# 極端天氣與氣候指標的區域統計降尺度:從日資料到極端事件

## Regional Statistical Downscaling of Extreme Weather and Climate Indices: From Daily Data to Extreme Events

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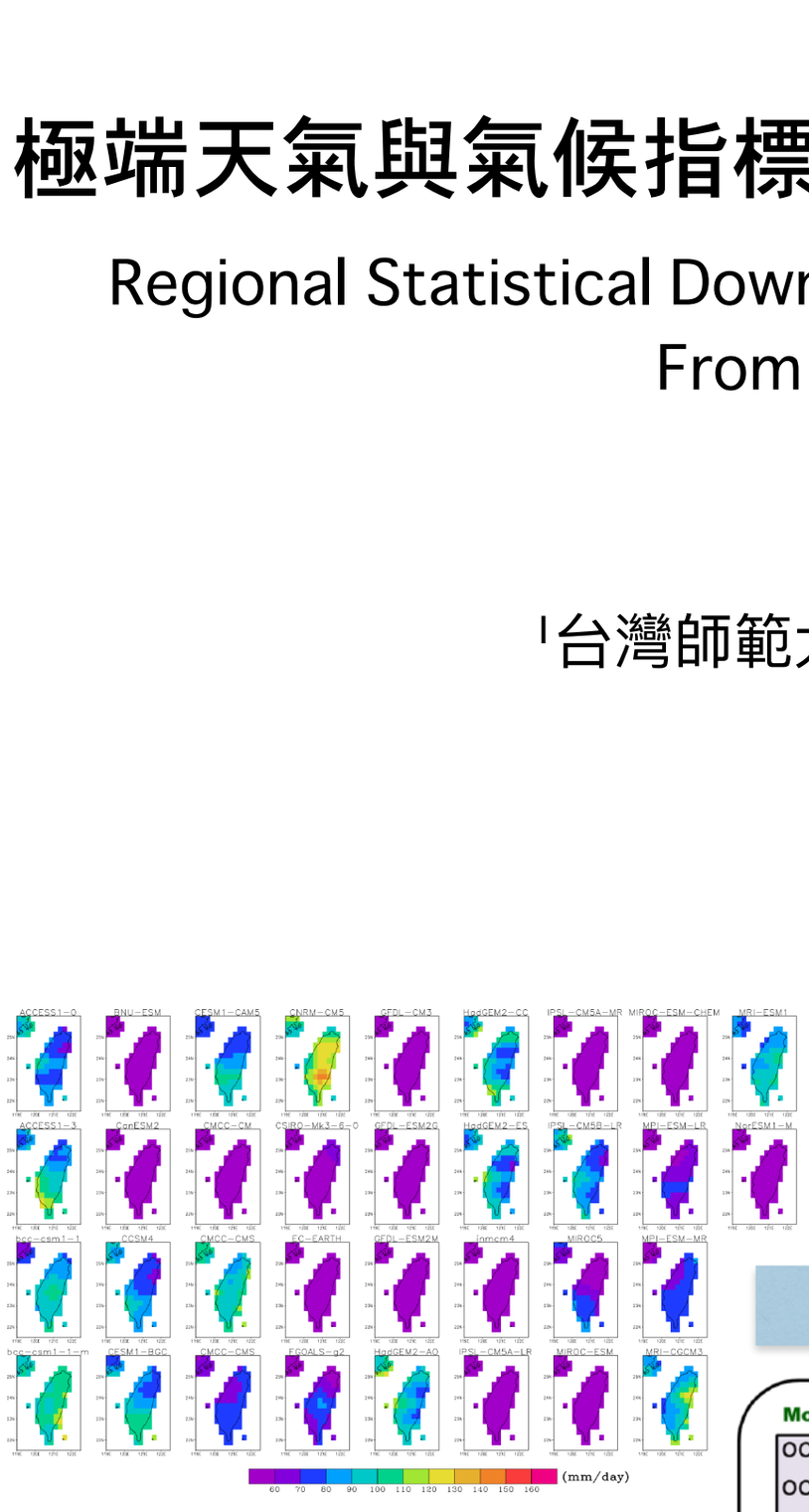
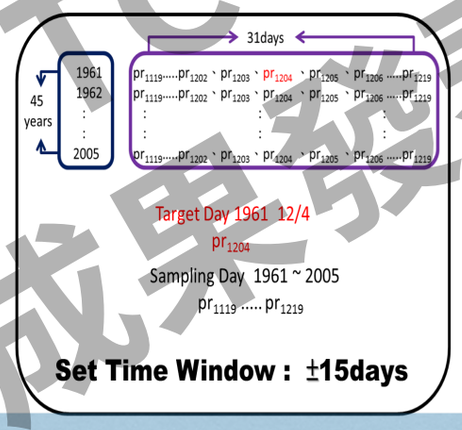
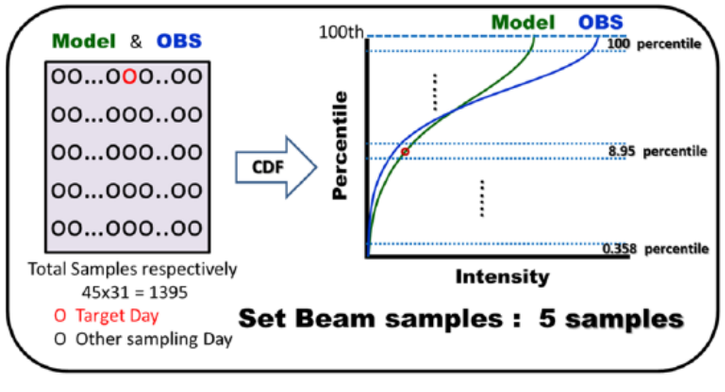



# Why do we need downscaling?

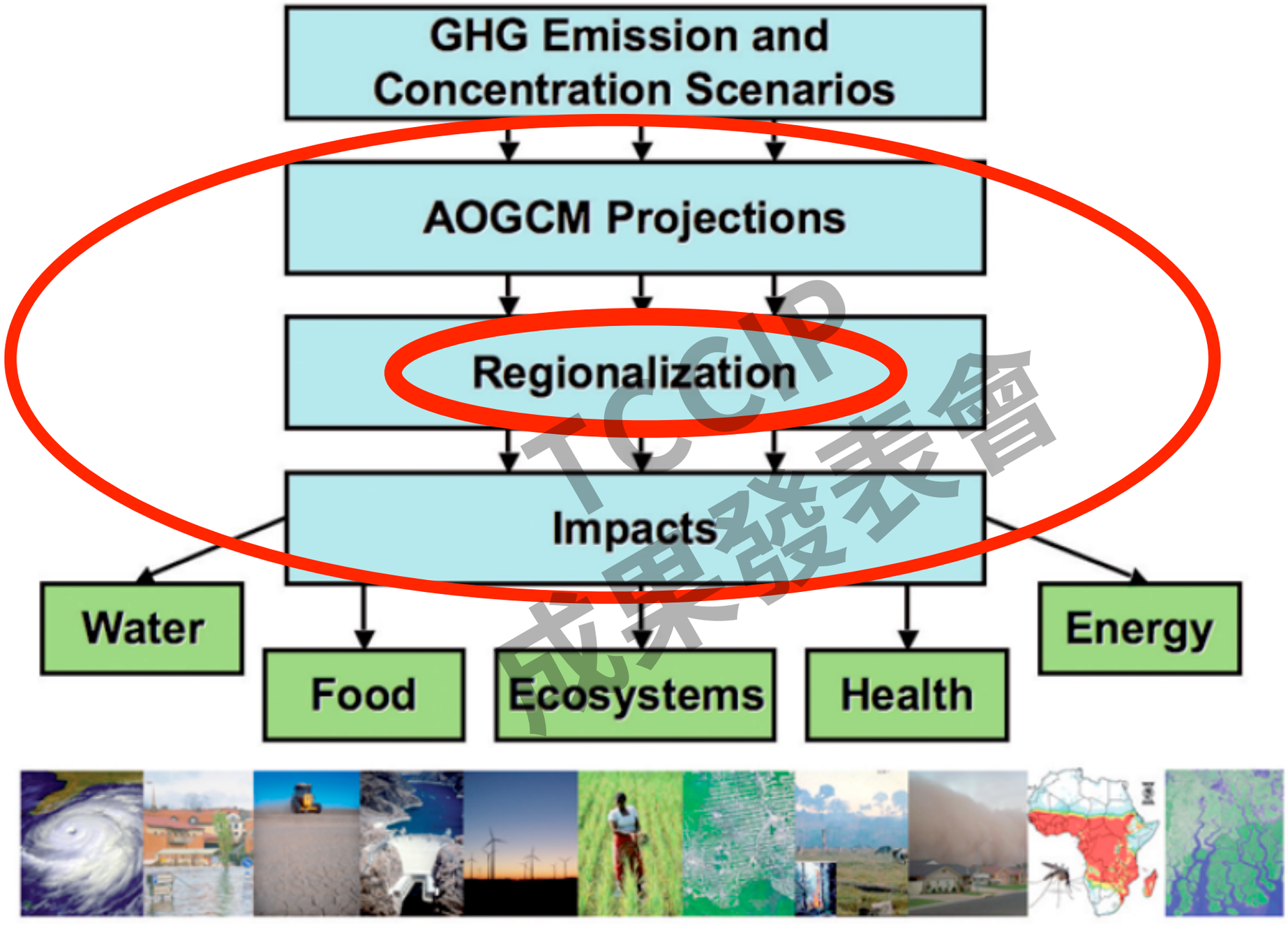
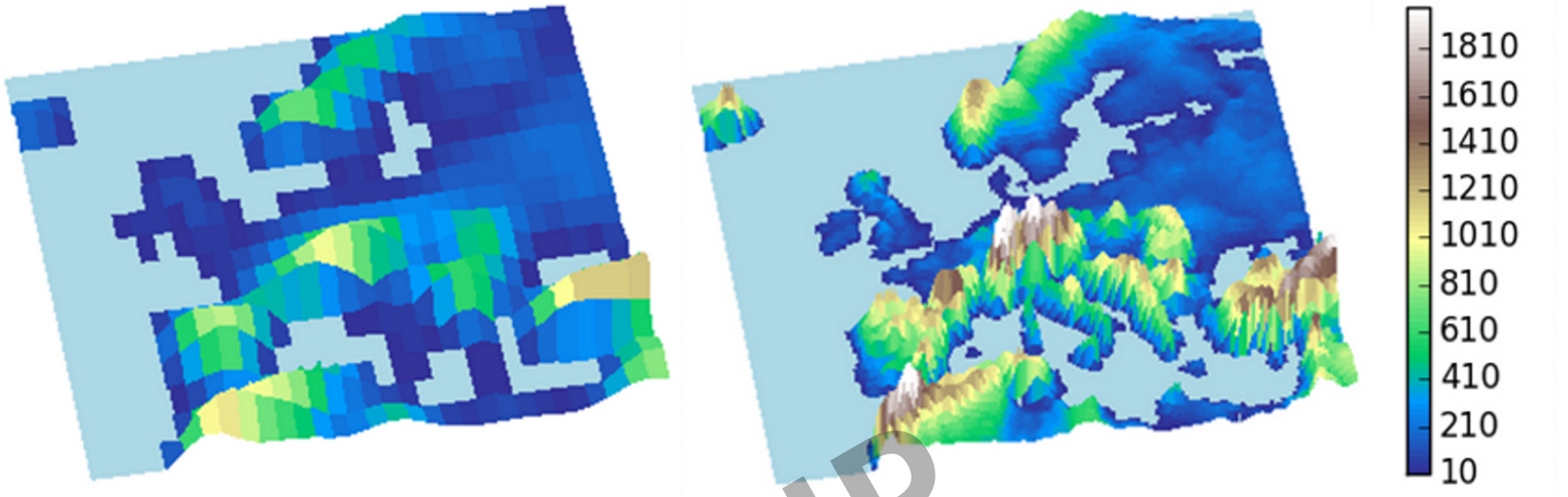
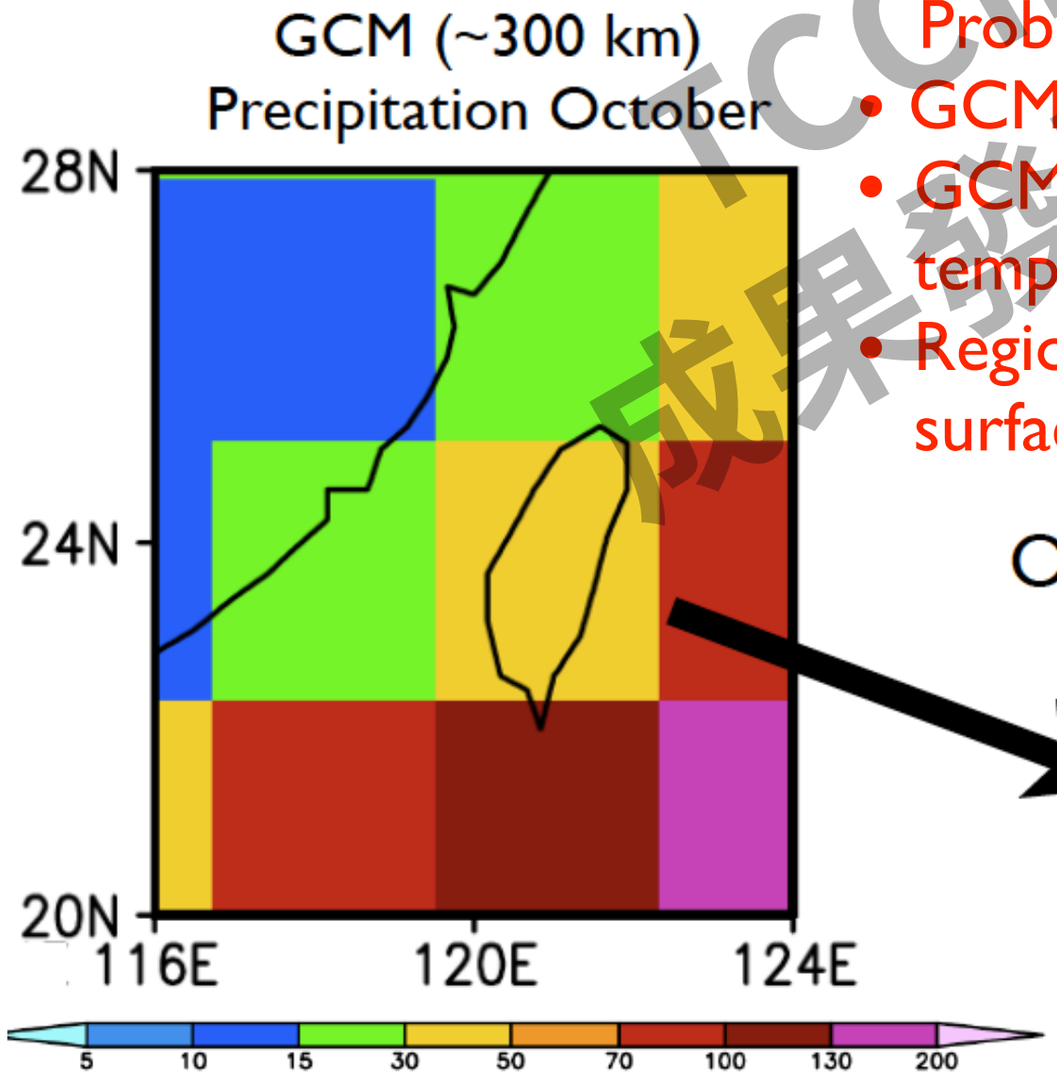



*Figure 3 — Schematic depiction of the steps involved in the production of climate change information usable for impact assessment work via regionalization methods*

Source: Giorgi (2008)

# Why do we need downscaling?

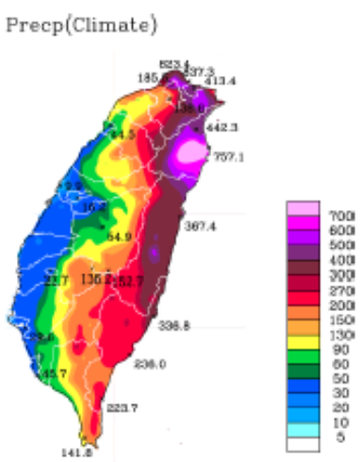



Problems:

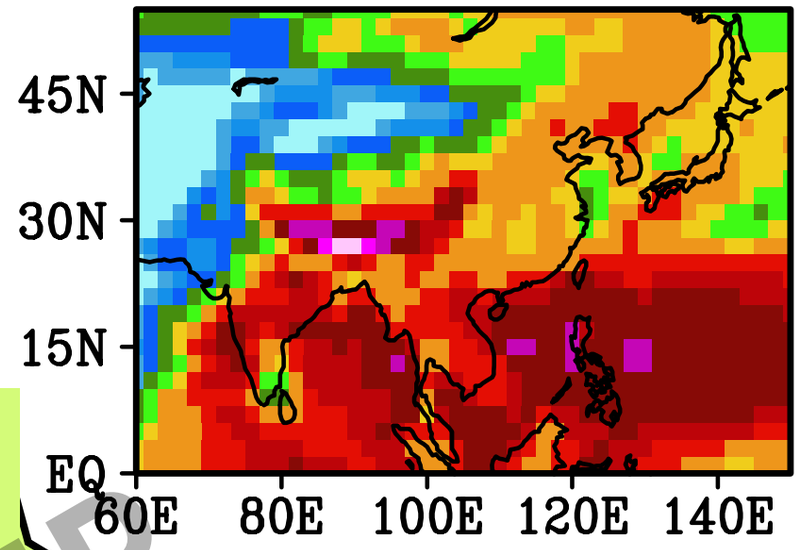
- GCM too coarse for local assessment
- GCM biases in climatology (spatially and temporally)
- Regional climate variability (topography, surface landscapes, coastlines)

Observation (~5km)

