Sea Level Rise, Climate Justice, and the Paris Agreement

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Abstract

In 2015, at the United Nations 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 it to 1.5°C. However, risks from sea level rise are not well encapsulated by temperature targets. Near term emissions will dictate long term sea level rise responses, but the tendency for policy and negotiations to concentrate on the year 2100 can limit our understanding of intergenerational justice concerns arising from this commitment. Here we present an analysis of the long term spatial variability of sea level rise, and an interdisciplinary review of associated justice considerations from across a wide range of literatures. We center the positioning of the Alliance of Small Island States (AOSIS) to show that AOSIS nations are disproportionately impacted by sea level rise, and that ice sheet instabilities, which could dominate the long term trend in sea level, are associated with feedbacks which can potentially exacerbate climate justice implications.

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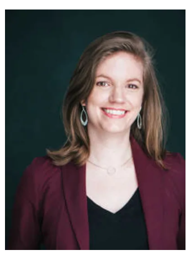
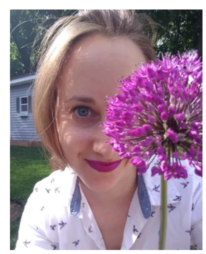




PRESENTED AT:

MOTIVATION

Background context

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).

Problem statement and guiding questions:

This temperature target, as it is currently framed, poses several challenges which can give rise to multiple sources of climate injustice.

We ask, how did temperature become the metric for the LTGG, what are the justice implications of that target particularly when considering sea level rise, and how do projections of Antarctic melt interface with temperature targets and justice considerations?

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).

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).

Third, and finally, "acceptable risk" is an ambiguous term with respect to the concept of DAI written into the UNFCCC. 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). 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. 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).

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.

The Antarctic component of SLR will exacerbate the uneven impacts for AOSIS nations and others over the coming centuries. 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. For a full analysis see our paper preprint.

The Antarctic 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.

METHODS AND FRAMING

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** argues that fair outcomes require equity throughout the decision making process.

2) **Recognition justice** relates to the existence rights of cultural and social groups (Burnham et al., 2013a; Fraser, 1997; Rawls, 1971).

3) **Distributive justice** assesses how impacts vary spatially and temporally, and are often uneven with respect to emissions contribution.

Methods

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.

We review and synthesize documents from United Nations (UN) archives and a review of the literature pertaining to three aspects of climate justice then turn to a case study of the Antarctic Ice Sheet (AIS).

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. 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. Details of these calculations will be provided in Roffman et al. (in prep). 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.

JUSTICE SUMMARY

Our paper reviews three aspects of climate justice with respect to sea level rise, temperature targets, and AOSIS. A brief summary is below:

Procedural Justice

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. AOSIS has played a prominent role in negotiations since their inception advocating for binding emissions reductions targets, multiple metrics, and a lower temperature goal. 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. While lower-emitting countries advocated for binding emissions targets on the basis of equity, higher emitting countries ultimately prevailed in achieving non-binding contributions. A full historical breakdown and annotated timeline are available in our preprint.

Recognition Justice

Recognition justice relates to differences in cultural and social groups, seeking to address injustices and systemic disadvantages (Fraser, 1997). 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). 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 and colonization impact adaptive capacity, recognition of this, and financial compensation, are key to any consideration of climate justice.

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. 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). Overshoot pathways have been used to justify nearterm delays in emissions reductions. Their normalization within the global climate and policy spheres, will exacerbate preexisting 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.

