Third-Party Interventions

***Verein KlimaSeniorinnen Schweiz and Others v. Switzerland* (Application no. 53600/20)**

***Carême v. France* (Application no. 7189/21)**

***Duarte Agostinho and Others v. Austria and 32 Others* (Application no. 39371/20)**

in front of the

Grand Chamber
European Court of Human Rights
Council of Europe
F-67075
Strasbourg
France

5 December 2022

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IN THE EUROPEAN COURT OF HUMAN RIGHTS GRAND CHAMBER

VEREIN KLIMASENIORINNEN SCHWEIZ AND OTHERS V. SWITZERLAND
APPLICATION NO. **53600/20**

DUARTE AGOSTINHO AND OTHERS V. PORTUGAL AND 32 OTHERS
APPLICATION NO. **39371/20**

CARÊME V. FRANCE
APPLICATION NO. **7189/21**

WRITTEN SUBMISSION ON BEHALF OF OUR CHILDREN'S TRUST, OXFAM, THE CENTRE FOR CLIMATE REPAIR AT CAMBRIDGE, AND THE CENTRE FOR CHILD LAW AT UNIVERSITY OF PRETORIA

5 DECEMBER 2022

These submissions are made by Our Children's Trust, Oxfam, the Centre for Climate Repair at Cambridge, and the Centre for Child Law at University of Pretoria (hereinafter "intervenors") pursuant to three separate requests to intervene granted by the President of the Grand Chamber on 24 October 2022 in accordance with Article 36 §2 of the European Convention on Human Rights and Rule 44 §3 of the Rules of Court.[1]

In light of the similarities in content intervenors' committed to address in each of the three requests, together with the Court's decision to hold the hearings regarding the admissibility and merits of the cases in question together—*Verein KlimaSeniorinnen Schweiz and Others v. Switzerland, Carême v. France,* and *Duarte Agostinho and Others v. Portugal and 32 Others*—intervenors submit one inclusive intervention as opposed to three shorter and substantially overlapping interventions to present the evidence and associated considerations to the Court in a succinct form that avoids duplication. If the Court prefers this submission be split and submitted separately, intervenors will immediately do so.

I. Summary of Intervention

To uphold the rights guaranteed by the European Convention on Human Rights (Convention) and to reflect its status as a "living instrument," intervenors submit that this Court must base its decisions on the most up-to-date and best available scientific evidence. For purposes of this intervention, "best available science" means the most up-to-date science that: i) maximizes the quality, objectivity, and integrity of information, including statistical information; ii) uses multiple peer-reviewed and publicly available data; and iii) clearly documents and communicates risks and uncertainties in the scientific basis for its conclusions. This is particularly relevant in a field such as climate science where the data is complex, constantly developing, and increasingly recognized as important to an issue of environmental degradation having an exponential impact on human rights. The purpose of this submission is to present the Court with a summary of the best available scientific evidence within the field of climate science that is relevant to the legal questions before the Court. The intervenors submit that scrutiny of this evidence provides a sound evidentiary basis upon which the Court could choose to make the findings set forth in Section I(D).

A. The 1.5°C and 2°C temperature targets specified in the Paris Agreement are insufficient to protect human rights

Too often, the politically negotiated Paris Agreement target established in 2015 of "[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"[2] (hereinafter "Paris temperature targets"), has improperly been presented to courts as the best scientific evidence and the *de facto* legal standard for fundamental rights protection in climate change cases. This assertion is not supported by scientific evidence.

To the contrary, as discussed further in Sections II, III, IV and V, leading climate scientists—and the Intergovernmental Panel on Climate Change (IPCC)—consistently state that allowing the Earth to heat up to 1.5°C or more above pre-industrial levels is categorically dangerous for human health, well-being, and life itself.[3] Because the temperature target is a global average, it is on its face

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[1] Our Children's Trust and Oxfam respectfully submit the full submission. The Centre for Climate Repair at Cambridge joins for the sections on science I-IV. The Centre for Child Law specifically joins for Sections I and V and supports the full submission.

[2] Paris Agreement to the United Nations Framework Convention on Climate Change art. 2 § 1(a), Dec. 12, 2015, 3156 U.N.T.S. 54113, https://unfccc.int/sites/default/files/english_paris_agreement.pdf [hereinafter Paris Agreement].

[3] *See, e.g.*, Intergovernmental Panel on Climate Change, *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* 44 (Valérie Masson-Delmotte et al. eds., 2019), https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Full_Report_LR.pdf [hereinafter *IPCC Special Report on 1.5°C*] ("Warming of 1.5°C is not considered 'safe' for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems as compared to the current warming of 1°C (*high confidence*).").

an inequitable measure of human rights protection because northern latitudes are already well over the 1.5°C Paris target. The Arctic Circle annual average temperature is now 3°C above the pre-industrial temperatures for that region and those temperatures over the past 20 years have been heating up to a rate 4 times faster than the rest of the planet, with alarming consequences for melting tundra and methane emissions, which further endanger the rest of the world's inhabitants.[4] Further, with respect to temperature increases, the length of time Earth stays at such hotter temperatures is very relevant,[5] none of which is addressed in the Paris Agreement. Allowing a 1.5°C or greater increase in average global surface temperatures above pre-industrial levels as an acceptable permanent level of heating is incompatible with State's obligations under the Convention to respect the right to life identified in Article 2; the right to respect private life, family life, and home identified in Article 8; and the prohibition on discrimination set out in Article 14[6] taken in conjunction with Articles 2 and 8.

The Paris Agreement is an important and relevant achievement of international negotiation and cooperation, but scrutiny of the Paris temperature targets shows that these targets are political, rather than scientific thresholds, reflecting the best consensus that States were able to reach in 2015 not the status of scientific knowledge at the time. Furthermore, seven years have passed since the agreement and the scientific evidence indicating the immense dangers of allowing global heating to continue up to—and then remain at—the Paris temperature targets continues to become more robust. As such, the Paris temperature targets would be a flawed reference point for determining State compliance with their human rights obligations and the Convention.

B. Scientists indicate that Earth's Energy Imbalance is the "most critical" metric for determining whether actions to combat climate change are working

To uphold human rights, instead of focusing on temperature targets, courts should consider what is scientifically necessary to stabilise the Earth's current energy imbalance (EEI). The EEI concept, although rarely used in policy discussions, is what climate scientists describe as the "*most critical*" metric for determining "*the prospects for continued global warming and climate change.*"[7]

EEI is driven by elevated atmospheric concentrations of greenhouse gases (GHGs)—mainly carbon dioxide (CO_2) as measured in parts per million (ppm)[8]—that are produced by human activities, particularly fossil fuel combustion. Average atmospheric CO_2 levels were approximately 416 ppm in 2021.[9] The 2022 calculation is expected to be higher and should be available to the Court by March 2023.[10]

Scientific consensus indicates that to restore the stability of Earth's climate so as to protect human life and health, States must reduce atmospheric concentrations of CO_2 to an equitable and environmentally sustainable level of 350 ppm (hereinafter "350 ppm standard")[11] To achieve this, at minimum, emission reductions and legacy carbon removal of CO_2[12] need to be implemented to prevent

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[4] Arctic Monitoring and Assessment Program, *Arctic Climate Change Update 2021: Key Trends and Impacts, Summary for Policy-makers*, Arctic Council 5 (2021), https://www.amap.no/documents/download/6759/inline ("From 1971–2019, the annually averaged Arctic near-surface air temperature increased by 3.1°C, three times faster than the global average."); Mika Rantanen, et al., *The Arctic Has Warmed Four Times Faster Than the Globe Since 1980*, 3 Comm. Earth & Env't 3 (2022), https://www.nature.com/articles/s43247-022-00498-3#citeas ("During 1970-2021, major portions of the Arctic Ocean were warming at least four times as fast as the global average[.]").

[5] *See generally* James Hansen et al., *Young People's Burden: Requirement of Negative CO_2 Emissions*, 8 Earth Sys. Dynamics 577, 595 (2017), https://esd.copernicus.org/articles/8/577/2017/) [hereinafter *Young People's Burden*] (noting that "[l]imiting the period and magnitude of temperature excursion above the Holocene range is crucial to avoid strong stimulation of slow feed-backs" that could trigger irreversible climate harms).

[6] In light of space limitations for this submission, intervenors are not able to meaningfully address the legal and evidential aspects of Article 14 issues raised by the impact of climate change. However, it is submitted that there is ample evidence in the public domain (some of which is contained within Section V of this submission) which would enable the Court to meet its obligations in fully considering the ramifications of this crucial issue. The intervenors would be at the Court's disposal to provide a further intervention on this specific topic should that be of assistance.

[7] Karina von Schuckmann et al., *Heat Stored in the Earth System: Where Does the Energy Go?*, 12 Earth Sys. Sci. Data 2013, 2014 (2020) (emphasis added).

[8] In this context, the term "parts per million" signifies "the number of carbon dioxide molecules per million molecules of dry air[]" based on "measurements [] from the mid-troposphere, [i.e.,] the layer of Earth's atmosphere that is 8 to 12 kilometers [] above the ground." Holly Shaftel et al., *Carbon Dioxide*, NASA Global Climate Change: Vital Signs Planet (Nov. 22, 2022), https://climate.nasa.gov/vital-signs/carbon-dioxide/.

[9] Dr. Pieter Tans & Dr. Ralph Keeling, *Trends in Atmospheric Carbon Dioxide: Data*, NOAA Global Monitoring Lab., https://gml.noaa.gov/ccgg/trends/data.html.

[10] *See* the NOAA data available at the following website after March 2023: https://gml.noaa.gov/webdata/ccgg/trends/co2/co2_annmean_mlo.txt.

[11] *See, e.g.*, Expert Report of James E. Hansen, Ph.D, Juliana v. United States, 339 F. Supp. 3d 1062, No. 6:15-cv-01517-TC (D. Or. Jun. 28, 2018), ECF No. 274-1, at 3, http://climatecasechart.com/wp-content/uploads/sites/16/case-documents/2018/20180628_docket-615-cv-1517_exhibit-7.pdf [hereinafter Hansen Expert Report]; James Hansen et al., *Target Atmospheric CO_2: Where Should Humanity Aim*, 2 The Open Atmospheric Sci. J. 217, 217 (2008), https://openatmosphericsciencejournal.com/contents/volumes/V2/TOASCJ-2-217/TOASCJ-2-217.pdf [hereinafter *Target Atmospheric CO_2*]; von Schuckmann et al., *supra* note 7, at 2029 (mentioning that "[t]he amount of CO_2 in the atmosphere would need to be reduced from 410 to 353 ppm to . . . bring[] Earth back towards energy balance").

[12] Although more GHGs contribute to climate change than just CO_2, CO_2 is by far the largest forcer of climate change amongst the various GHGs. Other GHGs such as nitrous oxide (N_2O) play a relatively minor role in causing planetary heating and are difficult to reduce due to their association with modern food production. Still other GHGs, such as methane (CH_4), eventually break down to atmospheric CO_2 and are therefore accounted for in the atmospheric CO_2 metric. Given these considerations, many scientific studies turn to CO_2 concentrations in the atmosphere as a useful

the worsening of, and to work to end, the many climate disasters the world has experienced in the last few decades.[13] The laws of physics make clear that restoring the stability of Earth's energy imbalance and climate system is the way to safeguard the Convention rights of people who will otherwise endure catastrophic climate harms.

Importantly, EEI also reflects the gravity and urgency of the current climate crisis more accurately than the Paris temperature targets. Global average surface temperatures have already reached ~1.1°C–1.3°C above pre-industrial levels[14] which can give the erroneous impression that an unused 'budget' remains for States to continue safely emitting CO_2 before reaching the Paris temperature target of 1.5°C is reached. By contrast, measurements of just atmospheric CO_2, which more accurately reflect the gravity of the current situation have exceeded 416 ppm., overshooting the scientifically endorsed 350 ppm limit.

The consequence of this overshoot is that humanity is already immersed in a climate emergency. An ever-growing body of science verifies the devastating outcomes: floods, fires, droughts, mega-storms, heatwaves, and sea-level rise are all made more frequent and severe by climate change, resulting in the loss of property, forced migration, food and water shortages, poverty, violence, disease, and death.[15] The science is clear that the only way to minimize these extreme dangers posed to human life and health from climate change is to stabilise EEI by bringing atmospheric CO_2 concentrations back down to 350 ppm.[16]

C. Urgent State action is required to avoid further harm

States have already overshot safe and stable levels of atmospheric CO_2, taking humanity out of the safe zone.[17] However, there remains a narrow window of opportunity to bring such dangerous levels of warming back down to levels that protect human life, health, and well-being by the end of the century.[18] Immediate action is required to limit the damage which has already been done and which will continue to accumulate for many years to come. Scientific evidence emphatically establishes that the necessary way for States to achieve the 350 ppm standard—thereby "restor[ing] planetary energy balance" is by rapidly phasing out fossil fuel emissions and drawing down atmospheric CO_2[19] outlined in Section III(E). The longer States take to act, including by allowing temperatures to reach 1.5°C of warming for any length of time, the greater the magnitude and severity of the harms to human life and health that will come to pass due to climate change.[20]

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metric that is directly correlated with, and therefore accurately indicates, the extent of EEI and global warming. *See* Richard Allan et al., *Summary for Policymakers, in* Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change 7 (Valérie Masson-Delmotte et al. eds., 2021), https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf (indicating a relatively small contribution to warming from N_2O relative to that from CO_2); von Schuckmann et al., *supra* note 7, at 2029 ("[S]ome continuing increase in N_2O, whose emissions are associated with food production, seems inevitable, so there is little prospect for much net reduction of non-CO_2 greenhouse gases, and thus the main burden for climate stabilization falls on CO_2 reduction[.]"); Martin Wahlen, *The Global Methane Cycle*, 21 Ann. Rev. Earth Planet Sci. 407, 407 (1993), https://adsabs.harvard.edu/pdf/1993AREPS..21..407W (noting that atmospheric methane ultimately breaks down into carbon dioxide and water after 8-12 years); Allan et al., *supra* note 12, at 28 (noting the "near-linear relationship between the cumulative CO_2 emissions and global warming" without mentioning any other GHGs).

[13] *See, e.g., Young People's Burden, supra* note 5, at 595 ("We conclude that the world has already overshot appropriate targets for GHG amount and global temperature, and we thus infer an urgent need for (1) rapid phasedown of fossil fuel emissions, (2) actions that draw down atmospheric CO2, and (3) actions that, at minimum, eliminate net growth of non-CO_2 climate forcings.").

[14] The indeterminacy of global average temperature rise is one of the reasons temperatures make a poor metric for evaluating the extent of global warming. For purposes of this submission, intervenors will use ~1.1°C–1.3°C of average global temperature rise above pre-industrial levels noting that ongoing temperature analysis by NASA determines that Earth has warmed "by at least 1.1° Celsius (1.9° Fahrenheit) since 1880[,]" whereas a separate study by Berkeley Earth states that the Earth has warmed by 1.3°C. The IPCC indicates a "likely range of total human-caused global surface temperature increase" of 0.8°C to 1.3°C. Such indiscrepancies make it difficult to determine whether and when global temperature targets may have been breached. Measurements of atmospheric CO_2 are much more precise. *See* Paul Przyborski, *World of Change: Global Temperatures*, NASA Earth Observatory (2022), https://earthobservatory.nasa.gov/world-of-change/global-temperatures; Berkeley Earth, *The World Has Warmed 1.3°C*, (2022), https://berkeleyearth.org/; Allan et al., *supra* note 12, at 5.

[15] *See generally* Stephen Omes, *How Does Climate Change Influence Extreme Weather? Impact Attribution Research Seeks Answers*, 115 Proc. Nat'l Acad. Sci. 8232 (2018), https://www.pnas.org/doi/epdf/10.1073/pnas.1811393115.

[16] *See, e.g.*, sources cited *supra* note 11.

[17] *See, e.g., Young People's Burden, supra* note 5, at 595 ("We conclude that the world has already overshot appropriate targets for GHG amount and global temperature[.]").

[18] *See generally* Mark Jacobson, *Low-cost Solutions to Global Warming, Air Pollution, and Energy Insecurity for 145 Countries*, Energy & Env't Sci., 15, 3343, 3344 (2022), https://web.stanford.edu/group/efmh/jacobson/Articles/I/145Country/22-145Countries.pdf [hereinafter *Low-cost Solutions for 145 Countries*] ("The world needs a rapid transition to clean, renewable energy to address air pollution, climate, and energy security issues. Here, roadmaps to transition 145 countries to 100% clean, renewable WWS energy and storage across all energy sectors are developed. The full transition should occur no later than 2050, but ideally by 2035, with no less than 80% by 2030.").

