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A Century of Warming: Reviewing Global Temperature Trends, Regional Patterns, and Climate Futures

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Abstract

The planet is slowly warming and the evidence is all around—albeit not so obvious as it is today. The planet is communicating to us that change is under way: melting glaciers, sweltering cities. This review illustrates the changes in temperatures throughout the world using extensive data and models. We learn that the world has experienced little more than a 1 degree Celsius rise in temperature since the close of the 19th century, but there is more to this story.

They are not warming equally and some areas are warming twice as fast as others, particularly in the Artic and mountain areas. Cities are suffering from the effects of the urban heat island effect that heat-absorbing concrete and glass surfaces cause. These temperature variations do not only reflect statistics but have significant practical impacts, such as altered ecosystems, disappearing glaciers, intensified heatwaves, stressed food production systems and growing risk to human well-being and water supplies.

If we make wise decisions now, we will have a bright future. Climate model simulations indicate that if climate action is taken boldly, the level of warming can be restricted to under 1.5°C. The solutions offered, however, if not adapted for the context and culture they're intended for, may carry unpredictable and significant consequences for the planet if adopted as is. Understanding temperature trends is not simply a matter of numbers - it is an issue of preparedness for the future, according to this paper. Science is clear, time is short, and it's our responsibility. The decisions we make today will impact the world for generations to come.

Keywords: Global Warming, Climate Change, Temperature trends, Regional differences, Climate Resilience, Future View

1. Introduction

Over the last century, global climate has been changing, and the relationship among natural and anthropogenic influences is complex. In early 20th century (1901-1950) warming is was due to roughly 40 to 54% of anthropogenic and natural forcing, with natural variability causing a strong regional effect, e.g., in the Arctic around 1920-30 exposure to natural variability was a major factor (Hegerl et al., 2018). The influences of GHGs, however, emerged since early industrialization, and the amount of warming due to greenhouse gases was apparent by 1900 according to paleoclimate records (Hegerl et al., 2019). Natural ocean cycles are thought to encompass 62-75% of warming observed in the second half of the 20th century (Taylor, 2025), yet hemispheric-scale evidence shows late 20th century warmth is unprecedented from the last 2000 years, and can only be attributed to the modern forcing from anthropogenic changes.Hemispheric-scale evidence shows warming over the second half of the 20th century is unprecedented over the last 2000 years, and can only be explained by modern anthropogenic forcing, although some studies suggest that natural ocean cycles may account for 62-75% of warming observed (Taylor, 2025). There are significant deviations from greenhouse warming trends that have occurred in the context of volcanic eruptions and anthropogenic aerosols, they have a strong tendency to counteract warming especially since about 1950 (Hegerl et al., 2019). Climate trends have been driven by greenhouse gases and greenhouse gas emissions have increased over time.

The idea of anthropogenic climate change first arose in 1896, but was resisted by scientists who believed that global climate change was not possible on any time scale other than geological (Weart, 2010). Even though much doubt remained, starting in the middle of the century, there was increasing scientific interest and a growing consensus, starting in the late 1970s and culminating by the end of the century in unanimous government acknowledgment. (Weart, 2010)

Late-20th century warmth was unprecedented over at least the past millennium, as evidenced by the paleoclimatic records, and thus has required anthropogenic forcing which began during the 19th and 20th centuries (Mann et al., 2003). Natural variability accounted for a significant portion of regional anomalies, the Greenhouse gas enhancements and combined energy of other natural forcings were estimated to be about half of the Early Twentieth Century Warming (1901-1950) (Hegerl et al., 2018). Simulations of the climate model show that the observed global variations of temperatures over a few decades are explained by external forcing, and that both natural and anthropogenic factors contribute to the variation of the 20th century temperature (Stott et al., 2000).

2. Historical Evidence and trends.

Instrumental records show a distinct warming in orders of the 20th century in global surface temperature, which has increased by around 0.5°C since the mid-19th century (Jones & Briffa, 1992). There were significant regional and seasonal differences with the 1980s being the warmest decade in 140 years of records (Jones & Briffa, 1992). Another indicator, provided by proxy and similar to the tree records, shows that warming in the late 20th century is unprecedented at hemispheric and perhaps global levels (Jones & Mann, 2004). The spectral attribution studies reveal that, by 1900, GHGs started to generate temperatures that started to be felt, with the effect of these naturally added to the atmosphere increasing over time and becoming stronger and more predominant in the recent increase in temperatures. Other forcings, however, led to significant deviations, such as volcanic eruptions and their respective cooling phases, and reductions in volcanic activity, which were important components in the warming phase in the early to mid-20th century (Hegerl et al., 2019). There is likely a need for anthropogenic aerosol forcing to offset the greenhouse warming, especially since the 1950s when the emissions of sulfates increased (Hegerl et al., 2019). It is clear that AHPU warming can only be explained by anthropogenic forcing in the past 30 years, while the larger centennial temperature changes are explainable by natural causes (Jones & Mann, 2004).

