CLIMATE EMERGENCY INSTITUTE

The Health and Human Rights Approach to Climate Change

The Oxford 1.5 degrees Conference

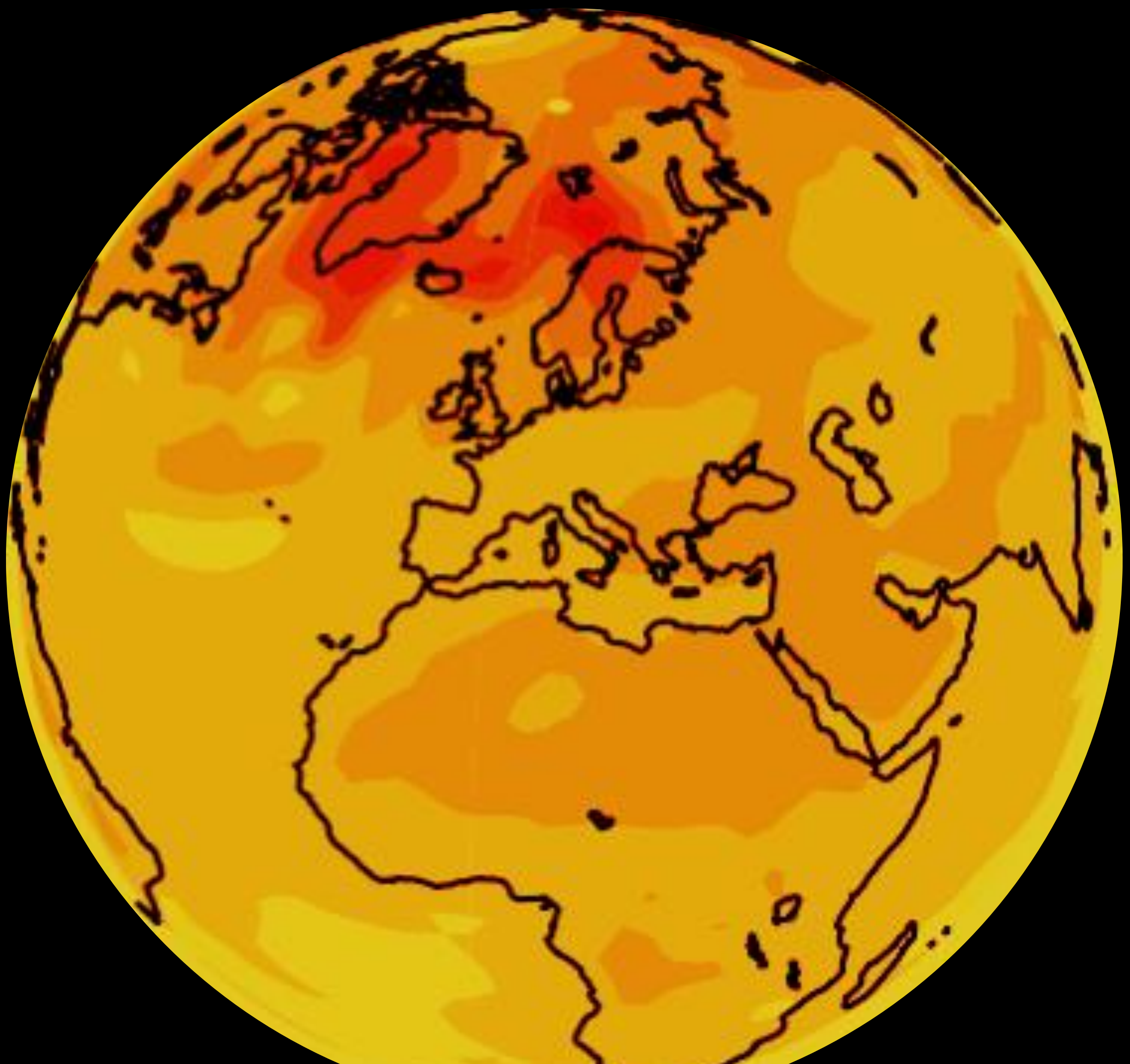
Oxford University 20-22 September

Power point version of 1.5°C impacts poster presentation

Peter Carter

Climate Emergency Institute

Our World at 1.5°C



Content of presentation

Each slide is a png. so that any may be used for climate change communication

1. NASA NEX maximum regional summer temperatures at 1.5°C
2. IPCC 2014 5th assessment (AR5) projections of global and regional impacts and changes at 1.5°C
3. IPCC AR5 mitigation for 1.5°C by 2100 and at equilibrium warming
4. UN Climate Secretariat projection of global emissions change by 2030 from national emissions targets (INDCs)

NASA NEX maximum regional temperatures

What we need to know for most policy relevance is the regional maximum daily summer actual temperatures, that will occur at 1.5°C.

This is the big climate change impact on human health, ability to work outdoors and crop yields.

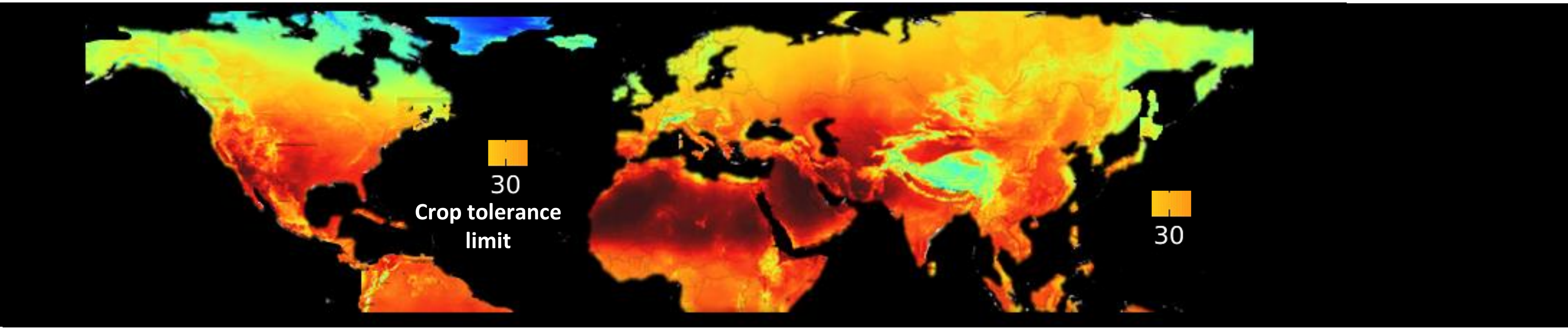
It is valuable information for risks of extreme intolerable heat to humans and livestock , drought and increased forest fires.

This is now (2015) provided by NASA NEX : NASA Earth Exchange (NEX) downscaled climate projections of maximum daily temperatures

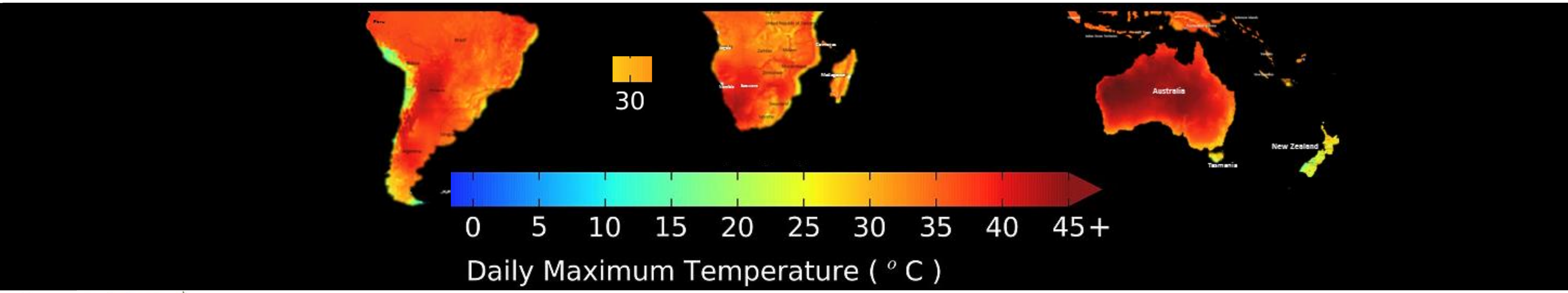
NASA Earth Exchange (NEX) Downscaled Climate Projections

Maximum daily temperatures

Northern Hemisphere maximum summer temperatures at 1.5°C in July

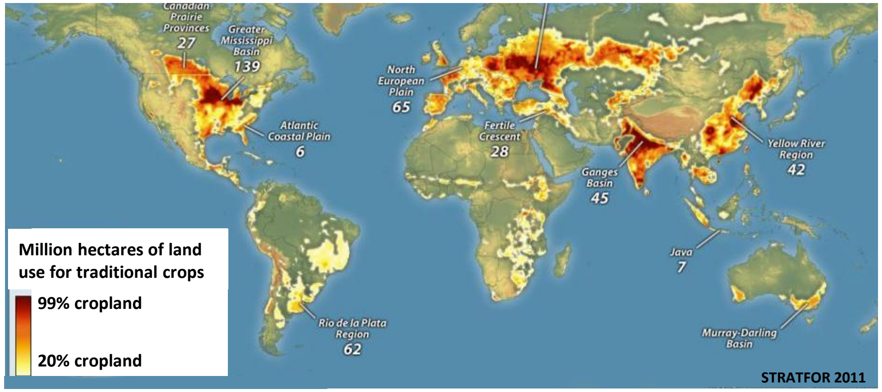


Southern Hemisphere maximum summer temperatures at 1.5°C in January



Crops

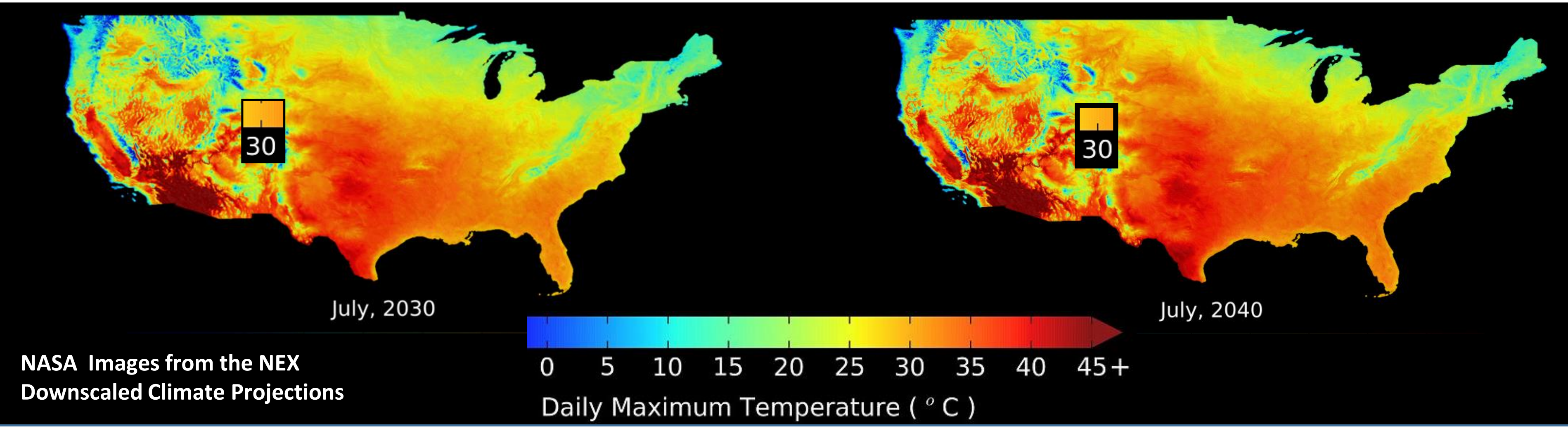
‘Crop yields have a large negative sensitivity to extreme daytime temperatures around 30°C, throughout the growing season (high confidence).’ (IPCC AR4 WG2 TS)



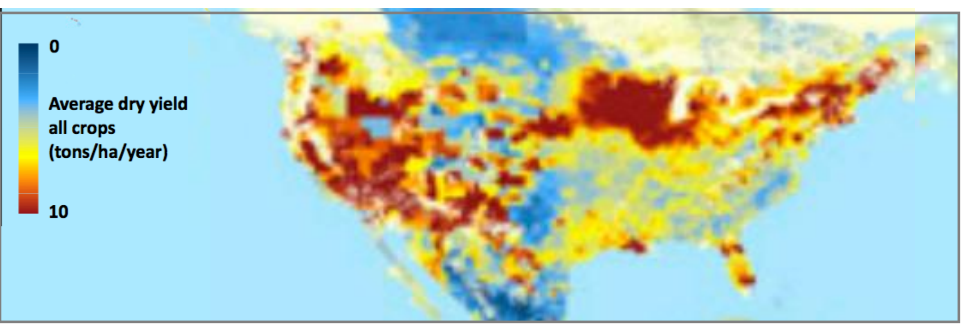
NASA Earth Exchange (NEX) Downscaled Climate Projections Maximum daily temperatures Climate International

USA at 1.5°C — daily maximum temperatures — USA at 2.0°C

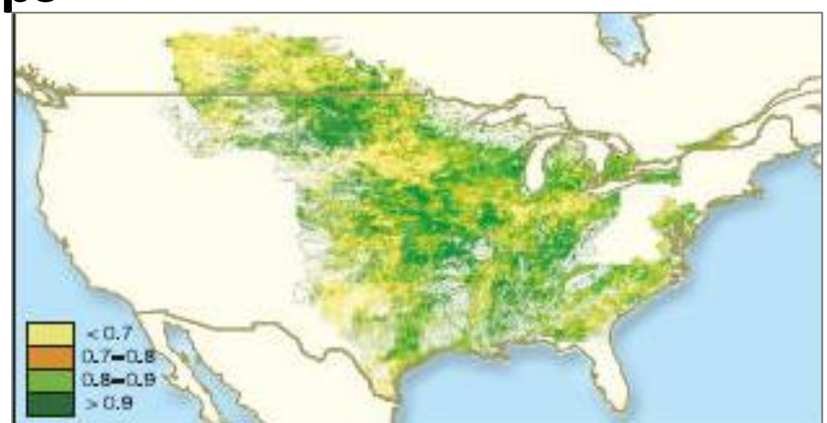
NASA Earth Exchange (NEX) Downscaled Climate Projections Maximum daily temperatures



Crops



Trading carbon for food: Global comparison of carbon stocks vs. crop yields on agricultural land Paul C. Westa, 2010. PNAS.

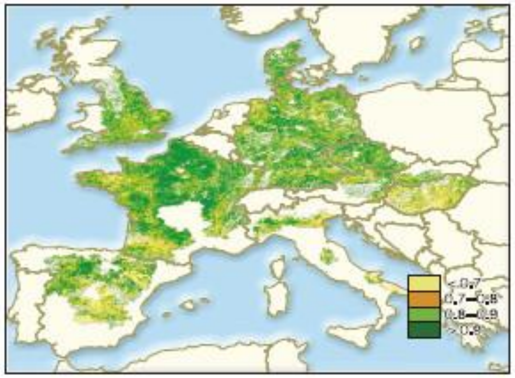


Report on Remote Sensing Monitoring of Global Ecosystem and Environment 2013. Supply situation of maize, wheat, rice and soybean. Figure 3 Oct 2013 to Jan 2014 Maximum VCI of North America MPZ

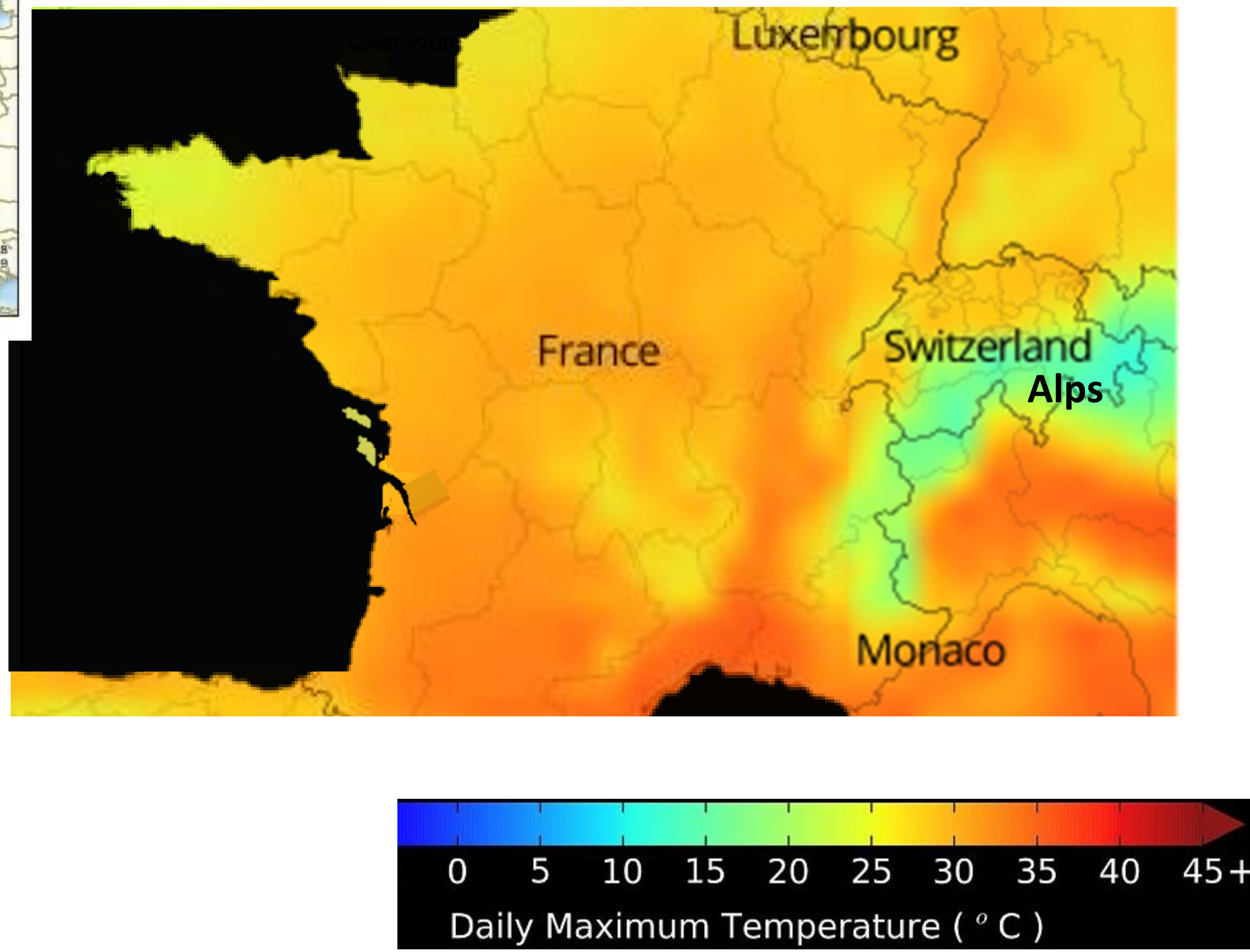
'Crop yields have a large negative sensitivity to daytime temperatures around 30°C, throughout the growing season (high confidence).' (IPCC AR4 WG2 TS)

