Subseasonal Tropical Cyclone Forecasts in the Western North Pacific Using the NCEP and ECMWF Ensemble Models

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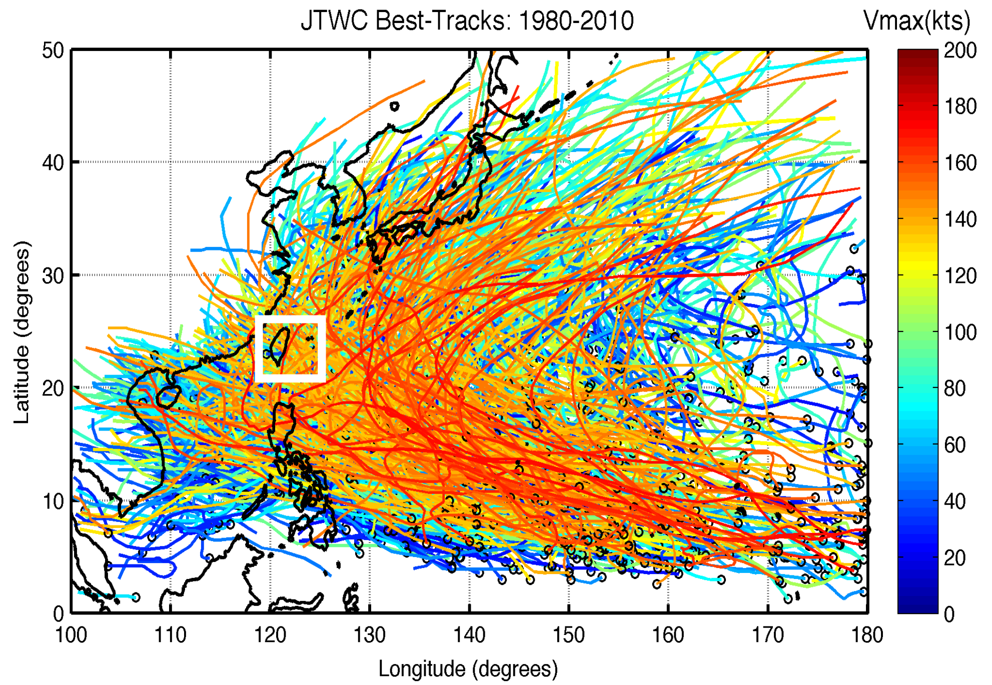
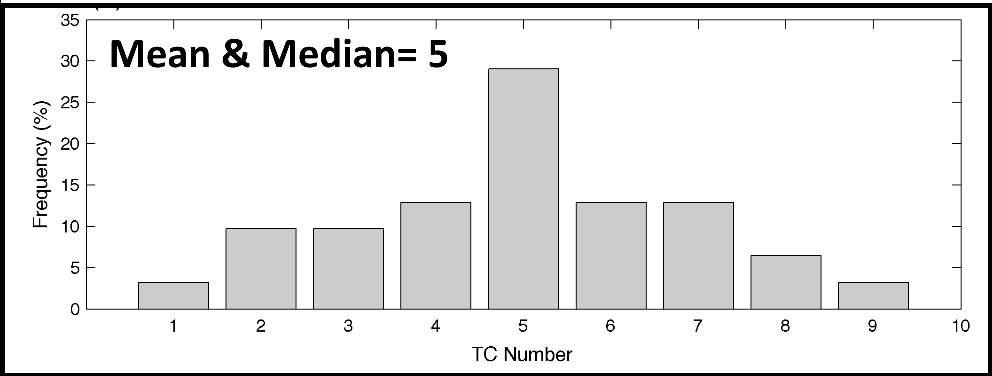
Central Weather Bureau, Taiwan

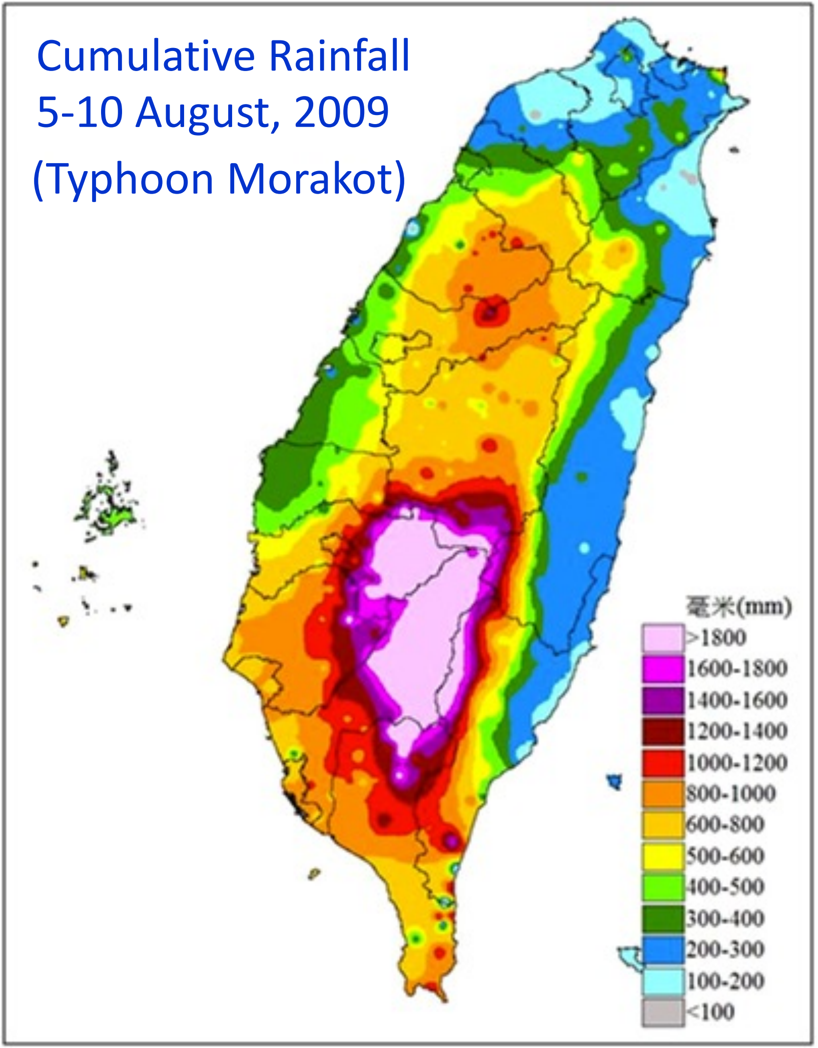
Acknowledgements:
Yuejian Zhu(NCEP), Kuo-Chen Lu(CWB), Mong-Ming Lu(NTU), Chung-Hsiung Sui(NTU),
Marcelino Q. Villafuerte II (PAGASA)

Average : 5 typhoons/year

Typhoon Hazards vs. Water Resources

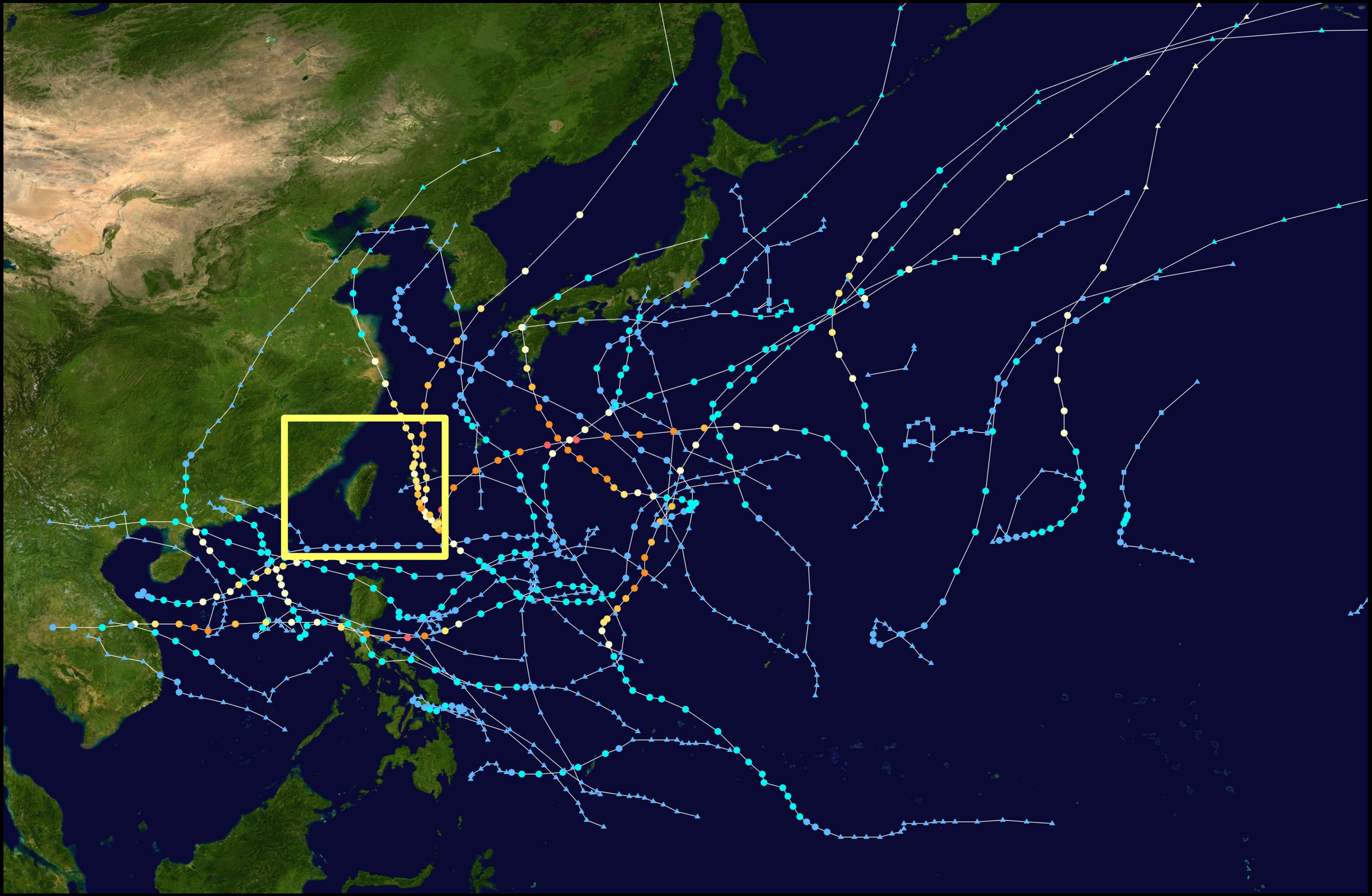

JTWC Best-Tracks: 1980-2010
Vmax(kts)
200
180
160
140
120
100
80
60
40
20
0
Latitude (degrees)
50
40
30
20
10
0
100
110
120
130
140
150
160
170
180
Longitude (degrees)


Mean & Median= 5


Cumulative Rainfall
5-10 August, 2009
(Typhoon Morakot)
毫米(mm)
>1800
1600-1800
1400-1600
1200-1400
1000-1200
800-1000
600-800
500-600
400-500
300-400
200-300
100-200
<100

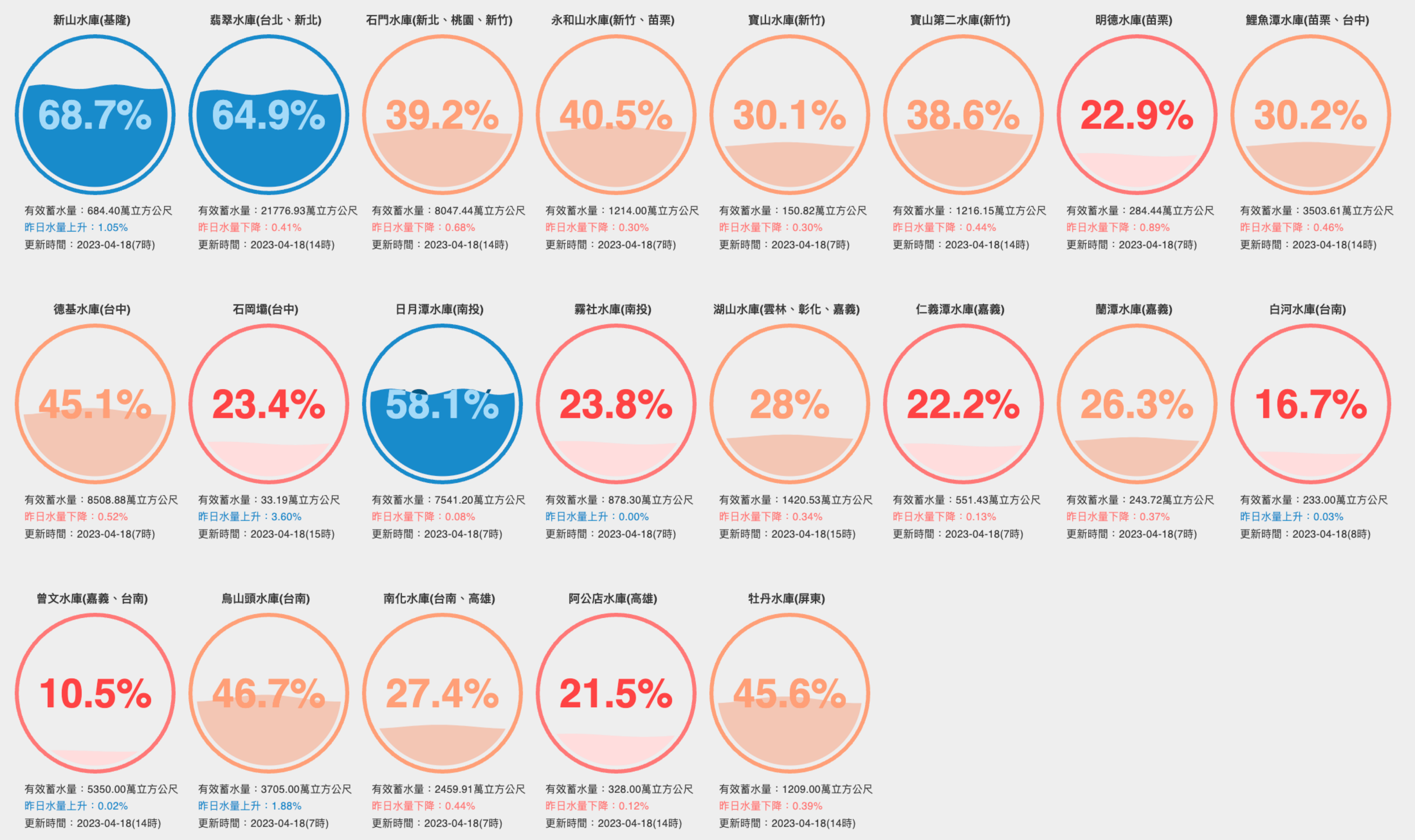
2022 Typhoon Season

No typhoon made landfall



Reservoirs in Taiwan (18 April 2023)

