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RESEARCH REPORT

Impact of Indian Radiosonde Observations on NWP

Azad S. Rajpoot, Sumit Kumar, John P. George

February 2025

National Centre for Medium Range Weather Forecasting
Ministry of Earth Sciences, Government of India
A-50, Sector-62, NOIDA-201 309, INDIA

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10	Abstract	This study examines the influence of Indian Radiosonde observations on a global numerical weather prediction (NWP) model forecasts using an adjoint based Forecast Sensitivity to Observation Impact (FSOI) technique. National Centre for Medium Range Weather Forecasting Unified Model (NCUM) provides numerical forecasts from nowcasting to seasonal time scales to its stake holders. Here we present the results from its global medium range NWP system, NCUM. The advanced Data Assimilation (DA) system of NCUM is based on Hybrid-4D-Var method, which provides initial conditions to the NCUM deterministic model. The DA system uses various observations from global in-situ observing system such as surface observatories, radiosonde, aircraft, etc and satellite observations. The primary aim of this study is to assess month wise contribution of each Indian radiosonde observations (total impact of all variables) in the 24 hours NCUM global deterministic forecast. The study considered five geographical regions for comprehensive evaluation. The operational FSOI data from NCUM system from June 2023 to May 2024 were used to identify the role of each radiosonde on the forecast error reduction. The study identified stations which are having maximum impact on the NWP model forecast. The study indicates the requirement of continues observations, mainly from stations which can potentially improve the forecast. However, there are stations which contribute minimally to the forecast error reduction, even though providing high volume of observations.
11	Security classification	Unrestricted
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सारांश

यह अध्ययन "एफ एस ओ आई" तकनीकों का उपयोग करके भारतीय रेडियोसोंडे प्रेक्षणों के वैश्विक "एन डब्ल्यू पी" मॉडल पूर्वानुमानों पर प्रभाव की जांच करता है। "एन सी यू एम" अपने हितधारकों को नाउकास्टिंग से लेकर मौसमी समय-सीमा तक संख्यात्मक पूर्वानुमान प्रदान करता है। यहाँ हम इसके वैश्विक मध्यम अवधि के (एन डब्ल्यू पी) प्रणाली, एन सी यू एम से प्राप्त परिणाम प्रस्तुत करते हैं। "एन सी यू एम" की उन्नत "डी ए" प्रणाली हाइब्रिड-4-डी-वार पद्धति पर आधारित है, जो "एन सी यू एम" निर्धारक मॉडल के लिए प्रारंभिक स्थितियाँ प्रदान करती है। यह "डी ए" प्रणाली सतह वेधशालाओं, रेडियोसोंडे, वायुगतिकीय प्रेक्षणों (एयरक्राफ्ट) और उपग्रह प्रेक्षणों जैसे वैश्विक "इन-सीटू" अवलोकन प्रणाली से विभिन्न प्रेक्षणों का उपयोग करती है। इस अध्ययन का मुख्य उद्देश्य प्रत्येक भारतीय "रेडियोसोंडे" प्रेक्षणों के मासिक योगदान (सभी चर का कुल प्रभाव) का आकलन करना है, विशेष रूप से 24 घंटे के "एन सी यू एम" वैश्विक निर्धारक पूर्वानुमान में। इस अध्ययन में व्यापक मूल्यांकन के लिए पाँच भौगोलिक क्षेत्रों को शामिल किया गया। "एन सी यू एम" प्रणाली से प्राप्त जून 2023 से मई 2024 तक के परिचालन "एफ एस ओ आई" डेटा का उपयोग करके प्रत्येक रेडियोसोंडे के पूर्वानुमान में योगदान की पहचान की गई। इस अध्ययन ने उन स्टेशनों की पहचान की, जिनका "एन डब्ल्यू पी" मॉडल पूर्वानुमान पर अधिकतम प्रभाव है। अध्ययन यह इंगित करता है कि लगातार प्रेक्षणों की आवश्यकता विशेष रूप से उन स्टेशनों से है जो संभावित रूप से पूर्वानुमान सुधार में योगदान कर सकते हैं। हालांकि, कुछ स्टेशन जो उच्च मात्रा में प्रेक्षण प्रदान कर रहे हैं, वे पूर्वानुमान त्रुटि को कम करने में न्यूनतम योगदान देते हैं।

Abstract

This study examines the influence of Indian Radiosonde observations on a global numerical weather prediction (NWP) model forecasts using an adjoint based Forecast Sensitivity to Observation Impact (FSOI) techniques. National Centre for Medium Range Weather Forecasting Unified Model (NCUM) provides numerical forecasts from nowcasting to seasonal time scales to its stake holders. Here we present the results from its global medium range NWP system, NCUM. The advanced Data Assimilation (DA) system of NCUM is based on Hybrid-4D-Var method, which provides initial conditions to the NCUM deterministic model. The DA system uses various observations from global in-situ observing system such as surface observatories, radiosonde, aircraft, etc and satellite observations. The primary aim of this study is to assess month wise contribution of each Indian radiosonde observations (total impact of all variables) in the 24 hours NCUM global deterministic forecast. The study considered five geographical regions for comprehensive evaluation. The operational FSOI data from NCUM system from June 2023 to May 2024 were used to identify the role of each radiosonde on the forecast. The study identified stations which are having maximum impact on the NWP model forecast. The study indicates the requirement of continues observations mainly from stations which can potentially improve the forecast. However, there are stations which contribute minimally to the forecast error reduction, even though providing high volume of observations.

1. Introduction

Numerical Weather Prediction (NWP) is a key pillar of contemporary meteorology, enabling precise and reliable weather forecasts through advanced computational models, enabling accurate forecasts that are critical for various sectors, including agriculture, aviation, and disaster management (Bauer et al., 2015). The effectiveness of NWP systems relies heavily on the quality and quantity of observational data assimilated into the models. Radiosondes provide accurate direct information on vertical profiles of temperature, humidity and horizontal winds. Hence, radiosonde network is a crucial part of the atmospheric observing system and is very important for the NWP.

National Centre for Medium Range Weather Forecasting (NCMRWF) does the operational NWP for more than three decades. Currently, seamless weather prediction based on NCMRWF Unified Model (NCUM) is operational at the centre. NCUM global medium range NWP system utilizes an advanced data assimilation technique (Sumit et al., 2021) Hybrid-4D-Var in its data assimilation system which provides initial condition to NCUM global model. In- situ and remote sensing observations, which are received at NCMRWF through various sources such as IMD, GTS, NOAA/NESDIS, EUMETCast, ISRO are assimilated routinely in the NWP systems. Currently, almost 56 radiosonde stations in India are operated and managed by the

IMD. Many of these stations have been upgraded to GPS sondes under the IMD modernization program. More details on the observation reception, processing and monitoring are available in Rani et al., (2024).

