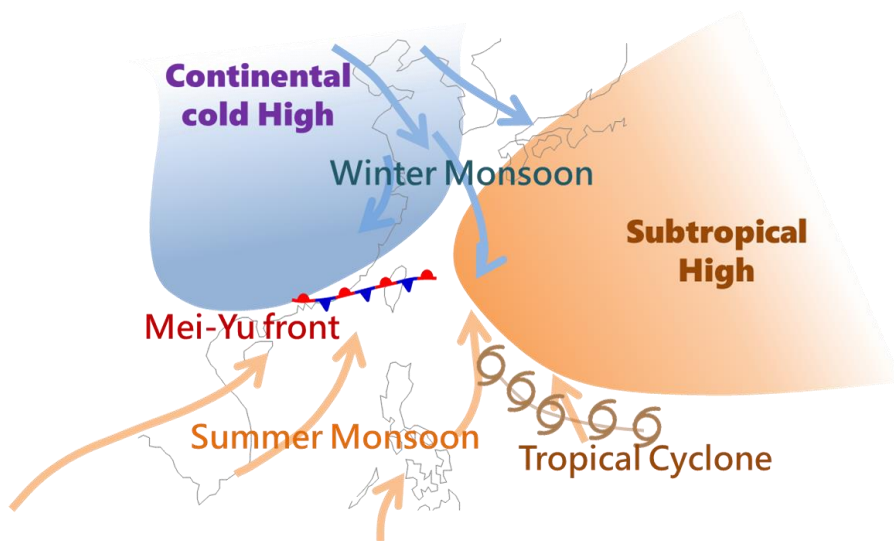




Impact of the 2020-2022 La Niña Event on Water Resources management in Chinese Taipei



Dr. Jing-Shan Hong

Director, Marine Meteorology and Climate Division

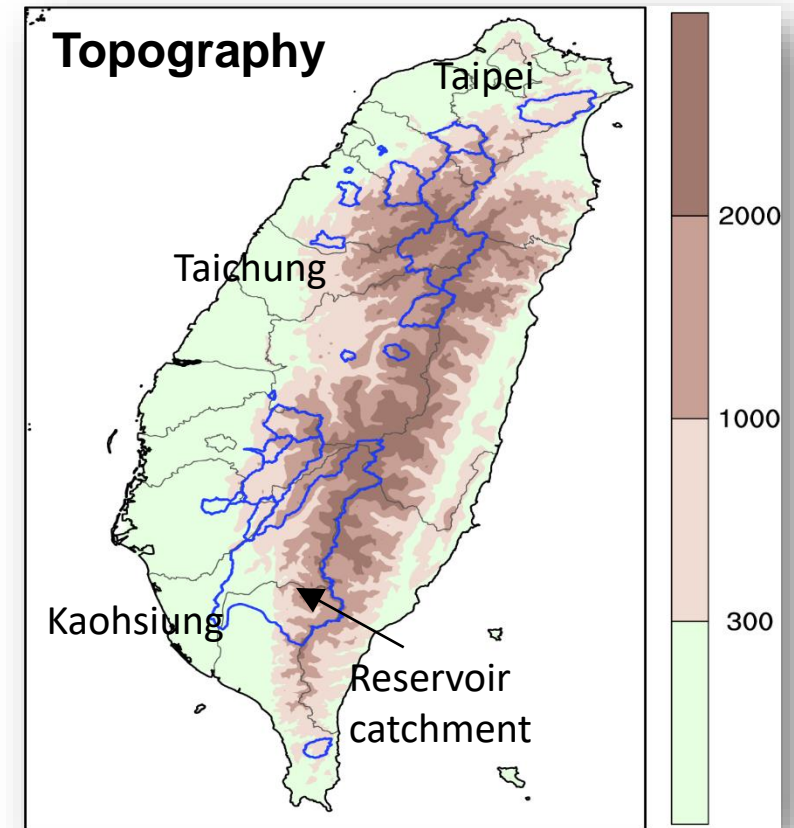
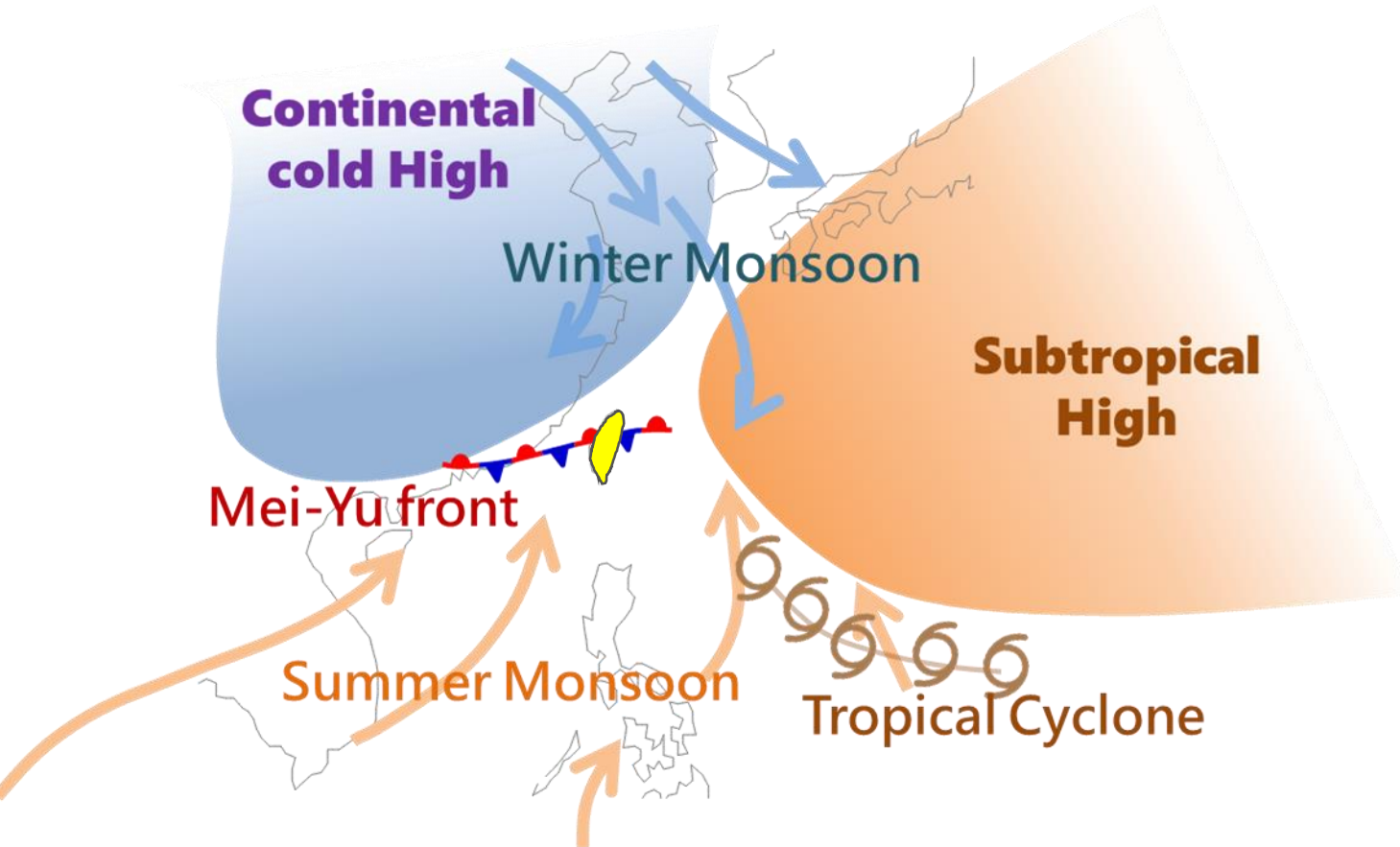
Central Weather Administration, Chinese Taipei



Background information

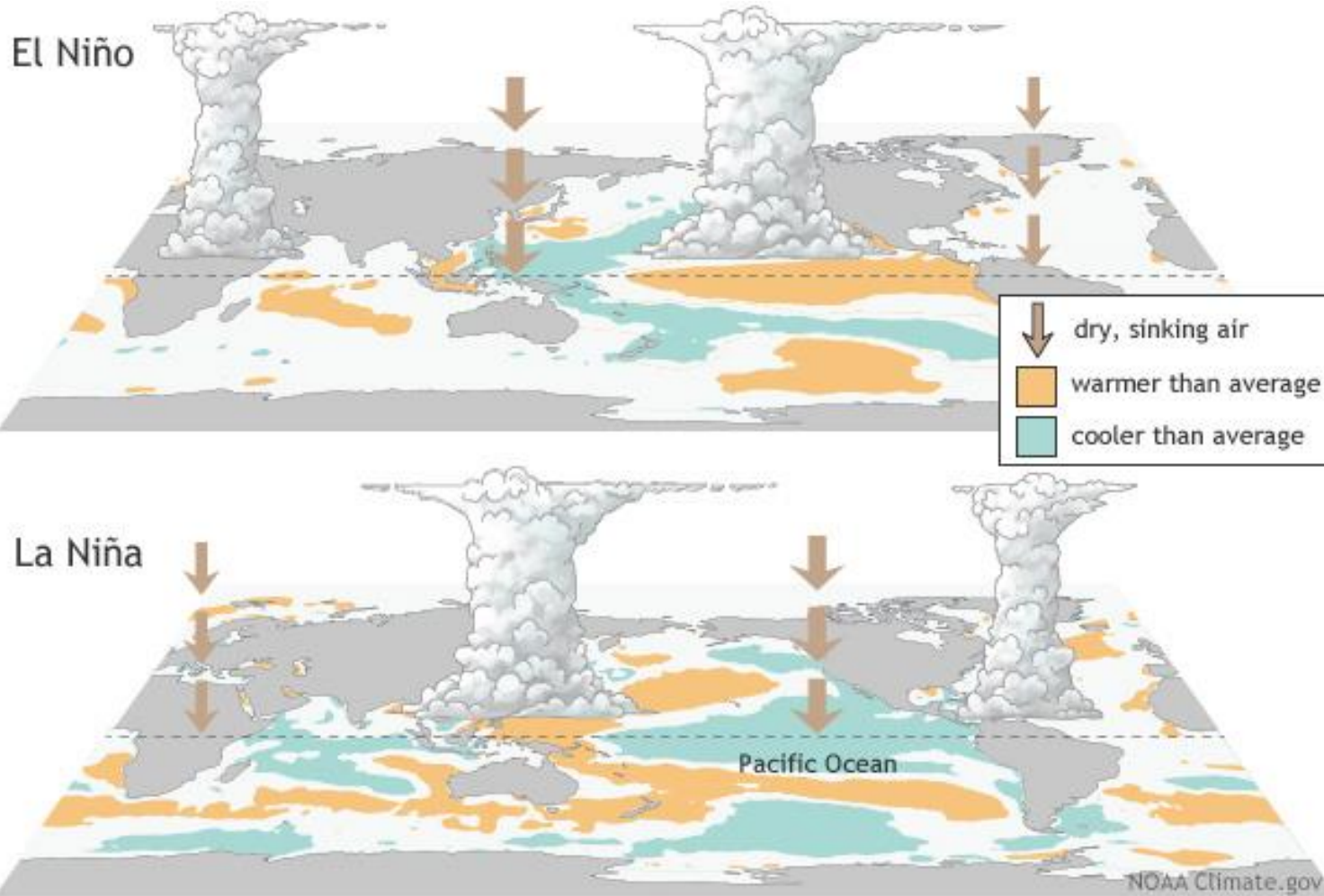


- ☀ Chinese Taipei is located at the intersection of the West Pacific Ocean and Asia, within the diverse variation of the Asian monsoon system.





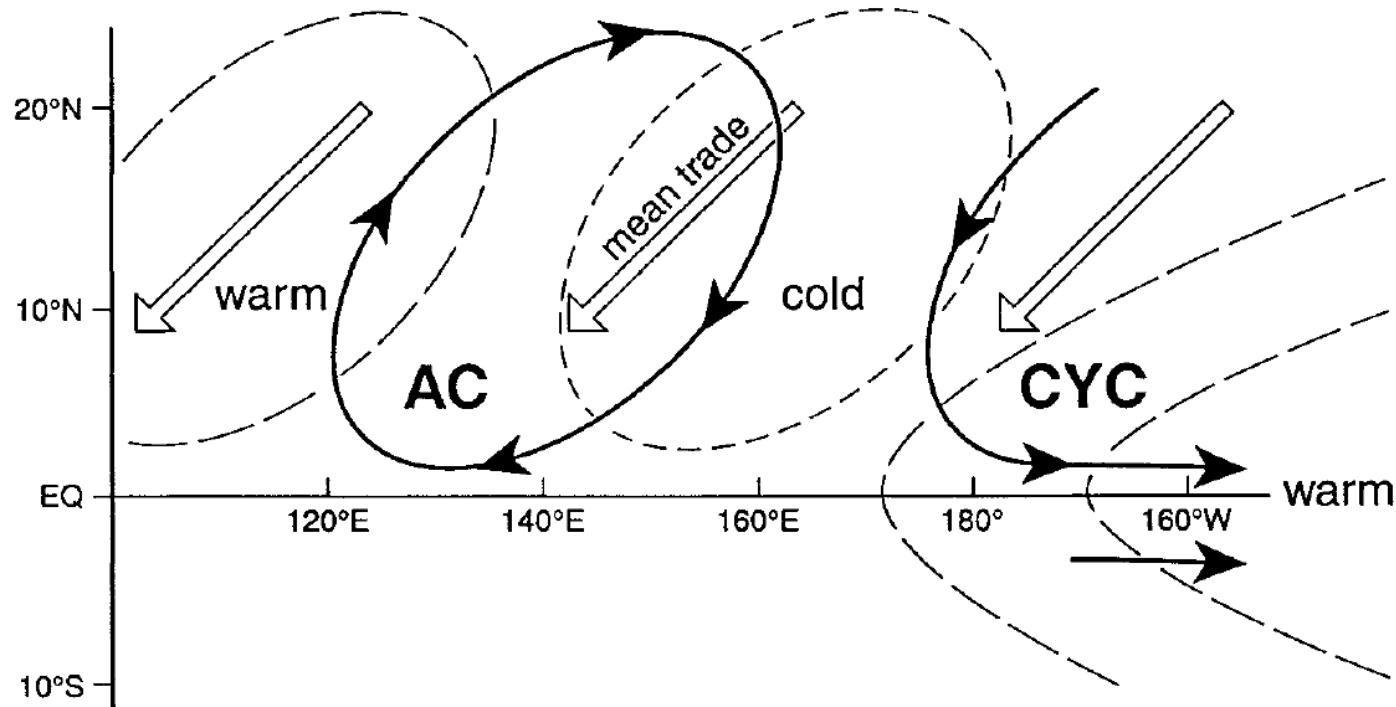
El Niño and La Niña



Although Chinese Taipei is not in the ENSO dominant area, the regional climate over Chinese Taipei is still indirectly affected by ENSO.



