

CLIK hands-on (PART I):
introduction and structure
(<http://clik.apcc21.org>)

Yun-Young Lee
8 Sep 2016

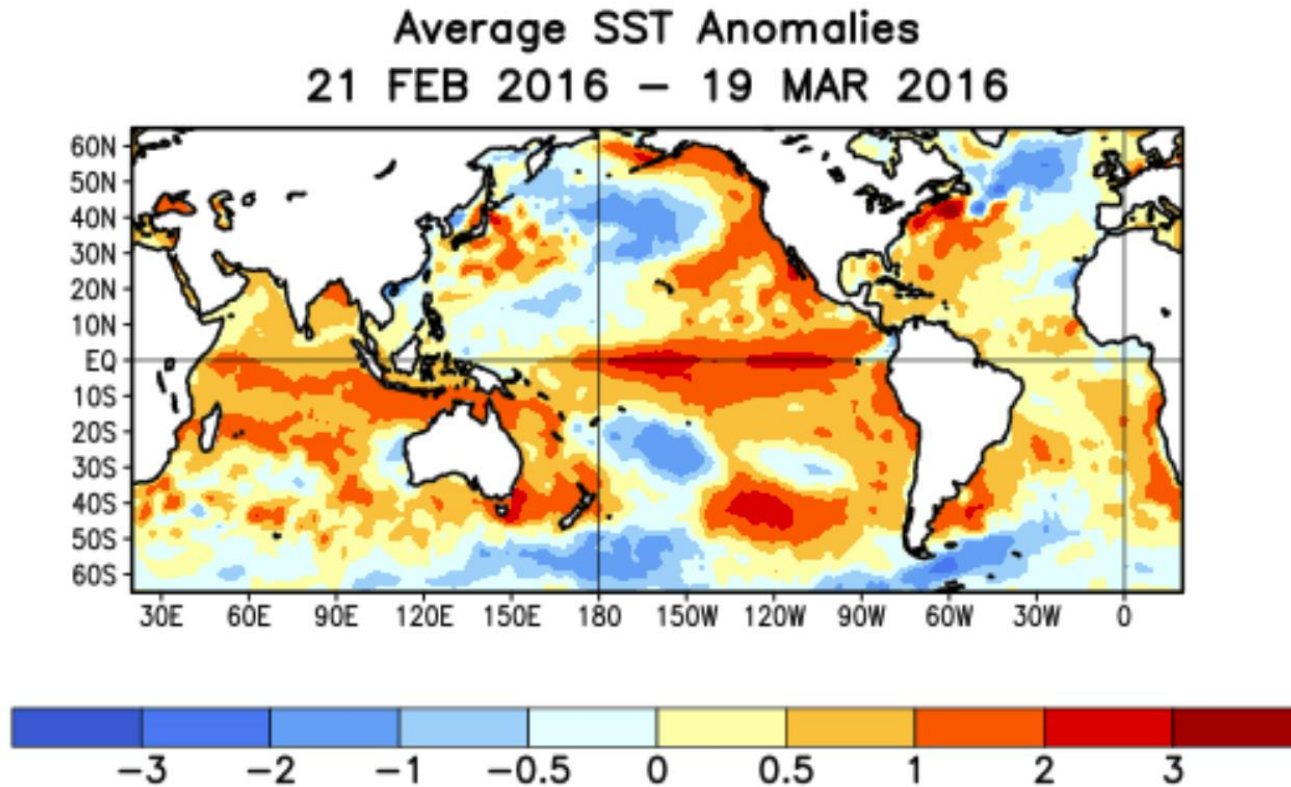
“Super” El Nino (15/16)

✓ Why ENSO is important?



“Super” El Nino (15/16)

- ✓ What happened in the world during 2015/16 El Nino season?



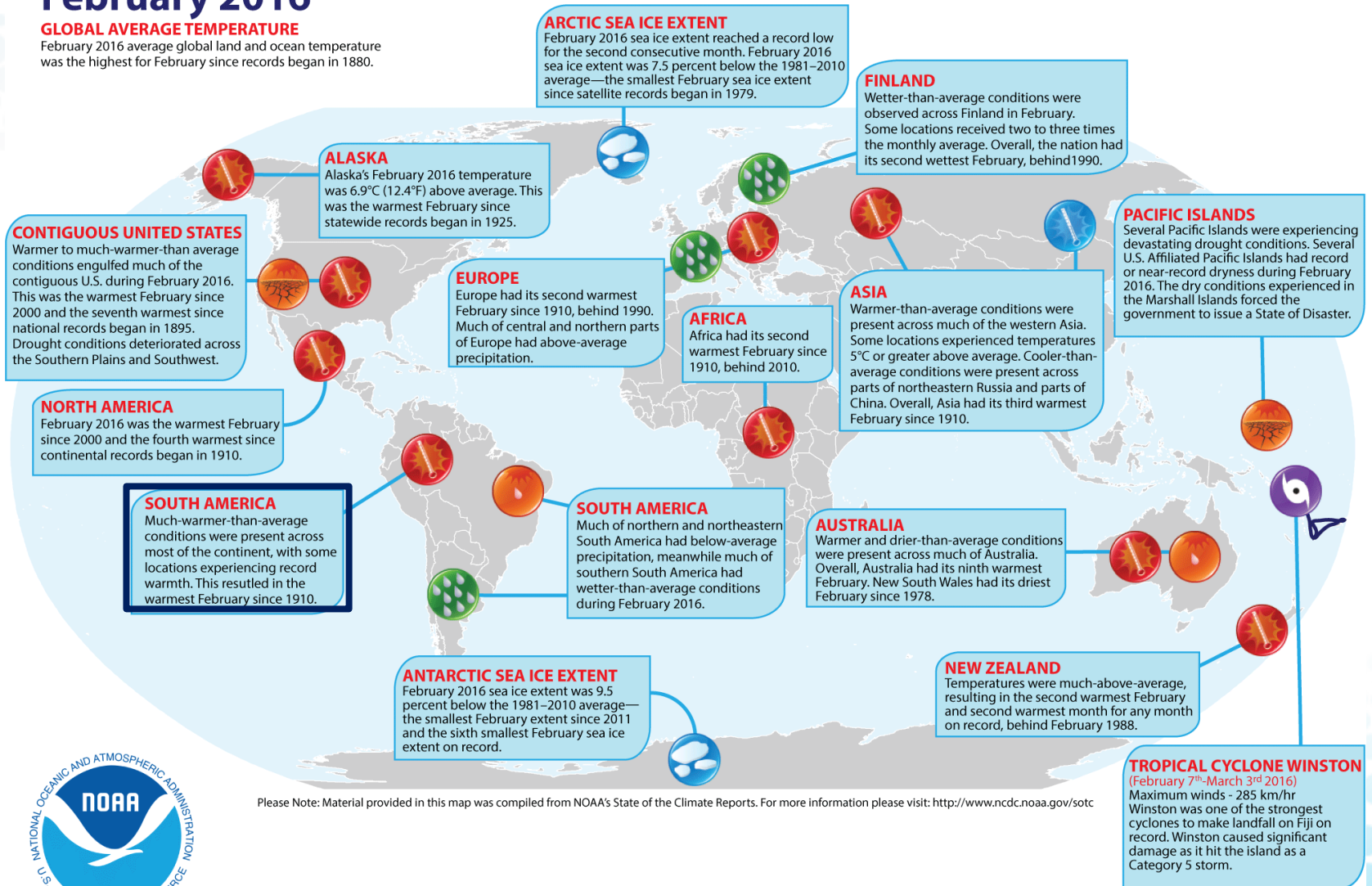
Extreme SST anomalies (up to 3 degrees) were recorded in the central Pacific, with values even higher than the records of the El Niño 1982-1983 and 1997-1998 seasons.

Feb 2016

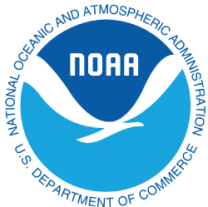
Selected Significant Climate Anomalies and Events February 2016

GLOBAL AVERAGE TEMPERATURE

February 2016 average global land and ocean temperature was the highest for February since records began in 1880.



Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: <http://www.ncdc.noaa.gov/sotc>



Climate disasters during El Nino



Flood



Mudslide

ENSO:

Peru is one of the countries that suffered most the effects of El Niño season, with several floods and landslides reported all over the country from north to south.

Heavy rains fall in the normally rainless **coastal regions**, leading to flooding and associated phenomena. At the same time, the **highlands** can suffer from **crippling droughts**. The 1997-1998 El Niño -- the worst in recent history -- affected an estimated 600,000 people, including hundreds of fatalities, 40,500 homes damaged or destroyed and the washing away of thousands of miles of roads and bridges.

