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RESEARCH REPORT

Comparison of NCMRWF and ECMWF Archives of Conventional Meteorological Observations

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National Centre for Medium Range Weather Forecasting
Ministry of Earth Sciences, Government of India
A-50, Sector-62, NOIDA-201309, INDIA

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10	Abstract	Indian Monsoon Data Assimilation and Analysis (IMDAA) is a project of Met Office, UK, funded by National Monsoon Mission (NMM) of Ministry of Earth Sciences (MoES) for producing a 12-km regional reanalysis for the satellite era. National Centre of Medium Range Weather Forecasting (NCMRWF) and India Meteorological Department (IMD) are associated with this project on various scientific and technical aspects. The IMDAA reanalysis domain extends from 30º E to 120º E longitude and from 15º S to 45º N latitude. The basic meteorological database for IMDAA reanalysis is the European Centre for Medium Range Weather Forecasting (ECMWF) archives of meteorological observations. In addition the Indian archives of surface and upper air observations over Indian region are also planned to be used. In order to ascertain the availability of additional data in the IMD/NCMRWF meteorological data archives in comparison with ECMWF archives, a sample of one month data (April 2014) from ECMWF archives is compared with that of IMD/NCMRWF archives. Both ECMWF and IMD/NCMRWF archives contain surface observations like LAND SYNOP, METAR, SHIP and BUOY and upper air observations like TEMP (RS/RW), PILOT, DROPSONDES and WIND PROFILERS. Additionally NCMRWF archives contain Surface MOBILE which includes observations from both Automatic Weather Station (AWS) and Automatic Rain gauges (ARG) only over India. The results show that IMD/NCMRWF archives have additional observations, mainly the LAND SYNOP, AWS/ARG, TEMP and PILOT type of observations and which can be used in IMDAA reanalysis. These additional observations which have not yet been used in any other reanalysis may provide additional benefits to the IMDAA high resolution regional reanalysis.
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Abstract

Indian Monsoon Data Assimilation and Analysis (IMDAA) is a project of Met Office, UK, funded by National Monsoon Mission (NMM) of Ministry of Earth Sciences (MoES) for producing a 12-km regional reanalysis for the satellite era. National Centre of Medium Range Weather Forecasting (NCMRWF) and India Meteorological Department (IMD) are associated with this project on various scientific and technical aspects. The IMDAA reanalysis domain extends from 30º E to 120º E longitude and from 15º S to 45º N latitude. Use of all available good conventional and satellite observations in this high resolution reanalysis is one of the major tasks of this project. The basic meteorological database for IMDAA reanalysis is the European Centre for Medium Range Weather Forecasting (ECMWF) archived meteorological observations. In addition the Indian archives of surface and upper air observations over Indian region are also planned to be used. In order to ascertain the availability of additional data in the IMD/NCMRWF meteorological data archives in comparison with ECMWF archives, a sample of one month data (April 2014) from ECMWF archives is compared with that of IMD/NCMRWF archives. Both ECMWF and IMD/NCMRWF archives contain surface observations like LAND SYNOP, METAR, SHIP and BUOY and upper air observations like TEMP (RS/RW), PILOT, DROPSONDES and WIND PROFILERS. Additionally NCMRWF archives contain Surface MOBILE which includes observations from both Automatic Weather Station (AWS) and Automatic Rain gauges (ARG) only over India. The results show that IMD/NCMRWF archives have additional observations, mainly the LAND SYNOP, AWS/ARG, TEMP and PILOT type of observations and which can be used in IMDAA reanalysis. These additional observations which have not yet been used in any other reanalysis may provide additional benefits to the IMDAA high resolution regional reanalysis.

1. Introduction

Indian Monsoon Data Assimilation and Analysis (IMDAA) is a project of Met Office, UK, funded by National Monsoon Mission (NMM) of Ministry of Earth Sciences (MoES) for producing a high resolution regional reanalysis for 1979 to present. National Centre for Medium Range Weather Forecasting (NCMRWF) and India Meteorological Department (IMD) are associated with the project on many aspects. The 12 km horizontal resolution IMDAA reanalysis domain extends from 30º E to 120º E longitude and from 15º S to 45º N latitude. The project proposed to utilize the observations archived at European Centre for Medium range Weather Forecasting (ECMWF) in the IMDAA system. However, there are conventional meteorological observations over the IMDAA domain that is not regularly going to the International Global Telecommunication System (GTS), which are not part of ECMWF data archives. In order to identify the additional conventional surface and upper air observations available with India Meteorological Department (IMD) and hence also with NCMRWF that are not available in the ECMWF archives, NCMRWF compared one month NCMRWF data with similar observations from ECMWF archives.

The scope of this study is double fold, first to compare the sample data sets from NCMRWF and ECMWF archives for April, 2014 and the second aspect is to prepare a list of additional stations, if any, in the NCMRWF archives and share the same with ECMWF. Met Office, UK provided the ECMWF archives of conventional (surface and upper air) observations for April 2014 to NCMRWF. Both ECMWF and NCMRWF archives contain, surface observations like LAND SYNOP, METAR, SHIP and BUOY and the upper air data like TEMP (RS/RW), PILOT, DROPSONDES and WIND PROFILIERS. Additionally NCMRWF archives also have Surface MOBILE which includes observations from both Automatic Weather Station (AWS) and Automatic Rain gauges (ARG), particularly over India. This study provides an overview of the available conventional observations especially over the IMDAA domain. Section 2 describes Data and Methodology used in the study, Section 3 briefly describes the results from the comparison and the conclusions are given in Section 4.

2. Data and Methodology

Data sets used in this study are the conventional surface and upper air data from ECMWF and NCMRWF archives for April 2014. ECMWF data archives are in ECMWF BUFR format, whereas the NCMWF data archives are in the WMO ASCII format, which is received through GTS at India Meteorological Department (IMD), and transferred to

NCMRWF through dedicated link. The latest ECMWF BUFR software is downloaded (http://old.ecmwf.int/products/data/software/download/bufr.html) and implemented at NCMRWF to decode the ECMWF archives. National Centers for Environmental Prediction (NCEP) decoder/encoder software is already available at NCMRWF to decode/encode the GTS data operationally. Both the data sets were selected for a period from 21 UTC of 31 March 2014 to 21 UTC of 30 April 2014. The observations are segregated into four groups each spanning an interval of six hours with the central time (referred hereafter "cycle") 00, 06, 12 and 18 UTC respectively. All observation valid for 21:00 UTC of the previous day to 2:59 UTC of the current day will be part of the 00 UTC cycle of the current day. Similarly observations from 3:00 UTC to 8:59 UTC will be part of 06 UTC cycle and similarly for other cycles.

Surface observation reports are selected for this study in such a manner that each report has at least one meteorological parameter (pressure, temperature, humidity and/or wind) reported other than the location (Latitude, Longitude) information. India has large number of AWS and ARG stations geographically well distributed over the country established under IMD's modernization programme. This data is available only in the internal GTS, and is available in the NCMRWF archives. This is one of the important additional data set which is not part of the ECMWF archives that can be used in the IMDAA, tentatively from the year 2005. In the case of upper air observations (TEMP and PILOT), each observation report is considered only if the station reports at least three levels with minimum one meteorological parameter. Since there is no WIND Profiler observations over the IMDAA domain, comparison of WIND Profilers has not attempted here. Bar diagrams representing number of reports available in both the data sets for different observation types over the globe as well as over the IMDAA domain are prepared. Plots depicting the geographical locations of stations in the two data sets for different observation sub-types are also prepared. Geographical locations of the additional observations in the NCMRWF archives are also prepared. It may be noted that this study provides only the comparison of data volume of two data archives; no attempt has been made to study the quality of the observations in the two archives.

3. Results

This section briefly describes the comparison of surface and upper air observations in the NCMRWF and ECMWF data archives for April 2014. Bar diagrams depicting the total number of observations reported in each observation type globally and over the IMDAA

domain is prepared separately. Apart from bar diagrams, geographical plots showing the locations of different stations in both the archives and the additional stations in the NCMRWF archives are also prepared for different types of observations.

3.1 Surface Observations

In Surface observations, LAND SYNOP, METAR, SHIP and BUOY platforms available with both the archives and MOBILE SYNOP (AWS and ARG) in the NCMRWF archives are considered in the study.

3.1.1. LAND SYNOP

Figure 1 shows the number of daily global LAND SYNOP reports of 00 UTC cycle available in NCMWRF (blue) and ECMWF (red) (Same legends are used throughout the report) archives for the period April, 2014. Global LAND SYNOP reports in ECMWF archives are more than that in NCMRWF archives. Figure 2 shows the number of daily LAND SYNOP observation reports for the 00 UTC cycle available with NCMRWF and ECMWF over IMDAA region for April, 2014. Though ECMWF archives contains more observations globally, over the IMDAA region NCMRWF archives shows more number of reports. Number of observation reports for 06, 12 and 18 UTC cycles also show similar behaviour; more global reports in the ECMWF archives whereas over IMDAA domain reports are more in the NCMRWF archives. Hence the additional LAND SYNOP reports over the IMDAA domain in the NCMRWF archives is one of the important additional observation data set for the IMDAA project.

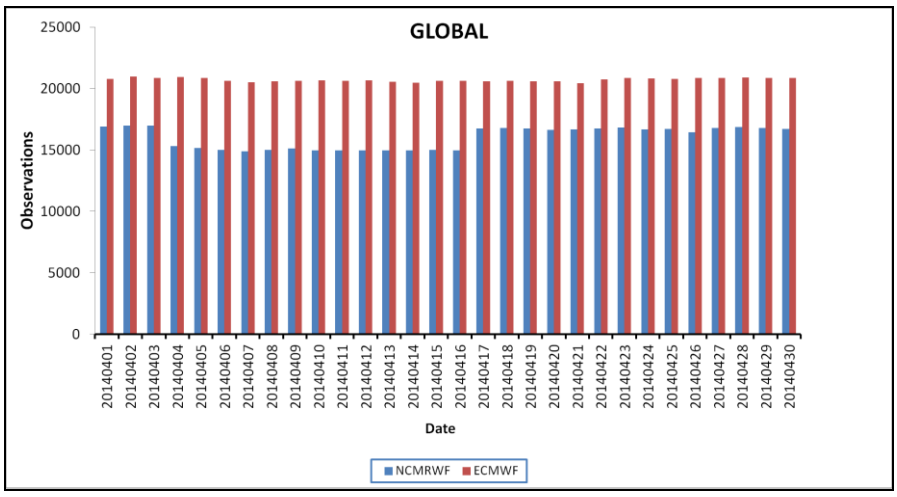

Figure 1: Number of Global SYNOP observations during April 2014 (00 UTC)

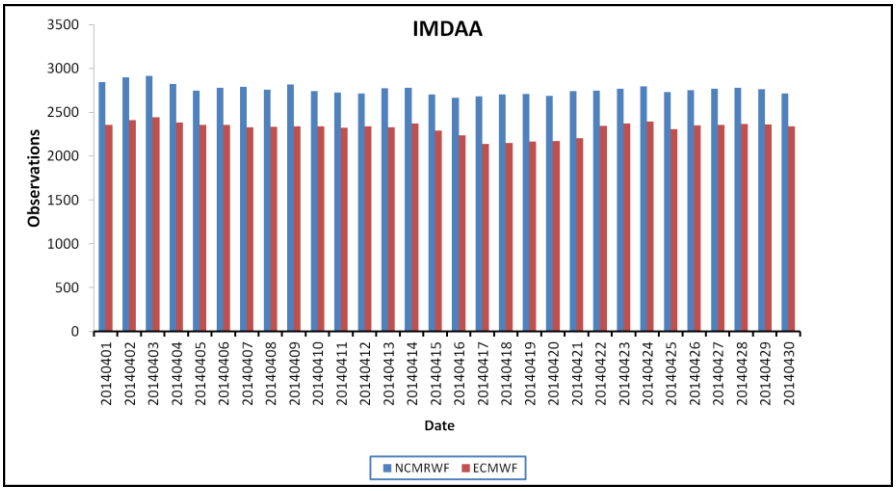

Figure 2: Number of SYNOP observations over IMDAA region during April 2014 (00 UTC)

As mentioned earlier, the bar diagrams (Figures 1 and 2) show the total LAND SYNOP reports. In order to see exactly how many stations are available in each datasets and the additional stations in the NCMRWF archives, geographical plots depicting the locations of the stations are prepared. Considering the area of interest, the geographical plots are prepared only over the IMDAA domain. Figure 3 depicts the geographical locations of LAND SYNOP stations from where observation reports are available in NCMRWF archives (Figure 3a), ECMWF archives (Figure 3b) and the additional stations available in the NCMRWF archives are compared to ECMWF archives (Figure 3c) on a typical day (12 UTC of 25 April 2014). The total numbers of observational stations within the domain are also mentioned in the plots. It is also noted that though NCMRWF archives has some additional stations, excluding these stations, the total stations in the ECMWF archives is higher than that in the NCMRWF archives both over the globe (figure not shown) and over the IMDAA domain (Figure 3). This clearly indicates that NCMRWF misses some of the global LAND SYNOP observations in its routine NWP assimilation.

