

# Rainfall Downscaling for Global Data-Driven Weather Prediction Models

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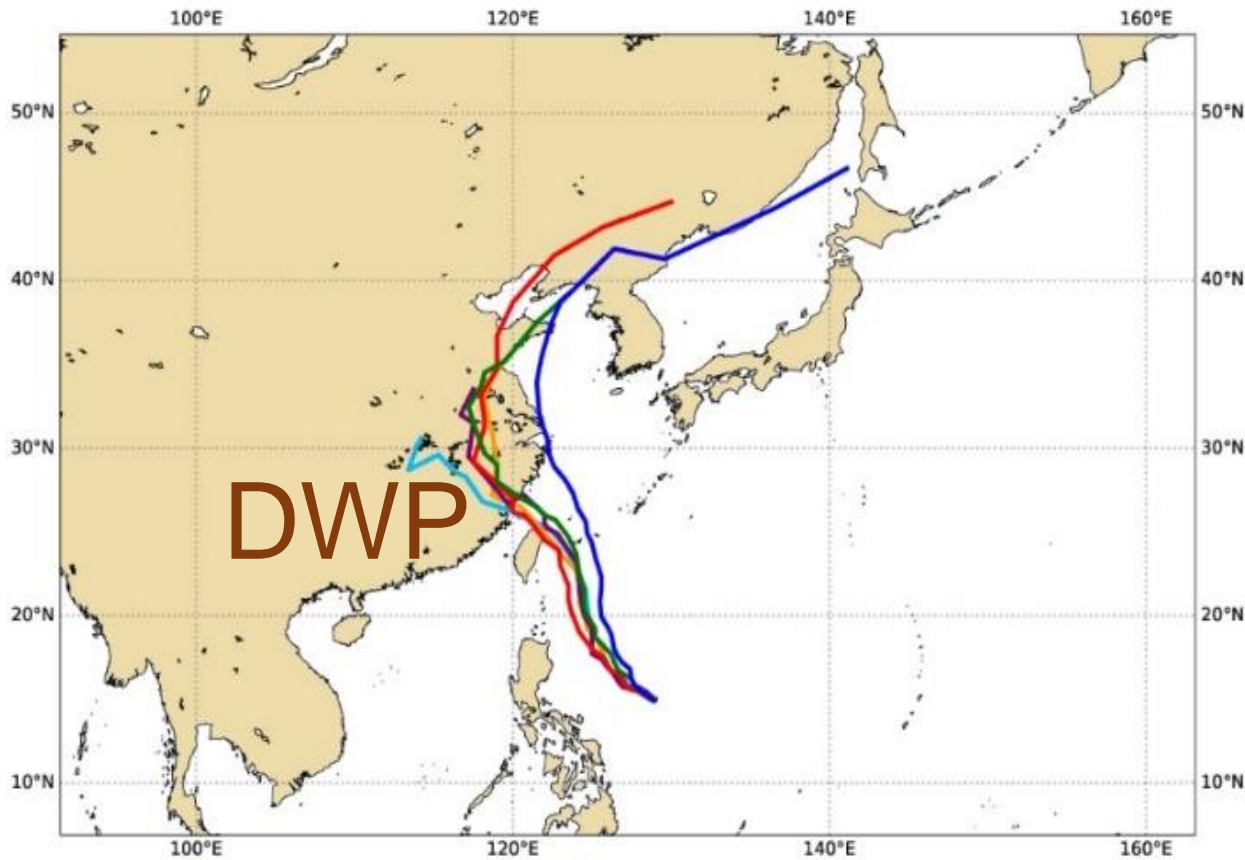
**Pei-Hsin Liu,**

**Yung-Yun Cheng, and Buo-Fu Chen**

Center for Weather Climate and Disaster Research, National Taiwan University

# Typhoon Gaemi

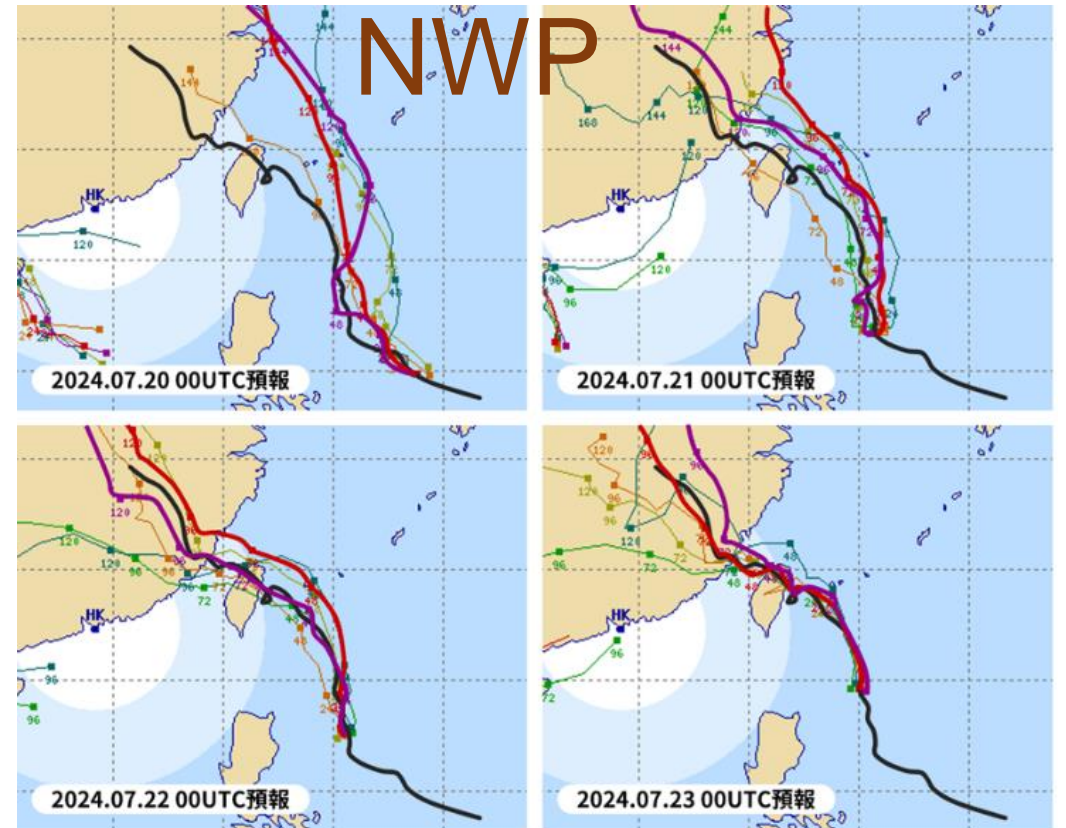
Date 20240720 00 UTC @ECMWF  
Individual trajectories for **04W** during the next 240 hours  
tracks in **solid**: AIFS SFNO FUXI PGUW DMGC IFS  
[reported minimum central pressure (hPa) 1004]