<http://goperu.about.com/od/healthandsafety/tp/Natural-Hazards-In-Peru.htm>

<http://floodlist.com/america/strong-el-nino-increased-preparedness-2015-2016-south-america>

During 15/16 El Nino

The major impact in term of floods occurred between December 2015 and January 2016, especially in northern Argentina, southern Brazil, Paraguay and Uruguay with the Paraná, Paraguay and Uruguay Rivers inundation that caused more the 150,000 people from their homes.

Localized floods occurred in [Guayaquil \(25 January 2016\)](#), [Cordoba \(15 February 2016\)](#), [Arequipa \(22 February 2016\)](#), [La Paz \(24 February 2016\)](#), [Rio de Janeiro \(29 February 2016\)](#) and [São Paulo \(11 March 2016\)](#).

During 15/16 El Nino

Heavy Rain in Central and Southern Peru – 1 Dead, 1 Missing

25 FEBRUARY, 2016 BY [ALESSANDRO MASOERO](#) IN [AMERICAS](#), [NEWS](#)



FOTOS. Lluvia de 10 horas y apagón afectaron la ciudad de Arequipa



 **Pachamama Radio**
@PachamamaRadio

 Follow

tinyurl.com/hvrcyu Senamhi Puno declaró alerta naranja en la región

2:06 AM - 25 Feb 2016



Importance of “Accurate” prediction

Preparedness in Peru:

The Emergency Decree authorised the funding and execution of structural and non-structural actions **to reduce risk and enhance preparedness for the 2015-2016 El Niño.**

A National Committee for the El Niño Phenomenon Risk Management was created, integrating the work of several government agencies or ministries including Internal Affairs, Agriculture, Education, Transportation, Health, Defence, Economy and Finance, Public Works and the National Disaster Manager Secretariat.

ACCURATE climate prediction optimized to your region (village) will make early warning possible and reduce economic and human losses in Peru & Chile.

APCC mission

- **Facilitating the share of high-cost climate data and information to minimize economic and human losses due to natural disasters**
- **Capacity building in climate prediction and sustainable social and economic applications of climate information**

CLIK (CLimate Information ToolKit) : online prediction tool

- For those **who wants to play with model data**
 - To allow **user manipulation of multi model prediction** in producing his/her own forecast
 - To provide **statistical downscaling** capability using multi model prediction
- Prediction : Diff. combinations
 - Downscaling : model to station matching
- Facilitate the cooperation in the exchange of information and services so that users are able to **cope with climate related disasters****

Development

2008

- The CLimate Information ToolKit(CLIK) version 1.0 was developed.
 - Deterministic Multi-Model Ensemble (DMME) prediction

2009-2010

- CLIK version 2.0
 - Probabilistic Multi-Model Ensemble (PMME)
 - Statistical Downscaling

2011-2013

- Clustering Computation
Enhancing Internal Algorithm

2014

- CLIK v3.0 with New Web Framework (New CLIK)
 - Enhancement of User Interface & Performance
 - Database optimization, Lightweight Map, etc.

CLIK

CLIK 3.0: Internals

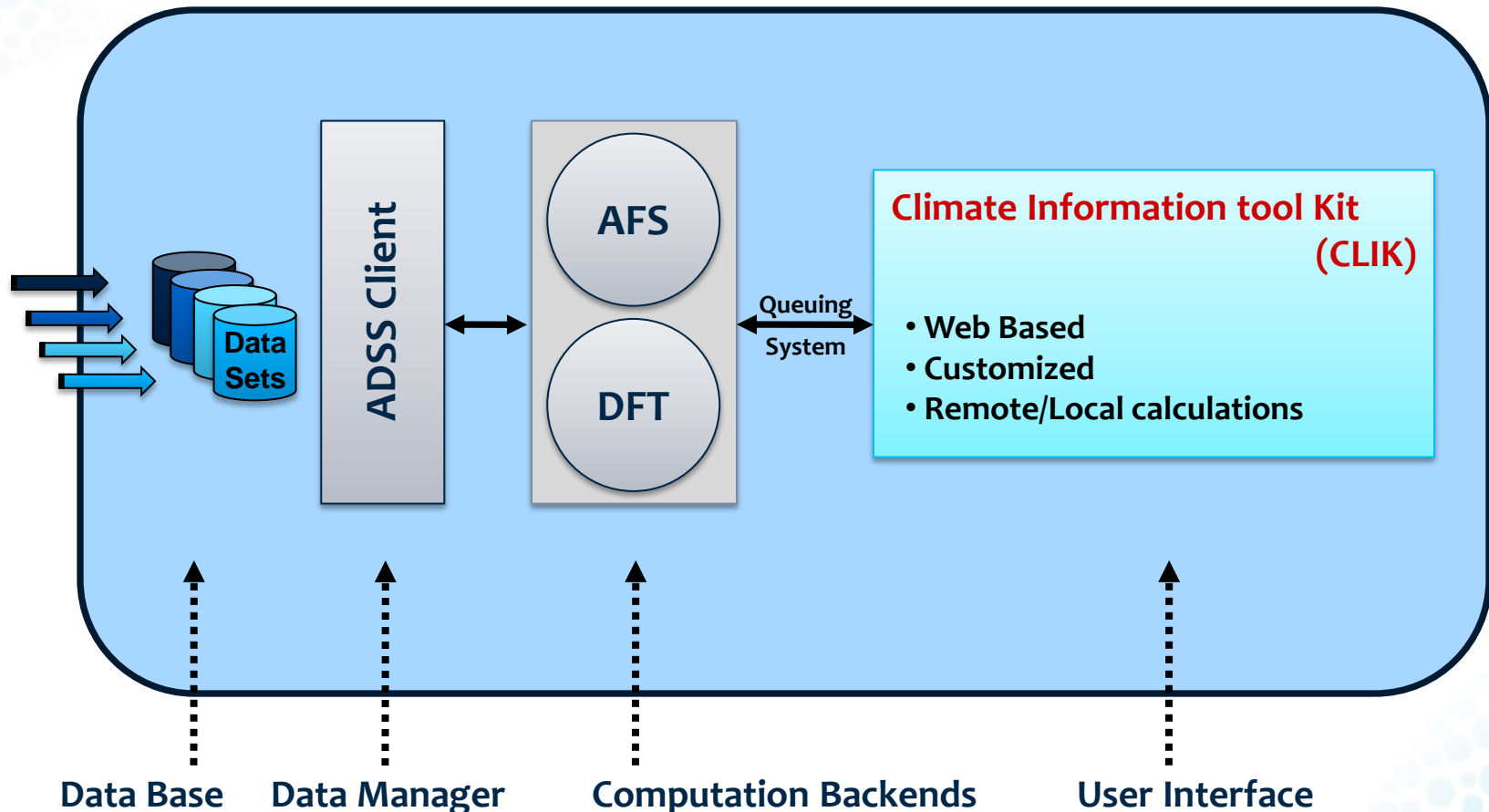
- **The Customized Climate Information Service**
- **Be able to produce and utilize the climate information data by CLIK with **only a computer and an internet connection.****
- **Based on Java and HTML with NCAR Command Language (NCL)**
- **Existing NCL, Fortran Code can be reused with Java Container**
- **Standard Web technology (HTML/JSP)**
- **CLIK 3.0 leverages on the robust functionality of previous product releases but at around 10 times the performance**

