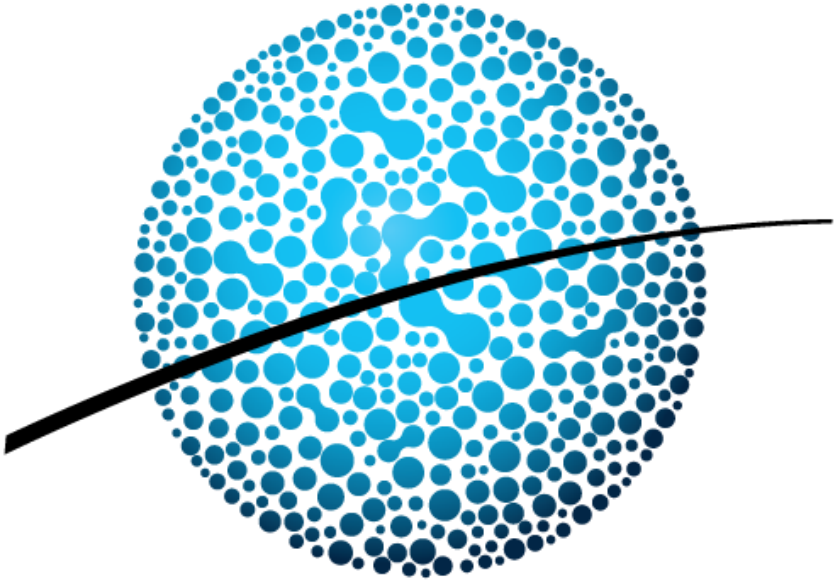
Localization of MME seasonal prediction using CLIK and PICASO

Yun-Young Lee

APCC APEC CLIMATE CENTER

High-end climate information service center

: operating MME climate prediction system utilizing state-of-the-art GCMs



APCC

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http://apcc21.org

APCC Climate Information

Seasonal outlook (global)

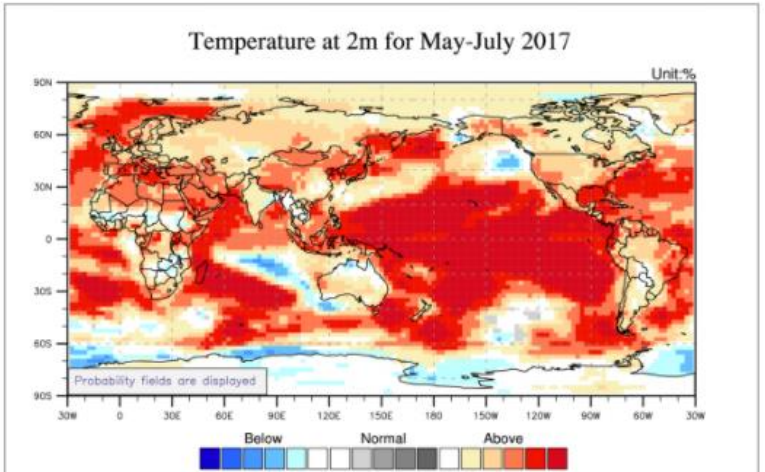
Climate Outlook for May- October 2017

BUSAN, 25 April 2017 – Synthesis of the latest model forecasts for May to October 2017 (MJJASO) at the APEC Climate Center (APCC), located in Busan, Korea, indicates persistent positive temperature anomaly across the tropical Pacific with the positive El Niño-Southern Oscillation (ENSO) phase. The forecast for the whole period shows a warm tendency over the most part of Eurasia and North and South America. Above normal temperature is highly probable over the tropical Pacific, eastern subtropical South Pacific, the western and southern Indian Ocean, and the Barents Sea. For the same period, below and near normal rainfalls are probable over the Great Australian Bight and the central Pacific, respectively. The forecast for MJJ 2017 suggests a negative temperature anomaly over the northeastern Pacific and the central Indian Ocean. Below normal rainfalls are highly probable for the central Indian Ocean. The forecast for ASO 2017 shows dry conditions over the maritime continent and the Caribbean Sea.

Temperature and Precipitation Outlook:

1. Forecast for May- July 2017

Strongly enhanced probability for above normal temperature is predicted for the tropical and subtropical Pacific and Atlantic, the Barents Sea, the Norwegian Sea, the Bering Sea, the Sea of Okhotsk, the Arabian Sea, the Bay of Bengal, the western and southern Indian Ocean including Madagascar, the Mediterranean Sea, the Gulf of Mexico, and the Caribbean Sea. Enhanced probability for above normal temperature is predicted for the eastern Indian Ocean, the maritime continent, Mongolia, the western and northeastern China, the Middle East, and northern Africa. A warm tendency is expected for the Arctic, Greenland, most of Eurasia, and North and South America. Enhanced probability for below normal temperature is predicted for the northeastern North Pacific and the central Indian Ocean. Enhanced probability for above normal precipitation is predicted for the southern Philippine Sea, central Africa, and southern South America. Strongly enhanced probability for below normal precipitation is predicted for the central Indian Ocean and the Great Australian Bight. Enhanced probability for below normal precipitation is predicted for the eastern Indian Ocean, Australia, the northern Philippine Sea, and the central off-equatorial North Pacific. Precipitation in the central and eastern equatorial Pacific, the Middle East, and the northern and southern Africa is predicted to be near normal.



ENSO & IOD prediction

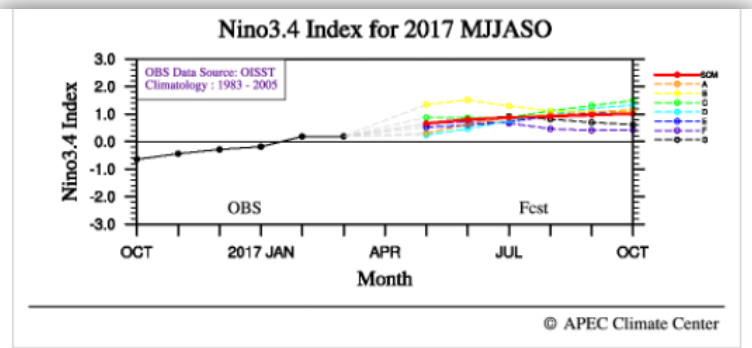
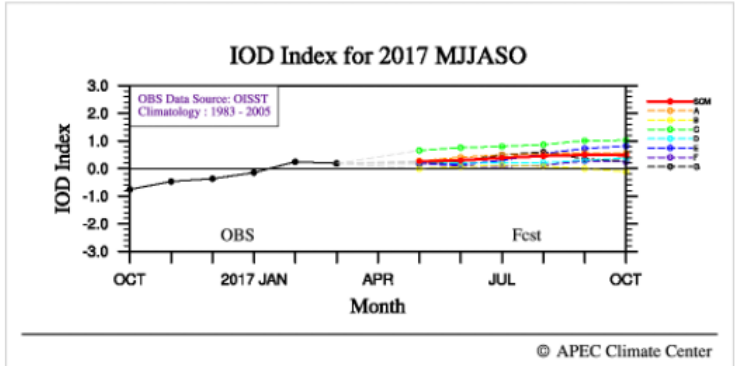
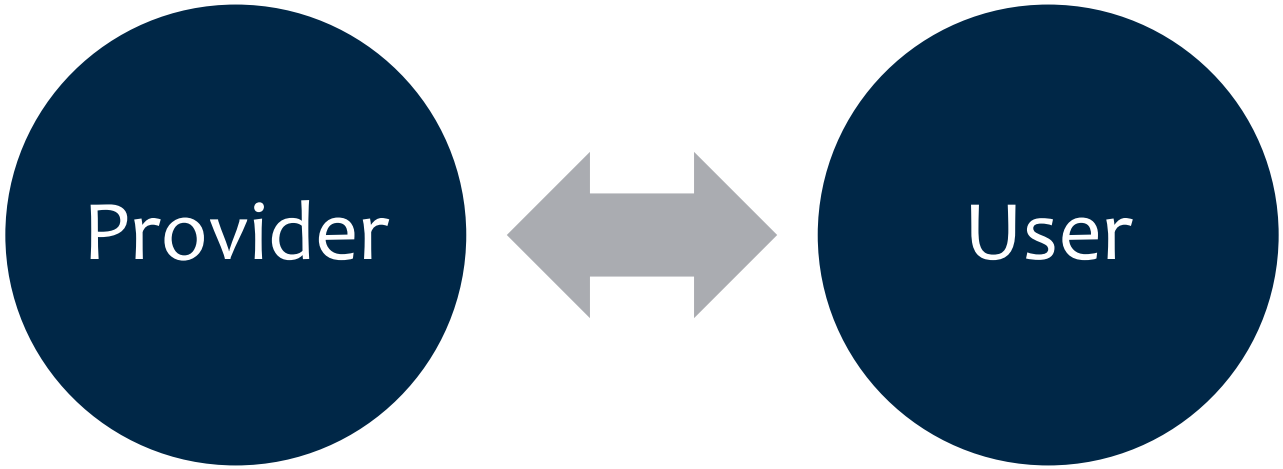


Fig. 1. Predicted Niño 3.4 Index from individual models (A, B, C, D, E, F and G) and the simple composite Multi-Model Ensemble (MME) method (SCM).