DWP: 7/20

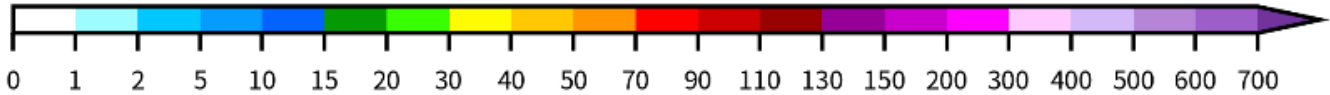
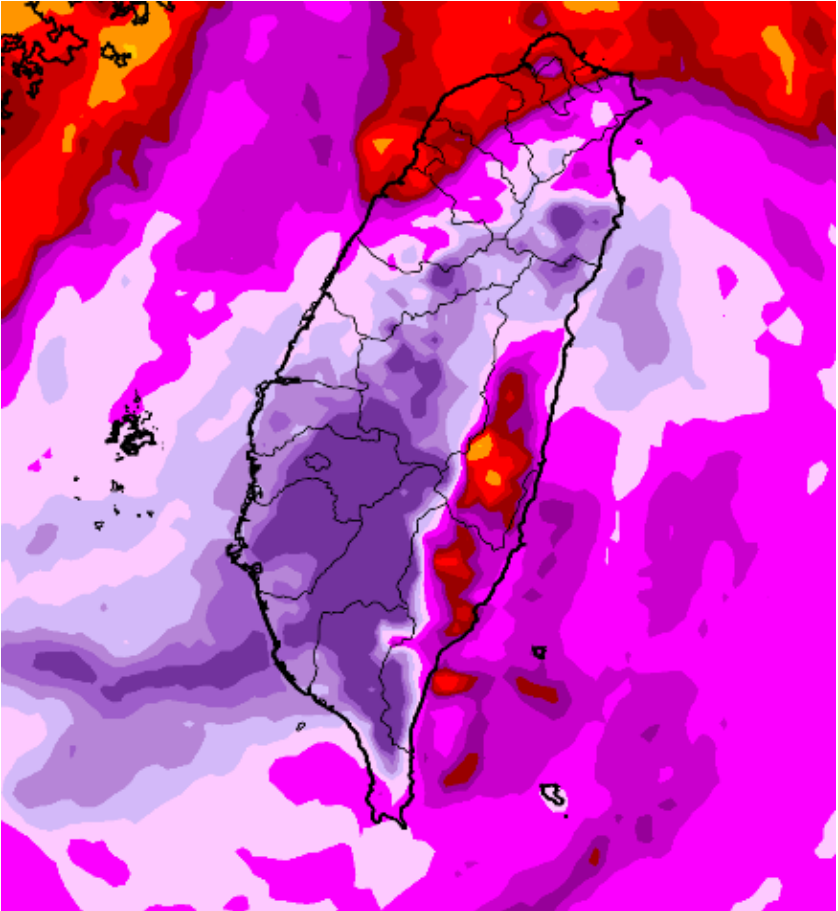
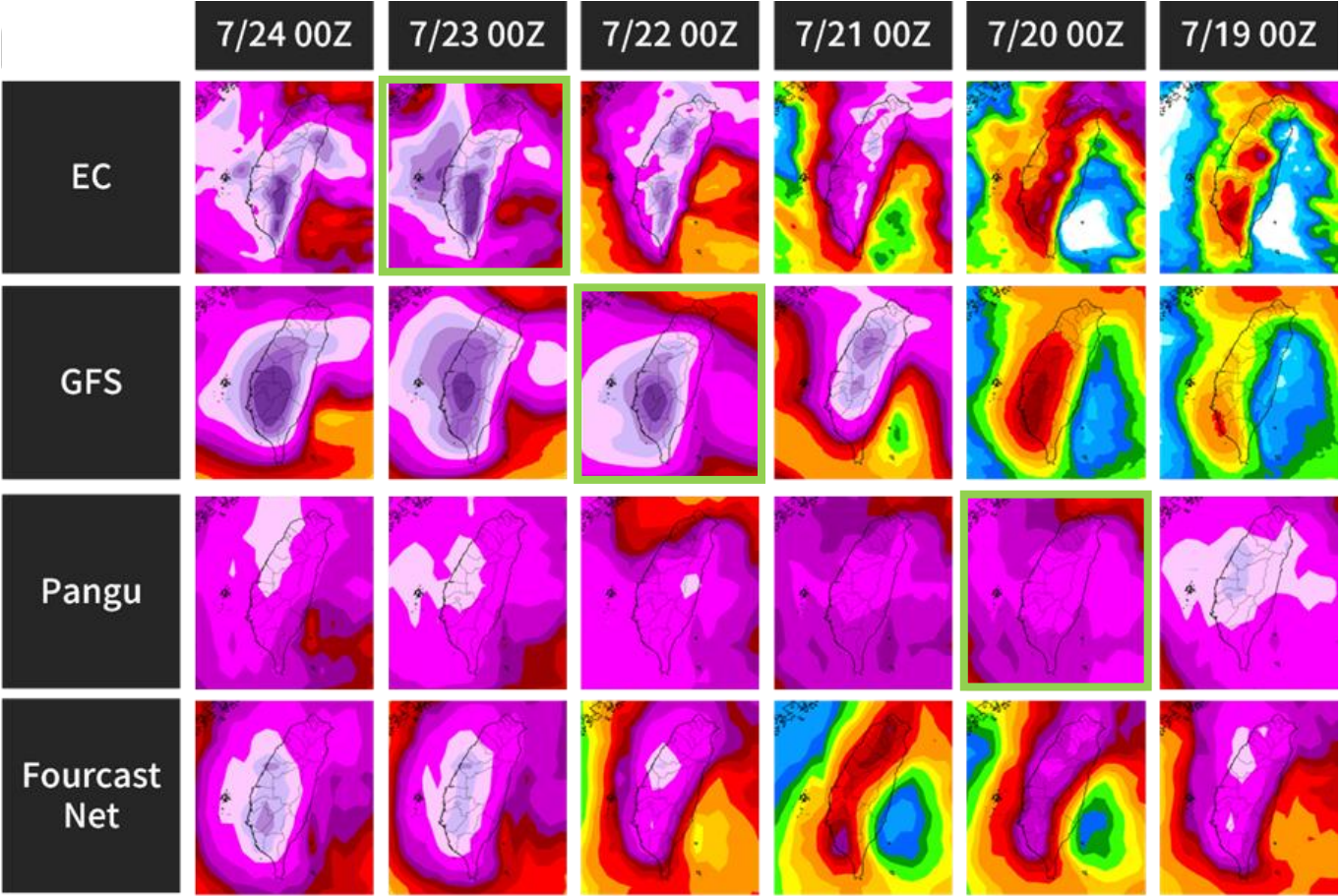
GFS: 7/22