France at 1.5°C July
daily maximum temperatures

Crops



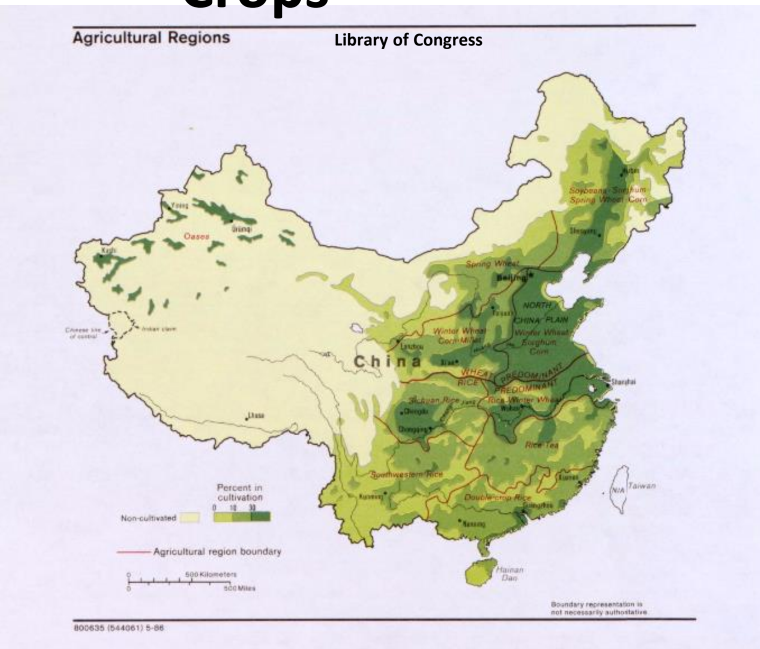
Report on Remote Sensing Monitoring of Global Ecosystem and Environment 2013. Supply situation of maize, wheat, rise and soybean. Figure 3-6 July to Oct 2013 Maximum VCI Western Europe MPZ



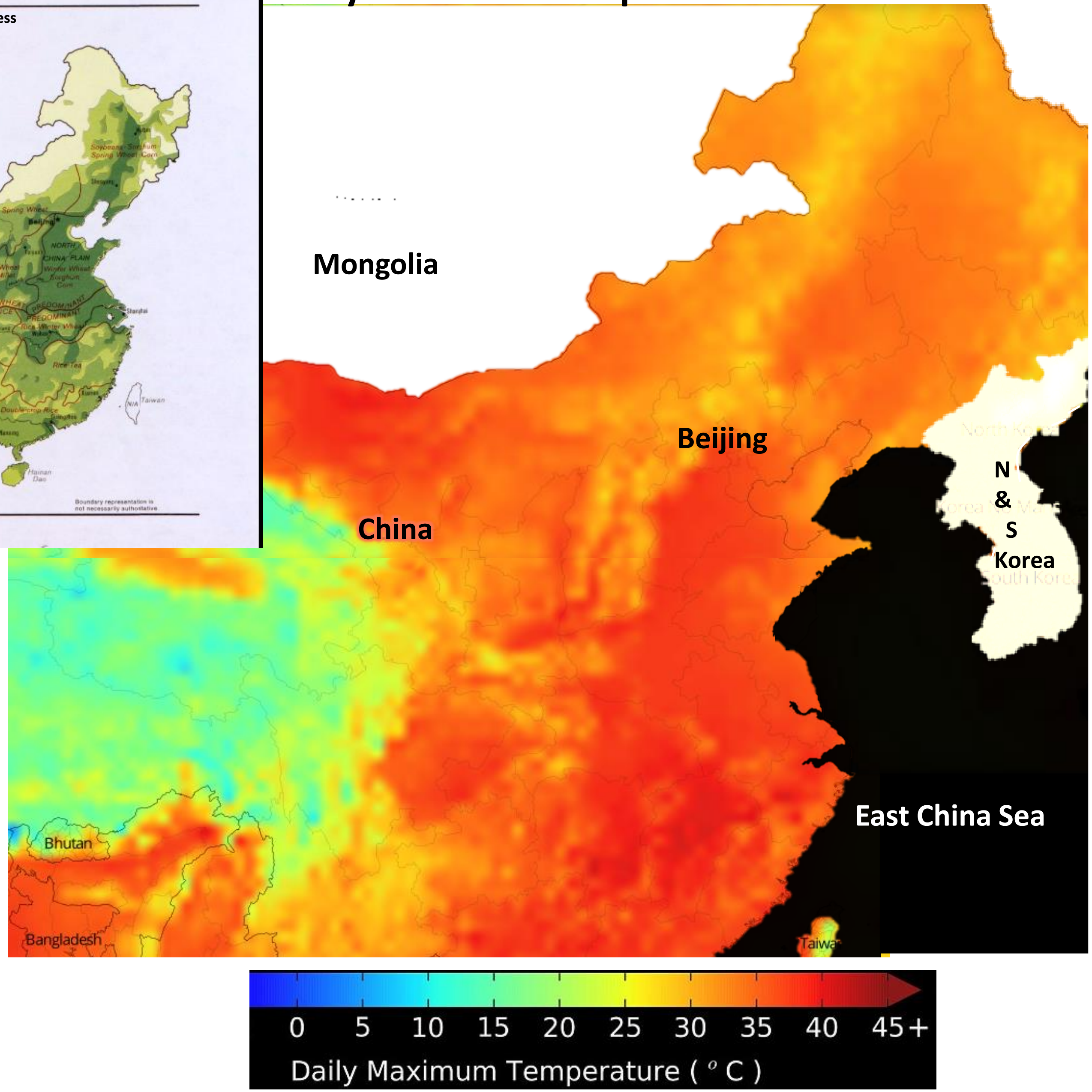
'Crop yields have a large negative sensitivity to extreme daytime temperatures around 30°C, throughout the growing season (high confidence)'.
(IPCC AR4 WG2 TS)

China at 1.5°C July

Crops



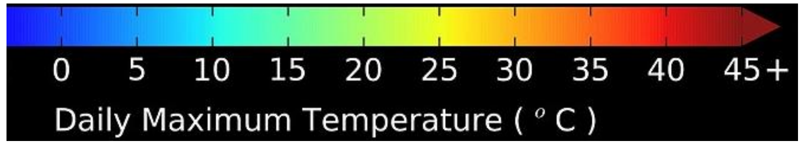
daily maximum temperatures

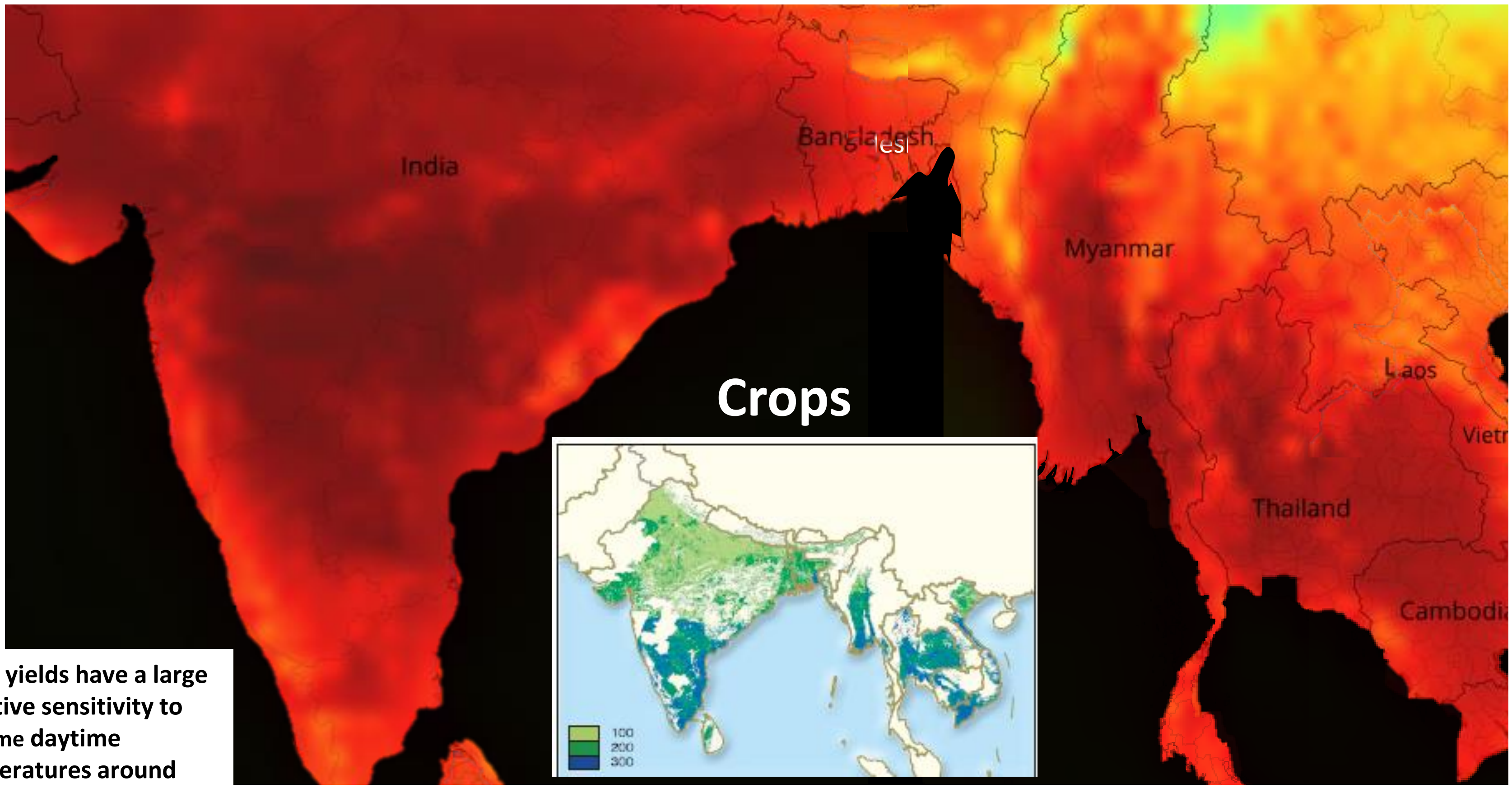


‘Crop yields have a large negative sensitivity to extreme daytime temperatures around 30°C, throughout the growing season (high confidence)’. (IPCC AR4 WG2 TS)

India, Thailand, & Cambodia at 1.5°C April

daily maximum summer temperatures





Crops

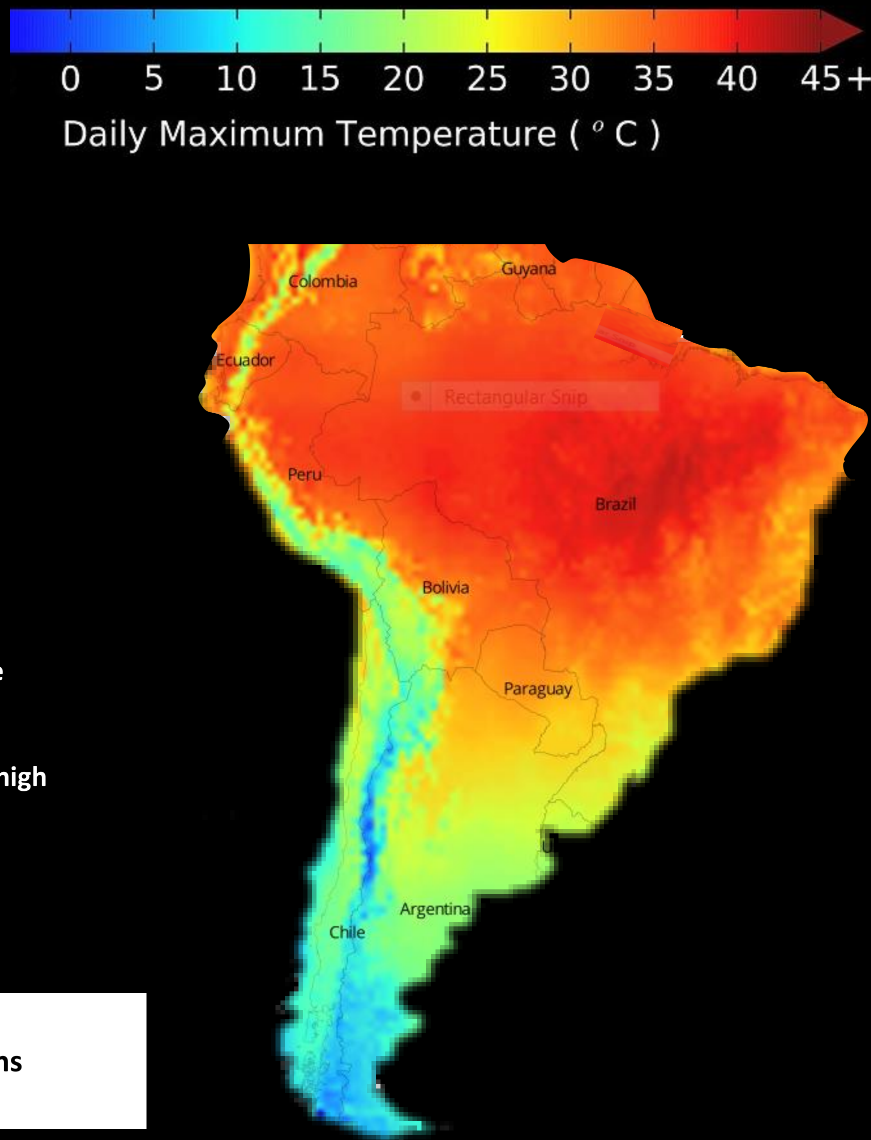
'Crop yields have a large negative sensitivity to extreme daytime temperatures around 30°C, throughout the growing season (high confidence)'.
(IPCC AR4 WG2 TS)

Report on Remote Sensing Monitoring of Global Ecosystem & Environment 2013. Supply situation of maize, wheat, rise & soybean. Figure 3-5 Cropping intensity of South & S. West Asia

Peter Carter Climate Emergency Institute

South America at 1.5°C (January)

maximum daily summer temperatures



Croplands

'Crop yields have a large negative sensitivity to extreme daytime temperatures around 30°C, throughout the growing season (high confidence)'.
(IPCC AR4 WG2 TS)

NASA Earth Exchange (NEX)
Downscaled Climate Projections
Maximum daily temperatures

Research Program on Climate Change and Food Security Univ. Copenhagen

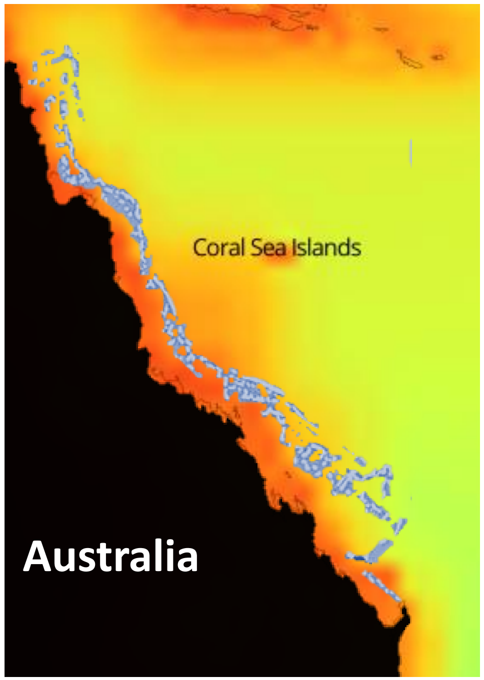
Peter Carter Climate Emergency Institute

The Great Barrier Reef at 1.5°C (January)

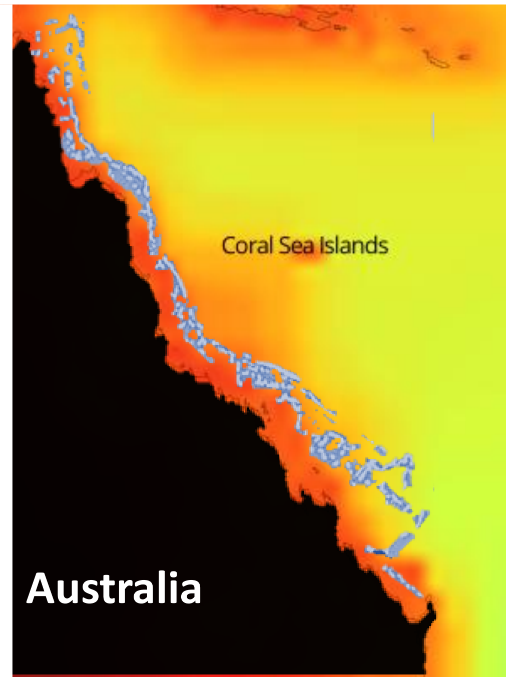
daily maximum temperatures

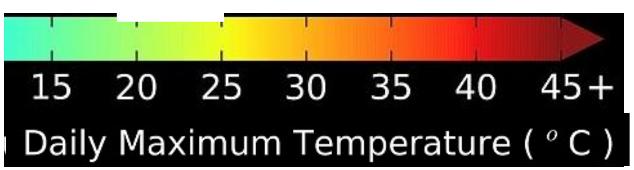
'The major coral bleaching episodes i the past 20 years we found to be associat with periods when ocean temperature were about 1°C high than the summer maximum'. IPCC TAI 17.2.4.1

