

Current Status of the Operational Multi-Model Ensemble Prediction System and Climate Service Activities at APEC Climate Center

(Feb. 8, 2018)

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APEC Climate Center

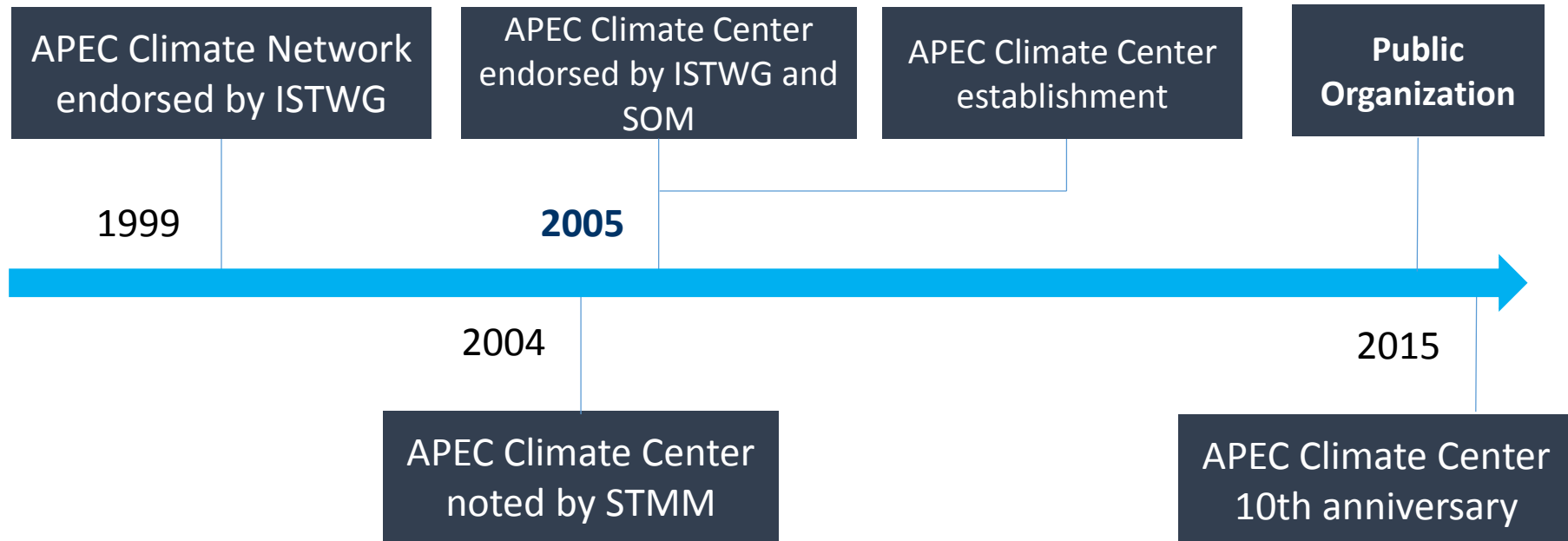
Overview of the APEC Climate Center

Asia-Pacific Economic Cooperation (APEC) Climate Center (APCC) is a leading climate information service provider in the Asia-Pacific region. We provide seasonal climate forecasts and other climate information products and services, conduct research and development activities, and organize capacity building initiatives for scientists from developing economies.



*APEC Climate Center
12 Centum 7-ro, Haeundae-gu, Busan, Rep. Korea*

History of the APEC Climate Center



2005 1st Senior Official Meeting (SOM) for the 17th APEC Ministerial Meeting Summary Report

41. SOM concluded that this was an important decision made by the ISTWG and endorsed the establishment of the APCC.



Mission of the APEC Climate Center

To enhance the socio-economic well-being of member economies by utilizing up-to-date scientific knowledge and applying innovative climate prediction techniques.



Climate Prediction

APCC produces value-added, reliable, and real-time climate prediction information and provides the APEC region with it.



Interdisciplinary Research

APCC leads in the development of interdisciplinary research and application techniques at the climate-environment-society nexus.



Climate Information Services

APCC strives to be a key climate database center to distribute climate data, information products, and related tools.



International Cooperation

APCC guides developing countries from the APEC region toward building their own capacity to produce reliable climate prediction information.

Climate Prediction & Information Service

✓ <http://www.apcc21.org>



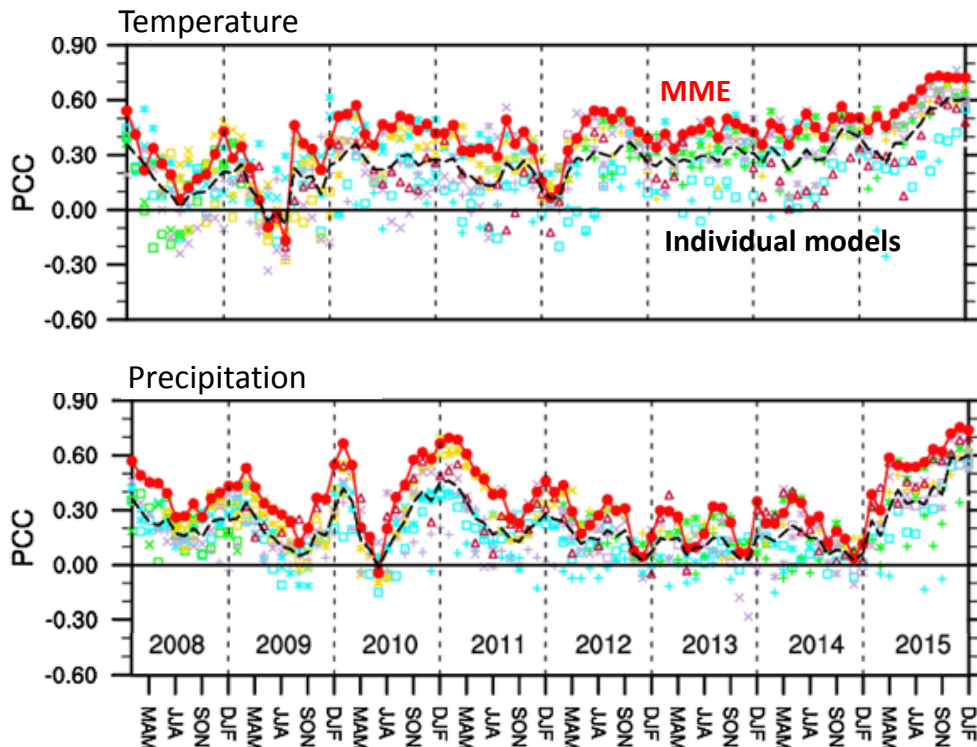
Climate Information

Information Service System

Multi-Model Ensemble

- Producing skillful real-time climate predictions and developing a value-added reliable climate prediction system based on a **Multi-Model Ensemble (MME)** technique.

