Monitoring of In-situ Observations over Indian Region

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ABSTRACT

Meteorological observations from all over the globe and from various conventional and remote sensing observing platforms are received at Regional Telecommunication Hub (RTH), India Meteorological Department (IMD), New Delhi through Global Telecommunication System (GTS) and the same is made available to NCMRWF in real time. The accuracy of Numerical Weather Prediction (NWP) is highly dependent on the initial conditions used models generated using observational data. The real time acquisition and processing of good quality and quantity of observations are very crucial. Since 2010 onwards along with the modernization of IMD, the observational network over Indian region has gone through major up-gradation.

In this paper an attempt has been made to quantify the volume and trend in the reception of in-situ observations of SYNOP, AWS/ARG, RS/RW along with data rejection statistics (average monthly count of 500 hpa TEMP), Pilot Ballon and BUOY for four months (June, July, August and September) at 00 UTC during 2012-2016on real time basis as well as its quality in recent years over Indian region.

***Keywords**: Meteorological observations, Indian observations, Real time data reception and Quality of observations.*

1. Introduction

Meteorological observations are the cornerstone for NWP and communication of these data was started since establishment of GTS (Das Gupta et al. 2007). As NWP is an initial value problem the quality of the final output is highly dependent on the observations assimilated in NWP system. Continuous efforts are on at NCMRWF to assimilate all possible types of observations. NCMRWF's

Table1. Different types of observation systems used at NCMRWF (Rajagopal et al. 2012)

OBSTORE (Observation File)	Details of different types of Observation
Surface.OBSTORE	Land Surface (SYNOP), Mobile SYNOP, Ship, Buoy
Sonde.OBSTORE	TEMP (Land and Marine), PILOT (Land and Marine), DROPSONDE, Wind profilers
Aircraft.OBSTORE	AIREP, AMDAR, TAMDAR (N. American AMDAR), Tropical Cyclone BOGUS winds
Satwind.OBSTORE	AMV from Meteosat-7, Meteosat-9, GOES-11, GOES-13, MTSAT-IR, MODIS (TERRA and AQUA), AVHRR from NOAA-15/6/7/8/9
Scatwind.OBSTORE	Scattrometer winds: ASCAT winds from MetOp Satellite, WINDSAT winds from Coriolis Satellite.
ATOVS.OBSTORE	ATOVS Radiance from MetOp-2, NOAA-15,NOAA-17, NOAA18, NOAA-19
IASI.OBSTORE	IASI Radiance from MetOp-2 Satellite
SSMIS.OBSTORE	SSMIS Radiance from DMSP
SEVIRIclear.OBSTORE	Clear sky IR Radiance from METEOSAT Second Generation Satellites
AIRS.OBSTORE	AIRS Radiance from AQUA satellite
GPSRO.OBSTORE	Bending angle (radio occultation data) from GPS satellites

Table 2. Requirements of optimum observational network
(IMD Report. 2010,metnet.**imd**.gov.in/**imd**news/**imd**mod**vol13**.pdf)

S.No	Observation Instrument	Optimum Number
1.	Automatic Rain Gauges	3600
2.	Automatic Weather Stations	1150
3.	Doppler Weather Radar	68
4.	Wind Profiler	15
5.	Upgrade RS/RW	44
6.	Upgraded Pilot Balloon	70

Global Data Assimilation and Forecast System (GDAFS) is a six-hourly intermittent assimilation system, which runs four times a day (viz. 0000, 0600, 1200 and 1800UTC) (Das Gupta et al. 2010). Short range predictions (up to 9 hours) from NWP model are used as first guess or background field for next assimilation cycle. Meteorological observations of various types viz. SYNOP, BUOY, METER, TEMP, PILOT, AIREP, AMDAR, ACARS, Atmospheric Motion Vector (AMV) from geostationary satellites viz: GOES, METEOSAT, INSAT and GMS, NOAA and satellite radiances, Global Positional System Radio Occultation (GPSRO) etc. are assimilated in NCMRWF global NWP system. Observations taken/falling within ±3 hours of the assimilation cycle are assimilated in that particular cycle.

Since these voluminous observations are very heterogeneous in nature, the proper monitoring of the reception quantity and quality is very important activity of any NWP centre. Real time observation monitoring system with special emphasis on Indian observations was implemented at NCMRWF during 2009-10. It generates cycle-wise data reception statistics along with the quality monitoring of Indian RS/RW observations.