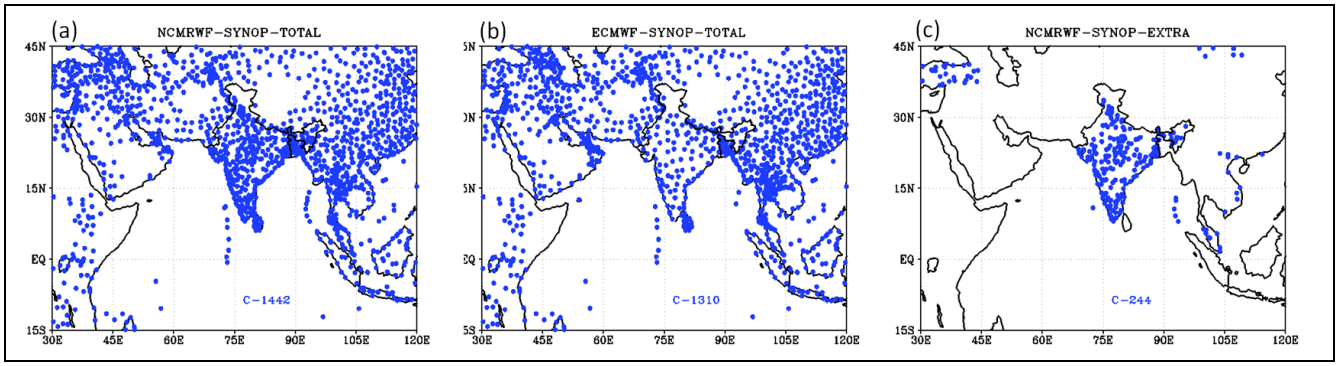

Figure 3: SYNOP observations stations of (a) NCMRWF-Total, (b) ECMWF-Total and (c) NCMRWF-Extra stations over IMDAA region

3.1.2. METAR

Figure 4 shows the number of daily global METAR reports valid for 00 UTC cycle available in NCMWRF and ECMWF data archives for April 2014. Figure 5 shows the number of METAR reports valid for 00 UTC cycle available in NCMWRF and ECMWF data archives over IMDAA domain for April, 2014. It is clear from Figure 4 that, globally ECMWF archives has more than double METAR observations compared to that of NCMRWF archives; however over the IMDAA domain the number of METAR observations is more in NCMRWF archives during certain days (Figure 5). Figure 6 depicts the geographical locations of METAR reports in NCMRWF archives (Figure 6a), ECMWF archives (Figure 6b) and the additional locations (stations) from where METAR reports available in the NCMRWF archives compared to ECMWF archives (Figure 6c) on a typical day (12 UTC of 25 April 2014). Some of these additional stations are nearby Indian stations, for example, NCMRWF routinely receives METAR reports from two nearby stations in Delhi, Safdarjung (VIDD) and Palam (VIDP) but the ECMWF archives contain the reports from Palam station only.

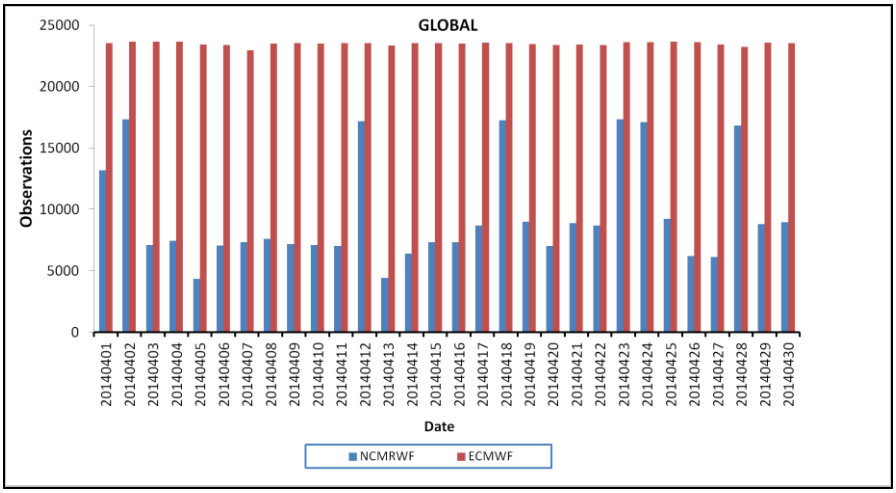

Figure 4: Number of Global METAR observations during April 2014 (00 UTC)

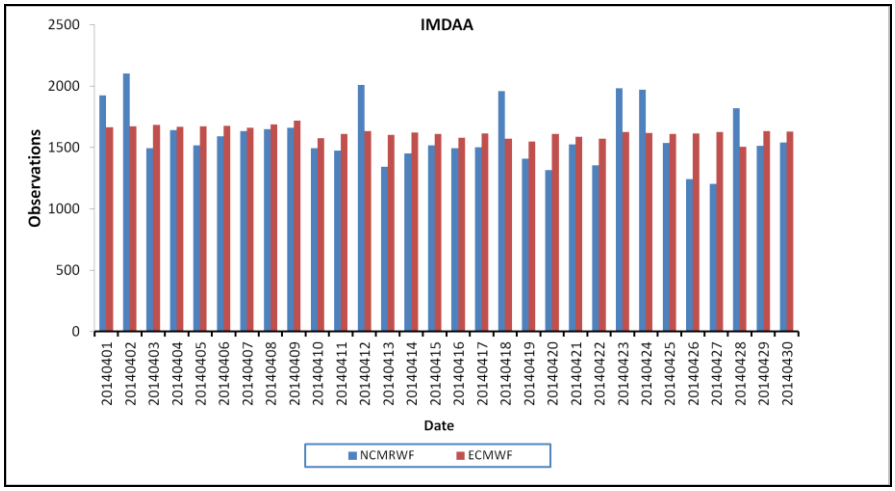

Figure 5: Number of METAR observations over IMDAA region during April 2014 (00 UTC)

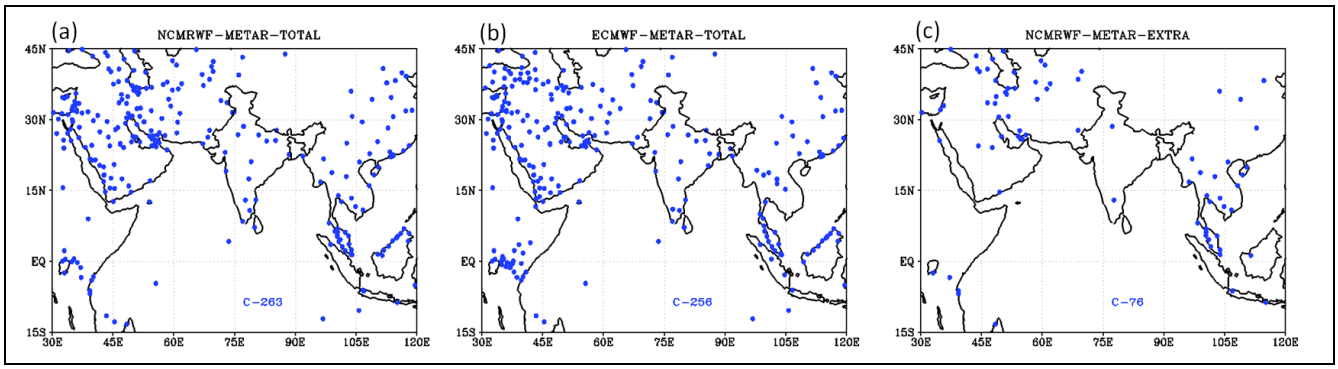

Figure 6: METAR observations of (a) NCMRWF-Total, (b) ECMWF-Total and (c) NCMRWF extra stations over IMDAA region

3.1.3. SHIP

Figures 7 and 8 depict the number of SHIP reports for 00 UTC in the two archives respectively over the global and IMDAA domain. Similar to SYNOP observations, SHIP observations are also more in the ECMWF archives globally, however over the IMDAA domain; the reports are more in the NCMRWF archives. In the other synoptic hours also, globally, ECMWF has more observations, however NCMRWF archives has more number of observations over the IMDAA domain. Figure 9 shows the total number of SHIP observations available in the NCMRWF archives (a), ECMWF archives (b) and the additional stations in the NCMRWF archives (c) for 12 UTC of 25 April 2014.

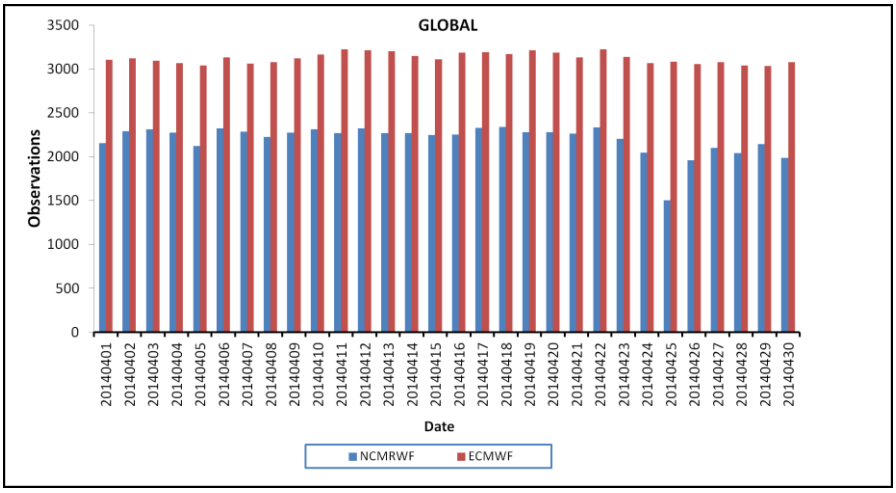

Figure 7: Number of Global SHIP observations during April 2014 (00 UTC)

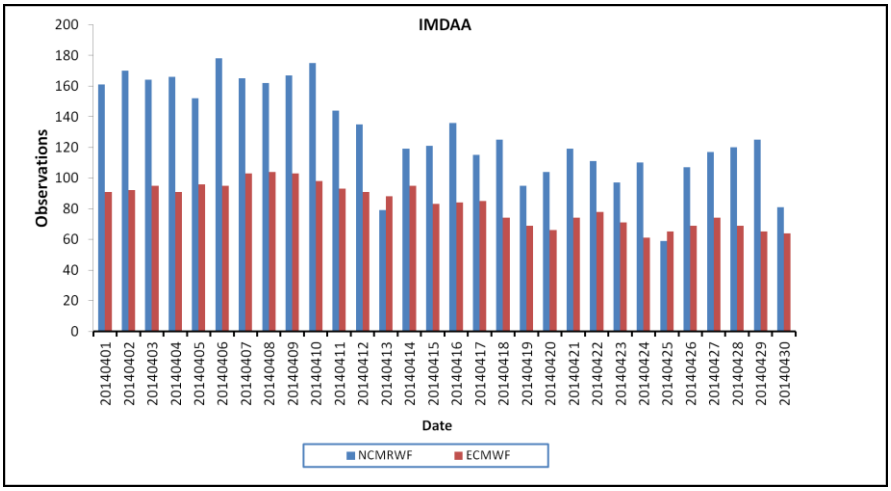

Figure 8: SHIP observations over IMDAA region for April 2014 (00UTC)

