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REGIONAL WORKSHOP ON IMPACT-BASED FORECASTING:

Training-of-Trainers and National Demonstration Planning for Temperature-Related Hazards

SAHF IBF Working Group Implementation Plan Project

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Kathmandu, Nepal

REGIONAL WORKSHOP ON IMPACT-BASED FORECASTING

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Bias Correction for Temperature Forecasting

Khan Md Golam Rabbani

RIMES

What is bias correction?

Global and Regional Climate model → Systematic Errors (Biases)

Temperatures can be consistently too high or too low

Sources of Biases

Incomplete Understanding of the Global Climate System

Limited Spatial Resolution (Large Grid Sizes)

Simplified Thermodynamic Processes and Physics

Impacts on Forecast due to Biases

Uncorrected Weather Output

Wrong Climate Impact Assessment

Things to be aware of

- Bias-correction methods assume that the causes of the biases do not change in the future.
- Sufficient observational data required (at least 10 years of data, often 30 years)
- Bias-correcting temperature may result in sub-zero values,
- Negative values for diurnal temperature range may be generated from daily minimal and maximal temperatures.
- Do not bias-correct if the biases are large.

Bias Correction Methods

- **Statistical Methods:** Mean BC, Linear Scaling, Variance Scaling, Delta Method (Climate applications)
- **Distribution-Based Methods**: Quantile Mapping (QM)
- **Regression-Based Methods:** Simple Linear Regression
- **Ensemble-Based Methods:** Model Output Statistics

Bias correction + statistical downscaling.

	Linear scaling	Variance scaling	Quantile mapping	Trend-preserving quantile-mapping
Description	Simple method that only adjusts for mean bias	A popular method that adjusts mean and variance bias	A method often used for precipitation as it preserves the distribution and can inform extreme values	A method endorsed by the ISIMIP project (www.isimip.org). It combines two steps: (1) linear scaling approach for the long-term trend and (2) quantile mapping approach for variability
Pros	Simple method	▪ Simple method that many have previously used ▪ Retains climate change signal	▪ Considers entire distribution ▪ Useful for changes in extreme values and where variability is important	Same as quantile mapping method but also preserving climate change signal
Cons	Only corrects for the mean	▪ Variability follows that of observed ▪ Restricted to range of observed anomalies UKCP18 Guidance: Bias correction	▪ Climate change signal can be altered ▪ Assumes correction increments are the same as in the current climate ▪ Extreme values restricted to observed	▪ As with other methods, variables corrected independently. Can lead to physical inconsistency ▪ Many more steps involved

Bias Correction Methods for Temperature

- Easier to correct Temp. than Precipitation (because it is typically more normally distributed)

- **Linear Scaling:** The average bias (e.g., model is consistently 2°C too warm) is subtracted from all daily future temperature projections.
- **Variance Scaling:** Used when it's important to get the daily variability right, not just the average. This ensures the model's range of daily temperatures matches historical records.
- **Quantile Mapping:** Highly recommended for temperature extremes, such as the number of heatwave days.

ML Methods

- Global Forecast System (GFS): cold biases in the 2-m temperature

- **Tree-Based:**
  Random Forest Regression
  Gradient Boosting Regression
  XGBoost
  Application: Tmax/Tmin
- **Neural Networks**
  ANN
  LSTM
  CNN (spatial bias correction)
  Application: heatwave prediction