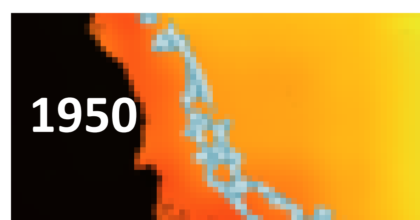
1950

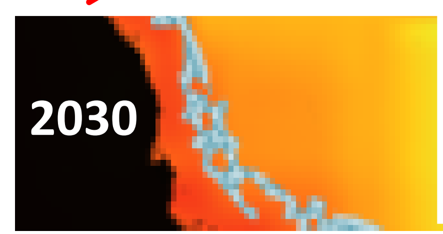


2030



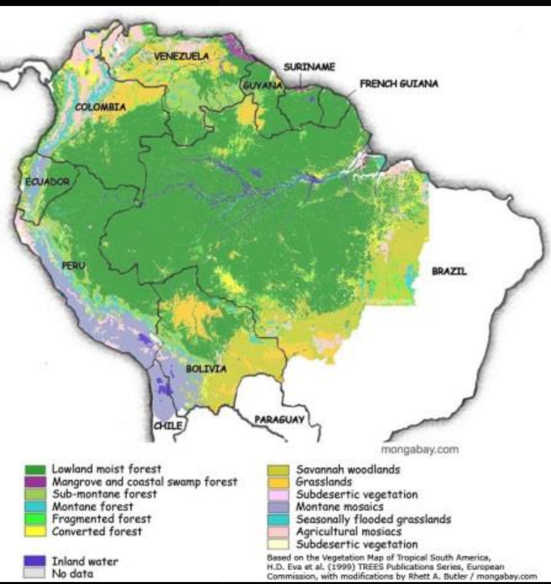






The Amazon rain forest at 1.5°C July

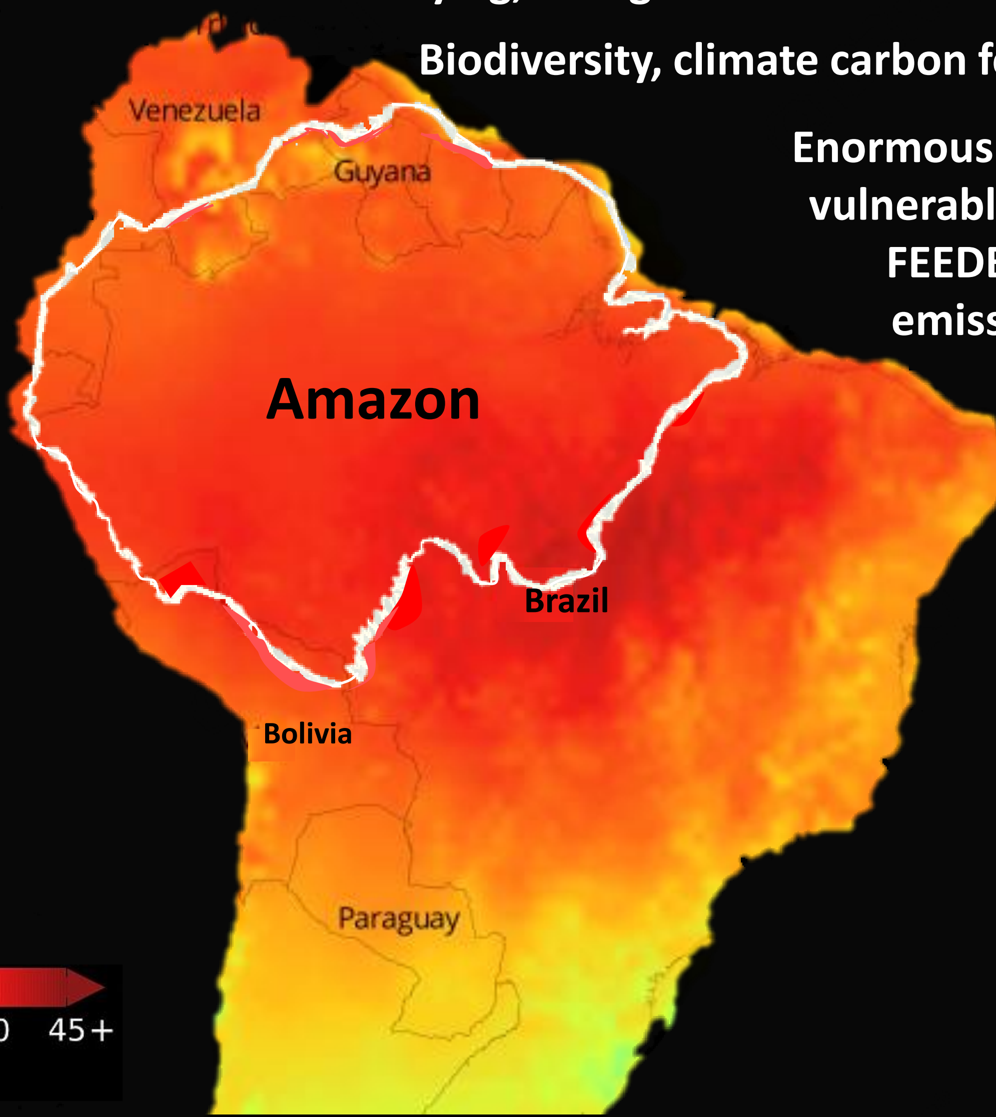
daily maximum temperatures

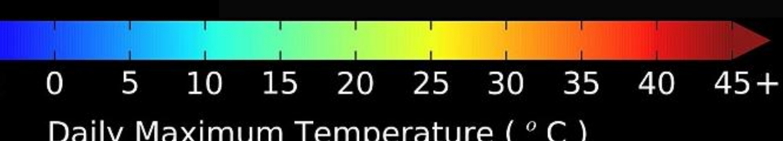


Drying, drought and fires

Biodiversity, climate carbon feedback

Enormous source of vulnerable carbon FEEDBACK emissions

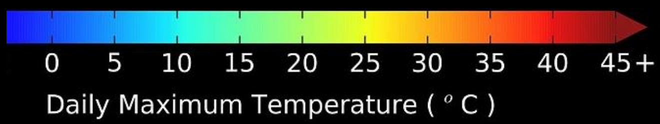




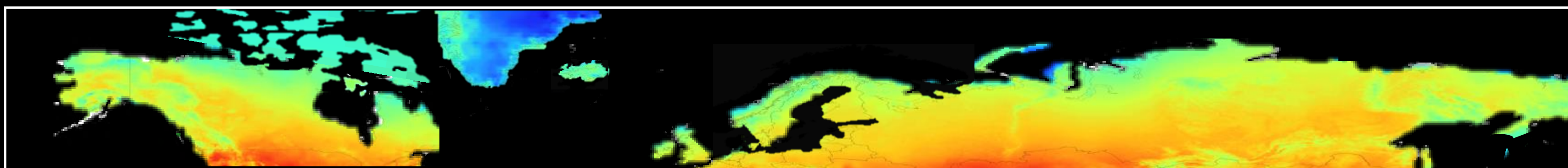
The Boreal and Arctic at 1.5°C (July)

daily maximum summer temperatures

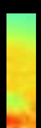
Enormous source of vulnerable carbon FEEDBACK emissions

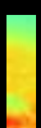


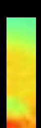
- **'High risk of abrupt & irreversible change of …ecosystems, e.g. … Arctic leading to substantial additional climate change' (IPCC AR5 WG2) .**
- **'Plausible tipping points of boreal-tundra Arctic systems' (IPCC AR5 WG2)**



NASA Earth Exchange (NEX) Downscaled Climate Projections Maximum daily temperatures







NASA NEX Maximum daily temperatures projected for July at 1.5°C global mean surface temperature NH high latitude

Conclusions from NASA NEX maximum temperatures

Summer temperature highs at 1.5°C will exceed out of doors work tolerance for people in some regions.

Global warming increases humidity that increases the above adverse heat effect to human beings.

In most food producing regions summer temperatures highs exceed safety to crops, many by a large degree. Increased extreme heat events, drought and tropospheric ozone will add to crop damage.

Coral reef mortality will be very high

Temperatures in most of the Amazon can be expected to lead to die back

Arctic temperatures can be expected to lead to irreversible carbon feedback emissions from tundra fires, warming wetlands, Boreal forest die back, and permafrost thaw, increasing over decades, hundreds and thousands of years.

IPCC AR5

Projected impacts and changes at 1.5°C

Note: A warming of 1.5C is absolutely committed (locked in) by climate system inertia.

Only immediate implementation of AR5 best case scenario (RCP 2.6) could possibly limit warming to 1.5°C and a >66% chance of 2.0°C by 2100.

(IPCC AR5 WG3, UN Climate Secretariat 2 May 2016 INDC Update)

Severe widespread IMPACTS at 1.5°C
+ zero tolerance risks

(RFC Reasons for concern)

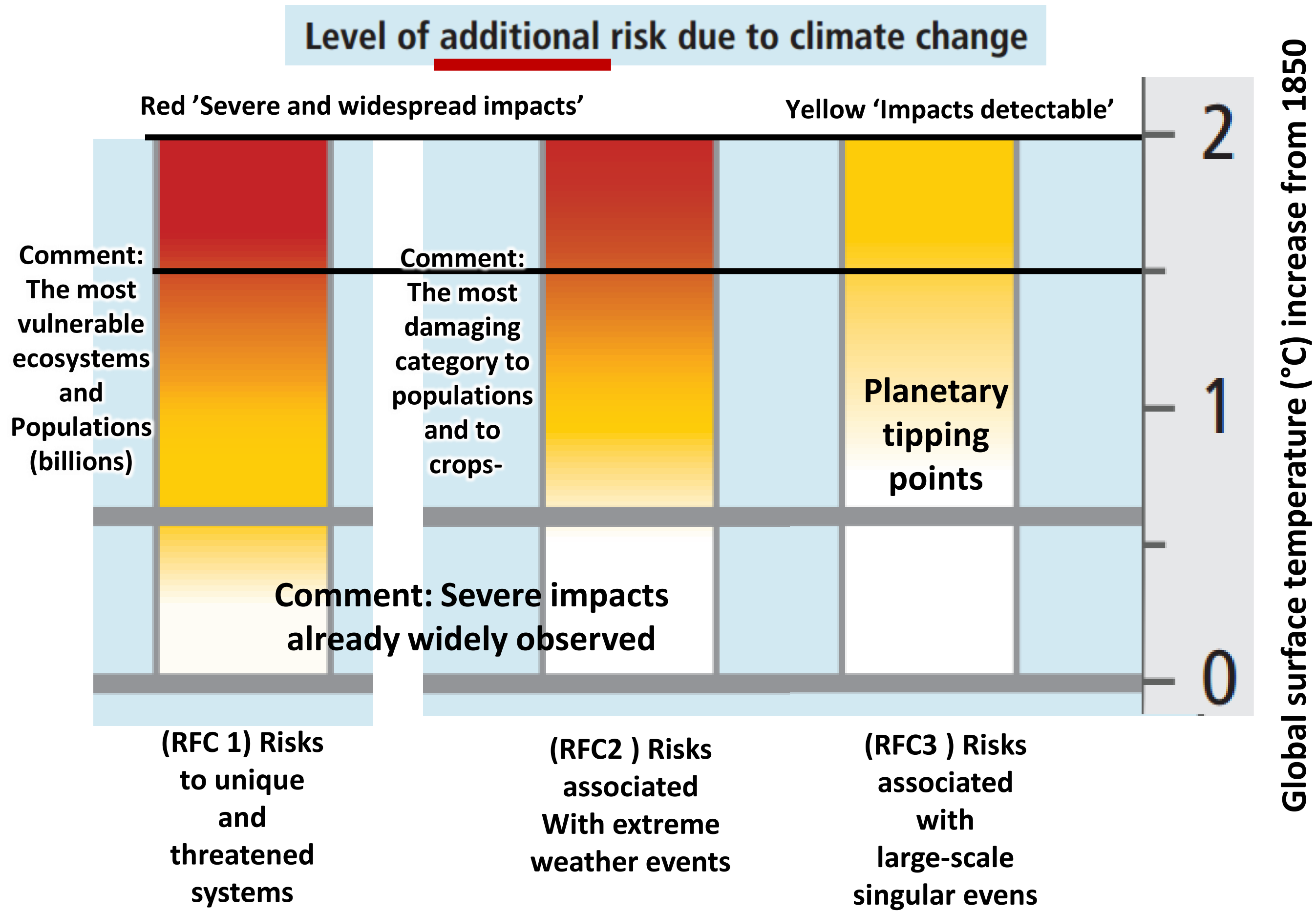
Risks are here defined as severity of IMPACTS

Comment: Rate of climate change increases vulnerability
Children and the elderly are most vulnerable to all human impacts

YELLOW 'Moderate risk (yellow) indicates that associated **IMPACTS** are both detectable and attributable to climate change with at least medium confidence.'

RED 'High risk (red) indicates severe and widespread **IMPACTS.'**

IPCC AR5 SYR Box 2.4
Figure 1 Figure 19-4

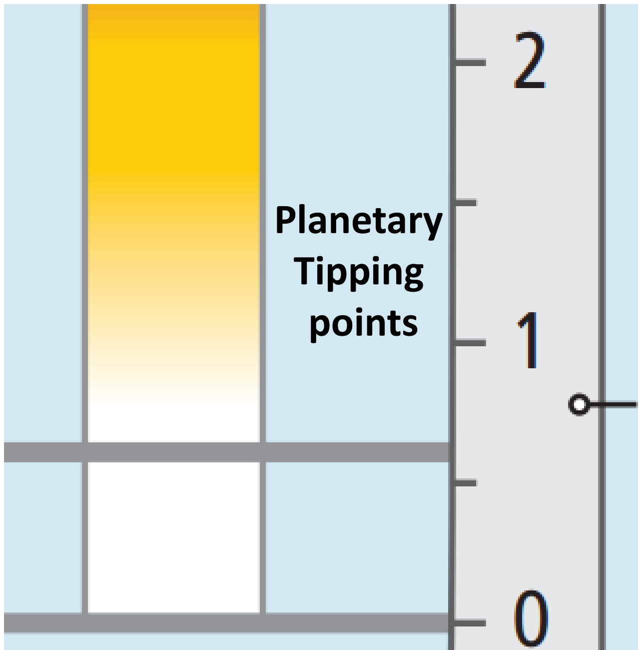


. Yellow indicates that associated impacts are both detectable and attributable to climate change

Red indicates severe and widespread impacts. **Box 2.4, Figure 1 |**

Tipping points at 1.5°C

Yellow ‘Impacts detectable’



(RFC3) Risks associated with large-scale singular evens

Large-scale singular events

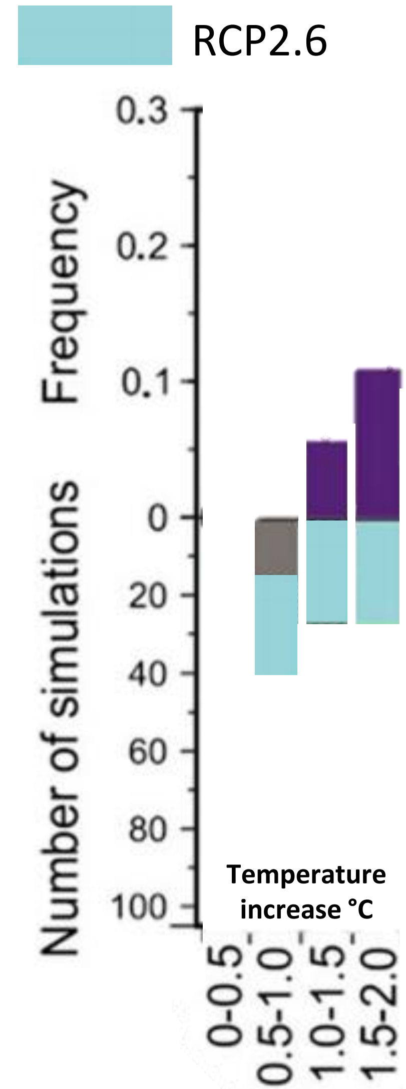
‘With increasing warming, some physical systems or ecosystems may be at risk of abrupt and irreversible changes.’

‘Risks associated with such tipping points become moderate between 0-1°C additional warming [1.6°C from 1850]

Risks increase disproportionately as temperature increases between 1-2°C additional warming’ [1.6°C -2.6°C].

Already Arctic sea ice and West Antarctic ice sheet are apst tipping. Greenland ice sheet lost 1 trillion tonnes of ice over the past 4 years.

IPCC AR5 SYR Box 2.4 Figure 1 Figure 19-4



Drijfhout, S. 2015. Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models

The 1.5°C scenario

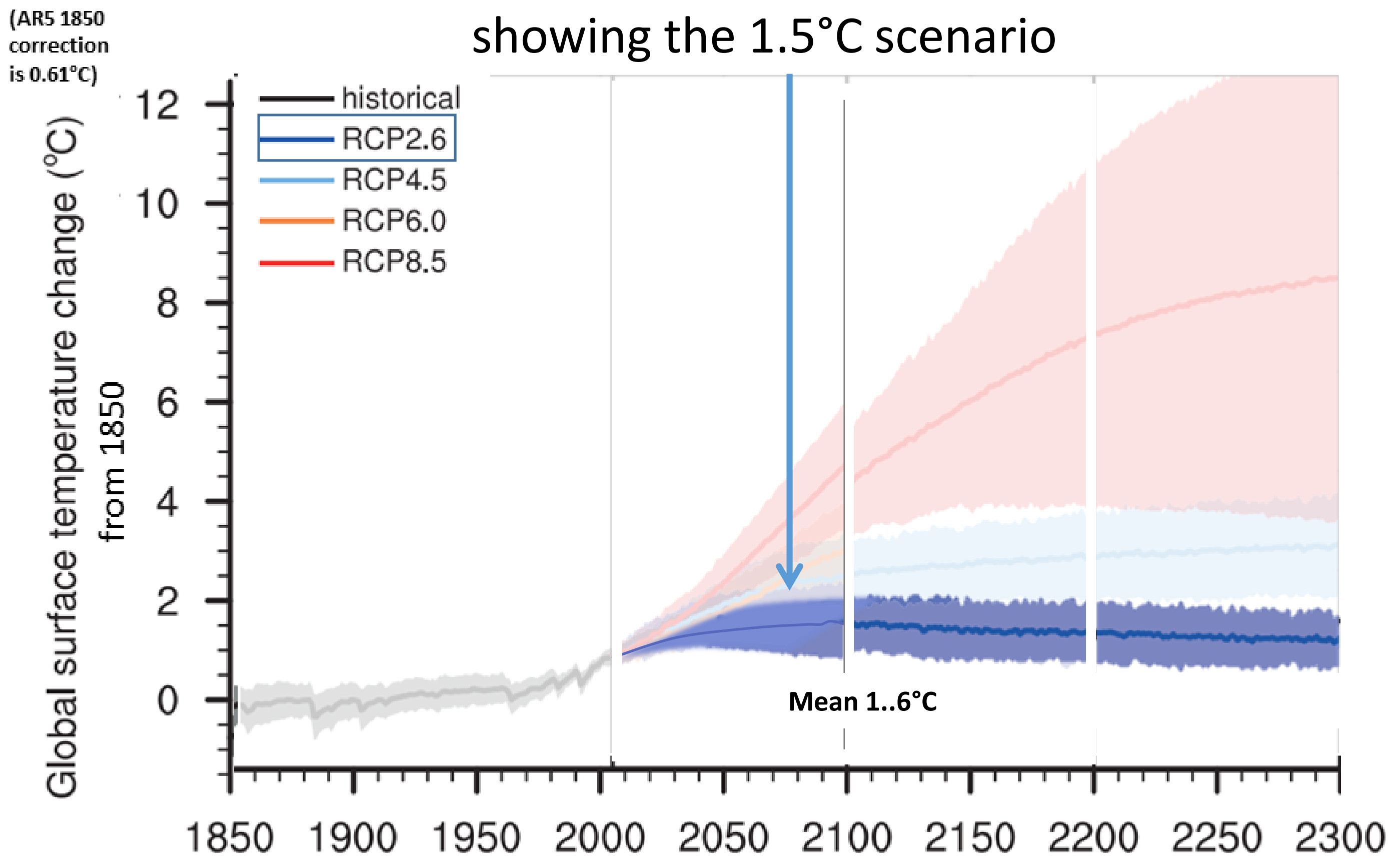
For assessing impacts at 1.5°C, as the UN Structured Expert dialogue on 1.5°C (2010-2014) did, the IPCC AR5 best-case scenario RCP2.6 is taken as the 1.5°C scenario

AR5 RCP global surface temperature increases extended beyond 2100

showing the 1.5°C scenario

For the 1.5°C scenario extended past 2100, global mean temperature increase is 1.6°C by 2100, and slowly declines after 2100.

All other scenarios are above 2°C by 2100 and continue increasing after 2100.



IPCC AR5 WG1 Figure 12.5 | Time series of global annual mean surface air temperature anomalies (relative to 1986-2005), 5 to 95% range.

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Mitigation according to IPCC

'In order to stabilize the concentration of GHGs in the atmosphere, emissions would need to peak and decline thereafter. The lower the stabilization level, the more quickly this peak and decline would need to occur. Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels'.
IPCC 2007 AR4 WG3 SPM

2°C [or 1.5°C] 'pathways would require substantial emissions reductions over the next few decades and near zero emissions of carbon dioxide and other long-lived greenhouse gases by the end of the century.'
IPCC AR5 SYR Headline Statements

Mitigation for 2°C requires OECD nations to peak emissions immediately.

Because of committing to unfeasible negative emissions and locking in fossil fuel infrastructure global emissions have to peak and decline immediately.

The UN Climate secretariat in 2016 finds that for greater than >66% likelihood of staying below 2.0Cmitigation is immediate
(P2 in 2 May 2016 INDC Update)

Peak year of emissions and emissions reduction by OECD nations for 2.0°C

		OECD-1990
Peak year of emissions	430–530 ppm CO_2eq	2010 (2010/2010)
2030 Emission reductions w.r.t. 2010	430–530 ppm CO_2eq	32 % (23/40 %)

IPCC AR5 WG3 Table 6.4 |
Regional peak year of CO2 emission and emissions reductions in 2030 over 2010

Note The 2°C limit has always been, and has to be, an equilibrium temperature increase – long after 2100.

