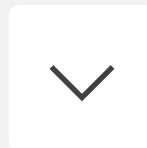


# Gaps and Opportunities in Climate Information Services

> Lessons learned from APCC's seasonal prediction and sectoral application in the Pacific <

WonMoo Kim

Climate Services and Research Department  
APEC Climate Center (APCC), Busan, Korea



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1

## Where are we?

Current Status

2

## What's missing?

Gaps and Needs

3

## What can we do?

Story of the Pacific

4

## Where to go?

Set the compass

Our current climate prediction systems are doing a great job especially in the Pacific region, and they are still improving. Sub-seasonal forecasts are proving their value in extended range.

Climate information provides worthy advice to sectors, e.g., agriculture, water management, and infrastructure.

However, there are still rooms to fill.

Here, we would like to share our story of climate services in the Pacific: our attempt to utilize state-of-the-art climate information to sectoral levels.

From our success and failure, we would like to set the compass for future climate information services.

Where are we?

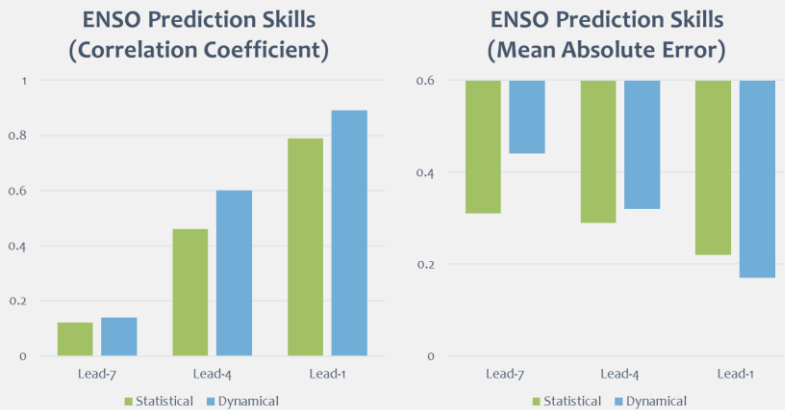
## Current Status of Climate Services

# Current Status of Climate Services

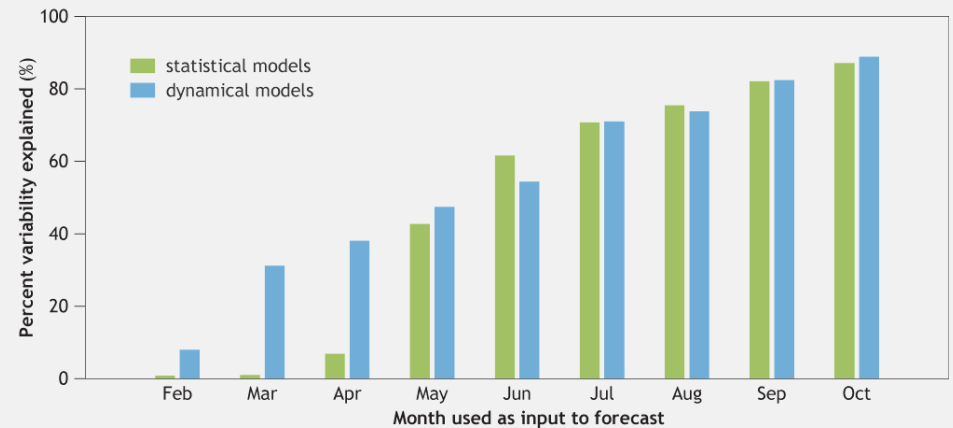
## Seasonal climate prediction

Seasonal prediction provides useful information few months ahead

e.g., El Niño-Southern Oscillation, is predictable ~ several seasons



How much ENSO variability can be predicted for Nov-Jan forecast?



figures adopted from **Michelle L'Heureux**. <https://www.climate.gov/news-features/blogs/enso/spring-predictability-barrier-we'd-rather-be-spring-break>

Subseasonal forecast shows great potential

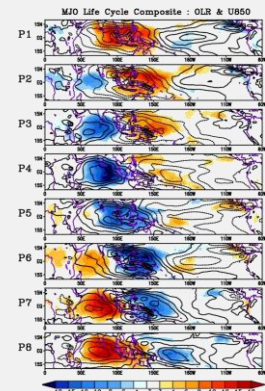
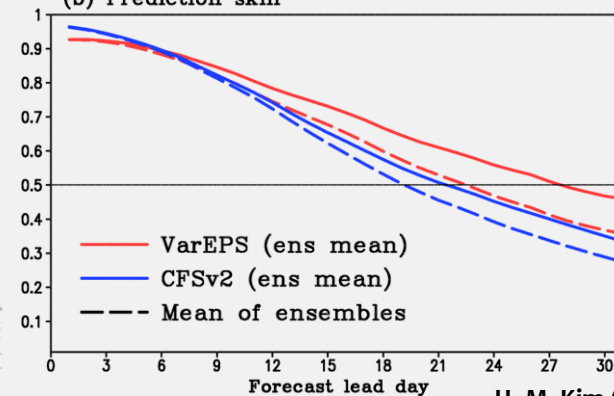
e.g., Madden-Julian Oscillation ~ a month

Sectoral application of climate information

Climate projection and Seasonal prediction



(b) Prediction skill



H.-M. Kim (2014)

# APCC's Climate Services

## Vision and Goals

The APCC aims to contribute to economic growth in the APEC region and support the protection of lives and property, the reduction of economic losses, and enhance economic opportunities.

## Mission

The mission of APCC is to enhance the socio-economic well-being of member economies by utilizing up-to-date scientific knowledge and applying innovative climate prediction techniques through



### 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.



Seasonal Forecast



BSISO Forecast



Climate Monitoring



CLIK



Data Service



CLIPs

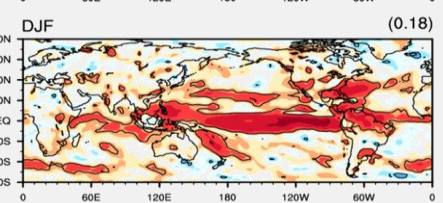
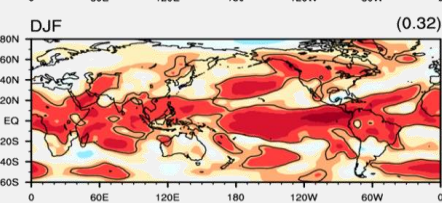
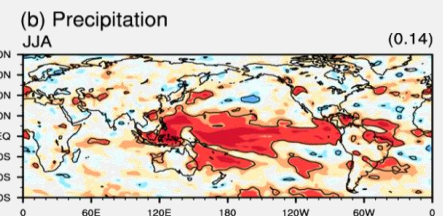
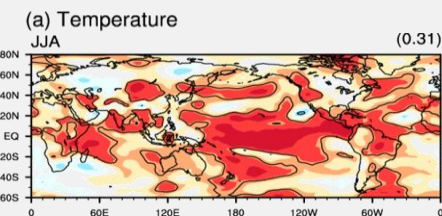
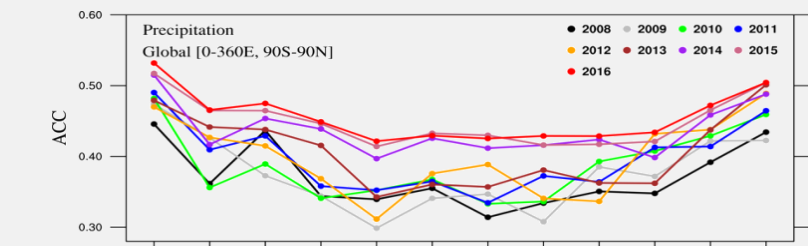
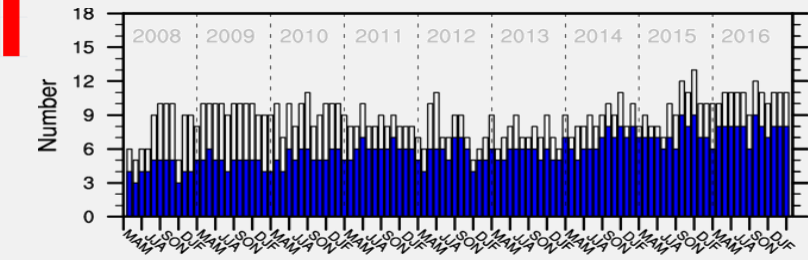
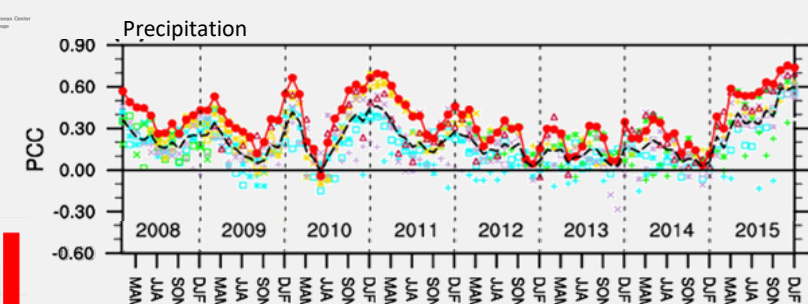
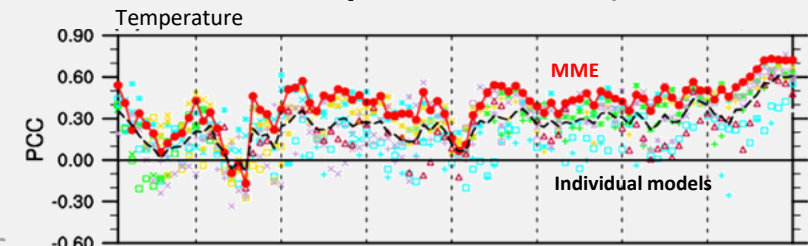
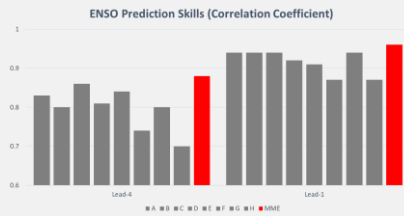
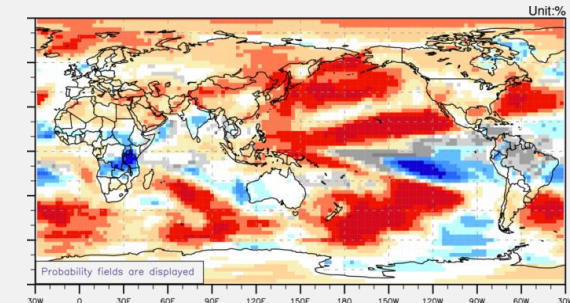
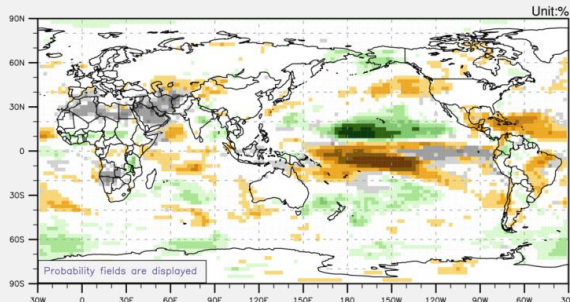


