Information Bulletin

Global Findings and Key Regional Observed changes reported within "The Physical Science Basis" of the IPCC's Sixth Assessment report

IB/2021/2

October 2021

On 9 August 2021, the IPCC Secretariat presented the Summary for Policy Makers (SPM) of the Working Group I (WGI) contribution to the Sixth Assessment Report (AR6), "Climate Change 2021: The Physical Science Basis".

This Information Bulletin presents the key global findings, followed by the key common regional observed changes in climate impact drivers[1] on Small Islands contained in the SPM of WGI of the AR6, and its interim report.

Key global scientific findings from the Physical Science Basis report of the AR6

a. Human activities are indisputably causing climate change, making extreme climate events, including heat waves, heavy rainfall and droughts more frequent and severe.

- Compared to IPCC's 5th Assessment Report (AR5), AR6 can attribute many more changes to the climate system at the global and regional level from human influence.
- Since 2011, concentrations have continued to increase in the atmosphere, reaching annual averages of 410 parts per million (ppm) for carbon dioxide (CO_2), 1866 parts per billion (ppb) for methane (CH_4), and 332 ppb for nitrous oxide (N_2O) in 2019.
- Human-caused emissions of greenhouse gases (GHGs) are the main driver of global warming, responsible for essentially all warming observed between 1850-1900 and 2010-2019. Some air pollutants contribute to cooling, which partially masks this warming.
- Human influence has been the main driver of ocean warming since the 1970s, and human-caused CO_2 emissions are the main driver of ocean acidification.
- Human influence is also contributing to reduced oxygen levels in many parts of the upper ocean observed since the mid-20th century.
- Human influence on the climate is leading to increases in combinations of concurrent extreme events known as compound events - such as concurrent heatwaves and droughts, the combination of hot, dry, windy conditions that are conducive to wildfires, and storm surges, combined with rainfall-driven flooding.

b. Changes in the climate are widespread, rapid and intensifying, and unprecedented in thousands of years.

- CO_2 concentrations in 2019 were higher than at any time in at least the past 2 million years.
- Each of the past four decades has been the warmest on record since pre-industrial times.
- There has been a larger average temperature increase over land (almost 1.6°C) than over the ocean (almost 0.9°C), and some regions are warming faster than others; for example, the Arctic has warmed at more than twice the global rate over the last 50 years.
- Sea level has risen faster over the last hundred years than during any century in at least the last 3000 years.
- Monsoon precipitation is changing in complex

1 *e.g. warming levels, sea level rise, rainfall trends and their associated impacts such as river flooding, flash floods, landslides, aridity and ecological droughts, wind speed, tropical cyclones, coastal flooding and erosion, and marine heatwaves.*
Please see IB/2021/1 for an explanation of likelihoods and confidence levels surrounding climate anomalies and events.

ways in response to the effects of both GHGs and aerosols.

- Since the 1950's, heavy rainfall events have become more frequent and intense over most land areas. Global average precipitation and evaporation are rising with global warming at a pace of 1-3% per degree Celsius (high confidence). Human-induced climate change is also contributing to increases in droughts in some regions.
- At a global scale, major tropical cyclones have become more frequent over the last four decades (although wide variations occur across different regions).

c. Climate change is already affecting every region in multiple ways. The changes we are experiencing will increase with future warming.

- There is medium confidence that global temperature will rise by more than 1.5°C than pre-industrial levels by 2030. Every additional half degree of warming causes increases in the intensity and frequency of hot extremes, heavy precipitation, and drought in some regions.
- At 2°C of global warming, heat extremes would more often reach critical tolerance thresholds for agriculture and health.
- Heavy rains will become more frequent and intense with more warming. At a global scale, extreme daily rainfall events are intensifying by about 7% for each 1°C of global warming.
- Rain and water flows are expected to become more variable within seasons and from year to year. Average annual rainfall on land is expected to increase with greater warming.
- Coastal areas will see continued sea level rise (SLR) throughout the 21st century, regardless of the level of emissions, contributing to more frequent and severe coastal flooding in low-lying areas and coastal erosion.
- Sea level extremes that previously occurred once in 100 years could happen every year by the end of the century in many parts of the world.
- Cities will experience increases in the severity of heatwaves.
- In coastal cities, flooding from heavy precipitation events and SLR will make flooding more probable. Further urbanization will increase these effects.
- A general decrease in the pH of surface ocean from -0.017 to -0.027 pH units per decade has been noted since the late 1980s, affecting coastal water acidification and impacting the marine biodiversity, and coral growth and cover.

d. There is no going back from some changes in the system. However, some could be slowed and others could be stopped by limiting warming.

