Interagency discrepancies in tropical cyclone intensity estimates over the western North Pacific in recent years

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Introduction

The best-track datasets (BTDs)

- **the China Meteorological Administration (CMA),**
- **the Regional Specialized Meteorological Center (RSMC) Tokyo,**
- **Hong Kong Observatory (HKO),**
- **and the Joint Typhoon Warning Center (JTWC).**

TC intensity is defined as

- **the maximum surface (10-m height) wind speed (MSW)**
- **and the minimum sea level pressure (MSLP)**

Previous studies have reported significant discrepancies in TC intensity estimates among the different BTDs.

Climate change:

- Song et al. (2010) found an increasing trend in the annual frequency of strong TCs during 1977–2007 in the JTWC data set, but decreasing trends in the CMA and RSMC data sets; this was later confirmed by Ren et al. (2011).
- Yeung (2006) andWu et al. (2006) also found that there was no increase in the activity of intense TCs in the RSMC and HKO data sets, in contrast to the JTWC data set.

Mean interagency discrepancies in different decades:

- Ren et al. (2011) noted that TC intensity discrepancies were smallest between the CMA, JTWC, and RSMC data sets during 1973–1987, whereas large discrepancies occurred during other periods.
- The TC intensity was overestimated during the period prior to the early 1970s in the CMA best track data set, but was overestimated in the JTWC data set after the termination of aircraft observations (Bai et al., 2019).

Introduction

Disparate MSW values between BTDs are the result of two main factors:

1. **MSW values are averaged over different time intervals**: the JTWC, CMA, and RSMC use 1-, 2-, and 10-min periods, respectively.
2. The various agencies employ **different operational procedures and incorporate additional observational data** into their MSW estimates.
   - Over the open ocean, the most widely used approach is the **Dvorak technique**. Various conversions of CI to MSW have been developed to account for different averaging periods of winds in these agencies.
   - **RSMC:** ocean surface wind data from microwave satellites and surface observations (Kunitsugu, 2012)

     CMA: in situ observations and radar data, particularly for landfalling and offshore TCs (Bai et al., 2022).

TABLE 1 Mapping tables relating CI to MSW employed by the JTWC, RSMC, and CMA

	MSW (m/s)		
CI	JTWC	RSMC	CMA
1.5	13	15	13
2.0	15	19	15
2.5	18	22	18
3.0	23	26	23
3.5	28	29	28
4.0	33	33	33
4.5	40	37	38
5.0	46	40	42
5.5	52	44	48
6.0	59	48	52
6.5	65	51	58
7.0	72	55	62
7.5	80	59	68
8.0	87	63	75

Introduction

Previous studies comparing TC intensity data sets have mostly focused on long-term trends and average discrepancies over different decades. **However, the analysis procedures for intensity estimations have varied during the last several decades.**

- ➢**The wind-pressure relationship (WPR)** suggested by Knaff and Zehr (2007) has replaced that of Atkinson and Holliday (1977) for operational TC intensity estimations **at the JTWC since 2007** (U. S. FleetWeather Facility, 2007; Bai et al., 2019).
- ➢**The CMA** improved the operational flow of TC intensity estimations and **adopted the technique of Dvorak** (1984) recommended by the World Meteorological Organization **since 2013** (Xu et al., 2015).

Therefore, it is necessary to compare interagency differences in intensity estimations of the TCs in recent years and to analyze the reasons for those differences.

This study want to answer the following questions to better understand the interagency discrepancies in intensity estimations since 2013:

① Have TC datasets become more consistent since all these three agencies adopted the Dvorak technique?

② What are the causes of discrepancies among BTDs?

Datasets

BTDs:

