The Paris Agreement and climate justice: inequitable impacts of sea level rise associated with temperature targets

S. Sadai[1]*, R.A. Spector[1], R. DeConto[1], N. Gomez[2]

[1]University of Massachusetts Amherst.
[2]McGill University.

Key Points:

- Temperature targets in 2100 do not fully capture other effects of climate destabilization, particularly sea level rise.
- The temperature target metric has significant climate justice implications for Island Nations disproportionately impacted by sea level rise.
- Modeling of Antarctic ice sheet melt indicates sea levels may rise while temperature increase slows, exacerbating justice concerns.

Abstract

Anthropogenic greenhouse gas emissions are causing unprecedented changes to the climate. In 2015, at the United Nations (UN) Conference of the Parties in Paris, France, countries agreed to limit the global mean surface temperature (GMST) increase to 2°C above preindustrial levels, and to pursue efforts to limit warming to 1.5°C. Due to the long-term irreversibility of sea level rise (SLR), risks to island and coastal populations are not well encapsulated by the goal of limiting GMST warming by 2100. This paper reviews and synthesizes the climate justice implications of temperature targets in light of our increasing understanding of the spatially variable impact and long temporal commitment to rising seas. In particular we highlight the impact that SLR will have on island states and the role of the Alliance of Small Island States (AOSIS) in UN climate negotiations. As a case study we review dual impacts from the Antarctic Ice Sheet (AIS) under a changing climate: 1) recent climate and ice sheet modeling shows that Antarctic melt has the potential to cause rapid SLR with a distinct spatial pattern leading to AOSIS nations experiencing SLR at least 11% higher than the global average and up to 33% higher; and 2) future ice sheet melt will result in a negative feedback on GMST, thus delaying temperature rise. When considering these impacts in conjunction, justice concerns associated with the Paris Agreement are exacerbated. This case study demonstrates that mitigation policies should consider climate impacts in addition to GMST, particularly sea level rise.

Plain Language Summary

At the Paris Climate Agreement in 2015, countries adopted a target for stabilizing climate change defined by how the rise in global average air temperature has increased relative to a pre-industrial baseline. Prior research has identified numerous climate justice implications associated with this approach. This study reviews climate justice issues associated with Paris Agreement temperature targets, finding that using air temperature by 2100 as the main metric does not adequately capture other climate risks, particularly sea level rise faced by island and coastal communities. We introduce a new climate justice consideration based on the simultaneous impacts of sea level rise and slowed warming caused by ice loss on Antarctica. Slowed warming might appear to delay the need for climate action, but a focus on temperature alone misses the impacts of accelerating sea level rise.

1 Introduction

Climate change impacts all parts of the Earth system, and the degree and nature of these impacts vary spatially and temporally. Sea level rise (SLR) presents a distinct threat to coastal communities and island nations (Magnan et al., 2019; Nurse et al., 2014). Global mean sea level (GMSL) has increased by 0.2 m since 1901, accelerating in recent decades to the current (2006-2018) rate of about 3.7 mm/yr (Fox-Kemper et al., 2021). The rate of SLR will increase by the end of the century even under low emissions scenarios. Sea levels will continue to rise for centuries after 2100, regardless of emissions trajectories or overall warming, and will remain elevated for millenia (Clark et al., 2016; Fox-Kemper et al., 2021; Oppenheimer et al., 2019). Sea level rise also has substantial regional variations, the impacts of which depend on geomorphological and sociopolitical considerations at the local scale. In some places SLR may cause islands to be rendered uninhabitable due to submersion, salt water intrusion into groundwater, storm surge, and other factors (Magnan et al., 2019; Oppenheimer et al., 2019).

Since the 1980s, a focal point of international negotiations has been to establish a common target in the form of a Long Term Global Goal (LTGG) for action to address climate change, yet the metric used for the LTGG does not explicitly consider sea level rise. In 2015, these negotiations led to the adoption of the Paris Agreement which framed the LTGG in terms of a temperature target. This temperature target become the quantitative expression of the United Nations Framework for the Convention on Climate Change (UNFCCC) Article 2 objective of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference [DAI] with the climate system" (UNFCCC, 1992 p9). According to the Paris Agreement (2015), countries agreed to limit global mean surface temperature (GMST) rise to "well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C". As of 2021, the average surface temperature is 1.1°C warmer than preindustrial, currently increasing at a rate of ~0.2°C per decade as greenhouse gas emissions rise at a rate of 59.1 gigatons of CO_2 equivalent per year (Gulev et al., 2021; Hoegh-Guldberg et al., 2018; UNEP, 2020).

This temperature target, as it is currently framed, poses several challenges which can give rise to multiple sources of climate injustice. First, the temperature target is generally considered to be in reference to the year 2100 however unlike GMST, sea level rise following greenhouse gas emissions evolves over centuries due to complex processes and feedbacks meaning that the full multi-century response is currently unaccounted for (Clark et al., 2016; Li et al., 2013, Mengel et al., 2018). Surface temperature depends mainly on cumulative emissions, thus temperature is expected to stabilize if CO_2 emissions reach net zero. However the thermal expansion component of SLR, which occurs as water warms and expands, will continue for centuries even after emissions stop (Bouttes et al., 2013; Meehl et al., 2012; Zanna et al., 2019). Specifically, higher emission rates at earlier times lead to higher SLR for the same cumulative emissions, which has implications for policy proposals if sea level were to be considered as a metric instead of or in addition to GMST (Bouttes et al., 2013; Li et al., 2020). While the rate of SLR from thermal expansion will likely decline as temperatures decline, dynamical contributions from ice sheets will dominate in the long-term with sea levels continuing to rise for hundreds of years even after temperatures stabilize (Wigley, 2018). This occurs even if speculative technologies to remove CO_2 from the atmosphere are deployed (DeConto et al., 2021).

Second, by adopting GMST as the metric for international climate action, the conversation around risk and impact has been skewed toward a globally averaged version of a single environmental stressor. This approach fails to convey the breadth of impacts which will vary geographically and over time. Following from this, there is significant discrepancy between 'danger as defined' by scientific assessments and 'danger as experienced' by communities on the frontlines of a changing climate (Dessai et al., 2004 p21). While climate change is a global risk, vulnerability is a locally experienced phenomena (Ayers, 2011; Tschakert, 2015). Systems of power and privilege impact the decision-making process regarding what is deemed an acceptable level of damage and risk, often disadvantaging those with less privilege (Dessai et al., 2004; Seager, 2009).

Third, and finally, "acceptable risk" is an ambiguous term with respect to the concept of DAI written into the UNFCCC. This is compounded by the vague language in the Paris Agreement that recommends a target of "well below" 2°C. In what has been termed "the political economy of delay" (Carton, 2019), these ambiguities have jointly enabled a delay in action to reduce carbon emissions by parties more concerned with near-term economic profit than ongoing and long-term environmental and societal harm. Because the Paris Agreement does not directly connect temperature to greenhouse gas emissions regulation, it moves the conversation away from the causes of climate change (increasing greenhouse gas emissions and systems of oppression which drive them). The ambiguities of the UNFCCC and Paris Agreement embody the status quo over principles of egalitarian justice (Morgan, 2016; Morseletto et al., 2017; Okereke, 2006; Tschakert, 2015). Indeed, while countries submit Nationally Determined Contributions (NDCs) to achieve Paris goals, emissions levels have not declined to meet them, and parties are not legally bound to enact them. Moreover, the temperature target has been interpreted as leaving room for overshooting in the coming decades with the promise of reaching it by 2100 (Rogelj et al., 2018), despite the risk of triggering rapid SLR.

Given these challenges posed by the GMST target, we argue that it is crucial to understand the target's origins in the context of broader inequalities that characterize the global climate negotiation process. The GMST target has its origins in scientific research, which informs policy processes. Predictive modeling plays an important role in negotiations by characterizing climate system changes of interest to policymakers and the public, and constraining potential future trajectories. Issues of justice are crucial in understanding impacts of climate policy (Klinsky et al., 2016), yet science is limited in its ability to answer questions about justice (Okereke; 2006; Oppenheimer, 2005). In scientific assessments there is a tendency for climate change to be framed as an environmental issue with social ramifications, as opposed to a social issue with environmental ramifications (Barnett & Campbell, 2011). This approach obscures the nuances of how social systems interface with vulnerability (Liverman, 2009). An interdisciplinary interpretation of scientific results allows for greater understanding of justice concerns (Colven & Thomson, 2019).

In this paper, we focus on three components of justice theory as they relate to the Alliance of Small Island States (AOSIS), an organization formed to amplify the needs of states particularly concerned with the impacts of sea level rise (Heileman, 1993; Liburd, 2021): 1) procedural justice, which notes that fair outcomes require equity throughout the decision making process, 2) distributive justice relating to how impacts vary spatially and temporally and are often uneven with respect to emissions contribution, and 3) recognition justice relating to the existence rights of cultural and social groups (Burnham et al., 2013a; Fraser, 1997; Rawls, 1971). We frame each justice consideration centering on AOSIS nations, negotiators, and inhabitants due to the geographic vulnerability of many AOSIS nations to sea level rise, the centrality of this in their negotiating positions, and their strong and ongoing history of advocacy within the UNFCCC. AOSIS statements and NDCs of member nations stress SLR as a threat to their existence (AOSIS, 2009; AOSIS and the LDC Group, 2020; Mills-Novoa & Liverman, 2019; Thomas & Benjamin, 2018c). Interviews with the AOSIS chair and negotiators from member countries note that loss and damage from extreme events had already been witnessed by all of them, and while direct impacts occurred in coastal communities, there were ramifications for the whole country (Thomas & Benjamin, 2018). Under 2°C, lands in island nations inhabited by half a million people could become permanently submerged (Storlazzi, 2015), though limiting warming can reduce risks (Hoegh-Guldberg et al., 2018; Hoegh-Guldberg et al., 2019).

Here, we leverage a range of scientific and sociopolitical research to explore the climate justice implications of defining the LTGG according to GMST, interpreted as being by 2100. By bridging physical and social sciences literatures we are able to consider physical earth system changes, while incorporating the sociopolitical context of climate change drivers, responses, and impacts. Scientific research is used to inform international negotiations yet can become detached from the lived experiences of people experiencing SLR (Abbott & Wilson, 2015). In order to understand the policy landscape as well as the experiences of people on the ground we bring together historical, sociological, geographic, and political research to contextualize scientific findings with human interactions and experiences.

First, we review and synthesize documents from United Nations (UN) archives and literature pertaining to three aspects of climate justice. We find that 1) power dynamics influenced the decision to adopt the GMST target, and while AOSIS nations had substantial achievements ultimately a weaker global metric was adopted, 2) vulnerability to SLR varies based on a wide range of climate system, historical, and political factors with some AOSIS islands in danger of being submerged and 3) the long time commitment of rising seas is particularly dangerous for AOSIS countries given the normalization of overshoot pathways that GMST targets have allowed for. This normalization increases the risk of more severe long term SLR commitments. Following this review we then turn to a case study of the projected impacts of Antarctic Ice Sheet melt on SLR, GMST, and AOSIS countries. We assess the spatial variability of the Antarctic SLR component in comparison to the global mean and find that AOSIS nations are disproportionately impacted relative to their emissions contribution (see Methods). This case study illuminates 1) the potential of negative feedbacks to justify increasing allowable emissions budgets while sea levels simultaneously rise and 2) the possibility that overshooting the Paris Agreement goals could further exacerbate climate justice inequities since Antarctic instability points lie near 2°C. The conclusion considers the broader climate justice implications of defining the LTGG according to GMST by 2100.

2 Temperature Targets: A Procedural Justice Critique

Procedural justice considers equity in decision making processes. While temperature targets have become a fixture of climate negotiations, the use of GMST as the LTGG was not inevitable. A complex multi-decade negotiating process embedded in international power dynamics led to the adoption of GMST (see Figure 1a for a timeline). GMST does not adequately capture all dangerous climate risks, particularly SLR, and moves the metric for action away from the causes of climate change, i.e. greenhouse gas emissions. AOSIS has played a prominent role in negotiations since their inception. Their initial advocacy was for binding emissions reductions, and they were instrumental in later reorienting discussions from 2°C to 1.5°C as negotiations solidified around temperature as the LTGG.

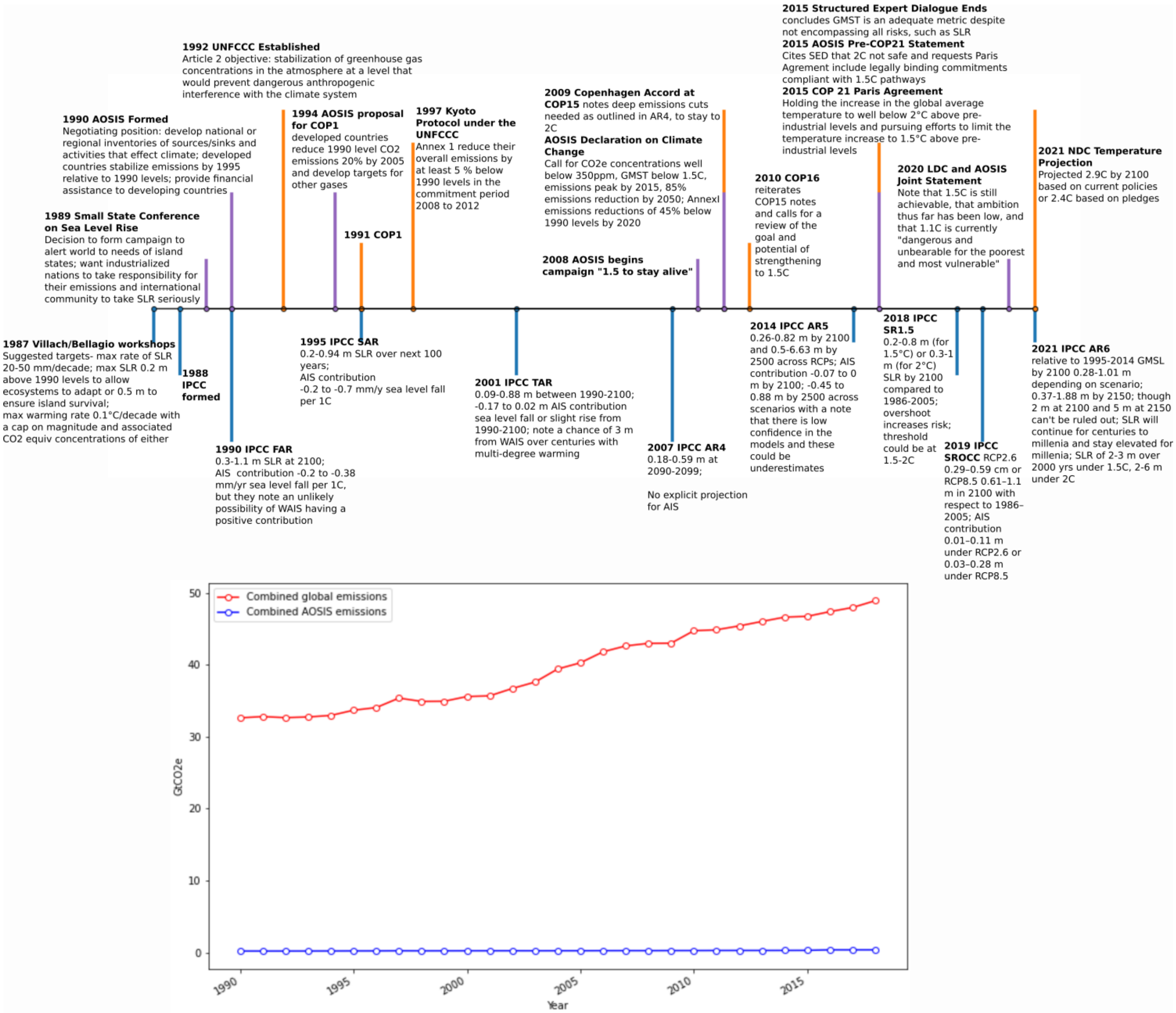


Figure 1. Emissions over time and major historical events. a) timeline of major historical events, statements, and publications shows UNFCCC proceedings (orange), AOSIS statements (purple), and IPCC and other scientific reports (blue). b) A comparison of global greenhouse gas emissions from 1990-2018 shows the low emissions contribution of AOSIS nations (blue) and increasing levels of total global emissions (red).

2.1 Early negotiations and potential targets

Beginning in the late 1980s, climate scientists held meetings to discuss options for climate targets. These focused on environmental indicators of change including stabilized atmospheric greenhouse gas concentrations (in CO_2 equivalent), and rates and magnitudes of GMST and SLR. These indicators were intended to be used to define quantitative targets with the possibility of combining several environmental indicators to be translated into emissions targets for regulatory policies (Jaeger, 1988; Rijsberman & Swart, 1990; Vellinga & Swart, 1991). They were also envisioned to serve as both evidence of the extent of the changes occurring and to monitor progress on policy implementation (Rijsberman & Swart, 1990). The rate-limit of temperature change was based on rates of past change that ecosystems adapted to, however this metric was abandoned because natural variability could produce rates higher than the proposed values (Randalls, 2010). The rate of change of sea level rise, with a cap on overall magnitude, was an early favorite among scientists, however lags in response times and ongoing uncertainty in SLR projections complicated the metric and it was rarely mentioned in the political arena (Rijsberman & Swart, 1990). Another reason could have been that SLR would mainly impact coastal communities and therefore may not have been as motivational to some countries. For instance Rijsbersman & Swart (1990, p.54) notes "For example, it is likely that the Maldives in the Indian Ocean would be devastated by a sea-level rise of only one meter. An absolute limit below this level would therefore be required *if saving the Maldives from destruction were a societal goal*" [emphasis added]. For GMST targets the rate of rise (0.1°C/decade) was suggested alongside a cap on the overall extent of the change. Suggested caps were 1°C, based on past ecosystem adaptation, and 2°C which was put forth as a hard upper limit beyond which climate responses could become nonlinear (Rijsberman & Swart, 1990).