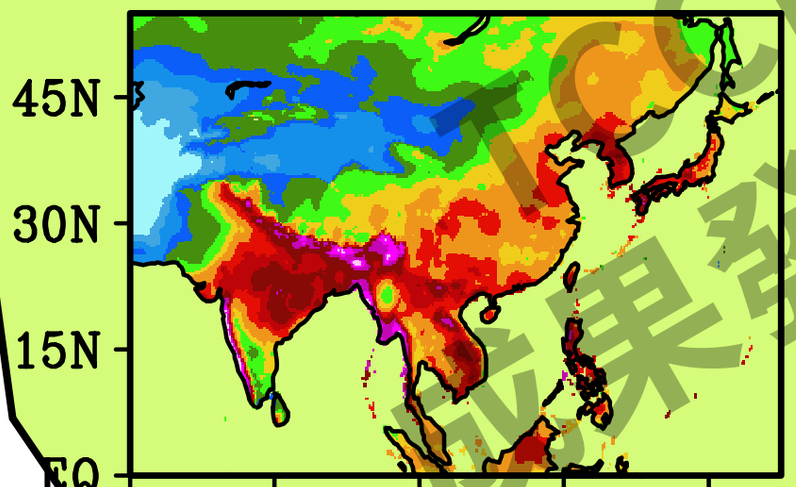


# Statistical Downscaling

Climate Model

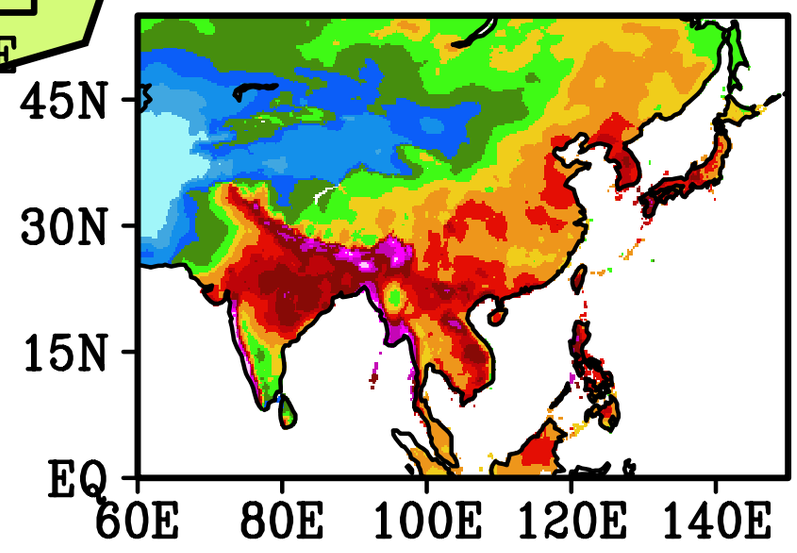



High Resolution Observation



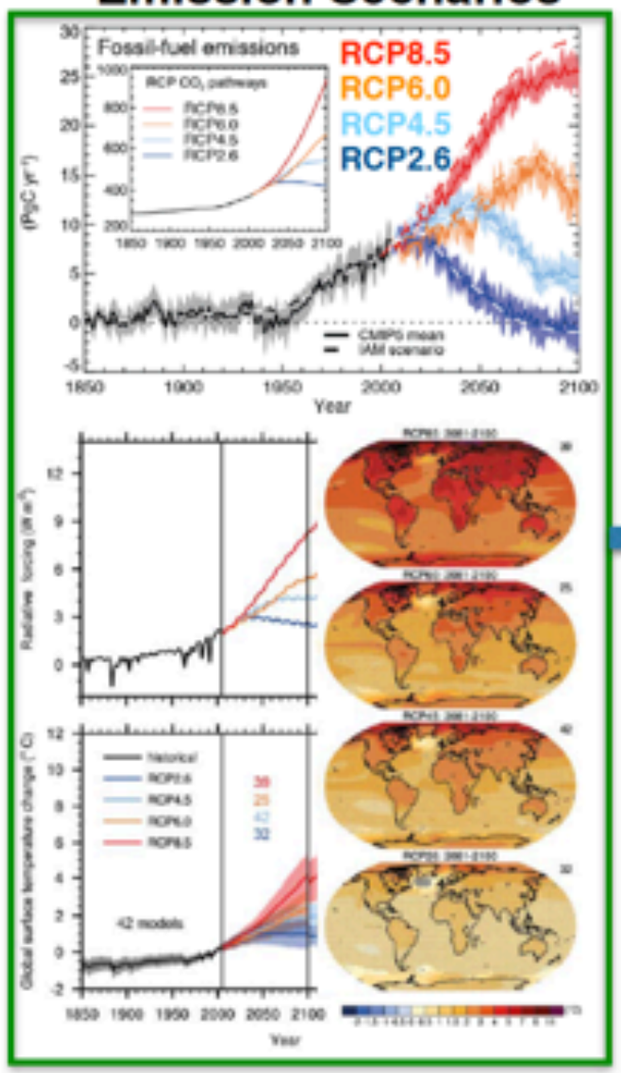

Develop transfer function

Downscaled

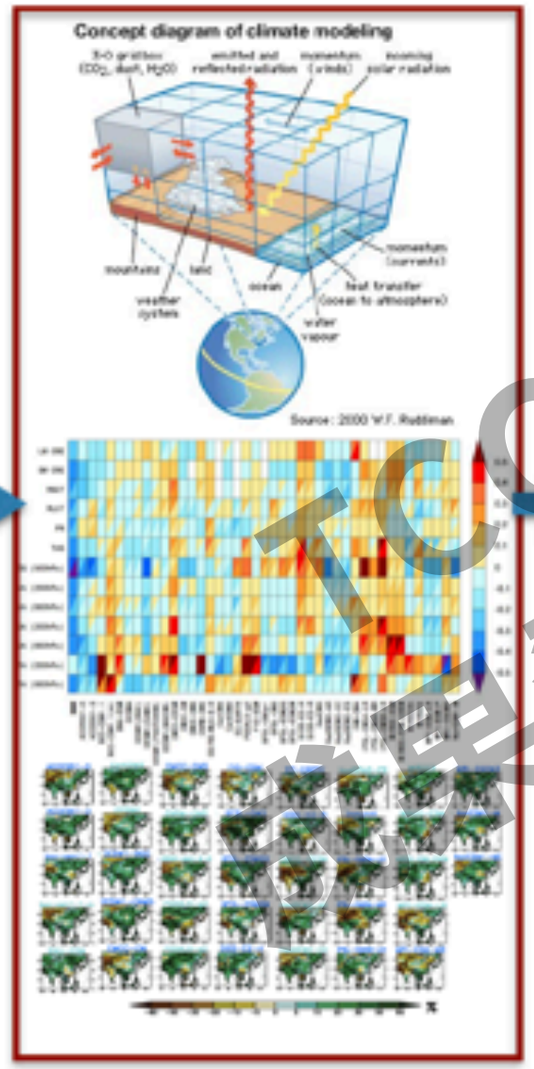


# Future Climate Scenarios Cascade (Statistical Downscaling)

## Emission Scenarios

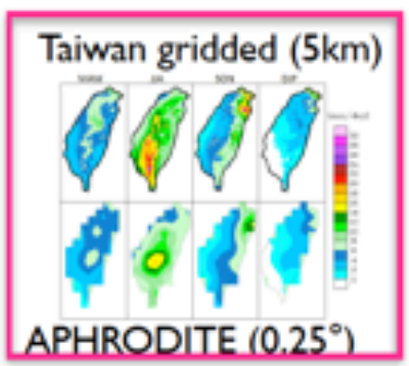



## Climate Modeling
## All CMIP5 GCMs

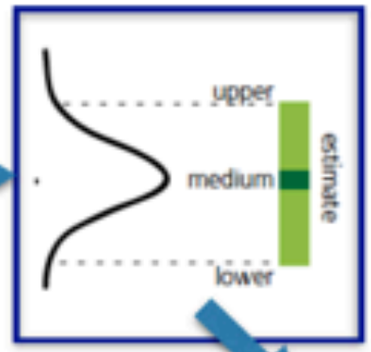



## Regionalization
## from CMIP5 GCMs

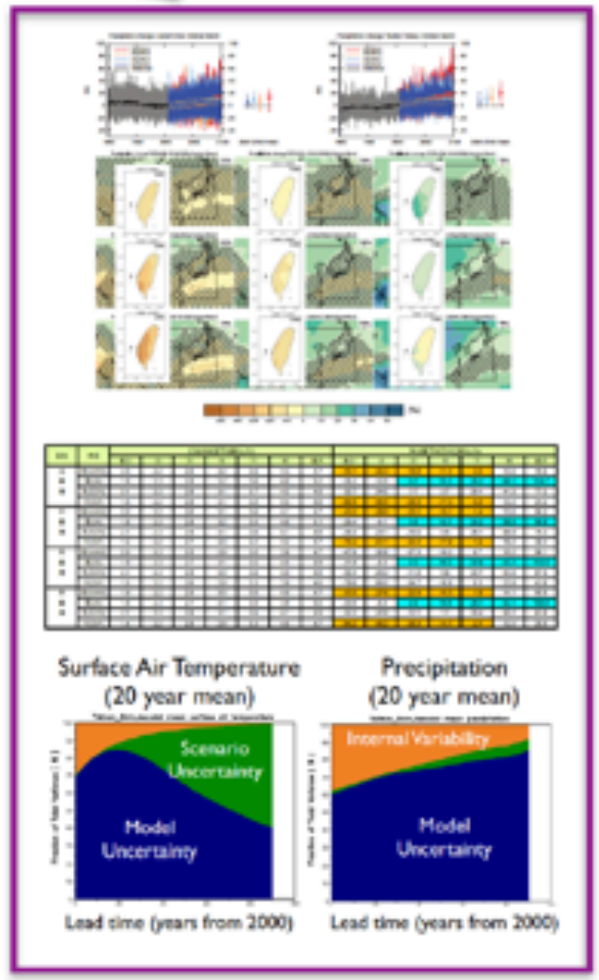
## High resolution
## Observation




## Probability
## Distribution

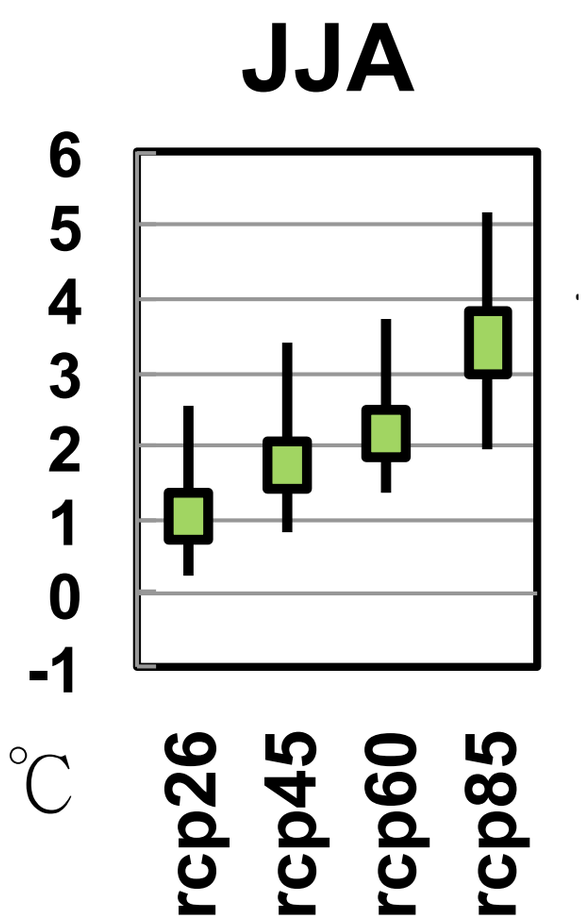


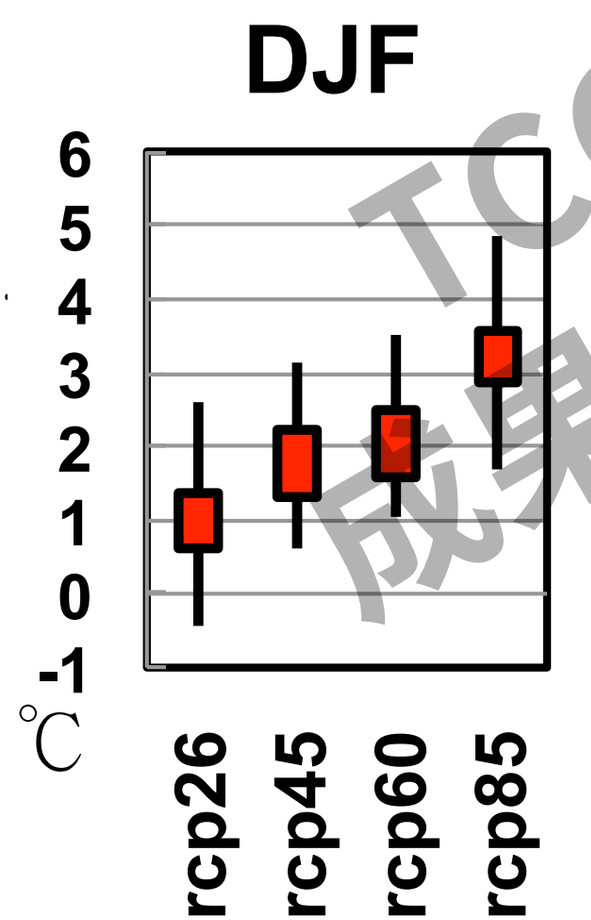

## Future
## Climate
## Scenarios



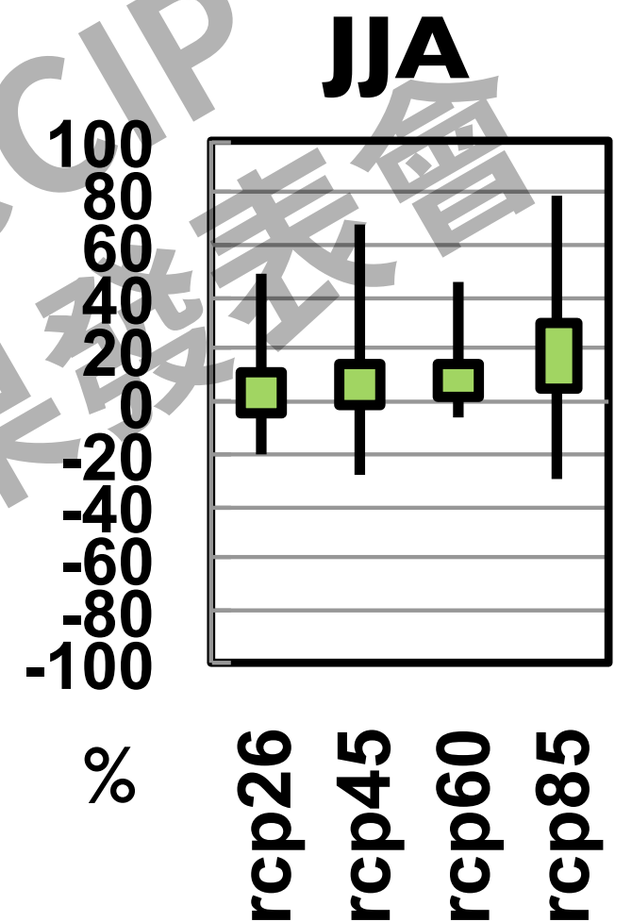
# Box-Whisker Plots of CMIP5 Model Projected Taiwan Mean Future (2080-2099) Climate Change with RCP8.5 scenario

