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臺灣氣候變遷推估與資訊平台建置計畫

Introduction of Taiwan Climate Change Projection and Information Platform Project (TCCIP)

Huang-Hsiung Hsu

Research Center for Environmental Changes, Academia Sinica

Outline

Taiwan Climate Change and Information Platform (TCCIP)

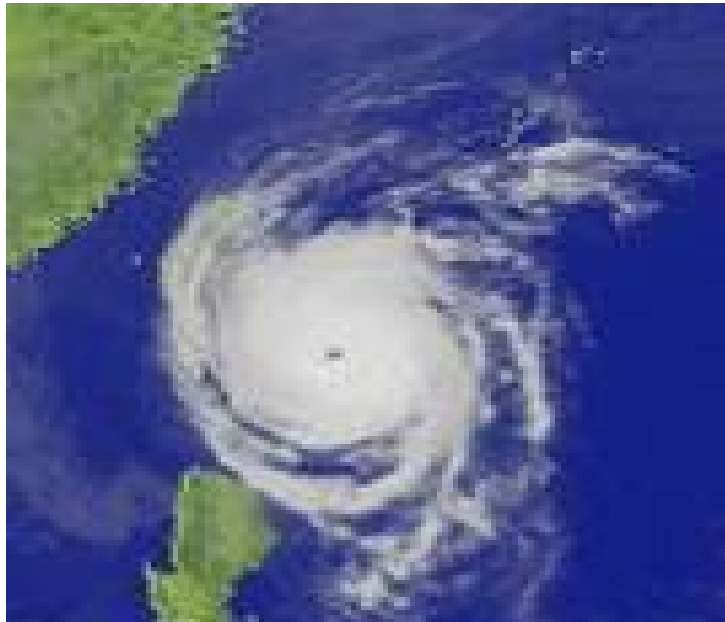
Introduction

The role of TCCIP

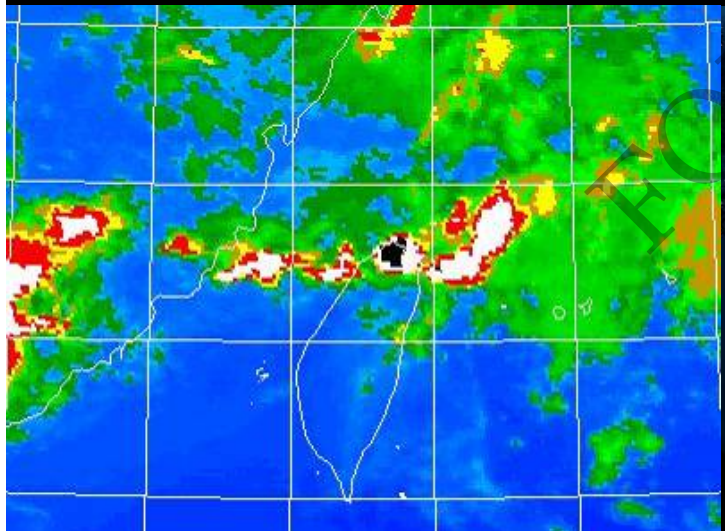
Overview of TCCIP

Summary

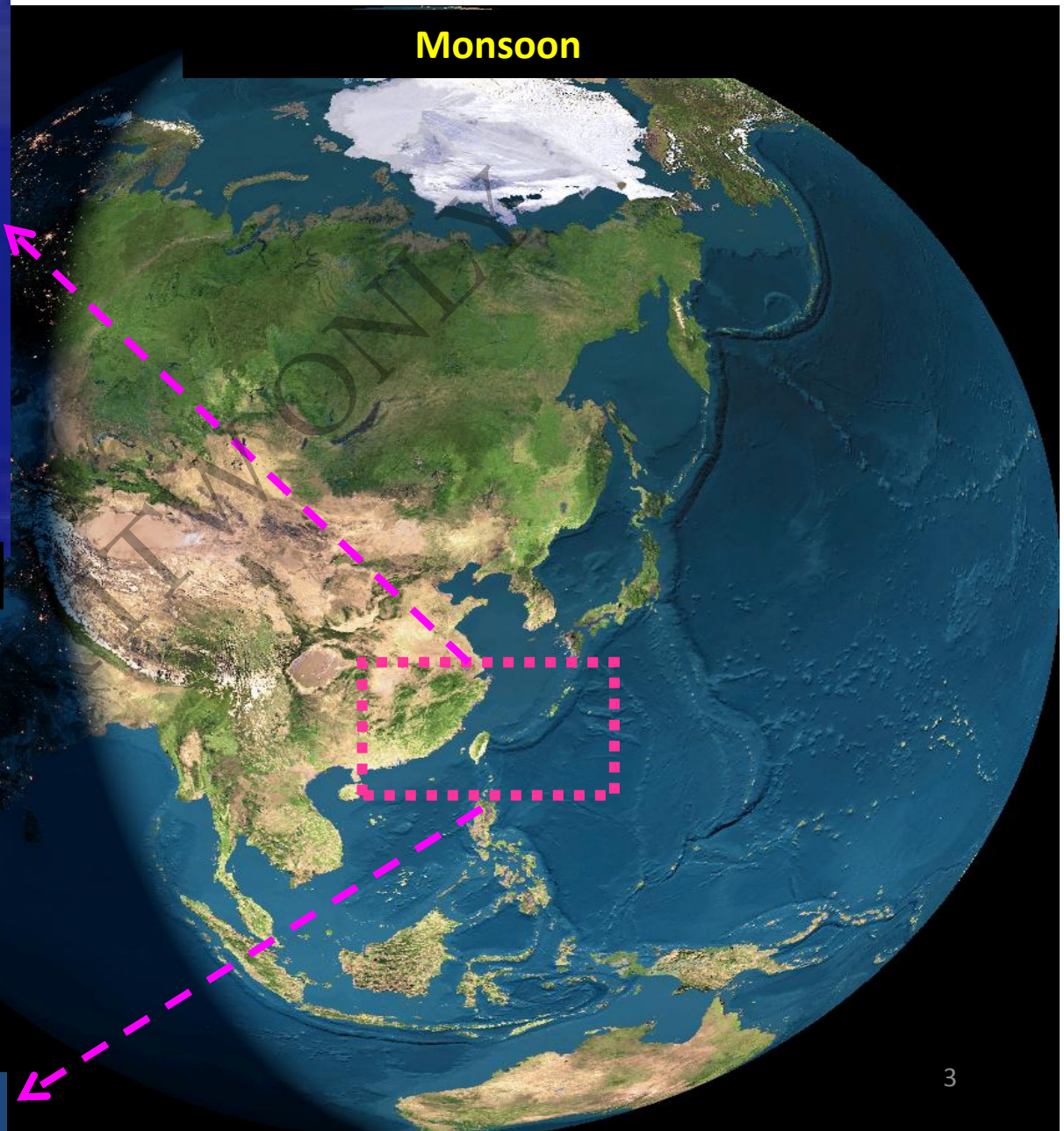
Introduction



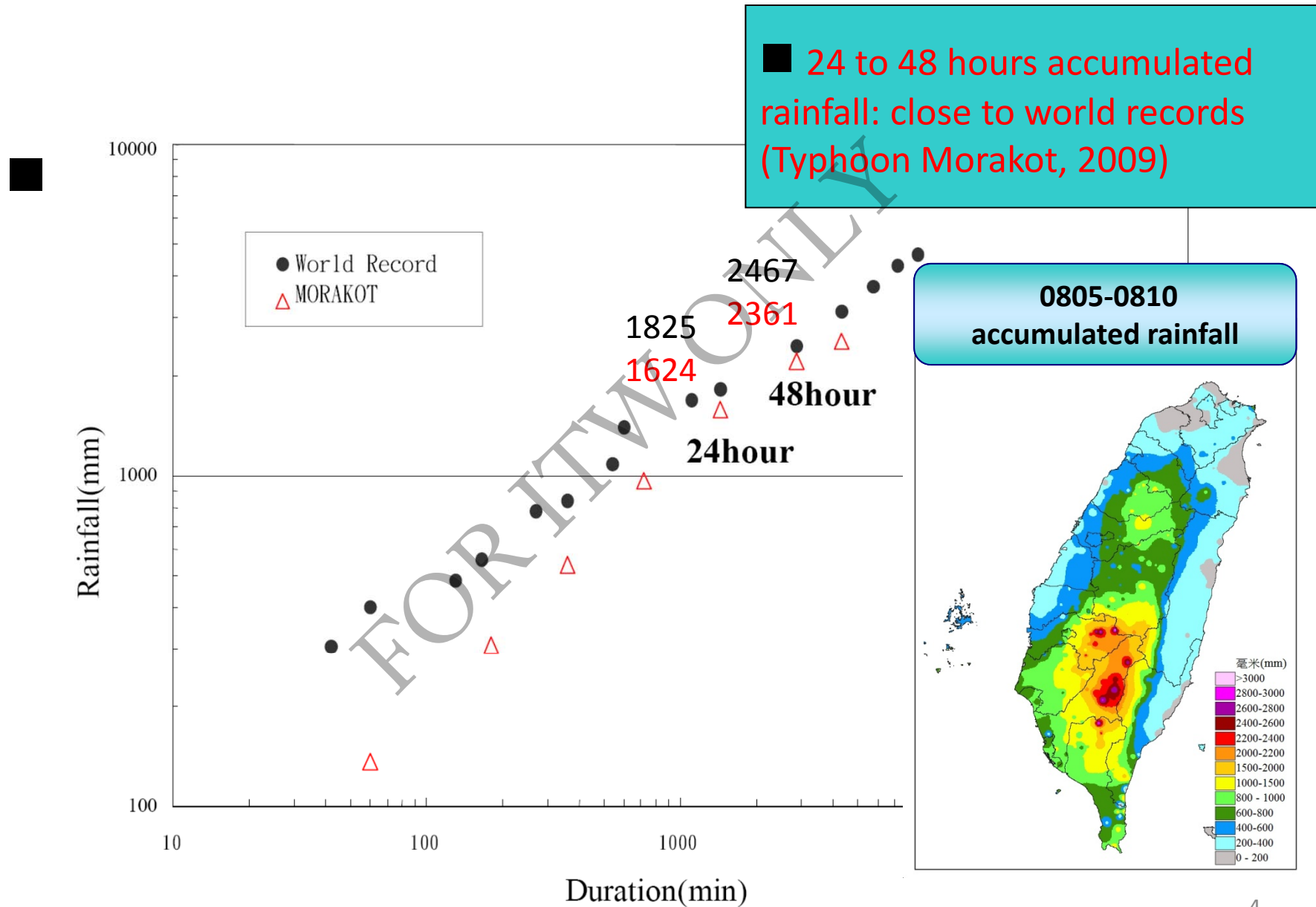
Typhoon



Mei-Yu



More and More Extreme Events in Taiwan ?



Typhoon Morakot claimed almost 700 lives

■ Massive deep landslide caused by Morakot

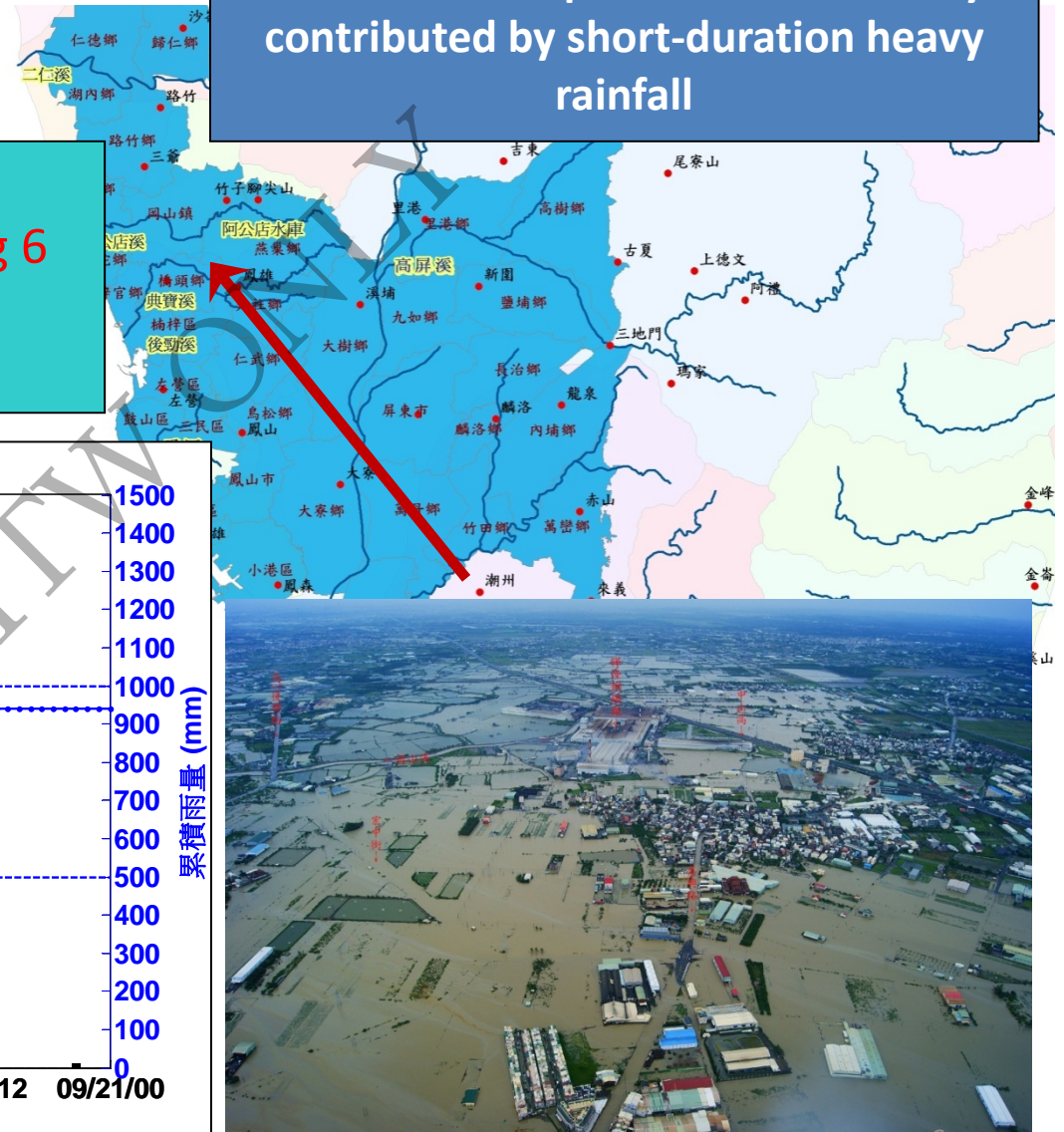
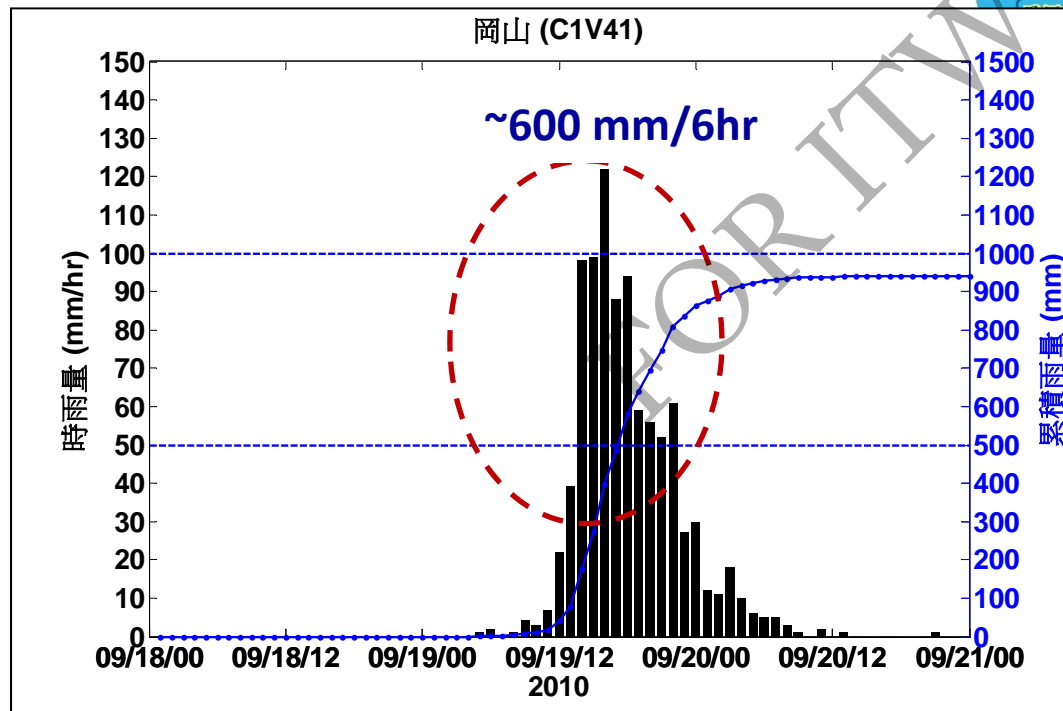


More and More Extreme Events in Taiwan ?