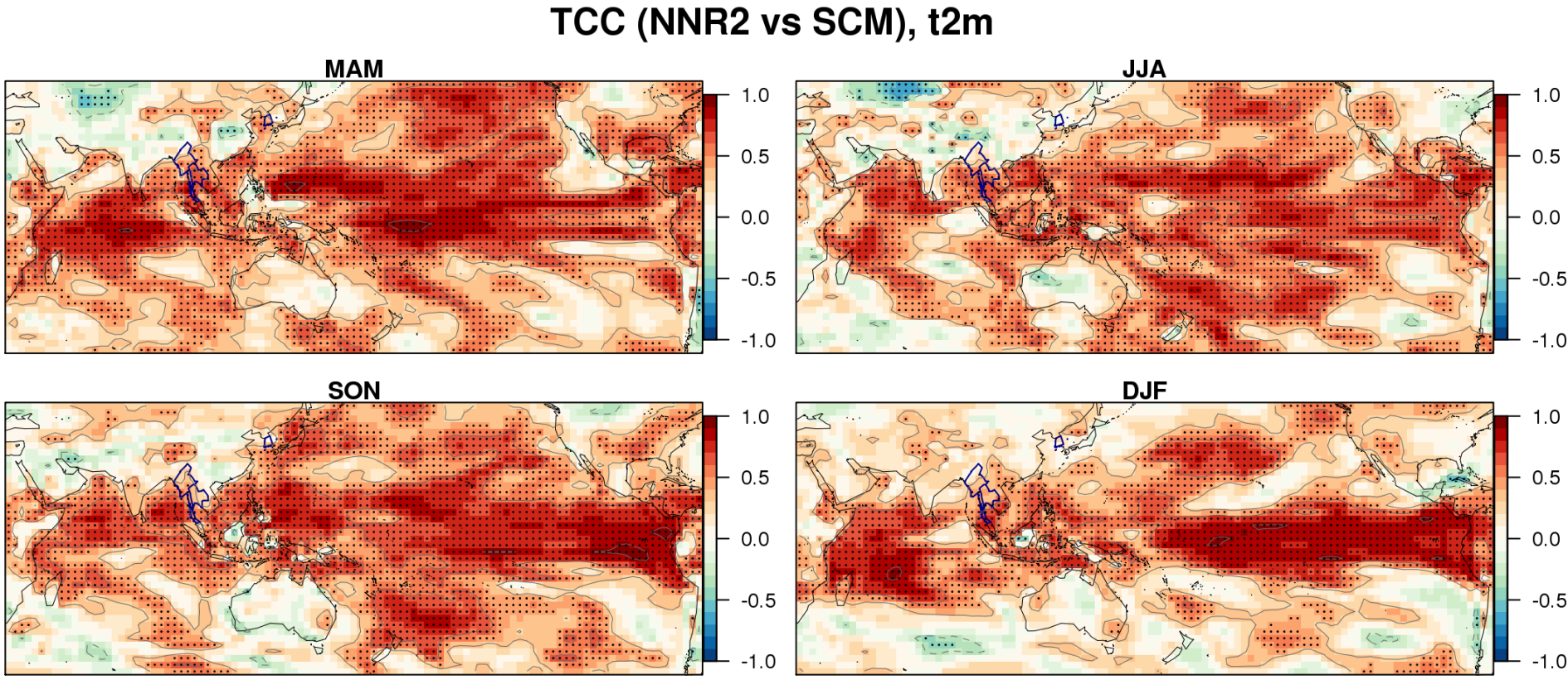
Fill the gap



Accuracy
Resolution
Contents

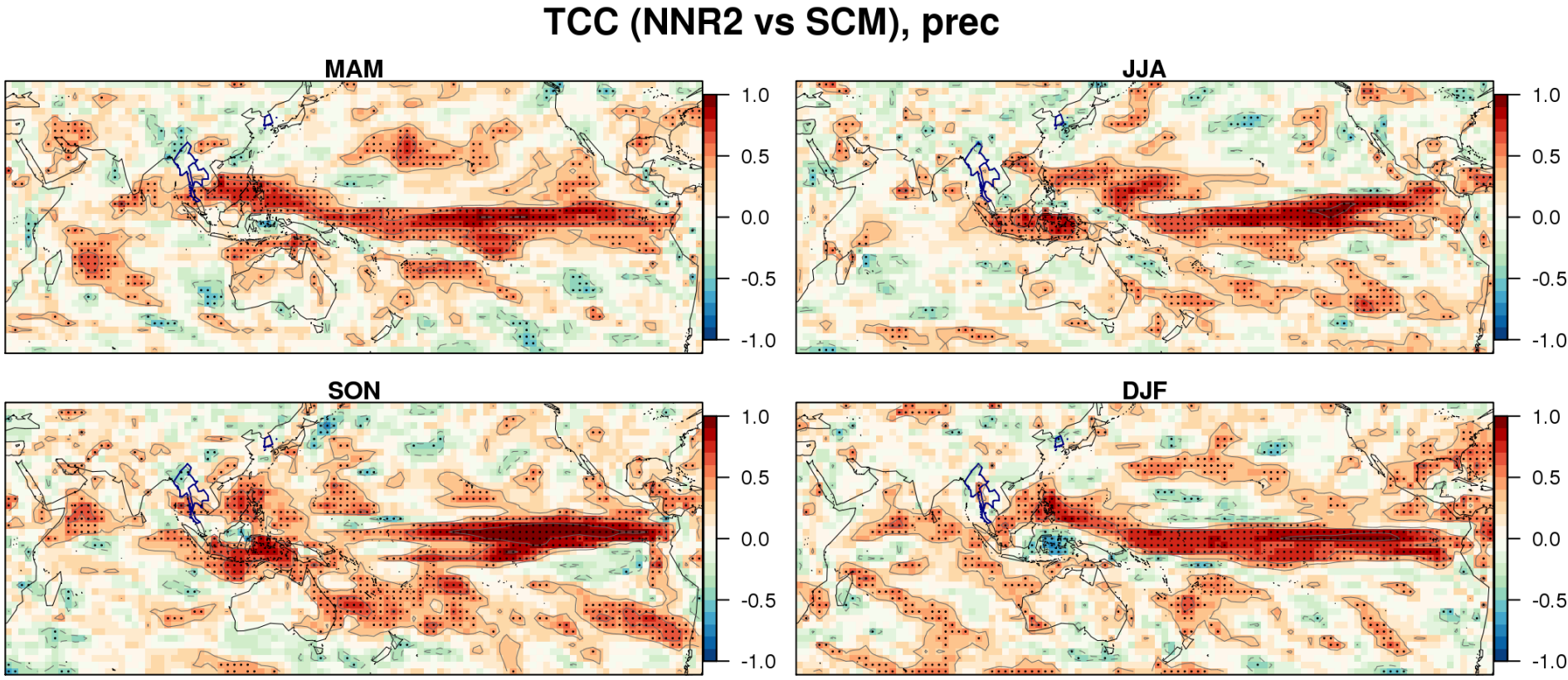
1. Low skill of dynamical seasonal forecast…

- near surface temperature…

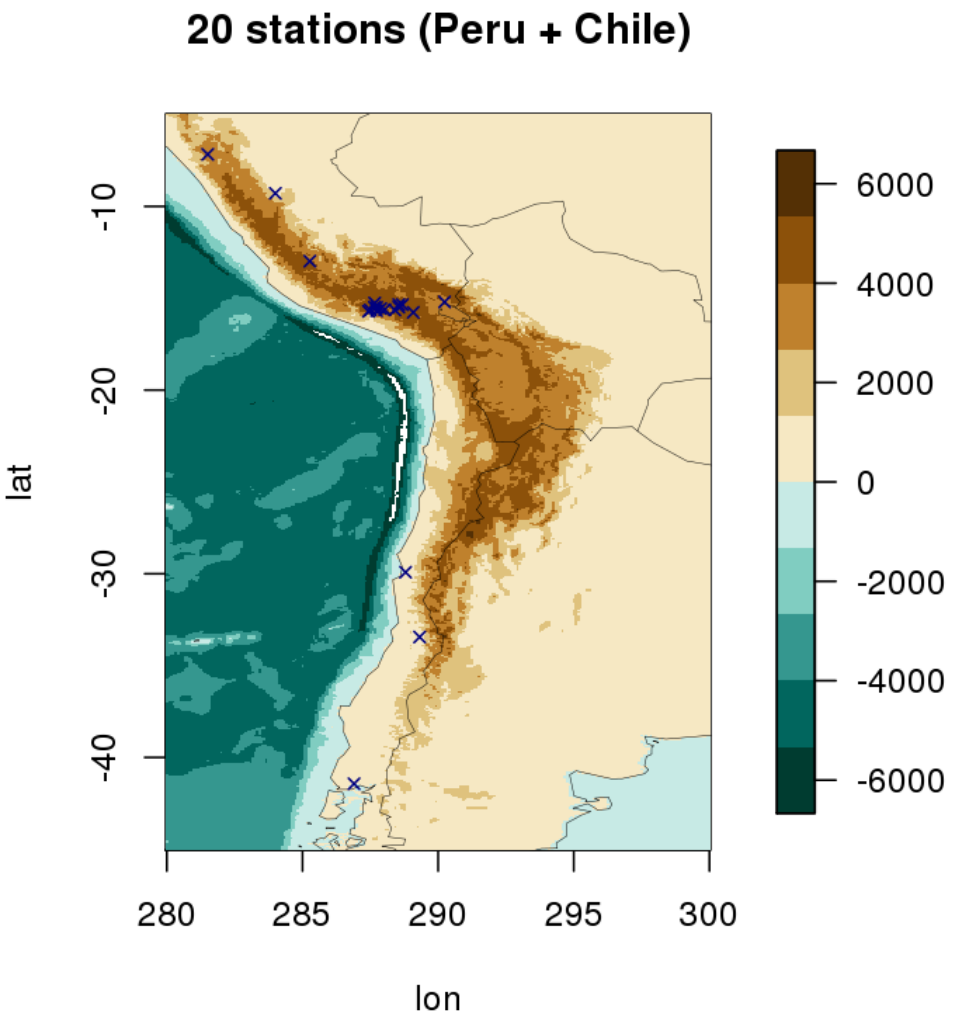


1. Low skill of dynamical seasonal forecast…

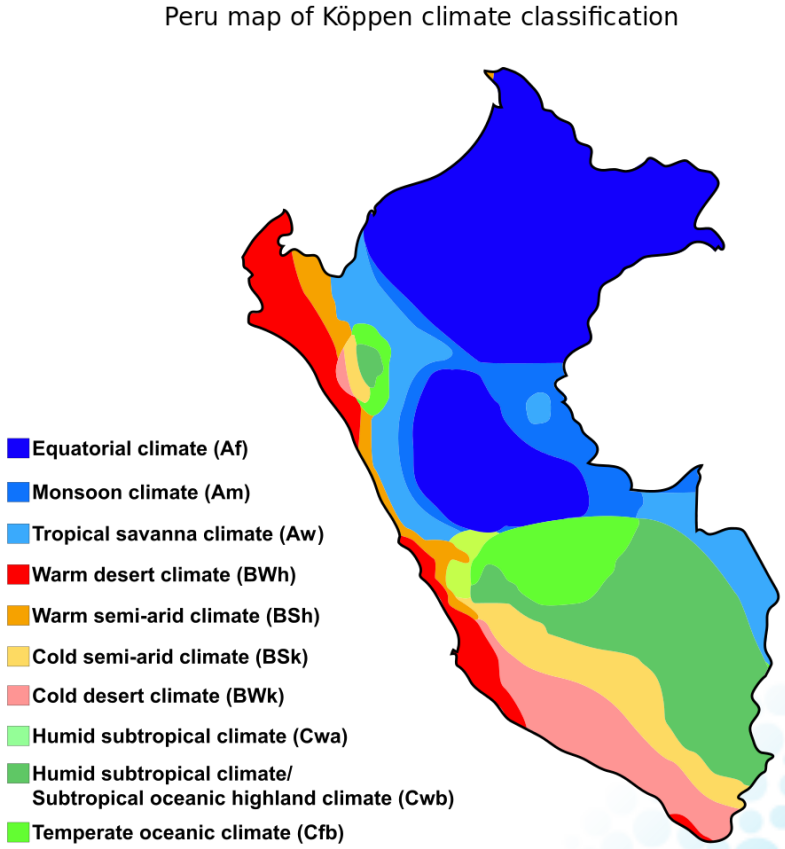
- ***Rainfall ?***
- *tropical Pacific only?*
- *Southeast Asia?*