International negotiations to confront climate change and establish an LTGG became centralized with the 1992 establishment of the UNFCCC. Annual negotiations, termed the Conference of the Parties (COP), began in 1995. Within the UNFCCC, the idea of equity is characterized through "common but differentiated responsibilities" (CBDR) and redistribution of wealth through financial aid and technology transfers (Hurrell & Sengupta, 2012; UN, 1992). CBDR is important since countries of the Global North [defined in the study as the USA, Canada, Europe, Israel, Australia, New Zealand, & Japan] are responsible for the largest share of historic greenhouse gas emissions (Hickel, 2020). The long residence time of greenhouse gases in the atmosphere, the lag time it takes to realize changes to the climate system (Liverman, 2009) and the fact that cumulative emissions determine the extent of climate damages make historical emissions relevant (Hickel, 2020). Equity and CBDR are key considerations of AOSIS, who have some of the lowest current and historic greenhouse gas emissions and are simultaneously among the most impacted, especially by SLR (Figure 1b) (Betzold, 2010).

2.2 AOSIS formation and binding emissions reductions

In 1990, following the first international conference on sea level rise hosted by the Maldives, the Alliance of Small Island States (AOSIS) was formed to increase the negotiating prominence of island nations and others sharing their concerns (Betzold et al., 2012; Ourbak & Magnan, 2018; Republic of Maldives, 1989; Shibuya, 1997). AOSIS represents 20% of the UN member states. Member nations are geographically widespread (AOSIS, 2021). They have varying interests, but are united in backing strong climate action (Kelman & West, 2009). Their joint efforts have impacted climate negotiations to a greater extent than possible individually. In the leadup to the establishment of the UNFCCC, they pushed for setting a binding emissions reduction target in which developed nations would stabilize their emissions at 1990 levels by 1995 (Ashe et al., 1999; Vanuatu, 1991). While wording related to stabilization of atmospheric greenhouse gas concentrations was included in the UNFCCC, a specific limit was not (Ashe et al., 1999). As noted by the AOSIS Chair and others: “AOSIS, whose member states are most vulnerable to the possible adverse effects of climate change, was particularly concerned about those provisions of the UNFCCC that were either watered-down significantly, made largely meaningless or excluded altogether. These include: the absence of definite targets or specific timetables, for the significant reduction of carbon dioxide by the industrialized countries of the North” (Ashe et al., 1999 p1). Subsequent AOSIS proposals at COP1 requested implementing UNFCCC Article 2 by requiring developed countries to reduce their 1990-level CO2 emissions by 20% by 2005 and to develop targets for other greenhouse gases (AOSIS, 1994). The United States and other countries, whose economies were based largely on fossil fuels, rejected this (Shibuya, 1997; UNFCCC, 1995).

In 1997 at COP3 the Kyoto Protocol set a target of legally binding emissions reductions (5% below 1990 levels) for developed nations (UNFCCC, 1997). However the agreement was not universally adopted by high emitters and emissions continued to rise globally at the end of the first commitment period in 2012 (Hurrell & Sengupta, 2012; UNEP, 2012). The US, the world's largest historic emitter, didn't ratify the Protocol (Gardiner, 2004) for several reasons: lobbying of Congress and the Bush administration by corporations and conservative think tanks, including those related to the fossil fuel industry (Brulle, 2014; Frumhoff et al., 2015; Supran & Oreskes, 2017), the rise of climate denialism, and the passage of a Congressional resolution prohibiting the US from signing onto a treaty that did not require developing countries to participate (McCright & Dunlap, 2003; Roberts, 2018). Fossil fuel industry lobbying was based on the economic interest of not devaluing their products and preference for keeping regulatory measures related to fossil fuel production at the national level and out of international treaties (Levy & Egan, 1998). These factors made the setting of binding emissions reduction targets virtually impossible and solidified the turn away from these targets and towards nationally determined pledges with a GMST target (Wewerinke-Singh & Doebbler, 2016).

2.3 Solidification of temperature targets

After Kyoto the 2°C temperature target rapidly gained prominence and solidified as the preferred LTGG within Europe. This was driven by many factors including the 2005 publication of a European Commission report determining 2°C the point at which the benefits of mitigation offset costs, and support for this metric at a number of high level European meetings including the G8 (Gao et al., 2017, Morseletto et al., 2017; Randalls, 2010). In opposition, AOSIS began formally advocating for a lower temperature target in 2008 using the phrase “1.5 to stay alive” (Benjamin & Thomas, 2016). COP negotiations became characterized by tension between those who wanted a 1.5°C target and those who wanted a 2°C target (Leemans & Vellinga, 2017; Morseletto et al., 2017).

Prior to COP15, AOSIS released their Declaration on Climate Change (2009) calling for the meeting outcome to include multiple interlocking targets including stabilization of atmospheric greenhouse gas concentrations at “well below 350 CO_2 -equivalent levels [meaning atmospheric greenhouse gas concentrations equivalent to 350 parts per million CO_2]”, GMST rise below 1.5°C, and emissions reductions of developed countries by 45% below 1990 levels by 2020. These calls did not gain traction and 2°C was written into the Copenhagen Accord with the intention of making it the LTGG, which was considered a “grave disappointment” to AOSIS negotiators (Liburd, 2021). However, the accord was not adopted, in part due to the objections of developing states over the lack of inclusion of 1.5°C (Benjamin, 2010; UNFCCC, 2009; Wewerinke-Singh & Doebbler, 2016). Farbotko and McGregor (2010, p.162) found that "The issue of a maximum 1.5°C temperature increase was pitched directly against the cost of reducing fossil fuel use before and during the Copenhagen COP. For Australia, the EU, China, India, the USA and many other states with fossil-fuel-dependent economies, reducing greenhouse gas emissions so significantly under the 1.5°C target was unpalatable at Copenhagen. The 1.5°C target advocated by [AOSIS nation] Tuvalu represented a significant void between its geographic vulnerability and financial interests elsewhere."

At COP16 in 2010, a coalition of middle and high income countries continued advocating for 2°C. Opposing them were a majority coalition of AOSIS and over 100 other countries that objected, arguing 2°C would put their survival at risk (Tschakert, 2015). They pushed for 1.5°C while acknowledging that no level of warming is safe (Knutti et al., 2016; Randalls, 2010; Seager, 2009; Tschakert, 2015). The compromise reached at COP16 was that 2°C would be the LTGG, necessitating deep near-term emissions cuts, but that it should be reviewed for adequacy with respect to UNFCCC Article 2 (UNFCCC, 2010**)**. AOSIS's insistence on 1.5°C led to the UNFCCC Structured Expert Dialogue (SED), a review of the scientific knowledge relating to the LTGG, which led to the inclusion of 1.5°C in the Paris Agreement.

The SED occurred from 2013-2015 to assess the adequacy of 2°C, the merit of strengthening the goal, and progress towards it (Benjamin & Thomas 2016; UNFCCC, 2015b). During the SED, Dr. Leonard Nurse noted that while islands in the Caribbean were experiencing temperature trends in line with the global average, they were experiencing higher than average SLR, while tropical western Pacific islands and locations in the Indian ocean were experiencing even higher rates (UNFCCC SBSTA, 2015a). SED participants noted that 'danger' is subjective and while fear of climate impacts united the parties, UNFCCC Article 2 divided them due to their disparate perceptions of acceptable risk (UNFCCC SBSTA, 2015a p64). The SED concluded that GMST was an adequate metric despite not encompassing all risks since other targets, or multiple metrics, would only reiterate the primary conclusion necessitating urgent near-term action. SLR was noted as being not well encapsulated by temperature targets. This is because the rate of mean SLR depends on CO_2 emissions paths (Mengel et al., 2018; DeConto et al., 2021), so if emissions reductions occur at an earlier time, long-term SLR responses are lower. This is unlike GMST which responds to cumulative emissions and is less dependent on emission times (UNFCCC SBSTA, 2015b). An IPCC author at SED wrote "the unevenness of the political landscape in discussions around 1.5ºC/2ºC as well as loss and damage is staggering...this unevenness epitomizes geographies of privilege, power, and inequality" (Tschakert, 2015, p.10).

2.4 The Paris Agreement

Preceding COP21 in 2015, AOSIS released a statement saying that 2°C is unsafe according to the SED outcome and requested that the Paris Agreement contain legally binding commitments compliant with 1.5°C pathways (AOSIS, 2015). They asked for SED results to be included at the COP, however objections from Saudi Arabia, China and other countries prevented this until the final days of negotiations (Benjamin & Thomas, 2016; Wewerinke-Singh & Doebbler, 2016). While 1.5°C was favored by a majority of parties, opposition came from countries with higher levels of historic emissions who opposed a stronger goal in part due to their potential culpability to loss and damage (Burkett, 2016; Hoad, 2016; Okereke & Coventry, 2016). AOSIS advocated for a legally binding protocol with firm emissions reduction commitments, but this was blocked by the US (Fry, 2016; Wewerinke-Singh & Doebbler, 2016). Instead, the 2°C target was formally adopted within the Paris Agreement, with the compromise language of pursuing efforts toward 1.5°C (UNFCCC, 2015). As a framework for achieving this, the agreement includes mechanisms for strengthening the global response through periodically revised NDCs and global stocktakes. The process outlined in the agreement is legally binding, though countries are not legally required to reduce emissions or achieve the proposals they include in their NDCs (Clémençon, 2016; UNFCCC, 2015; Wewerinke-Singh & Doebbler, 2016). Language on equity is included only in the preamble (in reference to the UNFCCC), and in Articles 2 and 4 in relation to CBDR and reducing emissions in the context of sustainable development (Klinsky et al., 2016; UNFCCC, 2015). Climate justice is only mentioned once in the preamble, where it states "noting the importance for some of the concept of 'climate justice' when taking action to address climate change" (UNFCCC, 2015).

2.5 Post-Paris

As of 2021, six years post-Paris, NDCs are insufficient to stay below a 2℃ GMST rise (Climate Action Tracker, 2021; UNFCCC, 2021) and 1.5°C may no longer be achievable (Schleussner et al., 2016; Warszawski et al., 2021; Zhou et al., 2021). Content analysis of NDCs show a continuation of the "divergent climate priorities that have existed within the UNFCCC for decades" (Stephenson et al., 2019 p1258). NDCs from AOSIS nations emphasize vulnerability and equity, while those of the US and EU nations demonstrate a lack of ambition on mitigation and a deprioritization of climate action in favor of economic priorities (Mills-Novoa & Liverman, 2019; Stephenson et al., 2019). The gap between rhetoric on climate and action specified in the

NDCs reveals the dichotomy between justice and economic and political power (Okereke & Coventry, 2016).

In summary, not all early target proposals (SLR, atmospheric greenhouse gas concentrations, temperature) put forth by the scientific community were given full consideration in negotiations. While the UNFCCC contains language on stabilizing atmospheric greenhouse gas concentrations, the Paris Agreement adopted GMST and moved away from emissions and concentration targets. While lower-emitting countries advocated for binding emissions targets on the basis of equity, higher emitting countries ultimately prevailed in achieving non-binding contributions. AOSIS advocated for binding emissions reductions targets, multiple metrics, and a lower temperature goal. Their negotiating position emphasized the uneven distribution of emissions versus impacts, noting that countries with high (low) emissions were among the least (most) impacted by climatic changes. However, despite the advocacy of AOSIS and others, non-binding pledges with temperature targets prevailed, in part due to power dynamics that privileged high-emitting nations. The negotiating position of AOSIS centered on their geographic vulnerability and the existential threat of sea level rise. To consider this we next turn to recognition justice.

3 Recognition justice - Adaptation, Displacement and Migration

AOSIS negotiators have always centered the current and future impacts of sea level rise in their negotiating positions. Recognition justice, recognizing differences in cultural and social groups and seeking to address injustices and systemic disadvantages between cultural groups (Fraser, 1997), is an under-researched topic in climate justice (Burnham et al., 2013a; Burnham et al., 2013b; Thomas et al., 2020). Long before the 2°C target was set, scientists predicted some islands could be pushed past adaptive limits due to inundation and saltwater intrusion into aquifers and atoll freshwater lenses, potentially rendering them uninhabitable (Pernetta & Hughes, 1990). This point is made often in AOSIS statements. Yet in the political realm, a goal that could ensure continued existence of all parties was not taken as a baseline need for an LTGG (Hoad, 2016). AOSIS leaders and the citizens of AOSIS nations often attribute their vulnerability to sea level rise to colonial history and ongoing aid dependence. The voices of people at the local and subnational levels experiencing SLR impacts are often left out of high level policy conversations and the physical sciences literature. This section reviews literature on how people in AOSIS nations perceive of and experience SLR, to motivate how this influences their negotiating position in international negotiations and their perspectives on climate justice more broadly.

3.1 Habitability, statehood, and exclusive economic zones

Especially in regards to atoll states, questions have been raised related to whether island states could lose statehood if their territories are submerged. Under international law expressed in the Convention on Rights and Duties of States (1933) a state must have “a defined territory”. However legal scholars have suggested this pertains more to the formation of a state than its dissolution and have posited multiple ways statehoods could be maintained if territory is lost (Yamamoto & Esteban, 2014), such as expanding the definition of statehood to include recognition of states constituted by people in diaspora (Burkett, 2011). Despite this, the uncertainty of the legal status is a concern in AOSIS nations. For example in this statement from the 2020 Thimphu Ambition Summit: “High on the minds of representatives was the sobering reflection that in another 75 years many of their members may no longer hold seats at the United Nations if the world continues on its present course and average warming exceeds 1.5°C” (AOSIS and LDC Group, 2020). Habitability questions will arise before submersion occurs, and will need to be ultimately decided by residents themselves (Liburd, 2021b). In addition to the issues related to the loss of habited locations, the submergence of uninhabited islands has potential ramifications for legal boundaries of Exclusive Economic Zones. EEZs define the boundaries within which a country has exclusive economic rights to resources as being within 200 nautical miles of the coast so loss of EEZ territory could lead to loss of resources and income (Yamamoto & Esteban, 2014). However the Pacific Islands Forum has declared that “our maritime zones, as established in accordance with the Convention [on the Law of the Sea].... shall continue to apply, without reduction, notwithstanding any physical changes connected to climate change-related sea-level rise” (Pacific Islands Forum, 2021).

3.2 Migration: discourses and perspectives

Island studies scholars have stressed that nuance, local perspectives, and historical grounding are needed in conversations on SLR and migration. AOSIS nations vary widely in terms of geomorphology, social and cultural makeup, and history (Barnett & Campbell, 2011; Bouchard, 2001; Perumal, 2018; UNDP, 2010), yet there is a tendency to view island nations as homogeneous and universally vulnerable (Kelman, 2018). While loss of land is referenced often in official statements, both negotiators and the general population in most states reject the narrative of inevitable climate refugees and emphasize their preference for mitigation and aid sufficient to allow for them to adapt in place (Corendea, 2016; Farbotko & Lazarus, 2010; McNamera & Gibson, 2009; Perumal, 2018; Thomas & Benjamin, 2018). Given uncertainties in the science and in the limits of adaptation, framings of inevitable loss of islands, which are common in the media, can normalize conditions that AOSIS residents are seeking to avoid (Barnett, 2017; Perumal, 2018). The discourse surrounding migration also presents narratives of climate refugees that promote victimization and lack of agency which can increase their marginalization while being at odds with how people in island nations see themselves and their own relationships to migration (Kelman, 2018; Kelman, 2020). Media narratives presenting island populations as inevitable refugees, or the loss of islands as 'canaries in the coalmine', have been criticized as falling into what has been termed the 'eco-colonial gaze' (Farbotko, 2010). Narratives of climate refugees are not always accurate as relocations have many underlying factors, and these narratives can have negative ramifications on how islanders view their environment (Siméoni & Ballu, 2012). Pacific scholars have put forth that imperialism created the view of islands as small, poor, and isolated, but that this contrasts with the expansive view islanders hold of an ocean of connected islands inhabited by resilient people who constantly adapt to ocean changes (Hau'ofa, 1994). In light of this, the term "large ocean states", emphasizing the reach of their ocean-based territory is often preferred to the more common "small island developing states" (Chan, 2018).

Even if states are not fully lost to sea level rise issues of recognition relating to SLR remain. Social values and identities of island populations are tied to physical place, but the physical changes SLR causes, and the adaptation measures used to confront them, pose risks to cultural heritage sites, burial grounds, and long-term habitability (Graham et al., 2013; Marzeion & Levermann, 2014; Mueller & Meindl, 2017; Oppenheimer et al., 2019). The UN Special Rapporteur on cultural rights has noted that "While most human rights are affected by climate change, cultural rights are particularly drastically affected, in that they risk being simply wiped out in many cases", highlighting SLR as an example (UNGA, 2020). Due to these factors, instances of relocation, regardless of statehood status, impact recognition justice (Robinson, 2020; Yamamoto & Esteban, 2014). In some Pacific and Caribbean island communities relocation due to environmental hazards has occurred, though few countries have national policies for this (Thomas & Benjamin, 2018c). Kiribati is the only country with a plan for international migration, as they have purchased land in Fiji (Corendea, 2016; Thomas & Benjamin, 2018c). In interviews, residents of villages in Fiji and Tuvalu note that people already view SLR as impacting their lives and expect that trend to continue (Martin et al., 2018; McMichael et al., 2021; Piggot-McKeller et al., 2021). Incremental retreat, which has already occurred in some villages in Fiji, where new construction must take place on higher ground, can be a way for people to maintain their place-based grounding to an extent (Piggot-McKeller et al., 2021). However preferences around relocation and adaptation responses vary between individuals and can be characterized by generational differences. Short distance relocation is not the preference of all community members (Martin et al., 2018; McMichael et al., 2021; Piggot-McKeller et al., 2021). Binary and linear discourses on remaining or leaving is in contrast to lived experiences of island residents (McMichael et al., 2021). Placed-based cultural connections are often very strong such that even when residents expressed seeing graves and homes wash away they express a strong desire to stay and retain their culture (McMichael et al., 2021).

