Opportunities and Limits of Using Generative AI for Climate Action

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There is growing interest in using Generative AI (Gen AI) in climate action strategies. In 2023, Microsoft introduced ClimaX, the first foundational model for weather and climate modeling tasks. In 2023, NASA partnered with IBM to release its first open-source Geospatial AI Foundational Model for earth observation data. The model has a wide range of potential applications such as tracking changes in land use, monitoring natural disasters, and predicting crop yields. Gen AI like conversational AI (chatGPT) are also being leveraged to improve access to climate information. For example, researchers have developed 'chatclimate.ai', a conversational climate bot trained on data from the 6th Assessment Report of the Intergovernmental Panel on Climate Change.

Climate datasets are spatio-temporal in nature, that is, changing with time and in space and one of the biggest challenges in climate has been accurate weather forecasting, especially for acute extreme events such as hurricanes, floods, and heatwaves. In the climate context, tasks such as forecasting are specific to agro-climate zones and linked to data abundance and quality. Thus, lack of contextual local data leads to inaccurate results as models trained in one geography may not be applicable in other geographies, as similar climate parameters keep varying. A group of researchers deployed a hybrid variational autoencoder (HyVAE) for time series forecasting on real world Darwin Sea level pressures from 1882 to 1998. Results showed that HyVAE achieves better time series forecasting accuracy than various counterpart methods. Thus VAEs are one way to predict weather patterns, and conduct risk assessments, on a very specific use case - sea level pressure prediction.

Gen AI such as Large Language Models (LLMs) have been found to be good at real-time voice based translation services in high-resource languages and have found good use cases in disaster relief efforts where issues of digital literacy would otherwise be barriers to information access to vulnerable communities. For example, floods are the most frequent natural disaster, and Gen AI language based tools for flood risk communication can surely increase the support for flood resilient infrastructure development.

GenAI for climate action poses two prominent challenges. One, commercial or large-scale use and application of the Gen AI model to replace the current baseline physics-informed numerical models of the atmosphere, in terms of physical consistency and realism, remain a major challenge. Second, Gen AI models trained on past scientific data would not generalize well to predicting future trends for climate change, as future weather patterns are expected to differ quite substantially from the past and most of the Gen AI models are trained on past datasets. To illustrate, a real-time Deep Convolutional Generative Adversarial Network (DCGAN) predictive modeling tool for flood forecasting had been developed with capabilities of dynamic learning and real-time forecast. Thus, DCGAN has great potential for flood hazard mitigation and preemptive decision making to flood prevention strategies but DCGAN applications have been tested and evaluated under controlled environment (urban areas) where the availability of datasets had been plenty, but whether DCGAN shall work in rural settings in areas where low or no dataset is available is in question.

Climate datasets parameters and type are plenty - images, data in form of text and numerals, knowledge graphs and geospatial vector data (such as OpenStreetMap's map layers). Thus, Gen AI applicability desires a good compute multimodal capability agnostic to the geographic region and which captures the climate footprint in totality. This demands standardization and interoperability of diverse datasets being created and one that allows local and hyper-local applicability of Gen AI application across different tasks in climate action. Finally, the environmental impacts of GenAI must always remain prime in designing climate action solutions, as there must always be a net zero carbon impact while deriving Gen AI climate solutions.[1]

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Notes

[1]According to some estimates, the training of 100 LLMs (trained for approximately 100 times, resulting in around 10K training sessions) would result in 2,000,000 tons of emissions (at 200 tons per training session)