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RESEARCH REPORT

Impact of Wind Profiler Observations on NWP: Study using FSOI method.

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

February 2024

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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11	Security classification	
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13	Key Words	FSOI, Wind Profiler, NCUM, Hybrid 4D-Var

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सारांश

यह अध्ययन पूर्वानुमान संवेदनशीलता-आधारित अवलोकन प्रभाव (एफ. एस. ओ. आई.) विधियों के माध्यम से वैश्विक संख्यात्मक मौसम पूर्वानुमान (एन. डब्ल्यू. पी.) मॉडल पूर्वानुमानों पर पवन प्रोफाइलर अवलोकनों के प्रभावों की रिपोर्ट करता है। राष्ट्रिय मध्यम अवधी मौसम पूर्वानुमान केंद्र (रा. म. मौ. पू. कें.) यूनिफाइड मॉडल (एन(एम.यू.सी. एनडब्ल्यूपी प्रणाली का उपयोग रा. म. मौ. पू. कें. में परिचालन एनडब्ल्यूपी पूर्वानुमान के लिए किया जाता है। एनडब्ल्यूपी मॉडल पूर्वानुमान के लिए प्रारंभिक स्थितियां (या विश्लेषण) उत्पन्न करने के लिए हाइब्रिड-4-डी-वार की उन्नत डेटा एसिमिलेशन तकनीक का उपयोग किया जाता है, जिसमें इन-सीटू माप, उपग्रह डेटा और रडार अवलोकन सहित विभिन्न अवलोकन संबंधी डेटा का उपयोग किया जाता है। इस अध्ययन का प्राथमिक उद्देश्य दिसंबर 2021 से नवंबर 2022 तक परिचालन एफएसओआई प्रणाली का उपयोग करके एनडब्ल्यूपी मॉडल पूर्वानुमानों पर पवन प्रोफाइलर अवलोकन के प्रभाव को निर्धारित करना है। एनसीएमआरडब्ल्यूएफ मुख्य रूप से पवन प्रोफाइलर अवलोकन के तीन नेटवर्क अर्थात् यूरोप, जापान और ऑस्ट्रेलिया से पवन प्रोफाइलर डेटा प्राप्त करता है। . कुल मिलाकर 138 विंड प्रोफाइलर स्टेशनों का डेटा एकत्र किया गया, जिनमें से 24 प्रोफाइलर जापान से, 10 स्टेशन ऑस्ट्रेलिया से, 101 स्टेशन यूरोप से और 3 अन्य स्टेशन हैं। पवन प्रोफाइलर अवलोकनों का आमतौर पर 900 से 300hpa के दबाव स्तर के बीच में बड़ा प्रभावी और लगातार योगदान देखा गया है। प्रभाव का ऊर्ध्वाधर वितरण तीन नेटवर्क से मिश्रित पैटर्न को प्रदर्शित है। पवन प्रोफाइलर अवलोकन प्रतिशत योगदान इस बात पर प्रकाश डालता है कि यूरोपीय नेटवर्क की तुलना में जापान पवन प्रोफाइलर नेटवर्क का प्रति अवलोकन अधिक प्रभाव है। ये निष्कर्ष एनडब्ल्यूपी मॉडल पूर्वानुमान त्रुटि में कमी के लिए पवन प्रोफाइलर अवलोकनों के योगदान की हमारी समझ को बढ़ाने के लिए बहुत महत्वपूर्ण हैं।

Abstract

This study reports the impacts of wind profiler observations on global NWP model forecasts through FSOI methods. National Centre for Medium Range Weather Forecasting Unified Model (NCUM) NWP system is utilized for operational NWP forecast at NCMRWF. Advanced data assimilation technique of Hybrid-4D-Var is employed to utilize various observational data, including in situ measurements, satellite data, and radar observations, to generate the initial conditions (or analysis) for the NWP model forecast. The primary objective of this study is to quantify the impact of wind profiler observation on NWP model forecasts using the operational FSOI system from December 2021 to November 2022. NCMRWF receives wind profiler data mainly from three networks of wind profiler observation namely Europe, Japan and Australia. In total 138 wind profiler stations' data were assimilated of which 24 profiler are from Japan, 10 stations from Australia, 101 stations of Europe and 3 other stations. It has been noticed that wind profiler's generally have the largest and most consistent contribution from the observations between pressure levels of 900 to 300hpa. The vertical distribution of impact shows mixed pattern from three networks. Network from Japan dominate over lower levels (700 hPa and below), the European over upper levels (600 hPa and above) and the Australian peaks over the middle levels (600hPa). The observation percentage contribution highlights that the Japan wind profiler network seems to have a higher impact per observation in comparison to the European network. These findings are important for enhancing our understanding of the contribution of wind profiler observations to NWP model forecast error reduction.