2. Climate Locality



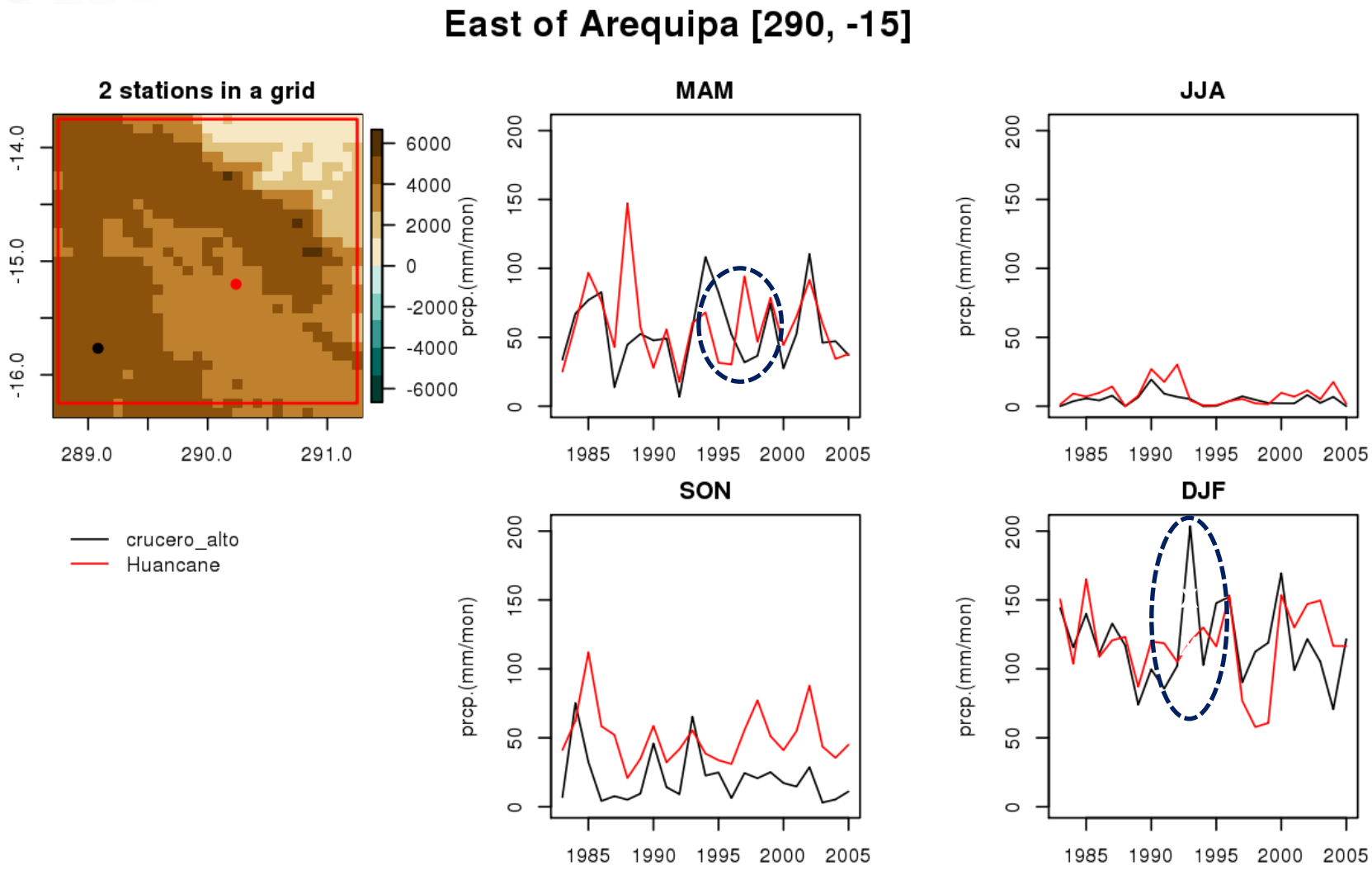
- Complicate climate of Peru



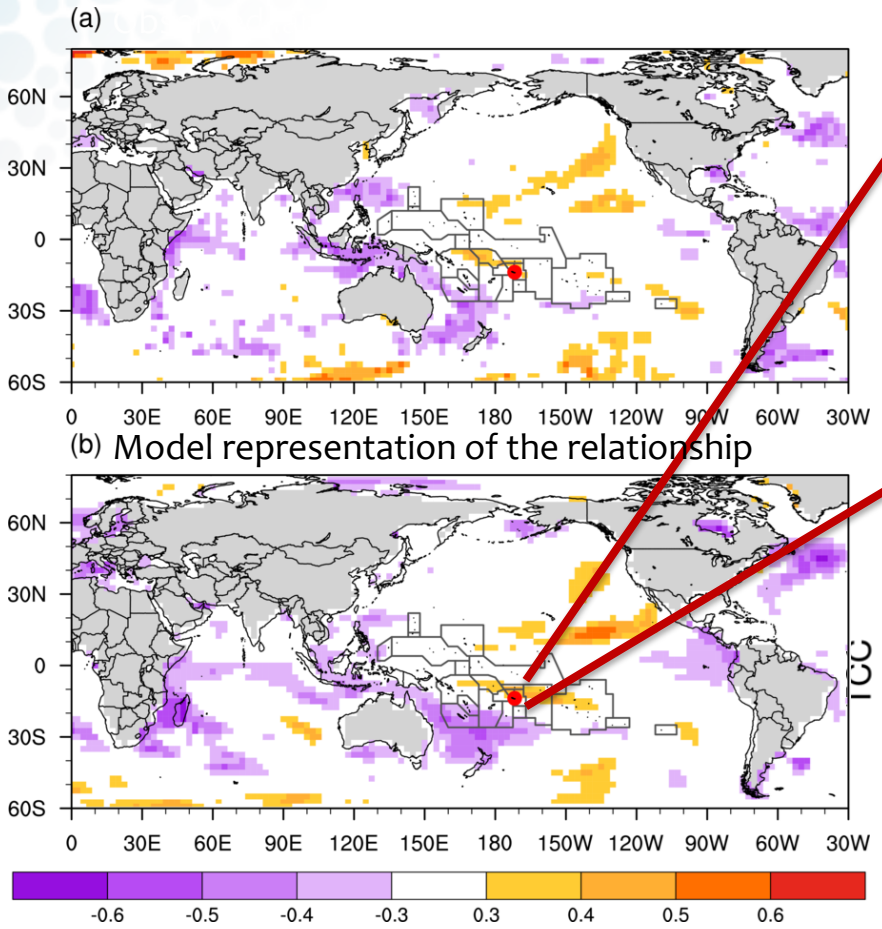
✓Can 2.5 by 2.5 grid pixel simulate ***steep terrain*** effect therefore ***locality of station climate*** ? Not really.

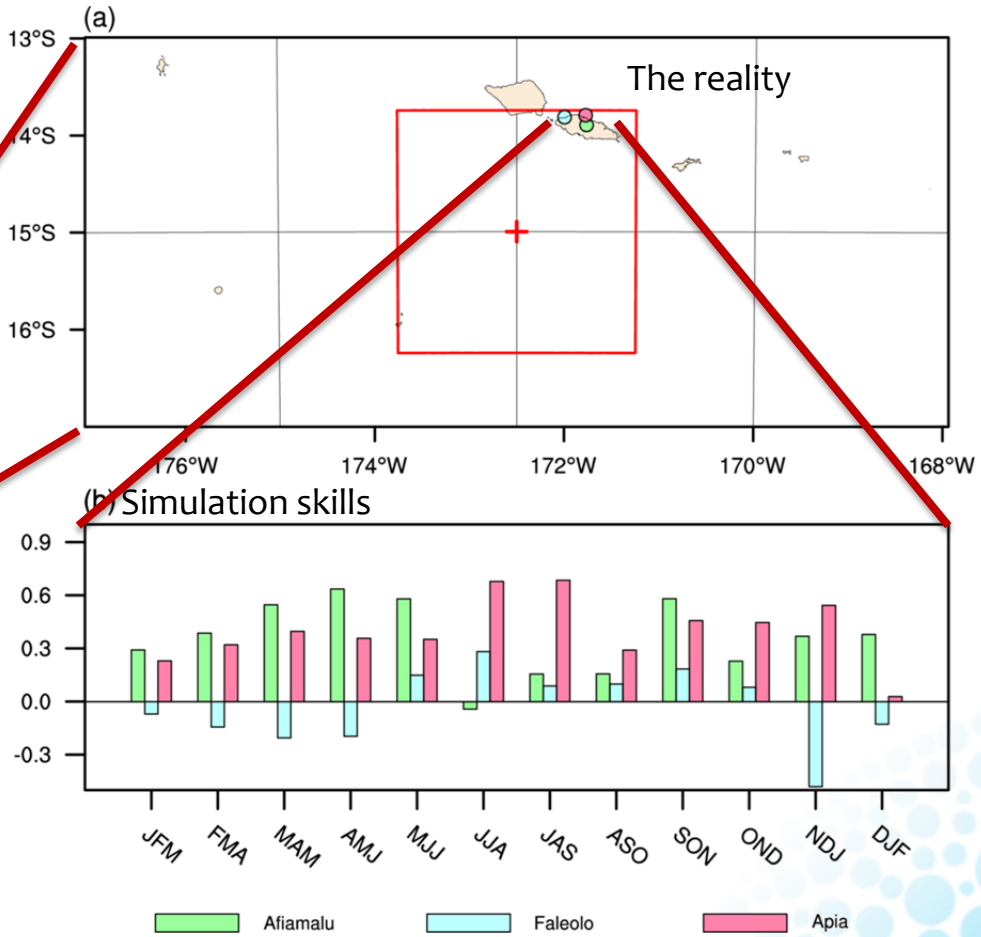
2. Climate Locality

How different is the climate between 2 adjacent stations in the east of Arequipa?
But, they are in one grid! OMG!!!



Island Climate





✓Can 2.5 by 2.5 grided model tell the difference of ***local climates between adjacent stations***? Not really.

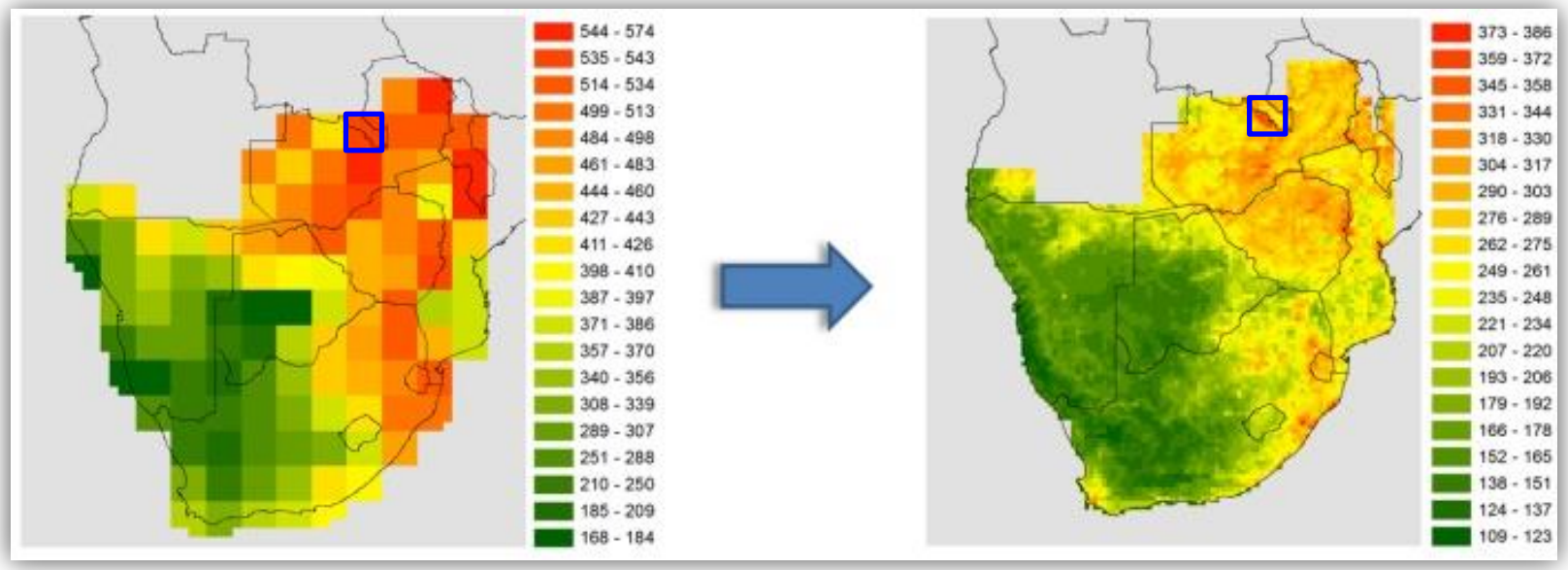
What is downscaling?

POST-PROCESSING!

=optimization/localization/customization of climate information

Who are you?

Look inside!


