Verification of NCMRWF CS EPS for Indian Summer Monsoon 2019

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NCMRWF, India
# Salient features of NCMRWF Ensemble Prediction Systems

## NEPS-Global (12km)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grid Points &amp; Resolution</strong></td>
<td>2048 x1536 12km</td>
</tr>
<tr>
<td><strong>Members</strong></td>
<td>22 perturbed +1 cntl</td>
</tr>
<tr>
<td><strong>Initial condition perturbations</strong></td>
<td>Perturbations in $\theta$, $\pi$, $q$, $u$, &amp; $v$ by ETKF method and perturbations in SST, SMC &amp; Deep Soil Temp</td>
</tr>
<tr>
<td><strong>Model Physics Perturbations</strong></td>
<td>Stochastic Kinetic Energy Backscattering and Random Parameter Schemes</td>
</tr>
<tr>
<td><strong>Observations Assimilated in NEPS</strong></td>
<td>AIRS, ATOVS, Aircraft, GOESClear, GPSRO, IASI, Satwind, Scatwind Sonde, Surface, SEVIRIClear, SSMIS</td>
</tr>
<tr>
<td><strong>Forecast length</strong></td>
<td>10 days</td>
</tr>
</tbody>
</table>

## NEPS-Regional (4km)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No of ensemble members</strong></td>
<td>Control + 11 members</td>
</tr>
<tr>
<td><strong>Driving model</strong></td>
<td>Global EPS- N1024 (NEPS-G)</td>
</tr>
<tr>
<td><strong>Domain</strong></td>
<td>67° E -98° E and 7° - 38° N</td>
</tr>
<tr>
<td><strong>Vertical levels</strong></td>
<td>80 levels up to 38.5 km</td>
</tr>
<tr>
<td><strong>Science configuration</strong></td>
<td>Proto-RA1T</td>
</tr>
<tr>
<td><strong>LBC frequency</strong></td>
<td>3hr</td>
</tr>
<tr>
<td><strong>Forecast Length</strong></td>
<td>75hrs</td>
</tr>
<tr>
<td><strong>Model time step</strong></td>
<td>60 seconds</td>
</tr>
<tr>
<td><strong>Convection</strong></td>
<td>Explicit</td>
</tr>
</tbody>
</table>
• Verification Period: August 1, 2019 - September 30, 2019
• Verification parameters: Precipitation and Zonal wind at 850 hPa
• Verifying data:
  (a) IMD-NCMRWF satellite & gauge merged precipitation of 0.25°×0.25° resolution
  (b) NCUM analysis of U at 850 hPa
• Verification Metrics: RMSE – Spread relationship, Rank histogram, Bias and RMSE of Ensemble Mean forecast, Reliability diagram, ROC, brier score and CRPS
• Quantitative Precipitation Forecast of a heavy rainfall event
• Performance of NEPS-R has been compared with that of NEPS-G
Rank Histogram for day-1 precipitation forecast
(Only for August 2019)

Precipitation bias (mm) of ensemble mean day-1 forecast

- NEPS-G shows larger wet bias due to overestimating light precipitation
- NEPS-R shows dry bias for light precipitation. The green bar at rank-1 may be due to the overestimation of heavy precipitation over some region including the area associated with Western Ghat.
- Both NEPS-G and NEPS-R are under-dispersive
Rank Histogram for day-2 precipitation forecast (Only for August 2019)

Precipitation bias (mm) of ensemble mean day-2 forecast
Increasing height of green bar at 13\textsuperscript{th} rank indicates \textbf{increasing dry bias} in NEPS-R forecast with forecast lead time.

Height of red bar at 1\textsuperscript{st} rank remains nearly same.

Both NEPS-R and NEPS-G are under-dispersive.
Rank Histograms for precipitation forecast (for August and September 2019)

- Increasing bar heights at 13th rank indicates increasing dry bias in NEPS-R forecast with forecast lead time.
- U shaped rank histograms indicates under-dispersive NEPS-R.

Day 1

Day 2

Day 3
Rank Histogram for Zonal wind speed at 850hPa
(for August and September 2019)

Positive bias increases with forecast lead time more in NEPS-G
Both NEPS-R and NEPS-G are under-dispersive which increases with forecast lead time
RMSE and Spread for Zonal wind speed at 850hPa

RMSE of NEPS-R is larger
Both NEPS-R and NEPS-G are under-dispersive during all forecast days
Reliability diagrams for precipitation forecast (for August and September 2019) exceeding 15.6 mm

Both NEPS-R and NEPS-G are over-confident in forecasting precipitation exceeding 15.6 mm/day.

NEPS-G is slightly more over-confident in forecasting precipitation exceeding 15.6 mm/day.
Reliability diagrams for precipitation forecast (for August and September) exceeding 15.6 mm.

