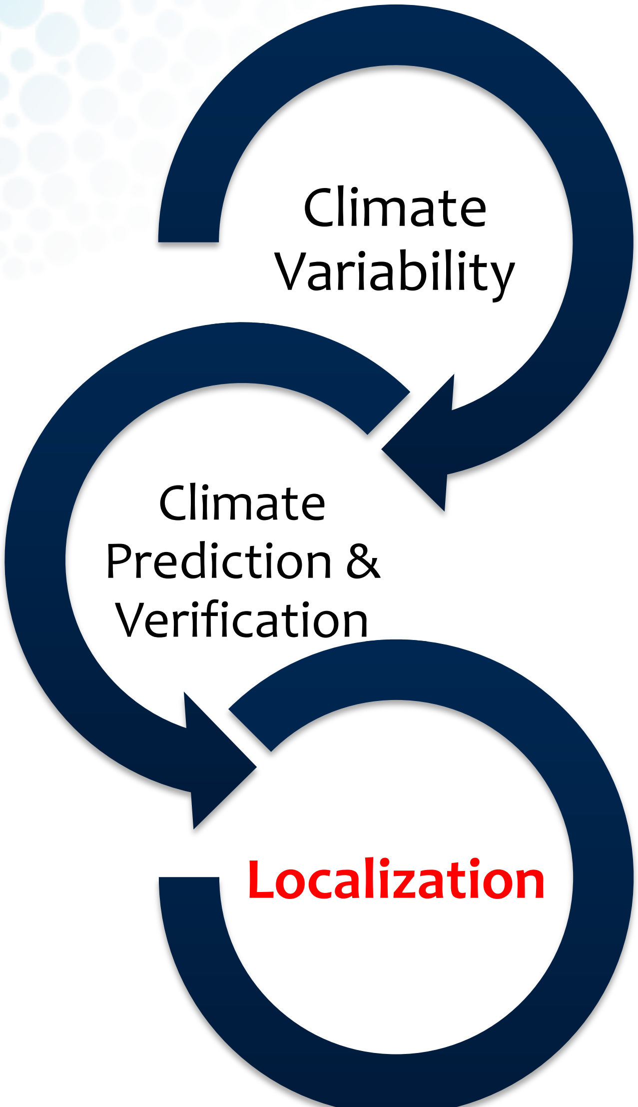
MME Seasonal Prediction & its Localization using CLIK



&

Clik
Climate Information Toolkit

Generating Seasonal Outlook

CLIK Training (28-30 Aug 2019 @ DMC, Santiago, Chile)

Downscaling of seasonal prediction

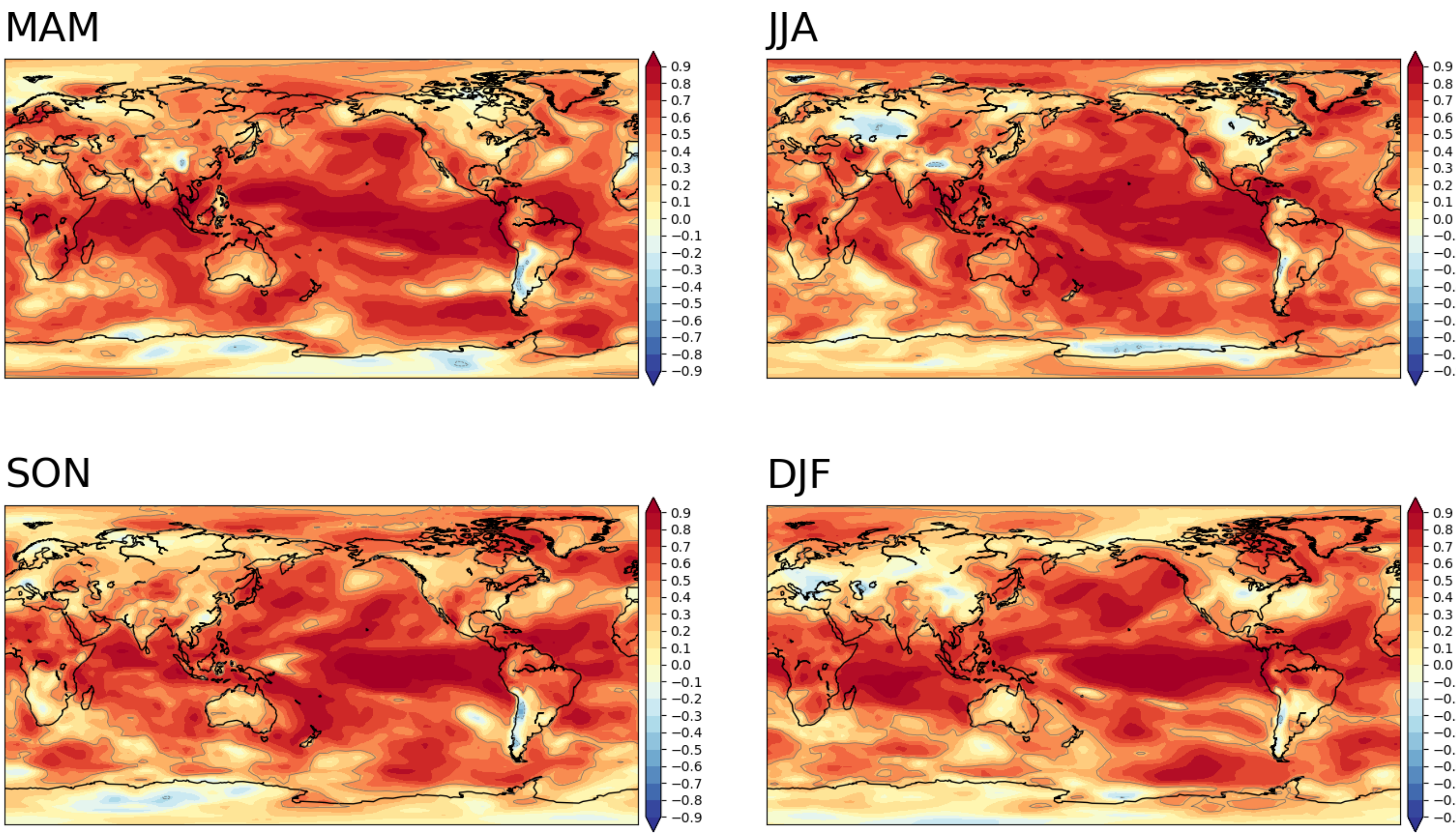
Yun-Young Lee

APCC APEC CLIMATE CENTER

Why downscaling is required?

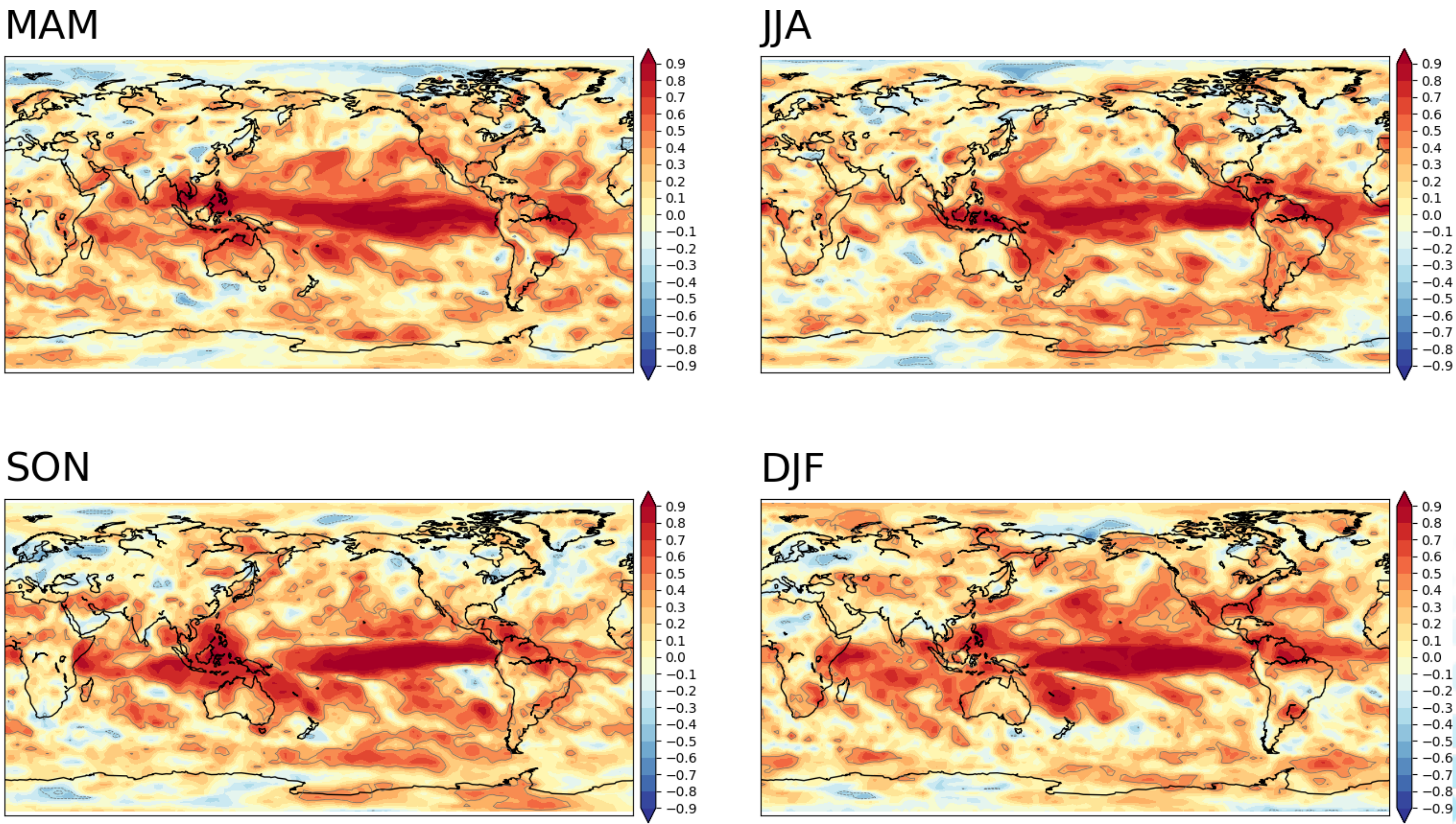
1. Low skill of dynamical seasonal forecast…

- near surface temperature…



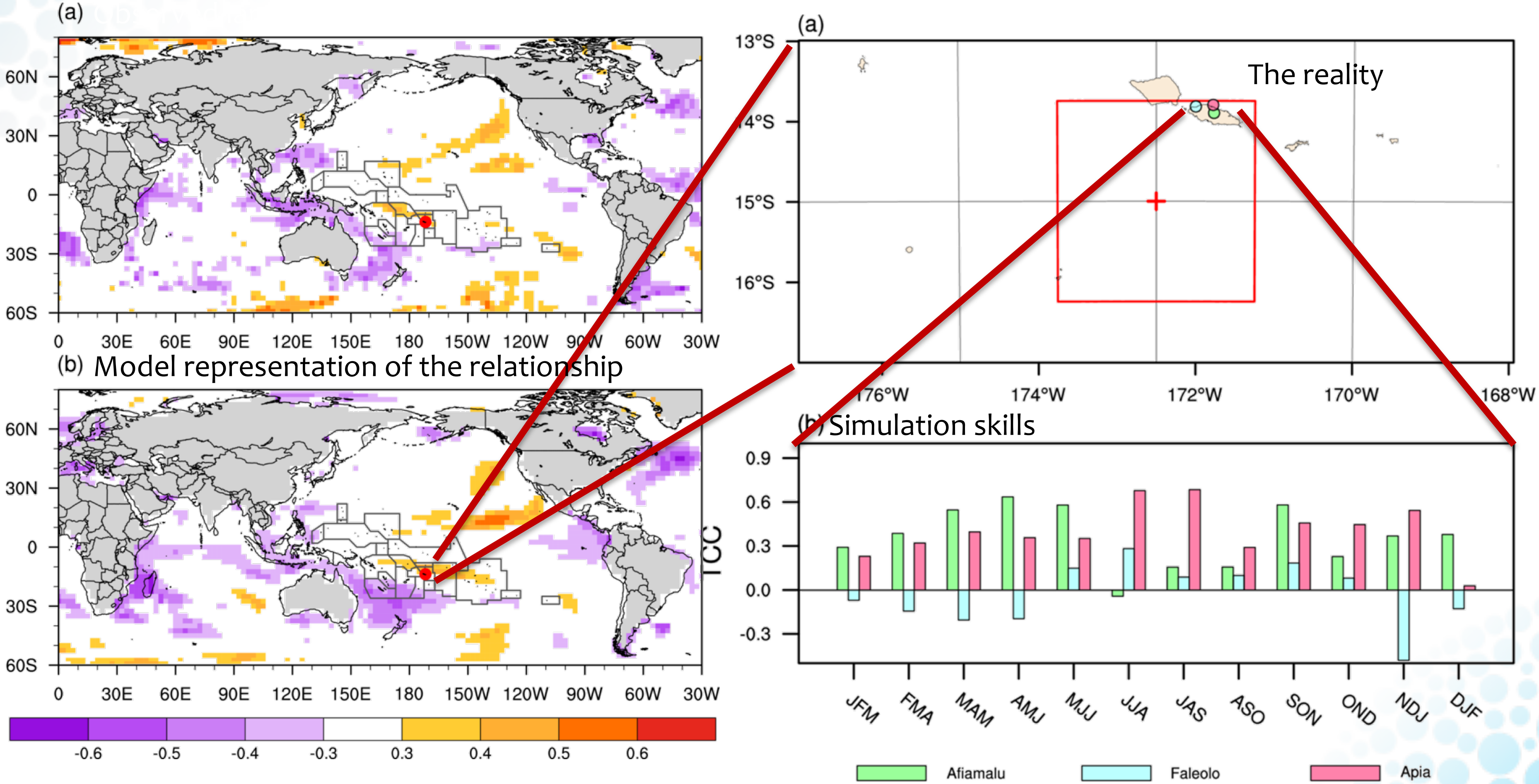
1. Low skill of dynamical seasonal forecast…

