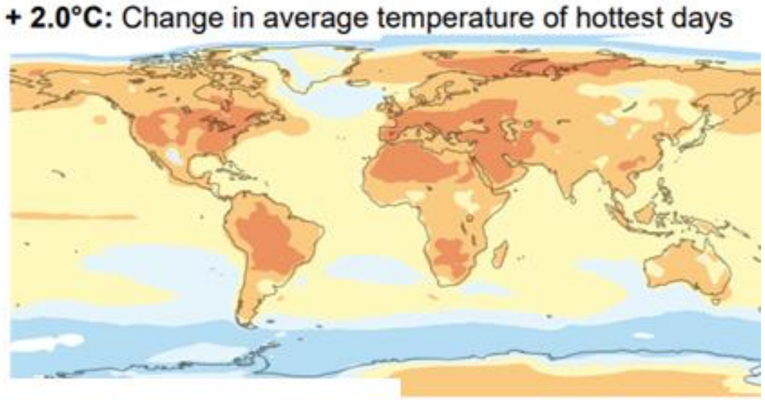
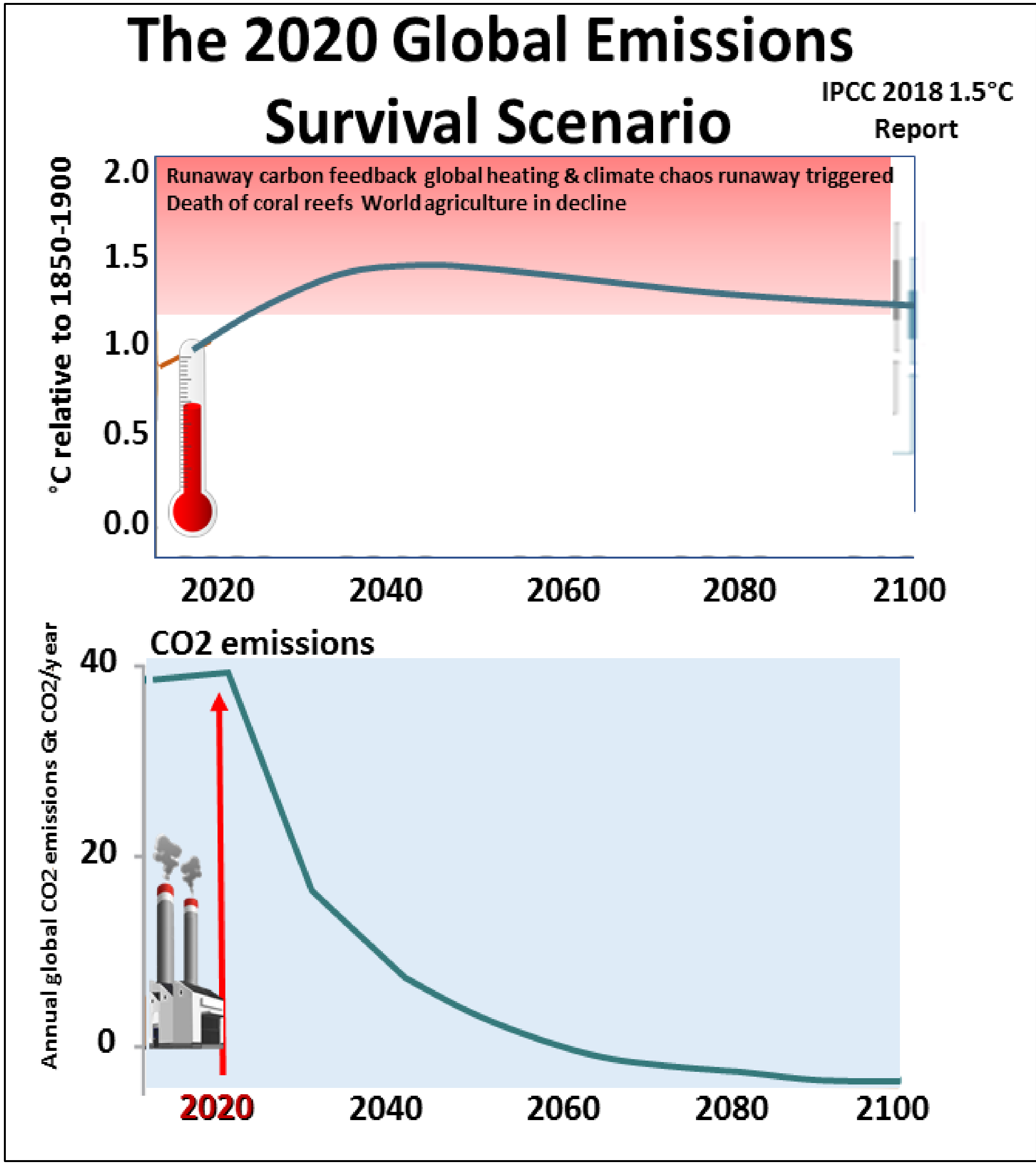
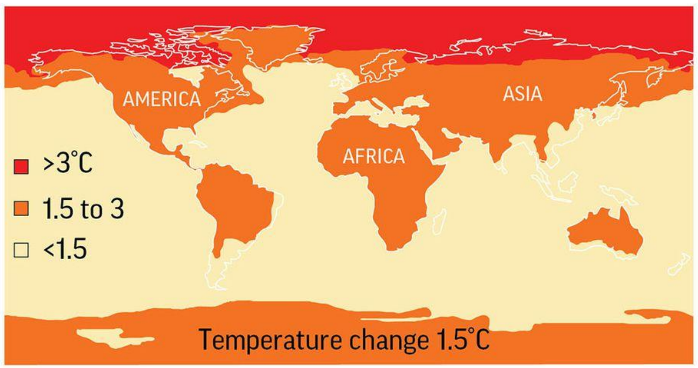
Extreme heat at 2.0C global surface temperature increase