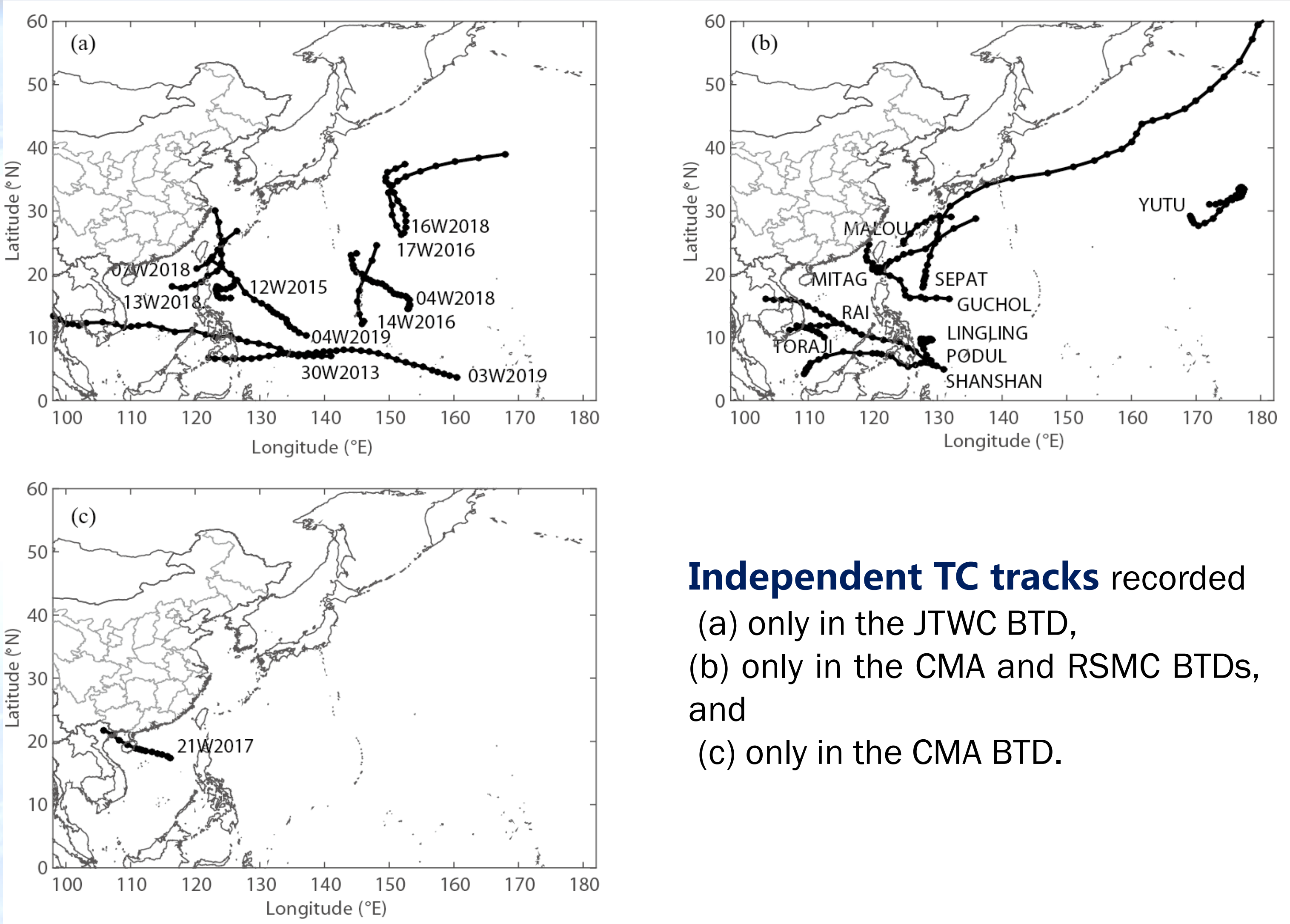
CMA, RSMC, and JTWC

2013-2019

The mean annual TC frequencies are highly consistent (JTWC = 26.6; CMA = 26.7; RSMC = 26.6) on the period 2013–2019.

However, the annual frequency of the concurred-TCs is 25.1, indicating that a number of “independent” TC events are not recorded in all three BTDs.

Only those events for which MSW ≧17.2 m/s and recorded in all three BTDs (n = 3287) are considered in this study.



Independent TC tracks recorded
(a) only in the JTWC BTD,
(b) only in the CMA and RSMC BTDs, and
(c) only in the CMA BTD.

Interagency intensity differences varied with TC intensity (1)

➢The interagency MSW differences remain significant, even after the universal adoption of the Dvorak technique.