- ***Rainfall ?***
- *Outside tropical Pacific?*



2. Climate Locality

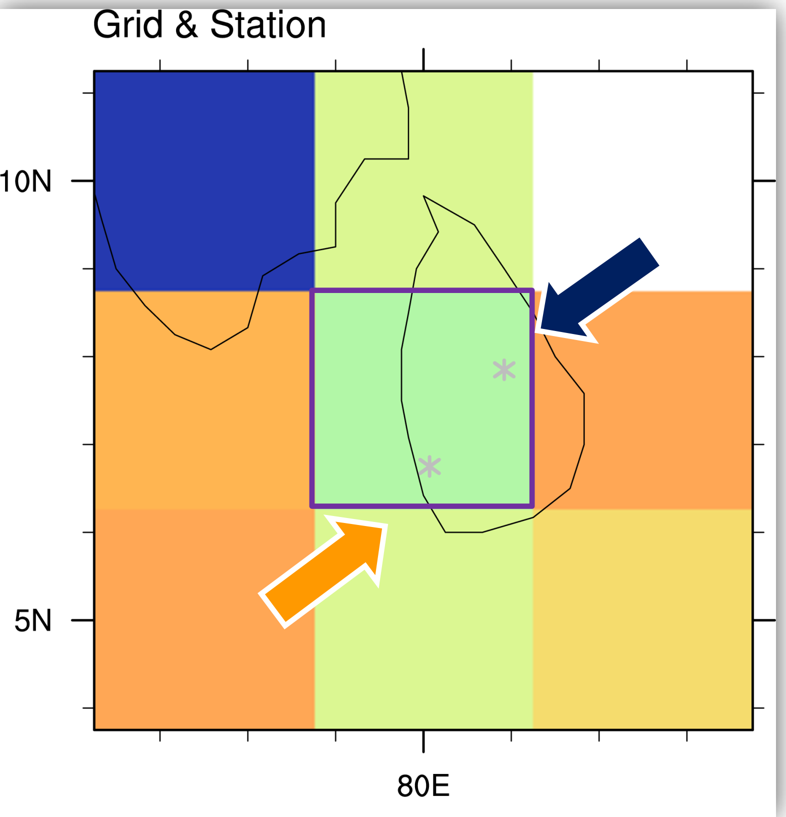
Very small Island Climate

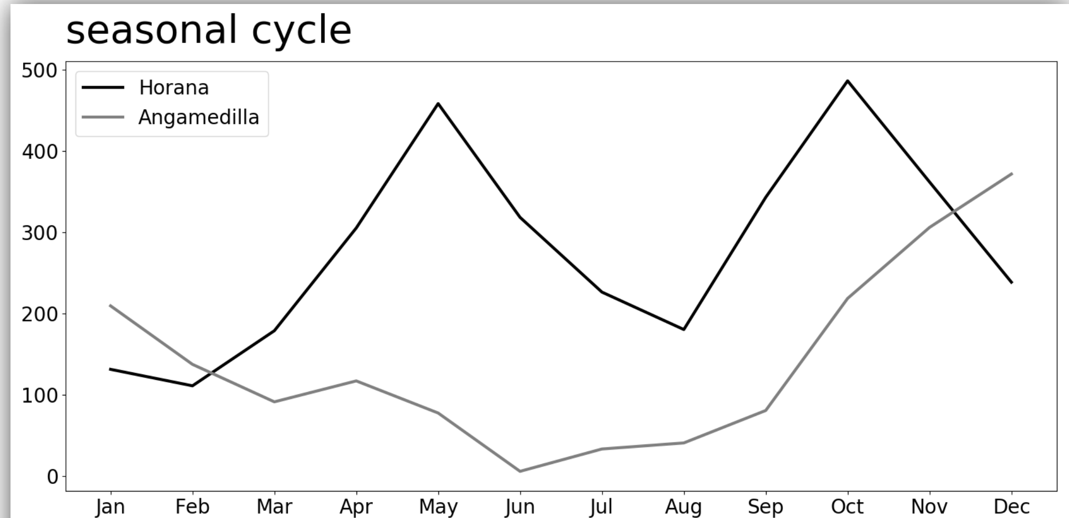


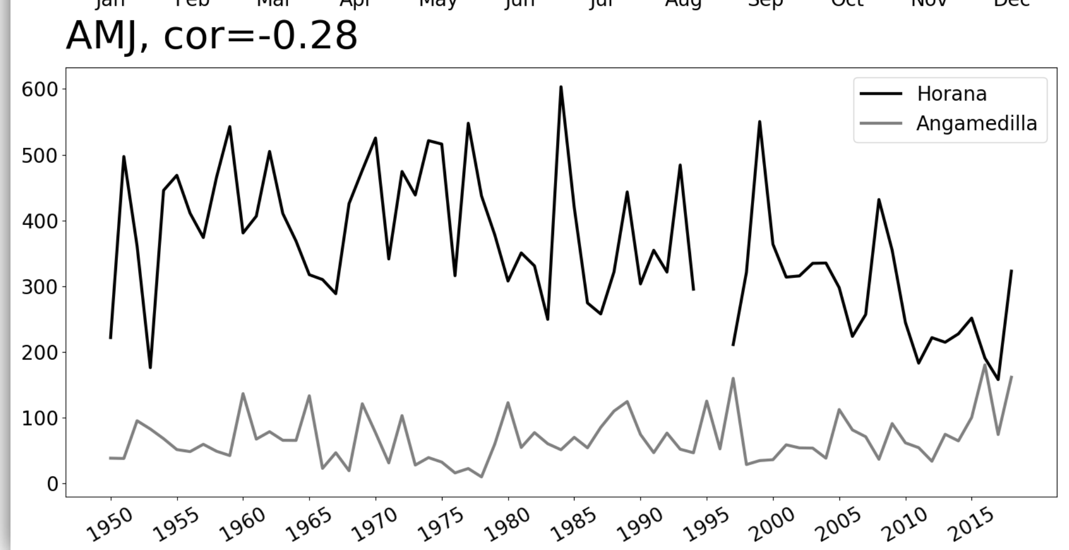
✓Can 2.5 by 2.5 grided model tell the difference of small island climate and ocean climat? Not really.

Island of Sri Lanka

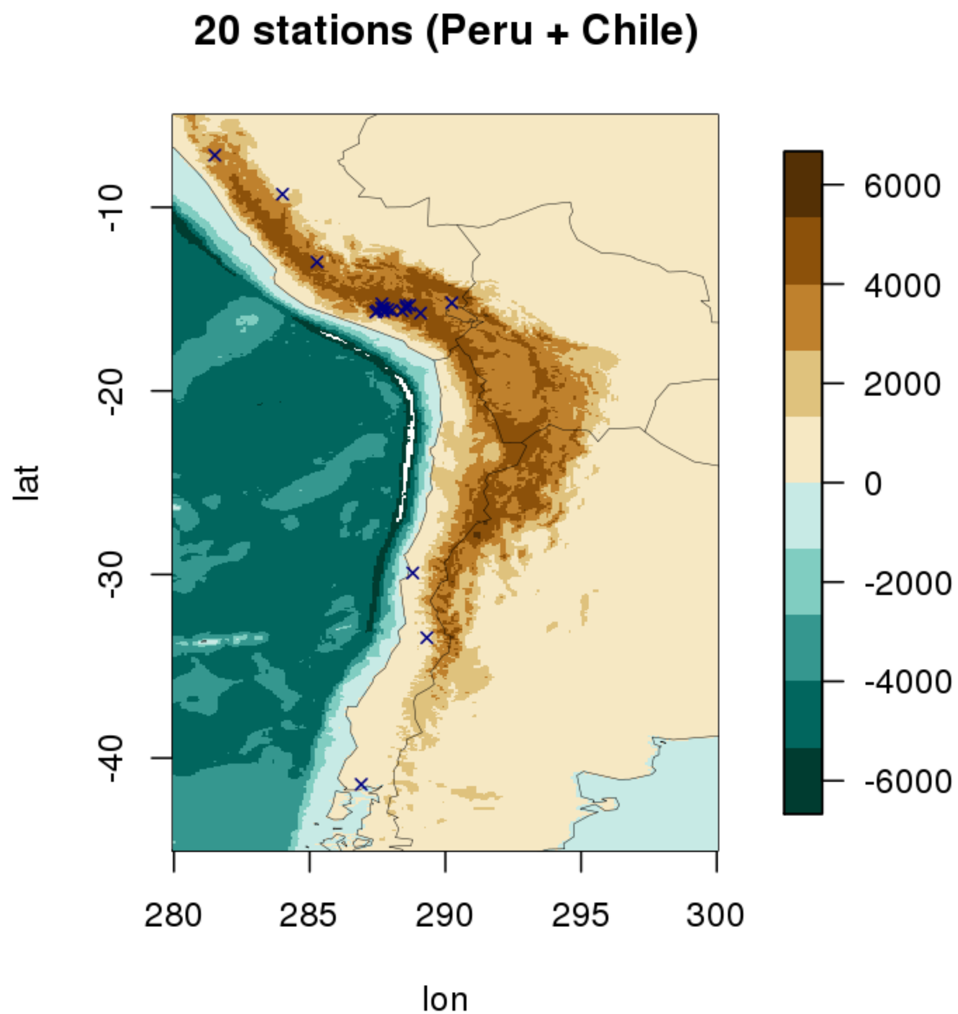
- *Horana in wet zone* ***vs*** *Angamedilla in dry zone*
- ***Almost opposite temporal variation between two stations in a grid***



