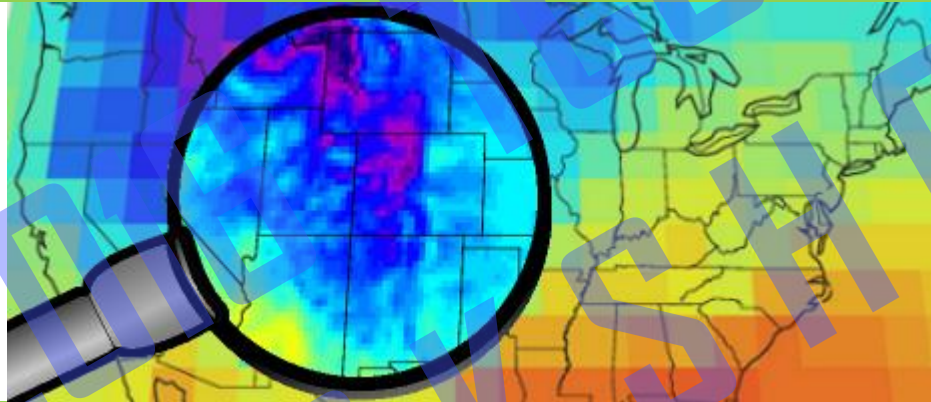
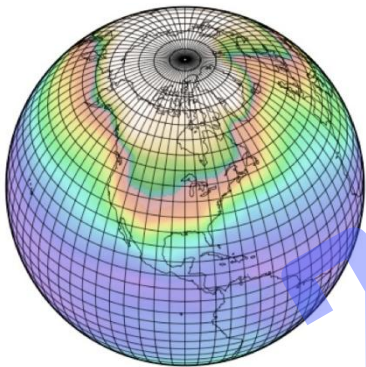


# Climate Change Impact Assessment on Agricultural Reservoirs in Korea under RCP Scenarios



2016/03/09

Jaepil Cho (APEC Climate Center)  
Kwangyoung Kim (Rural Research Institute)

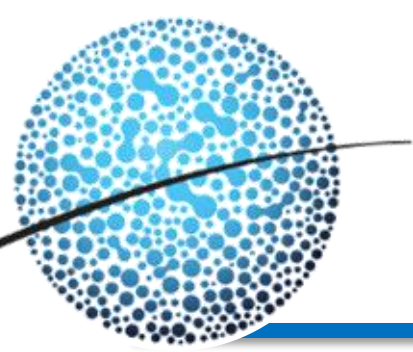
# Overview

## 1. Background information

## 2. Downscaling and Data Analysis

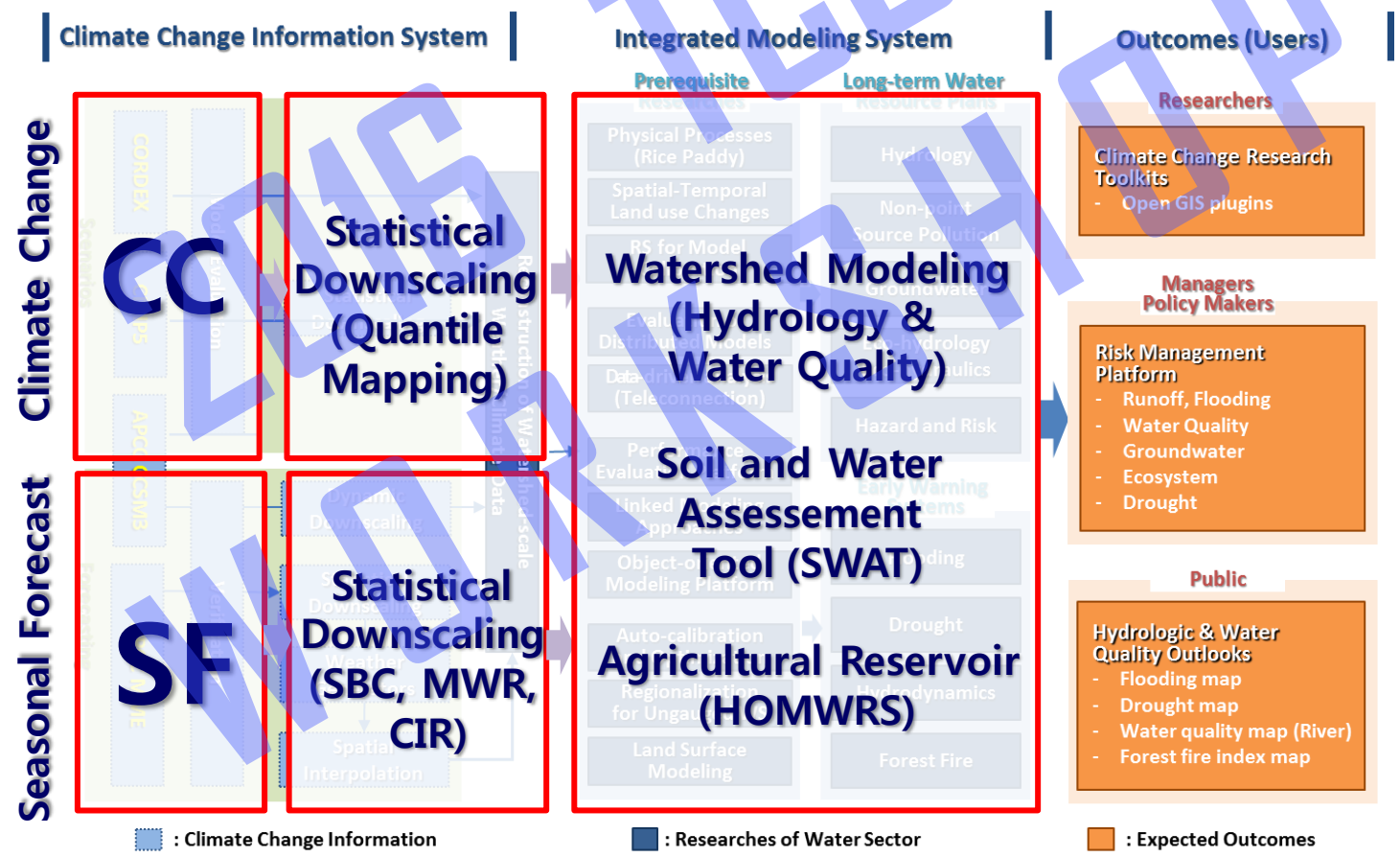
- ❖ Statistical downscaling (daily & Monthly)
- ❖ Precipitation index

## 3. Impact Assessment on Reservoirs



# Background Information

## ❖ Framework of APCC Water Sector



# Facilities for Agricultural Water Supply

(Source; KRCC, 2011)

Agricultural Facilities	Managed by KRC		Managed by Local Government		Total	
	Count	Area(ha)	Count	Area(ha)	Count	Area(ha)
Reservoirs	3,363	340,984 (65.4%)	14,206	112,327 (39.3%)	<b>17,569</b>	<b>453,311 (56.2%)</b>
Pumping Stations	4,077	166,142 (31.9%)	3,390	34,611 (12.1%)	7,467	200,753 (24.9%)
Weirs	5,887	13,669 (2.6%)	38,401	138,742 (48.6%)	44,288	152,411 (18.9%)
Total	13,327	520,795	55,997	285,680	69,324	806,475

- ❖ 62% of total water resources are used for agricultural water (2007)
- ❖ 80% of agricultural water are used for paddy irrigation during Apr-Sep.
- ❖ 80% of irrigation water for paddy areas are supplied from agricultural facilities
- ❖ 56% of total irrigated areas are supplied by agricultural reservoirs



# Agricultural drought with respect to reservoirs

- ❖ Small agricultural reservoirs are vulnerable to climate change



Source: <http://blog.daum.net/sangkunlee/969>



# Uncertainty in Future Projections of Climate Change

- ❖ How reliable are projections of future climate change scenarios?

Scenarios	Inflow	% Change
Historical	988.5	
RCP8.5: GFDL-ESM2G	1198.0	21.2
RCP8.5: inmcm4	953.7	-3.5

- How decisions can be utilized when opposite signals are projected in the same watershed?
- Even though MME-based projection shows same projection, what kind of additional information should be provided for decision-making?

**Uncertainty**  
of future projections

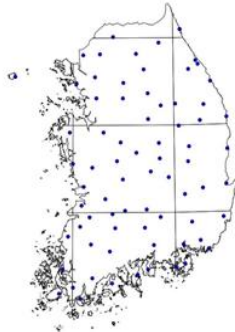
Scenarios	Inflow (mm)	% change
Historical	988.5	
RCP8.5	1078.1	9.1

Even though we have same future projection ..

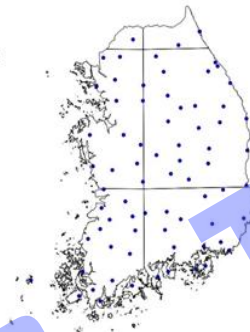
# Spatial resolution of GCMs in CMIP5



KMA-12.5km



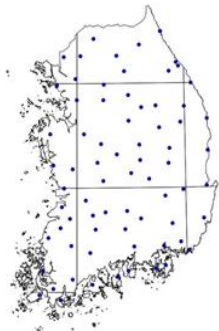
HadGEM2-CC



GFDL-CM3



CanESM2  
bcc-csm1-1  
MIROC-ESM  
MIROC-ESM-CHEM



inmcm4



IPL-CM5A-LR



GFDL-ESM2M  
GFDL-ESM2G

RCP8.5 Scenario

- KMA RCM
- 10 GCMs

## Climate Data

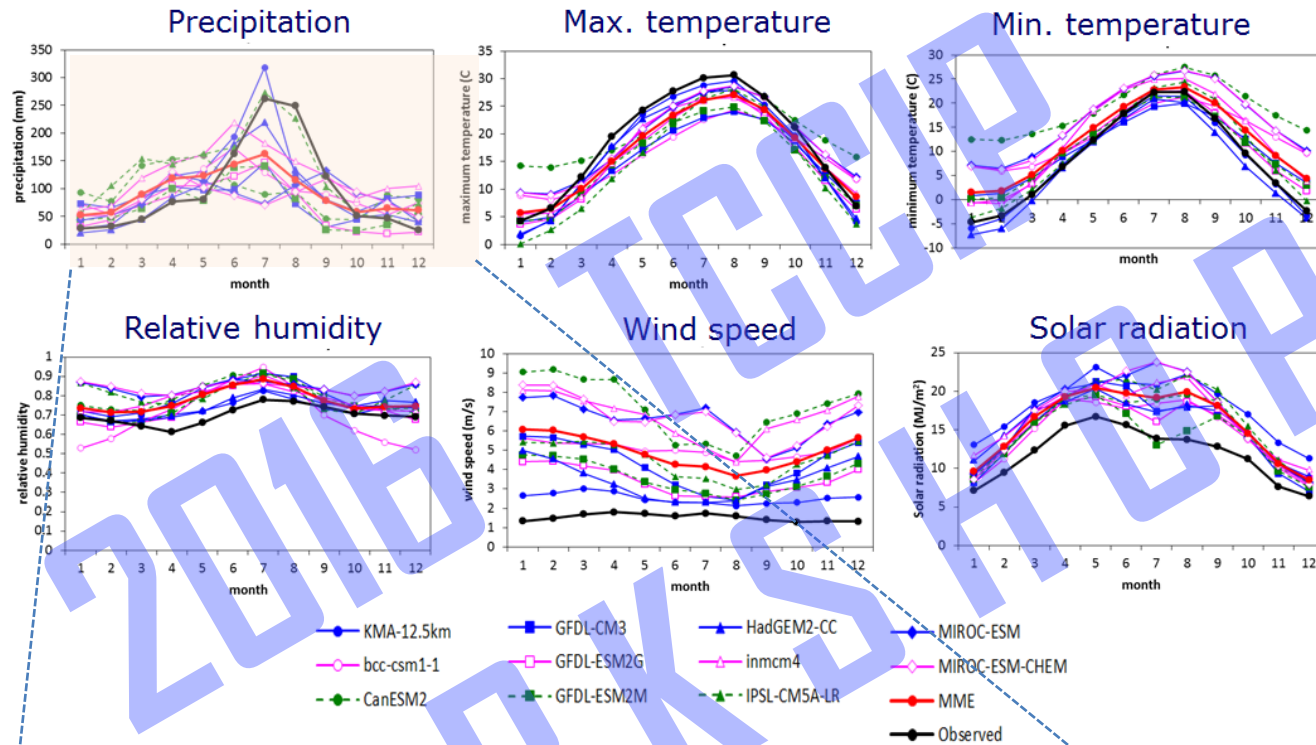
- Precipitation
- Min. temperature
- Max. temperature
- Wind speed
- Relative humidity
- Solar radiation

➔ Downscaling is required



# Temporal comparison of monthly mean values

## ❖ Jeonju (1976~2005, Before Bias-Correction)



Historical (1976~2005)  
after Bias-Correction

?

