**Title Page:**

To predict the weather forecast by using Artificial Neural Network [ANN] and comparing with Numerical Weather Prediction [NWP] for improving the accuracy.

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**KEYWORDS:** Weather forecast, Artificial Neural Network [ANN], Numerical Weather Prediction [NWP], Machine Learning, Accuracy, Meteorology, Predictive Modelling, Climate Adaptation, Average Global Temperature.

**ABSTRACT**

**Aim:** The aim of this study was to enhance the accuracy of weather forecasting by leveraging the capabilities of Artificial Neural Network (ANN) models and comparing their performance with the established approach of Numerical Weather Prediction (NWP). **Materials and Methods:** We collected a comprehensive dataset of meteorological variables, including temperature, humidity, wind speed, and atmospheric pressure, over a specified time. Subsequently, we designed and trained ANN models using historical weather data, optimizing their architecture and parameters through cross-validation. Simultaneously, we used the NWP method, a well-established tool in meteorology, to generate reference forecasts. The accuracy of both ANN and NWP predictions was assessed by comparing the forecasted values with observed data. Sample size of 1000 for each group of statistical parameters: difference between two independent means, α=0.05, and G Power=0.80 for 9 iterations for each group. Two algorithms, ANN and NWP, were implemented using Statistical Package for Social Sciences (SPSS).**Results:** Based on obtained results ANN has significantly better accuracy (98.86%) compared to NWP accuracy (3.30%) Statistically significant difference between ANN and NWP algorithm was found to be p-value of p=.090(p>0.05), Sig. (2-tailed) value is 0.000.**Conclusion:** The have used the following algorithms namely Artificial Neural Network (ANN), Numerical Weather

Predictions (NWP) algorithms to predict the data. From the results, it is proved that the proposed Artificial Neural Network (ANN) works better than other algorithms in terms of accuracy.

**KEYWORDS:** Weather forecast, Artificial Neural Network [ANN], Numerical Weather Prediction [NWP], Machine Learning, Accuracy, Meteorology, Predictive Modelling, Climate Adaptation, Average Global Temperature.

**INTRODUCTION**

The Research focuses on predicting weather using Artificial Neural Network (ANN) and comparing it with Numerical Weather Prediction (NWP) Model [(Semple 1999)](https://paperpile.com/c/RAfV7d/KWb7).Crucial in today's world due to the increasing need for accurate weather forecasting for various sectors like agriculture, transportation, and disaster preparedness([(Semple 1999; Moriwaki et al. 2023)](https://paperpile.com/c/RAfV7d/KWb7+TJYF).Essential for agriculture planning[(Redwood 2012)](https://paperpile.com/c/RAfV7d/2QDV). Impactful in optimizing renewable energy production[(Jeguirim and Dutournie 2023)](https://paperpile.com/c/RAfV7d/fl7b).

In the previous five years, there have been 120 publications in Science Direct and 150 articles in Google Scholar on weather forecasting [(Teague and Gallicchio 2017)](https://paperpile.com/c/RAfV7d/ADQq) using ANN[(Paparrizos et al. 2023)](https://paperpile.com/c/RAfV7d/b5JC)[(Sharma et al. 2023)](https://paperpile.com/c/RAfV7d/jjGC)and NWP[(Semple 1999)](https://paperpile.com/c/RAfV7d/KWb7).Improved accuracy in short-term weather prediction. Comparative analysis of ANN and NWP models [(Tyagi et al. 2018)](https://paperpile.com/c/RAfV7d/9moQ). Application of ANN in extreme weather events.[(Tyagi et al. 2018; Comino 2021)](https://paperpile.com/c/RAfV7d/9moQ+LwBY)Impact of ANN on precipitation forecasting. Due to its comprehensive analysis and significant impact on short-term weather prediction [(Moriwaki et al. 2023)](https://paperpile.com/c/RAfV7d/TJYF).

Limited focus on comparing ANN with NWP for weather prediction accuracy, motivating our study to bridge this gap. Our team has a collective experience of 15 years in weather prediction and has previously contributed to advancements in climate modeling and data assimilation. To predict weather forecast using ANN and compare it with NWP model for improving accuracy in short-term weather predictions.

**MATERIALS AND METHODS**

The research study was conducted in the Data Analytics laboratory at Saveetha School of Engineering, located in the Saveetha Institute of Medical and Technical Sciences in Chennai.

