

2017 APCC Training Program on
“User-oriented Statistical Downscaling of
Climate Information in
Agriculture and Water Resources”

Practice: Climate change

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Let me know your...

- **Responsibility in workplace?**
- **Motivation to be here?**
- **What do you expect to learn from 2017 APCC Training Program?**



Today practice class covers...

- **How to select GCMs suitable to a region of interest**
 - Temporal and spatial patterns
- **Statistical downscaling GCMs selected at stations**

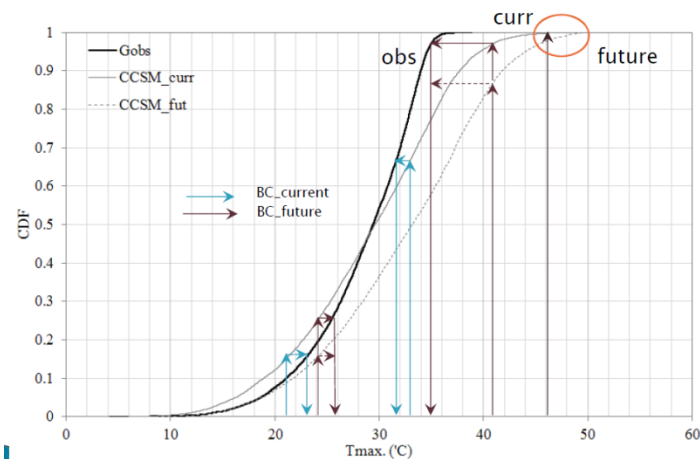
- **Analysis**
 - Climate indices
 - Variogram curve
 - Correlation between multiple points
 - Miscellaneous analysis
 - Weighting, Uncertainty, etc



SQM VS SDQDM

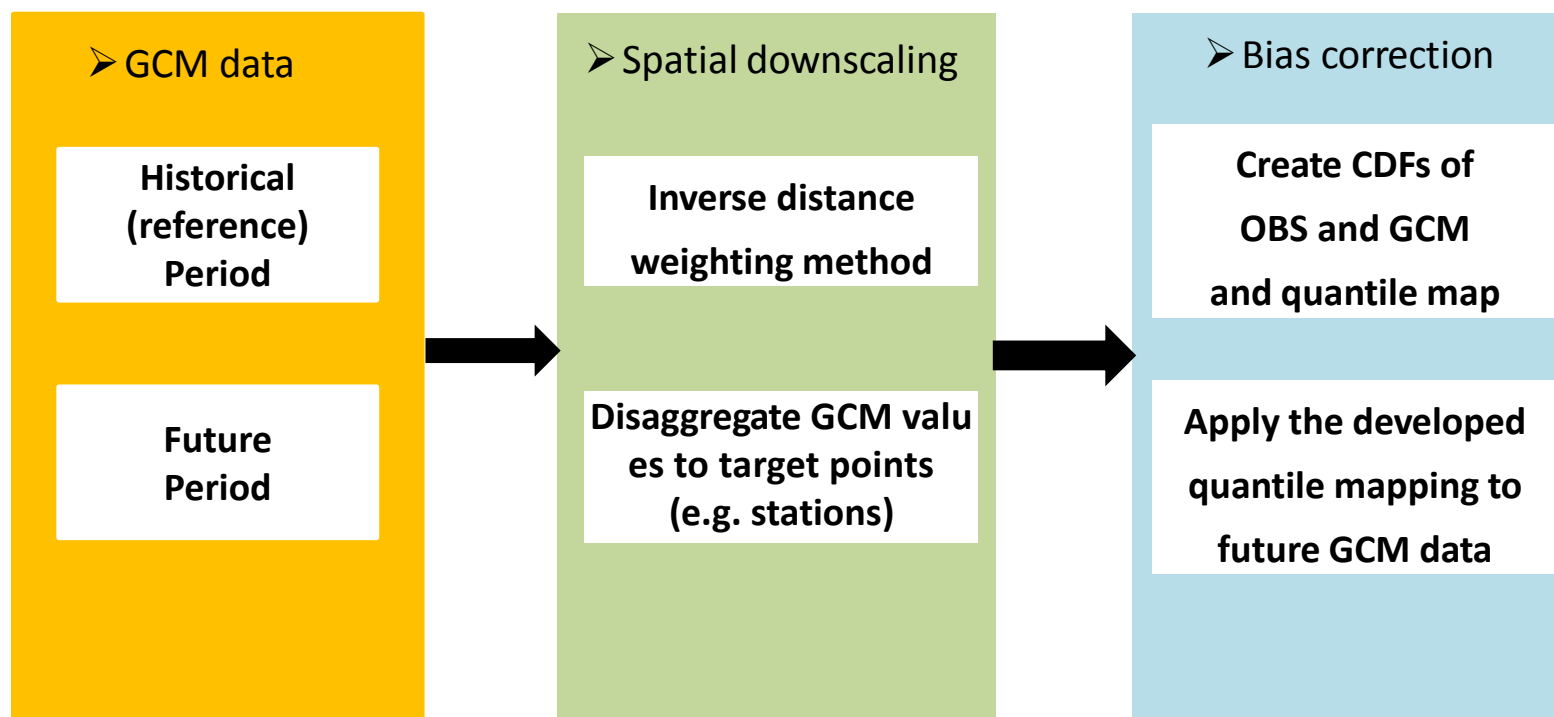
➤ What is SQM?

- Daily-based?
- Moving window?
- Bias-Correction
 - Bias-correction in marginal distribution
 - Quantile mapping



Simple Quantile Mapping (SQM)

➤ Sampling monthly data to build ECDF



Spatial Disaggregation-Quantile Delta Mapping (SDQDM)

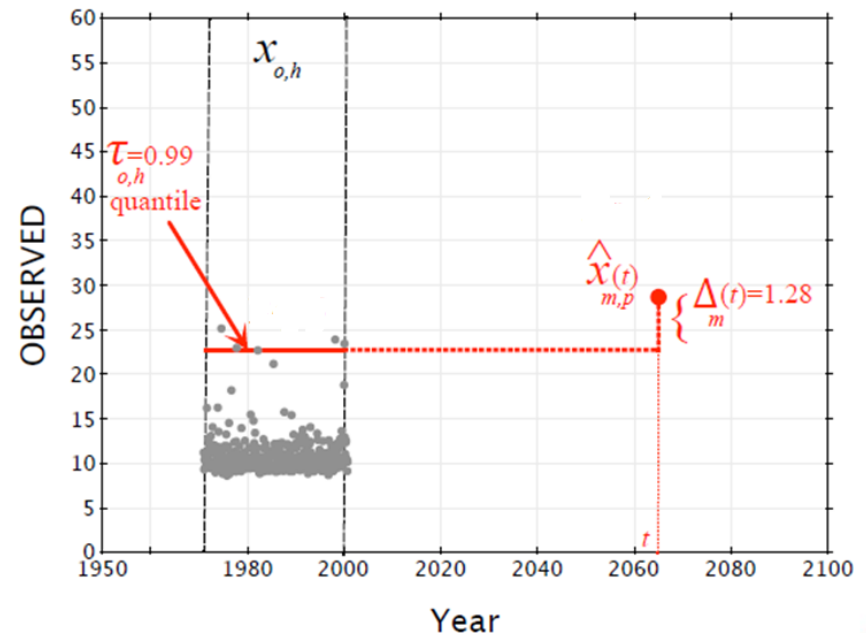
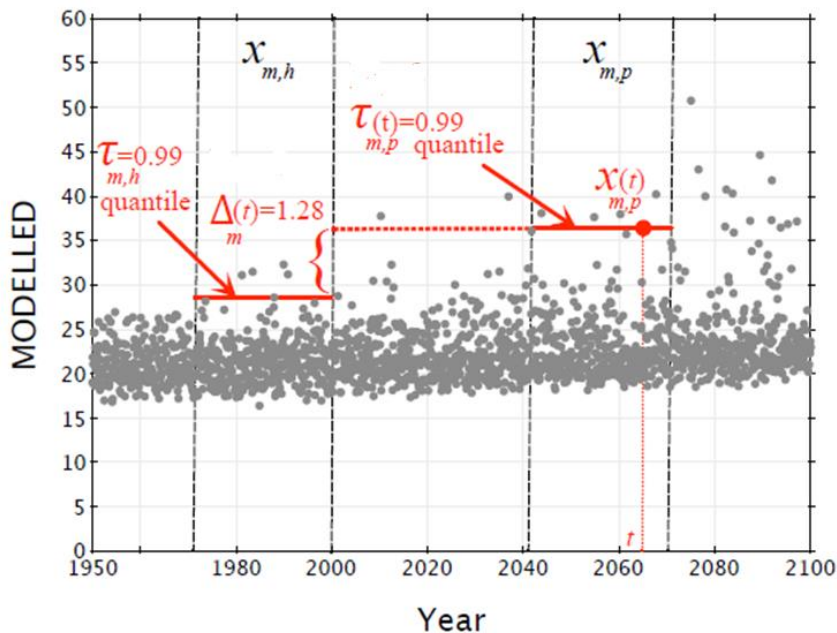
- **Daily-based?**
- **Moving window?**
 - 15-day or one month
 - Need to bias-correct with new sampling everyday?
- **Preserve GCM-driven relative changes at all quantiles**



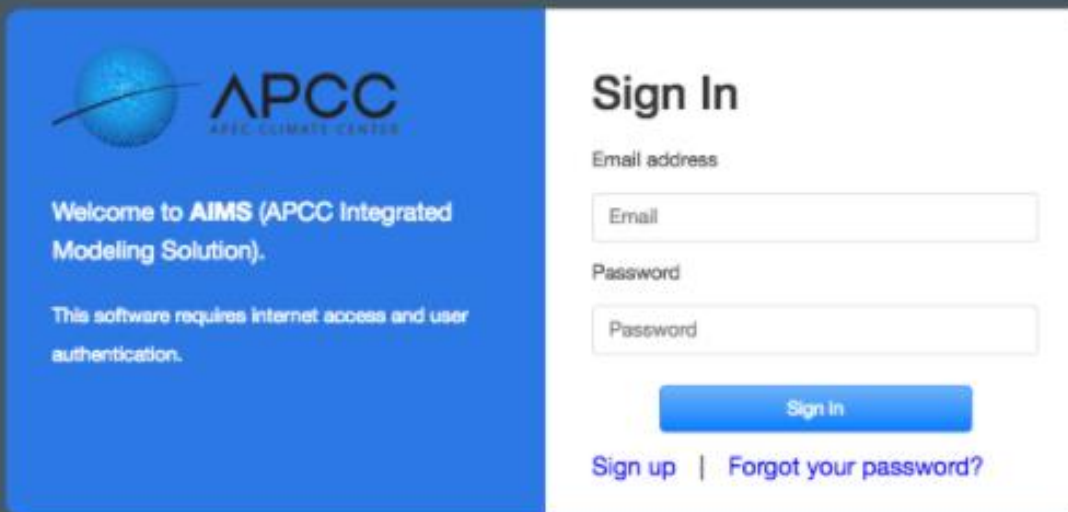
SDQDM


► Temperature

- 26.5 °C in 2064, $F^{-1}_{\text{ref}}(0.99)=25.25$ °C
- $F^{-1}_{\text{obs}}(0.99)=22.7$ °C $\rightarrow X(m,p)$?



