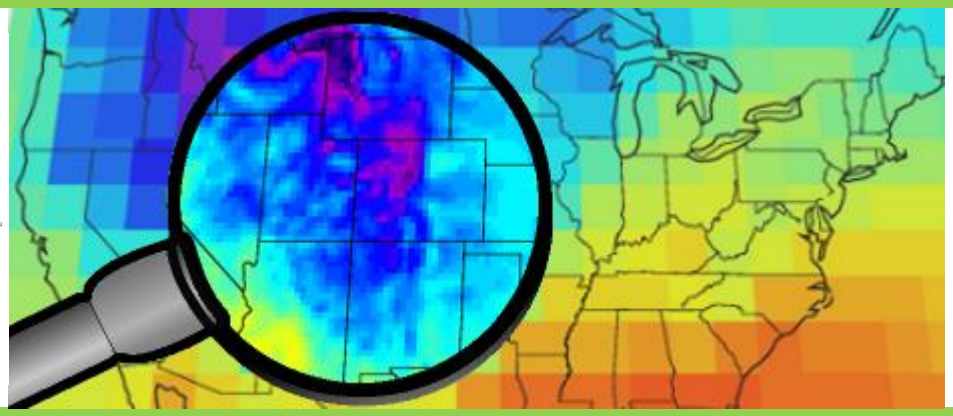
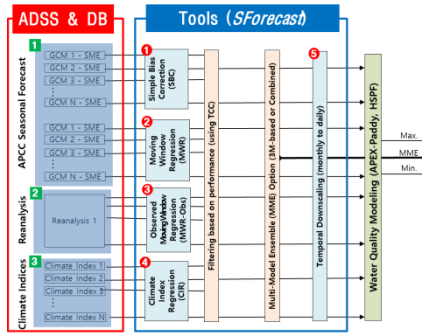
APCC
APEC CLIMATE CENTER

Introduction to Downscaling of Seasonal Forecast using *rSForecast*





Jaepil Cho

2017/08/24

Overview

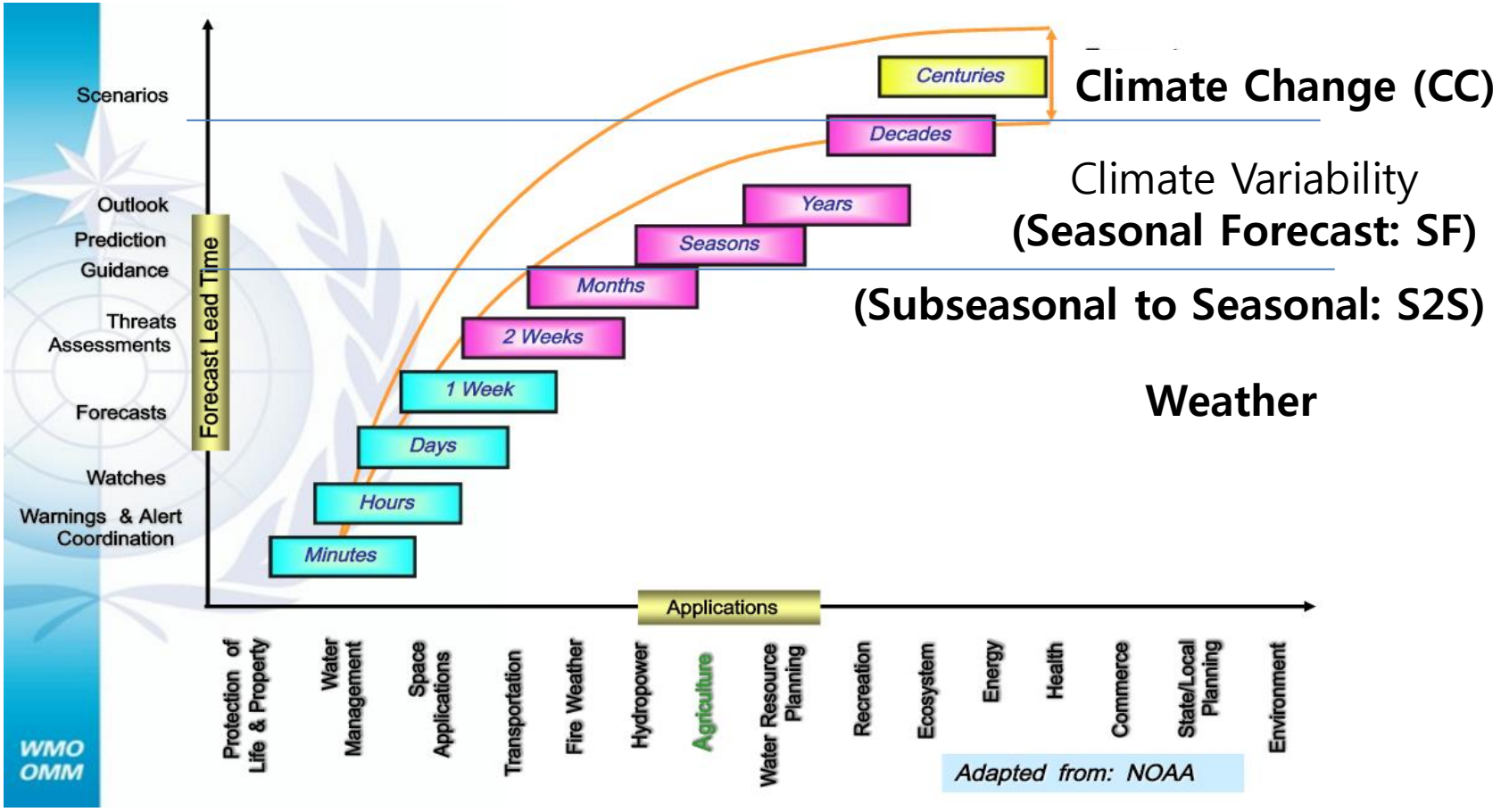
1. Introduction

2. Downscaling methods (modules)

3. Output of rSForecast

Introduction

Seamless Prediction and Services Framework

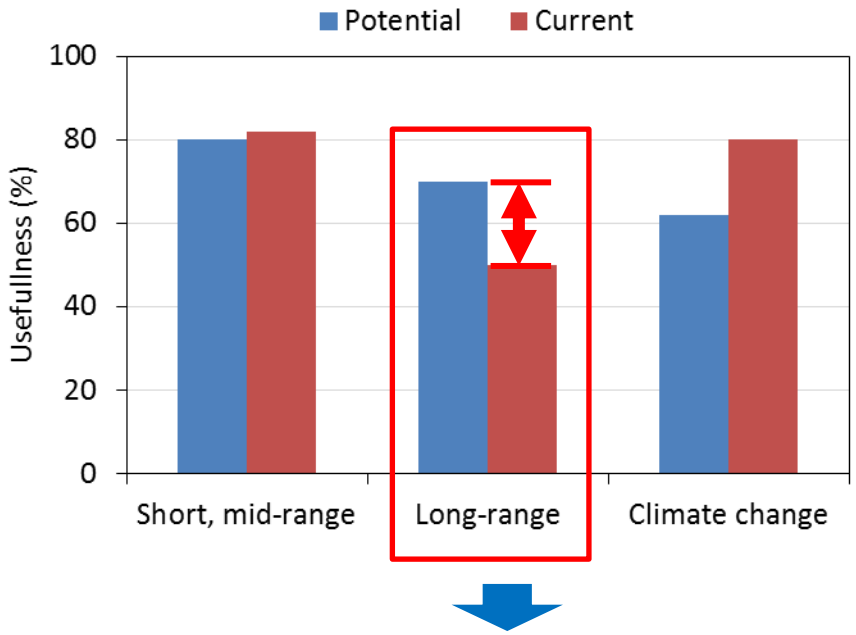


Source: http://slideplayer.com/slide/1447561/

Necessity of seasonal prediction in water resources in Korea

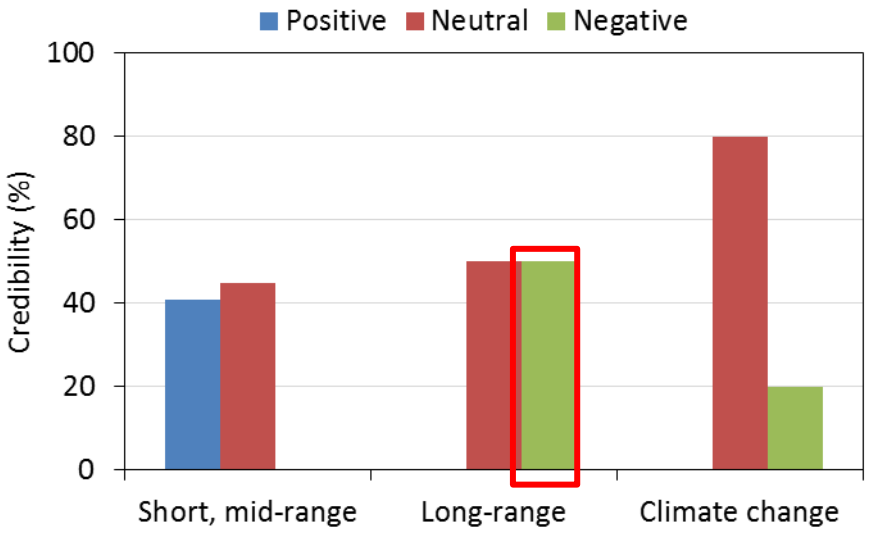
❖ Survey result targeting water related government agency, public enterprise, research institutes in Korea shows .....

