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A Tropical Cyclone Tangential Wind Speed Estimation Model Based on C-Band Cross-Polarization SAR Observations

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1. Introduction

As the nontrivial instrument to probe at high spatial resolution under extreme wind conditions, C-band synthetic aperture radar (SAR) can collect high resolution measurements covering with tropical cyclones (TCs) to support the modeling of TC wind speed. The tangential wind profile model is one of the effective and widely used methods to reconstruct the radial wind speed of TCs. However, there are two main defects for several widely used tangential wind speed models [1-3], one is the non-smooth changes of model derived wind speed in the radial direction, the other one is that using a linear function to estimate wind speed in the inner area of TC eyewall cannot fit the actual winds very well. Therefore, we proposed a tangential wind profile model (**TWP**) in the form of Gaussian-like function using the retrieval wind speed of cross-polarized SAR data to solve the two defects mentioned above.

2. Proposed TWP Model

Since the GV model has been verified to provide a smooth change of wind speed near the eyewall and the form of piecewise function is useful for the different change of TC wind inside and outside the eyewall, we design the TWP model function as a piecewise Gaussian-like function. Considering the enhancement-weakening process of the tangential wind as the distance from TC center increases, the growth parameter a and the decay parameter b are introduced in the piecewise function. Therefore, the proposed model function can be written as:

$$V = \begin{cases} V_m \, exp\left(-\left(\frac{1}{a}\left(\frac{r}{R_m}-1\right)\right)^2\right) & r \le R_m \\ V_m \, exp\left(-\left(\frac{1}{b}\left(\frac{R_m}{r}-1\right)\right)^2\right) & R_m < r \le 150\ km \end{cases}$$

where V_m is the maximum wind speed of the azimuthal-averaged tangential wind speed, and R_m is the corresponding radius of V_m; and r is the radius or distance to the hurricane center. Moreover, by adding the constant 1, the first segment of the function monotonically increases while the second monotonically decreases, which well fits the change trend of the tangential wind.