Data assimilation diagnostics such as Observing System Experiments (OSEs) and Forecast Sensitivity to Observation Impact (FSOI) are important for understanding the impact of observations on the NWP systems. The FSOI method has emerged as a robust framework to quantify the influence of different observational data on NWP forecasts (Lorenc and Marriott, 2014). This adjoint based technique measures the impact of observations on the analysis and forecast when the entire observation dataset is present in the assimilation system unlike OSE. However, the validity of FSOI technique is restricted by the tangent linear assumption. So, this method can be only used to measure the observation impact on 24 hours forecast only.

Objective of this study is to understand the impact of all the Indian radiosonde observations, throughout the year. FSOI method is used to compute the impact of these observations on the 24-hour forecast. Monthly mean observation impacts from June 2023 to May 2024, grouped over five distinct geographical regions are presented. Month-wise observation impact on forecast is calculated using the daily statistics produced by the operational FSOI system. The study aims to not only understand in-detail the impact of each radiosonde station on the accuracy of the NWP forecast but also help the operations, management and planning of the radiosonde network over India. Section 2 provides a brief description of the FSOI technique, followed by the methodology of analysis of this study in section 3. Results from this study are discussed in section 4 and the main findings are summarized in section 5.

2. Forecast Sensitivity to Observations Impact (FSOI): Technique and Methodology

NCMRWF operationally uses 12 km NCUM global system for medium-range NWP (for details see Sumit et al., 2020, 2021). This system has been adapted from Unified Model (UM) seamless prediction system of "UM Partnership" and is being upgraded periodically to include new scientific and technological advancements. The Hybrid 4D-Var data assimilation scheme used in the NCUM system optimally combines the background state of the atmosphere with available observations within a stipulated time window (06 hourly) to create an analysis field. Numerous observations, from various ground-based and space-borne platforms are being assimilated into the 06 hourly intermittent NCUM global data assimilation system. Global ensemble prediction system at NCMRWF, NEPS, provides the error of the day from the ensemble forecast to the NCUM Hybrid-4DVar system to calculate the flow dependent background error.

As discussed, the adjoint-based data assimilation diagnostic technique of FSOI is used to calculate the forecast impact of each assimilated observation in the NCUM system. This approach compares the skill of two forecasts initialized from two different initial conditions, one that benefits from observational information (analyses) and one that does not (background). FSOI quantifies impact of all assimilated observations using a moist energy norm and shows the impact of an observation or set of observations, whether it decreases or increases the forecast error. Using the FSOI technique, NCMRWF evaluates the impact of all observations in each data assimilation cycle.

3. Methodology

The study used the daily FSOI statistics from the operational runs of NCUM global NWP system. These datasets include details regarding all observations that were successfully assimilated in the Hybrid-4D-Var data assimilation.

In this study, we focus only on the radiosonde observations from the Indian stations, grouped into five geographical regions, viz, Northern Region (NR), Central Region (CR), Eastern Region (ER), Southwest Region (SWR) and Southeast Region (SER). In this geographical grouping, "Northern region" has eight radiosonde stations, "Central Region" has 16 stations, 10 stations in the "Eastern Region", 11 stations each in "Southwest Region "and "Southeast Region". Monthly data from June 2023 to May 2024 were used to compute station-wise FSOI statistics. The FSOI statistics include each assimilated observation and corresponding innovation (observation minus background), the sensitivity of the forecast to the observation, and metadata detailing the observational instrument, time of collection, and geographic coordinates.

Following key parameters from the FSOI statistics were used in this study:

1. **Innovation**: Innovations represent the differences between the observed values and the background (model forecast) values at each observation point.
2. **Sensitivity**: Sensitivity data are calculated using adjoint-based methods, which quantifies how each individual observation contributes to reducing or increasing forecast error for unit observation innovation.

   Impact = Innovation * Sensitivity

   Beneficial impacts are represented by negative impact values corresponding to reduction in forecast error. Conversely, positive impact values indicate a detrimental effect, suggesting that the observations do not contribute (or adversely affect) effectively to improving the accuracy of forecasts.

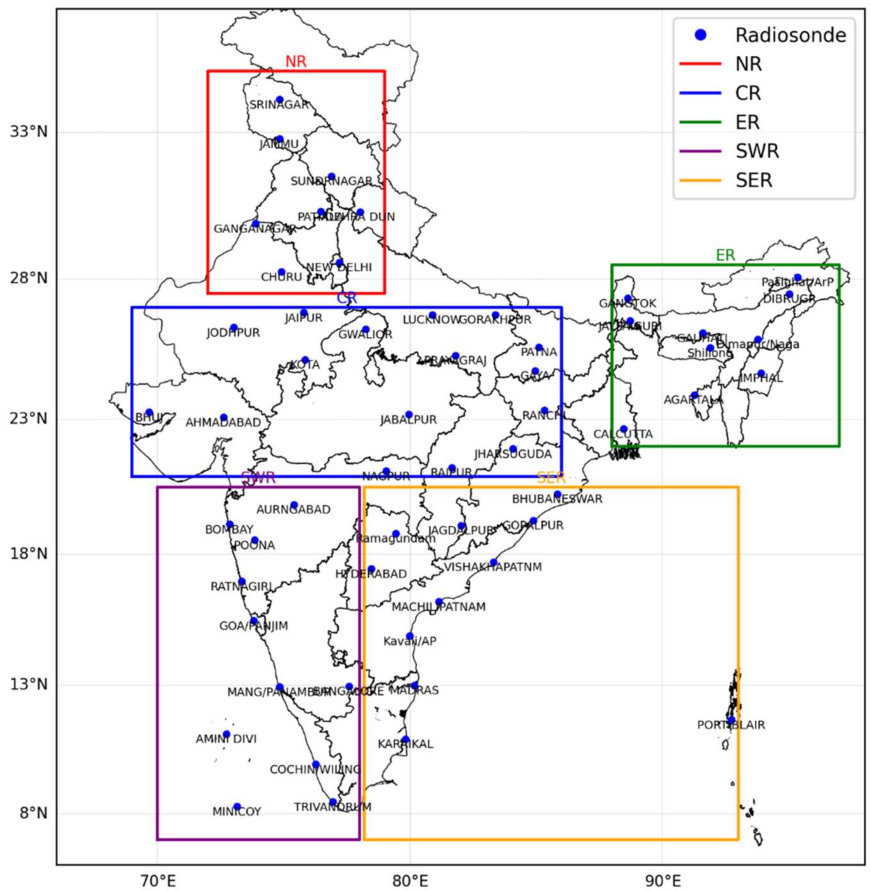


Figure 1. Geographic locations of Indian Radiosonde stations available for assimilation during June 2023 to May 2024. Radiosonde stations are categorized into five regions, NR-red, CR-blue, ER-green, SWR-Magenta, and SER-yellow.

Table 1. Region wise Indian Radiosonde Network Sounding from June 2023 to May 2024.

