

Assessment of tree-based boosting machine learning techniques for forecasting high-impact drought events across dry and hot future climate scenarios: A case study from Italy

Majid Niazkar^{1, 2*}, Jeremy Pal^{1, 2}, Jaroslav Mysiak^{1, 2}

¹Risk Assessment and Adaptation Strategy division, Euro-Mediterranean Center of Climate Change, Venice, Italy

²Ca' Foscari University of Venice, Venice, Italy

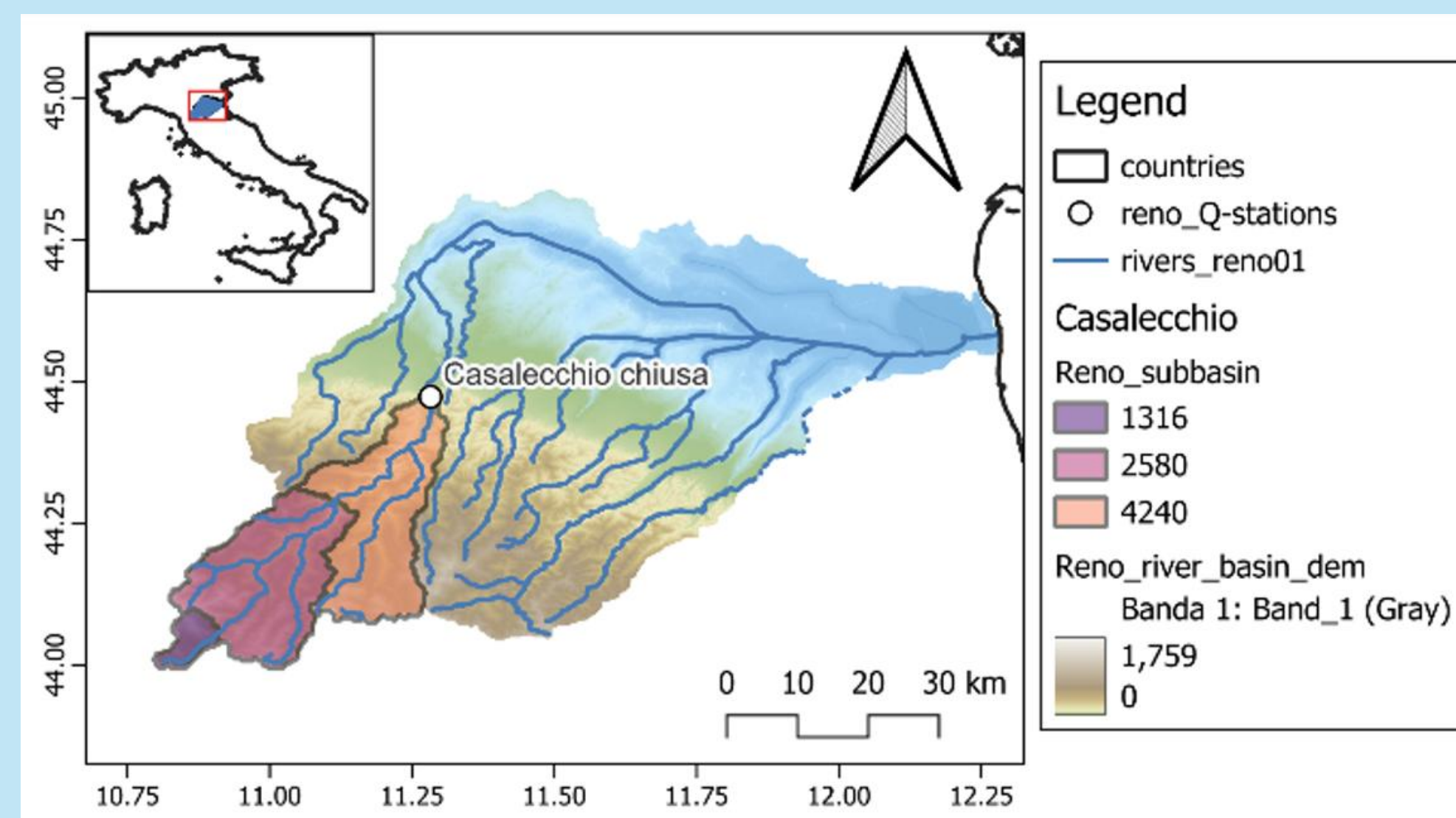
* e-mail: majid.niazkar@cmcc.it

Introduction:

In the realm of climate predictions and extremes, machine learning (ML) techniques serve as versatile tools not only for capturing climate patterns but also for climate change impact assessments.