OpenWPS

# APCC MME Seasonal Prediction

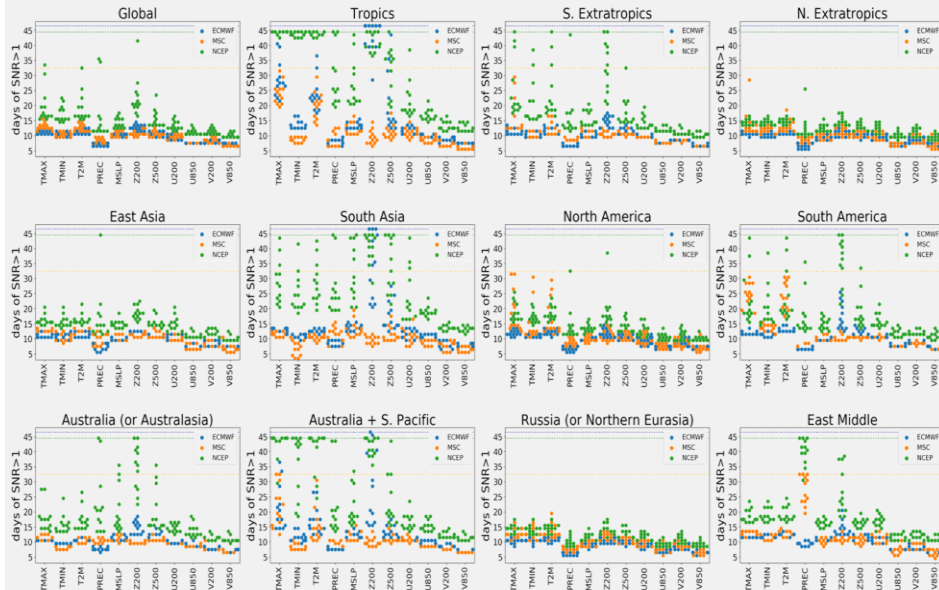
## APCC's Multi-Model Ensemble (MME) dynamical seasonal prediction system

Precipitation for June-August 2018

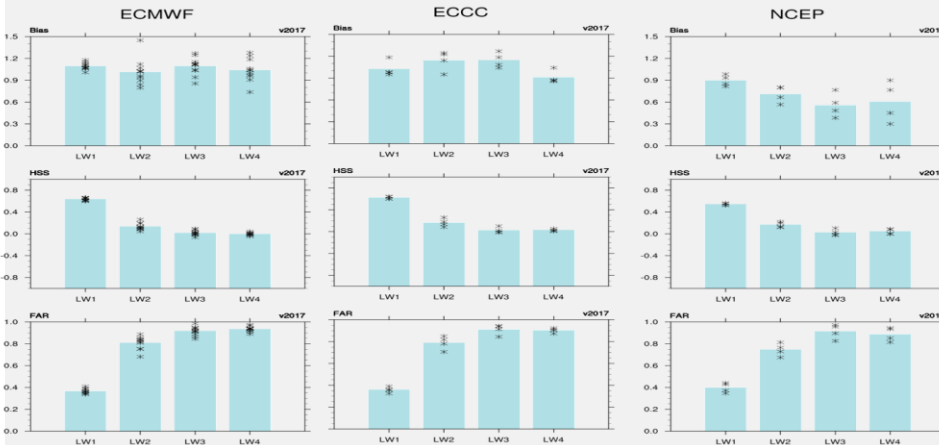


# Subseasonal to Seasonal (S2S)

## Subseasonal forecast

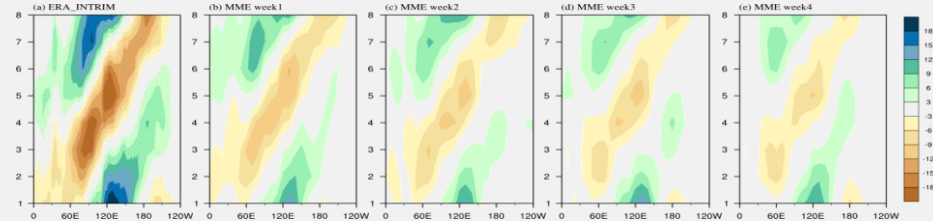


## Subseasonal Ural blocking

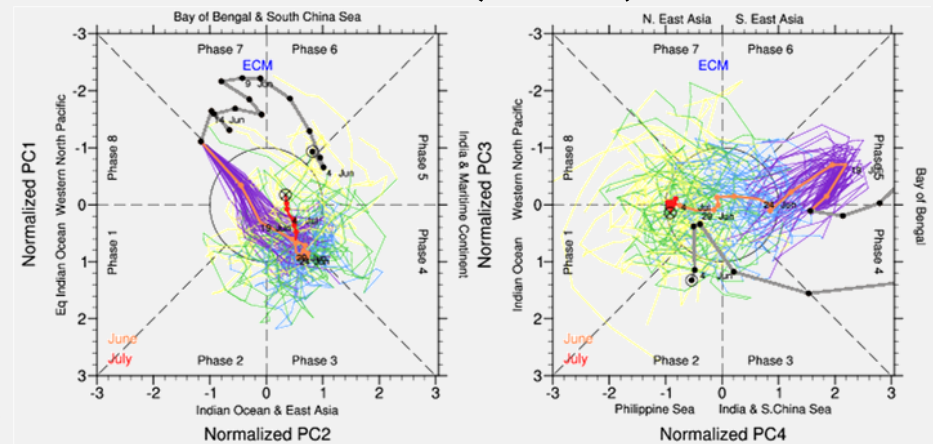


Bar: ensemble mean, mark: individual ensemble member

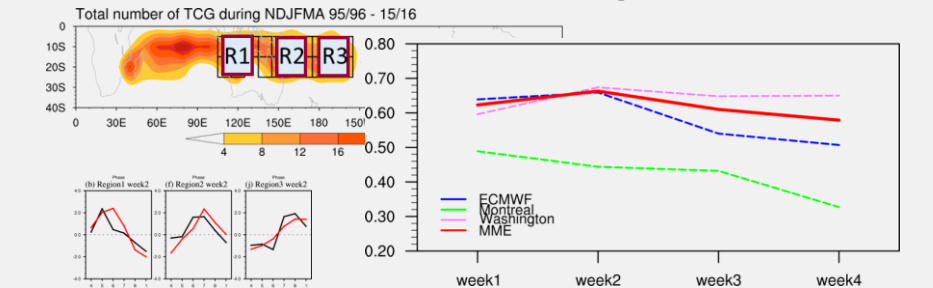
## Madden-Julian Oscillation (MJO)



## Boreal Summer ISO (BSISO)

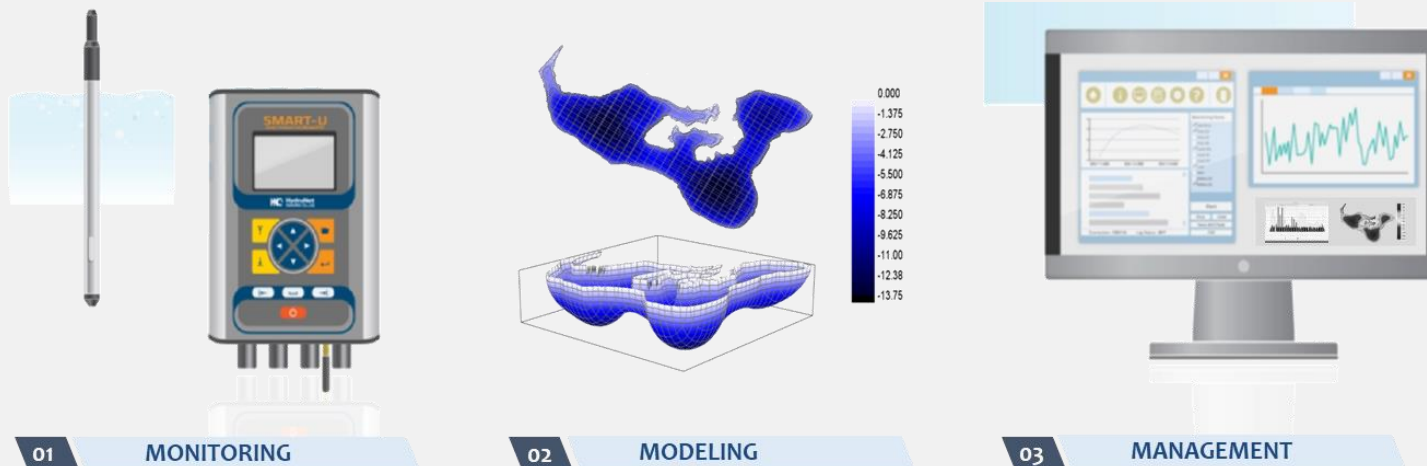


## Subseasonal tropical cyclogenesis

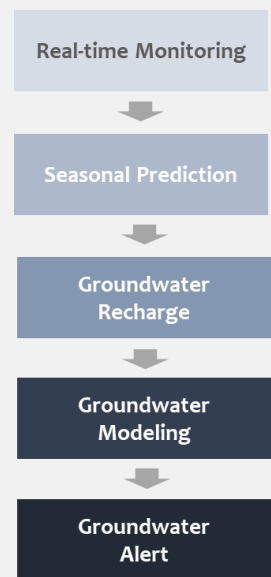
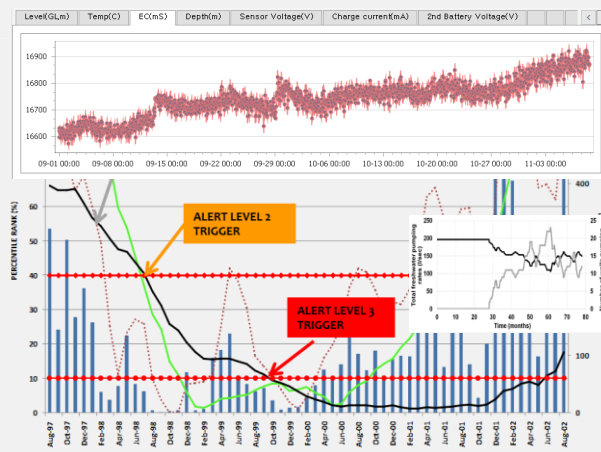
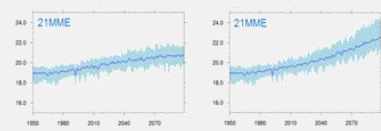
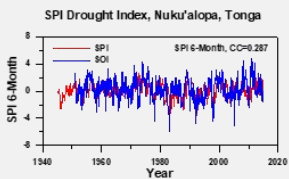


# Applied Climate Services

e.g., GroundWater Information System (ToGWIS)