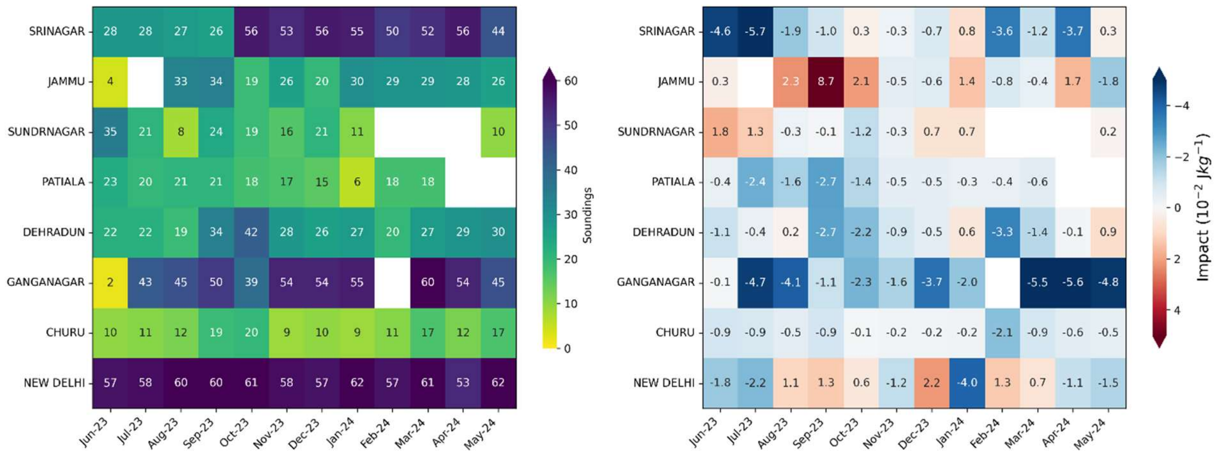
Indian Region	Stations	Total Sounding 00UTC/12UTC
NR (Northern Region)	8	1625/1217
CR (Central Region)	16	3879/2451
ER (Eastern Region)	10	2120/839
SWR (Southwest Region)	11	2092/1177
SER (Southeast Region)	11	3130/1864
Total	56	12840/7548

4. Result and discussion

Figure 1 shows the grouping of Indian radiosonde network based on its locations for ease of study. The region wise count of Indian Radiosonde Soundings received at NCMRWF for its assimilation within the cut-off time from June 2023 to May 2024 is given in Table 1. The Northern Region (NR) includes 8 stations, provided total of 2842 soundings (1625 at 00 UTC and 1217 at 12 UTC) during the study period. Similarly, the Central Region (CR), consisting of 16 stations provided 6324 soundings (3879 at 00 UTC and 2451 at 12 UTC); the Eastern Region (ER), with 10 stations provided 3285 soundings (2120 at 00 UTC and 839 at 12 UTC); the Southwest Region (SWR), containing 11 stations provided 3269 soundings (2092 at 00 UTC and 1177 at 12 UTC); and the Southeast Region (SER), with 11 stations provided 4994 soundings (3130 at 00 UTC and 1864 at 12 UTC). Table 2 contains the detailed information about Indian Radiosonde networks and their locations with their respective WMO ID. The total impact of all variable together is only presented in this report, which is calculated as the sum of the individual impacts from wind, temperature, and relative humidity observations. However, we have calculated variable-wise impact of at all radiosonde stations, which will be presented/published separately.

Northern region, it is noticed that New Delhi, Ganganagar and Srinagar had the highest number of soundings during the study period, with maximum from New Delhi (Fig 2(a)). However, the Ganganagar sounding have highest beneficial impact on the forecast (Fig 2 (b)). Additionally, Ganganagar's average observations per day had the greatest beneficial impact per day, as shown in (Fig. 3). New Delhi observations are by and large detrimental to the forecast during second half of the southwest monsoon season and pre-monsoon season. Jammu and Sundarnagar observations are largely detrimental to the forecast during majority of the months. Patiala and Dehradun observations are generally beneficial during the entire year, even though the impact is not as high as that of Ganganagar observations.

Figure 2 shows an overview of the monthly total radiosonde sounding count in the Northern region (Fig. 2(a)) and their total accumulated impact (10^{-2}J/kg) for each month (Fig. 2(b)). Figure 3 shows the month-wise observation count per day (wind, temperature, and relative humidity) and their impact per day (10^{-3}J/kg) in the Northern region. This figure helps assess the role of daily average observations in each month.



(a) **(b)**

Figure 2. (a) Monthly total Radiosonde sounding count in the Northern region and (b) their total accumulated impact (10^{-2}J/kg).

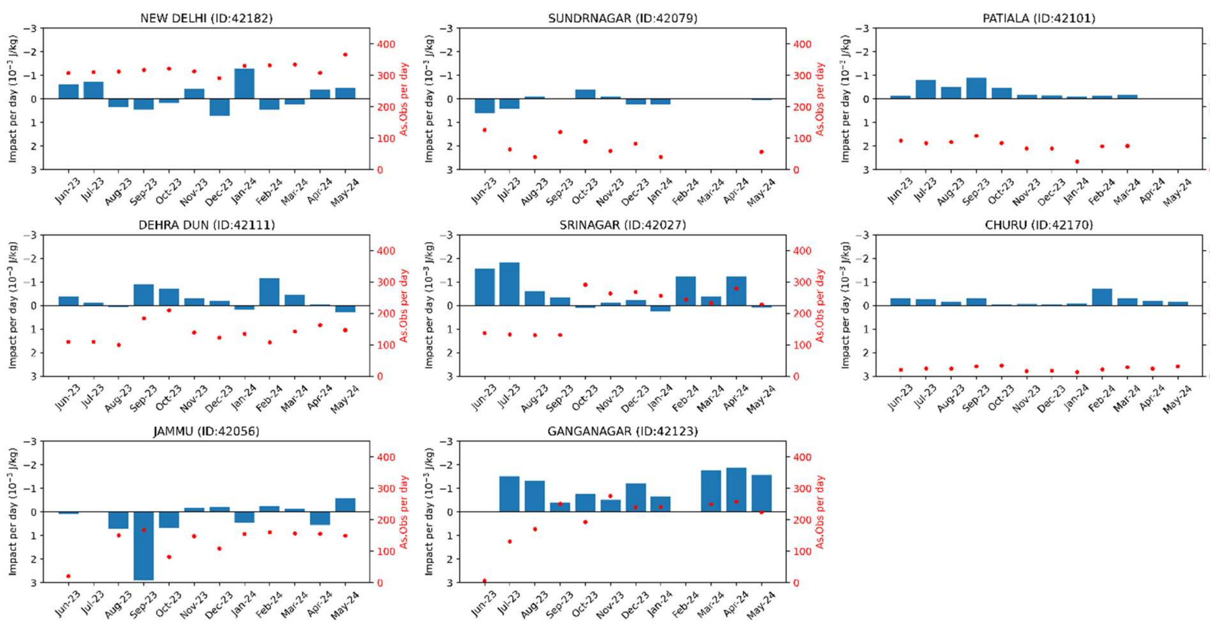
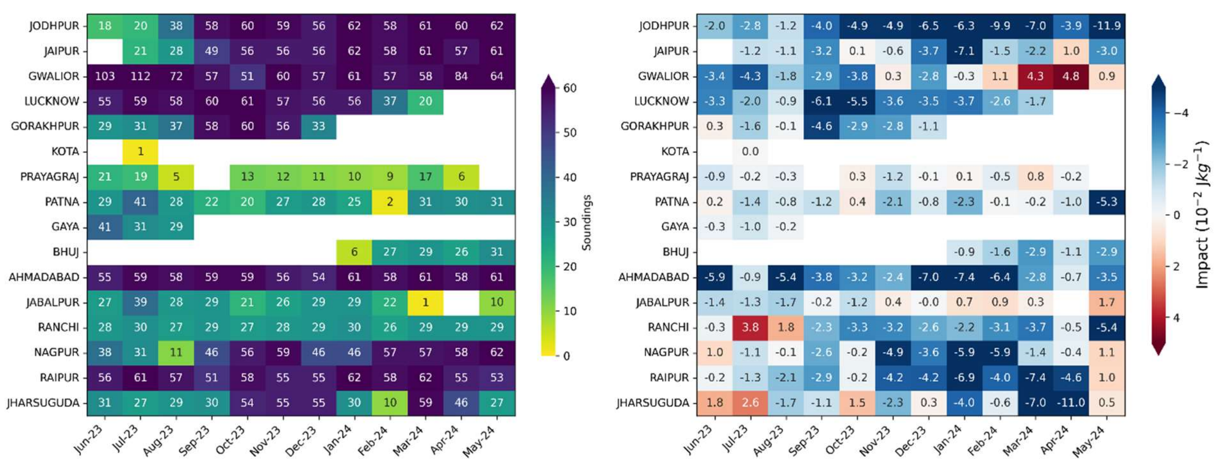