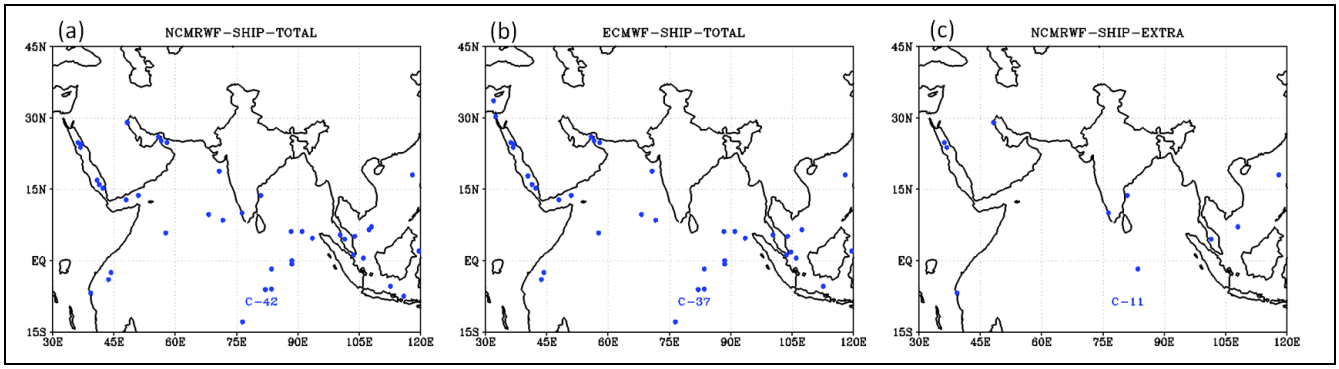

Figure 9: SHIP observations of (a) NCMRWF-Total, (b) ECMWF-Total and (c) NCMRWF extra stations over IMDAA region

3.1.4. BUOY

Figures 10 and 11 show the total number of Buoy reports available in NCMRWF and ECMWF data archives over the globe and IMDAA domain respectively. In contrast to other surface observations like SYNOP, METAR and SHIP, NCMRWF archives contains more

number of buoy observations over the globe. Over the IMDAA domain, the number of Buoy observations is almost same in both the archives. Figure 12 is the geographical locations of the Buoy reports present in (a) NCMRWF archives, (b) ECMWF archives and (c) the additional Buoys in NCMRWF archives over the IMDAA region. It is noted that only one extra Buoy report is available in NCMRWF archives compared to ECMWF in the IMDAA domain.

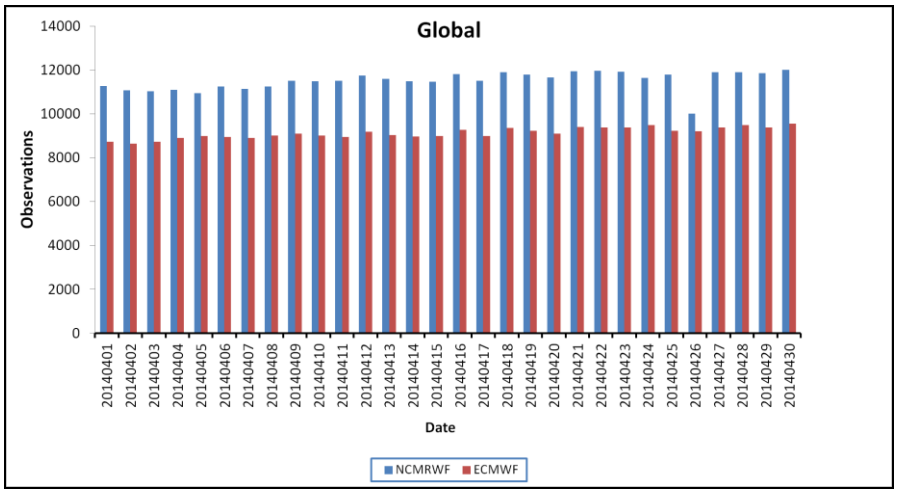

Figure 10: Number of Global BUOY observations during April 2014 (00 UTC)

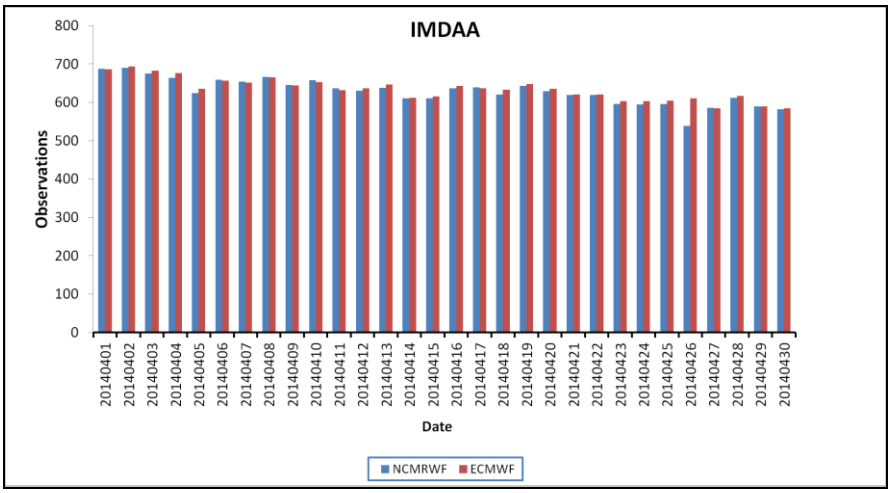

Figure 11: Number of BUOY observations over IMDAA region during April 2014 (00 UTC)

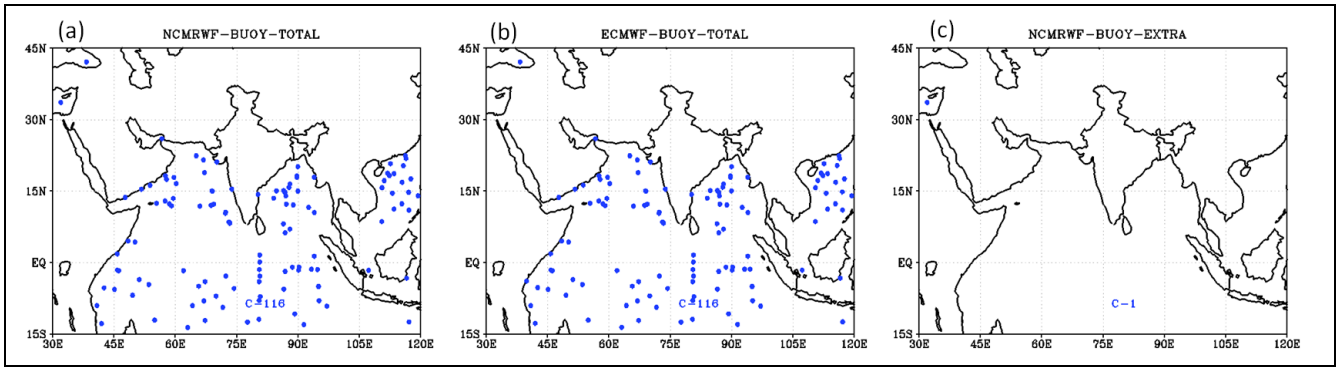

Figure 12: BUOY observations of (a) NCMRWF-Total, (b) ECMWF-Total and (c) NCMRWF extra stations over IMDAA region

3.1.5. MOBILE (AWS +ARG)

Under the modernization program, IMD deployed a large number of AWS (MOBILE SYNOP) stations and ARG all over India. However observation reports from these stations are not transferred to the international GTS. This is one of the important additional sources of surface observation that can be utilized in the IMDAA project. Figure 13 gives the total number of MOBIL SYNOP observations available in the NCMRWF archives for the period April 2014 valid for 00, 06, 12 and 18 UTC cycles.

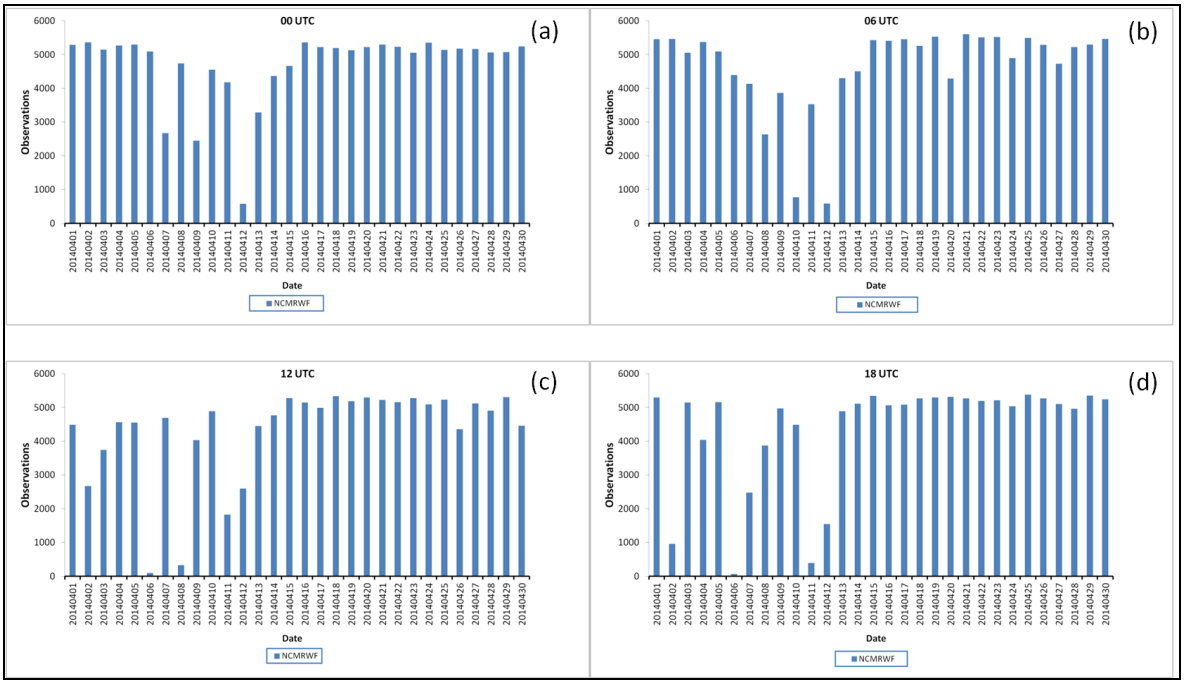

Figure 13: Number of MOBILE SYNOP observations over IMDAA region during April 2014 valid for (a) 00 UTC, (b) 06 UTC, (c) 12 UTC and (d) 18 UTC

Figure 14 shows the geographical locations of Indian SYNOP MOBILE stations. In Figure 14, (a) is the locations of AWS and ARG stations, (b) is the locations of AWS stations alone and (c) is the locations of ARG stations alone. There are around 1000 AWS and ARG stations which reports surface weather observation/ rainfall every 3 hourly interval.