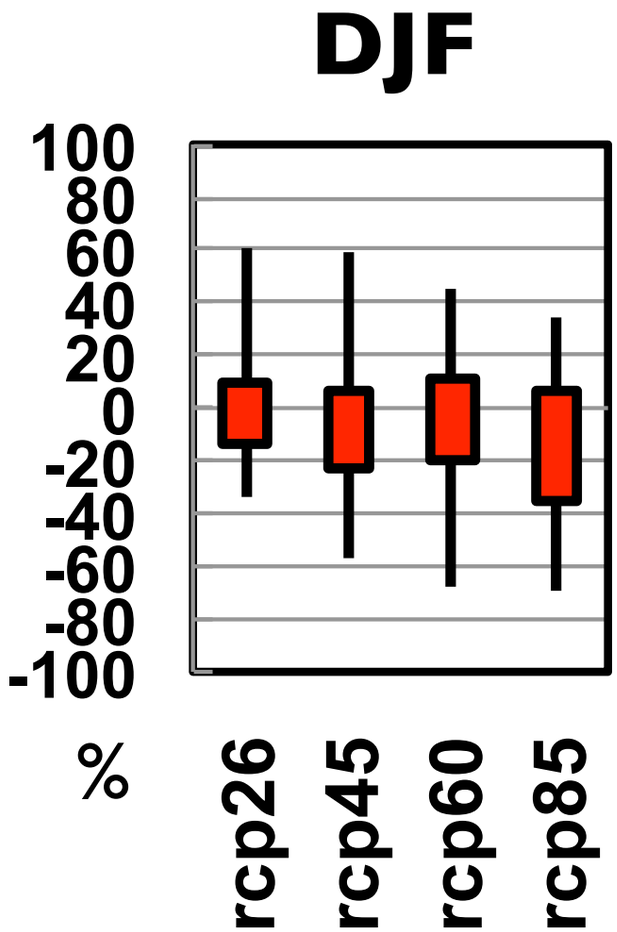
## Taiwan Mean Temperature Change




## Taiwan Mean Precipitation Change



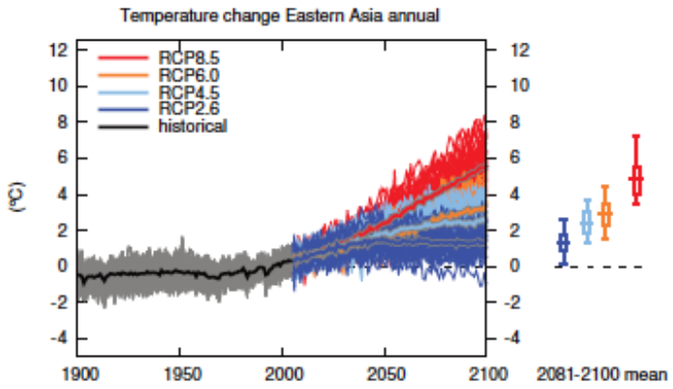



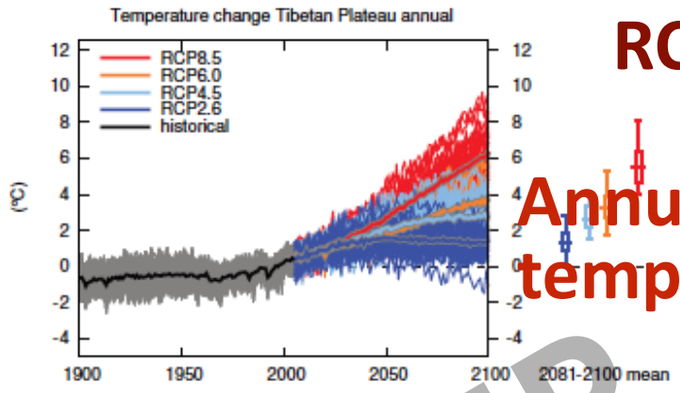
# IPCC AR5 Atlas

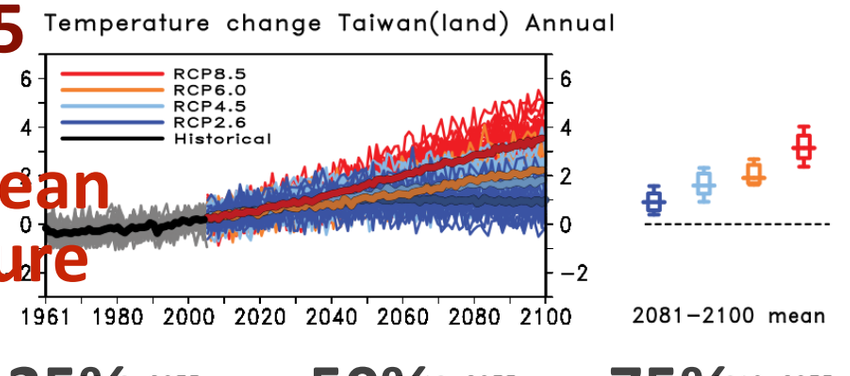
# TCCIP Atlas

**RCP 8.5**

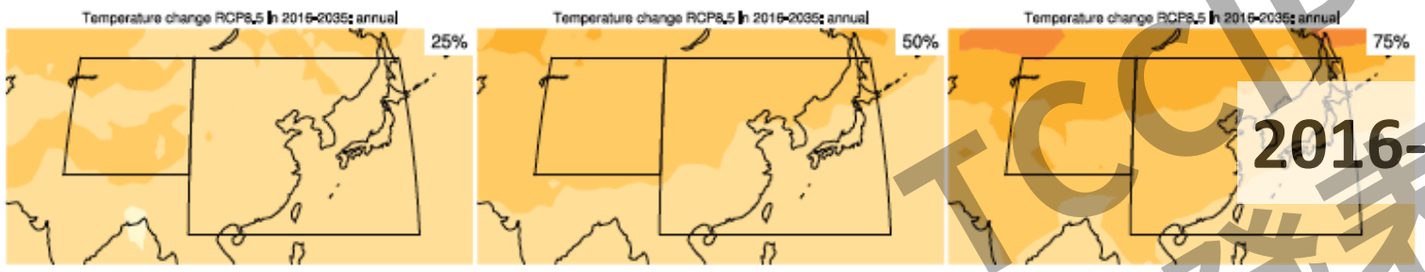
**Annual mean temperature**

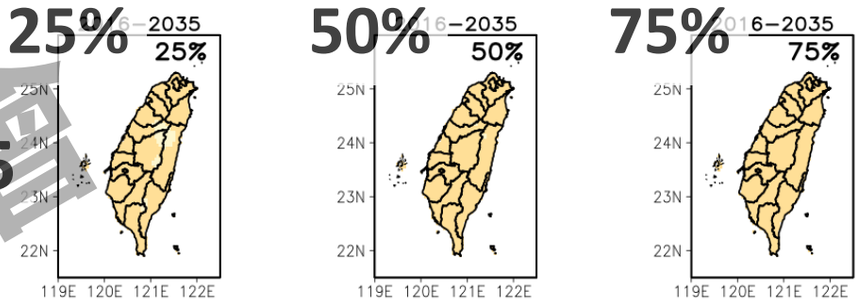


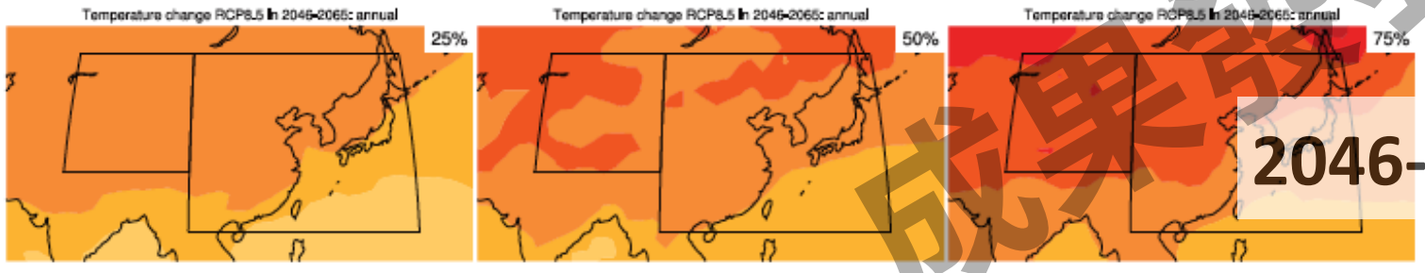



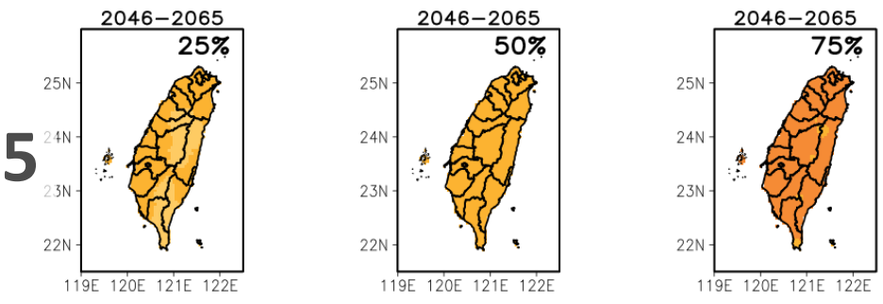

**2016-2035**



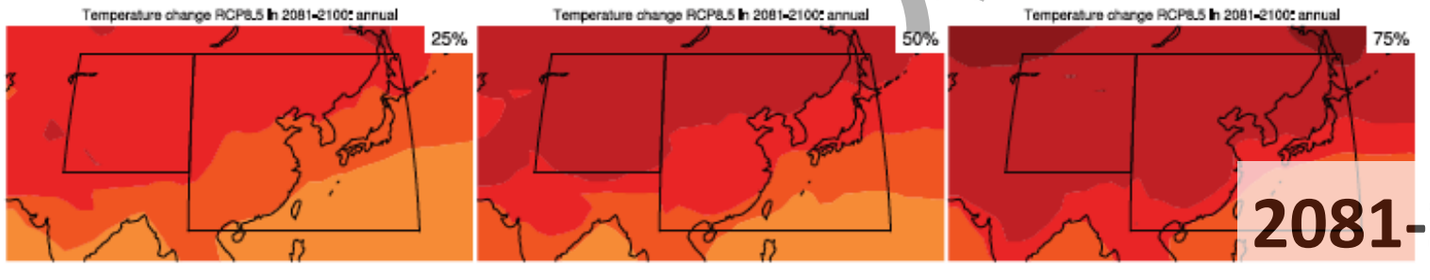



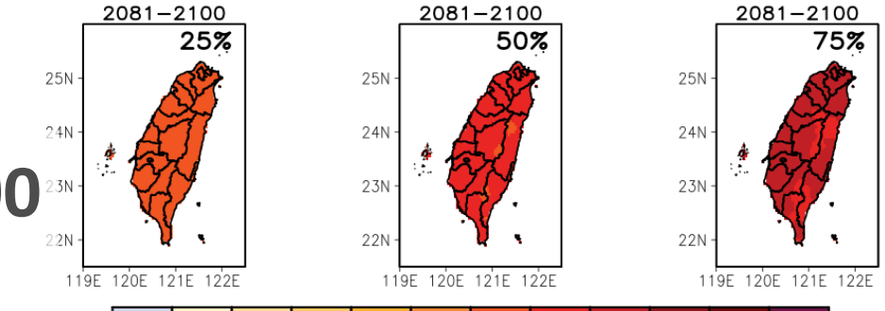

**2046-2065**

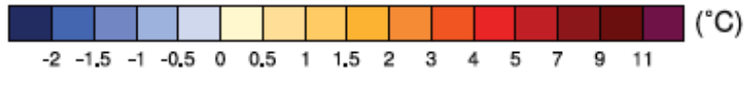


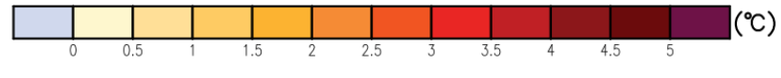




**2081-2100**



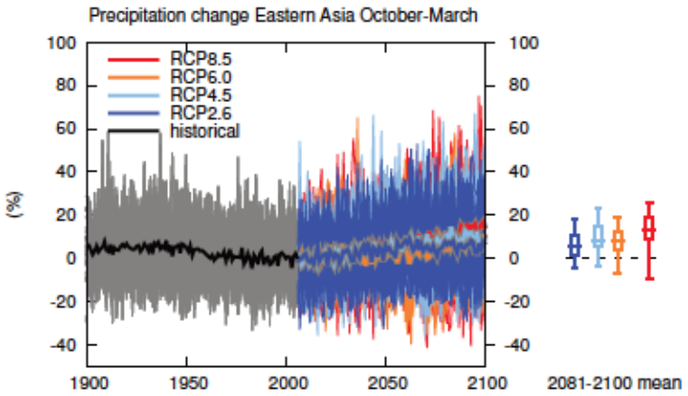



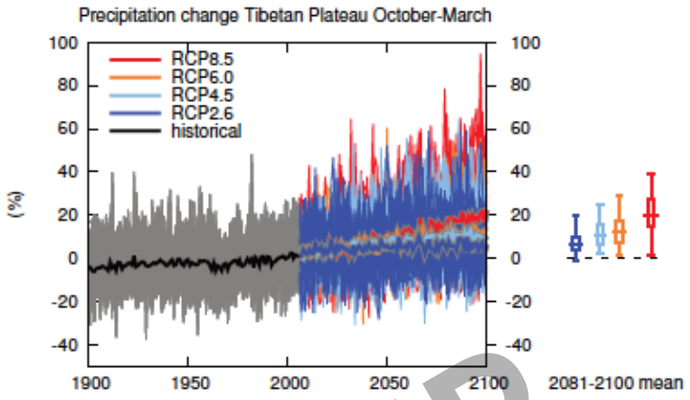



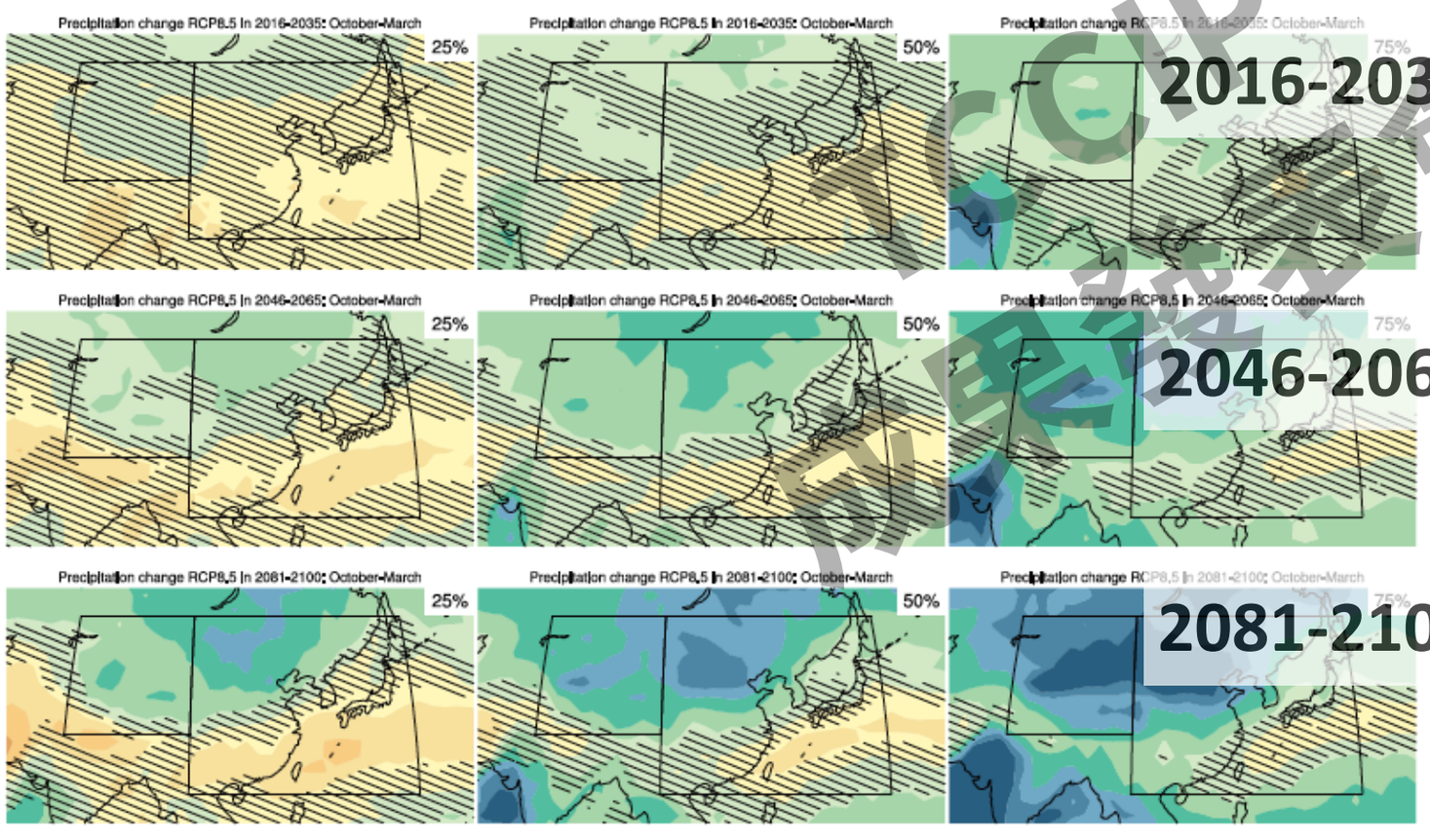
# RCP 8.5

# ONDJFM mean precipitation

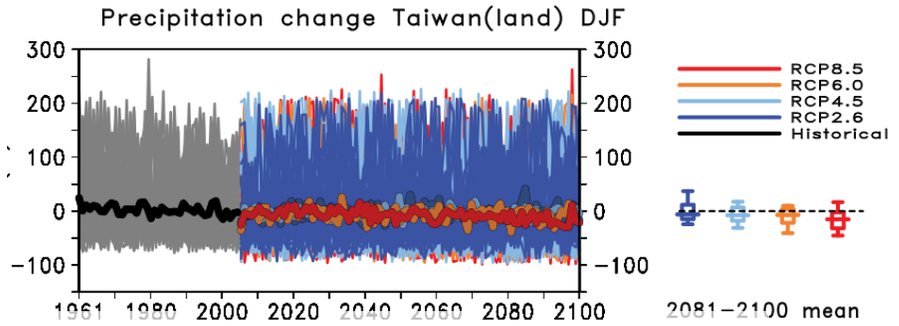
## IPCC AR5 Atlas

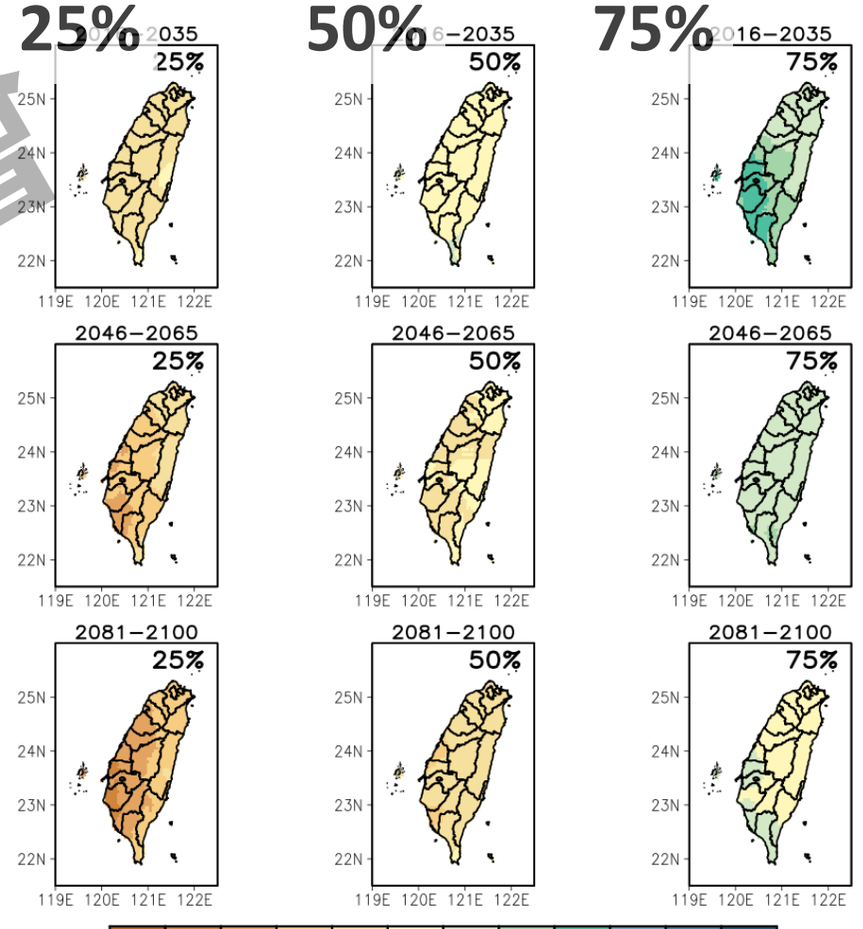



## TCCIP Atlas



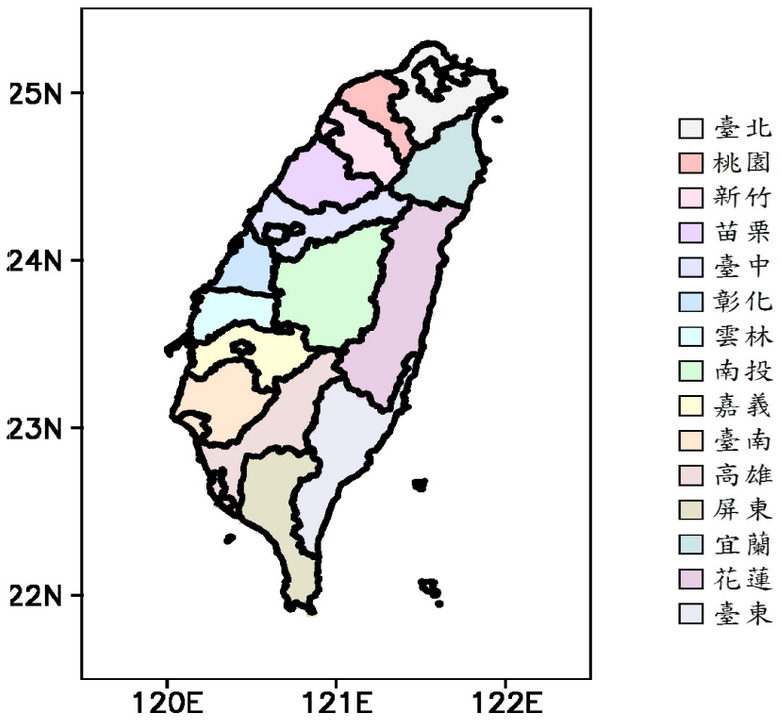
# RCP8.5
# 2081-2100

MAM 春

JJA 夏

SON 秋

DJF 冬




## 近地表氣溫變化 °C　　降雨變化 °C

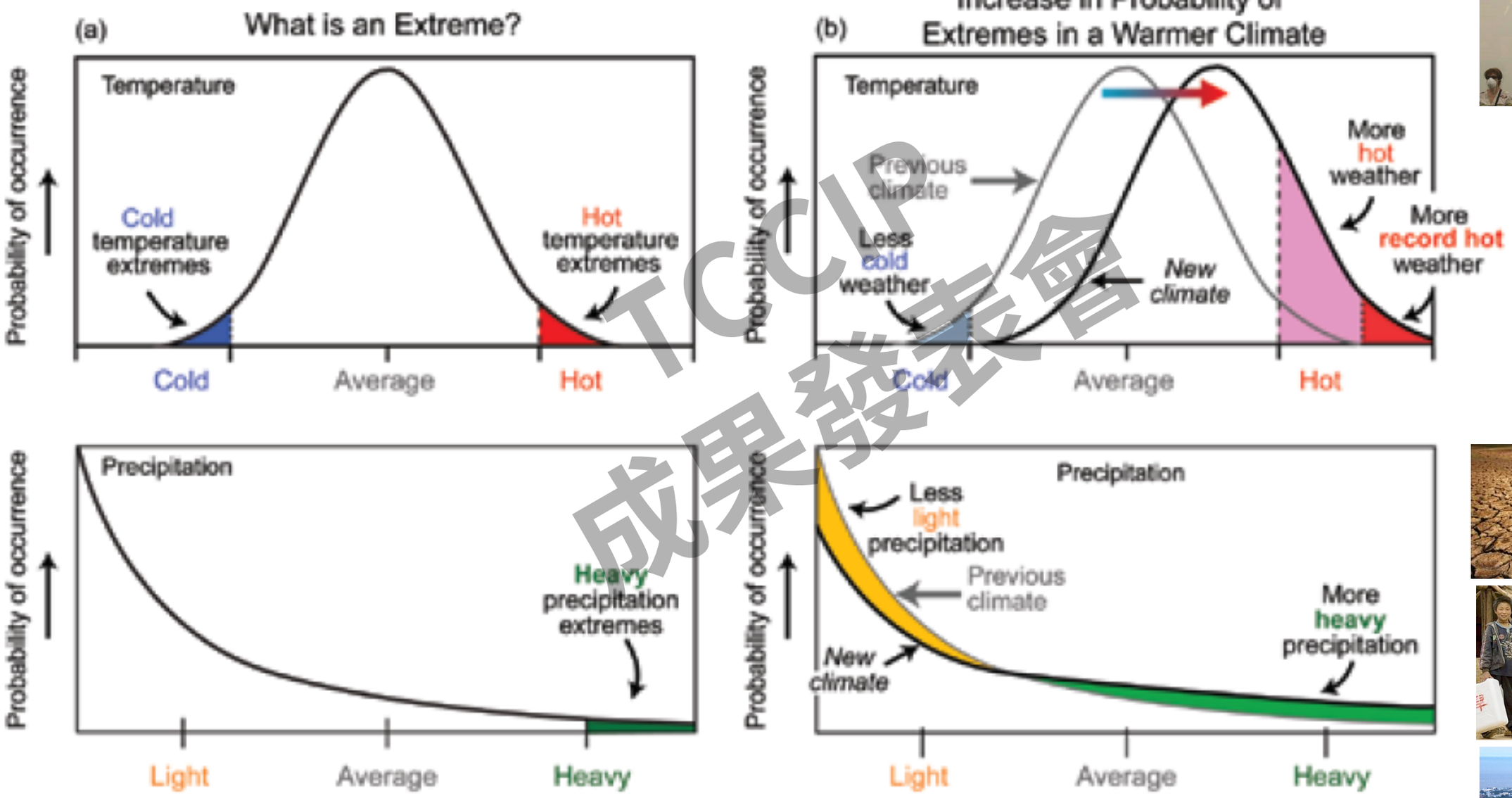
| 區域 | 季節 | 近地表氣溫平均變化 (℃) | | | | | | | 降水量平均百分比變化 (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 最小 | 10 | 25 | 50 | 75 | 90 | 最大 | 最小 | 10 | 25 | 50 | 75 | 90 | 最大 |
| 北北基 | 春(MAM) | 2.0 | 2.2 | 2.6 | 3.2 | 3.7 | 4.3 | 4.7 | -36.3 | -22.2 | -16.7 | -10.5 | -2.9 | 10.5 | 43.2 |
| | 夏(JJA) | 1.8 | 2.4 | 2.8 | 3.3 | 3.6 | 4.1 | 5.2 | -34.9 | -12.1 | -0.4 | 15.9 | 25.1 | 43.9 | 117.8 |
| | 秋(SON) | 2.1 | 2.4 | 2.9 | 3.2 | 3.7 | 4.3 | 4.9 | -27.4 | -19.8 | -7.8 | 1.0 | 15.1 | 31.4 | 58.3 |
| | 冬(DJF) | 1.5 | 2.2 | 2.8 | 3.1 | 3.5 | 4.4 | 4.9 | -53.2 | -34.3 | -24.9 | -15.2 | -4.5 | 8.1 | 15.9 |
| 桃園 | 春(MAM) | 1.9 | 2.2 | 2.6 | 3.2 | 3.6 | 4.3 | 4.7 | -42.3 | -26.0 | -19.3 | -11.1 | -2.9 | 12.8 | 51.0 |
| | 夏(JJA) | 1.8 | 2.4 | 2.8 | 3.3 | 3.6 | 4.1 | 5.3 | -36.4 | -12.8 | -0.3 | 14.7 | 26.3 | 47.5 | 117.3 |
| | 秋(SON) | 2.1 | 2.4 | 2.9 | 3.2 | 3.7 | 4.3 | 4.9 | -33.1 | -23.6 | -8.0 | 1.8 | 19.7 | 39.5 | 75.6 |
| | 冬(DJF) | 1.5 | 2.2 | 2.8 | 3.1 | 3.6 | 4.4 | 4.8 | -60.3 | -40.1 | -27.6 | -17.7 | -5.4 | 11.9 | 22.2 |
| 新竹 | 春(MAM) | 2.0 | 2.2 | 2.6 | 3.2 | 3.6 | 4.3 | 4.7 | -41.7 | -26.7 | -20.0 | -11.7 | -3.4 | 13.7 | 52.0 |
| | 夏(JJA) | 1.8 | 2.3 | 2.8 | 3.2 | 3.6 | 4.0 | 5.2 | -35.6 | -12.6 | 1.5 | 15.0 | 26.9 | 47.4 | 112.4 |
| | 秋(SON) | 2.1 | 2.3 | 2.8 | 3.1 | 3.7 | 4.2 | 4.8 | -34.1 | -25.5 | -8.0 | 2.9 | 20.7 | 42.8 | 81.6 |
| | 冬(DJF) | 1.5 | 2.2 | 2.8 | 3.1 | 3.5 | 4.4 | 4.8 | -63.2 | -42.2 | -28.7 | -18.2 | -5.7 | 13.6 | 27.1 |
| 苗栗 | 春(MAM) | 1.9 | 2.2 | 2.6 | 3.2 | 3.6 | 4.3 | 4.7 | -42.2 | -27.7 | -20.2 | -12.4 | -3.6 | 14.4 | 54.7 |
| | 夏(JJA) | 1.7 | 2.3 | 2.7 | 3.1 | 3.6 | 3.9 | 5.1 | -34.4 | -12.6 | 2.1 | 15.1 | 27.1 | 47.0 | 110.8 |
| | 秋(SON) | 2.1 | 2.2 | 2.8 | 3.0 | 3.6 | 4.2 | 4.8 | -38.1 | -30.2 | -7.1 | 5.4 | 26.4 | 53.9 | 99.2 |
| | 冬(DJF) | 1.5 | 2.2 | 2.8 | 3.1 | 3.6 | 4.4 | 4.8 | -67.9 | -47.5 | -32.8 | -19.0 | -5.6 | 16.4 | 34.0 |
| 臺中 | 春(MAM) | 2.0 | 2.2 | 2.6 | 3.2 | 3.6 | 4.2 | 4.7 | -43.2 | -27.2 | -21.7 | -13.7 | -3.2 | 13.9 | 54.7 |
| | 夏(JJA) | 1.7 | 2.2 | 2.7 | 3.1 | 3.5 | 3.9 | 5.1 | -33.1 | -12.2 | 2.2 | 16.1 | 26.4 | 44.8 | 110.7 |
| | 秋(SON) | 2.1 | 2.2 | 2.8 | 3.0 | 3.6 | 4.1 | 4.8 | -36.8 | -26.8 | -8.3 | 5.5 | 26.5 | 52.3 | 87.2 |
| | 冬(DJF) | 1.5 | 2.2 | 2.8 | 3.1 | 3.5 | 4.4 | 4.8 | -68.7 | -50.2 | -33.4 | -18.8 | -3.8 | 16.8 | 38.1 |
| 彰化 | 春(MAM) | 2.0 | 2.3 | 2.6 | 3.1 | 3.6 | 4.2 | 4.7 | -44.3 | -28.8 | -24.1 | -14.2 | -0.3 | 14.5 | 65.5 |
| | 夏(JJA) | 1.9 | 2.5 | 2.9 | 3.3 | 3.6 | 4.1 | 5.2 | -30.0 | -10.4 | 0.9 | 16.8 | 25.4 | 40.3 | 104.5 |
| | 秋(SON) | 2.1 | 2.3 | 2.9 | 3.1 | 3.7 | 4.2 | 4.9 | -40.8 | -25.8 | -10.6 | 9.3 | 35.9 | 65.4 | 91.5 |
| | 冬(DJF) | 1.5 | 2.2 | 2.8 | 3.1 | 3.5 | 4.3 | 4.7 | -75.5 | -58.6 | -37.4 | -20.1 | -0.4 | 19.7 | 45.3 |
| 南投 | 春(MAM) | 2.0 | 2.2 | 2.6 | 3.0 | 3.6 | 4.1 | 4.7 | -41.7 | -27.0 | -22.6 | -14.8 | -2.0 | 13.1 | 50.0 |
| | 夏(JJA) | 1.7 | 2.2 | 2.7 | 3.1 | 3.5 | 3.9 | 5.0 | -28.3 | -7.9 | 1.9 | 14.0 | 22.8 | 36.5 | 87.4 |