Figure 3. Month-wise Radiosonde observations (wind, temperature, relative humidity) count per day and their impact per day (10^{-3}J/kg) in the Northern region.

In Central region, it is observed that Gwalior, Ahmadabad, Raipur, Jaipur, Jodhpur and Nagpur have the highest number of soundings, maximum from Gwalior and Ahmadabad (Fig 4 (a)). Among these locations, Jodhpur and Ahmedabad stand out with a high sounding count and a consistently beneficial impact on the forecast throughout the year (Fig. 4(b)). Additionally, these locations also exhibit a high number of observations per day, along with a high beneficial impact per day (Fig. 5). Gwalior observations are by and large detrimental to the forecast during the pre-monsoon season. Jharsuguda observations are largely detrimental to the forecast during first half of the southwest monsoon season. Ranchi observations are largely detrimental to the forecast during large part of the southwest monsoon season. On the other hand, observations from Jodhpur, Lucknow, Gorakhpur, Nagpur and Raipur are generally beneficial to the forecast during the entire year even though the magnitude of the impact is relatively small. Figure 4 shows an overview of the monthly total radiosonde sounding count (Fig. 4(a)) and their total accumulated impact (10^{-2}J/kg) for each month (Fig. 4(b)). Figure 5 shows the month-wise observation count per day (wind, temperature, and relative humidity) and their impact per day (10^{-3}J/kg). This figure helps assess the role of daily average observations in each month.

Many of the Central Region (CR) reported observations only at 00UTC (Table 2). Kota, Gaya and Bhuj were not reported any observations during most of the months, but Bhuj observation volume/frequency has improved during the later part of the study period.



(a) **(b)**

Figure 4. (a) Monthly total Radiosonde sounding count in the Central region and (b) their total accumulated impact (10^{-2}J/kg).

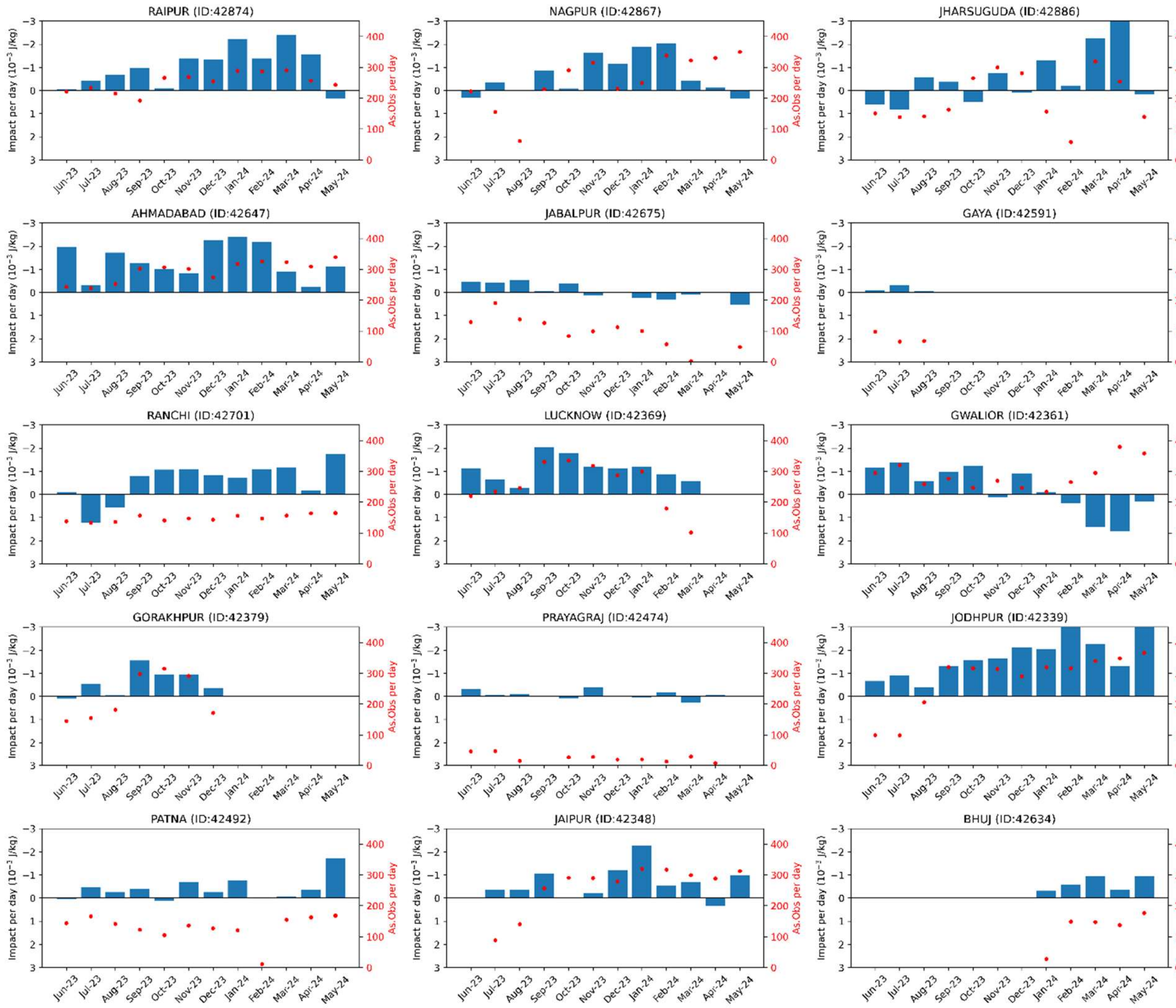
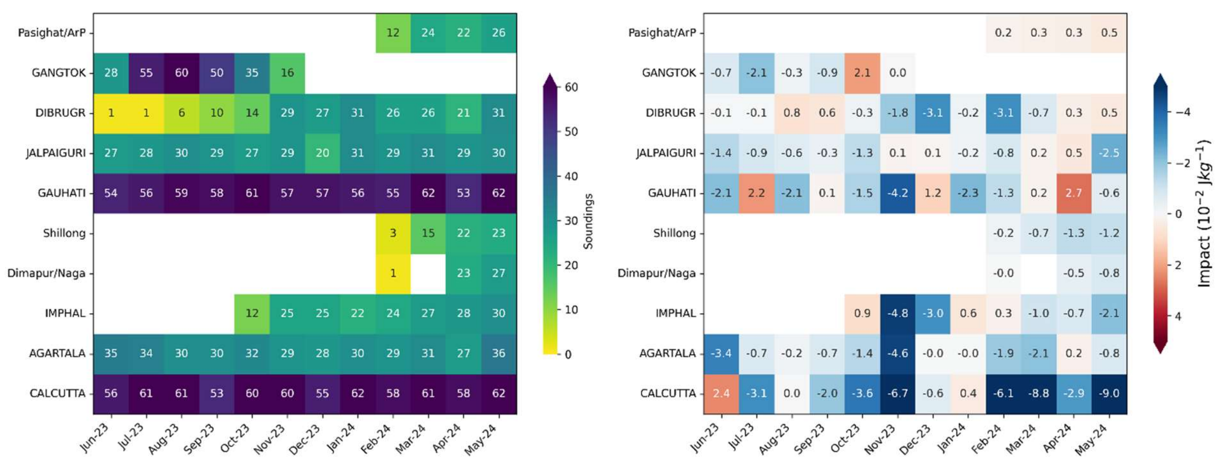