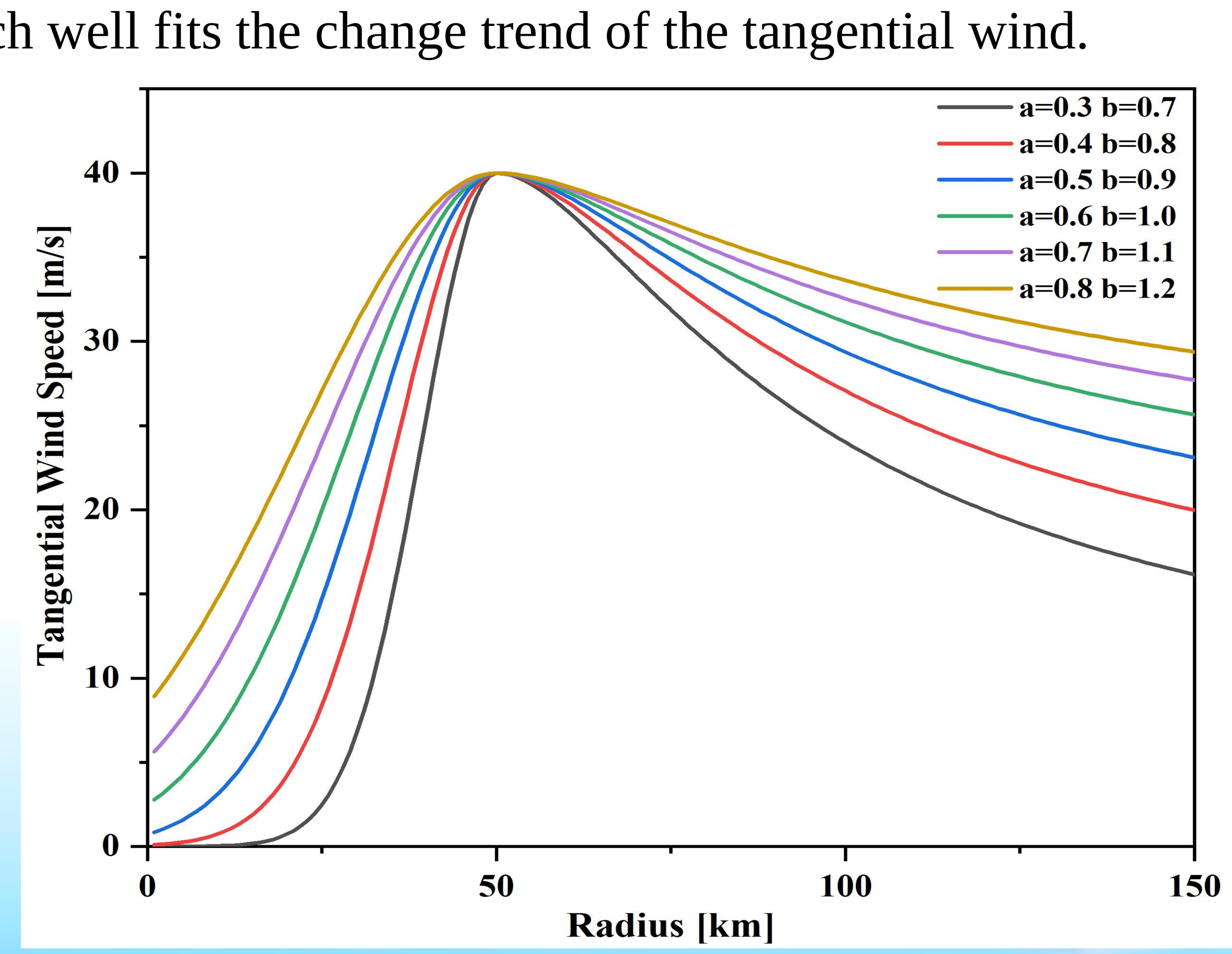