[19] *See e.g.,* James Hansen et al., *Ice Melt, Sea Level Rise and Superstorms: Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations That 2°C Global Warming Could Be Dangerous*, 16 Atmospheric Chemistry & Physics 3761, 3801 (2016) [hereinafter *Ice Melt, Sea Level Rise and Superstorms*].

[20] *See Young People's Burden, supra* note 5, at 577 ("If phasedown of fossil fuel emissions begins soon, improved agricultural and forestry practices, including reforestation and steps to improve soil fertility and increase its carbon content, may provide much of the necessary CO_2 extraction. In that case, the magnitude and duration of global temperature excursion above the natural range of the current interglacial (Holocene) could be limited and irreversible climate impacts could be minimized. In contrast, continued high fossil fuel emissions today place a burden on young people to undertake massive technological CO_2 extraction if they are to limit climate change and its consequences.").

The science further establishes that—because of the long-lasting nature of CO_2 in the atmosphere—the world will likely reach 1.5°C of warming based solely on the emissions States have already allowed to be released to date,[21] referred to as legacy emissions. However, according to pathway scenarios developed by energy scientists, it remains possible for ambitious GHG emissions reduction and drawdown of atmospheric CO_2 to facilitate a limited, temporary overshoot, followed by a slow but steady reduction of global average surface temperatures back below 1.5°C above pre-industrial levels[22] as outlined in Section III(E). However, States' current policies, actions, and international commitments are inadequate, in urgency and scope, to accomplish this goal with pro-fossil fuel policies undermining and working contrary to climate action.[23] The longer States take to sufficiently address the climate crisis, the greater the risks that irreversible climate tipping points will be triggered, initiating irreversible runaway heating,[24] rendering vast regions of the world "uninhabitable[,]"[25] and undermining the effectiveness of legal remedies. Specific and time-bound State action underpinned by scientific rather than political targets must commence immediately.

D. Findings available to the Court

The importance of this Court's findings and decisions in any climate case that comes before it cannot be overstated. It is vital that the Court acts decisively within the limited time when it may still be possible to protect humanity from egregious climate harms. In these circumstances, the intervenors submit that it would be unconscionable for a human rights court to adopt a "watch and wait" approach pronouncing on multiple irreversible violations only after they have occurred and only after it is too late to prevent further harm. There is abundant evidence of both existing violations as well as opportunity to prevent their worsening. Intervenors further submit that this Court's findings will serve as bellwether for domestic, regional, and international legal systems in Europe and around the world that are tasked with deciding similar climate cases. The consequential decisions this Court takes—together with findings of other courts and political actors who turn to the Court's expertise and judicial precedent—between today and 2030 "will determine the future of humanity for the next 10,000 years."[26]

In the exceptional circumstances of the climate crisis, the intervenors submit that the Court's careful consideration of the best available science presented in this submission, would, together with review of the critical studies in Annex I, provide the Court with a solid evidential basis for making the following findings:

a. The rights to life and respect for private life, family life, and home pursuant to Articles 2 and 8 of the Convention encompass the right to a stable climate system that protects human life, health, and well-being;
b. States' actions to address human-caused climate change must be based on the best available scientific evidence and therefore aligned to restore the Earth's energy balance which calls on States to pursue a pathway to reduce atmospheric concentrations from current levels to 350 ppm as rapidly as possible;
c. States whose laws, policies, and commitments are not aligned with achieving the 350 ppm standard must take specific, immediate, and adequate measures to phase out emissions of CO_2 and other greenhouse gas pollution and remove as much CO_2 from the atmosphere to stabilise the climate system and protect resources upon which human life, health and well-being depends;
d. Certain categories of people, including children and elders, are particularly at risk due to the effects of human-caused climate change, and State failures to act on the available science or to affirmatively act contrary to the science (depending on the underlying facts of each case) are capable of amounting to violations under Article 14 in conjunction with Articles 2 and 8 as well as of the underlying rights; and
e. Exceptional circumstances exist which would justify the Court indicating specific measures under Article 46 to guide States as to the relevant actions and pathway timetables in sufficiently specific terms to allow for robust and meaningful

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[21] Allan et al., *supra* note 12, at 15.

[22] *See* Joeri Roeglj et al., *A New Scenario Logic for the Paris Agreement Long-term Temperature Goal*, 573 Nature 357, Susanne Baur, *The Science of Temperature Overshoots: Impacts, Uncertainties and Implications for Near-term Emissions Reductions*, Climate Analytics 4-5 (Oct. 2021), https://climateanalytics.org/media/temperature-overshoots_ar6.pdf.

[23] *See* Hansen Expert Report, *supra* note 11, at 19 (noting that the U.S. federal government supports "even the development of unconventional sources of fossil fuels despite the fact that these 'unconventional' fossil fuels are even more carbon-intensive than conventional oil and gas and are thus more harmful to the climate[]"); *see also*, United Nations, Climate Change, *Climate Plans Remain Insufficient: More Ambitious Action Needed Now*, UN Climate Change News (2022), https://unfccc.int/news/climate-plans-remain-insufficient-more-ambitious-action-needed-now (noting that "the combined climate pledges of 193 Parties under the Paris Agreement could put the world on the track for around 2.5 degrees Celsius of warming by the end of the century[]" despite all Parties agreeing to aim for 1.5 or 2.0 degrees of warming. In fact, a recent UN report shows that Parties' cumulative "current commitments will increase emissions by 10.6% by 2030, compared to 2010 levels.").

[24] *See* Will Steffen, et al., *Trajectories of the Earth System in the Anthropocene*, 115 Proc. Nat'l Acad. Sci. 8252 (2018), https://www.pnas.org/doi/full/10.1073/pnas.1810141115.

[25] *See* Stockholm Resilience Centre, *Earth at Risk of Heading Towards "Hothouse Earth" State*, Sci. Daily (Aug. 6, 2018), https://www.sciencedaily.com/releases/2018/08/180806152040.htm (quoting co-author of study published in the Proceedings of the National Academy of Sciences); *see also* David Wallace-Wells, *The Uninhabitable Earth: Life After Warming* (2019).

[26] Sarah Naima Roller, *Cambridge To Explore Options for Climate Repair in New Research Centre*, Varsity (May 23, 2019), https://www.varsity.co.uk/news/17528 (quoting Sir David King, the UK Government's Chief Scientific Advisor from 2000 to 2007 and the UK's permanent Special Representative for Climate Change from September 2013 until March 2017).

supervision of the same by the Committee of Ministers of the Council of Europe.

To aid the Court in its examination and deliberations, intervenors therefore offer the following in this combined intervention. Section II provides a reference list of the most critical scientific findings that this Court should consider when determining the impact of climate change upon Convention rights. Section III provide a survey of scientific evidence from relevant peer-reviewed studies and reports that corroborate the critical findings. Section IV briefly addresses the misalignment between the Paris temperature targets and the 350 ppm standard. Section V provides a survey of key research finding at the intersection of climate change and children's health. Section VI applies the best available science to the Court's jurisprudence. Finally, Section VII discusses the remedies available to this Court in the context of climate change. Intervenors have also included "Annex I" which provides a curated bibliography of the most critical studies and source material cited, with short synopses and hyperlinks. Copies of any of the source materials relied upon in this intervention as well as further information regarding the qualifications of many of the cited scientific experts can be provided upon request and in-person testimony can be arranged.

II. Critical Scientific Findings: In Summary

The Paris Agreement[27] and the Glasgow Climate Pact[28] affirm that climate action and decisions must rely on the most up-to-date and best scientific evidence available to adequately protect fundamental rights in the context of climate change. Yet, the Paris Agreement embraces temperature targets that are not rooted in robust scientific evidence. Courts must not make this same error and, instead, must ensure that judicial decisions in climate cases are informed by what is scientifically necessary—rather than what is politically expedient—for States to do in order to uphold their legal obligations under the Convention.

The four critical scientific findings that should guide this Court's determination as to whether States have implemented all reasonable, adequate, and appropriate measures to protect fundamental rights in the context of climate change are as follows.

a. **Paris temperature targets are unprotective of human rights.** Scientific consensus, including findings as set out by the IPCC, concludes that 1.5°C of warming is unsafe for humanity. The 2018 IPCC Special Report on 1.5°C clearly stated that allowing a temperature rise of 1.5°C "is **not considered 'safe'** for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems as compared to the current warming of 1°C (*high confidence*)."[29]
b. **Staying at currently-too-high temperatures or exceeding 1.5°C could trigger multiple climate tipping points.** The best available science finds that heating of up to 1.5°C or beyond for any length of time risks crossing multiple climate tipping points, with the potential to result in a tipping cascade.[30]
c. **EEI and the 350 ppm standard is required to protect human rights.** Earth Energy Imbalance (EEI) is the "*most critical*" metric for determining "the prospects for continued global warming and climate change[.]"[31] To rebalance and stabilise the energy in Earth's climate system and protect human rights, atmospheric CO_2 concentrations must be reduced from the 2021 level of 416 ppm—a level *unprecedented* in human history[32]—to approximately 350 ppm as rapidly as possible.[33]
d. **Pathways to 350 ppm exist and are feasible.** To achieve climate stabilization, the 350 ppm standard, and protect human life, health, and well-being, States must rapidly reduce emissions to zero for energy generation and as close to zero as possible

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[27] Paris Agreement, *supra* note 2, at Preamble ("*The Parties to this Agreement*[] … *[r]ecognizing* the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge[] . . .").
[28] Glasgow Climate Pact, § I(1), Nov. 13, 2021 ("*Recognizes* the importance of the best available science for effective climate action and policymaking[]").
[29] *IPCC Special Report on 1.5°C*, *supra* note 3, at 44.
[30] David Armstrong McKay et al,, *Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points*, 377 Sci. 1, Summary (2022), https://www.science.org/doi/10.1126/science.abn7950. ("[E]ven the Paris Agreement goal of limiting warming to well below 2°C and preferably 1.5°C is not safe as 1.5°C and above risks crossing multiple tipping points. Crossing these [climate tipping points] can generate positive feedbacks that increase the likelihood of crossing other [climate tipping points].").
[31] von Schuckmann et al., *supra* note 7, at 2029.
[32] Bruno Latour, *Down to Earth* 44 (Catherine Porter trans., 2018), https://hscif.org/wp-content/uploads/2018/04/Latour-Bruno-Downt-to-Earthsmall.pdf ("We understand nothing about the vacuity of contemporary politics if we do not appreciate the stunning extent to which the situation [of the Anthropocene] is unprecedented."); *see also* Allan et al., *supra* note 12, at 6 ("Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years[.]").
[33] *See* von Schuckmann et al., *supra* note 7, at 2029 ("The amount of CO_2 in the atmosphere would need to be reduced from 410 to 353 ppm [] to . . . bring[] Earth back towards energy balance[.]"); *Target Atmospheric CO_2*, *supra* note 11, at 217 ("If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced . . . to at most 350 ppm, but likely less than that."); James Hansen et al., *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, 8 PLOS One 1, 5 (2013), https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0081648&type=printable [hereinafter *Assessing "Dangerous Climate Change"*] ("The measured energy imbalance indicates that an initial CO2 target "350 ppm" would be appropriate, if the aim is to stabilize climate without further global warming.").

in all other sectors by 2050 (27 years from now).[34] States must also maximize the natural removal of CO_2 and other greenhouse gases (GHGs) from the atmosphere by protecting carbon sinks and through regenerative measures.[35] Feasible pathways exist for States to achieve the 350 ppm standard and, in turn, provide the best available approach to protect Convention rights.[36]

III. Scientific Evidence Supporting the Critical Findings

A. Key background information

Current levels of CO_2 concentrations in our atmosphere are higher than ever experienced by humans on Earth. Pre-industrial CO_2 concentrations after the end of the last ice age were ~260-280 ppm.[37] In 2021, the world was at an average of 416 ppm,[38] which has already resulted in ~1.1°C–1.3°C of warming above the global average temperatures of Earth since the industrial revolution in the mid to late 1800s.[39]

To briefly address terminology, 'annual mean concentration of atmospheric CO_2' is the amount of carbon dioxide in the atmosphere. It is measured in 'parts per million' (ppm). A part per million is the number of CO_2 molecules per million molecules of the air that sits 8-12 kilometres above the Earth's surface. Just as one percent means one out of a hundred, one ppm means one out of a million. While each ppm denotes a *very* small numerical value, the geologically unprecedented large and rapid change in ppm of CO_2 in our atmosphere over the last century are devastating for the planet and human rights.

While the science is complex, the underlying principles of physics and chemistry are not. Scientists describe the principles as elementary and long understood. First, CO_2 and other GHGs absorb solar energy being reflected off the Earth's surface that would otherwise go back into outer space. Without these naturally occurring GHGs, Earth would be freezing. [40] With too many of these GHGs being emitted by humans and collected in the atmosphere over time, Earth gets too hot, leading to severe climate instability. By analogy, CO_2 and other GHGs act like a blanket around the Earth, trapping energy inside our atmosphere.[41] If too much heat is trapped, the Earth's energy is out of balance, which results in rising global temperatures that melt snowpack, ice sheets, glaciers, and sea ice, causing heatwaves, sea-level rise, extreme events such as storms, floods, drought, wildfires, food and water shortages, epidemics, and more.

B. Paris temperature targets are unprotective of human rights

Scientists have been raising the alarm bells that a world with planetary heating of 1.5°C will have disastrous consequences.[42] A 2018 Special Report from the IPCC—a partnership between scientists and policymakers set up to provide international climate negotiators with regular scientific assessments on climate change[43]—reached the same conclusion:

> "Warming of 1.5°C is not considered 'safe' for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems as compared to the current warming of 1°C (*high confidence*). [] The impacts of 1.5°C of warming would disproportionately affect disadvantaged and vulnerable populations through food insecurity, higher

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[34] Hansen Expert Report, *supra* note 11, at 29 ("[R]apid phasedown of CO_2 emissions and increased carbon storage in the soil and biosphere[] are minimally needed to restore Earth's energy balance, preserve the planet's climate system, and avert irretrievable damage to human and natural systems[.] . . . However, if rapid emissions reductions are delayed until 2030, for instance, then the global temperature will remain more than 1°C higher than preindustrial levels for about 400 years. Were the emissions cessation only to commence after 40 years, then the atmosphere would not return to 350 ppm CO_2 for nearly 1000 years at the earliest – and due to feedbacks described below, it is probable that returning to 350 ppm within that timeframe would become impossible."); *see Low-cost Solutions for 145 Countries*, *supra* note 18, at 3358 ("The world needs a rapid transition to clean, renewable energy to address air pollution, climate, and energy security issues. . . . The full transition should occur no later than 2050, but ideally by 2035, with no less than 80% by 2030.").

[35] *Ice Melt, Sea Level Rise and Superstorms*, *supra* note 19, at 3801 ("It may be feasible to restore planetary energy balance via improved agricultural and forestry practices and other actions to draw down atmospheric CO_2 amount, if fossil fuel emissions are rapidly phased out.").

[36] *See generally Low-cost Solutions for 145 Countries*, *supra* note 18.

[37] *See Ice Melt, Sea Level Rise and Superstorms*, *supra* note 29, at 3789 ("The CO_2 dial must be turned to 260 ppm to achieve a Holocene-level interglacial.").

[38] Tans & Keeling, *supra* note 9.

[39] Allan et al., *supra* note 12, at 5.

[40] *See* University Corporation for Atmospheric Research: Center for Science Education, *The Greenhouse Effect* (2022), https://scied.ucar.edu/learning-zone/how-climate-works/greenhouse-effect.

[41] *See* Hansen Expert Report, *supra* note 11, at 10 (describing GHGs as "gases that absorb infrared (heat) radiation and thus act as a blanket that warms the planetary surface[]").

[42] *See* Andrea Rodgers, et al., *The Injustice of 1.5°C–2°C: The Need for a Scientifically Based Standard of Fundamental Rights Protection in Constitutional Climate Change Cases*, 40 Va. Env't L. J. 102, 109-10 (2022) (noting that IPCC reports have summarized a significant body of science projecting that warming of 1.5°C of 2°C would be catastrophic[]"); McKay et al., *supra* note 30.