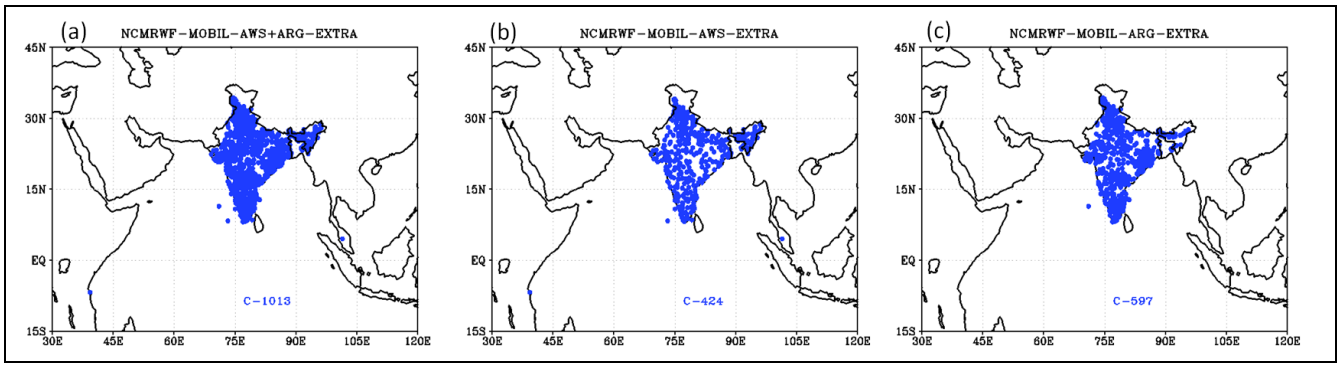

Figure 14: NCMRWF surface observations of (a) MOBILE-AWS+ARG, (b) MOBILE-AWS and (c) MOBILE-ARG over IMDAA region

3.2 Upper Air Observations

In the upper air observations, we have considered only TEMP (both TMPLND and TMPSHP) and PILOT reports for the comparison. Other upper air observations like DROPSONDE; WIND PROFILERS over the IMDAA region are negligible.

3.2.1 TMPLND and TMPSHP

Figures 15 and 16 depict the number of TMPLND reports in the NCMRWF and ECMWF archives in four different assimilation cycles over the globe and over the IMDAA domain for April 2014. It is noted from Figure 15 that NCMRWF archives contains more TMPLND observations compared to that of ECMWF. It is also noted that the number of TMPLND reports in the NCMRWF archives is more than double that in the ECMWF archives in 06 UTC and 18 UTC. Over the IMDAA domain, the number of TMPLND reports in both the archives is almost same in 00 UTC and 12 UTC (Figure 16), but during 06 UTC and 18 UTC, similar to global domain statistics, the number of TMPLND report is more than double in the NCMRWF archives compared to the ECMWF archives.

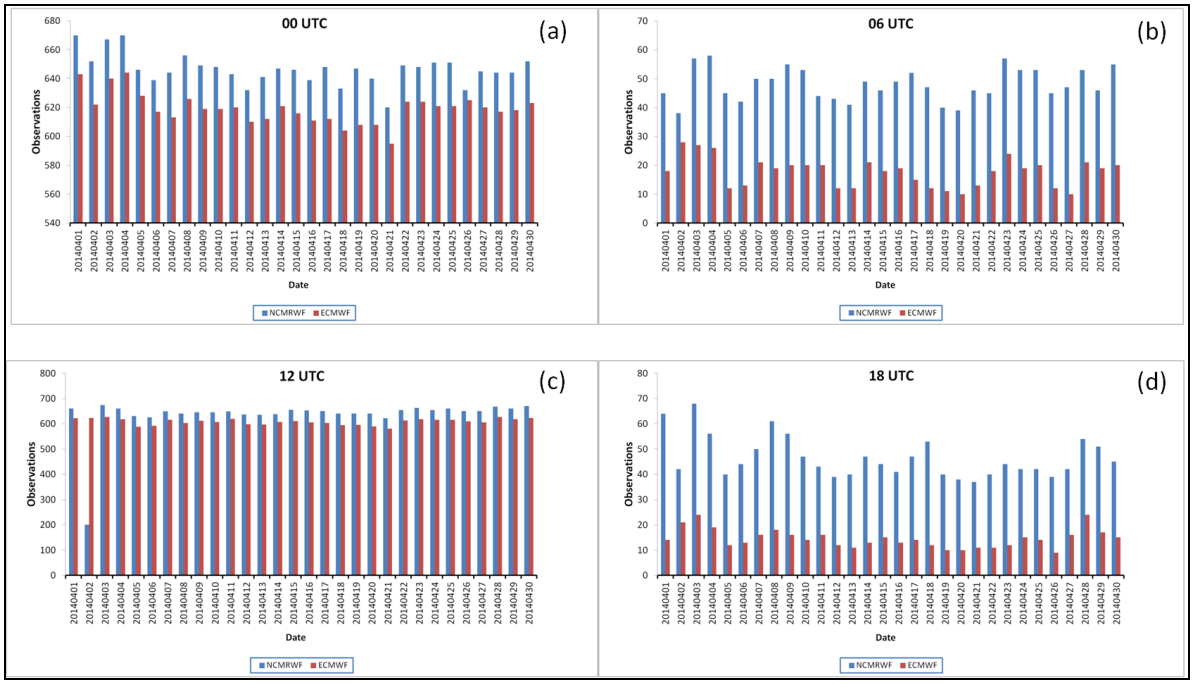

Figure 15: Number of Global TMPLND observations during April 2014 valid for (a) 00 UTC, (b) 06 UTC, (c) 12 UTC, and (d) 18 UTC

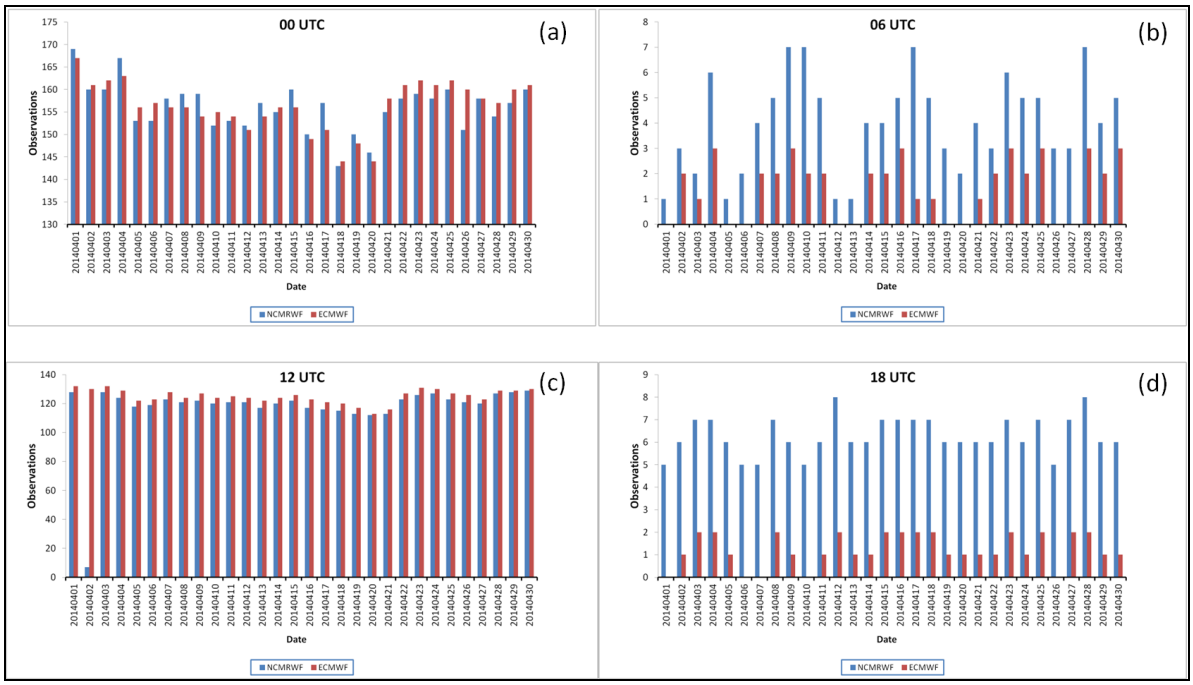

Figure 16: Number of TMPLND observation over IMDAA region during April 2014 valid for (a) 00 UTC, (b) 06 UTC, (c) 12 UTC and (d) 18 UTC

Figure 17 shows the total number of TMPLND stations available in the NCMRWF archives (Figure 17a), ECMWF archives (Figure 17b) and the extra stations in the NCMRWF archives that are absent in the ECMWF archives (Figure 17c) for 00 UTC of 25 April 2014.

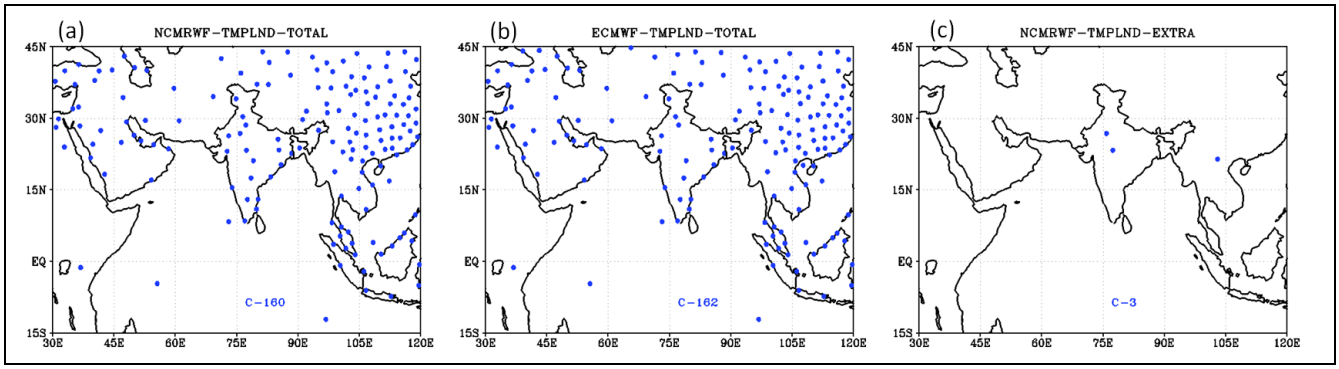

Figure 17: TMPLND observations of (a) NCMRWF-Total, (b) ECMWF-Total and (c) NCMRWF-Extra stations over IMDAA region

Almost same numbers of TMPSHP reports are found in both the archives for April 2014. Figure 18 is the bar diagram showing the number of TMPSHP reports in both the datasets in different assimilation cycles over the globe, and it is noted that there is no TMPSHP observations reported over the IMDAA domain in both the datasets during April 2014.