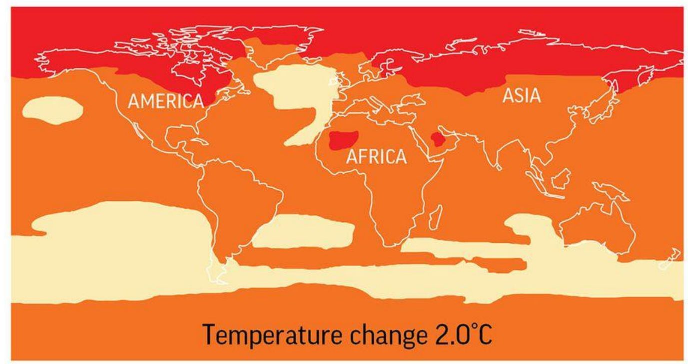


Regional average temperature increases at global temperature increase of 1.5°C and 2.0°C and sea surface temperature increases

Computer simulations for 1.5°C versus 2°C global warming show two very different worlds.



Associated Press rendering of the IPCC 1.5°C Report image



SOURCE: Intergovernmental Panel on Climate Change AP

Mean temperature change at 1.5°C GMST warming

Mean temperature change at 2.0°C GMST warming

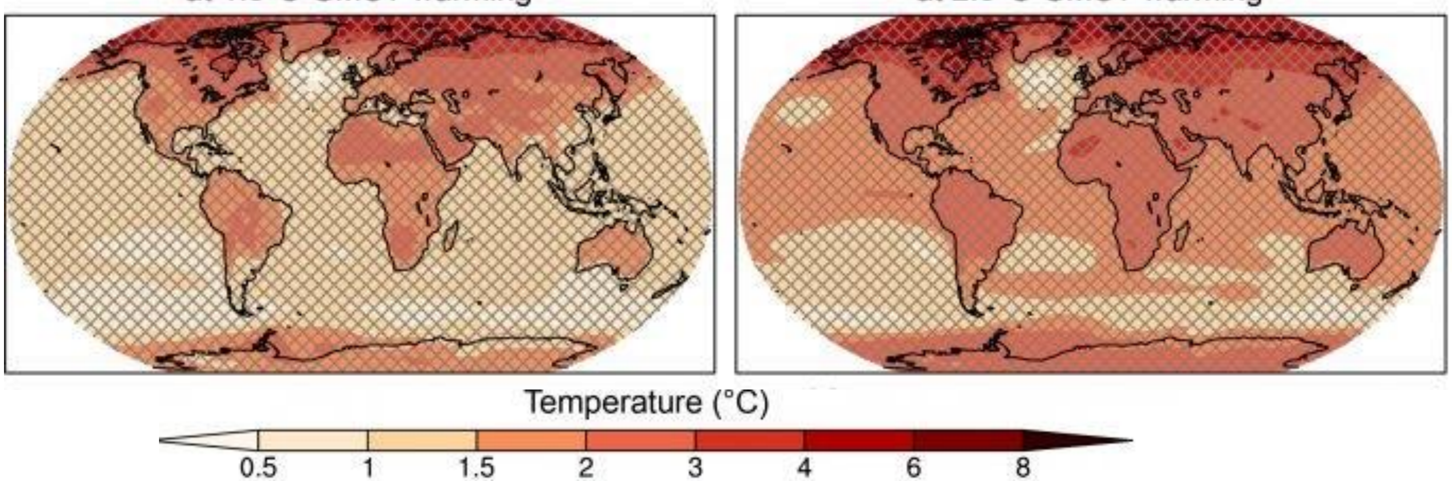


FIGURE 3.3 Projected changes in mean temperature at 1.5°C and 2°C compared to pre-industrial