APCC Integrated Modelling Solution (AIMS)



 **APCC**
APCC CLIMATE CENTER

Welcome to **AIMS** (APCC Integrated Modeling Solution).

This software requires internet access and user authentication.

Sign In

Email address

Password

[Sign In](#)

[Sign up](#) | [Forgot your password?](#)

Project and selection of climate scenarios in AIMS

Click + New project !!

History

Search for project

Papua New Guinea Test Project

Thailand Test Set

+ New Project

News

Welcome to the AIMS (APCC Integrated Modeling Solution) Personal Edition.
2017/08/17

← New Project

Please select a method of downscaling.

Downscaling Method:

- Climate Change**
Climate change is ...
- Seasonal Forecast
Seasonal Forecast...

← Select a Country

Please select a country.

Search for country name

- Bangladesh
- Bhutan**
- Cambodia
- Fiji
- India
- Indonesia
- Malaysia
- Myanmar
- Nepal
- Pakistan
- Papua New Guinea

News

Welcome to the AIMS (APCC Integrated Modeling Solution) Personal Edition.
2017/08/17

Version 0.2 (unstable) is released.
2017/08/16

Version 0.1 (unstable) is released.
2017/08/15

APCC
APEC CLIMATE CENTER

Make your own project name



Project page

AIMS - Papua New Guinea Test Project

Workflow Control

Workflow Configuration

Section Control

Data Source

Select one or more data sources. Internet connection is required for this task.

- CMIP5
Coupled Model Intercomparison Project Phase 5
- CORDEX
Coordinated Regional Climate Downscaling Experiment

↓

Local Data

You can download pre-calculated local observed data (GHCN observation data) or upload your own observed data. GHCN Observation data is disabled in the current version.

- GHCN Observation Data
- Custom Local Data

Instruction on preparing custom local data files

See [the detailed instruction](#) for more information. Internet connection is required for this task.

1. Station Data	2. Observation Data	3. Import Files
First save station data template file in your local computer and fill in the file. Do not rename or delete	For your observed data, save the template file in your local computer and rename the file to match the station ID given	When you are ready with all files, click below button.

