Backgrounder:

1.5°C global average temperature rise: useful papers

1. Comparing the impacts of 1.5°C and 2°C temperature rise

- **Different climate impacts:** Schleussner et al. (2016). Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 °C and 2 °C. Earth System Dynamics 6: 327-351. (writeup here)

  ABSTRACT: "an assessment of key impacts of climate change at warming levels of 1.5◦C and 2◦C, including extreme weather events, water availability, agricultural yields, sea-level rise and risk of coral reef loss. Our results reveal substantial differences in impacts between a 1.5◦C and 2◦C warming that are highly relevant for the assessment of dangerous anthropogenic interference with the climate system."

- **Water and food:** Betts et al. (2018) Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5°C and 2°C global warming with a higher-resolution global climate model. Philosophical Transactions of the Royal Society. 376: 2119 (Writeup here)

  ABSTRACT: "an assessment of changes in weather extremes, hydrological impacts and vulnerability to food insecurity at global warming of 1.5°C and 2°C relative to pre-industrial. Despite some degree of inconsistency between components of the study due to the need to correct for systematic biases in some aspects, the projections for weather extremes indices and biophysical impacts quantities support expectations that the magnitude of change is generally larger for 2°C global warming than 1.5°C."

- **Water:** Döll et al (2018) Risks for the global freshwater system at 1.5 °C and 2 °C global warming. Environmental Research Letters. 13, 4

  ABSTRACT: "an assessment of freshwater-related hazards and risks in worlds of approximately 1.5°C and 2°C warmer than pre-industrial. We analyzed seven hydrological hazard indicators that characterize freshwater-related hazards for humans, freshwater biota and vegetation. We identified for all but one indicator that areas with either significantly wetter or drier conditions are smaller in the 1.5°C world."

- **Economics**: Pretis et al (2017) Uncertain Impacts on Economic Growth When Stabilizing Global Temperatures at 1.5°C or 2°C Warming. Philosophical Transactions of the Royal Society A. doi:10.1098/rsta.2016.0460 (writeup here)

  ABSTRACT: "an assessment of the relative impacts of climate change onto economic outcomes when global mean surface temperature is stabilized at 1.5°C or at 2°C warming relative to pre-industrial levels. The projected impacts onto economic growth of 1.5°C warming are close to indistinguishable from current climate conditions, while 2°C warming suggests statistically lower economic growth for a large set of countries."

- **Coral reefs:** Frieler et al. (2013) Limiting global warming to 2 °C is unlikely to save most coral reefs. Nature Climate Change 3: 165–170

  ABSTRACT: "a comprehensive global study of coral bleaching in terms of global mean temperature change, based on an extended set of emissions scenarios and models. We show that preserving >10% of coral reefs worldwide would require limiting warming to below 1.5 °C relative to pre-industrial levels."

- **Sea level rise affecting coastal populations:** Rasmussen (2017) Coastal flood implications of 1.5 °C, 2.0 °C, and 2.5 °C temperature stabilization targets in the 21st and 22nd century. Environmental Research Letters submitted, 1–39

  ABSTRACT: "an assessment of the implications of temperature stabilization targets for coastal flood risk. We assess differences in the return periods of coastal floods at a global network of tide gauges between scenarios that stabilize global mean surface temperature (GMST) warming at 1.5°, 2°C, 2.5°C above pre-industrial levels. By 2150, relative to the 2°C scenario, GMST stabilization of 1.5°C inundates roughly 5 million fewer inhabitants that currently occupy lands, including 40,000 fewer individuals currently residing in Small Island Developing States."

- **Sea level rise affecting small island states:** Storlazzi et al (2018) Most atolls will be uninhabitable by the mid-21st century because of sea-level rise exacerbating wave-driven flooding. Science Advances 4, 4: 9741 (writeup here)

  ABSTRACT: "we project the impact of sea-level rise and wave-driven flooding on atoll infrastructure and freshwater availability under a variety of climate change scenarios. We show that, on the basis of current greenhouse gas emission rates, the nonlinear interactions between sea-level rise and wave dynamics over reefs will lead to the annual wave-driven overwash of most atoll islands by the mid-21st century."

