The Seasonal Variability in Forecast Skill of a Lagged Ensemble Prediction System

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Introduction

The horizontal resolution and ensemble size of NCMRWF Global Ensemble Prediction System (NEPS-G) are 12-km and 23 (22 perturbed + 1 control) respectively. The control member and 11 perturbed members run from 00 UTC of current day and another set of 11 perturbed members (lagged members) run from previous day 12 UTC

Objective

1. To evaluate and compare the skill of operational 23-member ensemble (E23) and 11-member ensemble starting from 00 UTC (E00_11) in two contrasting seasons: Summer and Winter.

2. To compare the forecast skill of E23 with that of the ensemble formed by 22 members, all running from 00 UTC i.e., E00_22 with forecast data of one summer month i.e., June 2019 and one winter month i.e., January 2020.

Brief Description of NEPS-G

Horizontal Resolution (grid size)	12 km
Model time step	5 min
Grid Points	2048 × 1536
Ensemble Size	23 (22 perturbed + 1 control)
Initial condition perturbations	Perturbations in θ, π, q, u, & v by ETKF method and perturbations in SST, SMC & Deep Soil Temp
Physics Perturbations	Stochastic Kinetic Energy Backscattering (SKEB) and Random Parameter (RP) schemes
Long Forecast	10 days from 11 members, twice daily at 00 and 12 UTC

Data and Methodology

- **Forecast data:** NEPS-G forecast based on IC of 00 and 12 UTC
- **Verifying analysis:** For Temperature and wind data of deterministic analysis (also of 12 km resolution
- **Verification Methods:** Spread-RMSE relationship, Brier Skill Score (BSS), ROC Skill Score, Outlier Statistics

Results

Variables : Temperature 850 hPa (T850) and Zonal wind at 850 hPa (U850)
Verification Period: April-May-June 2019 (AMJ) and December 2019 and January 2020 (DJ) to compare skill of E00_11 and E23.
June 2019 (hereafter, JUN 2019) and January 2020 (hereafter, JAN 2020) to compare skill of E00_22 and E23.
Area of study: Northern Hemisphere (0° to 90°N) for T850 and tropical region which includes India (0°N-40°N, 60°E-110°E; RSMC region) for U850.

1. Spread –RMSE Relationship of E23 and E00_11

T850 **U850**

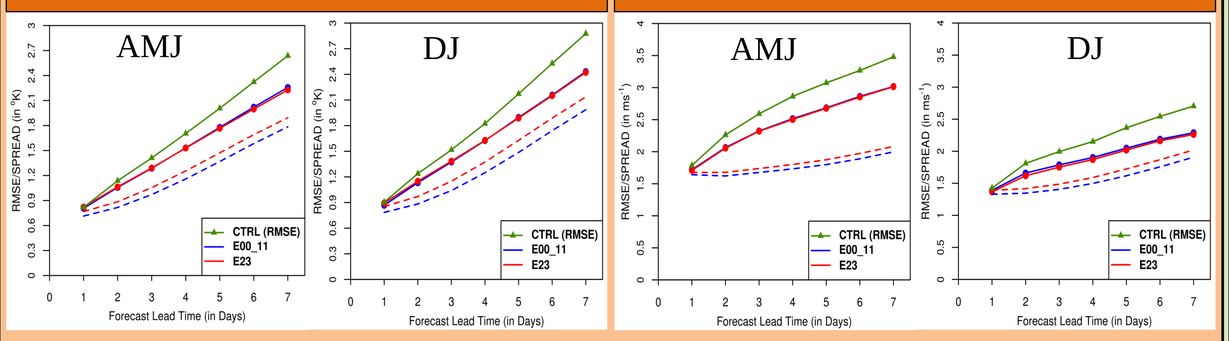

Figure 1. Variation of ensemble mean RMSE (solid lines with round symbol) and ensemble spread (dashed lines) with forecast lead time. Control member, E00_11 and E23 are indicated by green, blue and red lines, respectively.