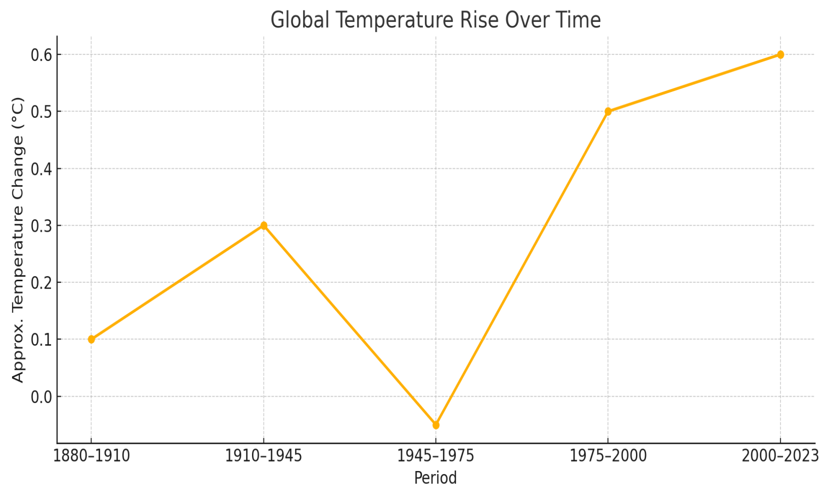

Figure 1: World temperature increase over period.

The above line graph shows the approximate temperature changes since 1880. The trends of each time period are different with different natural and anthropogenic factors. Multiple proxy analyses show that the warming in recent times is not normal when compared to the data from other sources of proxy for the Holocene. Using 73 global proxy records of temperature from around the globe, Marcott et al. (2013) has created the global trend over the past 11,300 years, which reveals that, according to proxy data, current latitudes are warmer than those during ~75% of the Holocene, while IPCC projections for 2100 would surpass the entire Holocene temperature distribution. This approach was further developed by Mann et al. (2008) who expanded their proxy data set and found evidence that the recent Northern Hemisphere warming is at best unusual over the last 1,300-1,700 years. Esper et al. (2024) reported that there is a lack of the type of temporal resolution needed when looking at recent extremes but they pointed out that the pre-instrumental Holocene warming in the past set by increased greenhouse gasses suggests recent warming similarly represents a unique natural phenomenon. In terms of the CO_2 concentration, Cui & Schubert (2020) showed that the CO_2 concentrations found over the past 23 million years are such that the current concentration (412 ppmv) is higher than the highest concentrations ever recorded (230 ppmv to 350 ppmv) since at least the Miocene.

3. Climate Forcings and Feedbacks

Climate change is caused by both natural and anthropogenic forcings; the warming that has taken place over the past century is mainly due to anthropogenic components. Other natural factors include variations in solar irradiance, volcanic eruptions and climate fluctuations, such as the North Atlantic Oscillation (NAO) and the combined effect of the Tropopause Height Oscillation (THEO) and the El Niño/Southern Oscillation (ENSO) (Mann, 2007). Modern climate changes, however, are a product of anthropogenic processes especially the heightened use of fossil fuels and the destruction and degradation of ecosystems since the dawn of the industrial revolution (Balaban, 2012). They demonstrate the significant contribution of GHG radiative forcing to the temperature rise, and recent decoupling of solar irradiance (direct input to the climate system) and temperature (Attanasio et al., 2013). Forcing of the modern period (the last quarter of the twentieth century) is unprecedented in at least the last 2000 years, and is solely explained by interactions with modern anthropogenic forcing (Mann, 2007). Research in the field of social science has brought attention to the importance of the contribution of cultural, economic, geographic, historical, political and social-structural factors, to carbon emissions and climate responses (Jorgenson et al., 2018).

