

Progress of WMO Typhoon Landfall Forecast Demonstration Phase IV (TLFDP-IV)

TEAM 2:

Tropical cyclone analyses and forecast technique application and evaluation

Guomin CHEN (STI/CMA)

Team Member

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Outline

- **Terms of reference**
- **Major progress (2019-2021)**
- **Plans in future**

Terms of reference

1. Study TCs with abnormal behaviors, such as **rapid intensification or weakening**, and **sudden change** in the speed or direction;
2. Identify **model errors** through model diagnostics of TC structure against observations and provide feedback to model developer;
3. Extend the targeted area from the western North Pacific **to other basins**, in collaborations with other basins affected by TCs;
4. Propose **TC intensity forecast products and verification techniques** to be demonstrated during the project, in cooperation with EXOTICCA.;
5. Propose **TC precipitation forecast products and verification techniques** to be demonstrated during the project, in cooperation with UPDRAFT;
6. Enhance the **evaluation system** for TC forecasts by implementing available and developing new verification techniques for TC deterministic and ensemble results;
7. Set up user-tailored TC forecast verification guidance through **project website**;
8. Participate in WMO workshops, UNESCAP/WMO Typhoon Committee Sessions, and training courses related to the TLFDP upon request .

Major progress

during 2019-2021

Recommendation of Basic Verification Metrics

Recommend Basic Verification Metrics to LC-TCFV

- The following scores are to be calculated against the best track dataset:

- Detection rate
 - Storm track verification:

- Position error: Distance between predicted and analysed tropical cyclone centres
 - Along-track & Cross-track (AT&CT) bias

AT bias: Bias in the direction of cyclone movement

CT bias: Bias in the rectangular direction of cyclone movement

- Bias of central pressure

- All calculated scores in the text and pictorial form shall be made:

- Detection rate: output and drawn every 12 h until 120h

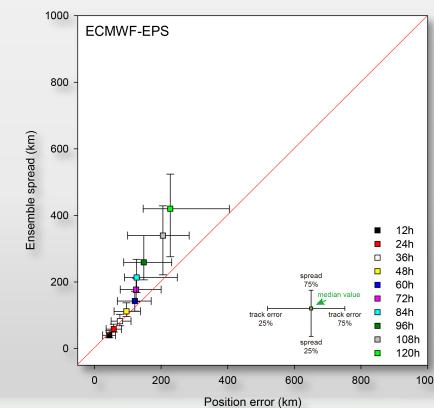
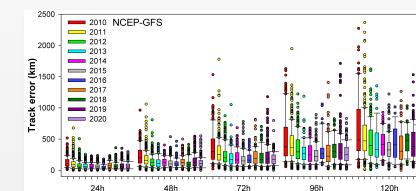
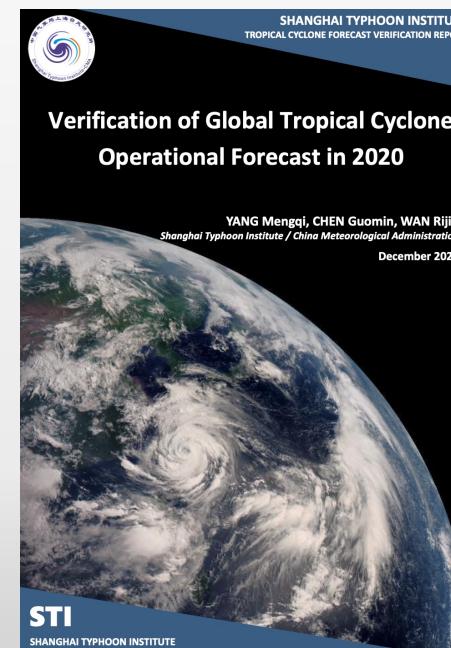
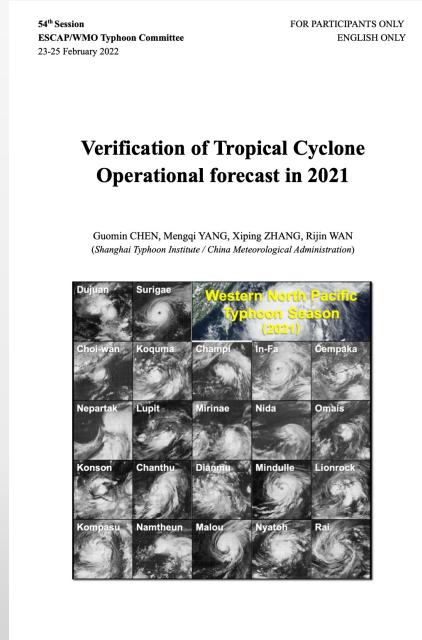
- Storm track verification:

- Position error and ATCT bias are output and shown every 24 h until 192 h
 - Position error is shown as a map; ATCT bias is shown in scatter-diagram form

- Bias of central pressure: A scatter diagram of analysed and predicted pressure shall be shown every 24 h until 192 h.

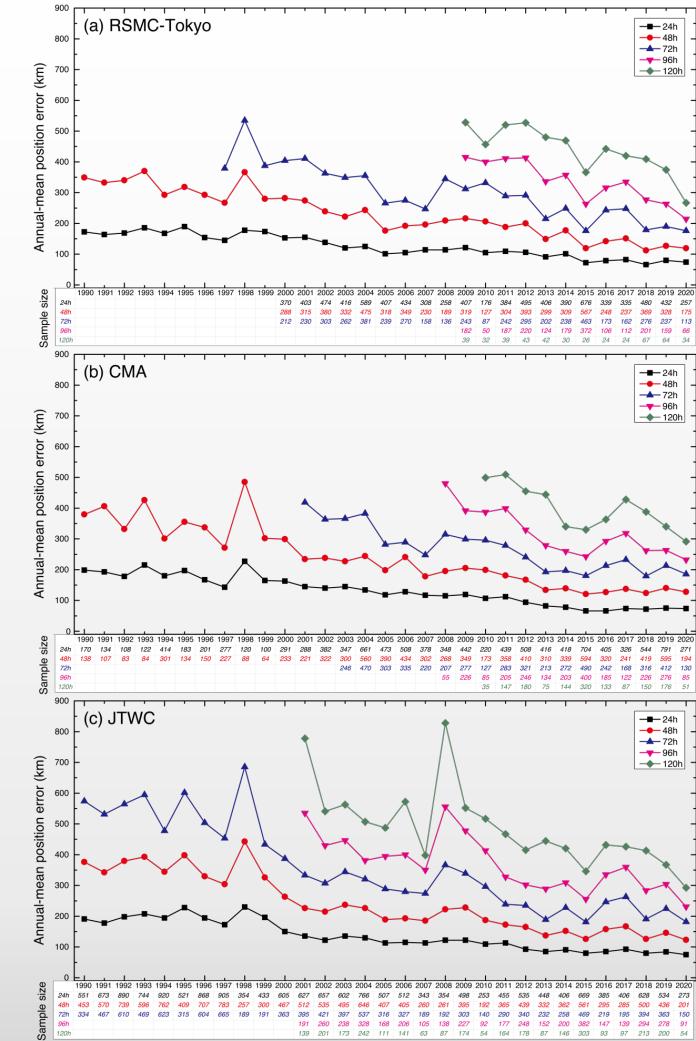
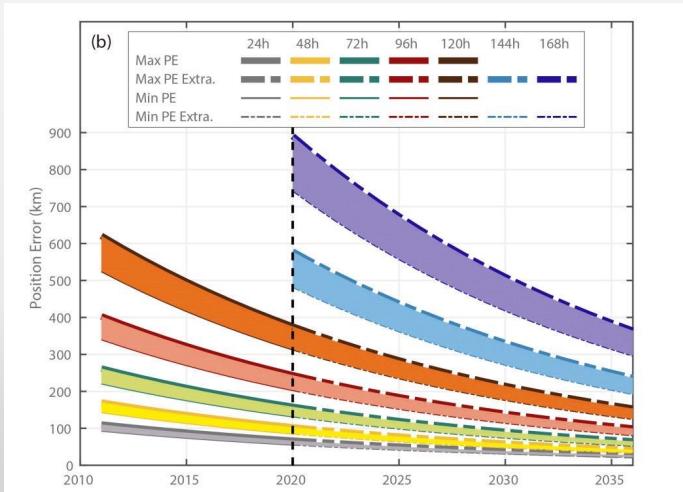
Verification report