1. Introduction

Wind profilers are ground-based active remote sensing instruments, which measure the vertical profile of wind in the column of atmosphere above the wind profiler antenna. Radar wind profiler (RWP), which is generally Doppler radar that operates at either the VHF (30-300 MHz) or UHF (300-1000 MHz) frequency bands, has been widely applied to atmospheric wind field research (Chipilski et al., 2019, Dolman et al., 2018; Hocking et al. 2016; Ishihara et al., 2006;). Radar wind profilers can continuously provide high-resolution details of the wind both temporally and spatially, which makes them one of the most crucial observations in the meteorological observation system. Globally wind profiler networks such as Europe, the USA, Australia, Japan, etc are providing valuable observation to operational and research applications, related to weather and climate (Benjamin et al., 2010, Dolman et al., 2018, Chipilski et al., 2019). Studies suggest that the addition of wind profiler data observations into the data assimilation system has considerably improved the model's initial condition and subsequently resulted in better weather forecasts (Benjamin et al., 2010, Hu et al., 2017).

This report presents the comprehensive performance of wind profiler data assimilation on short-range numerical weather forecasts. The Forecast Sensitivity to Observation Impact (FSOI) technique is used to assess the impact of the observation on the numerical weather forecast. The study utilizes the NCUM global 12 km NWP system (Sumit et al., 2021) to study the impact of global wind profiler observations. The FSOI method will help to quantify the impact of wind profiler observations on the forecast accuracy and provide insights into the effectiveness of the assimilation process.

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

NCMRWF is operationally using a 12 km NCUM global NWP system (for details see Sumit et al., 2020, 2021). This system has been adapted from the Unified Model (UM) seamless prediction system of “UM Partnership” and is being upgraded periodically to adapt to 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-hour cyclic

NCUM data assimilation system. This study mainly examines the impact of wind profiler data on the forecast in comparison with other observations.

An adjoint-based data assimilation diagnostic technique, called "Forecast Sensitivity to Observations Impact" (FSOI) (Lorenc and Marriott, 2014) is used to study 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 the impact of all assimilated observations using a moist energy norm and shows the impact of an observation or set of observations whether decreases or increases forecast error. Using the FSOI technique, we evaluated the overall impact of all observations in each cycle.

3. Data Collection and Preprocessing:

NCMRWF receives various worldwide observation datasets including wind profiler data through the Global Telecommunication System (GTS) of WMO through IMD (RTH). These observations are decoded and packed into a suitable format for its assimilation into NCUM NWP. Figure 1 shows the number of wind profile observations received at NCMRWF during 2022, with reports received from network of stations in Europe, Japan, and Australia. Table 1 and 2 shows the network-wise annual/seasonal availability of the number of wind profiler stations which were assimilated during 2022. Appendix I and II include detailed information about wind profiler networks and their stations with WMO ID.

Table 1 Wind profiler network and number of stations during 2022

Network Locations	Wind profiler stations count
Austrailia	10
Europe	101
Japan	24
Other	3
Total	138

Table 2. Wind profiler network-wise number of observation stations during different season of year 2022. Where DJF, MAM, JJAS and ON stands for December-January-February, March-April-May, June-July-August-September, October-November, respectively

Network Locations	Wind profiler Stations count			
	DJF	MAM	JJAS	ON
Austrailia	10	10	10	10
Europe	84	84	100	92
Japan	24	24	24	24
Other	2	2	3	3
Total	120	120	137	129

