문서번호 APCC-출장-18-1108(2018-11-20)

결재	팀장	부서장	원장직무대행	
	11/20 조재필	11/20 유진호	11/20 유진호	
협조				

TRAVEL REPORT FORM
출장보고서

I. Travel Overview 출장개요

1. Traveler(s) 출장자

Department 소속	Position 직위(직급)	Name 성명	Note 비고
기후사업본부	서비스개발팀장	조재필	

2. Travel Period 출장기간

○ 일시: 2018년 8월 11일 ~ 18일

3. Occasion and destination 행사 및 출장지

○ 장소: 캐나다(새스커툰)

○ 내용: ICID 국제 컨퍼런스 및 제69차 ICID 국제집행이사회 회의 참석

II. Major Activities 주요업무 수행내용

1. Main Contents and Activities 주요내용 및 활동

○ WG-CLIMATE(기후변화분과) 참석

- APCC 교육 프로그램 소개
- 구두발표
  - 일시: 2018년 08월 14일
  - 제목: Climate Change Impact Assessment on Water Balance of Agricultural Reservoirs in KOrea

○ WG-MWSCD(물부족 관리분과) 위원 활동

- 국가별 보고서 발표 및 논의: 선진국의 경우 상시적인 다분야 간의 물수요 충돌에 의한 물부족 문제가 발생하는 반면, 한국의 경우 가뭄에 의한 물부족이 발생. 향후 분과의 활동을 상시적인 물부족 상황에 대한 해결책 제시로 활동범위를 정함

- 계획되었던 Webinar 취소
- 지속적으로 미참가자 위원의 멤보쉽 취소(대만) 및 신규 멤버 결정
- 일본 위원 (Nagano) 편집위원으로 활동
- 한국 위원 (Dr. Cho) 총무로 선정
- 향후 보고서 준비에 있어서 보고서의 틀 논의

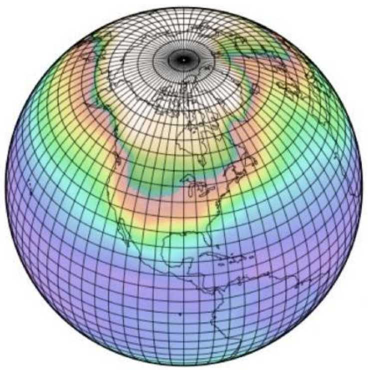
2. Relevance to APEC Climate Center's Activities 결론 및 소감

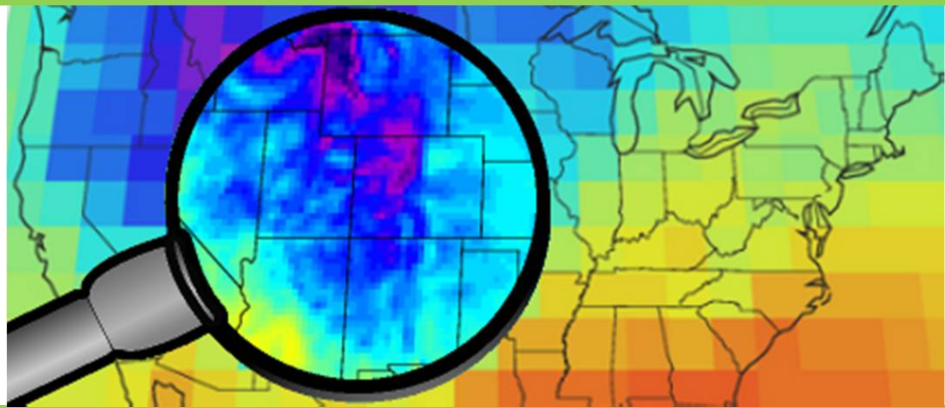
○ 국제 관개·배수 분야 기술동향 및 경험 공유를 통한 기술발전을 도모할 수 있었음
○ 해외 수자원 기관 및 인적 네트워트 구축을 통한 기술 협력활동을 강화하였음 (기후변화 관련)
○ 국제 컨퍼런스 및 국제집행이사회 참석을 통한 전체적인 운영체계 이해 및 KCID 역할 및 국제적 위상을 제고할 수 있었음

3. Suggestions and Remarks 건의사항

III. References (Presented and Collected Materials) 주요 수집자료
(with attachment of any information or report in case of attendance of conferences, workshops and meetings) 학술대회, 워크숍, 회의 등 참석 시 관련 정보 및 문서 첨부

Climate Change Impact Assessment on Water Balance of Agricultural Reservoirs in KOrea





Jaepil Cho

2018/08/14

Overview

1. Introduction
2. Climate change impacts
3. Ongoing & future works
4. Advertisement

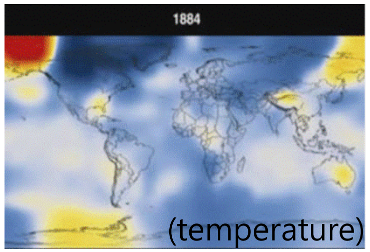
APEC CLIMATE CENTER

Introduction

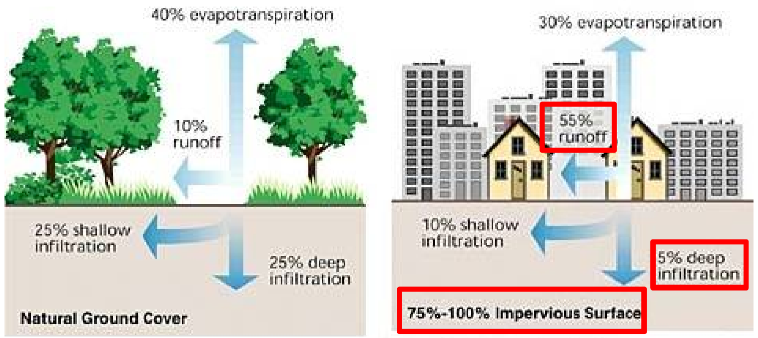
Changes

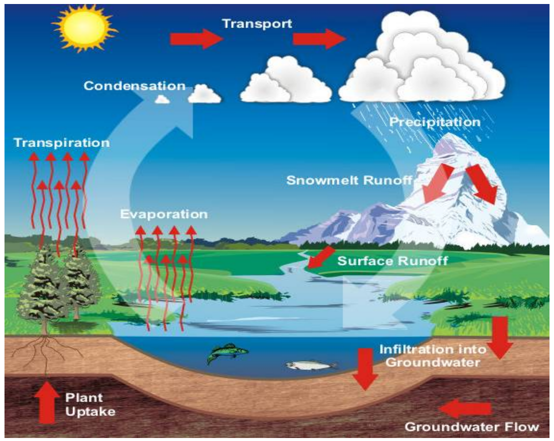
Land use (Urbanization)

Climate



Processes





Impacts

Impacts of climate change on water balances in agricultural reservoirs

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%)	**17,569**	**453,311 (56.2%)**
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

First approach which I tried…

IRRIGATION AND DRAINAGE
Irrig. and Drain. **(2016)**
Published online in Wiley Online Library (wileyonlinelibrary.com) **DOI**: 10.1002/ird.2035

CLIMATE CHANGE IMPACTS ON AGRICULTURAL DROUGHT WITH CONSIDERATION OF UNCERTAINTY IN CMIP5 SCENARIOS†

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[2]Farmland & Irrigation Development Office, Rural Community Development Division, Korea Rural Community Corporation, Naju, Republic of Korea
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[4]Future Policy Research Group, Rural Research Institute, Korea Rural Community Corporation, Ansan, Republic of Korea

ABSTRACT

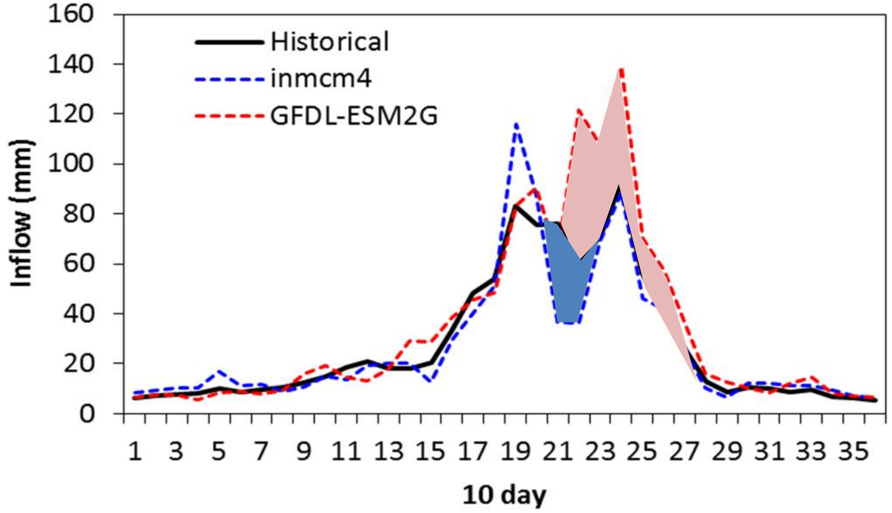
This study was conducted to evaluate the impact of climate change on agricultural drought on 104 agricultural reservoirs in Korea. The bias corrected data appropriately reproduced the temporal trends of inflow from upstream river basins, irrigation water demand from paddy areas and reservoir storage level. When eleven climate model data were applied to a representative reservoir, inflow by individual models had a range of -11.5 to 11.1%, compared to the multi-model ensembles mean value. Water demand also showed a similar trend to the inflow, had a range of -11.0 to 10.0%, while storage level had a narrow range of -3.9 to 2.1%. When 104 reservoirs were considered, inflow in the future period (2011 ~ 2040) increased by 7.8 and 9.3% for the Representative Concentration Pathways (RCP) 4.5 and 8.5 scenarios, respectively, mainly due to the increase in precipitation. Similarly, irrigation water demand increased by 2.3 and 1.6% for RCP4.5 and 8.5, respectively, due to the increase in temperature. As a result, the water storage level increased by 0.7 and 0.5% for RCP4.5 and 8.5, respectively. However, despite the increase in average reservoir storage level, the frequency of the number of droughts more severe than 10 year frequency drought increased.