| | 秋(SON) | 2.1 | 2.2 | 2.7 | 3.0 | 3.6 | 4.1 | 4.8 | -30.3 | -20.1 | -9.8 | 3.2 | 20.9 | 39.1 | 62.4 |
| | 冬(DJF) | 1.5 | 2.2 | 2.7 | 3.0 | 3.4 | 4.1 | 4.7 | -66.1 | -46.2 | -31.3 | -16.4 | -2.5 | 15.8 | 32.7 |
| 雲林 | 春(MAM) | 2.0 | 2.3 | 2.6 | 3.1 | 3.6 | 4.2 | 4.7 | -45.5 | -29.6 | -24.1 | -16.3 | 0.7 | 14.1 | 67.3 |
| | 夏(JJA) | 1.9 | 2.4 | 2.9 | 3.3 | 3.6 | 4.1 | 5.1 | -28.5 | -9.2 | 1.6 | 17.5 | 26.9 | 38.0 | 103.4 |
| | 秋(SON) | 2.1 | 2.3 | 2.9 | 3.1 | 3.7 | 4.2 | 4.9 | -39.6 | -24.4 | -12.9 | 8.1 | 34.0 | 59.4 | 85.3 |
| | 冬(DJF) | 1.5 | 2.1 | 2.7 | 3.0 | 3.5 | 4.2 | 4.7 | -75.2 | -57.4 | -39.4 | -19.2 | 2.0 | 21.6 | 44.7 |
| 嘉義 | 春(MAM) | 2.0 | 2.3 | 2.6 | 3.0 | 3.6 | 4.1 | 4.7 | -44.2 | -29.4 | -24.5 | -17.3 | -0.2 | 13.4 | 58.0 |
| | 夏(JJA) | 1.9 | 2.4 | 2.8 | 3.2 | 3.6 | 4.1 | 5.1 | -27.9 | -7.1 | 0.9 | 17.0 | 27.8 | 36.9 | 101.7 |
| | 秋(SON) | 2.1 | 2.3 | 2.8 | 3.1 | 3.7 | 4.1 | 4.8 | -33.1 | -22.7 | -11.9 | 6.4 | 25.6 | 48.8 | 72.8 |
| | 冬(DJF) | 1.5 | 2.2 | 2.7 | 3.0 | 3.4 | 4.1 | 4.7 | -74.9 | -54.0 | -36.8 | -17.3 | 0.0 | 21.7 | 42.4 |
| 臺南 | 春(MAM) | 2.0 | 2.3 | 2.6 | 3.0 | 3.6 | 4.0 | 4.7 | -48.4 | -32.8 | -27.6 | -19.0 | 0.5 | 15.9 | 60.8 |
| | 夏(JJA) | 1.9 | 2.4 | 2.8 | 3.2 | 3.5 | 4.0 | 5.0 | -32.8 | -7.9 | 2.5 | 20.4 | 34.7 | 44.7 | 127.6 |
| | 秋(SON) | 2.1 | 2.3 | 2.8 | 3.1 | 3.7 | 4.1 | 4.8 | -33.4 | -27.2 | -12.8 | 6.8 | 25.7 | 49.1 | 73.3 |
| | 冬(DJF) | 1.5 | 2.1 | 2.6 | 2.9 | 3.4 | 4.0 | 4.7 | -81.0 | -57.5 | -39.8 | -18.4 | -0.2 | 26.3 | 48.2 |
| 高雄 | 春(MAM) | 2.0 | 2.3 | 2.6 | 3.0 | 3.6 | 4.0 | 4.7 | -45.5 | -30.8 | -26.2 | -17.4 | -0.4 | 14.5 | 53.6 |
| | 夏(JJA) | 1.8 | 2.3 | 2.7 | 3.1 | 3.5 | 4.0 | 5.0 | -31.8 | -6.1 | 2.3 | 19.6 | 32.7 | 42.7 | 114.9 |
| | 秋(SON) | 2.1 | 2.2 | 2.7 | 3.0 | 3.6 | 4.0 | 4.8 | -29.2 | -23.4 | -11.6 | 4.4 | 21.2 | 41.0 | 63.4 |
| | 冬(DJF) | 1.5 | 2.2 | 2.6 | 2.9 | 3.3 | 3.9 | 4.6 | -79.3 | -55.0 | -35.3 | -17.8 | -0.8 | 23.4 | 42.8 |
| 屏東 | 春(MAM) | 1.9 | 2.2 | 2.5 | 2.9 | 3.5 | 3.9 | 4.7 | -49.3 | -34.3 | -28.3 | -18.7 | 1.9 | 15.4 | 55.1 |
| | 夏(JJA) | 1.8 | 2.3 | 2.7 | 3.1 | 3.5 | 3.9 | 4.9 | -31.0 | -5.2 | 2.3 | 18.0 | 30.7 | 42.5 | 104.4 |
| | 秋(SON) | 2.1 | 2.2 | 2.7 | 3.0 | 3.5 | 3.9 | 4.8 | -29.3 | -22.8 | -11.4 | 6.0 | 21.8 | 43.0 | 66.1 |
| | 冬(DJF) | 1.5 | 2.2 | 2.6 | 2.8 | 3.3 | 3.8 | 4.6 | -78.9 | -53.0 | -29.9 | -14.6 | 1.9 | 22.6 | 41.3 |
| 宜蘭 | 春(MAM) | 1.9 | 2.2 | 2.6 | 3.1 | 3.6 | 4.1 | 4.7 | -39.2 | -24.3 | -20.1 | -12.6 | -3.1 | 12.5 | 49.1 |
| | 夏(JJA) | 1.8 | 2.3 | 2.7 | 3.2 | 3.5 | 4.0 | 5.1 | -35.4 | -11.4 | 2.5 | 17.5 | 27.0 | 46.3 | 118.0 |
| | 秋(SON) | 2.1 | 2.3 | 2.8 | 3.2 | 3.7 | 4.2 | 4.9 | -29.4 | -21.9 | -9.3 | -2.2 | 16.8 | 32.6 | 54.1 |
| | 冬(DJF) | 1.5 | 2.2 | 2.7 | 3.0 | 3.4 | 4.3 | 4.8 | -60.9 | -36.6 | -26.2 | -16.9 | -4.7 | 8.5 | 19.9 |
| 花蓮 | 春(MAM) | 1.9 | 2.2 | 2.5 | 2.9 | 3.6 | 4.0 | 4.7 | -43.4 | -27.6 | -23.1 | -15.5 | -2.0 | 15.0 | 51.6 |
| | 夏(JJA) | 1.7 | 2.2 | 2.7 | 3.1 | 3.5 | 3.8 | 5.0 | -34.1 | -8.4 | 2.8 | 15.0 | 24.5 | 42.4 | 104.3 |
| | 秋(SON) | 2.1 | 2.3 | 2.8 | 3.1 | 3.6 | 4.1 | 4.9 | -32.7 | -23.4 | -12.8 | 0.0 | 20.4 | 39.6 | 63.3 |
| | 冬(DJF) | 1.4 | 2.2 | 2.6 | 2.9 | 3.3 | 4.0 | 4.6 | -58.9 | -36.4 | -25.2 | -14.3 | -2.9 | 11.2 | 23.3 |
| 臺東 | 春(MAM) | 1.9 | 2.2 | 2.5 | 2.9 | 3.5 | 3.9 | 4.7 | -45.2 | -29.8 | -24.7 | -16.8 | -0.8 | 14.0 | 49.9 |
| | 夏(JJA) | 1.8 | 2.3 | 2.7 | 3.1 | 3.5 | 3.9 | 4.9 | -31.2 | -6.2 | 1.9 | 16.1 | 27.8 | 38.8 | 99.5 |
| | 秋(SON) | 2.1 | 2.2 | 2.7 | 3.0 | 3.6 | 4.0 | 4.8 | -33.5 | -22.4 | -13.1 | 5.0 | 22.9 | 46.1 | 71.1 |
| | 冬(DJF) | 1.5 | 2.2 | 2.6 | 2.9 | 3.3 | 3.9 | 4.6 | -73.8 | -48.0 | -27.8 | -13.9 | -1.1 | 17.1 | 30.8 |
| 澎湖 | 春(MAM) | 2.0 | 2.3 | 2.6 | 3.1 | 3.6 | 4.2 | 4.7 | -42.7 | -26.9 | -21.6 | -11.6 | 1.5 | 13.9 | 64.8 |
| | 夏(JJA) | 1.9 | 2.5 | 2.9 | 3.3 | 3.6 | 4.1 | 5.1 | -29.4 | -10.4 | 1.8 | 16.7 | 31.4 | 42.7 | 119.4 |
| | 秋(SON) | 2.1 | 2.4 | 2.9 | 3.2 | 3.9 | 4.3 | 4.8 | -36.8 | -25.4 | -12.5 | 7.7 | 29.2 | 51.7 | 75.8 |
| | 冬(DJF) | 1.5 | 2.1 | 2.7 | 3.0 | 3.4 | 4.2 | 4.7 | -67.8 | -52.0 | -33.6 | -17.3 | 1.9 | 16.4 | 39.0 |