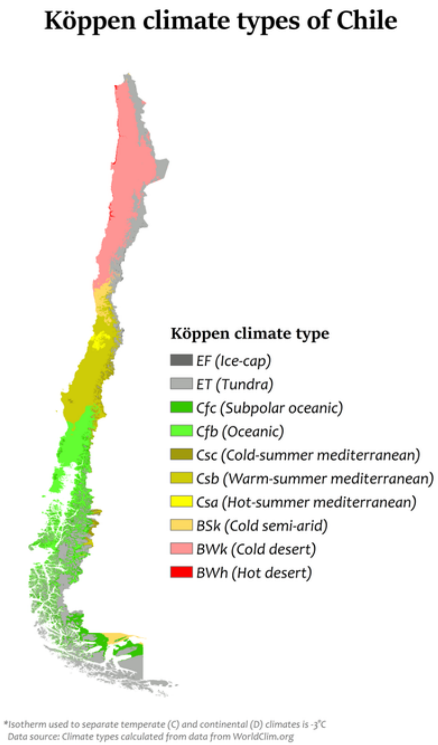




2. Climate Locality



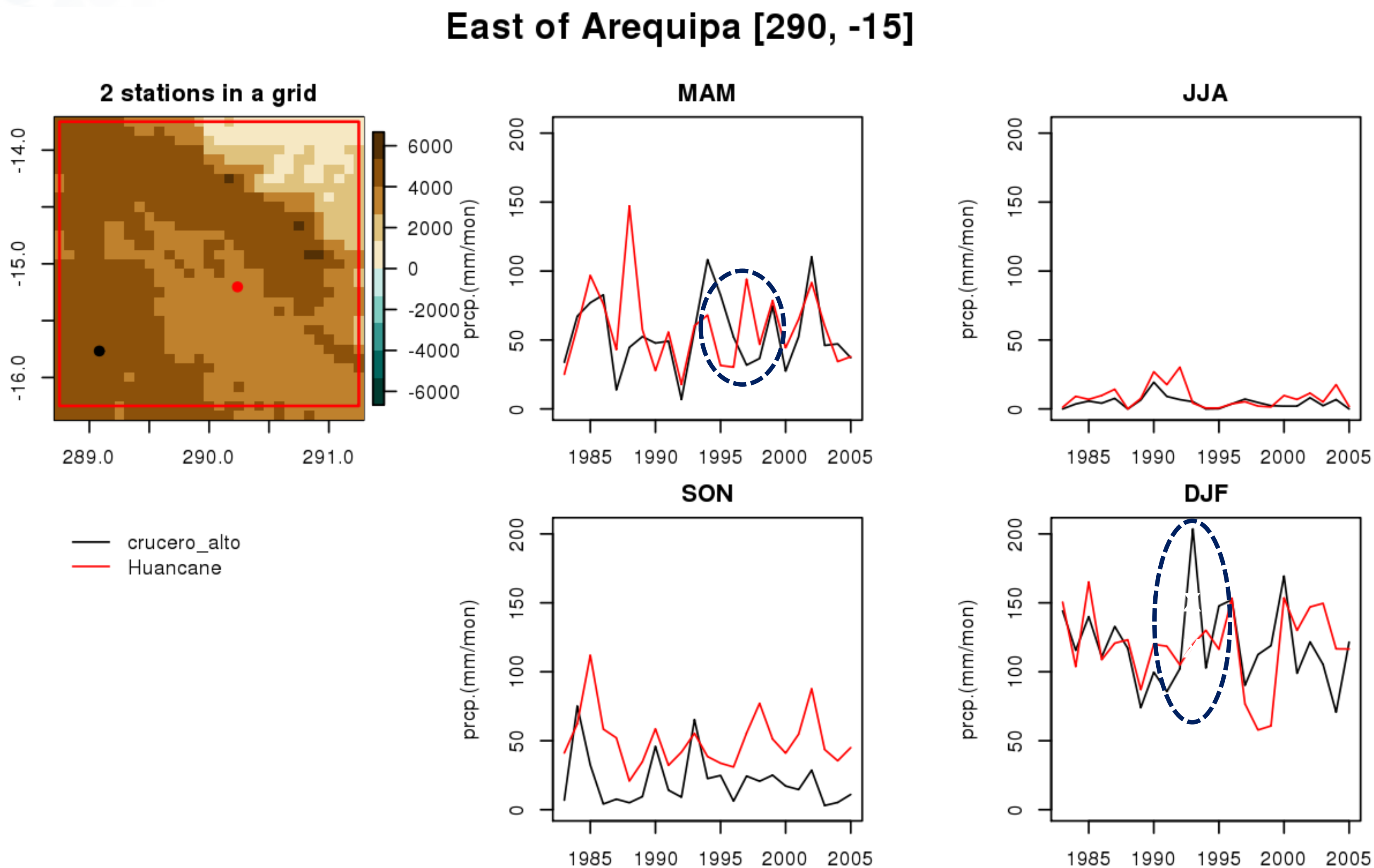
- Complicate climate of Chile



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

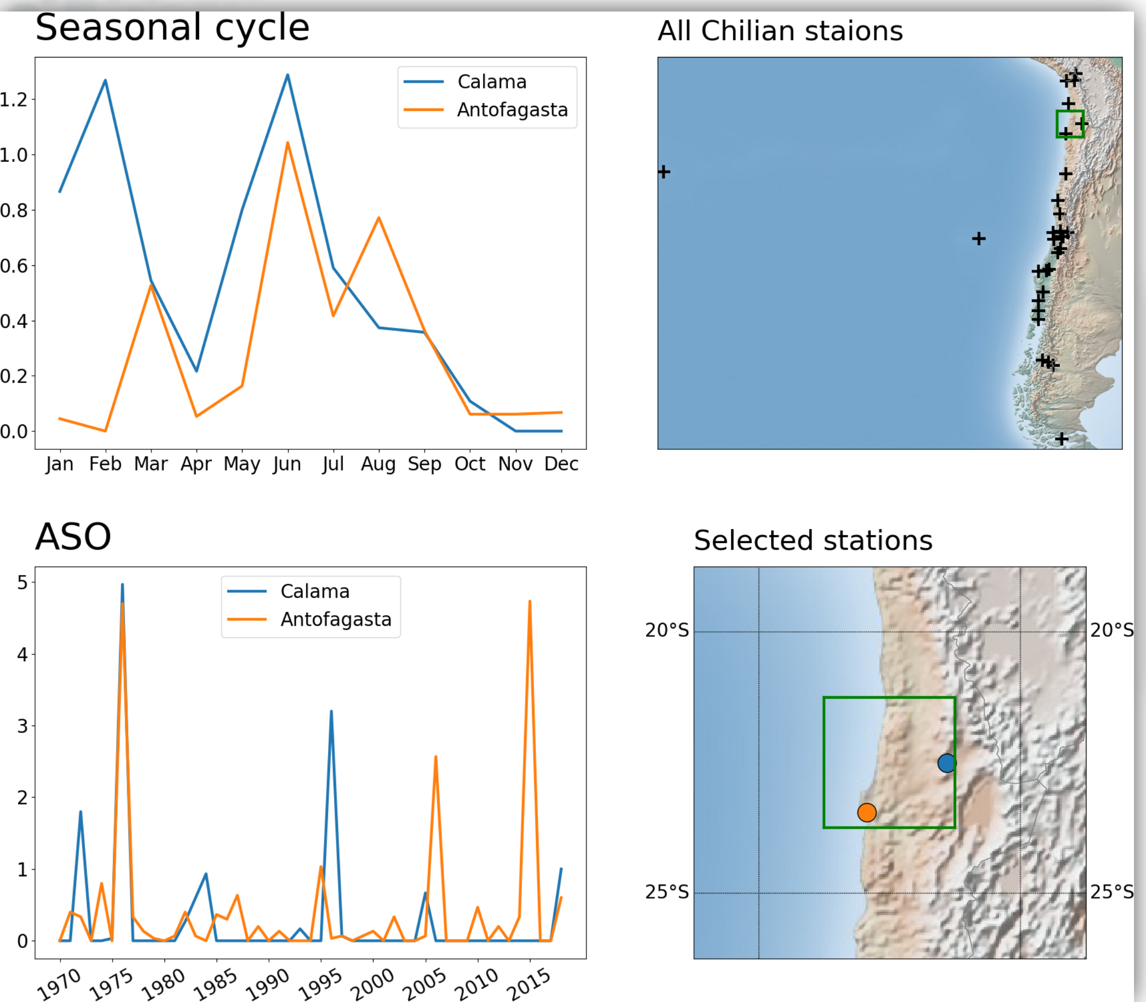
2. Climate Locality

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

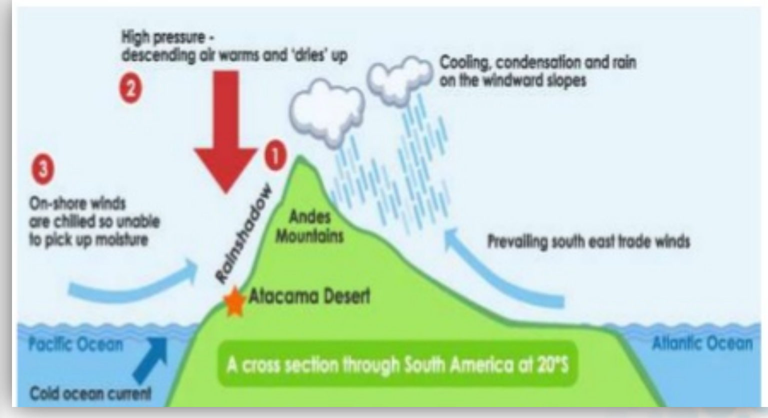


Northern arid region: RR Coast & Inland?

- ***2 stations (Calama & Antofagasta) in a grid (2.5degLat by 2.5 degLon)***
- ***Less consistency among stations in a grid***

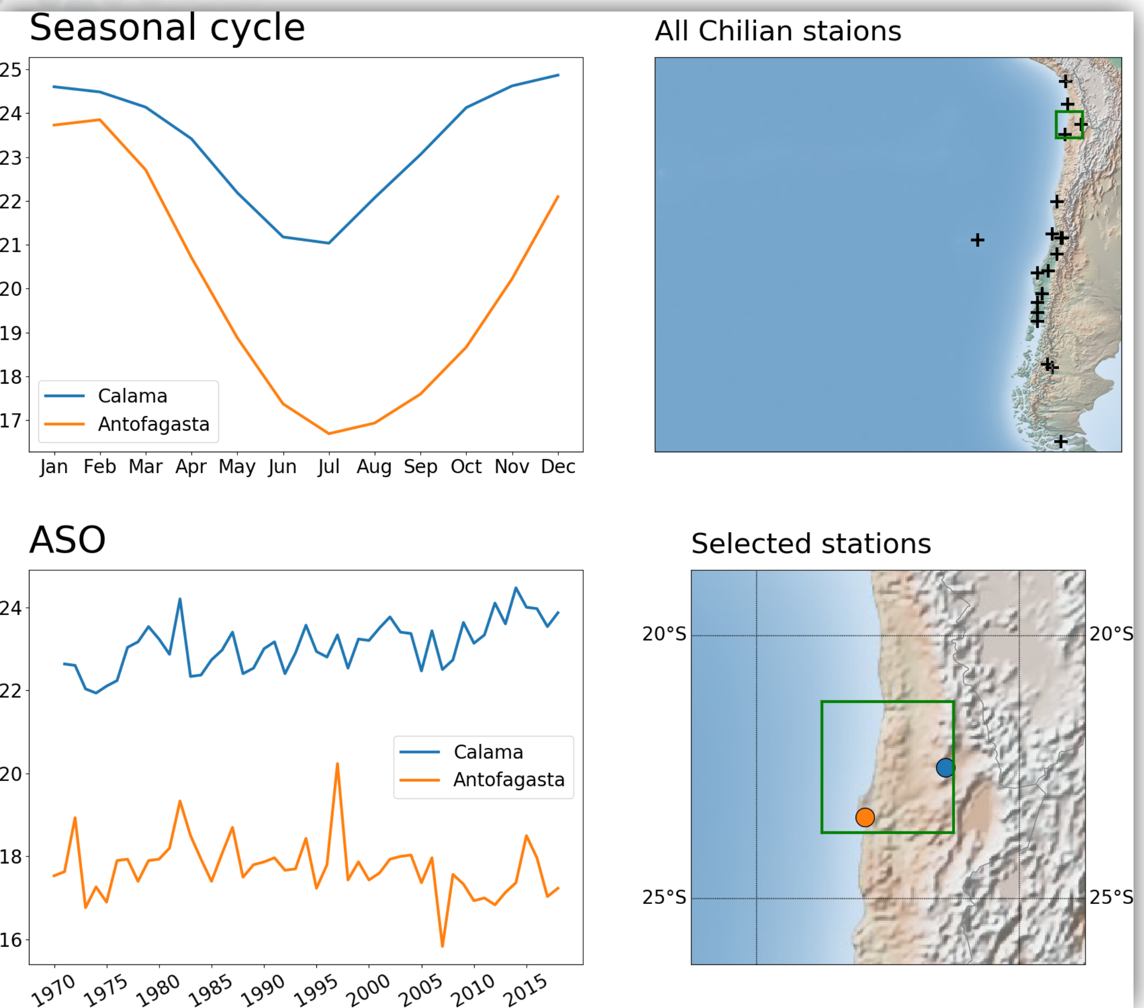


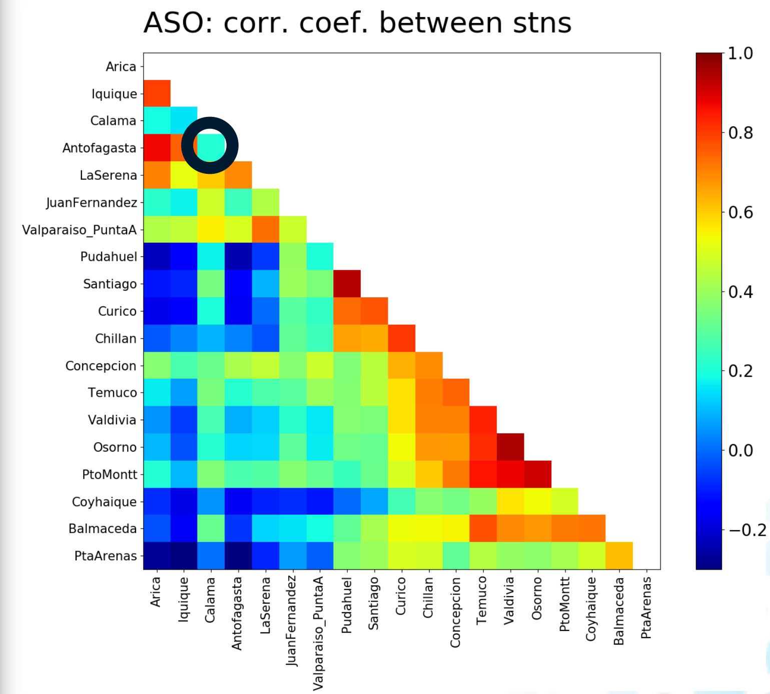
Rain shadow with strong solar insolation