2. Spread –RMSE Relationship of E23 and E00_22

T850 **U850**

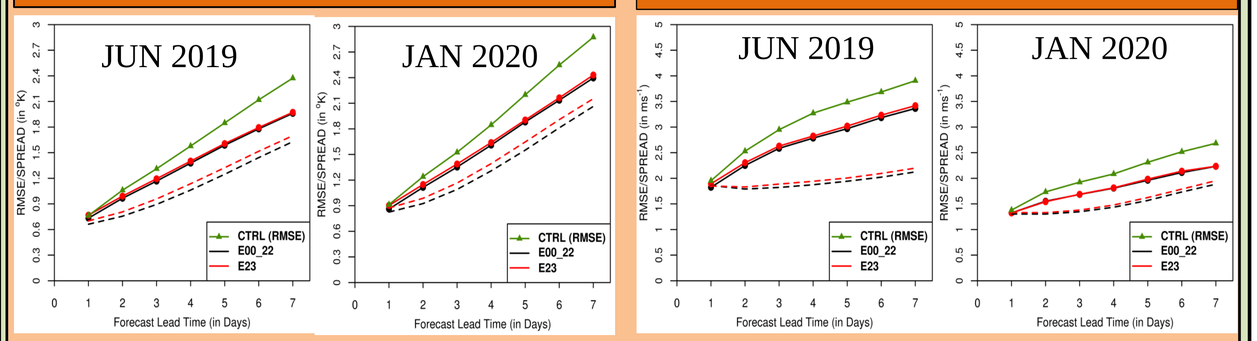

Figure 2. Variation of ensemble mean RMSE (solid lines with round symbol) and ensemble spread (dashed lines) with forecast lead time. Control member, E00_22 and E23 are indicated by green, black and red lines, respectively.

3. BSS of E23 and E00_11

T850 **U850**

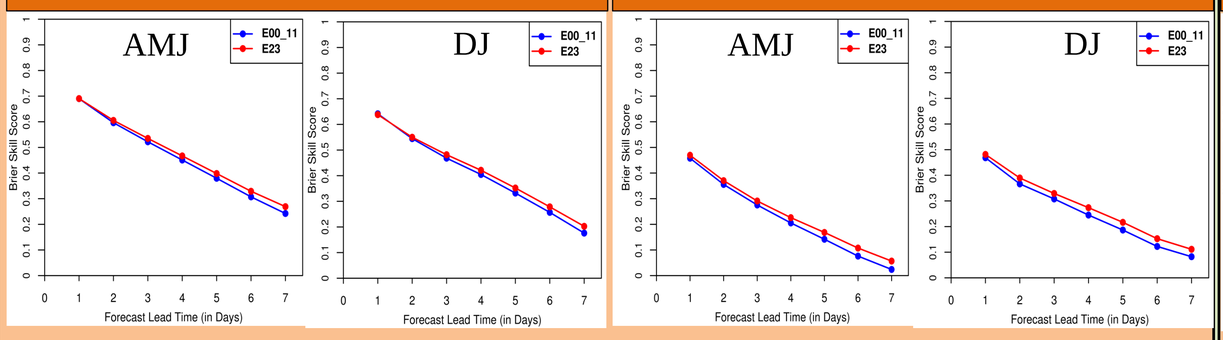

Figure 3. Variation of Brier Skill Score with lead time. E00_11 and E23 are indicated by blue and red lines, respectively.

4. Difference in BSS of E23 and E00_11

T850 **U850**

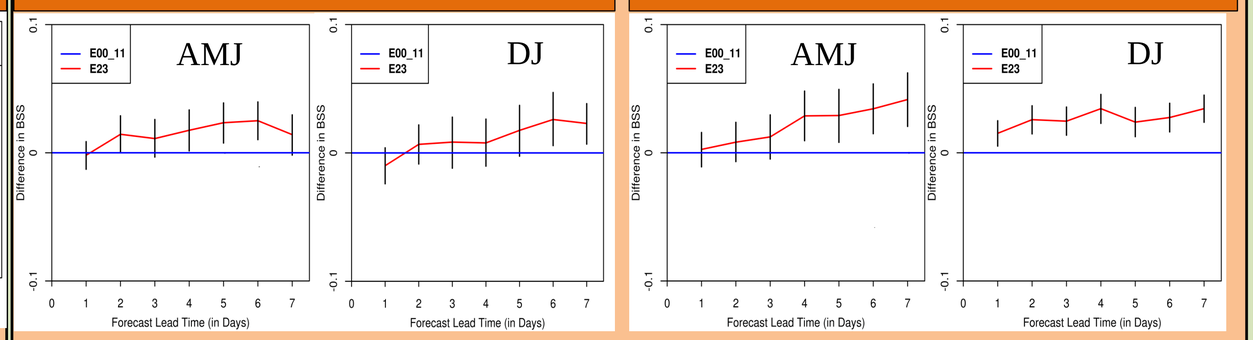

Figure 4. Variation of difference in Brier Skill Score of E23 (red) relative to E00_11(blue horizontal line) with lead time. Positive values indicate better skill than E00_11. Bars indicate significance at the 95% confidence interval using the bootstrap method.