# 兩期TCCIP計畫所產製的統計降尺度資料

| TCCIP-I | TCCIP-II |
| --- | --- |
| CMIP3 降雨　　月資料降尺度（月）<br>CMIP3 日均溫　月資料降尺度（月）<br><br>CMIP3 降水極端指標降尺度（年） | CMIP3 日最高溫月資料降尺度（月）<br>CMIP3 日最低溫月資料降尺度（月）<br>CMIP5 降雨　　月資料降尺度（月）<br>CMIP5 日均溫　月資料降尺度（月）<br>CMIP5 日最高溫月資料降尺度（月）<br>CMIP5 日最低溫月資料降尺度（月）<br>CMIP5 降水極端指標降尺度（年）<br>CMIP5 溫度極端指標降尺度（年）<br>CMIP5 日降雨資料降尺度（日） |
| 基期　　：1980~1999<br>近未來　：2020-2039<br><br>21 世紀末：2080-2099 | 基期　　：1986~2005<br>近未來　：2021-2030<br>近未來　：2041-2060<br>近未來　：2061-2080<br>21 世紀末：2081-2100 |
| 東亞地區：25 公里網格資料<br>臺灣地區：25、5 公里網格資料 | 臺灣地區：25、5 公里網格資料 |
| CMIP3 情境：B1、A1B、A2 | CMIP3 情境：B1、A1B、A2<br>CMIP5 情境：RCP2.6、RCP4.5、RCP6.0、RCP8.5 |

# High-impact and high-resolution climate information needed for:

- assessing environmental and societal relevant climate change impacts
- developing adaptation strategies and mitigation efforts



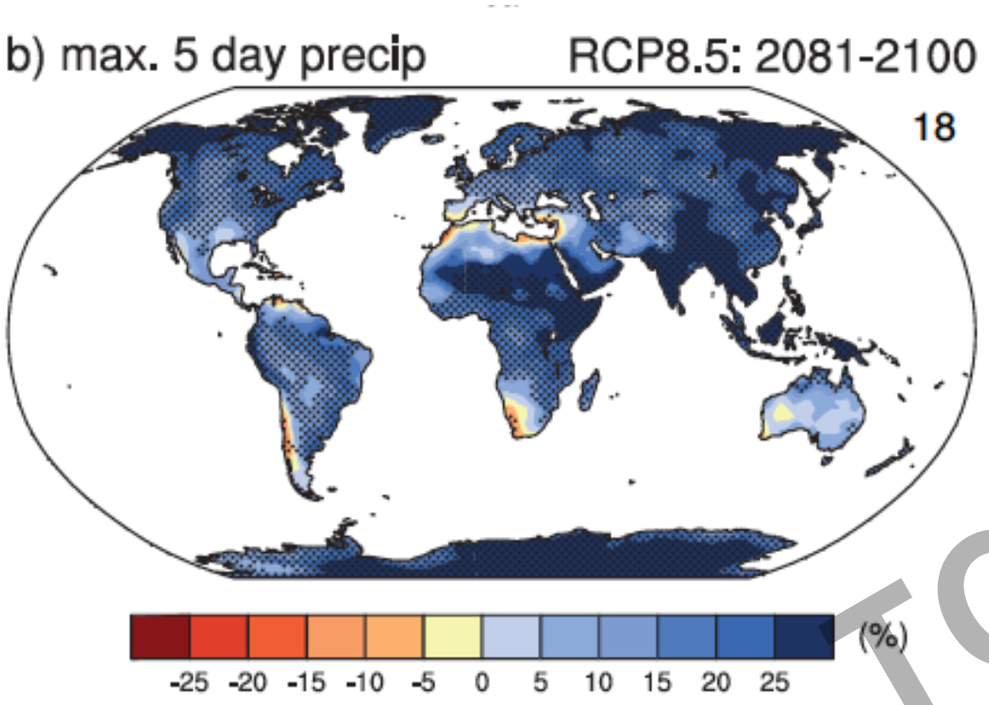

| | | | |
|---|---|---|---|
| TNn | Min TN | Let TNn be the daily minimum temperature in month $k$, period $j$. The minimum daily minimum temperature each month is then: $TNn_{kj} = \min(TNn_{kj})$ | °C |
| FD | Frost days | Let TN be the daily minimum temperature on day $i$ in period $j$. Count the number of days where $TN_{ij} < 0°C$ | days |
| ID | Ice days | Let TX be the daily maximum temperature on day $i$ in period $j$. Count the number of days where $TX_{ij} < 0°C$ | days |
| SU | | | s |
| TR | | | s |
| GSL | | | s |

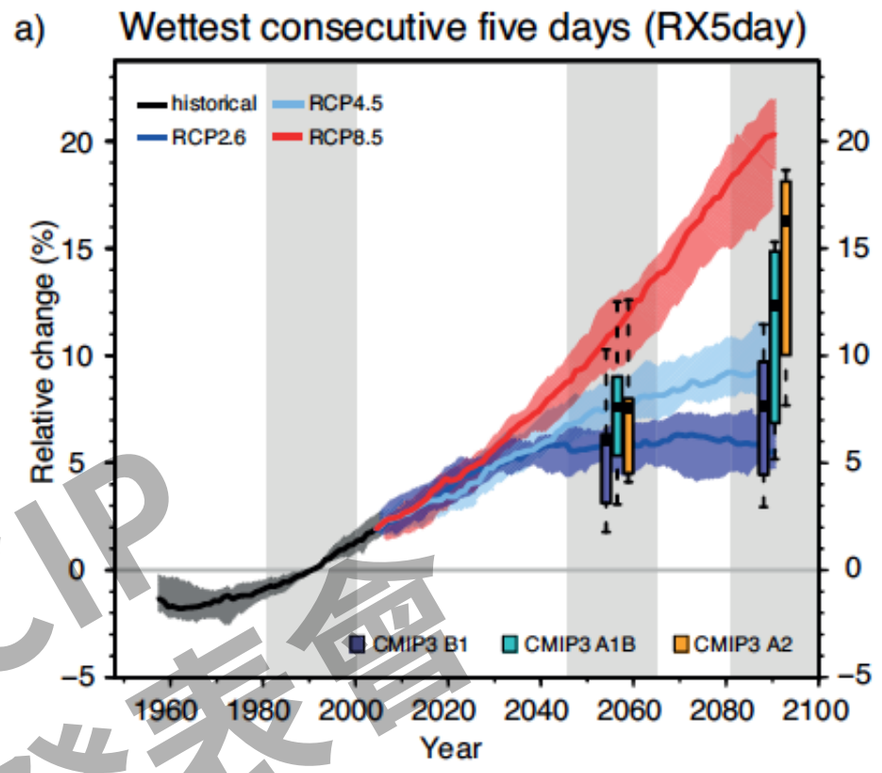
# Core Set of 27 Extreme Indices Recommended by the ETCCDI.

## Focused on Rainfall Related Extreme Indices

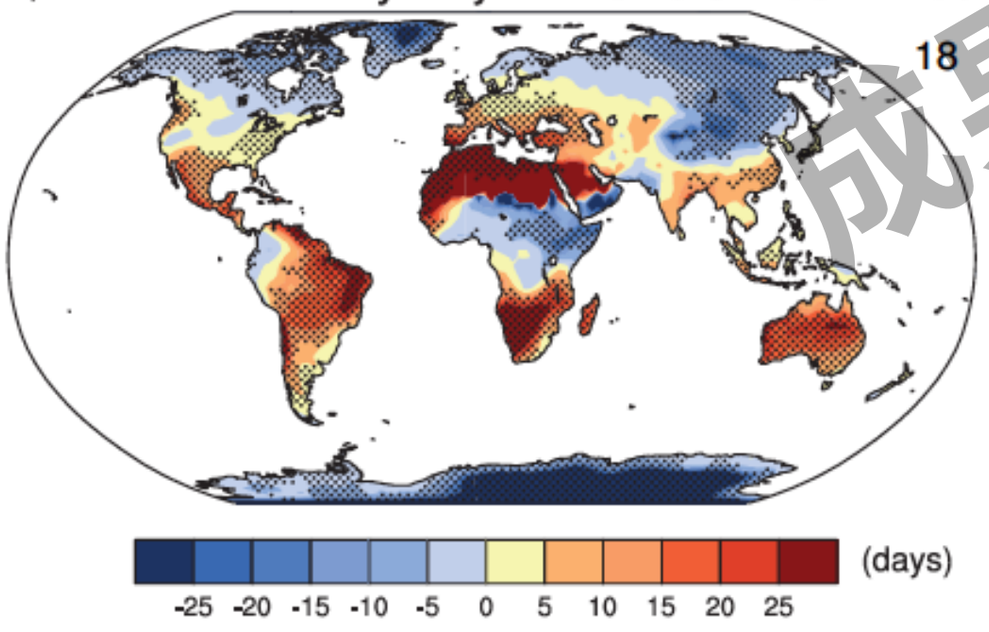
| | | | |
|---|---|---|---|
| DTR | Diurnal temperature range | Let TN and TX be the daily minimum and maximum temperature respectively on day $I$ in period $j$. If $I$ represents the number of days in $j$, then: $DTR_j = \sum_{i=1}^{I} (TX_{ij} - TN_{ij}) / I$ | °C |
| RX1day | Max 1 day precipitation | Let $PR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. The maximum 1 day value for period $j$ are: $RX1day_j = \max(PR_{ij})$ | mm |
| RX5day | Max 5 day precipitation | Let $PR_{kj}$ be the precipitation amount for the 5 day interval ending $k$, period $j$. Then maximum 5 day values for period $j$ are: $RX5day_j = \max(PR_{kj})$ | mm |
| SDII | Simple daily intensity | Let $PR_{wj}$ be the daily precipitation amount on wet days, PR >= 1 mm in period $j$. If $W$ represents number of wet days in $j$, then: $SDII_j = (\sum_{w=1}^{W} PR_{wj}) / W$ | mm |
| R1mm* | Number of wet days | Let $PR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. Count the number of days where $PR_{ij} > 1$ mm | days |
| R10mm | Heavy precipitation days | Let $PR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. Count the number of days where $PR_{ij} > 10$ mm | days |
| R20mm | Very heavy precipitation days | Let $PR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. Count the number of days where $PR_{ij} > 20$ mm | days |
| CDD | Consecutive dry days | Let $PR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. Count the largest number of consecutive days where $PR_{ij} < 1$ mm | days |
| CWD | Consecutive wet days | Let $PR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. Count the largest number of consecutive days where $PR_{ij} > 1$ mm | days |
| R95p | Very wet days | Let $PR_{wj}$ be the daily precipitation amount on a wet day $w$ (PR >= 1 mm) in period $i$ and let $PR_{wn}95$ be the 95th percentile of precipitation on wet days in the 1961–1990 period. If $W$ represents the number of wet days in the period, then: $R95p_j = \sum_{w=1}^{W} PR_{wj}$, where $PR_{wj} > PR_{wn}95$ | mm |
| R99p | Extremely wet days | Let $PR_{wj}$ be the daily precipitation amount on a wet day $w$ (PR >= 1 mm) in period $i$ and let $PR_{wn}99$ be the 95th percentile of precipitation on wet days in the 1961–1990 period. If $W$ represents the number of wet days in the period, then: $R99p_j = \sum_{w=1}^{W} PR_{wj}$, where $PR_{wj} > PR_{wn}99$ | mm |
| PRCPTOT | Total wet-day precipitation | Let $PR_{ij}$ be the daily precipitation amount on day $i$ in period $j$. If $I$ represents the number of days in $j$, then: $PRCPTOT_j = \sum_{n=1}^{I} PR_{ij}$ | mm |

