

Introduction

India Meteorological Department (IMD) routinely provides forecasts in medium range scale at T1534 resolution using deterministic model Global forecast system (GFS) and ensemble model Global ensemble Forecast system (GEFS) with 21 ensemble members. GFS model operational at IMD employs spectral dynamic core in NOAA Environmental Modelling System (NEMS) configuration with semi-Lagrangian dynamics in linear reduced Gaussian grid. Model uses hybrid 4D Ensemble Variational assimilation system for creating model initial condition and assimilating large number of observations over the Indian region ((Prasad et al., 2021). In GEFS system ensemble initial conditions are produced by combining Ensemble Kalman Filter (EnKF) forecast perturbations and deterministic analysis. In 2021 onset of the southwest monsoon over Kerala had taken place over Kerala on 3rd June and advanced to many parts of northern and central India by 13th June and further advanced to more parts of North Arabian Sea, Gujarat, Uttar Pradesh, Rajasthan by 19th June and there was no further advance of the system till July 11th. South west monsoon covered entire country by 13th July by advancing further to Delhi and remaining parts. GFS and GEFS model are operationally running in Mihir High Performance Computing System at NCMRWF.

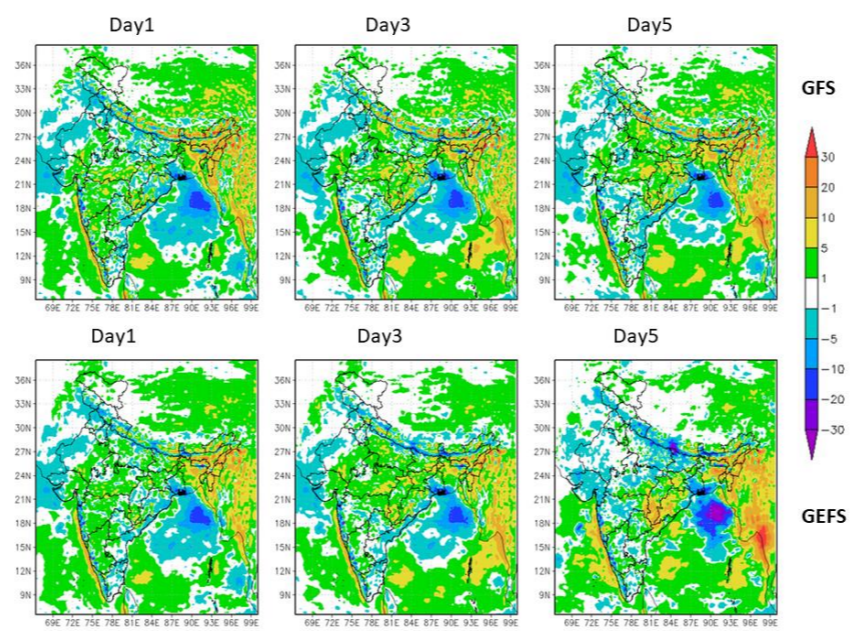
Objectives

GFS and GEFS model forecasts are evaluated during South west monsoon season from June to September, 2021 over different spatial domains and different rainfall categories over Indian region. Model forecasts in prediction of extreme rainfall events over the region is investigated.

