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RESEARCH REPORT

Performance of Rainfall Predictionof NCMRWF Global Models during the South-West Monsoon 2015

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10	Abstract	The real time rainfall forecasts based on two state-of-art high resolution global models are verified during the South-West Monsoon (June-September) of 2015.The unified model operational at National Centre for Medium Range Weather Forecasting (NCUM) and Global Forecast System at NCMRWF (NGFS) are used in this report. NCUM performs better; in terms of rainfall organization and rainfall amounts. This is adequately supported by the higher forecast skill scores in NCUM compared to NGFS. An object-based spatial verification method, namely Contiguous Rain Areas (CRA) has also been discussed in predicting the heavy rain events that occurred due to the deep depression formed over Gujarat and neighbouring region. CRA verification also confirms the better performance of NCUM over NGFS.
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Abstract

The real time rainfall forecasts based on two state-of-art high resolution global models areverified during the South-West Monsoon (June-September) of 2015. The forecasts from the unified model operational at National Centre for Medium Range Weather Forecasting (NCUM) and Global Forecast System at NCMRWF (NGFS) are evaluated in this report. NCUM performs better; in terms of rainfall organization and rainfall amounts. This is adequately supported by the higher forecast skill scores in NCUM compared to NGFS. An object-based spatial verification method, namely Contiguous Rain Areas (CRA) has also been discussed in predicting the heavy rain events that occurred due to the deep depression that formed over Gujarat and neighbouring region. CRA verification also confirms the better performance of NCUM over NGFS.

Key Words - Rainfall, South-West Monsoon, NCUM, NGFS, CRA

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1. Introduction

The rainfall during the south-west monsoon season (June to September) contributes to over 75% of the annual rainfall (Deshpande and Singh, 2010) in most parts of the Indian subcontinent and is the lifeline for agriculture and economy of the entire region. Prediction of monsoonal rain gets great attention due to its geo-economic implications. The south-westerly flow which leads to moisture build up in the lower troposphere brings widespread rainfall over India during the monsoon season. The monsoon rainfall occurs due to many sporadic weather events having spatial scales from 100 to 1000 km. The daily and weekly rainfall during the season poses a significant forecasting challenge in Numerical Weather Prediction (NWP). This is due to complex interactions involving topography, treatment of synoptic scale systems, and mesoscale convective systems and limited availability of good quality high-resolution observations over land and neighbouring seas.

2. Data and methodology

The performance of the two global models for medium range rainfall prediction over India during summer monsoon (JJAS) of 2015 has been evaluated. The first model is a variant of the National Center for Environmental Prediction (NCEP) Global Forecast System (GFS) run in real time at NCMRWF. UK Met office's Unified model has also been implemented at the centre which is referred as NCMRWF's Unified Model (NCUM). The two global forecast models, NGFS and NCUMhave a horizontal resolutionof T574L64 (~22 km in tropics) and N768L70 (~17 km in Mid-latitudes) respectively. Model predictions are based on the initial condition of 00UTC. Additional details about the deterministic models, NGFS and NCUM can be found at Prasad et al, (2011) and Rajagopal et al. (2012) respectively. The evaluation has been carried out for all 5 days ofprediction; however, the results of Day-1,Day-3 and Day-5 forecasts are only discussed. Detailed quantitative rainfall forecast verification presented here based on the IMD-NCMRWF daily high resolution (0.5°) rainfall analysis (Mitra et al. 2009, 2013). This is the merged data based on satellite and gauge at 0.5° x 0.5° resolution. The model forecast outputsare gridded to the 0.5° observed rainfall grids over Indian land regions for 122 days from 1st June to 30th September 2015.

This report is organized as described below. In the next section the mean and maximum JJAS 2015 monsoon rainfall long with Mean error and Root Mean Square Error (RMSE) over India are discussed. A brief analysis on the daily all-India rainfall series is also presented in the same section. Section 4deals with the verification statistics based on contingency table for thresholds of rainfall exceeding of 0.01, 0.02, 0.04, 0.08, 0.16, 0.32, 0.64, 1.28, 2.56, 5.12 & 10.24 cm in a day and the verification scores for the extreme rainfall. Section 5 covers the spatial verification using Contiguous Rain Area (CRA) method of a heavy rainfall event over Gujarat and adjoining areas. The summary of the report has been discussed in Section 6.

3. Mean, Maximum and RMSE of Rainfall over India

Figure 1 shows the observed and forecast mean monsoon (JJAS) rainfall (cm/day) over the India. As shown in the top panel of Figure1 (Obs), the seasonal mean rainfall along the west coast of India exceeded 2.5 cm/day except over southern tip of the west coast. Predictions from both models are in good agreement with the observations and clearly indicate mean rainfall excess of 2.5 cm/day all along the western coast. Over central and eastern India observed mean rain exceeds 0.6 cm/day (core monsoon) covering a large area with isolated pockets of higher (>1.5 cm/day) mean rainfall amounts. This broad structure of the core monsoon rain is fairly captured by both models. One noticeable feature of rainfall along the foot hills of Himalayis that NCUM is in very good agreement with the observations while in NGFS the rainfall distribution is isolated and patchy.The dry areas in the observations over parts of Uttar Pradesh areseen in Day-1 forecasts of both NGFS and NCUM whileDay-3 and Day-5 forecasts of both models clearly overpredict the rainfall. Rainfall is also overpredicted overnortheast India on all days by NCUM and NGFS. The All India Summer Monsoon Rainfall (AISMR) for Monsoon 2015 reported by IMD was 76.7 cm. Table 1 shows the observed (IMD-NCMRWF gridded) and model predicted accumulated rainfall values over India during June ï September 2015. The total rainfall is overpredicted byNCUM while NGFS underpredicts the rainfall at all lead times.

A comparison of the observed and forecast extreme rain during JJAS 2015 is presented in Figure 2. The plots show the highest rainfall in the season at each grid. Observations over central India, North Gujarat and eastern parts of India show several grids with the highest rainfall of over 10cm/day with isolated pockets of highest rain of over 15 cm/day. The NCUM forecasts prominently show similarity with the observations in Day-1 over Central India and North Gujarat while the peak is missing in NGFS. But both the models fairly capture maximum rainfall in some isolated pockets of eastern India. Maximum rainfall in Day-3 and Day-5 forecast over central India shows a shift to the east. Maximum rainfall over pockets of north-eastern states is captured fairly well by both models in all days of model prediction. Maximum rain predicted over Eastern coast of India (especially over the ocean, near Visakhapatnam) is found to beoverpredicted at all lead times.

The errors in Day-1, Day-3 and Day-5 model predictions in terms of Root Mean Square Error (RMSE) has been presented in Figure 3.

The Root Mean Squared Error is defined as

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2}$$

Where

Fi and O_i represent forecast and observed fields respectively for *N* days. The RMSE gives the average magnitude of the forecast error. While RMSE is a good measure of accuracy, it does not indicate the direction of the deviations. With values ranging from 0 to Đ, *RMSE* puts greater influence on large errors than smaller errors, which may be a good thing if large errors are especially undesirable, but may also encourage a conservative forecasting. RMSE shown in the Figure 3 and in Table 2 are similarin both the models.

The daily time series of the rainfall averaged over India (land points alone, region: 7-38.5^{0}N, 67-100.5^{0}E) is presented in Figure 4 from the observations and modelpredictions. The top, middle and lower panels show the Day-1, Day-3 and Day-5 forecasts along with the observations. Table 3 gives the correlation coefficients (r) for observed v/s predicted rainfall for both models. NCUM model predicted rainfall show higher correlations than NGFS at all lead times. However, correlation coefficient decreases as the lead time increases.

4. Rainfall Forecast Skill Score

Detailed and quantitative rainfall verification is presented in this section using the IMD-NCMRWFôs 0.5° daily rainfall data for the entire period of JJAS 2015 based on the components of contingency table. A large variety of categorical statistics is computed from the elements in the contingency table to describe particular aspects of forecast performance. The verification statistics are for thresholds of rainfall excess of 0.01, 0.02, 0.04, 0.08, 0.16, 0.32, 0.64, 1.28, 2.56, 5.12 and 10.24 cm in 24 hours. Based on the components of the contingency table, various statistical score like Equitable Threat Score (ETS) (Mesinger and Black,1992), Probability of Detection (POD) (Donaldson et al., 1975), Bias and False Alarm Ratio (FAR) (Donaldson et al., 1975) are computed.

4.1 Categorical Verification Scores

ETS measures the fraction of events that are correctly predicted accounting for hits by random chance. High ETS would imply that there is a large number of correctly predicted forecast entities near to the location of the matching observed entities (hits) and a lesser number of forecast entities far away from the observations (misses and false alarms). Figure 5a shows ETS for above mentioned various thresholds valid for Day-1, Day-3 and Day-5 forecasts during JJAS 2015. NCUM and NGFS show similar skill in terms of ETS till rainfall threshold of 0.16 cm/day. But ETS is marginally higher for rainfall thresholds beyond 0.32 cm/day in all days for NCUM.

POD is defined as the fraction of observed events that were correctly predicted therefore a high POD indicates good forecast skill of a model. In the current case, a high POD would imply that many forecast entities with intensities approximately matching the observations were lying close enough to the observed entities. POD for different thresholds valid for Day-1, Day-3 and Day-5 forecastsduring JJAS 2015 is shown in Figure 5b. It is seen that POD is consistently higher for NCUM (Day-1, Day-3 and Day-5) when compared to NGFS.