How Does ENSO Affect East Asian Climate?

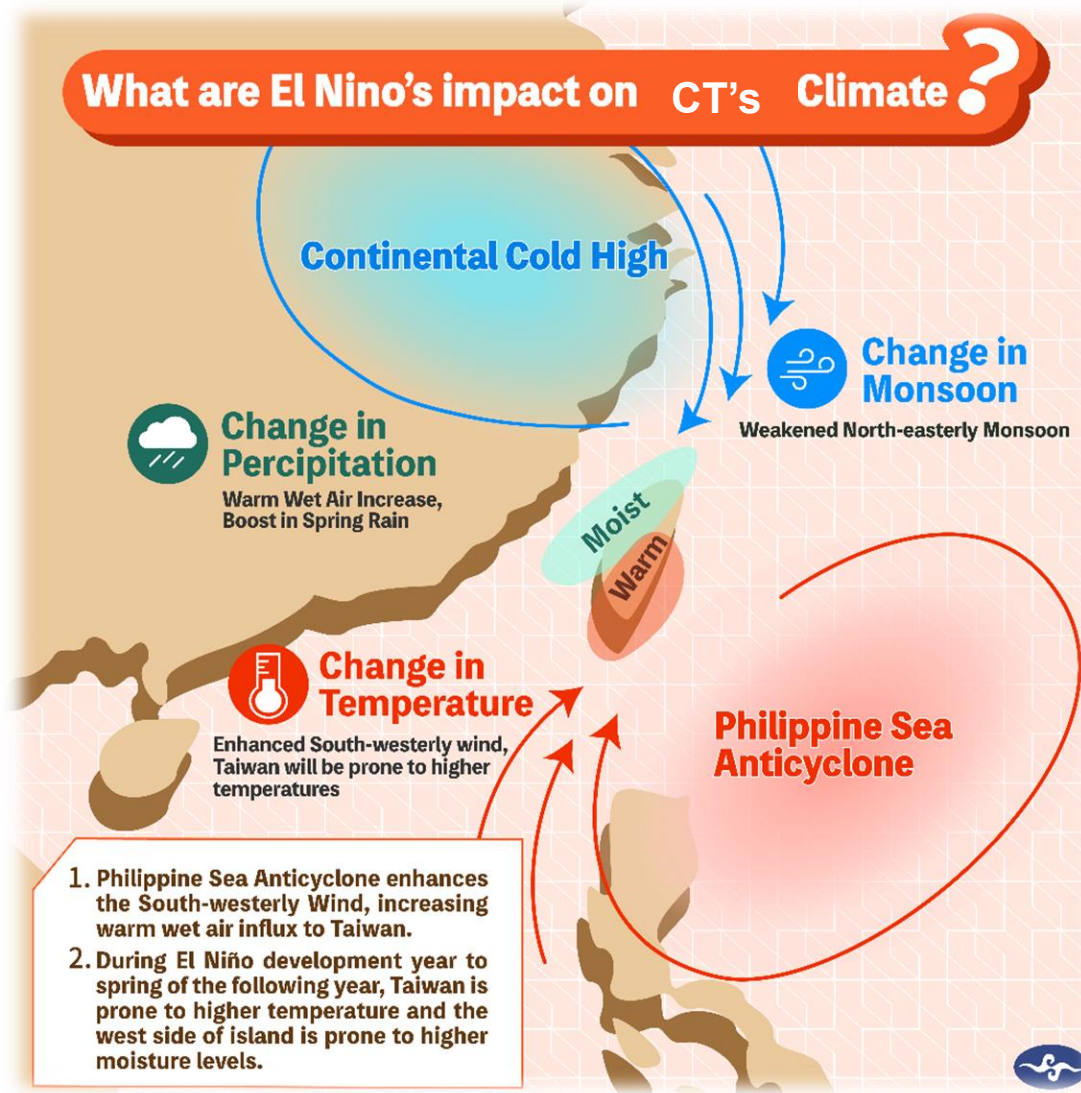


Wang et al.(2000)

Pacific-East Asian Teleconnection

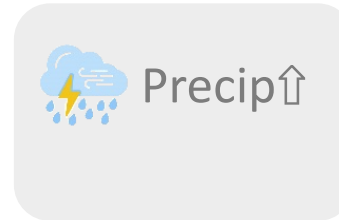
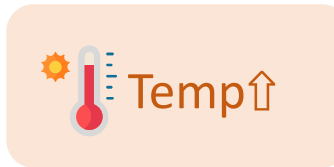
Cyclone/anticyclone associated with a Rossby-wave response to enhanced/suppressed convective heating, which is induced by ocean surface warming/cooling

The Impact of El Niño on Chinese Taipei's Climate



When El Niño occurs...

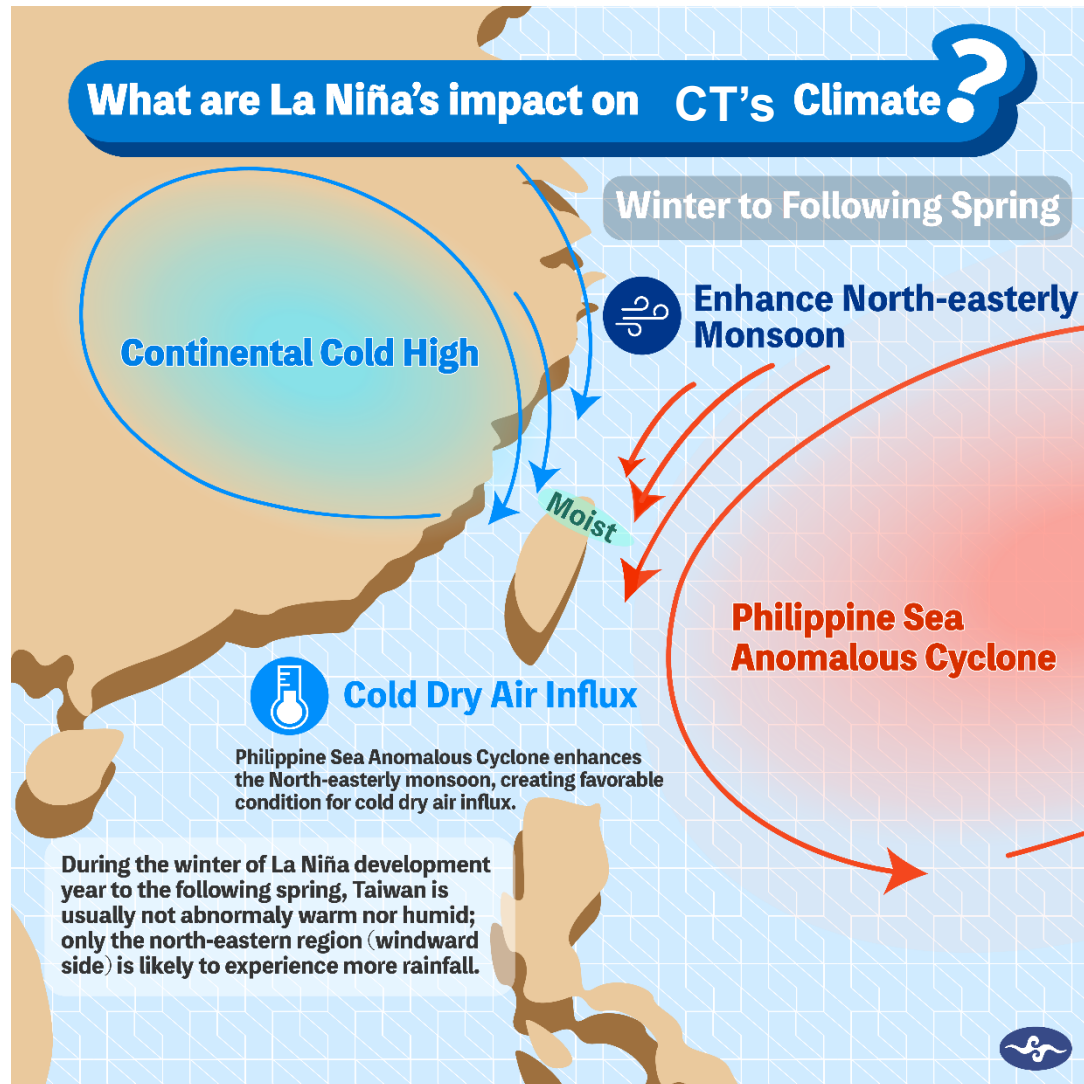
Chinese Taipei is expecting...



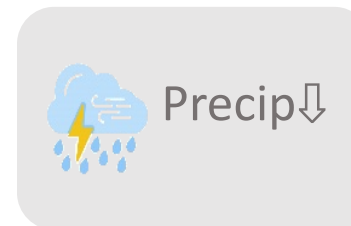
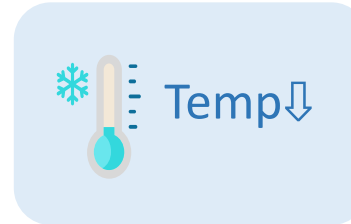
- “Warm Winter” in Winter and the following summer
- “Increase Precipitation” in Winter and Following Spring

Due to the enhanced South-westerly Wind associated with El Niño induced **Philippine Sea Anticyclone**

The Impact of La Niña on Chinese Taipei's Climate



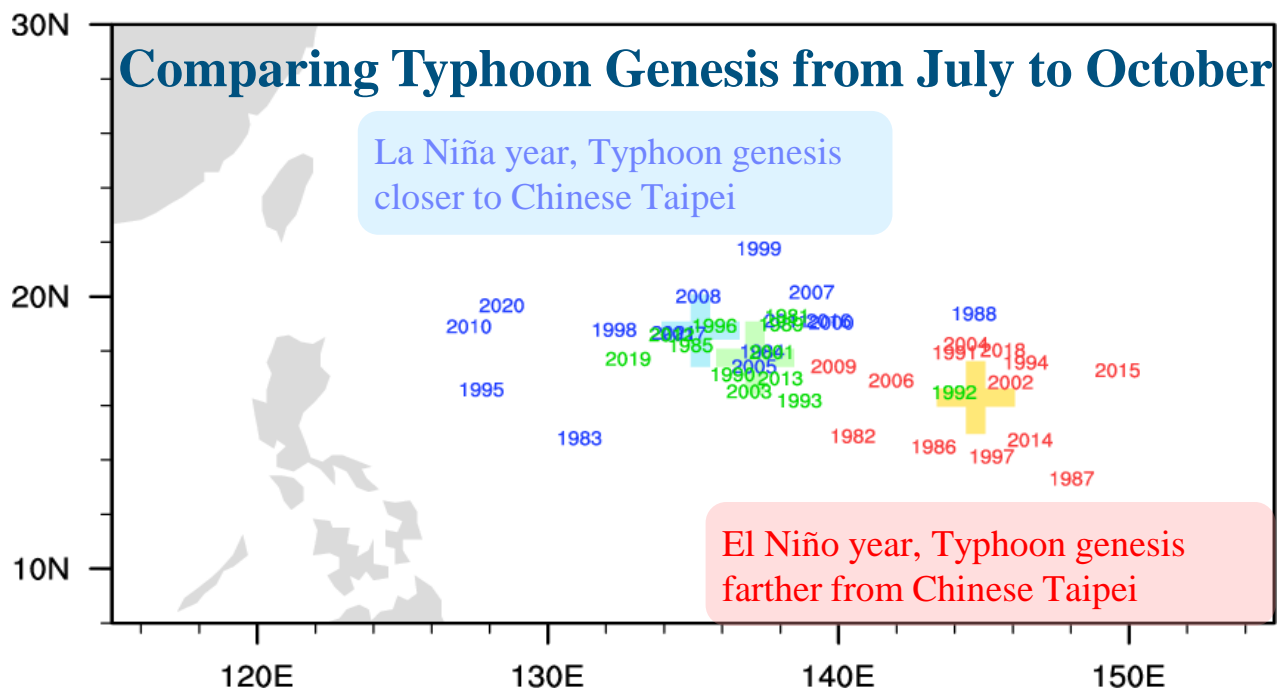
When La Niña occurs...



