



# Tailoring climate information and Services for Water Resources Management in Taiwan

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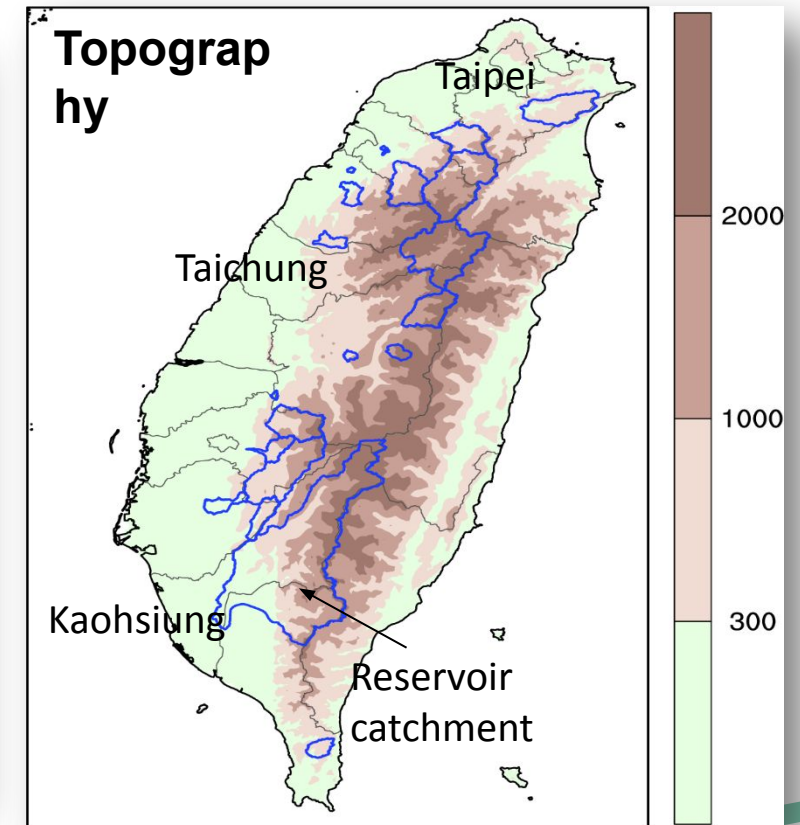
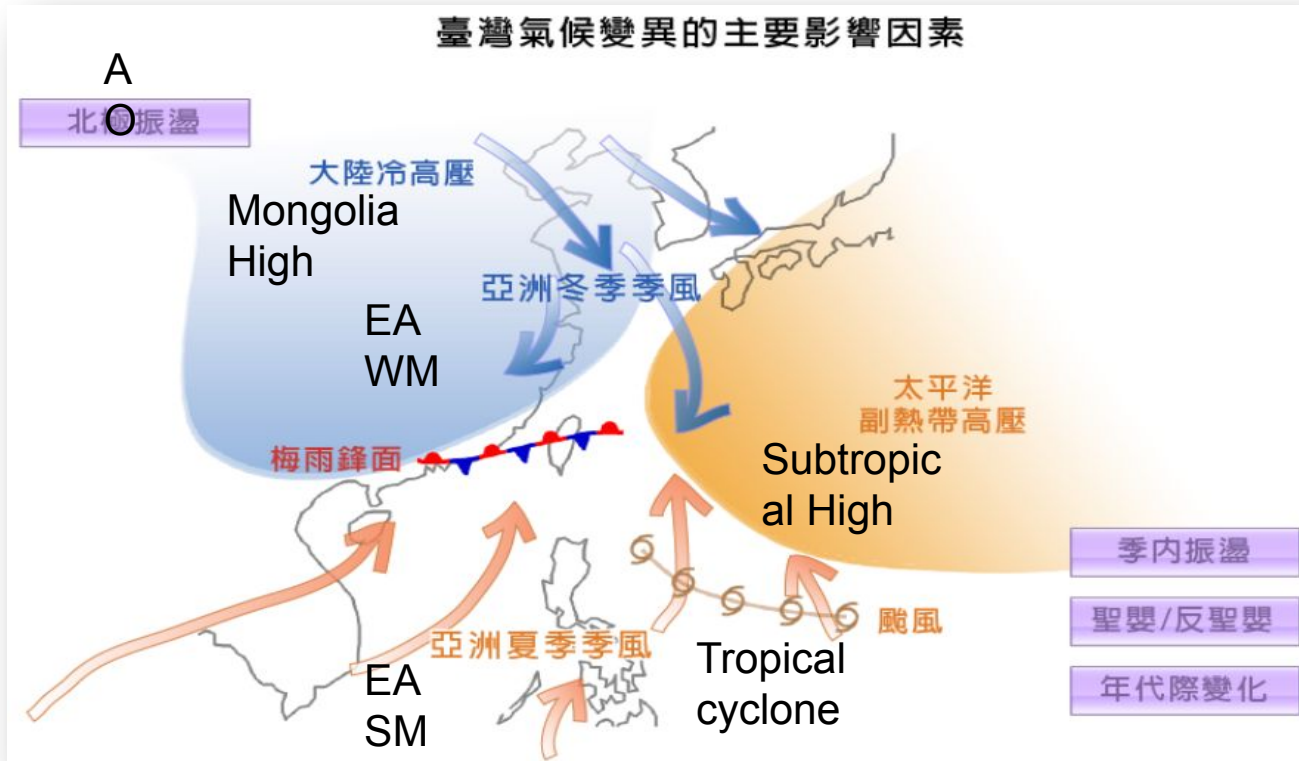