IFS: 7/23



# 7/24-7/27 Accumulated rain

## QPESUMS



# **Introduction**

DWP rainfall downscaling

Method

Results

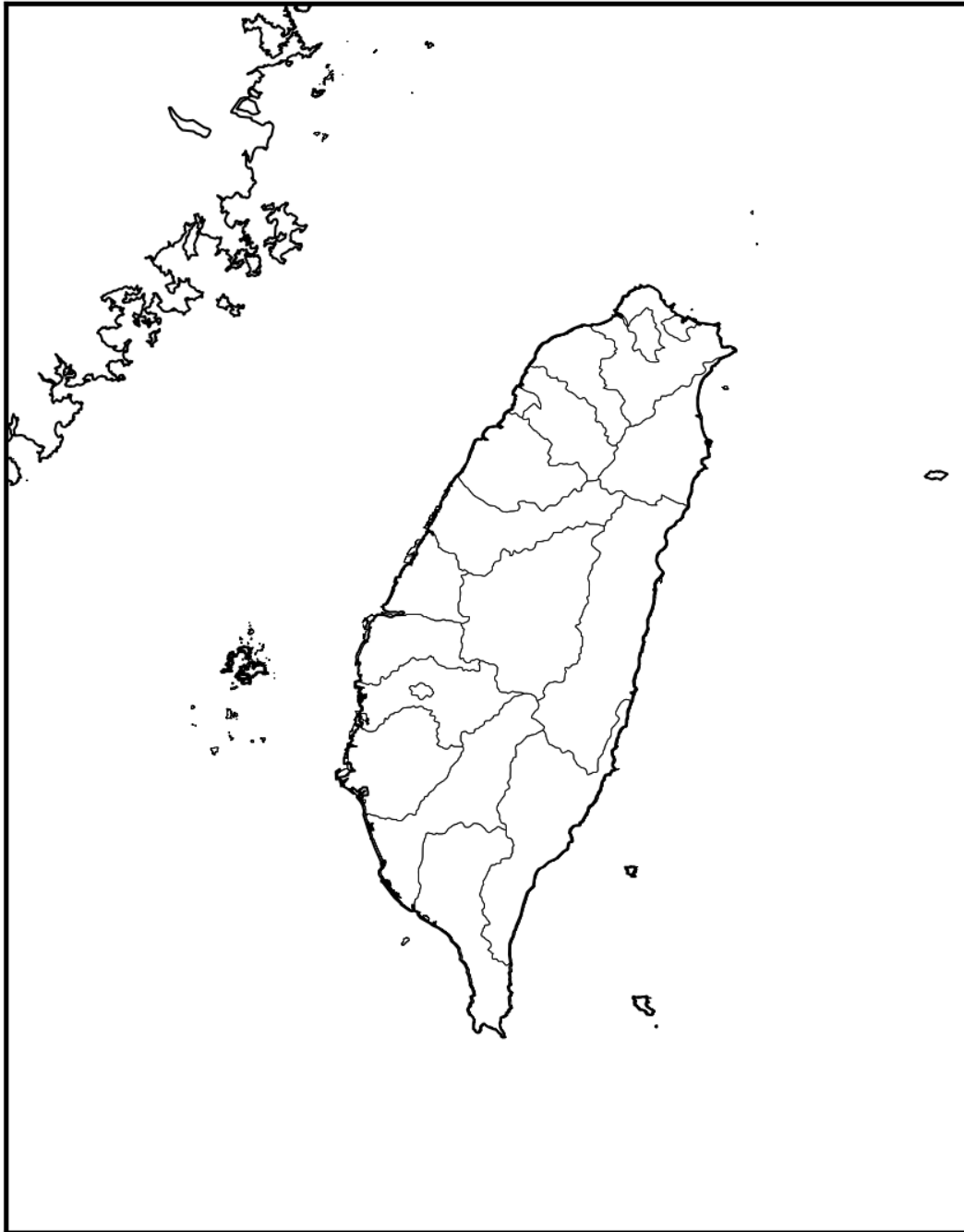
# Introduction

DWP rainfall downscaling

# Method

Deep learning

# Results



# Target

QPESUMS 24hr-rainfall

$0.0125^{\circ} \rightarrow 0.05^{\circ}$

# DWP Models

FourCastNet

Pangu-Weather

# Datasets

2021

2022

2023

## **Build datasets**

- Rerun FCN and Pangu by GFS in 2021-2023
- Pangu rainfall retrieved from FCN rainfall module