Anomaly Pattern Correlation



Min et al. (2017), *Climate Dynamics*

Operational Institute/Organization



International Research Institute
for Climate and Society



Government
of Canada

Gouvernement
du Canada



WMO Lead Centre for
Long-Range Forecast Multi-Model Ensemble

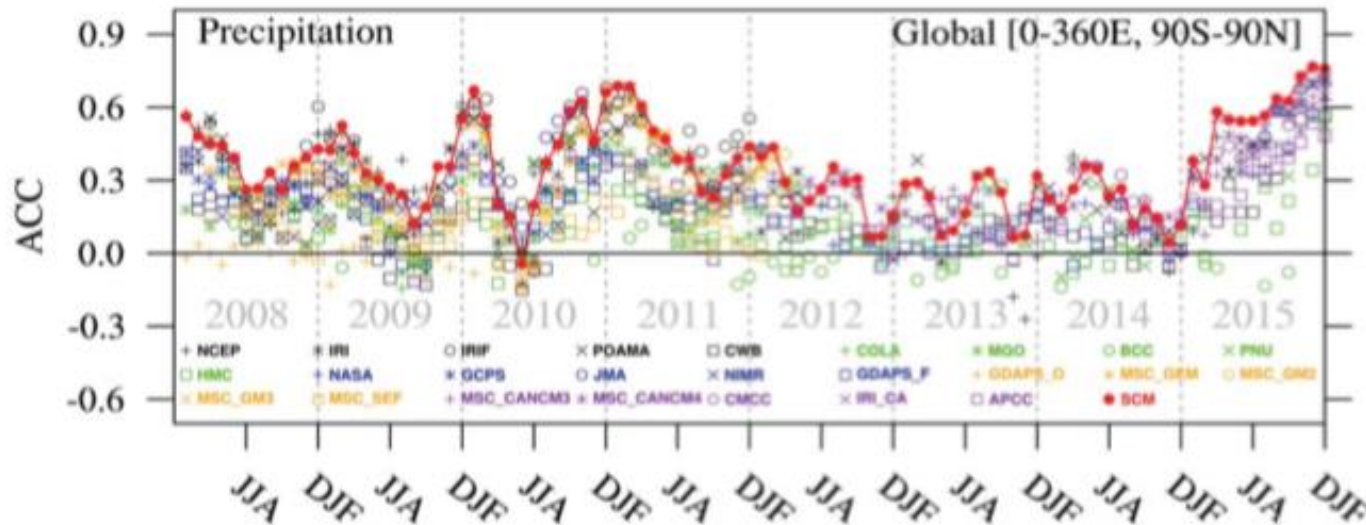
Why MME is better?

$$R_{MM} = \frac{\langle R \rangle}{\sqrt{V(\langle y \rangle)}} = \frac{\langle R \rangle}{\sqrt{\langle r \rangle}}$$

Average skill of all models

Inter-dependency among models

- Error cancellation
- Wider Prob. distribution

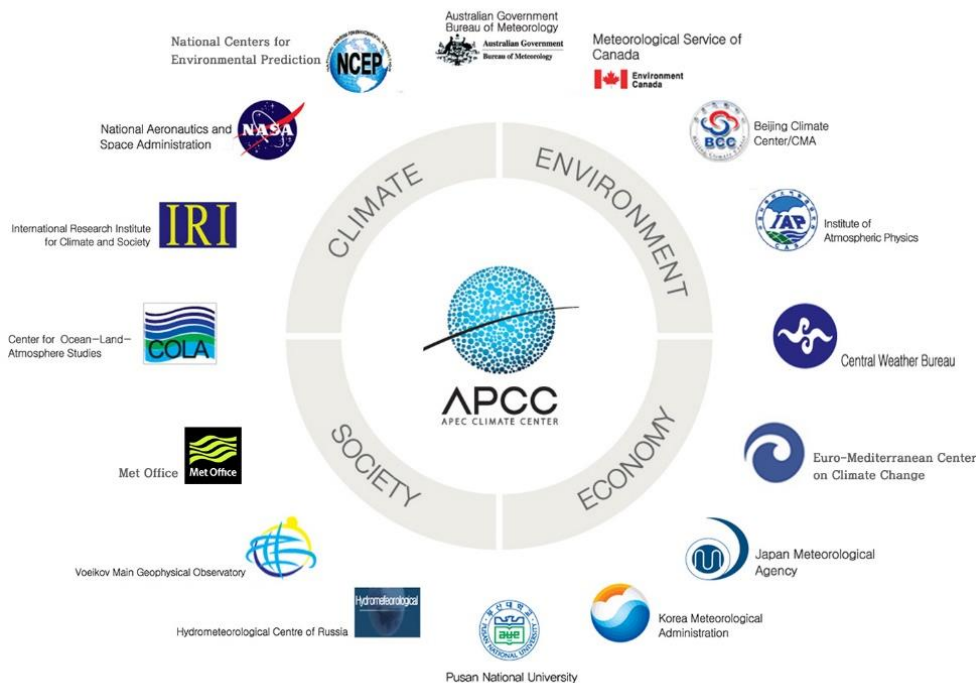


Not always but mostly similar to best performing model (changing)

APCC MME Prediction System

- The world's largest MME system based on international cooperation to generate monthly rolling 3-month and 6-month MME climate outlooks.