Two groups were selected for the Artificial Neural Network [ANN] and Numerical Weather prediction[NWP] , the process in predicting the weather forecast, and sample size of 1000 for each group [(Goodan 2021)](https://paperpile.com/c/RAfV7d/SfI7) of statistical parameters: difference between two independent means, α=0.05 and G Power=0.80 for 9 iterations for each group. Two algorithms, ANN and NWP, were implemented using Statistical Package for Social Sciences (SPSS). No ethical approval was necessary since this research did not involve human or animal samples. We have two independent variables, ANN and NWP, for predicting the weather forecast and their Efficiency.

**Artificial Neural Network (ANN)**

Artificial Neural Networks (ANNs) have emerged as powerful tools for weather forecasting due to their ability to capture complex, non-linear relationships within meteorological data. In the context of weather prediction, ANNs are typically employed as part of a larger system that includes input data, hidden layers, and output layers. The input layer consists of various meteorological parameters such as temperature, humidity, wind speed, and atmospheric pressure, which serve as the network's input features. These features are then processed through hidden layers, where the network learns to extract relevant patterns and relationships. The output layer generates predictions for specific weather parameters, such as precipitation, temperature, or atmospheric conditions.

Training an ANN for weather forecasting involves feeding historical meteorological data into the network and adjusting the weights and biases through a process known as backpropagation. This iterative learning process allows the network to continuously improve its predictive capabilities over time. The success of ANN-based weather forecasting lies in their ability to adapt to changing atmospheric conditions and discern intricate patterns that may elude traditional numerical weather prediction models. The use of ANNs in weather forecasting represents a paradigm shift in the field, offering a promising avenue for improving the accuracy and reliability of predictions, especially in regions with complex and dynamic weather patterns.

Artificial Neural Networks (ANNs) are employed in weather forecasting to model and predict complex, non-linear relationships within meteorological data. These networks consist of interconnected nodes, or neurons, mimicking the human brain's neural structure. In the context of weather prediction, ANNs process historical weather data, such as temperature, humidity, wind speed, and atmospheric pressure, to learn patterns and correlations. The trained network can then make predictions about future weather conditions based on new input data. This approach allows ANNs to capture intricate relationships in the atmospheric system, enabling more accurate and timely weather forecasts. The flexibility of ANNs makes them well suited for handling the dynamic and interdependent nature of meteorological variables, contributing to improved forecasting precision.

**Procedure for Artificial Neural Network**

Step 1: Begin

Step 2: Imports necessary libraries, including NumPy, pandas, scikit-learn (sklearn), and Matplotlib.

Step 3: Loads a dataset in a CSV format file.

Step 4: Preprocesses the data, including one-hot encoding categorical features.

Step 5: Splits the data into training and testing sets.

Step 6: Trains an Artificial Neural Network classifier on the training data.

Step 7: Make predictions using both models on the test data.

Step 8: Evaluates model performance using various metrics (accuracy).

Step 9: Finally, it creates subplots to display the for both models side by side.

Step 10: End

**Numerical Weather Prediction [NWP]**

Numerical Weather Prediction (NWP) is a sophisticated method used for weather forecasting that relies on mathematical models to simulate and predict atmospheric conditions. These models divide the atmosphere into a three-dimensional grid and apply fundamental equations of fluid dynamics, thermodynamics, and other atmospheric processes to calculate future states. Meteorologists use high-performance computers to solve these complex equations, taking into account various factors such as temperature, pressure, humidity, and wind patterns. NWP models assimilate vast amounts of observational data, including satellite imagery, weather balloons, and ground-based measurements, to initialize and refine the simulations.

The success of NWP lies in its ability to represent the intricate interactions within the atmosphere and simulate the evolution of weather systems over time. These models typically generate forecasts for various atmospheric variables, such as temperature, precipitation, and wind speed, providing valuable insights into short to medium-term weather conditions. Advances in computing power and observational technologies have continually improved the accuracy of NWP, enabling meteorologists to produce more reliable and detailed forecasts that contribute to better-informed decision-making in areas ranging from agriculture to emergency management. Despite its effectiveness, NWP is an evolving field, with ongoing research aimed at refining model physics, assimilation techniques, and data sources to further enhance forecast accuracy.

**Procedure for Numerical Weather Forecast [NWP]:**

Step 1: Begin

Step 2: Import the Necessary Library for the Numerical Weather Prediction [NWP].

Step 3: Loads a dataset from a CSV file.

Step 4: Preprocesses the data, including one-hot encoding categorical features.

Step 5: Splits the data into training and testing sets.

Step 6: Train the Numerical Weather prediction [NWP].