Figure 5. Month-wise Radiosonde observations (wind, temperature, relative humidity) count per day and their impact per day (10^{-3}J/kg) in the Central region.

In Eastern region, it is observed that Kolkata (Culcutta), Guwahati(Gauhati), Jalpaiguri and Agartala stations provided the highest number of soundings, with maximum soundings from Kolkata(Calcutta) and Guwahati (Fig 6 (a)). In general, Kolkata sounding have the highest beneficial impact, particularly during post-monsoon and pre-monsoon (Fig 6 (b)). Additionally, Kolkata observation per day have highest impact per day (Fig 7). Agartala, Jalpaiguri and Gangtok observations are generally beneficial to the forecast during the southwest monsoon season. Some station in the Eastern Region (ER) report observations only from 00 UTC (Table 2). In the eastern region, most of the stations showed high impact during post monsoon season - especially during November. Figure 6 shows an overview of the monthly total radiosonde sounding count (Fig. 6(a)) and their total accumulated impact (10^{-2}J/kg) for each month (Fig. 6(b)). Figure 7 shows the month-wise observation count per day (wind, temperature, and relative humidity) and their impact per day (10^{-3}J/kg).



(a) **(b)**

Figure 6. (a) Monthly total Radiosonde sounding count in the Eastern region and (b) their total accumulated impact (10^{-2}J/kg).

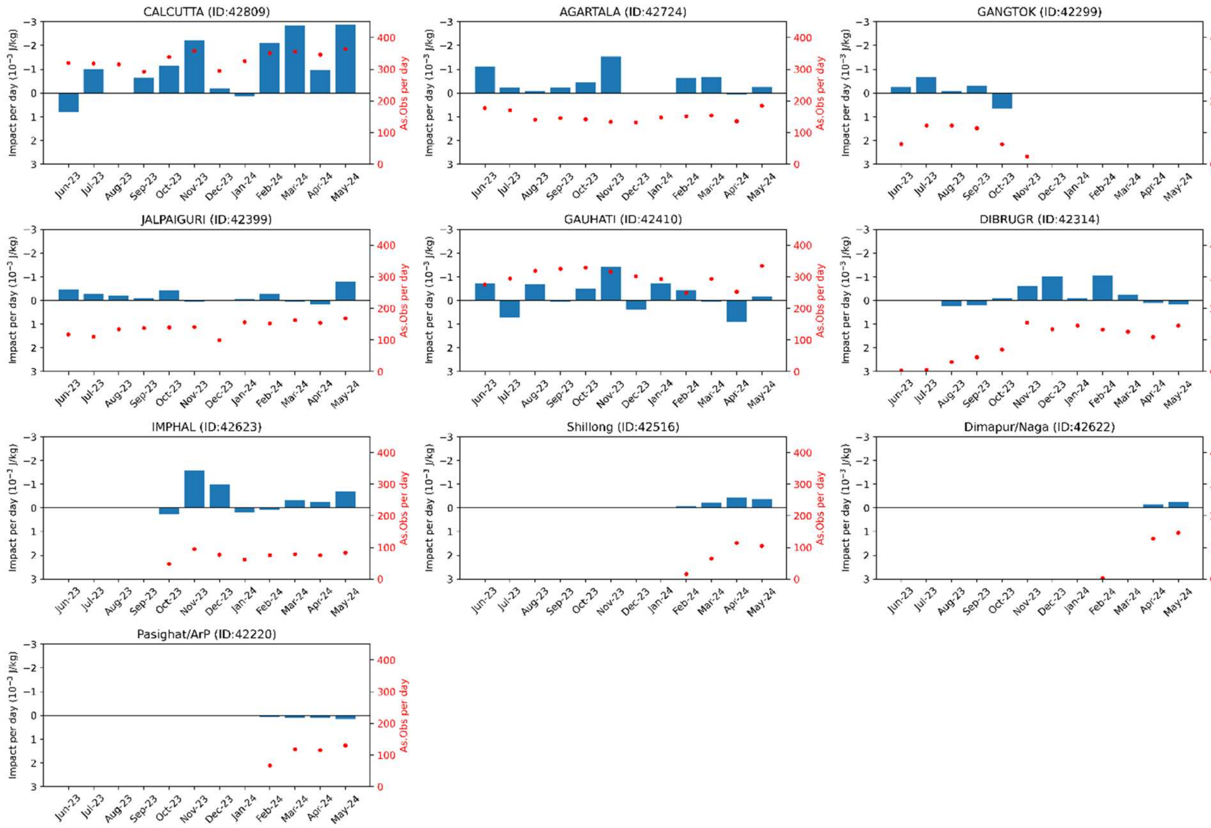
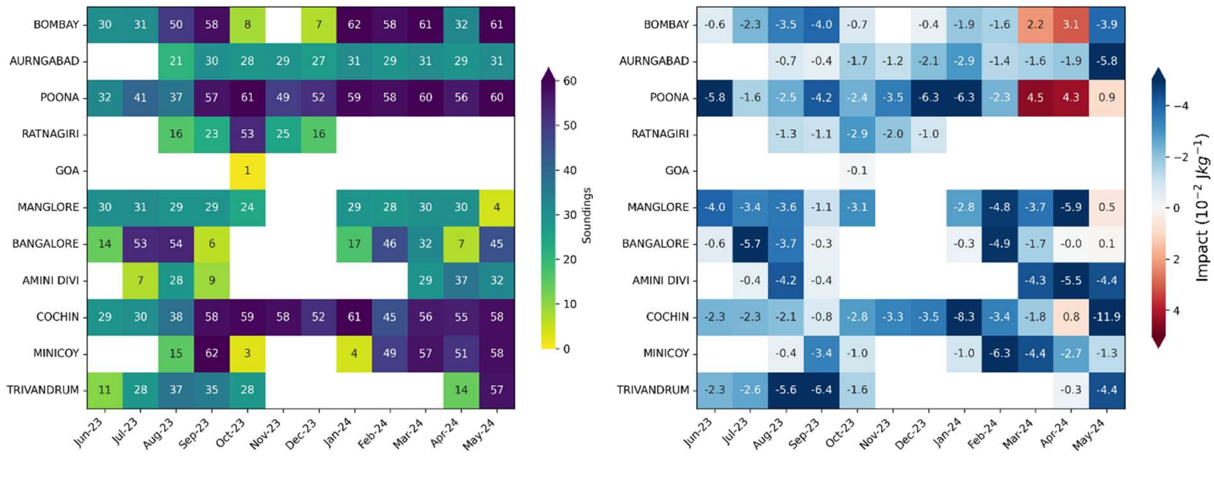