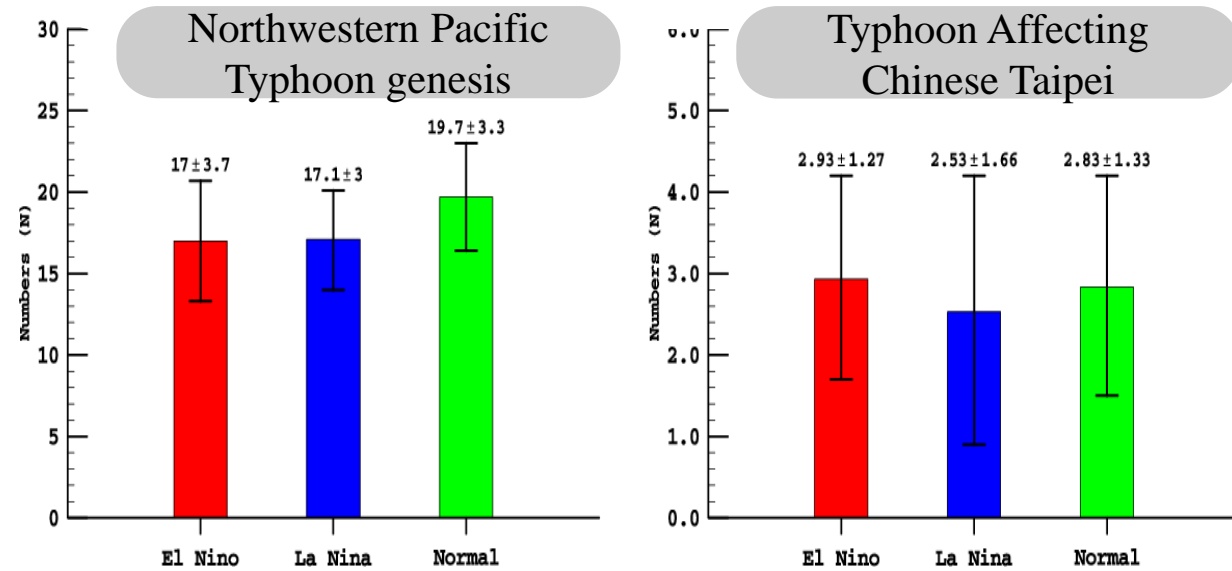
- Temperature
Winter → less likely above normal
Following Spring → Below Normal
- Precipitation
More in Winter and less in following Spring

Due to the enhanced NE Monsoon associated with **La Niña enhanced Philippine Sea Anomalous Cyclone**

The Impact of ENSO on Typhoons in WNP



Number represent year, **red are El Niño years**,
green are normal years, **blue are La Niña years**



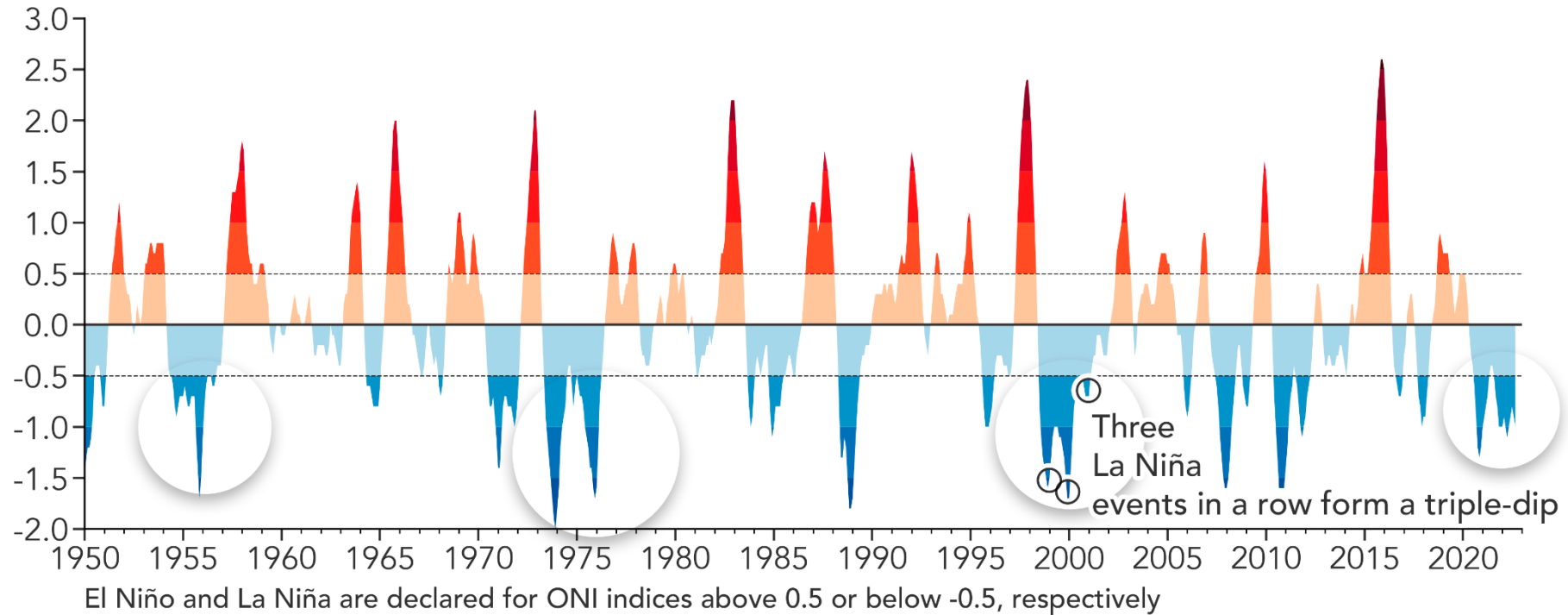
Data from 1981 to 2023 July-October



2020-2022 “Triple-dip” La Niña events

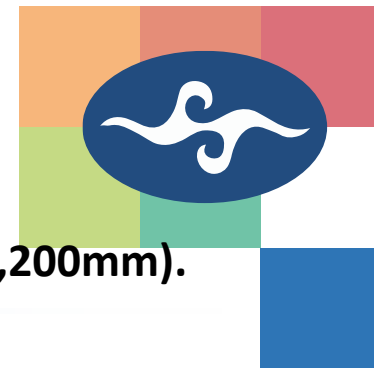
Triple-dips in seasonal trends of the Oceanic Niño Index (ONI)

In rare instances, a La Niña can return for three consecutive winters—a so-called ‘triple-dip’



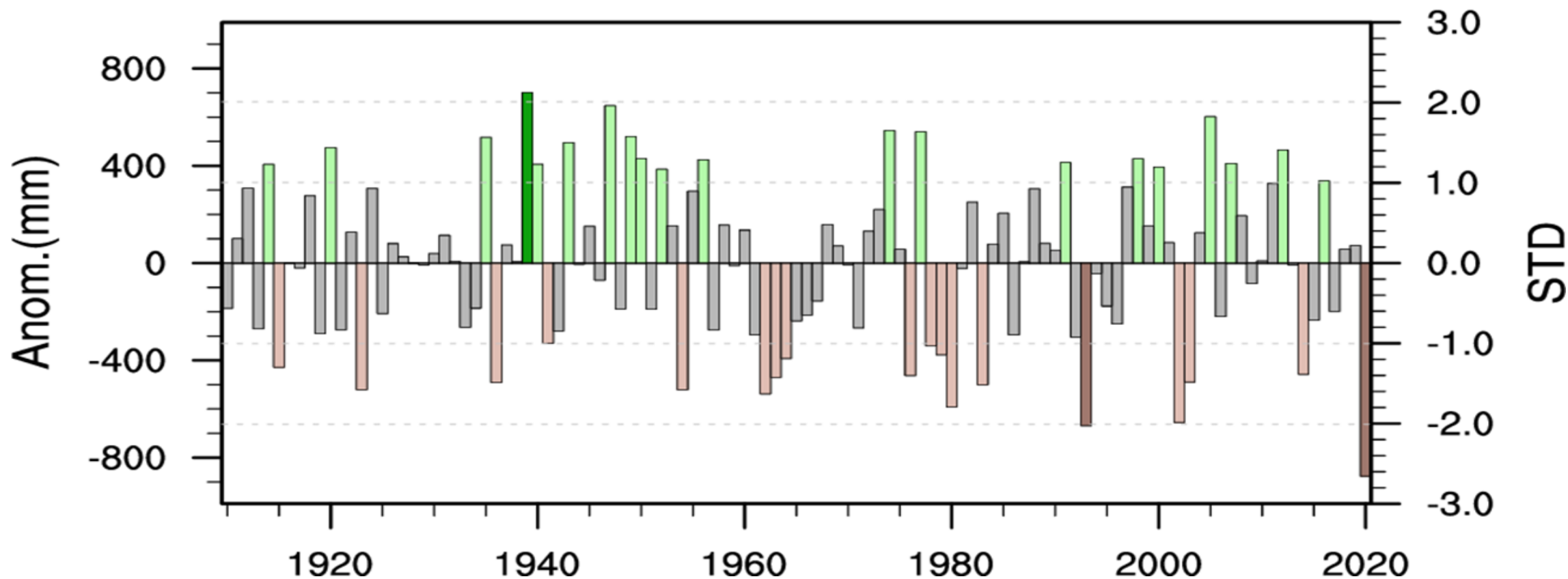
From NASA

2020-2021 mega drought in Chinese Taipei

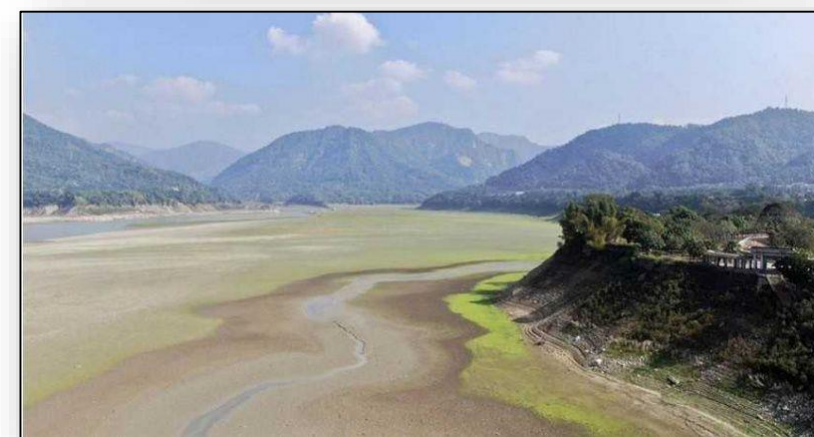
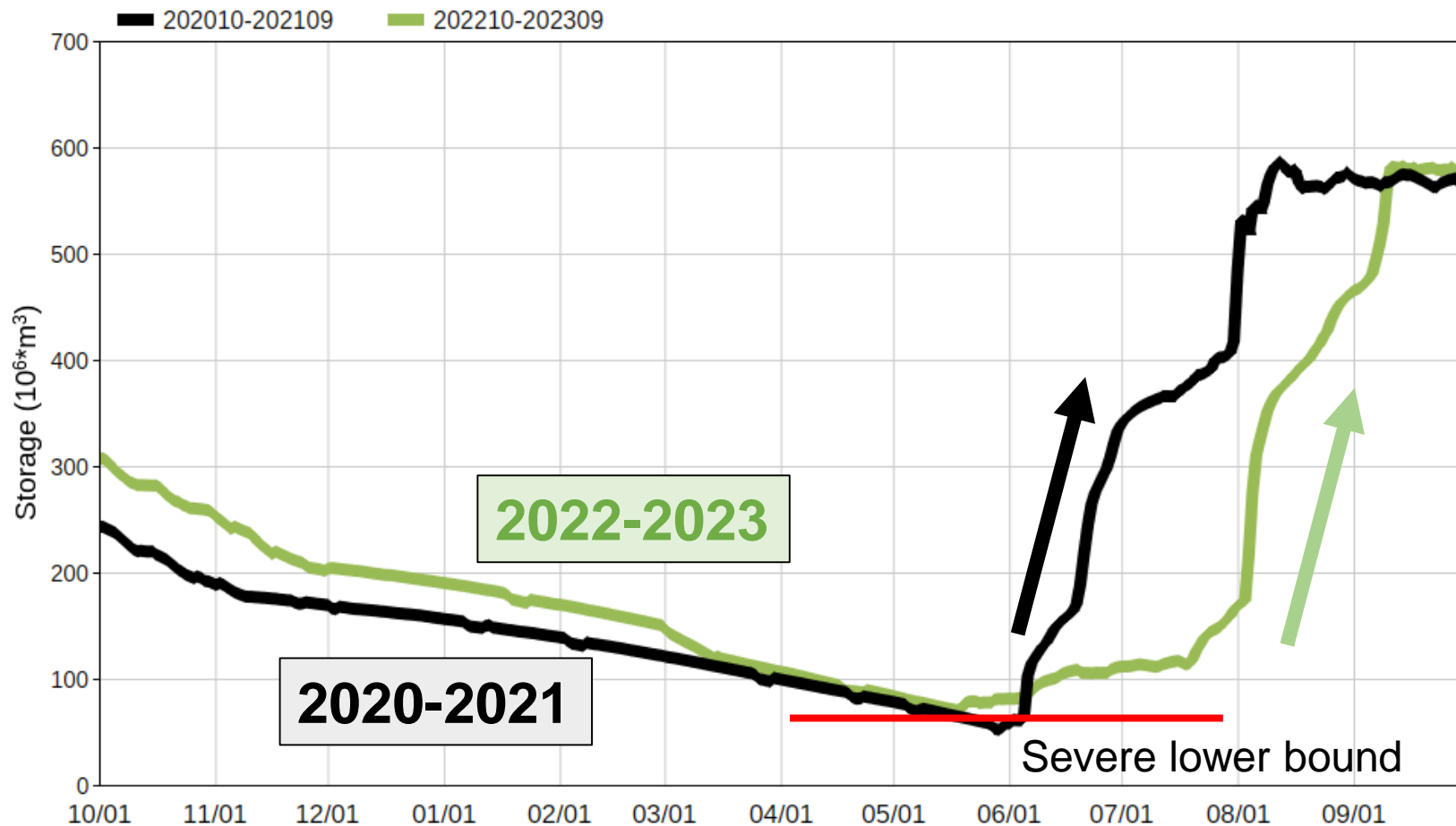


- ☀ The worst drought in Chinese Taipei! (According to data from six hundred-year stations)
- ☀ Accumulated rainfall from June 2020 to May 2021 was 1,160mm, only half of the climate normal (2,200mm).