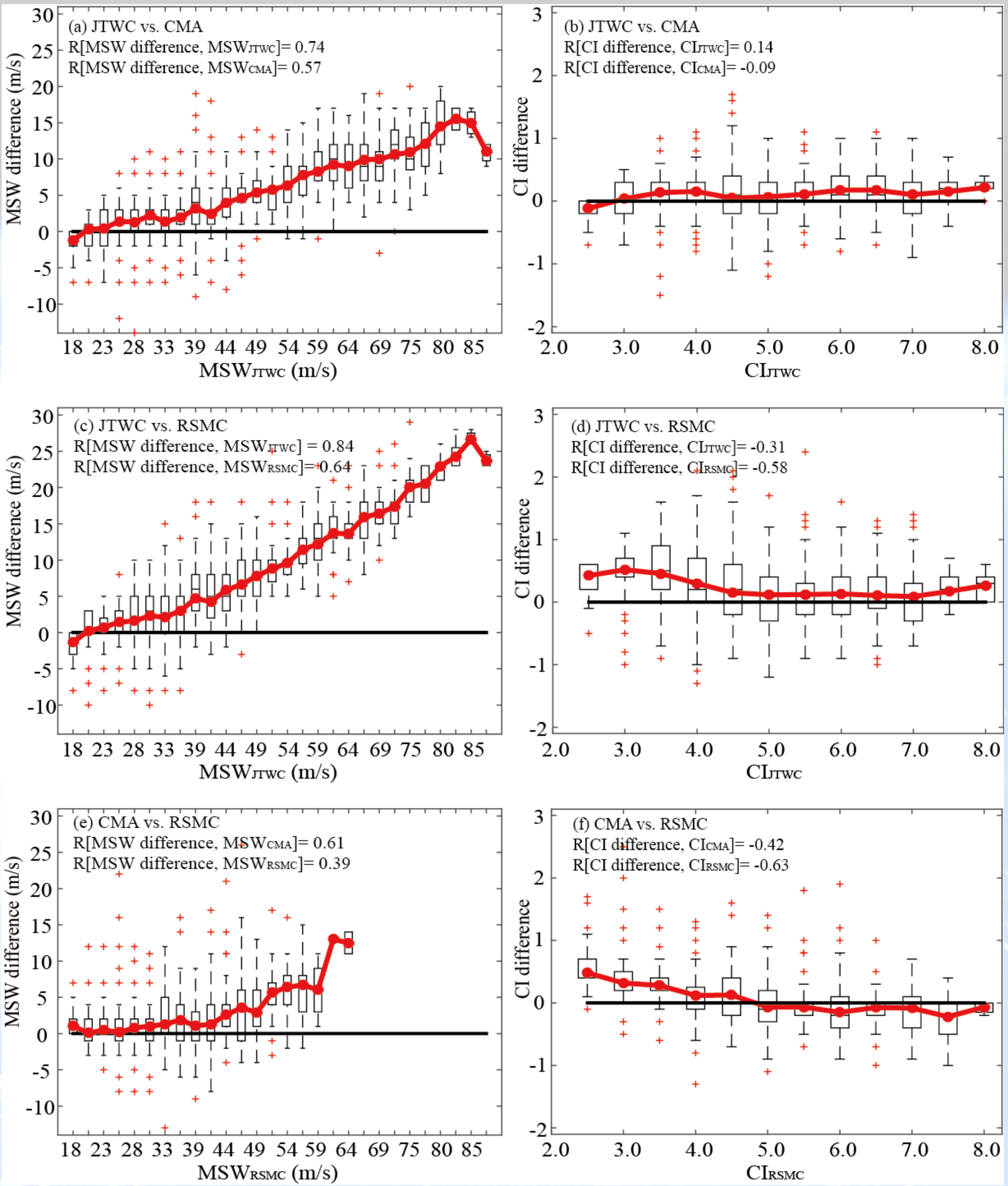
$MSW_{JTWC} > MSW_{CMA} > MSW_{RSMC}$

➢The interagency disparity among MSW estimates grows with increasing MSW.

➢The MSW were reversed to the CI numbers according to the specific CI–MSW relationship employed by each agency.

➢The CI discrepancies in the stronger intensity range can be diminished significantly. The mean interagency CI differences are less than 1.0.

The distinct CI–MSW relationships employed by each agency are the predominant factor that causes interagency discrepancies in MSW estimates.