2024 CDPW–CPASW Joint Workshop



# Background information

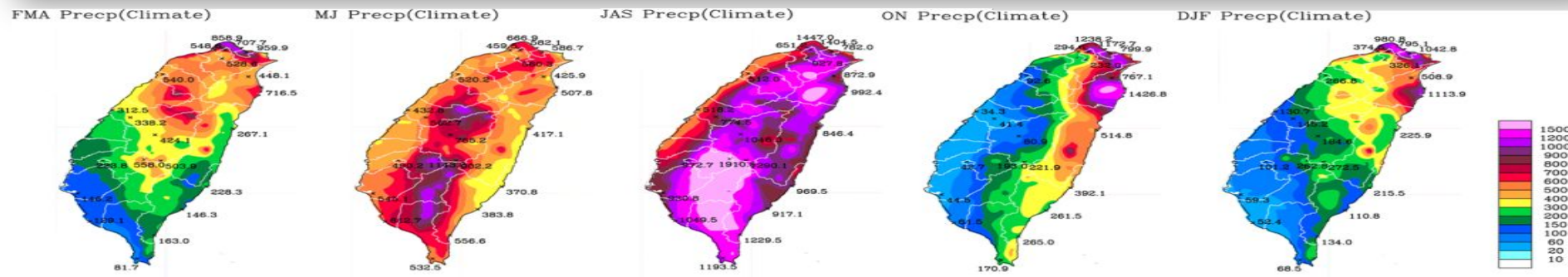
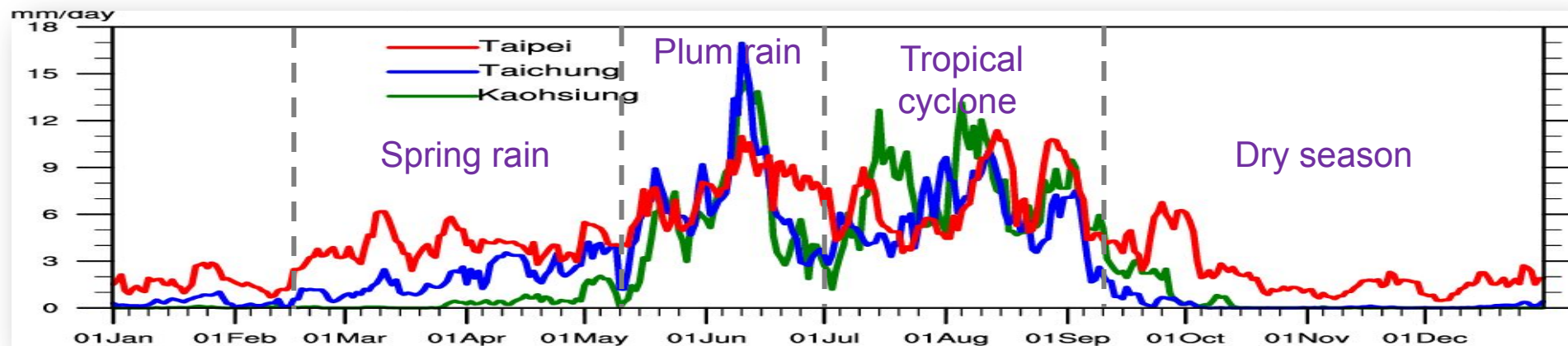
- Taiwan is located between Asian continent and Pacific Ocean, and the topography is steep.
- Although the amount of annual rainfall is abundant, but water resources are not easy to save, so reservoir storage is needed.
- In different season, Taiwan is affected by different systems like, monsoon, subtropical high, tropical cyclones. Furthermore, MJO, ENSO and decadal phenomenon will also be important factors. So the climate of Taiwan is complicated.





# The rainfall distribution of Taiwan

- The main source of rainfall of Taiwan is from Mei-yu from May to June and tropical cyclone from July to September.
- The rainy season in Taiwan varies by region. In western Taiwan, wet season is from May to September, while dry season is from October to next April.

