The Effect of Input Resolution for Atmospheric Models on Storm Surge Simulation

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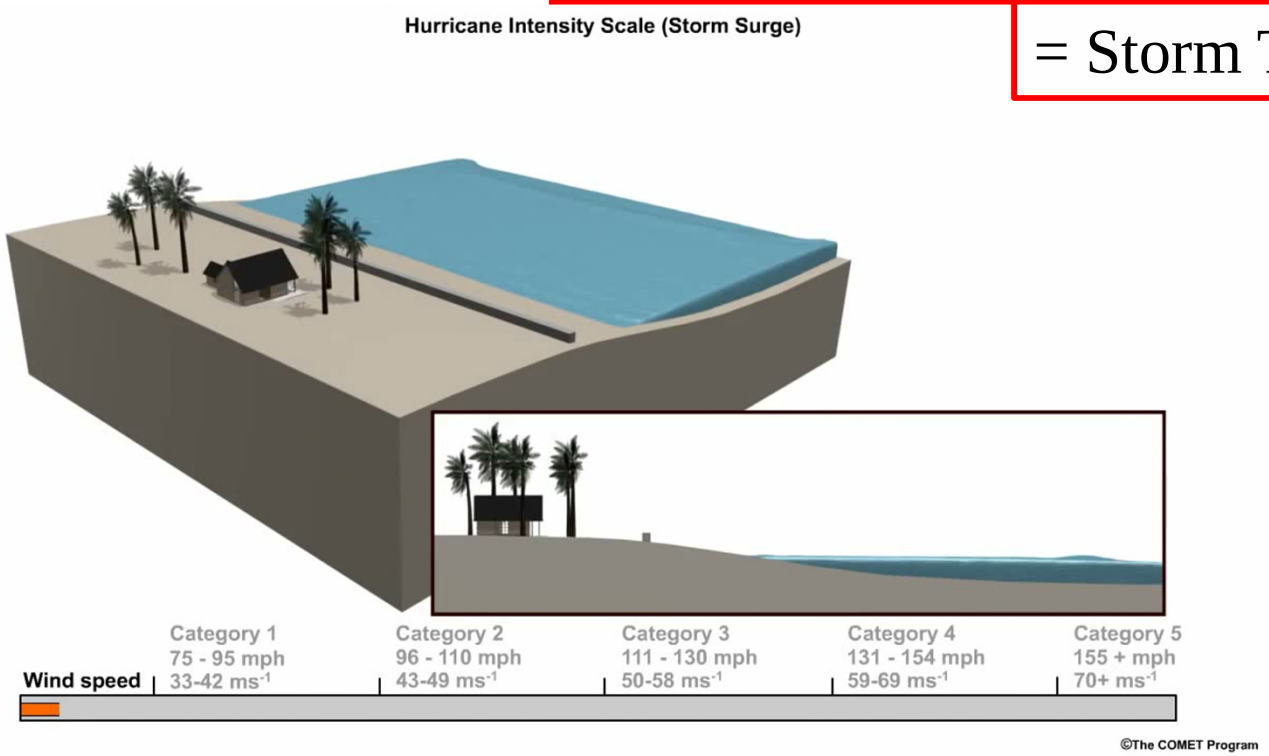
Storm Surge

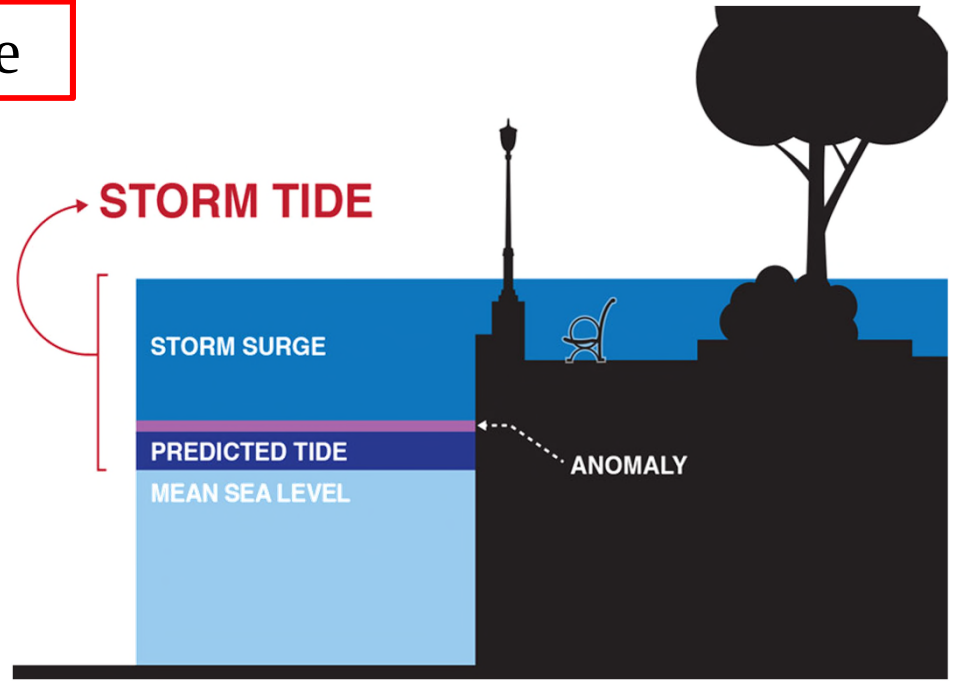
Tropical cyclones present major hazards (extreme winds, rainfall and **storm surges**) for coastal areas, and they respond to climate change.

Storm surge is the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide.

Total Water Level = Storm Surge + Astronomical Tide + Waves + Freshwater Input

= Storm Tide





NOAA. What is storm surge? National Ocean Service website, https://oceanservice.noaa.gov/facts/stormsurge-stormtide.html, 10/10/17.

Recent Storm Surge Events in West Pacific

Under the scenario of global warming and sea level rise caused by climate change in the future, the potential occurrence of severe storms has increased in the last decade and battered those countries at the edge of the Northwest Pacific.

2018/08 Jebi

https://www.bbc.com/news/world-asia-45419771

2018/09 Mangkhut

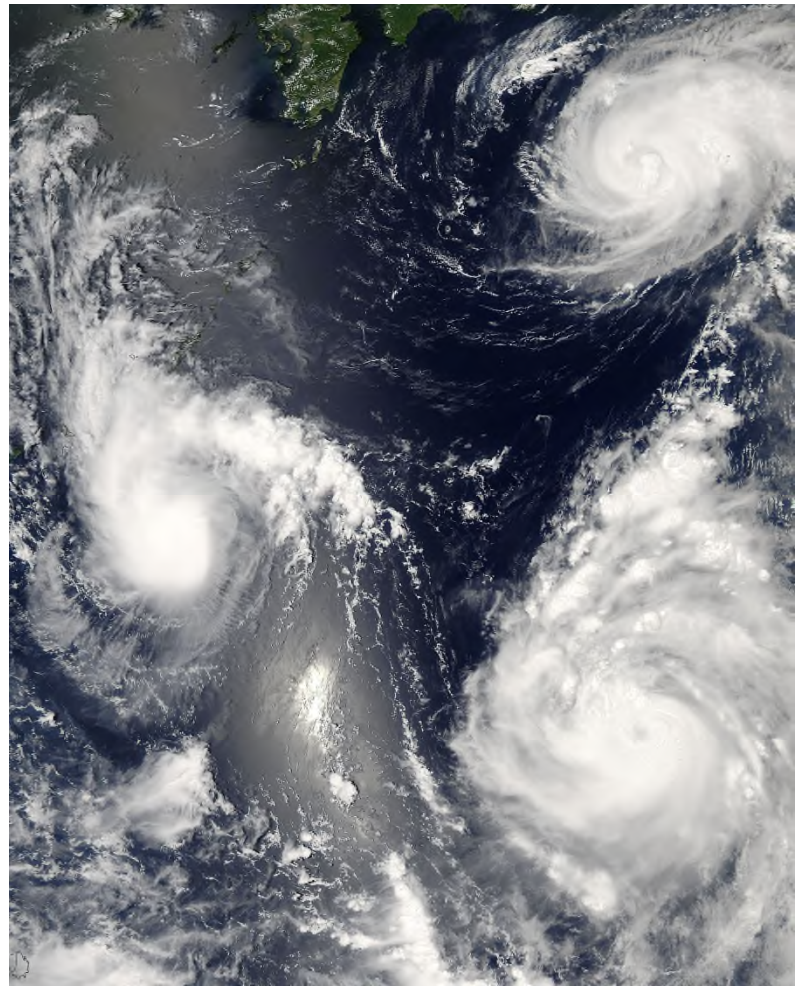
https://www.bbc.com/news/world-asia-45543664

2025/08 Kajiki

https://edition.cnn.com/2025/08/25/asia/vietnam-typhoon-kajiki-landfall-intl-hnk

2022/09 Hinnamnor

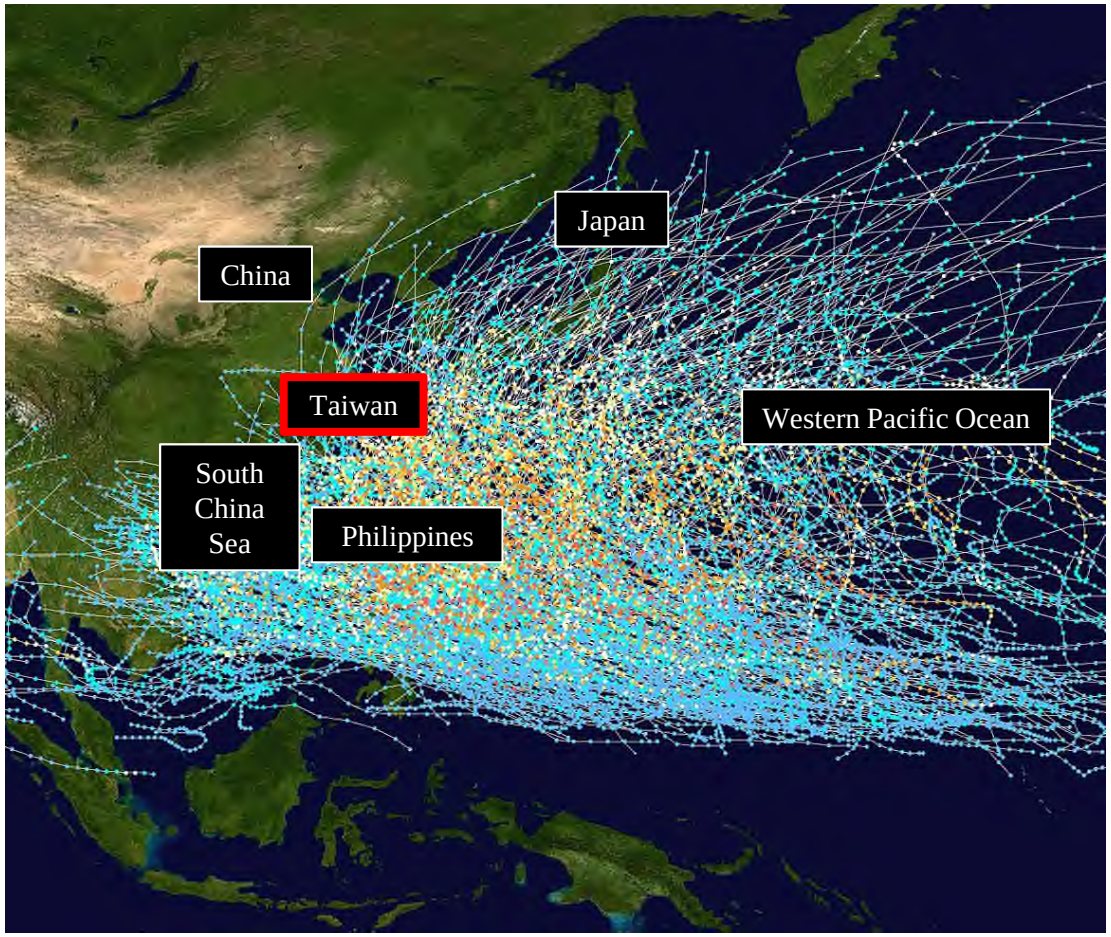
https://www.bbc.com/news/world-australia-62804211



Schmaltz, J. (2006, August 9). *Pacific Typhoons* [Satellite image]. NASA Visible Earth. NASA Goddard Space Flight Center. Retrieved from Visible Earth website.

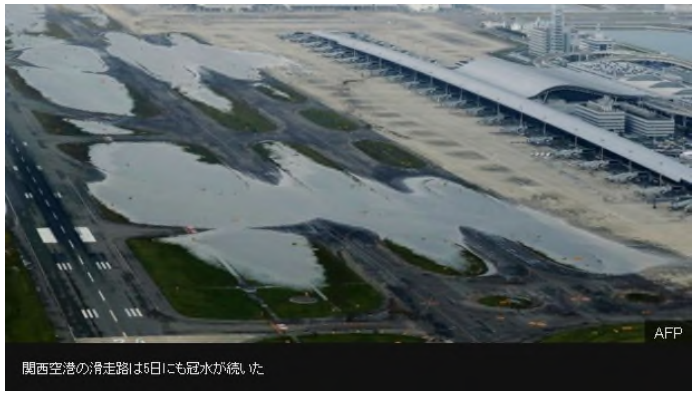
Recent Storm Surge Events in Asia Countries

Under the scenario of global warming and sea level rise caused by climate change in the future, the potential occurrence of severe storms has increased in the last decade and battered those countries at the edge of the Northwest Pacific.



Tracks of all tropical cyclones in the northernwestern Pacific Ocean between 1980 and 2005. The right boundary is the International Date Line. Created using WikiProject Tropical cyclones/Tracks

2018/08 Jebi



https://www.bbc.com/japanese/45416985

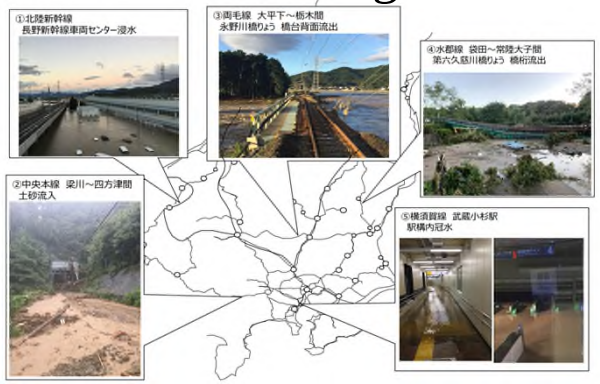
2018/09 Mangkhut

https://www.scmp.com/news/hong-kong/society/article/2164344/super-typhoon-mangkhut-hongkongers-warned-be-ready-saturday

2018/07 Maria

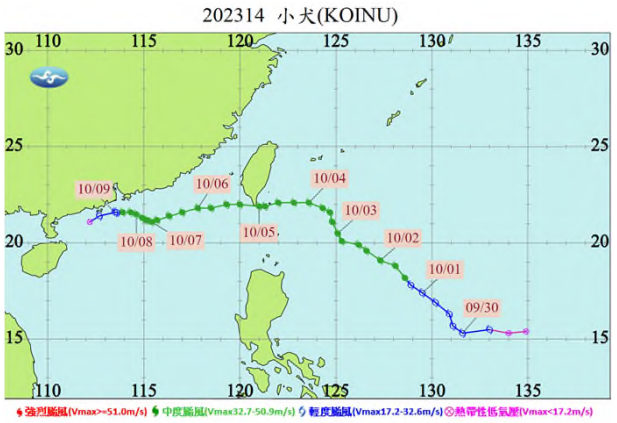
https://www.bbc.com/news/av/world-asia-china-44809623/typhoon-maria-wreaks-havoc-in-east-china

2019/10 Hagibis



台風 19 号による JR 東日本管内の設備等の主な被害状況について
https://www.jreast.co.jp/press/2019/20191013_ho01.pdf

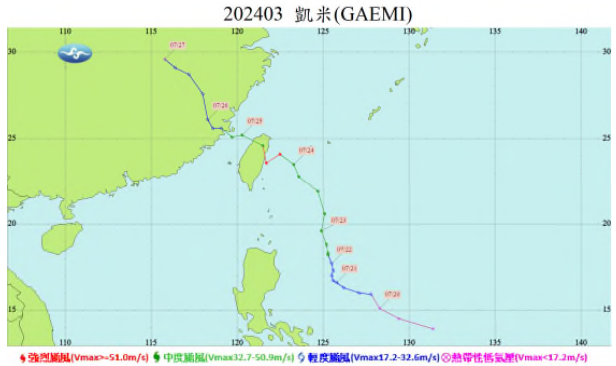
Cat-4 Typhoon KOINU (2023)



Lowest pressure: 930 hPa
Max 1-minute sustained wind : 220 km/h

https://www.cna.com.tw/news/ahel/202310050123.aspx

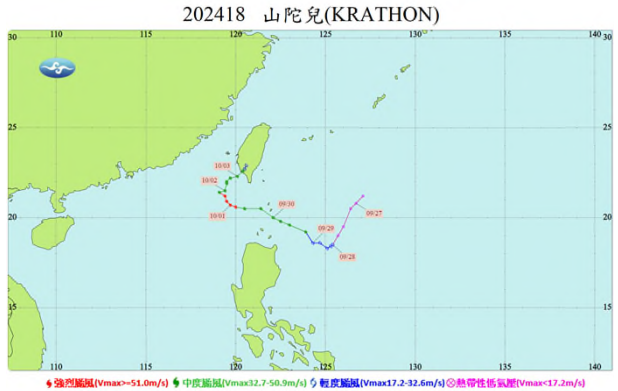
Cat-4 Typhoon GAEMI (2024)



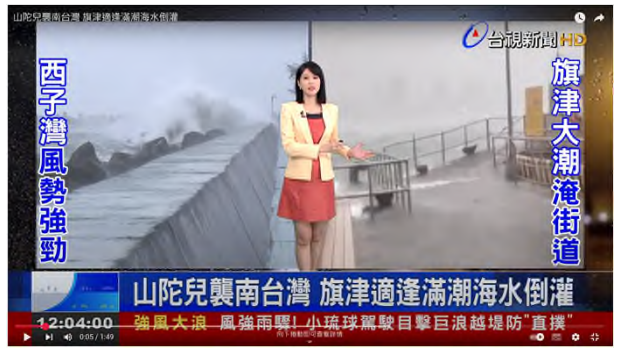
Lowest pressure: 935 hPa
Max 1-minute sustained wind : 230 km/h

https://youtu.be/uDEFe4OpQU4?si=VgtQR0frbtW-JStN

Cat-5 Typhoon KRATHON(2024)

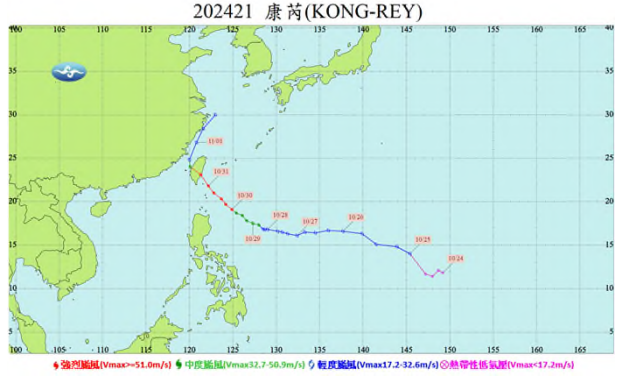


Lowest pressure: 920 hPa
Max 1-minute sustained wind : 240 km/h



https://youtu.be/ML8K78ZplIA?si=zUQ0OVHxVsxMTYng

Cat-5 Typhoon KONG-REY(2024)



Lowest pressure: 915 hPa
Max 1-minute sustained wind : 240 km/h

https://youtu.be/Z31fgmMWk20?si=-kK2iDZVQVRagVSN

Operational Storm Surge Forecast System in CWA, Taiwan (Cornell Multi-grid Coupled Tsunami Model – Storm Surge)

Nonlinear Shallow Water Equations on the Spherical Coordinate

$$\frac{\partial \eta}{\partial t}+\frac{1}{R\cos\varphi}\left\{\frac{\partial P}{\partial \psi}+\frac{\partial}{\partial \varphi}\left(\cos\varphi\cdot Q\right)\right\}=0$$

$$\frac{\partial P}{\partial t}+\frac{1}{R\cos\varphi}\frac{\partial}{\partial \psi}\left(\frac{P^2}{H}\right)+\frac{1}{R}\frac{\partial}{\partial \varphi}\left(\frac{PQ}{H}\right)+\frac{gH}{R\cos\varphi}\frac{\partial \eta}{\partial \psi}-fQ+F_{\psi}^{b}=-\frac{H}{\rho_w R\cos\varphi}\frac{\partial P_a}{\partial \psi}+\frac{F_{\psi}^{s}}{\rho_w}$$

$$\frac{\partial Q}{\partial t}+\frac{1}{R\cos\varphi}\frac{\partial}{\partial \psi}\left(\frac{PQ}{H}\right)+\frac{1}{R}\frac{\partial}{\partial \varphi}\left(\frac{Q^2}{H}\right)+\frac{gH}{R}\frac{\partial \eta}{\partial \varphi}+fP+F_{\varphi}^{b}=-\frac{H}{\rho_w R}\frac{\partial P_a}{\partial \psi}+\frac{F_{\varphi}^{s}}{\rho_w}$$

- Solve shallow water equations on **both spherical and Cartesian coordinate systems**
- **Explicit leapfrog Finite Difference Method** for stable and high speed calculation
- **Multi/Nested-grid system** for multiple shallow water wave scales
- **Moving Boundary Scheme** for inundation
- **High-speed efficiency**

• Moving Boundary Scheme

Moving boundary scheme was also introduced in COMCOT to model the run-up and run-down. The instant "shoreline" is defined as the interface between a dry grid and wet grid and volume flux normal to the interface is assigned to zero.

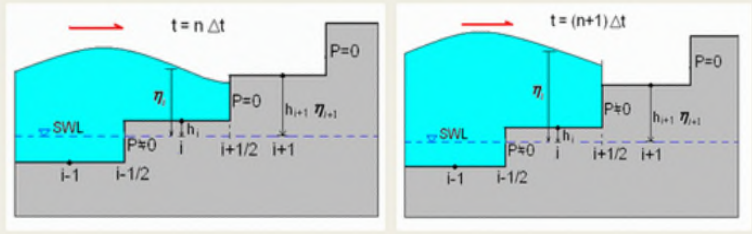
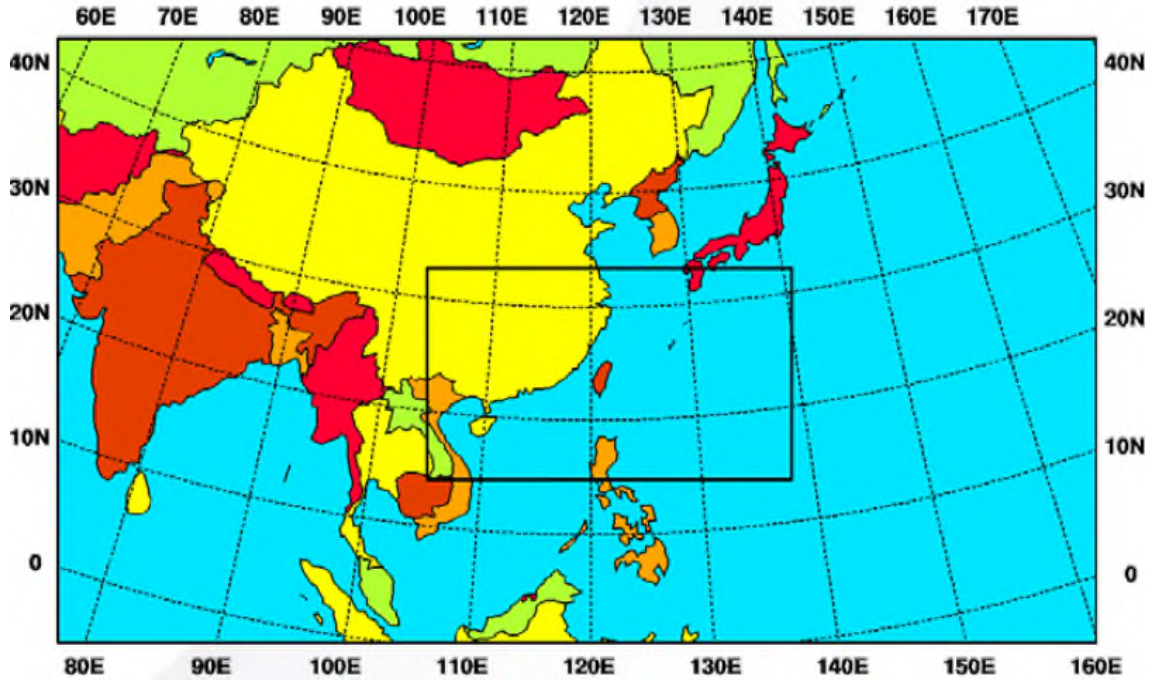


Fig.02 Moving Boundary Scheme

Meteorological Input: the Atmospheric Dynamic Models

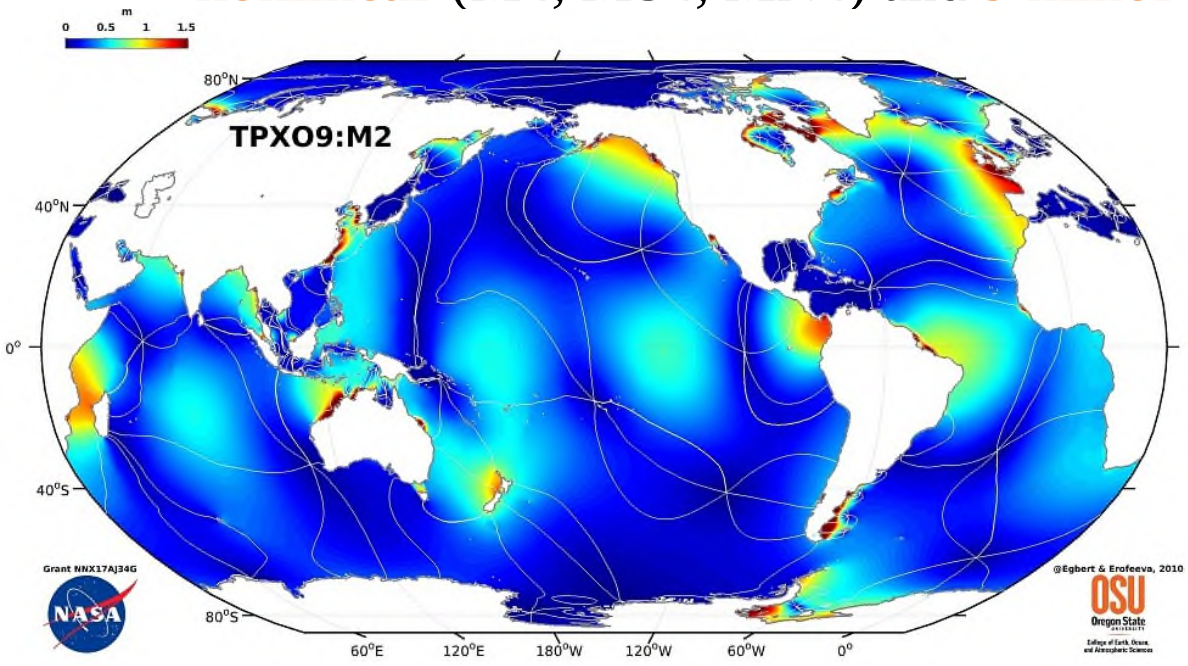
- TWRF-2.0
  (Typhoon Weather Research and Forecasting model)
- Lambert projection.
- Operates four times daily, at 00/06/12/18 UTC.
- The initial field comes from hybrid ensemble variational data assimilation with partial cycle strategy, and optimized with spatial filtering method to blend large-scale information from global analysis fields.
- The boundary conditions are provided by forecast data from the NCEP and ECMWF.



TWRF-2.0	Domain 1	Domain 2
Resolution	15 km	3 km
X Grid Points	661	1158
Y Grid Points	385	673
Central Longitude	118.59	121.75
Central Latitude	27.07	24.13

Tide Coupling with TPXO Model
(USA OSU TOPEX/POSEIDON Global Tidal Model)

TPXO9-atlas-v2 (Egbert & Erofeeva, 2002) applies a generalized inverse method by fitting the observation and **linear shallow water equations** in the **least square** sense (Egbert et al., 1994), and it provides **1/30-degree** resolution in the computational domain, with **eight linear primaries** (M2, S2, N2, K2, K1, O1, P1, Q1), **two long-period** (Mf, Mm), and **three nonlinear** (M4, MS4, MN4) and **9 minor** harmonic constituents.



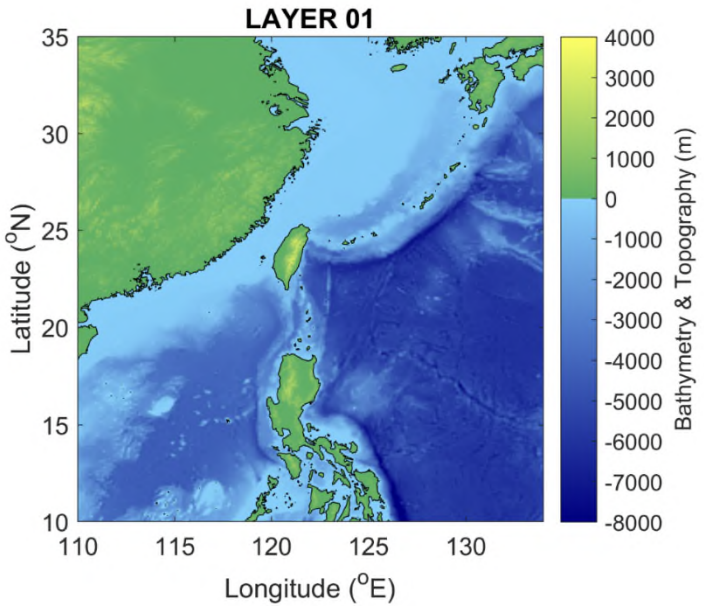
(https://www.tpxo.net/global)

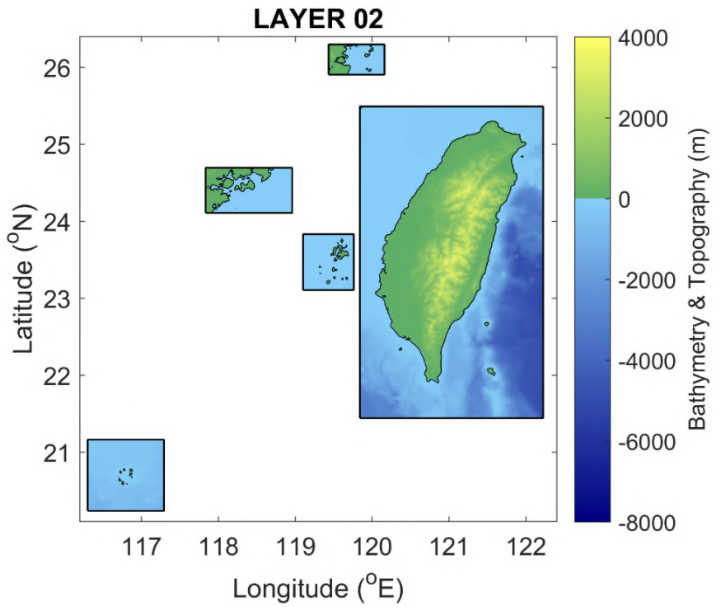
The partial tide component at time t for a constituent frequency ω at location x can be calculated by the following formula (Egbert & Erofeeva, 2002):

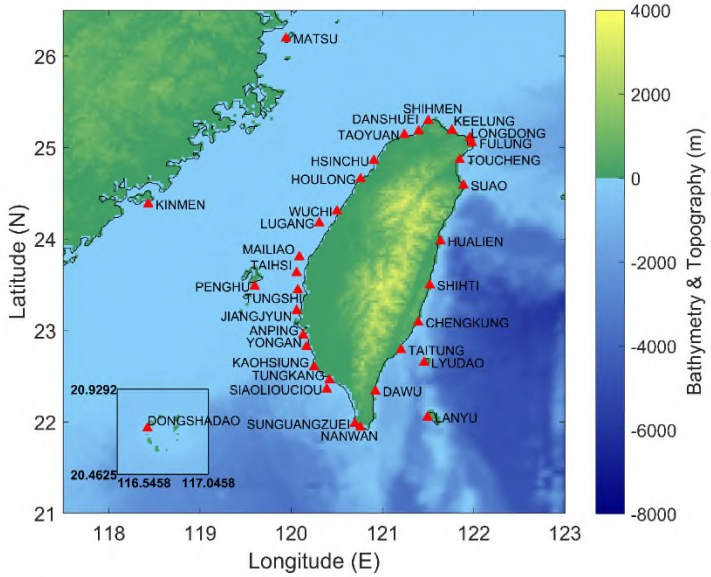
$$h(t,x) = pu(t,x) \cdot Re[h(x)\exp\{i[\omega(t-t0) + V0(t0) + ph(t,x)]\}]$$

where $V0(t0)$ is the astronomical argument for the constituent at time $t0$, $pu(t,x)$ and $ph(t,x)$ are nodal corrections. The amplitude will be $|h|$ and the phase will be $\operatorname{atan}\left(\frac{-Im(h)}{Re(h)}\right)$.