Future (XXXX~XXXX)  
after Bias-Correction

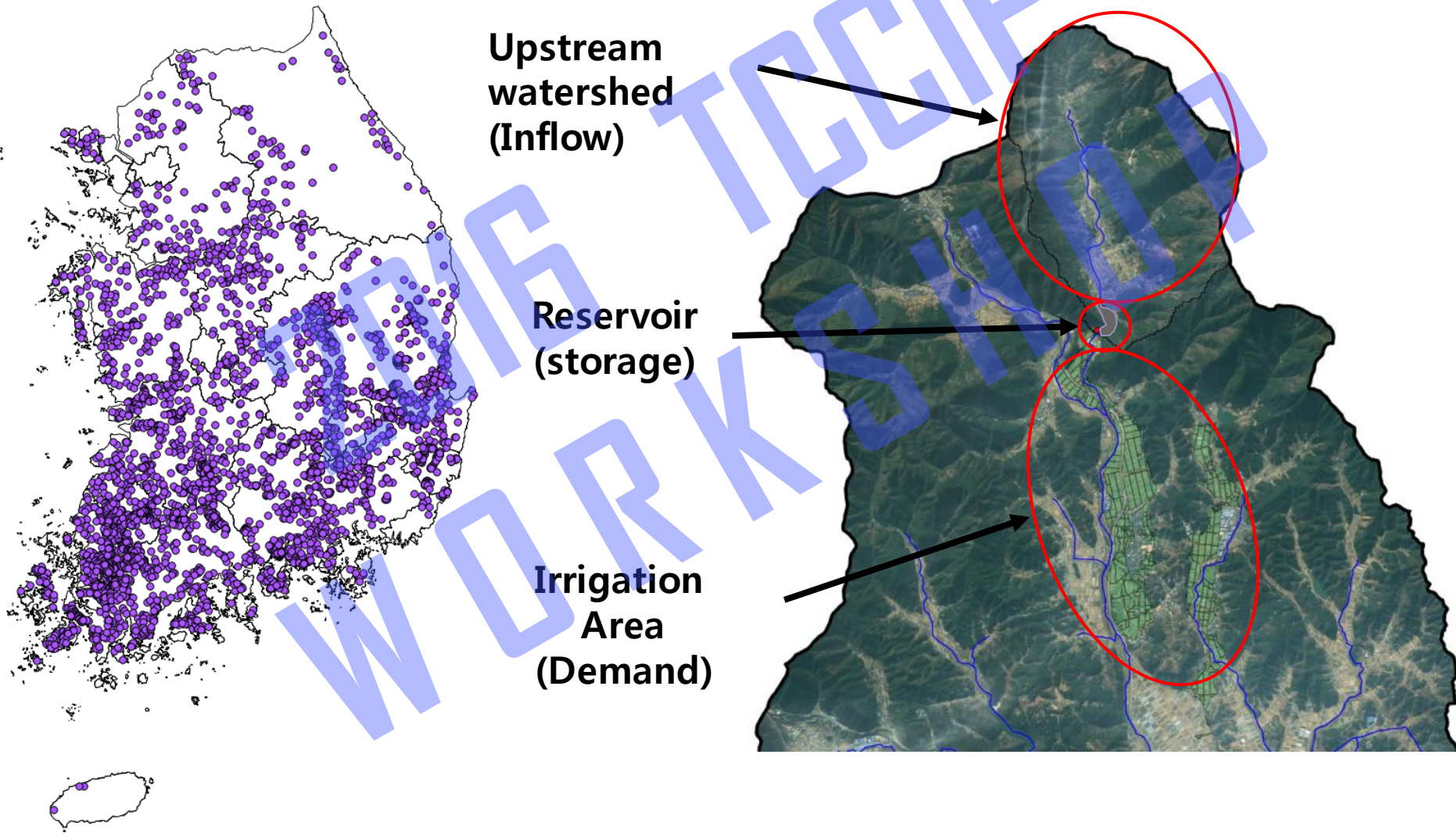
?

➔ Bias Correction (BC) is necessary



# Selected Agricultural Reservoirs

- ❖ 3372 reservoirs managed by Korea Rural Community Corporation (KRC) were selected



# Available Models in CMIP5 Data Portal

❖ <http://cmip-pcmdi.llnl.gov/cmip5/availability.html>

- 28 Modeling Centers and 61 Models

Availability  
Data Portal  
FAQs

For Data Providers +  
More Info +  
CMIP5 Status  
CMIP5 Errata  
CMIP5 Publications  
Obs4MIPs Wiki  
Contact

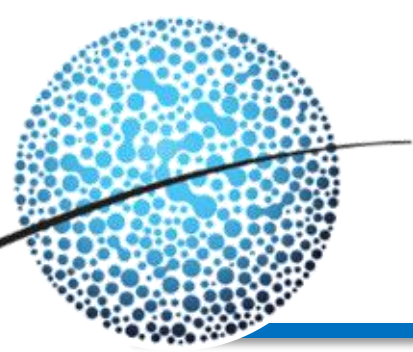
Important information concerning some models and simulations can be found by clicking on the "Modeling Center" name.

Modeling Center	Model	Institution	terms of use
BCC	BCC-CSM1.1 BCC-CSM1.1(m)	Beijing Climate Center, China Meteorological Administration	unrestricted
CCCma	CanAM4 CanCM4 CanESM2	Canadian Centre for Climate Modelling and Analysis	unrestricted
CMCC	CMCC-CESM CMCC-CM CMCC-CMS	Centro Euro-Mediterraneo per I Cambiamenti Climatici	unrestricted
<a href="#">CNRM-CERFACS</a>	CNRM-CM5	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique	unrestricted
<a href="#">CNRM-CERFACS</a>	CNRM-CM5-2	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique	unrestricted
<a href="#">COLA and NCEP</a>	CFSv2-2011	Center for Ocean-Land-Atmosphere Studies and National Centers for Environmental Prediction	unrestricted
<a href="#">CSIRO-BOM</a>	ACCESS1.0 ACCESS1.3	CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia), and BOM (Bureau of Meteorology, Australia)	unrestricted
<a href="#">CSIRO-QCCCE</a>	CSIRO-Mk3.6.0	Commonwealth Scientific and Industrial Research Organisation in collaboration with the Queensland Climate Change Centre of Excellence	unrestricted
EC-EARTH	EC-EARTH	EC-EARTH consortium	unrestricted
FIO	FIO-ESM	The First Institute of Oceanography, SOA, China	unrestricted
<a href="#">GCESS</a>	<a href="#">BNU-ESM</a>	College of Global Change and Earth System Science, Beijing Normal University	unrestricted
INM	INM-CM4	Institute for Numerical Mathematics	unrestricted
<a href="#">IPSL</a>	IPSL-CM5A-LR IPSL-CM5A-MR IPSL-CM5B-LR	Institut Pierre-Simon Laplace	unrestricted
LASG-CESM	FGOALS-g2	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences; and CESM, Tsinghua University	unrestricted
LASG-IAP	FGOALS-g1 FGOALS-s2	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences	unrestricted
MIROC	MIROC4h MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	non-commercial only
MIROC	MIROC-ESM MIROC-ESM-CHEM	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	non-commercial only
MOHC (additional)	HadCM3 HadCM3Q HadGEM2-A	Met Office Hadley Centre (additional HadGEM2-ES realizations)	unrestricted

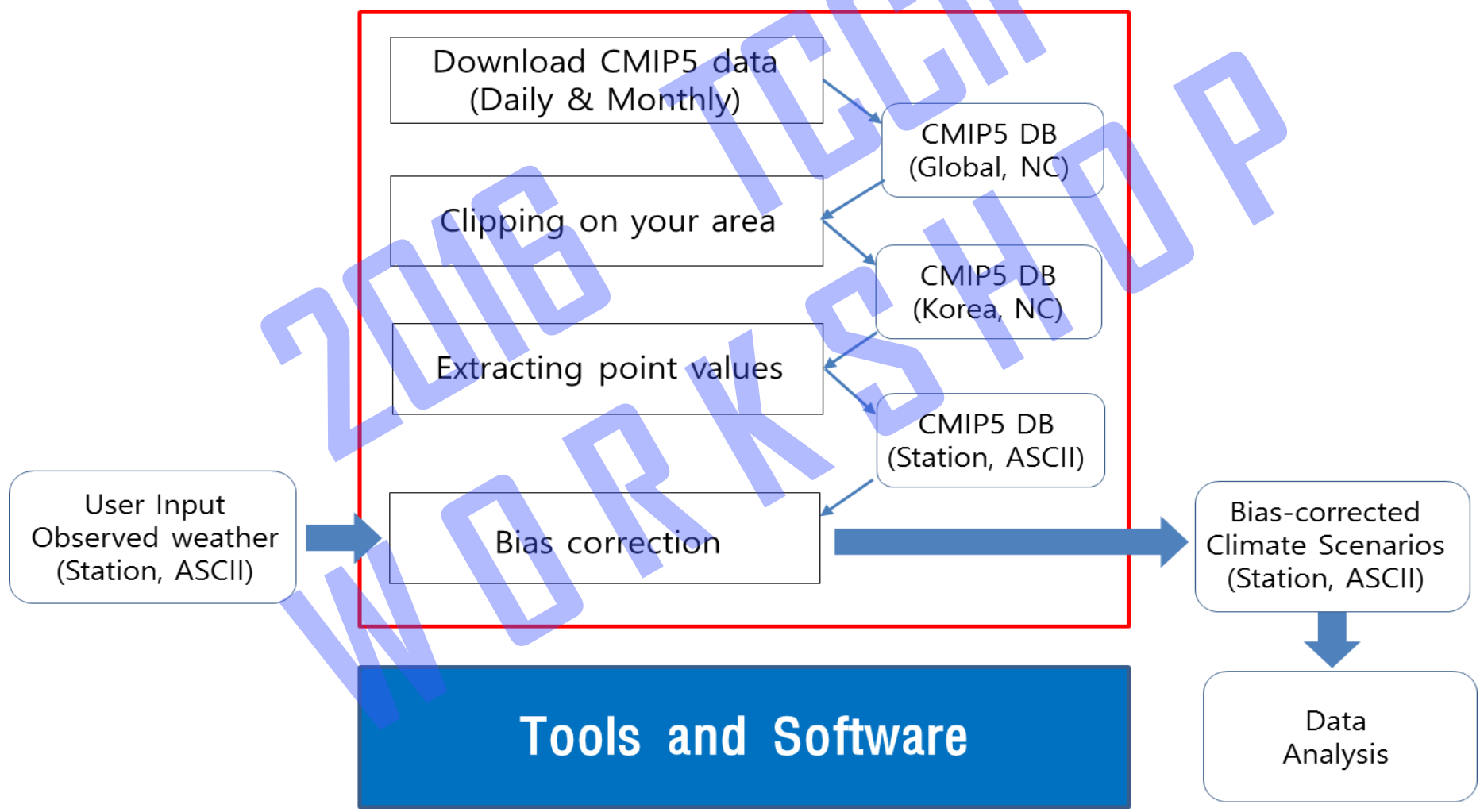
# Selected GCMs and variables

- 14 GCMs
- 6 variables: Precipitation, Temperature (Min. & Max.), Relative humidity, Wind speed, Solar radiation

NO	Models	Historical		RCP4.5		RCP8.5	
		Monthly	Daily	Monthly	Daily	Monthly	Daily
1	BNU-ESM	○		○		○	
2	IPSL-CM5A-MR	○		○		○	
3	IPSL-CM5B-LR	○		○		○	
4	MIROC5	○		○		○	
5	MRI-CGCM3	○		○		○	
6	bcc-csm1-1	○	○	○		○	○
7	MIROC-ESM-CHEM	○	○	○	○	○	○
8	MIROC-ESM	○	○	○	○	○	○
9	IPSL-CM5A-LR	○	○			○	○
10	CanESM2		○		○		○
11	GFDL-ESM2G		○		○		○
12	GFDL-ESM2M		○		○		○
13	HadGEM2-CC		○		○		○
14	inmcm4		○		○		○



# Statistical downscaling and Analysis of precipitation index

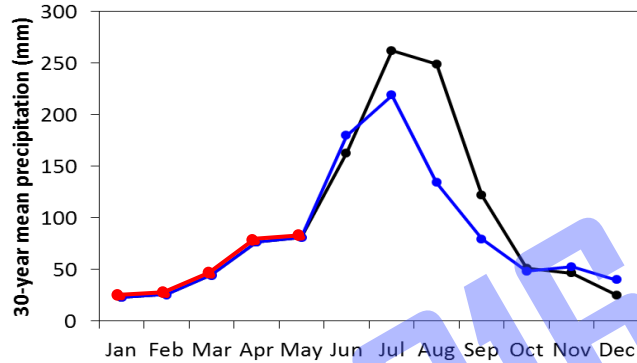




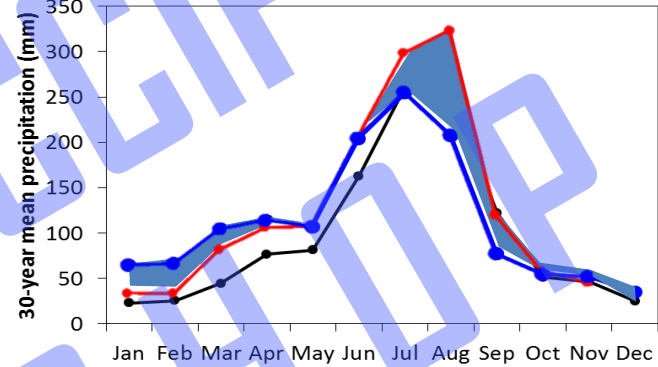
# Downscaling of Daily CMIP5 Data

## ❖ Non-parametric Quantile Mapping methods

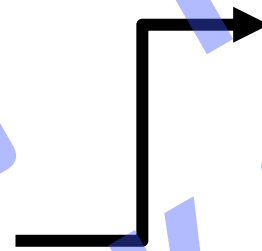
### Historical (1976~2005)



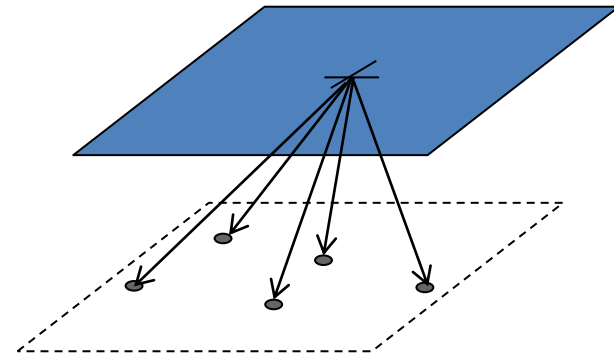
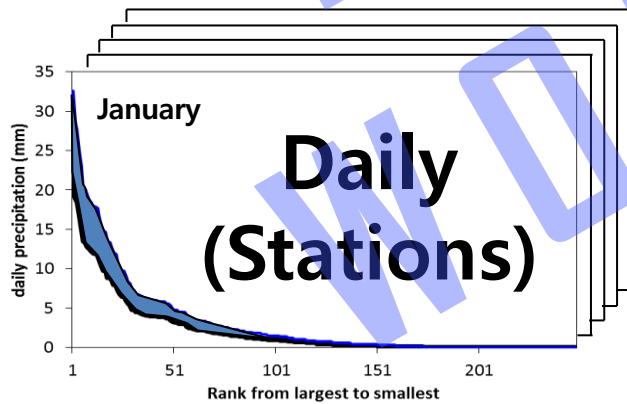
### Future (2011~2040)



- Observed or Historical
- Before quantile mapping
- Quantile mapping information
- After quantile mapping