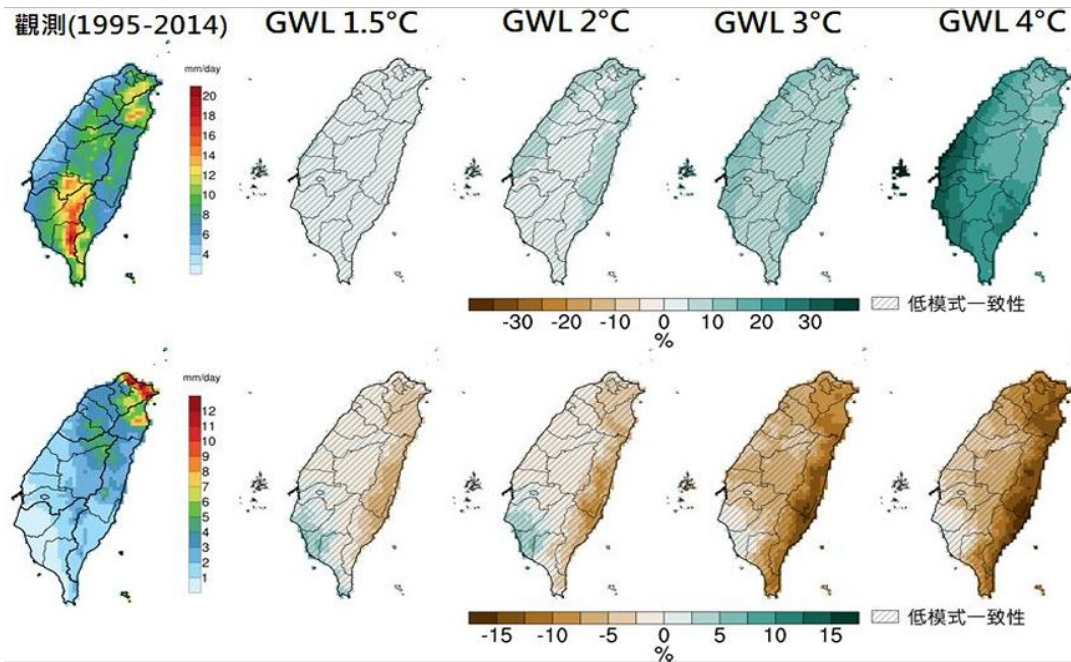




# Future change of rainfall in Taiwan

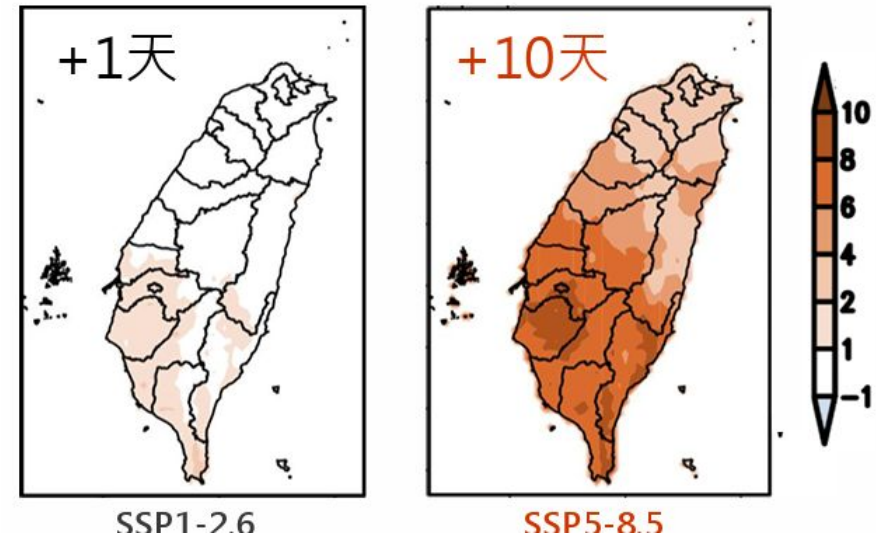
Wet gets wetter, dry gets drier

Wet season



Dry season

Duration for consecutive no rainfall will be longer



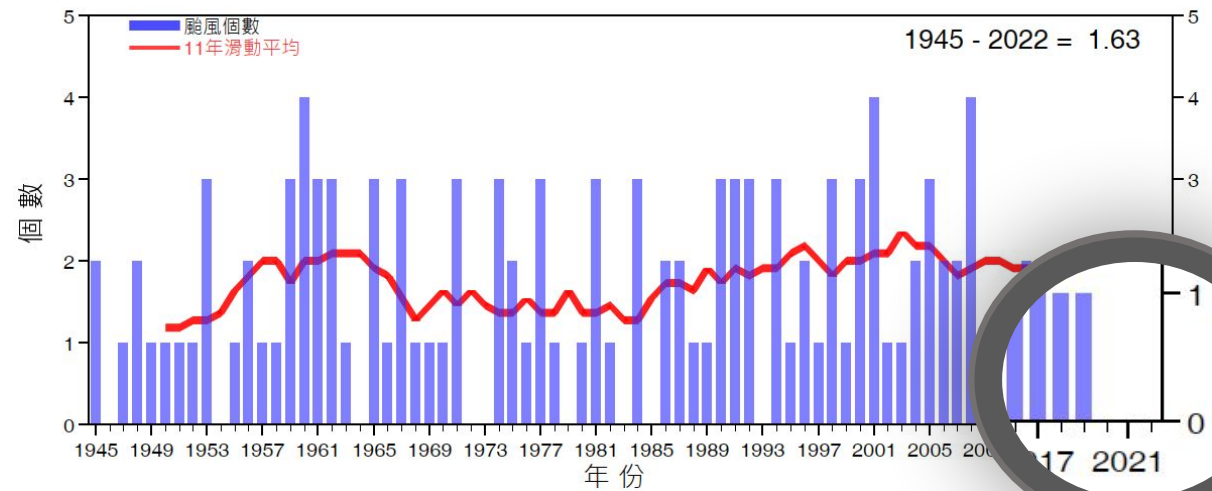
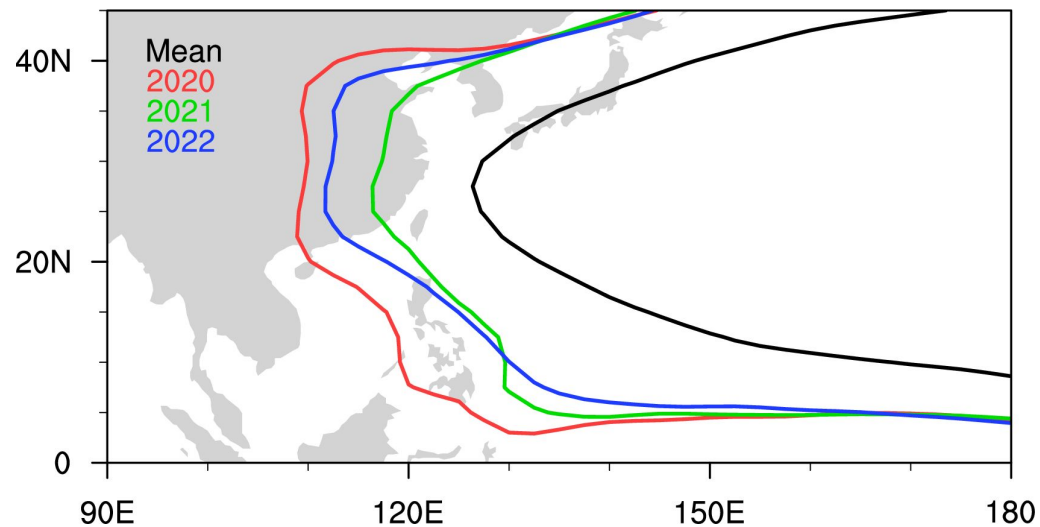
Courtesy of TCCIP project



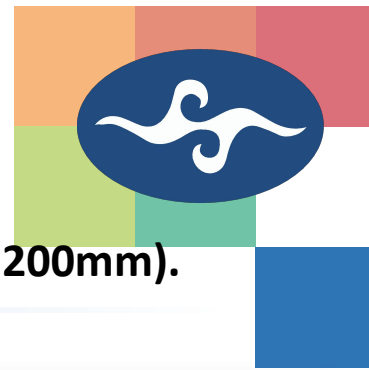
# Drought happened frequently in recent 5 years

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

## No landfall typhoon from 2020-2022

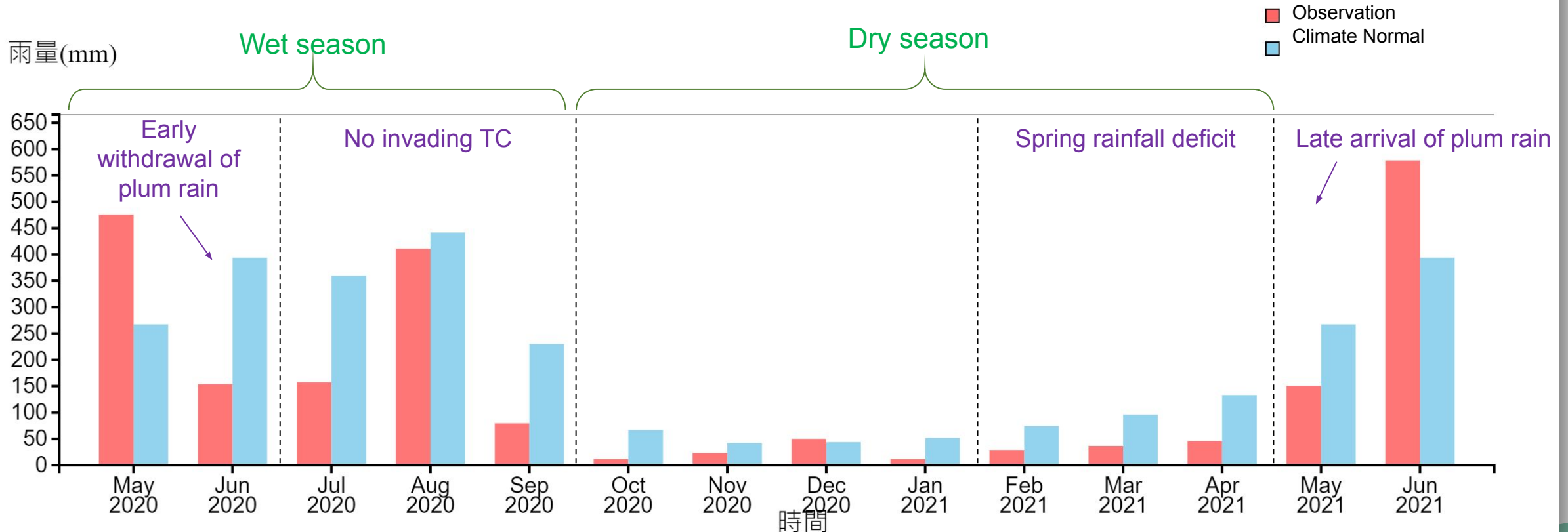


# 2020-2021 drought in Taiwan



- The worst drought in Taiwan! (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).