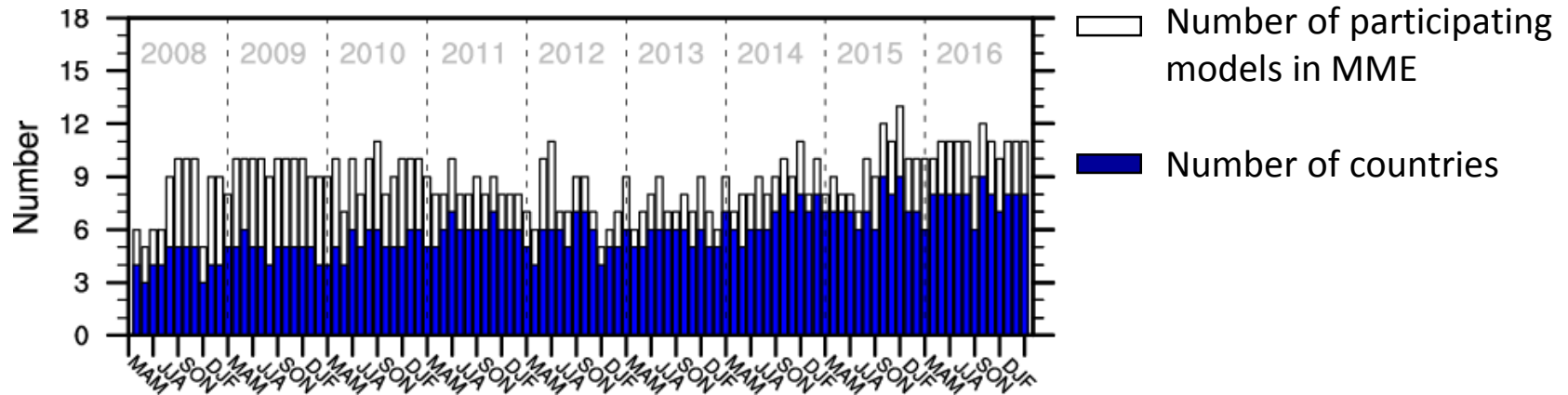
Multi-institutional Cooperation



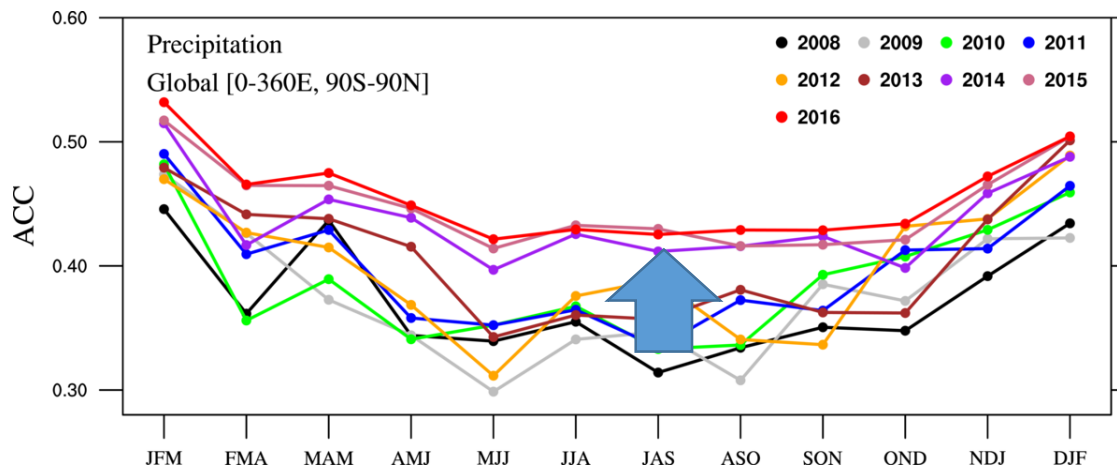
Economy	Organization/Institute
Australia	Bureau of Meteorology (BoM)
Canada	Meteorological Service of Canada (MSC)
China	Beijing Climate Center (BCC) Institute of Atmospheric Physics of China (IAP)
Chinese Taipei	Central Weather Bureau of Chinese Taipei (CWB)
Italy	Euro-Mediterranean Center on Climate Change (CMCC)
Japan	Japan Meteorological Agency (JMA)
Korea	Korea Meteorological Administration (KMA) Pusan National University (PNU)
Peru	Servicio Nacional de Meteorología e Hidrología (SENAMHI)
Russia	Hydrometeorological Centre of Russia (HMC) Main Geophysical Observatory of Russia (MGO)
UK	Met Office
USA	Center for Ocean-Land-Atmosphere Studies (COLA) International Research Institute for Climate and Society (IRI) National Aeronautics and Space Administration (NASA) National Center for Environmental Prediction (NCEP) / National Ocean and Atmospheric Administration (NOAA)

Performance of APCC MME

Number of Models and Countries

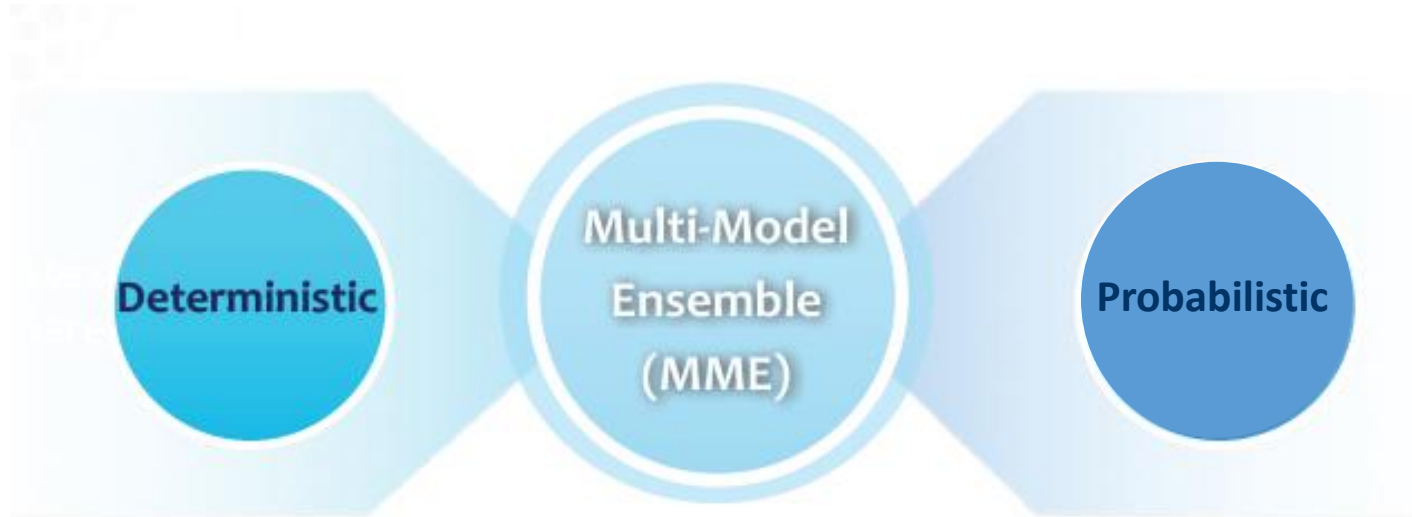


Hindcast Skill of APCC MME



The skill of forecasts has continuously increased.

Deterministic MME Method



SCM

Simple Composite Method:
Average of individual forecast with equal weighting

SPM

Step-wise pattern Projection Method:
Calibrated MME estimated as corrected single-model prediction (Kug et al. 2008)

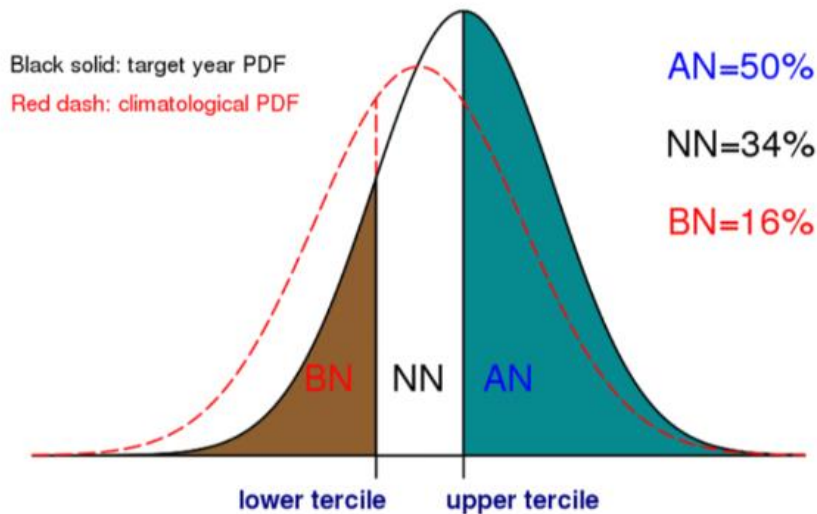
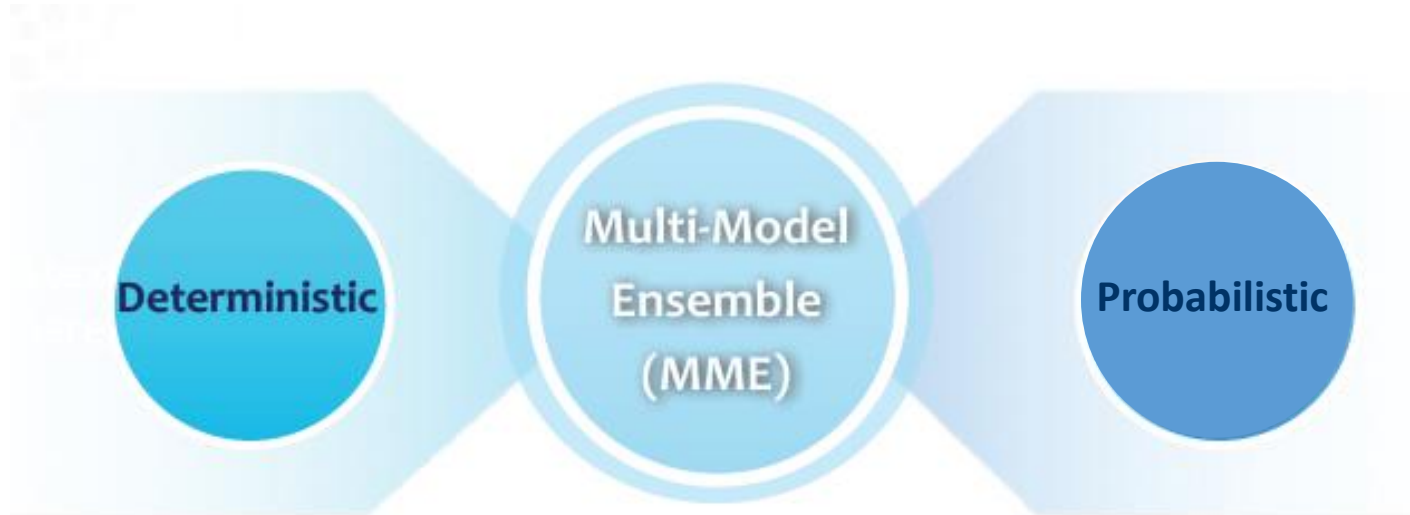
MRG