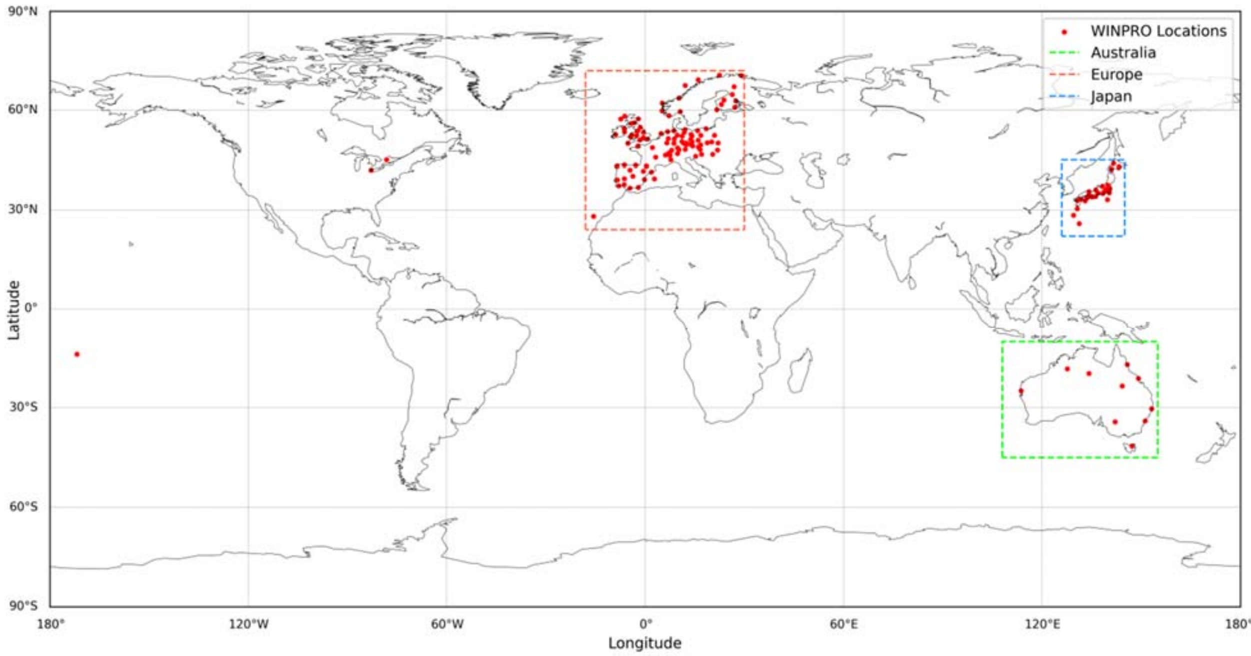

Figure 1. Geographic locations of wind profiler stations during the year 2022

Observation processing is the first step in the NWP system that ensures data quality and consistency by performing quality control procedures. The observation errors assigned to wind profilers are specified through the station lists file, which are updated/revised based on observation-background statistics. There are different error profiles specified for the main wind profiler networks/types. Wind profiler data are thinned to make one report from each station per hour. Observation thinning involves discarding observations such that observation density (spatial and temporal) is reduced to an acceptable level for the data assimilation system. OPS processes the "obstore" format input data and outputs them in the appropriate format which can be accepted by Hybrid 4D-Var. Upon application of additional quality control measures and averaging, hourly wind profiles are obtained, which are the data assimilated into the Global NCUM NWP System at NCMRWF.

4. Result and discussion

Figure 2 shows the percentage-wise contribution of the impact of various observation types and their respective data volume percentage that were assimilated during the period from 01 December 2021 to November 2022. In the NCUM NWP system, an aggregate wind profiler beneficial contribution of ~1% is seen during our study period. Given the volume of wind profiler observation, this contribution seems to be quite significant.