## **Training**

- U-Net GAN
- Swin-Transformer

## **Verification**

- Performance
- Case study

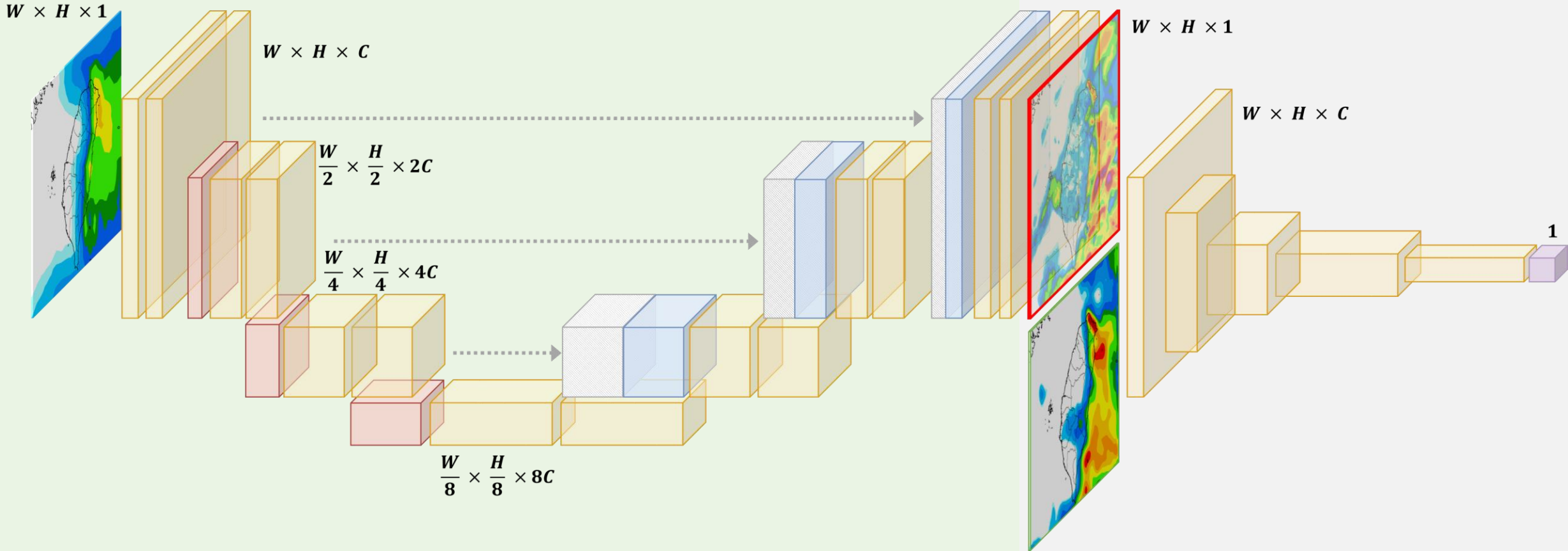


# GAN

## U-Net

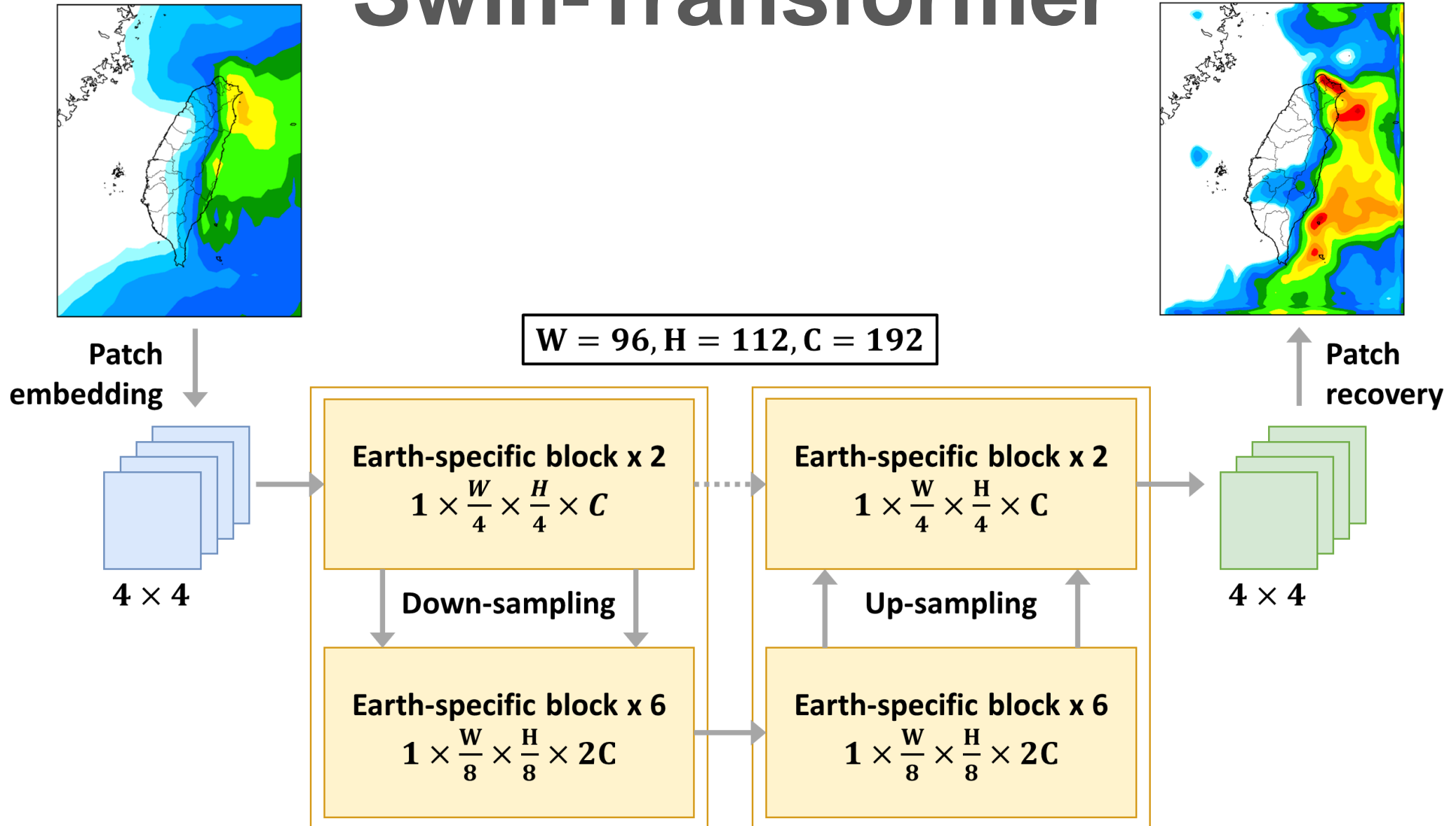
## Discriminator

$W = 96, H = 112, C = 64$





# Swin-Transformer



# Scale-separated loss

$$L = \begin{cases} L_{WMSE}(x, y) = \frac{1}{n} \frac{\sum_{i=1}^n w_i (x_i - y_i)^2}{\sum_{i=1}^n w_i}, w_i(x) = \begin{cases} 8, & x < 10 \\ 10, & 10 \leq x < 25 \\ 25, & 25 \leq x < 50 \\ 50, & 50 \leq x < 100 \\ 100, & x \geq 100 \end{cases} \\ L_{CRPS}(x', y') = \int_R [CDF(x') - CDF(y')]^2 dR \end{cases}$$

# Introduction

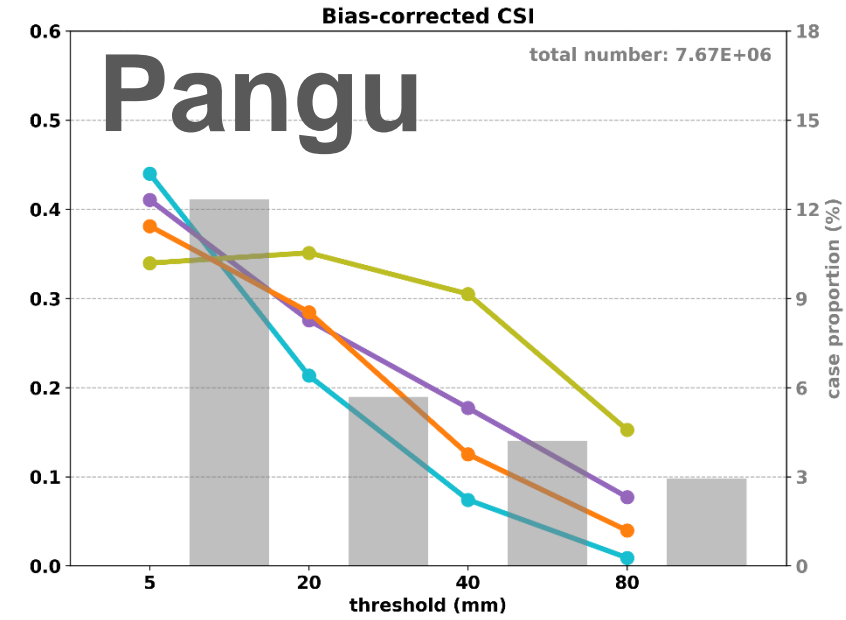
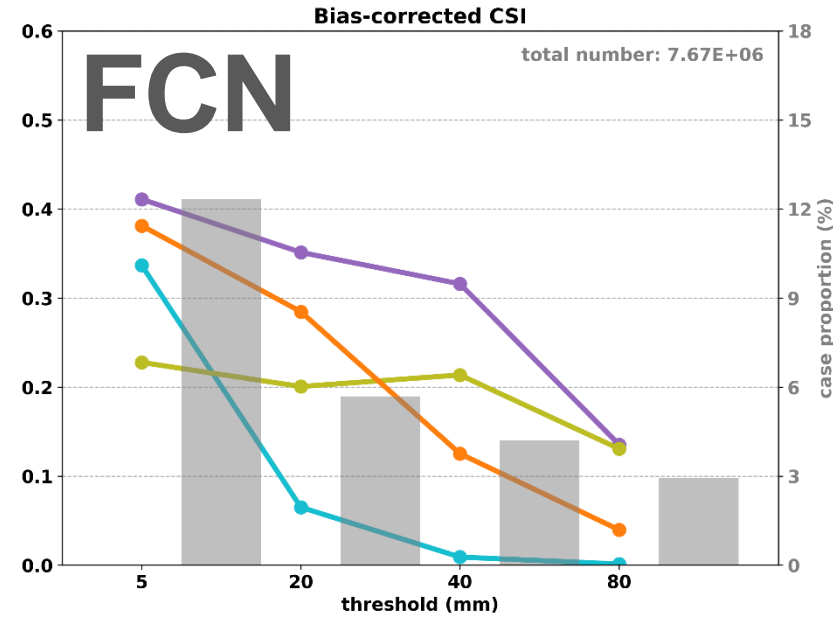
DWP rainfall downscaling