Rainfall of 6 stations in Jun-May, 1910-2020



Water level of Zengwen Reservoir

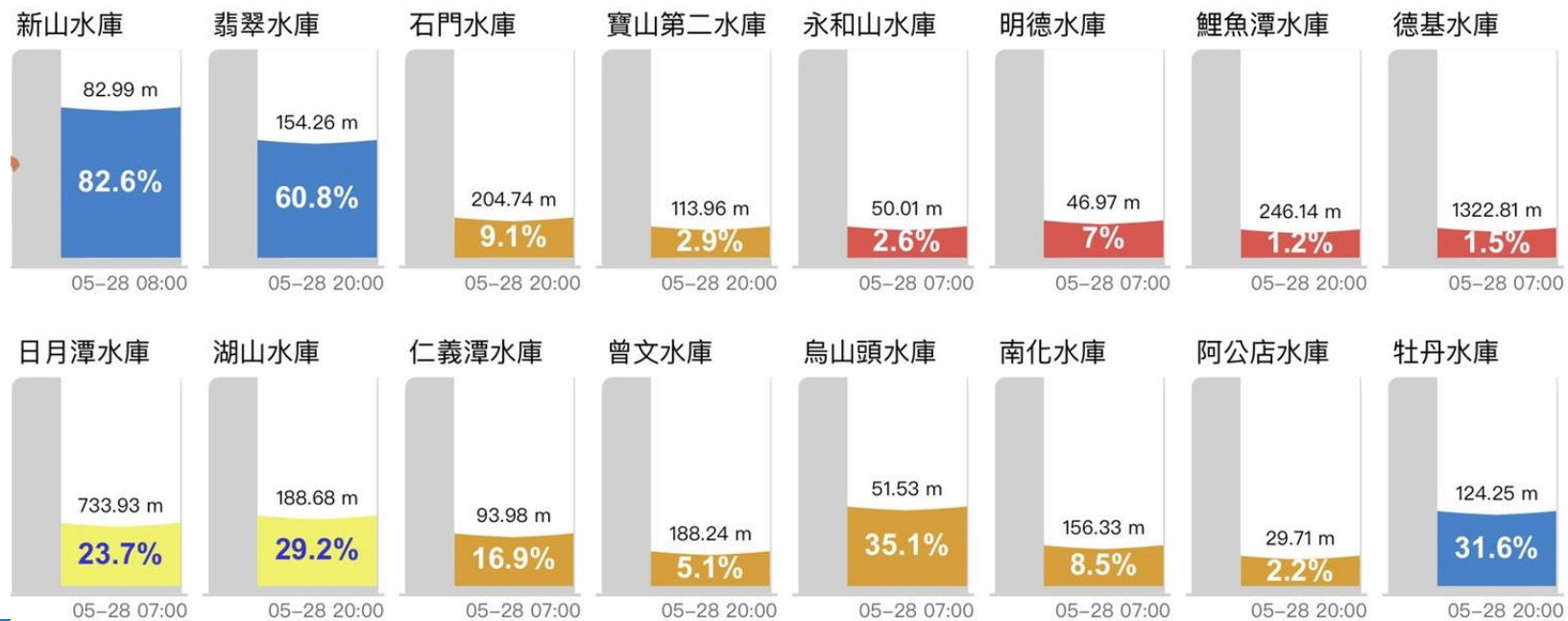




Taiwan Prays for Rain and Scrambles to Save Water

Some of the island's lakes and reservoirs have nearly run dry. And water restrictions have forced many residents to modify how they shower, wash dishes and flush.

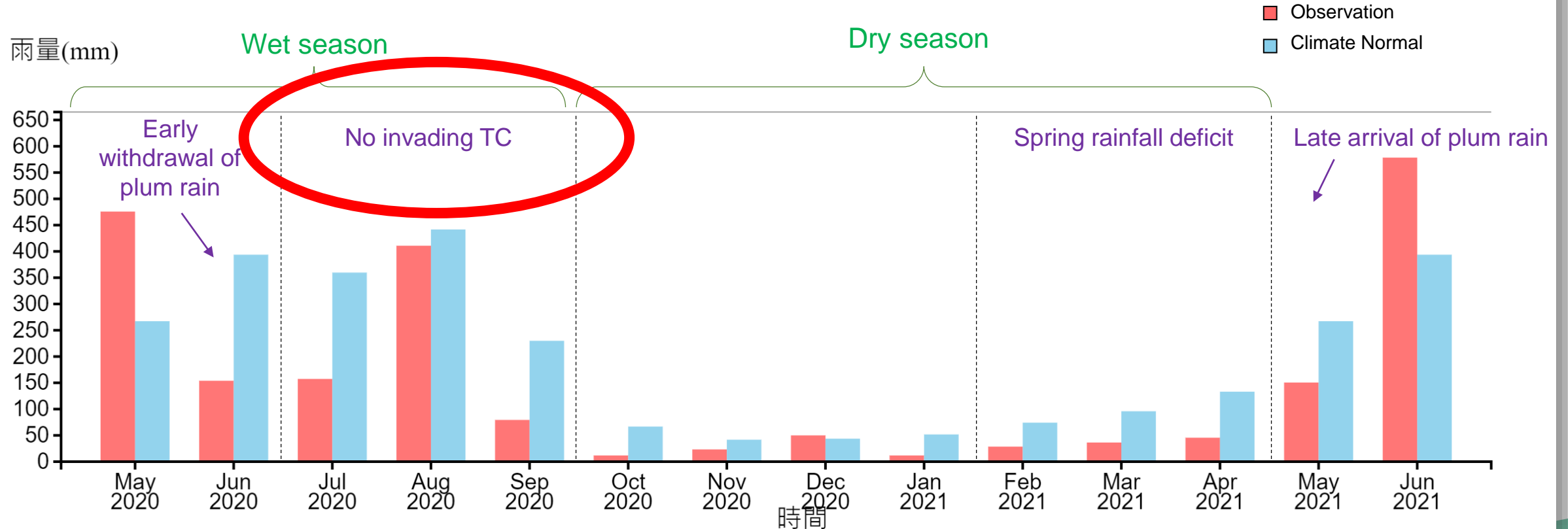
2021.05.28



- ☀️ Rice paddy irrigation suspended
- ☀️ Severe adverse effect on economic and industrial activities such as hydroelectric power generation and semiconductor supply chain
- ☀️ Water rationing for two months due to extremely low water level in reservoirs



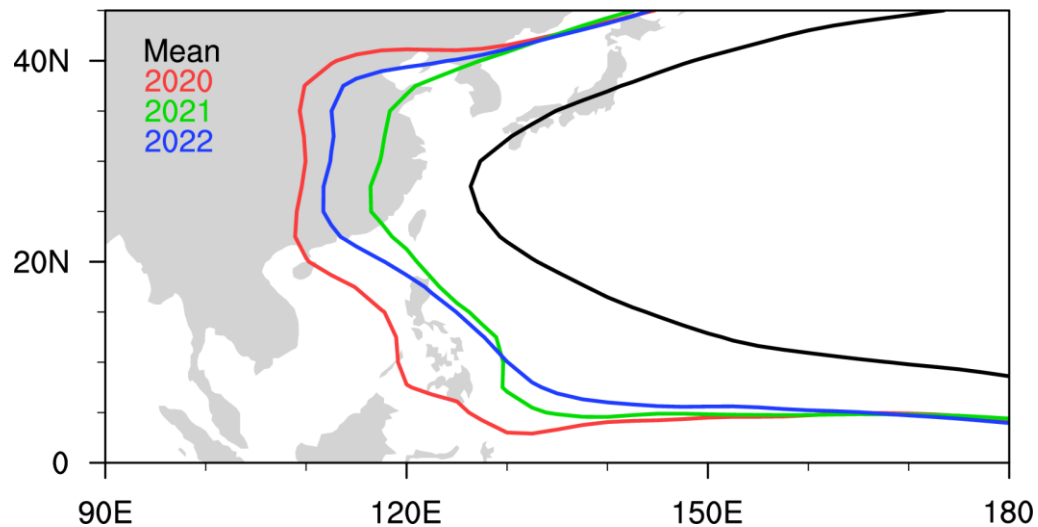
Monthly rainfall in western Chinese Taipei



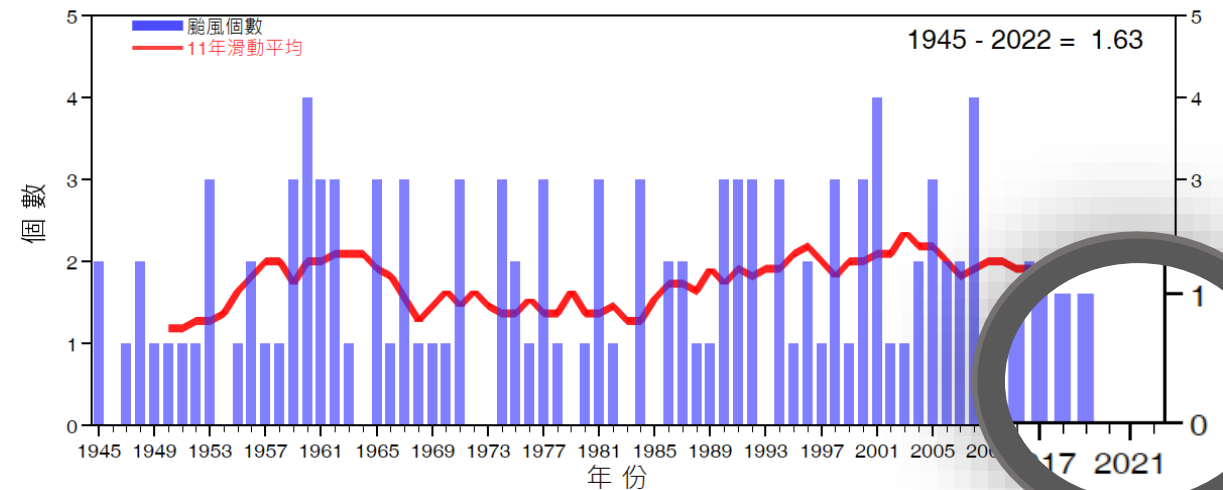


La Niña is one of the critical factors causing drought

- Extremely **strong subtropical high** and **there is no landfall typhoon in 2020-2022**.
- Simultaneous occurrence of sea temperature anomalies in various tropical oceans (LaNiña, warm Indian Ocean and warm Atlantic Ocean)
- A combination of many factors causing a drought event



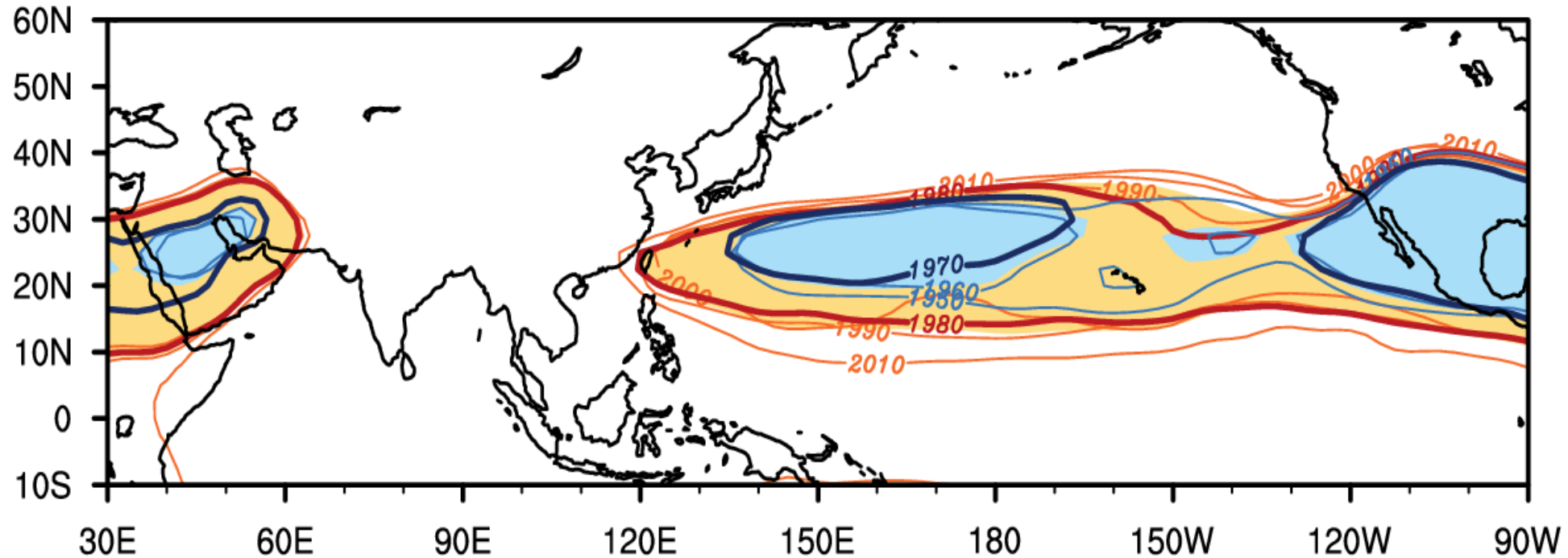
No landfall typhoon from 2020-2022





The subtropical high get stronger

JJA 500hPa Geopotential Height & 5870m Contour
Decadal Variability (10yrs mean, 1950-2015)





NATURAL SWINGS



NATURAL SWINGS PLUS CLIMATE CHANGE



NOAA Climate.gov

La Niña plus global warming
⇒ Stronger subtropical high
⇒ Frequent Drought events

The whole story could be further complicate...