Climate Change Index Calculation

Open working directory Show log
Reset section

Evaluation: Spatial Reproducibility

Open working directory Show log
Reset section

Weight Factor and Uncertainty for GCMs

Open working directory Show log
Reset section

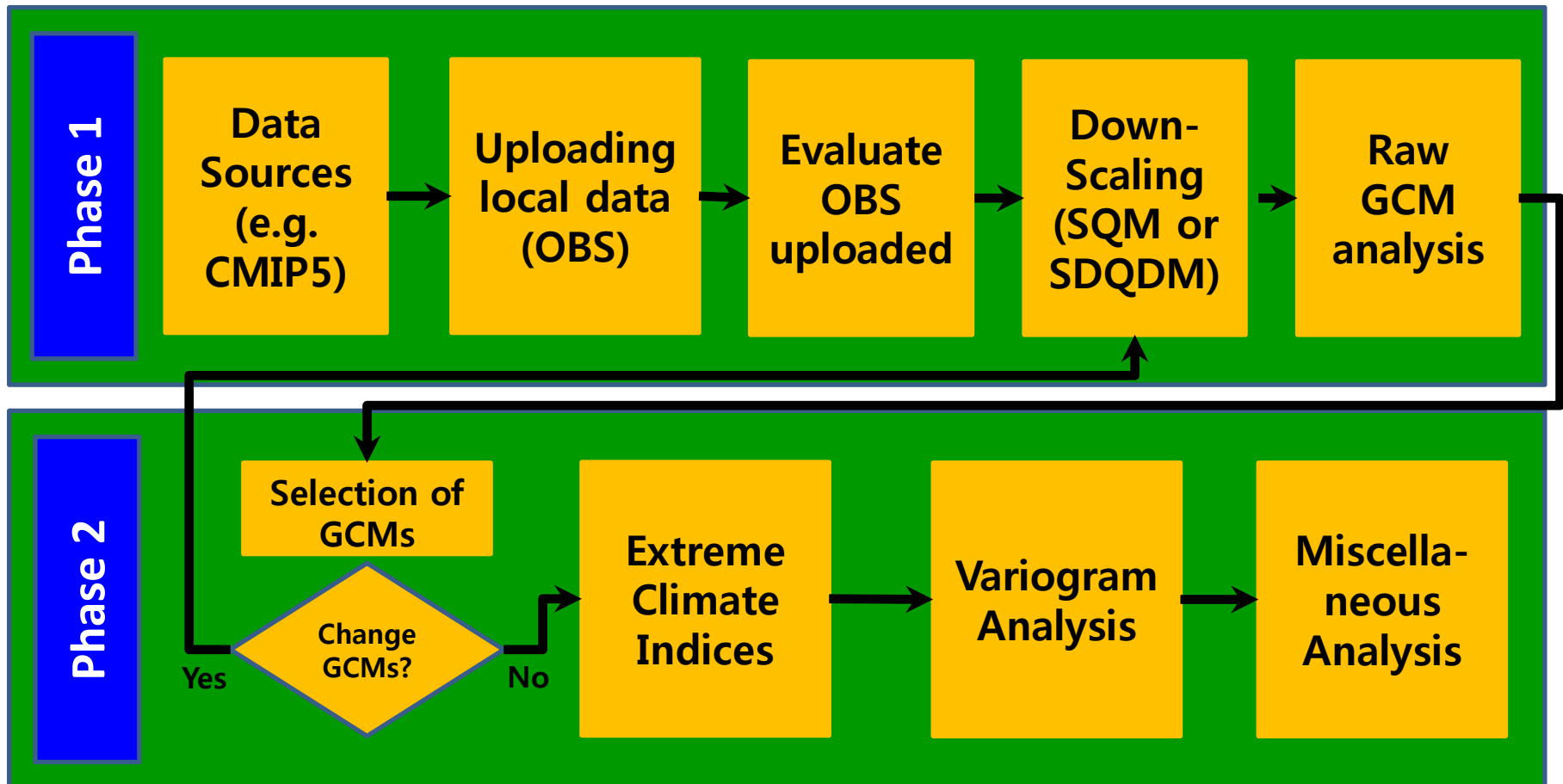
Modeling: Drought Index

Open working directory Show log
Reset section Check report

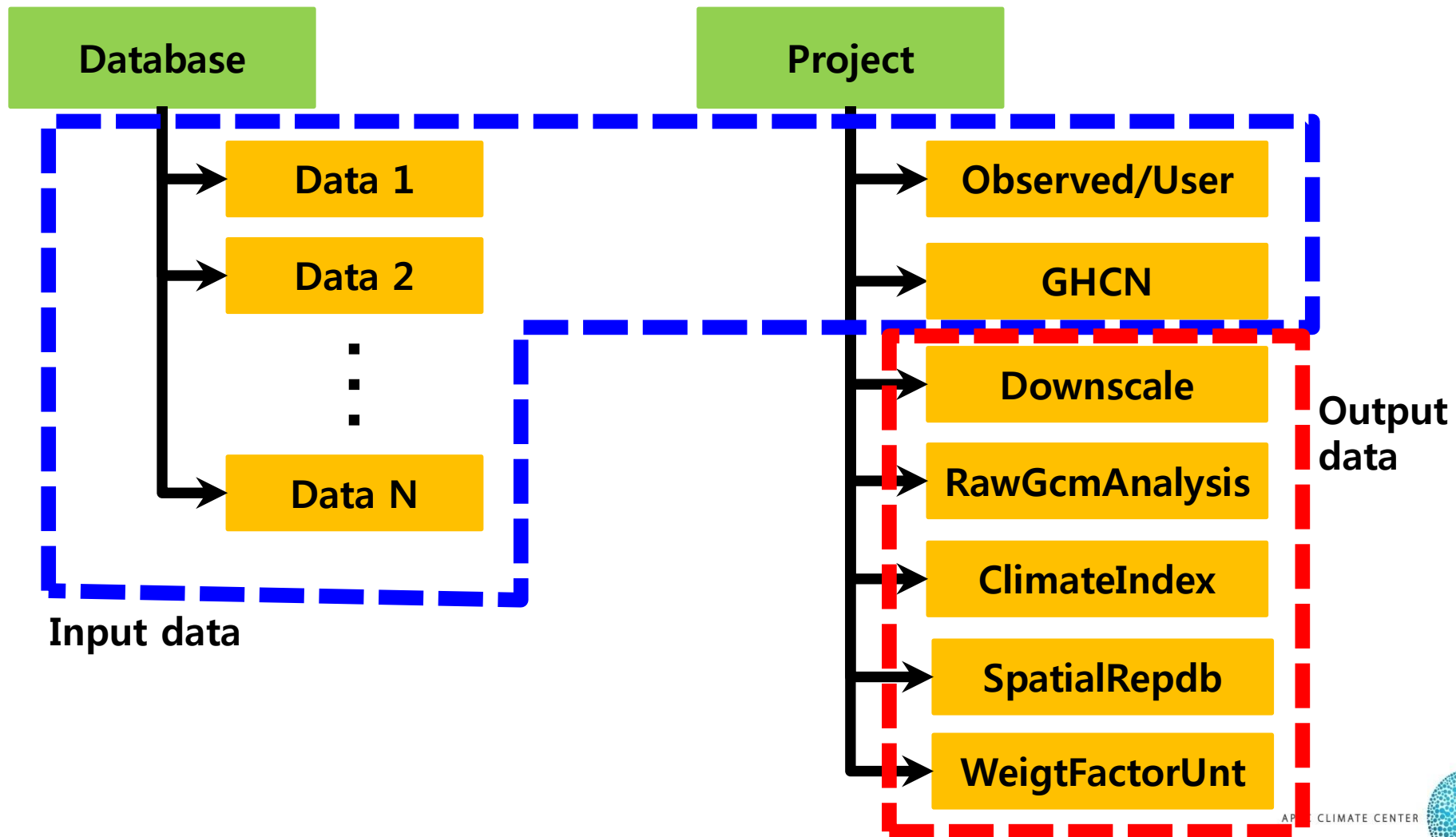


APCC Integrated Modelling Solution (AIMS)

➤ Workflow



Data structure in APCC Downscaling Platform



Data Source Card

Data Source

Select one or more data sources. Internet connection is required for this task.

































- CMIP5
Coupled Model Intercomparison Project Phase 5
- CORDEX
Coordinated Regional Climate Downscaling Experiment



Data source

➤ APCC Data Service System

- adss.apcc21.org

DataSet	Areal Coverage	Grid Size	Time Step	Access	Source	Requirements
APCC-MME(6-MON)	Global	2.5×2.5(degree)	Monthly	  	APCC	Login
APCC-MME(3-MON)	Global	2.5×2.5(degree)	Monthly	  	APCC	Login
NDIVIDUAL-MODEL(6-MON)	Global	2.5×2.5(degree)	Monthly	  	APCC	Login
NDIVIDUAL-MODEL(3-MON)	Global	2.5×2.5(degree)	Monthly	  	APCC	Login
CORDEX-SEA25	Regional	25km	Daily	  	APCC	
CORDEX-SEA50	Regional	50km	Daily	  	APCC	
Clipped CMIP5	National level (22 Countries)	Depending on GCMs	Daily	  	ESGF	
IRI_DATA_LIBRARY	Global	2.5×2.5(degree)	Various	 	IRI	
NCEP	Global	2.5×2.5(degree)	Daily	  	NOAA	
NCEP-SFC	Global	2.5×2.5(degree)	Daily	  	NOAA	
NOAA-OLR	Global	2.5×2.5(degree)	Daily	  	NOAA	



Clipped CMIP5 data

Clipped CMIP5 data

The climate change scenario data provided on this website was generated in a manner to ensure user convenience when carrying out climate change impact assessments in the field of application. The data was obtained through <https://pcmdi.llnl.gov/search/cmip5/>. This data was originally generated through a collection of coordinated global-scale multi-model data. Table 1 indicates what data was clipped from the aforementioned global-scale multi-model data using the

Table 3. Available meteorological variables based on GCMs and RCP scenarios.

Table 1. Available national-level data based on clipped CMIP5 climate change

Name	Code	xmi
Bangladesh	BD	88.0
Bhutan	BT	88.7
Burma	MM	92.1
Cambodia	KH	102.1
Chile	CL	-109.1
Colombia	CO	-81.7
Cuba	CU	-84.9
Egypt	EG	24.7
Ethiopia	ET	33.0
Federated States of Micronesia	FM	138.0
Fiji	FJ	-180.0
India	IN	68.1
Indonesia	ID	95.0

No	GCMs	Historical						RCP4.5						RCP8.5					
		PR	TX	TN	WD	SR	RH	PR	TX	TN	WD	SR	RH	PR	TX	TN	WD	SR	RH
1	bcc-csm1-1-m	○	○	○				○	○	○				○	○	○			
2	bcc-csm1-1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3	CanESM2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
4	CCSM4	○	○	○				○	○	○				○	○	○			
5	CESM1-BGC	○	○	○				○	○	○				○	○	○			
6	CESM1-CAM5	○	○	○				○	○	○				○	○	○			
7	CMCC-CM	○	○	○				○	○	○				○	○	○			
8	CMCC-CMS	○	○	○				○	○	○				○	○	○			
9	CNRM-CM5	○	○	○				○	○	○				○	○	○			
10	CSIRO-Mk3-6-0	○	○	○				○	○	○				○	○	○			
11	FGOALS-g2	○	○	○				○	○	○				○	○	○			
12	FGOALS-s2	○	○	○				○	○	○				○	○	○			
13	GFDL-CM3	○	○	○				○	○	○				○	○	○			
14	GFDL-ESM2G	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○



Local Data Card (1)

➤ If you do not have local observed data

- Select GHCN → Not activated yet...

➤ If not, i.e. you have a local data set

- Select “Custom Local Data”

Local Data

You can download pre-calculated local observed data (GHCN observation data) or upload your own observed data. GHCN Observation data is disabled in the current version.

GHCN Observation Data

Custom Local Data

Instruction on preparing custom local data files

See [the detailed instruction](#) for more information. Internet connection is required for this task.

1. Station Data First save station data template file in your local computer and fill in the file. Do not rename or delete header row in the csv file.	>	2. Observation Data For your observed data, save the template file in your local computer and rename the file to match the station ID given in the station data file. Fill in the csv file. Copy the file and repeat the process for all your station IDs.	>	3. Import Files When you are ready with all files, click below button.
--	---	--	---	--



Remarks in Local Data Card

➤ **Just keep the form of template file**

- Do not rename or delete header

➤ **Missing data**

- Please check if there is a considerable portion of missing values in your data
 - May distort the results of raw GCM analysis in next card

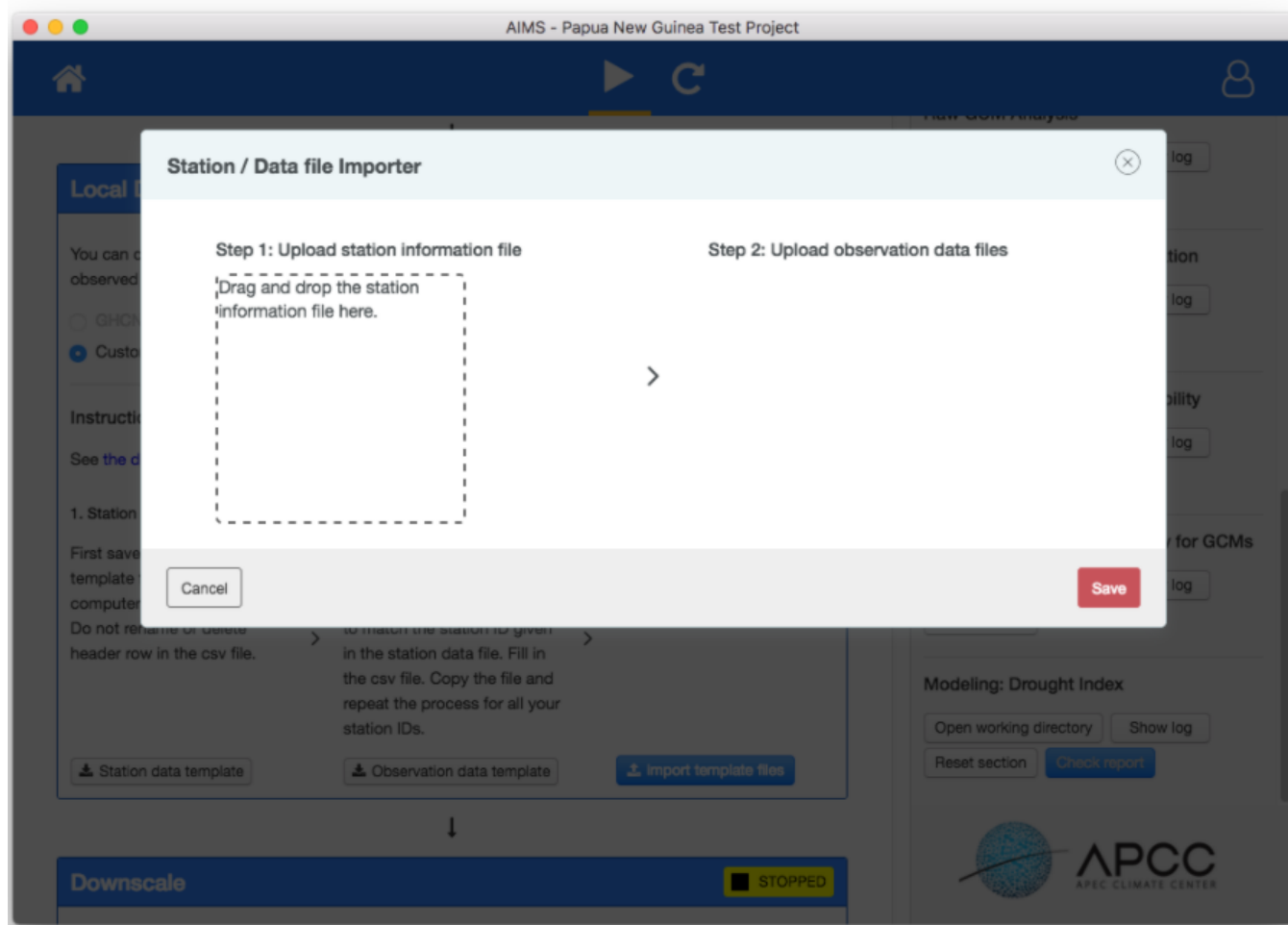
➤ **In the case of multiple stations,**

- Please check all stations have a same period

➤ **Station ID should be same with file names of station data**



Upload local data



Evaluate Observed Data Card

Evaluate Observed Data

Before you downscale the observation data, we highly recommend you to evaluate your data with this tool. This section will generate the summary of the observation data, and graphs for each variables.