Low water levels in most of the reservoirs



新山水庫(基隆)
68.7%
有效蓄水量：684.40萬立方公尺
昨日水量上升：1.05%
更新時間：2023-04-18(7時)

翡翠水庫(台北、新北)
64.9%
有效蓄水量：21776.93萬立方公尺
昨日水量下降：0.41%
更新時間：2023-04-18(14時)

石門水庫(新北、桃園、新竹)
39.2%
有效蓄水量：8047.44萬立方公尺
昨日水量下降：0.68%
更新時間：2023-04-18(14時)

永和山水庫(新竹、苗栗)
40.5%
有效蓄水量：1214.00萬立方公尺
昨日水量下降：0.30%
更新時間：2023-04-18(7時)

寶山水庫(新竹)
30.1%
有效蓄水量：150.82萬立方公尺
昨日水量下降：0.30%
更新時間：2023-04-18(7時)

寶山第二水庫(新竹)
38.6%
有效蓄水量：1216.15萬立方公尺
昨日水量下降：0.44%
更新時間：2023-04-18(14時)

明德水庫(苗栗)
22.9%
有效蓄水量：284.44萬立方公尺
昨日水量下降：0.89%
更新時間：2023-04-18(7時)

鯉魚潭水庫(苗栗、台中)
30.2%
有效蓄水量：3503.61萬立方公尺
昨日水量下降：0.46%
更新時間：2023-04-18(14時)

德基水庫(台中)
45.1%
有效蓄水量：8508.88萬立方公尺
昨日水量下降：0.52%
更新時間：2023-04-18(7時)

石岡壩(台中)
23.4%
有效蓄水量：33.19萬立方公尺
昨日水量上升：3.60%
更新時間：2023-04-18(15時)

日月潭水庫(南投)
58.1%
有效蓄水量：7541.20萬立方公尺
昨日水量下降：0.08%
更新時間：2023-04-18(7時)

霧社水庫(南投)
23.8%
有效蓄水量：878.30萬立方公尺
昨日水量上升：0.00%
更新時間：2023-04-18(7時)

湖山水庫(雲林、彰化、嘉義)
28%
有效蓄水量：1420.53萬立方公尺
昨日水量下降：0.34%
更新時間：2023-04-18(15時)

仁義潭水庫(嘉義)
22.2%
有效蓄水量：551.43萬立方公尺
昨日水量下降：0.13%
更新時間：2023-04-18(7時)

蘭潭水庫(嘉義)
26.3%
有效蓄水量：243.72萬立方公尺
昨日水量下降：0.37%
更新時間：2023-04-18(7時)

白河水庫(台南)
16.7%
有效蓄水量：233.00萬立方公尺
昨日水量上升：0.03%
更新時間：2023-04-18(8時)

曾文水庫(嘉義、台南)
10.5%
有效蓄水量：5350.00萬立方公尺
昨日水量上升：0.02%
更新時間：2023-04-18(14時)

烏山頭水庫(台南)
46.7%
有效蓄水量：3705.00萬立方公尺
昨日水量上升：1.88%
更新時間：2023-04-18(7時)

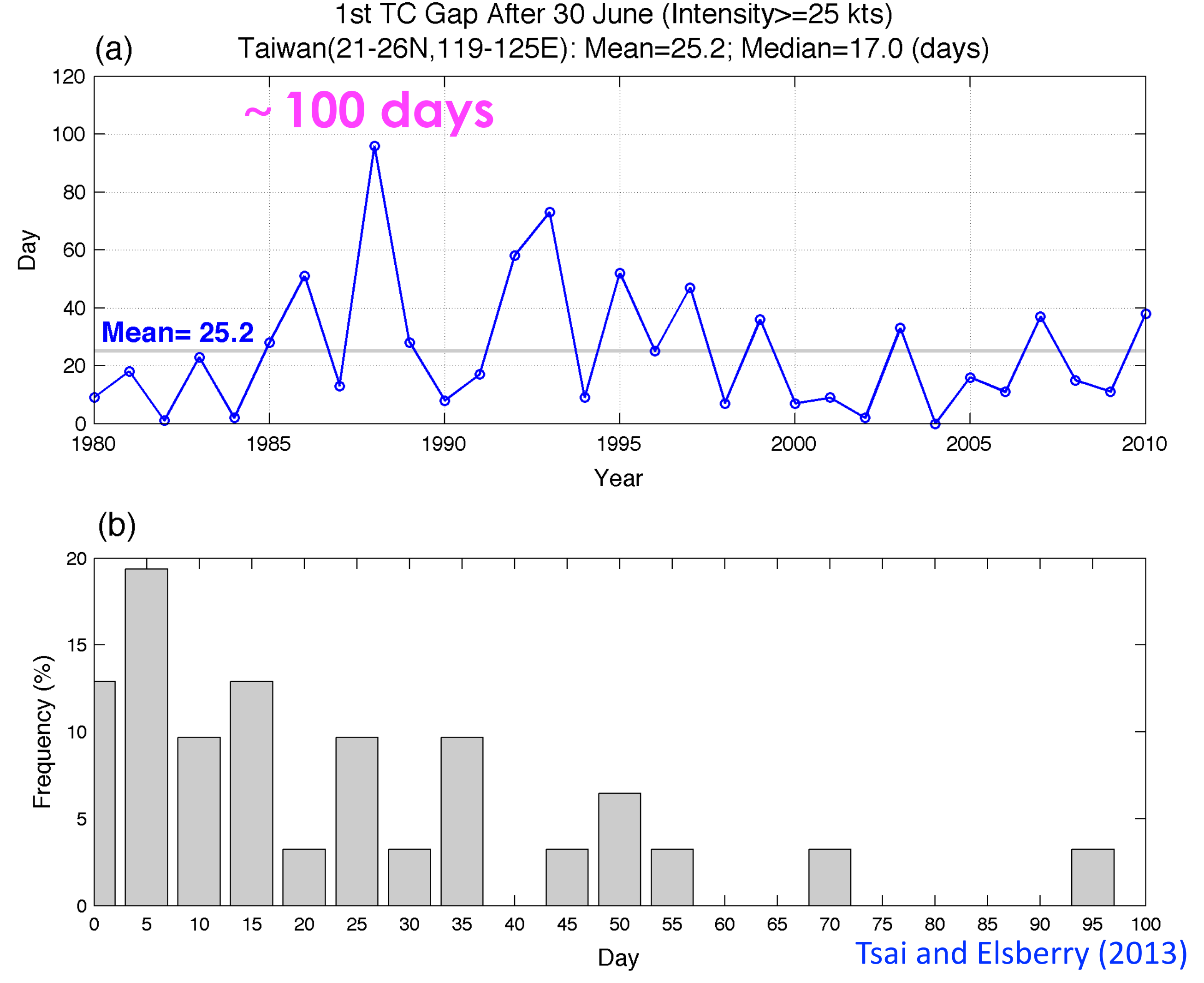
南化水庫(台南、高雄)
27.4%
有效蓄水量：2459.91萬立方公尺
昨日水量下降：0.44%
更新時間：2023-04-18(7時)

阿公店水庫(高雄)
21.5%
有效蓄水量：328.00萬立方公尺
昨日水量下降：0.12%
更新時間：2023-04-18(14時)

牡丹水庫(屏東)
45.6%
有效蓄水量：1209.00萬立方公尺
昨日水量下降：0.39%
更新時間：2023-04-18(14時)

How long do we have to wait for the next typhoon coming after the end of Mei-Yu season ?

1st TC Gap after the end of the Mei-Yu season

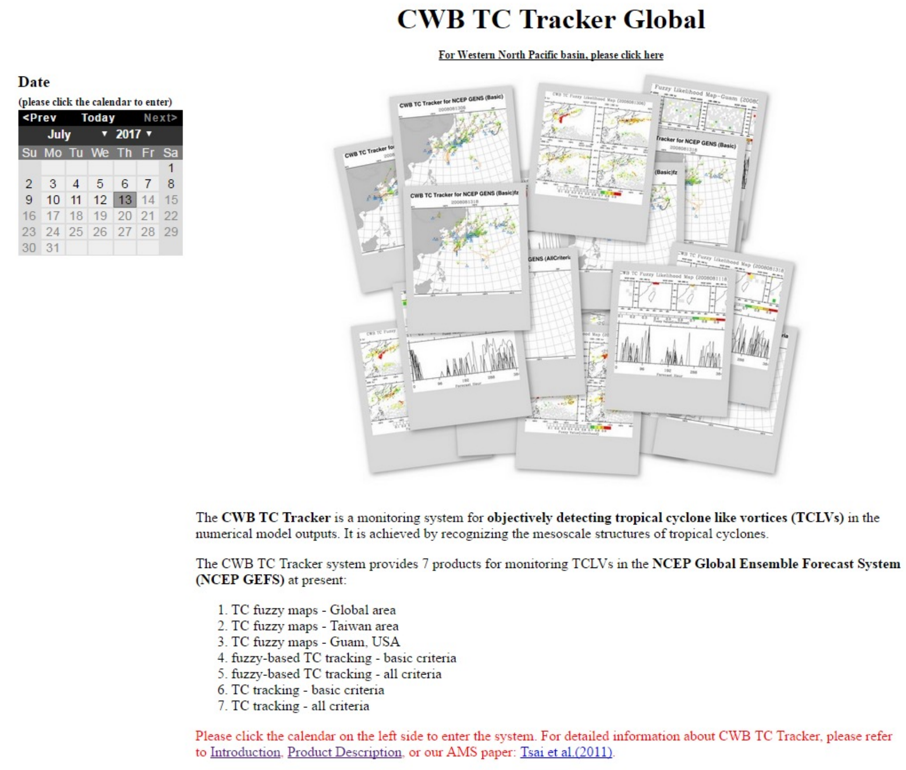


Tsai and Elsberry (2013)

CWB TC Tracker

Tsai et al. (2011)

- CWB has been monitoring the tropical cyclone (TC) forecasts beyond 7 days since 2008
  - 21-member NCEP GEFS real-time forecasts



CWB TC Tracker Global

For Western North Pacific basin, please click here

Date

(please click the calendar to enter)

<Prev
Today
Next>
July
2017

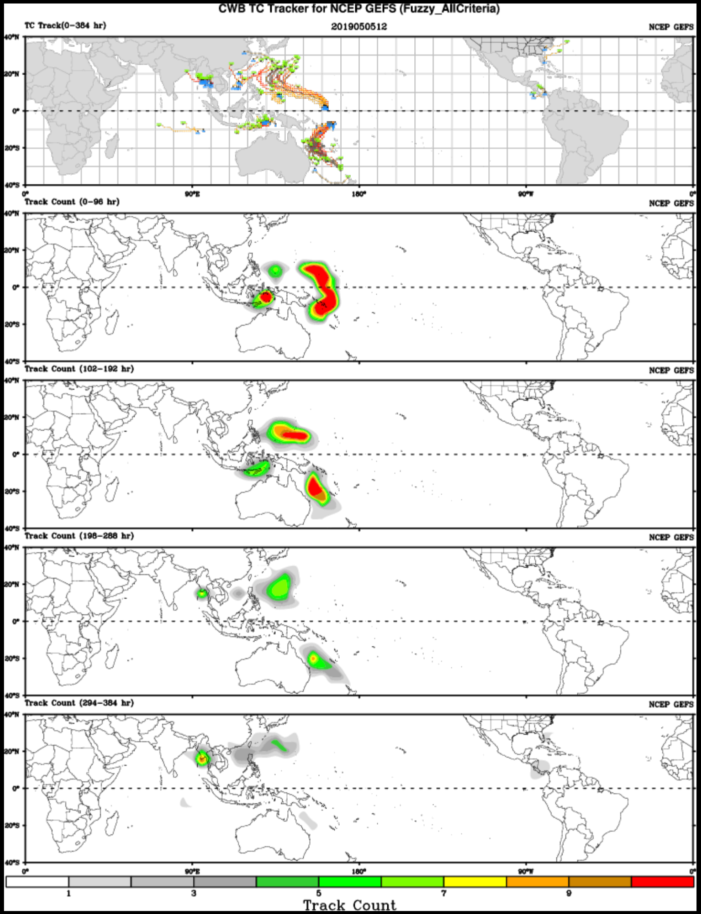
Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

The **CWB TC Tracker** is a monitoring system for **objectively detecting tropical cyclone like vortices (TCLVs)** in the numerical model outputs. It is achieved by recognizing the mesoscale structures of tropical cyclones.

