

## Climate emergency, human agency : making sense of the current state of scientific knowledge on climate change to strengthen climate literacy



https://www.ipcc.ch/report/ar6/syr/

### Climate literacy encompasses being aware of climate change, its anthropogenic causes and implications

### Systemic barriers to climate action include the lack of climate literacy





### Human influence on climate : where are we now?







## Climate science milestones



https://www.ipcc.ch/report/ar6/wg1/ figures/chapter-1/figure-1-6/ + WMO 2024 + NOAA 2024



## Attribution



Process of evaluating the relative contributions of multiple causal factors to a change or event with an assessment of confidence

Avoided emissions (mitigation) and avoided impacts (adaptation) resulting from climate action

Human activities, emissions and concentrations, and human influence on the Earth's radiative forcing

Observed global or regional trends and events, natural climate variability and human influence on climate

Observed impacts resulting from climatic impact-drivers (impact attribution)

Cross-Working Group Box on Attribution in IPCC AR6

## **Climate action is gaining momentum**





Steady decrease of greenhouse gas emissions in more than 18 countries

More than half of global greenhouse gas emissions in the scope of public policies

Progress in adaptation planning and implementation, but fragmented and incremental responses, limits, growing adaptation gaps and evidence of maladaptation

Insufficient financial flows

Public policies have prevented several billion tons of CO<sub>2</sub>-equivalent emissions each year

Renewable energies, batteries : decrease in costs, increases in installed capacities

Energy efficiency, demand management, reduction of food waste : affordable, high acceptability

Greening of cities, slowing of global net deforestation

but the pace and scale of what has been done so far, and current plans, are not sufficient to limit the escalation of climate risks

# Greenhouse gas emissions continue to increase, with unequal historical and ongoing contributions



ClimateChangeTracker.org

## Which activities contribute most to global greenhouse gas emissions?

#### Direct emissions by sector



## Which activities contribute most to global greenhouse gas emissions?

#### Direct emissions by sector



### What makes CO<sub>2</sub> emissions increase or decrease?

Decarbonisation of energy and energy efficiency are largely responsible for the reduced growth in CO<sub>2</sub> emissions over the last decade





© Global Carbon Project



## Sharp contrast in trends for top emitters in 2023

EU: -7.4% USA: -3.0% India: +8.2% China: +4.0%



GLOBAL

CARBON

project

## Strong differences in regional contributions per capita



Net CO<sub>2</sub> from land use, land use change, forestry (CO<sub>2</sub>LULUCF) Other GHG emissions Fossil fuel and industry (CO<sub>2</sub>FFI) All GHG emissions

Source: IPCC AR6 SYR Figure 2.2

### Stark emission inequalities between and within countries







Source: Emissions Gap Report (2023) – Figure 2.4

# Greenhouse gas concentrations continue to increase in the atmosphere



Current CO<sub>2</sub> level 50% above pre-industrial level Unprecedented in more than 2 million years 10 x faster / past 800 000 years 4-5x+ faster / past 56 millions d'années

## Atmospheric greenhouse gas concentration increase during the industrial era is unequivocally due to human activities



The additional CO<sub>2</sub> in the atmosphere is:

- very old
- originally from plants
- resulting from a combustion process
- predominantly emitted in the Northern Hemisphere



# Radiative forcing increases due to increases in heat-trapping greenhouse gases and reduced aerosol 🥭 effect



# Heating of the climate system causes widespread, rapid and intensifying changes



IPCC WGI 2021 FAQs

# Observed changes are unprecedented in thousands of years



# Observed changes are unprecedented in thousands of years

Changes in global surface temperature relative to 1850–1900



IPCC WGI 2021 SPM

## Human activities have unequivocally caused global warming

## Latest decade +1.2°C / 1850-1900



+ modulations by natural variability

2023



IPCC SYR updated up to 2022 from Forster et al ESSD (2022) and WMO State of Climate (2024)

## Improved understanding of each aspect of human influence







Evidence from radiative forcing and climate sensitivity studies

## Human influence on the climate system is an established fact



Atmosphere and water cycle       Warming of global mean surface air temperature since 1850-1900       #dog snapper of human contributions not range of observed warming (05-1)?         Warming of the toposphere since 1979       Main driver         Cooling of the lower stratosphere since the mid-20th century       Main driver 1979 - mid-1990;         Large-scale precipitation and upper troposphere humidity changes since 1979       Southern Hemisphere.         Ocean       Ocean heat content increase since the 1970s       Main driver         Global mean sea level rise since 1970       Main driver         Global mean sea level rise since 1970       Main driver         Cryosphere       Arctic sea ice loss since 1970       Main driver         Global mean sea level rise since 1970       Main driver       Main driver         Reduction in Northern Hemisphere springtim snow cover since 1980       Emitted evidence & medium agreent Retreat of glaciers       Main driver         Carbon cycle       Increased amplitude of the seasonal cycle of atmospheric Co <sub>2</sub> since the early 1960s       Main driver         Land dimate       Mean surface air temperature over land (about 40% larger than global surface ocean       Main driver         Synthesis       Warming of the global climate system since preindustrial times       Key       Main driver	Change in in	dicator	Observed change assessment	Human contribution assessment
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## Human influence on the climate system