Interagency intensity differences varied with TC intensity (2)

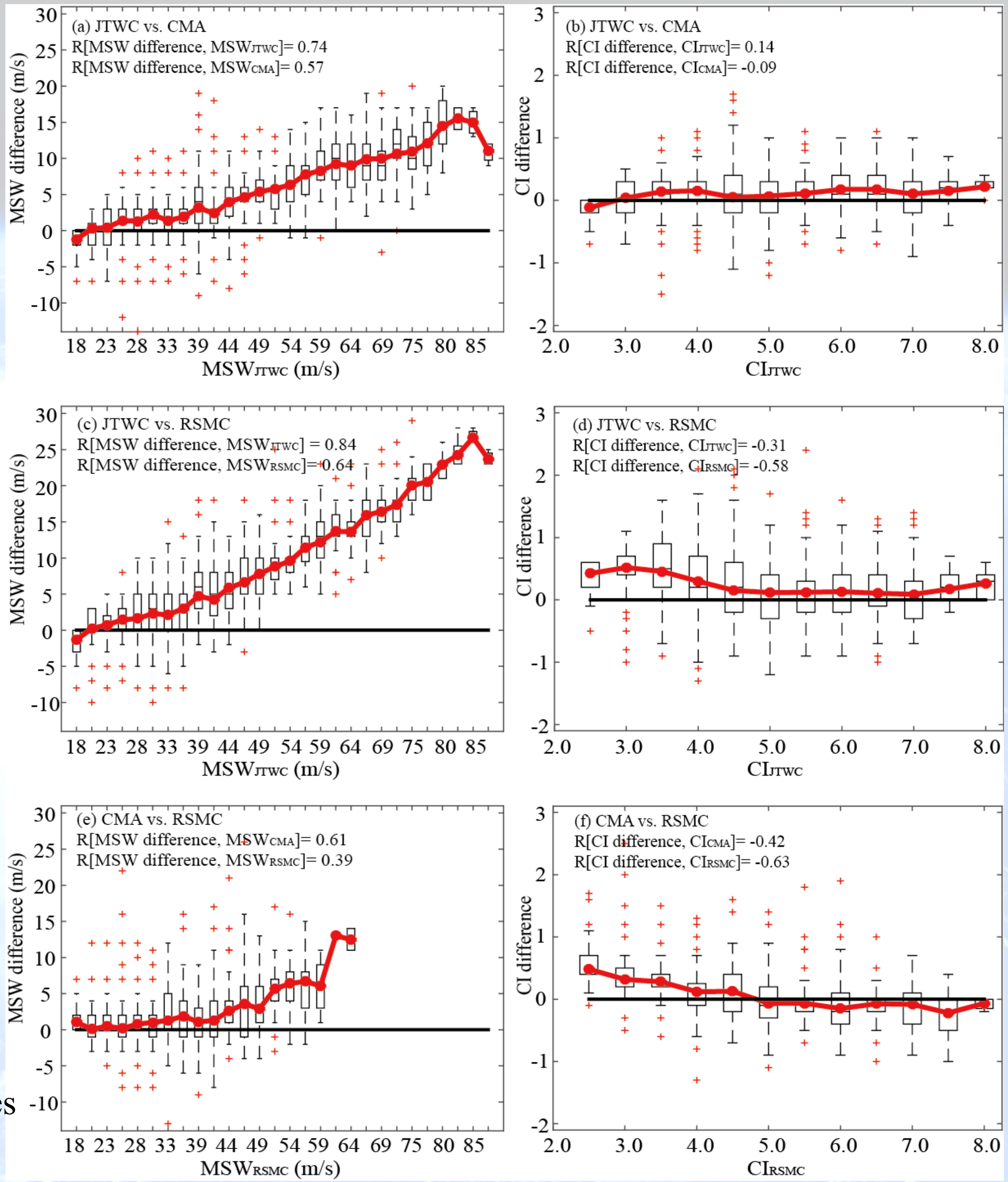
➢The MSW were reversed to the CI numbers according to the specific CI–MSW relationship employed by each agency.