ANTARCTIC CASE STUDY

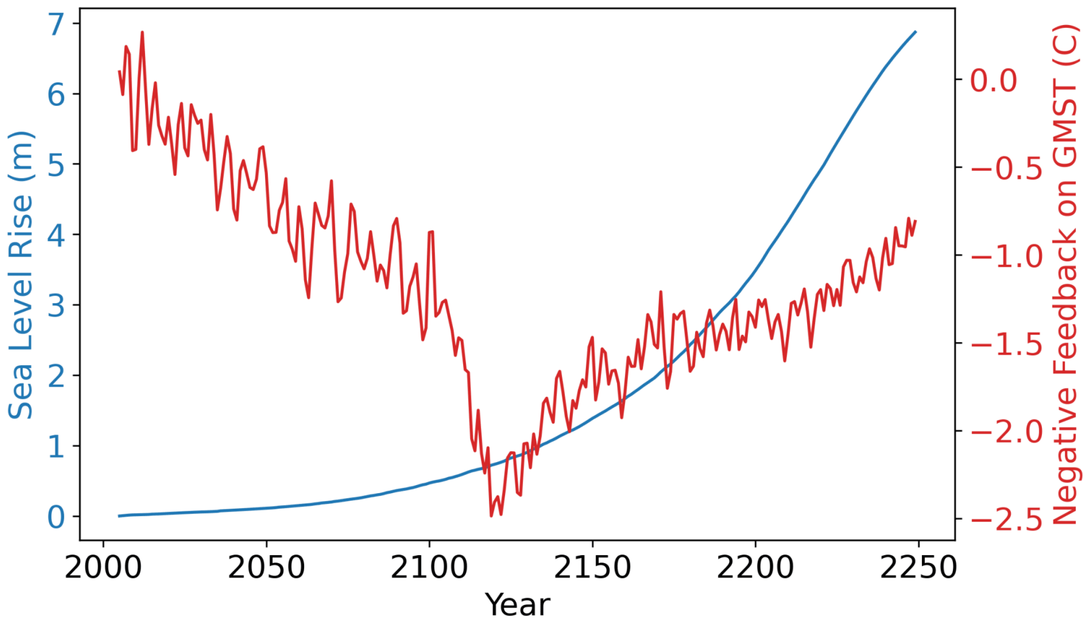


Figure above: Sea level rise and negative feedbacks on GMST. Under an RCP8.5 emissions scenario one climate model predicted GMST response to meltwater could be over 2°C lower at peak ice sheet collapse. When driven with these climatologies, an ice sheet model predicts that meltwater delays ice sheet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

Figures in center of poster slideshow:

The central figure of this poster shows sea level rise predictions normalized by global mean sea level rise. 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.

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 (See central figure). This remains true regardless of emissions trajectories (medium-high emissions) or time periods considered (2100-2300). 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.

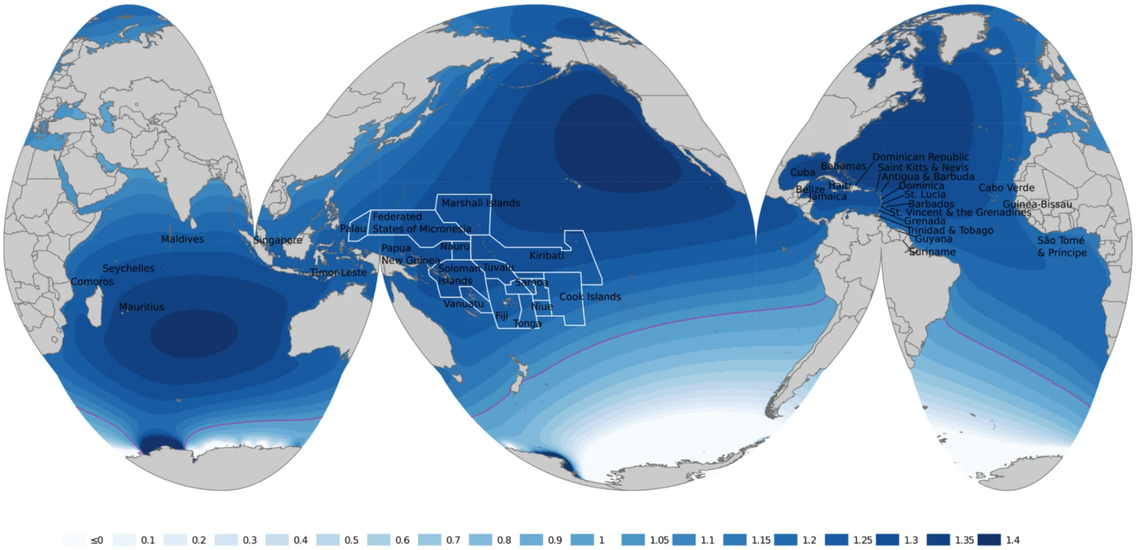
In either scenario the Cook Islands, Guyana, Suriname, Guinea-Bissau, and São Tomé and Príncipe consistently see the least amplification of SLR, though importantly it remains 12-17% above the global mean. This is due to their geographic placement. The Cook Islands are the southernmost islands of Oceania, 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.

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 (see preprint table). 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.