The bias score is a measure of the agreement between the forecast frequency of "yes" events and the observed frequency of "yes" events. It is given by the ratio of the frequency of forecast events to the frequency of observed events. The bias score does not measure how well the forecast corresponds to the observations, it only measures relative frequencies. The score values range from 0 to infinity and the score of 1 implies a perfect forecast. It indicates whether the forecast system has a tendency to underpredict (BIAS <1) or overpredict (BIAS>1) events. Figure 5c presents the Bias for different thresholds valid for Day-1, Day-3 and Day-5 forecasts during JJAS 2015. It can be seen from the figure that NCUM overpredicts the rainfall for all thresholds except for the threshold 10.24 cm/day when compared to NGFS.

FAR is defined as the fraction of predicted events which actually did not occur. The value of FAR ranges from 0 to 1 and score of 0 implies a perfect score. It is very much sensitive to false alarms it ignores the number of misses.The FAR can be controlled by deliberately underforecasting the event; such a strategy risks increasing the number of missed events, which is not considered in the FAR. For this reason, the POD and the FAR should both be considered for a better understanding of the performance of the forecast. Figure 5d presents FAR for different thresholds valid for Day-1, Day-3 and Day-5 forecasts during JJAS 2015. NCUM and NGFS show similar skill in terms of FAR for all lead times.

4.2. Verification Scores for Extreme rainfall

Categorical scores (like ETS, POD etc) are less skillful for higher thresholds (Ashrit et al., 2015). These scores could be used to monitor the forecast performance and model improvements. It can be seen from the Figure 5 that categorical scores decreases drastically especially in higher rainfall thresholds at all lead times. To address this issue, Ferro and Stephenson (2011) introduced a new set of categorical scores *viz.* Extreme Dependency Score (EDS), Extremal Dependence Index (EDI) and Symmetric EDI (SEDI) which is collectively called as EDS family of scores. Jolliffe and Stephenson (2011) and Wilks (2011) provide detailed descriptions of these scores. These scores measure the association between the observed and predicted rare events. These scores range from -1 to 1 with 0 meaning no skill and 1 indicating the perfect score. Though EDS does not approach 0, it has several undesirable properties like it has base rate dependence, sensitivity to hedging, varies from -1 to 1 etc. EDI and SEDI overcome most of the drawbacks since they have a non-degenerate limit, and are base-rate independent, insensitive to hedging etc. (Ferro and Stephenson, 2011).

It can be seen from Figure 6a, b and c that these scores do not converge to trivial values even at higher rainfall thresholds. Further, these scores allow one to examine the relative difference in the model to model skill. Thus, EDI and SEDI make very useful candidates for forecast model intercomparison for extreme rainfall forecasts. The EDS family of scores in Figure 6 a, b and c indicate that NCUM performs better compared to NGFS even at higher thresholds.

5. Spatial Verification of Heavy Rainfall event

During the South-West Monsoon 2015, two deep depressions occurred between 22 ï 24 June and another over land between 27-30 July. Both deep depressions were short-lived and occurred over the north-western part of India. Contiguous Rain Areas (CRA) method has been used to verify these two heavy rainfall events. But for brevity, rainfall verification associated with deep depression during 27-30 July 2015 is discussed.

The second deep depression (27-30 July) formed over southwest Rajasthan and neighbourhood. It concentrated into a depression over the Southwest Rajasthan near 26.2°N & 71.8°E, at 1200 UTC on 27th July. It intensified into a deep depression and lay over southwest Rajasthan and adjoining Gujarat near 24.8°N &71.8°E at 0300 hours UTC of 28th July. Moving north-north-eastwards, it weakened into a depression over west Rajasthan near 27.2°N & 73.0°E, at 0300 UTC on 29th July.

Spatial verification of predictionof 29th July heavy rainfall event by NGFS and NCUM using Contiguous Rain Area (CRA) method is discussed in this section. CRA method is an object-oriented method which verifies the properties of spatial forecasts of entities, where an entity is anything that can be defined by a closed contour. For each entity that can be identified in the forecast and the observations, CRA verification uses pattern matching techniques to determine the location error, as well as errors in the area, mean and maximum intensity, and spatial pattern. The total error can be decomposed into components due to location, volume, and pattern error. The detailed description of the method is available in Ebert and McBride (2000) and Ebert and Gallus (2009).

Figure 7a shows the observed and NCUM forecast (Day-1) rainfall over Gujarat. The 40 mm/day contour isolates the regions of greatest interest. The Day-1 forecast successfully captures the highest rainfall exceeding 16cm/day, although observations have it at two locations. The heaviest rainfall was forecast slightly to the south-west (0.7°) of where it actually occurred, as shown by the arrow. If it had been forecast in the correct location correlation coefficient would have been 0.57 (instead of 0.24). The highest rainfall amount is underpredicted while rain intensity and volume are well predicted. Error decomposition suggests that the pattern error (55%) and displacement errors (42%) both contributing significantly. CRA verifications for Day-3 (Figure 7b) and Day-5 (Figure 7c) predictions by NCUM are also presented. The Day-3 forecasts show highest rainfall amounts (347mm) comparable to the observations. However, the rainfall intensity and volume are underestimated due to smaller spatial coverage. The heaviest rainfall was predicted to the north-west (2.7°) of where it actually occurred, as shown by the arrow. If it had been forecast in the correct location the RMSE would have been 80mm/day (instead of 118mm/day) correlation coefficient would have been 0.49 (instead of -0.32). The Day-3 forecast has larger displacement error contribution to total error compared to Day-1 forecast. The Figure 7c shows the CRA analysis for Day-5 forecast in which spatial coverage of the 40 mm/day object covers a large area. The rainfall intensity, volume and highest rain amount are all underestimated. The location error (2.5°) is indicated by an arrow.

Similar CRA comparison between analysis and Day-1, Day-3 and Day-5 forecast obtained from NGFS valid of 29 July 2015 is also shown in Figure 8 (a), 8(b) and 8(c) respectively. Day -1 forecast fails to capture the high rainfall exceeding 16cm/day. If it had been forecast in the correct location correlation coefficient would have been 0.53 (instead of -0.11). The forecast highest rainfall amount and volume are underestimated. Error decomposition suggests that the contribution of pattern error (54%) and displacement errors (45%) are both significant. Day-3 forecast (Figure 8b) shows highest rainfall is overestimated and rainfall volume is underestimated. Day-5 forecast is so poor that it could not perform the error decomposition. This is the case of observation-forecast pairs being completely different.

6. Summary

This report summarizes the performance of NCUM and NGFS model in terms of predicting the rainfall during the JJAS 2015. The verification shows:

- NCUM (*NGFS*) predicts higher (lower) seasonal accumulated rainfall amount by 11% (*10%*) in Day1, 14% (*8%*) in Day-3 and 6% (*4%*) in Day-5 forecast with respect to observations.
- NCUM and NGFS show similar RMSE and FAR at all lead times
- The time series analysis of all-India rainfall from NCUM (NGFS) shows a higher (lower) correlation of 0.43 (0.29), 0.38 (0.24) and 0.34 (0.23) with the observations on Day-1, Day-3 and Day-5 respectively.
- ETS is almost similar for rainfall threshold of up to 0.16 cm/day while NCUM performs better for higher thresholds above 0.32 cm/day than NGFS
- POD computed for different rainfall thresholds shows that NCUM has higher skill score as compared with NGFS at all lead times
- Analysis of bias score shows that NCUM overpredicts the rainfall for all thresholds except for the threshold 10.24 cm/day as compared to NGFS
- Verification using the EDS family of the scores confirms that NCUM performs better than NGFS even at higher thresholds.
- CRA verification of heavy rainfall over Gujarat region shows that the performance of NCUM is better than NGFS in predicting the event.