Variables

pr tasmax tasmin sfwind rhs rds

Period

	Start Year		End Year
Observed	1999	~	2016

- **Eliminate stations inducing incorrect analysis by**
 - High rate of missing data
 - Errors in measuring



Evaluate Observed Data Card

- **Look up the results at**
 - `$(Project)/Observed/User/summary`
- **Select stations to be used for remaining work flow**



Downscale Card (1)

➤ Ch

The screenshot shows a web application window titled "AIMS - Papua New Guinea Test Project". The main content area is titled "Downscale" and contains the following sections:

- GCM names:** Two green buttons labeled "bcc-csm1-1" and "bcc-csm1-1-m".
- Scenario:** Two radio button options: "RCP4.5 Representative Concentration Pathway (RCP) 4.5 Scenarios" (unchecked) and "RCP8.5 Representative Concentration Pathway (RCP) 8.5 Scenarios" (checked).
- Variables:** A green button labeled "pr".
- Period:** A table with columns for "Start Year" and "End Year".

	Start Year		End Year
Observed	1979	~	2008
Historical (GCM)	1976	~	2005
Future (GCM)	2010	~	2039
	2040	~	2069

Below the table is a blue button with a "+" sign and a red button with a "-" sign.

The right sidebar contains the following sections:

- Project Information:** Project Name: Papua New Guinea Test Project; Target Country: Papua New Guinea; Method Type: Climate Change.
- Data Source:** Open working directory, Show log, Reset section.
- Local Data:** Open working directory, Show log, Reset section.
- Downscale:** APCC APEC CLIMATE CENTER logo.



Downscale Card (2)

➤ Downscale method

- SQM
 - Very fast
 - To select GCMs, run only SQM first...then go to next section
- SDQDM
 - Well preserve GCM-driven climate signals
 - Requires a considerable computational time



Downscale Card (3)

- Need a huge computational time to complete an assigned work for your project



Downscale Card (4)

➤ Look up output data at

- \$(Project)/Downscale/SQM or SDQDM
- Original, historical, rcp45, rcp85

Name	Date modified	Type	Size
TH431201_SQM_CCSM4_historical	17/08/2017 9:36 AM	Microsoft Excel C...	246 KB
TH431201_SQM_CCSM4_historical_original	17/08/2017 9:36 AM	Microsoft Excel C...	336 KB
TH431201_SQM_CCSM4_rcp45	17/08/2017 9:30 AM	Microsoft Excel C...	1,401 KB
TH431201_SQM_CCSM4_rcp45_original	17/08/2017 9:30 AM	Microsoft Excel C...	1,032 KB
TH431201_SQM_CCSM4_rcp85	17/08/2017 9:30 AM	Microsoft Excel C...	1,405 KB
TH431201_SQM_CCSM4_rcp85_original	17/08/2017 9:30 AM	Microsoft Excel C...	1,032 KB
TH431301_SQM_CCSM4_historical	17/08/2017 9:36 AM	Microsoft Excel C...	246 KB
TH431301_SQM_CCSM4_historical_original	17/08/2017 9:36 AM	Microsoft Excel C...	336 KB
TH431301_SQM_CCSM4_rcp45	17/08/2017 9:30 AM	Microsoft Excel C...	1,428 KB
TH431301_SQM_CCSM4_rcp45_original	17/08/2017 9:30 AM	Microsoft Excel C...	1,073 KB
TH431301_SQM_CCSM4_rcp85	17/08/2017 9:30 AM	Microsoft Excel C...	1,434 KB
TH431301_SQM_CCSM4_rcp85_original	17/08/2017 9:30 AM	Microsoft Excel C...	1,039 KB
TH431401_SQM_CCSM4_historical	17/08/2017 9:36 AM	Microsoft Excel C...	246 KB
TH431401_SQM_CCSM4_historical_original	17/08/2017 9:36 AM	Microsoft Excel C...	336 KB
TH431401_SQM_CCSM4_rcp45	17/08/2017 9:31 AM	Microsoft Excel C...	1,399 KB
TH431401_SQM_CCSM4_rcp45_original	17/08/2017 9:30 AM	Microsoft Excel C...	1,038 KB
TH431401_SQM_CCSM4_rcp85	17/08/2017 9:31 AM	Microsoft Excel C...	1,398 KB
TH431401_SQM_CCSM4_rcp85_original	17/08/2017 9:31 AM	Microsoft Excel C...	1,038 KB



Raw GCM Analysis Card (1)