Problem statement:

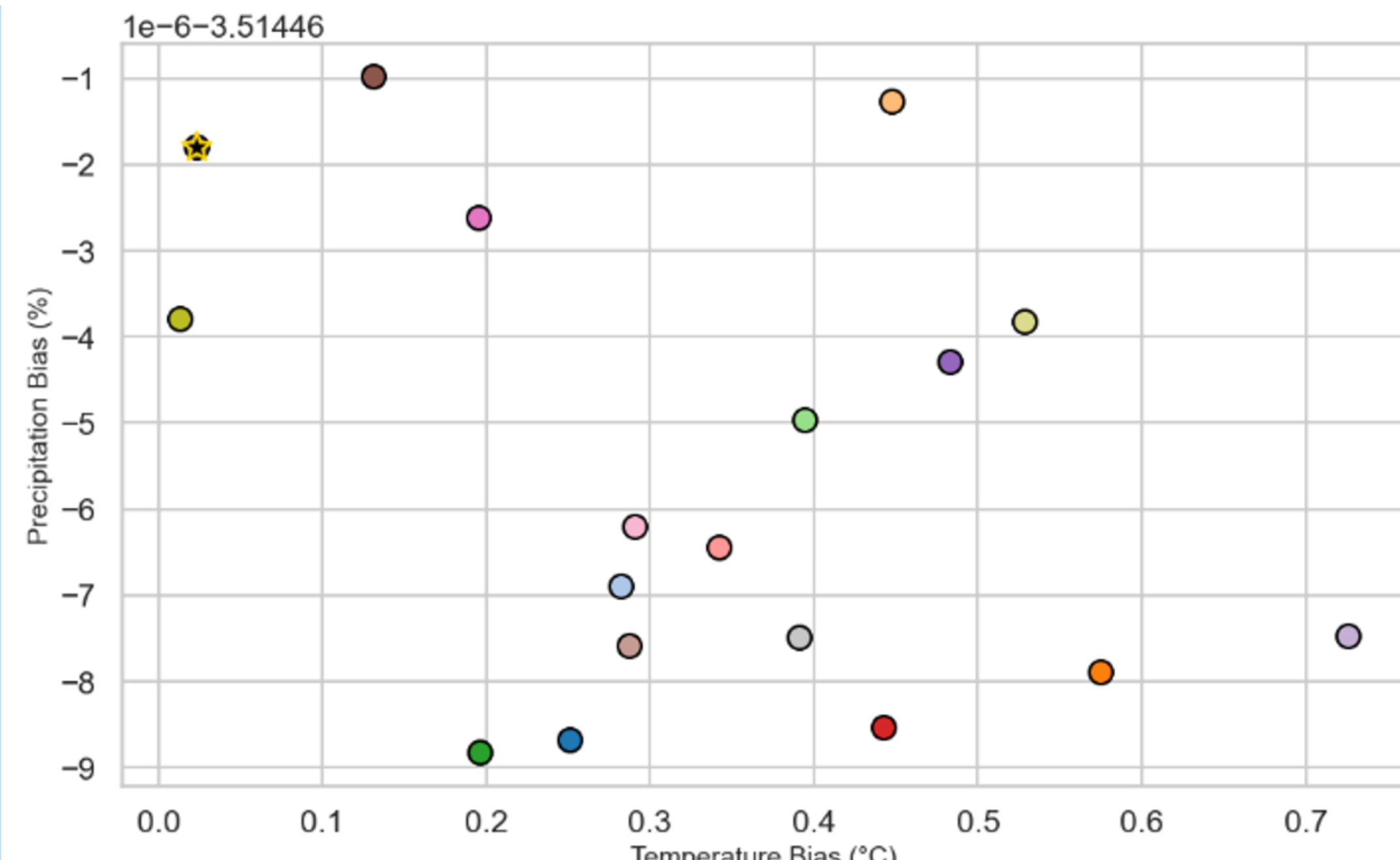
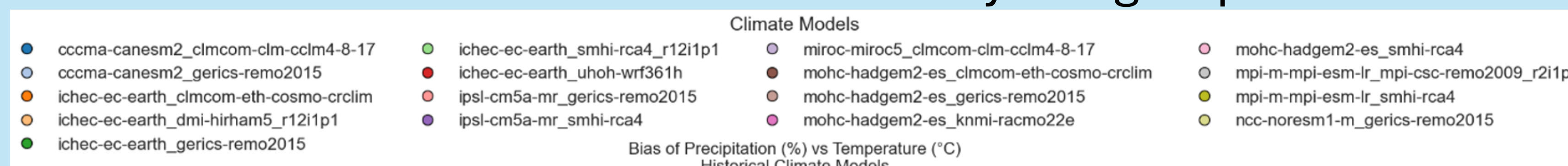
This study explores performances of tree-based boosting techniques including Adaptive Boosting (AdaBoost), eXtreme Gradient Boosting (XGBoost), Light Gradient-Boosting Machine (LightGBM), and Category Boosting (CatBoost) for predicting extreme drought under climate change impacts in the upper part of Reno basin, northern Italy.