[43] *See* IPCC, *Intergovernmental Panel on Climate Change* (2022), https://www.ipcc.ch/ ("The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options"). As a quasi-political body of volunteer scientists set up to inform the UNFCCC, the IPCC provides guidance that is policy-relevant, but not policy-prescriptive. In keeping with its role, the IPCC has neither endorsed nor recommended 2°C or 1.5°C as a target in any of its reports since it began publishing reports in 1990.

food prices, income losses, lost livelihood opportunities, adverse health impacts and population displacements (*medium evidence, high agreement*). [] Some of the worst impacts on sustainable development are expected to be felt among agricultural and coastal dependent livelihoods, [I]ndigenous people, children and the elderly, poor labourers, poor urban dwellers in African cities, and people and ecosystems in the Arctic and Small Island Developing States (SIDS) (*medium evidence, high agreement*)."[44]

The most recent (2021-2022) Sixth Assessment Report by the IPCC details what UN Secretary General, António Guterres called "an atlas of human suffering."[45] A comprehensive list of scientific findings detailing the climate injuries that will occur at 1.5°C of global warming is beyond the scope of this intervention. Instead, the following examples from peer-reviewed studies illustrate the stakes for human rights, specifically in Europe, in a world of 1.5°C global heating. At 1.5°C:

a. A 10-year heatwave will be 4.1 times more likely to occur, and heatwaves in general are projected to be hotter by 1.9°C on average.[46] A 50-year heatwave will be 8.6 times more likely to occur and will be hotter by 2.0°C on average.[47] Extremely hot Junes on par with those experienced in 2017 will have an increased likelihood of occurring in a given year by up to 23% in Belgium, 39% in England, 28% in France, 33% in the Netherlands, 28% in Portugal, 29% in Spain, and 31% in Switzerland.[48] Increased heatwaves and temperatures will cause more Europeans to suffer heat-related illnesses and deaths.[49]
b. The length of the fire season in Europe is expected to increase from an average of 17 days per year in the late 1800s to an average of 27 days per year[50] resulting in increased threats to human health from smoke exposure and increased risk of property damage and loss.[51]
c. Up to 66.3 million Europeans will be exposed to drought in any given year.[52] Specifically, a 10-year drought is projected to reoccur every 4-6 years, a 20-year drought to reoccur every 6-8 years, and a 30-year drought every 8-10 years.[53,54] This will result in economic loss, impacts on livelihoods, and a decrease in crop productivity, potentially leading to food insecurity.[55]
d. Europeans will experience an increase in tick-borne diseases, West Nile Fever, Dengue, Chikunga, Zika, Malaria, and Vibrio.[56]
e. Up to 3,600 km^2 of Europe will be submerged with up to 3.5 million Europeans exposed to coastal flooding in a given year.[57]
f. Overall agricultural yield will decline by about 4% in Europe[58] affecting food supplies.
g. European glaciers in the Alps are projected to lose up to 68% of their ice volume[59] and a majority of Scandinavian glacier ice will also melt away.[60] Additionally, World Heritage glaciers less than 10 km^2 in area are projected to almost completely disappear by 2050 in the Italian Dolomites, the French/Spanish Pyrénées, the Durmitor National Park of Montenegro, and the Swiss Tectonic Arena Sardona.[61] This reduction in glacial water storage, exacerbated with drought, will compound water scarcity. Broadly, up to 11.9 million Europeans are expected to experience water scarcity in a given year at 1.5°C of warming.[62]

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[44] *IPCC Special Report on 1.5°C*, *supra* note 3, at 44.
[45] *António Guterres (UN Secretary-General) to the Press Conference Launch of IPCC Report*, United Nations (Feb. 28, 2022), https://media.un.org/en/asset/k1x/k1xcijxjhp.
[46] United Nations Office for the Coordination of Humanitarian Affairs, et al., *Extreme Heat: Preparing for the Heatwaves of the Future* 33 (2022), https://www.ifrc.org/sites/default/files/2022-10/Extreme-Heat-Report-IFRC-OCHA-2022.pdf.
[47] *Id.*
[48] Friederike Otto et al., *Record June Temperatures in Western Europe*, World Weather Attribution (Fig. 4) (June 29, 2017), https://www.worldweatherattribution.org/european-heat-june-2017/.
[49] Joint Research Centre, *Climate Change Impacts and Adaptation in Europe*, European Union (2020) (noting that without climate mitigation, deaths from exposure to extreme heatwaves in Europe would increase 30-fold).
[50] Matthew W. Jones et al., *Global and Regional Trends and Drivers of Fire Under Climate Change*, 60 Revs. Geophysics 41 (2022).
[51] *See generally* Sarah Finlay et al., *Health Impacts of Wildfires*, PLOS Currents (Nov. 2012), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3492003/#.
[52] Rachel Warren et al., *Quantifying Risks Avoided by Limiting Global Warming to 1.5 or 2 °C Above Pre-Industrial Levels: Supplementary File 11*, 172 Climatic Change 1 (2022) https://static-content.springer.com/esm/art%3A10.1007%2Fs10584-021-03277-9/MediaObjects/10584_2021_3277_MOESM11_ESM.pdf.
[53] Hossein Tabari & Patrick Willems, *Trivariate Analysis of Changes in Drought Characteristics in the CMIP6 Multimodel Ensemble at Global Warming Levels of 1.5°, 2°, and 3°C*, 35 J. Climate, 5823, 5832 (2022).
[54] More specifically, at 1.5°C of warming, more than 30% of Ukrainian, 10% of French and Italian, and 25% of Spanish cropland will have at least a 50% annual probability of extreme drought. Isabelle Runde et al., *Human and Natural Resource Exposure to Extreme Drought at 1.0 °C-4.0 °C Warming Levels*, 17 Env't Res. Letters 1, 6 (2022).
[55] *See generally* Jürgen Vogt et al., *Drought Risk Assessment and Management: A Conceptual Framework*, Joint Research Centre Technical Report (2018), https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113937/vogt_etal_2018_drought_risk_assessment_final-online_1.pdf.
[56] Peter Alexander et al., *Europe, in* Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change 1862 (Hans Otto Pörtner et al. eds., 2022), https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf.
[57] Rachel Warren et al., *supra* note 52, at 1.
[58] *Id.*
[59] Loris Compagno et al., *Brief Communication: Do 1.0, 1.5, or 2.0°C Matter for the Future Evolution of Alpine Glaciers?*, 15 Cryosphere 2593, 2597 (2021).
[60] Loris Compagno et al., *Limited Impact of Climate Forcing Products on Future Glacier Evolution in Scandinavia and Iceland*, 67 J. Glaciology 727, 727 (2021).
[61] UNESCO, *World Heritage Glaciers: Sentinels of Climate Change* 24 (2022), https://unesdoc.unesco.org/ark:/48223/pf0000383551.
[62] Rachel Warren et al., *supra* note 52, at 1.

Additionally, while the violation of cultural rights are not the focus of this submission, it is worth noting that 1.5°C may be enough warming to trigger the transition from a snow-dominated to a rain-dominated Arctic in the summer and autumn.[63] The resulting rain often leads to a layer of ice on top of the snow that is hard for grazing herbivores to penetrate to access the vegetation they need to survive. The Sami people, an Indigenous People, rely heavily on grazing animals, particularly reindeer, for their own survival and livelihood.[64] Because climate change threatens reindeer and other animals, it threatens the way of life of the Sami people.

At 2.0°C of warming, the impacts and injuries will be significantly worse on almost every metric.[65] In a seminal paper published in 2008 by top paleoclimate researchers—including Dr. James Hansen, former Director of the NASA Goddard Institute for Space Studies,[66] and Yale Professor Robert Berner[67]—the investigators concluded the Earth is **"already in the danger zone at 385 ppm"**.

In 2018, Dr. Hansen testified that, **"2°C and 450 ppm were extremely dangerous[,]"**[68] finding that, "[s]uch warming would lock in eventual loss of coastal cities, including more than half of the world's large cities. In addition, the tropics in all seasons and subtropics in summer would become uncomfortably hot [] likely causing large scale emigration from those regions. Economic and social effects of such displacements would challenge the ability of governments to maintain order."[69] Further finding, "that the political guardrail of 2°C of warming . . . is highly dangerous," stating that restoring climate stability without delay was essential to "preserve coastal cities from rising seas and floods … and superstorms, and otherwise to restore a viable climate system on which the life, liberty, and property prospects … so thoroughly depend."[70]

C. Staying at currently-too-high temperatures or exceeding 1.5°C could trigger multiple climate tipping points

The best available science further finds that heating of up to 1.5°C or beyond for any length of time could drive our planet across several climate tipping points—also known as points of no return—that may make large areas of our planet uninhabitable for human beings.[71] Climate tipping points are critical thresholds that, if crossed, would lead to large and likely irreversible changes in a component of the Earth's climate system that contributes significantly to the well-being of humanity.[72] Tipping points do not stand alone. If one tipping point is crossed it increases the likelihood that others may be too, risking a "tipping cascade" of impact that may further reinforce global warming and result in runaway heating that cannot be controlled.[73] In other words, tipping points are like a row of dominoes. Once one is pushed over, it has the potential to drive Earth towards another and it becomes very difficult or impossible to stop the whole row from tumbling down.

In September 2022 researchers updated a comprehensive reassessment of climate tipping points focusing on tipping points breached at current levels of global warming, 1.5°C, and above. The investigators identified the approximate temperature threshold at which 16 core tipping points that are triggerable by global warming will become irreversible and result in significant ecological and human impacts. At warming of ~1.5°C of global warming, four of these sixteen large-scale, irreversible, and destabilizing "tipping points" in the global climate system are "likely" to be crossed, including the: i) collapse of the Greenland ice sheet; ii) collapse of West Antarctic ice sheet;

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[63] Michelle R. McCrystall et al., *New Climate Models Reveal Faster and Larger Increases in Arctic Precipitation Than Previously Projected*, 12 Nature Commc'ns 1, 1 (2021).

[64] Environmental Justice Foundation, *Rights at Risk: Arctic Climate Change and the Threat to Sami Culture* 6 (2019), https://ejfoundation.org/resources/downloads/EJF-Sami-briefing-2019-final-1.pdf noting that this report was published in 2019, and it states that the Arctic is warming almost twice as fast as the global average. Today, the Arctic is warming approximately four times as fast as the global average.

[65] If the Court would like more information on the ecological and human impacts of 2.0°C of warming, we would be happy to provide it pursuant to the Court's request.

[66] Dr. James Hansen worked at NASA for 46 years and served as the Director of NASA's Goddard Institute for Space Studies (GISS) for 32 years. (NASA is one of two primary U.S. federal expert agencies tasked with studying the climate system and climate change today.) Currently, he serves as Director of the Program on Climate Science, Awareness and Solutions at Columbia University's Earth Institute. *See Dr. James Hansen*, Columbia Climate School: Climate, Earth, and Society (2022), https://people.climate.columbia.edu/users/profile/james-e-hansen#:~:text=James%20Hansen%2C%20formerly%20Director%20of,space%20science%20program%20of%20Dr.; *see also*, Mark Memmott, *James Hansen, NASA Scientist Who Raised Climate Change Alarm, Is Retiring*, NPR (Apr. 2, 2013), https://www.npr.org/sections/thetwo-way/2013/04/02/176010296/james-hansen-nasa-scientist-who-raised-climate-change-alarm-is-retiring; David Biello, *Why Jim Hansen Stopped Being a Government Scientist [Video]*, Sci. Am. (Apr. 12, 2013), https://blogs.scientificamerican.com/observations/why-jim-hansen-stopped-being-a-government-scientist-video/.

[67] *Target Atmospheric CO_2*, *supra* note 11, at 225; Robert Berner "developed the first whole-Earth mathematical model of CO_2 exchange, which revealed marked changes in our planet's past atmospheric levels and the rates at which natural processes might remove anthropogenic CO_2 from the atmosphere." Don Canfield, *Robert A. Berner (1935-2015)*, Nature (Feb. 25, 2015), https://www.nature.com/articles/518484a.

[68] Hansen Expert Report, *supra* note 11, at 23 (emphasis added).

[69] Hansen Expert Report, *supra* note 11, at 23.

[70] Hansen Expert Report, *supra* note 11, at 4-5.

[71] *See generally* sources cited *supra* note 25.

[72] *See* McKay et al., *supra* note 30, at 2. There are multiple definitions of climate tipping points in scientific literature. A widely accepted definition is, "a critical threshold at which a tiny perturbation can qualitatively alter the state or development of a system[.]" Specifically, "[t]ipping points occur when change in part of the climate system becomes (i) self- perpetuating beyond (ii) a warming threshold as a result of asymmetry in the relevant feedbacks, leading to (iii) substantial and wide-spread Earth system impacts." McKay et al., *supra* note 30, at 1.

[73] McKay et al., *supra* note 30 at 1.

iii) the abrupt thaw of boreal permafrost; and iv) the die off of 70-90% of tropical and subtropical coral reefs.[74] Furthermore, at ~1.6°C of global warming, abrupt loss of sea ice over the Barents Sea north of Scandinavia is expected.[75] As warming and energy imbalance increase, it is more likely than not that additional tipping points will be crossed and, ultimately, triggered. Due to this increased risk of triggering irreversible and devastating tipping points at higher levels of warming, the comprehensive reassessment concludes that "[t]he Earth may have left a safe climate state beyond 1°C global warming."[76]

Other experts have identified that at current levels of warming, Earth may have already crossed another critical tipping point with the loss of summer ice over the Arctic Sea resulting in exposure of the blue sea to summer sun. As a result, the Arctic Circle has been heating up at a rate approximately four times faster than the average for the rest of the planet with an annual average temperature of ~3°C above pre-industrial temperatures for the region.[77] This heating is already causing the tipping point transition for this region to be reached,[78] and Greenland is losing so much ice that, without intervention, its complete melting will raise the seas more than 7 metres.[79] If all of the methane in the Arctic Circle permafrost were emitted within a 20-year period, the global average temperature may rise by 5.0°C-8.0°C.[80] Global CO_2 emissions are the primary forcer of Arctic heating, melting, and resulting methane release, driving the Arctic to that tipping point.

D. EEI and the 350 ppm standard is required to protect human rights

The scientific community has long understood that GHG pollution such as CO_2 causes a planetary energy imbalance that destabilises the climate. The aggregate of climate research underscores that warming up to 1.5°C–2°C or beyond will result in widespread human rights violations. This determination begs the question, what does the science say about the target humanity should aim for?