Typhoon Fanapi (2010)

■ 600mm accumulated rainfall during 6 hours at Gang-Shan station.

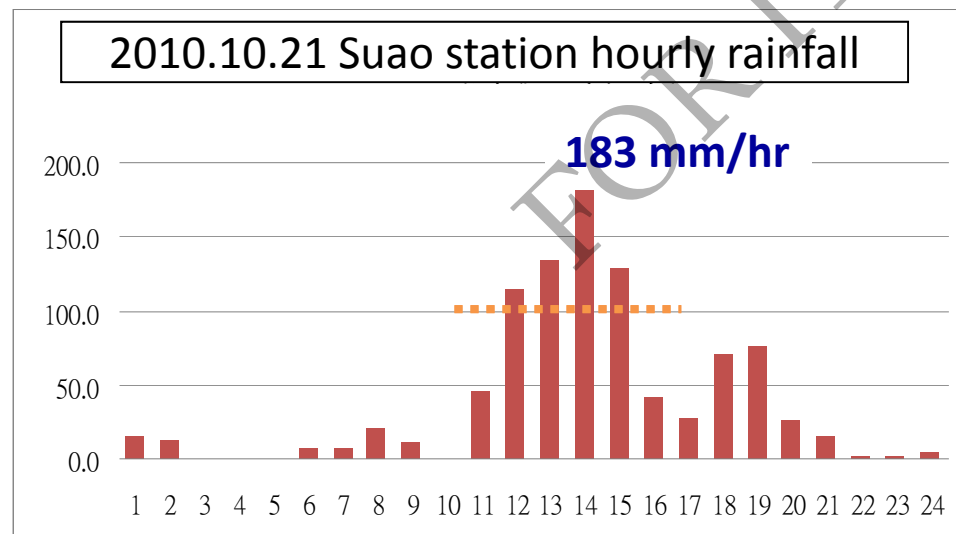
Water in flood-prone areas is mainly contributed by short-duration heavy rainfall



More and More Extreme Events in Taiwan ?

Typhoon Megi (2010)

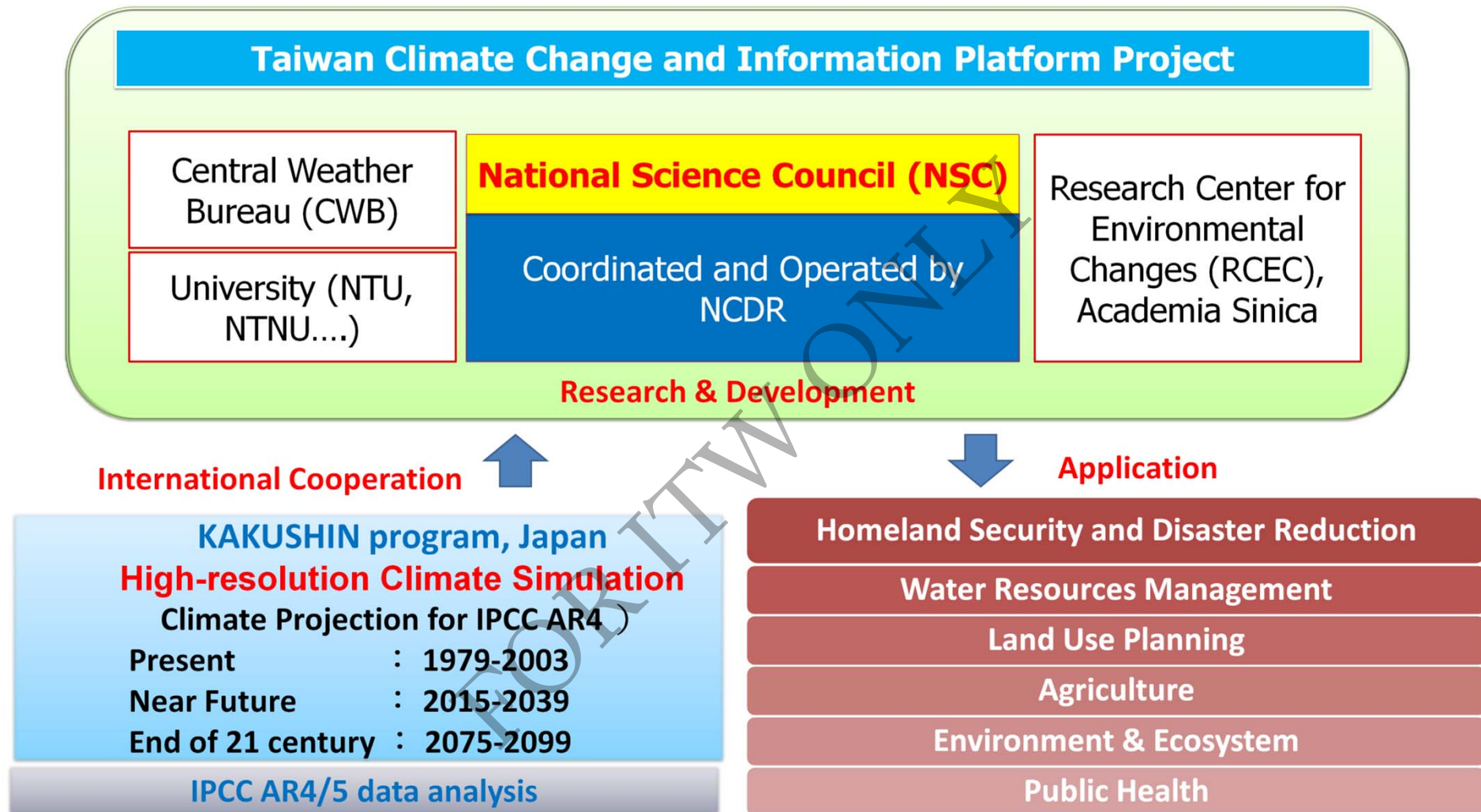
- Rainfall rate exceeding 100 mm/hr lasted 4 hours.
- Peak value: 183 mm



Landslide in Su-Hua Highway
During Megi

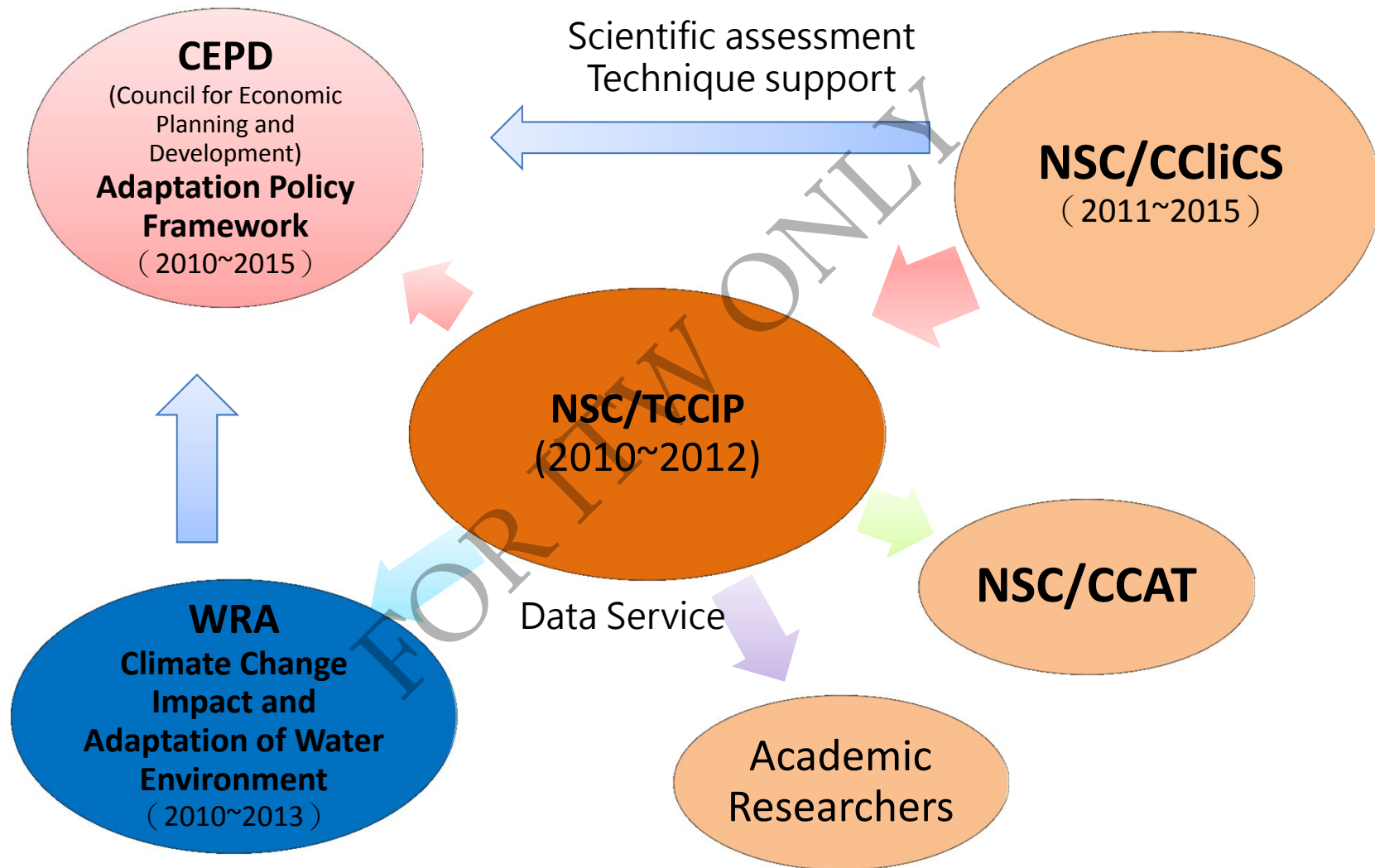


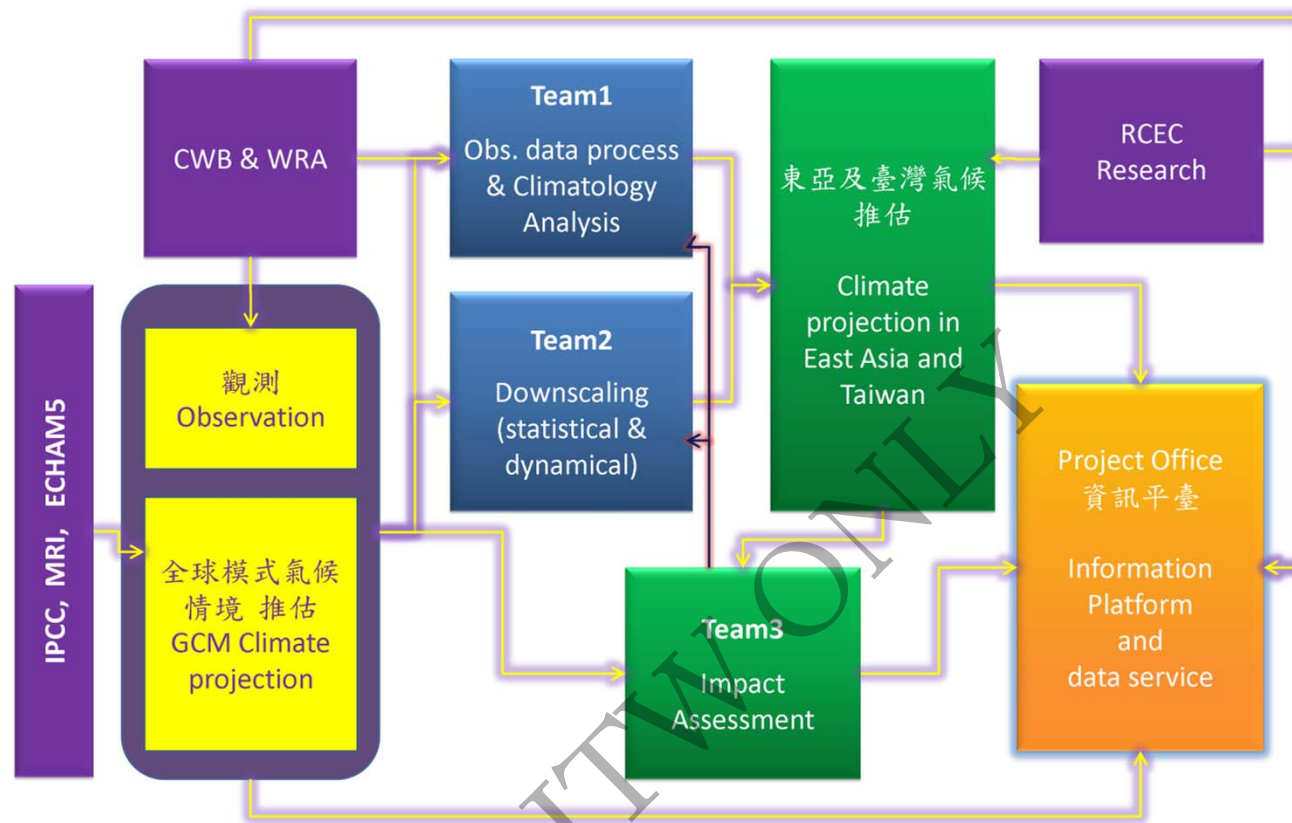
A Scientific Project: TCCIP



To fulfill the needs of government agencies and academia researchers, the TCCIP project, funded by NSC, aims to integrate and promote the resources of climate study, seek international collaboration and academic accomplishment, and generate data of climate projections for the policy making of climate mitigation and adaptation.

Role of TCCIP in Taiwan





Mission of TCCIP

Team 1 :

- Assess the climate change of Taiwan in the past century
- Project the future climate change in Taiwan based on climate projections of IPCC AR4/5
- Generate long-term and high-resolution observation data set

Team 2 :

- Develop and evaluate statistical and dynamical downscaling approaches for regional climate of Taiwan
- Provide high-resolution data for climate change projection of Taiwan
- Explain the limitation of downscaled data to data users. Helping users to use data in proper ways

Team 3 :

- Analyze extreme weather and climate events
- Analyze the variability of extreme precipitation event and assess its impact on disasters
- Analyze the variability of seasonal precipitation and assess its impact on water resources

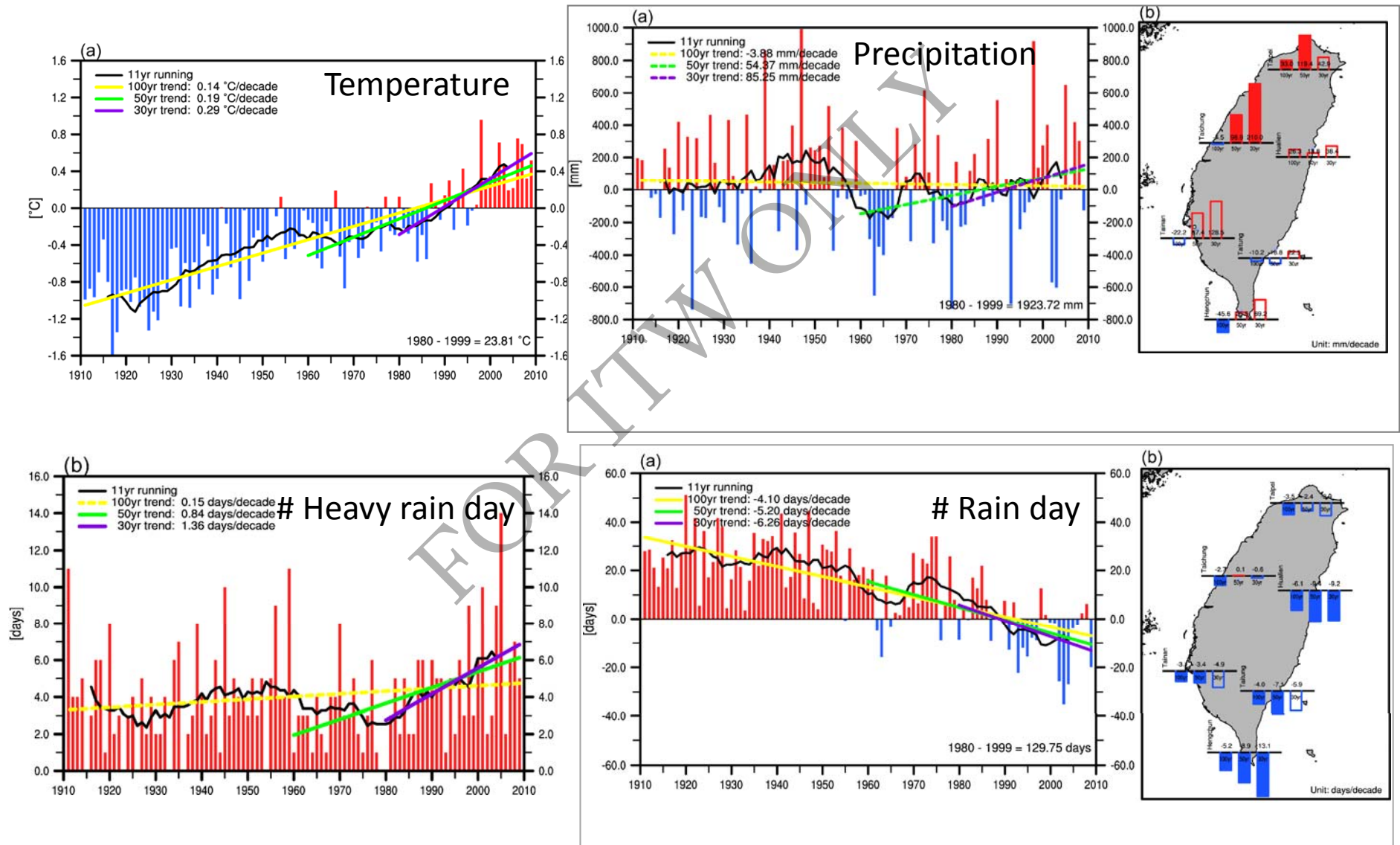
Project Office:

- Administration work
- Coordinate the operation of project
- Manage products of project
- Setup data and information sharing platform
- Communicate with data users
- Publish a Scientific Report of the climate change in Taiwan

Team1

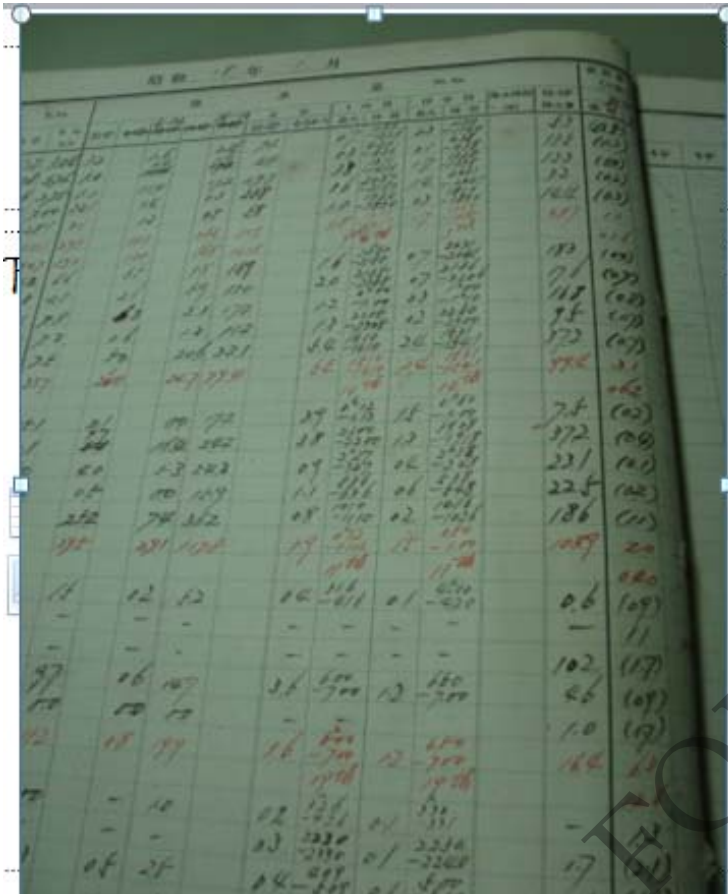
Observation Data Process and
Climatology Analysis

Analysis of Taiwan Climatology



Digitization of the meteorological observation data

Re-discovering Taiwan climate!



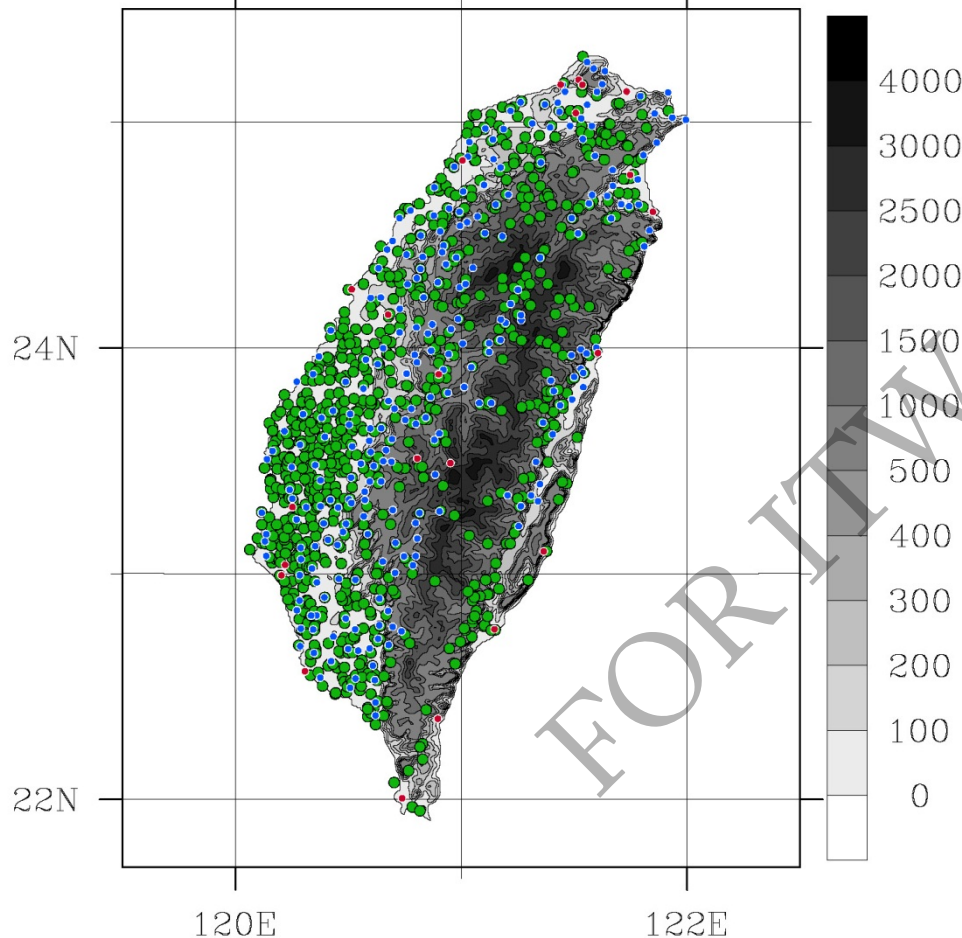
--- pressure 、 temperature 、
dew point temperature 、
Relative humidity 、 velocity
Precipitation, et al. (23 items)

Central Weather Bureau
Precipitation data,
paper records.
about 7.2 million documents

測站站名	設站年份	有報表年份
恆春	1896	1897-2000
臺中	1896	1897-2000
臺北	1896	1897-2000
臺南	1897	1897-2000
花蓮	1910	1910-2000
澎湖	1896	1897-2000
臺東	1901	1901-2000
彭佳嶼	1910	1909-1935, 1944-2000
蘭嶼	1941	1942, 1943, 1949-2000
高雄	1931	1931-2000
阿里山	1933	1933-2000
宜蘭	1935	1935-2000
大武	1940	1940-2000
新竹	1938	1938-2000
嘉義	1968	1968-2000
成功	1940	1940-2000
日月潭	1941	1942-2000
玉山	1943	1943-2000
淡水	1942	1942-2000
竹子湖	1937	1943-2000
鞍部	1937	1943, 1946-2000
東吉島	1962	1963-2000
永康	1947	1947-1974
鹿林山	1947	1947-1969
金六結	1940	1940-1972

Sources/Distributions of Rainfall observations

1885~2010 Farm 901stn(green),CWB 22stn(red),Auto 253stn(blue)

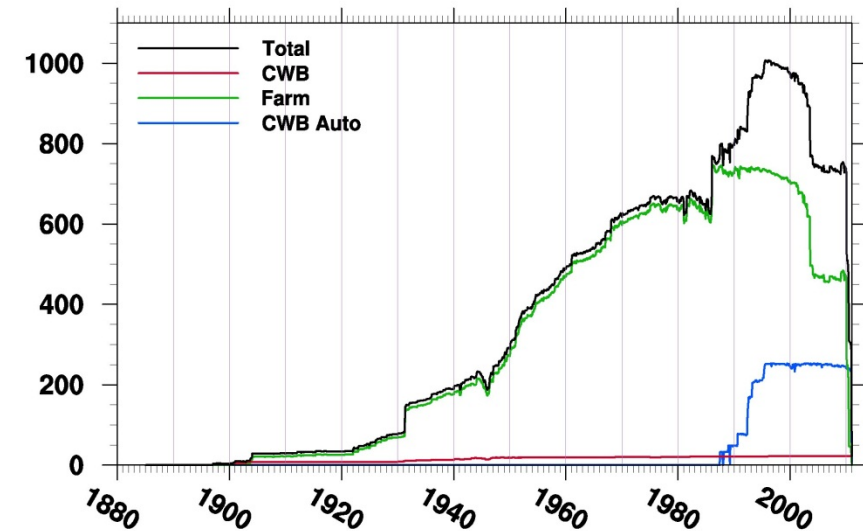


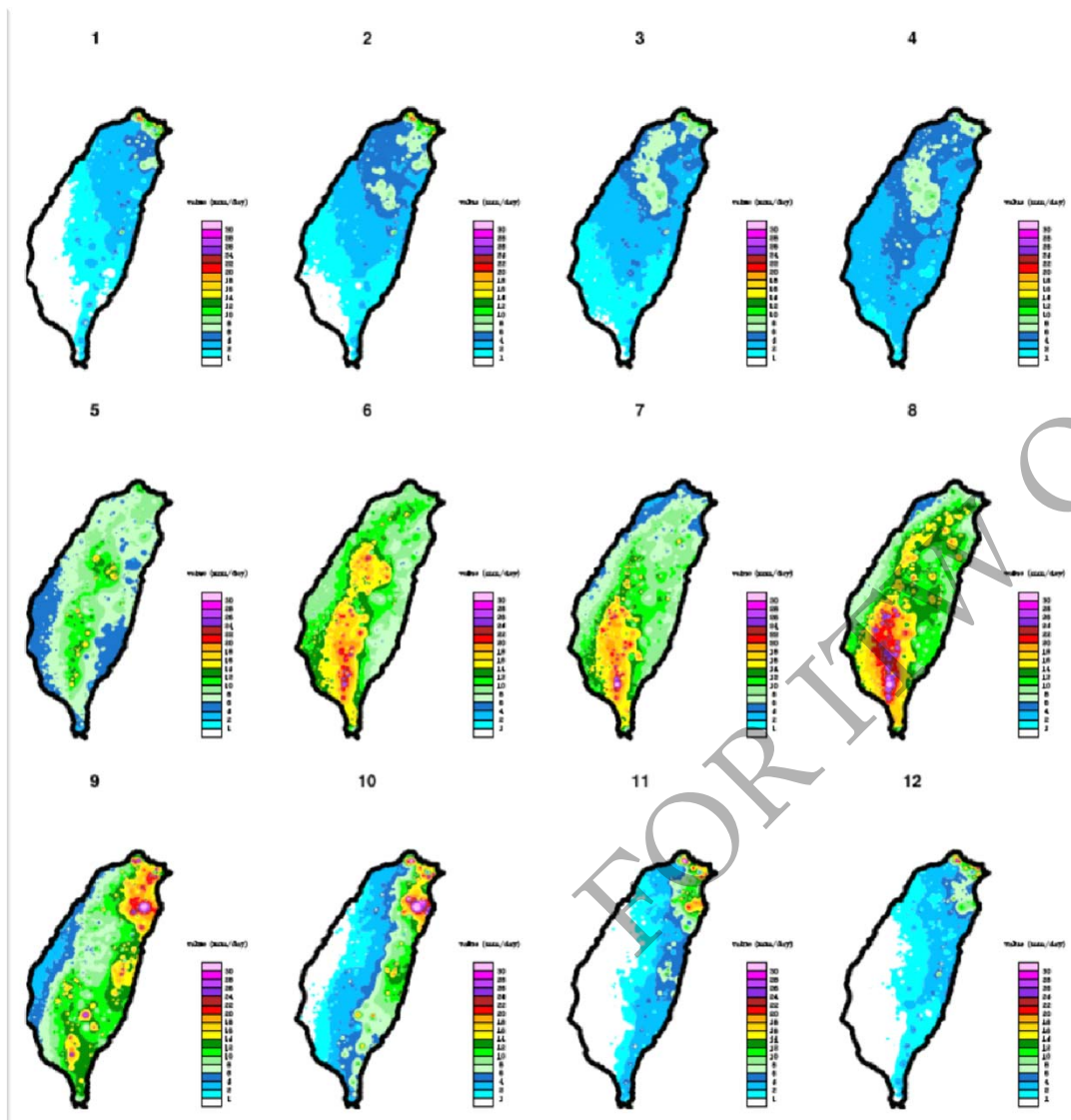
Red dots: CWB

Green dots:

Irrigation Associations + WRA

Blue dots: CWB Auto-gauge





Datasets now available

(Jan 1960 – Dec 2009)

1km & 5km monthly mean Precip.

1km & 5km monthly mean Tavg

1km & 5km monthly mean Tmax

1km & 5km monthly mean Tmin

Datasets to be available

(Jan 1960 – Dec 2009)

1km & 5km Daily Precip.

1km & 5km Daily Tavg

1km & 5km Daily Tmax

1km & 5km Daily Tmin

CLIMATE (1960-2009)