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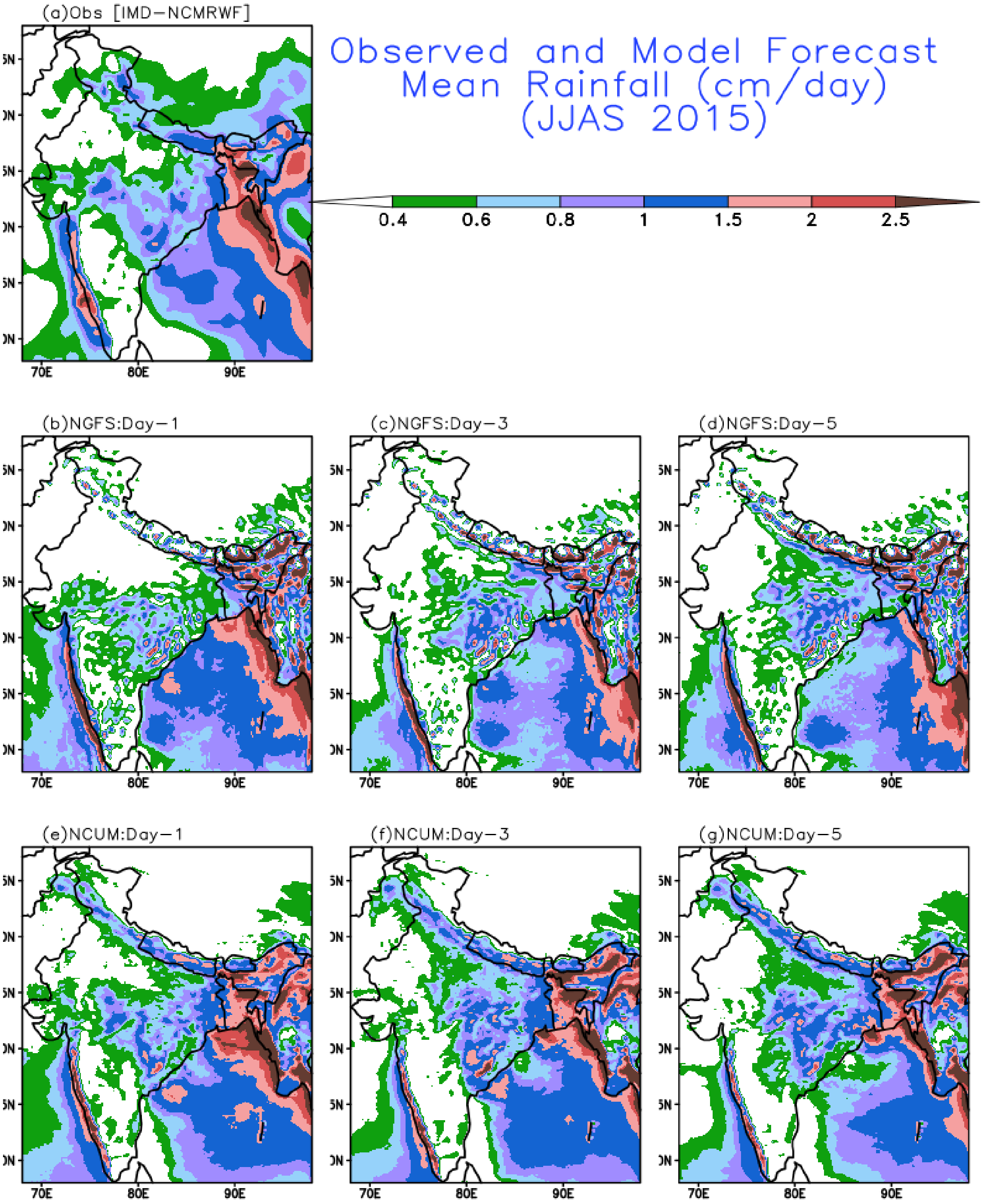


Figure 1 : Observed and Model predicted mean monsoon (JJAS) rainfall over India during June-Sept 2015

MODELS	**Day-1**	**Day-3**	**Day-5**
NCUM	89.7	91.9	85.8
NGFS	72.1	73.6	76.3
OBS (IMD-NCMRWF) merged gridded rainfall = 80.3			

Table 1 : Observed (IMD-NCMRWF) and Model Predicted accumulated rainfall values (cm) over India during JJAS -2015

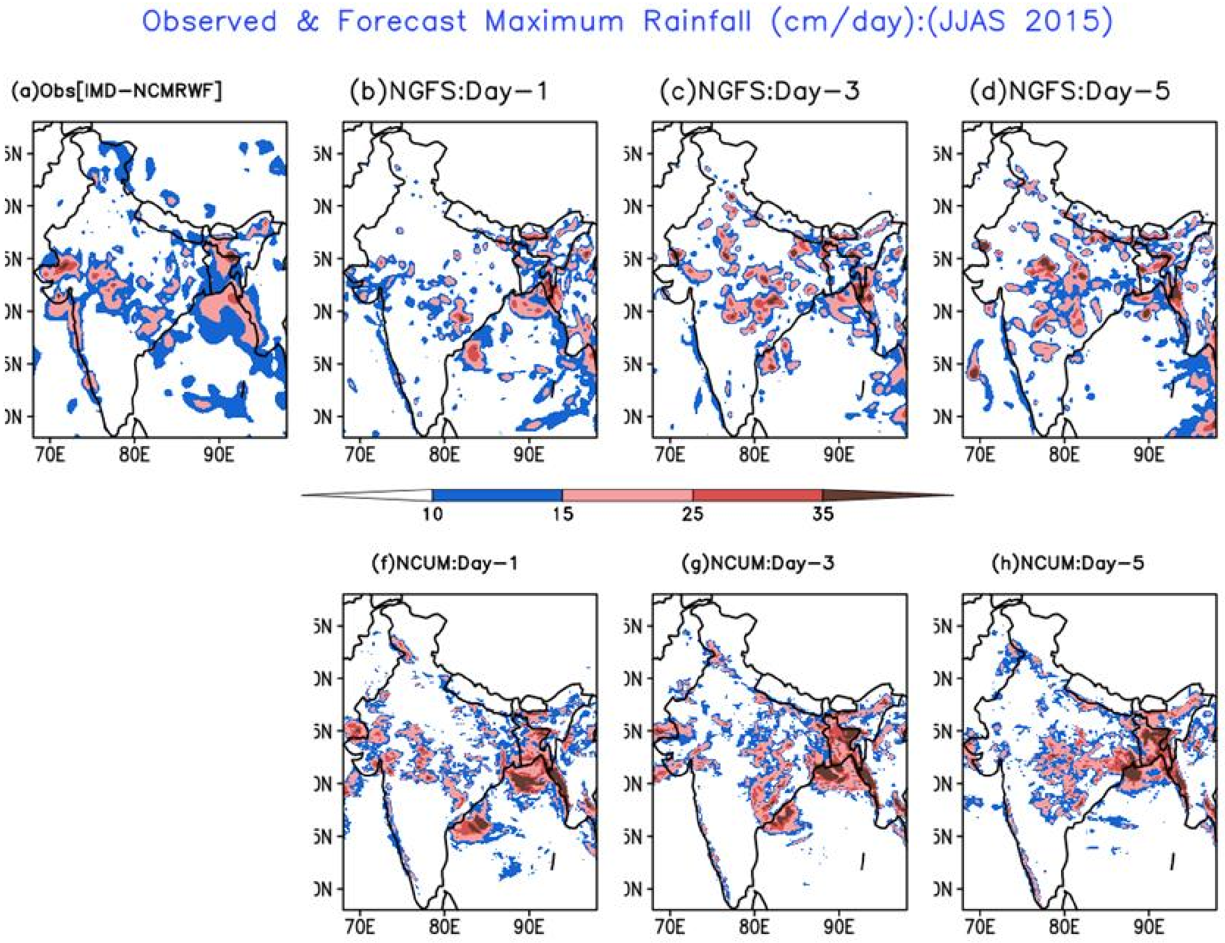


Figure 2: Observed and Model predicted Maximum rainfall over India during June-Sept 2015

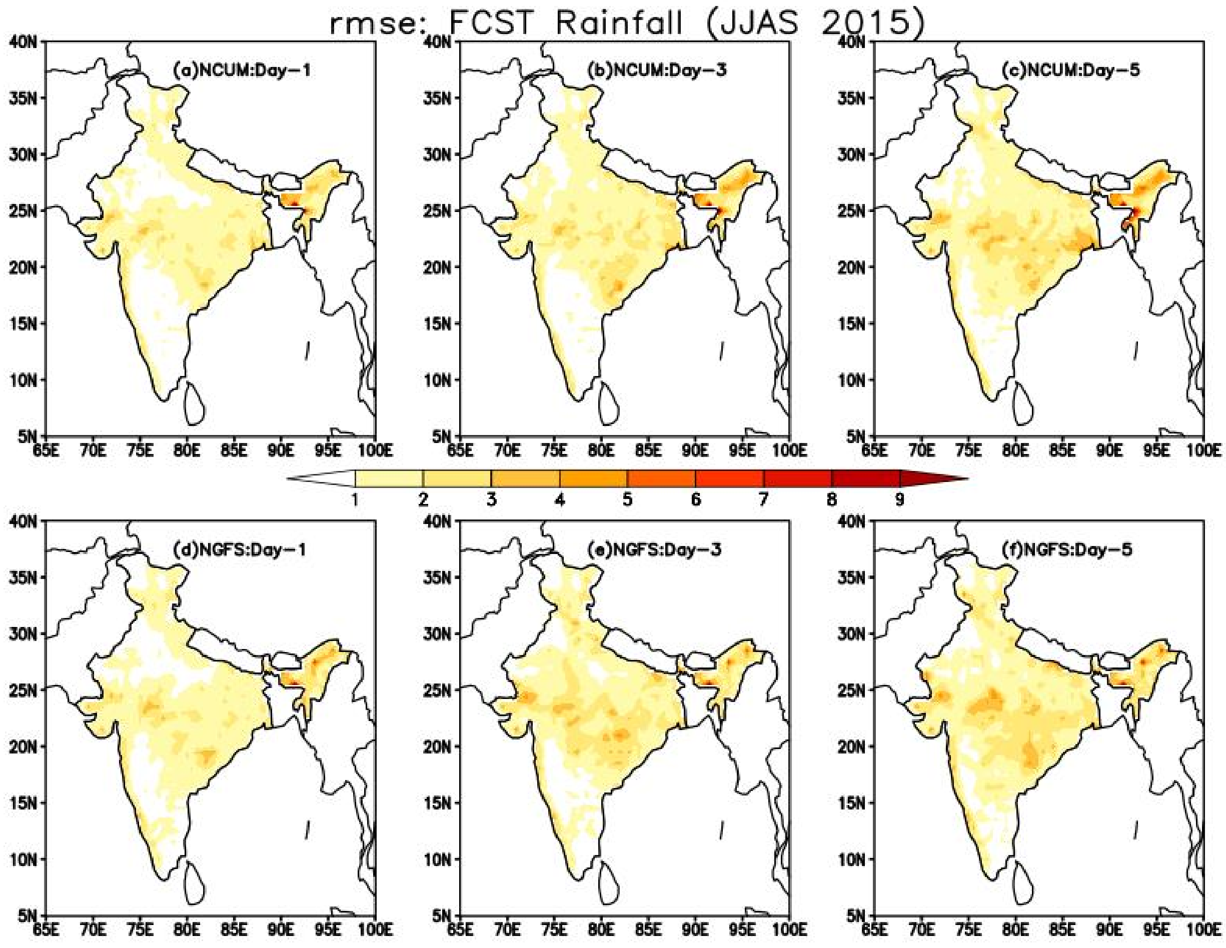


Figure 3: Root Mean Square Error (RMSE) for the predicted rainfall over the Indian land grids during JJAS 2015