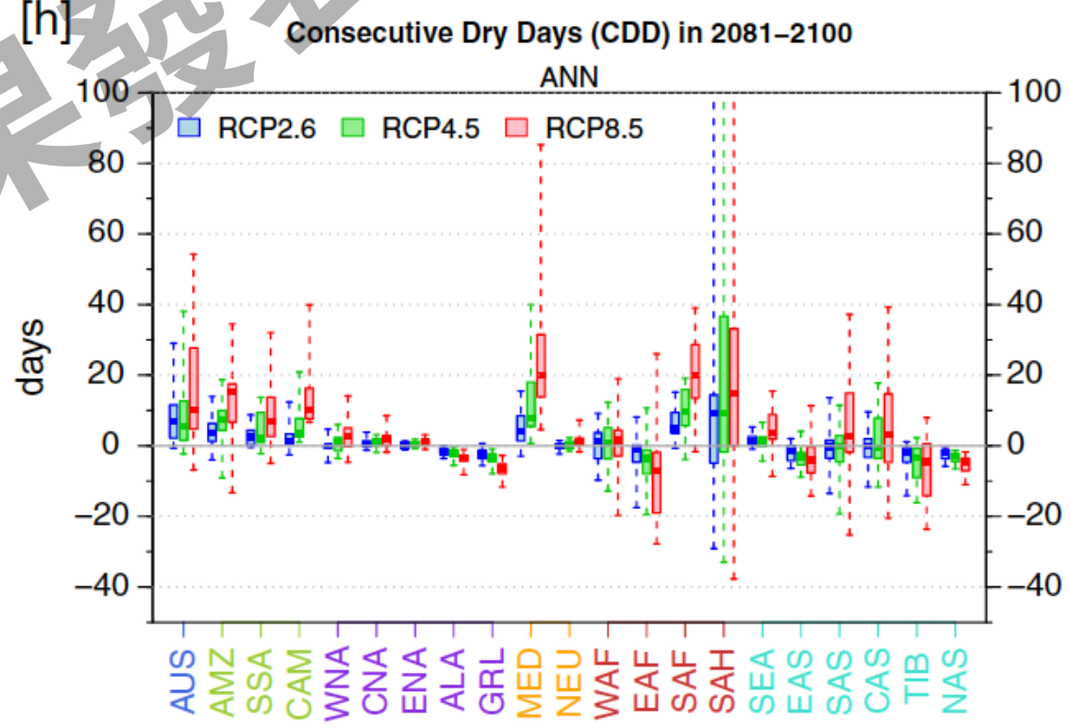
# Wet Get Wetter and the Dry Drier




RX5day



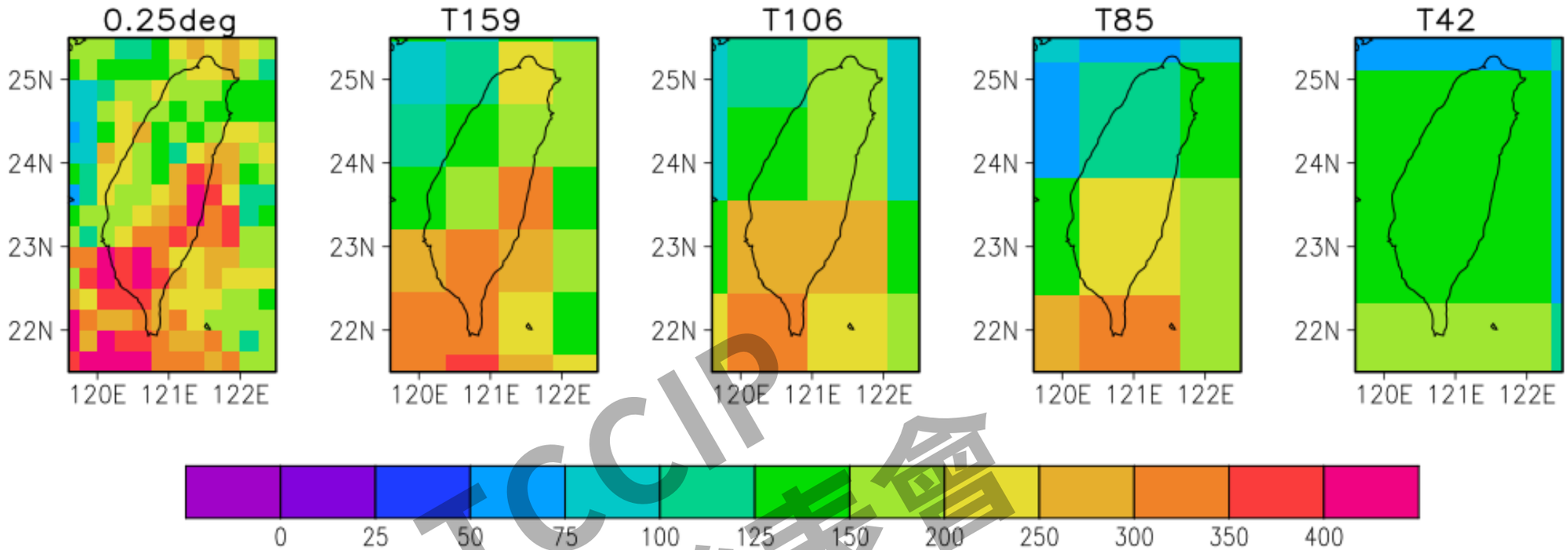



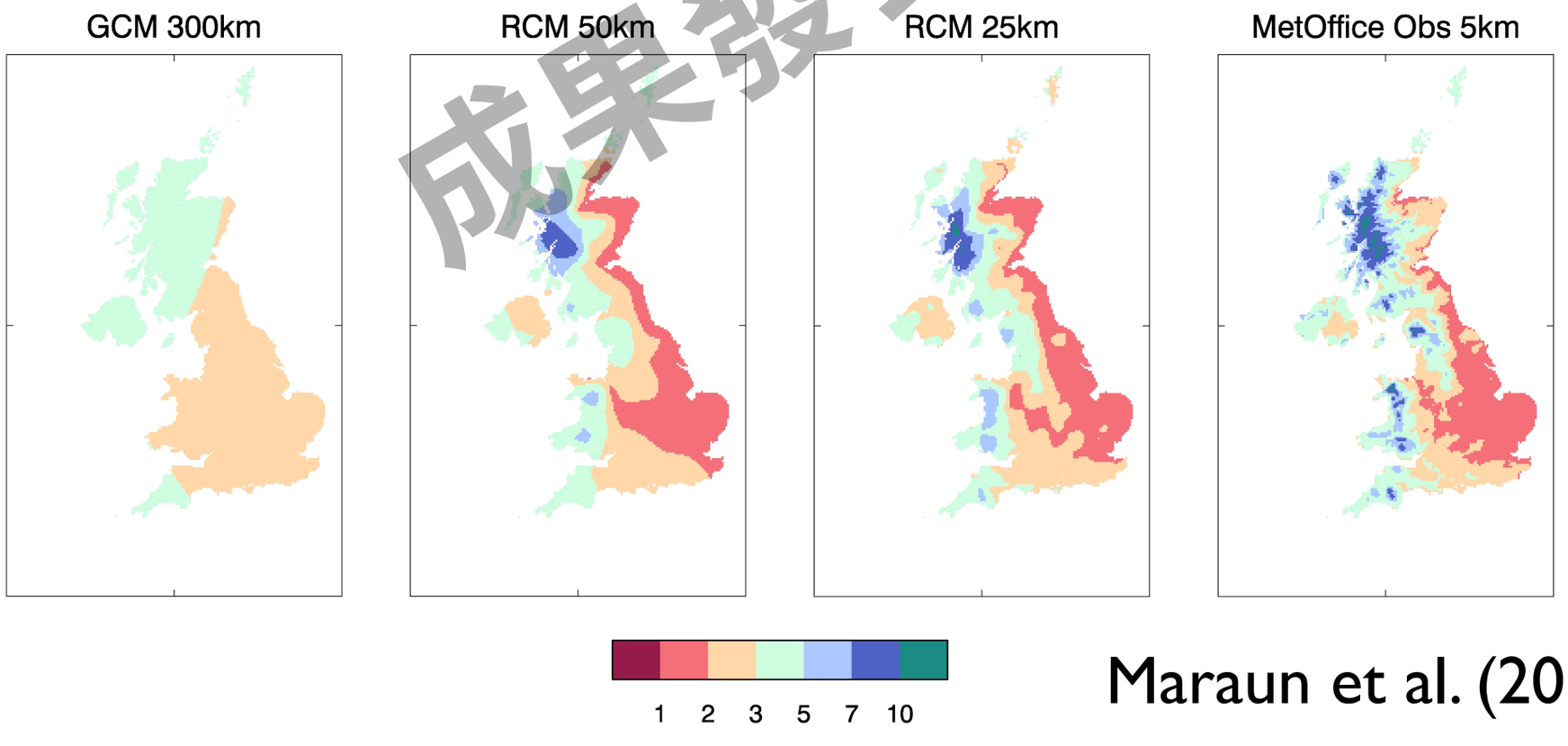

CDD

IPCC AR5, 2013

# Extreme events often has spatial scale dependence

TRMM
Rx1day

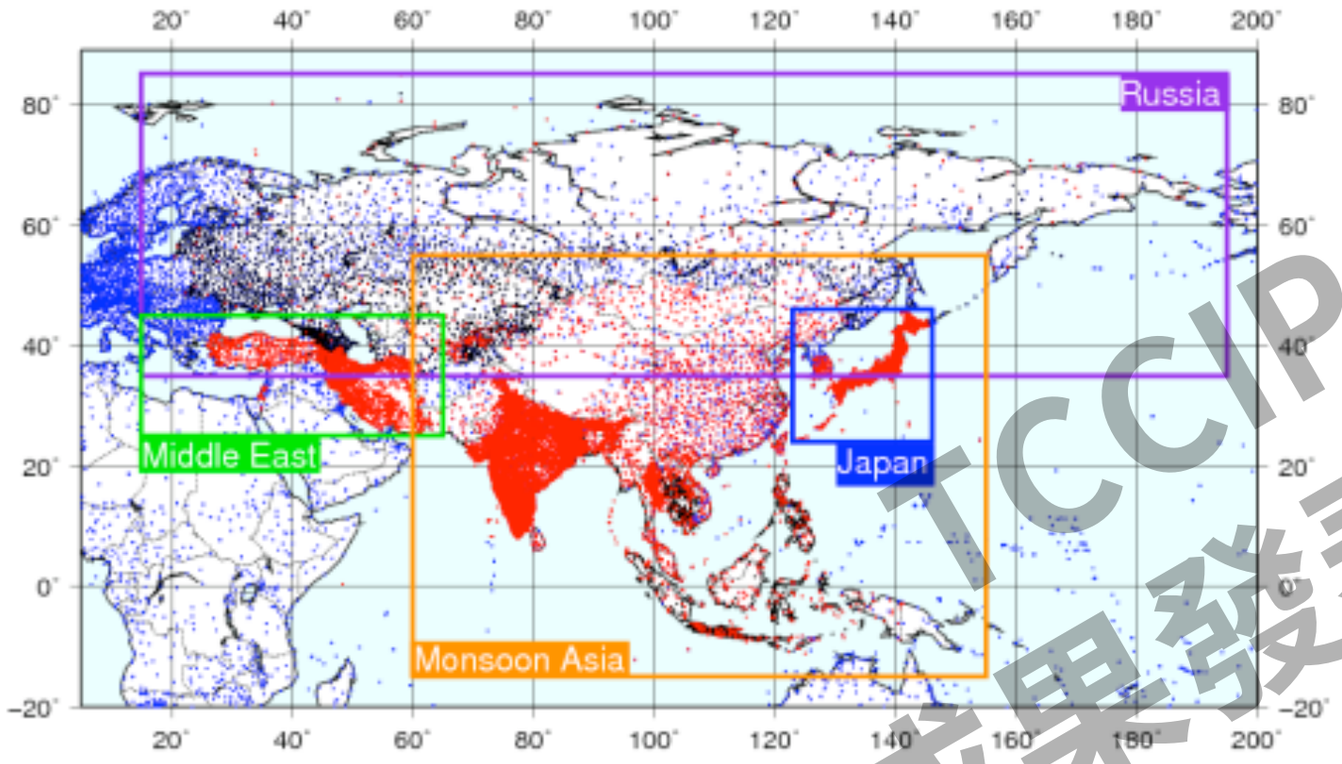



Maraun et al. (2010)

# Require long-term high-resolution observations

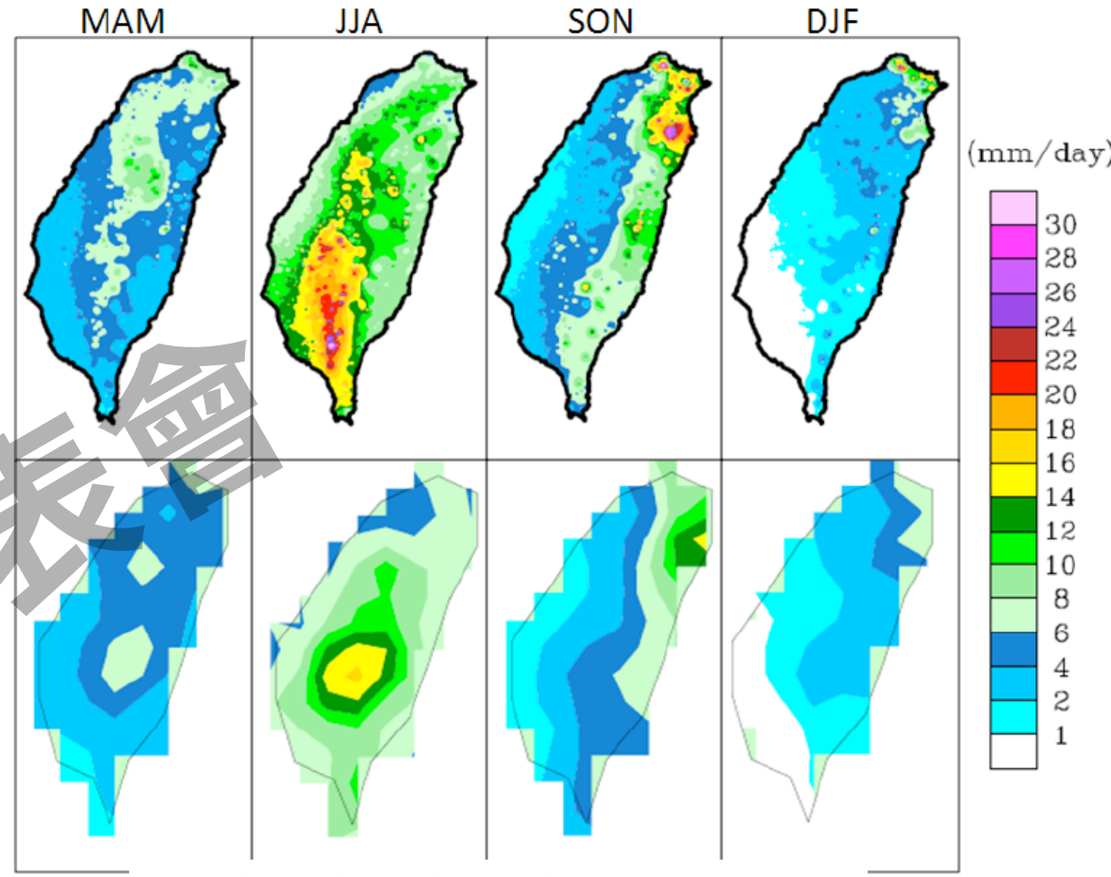
## APHRODITE (0.25°)

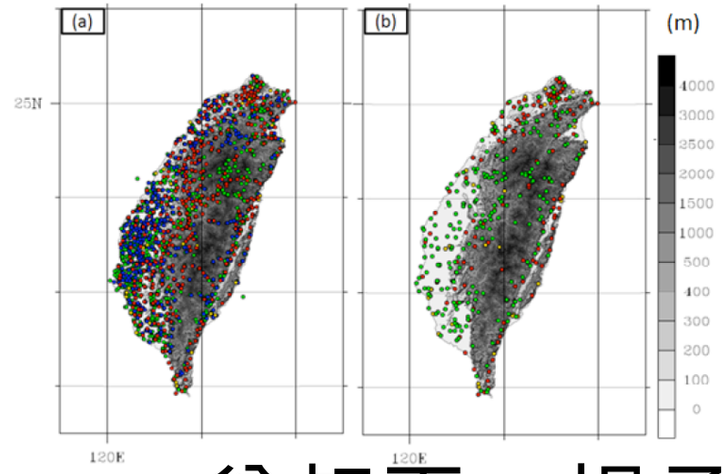



**Current version: V1003R1** Download »Readme »Errata

| Name | Domain | Resolution | Period |
|---|---|---|---|
| **Monsoon Asia (MA)** | 60°E-150°E, 15°S-55°N | 0.5° and 0.25°, daily | 1951-2007 |
| **Middle East (ME)** | 15°E-65°E, 25°N-45°N | | |
| **Russia (RU)** | 15°E-165°W, 34°N-84°N | | |

## New high-resolution (5km) gridded climate data over Taiwan

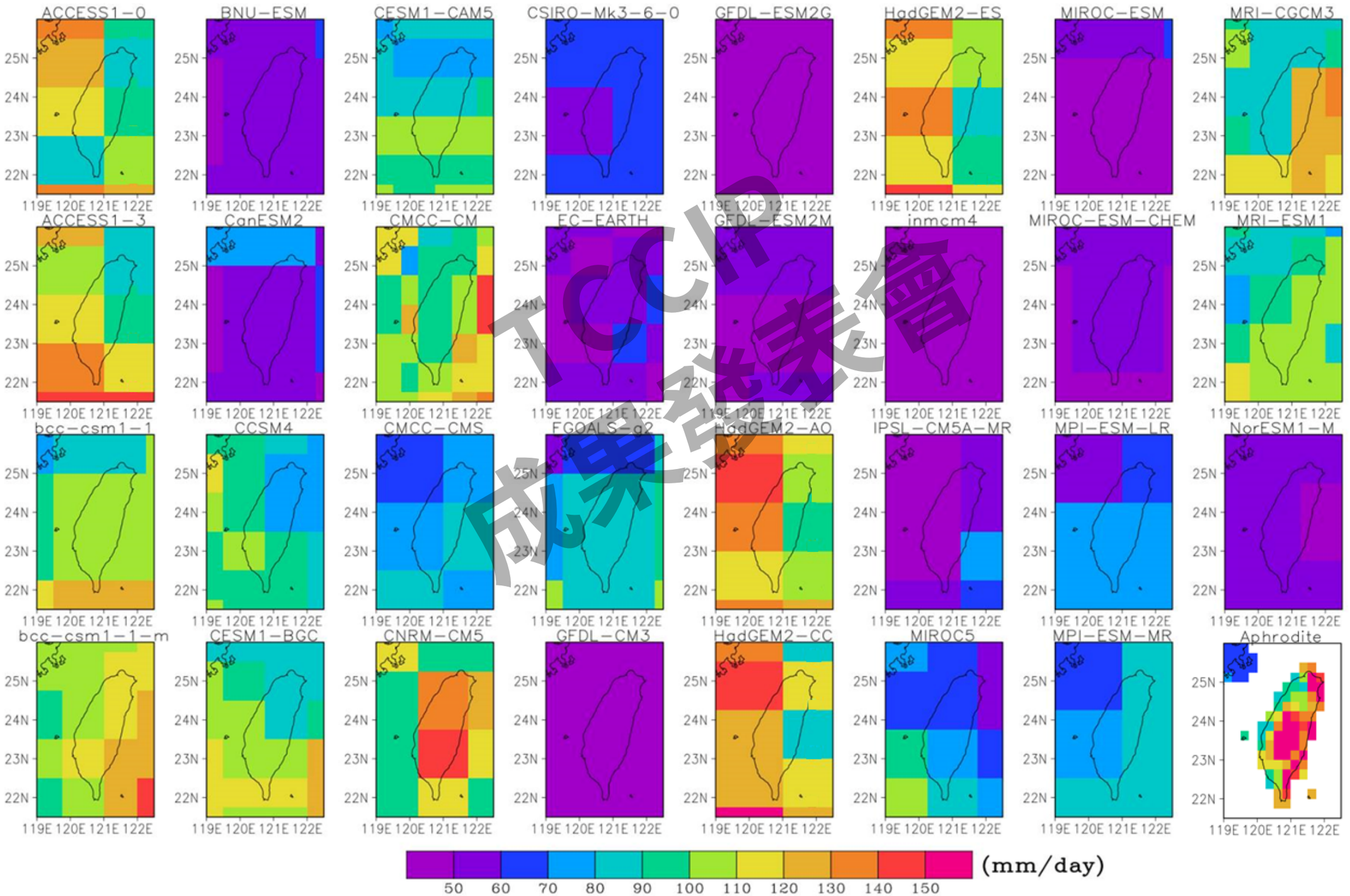


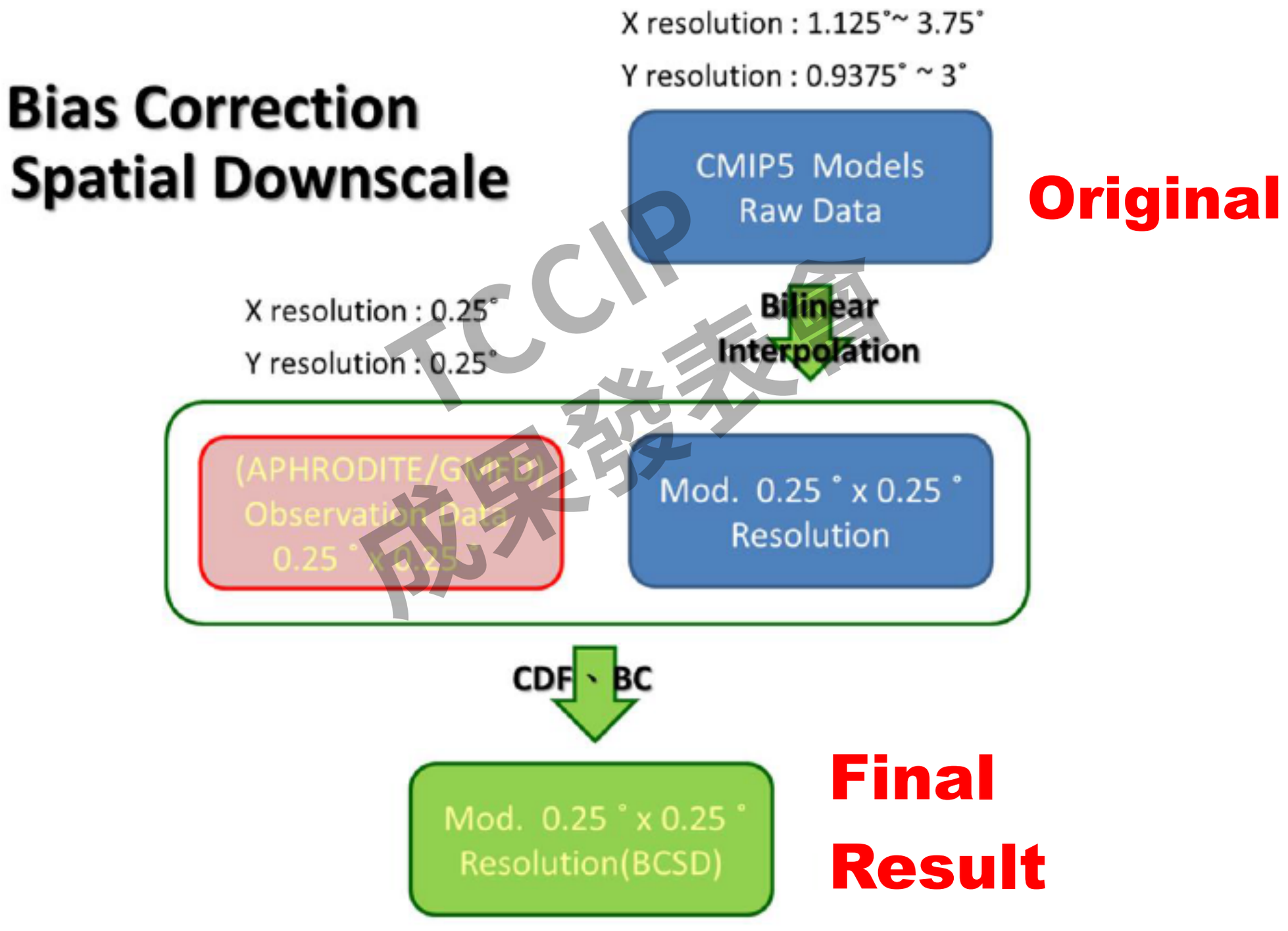



翁叔平、楊承道

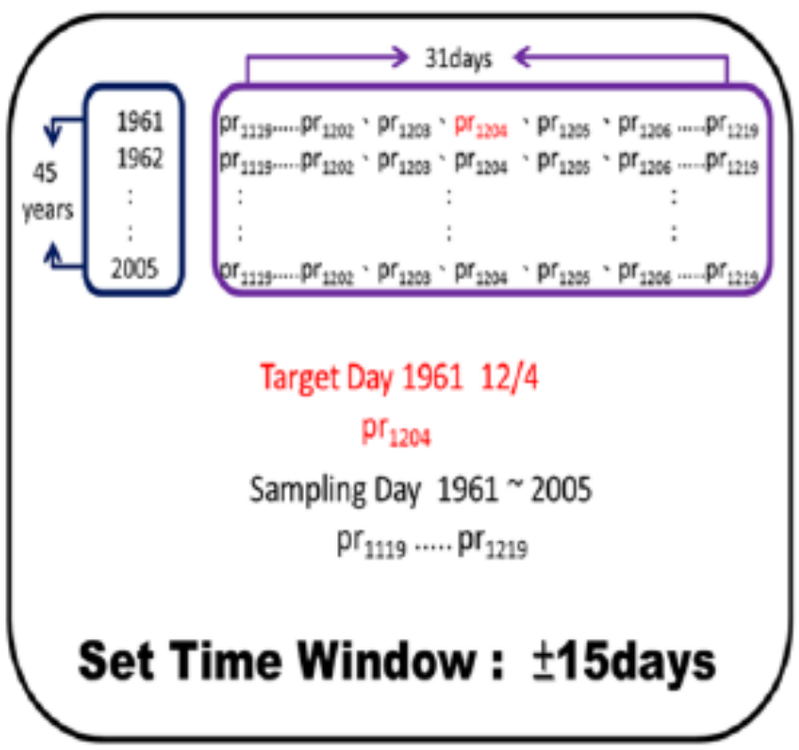
# RX1day from CMIP5 Historical Run with Original Model Resolution