**1990** : it is certain than greenhouse gases are increasing in the atmosphere because of **human activity** 



**1995** : discernable human influence on the global climate 2021: human activities have unequivocally caused global warming



2013: human influence on the climate system is clear





**2001** : most of warming seen over the previous 50 years was due to human activity



2007 : warming of the climate system is unequivocal

### Human-caused climate change increases the frequency and severity of extreme events



## Vulnerable communities who have least contributed to climate change are disproportionately affected



4. 3.3 to 3.6 billion people live in highly vulnerable contexts

# Widespread and substantial impacts and related losses and damages are attributed to climate change



# Impacts are driven by changes in multiple physical climate conditions attributed to human influence

Attribution of observed physical climate changes to human influence:



## every increment of future global warming will increase changes in these climatic impact-drivers

## What are future climate risks?

# Cause – effect chain : scenarios, emissions, global warming levels, climate change and risks



climate and carbon cycle feedbacks





IN PHYSICS 202

### Equilibrium climate sensitivity (ECS)

The equilibrium (steady state) change in the surface temperature following a doubling of the atmospheric carbon dioxide  $(CO_2)$ concentration from pre-industrial conditions



## Future warming depends on future emissions



+ short-lived forcers (net effect methane + aerosols) + modulations by natural variability

## With every increment of global warming, regional changes in mean climate become more widespread and pronounced



Change in annual mean temperature

Change in annual mean precipitation



Water cycle : more intense, more variable

https://interactive-atlas.ipcc.ch/

### With every increment of global warming, regional changes in climatic impact-drivers become more widespread and pronounced





### Key risks : ecosystems and biodiversity



## Risk of species losses

Percentage of animal species and seagrasses exposed to potentially dangerous temperature conditions





Includes 30,652 species of birds, mammals, reptiles, amphibians, marine fish, benthic marine invertebrates, krill, cephalopods, corals, and seagrasses.



3.0°C



**Protect ecosystems, reduce other pressures** 

## With every increment of global warming, cryosphere loss becomes more widespread and pronounced



Change in global surface temperature (°C)



### Key risks : land ecosystems



Hard limits for water, biomass and ecosystem-related responses

### Key risks : human health



### Key risks : food production



### Increasingly complex risks



## Lifetime exposure to hot extremes drastically increases for younger generations



Thiery et al, Science, 2021 https://myclimatefuture.info

### Key risks : food insecurity



low population growth reduced inequalities, high adaptive capacity low GHG food production systems effective land use regulation



### Key risks : sea level rise, irreversibility

Committed future sea-level rise from past emissions

Future rate and magnitude depend on future emissions ice sheet processes (deep uncertainty)

The likelihood of future abrupt / irreversible changes increases with global warming







### Examples of low-likelihood, high-impact eventualities

### High-end climate response



### **Tipping points**



### Volcanic eruptions









## How to limit future global warming?

## Every tonne of CO<sub>2</sub> emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO<sub>2</sub> emissions (GtCO<sub>2</sub>)



Source: IPCC AR6 WG1 SPM.10

## **Remaining carbon budgets**

Global Warming Between 1850–1900 and 2010–2019 (°C)		Historical Cumulative CO <sub>2</sub> Emissions from 1850 to 2019 (GtCO <sub>2</sub> )					
1.07 (0.8–1.3; likely range)		2390 (± 240; likely range)					
Approximate global warming relative to 1850–1900 until temperature limit (°C) <sup>a</sup>	Additional global warming relative to 2010–2019 until tem- perature limit (°C)	Estimated rea from the beg <i>Likelihood of</i> <i>to temperatu</i>	maining carbon inning of 2020 <i>limiting global</i> re limit <sup>b</sup>	budgets (GtCO <sub>2</sub> ) warming	6704	92%	Variations in reductions in non-CO2 emissions <sup>c</sup>
		17.70	5570	5070	07 /0	05 /0	
1.5	0.43	900	650	500	400	300	Higher or lower reductions in
1.7	0.63	1450	1050	850	700	550	accompanying non-CO <sub>2</sub> emissions can increase or decrease the values on
2.0	0.93	2300	1700	1350	1150	900	the left by 220 GTCO2 of more

# Updates to and clarifications of remaining carbon budgets show broad and increasing challenges

Global Warming Between 1850–1900 and 2010–2019 (°C)		Historical Cumulative CO <sub>2</sub> Emissions from 1850 to 2019 (GtCO <sub>2</sub> )					
1.07 (0.8–1.3; likely range)		2390 (± 240; likely range)					
Approximate global warming relative to 1850–1900 until temperature limit (°C) <sup>a</sup>	Additional global warming relative to 2010–2019 until tem- perature limit (°C)	Estimated remaining carbon budgets from the beginning of 2020 (GtCO <sub>2</sub> ) from the beginning of 2023 Likelihood of limiting global warming to temperature limit <sup>b</sup>			Variations in reductions in non-CO <sub>2</sub> emissions <sup>c</sup>		
		17%	33%	50%	67%	83%	/
1.5	0.43	900 500	<b>550</b> 300	500 250	400 150	300 100	Higher or lower reductions in accompanying non-CO <sub>2</sub> emissions can increase or decrease the values on the left by 220 GtCO <sub>2</sub> or more
1.7	0.63	1450 1100	1050 800	850 600	708 500	558 350	
2.0	0.93	2300 2000	1700 1450	1350 1150	950	800 800	

Central estimates require deep reductions in other greenhouse gases from 2020 to 2050.

