

Development of High resolution (12.5km) Global Forecast System (GFS/GEFS T1534) for High Impact Weather & Societal Application

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Application

- Initial conditions for Fv3 forecast Experiment
- Heavy rainfall forecast
- Initial Conditions for Solar and Wind forecasting
- Initial Conditions for hydrological modeling
- Risk Probability Assessment
- River Basins for Flood Monitoring
- Thunderstorm Prediction
- Initial Conditions for Forecast Error monitoring and forecast
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APPLICATIONS HIGH RESOLUTION GFS/GEFS MODEL

• NCEP Global Forecast System (GFS T1534), implemented and tested at ITM in June 2016.
 • On 1 June 2018, the high resolution short range Ensemble Prediction System has been operationalized at ITM for probabilistic prediction.
 • With this World's highest resolution (12km) Ensemble Prediction System (EPS) with 21 ensemble members for short range forecast system based on GEFS (T1534) has been put in place by ITM and handed over to IMD for operational implementation.
 • The forecast based on GEFS T1534 and GFS T1534 is being continued by IMD operationally. The forecast is available at http://srf.tropmet.res.in/srf/hires_gefs/index.php

Tropical Cyclones prediction and verification during 2019

Cyclone Name (category)	Duration	Intensity (hPa/kts)	Basin
1. Pabuk (CS)	4-7Jan	994	BoB
2. Fani (ExSCS)	26Apr -4May	932	BoB
3. Vayu (VSCS)	10-17 June	970	AS
4. Hikaa (VSCS)	22-25 Sept	972	AS
5. Kyarr (SuCS)	24Oct-1Nov	915	AS
6. Maha (ExSCS)	30Oct-7Nov	956	AS
7. Bulbul (VSCS)	6-11 Nov	971	BoB
8. Pawan (CS)	2-7Dec	999	AS

FANI (26Apr-4May) IC: 20190429 VAYU (10-17 June) IC: 20190615

Strike Probability Prediction

KACHCHH (Gujrat) GEFS based EPSgram

FANI Intensity (MSW) Prediction

Average GFS Track Error Year 2019

Average GFS Maximum Surface Wind Error Year 2019

2019 GEFS Track Error and Track Spread

About the Models

GEFS

GDAS EKF - GSI Hybrid Data Assimilation System

Analysis Control

Ensemble Initialization method: Ensemble Kalman Filter (EnKF) scheme. The 6-hr forecasts from the previous cycle

20 Perturbed members

Tropical Storm Relocation (if storm is present)

Centering of the perturbations on the ensemble control analysis (Distributes the spread around analysis instead of Ensemble Mean)

GFS

GDAS EKF - GSI Hybrid Data Assimilation System

Analysis Control

Forecast: 21 members runs for 243 hrs GFS Semi-Lagrangian T1534 (approx 12 km at equator) L64 vertical resolution. Near Real-time Surface Temperature NERSMO format.

Forecast: GFS Semi-Lagrangian T1534 (approx 12 km at equator) L64 vertical resolution, runs for 243 hrs (10 days)

POST PROCESSING: 120hr (10 days) forecast Resolution: Regular grid and Coarsest grid at different resolutions 0.125°x0.125°

GFS/GEFS (T1534) Model Physics for the operational set up for 2019

Convection

- Scale- & Aerosol-aware mass-flux shallow conv scheme
- Scale- & Aerosol-aware mass-flux deep conv scheme
- Zhao-Carr-Moorthi microphysics scheme for Grid-scale Condensation, Evaporation and Precipitation

Microphysics

- Orographic gravity wave drag, mountain-drag and stationary convective gravity wave drag

Gravity Wave Drag

- New PBL Hybrid Eddy-diffusivity Mass-flux Scheme (Estimate Subgrid-scale vertical turbulent mixing in the PBL and above; mass-flux approach to calculate the counter gradient diffusion terms)

PBL

- LW and SW radiation parameterizations are optimized and modified (AER) by NCEP and uses unevenly distributed 140 g-points (quadrature) in 16-bands and 112 g-points in 14-spectral bands respectively. To represent statistically the unresolved subgrid cloud variability Monte Carlo Independent Column Approximation (McICA) is used. Cloud fraction for radiation is computed diagnostically from prognostic cloud condensate

Radiation

Development of Thunderstorm Prediction System

This system is based on an idea of initiating guidance of GEFST1534 L64 by deriving probability of various thermodynamic indices. Based on these outlook, forecast of lightning and thunder/hail storm event has been attempted using WRF-ARW model derived indices viz SCP, HEI, LAYRH, Wind Gust, LPI.