- Changes in the ocean will continue for hundreds to thousands of years – but these changes would be slower with lower emissions. Over the course of this century:
  - o Ocean temperature is projected to rise 2 to 8 times as much as it increased from 1971-2018.
  - o Ocean stratification, acidification, and deoxygenation will continue.
- Under scenarios with increasing CO_2 emissions, the ocean and land carbon sinks are projected to be less effective at slowing the accumulation of CO_2 in the atmosphere.
- Changes in the earth's frozen regions, including retreating glaciers and loss of summer Arctic Sea ice, will continue for at least several decades, but could be slowed or stopped if emissions are reduced. Melting of the Greenland and Antarctic ice sheets will continue for thousands of years. With greater warming, ice loss will occur faster.
- Sea level will continue to rise over thousands of years, but the rate of rise may be slowed if emissions are reduced. SLR above the likely range cannot be ruled out.
- An analysis of worst-case outcomes leading to crossing of tipping points (such as a collapse of the Antarctic Ice Sheet, or abrupt changes in ocean circulation) has been undertaken within AR6. These events could potentially happen at any level of warming, but limiting warming reduces the risk.

e. Unless there are immediate and large-scale greenhouse gas emissions reductions, limiting warming to 1.5 °C will be beyond reach.

- Each 1000 gigatons of CO_2 that accumulate in the atmosphere cause 0.27-0.63°C increase in global surface temperature.
- From 1850 to 2019, 2,390 gigatons of CO_2 were released by human activities. An additional 400-500 gigatons could still be released, along with a chance to limit warming to 1.5°C, or 1150-1350 gigatons to limit warming to 2°C. With current emissions of about 40 Gigatons per year (and accounting for land and ocean carbon sinks), this amount would be reached in a matter of decades.
- Based on current development pathways, in the next 20 years, global average temperature is expected to reach or exceed 1.5°C above 1850-1900 levels.
- With rapid reductions of GHG emissions and reaching net zero CO_2 emissions around 2050, it is *extremely likely* that global warming can stay below 2°C, and *more likely* than not that temperature would stay below 1.6°C and decline to below 1.5°C by the end of the century.
- The WG1 report suggests that the planet has a remaining carbon budget of 460 billion tonnes of CO_2 in order to have a 50% probability of avoiding 1.5°C by 2050.

f. **To limit global warming, strong, rapid, and sustained reductions in CO_2, methane, and other greenhouse gases are necessary. This would not only reduce the consequences of climate change but also improve air quality.**

- Removing CO_2 from the atmosphere through natural or technological means could balance out some remaining CO_2 emissions. However, carbon dioxide removal is no substitute for reducing emissions.
- While CO_2 is the dominant GHG, and reaching net zero CO_2 is required to limit global warming, strong reductions in other GHG emissions are needed. Amongst these, methane reductions, together with strict air pollution controls, would benefit both the climate and improve air quality.
- Strong, rapid, and sustained reductions of CO_2 and non-CO_2 emissions will lead to discernible effects on GHG and aerosol concentrations, and air quality, within years. For trends in surface temperature and other important climate variables, the effects begin to emerge from natural variability after 20 years.

Common regional changes on Small Islands

With a view to structure the review of the latest climate-change relevant scientific literature, AR6 authors examine the global and regional impacts that are incurred by different climate impact drivers. The term "Climate impact drivers" has been coined by the IPCC to describe physical climate system conditions that affect an element of society or ecosystems. Examples of climate impact drivers include mean temperatures, growing season length, extreme heat, amongst others.

Some general observed common climate trends at a regional level on Small Islands include:

a. higher magnitude and frequency of temperatures, including warm extremes (*medium to high confidence*),

b. declines in high intensity rainfall events (*low to medium confidence*),

c. regional SLR with strong storm surge and waves resulting in increased coastal flood intensity (*high confidence*),

d. increased intensity and intensification rates of tropical cyclones at global scale (*medium confidence*), and

e. ocean acidification (*virtually certain*).