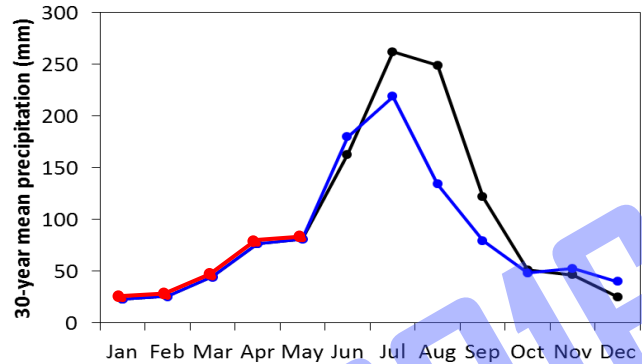


## Non-parametric Quantile Mapping methods



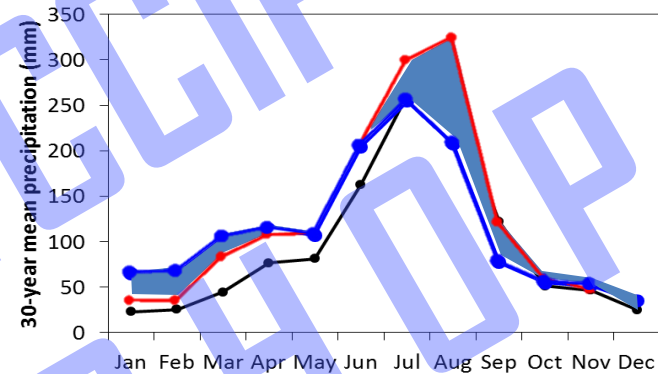
# Downscaling of Monthly CMIP5 Data

## Historical (1976~2005)

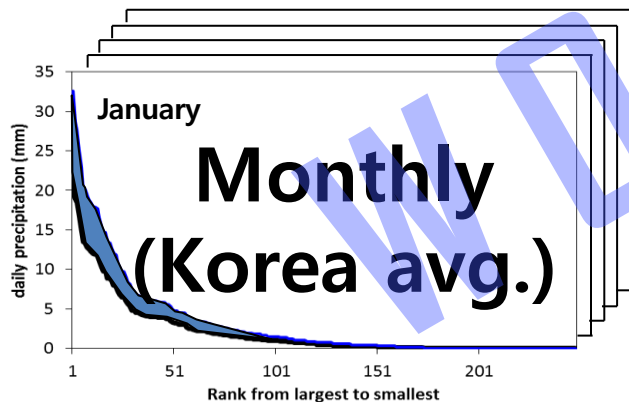


- Observed or Historical
- Before quantile mapping
- Quantile mapping information
- After quantile mapping

## Future (2011~2040)



Temporal  
Downscaling



# Temporal downscaling (Monthly to daily)

GCM's Korea avg.

Ovserved Korea avg.

yearmon	prec	t2m
Jan-83	0.623	-2.182
Feb-83	1.622	2.326
Mar-83	1.452	7.280
Apr-83	3.505	11.880
May-83	2.701	
Jun-83	3.572	
Jul-83	8.453	
Aug-83	9.573	24.114
Sep-83	7.755	20.920
Oct-83	2.115	14.774
Nov-83	2.419	6.643
Dec-83	0.221	1.669
Jan-84	0.189	-1.225
Feb-84	0.017	0.270
Mar-84	0.912	3.338

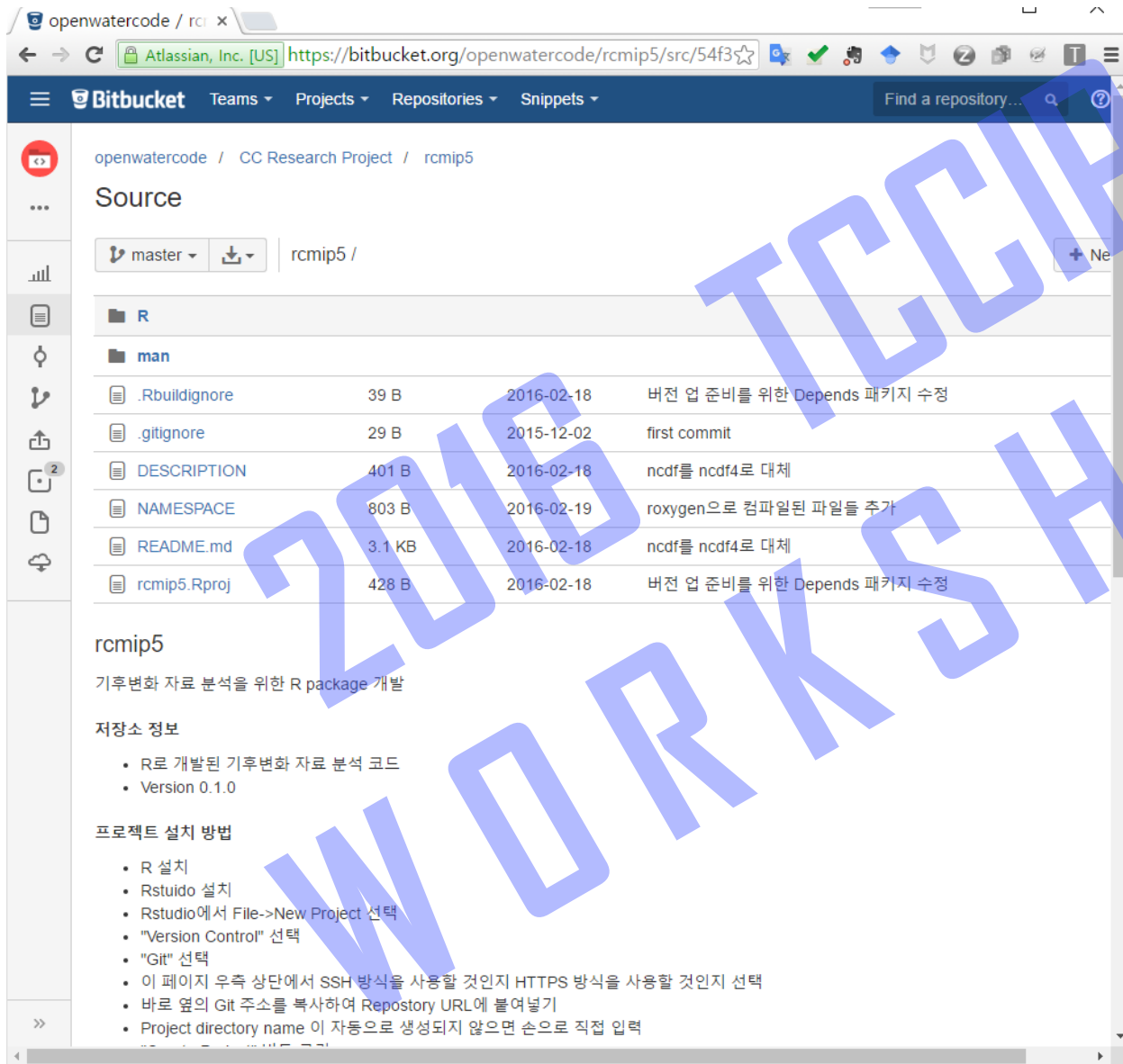
Jan-81

Mahalanobis distance  
= f(prec, t2m)

yearmon	prec	t2m
Jan-73	0.673	-1.631
Feb-73	1.789	2.631
Mar-73	1.428	7.052
Apr-73	3.586	12.139
May-73	2.619	17.243
Jun-73	3.681	21.332
Jul-73	7.041	23.314
Aug-73	8.509	24.722
Sep-73	7.145	20.680
Oct-73	2.092	14.745
Nov-73	2.375	7.133
Dec-73	0.151	1.442
.	0.076	-1.409
.	0.123	-0.368
Jan-11	0.997	-1.826
Feb-11	2.313	1.354
Mar-11	2.659	5.750
Apr-11	0.904	12.704
May-11	4.124	17.254
Jun-11	6.330	20.626
Jul-11	10.191	25.146
Aug-11	4.078	27.135
Sep-11	6.269	20.657
Oct-11	3.736	14.392
Nov-11	0.783	8.224
Dec-11	0.972	1.381

								ID135
date	prcp	tmax	tmin	wspd	rhum	rsds		ID136
1981								ID137
1981								
1981	1981	date	prcp	tmax	tmin	wspd	rhum	rsds
1981	1981	1981-01-01	0.8	1.4	-2.8	3.81	0.62	2.5
1981	1981	1981-01-02	0	-1.7	-7.9	9.43	0.47	5
1981	1981	1981-01-03	0	-3.2	-9.7	9.61	0.39	5.4
1981	1981	1981-01-04	0	-1.5	-9.7	5.05	0.34	7.1
1981	1981	1981-01-05	0	-2.7	-9.2	7.61	0.26	5.4
1981	1981	1981-01-06	0	0.8	-8.8	7.07	0.27	8.1
1981	1981	1981-01-07	0	3.6	-4.4	6.43	0.26	7.1
1981	1981	1981-01-08	0	6.4	-3	4.35	0.36	8
1981	1981	1981-01-09	0	7	-2.8	7.98	0.46	8.3
1981	1981	1981-01-10	0	0	-7	6.35	0.41	6.2
1981	1981	1981-01-11	0	0	-8.8	7.96	0.44	7.8
1981	1981	1981-01-12	0	0.8	-5.5	6.59	0.35	5.4
1981	1981	1981-01-13	0	-1.4	-8.4	5.18	0.39	6.3
1981	1981	1981-01-14	0	0.6	-10.4	3.1	0.45	8.9
1981	1981	1981-01-15	15.9	-1.7	-6	2.7	0.81	2.8
1981	1981	1981-01-16	0.1	0.3	-6.2	2.65	0.71	5.7
1981	1981	1981-01-17	0	2.6	-6.9	3.03	0.51	8.5
1981	1981	1981-01-18	0	3.2	-4.5	4.52	0.48	7.1
1981	1981	1981-01-19	0	0.9	-6.4	2.88	0.64	6.8
1981	1981	1981-01-20	0	2.4	-5.4	4.58	0.39	7.4
1981	1981	1981-01-21	0	0.3	-6.4	4.36	0.44	6.2
1981	1981	1981-01-22	0	-0.2	-9.1	2.43	0.5	8.5
1981	1981	1981-01-23	0	2.8	-6.7	1.52	0.58	9
1981	1981	1981-01-24	0	3.1	-1.5	3.16	0.72	3.4
1981	1981	1981-01-25	0	2.4	-4.6	3.82	0.62	6.9
1981	1981	1981-01-26	0	-0.2	-7.9	3.02	0.47	7.9
1981	1981	1981-01-27	0	0.6	-6.1	3.12	0.41	6.6
1981	1981	1981-01-28	0	3.1	-6.5	2.71	0.46	9.4
1981	1981	1981-01-29	0	4.2	-4.1	3.8	0.48	8.6
1981	1981	1981-01-30	0	5.6	-6.3	2.69	0.5	10
1981	1981	1981-01-31	0	3.2	-5.8	1.93	0.53	9.3

# Downscaling package (rcmip5) in R



The screenshot shows the Bitbucket web interface for the repository 'rcmip5'. The page displays a list of files and folders, including a table of file details. Below the file list, there is a description of the project and instructions for installation.

File Name	Size	Commit Date	Commit Message
R			
man			
.Rbuildignore	39 B	2016-02-18	버전 업 준비를 위한 Depends 패키지 수정
.gitignore	29 B	2015-12-02	first commit
DESCRIPTION	401 B	2016-02-18	ncdf를 ncdf4로 대체
NAMESPACE	803 B	2016-02-19	roxygen으로 컴파일된 파일들 추가
README.md	3.1 KB	2016-02-18	ncdf를 ncdf4로 대체
rcmip5.Rproj	428 B	2016-02-18	버전 업 준비를 위한 Depends 패키지 수정

**rcmip5**  
기후변화 자료 분석을 위한 R package 개발

**저장소 정보**

- R로 개발된 기후변화 자료 분석 코드
- Version 0.1.0

**프로젝트 설치 방법**

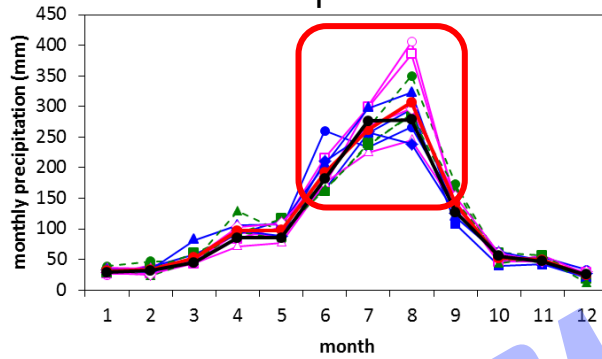
- R 설치
- Rstudio 설치
- Rstudio에서 File->New Project 선택
- "Version Control" 선택
- "Git" 선택
- 이 페이지 우측 상단에서 SSH 방식을 사용할 것인지 HTTPS 방식을 사용할 것인지 선택
- 바로 옆의 Git 주소를 복사하여 Repository URL에 붙여넣기
- Project directory name 이 자동으로 생성되지 않으면 손으로 직접 입력



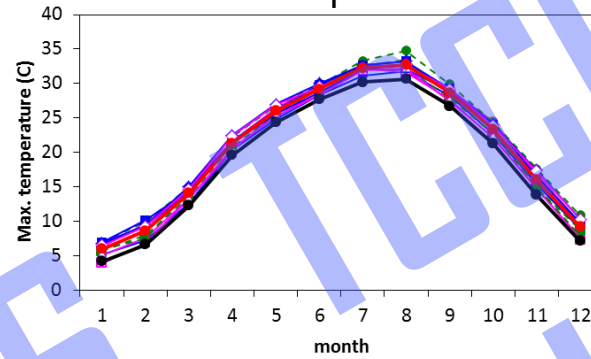
# Uncertainties of weather variables after bias correction