KEY WORDS: RCPs; reservoir; drought; climate change; uncertainty; reproducibility

Received 18 January 2016; Revised 14 February 2016; Accepted 15 February 2016

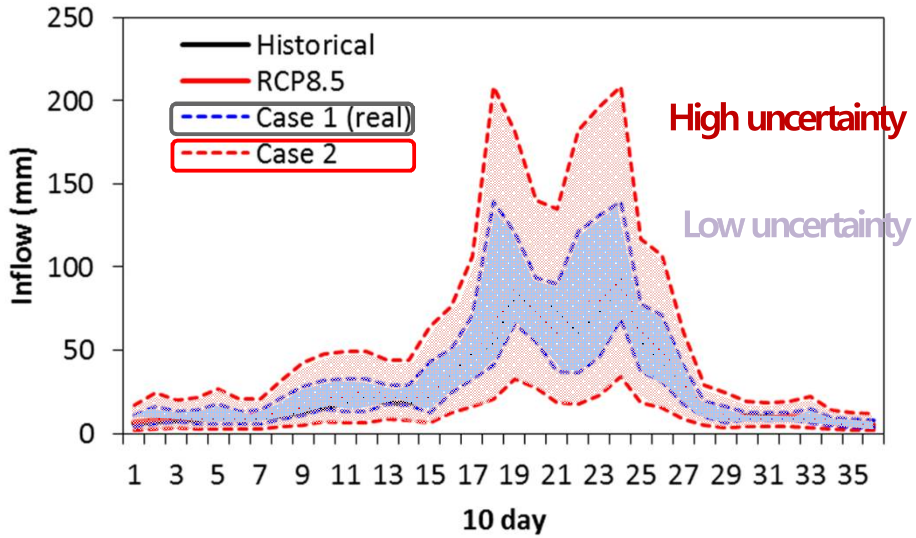
Uncertainty in Future Projections of Climate Change

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



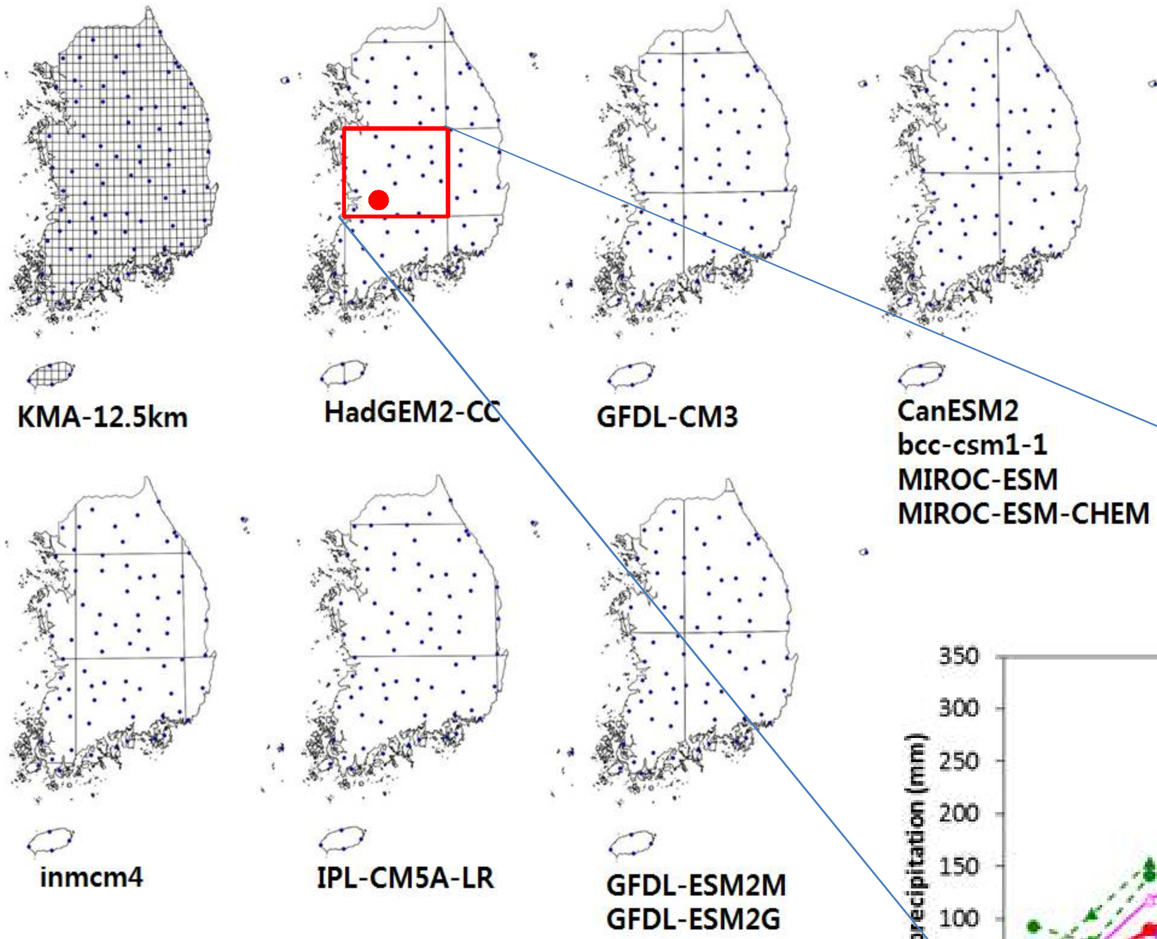
- **How decisions can be utilized when opposite directions are projected in the same watershed?**

- **Even though MME-based projection shows same projection, what kind of additional information should be provided for decision-making?**

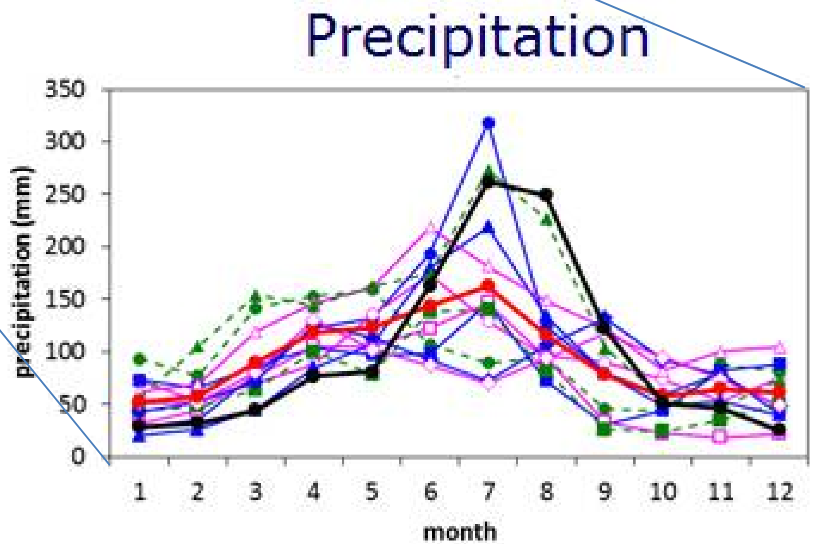


Uncertainty of future projections

Spatial resolution of multiple GCMs in CMIP5



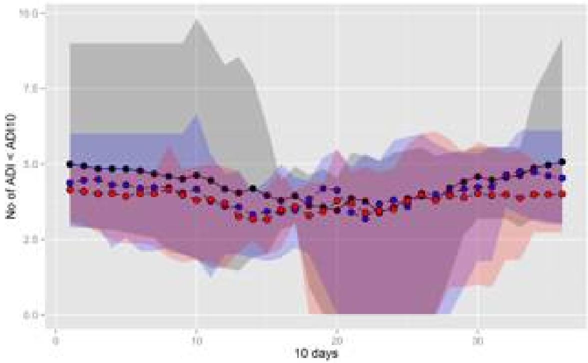
RCP8.5 Scenario
- KMA RCM
- 10 GCMs



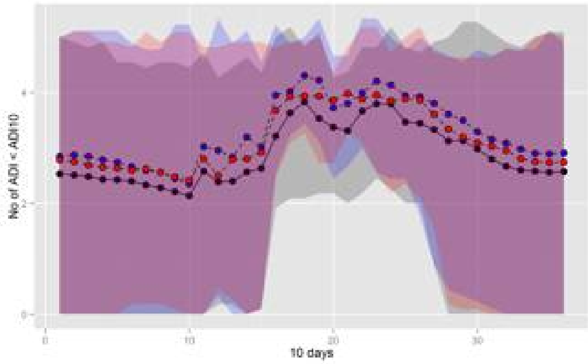
➡ **Downscaling with bias-correction is required**

Assessment of climate change impact on 104 agricultural reservoirs based on 5 clusters

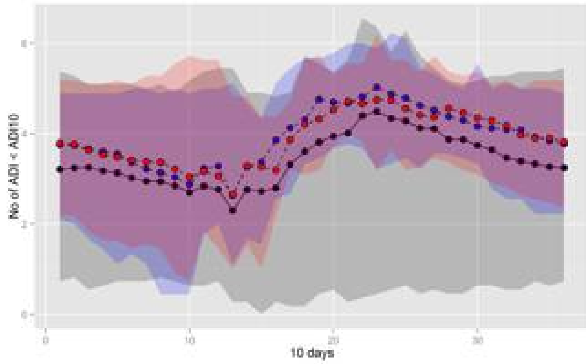
ADI projection (No of ADI < ADI$_{10year}$) (2011~2040)