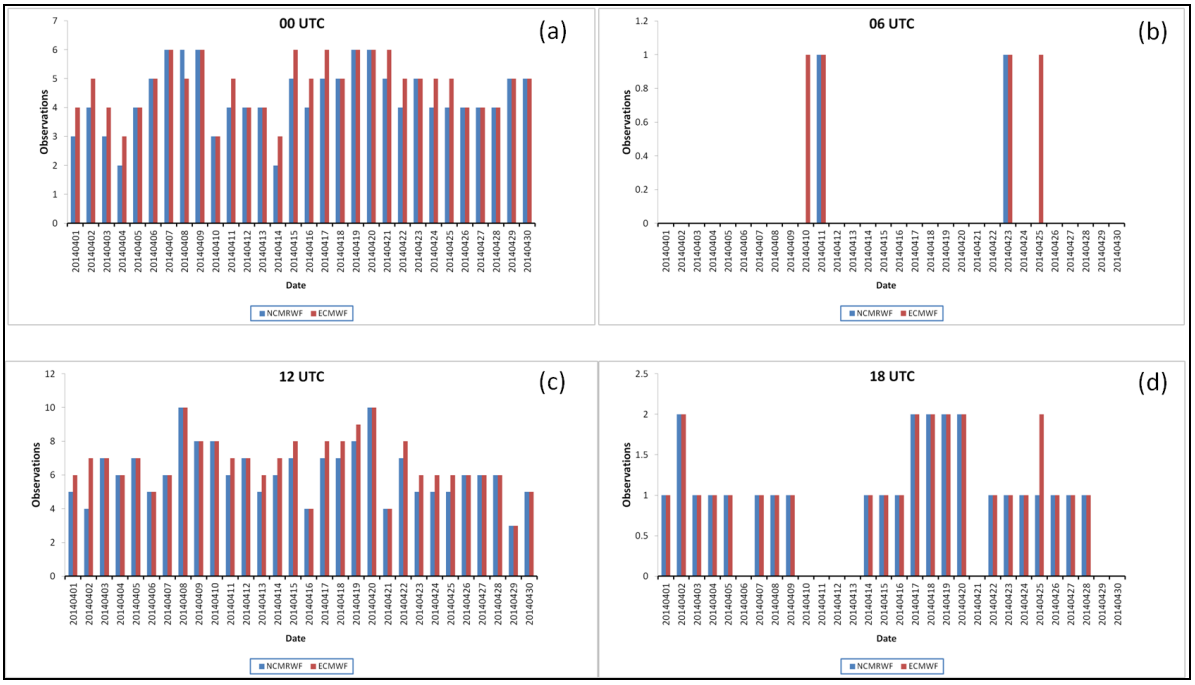

Figure 18: Number of Global TMPSHP observations during April 2014 valid for (a) 00 UTC, (b) 06 UTC, (c) 12 UTC and (d) 18 UTC

3.2.2 PILOT

Figure 19 shows the number of PILOT reports in both the archives in different assimilation cycles over the globe during April 2014. It is noted that except for 18 UTC, the number of PILOT reports in the ECMWF archives is higher than that in the NCMRWF archives. During

00 UTC and 12 UTC assimilation cycles, the number of PILOT reports in the ECMWF archives is more than double that in the NCMRWF archives. Figure 20 shows the PILOT reports over the IMDAA domain available at ECMWF and NCMRWF archives for all the four assimilation cycles during April 2014. Over the IMDAA domain also the number of PILOT reports is higher in the ECMWF archive except during 18 UTC. In 00 UTC and 12 UTC, the number of PILOT reports over the IMDAA domain is more in the ECMWF archives, whereas in 06 UTC, the numbers in both the archives are comparable. Figure 21 shows the geographical location of the PILOT stations from where the observation reports are available in both the archives (Figures 21 a and b) and the additional stations in the NCMRWF archives (Figure 21c) valid for 25 April 2014. It is noted that reports from some of the Indian PILOT stations are not available with ECMWF archives.

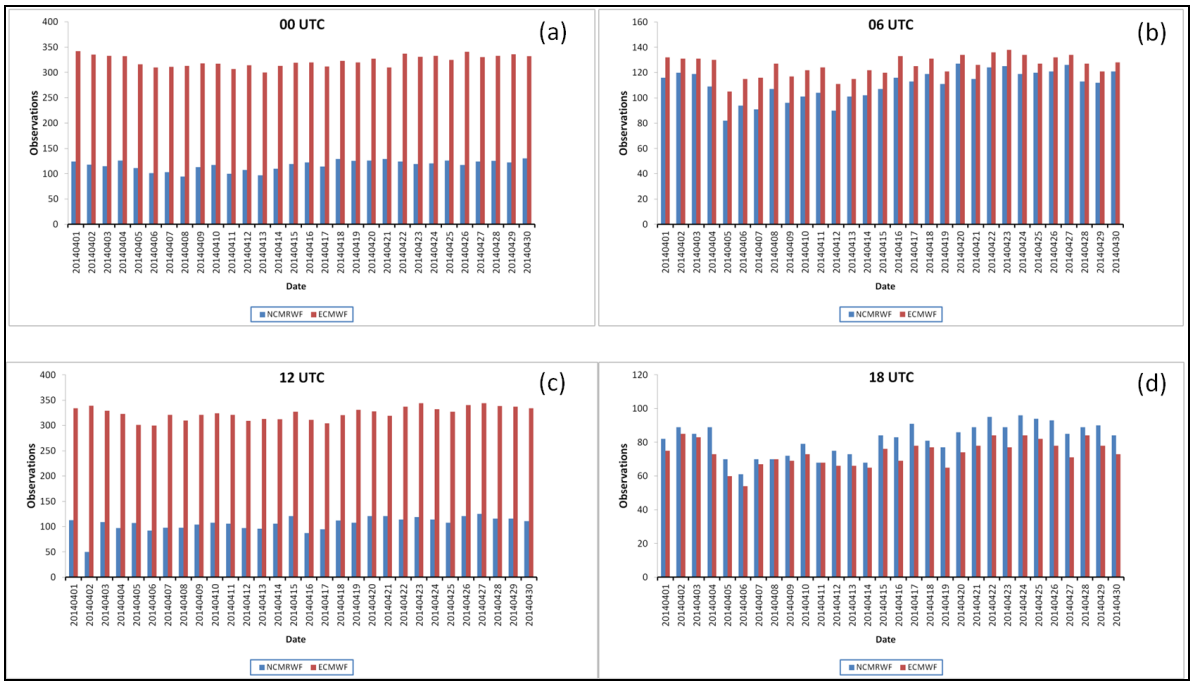

Figure 19: Number of Global PILOT observations during April 2014 valid for (a) 00 UTC, (b) 06 UTC, (c) 12 UTC and (d) 18 UTC

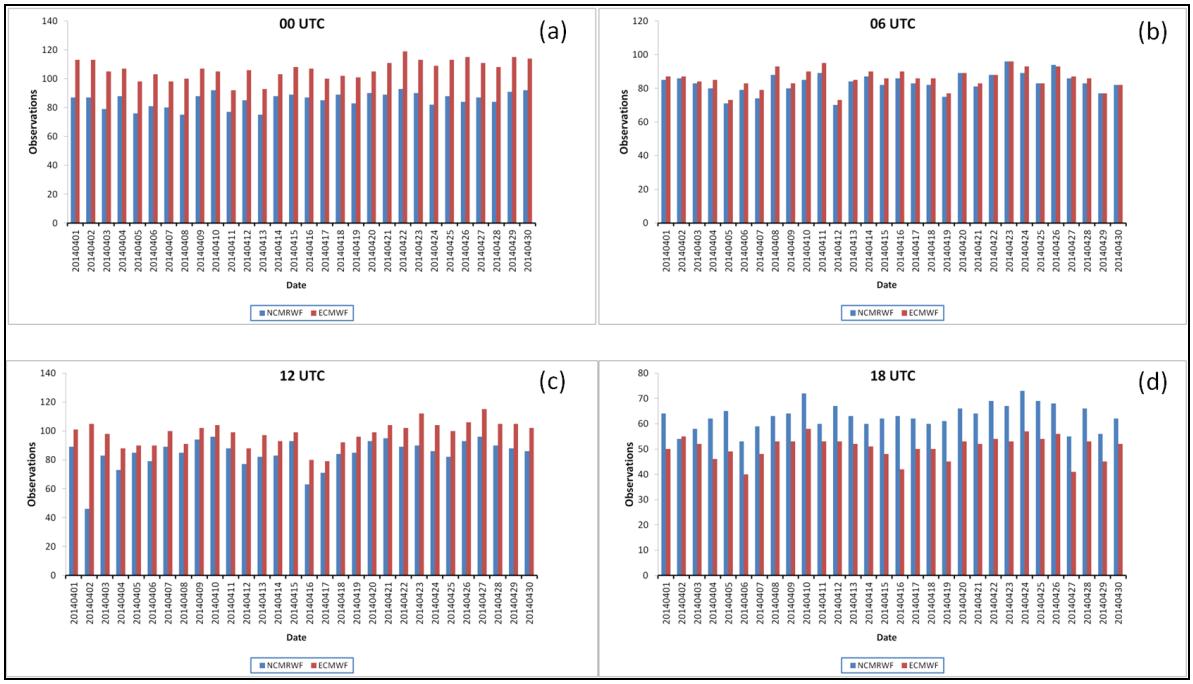

Figure 20: PILOT observation over IMDAA region during April 2014 valid for (a) 00 UTC, (b) 06UTC, (c) 12UTC and (d) 18 UTC

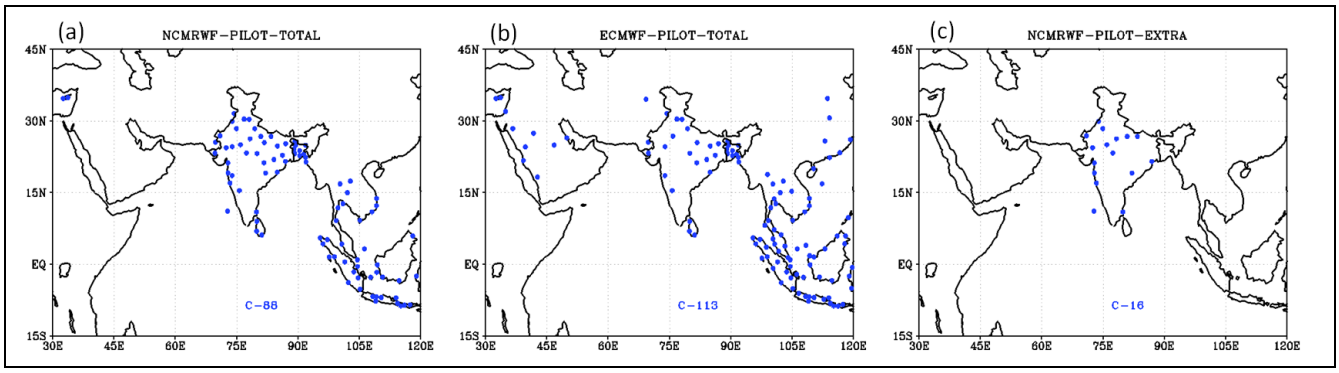

Figure 21: PILOT observations of (a) NCMRWF-Total, (b) ECMWF-Total and (c) NCMRWF-Extra stations over IMDAA region

3.3 Additional observations in the NCMRWF archives during April 2014

After comparing the total reports of different types of surface and upper air observations, efforts are put forward to generate a consolidated list of additional stations present in the NCMRWF archives during the study period of April 2014. Geographical plots depicting the locations of the additional stations from where reports are available with NCMRWF in different assimilation cycles as well as a consolidated list of stations in the entire study period are prepared. Figure 22 shows the locations of additional surface observations in the NCMRWF archives in different assimilation cycles. Figures 22 a, b, c, and d are the additional SYNOP observations in the NCMRWF archives compared to the ECMWF

archives for different assimilation cycles 00 UTC, 06 UTC, 12 UTC and 18 UTC. Additional SYNOP stations available in NCMRWF data archives in different assimilation cycles during the study period are 93 (00 UTC), 279 (06 UTC), 271 (12 UTC), and 86 (18 UTC). Figures 22 e, f, g, and h present the locations of additional METAR stations in the NCMRWF data archives in different assimilation cycles of 00 UTC, 06 UTC, 12 UTC, and 18 UTC. Similarly, Figures 22 i, j, k and l are the corresponding additional SHIP stations in the NCMRWF data archives. Unlike SYNOP stations, the number of additional METAR and SHIP stations is almost same in different assimilation cycles.

As mentioned earlier, NCMRWF data archives have the unique dataset from Indian AWS and ARG stations. Figure 23 shows the available AWS and ARG stations in the NCMRWF data archives. Figures 23 a, b, c and d are the locations of both AWS and Figures 23 e, f, g and h are the ARG stations reported during 00 UTC, 06 UTC, 12 UTC and 18 UTC cycles. It is noted that slightly more number of stations are reported during 06 UTC and 12 UTC compared to other cycles.

