4D-Ens-Var analysis system at NCMRWF

V.S. Prasad[1], C.J. Johny[1], Sujata Patnaik[1], Tarakeswar Singh, [1] Sateesh M[1]

(vsprasad@ncmrwf.gov.in (corresponding author)

Abstract

National Center for Medium Range Weather Forecasting (NCMRWF) is the leading Data Assimilation and Atmospheric modeling Center for Ministry of Earth Sciences (MoES). To support seamless weather forecasting activities of the institutes under the MoES, a GFS based 4D-ENS-Var analysis system is implemented at NCMRWF. This system is designed to support one of the highest resolution (T1534) ensemble forecasting system (GEFS) and also to support assimilation of additional observational data, in particular Indian Satellite observations, around the Indian region. India is also having a prestigious space program. and it launched many meteorological and Oceanographic satellites, such as Oceansat, MeghaTropiques, INSAT-3D system and Scatsat etc, under it. Further India Meteorological Department under its modernization program established Doppler Weather Radar Network, and 24 member ground based GNSS network etc. The details of these data sets, their assimilation schemes and results from forecast impact studies involving will be presented in this study.

1 Introduction

National Center for Medium Range Weather Forecasting (NCMRWF) is carrying out a routine runs of Global Data Assimilation and Forecasting (GDAF) runs since 1994. The system is being updated from time-to-time to include developments in Modeling, Data Assimilation and as well as to include new observations etc. First major change of the system was implemented in the year 2007 (Rajagopal et al 2007) by updating GFS model from T80L18 to that of T254L64. Subsequently Surya and Prasad 2011 modified data assimilation part by replacing the Spectral Statistical Interpolation (SSI) scheme with that of Grid Statistical Interpolation (GSI). In the second major update Prasad et al 2011 replaced the operational system with that T574L64 system. During this implementation, the data pre-processing and reception system was completely revamped and also upgraded (Prasad 2011, 2012) to support the parallel effort in implementing UK Metoffice based (Rajagopal et al) GDAF system.

All these modifications in modeling, DA and with additional observations etc, resulted in improvement of skill of medium range forecasts by about 1 day (Prasad et al 2014). Taking this success into account and also to support seasonal forecasting system, a global retrospective reanalysis from the year 1999 to 2018 was also carried out (Prasad et al 2017).

In order to include flow depend flow dependent multi-variate correlations in analysis work on hybrid assimilations schemes are initiated by performing a hybrid assimilation system experiment by combining 3D Var based NGFS (NCMRWF Global Forecast System) with ETR (Ensemble Transform with Rescaling) based Global Ensemble Forecast (GEFS) ofresolution T-190L28 is investigated (Prasad and Johny 2016). These studies clearly showed that this one-way coupled dual resolution hybrid assimilation did show moderate improvement in the model forecast skill on comparison with 3D Var during the investigation period. Following this study a two-way coupling with an 80 member Ensemble Kalman Filter of T254L64 resolution was successfully tested for the Indian summer monsoon season (June– September) for the year 2015 (Prasad et al., 2016). They found that hybrid assimilation marginally improved the quality of the forecasts of all variables over the deterministic 3D Var system, in terms of statistical skill scores and also in terms of circulation features. Taking encouraging results into consideration a hybrid analysis system based on GSI and ENKF was implemented at NCMRWF. The detail s of the same will be presented in the workshop.

2 Analysis system.

The present operational hybrid 4D-Ens-Var dataassimilation system uses deterministic model of T1534L64 resolutionand 80 member ensemble square root filter ensembles of T574L64 resolution within GSI version14.1.7. In this scheme 87.5% weigh t is givento ensemble error covariance and 12.5% weight to static error covariance. Here propagation of back ground error covariance intime is approximated by hourly ensemble forecasts rather than expensive tangent linear and adjoint models usedin other 4D Var formulations. Model is of NEMS (NOAA Environmental Modeling System) configuration, a shared, portable structure for all NCEP models and uses NSST (Near Surface Sea Temperature)model to provide near surface oceanic temperature profile. NSST can provide more realistic representation of SST within formation on diurnal warming and sublayer thermal cooling in oceans and helps in better utilization of observations. All skyassimilation of radiances introduced in GSI with the assimilation of AMSU-A radiances over ocean surface. Land surface representation in model is modified by Moderate Resolution Spectro-radiometer (MODIS) based albedo field sand1km classifications of land and soiltypes.

The uniue feature of this assimilation system is the assimilation of varous additional data sets, particularly Indian satellite and Remote Sensing observations, Viz,

- **AMV and radiances from INSAT-3D**
- **RO & SAPHIR radiance from MeghaTropiques**
- **ScatSat Ocean surface winds**
- **GOES016 & 17 Mode 6 AMV**
- **AHI radiance**
- **TAC2BUFR migation of Buoy/Synop/RSRW**
- **VAD & Radial Wind from IMD radar network**
- **T1534 ensembles for GEFS**