➤ Temporal s

- Correlatic
GCM and

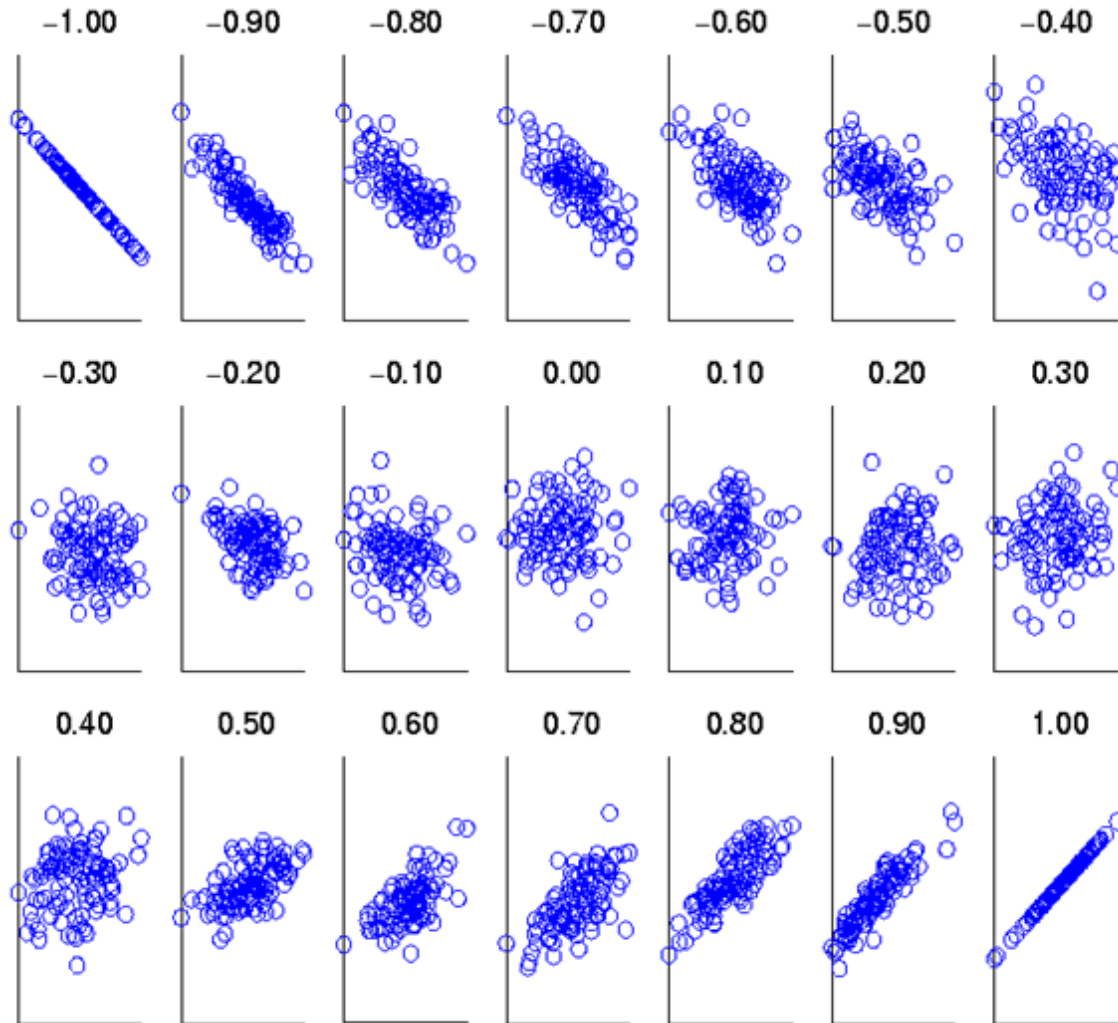
➤ Spatial patt

- Pattern c

Raw GCM

A general circula
general circulati

- ✓ Precipitation
- ✓ Temperature

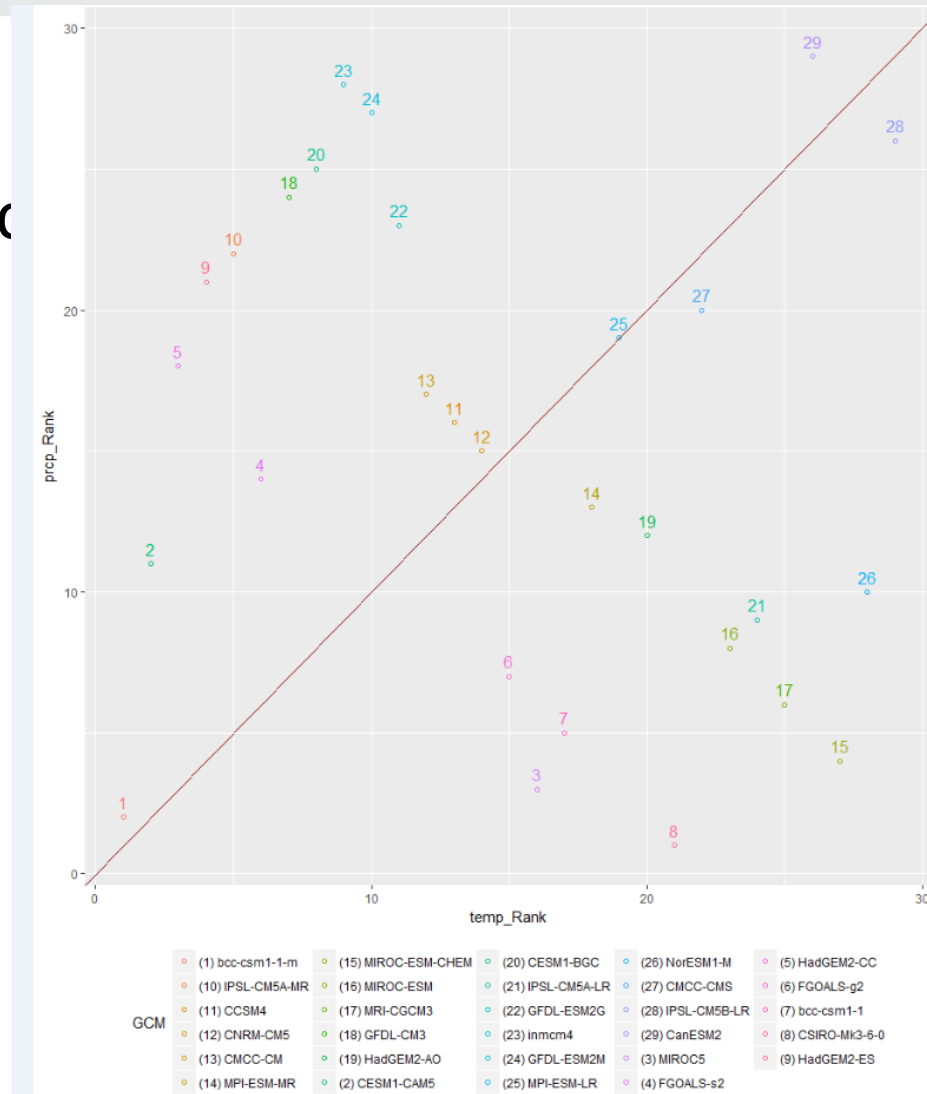


en

Raw GCM Analysis Card (2)

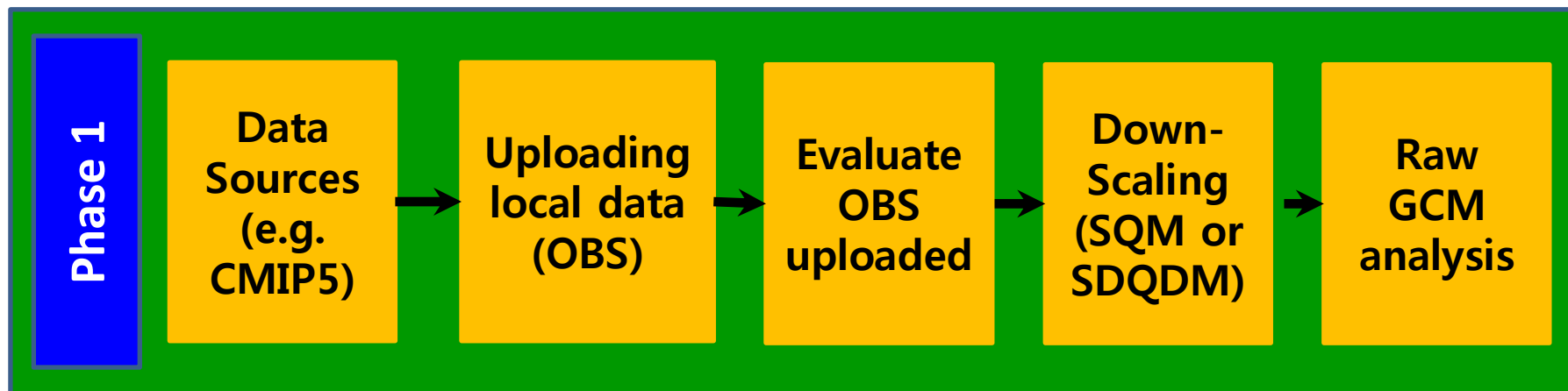
➤ Look up

- \$(Project



Phase 1

➤ Complete Phase 1 following the order of Phase 1



**Discussion with the results of
the raw GCM analysis**

**Please upload your results on
public folder**

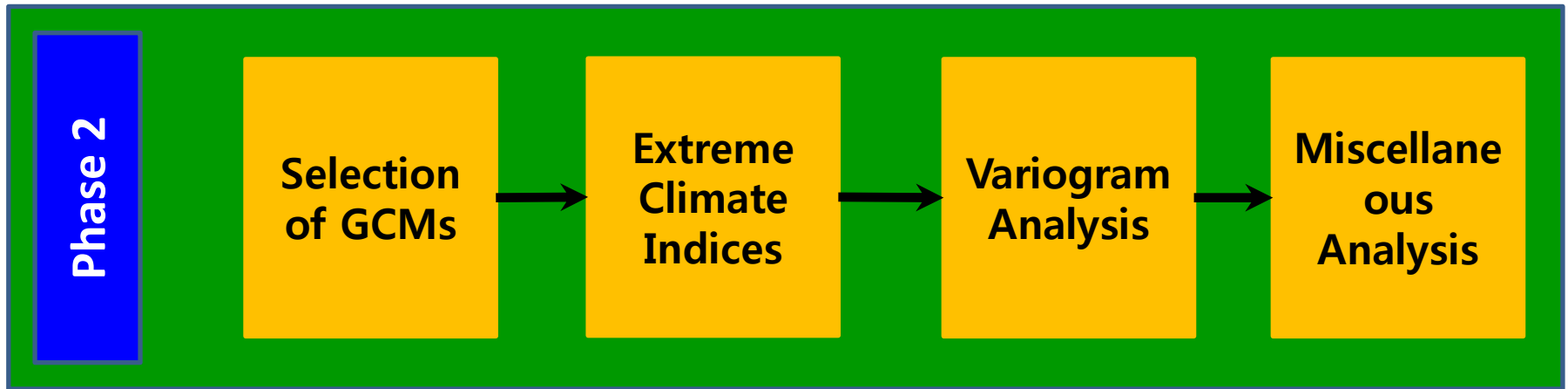


Check-point

- **GCM resolution VS study area**
- **Which variables are crucial to your study region?**
 - PRCP, Temp, or both
- **Clear seasonality in your region of interest?**
- **Spatial climate variability is an essential factor to rank GCMs?**
 - Multiple stations
 - Geographical characteristics




Phase 2



Selection of GCMs

- Check ranking of GCMs
- (Optional) Remove GCMs that have a poor skill in reproducing climate characteristics
- (Optional) Or select best top GCMs



The workflow will not stop.

I understand the risk, and I do not want the process stop here.



If you select GCMs...

- Return to **Downscale Section** again
- Choose GCMs, Emission scenario, Variables, and
 - “SDQDM”
 - Try one or two Top ranking GCMs
- Be patient...
 - Takes several hours...



Climate Change Index Calculation (1)

➤ Expert Team on Climate Change Detection and Indices (ETCCDI)

- <http://etccdi.pacificclimate.org/>

ID	Related variable	Description	Unit
CDD	PRCP	Consecutive dry days, PRCP < 1mm	Day
CWD		Consecutive wet days, PRCP ≥ 1mm	Day
PRCPTOT		Annual total PRCP in wet days (daily PRCP ≥ 1mm)	mm
Rx1day		Max 1-day precipitation	mm
Rx5day		Max 5-day precipitation	mm
R95pTOT		Annual total PRCP when daily PRCP > 95 percentile	mm
R99pTOT		Annual total PRCP when daily PRCP > 99 percentile	mm
SDII		Simple daily intensity index	mm/day
rnnmm		Annual count of days when PRCP ≥ nnmm	Day



Climate Change Index Calculation (2)

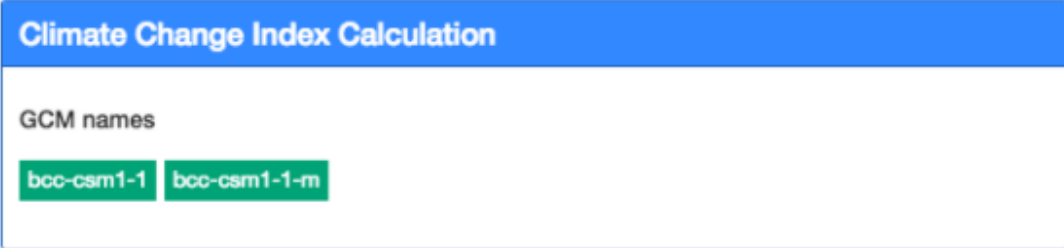
➤ ETCCDI related to TMAX and TMIN

ID	Related variable	Description	Unit
SU	TMAX	Summer day, TMAX > 25°C	Day
ID		Ice days, TMAX < 0°C	Day
TX _n		Min TMAX	°C
TX _x		Max TMAX	°C
TX10p		Cool days, TMAX < 10 th percentile	%
TX90p		Warm days, TMAX > 90 th percentile	Day
WSDI		Warm spell duration, TMAX > 90 th percentile	Day
FD		TMIN	Frost days TMIN < 0°C
TR	Tropical nights, TMIN > 20°C		Day
TN _n	Min TMIN		°C
TN _x	Max TMIN		°C
TN10p	Cool nights, TMIN < 10 th percentile		%
TN90p	Warm nights, TMIN > 90 th percentile		%
CSDI	Cold spell duration, TMIN < 10 th percentile		Day
DTR	TMAX & TMIN		Diurnal temperature range
GSL		Growing season length	Day



Climate Change Index Calculation (3)

➤ Calculate climate indices



The screenshot shows a web interface titled "Climate Change Index Calculation". Below the title, there is a section labeled "GCM names" containing two green buttons with the text "bcc-csm1-1" and "bcc-csm1-1-m".