In the same seminal paper that found that Earth is "already in the danger zone at 385 ppm" and indicated than 2.0°C of warming was extremely dangerous, scientists identified the 350 ppm target that lead to the determination that climate stabilization the Earth's Energy Imbalance (EEI) should be used as a reliable metric to monitor and gauge the effects of climate change, and, in turn, evaluate how well the world is responding to the task of bringing climate change under control.[81] Instead of looking at temperature targets, scientists describe **EEI as the "*most critical*" metric for determining "*the prospects for continued global warming and climate change*"**[82] because "EEI is less subject to decadal variations associated with internal climate variability than global surface temperature and therefore represents a robust measure of the rate of climate change[.]"[83]

EEI is the imbalance in Earth's energy system resulting from the Earth releasing less energy back into space than it absorbs from the Sun.[84] EEI can be thought of as an out-of-equilibrium energy balance sheet for our planet. For EEI to equalize, all energy that comes into Earth's system must be counterbalanced by an equivalent amount of energy leaving Earth's system. Only then will Earth's energy balance sheet keep a net balance around zero, thereby maintaining the stable climate system in which humanity evolved. Fossil fuel combustion is the predominant driver of climate change because it leads to GHG emissions, especially CO_2, which accumulates in Earth's atmosphere and traps excess energy.[85] This extra energy manifests in many ways: global heating and higher temperatures, melting

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[74] *Id.* at 7, 8.
[75] *Id.* at 2, 3.
[76] *Id.* at 8.
[77] Mika Rantanen et al., *The Arctic Has Warmed Nearly Four Times Faster Than the Globe Since 1979*, 3 Commc'n Earth Env't 168, 168 (2022), https://doi.org/10.1038/s43247-022-00498-3; Climate Crisis Advisory Group, *Extreme Weather Events in the Arctic and Beyond, A Global State of Emergency* 3 (2022), https://static1.squarespace.com/static/60ccae658553d102459d11ed/t/6102596bc768697d04731d55/1627543921216/CCAG+Extreme+Weather.pdf;
[78] Niklas Boers, et al., *Critical Slowing Down Suggests That the Western Greenland Ice Sheet Is Close to a Tipping Point*, 118 Proc. Nat'l Acad. Sci.: Earth, Atmospheric, & Planetary Sciences 21 (2021), https://doi.org/10.1073/pnas.2024192118.
[79] Global vulnerability to sea-level rise and coastal flooding resulting from unprecedented ice sheet melt affects hundreds of millions of people worldwide with catastrophic results not just to densely populated coastal cities but also to vital hubs of the global agricultural economy—like Vietnam's low-lying rich rice production region, which will be under water much of the year with tens of millions of people displaced. Scott Kulp et al., *New Elevation Data Triple Estimates of Global Vulnerability to Sea-Level Rise and Coastal Flooding*, 10 Nature Commc'ns 4844 (2019), https://doi.org/10.1038/s41467-019-12808-z; Benjamin H. Strauss et al., *Unprecedented Threats to Cities from Multi-century Sea Level Rise*, 16 Env't. Res. Letters 114015 (2021), https://iopscience.iop.org/article/10.1088/1748-9326/ac2e6b.
[80] Laurie Goering, *Analysis: As Climate 'Tipping Points' Near, Scientists Plan for the Unthinkable*, Reuters (Sept. 16, 2022), https://www.reuters.com/article/climate-change-science-disaster/analysis-as-climate-tipping-points-near-scientists-plan-for-the-unthinkable-idUSL8N30M40O (quoting Sir David King, the UK Government's Chief Scientific Advisor from 2000 to 2007 and the UK's permanent Special Representative for Climate Change from September 2013 until March 2017).
[81] *See Target Atmospheric CO_2, supra* note 1; *See, generally* Kevin Ternberth and Lijing Cheng, *A Perspective on Climate Change from Earth's Energy Imbalance*, 1 Envtl. Res.: Climate 1 (2022) https://phys.org/news/2022-07-earth-energy-imbalance-critical-global.html.
[82] von Schuckmann et al., *supra* note 7, at 2014 (emphasis added).
[83] *Id.* at 2015.
[84] *Id.* at 2014-15.
[85] *See* University Corporation for Atmospheric Research: Center for Science Education, *Why Does Climate Change?* (2022),

ice and snow, rising sea level, floods, droughts, more powerful blizzards and hurricanes, and deadlier extreme events.[86] Scientists have concluded that reducing this heat-trapping effect by lowering GHG levels in the atmosphere is the only way to bring Earth's energy system back into equilibrium, thereby stabilizing the climate system and ultimately reversing climate change.[87] By analogy, EEI can be thought of like cooking rice—if the right amount of heat is allowed to leave the pot, the rice cooks perfectly. If too much heat is trapped inside, the pot boils over. Right now, Earth is boiling over. Whereas temperature targets try to limit a symptom, ineffectively, EEI and 350 ppm speak directly to the cause of the problem: GHG accumulation caused by humans.

Specifically, climate scientists conclude that **GHG concentrations—particularly CO_2—must be reduced from 2021's level of 416 ppm to below 350 ppm as rapidly as possible to avoid catastrophic climate change.**[88]

E. Pathways to renewable energy and 350 ppm exist and are feasible

The longer Earth's energy remains out of balance, the higher the risk that irreversible feedback loops (e.g., ice-sheet melting and attendant sea-level rise, permafrost melting and attendant methane release, etc.) will be triggered.[89] To avoid these feedback loops and to prevent further global-warming induced climate destabilization, leading climate scientists conclude—as detailed above—that Earth's energy balance must be restored by rapidly reducing atmospheric CO_2 concentrations.[90] To do so, the U.S. National Academy of Sciences indicates that States must prioritize two fundamental actions: i) dramatically decreasing economy-wide CO_2 and other GHG emissions; and ii) maximizing the removal of already existing carbon pollution from the atmosphere.[91]

This submission focuses on the first action which will require transitioning quickly from relying on CO_2-emitting fossil fuel combustion for energy production in all sectors to cleaner, renewable energy. Action is also required to dramatically reduce GHG emissions to the lowest levels possible from other non-fossil fuel-based sources such as deforestation, industry, construction, and agricultural production.[92].

Despite the vastness of the challenge, numerous scientific studies indicate that rapid reductions in CO_2 emissions are feasible because CO_2-emitting fossil fuels are not needed to power human energy systems.[93] While the switch cannot flip over night, it is both technically and economically feasible for Europe, and indeed all States, to transition from a predominantly fossil fuel-based energy system to one that eliminates those fuels and their pollution, on a pathway that would be consistent with what science indicates is necessary to restore Earth's energy balance.[94] The bottom line is that in order to restore balance in line with the 350 ppm standard, fossil fuels must be replaced by 2050 globally, and even sooner for Europe, and Earth's natural carbon sinks such as forests and oceans need to be restored and protected to maximize sequestration—carbon removal—potential.[95]

Leading energy scientists have developed roadmaps providing States with pathways to rapidly transition energy infrastructure in all sectors to 100% clean, renewable energy by as early as 2035, but by no later than 2050 with an 80% transition by 2030.[96] States' transition to wind, water, and solar energy and their elimination of 80% of all emissions by 2030 and 100% by 2035–2050 is essential to avoid the dangers of locking in 1.5°C of heating for any length of time and will allow the Earth's climate to begin stabilizing and cooling to lower average temperatures.[97] And it is not only possible—it is reasonable and necessary to protect human rights.

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https://scied.ucar.edu/learning-zone/how-climate-works/why-does-climate-change; *see generally* United Nations, *Causes and Effects of Climate Change*, Climate Action, https://www.un.org/en/climatechange/science/causes-effects-climate-change#:~:text=Fossil%20fuels%20%E2%80%93%20coal%2C%20oil%20and,they%20trap%20the%20sun's%20heat.

[86] Liz Fuller-Wright, *'Less Than 1% Probability' That Earth's Energy Imbalance Increase Naturally, Say Scientists*, Phys.org (Jul 28, 2021), https://phys.org/news/2021-07-probability-earth-energy-imbalance-naturally.html.

[87] von Schuckmann et al., *supra* note 7, at 2029.

[88] *See, e.g., id.*; *Young People's Burden, supra* note 5, at 578.

[89] James Hansen et al., *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, 8 PLOS ONE 1, 6 (2013); *Young People's Burden, supra* note 5, at 578.

[90] von Schuckmann et al., *supra* note 7, at 2029.

[91] Nat'l Acad. of Sci., Eng'g, and Med., *Climate Change: Based on Science* (Oct. 27, 2021), https://www.nationalacademies.org/based-on-science/is-it-possible-to-achieve-net-zero-emissions#:~:text=Achieving%20zero%20emissions%20means%20releasing,oxide%20or%20other%20greenhouse%20gases.

[92] Steven Davis et al., *Net-Zero Emissions Energy Systems*, 360 Sci. 1, 1 (2018).

[93] *See, e.g.*, Price-Waterhouse-Coopers LLP et al., *100% Renewable Electricity: A Roadmap to 2050 for Europe and North Africa* (2010), https://www.pwc.co.uk/assets/pdf/100-percent-renewable-electricity.pdf; *Low-cost Solutions for 145 Countries, supra* note 18.

[94] *See generally* John Berger, *Mark Jacobson: How One American Atmospheric and Climate Scientist Created Clean Energy Roadmaps for 50 U.S. States—and 139 Nations*, Sustain Europe: U.S.A. Focus (2019), https://web.stanford.edu/group/efmh/jacobson/Articles/I/19-04-SustainEurope.pdf.

[95] *See generally* Mark Jacobson, *100% Clean, Renewable Energy and Storage for Everything* (Cambridge Univ. Press ed., 2020), http://web.stanford.edu/group/efmh/jacobson/Articles/I/CountryGraphs/CO2ChangesWithWWS.pdf; Christian Breyer et al., *On the History and Future of 100% Renewable Energy Systems Research*, 10 IEEE Access, 78176, 78195 (2022), https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9837910.

[96] *Low-cost Solutions for 145 Countries, supra* note 18 at 3347; *see also* Mark Jacobson, *More Hopeful Calculations for the Energy Transition*, Nat'l Acad. Eng'g: Issues Sci. & Tech. (Feb. 18, 2022), https://issues.org/renewables-minerals-energy-transition-jacobson-forum/.

[97] *Low-cost Solutions for 145 Countries, supra* note 18.

Hundreds of studies support this scientific truth:[98]

> "The main conclusion of most of these studies is that 100% renewables is feasible worldwide at low cost. Advanced concepts and methods now enable the field to chart realistic as well as cost- or resource-optimized and efficient transition pathways to a future without the use of fossil fuels."[99]

The roadmaps generally involve electrifying all energy sectors (electricity, transportation, heating/cooling buildings, industry) with existing or in-development technologies and generating the electricity to power all appliances and machines people use with 100% wind, water, and sunlight (i.e., renewable energy).[100] The necessary electricity can be generated by onshore and offshore wind, utility-scale photovoltaics, rooftop photovoltaics, geothermal power, tidal and wave power, and hydroelectric power.[101] A 100% renewable energy system requires electricity storage, heat storage, cold storage, and some hydrogen storage along with an expanded transmission and distribution system.[102] Importantly, in an electrified energy system, there is enormous reduction in end-use power demand because of: i) efficient and predominantly electric vehicles compared to internal combustion engines; ii) efficiency of heat pumps for air and water compared to combustion heaters; iii) efficiency in industrial heating processes over combustion; iv) elimination of fossil fuel mining, refining, transport, infrastructure; and) additional end-use appliance and machine efficiency improvements that will continue to evolve after eliminating fossil fuel combustion.[103]

As one example, a feasible pathway to 100% renewable energy by 2035-2050 in Switzerland results in an electricity grid that would be stable 100% of the time; end-use energy demand reduced by 53.2% by 2050 due to the efficiencies with electrification; Switzerland's annual energy costs reduced by 60.6%; a renewable energy footprint of only 0.28% of Switzerland's land; the creation of 43,331 more long-term, full-time jobs than would be lost; and importantly, 1,087 saved lives per year in 2050 from decreased air pollution alone, with 52 million tonnes-CO_2e[104] per year eliminated in 2050.[105] Denmark has already committed to achieve 100% renewable energy in all sectors by 2050.[106] Air transportation will likely be one of the last frontiers of the renewable energy transition during the 2040s, but Europe is leading there as well. Norway has already committed to a fleet of electric aircraft for short-haul flights by 2040[107] and many companies are currently developing electric and hydrogen fuel cell aircraft.[108] These judicially relevant roadmaps set out the technical and economic feasibility of States reaching 100% renewable energy production by 2035 and at the latest by 2050, resulting in increased energy security, national security, economic benefits, and crucially, the protection of the rights to life, privacy, and family life under the Convention.

Historically States have chosen, out of political preference, to develop widespread fossil fuel infrastructure and dependency. This was, and is now, unequivocally a choice. Today, States have the opportunity—a clear roadmap—to transition to renewables.

In light of space limitations, intervenors are unable to go into detail with respect the second and separate critical action required to restore Earth's energy balance: maximize the removal of already existing carbon pollution from the atmosphere, otherwise known as carbon draw down or sequestration. However, the Court can learn more about natural removal solutions, via wetlands, forests, agricultural lands, and rangelands from scientific experts across the world who have been researching the potential to remove vast

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[98] *See, e.g.*, Breyer et al., *supra* note 95, at 78187 (noting the field of 100% renewable energy systems research 'has quickly grown with hundreds of published papers by many different research groups across the world").

[99] *Id.* at 78176.

[100] *Low-cost Solutions for 145 Countries, supra* note 18; Mark Jacobson et al., *Zero Air Pollution and Zero Carbon from All Energy at Low Cost and Without Blackouts in Variable Weather Throughout the U.S. with 100% Wind-Water-Solar and Storage*, 184 Renewable Energy, 430 (2022) https://web.stanford.edu/group/efmh/jacobson/Articles/I/21-USStates-PDFs/21-USStatesPaper.pdf [hereinafter *Zero Air Pollution*].

[101] *Low-cost Solutions for 145 Countries, supra* note 18 at 3344-45; *Zero Air Pollution, supra* note 100 at 430.

[102] *Id.*

[103] *Id.* at 434.
https://web.stanford.edu/group/efmh/jacobson/Articles/I/21-USStates-PDFs/21-USStatesPaper.pdf.

[104] CO_2e, or CO_2 equivalent, is a denomination that converts and equalizes the contribution of various GHGs to global warming based on how they compare to the global warming potential of CO_2.

[105] Mark Jacobson, *A Solution to Global Warming, Air Pollution, and Energy Insecurity for Switzerland* (Oct. 22, 2021), https://web.stanford.edu/group/efmh/jacobson/Articles/I/145Country/21-WWS-Switzerland.pdf.

[106] William Brittlebank, *Denmark Targets 100% Renewable Electricity by 2050*, Climate Action (Jul. 28, 2016), https://www.climateaction.org/news/denmark_targets_100_renewable_electricity_by_2050#:~:text=William%20Brittlebank-,Currently%2C%2040%20per%20cent%20of%20Denmark's%20electricity%20comes%20from%20wind,per%20cent%20renewables%20by%202050.

[107] Stephen Dowling, *Norway's Plan for a Fleet of Electric Planes*, BBC Future (Aug. 22, 2018), http://www.bbc.com/future/story/20180814-norways-plan-for-a-fleet-of-electric-planes.

[108] Jessica Reed, *10 Airlines That Made Electric and Hydrogen-powered Aircraft Investments, Partnerships in 2021*, Avionics Int'l (Jan. 1, 2022), https://www.aviationtoday.com/2022/01/01/10-airlines-made-electric-hydrogen-powered-aircraft-investments-partnerships-2021/.

amounts of legacy CO_2.[109] Europe is also the home to Intervenor Centre for Climate Repair, which is engaged in innovative research and early small scale efforts towards marine biomass regeneration by restoring the whales' vital function in the ocean ecosystem and restoring giant kelp beds.[110] Additionally, if the Court would like a synopsis of this area of the science, intervenors could certainly provide a more detailed explication upon request.

IV. The Misalignment of the Paris Temperature Targets and the 350 ppm Standard

The difference between the seven year old policy target of 1.5°C–2.0° and the 350 ppm standard reflects the abyss between consensus political decision making and scientific evidence. The Paris temperature targets were reached through negotiations and by political consensus rather than being scientifically determined. While a thorough history of how 1.5°C–2.0°C became the politically accepted target for policy makers and States is beyond the scope of this intervention, it is available to the Court.[111] Instead, this section provides a very brief overview of the context that resulted in the international acceptance of Paris temperature targets even though they fail to protect human rights.

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty that came into force in 1994[112] with the goal to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[113] However, UNFCCC negotiators purposefully did not define "dangerous", nor did they promote a specific numeric target for GHG concentration stabilisation. Over the next twenty years, policy makers participated in contentious discussions striving to reach an international agreement on what an achievable this target should be and how best to reach it.

During that time, the ability of climate scientists "to understand the mechanisms driving global warming and predict the impacts more precisely [] improved dramatically."[114,115] As discussed above, analysis of Earth's energy imbalance led many leading scientists to determine as early as 2008 that 2°C global warming (equivalent to an atmospheric CO_2 concentration of around 450 ppm) would be "extremely dangerous."[116] Rather, their "scientific understanding indicated an initial target of no more than 350 ppm CO_2 to avoid dangerous impacts[.]"[117] Nevertheless, institutions around the world became set on the idea of 2.0°C as the long-term, political target, "even though there was substantial scientific evidence showing such a target was highly dangerous to humanity."[118]

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[109] *See, e.g.*, Keith Paustian, *Climate-smart Soils.* 532 Nature 49 (2016); Bronson Griscom, et al., *Natural Climate Solutions,* 114 Proc. Nat'l Acad. Sci.: Earth, Atmospheric, and Planetary Sciences 11645 (2017), https://doi.org/10.1073/pnas.1710465114; Joseph Fargione et al., *Natural Climate Solutions for the United States,* 4 Sci. Advances 1, 1 (2018); Beverly Law et al., *Land Use Strategies to Mitigate Climate Change in Carbon Dense Temperate Forests,* 115 Proc. Nat'l Acad. Sci. 3663 (2018); Pete Smith et al., *How to Measure, Report and Verify Soil Carbon Change to Realize the Potential of Soil Carbon Sequestration for Atmospheric Greenhouse Gas Removal,* 26 Glob. Change Biology 219 (Aug. 2019), https://doi.org/10.1111/gcb.14815; Mark A. Bradford et. al, *Soil Carbon Science for Policy and Practice,* 2 Nature Sustainability (2019); J. Boone Kauffman et al., *Total Ecosystem Carbon Stocks at the Marine-Terrestrial Interface: Blue Carbon of the Pacific Northwest Coast, United States,* 26 Glob. Change Biology 5679, 5679 (2020), https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.15248; G. Philip Robertson et al., *Land-based Climate Solutions for the United States,* 28 Glob. Change Biology 4912 (2022), https://doi.org/10.1111/gcb.16267.