Large-scale guidance from GEFST1534 forecast valid for 12Z21APR2019 based on IC:2019042100

Thunderstorm Events occurred on 21st April 2019

Day 1 Forecast based on IMD WRF (3km)

Data & Methodology

- Model: WRF-ARW V3.9.1
- Domain: 9 km, 3km with 45 vertical levels
- ICs & BCs: GFS T1534 (~12.5km)
- IAU/ALC: MOFIPED-JGPP, MODIS, NOAA (21 Land Category)
- MP: WDM6, GP, Cell 3D ensemble, PBL MYJ
- Radiation: RRTMG for short & Long wave radiation
- Indices: Lightning Potential Index (LPI), wind gust, Super Composite Parameter (SCP), LayRH
- Output saved at four intervals.

1. 21st April 2019 00:00 UTC to 06:00 UTC

2. 21st April 2019 06:00 UTC to 12:00 UTC

3. 21st April 2019 12:00 UTC to 18:00 UTC

4. 21st April 2019 18:00 UTC to 00:00 UTC

Legend: LPI > 3000, Moderate LPI > 6000, LPI > 10000

Legend: SCP > 3, Moderate SCP > 5, SCP > 7, LPI > 40, Moderate LPI > 60, LPI > 100

JJAS 2019 Verification and Heavy Rain Events

(a) Skill Scores for GFS from 2012 to 2019 (b) Stable Equitable Error in Probability Space (SEEPS) score for GFS T1534 JJAS 2019 for Indian land points only. It is an error score which uses the categories 'dry' (D), 'light precipitation' (L), and 'heavy precipitation' (H) based on the climatological cumulative precipitation distribution. (c) Check diagram for GFS T1534

Heavy Rainfall event over Kerala on 9th August 2019 IC: 0208AUG2019

Day 1 and Day 2 GFS T1534 (12km) forecast valid for 00:00 UTC of 09 August 2019 based on perturbed

Day 1 and Day 2 GFS T1534 (12km) forecast valid for 00:00 UTC of 09 August 2019 based on perturbed

Probability (contours, %) of rainfall up to lead time (Y axis) for thresholds of (a) clim-1SD, (b) clim-2SD and (c) clim-3SD for Aug 2019 over Kerala (land only). The blue line shows observation (right Y axis)

Development of Wind and Solar Radiation forecasting System

Table 1. Different sensitivity experiments conducted to generate a day ahead forecast over Karnataka region

Initial condition: GFS analysis (0.25° x 0.25°)

Sensitivity: GFS forecast (0.25° x 0.25°)

Physics boundary layer scheme: GFS T1534 forecast (0.125° x 0.125°)

Microphysics sensitivity: Morrison, Thompson, WWSM

Convection sensitivity: Kain-Fritsch (KF), Grell-3 (G3), Grell-Fritsch Ensemble (GFE)

No. of vertical levels: 45

LULC data: USGS, MODIS, NCEP

Both letters indicate final chosen configuration from diff. experiments

WRF Model Domain

Solar Forecast at 15min interval

Haikal (Karnataka)

Average Diurnal Cycle (July 2016)

Using yesterday's observations, calculate error (bias) in winds as Model (today) - obs (y day) for a day ahead forecast

Average earlier three consecutive times error and note this as Δ at time 't'

Depending on the sign of Δ, add or subtract it from model predicted winds at time 't'

These bias corrected winds now can be used as forecast.

Fig. Linear Bias Correction Method

Heat and Cold wave Events

Heat wave over North and Central parts of India on 29th May 2018. GEFS forecast probability along with observed maximum temperature (°C) (left) for Tmax > 46°C for Day 3 (middle) and Day 5 (right) lead time.

Cold wave over Northern and Central parts of India on 8th February 2019. GEFS forecast probability along with IMD's minimum temperature (°C) (left) for Tmin < 10°C for Day-3 (middle) and Day-5 (right) lead time.

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