Multiple Regression Method:
Empirically weighted MME with coefficients computed using multiple linear regression (Yun et al. 2003)

SSE

Synthetic Superensemble Method:
MRG with the EOF-filtered dataset to minimizing the residual error variance (Yun et al. 2005)

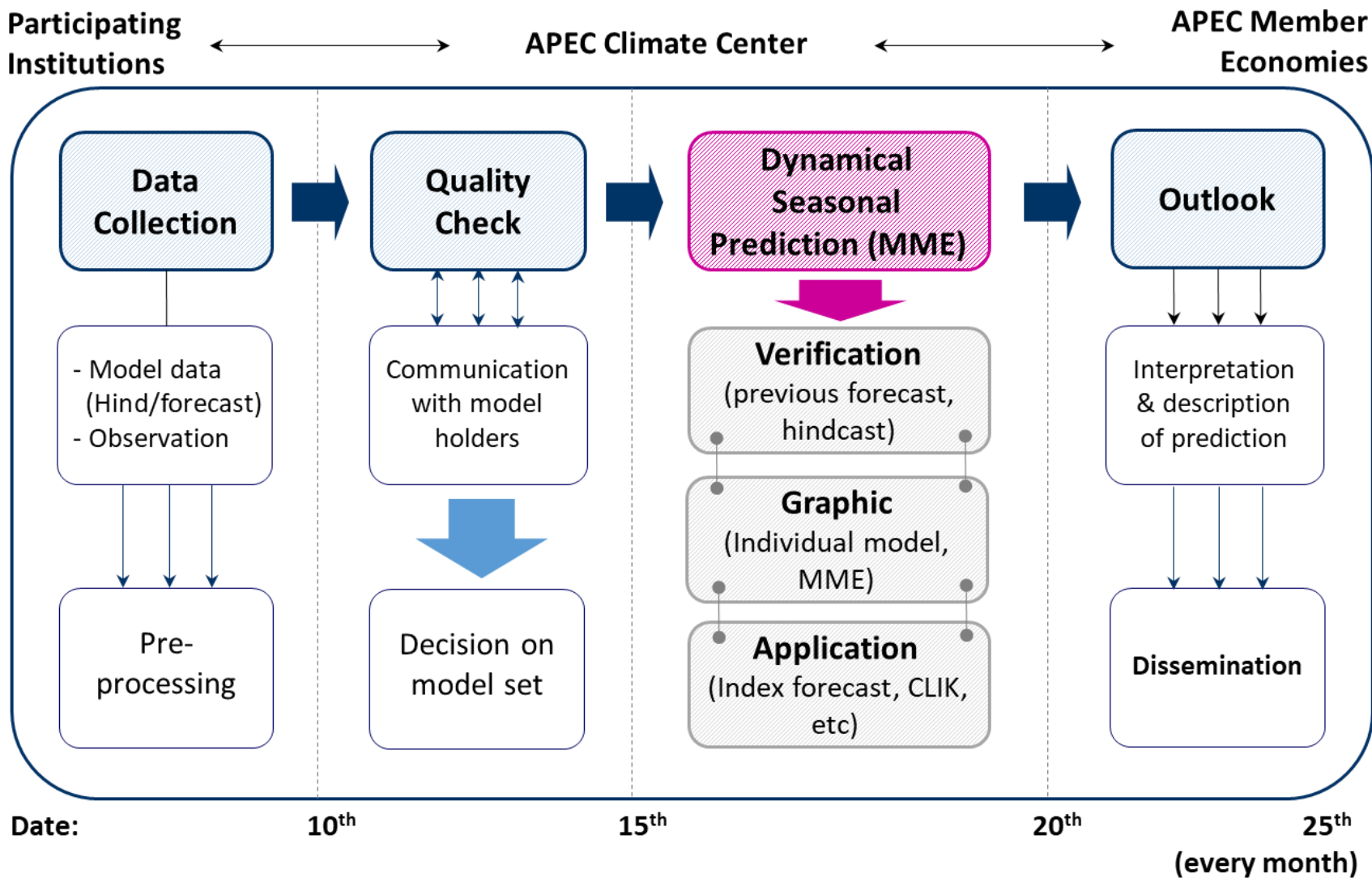
Probabilistic MME Method



GAUS

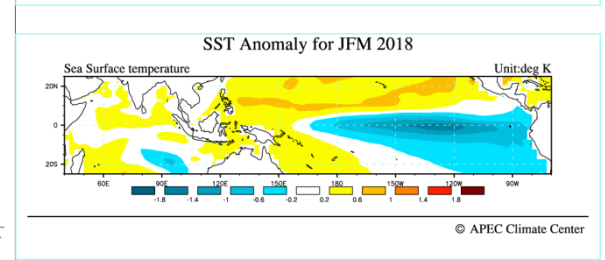
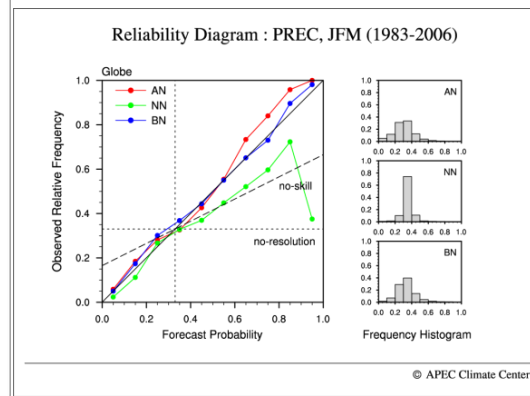
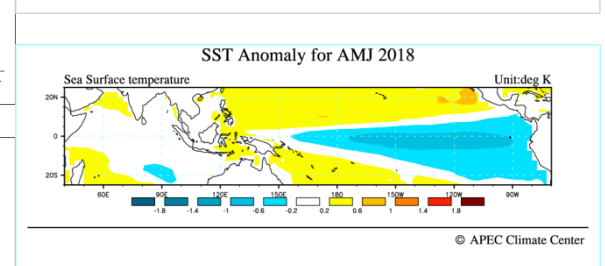
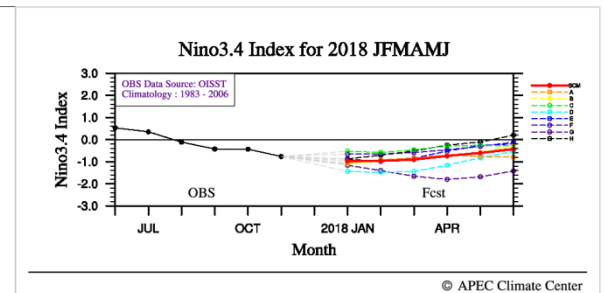
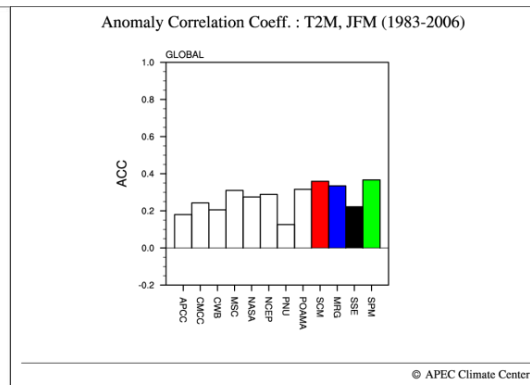
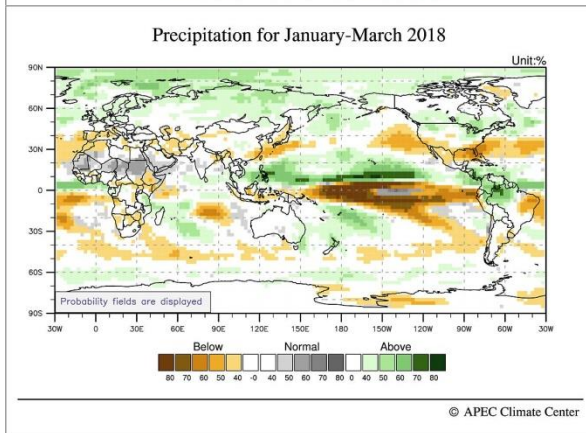
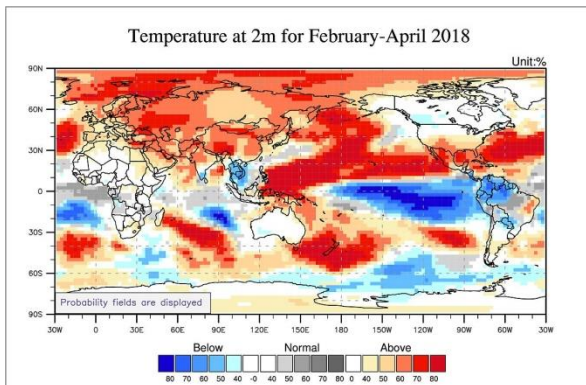