[110] Centre for Climate Repair, *Remove Greenhouse Gas,* https://www.climaterepair.cam.ac.uk/remove-greenhouse-gas (last visited, Dec. 4, 2022); *see generally* Christine Bertram, et al., *The blue carbon wealth of nations,* 11 Nature Climate Change, 704 (2021) at https://www.nature.com/articles/s41558-021-01089-4; Anaëlle Durfort, et al., *Recovery of Carbon Benefits by Overharvested Baleen Whale Populations Is Threatened by Climate Change,* 289 Proceed. of the Royal Soc. B 1 (2022), https://doi.org/10.1098/rspb.2022.0375; Wilson Thau Lym Yong, et al., *Seaweed: A Potential Climate Change Solution,* 159 Renewable & Sustainable Energy Rev. 112222 (2022), https://doi.org/10.1016/j.rser.2022.112222; Mohd Safwan Azman, et al., *Stand Structure, Biomass and Dynamics of Naturally Regenerated and Restored Mangroves in Malaysia,* 482 Forest Ecology & Mgmt. 118852 (2021), https://doi.org/10.1016/j.foreco.2020.118852; Ove Hoegh-Guldberg, et al. *The Ocean as a Solution to Climate Change: Five Opportunities for Action,* World Res. Inst. (2019); https://oceanpanel.org/publication/the-ocean-as-a-solution-to-climate-change-five-opportunities-for-action/.

[111] See Andrea Rodgers, et al., *The Injustice of 1.5°C–2°C: The Need for a Scientifically Based Standard of Fundamental Rights Protection in Constitutional Climate Change Cases,* 40 *Va. Envtl. L. J. (2022); Piero Morseletto, et al., *Governing by Targets: Reductio Ad Unum and Evolution of the Two-Degree Climate Target,* 17 Int'l Env't Agreements: Pol., L. & Econ. 660 (2017).

[112] United Nations Framework Convention on Climate Change, May 9, 1992, S. Treaty Doc No. 102-38, 1771 U.N.T.S. 107, https://perma.cc/4VRY-MTKP.

[113] Paris Agreement, *supra* note 2, at art. 2.

[114] Hansen Expert Report, *supra* note 11, at 17.

[115] Since scientists rely on climate models to project how changes will play out over decades, they continually sought ways to better corroborate their findings. Importantly, in the early 1990s, NASA launched its Earth Observing System (EOS). EOS is comprised of a series of coordinated polar-orbiting satellites designed to monitor and understand key components of the climate system and their interactions with long-term global observations. This marked a key turning point for climate science as these satellites gave scientists—and our political leaders—new eyes on the atmosphere allowing scientists to fact check the extensive climate modelling they had methodically been developing for over a century based on greenhouse gas measurements being taken at monitoring stations around the globe. *See* NASA's Earth Observing System, *Missions: Earth Observing System (EOS),* NASA (Dec. 4, 2022), https://eospso.nasa.gov/mission-category/3.

[116] Hansen Expert Report, *supra* note 11, at 23.

[117] *Id.* at 22.

[118] *Id.* at 23.

It all culminated in 2015 at the 21st Conference of the Parties[119] in Paris, where negotiators, committed to the 2°C target with an aspiration toward limiting global warming to 1.5°C in the 2015 Paris Agreement.[120] Now, this political target that is categorically dangerous for human rights is being relied upon as a *de facto* standard that upholds human rights in numerous court cases even though the global scientific community says otherwise.

V. Critical Scientific Findings: Current Levels of Warming are Causing and will Continue to Cause Severe Harms to Young People and Future Generations

Scientific research concludes that young people of today are being—and those yet to be born will be—particularly affected by climate harms in myriad ways. In particular, growing scientific consensus indicates that children are more susceptible than the average adult to negative physical and mental health outcomes resulting from climate change induced effects such as poor air quality and heatwaves.[121] In this section, intervenors will provide a survey of key research finding at the intersection of climate change and children's health.

A. Air pollutants and allergens increased by and associated with climate change are particularly injurious to children's health

Scientific studies have determined that climate change-causing fossil fuel emissions are increasing exposure to harmful air pollutants and allergens in numerous ways and that exposure to such air pollutants cause more severe harms in children than adults.[122] For example, scientific evidence points to the fact that climate change is increasing the intensity of wildfires, resulting in smoke-based air pollution that has a cumulative negative effect on the growing bodies of young people[123] and harms their performance in school.[124] Similarly, the science is clear that air pollutants resulting from the combustion of fossil fuels are especially harmful to young people.[125] Significant scientific evidence also exists that climate change is increasing the amount of pollen and other allergens in the air, leading to outsized impacts on young people.[126] Children have faster rates of respiration and are more active that most adults, which creates special risks

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[119] The Convening of the Parties is the negotiating decision-making body of the UNFCCC that meets annually and is charged with evaluating and promoting the implementation of the UNFCCC. *See* United Nations Climate Change, *Supreme Bodies: Conference of the Parties (COP)* (2022), https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop.

[120] Paris Agreement, *supra* note 2, at art. 2.

[121] See, e.g., Zhiwei Xu, et al., *Climate Change and Children's Health—A Call for Research on What Works to Protect Children,* 9 Int'l J. Env't Res. Public Health 3298, 3298-302 (2012("Children are particularly vulnerable to the impact of climate change. . . . As a result, children experience greater risk of mental disorders, malnutrition, infectious diseases, allergic diseases and respiratory diseases. . . . Children, together with elderly, represent subpopulations particularly sensitive to the negative health effects of air pollution[]. . . . [C]hildren, especially very young children, are particularly vulnerable to heat waves[]."); Marina Romanello et al., *The 2022 Report of the Lancet Countdown on Health and Climate Change: Health at the Mercy of Fossil Fuels,* 400 Lancet 1619, 1628 (2022), https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(22)01540-9/fulltext ("[Y]oung people have been shown to be more prone to anxiety, phobias, depression, stress-related conditions, substance abuse, sleep disorders, reduced capacity to regulate emotions, and increased cognitive deficits. The increasingly visible effects of the climate crisis have given rise to emerging concepts, such as climate change anxiety, solastalgia, eco-anxiety, and ecological grief.").

[122] See, e.g., Frederica Perera & Kari Nadeau, *Climate Change, Fossil-Fuel Pollution, and Children's Health,* 386 New England J. Med. 2303, 2303-04 (2022) ("The combustion of fossil fuels (coal, petroleum [oil], and natural gas) is the major source of both air pollution and the greenhouse-gas emissions driving climate change. . . . The fetus, infant, and child are uniquely vulnerable to climate-related environmental impacts and air pollution owing to a host of biologic and behavioral factors.[] The speed of development and the elaborate developmental programming during these stages confer high susceptibility to disruption by toxic chemicals and other stressors. In addition, the biologic defense mechanisms for detoxifying chemicals, repairing DNA damage, and providing immune protection are immature in the infant and child, thus heightening their vulnerability to psychosocial stress and physical toxicants").

[123] Nino Künzli et al., *Health Effects of the 2003 Southern California Wildfires on Children,* 174 Am. J. Respiratory & Critical Care Med. 1221, 1224 (2006) ("Having fire smoke smell indoors for more than 6 [days] was associated with more than fourfold higher rates of eye symptoms, approximately threefold increased rates of dry cough and sneezing, and more than twofold higher rates of cold, sore throat, wet cough, medication use, physician visits, and missed school due to symptoms. . . . Asthma attacks increased 63%."); *see also,* Nick Watts et al., *The 2019 Report of The Lancet Countdown on Health and Climate Change: Ensuring That the Health of a Child Born Today Is Not Defined by a Changing Climate,* 394 Lancet 1836, 1837 (2019) ("Through adolescence and beyond, air pollution – principally driven by fossil fuels and exacerbated by climate change – damages the heart, lungs, and every other vital organ. These effects accumulate over time, and into adulthood[.] . . .").

[124] Jeff Wen & Marshall Burke, *Lower Test Scores from Wildfire Smoke Exposure,* 5 Nature Sustainability 947, 948 (2022) ("We find that smoke exposure in the year leading up to the test negatively affects test scores.").

[125] *See, e.g.,* Leonardo Trasande & George Thurston, *The Role of Air Pollution in Asthma and Other Pediatric Morbidities,* 115(4) J. Allergy Clin. Immunol. 689, 690 (2005) ("In personal exposure studies in The Netherlands, children experienced a much higher personal exposure than adults exposed to the same outdoor concentrations of PM10. Although children were exposed to similar outdoor concentrations as those experienced by adults in the study (41.5 vs 38.5 mg/m3 for adults), children's personal exposures averaged 66.8 mg/m3 above ambient levels versus 26.9 mg/m3 above ambient levels for adults."); *see also,* Trasande & Thurston, *supra* note 125, at 691 ("Two other factors form the biologic basis of children's unique vulnerability: their differential ability to metabolize, detoxify, and excrete environmental agents[] and their higher number of remaining years of life. Many chronic diseases, including cancer and neurodegenerative diseases, are thought to arise through a series of changes within cells that require many years to evolve from initiation to actual manifestation of illness. Exposures to environmental agents early in life, including prenatal exposures, appear more likely to produce chronic disease than similar exposures encountered later.").

[126] U.N. H.R.C., *Analytical Study on the Relationship Between Climate Change and the Full and Effective Enjoyment of the Rights of the Child* ¶ 15, A/HRC/35/

for their developing lungs and bodies.[127]

Climate change increases the frequency and severity of wildfires,[128] putting children particularly at risk both from the fire itself, including property loss and displacement, and from exposure to the resulting wildfire smoke.[129] Due to climate change, the length of fire seasons around the globe have increased in the last few decades, particularly in Mediterranean forests where the fire season lengthened by an additional 12 to 19 days since 1979.[130] As a result, "fires burned more area than any year in the previous decade" in Spain during 2012.[131] Scientists project that this trend will continue as the planet continues to warm, leading to a potential 40–100% increase in how much land gets burned by wildfires annually.[132]

According to the European Union's Copernicus Atmosphere Monitoring Service, wildfires worldwide emitted massive amounts of smoke.[133] Exposure to smoke-based air pollution is especially dangerous for children who "are considered more sensitive to the impacts of air pollution because their lungs are smaller, and their dose per body weight and lung surface areas exceed those of the adult population[]"[134] and "because they have increased exposure (children often spend more time outdoors), . . . and they are still growing and developing."[135] Air pollutants cause damage to the lungs when inhaled and exacerbate pre-existing respiratory conditions such as asthma,[136] and "[r]ecent toxicological studies suggest that wildfire particulate matter may be more toxic than equal doses of ambient [air pollutants]."[137] Wildfire air pollutants can also lead to severe health complications such as childhood pneumonia, lower respiratory infections, and decreased lung functionality that can continue into adulthood.[138]

Similarly, a wide-ranging body of scientific evidence has found that fossil fuel combustion, the fundamental driver of climate change due to resultant GHGs, has direct negative impacts on air quality. Exposure to such air pollution is a "recognized risk factor" for premature birth, low birth weight, and other complications for pregnant women and can confer increased risks of lower respiratory

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(2017) ("[W]armer temperatures are also linked with the release of airborne allergens that can exacerbate asthma and allergic respiratory diseases.[] Thus, air pollution and climate change contribute to a vicious cycle that disproportionately affects children, who, due to their higher breathing rate, are more susceptible to respiratory problems and infections related to air pollution."); Lewis Ziska et al., *Recent Warming by Latitude Associated with Increased Length of Ragweed Pollen Season in Central North America*, 108 Proc. Nat'l Acad. Sci. 4248, 4248 (2011) ("Overall, these data indicate a significant increase in the length of the ragweed pollen season by as much as 13–27 [days] at latitudes above ~44 N since 1995.").

127 Stephanie M. Holm et al., *Health Effects of Wildfire Smoke in Children and Public Health Tools: A Narrative Review*, 31 J. of Exposure Sci. & Env't Epidemiology 1, 4 (2021), https://doi.org/10.1038/s41370-020-00267-4 ("[C]hildren have higher minute ventilation per kilogram of body weight, and therefore experience a higher dose of air pollution than adults. In addition, because children's systems are still growing and developing, they can be uniquely vulnerable to health effects of air pollutants.").

128 *See e.g.*, Piyush Jain et al., *Observed Increases in Extreme Fire Weather Driven by Atmospheric Humidity and Temperature*, 12 Nat. Climate Change 63, 63 (2022) ("In the future, the occurrence of extreme fire weather is expected to increase in many areas due to climate change . . . Recent increases in regional wildfire activity have been linked to climate change."); Zhongwei Liu et al., *A Global View of Observed Changes in Fire Weather Extremes: Uncertainties and Attribution to Climate Change*, 173 Climatic Change 1, 1 (2021) ("[T]he likelihood of climate-related fire risk has increased by at least a factor of four in approximately 40% of the world's fireprone regions as a result of rising global temperature.").

129 Sydney Leibel et al., *Increase in Pediatric Respiratory Visits Associated with Santa Ana Wind–Driven Wildfire Smoke and $PM_{2.5}$ Levels in San Diego County*, 70 Annals of the Am. Thoracic Soc'y 313, 319 (2020) ("Climate change is expected to result in more frequent and extensive wildfires in the region and will require greater preparedness and adaptation efforts to protect vulnerable populations, such as young children.").

130 W. Matt Jolly et al., *Climate-induced Variations in Global Wildfire Danger from 1979 to 2013*, 6 Nature Commc'n 1, 4 (2015); *see generally* Zhongwei Liu et al., *supra* note 128, at 10 ("Such increases in the likelihood of extreme fire danger are particularly strong in temperate North America, Europe, Africa, Boreal, and Central Asia."); Doug Richardson et al., *Global Increase in Wildfire Potential from Compound Fire Weather and Drought*, 5 Climate & Atmospheric Sci. 1, 4 (2022) ("For fire weather days, we find evidence of increasing trends and change points for many parts of the world, including western North America, Brazil, eastern Europe . . . .").

131 W. Matt Jolly et al., *supra* note 130 at 4.

132 David M. J. S. Bowman et al., *Vegetation Fires in the Anthropocene*, 1 Nature Rev. Earth & Env't 500, 507 (2020).

133 Katie Abnett, *This Is How Much Carbon Wildfires We Have Emitted This Year*, World Econ. Forum (Dec. 10, 2021), https://www.weforum.org/agenda/2021/12/siberia-america-wildfires-emissions-records-2021/#:~:text=said%20on%20Monday.-,Wildfires%20emitted%201.76%20billion%20tonnes%20of%20carbon%20globally%20in%202021,double%20Germany's%20annual%20CO2%20emissions.

134 Ana G. Rappold et al., *Community Vulnerability to Health Impacts of Wildland Fire Smoke Exposure*, 51 Env't Sci. & Tech. 6674, 6679 (2017) ("The effects of air pollution and wildfire smoke exposure on adults with preexisting respiratory conditions such as asthma and COPD are extensively documented in literature. These effects have also been noted in both children with asthma and children without asthma and have been noted to be stronger than in adults.").

135 Holm et al., *supra* note 127, at 2; *see also*, Perera & Nadeau, *supra* note 122, at 2304.

136 Holm et al., *supra* note 127, at 4 ("It has been demonstrated for over 25 years that pediatric asthma visits are increased in association with wildfire events."); Rappold et al., *supra* note 134, at 6674-75 ("Exposure to wildfire smoke is a serious health risk which can disproportionally impact sensitive groups. A number of studies have shown an association between smoke exposure and worsening of respiratory symptoms, increased rates of cardiorespiratory emergency visits, hospitalizations, and even death.").