- **Sea level rise affecting the USA:** National Oceanic and Atmospheric Administration (2017) Global and regional sea level rise scenarios for the United States. NOAA Technical Report NOS CO-OPS 083

  EXECUTIVE SUMMARY: "This technical report focuses on the production of gridded relative sea level projections for the United States associated with an updated set of global mean sea level scenarios. It articulates the linkages between scenario-based and probabilistic projections of future sea levels for coastal-risk planning, management of long-lived critical infrastructure, mission readiness, and other purposes. Along almost all U.S. coasts outside Alaska, relative sea level is projected to be higher than the global average under the Intermediate-High, High and Extreme scenarios."

- **Heat extremes (1):** Coumou and Robinson (2013) Historic and future increase in the global land area affected by monthly heat extremes. Environmental Research Letters 8:3

  ABSTRACT: "an assessment of the occurrence-probability of heat extremes under the CMIP5 (Coupled Model Intercomparison Project) climate models. For the near-term (i.e., by 2040), the models predict a robust, several-fold increase in the frequency of such heat extremes, irrespective of the emission scenario. However, mitigation can strongly reduce the number of heat extremes by the second half of the 21st century."

- **Heat extremes (2):** Matthews et al (2017) Communicating the deadly consequences of global warming for human heat stress. Proceedings of the National Academy of Sciences USA. Apr 11; 114,15: 3861-3866.

  ABSTRACT: "an assessment of the increasing frequency of deadly heat under specified amounts of global warming. Our results confirm that global mean air temperature is nonlinearly related to heat stress, meaning that the same future warming as realized to date could trigger larger increases in societal impacts than historically experienced. With only 1.5 °C of global warming, twice as many megacities could become heat stressed, exposing more than 350 million more people to deadly heat by 2050."

- **Heat Extremes in North Africa:** Weber at el (2018) Analyzing Regional Climate Change in Africa in a 1.5, 2, and 3°C Global Warming World. Earth's Future (writeup here)

  ABSTRACT: "an analysis of potential climate impacts for the African continent for various sectors under different thresholds of global warming—namely, 1.5°C, 2C°, and 3°C.The results show that the African continent, in particular the regions between 15°S and 15°N, has to expect an increase in hot nights and longer and more frequent heat waves even if the global temperature will be kept below 2°C."

- **Glacier loss and water availability:** Cogley (2017) Climate science: The future of Asia's glaciers. Nature 549: 166–167

  ABSTRACT: "an assessment of what an increase of 1.5 °C would mean for the glaciers in high mountains of Asia (HMA). We show that a global temperature rise of 1.5 °C will lead to a warming of 2.1 ± 0.1°C in HMA, and that 64 ± 7% of the present-day ice mass stored in the HMA glaciers will remain by the end of the century."

- **Water availability and flooding in Europe:** Thober et al (2018) Multi-model ensemble projections of European river floods and high flows at 1.5, 2, and 3 degrees global warming. Environmental Research Letters: 13, 1

  ABSTRACT: "a study that investigates climate change impacts on European floods under 1.5°C, 2°C, and 3°C global warming. The multi-model ensemble points to the Mediterranean region as a hotspot of changes with significant decrements in high flows mainly resulting from reduced precipitation."

- **Likelihood of reaching tipping points below 2C:** Drijfhout et al (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models. Proceedings of the National Academy of Sciences. 112: 43

  ABSTRACT: "an analysis of 37 forced regional abrupt changes in the ocean, sea ice, snow cover, permafrost, and terrestrial biosphere that arise after a certain global temperature increase. Eighteen out of 37 events occur for global warming levels of less than 2°C, a threshold sometimes presented as a safe limit."