A parametric **Gaussian fitting method** for the estimation of tercile-based categorical probabilities; forecast probability is estimated as a portion of the forecast PDF with respect to the historical one (Min et al. 2009).

Operation Schedule



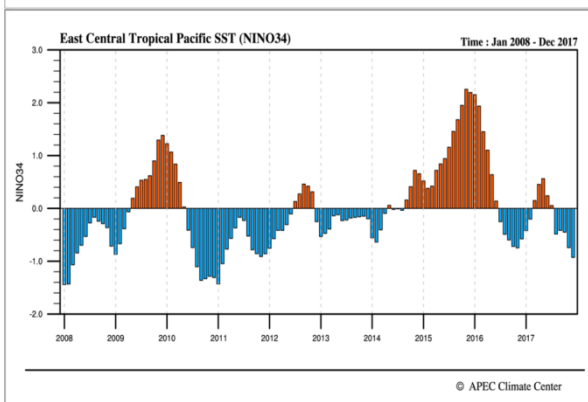
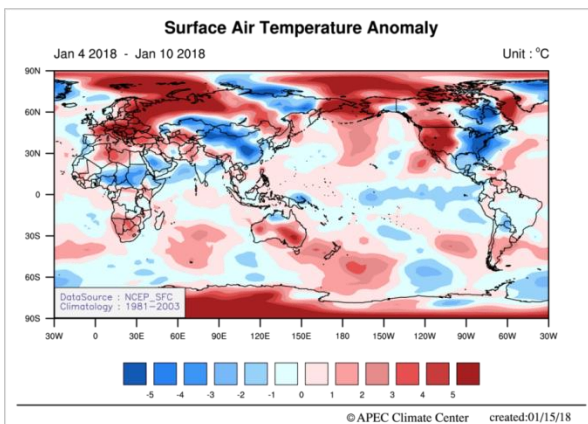
Seasonal Forecast Products

- Monthly & Seasonal mean forecast of Tsfc, Prec, T850, Z500, SLP, SST, UV (deterministic & probabilistic)
- Verification results (hindcast, realtime forecast)
- ENSO Outlook

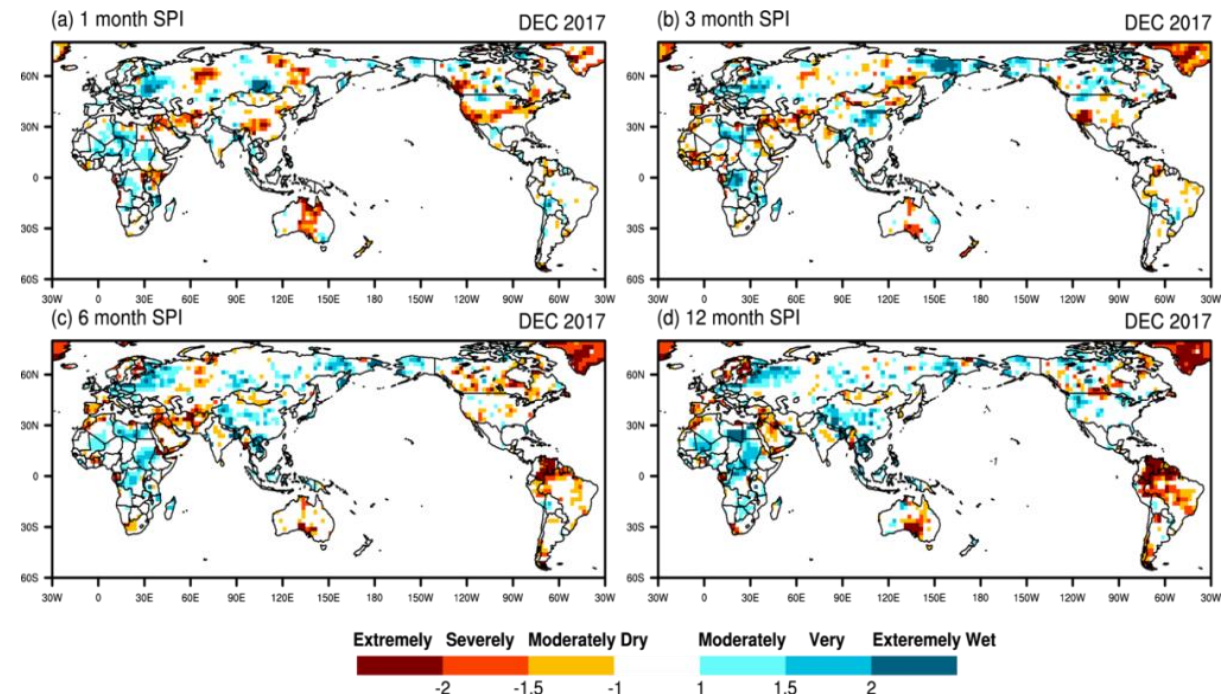


Climate Monitoring Products

- Current Conditions
 - Climate Highlight: Weekly/monthly/seasonal T/OLR/P/SST/UV/Z
 - Climate Indices: Pacific, Indian & Atlantic SST, Atmos. and Monsoon indices
 - Global droughts: SPI for the last 1-, 3-, 6-, and 9-month periods