Monthly rainfall in western Taiwan

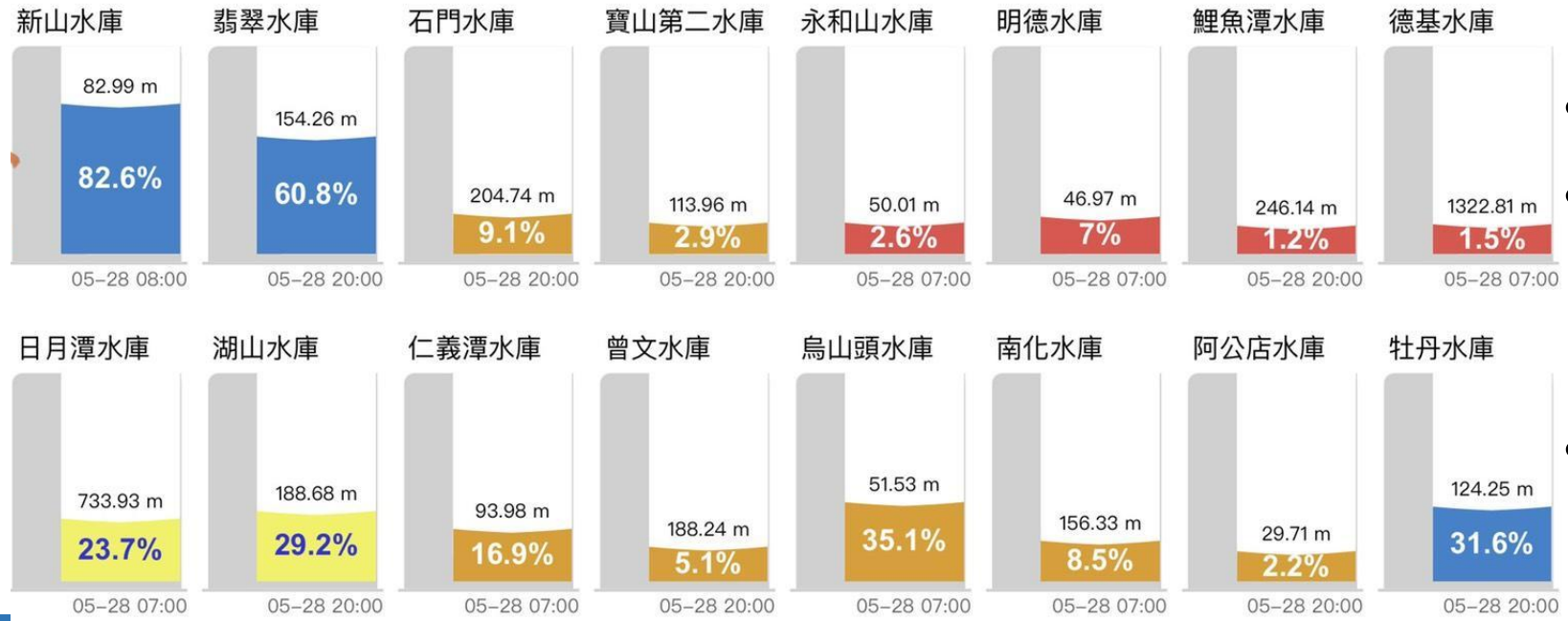




# Taiwan Prays for Rain and Scrambles to Save Water

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

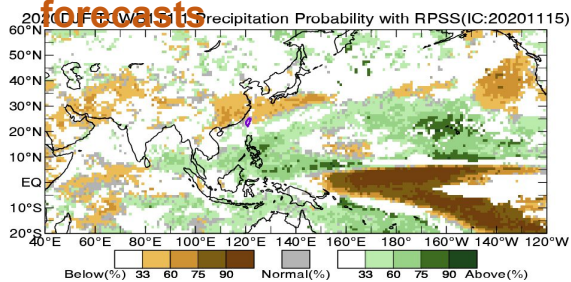


- Rice paddy irrigation suspended
- Severe adverse effect on economic and industrial activities such as hydroelectric power generation and semiconductor supply chain
- Water rationing for two months due to extremely low water level in reservoirs

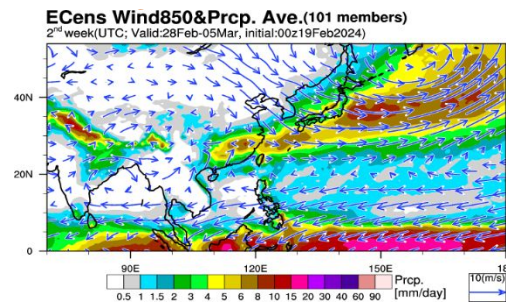
# Gap between meteorology and hydrology

- Water management needs several rainfall scenarios for decision-making
  - The most needed is **quantitative precipitation forecast for reservoirs**
- State-of-the-art climate models cannot resolve forecast information at local level
  - Needs **downscaling**, either dynamical or statistical

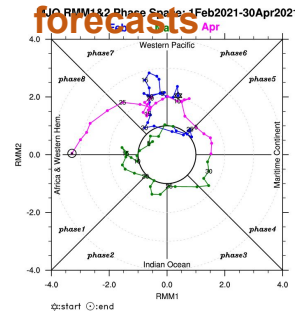
## 3-Month & 2<sup>nd</sup> Season forecasts



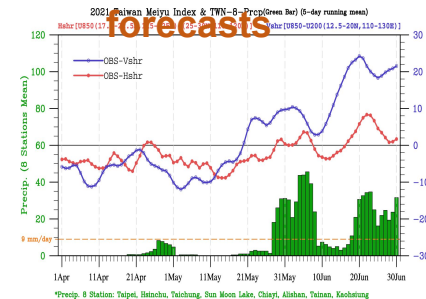
## Week1-4



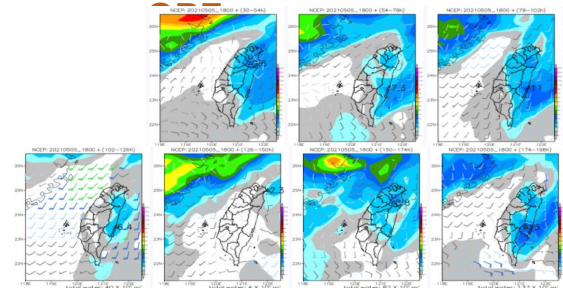
## MJO forecasts



## EASM onset forecasts



## Day1-7







# Memorandum of understanding(109-113)

Water Resources Agency & Central Weather Administration

## • Collaborative Goals

- Improving Subseasonal to Seasonal(S2S) rainfall forecasting
- Enhancing the applicability of forecasts
- Enhancing resilience to cope with **floods** and **droughts**