Observations

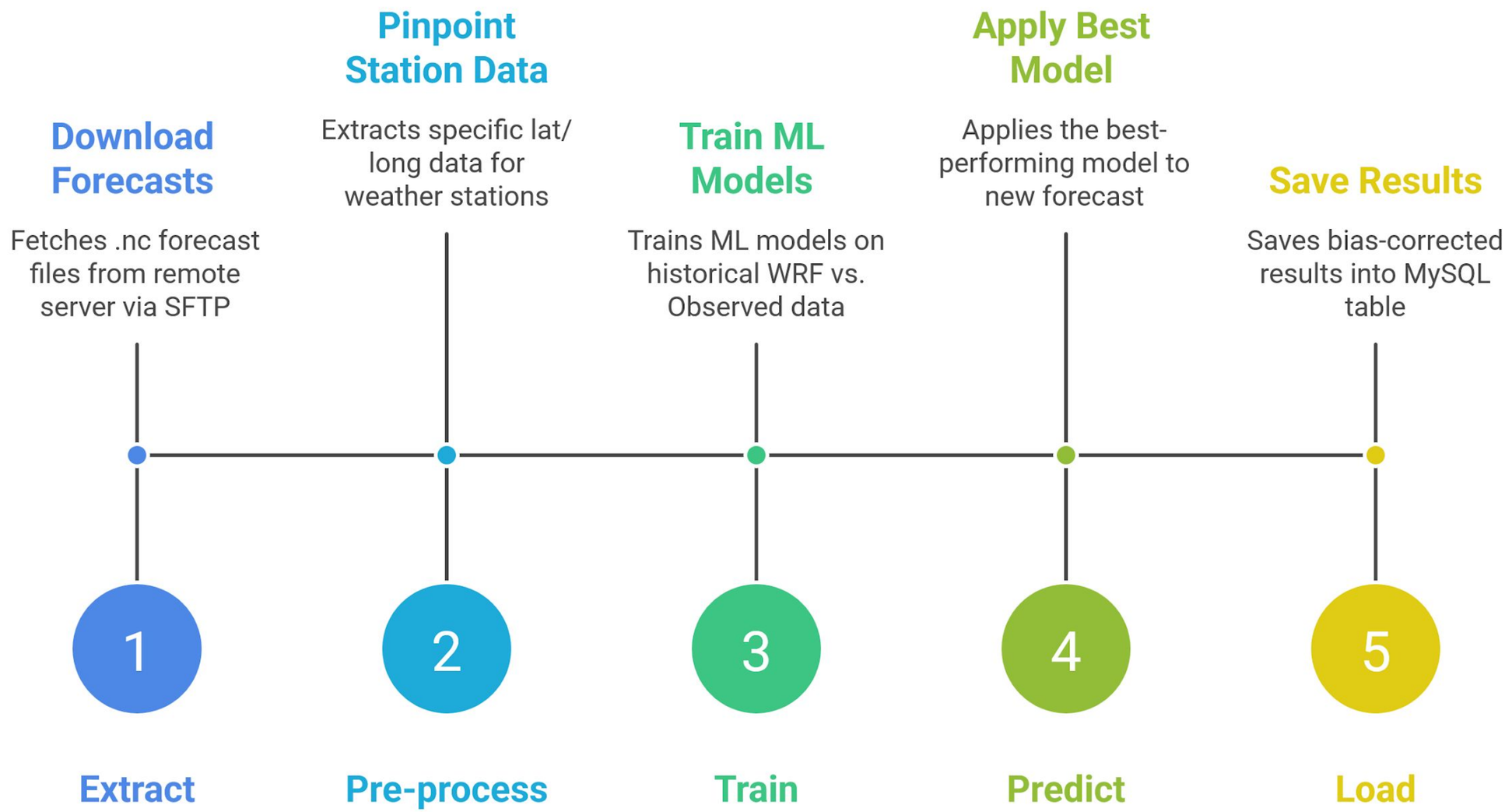
- NCEP ADP Global Surface Weather Observations

- Global Satellite Mapping of Precipitation (GSMaP),
- Integrated Multi-satellitE Retrievals for GPM (IMERG)
- Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)
- Multi-Source Weighted-Ensemble Precipitation (MSWEP)
- Multi-Source Weather (MSWX)

Bias Corrected Forecast in Bangladesh

https://nlas.dls.gov.bd/dashboard/home

Architecture: WRF Forecast Bias Correction



Architecture: WRF Forecast Bias Correction

Pre-processing

Data Extraction

Code to extract forecast data for identified grid points.