Usefulness



Proactive Preparedness & Prevention

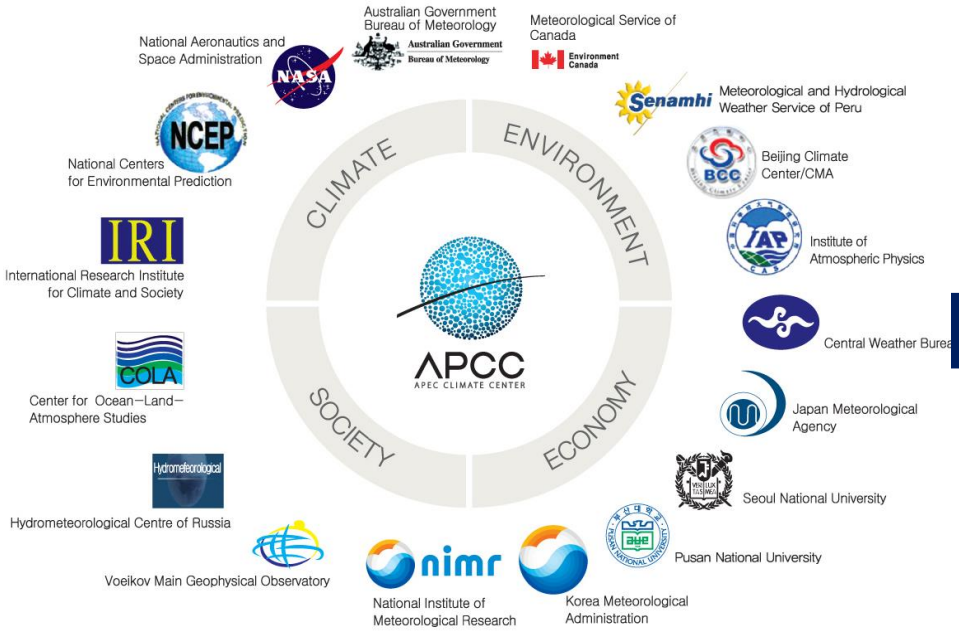
1. Credibility



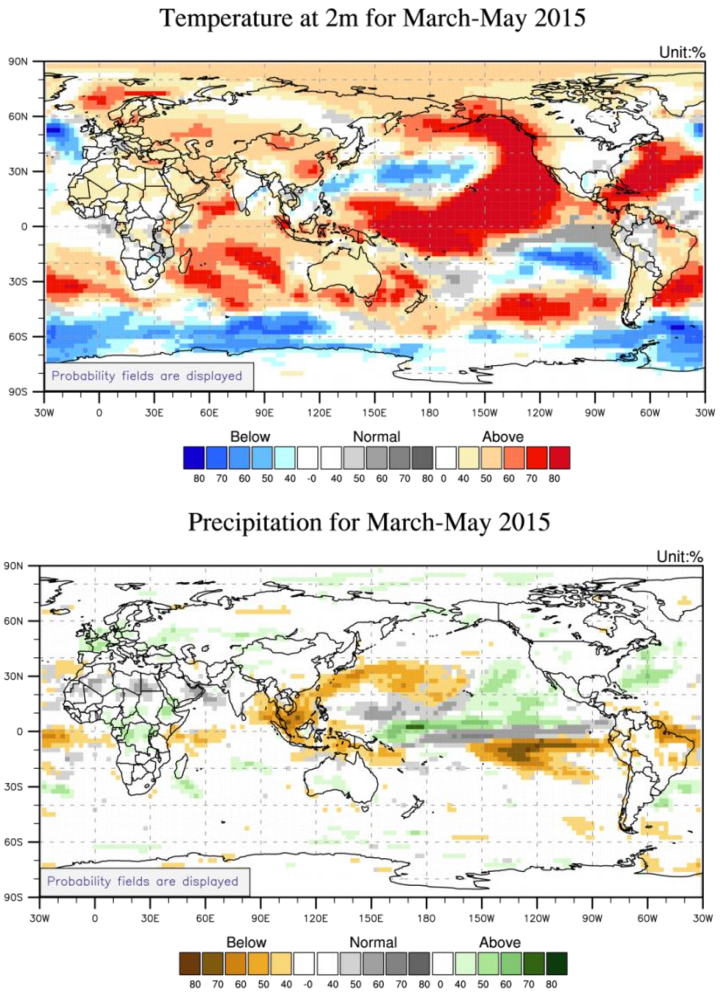
2. User friendliness

- **Spatial resolution(50%)**
- **Temporal scale (20%)**
- **Data format(20%)**

APCC Multi-Model Ensemble (MME) Seasonal Forecast Information

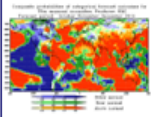
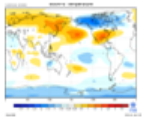


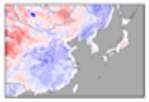
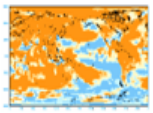
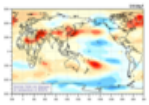
Multi-Model Ensemble (MME)



Climate Prediction : Predictability of APCC MME

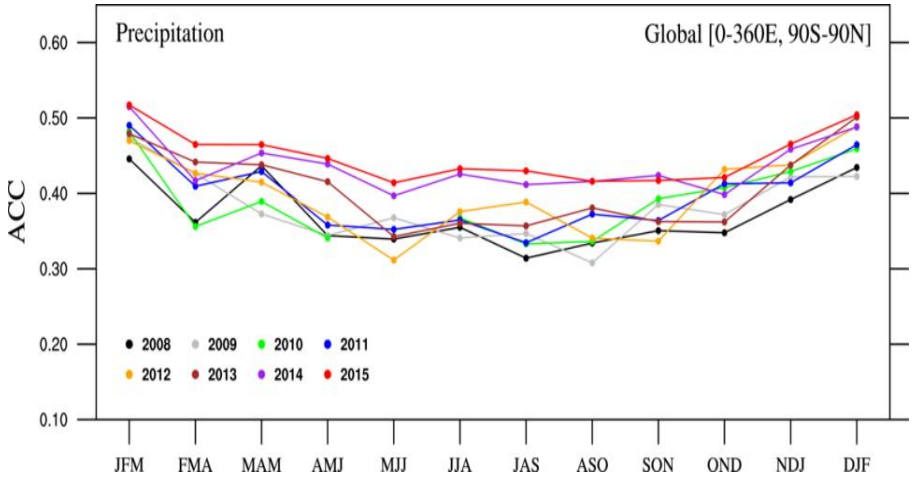
Predictability of APCC MME (2007)

	ECMWF[1], 영국	미국	러시아	WMO LRF[2]
대상	-	미국	전세계	전세계
예보기간	-	M+1,2,3 의 평균	M+1,2,3 의 평균	M+1,2,3
정확도 평가[6]	1, 2위	4위	10위	(3위↑)
접근성	접근불가	중	상	상
정밀도(해상도)	-		중 	상 

	일본	중국	한국	APCC[3]
대상	전세계	전세계	한국	전세계
예보기간	M+1,2,3	M+1	M+1,2,3	M+1,2,3
정확도 평가	3위	8위	7위	(3위↑)
접근성	상	상	상	상
정밀도(해상도)	중 	하 	상 	상 

1) European Centre for Medium-Range Weather Forecasts : 유럽중기예보센터
2) World Meteorological Organization LeadCentre for Long –Range Forecast : 세계기상기구 중장기예보센터
3) APEC Climate Center) : APEC산하 기후연구기관
출처 : 07년 세계기상기구 보고서, 08년 기상청 국정감사보고서

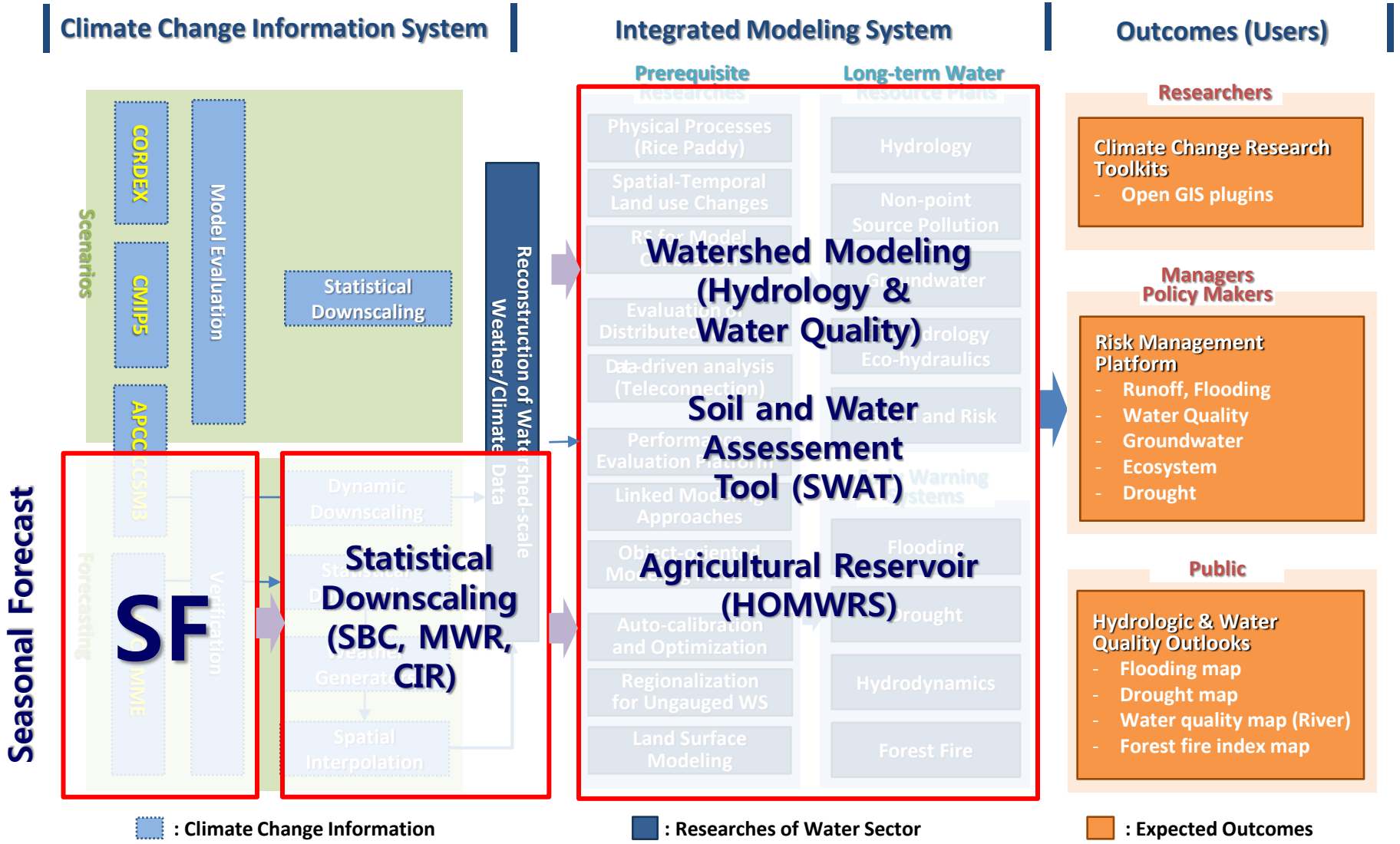
Rainfall hindcast ACC (08-15)



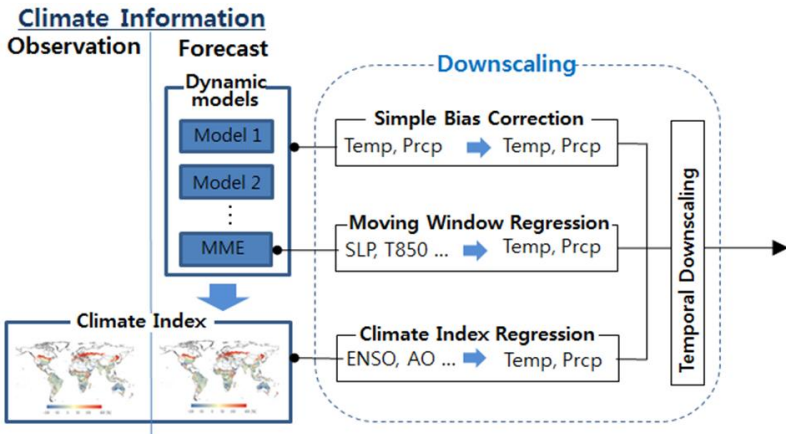
Real time rainfall forecast ROC score (12-15)