Ministry of
Transportation and
Communications

Ministry of Economic
Affairs



經濟部水利署
Water Resources Agency, MOEA

N M

H S

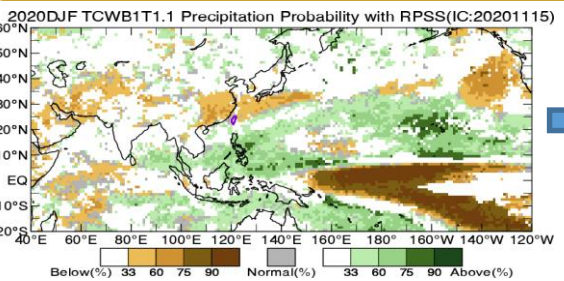
Seamless forecast guidance for Drought Mitigation

- For **Hydrology and Agriculture** sectors
- Close communication between meteorological and hydrological agencies
 - Water management and working group meetings every week (**46** and **38** times respectively during mega drought)
- Different forecasting guidelines are needed for various stages of drought
 - **Reservoir recharging** at the beginning of dry season (**S2S TC** frequency forecasts)
 - **Irrigation suspension** in December (first and second **seasonal forecasts**)
 - **Spring rain arrival** in February (**MJO/S2S forecasts**)
 - **Water rationing** in March/April (**Day 1-7/S2S**)
 - **Plum rain arrival** in May (**EASM** onset forecasts)

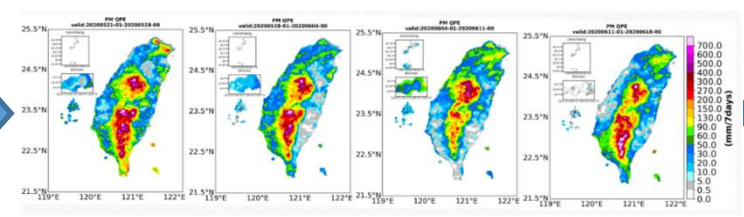


Tailored products for reservoirs

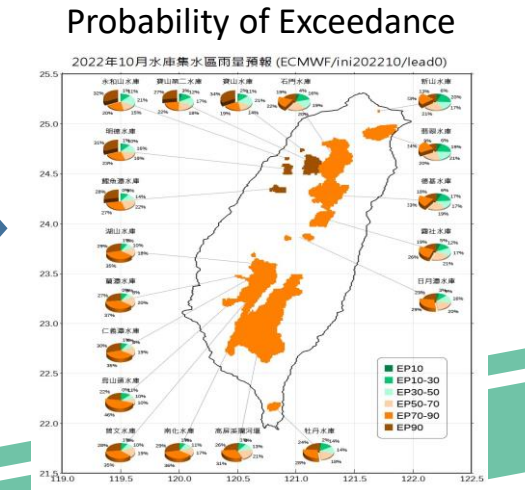
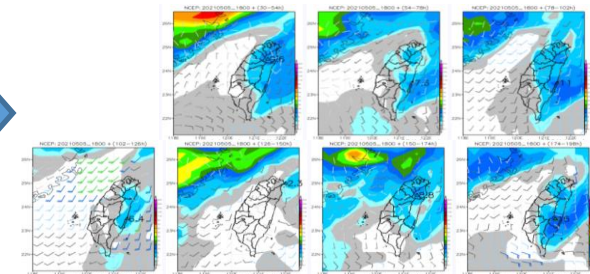
3-month and 2nd seasonal forecasts



Week 1-4 forecasts



Day 1-7 Quantitative Precipitation



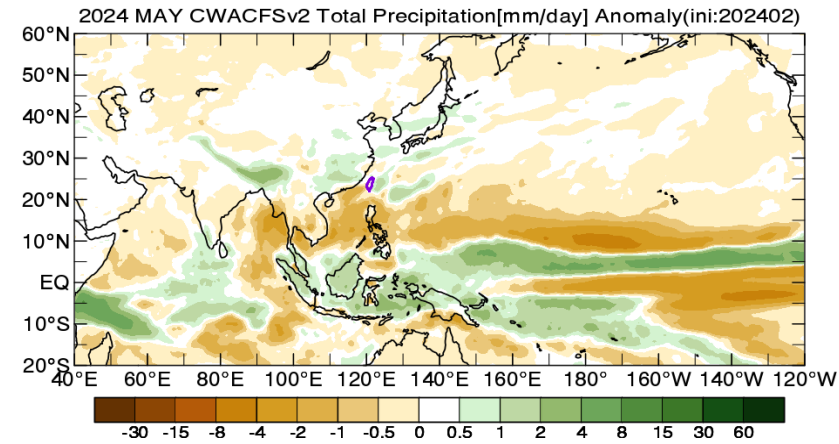


Generate science-based forecast guidance

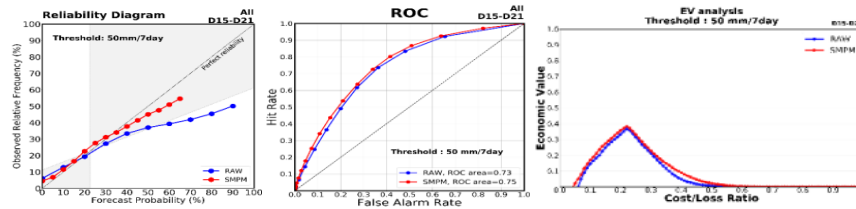
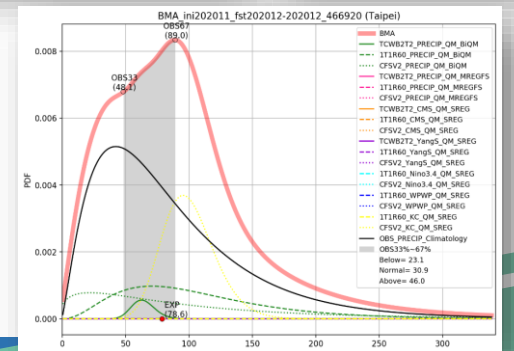
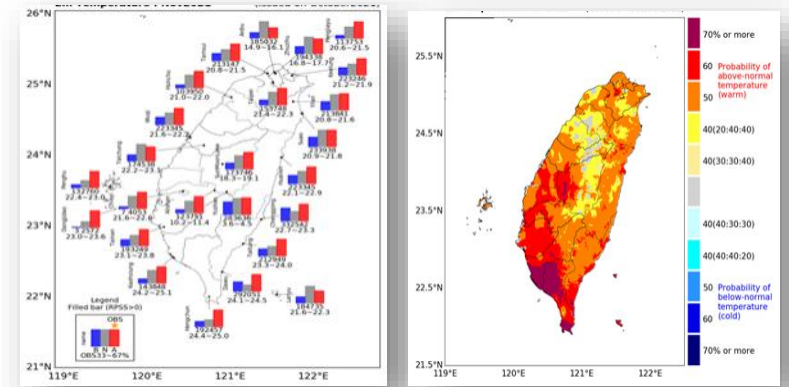
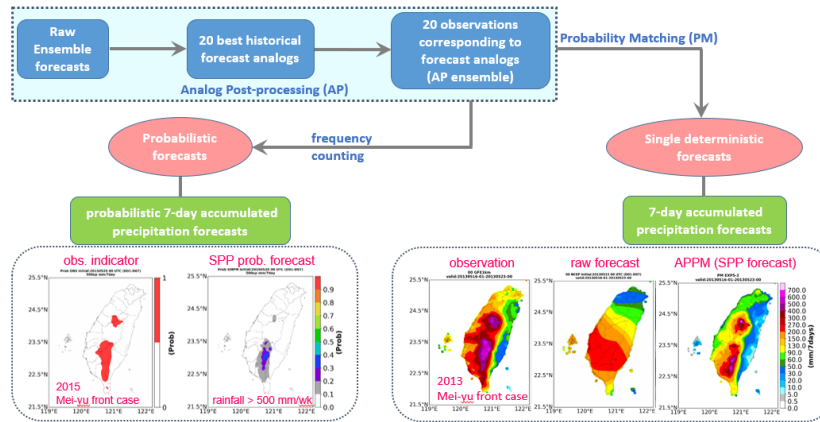
Air-sea coupled models
 Increasing model resolution
 Updating dynamic and physical frameworks
 Improving data assimilation

Statistical post-processing technique
 Bias correction
 Downscaling
 Multi-model ensemble

Tailored products
 Decision-making



Precipitation Forecast - Analog Post-processing (AP)

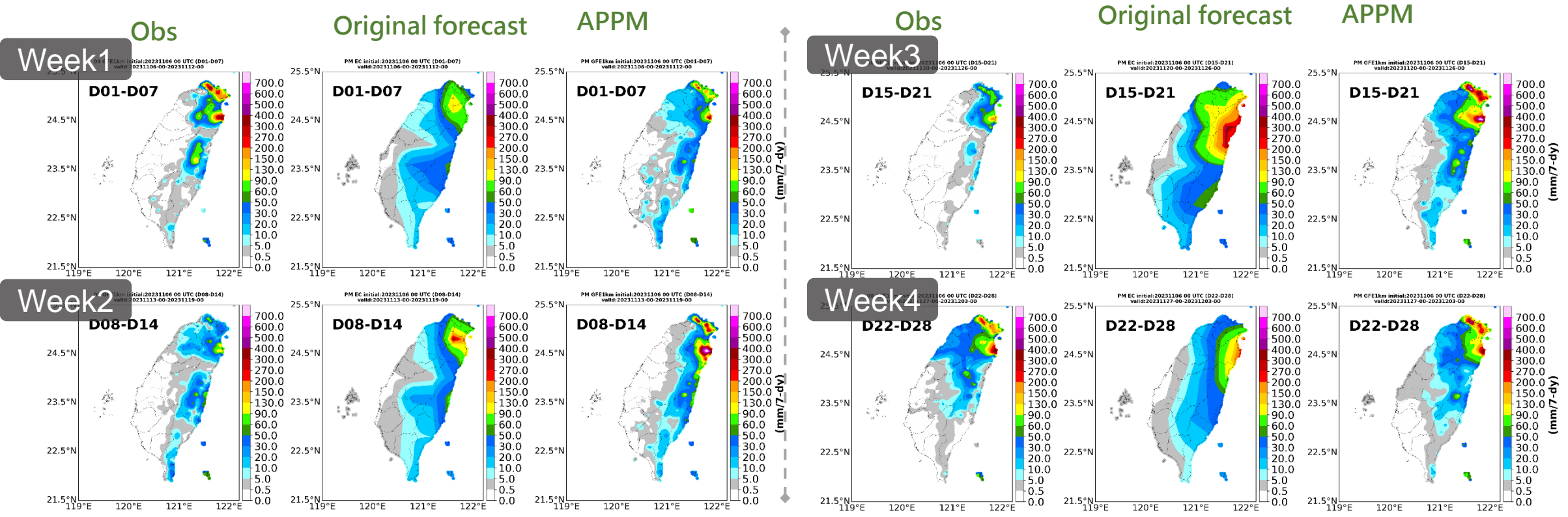


CWACFSv2	Atmospheric model		Ocean model	Sea ice model
	CWAGFS	RSM	MOM5	SIS
	Horizontal: T ₃₅₉ (~55km) Vertical: 60 levels	Horizontal: 12 km Vertical: 60 levels	Horizontal: 0.5° Vertical: 40 levels	Horizontal: 0.5° Vertical: 3 levels