For 1.5°C carbon budgets:

- -50% for methane
- -20% for nitrous oxide
- -90% fluorinated gases

#### For 2°C carbon budgets:

- -35% for methane
- -10% for nitrous oxide
- -50% fluorinated gases

### Updates since IPCC AR6 halve the remaining carbon budget for 1.5°C, and central estimates require equally stringent reductions in other greenhouse gases

Source: IPCC AR6 WG1 Table SPM.2 ; Indicators of Global Climate Change (Forster et al, 2023); Rogelj & Lamboll (2024)

## Remaining carbon budgets to limit warming to 1.5°C could soon be exhausted and those for 2°C largely depleted

Remaining carbon budgets are similar to emissions from use of existing and planned fossil fuel infrastructure, without additional abatement



## The proportion of CO<sub>2</sub> emissions taken up by land and ocean carbon sinks is smaller in scenarios with higher cumulative emissions



## Global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot reach net zero CO<sub>2</sub> emissions around 2050



Source: IPCC AR6 SYR Figure 3.6

## The transition towards net zero CO<sub>2</sub> will have different pace across different sectors

 $CO_2$  emissions from the electricity/fossil fuel industries sector and land-use change generally reach net zero earlier than other sectors



## Current state of play? An ambition and implementation gap



### **Broken Record**

Temperatures hit new highs, yet world fails to cut emissions (again)



**Emissions Gap Report** 2023

UN @

environment programme



**United Nations** Framework Convention on Climate Change

## What are COP28 outcomes?

### **Responding to loss and damage**





Human-cause climate change impacts felt in every region Those who have contributed the least being most vulnerable Unequally distributed, fragmented, incremental adaptation responses Adaptation gaps will continue to grow under current levels of implementation Impacts & losses & damages will increase with every increment of warming

National inventories of impacts Accessible, user-driven climate services systems, early warning for all

COP28 pledges \$ 0.77 B

Annual needs \$ 100 to 400 B by 2030



Emergencies, sea-level rise, displacement, relocation, migration Insufficient climate information and data, Climate-resilient reconstruction and recover How to avoid and respond to the risk of low-likelihood, high-impact outcomes

United Nations

Climate Change

Framework Convention on

### Framework for global climate resilience



**United Nations** Framework Convention on Climate Change

#### **National assessments**





Participatory and transparent adaptation plans and strategies Mainstreaming implementation of adaptation

Water, food, health, ecosystems and biodiversity, nature-based solutions Infastructures and settlements Poverty, livelihoods, social protection measures, cultural heritage

Transformational adaptation



Multi-hazard early warning systems Improved climate-related data, information and services

Gender-responsive, human rights approaches



Institutional capacity, operational systems for monitoring adaptation efforts, evaluation and learning Science-based indicators, metrics and targets Maladaptation avoidance



Expert dialogue on the disproportionate impacts of climate change on children and relevant policy solutions

### Mitigation gaps acknowledged at COP28



**United Nations** Framework Convention on Climate Change



Implementation of nationally determined contributions would reduce emissions by 2% (up to 5.3% conditional on funding and support) from 2019 to 2030

### **New COP28 initiatives and declarations**



**United Nations** Framework Convention on Climate Change

Renewables & energy efficiency, oil & gas decarbonisation, food & agriculture, cooling, carbon capture & storage



### **New COP28 initiatives and declarations**



**United Nations** Framework Convention on Climate Change



Policies & action Real world action based on current policies †

2030 targets only Based on 2030 NDC targets\* †

Pledges & targets Based on 2030 NDC targets\* and submitted and binding long-term targets

#### Optimistic scenario

Best case scenario and assumes full implementation of all **announced** targets including net zero targets, LTSs and NDCs\*

† Temperatures continue to rise after 2100

 If 2030 NDC targets are weaker than projected emissions levels under policies & action, we use levels from policy & action

CAT warming projections Global temperature increase by 2100

December 2023 Update

### **IPCC-related resources for teachers, to enhance climate literacy**

FAQs

Fact sheets : regions, sectors

Interactive atlas https://interactive-atlas.ipcc.ch

Sea-level projection atlas https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool ClimateQ&A

Summary for all



### www.ipcc.ch



Office for Climate Education

https://www.oce.global/en/ressources