The major contributors of climate warming of the last 100 years are human activities, such as the release of greenhouse gases that are changing Earth's radiative balance (D. Fahey et al., 2017). This warming is greatly strengthened by feedback processes, whose net effect is estimated to be three times the initial radiative forcing from the GHGs (D. Fahey et al., 2017). Observations and theory now securely confirm water vapor feedback: the additional warming that occurs as water vapor concentration increases in the atmosphere because of warming (A. Dessler & Sherwood, 2009). Polar amplification in polar regions is mainly driven by local feedbacks, such as the lapse-rate feedback, with ice-albedo and Planck feedbacks as secondary effects (M. Stuecker et al., 2018). Data and models limitations conceptualized by Yunfeng Cao & Liang (2018) have made it difficult to determine the relative roles and mechanisms of water vapor and cloudiness in recent warming in the Arctic, while oceanic sea-ice albedo feedback is important.

4. Regional and Sectoral Impacts

Climate change is scientifically shown to affect climate regions differently, with polar regions warming most. The warming rate over the last decade in the Arctic is 0.75°C, far higher than the global warming average, and is likely to reach 4°C mean annual warming if Earth climate reaches 2°C global warming (Post et al., 2019). It is regarded as Arctic amplification, which leads to reduction of sea ice and endangers traditional livelihoods of some four million people, including 30 Indigenous Peoples (Macpherson et al., 2016). It will be substantial contribution of land ice loss from both polar regions to the global sea level rise, with a potential increase of up to 3 meters when some threshold is reached (Post et al., 2019).

SIDS, which are home to more than 60 million inhabitants, are exposed to the existential threat of sea-level rise through their long, thin frontlands and are strongly impacted by climate change as a result of their vulnerability (Macpherson et al., 2016). Although the climate of the whole world is changing, there are significant differences in the vulnerability of African, Asian and other regions, with developing regions being especially vulnerable (Watson et al., 1997; van Ypersele de Strihou, 2001).

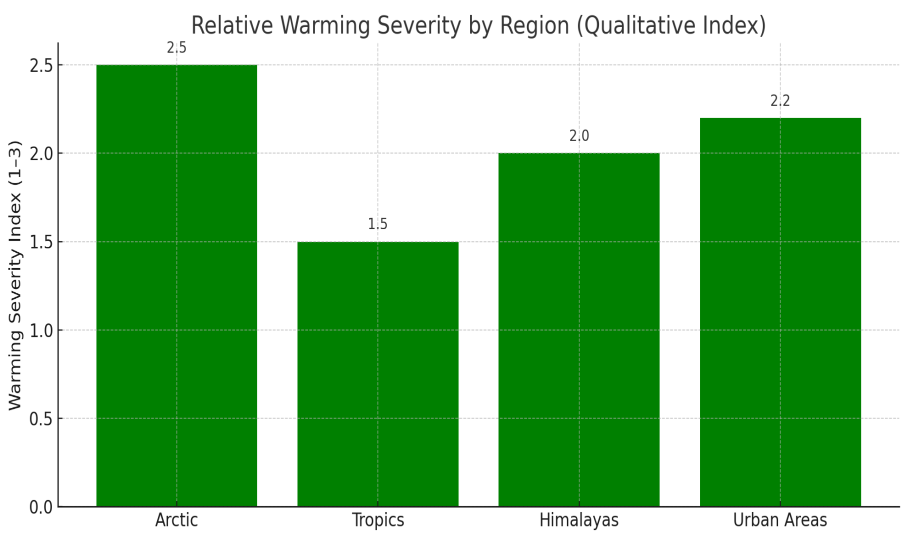

Figure 2: Relative Warming Severity by Region (Qualitative Index).

This figure shows the intensity of the warming in the Arctic, Tropical, Himalayan, and Urban regions. The areas with the greatest warming are in the Arctic and high-altitude regions.

Climate change has multi-sectorial implications in several areas. Agriculture would also suffer from higher temperatures as they would lower crop productivity and stimulate growth of weed and pests, especially developing countries in their key crops such as rice, wheat and corn (maize) (Nelson et al., 2009). Serious threats are water resources due to changes in precipitation becoming more unreliable (Hilemàn, 2000). The human health exposure effects include extreme temperature mortality and vulnerable populations effects, which have the potential to cause damages of hundreds of billions of dollars per year annually (Martinich & Crimmins, 2019). The economic impacts are significant, and worse, in developing countries, food security is likely to be affected by climate change, as the poorest populations there are less able to adapt (Mondal, 2024). There are also massive risks to infrastructure systems that are linked to intricate patterns of damages by region (Martinich & Crimmins, 2019). The climate impacts that are identified in the assessment vary by sector, but not by region, and for this reason, no regions are unaffected, particularly by adverse impacts, making adaptation investments and mitigation strategies essential (Hilemàn, 2000; Martinich & Crimmins, 2019).