2. Up-gradation in Observational Network and Telecommunication System of IMD

Meteorological observational network and telecommunication system of IMD was up-graded during 2010/11. It was initiated in December 2007 and the first phase was completed by 2011. In the program of IMD modernization, two major segments addressed for up-gradation (IMD Report. 2010, metnet.imd.gov.in/imdnews/imdmodvol13.pdf) are as follows-

1. Up-gradation of observational network
2. Advanced data communication and processing technology.

The expected outcomes of the IMD modernization program are to improve the acquisition, processing and monitoring of weather and climate observations. For this purpose various initiatives were taken for system up-gradation and installation of Doppler Radars, GPS Radio-Sondes, Automatic Weather Stations and Automatic Rain Gauges in the observational network. Details of required optimum number of observational network are as follows-

Telecommunication infrastructure was upgraded by Meteo France International (MFI) through installing system, TRANMET. It interlinked all the meteorological sub-systems in real time and data and other products can be shared by the meteorological communities.

3. Real Time Reception of Indian Observations at NCMRWF

In this study, data reception quantity for various types of in-situ observations over India viz: SYNOP, AWS/ARG, Radio-Sonde (RS/RW), Pilot Balloon and BUOY as received and monitored at NCMRWF has been discussed for June, July, August and September during 2012 – 2016. The reception of Indian satellite observation viz. AMVs for Kalpana-I and INSAT-3D are also discussed in brief. AWS/ARG reports hourly observations in GTS and hence the frequency of the data from any station is 24 per day and 6 per assimilation cycle. RS/RW observation data frequency is two per day i.e. 00 UTC and 1200 UTC whereas the frequency of pilot balloon is generally 4 per day (00,06, 12 and 18 UTC). The frequency of BUOY and SYNOP observations are generally eight per day i.e. three hourly observations and hence 2 per station per cycle. INSAT derived winds are tracing clouds and water vapor after every 30 minutes interval (Das Gupta et al. 2015). The data reception statistics for