NetCDF Library

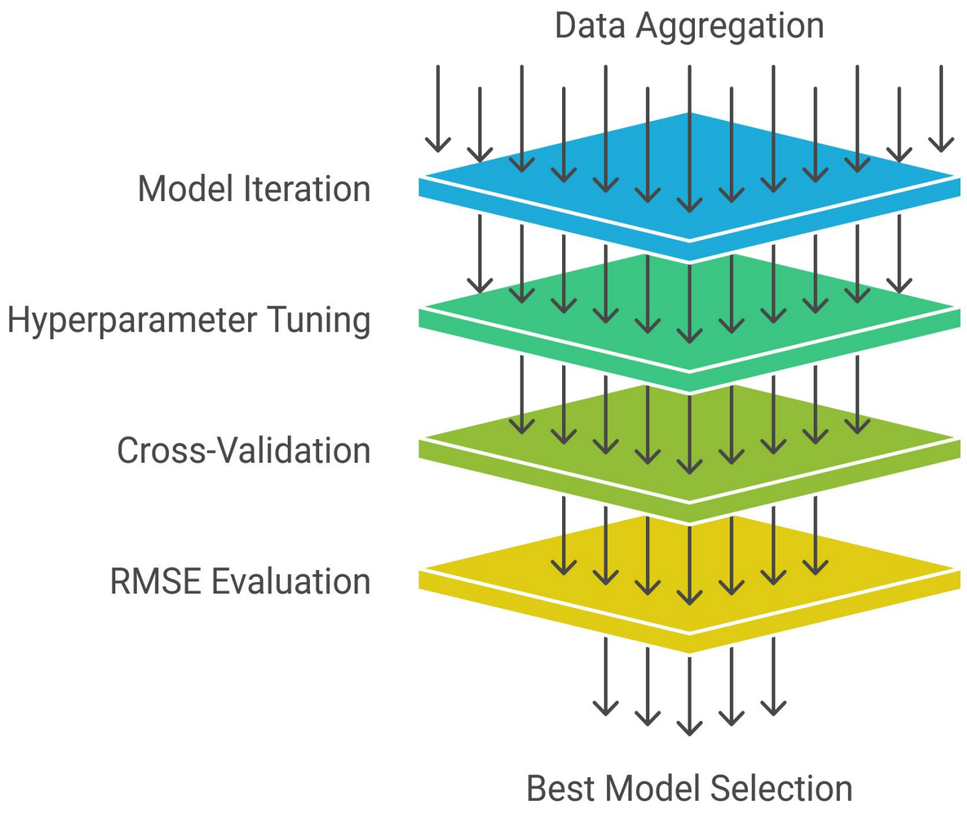
A library for reading and manipulating NetCDF files.

Coordinate Mapping

Logic to map weather station coordinates to grid points.