## ONE STOP SOLUTION FOR GROUNDWATER MANAGEMENT

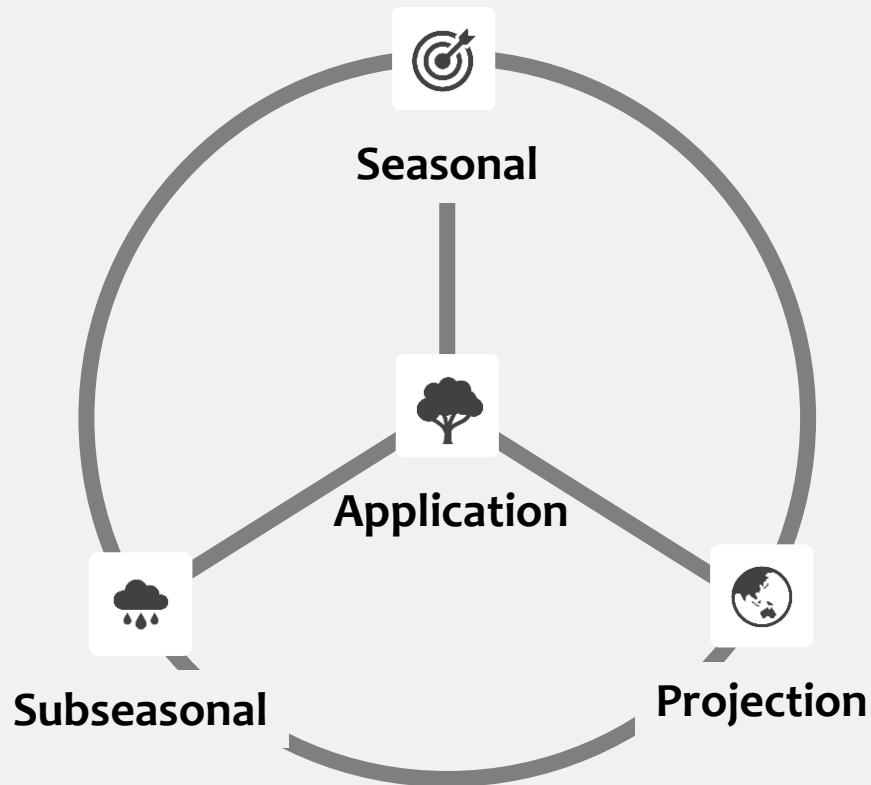


What is missing?

# Gaps and Needs in Climate Services

# Gaps and Needs

## Applied climate information services



## Progress, gaps, and needs

### Climate projection

Robust global response, but local?  
Poor understanding of uncertainty

### Seasonal prediction

Improved understanding in ENSO, ...  
Nonlinearity, surface processes, ...  
Extremes/types and flavors/extended

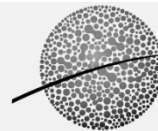
### Subseasonal prediction

Recent progress in MJO, BSISO  
Much to learn, land/snow/sea-ice, ...

### Sectoral application

Weak multidisciplinary communication  
Misunderstanding, loss of information  
Integration of seasonal & subseasonal





**APCC**  
APEC CLIMATE CENTER

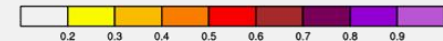
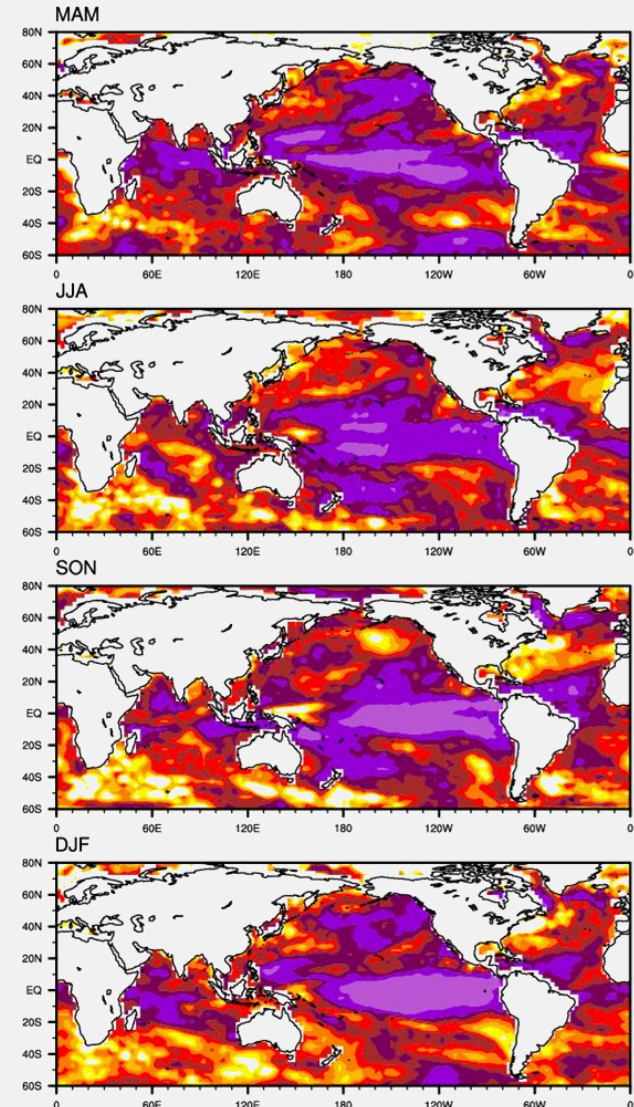
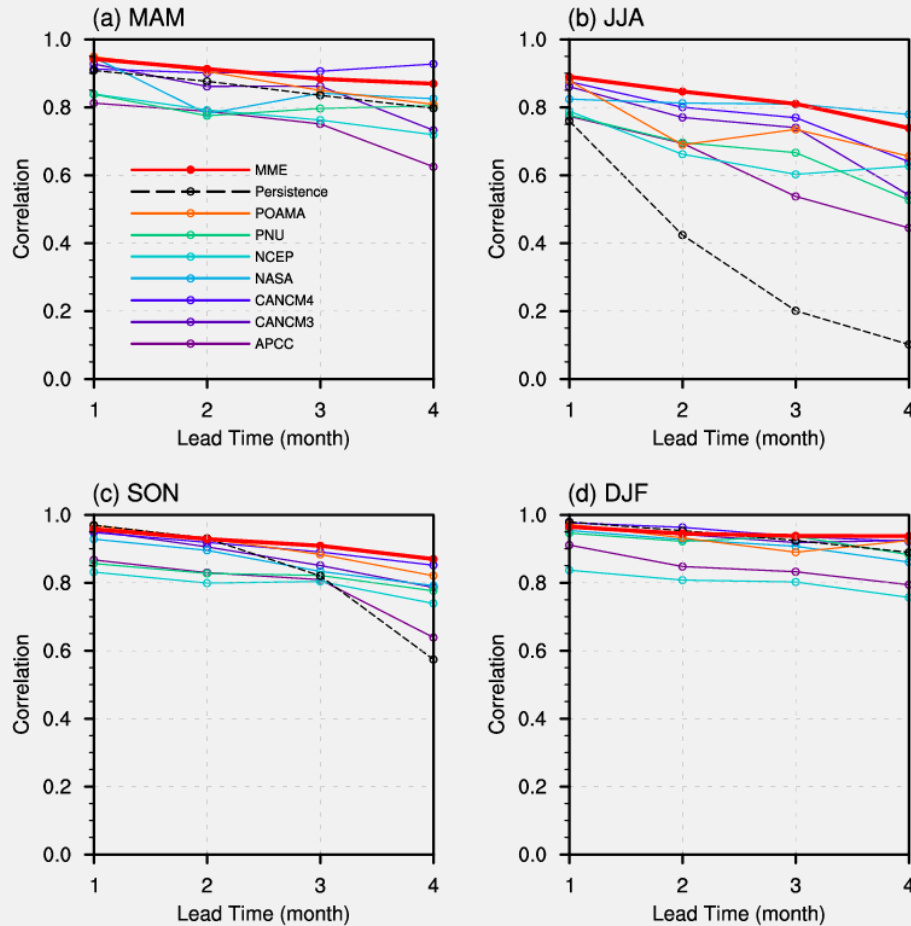


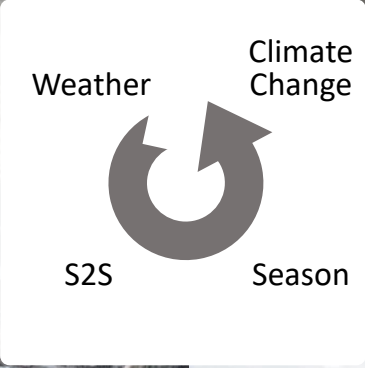
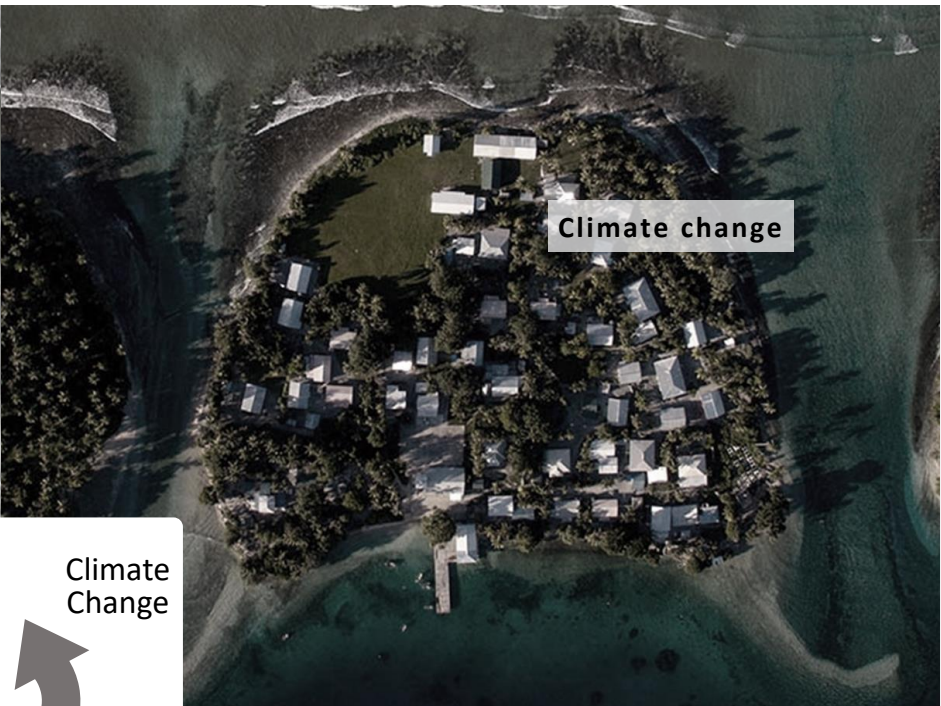
What can we do?

# A Story of Climate Services in the Pacific

# Prediction Data $\neq$ Information

Prediction skill is highest in the tropical Pacific, where the information is less utilized.





# A Story of the Pacific Islands

“The Pacific Islands as a group may be the planet’s most vulnerable nations to the effects of climate change, with some facing possible obliteration.”

