INSAT 3DR Sounder derived Wind Index and Dry Microburst Index role in aviation

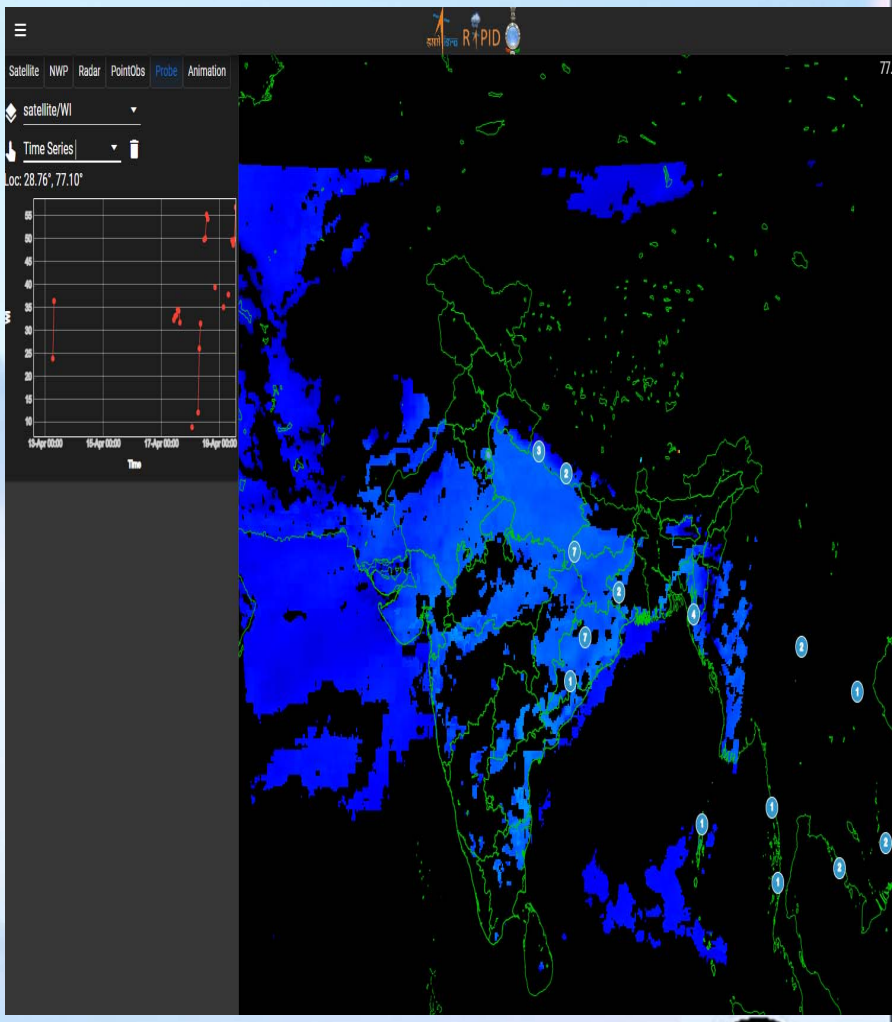
Information Paper Asia and Pacific (APAC) Thirteenth Meeting of the Meteorological Requirements Working Group (MET/R WG/13) Bangkok, Thailand, 22 to 26 April 2024

Presented by Dr. Neeti Singh,

Introduction

- The wind index(WI) and Dry microburst index(DMI) are one of the most valuable parameters and show significant changeable and intermittent over a range of timescales since it is weather-dependent.
- Therefore, accurate WI and DMI observation is acknowledged as a vital contribution to trustworthy large-scale Thunderstorm forecasts.
- Ground based radiosonde data have been used to evaluate Infrared (IR) sounder data onboard the Indian navigation satellite (INSAT-3DR) satellite.

https://satellite.imd.gov.in/



MMDRPS INSAT 3D/3R (Channels Imager + Sounder)

INSAT 3D/3R carries a six channel imager and 19 channel sounder.
The 6 spectral channels of INSAT-3D imager are:

Spectral Band	Wave length (μm)	Ground Resolution
VIS	0.55 – 0.75	1km
SWIR	1.55 – 1.70	1 km
MIR	3.80 – 4.00	1 km
WV	6.50 – 7.10	8 km
TIR-1	10.3 – 11.3	4 km
TIR-2	11.5 – 12.5	4 km

Literature Survey

- **WINDEX is based on studies of observed and modeled microbursts and is designed to help forecast the microburst wind gust potential (McCann 1994).**
- Their sudden development, vertical growth, and sudden downpours over a small area depend upon so many other processes that occur in the atmosphere.**(Federico et al 2020)**
- WINDEX is more sensitive to the low-level temperature lapse rate and it is a measure of downdraft instability making WINDEX a better local microburst potential index than other stability indices such as the Lifted Index (LI) or K-Index (KI).**, Pryor et al. (2004).**