Figure 24 shows the additional upper air stations (TEMP and PILOT) in the NCMRWF data archives in different assimilation cycles during the study period of April 2014. Figures 24 a, b, c and d present the additional TEMP stations in the NCMRWF data archives in different assimilation cycles of 00 UTC, 06 UTC, 12 UTC and 18 UTC, whereas the Figures 24 e, f, g, and h show the corresponding additional PILOT stations in the NCMRWF data archives. The additional TEMP stations are more in 00 UTC assimilation cycle compared to the other three cycles, however the number of PILOT stations are only two in the 06 UTC and approximately same number of additional PILOT stations (~27-32) in other three assimilation cycles

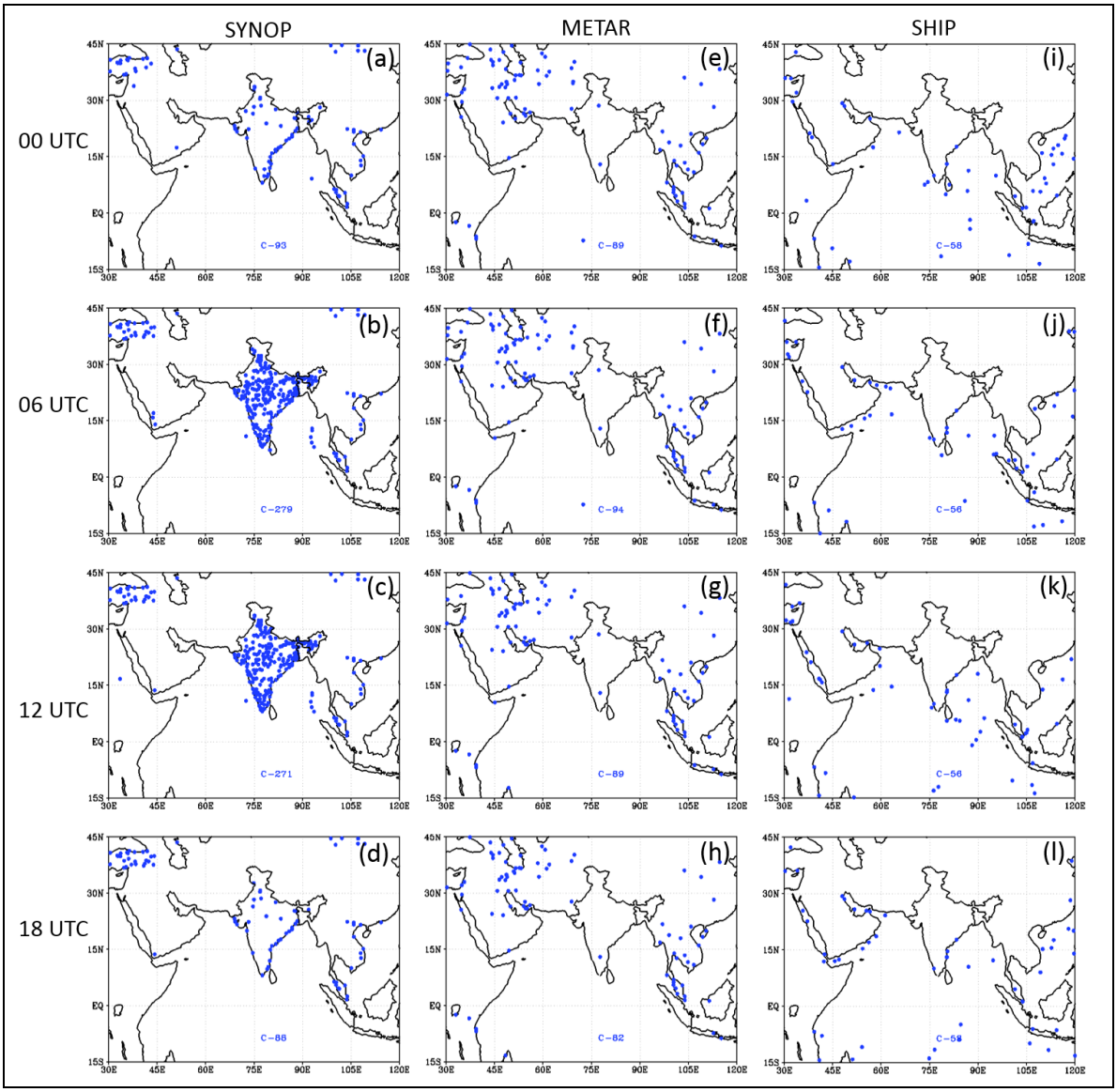

Figure 22: The locations of additional observations available with NCMRWF data for SYNOP (a, b, c, d), METAR (e, f, g, h) and SHIP (i, j, k, l) over IMDAA region for 00, 06, 12 and 18 UTC cycles

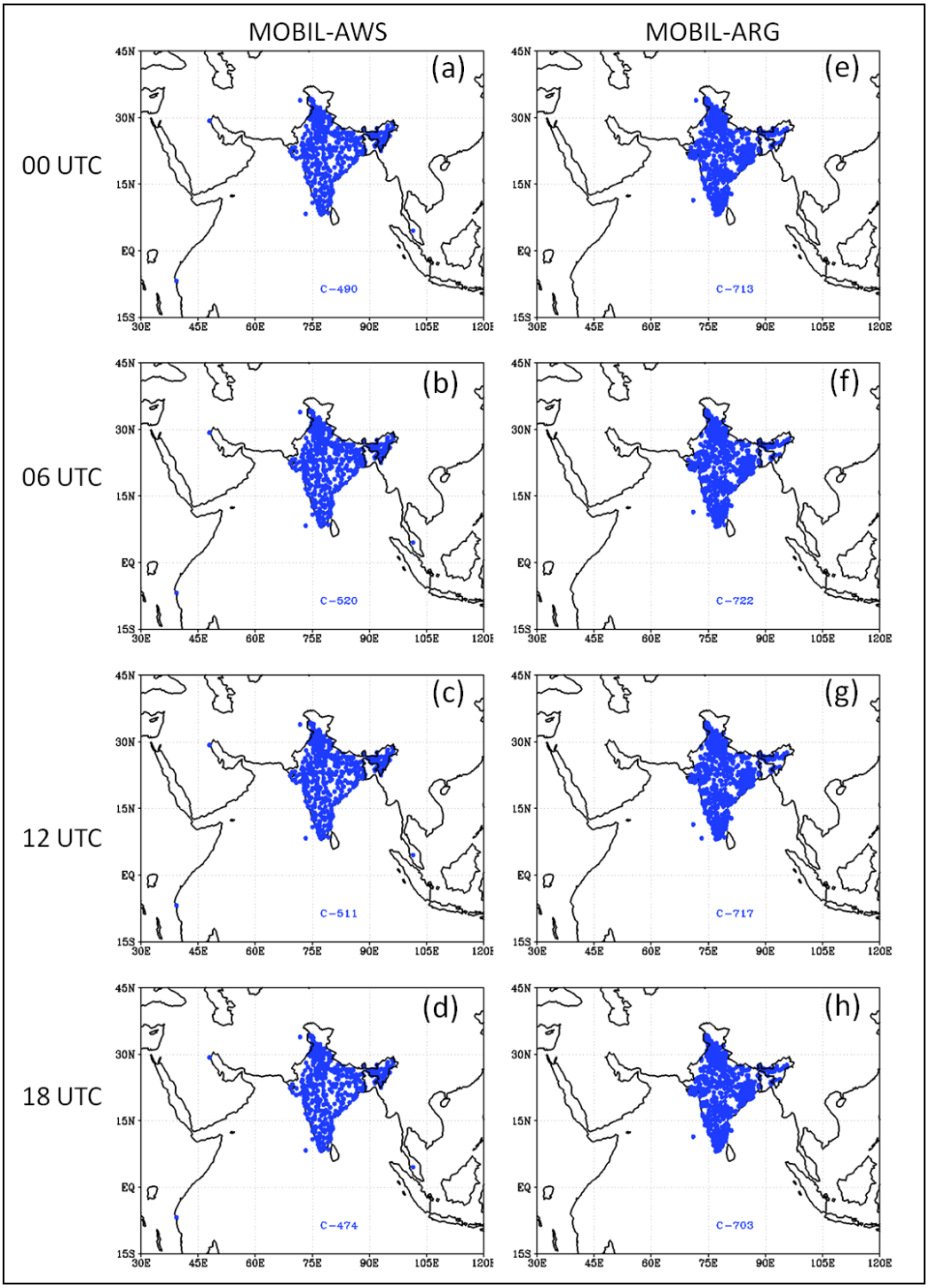

Figure 23: The locations of additional observations available with NCMRWF data for MOBILE-AWS (a, b, c, d) and MOBILE-ARG (e, f, g, h) over IMDAA region for 00, 06, 12 and 18 UTC cycles

.

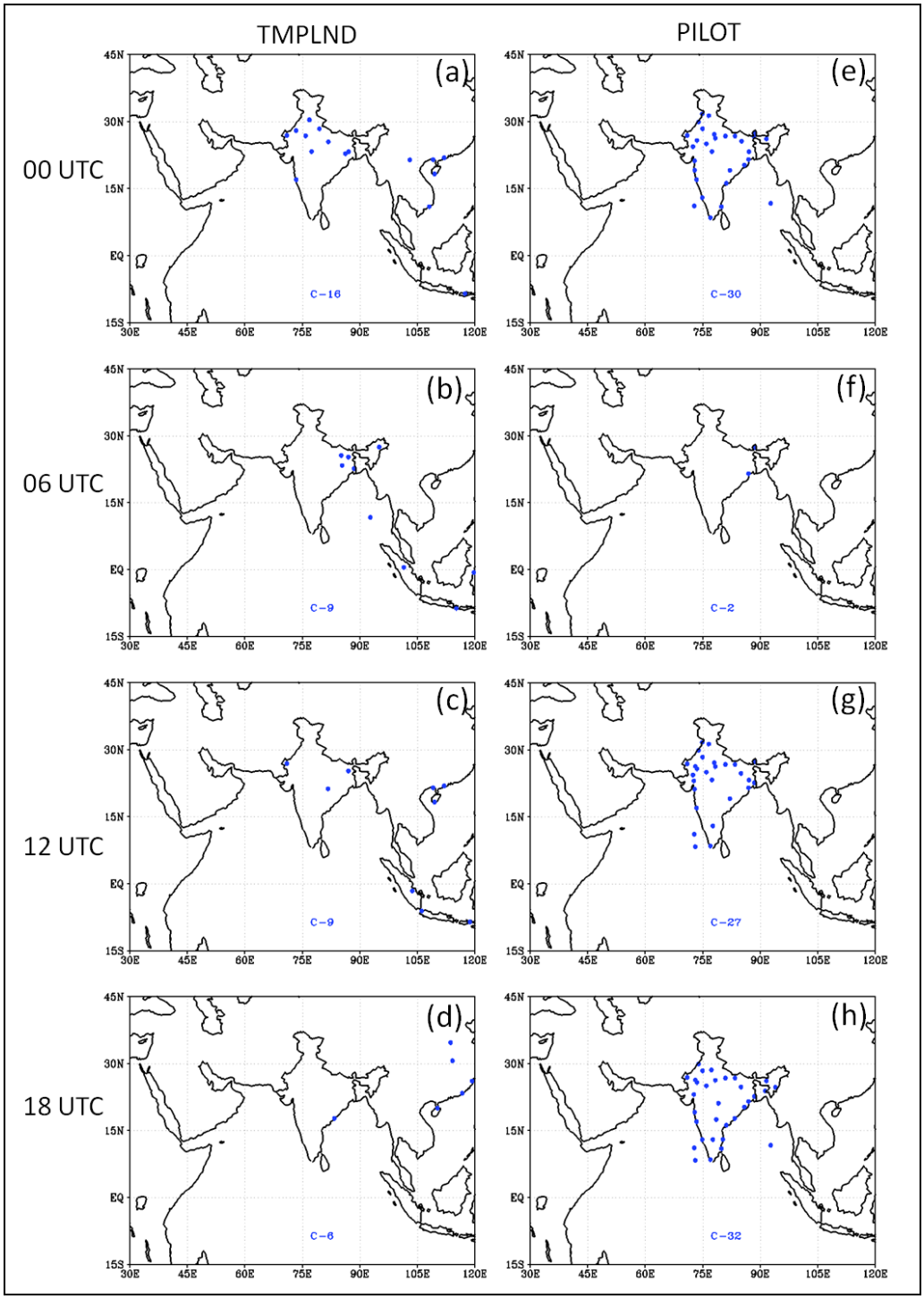

Figure 24: The locations of additional observations available with NCMRWF data for TMPLND (a, b, c, d) and PILOT (e, f, g, h) over IMDAA region for 00, 06, 12 and 18 UTC cycles

After preparing the list of additional stations in different assimilation cycles during the period of study, we generated a single consolidated list covering all the four cycles for different types of observations. This list provides the total number of extra stations present in the different types of observations in NCMRWF data archives for April 2014 (Figure 25).