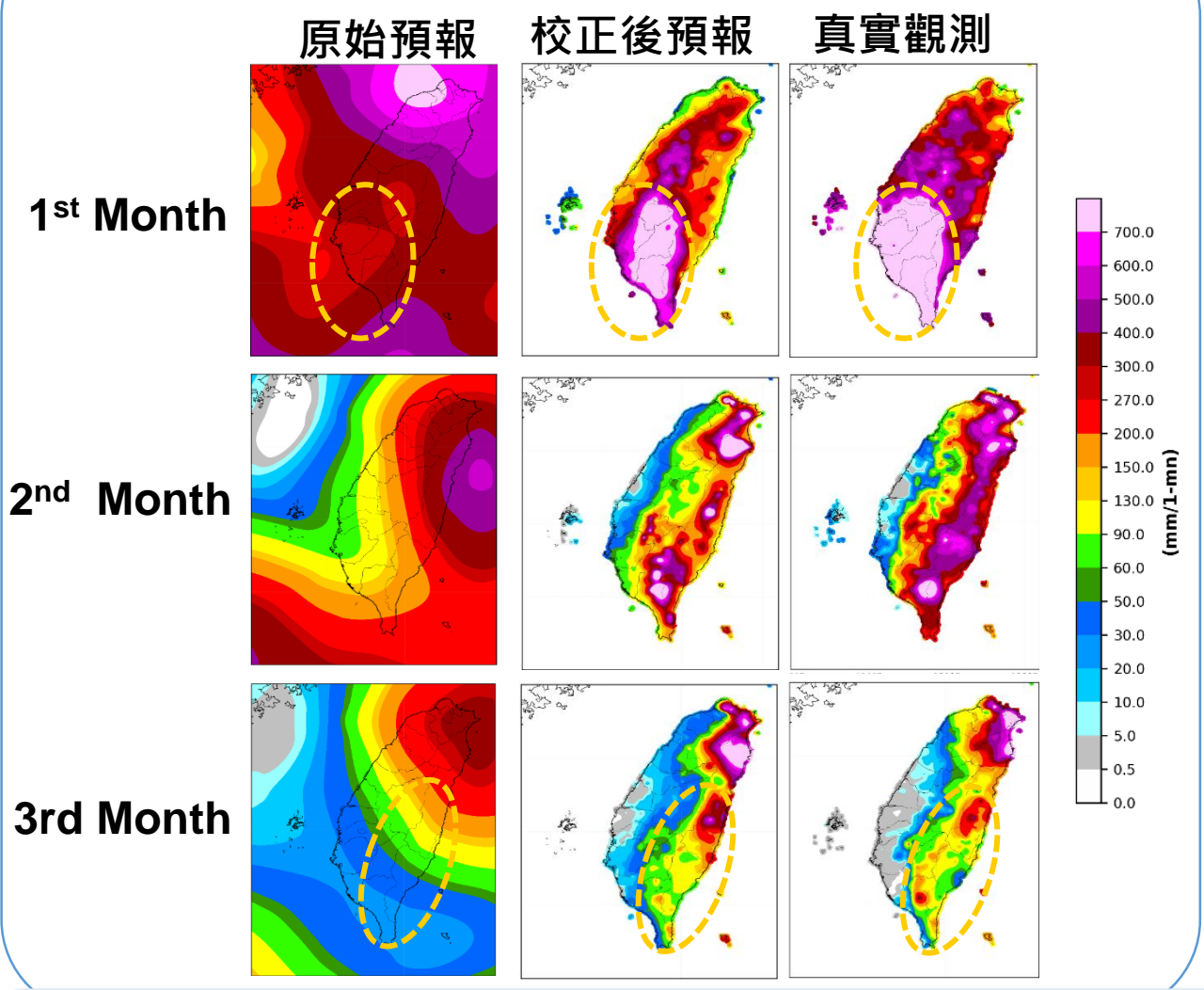
Employing analog post-processing pattern matching (APPM) for model bias correction and downscale



- After bias correction, the capability to understand the spatial distribution of rainfall can be enhanced.



Monthly accumulated rainfall forecast

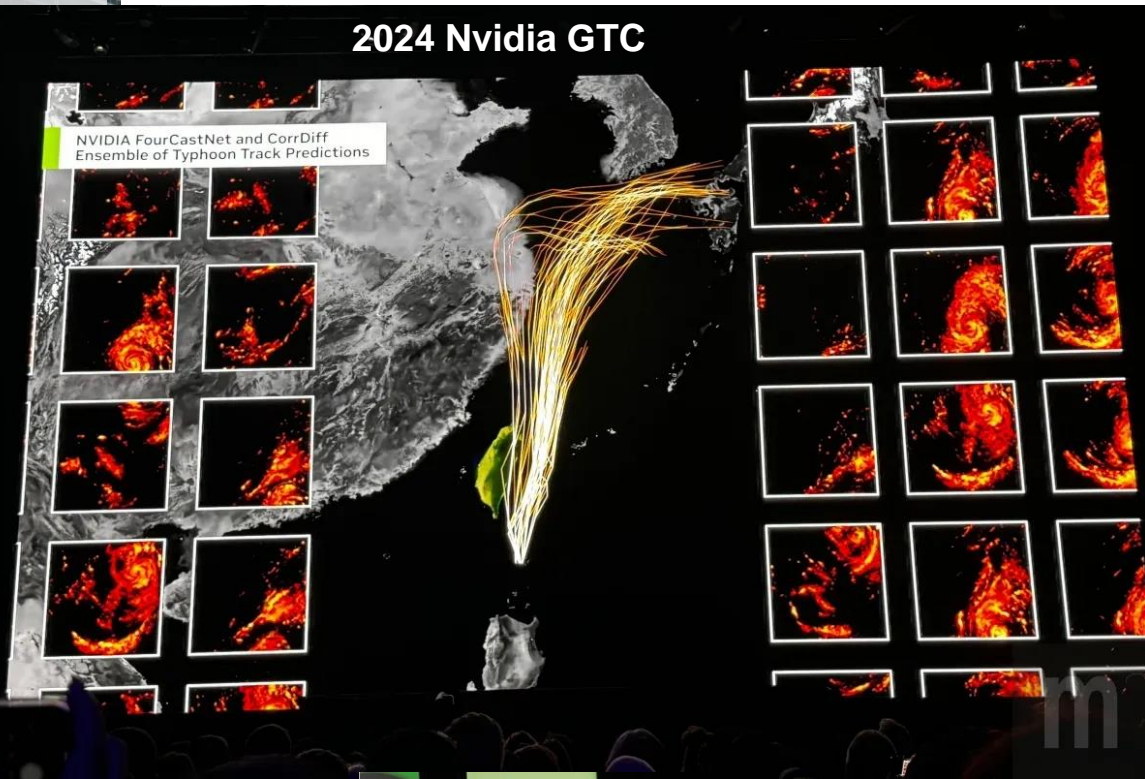


相較於原始預報，校正後預報有明顯較佳的降雨空間分布與量值

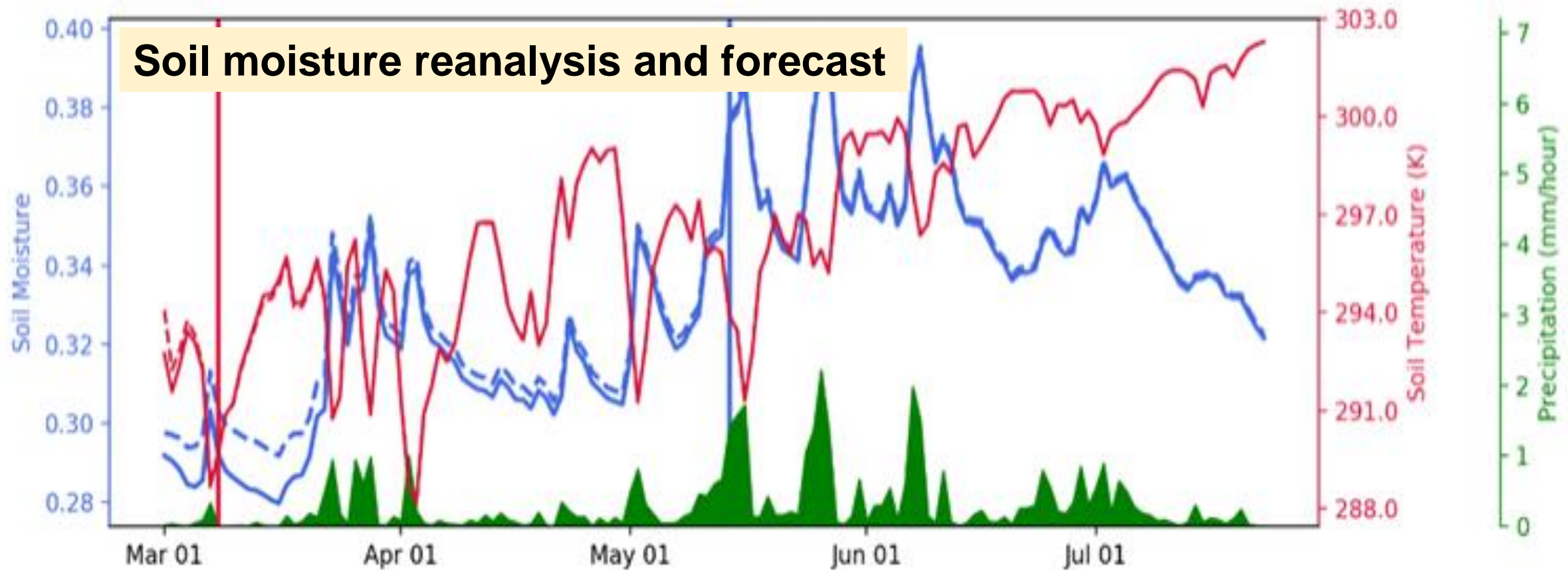
DL downscale: Corrector Diffusion (CorrDiff) with nVIDIA

2024 Nvidia GTC

NVIDIA FourCastNet and CorrDiff
Ensemble of Typhoon Track Predictions



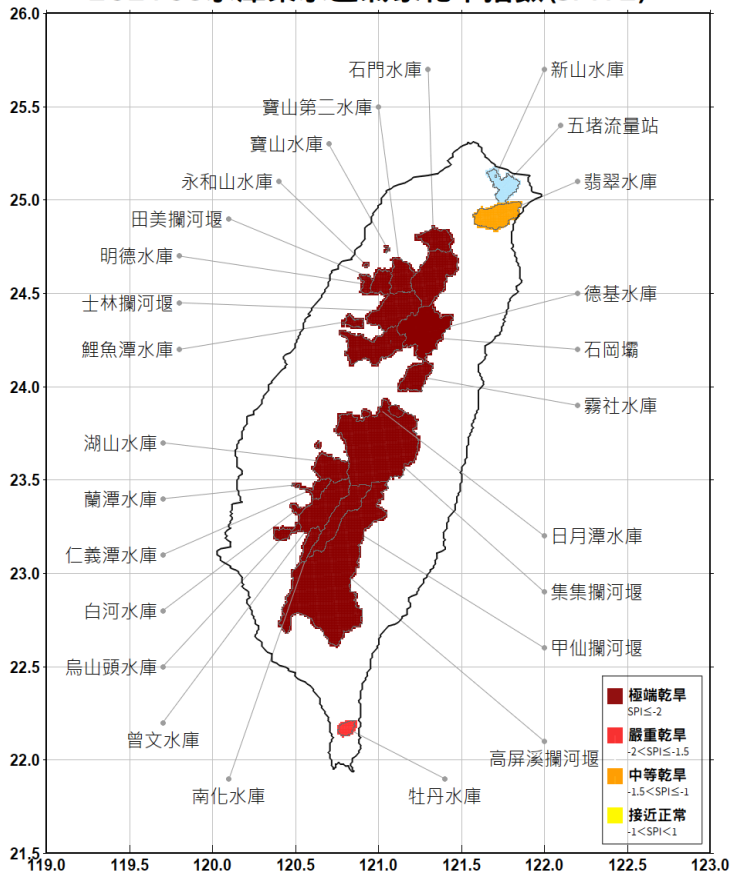
--- SM_PER — SM_CTL - - - ST_PER — ST_CTL



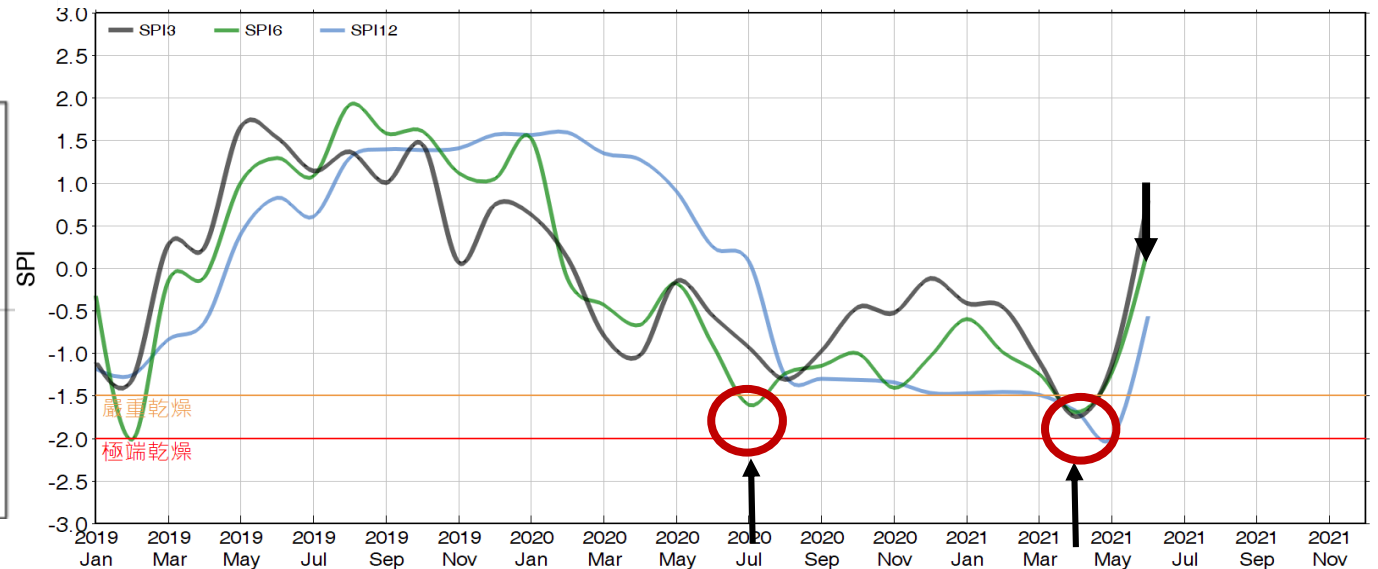
- Conduct the hourly, 10-year reanalysis with **100 m resolution**
- Apply to forecast using the CORDIFF
- Monitor/forecast for hydrology drought index