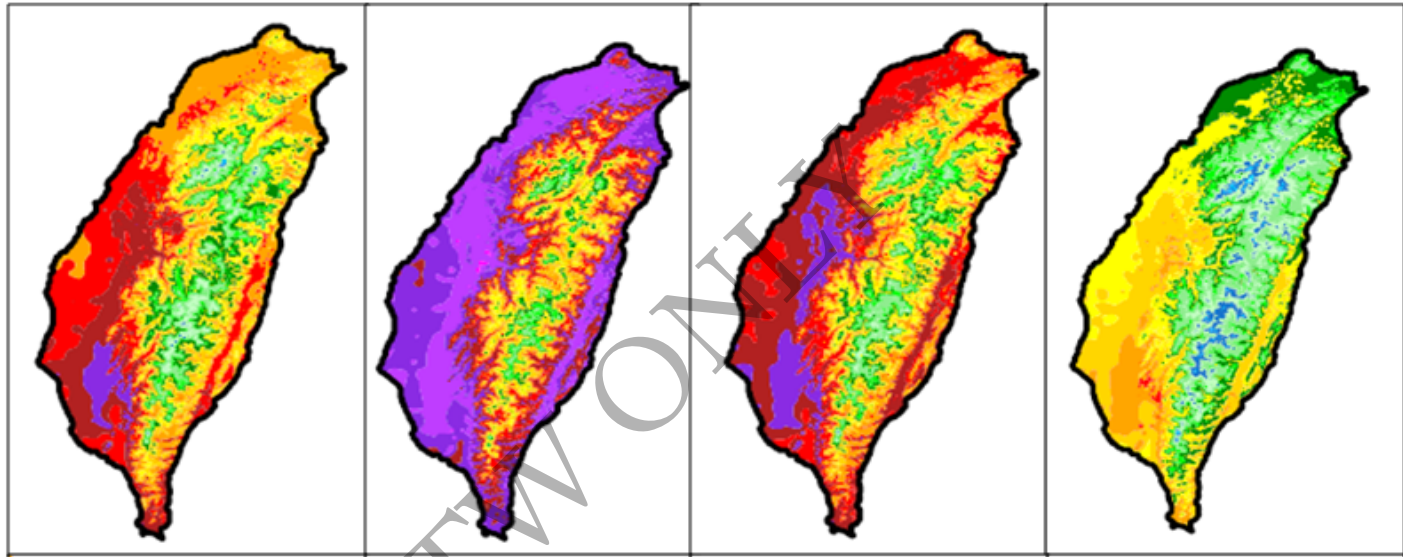
TCCIP_temp_1km

MAM

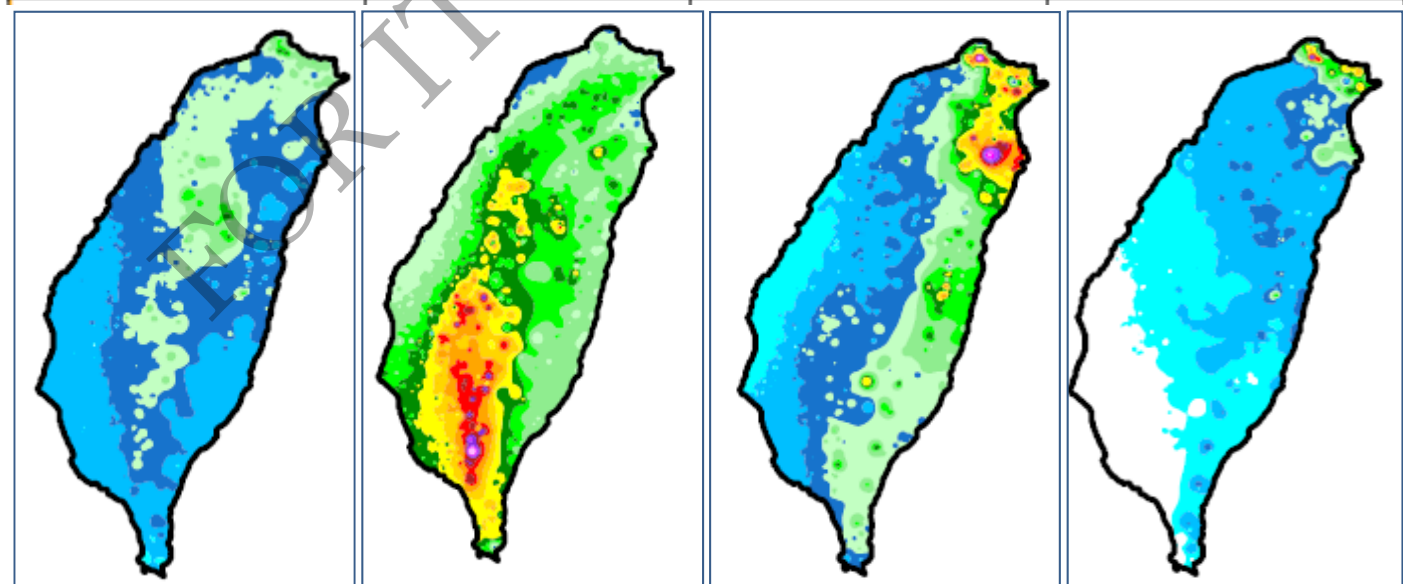
JJA

SON

DJF



TCCIP_Precip_1km



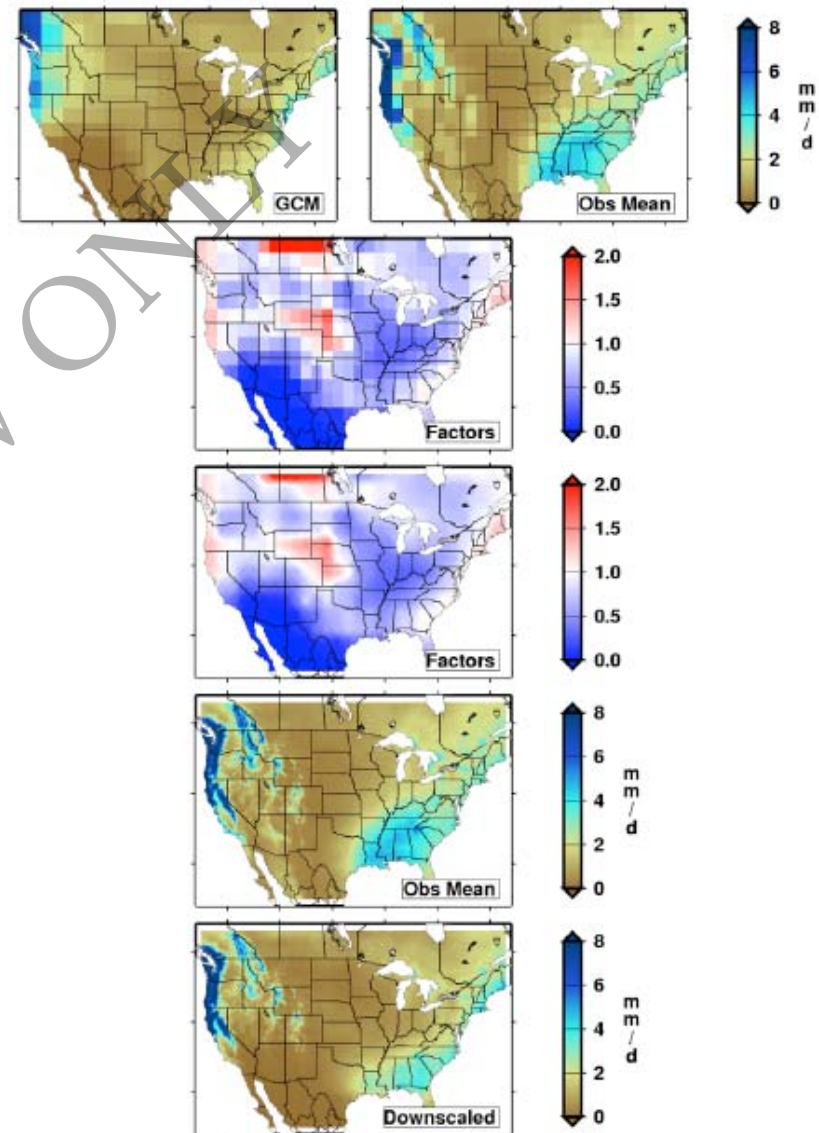
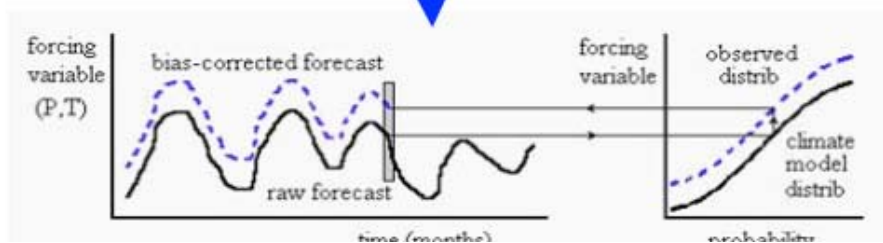
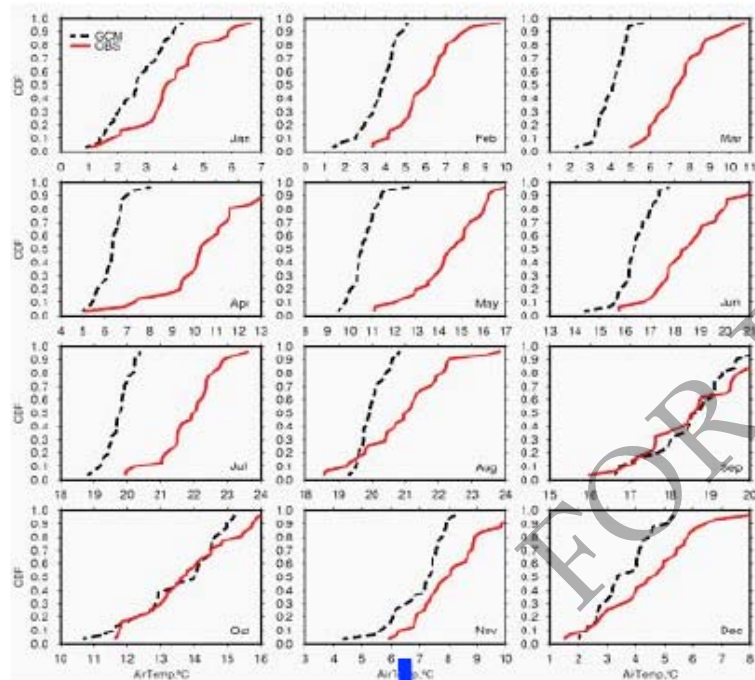
Team2

Statistical and Dynamical
Downscaling

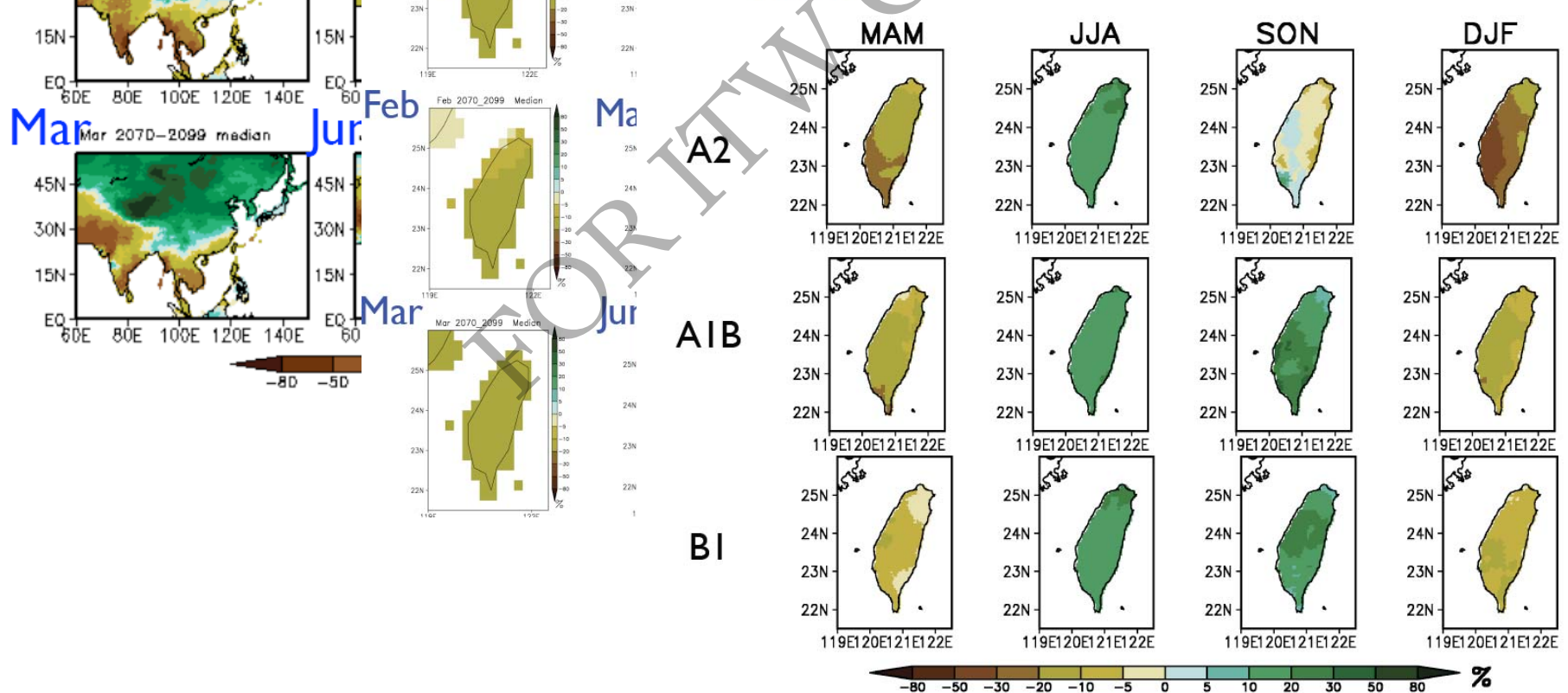
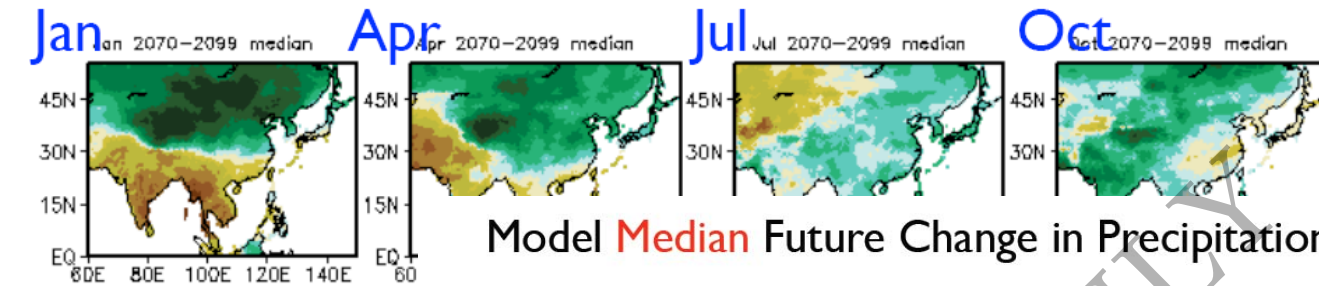
Statistical Downscaling

Wood et al. 2004, and Maurer 2007

Statistical downscaling and bias correction by cumulative distribution function and interpolation

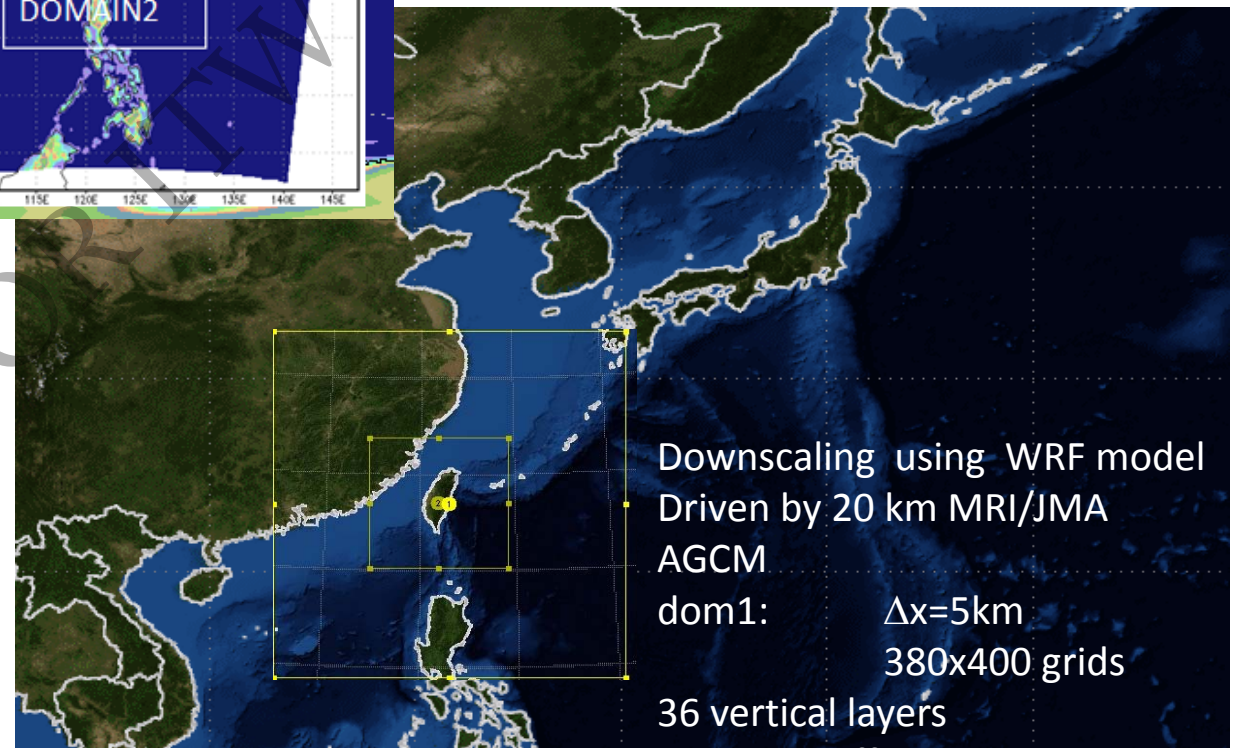
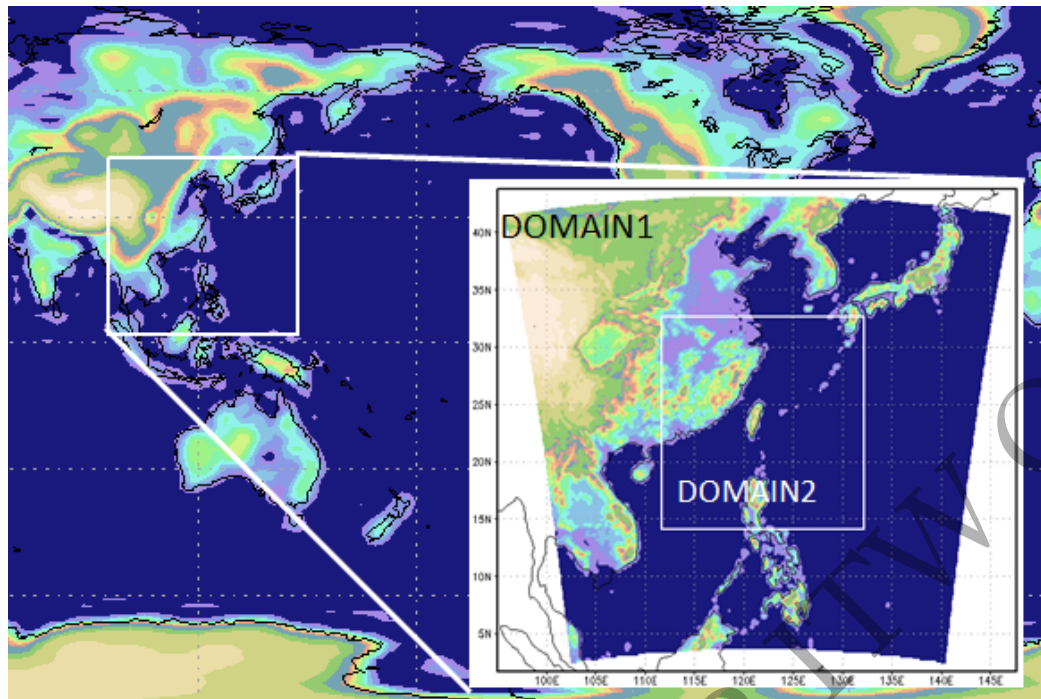


Model Median Future Change in Precipitation (%)