MODELS	**Day-1**	**Day-3**	**Day-5**
NCUM	1.5	1.7	1.9
NGFS	1.6	1.7	1.9

Table 2: RMSE: Observed Vs Model predicted daily rainfall Time Series

MODELS	**Day-1**	**Day-3**	**Day-5**
NCUM	0.43	0.38	0.34
NGFS	0.29	0.24	0.23

Table 3: Correlation coefficient: Observed Vs Model predicted daily rainfall Time Series

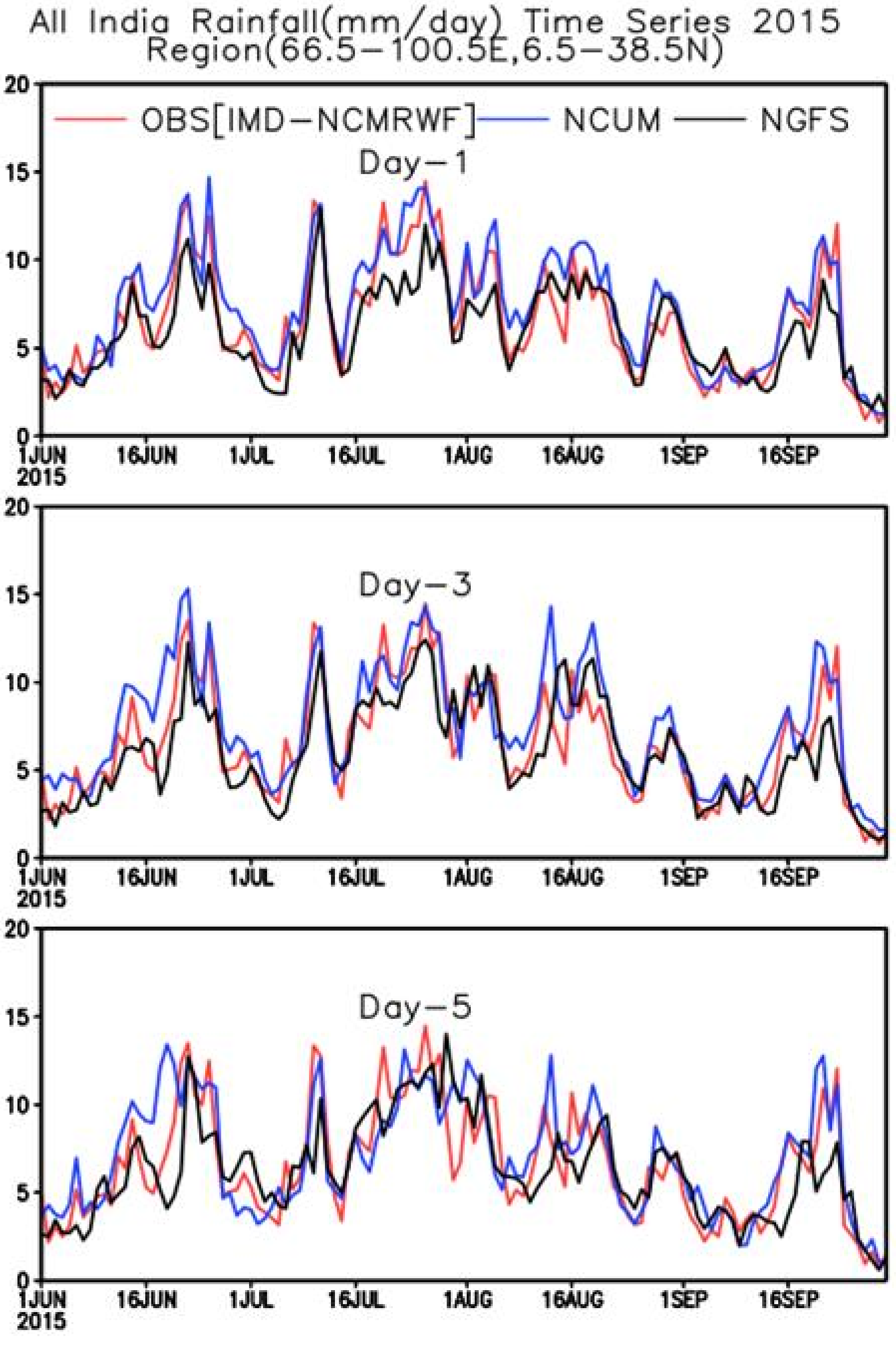


Figure 4: All-India time series of the observed, NCUM and NGFS forecast rainfall

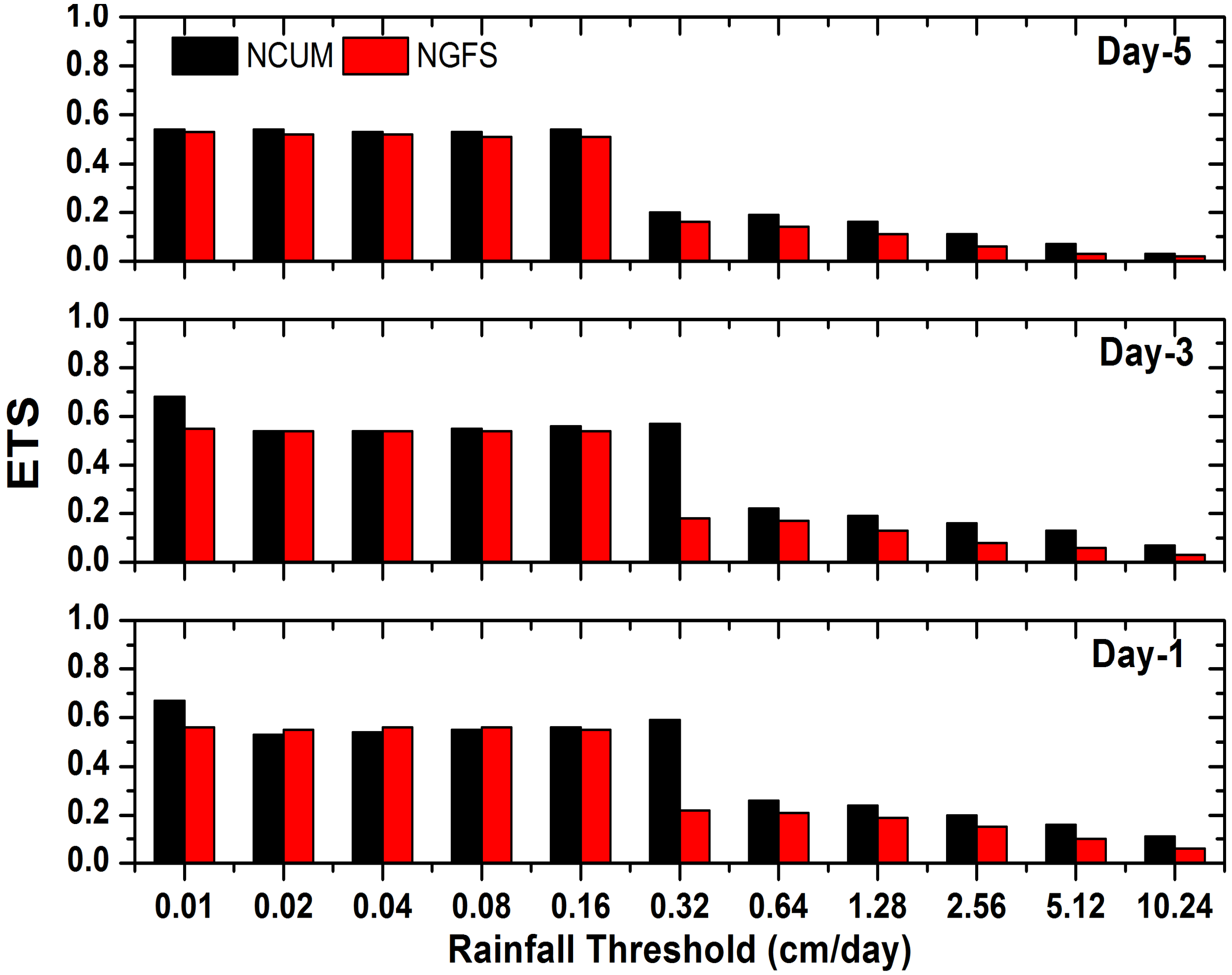


Figure 5a Bar Graph showing Equitable Threat Score (ETS) for NCUM (black bars) and NGFS (red bars) for Day-1 (Bottom Panel), Day-3(Middle panel) and Day-5 (Top panel) forecasts valid for JJAS 2015.