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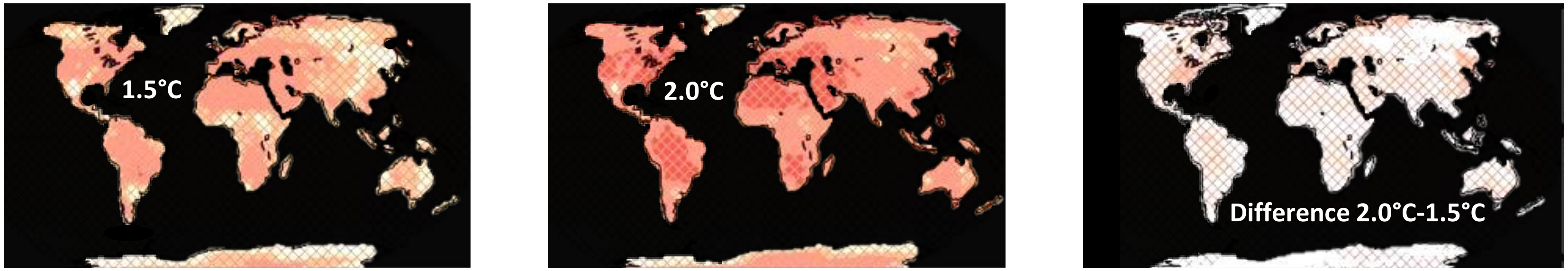
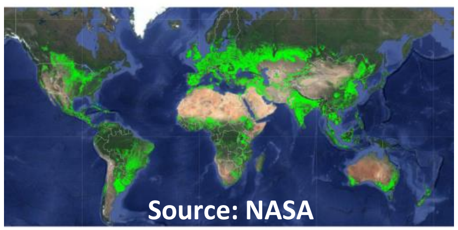
Increase in temperature of hottest days & number of hot days at 1.5°C and 2°C global temperature increase

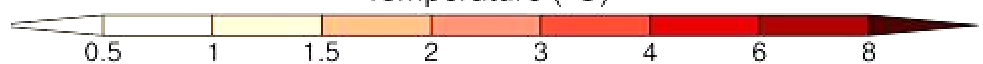
Change in temperature of hottest days

Change in temperature of hottest days (TXx) at 1.5°C GMST warming | Change in temperature of hottest days (TXx) at 2.0°C GMST warming | Difference in temperature of hottest days (TXx) (2.0°C – 1.5°C)



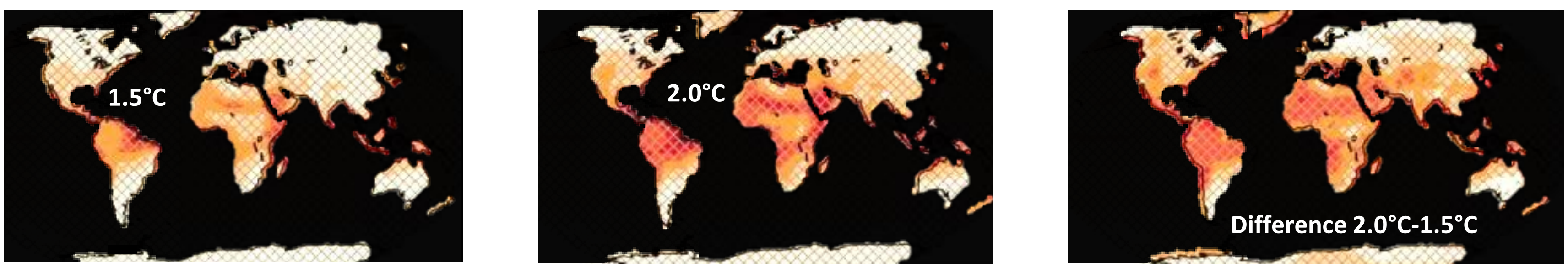
Global croplands from combined satellite data





Change in number of hot days

Change in number of hot days (NHD) at 1.5°C GMST warming | Change in number of hot days (NHD) at 2.0°C GMST warming | Difference in number of hot days (2.0°C – 1.5°C)



From IPCC 2018 1.5C Report, FIGURE 3.4 Projected changes in extremes at 1.5°C and 2°C of global warming compared to the pre-industrial period (1861–1880), and the difference between 1.5°C and 2°C of global warming.