$CI_{JTWC} > CI_{CMA}$; $CI_{JTWC} > CI_{RSMC}$

$CI_{CMA} > CI_{RSMC}$, when CI<5.0

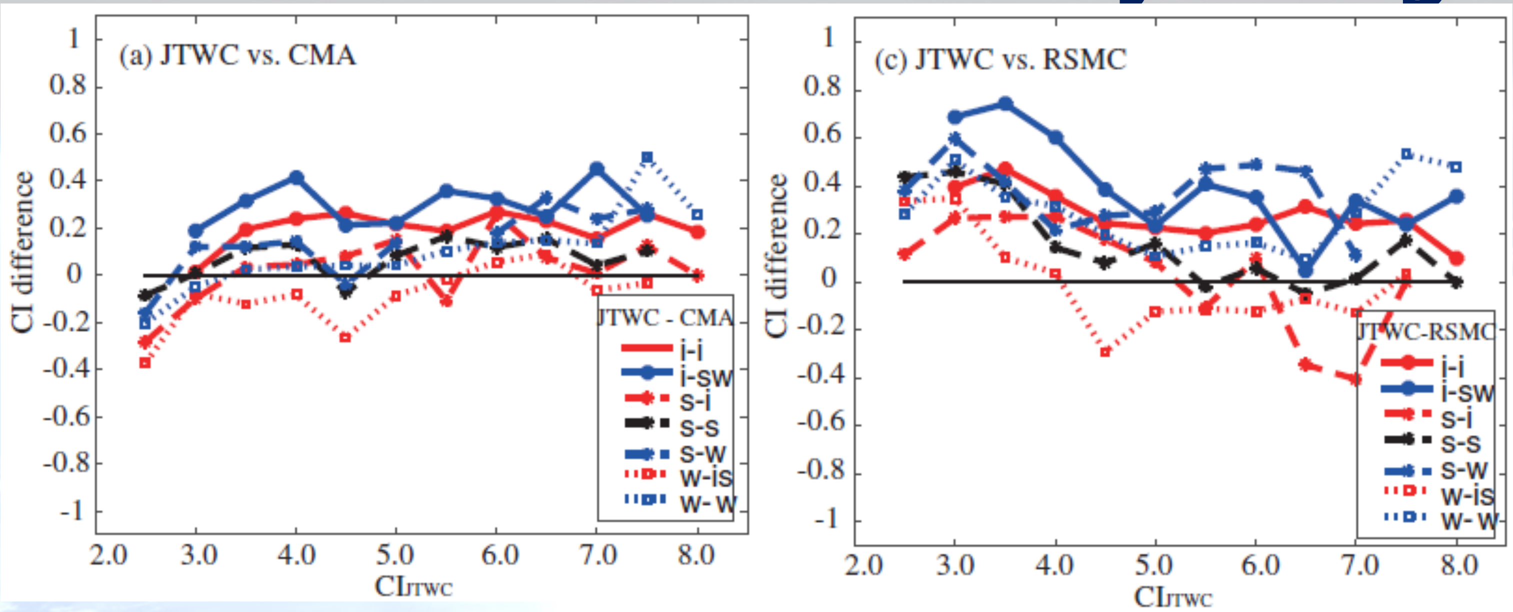
$CI_{CMA} < CI_{RSMC}$, when CI≧5.0

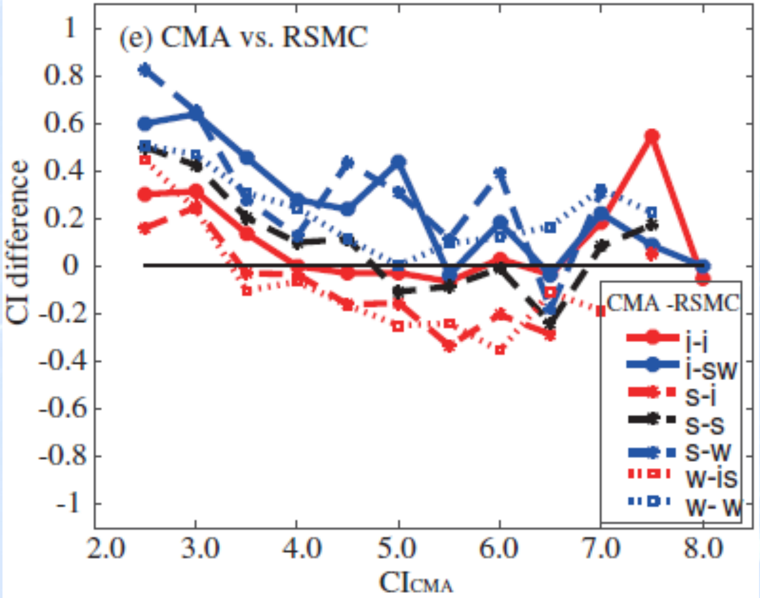
Besides that, the variable CI numbers derived from the Dvorak technique also cause interagency MSW discrepancies.