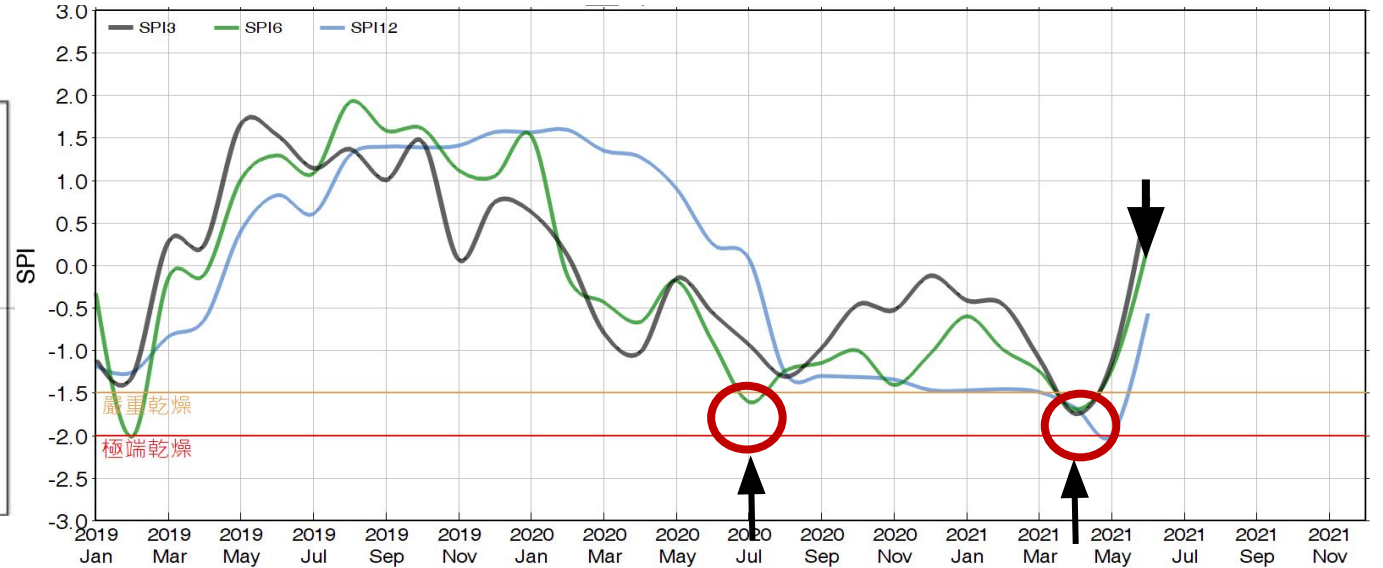
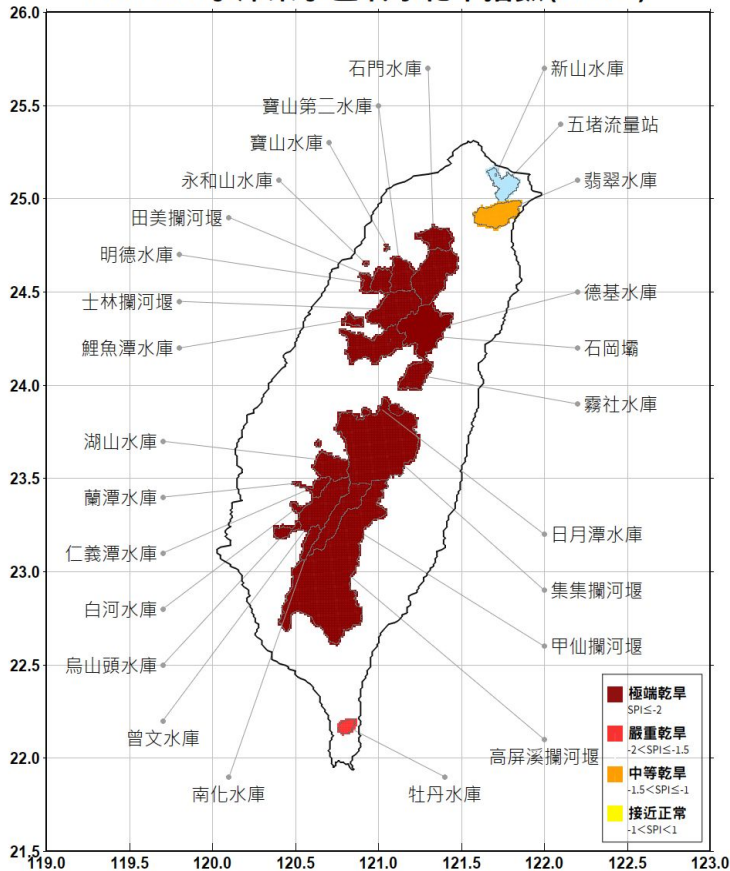
## • Focal Points

- Extending from plain monitoring stations to **reservoir catchment areas**
- Employing statistical methods for **model bias correction**
- Optimizing downscaling forecasts using long-term observational data from reservoir catchment areas

# Early Drought Warning Monitor Product

- Real-time monitoring of drought event for reservoir catchment area can provide warning messages to water resource management to plan disaster prevention strategy.
- If drought early warning information can be provided in advance, cross-field section can propose various preventive measures for water needs in advance.

2021 05 水庫集水區氣象乾旱指數(SPI12)



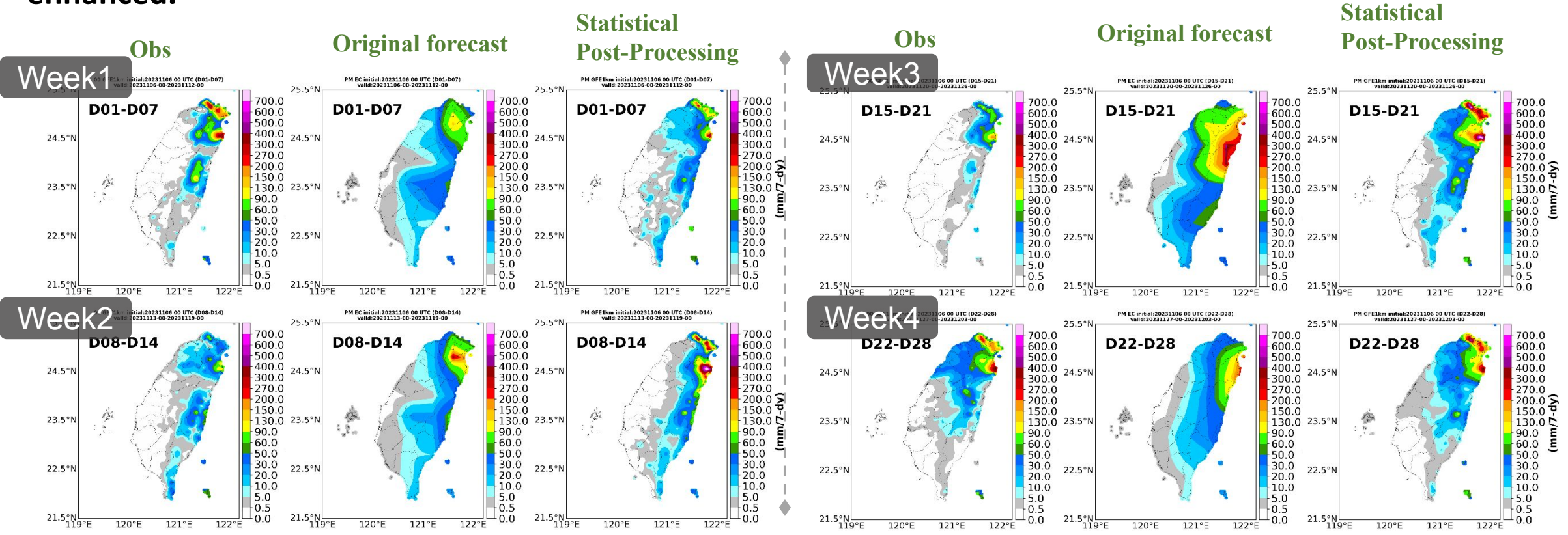
Time  
 2020/7  
 SPI16 < -1.5  
 SPI12 is decreasing  
 should pay attention