Numerical Sets for Current Forecast System

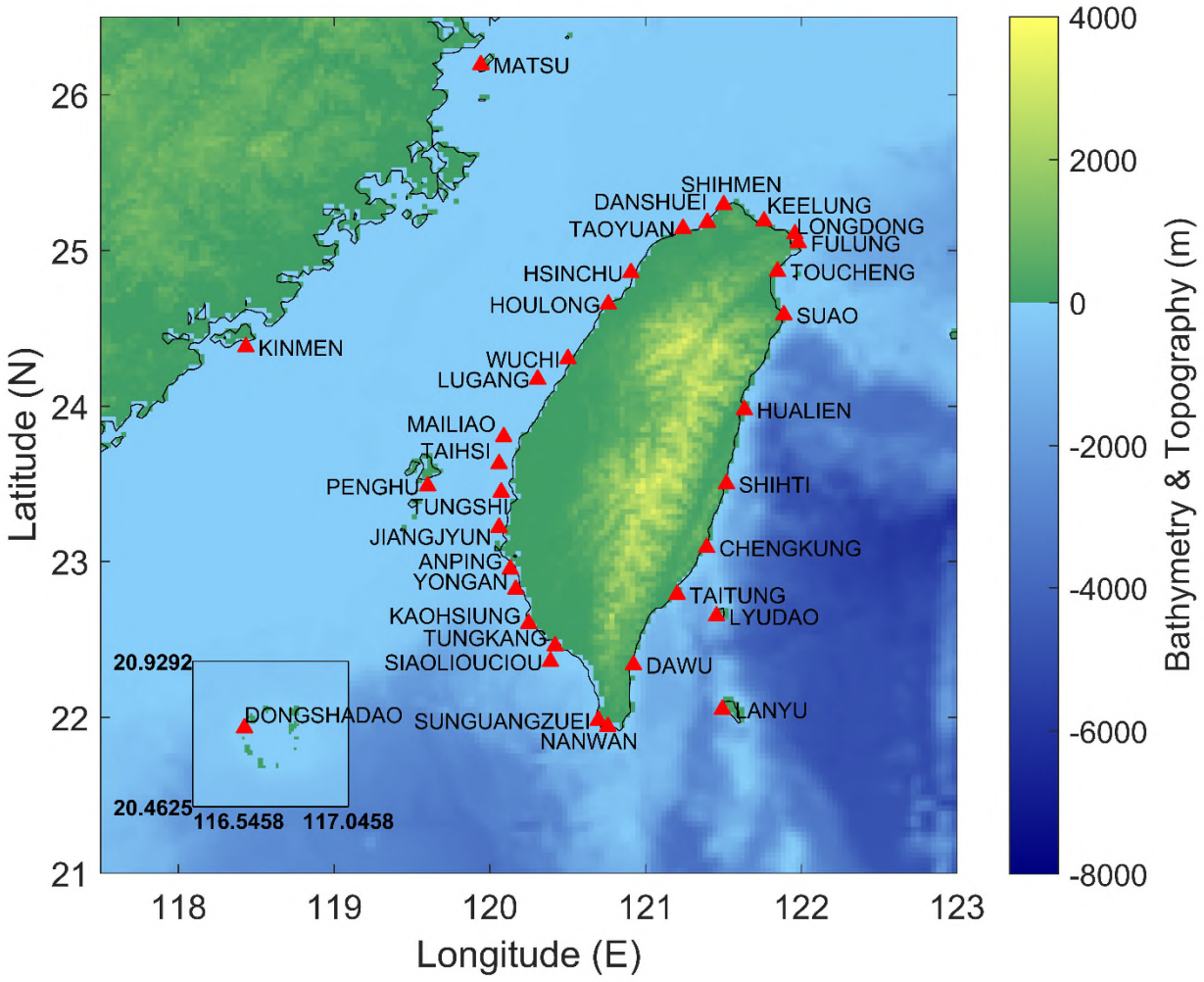






Layer ID	Domain	Array Size	Bathymetry Database	Resolution
LAYER-01	(110.00-134.00, 10.00-35.00)	361 * 376	ETOPO	4 arc-min
LAYER-02-A	(119.80-122.25, 21.40-25.50)	144 * 244	GEBCO	2.0 km
LAYER-02-B	(119.09-119.80, 23.05-23.89)	80 * 88	GEBCO	1.0 km
LAYER-02-C	(117.80-118.99, 24.09-24.70)	136 * 72	GEBCO	1.0 km
LAYER-02-D	(119.39-120.19, 25.84-26.35)	88 * 48	GEBCO	1.0 km
LAYER-02-E	(116.29-117.31, 20.19-21.23)	120*112	GEBCO	1.0 km

Numerical Gauge Set

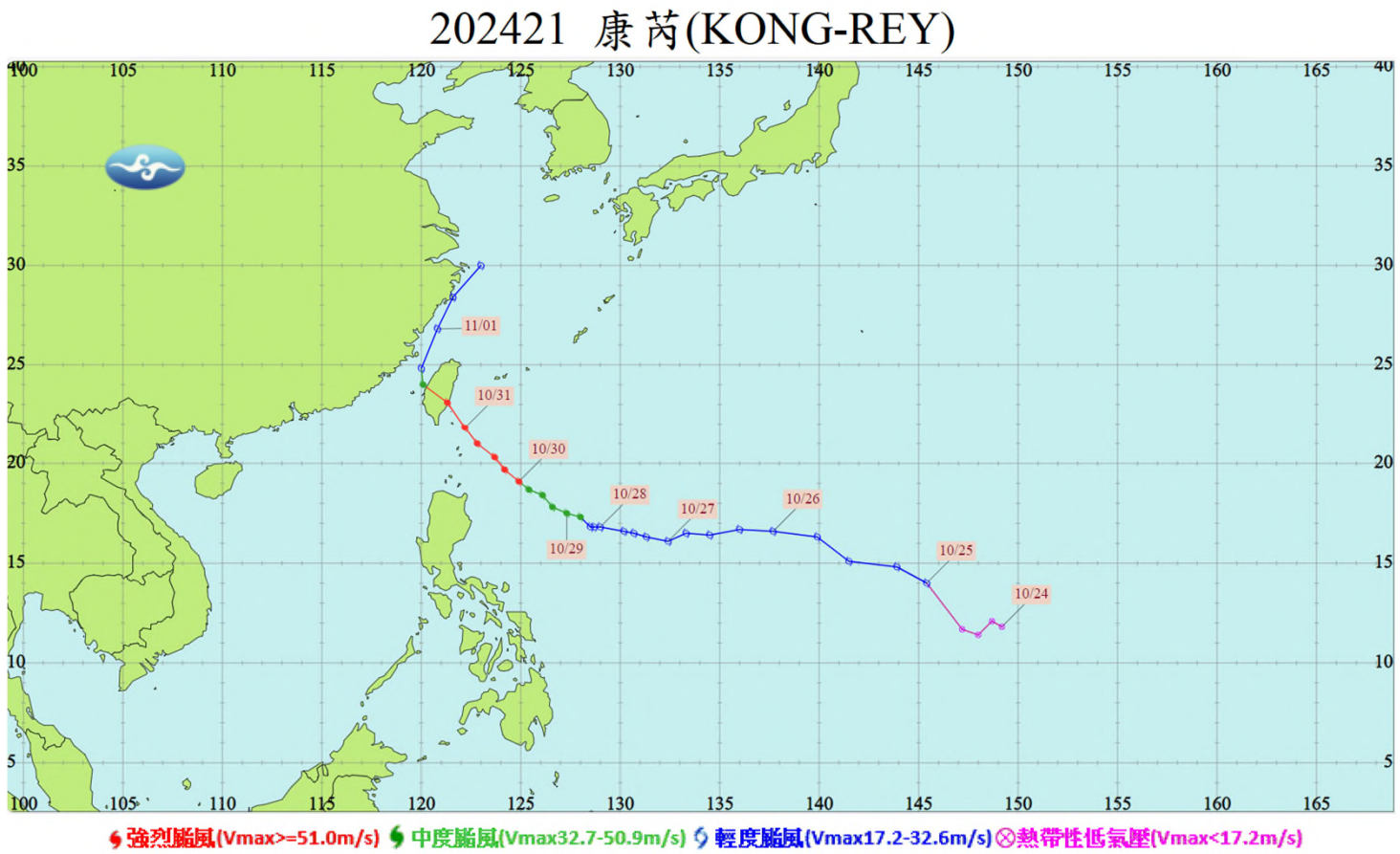


No.	Name	Station ID	Name (EN)	Lon.	Lat.
1	龍洞	1226	LONGDONG	121.95	25.12
2	基隆	1516	KEELUNG	121.75	25.16
3	福隆	1826	FULONG	121.95	25.02
4	頭城	1236	TOUCHENG	121.86	24.90
5	蘇澳	1246	SUAO	121.86	24.59
6	花蓮	1256	HUALIEN	121.61	23.96
7	石梯	1566	SHITI	121.50	23.49
8	成功	1276	CHENGKUNG	121.37	23.08
9	台東	1586	TAITUNG	121.19	22.79
10	大武	1596	DAWU	120.89	22.33
11	綠島	1676	LUDAO	121.46	22.66
12	蘭嶼	1396	LANYU	121.49	22.06
13	石門	1206	SHIHMEN	121.51	25.28
14	淡水	1102	DANSHUEI	121.42	25.18
15	桃園	1116	TAOYUAN	121.23	25.12
16	新竹	112	HSINCHU	120.91	24.85
17	後龍	113	HOULONG	120.77	24.65
18	梧棲	1436	WUCHI	120.53	24.29
19	鹿港	1146	LUGANG	120.42	24.08
20	麥寮	1456	MAILIAO	120.16	23.79
21	台西	1156	TAISI	120.14	23.62
22	東石	1162	TUNGSHI	120.14	23.44
23	將軍	1176	JIANGJUN	120.08	23.21
24	安平	1471	ANPING	120.18	22.98
25	永安	1786	YONGAN	120.20	22.82
26	高雄	1486	KAOHSIUNG	120.29	22.61
27	東港	1186	TUNGKANG	120.44	22.46
28	東沙島	198	DONGSHADAO	116.69	20.70
29	蟳廣嘴	1496	SUNGUANGZUEI	120.71	21.99
30	南灣	1196	NANWAN	120.75	21.95
31	小琉球	1386	SIAOLIOUCHIOU	120.38	22.35
32	澎湖	1356	PENGHU	119.58	23.56
33	金門	1956	KINMEN	118.43	24.41
34	馬祖	1926	MATSU	119.94	26.16

Research Background and Motivation

- Current System Limitations
  - **15-km resolution** TWRF-2.0 atmospheric data is used for Central Weather Administration's COMCOT-SS forecast system.
  - Forecast accuracy for complex terrain and local meteorological phenomena requires improvement.
- Advantages of High-Resolution Data
  - **3-km resolution** enables more accurate capture of terrain effects on wind fields
  - Enhanced description of mountain blocking effects and canyon wind speed amplification phenomena

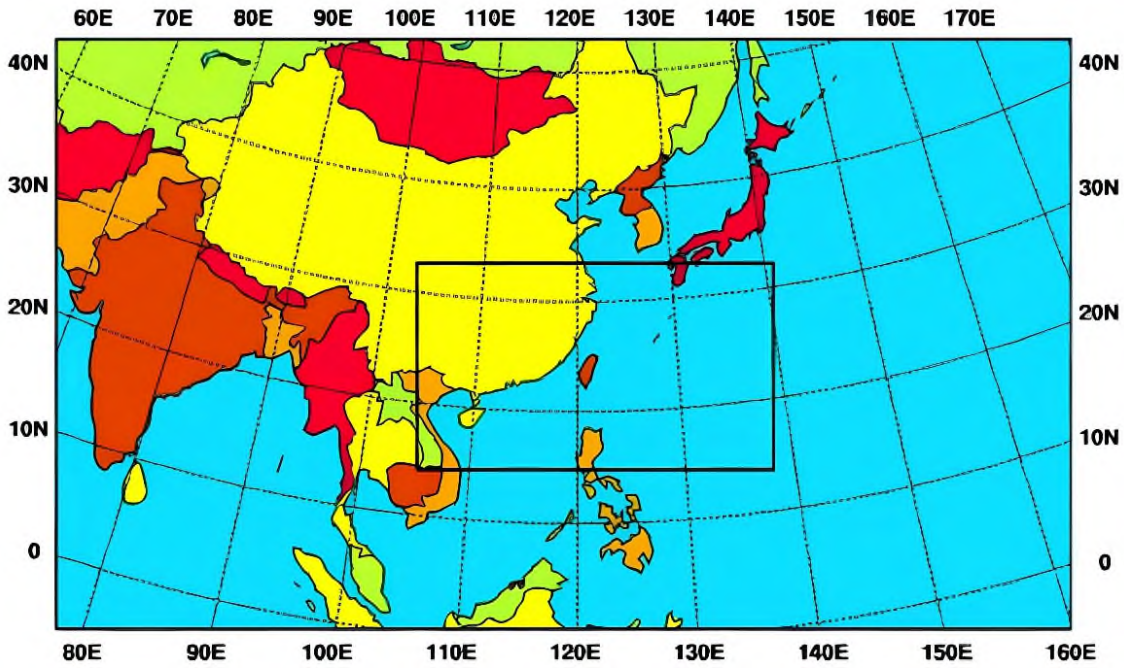
Case Study of Typhoon KONG-REY



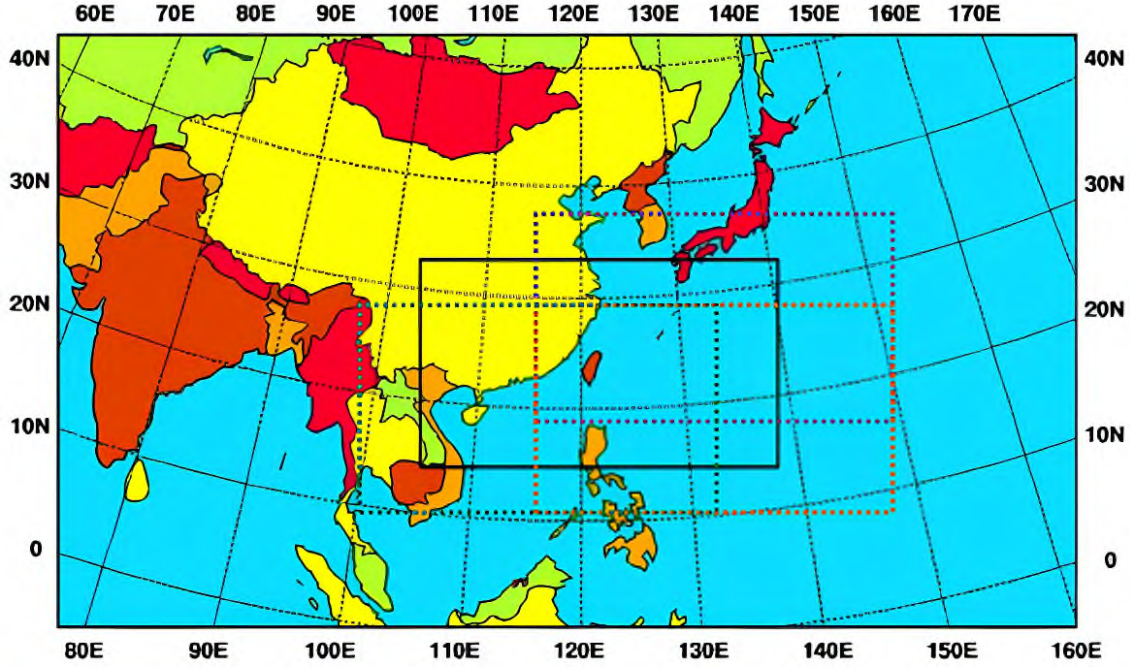
1. First strong typhoon to make landfall in late October in recorded history
2. Storm radius reached 320 km, largest in nearly 30 years
3. Significant terrain interaction effects

System Design and Data Source Selection

WRF_D vs TWRF System Comparison



WRF_D



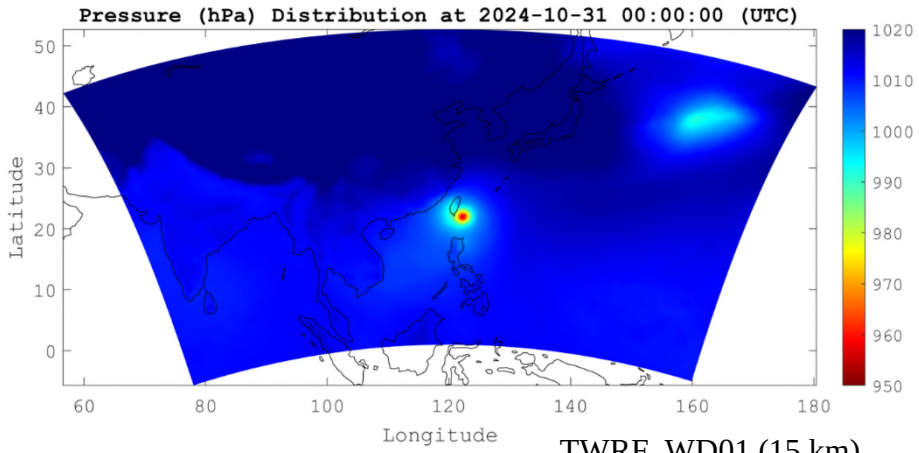
TWRF

1. WRF_D's fixed computational domain design better suits operational requirements
2. TWRF's dynamic computational domain increases operational workflow complexity
3. Considerations for data coverage completeness and predictability

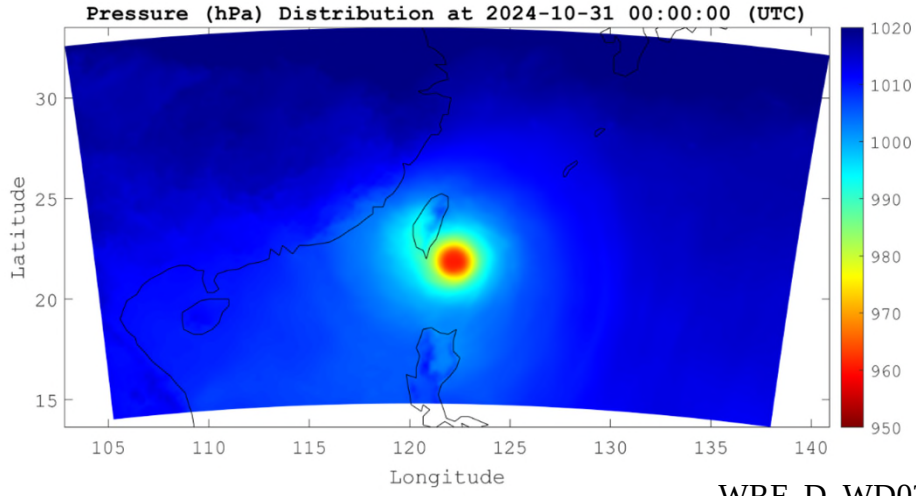
Evaluation of Atmospheric Input Enhancement (TWRF)

- **Analysis Field** (Initial Field) modeling
  - "best estimate" atmospheric state at a given time
  - Incorporates data assimilation from multiple observation sources
  - Updated every 6 hours with full data assimilation cycle
- **Forecast Field** (Predicted Field) modeling
  - Contains accumulated forecast errors that grow with lead time
  - Reflects real operational forecast conditions used in actual warnings
  - Subject to model physics limitations and initial condition uncertainties
- Operational **Timeliness Assessment**

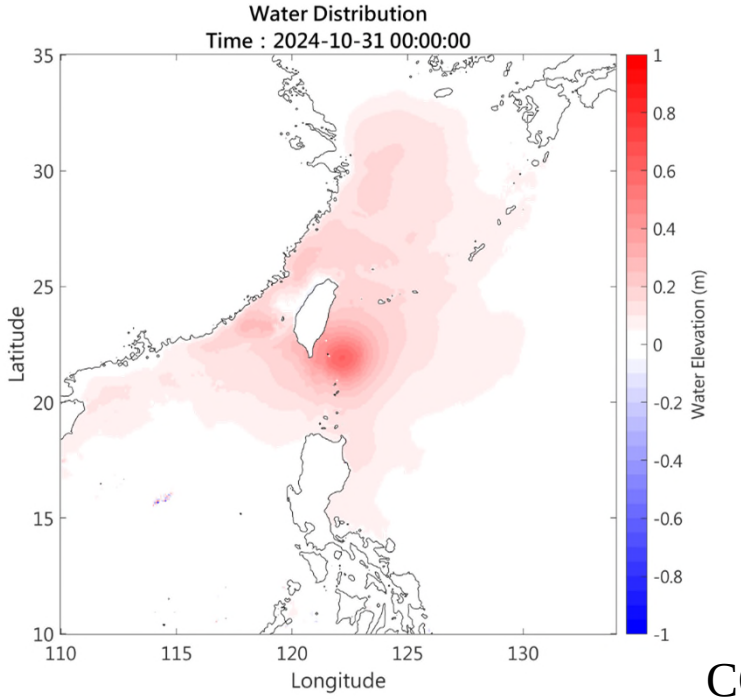
Computational Domain Adjustment for COMCOT-SS (1 km)

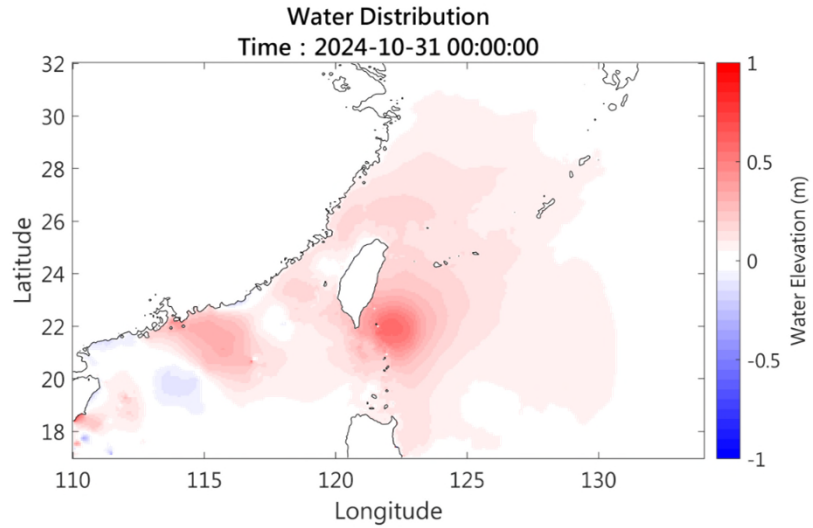


TWRF_WD01 (15 km)

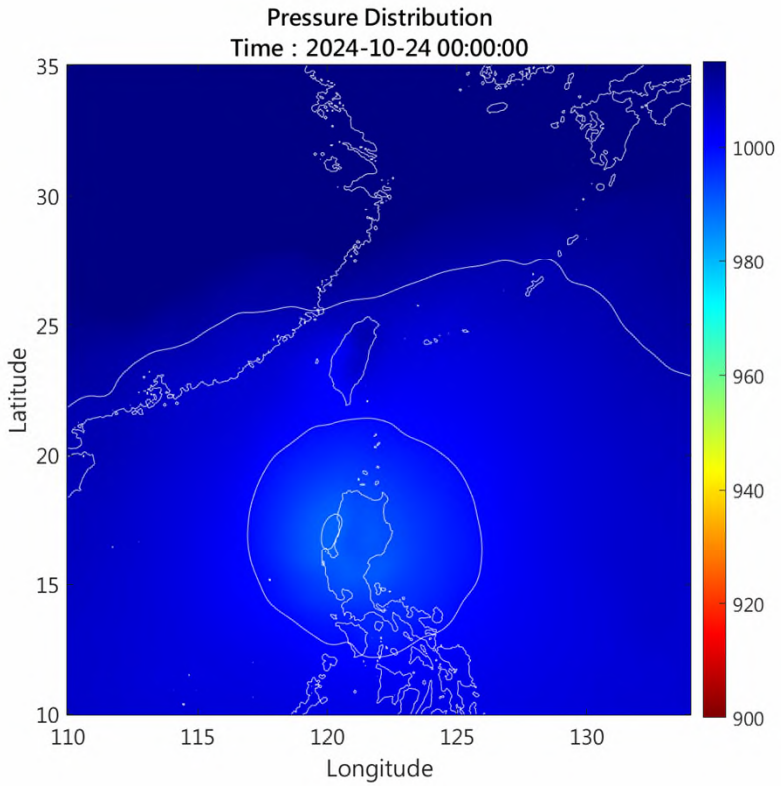


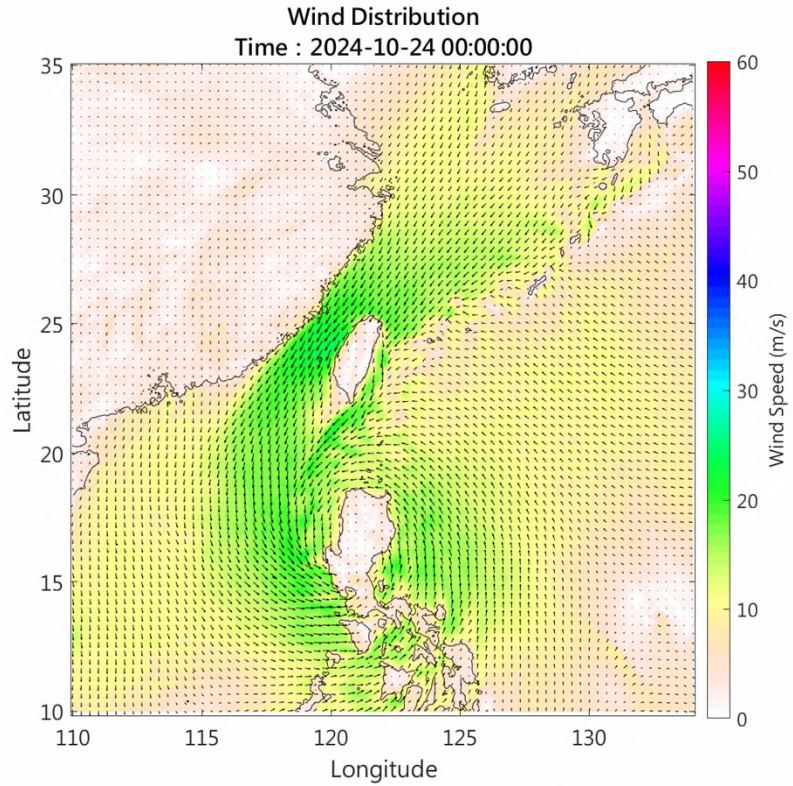
WRF_D_WD02 (3km)

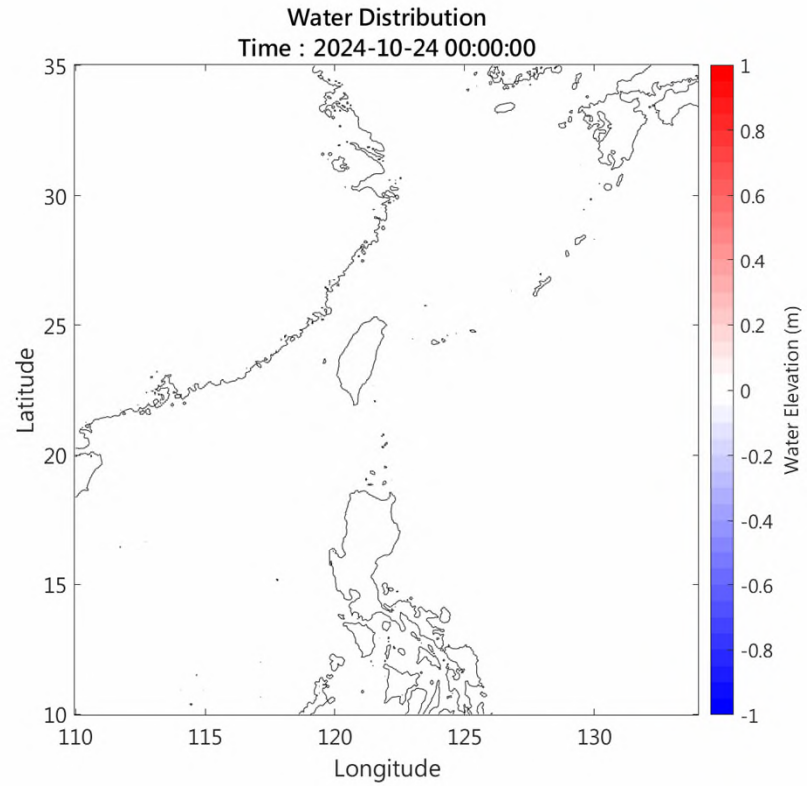




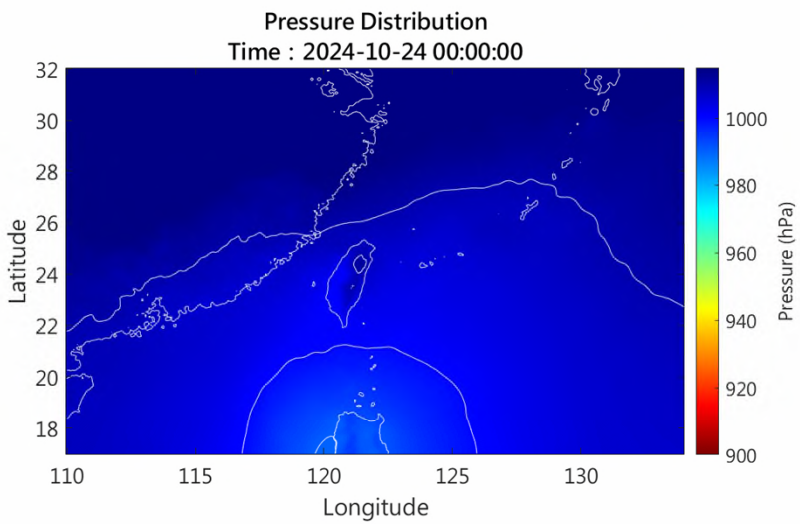
COMCOT-SS (layer01)