Climate hazard and vulnerability in the Pacific

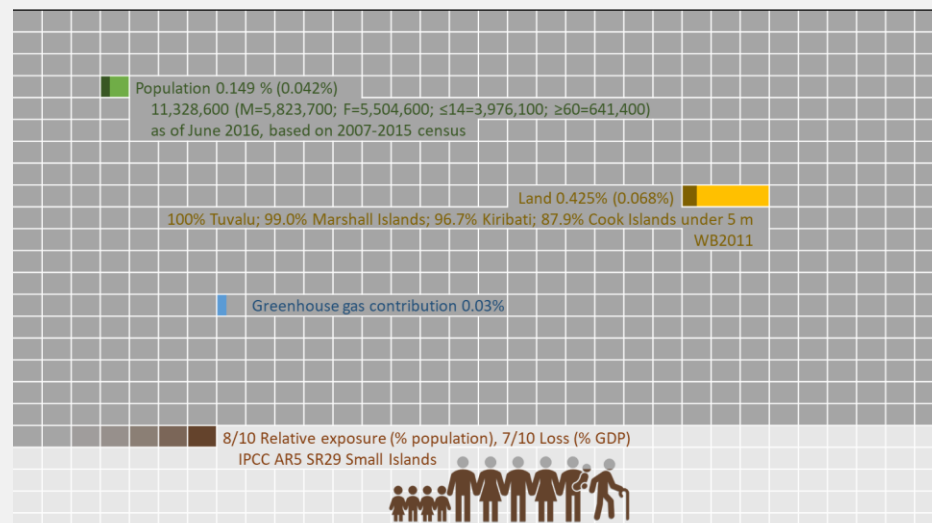
Subseasonal – Seasonal – Climate Change

APCC’s climate services in the Pacific

tailored seasonal outlook (PICASO)

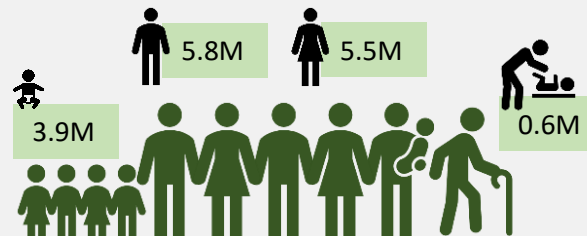
applied climate information services

Success and failure – Lessons learned



# Climate Change and the Pacific

## The Pacific region...



Population 0.149 %

11,328,600 (5,823,700 males and 5,504,600 females; 3,976,100 under 14 and 641,400 over 60)

global population = ~7.58 billion

as of June 2016, based on 2007-2015 census.

Land 0.425%

100% Tuvalu; 99.0% Marshall Islands; 96.7% Kiribati; 87.9% Cook Islands under 5 m

total land area = 130 million km<sup>2</sup>

from World Bank 2011

## Climate Change and the Pacific...

8/10 relative exposure

as % population and 7/10 Loss as % GDP



from IPCC AR5 SR29 Small Islands

Greenhouse gas 0.03%

global emission →

1994 estimates, from Hay and Sem, 1999



“HIGH TIDE COMPLETELY SURROUNDS THE VILLAGE OF EITA. IF THE SEAS CONTINUE TO RISE AT THE CURRENT RATE, IT WON’T BE LONG BEFORE THE VILLAGERS WILL HAVE TO RELOCATE. MANY ALREADY HAVE.”



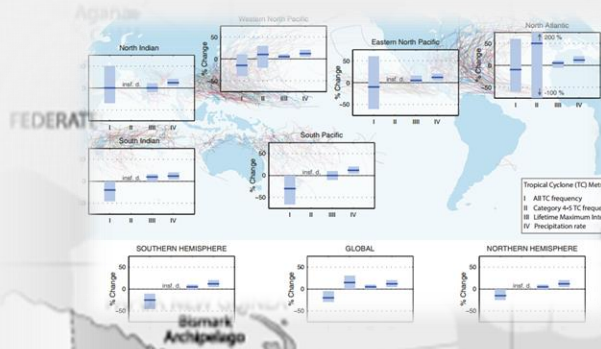
A FATHER AND SON BUILDING A 5 TO 7 METER HIGH SEA WALL IN FRONT OF THEIR HOUSE IN AN ATTEMPT TO FIGHT THE RISING SEA LEVELS.



“GRAVESITES ARE FALLING INTO THE SEA. EVEN IN DEATH WE’RE AFFECTED.”

- KAMINGA KAMINGA, CLIMATE CHANGE NEGOTIATOR, MARSHALL ISLANDS

# Weather-Subseason: Tropical Cyclone



Cyclone Winston [Feb 2016, CAT5]: Fiji, Niue, Tonga, Vanuatu  
- strongest tropical cyclone on record in the Southern Hemisphere

Cyclone Monica [Apr 2006, CAT5]:  
Papua New Guinea  
Cyclone Olaf [Feb 2005, CAT5]:  
Samoa, A. Samoa, Cook Islands  
Cyclone Zoe [Dec 2002, CAT5]:  
Solomon Islands, Fiji, Vanuatu

Cyclone Gita [Feb 2018, CAT5]: Samoa, A Samoa, Tonga, Fiji, New Caledonia  
- most intense tropical cyclone to impact Tonga

Cyclone Pat [Feb 2010, CAT3]: Cook Islands  
- 80% of architecture damaged

Cyclone Evan [Dec 2012, CAT4]:  
Samoa, American Samoa, Wallis and Futuna, Fiji, Tonga

Cyclone Pam [Mar 2015, CAT5]:  
Vanuatu, Fiji, Kiribati, PNG, Solomon Islands, Tuvalu

Pacific Island Countries



Cyclone Winston:  
Southern part of Taveuni Island in Fiji  
Some villages were completely destroyed and people were left without food for a week as access to the island was cut off

CYCLONE WINSTON: FEB. 2016; 42 DEAD IN FIJI



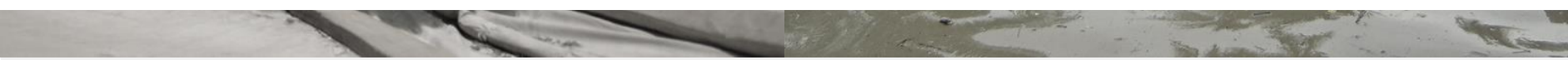
CYCLONE PAM: MAR. 2015



Source: The Guardian



DROUGHT AND FLOOD



# Season: Severe Droughts and Floods

## Seasonal climate extremes of PICTs

### Geographical location of PICTs

tropical-subtropical Pacific  
typically influenced by ENSO and SPCZ

### Severe droughts and floods

Super El Niño and double-dip La Niña  
multi-year drought and flood conditions

### ENSO predictable ~ several seasons

Different flavor/evolution characteristics  
Locality of impact & Sparse monitoring

Multi-sectoral impact of drought/flood  
agriculture, water, health, tourism, etc.

## Seasonal prediction of extremes

### Statistical prediction system

SCOPIC provides statistical prediction,  
drought monitoring, data analysis tools ...

### Hybrid dynamical-statistical prediction

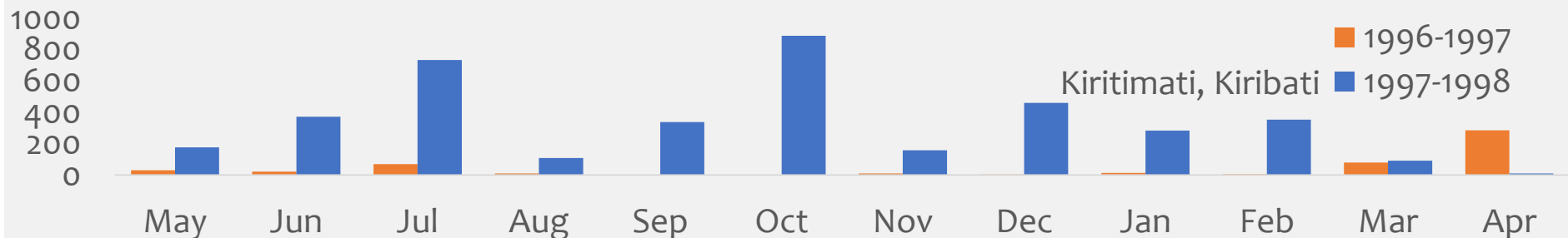
PICASO provides tailored dynamical MME  
prediction at station level

### Climate Outlook Forum (COFs)

Regional and national level drought and  
flood information is shared and discussed

### Dynamically downscaled ML system

APCC provides dynamically downscaled +  
ML-based drought monitoring system



# APCC's Climate Services in the Pacific



Tailored Multi-Model Ensemble dynamical seasonal prediction  
CliKp and **PICASO** (ROK-PI CliPS ~ PICAPS) – serviced by SPREP

## Disaster risk reduction

Tropical cyclone prediction (South Pacific) – subseasonal cyclogenesis  
Drought monitoring (RCM + ML) system – downscaled drought information

## Sectoral application of climate information

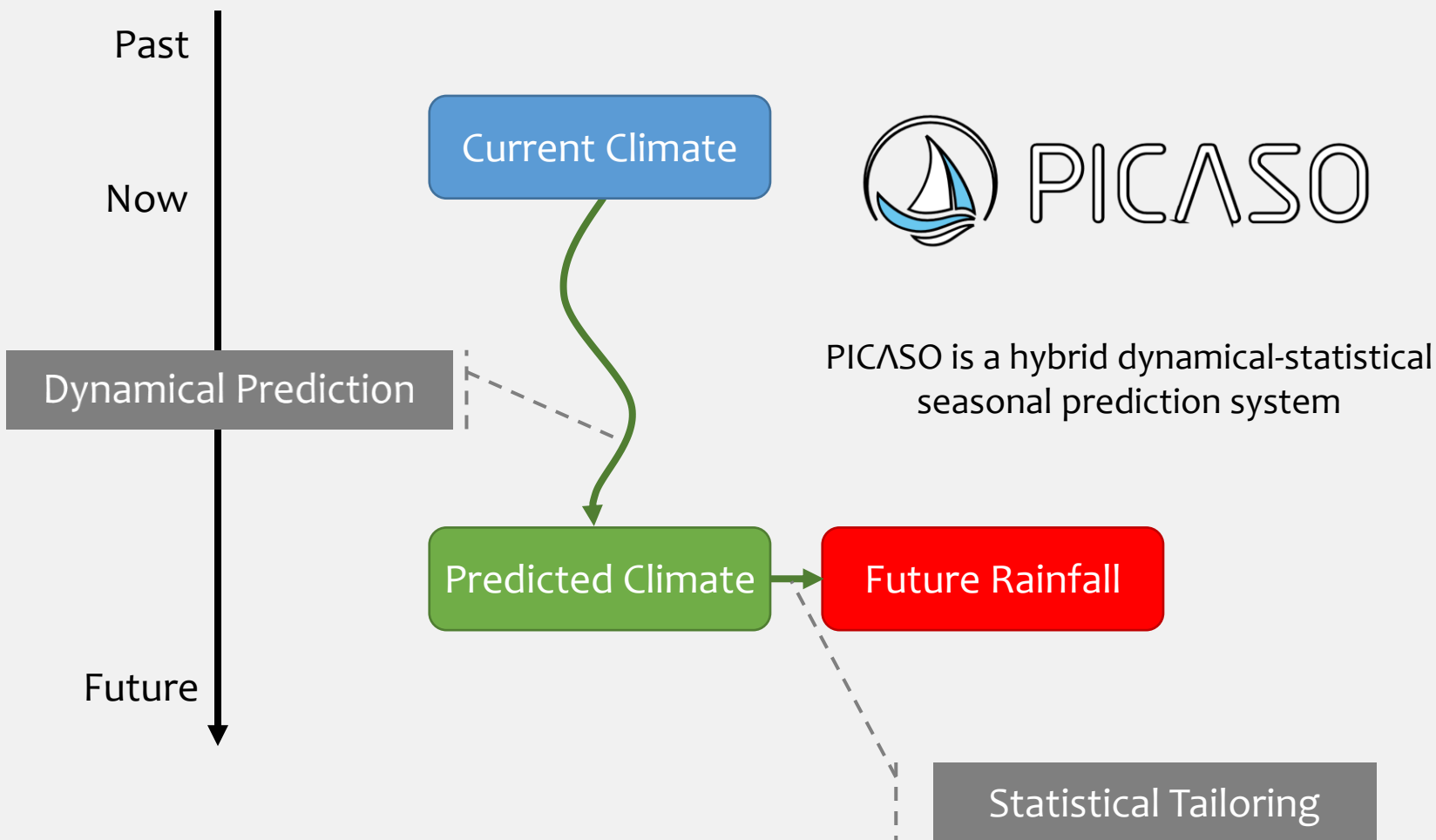
ToGWIS (GroundWater Information Service) – monitoring, modeling, prediction  
ToCSA (Climate-Smart Agriculture) – decision support system