Global Extreme Drought/Flood Monitoring



Climate Prediction & Information Service

✓ <http://www.apcc21.org>



Information Service System

ADSS

APCC Data Service System

<http://adss.apcc21.org>

✓ Disseminate up-to-date climate data and forecast information

Data Set	Areal Coverage	Grid Size	Time Step	Source	Requirement
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
INDIVIDUAL-MODEL(6-MON)	Global	2.5×2.5(degree)	Monthly	APCC	Login
INDIVIDUAL-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	
TMI	Global	2.5×2.5(degree)	Daily	REMSS	
QUICKSCAT	Global	0.25×0.25(degree)	Daily	REMSS	
GPCP	Global	1.0×1.0(degree)	Daily	NASA	
GHCN	Global	5.0×5.0(degree)	Monthly	NOAA	
UD	Global	0.5×0.5(degree)	Monthly	University of Delaware	

CLIK

CLimate Information toolKit

<http://clik.apcc21.org>

- ✓ On-line tool to generate customized & localized seasonal forecast

For those **who wants to play with model data,**

► To allow **user manipulation** of multi-model ensemble prediction in producing his/her own forecast

MME Prediction
with different model combination

CLIK

Downscaling:
Simulated large scale pattern to station matching

► To provide **statistical downscaling** capability using multi model prediction

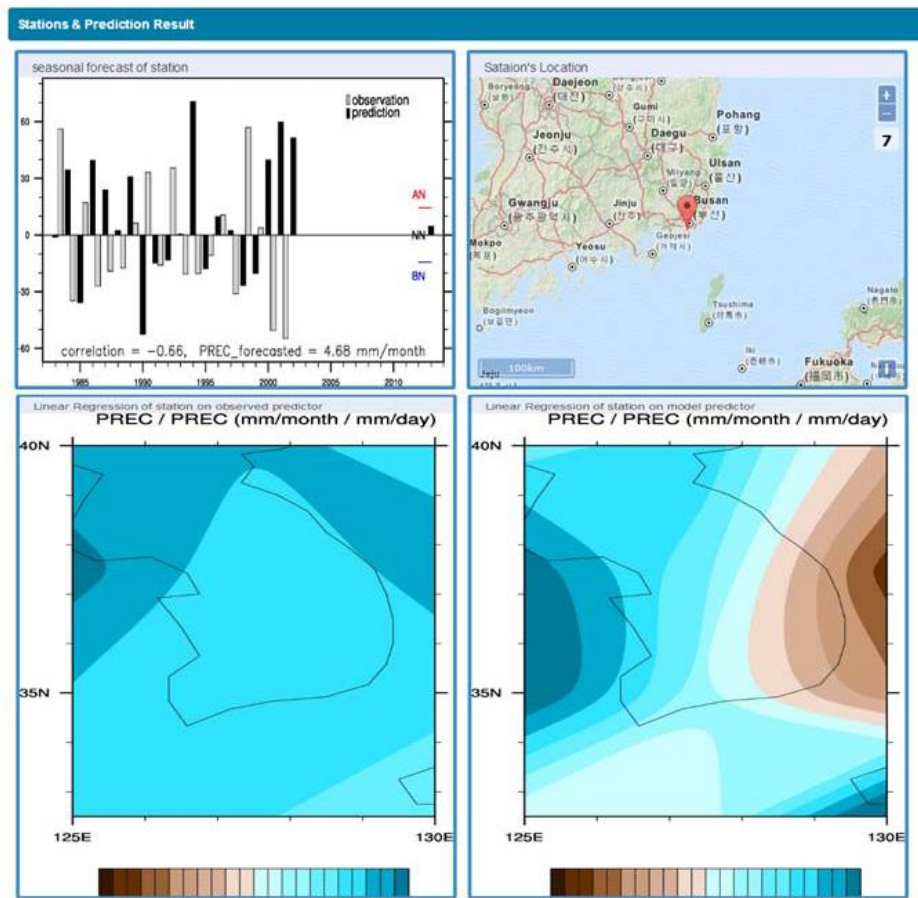
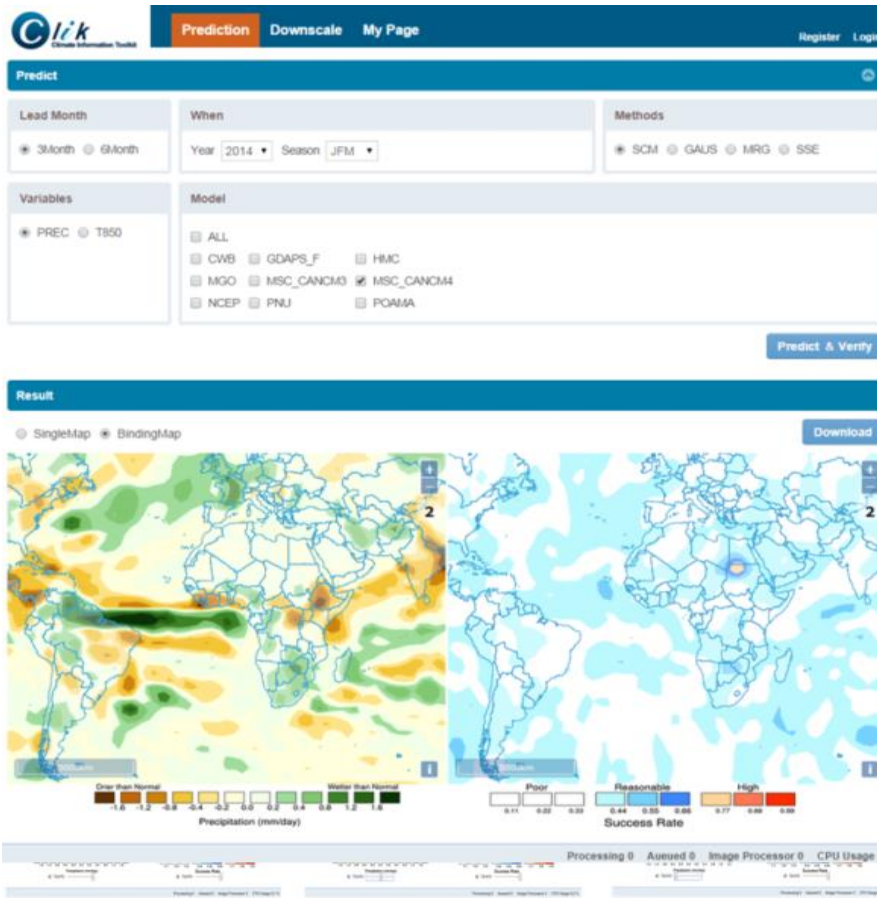
CLIK