5. Socio-Political and Economic Dimensions

Development and inequality is a major issue of global warming affecting development policy in an intricate manner. Actually, there are significant differences in the sources of emissions in the past, with rich countries as the real emitters and the poor countries as the major victims (Roberts, 2001). The inequality is measurable with economic impacts: global economic inequality has likely grown by around 25% in the last 50 years due to anthropogenic warming, and this warming resulted in a decline in the economic welfare of the least developed countries by 17-31%, while potentially benefitting some of the cooler and wealthier countries (Diffenbaugh & Burke, 2019).

Within the Climate Justice approach there is an orientation towards differentiated responsibilities such as the Greenhouse Development Rights that takes into account capacity-to-pay, historical emissions, and shielding of poor people via threshold development (Baer et al., 2009). The negotiations are, however, hindered by the fact that, although both regions are aware of the necessity of linking environment and development concerns, they continue to fight over the burden of adjustment. (Linnér & Jacob, 2005)

6. Policy Responses and International Agreements

The shift from the Kyoto Protocol to the Paris Agreement is from binding to flexible agreements in international climate governance. Most Annex I Parties reduced their emissions under given embedded mechanisms which were prescribed, but a lack of design fueled global emissions growth (Mor et al., 2023). After Copenhagen and considered a diplomatic triumph, the Paris Agreement offers a solid base of work against global warming in Nationally Determined Contributions (Christoff, 2016). Empirical studies, however, show geographic differences: In OECD and EU countries, the emission reduction shows a stable development, but in BRICS countries, the CO_2 intensity moves upwards, while in Asian and African countries, low progress is mostly due to financial and technological reasons (Ghosh & Sourav, 2025). Communication is the key, NDC acceptance key, improvement of target transparency key, and institutional diversity of international cooperation key to Paris's success (Chan et al., 2018; Mor et al., 2023).

Recent studies show that current climate policies and commitments are currently not enough to limit global warming to 1.5°C as set out by the Paris Agreement. Although emissions growth have been slowed and national targets made more ambitious, current target ambitions for reaching global carbon neutrality by the 2050s are not sufficient (Matthews & Wynes, 2022). If a successful mitigation policy is scaled up globally, GHG emissions would only be reduced by around 20% by 2030 under current policies scenarios, which would still exceed 2°C (Fekete et al., 2021). This will turn even more daunting because, in general progresses in incremental improvements of National Determined Contributions (NDCs) will not meet Paris Agreement objectives (Geiges et al., 2019). Demand-side mitigation solutions are available but would need very stringent policy portfolios and system shifts in technology and behaviour to maintain a reach of the 1.5 °C goal (Mundaca et al., 2018).

7. Future Outlook

Climate projections show striking differences between the various climate scenarios and their impacts. In a business-as-usual scenario, dramatic, potential (Gidden et al., 2018) and increasingly self-reinforcing feedbacks of crossing planetary thresholds (Steffen et al., 2018) are anticipated to be associated with the final warming. These would be a devastating impact on the ecosystem, society and economies.

More positive futures are realised under more aggressive mitigation scenarios and within the 1.5-2°C boundary but these still entail significant transformations. These speak to the need for decarbonization of the global economy, augmentation of carbon sinks, behavioural shifts and technological advancements (Steffen et al., 2018). Under scenarios with less greenhouse gas emissions, however, vital marine ecosystems and services still have considerable risk (Gattuso et al., 2015), and regional extremes of climate may still become dangerous (Seneviratne et al., 2018). The research projects highlights the importance of strategies of adaptation in addition to mitigating effects, given that options for management will further be constrained through continued warming and ocean acidification.

