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Utilizing radar-retrieved wind speeds in characterizing high intensity wind fields

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SUMMARY:
The design of spatially spread structures, like transmission lines, relies on the knowledge of wind field characteristics. Properties like spatial correlation, directionality and seasonality of high intensity winds were traditionally achieved through networks of anemometers. The current study presents an alternative method that utilizes NEXRAD WSR-88D weather radars to retrieve low-elevation wind speeds on a medium resolution grid to characterize high intensity wind fields. The retrieval relies on two algorithms; one is generically used due to its efficiency, and the other is only applied to wind fields with significant directional changes that would compromise the accuracy of the first algorithm. Results show that the retrieval process produces wind speeds that are comparable to ASOS anemometer measurements.

Keywords: Radar-retrieval, spatial wind field, high intensity wind

1. INTRODUCTION AND MOTIVATION

Spatial properties of wind fields are deterministic for the design of structures. Special cases, like the design of transmission line structures, require the knowledge of large-scale characteristics of the wind field. Acquiring such characteristics require the presence of a dense network of anemometers, which is hard to achieve. Alternatively, weather radars measure radial velocity (the component away from or towards the radar) at a radial grid that typically extends tens of kilometres. Using measurements at consequent points, numerical algorithms can be used to find the velocity magnitude and direction in a process called retrieval (Browning and Wexler 1968; Shapiro et al. 2003; Liou et al. 2018).

Characterization of high intensity wind fields requires the availability of extended historic archives. The NEXRAD WSR-88D radar network operates 160 radars across the United States and has been archiving measurements since 1991 (NWS 2021). Moreover, the availability of ASOS anemometers in close proximity to radars has been utilized by (Ibrahim et al. 2022) to validate the retrieved wind velocities at 19 locations. It is important to note that the validated data corresponds to events recorded as thunderstorms in ASOS archives. The validated results were compared with retrieved data using another algorithm by (Xu et al. 2006).

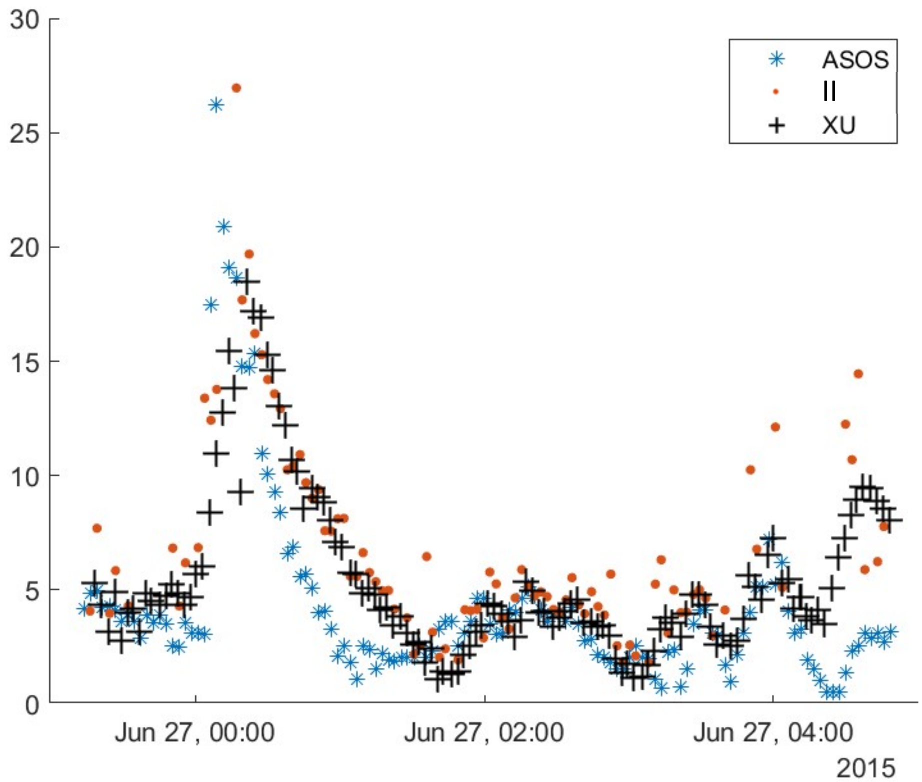

Figure 1. Radar retrieved velocities compared to ASOS 3-s gust

The analysed data have shown that the algorithm used by (Ibrahim et al. 2022) is closer to peak ASOS measurements compared to estimates produced using (Xu et al. 2006). An example of the comparisons made is shown in **Figure 1**. The main reason behind the difference in performance between the two techniques is the area considered for analysis. While (Ibrahim et al. 2022) utilizes a series of points on the radial grid that are tens to hundreds of meters apart, (Xu et al. 2006) analyse an area that is at least an order of magnitude more than the other study. Although this difference affects the accuracy of peak wind speeds in the case of thunderstorms due to their local nature, it significantly decreases the computational time needed to analyse larger grids of points.