544 - 574
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262 - 275
249 - 261
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152 - 165
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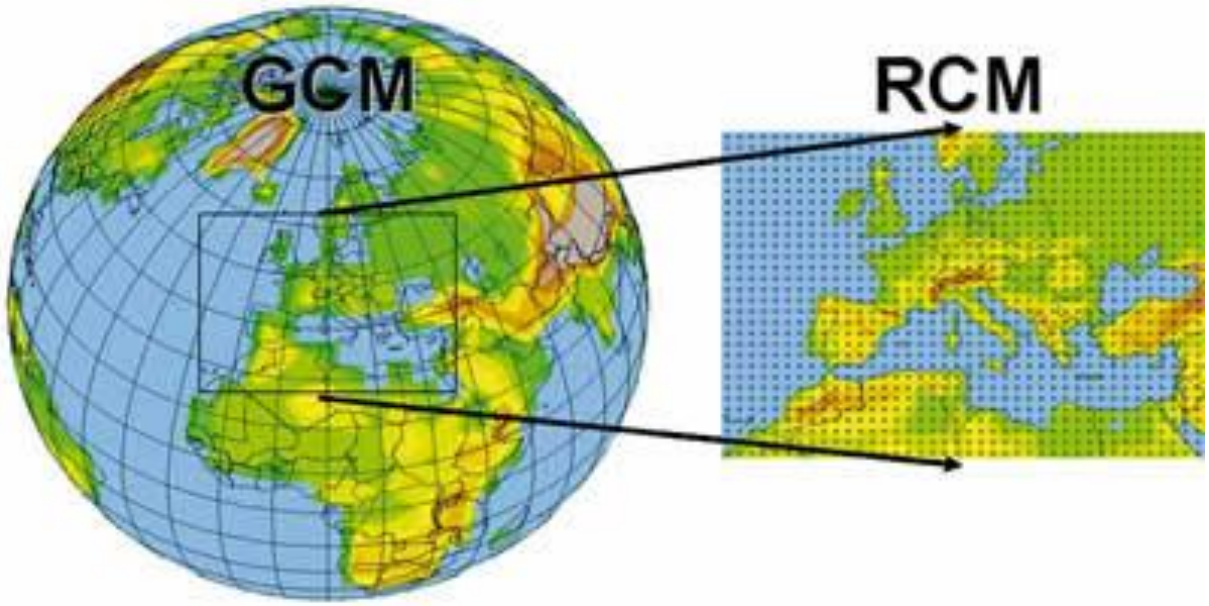
124 - 137
109 - 123

What is dynamical downscaling?



- Simply, it is running a regional climate model (**RCM**).

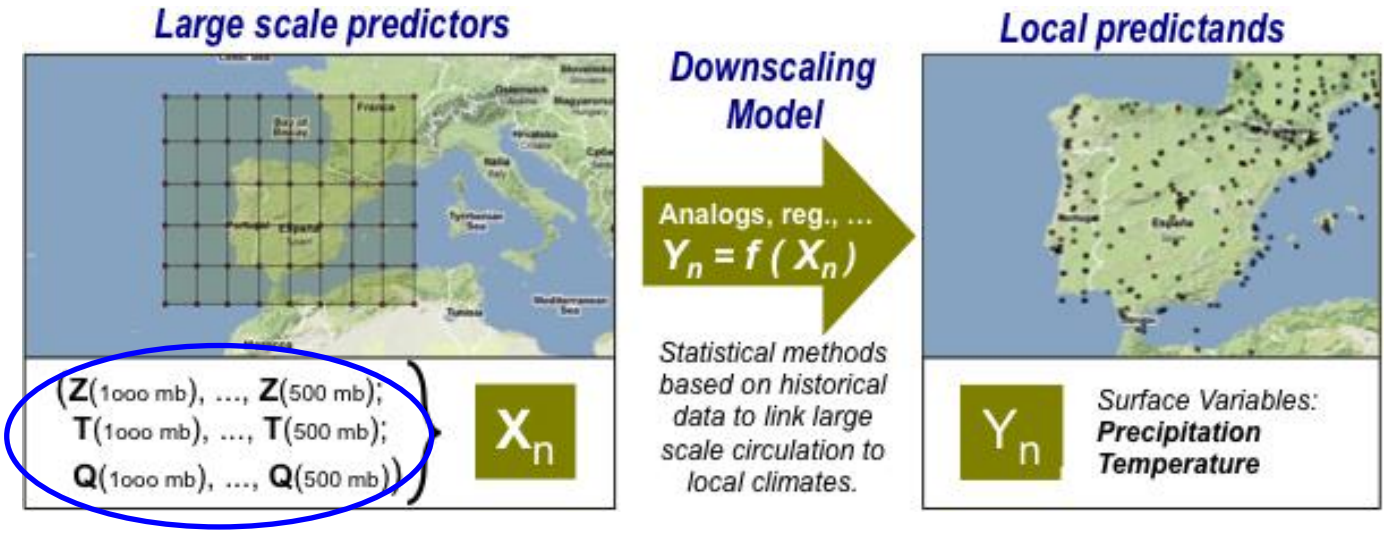
- BC from GCM, IC → solving dynamic equations!

- **1 month computing time for 1 month prediction ?**

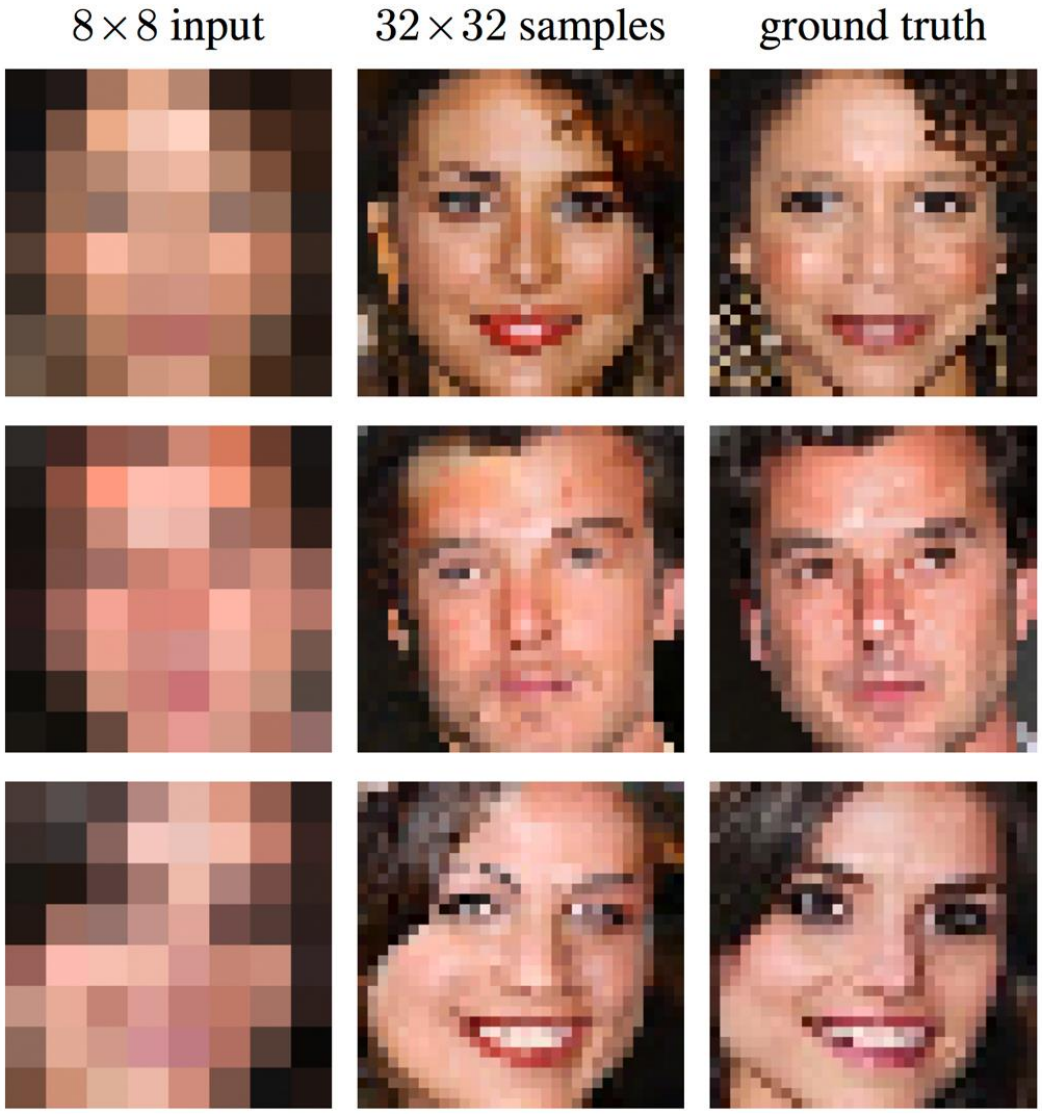
Empirical-statistical downscaling

- Based on empirical relationship between **precipitation/temperature** at particular stations and in-situ/remote large scale **Atmospheric/Oceanic condition**

→ **Developing simple downscaling model (regression)**



Google uses AI to sharpen low-res images



https://www.engadget.com/2017/02/07/google-ai-image-enhancement/

Rationale of Downscaling

✓***In changing climate …***

: increase of climate related disasters

✓***The gaps…***

: low dynamical prediction skill, coarse model resolution but climate locality, limited human and material resources

✓***The needs…***

: prediction of next season climate in local community (e.g. small islands)

Clik Downscale
Climate Information Toolkit

http://clik.apcc21.org/

PICASO

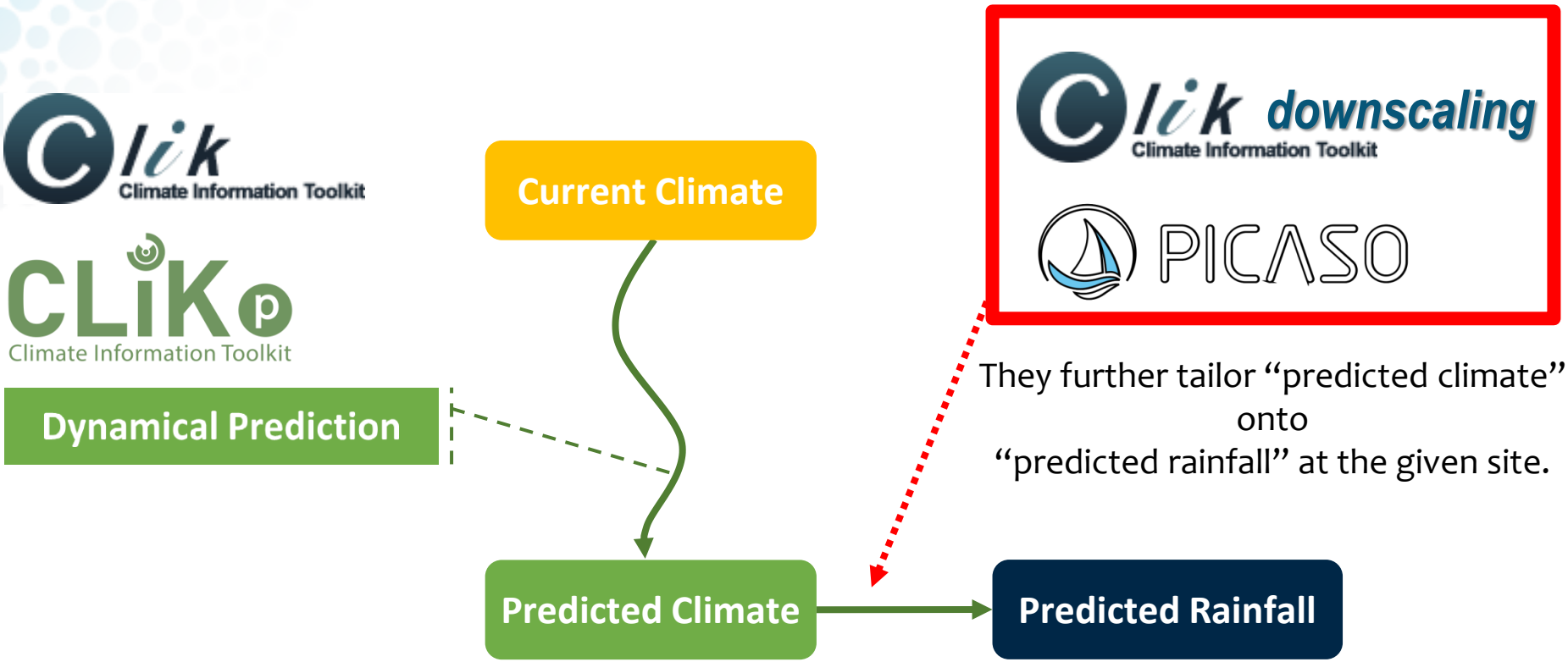
✓***What we have!***

: Prcp/temp station data (past) & coarse GCM data (past & future)