# Method

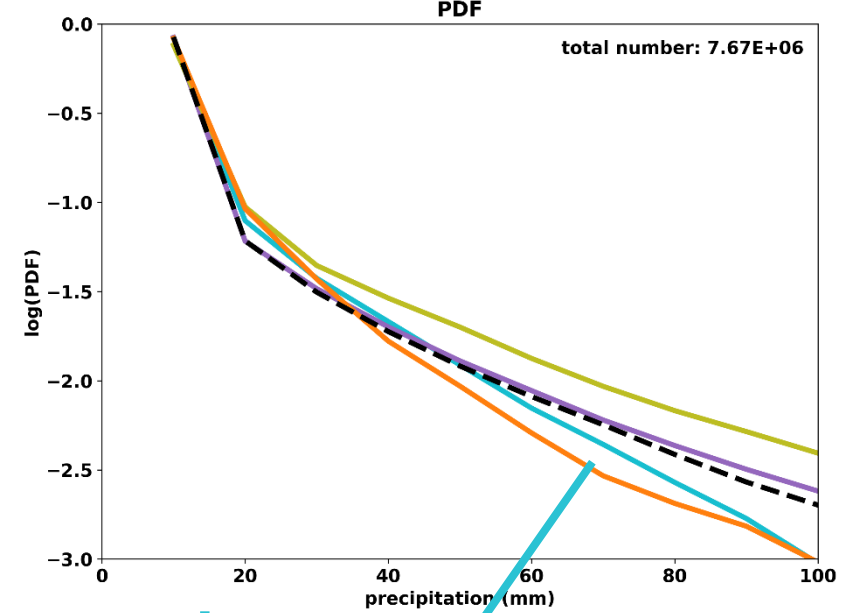
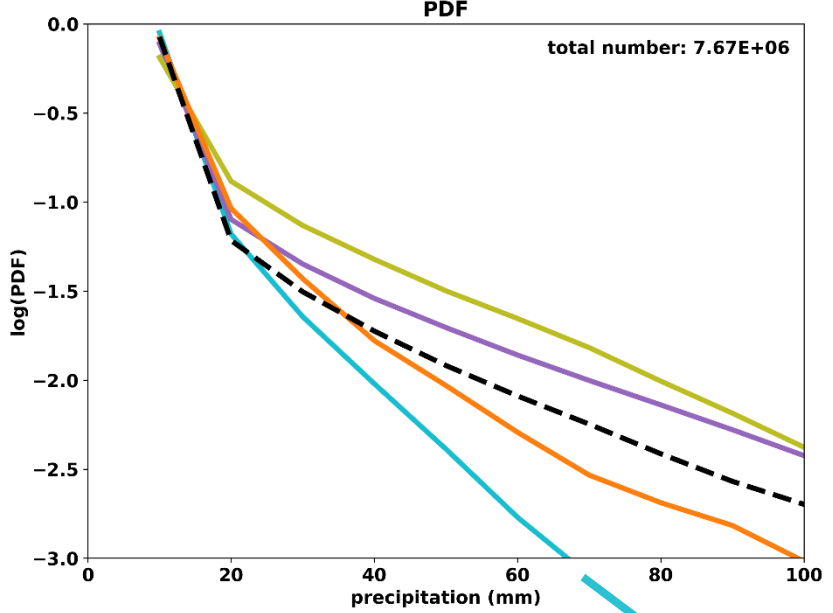
Deep learning

# Results

CSI\*



PDF

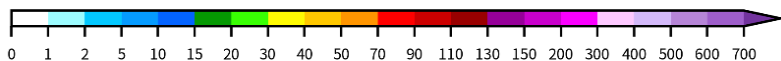
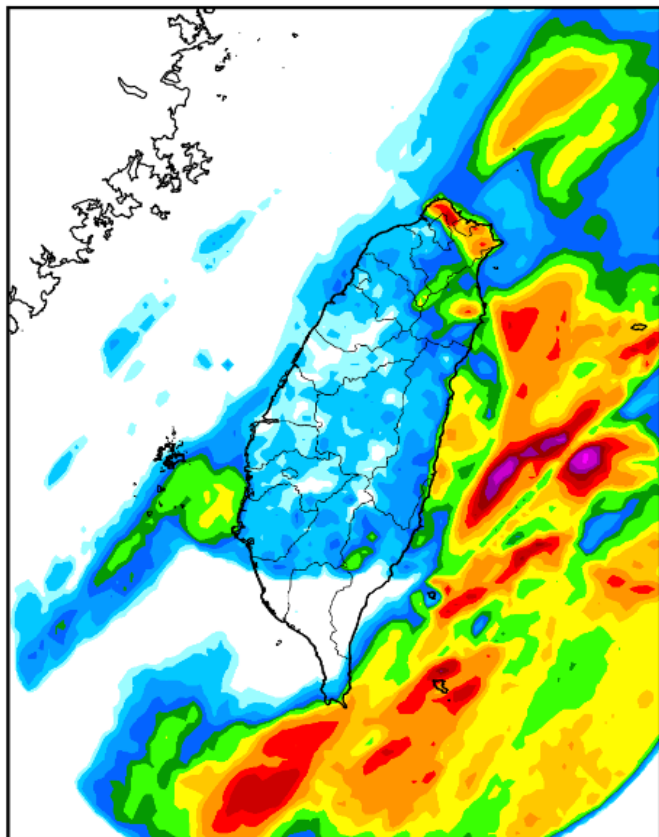