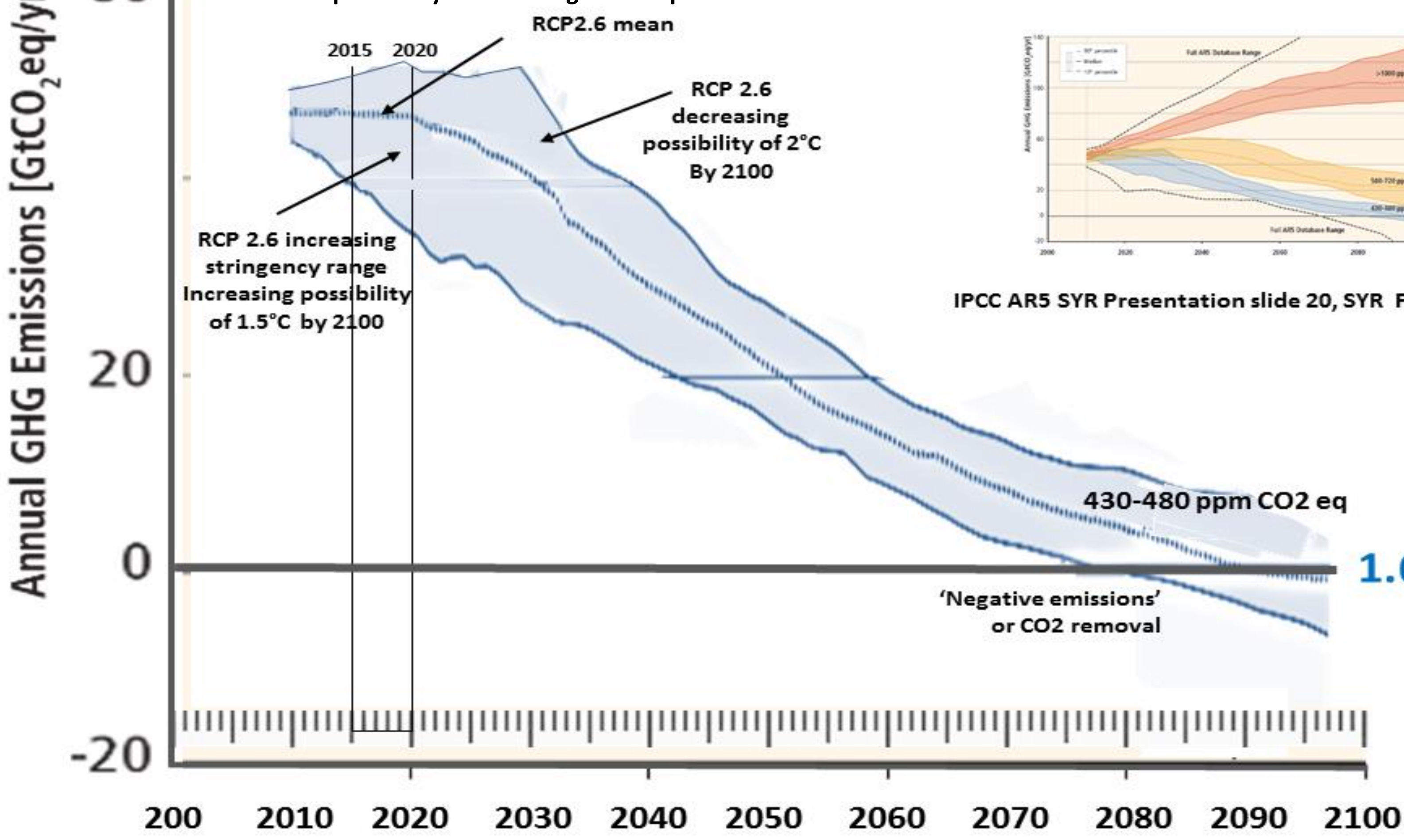
Mitigation scenario for 1.5°C

The best case IPCC AR5 scenario is RCP 2.6

'…the RCPs include a strong mitigation scenario (RCP2.6)'(IPCC AR5 WG 1 TS)

In 2016, for 1.5°C (or 2°C) global emissions decline immediately.

For the high stringency to mean projections, global emissions decline from 2010 to 2020.
Negative emissions are assumed in about half the RCP2.6 models, increasing with stringency.
Because of cumulative carbon, early peaking (global decline) means lower rates of global decline and less negative emissions, so a better possibility of achieving the temperature limit.



IPCC AR5 SYR Presentation slide 20, SYR Fig 6.7

RCP 2.6 picked out from IPCC AR5 SYR Presentation, slide 20, Fig 6.7

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The UN Paris Agreement and 1.5°C

UN Climate Secretariat Update of INDCs 2 May 2016

The implementation of the communicated INDCs is estimated to result in aggregate global emission levels of 56.2 (52.0 to 59.3) Gt CO2 eq in 2030.

This is a 16% increase on 2010 global emissioms

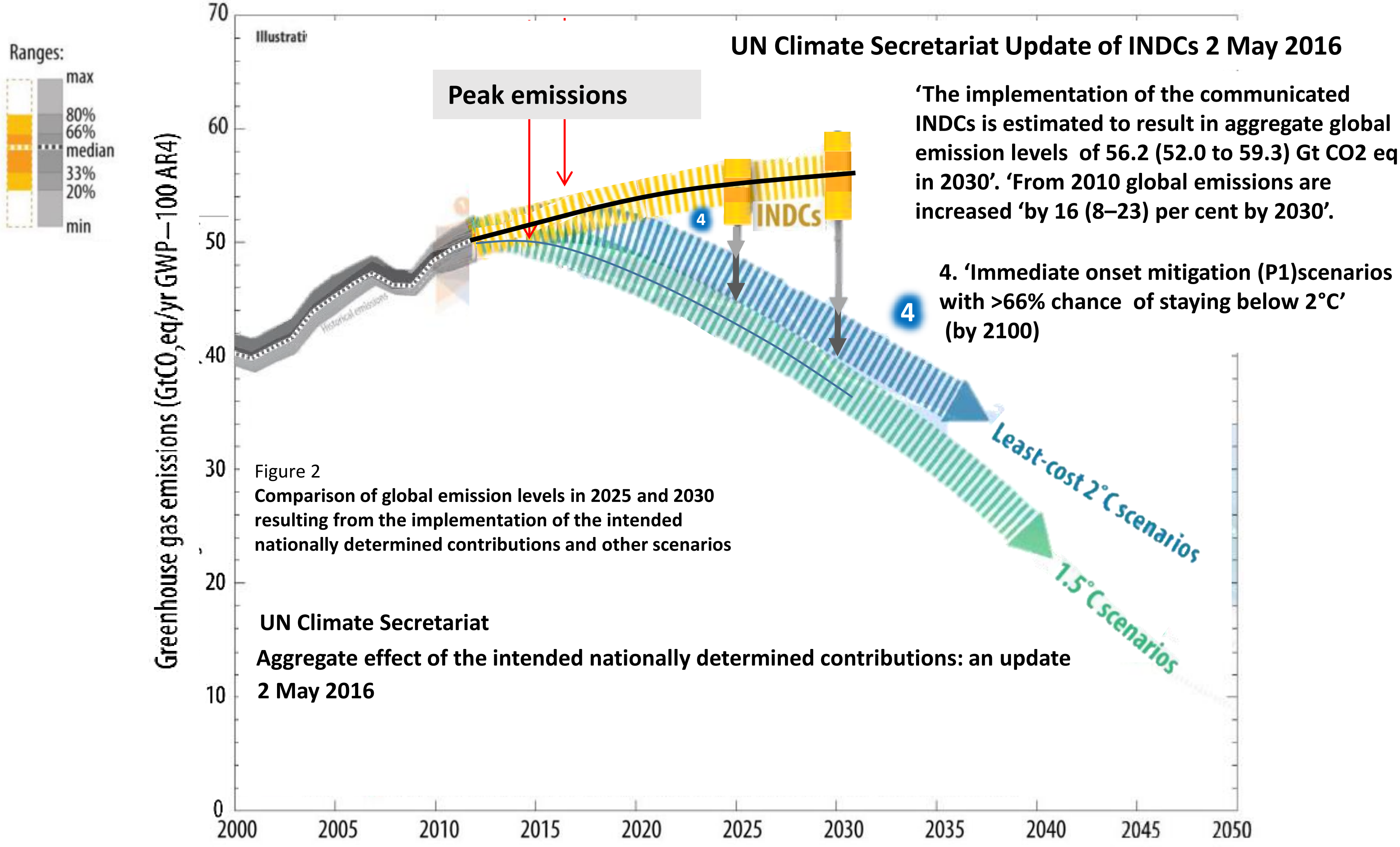
It is 67% higher than the 1.5°C scenario in 2030, (making 1.5°C unfeasible)

Compared with emission levels estimated to be consistent with 1.5 °C scenarios, aggregate emission levels resulting from INDCs are expected to be higher by 22.6 (17.8 to 27.5) Gt CO2 eq (67 per cent, range 49–90 per cent) in 2030.

36% higher than the 2C scenario by 2030

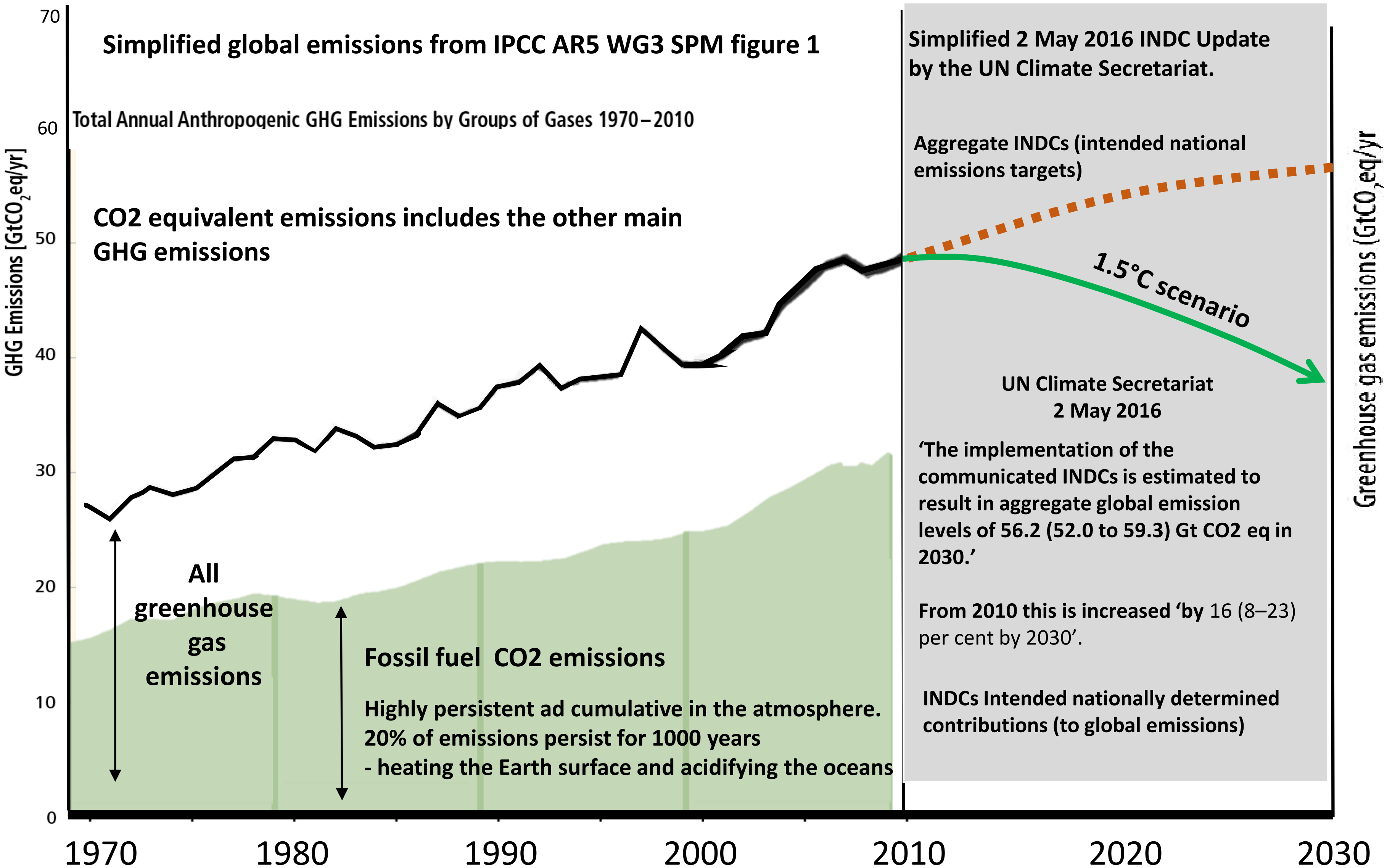
Compared with the emission levels under the 2 ºC scenarios, aggregate GHG emission levels resulting from implementation of the INDCs are expected to be higher by 15.2 (10.1 to 21.1) Gt CO2 eq (36 per cent, range 24–60 per cent) in 2030.

- 4 Emissions decline for 2°C, and so 1.5°C, is immediate
- Current national emissions targets lead to increased global emissions of 16% by 2030



Sources: Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report scenario database, 1.5 °C

The post Paris Agreement national emissions targets lead to a 16% global emissions increase by 2030



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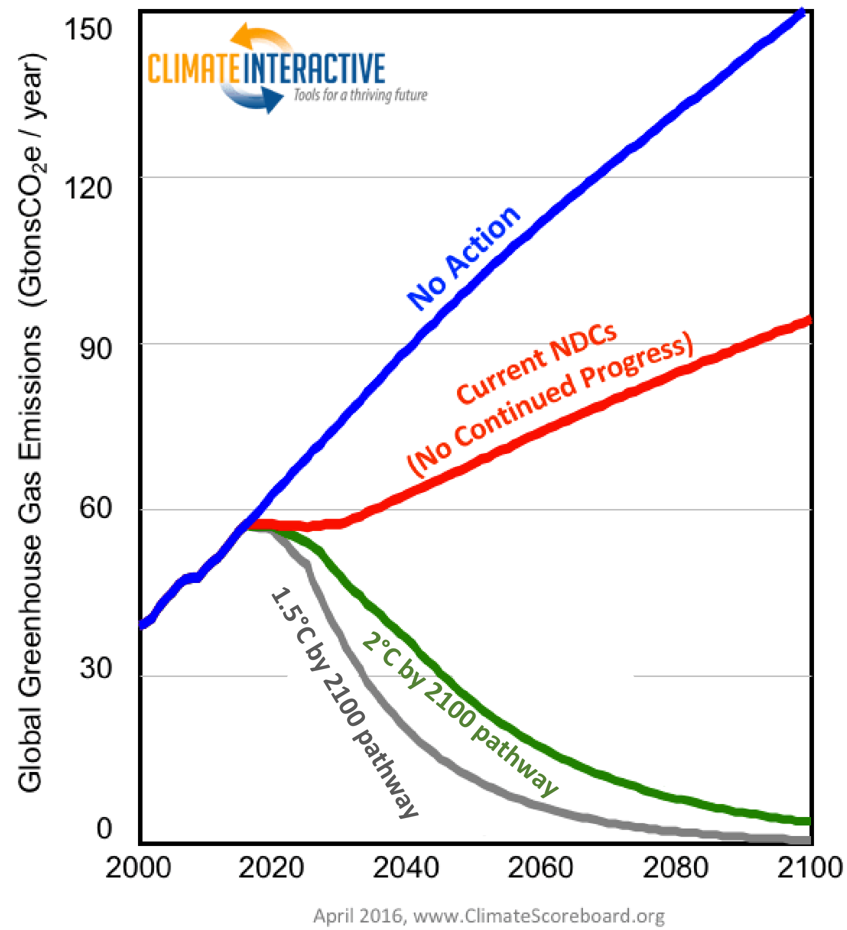
Projections of global temperature increases from national emissions targets (2016)

‘Our analysis shows that the national contributions to date, result in expected warming in 2100 of 3.5°C’ (April 2016 Climate Interactive).

Notes added

- **The May 2016 INDC (emissions targets) Update projected a 16% increase in global emissions by 2030**
- **The IPCC AR5 2°C pathway (best case emissions RCP 2.6) reaches 1.6°C mean by 2100**
- **The 1.5°C pathway shown here is in keeping with Climate Action network International 2014 position.**
- **These are mean projections which have only >66% chance of meeting target**



Estimated 2100 temp:

4.5°C **(up to 5.8°C)**
8.1°F

3.5°C **(up to 4.6°C)**
6.3°F

1.8°C **(up to 2.5°C)**
3.2°F

1.5°C **(up to 2.1°C)**
2.7°F

After 2100 Full equilibrium increase

7.8°C

6.0°C

Possible stabilization

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Impacts at 1.5°C (IPCC)

Generally these are additional impacts on top of environmental degradations.

Impacts start where text begins.

Rate of change increases vulnerability (AR5)

1.0°C — 1.5°C — ALL IMPACTS INCREASE WITH TEMPERATURE

Water

Decreasing water availability, increasing drought in mid to low latitude (AR4)
Caribbean rainfall declining Lower water availability
100's of millions facing increasing water stress (AR4)
For each degree of global warming, 7% of the global population is projected to have a decrease of water resources of at least 20% (AR5)

Ecosystems

High unadaptable vulnerability – especially relevant for indigenous people & future generations

Loss of ecosystem services globally

Increasing ecosystem impacts, all regions (AR5)
Increased species range shifts, increased coral bleaching (AR4)
Increasing wild fires observed (AR5)
Widespread stress on temperate forests and die back (AR5)
Amazon altered by drought, fires, on top of deforestation (AR5)

Most coral reefs bleached by warming (AR4)
Tree & herbs species can't keep up with rate of climate change (AR5)
'15% more species committed to extinction' (AR4)
Ocean acidification poses substantial risks to coral reefs (AR5)
Large fraction of species at added risk of extinction (AR5)

Food

Complex local negative impacts on small holders, subsistence farmers, fishers (most world food production) (AR4); not adaptable (AR5)
Climate effects observed, most negative (AR5)
Tropical and African crops decline (AR5); are the least adaptable (AR5)
Indigenous most vulnerable
Above 1°C, -ve effects in both tropical & temperate regions (AR5 WG2 final draft) Most temperate region crops decline (AR5)
N.B. Some adverse effects & combined effects are not captured by crop models
High risk of severe impacts (UN Climate Sec. Structured Expert Dialogue – SED 2013)
N.B. Necessary adaptation to increasing climate variation, extremes & other impacts cannot be assumed effective for long (IPCC AR5 WG2 7.6)

Coasts

Increased damage from floods & storms, highly damaging to small island peoples (AR4, AR5)
Greenland ice – significant decay of ice sheet & at over 1.0°C (AR5)

Sea level rise continues for 100s of years (SED)
Potentially millions exposed to floods (AR4, AR5)
Limit of adaptation for some coasts & ecosystems (SED)

Health

There is no safe limit (SED WHO Report 2013)
In recent decades, climate change has contributed to levels of ill health (AR5)
Local changes in temperature & rainfall have altered distribution of water-borne illnesses & disease vectors, & reduced food production for vulnerable populations (AR5)
In 2010, more than 7% of the global burden of disease was caused by climate active air pollutants (AR5)
Children, young people, and the elderly are at increased risk of climate related injury and illness (AR5)
Increasing burden from malnutrition, diarrheal, cardiovascular, infectious, food- & water-borne diseases (AR4, AR5)
Increasing morbidity and mortality from heat waves, floods and droughts
Changes in some disease vectors Malaria & dengue increased Pacific Islands

Extreme Weather

Highly (additionally) damaging to population health, crops & public services
Increasing extremes – including heat extremes, forest fires, regional drought, tropical cyclone intensity – will continue to increase (AR5)

GHG Feedbacks

Large amplifying feedback sources not accounted for in RCP model projections

The carbon cycle climate feedback will be +ve 'Climate warming projected to reduce oceanic carbon uptake in most regions (AR5)
All tropical carbon sinks weaken above 1.5°C (AR5)
CH_4 concentration growth since 2006 involves natural wetlands (feedback) – will increase (AR5)
1.5°C irreversible 'thaw down' of Siberia permafrost (A. Vaks 2010)

Cryosphere Arctic

Ice sheets losing mass, Antarctic & Greenland (accelerating)
Arctic sea ice and N.H. spring snow cover have decreased in extent (AR5)
70% loss in sea ice volume since 1980