Northern arid region: Tmax (Coast vs Inland)

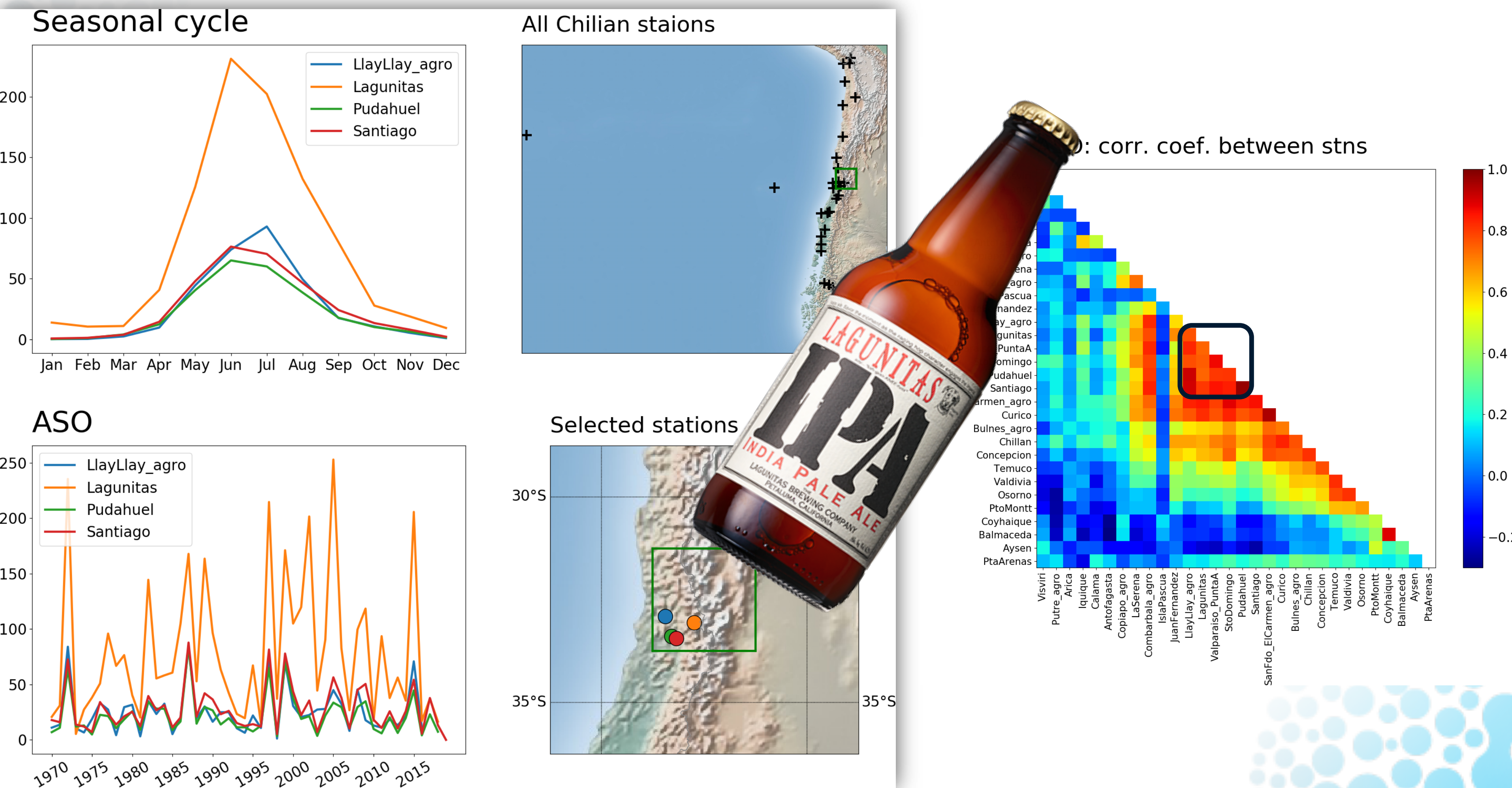
- *2 stations (Calama & Antofagasta) in a grid (2.5 by 2.5)*
- ***Less consistency among stations in a grid***





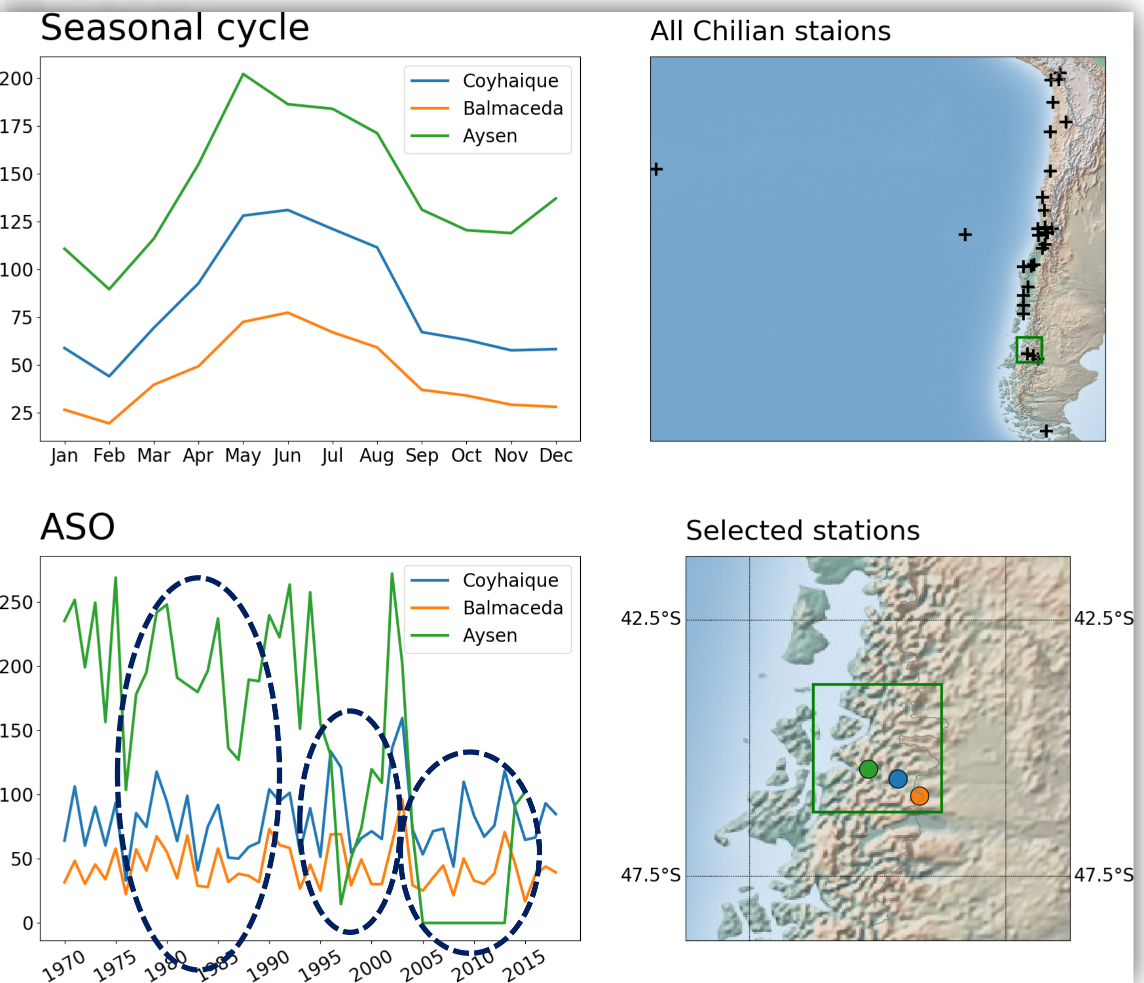
Central region: RR Slope & Valley?

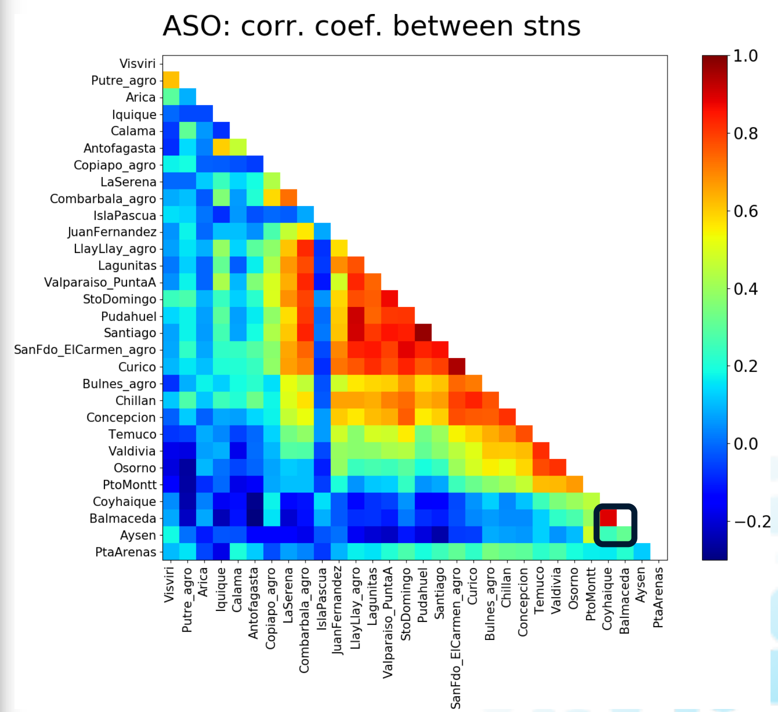
- *4 stations in a grid (2.5 degLat by 2.5 degLon)*
- *strong temporal consistency among stations in a grid*



South region: RR Slope & Inland?

- *3 stations in a grid (2.5degLat by 2.5 degLon)*
- *Aysen: less consistent with other stations in a grid*

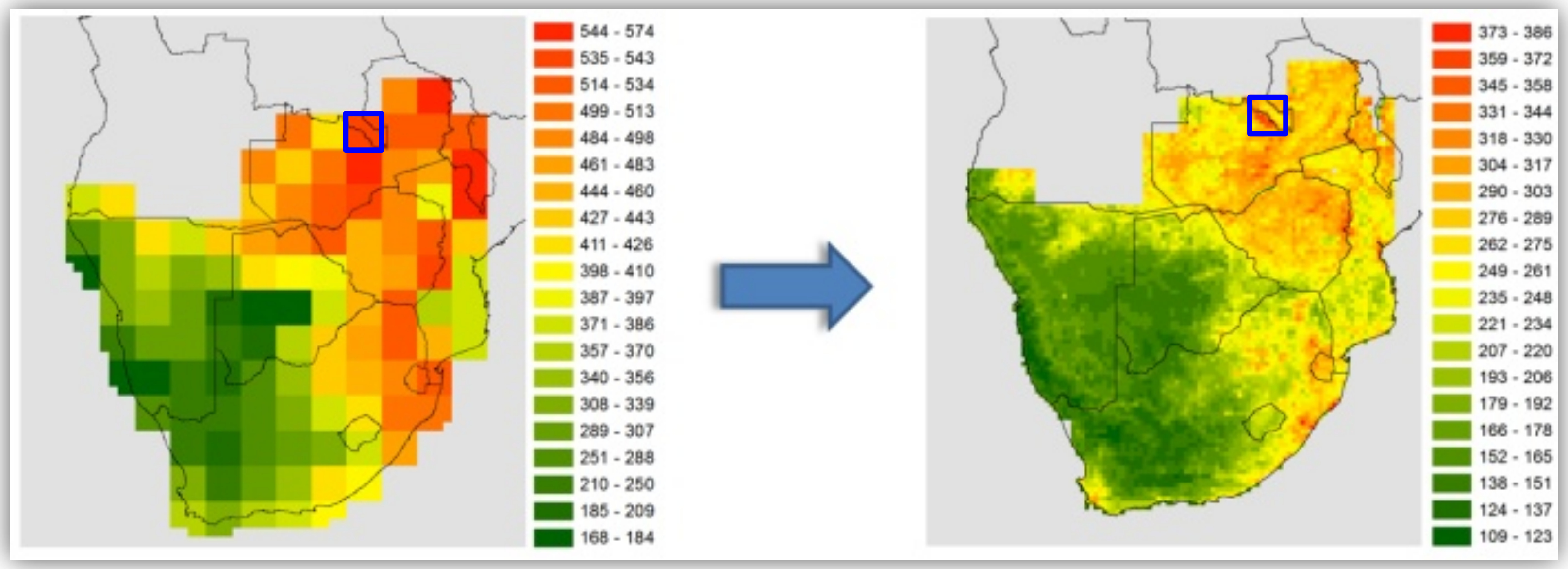




What is downscaling?