Real-time monitoring of drought for all reservoir catchment area

202105水庫集水區氣象乾旱指數(SPI12)



SPI3, SPI6, SPI12



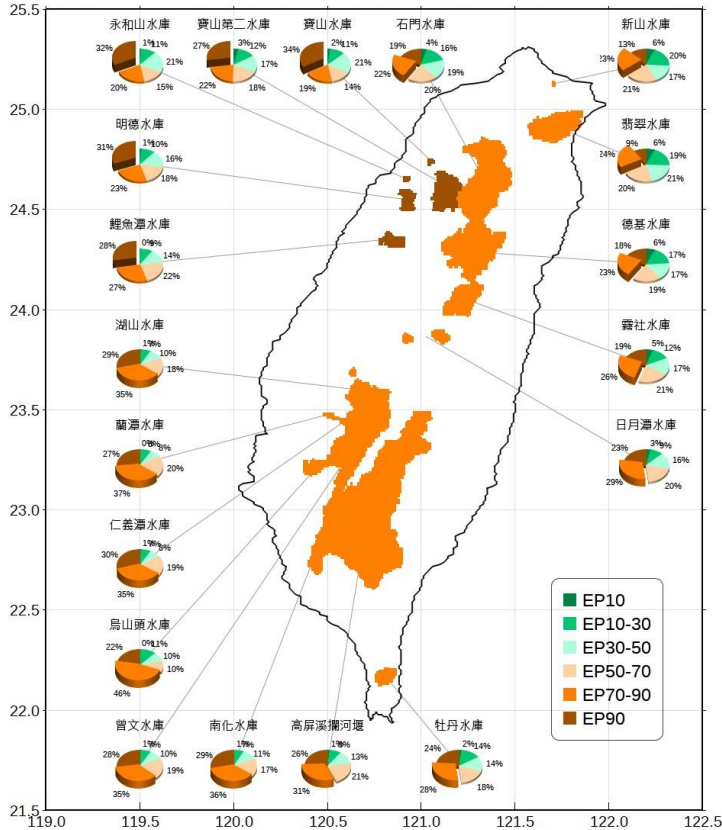
Time
 2020/7
 SPI6 < -1.5
 SPI12 is decreasing
 should pay attention

2021/4
 Water supplies
 suspend

Subseasonal-Seasonal Forecast Products



2022年10月水庫集水區雨量預報 (ECMWF/ini202210/lead0)



* 水庫集水區降雨類別預報(ECMWF/T1/初始場2022年10月)

	10月	11月	12月	1月	2月	3月	4月
仁義潭水庫	11.6 - 22.3	13.9 - 19.2	3.6 - 17.2	4.5 - 16.5	11.3 - 25.9	17.2 - 31.7	35.7 - 84
日月潭水庫	14.6 - 23.3	31.9 - 51.6	35.7 - 50.5	27.8 - 37.4	6.4 - 13.2	35.5 - 64.6	57.6 - 106.7
永和山水庫	< 4	6.4 - 15.8	17.6 - 37.3	50 - 63.9	45.8 - 55.1	96.4 - 135.9	36.8 - 85.8
石門水庫	88.6 - 122.3	95.5 - 134.2	136.5 - 204.7	80 - 92.5	129 - 253.9	84.5 - 121.8	68.8 - 111.8
牡丹水庫	38.4 - 85	88.6 - 155.2	26.1 - 45.9	69.3 - 92.2	69.1 - 77.5	32.9 - 52.4	42.4 - 52.9
明德水庫	< 13.7	7.3 - 21.4	17.7 - 42.2	53.9 - 69.5	40.2 - 59.8	93.2 - 146.2	37.6 - 92.9
南化水庫	9.1 - 20.6	4 - 12.1	1.5 - 9.7	1.2 - 8.1	2.6 - 17.1	8.6 - 18.7	27.6 - 40.4
烏山頭水庫	2.3 - 8.9	3.5 - 10	1.2 - 9.9	1.1 - 5.3	13.7 - 20.8	8.8 - 13	16.1 - 39
高屏溪攔河堰	30.8 - 56.8	44.1 - 59.1	7.5 - 18.2	5.9 - 15.2	12 - 26.2	21.9 - 34	52 - 63.8
曾文水庫	8.6 - 26	14.3 - 25.6	4.4 - 19.1	5.6 - 18.6	11.1 - 27.4	22.1 - 38.1	46.8 - 74.2
湖山水庫	7.2 - 32.1	21.2 - 27.2	6.6 - 24.1	28.2 - 56.4	18 - 31.2	23.8 - 41.1	48.6 - 87
新山水庫	88.6 - 179.2	345.1 - 386.8	162.1 - 270.5	429.5 - 537.4	271.5 - 377.9	135.5 - 223.5	99.5 - 150.9
翡翠水庫	137 - 238.2	248.8 - 316.2	232 - 331.7	177.5 - 210.6	214.1 - 327.3	73 - 124.7	124.5 - 160.1
德基水庫	57.2 - 86	98.5 - 127.6	39.3 - 82.6	69.4 - 89	33.7 - 42.3	76.3 - 125.5	52.7 - 86
鯉魚潭水庫	< 2.7	4.4 - 16.2	11.3 - 22.7	30.7 - 46.6	22.1 - 40.2	53.5 - 65.4	26 - 61.8
霧社水庫	19 - 43.5	48 - 74.3	16.8 - 51.7	66.2 - 88.2	48.9 - 103.9	75.6 - 104.5	97.6 - 208.9
寶山水庫	< 10	9.4 - 22.4	22 - 35.9	24.7 - 35.9	47.7 - 66.2	120.4 - 168.3	47.2 - 85.8
寶山第二水庫	< 37.4	46.9 - 66.9	27 - 55.3	81.1 - 98.6	41.8 - 77.2	92.7 - 120.5	75.9 - 120.6
蘭潭水庫	1.5 - 8.9	3.7 - 10.5	1.9 - 10.5	2.1 - 8.6	6 - 18.3	8.2 - 16.6	8.9 - 43.2

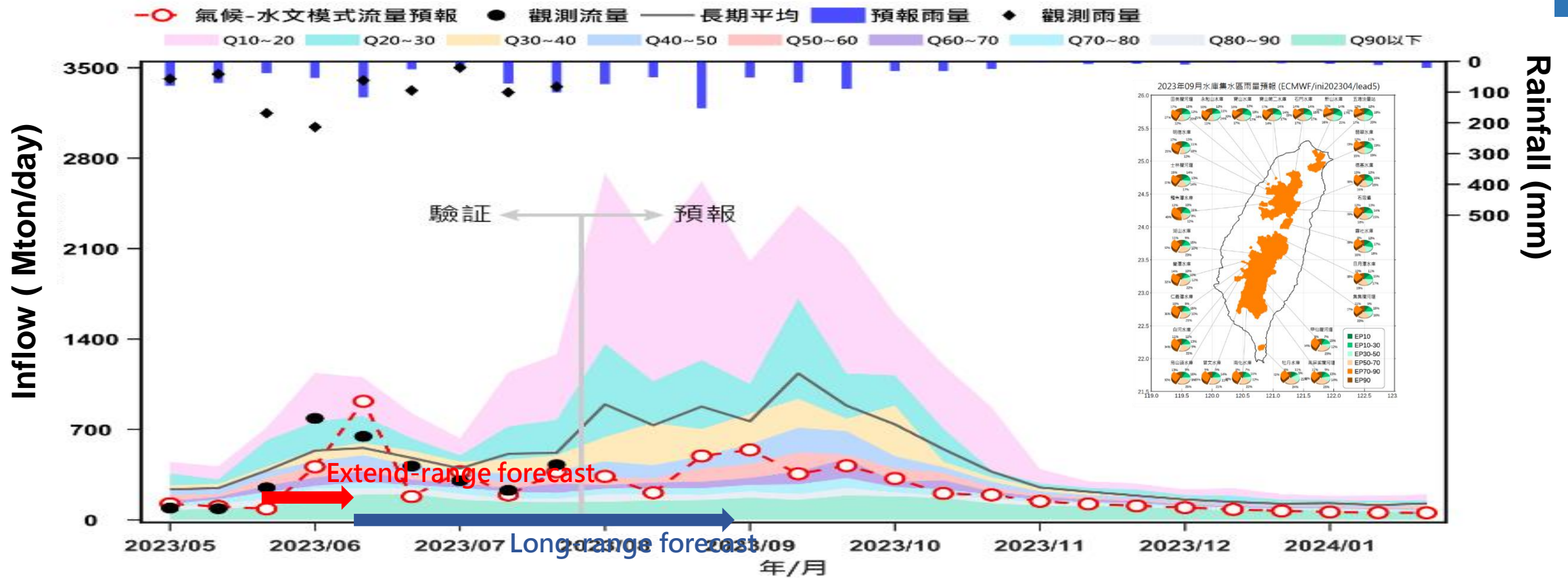
- CWA provides the rainfall forecast of maximum probability for next 6 months.
- The 6 categories of exceedance probability can show probability of extreme situation and shading indicates forecast with skill score during hindcast period.

預報類別 EP10 EP10-30 EP30-50 EP50-70 EP70-90 EP90

Probabilistic rainfall forecast for all reservoir catchment area



Seamless inflow forecasts



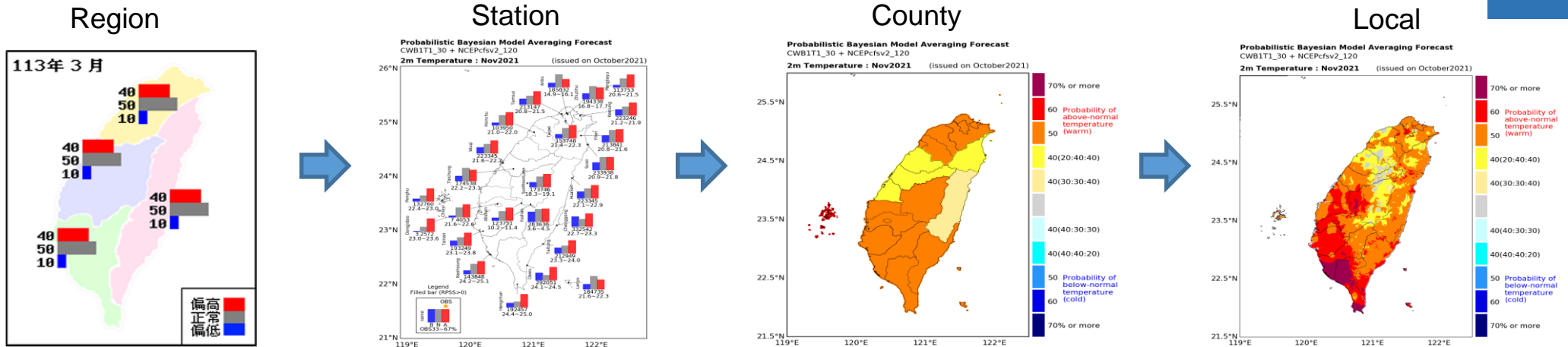
We provide seamless (extended-range and long-term range) inflow forecasts for all water catchment areas in Chinese Taipei.