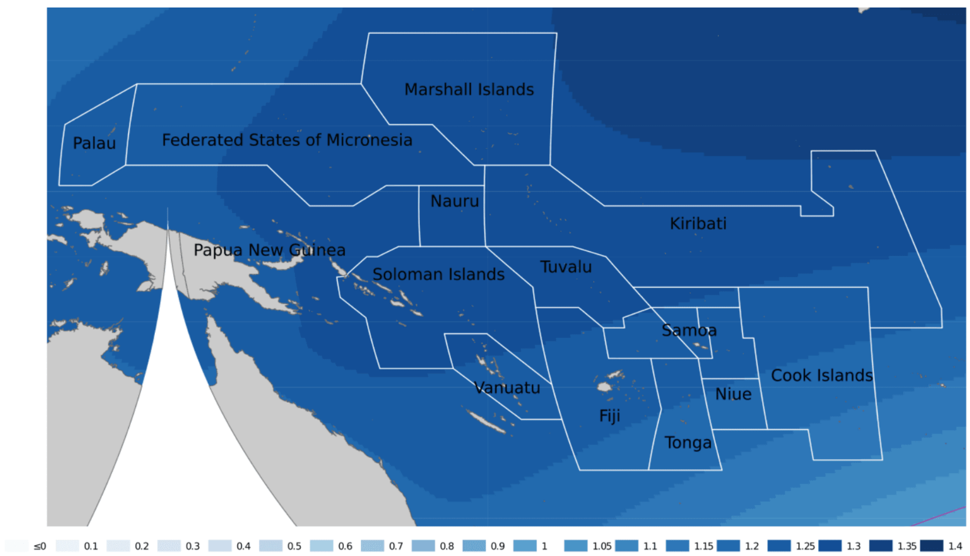
Sea level fingerprint calculations and data were provided by Jeremy Roffman and Natalya Gomez. Calculations of sea level rise at AOSIS locations were done by Shaina Sadai.

Alt text for slideshow:

The slideshow below contains 4 maps. The first is a global map in a Goode Homolosine projection which shifts focus from the landmasses to the oceans. The other 3 images are closeups of different sections of the main map. On all maps there is a color scale in shades of blue showing sea level rise compared to the global mean. A purple line indicates where values are equal to the global mean. AOSIS nations are labeled in black text with guide lines indicating islands that are closer together. The Indian Ocean is on the left of the image, Pacific in the center, and Caribbean and Atlantic Oceans on the right. In the Pacific the large ocean states are also shown with white polygons indicating the boundaries of their exclusive economic zones (EEZs). The map shows that regional SLR values less than the global mean exist south of the equator mainly in the Southern Ocean. All AOSIS locations lie above the line indicating where regional SLR is higher than GMSL. Places with the highest SLR are in the center of the Indian Ocean basin, and by the coasts of North America. In the closeup of the Indian Ocean Mauritius is very close to the center of the basin and at the point where SLR is highest, approximately 30% above GMSL. Comoros is between the African continent and Madagascar with Seychelles slightly above it. They are both in a band of SLR about 20% above GMSL. The islands of the Maldives stretch across multiple bands. Singapore and Timuo-Leste are located within the chains of islands between Australia and Southeast Asia. Singapore has a slightly lower regional SLR impact than other places in this map but Timor-Leste is in the same band as Comoros and Seychelles. In the Pacific map the white EEZ boundaries demonstrate that many of the large island states cover substantial ocean territory. Many of them stretch across multiple bands of SLR regional impact. The Cook Islands, Niue, Tonga, and the southern parts of Fiji have the least impact due to their positioning relatively far south near the GMSL delineation. The Marshall Islands, Kiribati, Nauru, Tuvalu, the Soloman Islands, and portions of Papua New Guinea and the Federated States of Micronesia have the highest regional impact at around 25-30% above GMSL. In the closeup of the Atlantic and Caribbean oceans Bahamas are in the zone of highest impact with 25-30% above GMSL. Just below that in impact are Haiti, Dominican Republic, Belize, Jamaica, Saint Kitts and Nevis, Antigua & Barbuda, Dominica, St. Lucia, Barbados, and St. Vincent and the Grenadines with around 20-25% above GMSL. Grenada, Trinidad and Tobago, and Cabo Verde (off the western side of Africa) are in the next band down. Regions close to continental coasts including Guyana, Suriname, Sao Tome and Principe, and Guinea-Bissau are the lowest impact but still 10-15% above GMSL.