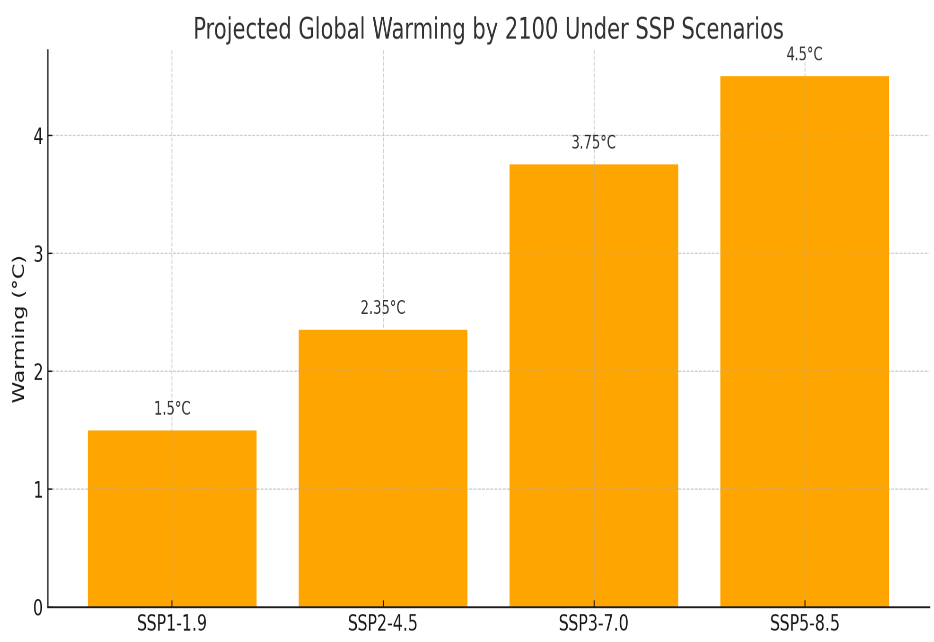

Figure 3: Global warming projections for 2100 by SSP scenarios.

This bar chart presents the expected temperature rise under different socioeconomic pathways. SSP1 shows low emissions while SSP5 indicates worst-case warming.

The temperature rise through the temperature projections (expected from the various socioeconomic pathways) is displayed in this bar chart. Prominent low emissions scenario is SSP1, and a worst-case emissions scenario is SSP5.In total, these papers highlight the importance of required actions now on planet where environmental and climate crises have interconnected. Stressing the urgent need for a transition to a low carbon economy, and a shift away from exploitative capitalisms to sustainability and justice, Fletcher et al. (2024) bring together the converging crises of climate change, ecological destruction and socioeconomic inequality. Stressed climate change and the impending need to feed a population of 9.7 billion people by 2050 are crucial for food systems to remain intact, as warned by Fanzo & Miachon (2023), "the window is closing, and closing fast. While the world is suffering from a Global Climate Emergency, Gills & Morgan (2020) state that humanity's response is not sufficiently urgent to call for a change of essentially altogether different type to the existing institutional responses. Hamid et al. (2007) provide a description of policy programmes for international collective action on climate change. All papers highlight the need for fast and synchronised international reactions to avoid irreversible environmental, social impacts.

8. Conclusion

Scientific evidence over a century has proved that global warming is no more a far-fetched concept than a reality. Instrumental records, proxy data and attribution studies all arrive at one common conclusion: the warming since half way through the 20th century has never been seen before, and can only be attributed to the anthropogenic (human) greenhouse gas emissions. Sunspot cycles, other changes in solar activity, and volcanic eruptions are more important than in the past but are small in comparison to what man is now doing.

The effects are tremendous and unequal; polar regions are warming at a quicker pace than other parts of the world; small islands are at risk of 'disappearing' due to sea level rise; and vulnerable people in the developing world are suffering the highest economic and social losses. Remoteness conditions are already a strain on agriculture, water resources, health systems, as well as infrastructure, driving the need for both mitigation, and adaptation, especially now.

The political solutions and the resulting cooperation mechanisms in place, ranging from the Kyoto Conference to Paris, have been very important, but are not sufficient to limit warming to 1.5 °C. Critical risks might be avoided with more ambitious mitigation and adaptation pathways.

In conclusion, it is important to recognize that the climate crisis is an issue of social, economic and moral change. The science is indisputable, the threat only grows and the window of opportunity is quickly closing. The choices we make today will impact the world we leave for future generations – either through damage that we create and for which we can no longer repair or in a way that will enable them to have a world of resilience and stability.