3.3 Legacies of colonization

AOSIS states have traditionally had high adaptive capacity for environmental change, however these capacities were reduced in many places due to colonization and globalization (Barnett, 2001; Barnett & Campbell, 2011; Bordner et al., 2020; Douglass & Cooper, 2020; Nunn & Campbell, 2020). Almost all AOSIS nations have histories of being colonized, and the majority gained independence within the past century (United Nations, 2021). Legacies of resource extraction, colonial occupation, genocide, and forced migration increase vulnerability to SLR and other climate impacts, a situation that scholars are increasingly calling for recognition of (Baptiste, 2016; Barnett & Campbell, 2011; Bordner, 2020; Corendea, 2016; Douglass & Cooper, 2020; Hau'ofa, 1994; Kelman, 2018). Anthropological and paleoecological research demonstrates that in the Caribbean, for example, genocide in the 16th century carried out by Europeans led to loss of the traditional ecological knowledge of past adaptation strategies and introduced more vulnerable infrastructure and settlement patterns (Douglass & Cooper, 2020). The introduction of new settlement patterns, loss of traditional ecological knowledge, and removal of mangrove forests following European colonization is also implicated in increased vulnerability of Pacific volcanic islands (Nunn & Campbell, 2020). In the Indian Ocean political and economic marginalization from past colonization, as well as current economic reliance on extractive industries and tourism increase vulnerability (Bouchard, 2008; Douglass & Cooper, 2020). In the Marshall Islands narratives of sea level rise leading to unavoidable migration can activate collective trauma from their history of forced migration to escape nuclear contamination following US nuclear weapons testing on their islands (Bordner et al., 2020). While different islands have different histories, geomorphologies, and current socioeconomic conditions, this history shapes AOSIS states today.

Colonization was in part motivated by extraction of wealth which paved the way for industrialization that released fossil greenhouse gas emissions (Sealey-Huggins, 2017). Contemporary climate change is tied to global power and inequity, which is in turn tied to economic development (Hurrell & Sengupta, 2012). Colonial legacies are a key factor in the creation of these gradients of power and wealth, and the resulting systems of dependency in terms of debt, aid, and international political power (Barnett & Campbell, 2011; Bordner et al., 2020; Sealey-Huggins, 2017). Several high-emitting countries, such as the US, Australia, and European nations who advocated for 2°C were colonizing nations whose actions reduced the natural adaptive capacities that island nations traditionally had (Barnett, 2001; Barnett & Campbell, 2011; Bordner et al., 2020; Douglass & Cooper, 2020; Nunn & Campbell, 2020).

These historical dynamics between industrialized high emitters and more vulnerable states come into UNFCCC negotiations through mechanisms to address loss and damage. One concrete approach is to allocate financial aid, leading to questions about who qualifies, how this will be determined, and who pays (Klein & Möhner, 2011). Yet in later negotiations and within the Paris Agreement, there has been a shift away from financial reparations for loss and damage on the part of countries with larger historical emissions, higher wealth, and colonial histories (Morgan, 2016; Okereke & Coventry, 2016). Instead, places with higher vulnerabilities become reliant on international financial aid for adaptation projects. Developed countries had agreed to provide $100 billion per year in financial assistance to developing nations however currently nations have provided far less, much in the form of loans, and only 3% of the total has gone to small island developing states [most SIDS are AOSIS members, but not all] (Oxfam, 2020; Virtual Island Summit, 2021). Aid providers who view migration as unavoidable don't provide adequate funding for the extent of adaptation islanders see as necessary to achieve their goal of adapting in place (Bordner et al., 2020). Moreover, there is also no mechanism of accountability of multinational corporations who are responsible for the majority of industrial emissions (Frumhoff, 2015; Heede, 2014). Scientific research has attributed 50% of the rise in GMST and 32% of the current sea level rise to emissions from industrial producers over the full historical period (1880-2010). A substantial portion of this contribution is from recent decades (1980-2010) where 35% of the GMST rise and 14% of the GMSL rise are attributed to the top 90 industrial producers (Ekwurzel et al., 2017).

3.4 Inclusion

Recognition justice would also entail increased consideration of local perspectives and support for AOSIS researchers in the scientific community. This would yield a wider reach in regards to policy influence and a greater understanding of the nuances of SLR impacts. AOSIS nations are very supportive of the work of the IPCC and reference its reports often, however their researchers are significantly underrepresented on IPCC author teams (Barnett & Campbell, 2011; Livingston & Rummukainen, 2020; McSweeney, 2018; O'Reilly, 2012; Walshe, 2018). Following the publication of IPCC AR5 in 2014 there was an expanded interest in issues of justice and migration, however scholarship on this has been dominated by developed nations (Robinson, 2020). Determining the impact that SLR will have locally will require more detailed regional studies and increased research funding (Robinson, 2020). Most current research focuses on the Pacific, with Caribbean, Indian, African, and South China Sea regions understudied (Douglass & Cooper, 2020; Robinson, 2020). In NDCs several AOSIS nations noted wanting to collect "geospatial, migration and displacement data...but lack the financial resources to do so" (Thomas & Benjamin, 2018c p95). In policy discussions and scientific research there is also a lack of local community perspectives (Baptiste, 2016; Barnett, 2017; Klinsky & Dowlatabadi, 2009; Perumal, 2018; Thomas & Benjamin 2018b) and traditional Indigenous knowledge and other local knowledges (David-Chavez & Gavin, 2018; Kelman & West, 2012). This is reflected in the words of Marshallese poet Kathy Jetñil-Kijiner reflecting on her time speaking at COP negotiations "I was told to perform my poem and then sit down while the professionals spoke" (Jetñil-Kijiner, 2021). Science relevant to island nations is also lacking from a modeling standpoint since the resolution of global climate models used for future assessments is too coarse to capture most islands and downscaling or aggregation by region can obscure them (Kelman & West, 2012; Nurse et al, 2014). Bridging diverse assessments of SLR, including scientific assessments, local, and Indigenous knowledge systems will aid understanding of SLR impacts and responses (McMichael et al., 2021).

In sum, while SLR could potentially lead to loss of territory and migration in some places, islanders have repeatedly emphasized the desire to adapt in place and not allow discourses of inevitable migration to limit adaptation possibilities. In the literature there is a tendency to homogenize island nations rather than gain a deeper understanding of their diverse perspectives. The diversity between places means that SLR impacts will be widely varying as well. The greatest potential habitability impacts are in atolls, but even at higher elevations the long-term SLR commitment will alter coastlines and impact populations for generations to come. The extent of multigenerational recognition justice remains to be seen and will be determined by nearterm policy and emissions. Increased recognition of local perspectives and further studies at the regional level are needed to guide adaptation planning. As historical oppression impacts adaptive capacity, recognition of this, and financial compensation, are key to any consideration of climate justice. Recognition justice and the continued existence of islanders in their homes, especially across generations, will be in part determined by the temporal and spatial distribution of sea level rise, which we turn to next.

4 Distributive justice

Distributive justice relates to addressing spatial and temporal variability of climate impacts, particularly with respect to uneven contribution to the causes of climate change. Distributive justice is tied to recognition justice as differences in distribution of resources and impacts are often related to hierarchies in cultural, political, and social groups (Fraser, 1997). The spatial and temporal distribution of sea level rise impacts are unaccounted for in GMST targets. Many AOSIS nations already experience SLR rates higher than the global average, but have had very low contributions to the greenhouse gas emissions driving it. This mismatch has been shown to be a source of inequity (Althor et al., 2016). Moreover, higher sea levels will persist for centuries to millennia, with the exact time profile to be determined by emissions pathways (Mengel et al., 2018). Finally, overshoot pathways, a feature of temperature targets, have become normalized via integrated assessment modeling, even though overshoot pathways increase the risk of SLR (DeConto et al., 2021).

4.1 Regional sea level rise

Regional SLR is projected to differ from GMSL (Clark & Lingle, 1977; Gomez et al., 2010; Hamlington, 2020; Nurse et al., 2014; Oppenheimer et al., 2019). Impacts vary spatially due to thermal expansion, gravitational, and Earth rotational effects from changing land ice storage, glacial isostatic rebound, land subsidence, and other factors. Gravitational, Earth rotational, and deformational (GRD) effects associated with ice sheet mass loss have been shown to explain variations in regional sea level observed in tide gauges (Farrel & Clark, 1976; Mitrovica et al., 2001). Current sea level trends show high SLR rates at many AOSIS locations, though analysis is complicated by sparse tide gauge locations and short observation periods (Holgate et al, 2013; Palanisamy et al. 2012; Hsu & Velicogna, 2017). In the Caribbean basin, the average SLR is in line with the global mean (Jevrejeva et al., 2020; Palanisamy et al. 2012), however small scale regional variability is large with some places experiencing substantially higher rates (up to 5.3 mm/yr) (Torres & Tsimplis, 2013) and a recent rapid rise was detected (Ibrahim & Sun, 2020). In the western tropical Pacific SLR rates are up to 4 times the global average (Hamlington, 2020; Nurse et al., 2014). At Funafuti in Tuvalu, rates are significantly higher than the global mean (5 mm/yr) with the island experiencing 30 cm of SLR over the past 60 years (Becker et al., 2012). In the Indian Ocean SLR is occurring 37% faster than the global average and can differ regionally from expected rates. For instance in the Seychelles the expected rate is 2.21 mm/yr while the actual rate is 5.19 mm/yr (Jyoti et al., 2018).

While there are regional differences, local-scale physical geographic features will also determine impact (Mycoo, 2018; Simpson et al., 2010). For example, islands situated on atolls and reefs typically have maximum elevations around 3 meters while volcanic islands have higher elevations (Kumar & Taylor, 2015; Mimura, 1999; Nurse et al., 2014). Island nations often have population centers and built infrastructure proximal to the land-ocean interface in regions that already experience flooding and erosion (Magnan et al., 2019). Most Pacific island nations have the majority of infrastructure within 500 m of the coast, while Tuvalu, the Marshall Islands, and Kiribati have 95% of infrastructure within that distance (Kumar & Taylor, 2015).

Damage from SLR is often due to extreme sea level events arising from storm surge, cyclones, wave propagation or other factors. Tropical storms lead to the largest sea level extremes in the South Pacific and northern Caribbean. The severity and frequency of these events is intensified by climate warming in a number of ways, including through sea level rise. Tropical storms have caused damage to island nations in recent years, a trend projected to worsen, even under low emissions (Hoegh-Guldberg et al., 2018; Magnan et al., 2019). In many locations, flood events that historically occurred once every hundred years are projected to become annual in the coming decades even under RCP2.6 (Oppenheimer et al., 2019). Modeling work in Fiji has shown that local inundation impacts will vary based on topography, bathymetry, and wind conditions (Sabūnas et al., 2020). The impact of waves in addition to SLR can double flood heights during extreme events (Arns et al., 2017; Biondi & Guannel, 2018). Wave impacts can also double the inundation area, which could make some atolls uninhabitable within decades (Storlazzi et al., 2015). A study considering nonlinear interactions between SLR and wave induced overwash finds two tipping points for atoll islands by mid-century under Paris compliant pathways- a lack of potable drinking water due to salinization and the time at which more than half of the island could experience annual flooding (Storlazzi et al., 2018). Using an updated methodology for assessing elevation it was found that 1 million people in the Caribbean live less than 1 m above local high tide while 600,000 less than 0.5 m above tides. Flooding of 0.5 m above high tide could be common within decades with floods above 1 m occurring by 2100 (Strauss, & Kulp, 2018). Assessments of atoll habitability will need to consider multiple interlocking risk factors to understand how risk varies in different locations (Duvat et al., 2021). Due to these complicating factors local scale impacts in island nations can be substantial, and are worsened by warming above 1.5°C (Hoegh-Guldberg et al., 2019).

4.2 Temporal justice

SLR is a slow onset event which presents intergenerational equity concerns. Temporal justice is a guiding principle stated in Article 3 of the UNFCCC: "the Parties should protect the climate system for the benefit of current and future generations" (UN, 1992). Paris Agreement Article 8 states "the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including...slow onset events." SLR is a slow onset event which presents intergenerational equity concerns.

Sea level rise will increase over time, therefore assessing the climate justice implications of temperature targets necessitates a consideration of distributive impacts over the long-term. The year 2100, while not directly mentioned within the Paris Agreement, is the main point of temporal reference generally associated with it. While policy discussions focus primarily on the current century, many predicted changes to the Earth system, including SLR, are irreversible. The implications for intergenerational equity are vast considering sea levels are projected to continue to rise for thousands of years, with no hope of returning to present values for the foreseeable future (Clark et al., 2016; DeConto et al., 2021; Oppenheimer et al., 2019). The long-term SLR committed by the NDCs is at least 1 m by 2300 and higher thereafter unless the world stays below 1.5°C (DeConto et al., 2021; Fox-Kemper et al., 2021; Nauels et al., 2019). Even if a 1.5°C temperature target is achieved, SLR could still rise by 2.3-3.1 m over 2000 years and 6-7 m over 10,000 years. Under 2°C the commitment would be 2-6 m and 8-13 m, respectively (Clark et al., 2016; Fox-Kemper et al., 2021).

Past inaction suggests that these temporal justice concerns may accelerate in the future. It took 23 years from the UNFCCC establishment to the creation of the Paris Agreement, while emissions continued to increase (Figure 1b). Emissions released over that time have increased the long-term SLR commitment. An analysis of this commitment shows that emissions that occured between 1991-2016 will lead to 12 cm more SLR by 2100 and 25 cm more by 2300. Of these values, emissions from the top 5 highest emitters during that time period (China, US, EU, Russia, India) are responsible for 7 cm by 2100 and 14.4 cm by 2300 (Nauels et al., 2019).

4.3 Overshoot pathways and integrated assessment modeling

Spatial and temporal justice concerns are magnified by the current trend in the acceptance of overshoot pathways. Overshoot pathways allow for the temporary exceedance of the temperature target if it can be returned to at a later time, for example, by using negative emissions technologies such as carbon capture to reduce atmospheric greenhouse gas concentrations and GMST (Rogelj et al., 2018). The Paris Agreement came with an invitation for the IPCC to compile a Special Report assessing pathways by which the goals were achievable and highlighting differences in impact and risk between 1.5-2°C (Ourbak & Tubiana, 2017**;** UNFCCC, 2016). This invitation represented a shift in interaction between scientists and policy as it was the first time the IPCC directly engaged with the question of the temperature targets which were formerly thought to be too political and thus not in line with the IPCC mandate to be policy relevant but not policy prescriptive (Livingston & Rummukainen, 2020). The report showed substantial differences in risk between the two temperature goals and found that the majority of 1.5°C-compliant emissions pathways required temperature overshoot (Rogelj et al., 2018).

Integrated assessment models (IAMs) used to produce the pathways are optimization models operating under neoclassical economic assumptions (Carton, 2019) which rely on "minimization of mitigation expenditures, but not climate-related damages" (Rogelj et al., 2018 p98). In other words, while they model the costs and feasibility of different scenarios, they do not consider the cost of climate damages. Specifically, when IAMs contain overshoot pathways there is no accounting for irreversible climate damages incurred during an overshoot period which would not have happened in the absence of overshoot (Tavoni & Socolow, 2013). Modelled pathways from IPCC AR4, released in 2007, primarily assessed scenarios with atmospheric CO_2 concentrations of 550-650 ppm. The few IAMs that considered a lower 450 ppm concentration broadly consistent with 2°C targets incorporated overshoot and drawdown with carbon dioxide removal, a new modeling development at the time. This dramatically underestimated the cost, making those scenarios look more feasible (Tavoni & Tol, 2010). At that time European nations were consolidating around support for 2°C, modelers were asked to further assess these more stringent pathways for IPCC AR5 (Randalls, 2010; Tavoni & Socolow, 2013). This required expanding use of overshoot pathways to be achievable (Tavoni & Socolow, 2013). The normalization of overshoot pathways, thus, serves to allow the continuation of the status quo fossil fuel-based emissions and in turn helps to justify delays in mitigation during international climate negotiations. This process has been termed the “political economy of delay” (Carton, 2019). Since IAMs rely on cost-minimization, anticipating negative emissions becomes a substitute for near-term emissions reductions. However negative emissions technologies are unproven and one analysis determined that if they fail to deliver the stated reductions or come with side effects, they could increase overshoot by up to 1.4°C (McLaren, 2020). Distributive justice issues inherent in integrated assessment modeling have only recently been acknowledged within the modeling community (Jafino et al., 2021).

The distributive implications of climate policy are key for assessing justice (Klinsky & Dowlatabadi, 2009) and the additive sea level impacts caused by overshoot presents a key challenge to distributive justice. Framing overshoot pathways as acceptable under the Paris Agreement simultaneously justifies the targets as achievable, while legitimizing the lack of action likely to render them unachievable. If the >2°C pathway implied by the NDCs is followed, implementing carbon dioxide removal after 2060 in hopes of meeting the Paris Agreement goal will likely be too late to prevent a sharp jump in SLR. Every decade of delay thereafter comes with a commitment to higher, long-term SLR despite reductions in GMST (DeConto et al., 2021). If the commitments to future SLR are locked in, then the inclusion of pathways that allow for an overshoot exacerbate the distributive climate justice issues brought about by insufficient global climate action.

In sum, overshoot pathways have been used to justify nearterm delays in emissions reductions. Their normalization within the global climate and policy spheres, will exacerbate pre-existing justice issues for communities confronting sea level rise. AOSIS nations are already experiencing higher than average rates of SLR in many locations. Given their small contribution to emissions, the impacts of sea level rise present a distributive injustice. As discussed next, this trend of higher impacts from SLR will become more severe if Antarctic instability thresholds are breached.

The preceding three sections have looked into procedural, recognition, and distributive justice considerations of using GMST, normatively framed as being by 2100, as the international metric for climate action. We have found that procedural power dynamics between negotiating parties solidified the GMST target as opposed to a target like binding emissions reductions initially advocated by AOSIS negotiators. Furthermore, sea level rise has an uneven spatial footprint, long term irreversible impact, and can become exacerbated by the overshoot pathways normalized by temperature targets. The impacts of sea level rise have long been a concern to AOSIS nations as they threaten the physical spaces and cultural practices of these nations. We now turn to highlighting the complexities of the Earth system processes that contribute to future SLR and the implications of these complexities for AOSIS nations through a case study of the Antarctic Ice Sheet (AIS) component of SLR.