Both NEPS-R and NEPS-G is over-confident in forecasting precipitation exceeding 15.6 mm/day.
Over-forecasting is more in NEPS-R than in NEPS-G for U at 850 hPa.
Reliability diagrams for $u$ at 850 hPa
(for August and September 2019)

Day 3

In day 3 forecast also NEPS-G shows better reliability than NEPS-R for U at 850 hPa.
ROC diagrams for precipitation forecast (for August and September); Precipitation Threshold – 15.6 mm

Day 1

NEPS-R

min(AUC) = 0.78
max(AUC) = 0.78

NEPS-G

min(AUC) = 0.82
max(AUC) = 0.82
ROC diagrams for precipitation forecast (for August and September); Precipitation Threshold – 15.6 mm

Day 3

NEPS-R

\[
\begin{align*}
\text{min}(\text{AUC}) &= 0.71 \\
\text{max}(\text{AUC}) &= 0.71
\end{align*}
\]

NEPS-G

\[
\begin{align*}
\text{min}(\text{AUC}) &= 0.79 \\
\text{max}(\text{AUC}) &= 0.79
\end{align*}
\]
ROC diagrams for $U$ at 850 hPa forecast (for August and September); Threshold = 1 sd

Day 1

**NEPS-R**

- $\min(AUC) = 0.87$
- $\max(AUC) = 0.87$

**NEPS-G**

- $\min(AUC) = 0.92$
- $\max(AUC) = 0.92$
Both NEPS-R and NEPS-G show good discrimination property.
NEPS-G exhibits better ability to discriminate between events and non events at all forecast lead times.
Brier Score for precipitation

NEPS-R precipitation forecast has more skill than NEPS-G but the skill declines fast with forecast lead time.
Brier Score and CRPS for U at 850 hPa

**Brier Score**

![Brier Score Graph](image)

**CRPS**

![CRPS Graph](image)

Both Brier Score and CRPS of NEPS-G is better for U at 850 hPa
CRPSS of NEPS-R is negative w.r.t NEPS_G but the skill is improving with forecast lead time.
Heavy precipitation event on 4\textsuperscript{th} August 2019
Ensemble Mean Precipitation forecast for Day-1 valid on 20190804

Observation

Ensemble Mean Precipitation

NEPS-R

NEPS-G
Both NEPS-R and NEPS-G predicts heavy rainfall well over Western Ghat. NEPS-R predicts rain with higher Probability over east Maharashtra.
NEPS-R predicts very heavy (>11.5 cm) precipitation with more than 90% probability. It also predicts Extremely heavy (19.5 cm) precipitation with more than 50% probability. NEPS-G didn’t predict extremely heavy precipitation.
Both NEPS-R and NEPS-G predicts heavy rainfall well over Western Ghat in day-3 Forecast also.
NEPS-R predicts very heavy (>11.5 cm) precipitation in day-3 forecast with more than 70% probability over small areas of Western Ghat. It also predicts Extremely heavy (19.5 cm) precipitation with probability greater than 30% over some area. NEPS-G couldn’t predict extremely heavy precipitation.
Member tracks and strike probability for TC Fani

NEPS-R_4km: Forecast tropical storm tracks for FANI from 00UTC 01/05/2019

NEPS-R_4km: Forecast tropical storm strike probability for FANI from 00UTC 01/05/2019

Observation

Ens Mean

Control
Storm Following EPSGRAM

IC: 00Z 20190429

NEPS-G

NEPS-G 12km REGfani ensemble: Tropical Cyclone storm-following meteogram FANI (8.3N 87.4E) from 00UTC 29 April 2019

- Number of ensemble members tracked
- 10m wind maxima within 5 degree radius (kn)
- Mean sea level pressure minima (hPa)

NEPS-R

NEPS-R 4km 500 ensemble: Tropical Cyclone storm-following meteogram FANI (8.3N 87.4E) from 00UTC 29 April 2019

- Number of ensemble members tracked
- 10m wind maxima within 5 degree radius (kn)
- Mean sea level pressure minima (hPa)

--- Median ---

Rapid Intensification of “Fani” in NEPS-R
Initially CTE of NEPS-R is large but after 12 hours it does not exceed 40 km.

After 30 hours DPE of NEPS-R track becomes less than NEPS-G track.
• NEPS-R precipitation forecast has high positive bias over west coast. **High resolution observation is required for better validation.**

• Dry bias for light precipitation in NEPS-R forecast increases with forecast lead time.

• Both NEPS-R and NEPS-G are under-dispersive for U at 850 hPa and also for precipitation.

• Both NEPS-R and NEPS-G have good discrimination property.

• RMSE of NEPS-R is more for u at 850 hPa.

• NEPS-R has positive BSS for precipitation w.r.t NEPS-G but skill score decreases with forecast lead time.

• Both Brier Score and CRPS of NEPS-G for u at 850 hPa is better.

• NEPS-R is successful in predicting very heavy and extremely heavy precipitation with higher probability over west coast.
Thanks