2021/4  
 Water supplies  
 suspend



# Employing analog post-processing pattern matching for model bias correction

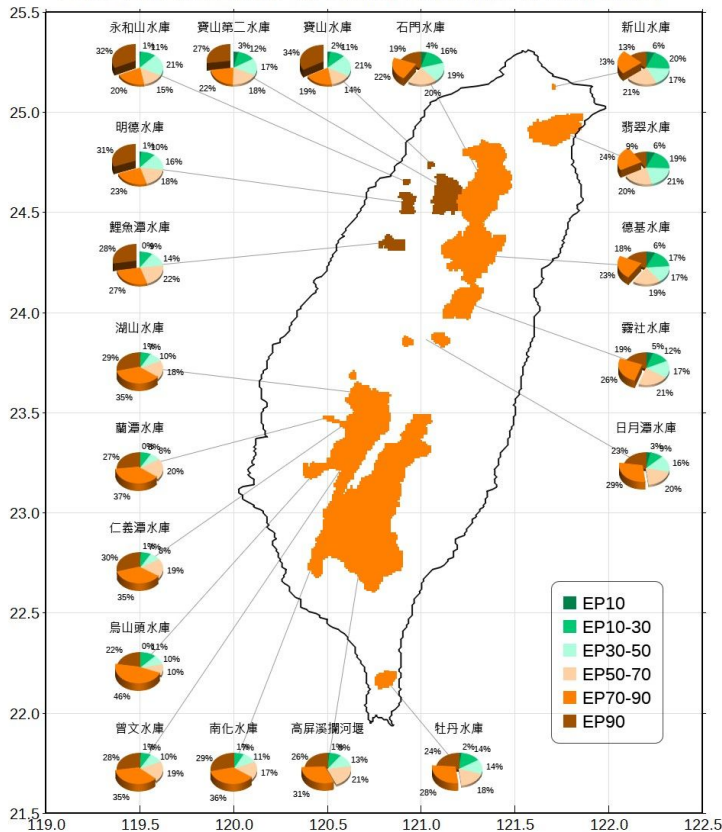
- After bias correction, the capability to understand the spatial distribution of rainfall can be enhanced.



# 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	90 - 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

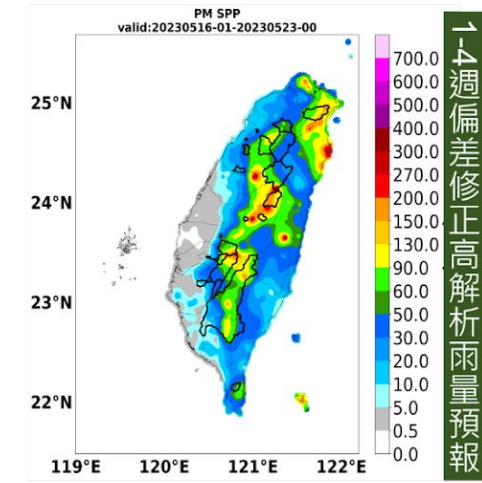
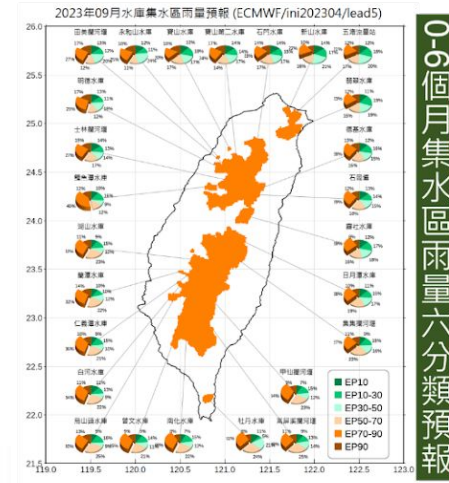
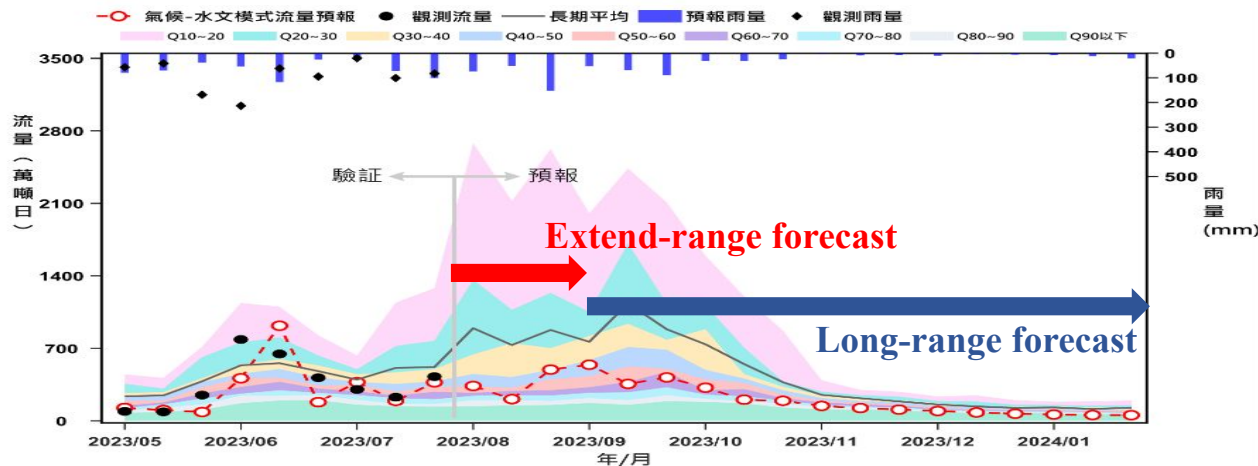
- CWA provides the rainfall forecast of maximum probability for next 6 months.
- The 6 categories of exceedance probability can show probability of extreme situation and shading indicates forecast with skill score during hindcast period.