W. Antarctic ice sheet collapsing (J. Feldman 2015)
Arctic warming 2-3X mid latitudes; Arctic will keep warming fastest (AR5)
N.H. Snow and summer sea ice will decline rapidly (albedo feedback) (AR5)
Loss of all late summer sea ice (SED)

Oceans

Pacific coral bleaching increasing, and reef building declining 1-2%/yr (AR5)
Ocean warming and acidification increase under all scenarios Only RCP2.6 stabilizes acidification after 2050 (AR5)
Ocean heat & acidification accelerating with adverse effects on marine organisms (WMO 2015)
Temperate seagrass and kelp ecosystems will decline with the increased frequency of heat waves and sea temperature extremes (AR5)
Marine organisms are being affected (AR5) 'Warming leads to decline of dissolved O2 in the oceans' interior' (AR5)

Tipping Points

Increasing likelihood of severe irreversible impacts to people & ecosystems (AR5)
'There are 'plausible tipping points' of the boreal-tundra Arctic systems and Amazon' (AR5)
At 1.6°C, tipping point risks 'increase disproportionately' (AR5)
Increasing risk with warming for crossing MULTIPLE TIPPING POINTS (AR5)

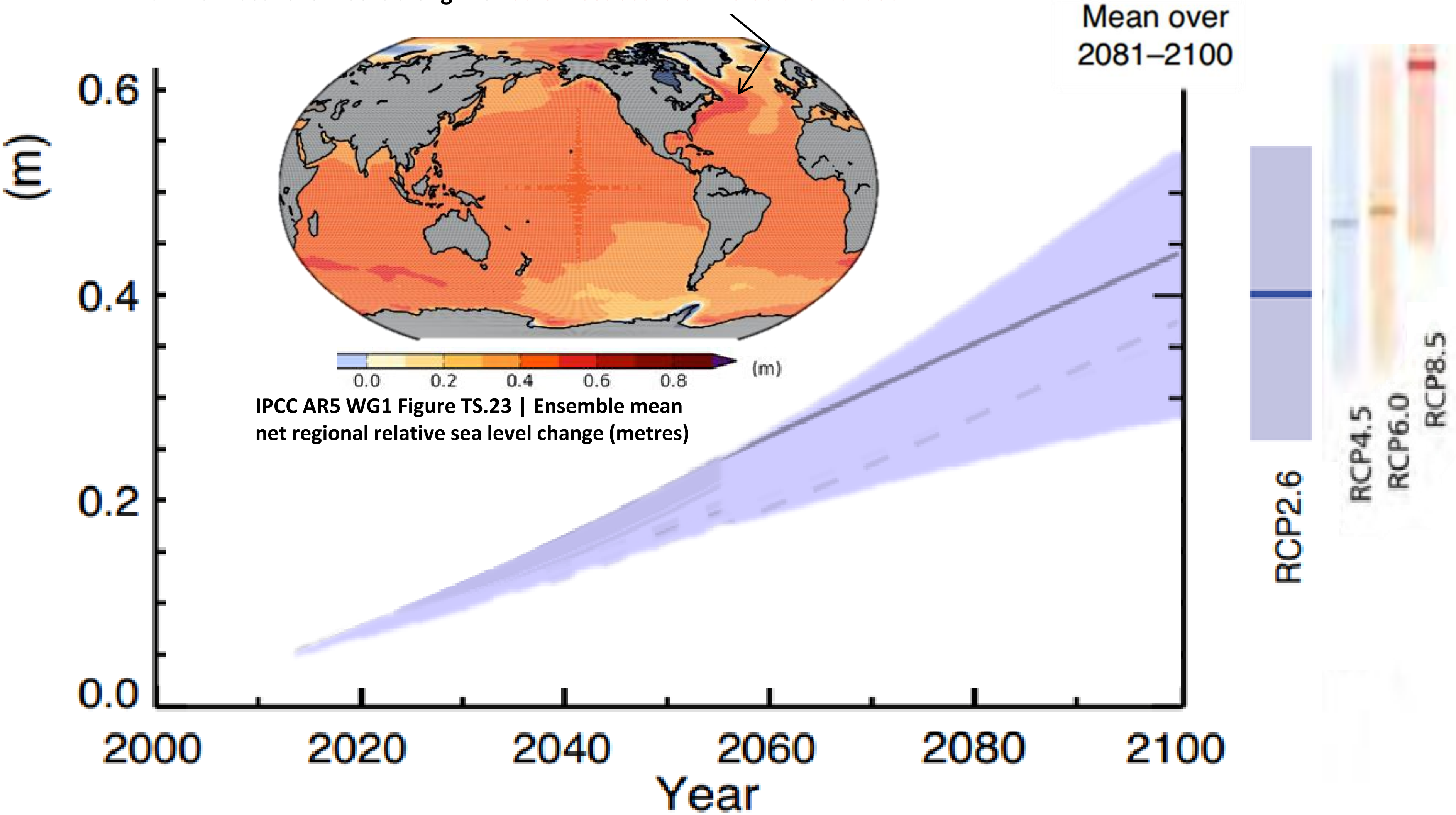
P. Carter, 2016 1.5°C impacts

SED: UN Structured Expert Dialogue reports 2013 Other reference details are in poster presentation

Sea level rise at 1.5°C

Under the 1.5°C scenario, sea level continues to rise with slight slowing from 2070.
It is still rising at 2100 at about the same rate as from 2000-2013.

Maximum sea level rise is along the Eastern seaboard of the US and Canada



IPCC AR5 WG1 Figure TS.23 | Ensemble mean net regional relative sea level change (metres)

IPCC AR5 WG1 Figure TS.22 | Projections from process-based models of global mean sea level (GMSL) rise relative to 1986–2005

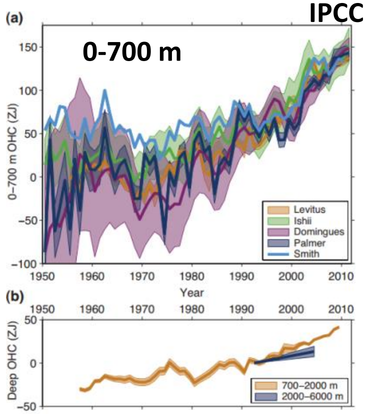
Ocean heating at 1.5°C

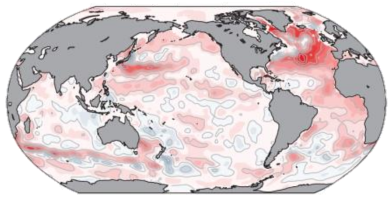
Today

Ocean heating is presently accelerating, particularly the heat that is going deeper.

Annual global mean upper ocean heat content

IPCC AR5



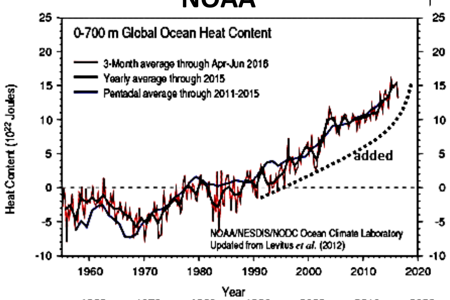


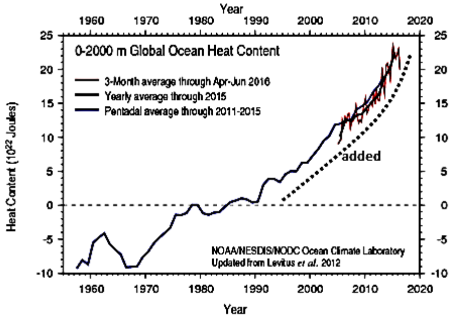
700-2000 m

2000-6000 m

IPCC AR5 WG1 Fig 3.1, 3.2

NOAA

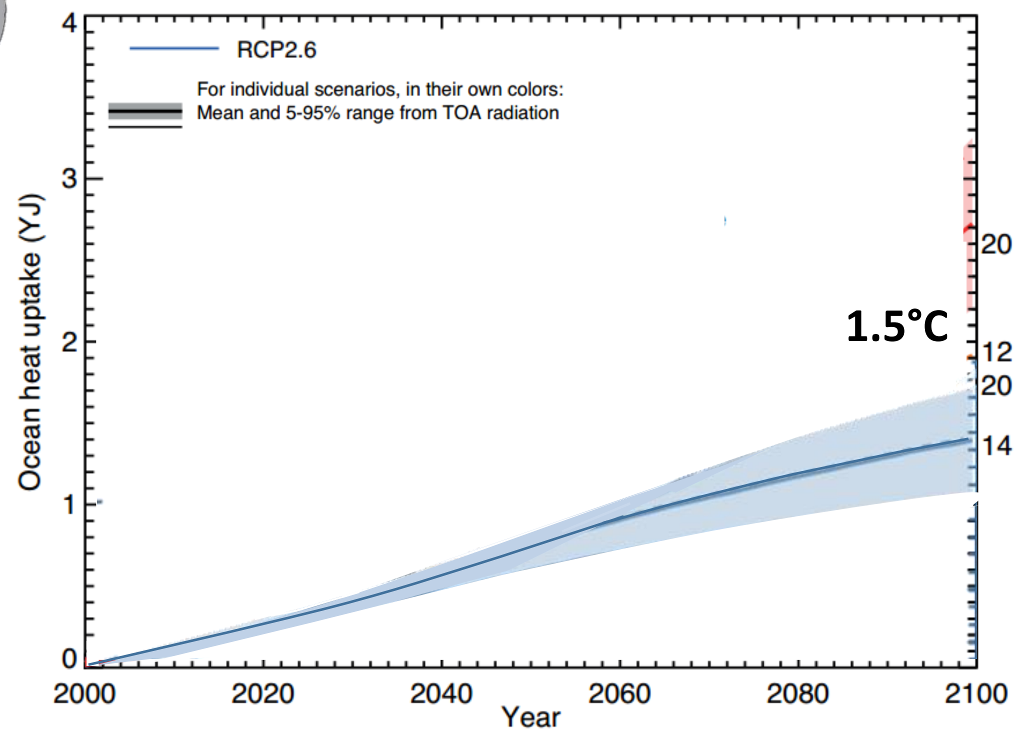




At 1.5°C

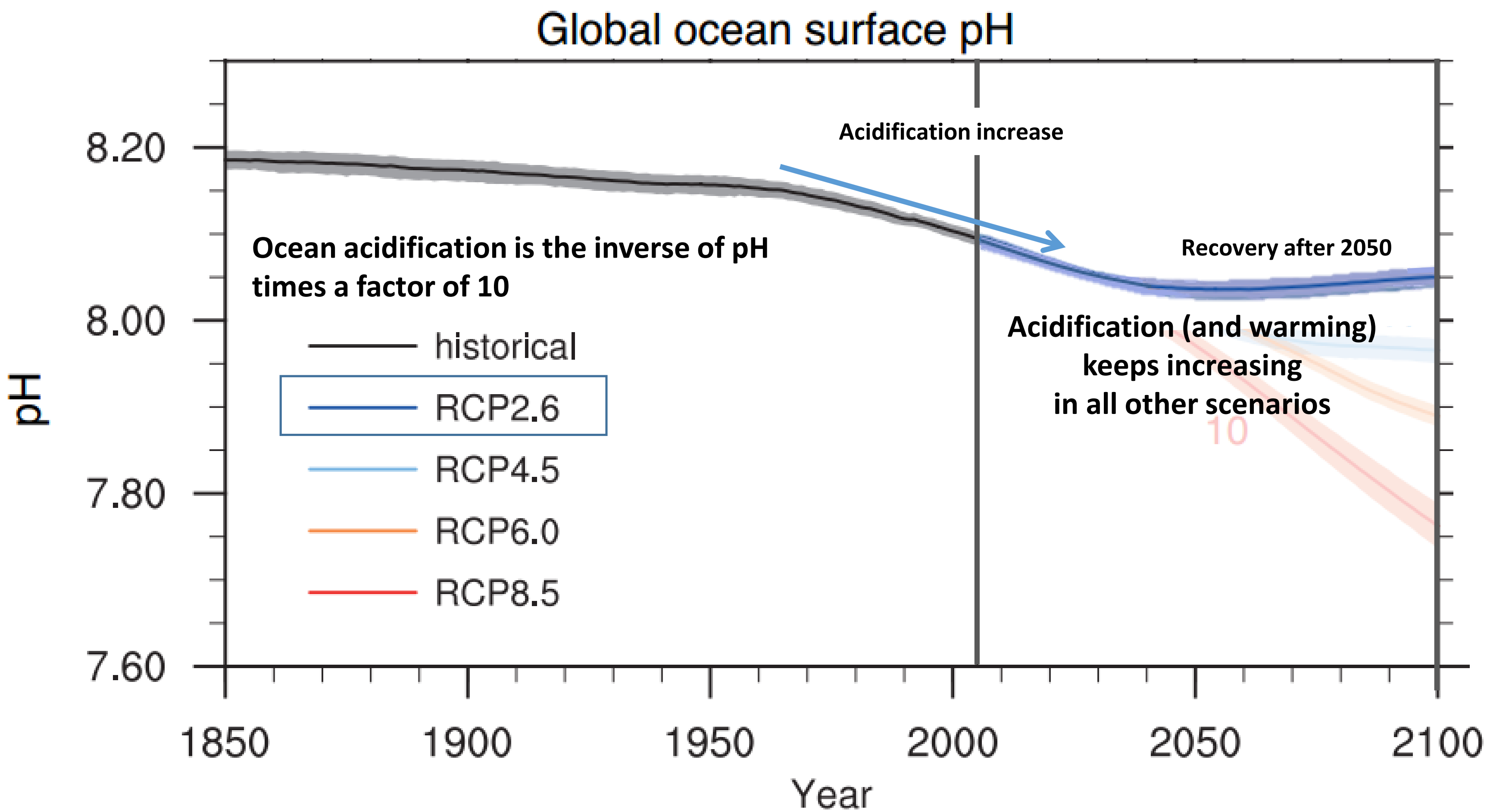
Ocean heating increases, with slight slowing from 2070.

It is still increasing at 2100 at about the same rate as from 2000-2013.



Ocean acidification at 1.5°C

Ocean warming and acidification have synergistic adverse effects on corals and marine organisms (UNFCC SED 2014)

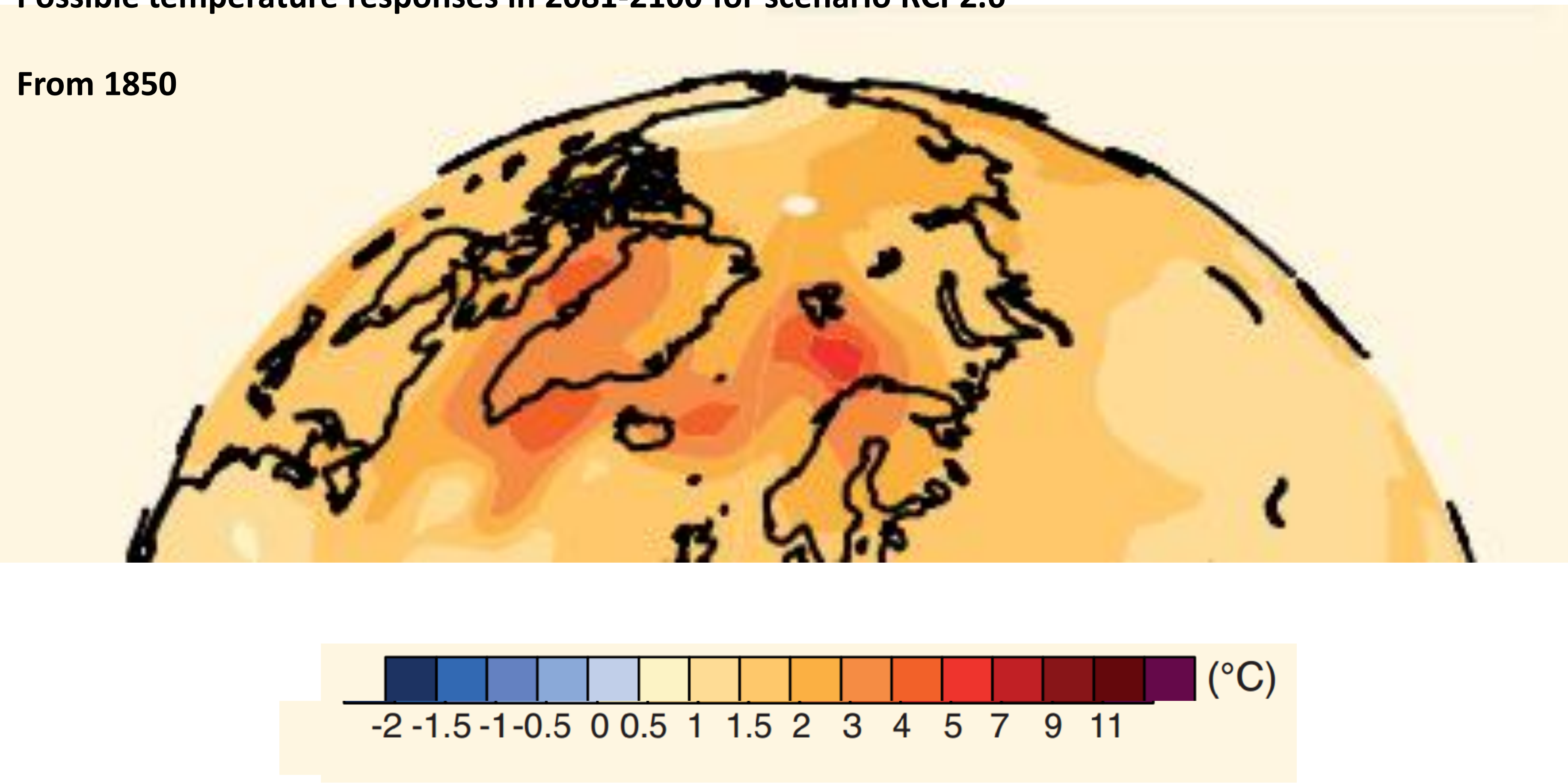


IPCC AR5 WG1 Figure TS.20 | (a) Time series (model averages and minimum to maximum ranges) of multi-model surface ocean pH in 2081–2100.

The Arctic at 1.5°C

Possible temperature responses in 2081-2100 for scenario RCP2.6

From 1850



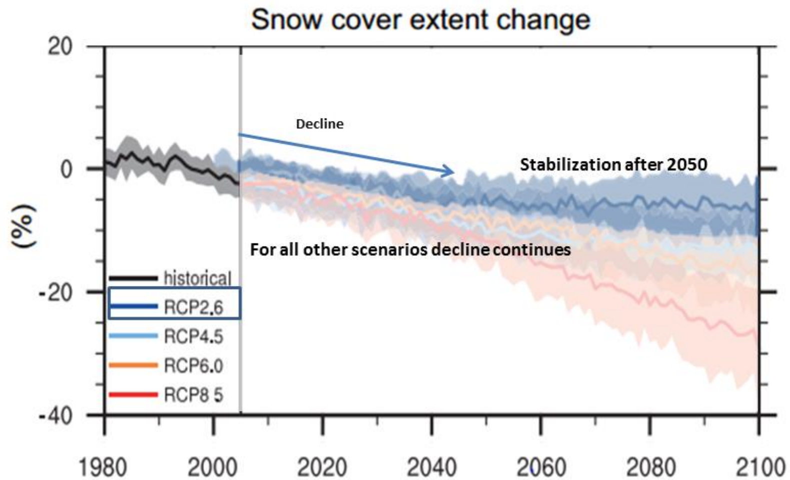
IPCC AR5 WG1 FAQ 12.1, Figure 1

The Arctic at 1.5°C

Northern hemisphere snow cover decline at 1.5°C

Arctic amplifying feedback

Far North snow cover provides albedo cooling-about the same amount as Arctic sea ice (Flanner)
Decline of NH albedo cooling due to melting of snow and sea ice is an amplifying feedback (snow ice albedo feedback)
Effects on northern hemisphere weather and climate are intuitive.