	APCC	WMOLC	ECMWF	NCEP	UKMO	JMA
AN	0.57	0.54	0.54	0.53	0.53	0.53
NN	0.52	0.52	0.54	0.52	0.52	0.51
BN	0.57	0.53	0.52	0.54	0.52	0.53

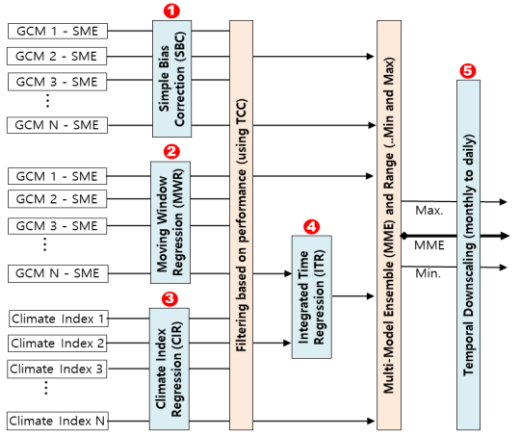
Framework of APCC Water Sector



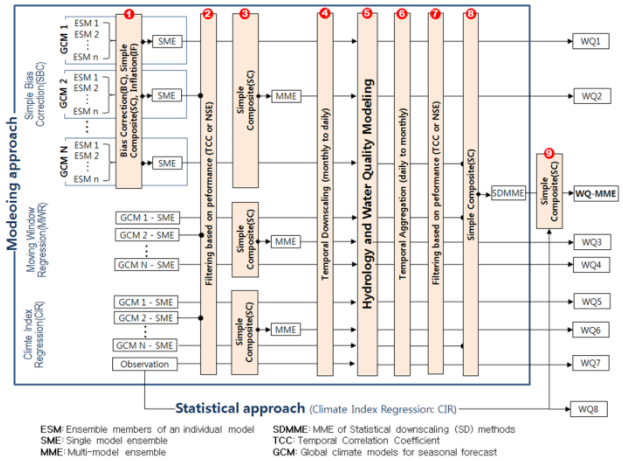
History of rSForecast



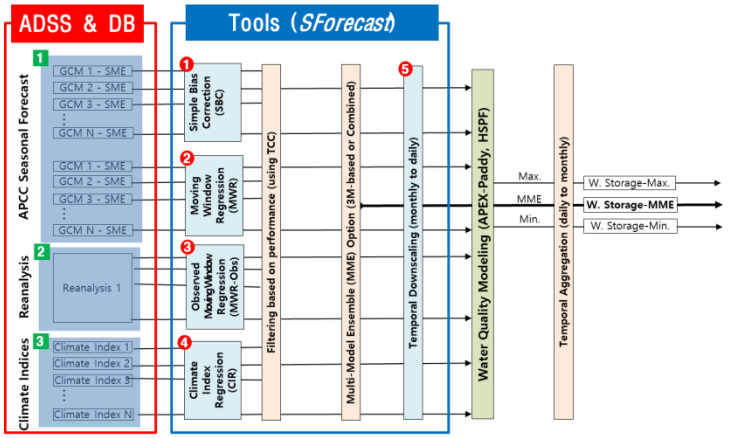
2014



2015

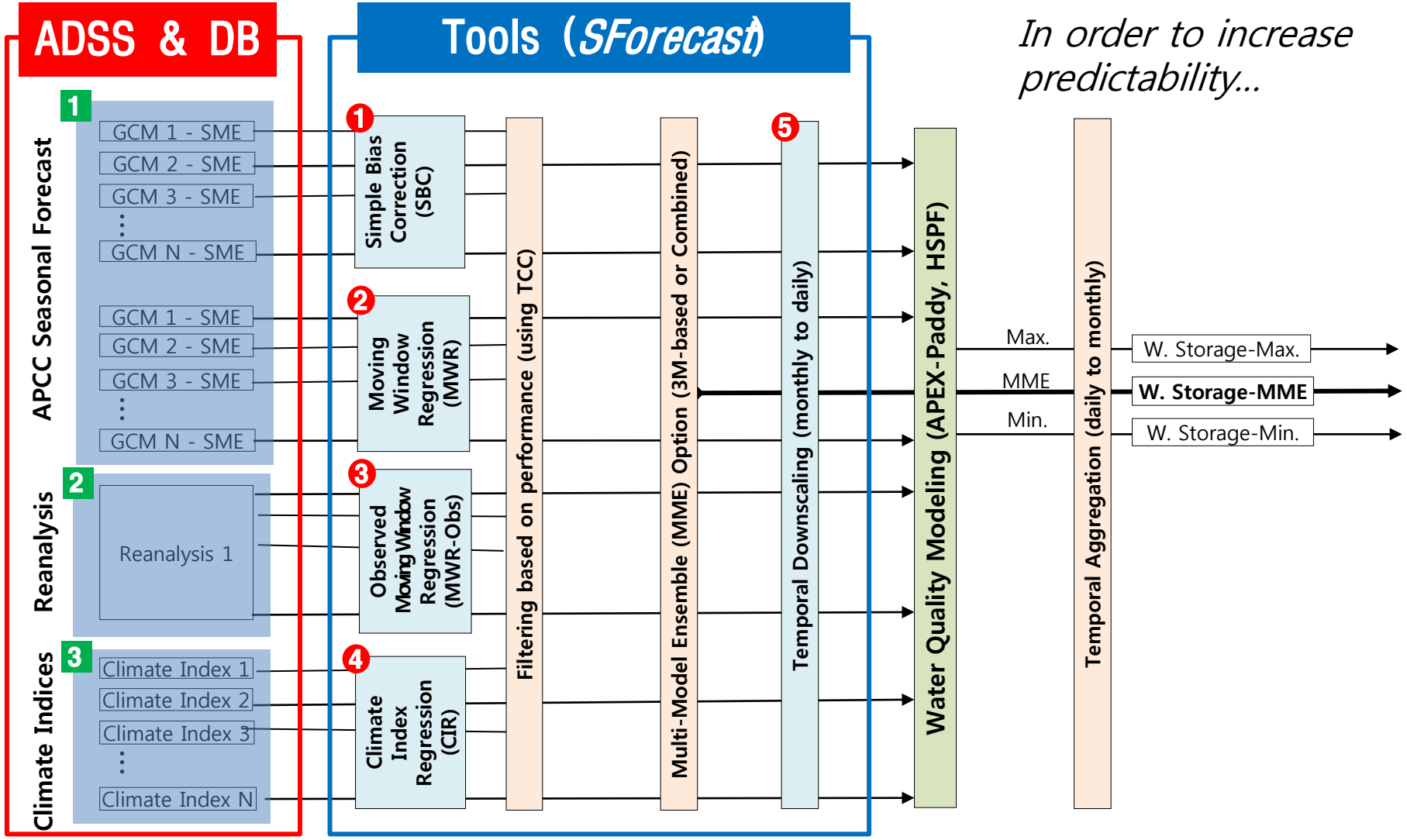


2016

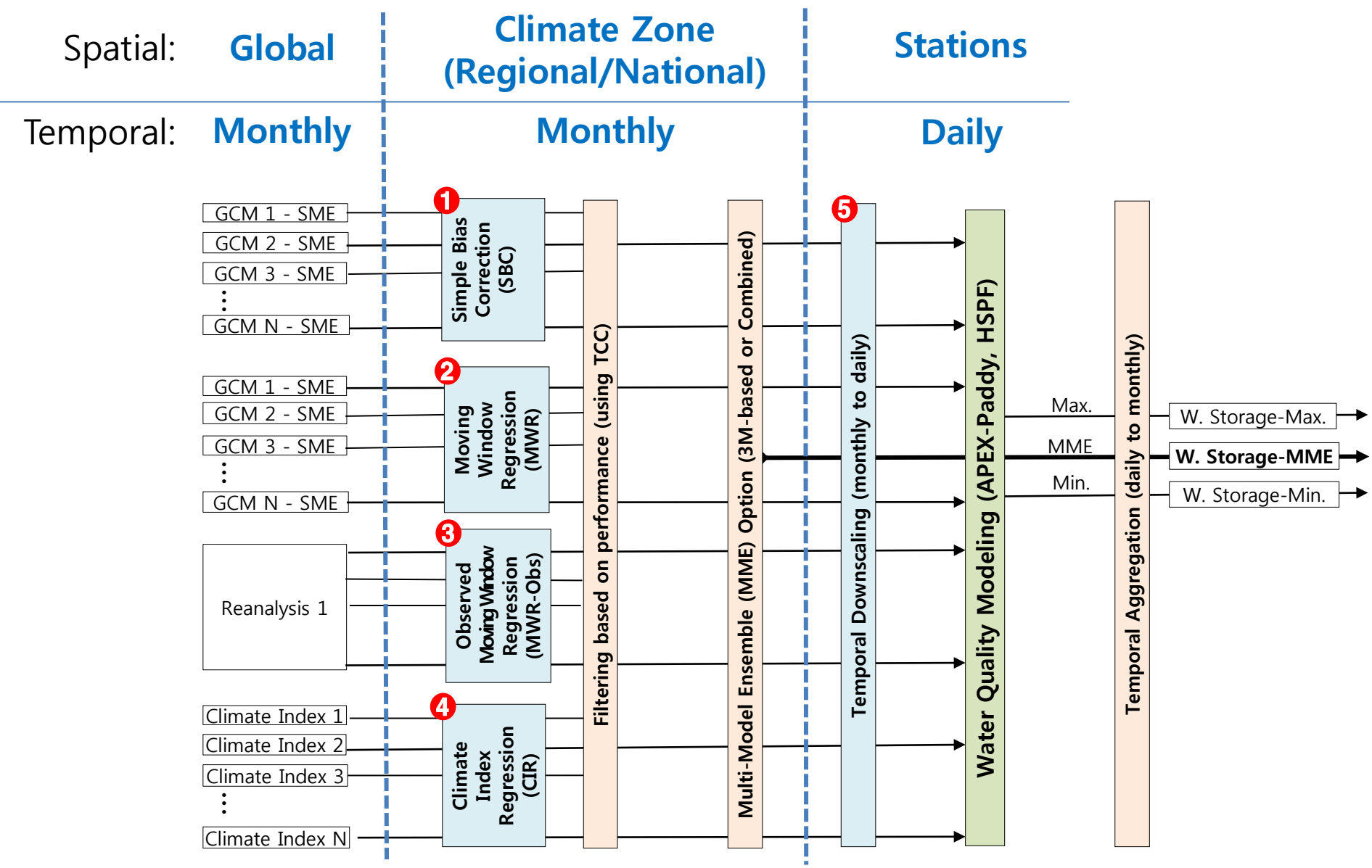


2017

Downscaling modules of rSForecast

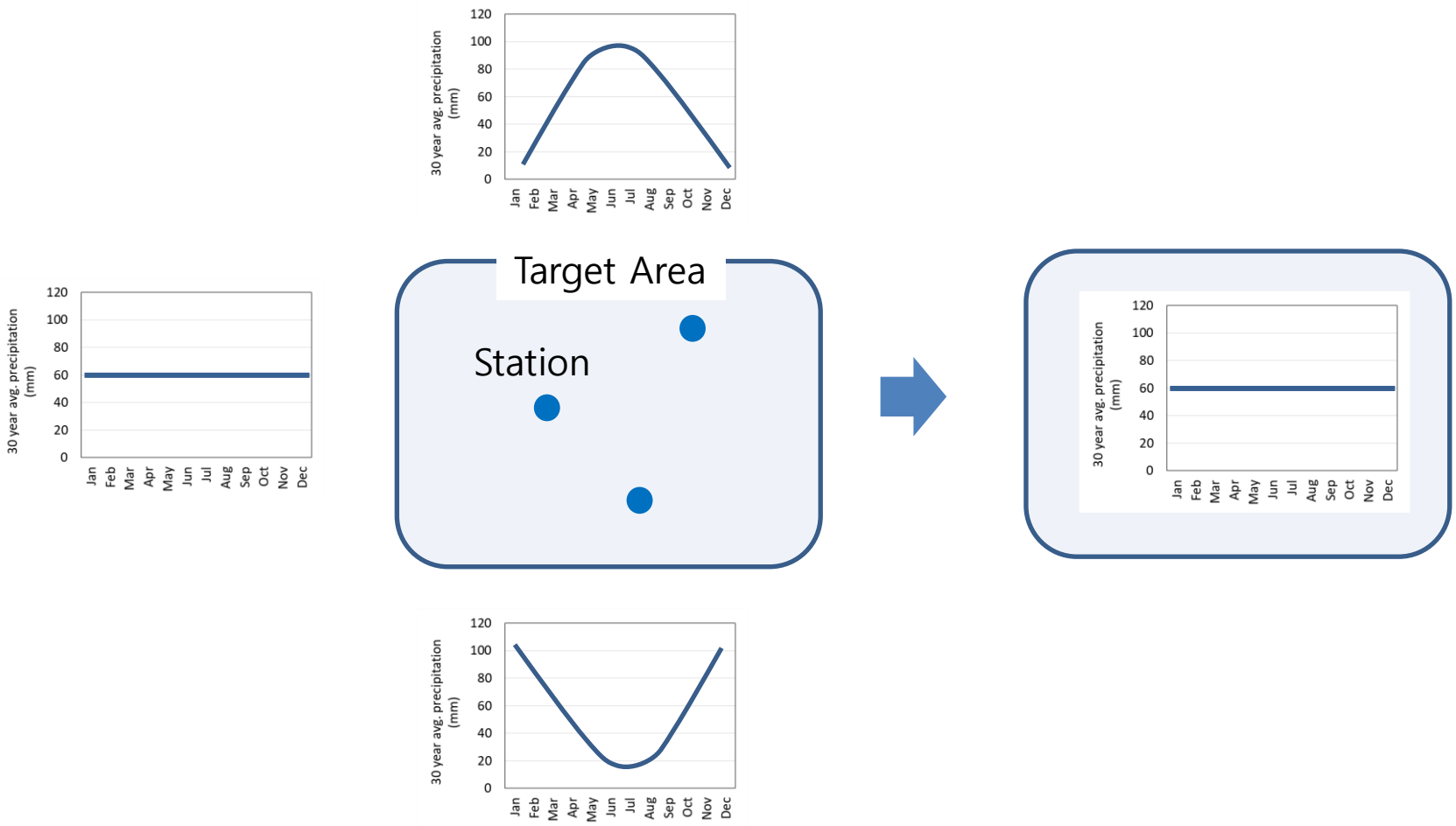


Temporal and spatial scale for each procedure

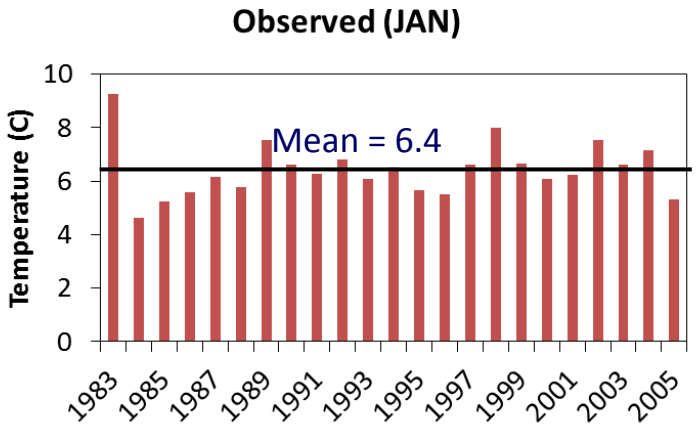


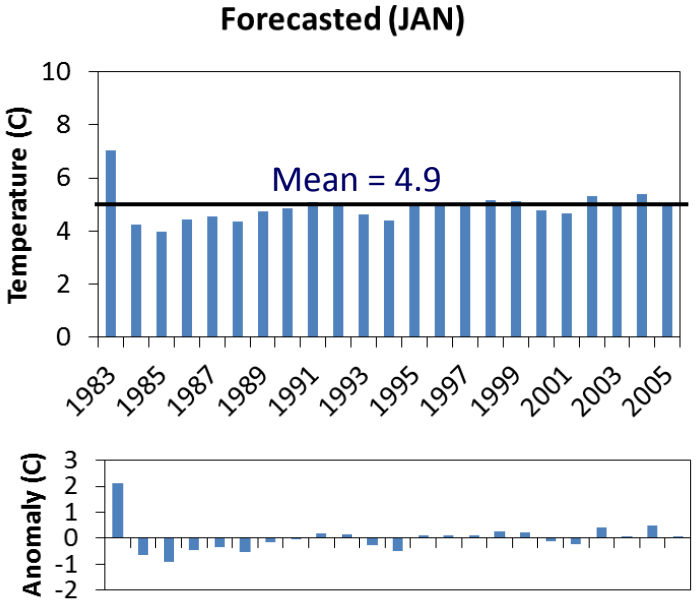
Why is Climate Zone important?