➤ Look up the indices at

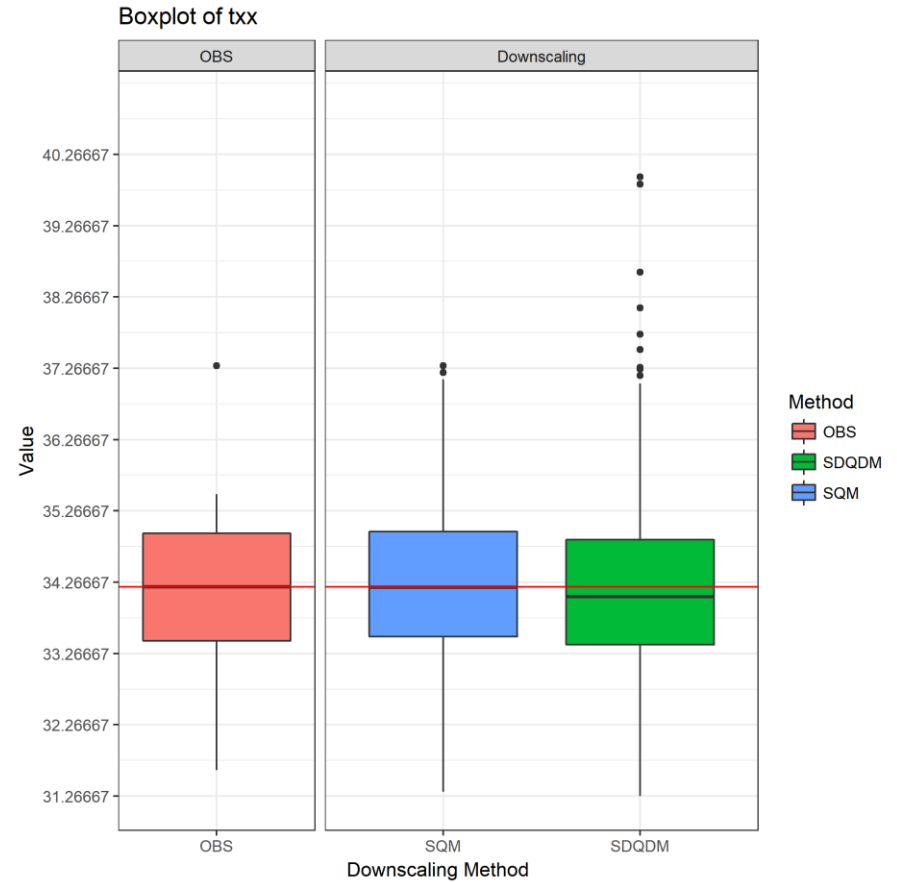
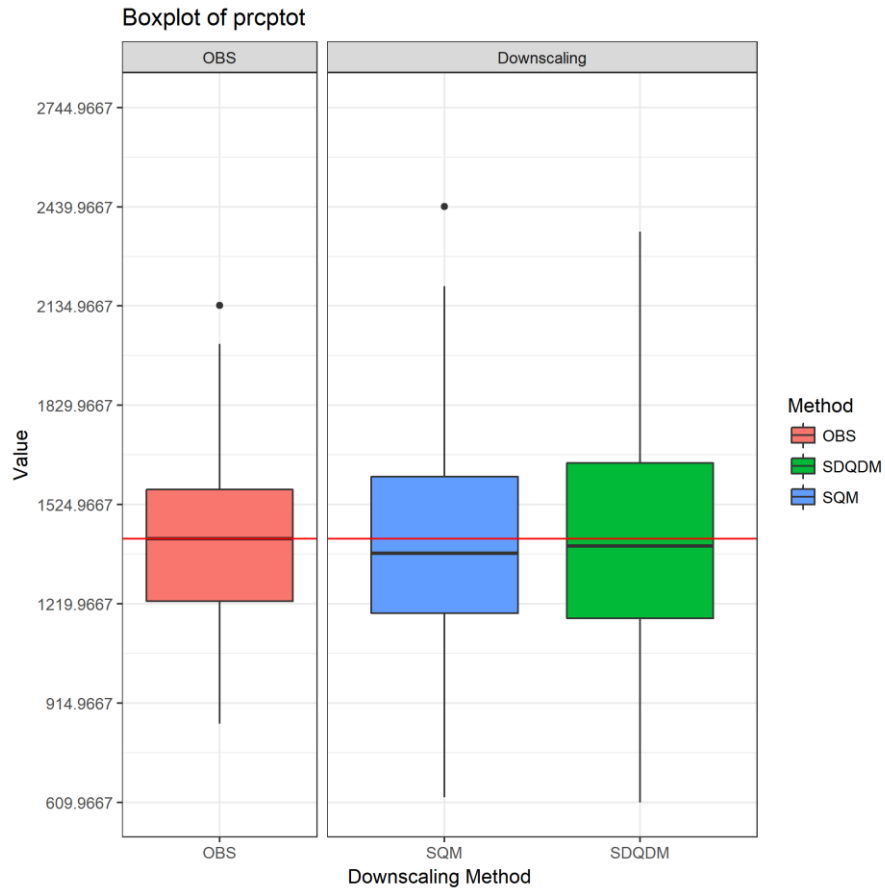
- $\$(project)/ClimateIndex/Raw$
 - OBS, SDQDM, SDM

➤ Box-plot for each indices

- $\$(project)/ClimateIndex/Historical$
- $\$(project)/ClimateIndex/Future$

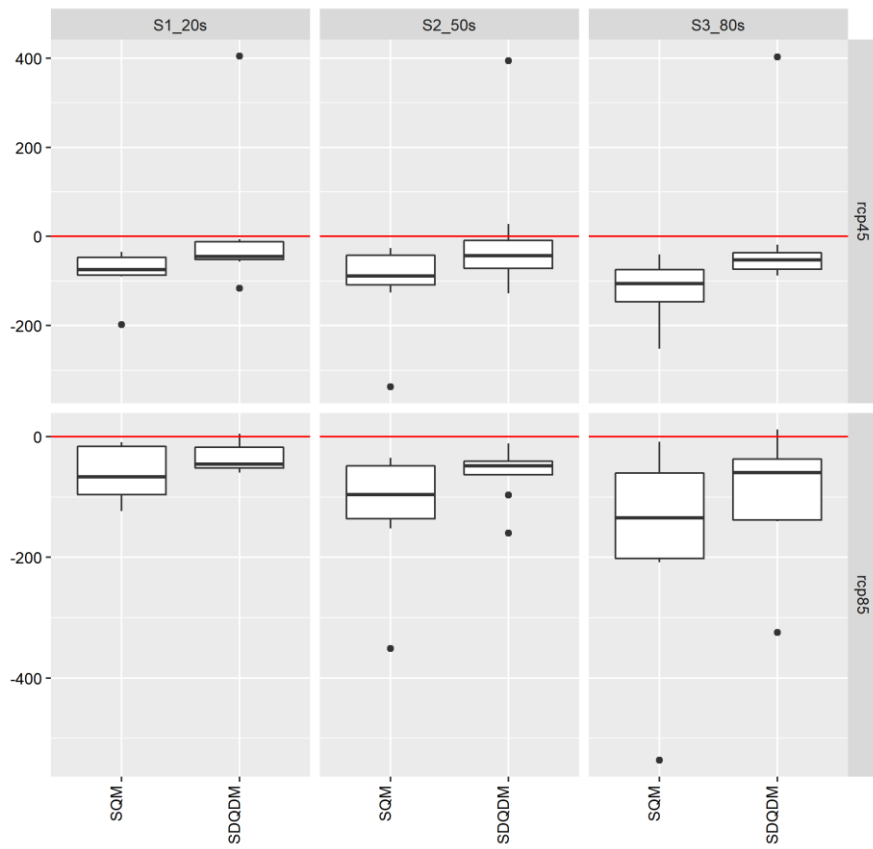


Box-plot for climate indices (Historical)

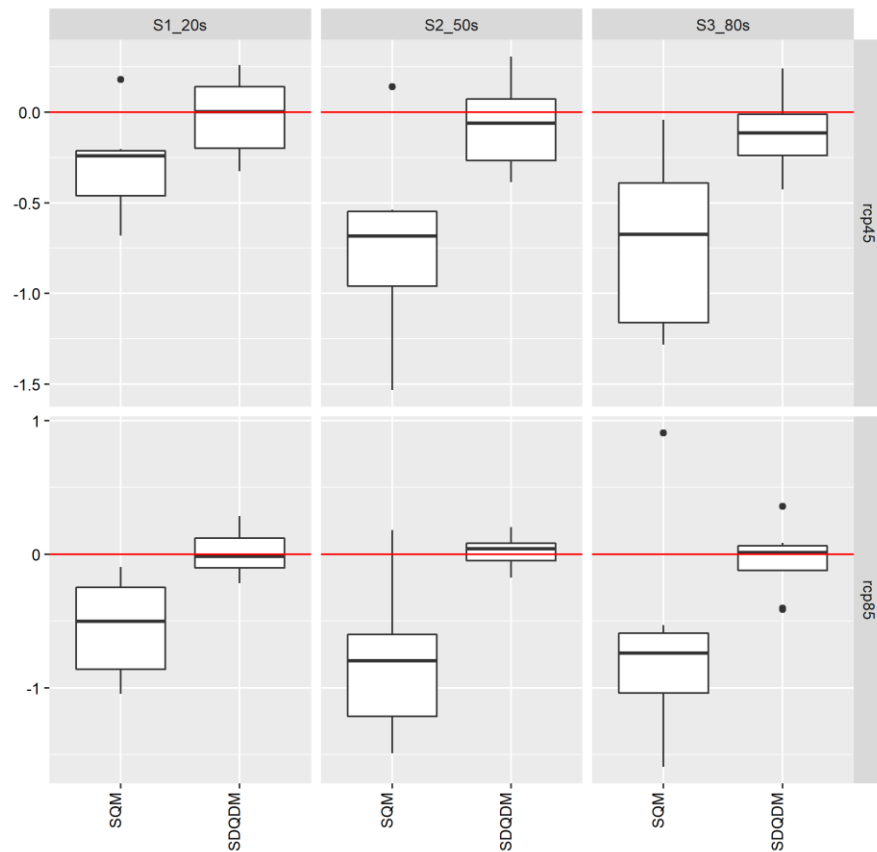


Box-plot for climate indices (Future)

Future scenario of prcptot



Future scenario of txx



Do you want to do more analysis with raw data of climate indices?