Figure 7. Month-wise Radiosonde observations (wind, temperature, relative humidity) count per day and their impact per day (10^{-3}J/kg) in the Eastern region.

In Southwest region, it is observed that Pune (Poona), Mumbai (Bombay), Aurangabad, Mangalore, Minicoy and Kochi (Cochin) have highest number of soundings, with maximum from Pune and Cochin (Fig 8 (a)). Among these locations, Pune and Kochi sounding count stand out, as having the highest beneficial impact on the forecast (Fig 8 (b)). Additionally, Pune and Kochi observation per day have highest impact per day (Fig 9). On the other hand, observations from Mumbai, Pune, Mangalore, Bengaluru (Bangalore), AminiDivi, Kochi, Minicoy and Thiruvananthapuram (Trivandrum) are generally shows beneficial to the forecast error reduction during the southwest monsoon season. Even though many of these stations has beneficial impact to forecast, the magnitude of their impact is not as high as that of Thiruvananthapuram observations. Observations from Pune and Mumbai are largely detrimental to the forecast during the pre-monsoon months. In general observations from all the stations from the southern regions shows good beneficial impact on the forecast throughout the year, except few stations show detrimental impact during pre-monsoon season. Figure 8 shows an overview of the monthly total radiosonde sounding count (Fig. 8(a)) and their total accumulated impact (10^{-2}J/kg) for each month (Fig. 8(b)). Figure 9 shows the month-wise observation count per day (wind, temperature, and relative humidity) and their impact per day (10^{-3}J/kg).



(a) **(b)**

Figure 8. (a) Monthly total Radiosonde sounding count in the Southwest region and (b) their total accumulated impact (10^{-2}J/kg).

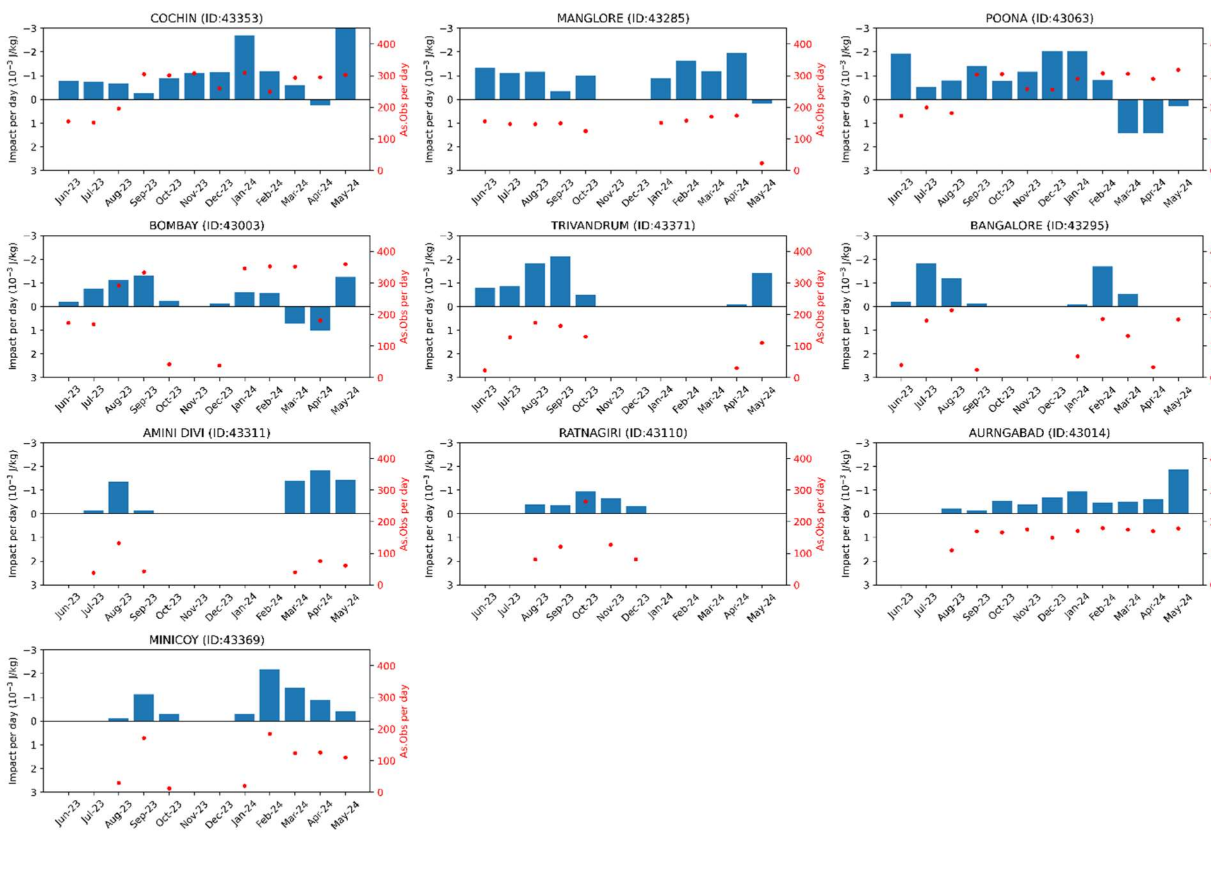
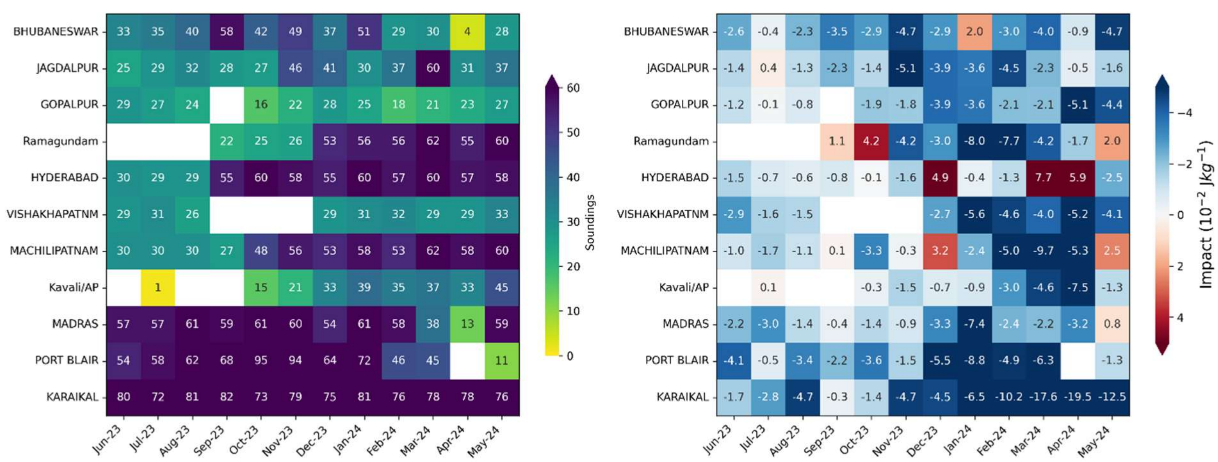


