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Editorial

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EDITORIAL

Rationale and remit of *Oxford Open Climate Change*

With the raging novel coronavirus pandemic, it is all too easy to lose sight of the other wave of potential global catastrophe that is building up. Even the dramatic imagery of extreme bushfires in 2019 and 2020 seems nearly forgotten because of the superimposed health crisis. In the case of Australia, this memory fade is aided by the remarkable swing to La Niña conditions and a flip in the Indian Ocean Dipole, which together brought abundant rains that broke the previous drought of several years and actually caused major regional flooding events (but note that La Niña intensifies drought and thus intensifies the fire conditions along the US West Coast). Climate change all but slipped off the active agendas of international politics, underscoring important lessons in the nature of global crises, crisis communication and governance [1].

Yet, climate change has not conveniently stopped to allow us to deal with the pandemic. In fact, 2020 tied with 2016 for the warmest year on record in terms of global mean temperature [2, 3]. However, while 2016 temperatures were especially high because of an El Niño event, this was not the case for 2020. This makes the warmth of 2020 even more remarkable.

The increasing temperatures coincide with an increase in climate extremes, emphasizing the importance of anticipating and adapting to compound and complex risks [4]. The climate extremes include deep droughts that facilitated the rapid spread of violent bushfires in 2019–20 [5]. For example, ~19 million hectares were burnt in Australia [6], along with ~20 million hectares in Siberia in the first half of 2020 alone [7], and ~5.6 million hectares along the US West Coast [8]. Other major areas were burnt in Canada, China, the Amazon rainforest and Indonesia. The immediate causes vary from lightning strikes to human carelessness and intentional actions, but the underlying issue facilitating widespread growth of the fires beyond control has been exceptional regional drought, often associated with exceptional high-temperature anomalies. In the Amazon rainforest, droughts together with increasing human-made deforestation (commonly with fire) and land-use could bring the Amazon region closer to its tipping point—abruptly turning into savanna and consequently into an additional CO_2 source [9, 10].

The trend toward intensified climate extremes also includes dramatic changes in hurricane, typhoon and tropical cyclone activity and intensity. These changes tend to be region-specific and are modulated by superimposed natural multiyear cycles such as the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole. For example, 2020 saw extraordinarily high activity of Atlantic hurricanes and tropical storms [11], about average Indian tropical cyclone activity, and a remarkably quiet Pacific hurricane (typhoon) season [12]. With shifts in ENSO and the Indian Ocean Dipole, these activity patterns are expected to change between regions, but the overall trend seems to be toward fewer, but more intense, storms [13]. Such storms, as well as extra-tropical cyclones, drive massive rainfalls, storm surges, flooding, wind damage and widespread coastal erosion.

Another important expression of the increasing climate extremes trend concerns the global increase in heatwaves [14] and marine heatwaves [15]. This increase causes expanding heat stress and heat death conditions that affect sustainability of the human habitation niche [16, 17] and that have critical impacts on marine ecosystems [15, 18].

Increasing warming leads to shifting climate zones and associated animal and vegetation migrations [19], including expansions in the spread of pests and disease vectors (e.g. malaria). Links have also been suggested between the worsening of locust plagues and both warming and increases in rainfall extremes in East Africa [20], posing an additional threat to food security. This region's widespread rainfall anomalies are wet expressions of the multiyear Indian Ocean Dipole cycle, which coincide with pronounced droughts over Australia that intensify fire conditions. The Indian Ocean Dipole cycle is thought to gain intensity with the ongoing global warming [21].

Rising temperatures are also likely to reduce cereal yields [22] and change the nutritional quality of the grain that is produced [23]. Variations in the availability of food due to widespread changes in climate-related growing conditions are likely to reduce yield gains and increase food costs, affecting the affordability of food for the world's poor [24]. Furthermore, temperature extremes have direct physical effects on the well-being of infants [25] and on the productivity of rural populations with little access to technology [26]. These impacts are likely to further degrade food security of the world's poorest [27].

