Bias Correcting the High Resolution Ensemble Forecast for Heatwave Prediction over India and its Verification

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Abstract

In spite of many significant improvements in Numerical Weather Prediction models including major improvements in the model physics and resolution, these models still suffer from systematic biases. There are several methods available to remove these systematic errors from a model, for example by applying statistical post processing algorithms. In the current study we have made an attempt to correct the bias in the maximum temperature forecasts obtained from the National Centre for Medium Range Weather Forecasting Ensemble Prediction System.

1 Introduction

Tropical weather is difficult to forecast. In the mid-latitudes weather is dominated by synoptic systems moving in the westerlies and the baroclinic instability results from air masses with contrasting temperature and density. However, in the tropics, there is a relatively homogeneous air mass and fairly uniform distribution of surface temperature and pressure. Therefore, local and mesoscale effects are more dominant than synoptic influences [4]. For example, surface temperature and pressure can change quickly with convective processes.

In the current study, an attempt has been made to correct the bias in the forecast of the 2m temperature (*Tmax*) over Indian region for MAM 2019. Bias correction is done by the following study performed by Cui et al., 2012 and they have corrected the bias in different variables using two different methods: (a). moving average bias estimation and correction and (b) Decaying average method. Further, the raw and bias corrected forecasts are compared by using some standard verification scores like probability of detection (POD), false alarm rate (FAR) and Hanssen and Kuipers Score or Peirce's skill score (PSS).

2 Data and Methodology

2.1 Observed Temperatures

For correcting the biases in the forecast issued by an NWP model, a reliable set of analysis/observations are required. For surface temperature, IMD has recently developed a high resolution daily gridded dataset with 0.5° resolution. Data processing procedure adopted by IMD in preparing this dataset is available in many research papers [5]. The final compiled, digitized, quality controlled and archived dataset is obtained from the National Data Centre (NDC). In this study, we have used IMD's real-time daily gridded [5][6].

2.2 NCMRWF Ensemble Prediction System (NEPS)

The NCMRWF global Ensemble Prediction System (NEPS) operational and generating of 10 day forecasts at 00 and 12 UTC. The initial condition perturbations are generated by Ensemble Transform Kalman Filter (ETKF) method. The forecast perturbations obtained from 6 hour short forecasts of 22 ensemble members are updated by ETKF four times a day at 00, 06, 12 and 18 UTC. The model uncertainties are estimated by the Stochastic Kinetic Energy Backscatter (SKEB) and Random Parameters (RP) schemes. Surface parameters like sea surface temperature, soil moisture content and soil temperature are also perturbed in the initial condition to remove the deficiency of lack of ensemble spread near the surface. 10-day probabilistic forecasts are issued daily using 23 ensemble members (1 control + 22 perturbed). The operational deterministic forecast running from 00 UTC is used as control forecast. One set of 11 perturbed members run from 00 UTC of current day and another set of 11 perturbed members run from 12 UTC of previous day to form 22 perturbed ensemble members.

2.3 Methodology

In this study we have made an attempt to correct the bias in *Tmax* forecasts obtained from NEPS for MAM 2019 by applying by:

Decaying Average Bias Correction: This statistical post-processing method applies an adaptive [Kalman filter type (KF)] algorithm to accumulate the decaying averaging bias [1][2][3].

At a particular time '*t*' the bias is updated by using the bias calculated at a previous time '*t-1*' by using a weight called the 'decaying average' [1], i.e.,

$$BIAS(t) = (1 - w) \times b(t-1) + B \quad (1)$$

where w is weight, b(t-1) is day 1 bias ($[F_1\text{-}O_1]$) and $B = \frac{1}{N}\sum_1^{30}(F_i - O_i)$ mean bias for last month.

This method allows the incorporation of the most recent behaviour of the system into the estimation of the bias. Sensitivity experiments have been performed with different values of the decaying weight (0.02, 0.05, 0.1, 0.2 and 0.3) and an optimal value of 30% has been adopted for the current study. After the bias estimation has been done for the current time the bias correction of the output is performed as per equation (1).

2.4 Figures and Tables

Table 1. Heat waves during summer 2019.

S.No.	Heat wave episodes during summer 2019	
	Duration	***Effected Regions***
1.	07-09 Mar	South East India
2.	28-30 Mar	West and Peninsular India
3.	06-11 Apr	Northwest India
4.	28-30 Apr	West and Central India

5.	01-04 May	West and Central India
6.	09-11 May	North and East India
7.	28-31 May	Northwest to East India
8.	01-04 Jun	Northwest to East India
9.	10-15 Jun	Northwest to East India

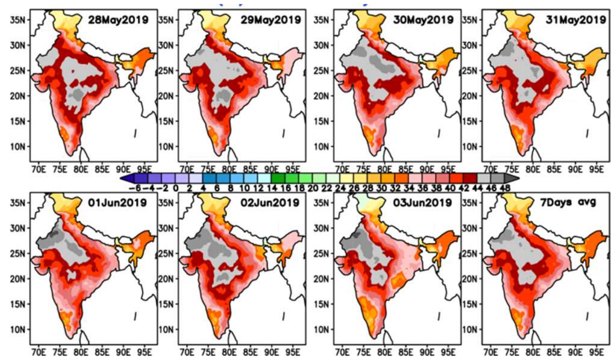

Figure 1. The spatial distribution of IMD's observed Tmax from 28[rd] May to 03[rd] Jun 2019 and the average Tmax for these 7 days.