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

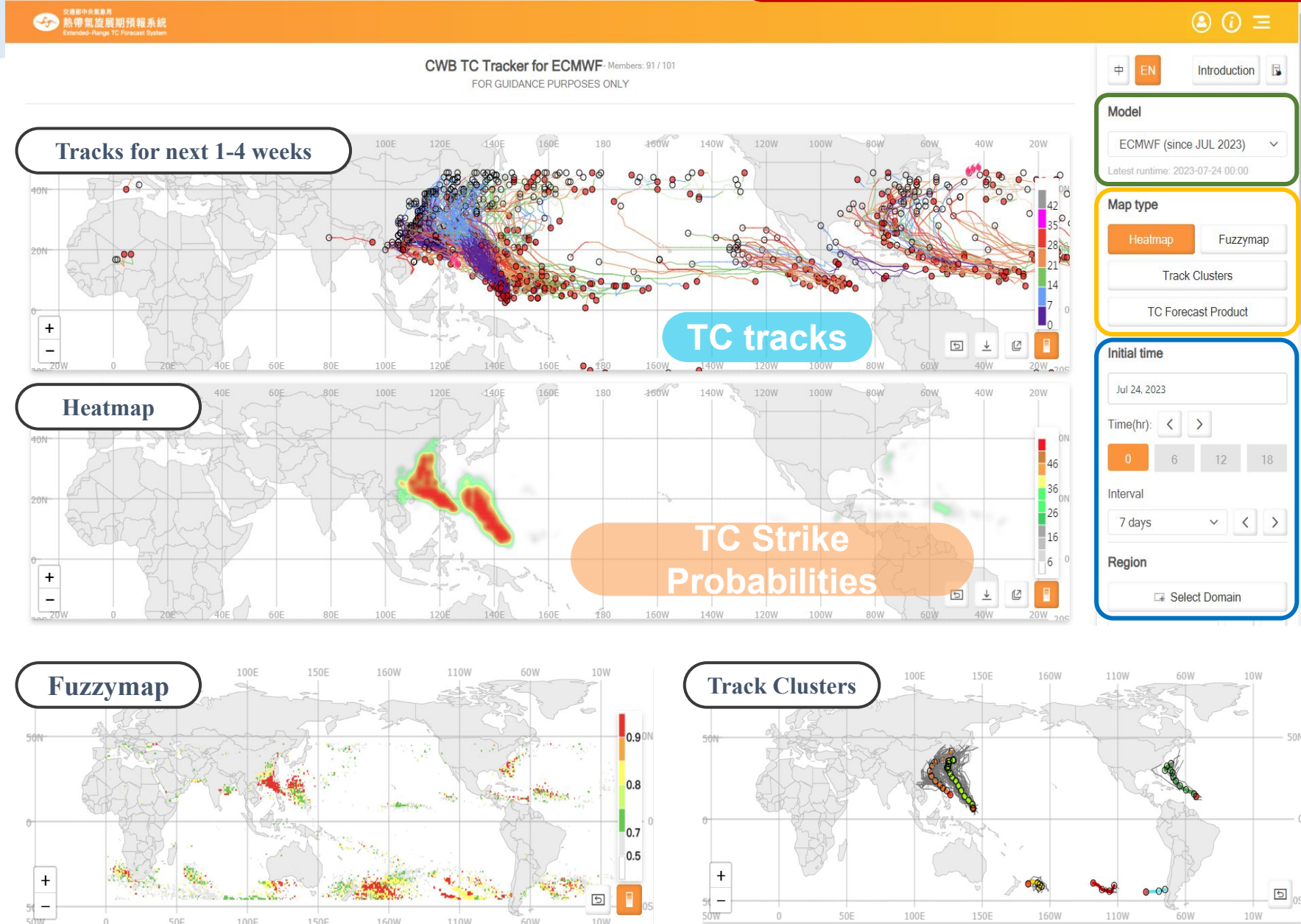


# Cross-domain cooperation to provide inflow forecasts

- Monthly (month1-6) → weekly (week1-4)
- Global → National → Reservoir catchment areas
- Qualitative → Quantitative



Through cross-domain cooperation with National Cheng Kung University, we provide seamless (extended-range and long-term range) **inflow forecasts** for all water catchment areas in Taiwan.



## Models

- ECMWF
- NCEP GEFSv12
- NCEP CFSv2
- CWA CFSV1

## Information

- Heatmap
- Fuzzymap
- Track Clusters

## Flexible functions

- Buttons to switch
- Adjust time interval
- Zoom-in or out maps
- Download maps
- Custom conditions

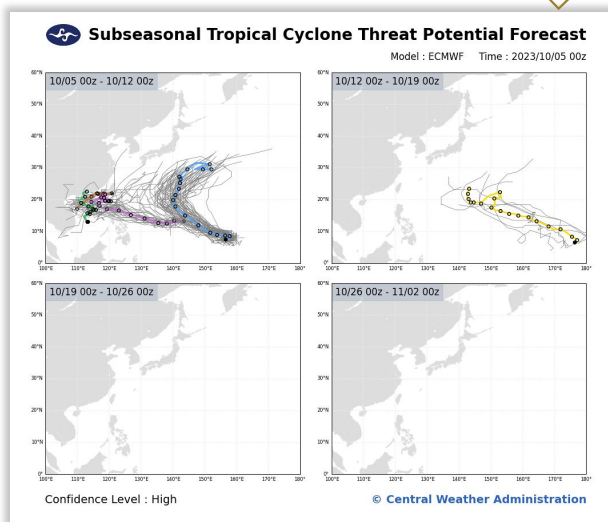
# Subseasonal Tropical Cyclone Threat Potential Forecast Product

2023年

- Develop **subseasonal tropical cyclone threat potential forecast product**

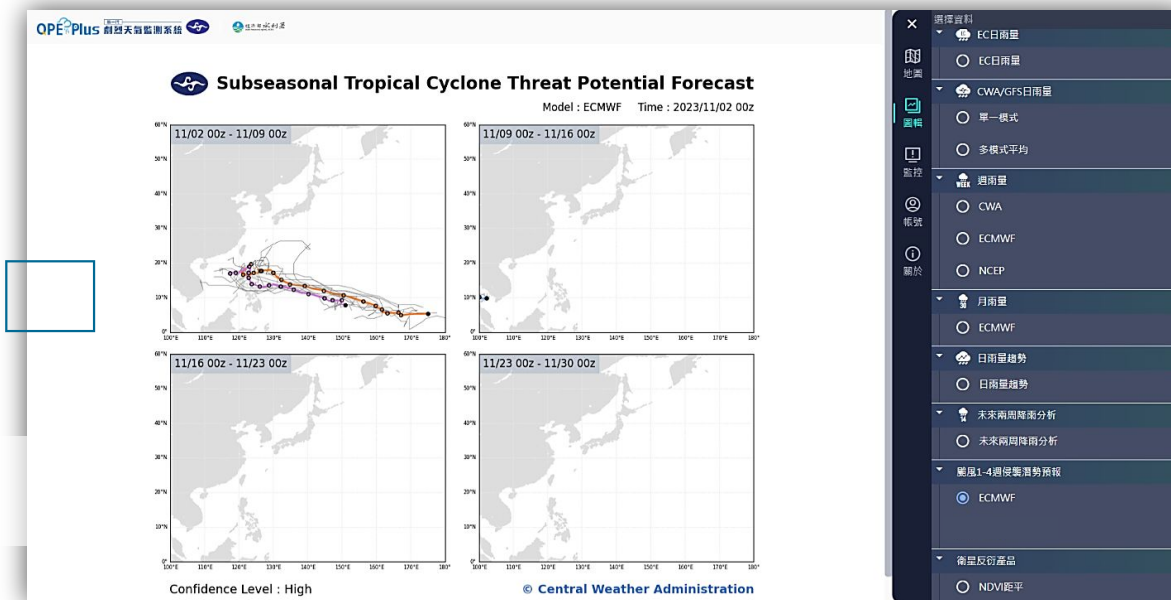
2024年

**Extended-range typhoon rainfall probability forecast**



**Integration of Track Clusters and Summer Monsoon Index (as Confidence Level)**

**Customized display platform for WRA**



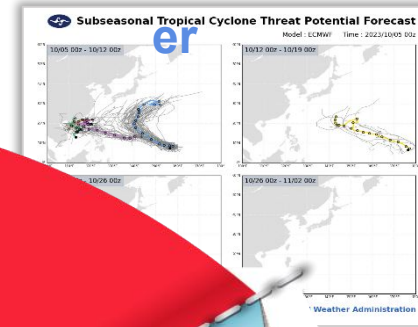
# Climate Service for Water Resource Management