Algorithm

$$WI = 5[H_M R_Q (G^2 - 30 + Q_L - 2Q_M)]^{0.5}$$

Convective Wind Gust Magnitude Corresponding to WMSI Values	
WI	Wind Gusts(KT)
<10	Convection Microburst Unlikely
10--49	<35
49-79	35-49
>79	>50

Wind Index Mechanism	
H_M	Melting Levels (height in kilometres above ground)
G	lapse rate (degrees Celsius per kilometre)
Q_L	The Mixing Ratio (1 km above the surface)
Q_M	The mixing ratio at the melting level.
RQ	QL/12

The Lapse Rate is the rate at which temperature changes with height in the Atmosphere.

Hm=y = mx+c

T1—Surface Temp, T2 –Change in temp

H1- Surface Height, H2-change in height

Lapse rate-- T2-T1/H2-H1

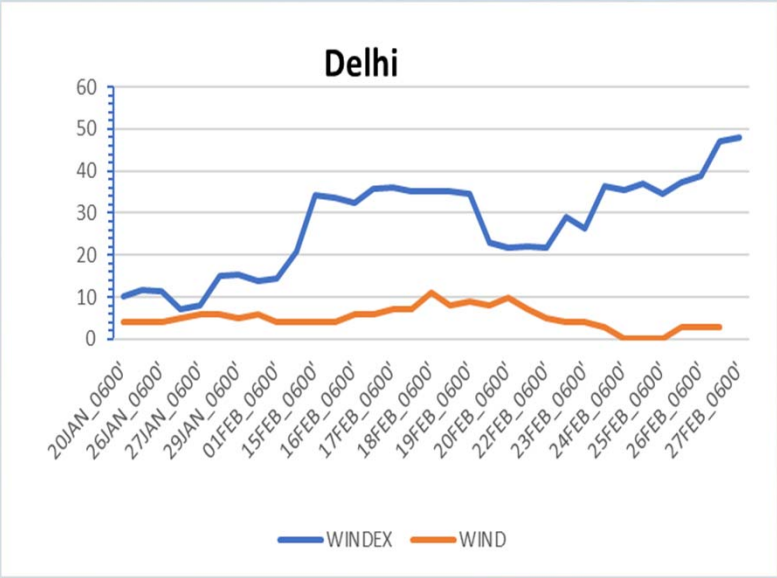
Validation of WI Radiosonde Vs. INSAT 3DR

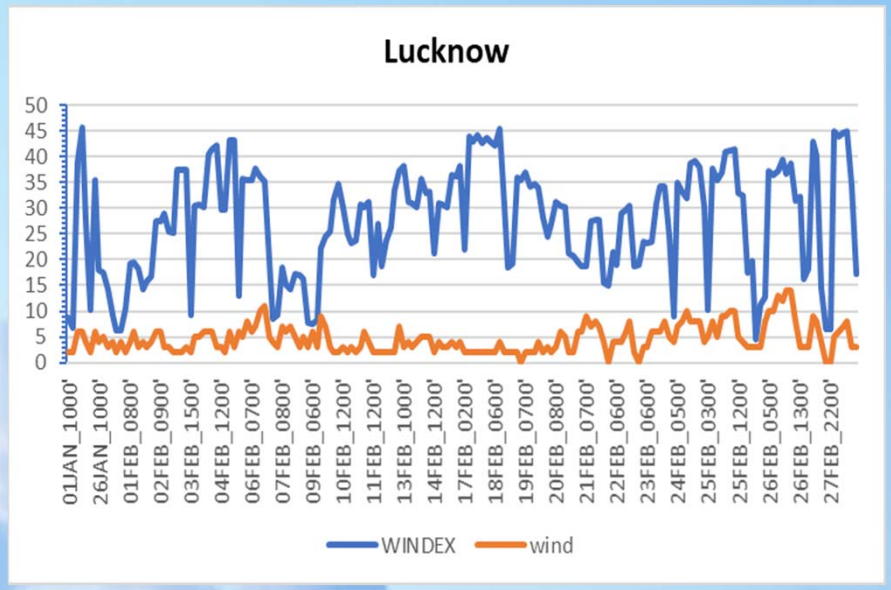
- Level 2B (L2B) products of INSAT 3D/3DR from 2020 to 2022 are collected and correlated with Radiosonde observations.
- This remote-sensing information is associated with errors and needs to be validated.
- http://weather.uwyo.edu/upperair/spunding.html) Radiosonde data was collected and Wind Index was calculated.