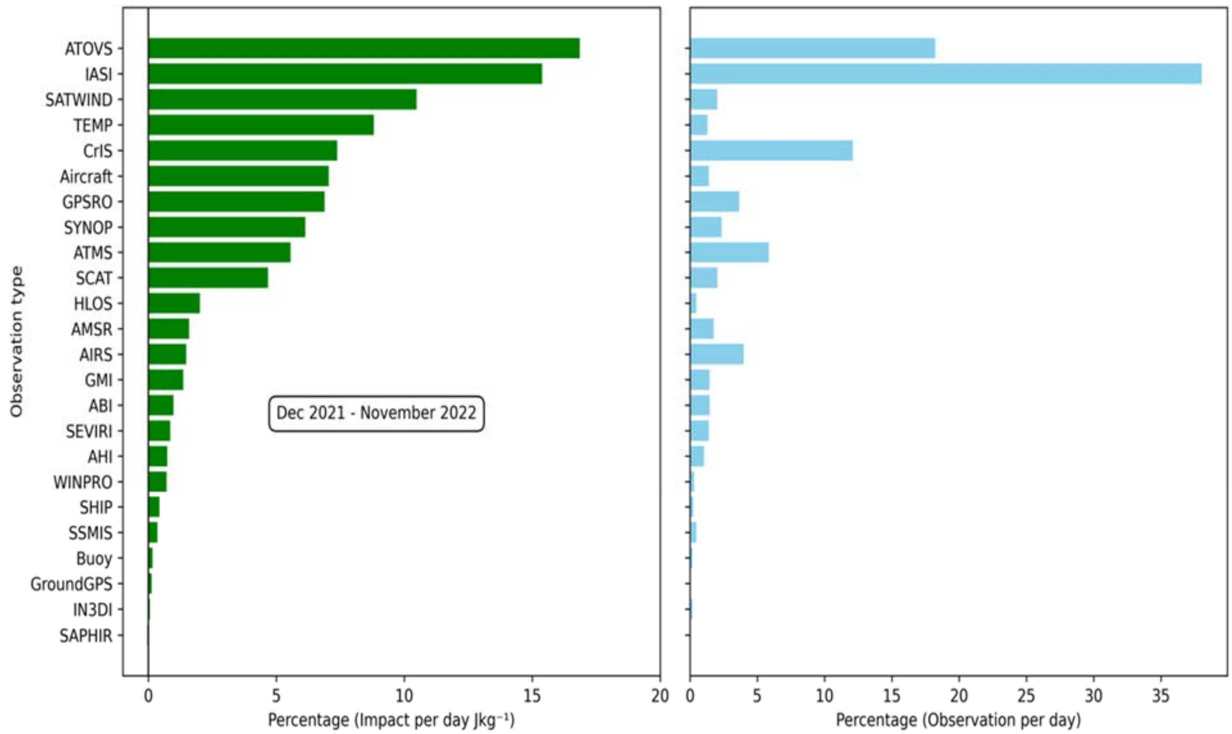

Figure 2. Impact percentage of various observation types and their assimilated observation (per day). The percentage is computed w.r.t. all assimilated observation/impact.

Figure 3 shows the vertical distribution of the annual averaged impact per day of wind profiler observation and the corresponding percentage of assimilated observation at each level. The observation impact is categorized into ten vertical levels: 1000, 900, 800, 700, 600, 500, 400, 300, 200, and 100 hPa. The largest impact is consistently seen between 900-400 hPa despite the continuous decrease in assimilated observation count with height. This may be attributed to the scarcity of quality wind observation between these levels. The levels > 900 hPa and < 300 hPa have relatively less impact but the wind profiler data at 200hPa and above have a detrimental impact on the forecast.

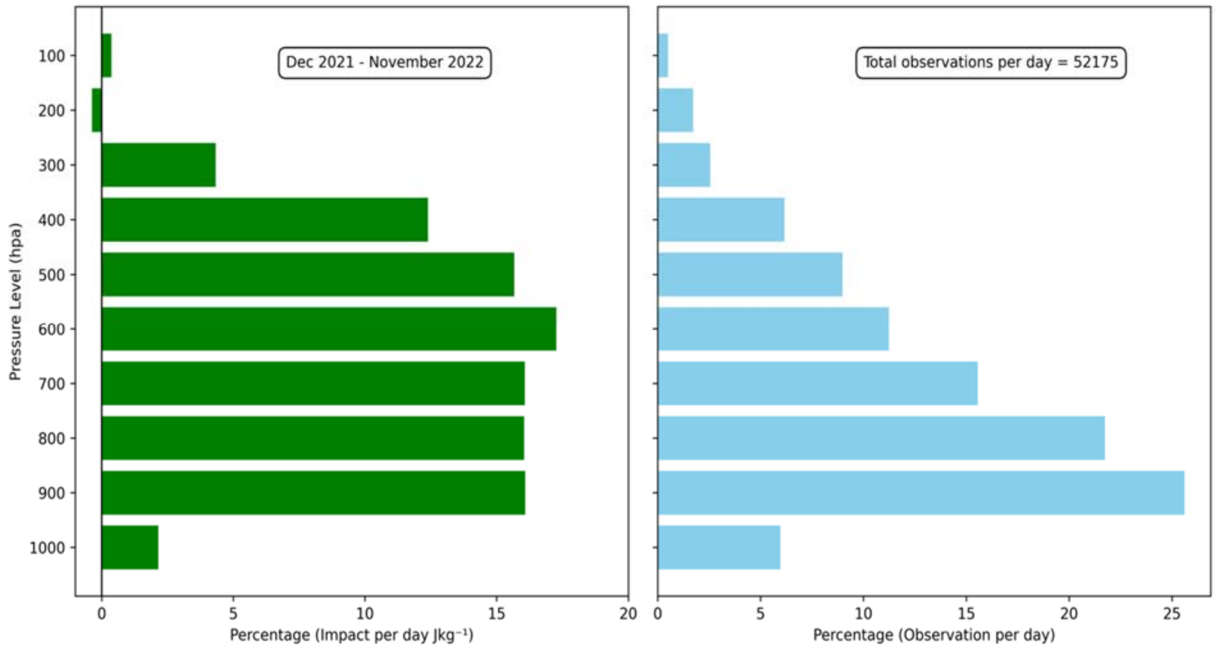

Figure 3. Annual mean (per day) vertical impact of wind profiler and corresponding percentage of assimilated observations from December 2021 to November 2022.