Figure 9. Month-wise Radiosonde observations (wind, temperature, relative humidity) count per day and their impact per day (10^{-3}J/kg) in the Southwest Region.

In Southeast region, it is noticed that Gopalpur, Jagdalpur, Bhubaneshwar, Ramagundam, Hyderabad, Machilipatnam, Chenni (Madras), Port Blair and Karaikal had the highest number of soundings, with maximum from Karaikal (Fig 10(a)). Sounding from Karaikal showed a consistently very high beneficial impact on the forecast thorough out the year (Fig 10 (b)). Additionally, Karaikal's average observations per day had the highest impact per day across the year (Fig. 11). Bhubaneshwar, Jagdalpur, Gopalpur, Kavali, Madras, Vishakhapatnam, and Port Blair observations are generally beneficial during the entire year, even though the impact is not as high as that of Karaikal observations. Hyderabad observations are detrimental to the forecast during the pre-monsoon season. Observations from Gopalpur, Kavali and Vishakhapatnam in the Southeast Region (SER) are only reported observations from 00 UTC (Table 2) but have good beneficial impact on the forecast throughout the year, despite having fewer observations compared to others. Figure 10 shows an overview of the monthly total radiosonde sounding count (Fig. 10(a)) and their total accumulated impact (10^{-2}J/kg) for each month (Fig. 10(b)). Figure 11 shows the month-wise observation count per day (wind, temperature, and relative humidity) and their impact per day (10^{-3}J/kg).



(a) **(b)**

Figure 10. (a) Monthly total Radiosonde sounding count in the Southeast region and (b) their total accumulated impact (10^{-2}J/kg).

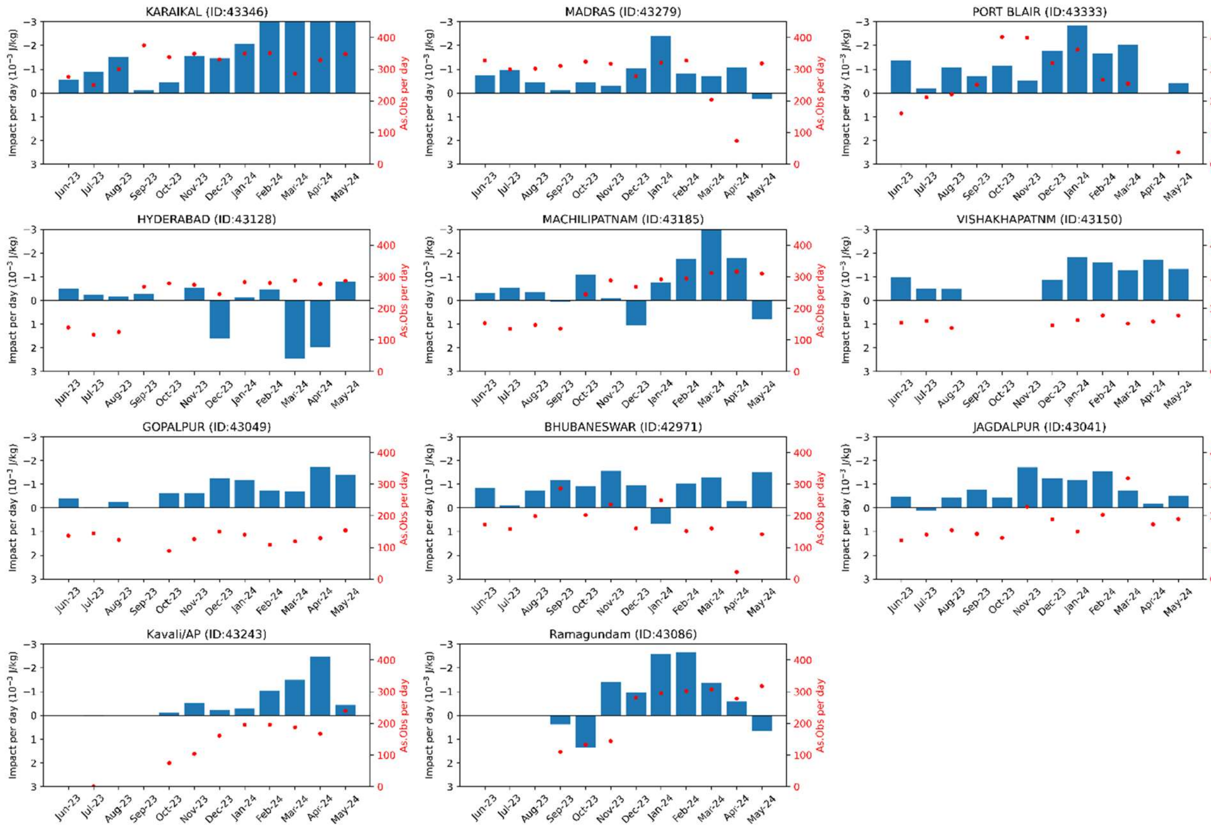


Figure 11. Month-wise Radiosonde observations (wind, temperature, relative humidity) count per day and their impact per day (10^{-3}J/kg) in the Southeast Region.