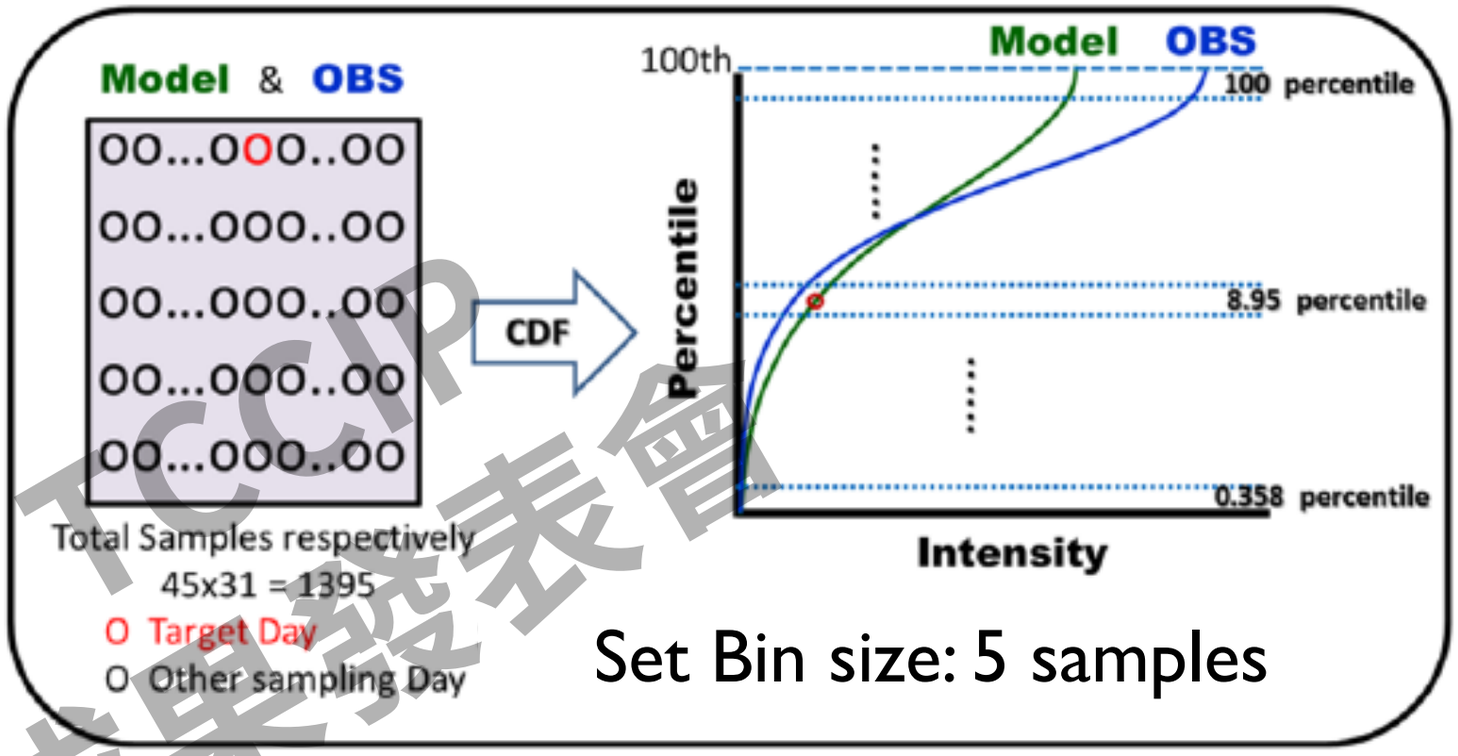


# Statistical downscaling for daily data from CMIP5 models



# Daily Data Bias Correction




$$OBS_{8.95p} = \sum Pr_{obs121st\text{-}125th} / 5$$

$$Model_{8.95p} = \sum Pr_{model121st\text{-}125th} / 5$$

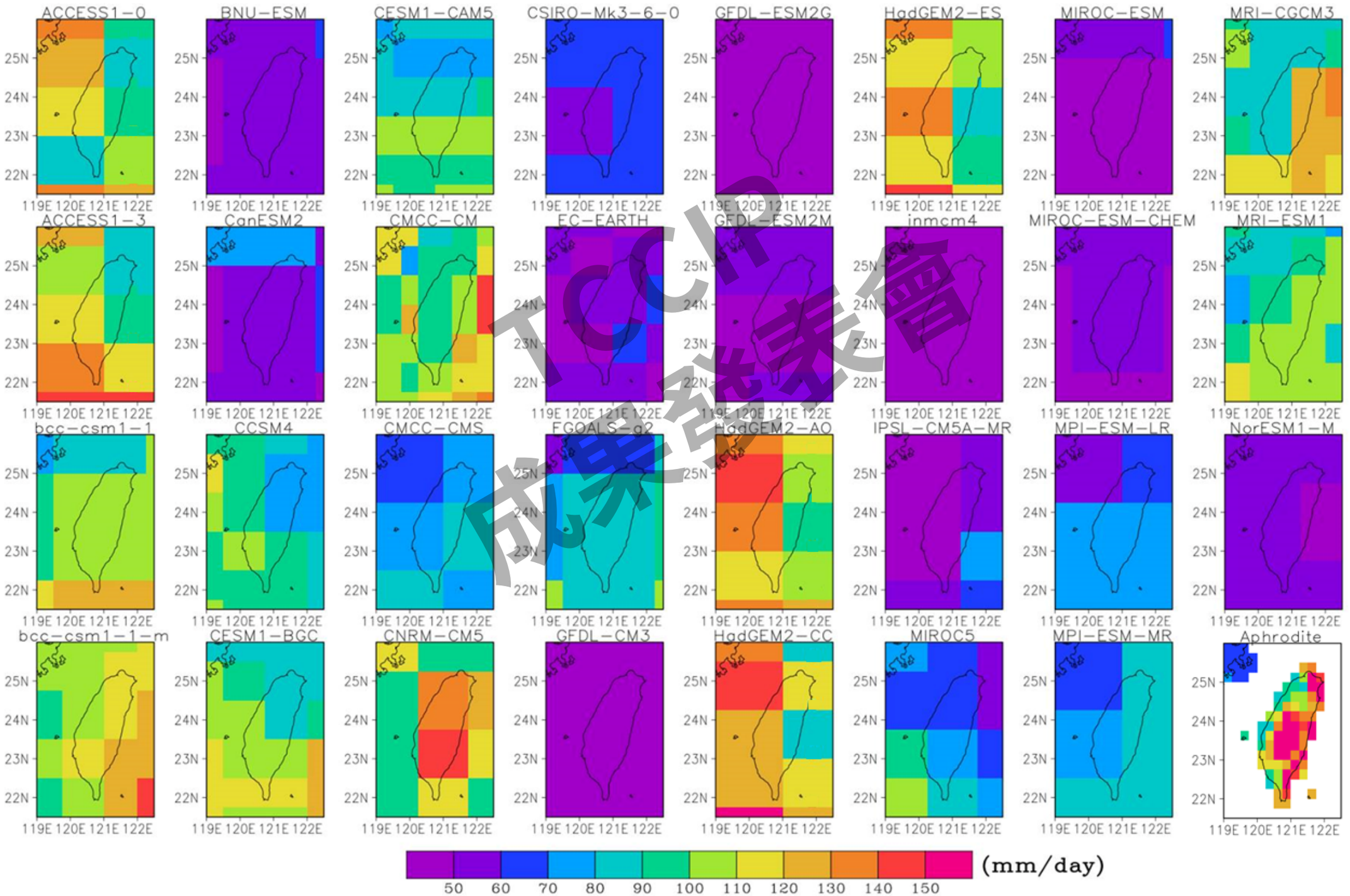
**Target Day 1961 12/4 Model Bias Correction**

$$Model\_BC_{pr_{1204}} = (Model_{pr_{1204}} \times OBS_{8.95p} / Model_{8.95p})$$

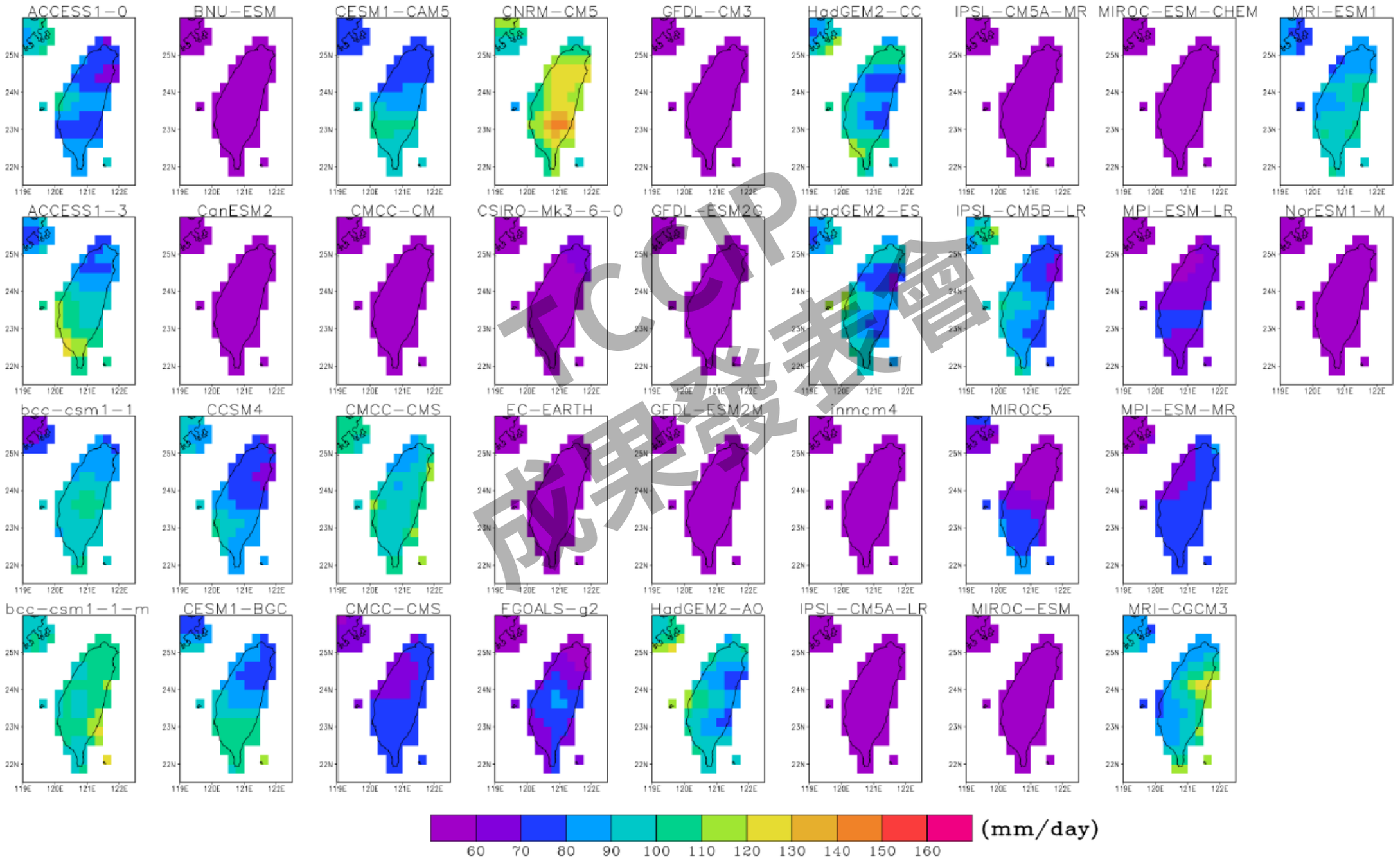
← Model Range of Extremes →　　Observation

| 氣候指標 | Min | 10th % | 25th% | Median | 75th % | 90th % | Max | Mean | aphrodite | 單位 |
|---|---|---|---|---|---|---|---|---|---|---|
| **rx1day** | 106.7 | 116.1 | 121.9 | **128.4** | 136.4 | 141.9 | 152.3 | **129.1** | **131.4** | mm |
| **rx5day** | 238.2 | 254.3 | 270.6 | **293.2** | 321.3 | 339.6 | 384.1 | **297.0** | **253.9** | mm |
| **sdii** | 11.0 | 11.5 | 11.8 | **12.1** | 12.4 | 12.8 | 13.3 | **12.1** | **11.9** | mm |
| **rr1** | 126.5 | 129.3 | 131.1 | **133.0** | 134.9 | 136.5 | 138.6 | **133.0** | **124.7** | day |
| **r10mm** | 36.8 | 39.5 | 40.3 | **41.3** | 42.4 | 43.5 | 45.2 | **41.4** | **38.7** | day |
| **r20mm** | 18.5 | 19.7 | 20.3 | **21.0** | 21.8 | 22.6 | 23.8 | **21.1** | **19.6** | day |
| **r50mm** | 4.7 | 5.2 | 5.5 | **5.9** | 6.3 | 6.7 | 7.4 | **6.0** | **5.3** | day |
| **r80mm** | 1.6 | 2.0 | 2.2 | **2.5** | 2.8 | 3.1 | 3.6 | **2.5** | **2.2** | day |
| **cdd** | 25.6 | 27.9 | 29.8 | **31.9** | 34.6 | 37.0 | 41.4 | **32.3** | **31.9** | day |
| **cwd** | 11.4 | 12.5 | 14.0 | **15.5** | 17.4 | 18.6 | 20.5 | **15.7** | **11.8** | day |
| **r95pTOT** | 572.1 | 598.1 | 610.9 | **628.3** | 646.1 | 662.5 | 691.5 | **629.3** | **610.4** | mm |
| **r99pTOT** | 256.5 | 281.2 | 300.4 | **324.0** | 353.9 | 386.1 | 440.2 | **330.3** | **338.5** | mm |
| **prcpTOT** | 1475.4 | 1529.9 | 1572.9 | **1613.6** | 1656.2 | 1726.7 | 1802.3 | **1622.3** | **1508.0** | mm |

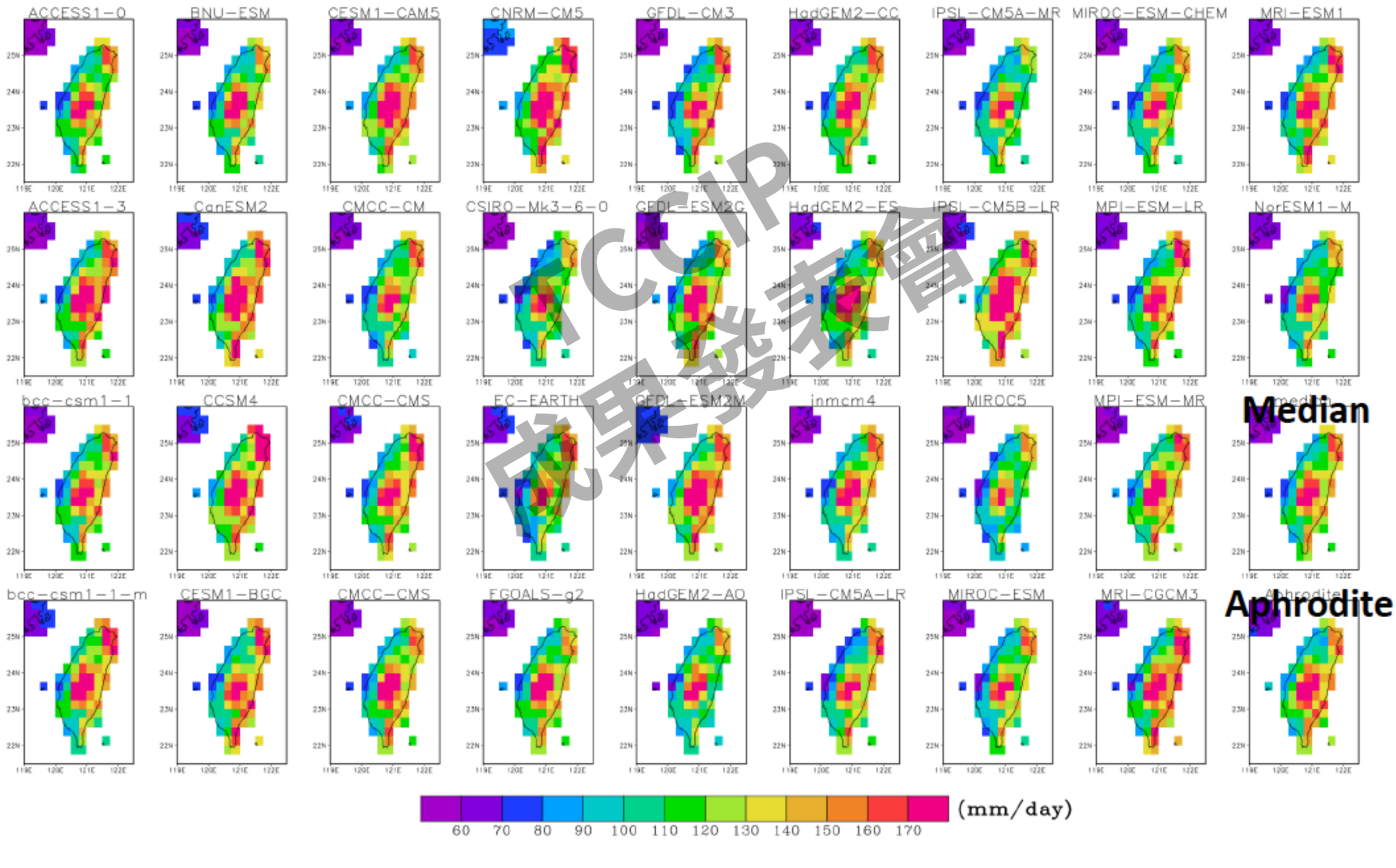
# RX1day from CMIP5 Historical Run with Original Model Resolution