The network-wise vertical distribution of FSOI is presented in Figure 4. The European and Australian wind profilers have larger vertical penetration (up to 100 hPa) whereas the Japanese network has observation up to 300 hPa. The assimilated observation contribution is higher from the European network wind profiler followed by Japan and Australia (Figure 4 right panel). Figure 4 (left panel) shows that wind profilers from Japan have a higher impact at lower levels (<= 700hPa) whereas the European wind profiler has higher impact at upper levels (>= 600 hPa). However, at lower levels (700hPa and below), the European network presents a smaller observation impact than the Japanese although the European network has more observation at these levels. It is likely a function of the model-assigned larger observation error for the European network wind observations than that of the Japanese. On the other hand, the wind profiler from the Australian network has overall less impact on the forecast and it follows bell shape like impact with a peak at 600 hPa. Figure 4 (left panel) shows that the detrimental mean impact observed in Figure 3 at 200 hPa is observed to be from the European Network.

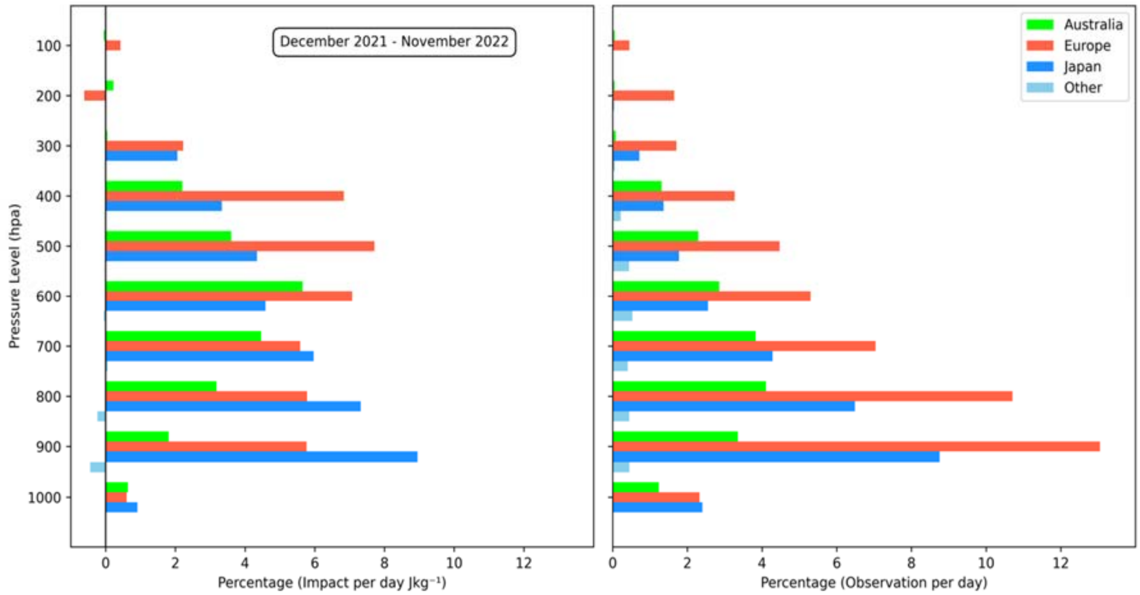

Figure 4. Same as Figure 3, but for different wind profiler networks.