5. Summary & Conclusions:

The study analysed one year (June 2023 to May 2024) operational FSOI runs and presented month wise impact of individual radiosonde observations. This study grouped all the Indian radiosonde observatories into five geographical regions. The FSOI system provides the impact of observations on 24 hours forecast of global NCUM. The study also presented the observation availability from each station. The observation volume clearly shows that only half of the stations provide a good number of observations throughout the year. Most of the Stations from southeast region, observation volumes are high and continue throughout the year.

Stations like Ganganagar, Jodhpur, Lucknow, Ahmedabad, Raipur, Karaikal, Kochi, Kolkata, consistently demonstrated the high beneficial impact to forecast almost throughout the year. Some stations, impact varies seasonally, having beneficial impact on one season but detrimental in another season. All southwest region stations show beneficial impact during southwest monsoon season. Most of the southeast regions stations show high beneficial impact during Northeast monsoon/post monsoon season, winter and pre monsoon season. Many of the southwest and some central stations which are not reporting observations throughout the year also shows good impact of observations whenever observations are available.

Some stations observations are not benefiting the NWP system. During most part of the year, Jammu observations have detrimental impact on the forecast. Even though throughout the year observation volume is quite good, New Delhi station observations also shows detrimental impact half of the year.

The FSOI results further highlight the requirement of taking observation without any gap from those stations which are showing high beneficial impact throughout the year. The study helps to identify the most important stations for entire year or a season or a month form this type of study which help to use the resources wisely so that the observation taken will be useful for the NWP and the forecast model performance will be improved.

Author contributions

Azad S. Rajpoot: conceptualized the research idea for taking up the study, performed all data analysis, generated plots, and prepared initial draft. Sumit Kumar: Verified and reviewed the performed numerical computation. John P. George: supervised the findings of this work., provided expert guidance throughout the study and reviewed the final version of the report. All authors discussed the results and finalized the report.

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Appendix

Table 2. Indian Radiosonde Network Station Sounding from June 2023 to May 2024 with WMO ID

S. No.	WMO ID	x_lat	x_lon	Station_Name	Region	Total Sounding	00UTC Sounding	06UTC Sounding	12UTC Sounding	18UTC Sounding
1	42182	28.58	77.2	NEW DELHI	NR	706	355	0	351	0
2	42079	31.53	76.9	SUNDRNAGAR	NR	165	148	0	17	0
3	42101	30.33	76.47	PATIALA	NR	177	176	0	1	0
4	42111	30.32	78.03	DEHRA DUN	NR	328	301	1	26	0
5	42027	34.08	74.83	SRINAGAR	NR	531	303	0	228	0
6	42170	28.25	74.92	CHURU	NR	157	56	0	101	0
7	42056	32.78	74.83	JAMMU	NR	278	48	0	230	0
8	42123	29.92	73.88	GANGANAGAR	NR	501	238	0	263	0
9	42874	21.23	81.65	RAIPUR	CR	683	343	10	330	0
10	42867	21.1	79.05	NAGPUR	CR	567	326	0	241	0
11	42886	21.92	84.08	JHARSUGUDA	CR	453	278	0	175	0
12	42647	23.07	72.63	AHMADABAD	CR	699	354	0	345	0
13	42675	23.17	79.95	JABALPUR	CR	261	245	0	16	0
14	42591	24.75	84.95	GAYA	CR	101	43	0	58	0
15	42701	23.32	85.32	RANCHI	CR	341	341	0	0	0
16	42369	26.75	80.88	LUCKNOW	CR	519	285	0	234	0
17	42361	26.23	78.25	GWALIOR	CR	836	349	104	324	59
18	42379	26.75	83.37	GORAKHPUR	CR	304	197	0	107	0
19	42474	25.3	81.8	PRAYAGRAJ	CR	123	68	0	55	0
20	42339	26.3	73.02	JODHPUR	CR	612	335	0	277	0
21	42492	25.6	85.1	PATNA	CR	314	297	1	16	0
22	42348	26.82	75.8	JAIPUR	CR	565	293	0	272	0
23	42452	25.15	75.85	KOTA	CR	1	0	0	1	0
24	42634	23.25	69.67	BHUJ	CR	119	119	0	0	0
25	42809	22.65	88.45	CALCUTTA	ER	707	353	0	354	0
26	42724	23.88	91.25	AGARTALA	ER	371	349	1	21	0
27	42299	27.33	88.62	GANGTOK	ER	244	140	0	104	0
28	42399	26.53	88.72	JALPAIGURI	ER	340	340	0	0	0
29	42410	26.1	91.58	GAUHATI	ER	690	334	3	350	3
30	42314	27.48	95.02	DIBRUGR	ER	223	213	0	10	0
31	42623	24.67	93.9	IMPHAL	ER	193	193	0	0	0
32	42516	25.57	91.88	Shillong	ER	63	63	0	0	0
33	42622	25.88	93.77	Dimapur/Naga	ER	51	51	0	0	0
34	42220	28.07	95.34	Pasighat/ArP	ER	84	84	0	0	0
35	43353	9.95	76.27	COCHIN	SWR	599	349	0	250	0
36	43285	12.95	74.83	MANGLORE	SWR	264	264	0	0	0
37	43063	18.53	73.85	POONA	SWR	622	333	1	288	0
38	43003	19.12	72.85	BOMBAY	SWR	458	203	0	255	0
39	43371	8.48	76.95	TRIVANDRUM	SWR	211	148	0	63	0
40	43295	12.97	77.58	BANGALORE	SWR	274	158	0	116	0
41	43311	11.12	72.73	AMINI DIVI	SWR	142	89	0	53	0
42	43110	16.98	73.33	RATNAGIRI	SWR	133	106	0	27	0
43	43014	19.85	75.4	AURNGABAD	SWR	286	281	0	5	0
44	43369	8.3	73.15	MINICOY	SWR	299	160	19	120	0
45	43192	15.48	73.82	GOA/PANJIM	SWR	1	1	0	0	0
46	43346	10.92	79.83	KARAIKAL	SER	931	342	256	333	0
47	43279	13	80.18	MADRAS	SER	638	319	0	319	0
48	43333	11.67	92.72	PORT BLAIR	SER	669	284	103	161	121
49	43128	17.45	78.46	HYDERABAD	SER	608	351	0	257	0
50	43185	16.2	81.15	MACHILIPATNAM	SER	565	347	0	218	0
51	43150	17.7	83.3	VISHAKHAPATNM	SER	269	260	1	8	0
52	43049	19.27	84.88	GOPALPUR	SER	260	240	0	20	0
53	42971	20.25	85.83	BHUBANESWAR	SER	436	317	1	118	0
54	43041	19.08	82.03	JAGDALPUR	SER	426	333	0	93	0
55	43243	14.91	79.99	Kavali/AP	SER	259	152	0	107	0
56	43086	18.78	79.44	Ramagundam	SER	415	185	0	230	0
					Total	21072	12840	501	7548	183