IFS  
DWP  
unet  
swin  
QPE

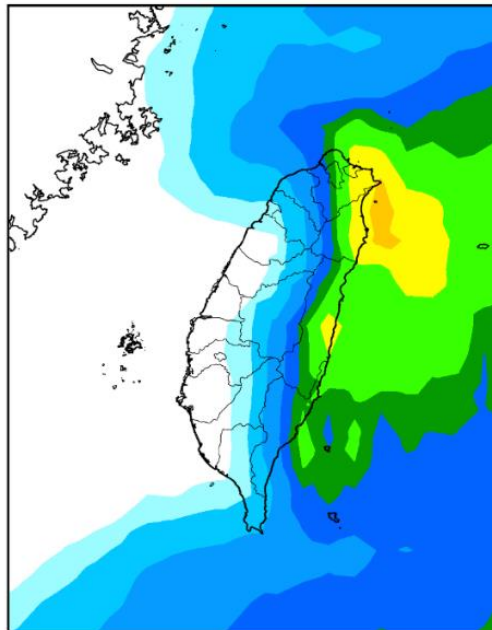
underestimate

# 2022/12/29

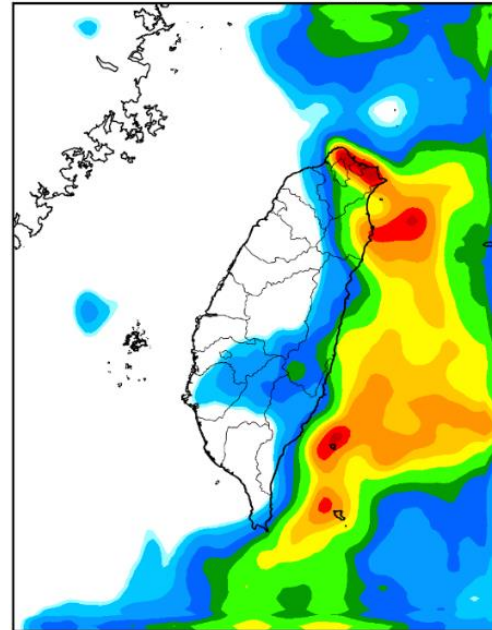
## QPESUMS



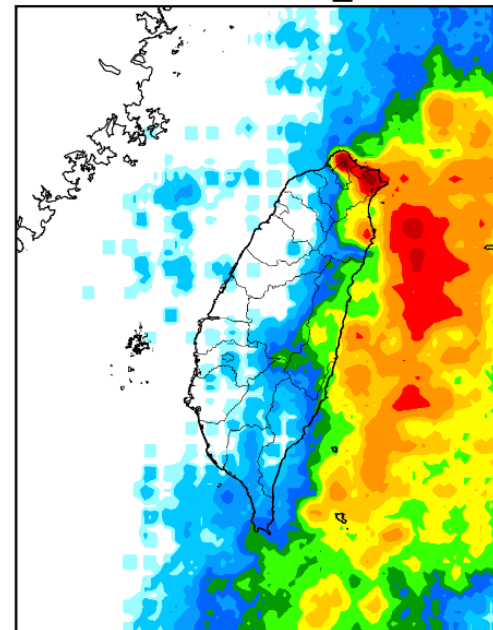
Fourcastnet



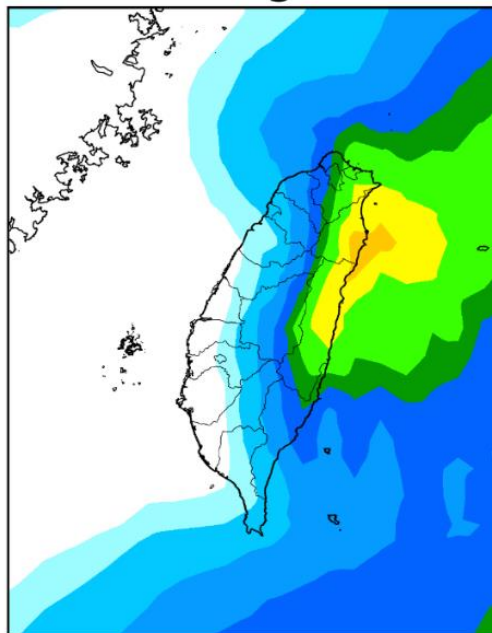
Fourcastnet\_unet



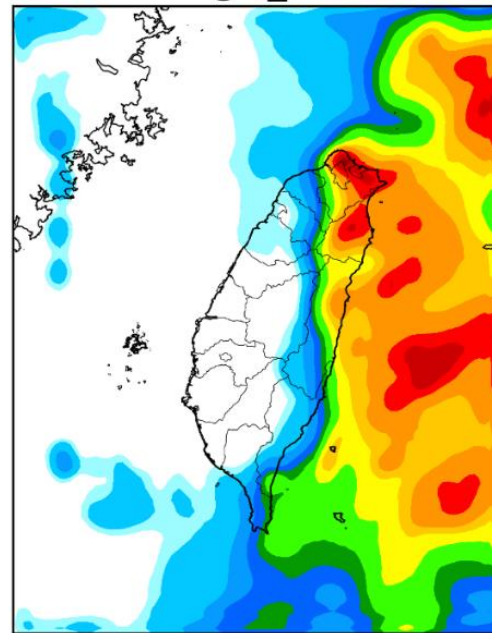
Fourcastnet\_swin



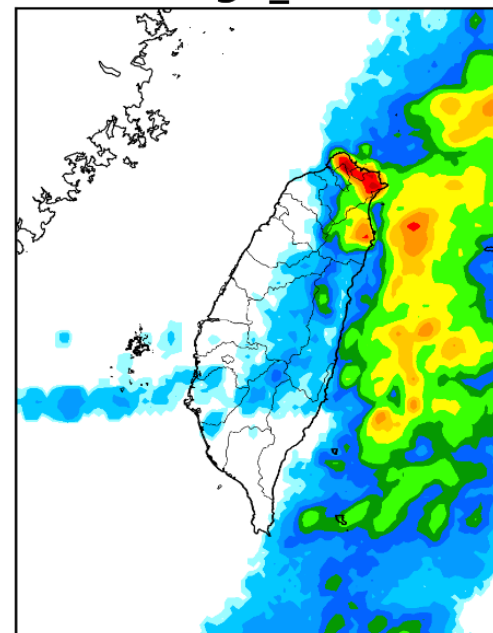
Pangu



Pangu\_unet



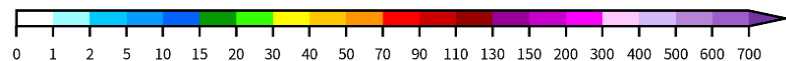
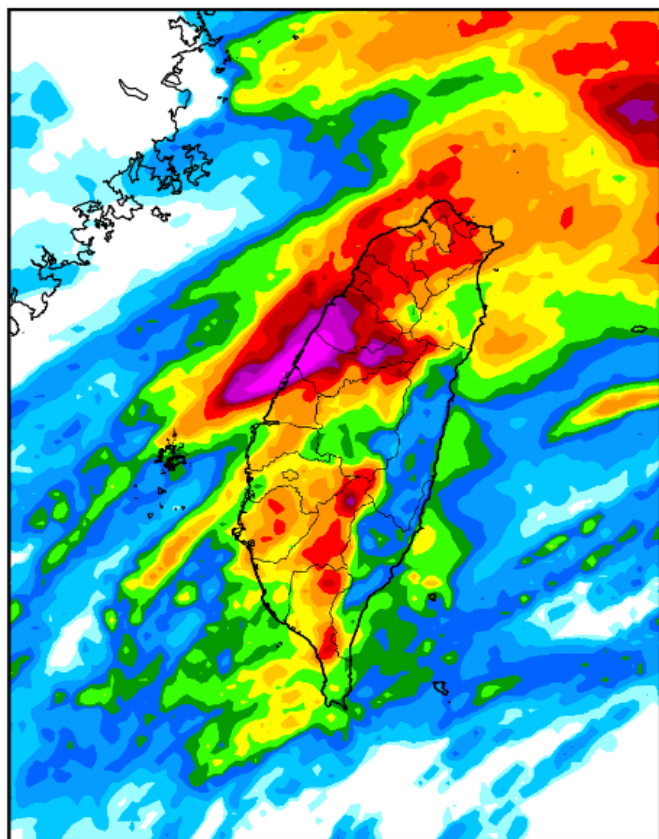
Pangu\_swin