Who are you?

Look inside!



544 - 574
535 - 543
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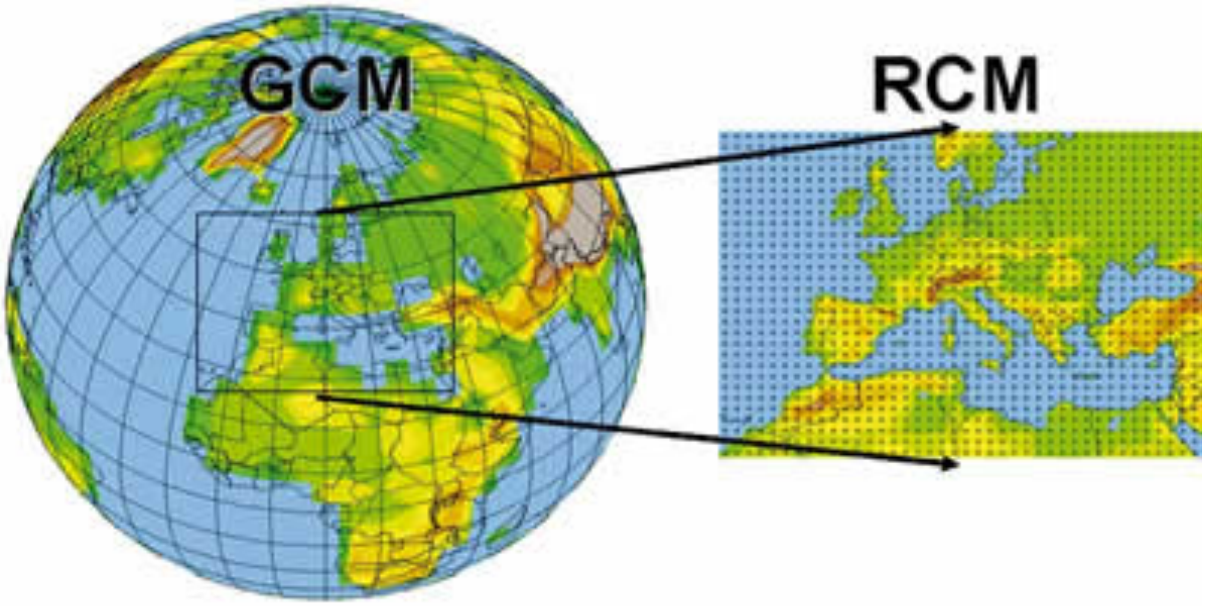
276 - 289
262 - 275
249 - 261
235 - 248
221 - 234
207 - 220
193 - 206
179 - 192
166 - 178
152 - 165
138 - 151
124 - 137
109 - 123

What is downscaling?

POST-PROCESSING!

=optimization/localization/customization of climate information

What is dynamical downscaling?



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

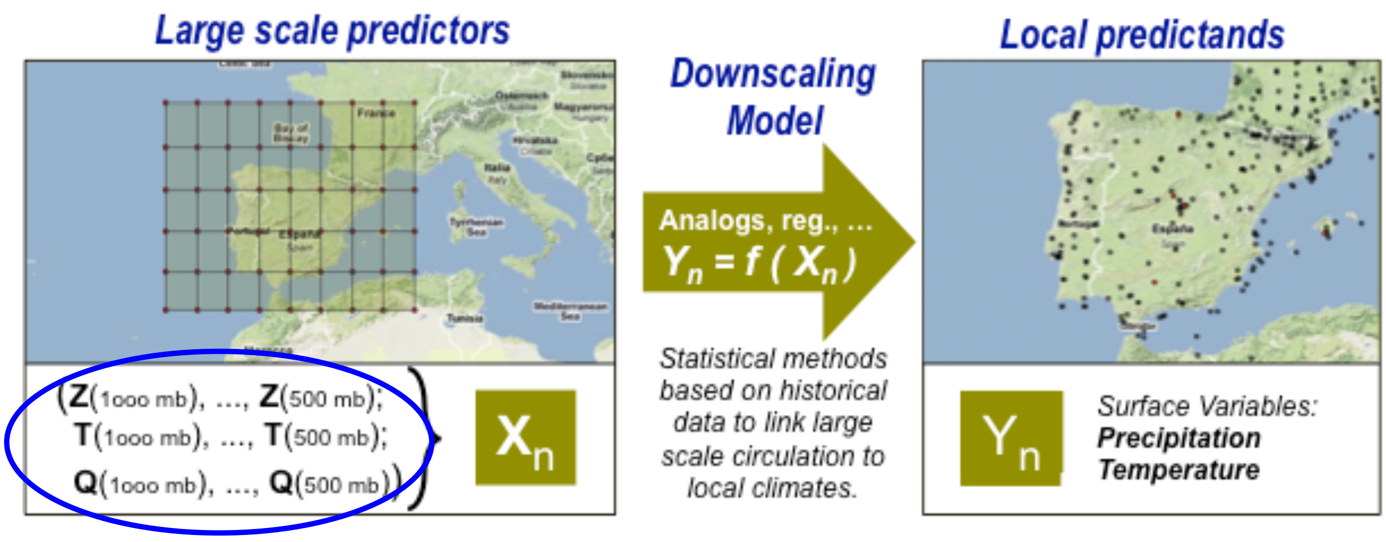
- BC from GCM, IC → solving dynamic equations!

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

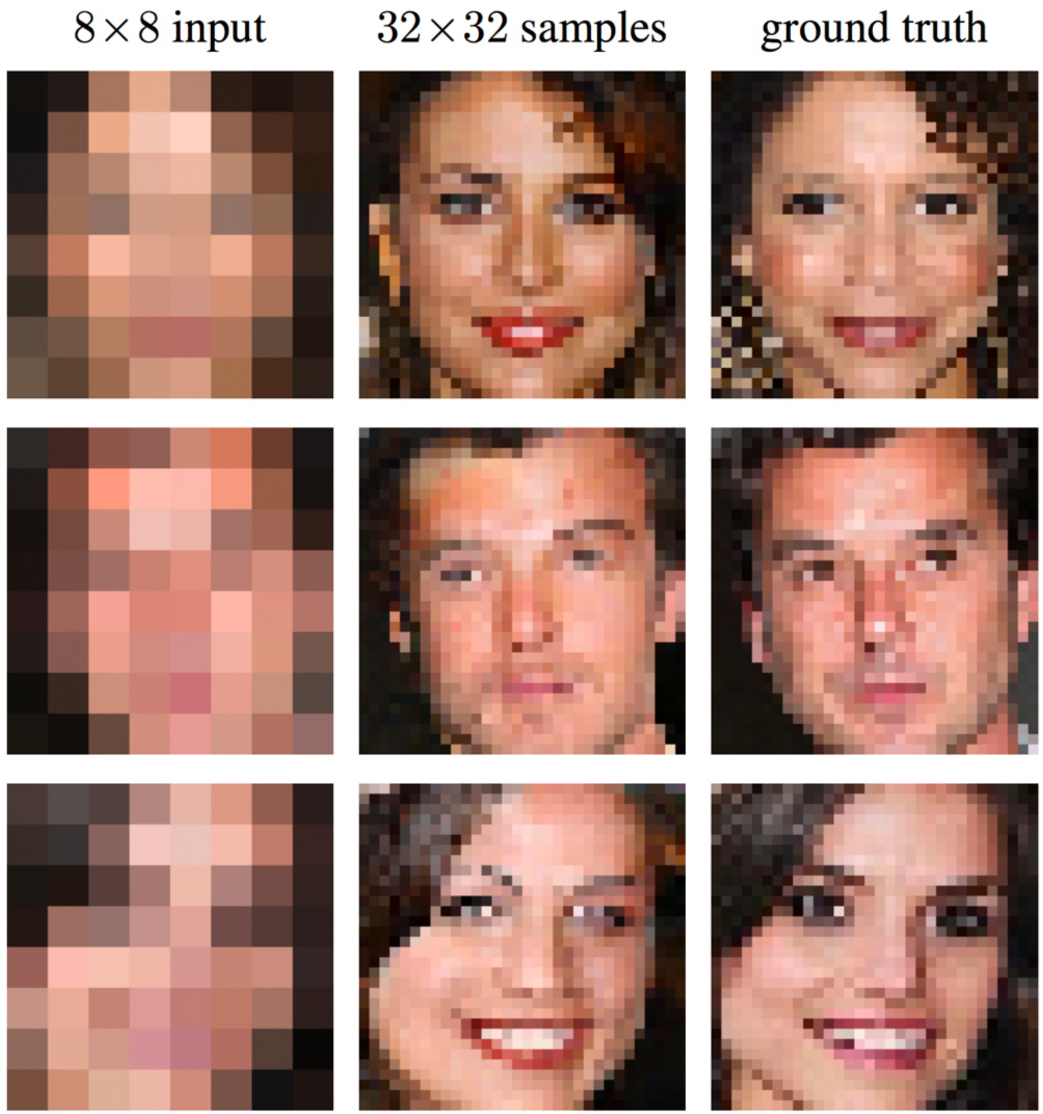
Empirical-statistical downscaling

- 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/

CLIK 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

✓*What we have!*

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

✓*What we know!*

: past relationship (site – large scale field)

Clik Climate Information Toolkit — Downscale

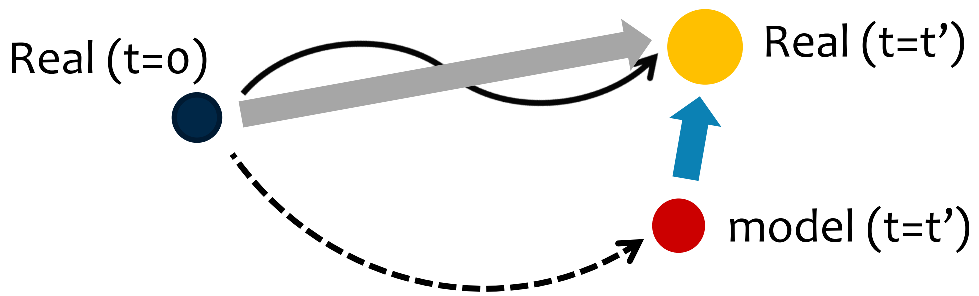
http://clik.apcc21.org/

Approach

- **Statistical downscaling forecast based on *past forecast***

$y(s,t)$: observation
$x(s,t)$: forecast

$$y'(t) = f(x(t), \alpha), \alpha = g(x(1:t-1), y(1:t-1))$$



- **The most common way : Regression**

$$\sum_j b_j y_j = \sum_i a_i x_i + \epsilon$$

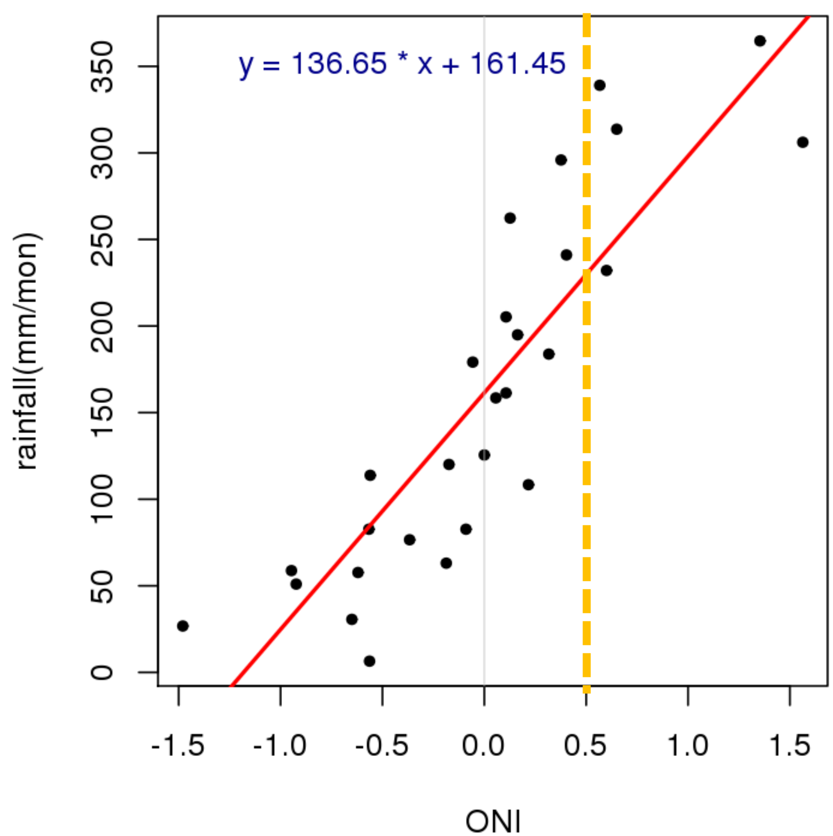
If i & j = 1 : Linear regression
i > 1, j = 1 : Multiple regression
i & j > 1 : CCA, SVD, etc