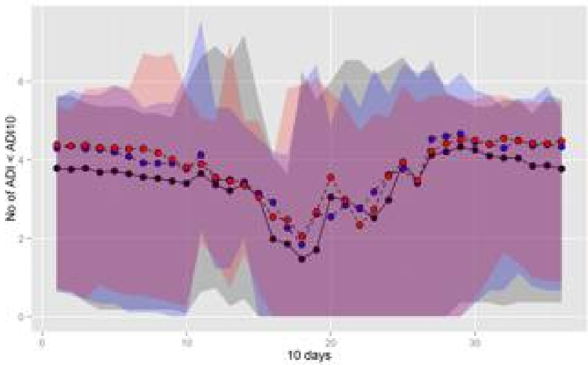
Cluster 1



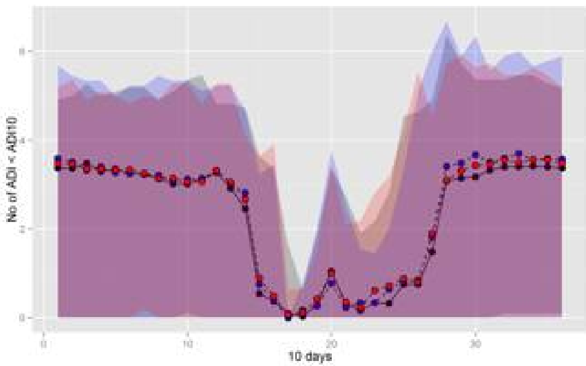
Cluster 2



Cluster 3



Cluster 4

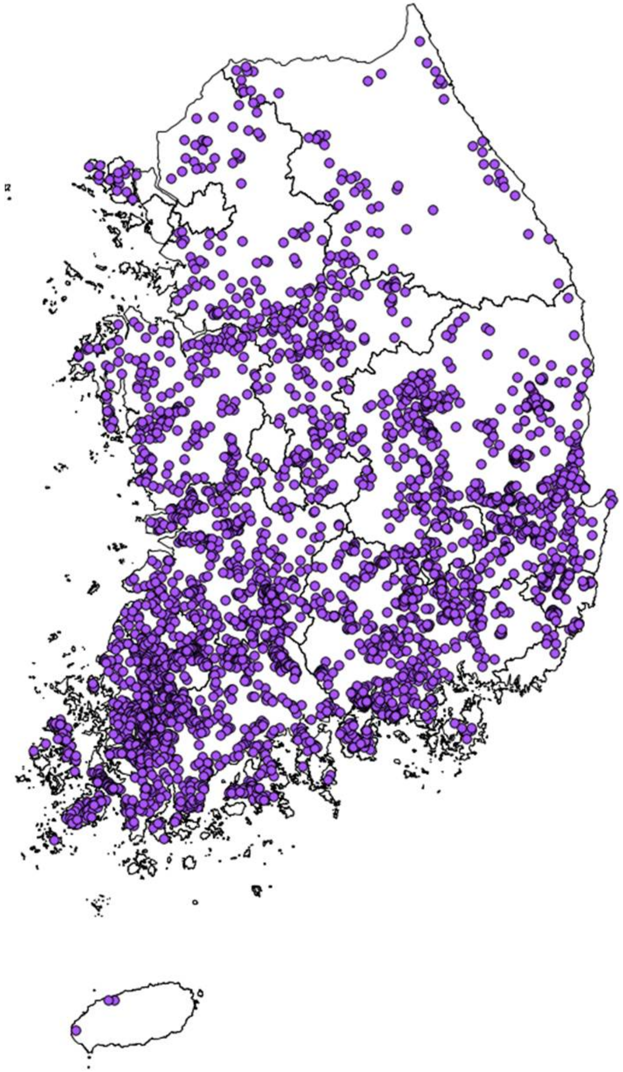


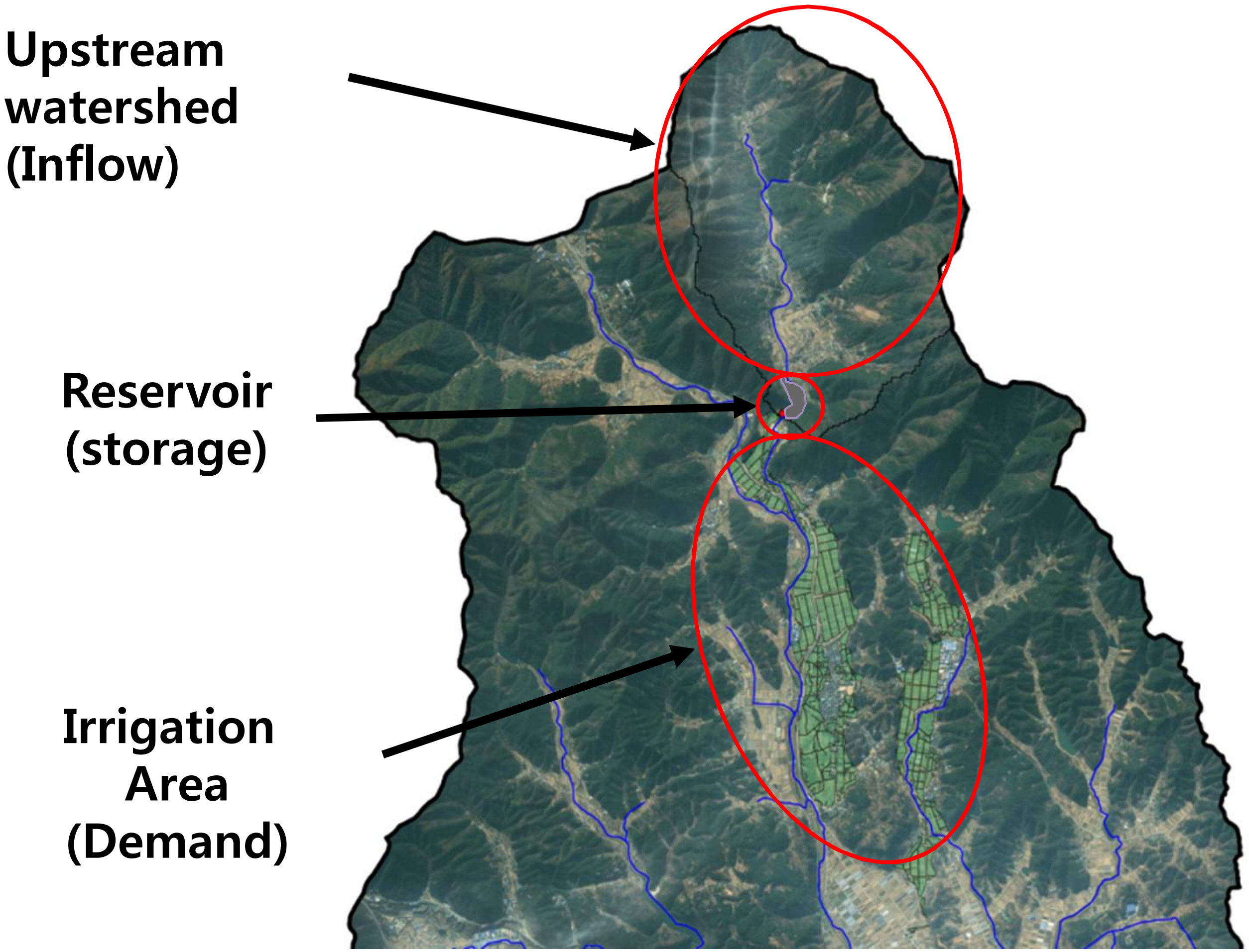
Cluster 5

Clusters		Historical	RCP4.5	RCP8.5
1	1 of ADI<ADI$_{10}$	154.6	145.0	136.0
	% change		-6.2	-12.0
2	No of ADI<ADI$_{10}$	103.7	118.1	113.0
	% change		13.8	8.9
3	No of ADI<ADI$_{10}$	122.9	141.4	139.8
	% change		15.1	13.8
4	No of ADI<ADI$_{10}$	122.3	135.0	136.4
	% change		10.4	11.5
5	No of ADI<ADI$_{10}$	80.4	84.7	84.4
	% change		5.3	4.9

-12.0% ~ 13.8%

Impacts on 3372 agricultural reservoirs managed by KRC





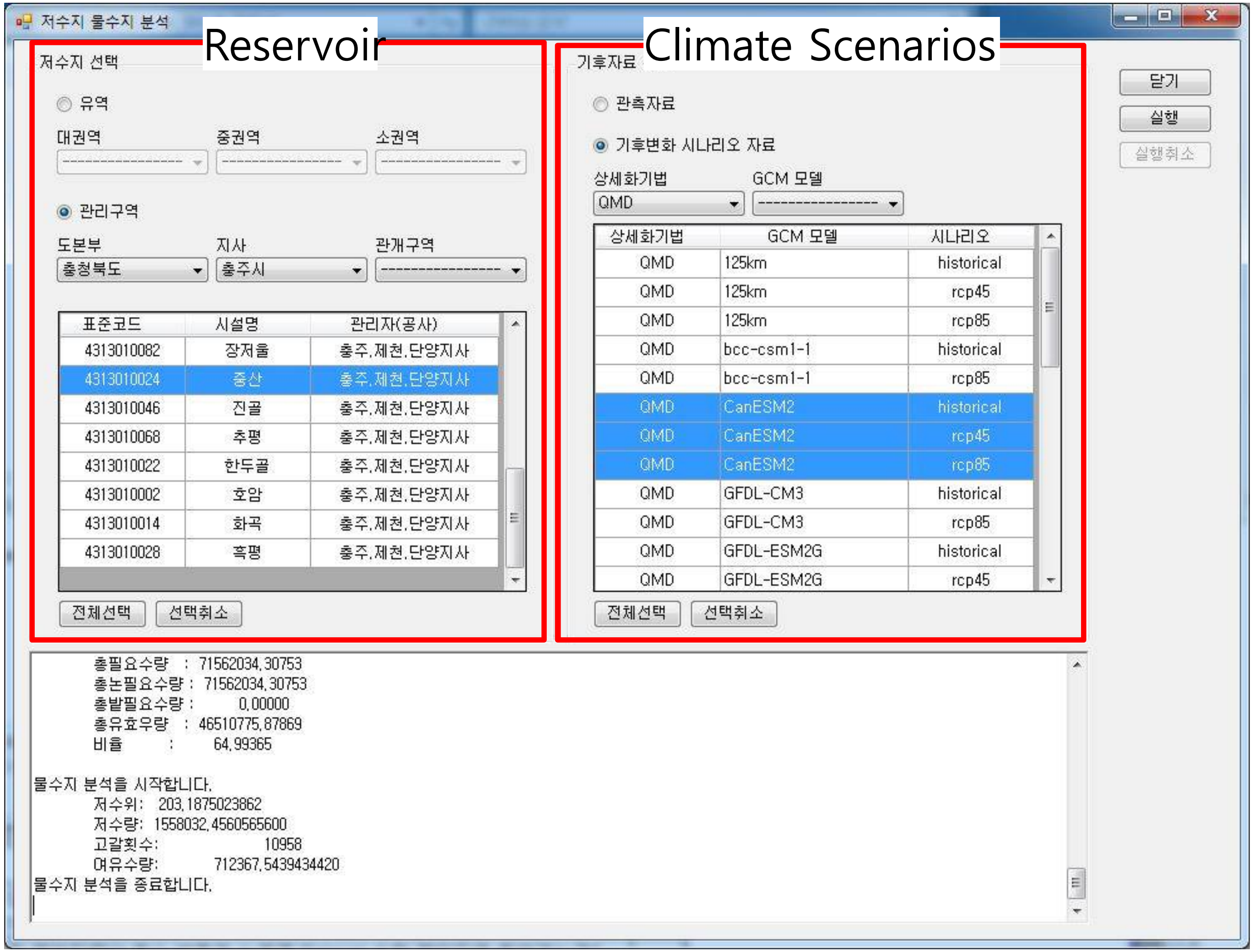
Downscaling using monthly CMIP5 was added

- 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	O		O		O	
2	IPSL-CM5A-MR	O		O		O	
3	IPSL-CM5B-LR	O		O		O	
4	MIROC5	O		O		O	
5	MRI-CGCM3	O		O		O	
6	bcc-csm1-1	O	O	O		O	O
7	MIROC-ESM-CHEM	O	O	O	O	O	O
8	MIROC-ESM	O	O	O	O	O	O
9	IPSL-CM5A-LR	O	O		O	O	O
10	CanESM2		O		O		O
11	GFDL-ESM2G		O		O		O
12	GFDL-ESM2M		O		O		O
13	HadGEM2-CC		O		O		O
14	inmcm4		O		O		O