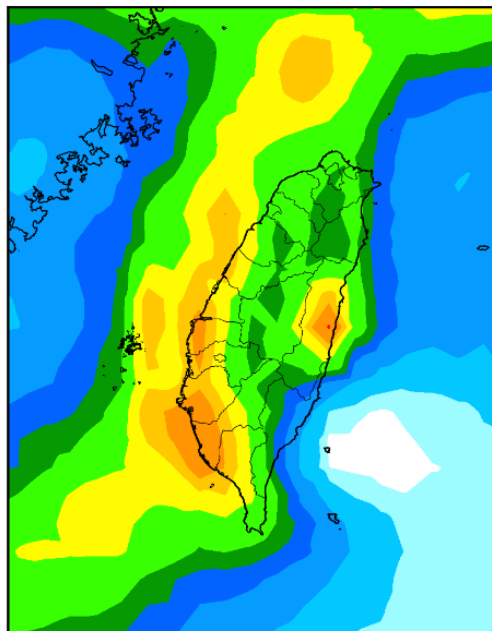


# 2022/05/26

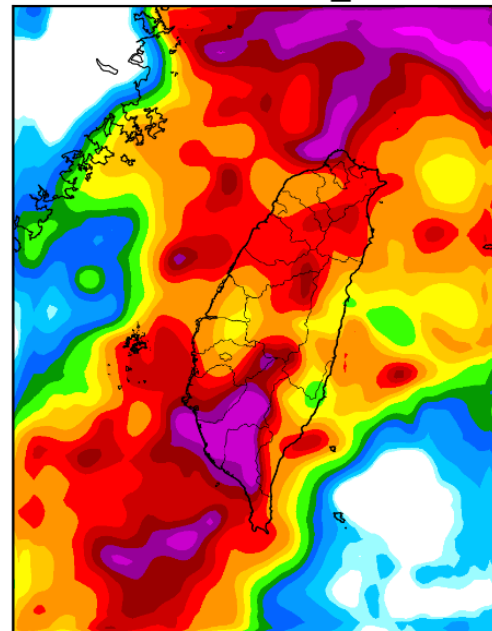
## QPESUMS



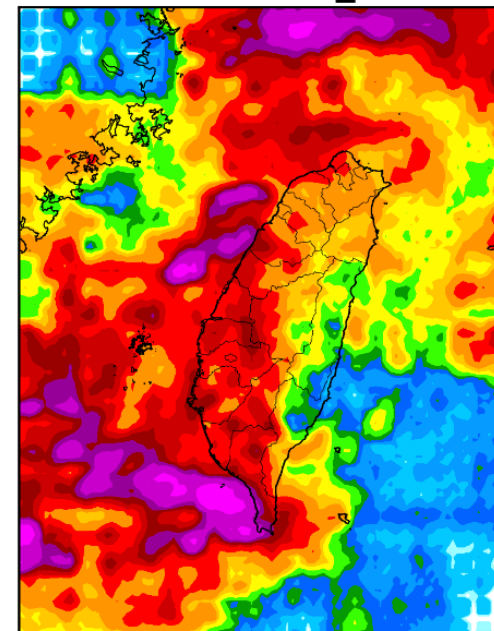
### Fourcastnet



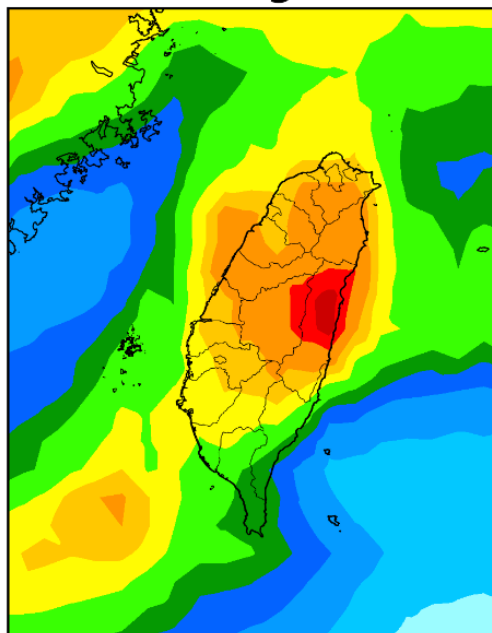
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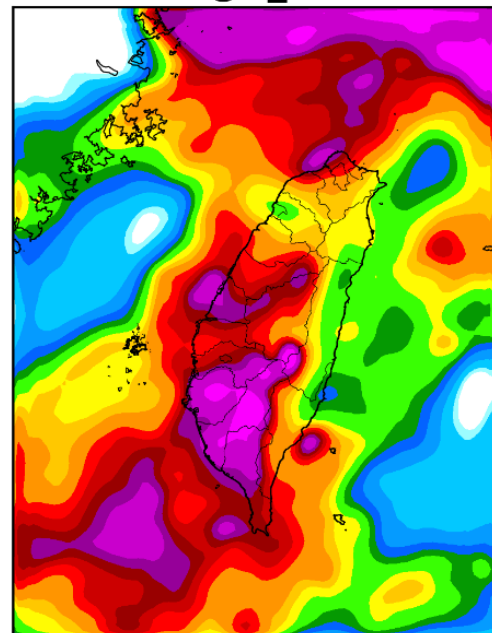
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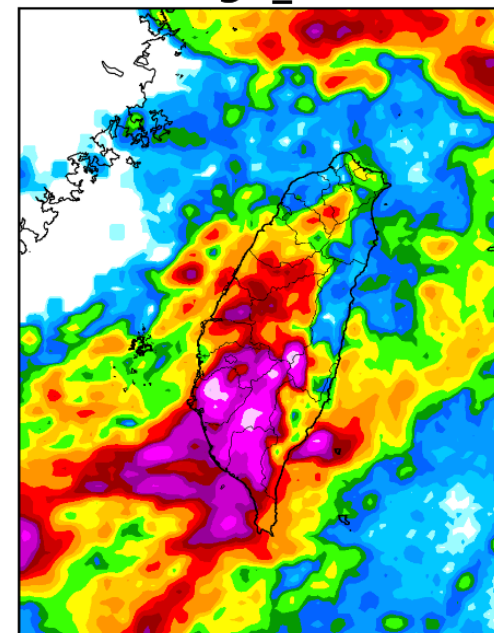
### Pangu