<http://clik.apcc21.org>

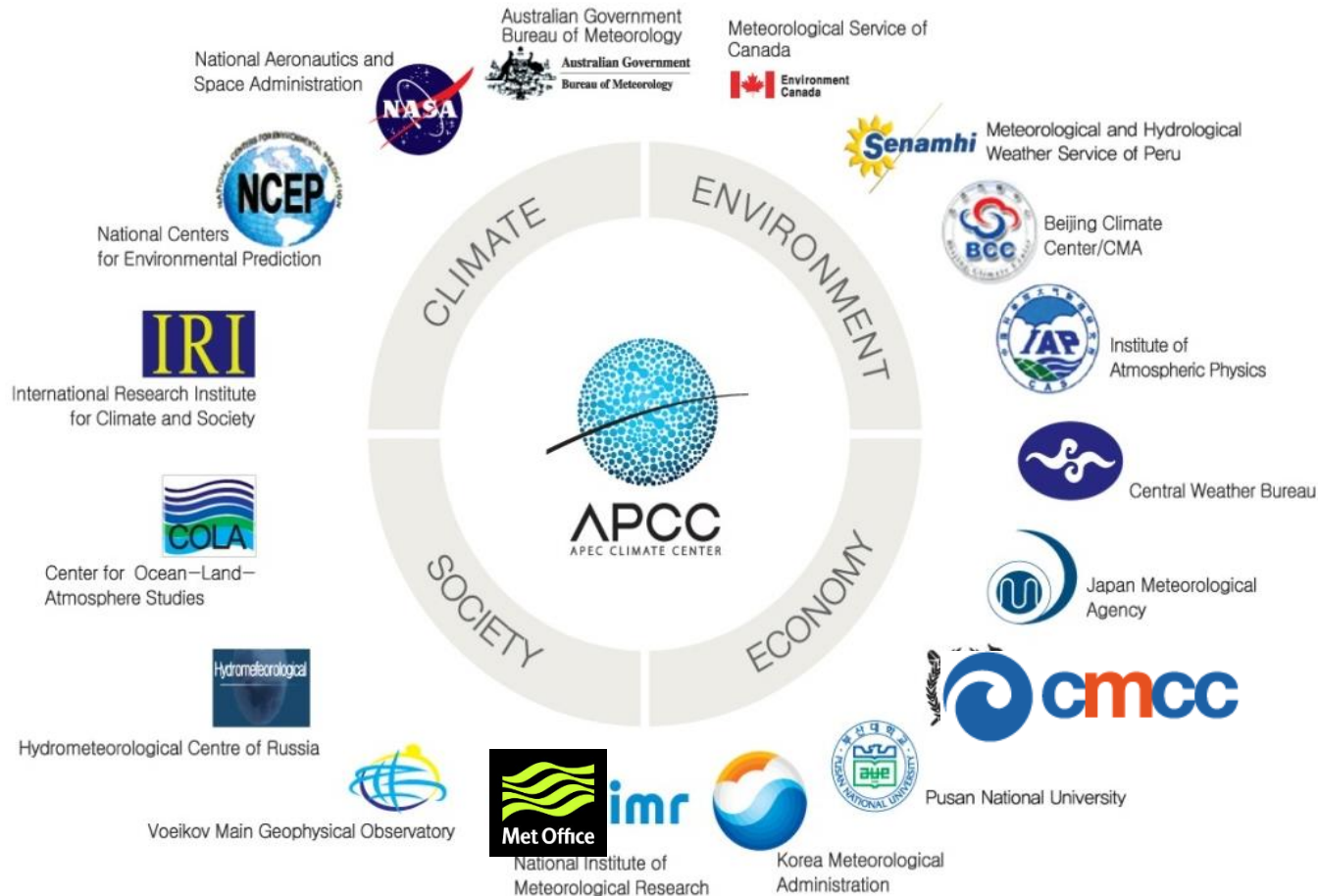
<https://www.youtube.com/watch?v=5CNPoX1flXY>

CLIK: process diagram

APCC Climate Application System



APCC: data collection



- Collection of Dynamic ensemble seasonal prediction data from NMHS and research institutes (16 operations/institutions from 10 countries)

List of available models

DATA SOURCES

Nation	Organization	Acronym
Australia	Bureau of Meteorology	BoM
Canada	Meteorological Service of Canada	MSC
China	National Climate Center, CMA	NCC
	Institute of Atmospheric Physics	IAP
Chinese Taipei	Central Weather Bureau	CWB
Italy	Centro Euro-Mediterraneo sui Cambiamenti Climatici	CMCC
Japan	Japan Meteorological Agency	JMA
Korea	Korea Meteorological Administration	KMA
	Pusan National University	PNU
	National Institute of Meteorological Research	NIMR
Peru	Servicio Nacional de Meteorología e Hidrología	SENAMHI
Russia	Hydrometeorological Research Centre of Russian Federation	HMC
	Voeikov Main Geophysical Observatory	MGO
UK	Met Office	Met Office
USA	International Research Institute for Climate & Society	IRI
	Center for Ocean-Land-Atmosphere Studies	COLA
	National Centers for Environmental Prediction, NOAA	NCEP
	National Aeronautics and Space Administration	NASA

Why MME?

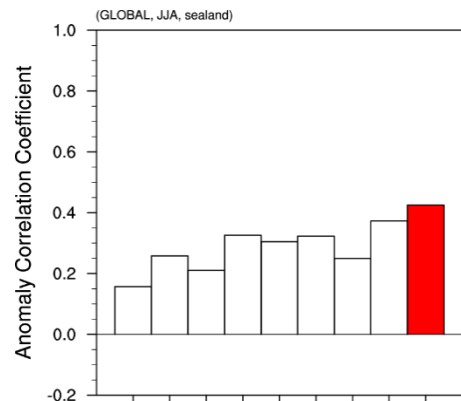
- Climate predictions have **uncertainty** coming from two major sources,

- Initial conditions uncertainty (errors in obs. system or estimates)
- Model formulation uncertainty (errors due to discrete representation of temporally and spatially continuous real world)

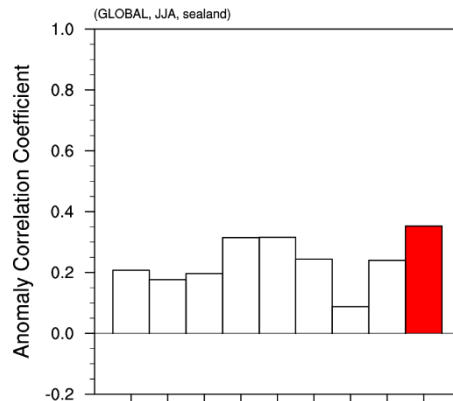
➔ multi-institutional multi-model ensemble approach **to minimize the uncertainty**

➔ multi-model ensemble (MME) approach yields **superior forecasts** compared to any single model.

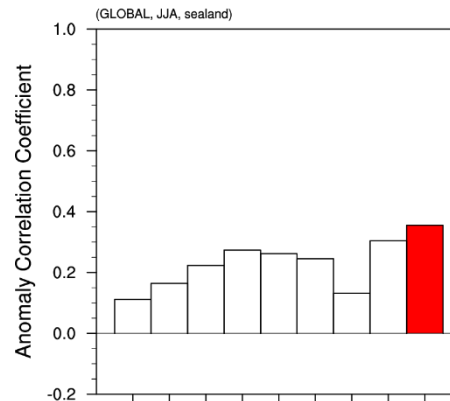
ACC prec hindcast



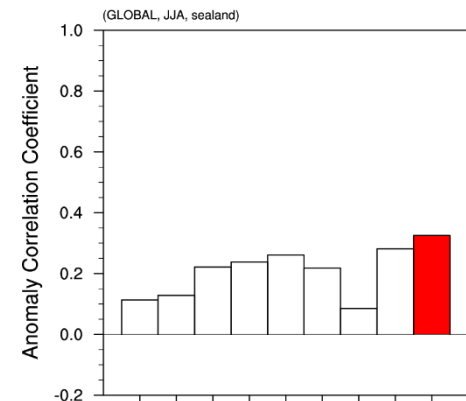
ACC t2m hindcast



ACC z500 hindcast



ACC slp hindcast



PREDICTION_methodology

Add text
in here

Deterministic

Multi-Model
Ensemble
(MME)

Probabilistic

SCM

GAUS

Simple Composite Method:

Average of individual forecast
with equal weighting

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

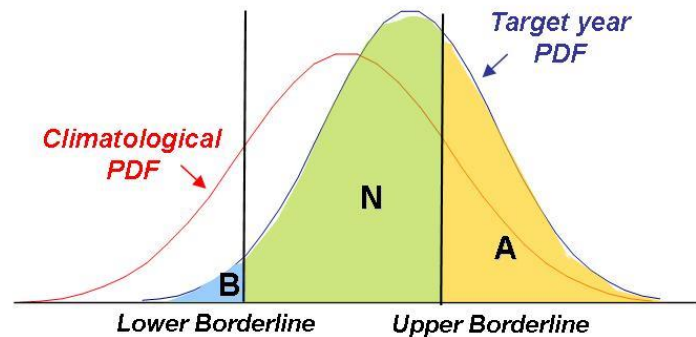
A parametric [Gaussian fitting method](#) for the estimation of tercile-based categorical probabilities; forecast probability of each category is estimated as a portion of the forecast PDF(Probability Density Function) with respect to the historical one.

Probabilistic MME Scheme(GAUS)

A parametric **Gaussian fitting method** for the estimation of tercile-based categorical probabilities; forecast probability of each category is estimated as a portion of the forecast PDF(Probability Density Function) with respect to the historical one.