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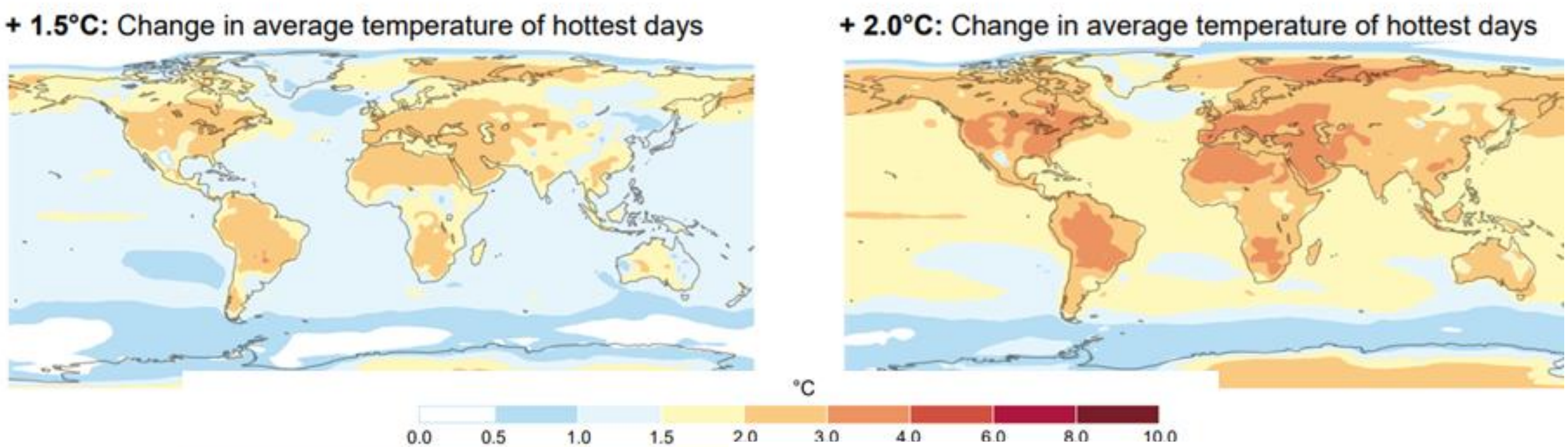
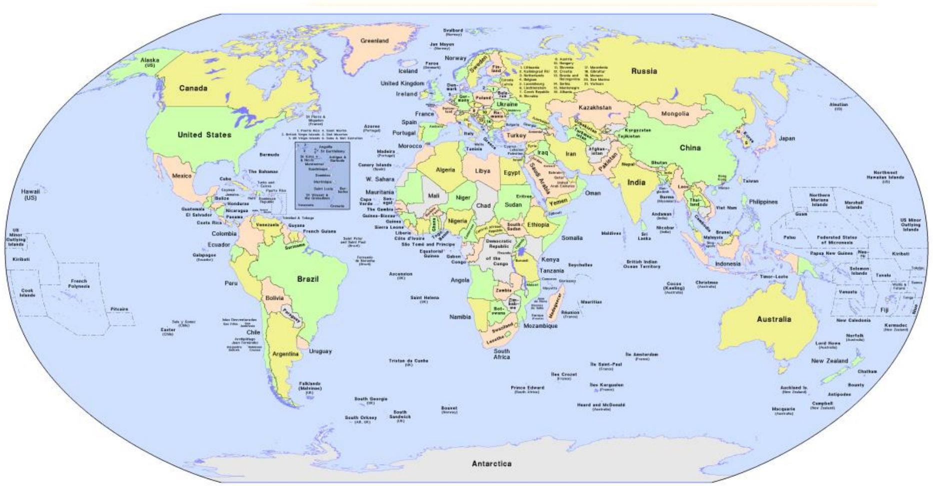
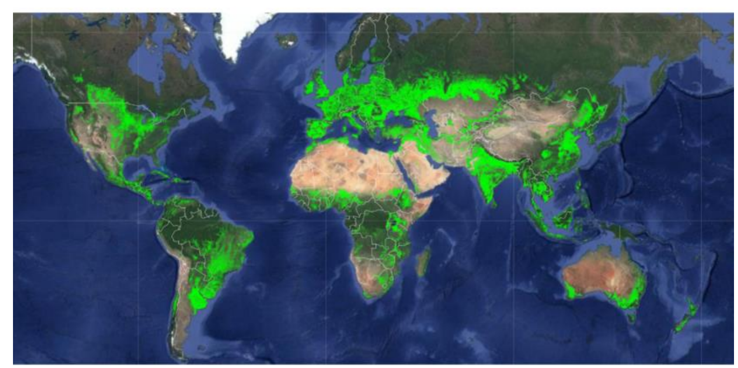
Hottest regions are best food producing regions at 1.5°C and at 2.0°C