137 Rosana Aguilera et al., *Wildfire Smoke Impacts Respiratory Health More Than Fine Particles from Other Sources: Observational Evidence from Southern California*, 12 Nature Commc'n 1 (2021), https://doi.org/10.1038/s41467-021-21708-0; Breanna L. Alman et al., *The Association of Wildfire Smoke with Respiratory and Cardiovascular Emergency Department Visits in Colorado in 2012: A Case Crossover Study*, 15 Env't Health 1, 8 (2016) ("People are exposed to wildfire particulate matter relatively infrequently compared to other ambient air pollutants, but there is some evidence to suggest that PM2.5 from wildfires may have a stronger adverse effect on respiratory morbidity at the same levels . . . .").

138 Holm et al., *supra* note 127, at 3.

infections, other infectious diseases, asthma, and long-term intellectual disabilities on the baby.[139] In addition, children are uniquely vulnerable to air pollution resulting from fossil fuel combustion[140] because of "[t]heir immature physiology and metabolism; incomplete development; higher exposure to air, food, and water per unit body weight; unique behaviour patterns; and dependence on caregivers."[141]

Climate change also increases the level of allergenic irritants in the air, once again leading to particularized injuries on children. For example, "[c]hildren are [] having more allergy and asthma attacks from increased levels of airborne pollen as a result of higher temperatures and rising levels of carbon dioxide, which have resulted in longer growing seasons and increased pollen production."[142]

B. Climate change increases the frequency and severity of heatwaves which have particularly harmful effects on children's health

Many scientific studies have determined that climate change is increasing and will continue to increase the incidence and intensity of heatwaves.[143] Indeed, the number of heatwaves in recent years "would be extraordinarily unlikely to occur in the absence of climate change."[144] In general, the summer climate of Europe is warming "rapidly,"[145] particularly in the Mediterranean region where "future summer warming is expected to exceed global rates by 40%[.]"[146] Most recently, the European Mediterranean region experienced a heatwave in 2021 that was "record breaking in length."[147]

In addition to heatwaves and generally hot temperatures, overwhelming scientific evidence indicates that climate change is causing increasingly severe droughts, particularly in southern Europe which is predicted to be a "future global hotspot[] of drought[.]"[148] Both because of their increased susceptibility to heat-induced harms and because they will live long into the future, today's children and future generations will be particularly harmed by this trend toward increasing drought conditions.

Widely replicated scientific evidence indicates that climate change-induced heatwaves are severely and especially harmful to young people throughout all stages of development.[149] For example, scientific studies have found that exposure to extreme heat during the first days of life can increase infant mortality by 25%[150] and exposure to extreme heat while in utero increases the risk for preterm birth

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[139] Perera & Nadeau, *supra* note 122, at 2308; *see also* Fiona C. Goldizen et al., *Respiratory Effects of Air Pollution on Children*, 51 Pediatric Pulmonology 94, 100 (2016) (noting that impaired fetal growth associated with prenatal air pollution exposure "contributes to lung function deficits in later life.").

[140] Federica Perera, *Pollution from Fossil-Fuel Combustion Is the Leading Environmental Threat to Global Pediatric Health and Equity: Solutions Exist*, 15 Int'l J. Env't Res. & Pub. Health 16 (2017) (noting that children "bear a disproportionate burden of disease and developmental impairment from both environmental pollution and climate change due to the combustion of coal, oil, gasoline, diesel and natural gas.").

[141] Samantha Ahdoot & Susan E. Pacheco, *Global Climate Change and Children's Health*, 136 Pediatrics e1468, e1470 (2015), https://pediatrics.aappublications.org/content/pediatrics/136/5/e1468.full.pdf; *see also*, Holm et al., *supra* note 127, at 4 ("[C]hildren have higher minute ventilation per kilogram of body weight, and therefore experience a higher dose of air pollution than adults. In addition, because children's systems are still growing and developing, they can be uniquely vulnerable to health effects of air pollutants."); Perera & Nadeau, *supra* note 122, at 2304 ("Infants and children are more vulnerable than adults to severe heat because of their compromised thermoregulatory function at extreme temperatures[] and their dependence on care by adults who may be unaware of the risks, as when infants left in cars have died from the heat.").

[142] Perera & Nadeau, *supra* note 122, at 2307; *see generally*, William Anderegg et al., *Anthropogenic Climate Change Is Worsening North American Pollen Seasons*, 118 Proc. Nat'l Acad. Sci. 1, 1 (2021), https://www.pnas.org/doi/10.1073/pnas.2013284118 ("Our results reveal that anthropogenic climate change has already exacerbated pollen seasons in the past three decades with attendant deleterious effects on respiratory health.").

[143] Ondřej Lhotka & Jan Kysely, *The 2021 European Heat Wave in the Context of Past Major Heat Waves* 2 (2022), https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2022EA002567 ("The severity of heat waves has increased in the past two decades . . . .").

[144] Perera & Nadeau, *supra* note 122, at 2304-05.

[145] Lhotka & Kysely, *supra* note 143, at 2.

[146] *Id.* at 3.

[147] *Id.* at 2.

[148] Isabelle Runde et al., *Human and Natural Resource Exposure to Extreme Drought at 1.0 °C–4.0 °C Warming Levels*, 17 Env't Res. Letters 1, 6 (2022), https://doi.org/10.1088/1748-9326/ac681a; *see also*, Hossein Tabari & Patrick Willems, *Trivariate Analysis of Changes in Drought Characteristics in the CMIP6 Multimodel Ensemble at Global Warming Levels of 1.5°, 2°, and 3°C*, 35 J. Climate 5823, 5827 (2022) ("The univariate analysis of drought properties shows an uneven spatial pattern of the changes, with the largest increases in South America, central America, the Middle East and North Africa (MENA), southern Europe. . . .").

[149] Romanello et al., *supra* note 121, at 1625 ("Young children and older people are especially susceptible to the health risks of high temperatures and heatwaves" (citing World Health Org., *Heat and Health* (June 1, 2018)).

[150] Xavier Basagña et al., *Heat Waves and Cause-specific Mortality at All Ages*, 22 Epidemiology 765, 769 (2011), https://pubmed.ncbi.nlm.nih.gov/21968768/ ("In infants, the effect of heat was particularly strong, with mortality increases of 25% when considering only the first hot day."); *see also*, Zhiwei Xu et al., *The Impact of Heat Waves on Children's Health: A Systematic Review*, 58 Int'l J. Biometeorology 239, 245 (2014) [hereinafter *Impact of Heat Waves*] ("[M]ore heat-related deaths among infants are reported during heat wave periods."); Sarah Chapman, *Past and Projected Climate Change Impacts on Heat-related Child Mortality in Africa*, 17 Env't Res. Letters 1, 9 (2022) ("[C]limate change, through increasing exposure to high temperatures, may have already led to double the heat related child mortality compared to what would have been expected without climate change."); *see also*, Linda Giudice, *A Clarion Warning About Pregnancy Outcomes and the Climate Crisis*, 3 JAMA Network Open e208811, e208811 (2020) (noting that "exposures mainly in the third trimester (or averaged across gestation) to $PM_{2.5}$, O_3, and heat, alone or together, are associated with [preterm birth, low birth weight, and stillbirth] in the vast majority of studies analyzed").

and low birth weight.[151] Averaged across the world, every child less than one year old experienced 4.6 more days of heatwave exposure in 2020 as compared to the baseline average from 1986 to 2005 due to climate change.[152] High ambient temperatures can also increase both the risk of emergency room visits for 0-4 year olds[153] and the risk of hospitalizations for 13-16 year olds.[154] High school athletes in particular have a high incidence of heat related illness according to the U.S. Center for Disease Control such that "[h]eat illness during practice or competition is a leading cause of death and disability among U.S. high school athletes[.]"[155] Children are more likely than adults to develop kidney disease, respiratory disease, fever, and electrolyte imbalance as a result of very hot temperatures.[156] Even further, a systematic review of the relevant scientific literature indicates that high temperatures increase bacterial diarrheal disease incidence in children and that "[d]iarrheal disease is one of the three main causes of child death globally, estimated consistently to cause around 21-22% of all under-five deaths[.]"[157] The increased risk for these illnesses derives from a number of factors such as children's still developing thermoregulatory systems and higher surface area to mass ratio which allows for increased heat transfer in and out of the body, higher metabolic rates which can increase sensitivity to heat, relatively low cardiac output, relatively high heart rate, increased time spent outdoors and engaged in elevated physical activity, and reliance on adults for ensuring their personal health and safety.[158]

C. Climate change has particularly deleterious effects on children's mental health

Above and beyond these physical impacts, a growing body of scientific research shows that climate change can have severe psychological impacts on young people. Studies suggest that extreme heat caused by climate change negatively affects children's mental health as well as their ability to learn.[159] Additionally, traumatic events resulting from climate change such as home evacuations—which regularly happen before, during and after climate disasters—can have significant impacts on children's mental health and development.[160] In addition, growing up with an awareness of the gravity and urgency of climate change has been documented to have a negative impact on young people's psychological well-being.[161] A global survey of 10,000 children living in 10 different countries including four Council of Europe Member States found that children are experiencing severe emotional distress and anxiety due to climate change. In the survey study, the researchers determined that,

> "[C]hildren and young people in countries around the world report climate anxiety and other distressing emotions and thoughts about climate change that impact their daily lives. This distress was associated with beliefs about inadequate governmental response and feelings of betrayal. A large proportion of children and young people around the world report emotional distress and a wide range of painful, complex emotions (sad, afraid, angry, powerless, helpless, guilty, ashamed, despair, hurt, grief, and depressed). Similarly, large numbers report experiencing some functional impact and have pessimistic beliefs about the future (people have failed to care for the planet; the future is frightening; humanity is doomed; they won't have access to the same opportunities their parents had; things they value will be destroyed; security is threatened; and they are hesitant to have children)."[162]

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151 Perera & Nadeau, *supra* note 122, at 2305 (2022); Virginia Arroyo et al., *Short Term Effect on Air Pollution, Noise and Heat Waves on Preterm Births in Madrid (Spain)*, 145 Env't Res. 162, 166-67 (2016) (noting that "heat . . . has a short term effect on preterm births . . . .").

152 Romanello et al., *supra* note 121, at 1625.

153 Li Niu et al., *High Ambient Temperature and Child Emergency and Hospital Visits in New York City*, 36 Pediatric & Perinatal Epidemiology 36, 36 (2022); *see generally* Aaron S. Bernstein et al., *Warm Season and Emergency Department Visits to U.S. Children's Hospitals*, 130 Env't Health Persp. 17001-1, 17001-1 (2022) ("[D]ays with higher temperatures were associated with higher rates of visits to children's hospital EDs [emergency departments]."); Aaron S. Bernstein et al., *supra* note 153, at 17001-4 (2022) ("Our results suggest that higher maximum daily temperatures during the warm season may increase the risk of ED visits among children and adolescents.").

154 Li Niu et al., *supra* note 153, at 36.

155 Centre Disease Control and Prevention, *Heat Illness Among High School Athletes -- United States, 2005—2009*, 59 Morbidity and Mortality Weekly Report 1009, 1009 (Aug. 20, 2010) https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5932a1.htm; *see also*, Perera & Nadeau, *supra* note 122, at 2306 ("In the United States, heat-related illness is a leading and increasing cause of death and illness among student athletes."); Perry Sheffield et al., *Climate Change and Schools: Environmental Hazards and Resiliency*, 14 Int'l J. Env't Res. & Pub. Health 1397, 1399 (Nov. 16, 2017) (noting that climate change-induced extreme heat "is of particular concern for student athletes . . . .").

156 Nick Watts et al., *supra* note 123, at 1841; *see also Impact of Heat Waves*, *supra* note 150, at 245.

157 Zhiwei Xu et al., *Impact of Ambient Temperature on Children's Health: A Systematic Review*, 117 Env't Rsch. 120, 128 (2012) [hereinafter *Impact of Ambient Temperature*].

158 *Impact of Heat Waves*, *supra* note 150, at 239-40 (2014); *see also id.* at 127; Chapman, *supra* note 150, at 1 ("Children (<5 years) are highly vulnerable during hot weather due to their reduced ability to thermoregulate.").

159 Perera & Nadeau, *supra* note 122, at 2306.

160 Daniel Martinez Garcia & Mary C. Sheehan, *Extreme Weather-Driven Disasters and Children's Health*, 46 Int'l J. Health Serv. 79, 88 (2016), https://journals.sagepub.com/doi/abs/10.1177/0020731415625254 ("Abrupt disruptions in a child's life such as family loss or separation; school interruption; changes in food and water supply and shelter conditions; and public service outages may cause direct acute shock and other emotional trauma, as well as longer-term indirect effects."); *see, e.g.*, Holm et al., *supra* note 127, at 6 (2021), https://doi.org/10.1038/s41370-020-00267-4 ("Because a wildfire event in a child's community may be a traumatic event, wildfires have been associated with a number of stress-related effects, including changes in infant feeding practices and high rates of psychiatric symptoms[.]").

161 Susie E. L. Burke et al., *The Psychological Effects of Climate Change on Children*, 20 Current Psychiatry Rep. 35 (2018), https://pubmed.ncbi.nlm.nih.gov/29637319/.

162 Caroline Hickman et al., *Climate Anxiety in Children and Young People and Their Beliefs About Government and Responses to Climate Change: A Global Survey*, 5 Lancet Planet Health e863, e870 (2021).

In addition, the Royal College of Psychiatrists determined that 57% of surveyed child and adolescent psychiatrists in England are working with young people who are distressed about climate change.[163]

Climate change harms can leave young people feeling particularly devastated because, in addition to their vast breadth, such effects also extend deep, cutting across many layers of a young person's lived experience. Several examples of climate change harms described above such as exposure to heatwaves are classified as primary effects, meaning they have a direct impact on children's health.[164] Other examples listed above are more appropriately classified as secondary risks, meaning climate change leads to health injuries for young people but those injuries are mediated by some ecological alteration, e.g., warmer weather increasing the range of malaria-carrying mosquitos.[165] Finally, tertiary risks include those large-scale adverse consequences of climate change that result in social instability such as population migration or the loss of ecosystem services.[166] Not only do these layers of effects overlap but they also compound, increasing their deleterious consequences such as the psychological toll they impose on young people.[167]

VI. Applicability of the Best Available Scientific Evidence to the Court's Jurisprudence

There is no controversy that the very foundation of judicial systems around the world relies on the use of the most up-to-date and best available scientific evidence to assure just, practical, and effective remedies. This Court's jurisprudence with respect to the protection of rights is also uncontroversial: States' have a positive obligation to protect life under Article 2 and this obligation applies to both man-made and natural disasters.[168] Further, where the evidence before the Court does not meet the threshold to establish a lethal risk, the same evidence may be sufficient to substantiate a finding under Article 8 of the Convention.[169]

For the avoidance of doubt, the intervenors submit that the scientific evidence available to this Court is sufficient to meet the relevant thresholds under both Articles 2 and 8 of the Convention. Further, the evidence presented within, together with the greater body of climate science, establish that States can effectively prevent innumerable future harms to human life, health, and well-being by meeting the 350 ppm standard.

It will be obvious nonetheless, that specific questions arise for the Court when assessing the current and unique factual context of climate change. The intervenors will briefly address only the priority questions that arise at the intersection of this Court's jurisprudence and science:

a. Does the body of climate science evidence establish a "clearly identifiable" danger to individual lives as opposed to general global catastrophe?
b. What is the appropriate definition of "imminent" in the context of climate change?
c. Can it be established that States had the requisite knowledge of the scientific evidence showing that the continued emissions of CO_2 and other GHGs would have dangerous impacts on Convention rights?
d. How to assess whether a State has done all it could to take appropriate, adequate, and reasonable steps to safeguard the lives of those protected by the Convention?
e. What, if any, interplay should exist between scientific evidence and a State's margin of appreciation in climate change cases?

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163 Royal Coll. of Psychiatrists, *The Climate Crisis Is Taking a Toll on the Mental Health of Children and Young People* (Nov. 20, 2020), https://www.rcpsych.ac.uk/news-and-features/latest-news/detail/2020/11/20/the-climate-crisis-is-taking-a-toll-on-the-mental-health-of-children-and-young-people.

164 American Academy Pediatrics, *Global Climate Change and Children's Health*, 136 Pediatrics 922, 994 (2015).

165 *Id.* at 994.

166 *Id.* at 994.