Figure 25 shows the locations of the different types of the additional stations such as (a) the SYNOP, (b) the METAR, (c) the AWS and ARG, (d) SFCSHP, (e) TMPLND, and (f) PILOT. Table 1 gives the total number of each type of additional observations present in the NCMRWF archives during April 2014. The details of these stations are provided in APPENDIX-I

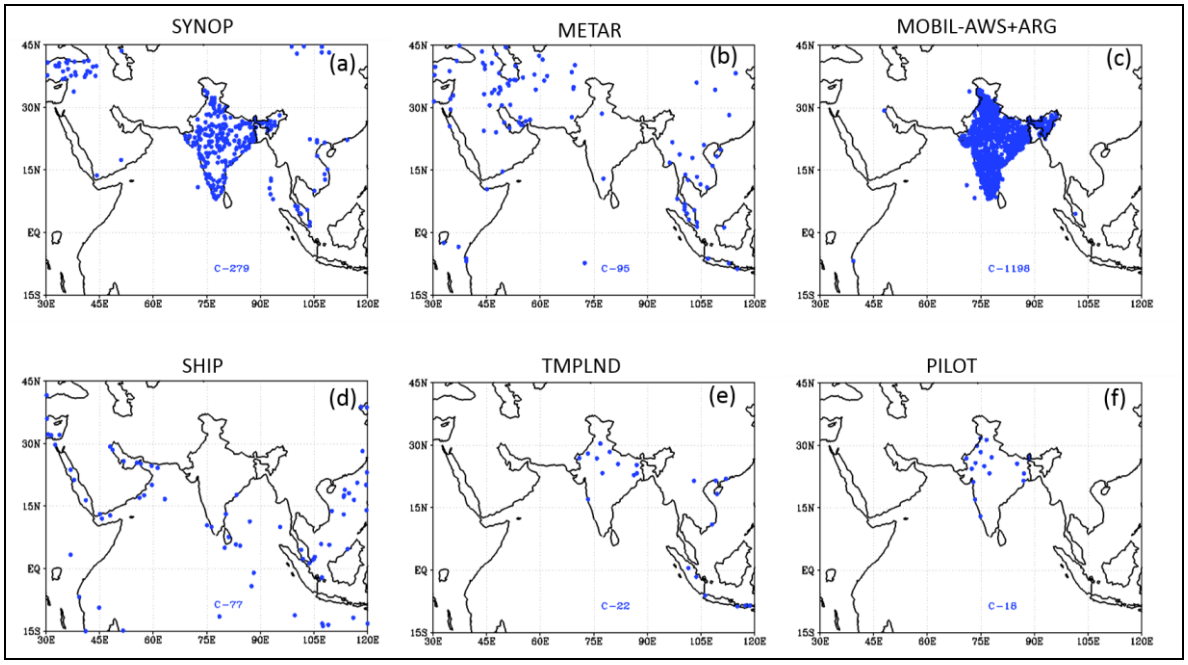

Figure 25: The locations of all additional observations available with NCMRWF data for (a) SYNOP, (b) METAR, (c) MOBILE-AWS+ARG, (d) SHIP, (e) TMPLND, (f) PILOT over IMDAA region

Table 1: Consolidated Additional Observations in NCMRWF data

Sl. No.	Type of Observation	No. of Observations
1	SYNOP	279
2	METAR	95
3	SHIP	77
4	AWS+ARG	1198
5	TMPLND	22
6	PILOT	18

So far we were discussing about the additional observations in the NCMRWF data archives, it does not mean that NCMRWF data archives is superior to ECMWF data archives. There are many stations in different types of observations in the ECMWF data archives which are

absent in the NCMRWF data archives, not only over the globe but also over the IMDAA domain. Figure 26 shows the additional stations in the ECMWF data archives that are absent in the NCMRWF archives. Figure 26 is similar to Figure 25, but the difference is that it depicts the additional observational stations in the ECMWF archives for different types of observations like, (a) SYNOP, (b) METAR, (c) Buoy, (d) SHIP, (e) TEMP and (f) PILOT over the IMDAA domain.

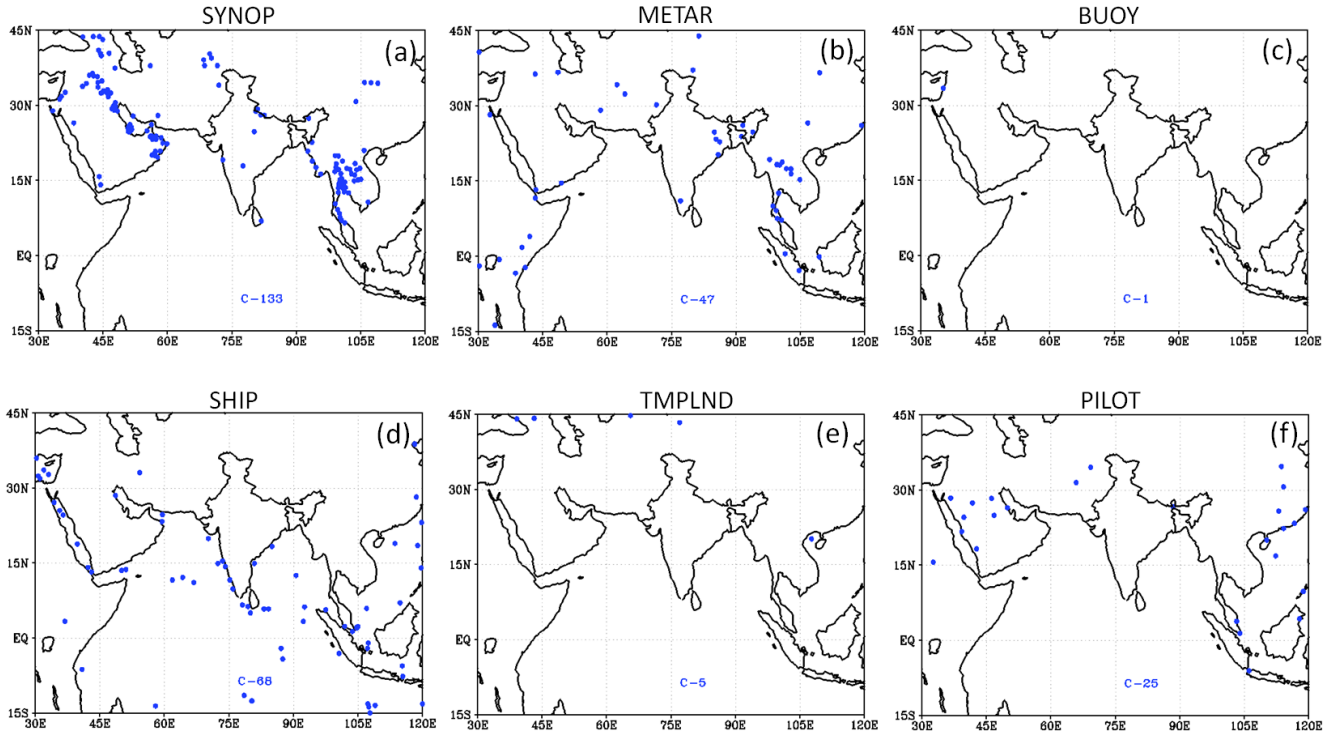

Figure 26: The locations of all additional observations available in ECMWF data archives for (a) SYNOP, (b) METAR, (c) Buoy, (d) SHIP, (e) TMPLND, (f) PILOT over IMDAA region

4. Conclusions

In this study, two archives of meteorological datasets respectively from NCMRWF and ECMWF data archives are compared for a month period of April 2014. The main objective of this study is to compare the two datasets and to bring out the details of the observation reports available at NCMRWF which are not part of the ECMWF archives. This will enable to use these additional observations in the IMDAA reanalysis. It is noted that good number of surface stations and a few upper air stations present in the NCMRWF archives is not available in the ECMWF data archives. Details of the additional observations are presented in APPENDIX-I of this report.

Acknowledgments

Fruitful discussion with Drs. V. S. Prasad and Priti Sharma during the course of this study is mentioned with gratitude. Thanks are also due to Met Office, UK for providing the ECMWF data archives.

APPENDIX-I

Table 1: SYNOP additional stations in NCMRWF data archives

ID	LAT	LON		ID	LAT	LON		ID	LAT	LON		ID	LAT	LON
17040	41.03	40.52		42503	25.03	88.13		42708	23.65	87.7		43301	12.13	78.03
17069	40.78	30.42		42516	25.57	91.88		42811	22.18	88.2		43302	12.48	78.57
17080	40.6	33.62		48674	2.45	103.83		42812	22.25	88.67		43318	11.35	76.8
17099	39.73	43.05		43275	13.67	79.58		43309	12.92	92.92		43330	10.78	79.13
17127	40.07	32.57		43278	13.07	80.2		43310	12.42	92.93		43342	10.95	78.08
17129	39.95	32.68		42500	25.27	87.47		43382	7.98	93.53		43379	8.75	78.18
17131	39.93	32.75		42273	27.57	81.6		43364	10.58	92.55		42299	27.33	88.62
17135	39.85	33.52		42044	33.58	75.08		42805	22.5	87.95		42399	26.53	88.72
17238	37.67	30.33		42045	33.5	75.17		42704	23.47	87.43		42403	26.33	89.47
48846	18.35	105.9		42237	27.13	72.37		43266	10.85	72.47		42404	26.02	89.98
48863	15.13	108.78		42137	29.7	77.03		42515	25.25	91.73		42619	24.75	92.8
48907	10	105.08		43021	19.08	77.33		42407	26.18	90.63		42976	20.3	86.68
48866	13.98	108		42065	32.27	77.17		42408	26.43	91.62		43339	10.23	77.47
48875	12.68	108.08		42077	31.47	76.27		42413	26.75	92.35		43057	18.9	72.82
42103	30.38	76.77		42177	28	76.08		42420	26.52	93.98		43197	15.85	74.53
42170	28.25	74.92		43111	17.93	73.67		42527	25.63	94.17		43229	14.07	74.53
42343	26.45	74.62		43009	19.08	74.8		42187	28.83	78.75		43257	13.5	75.08
48838	21.52	107.97		43058	18.63	72.87		42961	20.3	83.3		43263	13	76.15
42181	28.57	77.12		43062	18.45	73.4		43097	18.82	82.72		43289	12.5	76.83
45045	22.18	114.3		43158	16.85	74.6		42970	20.47	85.93		43285	12.95	74.83
42830	21.65	69.67		42851	21.05	75.57		42969	20.83	85.1		42406	26.15	89.92
42748	22.33	73.27		43017	19.27	76.77		42966	20.48	84.27		42414	26.2	92.52
42731	22.37	69.08		43335	10.77	76.65		43042	19.92	83.18		42416	26.72	92.8
42631	23.25	68.85		43355	9.58	76.52		42792	22.02	84		42453	25.98	76.37
42730	22.48	69.12		43354	9	76.92		42894	21.93	86.77		42506	25.22	88.78
17265	37.75	38.28		43315	11.83	75.33		42770	22.95	79.18		17033	40.98	37.9
17340	36.8	34.63		43320	11.13	75.95		42574	24.53	81.3		17085	40.65	35.85
17352	36.98	35.3		43372	8.47	76.95		42577	24.42	81.87		17193	38.62	34.7
17030	41.28	36.3		42883	21.47	83.97		42674	23.83	79.45		17204	38.73	41.52
17045	41.18	41.82		42891	21.62	85.52		42672	23.32	77.83		17255	37.6	36.93
17082	40.85	35.58		42114	30.4	78.48		42467	25.07	79.45		17275	37.3	40.73
17130	39.95	32.88		42147	29.47	79.65		42661	23.32	75.05		17282	37.88	41.12
17200	38.43	38.08		42148	29.03	79.47		42567	24.98	79.92		17285	37.57	43.77
42671	23.85	78.75		43109	17.82	73.1		42665	23.43	76.32		17100	39.92	44.05
42693	23.17	83.25		42483	25.3	83.02		42557	24	76.72		17162	39.18	36.07
43147	17.35	82.55		42139	29.02	77.63		42662	23.18	75.78		17205	38.48	42.3
43149	17.72	83.23		42099	30.87	75.93		42763	22.77	77.77		43160	16.7	75.25
43187	16.43	81.7		42262	27.88	78.07		42767	22.47	78.43		43260	13.25	75.75
43220	15.9	80.47		43071	18.2	75.2		42860	21.87	77.93		43368	9.15	92.82
43243	14.9	79.98		43193	15.87	73.63		42460	25.67	78.47		43367	9.17	92.83
43331	11.97	79.82		43113	17.52	74.05		42459	25.33	77.65		41390	13.68	44.15
43348	10.33	79.38		42463	25.45	78.58		42562	24.77	78.83		42925	20.55	74.53
43361	9.73	79.03		42081	31.83	77.17		42456	25.67	76.68		42523	25.75	93.18
43377	8.08	77.5		42083	31.1	77.17		42849	21.82	75.62		42522	25.17	93.02
42056	32.67	74.83		42937	20.93	77.78		42855	21.83	76.37		42900	21.78	87.75
42973	20.78	86.73		42946	20.6	79.85		42679	23.53	80.88		42709	23.23	87.85
43049	19.27	84.88		42931	20.53	76.23		42771	22.08	79.55		42295	27.05	88.27
43053	19.8	85.82		43029	19.97	79.3		42715	22	80.7		42296	27.07	88.47
42105	30.73	76.88		42871	21.47	80.2		42546	24.88	74.63		42555	24.53	76.17