## Multi-aspect climate information services for resilient development

Van-CISRDP (Green Climate Fund) – climate information for sectors

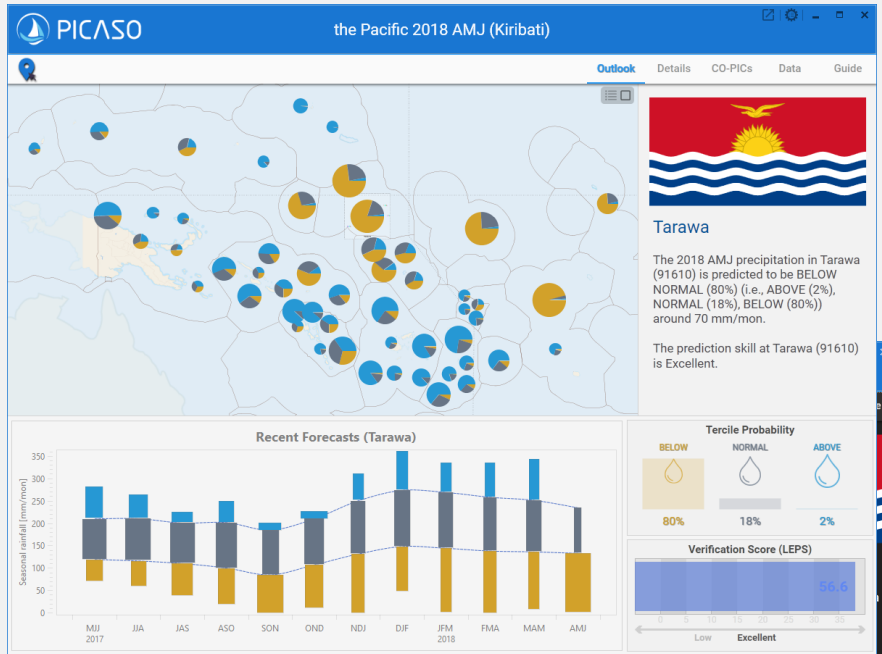
## Capacity building and sustainability program

Young Scientist Support Program (YSSP) – Pacific YSSP 2015/2017

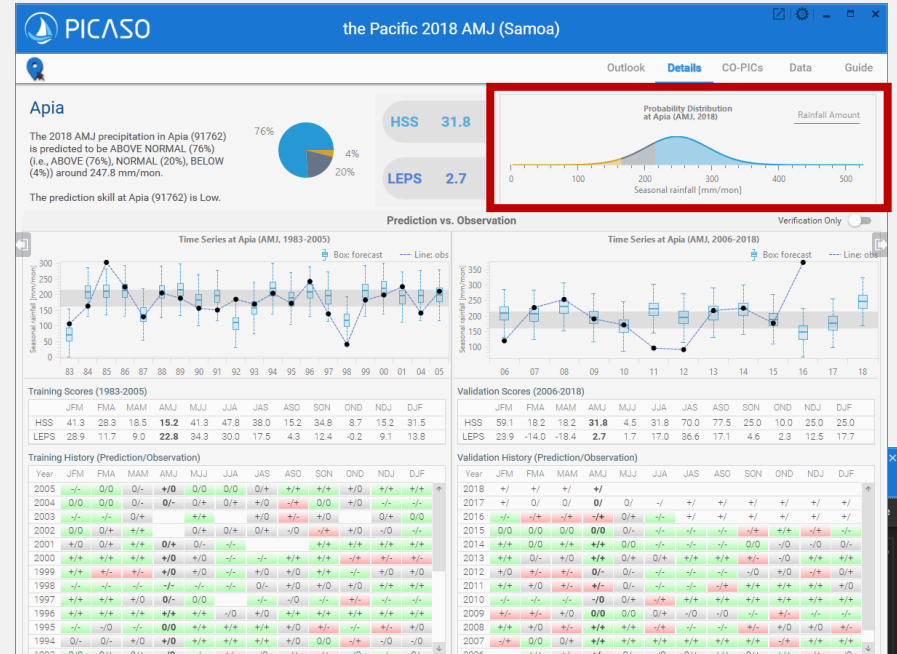


# PICASO: accurate, tailored, and easy

## Outlook: Climate at a glance

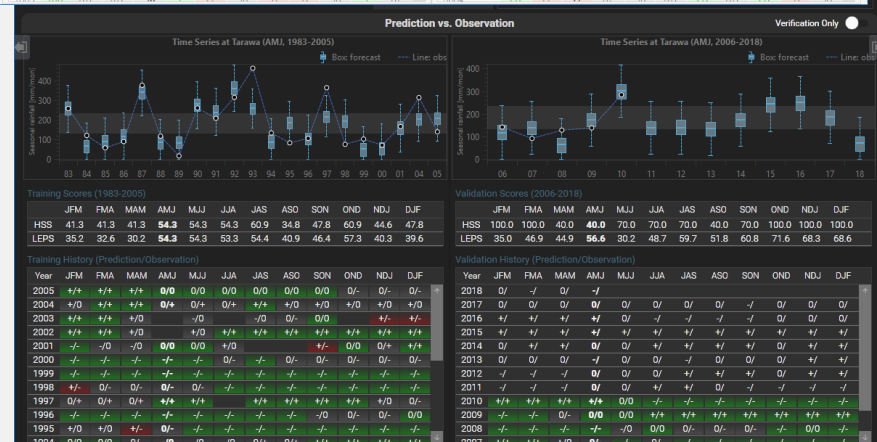


## Details: All the information you need



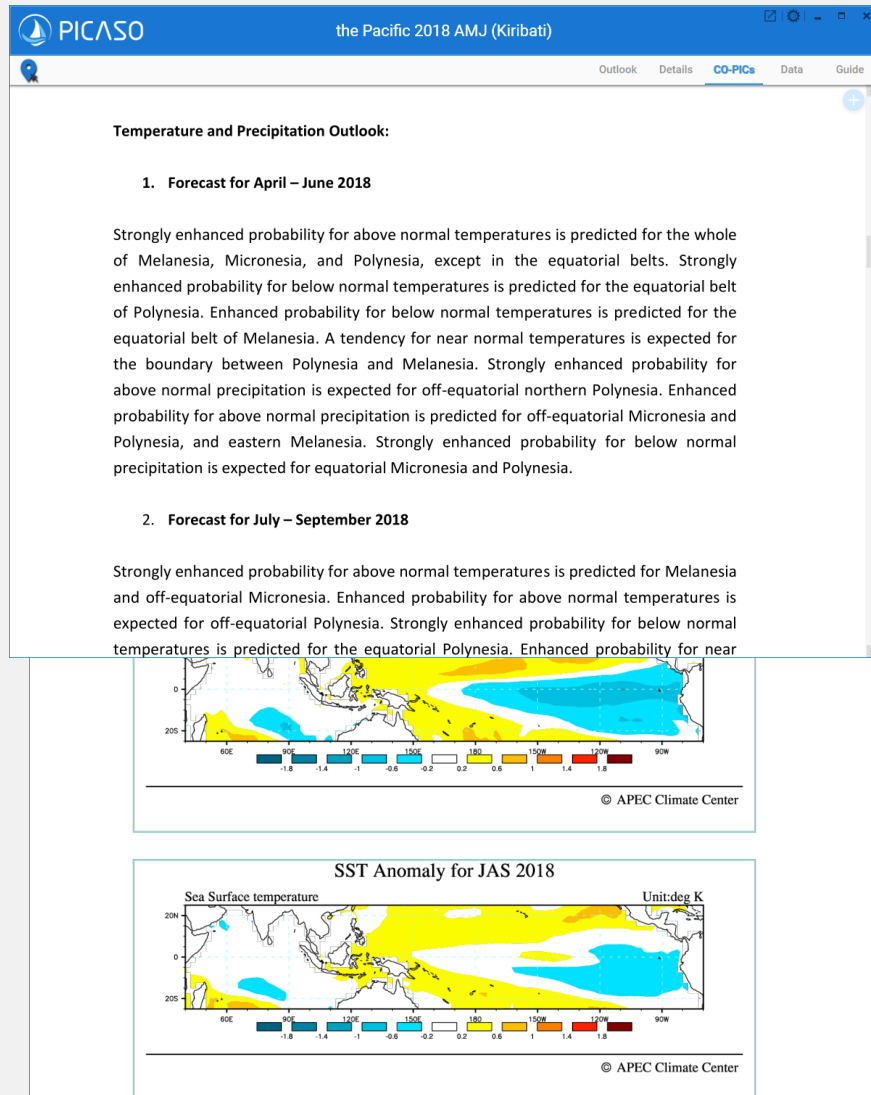
**PICASO OUTLOOK TABLE**

Station	Tercile Probability			Verification Score (LEPS)	Verification Score (HSS)	Hit/Near/Miss/Max
<b>Rotuma</b>	16%	32%	52%	29.7	Very High	-20
<b>Udu Point</b>	16%	79%		21.2	High	100
<b>Nabowale</b>	12%	34%	54%	42.8	Excellent	70
<b>Nadi Airport</b>	31%	63%		57.8	Excellent	70
<b>Sova</b>	35%	33%	33%	-2.7	Very Low	-50
<b>Ono I Lau</b>	18%	29%	53%	7.6	Moderate	25
<b>Kiribati</b>						
<b>Kiritimati</b>	67%	31%		74.9	Excellent	70
<b>Butaritari</b>	34%	40%	26%	45.2	Excellent	118.8
<b>Tarawa</b>	42%	43%	15%	68.6	Excellent	100
<b>Kanton</b>	75%	23%		66.8	Excellent	70
<b>Marshall Islands</b>						
<b>Kwajalein Bucholz Aaf</b>	28%	36%	36%	2.6	Low	10



# PICASO: accurate, tailored, and easy

## CO-PICs: Set the large-scale context



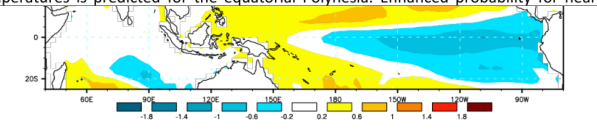
**Temperature and Precipitation Outlook:**

- Forecast for April – June 2018**

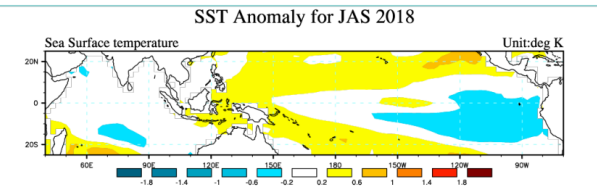
Strongly enhanced probability for above normal temperatures is predicted for the whole of Melanesia, Micronesia, and Polynesia, except in the equatorial belts. Strongly enhanced probability for below normal temperatures is predicted for the equatorial belt of Polynesia. Enhanced probability for below normal temperatures is predicted for the equatorial belt of Melanesia. A tendency for near normal temperatures is expected for the boundary between Polynesia and Melanesia. Strongly enhanced probability for above normal precipitation is expected for off-equatorial northern Polynesia. Enhanced probability for above normal precipitation is predicted for off-equatorial Micronesia and Polynesia, and eastern Melanesia. Strongly enhanced probability for below normal precipitation is expected for equatorial Micronesia and Polynesia.

