

PiggyCast: Improving Weather Prediction Accuracy through a Stacking-Based Ensemble AI Approach

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Abstract

Recently, AI Weather Prediction (AIWP) models have outperformed classical Numerical Models in various weather prediction benchmarking criteria. Given the paradigm shift from numerical to machine learning models, such forecasts can be generated in seconds to minutes on a standard laptop. Forecast datasets from frontier AIWP models for the year 2020 have been made publicly available on the WeatherBench 2 website, facilitating independent analysis, evaluation, and further research. In this study, we introduce a traditional machine learning model trained on top of these forecast datasets (a method known as “stacking”) to predict ERA5 variables, thereby exploiting the strengths of each base model and aiming to outperform forecasts from any base model alone. We coin our model '**PiggyCast**', as we effectively piggyback off the work done by leading AI research teams with expertise and compute budgets for model training that are hard to match in an MSc thesis. The improvement in PiggyCast's Root Mean Squared Error on Geopotential Height at 500 hPa pressure, relative to the base models, was notable, with an increase in performance as forecast lead time increased. Given the low compute cost of making forecasts, and that each frontier AIWP model has its strengths and limitations (depending on the weather variable, region of the globe, and forecast lead time), we argue that the future of the most skilful weather forecasts will likely come from machine learning stacking, by the very nature that stacking typically yields performance better than any base model alone.

Declaration

I, the undersigned, hereby declare that the work contained in this research project is my original work, and that any work done by others or by myself previously has been acknowledged and referenced accordingly.



Josiah Kiarie Kimani, 13 June 2025