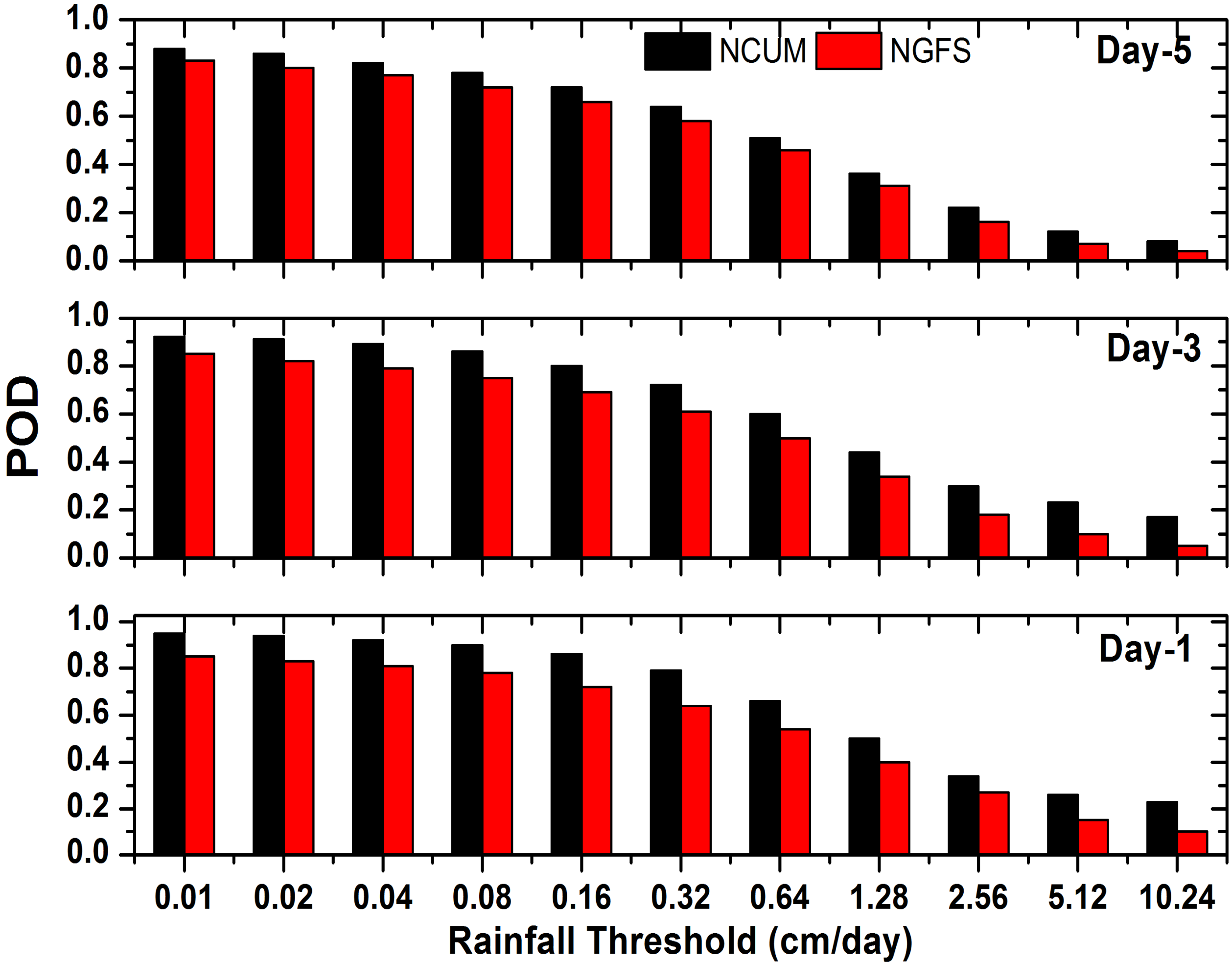


Figure 5b: Bar Graph showing Probability of Detection (POD) for NCUM (black bars) and NGFS (red bars) for Day-1 (Bottom Panel), Day-3(Middle panel) and Day-5 (Top panel) forecasts valid for JJAS 2015.

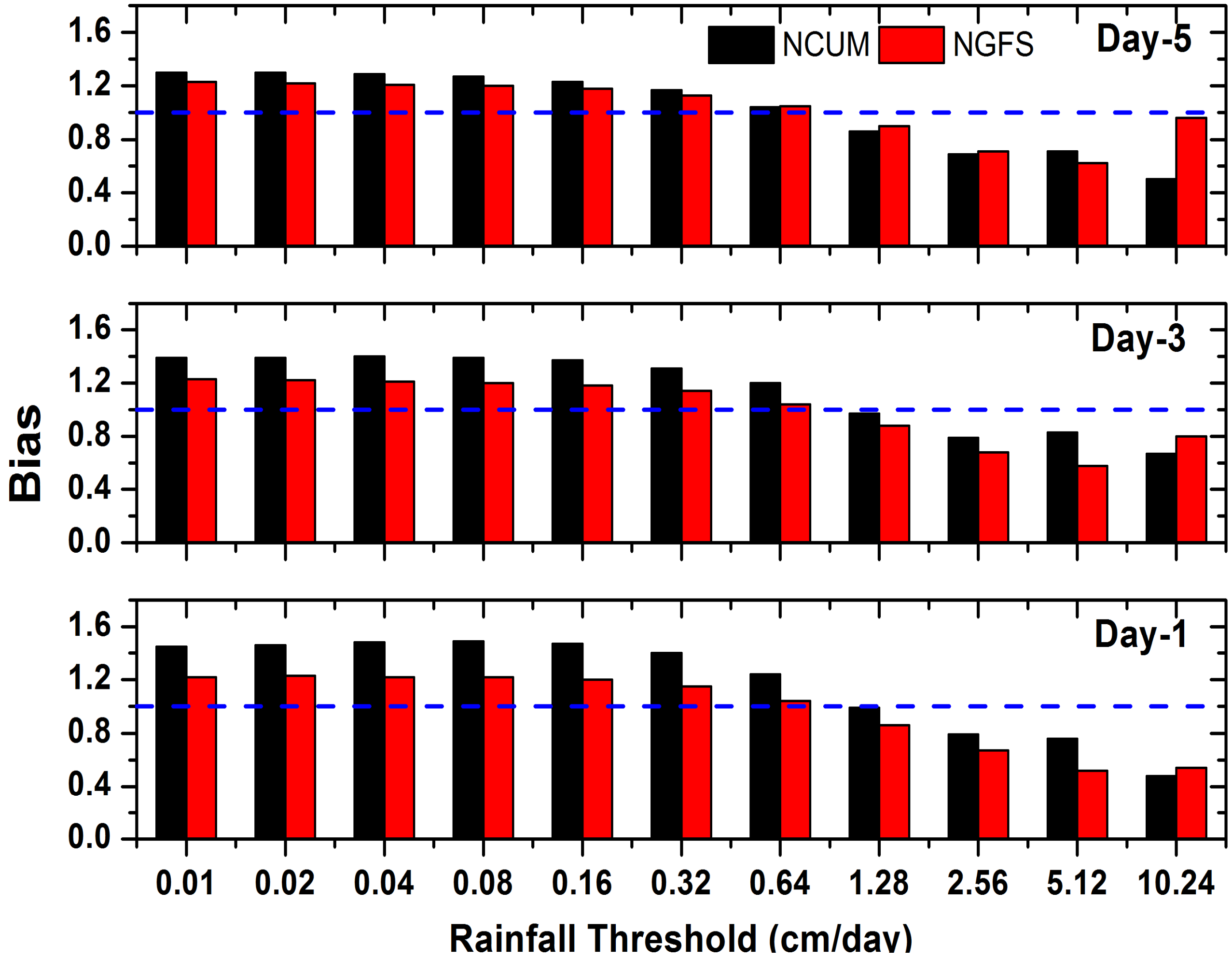


Figure 5c: Bar Graph showing rainfall Bias for NCUM (black bars) and NGFS (red bars) for Day-1 (Bottom Panel), Day-3(Middle panel) and Day-5 (Top panel) forecasts valid for JJAS 2015