❖ *sforecast* package uses observed monthly area average precipitation and mean temperature as predictands.

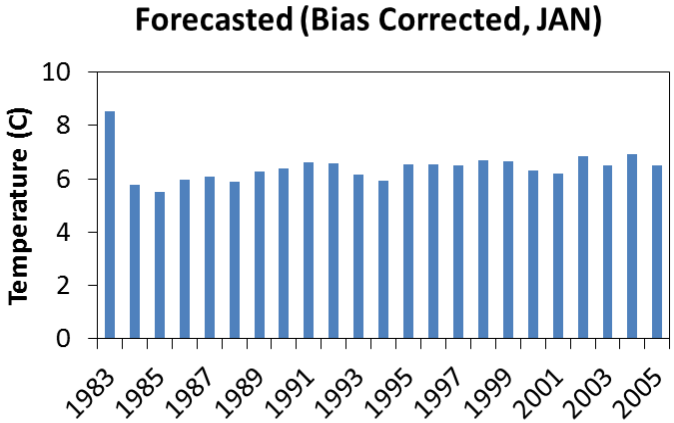


Simple Bias Correction (SBC)





- **Temporal**: same
- **Spatial**: same
- **Variable**: same



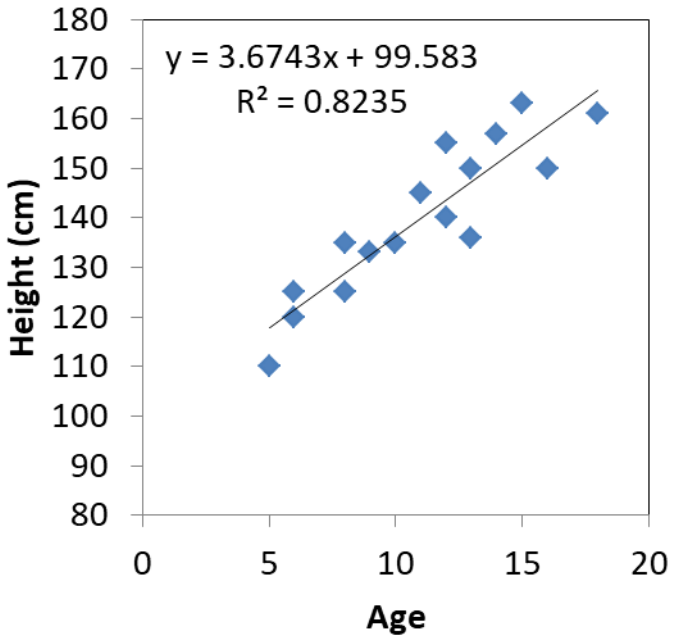
$$T'_{y,m} = (T_{y,m} - T_{hist,m}) + T_{obs,m}$$

$$P'_{y,m} = \begin{cases} (P_{y,m} - P_{hist,m}) + P_{obs,m} & \text{for } P_{y,m} \geq P_{obs,m} \\ (P_{y,m} \div P_{hist,m}) \times P_{obs,m} & \text{for } P_{y,m} < P_{obs,m} \end{cases}$$

Regression model

- What is the expected output?

Age = 7



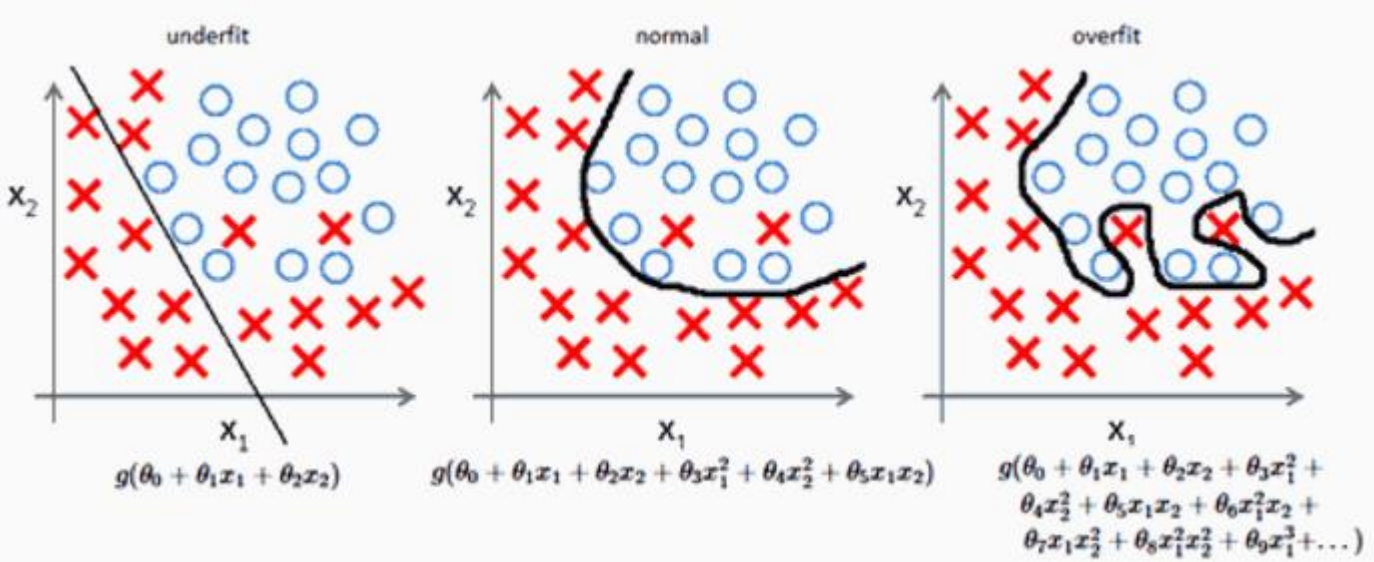
Age	Height
5	110
6	125
6	120
8	125
8	135
9	133
10	135
11	145
12	155
12	140
13	150
13	136
14	157
15	163
16	150
18	161