- **Open EXCEL spread sheet...**
- **Go to the folder that has results**
 - \$(project)/ClimateIndex/Raw



Spatial Reproducibility

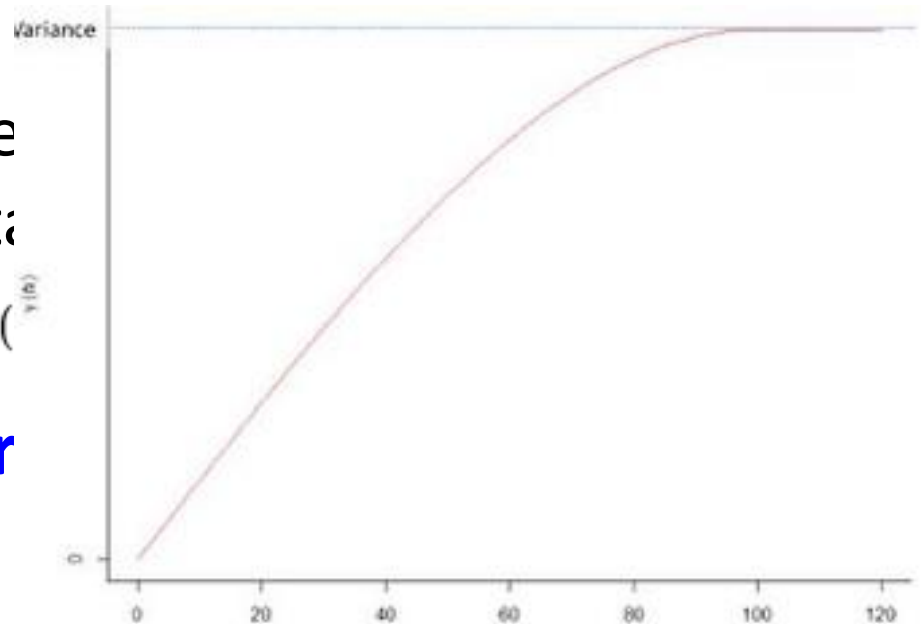
➤ Variogram curve

- Variance of difference corresponding to distance

$$2\gamma(x, y) = E \left[(y(x) - y(y))^2 \right]$$

➤ \$(project)/SpatialRepr

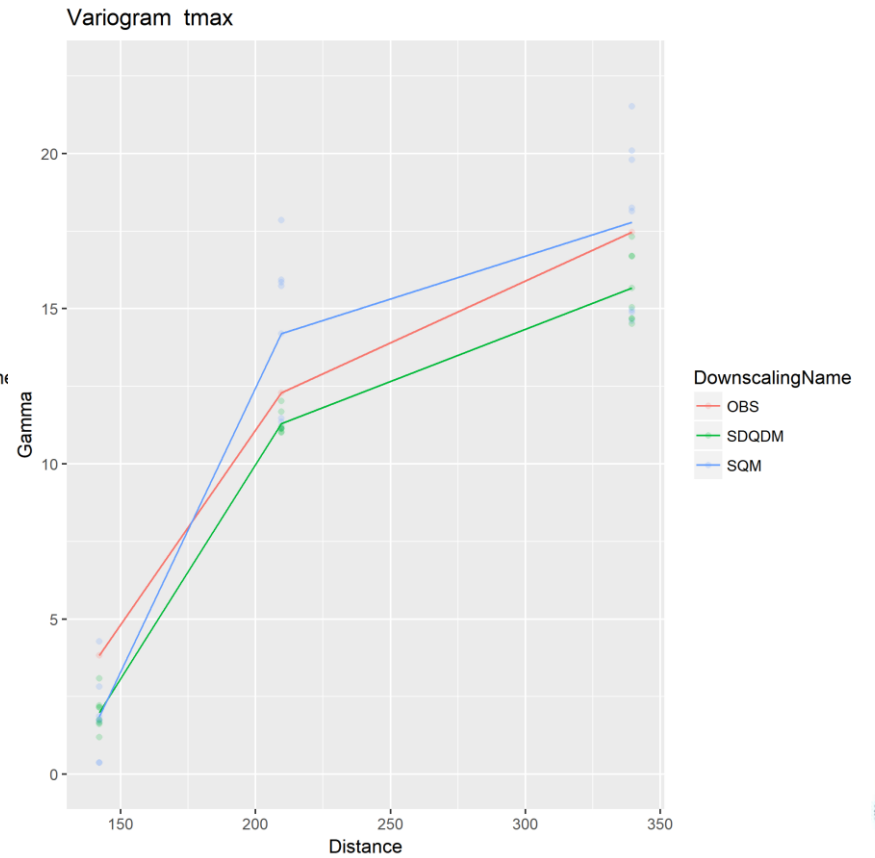
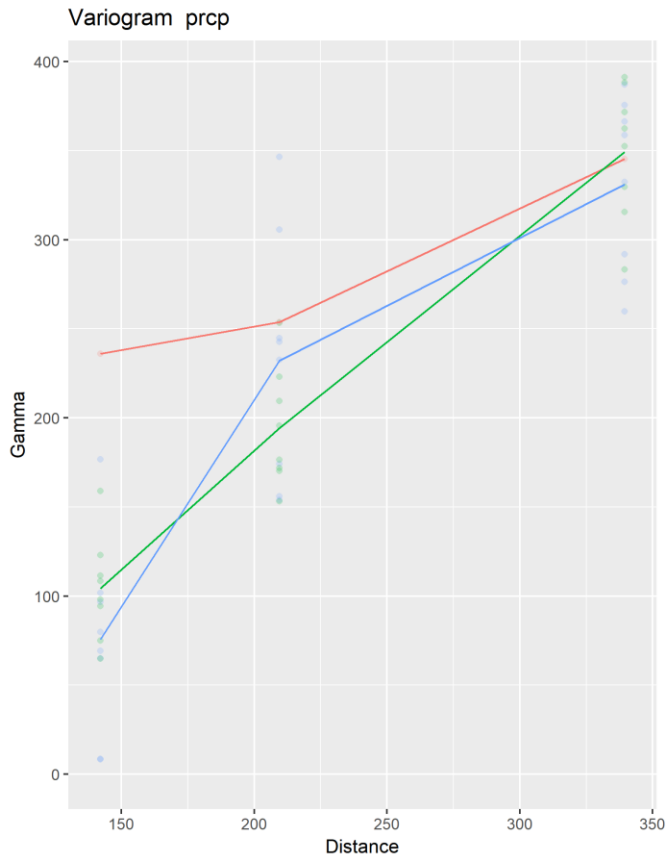
- Data
- graph



Variogram curves

Evaluation: Spatial Reproducibility

You do not have to do anything here.



WeightFactorUncertainty

Weight Factor and Uncertainty for GCMs

Indices

prcptot
 odd
 owd
 r95ptot
 r99ptot
 rx1day
 rx5day
 edii
 rnnmm
 r10mm
 r20mm
 su

id
 bxn
 box
 tx10p
 tx90p
 wsdj
 fd
 tr
 tnn
 trx
 tn10p
 tn90p
 csdi
 dtr
 gsl

Downscale method

SDQDM (Spatial Disaggregation-Quantile Delta Mapping)

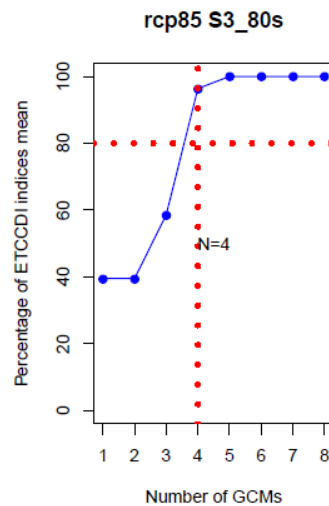
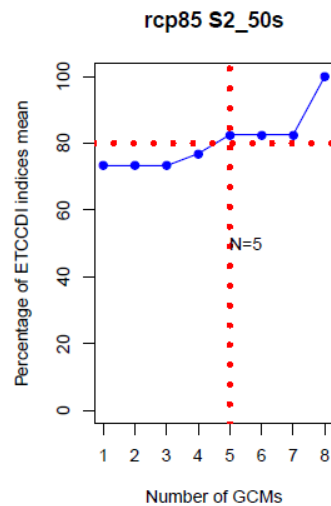
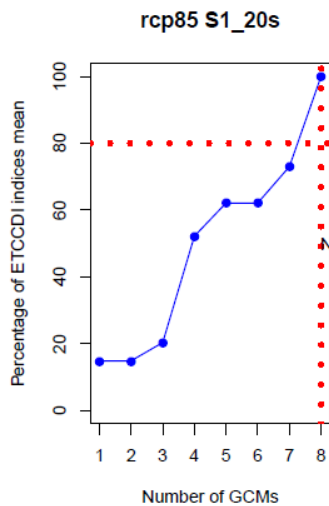
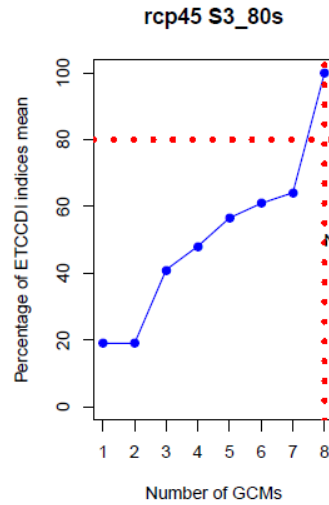
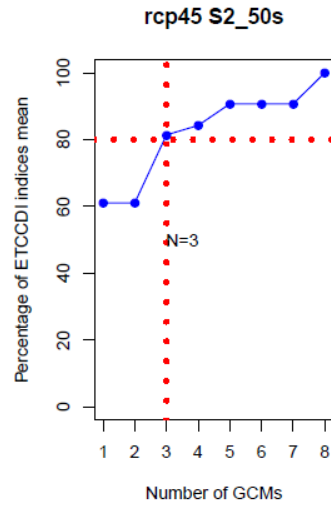
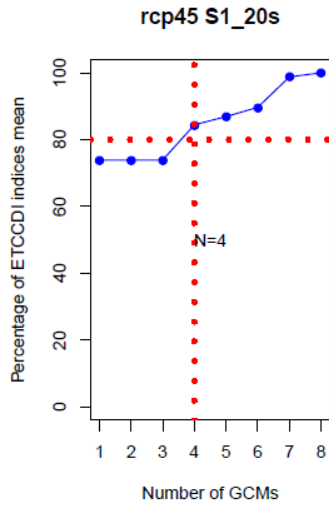
- **\$(project)/WeightFactorUncertainty**
- **Choose any indices you consider to calculate distance**