References

1. Hegerl, G.C., Brönnimann, S., Schurer, A.P., & Cowan, T. (2018). The early 20th century warming: Anomalies, causes, and consequences. *Wiley Interdisciplinary Reviews. Climate Change, 9*. https://doi.org/10.1002/wcc.522
2. Taylor, P.J. (2025). Natural Drivers of Global Warming: Ocean Cycles, Anthropogenic Greenhouse Gases and the Question of Percentages. *Journal of Environmental & Earth Sciences*. https://doi.org/10.30564/jees.v7i2.7683

3. Mann, M.E. (2007). Climate Over the Past Two Millennia. Annual Review of Earth and Planetary Sciences, 35, 111-136. https://doi.org/10.1146/ANNUREV.EARTH.35.031306.140042
4. Weart, S.R. (2010). The idea of anthropogenic global climate change in the 20th century. Wiley Interdisciplinary Reviews: Climate Change, 1. https://doi.org/10.1002/wcc.6
5. Mann, M.E., Amman, C., Bradley, R.S., Briffa, K.R., Jones, P.D., Osborn, T.J., Crowley, T.J., Hughes, M.K., Oppenheimer, M., Overpeck, J.T., Rutherford, S.D., Trenberth, K.E., & Wigley, T.M. (2003). On past temperatures and anomalous late-20th-century warmth. *Eos, Transactions American Geophysical Union, 84*, 256-256. https://doi.org/10.1029/2003EO270003
6. Hegerl, G.C., Brönnimann, S., Schurer, A.P., & Cowan, T. (2018). The early 20th century warming: Anomalies, causes, and consequences. *Wiley Interdisciplinary Reviews. Climate Change, 9*. https://doi.org/10.1002/wcc.522
7. Stott, P.A., Tett, S.F., Jones, G.S., Allen, M.R., Mitchell, J., & Jenkins, G.J. (2000). External control of 20th century temperature by natural and anthropogenic forcings. *Science, 290 5499*, 2133-7 . https://doi.org/10.1126/SCIENCE.290.5499.2133
8. Jones, P., & Briffa, K.R. (1992). Global Surface Air Temperature Variations During the Twentieth Century: Part 1, Spatial, Temporal and Seasonal Details. *The Holocene, 2*, 165 - 179. https://doi.org/10.1177/095968369200200208
9. Hegerl, G.C., Broennimann, S., Cowan, T., Friedman, A.R., Hawkins, E., Iles, C.E., Mueller, W.A., Schurer, A.P., & Undorf, S. (2019). Causes of climate change over the historical record. Environmental Research Letters, 14. https://doi.org/10.1088/1748-9326/ab4557
10. Marcott, S.A., Shakun, J.D., Clark, P.U., & Mix, A.C. (2013). A Reconstruction of Regional and Global Temperature for the Past 11,300 Years. Science, 339, 1198 - 1201. https://doi.org/10.1126/science.1228026
11. Mann, M.E., Zhang, Z., Hughes, M.K., Bradley, R.S., Miller, S.K., Rutherford, S.D., & Ni, F. (2008). Proxy-based reconstructions of hemispheric and global surface temperature variations over the past two millennia. *Proceedings of the National Academy of Sciences, 105*, 13252 - 13257. https://doi.org/10.1073/pnas.0805721105
12. Esper, J., Schulz, P., & Büntgen, U. (2024). Is Recent Warming Exceeding the Range of the Past 125,000 Years? *Atmosphere*. https://doi.org/10.3390/atmos15040405
13. Cui, Y., & Schubert, B.A. (2020). A 23 m.y. record of low atmospheric CO2. *Geology*. https://doi.org/10.1130/geol.s.12307451.v1
14. Mann, M.E. (2007). Climate Over the Past Two Millennia. *Annual Review of Earth and Planetary Sciences, 35*, 111-136. https://doi.org/10.1146/ANNUREV.EARTH.35.031306.140042
15. Balaban, O. (2012). CLIMATE CHANGE AND CITIES: A REVIEW ON THE IMPACTS AND POLICY RESPONSES. https://doi.org/10.4305/metu.jfa.2012.1.2
16. Attanasio, A., Pasini, A., & Triacca, U. (2013). Granger Causality Analyses for Climatic Attribution. *Applied Categorical Structures, 2013*, 515-522. https://doi.org/10.4236/ACS.2013.34054
17. Jorgenson, A.K., Fiske, S.J., Hubacek, K., Li, J., McGovern, T., Rick, T.C., Schor, J.B., Solecki, W., York, R., & Zycherman, A. (2018). Social science perspectives on drivers of and responses to global climate change. *Wiley Interdisciplinary Reviews. Climate Change, 10*. https://doi.org/10.1002/wcc.554
18. Fahey, D.W., Doherty, S.J., Hibbard, K.A., Romanou, A., & Taylor, P.C. (2017). Physical drivers of climate change.