- Submit 2019, 2020, and 2021 annual verification reports on western North Pacific typhoon season to the Session of the UNESCAP/WMO Typhoon Committee
 - <http://www.typhooncommittee.org/50th/6-TC50Technical.html>
 - <http://www.typhooncommittee.org/51st/6-TC51Technical.html>
 - <http://www.typhooncommittee.org/52nd/6-TC52Technical.html>
- Release verification report on global tropical cyclone operational forecast since 2019 through WMO-TLFDP



Tropical cyclone track predictability

- The annual-mean position errors of tropical cyclone track forecasts from **RSMC-Tokyo**, **CMA** and **JTWC** are analyzed.
- To **document the past improvements** and **project future tendency** in track forecast accuracy for TCs in the western North Pacific.
- The stepwise improvement features differ among the three forecast agencies, but are **highly related to the development of objective forecast guidance** and the **application strategy**.
- A further **2-day improvement** in TC track forecast lead times may be projected for the coming **fifteen years up to 2035**.

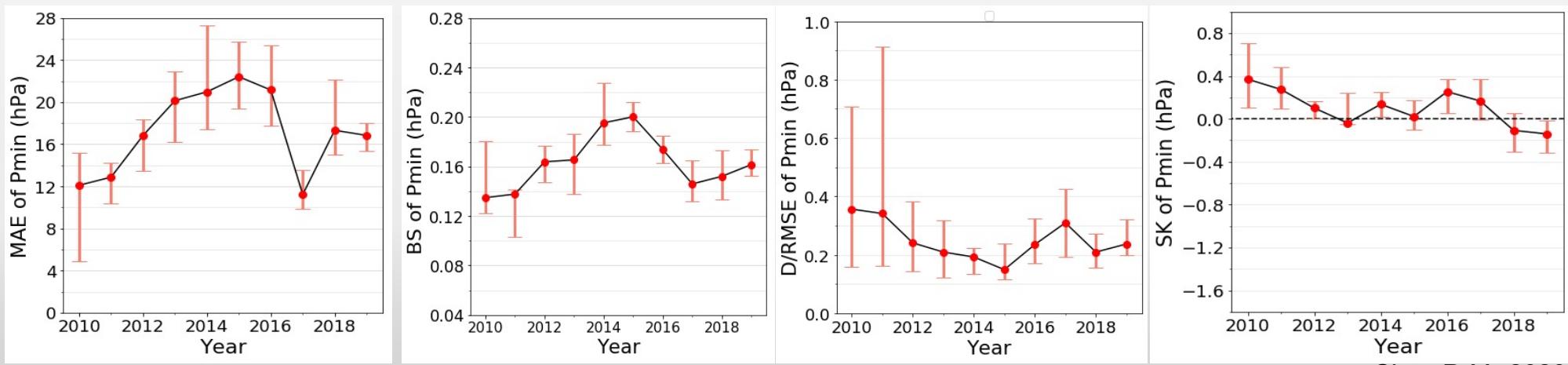


Yu and Chen, et al., BAMS, 2022

EPS TC intensity forecast verification

➤ 10-year evaluation of operational global EPSs on TC intensity forecasts in the WNP