User interface developed for tons of simulations

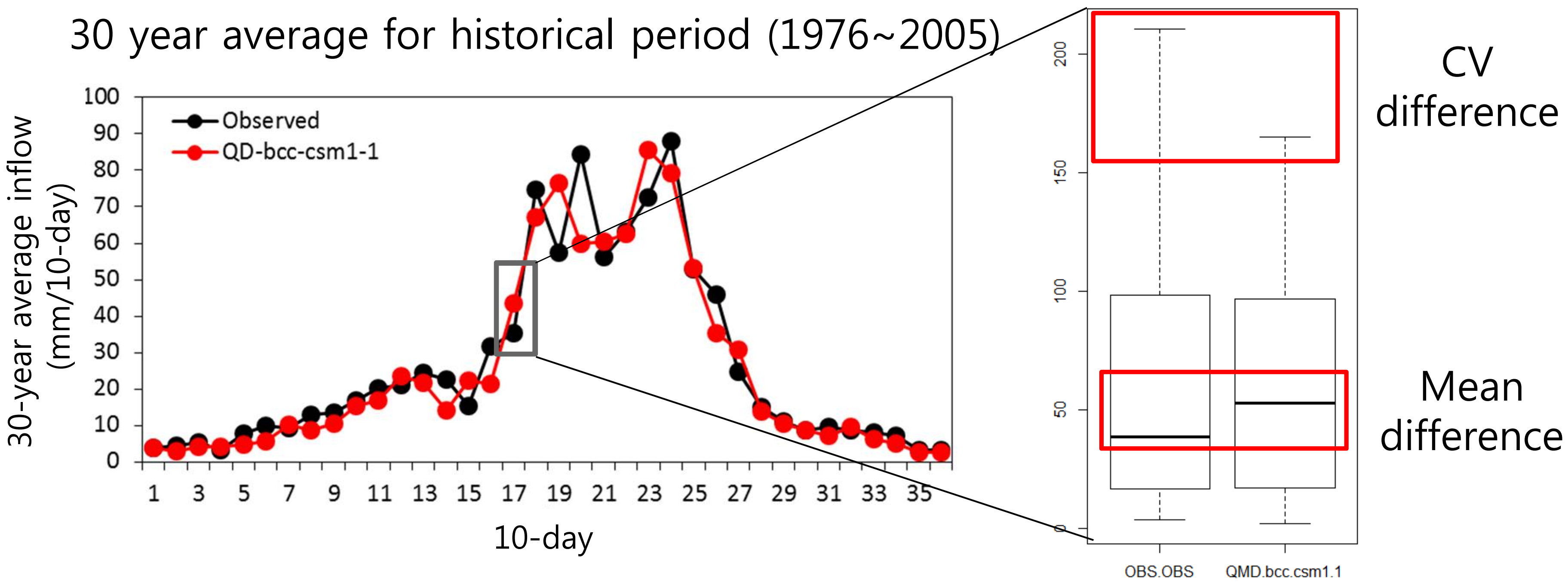
❖ Hydrological Operation Model for Water Resources System (HOMWRS)



Considering weight factors for MME calculation based on the reproducibility test

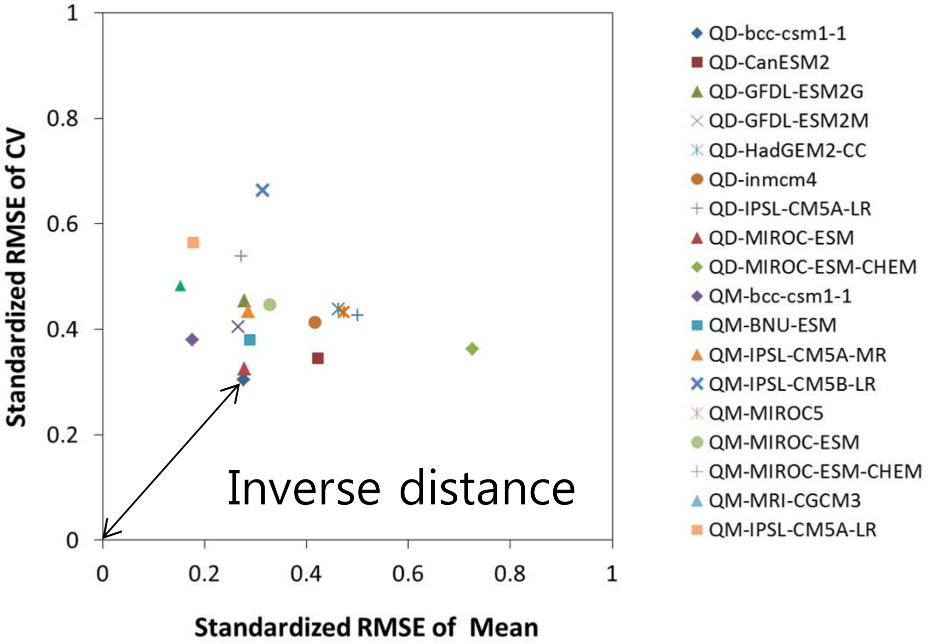
- Comparing observation- and model(GCM)-based 10-day inflow, demand, and storage for historical period
- Mean and variation were considered using RMSE and coefficient variation (CV), respectively

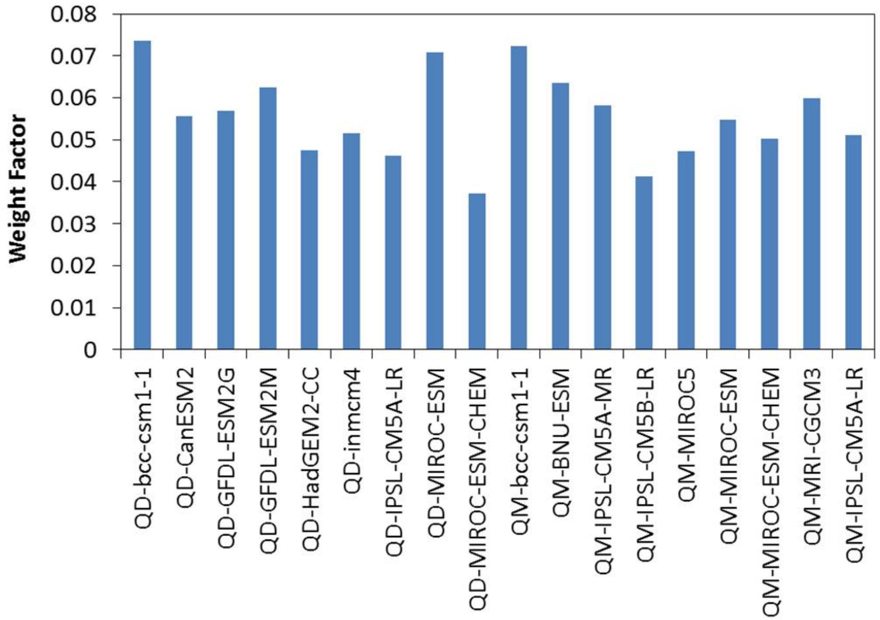
30 year average for historical period (1976~2005)



Weighting factor based on reproducibility

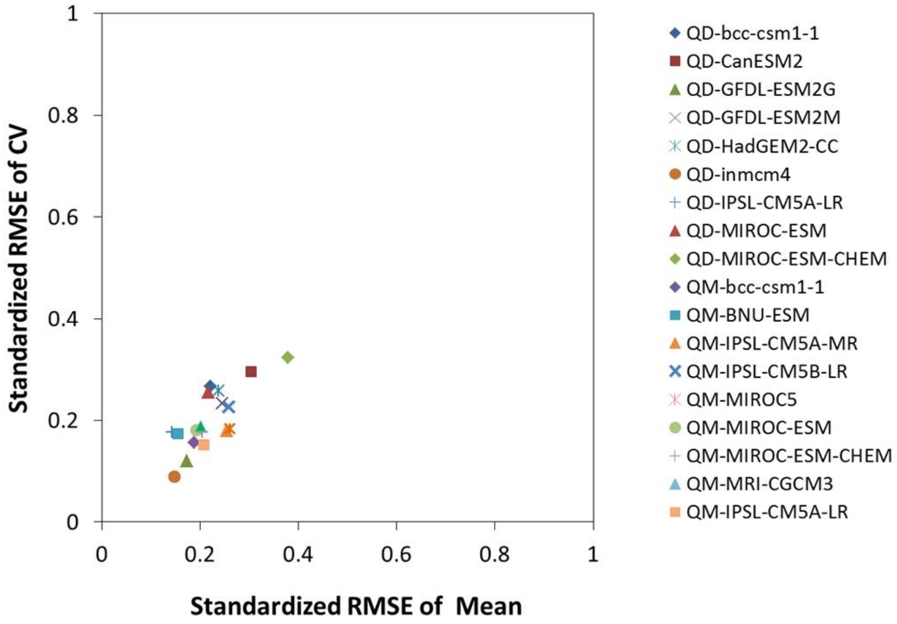
- Inflow from upstream watershed
  - Standardization using mean and coefficient of variation
  - Inverse distance weighting factor for MME estimation

