Chapter 4
Quantum Machine Learning Applications to Address Climate Change:
A Short Review

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ABSTRACT

In the previous three to four decades, numerical weather and climate modelling have advanced significantly, yet many challenges still exist. Appropriate adaptation techniques to reduce loss of life and property require geographically and temporally targeted predictions. Artificial Intelligence and machine learning (AI and ML) based technologies are improving predictions. However, they are bound by the absence of a hardware's or a software's—or both—capable of handling the enormous data volumes created on a global basis. The burgeoning paradigm of quantum computing (QC) has potential applications across many industries. This review shows that the current progress in quantum ML for quantum computers may lead to technological advancements in climate change research. The subsequent climate forecasting improvements are expected to have several socioeconomic benefits. The authors have also provided three or four examples showing how quantum technology might be used with ML systems to study climate change.

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INTRODUCTION

An area or area's environment refers to its usual or average weather. Mumbai, for instance, has warm and humid weather. However, Kashmir's environment is quite chilly. The global climate (Abbass et al., 2022) is an aggregate of the various regions on the planet. Thus, climate change refers to a shift in an area or area's usual or ordinary environment. An example may be a shift in an area's mean annual precipitation(Zhu et al., 2022). Alternately, it may represent a shift in a metro's typical temperature for a specific timeframe or season. Changes in the global climate are also referred to as climate change(Pal et al., 2022). For instance, there can be a shift in the planet's mean temperature. Alterations to Planet's normal rainfall distribution might also be the cause. The brief variations in temperatures, overcast, rainfall, moisture, and air that we experience in an area or city are called weather. Throughout a single day, the weather might drastically change(Zittis et al., 2022). There's a chance of gloomy, chilly weather as in the mornings. This could, however, turn bright and pleasant by the afternoon. An area or metro's environment may be defined as the weather over a long period of various seasons that generally vary. For instance, a municipality or area may have a summertime climate that tends to be warmer and muggy. In contrast, the winter months are chilly and snowy. Climate changes are sluggish(Roy, n.d.), whether local, regional, or global. Dozens and decades are needed to observe these effects. One of the significant worldwide issues today, climate change, is endangering the planet's habitat. Recent events, like intense heat-waves in China and devastating-floods in India and Pakistan, show how climate change contributes to the rising frequency of extreme weather.

Over past few decades, the Earth's average temperature has risen sharply, resulting in a wide range of global-scale effects like glacier melt, sea level rise, and a spike in the frequency of extreme weather(Hyon et al., 2022; Rolnick et al., 2022). Due to the increased atmospheric carbon pollution brought on by the usage of fossil fuels during the industrial era(Adebayo, 2022; Romanello et al., 2022). Today's average Earth temperature is around one-degree Celsius (C), more significant than before the industrial revolution. According to recent scientific advancements, "the Earth system may lurch through a cascading set of "tipping points," or states of no return, causing an irreversible transition to a hotter planet" (Singh, Dhara, et al., 2021). This is especially true if global warming exceeds 1.5 degrees Celsius(Henderson et al., 2020). Even though climate change is occurring worldwide, its effects and expressions will vary. As a result, estimating future changes at the local and regional levels is essential for developing wise policies. But there's still a big problem with it. We discuss the most recent scientific and technological developments concerning these issues and their limitations. With this background, we may move on to this article's central point, which is the potential of the new QC paradigm QAIML to deliver some of the technological advances required in climate science. To add more emphasis to this short review we add two case studies with respective results.

Climate models have become crucial for analyzing how the Earth's climate is changing, especially how it will respond to anthropogenic forcing in the future. Coupled partial differential equations must be solved for climate modelling all over the world. These models, which are run on supercomputers with speeds of peta-flops and more, show the physical parts of the Earth-system, such as "the atmosphere, ocean, land, cryosphere, and biosphere, as well as how they interact with each other" (Singh, Dhara, et al., 2021). In order for the globe to work, it is broken up into grids of a certain size. This size is set by the model resolution. Then, the dynamic equations are solved to get a result area that is an average of the size of the grid (Henderson et al., 2020; Singh, Dhara, et al., 2021). So, things like clouds and deep convection that happen on more manageable scales are represented by empirical relationships that are

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