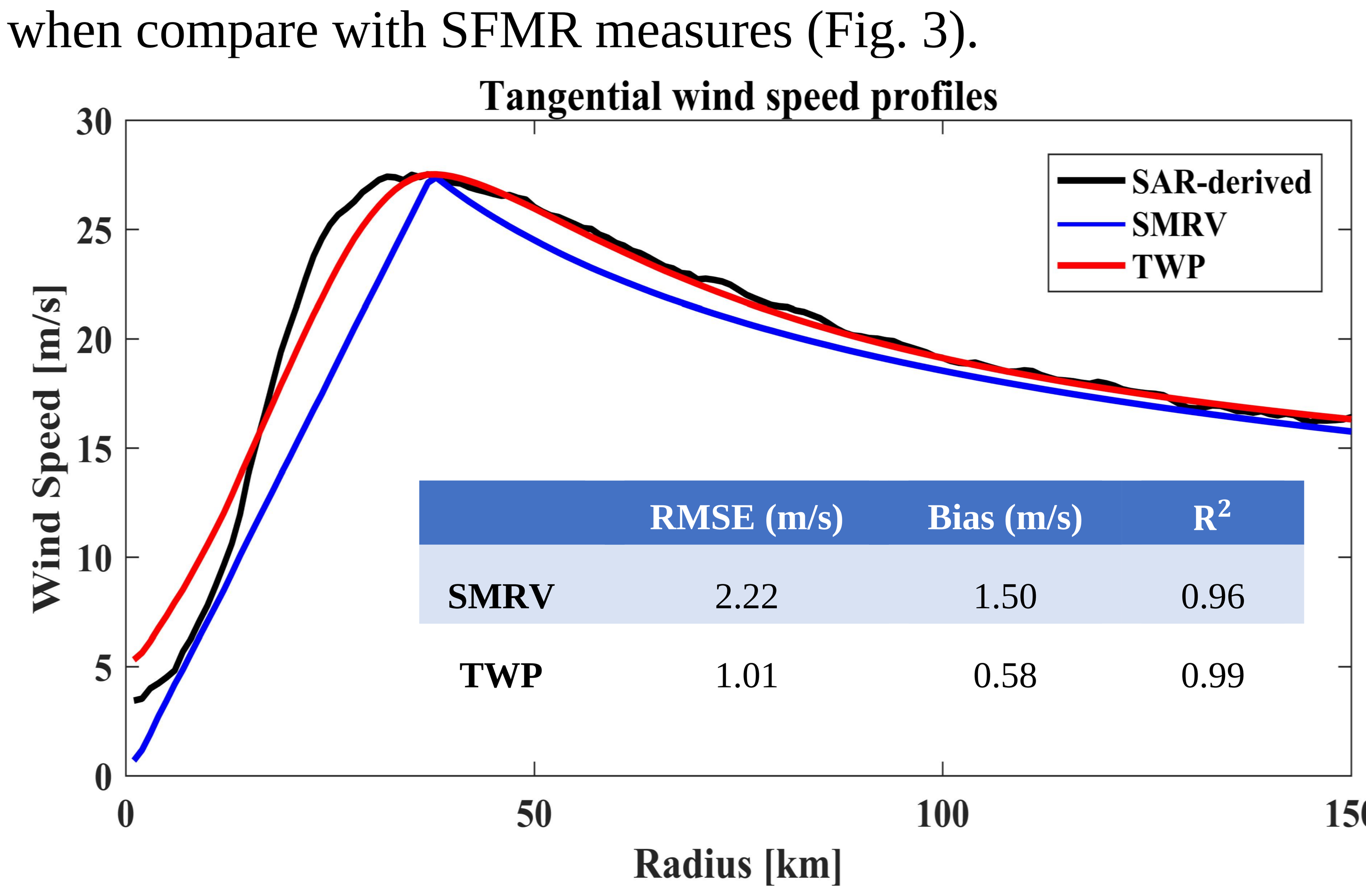