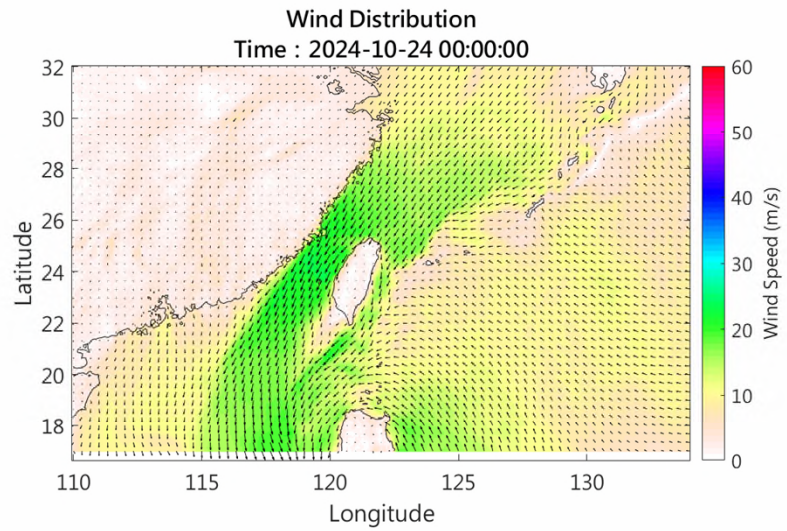


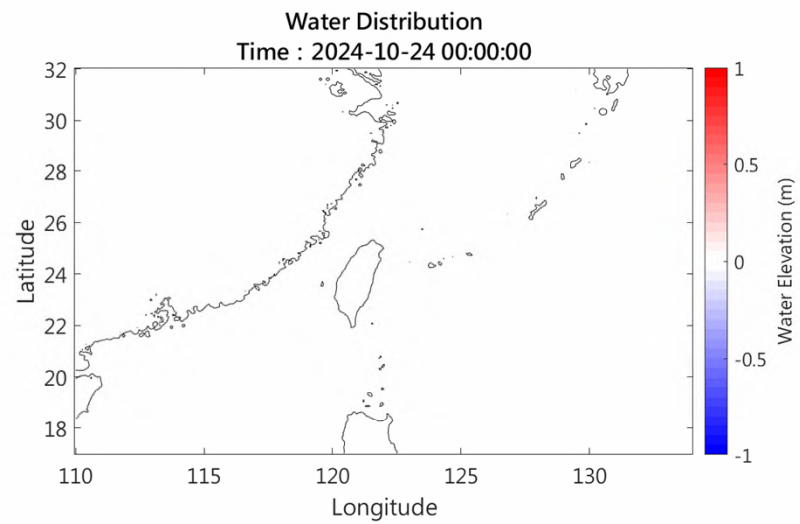




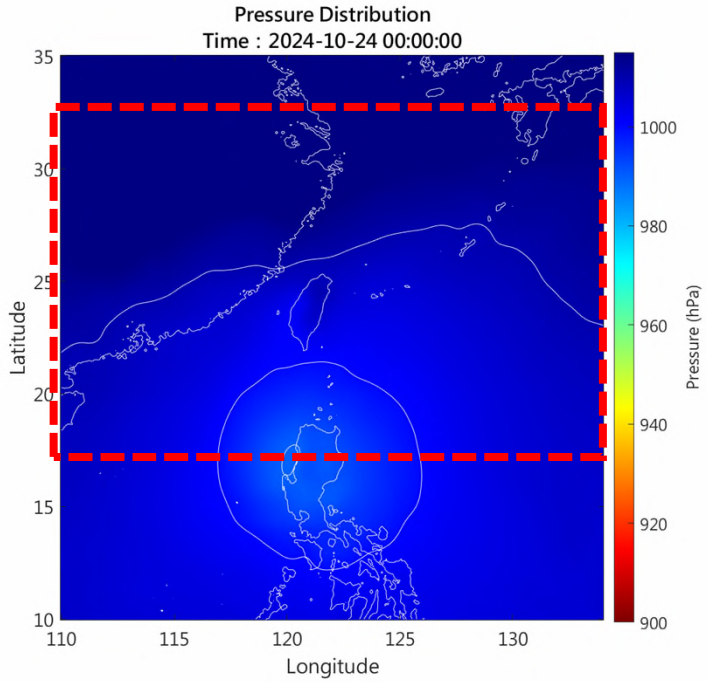
TWRF_WD01 (15 km)







WRF_D_WD02 (3km)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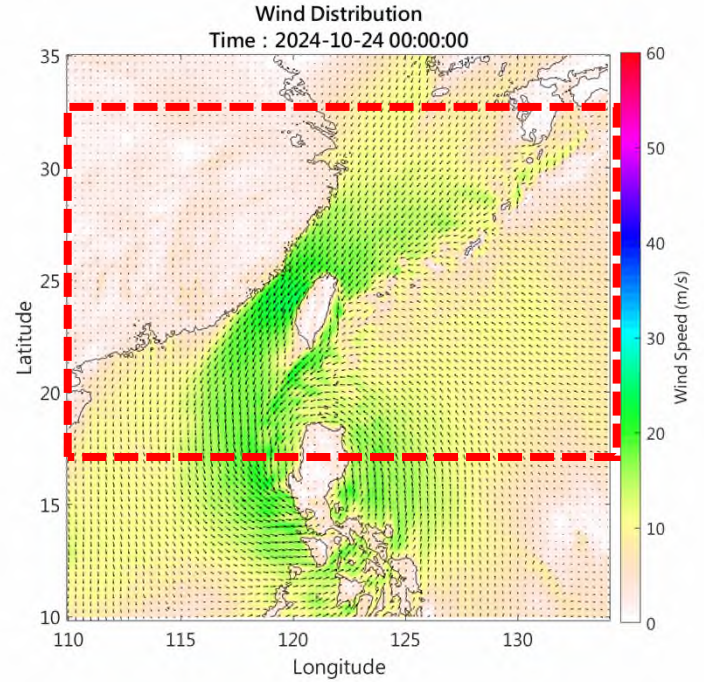
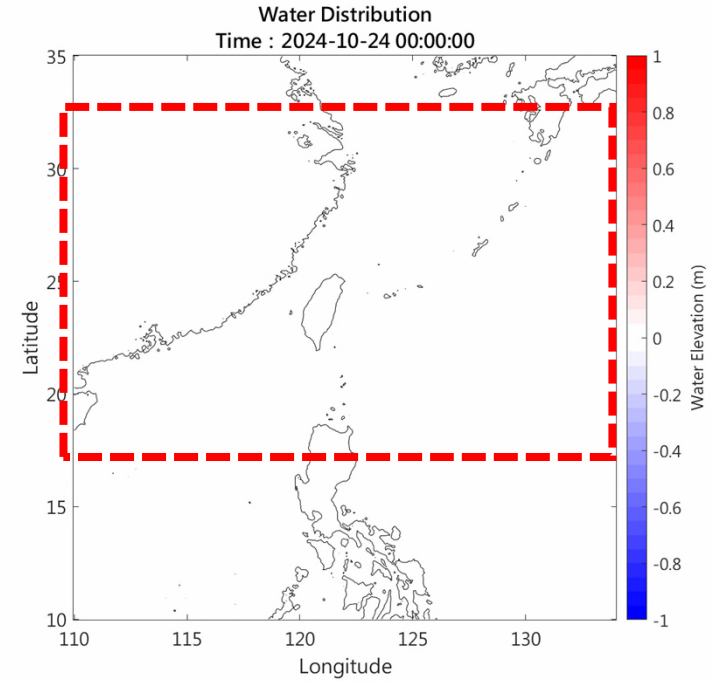
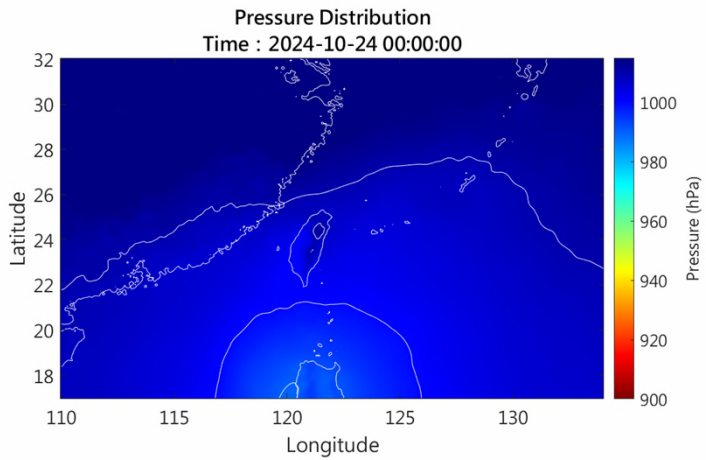
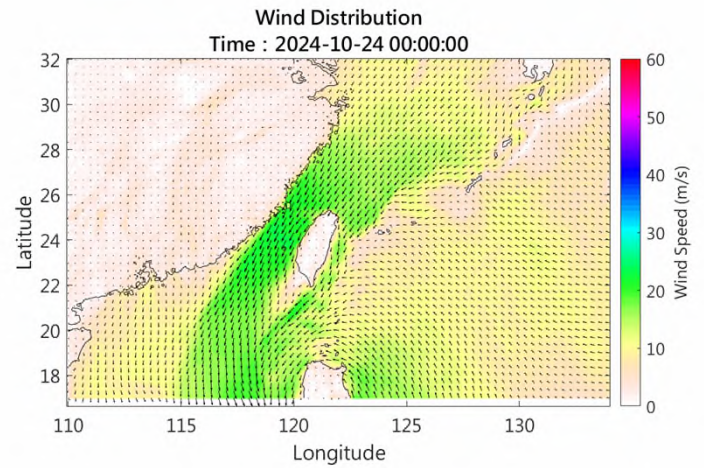
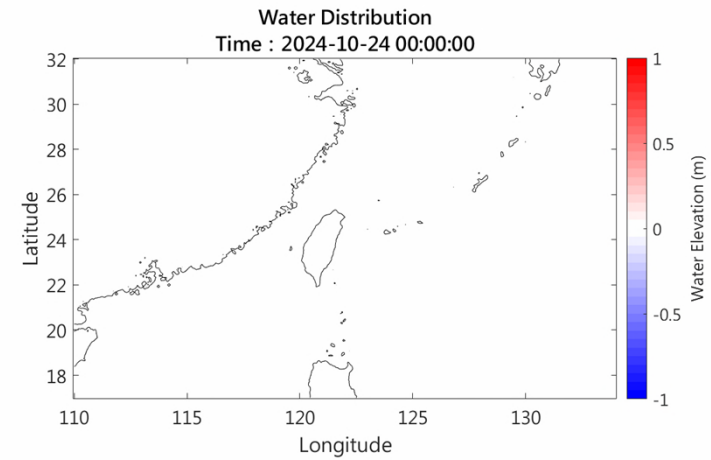
Latitude
Longitude
Pressure (hPa)
35
30
25
20
15
10
110
115
120
125
130
1000
980
960
940
920
900

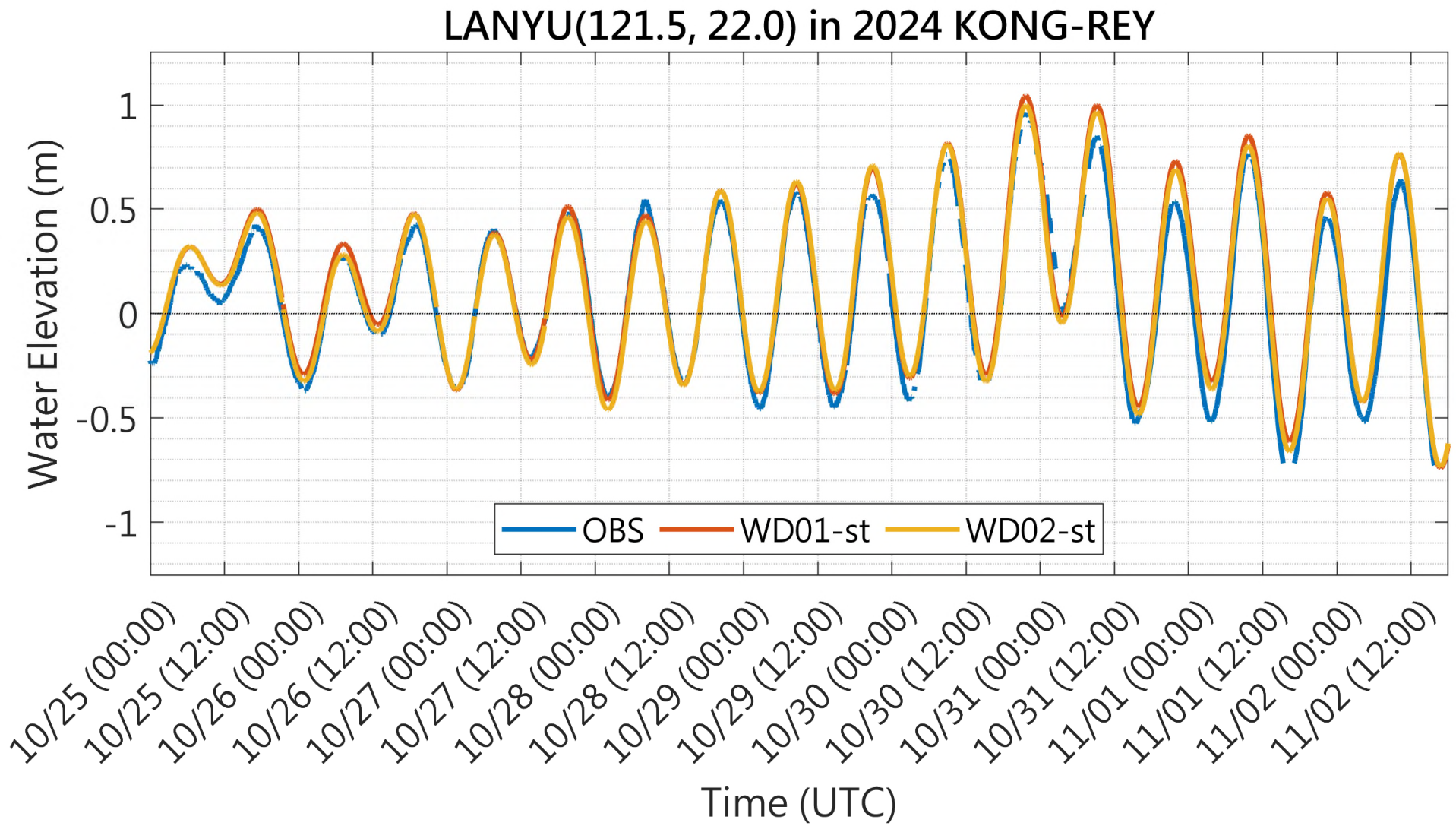

Wind Distribution
Time : 2024-10-24 00:00:00
Latitude
Longitude
Wind Speed (m/s)
35
30
25
20
15
10
110
115
120
125
130
60
50
40
30
20
10
0

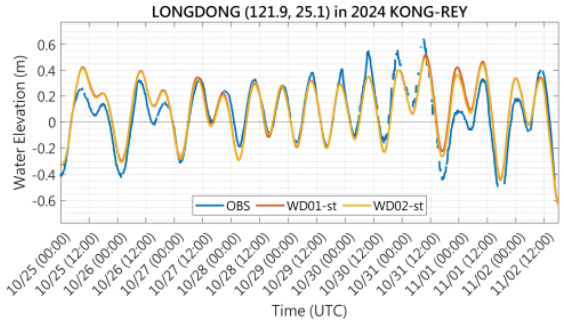

Water Distribution
Time : 2024-10-24 00:00:00
Latitude
Longitude
Water Elevation (m)
35
30
25
20
15
10
110
115
120
125
130
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

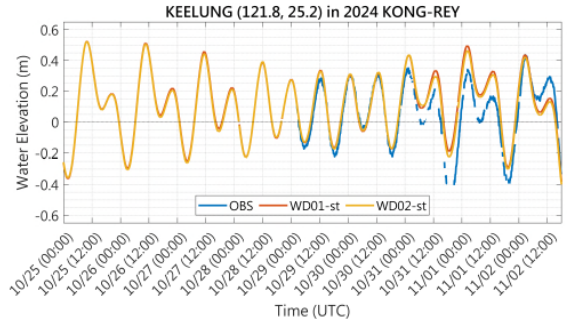

Pressure Distribution
Time : 2024-10-24 00:00:00
Latitude
Longitude
Pressure (hPa)
32
30
28
26
24
22
20
18
110
115
120
125
130
1000
980
960
940
920
900

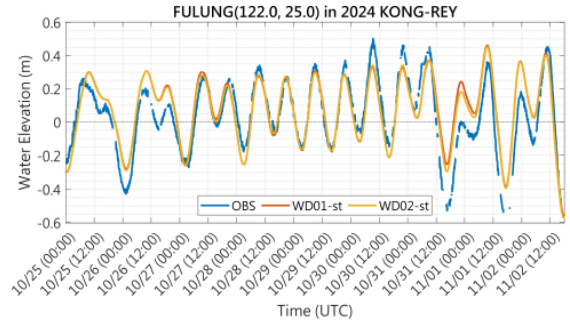

Wind Distribution
Time : 2024-10-24 00:00:00
Latitude
Longitude
Wind Speed (m/s)
32
30
28
26
24
22
20
18
110
115
120
125
130
60
50
40
30
20
10
0

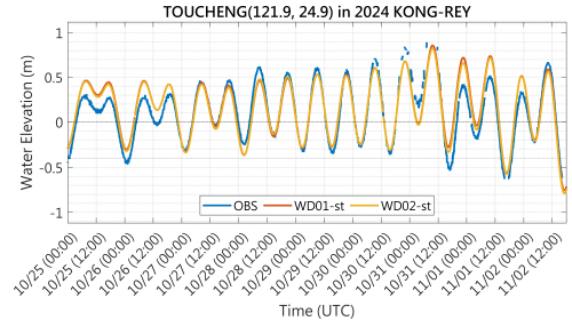

Water Distribution
Time : 2024-10-24 00:00:00
Latitude
Longitude
Water Elevation (m)
32
30
28
26
24
22
20
18
110
115
120
125
130
1
0.5
0
-0.5
-1

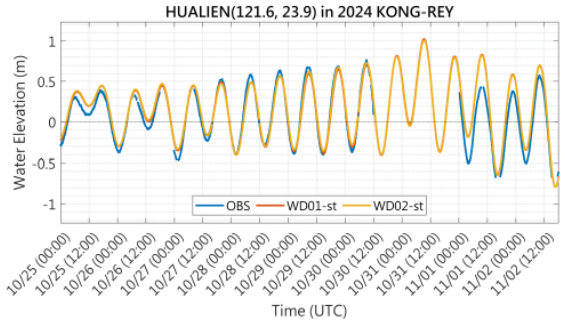

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
1
0.5
0
-0.5
-1
OBS
WD01-st
WD02-st
10/25 (00:00)
10/25 (12:00)
10/26 (00:00)
10/26 (12:00)
10/27 (00:00)
10/27 (12:00)
10/28 (00:00)
10/28 (12:00)
10/29 (00:00)
10/29 (12:00)
10/30 (00:00)
10/30 (12:00)
10/31 (00:00)
10/31 (12:00)
11/01 (00:00)
11/01 (12:00)
11/02 (00:00)
11/02 (12:00)
Time (UTC)