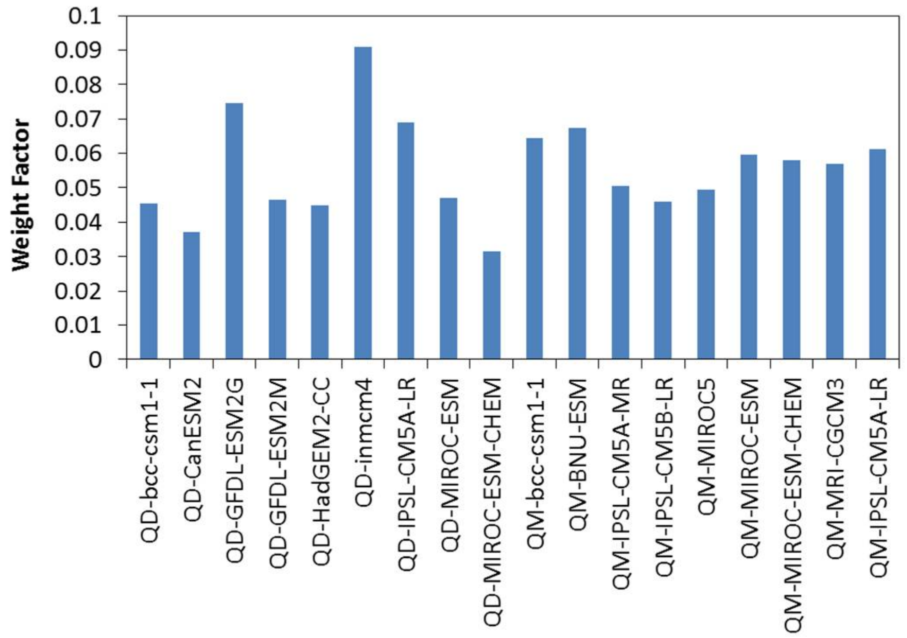




Weighting factor based on reproducibility

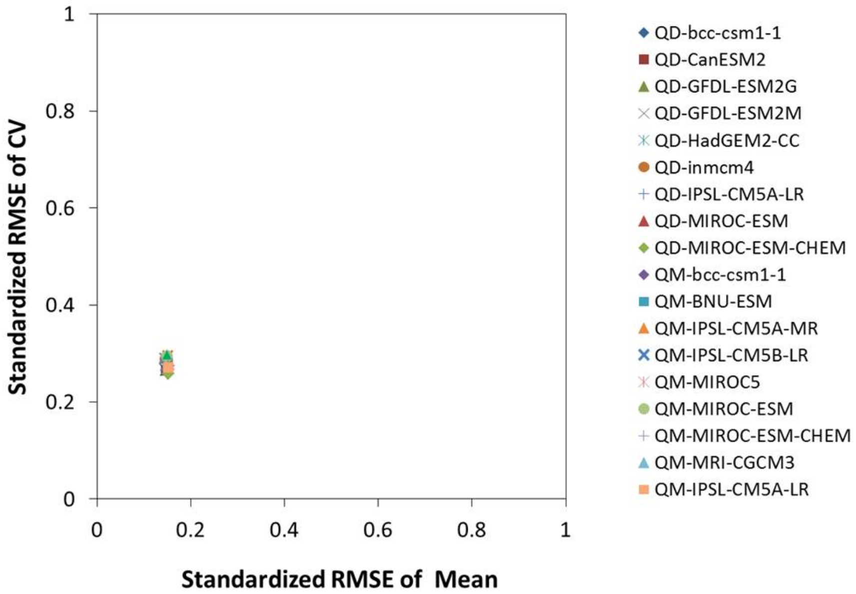
- Irrigation Water Demands

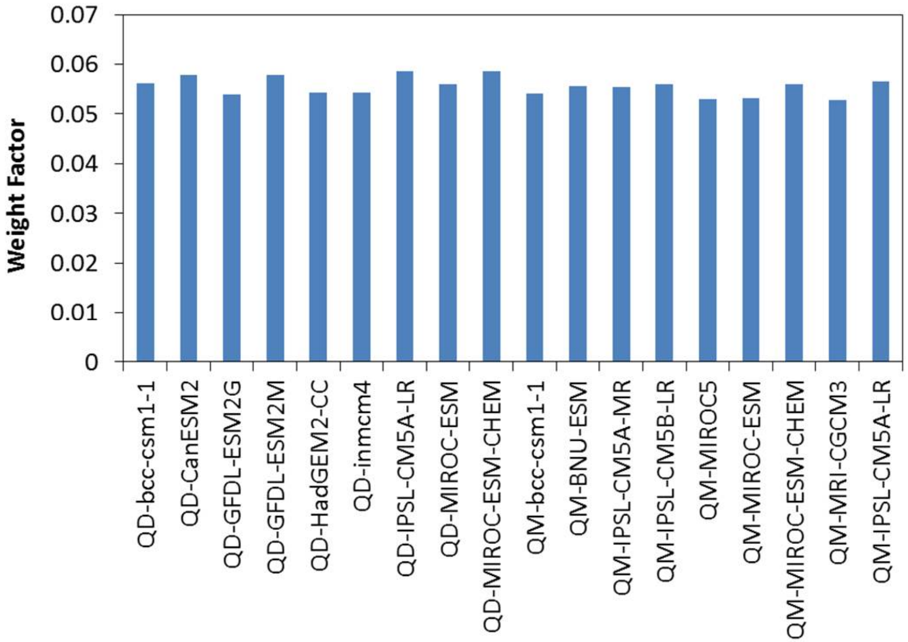




Weighting factor based on reproducibility

- Storage





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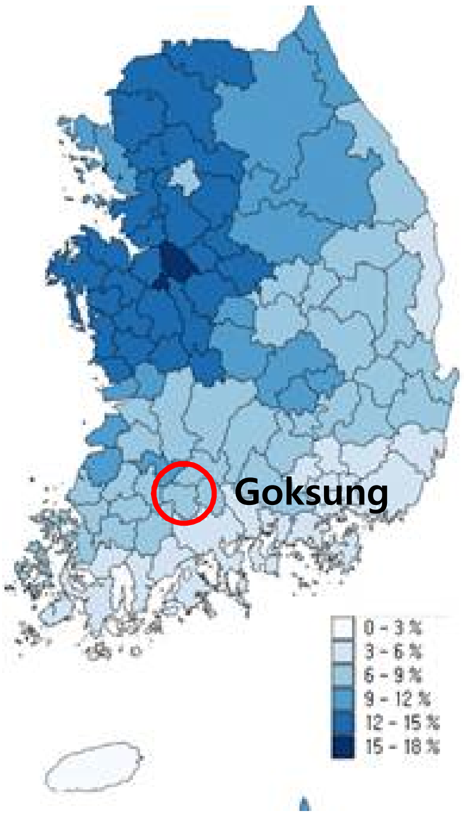
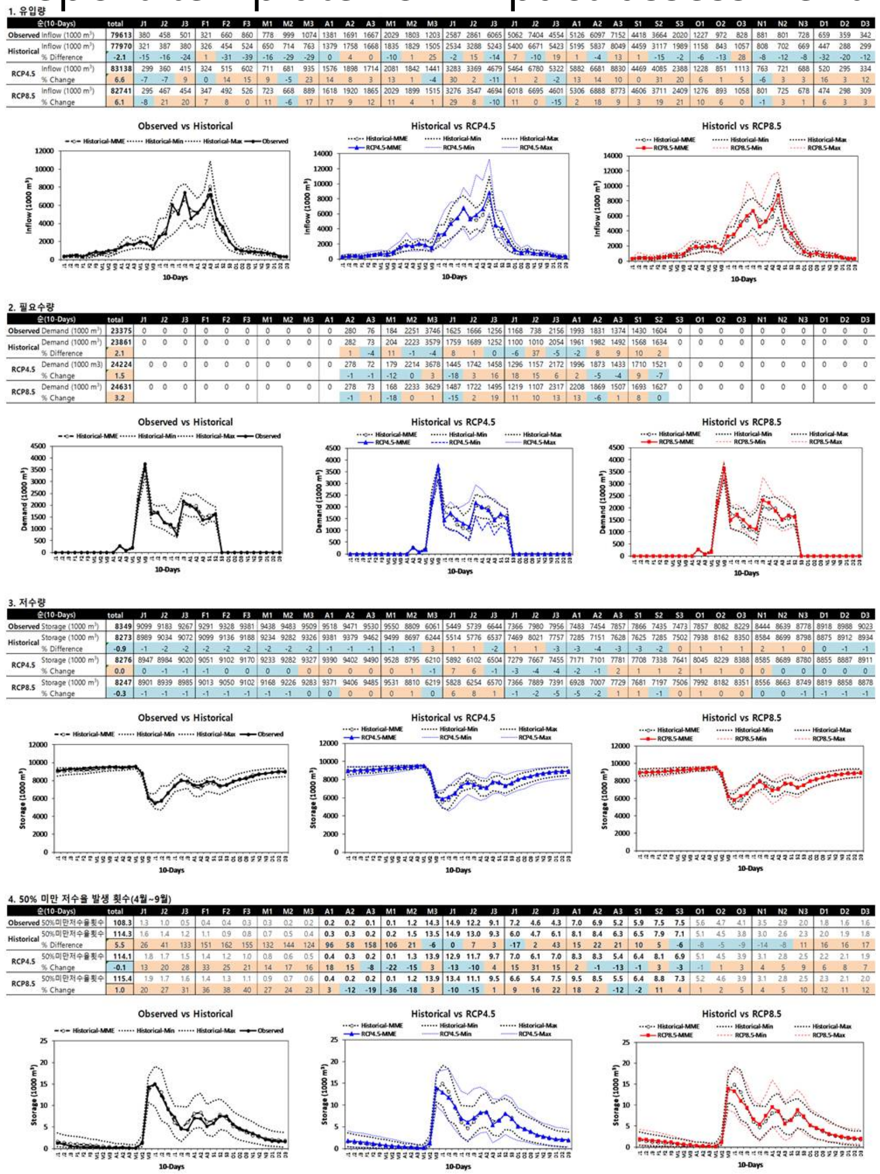
Impact assessment report at district level



- Report template for impact assessment



Inflow

Demand

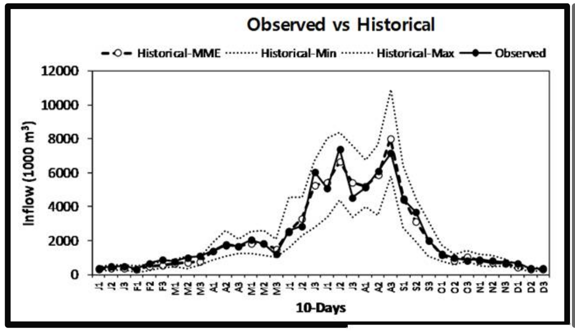
Storage

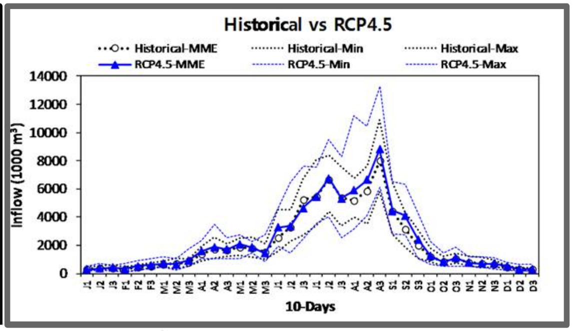
Drought

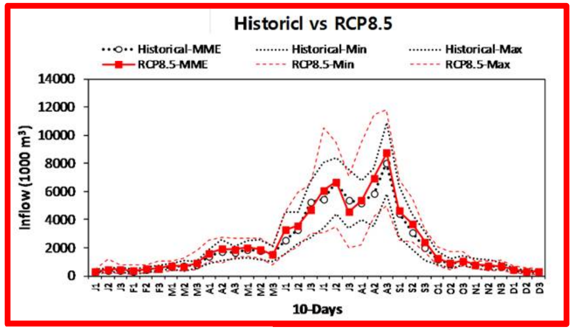
Impact assessment on 10-day inflow (Goksung)

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 m³)	**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 m³)	**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 m³)	**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 m³)	**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