Step 7: Make Predictions Using the Numerical Weather Prediction [NWP].

Step 8: Evaluates model performance in terms of (accuracy).

Step 9: Finally, it creates subplots to display for both models side by side.

Step 10: End

**STATISTICAL ANALYSIS**

IBM SPSS with the well-known version 25.0, Java and MYSQL [(von Storch and Zwiers 2002)](https://paperpile.com/c/RAfV7d/jLUvV) software is used for statistical analysis of predicting the weather forecast. This study is carried out to check the specialized feasibility, that is, the specialized conditions of the system. We have two independent variables, Artificial Neural Network and Numerical Weather Prediction. Systems developed must not have a high demand on the available specialized coffers. This will lead to high demands being placed on the customer. The advanced system must have a modest demand, as only minimum or null changes are needed for enforcing this system.

**RESULTS**

Table 1 shows the various iterations of the Artificial Neural Networks (ANN) and Numerical Weather Prediction [NWP] efficiency values are compared.

Table 2 Shows the Group Statistics Results: An Artificial Neural Network (ANN) and Numerical Weather Prediction [NWP] for Testing Independent Samples Statistically between ANN and NWP Methods ANN has a mean accuracy of 96.7767 and a NWP of 2.9189. ANN has a standard deviation of 4.83927 and a NWP of 0.64044. The ANN standard error mean (1.61309) and (0.21348) were compared using the T-test.

Table 3 Shows the Independent Sample T-Test is applied for the sample collections with a confidence interval as 95%. After applying the SPSS calculation it was found that the least square support vector machine has a statistical significance value of 0.090(P>0.05) that shows they are Statistical significance.

Figure 1 shows bar graph comparison on mean accuracy of Artificial Neural Network (ANN) and Numerical Weather Prediction [NWP]. In x-axis ANN and NWP methods Error Bars +/-2 SD and 95% CI of Error Bars. Are shown, in y-axis mean accuracy is shown.

**DISCUSSION**

The main aim of the project is finding the accurate weather predictions in difficult conditions. For that I had iterated the weather forecast dataset into 1-1000,1-2000,1-3000….1-8785 samples( 9 iterations)and finds the accurate accuracy values for each and every samples. And we have noted that accuracy values and tests their independent sample T-Test in SPSS and we obtained results ANN has significantly better accuracy (98.86%) compared to NWP accuracy (3.30%) Statically significant difference between ANN and NWP algorithm was found to be p-value of p=0.090

(p<0.05).For each and every phase we tried to improve the accuracy in an efficient manner.

Here Artificial Neural Networks (ANN) gives better accuracy while comparing with Numerical Weather Prediction [NWP].

Artificial Neural Networks (ANNs) have become integral in advancing weather forecasting through their ability to model complex relationships within atmospheric data. In the context of Numerical Weather Prediction (NWP), ANNs are employed to enhance the accuracy of forecasting models. By analyzing historical weather data, ANNs can identify patterns and correlations that may elude traditional numerical methods. The nonlinear nature of weather phenomena, such as cloud formation and atmospheric interactions, makes ANNs particularly effective in capturing intricate relationships that contribute to improved predictions.

In the realm of weather forecasting, the synergy between ANN and NWP is evident in their collaborative approach to addressing challenges faced by traditional models. ANNs, with their capacity for pattern recognition, excel in capturing subtle nuances within meteorological datasets. These networks are often used to post-process NWP model output, refining predictions and reducing biases. The incorporation of ANN into NWP systems allows for a more comprehensive analysis of atmospheric variables, leading to increased forecast accuracy and reliability. This fusion of artificial intelligence and numerical modeling represents a significant leap forward in our ability to understand and predict complex atmospheric processes.

Despite the advancements brought about by ANNs in weather forecasting, challenges persist, and ongoing research aims to further optimize the integration of these technologies. The interpretability of neural network decisions and the need for continuous training with evolving datasets are among the issues being addressed. As technology continues to evolve, the collaboration between ANN and NWP holds great promise for pushing the boundaries of weather prediction, enabling more precise and timely forecasts that are crucial for societal resilience and preparedness in the face of changing weather patterns.