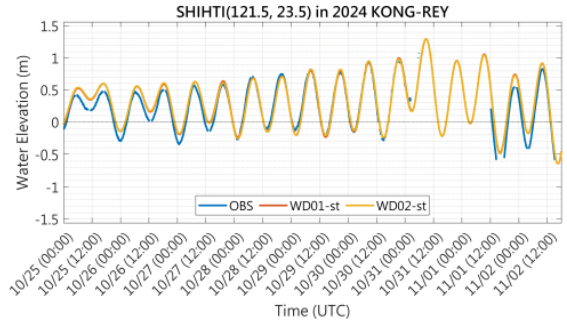

LONGDONG (121.9, 25.1) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

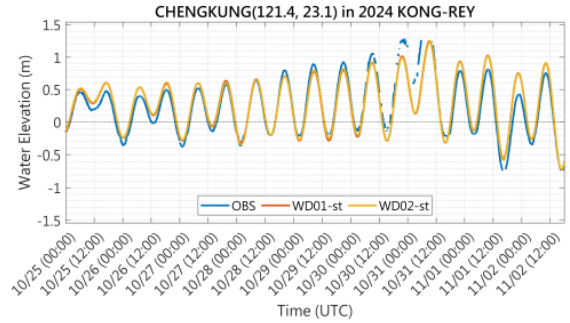

KEELUNG (121.8, 25.2) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

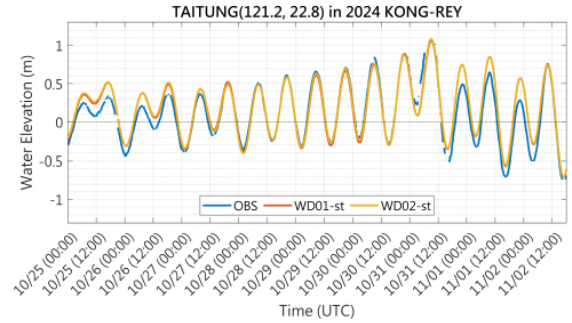

FULUNG(122.0, 25.0) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

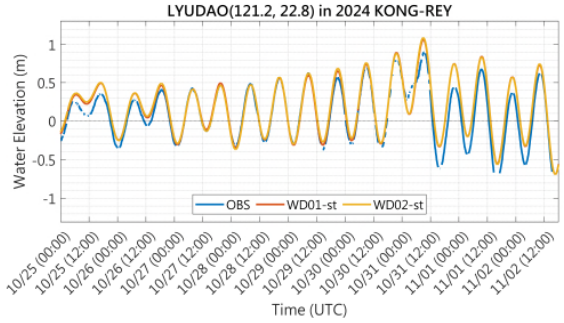

TOUCHENG(121.9, 24.9) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

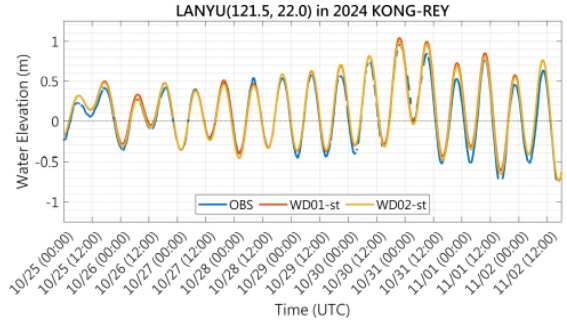

HUALIEN(121.6, 23.9) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

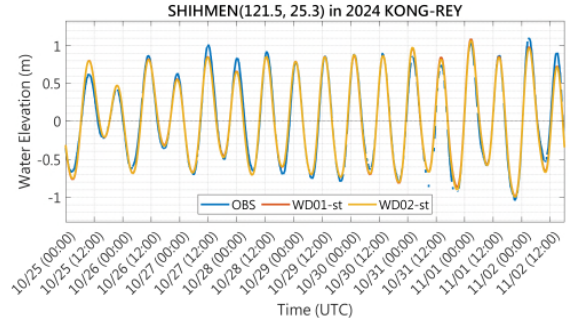

SHIHTI(121.5, 23.5) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

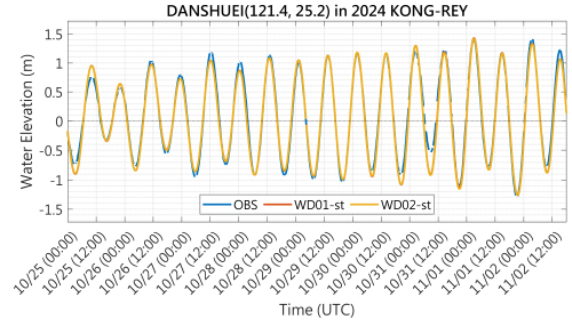

CHENGKUNG(121.4, 23.1) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

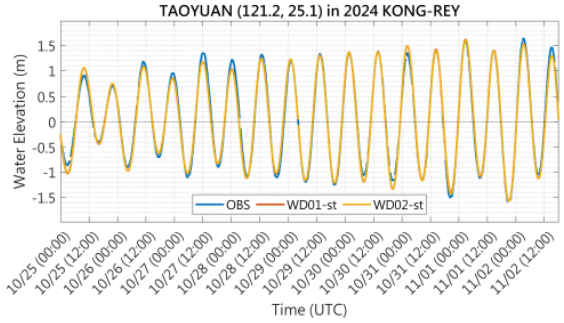

TAITUNG(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

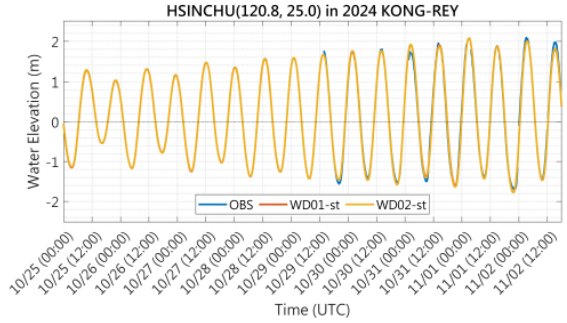

LYUDAO(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

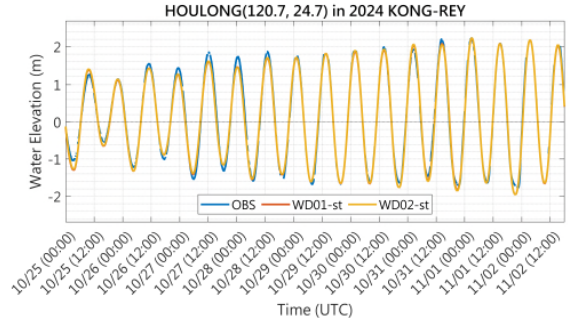

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

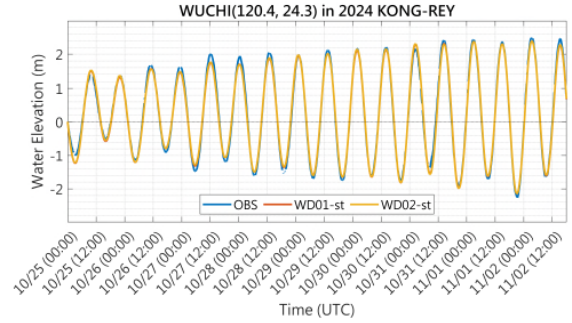

SHIHMEN(121.5, 25.3) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

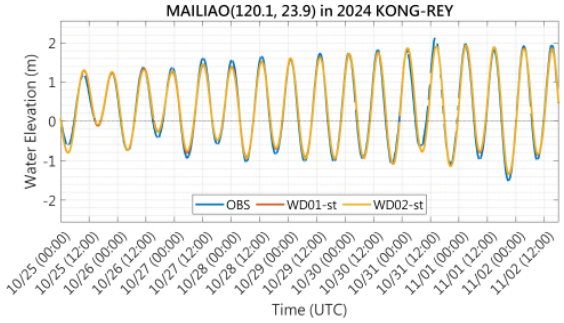

DANSHUEI(121.4, 25.2) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

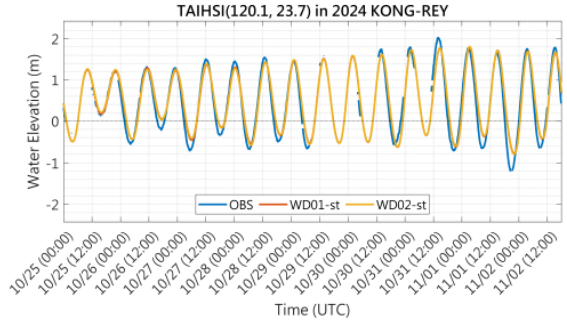

TAOYUAN (121.2, 25.1) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

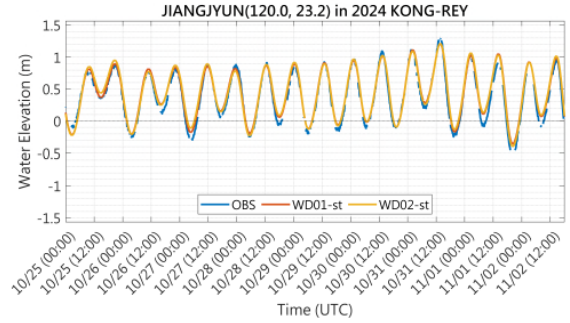

HSINCHU(120.8, 25.0) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

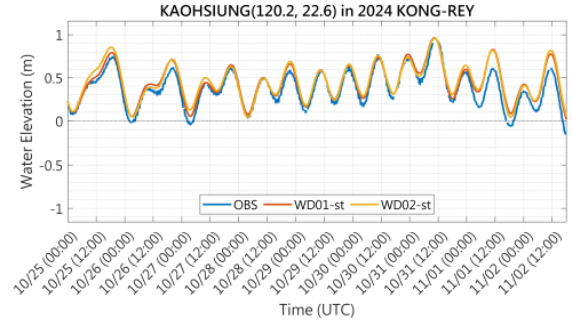

HOULONG(120.7, 24.7) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

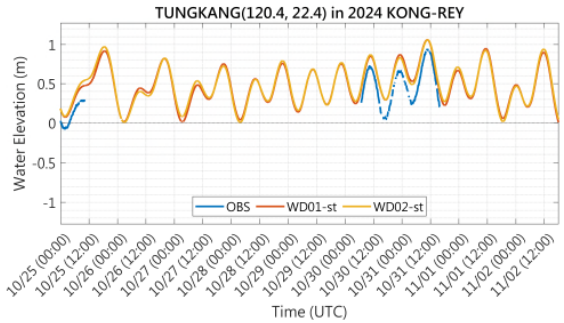

WUCHI(120.4, 24.3) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

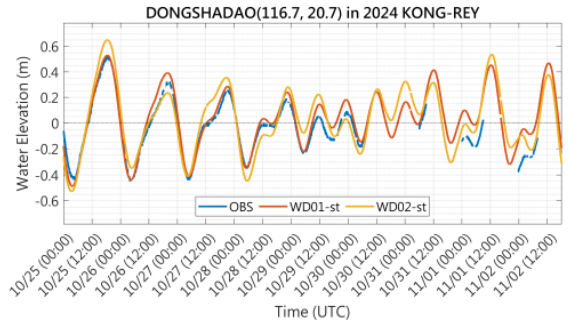

MAILIAO(120.1, 23.9) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

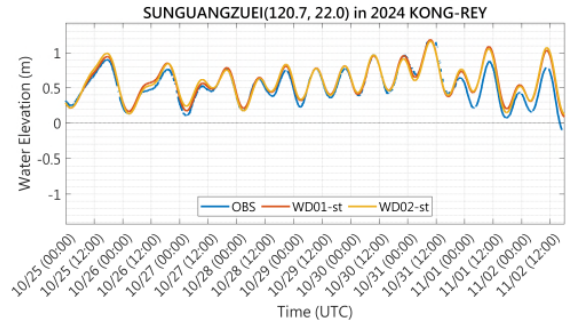

TAIHSI(120.1, 23.7) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

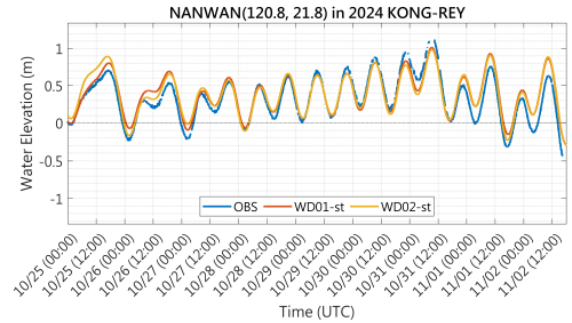

JIANGJYUN(120.0, 23.2) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

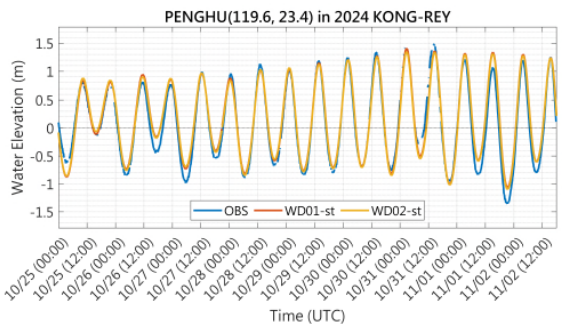

KAOHSIUNG(120.2, 22.6) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

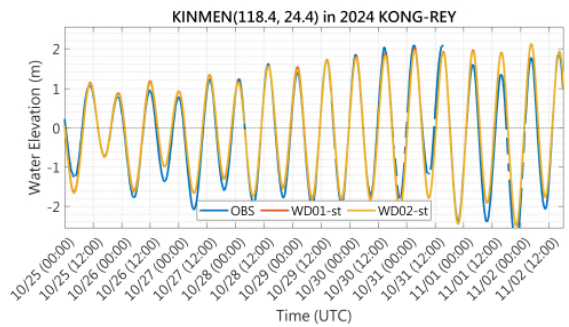

TUNGKANG(120.4, 22.4) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

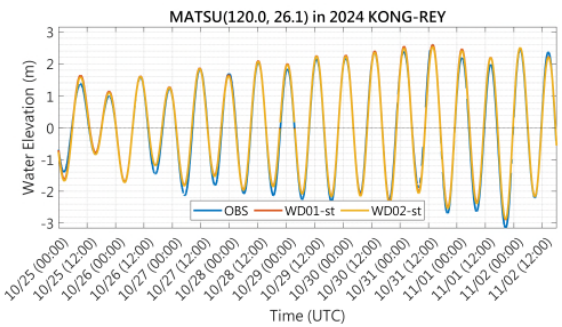

DONGSHADAO(116.7, 20.7) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

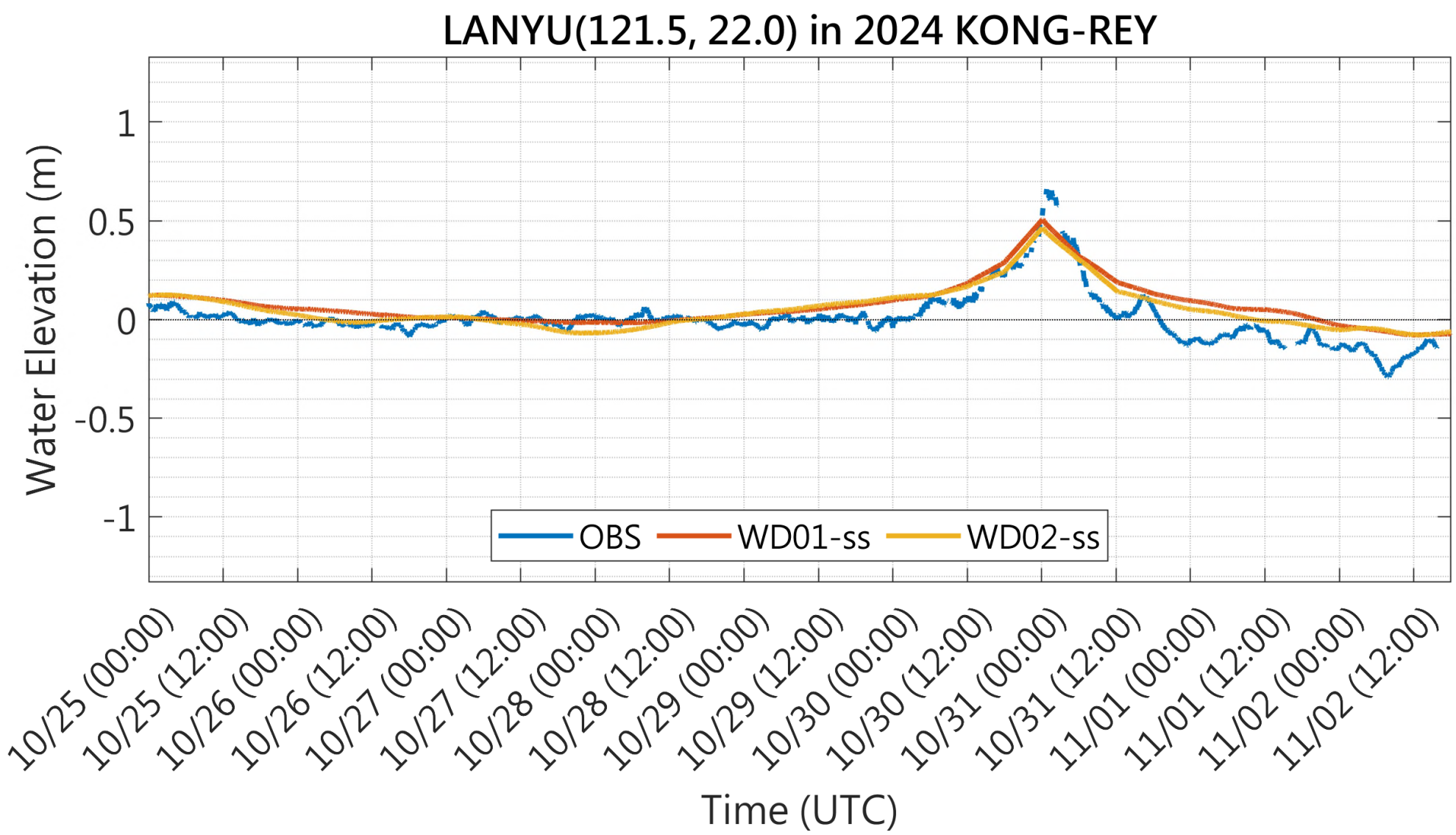

SUNGUANGZUEI(120.7, 22.0) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

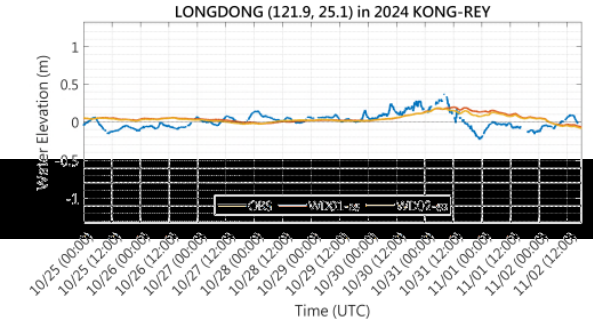

NANWAN(120.8, 21.8) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

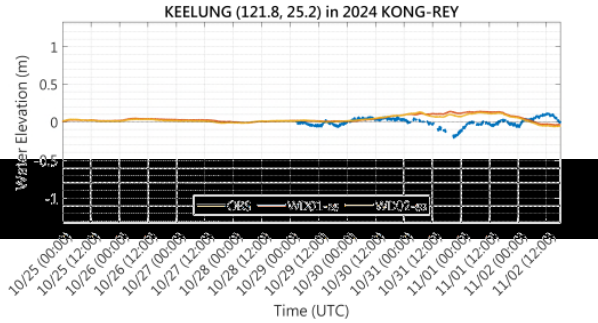

PENGHU(119.6, 23.4) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

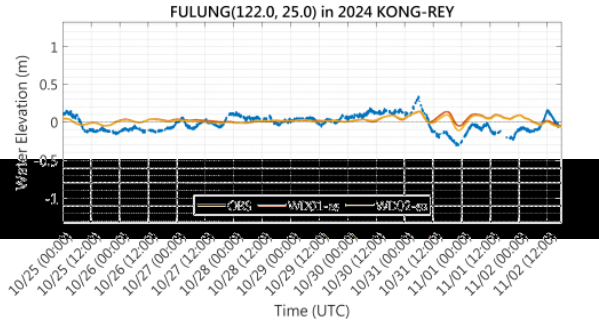

KINMEN(118.4, 24.4) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

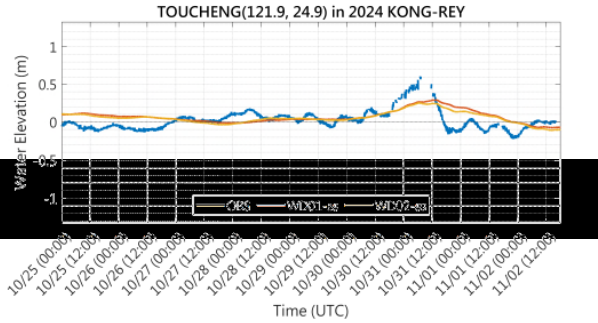

MATSU(120.0, 26.1) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01-st
WD02-st
Time (UTC)

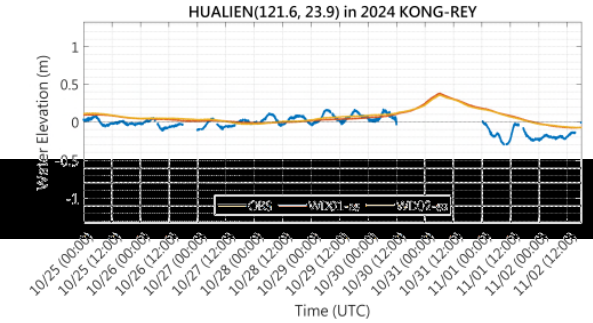

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
1
0.5
0
-0.5
-1
OBS
WD01-ss
WD02-ss
10/25 (00:00)
10/25 (12:00)
10/26 (00:00)
10/26 (12:00)
10/27 (00:00)
10/27 (12:00)
10/28 (00:00)
10/28 (12:00)
10/29 (00:00)
10/29 (12:00)
10/30 (00:00)
10/30 (12:00)
10/31 (00:00)
10/31 (12:00)
11/01 (00:00)
11/01 (12:00)
11/02 (00:00)
11/02 (12:00)
Time (UTC)

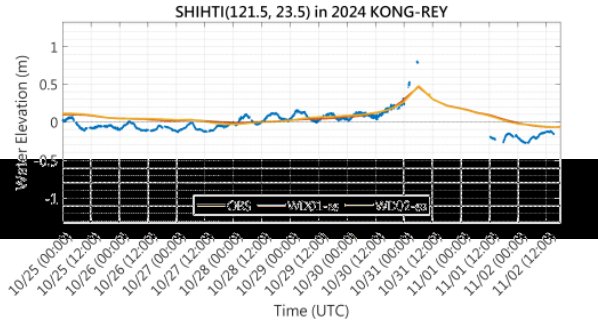

LONGDONG (121.9, 25.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

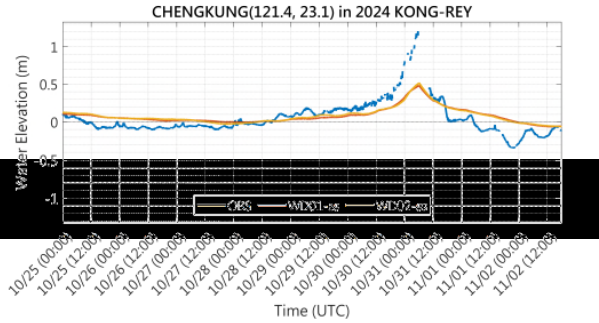

KEELUNG (121.8, 25.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

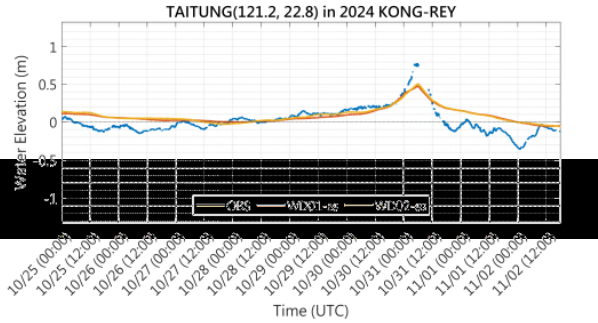

FULUNG(122.0, 25.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

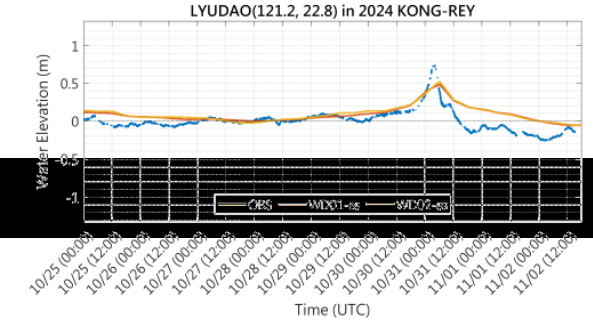

TOUCHENG(121.9, 24.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

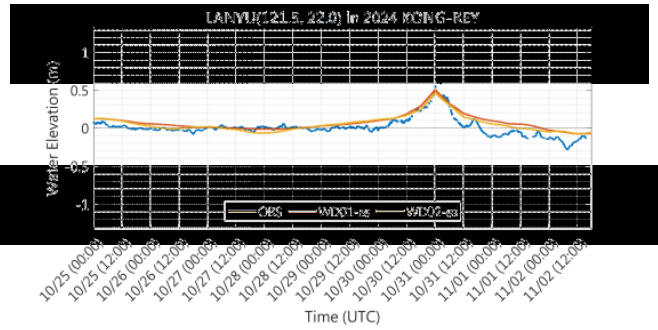

HUALIEN(121.6, 23.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

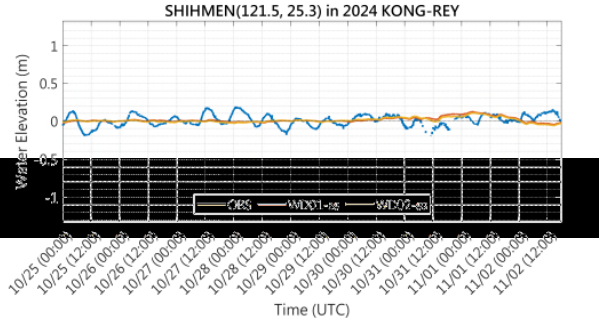

SHIHTI(121.5, 23.5) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

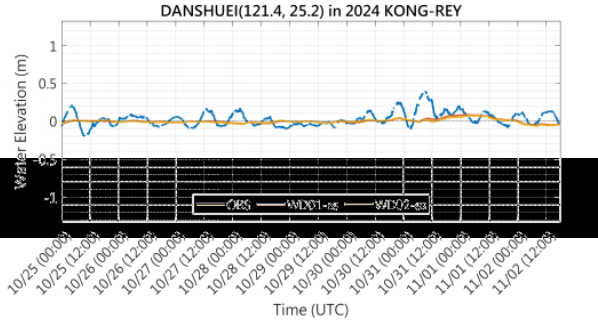

CHENGKUNG(121.4, 23.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

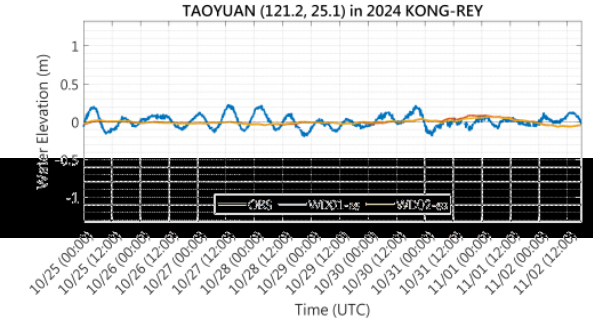

TAITUNG(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

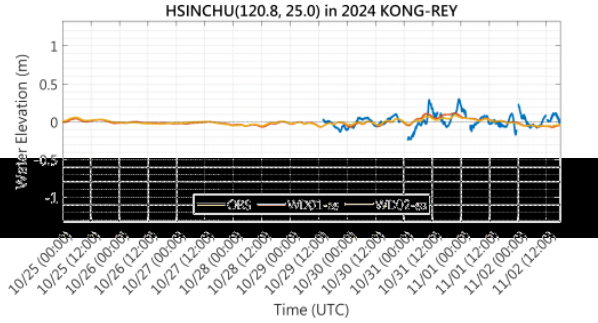

LYUDAO(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

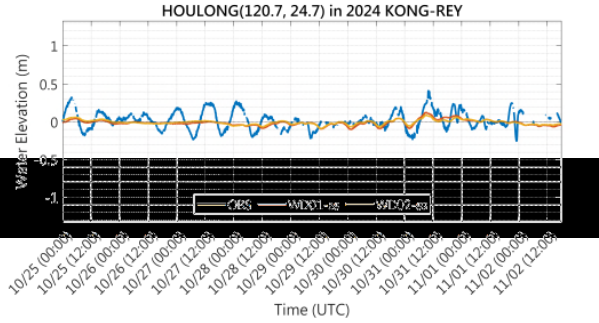

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

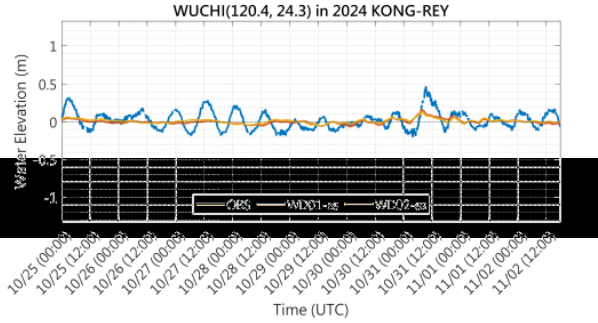

SHIHMEN(121.5, 25.3) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

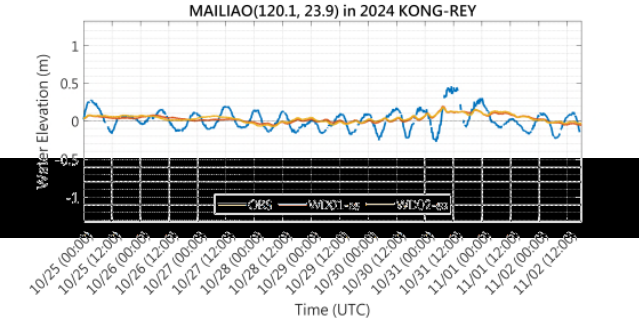

DANSHUEI(121.4, 25.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

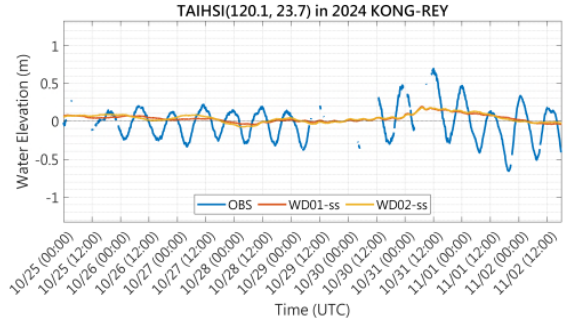

TAOYUAN (121.2, 25.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

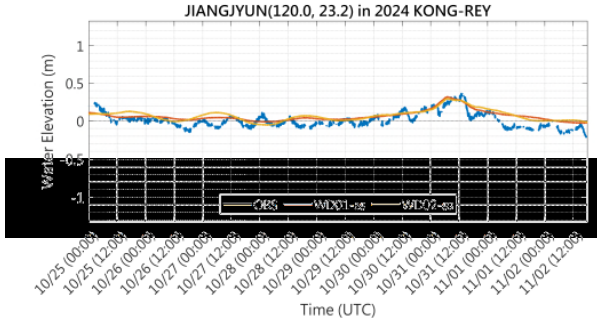

HSINCHU(120.8, 25.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

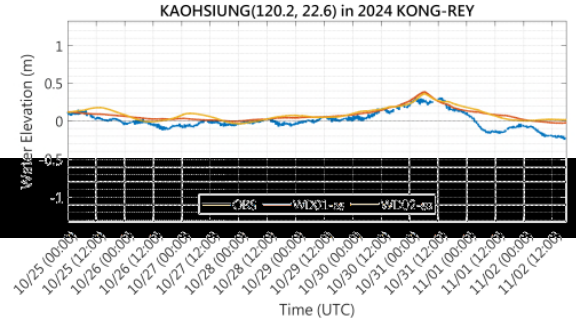

HOULONG(120.7, 24.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

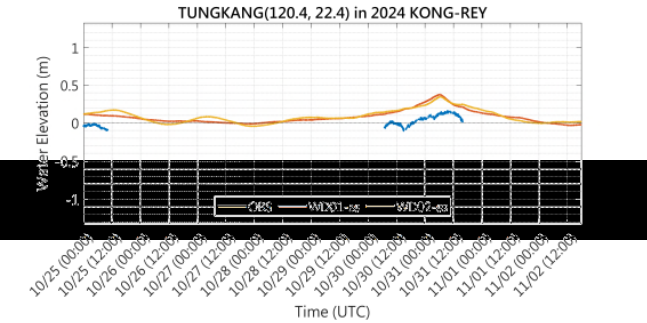

WUCHI(120.4, 24.3) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WL001-ss
WL002-ss

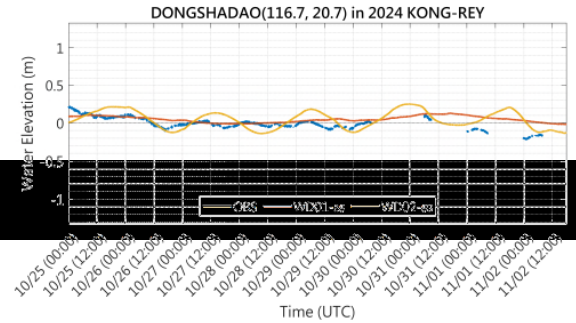

MAILIAO(120.1, 23.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

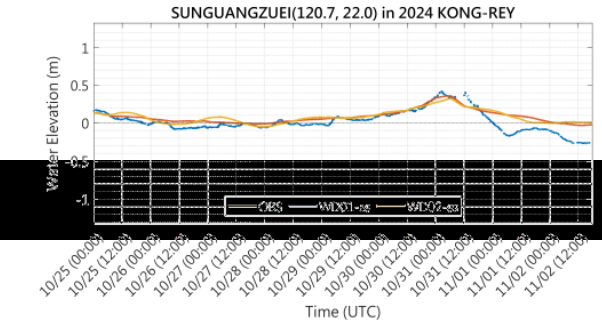

TAIHSI(120.1, 23.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

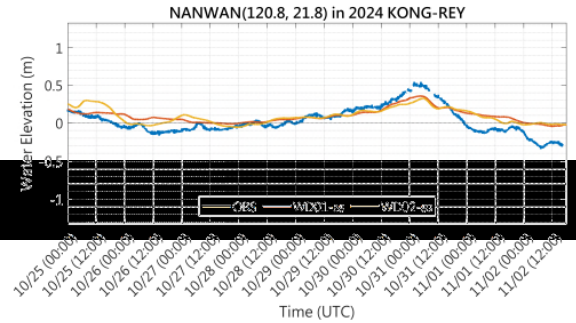

JIANGJYUN(120.0, 23.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

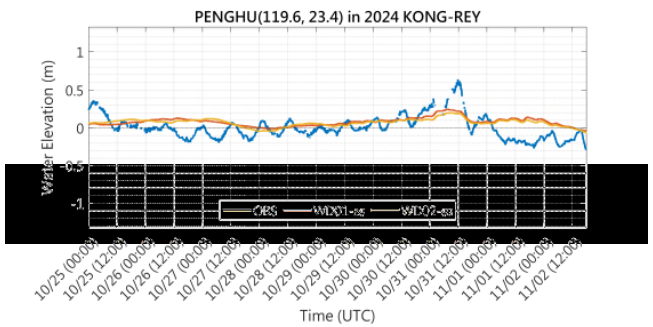

KAOHSIUNG(120.2, 22.6) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

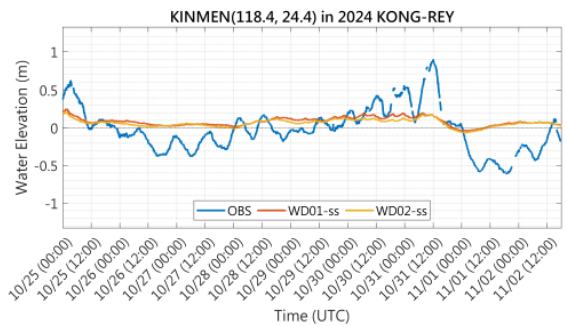

TUNGKANG(120.4, 22.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

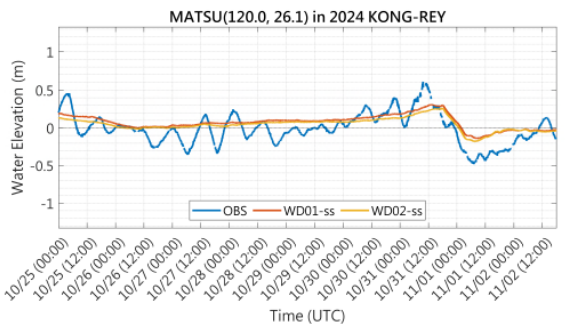

DONGSHADAO(116.7, 20.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss


SUNGUANGZUEI(120.7, 22.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

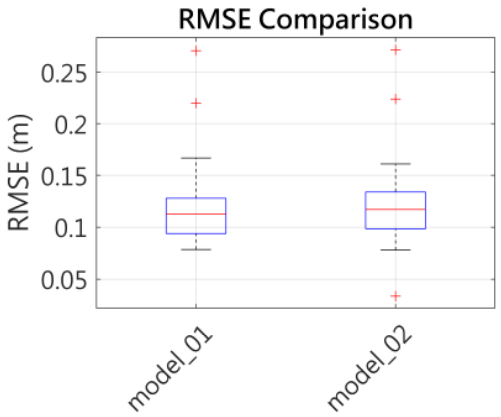

NANWAN(120.8, 21.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

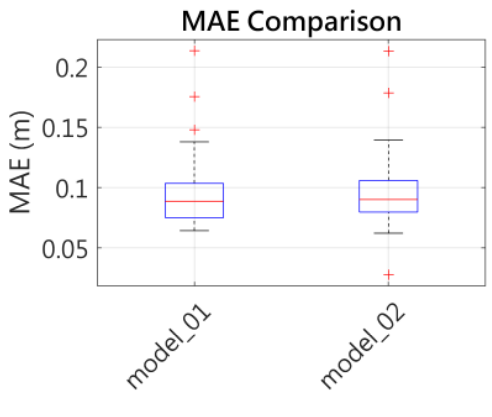

PENGHU(119.6, 23.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

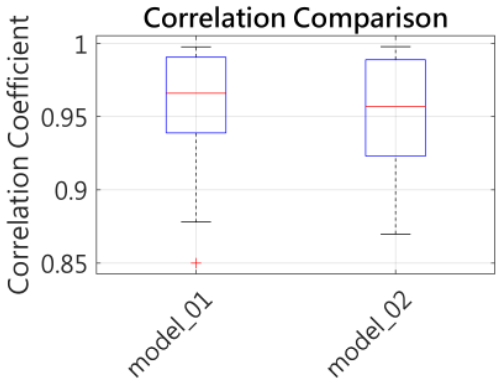

KINMEN(118.4, 24.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

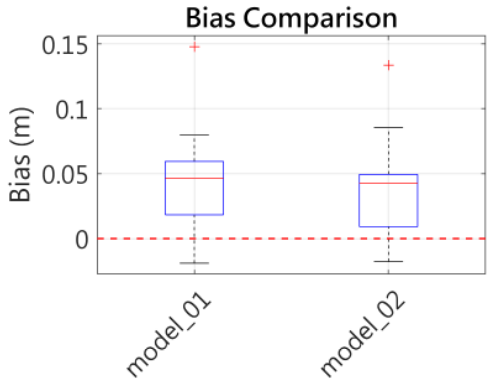

MATSU(120.0, 26.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01-ss
WD02-ss