19. Dessler, A.E., & Sherwood, S.C. (2009). A Matter of Humidity. *Science, 323*, 1020 - 1021. https://doi.org/10.1126/science.1171264

20. Stuecker, M.F., Bitz, C.M., Armour, K.C., Proistosescu, C., Kang, S.M., Xie, S., Kim, D., McGregor, S., Zhang, W., Zhao, S., Cai, W., Dong, Y., & Jin, F. (2018). Polar amplification dominated by local forcing and feedbacks. *Nature Climate Change, 8*, 1076-1081. https://doi.org/10.1038/s41558-018-0339-y

21. Cao, Y., & Liang, S. (2018). Recent advances in driving mechanisms of the Arctic amplification: A review. *Chinese Science Bulletin*. https://doi.org/10.1360/N972018-00462

22. Post, E., Alley, R.B., Christensen, T.R., Macias-Fauria, M., Forbes, B.C., Gooseff, M.N., Iler, A.M., Kerby, J.T., Laidre, K.L., Mann, M.E., Olofsson, J., Stroeve, J.C., Ulmer, F., Virginia, R.A., & Wang, M. (2019). The polar regions in a 2°C warmer

23. world. *Science Advances, 5*. https://doi.org/10.1126/sciadv.aaw9883

24. Macpherson, C.C., Bidaisee, S., & Macpherson, C.N. (2016). Environmental Harms in Distant Polar Regions and Small Island Developing States. https://doi.org/10.1007/978-3-319-26167-6_10

25. Watson, R.T., Zinyowera, M.C., Moss, R.H., & Dokken, D.J. (1997). The regional impacts of climate change : an assessment of vulnerability.

26. Strihou, J.V. (2001). Overview of Impacts, Adaptation, and Vulnerability to Climate Change.

27. Nelson, G.C., Rosegrant, M.W., Koo, J., Robertson, R., Sulser, T.B., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R.A., Ewing, M., & Lee, D.R. (2009). Climate Change: Impact on Agriculture and Costs of Adaptation. https://doi.org/10.2499/089629535

28. Hilemàn, B. (2000). CONSEQUENCES OF CLIMATE CHANGE: Government study finds negative effects on coastlines, water supplies, and health, but little economic impact on crops and forests. *Chemical & Engineering News, 78*, 18-19. https://doi.org/10.1021/CEN-V078N013.P018

29. Martinich, J., & Crimmins, A. (2019). Climate damages and adaptation potential across diverse sectors of the United States. Nature Climate Change, 9, 397-404. https://doi.org/10.1038/s41558-019-0444-6

30. Mondal, D. (2024). SOCIO-ECONOMIC IMPACTS OF CLIMATE CHANGE. International Journal on Agricultural Sciences. https://doi.org/10.53390/ijas.2024.15203

31. Roberts, J. (2001). Global Inequality and Climate Change. Society & Natural Resources, 14, 501 - 509. https://doi.org/10.1080/08941920118490

32. Diffenbaugh, N.S., & Burke, M. (2019). Global warming has increased global economic inequality. Proceedings of the National Academy of Sciences of the United States of America, 116, 9808 - 9813. https://doi.org/10.1073/pnas.1816020116

33. Baer, P., Kartha, S., Athanasiou, T., & Kemp-Benedict, E. (2009). The Greenhouse Development Rights Framework: Drawing Attention to Inequality within Nations in the Global Climate Policy Debate. Development and Change, 40, 1121-1138. https://doi.org/10.1111/J.1467-7660.2009.01614.

34. XLinnér, B., & Jacob, M. (2005). From Stockholm to Kyoto and beyond: A review of the globalization of global warming policy and North–South relations. Globalizations, 2,403-415. https://doi.org/10.1080/14747730500368007

35. Mor, S., Aneja, R., Madan, S., & Ghimire, M. (2023). Kyoto Protocol and Paris Agreement: Transition from Bindings to Pledges – A Review. Millennial Asia, 15, 690 - 711. https://doi.org/10.1177/09763996221141546

36. Christoff, P.K. (2016). The promissory note: COP 21 and the Paris Climate Agreement. Environmental Politics, 25, 765 - 787. https://doi.org/10.1080/09644016.2016.1191818

37. Ghosh, A., & Sourav, S. (2025). Heterogeneous impacts of climate agreements: Empirical insights into Kyoto and Paris Commitments. ECONOMICS AND POLICY OF ENERGY AND THE ENVIRONMENT. https://doi.org/10.3280/efe2025-001002