CLimate Information toolKit

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(Customized MME prediction)

(Downscaled prediction)

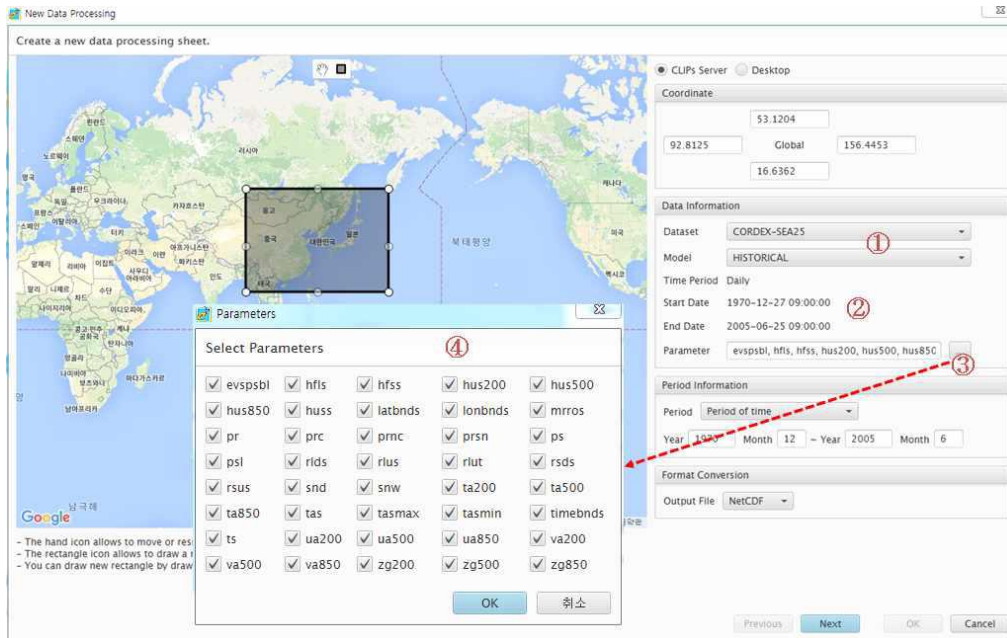


CLIPs

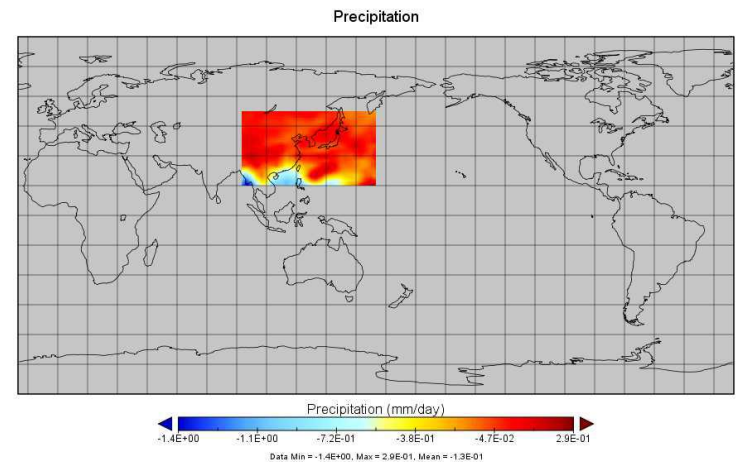
CLimate Information Process System

<http://clips.apcc21.org>

- ✓ Utilize big climate data that has been processed into one standard user-friendly file format, reducing the time spent on data processing and eliminating the need for costly high-end hardware and software



이름	수정된 날짜	유형	크기
_2004_prec.nc	2015-12-10 오후...	NC 파일	4KB
_2004_t850.nc	2015-12-10 오후...	NC 파일	4KB
_2004_z500.nc	2015-12-10 오후...	NC 파일	4KB
_2005_prec.nc	2015-12-10 오후...	NC 파일	4KB
_2005_t850.nc	2015-12-10 오후...	NC 파일	4KB
_2005_z500.nc	2015-12-10 오후...	NC 파일	4KB
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_2006_t850.nc	2015-12-10 오후...	NC 파일	4KB
_2006_z500.nc	2015-12-10 오후...	NC 파일	4KB
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_2007_u850.nc	2015-12-10 오후...	NC 파일	4KB
_2007_v850.nc	2015-12-10 오후...	NC 파일	4KB



- target area, parameter, time period, data format, etc.

Interdisciplinary Research

THEME 1: Enhancing Climate Prediction Abilities Across Various Timescales

- [2016 - ongoing] Improved austral winter seasonal forecast and tropical cyclone sub-seasonal to seasonal outlooks in Tonga (with Tonga Meteorological Service)
- [2014 – ongoing] Republic of Korea – Pacific Islands Climate Prediction Services (with PIFs and SPREP)
- [2011-2012] Extending APCC seasonal forecast and climate application products for improved societal applications (with Uni. Of Aizu, Japan)

THEME 2: Application of Prediction Information to Sectors such as Agriculture, Water, Health, and Energy

- [2016 - ongoing] Real-time Urban Inundation Forecasting System using Remote Sensing Technology
- [2016 – ongoing] Contributing to food security with improved climate risk management in Lao-PDR (with International Research Institute for climate and Society)
- [2016 – 2017] Development of smart groundwater management system: utilizing climate information in response to shortage of water (with Ministry of Lands, Survey, and Natural Resources of Tonga)

* *PIFs: Pacific Island Forum Secretariat, SPREP: Secretariat of the Pacific Regional Environment Program*

Interdisciplinary Research

THEME 2 (continue)

- [2015 – 2017] ASEAN Science-Based Disaster Management Platform (with ASEAN Secretariat and ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management)
- [2015 – 2017] Application of rice disease model for seasonal yield loss simulation in the Bicol region (with International Research Institute for climate and Society)
- [2014 – 2016] Improving agricultural productivity through ensuring data availability and enhancing agro-meteorological services (with MAFFF and Tongan Meteorological Service)
- [2013 – 2014] Assessing rice productivity and adaptation strategies for Southeast Asia under climate change through multi-scale crop modeling (with Cambodian Agricultural Research and Development Institute)
- [2012 – 2015] Toward a fire and haze early warning system for southeast Asia (with Uni. of Aizu, Columbia Uni., National Institute of Aeronautics and Space in Indonesia, Malaysia Meteorological Department, Indonesia Meteorology, Climatological and Geophysical Agency, ASEAN Specialized Meteorological Centre, and Department of Forestry in Indonesia)
- [2008- 2011] Application of seasonal forecasts to predict the electricity demand in Japan (with Central Research Institute of Electric Power Industry)

Summary

- APEC Climate Center (APCC) is a leading operational center providing seasonal forecast based on the **Multi-Model Ensemble** (MME) prediction system.
- MME seasonal prediction is one of the **most reliable** seasonal forecast information at present.
- APCC focuses on producing and sharing valuable and reliable high quality climate prediction information applying that information to sectors through **interdisciplinary research** and **building capacity** in both climate prediction and application.