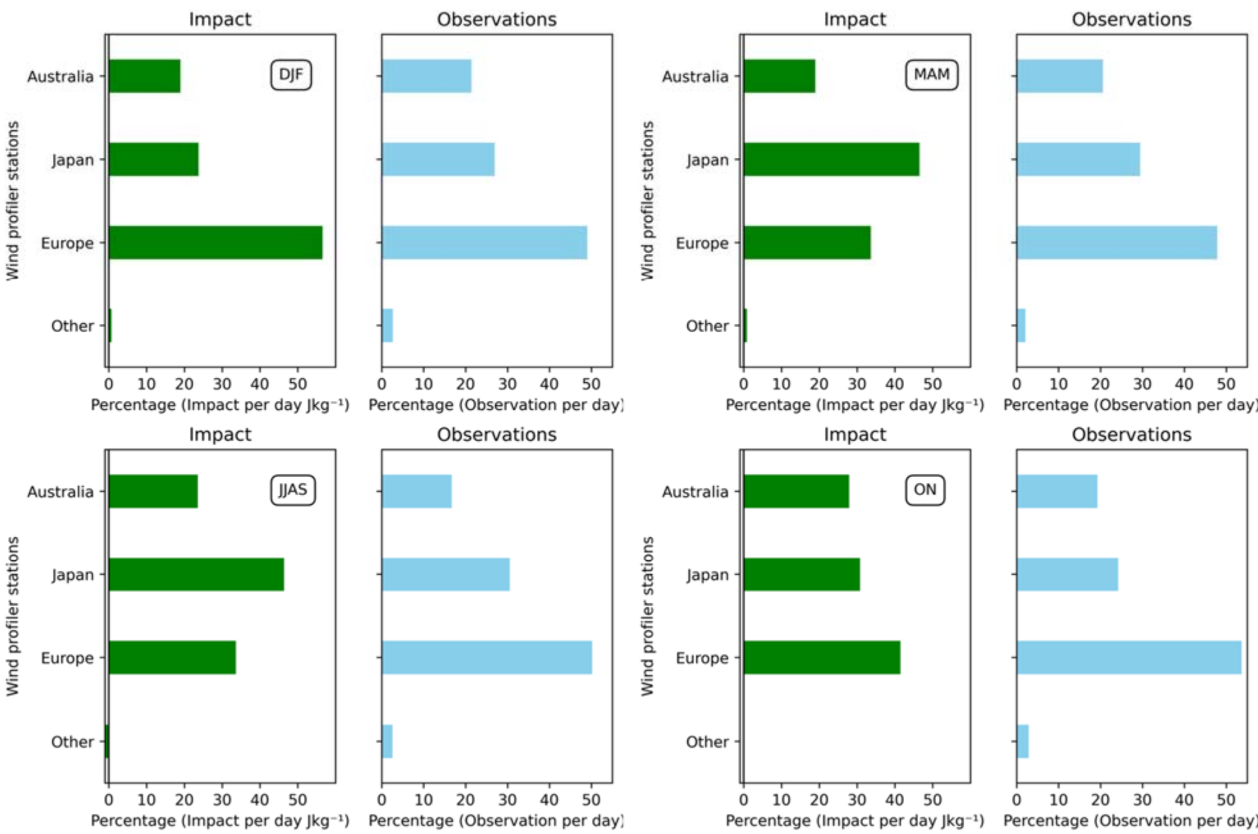

Figure 5. Seasonal mean impact and corresponding percentage of assimilated observations

Figure 5 shows the network-wise variation of seasonal mean impact and corresponding assimilated observations. The Japanese network has a higher beneficial impact on forecast compared to other networks in JJAS and MAM months whereas the European network has a higher impact contribution in DJF and ON months. The Australian network's seasonal contribution overall remains smaller in comparison with that of the Japanese and European networks. Japan's wind profiler shows a higher impact per observation in comparison to Europe's network

Conclusion:

This study presents an application of the operational NCMRWF FSOI system for estimating the impact of observations on the global forecast (up to 24-hour forecast) through error reduction.

- FSOI results suggest that on average all the wind profiler network systems play a positive role in reducing the 24-hour forecast error.
- WINPRO is contributing ~1% of the total observation impact per day from December 2021 to November 2022.
- A total of 138 wind profilers were assimilated in the NCUM assimilation-forecasting system during the study period.
- Seasonal variation of the European wind profiler network shows 8% to 10% variations (Impact per day J/kg) during DJF (Dec 2021 to Feb 2022) between the 900-400 hPa pressure level.
- Seasonal variation of the Japan wind profiler network shows 10% to 12% variations (Impact per day J/kg) between the pressure level 900-500 hPa, during MAM and JJAS 2022.
- Seasonal variation of the Australia wind profiler network shows 6% to 10% variations (Impact per day J/kg) between the pressure level 600-500 hpa, during ON 2022.
- The Japanese network has a higher impact at 700 hPa and below, while the wind profiler from the European network has a higher impact at 600 hPa and above. Whereas the Australian network shows overall less impact than the other two networks, its vertical impact profile follows a bell shape like pattern with a peak at 600hPa

Author contributions

ASR: Analyzed and prepared initial draft. SK: conceived, performed numerical computation and finalized draft. JPG: Verified, reviewed and supervised the findings of this work. All authors discussed the results and finalized the report.

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References:

Benjamin,S. G.,B. D.Jamison,W. R.Moninger,S. R.Sahm,B. E.Schwartz, and T. W. Schlatter, (2010), Relative short-range forecast impact from aircraft, profiler, radiosonde, VAD, GPS-PW, METAR, and mesonet observations via the RUC hourly assimilation cycle. *Mon. Wea. Rev.*,138, 1319–1343, doi:10.1175/2009MWR3097.1.