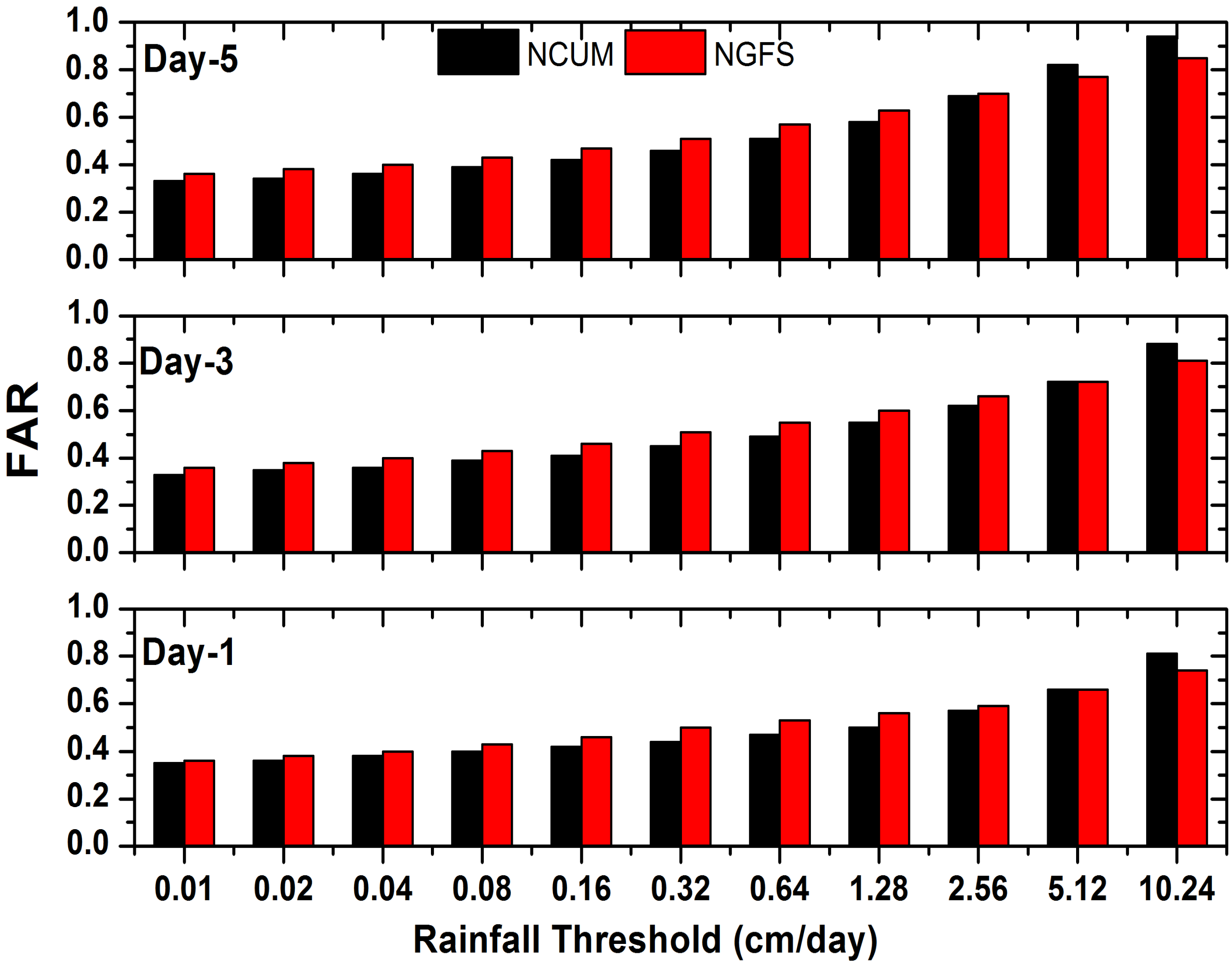


Figure 5d: Bar Graph showing False alarm ratio (FAR) for NCUM (black bars) and NGFS (red bars) for Day-1 (Bottom Panel), Day-3(Middle panel) and Day-5 (Top panel) forecasts valid for JJAS 2015

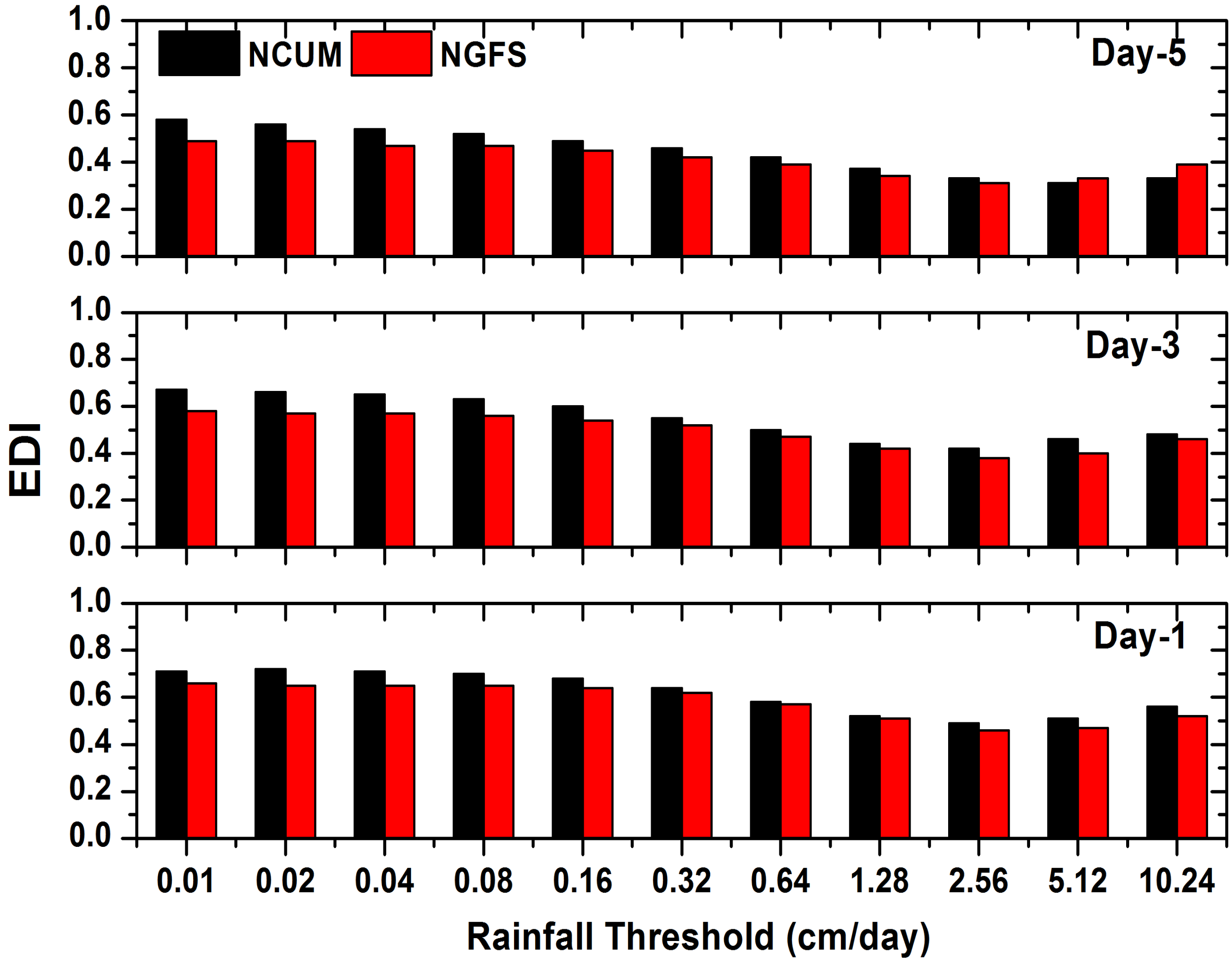


Figure 6a: Bar Graph showing Extremal Dependence Index (EDI) for NCUM (black bars) and NGFS (red bars) for Day-1 (Bottom Panel), Day-3(Middle panel) and Day-5 (Top panel) forecasts valid for JJAS 2015