5 Antarctic case study

The Antarctic Ice Sheet is the biggest wildcard in SLR projections and has the potential to dominate the long-term response. Scientific knowledge of Antarctica and its contribution to SLR has expanded greatly in the past few decades. The Antarctic component of SLR will exacerbate the uneven impacts for AOSIS nations and others over the coming centuries (Figure 2). AIS melt could also lead to negative feedbacks on GMST rise (Golledge et al., 2019; Sadai et al., 2020), which could potentially be used to justify the increase in allowable carbon budgets further enabling the political economy of delay. It is crucial to understand that any negative feedbacks on GMST resulting from AIS melt would occur in conjunction with SLR and would therefore be at the expense of AOSIS nations and coastal communities, exacerbating climate injustice.

5.1 Historical and current Antarctic science

The AIS stores the largest potential reservoir of freshwater, with a GMSL equivalent of 58 meters (Morlighem et al., 2020), and the current science projects it could become the largest contributor to long-term SLR (Clark et al., 2016; DeConto et al., 2021; Fox-Kemper et al., 2021;

Golledge et al., 2015; Rintoul et al., 2018). Antarctica has a unique bed configuration in which substantial regions of the ice sheet are in direct contact with the ocean and lie on bedrock below sea level (Morlighem, 2020) making it vulnerable to instabilities. This has been a cause for concern since the 1970s (Mercer, 1978; Oppenheimer & Alley, 2005; Weertmen, 1974). While the combined melting of land ice (Antarctica, Greenland, and all glaciers) is already the dominant component of SLR, exceeding the rate of thermal expansion (Oppenheimer et al., 2019), Antarctica could become the primary contributor under high emissions scenarios leading to non-linearly increasing SLR (Rintoul et al., 2018). Under such circumstances the current rate of global mean SLR of ~3.6 mm/yr (2006-2015) could increase by an order of magnitude to rates of centimeters per year (Oppenheimer et al, 2019).

The science of the Antarctic contribution to SLR has advanced significantly over the past decades, as has modeling showing the projected climatic impacts. While portions of the AIS were known since the 1970's to be vulnerable to destabilization, throughout the 90s and into the 2000s the first, second, and third Intergovernmental Panel on Climate Change (IPCC) reports reflected the scientific consensus at the time which was that AIS would almost certainly have a net gain of mass through 2100 (Figure 1a). This is due to higher snowfall in a warming atmosphere, the result being AIS contributing to a sea level fall instead of rise (Church et al., 2001; Warrick & Oerlemans, 1990; Warrick, et al. 1996). Models used for projections in the IPCC Third Assessment Report (TAR) in 2001 had ruled out dynamical processes occurring in the 21st century which could result in larger SLR from AIS instability as these were assumed to only be possibly on longer multi-century timescales with warming of a few degrees (Church et al., 2001), however scientific advancements following its publication suggested that threat was likely underestimated (O'Reilly et. al, 2012; Rapley, 2006). Shortly before the publication of IPCC Assessment Report 4 (AR4) in 2007, observational evidence showed that rapid ice loss was already occurring in sensitive regions of the West Antarctic Ice Sheet. These results were discovered too late to be included in the report, though were noted by the author team (IPCC, 2007; O'Reilly, 2012).

By the time of IPCC Assessment Report 5 (AR5) in 2014, physics based models had advanced significantly and showed the potential for larger Antarctic SLR contributions (Church, 2013; O'Reilly, 2012). The ice sheet modeling community was increasingly recognizing that marine based sectors of the AIS were vulnerable to instability. This was recognized within AR5 where it states "Only the collapse of the marine-based sectors of the Antarctic ice sheet, if initiated, could cause GMSL to rise substantially above the likely range during the 21st century. This potential additional contribution cannot be precisely quantified but there is medium confidence that it would not exceed several tenths of a meter" (Church, 2013, p. 1140). This led to expanded research into instability points following the release of this report. At present, observation evidence shows an increasing SLR contribution (Shepherd et al, 2018). Modeling developments are showing the potential for even greater Antarctic ice loss than previously projected mainly as a result of brittle glaciological processes including meltwater-enhanced break up of ice shelves and rapid calving at tall ice cliffs, not included in previous modeling studies. Yet despite observational evidence of these processes in nature there is ongoing debate regarding their validity and their application to Antarctica (DeConto & Pollard, 2016; DeConto et al., 2021; Edwards et al., 2019; Fox-Kemper et al., 2021). There is a long-standing documented tendency for scientists to err on the side of more conservative estimates, which contributed in the past to the lower AIS SLR estimates seen in TAR and AR4 (Brysse, 2013). Yet erring on the side of conservative estimates can work in opposition to the precautionary principle enshrined in the UNFCCC as policymakers are generally not preparing for the worst case scenarios (Brysse, 2013).

Today, much of the Antarctic continent is fringed by buttressing ice shelves that slow the seaward flow of the ice sheet (Fürst et al., 2016). The loss of these ice shelves can trigger dynamic instabilities in the ice sheet, with the potential to produce rapid sea level rise (Oppenheimer et al., 2019). Recent work suggests the global warming threshold for the onset of widespread ice-shelf loss could be as low as 1.5-3°C (DeConto et al., 2021; Fox-Kemper et al., 2021; Hoegh-Guldberg et al., 2018). One recent modeling study showed that with global mean warming limited to less than 2°C, SLR from Antarctica will likely remain modest within the current century but could rise to 1-2 m on multi-century timescales (DeConto et al., 2021; Fox-Kemper et al., 2021). Given that Paris Agreement aspirations are not currently being met, it remains prudent to consider the implications of temperatures exceeding 2°C this century. With 3°C warming committed by the current NDCs, sea levels are projected to rise up to 0.2 m this century, and 1.5 m by 2300 from the AIS contribution alone (DeConto et al., 2021). Temperatures beyond 3°C could lead to substantial disintegration of the marine-based sectors of the ice sheet (Fox-Kemper et al., 2021). Once ice shelves are lost and instabilities are triggered, the long thermal memory of the ocean will impede the re-growth of the ice sheet, leading to centuries of ongoing SLR even if carbon dioxide is removed from the atmosphere (DeConto et al., 2021).

5.2 Projections of AIS SLR for AOSIS locations

As the ice sheet loses mass, reduced gravitational attraction between ice and water leads to a draw down of the sea surface resulting in sea levels falling within ~2000 km of the melting ice sheet, while sea level rises outside this zone increasing with distance from the location of ice loss. Uplift of the solid Earth beneath retreating marine sectors of the AIS reduces water accommodation space and expels water out into the global ocean, amplifying the SLR away from Antarctica (Gomez et al., 2010; Pan et al., 2021). A shift of the Earth's rotation axis towards the missing ice mass, and Earth deformation associated with water loading across the global ocean both contribute further geographic variability in the far field sea level rise.

The maps showing spatial heterogeneity of SLR produced by Antarctic ice loss in Figure 2 indicate that regions in the Atlantic, Pacific, and Indian ocean basins are at disproportionate risk from the AIS component of SLR (Gomez, et al., 2010; Mitrovica et al., 2011). These maps show how much regional sea level would differ from the global mean for each of the 38 AOSIS member nations. We find that all AOSIS countries will experience SLR from Antarctica that is at least 11.6% higher than the global mean and that the majority (22-32 countries, depending on scenario) will experience an average SLR more than 20% higher than the global mean, with some up to 33% higher (Table 1, Figure 2). This remains true regardless of emissions trajectories (medium-high emissions) or time periods considered (2100-2300) (see Methods). Under high emissions simulations where the ice sheet includes marine ice cliff instability (MICI) in addition to marine ice sheet instability (MISI) the spatial pattern changes slightly. MISI occurs when buttressing support from fringing ice shelves is lost in sections where the bed deepens upstream, leading to runaway retreat of the grounding line. MICI is theorized to occur when fringing ice shelves are lost, leading to the exposure of ice cliffs at thick ice margins, which are vulnerable to collapse if they exceed a critical height and lose structural integrity (DeConto & Pollard, 2016; Pattyn et al., 2018).

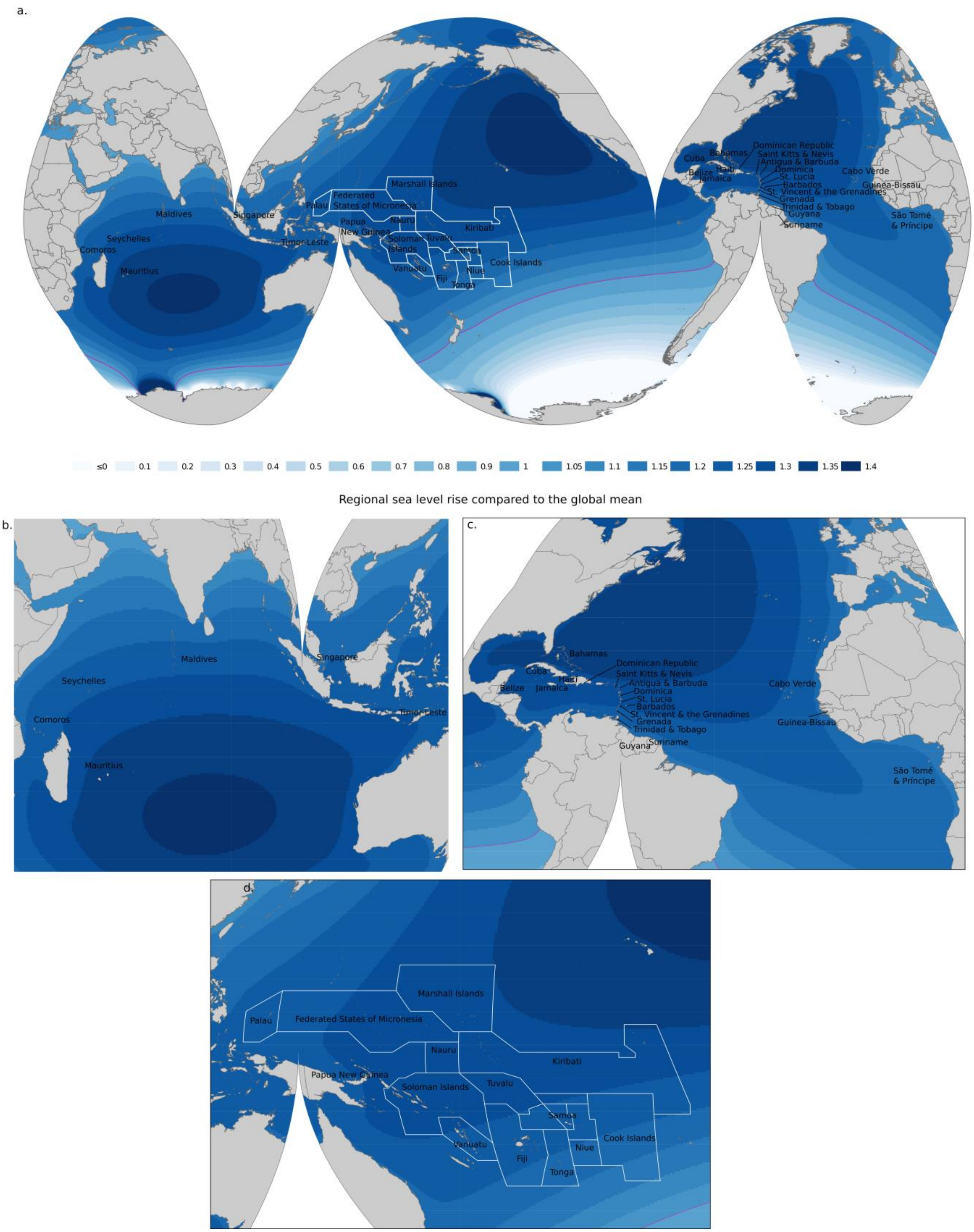
Due to GRD effects, the spatial pattern of Antarctic-driven SLR shows the largest amplification occurring near the center of ocean basins, with values tapering by coastlines (Gomez et al., 2010; Figure 2). As a result, Mauritius (near the center of the Indian Ocean) experiences the highest SLR of all AOSIS nations. The countries experiencing the second and third highest SLR are the Bahamas and Cuba due to their positioning within a North Atlantic basin sea level bulge. This pattern holds across both emissions scenarios and all time periods where the ice model only considers MISI processes. In the case where both MISI and MICI processes are included the sea level bulge over the Pacific Ocean is more centered over the basin leading to the western Pacific experiencing the highest AIS-sourced SLR. The most impacted nations under this scenario are the Marshall Islands, Kiribati, Nauru, the Federated States of Micronesia, Tuvalu, and Palau. In either scenario the Cook Islands, Guyana, Suriname, Guinea-Bissau, and São Tomé and Príncipe consistently see the least amplification of SLR, though importantly it remains 12-17% above the global mean. This is due to their geographic placement. The Cook Islands are the southernmost islands of Oceania, closest to the Antarctic Ice Sheet and the delineation between sea level rise and sea level fall. The remaining countries with lower impact lie in regions of tapering sea level impact along continental margins: São Tomé and Príncipe are the largest islands of archipelagos close to the western equatorial coast of Africa, Guyana and Suriname are continental lying on the northern coast of South America, while Guinea-Bissau is on the northwest coast of Africa.

	RCP45 MISI 2100 PAGM	RCP45MISI 2200 PAGM	RCP45 MISI 2300 PAGM	RCP45 MISI 2100 MEAN SLR (m)	RCP45 MISI 2200 MEAN SLR (m)	RCP45 MISI 2300 MEAN SLR (m)	RCP85MISI 2100 PAGM	RCP85MISI 2200 PAGM	RCP85 MISI 2300 PAGM	RCP85MISI 2100 MEAN SLR (m)	RCP85MISI 2200 MEAN SLR (m)	RCP85 MISI 2300 MEAN SLR (m)	RCP85MICI 2100 PAGM	RCP85MICI 2200 PAGM	RCP85MICI 2300 PAGM	RCP85 MICI 2100 MEAN SLR (m)	RCP85 MICI 2200 MEAN SLR (m)	RCP85 MICI 2300 MEAN SLR (m)
Antigua and Barbuda	28.84	27.24	27.32	0.073	0.24	0.462	30.03	27.89	28.59	0.043	0.487	1.654	22.88	23.19	21.81	0.418	6.566	11.657
Bahamas	30.99	29.31	29.44	0.075	0.244	0.47	32.66	30.4	30.95	0.044	0.497	1.684	23.1	23.53	21.64	0.419	6.584	11.641
Barbados	25.76	24.22	24.34	0.072	0.234	0.451	26.58	24.66	25.56	0.042	0.475	1.615	20.91	21.6	20.67	0.411	6.481	11.548
Belize	25.21	23.36	23.55	0.071	0.233	0.448	26.22	24.44	25.28	0.042	0.474	1.611	19.28	20.38	18.99	0.406	6.416	11.388
Comoros	22.59	21.19	21.58	0.07	0.229	0.441	23.27	21.58	22.94	0.041	0.463	1.581	14.58	17.71	17.41	0.39	6.274	11.236
Cook Islands	14.29	13.4	12.81	0.065	0.214	0.41	14.03	12.24	12.85	0.038	0.428	1.451	17.06	15.86	16.17	0.398	6.176	11.117
Cuba	29.64	27.96	28.11	0.074	0.242	0.465	31.11	28.98	29.65	0.043	0.491	1.667	22.31	23.01	21.33	0.416	6.556	11.611
Dominica	27.59	26.02	26.12	0.073	0.238	0.458	28.62	26.57	27.36	0.042	0.482	1.638	22.07	22.55	21.36	0.415	6.532	11.614
Dominican Republic	28.77	27.1	27.21	0.073	0.24	0.462	30.08	27.96	28.62	0.043	0.488	1.654	22.25	22.65	21.06	0.416	6.537	11.586
Federated States of Micronesia	26.54	24.71	25.1	0.072	0.236	0.454	26.14	24.82	26.5	0.042	0.476	1.627	24.94	26.95	27.39	0.425	6.766	12.191
Fiji	22.3	21.14	20.69	0.07	0.229	0.438	23.18	20.74	20.95	0.041	0.46	1.555	20.52	18.52	17.29	0.41	6.317	11.225
Grenada	23.99	22.43	22.57	0.071	0.231	0.445	24.71	22.88	23.84	0.041	0.468	1.593	19.44	20.33	19.49	0.406	6.414	11.435
Guinea-Bissau	16.67	15.09	15.1	0.067	0.218	0.418	16.94	15.42	16.34	0.039	0.44	1.496	14.51	14.96	14.35	0.389	6.127	10.944
Guyana	13.66	12.02	12.21	0.065	0.212	0.407	13.6	12.37	13.63	0.037	0.428	1.461	11.65	13.17	12.93	0.38	6.032	10.807
Haiti	28.72	27.04	27.16	0.073	0.24	0.462	30.02	27.92	28.6	0.043	0.487	1.654	22.14	22.63	21.06	0.415	6.536	11.585
Jamaica	28.66	27.02	27.17	0.073	0.24	0.462	29.89	27.84	28.63	0.043	0.487	1.654	22.12	22.89	21.48	0.415	6.55	11.626
Kiribati	28.44	26.73	26.93	0.073	0.24	0.461	28.41	26.78	28.11	0.042	0.483	1.648	26.59	27.73	27.76	0.43	6.808	12.227
Maldives	20.91	19.31	19.54	0.069	0.236	0.434	20.76	19.35	20.77	0.04	0.455	1.553	18.34	20.23	20.51	0.402	6.408	11.533
Marshall Islands	28.92	27.06	27.46	0.073	0.24	0.463	28.65	27.22	28.85	0.042	0.485	1.657	26.93	28.86	29.18	0.432	6.868	12.362
Mauritius	32.13	30.65	31.07	0.075	0.247	0.476	33.99	31.64	32.61	0.044	0.502	1.705	18.58	21.94	20.53	0.403	6.5	11.534
Nauru	27.95	26.24	26.42	0.073	0.239	0.459	28.1	26.36	27.58	0.042	0.481	1.641	25.58	26.41	26.17	0.427	6.738	12.075
Niue	19	17.98	17.45	0.068	0.223	0.426	19.38	17.18	17.54	0.039	0.446	1.512	19.34	17.61	17.07	0.406	6.268	11.203
Palau	22.71	20.96	21.33	0.07	0.229	0.44	22.19	21	22.72	0.04	0.461	1.578	21.46	23.58	24.17	0.413	6.587	11.883
Papua New Guinea	22.09	20.38	20.41	0.07	0.228	0.437	22.85	20.99	21.71	0.041	0.461	1.565	18.17	18.35	17.16	0.402	6.308	11.212
Republic of Cabo Verde	24.58	23.08	23.05	0.071	0.233	0.447	25.26	23.32	24.09	0.041	0.47	1.596	21.17	21.15	20.28	0.412	6.457	11.51
Saint Kitts and Nevis	28.79	27.19	27.28	0.073	0.24	0.462	29.98	27.85	28.55	0.043	0.487	1.653	22.8	23.12	21.74	0.418	6.562	11.65
Saint Lucia	26.27	24.72	24.84	0.072	0.236	0.453	27.16	25.2	26.07	0.042	0.477	1.621	21.18	21.81	20.79	0.412	6.492	11.56
Saint Vincent and the Grenadines	25.48	23.93	24.05	0.072	0.234	0.45	26.3	24.39	25.29	0.042	0.474	1.611	20.58	21.3	20.36	0.41	6.465	11.518
Samoa	22.73	21.47	21.16	0.07	0.23	0.44	23.07	20.99	21.61	0.041	0.461	1.564	22.19	21.22	20.74	0.415	6.461	11.555
São Tomé and Principe	15.16	13.83	14.1	0.066	0.215	0.414	14.89	13.69	15.24	0.038	0.433	1.482	12.68	14.79	15.2	0.383	6.118	11.025
Seychelles	23.86	22.37	22.68	0.071	0.231	0.445	24.38	22.68	23.99	0.041	0.467	1.595	17.41	19.93	19.69	0.399	6.392	11.454
Singapore	18.96	17.19	17.44	0.068	0.221	0.426	19.04	17.71	18.99	0.039	0.448	1.53	15.95	17.77	17.62	0.394	6.277	11.256
Solomon Islands	26.31	24.81	24.74	0.072	0.236	0.453	27.16	25	25.63	0.042	0.476	1.616	22.69	22.06	20.89	0.417	6.506	11.569
Suriname	13.91	12.28	12.49	0.065	0.212	0.408	13.79	12.57	13.88	0.038	0.429	1.465	12.05	13.62	13.48	0.381	6.056	10.86
Timor-Leste	24.67	23.12	23.2	0.071	0.233	0.447	25.89	23.83	24.5	0.042	0.472	1.601	18.36	18.44	16.9	0.402	6.313	11.187
Tonga	19.6	18.59	18.02	0.068	0.224	0.428	20.26	17.87	18.05	0.04	0.449	1.518	19.1	16.93	16	0.405	6.232	11.102
Trinidad and Tobago	21.41	19.82	19.97	0.069	0.226	0.435	21.95	20.28	21.3	0.04	0.458	1.56	17.48	18.63	17.95	0.399	6.323	11.288
Tuvalu	25.84	24.39	24.26	0.072	0.235	0.451	26.27	24.21	24.97	0.042	0.473	1.607	24.09	23.59	22.99	0.422	6.587	11.77
Vanuatu	21.78	23.26	22.9	0.071	0.233	0.446	25.75	23.19	23.33	0.041	0.469	1.586	21.01	18.98	17.29	0.411	6.342	11.224
GMSL				**0.057**	**0.189**	**0.363**				**0.033**	**0.381**	**1.286**				**0.34**	**5.33**	**9.57**