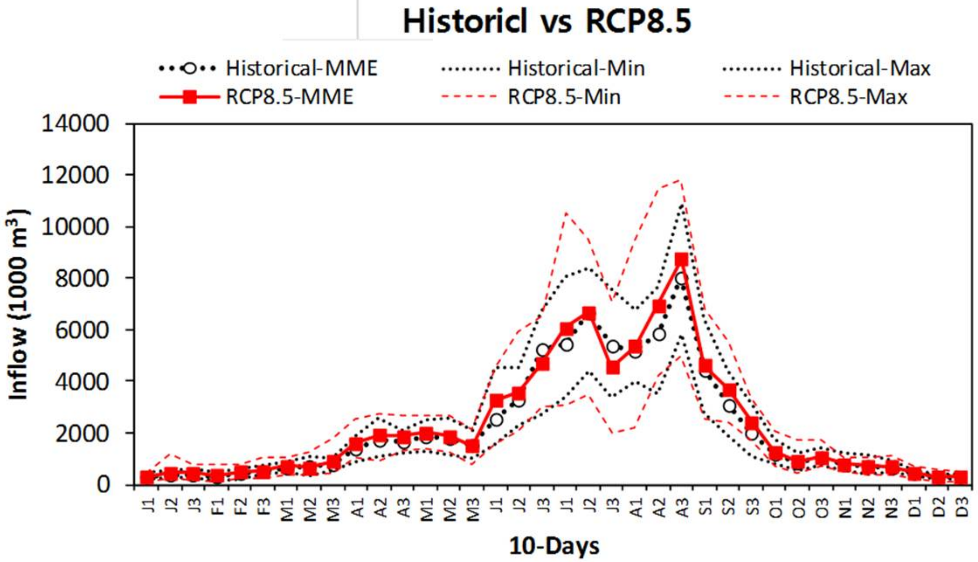






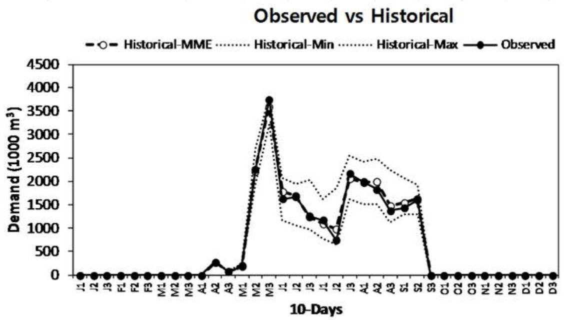
Reproducibility

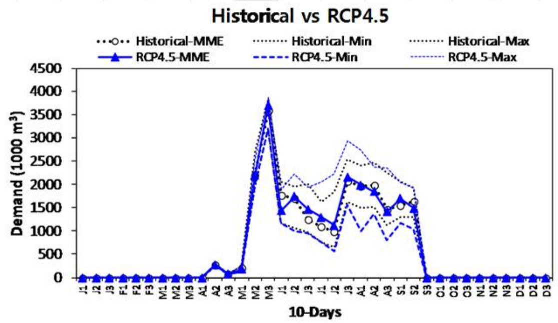
Future climate change impact assessment

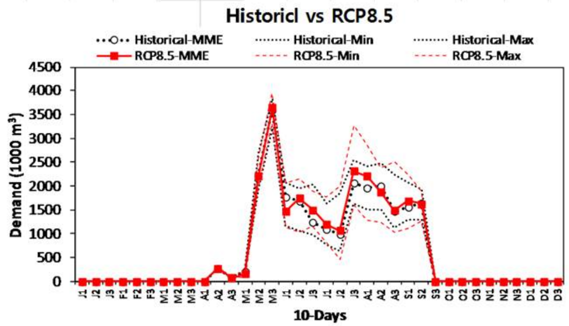


Impact assessment on 10-day demand (Goksung)

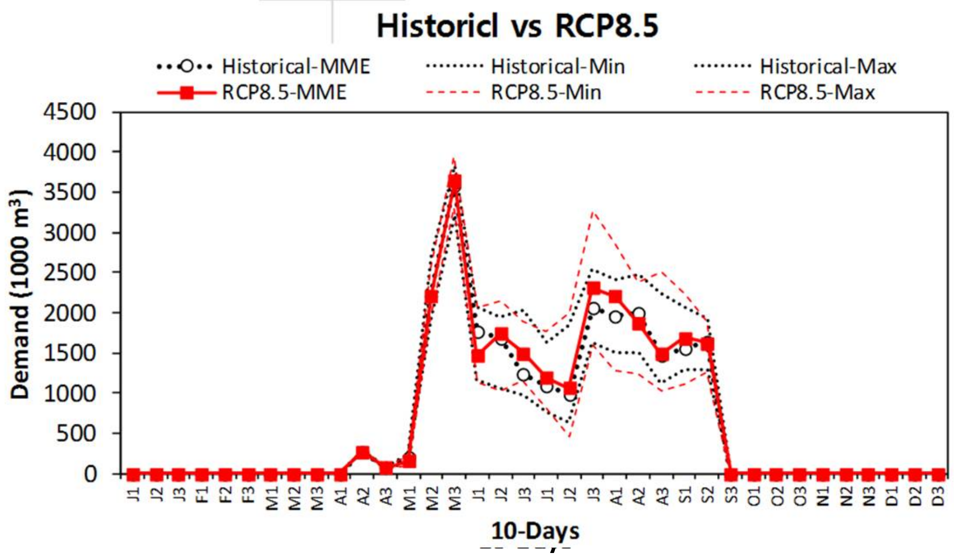
순(10-Days)		total	J1	J2	J3	F1	F2	F3	M1	M2	M3	A1	A2	A3	M1	M2	M3	J1	J2	J3	J1	J2	J3	A1	A2	A3	S1	S2	S3	O1	O2	O3	N1	N2	N3	D1	D2	D3
Observed	Demand (1000 m³)	23375	0	0	0	0	0	0	0	0	0	0	280	76	184	2251	3746	1625	1666	1256	1168	738	2156	1993	1831	1374	1430	1604	0	0	0	0	0	0	0	0	0	0
Historical	Demand (1000 m³)	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
	% Difference	1.9											1	-4	11	-2	-4	9	2	-1	-6	33	-4	-2	9	7	8	2										
RCP4.5	Demand (1000 m3)	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
	% Change	1.1											-1	-1	-14	0	3	-19	3	18	19	15	5	1	-7	-4	9	-9										
RCP8.5	Demand (1000 m³)	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
	% Change	3.0											-2	1	-20	0	1	-17	3	21	10	9	12	13	-6	1	9	-1										







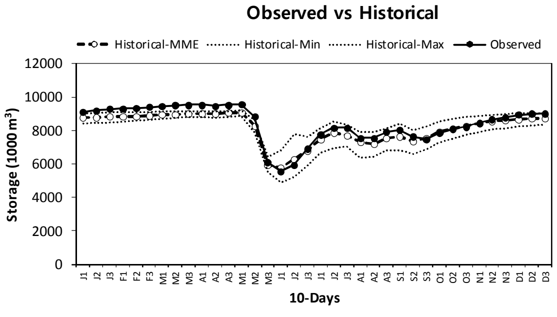
순(10-Days)		total
Observed	Demand (1000 m³)	23375
Historical	Demand (1000 m³)	23819
	% Difference	1.9
RCP4.5	Demand (1000 m3)	24086
	% Change	1.1
RCP8.5	Demand (1000 m³)	24540
	% Change	3.0

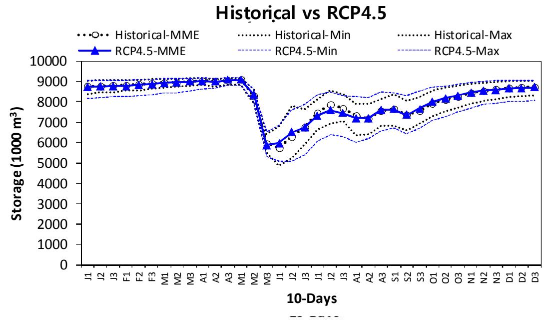


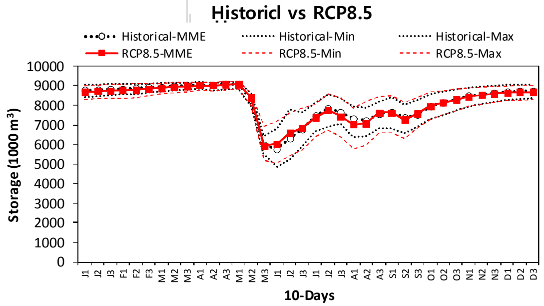
Impact assessment on 10-day storage (Goksung)

순(10-Days)		total	J1	J2	J3	F1	F2	F3	M1	M2	M3	A1	A2	A3	M1	M2	M3
Observed	Storage (1000 m^3)	**302883**	9110	9194	9278	9302	9339	9392	9448	9494	9519	9528	9481	9541	9561	8818	6088
Historical	Storage (1000 m^3)	**292767**	8760	8791	8816	8834	8862	8901	8935	8968	8998	9032	9002	9047	9076	8295	5965
	% Difference	**-3.3**	-4	-4	-5	-5	-5	-5	-5	-6	-5	-5	-5	-5	-5	-6	-2
RCP4.5	Storage (1000 m^3)	**292455**	8728	8753	8774	8792	8830	8880	8927	8959	8991	9023	9000	9078	9093	8351	5890
	% Change	**-0.1**	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1
RCP8.5	Storage (1000 m^3)	**291719**	8686	8713	8744	8762	8789	8828	8878	8922	8960	9011	9003	9054	9090	8372	5918
	% Change	**-0.4**	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	0	0	1	-1

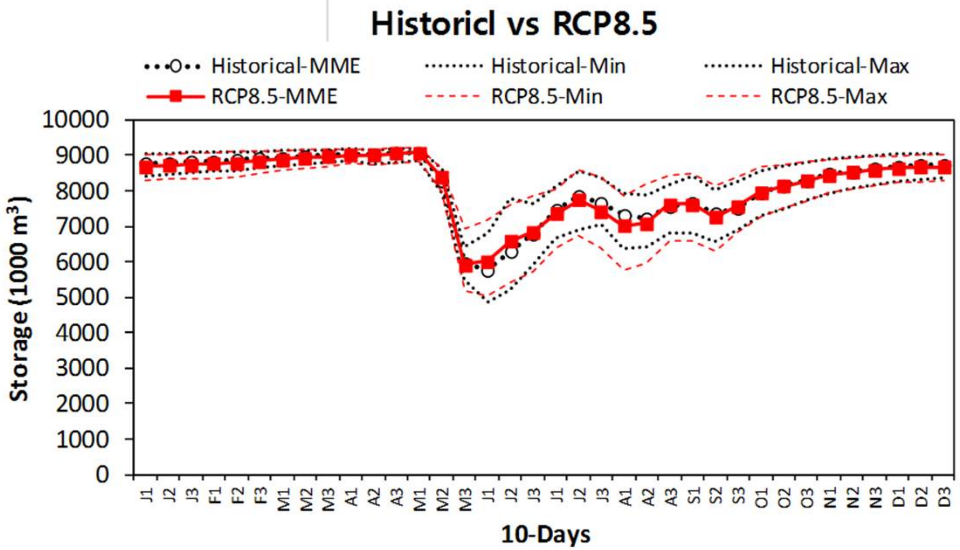
순(10-Days)		J1	J2	J3	J1	J2	J3	A1	A2	A3	S1	S2	S3	O1	O2	O3	N1	N2	N3	D1	D2	D3
Observed	Storage (1000 m^3)	5545	5942	6913	7782	8177	8176	7559	7551	7925	8041	7634	7485	7869	8094	8241	8456	8650	8789	8929	8999	9034
Historical	Storage (1000 m^3)	5750	6284	6778	7471	7865	7680	7317	7199	7543	7643	7347	7535	7926	8120	8272	8459	8552	8627	8684	8710	8722
	% Difference	4	6	-2	-4	-4	-6	-3	-5	-5	-5	-4	1	1	0	0	0	-1	-2	-3	-3	-3
RCP4.5	Storage (1000 m^3)	5983	6506	6751	7331	7600	7449	7185	7197	7612	7625	7348	7655	8017	8177	8306	8450	8536	8605	8664	8687	8701
	% Change	4	4	0	-2	-3	-3	-2	0	1	0	0	2	1	1	0	0	0	0	0	0	0
RCP8.5	Storage (1000 m^3)	6021	6575	6846	7342	7744	7431	7010	7085	7614	7628	7258	7570	7969	8129	8270	8435	8517	8581	8633	8660	8672
	% Change	5	5	1	-2	-2	-3	-4	-2	1	0	-1	0	1	0	0	0	0	-1	-1	-1	-1