Forecast probability

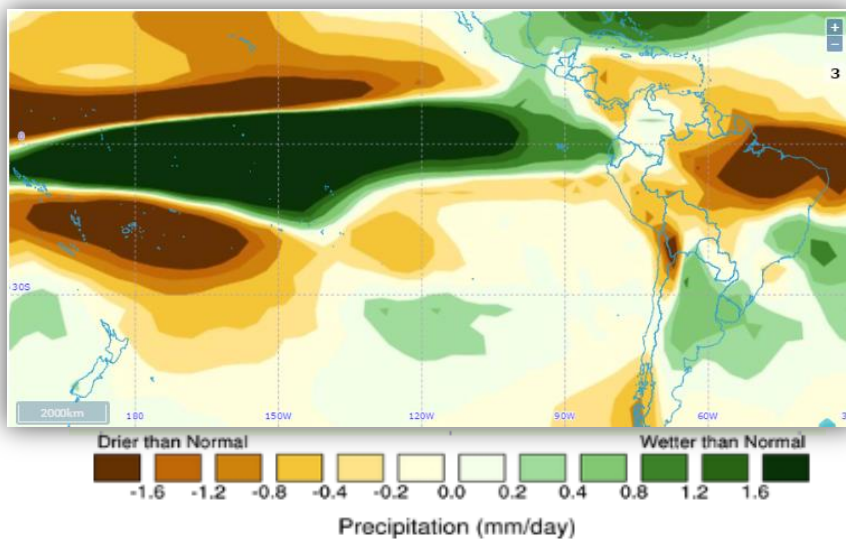
- A** Probability of Above-normal
- N** Probability of Near-normal
- B** Probability of Below-normal



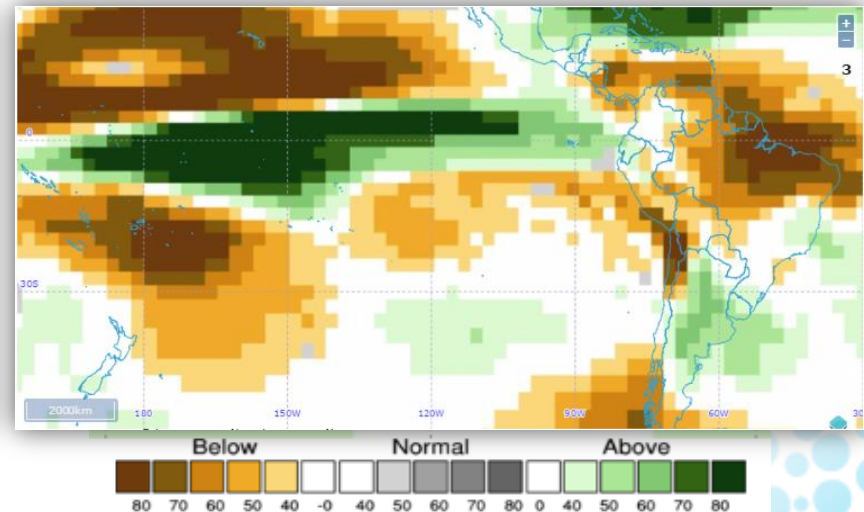
PREDICTION_product

Lead Month <input checked="" type="radio"/> 3Month	When Year <input type="text" value="2016"/> Season <input checked="" type="text" value="JFM"/>
Variables <input checked="" type="radio"/> PREC <input type="radio"/> T850	Model <input checked="" type="checkbox"/> ALL <input checked="" type="checkbox"/> APCC <input checked="" type="checkbox"/> CMCC <input checked="" type="checkbox"/> COLA <input checked="" type="checkbox"/> CWB <input checked="" type="checkbox"/> HMC <input checked="" type="checkbox"/> IRIF <input checked="" type="checkbox"/> IRI_CA <input checked="" type="checkbox"/> MGO <input checked="" type="checkbox"/> MSC <input checked="" type="checkbox"/> NASA <input checked="" type="checkbox"/> NCEP <input checked="" type="checkbox"/> PNU <input checked="" type="checkbox"/> POAMA

DMME (SCM)

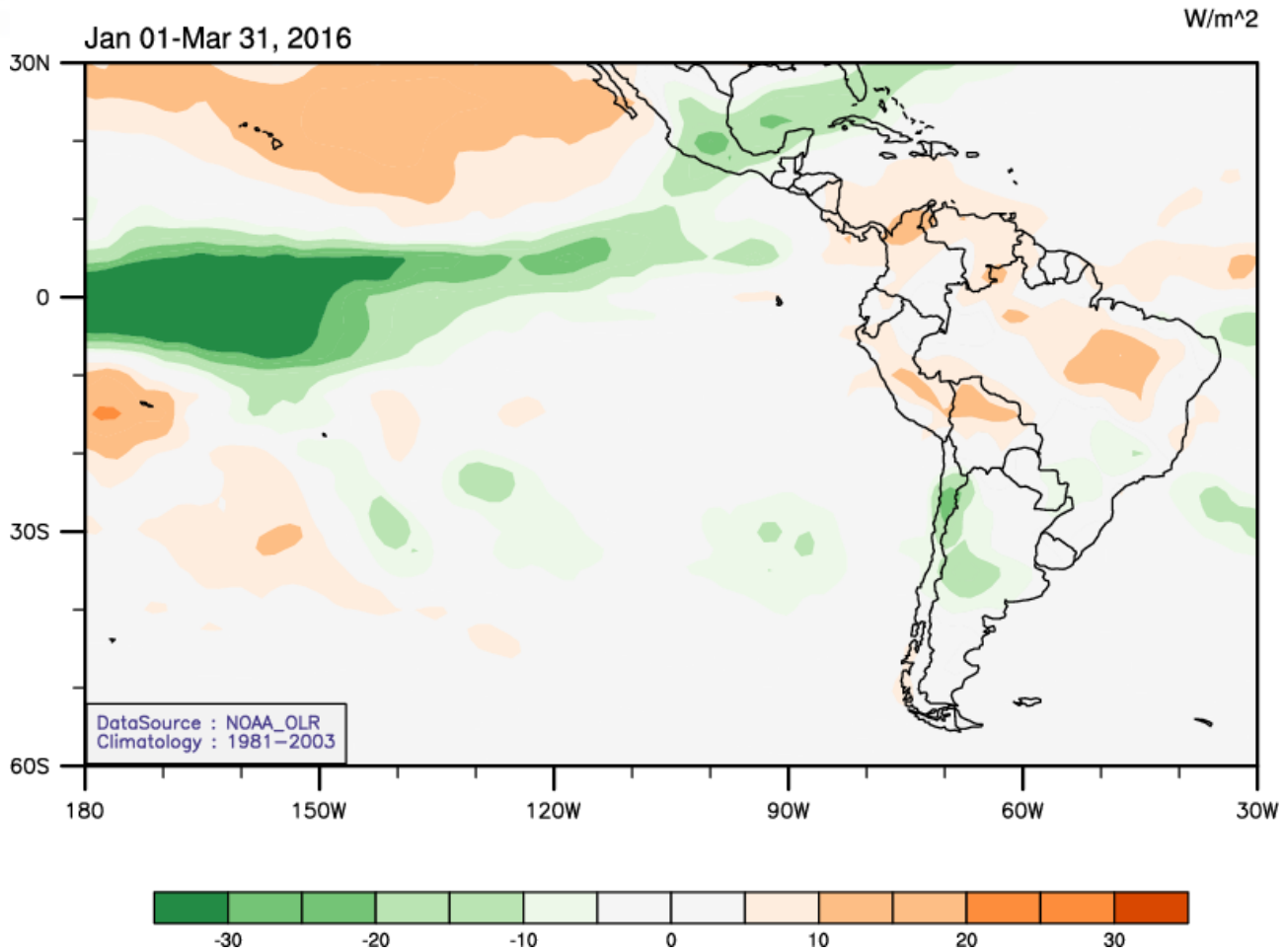


PMME (GAUS)



JFM!

OLR Anomaly



PREDICTION_skill_score

Success Rate

the fraction or percentage of success among a number of attempts. CLIK provides a simple success rate as the hindcast skill score

F \ O	AN	NN	BN
AN	1	4	9
NN	2	3	4
BN	2	6	3

$$= 7/34 \sim 0.20$$

~0.33 : Poor skill region

0.33~0.66 : Reasonable skill region

0.66~ : High skill region

Heidke Skill Score (HSS)

measuring the fractional improvement of the forecast over the standard forecast

F \ O	Yes	No
Yes	Hit (H)	False Alarm (F)
No	Miss (M)	Correct Rejection (C)

$$HSS = (\text{score} - \text{score by chance})$$

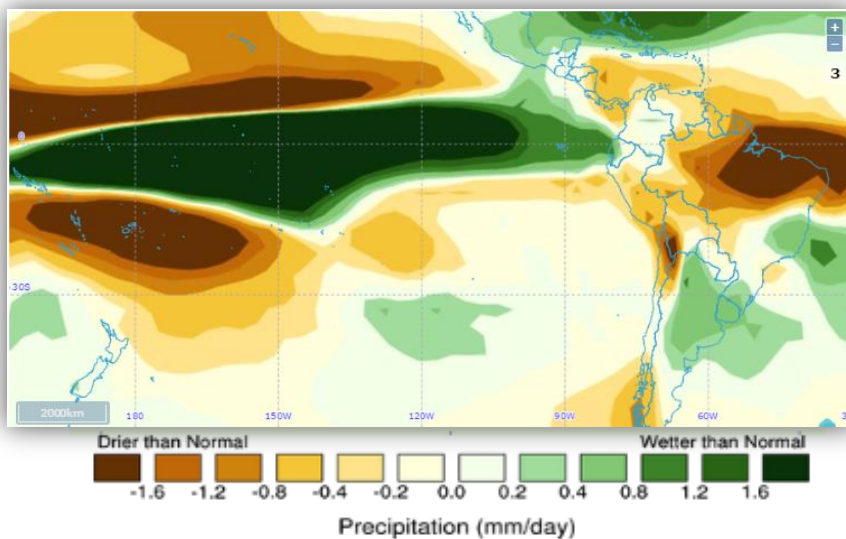
$$/(\text{perfect score} - \text{score by chance})$$

$$\frac{\{(h+c)/n - [(h+f)(h+m) + (f+c)(m+c)]/n^2\}}{\{1 - [(h+f)(h+m) + (f+c)(m+c)]/n^2\}}$$