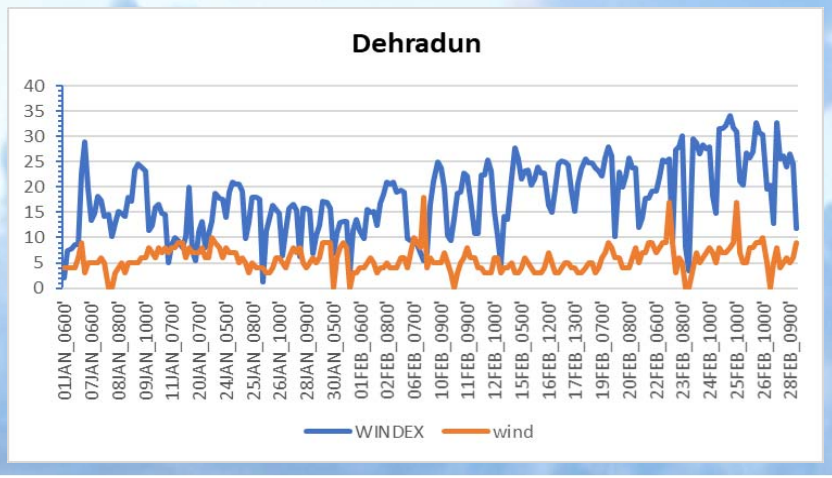
42101 Observations at 00Z 04 Jan 2020

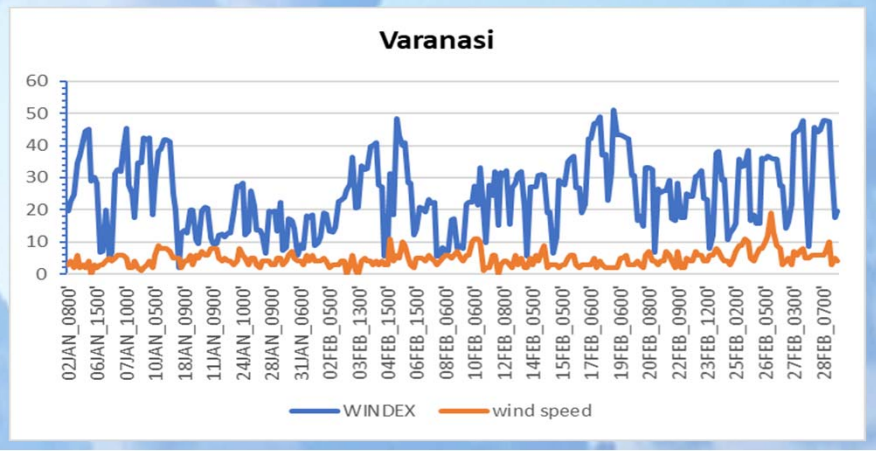
PRES	HGHT	TEMP	DWPT	FRPT	RELH	RELI	MIXR	DRCT	SKNT	THTA	THTE	THTV
hPa	m	C	C	C	%	%	g/kg	deg	knot	K	K	K
1000.0	141											
987.0	251	6.6	5.2	5.2	91	91	5.65	0	0	280.8	296.5	281.8
985.0	268	7.4	7.0	7.0	97	97	6.42	30	1	281.8	299.6	282.9
974.0	361	13.0	8.0	8.0	72	72	6.95	21	1	288.3	308.1	289.5
962.0	465	14.4	5.4	5.4	55	55	5.88	11	2	290.8	307.8	291.8

Graphical representation of different stations showing Windex/Wind speed vs. Date and Time in the months of January and February 2021