Boxplots depicting interagency differences in MSW and CI between pairs of BTDs

Interagency intensity differences varied with TC intensity change (1)





Composites of CI differences for the stratifications of intensity change. The legends denote the intensity change during the last 6 h.
"i" - intensified,
"s" -steady,
"w"- weakened

The largest CI differences appeared for the samples intensifying in the one dataset but steady/weakening in another dataset (blue solid lines).

This contrast in estimated intensity trends serves to enlarge the CI offset between the agencies.

For those samples recorded as intensifying in both datasets (red solid lines), the mean CI_{JTWC} are still larger than CI_{CMA} and CI_{RSMC}.

Further analyses found that the relatively high CI_{JTWC} likely relate to the stronger initial intensity recorded in that dataset.

Interagency intensity differences varied with TC intensity change (2)

TABLE 2. Number of samples based on different △CI groups

	JTWC		CMA		RSMC	
△CI	CI <4.0	CI ≧ 4.0	CI <4.0	CI ≧ 4.0	CI <4.0	CI ≧ 4.0
>1.0	0	7	1	4	1	21
>0.5	5	164	5	96	67	186
>0	536	684	547	547	510	454
= 0	590	340	691	596	838	676
<0	338	625	298	434	297	338
<−0.5	49	104	48	57	111	98
<−1.0	7	7	10	9	29	22

Note: △CI denotes the CI change during the last 6 h.

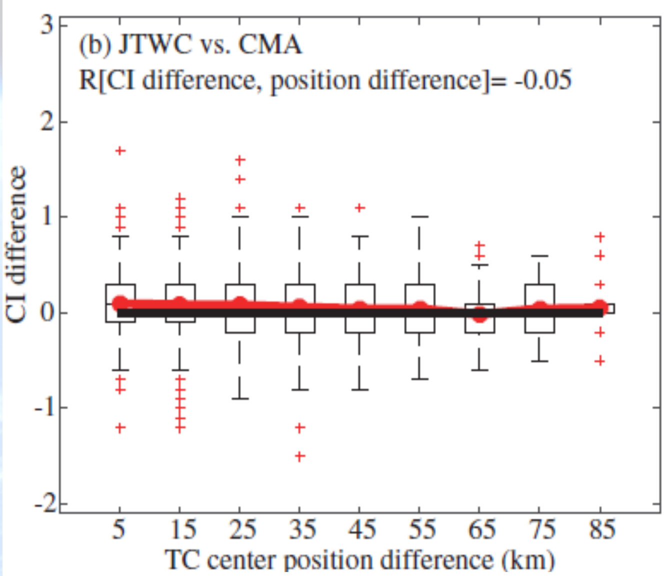
Both the intensifying (△ CI > 0) and decaying (△CI < 0) numbers are the least, but the rapid intensifying (△CI > 1.0) and rapid decaying (△CI < 1.0) numbers are the most in RSMC dataset.

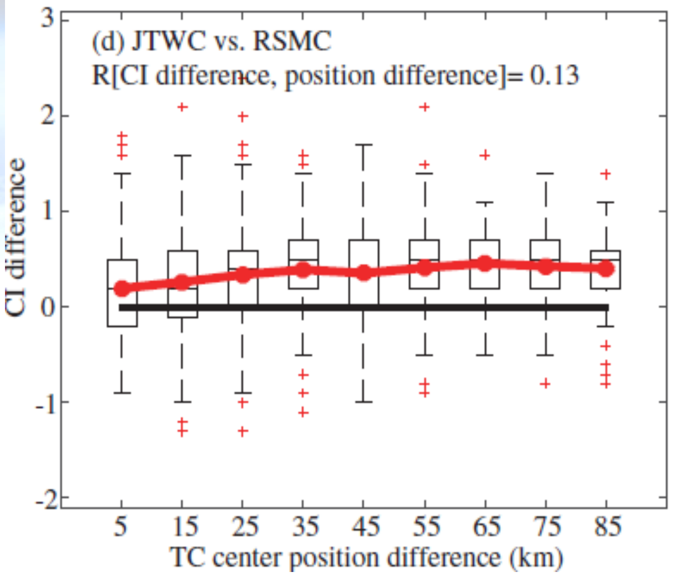
Dvorak (1984):