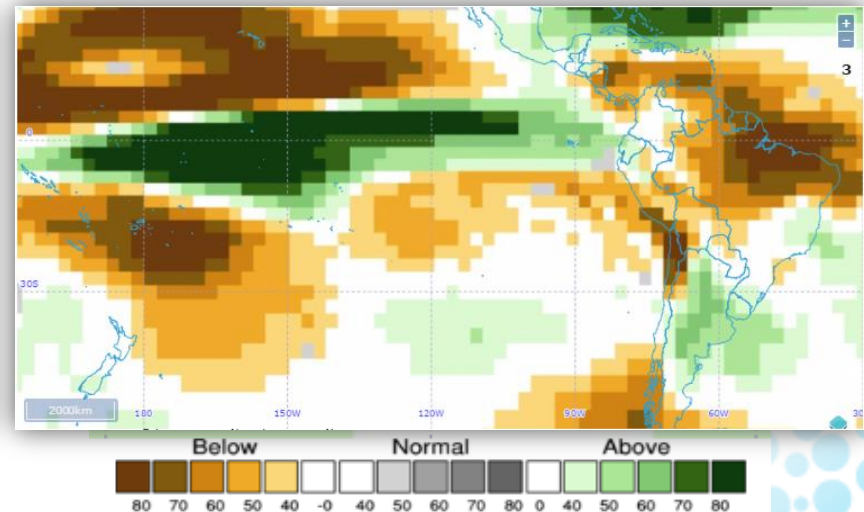
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DMME (SCM)



PMME (GAUS)

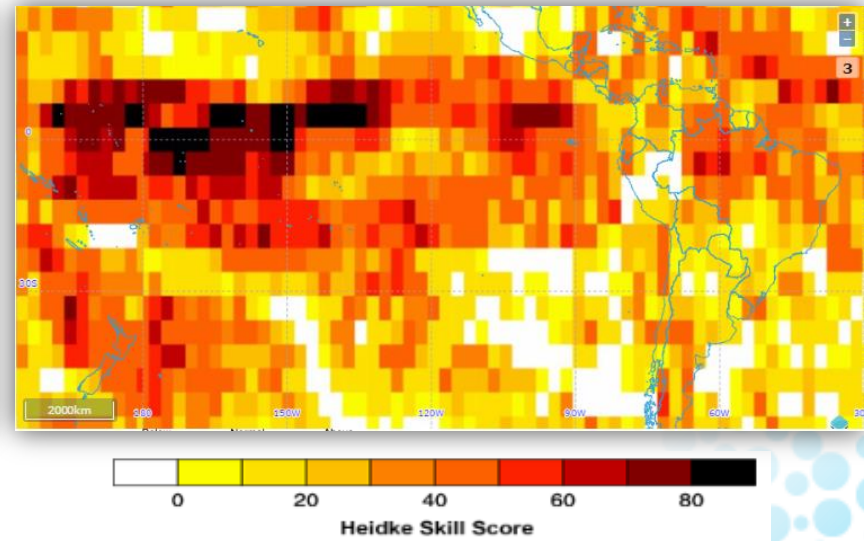
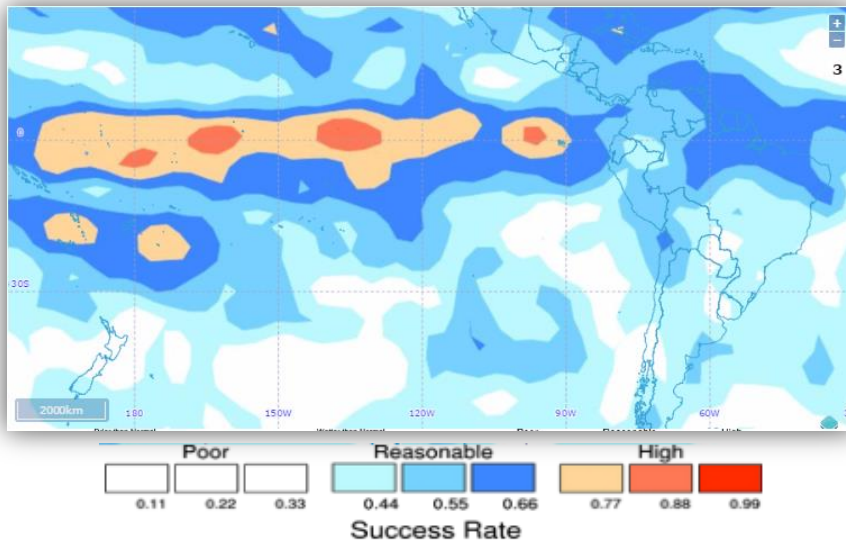


PREDICTION_skill_score

Lead Month <input type="radio"/> 3Month	When Year <input type="text" value="2016"/> Season <input type="text" value="JFM"/>
Variables <input type="radio"/> PREC <input type="radio"/> T850	Model <input checked="" type="checkbox"/> ALL <input checked="" type="checkbox"/> APCC <input checked="" type="checkbox"/> CMCC <input checked="" type="checkbox"/> COLA <input checked="" type="checkbox"/> CWB <input checked="" type="checkbox"/> HMC <input checked="" type="checkbox"/> IRIF <input checked="" type="checkbox"/> IRI_CA <input checked="" type="checkbox"/> MGO <input checked="" type="checkbox"/> MSC <input checked="" type="checkbox"/> NASA <input checked="" type="checkbox"/> NCEP <input checked="" type="checkbox"/> PNU <input checked="" type="checkbox"/> POAMA

DMME (SCM) → Success rate

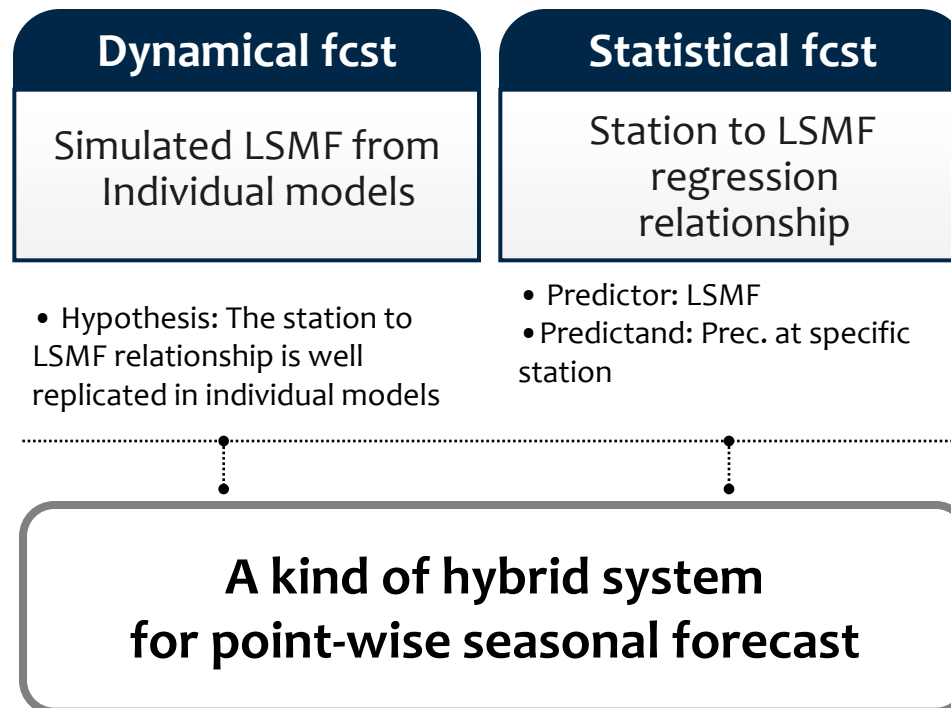
PMME (GAUS) → HSS



CLIK downscaling

➡ A way to localize existing coarse climate information

CLIK downscaling is mainly based on station to Large Scale Meteorological Field (LSMF) relationship. ($Y = a * X + b$) By utilizing the simulated LSMF (X, predictor), CLIK estimates seasonal mean precipitation/temperature (Y, predictand) at specific station.