- Forecast for July – September 2018**

Strongly enhanced probability for above normal temperatures is predicted for Melanesia and off-equatorial Micronesia. Enhanced probability for above normal temperatures is expected for off-equatorial Polynesia. Strongly enhanced probability for below normal temperatures is predicted for the equatorial Polynesia. Enhanced probability for near

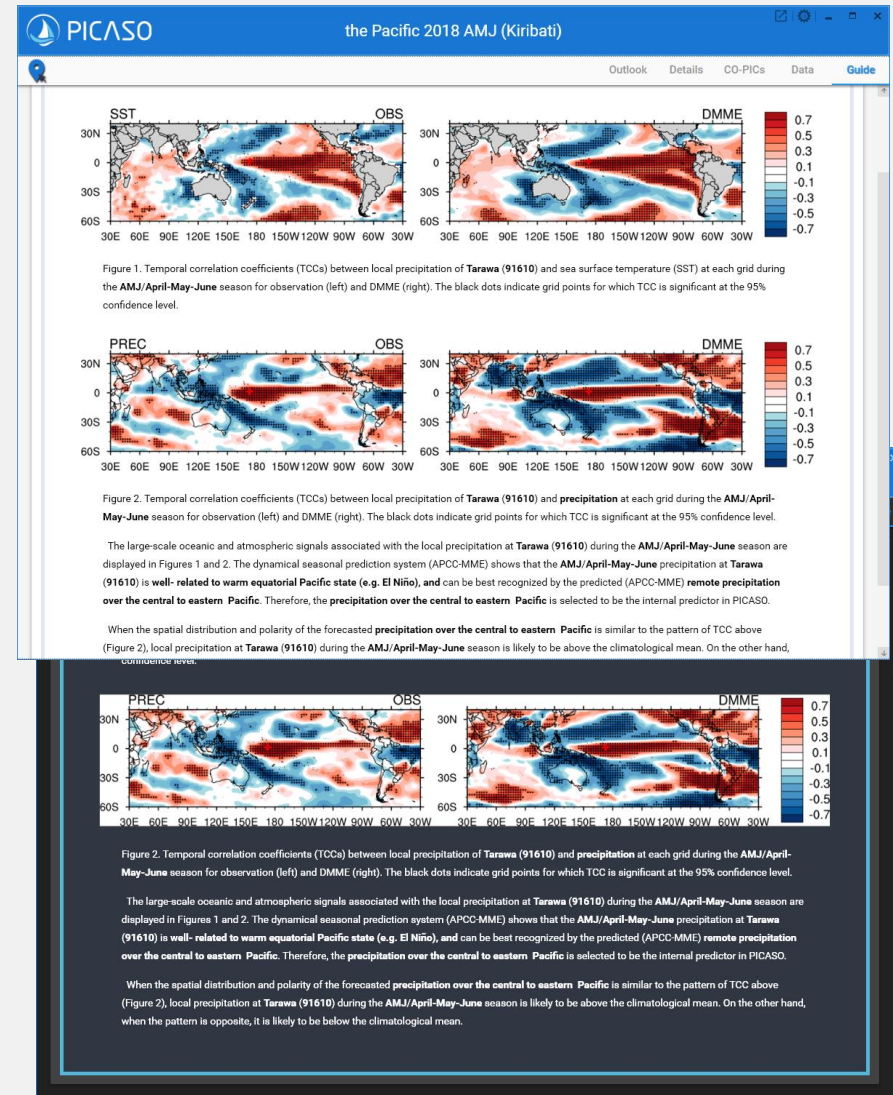


© APEC Climate Center



© APEC Climate Center

## Guide: Look beyond the prediction

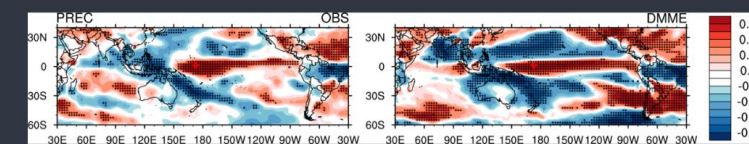


**Figure 1.** Temporal correlation coefficients (TCCs) between local precipitation of Tarawa (91610) and sea surface temperature (SST) at each grid during the AMJ/April-May-June season for observation (left) and DMME (right). The black dots indicate grid points for which TCC is significant at the 95% confidence level.

**Figure 2.** Temporal correlation coefficients (TCCs) between local precipitation of Tarawa (91610) and precipitation at each grid during the AMJ/April-May-June season for observation (left) and DMME (right). 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 Tarawa (91610) during the AMJ/April-May-June season are displayed in Figures 1 and 2. The dynamical seasonal prediction system (APCC-MME) shows that the AMJ/April-May-June precipitation at Tarawa (91610) is well-related to warm equatorial Pacific state (e.g. El Niño), and can be best recognized by the predicted (APCC-MME) remote precipitation over the central to eastern Pacific. Therefore, the precipitation over the central to eastern Pacific is selected to be the internal predictor in PICASO.

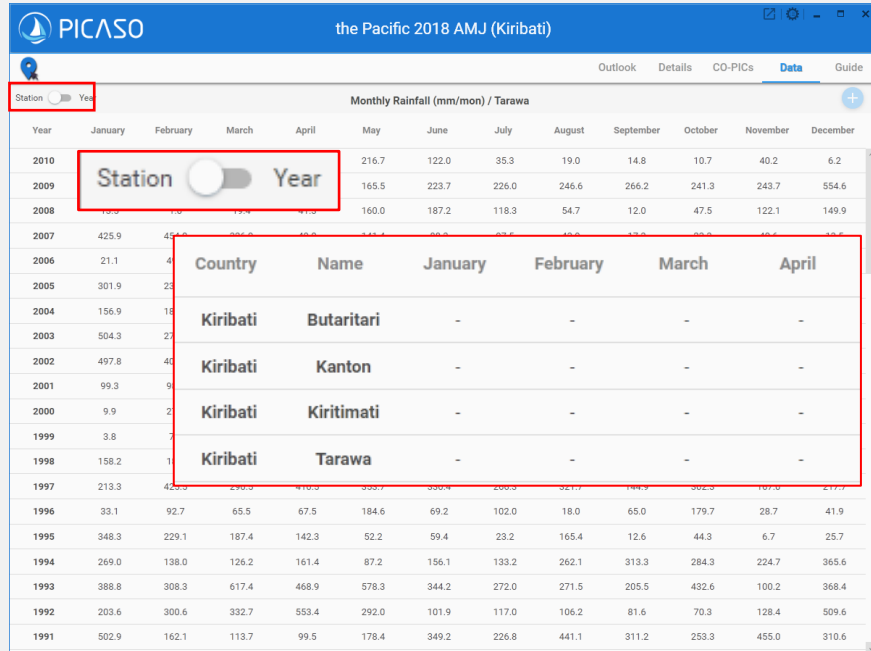
When the spatial distribution and polarity of the forecasted precipitation over the central to eastern Pacific is similar to the pattern of TCC above (Figure 2), local precipitation at Tarawa (91610) during the AMJ/April-May-June season is likely to be above the climatological mean. On the other hand, when the pattern is opposite, it is likely to be below the climatological mean.