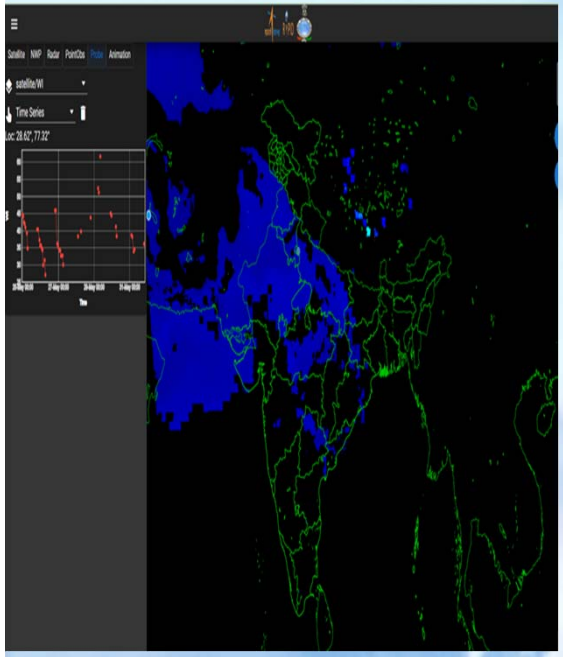




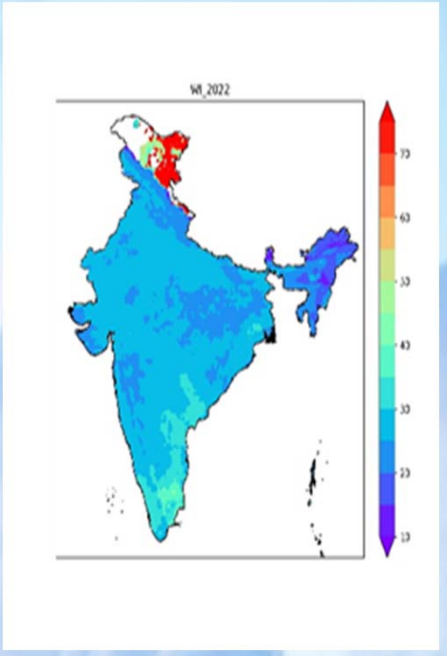


INSAT 3DR WI/DMI

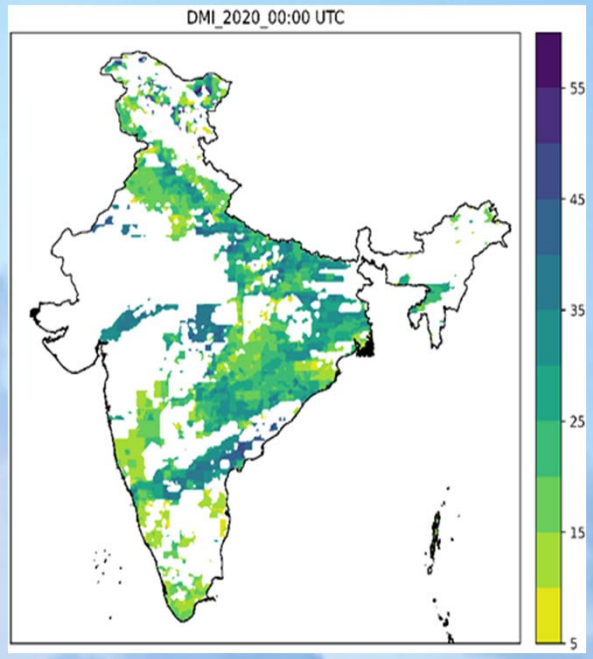
Rapid WI



WI



DMI



Result Discussion

- Validation results show Radiosonde WINDEX is overestimated compared to INSAT 3DR WINDEX.
- Windex is always 3-4 times more than Wind speed.
- Thunderstorm case analysis is done and it shows before 3-4h of thunderstorm WINDEX value goes higher side compared to normal conditions.
- It shows a good correlation between Windex and Wind Gust.
- The forecaster now has one chart that can be monitored for the potential of wet microburst events and the associated wind gust maxima.
- Small aircraft specially helicopter operation this can be a one of the useful tool, few case analysis done on helicopter suspension and find out satisfactory result.

Result Discussion

- The high value of WINDEX supports the high vertical convective development and can cause more damage over the area.
- At the same time if we have high values of horizontal wind speed measured with an anemometer then the moisture can advert over a large area and it can affect more population over the area.
- The lapse rate between the surface and the melting level is the most important atmospheric variable in the WINDEX, Low WINDEX values result from the low-level lapse rates' relative stability.

Conclusion

- This allows the forecaster to monitor how changes in the surface parameters affect the WINDEX gust potential value.
- This work emphasizes the Wind Index accuracy for helicopter operation.
- However, wind index information is derived by satellite but always missing by Radiosonde.
- The proposed method is applied to the estimating Radiosonde wind index.

References

- Atkins, N. T., and R. M. Wakimoto, 1991: Wet microburst activity over the Southeastern United States: Implications for Forecasting. Wea. Forecasting, 6, 470-482.
- McCann, D., 1994: WINDEX - A New Index For Forecasting Microburst Potential. Wea. Forecasting; 9, 532- 541.
- Wakimoto, R. M., 1985: Forecasting dry microburst activity over the High Plains. Mon. Wea. Rev., 113, 1131-1143.
- Pryor, S. C., R. Conrick, C. Miller, J. Tytell, and R. J. Barthelmie, 2014: "Intense and extreme wind speeds observed by anemometer and seismic networks: An eastern U.S. case study". J. Appl. Meteor. Climatol., 53, 2417–2429.
- Aja, M. A. P., Espadas, D.C., & Ramirez, E. A. 2020, "Operational use of a wind profiler for aeronautical meteorology", Minutes of the Scientific Conference of the Spanish Meteorological Association, 33(1).

Thank You