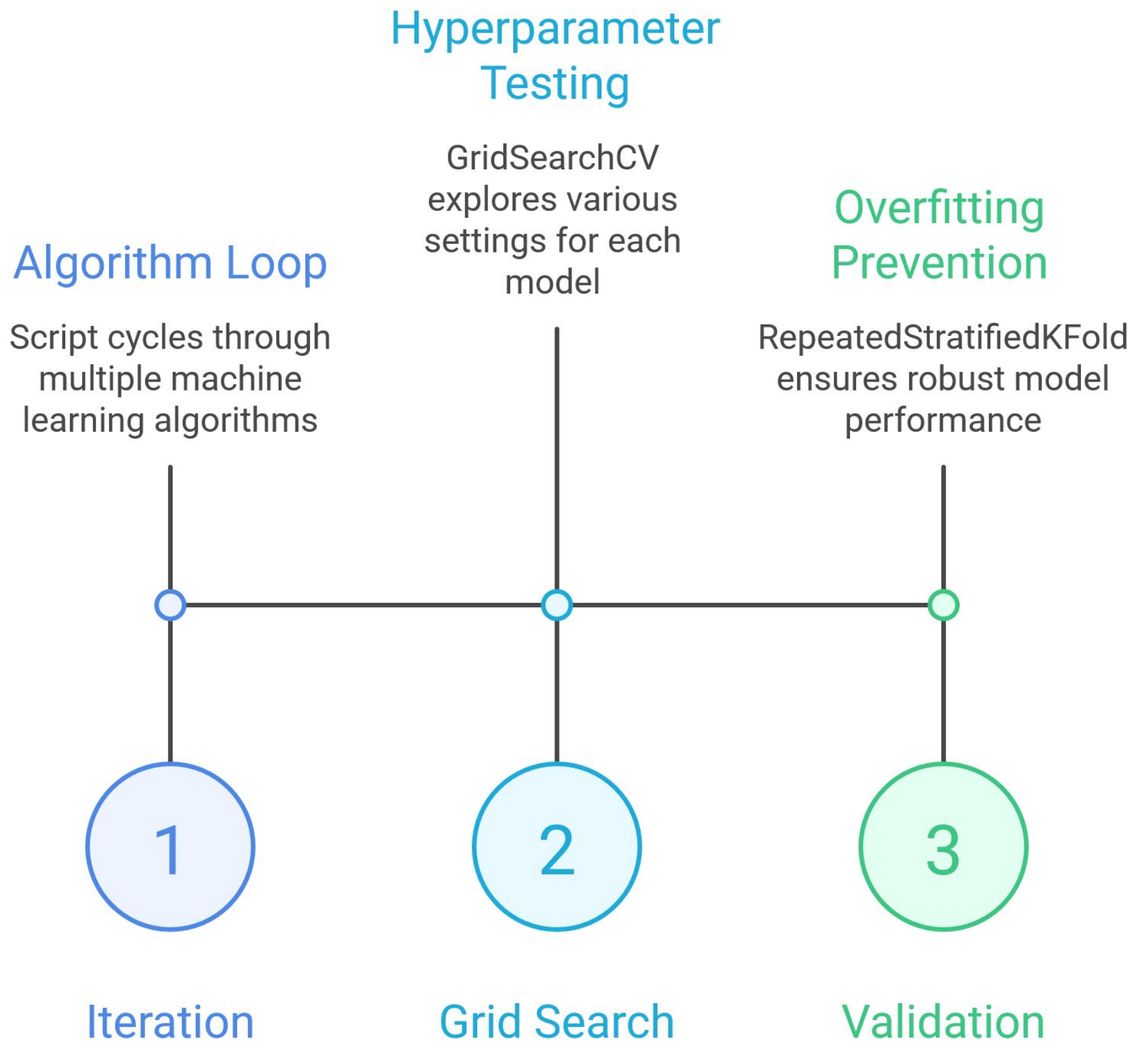
Architecture: WRF Forecast Bias Correction