The CWB TC Tracker system provides 7 products for monitoring TCLVs in the **NCEP Global Ensemble Forecast System (NCEP GEFS)** at present:

1. TC fuzzy maps - Global area
2. TC fuzzy maps - Taiwan area
3. TC fuzzy maps - Guam, USA
4. fuzzy-based TC tracking - basic criteria
5. fuzzy-based TC tracking - all criteria
6. TC tracking - basic criteria
7. TC tracking - all criteria

Please click the calendar on the left side to enter the system. For detailed information about CWB TC Tracker, please refer to Introduction, Product Description, or our AMS paper: Tsai et al.(2011).

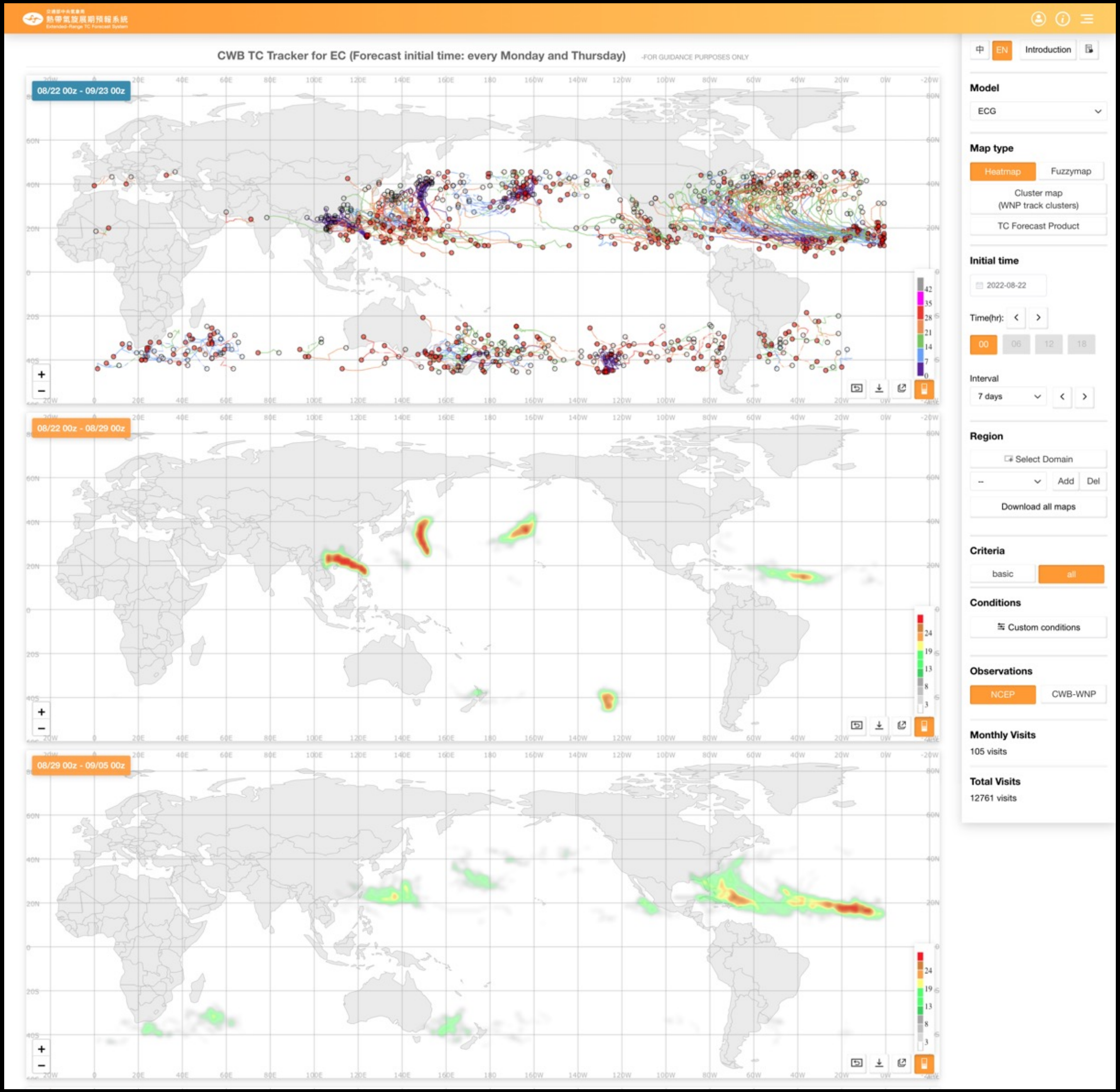


CWB TC Tracker for NCEP GEFS (Fuzzy_AllCriteria)
TC Track(0-384 hr)
2019050512
NCEP GEFS
Track Count (0-96 hr)
Track Count (102-192 hr)
Track Count (198-288 hr)
Track Count (294-384 hr)
40°N
20°N
0°
20°S
40°S
0°
90°E
180°
90°W
1
3
5
7
9
Track Count

Starting from 2020…

CWB TC Tracker 2.0

https://tctracker.cwb.gov.tw/


交通部中央氣象局
熱帶氣旋展期預報系統
Extended-Range TC Forecast System
中
EN
Introduction
Heatmap
Fuzzymap
Cluster map (WNP track clusters)
TC Forecast Product
Select Domain
Add
Del
Download all maps
basic
all
Custom conditions
NCEP
CWB-WNP
20W
0
20E
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
100W
80W
60W
40W
80N
60N
40N
20N
20S
40S
42
35
28
21
14
7
0
24
19
13
8
3

CWB TC Tracker for EC (Forecast initial time: every Monday and Thursday) -FOR GUIDANCE PURPOSES ONLY

08/22 00z - 09/23 00z

08/22 00z - 08/29 00z

08/29 00z - 09/05 00z

Model: ECG

Map type: Heatmap

Initial time: 2022-08-22

Time(hr): 00

Interval: 7 days

Region: --

Criteria: all

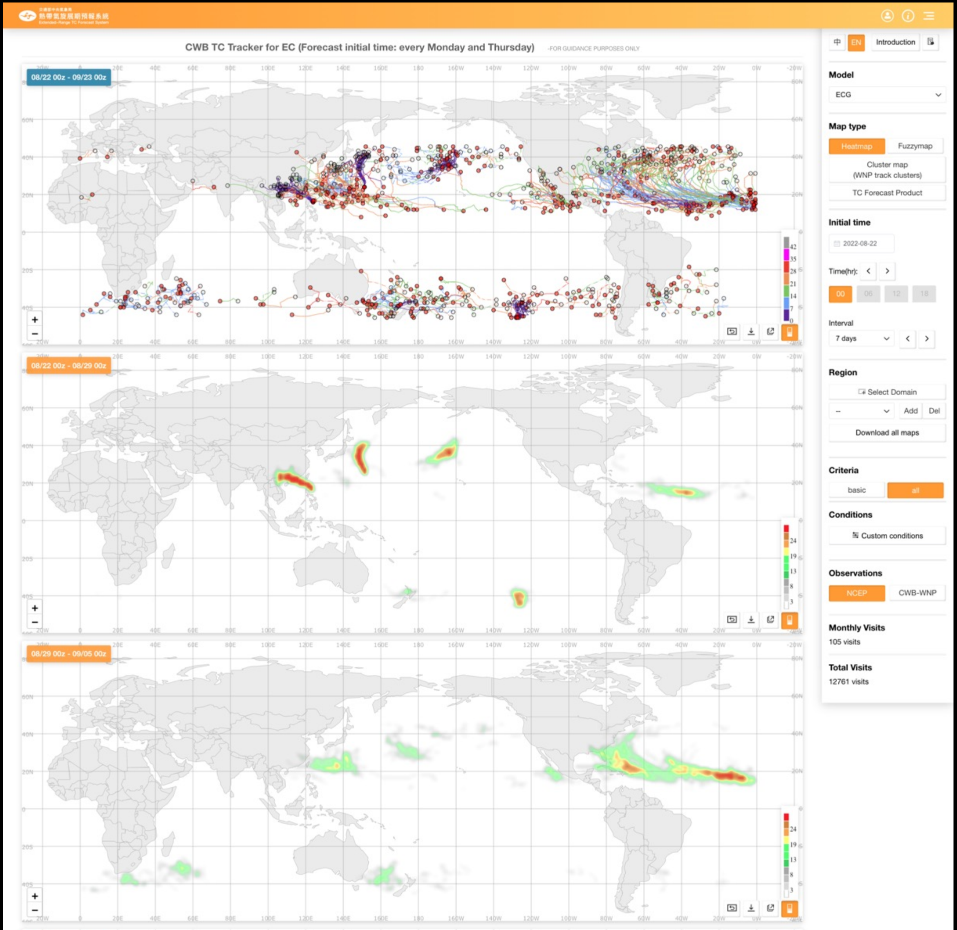
Observations: NCEP

Monthly Visits
105 visits

Total Visits
12761 visits

CWB TC Tracker 2.0

https://tctracker.cwb.gov.tw/



CWB TC Tracker for EC (Forecast initial time: every Monday and Thursday) -FOR GUIDANCE PURPOSES ONLY

08/22 00z - 09/23 00z

08/22 00z - 08/29 00z

08/29 00z - 09/05 00z

Model: ECG

Map type: Heatmap

Initial time: 2022-08-22

Time(hr): 00

Interval: 7 days

Criteria: all

Observations: NCEP

Monthly Visits
105 visits

Total Visits
12761 visits

交通部中央氣象局
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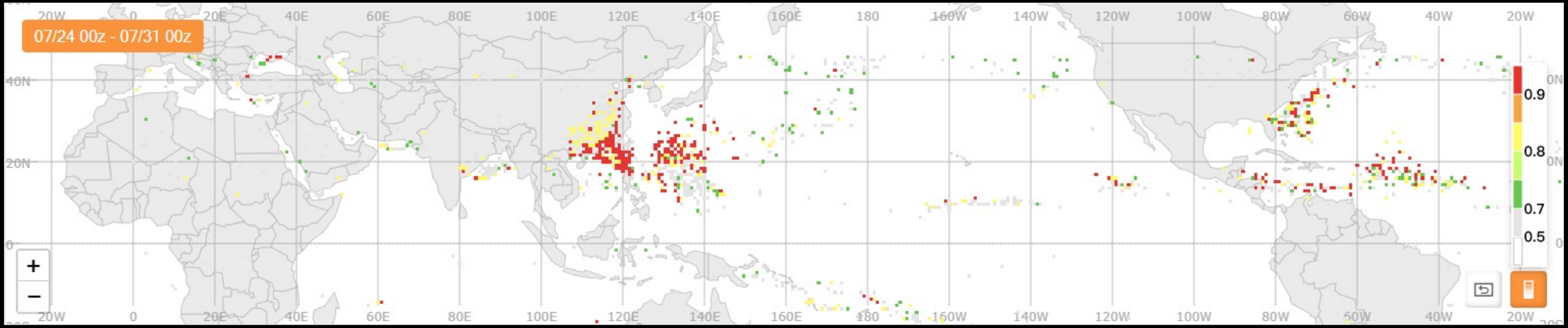
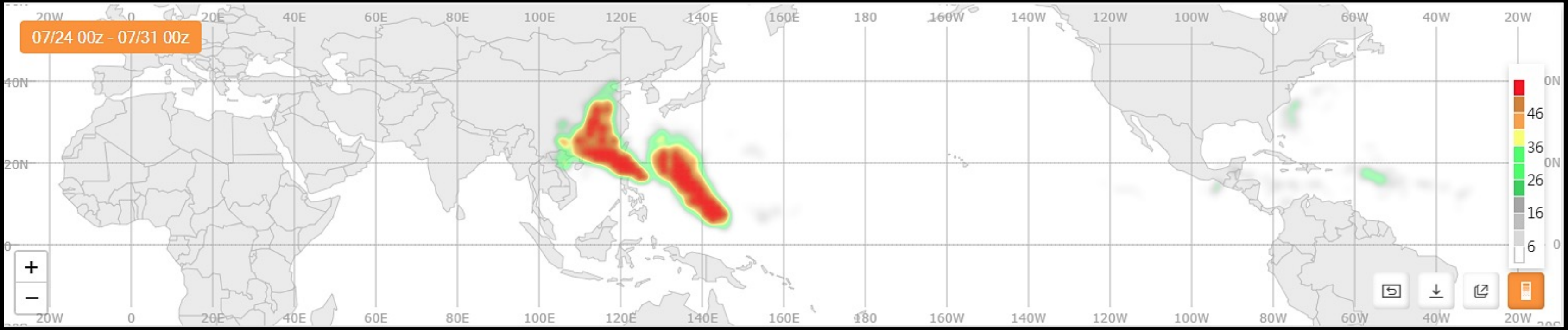
06
12
18
Region
Select Domain
Add
Del
Download all maps
basic
Conditions
Custom conditions
CWB-WNP
20E
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
100W
80W
60W
40W
20W
60N
40N
20N
0
20S
42
35
28
21
14
7
0
24
19
13
8
3

- Forecast lead-time: 4 weeks
- Multiple models:
  - NCEP GEFSv12
  - ECMWF 46-day ensemble (password protected)
  - NCEP CFSv2
  - CWB1T1 (CWB 1-tier climate forecast model)
- Users can download the TC tracking results (ascii files) and create their own products.
  - Forecasters at CWB and PAGASA are jointly using the CWB TC Tracker 2.0.