✓***What we know!***

: past relationship (site – large scale field)

Downscaling/tailoring of dynamical MME



1) Physical/dynamical process
2) Model biases *vs* Observed dynamics

Clik
Climate Information Toolkit

CLIK

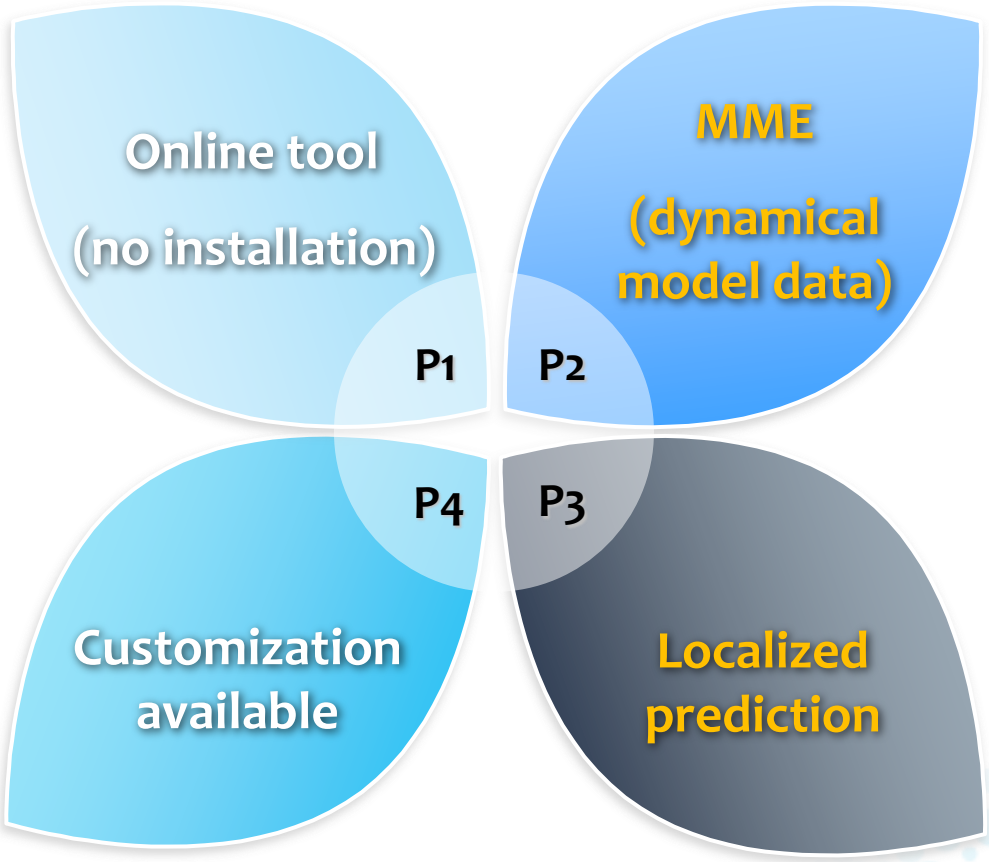
CLimate Information ToolKit

http://clik.apcc21.org

Climate Information Toolkit

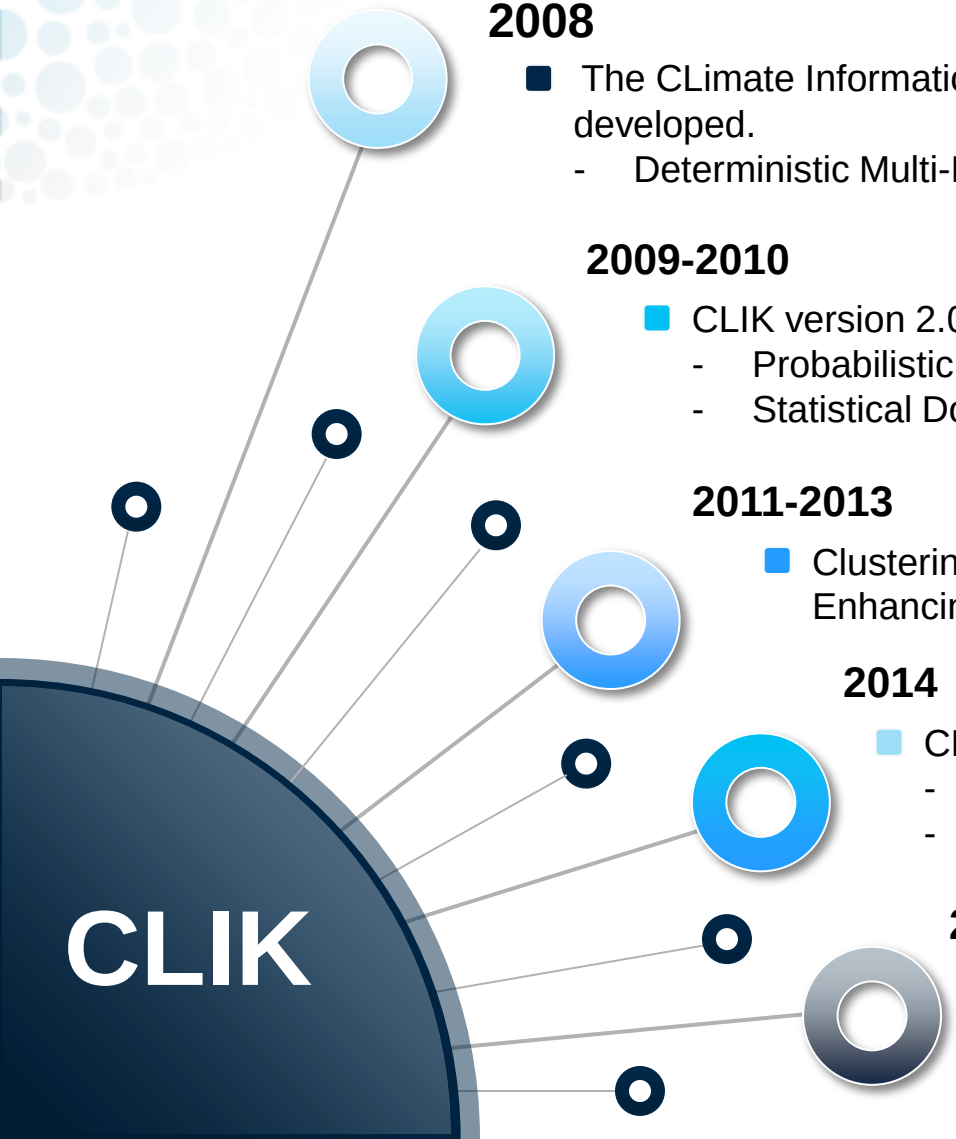
CLIK was developed and updated based on the analysis of potential users: their status and needs.

1. Limitation of manpower and computing resources
2. Desire for utilizing **dynamical forecast data**
3. Direct benefit on **regional community**
4. Thirsty for Capacity building: Interests in learning science and technology and high satisfaction when participating in the model developing process



➔ Target users are, but are **not limited to NMHS staffs** of developing countries having basic understanding of climate and meteorology.

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.

2015-2018

- Improvement of User Interface & Functions
  - New PMME Verification Metric (HSS)
  - Downscaling Dataset Management
  - Downscaling Correlation Map

With only a computer and an internet connection

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

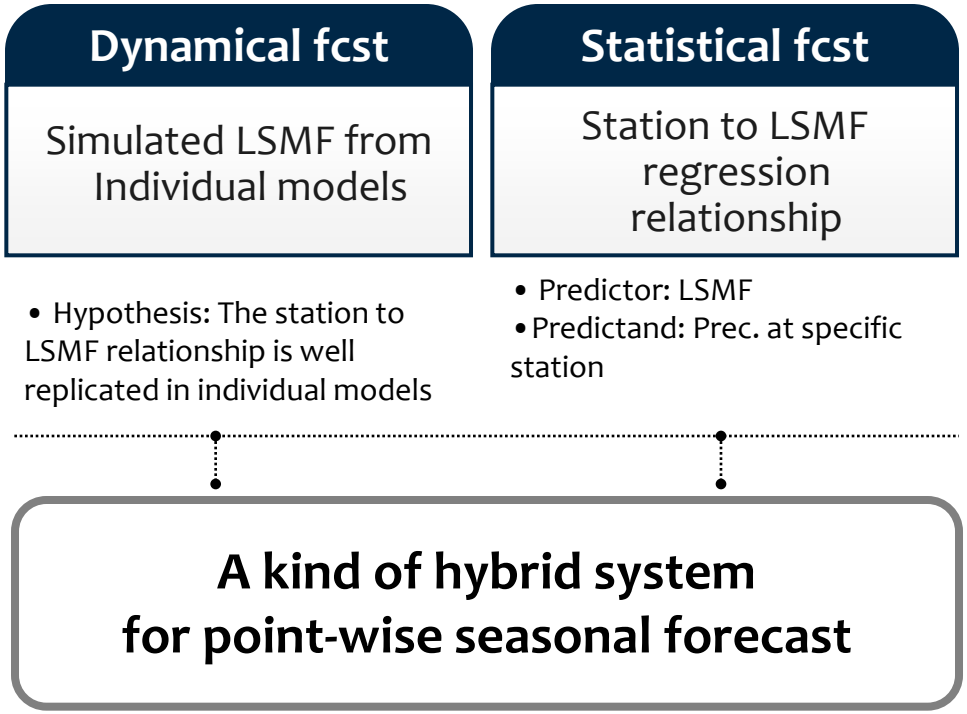
Downscaling:
Simulated large scale pattern to station matching

▸ To provide statistical downscaling capability using **MME** prediction

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

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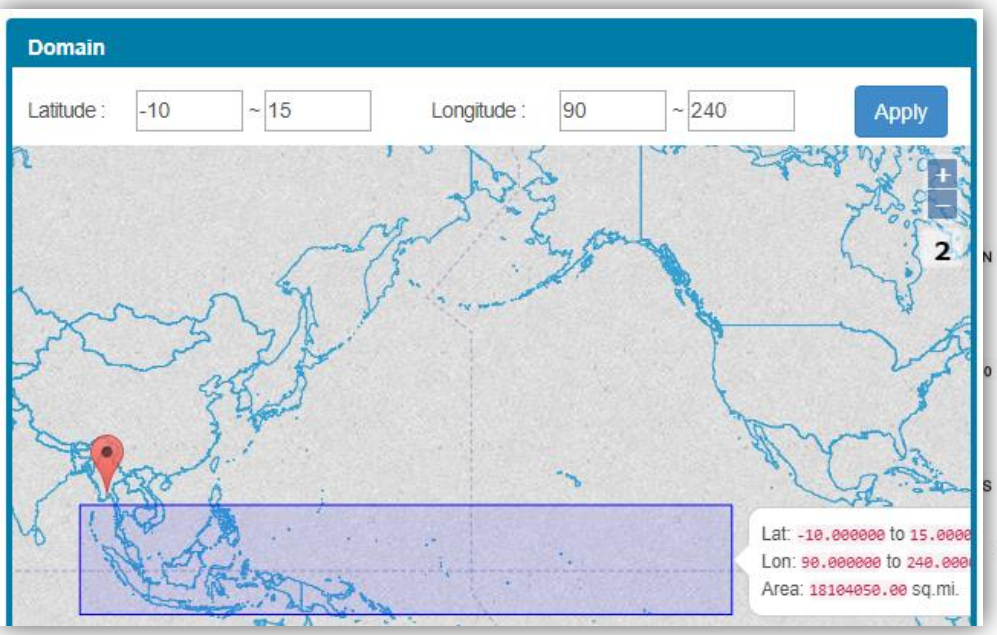
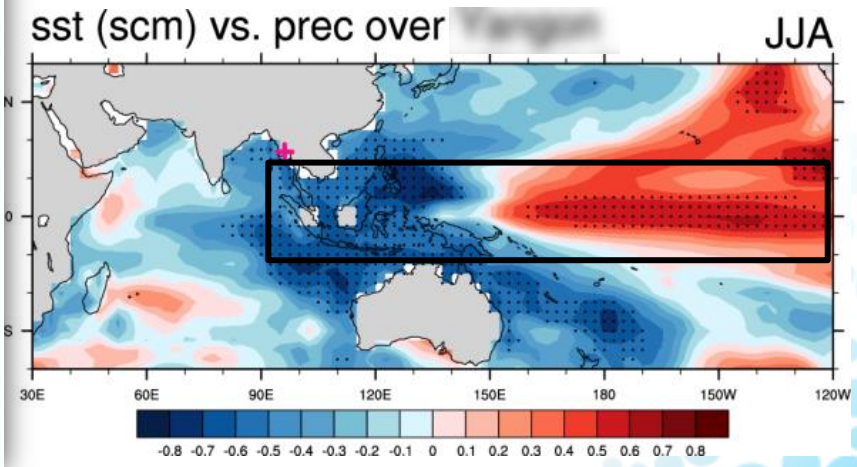
Empirical relationship: LSMP (OBS) ~ local station rainfall