Height = 125.3

Overfitting

- Overfitting occurs when a model is excessively complex, such as having too many parameters relative to the number of observations. A model that has been overfitted has poor predictive performance, as it overreacts to minor fluctuations in the training data

Source: wikipedia

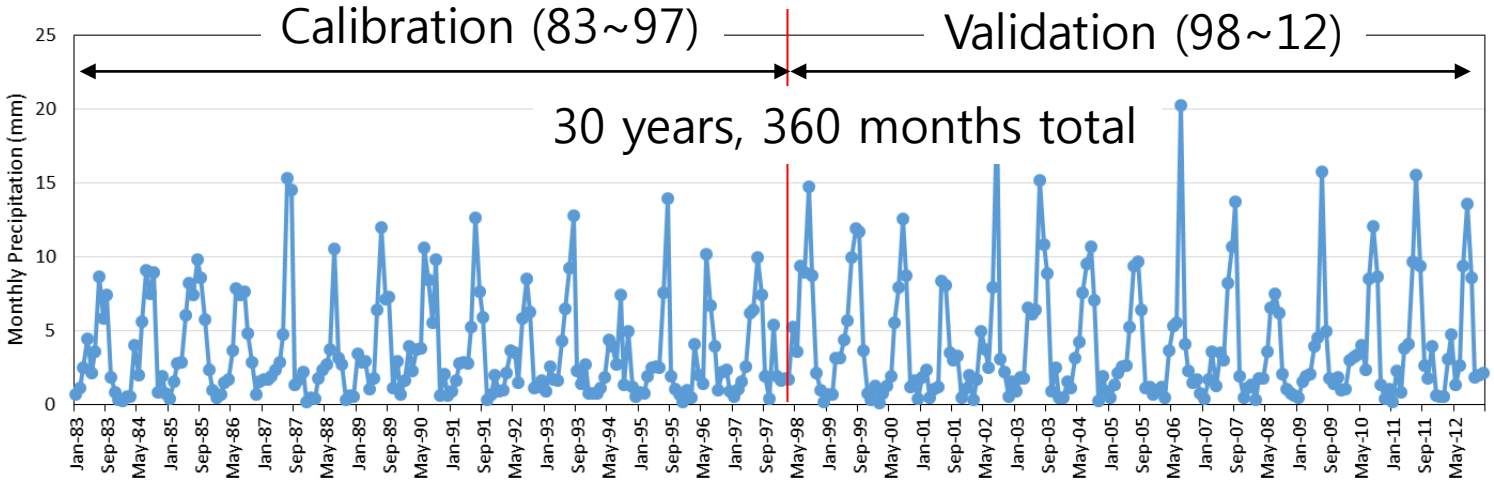


Source: http://mlwiki.org/index.php/Overfitting

Cross-validation

- What is the difference between split-validation and cross-validation?

split-validation



- Can we use same approach for seasonal forecast?

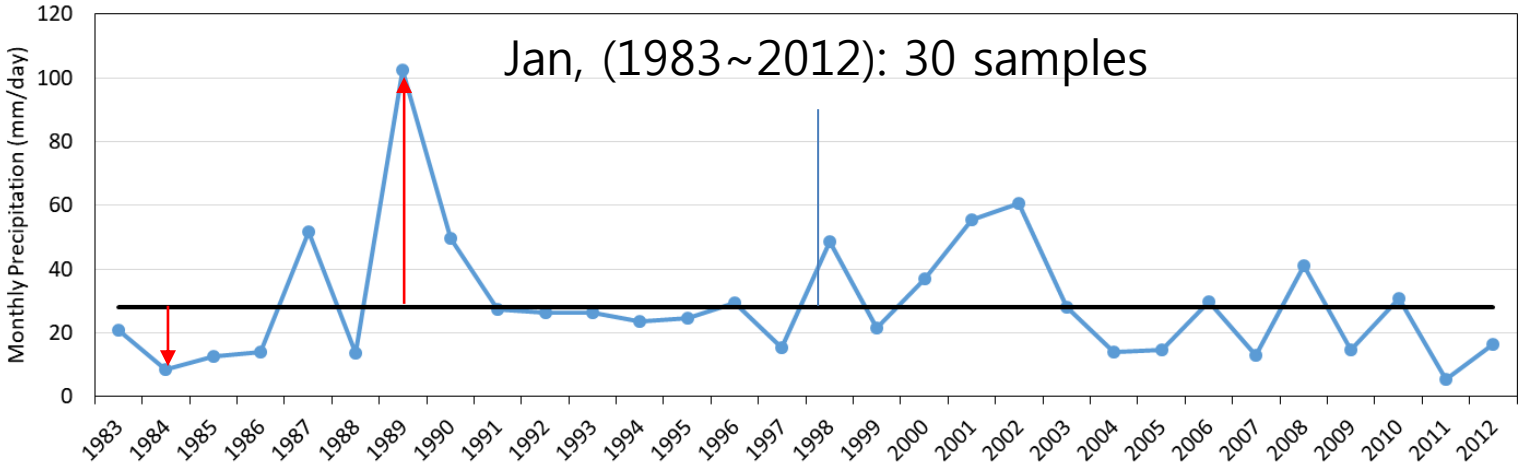
No. Why?

Because we are independently forecasting each month.

We are interested in variations compared to the climatology (Anomaly).

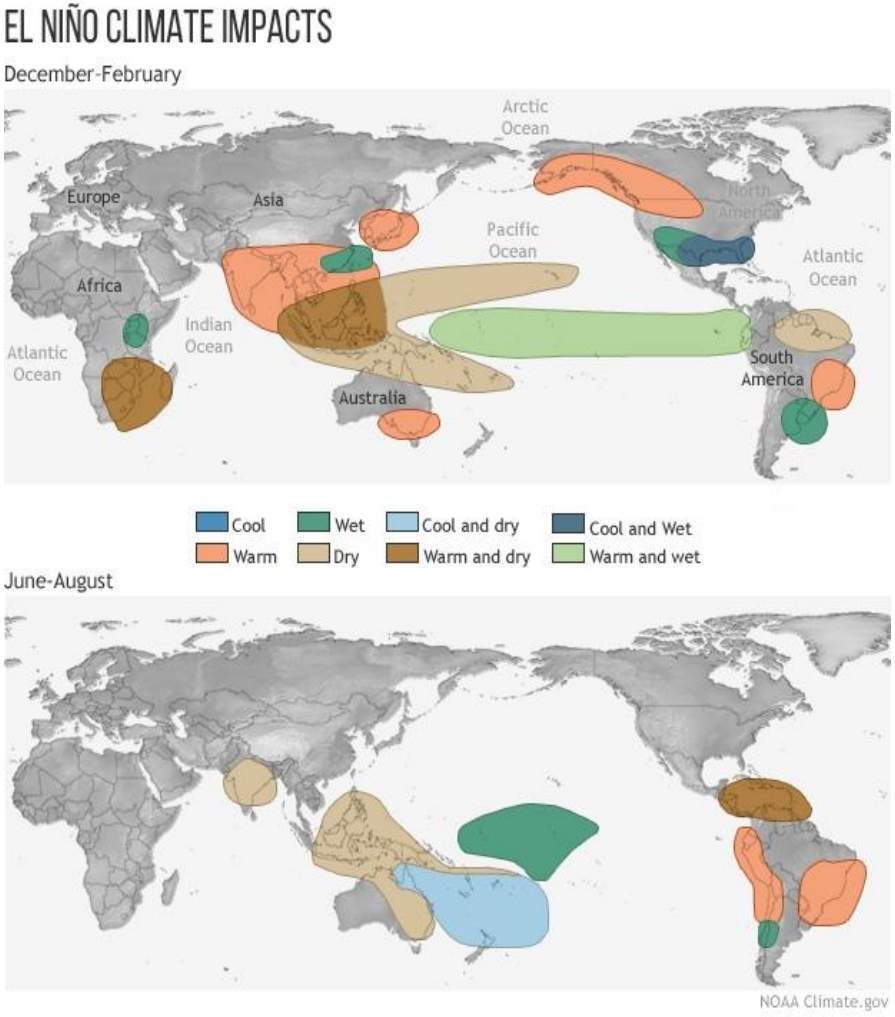
Cross-validation

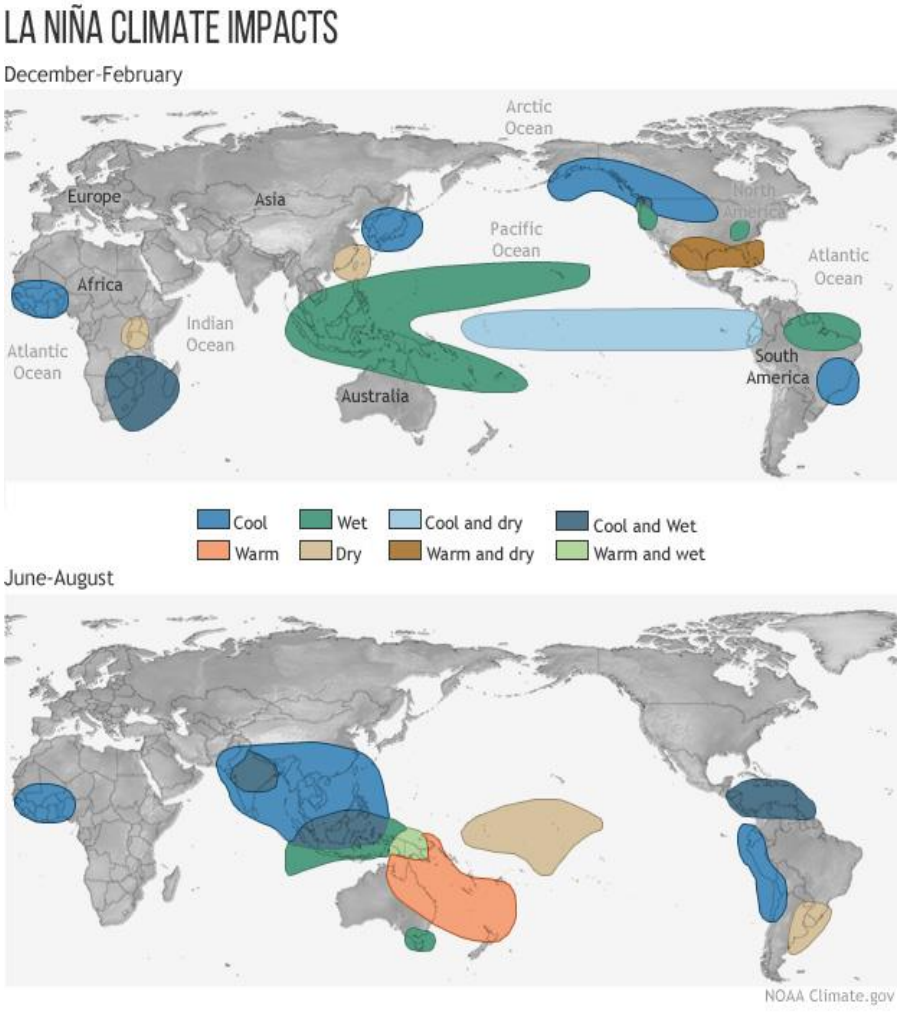
- We usually have very limited number of samples.