Observed changes in Small Islands in the Western Indian Ocean (WIO) region

Mauritius is considered as forming part of Small Islands that belong to the Western Indian Ocean (WIO) region. The following section summarises pertinent trends that emerge from latest scientific papers on small islands (including findings on the WIO region) with regard to key climate data.

i. **Over the past 50-60 years, rainfall trends in the WIO islands have been declining.**

- Both Mauritius and La Réunion have experienced rainfall decreases of 8% during 1951–2016 and 1.2% per decade during 1961–2019.
- It is *likely* that drying has occurred since the mid-20th century in some parts of the WIO.
- Current estimates identify many Small Islands as being under water stress.
- Recent trends toward more frequent and severe droughts have been noted in the Small Islands (*low confidence*), including heightened drought on the leeward side (i.e. opposite the windward side) of islands.

ii. **Relative SLR has increased as compared to Global Mean SLR.**

- Relative SLR rates based on satellite altimetry for the period 1993-2018 increased to 3.65 mm per year, compared to a Global Mean SLR of 3.25 mm per year.
- SLR for Mauritius has been reported at 5.6 mm per year over 2007–2016.

iii. **Significant warming trends are clearly evident in the Small Islands.**

- Over the WIO, significant warming trends have been reported for Mauritius (1.2°C during 1951–2016), La Réunion (0.18°C per decade over 1968–2019), and Maldives.
- A detectable anthropogenic increase in summertime heat stress index has been identified over a number of island regions in the Caribbean, western tropical Pacific, and tropical Indian Ocean, based on wet bulb globe temperature index trends for 1973–2012 (*medium confidence*).
- There is very high confidence that the Indian Ocean, western equatorial, the Pacific Ocean, and western boundary currents have warmed faster than the global average.

iv. **The frequency of marine heatwave events has increased.**

- Ocean temperatures from satellite observations noted a moderate increase of 1–4 annual marine heat wave events between 1982–1988 and 2000–2016 over some areas in the Indian Ocean, subtropical parts of the North and South Atlantic, and central and western parts of the North and South Pacific, but a decrease in frequency over the eastern Pacific Ocean.

v. **It is likely that tropical cyclone intensity and intensification rates at a global scale have increased in the past 40 years.**

Bibliography

- Arias, P. A., et al., 2021, Technical Summary. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press. In Press
- Gutiérrez, J. M., et al., 2021, Atlas. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press. In Press.
- IPCC 2021. The Intergovernmental Panel on Climate Change. Available at https://www.ipcc.ch/. Accessed on August 23, 2021.
- IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press. In Press.
- IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press. In Press.

Contact Information

Dr Zyaad Boodoo, Lecturer in Multidisciplinary Studies, Department of Emerging Technologies, Faculty of Sustainable Development and Engineering, Université des Mascareignes, Mauritius. (E-mail: zboodoo@udm.ac.mu)

Report Citation

Future by Design, 2021. Global Findings and Key Regional Observed changes reported within “The Physical Science Basis” of the IPCC’s 6th Assessment report - IB/2021/2. Université des Mascareignes.

Editorial Team

- Dr Rajeev Khoodeeram, Senior Lecturer, Department of Emerging Technologies, Faculty of Sustainable Development and Engineering, Université des Mascareignes
- Dr. Tyagaraja (Kesseven) Cunden, Dean, Faculty of Sustainable Development and Engineering, Université des Mascareignes
- Dr Jay Rovisham Doorga, Lecturer, Department of Emerging Technologies, Faculty of Sustainable Development and Engineering, Université des Mascareignes
- Dr Yogeshwarsing Calleecharan, Lecturer, Department of Emerging Technologies, Faculty of Sustainable Development and Engineering, Université des Mascareignes
- Dr Mohammad Irshad Khodabocus, Lecturer, Department of Emerging Technologies, Faculty of Sustainable Development and Engineering, Université des Mascareignes
- Mr Abdel Isker Mudhawo, Senior Lecturer, Department of Civil Engineering, Université des Mascareignes

Design and Layout

inshō

Disclaimer