Figure 1 is showing the prevailing heat wave conditions over Punjab, Rajasthan, Madhya Pradesh, Uttar Pradesh, Delhi, Haryana, Punjab and some parts of Maharashtra. The observed maxima of Tmax (> 44°C) is seen over a wide region over northwest to central parts of India

In Fig. (2) Tmax ≥ 43°C observed in Rajasthan, Punjab, Haryana, Delhi, Uttar Pradesh, Madhya Pradesh, Jharkhand, Odisha, and Maharashtra regions NEPS raw forecast are forecasted in the range of 65-95% probabilities. After bias correction the probabilities increased to more than 95% for all the states for all lead times.

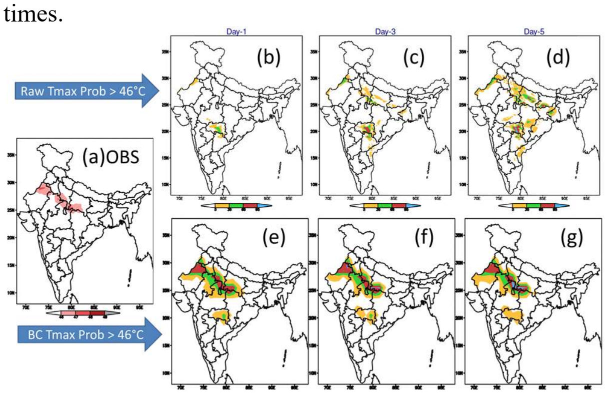

Figure 2. The probabilistic verification of NEPS with (a) IMD observations Tmax 43°C, upper-panel day1, day3 and day5 lead time (b, c & d) are from model raw forecast and lower panel (e, f & g) are bias corrected forecast valid for 30 May 2019.

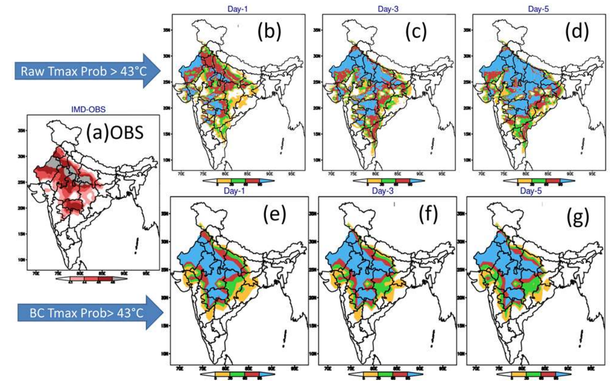

Figure 3. The probabilistic verification of NEPS with (a) IMD observations Tmax 46°C, upper-panel day 1, day 3 and day 5 lead time (b, c & d) are from model raw forecast and lower panel (e, f & g) are bias corrected forecast valid for 30 May 2019.

In Fig (3) for Tmax ≥ 46°C observed in northern parts of Rajasthan, Haryana, Delhi, Uttar Pradesh, Madhya Pradesh regions. In the NEPS raw forecast Tmax ≥ 46°C probabilities varying from 5-65% in isolated places over northern Rajasthan and Vidharbha region in Day-1 to Day-5 these probabilities wide spread over UP. Bihar, Jharkhand and AP. The bias corrected Tmax ≥ 46°C probabilities (65-96%) are very much organised and centred over the observed regions. However, bias correction for higher Tmax producing warm bias over Vidharbha region and probability varies from 5 to 35%.

References

1. Cui, B., Z. Toth, Y. Zhu, and D. Hou, 2012: Bias Correction for Global Ensemble Forecast. *Wea. Forecasting,* **27**, 396–10, https://doi.org/10.1175/WAF-D-11-00011.1
2. Glahn B 2012 Bias correction of MOS temperature and dewpoint forecasts; U.S. Department of Commerce National Oceanic and Atmospheric Administration, National Weather Service Office of Science and Technology,Meteorological Development Laboratory, MDL Office note 12-1.
3. Kalman R E 1960 A new approach to linear filtering and prediction problems; ASME. J. Basic Eng. 82(1) 35–45, https://doi.org/10.1115/1.3662552.
4. Lang, A. and Jenni-Louise Evans. Introduction to Tropical Meteorology 2[nd] edition. The COMET Program and National Center for Atmospheric Research.
5. Rajeevan M, Jyoti B, Kale J D and Lal B 2005 Development of a high resolution daily gridded rainfall data for Indian region; IMD Meteorological Monograph No: Climatology 22, Pune, India, 27p.
6. Srivastava A K, Rajeevan M and Kshirsagar S R 2009 Development of a high resolution daily gridded temperature data set (1969–2005) for the Indian region; *Atmos. Sci. Lett.* 10 249–254, https://doi.org/10.1002/asl.232.