IPCC 2018 1.5°C Report FAQ 3.1 Figure 1

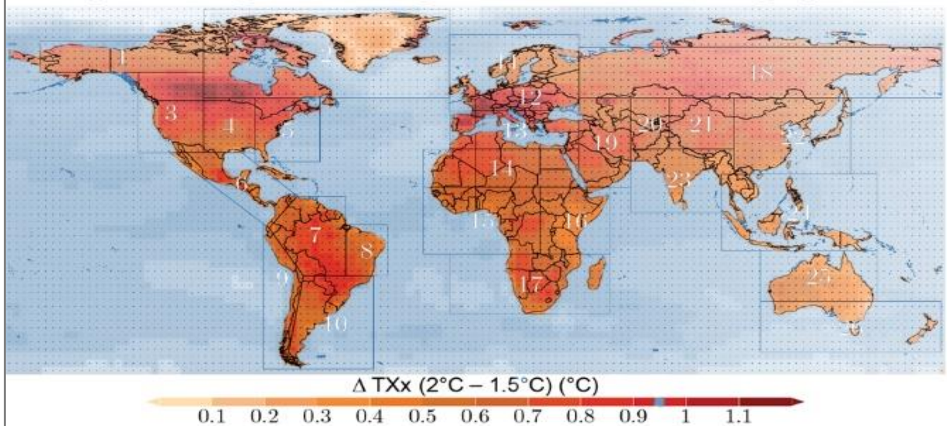




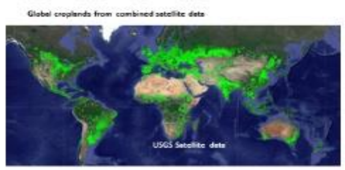
Global croplands from combined satellite data



Projected Regional Change in Extreme Warming up to 2°C



From IPCC 2018 1.5°C Report, Figure 3.5 |
Projected changes in annual maximum daytime temperature (TXx) as a function of global warming



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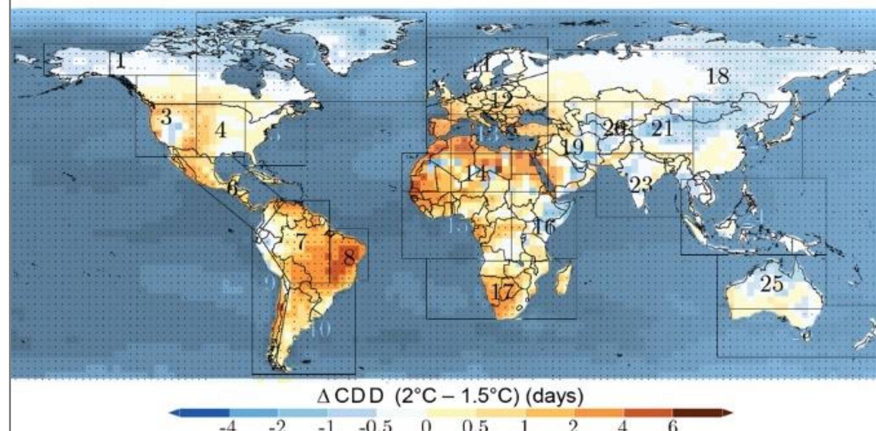
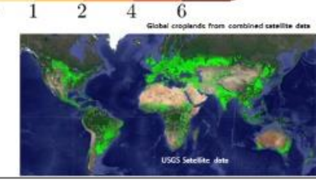
Projected Regional Change in Consecutive Dry Days up to 2C



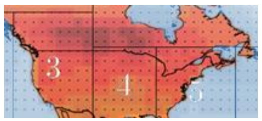


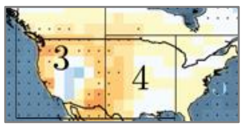
IPCC 2018 1.5°C Report Figure 3.13 | Projected changes in consecutive dry days (CDD) as a function of global warming

IPCC 2018, 1.5°C Report: Regional extreme heat and dryness trends of land up to 2°C global average temperature increase

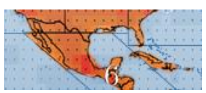
Vital regions impacted by extreme heat and drying

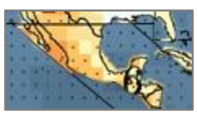
USA & Canada crops



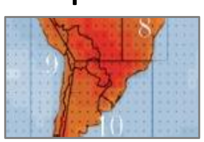


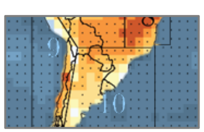
Mexico
Latin America
Crops



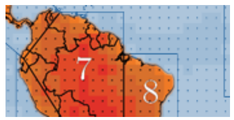


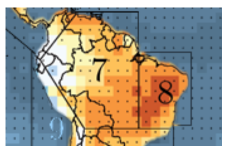
S. America
Crops



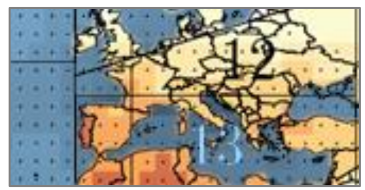


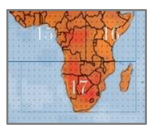
Amazon
Heat+drying
Forrest collapse
Huge feedback
emissions