Regional sea level rise compared to the global mean



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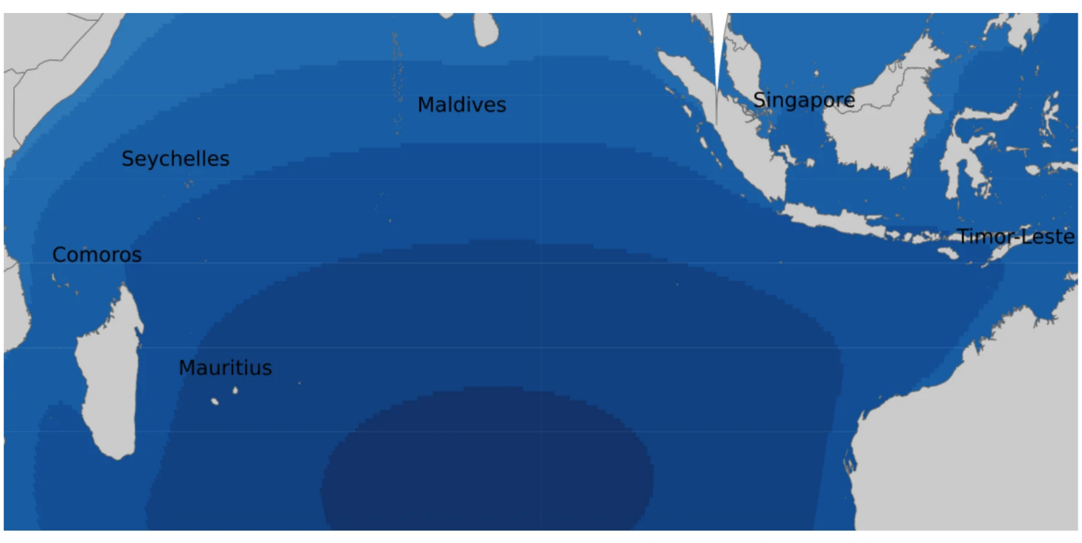

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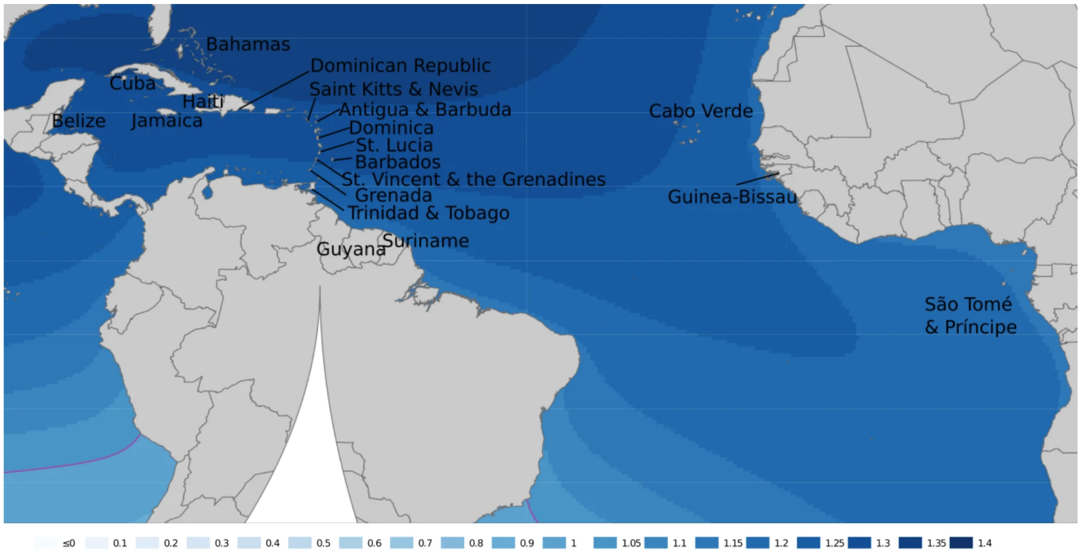

Regional sea level rise compared to the global mean

FOR MORE INFO

This work is currently under review at AGU Earth's Future. The preprint is available at ESSOAr here (https://www.essoar.org/doi/10.1002/essoar.10508929.1).

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.

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.

ABSTRACT

In 2015, at the United Nations 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 it to 1.5°C. However, risks from sea level rise are not well encapsulated by temperature targets. Near term emissions will dictate long term sea level rise responses, but the tendency for policy and negotiations to concentrate on the year 2100 can limit our understanding of intergenerational justice concerns arising from this commitment. Here we present an analysis of the long term spatial variability of sea level rise, and an interdisciplinary review of associated justice considerations from across a wide range of literatures. We center the positioning of the Alliance of Small Island States (AOSIS) to show that AOSIS nations are disproportionately impacted by sea level rise, and that ice sheet instabilities, which could dominate the long term trend in sea level, are associated with feedbacks which can potentially exacerbate climate justice implications.

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