Chipilski, H. G., Wang, X., and Parsons, D. B., (2019), Impact of Assimilating PECAN Profilers on the Prediction of Bore-Driven Nocturnal Convection: A Multi-Scale Forecast Evaluation for the 6 July 2015 Case Study, *Mon. Wea. Rev.*, 148, 1147-1175, https://doi.org/10.1175/MWR-D-19-0171.1

Dolman, B. K., Reid, I. M., and Tingwell, C., (2018), Stratospheric tropospheric wind profiling radars in the Australian network, *Earth Planet. Space*, 70, 170, https://doi.org/10.1186/s40623-018-0944-z

Hocking, W. K.,Röttger, J.,Palmer, R. D.,Sato, T., &Chilson, P. B., (2016), Atmospheric radar: Application and science of MST radars in the Earth's mesosphere, stratosphere, troposphere, and weakly ionized regions.New York, NY: Cambridge University Press.

Hu, H., Sun, J. and Zhang, Q., (2017), Assessing the impact of surface and wind profiler data on fog forecasting using WRF 3DVAR: an OSSE study on a dense fog event over North China. *J. Appl. Meteorol. Climatol.*, 56, 1059–1081. doi:10.1175/JAMC-D-16-0246.1

Ishihara, M., Kato, Y., Abo, T., Kobayashi, K., and Izumikawa, Y., (2006), Characteristics and performance of the operational wind profiler network of the Japan Meteorological Agency. *J.Met. Soc. Japan,* Ser. II, 84(6), 1085-1096.

Lorenc, A. C., and R. Marriott, (2014). Forecast sensitivity to observations in the Met Office global numerical weather prediction system. *Quart. J. Roy. Meteor. Soc.*, 140, 209-224, https://doi.org/10.1002/qj.2122.

Sumit Kumar, Gibies George, Buddhi Prakash J., M. T. Bushair, S. Indira Rani and John P. George, (2021), NCUM Global DA System: Highlights of the 2021 upgrade, NMRF/TR/05/2021.

Sumit Kumar, M. T. Bushair, BuddhiPrakash J., AbhishekLodh, Priti Sharma, Gibies George, S. Indira Rani, John P. George, A. Jayakumar, Saji Mohandas, Sushant Kumar, Mohana S. Thota, RaghavendraAshrit, and E. N. Rajagopal, (2020), NCUM Global NWP System: Version 6 (NCUM-G:V6), NCMRWF Technical Report, NMRF/TR/06/2020.

Appendix –I

Table 3 Japan wind profiler network Station Locations with WMO ID

S. No.	Station_ID	x_lat	x_lon	Impact(J/kg)
1	47570	37.49	139.91	-0.923
2	47406	43.95	141.63	-0.809
3	47678	33.12	139.78	-0.705
4	47674	35.15	140.31	-0.671
5	47945	25.83	131.23	-0.594
6	47417	42.92	143.21	-0.577
7	47909	28.38	129.5	-0.541
8	47656	34.98	138.4	-0.537
9	47893	33.57	133.55	-0.499
10	47629	36.38	140.47	-0.486
11	47898	32.72	133.01	-0.478
12	47616	36.06	136.22	-0.397
13	47891	34.32	134.05	-0.349
14	47423	42.32	140.97	-0.348
15	47663	34.07	136.19	-0.299
16	47636	35.17	136.96	-0.295
17	47815	33.24	131.62	-0.285
18	47819	32.81	130.71	-0.224
19	47795	33.89	135.13	-0.200
20	47746	35.53	134.2	-0.176
21	47836	30.38	130.66	-0.142
22	47626	36.15	139.38	-0.087
23	47612	37.11	138.25	0.093
24	47640	35.5	138.76	0.407

Table 4 Australian wind profiler network Station Locations with WMO ID

S. No.	Australia_ID	x_lat	x_lon	Impact(J/kg)
1	94300	-24.89	113.67	-1.462
2	94212	-18.23	127.66	-1.068
3	94346	-23.44	144.28	-1.016
4	94288	-16.95	145.75	-0.983
5	94238	-19.64	134.18	-0.939
6	94693	-34.24	142.09	-0.409
7	94352	-21.17	149.15	-0.314
8	95759	-33.96	151.19	-0.197
9	95966	-41.55	147.22	0.415
10	95729	-30.32	153.12	0.675

Table 5 Other wind profiler Station Locations with WMO ID.

S. No.	Other_ID	x_lat	x_lon	Impact(J/kg)
1	71847	45.06	-78.21	-0.0007
2	71993	42.04	-82.89	0.0188
3	91762	-13.82	-171.79	0.1394