## ❖ RCP8.5 (2011~2040, Jeonju)

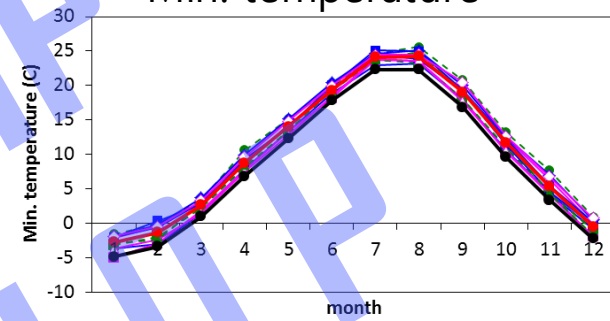
### Precipitation



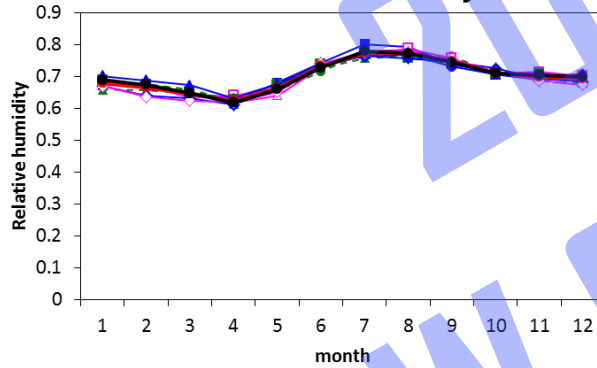
### Max. temperature



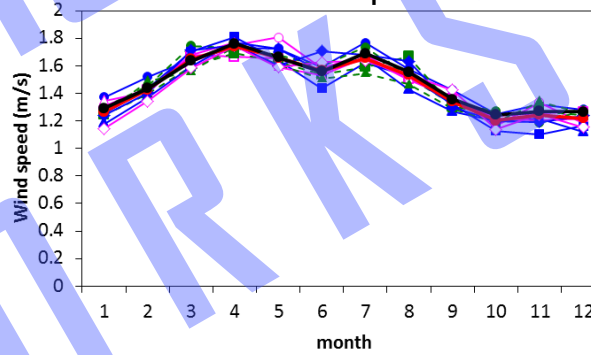
### Min. temperature



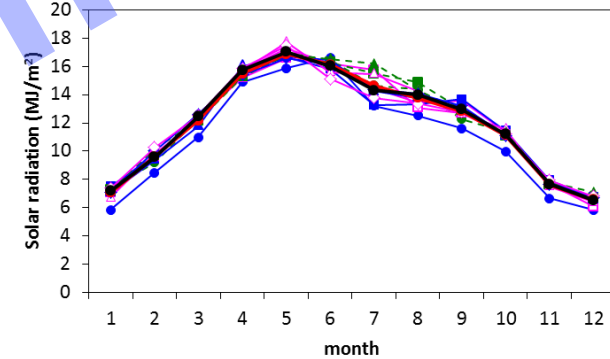
### Relative humidity



### Wind speed



### Solar radiation



—●— KMA-12.5km

—■— GFDL-CM3

—▲— HadGEM2-CC

—◆— MIROC-ESM

—○— bcc-csm1-1

—□— GFDL-ESM2G

—△— Inmcm4

—◇— MIROC-ESM-CHEM

—●— CanESM2

—■— GFDL-ESM2M

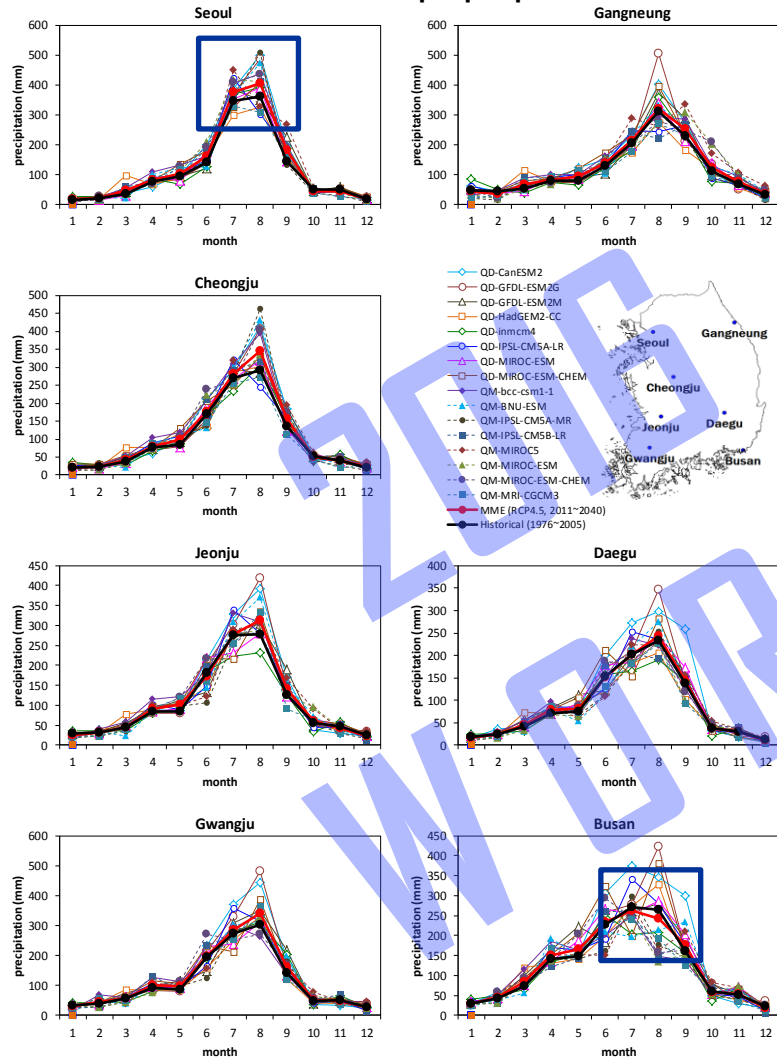
—▲— IPSL-CM5A-LR

—●— MME

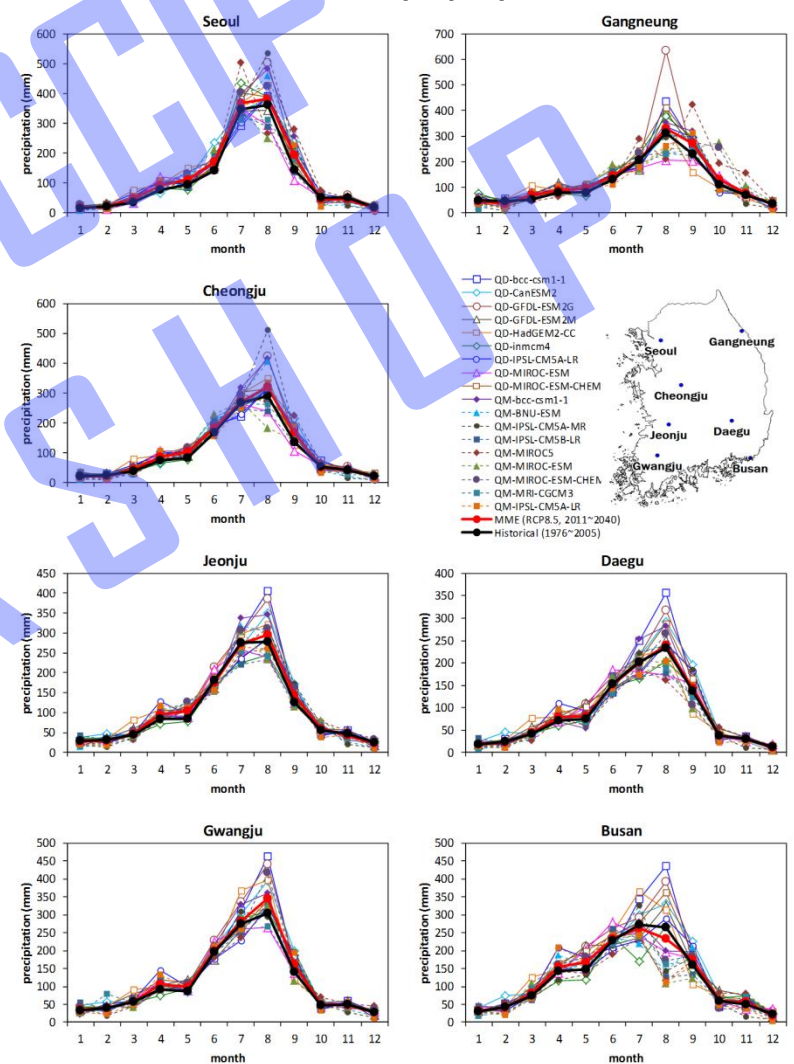
—●— Historical

# Spatial pattern of monthly precipitation changes

## RCP4.5 시나리오



## RCP8.5 시나리오



# Precipitation index

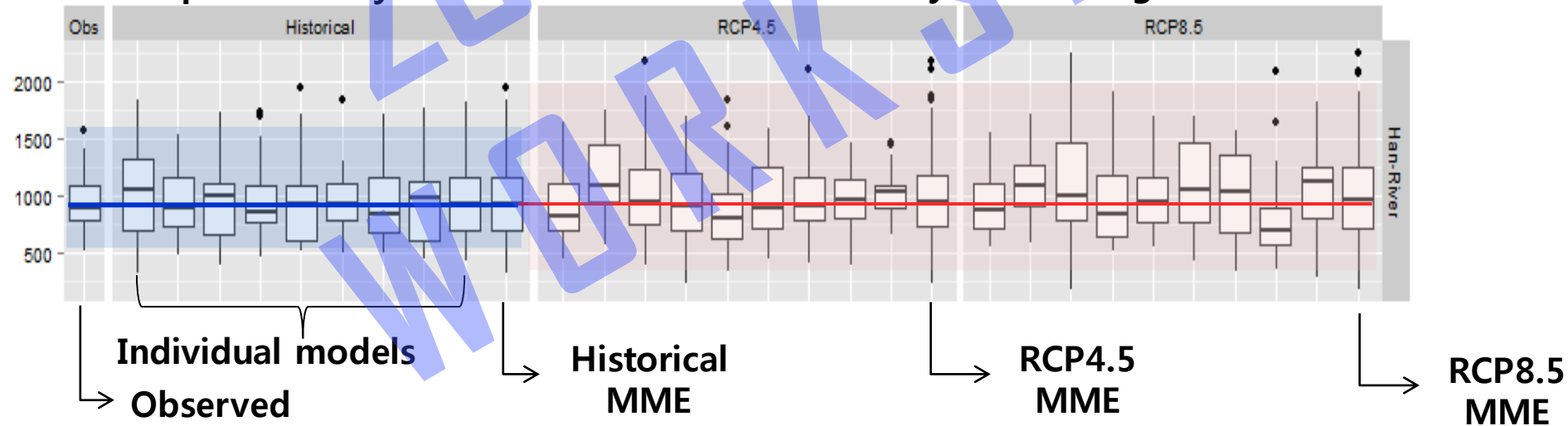
- ❖ Wet season(Jun~Sep) precipitation
- ❖ Max. daily precipitation
- ❖ Number of days daily precipitation  $\geq 80\text{mm}$
- ❖ Dry season(Oct~May) precipitation
- ❖ Maximum number of consecutive dry days

Flood

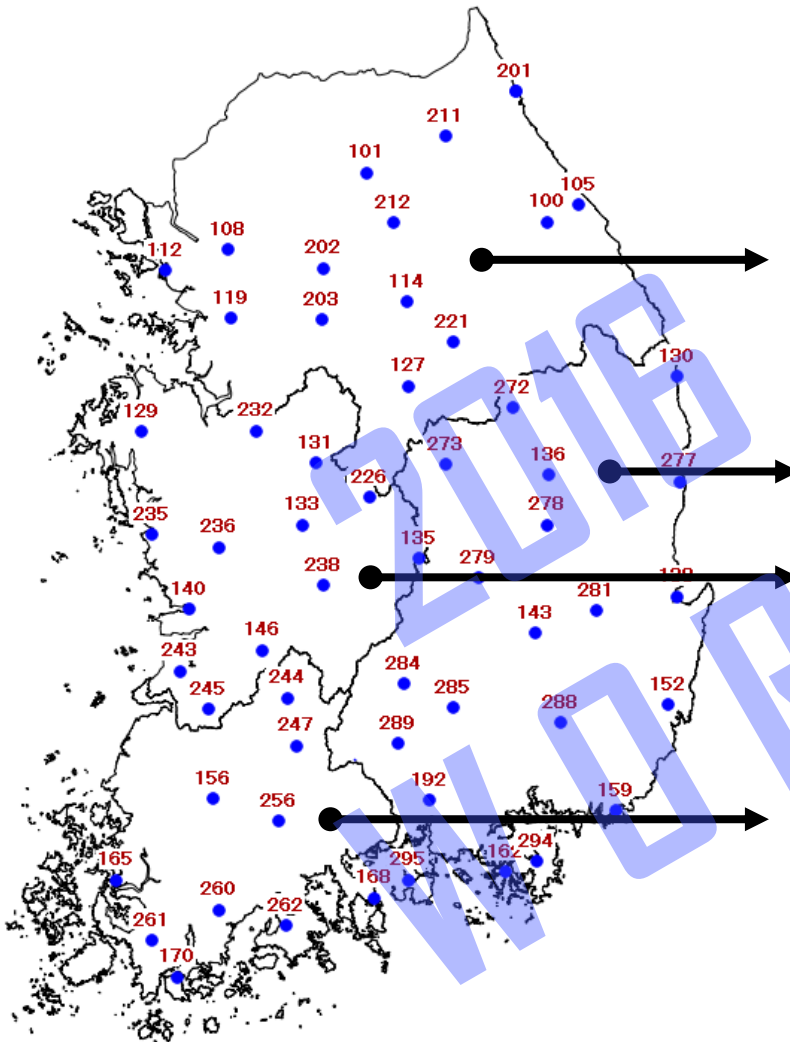
Drought

Reproducibility

Uncertainty & % Change



# 4-River Basins



Han-River Basin  
(15 stations)