Utilizing the two retrieval techniques mentioned, the aim of this study is to characterize the wind field at instances of high intensity wind speeds through the computation of wind velocities on a spatial grid. Results can aid with identifying: a) the directionality of wind fields during high intensity events, b) scale of high intensity portions of the wind field and c) the seasonality of high intensity wind field occurrence.

2. METHODOLOGY

The characterization of high intensity wind fields is achieved by applying the following steps:

1. Analyze historical records using (Xu et al. 2006) and archive wind speed and direction for a 1 km resolution grid.
2. Results that indicate the presence of local events (thunderstorms) are reanalyzed using

(Ibrahim et al. 2022) as it has been shown to produce more accurate results for cases of thunderstorms.

3. Archived results are utilized as follows:
    a. Wind direction, similar to examples in **Figure 2**, indicates nature of wind field (whether synoptic or non-synoptic) as well as uniformity and dominant direction of the high intensity portion of the wind field.
    b. The area of high intensity wind can be deduced from the grid of retrieved wind speeds as shown in the contour plot presented in **Figure 3**.
    c. Report the seasonality of archived high intensity wind occurrences.

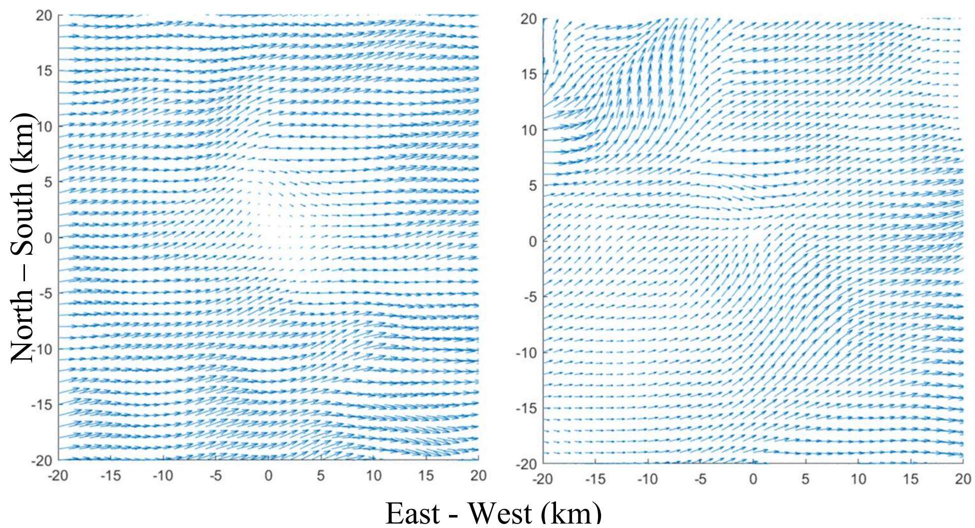

Figure 2. Examples of retrieved wind direction for wind field with high uniformity (left) and non-uniform (right)

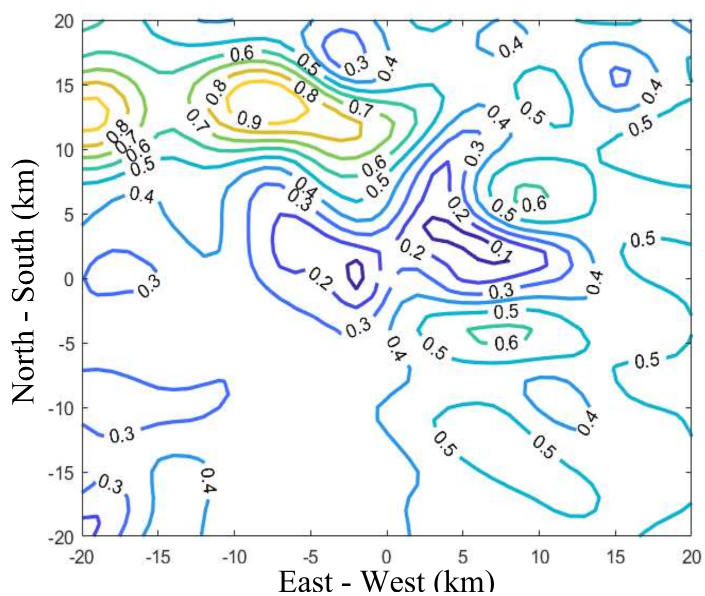

Figure 3. Contour plot of wind speeds normalized by maximum speed showing the area affected by high speeds.

3. CONCLUSIONS

The current study presents a method that relies on radars to estimate characteristics of wind fields as an alternative to using a network of anemometers, which is usually hard to achieve. The presented method produces a 1 km resolution grid of estimated wind velocity and direction from which wind field characteristics can be found. The first characteristic is wind directionality, which signifies the type of wind field and whether it belongs to synoptic or non-synoptic wind. Second, the area affected by high intensity wind can be measured on the grid, which is of particular use for the design of special structures like transmission line systems. Lastly, since the analysed results correspond to a historical archive, the properties previously defined can be related to different seasons that are region specific. The presented document is a generic overview of the study. A full conference presentation would include in depth details of the methodology and key findings related to the studied region.

4. REFERENCES

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