Note: PAGM stands for percentage above global mean

Table 1. Projected Antarctic contribution to sea level rise at AOSIS member locations. Values are given for percentage above global mean (PAGM), and for absolute sea level rise for three time periods (2100, 2200, 2300) and three scenarios- RCP4.5 with only MISI dynamics, RCP8.5 with only MISI dynamics, and RCP8.5 with both MISI and MICI dynamics. Values for global

mean sea level under each scenario are provided in bold for comparison.


a.
Maldives
Seychelles
Comoros
Mauritius
Singapore
Timor-Leste
Palau
Federated States of Micronesia
Marshall Islands
Papua New Guinea
Nauru
Kiribati
Solomon Islands
Tuvalu
Samoa
Vanuatu
Fiji
Niue
Tonga
Cook Islands
Cuba
Bahamas
Belize
Jamaica
Haiti
Dominican Republic
Saint Kitts & Nevis
Antigua & Barbuda
Dominica
St. Lucia
Barbados
St. Vincent & the Grenadines
Grenada
Trinidad & Tobago
Guyana
Suriname
Cabo Verde
Guinea-Bissau
São Tomé & Príncipe
≤0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.05 1.1 1.15 1.2 1.25 1.3 1.35 1.4
Regional sea level rise compared to the global mean
b.
c.
d.

889

Figure 2. Sea level rise predictions normalized by global mean sea level rise. a) The spatial distribution of the Antarctic contribution to sea level rise at 2100 (relative to 2000) under an RCP4.5 emissions scenario (without MICI) demonstrates that AOSIS members are highly impacted. The purple line indicates where SLR values are equal to GMSL. Closer sections are shown for b) the Indian Ocean c) the Caribbean and Atlantic, and d) Oceania.

While these sea level calculations provide a regional perspective on the distribution of SLR from Antarctic ice loss, the actual impacts felt in these countries are highly variable at the local level and influenced by socio-political factors in addition to physical impacts. Across all the scenarios, sea level continues to rise for centuries (Table 1). Values in this table are a lower bound as they only reflect the AIS contribution to SLR and not the components from thermal expansion, Greenland mass loss, and other factors. AOSIS nations are not the only ones to experience an Antarctic contribution to SLR above the global mean, but we stress the distributive justice issues in relation to their advocacy for more stringent climate targets, the inherent vulnerability many have to SLR, and their extremely low contribution to greenhouse gas emissions (Figure 1b).

5.3 Impacts of Antarctic ice loss on climate

In addition to SLR, AIS melt impacts the global climate system in complex ways. These interconnections have been difficult to constrain, because most global climate models (GCMs) used to predict future climate impacts and inform policy, don't include dynamic, interactive ice-sheet components in part due to the complexity of modeling the two-way interactions between a changing ice sheet with the surrounding ocean and overlying atmosphere (Meijers, 2014).

Recent modeling incorporating ice-ocean-atmosphere interactions have demonstrated that freshwater and ice discharged from the AIScan have a negative feedback on GMST- delaying the rise in air temperature while simultaneously raising global sea levels (Bronselear, 2018; Golledge, 2019; Sadai et al, 2020; Schloesser, 2019). Model responses show a decrease in salinity induced by freshwater input into the saline Southern Ocean which raises the freezing temperature of the water while increasing stratification. Expanded sea-ice and stratification stabilizes the water column, inhibiting the normal vertical mixing that is important for distributing heat. This stratification results in the accumulation of heat in subsurface layers, warming the ocean at intermediate depths around Antarctica, a process that can increase melting at the base of the ice shelves that fringe the continent. At the same time, freshwater induced expansion and thickening of perennial sea-ice around the continental margin increases albedo, reflecting more solar radiation to space. This negative sea-ice-albedo feedback slows the pace of warming around and over Antarctica and the cooling feedback is felt globally. Overall, model simulations show GMST values 0.3-1°C lower at the end of the 21st century under high emissions scenarios when meltwater impact is considered (Bronselear et al., 2018; Golledge et al., 2019; Sadai, 2020). Looking beyond the current century, model results indicate that this meltwater feedback reduces the amount of global warming by up to 2.5°C during peak ice loss under RCP8.5 (around the year 2120, Figure 3) and up to 1°C under RCP4.5 (by mid 22nd century) (Sadai et al., 2020).

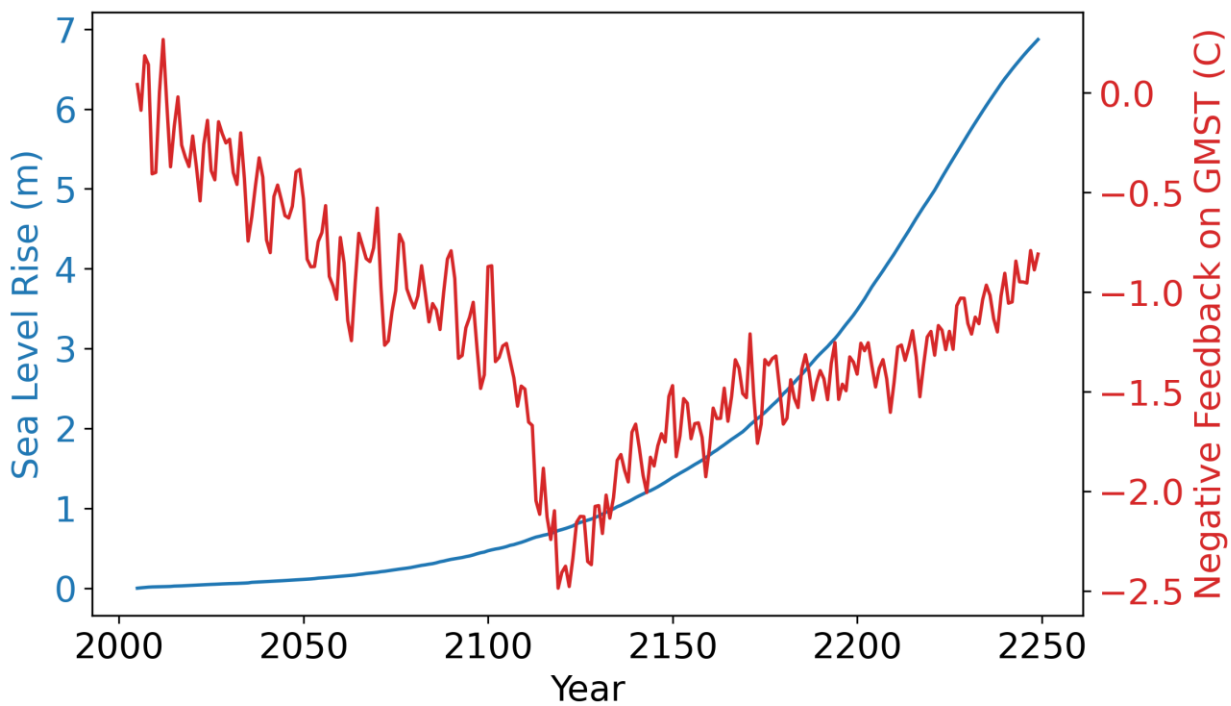


Figure 3. Sea level rise and negative feedbacks on GMST. Under an RCP8.5 emissions scenario one climate model predicted GMST response to meltwater could be over 2°C lower at peak ice sheet collapse. When driven with these climatologies, an ice sheet model predicts that meltwater delays ice sheet loss but that up to 7 m of sea level rise is still locked in over the coming centuries.

This negative feedback on GMST rise impacts the ice sheet's stability and contribution to SLR. First, increased subsurface warming could accelerate the melting of buttressing ice shelves that could lead to faster SLR (Golledge et al., 2019). However, in models that consider the effect of atmospheric warming and meltwater on ice shelf surfaces, the albedo cooling feedback slows the pace of ice loss despite the warmer sub-surface ocean (DeConto et al., 2021). Although, even in the high emissions RCP8.5 scenario in which negative feedbacks can substantially lower GMST during peak ice loss, model projections still yield ~0.5 m of SLR from Antarctica alone by mid-century and 7 m by 2250 (Figure 3) (DeConto et al., 2021; Sadai et al., 2020). In a scenario in line with a 1.5-2ºC Paris GMST target, these ice-sheet induced negative feedbacks on GMST would be small, the risk of triggering widespread ice sheet instabilities in Antarctica would be small, and the rate of SLR would remain similar to today throughout the 21st century (DeConto et al., 2021), giving island nations and coastal communities a better chance at adapting in place. However, as of 2021, submitted NDCs commit ~2.7°C warming (UNFCCC, 2021), and current policies would lead to 2.9°C warming (Climate Action Tracker, 2021). In this scenario, SLR rates and magnitudes will be much higher, and pose much larger threats during this century (DeConto et al., 2021) while at the same time triggering larger negative feedbacks on GMST.

5.4 Negative ice-loss feedbacks and carbon budgets

While the combined effect of all known climate feedbacks is thought to be positive (Forster et al., 2019), the existence of negative feedbacks, particularly when they are correlated with climate impacts that enhance vulnerability of specific populations (in this case AOSIS nations), are critical components to assessing the justice implications of temperature targets. Carbon budgets, which predict the remaining emissions before a given temperature is exceeded, can be calculated in a variety of ways (Rogelj et al, 2016). Current estimates of the remaining carbon budget generally do not account for feedbacks within the climate system, including the strong Antarctic ice loss-cooling feedback described here. Attempts to estimate the impact of these feedbacks yields a low probability that they will increase the remaining budget and a high probability that they will lower it, primarily due to the large additional warming contribution from permafrost melt (Lowe & Bernie, 2018). A framework for standardizing the way carbon budgets are calculated has called for the inclusion of feedbacks into budget calculations (Rogelj et al., 2019). To our knowledge the impact that negative feedbacks resulting from AIS discharge would have on carbon budgets has never been estimated. Given that the feedback is negative, on its own it would raise the remaining allowable emissions, however it remains unclear how this would interface with other positive feedback mechanisms like permafrost melt. Furthermore and crucially, any reduction in GMST resulting from Antarctic ice loss would come at the expense of flooded coastlines in AOSIS countries and around the world. If emissions budget estimates are raised, and high emitters use it as justification for delaying mitigation, this could lead to greater long-term SLR. This scenario would exacerbate already existing trends that disadvantage island nations and other coastal communities. With the low remaining carbon budgets for the Paris goals, it is possible that the impact of feedbacks on policy will be small. However if temperature continues to be used as an LTGG during future negotiations, particularly on post-2100 timescales, the inclusion of negative feedbacks could become more relevant. In this eventuality, negative feedbacks entangled with SLR will be a key component in assessing the climate justice impacts of policy decisions.

Conclusions

The adoption of global mean surface temperature as a target for climate action has significant procedural, recognition, and distributive justice issues when considering the effects of sea level rise. Physical sciences alone are inadequate to fully assess climate justice considerations. Here, we integrate the historical legacy of policy decisions and key findings from the physical and social sciences to gain a greater understanding of how climate justice interfaces with SLR and temperature targets.

Within the framework of the UNFCCC climate negotiations the Alliance of Small Island States has been pivotal in bringing to the forefront the needs of countries most concerned with the impacts of sea level rise. AOSIS countries have had many successes in UNFCCC negotiations and were instrumental in gaining the inclusion of the lower 1.5ºC temperature target into the Paris Agreement following unification of the international community around temperature targets. However, uneven power divisions within the negotiating landscape favored high carbon-emitting nations and led to a weak and disembedded LTGG lacking enforcement mechanisms. As a metric, global mean surface temperature by 2100 fails to fully encompass the UNFCCC Article 2 goal of avoiding dangerous anthropogenic interference in the climate system when considering the regional and temporal variations of rising sea levels. The adoption of a GMST target led to the normalization of overshoot pathways via integrated assessment modeling. These pathways enable the political economy of delay that is used to justify a lack of nearterm emissions reductions. As climate damages incurred during an overshoot are not accounted for, the use of these pathways can increase vulnerability to sea level rise. Vulnerability is shaped by a variety of physical and sociopolitical factors and will vary at the regional, national, and local scales. Recognition of historical factors impacting ongoing vulnerability, such as colonization, as well as considering how migration and displacement are discussed, will be key factors in assessing climate justice implications of SLR. Greater inclusion of the voices of island inhabitants is needed in the scientific and policy spheres; social sciences and humanities work has focused on this, which we have highlighted here.

The complications presented by the entangled climate impacts from sea level rise and negative feedbacks on GMST arising from Antarctic Ice Sheet destabilization provide a case study for assessing climate justice. These dual AIS impacts exacerbate climate inequities inherent in GMST targets. This is seen in 1) the disproportionate impact of the Antarctic contribution to sea level rise on island nations relative to their emissions, 2) the possibility for AIS to become the dominant contributor to SLR exacerbating the long-term and irreversible commitment to rising seas and its associated multigenerational recognition justice issues, and 3) the potential for islands to be pushed past adaptation limits, while at the same time the threat of extreme warming is reduced. As recent modeling developments demonstrate negative feedbacks on GMST arising from ice sheet loss, these findings could lead to higher allowable carbon budgets under the Paris Agreement goals. The potential for higher carbon budgets and emissions could further entrench the political economy of delay, thus slowing emissions reductions while further impacting communities vulnerable to sea level rise. The long-term commitment to rising seas, potential impacts of AIS melt on carbon budgets, and the historical injustices that increase vulnerability and exacerbate recognition justice issues are areas needing further study. Future work should investigate other ways climate system feedbacks on GMST could have ramifications for vulnerable communities and climate justice.

Acknowledgements

Authors declare no competing interests. Thank you to Natalya Gomez and Jeremy Roffman for providing data for the sea level rise fingerprints. Thank you to Mara Freilich, Eve Vogel, Ambarish Karmalkar, Ed Gasson, and Ruthie Halberstadt for helpful comments on paper drafts. Thank you to Becky Seifried and Forrest Bowlick for assistance with GIS.