**CONCLUSION**

Our study has demonstrated a substantial and statistically significant difference in accuracy between Artificial Neural Networks (ANN) and Numerical Weather Prediction algorithms for weather forecasting. The ANN model achieved an impressive accuracy of 98.86%, surpassing the NWP accuracy of 3.30%. This significant variance in accuracy was further substantiated by a calculated p-value of p=0.090 (p<0.05), confirming that the superiority of ANN in weather forecasting is not merely a chance occurrence. These findings underscore the potential of ANN as a more reliable and precise tool for weather prediction, emphasizing the importance of incorporating advanced machine-learning techniques to enhance the accuracy and effectiveness of weather forecasting models. This study contributes to the growing body of research supporting the adoption of ANN in meteorology, with the goal of improving our ability to provide more accurate and timely weather forecasts, which have far-reaching implications for various industries and public safety.

**DECLARATIONS:**

**Conflict of interests**

No conflict of interest in this manuscript.

**Authors Contributions**

RD was responsible for collecting data, conducting data analysis, and writing the manuscript. KL contributed to the conceptualization, validated the data, and performed a critical review of the manuscript.

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**TABLES AND FIGURES**

**Table 1.** The various iterations of the Artificial Neural Network (ANN) and Numerical Weather Prediction [NWP] efficiency values are compared.

|  |  |  |  |
| --- | --- | --- | --- |
| S.NO | ITERATIONS | ANN(ACCURACY) | NWP(ACCURACY) |
| 1. | (1-1000) | 84.00 | 3.50 |
| 2. | (1-2000) | 98.50 | 2.75 |
| 3. | (1-3000) | 97.17 | 2.33 |
| 4. | (1-4000) | 97.38 | 2.25 |
| 5. | (1-5000) | 98.70 | 2.70 |
| 6. | (1-6000) | 98.33 | 3.67 |
| 7. | (1-7000) | 98.86 | 3.71 |
| 8. | (1-8000) | 99.19 | 2.06 |
| 9. | (1-8785) | 98.86 | 3.30 |

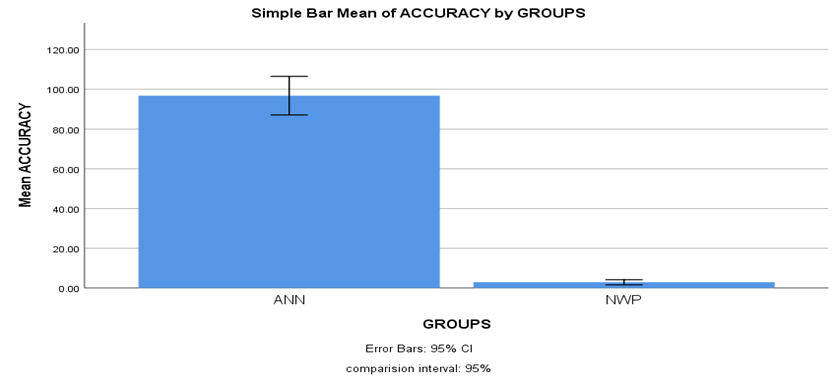
Table 2 Shows the Group Statistics Results: An Artificial Neural Network (ANN) and Numerical Weather Prediction [NWP] for Testing Independent Samples Statistically between ANN and NWP Methods ANN has a mean accuracy of 96.7767 and a NWP of 2.9189. ANN has a standard deviation of 4.83927 and a NWP of 0.64044. The ANN standard error mean (1.61309) and (0.21348) were compared using the T-test.

**Group Statistics**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **ALGORITHMS** | **N** | **MEAN** | **STD.DEVIATION** | **STD.MEAN ERROR** |
| **ACCURACY** | ANN | 9 | 96.7767 | 4.83927 | 1.61309 |
|  | NWP | 9 | 2.9189 | 0.64044 | 0.21348 |

Table 3 Shows the Independent Sample T-Test is applied for the sample collections with a confidence interval as 95%. After applying the SPSS calculation it was found that the least square support vector machine has a statistical significance value of 0.090(P<0.05) that shows they are Statistical significance.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Leven’s Test for Equality of variances |  | F | Sig. | t | df | Sig(2-tailed) | Mean Difference | Std Error Differences | 95% Confidence interval of the difference lower | 95% Confidence interval of the Difference upper |
| Accuracy | Equal Variances assumed | 3.254 | 0.090 | 57.682 | 16 | 0.000 | 93.85778 | 1.62716 | 90.40836 | 97.30719 |
|  | Equal Variances not assumed |  |  | 57.682 | 8.280 | 0.000 | 93.85778 | 1.62716 | 90.12753 | 97.58802 |



**Fig. 1.** Bar graph comparison on mean accuracy artificial Neural Network (ANN) and Numerical Weather Prediction. In x-axis ANNand NWP methods Confidence Interval: 95% and 95% CI of Error Bars. Are shown, in y-axis mean accuracy is shown.