IPCC AR5 WG 1 Figure TS.18 | (Top) Northern Hemisphere (NH) spring (March to April average)

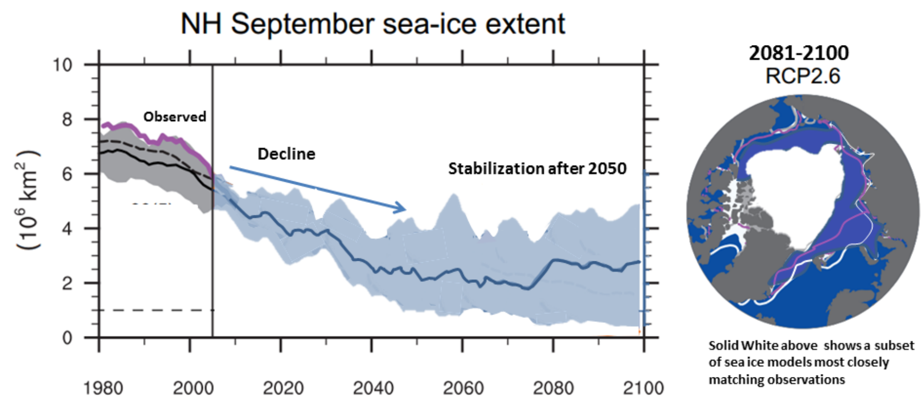
Arctic summer sea ice loss at 1.5°C

Arctic summer sea ice extent decline is a regional amplifying feedback leading to 'Arctic amplification' of global warming. Arctic amplification increases Arctic carbon feedback emissions (e.g., by thawing permafrost) – a global warming feedback.

Effects on Northern Hemisphere weather and climate are intuitive, with some evidence for increased NH extreme weather.

As Arctic sea ice is the summer 'air conditioner' for the Northern Hemisphere, retaining sea ice is required for NH and world food security.

On the 1.5°C scenario, sea ice declines and stabilizes and increases slightly after 2050, so that by 2100 about half the late summer sea ice melts away and about half is retained. In all other scenarios, summer sea ice decline continues to zero.



Solid White above shows a subset of sea ice models most closely matching observations

IPCC AR5 WG1 Figure TS.17 | Northern Hemisphere (NH) sea ice extent in September over the late 20th century and the whole 21st century for the scenario RCP 2.6

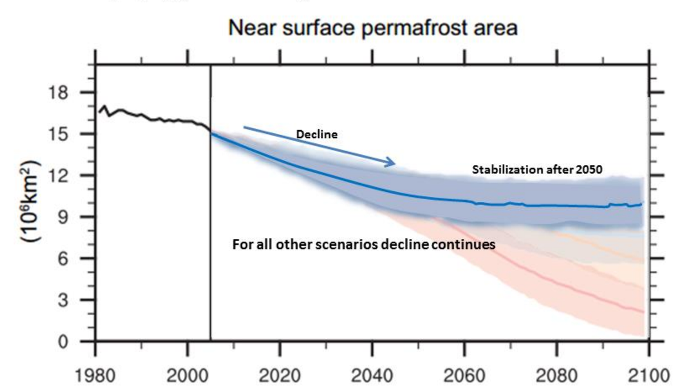
'There is high confidence that reductions in permafrost extent due to warming will cause thawing of some currently frozen carbon. However, there is low confidence on the magnitude of carbon losses through CO2 and CH4 emissions to the atmosphere.'

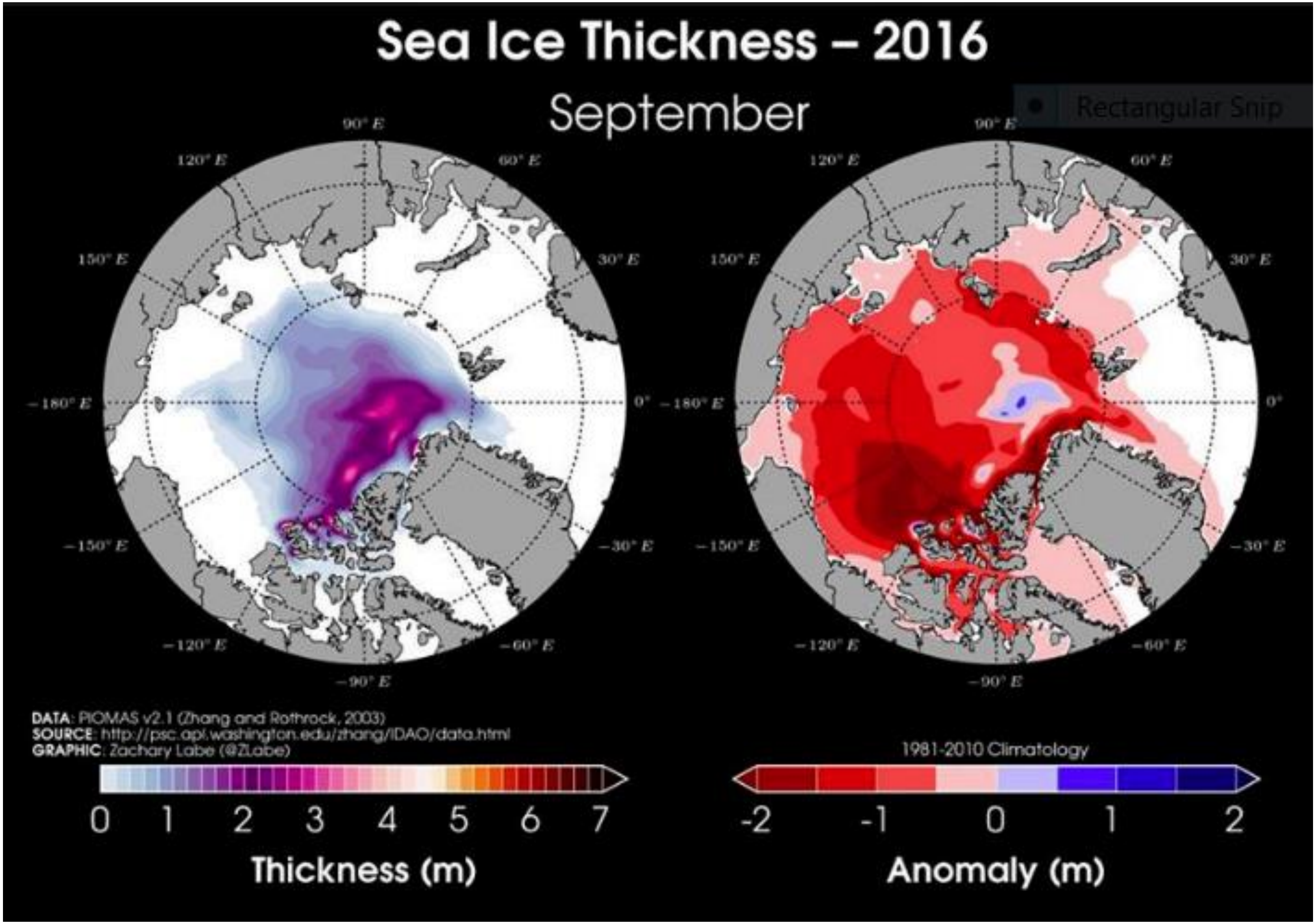
'The loss of carbon from frozen soils constitutes a positive radiative feedback that is missing in current coupled ESM projections.

IPCC AR5 Figure TS.18 NH diagnosed near-surface permafrost area in CMIP5

Far North permafrost thawing at 1.5°C

Amplifying global warming feedback from CO2 and methane emissions

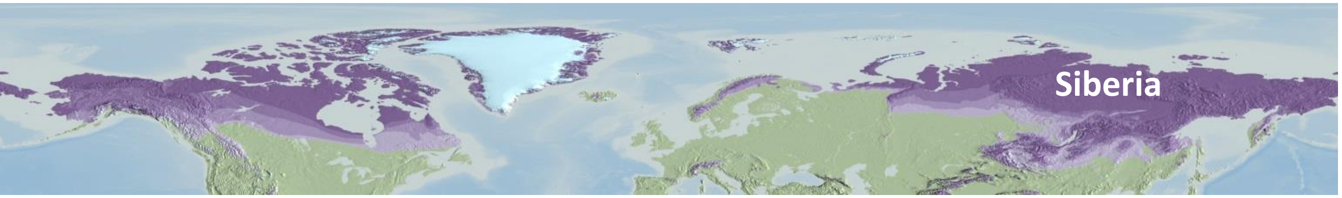




Source PIOMAS validation

Permafrost ‘thaw-down’ at 1.5°C

Permafrost

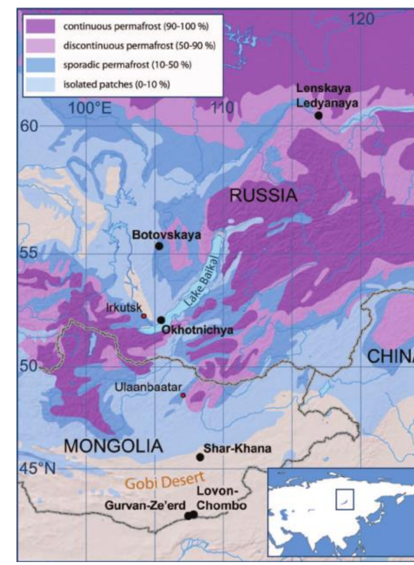


From T. Lenton Tipping elements in the Earth's climate system. PNAS

? 1.5°C scenario

We suggest that permafrost carbon release could lead to significant warming, even under less intensive emissions trajectories.
Andrew H. MacDougall, 2015

Siberia research site



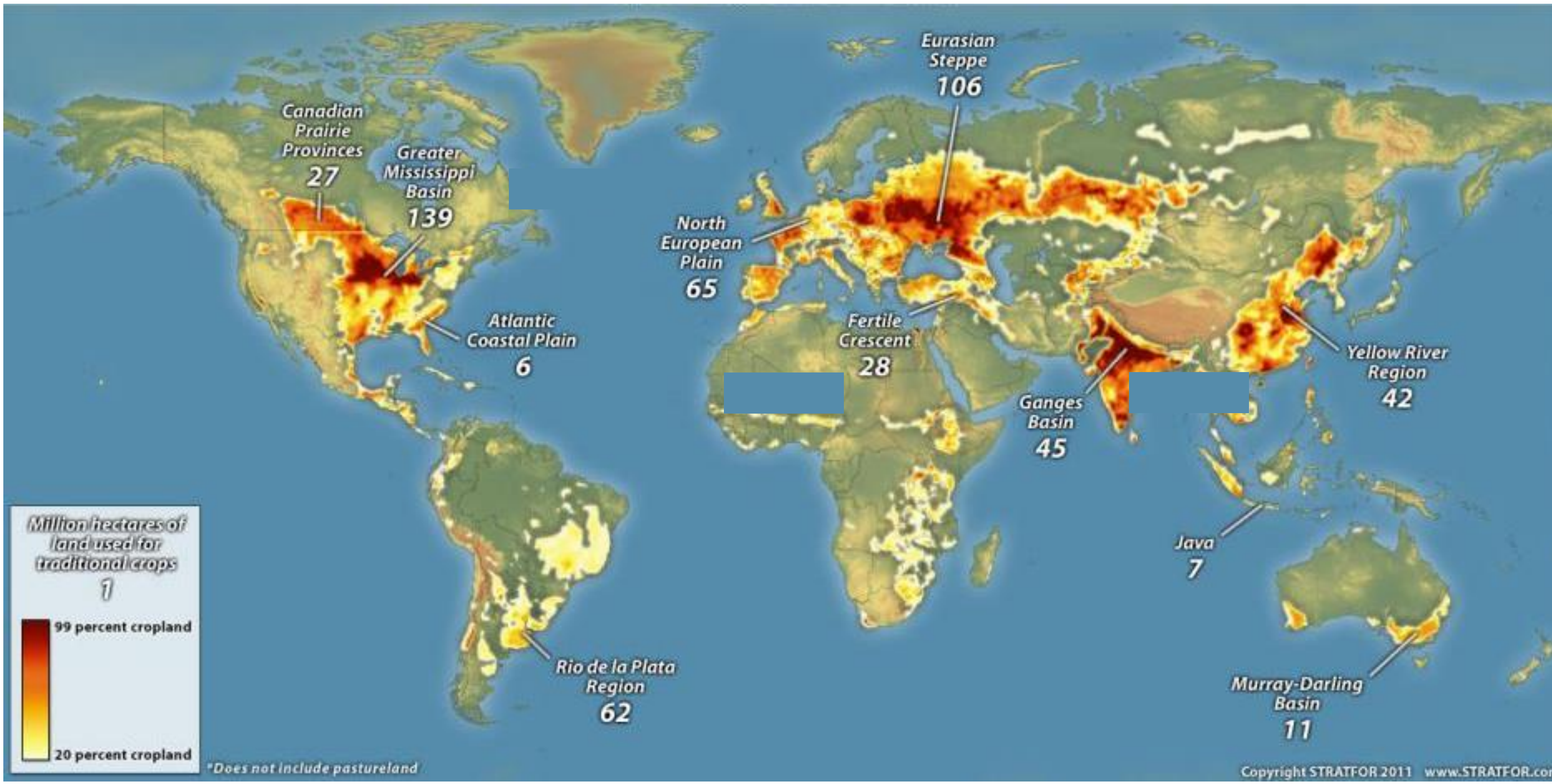
Climate records captured in Siberian caves suggest 1.5 degrees of warming is enough to trigger thawing of permafrost, (The Geological Society of London June 2013)

‘Permafrost contains twice as much carbon as the atmosphere which could have serious consequences if it were to be released by widespread thawing.

Vaks et al. (21 February)
The authors conclude that conditions only slightly warmer than those of today would cause widespread thawing of continuous permafrost as far north as 60°N.
The authors conclude that conditions only slightly warmer than those of today would cause widespread thawing of continuous permafrost as far north as 60°N’.
(Speleothems Reveal 500,000-Year History of Siberian Permafrost A. Vaks et al April 2013)

Impact of 1.5°C on crop yields

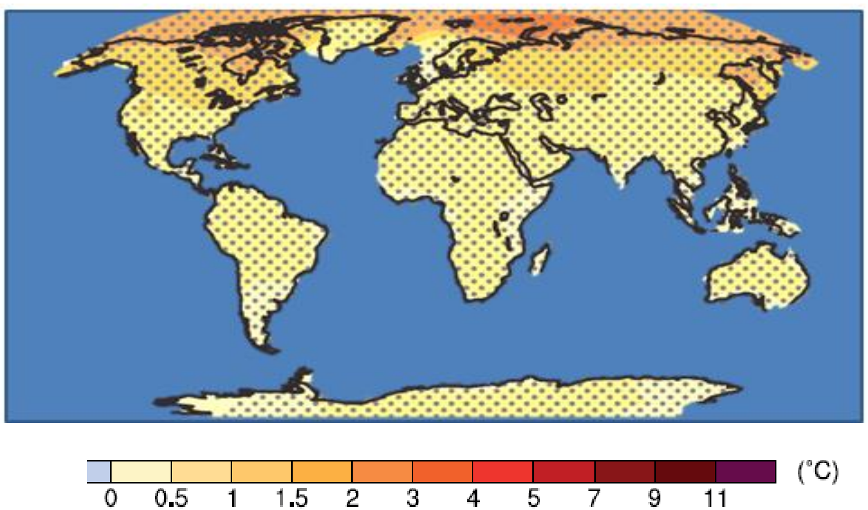
Global Agricultural Zones



Surface temperature increase at 1.5°C

‘There is very high confidence that globally averaged changes over land will exceed changes over the ocean at the end of the 21st century by a factor that is likely in the range 1.4 to 1.7°C.’ (AR5 WG TS)

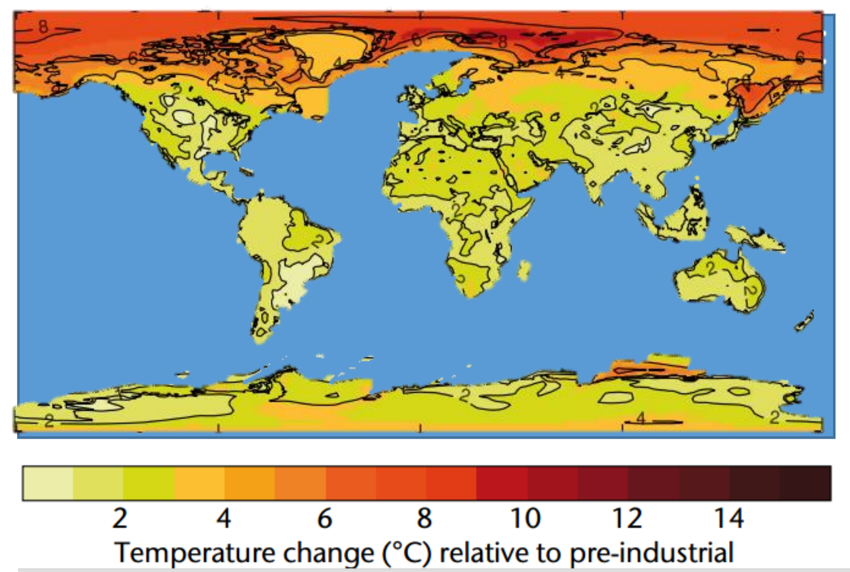
RCP 2.6 from 2000



IPCC AR5 WG1 Figure TS.15 |Map Multi-model ensemble average of annual mean surface air temperature change by 2100 (compared to 1986-2005 base period)

The largest temperature increase affects the entire Arctic, which is an extreme increase due to Arctic amplification: +8°C for 1.5°C global warming.

RCP 2.6 from pre-industrial

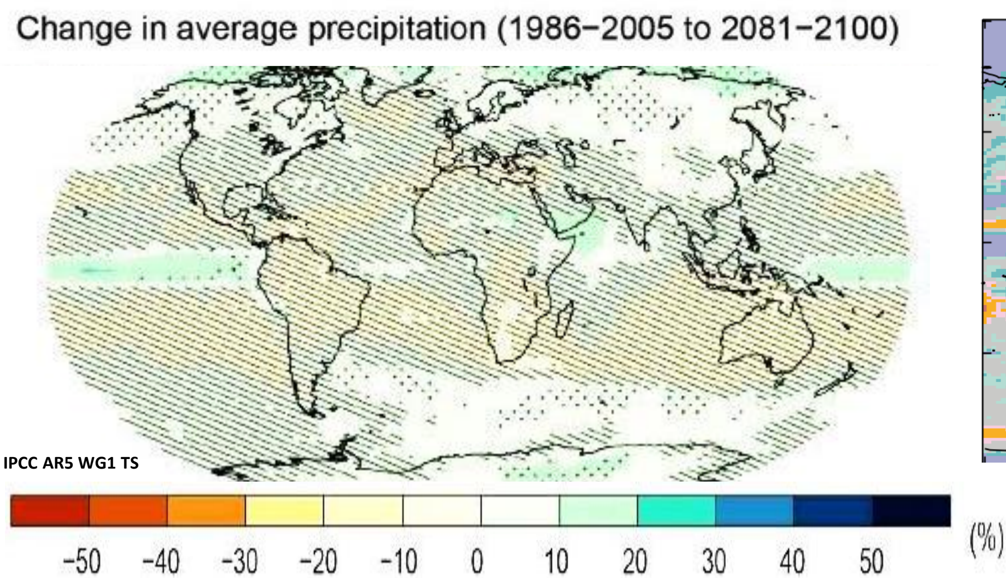


UK Met Office Advance: Improved science for mitigation policy advice 2010. Mean temperature change

(The ocean has been removed for clarity.)
(The UK Met Office Advance model projection is included as it is clearer than the AR5 and it is from pre-industrial, hence the more warming shown).