Machine Learning Model Selection Process



Execution Flow

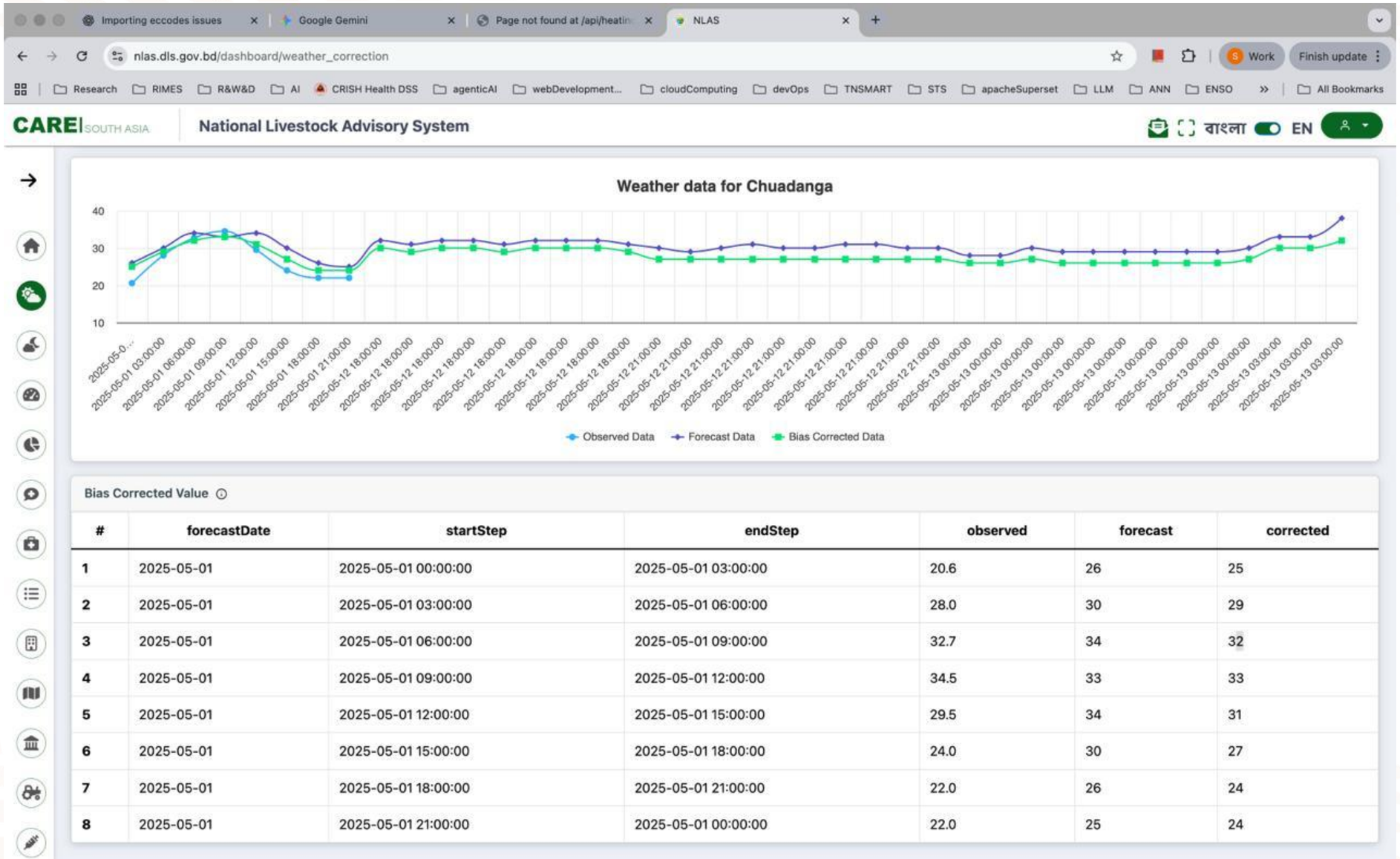
Methodology: Hyperparameter Tuning



Validation: Key Metrics Used

- **MSE (Mean Squared Error):** Used during training to penalize large errors heavily.
- **RMSE (Root Mean Squared Error):** Used to select the “Best" model, as it provides an error value in the same units as temperature (°C).

