AI and Climate Change: Opportunities, Challenges, and Recommendations

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I will be talking about how artificial intelligence (AI) can play a role in climate action. I'll discuss opportunities for AI in this space, broader considerations and challenges, and policy recommendations for enabling the impactful and responsible use of AI to help tackle climate change.

Before we dive in, it may be helpful to give some context on what AI is Artificial intelligence refers to any computer algorithm that makes predictions, recommendations, or decisions based on a defined set of objectives. Within that overall framework, certain AI algorithms are known as "machine learning", a term that some of you may have heard because machine learning has become extremely popular and effective in recent years, with applications from the automatic translation to self-driving cars. In a machine learning algorithm, the exact computation that the computer performs isn't specified in advance but instead it's "learned" by the algorithm by identifying patterns within data, generally large amounts of data. The algorithm can then use these patterns to make predictions on new data. Most of the AI techniques we consider here will fall under the heading of machine learning.

It's worth understanding, at a high level, what some of the strengths and weaknesses of machine learning algorithms are. They are good at performing a wide array of simple tasks quickly and automatically, for example, scaling up repetitive activities like labeling images. They can pick out subtle patterns from large datasets that humans might not be able to. And they're able to optimize complicated systems, like industrial machines with many possible controls, to maximize efficiency or minimize cost. However, since they rely on data, machine learning algorithms are also prone

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to failure if the data are inaccurate. If the data that an algorithm is given is biased, then the algorithm can perpetuate that bias. Moreover, machine learning typically finds correlation, not causation—it's generally unable to solve problems requiring broader conceptual understanding or creativity. And these algorithms can also be inapplicable for problems where it's necessary to "show one's work"—often, the answer appears without much explanation of why it is accurate or how confident the algorithm is in that answer.

With those strengths and weaknesses in mind, let's turn to how AI can be relevant to climate action. A large team of experts across many fields and I wrote a report detailing key opportunities and leverage points for AI both in climate change mitigation (reducing greenhouse gas emissions) and adaptation (responding to the effects of climate change). I'll summarize some of the takeaways here, but if you're interested in more details, I do encourage you to check out the full report, or (if you'd prefer a shorter version instead of the whole hundred pages) we have interactive summaries of the information available online, which you can search through by application area or by subfield of AI.

There are opportunities for AI to help advance climate action across many sectors—from electricity systems to transportation, land use, and disaster response. Across all of these, there are four key roles that AI can play.

First, AI can distill large amounts of raw data into actionable information by scaling up labels that humans could provide more laboriously. For example, AI can analyze satellite imagery to track greenhouse gas emissions, update coastal elevation maps to identify communities at risk from sea-level rise or filter large databases of corporate financial disclosures to find climate-relevant information.

Second, AI can improve predictions by learning from past data to predict what will happen in the future. For example, AI can provide forecasts of electricity demand to help balance power grids or predict the supply of electricity when it comes from renewable sources like solar and wind that can change from minute to minute. AI is also being used to predict agricultural yield as extreme weather threatens food security.

Third, AI methods can optimize a complex system with many variables that can be controlled simultaneously. For example, AI algorithms can reduce the energy needed to heat and cool a building or optimize freight transportation schedules to reduce inefficiency or increase robustness.

Finally, AI can accelerate scientific modeling and discovery, often by blending known physical laws with approximations learned from data. For example, AI can speed up the discovery of new materials for batteries or catalysts by learning from past experiments and suggesting promising candidate materials to try out in new experiments. AI can also quickly approximate physics simulations used in climate modeling or energy-efficient building design, which can otherwise be extremely slow to run.

All four functions for AI—distilling data, improving predictions, optimizing complex systems, and accelerating modeling and discovery—cut across sectors. And it's worth noting that all of these example applications I've given are already being developed or deployed.

Importantly, in all of these applications that we've discussed, the role of AI is to support existing work in climate action. AI is not a silver bullet—it's only one of the many tools we need in climate action, and it's not applicable everywhere. It should never replace or distract from other actions needed to fight climate change. Some of the most impactful (and interesting) applications aren't flashy. For instance, detecting failures in railroad systems doesn't receive as much press as self-driving cars, but it's probably more beneficial from a climate perspective.

It's also worth noting that, while cutting-edge AI can be helpful in some cases, in other cases, simpler methods from AI or data science may be enough—one shouldn't leap to using the fanciest technology when a simpler tool will do the job. In addition, AI will optimize for the objective that it's given, and it isn't a replacement for framing the problem carefully—in fact, it's straightforward to use AI to get the wrong answer fast if you've asked it the wrong question.

To avoid pitfalls, it's essential to develop partnerships between AI experts and the stakeholders who will be using the AI and who understand the problem to it's being applied to. This is important to ensure that the algorithm is solving the right problem and that it incorporates domain-specific knowledge. It's also essential to consider the pathway to impact and plan ahead to make sure that any deployment considerations are built into the design right from the start.