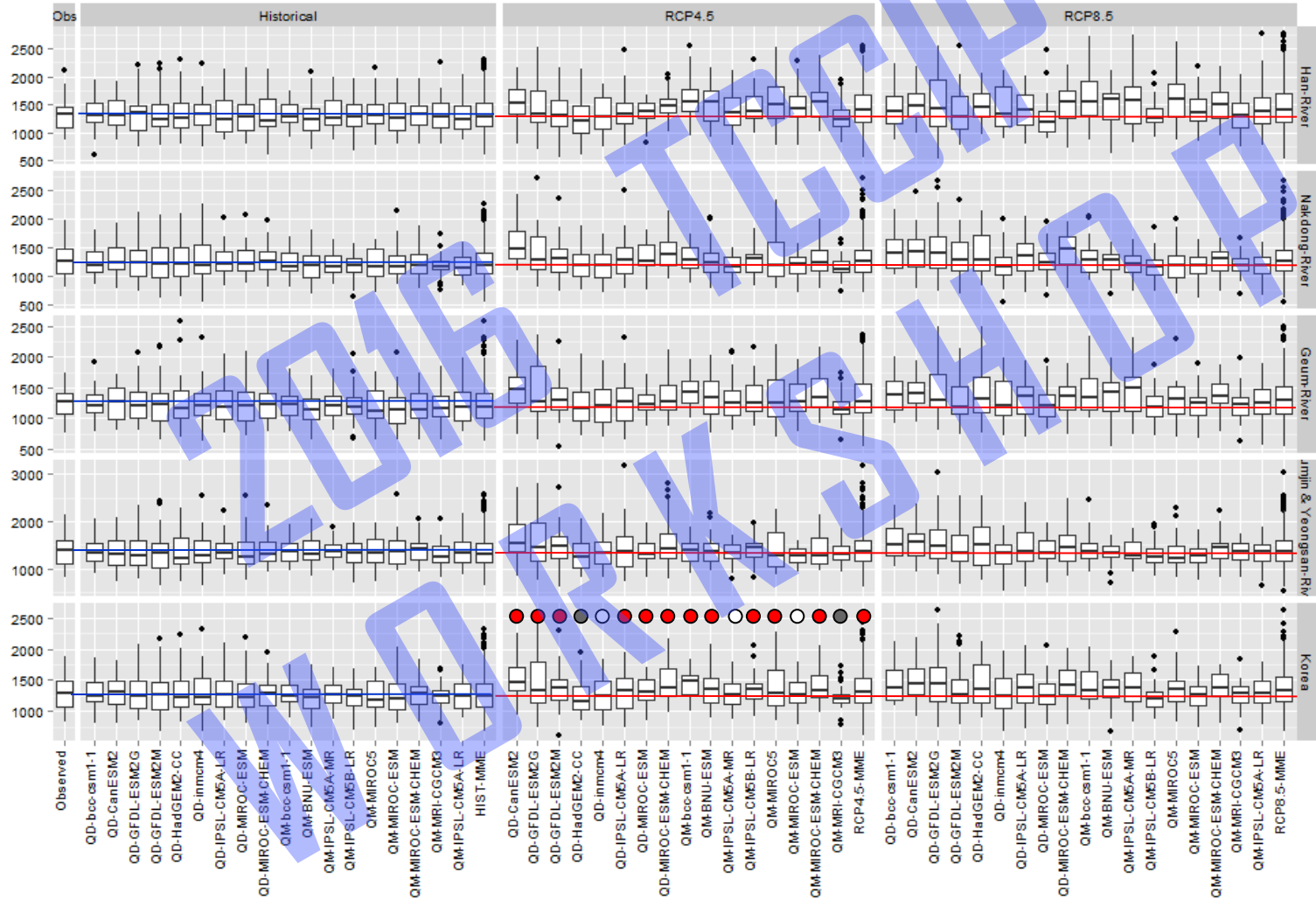
Nakdong-River Basin  
(21 stations)

Geum-River Basin  
(13 stations)

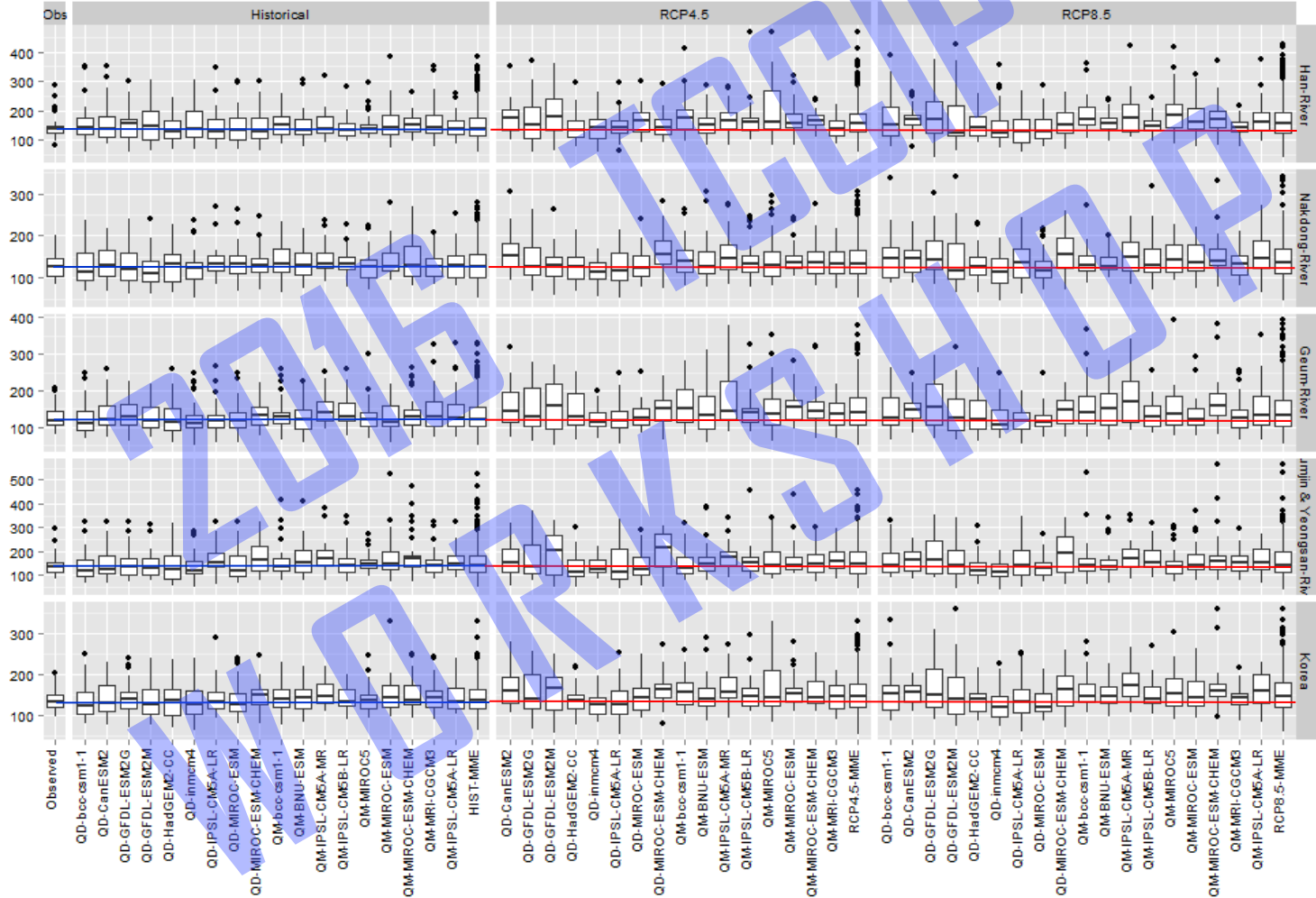
Sumjin/Yeongsan-River Basin  
(10 stations)



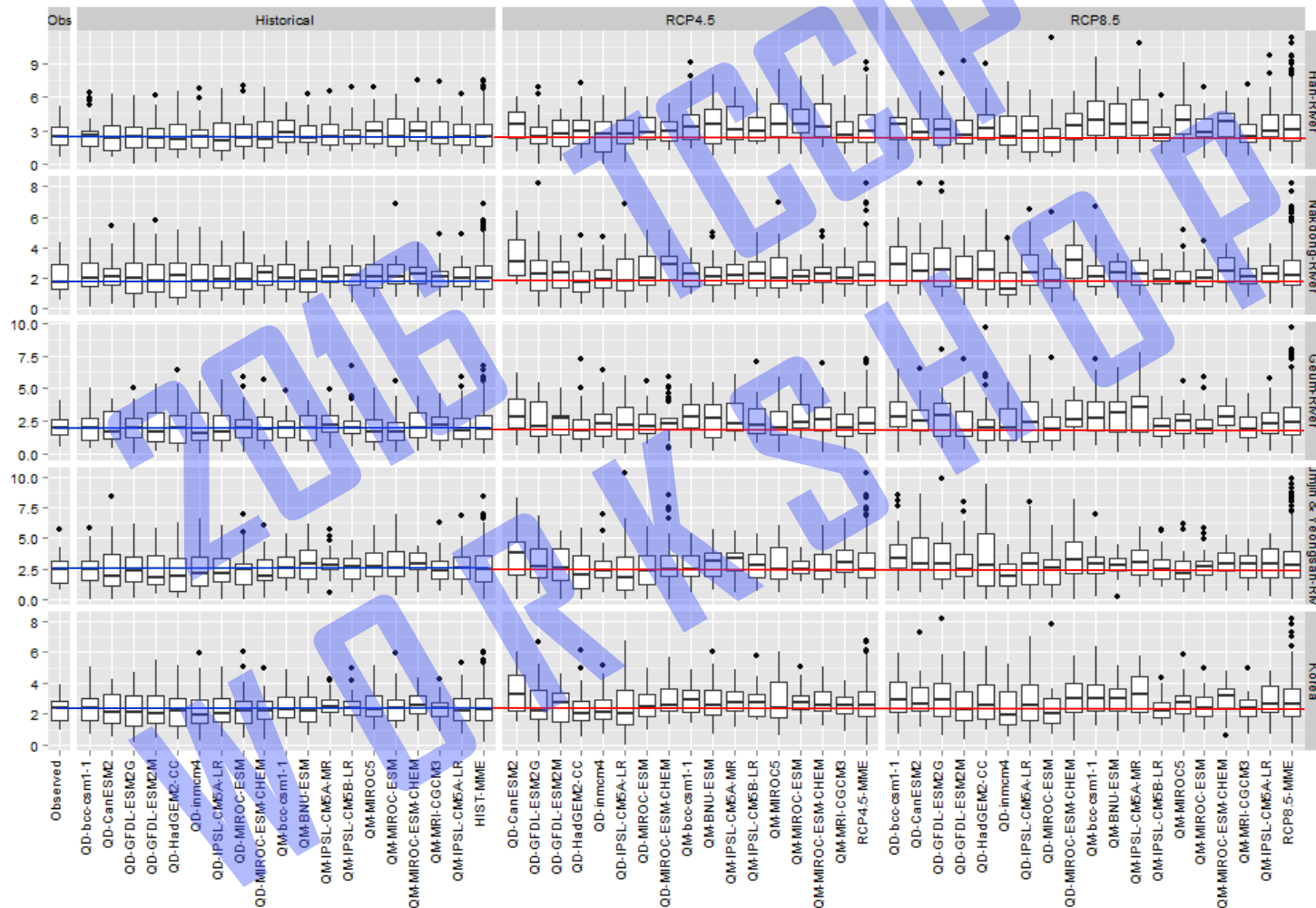
# Annual precipitation amount



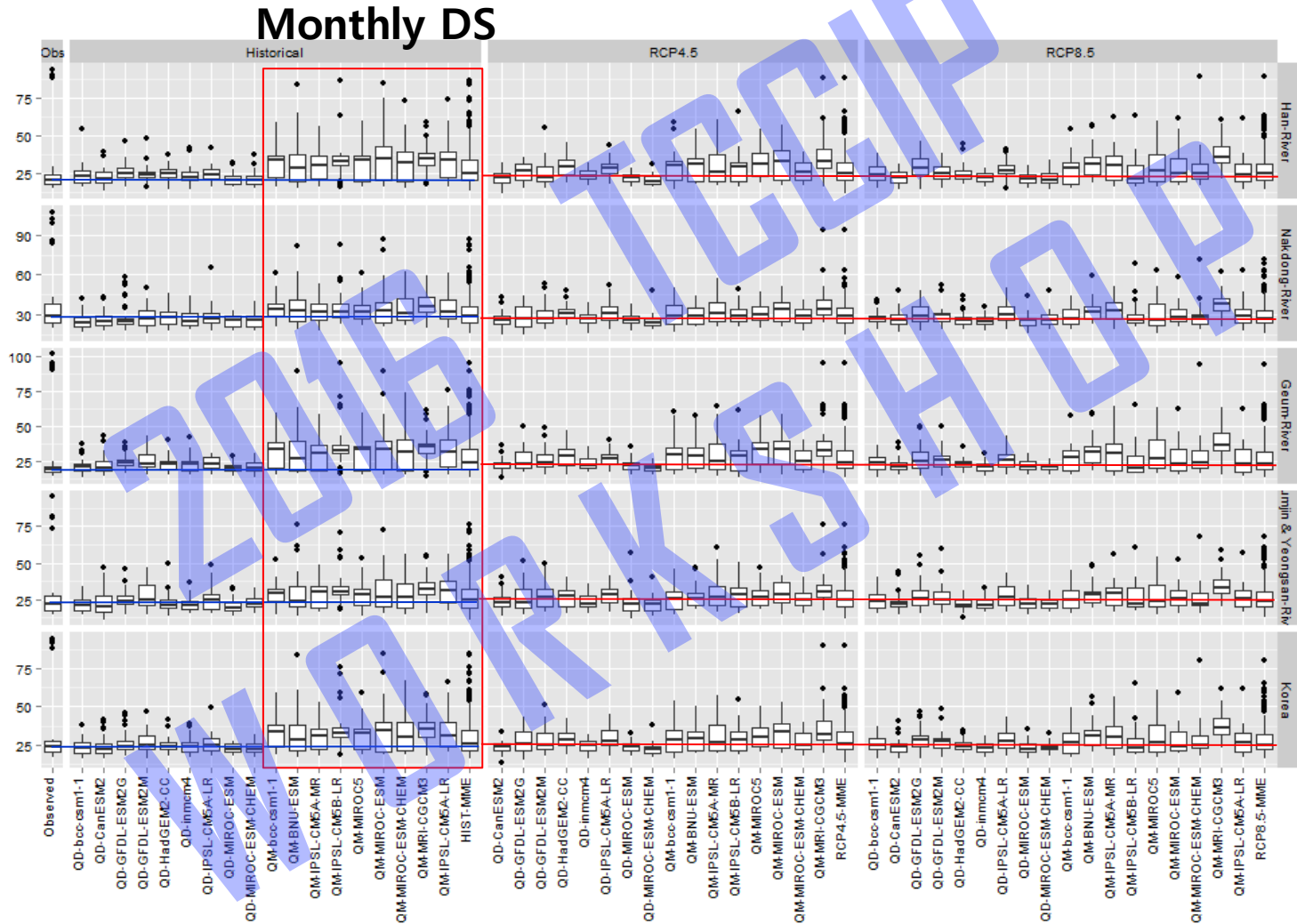
# Daily maximum precipitation (mm)