LSMP (MME) → Local station rainfall



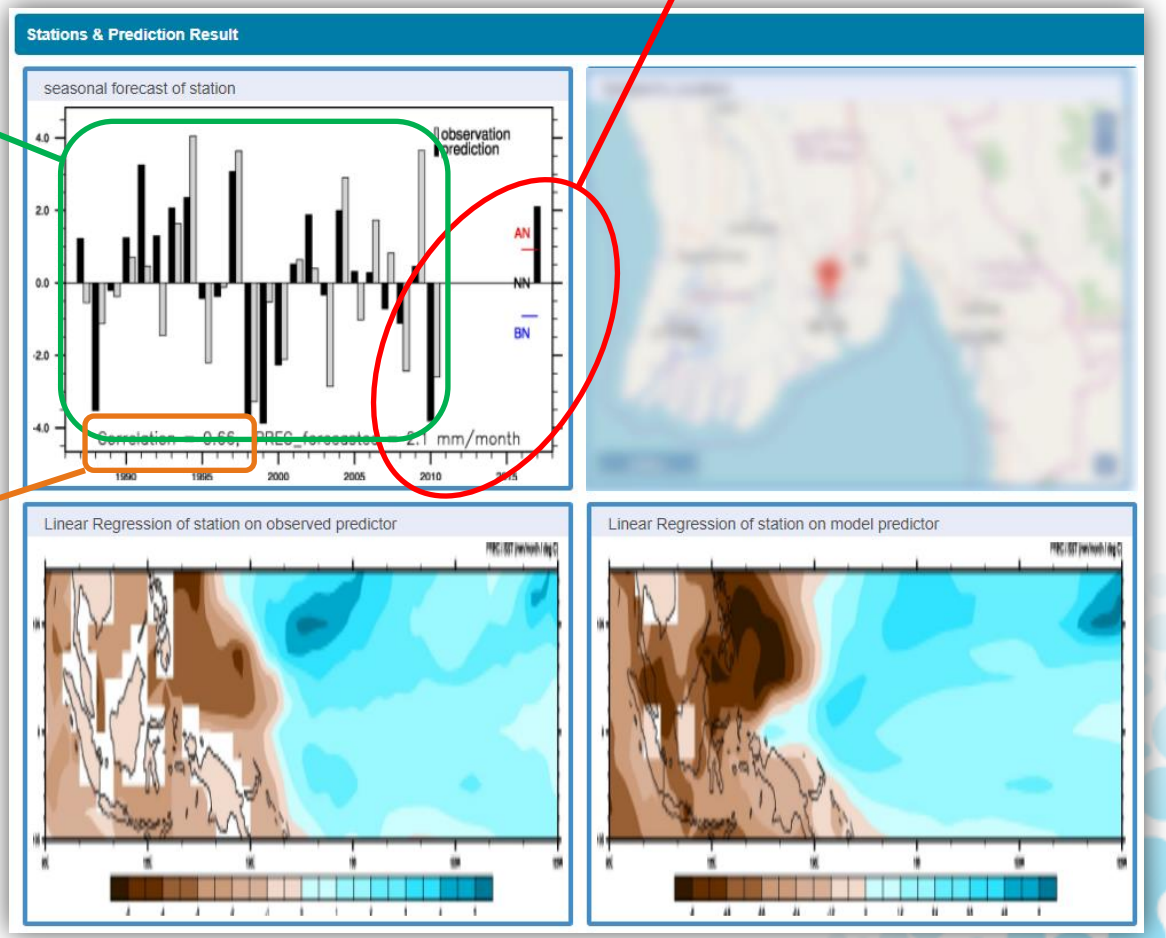


Downscaled forecast at a given site

Deterministic forecast with **tercile range** for target year/season

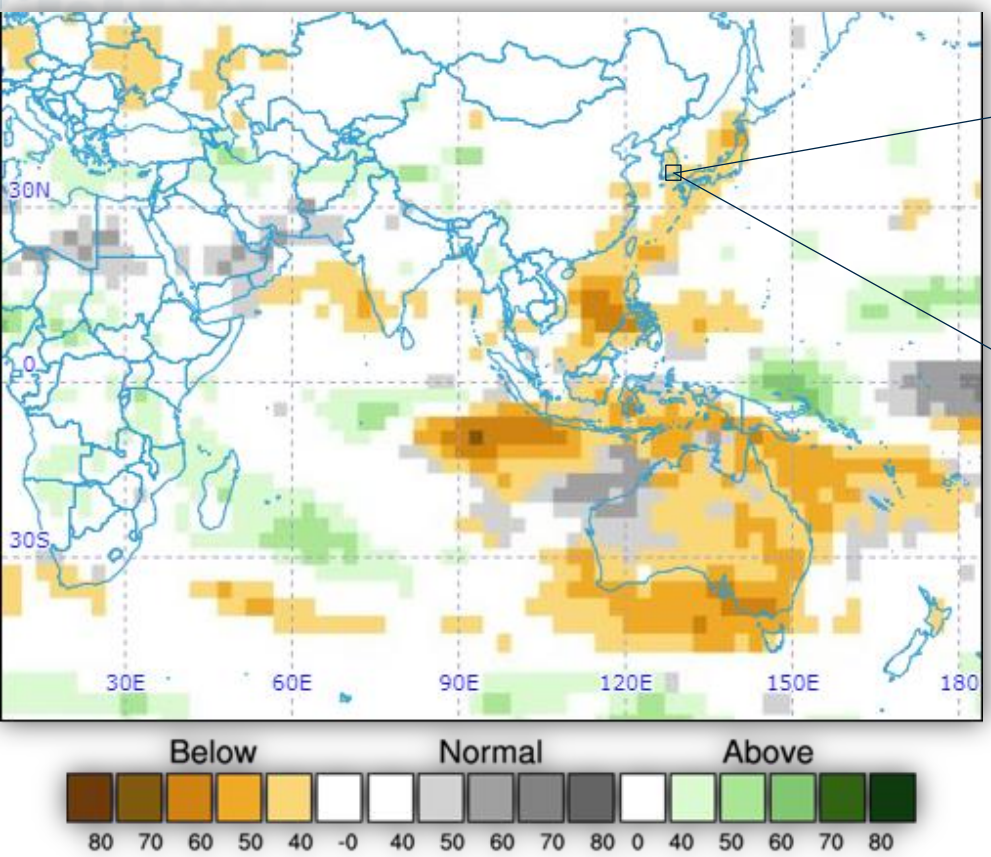
Historical time series: obs & downscaled from MME

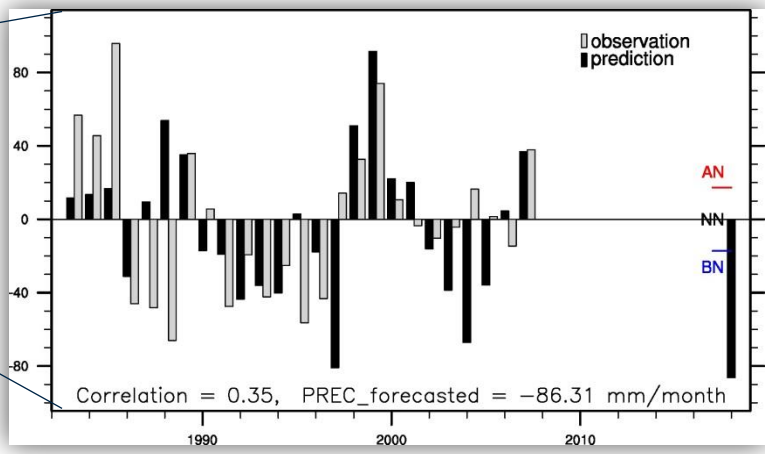
Temporal Correlation Coefficient **(TCC) skill**



2018 SON Rainfall forecast (Busan, KOREA)

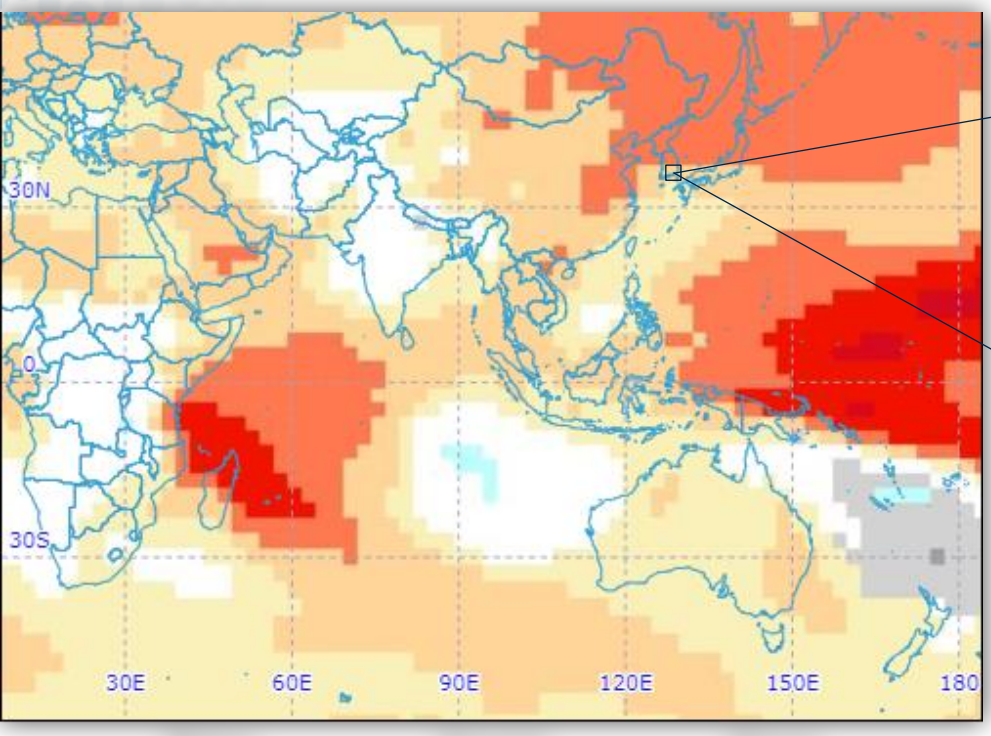
PMME (dynamical, grid) & Downscaled (pointwise)