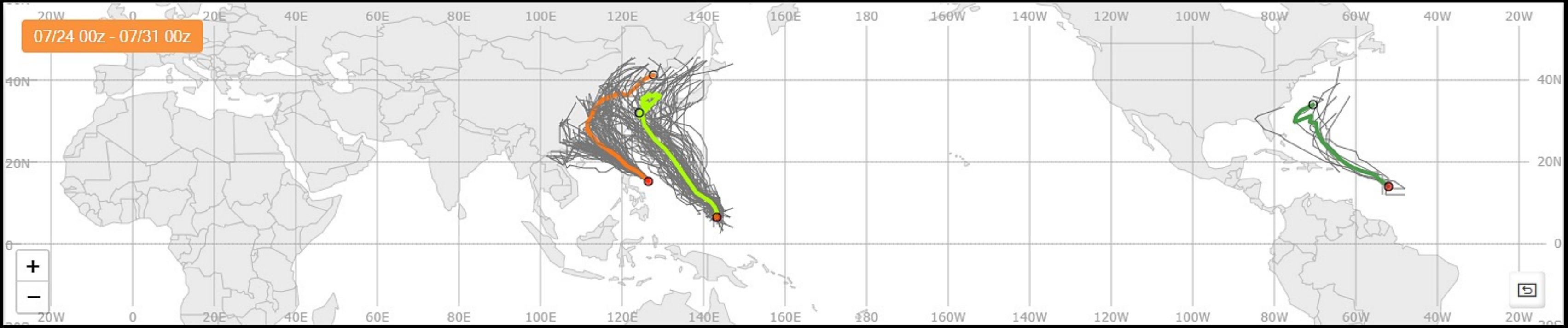
Fuzzymap (Pointwise TC Detection)


07/24 00z - 07/31 00z
0.9
0.8
0.7
0.5
20W
0
20E
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
100W
80W
60W
40W
20W
40N
20N
0
+
−

Heatmap (TC Strike Probabilities)

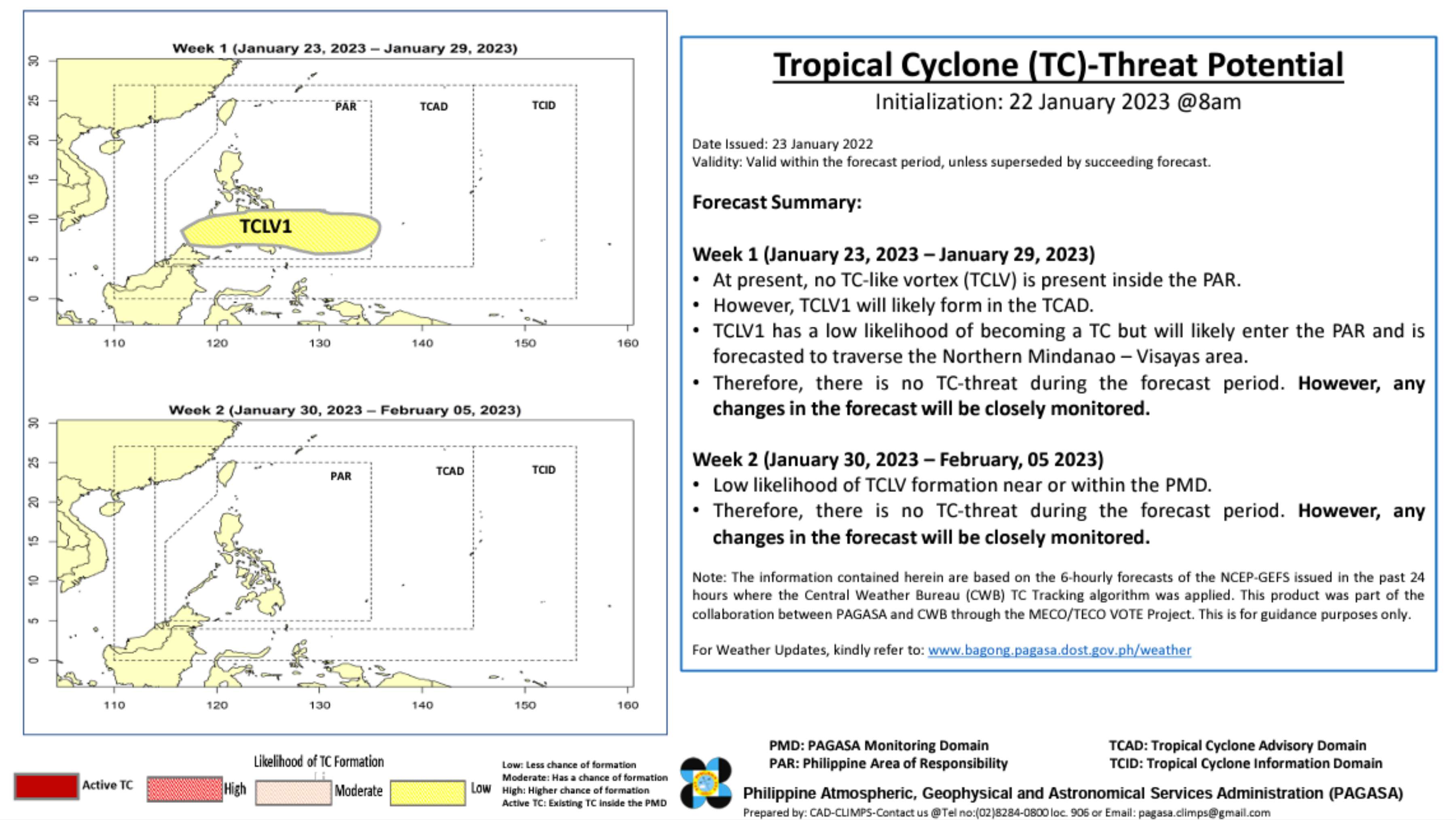

07/24 00z - 07/31 00z
46
36
26
16
6
20W
0
20E
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
100W
80W
60W
40W
20W
40N
20N
0
+
−

Track Clusters (Spatio-Temporal Track Clustering)


07/24 00z - 07/31 00z
20W
0
20E
40E
60E
80E
100E
120E
140E
160E
180
160W
140W
120W
100W
80W
60W
40W
20W
40N
20N
0
+
−

Collaboration between CWB and PAGASA

TC Threat Potential


Week 1 (January 23, 2023 – January 29, 2023)
PAR
TCAD
TCID
TCLV1
30
25
20
15
10
5
0
110
120
130
140
150
160
Week 2 (January 30, 2023 – February 05, 2023)
PAR
TCAD
TCID
30
25
20
15
10
5
0
110
120
130
140
150
160
Likelihood of TC Formation
Active TC
High
Moderate
Low

Low: Less chance of formation
Moderate: Has a chance of formation
High: Higher chance of formation
Active TC: Existing TC inside the PMD

Tropical Cyclone (TC)-Threat Potential

Initialization: 22 January 2023 @8am

Date Issued: 23 January 2022
Validity: Valid within the forecast period, unless superseded by succeeding forecast.

Forecast Summary:

Week 1 (January 23, 2023 – January 29, 2023)

- At present, no TC-like vortex (TCLV) is present inside the PAR.
- However, TCLV1 will likely form in the TCAD.
- TCLV1 has a low likelihood of becoming a TC but will likely enter the PAR and is forecasted to traverse the Northern Mindanao – Visayas area.
- Therefore, there is no TC-threat during the forecast period. **However, any changes in the forecast will be closely monitored.**

Week 2 (January 30, 2023 – February, 05 2023)

- Low likelihood of TCLV formation near or within the PMD.
- Therefore, there is no TC-threat during the forecast period. **However, any changes in the forecast will be closely monitored.**

Note: The information contained herein are based on the 6-hourly forecasts of the NCEP-GEFS issued in the past 24 hours where the Central Weather Bureau (CWB) TC Tracking algorithm was applied. This product was part of the collaboration between PAGASA and CWB through the MECO/TECO VOTE Project. This is for guidance purposes only.

For Weather Updates, kindly refer to: www.bagong.pagasa.dost.gov.ph/weather

PMD: PAGASA Monitoring Domain
PAR: Philippine Area of Responsibility
TCAD: Tropical Cyclone Advisory Domain
TCID: Tropical Cyclone Information Domain

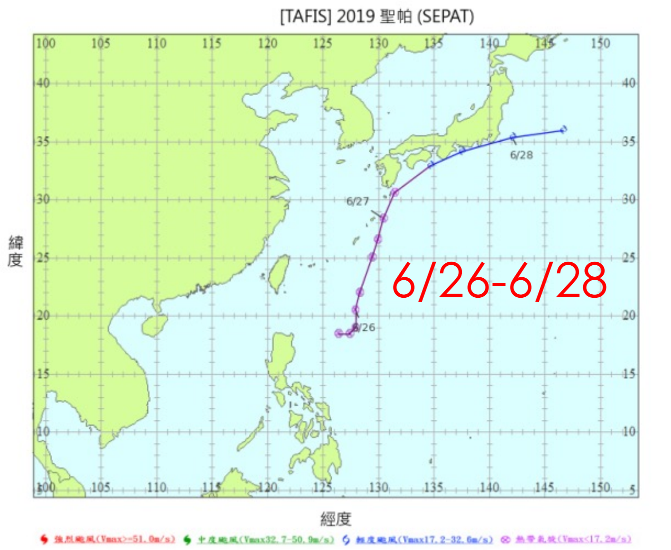
Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)
Prepared by: CAD-CLIMPS-Contact us @Tel no:(02)8284-0800 loc. 906 or Email: pagasa.climps@gmail.com

PAGASA

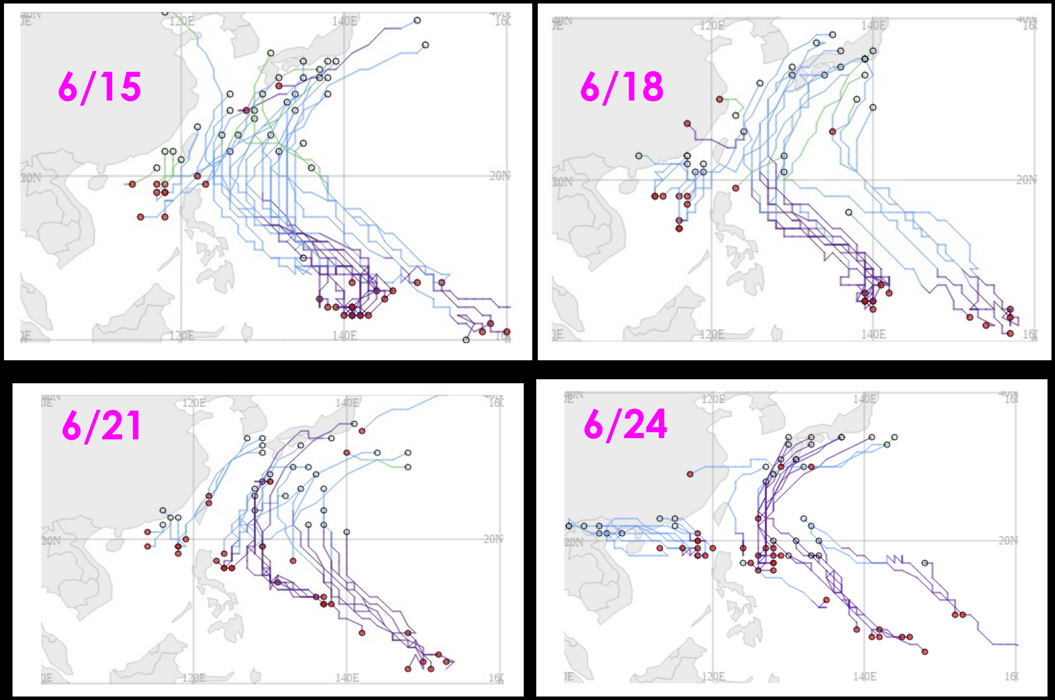
Forecast Verifications

- Weeks 1-4 TC forecast skill in the western North Pacific
  - Realtime forecasts
  - Long-term reforecasts
  - Research to operations (R2O)

Typhoon Sepat (2019)
~11 days in advance


[TAFIS] 2019 聖帕 (SEPAT)

緯度
經度
6/26
6/27
6/28
6/26-6/28

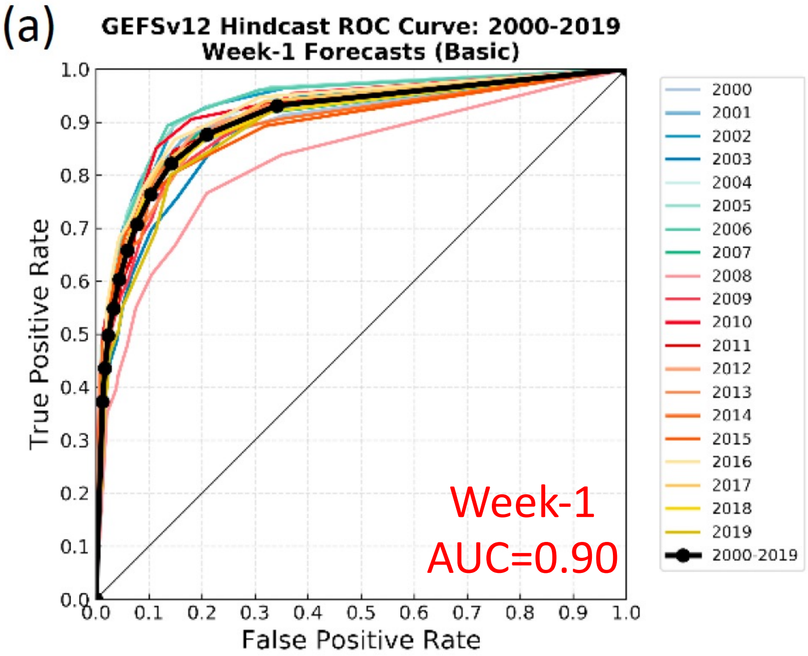

6/15
6/18
6/21
6/24
120E
140E
20N

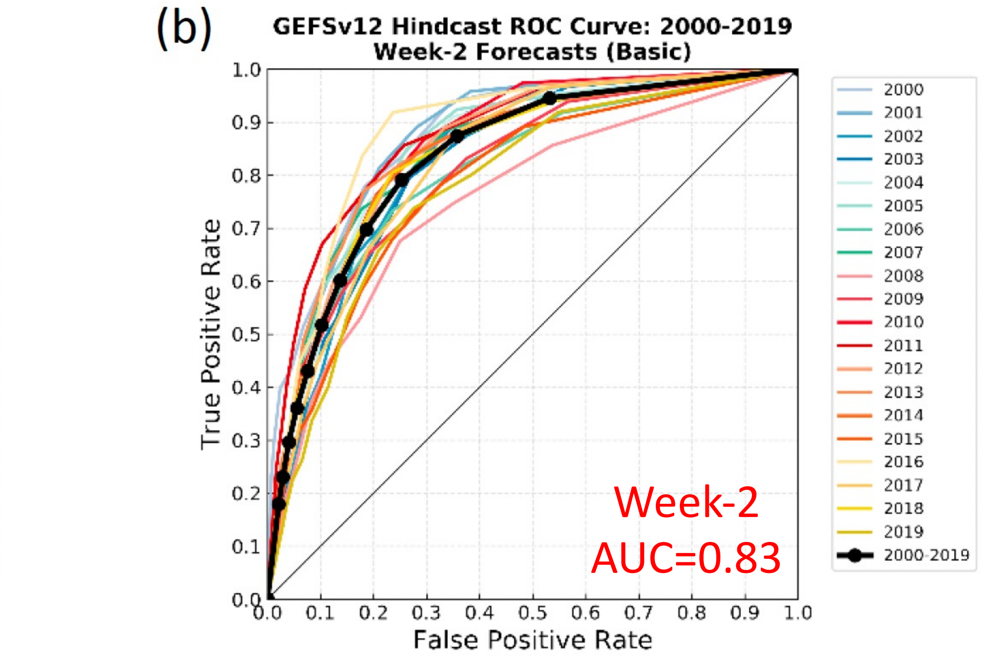
Credit: Kovia Lo (CWB)

