Steps	Objectives and Action Items
Step 1 **Multimodal Data Integration**	**Objective**: Collect and integrate data for PCF modeling. *Gather field measurements (ALT, CH4, CO2), integrate high-resolution remote sensing data (UAVSAR, AVIRIS-NG), incorporate outputs from process-based models (SIBBORK-TTE, TCFM-Arctic), and reconcile data into a unified framework.*
Step 2 **Data Preprocessing**	**Objective**: Prepare data for GeoCryoAI framework. *Apply dimensionality reduction to handle high-dimensional data, resample and scale data to a common grid resolution (i.e., 1 km), and address spatial and temporal disparities using specialized scaling laws and diagnostic statistical testing.*
Step 3 **GeoCryoAI Development**	**Objective**: Simulate the PCF using GeoCryoAI. *Employ a hybridized ensemble learning framework combining convolutional layers with LSTM-RNNs, integrate process-constrained learning to ensure physical accuracy, and use optimization techniques like Bayesian Optimization and regularization methods to fine-tune the model.*
Step 4 **GeoCryoAI Training**	**Objective**: Model training and validation. *Use teacher forcing to accelerate learning, incorporate time-lagged inputs and outputs to capture temporal dynamics, and validate model performance using RMSE and inverse transformations.*
Step 5 **GeoCryoAI Forecasting**	**Objective**: Predict future states of the PCF with GeoCryoAI. *Generate spatiotemporal forecasts for ALT, CH4, and CO2 fluxes, and capture both gradual and abrupt changes in the permafrost carbon system.*
Step 6 **Data Post-processing**	**Objective**: Analyze and interpret model predictions. *Perform error analysis to quantify uncertainty, leverage ecological memory for long-term predictions, and visualize results for stakeholder communication.*

Table 1. The pre-processing, GeoCryoAI architecture, and post-processing elements of the methodology are delineated in the table above. It illustrates a step-by-step approach briefly describing the primary functions, objectives, and action items of the workflow.