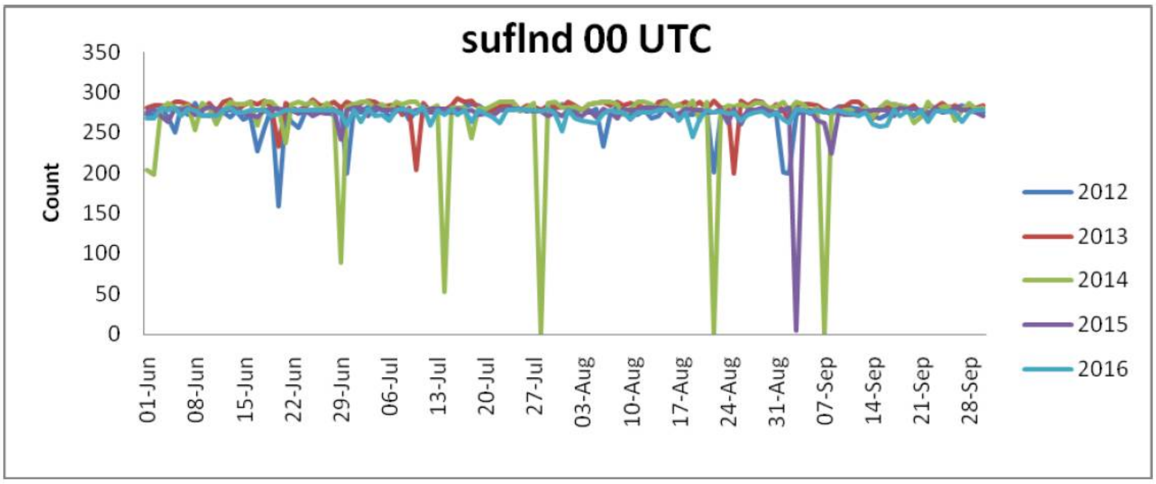

Figure 1: Data reception of SYNOP at 00 UTC during 2012-2016

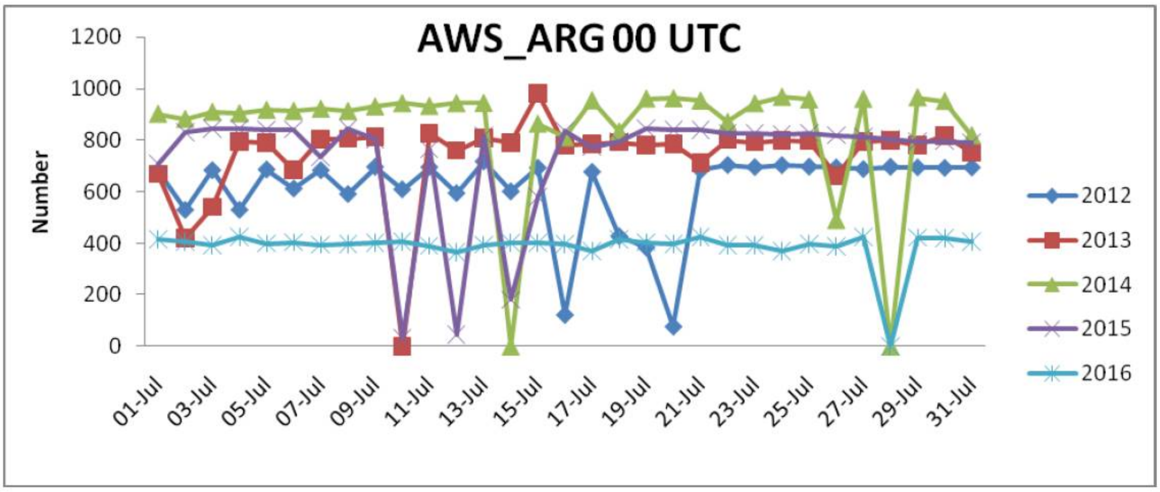

Figure 2: Data reception of AWS_ARG at 00 UTC during 2012-2016

2012,2013,2014, 2015 and 2016 at 00UTC are depicted in the following figures.

During June, July, August and September (Fig. 1) 2012 – 2013respectivelyexcept few days, it has been observed for SYNOP (surface land observations) at 00 UTC that similar amount of observations have been recorded. The particular days of the year 2014, the data reception have shown malfunctioning due various technical issues at both ends, however significant improvement can be noticed in the years 2015 and 2016.

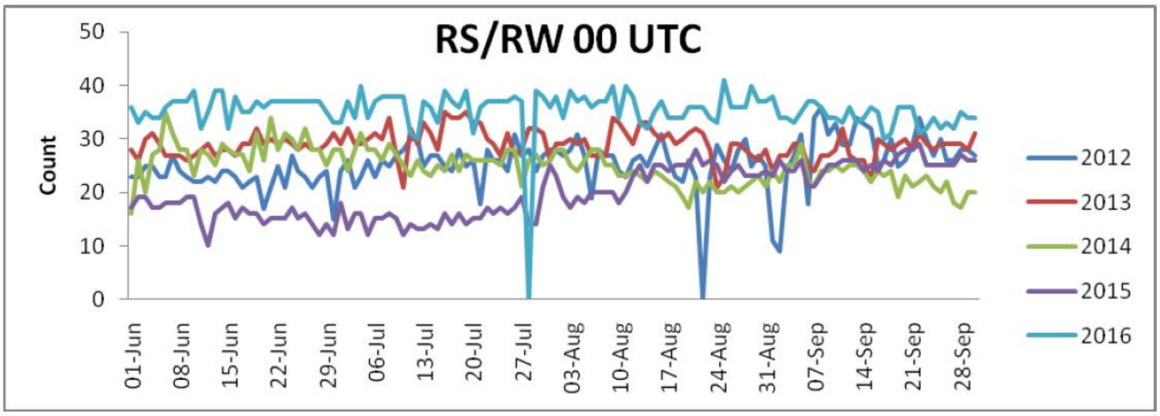

Figure 3: Data reception of RS/RW at 00 UTC during 2012-2016

Figure 2 depicts the data reception statistics for AWS/ARG at 00 UTC, for July month during 2012-2016. As seen from the plot that the quantity of the reception of AWS/ARG data is initially in general increased from 2012 to 2014 and again decreased since 2015 and further reduced in 2016.At each year on few days very less reception of observation can be noticed, which is possibly due to various technical problems at both the ends.