Concurrent extremes—superimposed upon long-term trends and now further exacerbated by the global pandemic—have made starkly visible the persistent social inequities in access to

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resources, infrastructure and information that underpin social vulnerability and reinforce climate injustices [28]. These social aspects not only exacerbate the uneven impacts of climate extremes, but also causally connect patterns in outcomes of disparate extreme events. Consequently, they demand innovation in governance [29] and explicit attention to equity in climate adaptation and governance [30, 31].

Profound impacts of climate change on land ice and sea ice drive long-term consequences such as sea-level rise and immediate issues such as fundamental impacts on high-latitude ecosystems, respectively [32]. There are also less well understood but potentially very dangerous feedbacks related to processes such as permafrost decomposition and associated CO_2 and methane releases [33, 34]. This ties in with the growing concern that we are moving perilously close to major climate/environmental tipping points, such as collapse of permafrost, rainforest and/or major portions of the world's great ice sheets. Because crossing a tipping point causes long-term irreversible change (for a concise discussion, see Moore [35]), not even the most aggressive climate mitigation would succeed in bringing climate back to anything like present-day conditions. Instead, there would be variations around a new stable state that has considerably less ice volume, severely reduced permafrost and enhanced methane and CO_2 levels caused by the permafrost reduction.

Transitions between different stable climate states have not yet happened during historical times but are known from the geological past under natural climate forcing. Therefore, deeper-time (paleoclimate) assessments are essential for developing a better understanding and future prediction capacity regarding the stability and sensitivity of different climate states and either slow or abrupt (tipping-point) transitions between them. Moreover, most paleoclimate abrupt transitions involve several climate subsystems, and thus hold important clues about interconnecting processes between them, which cannot be investigated using the instrumental record alone. For example, during the glacial Dansgaard–Oeschger events, an interplay between land ice, sea ice, ocean circulation and possibly the carbon cycle led to a global imprint of abrupt warming events (within decades) that were initialized in the North Atlantic region [36, 37].

Climate change–related impacts on natural ecosystems are of grave concern because these impacts are superimposed upon other major stressors. These other stressors include over-exploitation and other detrimental methods in food production and low-cost manufacturing, excessive land-clearance for agriculture and infrastructure, and damage and pollution associated with mining for resources, such as water, minerals, metals, fuels and building materials. The accumulated stresses on natural ecosystems not only threaten biodiversity, but also influence the resilience of humanity's diverse livelihoods to the impacts of climate change because the ecosystems offer many critical ecosystem services (direct and indirect contributions to human well-being, including climate regulation, water purification, pest and disease control and cultural aspects).

There are further emerging concerns about climate change–related impacts on how goods and services are produced and consumed, and how such activities are financed. As climate change can present risks and opportunities for companies and those financing or investing in them, banks have begun to assess physical climate risks in their corporate loan portfolios, using climate scenarios and methodologies for evaluating key credit risk metrics [38]. Moreover, strengthening policy response to limit the global mean temperature well below 2°C above pre-industrial levels, including carbon dioxide removal approaches, presents new types of risks and opportunities associated with transitioning to a low-carbon economy. Risks of crossing tipping points in the climate system, and their impacts on economic developments, are another poorly explored area that requires urgent research [39].

In sum, humanity is facing a future in which a broad understanding across all relevant disciplines is needed for climate change processes, impacts, mitigation strategies including negative emissions approaches, adaptation needs and socioeconomic implications. This understanding must integrate across a complex, interwoven suite of aspects that includes physics, biology, bio- and geo-chemistry, natural background variability, change monitoring, social dimensions, behavioral responses, governance and legal matters, business and economics, planning and implementation issues, and matters of diversity, equity and equality.

Oxford Open Climate Change aims to provide a platform to high-quality contributions across all these topics and facets of the problem to facilitate the multidisciplinary dialogue and understanding that will be needed for a successful international response to climate change across all levels of society.

CONFLICT OF INTEREST STATEMENT

None declared.

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