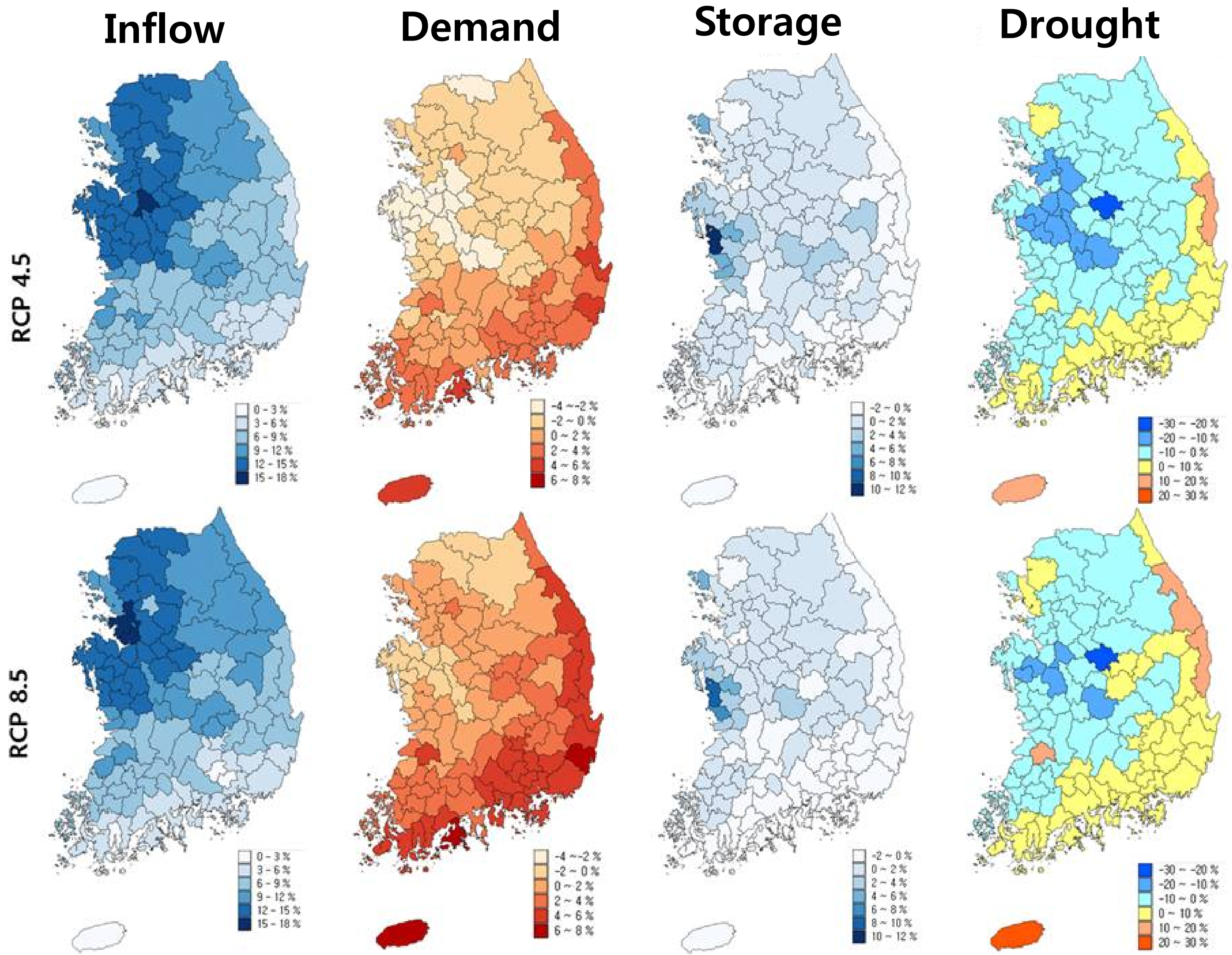




순(10-Days)		total
Observed	Storage (1000 m^3)	**302883**
Historical	Storage (1000 m^3)	**292767**
	% Difference	**-3.3**
RCP4.5	Storage (1000 m^3)	**292455**
	% Change	**-0.1**
RCP8.5	Storage (1000 m^3)	**291719**
	% Change	**-0.4**

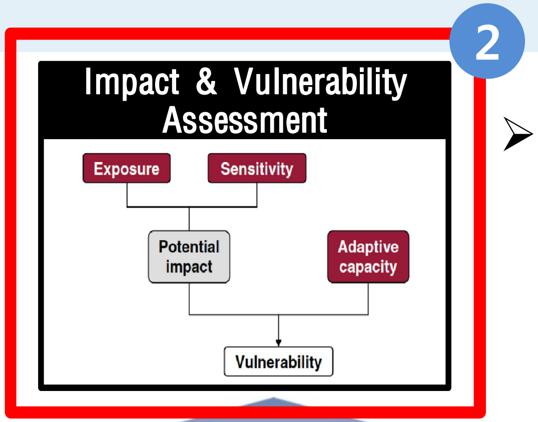


Spatial distribution of climate change impact on agricultural reservoir

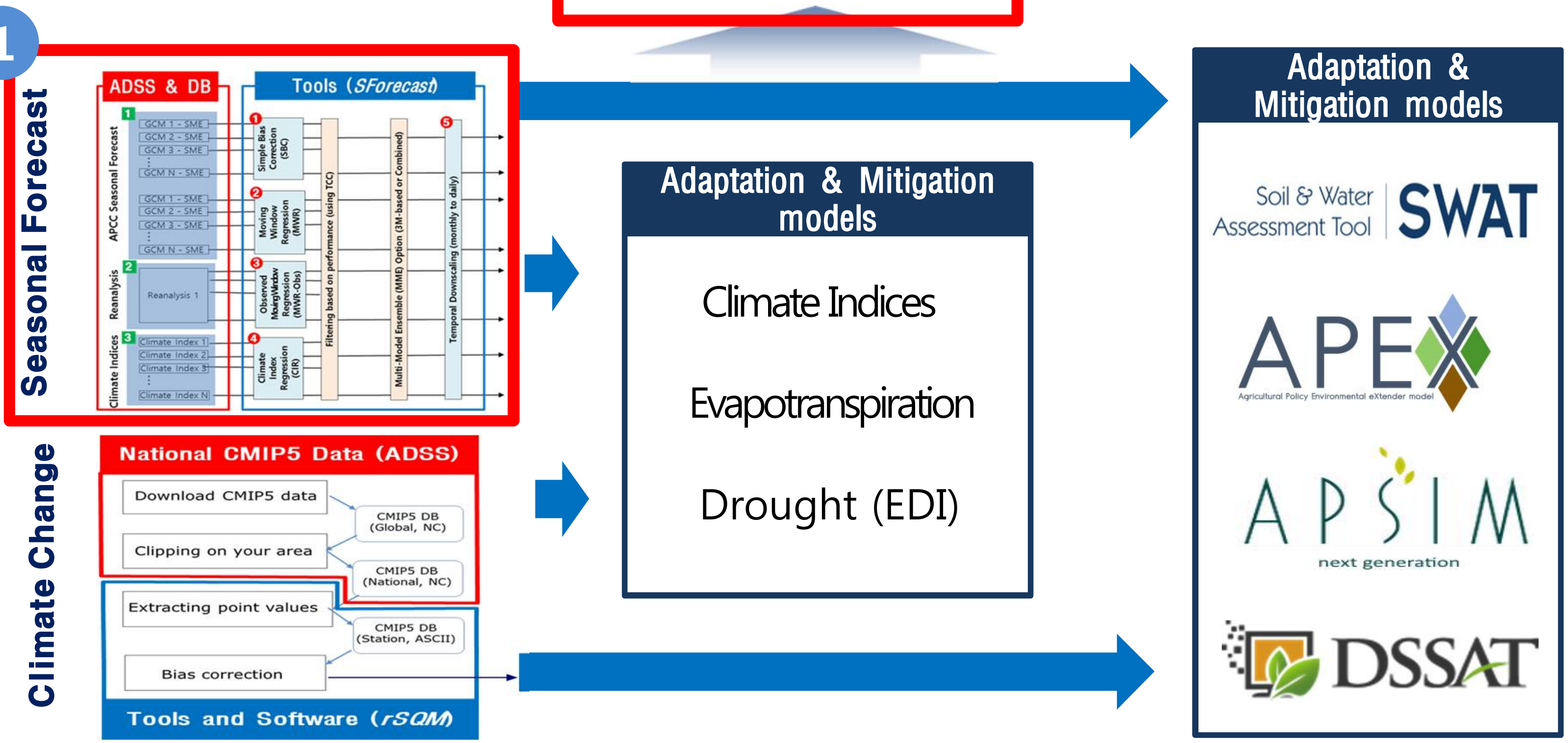


Ongoing & future works

- 6-month forecasting of inflow, demands, storage level as drought management measures