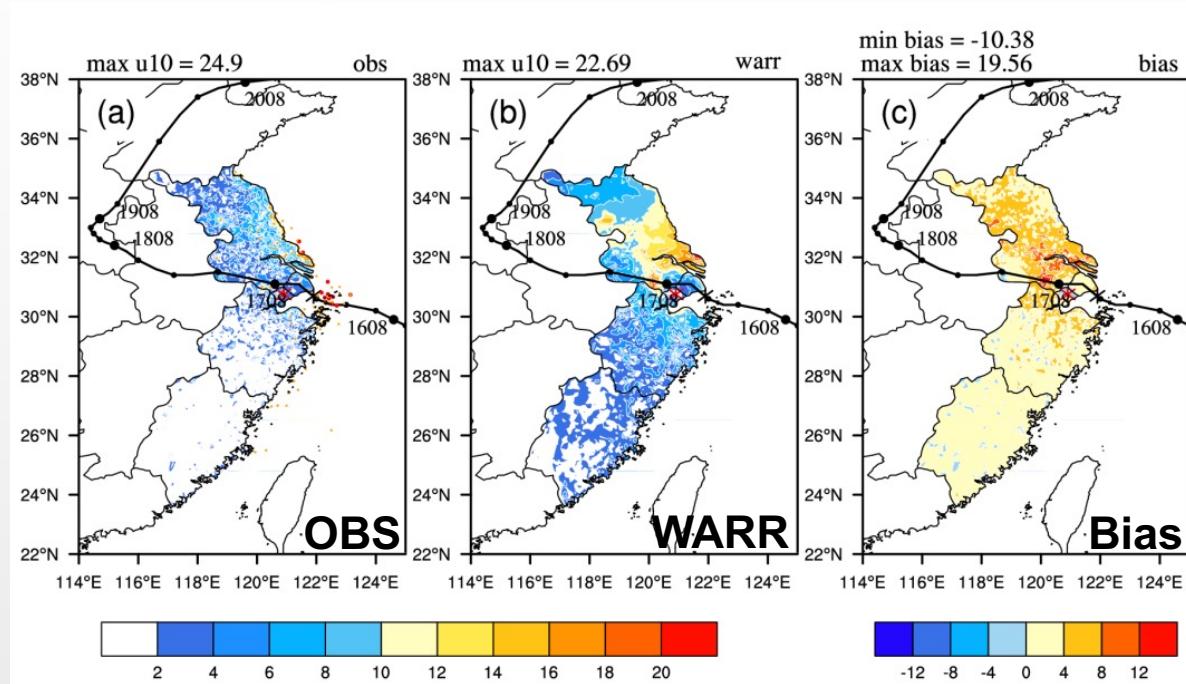
- **5 Global EPSs:** ECMWF-EPS, JMA-GEPS, MSC-CENS, NCEP-GEFS, and UKMO-EPS
- **10 years:** 2010-2019
- In 2010-2015, the intensity errors did not decrease significantly, while in 2015-2019, the intensity errors generally showed a obvious decreasing trend, especially at long lead times.
- In 2018-2019, Global EPS's probabilistic forecast performance of max wind speed is lower than those of minimum pressure at short lead times, but have the opposite conclusion for long lead times.



Chen P. Y., 2020

Wind speed verification on SMS-WARR

Verification on Wind Speed Forecast of Shanghai Meteorological Service
WRF ADAS Rapid Refresh System (SMS-WARR)



Observational wind speed (a), forecast wind speed of 1-hour lead time (b) and BIAS (c) at 04:00 BT