Open Research

Literature review- A search was conducted across multiple databases including Directory of Open Access Journals, Gale, ERIC, and Academic Search Premier for combinations of search terms- climate justice, recognition justice, distributive justice, procedural justice, sea level rise, AOSIS, Caribbean, Indian Ocean, Pacific, temperature targets. Back searches were done on included references as needed. In addition to the database search the *Journal of Island Studies* was searched for sea level, AOSIS, UNFCCC, and climate justice. The United Nations archive was utilized for documents written by AOSIS and member states, proceedings and decisions from major COP meetings, and materials related to the 2013-2015 Structured Expert Dialogue.

Emissions data (Figure 1) - Data were obtained from Climate Watch Historical GHG Emissions data archive and include emissions from fossil fuel combustion as well as Land-Use Change and Forestry or Agriculture. Data sources are FAO 2020, FAOSTAT Emissions Database, CO2 Emissions from Fuel Combustion, OECD/IEA, 2020. Data were summed across all countries for the 'World' values and across AOSIS nations for the 'AOSIS' values.

Sea level rise data (Figure 2)- Sea level predictions were computed with the pseudo-spectral, gravitationally self-consistent sea level model described in Gomez et al. (2010) that includes gravitational and rotational effects associated with surface ice and water mass redistribution, viscoelastic deformation of the solid Earth and migrating shorelines. The Earth rheological structure in the model varies radially, with elastic and density structure given by the Preliminary Reference Earth Model, lithospheric thickness of 120 km, and upper and lower mantle viscosities of 0.5 and 5 $\times 10^{21}$ Pa s, respectively. Global sea level changes were computed relative to 2000 using the coupled Earth-ice sheet simulations from DeConto et al. (2021) in which the Penn State University ice sheet model was coupled to a high viscosity viscoelastic Earth model and run under RCP4.5 and 8.5 emissions scenarios, with and without the inclusion of brittle ice processes (MICI dynamics). Values were normalized by the global mean sea level equivalent change (termed the "effective eustatic value") in Gomez et al., 2010, computed by filling areas freed of marine based ice with water and spreading the rest of the water evenly across the modern ocean area. Plotting was done using ArcGIS following the methodology of Gosling-Goldsmith, Ricker, and Jan Kraak (2020) to highlight AOSIS locations. Country polygons were obtained from the following Natural Earth shapefiles: *Pacific groupings*, *1:10 m countries*, *1:50 m Tiny Country Points*. Spatial statistics of sea level values at AOSIS locations were calculated in ArcGIS for years 2100, 2200, and 2300 under RCP4.5 and for RCP8.5. For the RCP8.5 case a scenario that includes marine ice cliff instability and a scenario that only includes marine ice sheet instability were both used.

Sea level and GMST data (Figure 3)- GMST values under RCP8.5 showing the meltwater induced negative feedback values were from Sadai et al., 2020. Sea level rise estimates were from DeConto et al., 2021, in which the Penn State University ice sheet model was driven by meltwater perturbed climatology data from Sadai et al., 2020.

Data Availability- The emissions data used in Figure 1 is available at https://www.climatewatchdata.org/ghg-emissions. The data used for the negative feedback shown in Figure 3 from Sadai et al., 2020 are available at the US Antarctic Program Data Center, cited below as Condron, 2021 and downloadable here https://doi.org/10.15784/601449. The data used for Figure 2 and Table 1, as well as the sea level rise estimate in Figure 3 will be available through the UMass ScholarWorks website at publication and are available for peer review at this share link: https://drive.google.com/drive/folders/1CWqi-Dv9JHCnCOGlvT7ygmXrgQGYSkV6?usp=sharing. The sea level code used to generate this data will be published in association with Han et al. (in review) and is viewable here: https://osf.io/8ptfm/. Natural Earth shapefiles used in Figure 2 are available at https://www.naturalearthdata.com/downloads/.

References

Abbott, D. & Wilson, G. (2015). The Lived Experience of Climate Change: Knowledge, Science and Public Action. Switzerland: Springer International Publishing. 10.1007/978-3-319-17945-2

Althor, G., Watson, J. E. M., & Fuller, R. A. (2016). Global mismatch between greenhouse gas emissions and the burden of climate change. *Scientific Reports*, *6*, 1–6. https://doi.org/10.1038/srep20281

AOSIS. (1994). A/AC.237/L.23 MATTERS RELATING TO COMMITMENTS: REVIEW OF THE ADEQUACY OF COMMITMENTS IN ARTICLE 4, PARAS. 2 (A) AND (B). *246*(April), 1–70.

AOSIS. (2009) Declaration on Climate Change. https://sustainabledevelopment.un.org/content/documents/1566AOSISSummitDeclarationSept2

1FINAL.pdf

AOSIS. (2015). AOSIS opening statement for 21st Conference of Parties to the UNFCCC. https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/cop21cmp11_hls_speech_aosis_maldives.pdf

AOSIS. (2021). *AOSIS Member States*. Retrieved August 1, 2021, from https://www.aosis.org/about/member-states/

AOSIS and the LDC Group. (2020). Joint Statement – AOSIS and the LDC Group. Retrieved August 1, 2021, from https://www.ldc-climate.org/wp-content/uploads/2020/09/200925-Outcome-for-AOSIS-LDC-event_Final.pdf

Arns, A., Dangendorf, S., Jensen, J., Talke, S., Bender, J., & Pattiaratchi, C. (2017). Sea-level rise induced amplification of coastal protection design heights. *Scientific Reports*, *7*, 1–9. https://doi.org/10.1038/srep40171

Ashe, J. W., Lierop, R. Von, & Cherian, A. (1999). The role of the Alliance of Small Island States (AOSIS) in the negotiation of the United Nations Framework Convention on Climate Change (UNFCCC). *Natural Resources Forum*, *23*(3), 209–220. https://doi.org/10.1111/j.1477-8947.1999.tb00910.x

Ayers, J. (2011). Resolving the adaptation paradox: Exploring the potential for deliberative adaptation policy-making in Bangladesh. *Global Environmental Politics*, *11*(1), 62–88. https://doi.org/10.1162/GLEP_a_00043

Baptiste, A. K., & Rhiney, K. (2016). Climate justice and the Caribbean: An introduction. *Geoforum*, *73*, 17–21. https://doi.org/10.1016/j.geoforum.2016.04.008

Barnett, J. (2001). Adapting to climate change in Pacific Island countries: The problem of uncertainty. *World Development*, *29*(6), 977–993. https://doi.org/10.1016/S0305-750X(01)00022-5

Barnett, J., & Campbell, J. (2011). Climate change and small Island states: Power, Knowledge and the South Pacific. Earthscan.

Barnett, J. (2017). The dilemmas of normalising losses from climate change: Towards hope for Pacific atoll countries. *Asia Pacific Viewpoint*, *58*(1), 3–13. https://doi.org/10.1111/apv.12153

Becker, M., Meyssignac, B., Letetrel, C., Llovel, W., Cazenave, A., & Delcroix, T. (2012). Sea level variations at tropical Pacific islands since 1950. *Global and Planetary Change*, 80–81, 85–98. https://doi.org/10.1016/j.gloplacha.2011.09.004

Benjamin, L. (2010). Climate Change and Caribbean Small Island States: The State of Play. *The International Journal of Bahamian Studies*, *16*, 78. https://doi.org/10.15362/ijbs.v16i0.129

Benjamin, L., & Thomas, A. (2016). 1.5 To Stay Alive? AOSIS and the Long Term Temperature Goal in the Paris Agreement. *SSRN Electronic Journal*, *17*, 157–167. https://doi.org/10.2139/ssrn.3392503

Betzold, C. (2010). "Borrowing" Power to Influence International Negotiations: AOSIS in the Climate Change Regime, 1990-1997. *Politics*, *30*(3), 131–148. https://doi.org/10.1111/j.1467-9256.2010.01377.x

Betzold, C., Castro, P., & Weiler, F. (2012). AOSIS in the UNFCCC negotiations: From unity to fragmentation? *Climate Policy*, *12*(5), 591–613. https://doi.org/10.1080/14693062.2012.692205

Biondi, E. L., & Guannel, G. (2018). Practical tools for quantitative analysis of coastal vulnerability and sea level rise impacts—application in a Caribbean island and assessment of the 1.5 °C threshold. *Regional Environmental Change*, 18(8), 2227–2236. https://doi.org/10.1007/s10113-018-1397-4

Bittermann, K., Rahmstorf, S., Kopp, R. E., & Kemp, A. C. (2017). Global mean sea-level rise in a world agreed upon in Paris. *Environmental Research Letters*, *12*(12). https://doi.org/10.1088/1748-9326/aa9def

Bordner, A. S., Ferguson, C. E., & Ortolano, L. (2020). Colonial dynamics limit climate adaptation in Oceania: Perspectives from the Marshall Islands. *Global Environmental Change*, *61*. https://doi.org/10.1016/j.gloenvcha.2020.102054

Bouchard, C. (2008). Climate Change, Sea Level Rise, and Development in Small Island States and Territories of the Indian Ocean. In DOYLE T. & RISELY M. (Eds.), *Crucible For Survival: Environmental Security and Justice in the Indian Ocean Region* (pp. 258-272). Rutgers University Press. Retrieved May 21, 2021, from http://www.jstor.org/stable/j.ctt5hj2rg.22

Bouttes, N., Gregory, J. M., & Lowe, J. A. (2013). The reversibility of sea level rise. *Journal of*

Climate, *26*(8), 2502–2513. https://doi.org/10.1175/JCLI-D-12-00285.1

Bronselaer, B., Winton, M., Griffies, S. M., Hurlin, W. J., Rodgers, K. B., Sergienko, O. V., Stouffer, R. J., & Russell, J. L. (2018). Change in future climate due to Antarctic meltwater. *Nature*, *564*(7734), 53–58. https://doi.org/10.1038/s41586-018-0712-z

Brulle, R. J. (2014). Institutionalizing delay: foundation funding and the creation of U.S. climate change counter-movement organizations. *Climatic Change*, *122*(4), 681–694. https://doi.org/10.1007/s10584-013-1018-7

Brysse, K., Oreskes, N., O'Reilly, J., & Oppenheimer, M. (2013). Climate change prediction: Erring on the side of least drama? *Global Environmental Change*, 23(1), 327–337. https://doi.org/10.1016/j.gloenvcha.2012.10.008

Burkett, M. (2011). The Nation Ex-Situ: On climate change, deterritorialized nationhood and the post-climate era. *Climate Law*, *2*(3), 345–374. https://doi.org/10.3233/CL-2011-040

Burkett, M. (2016). Reading between the Red Lines: Loss and Damage and the Paris Outcome. In *Climate Law*, 6(1–2), 118–129. https://doi.org/10.1163/18786561-00601008

Burnham, M., Radel, C., Ma, Z., & Laudati, A. (2013). Extending a Geographic Lens Towards Climate Justice, Part 1: Climate Change Characterization and Impacts. In *Geography Compass,* 7(3), 239–248. https://doi.org/10.1111/gec3.12034

Burnham, M., Radel, C., Ma, Z., & Laudati, A. (2013b). Extending a Geographic Lens Towards Climate Justice, Part 2: Climate Action. In *Geography Compass*, 7(3), 228–238. https://doi.org/10.1111/gec3.12033

Carton, W. (2019). "Fixing" Climate Change by Mortgaging the Future: Negative Emissions, Spatiotemporal Fixes, and the Political Economy of Delay. *Antipode*, *51*(3), 750–769. https://doi.org/10.1111/anti.12532

Chan, N. (2018). "large ocean states": Sovereignty, small islands, and marine protected areas in global oceans governance. In *Global Governance*, 24(4), 537–555. https://doi.org/10.1163/19426720-02404005

Church, J.A., Gregory, J. M., Huybrechts, P., Kuhn, M., Lambeck, K., Nhuan, M. T., Qin, D., & Woodworth, P. L. (2001). Changes in Sea Level. In: Climate Change 2001: The Scientific Basis.

Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge: Cambridge University Press.

Church, J.A., Clark P.U., Cazenave A., Gregory J.M., Jevrejeva S., Levermann A., et al. (2013). Sea Level Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Clark, J. A., & Lingle, C. S. (1977). Future sea-level changes due to West Antarctic ice sheet fluctuations. Nature, 269(5625), 206–209. https://doi.org/10.1038/269206a0

Clark, P. U., Shakun, J. D., Marcott, S. A., Mix, A. C., Eby, M., Kulp, S., et al. (2016). Consequences of twenty-first-century policy for multi-millennial climate and sea-level change. In *Nature Climate Change*, 6(4), 360–369. https://doi.org/10.1038/nclimate2923

Clémençon, R. (2016). The Two Sides of the Paris Climate Agreement: Dismal Failure or Historic Breakthrough? In *Journal of Environment and Development*, 25(1), 3–24. https://doi.org/10.1177/1070496516631362

Climate Action Tracker (2021). CAT global pathway methodology. Retrieved October 1, 2021 from, http://climateactiontracker.org/methodology/18/Global-pathways.html

Climate Watch Historical GHG Emissions. (2021.) Washington, DC: World Resources Institute. Available at: https://www.climatewatchdata.org/ghg-emissions

Corendea, C. (2016). Development implications of climate change and migration in the Pacific. Climate Law and Governance Working Paper Series No 3/2016, McGill University, Montreal.

Colven, E., & Thomson, M. J. (2019). Bridging the divide between human and physical geography: Potential avenues for collaborative research on climate modeling. Geography Compass, 13(2), 1–15. https://doi.org/10.1111/gec3.12418

Condron, A. (2021). Future climate response to Antarctic Ice Sheet melt caused by anthropogenic warming (Version 1) [Data set]. U.S. Antarctic Program (USAP) Data Center. https://doi.org/10.15784/601449

Convention on Rights and Duties of States. (1933, December 26) Adopted by the Seventh International Conference on American States Signed at Montevideo. Retrieved August 1, 2021 from, https://avalon.law.yale.edu/20th_century/intam03.asp

David-Chavez, D. M., & Gavin, M. C. (2018). A global assessment of Indigenous community engagement in climate research. *Environmental Research Letters*, *13*(12). https://doi.org/10.1088/1748-9326/aaf300

DeConto, R. M., & Pollard, D. (2016). Contribution of Antarctica to past and future sea-level rise. *Nature*, *531*(7596), 591–597. https://doi.org/10.1038/nature17145

Deconto, R. M., Pollard, D., Alley, R. B., Velicogna, I., Gasson, E., Gomez, N., et al. (2021). The Paris Climate Agreement and future sea-level rise from Antarctica. *Nature*, *593*(May). https://doi.org/10.1038/s41586-021-03427-0

Dessai, S., Adger, W. N., Hulme, M., Turnpenny, J., Köhler, J., & Warren, R. (2004). Defining and experiencing dangerous climate change: An editorial essay. In *Climatic Change*, 64(1–2), 11–25. https://doi.org/10.1023/B:CLIM.0000024781.48904.45

Douglass, K., & Cooper, J. (2020). Archaeology, environmental justice, and climate change on islands of the Caribbean and southwestern Indian Ocean. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(15), 8254–8262. https://doi.org/10.1073/pnas.1914211117

Duvat, V. K. E., Magnan, A. K., Perry, C. T., Spencer, T., Bell, J. D., Wabnitz, C. C. C., et al., (2021). Risks to future atoll habitability from climate-driven environmental changes. *Wiley Interdisciplinary Reviews: Climate Change*, *12*(3), 1–28. https://doi.org/10.1002/wcc.700

Edwards, T. L., Nowicki, S., Marzeion, B., Hock, R., Goelzer, H., Seroussi, H., et al. (2021). Projected land ice contributions to twenty-first-century sea level rise. *Nature*, *593*(7857), 74–82. https://doi.org/10.1038/s41586-021-03302-y

Ekwurzel, B., Boneham, J., Dalton, M.W. et al. (2017) The rise in global atmospheric CO2, surface temperature, and sea level from emissions traced to major carbon producers. *Climatic*

Change 144, 579–590. https://doi.org/10.1007/s10584-017-1978-0

Farbotko, C. (2010). Wishful sinking: Disappearing islands, climate refugees and cosmopolitan experimentation. *Asia Pacific Viewpoint*, *51*(1), 47–60. https://doi.org/10.1111/j.1467-8373.2010.001413.x

Farbotko, C., & Lazrus, H. (2012). The first climate refugees? Contesting global narratives of climate change in Tuvalu. *Global Environmental Change*, *22*(2), 382–390. https://doi.org/10.1016/j.gloenvcha.2011.11.014

Farbotko, C., & McGregor, H. V. (2010). Copenhagen, climate science and the emotional geographies of climate change. *Australian Geographer*, *41*(2), 159–166. https://doi.org/10.1080/00049181003742286

Farrell, W. E., & Clark, J. A. (1976). On Postglacial Sea Level. *Geophysical Journal of the Royal Astronomical Society*, *46*(3), 647–667. https://doi.org/10.1111/j.1365-246X.1976.tb01252.x

Favier, L., Durand, G., Cornford, S. L., Gudmundsson, G. H., Gagliardini, O., Gillet-Chaulet, F., et al. (2014). Retreat of Pine Island Glacier controlled by marine ice-sheet instability. *Nature Climate Change*, 4(2), 117–121. https://doi.org/10.1038/nclimate2094

Forster, P., T. Storelvmo, K. Armour, W. Collins, J.L. Dufresne, D. Frame, D.J. et al. (2021). The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. 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., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Fox-Kemper, B., H.T. Hewitt, C. Xiao, G. Aðalgeirsdóttir, S.S. Drijfhout, T.L. Edwards, et al. (2021). Ocean, Cryosphere and Sea Level Change. 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* [MassonDelmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Fraser, N. (1997). Justice Interruptus: Critical Reflections on the "Postsocialist" Condition. London: Routledge.