Users are not familiar with probability forecasts

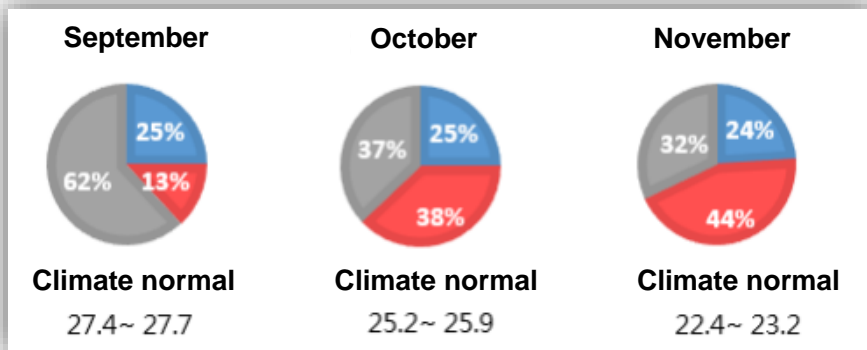
Translate probability forecasts into tailored products



Meteorological perspective



User's perspective



Warning Signal is expected

1 溫度事件警示燈號
 每天早上9點以前更新, 最後更新時間: 2021-10-19 08:56:34

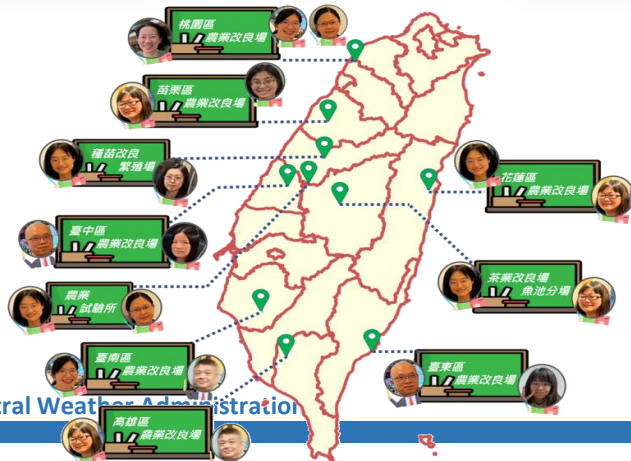
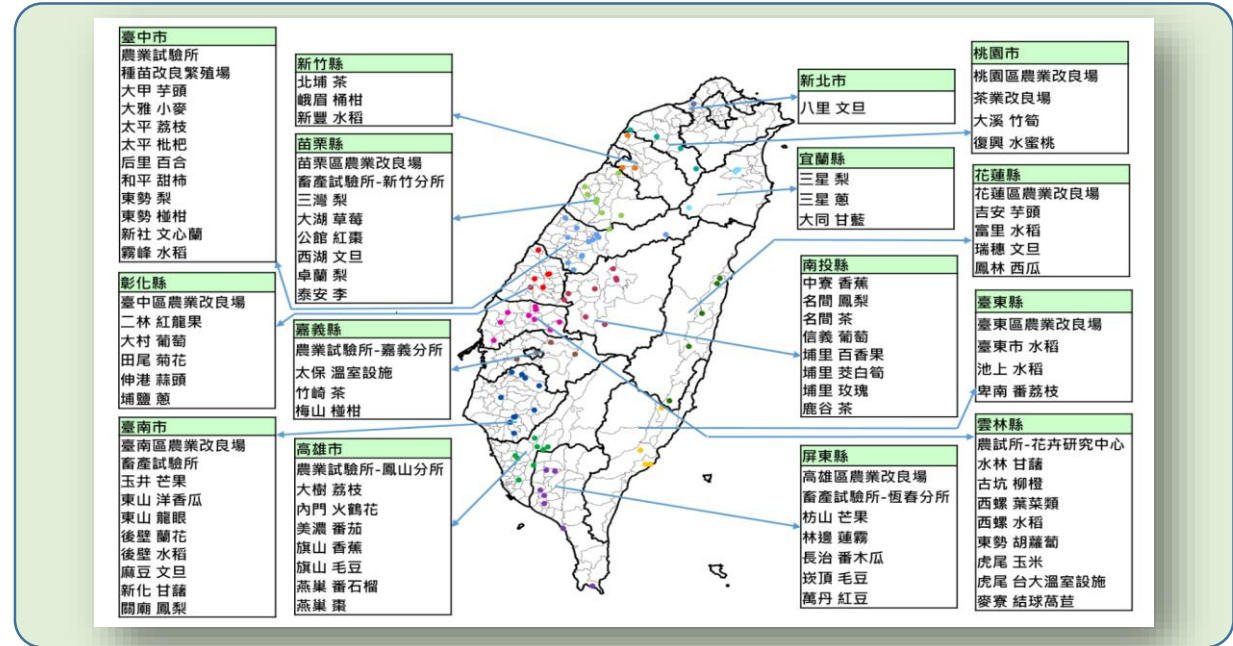
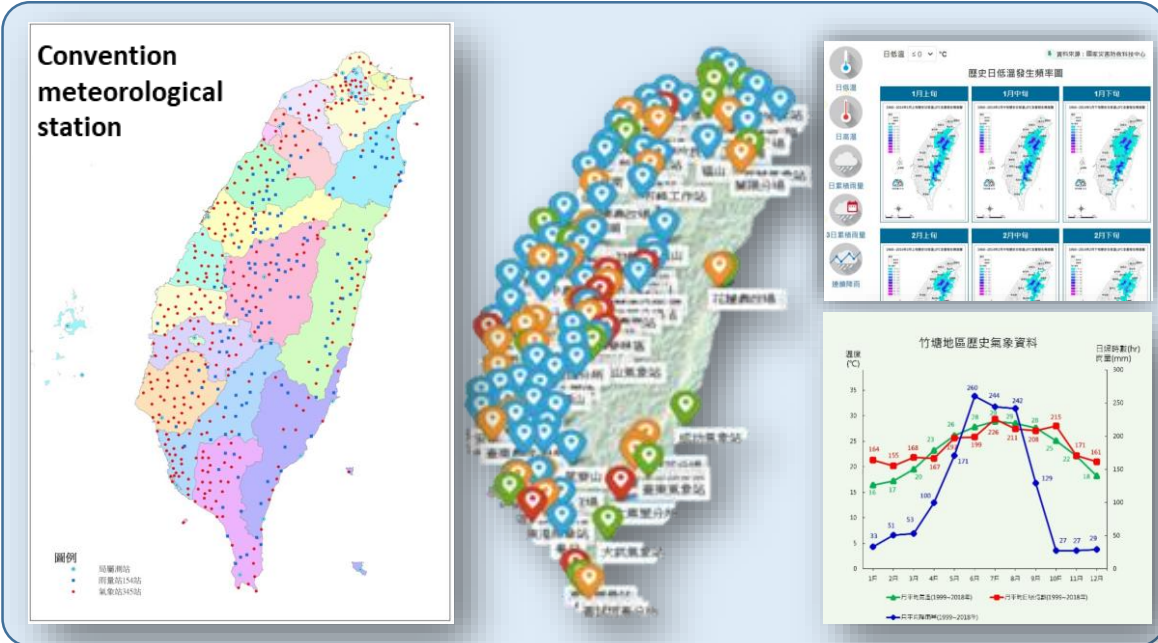
警示燈號日期	10/26	10/27	10/28	10/29	10/30	10/31	11/01	11/02
最低溫 <6	●	●	●	●	●	●	●	●
最高溫 >25	●	●	●	●	●	●	●	●

警示燈號備註:
 ● 表示資料尚未更新。
 ● 表示事件發生機率低。
 ● 表示事件當日發生機率低, 但合併評估前後一日內, 有發生機率。
 ● 表示事件發生機率高。

Outreach to promote/translate climate information

Enhancement of agriculture observatory and forecast guidance

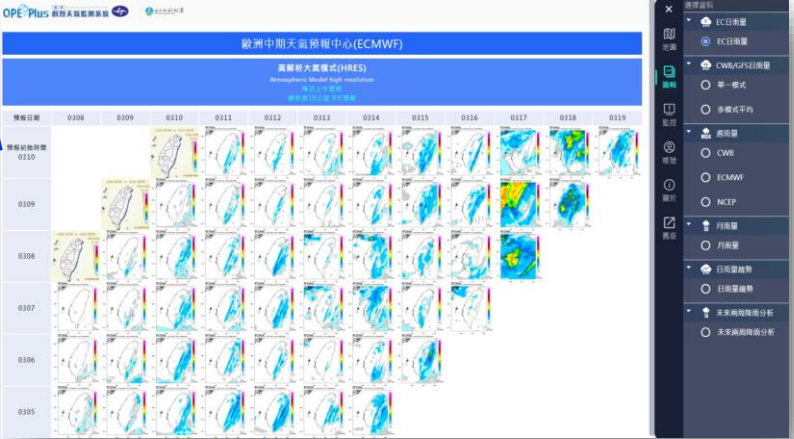
Establishing agriculture disaster early warning system for 41 crops at 92 locations



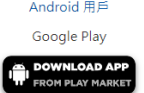
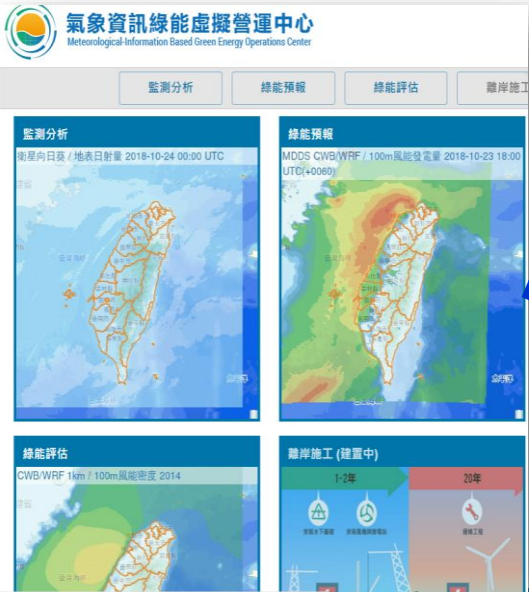
Climate Service Information System

<https://qpeplus.cwa.gov.tw/WRA/>

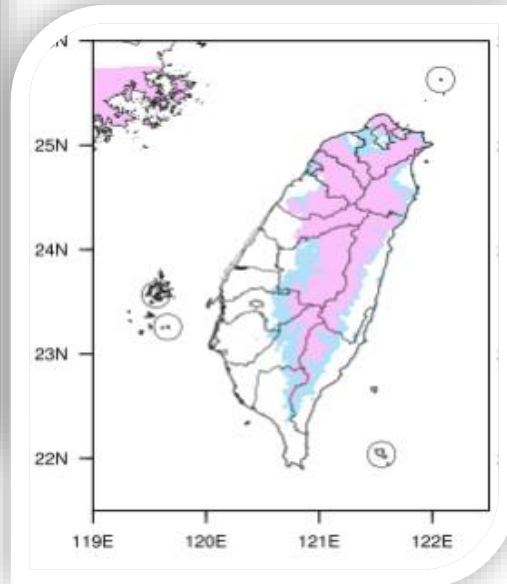
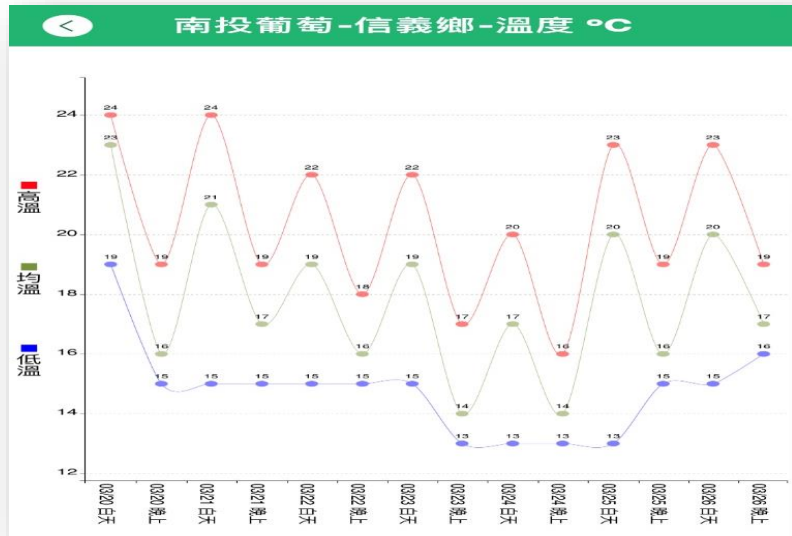
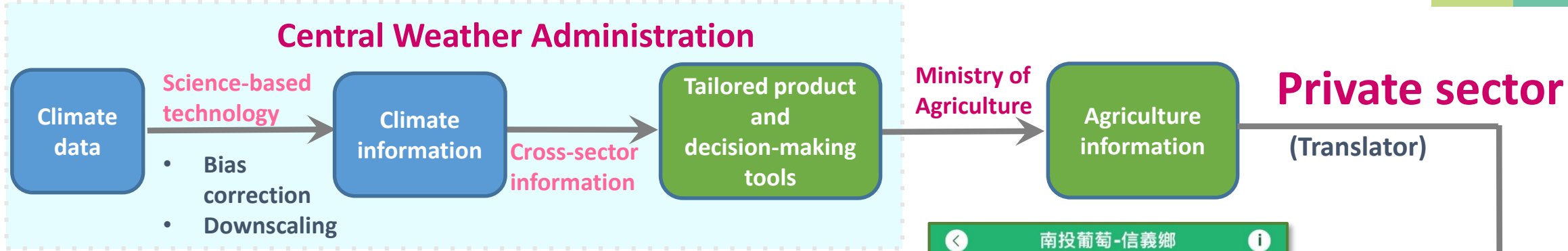
<https://agr.cwa.gov.tw/>



<https://greenmet.cwa.gov.tw/>



Smart Climate Services for Cross-Sector: **Public-Private Partnership**



Summary



- ☀ Chinese Taipei has faced the challenges of climate extreme, particularly the difficulties in water resource management caused by drought/flooding.
 - ☁ La Niña under the climate change might contribute to the frequent Drought events
- ☀ Instead of the improvement of scientific understanding and the climate predictability, the bias correction, downscale, and the decision making relevant products based on the AI/ML are essential for climate services to enhance the climate resilience.



Thank you for your attention!
Welcome to Chinese Taipei😊

Sun-moon lake, Chinese Taipei