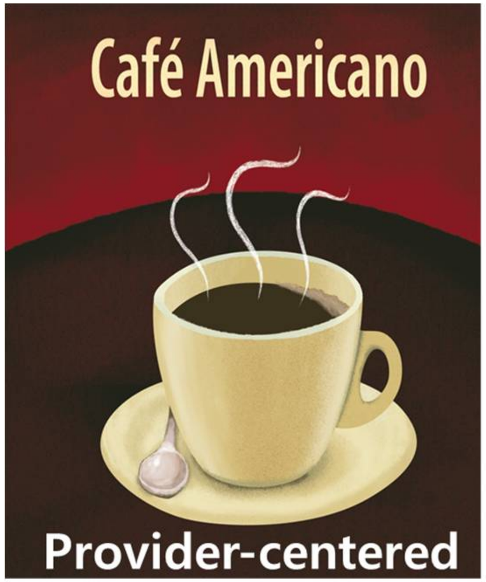


- Vulnerability assessment considering socio-economic factors

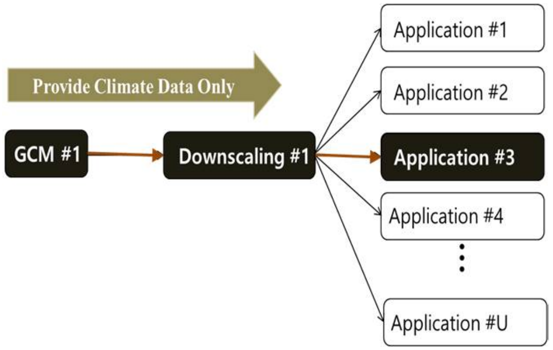


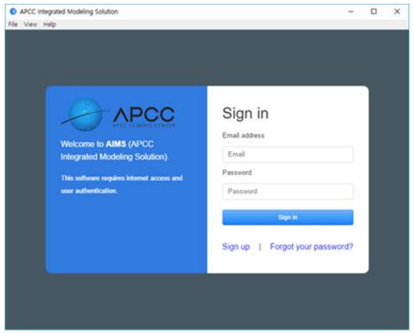
2018 APEC Climate Center Training Program

User-oriented Statistical Downscaling of Climate Change Scenario for Agriculture and Water Resources

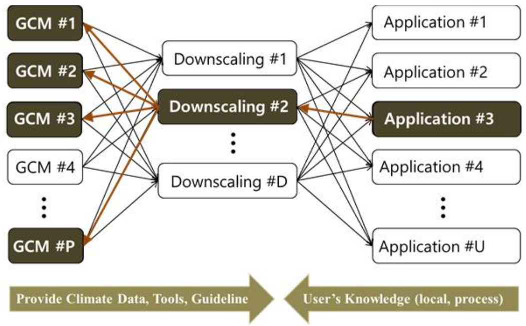


What is your favorite GCMs and downscaling methods?





using AIMS



Topics and financial support

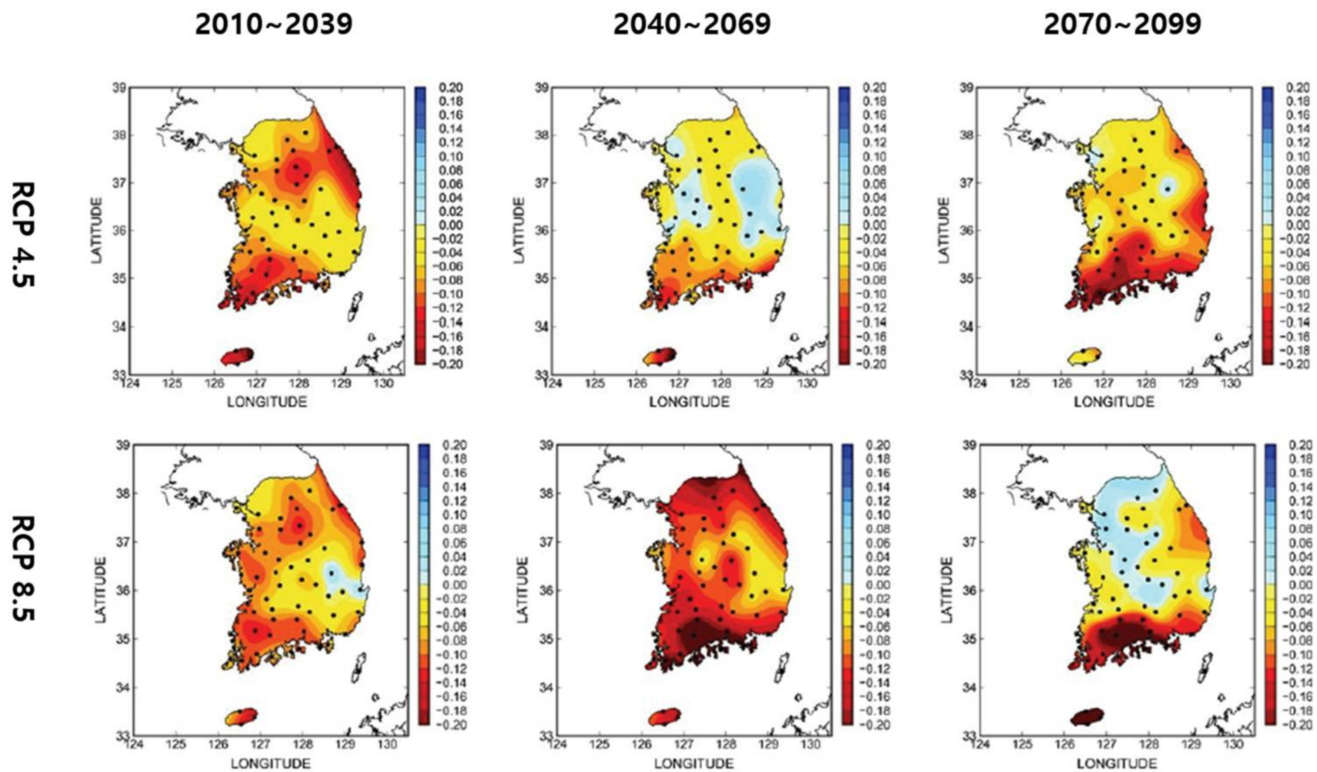
Sessions	Contents
Lectures	**Understanding climate information (seasonal prediction and climate change scenario) and introduction to climate information produced by APCC** **Downscaling of climate change scenarios** - User interface and steps to using climate change scenario data - Introduction to downscaling methods - Case studies on using climate change scenario data **Introduction to APCC seasonal prediction and downscaling**
Practical Sessions	**Producing downscaled climate change scenario data for each nation and user-oriented analysis of climate characteristics** **Assessment of climate change impact on drought using EDI**
Presentation	**Participant's presentation based on the results of the lecture and the practical session**

Financial Support

- Airfare, accommodation and per-diem will be supported by APCC

Expected output from the training workshop

- **Downscaled climate change projections on their own observation stations (29 GCMs, 2 downscaling methods)**
- **Impacts on drought characteristics (intensity, duration, frequency) on their own countries as below**
- **Research papers (if participants want)**



Intensity changes

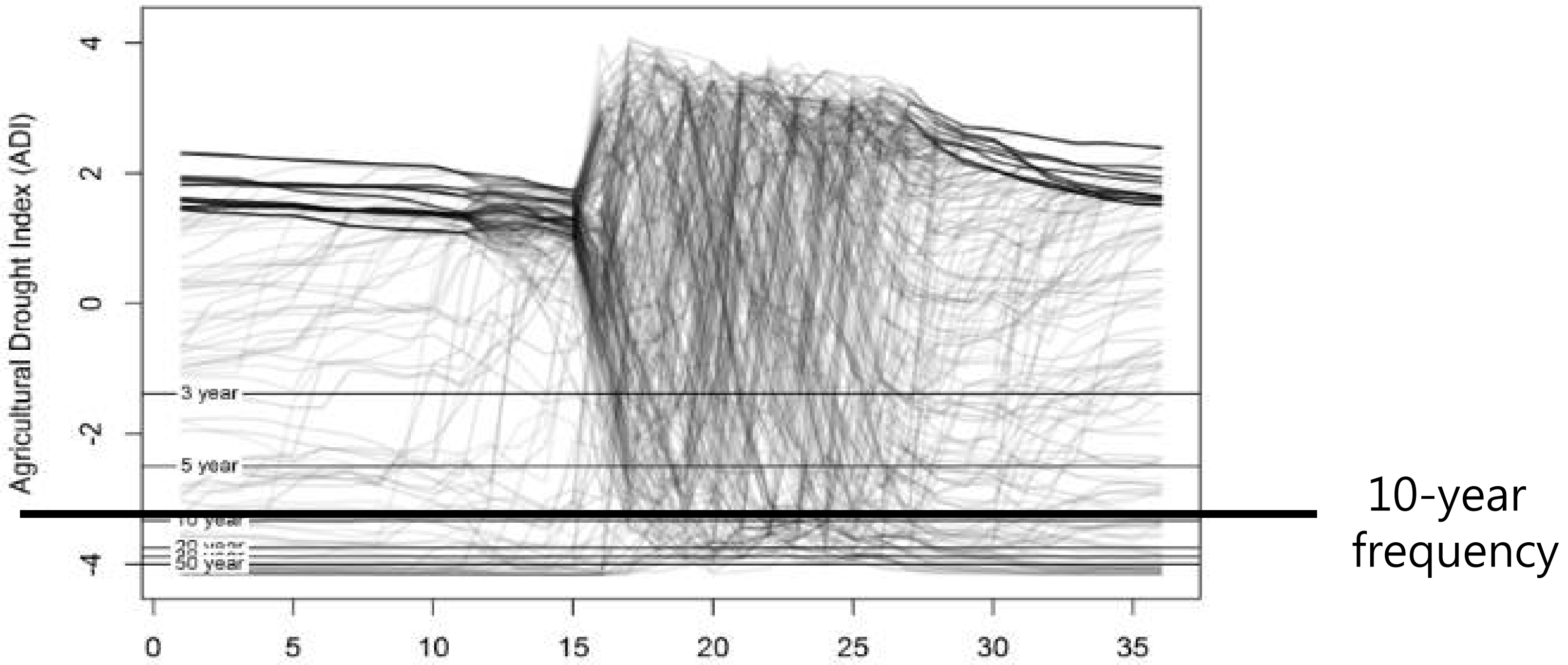
2018 APEC Climate Center Downscaling Training Program

- **Period:** Monday 15th – Saturday 20th October 2018
- **Location:** APEC Climate Center, Busan, Korea
- **Topic:** User-oriented Statistical Downscaling of Climate Change Scenario for Agriculture and Water Resources
- **Target Applicants:** Scientists and working level staff from national research institutes in agriculture and/or water-related fields in developing countries, preferably APEC economies
- **Closing Date:** Friday 31st August 2018 by 23:59 (Korea Standard Time)
- **Application Form & Detailed Information:** http://apcc21.org/notice/apccnewsView.do?lang=en&bbsId=BBSMSTR_000000000016&nttId=5664
- **Contact Information:** daeinkang@apcc21.org

Thank You!

Agricultural drought index based on storage level

- Storage → Agricultural Drought Index (ADI)



Frequency(yr)	~3	3	5	10	20	30	50	50~
P(X≤x)		0.33	0.20	0.10	0.05	0.03	0.02	
ADI		-1.39	-2.50	-3.33	-3.75	-3.89	-4.00	
Classification	Normal		Moderate drought	Severe drought				Extreme drought