Appendix - II

Table 6 Euorope wind profiler network Station Locations with WMO ID

S. No.	Europe_ID	x_lat	x_lon	Impact(J/kg)
1	3019	57.35	-7.37	-0.7340
2	3501	52.42	-4.01	-0.5690
3	1042	70.61	22.44	-0.5191
4	1018	69.24	16	-0.4644
5	3020	57.35	-7.37	-0.4326
6	1079	70.51	29.02	-0.3976
7	10135	53.78	8.67	-0.3770
8	3962	52.69	-8.92	-0.3530
9	10266	53.31	11.84	-0.3484
10	10678	49.98	11.68	-0.2764
11	10394	52.21	14.13	-0.2700
12	1206	62.19	5.13	-0.2464
13	3018	58.21	-6.18	-0.2293
14	1104	67.53	12.1	-0.2212
15	2925	63.11	23.83	-0.2046
16	8550	39.07	-8.4	-0.2025
17	8386	37.69	-6.33	-0.1771
18	1498	59.63	10.56	-0.1732
19	2870	64.77	26.32	-0.1574
20	2954	60.9	27.11	-0.1567
21	2918	62.86	27.39	-0.1435
22	11036	48.11	16.59	-0.1349
23	1438	58.36	7.17	-0.1296
24	60028	28.02	-15.61	-0.1255
25	8007	43.17	-8.53	-0.1200
26	14024	46.07	15.28	-0.1164
27	8228	40.18	-3.71	-0.1115
28	12921	46.66	17.06	-0.1097
29	8289	39.18	-0.25	-0.1072
30	8475	36.61	-4.66	-0.0992
31	8489	36.83	-2.08	-0.0932
32	3897	49.18	-2.22	-0.0920
33	6234	52.96	4.79	-0.0920
34	3813	50	-5.22	-0.0914
35	1405	59.85	5.09	-0.0900
36	2933	60.13	21.65	-0.0876
37	12892	47.96	21.89	-0.0802
38	8072	42	-4.6	-0.0797
39	2840	67.14	26.9	-0.0792
40	8179	41.41	1.88	-0.0789
41	1247	63.69	10.2	-0.0780
42	2941	61.77	23.08	-0.0779
43	3918	54.5	-6.34	-0.0702
44	3159	56.21	-3.31	-0.0687
45	12985	46.64	20.43	-0.0663
46	11406	50.07	12.39	-0.0643
47	12151	54.38	18.46	-0.0613
48	12544	50.89	16.04	-0.0611
49	11480	49.66	13.82	-0.0568
50	10605	50.11	6.55	-0.0548

Table 7 Euorope wind profiler network Station Locations with WMO ID

S. No.	Europe_ID	x_lat	x_lon	Impact(J/kg)
51	8553	37.31	-7.95	-0.0541
52	3142	56.02	-4.22	-0.0518
53	10557	50.5	11.14	-0.0517
54	11538	49.19	14.34	-0.0513
55	3771	51.29	0.61	-0.0506
56	3375	53.34	-0.56	-0.0490
57	11718	49.5	16.79	-0.0476
58	3253	54.8	-1.47	-0.0447
59	10780	49.54	12.4	-0.0426
60	10410	51.41	6.97	-0.0422
61	8308	39.38	2.79	-0.0414
62	3086	57.43	-2.04	-0.0402
63	8081	43.4	-2.84	-0.0393
64	8262	39.43	-6.29	-0.0367
65	6726	46.37	7.49	-0.0366
66	3675	51.68	-0.53	-0.0353
67	11698	48.88	16.09	-0.0338
68	8019	43.46	-6.3	-0.0334
69	3331	53.75	-2.29	-0.0332
70	10873	48.17	12.1	-0.0329
71	10103	53.56	6.75	-0.0318
72	10950	48.04	10.22	-0.0290
73	10339	52.46	9.69	-0.0261
74	10629	49.98	8.71	-0.0255
75	12331	52.41	16.8	-0.0242
76	12374	52.41	20.96	-0.0224
77	10440	51.31	8.8	-0.0221
78	3523	52.4	-2.6	-0.0219
79	10488	51.12	13.77	-0.0175
80	10169	54.18	12.06	-0.0174
81	10908	47.87	8	-0.0158
82	7462	45.79	3.15	-0.0151
83	12568	50.39	20.08	-0.0151
84	8162	41.73	-0.55	-0.0148
85	10356	52.16	11.18	-0.0144
86	6776	46.84	9.79	-0.0136
87	12514	50.15	18.73	-0.0096
88	6699	46.43	6.1	-0.0090
89	12579	50.11	22.04	-0.0067
90	12220	53.79	15.83	-0.0059
91	10832	48.59	9.78	-0.0049
92	10392	52.65	13.86	0.0065
93	3859	51.03	-1.65	0.0102
94	11509	50.46	14.17	0.0109
95	16061	45.03	7.73	0.0134
96	6632	47.18	7.42	0.0168
97	3969	53.43	-6.24	0.0190
98	6610	46.81	6.94	0.0213
99	3601	51.98	-4.44	0.0328
100	7626	43.13	0.37	0.1033
101	7151	48.72	2.21	0.1371