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Predicting Antarctic Blizzards Using Hybrid Deep Learning Models on Meteorological Data

This research presents a hybrid Deep Learning (DL) framework for the prediction of extreme weather events, with a particular focus on Antarctic blizzards—hazardous phenomena that pose significant operational and safety challenges in polar environments. The proposed model integrates a Recurrent Neural Network (RNN) architecture enhanced with Long Short-Term Memory (LSTM) units and is trained on real-time meteorological data collected from Bharati Station, India's coastal Antarctic research base. Two predictive configurations were developed and evaluated: a univariate model using wind speed alone, and a bivariate model combining wind speed and atmospheric pressure. The hybrid RNN+LSTM model achieved classification accuracies of 49.60% (univariate) and 55.19% (bivariate), with corresponding RMSE values of 0.0023 and 0.0021. These results outperformed baseline models including ANN, CNN, and standalone RNN/LSTM, demonstrating superior robustness in sparse and extreme meteorological environments. Feature importance analysis indicated wind speed and air pressure as the most significant predictors for blizzard forecasting, while temperature and humidity showed limited impact. The model architecture (Figure 1) comprises sequential RNN and LSTM layers followed by dense layers, enabling the capture of both short-term fluctuations and long-term dependencies in time-series data. This makes the model particularly effective for identifying abrupt and prolonged weather events such as blizzards. In addition to improving forecasting accuracy, the model supports early warning systems, enhances safety protocols, and aids operational planning in Antarctica. The architecture's flexibility allows for further tuning—such as increasing training epochs or expanding input datasets—to improve performance. Beyond polar applications, this adaptive model holds potential for forecasting other extreme weather events, including heatwaves and cold waves in non-polar regions.

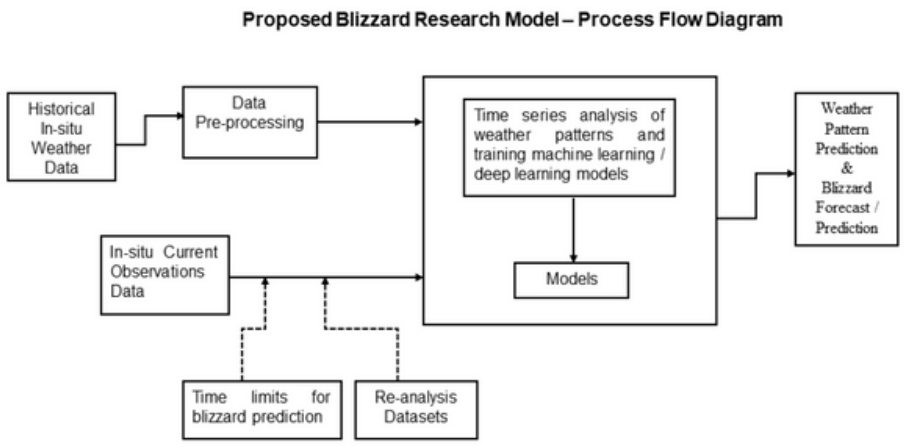

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Figure 1. Proposed deep learning architecture based on a hybrid Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM) model, developed within a data-driven and free-model framework for predicting Antarctic blizzards.

Keywords: writing, template, sixth, edition, self-discipline, good

Biography

V S Samy, Scientist F, Polar Data Service Section, National Centre for Polar and Ocean Research (NCPOR), Goa, India. His research lies in the prediction of weather pattern and extreme events using the polar weather datasets. He developed National Polar Data Center at National Centre for Polar and Ocean Research, Ministry of Earth Sciences, Govt. of India.

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