Statistical Parameter Comparison

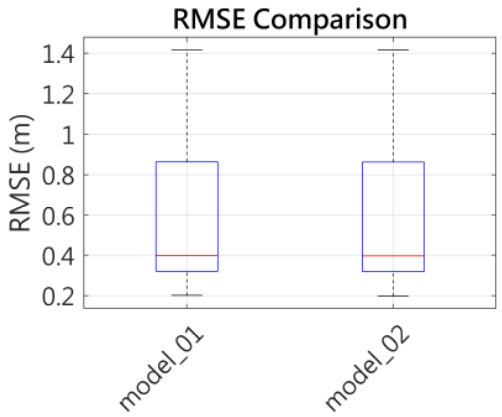


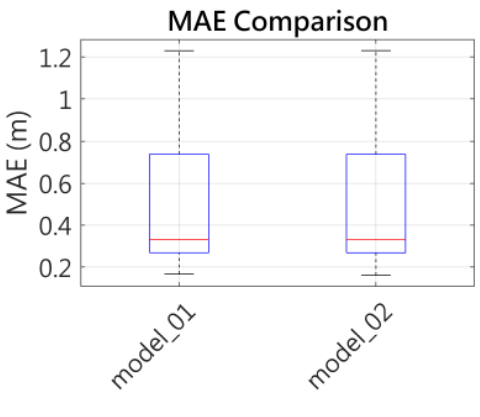


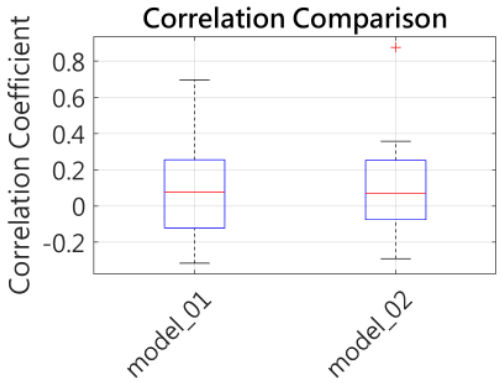


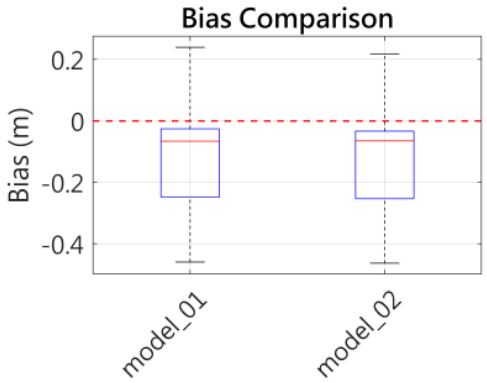


總水位（Storm Tide）



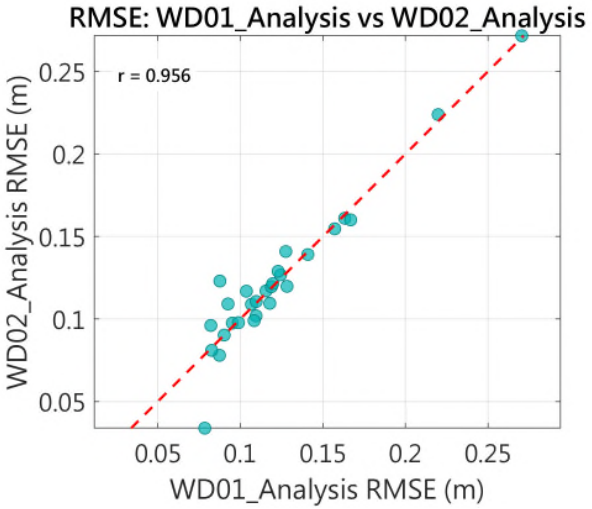


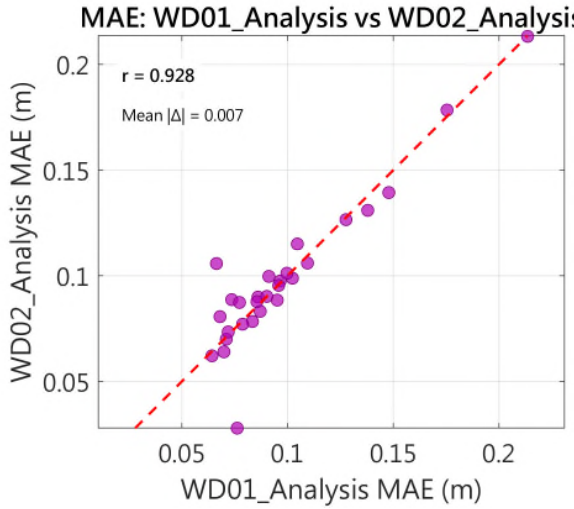


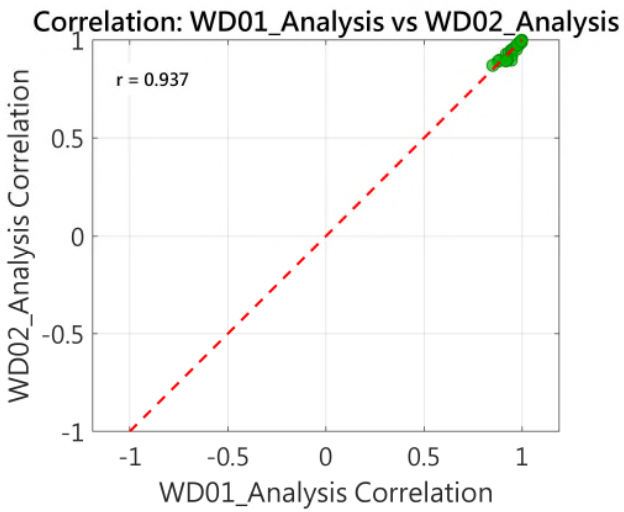


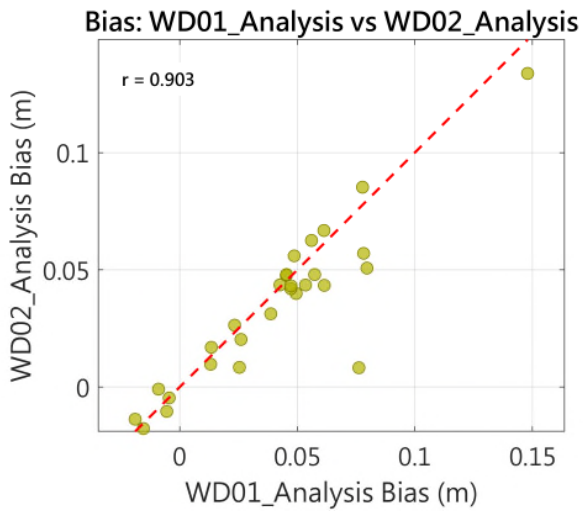
暴潮水位（Storm Surge）

Statistical Parameter Comparison

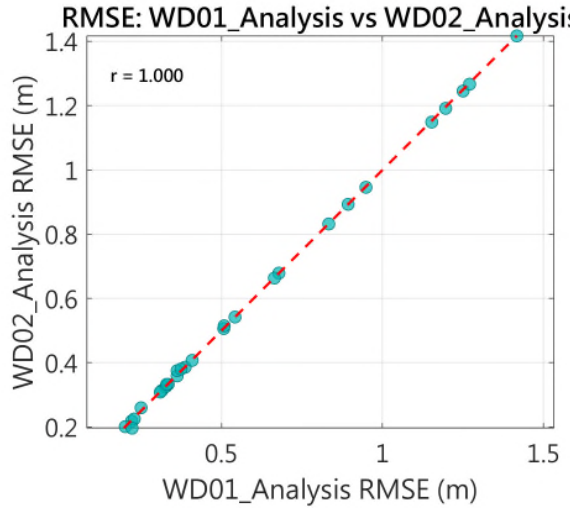


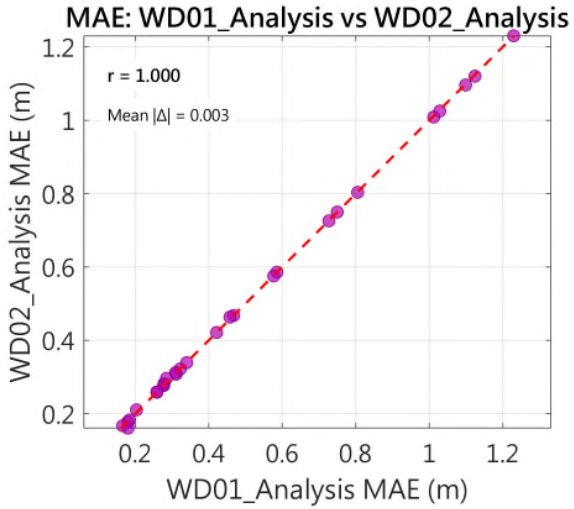


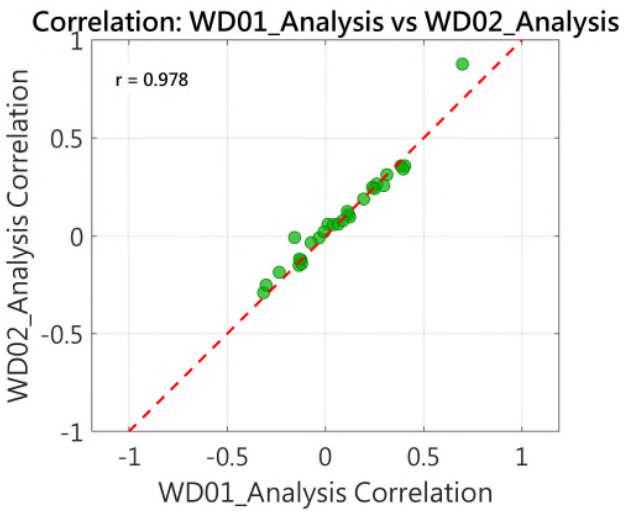


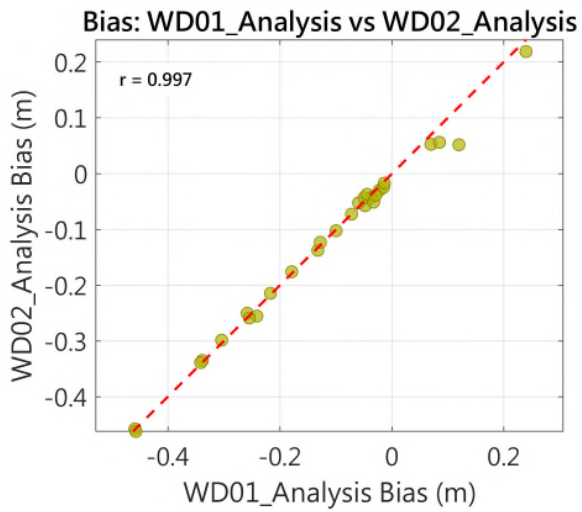


總水位（Storm Tide）



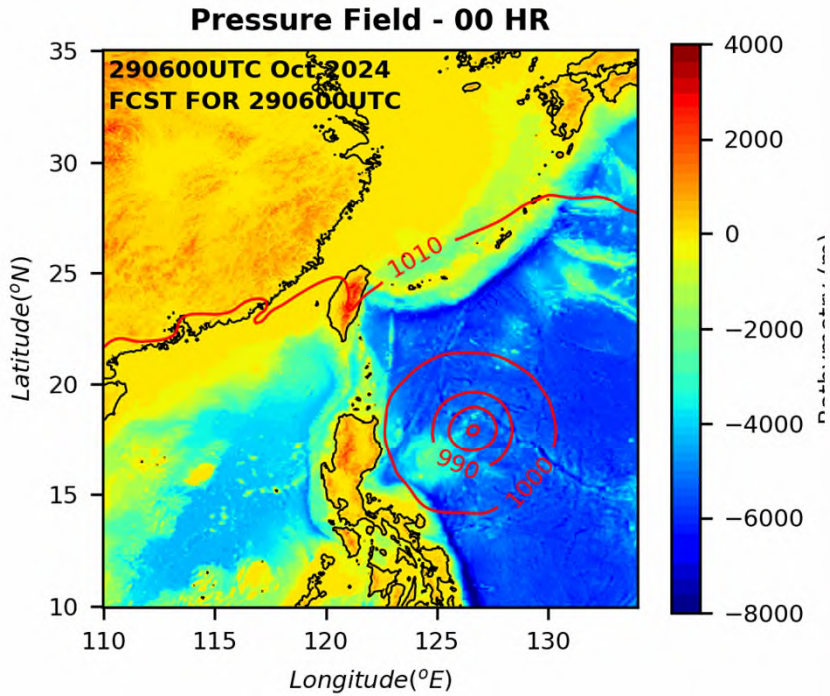


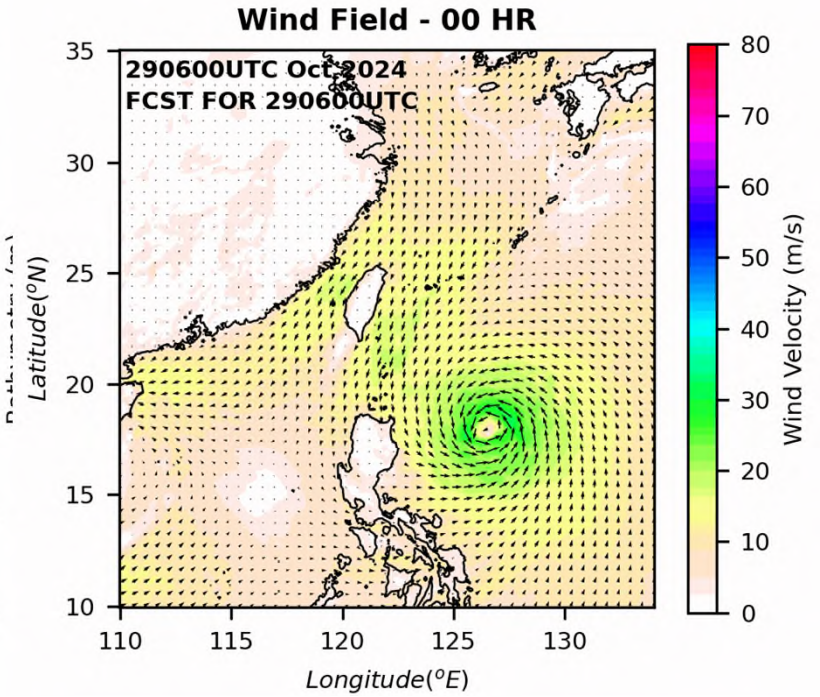


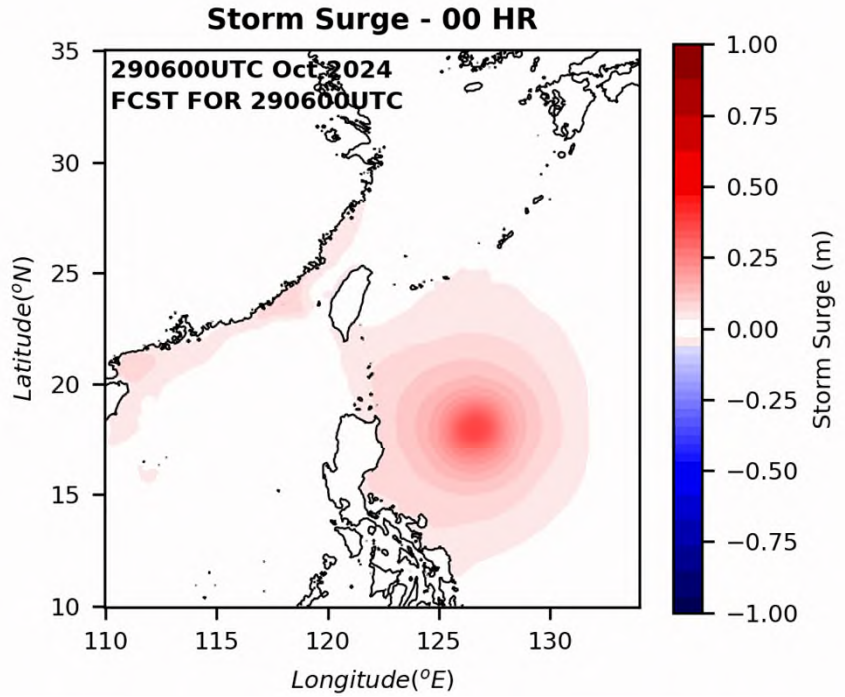


暴潮水位（Storm Surge）

Forecast Results: 2024/10/29 06:00(UTC)

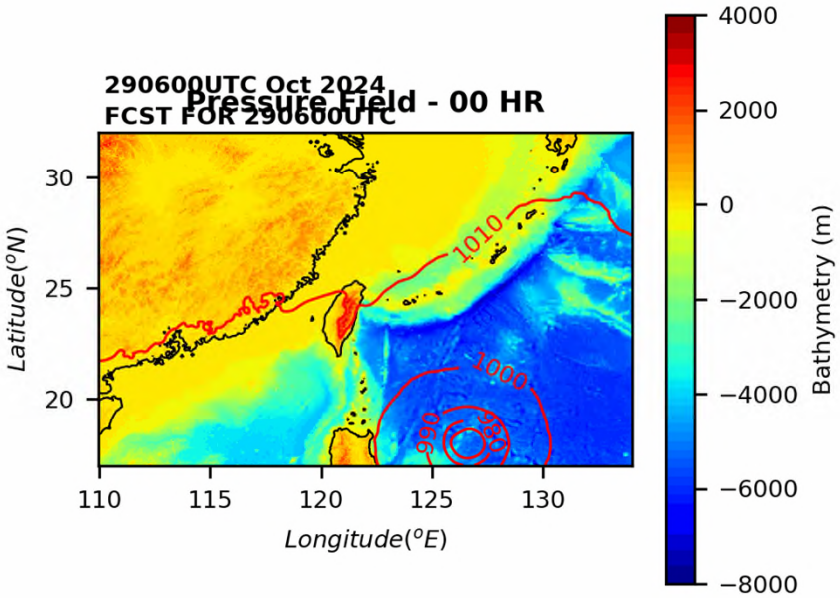


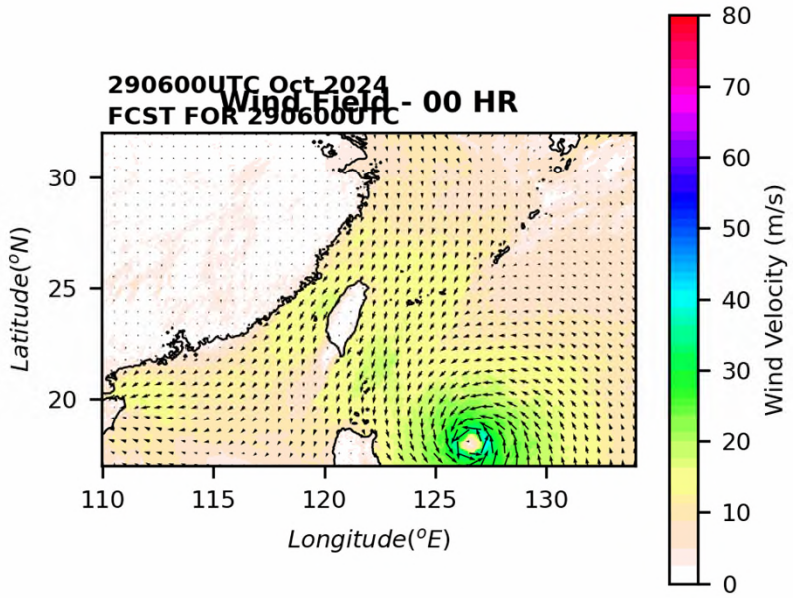


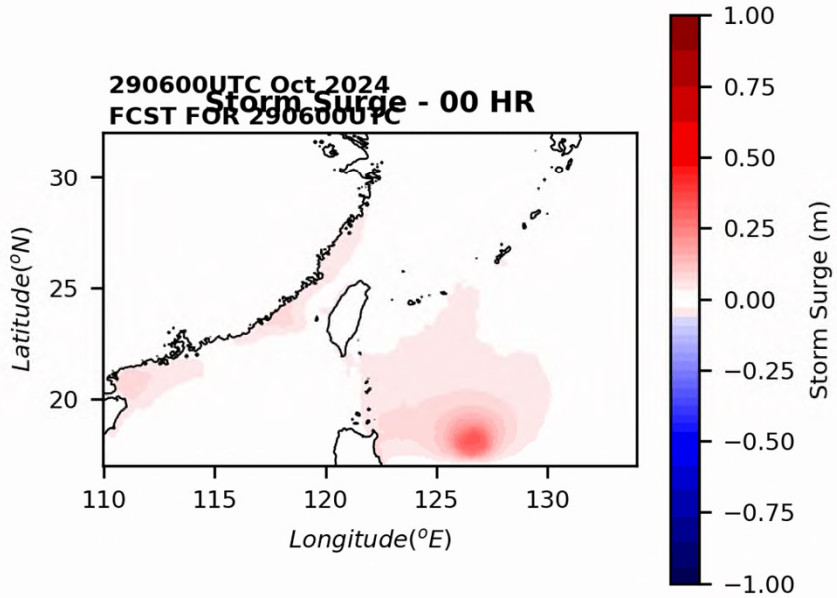


TWRF_WD01 (15 km)

Forecast Results: 2024/10/29 06:00(UTC)

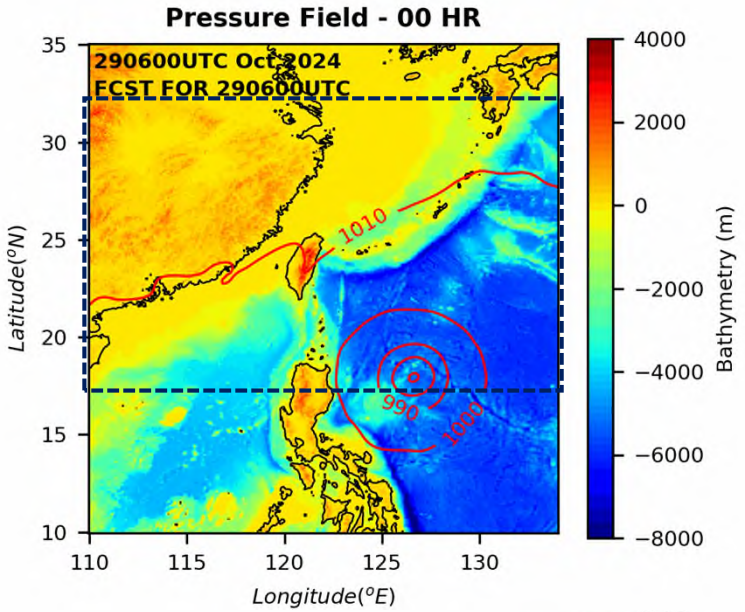


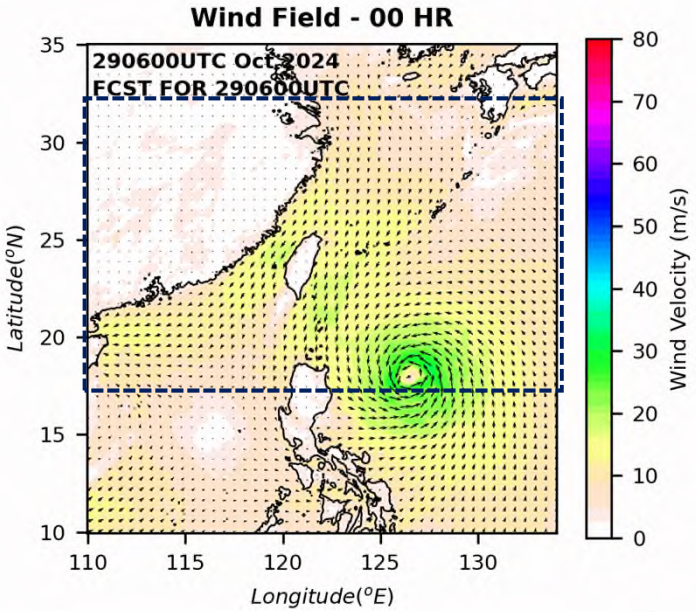


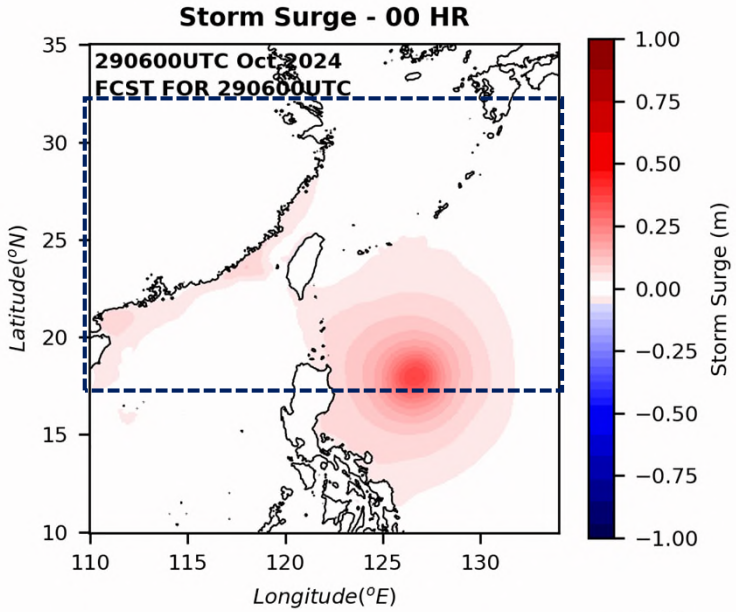


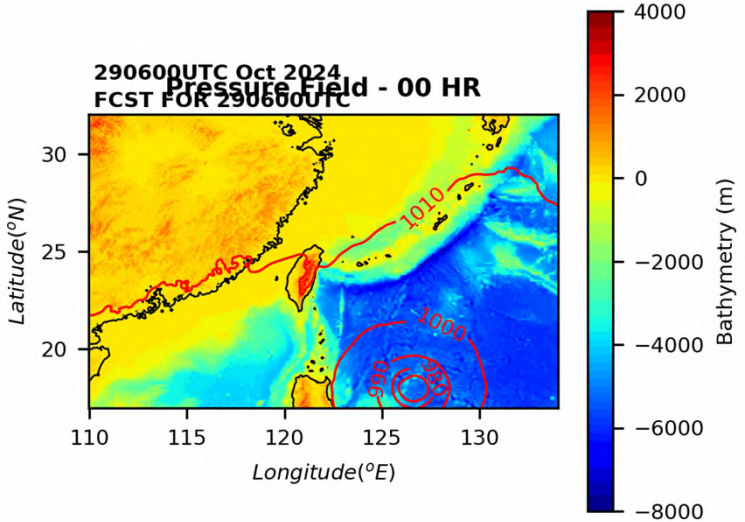
WRF_D_WD02 (3km)

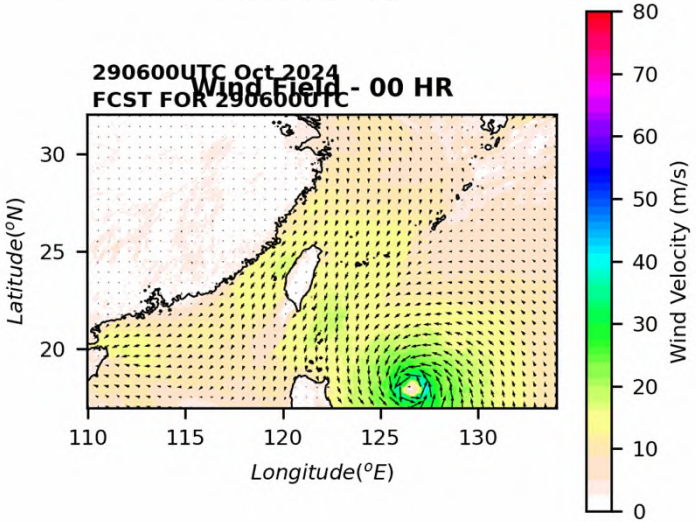
Forecast Results: 2024/10/29 06:00(UTC)