Frumhoff, P. C., Heede, R., & Oreskes, N. (2015). The climate responsibilities of industrial carbon producers. *Climatic Change*, *132*(2), 157–171. https://doi.org/10.1007/s10584-015-1472-5

Fry, I. (2016). The Paris Agreement: An Insider's Perspective - The Role of Small Island Developing States. *Environmental Policy and Law*, *46*(2), 105–108. http://www.iisd.ca/unep/oecpr2Ol6/images/19feb/3K1A8759-tn.jpg

Fürst, J. J., Durand, G., Gillet-Chaulet, F., Tavard, L., Rankl, M., Braun, M., & Gagliardini, O. (2016). The safety band of Antarctic ice shelves. *Nature Climate Change*, *6*(5), 479–482. https://doi.org/10.1038/nclimate2912

Gao, Y., Gao, X., & Zhang, X. (2017). The 2 °C Global Temperature Target and the Evolution of the Long-Term Goal of Addressing Climate Change—From the United Nations Framework Convention on Climate Change to the Paris Agreement. *Engineering*, *3*(2), 272–278. https://doi.org/10.1016/J.ENG.2017.01.022

Gardiner, S. M. (2004). The Global Warming Tragedy and the Dangerous Illusion of the Kyoto Protocol. Ethics & International Affairs, 18(1), 23–39. https://doi.org/10.1111/j.1747-7093.2004.tb00448.x

Golledge, N., Kowalewski, D., Naish, T. et al. The multi-millennial Antarctic commitment to future sea-level rise. *Nature* 526, 421–425 (2015). https://doi.org/10.1038/nature15706

Golledge, N. R., Keller, E. D., Gomez, N., Naughten, K. A., Bernales, J., Trusel, L. D., Edwards, T. L. (2019). Global environmental consequences of twenty-first-century ice-sheet melt. *Nature*, *566*(7742), 65–72. https://doi.org/10.1038/s41586-019-0889-9

Gomez, N., Mitrovica, J. X., Tamisiea, M. E., & Clark, P. U. (2010). A new projection of sea level change in response to collapse of marine sectors of the Antarctic Ice Sheet. *Geophysical Journal International*, *180*, 623–634. https://doi.org/10.1111/j.1365-246X.2009.04419.x

Gosling-Goldsmith, J., Ricker, B., & Jan Kraak, M. (2020). Topographic and thematic (in)visibility of Small Island Developing States in a world map. *Journal of Maps*, 16(1), 50–56.

https://doi.org/10.1080/17445647.2020.1736194

Graham, S., Barnett, J., Fincher, R., Hurlimann, A., Mortreux, C., & Waters, E. (2013). The social values at risk from sea-level rise. *Environmental Impact Assessment Review*, *41*, 45–52. https://doi.org/10.1016/j.eiar.2013.02.002

Gulev, S.K., P.W. Thorne, J. Ahn, F.J. Dentener, C.M. Domingues, S. Gerland, et al. (2021). Changing State of the Climate System. 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* [MassonDelmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Hamlington, B. D., Frederikse, T., Nerem, R. S., Fasullo, J. T., & Adhikari, S. (2020). Investigating the Acceleration of Regional Sea Level Rise During the Satellite Altimeter Era. *Geophysical Research Letters*, *47*(5), 1–8. https://doi.org/10.1029/2019GL086528

Han, H.K., Gomez, N., Wan, J.X.W. (2021) Capturing the interactions between ice sheets, sea level and the solid Earth on a range of timescales: A new "time window" algorithm. Geoscientific Model Development (in review). https://doi.org/10.5194/gmd-2021-126

Hau'ofa, E. (1994). Our Sea of Islands. *The Contemporary Pacific*, *6*(1), 148–161.

Heede, R. Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010. *Climatic Change* 122, 229–241 (2014). https://doi.org/10.1007/s10584-013-0986-y

Heileman, L. (1993). The Alliance of Small Island States (AOSIS) : A mechanism for coordinated representation of small island states on issues of common concern. Ambio, 22(1), 55–56. https://doi.org/10.2307/4314040

Hickel, J. (2020). Quantifying national responsibility for climate breakdown: an equality-based attribution approach for carbon dioxide emissions in excess of the planetary boundary. *The Lancet Planetary Health*, *4*(9), e399–e404. https://doi.org/10.1016/S2542-5196(20)30196-0

Hoad, D. (2016). The 2015 Paris Climate Agreement: outcomes and their impacts on small island states. *Island Studies Journal*, 11(1), 315-320.

Hoegh-Guldberg, O., D. Jacob, M. Taylor, M. Bindi, S. Brown, I. Camilloni, A. et al. (2018). Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

Hoegh-Guldberg, O., Jacob, D., Taylor, M., Guillén Bolaños, T., Bindi, M., Brown, S., et al. (2019). The human imperative of stabilizing global climate change at 1.5°C. *Science*, *365*(6459). https://doi.org/10.1126/science.aaw6974

Holgate, S. J., Matthews, A., Woodworth, P. L., Rickards, L. J., Tamisiea, M. E., Bradshaw, E., et al. (2013). New data systems and products at the permanent service for mean sea level. *Journal of Coastal Research*, *29*(3), 493–504. https://doi.org/10.2112/JCOASTRES-D-12-00175.1

Hsu, C. W., & Velicogna, I. (2017). Detection of sea level fingerprints derived from GRACE gravity data. *Geophysical Research Letters*, *44*(17), 8953–8961. https://doi.org/10.1002/2017GL074070

Hurrell, A., & Sengupta, S. (2012). Emerging powers, North-South relations and global climate politics. *International Affairs*, 88(3), 463–484.

Ibrahim, H. D., & Sun, Y. (2020). Mechanism study of the 2010–2016 rapid rise of the Caribbean Sea Level. *Global and Planetary Change*, *191*(103219), 1–8. https://doi.org/10.1016/j.gloplacha.2020.103219

IPCC. (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

Jaeger, J. (1988). DEVELOPING POLICIES FOR RESPONDING TO CLIMATIC CHANGE: A summary of the discussions and recommendations of the workshops held in Villach and Bellagio. World Meteorological Organization and United Nations Environment Programme. Retrieved September 20, 2020 from, https://library.wmo.int/doc_num.php?explnum_id=9482

Jafino, B. A., Kwakkel, J. H., & Taebi, B. (2021). Enabling assessment of distributive justice through models for climate change planning: A review of recent advances and a research agenda. *Wiley Interdisciplinary Reviews: Climate Change*, *12*(4), 1–23. https://doi.org/10.1002/wcc.721

Jetñil-Kijiner, K. (2017). Two Degrees. In *Iep Jaltok: Poems from a Marshallese Daughter*(pp. 76-79). University of Arizona Press.

Jetñil-Kijiner, K. (2021). REMARKS FOR 2020 PACIFIC OCEAN PACIFIC CLIMATE CHANGE CONFERENCE. Retrieved October 10, 2021 from, https://www.kathyjetnilkijiner.com/remarks-for-2020-pacific-ocean-pacific-climate-change-conference/

Jevrejeva, S., Bricheno, L., Brown, J., Byrne, D., De Dominicis, M., Matthews, A. et al. (2020). Quantifying processes contributing to marine hazards to inform coastal climate resilience assessments, demonstrated for the Caribbean Sea. *Natural Hazards and Earth System Sciences*, *20*(10), 2609–2626. https://doi.org/10.5194/nhess-20-2609-2020

Jyoti, J., Swapna, P., Krishnan, R., & Naidu, C. V. (2019). Pacific modulation of accelerated south Indian Ocean sea level rise during the early 21st Century. Climate Dynamics, 53(7–8), 4413–4432. https://doi.org/10.1007/s00382-019-04795-0

Kelman, I., & Stojanov, R. (2020). Islander migrations and the oceans: From hopes to fears? *Island Studies Journal*, 1–20. https://doi.org/10.24043/isj.120

Kelman, I., & West, J. J. (2009). Climate Change and Small Island Developing States: A Critical Review. *Ecological and Environmental Anthropology*, *5*(1). https://doi.org/10.2307/454775

Klein, R.J. and Möhner, A. (2011), The Political Dimension of Vulnerability: Implications for the Green Climate Fund. *IDS Bulletin*, 42: 15-22. https://doi.org/10.1111/j.1759-5436.2011.00218.x

Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., et al. (2016). Why equity is fundamental in climate change policy research. *Global Environmental Change*.

https://doi.org/10.1016/j.gloenvcha.2016.08.002

Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., et al. (2017). Why equity is fundamental in climate change policy research. *Global Environmental Change*, *44*, 170–173. https://doi.org/10.1016/j.gloenvcha.2016.08.002

Knutti, R., Rogelj, J., Sedlácek, J., & Fischer, E. M. (2015). A scientific critique of the two-degree climate change target. In *Nature Geoscience* (Vol. 9, Issue 1, pp. 13–18). Nature Publishing Group. https://doi.org/10.1038/ngeo2595

Kumar, L., & Taylor, S. (2015). Exposure of coastal built assets in the South Pacific to climate risks. *Nature Climate Change*, *5*(11), 992–996. https://doi.org/10.1038/nclimate2702

Leemans, R., & Vellinga, P. (2017). The scientific motivation of the internationally agreed 'well below 2 °C' climate protection target: a historical perspective. *Current Opinion in Environmental Sustainability*, 26–27, 134–142. https://doi.org/10.1016/j.cosust.2017.07.010

Levy, D. L., & Egan, D. (1998). Capital contests: National and transnational channels of corporate influence on the climate change negotiations. In *Politics and Society*, 26(3), 337–361. SAGE Publications Inc. https://doi.org/10.1177/0032329298026003003

Li, C., von Storch, J. S., & Marotzke, J. (2013). Deep-ocean heat uptake and equilibrium climate response. *Climate Dynamics*, *40*(5–6), 1071–1086. https://doi.org/10.1007/s00382-012-1350-z

Li, C., Held, H., Hokamp, S., & Marotzke, J. (2020). Optimal temperature overshoot profile found by limiting global sea level rise as a lower-cost climate target. *Science Advances*, *6*(2). https://doi.org/10.1126/sciadv.aaw9490

Liburd, A. (Host). (2021, September 13). Alliance Assemble! [Audio podcast episode]. In *Islands on Alert*. https://www.aosis.org/aosis-islands-on-alert-episode-2-alliance-assemble/

Liburd, A. (Host). (2021b, October 4). A Case for Climate Justice [Audio podcast episode]. In *Islands on Alert*. https://www.aosis.org/aosis-islands-on-alert-episode-5-a-case-for-climate-justice/

Liverman, D. M. (2009). Conventions of climate change: constructions of danger and the dispossession of the atmosphere. *Journal of Historical Geography*, *35*(2), 279–296. https://doi.org/10.1016/j.jhg.2008.08.008

Livingston, J. E., & Rummukainen, M. (2020). Taking science by surprise: The knowledge politics of the IPCC Special Report on 1.5 degrees. *Environmental Science and Policy*, *112*, 10–16. https://doi.org/10.1016/j.envsci.2020.05.020

Lowe, J. A., & Bernie, D. (2018). The impact of Earth system feedbacks on carbon budgets and climate response. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2119). https://doi.org/10.1098/rsta.2017.0263

Magnan, A.K., M. Garschagen, J.-P. Gattuso, J.E. Hay, N. Hilmi, E. Holland, F. Isla, G. Kofinas, I.J. Losada, J. Petzold, B. Ratter, T.Schuur, T. Tabe, and R. van de Wal, 2019: Cross-Chapter Box 9: Integrative Cross-Chapter Box on Low-Lying Islands and Coasts. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In Press.

Martin, P. C. M., Nunn, P., Leon, J., & Tindale, N. (2018). Responding to multiple climate-linked stressors in a remote island context: The example of Yadua Island, Fiji. *Climate Risk Management*, *21*(April), 7–15. https://doi.org/10.1016/j.crm.2018.04.003

Martyr-Koller, R., Thomas, A., Schleussner, C. F., Nauels, A., & Lissner, T. (2021). Loss and damage implications of sea-level rise on Small Island Developing States. *Current Opinion in Environmental Sustainability*, *50*, 245–259. https://doi.org/10.1016/j.cosust.2021.05.001

Marzeion, B., & Levermann, A. (2014). Loss of cultural world heritage and currently inhabited places to sea-level rise. *Environmental Research Letters*, *9*(3). https://doi.org/10.1088/1748-9326/9/3/034001

McCright, A. M., & Dunlap, R. E. (2003). Defeating Kyoto: The Conservative Movement's Impact on U.S. Climate Change Policy. In *Social Problems*, 50(3), 348–373. https://doi.org/10.1525/sp.2003.50.3.348

McLaren, D. (2020). Quantifying the potential scale of mitigation deterrence from greenhouse gas removal techniques. *Climatic Change*, *162*(4), 2411–2428. https://doi.org/10.1007/s10584-020-02732-3

McMichael, C., Kothari, U., McNamara, K. E., & Arnall, A. (2021). Spatial and temporal ways of knowing sea level rise: Bringing together multiple perspectives. *Wiley Interdisciplinary Reviews:*

Climate Change, *12*(3), 1–15. https://doi.org/10.1002/wcc.703

McSweeney, R. (2018, May 15). *Analysis: The gender, nationality and institution of IPCC AR6 scientists.* Carbon Brief. https://www.carbonbrief.org/analysis-gender-nationality-institution-ipcc-ar6-authors

Meehl, G. A., Hu, A., Tebaldi, C., Arblaster, J. M., Washington, W. M., Teng, H., Sanderson, B. M., Ault, T., Strand, W. G., & White, J. B. (2012). Relative outcomes of climate change mitigation related to global temperature versus sea-level rise. In *Nature Climate Change*, 2(8), 576–580. https://doi.org/10.1038/nclimate1529

Meijers, A. J. S. (2014). The Southern Ocean in the Coupled Model Intercomparison Project phase 5. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *372*. https://doi.org/10.1098/rsta.2013.0296

Mengel, M., Nauels, A., Rogelj, J., & Schleussner, C. F. (2018). Committed sea-level rise under the Paris Agreement and the legacy of delayed mitigation action. *Nature Communications*, *9*(1), 1–10. https://doi.org/10.1038/s41467-018-02985-8

Mercer, J. H. (1978). West Antarctic ice sheet and CO2 greenhouse effect: a threat of disaster. *Nature*, *271*, 321–325. https://doi.org/10.1145/147126.147129

Mills-Novoa, M., & Liverman, D. M. (2019). Nationally Determined Contributions: Material climate commitments and discursive positioning in the NDCs. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(5), e589. https://doi.org/10.1002/wcc.589

Mimura, N. (1999). Vulnerability of island countries in the South Pacific to sea level rise and climate change. *Climate Research*, *12*(2-3 SPEC. ISS. 6), 137–143. https://doi.org/10.3354/cr012137

Mitrovica, J. X. (2001). Recent mass balance of polar ice sheets inferred from patterns of global sea-level change. *Nature*, *409*, 1026–1029.

Mitrovica, J. X., Gomez, N., Morrow, E., Hay, C., Latychev, K., & Tamisiea, M. E. (2011). On the robustness of predictions of sea level fingerprints. *Geophysical Journal International*, *187*(2), 729–742. https://doi.org/10.1111/j.1365-246X.2011.05090.x

Morgan, J. (2016). Paris COP 21: Power that Speaks the Truth? *Globalizations*, *13*(6), 943–951.

https://doi.org/10.1080/14747731.2016.1163863

Morlighem, M., Rignot, E., Binder, T., Blankenship, D., Drews, R., Eagles, G., et al. (2020). Deep glacial troughs and stabilizing ridges unveiled beneath the margins of the Antarctic ice sheet. *Nature Geoscience*, *13*(2), 132–137. https://doi.org/10.1038/s41561-019-0510-8

Morseletto, P., Biermann, F., & Pattberg, P. (2017). Governing by targets: reductio ad unum and evolution of the two-degree climate target. *International Environmental Agreements: Politics, Law and Economics*, *17*(5), 655–676. https://doi.org/10.1007/s10784-016-9336-7

Mueller, N. J., & Meindl, C. F. (2017). Vulnerability of Caribbean Island Cemeteries to Sea Level Rise and Storm Surge. Coastal Management, 45(4), 277–292. https://doi.org/10.1080/08920753.2017.1327343

Mycoo, M. A. (2018). Beyond 1.5 °C: vulnerabilities and adaptation strategies for Caribbean Small Island Developing States. *Regional Environmental Change*, *18*(8), 2341–2353. https://doi.org/10.1007/s10113-017-1248-8

Nauels, A., Gütschow, J., Mengel, M., Meinshausen, M., Clark, P. U., & Schleussner, C. F. (2019). Attributing long-term sea-level rise to Paris Agreement emission pledges. Proceedings of the National Academy of Sciences of the United States of America, 116(47), 23487–23492. https://doi.org/10.1073/pnas.1907461116

Nunn, P. D., & Campbell, J. R. (2020). Rediscovering the past to negotiate the future: How knowledge about settlement history on high tropical Pacific Islands might facilitate future relocations. *Environmental Development*, *35*, 100546. https://doi.org/10.1016/j.envdev.2020.100546

Nurse, L.A., R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb. (2014). Small islands. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1613-1654.

O'Reilly, J., Oreskes, N., & Oppenheimer, M. (2012). The rapid disintegration of projections: The West Antarctic Ice Sheet and the Intergovernmental Panel on Climate Change. Social Studies of Science, 42(5), 709–731. https://doi.org/10.1177/0306312712448130

Okereke, C. and Coventry, P. (2016), Climate justice and the international regime: before, during, and after Paris. *WIREs Clim Change,* 7: 834-851. https://doi-org.silk.library.umass.edu/10.1002/wcc.419

Okereke, C. (2006). Global environmental sustainability: Intragenerational equity and conceptions of justice in multilateral environmental regimes. *Geoforum*, *37*(5), 725–738. https://doi.org/10.1016/j.geoforum.2005.10.005

Oppenheimer, M., & Alley, R. B. (2005). Ice sheets, global warming, and Article 2 of the UNFCCC: An editorial essay. In *Climatic Change* (Vol. 68, Issue 3, pp. 257–267). Springer. https://doi.org/10.1007/s10584-005-5372-y

Oppenheimer, M. (2005). Defining Dangerous Anthropogenic Interference: The Role of Science, the Limits of Science. *Risk Analysis*, *25*(6), 1399–1407. https://doi.org/10.1111/j.1539-6924.2005.00687.x

Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. et al., (2019). Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In Press.