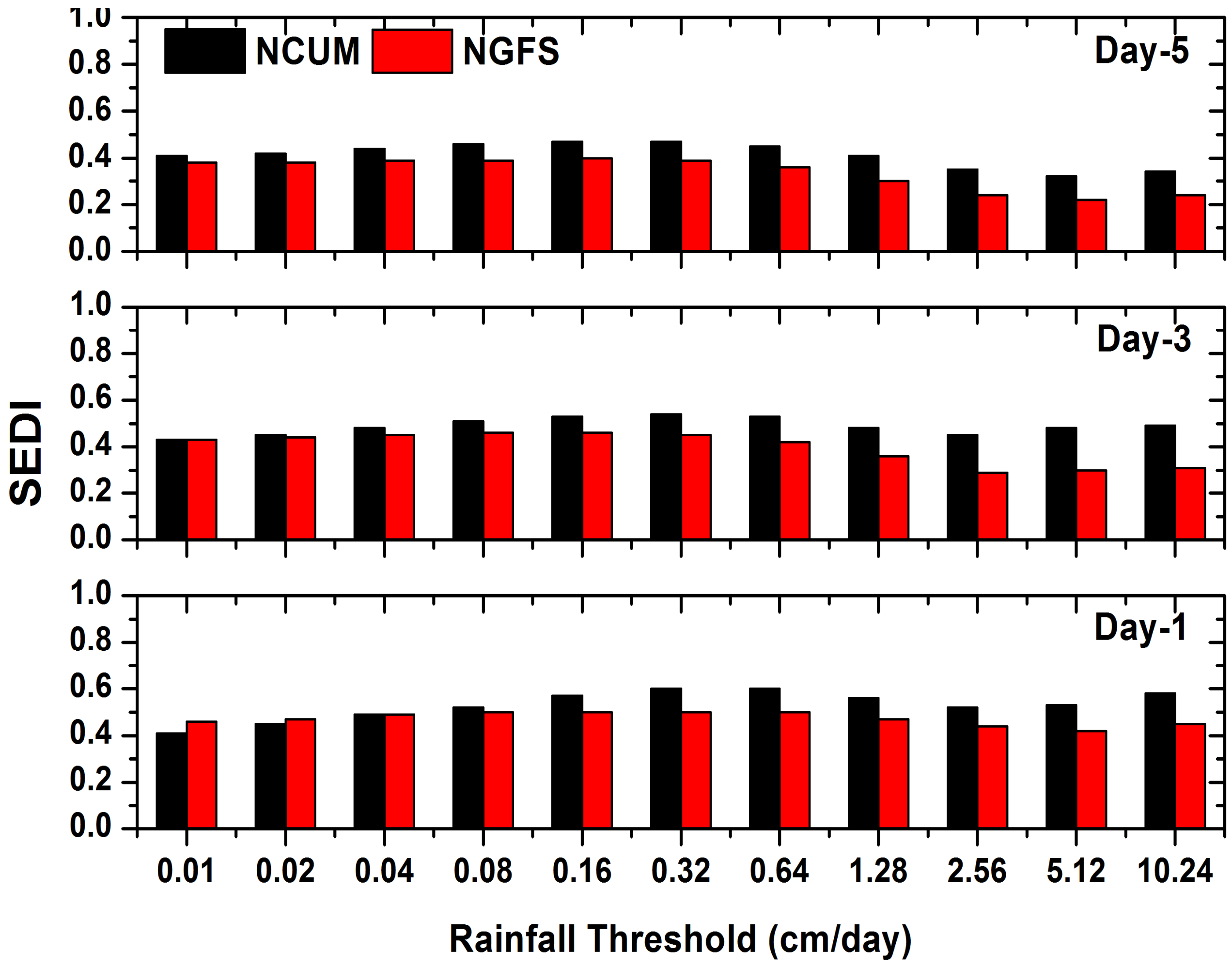


Figure 6b: Bar Graph showing Symmetric Extremal Dependence Index (SEDI) for NCUM (black bars) and NGFS (red bars) for Day-1 (Bottom Panel), Day-3(Middle panel) and Day-5 (Top panel) forecasts valid for JJAS 2015

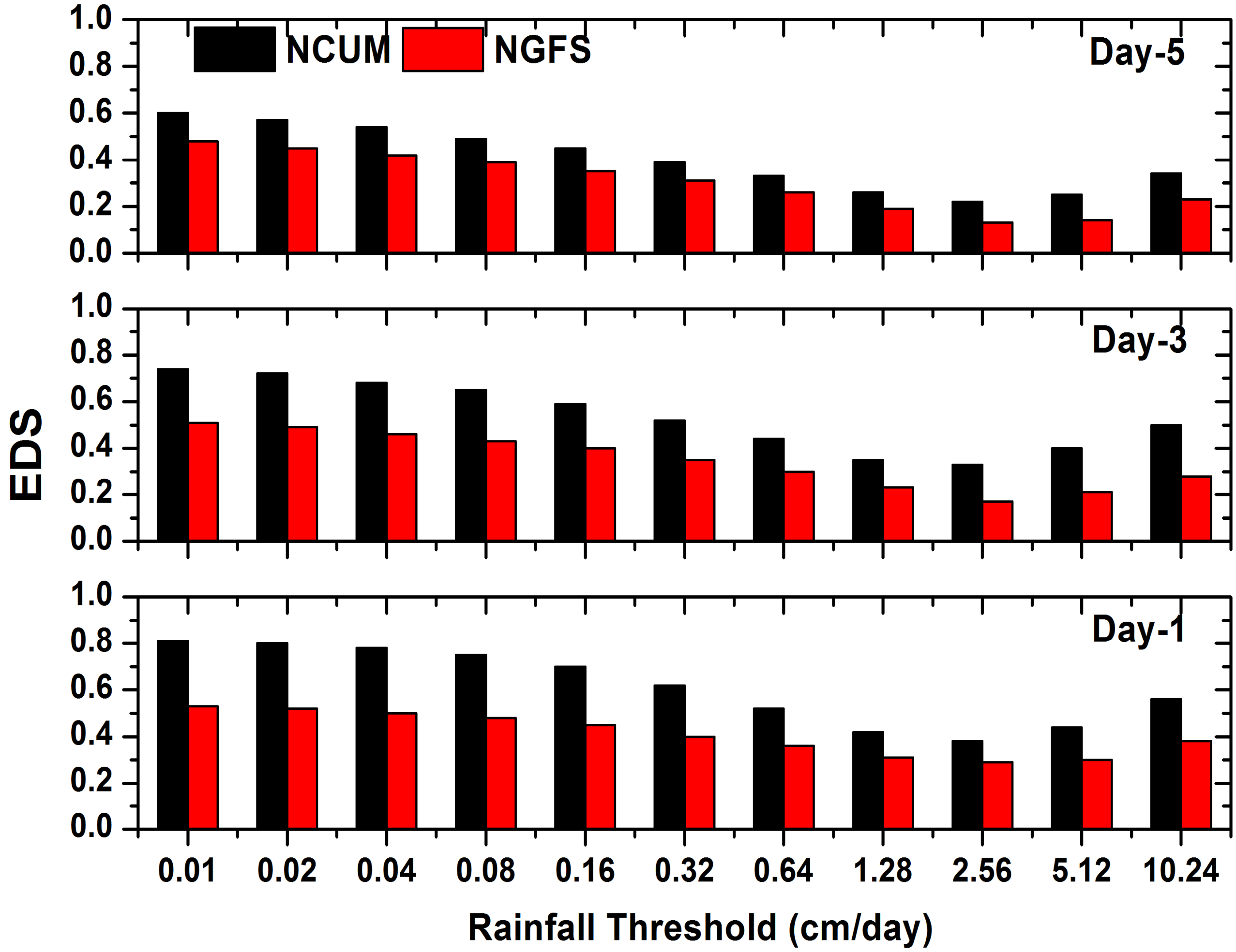
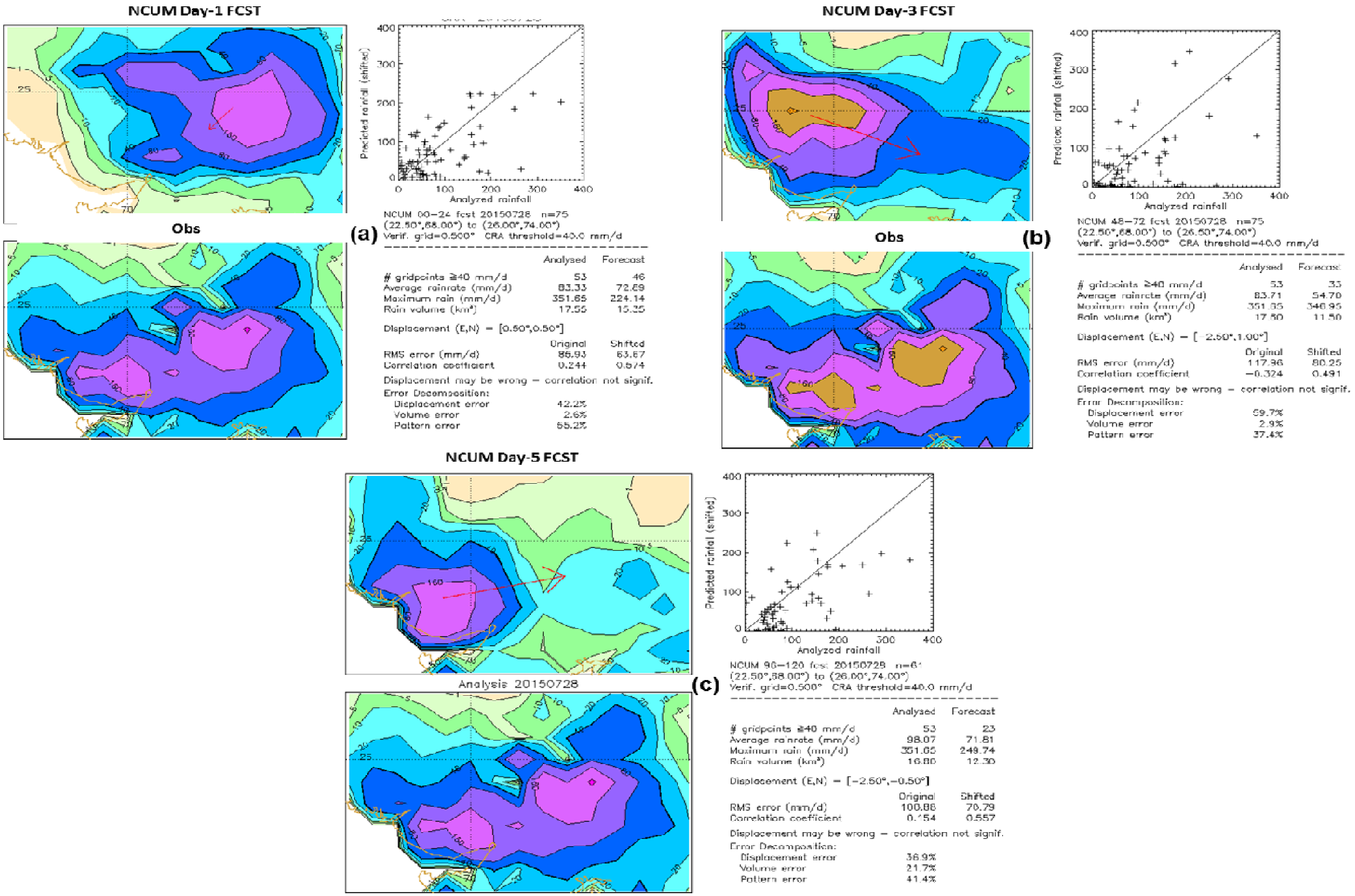