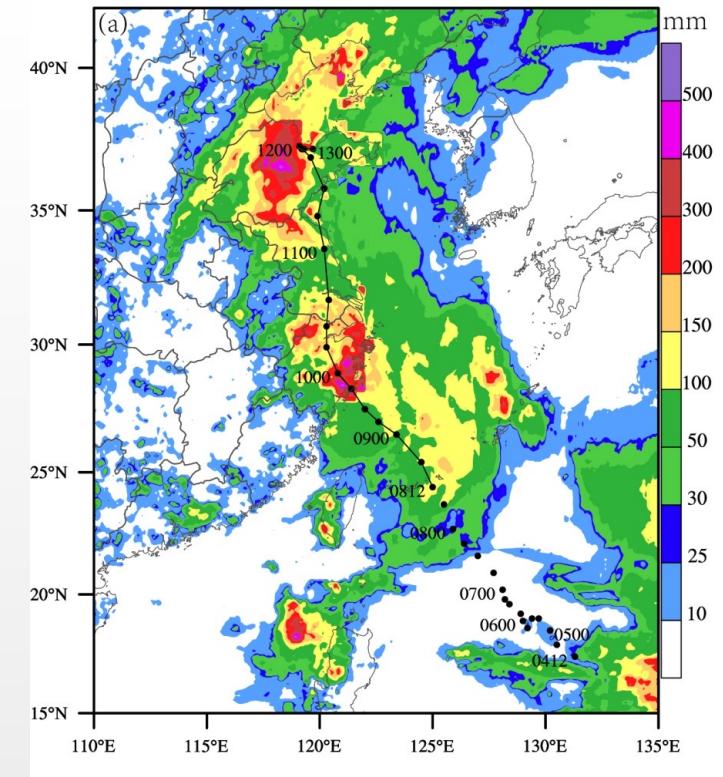
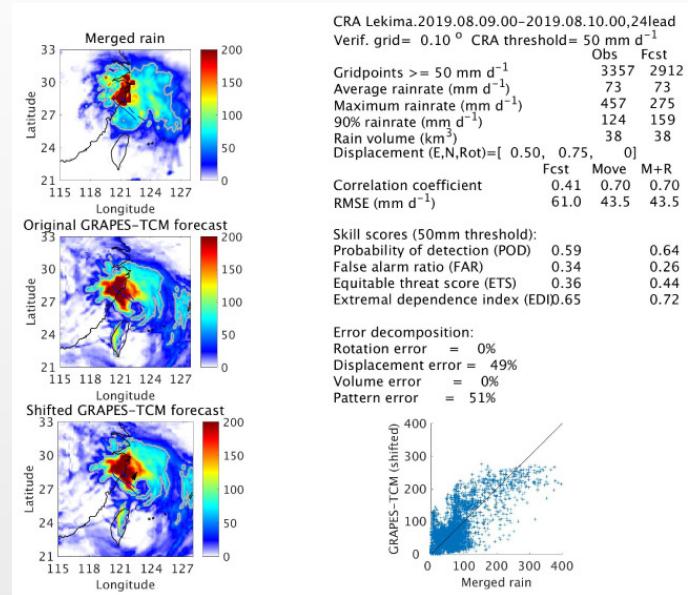
17(The black solid line indicates the best track of typhoon “**RUMBIA**”. Black and red asterisks show the observed and predicted location of typhoon center respectively. Red dots in fig(a) shows stations with wind observed greater than 8 grades, and orange dots shows stations with wind observed between six and eight grades , the same below.)

- The area of **strong breeze**(>6 grade) is much larger than the area where the strong breeze was actually recorded.
- The area of **large deviation** is mainly distributed in the area of forecast strong breeze.
- The wind speed error is related to the weak predictability of the wind field **during the rapid intensification phase** of typhoons.

Landfalling TCs rainfall verification

GRAPES-TCM

- Case test of typical typhoon in 2018
- CRA target inspection system for precipitation forecasting
- Carry out trial operational forecast system in middle of 2020



- The inland TC heavy rain forecast ability is inferior to that just near landfall.
- With the time-length after landfall, the 24h forecast ETS of rainfall over 100mm declines quickly after the landfall.

Study challenging case of Lekima

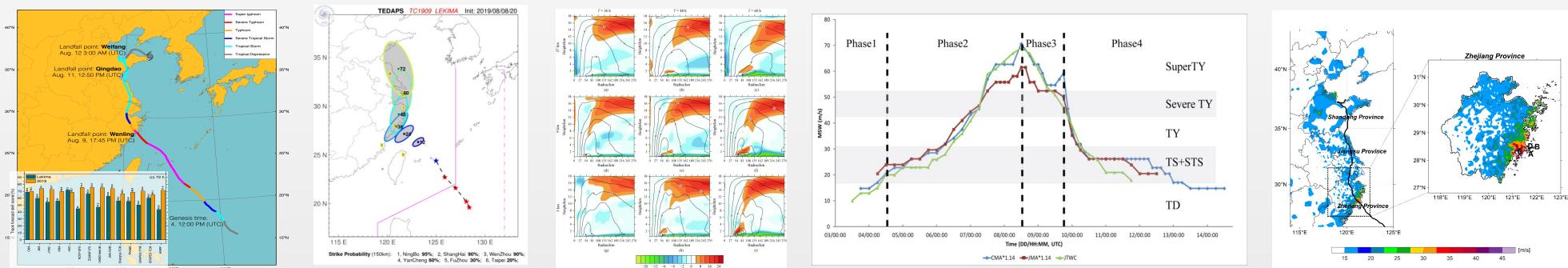
Carry out a series of studies on Super Typhoon Lekima (2019):