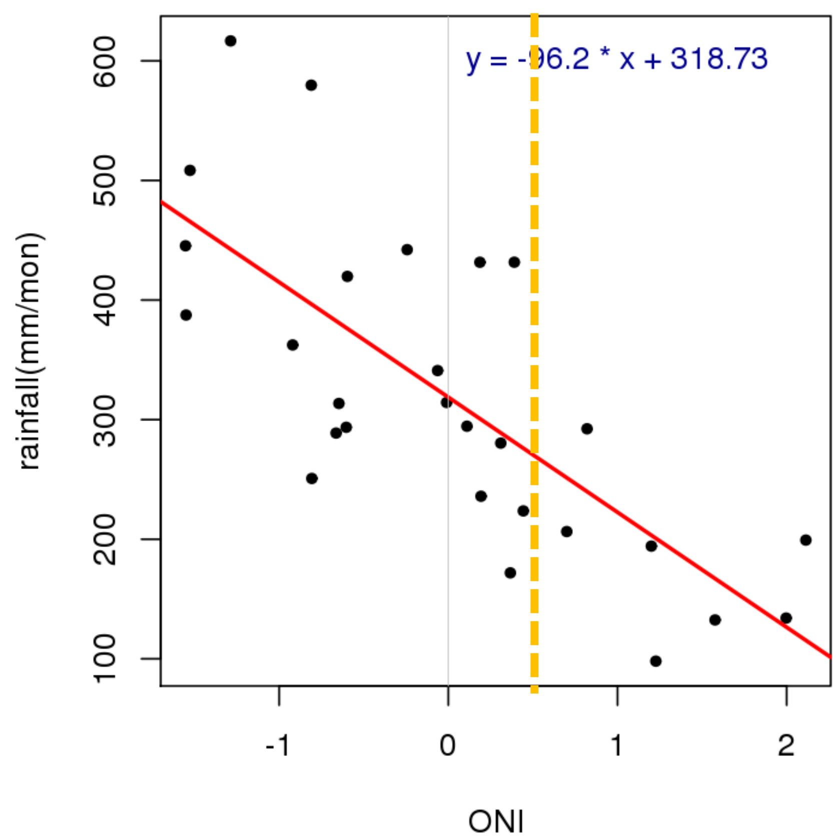
Regression concept!

Scatter plot & least square fitting!

Y= a*x+b

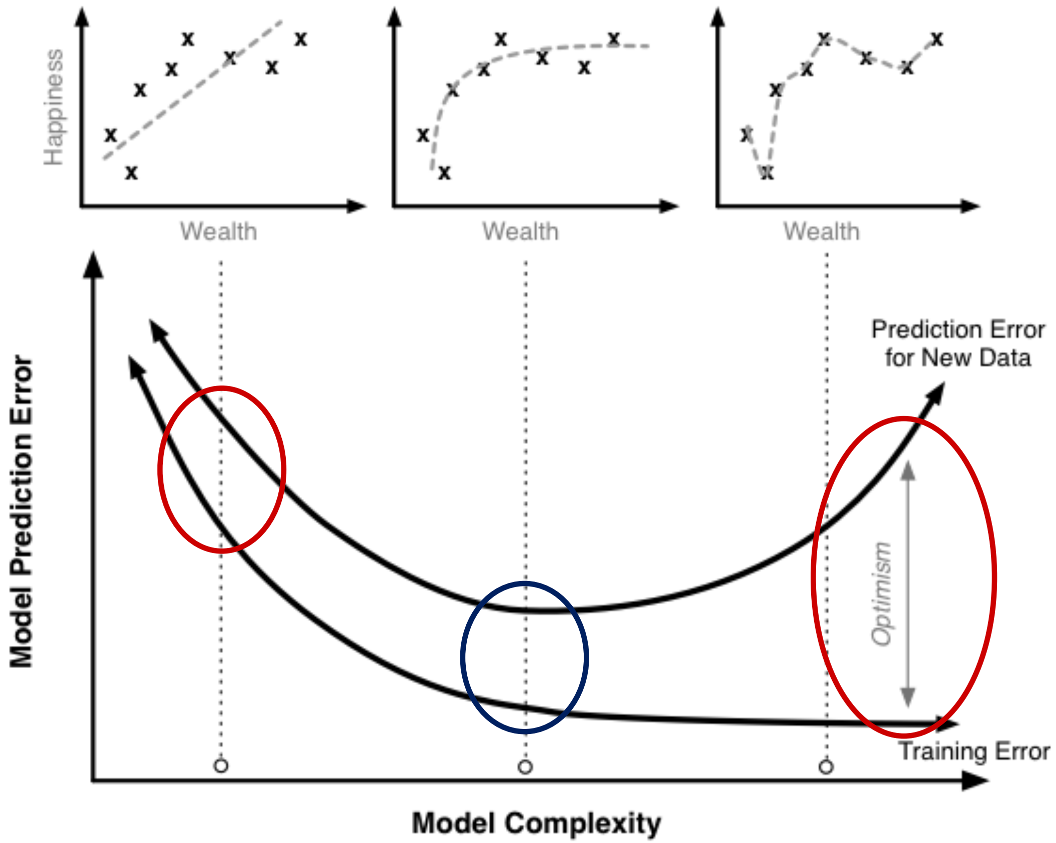
x: predictor (ONI)
y: predictand (rainfall)





Weakness : overfitting

- Consider potential predictability

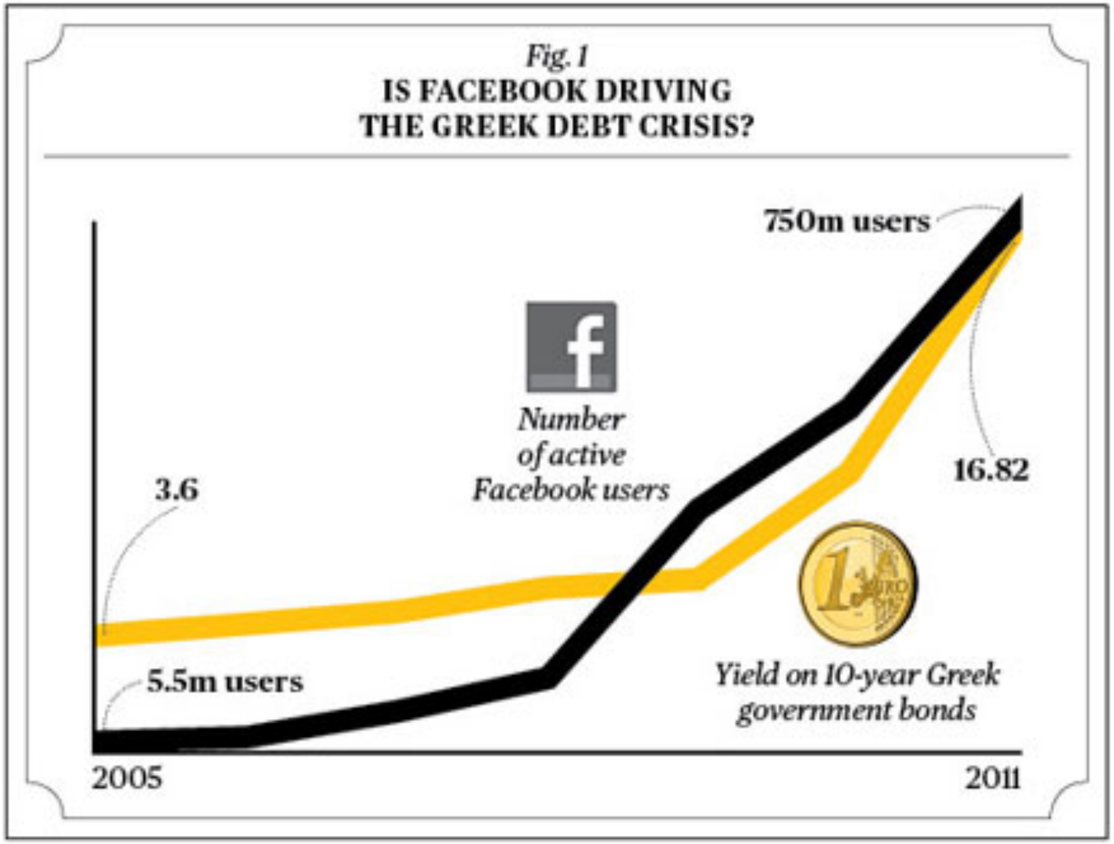


from Scott Fortmann-Roe 2012

If model output is fitted to the unpredictable noise : Overfitting. What if we remove "noise" in the observation?

Predict yield of Greek bonds with number of Facebook users

Is it appropriate?



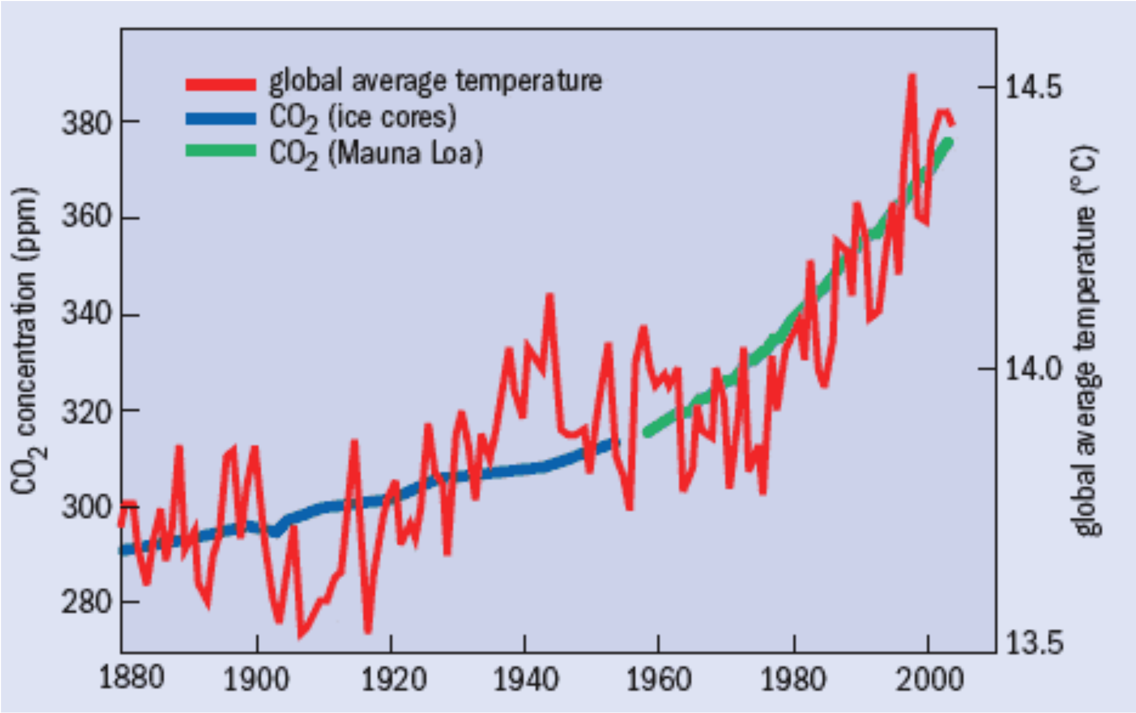
From *business week*

If yes, why?

If not, why?

Predict global average temperature with Carbon dioxide concentration

Is it appropriate?



If yes, why?

If not, why?

Image Source: images.iop.org

The most important things…

1. Physical understanding of,
   - What weather event/system consists of your seasonal climate (LOCAL, predictand)
   - What external (slow varying factor) controls the weather system (GLOBAL, predictor)

➔ Finding ***predictors*** (large scale meteorological patterns (circulations) associated with local prec/temp of your station)

2. whether GCM (MME) is able to reproduce those patterns/relationship?