Figure 6c: Bar Graph showing Extreme Dependence Score (EDS) for NCUM (black bars) and NGFS (red bars) for Day-1 (Bottom Panel), Day-3(Middle panel) and Day-5 (Top panel) forecasts valid for JJAS 2015



```
NCUM 00-24 fcst 20150728  n=75
(22.50°,68.00°) to (26.00°,74.00°)
Verif. grid=0.500°  CRA threshold=40.0 mm/d
------------------------------------------
                              Analysed   Forecast

# gridpoints ≥40 mm/d               53         46
Average rainrate (mm/d)          83.33      72.69
Maximum rain (mm/d)             351.65     224.14
Rain volume (km³)                17.55      15.35

Displacement (E,N) = [0.50°,0.50°]
                              Original    Shifted
RMS error (mm/d)                 86.93      63.67
Correlation coefficient          0.244      0.574

Displacement may be wrong - correlation not signif.
Error Decomposition:
  Displacement error             42.2%
  Volume error                    2.6%
  Pattern error                  55.2%
```

```
NCUM 48-72 fcst 20150728  n=75
(22.50°,68.00°) to (26.50°,74.00°)
Verif. grid=0.500°  CRA threshold=40.0 mm/d
------------------------------------------
                              Analysed   Forecast

# gridpoints ≥40 mm/d               53         33
Average rainrate (mm/d)          83.71      54.70
Maximum rain (mm/d)             351.65     346.95
Rain volume (km³)                17.50      11.50

Displacement (E,N) = [-2.50°,1.00°]
                              Original    Shifted
RMS error (mm/d)                117.96      80.25
Correlation coefficient         -0.324      0.491

Displacement may be wrong - correlation not signif.
Error Decomposition:
  Displacement error             59.7%
  Volume error                    2.9%
  Pattern error                  37.4%
```

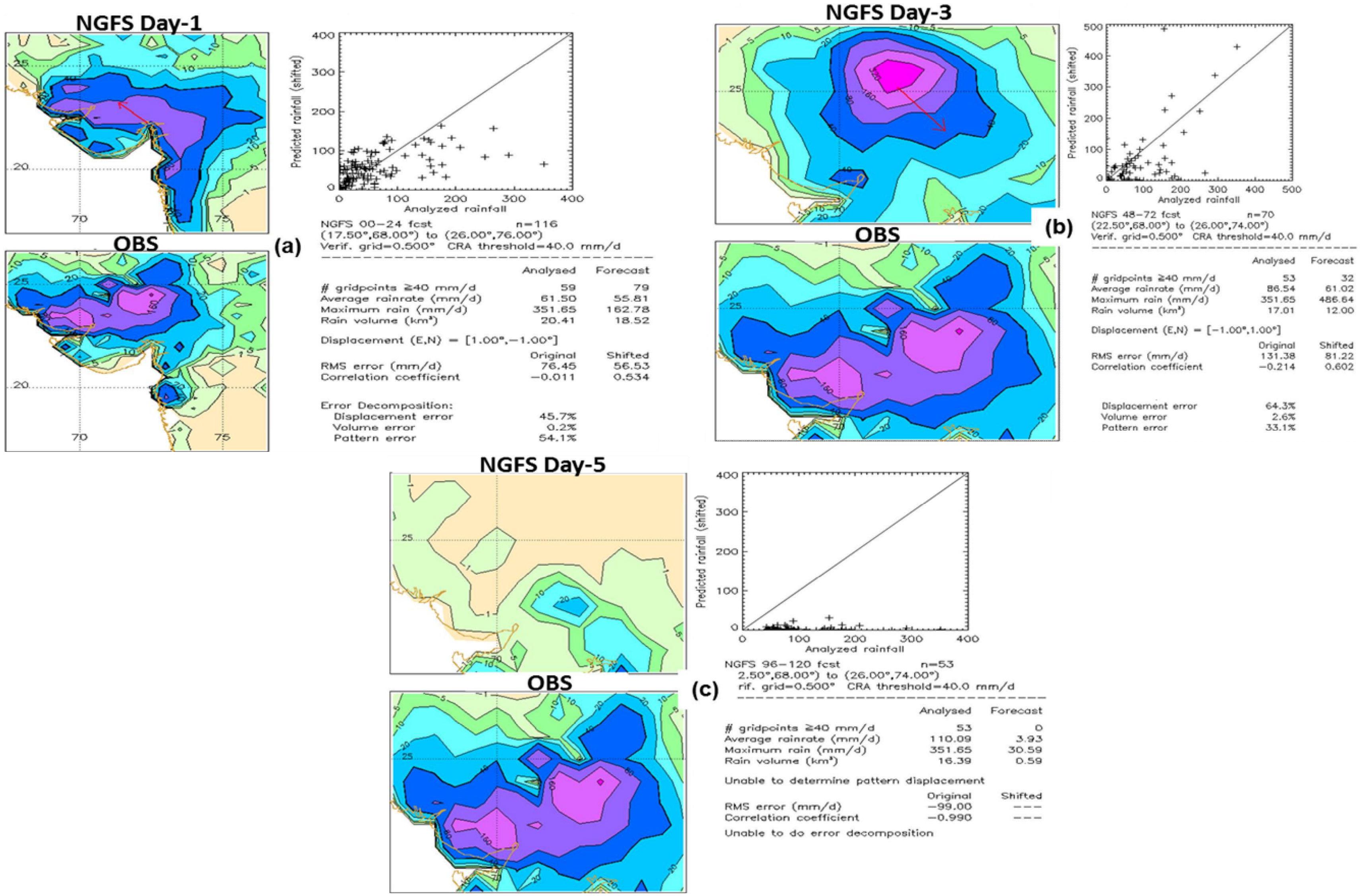
```
NCUM 96-120 fcst 20150728  n=61
(22.50°,68.00°) to (26.00°,74.00°)
Verif. grid=0.500°  CRA threshold=40.0 mm/d
------------------------------------------
                              Analysed   Forecast

# gridpoints ≥40 mm/d               53         23
Average rainrate (mm/d)          98.07      71.81
Maximum rain (mm/d)             351.65     249.74
Rain volume (km³)                16.80      12.30

Displacement (E,N) = [-2.50°,-0.50°]
                              Original    Shifted
RMS error (mm/d)                100.88      70.79
Correlation coefficient          0.154      0.557

Displacement may be wrong - correlation not signif.
Error Decomposition:
  Displacement error             36.9%
  Volume error                   21.7%
  Pattern error                  41.4%
```

Figure 6: CRA comparison between analysis and Day 1, Day-3 as well as Day-5 rainfall obtained from NCUM for 03Z of 29 July 2015



```
NGFS 00-24 fcst                       n=116
(17.50°,68.00°) to (26.00°,76.00°)
Verif. grid=0.500°  CRA threshold=40.0 mm/d
--------------------------------------------
                                Analysed    Forecast

# gridpoints ≥40 mm/d                 59          79
Average rainrate (mm/d)            61.50       55.81
Maximum rain (mm/d)               351.65      162.78
Rain volume (km³)                  20.41       18.52

Displacement (E,N) = [1.00°,-1.00°]
                                Original     Shifted
RMS error (mm/d)                   76.45       56.53
Correlation coefficient           -0.011       0.534


Error Decomposition:
  Displacement error               45.7%
  Volume error                      0.2%
  Pattern error                    54.1%
```

```
NGFS 48-72 fcst                  n=70
(22.50°,68.00°) to (26.00°,74.00°)
Verif. grid=0.500°  CRA threshold=40.0 mm/d
--------------------------------------------
                                Analysed    Forecast

# gridpoints ≥40 mm/d                 53          32
Average rainrate (mm/d)            86.54       61.02
Maximum rain (mm/d)               351.65      486.64
Rain volume (km³)                  17.01       12.00

Displacement (E,N) = [-1.00°,1.00°]
                                Original     Shifted
RMS error (mm/d)                  131.38       81.22
Correlation coefficient           -0.214       0.602


  Displacement error               64.3%
  Volume error                      2.6%
  Pattern error                    33.1%
```

```
NGFS 96-120 fcst                      n=53
 2.50°,68.00°) to (26.00°,74.00°)
 rif. grid=0.500°  CRA threshold=40.0 mm/d
 -------------------------------------------
                                Analysed    Forecast

# gridpoints ≥40 mm/d                 53           0
Average rainrate (mm/d)           110.09        3.93
Maximum rain (mm/d)               351.65       30.59
Rain volume (km³)                  16.39        0.59

Unable to determine pattern displacement
                                Original     Shifted
RMS error (mm/d)                  -99.00         ---
Correlation coefficient           -0.990         ---

Unable to do error decomposition
```

Figure 8: CRA comparison between analysis and Day 1, Day-3 as well as Day-5 rainfall obtained from NGFS for 03Z of 29 July 2015