- Track and intensity forecast performance
- Rainfall forecast verification
- Interagency differences in intensity estimation
- Discussion on rapid intensification predictability
- Simulation and investigation of extreme rainfall
- Post survey of disaster damage

Lekima (2019):

Peak intensity: **62 m/s**

Landfall intensity: **52 m/s**



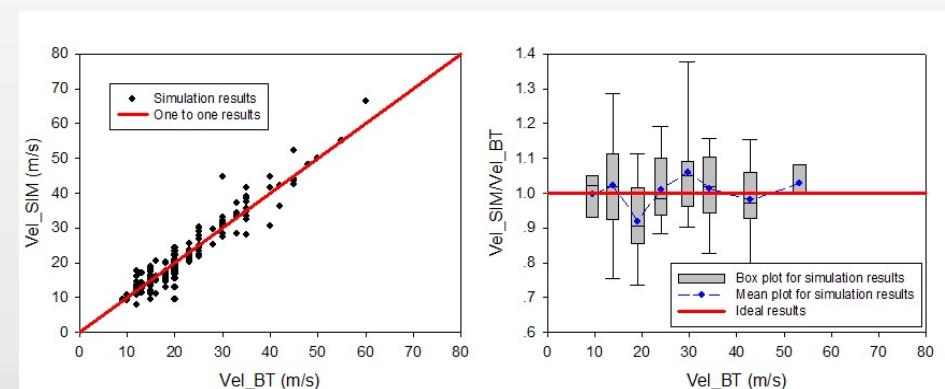
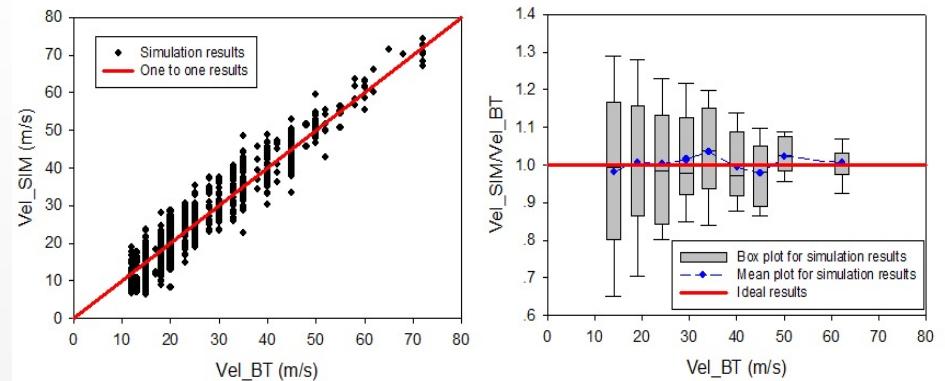
Publication:

- Chen, G., Zhang, X., Cao, Q. et al. Evaluation of forecast performance for Super Typhoon Lekima in 2019. *Front. Earth Sci.* (2021). <https://doi.org/10.1007/s11707-021-0900-2>
- Bai, L., Tang, J., Guo, R. et al. Quantifying interagency differences in intensity estimations of Super Typhoon Lekima (2019). *Front. Earth Sci.* (2021). <https://doi.org/10.1007/s11707-020-0866-5>
- Liu, M., Deng, L., Huang, W. et al. The impact of vertical resolution on the simulation of Typhoon Lekima (2019) by a cloud-permitting model. *Front. Earth Sci.* (2021). <https://doi.org/10.1007/s11707-021-0923-8>
- He, B., Yu, Z., Tan, Y. et al. Rainfall forecast errors in different landfall stages of Super Typhoon Lekima (2019). *Front. Earth Sci.* (2021). <https://doi.org/10.1007/s11707-021-0894-9>
- Zhou, C., Chen, P., Yang, S. et al. The impact of Typhoon Lekima (2019) on East China: a post-event survey in Wenzhou City and Taizhou City. *Front. Earth Sci.* (2021). <https://doi.org/10.1007/s11707-020-0856-7>
- Xu, M., Li, H., Luo, J. et al. Predictability and dynamics of the rapid intensification of Super Typhoon Lekima (2019). *Front. Earth Sci.* (2021). <https://doi.org/10.1007/s11707-021-0877-x>