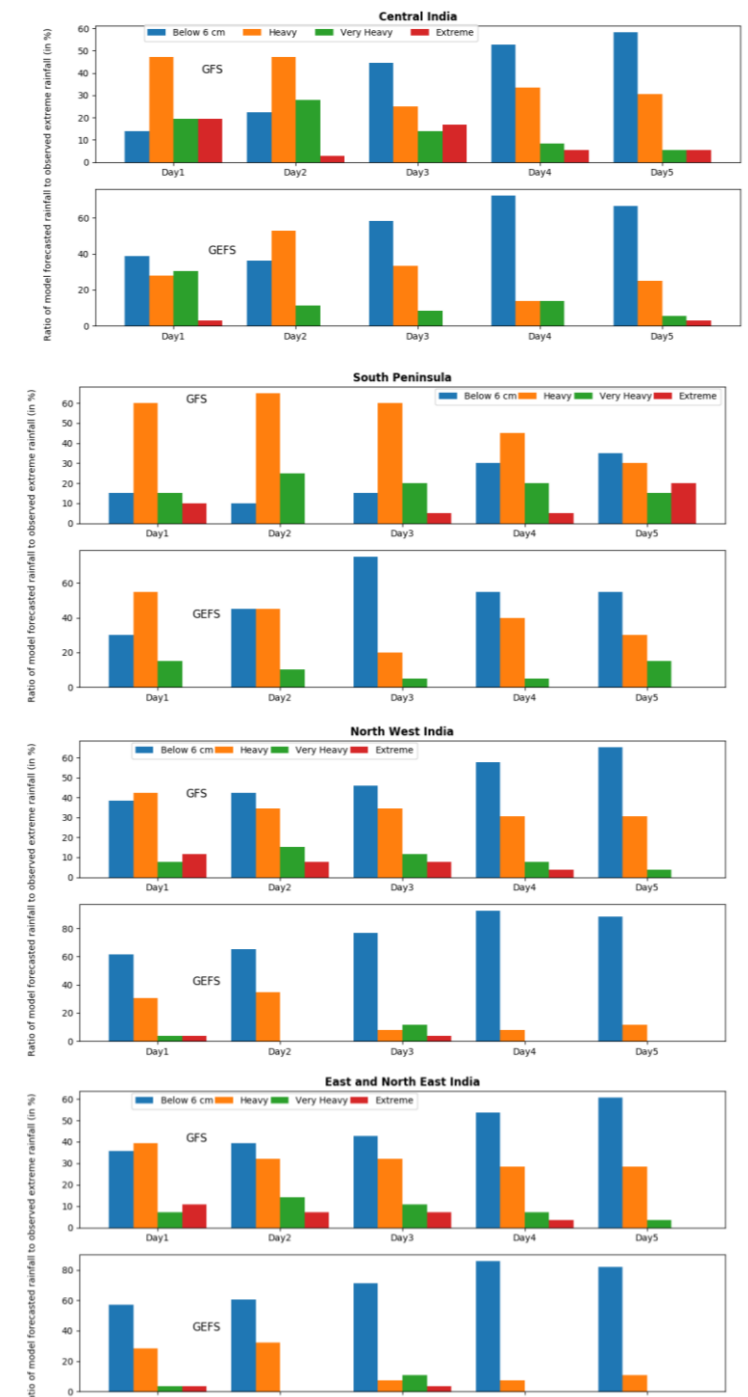
Data & Methodology

GFS and GEFS model Rainfall forecasts over Indian region are verified against gridded rainfall observations combining IMD rain gauge observations and satellite derived rainfall (Mitra et al., 2009). Mean error in model forecast (model-observation) is computed for the period June to September, 2021. Skill scores are computed for the model rainfall forecast for different rainfall thresholds against gridded rainfall observations. Extreme rainfall events over Indian region are investigated separately to find out ability of models to forecast these events. Extreme events are chosen using rainfall observations from IMD synoptic stations and applying criteria of more than 20 cm accumulated rainfall in 24 hours and highest rainfall in each subdivision in daily observations. Daily accumulated rainfall observations from previous day 3 UTC to current day 3 UTC is compared with models forecasts up to lead time of day 5. In computing accumulated rainfall from model, maximum rainfall forecasted within 0.5 degree of station location is used accounting for comparing model gridded rainfall with station observation. Percentage of rainfall events models (GFS and GEFS) are able to capture in different rainfall threshold category (extreme, very heavy and heavy, below 6 cm) out of total observed extreme rainfall events in the homogeneous regions south peninsula, Central India, East and North East India and North West India is investigated. A case study of model forecasts of a very heavy rainfall event occurred in Delhi on August 21, 2021 (~ 15 cm of rainfall in 24 hours) is carried out.