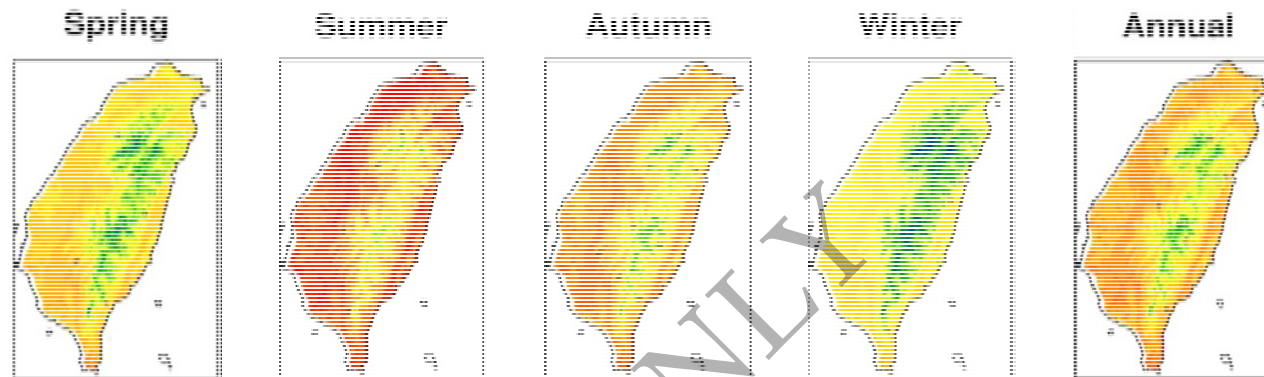
Dynamical Downscaling

ECHAM5-WRF
& MRI-WRF

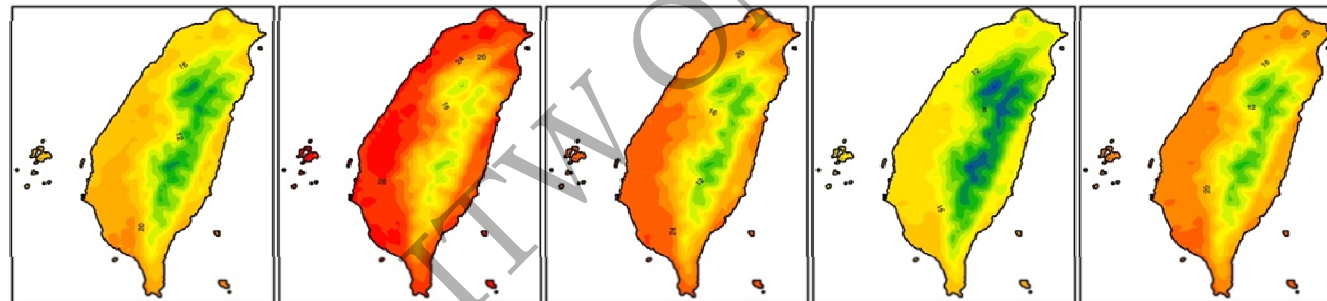


Temperature @ 2m

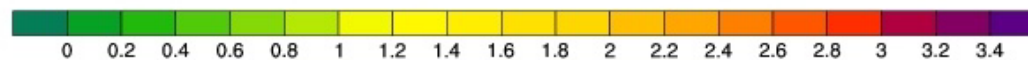
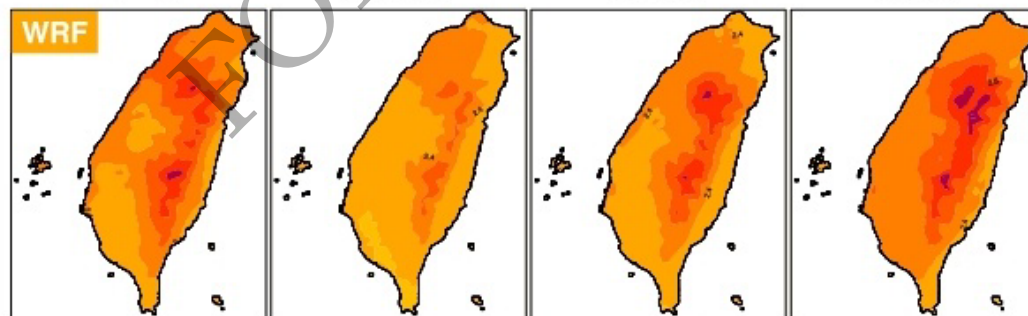
OBS
(1979-2003)



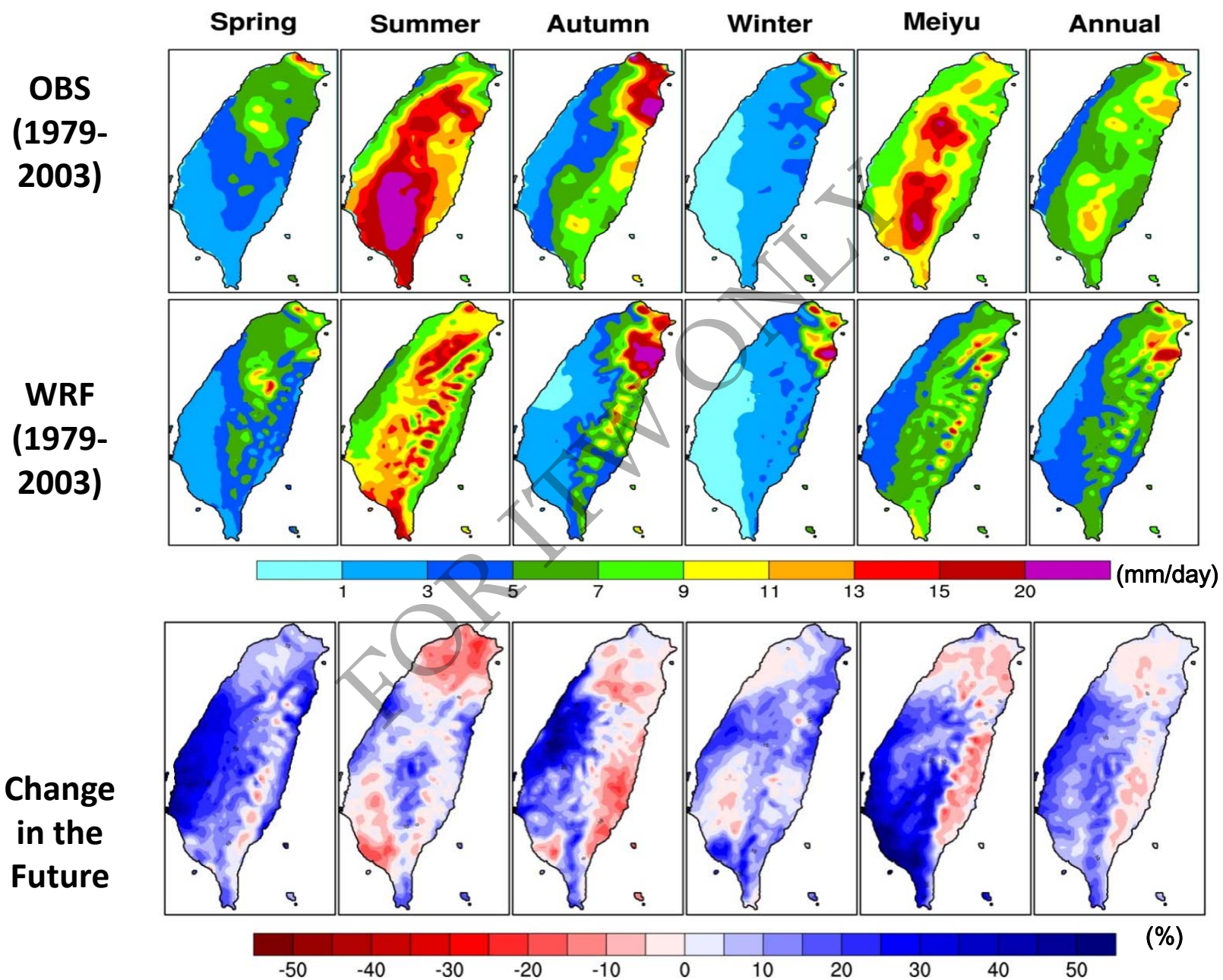
WRF
(1979-2003)



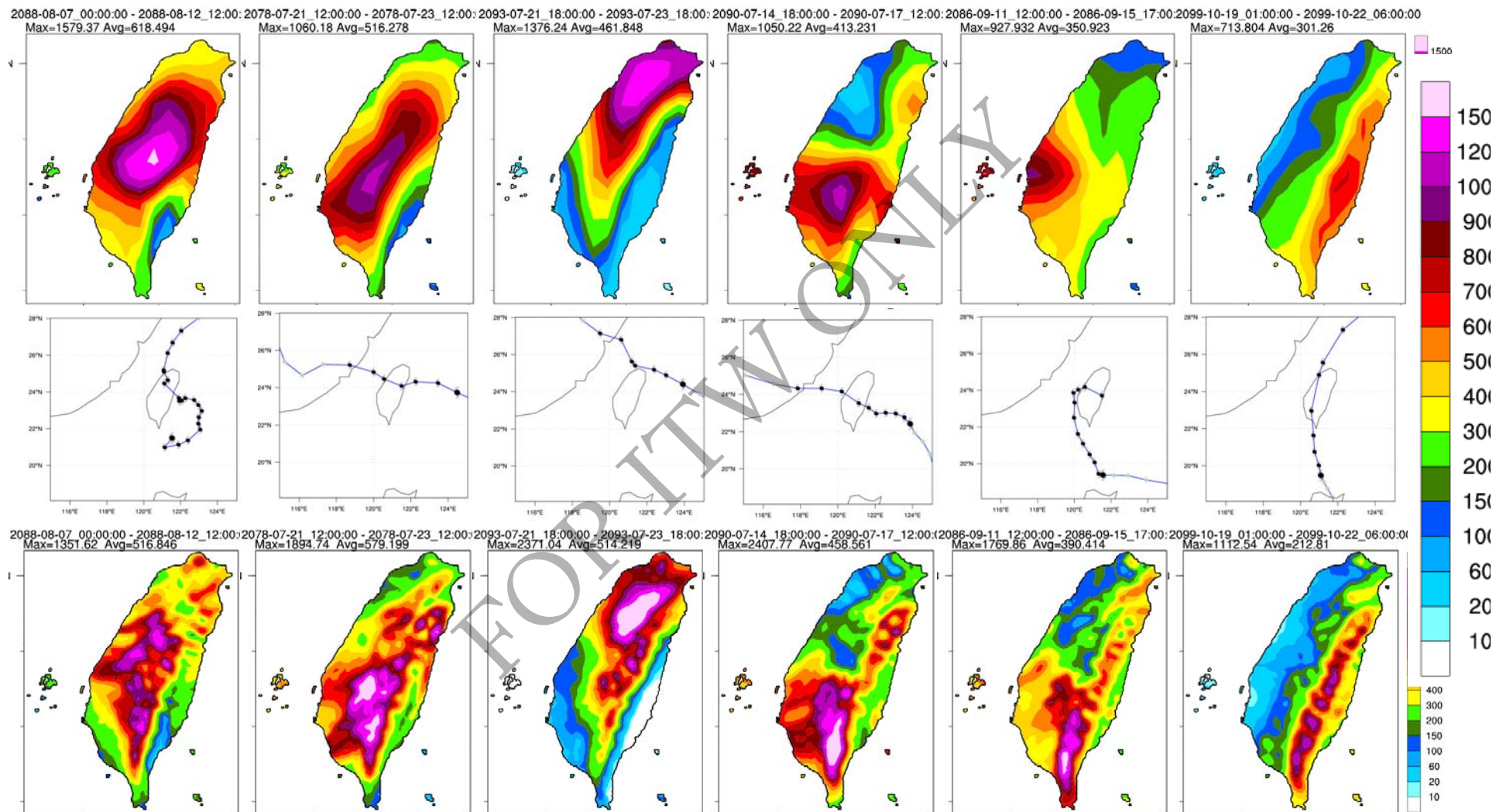
Change in the Future



Seasonal Precipitation

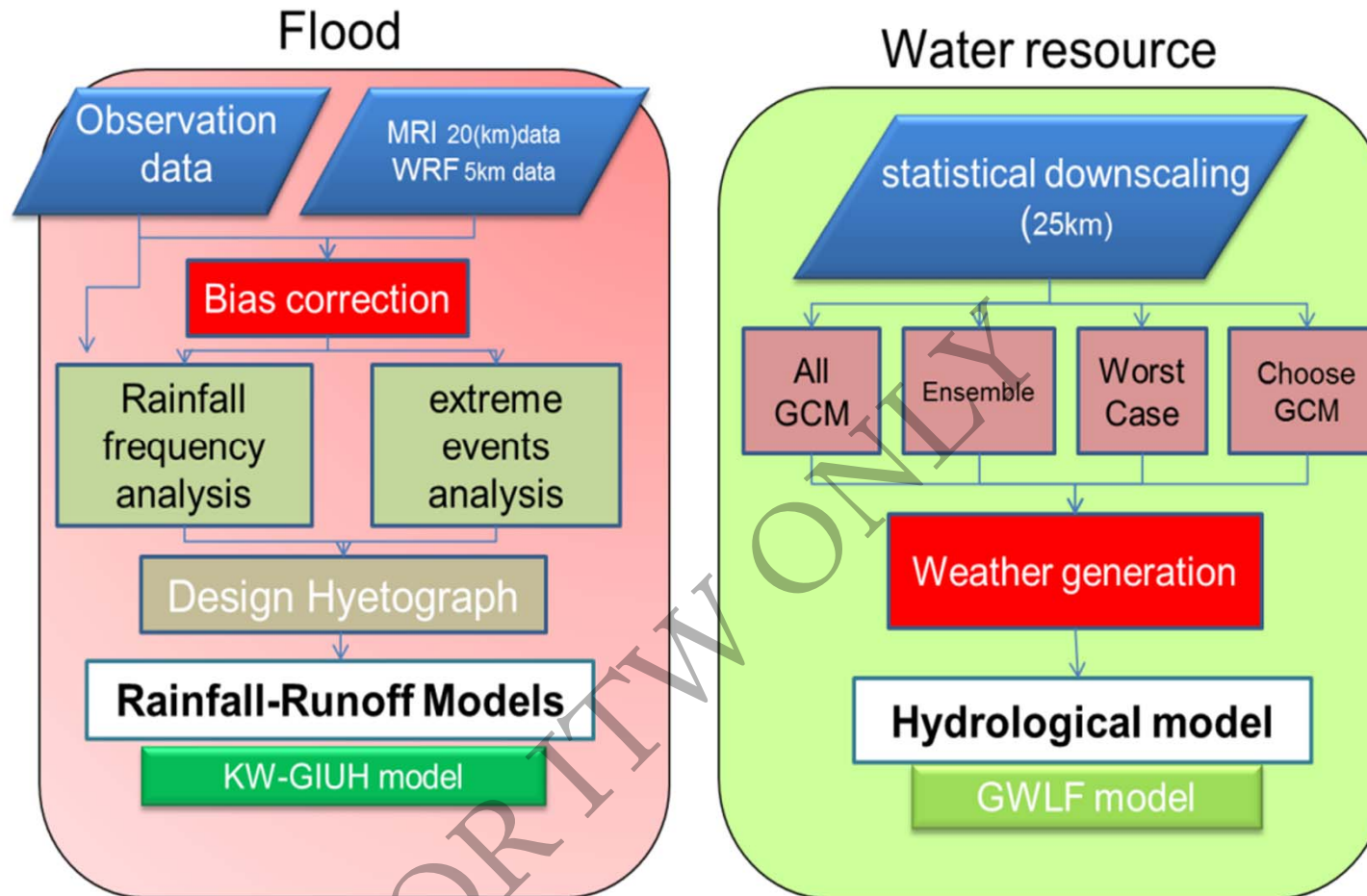


Precipitation of top 6 typhoons in 2075-2099



Team3

Impact Assessment
(water resources and extreme
precipitation events)



- To assess influence and uncertainty of hydrologic design due to climate change through analyzing the **100 year return period** maximum annual **24-hour rainfall** from observation, high-resolution MRI-AGCM data, and dynamical downscaled data.
- To estimate impacts and uncertainty of **water resources** due to climate change, **stream flows in wet and dry spells** are simulated using hydrological model, statistical downscaling (25km x 25km), weather generator, and data derived from IPCC 24 GCMs with different emission scenarios.