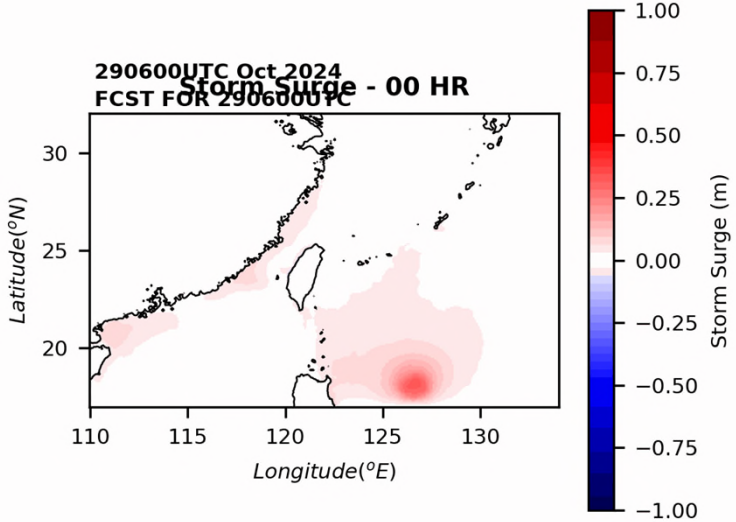






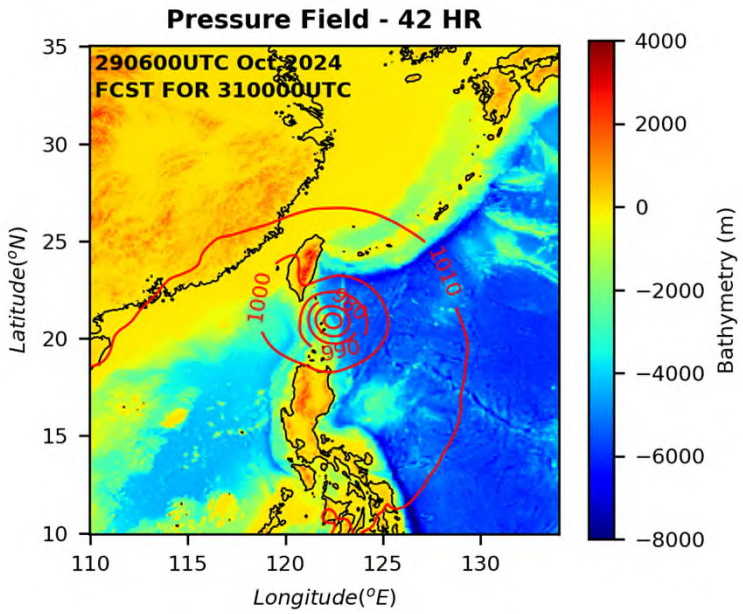


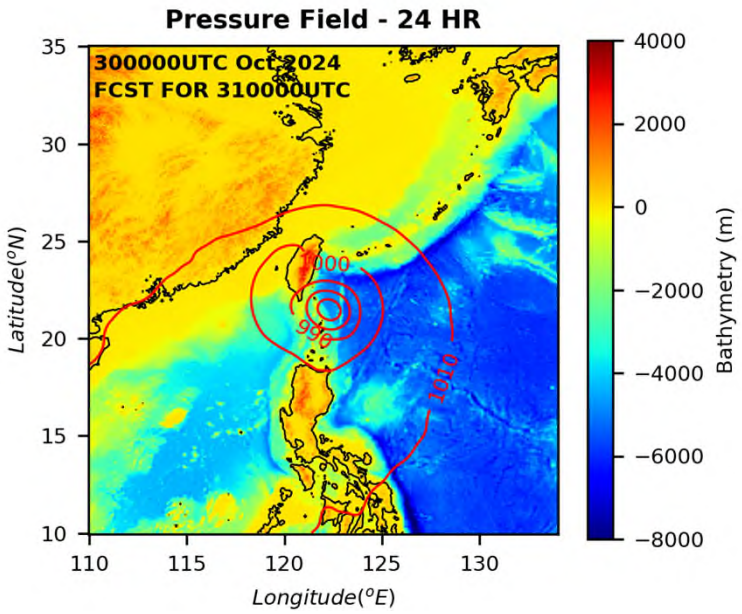


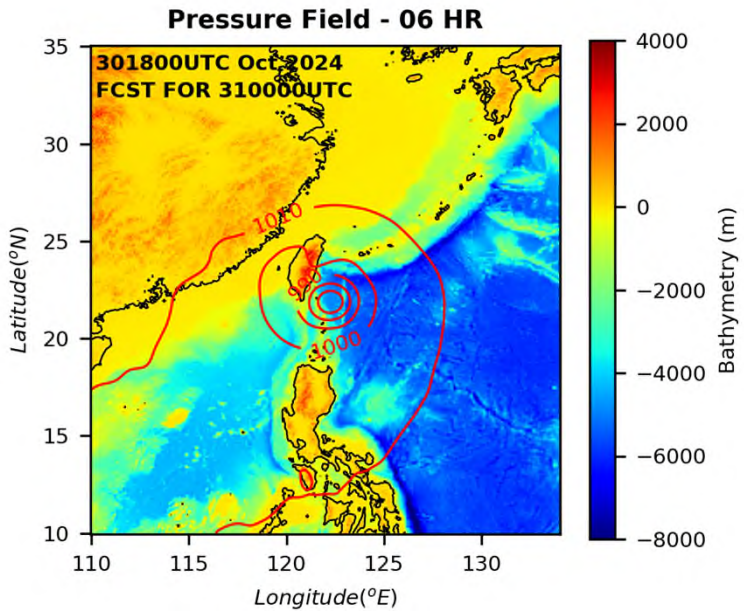


2024/10/29 06:00 2024/10/30 00:00 2024/10/30 18:00

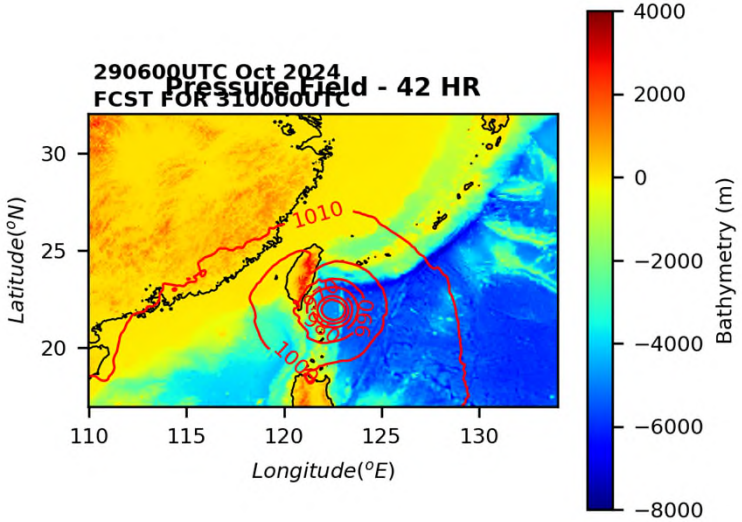
WD01

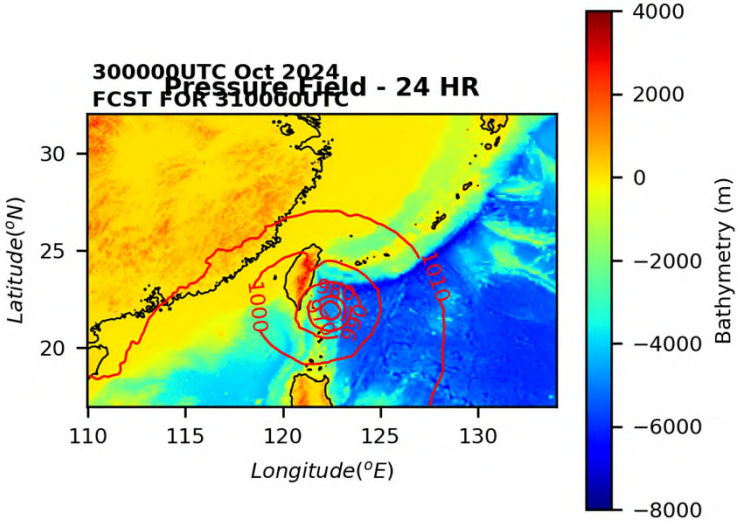


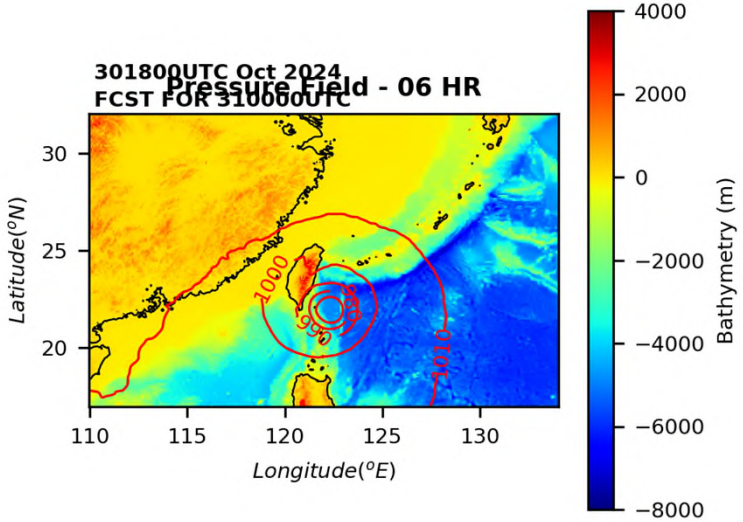


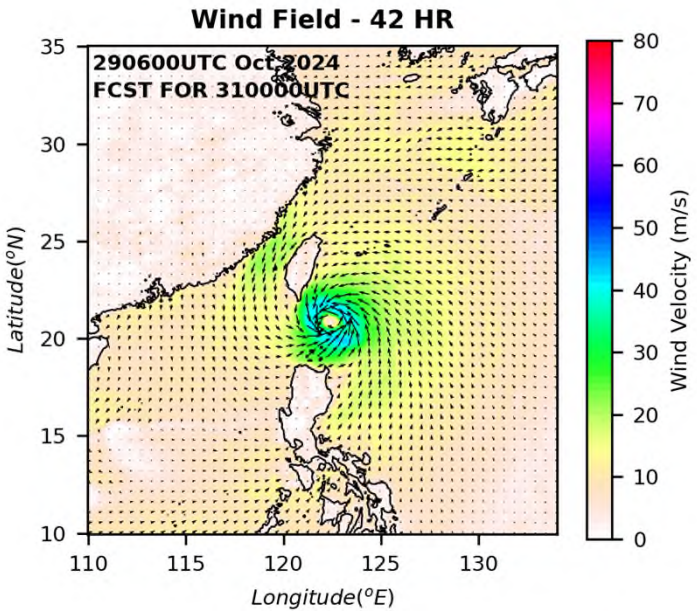
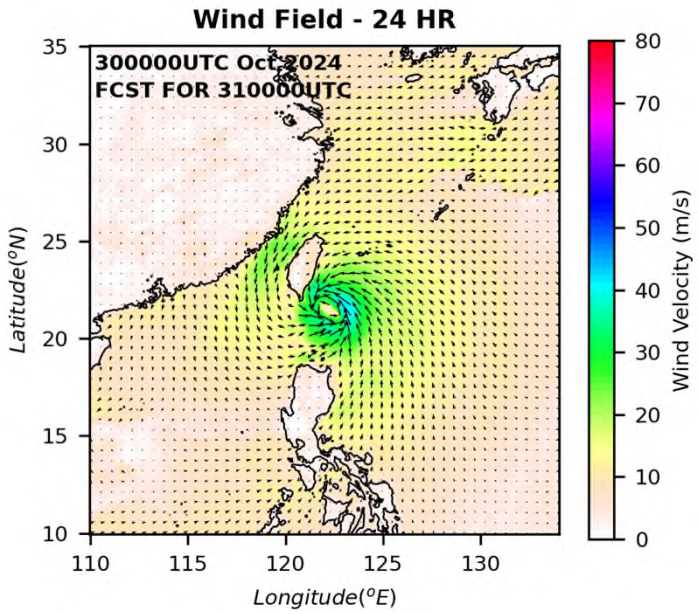
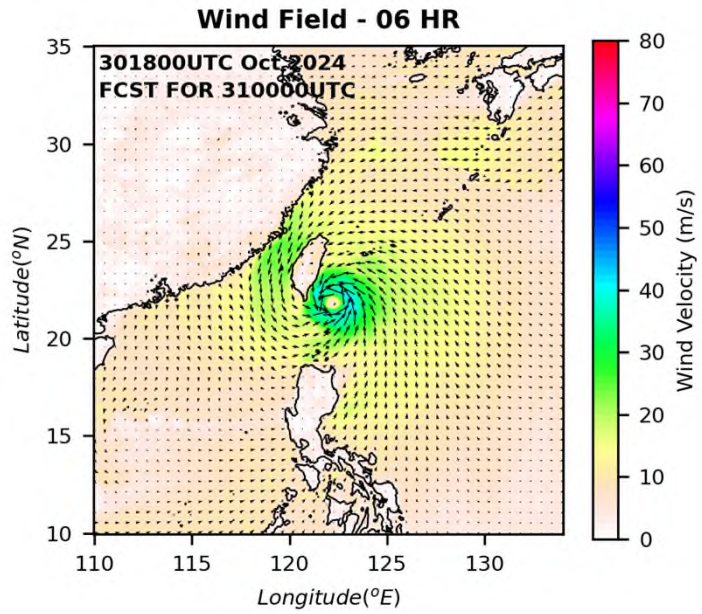
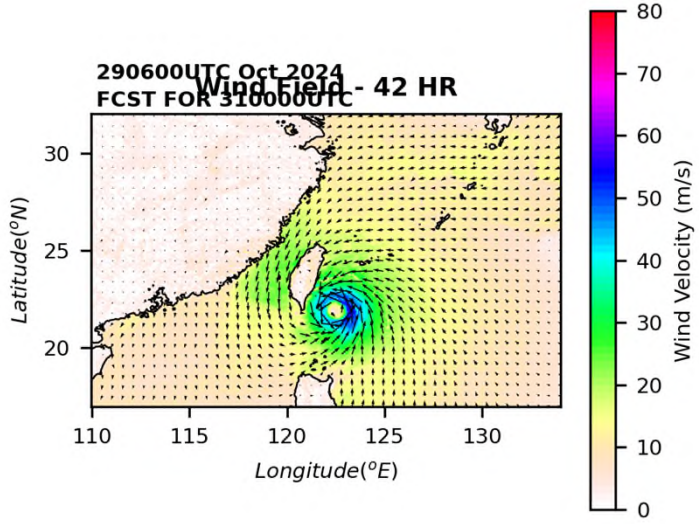
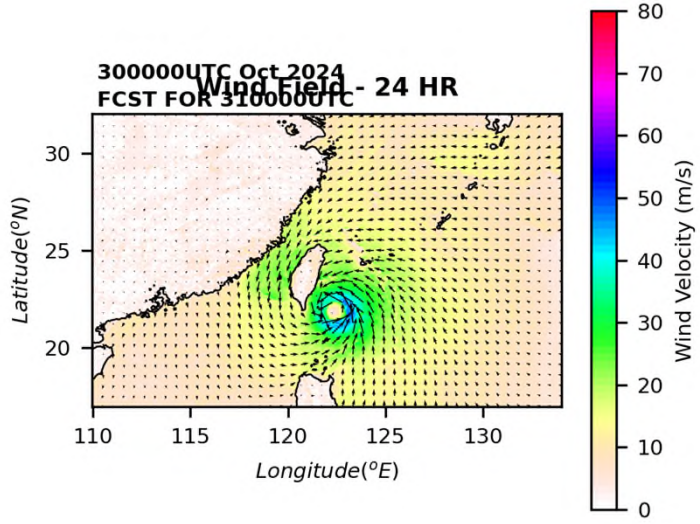
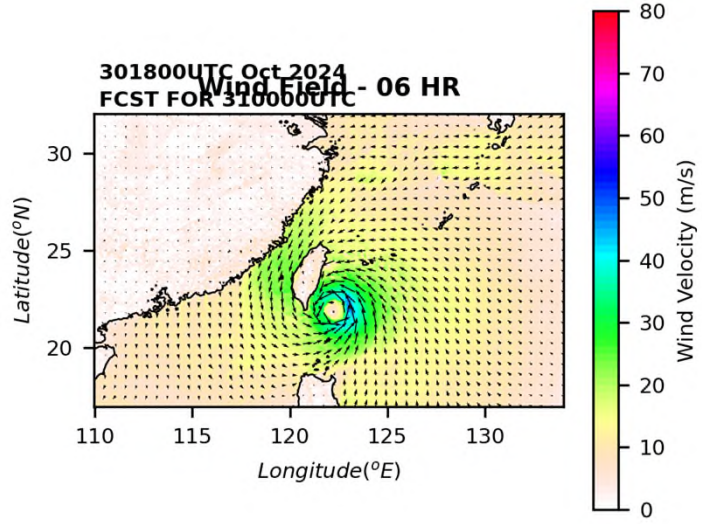


WD02



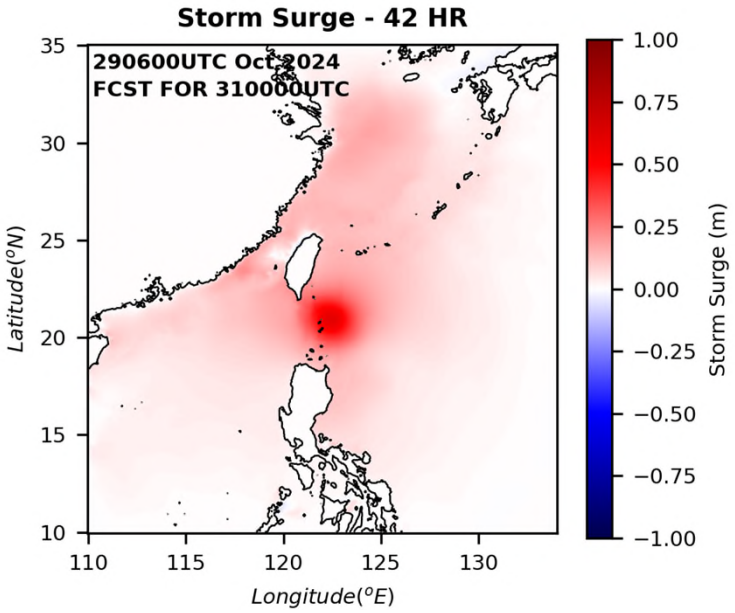


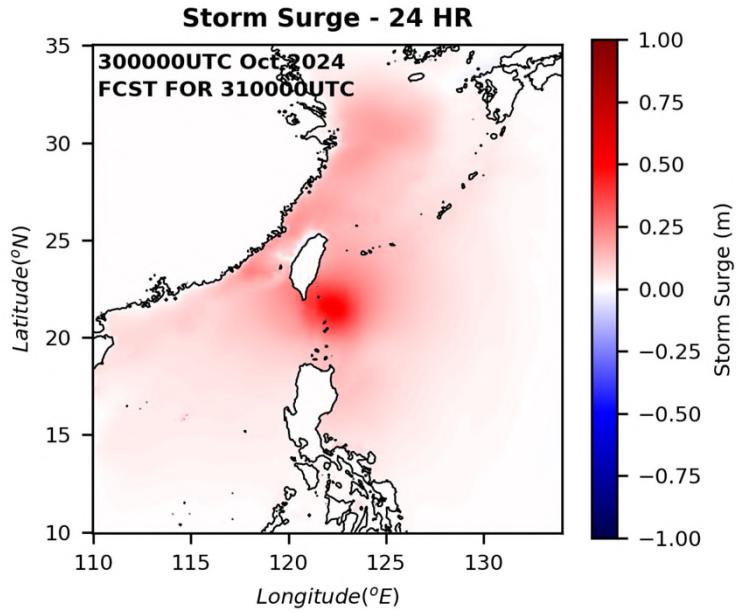


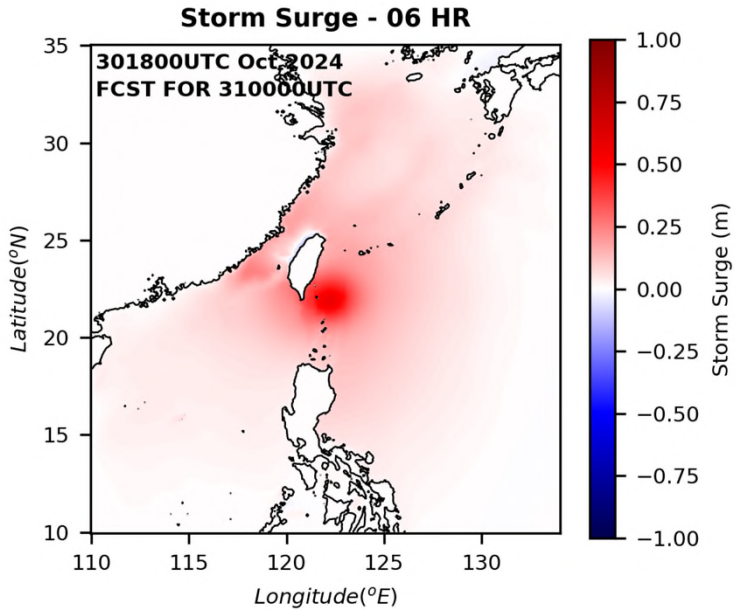
	2024/10/29 06:00	2024/10/30 00:00	2024/10/30 18:00
WD01			
WD02			

2024/10/29 06:00 2024/10/30 00:00 2024/10/30 18:00

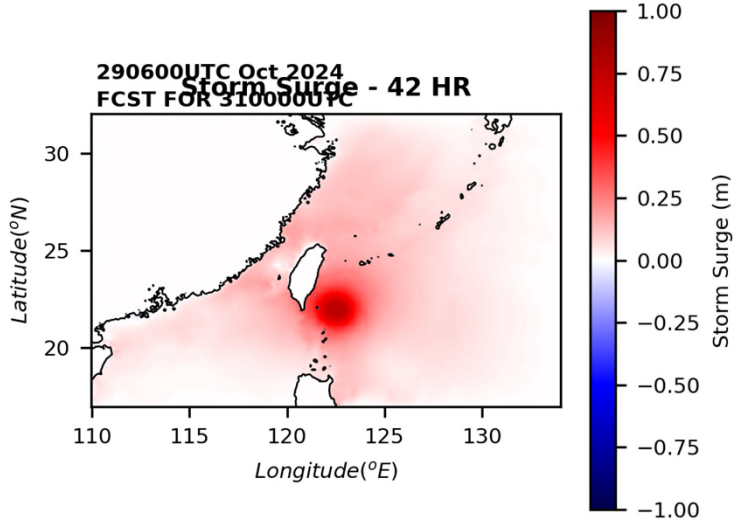
WD01

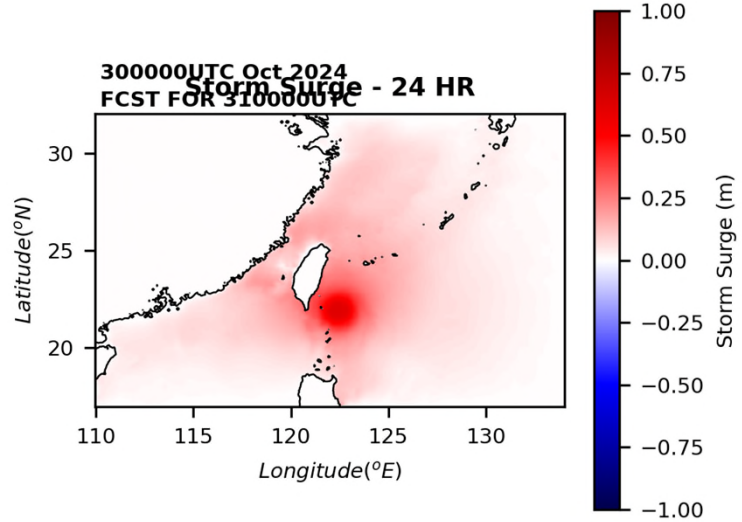


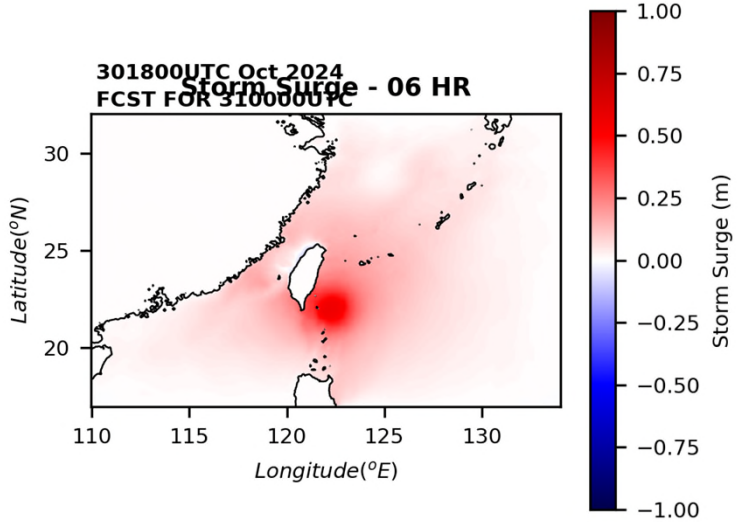


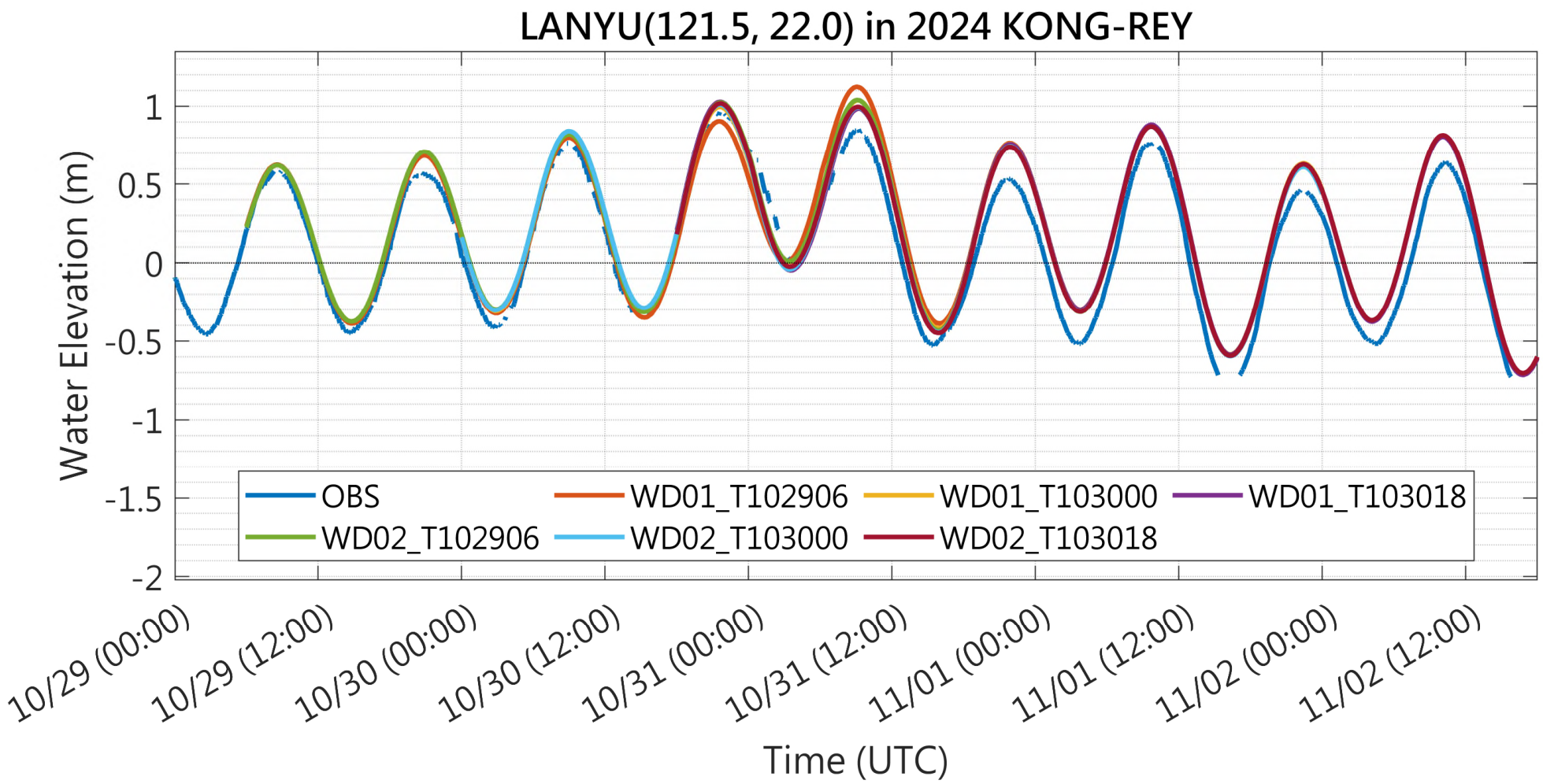


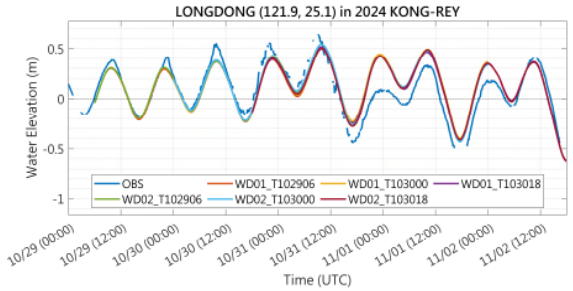
WD02

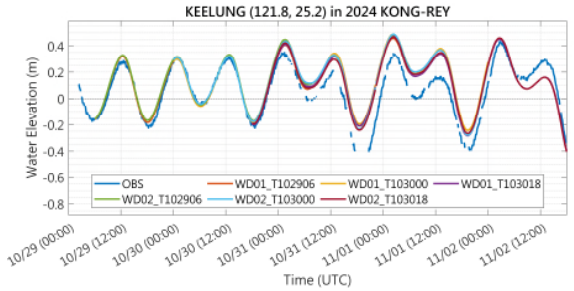


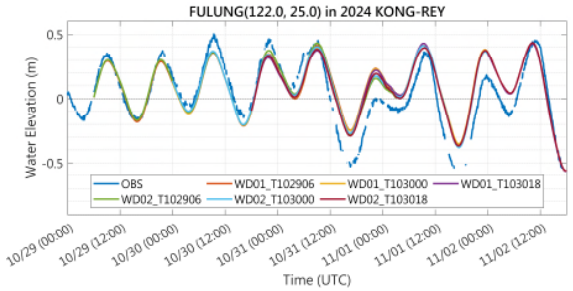


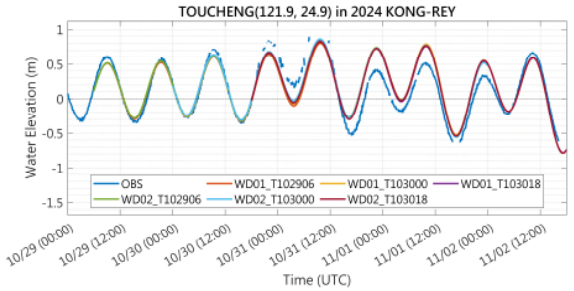


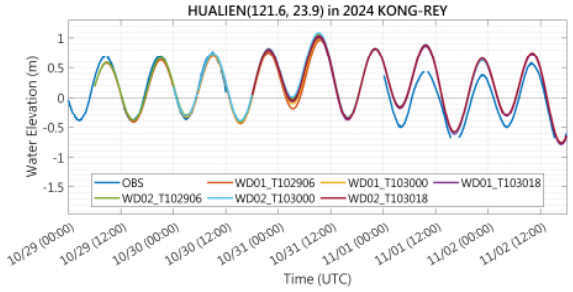

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
1
0.5
0
-0.5
-1
-1.5
-2
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018
10/29 (00:00)
10/29 (12:00)
10/30 (00:00)
10/30 (12:00)
10/31 (00:00)
10/31 (12:00)
11/01 (00:00)
11/01 (12:00)
11/02 (00:00)
11/02 (12:00)
Time (UTC)