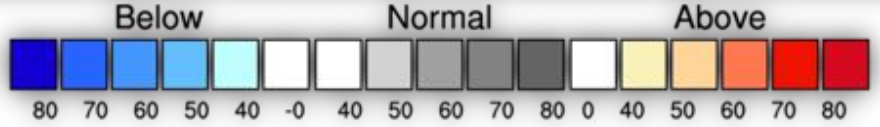


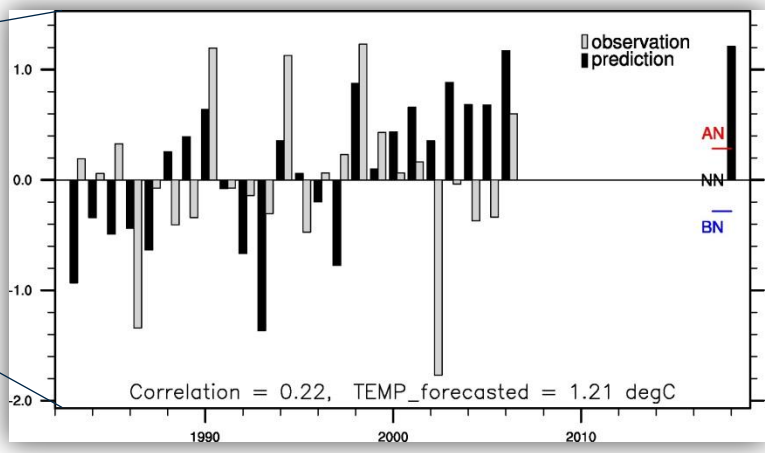


2018 SON Temp. forecast (Busan, KOREA)

PMME (dynamical, grid) & Downscaled (pointwise)







Lead Month: 3, Year: 2018, Season: 9, Methods: GAUS

Model: APCC,CMCC,CWB,MSC,NASA,NCEP,PNU,POAMA

created by CLIK(2018-8-22)


PICASO
Pacific Island Countries Advanced Seasonal Outlook

ROK-PI CliPS: Overview

Republic **O**f **K**orea-**P**acific **I**slands **Cli**mate **P**rediction **S**ervices

- Objective:

  "*To strengthen the adaptive capacity of vulnerable communities to climate risks at the seasonal timescale.*"

- Working Pillars:

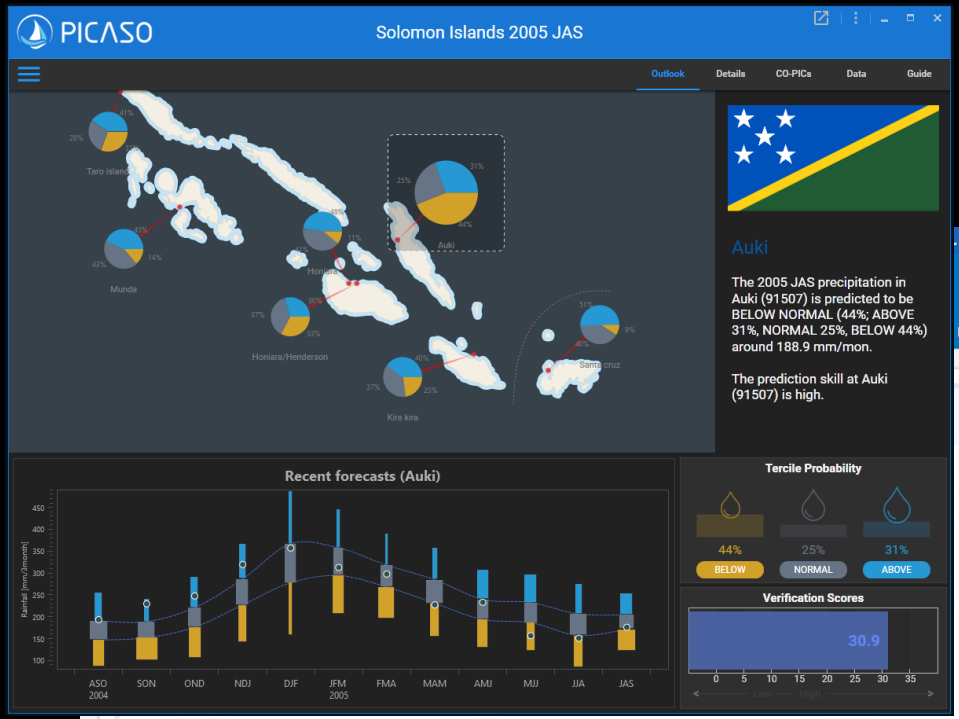
  One Dynamical Seasonal Forecasting System
  → CLiKP Climate Information Toolkit

  Two Downscaled Prediction System
  → PICASO

  Three Development of the Application Guideline
  → Forecast Guidance I & II

  Four Training of the Climate Information Application
  → Training & Young Scientist Support Program

Intuitive climate outlook



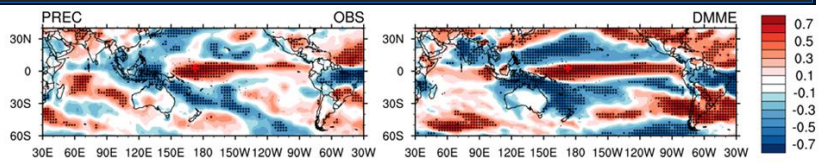


Figure 2.Temporal correlation coefficients (TCCs) between local precipitation of Butaritari(91601) and precipitation at each grid during the April – June(AMJ) for (left) observation and (right) DMME. The black dots indicate grid points for which TCC is significant at the 95% confidence level.

The large-scale oceanic and atmospheric signals associated with the local precipitation at Butaritari(91601) during April - June(AMJ) season are displayed in Figure 1 and 2. The dynamical seasonal prediction system (APCC-MME based PICASO) represents that the AMJ precipitation of Butaritari(91601) is wellrelated to warm equatorial Pacific state (e.g., El Niño), and it can be best recognized by the predicted (MME) remoteprecipitationover the Western Pacific. Therefore, remotepre-cipitationis selected as the internal predictor in PICASO.

TRAINING SCORES

Name	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ	TOTAL
HSS	0.14	0.2	0.14	0.57	0.5	0.03	0	0.32	0.14	0.28	0.09	0.11	0.21
LEPS	33%	35%	27%	31%	35%	22%	35%	20%	22%	38%	38%	23%	0%

TRAINING HISTORY (PREDICTION/OBSERVATION)

Name	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2005	0-/0	0-/-	+/0	0-/+	-/+	+/+	0/+	+-/0	0-/+	+-/-	0+-/-	+/+
2004	0+-/+	0+-/+	0-/0	0/0	0-/0	+/+	0+-/+	0-/0	0+-/0	0-/0	0+-/+	+/-
2003	0+/0	+/-	0/0	0+/-0	+-/-	0+-/0	+/-	0+-/+	+/+	+-/-	0+/0	0+-/+
2002	0-/0	0+-/0	0+/0	0-/0	+-/-	-/-	0/0	0+/0	0-/0	+/-	0-/0	0+-/+
2001	+-/-	0+/-0	0-/0	0+-/+	0+-/0	-/-	0+/-0	0-/0	0+-/+	0+-/0	+-/-	0-/+
2000	+-/-	0-/0	+-/-	+-/-	0+-/0	+-/-	0/0	-/-	+-/-	-/-	+-/-	0-/+
1999	0+-/0	0+-/+	+-/-	0+-/0	0/-	0+-/0	0+-/+	+-/-	0+-/0	0-/0	0+-/0	+/0
1998	0/-	0+/0	0+-/0	0/-	-/-	0/-	0+/0	0+-/0	0/-	0-/0	0/0	0+-/+
1997	0-/+	0-/0	0/0	0-/+	0+/-	0-/+	-/-	0/-	0-/+	-/-	0-/+	0+-/-
1996	0+/-	0+-/0	0-/+	-/-	0+/-0	0+/-	0+-/0	0-/+	0/0	0+/-0	0+/-	+/+
1995	0+/-	0/-	-/-	-/-	0/0	0+/-	0/-	0+/-	0/-	+/+	0+/-	+/+
1994	0/0	+/-	+-/-	0/-	0-/0	0-/+	+/-	0-/0	0-/+	0-/0	0/0	+/0

VALIDATION SCORES

Name	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	N
HSS	0.14	0.2	0.14	0.57	0.5	0.03	0	0.32	0.14	0.28	0.09	0.
LEPS	33%	35%	27%	31%	35%	22%	35%	20%	22%	38%	38%	23

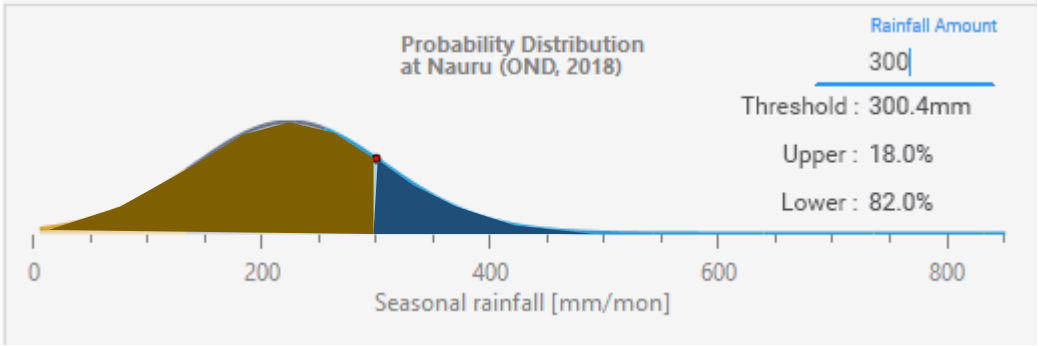
VALIDATION HISTORY (PREDICTION/OBSERVATION)

Name	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	
2016	0-/0	0-/-	+/0	0-/+	-/+	+/+	0/+	+-/0	0-/+	+-/-	0-/+	
2015	0+-/+	0+-/+	0-/0	0/0	0-/0	+/+	0+-/+	0-/0	0+-/0	0+-/0	0+-/0	0
2014	0+/0	+/-	0/0	0+/-0	+-/-	0+-/0	+/-	0+-/+	+/+	+-/-	0+/0	0
2013	0-/0	0+-/0	0+/0	0-/0	+-/-	-/-	0/0	0+/0	0-/0	+/-	0-/0	0
2012	+-/-	0+/-0	0-/0	0+-/+	0+-/0	-/-	0+/-0	0-/0	0+-/+	0+-/0	0+-/+	0+
2011	+-/-	0-/0	+-/-	+-/-	0+-/0	+-/-	0/0	-/-	+-/-	-/-	+-/-	
2010	0+-/0	0+-/+	+-/-	0+-/0	0/-	0+-/0	0+-/+	+-/-	0+-/0	0+-/+	0-/0	0
2009	0/-	0+/0	0+-/0	0/-	-/-	0/-	0+/0	0+-/0	0+-/0	0/-	0-/0	0
2008	0-/+	0-/0	0/0	0-/+	0+/-	0-/+	-/-	0/-	0-/+	-/-	0-/+	
2007	0+/-	0+-/0	0-/+	-/-	0+/-0	0+/-	0+-/0	0-/+	0/0	0+/-0	0+/-	
2006	0+/-	0/-	-/-	-/-	0/0	0+/-	0/-	0+/-	0/-	+/+	0+/-	