- E.g. Prcp
 - Mean
 - CV
 - Total amount
 - rx5day

Downscaling	GCM	Distance	Weight	Rank
SQM	CESM1-BGC	0.621734495	0.206093759	1
SQM	CanESM2	0.670270629	0.177326805	2
SQM	bcc-csm1-1	0.77085513	0.134069266	3
SQM	CCSM4	0.777531392	0.131776783	4
SQM	CMCC-CM	0.822422074	0.117783716	5
SQM	CMCC-CMS	0.935410841	0.091047908	6
SQM	CESM1-CAM5	0.976363318	0.08357028	7
SQM	bcc-csm1-1-m	1.168653798	0.058331483	8



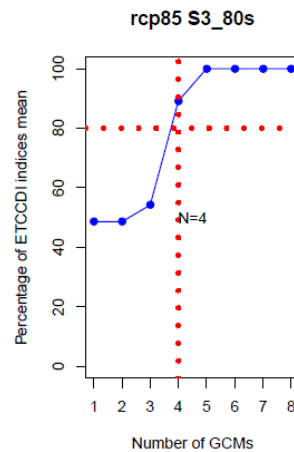
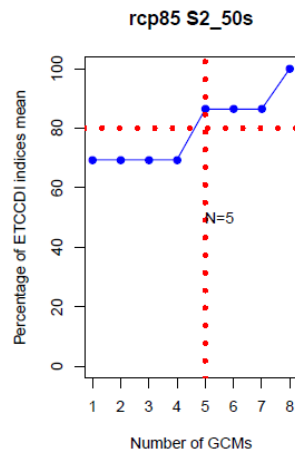
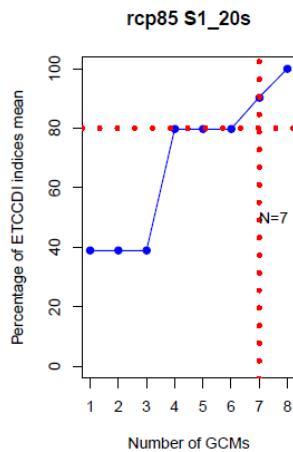
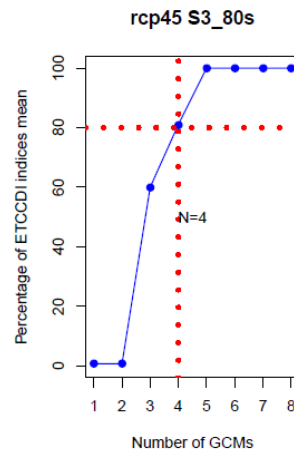
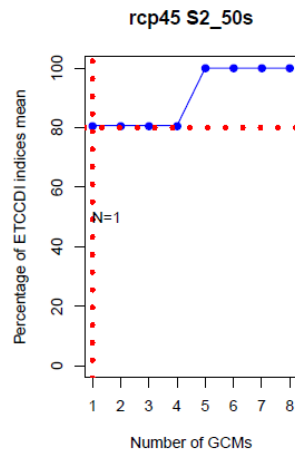
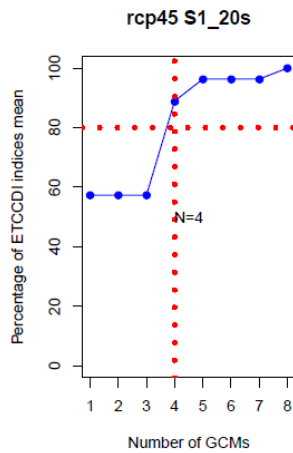
Overall



Rank	GCM
1	CESM1-BGC
2	CanESM2
3	bcc-csm1-1
4	CCSM4
5	CMCC-CM
6	CMCC-CMS
7	CESM1-CAM5
8	bcc-csm1-1-m



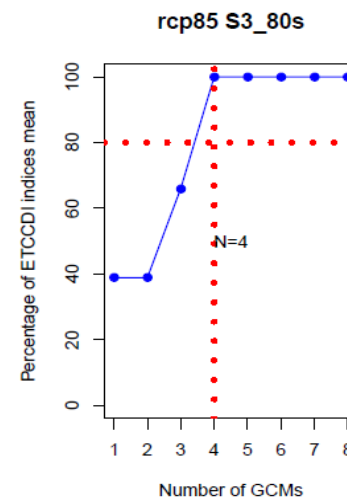
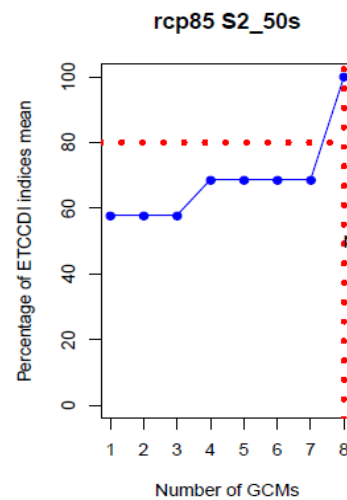
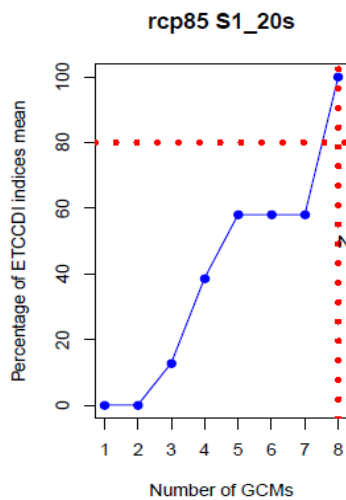
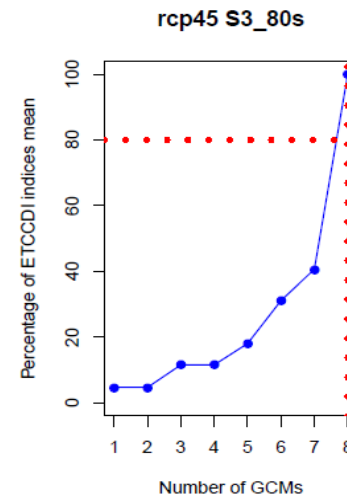
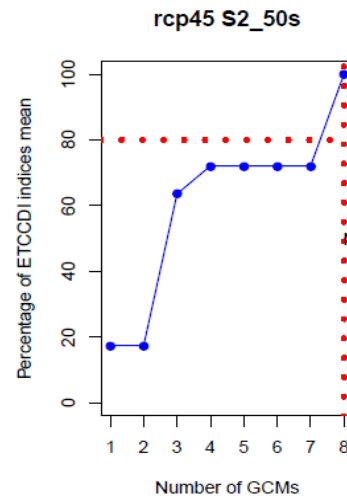
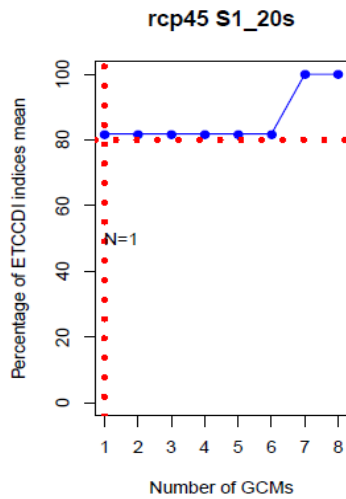
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Rank	GCM
1	CESM1-BGC
2	CanESM2
3	bcc-csm1-1
4	CCSM4
5	CMCC-CM
6	CMCC-CMS
7	CESM1-CAM5
8	bcc-csm1-1-m



rx1day



Rank	GCM
1	CESM1-BGC
2	CanESM2
3	bcc-csm1-1
4	CCSM4
5	CMCC-CM
6	CMCC-CMS
7	CESM1-CAM5
8	bcc-csm1-1-m



Discussion with the results of Phase 2

Please upload your results on
public folder



Discussion

- **Critical point 1: GCM screening...**
 - Raw GCM Analysis
 - Which measures should be considered?
- **Critical point 2: Downscaling methods**
 - Many methods with their own strengths
 - Select the most suitable methods to your aims
- **Critical point 3: Representative GCMs**
 - Which indices are most critical to your aims?
 - Select representative GCMs to capture future climate variability for next stages
 - e.g. agricultural and hydrologic projections



**You are now a Professional on downscaling
climate change scenarios**

Congratulations !!