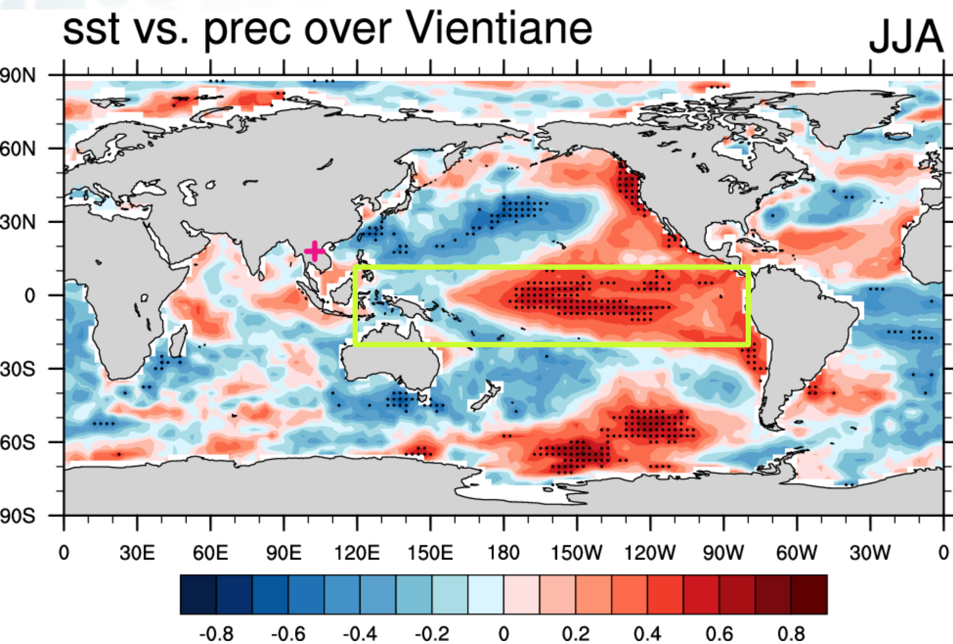
➔ ***Applicability*** of downscaling

Example of Domain Selection

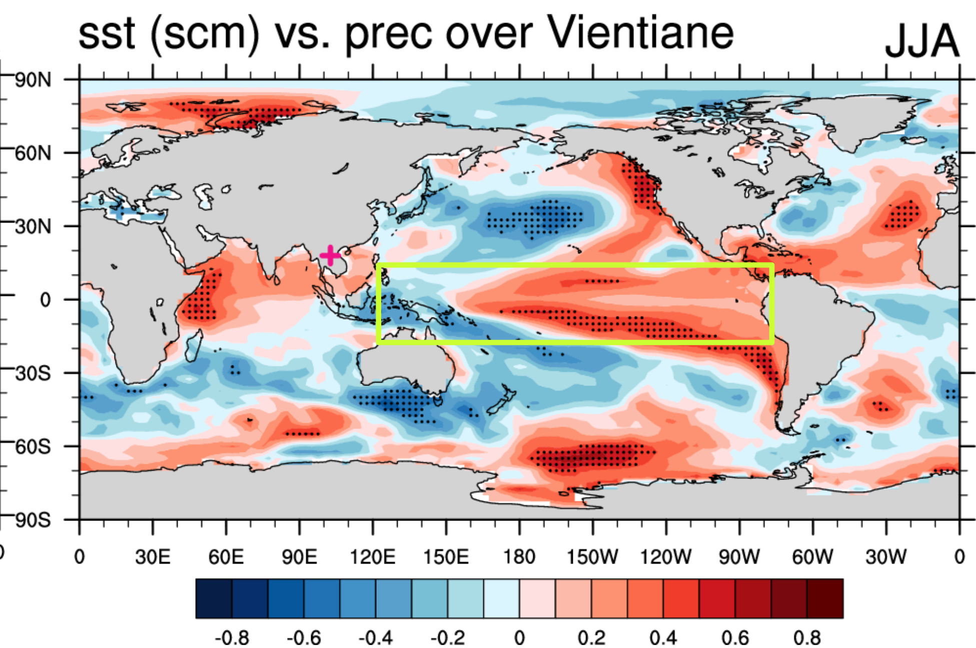
:should be based on **large scale pattern** associated with local temperature/rainfall

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



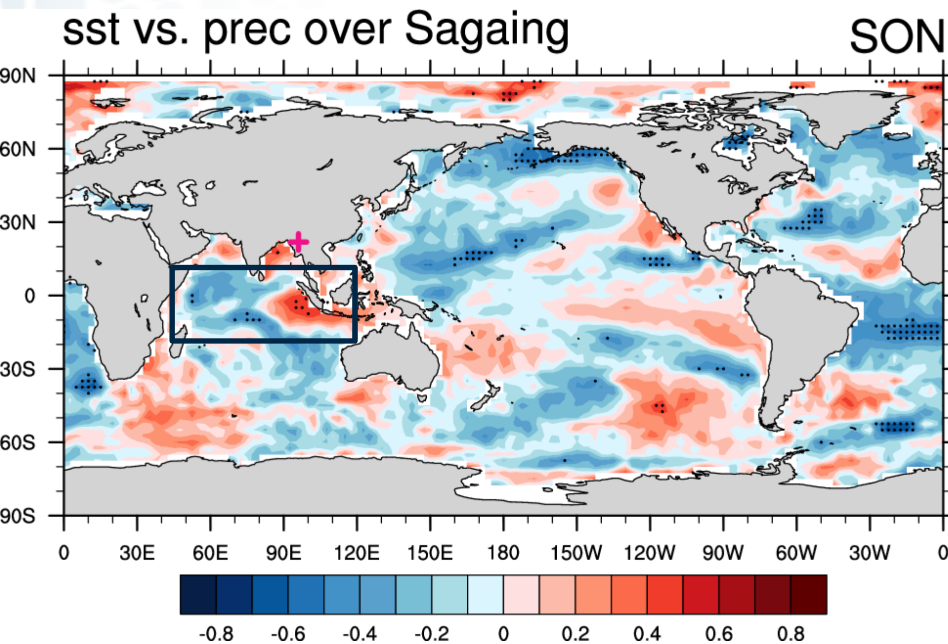
ENSO system:

El Nino → Vientiane rain ↑

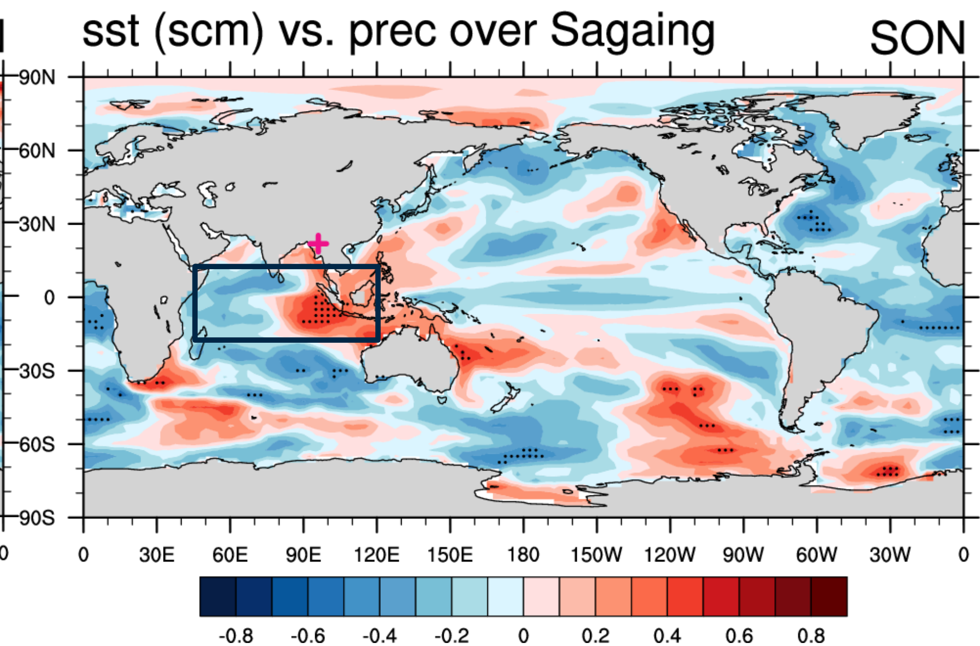
La Nina → Vientiane rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



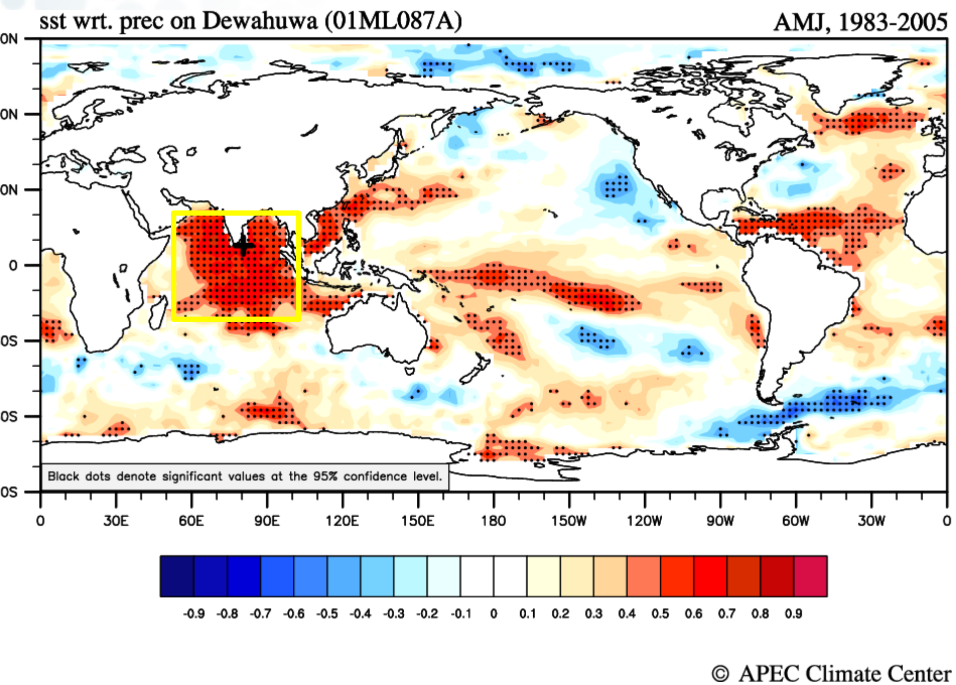
Indian Ocean Dipole:

Neg. IOD → Sagaing rain ↑

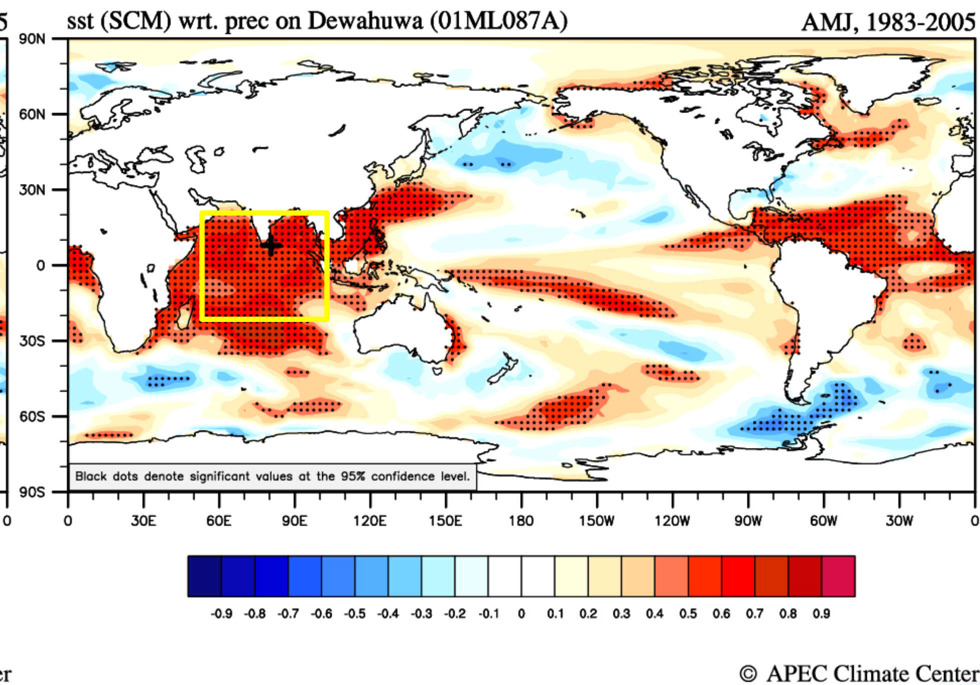
Pos. IOD → Sagaing rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