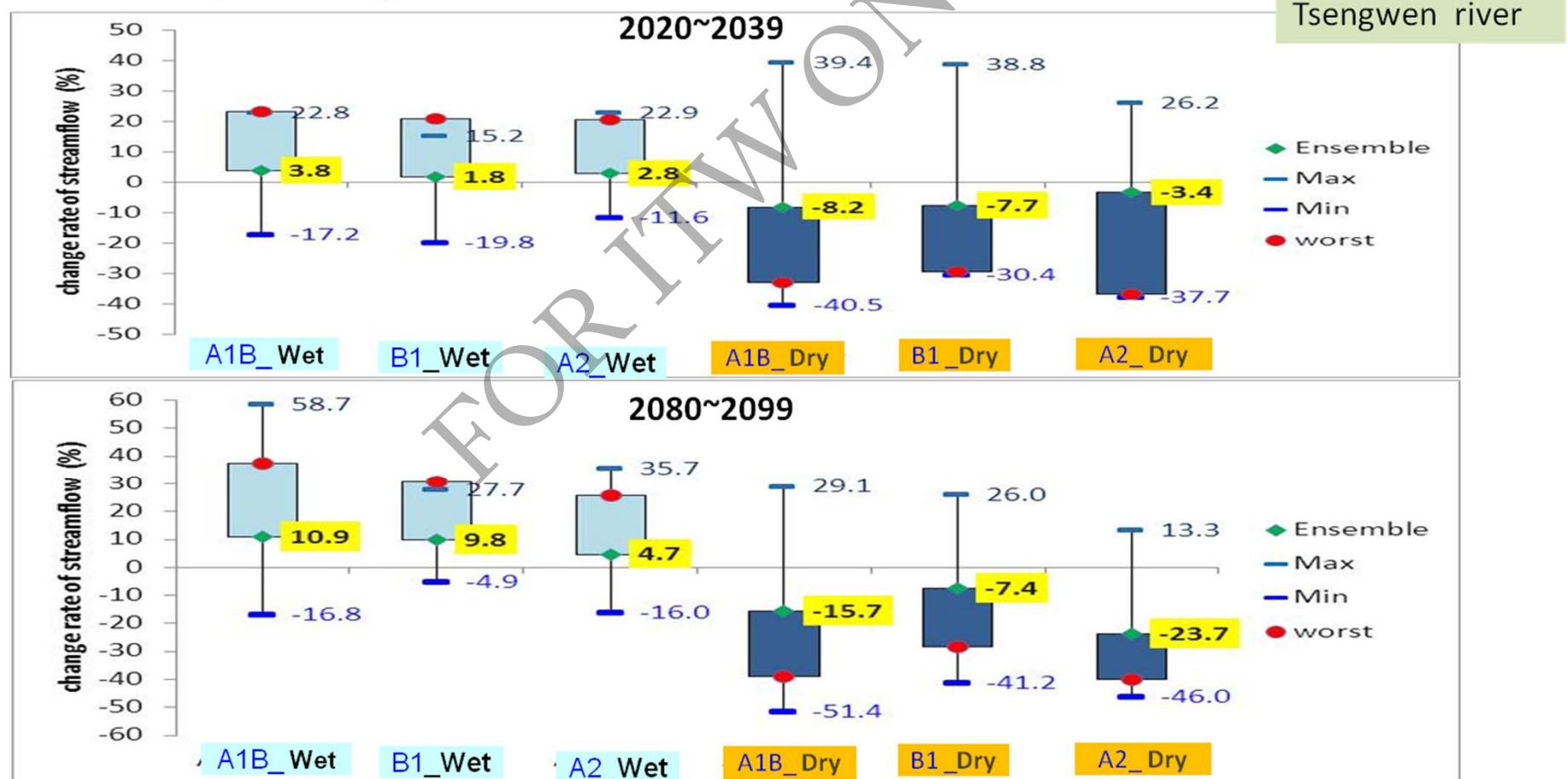
R1

what is 1/100 maximum?
RCEC, 2012/5/9

FOR ITW ONLY

Change rate of stream flow in wet and dry spell

- Multi-model ensemble result is not significant. Change rate of stream flow only 2~4% in wet spell and -3~-8% in dry spell in near future.
- Greater variability of change rate of stream flow is in dry spell
- Variability of change rate: A1B>B1>A2



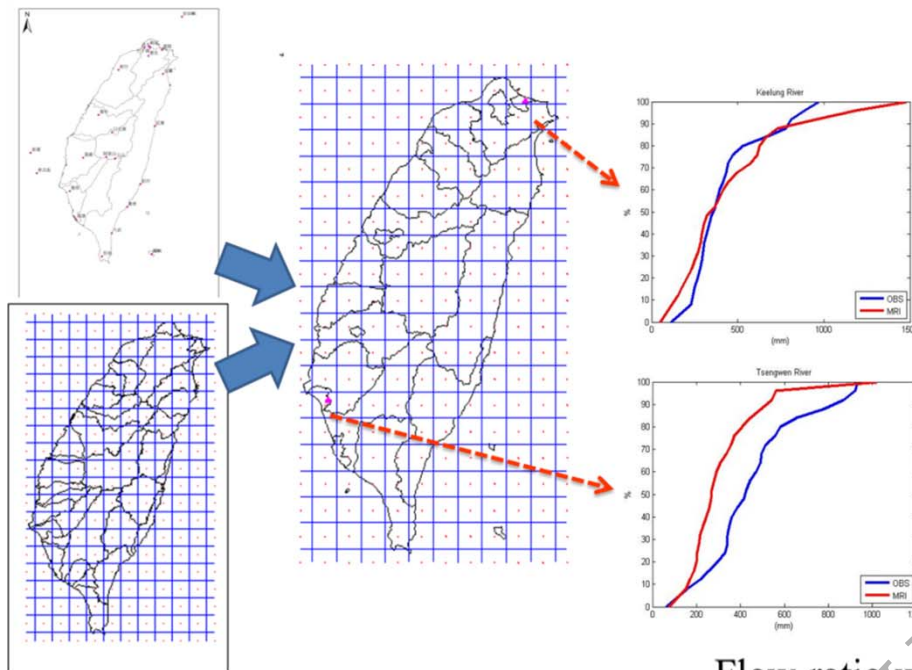


Fig3. Bias correction with MRI data

Flow ratio with original model output using KW-GIUH

KW-GIUH (original)	Tam-Sui river			Tseng-Wen stream		
	1979-2003	2015-2039	2075-2099	1979-2003	2015-2039	2075-2099
5km WRF	1	1.05	0.81	1	1.25	1.64
20km MRI	1	0.57	0.87	1	1.15	1.91

Flow ratio with bias-corrected data using KW-GIUH

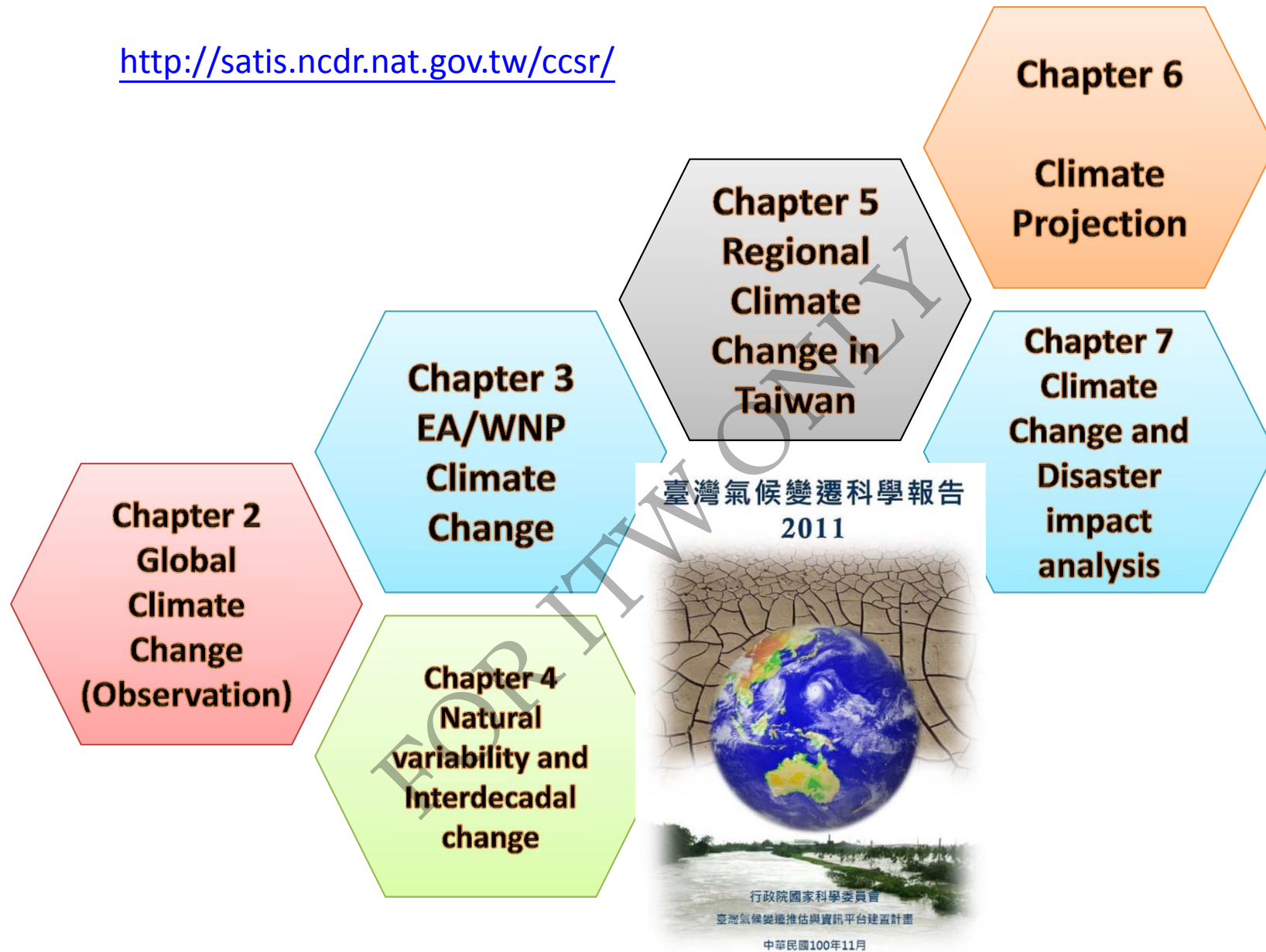
KW-GIUH (BC1)	Tam-Sui river			Tseng-Wen stream		
	1979-2003	2015-2039	2075-2099	1979-2003	2015-2039	2075-2099
5km WRF	1	1.18	0.89	1	0.98	1.43
20km MRI	1	0.63	0.88	1	1.11	1.9

Project Office

Science Report

TCCIP Information Platform

<http://satis.ncdr.nat.gov.tw/ccsr/>



TAIWAN CLIMATE CHANGE SCIENCE REPORT 2011

TCCIP webpage

<http://tccip.ncdr.nat.gov.tw/NCDR/main/index.aspx>

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Past Climate in Taiwan

- Temperature
- Precipitation
- Humidity
- Wind Speed
- Sea Level Surface
- Typhoon

Future Climate in Taiwan 2020-2099

- Spatial Distribution
- Change in Time Series

Change in East Asian

- Temperature
- Precipitation
- Monsoon
- Typhoon

Hydrological Change in Taiwan

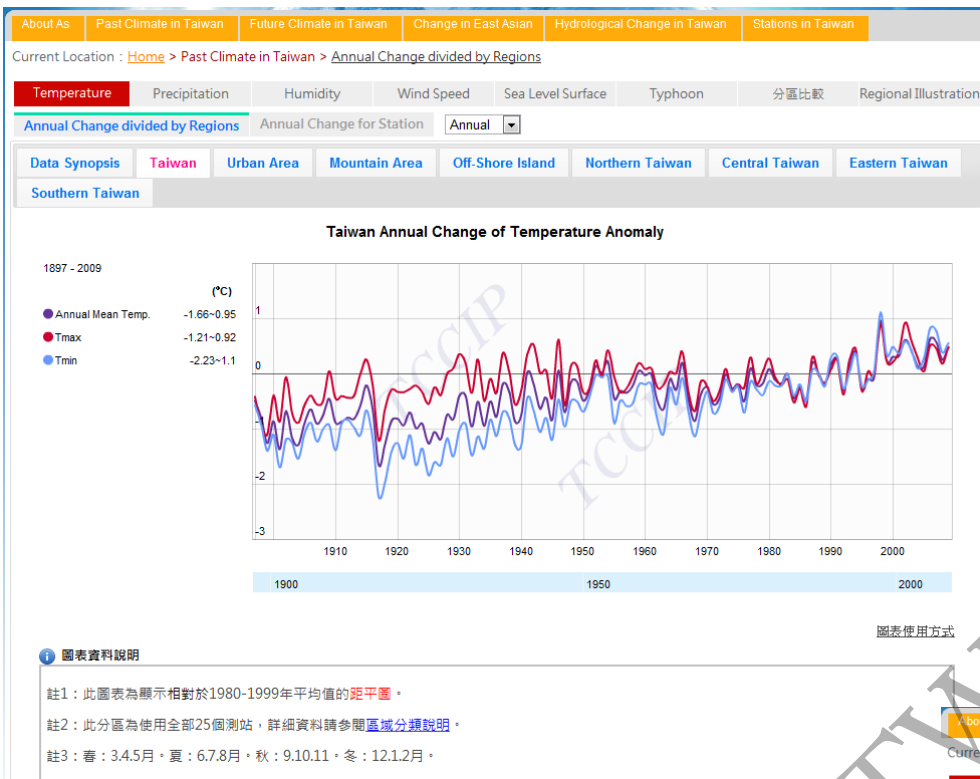
- Analysis of Variation in the Past
- Projection for Future

2011.12.06-08
2011 International Conference on
Climate Change

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National Science and Technology Center for Disaster Reduction

E-mail: tccip.office@ncdr.nat.gov.tw
TEL: +886-2-8195-8688 Visitor Counts: 10210

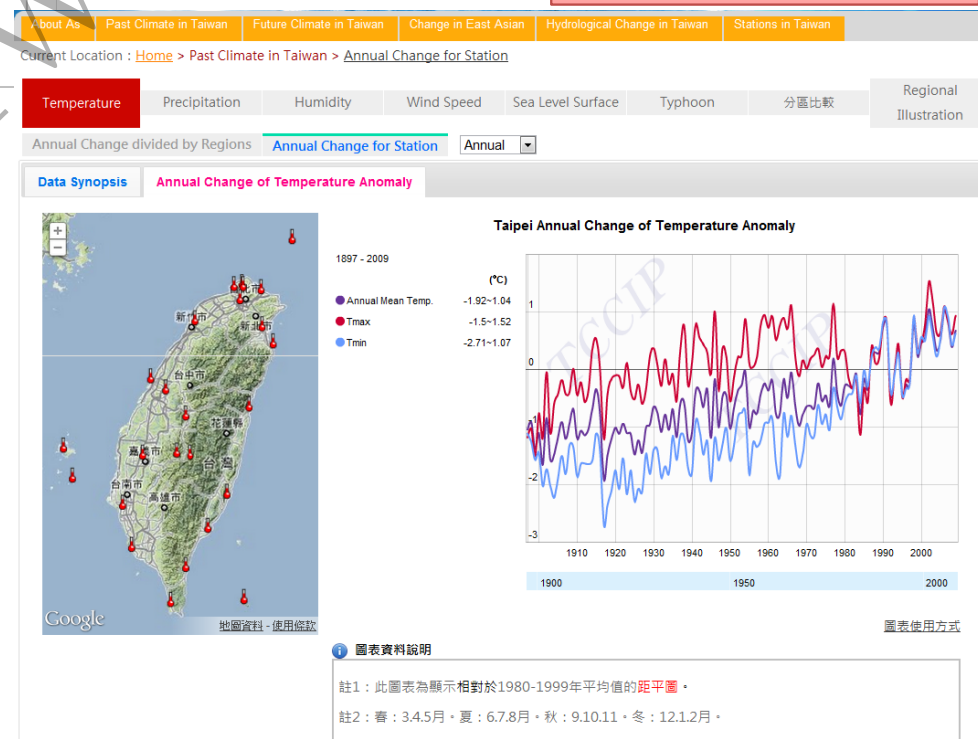
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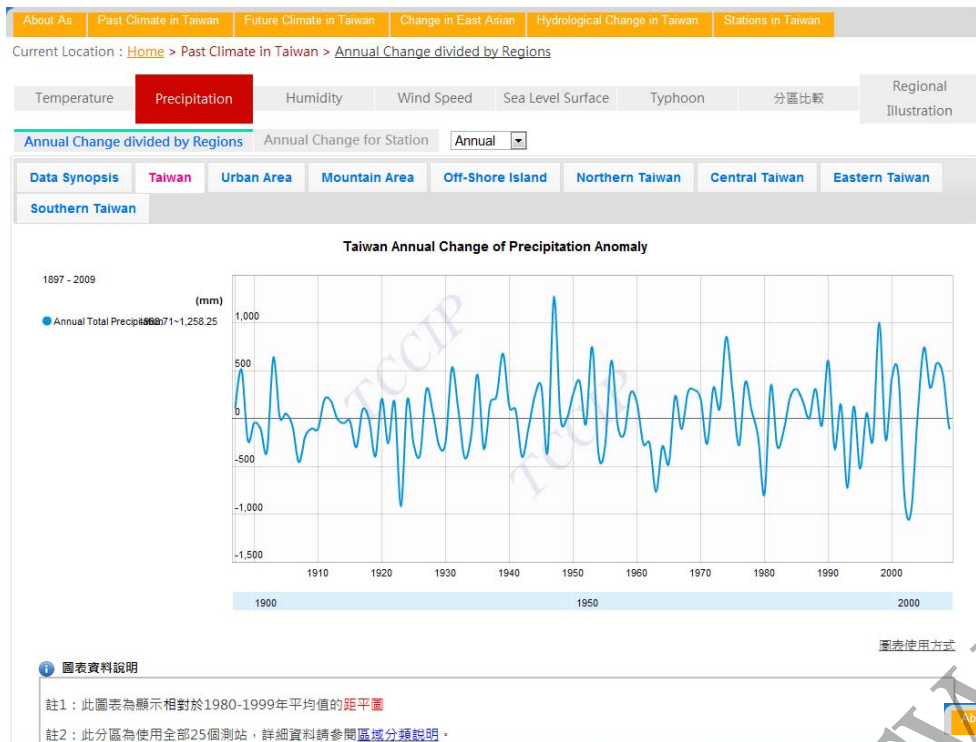