42901	21.83	87.78		42939	20.67	78.58		42540	24.6	72.72		43011	19	75.72
42807	22.53	88.33		42943	20.4	78.15		42174	28.33	75.58		43025	19.65	78.53
48802	22.35	103.82		42876	21.18	81.28		42543	24.58	73.7		38111	43.58	51.08
48810	22.15	105.83		42783	22.03	82.7		42450	25.45	75.63		42387	26.12	85.4
48831	21.6	105.83		43168	16.75	78		42655	23.55	74.45		42499	25.23	87.07
48600	6.33	99.73		42539	24.2	72.2		42441	25.08	73.08		42393	26.13	86.58
48602	5.47	100.38		42838	21.75	72.2		42439	25.35	72.62		42488	25.78	84.73
48603	6.2	100.4		42638	23.15	70.12		42062	32.27	76.38		42383	26.67	84.92
48618	5.38	103.1		42834	21.6	71.22		42473	25.47	80.37		42395	26.3	87.27
48625	4.57	101.1		42740	22.73	71.6		42484	25.75	84.17		42391	26.17	85.9
48632	4.47	101.37		42837	21.08	71.78		42266	27.88	79.9		42799	22.82	86.18
48679	1.63	103.67		42914	20.72	70.92		42468	25.98	79.5		42795	22.55	85.82
42220	28.1	95.38		42639	23	70.22		42143	29.62	78.38		41414	17.37	50.95
42618	24.32	92		42744	22.57	72.93		42469	25.95	80.15		43083	18.05	78.27
43001	19.97	72.72		42654	23.23	72.72		42271	27.38	80.17		42026	34.05	74.4
44329	44.62	98.7		42915	20.62	72.93		43258	13.93	75.63		42776	22.58	80.37
44338	44.65	102.17		42651	23.83	73.03		42482	25.4	83.55		43184	16.83	81.58
44348	44.57	107.18		42714	22.98	88.37		43133	17	79.25		42588	24.92	84.18
44374	42.9	100.22		42803	22.42	87.32		43137	17.25	80.15		42121	30.12	80.25
44385	43.2	107.17		42603	24.13	88.27		43182	16.78	80.28		40085	33.78	37.7
44386	43.18	109.22		42711	23.4	88.52		43277	13.15	79.53				

Table 2: METAR additional stations in NCMRWF data archives

ID	LAT	LON		ID	LAT	LON		ID	LAT	LON		ID	LAT	LON
WADD	-8.75	115.17		VVDN	16.03	108.18		OICI	33.58	46.4		UDYZ	40.15	44.4
WARR	-7.38	112.78		VYYY	16.77	96.17		OIGK	34.28	47.12		UTDL	40.22	69.68
FJDG	-7.3	72.4		VLVT	17.95	102.57		OIHM	34.28	48.82		UBBG	40.73	46.4
HTDA	-6.87	39.2		ZJSY	18.3	109.4		ZLXY	34.3	108.93		UDSG	40.75	43.85
WIHH	-6.27	106.89		VTCC	18.78	98.99		OIMD	34.35	58.68		LTFH	41.25	36.57
HTZA	-6.22	39.22		ZJHK	19.93	110.45		OAKB	34.55	69.22		UTNU	41.58	60.63
HTKJ	-3.42	37.07		VVNB	21.02	105.8		OIHH	34.87	48.55		UTNN	42.48	59.63
HTMW	-2.47	32.92		VYMD	21.7	96.97		OICJ	34.9	48.63		URML	42.82	47.65
WBGY	1.22	111.45		OEKJ	24.07	47.58		KQSA	34.95	69.28		URMN	43.5	43.63
WSSL	1.42	103.89		KQIR	25.12	51.3		OIIE	35.4	51.15		UATE	44.55	50.25
WMAU	2.45	103.83		HEMA	25.55	34.58		ZLLL	36.02	103.75		URKA	44.9	37.3
WMSA	3.13	101.55		OEDF	26.44	49.81		OIMC	36.5	61.05		OEDM	24.45	44.12
WMKI	4.57	101.08		OIBK	26.52	53.97		OINZ	36.63	53.18		OIBA	25.87	55.03
WMKN	5.38	103.1		OIKQ	26.75	55.9		OINN	36.65	51.45		OIBS	25.9	54.53
WMKB	5.47	100.38		OISL	27.67	54.37		OINB	36.72	52.65		OIKO	27.12	57.1
WMKA	6.2	100.4		OPSK	27.72	68.79		UTAM	37.62	61.9		LLIB	32.98	35.57
VTSS	6.92	100.43		ZGHA	28.23	112.87		LTFC	37.85	30.37		OIIP	35.77	50.82
VTSP	8.12	98.32		VIDD	28.58	77.2		UTAA	37.97	58.33		OINK	37.25	55.1
VVTS	10.82	106.67		OIAM	30.55	49.2		ZBSJ	38.28	114.68		HCMI	10.42	45.02
VDPP	11.55	104.85		ORMM	30.57	45.78		OITL	38.32	48.42		HETB	29.58	34.78
VTBU	12.63	101.35		OISY	30.68	51.55		UTDD	38.55	68.78		OYRN	14.65	49.37
VOBG	12.95	77.63		HEBA	31.52	30.17		LTAZ	38.77	34.53		OICK	33.43	48.28
VDSR	13.37	103.85		LLSD	32.1	34.77		OITU	39.33	44.43		UTAK	40.05	53
VTBD	13.92	100.6		KQTZ	33.25	44.23		LTBY	39.82	30.52				

Table 3: SHIP additional stations in NCMRWF data archives

ID	LAT	LON		ID	LAT	LON		ID	LAT	LON		ID	LAT	LON
V9128	-11.5	78.5		A3489	2.8	105.2		WUK11	20.6	117.1		A3487	38.7	119.8
WUK10	-11.2	99.6		WUK37	4.7	114.4		REU67	36	30.2		WUK59	32	31.4
TFR55	-9.4	44.8		WUK50	10.4	75		TFR45	-15	41		G8555	23.7	36.8
TZP64	-6.8	39.2		WUK04	-1	88.1		VRGH7	-11.8	116		V8797	23.1	119.8
WUK32	-4.2	87.5		A3473	5.5	84.3		V9724	12.8	47.9		PJVQ	16.5	116.2
OHK02	-2.3	107.1		WUK54	13.8	110		V9116	5.7	109.3		V6784	-13.8	107.5
TFR56	1.3	103.7		WUK68	16.4	41.1		UK449	29.7	32.5		V8741	18.9	113.6
E8265	3.3	36.8		WUK57	20.1	59.6		BWU50	2.3	105		A3557	5.9	107
MYP42	4.5	101.4		V6346	14	119.7		WUK52	25.8	51.7		E8293	32.2	30.5
VWXS	10	76.3		WUK47	24.2	61.2		WUK63	25.2	56.5		V7963	28.2	118.6
VWSK	10	76.3		E8264	7.6	81.1		TFR08	-14.9	51.5		REU70	36	30.2
WUK64	10	95.5		VWSM	13.1	80.3		A3289	13.1	45		CTTQ3	18.1	114.8
VTJR	11.3	87		A3474	17.6	113.4		E9586	-13.2	107.3		A3015	38.8	118.2
WUK53	13	113.3		WUK65	32.1	33.7		F2960	2.1	104.7		V9450	-13.2	120
AUCE	13.1	80.3		WUK58	16.7	63.2		TFR28	1.3	103.7		V9131	-13.5	109
AUKJ	13.1	80.3		D9433	5.8	83.1		WUK14	20.1	119.6		SING1	5	80
WUK49	17.6	57.4		V2024	24.7	59.5		A8PQ6	25.4	55.4		A3490	17.2	113.3
AUYB	17.7	83.3		F6832	12	45.6		REU72	41.6	30.1				
WUK48	21.3	37.8		IBJD	17	56.1		V6535	-2.1	107.2				
KWP40	29.3	47.9		V9746	28.5	48.6		V9144	2.3	101.9				

Table 4: TMPLND additional stations in NCMRWF data archives

ID	LAT	LON		ID	LAT	LON		ID	LAT	LON		ID	LAT	LON
48811	21.4	103.02		96109	0.47	101.45		42798	22.82	86.18		96737	-6.12	106.13
42348	26.82	75.8		42475	25.45	81.73		48887	10.93	108.1		97270	-8.55	118.7
42328	26.9	70.9		42189	28.37	79.4		43110	16.98	73.33		42667	23.28	77.35
42165	28	73.3		96195	-1.63	103.65		42706	23.25	87.03		97230	-8.75	115.17
42103	30.38	76.77		97260	-8.52	117.42		42498	25.23	86.95		59948	18.28	109.47
48811	21.4	103.02		96109	0.47	101.45		42798	22.82	86.18		96737	-6.12	106.13
59644	21.48	109.1		59663	21.87	111.97								

Table 5: PILOT additional stations in NCMRWF data archives

ID	LAT	LON		ID	LAT	LON		ID	LAT	LON		ID	LAT	LON
43110	16.98	73.33		42328	26.9	70.9		42435	25.75	73.45		42299	27.39	88.57
42840	21.2	72.83		42260	27.15	77.97		42071	31.7	74.8		42492	25.6	85.1
42895	21.5	86.93		42170	28.4	74.9		43285	12.95	74.83		42667	23.28	77.35
42539	24.4	72.39		42123	29.92	73.88		42079	31.32	76.54				
42452	25.01	75.9		42706	23.25	87.03		42398	26.63	88.32				