## Climate change – present and future extremes **IPCC Update: Selected Assessments and Regional Differences**

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IPCC Lead Author, AR6 (2018–2023) IPCC Contributing Author, AR5 (2009–2013)

(Update 07.01)





## A Changing Climate System is about:

- The Global Carbon Cycle
- The Radiation and Energy Balances
- The Water Balance



## A Changing Climate System is about:

- Trends
- Variations/Oscillations
- Extremes (frequency, intensity, duration, space, and links to coupled events)





WORKING GROUP I CONTRIBUTION TO THE IPCC SIXTH ASSESSMENT REPORT FIRST LEAD AUTHOR MEETING GUANGZHOU, CHINA, 25-29 JUNE 2018



#### Assessment Report 5/WG1

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CLIMATE CHANGE 2013

The Physical Science Basis

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Ca. 1,500 pages Ca. 4.2 kg 255 authors from 39 countries 💦 Review comments: 54,000+ INTERGOVERNMENTAL PANEL ON CLIMATE CHAINGE

Assessment Report 6/WG1 Ca. 2,400 pages Ca. 6.4 kg 234 authors from 64 countries Review comments: 78,000+

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Climate Change 2021

The Physical Science Basis



and thomas climate models or the reanalyse the momas, 2019; wang to 19), this tra by regional 30; van Wessern et al. 2016

According to the ice-core reconstru AP) has likely increased during t All 2.9 Gtyr-' per decade (1900-2) global mean sea level rise by, res decade (WAN excluding AP, during 1 per decade (AP, during 1979-2000 Significant spatial heterogeneity in s over AP and WAN:

0.13°C±0.09°C Western AP has likely experienced beginning around 1930 and acc which is outside of the natural 300 years (Thomas et al., 2017: Wang et al., 2019);

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al. 2017).

mer et al., ast based eastern AP has no significant SMB tr (low confidence, observations limiter interannual variability) (Thomas et al. • overall WAN SMB (excluding AP) was but exhibited high regional variabili significant increases (5–15 mm per d to the east of the West Antarctic Ice She decrease (-1 to -5 mm per decade duri -15 mm per decade during 1957-2000 Thomas, 2019; Wang et al., 2019).

he SMB of EAN increased during the 20th bal mean sea level rise by  $0.77 \pm 0.40$ 1-2000 (medium confidence) (Medley SMB has been increasing at a much low by observations, while regional climat nual variability masking any trend (lo observations) (Figure Atlas.30; Medley al., 2019). EAN SMB changes during the 20th century

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### **CLIMATE CHANGE 2023** Synthesis Report

### Summary for Policymakers

A Report of the Intergovernmental Panel on Climate Change

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et al (2020) Mean t et al (2019)

Ice Sheet (AIS) - Mottram et al pr - Ensemble Met MANAM Rignot et al (2011 2010 2000

WAIS 2020 2010 2000

(SMB) rates (in Gt a<sup>-1</sup>) for the Greenland Ice Sheet and its region. (3000) rates (11 Gt a ) for the Greenland to sheet and is regardle (3000) rates (11 Gt a ) for the Greenland to sheet and is regardle (10 Gt a ) for the Greenland to ) for the Greenland to sheet and is regardle dimete models. The Antarctic inset map also shows the location of the sec

(Upper panels) Time series of annuals

it average (Gorodetska and SMB exhibition and second tender if averaged over an initial cycle (Gorodetska attorning et al., 2019). Precipitation and SMP and some of the second emporal variables and moisture advection from lower large-s emportant component of the total ice-sheet mas important contribution to sea to mas most important the Antarctic contribution to sea level mass of the second secon an 9.4.2.1). the show accumulation to sea level re-ction 9.4.2.1). Ice shelves buttress the ice the interaction of the second and atmospheric drivers (Box 9.1). Ice shelves buttress the ice she into and atmospheric drivers (Box 9.1). the ocean coenic and atmospheric drivers the ice she the ocean by oceanic and atmospheric drivers (Box 9.1).

antarctic climate variability is influenced by the South Antarctic climits and regionally by other modes, including EN Antai (SAM) and pattern, Pacific Decadal Variability (PDV), 1 Mode American pattern, Pacific Decadal Variability (PDV), 1 South American Wave 3 (Annex IV). Climate ch. SouthAmerican Wave 3 (Annex IV). Climate change i south and Zonal Wave 3 (Annex IV). Climate change i pipole and Southern Ocean is influenced by interpipole and Longen Ocean is influenced by interactions in and the southern Ocean, sea ice and atmosphere (Southern Southern Southe and the southern, sea ice and atmosphere (Sections ) and the sheet, ocean, sea ice and atmosphere (Sections ) ice sheet, Meredith et al., 2019). In addition to characteristic and 9.4.2; Meredith et al., 2019). In addition to Chapter

35 CMIP6 models and relative to 1. for the SSP1-2.6 emissions sce 10r une 3.5°C (2°C-5°C) for 55P3-1.0, and 4.4°C (2.8°C-6.4°C) for (Interactive Atlas). Both temperature and precipitation pro characterized by a relatively large multi-model range in and the Interactive Atlas). A strong regional variability the projected changes over coastal Antarctica na with global forcing. While continental mean linearly related to global mean temperatures in relative increase in coastal temperatures are in scenarios due to stronger relative Southern relatively stronger effects of ozone recovery A higher multi-model average increase in by CMIP6 models compared to CMIPS. Antarctic near-surface temperature at (Kittel et al., 2021). While similar m projected for WAN and EAN, the

higher projected temperature rang

AR6 Synthesis Report Climate Change 2023



CO2 concentration is today higher than at any time in at least 2 million years Cumulative net CO2 emissions: About 42% occurred between 1990–2019 Human activities have unequivocally caused global warming of 1.1°C since 1850–1900