Figure 1. Tangential wind profiles for different combinations of parameters *a* and *b* with the *Vmax*=40 m/s, *Rmax*=50 km.

3. Model Evaluation

We select the hurricane Arthur (2014) as the study case to evaluate proposed model. The Fig. 2 shows that TWP model wind profile has a better agreement with SAR-derived one than classical SMRV model. Especially, it’s obvious that the actual SAR wind has a smooth transition at high wind aera and changes non-linearly in the inside of eyewall. Fortunately, the TWP model can capture these characteristics well. Finally, the TWP also performs well when compare with SFMR measures (Fig. 3).



	RMSE (m/s)	Bias (m/s)	R^2
SMRV	2.22	1.50	0.96
TWP	1.01	0.58	0.99

Figure 2. The tangential wind derived by SMRV model (blue), TWP model (red), and the SAR-derived azimuthally-averaged (black) one. The table above figure are statistical scores.

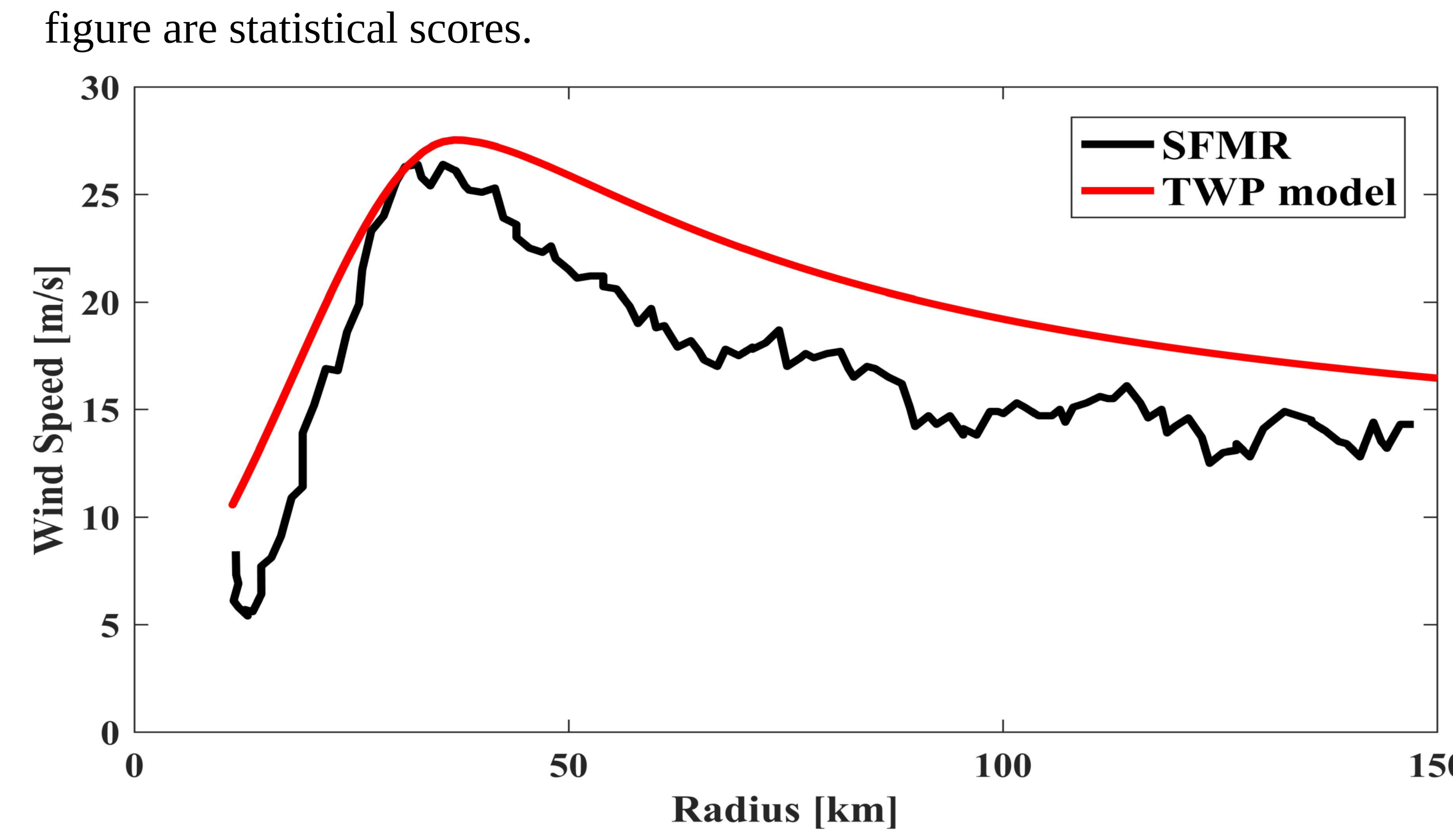


Figure 3. The tangential wind profiles simulated by the TWP model (red) and the SFMR measurements with time window from 11:00 to 11:20 UTC on 3 July, 2014 (black) for hurricane Arthur (2014).

4. Summary and References

Highlights:

- The proposed TWP model can reconstruct the tangential wind speed with smooth transition in high wind area.
- Non-linear fitting function of TWP model can improve the accuracy of wind speed estimation inside the TC eyewall area.

References:

[1] Mallen, K. J., M. T. Montgomery, and B. Wang (2005), Reexamining the near-core radial structure of the tropical cyclone primary circulation: Implications for vortex resiliency, J. Atmos. Sci., 62(2), 408-425, doi:10.1175/jas-3377.1.
[2] Sitkowski, M., J. P. Kossin, and C. M. Rozoff (2011), Intensity and Structure Changes during Hurricane Eyewall Replacement Cycles, Mon. Weather Rev., 139(12), 3829-3847, doi:10.1175/mwr-d-11-00034.1.
[3] Zhang, G. S., B. Zhang, W. Perrie, Q. Xu, and Y. J. He (2014), A Hurricane Tangential Wind Profile Estimation Method for C-Band Cross-Polarization SAR, IEEE Trans. Geosci. Remote Sens., 52(11), 7186-7194, doi:10.1109/tgrs.2014.2308839.