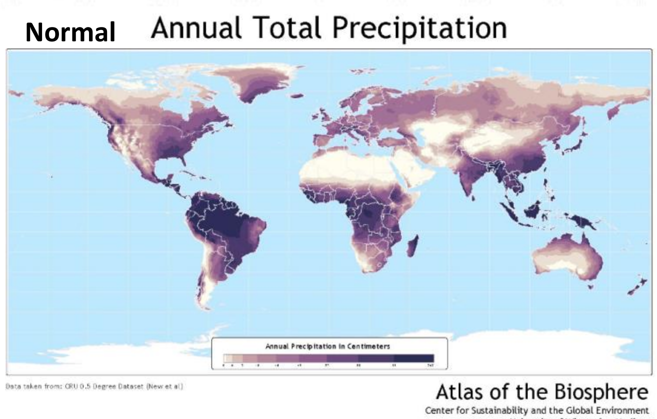
Precipitation change at 1.5°C

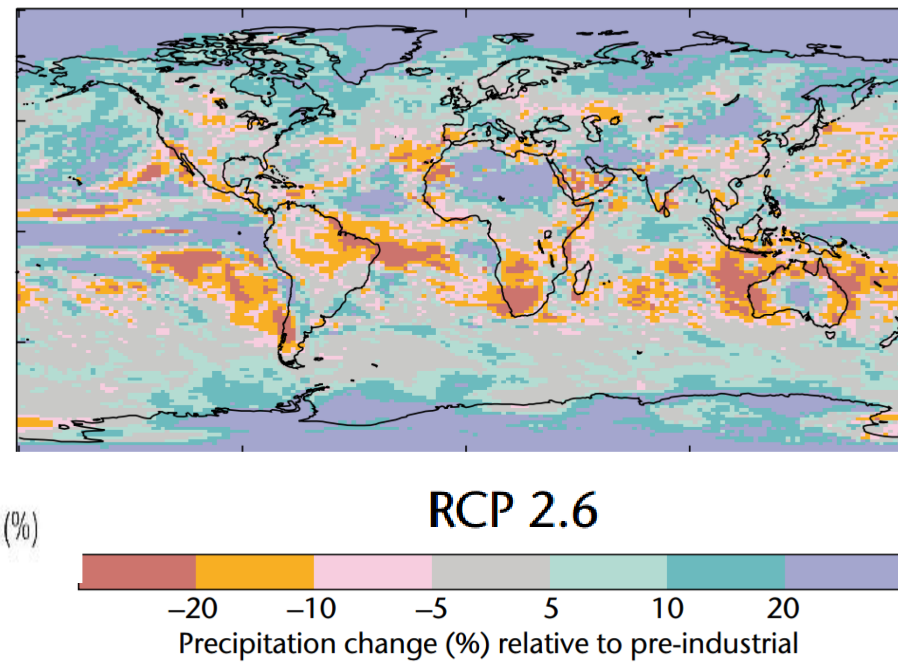
- Precipitation changes are uncertain, hence the difference in the two projection maps.
- There are some large changes at 1.5°C.
- Largest increased precipitation affects both polar regions.
- Some decrease in precipitation affects the dry regions of the Southern Hemisphere.
- Wet India gets wetter.
- California gets drier.
- The normally wet Amazon gets drier.



IPCC AR5 WG1 TS

Normal

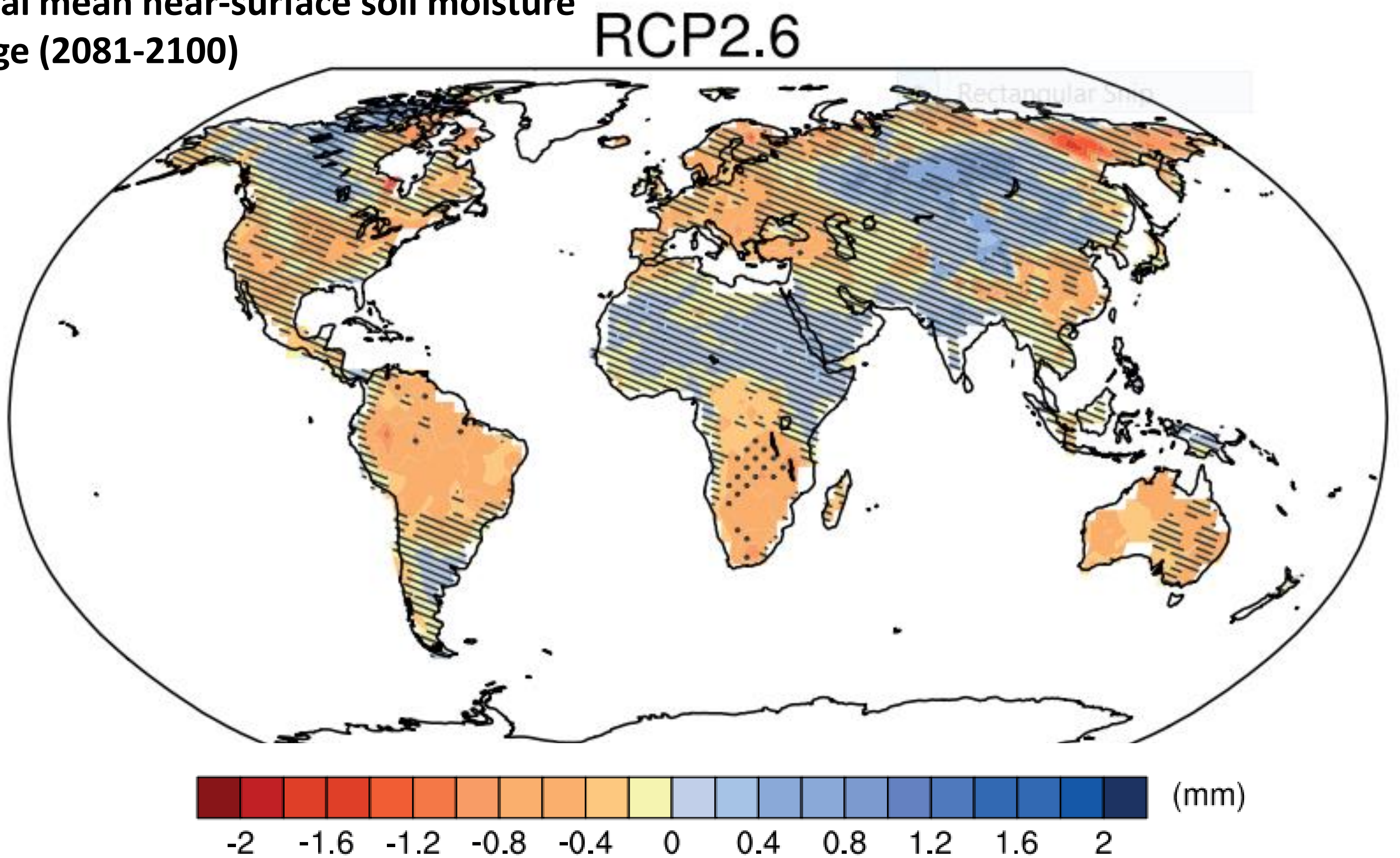




UK Met Office Advance: Improved science for mitigation policy advice 2010

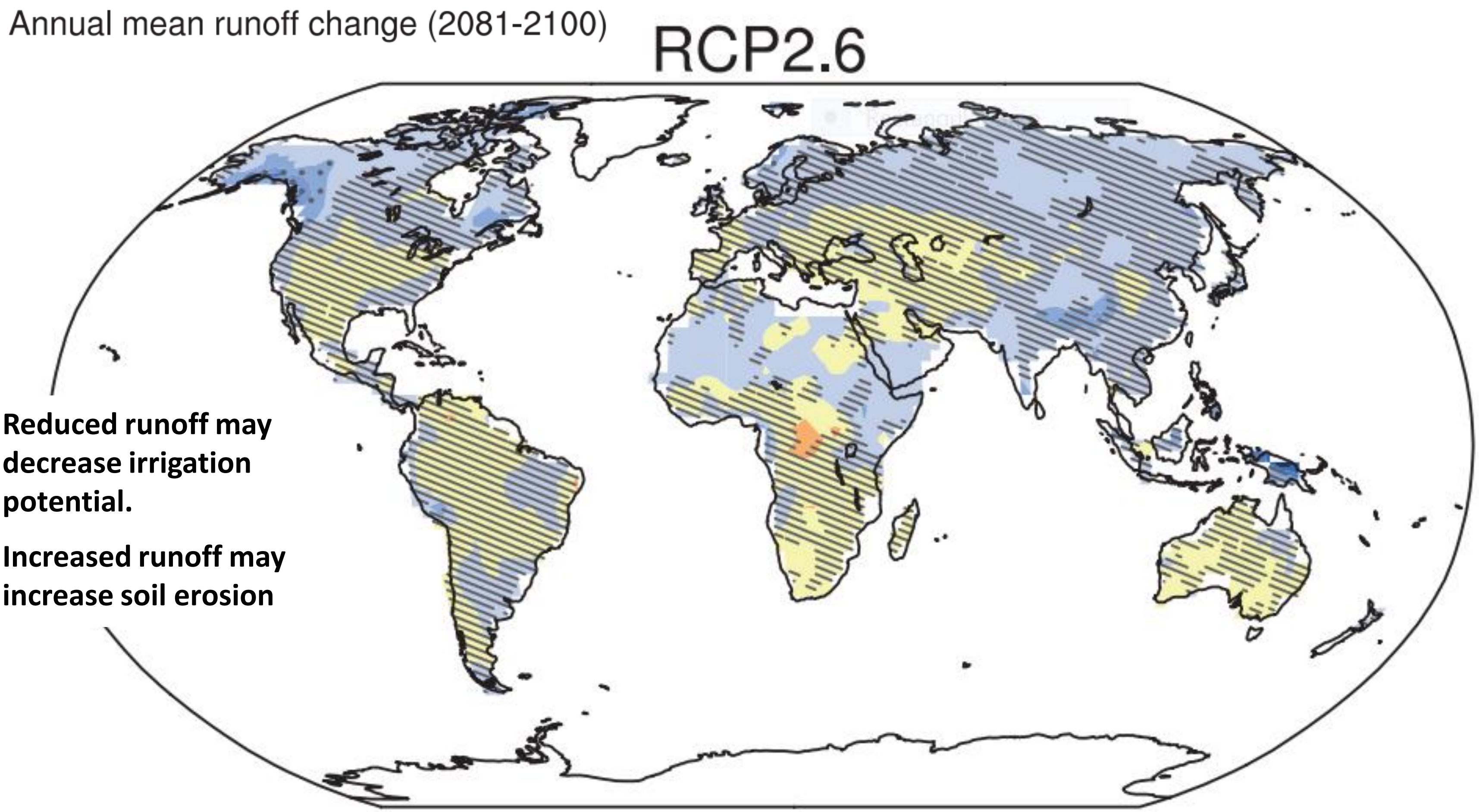
Soil Moisture at 1.5°C

Annual mean near-surface soil moisture change (2081-2100)



IPCC AR5 WG1 Figure 12.23 | Change in annual mean soil moisture (mass of water in all phases in the uppermost 10 cm of the soil) (mm) relative to the reference period 1986–2005 projected for 2081–2100 from the CMIP5 ensemble. Hatching indicates regions where the multi-model mean change is less than one standard deviation of internal variability. Stippling indicates regions where the multi-model mean change is greater than two standard deviations of internal variability and where at least 90% of models agree on the sign of change.

Runoff at 1.5°C



Reduced runoff may decrease irrigation potential.

Increased runoff may increase soil erosion

IPCC AR% WG1 Figure 12.24 | Change in annual mean runoff relative to the reference period 1986–2005 projected for 2081–2100 from the CMIP5 ensemble. Hatching indicates regions where the multi-model mean change is less than one standard deviation of internal variability. Stippling indicates regions where the multi-model mean change is greater than two standard deviations of internal variability and where at least 90% of models agree on the sign of change (see Box 12.1). The number of CMIP5 models used is indicated in the upper right corner of each panel

Extreme wet days at 1.5°C

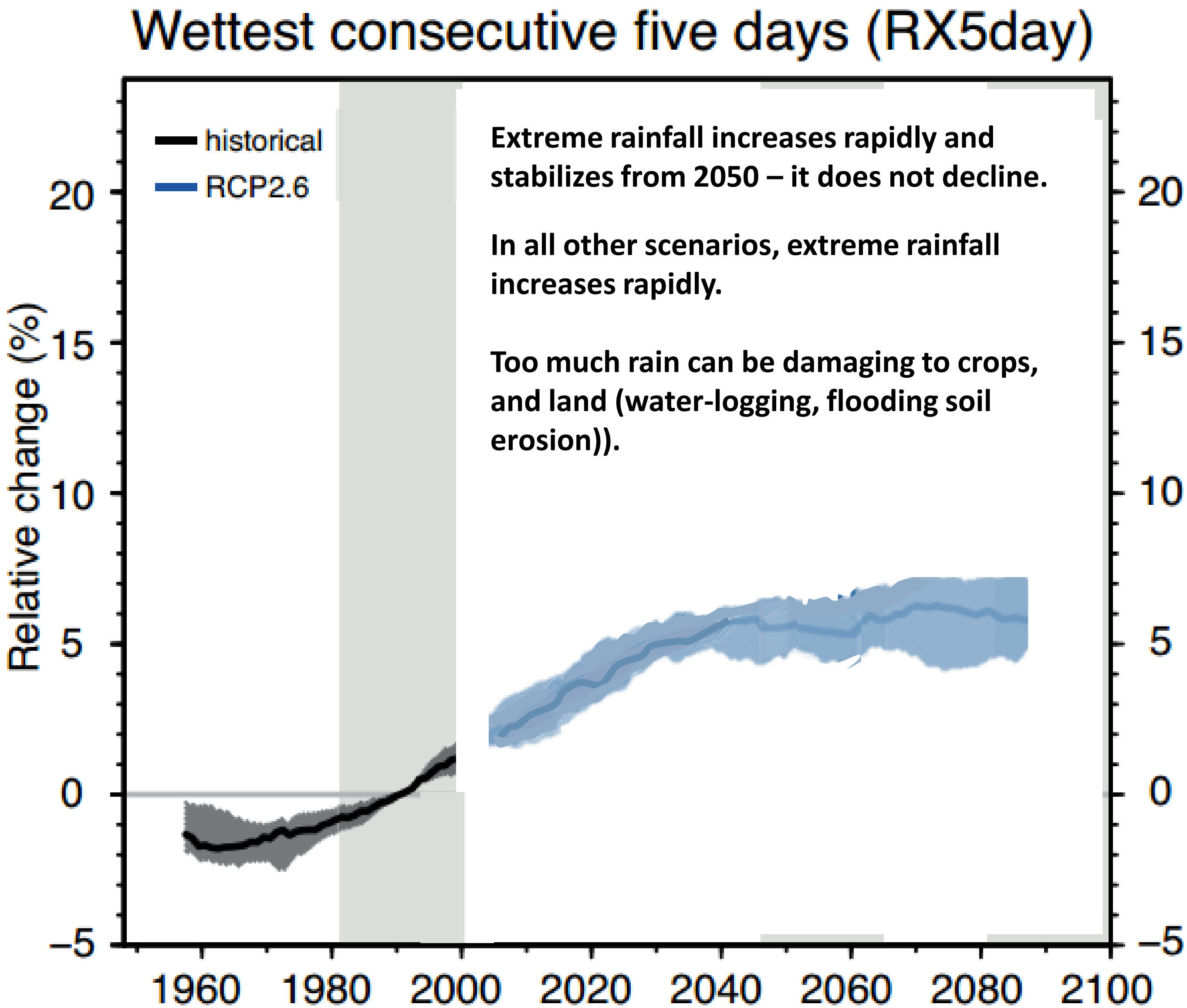
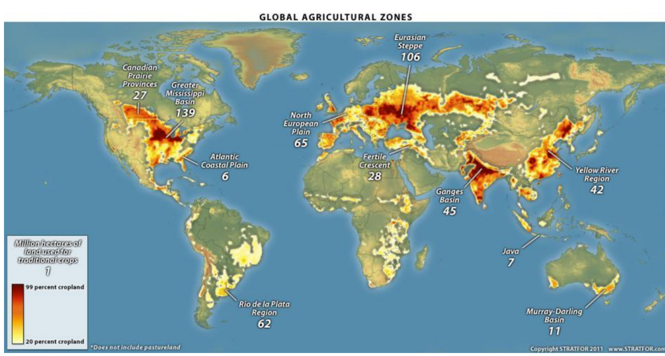


Figure 12.26 | (a,) Projected percent changes (relative to the 1981–2000 reference period in RX5day, the annual maximum five-day precipitation accumulation.

Increased dry days at 1.5°C

Regions affected by drying include

- **US and Canada corn belts**
- **Southeast USA**
- **Southwest USA**
- **Mexico**
- **Latin America**
- **Eastern Amazon**
- **South America food-producing regions**
- **Spain, Italy, Greece**
- **Turkey**
- **North Africa**
- **West Africa**
- **Madagascar**
- **South central Africa**
- **South Africa**
- **China**
- **Indonesia**
- **Australia**