Surface temperature has increased fast since 1970, looking back 2000 years Evidence of observed changes in extremes e.g. heatwaves, heavy precipitation, droughts, and tropical cyclones Human influence was very likely the main driver of sea level rise increases, since at least 1971 AR6 Synthesis Report Climate Change 2023

There are gaps between projected emissions from implemented policies and those from NDCs

If climate goals are to be achieved, both adaptation and mitigation financing would need to increase many-fold Limit warming to 1.5°C (>50%) with no/limited overshoot, global GHG emissions are reduced by 43% by 2030, relative to 2019

Deep, rapid, and sustained reductions in GHG emissions would lead to a discernible slowdown in global warming within around two decades...and



Overshooting 1.5°C will result in irreversible adverse impacts on certain ecosystems with low resilience

....would reduce projected losses and damages for humans and ecosystems

# **Our climate is changing – Temperatures!**



# Our climate is changing – Water!











### Global Mean Surface Air Temperature, 1880–2023





### Monthly global surface air temperature anomalies

Data: ERA5 1940-2024 • Reference period: 1850-1900 • Credit: C3S/ECMWF



Annual J-D



-4.1-4.0-2.0-1.0-0.5-0.2 0.2 0.5 1.0 2.0 4.0 4.1





IPCC WGI Interactive Atlas: Regional information (Advanced)



Light / dark area: Spread P10-P90 / P25-75





The best estimate of reaching 1.5°C of global warming lies in the first half of the 2030s





#### **Region: Northern Europe**



Scenario: SSP3-7.0



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Scenario: SSP3-7.0



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#### **Region: Northern Europe**



Scenario: SSP3-7.0



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### Summary, Overview Table (changes from today and to 2100)



Region, Today–2100	Northern Europe	Central Europe	Southern Europe	Western US	Central US	Eastern US	SE South America	S South America	Southern Australia	New Zealand	East Asia
Mean temperature change (C)	2.5 to 3.5	2.5 to 4.0	2.5 to 3.5	3.0 to 4.5	3.5 to 5.5	3.5 to 4.5	2.5 to 3.5	1.5 to 2.5	2.0 to 3.0	2.0 to 3.0	3.0 to 4.0
Maximum temperature change (C)	2.5 to 3.5	3.0 to 4.0	3.0 to 4.0	3.0 to 4.5	3.5 to 5.0	3.5 to 4.5	2.5 to 3.5	1.5 to 2.5	2.0 to 3.0	2.0 to 3.0	3.0 to 4.0
Seasonal variability, temperature	W (++) S (+)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (+)	W (+) S (+)	W (++) S (+)	W (++) S (+)	W (++) S (+)	W (+) S (+)
Total precipitation change (%)											
Maximum precipitation change (%)											
Seasonal variability, precipitation											

### Summary, Overview Table (changes from today and to 2100)



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Seasonal variability, temperature	W (++) S (+)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (++)	W (+) S (+)	W (+) S (+)	W (++) S (+)	W (++) S (+)	W (++) S (+)	W (+) S (+)
Total precipitation change (%)	5 to 8	-5 to 10	-10 to -20	7 to 15	-8 to 12	5 to 10	0 to 15	0 to 7	0 to -10	5 to -5	0 to 15
Maximum precipitation change (%)	8 to 18	10 to 20	4 to 9	10 to 20	10 to 25	10 to 25	10 to 20	10 to 20	10 to 20	15 to 25	15 to 25
Seasonal variability, precipitation	W (+) S (same)	W (+) S (-)	W (-) S (-)	W (+) S (- <i>,</i> same)	W (+) S (-)	W (+) S (-)	W (-) S (+)	W (+) S (-)	W (-) S (-)	W (same) S (same)	W (-, same) S (+)





### **Region: Africa**

Over most parts of Africa, minimum temperatures have warmed more rapidly than maximum temperatures during the last 50 to 100 years (medium confidence).

In the same period, **minimum and maximum temperatures have increased by more than 0.5°C** relative to 1850–1900 (high confidence).

Surface air temperatures in Africa are projected to rise **faster than the global average increase** and are likely to increase by more than **2°C and up to 6°C by the end of the century**, relative to the late 20th century, if global warming reaches 2°C.



### Region: Western and Central Africa



Scenario: SSP3-7.0



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### Region: Western and Central Africa



Scenario: SSP3-7.0



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### Region: Western and Central Africa



Scenario: SSP3-7.0







Dotted line: Model Solid line: P50 (median) Light / dark areas: Spread P10-P90 / P25-75



### Evidence that tipping point are under way...





Risks associated with largescale singular events or *tipping points*, such as ice sheet instability or ecosystem loss from tropical forests, transition to high risk between 1.5°C–2.5°C (*medium confidence*) and to very high risk between 2.5°C–4.0°C (*low confidence*).

### 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>)





### AR6, WG1 (2021):

# Estimated remaning carbon budgets from the beginning of 2020 (GtCO2).....it is about likelihood!



Approximate global warming relative to 1850–1900 until temperature limit (°C) <sup>a</sup>	Estimated ren from the begin Likelihood of to temperatur	naining carbon inning of 2020 <i>limiting global</i> re limit <sup>ь</sup>	budgets (GtCO <sub>2</sub> ) <i>warming</i>		
	17%	33%	50%	67%	83%
1.5	900	650	500	400	300
2.0	2300	1700	1350	1150	900



Global Greenhouse Gas Emissions by Economic Sector



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# Impacts of Climate Change on Human Health

### The Lancet Countdown Report, 2019



- Undernutrition
- Impact on mental health
- Cardiovascular disease
- Respiratory disease
- Harmful algal blooms
- Vector-borne disease

## Thank you for your attention...

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