Study area and location of the basin

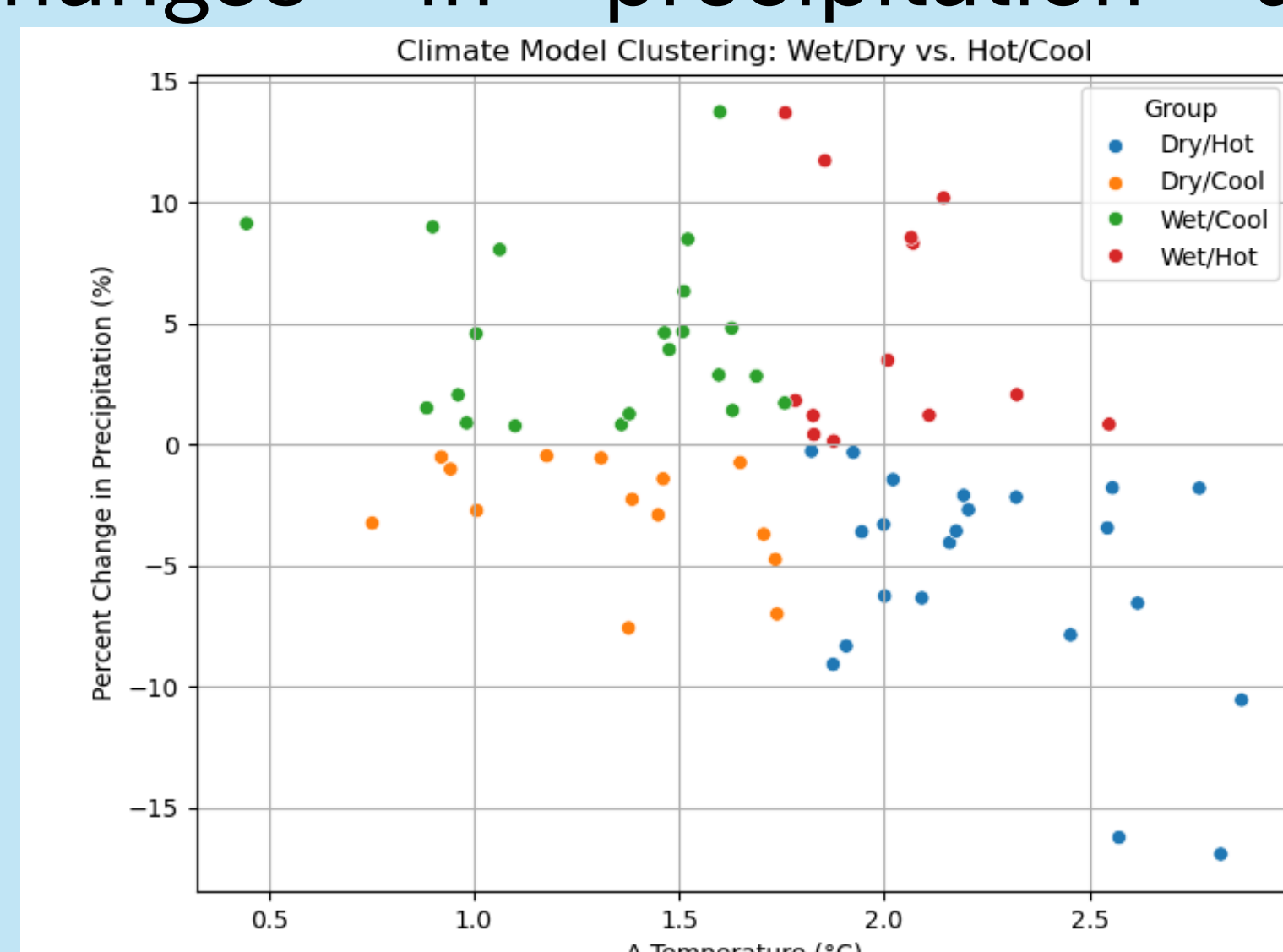
Step-by-step process and results:

- 1) Extract 39 bias-adjusted EURO-CORDEX CMIP5 climate models with 71 future projections (rcp2.6, rcp4.5, and rcp8.5)
- 2) Calculate precipitation and temperature bias for baseline of climate models in the dry-hot group



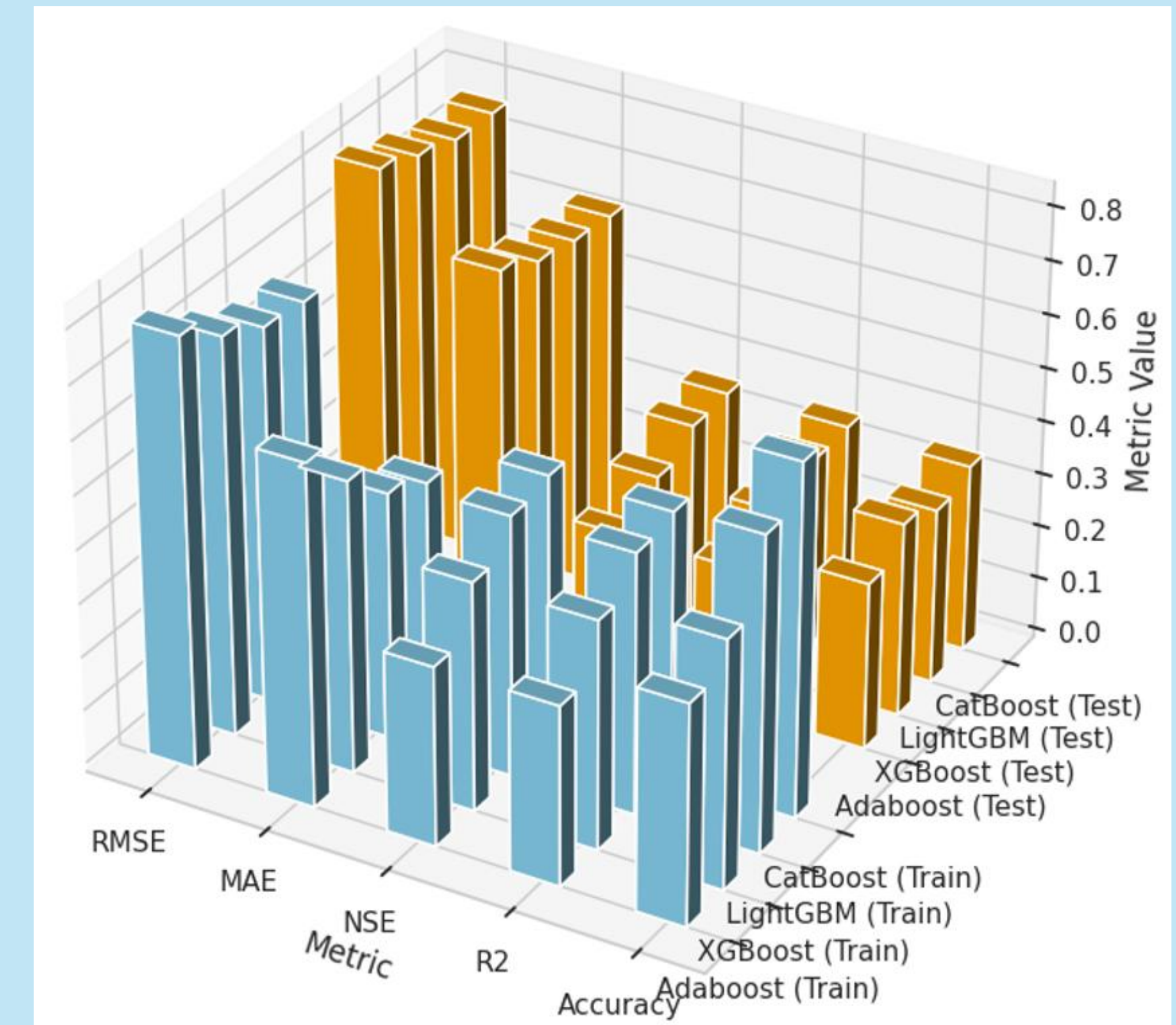
Precipitation bias vs. temperature bias for all climate models (the climate model with the lowest bias is mohc-hadgem2-es_uhoh-wrf361h)