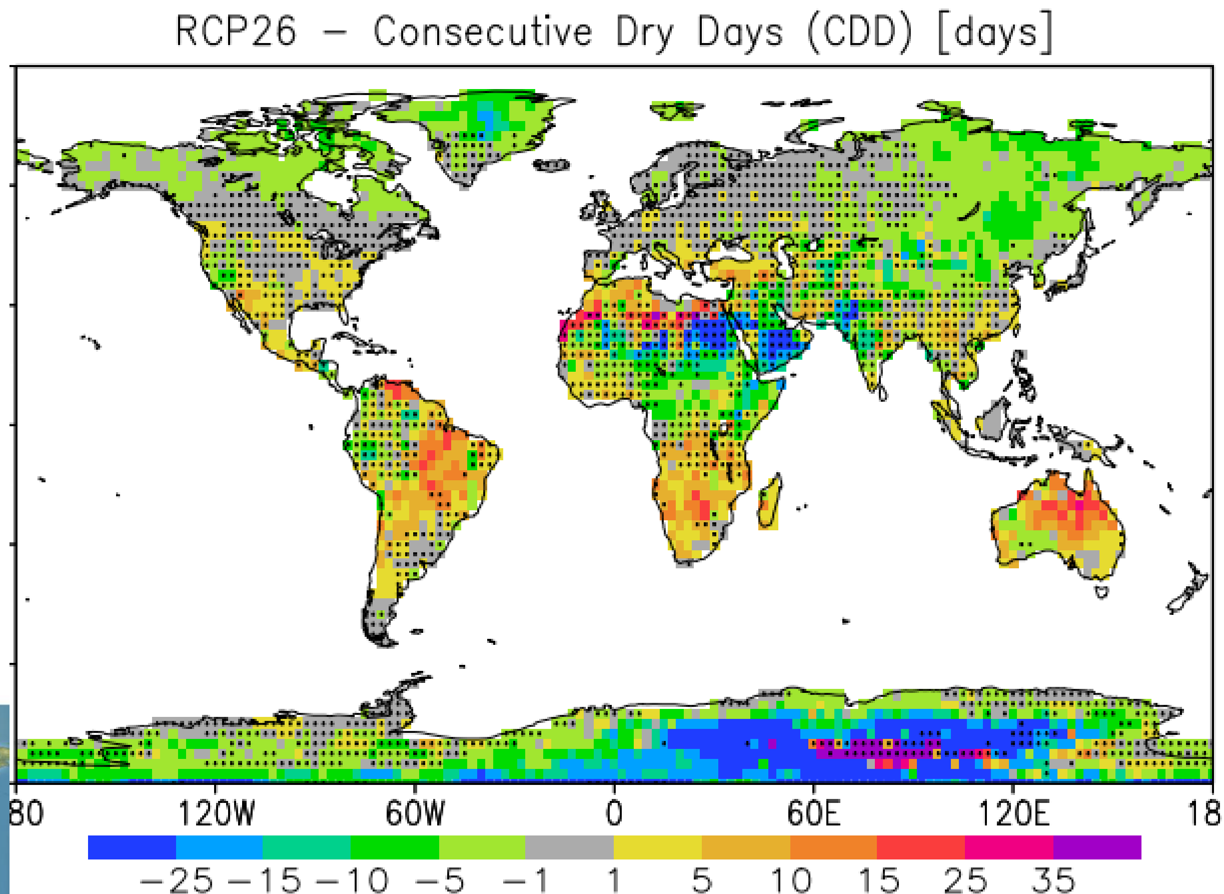


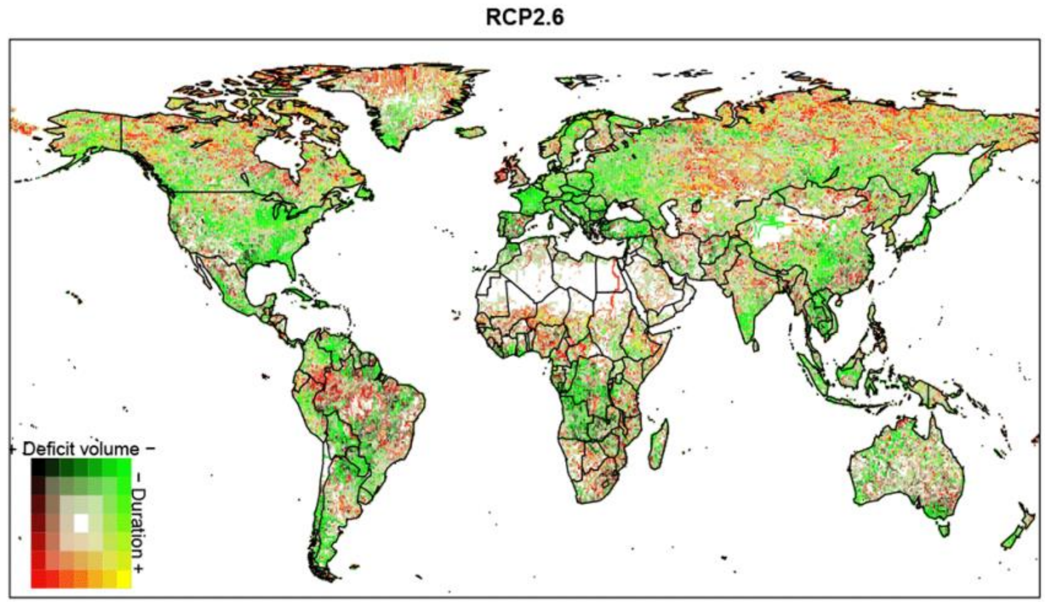
Figure 13. The multi-model median of temporally averaged changes of consecutive dry days over the time period 2081 to 2100 for RCP2.6
Changes are displayed as differences [in days] relative to the reference period (1981-2000)

Climate extreme indices in the CMIP5 multi-model 2 ensemble. 2012 J. Sillmann Canadian Centre for Climate Modelling and Analysis,

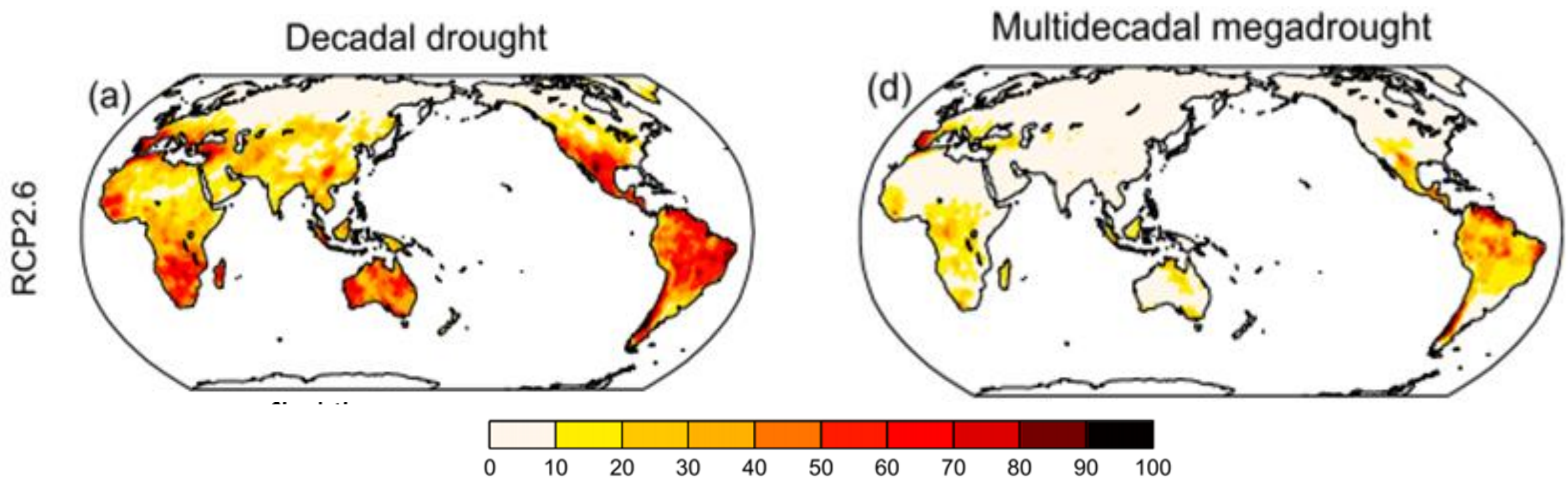
Global drought at 1.5°C

Wanders, N. 2015. Global hydrological droughts in the 21st century at 1.5°C

Figure 3. Average trends in drought duration and drought deficit volume, derived with a transient Q90 threshold from discharge simulation of PCR-GLOBWB. Colours indicate the robustness of the trend where the darkest colours are robust (five GCMs agree), thereafter likely (four GCMs agree) and plausible (three GCMs agree). A white colour indicates areas where no drought characteristics were calculated.



Drought: decadal & multi-decadal T. Ault 2014 at 1.5°C



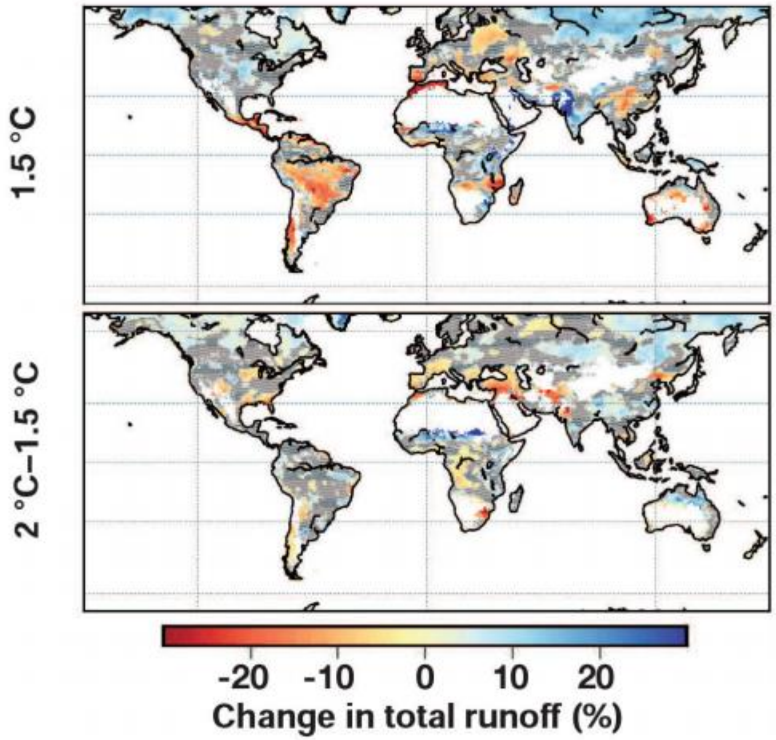
The percent of the total number of models that simulate a decadal or mega-drought (2005–2100)

T.R. Ault 2014 Assessing the risk of persistent drought using climate model simulations and paleoclimate data

Drought in a changing climate: AR5 and recent scientific advances

Valérie Masson-Delmotte (WGI Co-Chair) - Wilfran Moufouma-Okia (WGI TSU) - Thanks to Sonia Seneviratne (ETH Zürich)
Contact: tsu@ipcc-wg1.universite-paris-saclay.fr

Link with global temperature target



Source: Schleussner et al, Earth Syst. Dynam., 2016.

- Increased reduction in annual water availability projected in the Mediterranean region (from 9 % to 17 %), Central America, South Africa for 2°C compared to 1.5°C above 1850-1900 (ISI-MIP).

Drought in a changing climate: AR5 and recent scientific advances

Valérie Masson-Delmotte (WGI Co-Chair) - Wilfran Moufouma-Okia (WGI TSU) - Thanks to Sonia Seneviratne (ETH Zürich)
Contact: tsu@ipcc-wg1.universite-paris-saclay.fr

Fresh water stress in small islands

- Robust yet spatially variable tendency towards increasing aridity for 73 % of island groups by 2050 (RCP8.5, 22 models).

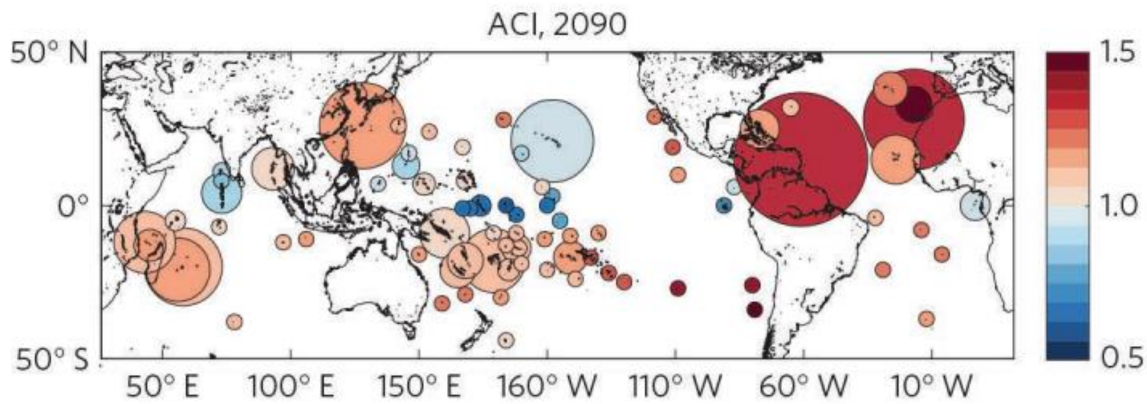
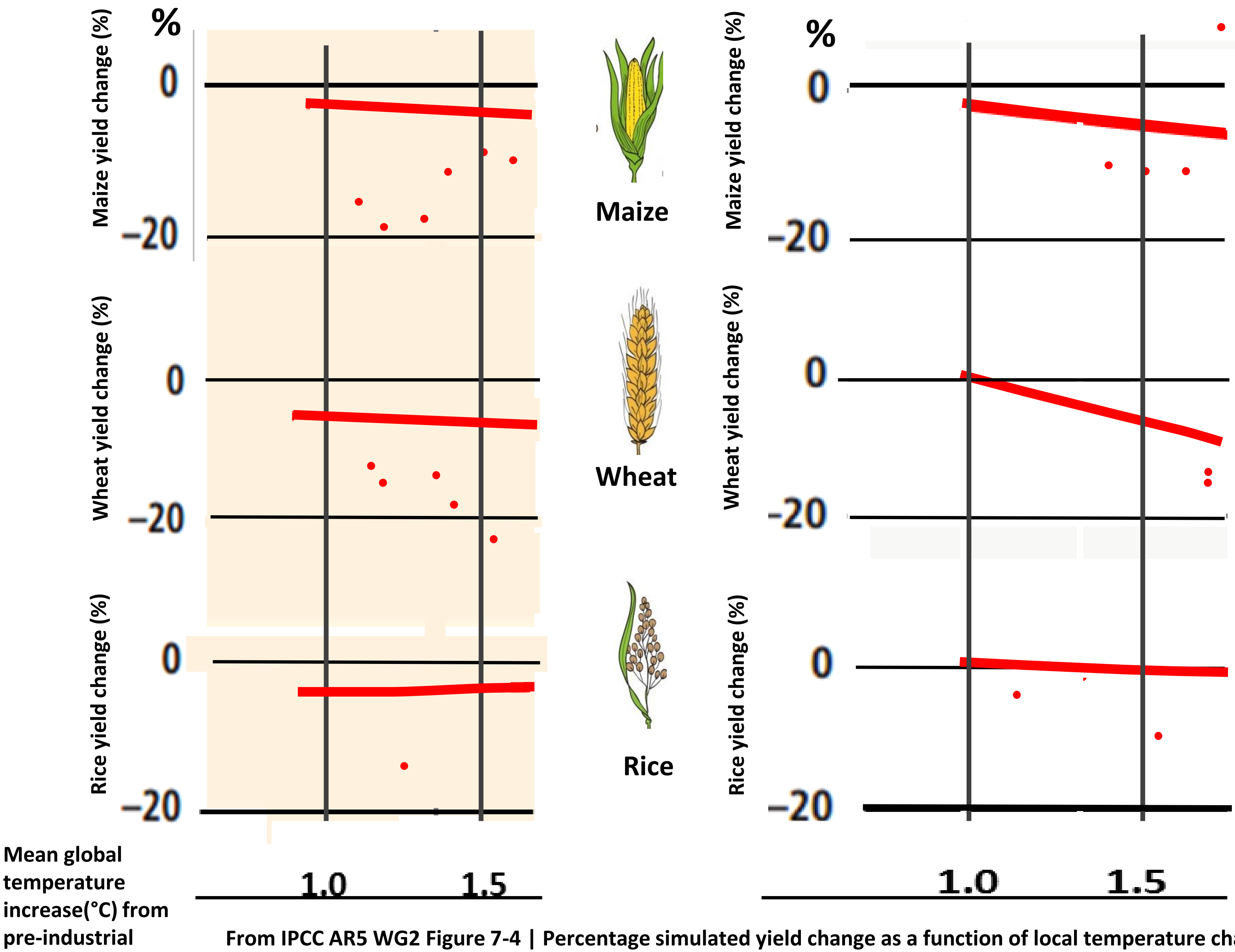


Figure: aridity change index (ratio of change in potential evaporation to fractional change in precipitation) compared to 1981-1999. Area of bubble proportional to the population. From Karnauskas et al., 2016, Nature Climate change.

Crop yields at 1.5°C



IPCC AR5 WG2 final science draft Ch. 7 Food Executive Ssummary

'Without adaptation, local [= global] temperature increases in excess of about 1.0°C above pre-industrial is [sic] projected to have negative effects on yields for the major crops (wheat, rice and maize) in both tropical and temperate regions.'

Comment: At 1.0°C, local and global temperature increases are the same.

Adaptation is essential but success cannot be assumed for long under an increasingly disruptive climate.

Many large adverse effects cannot be captured by the models.

From IPCC AR5 WG2 Figure 7-4 | Percentage simulated yield change as a function of local temperature change.

Projections above zero and adaptation excluded in view of adverse effects not captured by the models

Peter Carter, Climate Emergency Institute

Species extinction at 1.5°C

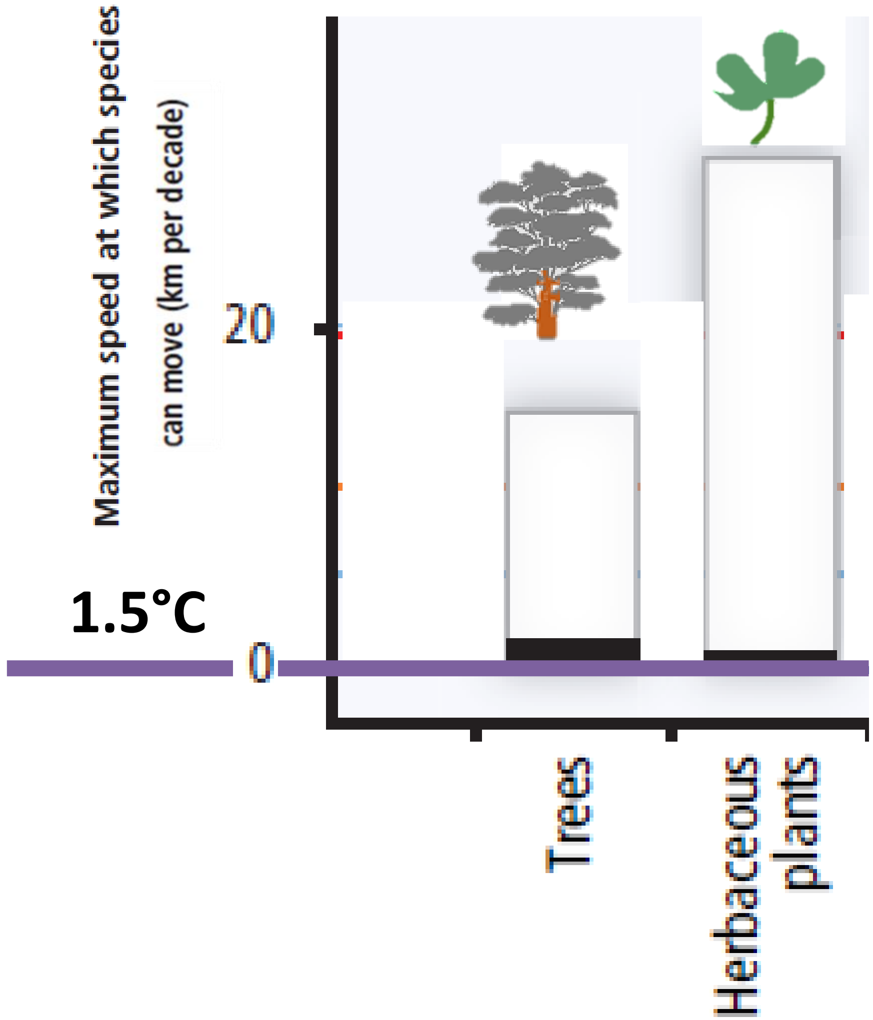
Climate and ocean disruption will compound the present sixth mass extinction event of species loss, which is 1000 times the natural background rate, mainly due to habitat loss and alien species (S. Pimm, 2014).

Trees and shrubs are below the 1.5°C adaptive limit line, and all other land species depend on them for their survival.

IPCC AR5 text
'For medium- to high-emission scenarios (RCP4.5, 6.0, and 8.5) [i.e., all except RCP2.6], ocean acidification poses substantial risks to marine ecosystems, associated with impacts of individual species from phytoplankton to animals. Ocean acidification acts together with other global changes (e.g., warming, decreasing oxygen levels) and with local changes (e.g., pollution, eutrophication). Simultaneous drivers, such as warming and ocean acidification, can lead to interactive, complex, and amplified impacts for species and ecosystems.'
(AR5 WG2 SPM Marine systems)

'A large fraction of both terrestrial and freshwater species faces increased extinction risk under projected climate change during and beyond the 21st century, especially as climate change interacts with other stressors, such as habitat modification, over-exploitation, pollution, and invasive species. Extinction risk is increased under all RCP scenarios, with risk increasing with both magnitude and rate of climate change. Many species will be unable to track suitable climates under mid- and high-range rates of climate change (i.e., RCP4.5, 6.0, and 8.5) [i.e., all except RCP 2.6] during the 21st century.'
(IPCC AR5 WG2 SPM Terrestrial and freshwater ecosystems)

Species with a rate of movement below the 1.5°C rate of climate change



From IPCC AR5 WG2 Figure SPM.5 | Maximum speeds at which species can move across landscapes (based on observations and models; vertical axis on left), compared with speeds at which temperatures are projected to move across landscapes.
Human interventions, such as habitat fragmentation, can greatly decrease speeds of movement.