PICΛSO > Details > Probability Distribution

- **Interactive Probability Scale**

  Probability below/above specific criteria



Chance of rainfall more than 299.3mm/mon during SON, 2017 = 50.9%

Chance of rainfall less than 299.3mm/mon during SON, 2017 = 49.1%

- **Applicable to other sectors**

Water resources management — Disaster Risk Reduction — Agricultural planning

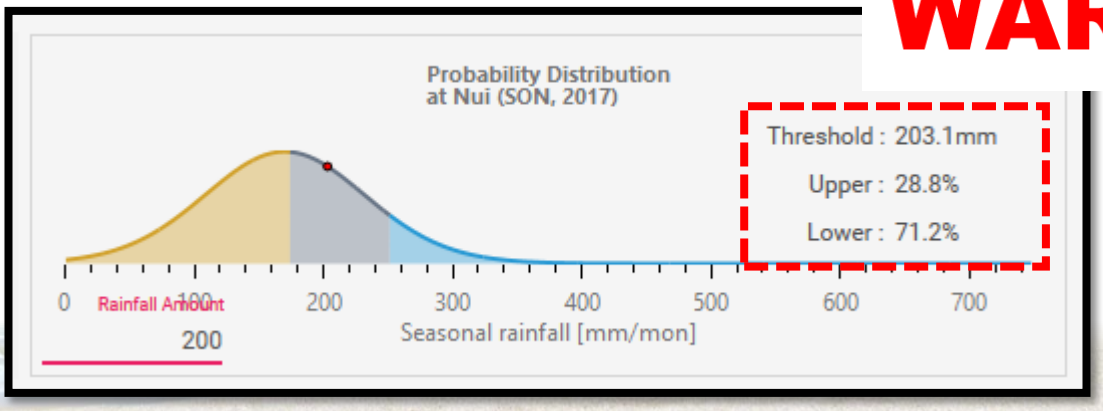
Tuvalu

Current Water Resources

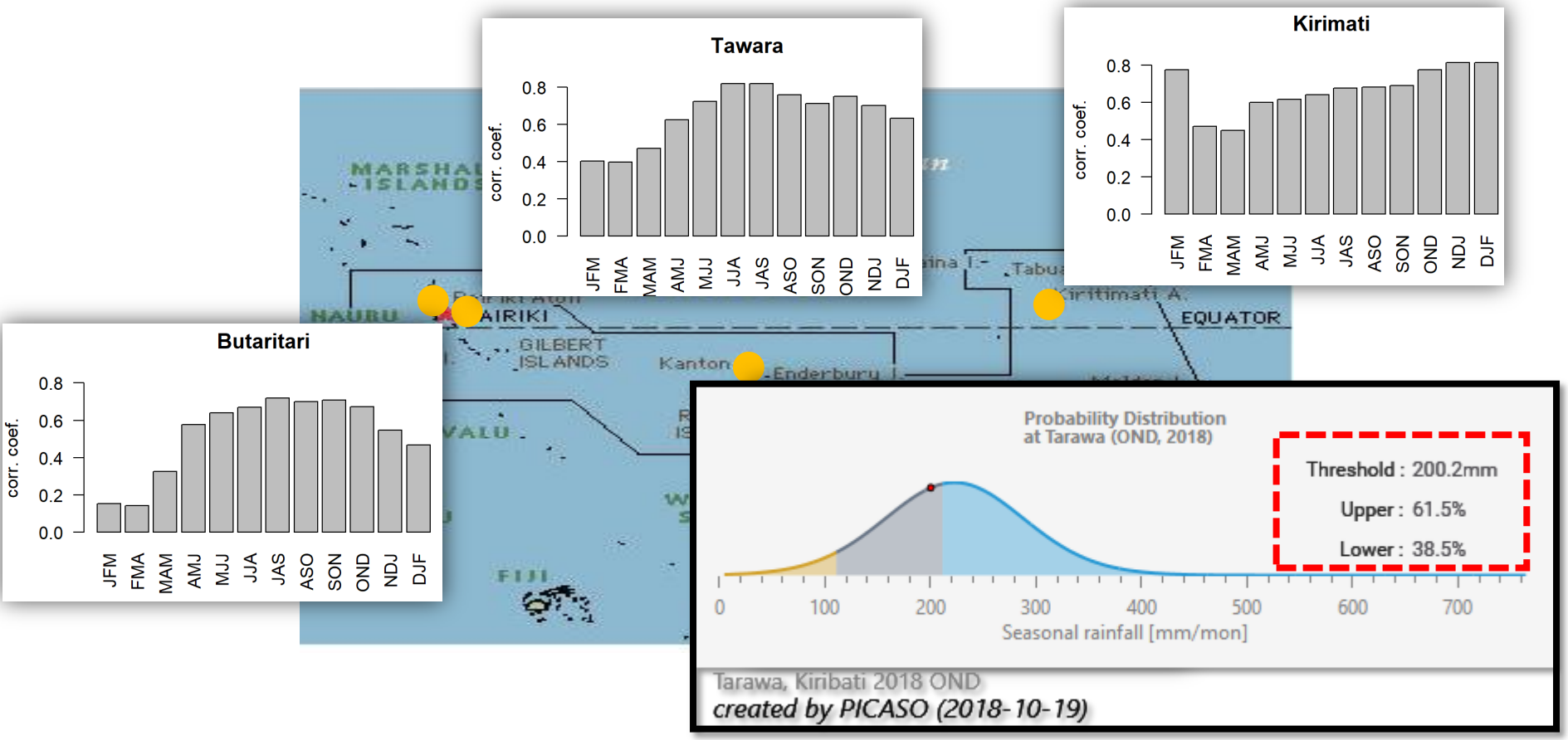
- **Primary - Rain water (rain harvest and banked at individual household)**
- Supplementary - RO desalination plant source from either the groundwater or direct from the sea.
- Secondary - ground water (only for secondary usage - lavatory cleaning, bathing) mainly during the dry spells.

Average annual rainfall: 3000mm ~ 4000mm (in the southern islands)

WARNING!



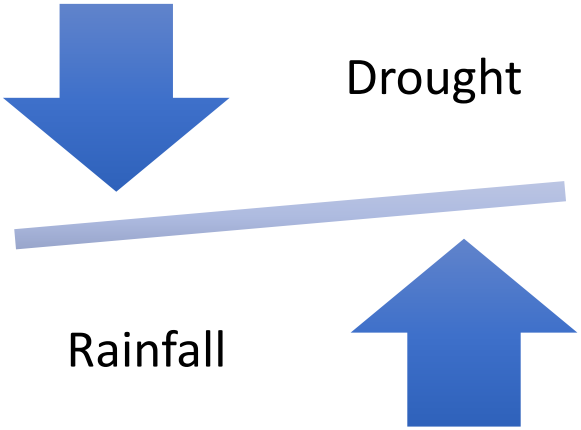
Kiribati



- A vast area of territory covering most equatorial Pacific
- Regionally/seasonally varying - ENSO dependent rainfall
- Weak CP-type El Nino coming → No Drought expected
  → Advise **the Drought Committee** on the status of the Water reserve

Tonga

Recharge to groundwater

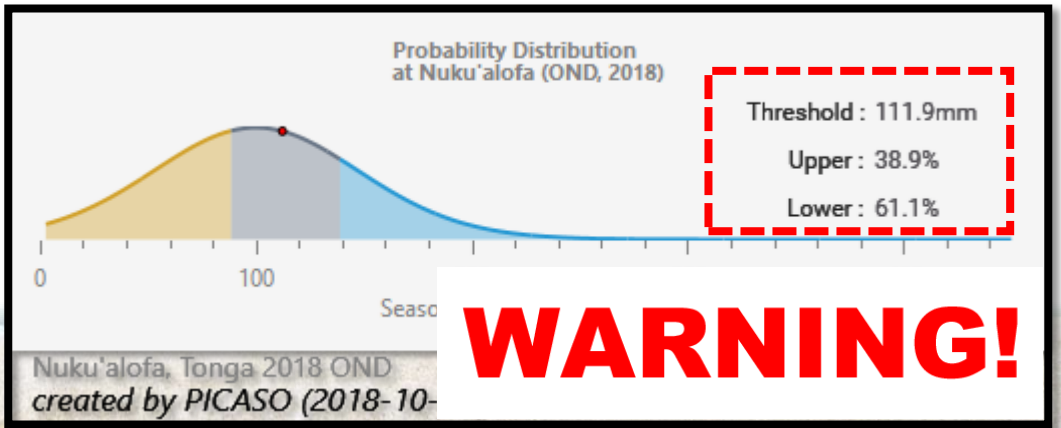


http://www.tonga-broadcasting.net/?p=3959

Watering
For good growth, squash and pumpkins require at least one inch of water per week. (One inch of water per thousand square feet is 620 gallons). If water is needed, irrigate thoroughly early in the morning until the soil is moistened eight to twelve inches deep. If rainfall is deficient, it may be necessary to water once a week, perhaps two times per week in sandy soils.

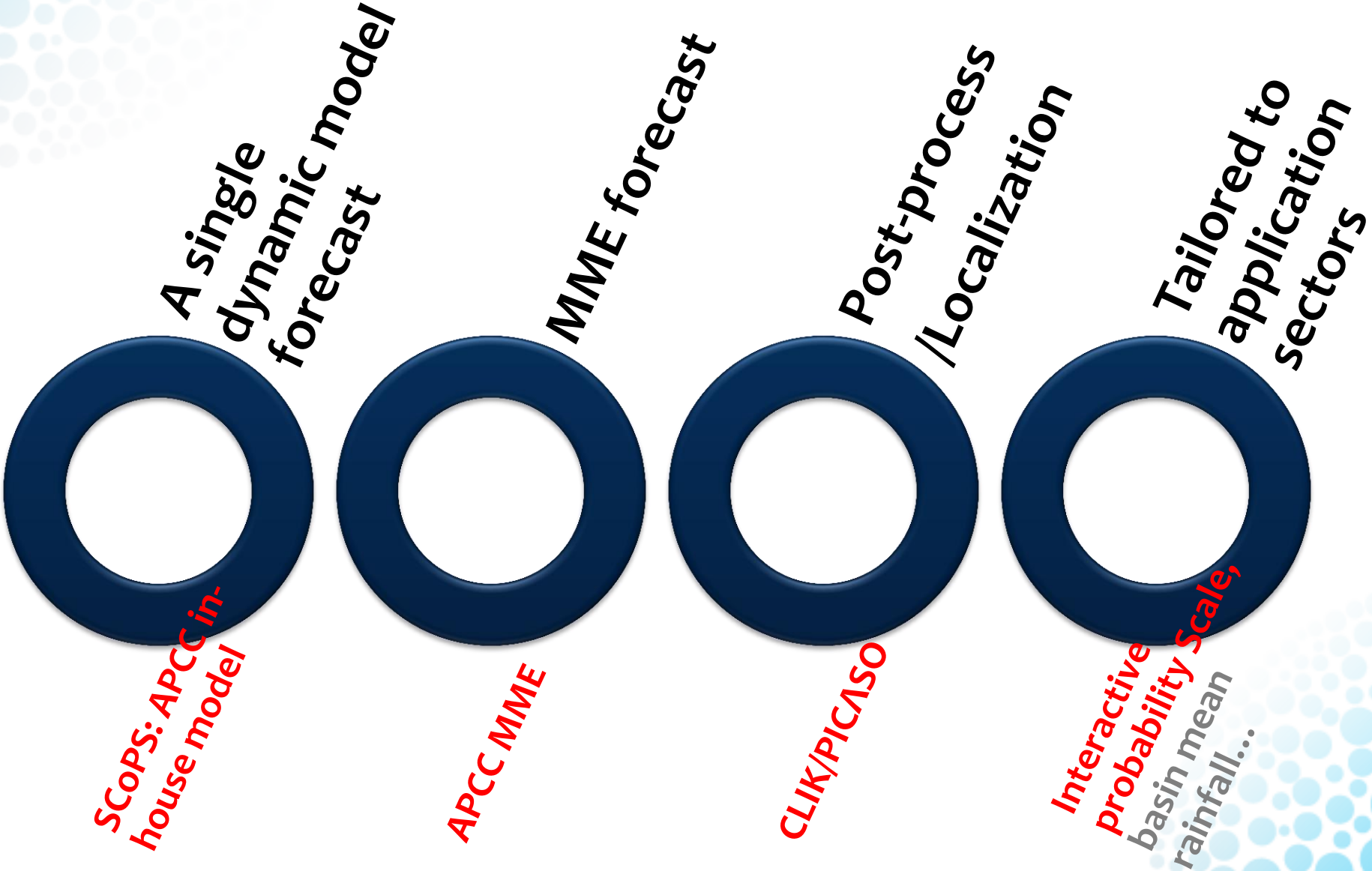
https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/pumpkins_and_squash.pdf

Annual Rainfall: 1,770 mm
Potential Evaporation: 1,550 mm



Tonga Water Board (TWB)
: **water supply services** for domestic, stock, horticultural, industrial, commercial, recreational, environmental and other beneficial uses

Climate Prediction Service Enhancement




Thank you.