TC Forecast Skill Verifications

GEFSv12 Weeks 1-4 Reforecasts

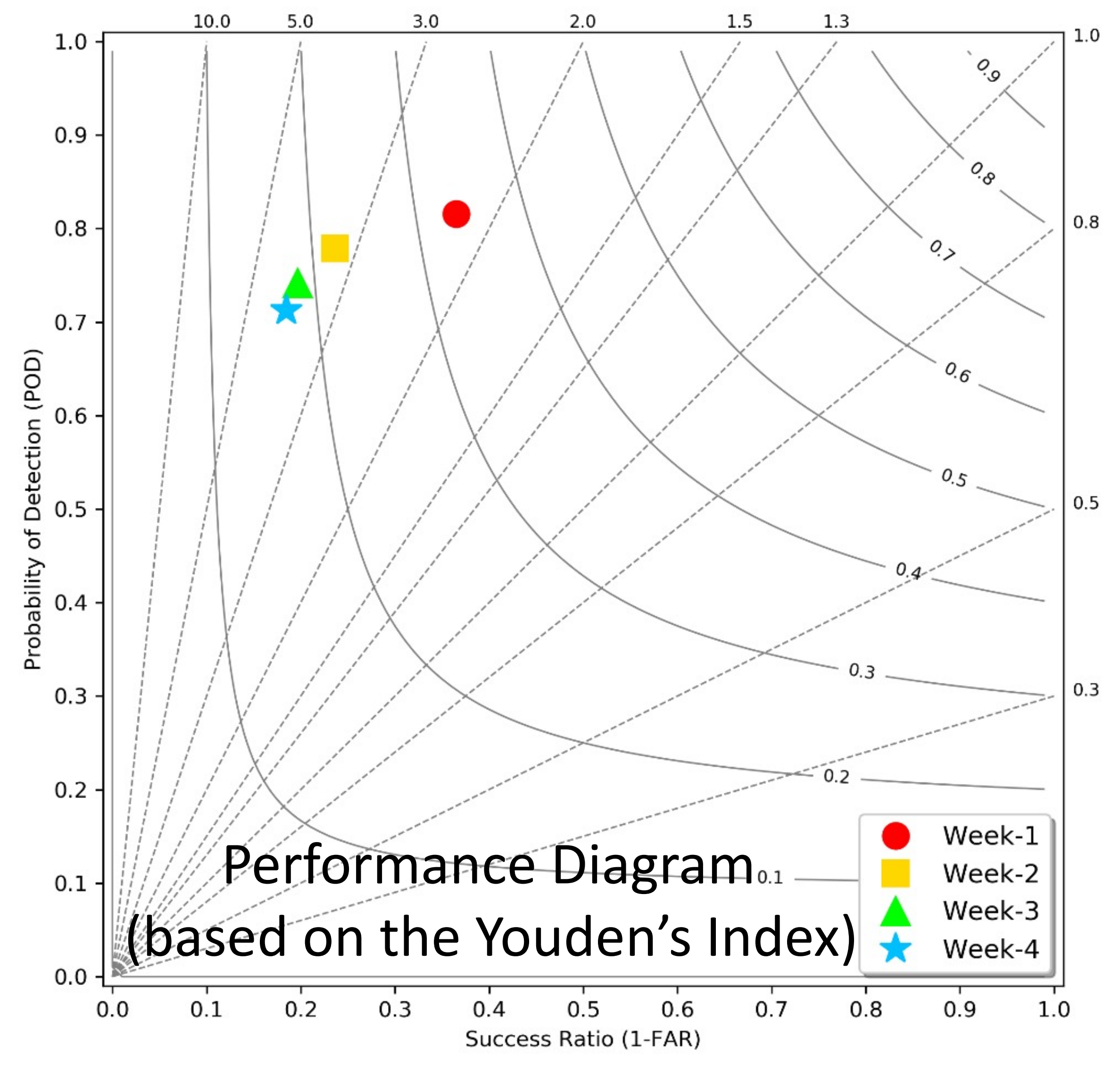
- Reforecasts during 2000-2019
- 11 ensemble members
- TC strike probabilities in the western North Pacific
  - ROC curve, reliability diagram, performance diagram, PR Curve, etc.





TC Forecast Skill Verifications

GEFSv12 Weeks 1-4 Reforecasts



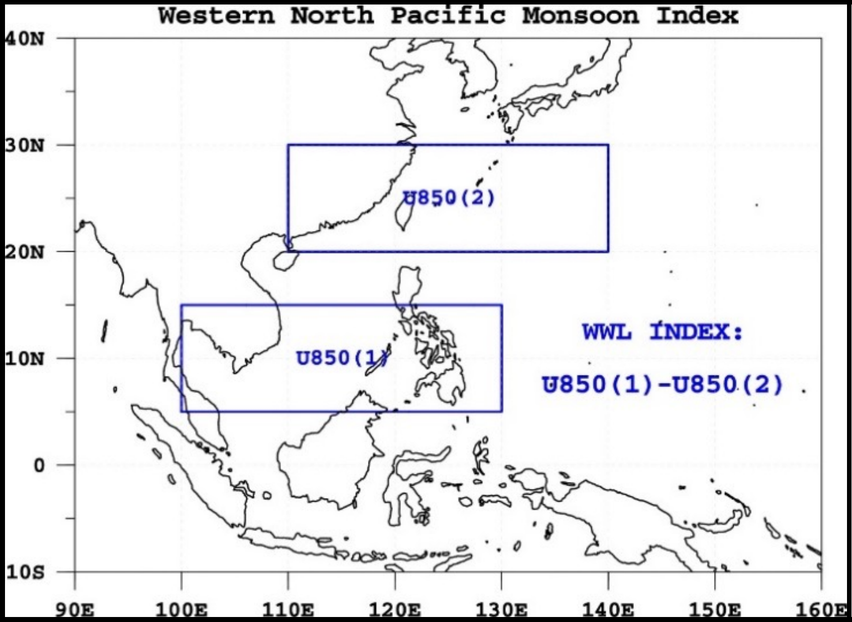
Performance Diagram
(based on the Youden's Index)

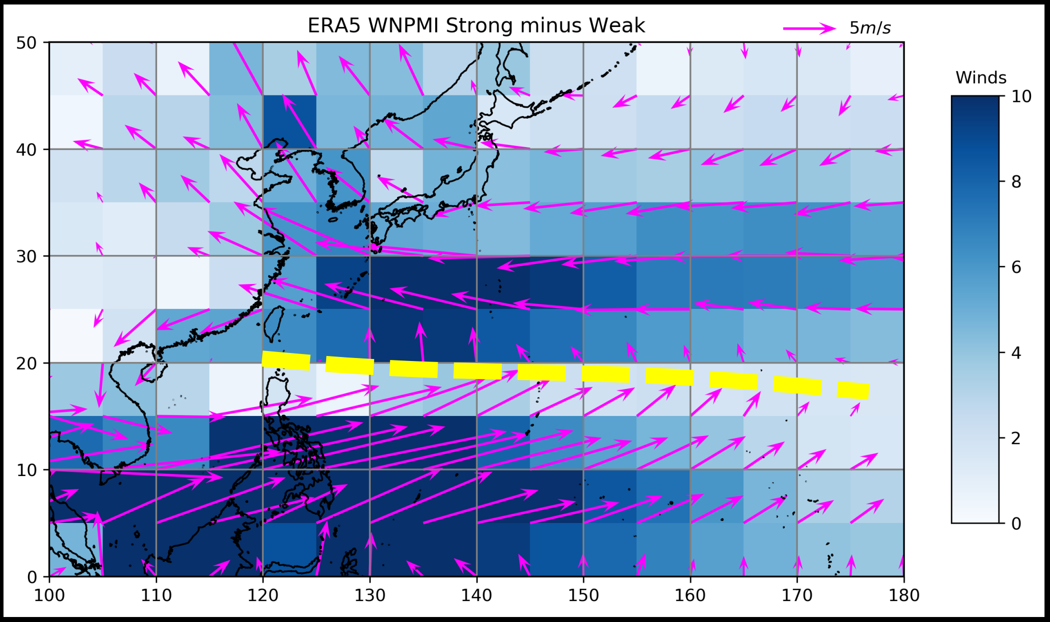
TC Forecast Skills under Different Large-Scale Environments

1. **ENSO**
2. **WNPMI (Western North Pacific Monsoon Index)**
3. **MJO (Madden–Julian Oscillation)**
    - Eastward propagation along the equator
4. **BSISO (Boreal Summer Intraseasonal Oscillation)**
    - Northward/northwestward propagation

WNPMI

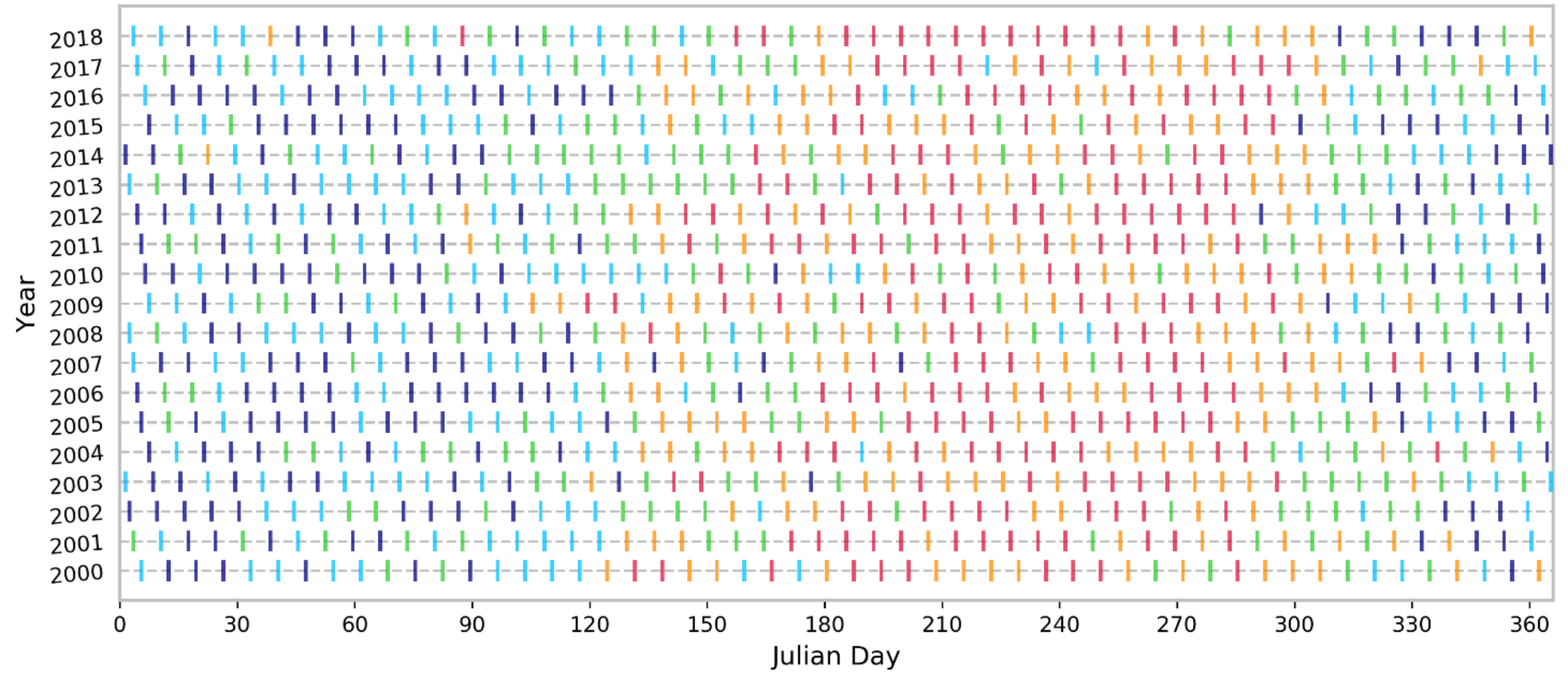
(Western North Pacific Monsoon Index; Wang et. al 2001)