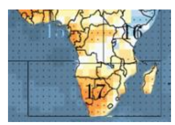




Europe crops







Central & S.
Africa crops

Global crops

Global croplands from combined satellite data

Working Group on Global Croplands USGS Satellite data
Access 2017

FIGURE 3.5 Projected changes in annual maximum daytime temperature (TXx) as a function of global warming up to 2°C

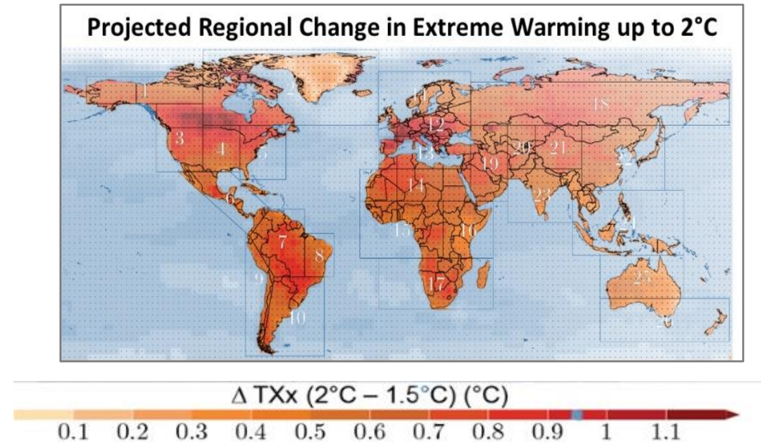
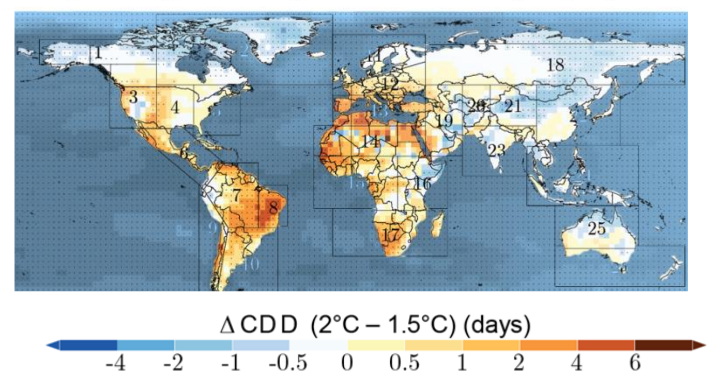


FIGURE 3.13 Projected changes in consecutive dry days (CDD) as a function of global warming to 2°C

Projected Regional Change in Consecutive Dry Days up to 2C



Climate Emergency Institute

The North American grain belt crops under extreme heat and drying trend under global surface warming up to 2.0°C

FIGURE 3.5 Projected changes in annual maximum daytime temperature (TXx) as a function of global warming up to 2°C