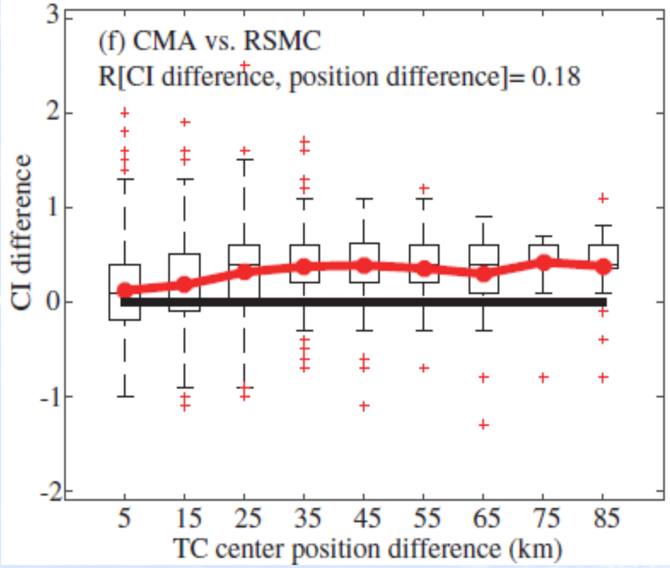
The final T number change is limited less than 0.5 (1.0) over 6 hours when T-number < 4.0 (≥ 4.0).

This discrepancy of the rapid intensifying and decaying numbers suggests that the permissible margin of intensity variability proposed by Dvorak (1984) is somewhat relaxed by the RSMC.