TCCIP webpage

Past Climate in Taiwan
(Temperature-station)

Past Climate in Taiwan
(Temperature)

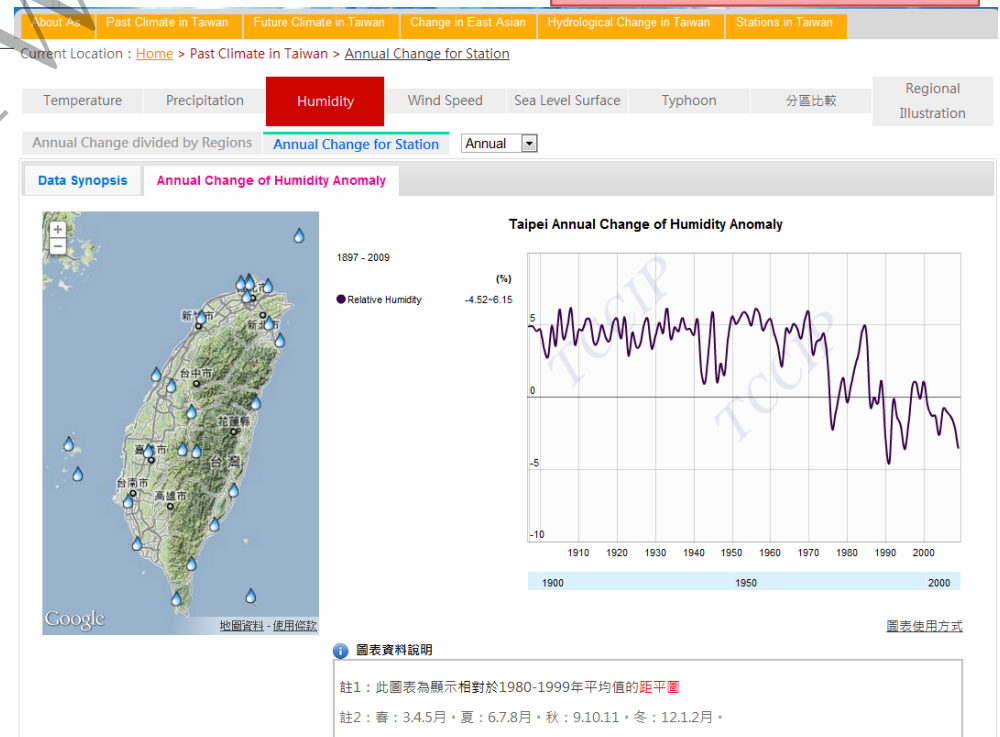




Past Climate in Taiwan (Precipitation)

TCCIP webpage

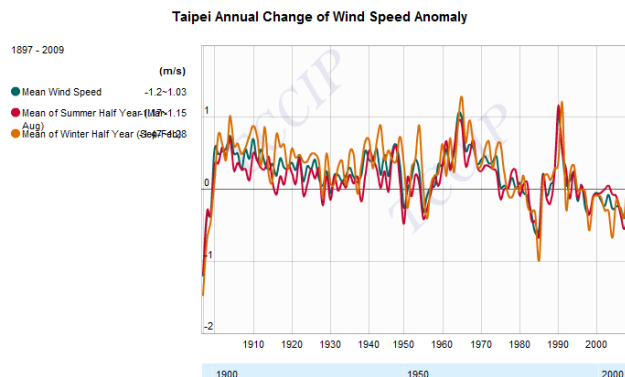
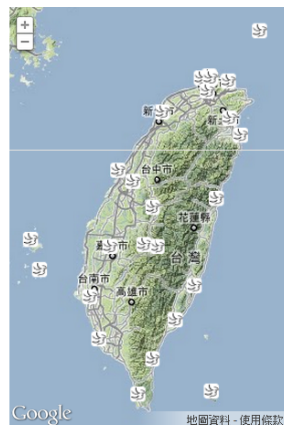
Past Climate in Taiwan (Humidity)



Current Location : [Home](#) > [Past Climate in Taiwan](#) > [Annual Change for Station](#)

Annual Change divided by Regions [Annual Change for Station](#) [Annual](#)

[Data Synopsis](#) [Annual Change of Wind Speed Anomaly](#)



圖表資料說明

註1：此圖表為顯示相對於1980-1999年平均值的距平圖
 註2：春：3.4.5月，夏：6.7.8月，秋：9.10.11，冬：12.1.2月。

圖表使用方式

TCCIP webpage

Past Climate in Taiwan
(Typhoon)

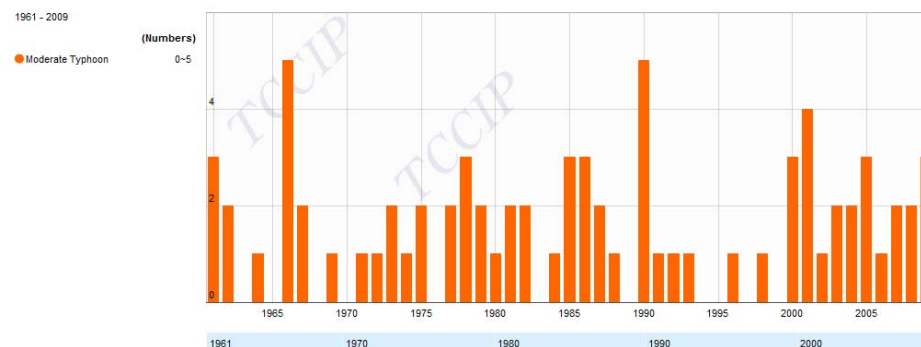
Past Climate in Taiwan
(Wind speed)

Location : [Home](#) > [Past Climate in Taiwan](#) > [Typhoon](#)

[Data Synopsis](#)
[Typhoon Affecting Taiwan](#)
[Frequency of Extreme Precipitation](#)
[Change of Number by Route \(10 types\)](#)

[Change of Number by Route \(4 types\)](#)

Moderate Typhoon



圖表使用方式

圖表資料說明

1.此處為影響臺灣颱風(進入台灣附近300km範圍內)之颱風個數統計。
 2.颱風的強度是以近中心附近最大平均風速為準，劃分為3種強度。風速對應強度如下所示：
 輕度颱風：17.2 ~ 32.6 m/s
 中度颱風：32.7 ~ 50.9 m/s

TCCIP webpage

<http://tccip.ncdr.nat.gov.tw/NCDR/main/index.aspx>

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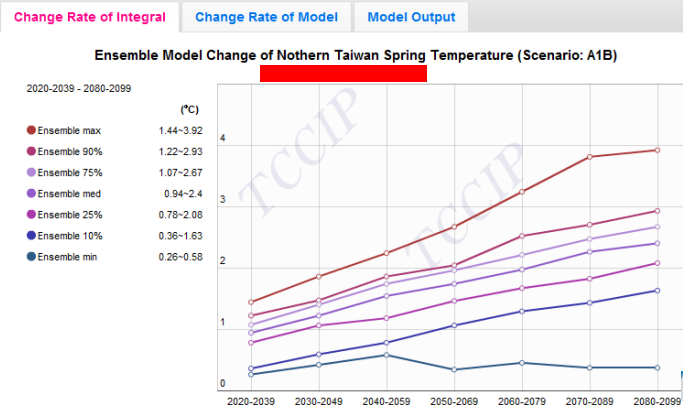
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[Spatial Distribution](#)
[Change in Time Series](#)
[Model Illustration](#)
[Research Method](#)

Scenario : ☒ A1B ☐ B1 ☐ A2
 Measurement :
 Area :
 Time Scale :



圖表資料說明

註1：此處資料是依據IPCC排放情境特別報告(SRES)所定義之未來情境所推估出來的模式整體改變量(比較年：1980-1999)，溫度的單位為°C，雨量的單位為%。

註2：此處提供的情境為A1B、B1、A2；A與B則是區別未來的經濟是(A)以市場導向發展為重；抑或(B)以環境保護優先。數字1與2分別表示未來的社會將(1)更趨全球化發展或(2)開始著重區域特性。因此A1代表未來經濟以市場導向發展且更全球化，其中A1又細分為三種次情境，主要是使用能源的不同，A1B代表同時運用再生能源與石化燃料，發展比較平衡。

更多的未來推估情境請參考 [未來發展與排放情境\(PDF\)](#)

Future Climate in Taiwan 2020-2099
(Change in time series)

TCCIP webpage

Future Climate in Taiwan 2020-2099
(Spatial distribution)

Current Location : [Home](#) > [Future Climate in Taiwan](#) > [Spatial Distribution](#)

[Spatial Distribution](#)
[Change in Time Series](#)
[Model Illustration](#)
[Research Method](#)

Measurement : ☒ Temperature ☐ Precipitation
 Scenario : ☒ A1B ☐ B1 ☐ A2
 Area :
 Time Scale :
 Time Period :
 Model :

Change in East Asia Annual Mean Temperature by 2040-2069 (Model: Ensemble Average, Scenario: A1B)



圖表資料說明

註1：此處資料是依據IPCC排放情境特別報告(SRES)所定義之未來情境所推估出來的氣候變化(比較年：1980-1999)，是對於未來全球與區域的社會、經濟、科技、環境等變化設計一些不同的故事情境。

註2：此處提供的情境為A1B、B1、A2；A與B則是區別未來的經濟是(A)以市場導向發展為重；抑或(B)以環境保護優先。數字1與2分別表示未來的社會將(1)更趨全球化發展或(2)開始著重區域特性。因此A1代表未來經濟以市場導向發展且更全球化，其中A1又細分為三種次情境，主要是使用能源的不同，A1B代表同時運用再生能源與石化燃料，發展比較平衡。

更多的未來推估情境請參考 [未來發展與排放情境\(PDF\)](#)

註3：因為google map與瀏覽器支援度的問題，使用IE僅能縮放到某一層級。使用其他瀏覽器(Google Chrome、Firefox)則無此問題。

TCCIP webpage

<http://tccip.ncdr.nat.gov.tw/NCDR/main/index.aspx>

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National Science and Technology Center for Disaster Reduction

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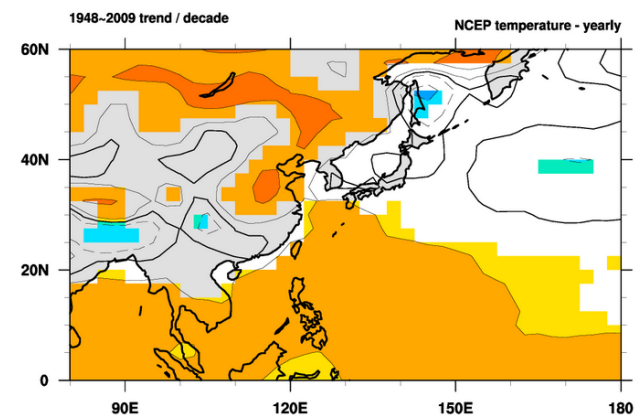
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Current Location : [Home](#) > [Change in East Asian](#) > [Temperature](#)

[Temperature](#)
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[Monsoon](#)
[Typhoon](#)

[Data Synopsis](#)
[Spatial Distribution](#)

Spatial Distribution ☒ Annual ☐ Spring ☐ Summer ☐ Autumn ☐ Winter



1948~2009全年平均近表面氣溫長期線性趨勢，粗實線為0值等值線，填色部分通過95%統計顯著檢定，單位為°C/10年。
(使用資料：NCEP Reanalysis I)

Change in East Asian
(Temperature)

TCCIP webpage

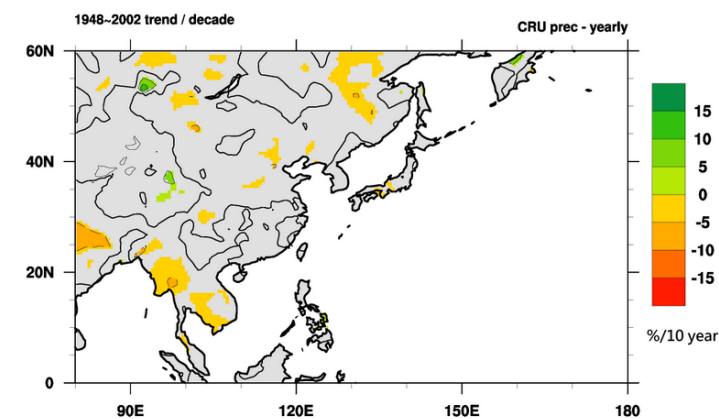
Change in East Asian
(Precipitation)

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[Data Synopsis](#)
[Spatial Distribution](#)

Spatial Distribution ☒ Annual ☐ Spring ☐ Summer ☐ Autumn ☐ Winter



1948~2002全年降水量長期線性趨勢，以相對於氣候平均全年降水量之百分比表示，填色部分為表示變化趨勢通過95%統計顯著檢定，單位為%/10年。
(使用資料：CRU v2.1)

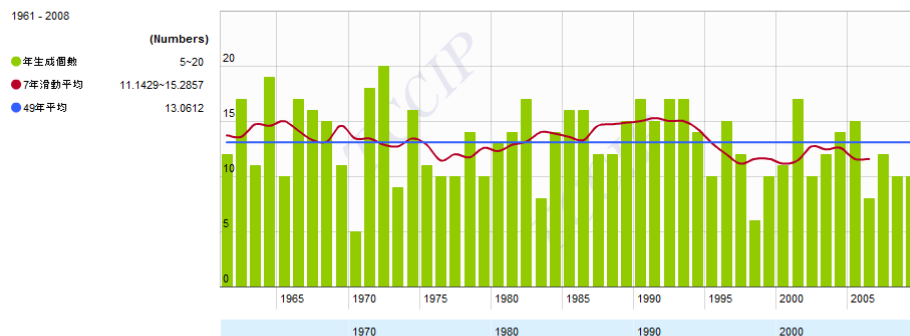
Current Location : [Home](#) > [Change in East Asian](#) > [Typhoon](#)

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[Precipitation](#)
[Monsoon](#)
[Typhoon](#)

[Data Synopsis](#)
[Annual Change of Number/Strength](#)
[Trend of Genesis Location](#)
[Trend of Route](#)

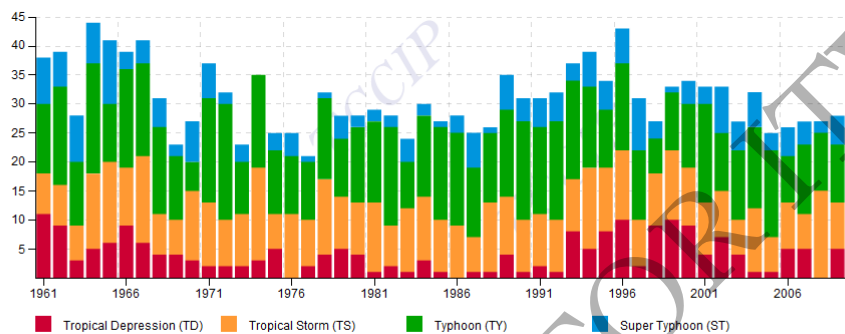
Typhoon (TY)

WNP Typhoon (TY) Formation Annual Change



圖表使用方式

WNP Typhoon Density Annual Change



圖表使用方式

Change in East Asian- Typhoon
(Annual change of number/strength)

TCCIP webpage

Change in East Asian- Monsoon

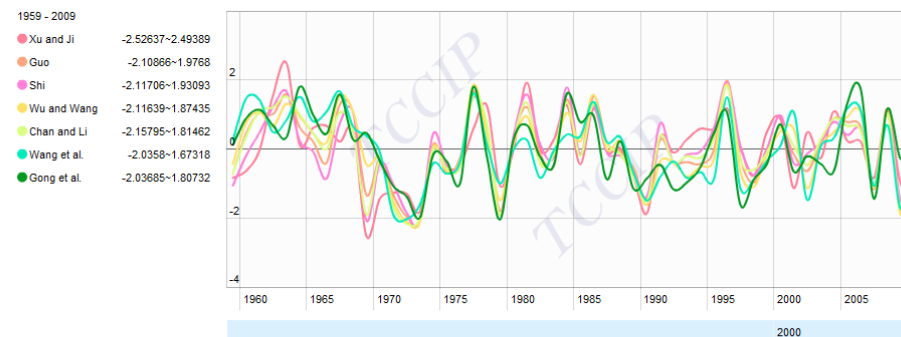
Current Location : [Home](#) > [Change in East Asian](#) > [Monsoon](#)

[Temperature](#)
[Precipitation](#)
[Monsoon](#)
[Typhoon](#)

[Data Synopsis](#)
[Winter Monsoon](#)
[Summer Monsoon](#)

Winter Monsoon : ☒ Sea Level Pressure ☐ Wind ☐ GH_500

Winter Monsoon / Sea Level Pressure



圖表使用方式

圖表資料說明

註1：已經過標準化處理（相對於長期的標準差）的指數逐年變化，本組指數指數值越高代表季風越強。

註2：指數定義及參考文獻，請參照[冬季季風指數說明\(PDF\)](#)