167 *See, e.g.*, U.N. H.R.C., *Analytical Study on the Relationship Between Climate Change and the Full and Effective Enjoyment of the Rights of the Child* 18, A/HRC/35/ (2017), ("Climate change and the impacts of traumatic stress connected to climate change, such as war/insecurity, sexual and physical violence and witnessing deaths and injury related to extreme weather disasters, negatively affect children's mental health. Children who lose a family member or experience life-threatening situations as a result of the impacts of climate change have a higher chance of experiencing post-traumatic stress, anxiety disorders, suicidal ideation and depression. Disasters can also affect children's cognitive capacity with corresponding impacts on their emotional well-being. For example, children affected by El Niño during early childhood posted lower scores in language development, memory and spatial reasoning than other children of a similar age.[] Lower cognitive functioning in early life has been shown to increase the risk of future mental health problems.[]"); Zhiwei Xu, et al., *supra* note 121, at 3303 ("Climate change is threatening a number of fragile ecosystems []. Children's health depends on the continuous supply of various ecological services—'the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life' [], and ecological services are underpinned by biodiversity which is also threatened by a number of climate change mechanisms. In addition rising sea levels and inundation of coastal areas, exacerbated by climate change, could render major disruption of social systems.").

168 *Kolyadenko and Others v. Russia* (judgement), no. 17423/05, § 164, ECHR 2012; *Budayeva and Others v. Russia* (judgement), no. 15339/02, §§ 137 and 142, ECHR 2008; *M. Özel and Others v. Turkey* (judgement), no. 14350/05, §§ 170-171, ECHR 2015; *Brincat and Others v. Malta* (judgement), § 80, ECHR 2014; as mentioned in *Guerra and Others v. Italy*, (judgement), no. 116/1996/735/932 [GC], § 60, ECHR 1998.

169 *Brincat and Others v. Malta* (judgement), no. 60908/11, §§ 84-85, ECHR 2014.

A. "Clearly identifiable" danger to individual lives[170]

There is universal scientific consensus and voluminous research which demonstrates that climate change presents a "clearly identifiable" danger to individual life and human health. In addition to the Europe-specific examples provided in Section III(B) and (C) and the harms to children provided in Section V of this submission, climate scientists have found and, in 2021, the IPCC confirmed *inter alia* that:

a. "climate-related illnesses, premature deaths, malnutrition in all its forms, and threats to mental health and well-being are increasing *(very high confidence)*";[171]
b. "[c]limate hazards are increasingly contributing to a growing number of adverse health outcomes (including communicable and non-communicable diseases) [] in multiple geographical areas *(very high confidence)*; and[172]
c. "[a] significant increase in ill health and premature deaths from climate-sensitive diseases and conditions is projected due to climate change *(high confidence)*".[173]

If States are required to immediately implement plans to achieve the pathway to 350 ppm, risks for human health and well-being could be drastically reduced and innumerable injuries avoided altogether.

B. "Imminence" and climate change[174]

With respect to the climate crisis, the intervenors submit that the point of imminence has past and the dangers are already resulting in widespread violations to life and health now not only in Europe but across the globe. For instance, today at ~1.1°C–1.3°C of warming:

a. Extraordinary downpours are becoming more frequent and intense due to climate change.[175] A recent study by 39 expert contributors examined the record rainfall flooding in Germany, Belgium, Luxembourg, and the Netherlands from 12 to 15 July 2021. The research found that climate change increased the intensity of the maximum one-day rainfall event in the summer season in this large region by approximately 3–19% compared to a global climate 1.2°C cooler than today.[176] Over 200 people lost their lives, at least 820 more people were injured, and thousands were economically affected.[177]
b. The European summers of 2021 and 2022 have been two of the three hottest in recorded history.[178] In the UK for instance, temperatures of over 40°C were recorded for the first time during July 2022.[179] Scientists from eight countries found that the likelihood of observing such an event in a 1.2°C cooler world is extremely low and that the heatwave was made at least 10 times more likely as a result of human-induced climate change.[180] The UK government estimated that 1,012 deaths in those aged over 65 resulted from the heatwave.[181]
c. Beyond extreme weather events, health and well-being are also already being affected by expanding ranges for infectious disease contraction in Europe.[182] Climatic conditions have facilitated vector-borne disease outbreaks like chikungunya, dengue, and West Nile fever and have contributed to a geographic range expansion of tick vectors that transmit Lyme disease and tick-borne encephalitis.[183] Extreme precipitation events have caused waterborne outbreaks and longer summer seasons have contributed to increases in foodborne diseases.[184] For this and many other reasons, doctors and leading medical institutions

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[170] *Budayeva and Others v. Russia* (judgement), no. 15339/02, § 137, ECHR 2008; *M. Özel and Others v. Turkey* (judgement), no. 14350/05 §
[171] Guéladio Cissé et al., *Health, Wellbeing and Changing Structure of Communities, in* Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change 1044 (Hans Otto Pörtner et al. eds., 2022).
[172] *Id.* at 1045.
[173] *Id.* at 1046.
[174] *Budayeva and Others v. Russia* (judgement), no. 15339/02, § 137, ECHR 2008; *M. Özel and Others v. Turkey* (judgement), no. 14350/05 § 171.
[175] Frank Kreinkamp, et al., *Rapid Attribution of Heavy Rainfall Events Leading to Severe Flooding in Western Europe During July 2021*, World Weather Attribution (2021), https://www.worldweatherattribution.org/wp-content/uploads/Scientific-report-Western-Europe-floods-2021-attribution.pdf.
[176] *Id.* at 1.
[177] *Id.*; *see also*, Paul A. Korswagen et al., *Post-flood Field Survey of the Ahr Valley (Germany): Building Damages and Hydraulic Aspects*, Delft Univ. Tech. (2022), https://doi.org/10.4233/uuid:3cafd772-facd-4e3a-8b1a-cee978562ff1.
[178] Copernicus Climate Change Service, *Surface Air Temperature for August 2022*, Copernicus (2022), https://climate.copernicus.eu/surface-air-temperature-august-2022.
[179] Mariam Zacariah, et al., *Without Human-caused Climate Change Temperatures of 40°C in the UK Would Have Been Extremely Unlikely*, World Weather Attribution (2022) at 3, https://www.worldweatherattribution.org/wp-content/uploads/UK-heat-scientific-report.pdf.
[180] *Id.* at 2.
[181] UK Health Security Agency and the Office for National Statistics release estimates of excess deaths during summer of 2022, https://www.gov.uk/government/news/ukhsa-and-ons-release-estimates-of-excess-deaths-during-summer-of-2022#:~:text=The%20heat%2Dperiod%20in%20the,over%20the%20age%20of%2065.
[182] Jan Semenza & Shlomit Paz, *Climate Change and Infectious Disease in Europe: Impact, Projection and Adaptation*, 9 Lancet Regional Health 4 (2021), https://www.thelancet.com/action/showPdf?pii=S2666-7762%2821%2900216-7.
[183] *Id.*
[184] *Id.*

are calling climate change a "health emergency".[185]

d. Glaciers in the Alps have been pushed past the threshold for "peak water," i.e., the point at which meltwater begins to decrease in availability shrinking fresh water supplies.[186]
e. Melting sea ice is already severely impacting the Sami people by reducing the amount of phytoplankton in the waters of the Arctic Ocean. Phytoplankton form the base of a complex food web upon which marine animals ranging from shrimp to whales rely. In addition, disappearing sea ice habitat for many other marine animals such as seals, polar bears, and walruses makes it difficult for them to survive.[187] The Sami people's way of life relies on these animals and is thereby threatened by accelerating ice melt due to climate change.
f. While this submission is focused on violations of Article 2 and Article 8, the economic impact is worth underscoring. Over the past decade, climate-related losses cost the European Union approximately €145 billion.[188] These costs will only escalate as the climate crisis persists.

The intervenors submit that it is incumbent upon the Court when assessing State obligations, to consider the weight of evidence showing that planetary warming is already resulting in serious rights violations today together with the scientific findings that future harms will only increase in numbers and severity as CO_2 concentrations and temperatures continue to rise.

The future threat is relevant to how much more dangerous States and the world's courts will allow climate change to become.

C. Requisite State knowledge[189]

Scientists first starting researching the impact of the emission of fossil fuels on global warming in the 1890s.[190] Clear and consistent warnings as to the identifiable and imminent risks that climate change presents to human life and health have certainly been provided to the global community since at least 1981, and in many countries even earlier. A full timeline of what exactly individual States knew and when is beyond the scope of this intervention but could be provided upon request. Instead, the frank and succinct conclusions from the Expert Report entered into evidence in U.S. federal court by Dr. James Hansen—a globally respected climate scientist who has been at the forefront of historical progress in the development of international understanding of human-caused climate change for well over five decades—provide an excellent overview of States' requisite knowledge:

a. "Based on simple climate models, temperature measurements at weather stations, and limited paleoclimate data, colleagues and I were able, *as early as 1981*, to anticipate discernible warming for the 1980s and 1990s, and 21st century shifts in climate zones, increasing climate extremes, eroding ice sheets, and accelerated sea level rise. *We urged, as an appropriate strategy, a shift to low-carbon and non-carbon energy sources, coupled with conservation, with fossil fuels used only as necessary for a few decades more.*" (emphasis added).[191]

b. "*Over nearly four decades*, colleagues and I developed increasingly compelling evidence that ensuing and unconstrained emissions markedly raised the atmospheric CO_2 CH_4, and N_2O concentrations in the atmosphere, enhancing the greenhouse effect and, accordingly, *posing an increasingly dire threat to coastal cities, natural systems, essential human services, and human life.*" (emphasis added).[192]

c. While there was more than enough scientifically-credible evidence to act on climate change in prior decades, *by the early 2000s, the reality of global warming had become unequivocal.* (emphasis added).[193]

Solutions to address global warming, recommended pathways to transition away from fossil fuels, including through conservation efficiency, and solar and other renewables were also 'known' to States as early as 1981.[194] It is, and has been for at least 13 years, both technically and economically feasible for Europe, and indeed all States across the globe, to transition from a predominantly fossil fuel-based energy system to one that eliminates those fuels and their pollution, on a pathway that would be consistent with what science indicates is necessary to restore Earth's energy balance and achieve the 350 ppm standard and restore Earth's energy balance (see section

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185 Caren Solomon & Regina LaRocque, *Climate Change – A Health Emergency*, 380 N. Engl. J. Med. 209 (2019), https://www.nejm.org/doi/full/10.1056/NEJMp1817067.
186 McKay et al., *supra* note 30, at 5; *see also*, Adam Vaughn, *Thin Glaciers Suggest Andes Faces 'Peak Water' Sooner Than Thought* (Feb. 7, 2022), https://www.newscientist.com/article/2307363-thin-glaciers-suggest-andes-faces-peak-water-sooner-than-thought/ (defining the term "peak water").
187 Environmental Justice Foundation, *supra* note 64, at 5.
188 EuroStat, *Losses from Climate Change: €145 Billion in a Decade* (Oct. 25, 2022), https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20221024-1.
189 *Öneryildiz v. Turkey* (judgement)[GC], no. 48939/99, § 101, 2004; *Brincat and Others v. Malta* (judgement), no. 60908/11, §§ 105-106, 2014.
190 University Corporation for Atmospheric Research: Center for Science Education, *History of Climate Science Research* (2022), https://scied.ucar.edu/learning-zone/how-climate-works/history-climate-science-research.
191 Hansen Expert Report, *supra* note 11, at 4.
192 *Id.*
193 *Id.*
194 *See generally* James G. Speth, *They Knew: The U.S. Federal Governments Fifty-Year Role in Causing the Climate Crisis.*

III(E)).[195]

In this regard, although the impacts of climate change on Convention rights are a new area for the Court, the clear and copious warnings provided by experts far exceed warnings in many other cases that the Court has previously considered.[196]

D. Assessment of State action[197]

The assessment of whether a relevant state has done all that could have been required of it to avoid putting lives at risk[198] is—and will continue to be—at the very core of each and every climate-related case before the Court. It is submitted that this assessment requires the Court to identify the **correct scientific standard** for assessing State action and as set out in Sections I-IV the best available scientific evidence requires States to restore the stability of Earth's climate by bringing atmospheric concentrations of CO_2 down from current levels (416 ppm in 2021) to an equitable and environmentally sustainable level of 350 ppm.[199] This will restore EEI and thereby protect the rights of people within the jurisdiction of the Convention. Candidly, if the Court holds States accountable only to the negotiated Paris temperature targets, the Court would not only be legally authorizing even more heating and even greater harms, it would also fail in its role to safeguard rights under Articles 2 and 8 of the Convention and fairly administer justice (see Sections I(A), II and III(B)).

E. "Margin of appreciation"[200]

The Court has regularly stated that where a State is required to take positive measures, the choice of which measures to take, is one for the State itself to take within its **margin of appreciation**. However, where, as here, the scientific evidence is clear that the 350 ppm standard must be met in order to safeguard human life and health, the margin of appreciation available to States in addressing their positive obligations must apply only to the means by which the standard is reached, not the standard itself, which is based on the unmovable law of physics. In other words, it is not open for States to depart from scientific consensus and set their own politically expedient standard, or to simply to fail to act in a manner which would meet the evidenced-based standard that scientists agree upon. Climate change is perhaps the only human rights violation that has a deadline, after which there can be no correction for the violation, and it becomes irreversible for generations of people. With every other threat to human rights, individuals may permanently be harmed, but the opportunity to still right the wrong for others will remain; not so with climate.

VII. Remedies

A. Remedies are needed urgently

In 2019, the UN High Commissioner recognized with regard to climate change that "The world has never seen a threat to human rights of this scope."[201] In the same year, five different UN human rights treaty bodies observed that "adverse impacts on human rights are already occurring at 1°C of warming and every additional increase in temperatures will further undermine the realization of rights."[202]

The following year, the first 'climate' case to be filed with this Court was lodged on 7 September 2020 and communicated on 13 November 2020.[203] Even against the backdrop of the Court's fast-tracking procedure decision[204] and its subsequent relinquishment to the Grand Chamber, the case remains pending more than two years after it was first lodged. During that period, a number of additional 'climate' cases have been joined before the Court and still more are anticipated.

During the years that have elapsed since these warnings and the lodging of these cases before the Court, the dangers to human life and health as a result of climate change has continued to rise and the window of opportunity for States to act so as to prevent irreversible

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[195] *See generally* John Berger, *supra* note 94.

[196] The Court found that Russian authorities had requisite knowledge based on multiple science-based warnings over 12 months that fatalities and property damage were poised to occur if appropriate restoration work to a dam and mitigation actions were not implemented. In the cases before the Court, States been clear and copious warnings that fossil fuel emission hasten climate change for over 40 years. *Budayeva and Others v. Russia* (judgement), no. 15339/02, § 18-35, ECHR 2008.

[197] *Centre for Legal Resources on behalf of Valentin Câmpeanu v. Romania* (judgement)[GC], no. 47848/08, § 130, ECHR 2014.

[198] *L.C.B. v. United Kingdom,* (judgement), no. 14/1997/798/1001, § 36, ECHR 1998.

[199] von Schuckmann et al., *supra* note 7, at 2029.

[200] *Vilnes and Others v. Norway* (judgement), no. 52806/09, § 160, ECHR 2014; *Budayeva and Others v. Russia* (judgement), no. 15339/02, §§ 134-135, ECHR 2008; and *Brincat and Others v. Malta* (judgement), no. 60908/11, § 97, ECHR 2014.

[201] Opening statement by the UN High Commissioner for Human Rights, Michelle Bachelet, 9 September 2019, https://www.ohchr.org/en/statements/2019/09/global-update-42nd-session-human-rights-council?LangID=E&NewsID=24956.

[202] Joint Statement on "Human Rights and Climate Change" from the Committee on the Elimination of all Forms of Discrimination against Women, Committee on Economic, Social and Cultural Rights, Committee on the Protection of the Rights of All Migrant Workers and Members of their Families, Committee on the Rights of the Child, and Committee on the Rights of Persons with Disabilities, 16 September 2019, https://www.ohchr.org/en/statements/2019/09/five-un-human-rights-treaty-bodies-issue-joint-statement-human-rights-and?LangID=E&NewsID=24998.

[203] *Duarte Agostinho and Others v. Portugal and 32 Others* (lodged), no. 39371/20, ECHR 7 September 2020.

[204] *Duarte Agostinho and Others v. Portugal and 32 Others* (relinquished)[GC], no. 39371/20, ECHR 28 June 2022.

harm becomes smaller by the day. As the IPCC has made clear, every additional tonne of CO_2 emitted adds to global warming and its damages meaning every year of inaction increases the harms to humanity.