© APEC Climate Center

# PICASO: accurate, tailored, and easy

## Data: Privately manage your data



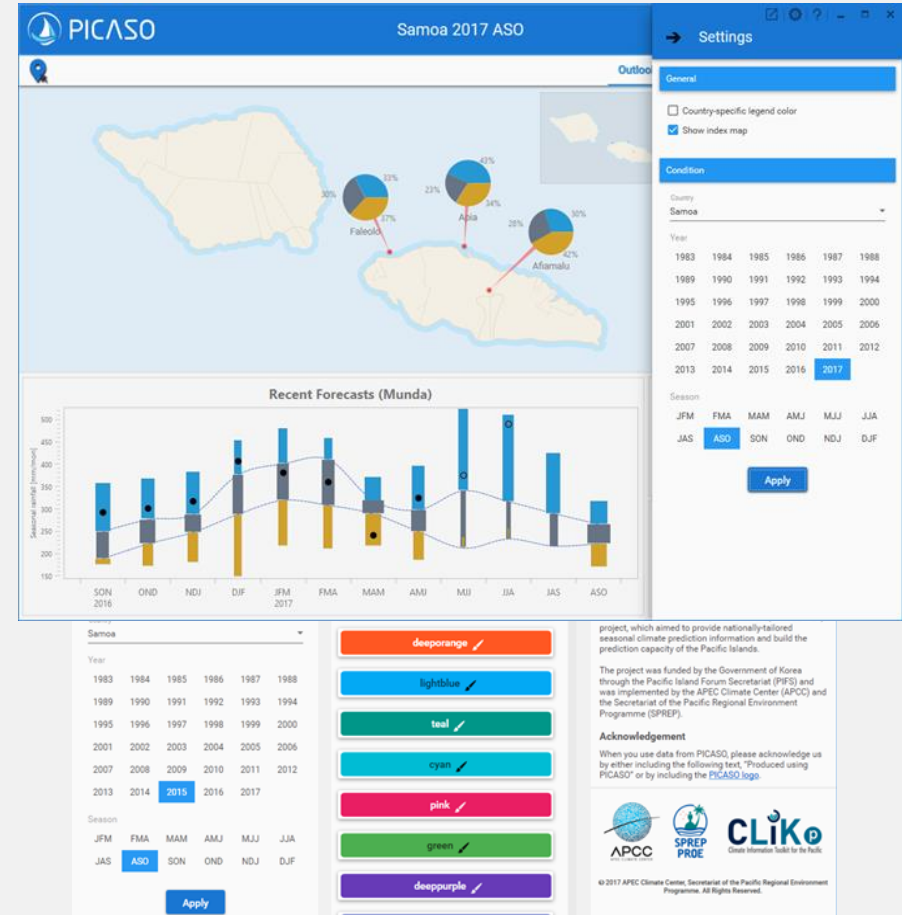
Station  Year

Monthly Rainfall (mm/mon) / Tarawa

Year	January	February	March	April	May	June	July	August	September	October	November	December
2010					216.7	122.0	35.3	19.0	14.8	10.7	40.2	6.2
2009					165.5	223.7	226.0	246.6	266.2	241.3	243.7	554.6
2008					160.0	187.2	118.3	54.7	12.0	47.5	122.1	149.9
2007	425.9	451.4	385.6	385.6	311.2	252.6	237.6	198.8	133.6	88.3	48.4	18.7
2006	21.1	4	4	4	4	4	4	4	4	4	4	4
2005	301.9	23	23	23	23	23	23	23	23	23	23	23
2004	156.9	18	18	18	18	18	18	18	18	18	18	18
2003	504.3	27	27	27	27	27	27	27	27	27	27	27
2002	497.8	40	40	40	40	40	40	40	40	40	40	40
2001	99.3	9	9	9	9	9	9	9	9	9	9	9
2000	9.9	2	2	2	2	2	2	2	2	2	2	2
1999	3.8	7	7	7	7	7	7	7	7	7	7	7
1998	158.2	1	1	1	1	1	1	1	1	1	1	1
1997	213.3	425.9	451.4	385.6	385.6	311.2	252.6	237.6	198.8	133.6	88.3	48.4
1996	33.1	92.7	65.5	67.5	184.6	69.2	102.0	18.0	65.0	179.7	28.7	41.9
1995	348.3	229.1	187.4	142.3	52.2	59.4	23.2	165.4	12.6	44.3	6.7	25.7
1994	269.0	138.0	126.2	161.4	87.2	156.1	133.2	262.1	313.3	284.3	224.7	365.6
1993	388.8	308.3	617.4	468.9	578.3	344.2	272.0	271.5	205.5	432.6	100.2	368.4
1992	203.6	300.6	332.7	553.4	292.0	101.9	117.0	106.2	81.6	70.3	128.4	509.6
1991	502.9	162.1	113.7	99.5	178.4	349.2	226.8	441.1	311.2	253.3	455.0	310.6

Country	Name	January	February	March	April
Kiribati	Butaritari	-	-	-	-
Kiribati	Kanton	-	-	-	-
Kiribati	Kiritimati	-	-	-	-
Kiribati	Tarawa	-	-	-	-

## Settings: Build your own PICASO



Samoa 2017 ASO

Settings

General

- Country-specific legend color
- Show index map

Condition

Country Samoa

Year

1983 1984 1985 1986 1987 1988  
1989 1990 1991 1992 1993 1994  
1995 1996 1997 1998 1999 2000  
2001 2002 2003 2004 2005 2006  
2007 2008 2009 2010 2011 2012  
2013 2014 2015 2016 2017

Season

JFM FMA MAM AMJ MJJ JJA  
JAS ASO SON OND NDJ DJF

Apply

Recent Forecasts (Munda)

Seasonal rainfall (mm/mon)

SON 2016 OND NDI DJF JFM FMA MAM AMJ MJJ JJA JAS ASO

Samoa

Year

1983 1984 1985 1986 1987 1988  
1989 1990 1991 1992 1993 1994  
1995 1996 1997 1998 1999 2000  
2001 2002 2003 2004 2005 2006  
2007 2008 2009 2010 2011 2012  
2013 2014 2015 2016 2017

Season

JFM FMA MAM AMJ MJJ JJA  
JAS ASO SON OND NDJ DJF

Apply

Color palette:

- deeporange ✓
- lightblue ✓
- teal ✓
- cyan ✓
- pink ✓
- green ✓
- deeppurple ✓

project, which aimed to provide nationally-tailored seasonal climate prediction information and build the prediction capacity of the Pacific Islands.

The project was funded by the Government of Korea through the Pacific Island Forum Secretariat (PIFS) and was implemented by the APEC Climate Center (APCC) and the Secretariat of the Pacific Regional Environment Programme (SPREP).

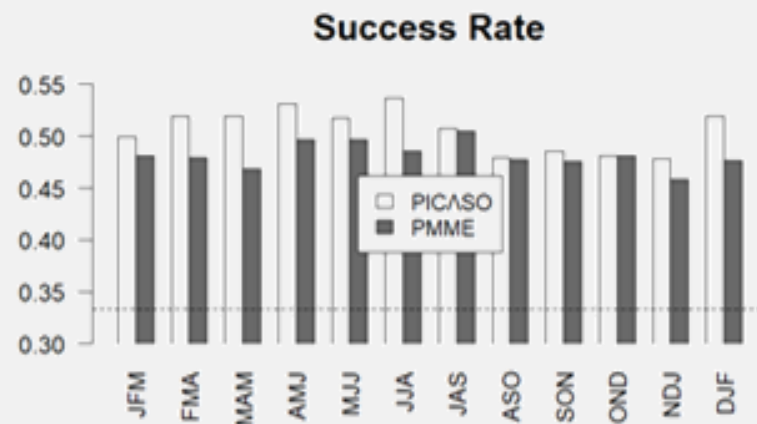
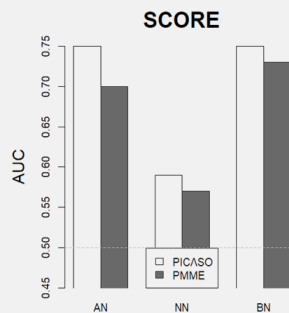
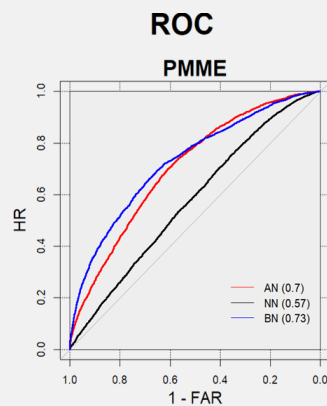
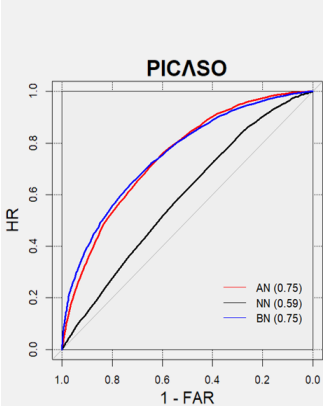
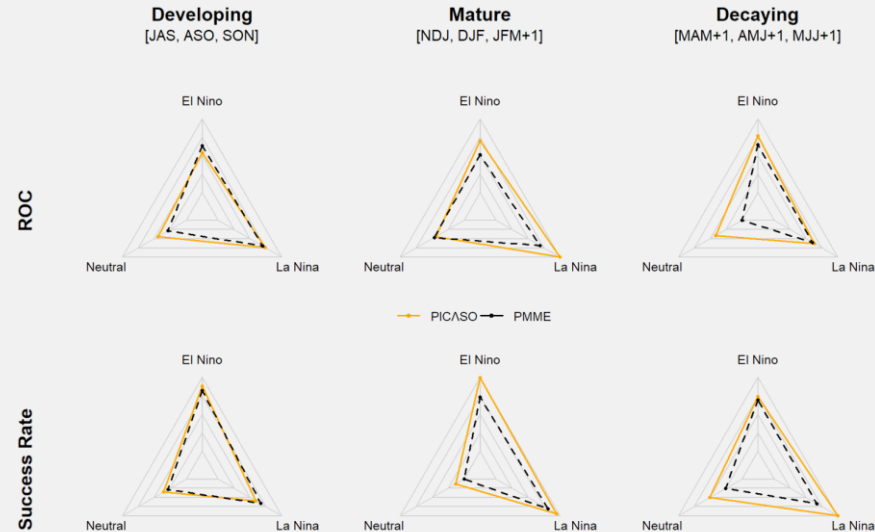
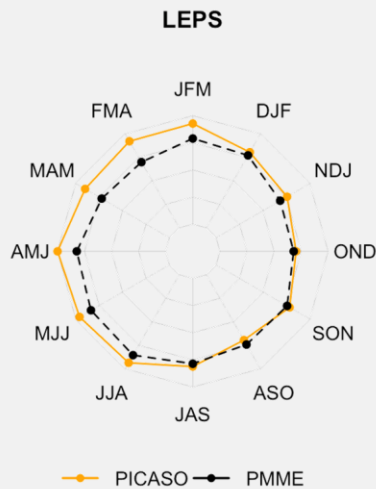
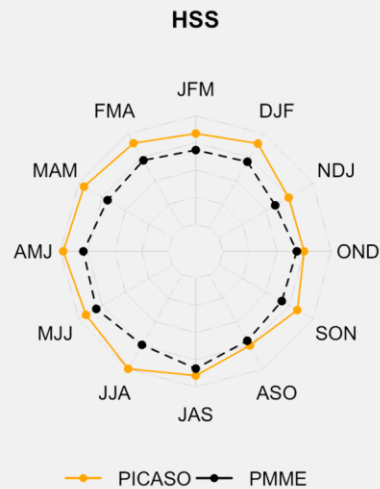
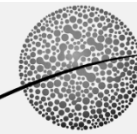
Acknowledgement

When you use data from PICASO, please acknowledge us by either including the following text, "Produced using PICASO" or by including the PICASO logo.