Interagency intensity differences varied with differences in TC center position



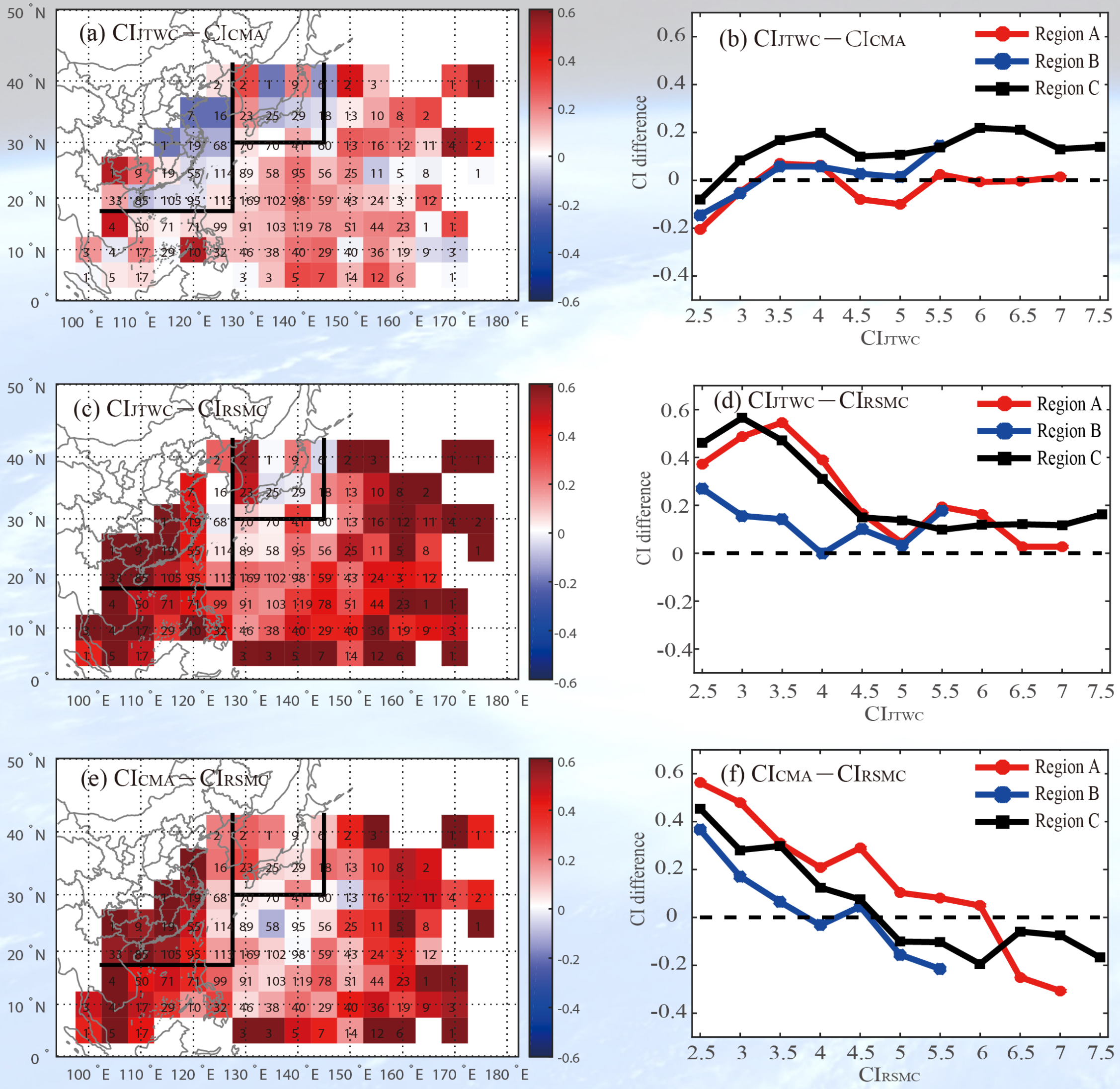




Boxplots depicting interagency CI differences for the TC center position difference

Positive relationships exist between the RSMC and the other two BTDs, suggesting that discrepancies in CI are greater when there is larger difference in estimated TC position.

Spatial distribution of interagency intensity differences



Regional distributions of the CI differences (left) among pairs of BTDs. The grid size is 5*5. The numbers in each grid square is the sample size (right) the distributions of interagency CI differences in the three regions.

- ➢An important feature of these distributions is that CI differences over mainland China and Japan (and the coastal areas) contrast obviously with those over the open ocean.
- ➢The CI_{JTWC} are not always larger than those from the other two agencies in these regions.

Region A: China mainland and coastal zone,

Region B: Japan mainland and coastal zone,

Region C: Open WNP ocean outside regions A and B.

- ➢CI_{CMA} are higher than those in the JTWC dataset for TCs in region A (red line in figure b).
- ➢The values of CI_{JTWC}-CI_{RSMC} in Region B (blue line in figure d), which are much smaller, are well distinguishable from that in the other regions.

The broad use of additional supplementary sources by the CMA and RSMC is potentially causing divergent CI estimates, particularly for landfalling and offshore TCs.

Summary

This study evaluates interagency discrepancies in estimates of TC intensity over the WNP between 2013 and 2019.

- The interagency MSW differences remain significant, even after the universal adoption of the Dvorak technique.
- Reported CI values are reversed by the MSWs based on the respective CI–MSW relationship employed by each agency. There remain systematic CI disparities among the three datasets. This result indicates that, **in addition to the variable CI–MSW relationships, the different CI numbers estimated via the Dvorak technique are also a source of interagency discrepancy.**
- The further analyses find that discrepancies in CI number are linked to differences in estimates of **intensity change, initial intensity, TC position estimation and the use of additional supplementary sources by these agencies.**
- Finally, the spatial distribution of interagency difference reveals that the distribution characteristics for MSW and CI disparities near the coasts of China and Japan are starkly different from those in the open ocean. **Both the CMA and RSMC emphasize the importance of supplementing estimates with surface observational data, which potentially results in interagency differences in TC intensity estimates near the shores of China and Japan.**

Thank you for your attention!

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Bai Lina, Xu Yinglong, Tang J*, et. al., 2022. Interagency discrepancies in tropical cyclone intensity estimates over the western North Pacific in recent years. *Atmospheric Science Letters*, doi: 10.1002/asl.1132.

Bai Lina*, Tang J, Guo Rong, et. al., 2022. Quantifying interagency differences in Lekima (2019) intensity estimations. *Frontiers of Earth Science*, 16: 5-16.