- **Implications for global biodiversity:** Warren et al (2018) The implications of the United Nations Paris Agreement on climate change for globally significant biodiversity areas. Climatic Change. 47, 3–4: 395–409 (writeup here)

ABSTRACT: “an assessment of the climate change-related risks to the species in globally significant biodiversity conservation areas over a range of climate scenarios, assessing their value as climate refugia. We quantify the aggregated benefit of countries’ emission reduction pledges and also of further constraining global warming to 2°C above pre-industrial levels, against an unmitigated scenario of 4.5 °C warming. We find that if warming is constrained to 2°C, the average area of climate refugees doubles to 67% of each conservation area.”

- **Arctic sea ice melt:** Jahn (2018) Reduced probability of ice-free summers for 1.5 °C compared to 2 °C warming. Nature Climate Change. 8: 409–413

  ABSTRACT: “an assessment of the climate impacts on Arctic sea ice under different scenarios. Constraining warming to 1.5 °C rather than 2.0 °C reduces the probability of any summer ice-free conditions by 2100 from 100% to 30%.”

- **Implications of Arctic sea ice melt:** González-Eguino (2017) Mitigation implications of an ice-free summer in the Arctic Ocean. Earth’s Future, January 2017

  ABSTRACT: “an assessment of the implications of a potentially rapid sea-ice-loss process under different. Our results show that sea-ice melting in the Arctic requires more stringent mitigation efforts globally. We find that global CO2 emissions would need to reach zero levels 5–15 years earlier and that the carbon budget would need to be reduced by 20%–51% to offset this additional source of warming.”

- **Agriculture:** Zhao et al (2017) Temperature increase reduces global yields of major crops in four independent estimates. Proceedings of the National Academy of Sciences of the United States of America , National Academy of Sciences. 114, 35: 9326-9331

  ABSTRACT: “an assessment of the impact of global temperature increase on yields of wheat, rice, maize, and soybean. Results from the different methods consistently showed negative temperature impacts on crop yield at the global scale, generally underpinned by similar impacts at country and site scales.”

- **Heat extremes in the Middle East and North Africa:** Lelieveld (2016) Strongly increasing heat extremes in the Middle East and North Africa (MENA) in the 21st century. Climatic Change. 137, 1–2: 245–260 (writeup here)

  ABSTRACT: “a study that investigates climate change and temperature extremes in the Middle East and North Africa (MENA). Results imply that climate warming in the MENA is strongest in summer while elsewhere it is typically stronger in winter.”

  Vulnerability to multi-sector impacts, particularly in Asia and Africa: Byers et al (2018) Global exposure and vulnerability to multi-sector development and climate change hotspots. Environmental Research Letters. 13, 5. (writeup here)

  ABSTRACT: “an analysis of the links between multiple climate change risks and socioeconomic development. We calculate a set of 14 impact indicators at different levels of global mean temperature (GMT) change and socioeconomic development covering water, energy and land sectors from an ensemble of global climate, integrated assessment and impact models. We show that global exposure to multi-sector risks approximately doubles between 1.5°C and 2°C.”

2. Scenarios for hitting 1.5C - do we need CDR?

- **Overview of different scenarios limiting temperature rise to 1.5C by the end of the century:**
  Rogelj et al. (2018) Scenarios towards limiting global mean temperature increase below 1.5 °C. Nature Climate Change. 8: 325–332 (writeup here)

  ABSTRACT: “an analysis of the transition pathways that can meet a 1.5°C target under different socio-economic, technological and resource assumptions.We find that some, but not all, pathways are amenable to pathways to 1.5 °C.”