Western North Pacific Monsoon Index
U850(2)
U850(1)
WWL INDEX:
U850(1)-U850(2)
40N
30N
20N
10N
0
10S
90E
100E
110E
120E
130E
140E
150E
160E


ERA5 WNPMI Strong minus Weak
5m/s
Winds
10
8
6
4
2
0
50
40
30
20
10
0
100
110
120
130
140
150
160
170
180

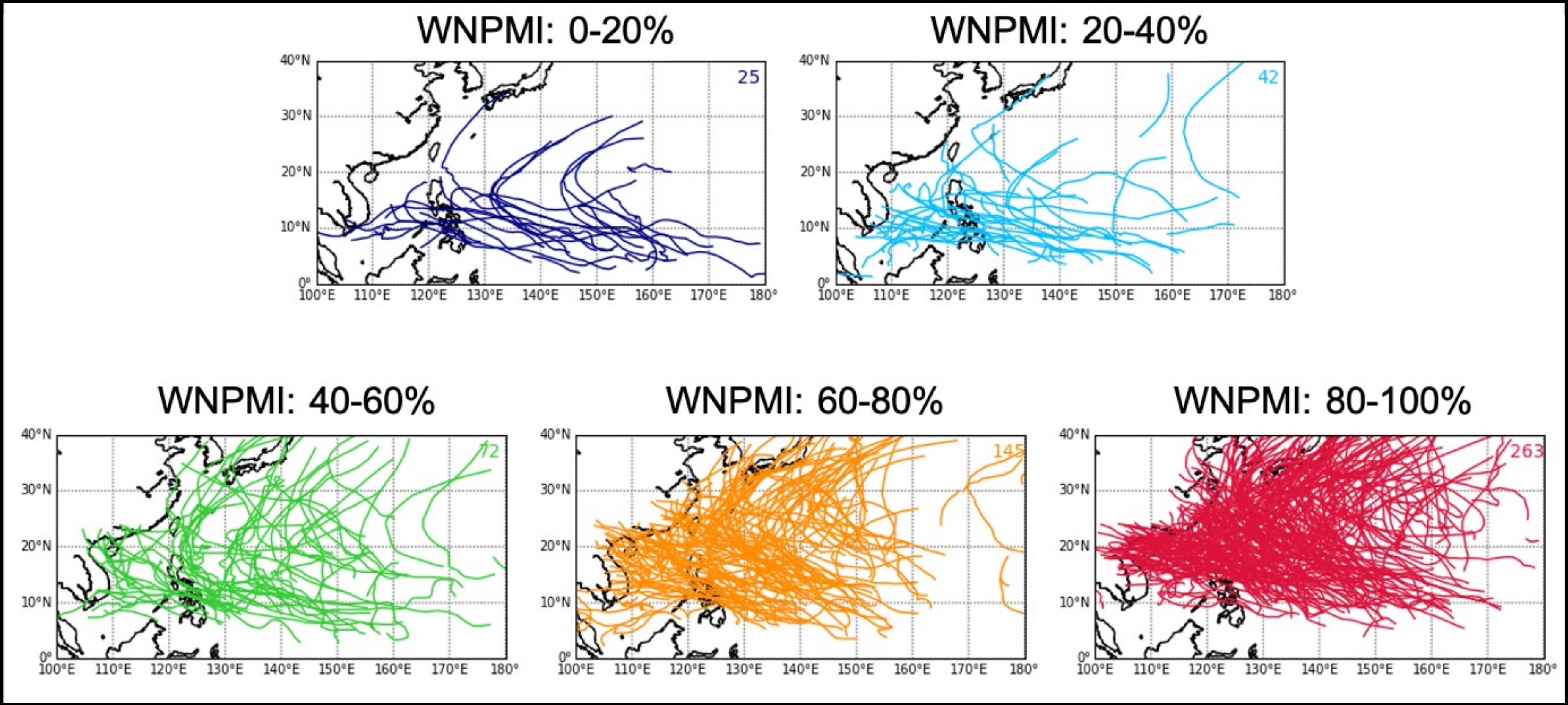
WNPMI

WNPMI is divided into 5 categories based on the cumulative probabilities

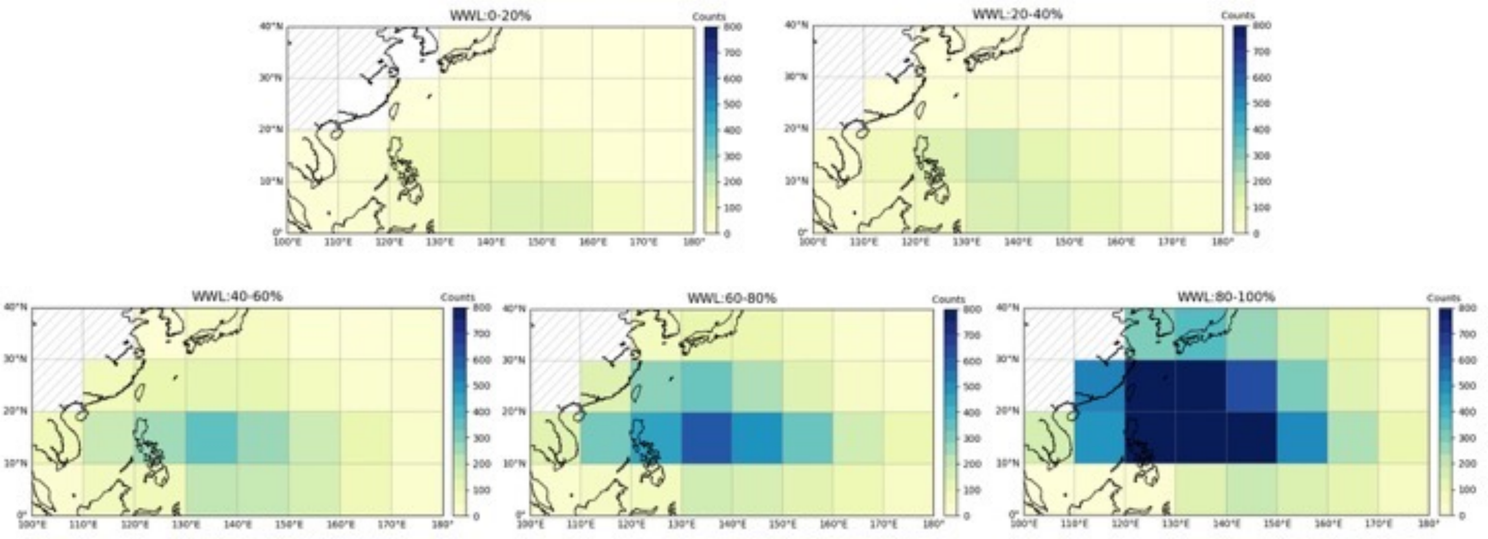


JTWC Best Tracks

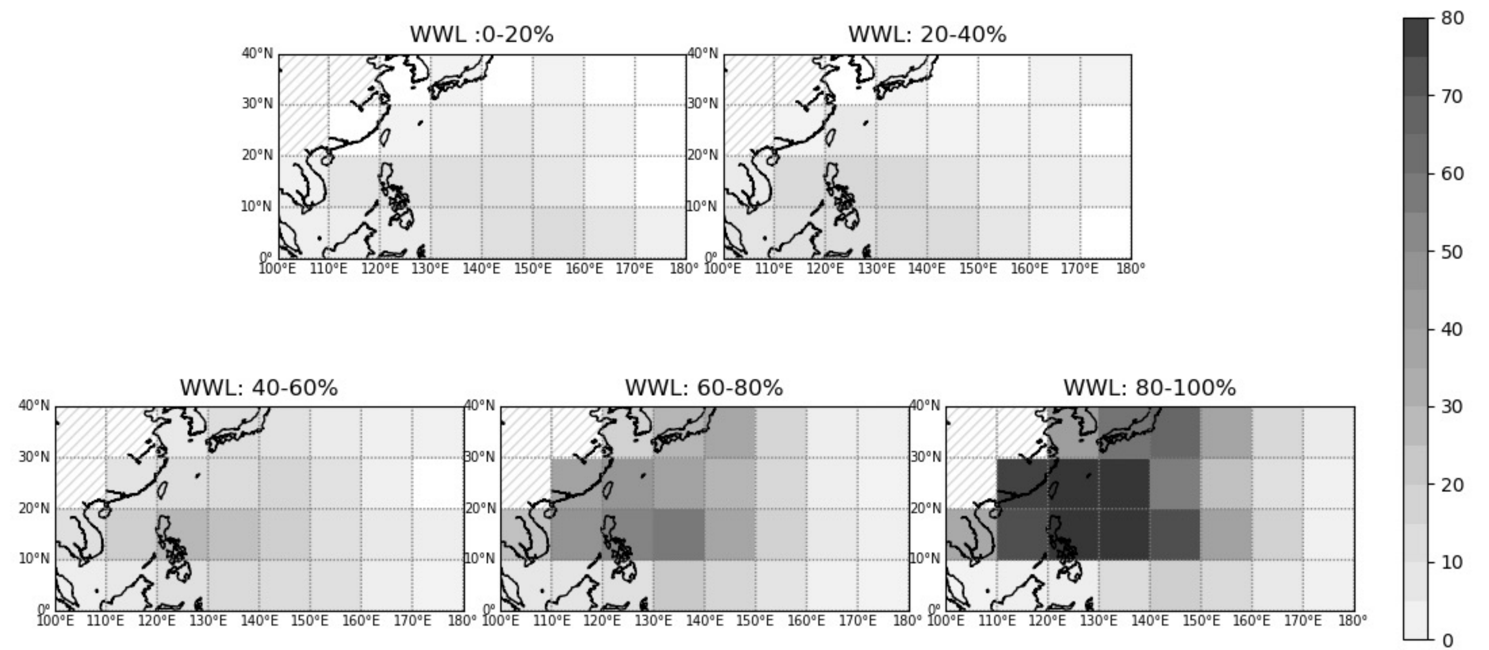
Best tracks are divided into 5 groups based on the WNPMI categories


WNPMI: 0-20%
25
WNPMI: 20-40%
42
WNPMI: 40-60%
72
WNPMI: 60-80%
145
WNPMI: 80-100%
263
40°N
30°N
20°N
10°N
0°
100°E
110°E
120°E
130°E
140°E
150°E
160°E
170°E
180°

GEFSv12 TC Tracks


WWL:0-20%
WWL:20-40%
WWL:40-60%
WWL:60-80%
WWL:80-100%
Counts
0
100
200
300
400
500
600
700
800
0°
10°N
20°N
30°N
40°N
100°E
110°E
120°E
130°E
140°E
150°E
160°E
170°E
180°

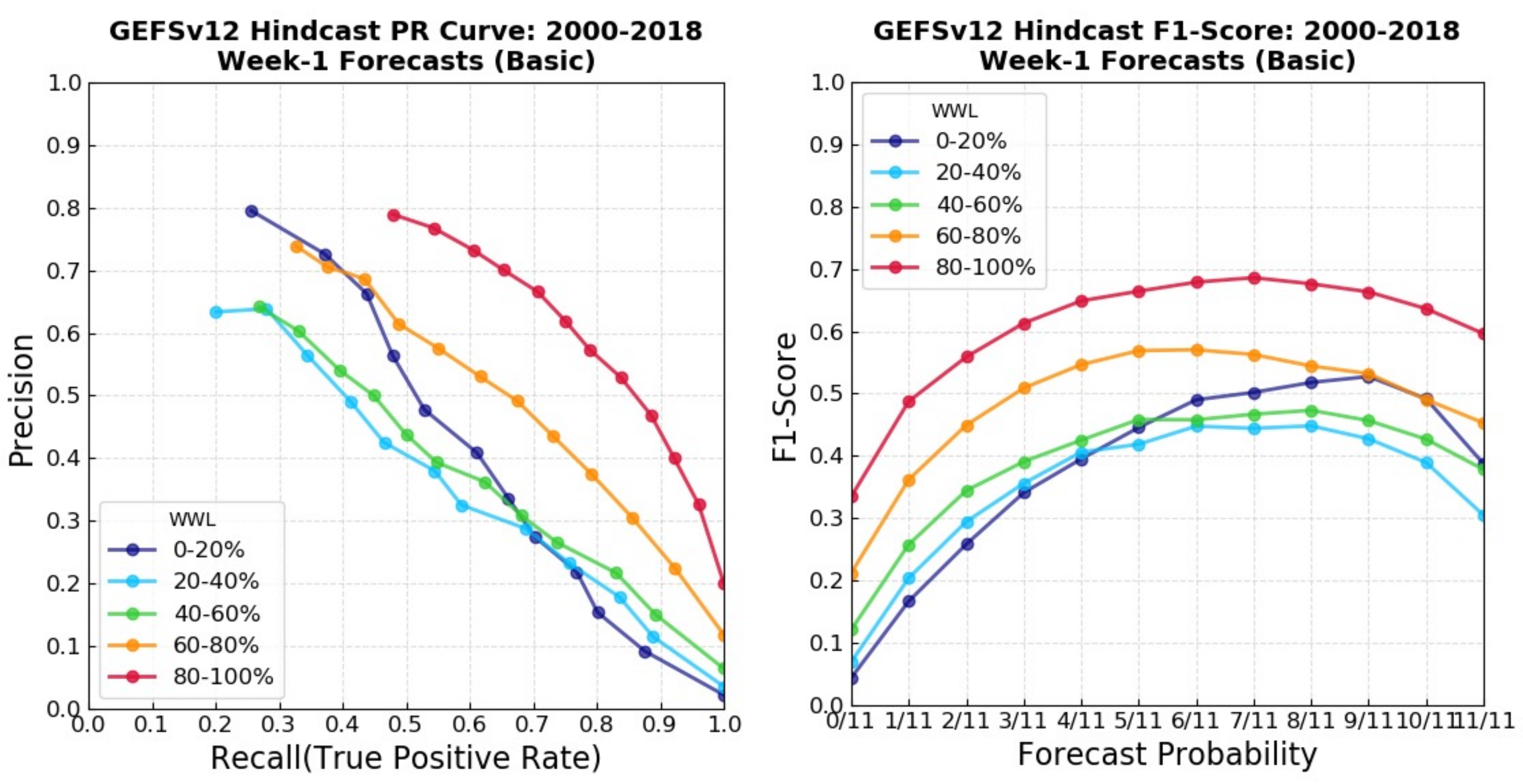
Best Tracks


WWL :0-20%
WWL: 20-40%
WWL: 40-60%
WWL: 60-80%
WWL: 80-100%
0°
10°N
20°N
30°N
40°N
100°E
110°E
120°E
130°E
140°E
150°E
160°E
170°E
180°
0
10
20
30
40
50
60
70
80