CLIK downscaling

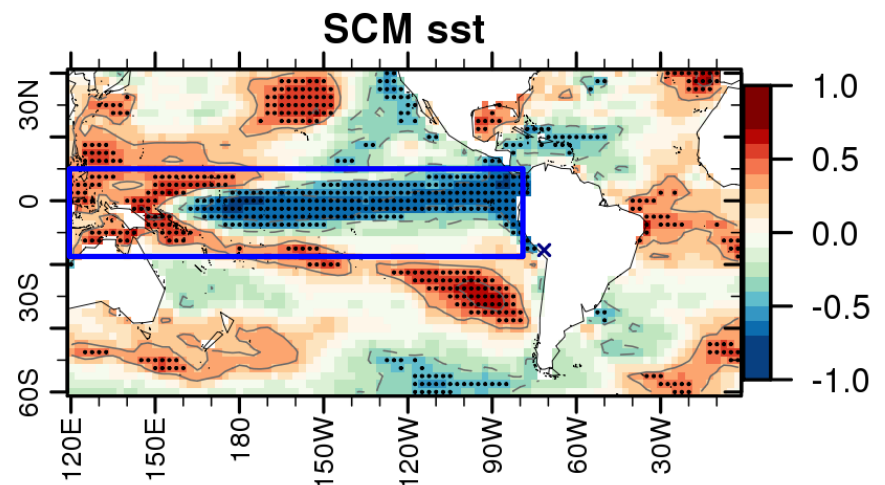
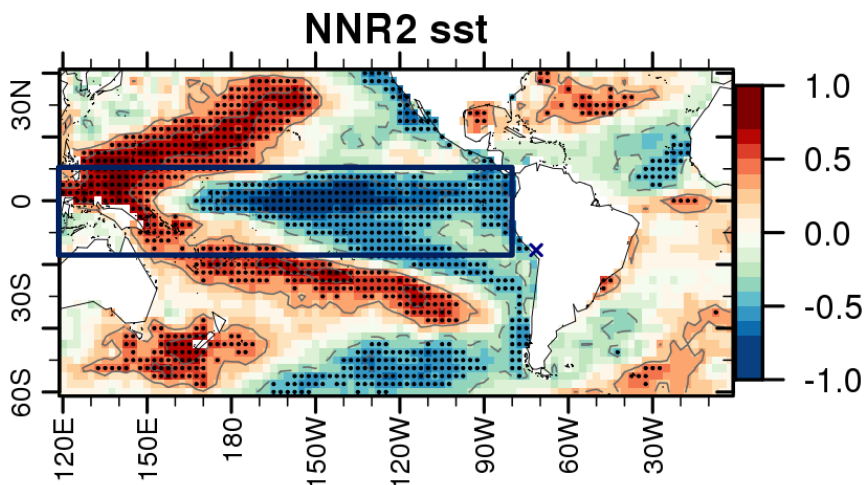
➤ A way to localize existing coarse climate information

CLIK downscaling is mainly based on station to Large Scale Meteorological Field (LSMF) relationship. ($Y = a*X + b$) By utilizing the simulated LSMF (X, predictor), CLIK estimates seasonal mean precipitation/temperature (Y, predictand) at specific station.

Empirical relationship: LSMP ~ local station rainfall

LSMP (model) → Local station rainfall

sibayo [FMA]



CLIK downscaling

➡ A way to localize existing coarse climate information

CLIK downscaling is mainly based on station to Large Scale Meteorological Field (LSMF) relationship. ($Y = a * X + b$) By utilizing the simulated LSMF (X, predictor), CLIK estimates seasonal mean precipitation/temperature (Y, predictand) at specific station.

The screenshot shows the CLIK Climate Information Toolkit interface. The top navigation bar includes 'Prediction', 'Downscale', and 'My Page' tabs, along with 'Logout' and 'Edit' links. The main section is titled 'Set-up Downscaling' and contains several configuration panels:

- Prediction Season:** Year: 2016, Season: JFM
- Variable:** Radio buttons for PREC, T850, Z500, SLP, U850, V850, U200, V200, and SST.
- Models:** Checkboxes for APCC, MSC, NASA, NCEP, PNU, and POAMA.
- Predictand:** Radio buttons for Precipitation and Temperature.
- Training Period:** Form: 1998, To: 2009
- Method:** Radio button for Linear Regression.
- Advanced Options:** Significance Level: 5%, Minimum Pattern Score: 0.3%

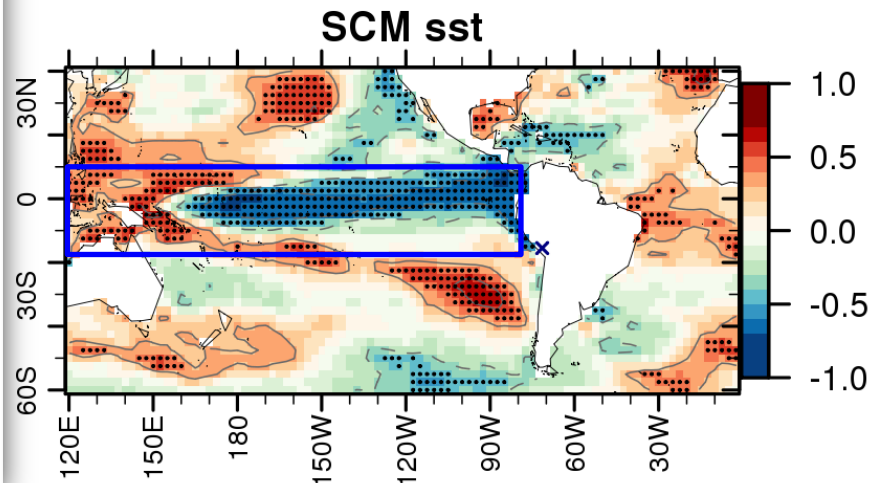
The central 'Downscaling Region' panel features a map of the Pacific Ocean with a purple rectangular region highlighted. The region's coordinates are Latitude: -3.447 to 27.742 and Longitude: -224.304 to -82.976. A red pin marks a specific location with coordinates: Lat: -3.447355 to 27.742381, Lon: -224.384251 to -82.976126, and Area: 21878747.19 sq.mi. A scale bar indicates 5000km.

At the bottom of the interface are 'Previous' and 'Downscale' buttons.

P ~ local station rainfall

local station rainfall

[FMA]



CLIK

CLimate Information ToolKit

<http://clik.apcc21.org>



CLIK - main page



Prediction Downscale My Page

Register Login

Background

The CLimate Information ToolKit version 1.0 (CLIK1.0) was developed in line with APCC's mission of empowering users to maximize the use of climate information and forecasts. The CLIK system provides customized multi-model ensemble (MME) prediction with verification. It also has a statistical downscaling tool which conducts predictor variable pre-screening, basic diagnostic testing, and graphing of climate data from January 2008 onwards. More than 1,200 registered users enjoy the service and about 7,500 predictions have been generated based on the users' request since 2008. Building on the success of CLIK 1.0, new features such as inclusion of other MME methods, improving the downscaling function, enhancing performance, and supporting multiplatform use have been added in the updated version CLIK 2.0 based on user feedback. The product is continuously being improved as APCC responds to the climate information needs of APEC member economies and users worldwide.

Product Description

CLIK aids users in retrieving and using climate prediction data and information available from APCC data servers in a user-friendly manner. Climate forecasters, disaster managers, water resource managers, researchers, and other users anywhere in the world can use this service to generate customized climate predictions on seasonal to inter-annual timescales for their region of interest. The tool has an immense potential to contribute to early warning and management of climate-related disasters and resource management, particularly in developing countries.

The data processing engines powering CLIK at the backend are built on the NCAR Command Language (NCL), a powerful suite of libraries for climate data manipulation and visualization. The web interface of CLIK 1.0 and CLIK 2.0 was built on the web framework Ruby on Rails (RoR). RoR provided simplicity and productivity to the developers but resulted in heavy use of computing resources and raised software incompatibility problems. To resolve these performance and incompatibility issues, we have designed and developed a faster, lighter CLIK 3.0 based on Java and pure HTML with NCL. The main motivation for the new developments is to make the product more useful to developing countries.

CLIK 3.0 leverages on the robust fun

User Interface:

- Modern layout and more use
- Higher resolution maps with
- Side-by-side viewing of pred
- Simultaneous panning of pre
- Layered prediction and verif

Performance:

- Cleaner user interface that re
- Web display is up to five time
- Climate information processi
- Database access is up to 13
- Reduction of downscaling st

Future product development plans in

User Manual

PDF

Contact Information

If you have any questions or feedback regarding APCC CLIK, please contact the Climate Informatics and Application Team (clik@apcc21.org)

Data Sources

Please refer to [\[DATA SOURCES\]](#)

Terms of Data Use

Please refer to [\[TERMS OF DATA USE\]](#)

✓ User can see the information about the **CLIK background, product description, user manual** and so forth.