Figure 3, 4and 5depict the data reception statistics for RS/RW, Pilot Balloon and Buoy observations at 00 UTC, for June, July, August and September during 2012-2016 respectively. The reception of RS/RW observations (Fig. 3) has improved initially from 2012 to 2013 and started deteriorating since last few days of 2014. This subsequently has shown lot of improvement in 2016 with almost 40 stations reporting at 00UTC. The reception of Pilot balloon observations (Fig. 4) improved gradually since 2012 and in 2016 about 56

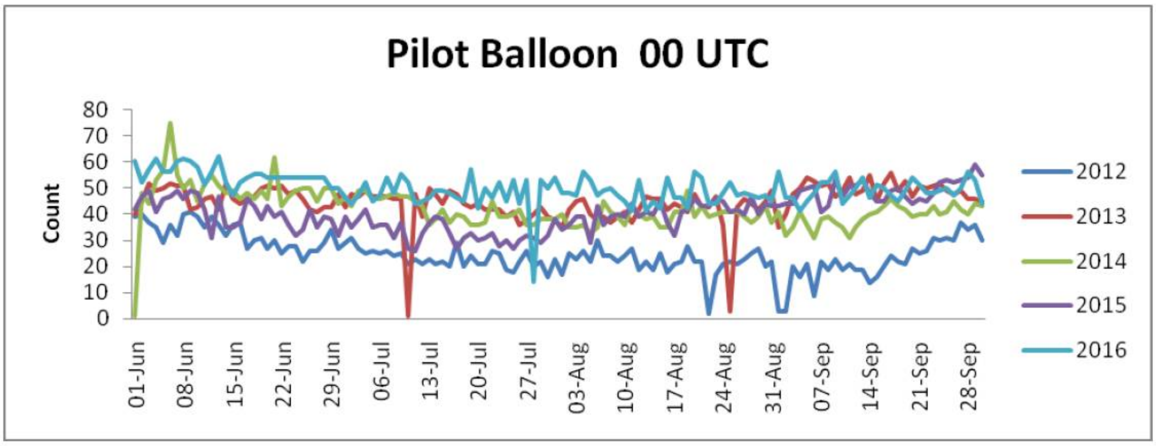

Figure 4: Data reception of Pilot Balloon at 00 UTC during 2012-2016

stations are reporting the pilot balloon observation at 00 UTC. Also, the reception of BUOY observation has shown (Fig. 5) continuous improvement, with 12 buoys in 2012 to 18 buoys in 2016. The increased number of stations and buoys represent that in recent years, significant improvement has been noticed in those observations which can help to provide the better information as an initial condition used in NWP models.

The qualities of Indian RS/RW observation are monitored through the rejection statistics of these observations by data assimilation system. The number of observations received along with % of data rejected (red colour) for Indian RS/RW observations are shown in figure 5 & 6. IMD replaced Indian make radio-sonde by GPS sonde for 20 stations by 2013 as shown in Figure 6(a). For these stations average number of data reception for 500 hPa temperature per month since 2012 along with rejection perctentage are shown in Figure 6(b).