GEFSv12 Reforecasts: Week-1

Precision-Recall Curve & F1-Score

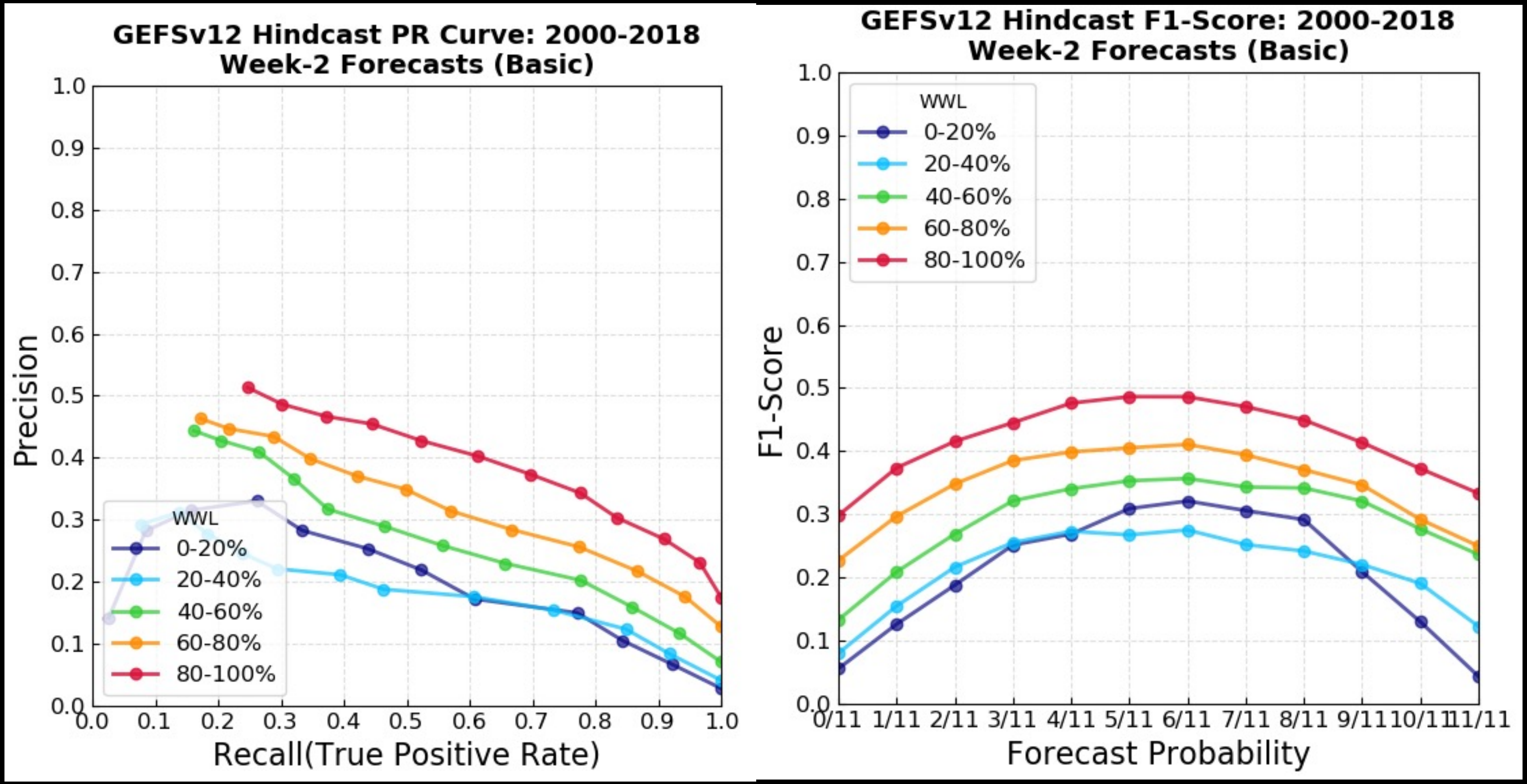
Larger WNPMI→ Better TC forecast skill



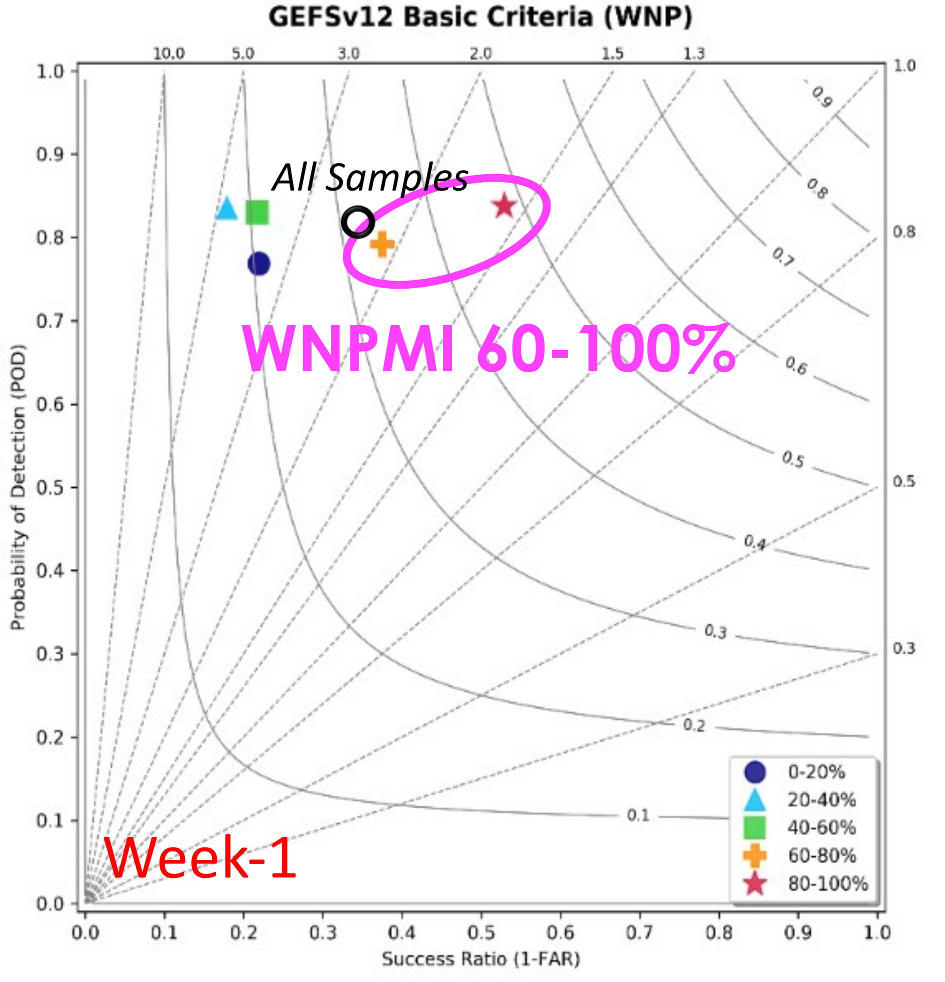
GEFSv12 Reforecasts: Week-2

Precision-Recall Curve & F1-Score

Larger WNPMI→ Better TC forecast skill



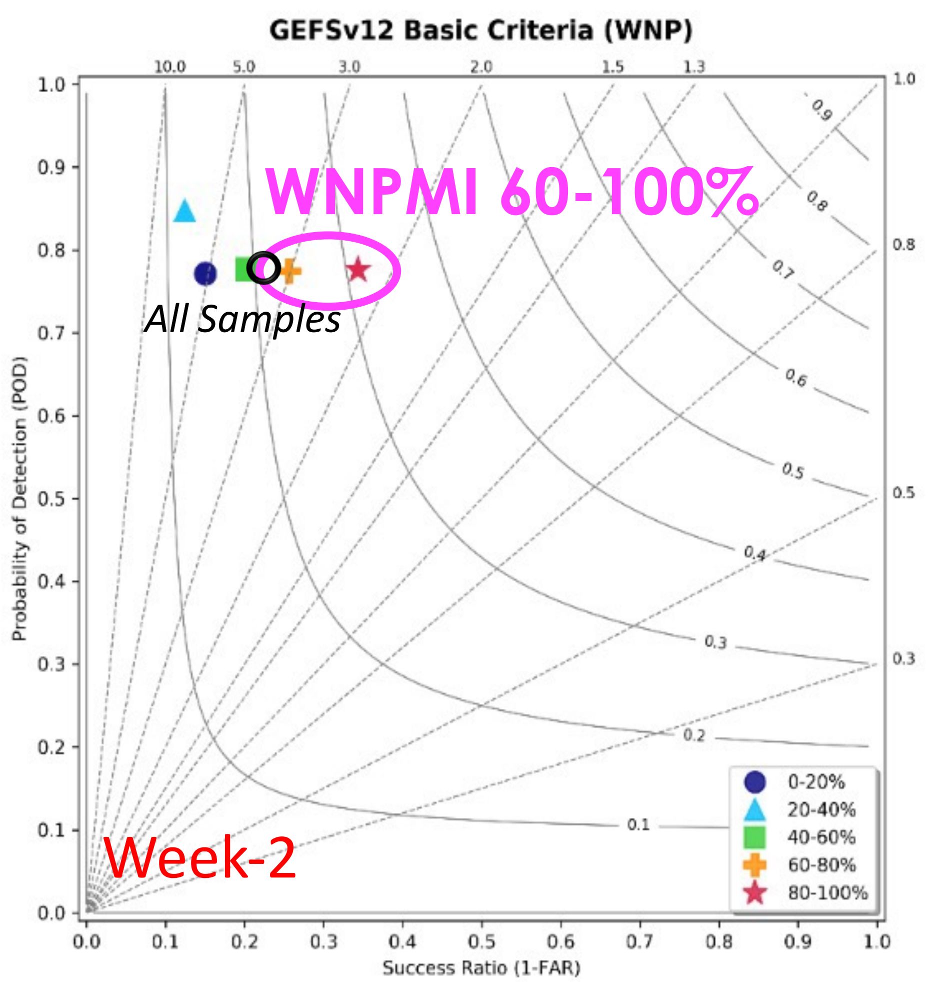
GEFSv12 Reforecasts: Performance Diagram



All Samples

WNPMI 60-100%

Week-1



WNPMI 60-100%

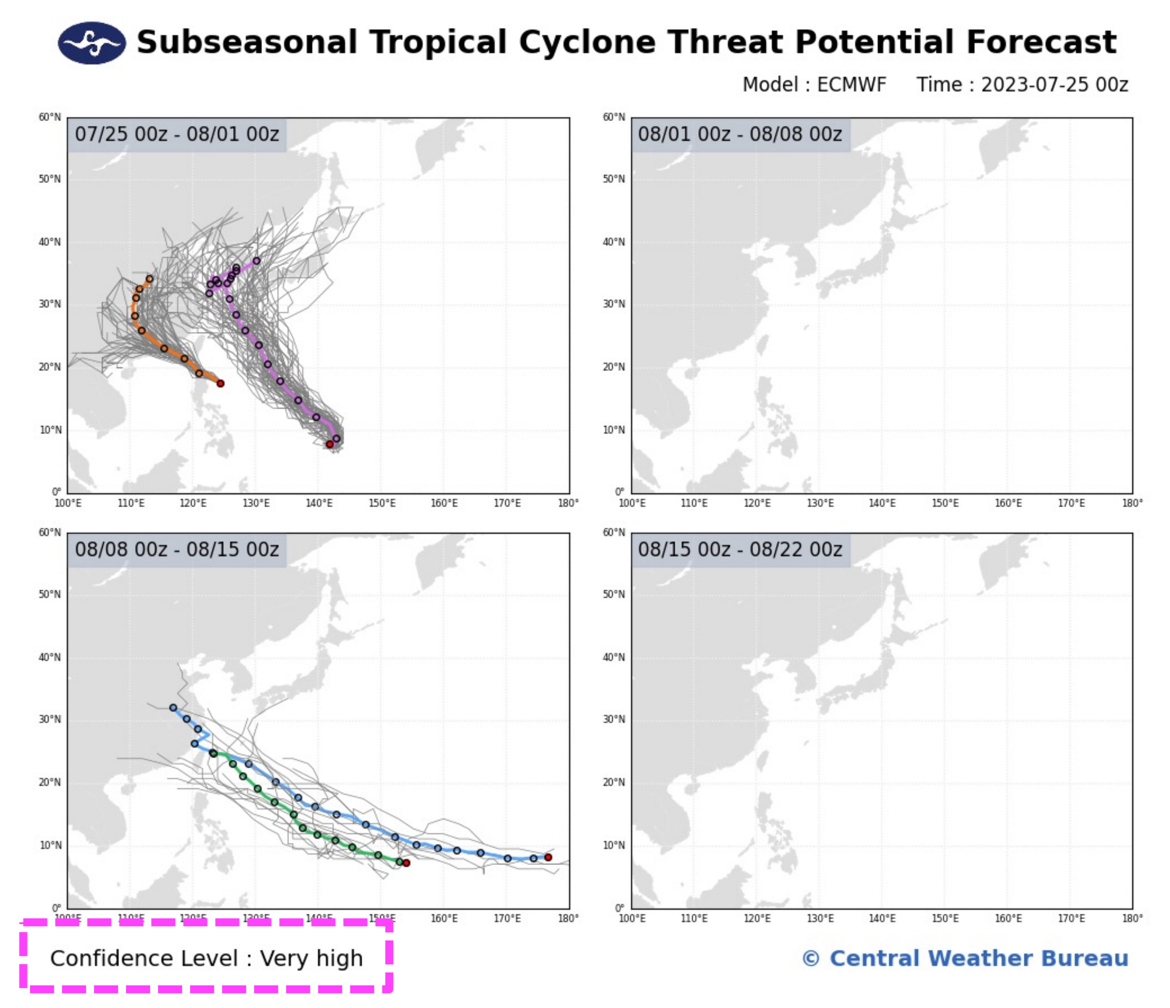
All Samples

Week-2

Similiar results can also be found in the ECMWF ensemble forecasts.