- Leave-one-out cross-vallidation

El Nino & La Nina Impacts

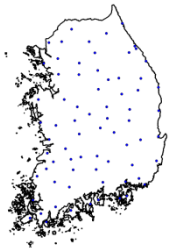


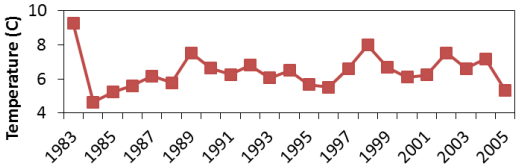


Source: https://www.pmel.noaa.gov/elnino/impacts-of-el-nino

Moving Window Regression (MWR)

Observed





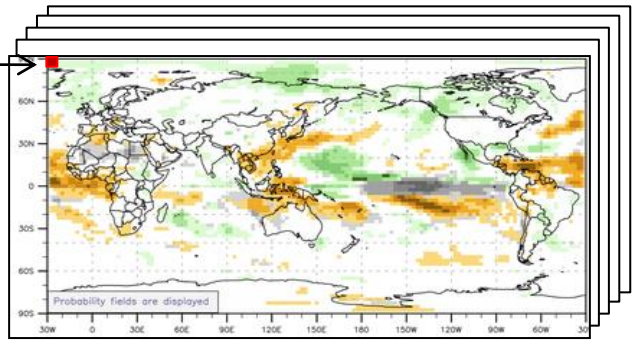
Temperature
(JAN, 1983~2005,Korea)

Temp = a *SLP + b

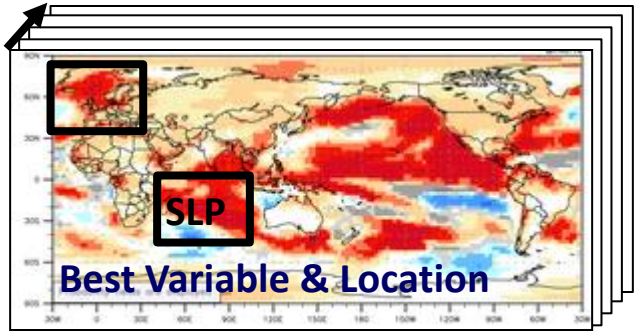
Forecasted

Models: BCC, CWB, HMC, IRI_CA, APCC, CMCC, MSC, NASA, NCEP, PNU, POAMA

Variables: PREC, T2M, T850, U200, V200, U850, V850, Z500, SLP, SST (JAN, 1983~2013)



Temporal Correlation Coefficient (TCC)

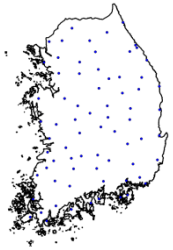


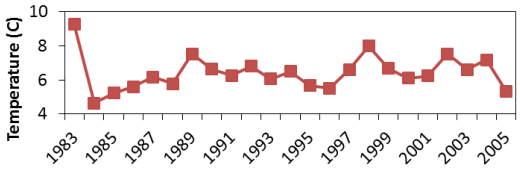
(Kang et al., 2009)

- **Temporal**: same
- **Spatial**: different
- **Variable**: different

Climate Index Regression (CIR)

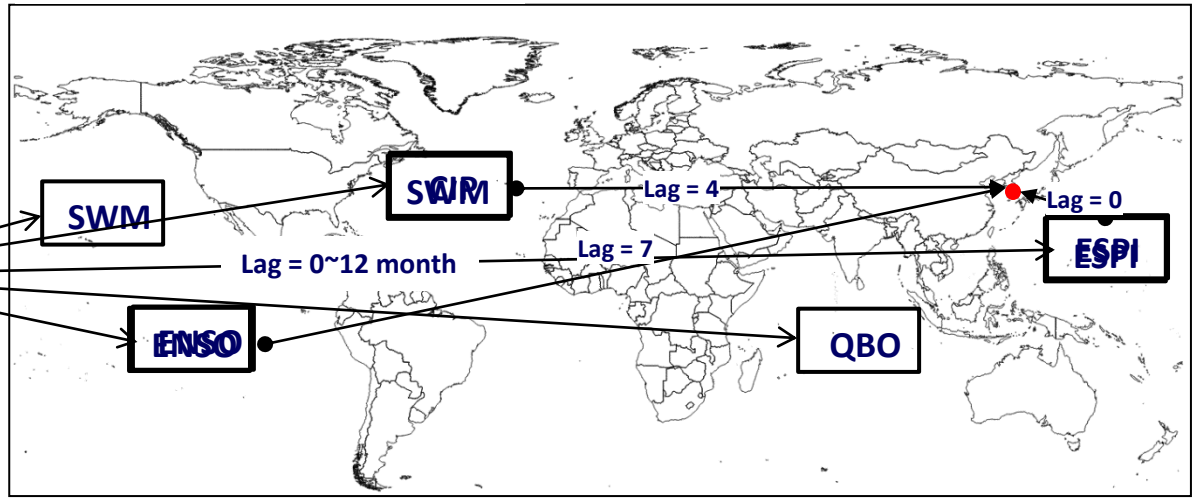
Observed





Temperature
(JAN, 1983~2005,Korea)

Climate Index from CPC



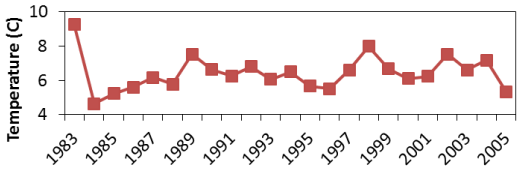
1. Linear regression (all CIs * Lags)
2. Select N best CIs and Lags
3. Decide multivariate regression model
   Y = a *ENSO_lag7 + b*ESPⓘ lag0 + c

- **Temporal**: different
- **Spatial**: different
- **Variable**: different

Observed Moving Window Regression (MWR-Obs)

Reanalysis 1

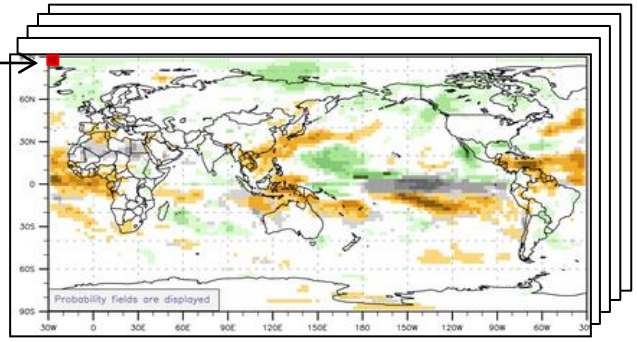
Variables: PREC, T2M, T850, U200, V200, U850, V850, Z500, SLP, SST



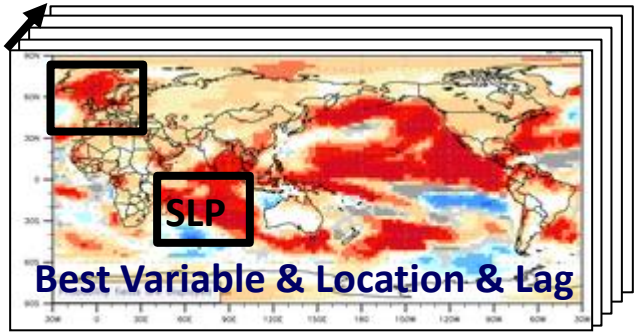
Temperature
(JAN, 1983~2005,Korea)

Temp = a *SLP + b

← **Lag = 0~12 month**



Temporal Correlation Coefficient (TCC)



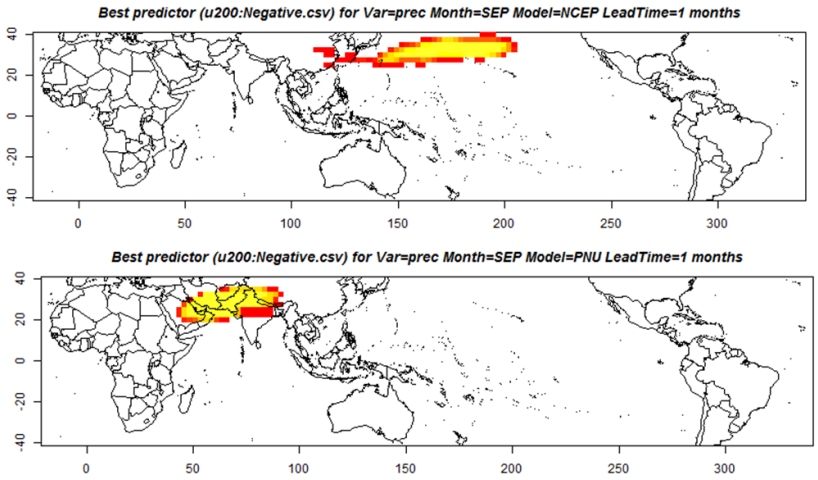
- **Temporal**: different
- **Spatial**: different
- **Variable**: different