### Pangu\_unet



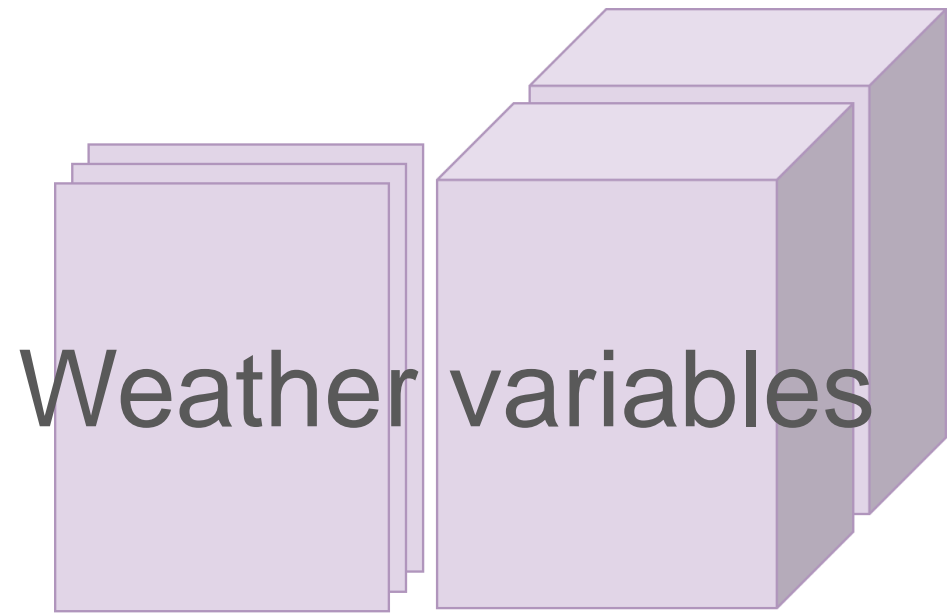
### Pangu\_swin



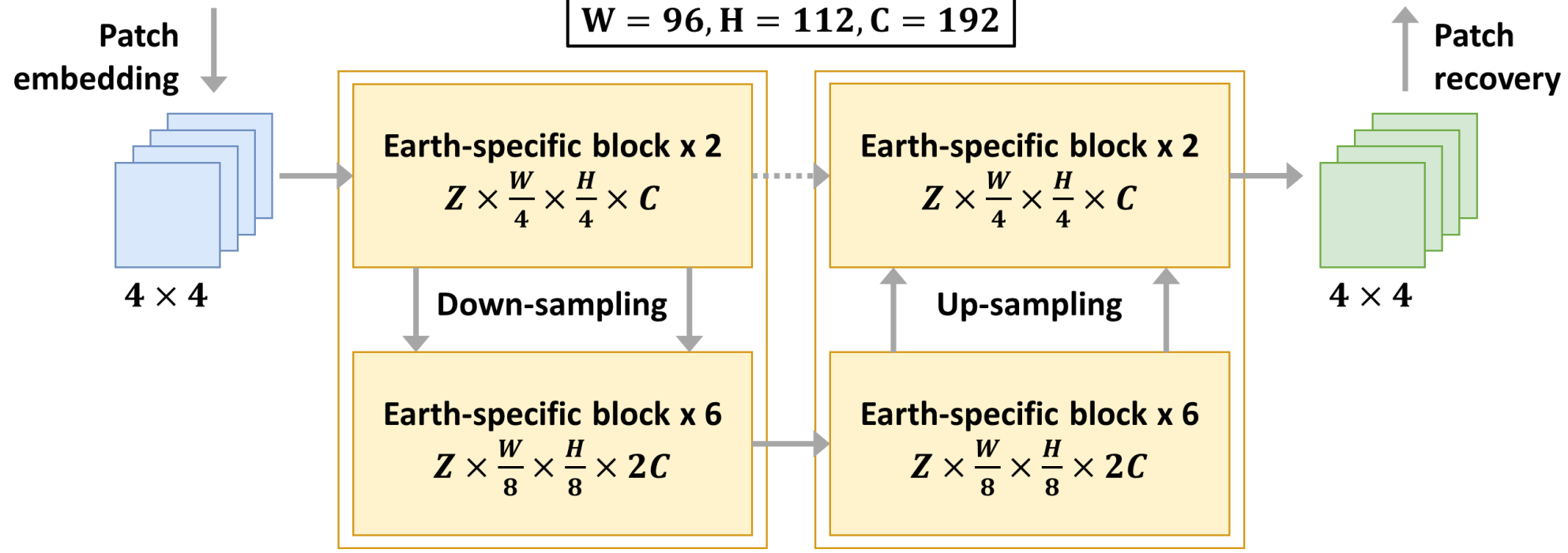
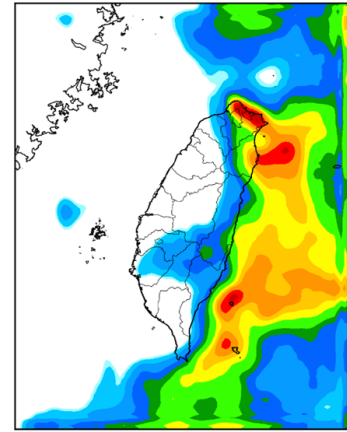
# Summary

Both U-Net and Swin-Transformer correct the systematic biases in global DWP models' rainfall forecasts, improving forecasts of heavy rainfall and terrain-induced rainfall.





$W = 96, H = 112, C = 192$



# Contribution

By applying deep learning methods to downscale the DWP models, we enhance their applicability for regional forecast, and have implemented these methods operationally.

08/25  
00-24 UTC

08/26  
00-24 UTC

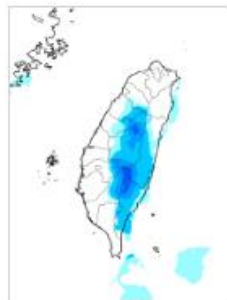
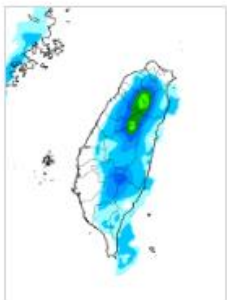
08/27  
00-24 UTC

08/28  
00-24 UTC

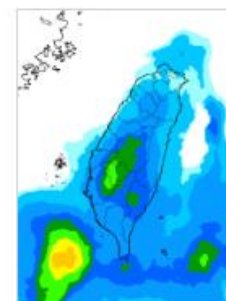
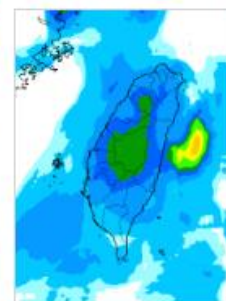
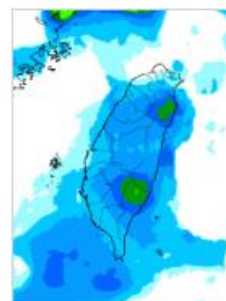
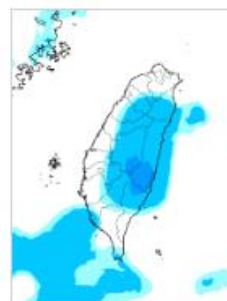
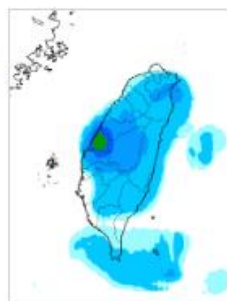
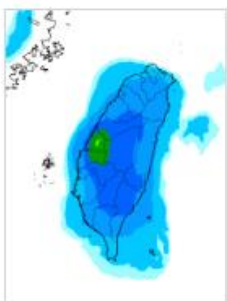
08/29  
00-24 UTC

08/30  
00-24 UTC

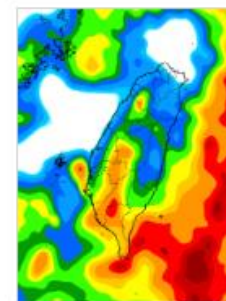
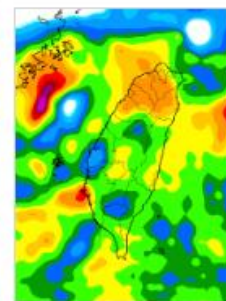
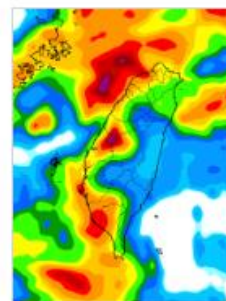
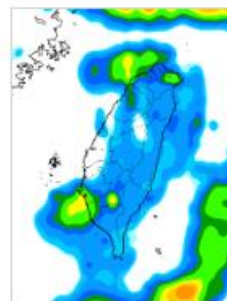
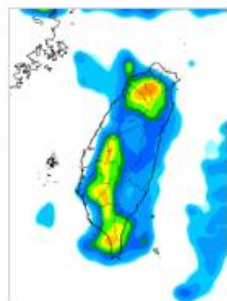
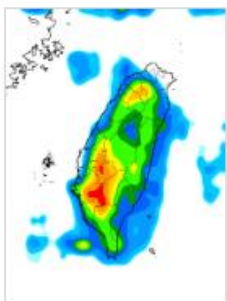
EC



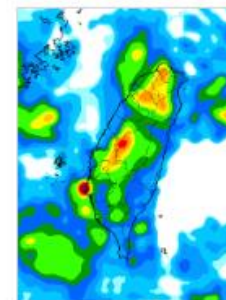
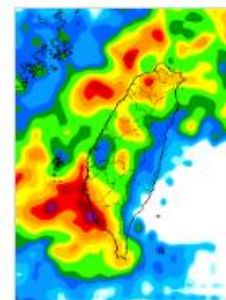
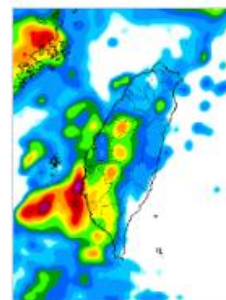
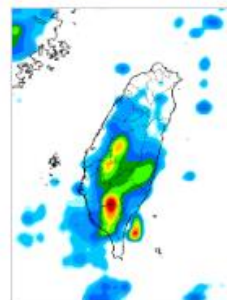
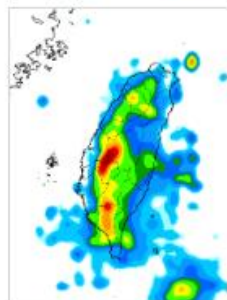
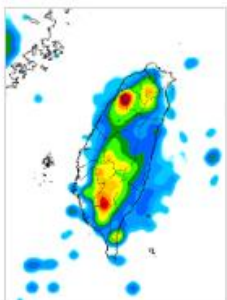
GFS



FCN



Pangu



**TSWP**

account: cwb

password: cwb