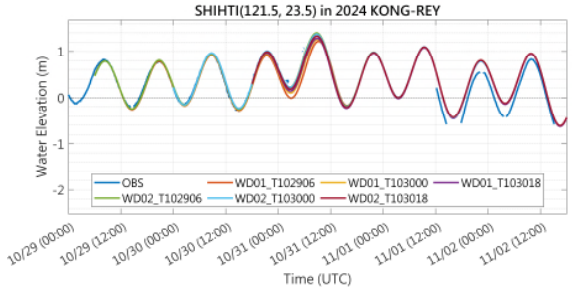

LONGDONG (121.9, 25.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

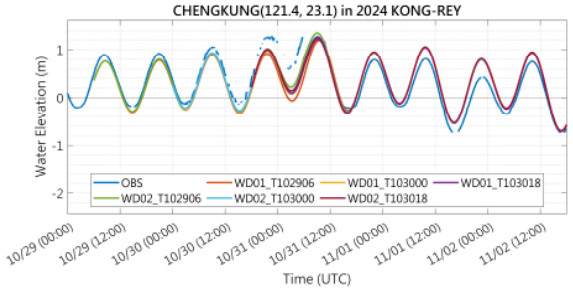

KEELUNG (121.8, 25.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

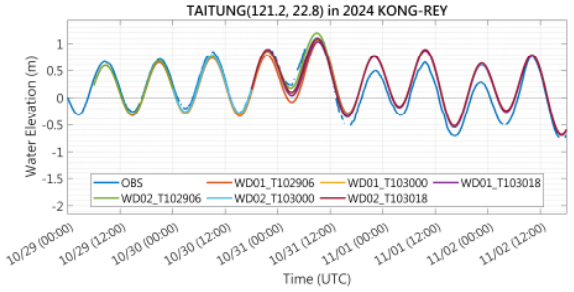

FULUNG(122.0, 25.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

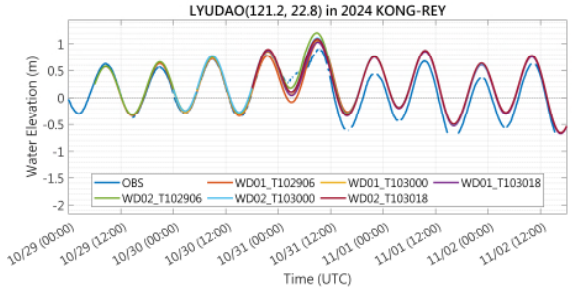

TOUCHENG(121.9, 24.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

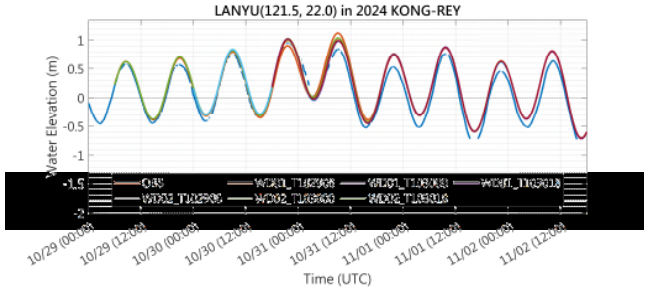

HUALIEN(121.6, 23.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

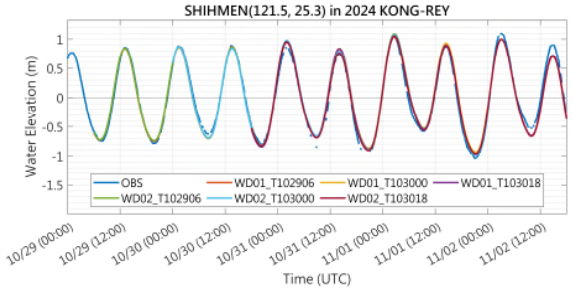

SHIHTI(121.5, 23.5) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

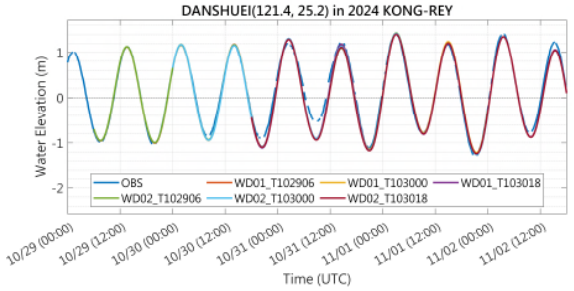

CHENGKUNG(121.4, 23.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

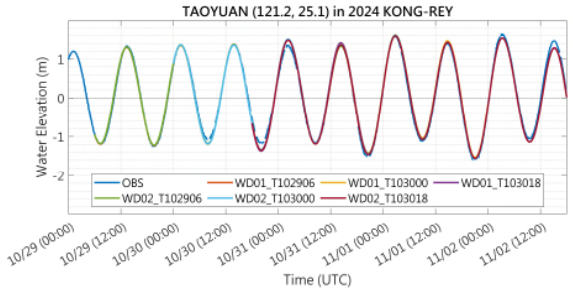

TAITUNG(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

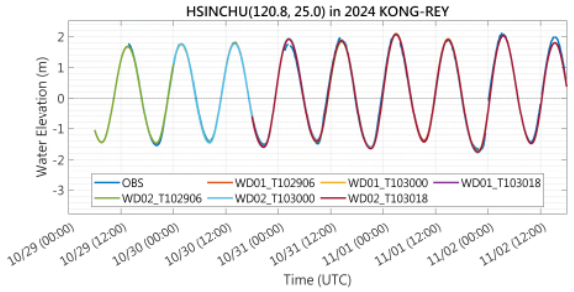

LYUDAO(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

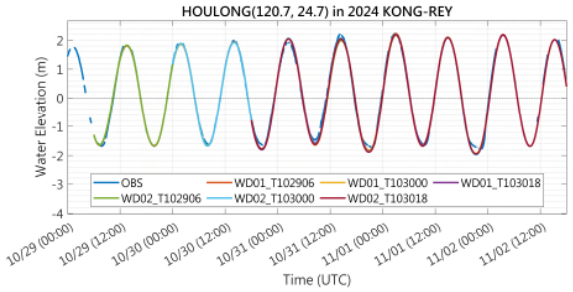

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

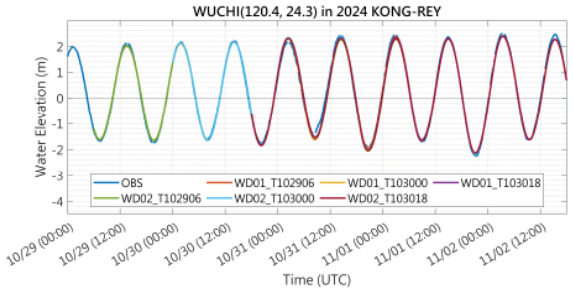

SHIHMEN(121.5, 25.3) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

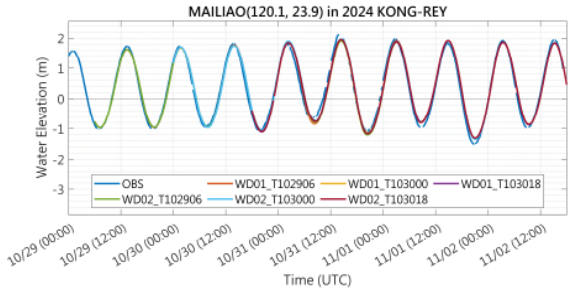

DANSHUEI(121.4, 25.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

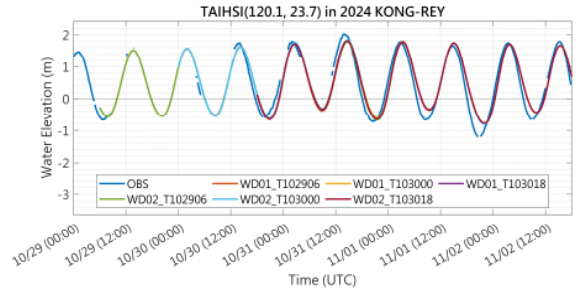

TAOYUAN (121.2, 25.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

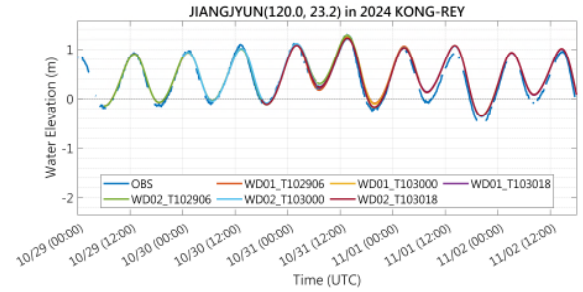

HSINCHU(120.8, 25.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

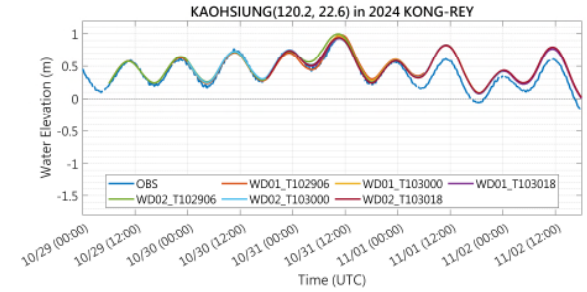

HOULONG(120.7, 24.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

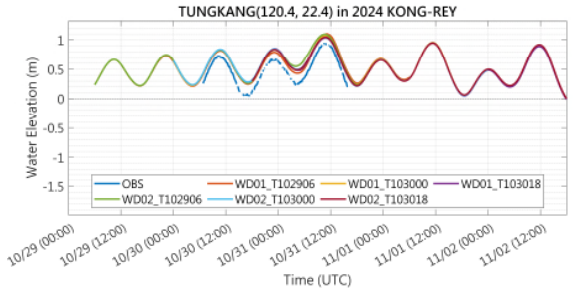

WUCHI(120.4, 24.3) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

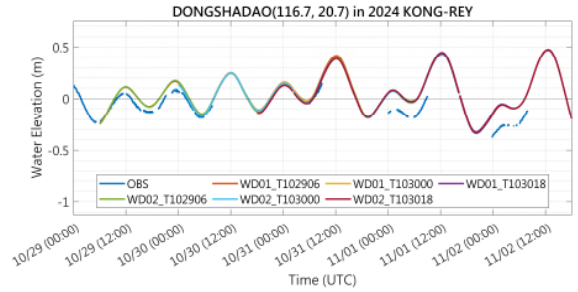

MAILIAO(120.1, 23.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

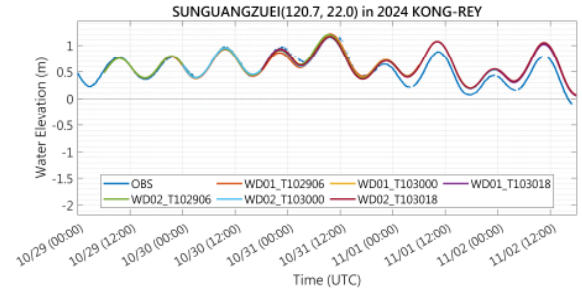

TAIHSI(120.1, 23.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

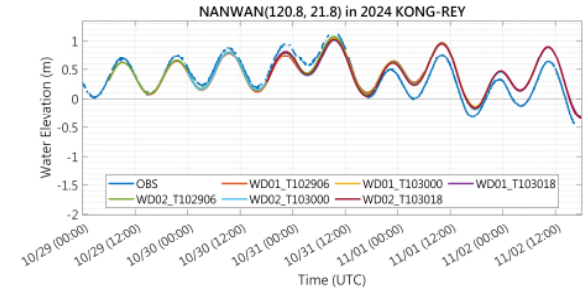

JIANGJYUN(120.0, 23.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

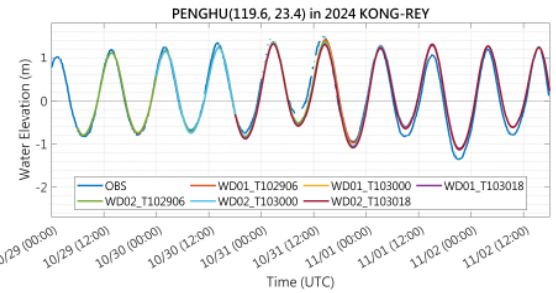

KAOHSIUNG(120.2, 22.6) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

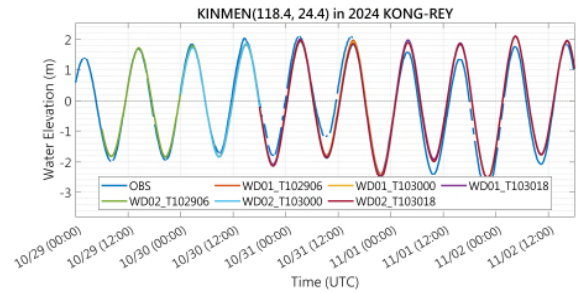

TUNGKANG(120.4, 22.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

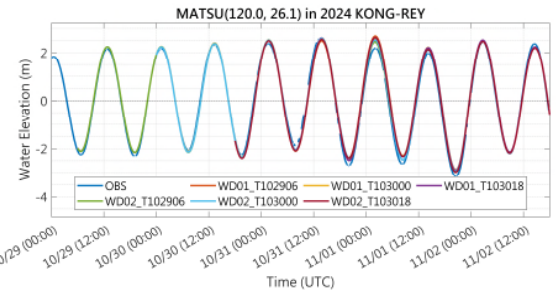

DONGSHADAO(116.7, 20.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

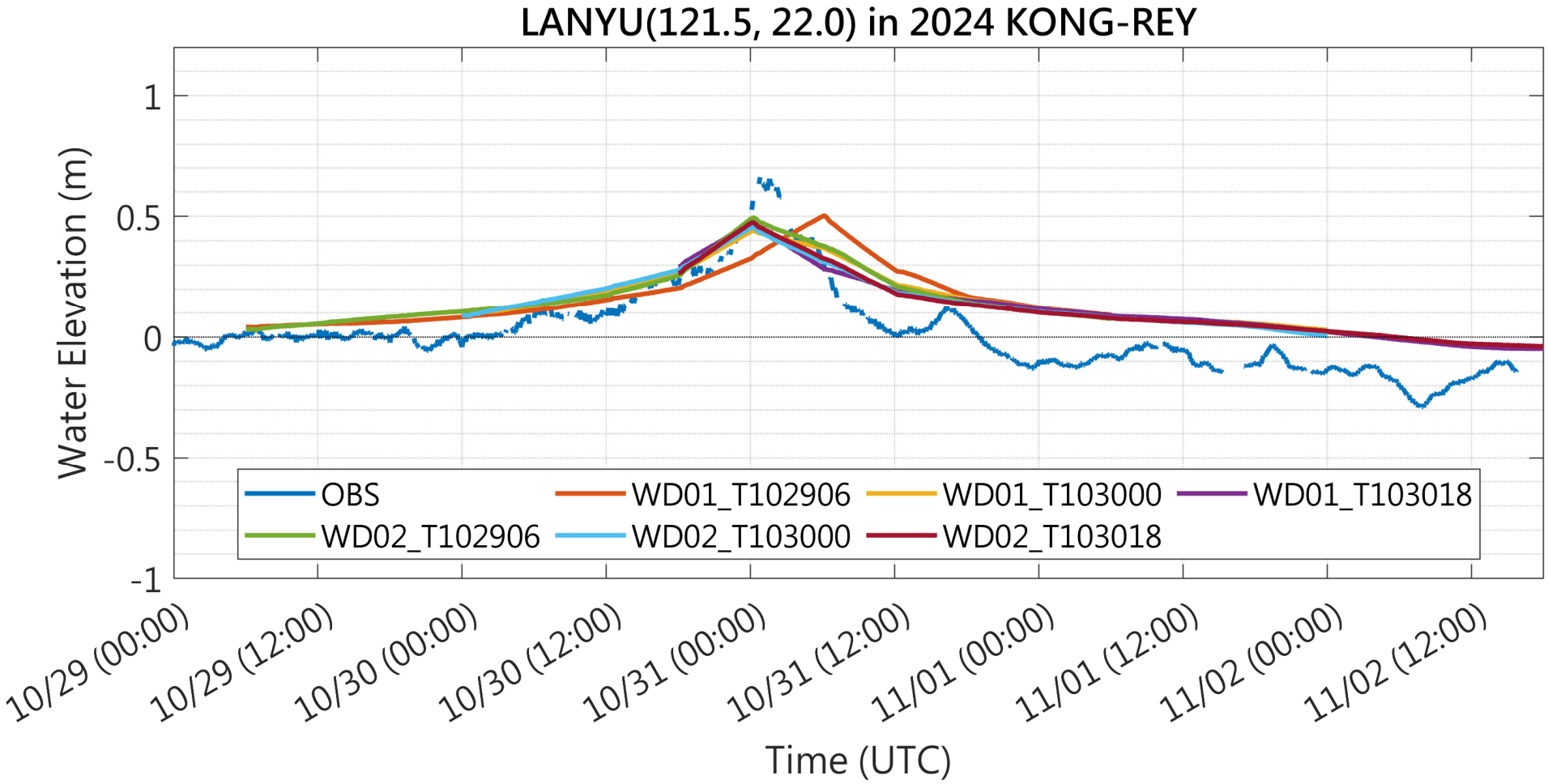

SUNGUANGZUEI(120.7, 22.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

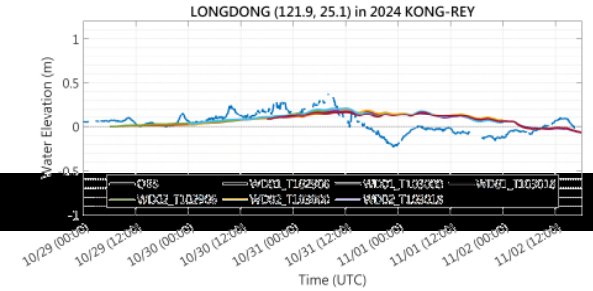

NANWAN(120.8, 21.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

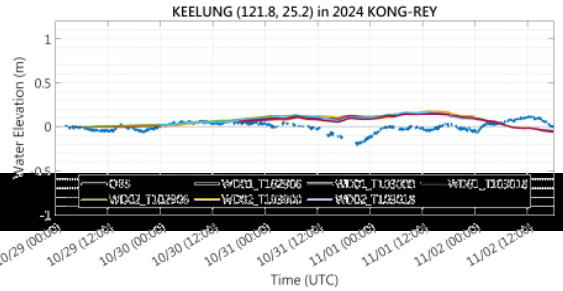

PENGHU(119.6, 23.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

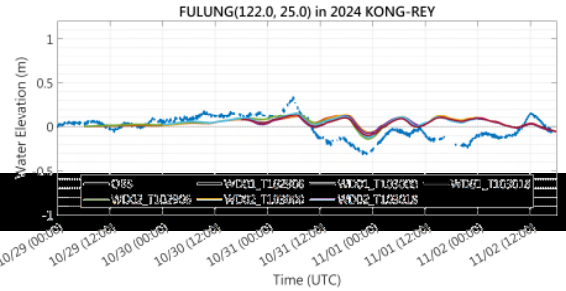

KINMEN(118.4, 24.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

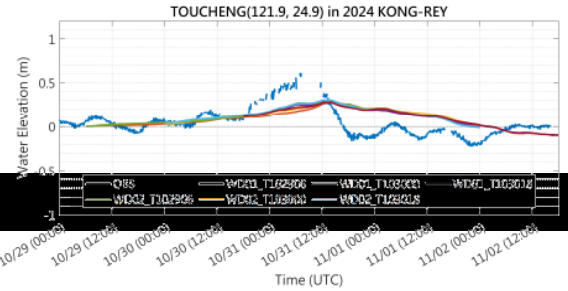

MATSU(120.0, 26.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018

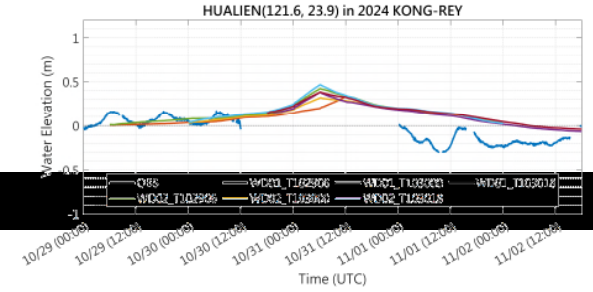

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
1
0.5
0
-0.5
-1
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018
10/29 (00:00)
10/29 (12:00)
10/30 (00:00)
10/30 (12:00)
10/31 (00:00)
10/31 (12:00)
11/01 (00:00)
11/01 (12:00)
11/02 (00:00)
11/02 (12:00)
Time (UTC)

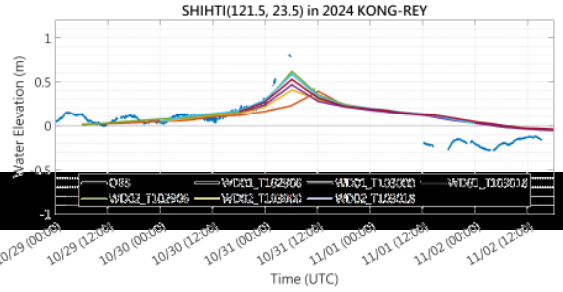

LONGDONG (121.9, 25.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

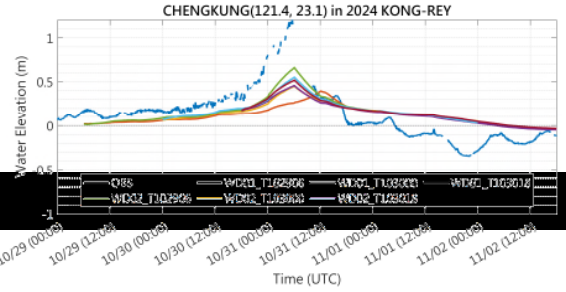

KEELUNG (121.8, 25.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

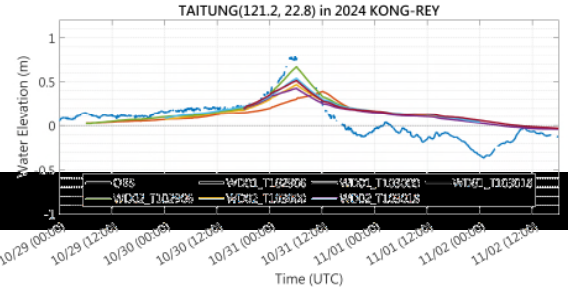

FULUNG(122.0, 25.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

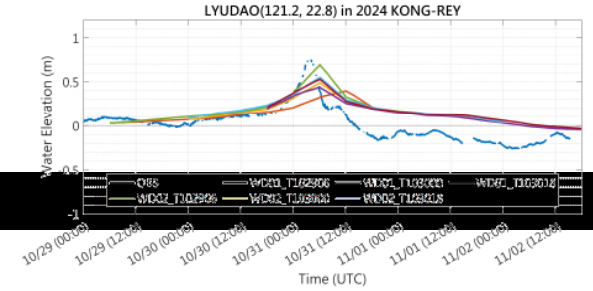

TOUCHENG(121.9, 24.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

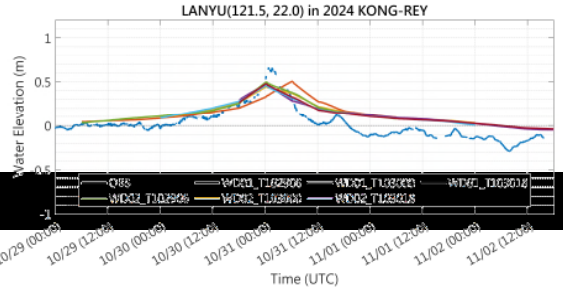

HUALIEN(121.6, 23.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

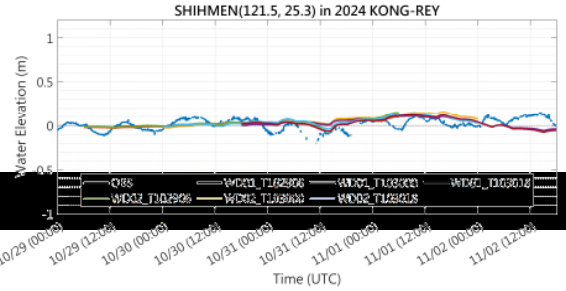

SHIHTI(121.5, 23.5) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

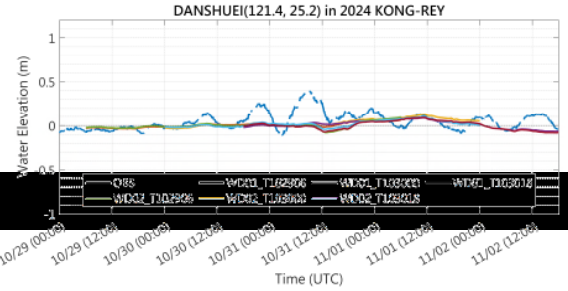

CHENGKUNG(121.4, 23.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

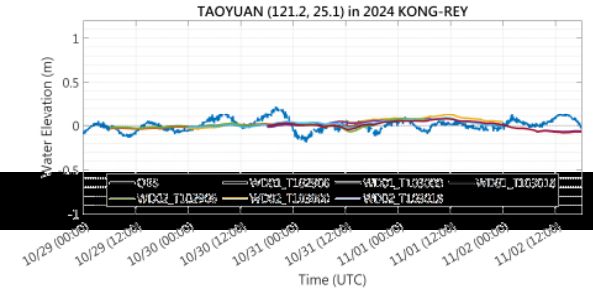

TAITUNG(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

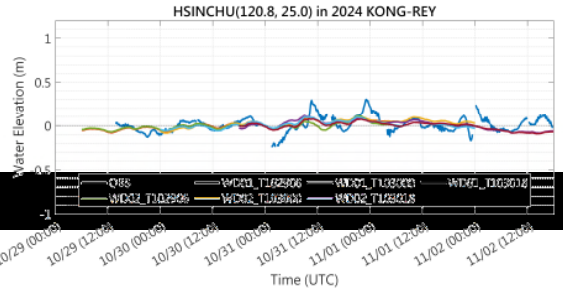

LYUDAO(121.2, 22.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

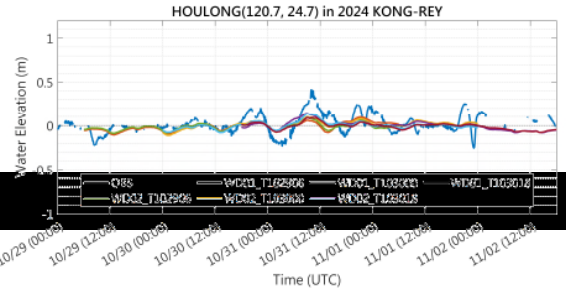

LANYU(121.5, 22.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

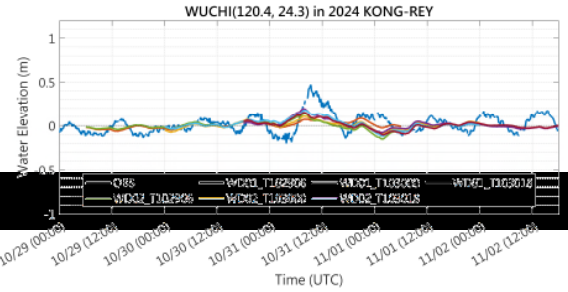

SHIHMEN(121.5, 25.3) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

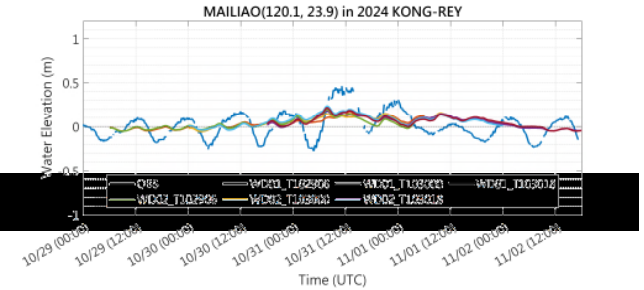

DANSHUEI(121.4, 25.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

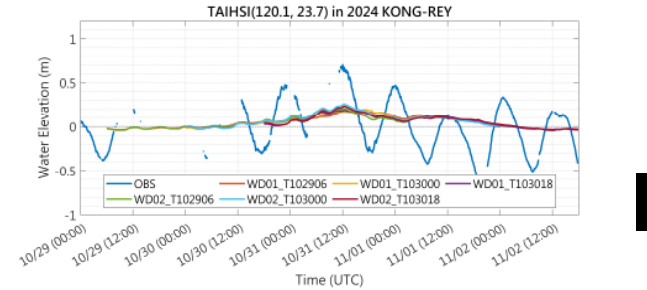

TAOYUAN (121.2, 25.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

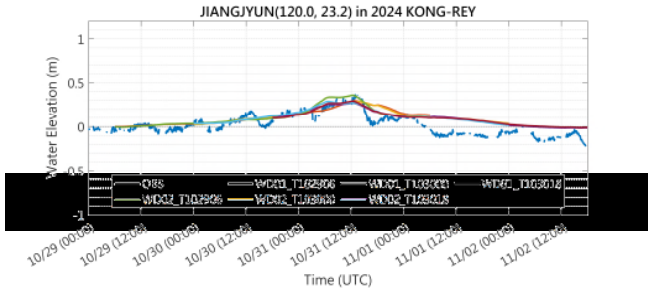

HSINCHU(120.8, 25.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

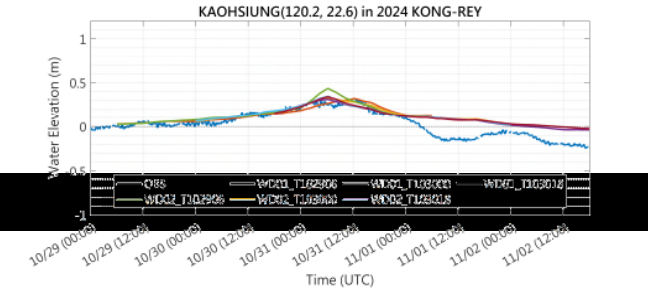

HOULONG(120.7, 24.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

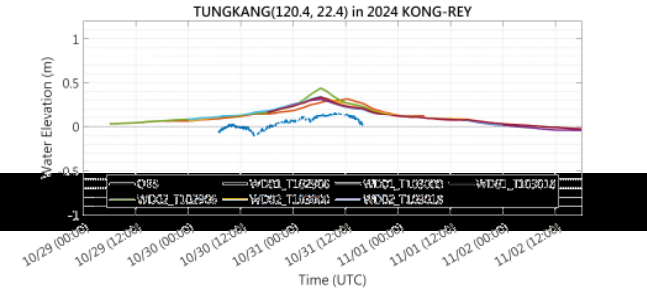

WUCHI(120.4, 24.3) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

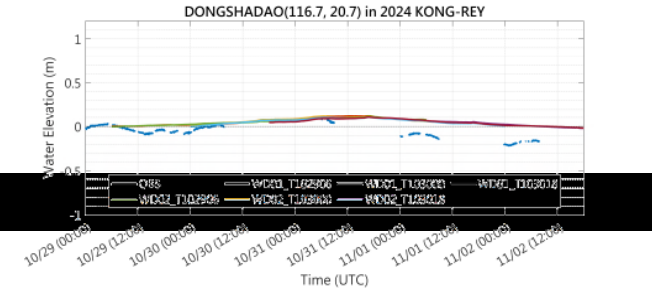

MAILIAO(120.1, 23.9) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

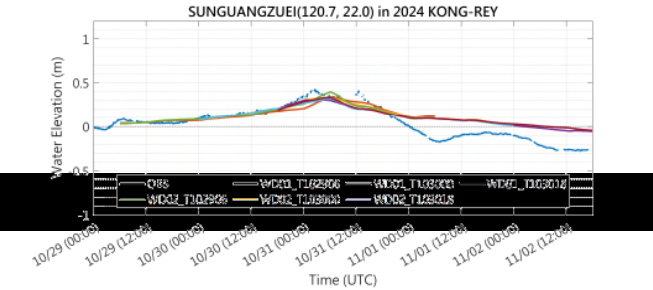

TAIHSI(120.1, 23.7) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018
Time (UTC)

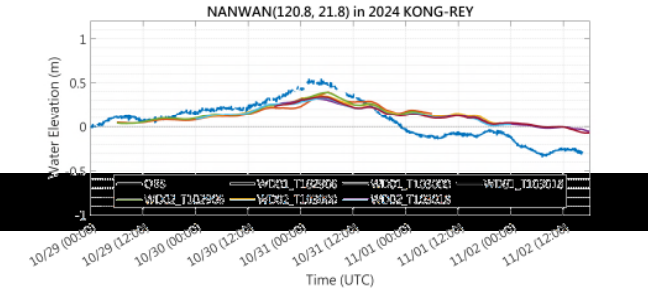

JIANGJYUN(120.0, 23.2) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

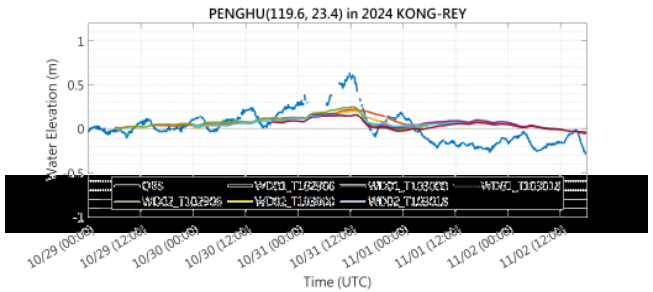

KAOHSIUNG(120.2, 22.6) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

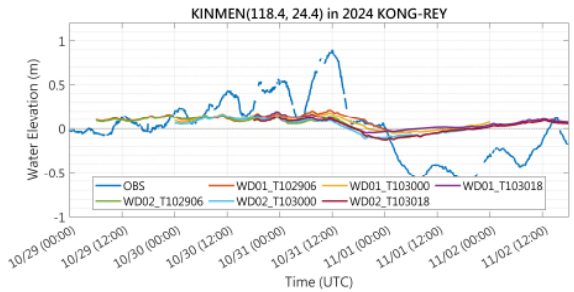

TUNGKANG(120.4, 22.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

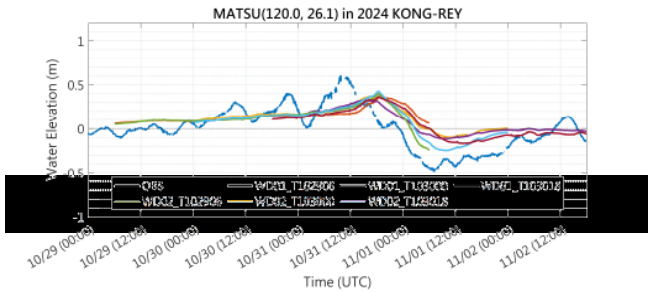

DONGSHADAO(116.7, 20.7) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)