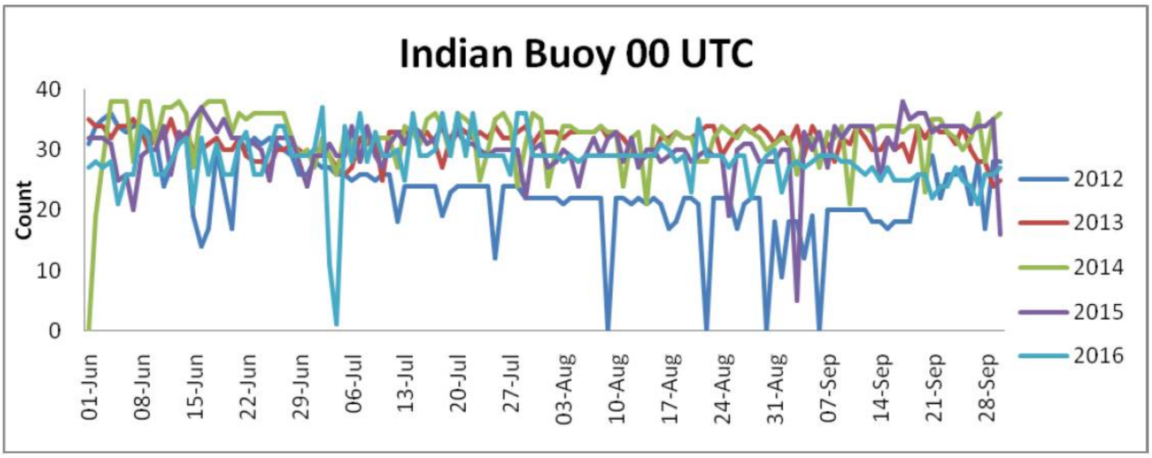

Figure 5: Data reception of Indian BUOY at 00 UTC during 2012-2016

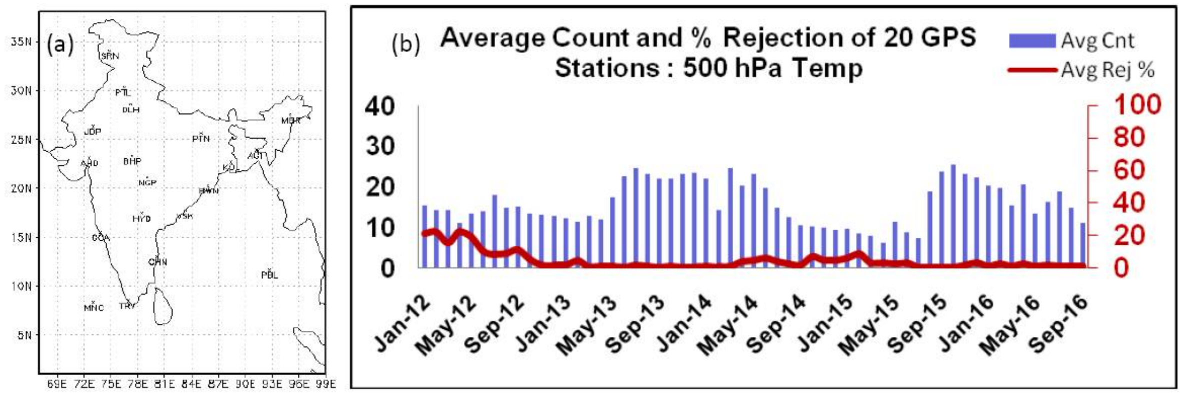

Figure 6: (a) The location of Indian 20 RS/RW stations (with GPS-sonde) (b) Average monthly count of 500 hPa TEMP received from these stations alongwith data rejection (%) statistics

As seen from the plot the average rejection of observation has been reduced considerably for these stations after the implementation GPS sonde since 2013 and the average monthly data reception of count also improved during the same time. However, in the later part of 2014 and 2015 the reception of the observations reduced drastically mainly due to non-availability of sondes. Since, September 2015, the situation improved and currently the frequency of these observations is more than 25 per month at 00 UTC. The location of the rest of the RS/RW stations is shown in figure 7(a). As all these stations were not using GPS sonde prior to September 2015 and hence showing high rejection (~ 40 %) during that period. However at present all the stations are also equipped with GPS sonde and hence showed drastic reduction in rejection percentage and improvement in average monthly data reception 7(b).