- 3) Classify climate into four groups (dry vs. wet and hot vs. cool) based on changes in precipitation and temperature

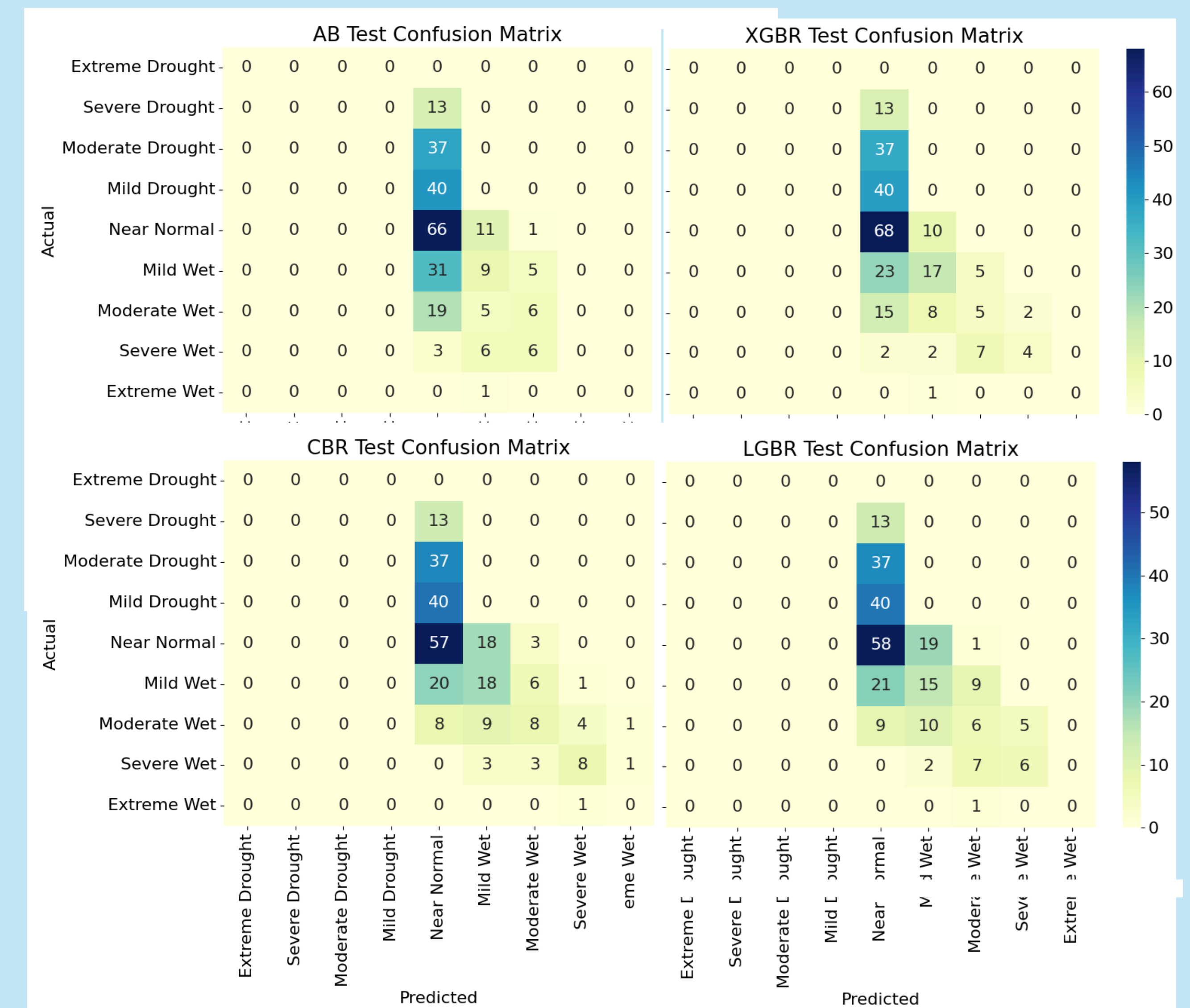


Categorizing climate models in four groups of dry vs. wet and hot vs. cool

- 4) Calculate 6-month Standardized Precipitation Evapotranspiration Index (SPEI) for E-OBS (1971-2005) and observed data (2001-2023)
- 5) Train ML models for estimating SPEI using E-OBS and validate for observed data