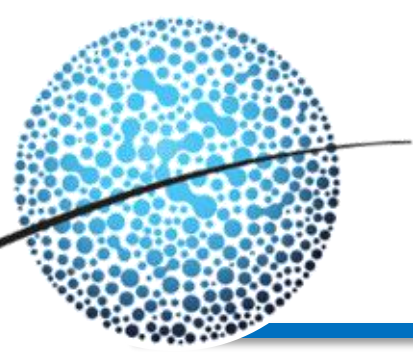
# Number of days daily precipitation $\geq 80\text{mm}$



# Maximum number of consecutive dry days







# Assessment of Climate Change Impact on Agricultural Reservoirs

## ❖ Hydrological Operation Model for Water Resources System (HOMWRS)

The screenshot displays two main panels in the HOMWRS software interface:

### Reservoir Selection Panel

**저수지 선택 (Reservoir Selection)**

- 유역 (Basin)
  - 대권역 (Large Basin): [Dropdown]
  - 중권역 (Medium Basin): [Dropdown]
  - 소권역 (Small Basin): [Dropdown]
- 관리구역 (Management Area)
  - 도분부 (Province/Division): 충청북도 (Chungcheongbuk-do)
  - 지사 (City): 홍주시 (Hongju-si)
  - 관개구역 (Irrigation Area): [Dropdown]

표준코드 (Standard Code)	시설명 (Facility Name)	관리자(공사) (Manager/Company)
4313010082	장저울	홍주, 제천, 단양지사
4313010024	중산	홍주, 제천, 단양지사
4313010046	진굴	홍주, 제천, 단양지사
4313010068	추평	홍주, 제천, 단양지사
4313010022	한두골	홍주, 제천, 단양지사
4313010002	호암	홍주, 제천, 단양지사
4313010014	화곡	홍주, 제천, 단양지사
4313010028	곡평	홍주, 제천, 단양지사

Buttons: 전체선택 (Select All), 선택취소 (Cancel Selection)

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### Climate Change Information Panel

**기후자료 선택 (Climate Data Selection)**

- 관측자료 (Observed Data)
- 기후변화 시나리오 자료 (Climate Change Scenario Data)
  - 상세화기법 (Detailed Method): QMD
  - GCM 모델 (GCM Model): [Dropdown]

상세화기법 (Detailed Method)	GCM 모델 (GCM Model)	시나리오 (Scenario)
QMD	125km	historical
QMD	125km	rcp45
QMD	125km	rcp85
QMD	bcc-csm1-1	historical
QMD	bcc-csm1-1	rcp85
QMD	CanESM2	historical
QMD	CanESM2	rcp45
QMD	CanESM2	rcp85
QMD	GFDL-CM3	historical
QMD	GFDL-CM3	rcp85
QMD	GFDL-ESM2G	historical
QMD	GFDL-ESM2G	rcp45

Buttons: 전체선택 (Select All), 선택취소 (Cancel Selection)

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**Water Resource Statistics**

- 홍필요수량 (Required Water): 71562034, 30753
- 홍가능수량 (Possible Water): 71562034, 30753
- 홍발필요수량 (Developed Water): 0, 00000
- 홍유효수량 (Effective Water): 46510775, 87869
- 비율 (Ratio): 64, 93365

물수지 분석을 시작합니다. (Start water balance analysis.)  
 저수위: 203, 1875023862  
 저수량: 1558032, 4560565600  
 고갈회수: 10958  
 여유수량: 712367, 5439434420  
 물수지 분석을 종료합니다. (End water balance analysis.)

# Reproducibility for historical period

How well does a climate change scenario reproduce the spatial and temporal pattern during the historical period?

Scenarios	Inflow (mm)	% change
Historical	988.5	
RCP8.5	1078.1	9.1

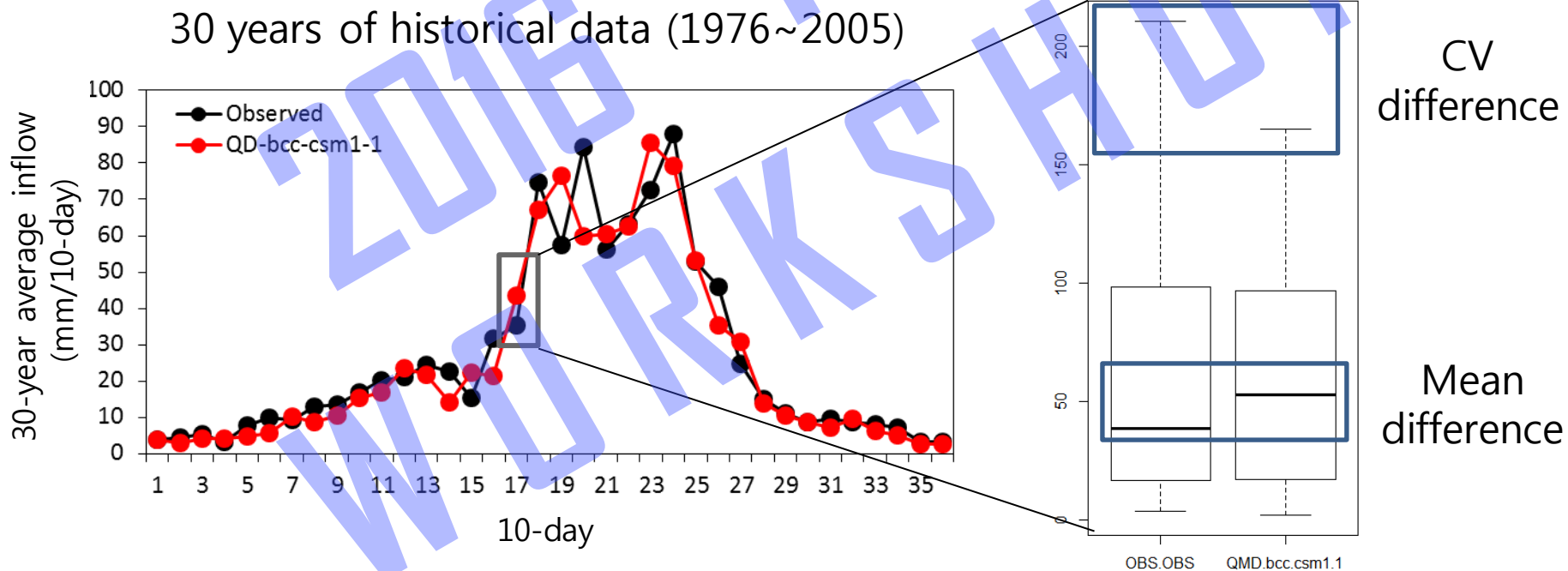
Even though we have same future projection....

- ❖ What should be premised in order to have significant meanings within the future climate change projections?
- ❖ Does scenario-based data reproduce the characteristics of rainfall (extreme, spatial/temporal patterns) during the historical period, compared to the observations ?

**Reproducibility**  
for historical period

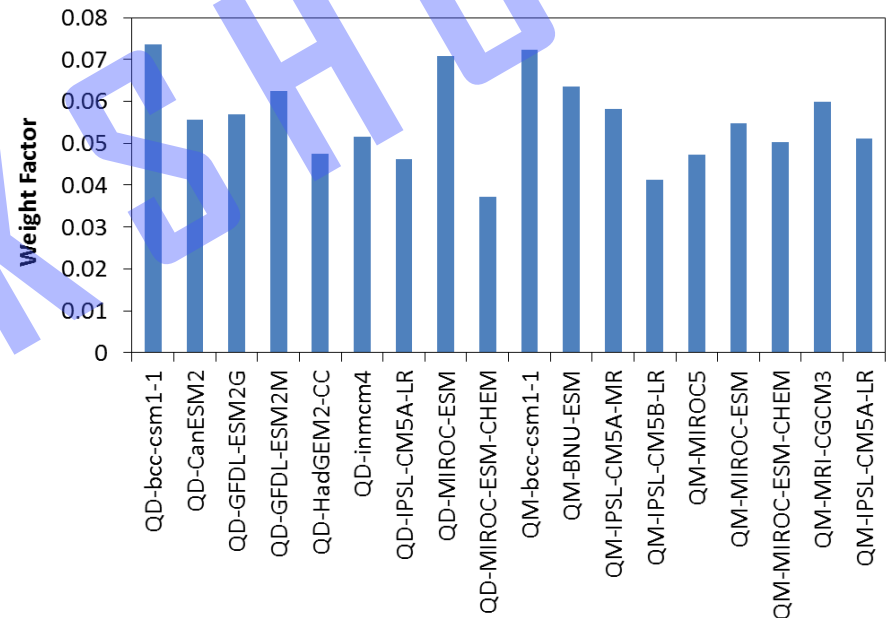
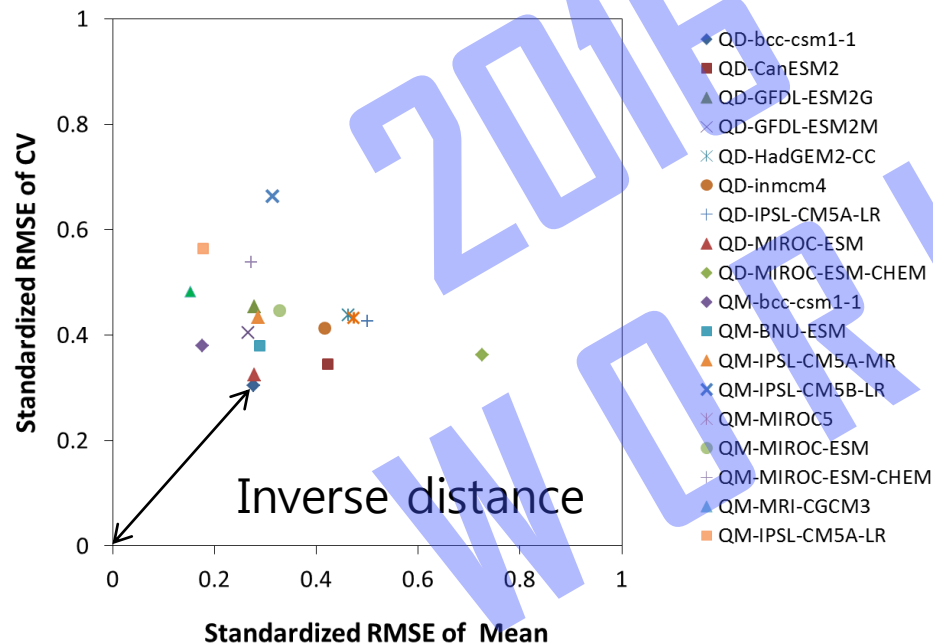
# Considering factors for reproducibility test

- ❖ Comparing observed and modeled (GCM) 10-day inflow, demand, and storage for historical period
- ❖ RMSE in mean and coefficient variation (CV) are used



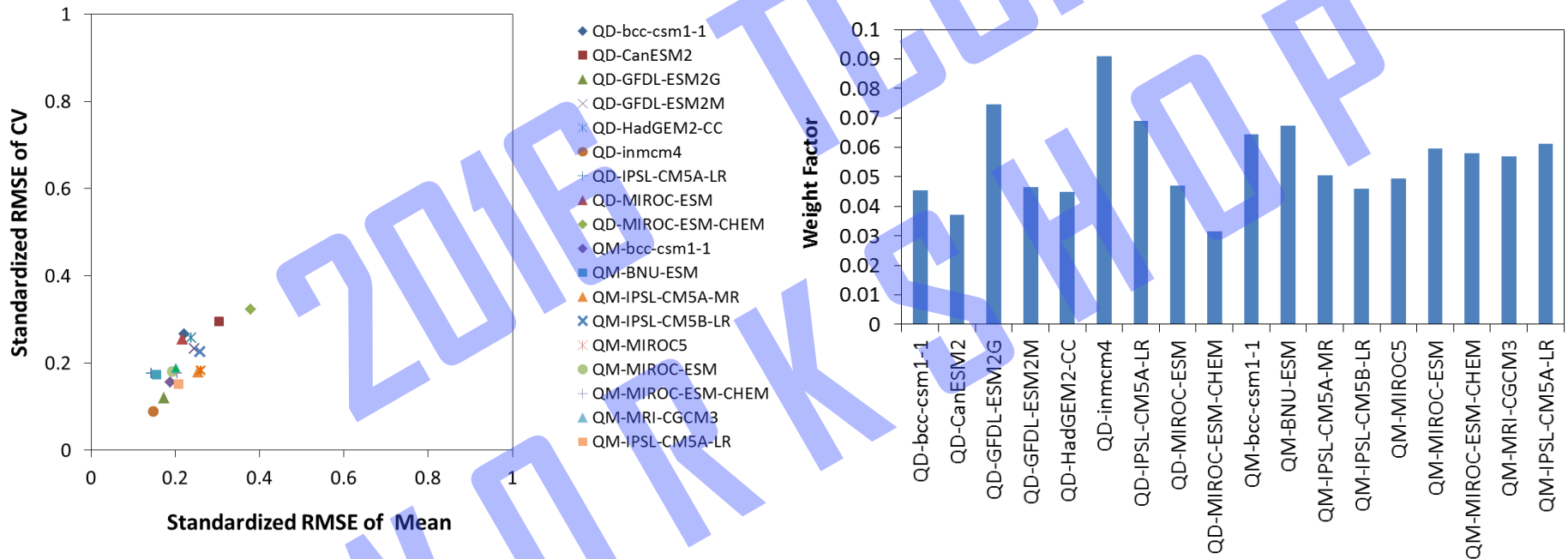
# Weighting factor based on reproducibility