Equity considerations are also fundamentally important in AI-for-climate—including who is building solutions, what problems are prioritized, and how these problems are worked on. Empowering a diverse and global set of stakeholders is essential to ensure that technologies are owned by the people affected by them, rather than reinforcing existing power imbalances across countries and institutions. Related to the question of who is the question of what is being worked on, since problem priorities often reflect existing inequities within AI and technology. For instance, AI to fight wildfires (which is a key problem in North America, Europe, and Australia) tends to receive more attention and funding than AI to fight locusts (which affect East Africa, the Middle East, and southern Asia), even though both problems are extremely important and are exacerbated by climate change. And how projects are worked on is also important. Data imbalances between regions or communities within a region can mean AI solutions are only applicable to a subset of the population or that algorithms are most effective within data-rich areas. Ideally, AI-for-climate will serve to improve equity, but this takes active work—both at the policy level and at the project design and management level.

Finally, the impacts of AI depend on how we use it, and some applications of AI are definitely making climate change worse. For example, AI-based recommender systems used in advertising are designed to increase consumption. AI is also being used extensively to accelerate the discovery and extraction of fossil fuels.

I'm now going to turn to a report that we recently released for the Global Partnership on AI (GPAI), a coalition of countries working to support AI-related priorities and foster international cooperation. In this report, we provide detailed recommendations for actions that governments can take to foster the impactful and responsible use of AI in the context of climate change. These include recommendations in the

areas of data and digital infrastructure, research and innovation funding, and deployment and systems integration. We also discuss how AI can have negative impacts on the climate—through its applications and via computation and hardware—and what we can do about it. Cutting across these areas is the need to adopt a responsible AI lens, build capacity among many societal players, set up frameworks for impact assessment, and foster international collaboration.

We make 48 concrete policy recommendations in this report, illustrated with case studies from the private and public sectors. I'll provide some highlights. First, there's an urgent need for data on many climate-relevant problems. Data may be siloed in private entities without the existence of data-sharing structures—even when data-sharing could be to the benefit of all stakeholders. Data may also be scattered across multiple sources and structured inconsistently without standards to enable interoperability. We recommend the creation of data task forces in climate-relevant sectors to identify priorities and work with industry and researchers to develop healthy data ecosystems that enable beneficial work while preserving IP and privacy.

Funding for research and innovation in AI-for-climate can often fall between the cracks. AI funding usually focuses on novel methodologies that improve performance on standardized benchmark datasets. These kinds of pure innovations are important, but they should be complemented by impact-driven funding opportunities that enable projects in AI that help society in mitigating or adapting to climate change, with success being measured by how useful the algorithms are in practice.

To be helpful, innovations in AI-for-climate have to make their way from development to deployment at scale. This requires collaboration between researchers and practitioners in the relevant sectors and incorporating relevant deployment considerations. For example, stakeholders such as electrical grid operators may need guarantees of robustness and safety before using any new technology, given the critical nature of grid infrastructure and how serious any failures would be. We recommend the creation of cross-sectoral innovation centers bringing stakeholders together to partner in addressing challenges and incubating solutions.

Private and public sector entities often don't have the expertise in AI and digital technologies necessary to understand where AI is and is not relevant or how best to deploy it. This can lead either to failures to use technologies where they could be helpful or, conversely, to techno solutionism and over-optimism about what AI can and should do. For both these reasons, it's important to build capacity and literacy in AI. We recommend both upskilling programs—training people already in the relevant organizations—and secondment programs, where AI experts are embedded within these organizations to strengthen communication and cross-sector expertise.

All of the applications of AI that we've highlighted here require care in development and deployment with respect to considerations such as fairness and accountability—best practices should be established across relevant sectors. Participatory design is also crucial to ensure that new technologies are shaped and owned by the communities they're meant to benefit.

Finally, we encourage policymakers to consider the potential positive and negative climate impacts in shaping the development of new technology—for example, by incorporating climate considerations into the framing of "high risk" use cases. Often,

initial choices and incentives can greatly change the impact of new technology. For example, designing autonomous vehicles focusing on personal cars will make driving easier, people may drive more, and global carbon emissions may increase. On the other hand, incentivizing self-driving technology focused on vehicle sharing and public transportation could help decrease carbon emissions. The effects of new technology are not pre-determined—they are up to us, and both implicit and explicit choices are meaningful.

Both of these reports (*Tackling Climate Change with Machine Learning* and *the Global Partnership on AI Climate Change and AI Repor*t) were projects involving Climate Change AI, an organization of which I am a co-founder and chair, alongside Priya Donti of Carnegie Mellon University in the US and Lynn Kaack of the Hertie School in Germany. Climate Change AI is an international non-profit focused on catalyzing impactful work at the intersection of climate change and AI. We offer opportunities for partnership and collaboration across a network of thousands of experts worldwide, spanning research, industry, and policy. We advise stakeholders in the public and private sectors and produce reports and other informational content. We provide resources such as grant programs, courses, and discussion platforms. And we run knowledge-sharing events drawing thousands of attendees from across the world, for example, at the AI conferences Conference and Workshop on Neural Information Processing Systems (NeurIPS), International Conference on Machine Learning (ICML), and International Conference on Learning Representations (ICLR), via Technology, Entertainment, Design (TEDx), and at the UN Climate Change Conference (the COP). If you're interested in learning more about this space, I encourage you to check out the additional resources at Climate Change AI.