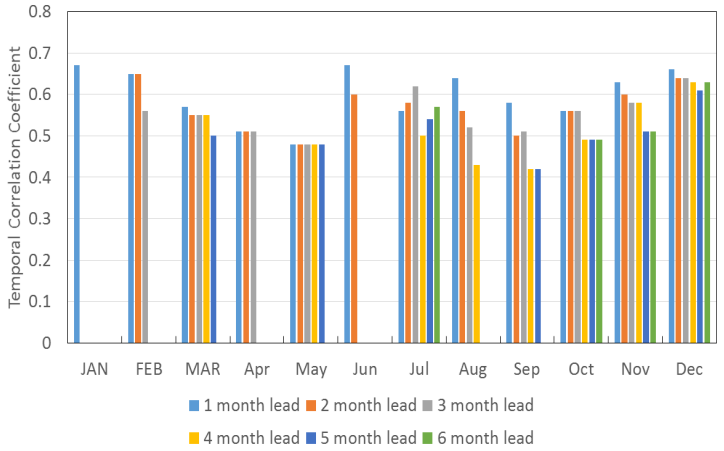
Comparison of seasonal forecast modules

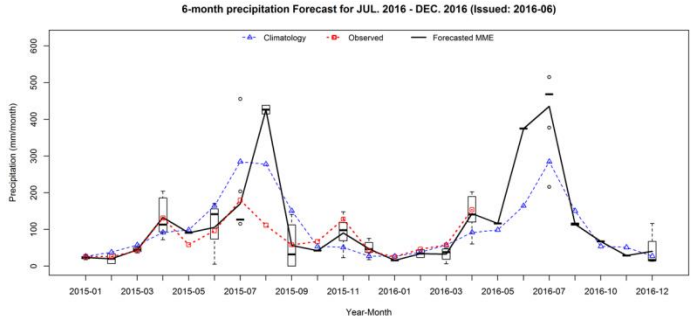
- Simple Bias Correction (SBC): Forecast-based direct method
- Moving Window Regression (MWR): Forecast-based indirect method
- Climate Index Regression (CIR): Observation-based indirect method
- Moving Window Regression-Observed (MWR-Obs): Observation-based direct method

	SBC	MWR	CIR	MWR-Obs
Used climate information	Individual Seasonal Forecast models (APCC)	Individual Seasonal Forecast models (APCC)	NOAA/APCC climate indices	NCEP/NCAR Reanalysis1
Are the target variable and predictor same?	Yes	No	No	No
Are the target area and selected area for predictor same?	Yes	No	No	No
Are the target variable and predictor simultaneous?	Yes	Yes	No (lag-time)	No (lag-time)

Output of rSForecast







Monthly skil score for JAN 1983 - APR 2016

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LT1-TCC	0.67	0.7	0.63	0.65	0.45	0.59	0.61	0.43	0.65	0.37	0.67	0.68
LT1-HSS	0.22	0.25	0.29	0.19	0.13	0.14	0.33	0.28	0.41	0.27	0.15	0.36
LT2-TCC	0.35	0.7	0.59	0.64	0.45	0.57	0.63	0.36	0.63	0.37	0.65	0.67
LT2-HSS	0.035	0.25	0.33	0.13	0.13	0.18	0.33	0.37	0.36	0.27	0.065	0.32
LT3-TCC	-	-	0.52	0.59	0.67	0.45	-	0.62	0.38	0.61	0.37	0.54	0.69
LT3-HSS	-	-	0.25	0.33	0.17	0.13	-	0.36	0.37	0.45	0.27	0.1	0.32
LT4-TCC	-	-	-	0.59	0.61	0.45	-	0.55	0.36	0.51	0.37	0.41	0.66
LT4-HSS	-	-	-	0.33	0.13	0.13	-	0.4	0.37	0.33	0.27	0.31	0.45
LT5-TCC	-	-	-	0.48	0.64	0.45	-	0.57	-	0.51	0.37	0.41	0.63
LT5-HSS	-	-	-	0.29	0.17	0.13	-	0.4	-	0.33	0.27	0.31	0.41
LT6-TCC	-	-	-	-	0.55	-	-	0.58	-	0.44	0.37	0.41	0.58
LT6-HSS	-	-	-	-	0.24	-	-	0.31	-	0.077	0.27	0.31	0.32

Probapbility forecast for 2016

	JUL	SEP	OCT	NOV	DEC
Low	11	0	0	100	75
Normal	0	100	0	0	0
High	89	0	100	0	25

Selected Method and Models for Precipitation

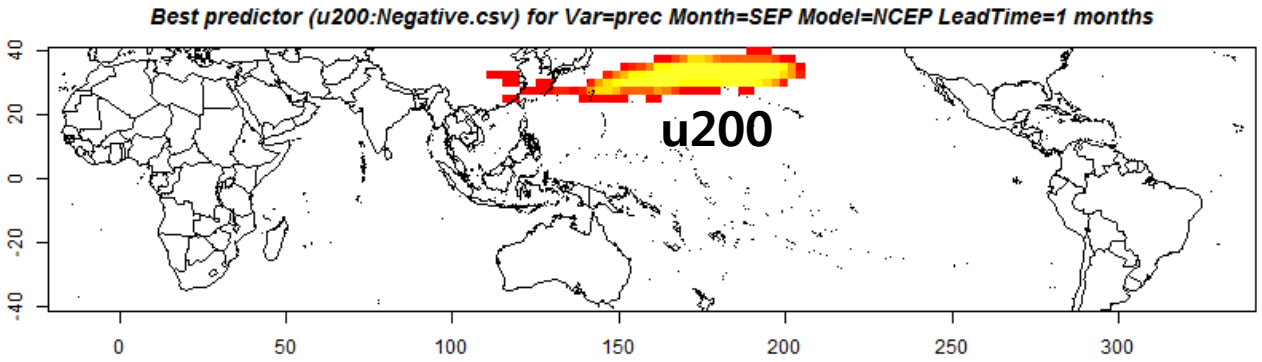
Lead time	1 month lead	2 month lead	3 month lead
Jan	ⓢ JMA, ⓢ POAMA		
Feb		ⓜ CWB	ⓜ GDAPS_F
Mar	ⓢ POAMA		
Apr			ⓢ NASA, ⓢ HMC ⓜ NCEP, ⓜ PNU
May			
Jun	ⓜ HMC	ⓜ MSC_CANCM4	
Jul	ⓒ Lag	ⓒ Lag	ⓘ PNU
Aug	ⓢ JMA	ⓢ GDAPS_F	ⓜ POAMA
Sep	ⓜ NCEP, ⓜ PNU ⓜ POAMA	ⓢ PNU	ⓢ GDAPS_F, ⓢ PNU
Oct			ⓜ MSC_CANCM4
Nov	ⓢ PNU	ⓢ GDAPS_F, ⓢ PNU ⓢ JMA	ⓢ PNU, ⓢ JMA ⓢ POAMA ⓜ MSC_CANCM3
Dec	ⓢ POAMA ⓜ MSC_CANCM4 ⓜ PNU	ⓢ JMA, ⓢ POAMA ⓜ HMC, ⓜ POAMA	ⓢ POAMA ⓜ GDAPS_F ⓜ POAMA ⓜ NASA

Selected Method and Models for Temperature

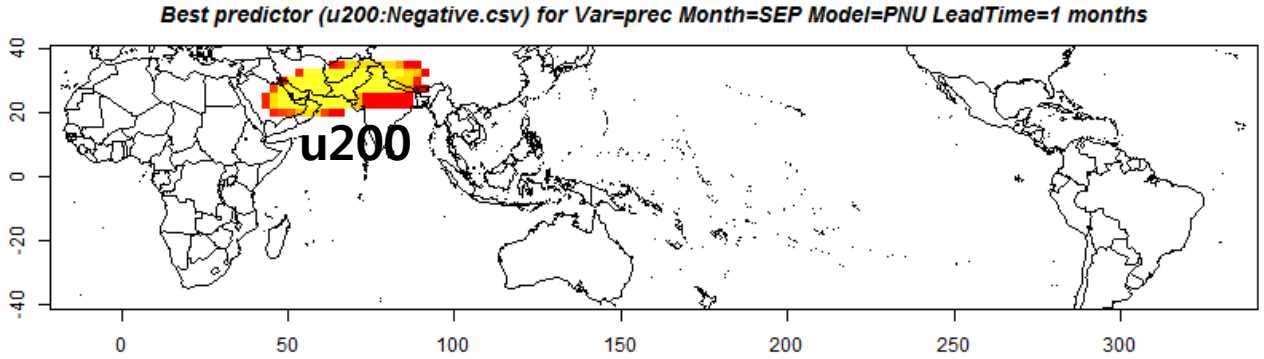
Variables	TEMP	TEMP	TEMP
Jan	ⓢ GDAPS_F, ⓢ PNU, ⓢ MSC_CANCM3, ⓢ MSC_CANCM4, ⓜ POAMA	ⓢ POAMA	ⓜ CWB
Feb		ⓢ JMA	
Mar	ⓢ GDAPS_F, ⓢ JMA		
Apr	ⓜ GDAPS_F	ⓢ NASA	
May	ⓜ CWB	ⓜ PNU	ⓜ MSC_CANCM3
Jun			
Jul	ⓢ JMA	ⓜ GDAPS_F	
Aug	ⓢ HMC, ⓢ PNU		ⓜ CWB
Sep	ⓢ GDAPS_F, ⓢ HMC, ⓢ JMA, ⓢ PNU, ⓢ NASA, ⓢ POAMA ⓘ NASA	ⓢ GDAPS_F, ⓢ NASA, ⓢ PNU, ⓘ MSC_CANCM4, ⓘ NCEP	ⓢ GDAPS_F, ⓢ HMC, ⓢ JMA, ⓢ NASA, ⓢ PNU ⓒ Lag
Oct	ⓢ GDAPS_F, ⓢ HMC, ⓢ PNU ⓘ MSC_CANCM3	ⓢ GDAPS_F, ⓢ JMA, ⓢ NASA, ⓢ PNU ⓒ Lag	ⓢ GDAPS_F ⓒ Lag
Nov	ⓢ POAMA		ⓢ JMA ⓜ PNU
Dec	ⓢ POAMA		ⓢ JMA

Selected predictors in MWR (Ex. 1 month lead September precipitation)

