A SAR-based Parametric Model for Tropical Cyclone Tangential Wind Speed Estimation

Sheng Wang[1,2]   Xiaofeng Yang[1]   Marcos Portabella[3]   Ka-Veng Yuen[2]

(wangsheng@radi.ac.cn)   (yangxf@radi.ac.cn)   (portabella@icm.csic.es)   (kvyuen@um.edu.mo)

1 State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing, 100101, China

2 University of Macau, Macau, 999078, China

3 the Barcelona Expert Centre (BEC), Institute of Marine Sciences (ICM-CSIC), Barcelona, 08003, Spain

1. Introduction

The tangential wind profile model is one of the most effective and widely used methods to reconstruct the TC radial wind speed. Generally, there are two main types of model functions in the literature: one is designed piecewise to describe the radial wind speed in the ascending and descending segments of the tangential wind, with the segmental threshold being the maximum wind speed. The other uses a continuous function to directly describe the whole tangential winds. However, existing piecewise function-based models have an apparent sharp inflection at the maximum wind speed, and the continuous function-based ones usually have low estimation accuracy.

Based on high-spatial-resolution SAR observations, this study propose a novel tangential wind speed model (TWP), which is designed by exploiting the advantages of both the piecewise and the continuous functions. The model functions include two sections, and each one is a Gaussian-like function. Satisfactorily, the new model can accurately estimate the tangential winds with a relatively concise form, and its wind profile transition is smooth in the high wind area.

2. Design of TWP Model

$$V = \begin{cases} V_{max} \exp\left(-\left(\frac{1}{a}\left(\frac{r}{R_{max}} - 1\right)\right)^2\right) & r \leq R_{max} \\ V_{max} \exp\left(-\left(\frac{1}{b}\left(\frac{R_{max}}{r} - 1\right)\right)^2\right) & R_{max} < r \leq 150\ km \end{cases}$$

V_{max} : maximum wind speed of the azimuth-averaged tangential wind speed

R_{max} : corresponding radius of V_{max} r : distance to the TC center

a :   growth parameter b : decay parameter

Note: the unity constant term guarantees the zero derivatives at the segmentation point (R_{max}) of model function.

4. Discussions on Model Parameters

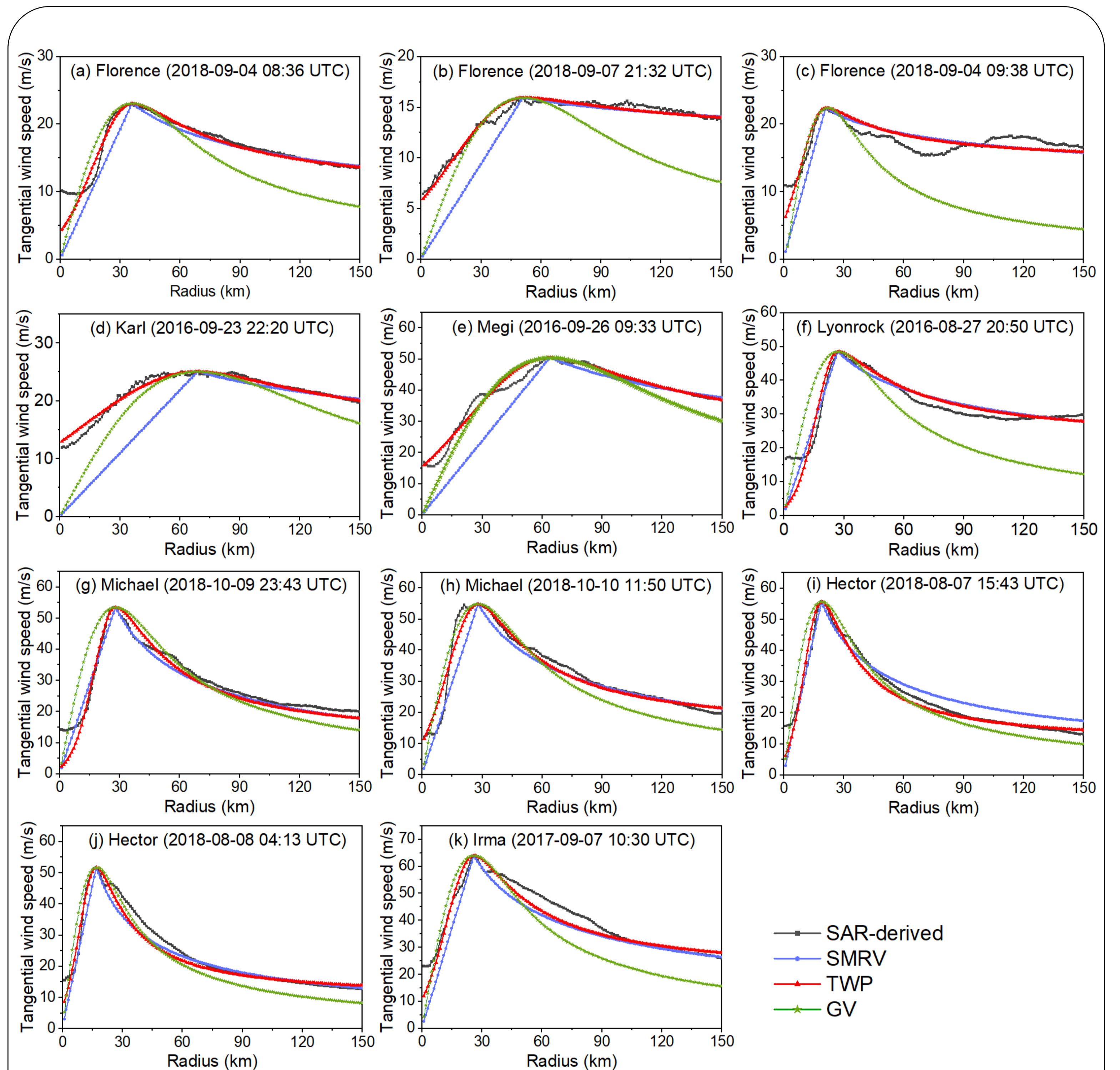| Statistics	Category	Number	Mean	Std	Range
a	Small	301	0.90	0.21	0.53-1.66
	Moderate	206	0.76	0.18	0.48-1.45
	Major	113	0.61	0.09	0.45-0.94
b	Small	301	0.99	0.43	0.03-2.63
	Moderate	206	1.01	0.32	0.10-2.34
	Major	113	0.93	0.13	0.32-1.66
R_{max} (km)	Small	301	67.75	39.17	2.5-149
	Moderate	206	56.92	34.28	14-149
	Major	113	30.06	16.14	11.15-123.5