TCCIP webpage

<http://tccip.ncdr.nat.gov.tw/NCDR/main/index.aspx>

臺灣氣候變遷推估與資訊平台計畫
TAIWAN
Climate Change Projection & Information Platform

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About As | Past Climate in Taiwan | Future Climate in Taiwan | Change in East Asian | Hydrological Change in Taiwan | Stations in Taiwan

Past Climate in Taiwan

- Temperature
- Precipitation
- Humidity
- Wind Speed
- Sea Level Surface
- Typhoon

Future Climate in Taiwan 2020-2099

- Spatial Distribution
- Change in Time Series

Change in East Asian

- Temperature
- Precipitation
- Monsoon
- Typhoon

Hydrological Change in Taiwan

- Analysis of Variation in the Past
- Projection for Future

2011.12.06-08
2011 International Conference on
Climate Change

Taiwan Climate Change Projection and Information Platform Project
9F., No.200, Sec. 3, Beisun Rd., Sindian City, Taipei County 231, Taiwan (R.O.C.)
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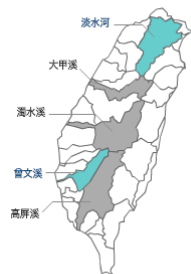
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過去變化分析 未來推估

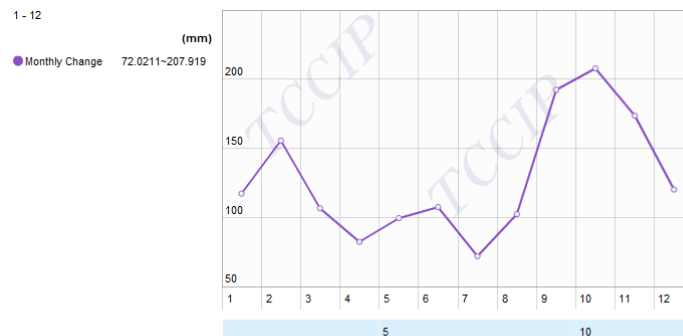
Danshui River Basin :

- ☐ Nanshi River
- ☐ Beishi River
- ☐ Dahan River
- ☐ Sansia River
- ☒ Keelung River



Data Synopsis Precipitation Stream flow

Keelung River Monthly Change of Precipitation



圖表使用方式

Hydrological Change in Taiwan
(Analysis of Variation in the Past)

TCCIP webpage

Hydrological Change in Taiwan
(Projection for Future)

Current Location : [Home](#) > [Hydrological Change in Taiwan](#) > [Projection for Future](#)

過去變化分析 未來推估

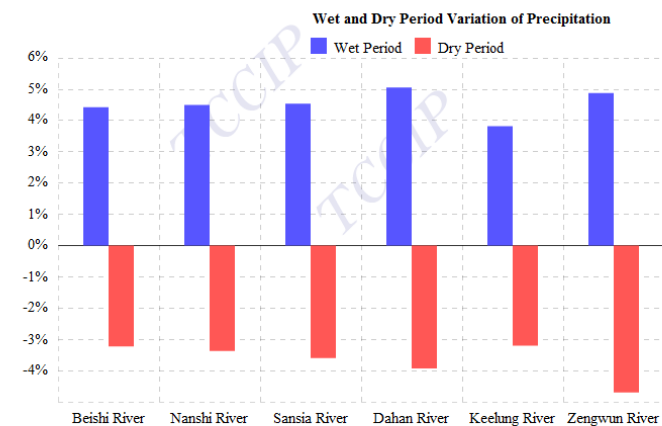
Danshui River Basin :

- ☐ Nanshi River
- ☐ Beishi River
- ☐ Dahan River
- ☐ Sansia River
- ☒ Keelung River



Data Synopsis Precipitation Stream flow

Monthly Variation Wet and Dry Period Variation



圖表使用方式

Summary

Producing projections of climate change in Taiwan through scientific methods

Facilitating interdisciplinary cooperation and information integration in climate change research

Enhancing international connection and collaboration on climate change research

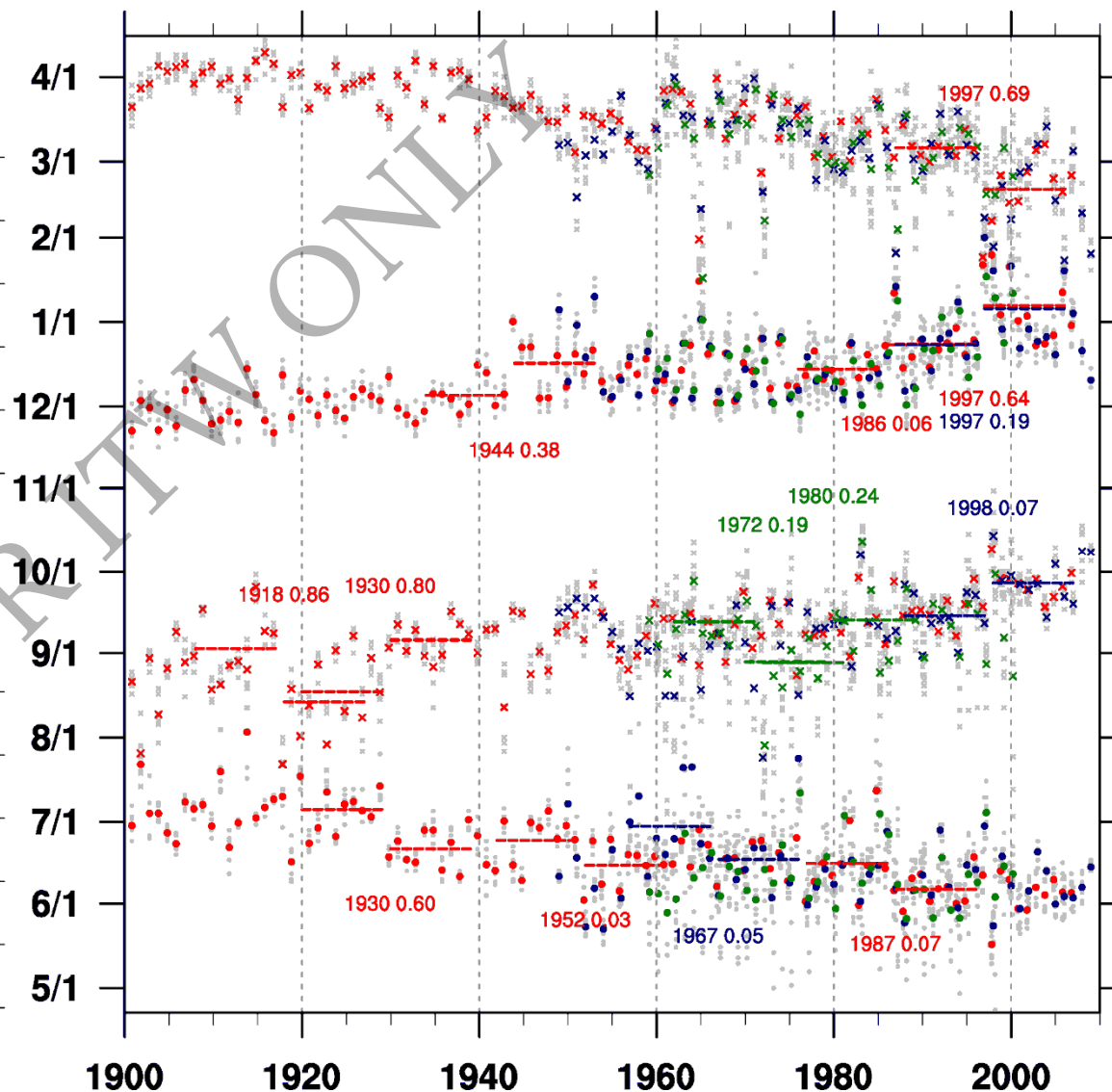
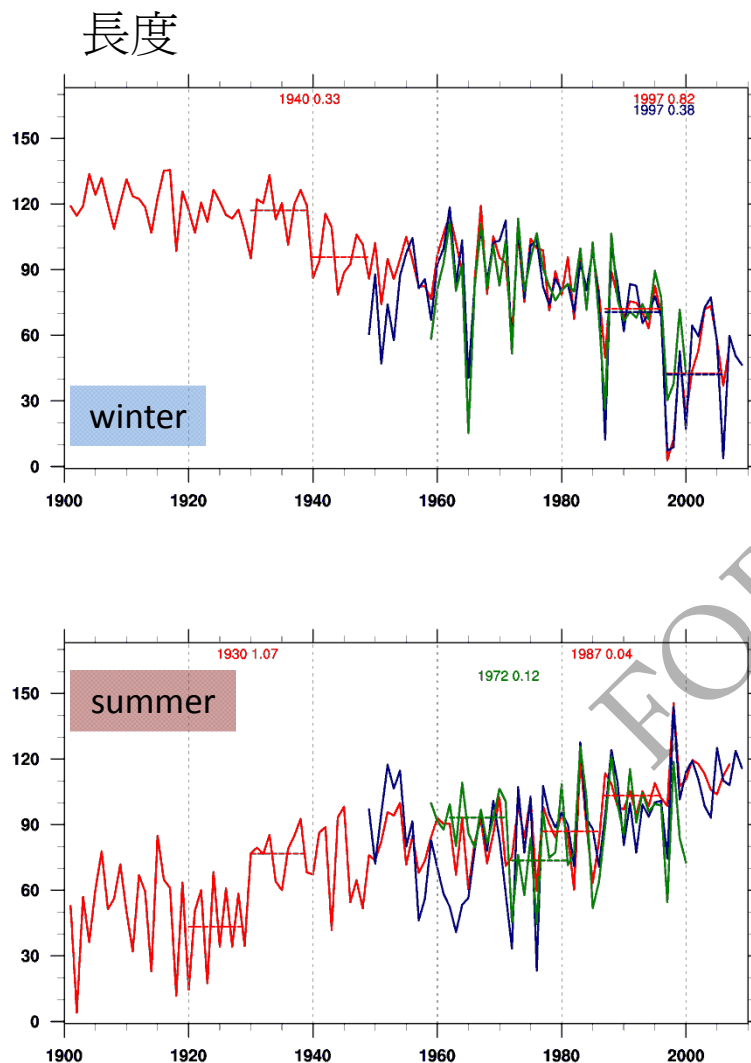
Providing TCCIP products to government agencies for policy making

Publishing reports on climate change research and accomplishment in Taiwan

Thanks for your attention!

台灣鄰近區域 北緯20~25度、東經120~125度

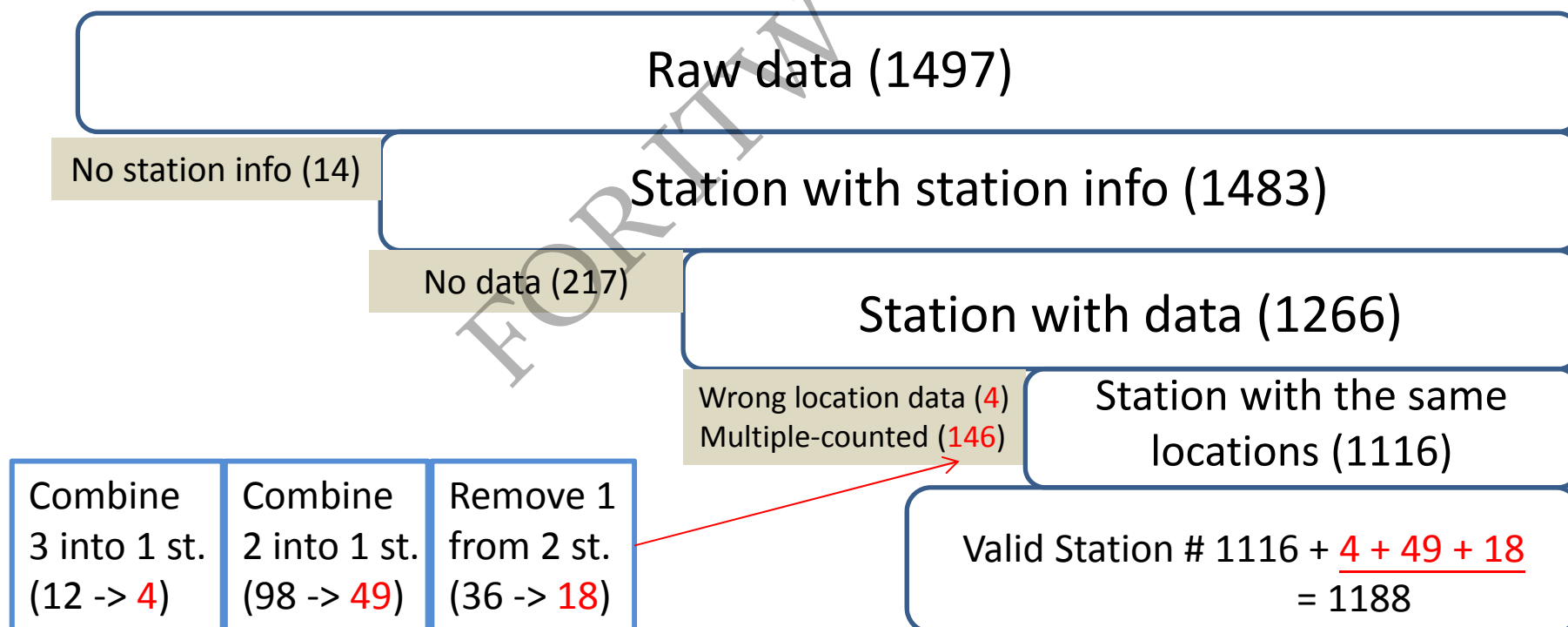
20C Reanalysis
(1901~2007)
NCEP R1
(1949~2009)
ERA 40
(1959~2000)



測站降水資料均一化、補遺、網格化

Data sifting process

- ✓ Remove stations without station info
- ✓ Remove stations without obs data
- ✓ Remove stations with wrong location data
- ✓ Combine/Remove multiple-counted stations

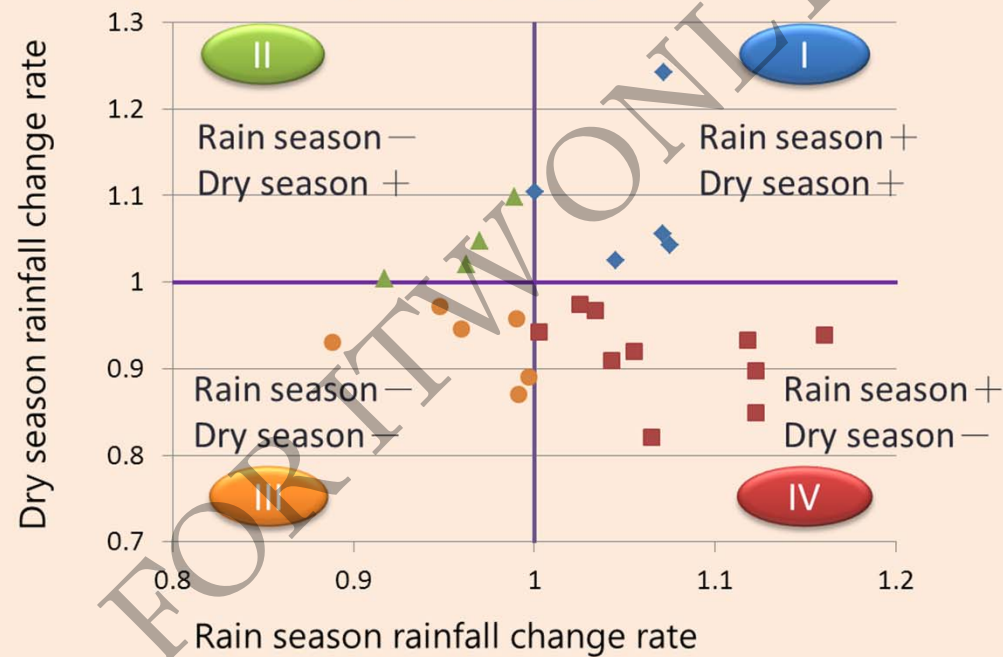


Flowchart for Assessing Impact on Water Resource

GCMs after Statistic Downscaling

Projection of rain/dry season rainfall change rates

Dansui River basin



Selection of GCM

- Performance of East Asian monsoon (9 GCMs)
- Characteristic of rainfall change rate in wet and dry spell (4 scenarios)

Worst case

Multi-model ensemble

Basin

Ensemble



Uncertainty

- Scenarios (A1, B1, C1, D1)
- Selection of GCM
- Weather generation

Critical Issues

1: How does the Taiwan's climate change comparing to the global climate change?

2: How will typhoons, torrential rains, droughts, heat waves, and cold surges be influenced by climate changes? Becoming more intense and/or frequent in the future?

3: How are climate changes related to climate variability such as the El Nino/Southern Oscillation?

4: The disasters in Taiwan seem to occur more frequently and more severely in recent years. Is that related to climate changes?

5: How reliable are the projections of future climate changes in Taiwan? How should the government and the general public interpret the related information?