2019.10.12 Dr. Christina Bandaragoda and GeoHealth Comments Integrated in AGU Position Statement (with additional comments in bold by @dr_cband). This is a review version for additional commenting on GeoHealth Section edits Submitted by Aubrey Miller (President) and Claire Horwell (President-Elect) on behalf of the GeoHealth Section Leadership (October 11, 2019). AGU commenting period ends 2019.10.13.

FOR REVIEW: SOCIETY MUST ADDRESS THE GROWING CLIMATE CRISIS NOW

Prompt and concerted actions to limit and adapt to human-caused climate change are less costly than remaining on the current trajectory and can provide great benefits for human well-being.

The Challenge

Human activities are changing Earth's climate, causing increasingly disruptive impacts to society and the environment. To limit these impacts, the world's nations agreed to hold the increase in global average temperature, relative to pre-industrial levels, to well below 2°C (3.6°F). To have a good chance of achieving this goal, human society must promptly reduce its greenhouse gas emissions, including bringing net carbon dioxide emissions to zero. Such reductions require substantial near-term transformations in energy sources and consumption, more efficient food systems, and enhanced removal of carbon dioxide (CO_2) from the atmosphere. At the same time, societies must prepare to cope with and adapt to the adverse impacts of climate change. Done strategically, efficiently and equitably, the needed transformations can provide increased health, well-being, and prosperity for society.

The Evidence

Concentrations of greenhouse gases—including CO_2, methane, nitrous oxide, and halocarbons—in the atmosphere rose to unprecedented levels in at least the last 800,000 years due to fossil-fuel burning and other human activities. Extensive, scientific observations document that the global average surface temperature in the atmosphere and ocean has increased by about 1°C (1.8°F) since the late 1800s. It is extremely likely that human influences are responsible for most, and possibly all, of the observed global warming since the mid-20th century.

In addition to increasing average temperatures, many other striking changes have been documented. These include more frequent heat waves on land and in the ocean; reductions in Arctic sea ice, Northern hemisphere snow cover, Greenland and West Antarctic ice sheets, and mountain

glaciers; changes in the global water cycle that escalate precipitation; and a rise in global sea-level. Increased CO_2 concentrations in the atmosphere are also directly acidifying ocean waters and affecting the growth and nutritional value of land plants.

The Predictions

Realistic and continually improving computer simulations of the global climate predict that both temperature and sea level will continue to rise as a result of past and future greenhouse gas emissions. Past emissions will contribute to some additional heating into the near-future. However, the amount of rise will be predominantly determined by future human-caused emissions. Global average temperature will only stabilize after net emissions of CO_2 reach zero, i.e. the amount entering the atmosphere is matched by the amount removed, and emissions of other greenhouse gases are stable or decreasing. Simulations demonstrate that limiting the temperature increase to 1.5°C, including the 1.0°C warming that has already occurred, requires that human-caused CO_2 net emissions reach zero by or shortly after 2050. Large reductions in emissions of other greenhouse gases are also required, as well as active removal of CO_2 from the atmosphere during subsequent decades. Even if global temperature is stabilized, sea level will continue to rise, but at a much slower rate than if warming continued.

The Consequences

Climate change has been and will continue to be disruptive because ecosystems and human communities were established under previous climatic conditions. Climate change and associated uncertainties will cause increasing health, economic, security, and ecological risks. Preserving the habitability of the planet for humans, flora, and fauna is paramount. Further, the impacts of climate change on human health and well-being include heat-related death, illness, and loss of labor productivity; increased exposures to allergens, vector-borne and infectious diseases, and algal toxins; changing patterns and increasingly severe hazards such as landslides, flooding and wildfires, and water scarcity; uncertainty in aquatic and traditional food systems, and decreased mental health. The increasing frequency and severity of extreme events can also slow economic growth and increase civil conflict, thus affecting global migration patterns and increasing global security risks.

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Climate change presents new challenges, and is also a threat multiplier. Impacts will vary based not only on geography and availability and quality of infrastructure (e.g. the disruption of normal healthcare delivery during a storm), but also by race, age, and socioeconomic status. People of color, children, the elderly, and low income communities are some of the most vulnerable to climate change. Climate change will amplify pre-existing inequalities in all populations with less capacity to adapt to change. It will continue to severely damage threatened ecosystems, such as coral reefs, permafrost landscapes and the Arctic, and cause loss of biodiversity on land and in the oceans. It can increase the risks and negative effects of wildfires and extreme weather events and affect the spread of invasive species, pests and diseases.

The Needed Responses

Effective climate policies will rely on innovative and responsive science to inform and weigh response options. Scientists and engineers must continue to engage broadly with youth, community, business and non-profit leaders; local, state, and tribal government resource managers and planners; and federal policy makers, to undertake solution-oriented research and analysis. Scientific organizations, including academic institutions and government agencies, should expand their support for research, application, and information dissemination that addresses the climate crisis.

Deleterious consequences of global climate change can be moderated by taking prompt actions. We have included broader political and societal recommendations, as well as recommendations specifically targeted for the geophysical scientific community:

Political and Societal Recommendations:

- transition to renewable sources of energy,
- reduce demand for high greenhouse gas emitting products and services,
- implement existing and novel technologies and practices to remove CO_2 from the atmosphere,
- change diets and promote sustainable food systems,
- improve access to family planning and women's education,
- promote collective action/mobilization in engaging with policymakers,
- promote active transport and smart design of cities,

- develop processes that enhance and diversify decision making based on direct input from the geoscience community, including scientifically accurate technical explanations of Earth processes and climate change impacts to humanity,
- support innovative geoscience communication **and education** efforts which improve individual data reasoning in a digital world,
- prepare for changes already underway.

Scientific Community Recommendations:

- measure and model the feedback of moderating actions (listed above) using current observations and climate predictions,
- expand diverse, inclusive and culturally relevant geoscience education that enables growth of a global digitally-enabled geoscience research, education and information management workforce, which can be used to
- **develop innovative education initiatives which address the broader impacts of the physical and mental health risks to individuals when presented with geoscience and data reasoning related to future uncertainties,**
- translate and deliver high-impact, accessible, geoscience research products to the public, education and scientific research communities **that enable individual action and participation in moderating actions** (listed above).
- in order to advance our understanding of changes already underway.

Climate intervention approaches, such as carbon dioxide removal and albedo modification, cannot substitute for deep cuts in emissions or the need for adaptation, but might contribute to a comprehensive climate risk-management strategy. These actions must involve integration of knowledge, risks, and solutions with scales of impact across local, regional, national, and global communities. With creativity and innovation, our actions to address global climate change can also yield significant economic, environmental, health, and social benefits. **As we improve best practices in public education, citizen and participatory science, the negative mental health impacts of an uncertain future should be moderated by geoscience understanding that enables society to determine a healthy future.** Positive impacts of our actions could include new employment opportunities in clean energy and digital infrastructure, opportunities to enhance political diplomacy and maintain collaborative agreements, risk-informed economic stability, natural

hazard preparedness, life-saving planning and communication systems, protection of endangered species and threatened ecosystems, equitable access to public global geoscience information resources, and improved public health for all of Earth's geographically diverse communities.