THANK YOU

(<http://www.apcc21.org>)

Climate Prediction

❖ Deterministic MME Forecast

✓ Simple Composite Method (SCM)

- Simple average of individual models' forecasts with equal weightings

$$P = \frac{1}{M} \sum_i F_i'$$

✓ Step-wise Pattern Projection Method (SPM)

- Calibrated MME estimated as corrected single-model predictions (Kug et al. 2008)

$$P = \frac{1}{M} \sum_i \hat{F}_i'$$

✓ Multiple Regression Method (MRG)

- Empirically weighted MME with coefficients computed using multiple linear regression (Yun et al. 2003)

$$P = \sum_i \alpha_i F_i'$$

✓ Synthetic Superensemble Method (SSE)

- MRG with the EOF-filtered datasets to minimizing the residual error variance (Yun et al. 2005)

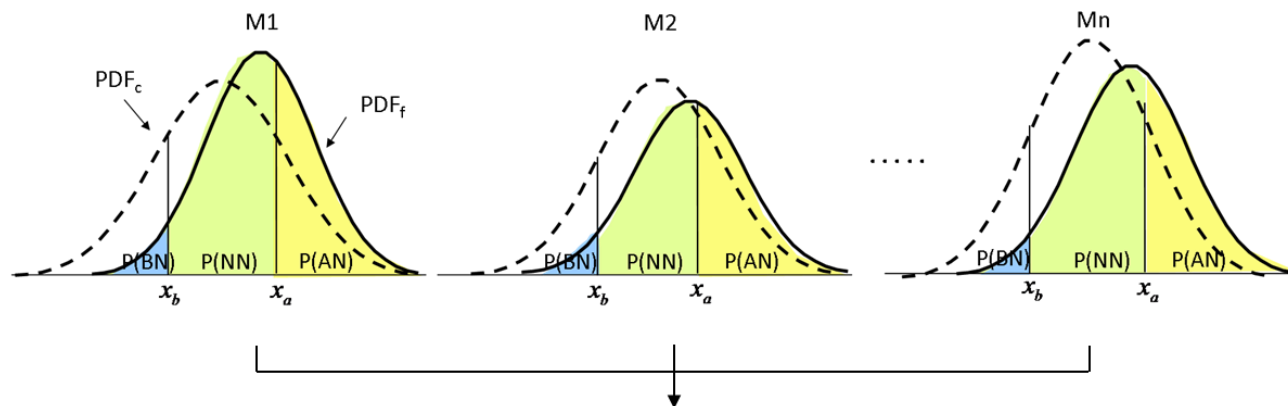
$$P = \frac{1}{M} \sum_i \alpha_i \hat{F}_i'$$

Climate Prediction

❖ Probabilistic MME Forecast

✓ Probabilistic MME Method (PMME)

- Forecast probability is estimated based on a parametric Gaussian fitting method for each model and then combined with model weights being proportional to the square root of ensemble size (Min et al. 2009)



$$P(E) = \sum_{i=1}^M \underbrace{P(\text{Model}_i)}_{\text{Model Weight}} \times \underbrace{P(E / \text{Model}_i)}_{\text{Forecast Probability of an Event}}$$

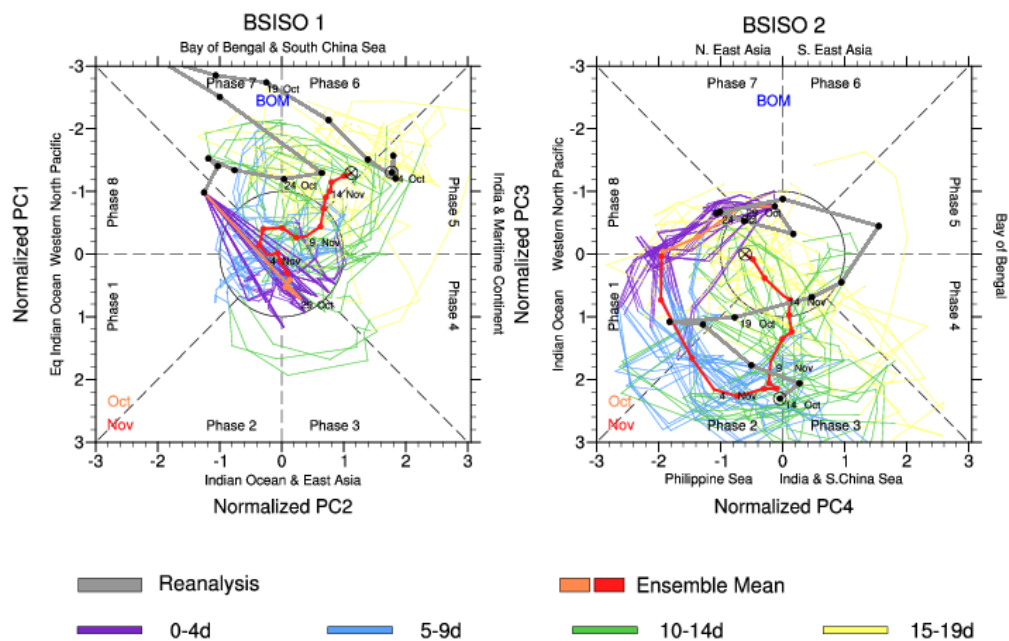
Model Weight **Forecast Probability of an Event**

Climate Information Service: “BSISO Forecast”

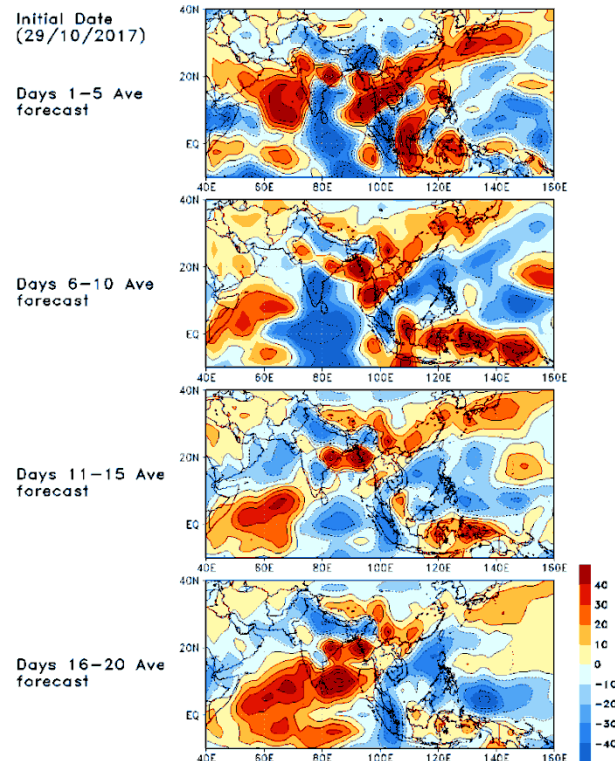
❖ Boreal Summer Intraseasonal Oscillation (BSISO)

- Initiated in 2013 in cooperation with the CAS/WCRP Working Group on Numerical Experimentation (WGNE) Madden Julian Oscillation (MJO) Task Force
- Monitoring, forecast, and verification information available from May - October
- BOM, CFS, GFS, ECM, and CWB

BSISO Forecast for 29Oct-17Nov, 2017



5-day mean OLR composite



* BOM (Australia Bureau of Meteorology-POAMA2.4), CFS (Climate Forecast System from NCEP), GFS (Global Forecast System from NCEP), CWB (Taiwan's Central Weather Bureau), ECM (European Center for Medium Range Weather Forecasts)

International Cooperation: Capacity Building