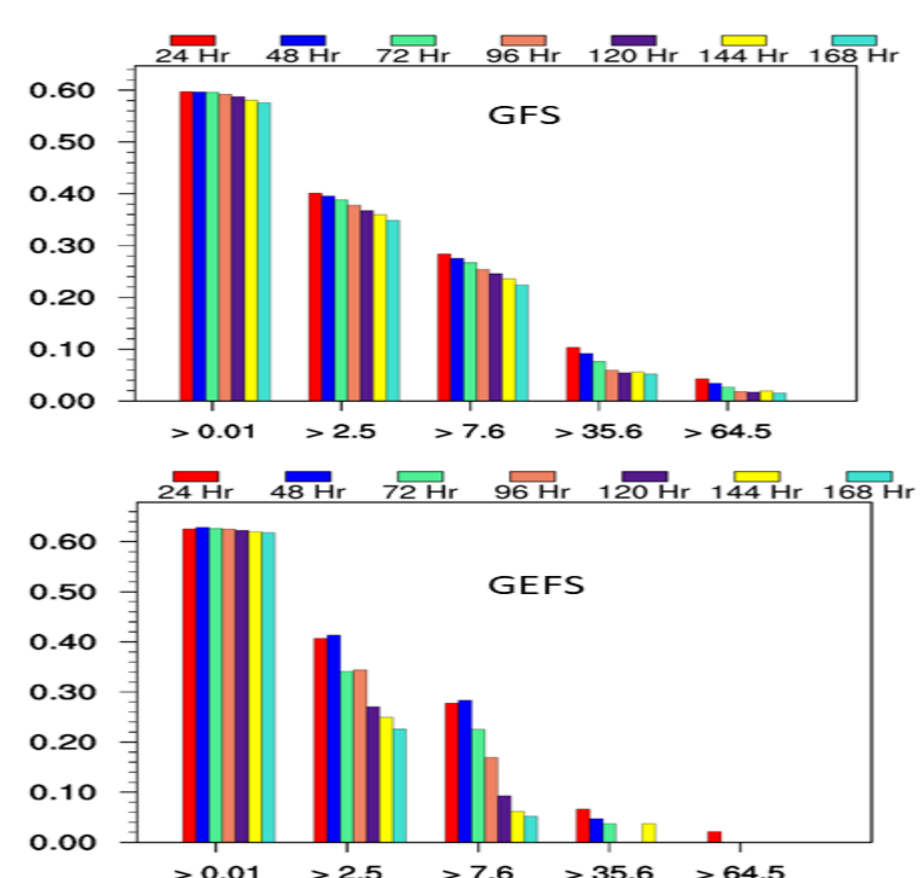
Results & Discussion



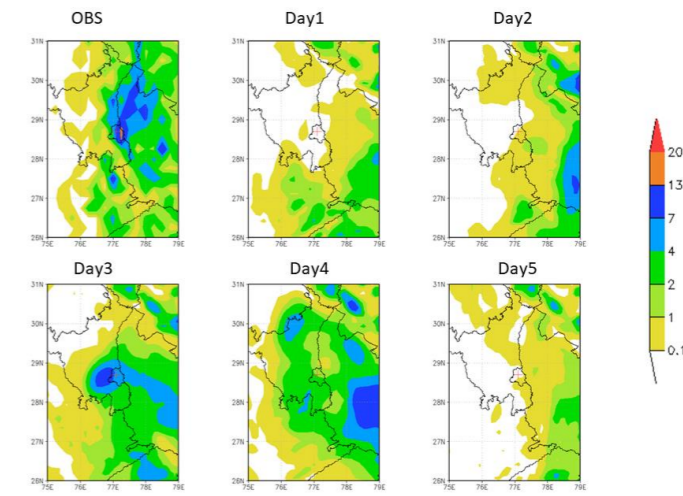
Mean error in GFS (top panel) and GEFS (bottom panel) model Rainfall forecasts during June to September 2021



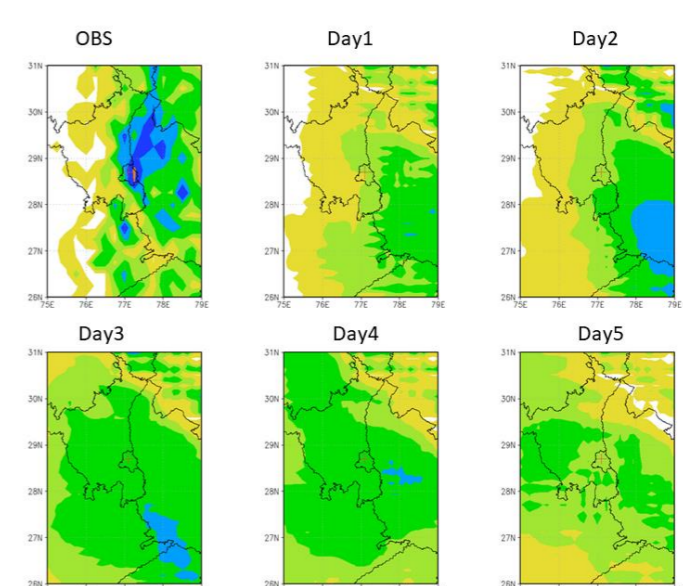
Ratio model forecasted rainfall in different rainfall thresholds to extreme rainfall observations over different homogeneous regions of IMD



Critical success index (CSI) of GFS and GEFS model rainfall forecasts for different rainfall thresholds (mm) at different forecast lead times



Rainfall accumulated over 24 hours around Delhi valid on 03 UTC of August 21 in observations and GFS model forecasts. (Delhi is marked with cross)



Rainfall accumulated over 24 hours around Delhi valid on 03 UTC of August 21 in observations and GEFS model forecasts. (Delhi is marked with cross)

Summary/Conclusion

Models are able to represent general characteristics of rain fall in all the months. There is an overall under estimation of rainfall over land region of west coast of India and over estimation of rainfall over North East region in both the models. In the forecast of extreme rainfall events, there is under estimation in both the models while GFS forecasted these events better than GEFS ensemble mean forecasts. It is found that in the 3 homogeneous regions South peninsula, Central India and East and North East India, GFS model forecasted 10% of the observed extreme rainfall events in extreme category, 25 % of observed extreme rainfall events in very heavy rain or above and 85 % observed extreme rainfall events in heavy rain or above category. CSI scores are decreasing as rainfall threshold increases to higher values.

Acknowledgements & References

Prasad V. S., Suryakanti Dutta, Sujata Pattanayak, C. J. Johny, John P. George, Sumit Kumar and S. Indira Rani (2021) Assimilation of satellite and other data for the forecasting of tropical cyclones over NIO, MAUSAM, Vol. 72, No. 1.
 Mitra A. K., Bohra A. K., Rajeevan M. and Krishnamurti T. N. (2009) Daily Indian precipitation analyses formed from a merge of rain-gauge with TRMM TMPA satellite derived rainfall estimates; J. Meteorol. Soc. Japan, 87A, 265–279.