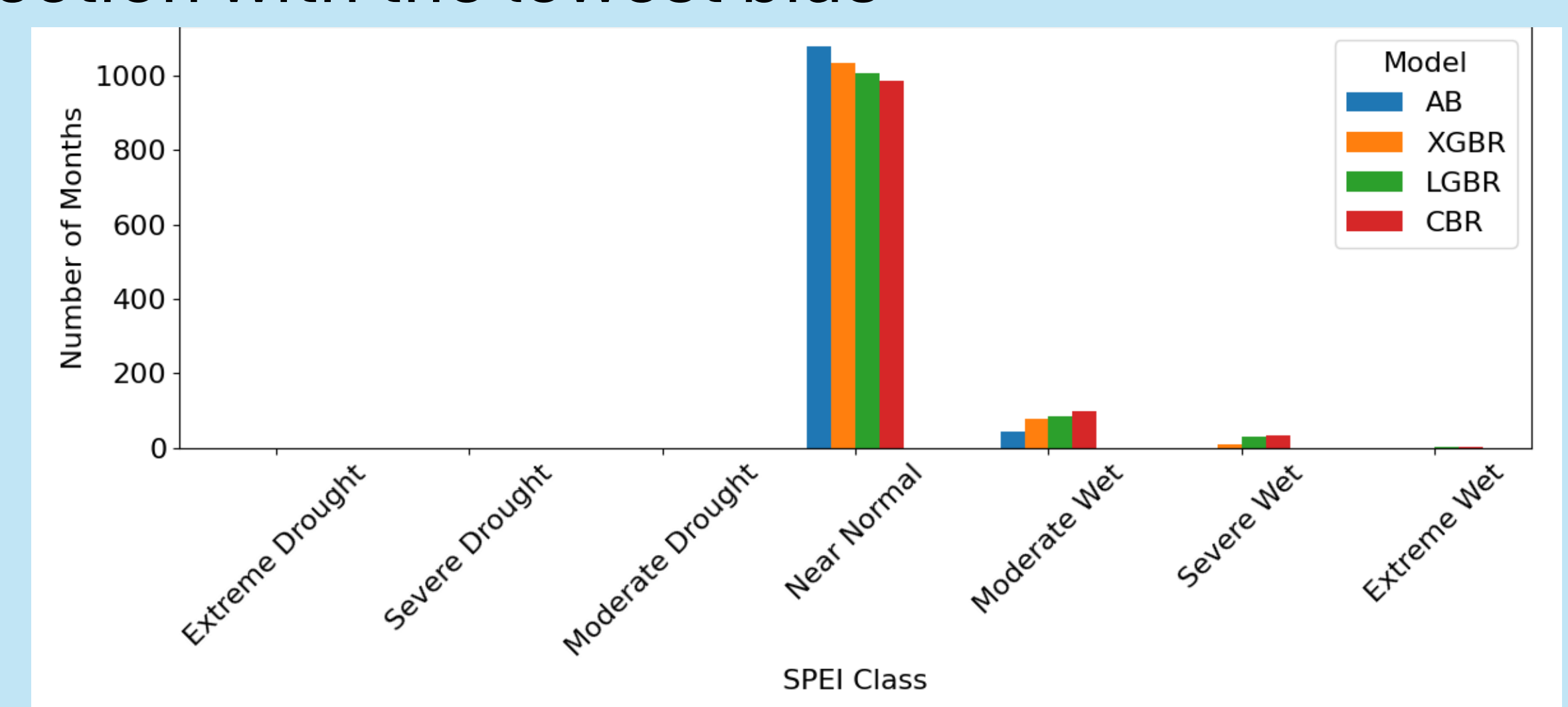


Performance of different tree-based ML models for estimating SPEI (accuracy equal to one indicates that the model predicted correct SPEI class for all data)



Confusion matrices for SPEI estimated by ML models for test data

- 6) Forecast SPEI using trained ML models for the climate projection with the lowest bias



Frequency of SPEI classes estimated by different ML models for the future projection with the lowest bias

Conclusion: SPEI values forecasted by tree-based ML models under hot and dry projections provide valuable insights for high-impact drought events in future.