SUNGUANGZUEI(120.7, 22.0) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

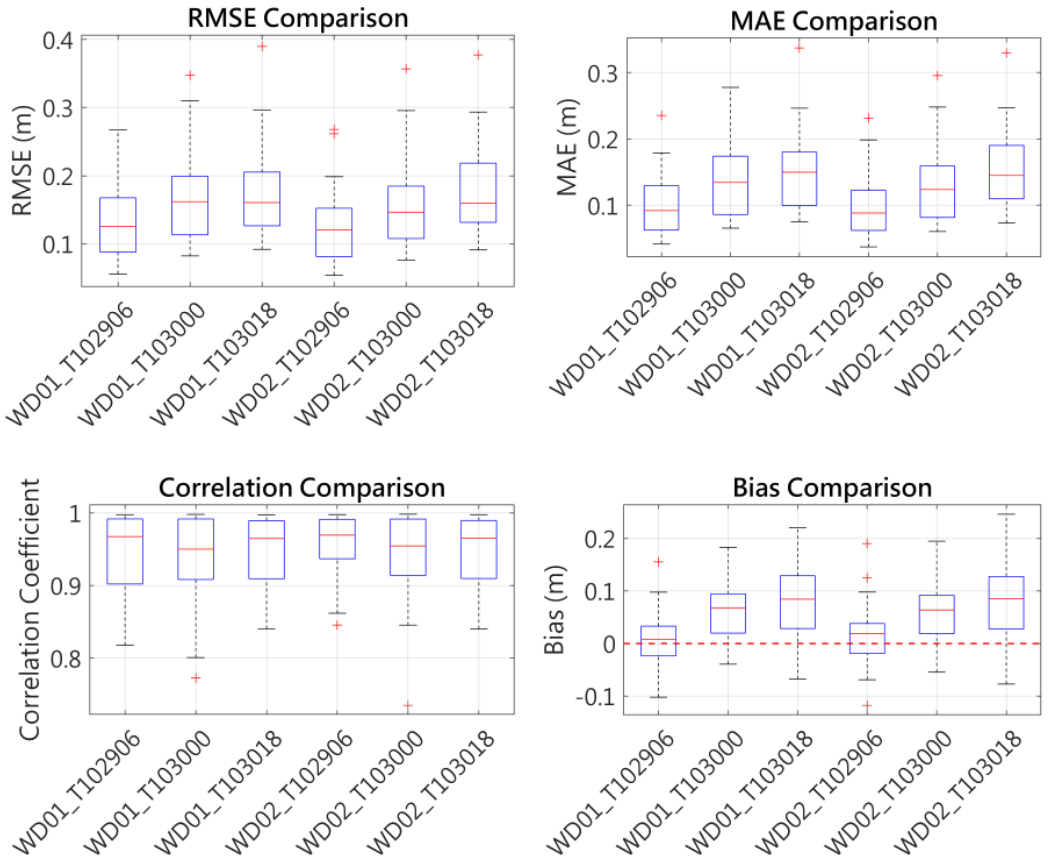

NANWAN(120.8, 21.8) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)


PENGHU(119.6, 23.4) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

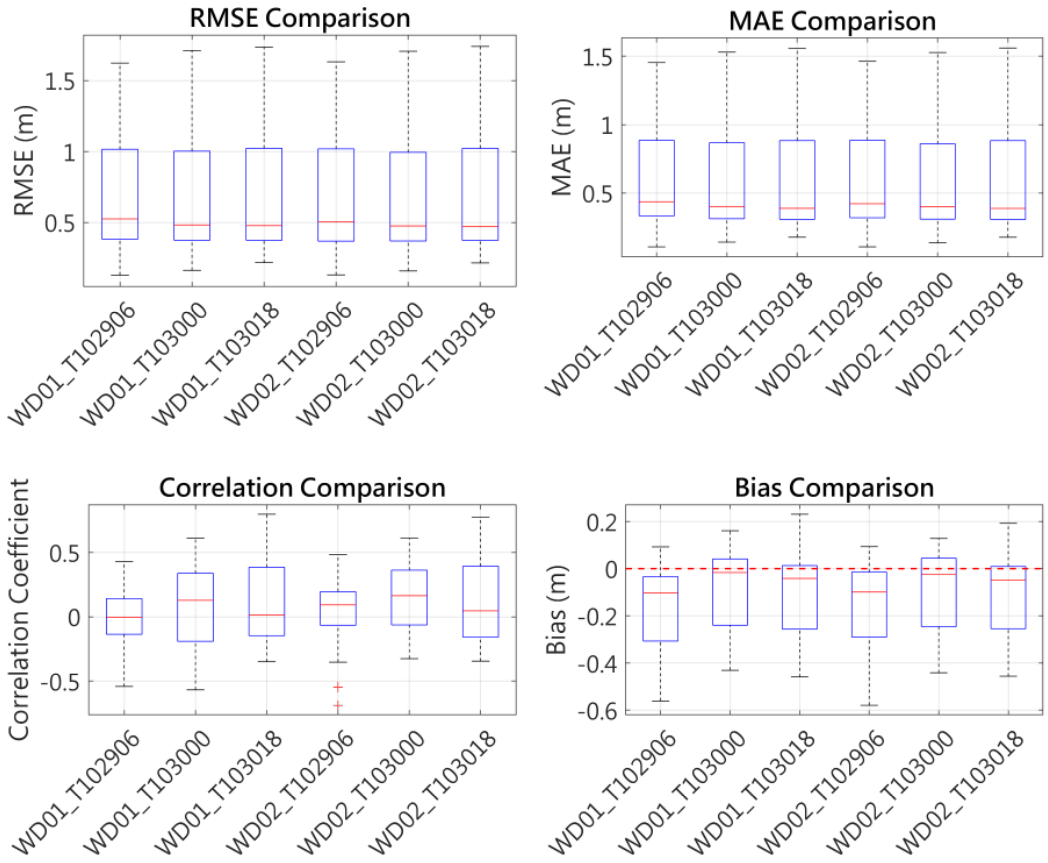

KINMEN(118.4, 24.4) in 2024 KONG-REY
Water Elevation (m)
OBS
WD01_T102906
WD01_T103000
WD01_T103018
WD02_T102906
WD02_T103000
WD02_T103018
Time (UTC)


MATSU(120.0, 26.1) in 2024 KONG-REY
Water Elevation (m)
Time (UTC)

Statistical Parameter Comparison

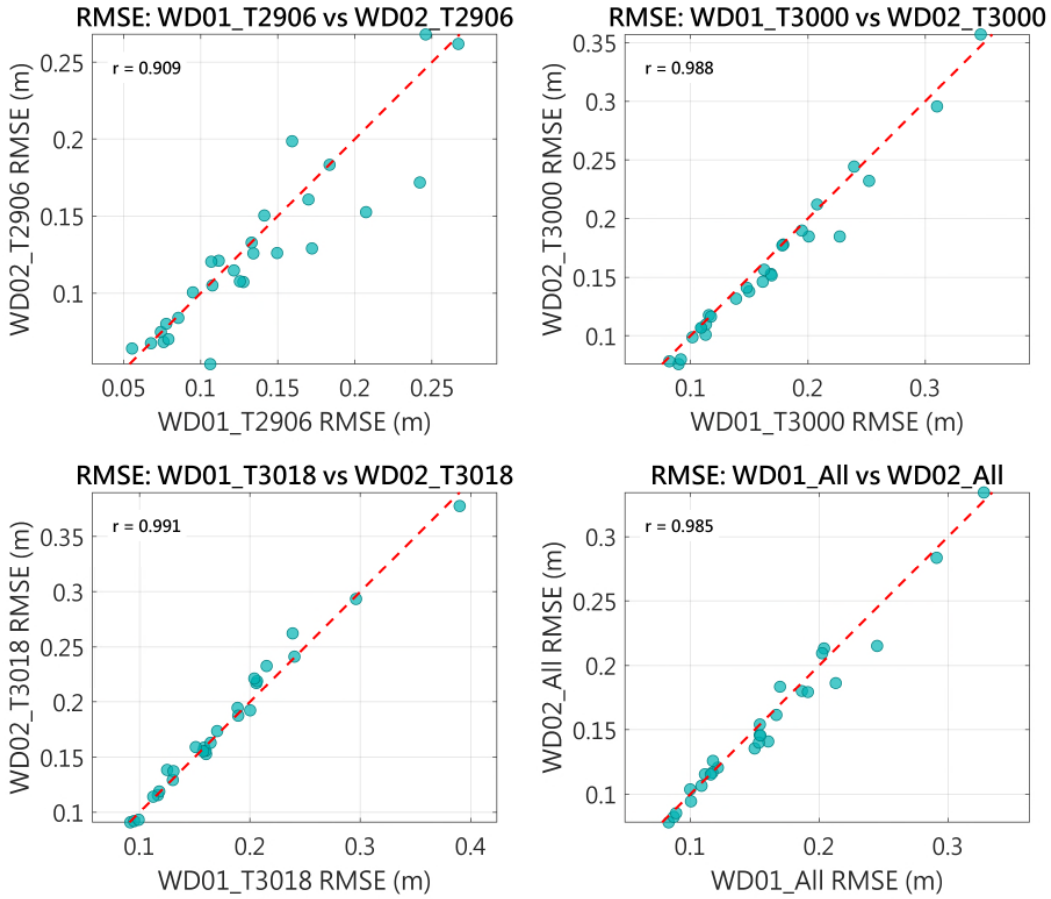


總水位（Storm Tide）

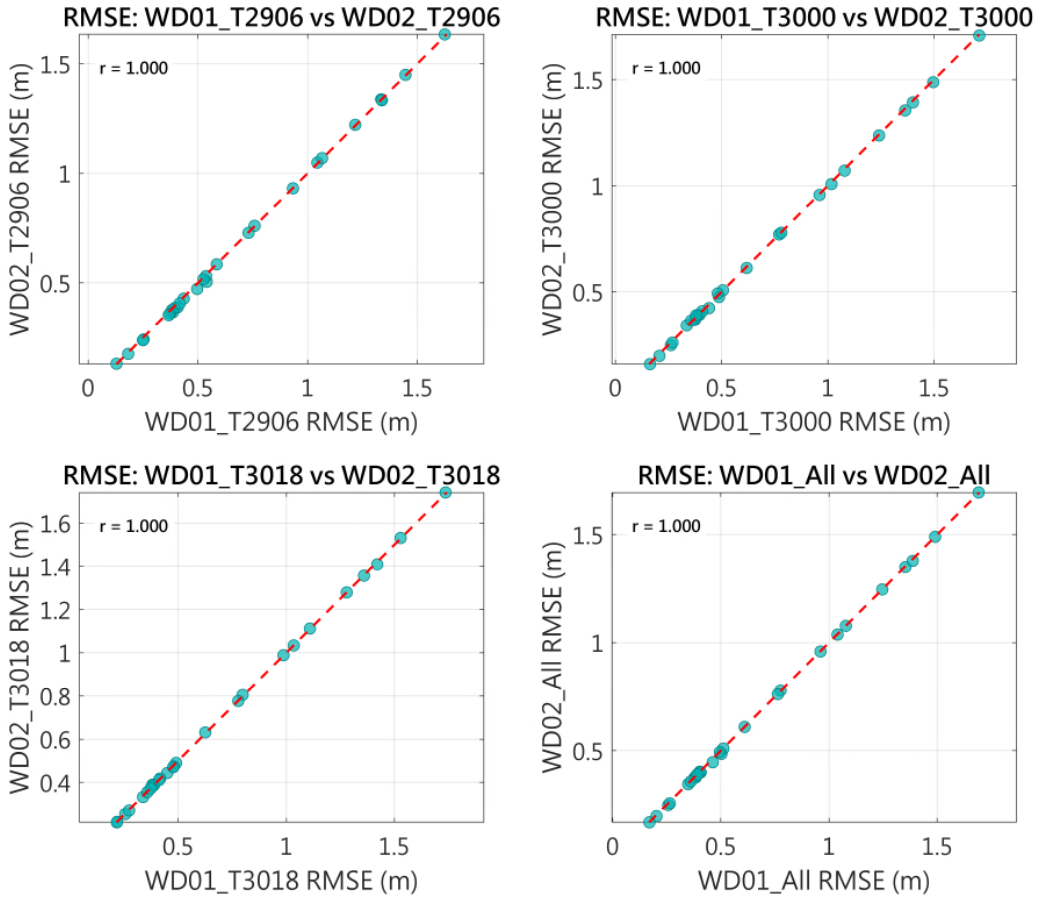


暴潮水位（Storm Surge）

Forecast Root Mean Square Error Comparison

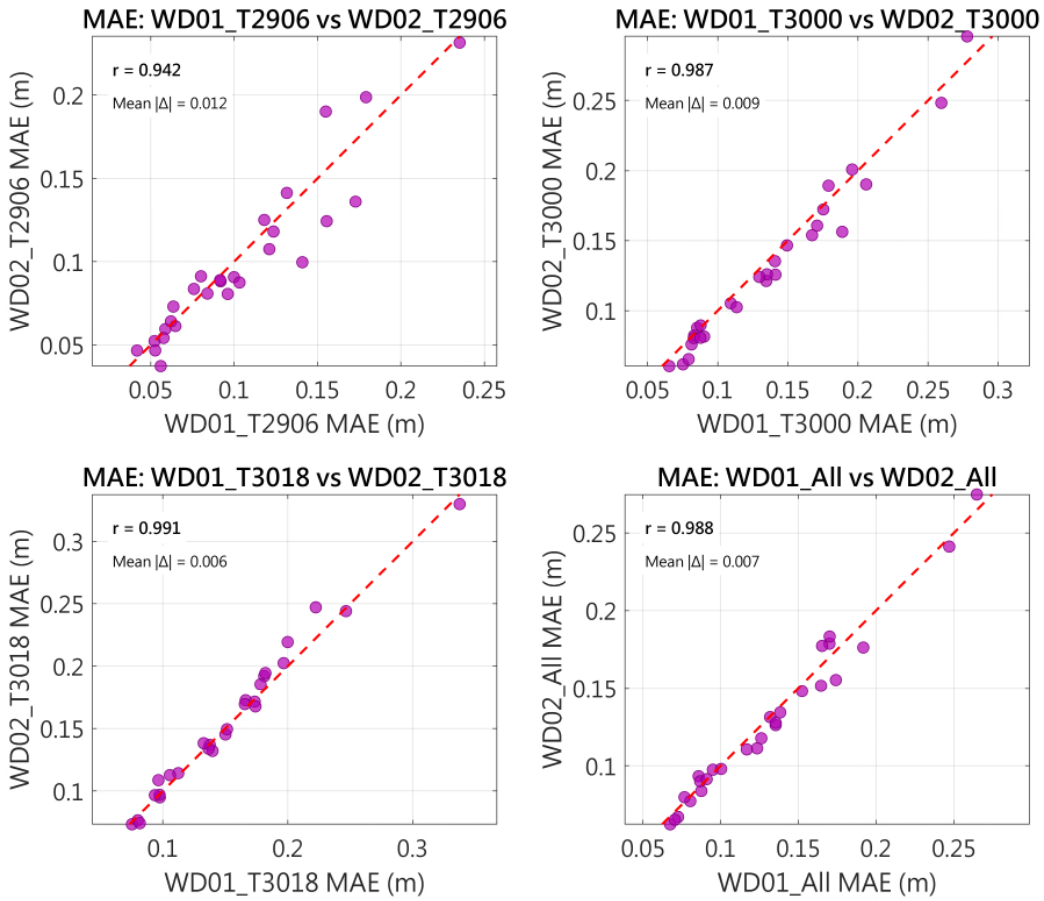


總水位（Storm Tide）

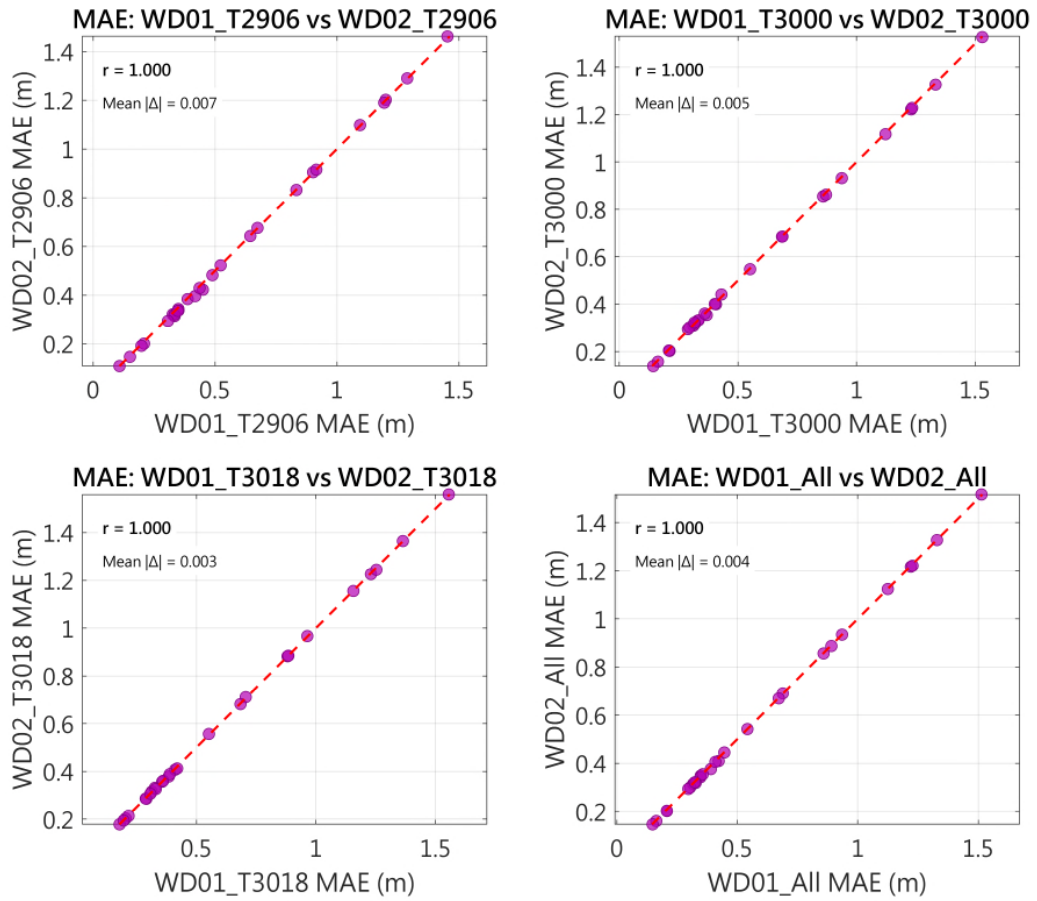


暴潮水位（Storm Surge）

Forecast Mean Absolute Error Comparison

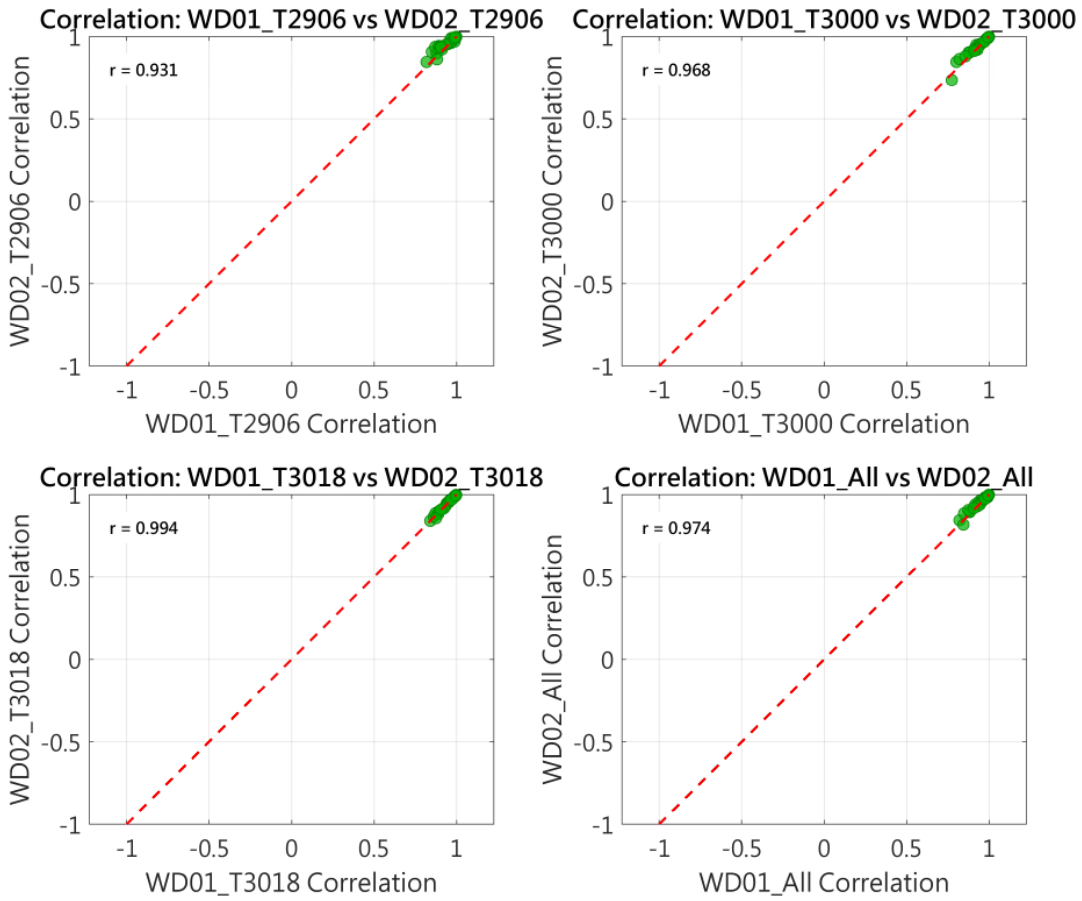


總水位（Storm Tide）

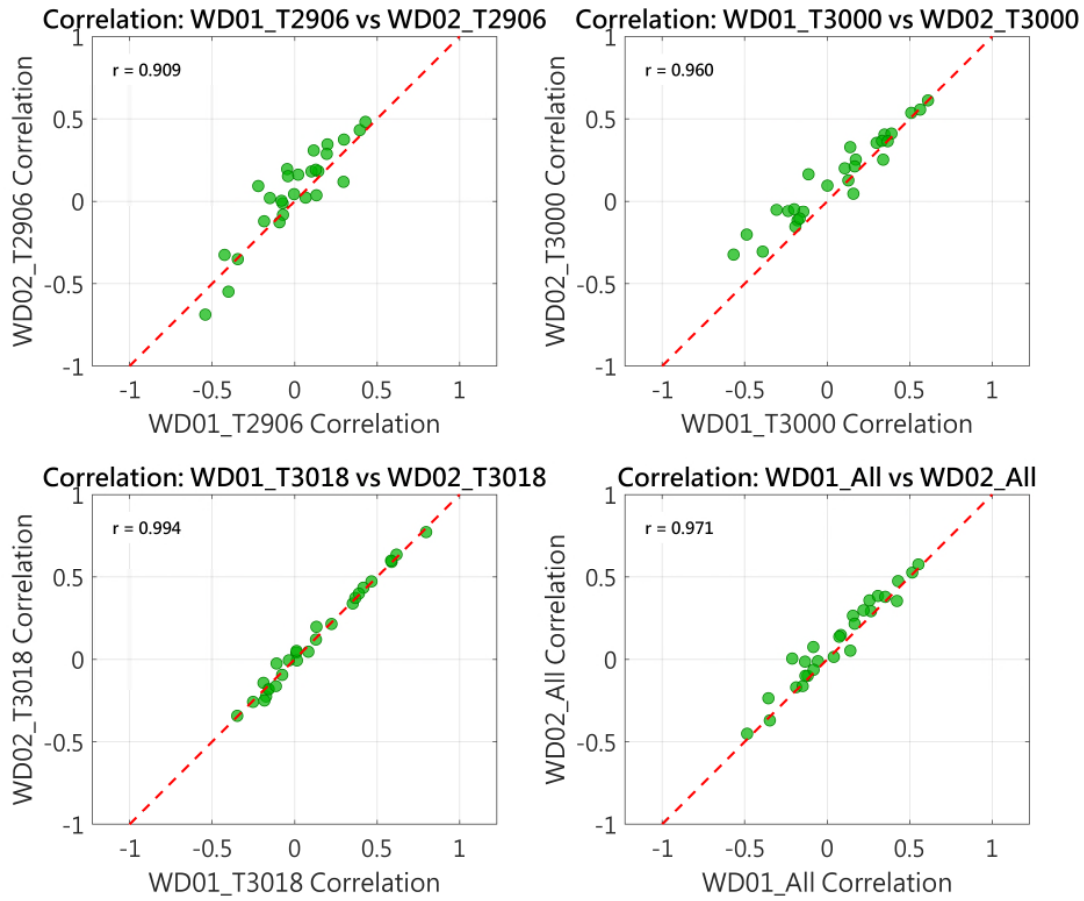


暴潮水位（Storm Surge）

Forecast Correlation Coefficient Comparison

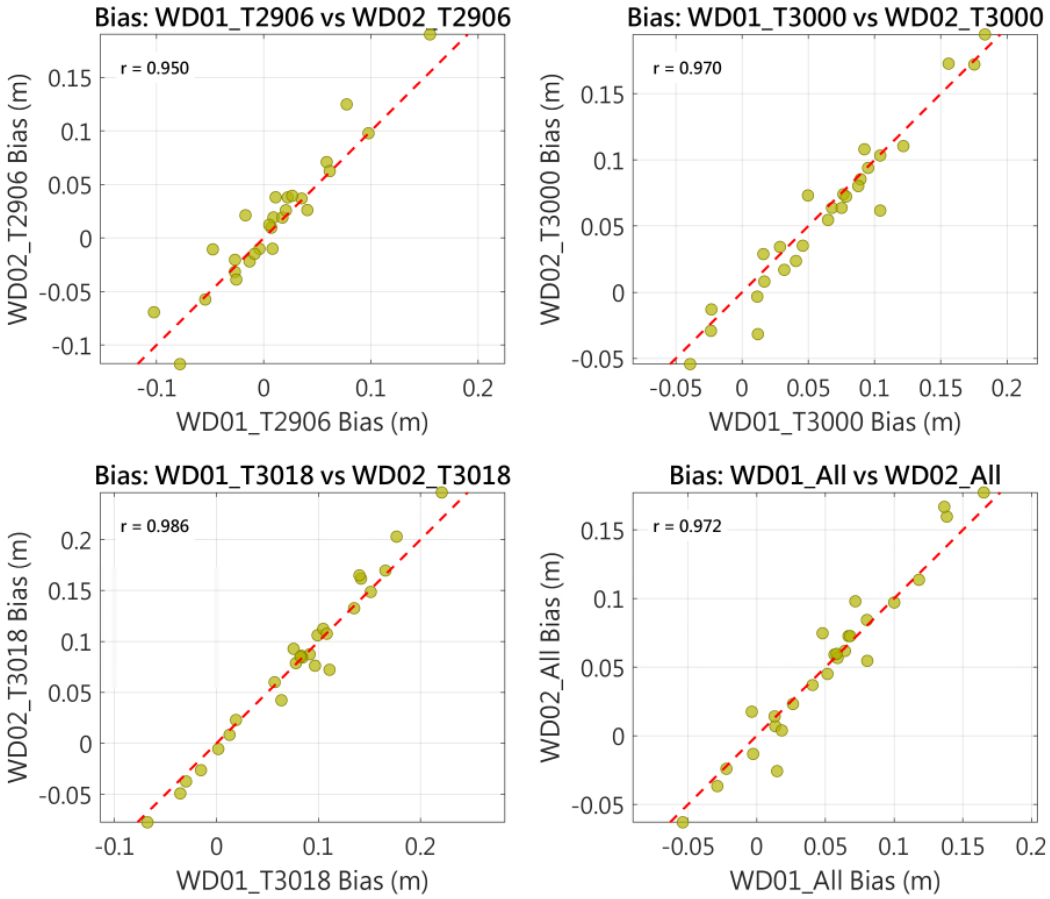


總水位（Storm Tide）

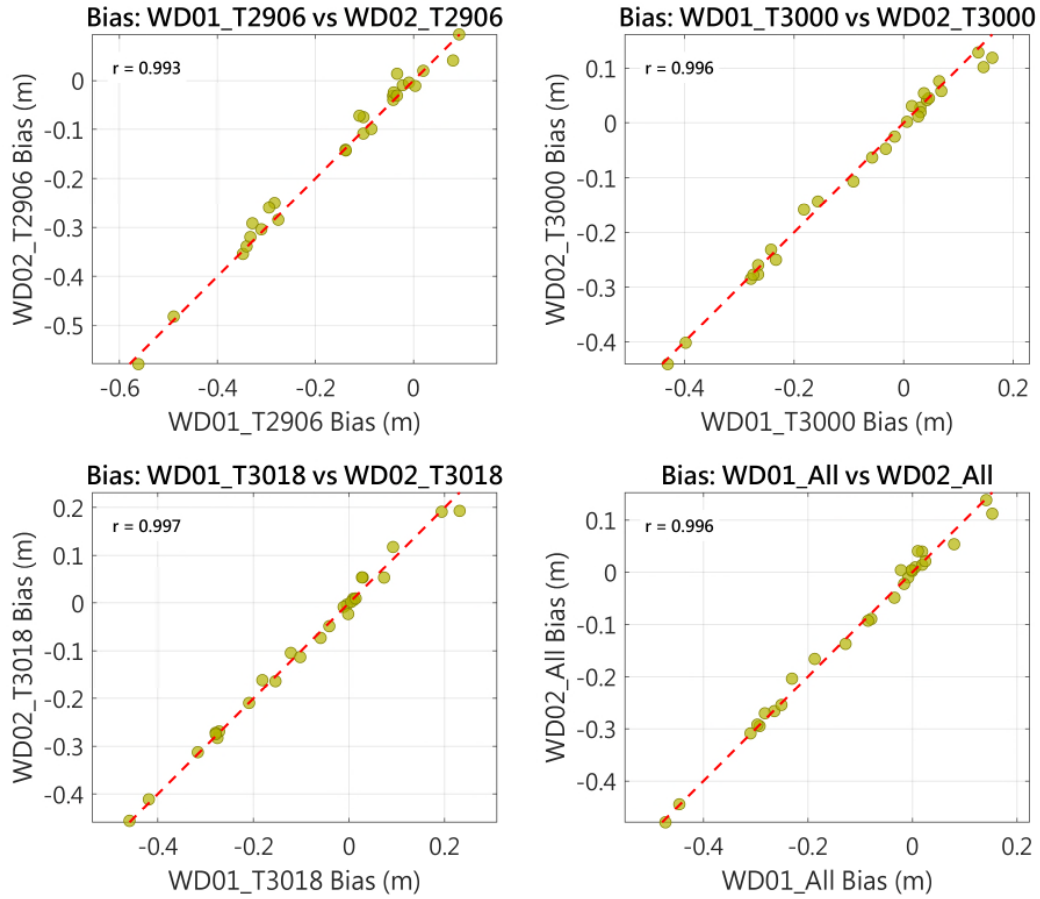


暴潮水位（Storm Surge）

Forecast Bias Comparison



總水位（Storm Tide）



暴潮水位（Storm Surge）

Operational Testing and Evaluation of the Improvement

WD_{ID}	CPU#	Conversion	Tidal BC	COMCOT	Post Process	Total
1	16	14	<1	16.11	6.96	37.07
1	32	14	<1	15.83	7	36.83
2	8	45.6	<1	16.6	5	68.2
2	16	45.3	<1	14.64	5	65.94
2	32	45.34	<1	12.12	4.92	62.48

Is Higher Resolution Atmospheric Model Data Recommended for Storm Surge Forecasting?

Answer: Conditionally Yes, with Important Caveats.

- **Modest but positive** improvements in forecast accuracy, marginal improvement in critical metrics.
- **Operationally feasible** - WD02 takes 1.5x longer than WD01 but remains within acceptable timing
- **Limited impact** on storm surge prediction - two resolutions perform almost identically for pure storm surge forecasting. Astronomical tide dominance dilutes meteorological field difference impacts.
- **Benefits vary by conditions** - improvements not uniform across all meteorological situations.