APCC SPREP CLiKe

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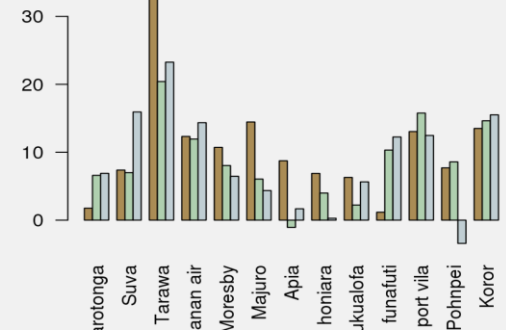
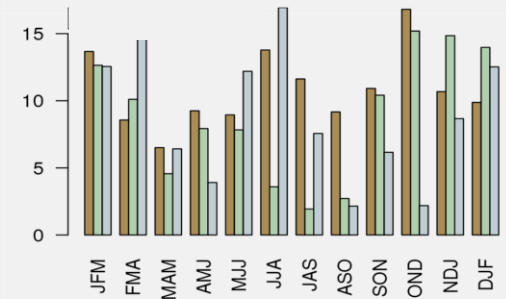
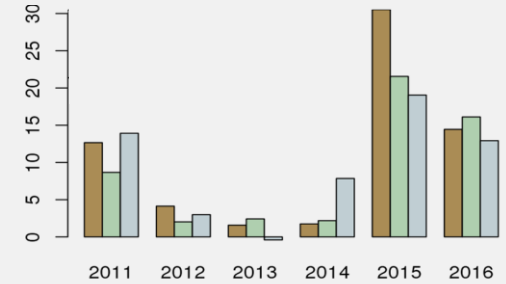
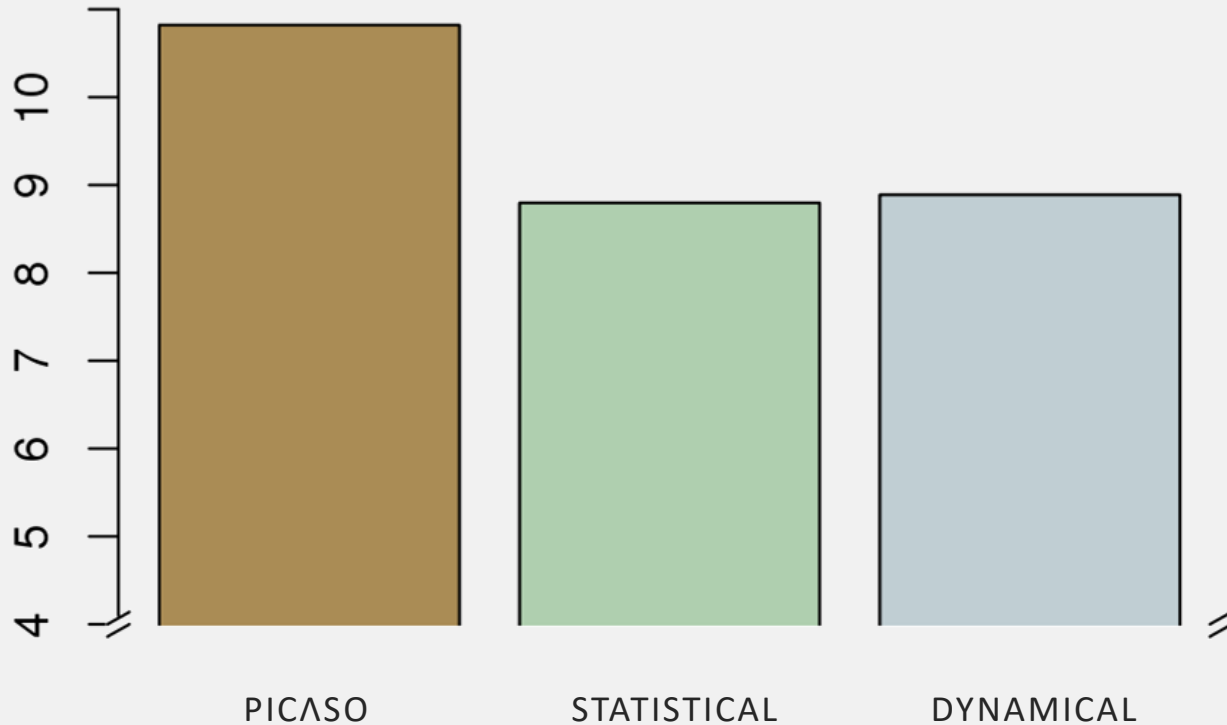
# PICASO skill improvement by tailoring



# Skills: PICASO vs Existing Systems

PICASO > MME > single dynamical ~ statistical

Dynamical approach often outperforms statistical method.  
 Prediction skill is improved through Multi-Model Ensemble.  
 Tailoring (post-processing) can further enhance the skill.  
 As a result,  
 PICASO shows highest skill among the existing systems!



# Sustainability comes from Ownership

## Why do we want to do this?

### Climate Prediction

value-added, reliable, and real-time climate prediction information

### Interdisciplinary Research

development of interdisciplinary research and application techniques

### Climate Information Services

climate center to distribute climate data, information products, and related tools

### International Cooperation

building their own capacity to produce reliable climate prediction information

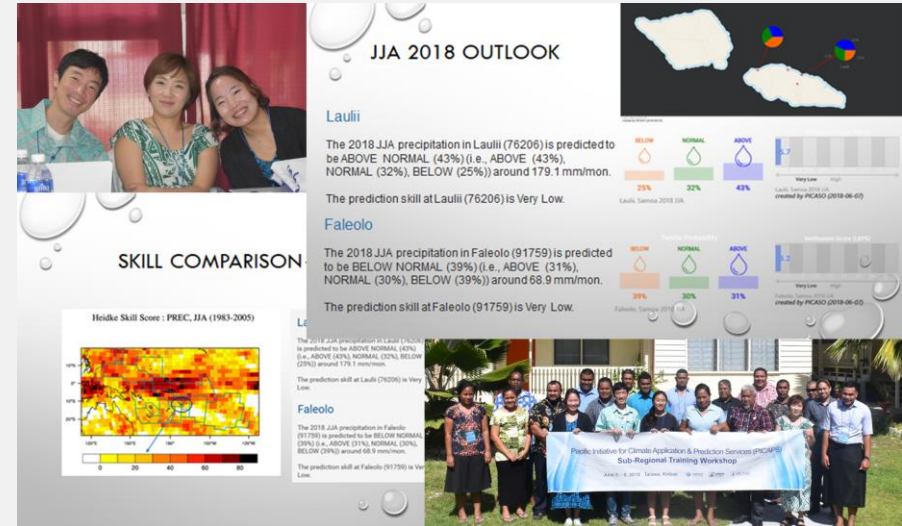
## Capacity building for sustainability

Relevant target setting

Transfer of the ownership

## Target-oriented capacity building

### Workshop/training, continuous



Where to go?

# Set the compass for future climate services

## Pacific Islands Meteorology Strategy (PIMS) 2017–2026

NMHSs of the PICTs provide relevant weather, climate, water and ocean services to their people to make informed decisions for their safety, socio-economic well-being, prosperity and sustainable livelihoods.

### **PRIORITY 1. IMPROVED WEATHER SERVICES**

- PKO1. Improved aviation weather services
- PKO2. Improved marine weather services and establishment of ocean services
- PKO3. Improved public weather services

### **PRIORITY 2. DISASTER RISK REDUCTION**

- PKO4. Strengthened NMHS capacity to implement Multi-Hazard Early Warning systems
- PKO5. NMHS contribution to climate change activities

### **PRIORITY 3. IMPROVED CLIMATE AND HYDROLOGICAL SERVICES**

- PKO6. Improved climate information and prediction services

### **PRIORITY 4. INTEGRATED OBSERVING/COMMUNICATION SYSTEMS**

- PKO8. Integrated observing/communication systems

### **PRIORITY 5. COORDINATED SUPPORT FOR NMHSs AND PMC**

- PKO9. NMHSs institutional strengthening and capacity development
- PKO10. Support to NMHS is coordinated
- PKO11. PMC efficient and effective via partnerships, inclusivity, consideration of staff safety, w/ funding support

# Remaining Needs and Demand

## PMC Honiara statement [Aug. 2017]

“... requested additional resources to develop a **user-friendly integrated approach** to determine the optimal prediction for higher quality forecast information in the Pacific Islands; and requested additional resources for communication, **capacity building and training of NMHS** and in-country stakeholders to ensure that the tools and products developed by ROK-PI CliPS are taken up for **decision making in sectors such as Agriculture, Health, Water, Disaster Risk Reduction, etc.**”

PMC statement from Honiara, Solomon Islands

## APCC's next step with the Pacific

### Consensus forecast information

CoCO: Consensus Climate Outlook  
simple and user-friendly method

### Increased capacity building

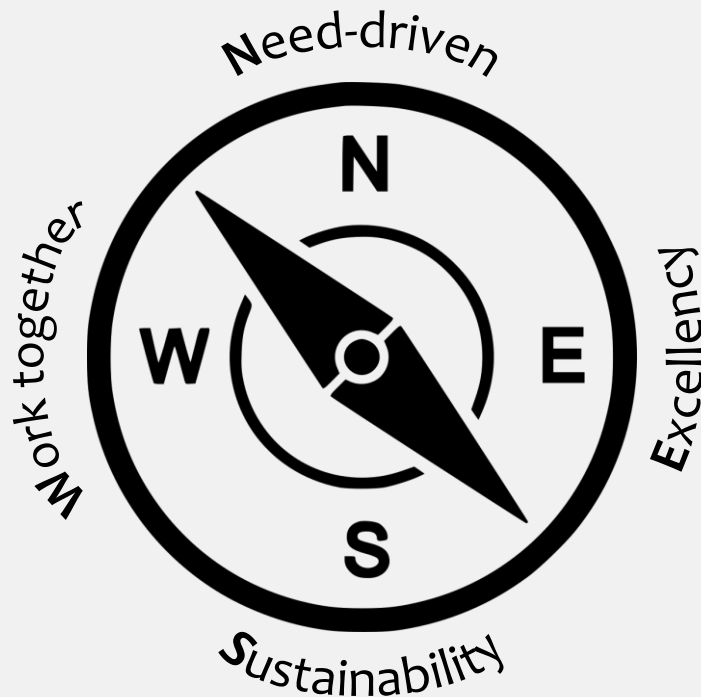
sustained & systemized usage of the highest quality climate information  
training and workshop programs

### Customized forecasts for sectors

addition of tailored T/P forecasts  
sector application of climate information

# Lessons Learned/Personal Reflection

It's not for us, but for them



It's not them, it's us!

## **Need-driven (relevance):**

Do it for greater good: it has to address the people's real needs

## **Excellency (high quality):**

Do something meaningful: appropriate cutting-edge science and technology

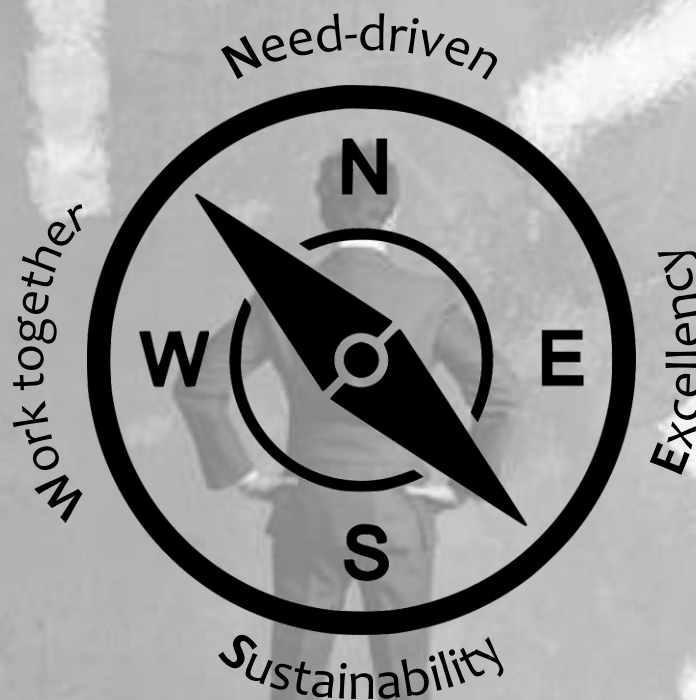
## **Work together (coordination):**

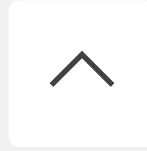
Don't duplicate: align with the existing mechanism

## **Sustainability (ownership/capacity):**

User owns it: understood, utilized, operated, and maintained by the users

# Where to Go: Set the Compass





# Gaps and Opportunities in Climate Information Services

> Lessons learned from APCC's seasonal prediction and sectoral application in the Pacific <

WonMoo Kim

Climate Services and Research Department  
APEC Climate Center (APCC), Busan, Korea

# Overcoming the challenges of an uncertain future with enhanced climate information and services