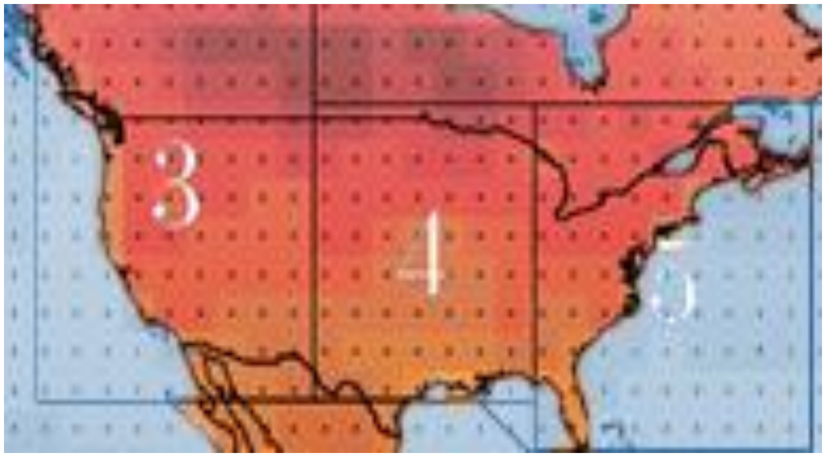
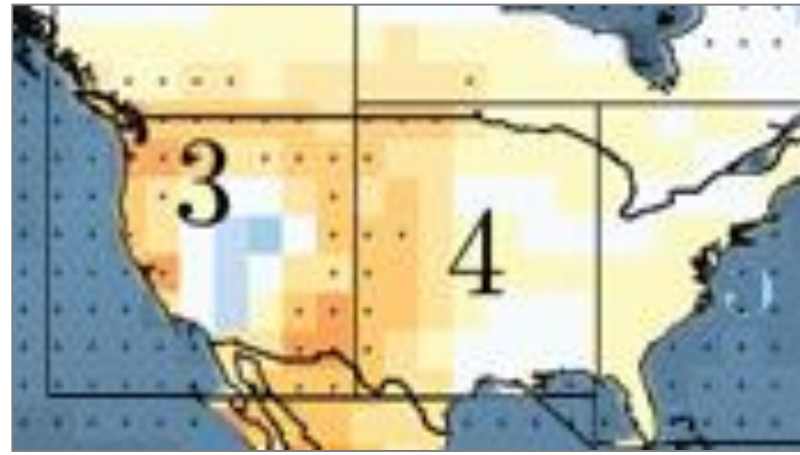
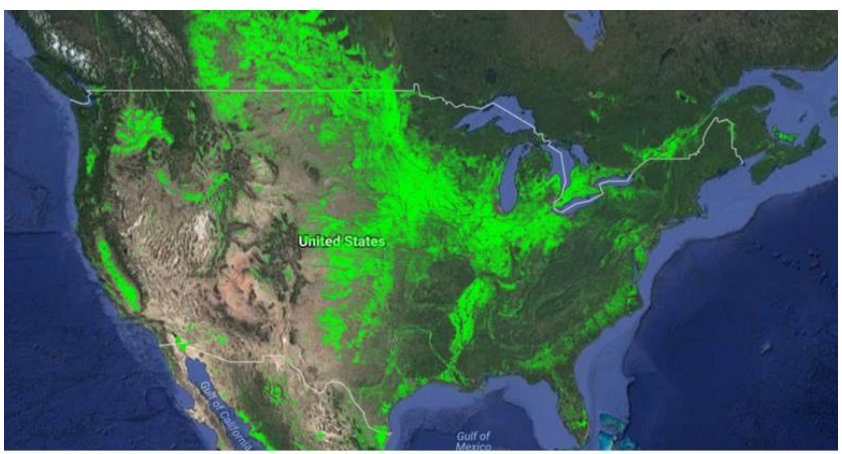
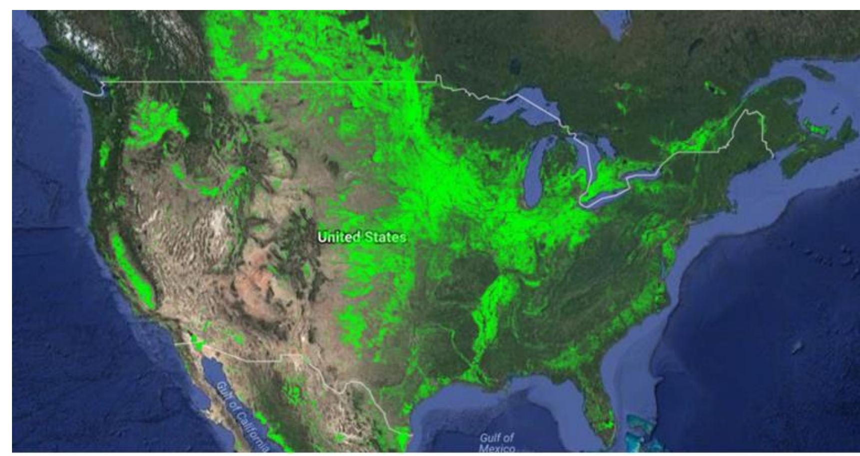


FIGURE 3.13 Projected changes in consecutive dry days (CDD) as a function of global warming to 2°C