5. ROC Skill Score of E23 and E00_11

T850 **U850**

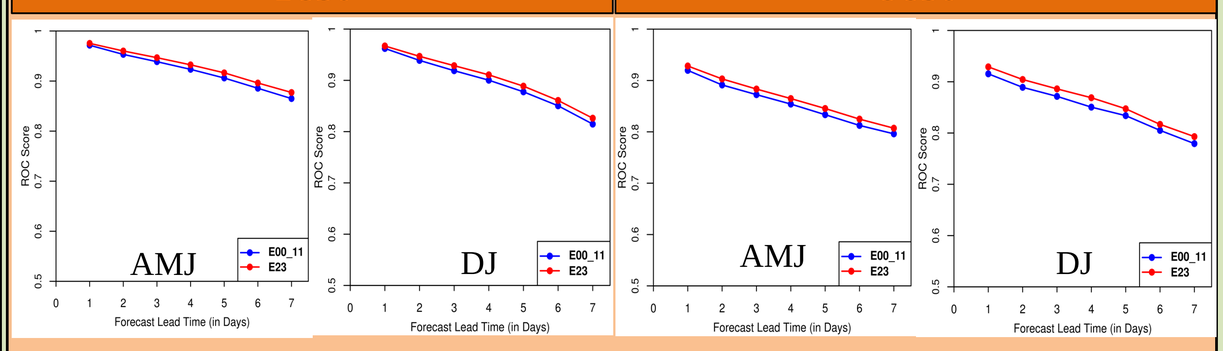

Figure 5. Variation of ROC Score with lead time. E00_11 and E23 are indicated by blue and red lines, respectively.

6. Outlier Statistics of E23 and E00_11

T850 **U850**

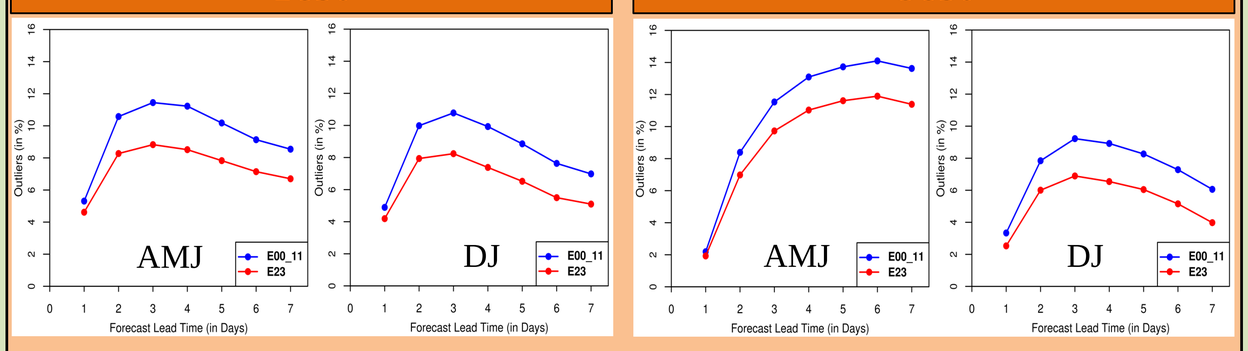

Figure 6. Variation of outliers (in %) with forecast lead time. Outlier values in plots are computed after subtracting the ideal base rate for a consistent ensemble i.e. 100*[2/(M + 1)], where M is the number of ensemble members. E00_11 and E23 are indicated by blue and red lines, respectively.

Conclusion

- The rate of growth of the ensemble mean RMSE and ensemble spread for all three configurations i.e., E00_11, E00_22, and E23 are greater in the winter than in the summer for T850 over NH, but the converse is true for U850 over the RSMC region.
- The faster error growth of T850 may be mainly due to the baroclinic instability which is more pronounced in the winter season over NH. On the contrary, the rate of error growth of U850 over the RSMC region (the major part of which lies in the tropical region) is faster in the summer season mainly due to the more active convective instability during this season.
- The E23 configuration is statistically more reliable, has better resolution, and is more accurate than E00_11. Also, E23 is nearly as skilful as E00_22 which requires larger computational resources.