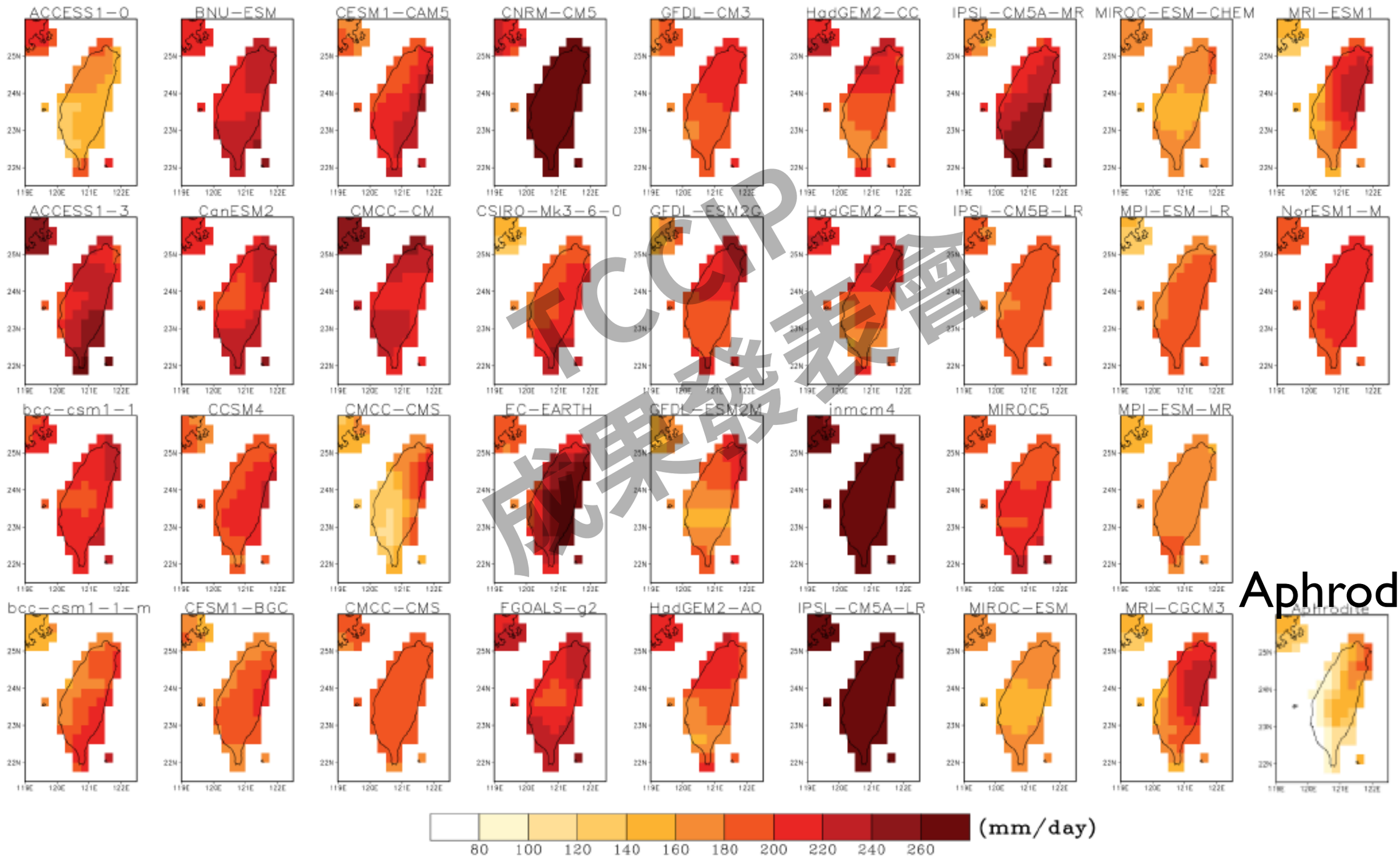
# RX1day from CMIP5 Historical Run spatially interpolate to 0.25° Resolution



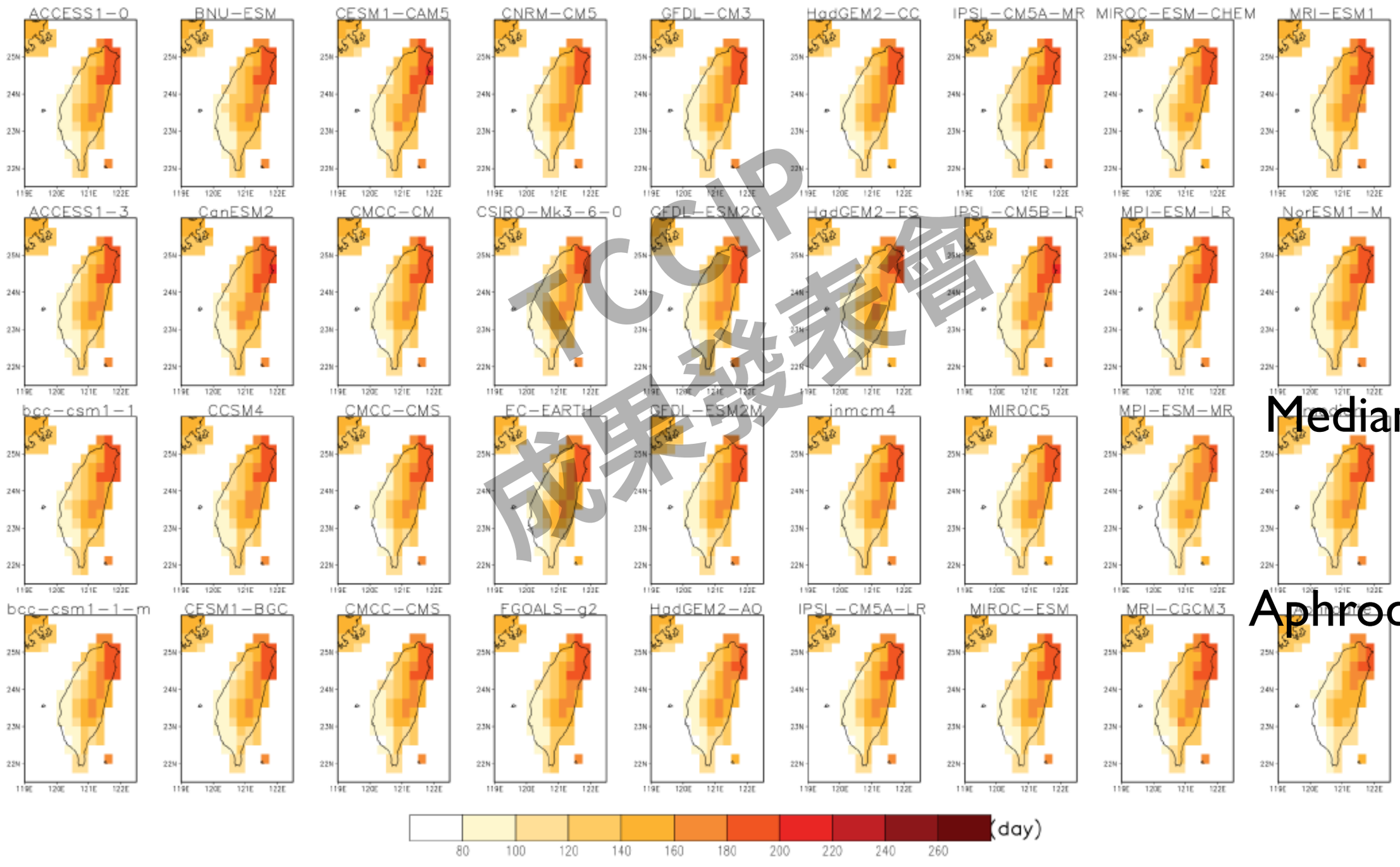
# RX1day from CMIP5 Historical Run
# Daily Downscaling Precipitation



# Wet-day Frequency (RR1) from CMIP5 Historical Run Daily Downscaling Precipitation



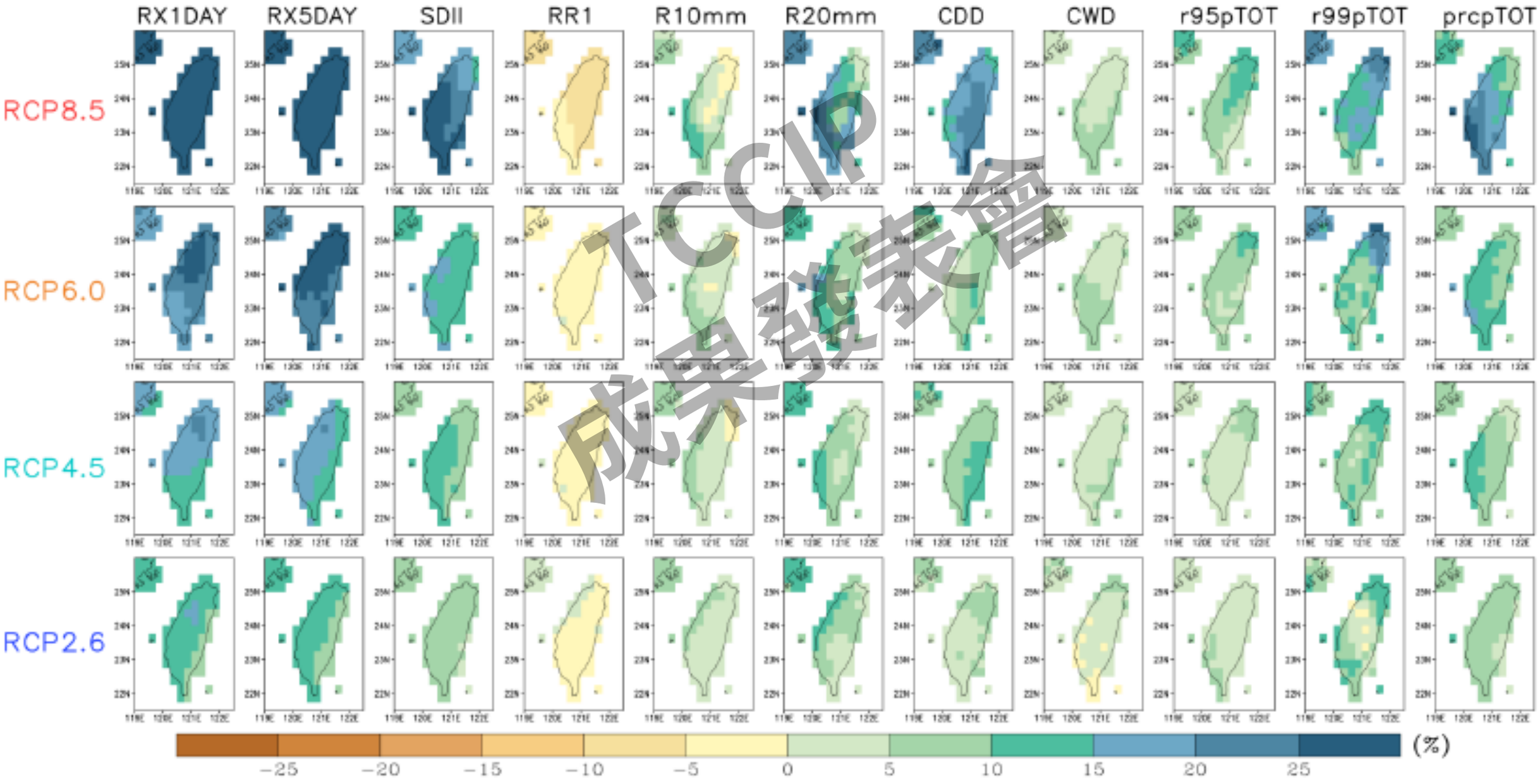
# Wet-day Frequency (RR1) from CMIP5 Historical Run Daily Downscaling Precipitation



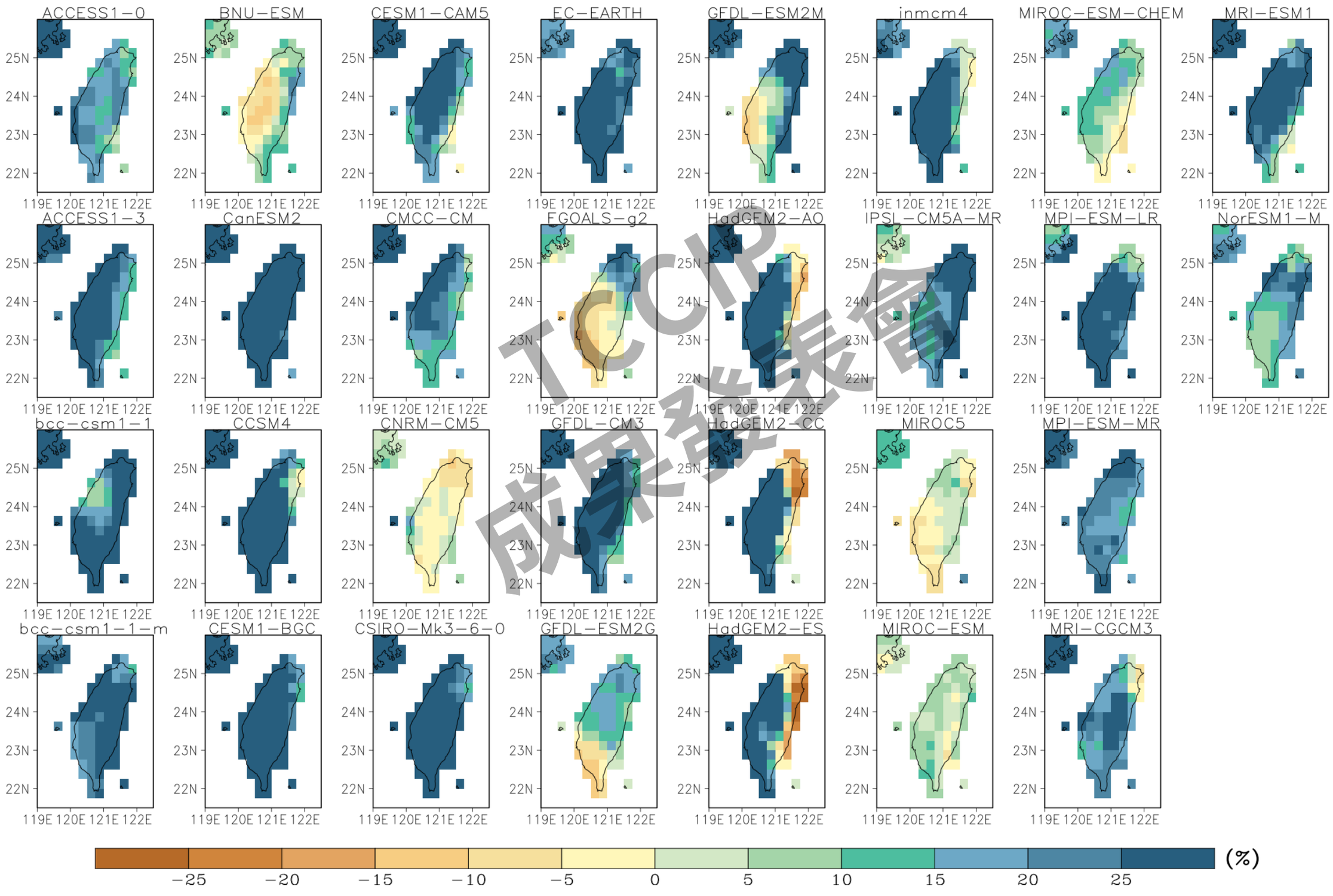

Median

Aphrodite

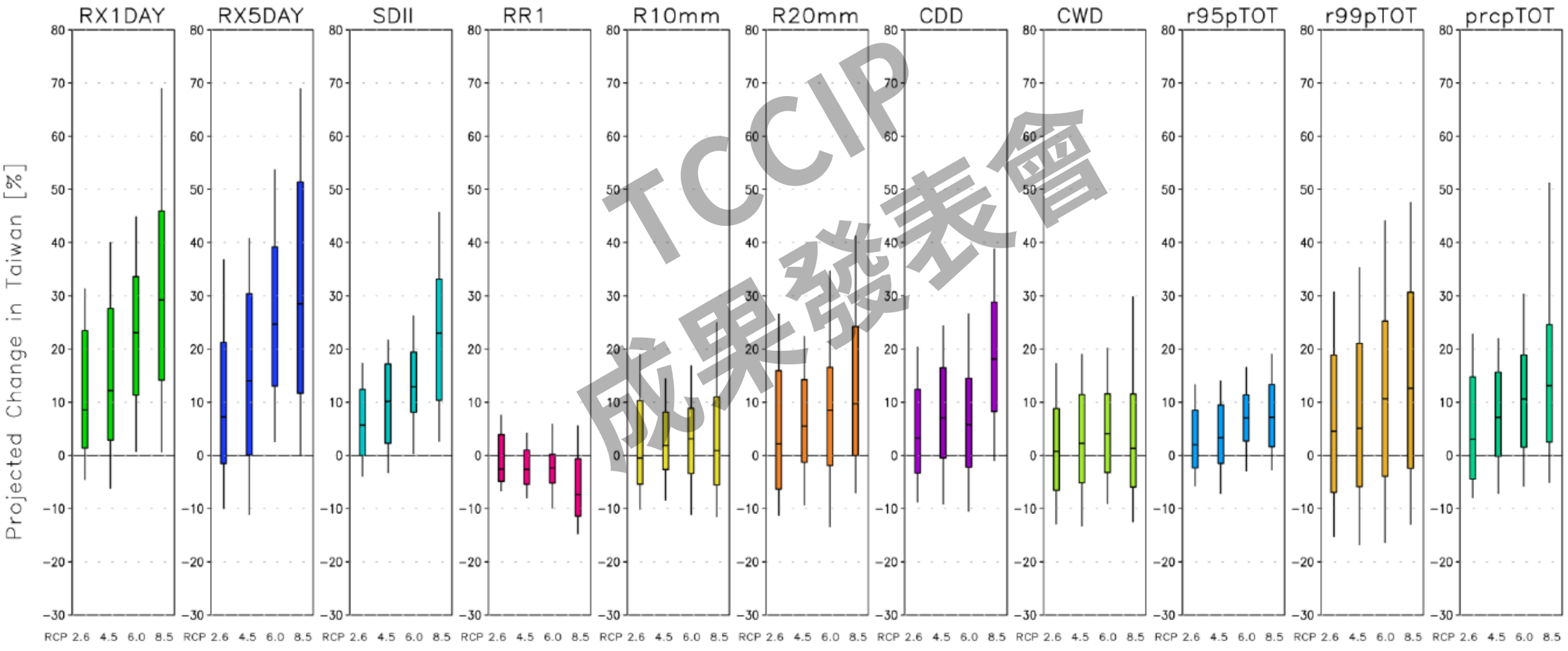
# Projected multi-model ensemble mean future changes (%) in 11 rainfall related extremes indices from CMIP5 downscaling daily precipitation with different scenarios



# Projected future changes (%) in RX1day from CMIP5 models under RCP8.5 scenarios (Uncertainty)



# Uncertainty range of projected future Taiwan area averaged changes (%) in 11 rainfall related extreme indices from CMIP5 models under 4 different RCP scenarios (Uncertainty)



# Summary and Concluding Remarks

- Large resources are needed for dealing with all the uncertainties using dynamical downscaling approach. Statistical approach is a relatively simple and cheap alternative.
- Statistical downscaling methods for both monthly and daily climate data have been applied to CMIP data archive to derive high-resolution regional data for impact and adaptation studies based on high-resolution observation.
- Must consider the other major uncertainties (emission scenario, model, etc.) regarding future climate in addition to downscaling to local scale. Probabilistic projection better represent the uncertainty.

- 收集與運用全球氣候模式資料與高解析度觀測資料，發展將氣候模式所產生日資料降尺度到台灣區域的方法，並進一步用以計算極端天氣與氣候指標以及機率分佈特性。

- 以觀測資料驗證CMIP5低解析氣候模式資料中所模擬的極端天氣與氣候指標， 探究統計降尺度方法細部調整對極端天氣與氣候指標模擬誤差修正與未來推估可能範圍的影響，比較不同氣候模式模擬結果表現與分佈範圍，分析模式不確定性。