CLIK - "Prediction"



Prediction Downscale My Page

Logout Edit

Predict

Lead Month

3Month

When

Year Season

Methods

Deterministic Probabilistic

Variables

PREC T850

Model

ALL
 APCC CMCC COLA CWB
 HMC IRI_CA MGO MSC
 NASA NCEP PNU POAMA

✓ User can produce the **customized MME climate forecast**, then view the result figure map and download corresponding data.

Predict & Verify

Result

SingleMap BindingMap

Move Center

Download



CLIK - “Downscale”



Prediction **Downscale** My Page

Logout Edit

Select Dataset / Station

Datasets

Dataset Name	Countries	Total Stations	Period(prec)	Period(temp)	Public
MCDW(Monthly Climatic Data for th...	The World	6463	1998 ~ 2014	1998 ~ 2014	PUBLIC
Imsi		0	N/A	N/A	dolkong400
GHCN	GHCN	3707	1950 ~ 2009	N/A	PUBLIC
Aphrodite data interploated to Mons...	Afghanistan, Bangladesh, Brunei D...	4918	1961 ~ 2004	N/A	PUBLIC
Korea 60 Stations	Korea, Republic of	60	1973 ~ 2008	1973 ~ 2006	PUBLIC
NewCLIK dataset		0	N/A	N/A	dolkong400

Create

Edit

Remove



- ✓ User can upload their own regional station data and make a **downscaled forecast**

CLIK - "My Page"



Prediction Downscale **My Page**

Logout Edit

My Page

Jobs				System Status		
Last Updated At: 14:19:22 (auto refresh at about every 60 seconds)				Auto Refresh <input checked="" type="checkbox"/>		
10	records per page		Search: <input type="text"/>			
JOB ID	TYPE	STATE	RESULT DATA	CREATED	UPDATED	
4839	Prediction	success	download	2016-08-31 13:08:07	2016-08-31 13:22:59	
4838	Prediction	success	download	2016-08-31 11:25:42	2016-08-31 11:45:43	
4837	Prediction	success	download	2016-08-31 10:35:47	2016-08-31 10:57:02	
3931	Prediction	success	download	2016-05-23 19:11:14	2016-05-23 19:12:48	
3930	Prediction	success	download	2016-05-23 17:08:30	2016-05-23 17:19:10	
3929	Prediction	success	download	2016-05-23 17:04:11	2016-05-23 17:04:51	
3864	Prediction	success	download	2016-05-13 15:40:26	2016-05-13 15:41:08	
3851	Prediction	fail		2016-05-13 11:16:03	2016-05-13 11:16:07	
3850	Prediction	fail		2016-05-13 10:39:59	2016-05-13 10:40:30	
3822	Prediction	fail		2016-04-01 16:56:12	2016-04-01 16:56:21	

- ✓ Users can find the **list of jobs requested**, identify the status of jobs, and download result data of successful jobs.

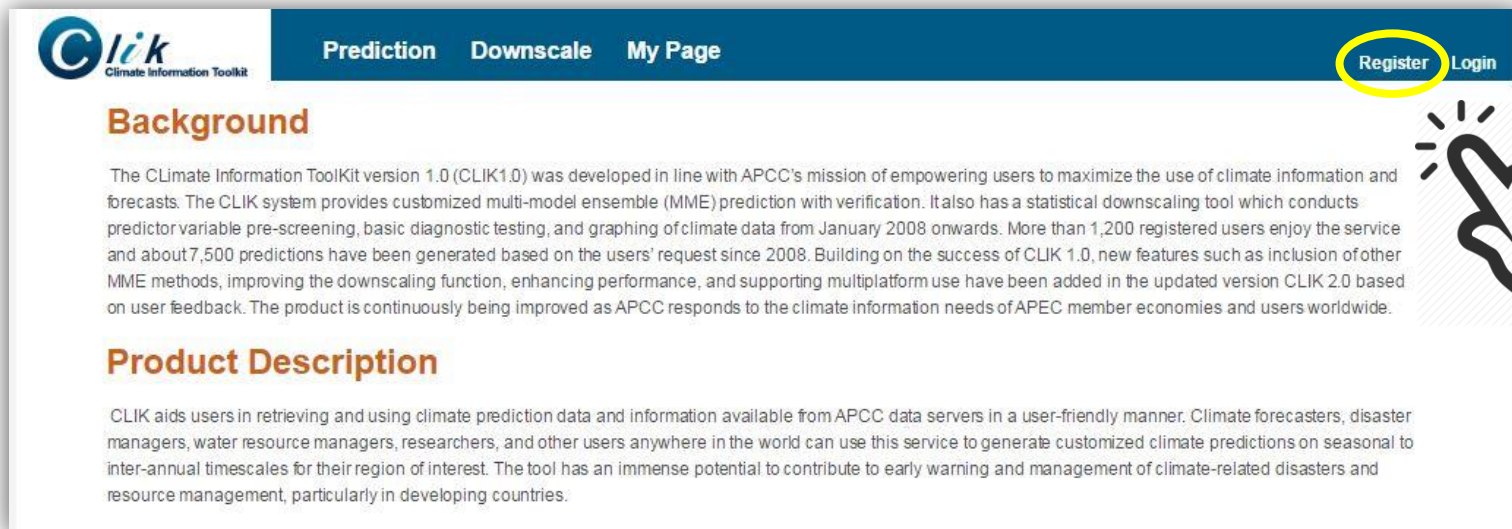
CLIK

<http://clik.apcc21.org>



CLIK - Getting Started

- **Creating your account**



The screenshot shows the CLIK website interface. The top navigation bar is dark blue with the CLIK logo on the left and the text "Prediction Downscale My Page" in the center. On the right side of the navigation bar, the "Register" button is highlighted with a yellow circle, and the "Login" button is next to it. Below the navigation bar, the "Background" section is titled in orange. The text describes the development of CLIK 1.0 and its features. The "Product Description" section is also titled in orange and describes the service's purpose. A hand icon with the word "CLIK" in red is pointing towards the "Register" button.

CLIK
Climate Information Toolkit

Prediction Downscale My Page

Register Login

Background

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CLIK - Getting Started

- **Creating your account**

The screenshot shows the APCC Single Sign On System registration page. It features the APCC logo (APEC Climate Center) and the title 'APCC Single Sign On System'. The page contains two agreement sections and a registration form. Red annotations highlight key steps: 1. A red circle with the number '1' is next to a checked checkbox labeled 'I read the contents and I Agree' under the 'Agreement of Getting Personal Information' section. 2. A red circle with the number '2' is next to a checked checkbox labeled 'I read the contents and I Agree' under the 'Agreement of Registering for APCC Website / CLIK / ADSS' section. 3. A red circle with the number '3' is next to a red-bordered box that encloses the 'First Name', 'Last Name', and 'E-mail' input fields. 4. A red circle with the number '4' is next to a hand icon pointing to the 'apply' button. The 'apply' button itself is also circled in red.

APCC
APEC CLIMATE CENTER

APCC Single Sign On System

1

Agreement of Getting Personal Information

Agreement to collecting personal information
(APEC Climate Center)

Purposes for collecting personal information
We collect and use the information that you provide for the following purposes:
To provide customized information;
To manage website usership, such as maintaining a membership database, member identification, and transmitting announcements; and
To gauge and improve the effectiveness of the website and services

I read the contents and I Agree

2

Agreement of Registering for APCC Website / CLIK / ADSS

PRIVACY POLICY
(APEC Climate Center)

Purposes for collecting and using personal information
We collect and use information that you provide
To provide customized information;
To manage website usership, such as maintaining a membership database, member identification, and transmitting announcements; and
To gauge and improve the effectiveness of the website and services
To improve your interaction with the site or service

I read the contents and I Agree

3

- Check your name and E-mail for uniqueness property

First Name	<input type="text"/>
Last Name	<input type="text"/>
E-mail	<input type="text"/>

4

CLIK

CLIK - Getting Started

- **Creating your account**

APCC
APEC CLIMATE CENTER

APCC Single Sign On System

You have already registered one of our site, but we integrate our site (APCC website / CLIK / ADSS) recently.
Please check our new Single Sing On Service and Re-register our new Service. There are your old registered information below :

Your Registered Information

Site	E-mail	ID
APCC WebSite	Not Registered	
CLIK	Not Registered	
ADSS	Not Registered	

By checking the button, then you can re-register our sites NOW

APCC CLIK ADSS

apply



CLIK - Getting Started

- **Creating your account**

✓ Please fill in the blanks!