QPEPI



Tracker



Information System

Water Resource

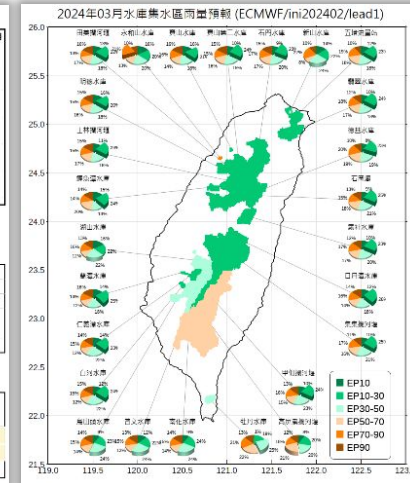
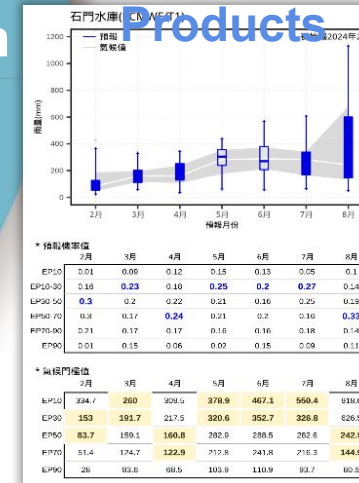
User-Oriented Products

User Interface

Working Group Meetings



Customized S2S







# Summary

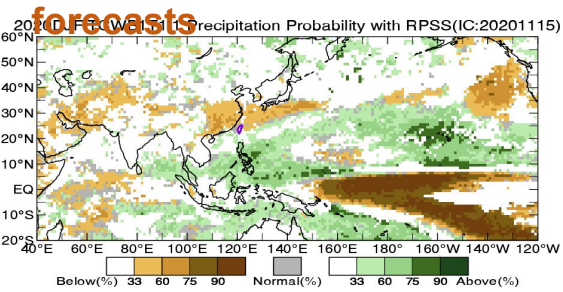
- Taiwan has faced the challenges of extreme weather conditions due to climate change, particularly the difficulties in water resource management caused by drought.
- Sub-seasonal to seasonal rainfall forecast products in high spatial resolution were developed using a statistic downscaling and bias correction method, specifically for reservoir catchment areas.
- A sub-seasonal tropical cyclone (TC) threat potential forecast product was developed for the wet season from May to October, which can provide information on the possible scenarios of the TC's impact in advance.
- The CWA establishes a robust framework for proactive water resources management. Tailoring climate information and **facilitating** cross-sector communication will enhance resilience in preparation for frequent extreme events.



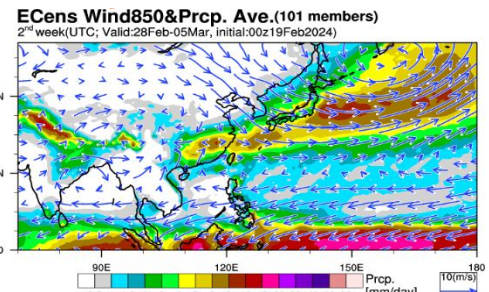
Sun-moon lake, Taiwan

- At 2020/21, forecast information only provided by models directly.
  - 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 / seasonal forecasts)
  - Plum rain arrival in May (EASM onset forecasts)

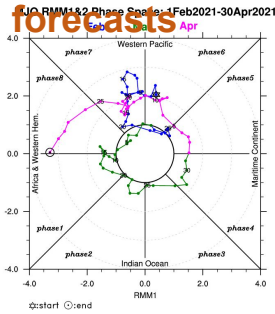
### 3-Month & 2<sup>nd</sup> Season forecasts



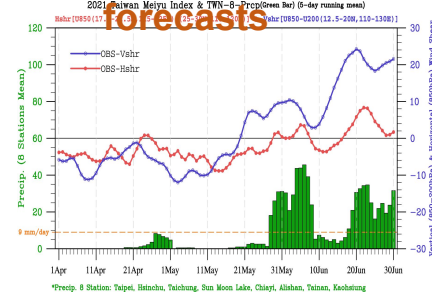
### Week1-4



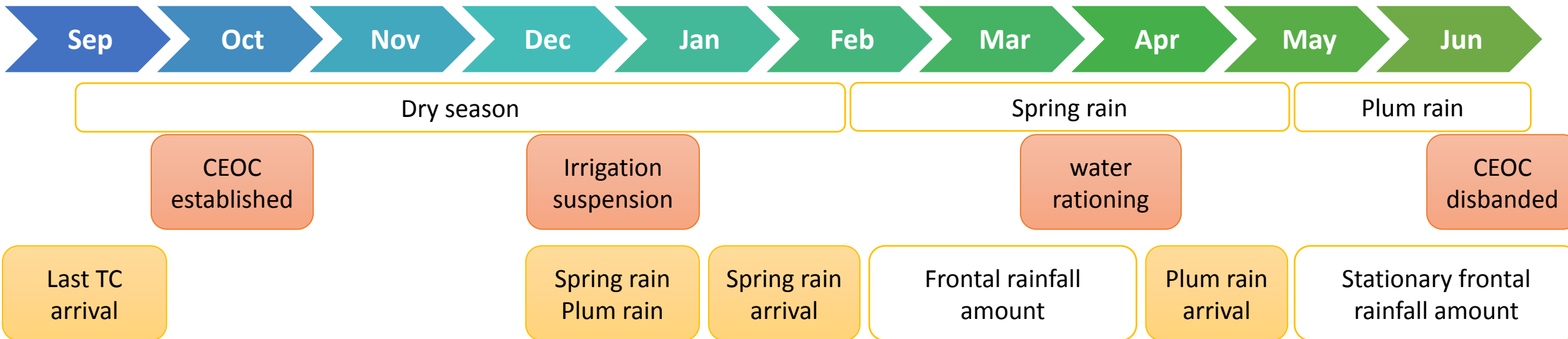
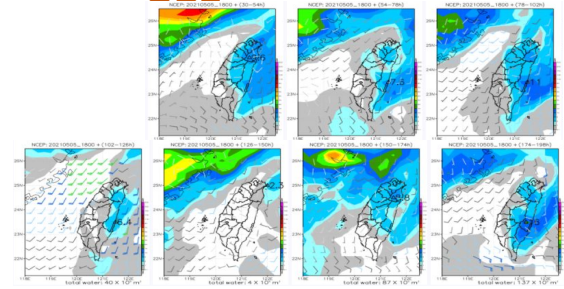
### MJO



### EASM onset forecasts



### Day1-7



# Analog Postprocessing Pattern Matching