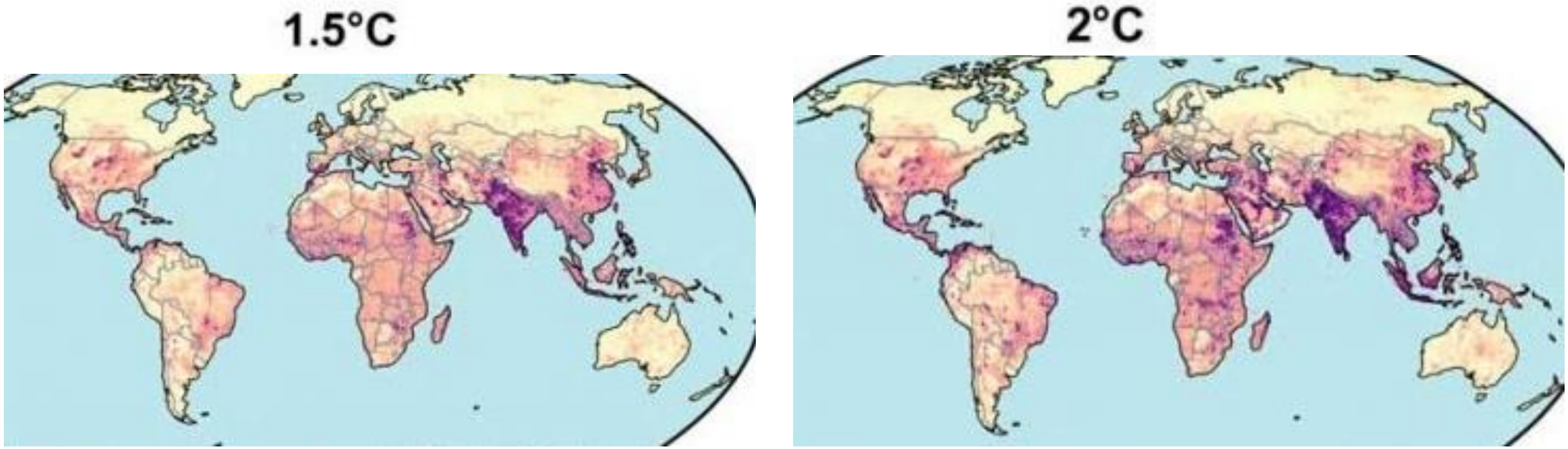
ecial Issue on Global Cropl

Photogrammetric Engineering and Remote Sensing, August 2012 Special Issue on Global Croplands:

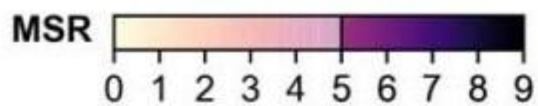
Global Food Security Analysis-Support Data at 30 Meters (GFSAD30) Project

Risk of Multiple Sources of Climate Change Impacts

(Like heat waves , drought and water insecurity impacting together:3)



Multi-sector risk (MSR) maps for 1.5°C and 2°C



Climate Emergency Institute

Global Surface Temperature Increase of 7.8°C by 2100

Without additional efforts to reduce GHG emissions beyond those in place today, emissions growth is expected to persist driven by growth in global population and economic activities.

Baseline scenarios, those without additional mitigation, result in global mean surface temperature increases in 2100 from 3.7 °C to 4.8 °C compared to pre-industrial levels - range based on median climate response; the range is 2.5 °C to 7.8 °C when including climate uncertainty. **(IPCC 5th assessment WG3 SPM)**

Climate uncertainty includes inevitable amplifying feedbacks emissions (several very large sources), declining efficiency carbon sinks, higher climate sensitivity than 3°C (as research now shows) , and abrupt surface temperature increase.

With climate sensitivity at 4.5°C instead of 3°C, 7.8°C by 2100 looks certain

However anything over 2°C is planetary catastrophe hot-house Earth runaway global heating and climate change (

The false, fatally flawed allowable carbon budget- left to burn

**The idea of an allowable carbon budget to burn is profoundly flawed.
Some of the flaws are acknowledged by the IPCC (below)**

The budget first appeared in research papers published during 2009, receiving much publicity, being reported as half a trillion tons of carbon left to burn. These papers also changed the full long term equilibrium warming limit to a limit only by 2100, thus reducing the reductions of GHG emissions for mitigation.

Warming caused by cumulative carbon emissions towards the trillionth tonne, Myles R. Allen, Nature, 30 April 2009

All best-case IPCC emissions scenarios include the removal of CO_2 for limits of 2°C (old danger limit) and 1.5°C (new limit). There can therefore not be a carbon budget now left to burn.

<u>IPCC 2018 1.5°C Report, remaining carbon budget</u>
"Using global mean surface air temperature, as in AR5, gives an estimate of the remaining carbon budget of 580 $GtCO_2$ for a 50% probability of limiting warming to 1.5°C, and 420 $GtCO_2$ for a 66% probability".

**"Uncertainties in the size of these estimated remaining carbon budgets are substantial and depend on several factors. Uncertainties in the climate response to CO_2 and non-CO_2 emissions contribute ±400 $GtCO_2$ and the level of historic warming contributes ±250 $GtCO_2$.
Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 $GtCO_2$ over the course of this century and more thereafter".**

The false, fatally flawed allowable carbon budget- left to burn

Sources of inevitable global heating not accounted in the carbon budget

- **A 66% chance at the 1.5°C limit is not nearly good enough**
- **Other GHG emissions (it is a CO_2 emissions budget)**
- **It is only up 2100** (see next slide)
- **It is based on the single climate sensitivity of 3°C, and from latest research the sensitivity is much higher**
- **The very large loss of albedo cooling with the total loss of Arctic summer sea ice extent and Far North snow cover albedo**
- **Inevitable added GHG feedback emissions**
- **Inevitable weakening of the land and ocean (currently increased) carbon sinks**
- **Unmasking of heat when global cooling air pollution acid aerosols are no emitted**
- **Increased El Ninos**
- **Large changes in major ocean currents**

Fortunately the science is now totally agreed that global emissions must decline rapidly from 2020, making the carbon budget irrelevant for policy

Global temperature increase by 2100, will continue to increase long after 2100, albeit slowing down These projections do not account for amplifying feedbacks