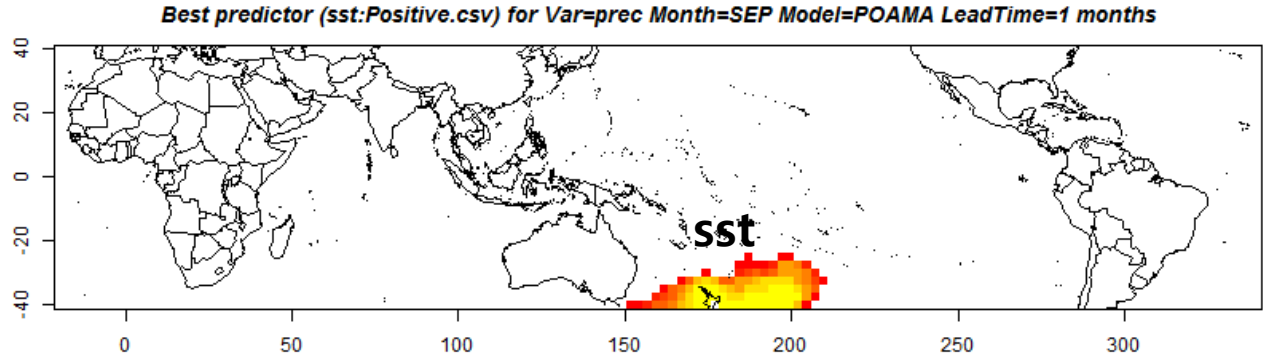
NCEP



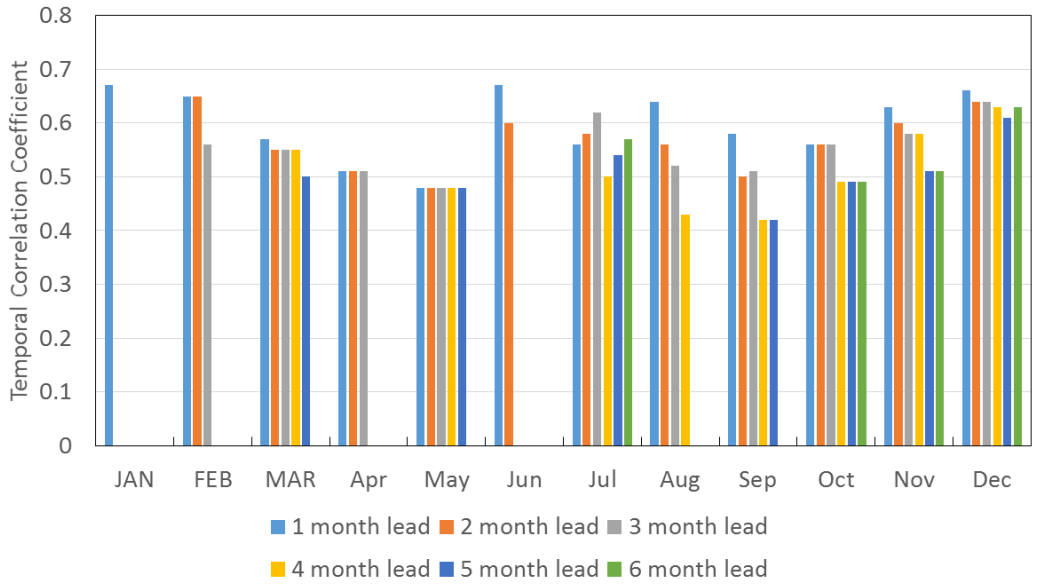
PNU



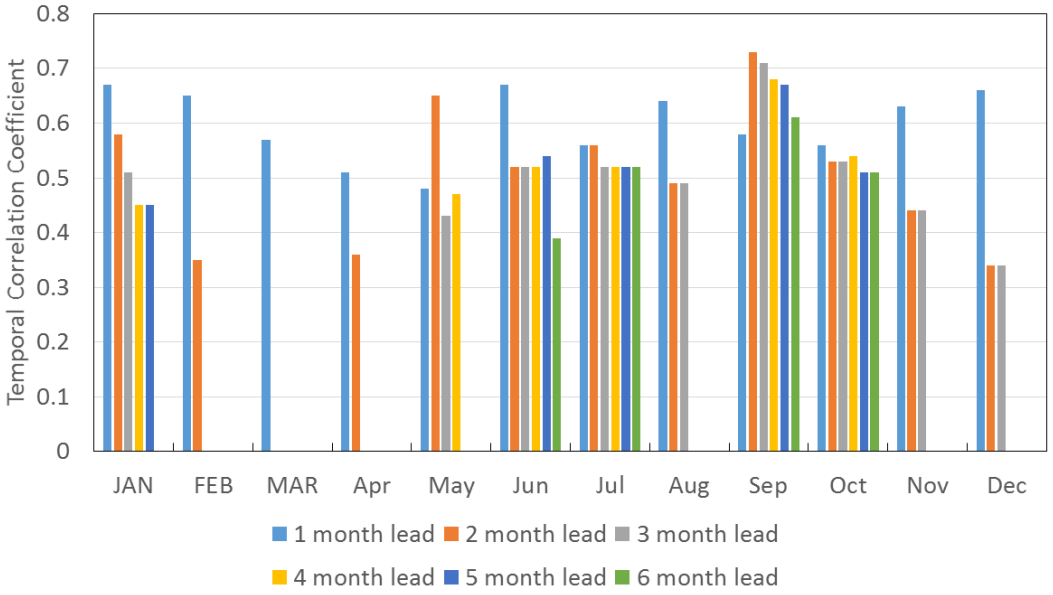
POAMA



Monthly Temporal Correlation Coefficient(TCC)

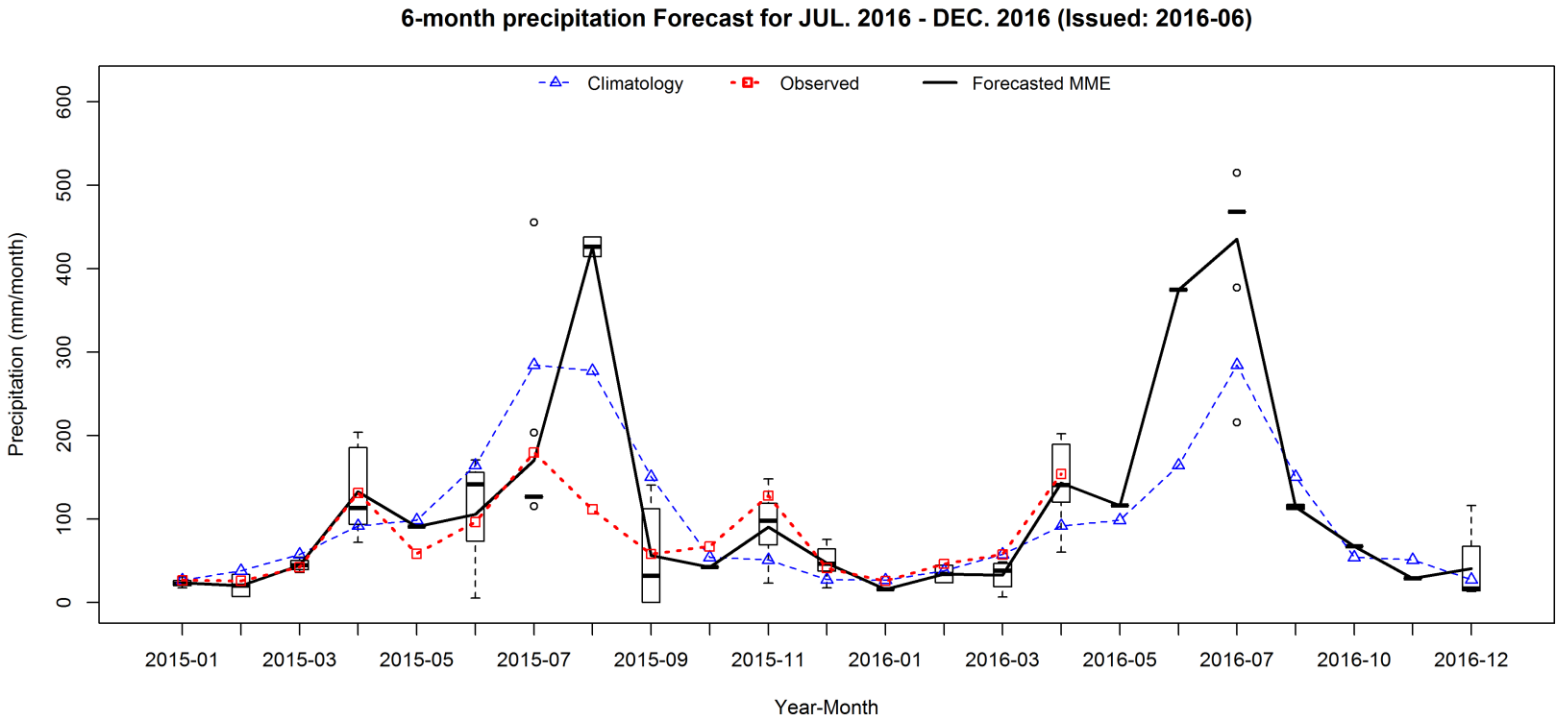


Month	1 month	2 month	3 month	4 month	5 month	6 month
JAN	0.67					
FEB	0.65	0.65	0.56			
MAR	0.57	0.55	0.55	0.55	0.5	
APR	0.51	0.51	0.51			
MAY	0.48	0.48	0.48	0.48	0.48	
JUN	0.67	0.6				
JUL	0.56	0.58	0.62	0.5	0.54	0.57
AUG	0.64	0.56	0.52	0.43		
SEP	0.58	0.5	0.51	0.42	0.42	
OCT	0.56	0.56	0.56	0.49	0.49	0.49
NOV	0.63	0.6	0.58	0.58	0.51	0.51
DEC	0.66	0.64	0.64	0.63	0.61	0.63



Month	1 month	2 month	3 month	4 month	5 month	6 month
JAN	0.67	0.58	0.51	0.45	0.45	
FEB	0.65	0.35				
MAR	0.57					
APR	0.51	0.36				
MAY	0.48	0.65	0.43	0.47		
JUN	0.67	0.52	0.52	0.52	0.54	0.39
JUL	0.56	0.56	0.52	0.52	0.52	0.52
AUG	0.64	0.49	0.49			
SEP	0.58	0.73	0.71	0.68	0.67	0.61
OCT	0.56	0.53	0.53	0.54	0.51	0.51
NOV	0.63	0.44	0.44			
DEC	0.66	0.34	0.34			

Example of seasonal precipitation forecast



Monthly skil score for JAN. 1983 - APR. 2016

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LT1-TCC	0.67	0.7	0.63	0.65	0.45	0.59	0.61	0.43	0.65	0.37	0.67	0.68
LT1-HSS	0.25	0.25	0.29	0.19	0.13	0.14	0.33	0.28	0.41	0.27	0.15	0.36
LT2-TCC	0.35	0.7	0.59	0.64	0.45	0.57	0.63	0.36	0.63	0.37	0.65	0.67
LT2-HSS	0.035	0.25	0.33	0.13	0.13	0.18	0.33	0.37	0.36	0.27	0.065	0.32
LT3-TCC	-	0.62	0.59	0.67	0.45	-	0.62	0.36	0.61	0.37	0.54	0.67
LT3-HSS	-	0.25	0.33	0.17	0.13	-	0.36	0.37	0.45	0.27	0.1	0.32
LT4-TCC	-	-	0.59	0.61	0.45	-	0.55	0.36	0.51	0.37	0.41	0.66
LT4-HSS	-	-	0.33	0.13	0.13	-	0.4	0.37	0.33	0.27	0.31	0.45
LT5-TCC	-	-	0.48	0.64	0.45	-	0.57	-	0.51	0.37	0.41	0.63
LT5-HSS	-	-	0.29	0.17	0.13	-	0.4	-	0.33	0.27	0.31	0.41
LT6-TCC	-	-	-	0.55	-	-	0.58	-	0.44	0.37	0.41	0.58
LT6-HSS	-	-	-	0.24	-	-	0.31	-	0.077	0.27	0.31	0.32

Probapbility forecast for 2016

	JUL	SEP	OCT	NOV	DEC
Low	11	0	0	100	75
Normal	0	100	0	0	0
High	89	0	100	0	25

Thank You!