- **Limiting temperature rise to 1.5C without CDR:**
  Van Vuuren (2018) Alternative pathways to the 1.5 °C target reduce the need for negative emission technologies. Nature Climate Change 8: 391–397 (writeup here)

  ABSTRACT: “a study that investigates the impact of alternative pathways to the 1.5°C target, including lifestyle change, additional reduction of non-CO2 greenhouse gases and more rapid electrification of energy demand based on renewable energy. Although these alternatives also face specific difficulties, they are found to significantly reduce the need for carbon dioxide removal, but not fully eliminate it. The alternatives offer a means to diversify transition pathways to meet the Paris Agreement targets, while simultaneously benefiting other sustainability goals.

- Grubler et atl (2018) A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies. Nature Energy. 3: 515–527

  ABSTRACT: “a study that develops a scenario that meets the 1.5°C target under low energy demand without negative emission technologies. We describe and quantify changes in activity levels and energy intensity in the global North and global South for all major energy services. We project that global final energy demand by 2050 decreases 40% compared to today’s levels, despite rises in population, income and activity.”

- **Potential for land use methods to reduce the need for CDR:**
  Griscom et al (2017) Natural climate solutions. Proceedings of the National Academy of Sciences. 114, 44: 11645-11650

  SIGNIFICANCE: “an assessment of how much climate mitigation nature can contribute to a 2°C target with a comprehensive analysis of “natural climate solutions” (NCS) that increase carbon storage and/or avoid greenhouse gas emissions across global forests, wetlands, grasslands, and agricultural lands. We show that NCS can provide over one-third of the cost-effective climate mitigation needed between now and 2030 to stabilize warming to below 2°C.”

  Hausfather (2018) Analysis: How ‘natural climate solutions’ can reduce the need for BECCS. Carbon Brief, 21 May 2018. Blog.

  BLOG: “Carbon Brief uses the recently published review of “natural climate solutions” (NCS) to examine how big a role they could play in contributing to negative emissions. This analysis shows that NCS could provide a sizable portion of the required emissions and reduce the need for bioenergy with carbon capture and storage (BECCS) in pathways limiting warming to below 1.5°C, particularly when coupled with faster emissions reductions over the next few decades.”

- **How fast are temperature rising now, and what does that mean for temperature rise?**
  Berkeley Earth. Global Temperature Report for 2017

INTRO: “a report on global mean temperature during 2017. We conclude that 2017 was likely the second warmest year on Earth since 1850. Global mean temperature in 2017 was 0.03 °C (0.05 °F) warmer than 2015, but 0.11°C (0.20 °F) colder than 2016. As a result, 2016 remains the warmest year in the historical observations.”

IPCC. 2014. Summary for Policymakers. Table SPM.1, p.13

Attributing extreme weather events to climate change

- Attribution briefing has lots of useful sources.
- Carbon Brief map
- The Bulletin of the American Meteorological Society publishes an annual summary of attribution studies.

Air pollution

- RU briefing: Coal fired power stations and health

Human health

- RU briefing: Coal fired power stations and health
- RU briefing: Health and climate change briefing 2016

Rising sea levels

- Sea level rise briefing (October 2017)
- NOAA’s January 2017 report assessed the most scientifically up to date literature on upper end sea level rise projections.
- Sea level could rise 6 metres (20 feet) by 2200 as a result of polar ice melt, according to recent paper.
- More than a quarter of the the population of Shanghai, Hong Kong, Mumbai and Calcutta live 6 metres or less below sea level. The top 20 cities who would be affected by a 6m sea level rise are all in Asia.
- Interactive global map showing the influence of sea level rise from current levels to six foot. The map allows you to search on different locations in the USA and view the changes under varying levels of sea level rise (NOAA)

Policy benchmarks - how do we hit 1.5C?

- Climate Action Tracker benchmarks

Rate of renewable energy transition

- Ren21
- UNEP Global Trends in Renewable energy Investment
- IEA World Energy Outlook and
- https://www.iea.org/publications/renewables2017/

This paper was prepared by GSCC to support understanding of issues arising from the IPCC’s Special Report on 1.5°C warming.

Why we are here

To stop the degradation of the planet’s natural environment and to build a future in which humans live in harmony with nature.

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