Ourbak, T., & Magnan, A. K. (2018). The Paris Agreement and climate change negotiations: Small Islands, big players. In *Regional Environmental Change*, 18(8), 2201–2207. https://doi.org/10.1007/s10113-017-1247-9

Ourbak, T., & Tubiana, L. (2017). Changing the game: the Paris Agreement and the role of scientific communities. *Climate Policy*, *17*(7), 819–824. https://doi.org/10.1080/14693062.2017.1348331

Oxfam. (2020). *Climate Finance Shadow Report 2020: Assessing Progress Towards the $100 Billion Commitment*. Retrieved October 15, 2021 from: https://unfccc.int/sites/default/files/resource/bp-climate-finance-shadow-report-2020-201020-

en.pdf

Pacific Islands Forum. (2021). *DECLARATION ON PRESERVING MARITIME ZONES IN THE FACE OF CLIMATE CHANGE-RELATED SEA-LEVEL RISE*. 1–4. Retrieved October 15, 2021 from: https://www.forumsec.org/wp-content/uploads/2021/08/Declaration-on-Preserving-Maritime.pdf

Palanisamy, H., Becker, M., Meyssignac, B., Henry, O., & Cazenave, A. (2012). Regional sea level change and variability in the Caribbean sea since 1950. *Journal of Geodetic Science*, *2*(2), 125–133. https://doi.org/10.2478/v10156-011-0029-4

Pan, L., Powell, E. M., Latychev, K., Mitrovica, J. X., Creveling, J. R., Gomez, N., et al. (2021). Rapid postglacial rebound amplifies global sea level rise following West Antarctic Ice Sheet collapse. *Science Advances*, *7*(18), 1–10. https://doi.org/10.1126/sciadv.abf7787

Pattyn, F., Ritz, C., Hanna, E., Asay-Davis, X., DeConto, R., Durand, G., Favier, L., Fettweis, X., Goelzer, H., Golledge, N. R., Kuipers Munneke, P., Lenaerts, J. T. M., Nowicki, S., Payne, A. J., Robinson, A., Seroussi, H., Trusel, L. D., & van den Broeke, M. (2018). The Greenland and Antarctic ice sheets under 1.5 °C global warming. *Nature Climate Change*, *8*(12), 1053–1061. https://doi.org/10.1038/s41558-018-0305-8

Pernetta, J.C & Hughes, P. J. (1990). *Implications of expected climate changes in the South Pacific region: an overview UNEP*. *128*, 290.

Perumal, N. (2018). "The place where I live is where I belong": Community perspectives on climate change and climate-related migration in the Pacific island nation of Vanuatu. *Island Studies Journal*, *13*(1), 45–64. https://doi.org/10.24043/isj.50

Piggott-McKellar, A., McMichael, C., & Powell, T. (2021). Generational retreat: locally driven adaption to coastal hazard risk in two Indigenous communities in Fiji. *Regional Environmental Change*, *21*(2). https://doi.org/10.1007/s10113-021-01780-4

Randalls, S. (2010). History of the 2°C climate target. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(4), 598–605. https://doi.org/10.1002/wcc.62

Rapley, C. (2006). The Antarctic Ice Sheet and Sea Level Rise. In Schnellnhuber, H. J., Cramer, W., Nakicenovic, N., Wigley, T., Yohe, G. (Eds). *Avoiding dangerous climate change*.

Cambridge University Press, New York.

Rasmussen, D. J., Bittermann, K., Buchanan, M. K., Kulp, S., Strauss, B. H., Kopp, R. E., & Oppenheimer, M. (2018). Extreme sea level implications of 1.5 °c, 2.0 °c, and 2.5 °c temperature stabilization targets in the 21st and 22nd centuries. *Environmental Research Letters*, *13*(3). https://doi.org/10.1088/1748-9326/aaac87

Rawls, J. (1971). A Theory of Justice. Oxford: Oxford University Press.

Republic of Maldives (1989). *Small States Conference on Sea Level Rise*. Retrieved May 1, 2021 from http://www.islandvulnerability.org/slr1989/report.pdf

Rijsberman, F. R., Swart, R. J., & Stockholm Environment Institute. (1990). *Targets and indicators of climatic change*. Stockholm Environment Institute.

Rintoul, S. R., Chown, S. L., DeConto, R. M., England, M. H., Fricker, H. A., Masson-Delmotte, V., Naish, T. R., Siegert, M. J., & Xavier, J. C. (2018). Author Correction: Choosing the future of Antarctica. *Nature*, *562*(7726), E5–E5. https://doi.org/10.1038/s41586-018-0369-7

Roberts, J. (2018). Undermining weak agreement: Fossil capitalism, neoliberal climate governance, paris and just transition after trump. *Connecticut Journal of International Law,* 33(3), 425-[xiii].

Robinson, S. Ann. (2020). Climate change adaptation in SIDS: A systematic review of the literature pre and post the IPCC Fifth Assessment Report. Wiley Interdisciplinary Reviews: Climate Change, 11(4), 1–21. https://doi.org/10.1002/wcc.653

Rogelj, J., Schaeffer, M., Friedlingstein, P., Gillett, N. P., Van Vuuren, D. P., Riahi, K., Allen, M., & Knutti, R. (2016). Differences between carbon budget estimates unravelled. In *Nature Climate Change*, 6(3), 245–252. https://doi.org/10.1038/nclimate2868

Rogelj, J., Shindell, D., Jiang, K., Fifita, S., Forster, P., Ginzburg, V., et al. (2018), Mitigation pathways compatible with 1.5°C in the context of sustainable development. In: *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J.

Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. In Press.

Rogelj, J., Forster, P. M., Kriegler, E., Smith, C. J., & Séférian, R. (2019). Estimating and tracking the remaining carbon budget for stringent climate targets. *Nature*, *571*(7765), 335–342. https://doi.org/10.1038/s41586-019-1368-z

Sabūnas, A., Mori, N., Fukui, N., Miyashita, T., & Shimura, T. (2020). Impact Assessment of Climate Change on Storm Surge and Sea Level Rise Around Viti Levu, Fiji. *Frontiers in Climate*, *2*. https://doi.org/10.3389/fclim.2020.579715

Sadai, S., Condron, A., DeConto, R., & Pollard, D. (2020). Future climate response to Antarctic Ice Sheet melt caused by anthropogenic warming. *Science Advances*, *6*(39), 1–9. https://doi.org/10.1126/sciadv.aaz1169

Sealey-Huggins, L. (2017). '1.5°C to stay alive': climate change, imperialism and justice for the Caribbean. *Third World Quarterly*, *38*(11), 2444–2463. https://doi.org/10.1080/01436597.2017.1368013

Schleussner, C. F., Rogelj, J., Schaeffer, M., Lissner, T., Licker, R., Fischer, E. M., Knutti, R., Levermann, A., Frieler, K., & Hare, W. (2016). Science and policy characteristics of the Paris Agreement temperature goal. In *Nature Climate Change* (Vol. 6, Issue 9, pp. 827–835). Nature Publishing Group. https://doi.org/10.1038/nclimate3096

Schloesser, F., Friedrich, T., Timmermann, A., DeConto, R. M., & Polllard, D. (2019). Antarctic Iceberg impacts on future Southern Hemisphere Climate. *Nature Climate Change*, *9*, 672–677.

Seager, Joni. (2009). Death by Degrees: Taking a Feminist Hard Look at the 2° Climate Policy. *Kvinder, Køn & Forskning* 3/4: 11–21.

Seroussi, H., Nowicki, S., Payne, A. J., Goelzer, H., Lipscomb, W. H., Abe Ouchi, A., et al. (2020). *ISMIP6 Antarctica: a multi-model ensemble of the Antarctic ice sheet evolution over the 21st century*. Ice sheets/Antarctic. https://www.the-cryosphere-discuss.net/tc-2019-324/

Shepherd, A., Ivins, E., Rignot, E., Smith, B., van den Broeke, M., Velicogna, I., et al. (2018). Mass balance of the Antarctic Ice Sheet from 1992 to 2017. *Nature*, *558*(7709), 219–222.

https://doi.org/10.1038/s41586-018-0179-y

Shibuya, E. (1997). "Roaring Mice Against the Tide": The South Pacific Islands and Agenda-Building on Global Warming. *Pacific Affairs*, *69*(4), 541–555.

Siméoni, P., & Ballu, V. (2012). The myth of the first climatic refugees: Population movements and environmental changes in the Torres Island (Vanuatu, Melanesia). *Annales de Geographie*, *121*(685), 219–241. https://doi.org/10.3917/ag.685.0219

Simpson, M.C, Scott, D., Harrison, M., Sim, R., Silver, N., O'Keeffe, E., et al. (2010). Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean (Full Document). United Nations Development Programme (UNDP), Barbados, West Indies.

Steinacher, M., Joos, F., & Stocker, T. F. (2013). Allowable carbon emissions lowered by multiple climate targets. *Nature*, *499*(7457), 197–201. https://doi.org/10.1038/nature12269

Stephenson, S. R., Oculi, N., Bauer, A., & Carhuayano, S. (2019). Convergence and Divergence of UNFCCC Nationally Determined Contributions. *Annals of the American Association of Geographers*, *109*(4), 1240–1261. https://doi.org/10.1080/24694452.2018.1536533

Storlazzi, C. D., Elias, E. P. L., & Berkowitz, P. (2015). Many Atolls May be Uninhabitable Within Decades Due to Climate Change. *Scientific Reports*, *5*, 1–9. https://doi.org/10.1038/srep14546

Storlazzi, C. D., Gingerich, S. B., Van Dongeren, A., Cheriton, O. M., Swarzenski, P. W., Quataert, E., Voss, C. I., Field, D. W., Annamalai, H., Piniak, G. A., & McCall, R. (2018). Most atolls will be uninhabitable by the mid-21st century because of sea-level rise exacerbating wave-driven flooding. Science Advances, 4(4), 1–10. https://doi.org/10.1126/sciadv.aap9741

Strauss, B., & Kulp, S. (2018). Sea-Level Rise Threats in the Caribbean: Data, tools, and analysis for a more resilient future. *Inter-American Development Bank*, *February*, 1–25. Retrieved October 15, 2021 from, http://sealevel.climatecentral.org/uploads/ssrf/Sea-level-rise-threats-in-the-Caribbean.pdf

Supran, G., & Oreskes, N. (2017). Assessing ExxonMobil ' s climate change Assessing ExxonMobil ' s climate change communications. *Environmental Research Letters*, *12*(8).

https://doi.org/10.1088/1748-9326/aa815f

Tavoni, M., & Socolow, R. (2013). Modeling meets science and technology: an introduction to a special issue on negative emissions. *Climatic Change*, *118*, 1–14. https://doi.org/10.1007/s10584-013-0757-9

Tavoni, M., & Tol, R. S. J. (2010). Counting only the hits? The risk of underestimating the costs of stringent climate policy: A letter. Climatic Change, 100(3), 769–778. https://doi.org/10.1007/s10584-010-9867-9

Thomas, A., Baptiste, A., Martyr-Koller, R., Pringle, P., & Rhiney, K. (2020). Climate change and small island developing states. *Annual Review of Environment and Resources*, *45*, 1–27. https://doi.org/10.1146/annurev-environ-012320-083355

Thomas, A., & Benjamin, L. (2018). Management of loss and damage in small island developing states: implications for a 1.5 °C or warmer world. *Regional Environmental Change*, *18*(8), 2369–2378. https://doi.org/10.1007/s10113-017-1184-7

Thomas, A., & Benjamin, L. (2018b). Perceptions of climate change risk in The Bahamas. *Journal of Environmental Studies and Sciences*, *8*(1), 63–72. https://doi.org/10.1007/s13412-017-0429-6

Thomas, A., & Benjamin, L. (2018c). Policies and mechanisms to address climate-induced migration and displacement in Pacific and Caribbean small island developing states. *International Journal of Climate Change Strategies and Management*, *10*(1), 86–104. https://doi.org/10.1108/IJCCSM-03-2017-0055

Torres, R. R., & Tsimplis, M. N. (2013). Sea-level trends and interannual variability in the Caribbean Sea. *Journal of Geophysical Research: Oceans*, *118*(6), 2934–2947. https://doi.org/10.1002/jgrc.20229

Tschakert, P. (2015). 1.5°C or 2°C: a conduit's view from the science-policy interface at COP20 in Lima, Peru. *Climate Change Responses*, *2*(1). https://doi.org/10.1186/s40665-015-0010-z

United Nations Framework Convention on Climate Change. (1992). United Nations. https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

United Nations. (2021). List of Former Trust and Non-Self-Governing Territories. Retrieved from: https://www.un.org/dppa/decolonization/en/history/former-trust-and-nsgts

UNEP. (2012). The Emissions Gap Report 2012. https://www.unenvironment.org/resources/emissions-gap-report-2012

UNEP. (2020). The Emissions Gap Report 2020. https://www.unenvironment.org/emissions-gap-report-2020

UNFCCC. (1995). FCCC/CP/1995/7 Report of the Conference of the Parties of its first session held at Berlin from 28 March to 7 April 1995. https://unfccc.int/sites/default/files/resource/docs/cop1/07.pdf

UNFCCC. (1997). Report of the Conference of the Parties on its third session, held Kyoto from 1 TO 11 December 1997. https://unfccc.int/resource/docs/cop3/07a01.pdf

UNFCCC. (2009). Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009. Addendum. Part Two: Action taken by the Conference of the Parties at its fifteenth session. https://unfccc.int/sites/default/files/resource/docs/2009/cop15/eng/11a01.pdf

UNFCCC. (2010). Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010. https://unfccc.int/sites/default/files/resource/docs/2010/cop16/eng/07a01.pdf

UNFCCC. (2015). The Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf

UNFCCC. (2016). FCCC/CP/2015/10/Add.1 Decision 1/CP.21 Adoption of the Paris Agreement. Retrieved from https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf

UNFCCC. (2021). FCCC/PA/CMA/2021/8. Nationally determined contributions under the Paris Agreement. https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf

UNFCCC Subsidiary Body for Scientific and Technological Advice (UNFCCC SBSTA). (2015a). Summary report on the fourth session of the structured expert dialogue, Lima, Peru, 2 and 3

December 2014 and Geneva, Switzerland, 8 and 9 February 2015. Retrieved from https://unfccc.int/files/science/workstreams/application/pdf/structuredexpertdialogue.2015.1.summaryreport.pdf

UNFCCC Subsidiary Body for Scientific and Technological Advice (UNFCCC SBSTA). (2015b). Subsidiary Body for Scientific and Technological Advice Subsidiary Body for Implementation Item 12 of the provisional agenda The 2013-2015 review Report on the structured expert dialogue on the 2013-2015 review. Retrieved from https://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf

UNGA. (2020). Report of the Special Rapporteur in the field of cultural rights, Karima Bennoune: A/75/298. United Nations General Assembly. https ://www.undoc s.org/en/A/75/298

Vanuatu. (1991). *Statement on commitments submitted by the delegation of Vanuatu on behalf of the States members of the Alliance of Small Island States to Working Group I at the fourth meeting of the Intergovernmental Negotiating Committee*. Retrieved from https://unfccc.int/documents/910

Vellinga, P., & Swart, R. (1991). The greenhouse marathon: proposal for a global strategy. *Climate Change. Proc. 2nd World Climate Conference, Geneva, 1990*, 129–134.

Virtual Island Summit. (2021). Climate and Environmental Justice: Island Perspectives. https://islandinnovation.co/webinar/climate-and-environmental-justice/ Accessed Oct 1 2021.

Walshe, R. A., & Stancioff, C. E. (2018). Small Island perspectives on climate change. *Island Studies Journal*, *13*(1), 13–24. https://doi.org/10.24043/isj.56

Warrick, R.A., Oerlemans, J. (1990). Sea Level Rise. In J.T. Houghton, G.J. Jenkins, and J.J. Ephraums (Eds.), *Climate Change: The IPCC Scientific Assessment* (pp. 257–81). Cambridge: Cambridge University Press.

Warrick, R.A., Provost C. LE, Meier M.F., Oerlemans, J., Woodworth RL. (1996) Changes in Sea Level. In y J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg and K. Maskell (Eds.), *Climate Change 1995: The Science of Climate Change Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 359-406). Cambridge: Cambridge University Press.

Warszawski, L., Kriegler, E., Lenton, T. M., Gaffney, O., Jacob, D., Klingenfeld, D., Koide, R., Costa, M. M., Messner, D., Nakicenovic, N., Schellnhuber, H. J., Schlosser, P., Takeuchi, K., van der Leeuw, S., Whiteman, G., & Rockström, J. (2021). All options, not silver bullets, needed to limit global warming to 1.5 °C: A scenario appraisal. *Environmental Research Letters*, *16*(6). https://doi.org/10.1088/1748-9326/abfeec

Weertman, J. (1974). Stability of the Junction of an Ice Sheet and an Ice Shelf. *Journal of Glaciology*, *13*(67), 3–11. https://doi.org/10.3189/s0022143000023327

Wewerinke-Singh, M., & Doebbler, C. (2016). The paris agreement: Some critical reflections on process and substance. University of New South Wales Law Journal, 39(4), 1486-1517.

Wigley, T. M. L. (2018). The Paris warming targets: emissions requirements and sea level consequences. *Climatic Change*, *147*(1–2), 31–45. https://doi.org/10.1007/s10584-017-2119-5

Yamamoto, L., & Esteban, M. (2014). Atoll Island States and International Law. https://doi.org/10.1007/978-3-642-38186-7

Zhou, C., Zelinka, M. D., Dessler, A. E., & Wang, M. (2021). Greater committed warming after accounting for the pattern effect. *Nature Climate Change*, 1–5. https://doi.org/10.1038/s41558-020-00955-x

Zanna, L., Khatiwala, S., Gregory, J. M., Ison, J., & Heimbach, P. (2019). Global reconstruction of historical ocean heat storage and transport. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(4), 1126–1131. https://doi.org/10.1073/pnas.1808838115