- ❖ Inflow from upstream watershed
  - Standardization using mean and coefficient of variation (CV)
  - Inverse distance weighting factor for MME estimation



# Weighting factor based on reproducibility

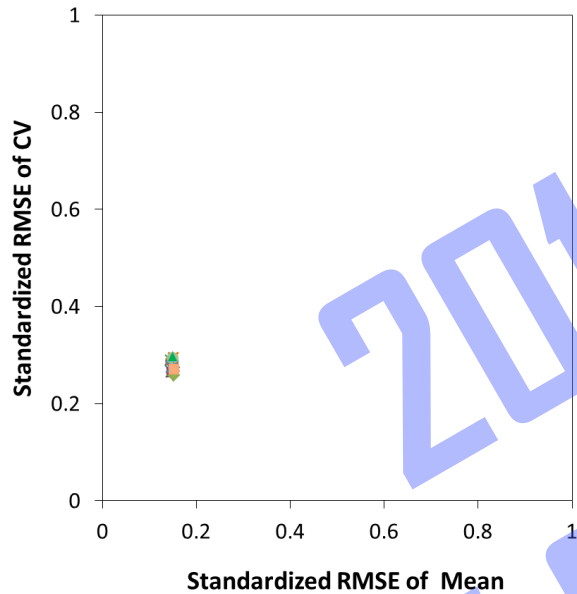
## ❖ Irrigation Water Demands



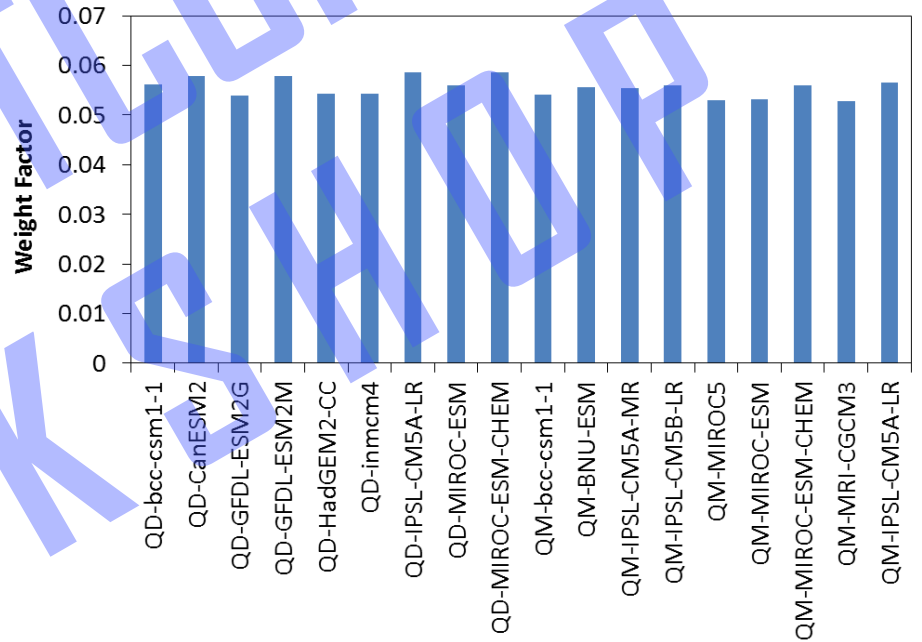


# Weighting factor based on reproducibility

## ❖ Storage

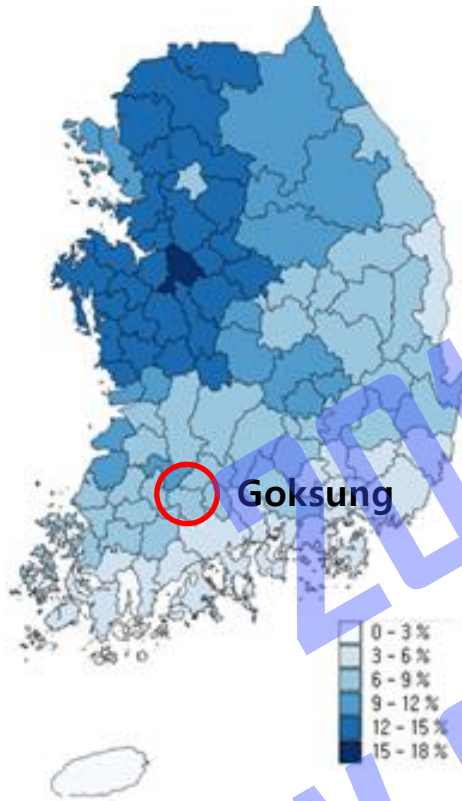



- ◆ QD-bcc-csm1-1
- QD-CanESM2
- ▲ QD-GFDL-ESM2G
- × QD-GFDL-ESM2M
- × QD-HadGEM2-CC
- QD-inmcm4
- + QD-IPSL-CM5A-LR
- ▲ QD-MIROC-ESM
- ◆ QD-MIROC-ESM-CHEM
- ◆ QM-bcc-csm1-1
- QM-BNU-ESM
- ▲ QM-IPSL-CM5A-MR
- × QM-IPSL-CM5B-LR
- × QM-MIROC5
- QM-MIROC-ESM
- + QM-MIROC-ESM-CHEM
- ▲ QM-MRI-CGCM3
- QM-IPSL-CM5A-LR



# Impact Assessment Report at Branch Level

## ❖ Report template for impact assessment



 The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

Inflow

Demand

Storage

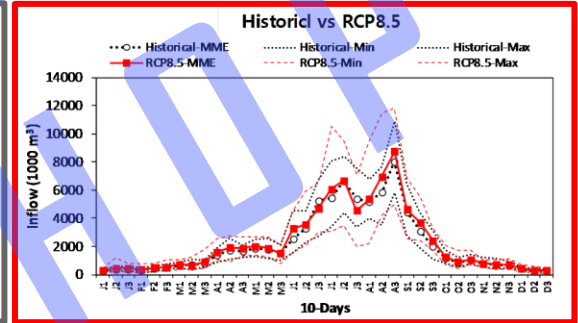
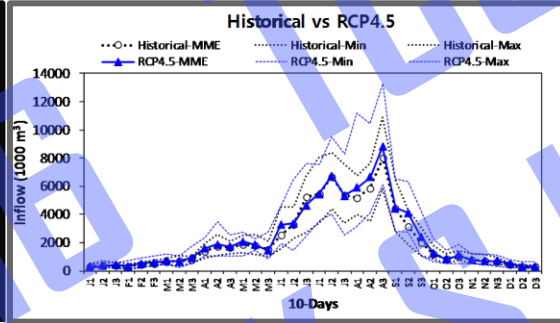
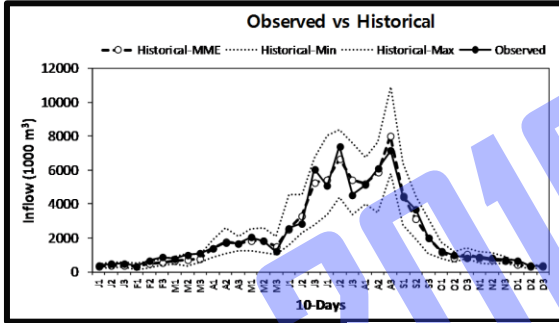
Drought

2016 TCCIP WORKSHOP

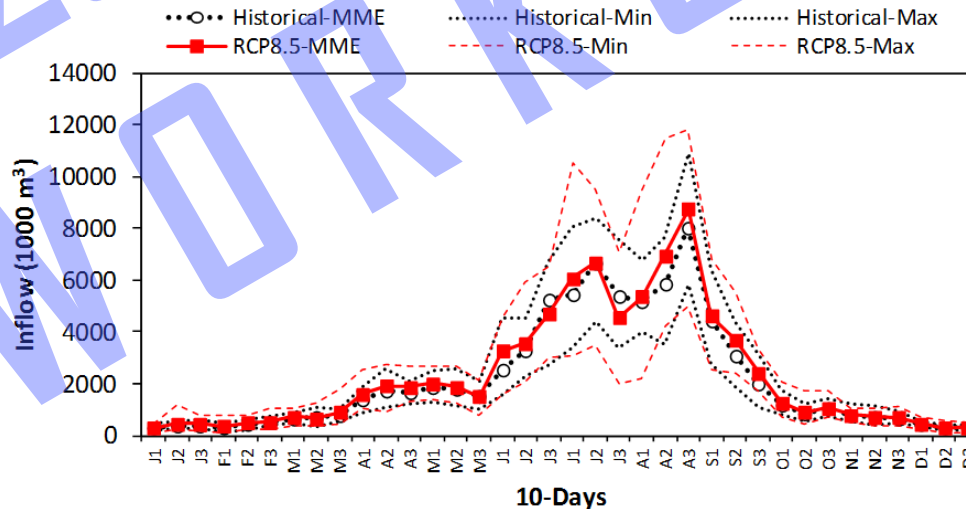
# Impact assessment on 10-day inflow (Goksung)

## 1. 유입량

순(10-Days)	total	J1	J2	J3	F1	F2	F3	M1	M2	M3	A1	A2	A3	M1	M2	M3	J1	J2	J3	J1	J2	J3	A1	A2	A3	S1	S2	S3	O1	O2	O3	N1	N2	N3	D1	D2	D3
Observed Inflow (1000 m <sup>3</sup> )	79613	380	458	501	321	660	860	778	999	1074	1381	1691	1667	2029	1803	1203	2587	2861	6065	5062	7404	4554	5126	6097	7152	4418	3664	2020	1227	972	828	881	801	728	659	359	342
Historical Inflow (1000 m <sup>3</sup> )	77983	323	385	379	328	456	523	655	717	767	1379	1753	1670	1834	1813	1513	2521	3302	5251	5447	6651	5413	5192	5874	8001	4453	3116	2006	1159	840	1051	807	701	668	447	290	300
% Difference	-2.0	-15	-16	-24	2	-31	-39	-16	-28	-29	0	4	0	-10	1	26	-3	15	-13	8	-10	19	1	-4	12	1	-15	-1	-6	-14	27	-8	-13	-8	-32	-19	-12
RCP4.5 Inflow (1000 m <sup>3</sup> )	83104	301	360	415	326	518	602	712	681	941	1579	1889	1717	2082	1845	1446	3274	3385	4643	5471	6758	5338	5904	6659	8795	4461	4096	2407	1233	847	1100	756	714	694	521	296	335
% Change	6.6	-7	-7	10	0	14	15	9	-5	23	15	8	3	14	2	-4	30	3	-12	0	2	-1	14	13	10	0	31	20	6	1	5	-6	2	4	17	2	11
RCP8.5 Inflow (1000 m <sup>3</sup> )	82835	296	460	453	352	496	525	724	667	896	1623	1900	1869	2027	1891	1523	3282	3566	4682	6086	6678	4555	5361	6941	8741	4614	3716	2409	1260	886	1057	806	728	684	474	300	311
% Change	6.2	-9	20	20	7	9	0	11	-7	17	18	8	12	11	4	1	30	8	-11	12	0	-16	3	18	9	4	19	20	9	5	1	0	4	2	6	3	3



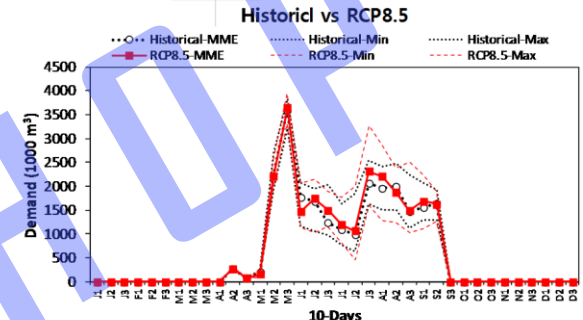
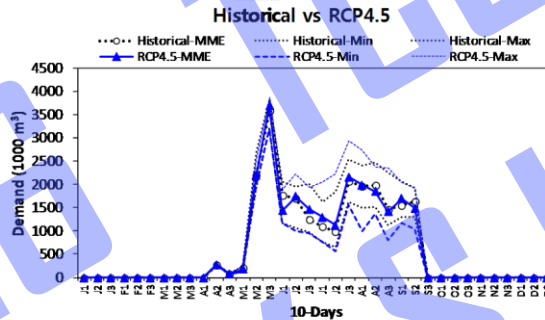
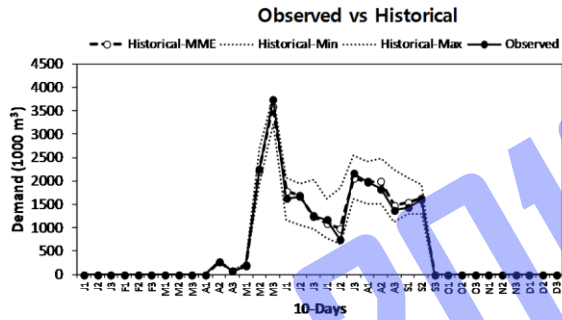
## Historical vs RCP8.5



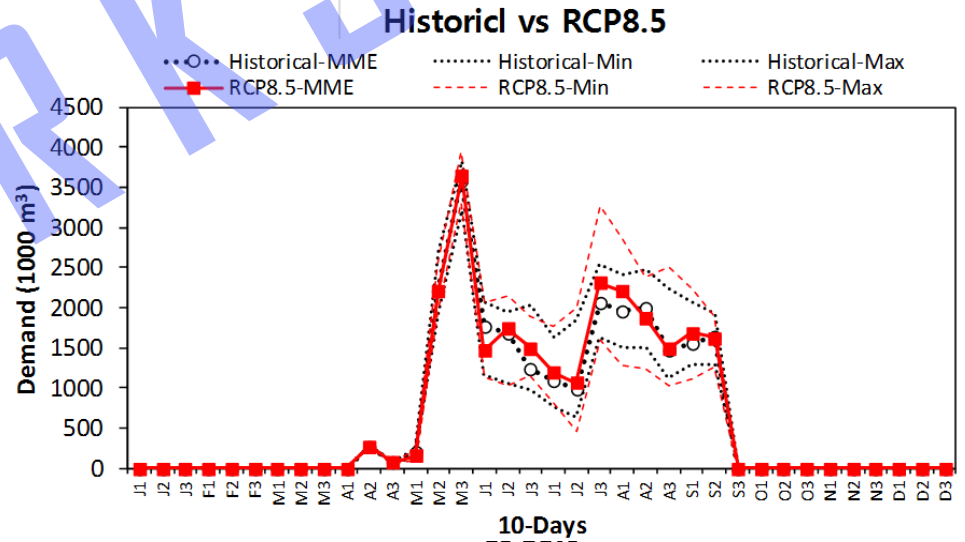
Reproducibility  
Future climate  
change impact  
assessment