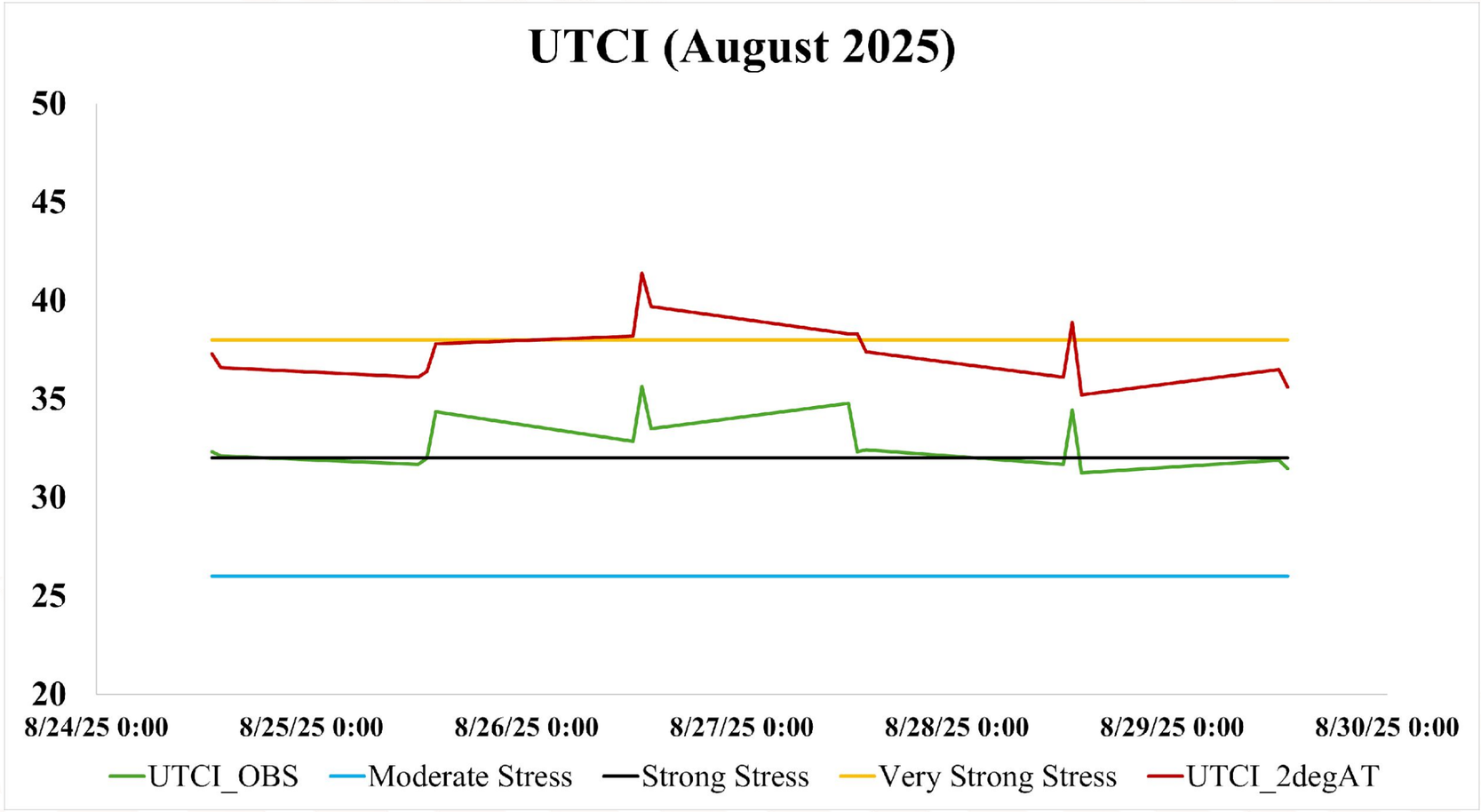
Bias Corrected Forecast in Bangladesh

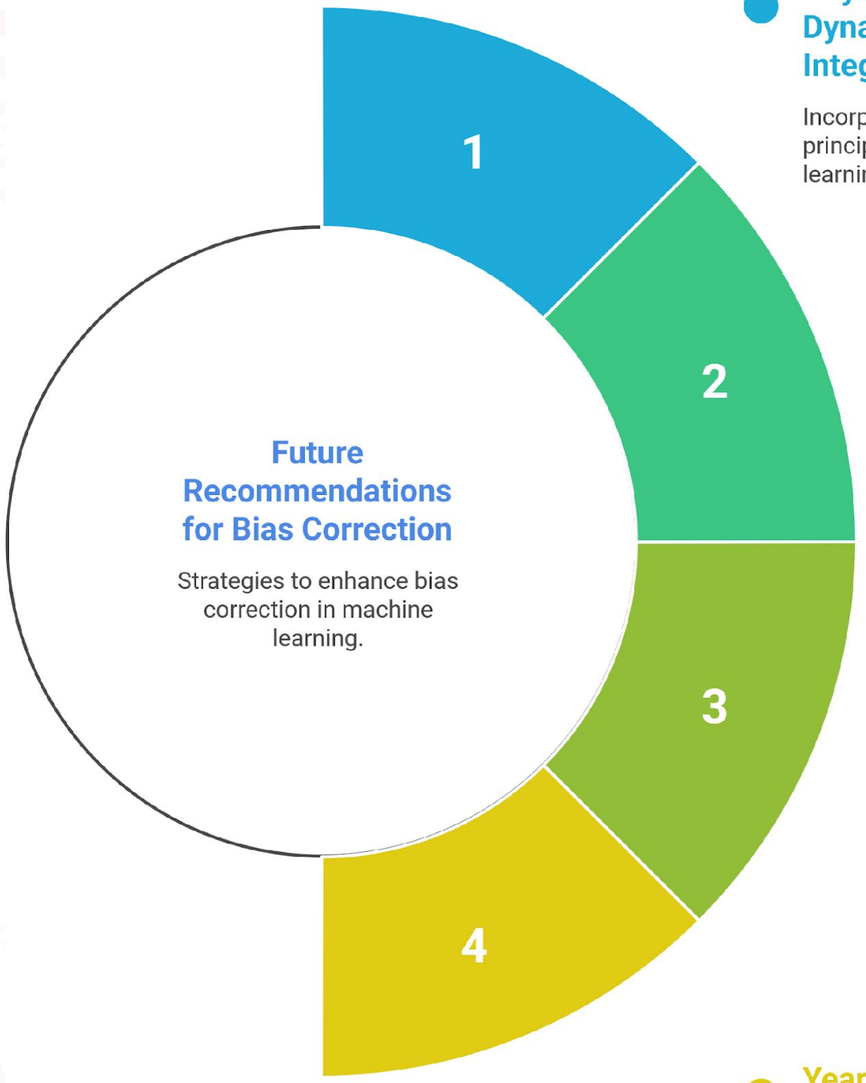


Bias Corrected Value

#	forecastDate	startStep	endStep	observed	forecast	corrected
1	2025-05-01	2025-05-01 00:00:00	2025-05-01 03:00:00	20.6	26	25
2	2025-05-01	2025-05-01 03:00:00	2025-05-01 06:00:00	28.0	30	29
3	2025-05-01	2025-05-01 06:00:00	2025-05-01 09:00:00	32.7	34	32
4	2025-05-01	2025-05-01 09:00:00	2025-05-01 12:00:00	34.5	33	33
5	2025-05-01	2025-05-01 12:00:00	2025-05-01 15:00:00	29.5	34	31
6	2025-05-01	2025-05-01 15:00:00	2025-05-01 18:00:00	24.0	30	27
7	2025-05-01	2025-05-01 18:00:00	2025-05-01 21:00:00	22.0	26	24
8	2025-05-01	2025-05-01 21:00:00	2025-05-01 00:00:00	22.0	25	24

UTCImax with Temp. having +2 Degree Bias in Lalmonirhat, Bangladesh





Physics-Based Dynamic Method Integration

Incorporating physics principles into machine learning models.

Multi-Parameter Model Training

Expanding training parameters for improved bias correction.

Spatiotemporal ML Method Utilization

Employing spatiotemporal ML for better bias correction.

Yearly Updated Estimated Baseline Delta/Factors

Regularly updating baselines to maintain bias correction accuracy.

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THANK YOU!