

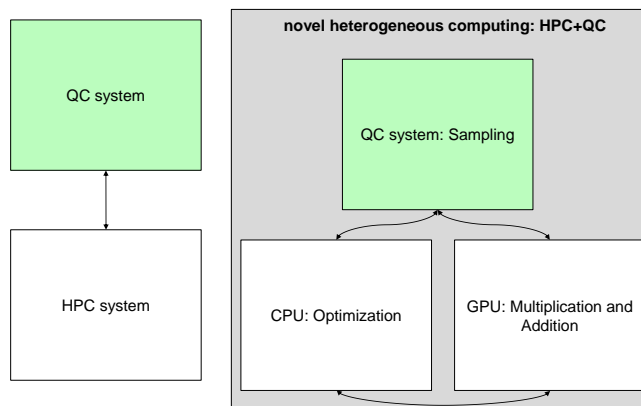
# EXPLOITING THE QUANTUM ADVANTAGE FOR SATELLITE IMAGE PROCESSING

*Soronzonbold Otgonbaatar, Dieter Kranzlmüller*

German Aerospace Center, Ludwig-Maximilians-Universität München

## 1. INTRODUCTION

This study examines the current status of quantum computing in Earth observation (EO) and satellite imagery. We analyze the potential limitations and applications of quantum learning models when dealing with satellite data, considering the persistent challenges of profiting from quantum advantage and finding the optimal sharing between high-performance computing (HPC) and quantum computing (QC). We then assess some parameterized quantum circuit models transpiled into a Clifford+T universal gate set. The T-gates shed light on the quantum resources required to deploy quantum models, either on an HPC system or several QC systems. In particular, if the T-gates cannot be simulated efficiently on an HPC system, we can apply a quantum computer and its computational power over conventional techniques. Our quantum resource estimation showed that quantum machine learning (QML) models, with a sufficient number of T-gates, provide the quantum advantage if and only if they generalize on unseen data points better than their classical counterparts deployed on the HPC system and they break the symmetry in their weights at each learning iteration like in conventional deep neural networks. We also estimated the quantum resources required for some QML models as an initial innovation. Lastly, we defined the optimal sharing between an HPC+QC system for executing QML models for hyperspectral satellite images (see Fig. 1). These are a unique dataset compared to other satellite images since they have a limited number of input qubits and a small number of labeled benchmark images, making them less challenging to deploy on quantum computers.



**Fig. 1.** Novel heterogeneous computing: a high performance and quantum computing paradigm. Here, conventional heterogeneous computing refers to the programming of CPU and GPU, whereas we call novel heterogeneous computing when integrating QPUs with CPUs and GPUs. QPUs can be several parallel quantum machines based on different quantum technologies such as quantum annealing, neutral atoms, superconducting, and photonic.

## 2. REFERENCES