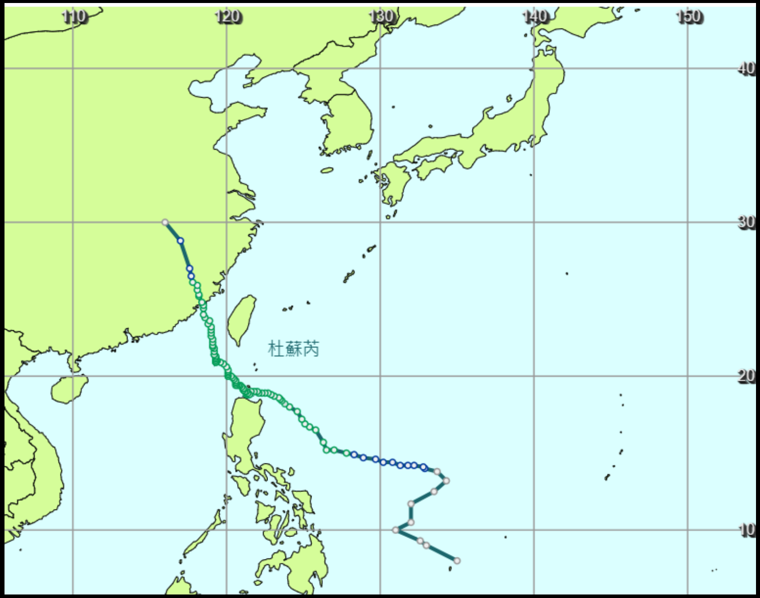
New TC Forecast Product at CWB

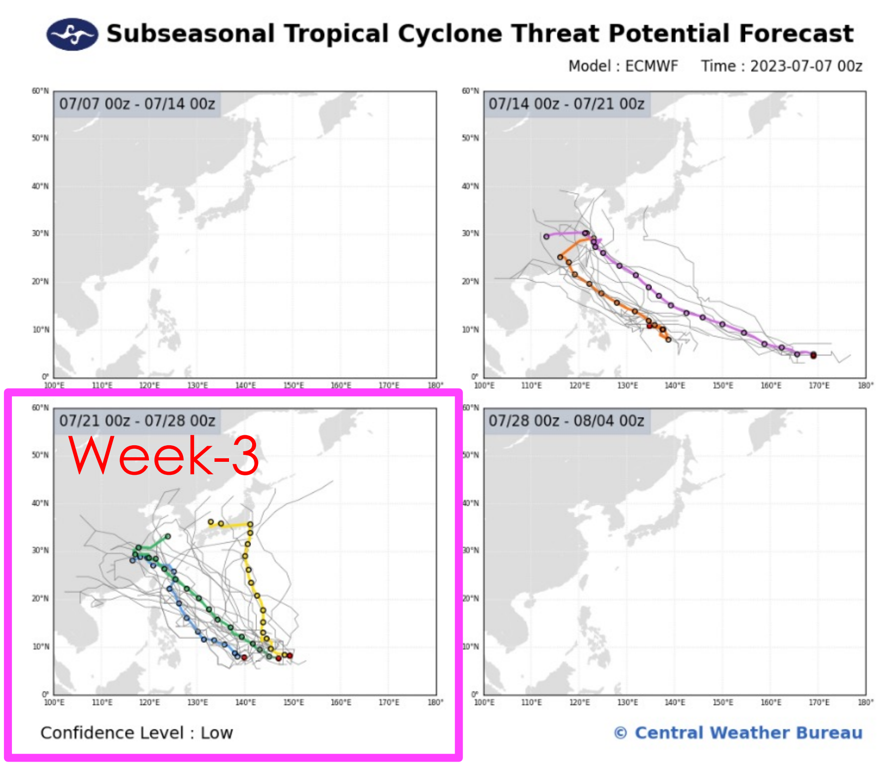
WNPMI + Track Clusters

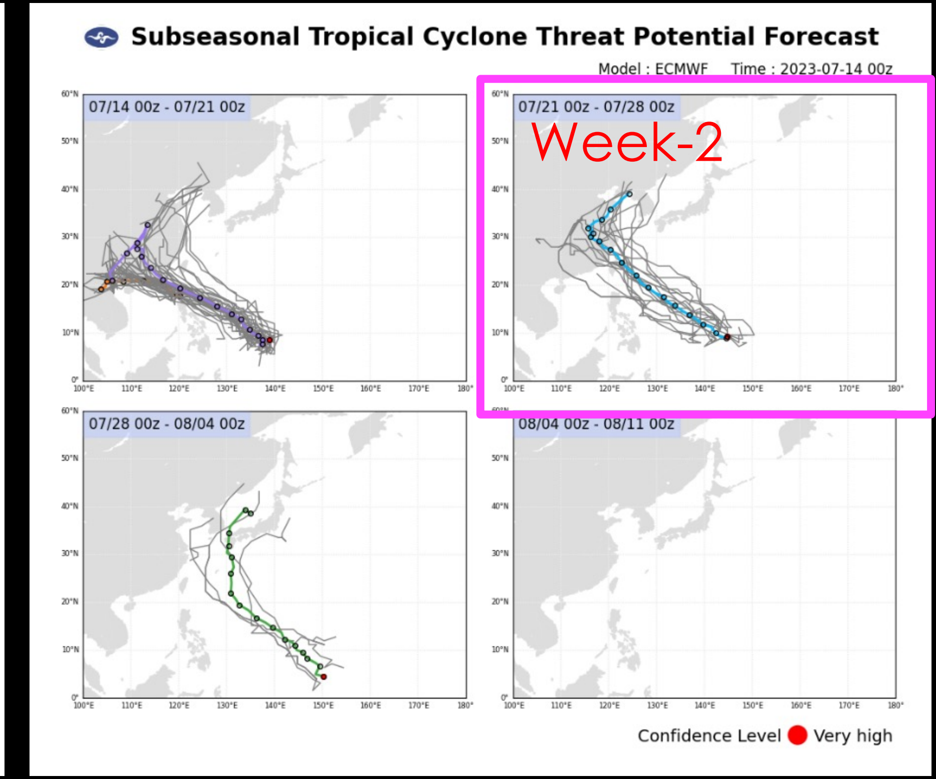

Subseasonal Tropical Cyclone Threat Potential Forecast
Model : ECMWF
Time : 2023-07-25 00z
07/25 00z - 08/01 00z
08/01 00z - 08/08 00z
08/08 00z - 08/15 00z
08/15 00z - 08/22 00z
60°N
50°N
40°N
30°N
20°N
10°N
0°
100°E
110°E
120°E
130°E
140°E
150°E
160°E
170°E
180°
Confidence Level : Very high
© Central Weather Bureau

WNPMI is used to indicate the *confidence level of* the current forecast

Typhoon Doksuri (20-29 July 2023)

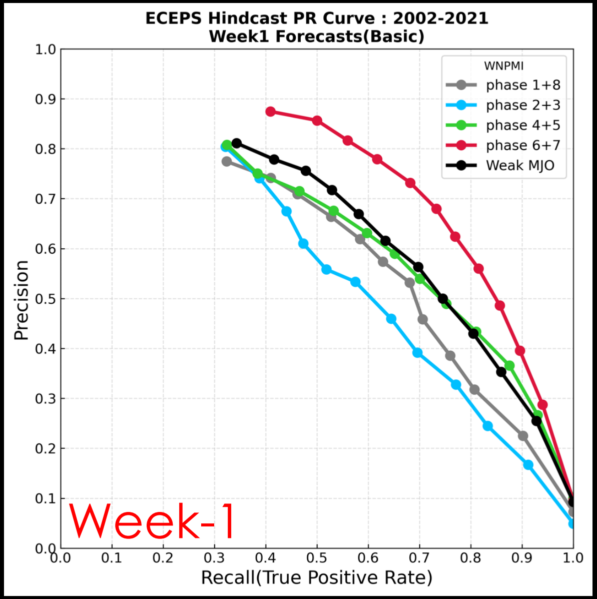

110
120
130
140
150
40
30
20
10
杜蘇芮

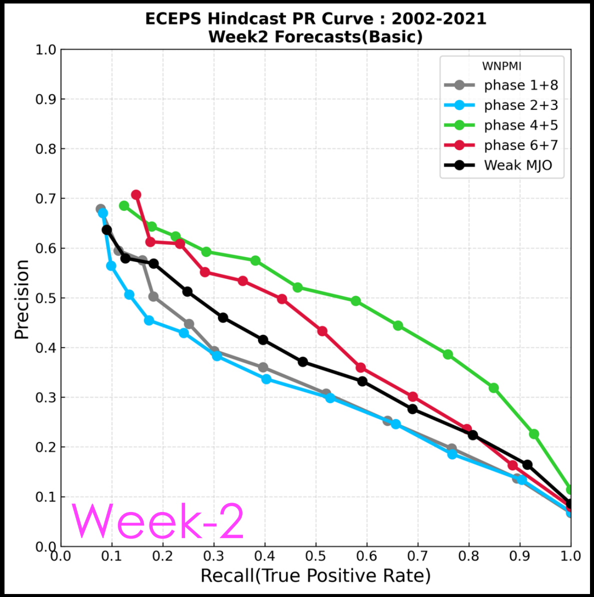

Subseasonal Tropical Cyclone Threat Potential Forecast
Model : ECMWF Time : 2023-07-07 00z
07/07 00z - 07/14 00z
07/14 00z - 07/21 00z
07/21 00z - 07/28 00z
Week-3
07/28 00z - 08/04 00z
Confidence Level : Low
© Central Weather Bureau


Subseasonal Tropical Cyclone Threat Potential Forecast
Model : ECMWF Time : 2023-07-14 00z
07/14 00z - 07/21 00z
07/21 00z - 07/28 00z
Week-2
07/28 00z - 08/04 00z
08/04 00z - 08/11 00z
Confidence Level ● Very high

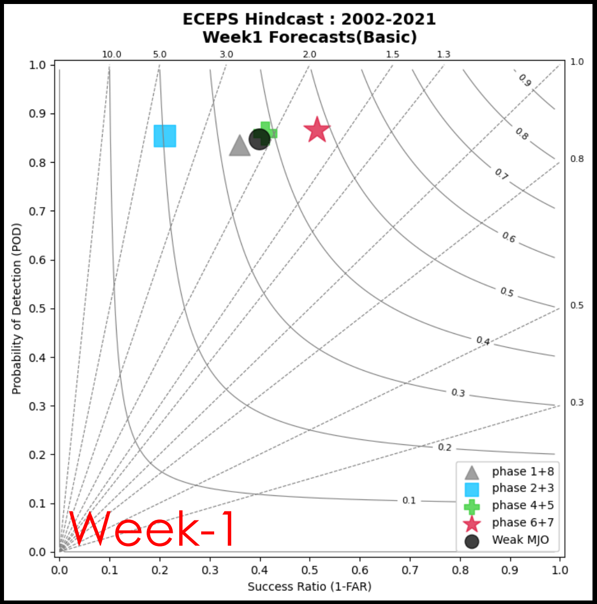
ECMWF Forecast Skill – MJO

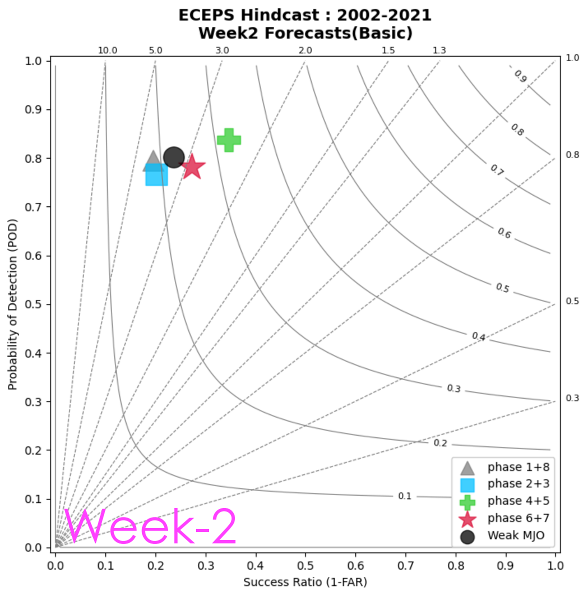
PR Curve





Performance Diagram





Summary

- CWB TC Tracker 2.0
  - https://tctracker.cwb.gov.tw/
- Week-1 to week-4 TC forecast skills
  - Large-scale environments
    - WNPMI, MJO, BSISO, ENSO
- New TC forecast product
  - Track clusters & confidence level

Questions or Comments?
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Kovia Lo(kovia@cwb.gov.tw)

Thank You!