Register info

*ID	<input type="text"/>	<input type="button" value="ID Check"/>
*First Name	<input type="text" value="Alex"/>	
*First Name	<input type="text" value="Lee"/>	
*E-mail	<input type="text" value="yyalexlee@gmail.com"/>	
*Country	<input type="text" value="select"/>	
Institution	<input type="text"/>	
Department	<input type="text"/>	
Position	<input type="text"/>	
Tag	<input type="text"/>	
*Password	<input type="text"/>	
*Re-Password	<input type="text"/>	
* Do you want to receive mail?	<input checked="" type="radio"/> YES <input type="radio"/> NO	
Register Site	APCC <input checked="" type="checkbox"/> CLIK <input checked="" type="checkbox"/> ADSS <input checked="" type="checkbox"/>	

Other info

CLIK

Time Zone	<input type="text"/>
purpose	<input type="text"/>
Sub email	<input checked="" type="radio"/> YES <input type="radio"/> NO

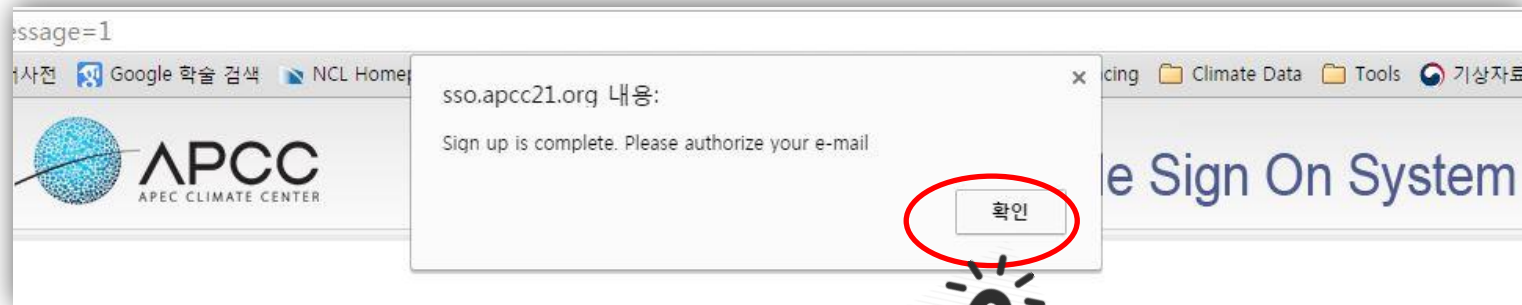
ADSS

purpose	<input type="text"/>
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CLIK - Getting Started

- **Creating your account**



CLIK - Getting Started

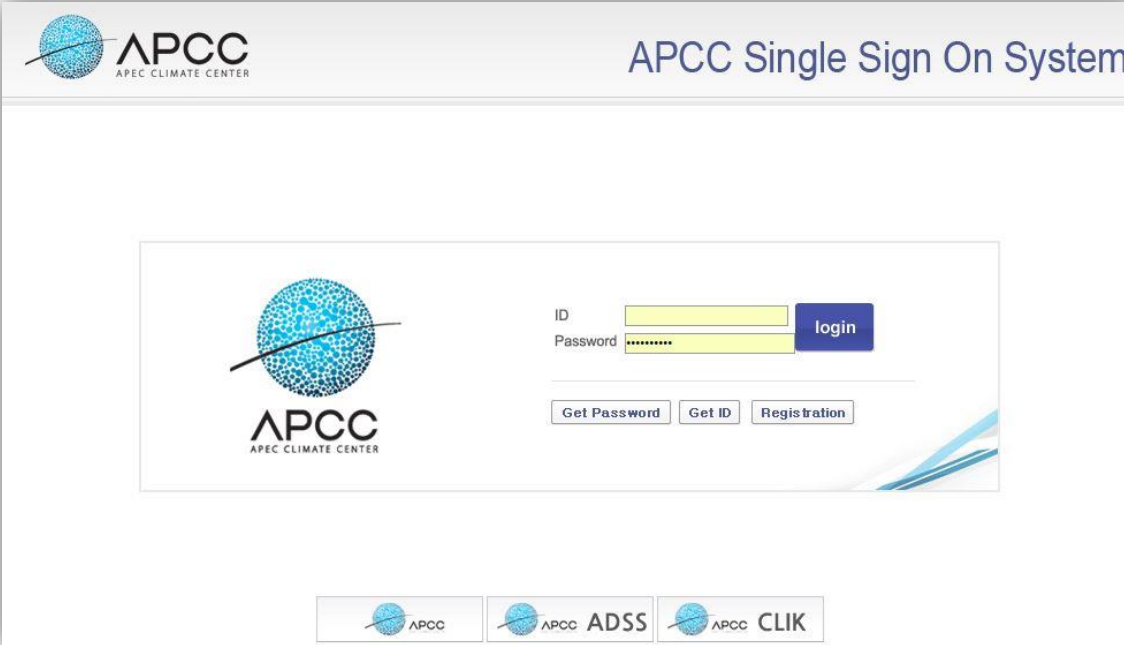
- **Creating your account**



✓ Please **activate your account** by clicking the LINK in the e-mail sent you.

CLIK - Getting Started

- **Creating your account**



The screenshot shows the APCC Single Sign On System login page. At the top left is the APCC logo (APEC Climate Center). At the top right is the text "APCC Single Sign On System". The main content area features a large APCC logo on the left and a login form on the right. The login form has two input fields: "ID" and "Password". The "ID" field is empty, and the "Password" field contains several dots. To the right of the "Password" field is a blue "login" button. Below the input fields are three buttons: "Get Password", "Get ID", and "Registration". At the bottom of the page, there are three small icons with labels: "APCC", "APCC ADSS", and "APCC CLIK".

- ✓ Please **log in** with your ID and password.
- ✓ Finally, you guys are **READY** to use the CLIK system!



Thank you.

CLIK:

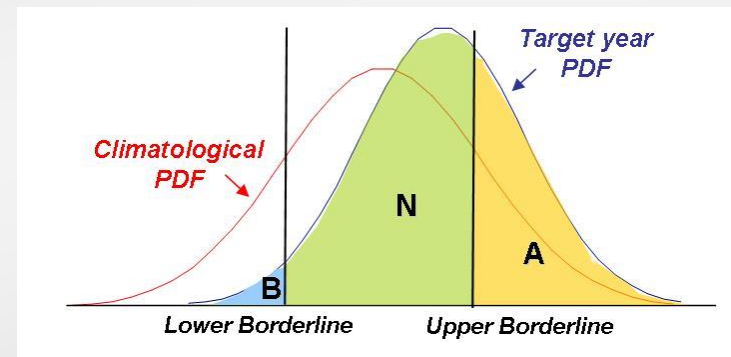
- Aids users in retrieving and utilizing climate prediction data and information available from APCC data servers **in a user friendly manner** through **web-based format**
- Provides **the customized multi-model ensemble (MME) prediction** and **the statistical downscaling tool** which performs ancillary tasks of predictor variable prescreening, basic diagnostic testing, and graphing of climate data

Probabilistic MME Scheme(GAUS)

A parametric **Gaussian fitting method** for the estimation of tercile-based categorical probabilities; forecast probability of each category is estimated as a portion of the forecast PDF(Probability Density Function) with respect to the historical one.

Forecast probability

- A** Probability of Above-normal
- N** Probability of Near-normal
- B** Probability of Below-normal



Skill Scores: Success Rate (SCM)

Success Rate

is the fraction or percentage of success among a number of number of attempts. CLIK provides a simple success rate as the hindcast skill score.

- ~0.33 : Poor skill region
- 0.33~0.66 : Reasonable skill region
- 0.66~ : High skill region

Skill Scores: Success Rate (SCM)

The verification metric is success rate.

Divided the prediction into 3 categories normal, above normal and below normal. The observations are also similarly divided.

If model and observations are in the same category then the forecast is counted a success. Otherwise it is a failure. For example,

- Model predicted **above normal** and observations was **normal** – failure
- Model predicted **above normal** and observations was **below normal** – failure
- Model predicted **above normal** and observations was **above normal** – success

Because the forecast is divided into 3 equal category, and there is equal chance to be in each category then there is 33.3% chance that a forecast can be any of normal, above or below normal. That is why the forecast has some skill if the success rate is above 33.3%(0.33).

Skill Scores: Heidke Skill Score (GAUS)

- HSS (Heidke Skill Score)

	O	Yes	No
F		Hit (H)	False Alarm (F)
		Miss (M)	Correct Rejection (C)

- $HSS = (score - score\ by\ chance) / (perfect\ score - score\ by\ chance)$

$$\frac{\{(h+c)/n - [(h+f)(h+m) + (f+c)(m+c)]/n^2\}}{\{1 - [(h+f)(h+m) + (f+c)(m+c)]/n^2\}}$$