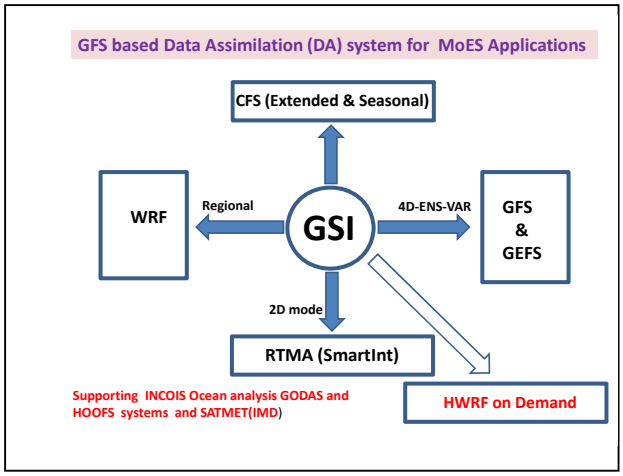

Figure 1. Depicting the Applications of GSI analysis in MoES

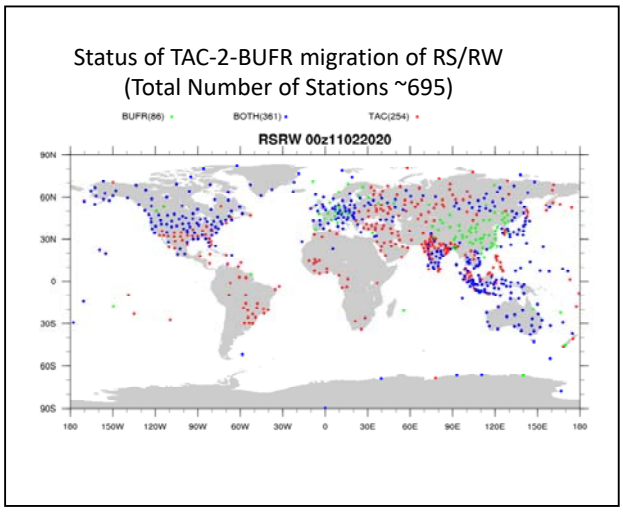

Figure 2. Showing status of TAC-2-BUFR migration global RS/RW data.

Acknowledgements (Optional)

Authors express their sincere thanks to Dr. E.N. Rajagopal, Head, NCMRWF for his encouragement and support that he provided in carrying out this work.

References

1. **VS Prasad and C J Johny(2016), Impact of hybrid GSI analysis using ETR ensembles, J . Earth Syst. Sci.,125, 3, 521-538.**
2. **V S Prasad , JohnyC J,and JagdeepSingh Sodhi, 2016: Impact of 3D VarGSI-ENKF Hybrid Data Assimilation system. J . Earth Syst. Sci., 125 (8), 1509-1725.**
3. **V S Prasad, C J Johny, JagdeepSingh Sodhiand E N Rajagopal(2016), Impact of EnVarhybrid assimilation using EnKFensembles, Proc. SPIE9882.**
4. **SanjeevKumar Singh and V S Prasad (2018), Evaluation of precipitation forecasts from 3D-Var and hybrid GSI-based system during Indian summer monsoon 2015. Meteorology and Atmospheric Physics**
5. **C J Johny, Sanjeev Kumar Singh and V S Prasad, (2019): Validation and impact of SCATSAT-1 Scatterometer winds, Pure and Applied Geophysics.**
6. **P Mukhopadhyay, V S Prasad, R PhaniMuraliKrishna, MedhaDeshpande, Malay Ganai, SnehlataTirkey, SahadatSarkar, TanmoyGoswami, C J Johny, Kumar Roy, M Mahakur, V R Duraiand M Rajeevan(2019), Performance of a very high-resolution global forecast system model (GFS T1534) at 12.5 km over the Indian region during the 2016–2017 monsoon seasons, Journal of Earth System Science, 128(155).**
7. E.N. Rajagopal, Munmun Das Gupta, Saji Mohandas, **V.S. Prasad,** John P. George, G.R. Iyengar and D. Preveen Kumar," Implementation of T254L64 Global Forecast System at NCMRWF", May 2007, NMRF/TR/1/2007,http://www.ncmrwf.gov.in/gfs_report_final-t264 .pdf
8. **V.S. Prasad**, Saji Mohandas, Munmun Das Gupta, E.N. Rajagopal and Surya Kanti Dutta," Implementation of Upgraded Global Forecasting Systems (T382L64 and T574L64) at NCMRWF",May 2011 NCMR/TR/5/2011, http://www.ncmrwf.gov.in/gfs_report_final.pdf
9. Dutta, Surya K. and **V. S. Prasad**, 2011: "Impact of Gridpoint Statistical Interpolation Scheme over Indian Region"; Journal of Earth System Sciences, 120, 6, pp. 1095-1112.
10. **V.S. Prasad**, "Conversion of NCEP Decoded data to UK MET office Obstore format", NCMR/OB/1/2012,http://www.ncmrwf.gov.in / obstore_uk.pdf
11. **V.S. Prasad**, "Satellite Data Processing for NCMRWF Unified Model (NCUM),January 2014,http://www.ncmrwf.gov.in/radiance_obstore_ ver2.pdf
12. **Prasad, V. S.**, S. Mohandas, S. K. Dutta , M. Das Gupta, G. R. Iyengar, E.N. Rajagopal and S. Basu, 2013, Improvements in Medium Range Weather Forecasting System of India, Journal of Earth System Science ,Vol 123, No2, Mar 2014, 347-258
13. **Prasad, V. S.**, C. J. Johny, P. Mali, Sanjeev Kumar Singh, and E. N. Rajagopal, 2016: Retrospective Analysis of NGFS for the years 2000-2011. Current Science, vol,112,No2,370-377.
14. Sandeep, A., **V. S. Prasad 2018**, An assessment of heat waves over southeastern region of India, International Journal of Climatology, https://doi.org/10.1002/joc.5395