5. Conclusion

TWP model presents three main improvements with respect to the existing models:

➤ (1) It effectively addresses the unsmooth transition of the tangential wind profile in the peak wind region;

➤ (2) It better fits the actual tangential wind speed profile as depicted by SAR and SFMR;

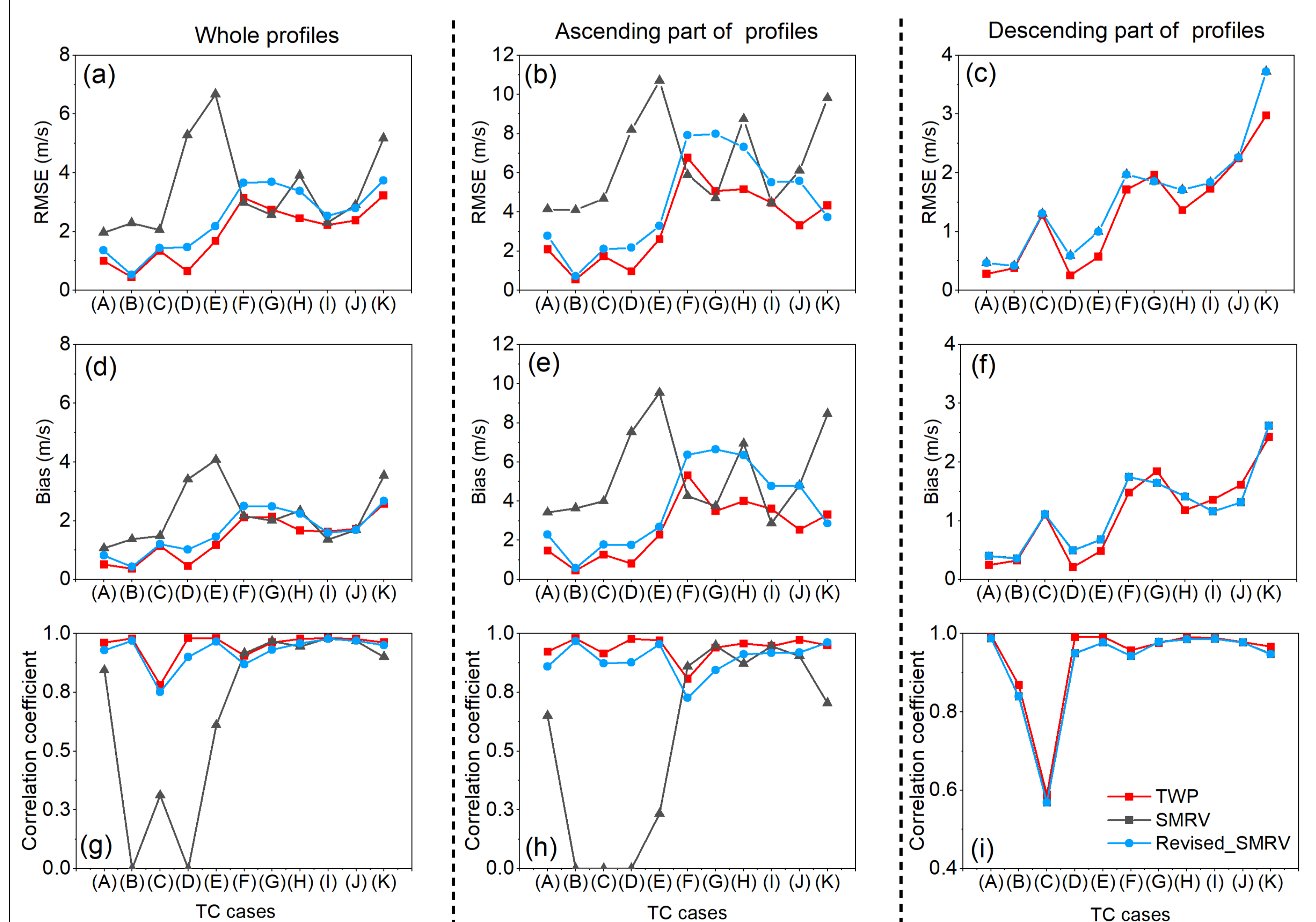➤ (3) It has higher accuracy in TC tangential wind speed reconstruction.

3. Model Results and Comparisons

The model estimated tangential wind speed profiles versus the ones derived from SAR images and other models for 11 TC cases:

The RMSE, bias of the model estimated tangential wind speed against the SAR-derived one.

References

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