As such, a decision of this Court with regard to climate related human rights violations is long-awaited and will have profound consequences for all humanity. Any further deferral or delay risks the possibility that violations which this Court currently has the power to prevent will no longer be preventable at the time the Court issues its findings. In turn, the role of the Court as a regional protector of human rights would be nullified.

It is clearly a matter for the Court in the individual cases before it as to whether the relevant thresholds are passed to substantiate the allegations before it. However, it is submitted that the extraordinary circumstances of these cases and the fundamental role of this Court in protecting human rights within its jurisdiction should in in the event of any further delay lead the Court to consider the application of interim measures of its own motion under the provisions of Rule 39(1) of the Court in light of the imminent risk of irreparable harm identified (without prejudging subsequent decisions).

B. A declaratory right to a healthy climate

The intervenors support the intervention made by the Council of Europe Commissioner for Human Rights that these cases provide the Court with "a unique opportunity to continue to forge the legal path towards a more complete implementation of the Convention, to expand and give more meaning to its existing case-law on the environment, and to offer real-life protection to individuals affected by environmental degradation and climate change"[205] and that "the increasingly manifest negative impact of climate change on human rights and the gravity of this impact place a special onus on States to take concrete preventive measures at national and local level, grounded in the human rights standards of the Council of Europe, rather than follow a piecemeal approach that merely reacts to individual complaints."[206]

It is submitted that one significant finding available to the Court in this context would be to specifically recognise that the right to a stable climate system which protects human life, health, and well-being is subsumed within the meaning of Article 2 of the Convention. This is a route which has already been explored in US courts although yet to be finally resolved.

In denying the U.S. federal government and fossil fuel industry motions to dismiss a case brought by 21 young plaintiffs in *Juliana v. U.S.*, Oregon District Court Judge Ann Aiken became the first judge to recognize a climate-specific fundamental right, closely tied to the rights to life and liberty secured by the U.S. Constitution:

> "Exercising my "reasoned judgment," I have no doubt that the right to a climate system capable of sustaining human life is fundamental to a free and ordered society. Just as marriage is the "foundation of the family," a stable climate system is quite literally the foundation "of society, without which there would be neither civilization nor progress . . . . . In this opinion, this Court simply holds that where a complaint alleges governmental action is affirmatively and substantially damaging the climate system in a way that will cause human deaths, shorten human lifespans, result in widespread damage to property, threaten human food sources, and dramatically alter the planet's ecosystem, it states a claim for a due process violation. To hold otherwise would be to say that the Constitution affords no protection against a government's knowing decision to poison the air its citizens breathe or the water its citizens drink. Plaintiffs have adequately alleged infringement of a fundamental right."[207]

The Hawai'i Supreme Court followed suit ruling that the state's constitutional right to a clean and healthful environment "subsumes a right to a life-sustaining climate system."[208] These ground-breaking decisions provide the first cornerstones upon which to build a robust right to a climate system capable of protecting human life, health and well-being.

As one of the world's most influential courts, a declaration that a healthy climate system is necessary for the full exercise and enjoyment of Convention rights to life, privacy, family, and home and to be free from discrimination, would, candidly, ignite the building of robust jurisprudence at the intersection of climate change and human rights and potentially, put society back on a path to climate stability. Declaring the restoration of Earth's energy imbalance and a 350 ppm standard as necessary to a healthy climate system would similarly set the requisite target for State action.

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[205] *Duarte Agostinho and Others v. Portugal and 32 Others* (TPI), no. 39371/20, ECHR 5 May 2021,Third Party Intervention by the Council of Europe Commissioner for Human Rights at 5, https://rm.coe.int/third-party-intervention-by-the-council-of-europe-commissioner-for-hum/1680a26105.

[206] *Id.*

[207] *Juliana v. United States,* 217 F. Supp. 3d 1224, 1250 (D. Or. 2016), *rev'd and remanded,* 947 F.3d 1159 (9th Cir. 2020) noting that this case was dismissed on 17 January 2020 by the Ninth Circuit Court of Appeals in a 2-1 decision with the dissent strongly affirming a constitutional climate right. The complaint was amended and refiled on 9 March 2021. Oral arguments took place on 25 June 2021 and Judge Aiken's next ruling on the youth plaintiffs request to amend is expected in early 2023. Notice to the Court once this decision is issued can be provided.

[208] *In re* Maui Elec. Co., 506 P.3d 192, 202 n.15 (Haw. 2022).

C. Article 46

The intervenors submit that in any ruling made by the Court in the context of climate related harms, it would be appropriate for the Court to exercise its powers to provide guidance to the parties as to the measures which must be taken as a matter of urgency to address the systemic failure by States to deal with the issues identified.[209]

It is further submitted that the circumstances of the violations alleged in any climate related litigation before the Court falls into the category of cases where 'the nature of the violation found may be such as to leave no real choice as to the measures required to remedy it and the Court may decide to indicate a specific measure'.[210]

In this regard, the intervenors refer back to the standard of 350 ppm outlined at Section I(B) and III(D) and the pathways for States to achieve those targets addressed at Section III(E).

D. Article 39

Furthermore, the intervenors submit that in light of the extremely limited time window available to prevent catastrophic harm, that clear and specific guidance is required from the Court **both as to the standard** States should be required to achieve **and the timeline for achieving the same.** This is of particular importance where any judgment is issued to enable effective and meaningful monitoring of implementation by the Committee of Ministers of the Council of Europe.

Conclusion

Ttoday, climate is the prism through which all humanity will pass. As the Grand Chamber originates a robust body of jurisprudence at the intersection of human rights and climate change that will inform the impending eruption of cases before this Court along with the courts of the world, the words of the Court in *Öneryıldız v. Turkey* are particularly helpful in assessing the approach to take in the 'new' factual situation before the Court invoking Articles 2, 8, and 14:

> "[T]he interpretation of Article 2 is guided by the idea that the object and purpose of the Convention as an instrument for the protection of individual human beings requires its provisions to be interpreted and applied in such a way as to make its safeguards practical and effective."[211]

Intervenors respectfully submit that the 350 ppm standard and attendant pathways to 350 ppm presented within this submission, provides for the only practical and effective scientific standard for human rights protection in the context of the climate emergency.

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[209] *See e.g., Aslakhanova and Others v. Russia* (judgement), no. 2944/06, §§ 221-37, ECHR 2013.

[210] *Oleksandr Volkov v. Ukraine* (judgement), no. 21722/11, § 95, ECHR 2013 citing to *Assanidze v. Georgia* (judgement)[GC], no. 71503/01, §§ 202-203, ECHR 2004-II; *Aleksanyan v. Russia* (judgement) no. 46468/06, § 240, ECHR 2008; and *Fatullayev v. Azerbaijan* (judgement), no. 40984/07, §§ 176-77, 2010.

[211] *Öneryildez v. Turkey* (judgement)[GC], no. 48939/99, § 69, ECHR 2004, citing *Yasa v. Turkey* (judgement), no. 44827/08, ECHR 1998 and (reports) p. 2429, § 64, ECHR 1998-VI.

ANNEX I
CRITICAL SCIENTIFIC STUDIES

This Annex presents a curated bibliography of the most critical scientific studies by subject and with links[212] for the Court's convenience. These studies are relied on and cited in the Third Party Intervention submitted by Our Children's Trust, Oxfam, the Centre for Climate Repair at Cambridge, and the Centre for Child Law at the University of Pretoria in *Verein KlimaSeniorinnen Schweiz and Others v. Switzerland, Duarte Agostinho and Others v. Portugal and 32 Others*, and *Carême v. France*. Further information with respect to the qualifications of many of the scientific experts cited to within is available upon request.

History: Climate Science

University Corporation for Atmospheric Research: Center for Science Education, *History of Climate Science Research* (2022), https://scied.ucar.edu/learning-zone/how-climate-works/history-climate-science-research.
Synopsis: This peer reviewed, interactive web-based resource, developed in collaboration with the U.S. National Science Foundation's National Center for Atmosphere Research, includes a detailed timeline for the historical development of scientific knowledge regarding the phenomenon of climate change.

CarbonBrief and Others, *Timeline: The History of Climate Modelling*, Carbon Brief (2018), https://www.carbonbrief.org/timeline-history-climate-modelling/.
Synopsis: This peer reviewed, interactive web-based resource provides a detailed timeline of the crucial moments in the historical development of scientific climate modelling.

History: Popularization of the Paris consensus-driven Temperature Target of 1.5°C–2.0°C

Andrea Rodgers, Lauren Sancken, & Jennifer Marlow, *The Injustice of 1.5°C–2°C: The Need for a Scientifically Based Standard of Fundamental Rights Protection in Constitutional Climate Change Cases*, 40 Va. Env't L. J. 102 (2022), http://www.velj.org/uploads/1/2/7/0/12706894/40.2_va_envt_l.j._rodgers_sancken_marlow_102_151.pdf.
Synopsis: This law review article articulates how the politically negotiated Paris temperature targets rose to prominence as a standard for climate action and why a scientifically based legal standard for action must be used instead to adequately protect human rights.

Impacts at 1.5-2.0°C

David Armstrong McKay and 9 Others, *Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points*, 377 Sci. 1 (2022), https://www.science.org/doi/10.1126/science.abn7950.
Synopsis: This scientific article identifies a series of irreversible tipping points in Earth's climate system that are increasingly likely to be triggered as global average surface temperature increases to 1.5°C or 2.0°C above pre-industrial levels, leading to dramatic and difficult to predict consequences for Europe and all other regions of the world.

Loris Compagno and 4 Others, *Brief Communication: Do 1.0, 1.5, or 2.0°C Matter for the Future Evolution of Alpine Glaciers?*, 15 The Cryosphere 2593 (2021), https://tc.copernicus.org/articles/15/2593/2021/.
Synopsis: This brief communication article demonstrates the consequences of current levels of global warming—as well as the consequences of allowing global average surface temperature to increase to 1.5°C or 2.0°C above pre-industrial levels—on European Alpine glaciers: lower snowpack and more drought leading to reduced glacier volume and glacial runoff.

Earth Energy Imbalance

Karina von Schuckmann and 37 Others, *Heat Stored in the Earth System: Where Does the Energy Go?*, 12 Earth Sys. Sci. Data 2013 (2020), https://essd.copernicus.org/articles/12/2013/2020/essd-12-2013-2020.pdf.
Synopsis: This scientific study makes it clear that EEI is the most accurate and reliable metric for measuring the extent of global warming and that the only way to stabilise Earth's energy balance is to bring atmospheric CO_2 concentrations back down to less than 350 ppm.

Emission Reductions & Means

James Hansen and 14 Others, *Young People's Burden: Requirement of Negative CO_2 Emissions*, 8 Earth Sys. Dynamics 577 (2017),

[212] All links were last accessed on 2 December 2022. If, for any reason a study cannot be accessed online, they are all available upon request.

https://esd.copernicus.org/articles/8/577/2017/
Synopsis: This scientific article clarifies that limiting the climate harms experienced by young people throughout their lives will require not only immediate and drastic reductions in GHG emissions but also the removal of CO_2 from the atmosphere down to the 350 ppm level.

Mark Jacobson and 6 Others, *Low-cost Solutions to Global Warming, Air Pollution, and Energy Insecurity for 145 Countries*, 15 Energy & Env't Sci. 3343 (2022),
https://web.stanford.edu/group/efmh/jacobson/Articles/I/145Country/22-145Countries.pdf
Synopsis: This scientific study provides roadmaps for 145 countries around the world to transition from current fossil fuel based energy systems to 100% renewable energy sources that emit no GHGs by 2050.

Christian Breyer and 22 Others, *On the History and Future of 100% Renewable Energy Systems Research*, 10 IEEE Access 78176 (2022),
https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9837910
Synopsis: This meta-analysis surveys and analyses numerous scientific studies that determine a transition to 100% renewable energy is feasible globally at low cost.

Natural Carbon Removal and Drawdown

Pete Smith and 17 Others, *How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal*, 26 Glob. Change Biology 219, (Aug. 2019),
https://doi.org/10.1111/gcb.14815
Synopsis: This study examines methods to measure and manage soils to support and grow national and international climate initiatives to use soils to mitigate climate change.

Bronson W. Griscom and 31 Others, *Natural climate solutions*, 114 Earth, Atmospheric, and Planetary Sciences 11645 (2017),
https://doi.org/10.1073/pnas.1710465114
Synopsis: This comprehensive analysis identifies 20 natural climate solutions via conservation, restoration, and improved land management actions that increase carbon storage and/or avoid greenhouse gas emissions across global forests, wetlands, grasslands, and agricultural lands.

G. Philip Robertson and 4 Others, *Land-based climate solutions for the United States*, 28 Glob. Change Biology 4912 (2022),
https://doi.org/10.1111/gcb.16267
Synopsis: This article provides a simplified analysis of the benefits of combining nature-based solutions (reforestation, grassland and wetland protection, and agricultural practice change) and cellulosic bioenergy for a single geographic region, the U.S. The principles and findings can be extrapolated to other regions.

Heatwave Occurrence & Impacts

Ana Maria Vicedo-Cabrera and 69 Others, *The Burden of Heat-Related Mortality Attributable to Recent Human-Induced Climate Change*, 11 Nature Climate Change 492 (2021),
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7611104/pdf/EMS127821.pdf
Synopsis: This scientific study quantifies the heat-related harms that climate change has already caused worldwide, revealing that Europe is the global locus of climate change-induced mortality associated with excessive heat exposure.

Ondřej Lhotka & Jan Kyselý, *The 2021 European Heat Wave in the Context of Past Major Heat Waves*, 9 Earth & Space Sci. 1 (2022),
https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2022EA002567
Synopsis: This scientific article analyses trends in European heatwaves since 1950, determining that the overall magnitude of European heatwaves in the past decade was approximately 50% greater than the previous decade and 10 times as high as the average across the second half of the twentieth century.

U.N. Office for the Coordination of Humanitarian Affairs, the International Federation of Red Cross and Red Crescent Societies, and the Red Cross Red Crescent Climate Centre, *Extreme Heat: Preparing for the Heatwaves of the Future* (2022),
https://www.ifrc.org/sites/default/files/2022-10/Extreme-Heat-Report-IFRC-OCHA-2022.pdf
Synopsis: This report provides an excellent summary of the current state of and future trends in climate change-induced heatwaves, including an overview of the deadly effects that intensified heatwaves are having and will continue to have on the two most at risk groups: children and older persons.

Nikolaos Christidis, Gareth S. Jones, & Peter A. Stott, *Dramatically Increasing Chance of Extremely Hot Summers Since the 2003 European Heatwave*, 5 Nature Climate Change 46 (2014),

https://www.readcube.com/articles/10.1038%2Fnclimate2468[213]
Synopsis: This scientific article determines that severe heatwaves that would have been expected to occur twice in a century at the turn of the twenty-first century can now be expected to occur twice in a decade due to human-induced climate change.

Robert Vautard and 15 Others, *Human Contribution to the Record-Breaking June and July 2019 Heatwaves in Western Europe*, 15 Env't Res. Letters 094077 (2020),
https://iopscience.iop.org/article/10.1088/1748-9326/aba3d4/pdf
Synopsis: This scientific article finds that human-caused climate change can be attributed with increasing extreme heatwave frequency in Western Europe from once every >1000 years to once every 50-150 years and further notes that the increase in European heatwave intensity is 2-3 times greater than the global average.

Health & Children

Caroline Hickman and 8 Others, *Climate Anxiety in Children and Young People and Their Beliefs About Government and Responses to Climate Change: A Global Survey*, 5 Lancet Planet Health e863 (2021),
https://www.thelancet.com/action/showPdf?pii=S2542-5196%2821%2900278-3
Synopsis: This comprehensive survey study identifies high levels of climate anxiety for young people in ten countries around the world, including widespread feelings of fear, powerlessness, and betrayal by the governments entrusted to protect them.

Frederica Perera & Kari Nadeau, *Climate Change, Fossil-Fuel Pollution, and Children's Health*, 386 New England J. of Med. 2303 (2022),
https://www.nejm.org/doi/pdf/10.1056/NEJMra2117706
Synopsis: This review article provides a comprehensive summary of the best available and up-to-date scientific research on the harms that climate change and fossil fuel combustion impose on children.

[213] This article is only available for a fee. If the Court would like access to it, intervenors have it on file and can submit it to the Court upon request.