# Impact assessment on 10-day demand (Goksung)

순(10-Days)	total	J1	J2	J3	F1	F2	F3	M1	M2	M3	A1	A2	A3	M1	M2	M3	J1	J2	J3	J1	J2	J3	A1	A2	A3	S1	S2	S3	O1	O2	O3	N1	N2	N3	D1	D2	D3					
Observed Demand (1000 m <sup>3</sup> )	23375	0	0	0	0	0	0	0	0	0	0	280	76	184	2251	3746	1625	1666	1256	1168	738	2156	1993	1831	1374	1430	1604	0	0	0	0	0	0	0	0	0	0	0	0			
Historical Demand (1000 m <sup>3</sup> )	23819	0	0	0	0	0	0	0	0	0	0	282	73	205	2208	3589	1775	1694	1241	1095	979	2066	1963	1994	1469	1550	1637	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
% Difference	1.9											1	-4	11	-2	-4	9	2	-1	-6	33	-4	-2	9	7	8	2															
RCP4.5 Demand (1000 m <sup>3</sup> )	24086	0	0	0	0	0	0	0	0	0	0	278	72	177	2208	3692	1438	1742	1465	1300	1126	2159	1986	1847	1410	1691	1494	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
% Change	1.1											-1	-1	-14	0	3	-19	3	18	19	15	5	1	-7	-4	9	-9															
RCP8.5 Demand (1000 m <sup>3</sup> )	24540	0	0	0	0	0	0	0	0	0	0	277	73	164	2216	3639	1472	1738	1499	1199	1070	2313	2209	1874	1486	1688	1623	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% Change	3.0											-2	1	-20	0	1	-17	3	21	10	9	12	13	-6	1	9	-1															

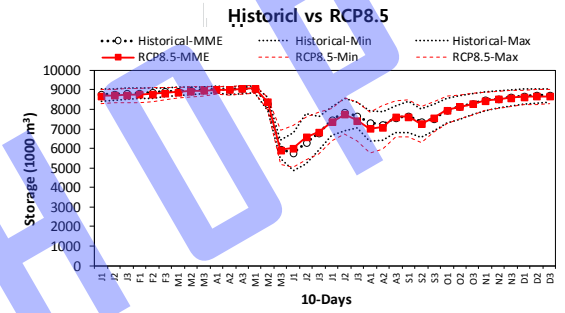
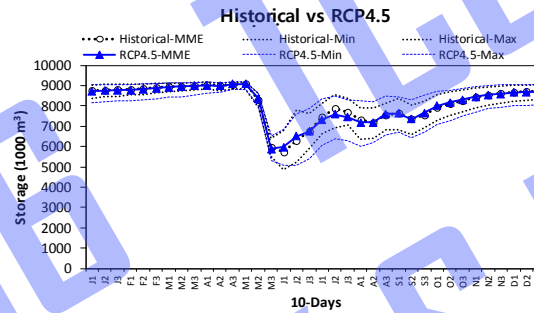
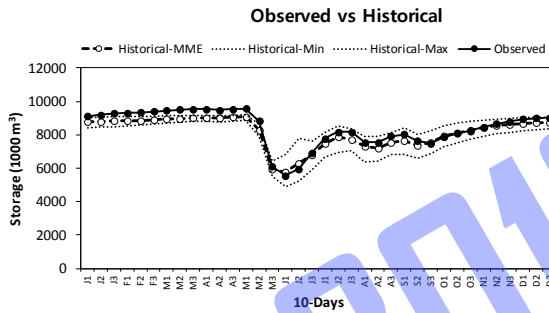


순(10-Days)	total
Observed Demand (1000 m <sup>3</sup> )	23375
Historical Demand (1000 m <sup>3</sup> )	23819
% Difference	1.9
RCP4.5 Demand (1000 m <sup>3</sup> )	24086
% Change	1.1
RCP8.5 Demand (1000 m <sup>3</sup> )	24540
% Change	3.0

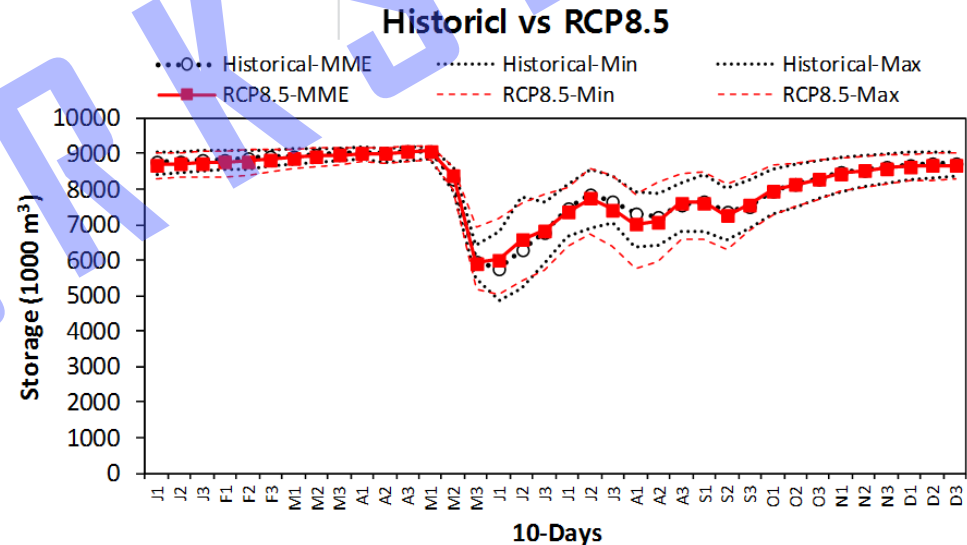


# Impact assessment on 10-day storage (Goksung)

순(10-Days)	total	J1	J2	J3	F1	F2	F3	M1	M2	M3	A1	A2	A3	M1	M2	M3	J1	J2	J3	J1	J2	J3	A1	A2	A3	S1	S2	S3	O1	O2	O3	N1	N2	N3	D1	D2	D3
<b>Observed</b> Storage (1000 m <sup>3</sup> )	<b>302883</b>	9110	9194	9278	9302	9339	9392	9448	9494	9519	9528	9481	9541	9561	8818	6088	5545	5942	6913	7782	8177	8176	7559	7551	7925	8041	7634	7485	7869	8094	8241	8456	8650	8789	8929	8999	9034
<b>Historical</b> Storage (1000 m <sup>3</sup> )	<b>292767</b>	8760	8791	8816	8834	8862	8901	8935	8968	8998	9032	9002	9047	9076	8295	5965	5750	6284	6778	7471	7865	7680	7317	7199	7543	7643	7347	7535	7926	8120	8272	8459	8552	8627	8684	8710	8722
% Difference	<b>-3.3</b>	-4	-4	-5	-5	-5	-5	-5	-6	-5	-5	-5	-5	-5	-6	-2	4	6	-2	-4	-4	-6	-3	-5	-5	-5	-4	1	1	0	0	0	-1	-2	-3	-3	-3
<b>RCP4.5</b> Storage (1000 m <sup>3</sup> )	<b>292455</b>	8728	8753	8774	8792	8830	8880	8927	8959	8991	9023	9000	9078	9093	8351	5890	5983	6506	6751	7331	7600	7449	7185	7197	7612	7625	7348	7655	8017	8177	8306	8450	8536	8605	8664	8687	8701
% Change	<b>-0.1</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	4	4	0	-2	-3	-3	-2	0	1	0	0	2	1	1	0	0	0	0	0	0	0
<b>RCP8.5</b> Storage (1000 m <sup>3</sup> )	<b>291719</b>	8686	8713	8744	8762	8789	8828	8878	8922	8960	9011	9003	9054	9090	8372	5918	6021	6575	6846	7342	7744	7431	7010	7085	7614	7628	7258	7570	7969	8129	8270	8435	8517	8581	8633	8660	8672
% Change	<b>-0.4</b>	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	0	0	1	-1	5	5	1	-2	-2	-3	-4	-2	1	0	-1	0	1	0	0	0	0	-1	-1	-1	-1



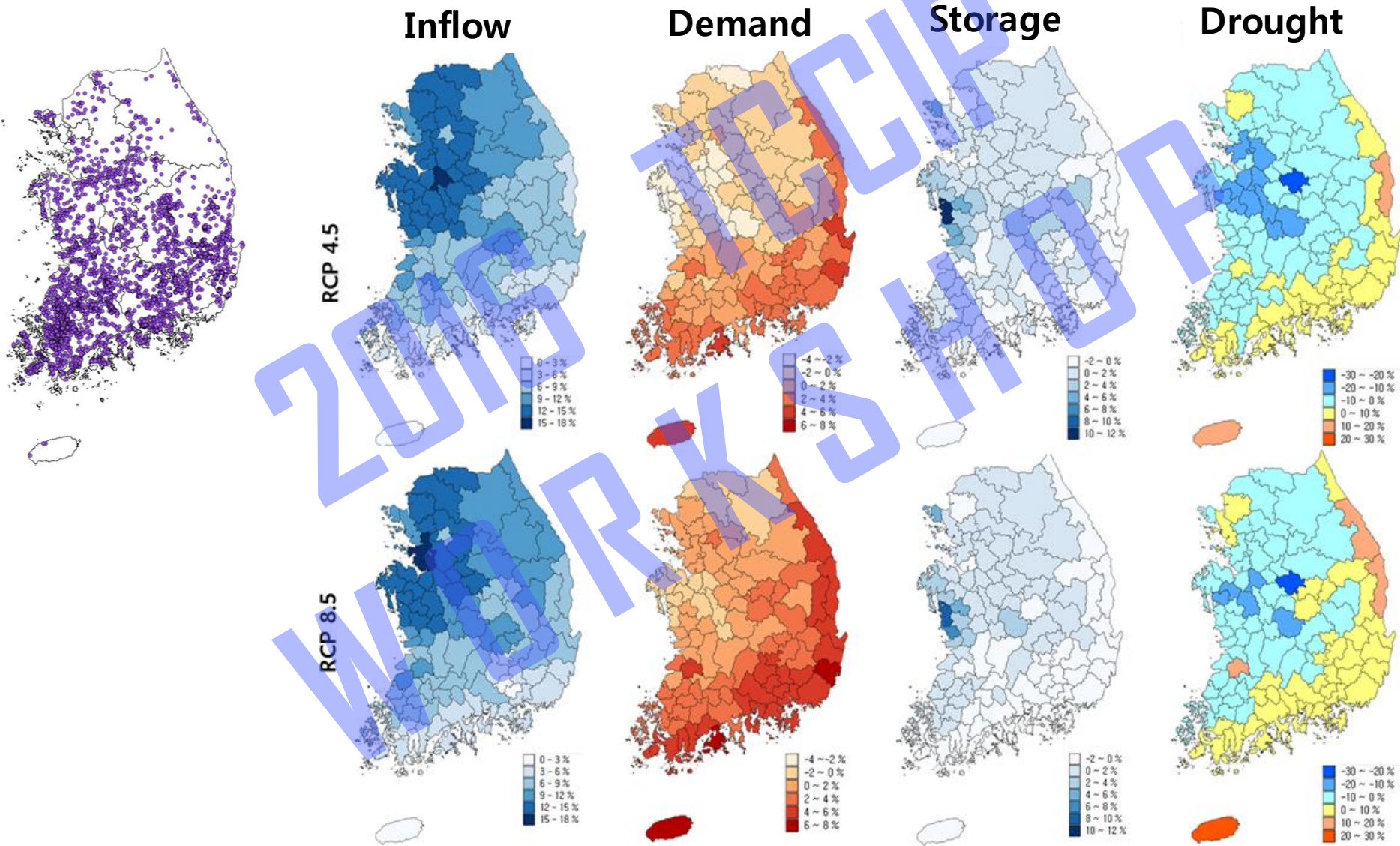
순(10-Days)	total
<b>Observed</b> Storage (1000 m <sup>3</sup> )	<b>302883</b>
<b>Historical</b> Storage (1000 m <sup>3</sup> )	<b>292767</b>
% Difference	<b>-3.3</b>
<b>RCP4.5</b> Storage (1000 m <sup>3</sup> )	<b>292455</b>
% Change	<b>-0.1</b>
<b>RCP8.5</b> Storage (1000 m <sup>3</sup> )	<b>291719</b>
% Change	<b>-0.4</b>

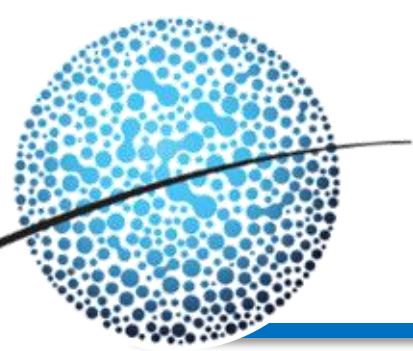




# Climate Change Impact on Agricultural Reservoir

## ❖ Spatial distribution of impact assessment results





# Concluding Remarks

- ❖ Weighting factor method based on the reproducibility test (ten-day mean and variation) of individual GCMs was developed for estimating MME for upstream inflow, demand of water supply, and storage level of reservoirs.
- ❖ Future projection according to climate changes predicted highest changes in upstream inflow by showing that: 1) 8.5% and 8.1% increase in upstream inflow, 2) 0.6% and 2.6% increase in demand, 3) 0.7% and 0.4% increase in storage level, and 4) 1.6% and 0.4% decrease in the number of occurrence of 50% or less storage level, respectively, for RCP4.5 and 8.5 scenarios as compared to the past period.
- ❖ However, result of the spatial distribution analysis at 93-Jisa level shows that the Midwest region can be changed to positive direction while Southeast region can be changed to negative direction for water management purpose by showing significant increases in demands compared to the upstream inflow.



By [HikingArtist.com](http://HikingArtist.com)

**Thank You!**