NCMRWF also regularly monitoring and validating Indian geo-stationary satellite

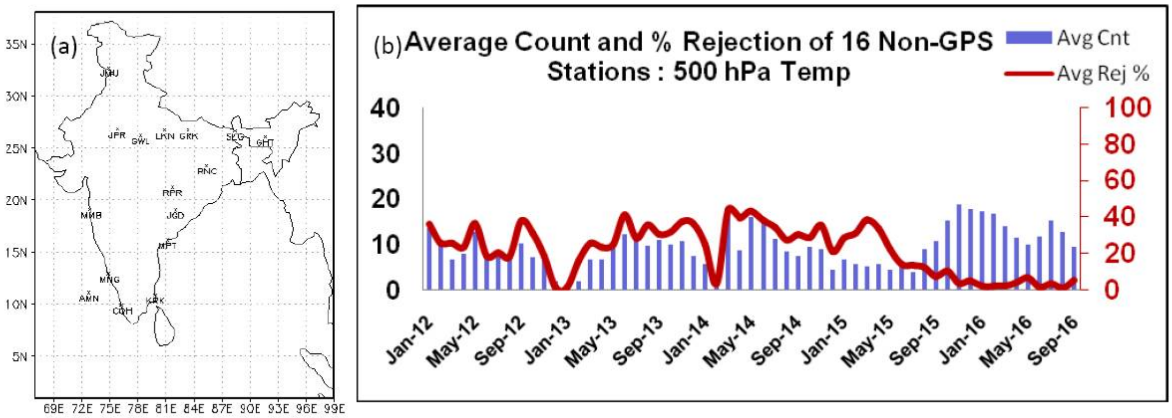

Figure 7: (a) The location of Indian rest of RS/RW stations (with GPS from 2015 onwards) (b) Average monthly count of 500 hPa TEMP received from these stations along with data rejection (%) statistics

derived AMVs since 2011. AMVs from the Indian geostationary satellite Kalpana-1 disseminated through GTS since 2011, and these winds are validated against NCMRWF short range predictions as well as in-situ winds for monsoon 2011 and compared with METEOSAT-7 AMVs (Rani et al. 2013). These studies showed that the Kalpana-1 AMVs have high Root Mean Square Vector Difference (RMSVD) when compared against NWP first guess and in-situ observations and the same is almost double to that of METEOSAT-7. After the lunch of INSAT-3D in July 2013, NCMRWF started validating INSAT-3D AMVs in active collaboration with SAC and shared continuous feedback to SAC since August 2013. There were several issues with the derived AMVs initially, which were rectified subsequently and the AMV derivation algorithm/process significantly stabilized in September 2014.Validation of INSAT-3D for January 2015 shows that root mean square vector difference and biases of INSAT-3D AMVs are either comparable or lower than that of METEOSAT-7 (Das Gupta et al. 2015). This is mainly due to the up gradation of wind deriving algorithm.

4. Summary

Monitoring of in-situ observation is an essential tool and an useful feedback for the data analysis. Based on these feedbacks, these data can be improved in terms of fine tunes the instruments, algorithms etc. for better quality/coverage of observations. The volume and trend in the reception of in-situ observations of SYNOP, AWS-ARG, RS/RW along with data rejection statistics (average monthly count of 500 hPa TEMP), Pilot Ballon and BUOY has been described for four months (June, July, August and September) at 00 UTC, during 2012-2016 on real time basis as well as its quality in recent years over Indian region. The salient results revealed from the study are summarized below.

i. It can be seen that after the modernization of IMD during 2010/11 significant improvement have been noticed in the data reception of various types of in-situ observations viz. SYNOP, AWS/ARG, RS/RW, Pilot Ballon and BUOY over India which could be a motivation for capacity building of observation instruments and their maintenance.
ii. The volume and trend of SYNOP observation at 00 UTC reflect that similar amount of data have been recorded except few days particularly in 2014. However,

the quality has been improved in the subsequent years. In case of AWS/ARG, initially the quantity has been increased for first three years (2012-2014) but slowly decreased in 2015 (≤ 800) and further reduced in 2016 (≤ 400) which could be possible due to various technical problems at both ends in this particular year.

iii. The quality of RS/RW, Pilot Ballon and BUOY observations represent remarkable improvement at 00 UTC during 2012 to 2016 with increased number of stations and buoys. In 2013, the implementation of 20 GPS sonde for 20 stations has been observed the considerable reduction in average rejection of observation and significant improvement in the count of average monthly data reception. Since September 2015, all the stations are equipped with GPS sonde hence showed constantly reduced in rejection percentage and with improved average monthly data reception.

In recent years, the increased availability of observational data include conventional in-situ surface and upper-air observations, those using new technologies such as drifting weather buoys, wind profilers and AMDAR (aircraft meteorological data relay) data and remote sensing data via satellites and the refinement of its process in NWP models enhance the advantage in the quality of forecast guidance. It would be achieved by increasing the spatial and temporal resolution of such observations in data sparse areas as well as by incorporating the use of additional observations information in the NWP models on which the further study are needed. Also, further research on this study is still required to investigate the advantage on forecast due to these additional observational data in near future.

Acknowledgement

The authors are grateful to Head, NCMRWF for the constant encouragement during this work.

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