38. Chan, G., Stavins, R., & Ji, Z. (2018). International Climate Change Policy. Annual Review of Resource Economics. https://doi.org/10.1146/ANNUREV-RESOURCE-100517-023321

39. Matthews, H.D., & Wynes, S. (2022). Current global efforts are insufficient to limit warming to 1.5°C. Science, 376, 1404 - 1409. https://doi.org/10.1126/science.abo3378

40. Fekete, H., Kuramochi, T., Roelfsema, M., Elzen, M.D., Forsell, N., Höhne, N., Luna, L., Hans, F., Sterl, S., Olivier, J.G., van Soest, H.L., Frank, S., & Gusti, M. (2021). A review of successful climate change mitigation policies in major emitting economies and the potential of global replication. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2020.110602

41. Geiges, A., Nauels, A., Parra, P.Y., Andrijevic, M., Hare, W., Pfleiderer, P., Schaeffer, M., & Schleussner, C. (2020). Incremental improvements of 2030 targets insufficient to achieve the Paris Agreement goals. Earth System Dynamics Discussions, 11, 697-708. https://doi.org/10.5194/esd-2019-54

42. Mundaca, L., Ürge-Vorsatz, D., & Wilson, C. (2018). Demand-side approaches for limiting global warming to 1.5 °C. Energy Efficiency, 12,343- 362. https://doi.org/10.1007/s12053-018-9722-9

43. Gidden, M.J., Riahi, K., Smith, S.J., Fujimori, S., Luderer, G., Kriegler, E., van Vuuren, D.P., van den Berg, M., Feng, L., Klein, D., Calvin, K.V., Doelman, J.C., Frank, S., Fricko, O., Harmsen, M.J., Hasegawa, T., Havlík, P., Hilaire, J., Hoesly, R., Horing, J., Popp, A., Stehfest, E., & Takahashi, K. (2018). Global emissions pathways under different socioeconomic scenarios for use in CMIP6: a dataset of harmonized emissions trajectories through the end of the century. Geoscientific Model Development. https://doi.org/10.5194/GMD-12-1443-2019

44. Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D.M., Summerhayes, C., Barnosky, A.D., Cornell, S.E., Crucifix, M.C., Donges, J.F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R., & Schellnhuber, H.J. (2018). Trajectories of the Earth System in the Anthropocene. Proceedings of the National Academy of Sciences of the United States of America, 115,8252-8259. https://doi.org/10.1073/pnas.1810141115

45. Gattuso, J., Gattuso, J., Gattuso, J., Magnan, A.K., Billé, R., Cheung, W.W., Howes, E.L., Joos, F., Allemand, D., Bopp, L., Cooley, S.R., Eakin, C.M., Hoegh-Guldberg, O., Kelly, R.P., Pörtner, H., Rogers, A., Baxter, J.M., Laffoley, D., Osborn, D.I., Ranković, A., Ranković, A., Rochette, J., Sumaila, U.R., Treyer, S., & Turley, C.M. (2015). Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios.Science,349. https://doi.org/10.1126/science.aac4722

46. Seneviratne, S.I., Rogelj, J., Séférian, R., Wartenburger, R., Allen, M.R., Cain, M., Millar, R.J., Ebi, K.L., Ellis, N.R., Hoegh-Guldberg, O., Payne, A.J., Schleussner, C., Tschakert, P., & Warren, R. (2018). The many possible climates from the Paris Agreement's aim of 1.5 °C warming. Nature,

558, 41 - 49. https://doi.org/10.1038/s41586-018-0181-4

47. Fletcher, C.H., Ripple, W.J., Newsome, T., Barnard, P., Beamer, K., Behl, A., Bowen, J., Cooney, M., Crist, E., Field, C.B., Hiser, K., Karl, D.M., King, D.A., Mann, M.E., McGregor, D.P., Mora, C., Oreskes, N., & Wilson, M. (2024). Earth at risk: An urgent call to end the age of destruction and forge a just and sustainable future. PNAS Nexus, 3. https://doi.org/10.1093/pnasnexus/pgae106
48. Fanzo, J.C., & Miachon, L. (2023). Harnessing the connectivity of climate change, food systems and diets: Taking action to improve human and planetary health. Anthropocene, 42, 100381 - 100381. https://doi.org/10.1016/j.ancene.2023.100381
49. Gills, B.K., & Morgan, J. (2020). Global Climate Emergency: after COP24, climate science, urgency, and the threat to humanity. Globalizations, 17, 885 - 902. https://doi.org/10.1080/14747731.2019.1669915