Developed a parametric wind field model

➤ Parametric Wind Field Model

- Parametric wind field model performs well in capturing the intensities (V_{max}) for each typhoon.
- Smaller errors exist in the intensities for typhoons generated after 1980 compared with those before 1980.
- The simulated intensities over the ocean for typhoons generated after 1980 are more reliable than those over the land.
- The wind field model has a **high reliability in capturing the wind field within 250 km from the typhoon center, especially for the one within 100 km of strong typhoon.**



(Fang and Yu. 2020)

New Project Website

Brand new WMO-TLFDP website

- Project basic information (background, goals, organization...)
 - Project progress and project news
 - Verification reports, publications and presentations

Typhoon Landfall Forecast Demonstration Project (WMO-TLFPD) Global Tropical Cyclone Forecast & Verification			
	Home	Verification Reports	Publications
			Presentations
Members	Xiaotu LEI	SMS/CMA	PROJECT NEWS
	Hui YU	STU/CMA	GD ANNUAL REPORT
	Chuanhai QIAN	NMC/CMA	The 3rd Joint Project Meeting of WWRP Projects (EXOTICCA-TLFPD-UPDRAFT)
	Jixin YU	TCS of ESCAP/WMO	→
WMO Secretariat Representatives	Taoyong PENG	TCP/WMO	Typhoon Committee Research Fellowship (Summary of 2013-2016)
	Nanette LOMARDA (2019-2021)	WWRP/WMO	→
2. International Scientific Steering Committee (ISSC) of TLFPD-IV (2019-2022)			
Chairperson	Ajit TYAGI	IRAdE	Typhoon Committee Research Fellowship (2016)
	Hui YU	STU/CMA	→
Co-Vice Chairperson	Chi-kin PAN	HKO	Typhoon Committee Research Fellowship (2015)
	Jing CHEN	NMC/CMA	→
Members	Jane ROVINS	MU	Typhoon Committee Research Fellowship (2014)
	Yihong DUAN	CAMS/CMA	→
	Johnny CHAN	CityU	The 47th Session of the ESCAP/WMO Typhoon Committee
	Yuqing WANG	UH/HI	→
	Yuan WANG	NJU	The 16th Annual Meeting of the Working Group on Tropical Meteorology Research & Joint Workshop/Progress Meetings of TCP & WWRP Projects (TLFPD and UPDRAFT)
	Liguang WU	NUIST	→
	Yinglong XU	NMOC/CMA	Typhoon Committee Research Fellowship (2013)
	Jonathan VIGH	NCAR	→
3. Project Implementation Teams of TLFPD-IV (2019-2022)			
Team 1: Tropical cyclone data collection and sharing			
Team Leader	Jonathan VIGH	NCAR	WMO Typhoon Landfall Forecast Demonstration Project (TLFPD) Workshop and Training Course on Operational Tropical Cyclone Forecast
Team 2: Tropical cyclone analyses and forecast technique application and evaluation			
Team Leader	Guanmin CHEN	STU/CMA	→
Pilot project of WMO S/ GDPFS: Tropical Cyclone Probability Forecast Project (Launched in 2021) https://community.wmo.int/wwrp-tropical-cyclone-probabilistic-forecast-products			
Project Leader	Jason Dunton	HRD/NOAA	WMO-TLFPD Training Workshop
Contact us We welcome feedback from all users of this site. If you have any comment or suggestion, please contact the webmaster at: chenqin@typhoon.org.cn			

Plans in future

TC verification:

- Verification reports on western North Pacific and Global region
- TC precipitation forecast verification
- TC probability forecast verification

TC analyses:

- TC intensity and wind structure analyses
- TC track forecast busts analyses
- TC intensity and size estimation technique improvement

Project website:

- Verification reports, publications, presentations update



Thanks !

Expand Verification Metrics

- **TC size:** Verification of TC wind structure forecasts from global NWP models and ensemble prediction systems (Supported by HKO&STI through the Typhoon Committee Fellowship Project).
- **TC precipitation:** Formulation of daily precipitation verification metrics by referring precipitation yearbook data from STI for landfall TC in China.
- **EPS:** Recommendation of TC ensemble track, intensity and spread verification metrics.