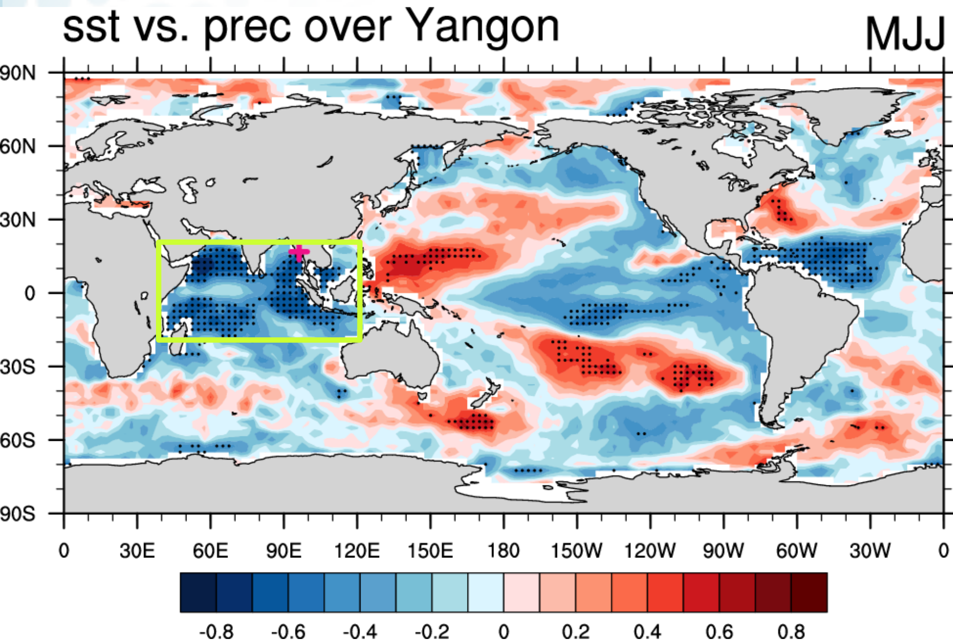
IOBM:

IO warming → Dewahuwa rain ↑

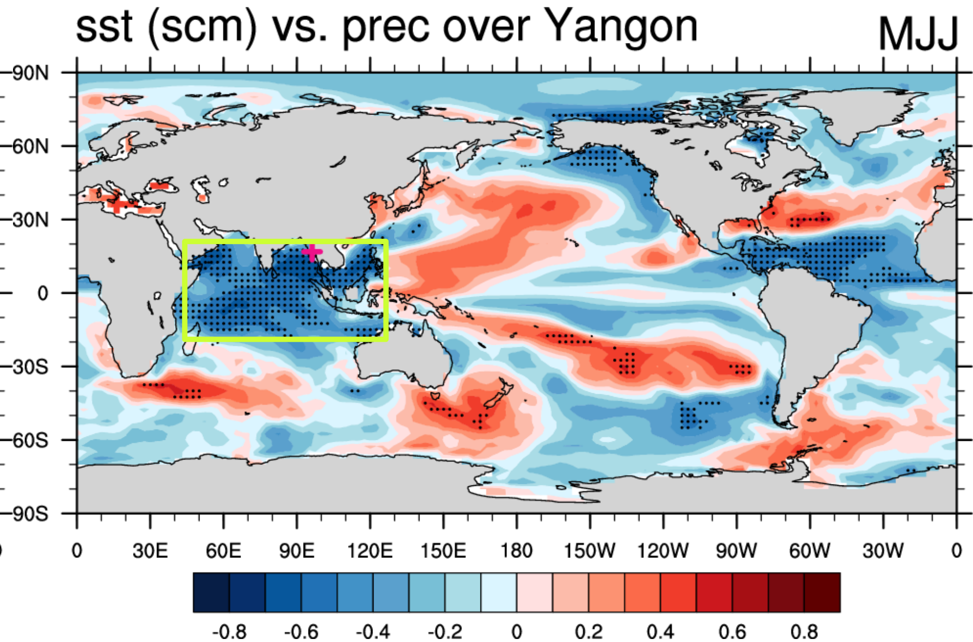
IO cooling → Dewahuwa rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)

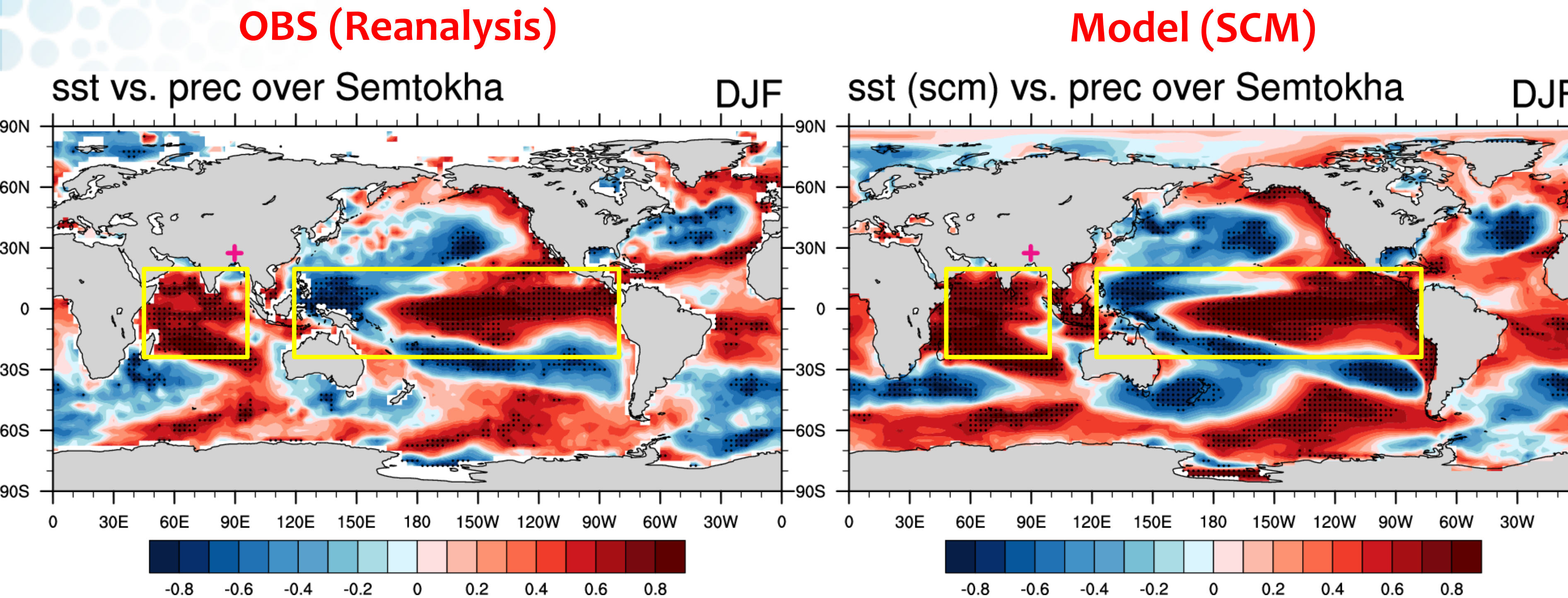


Indian Ocean Basin-wide Cooling:

SST↓ → Yangon rain ↑

SST↑ → Yangon rain ↓

Station to LSMP relationship



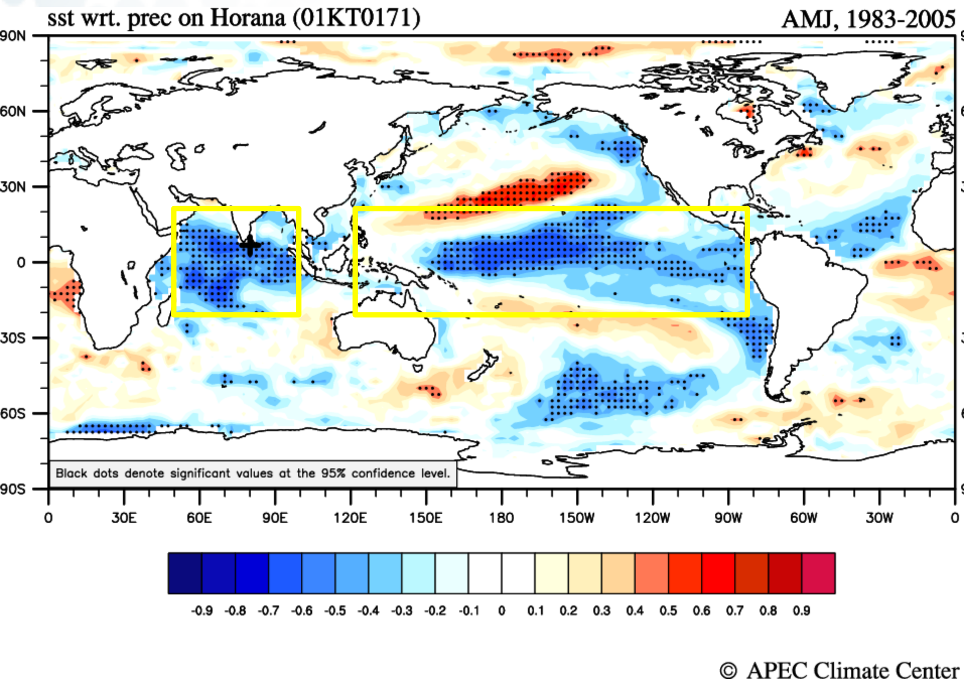
IOBM + ENSO:

IO warming & El Nino → Semtokha rain ↑

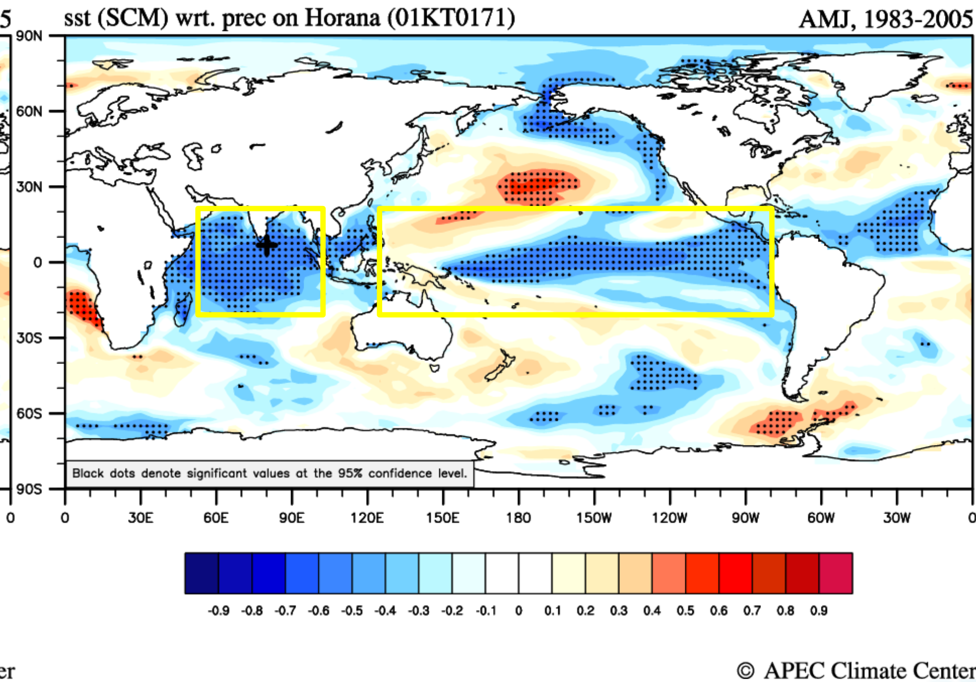
IO cooling & La Nina → Semtokha rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



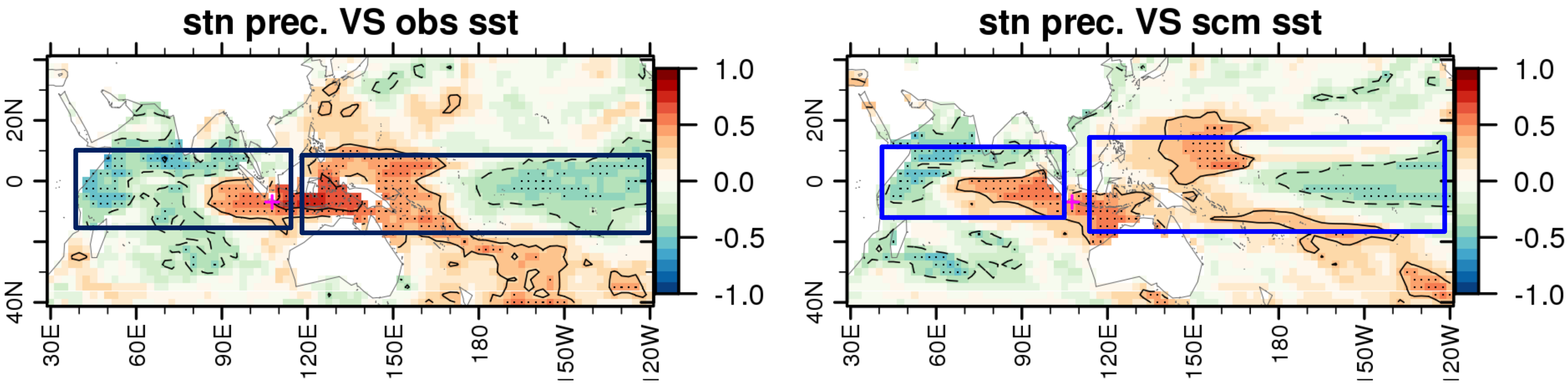
IOBM + ENSO:

IO cooling & La Nina → Horana rain ↑

IO warming & La Nina → Horana rain ↓

Maritime Continent: Indonesia

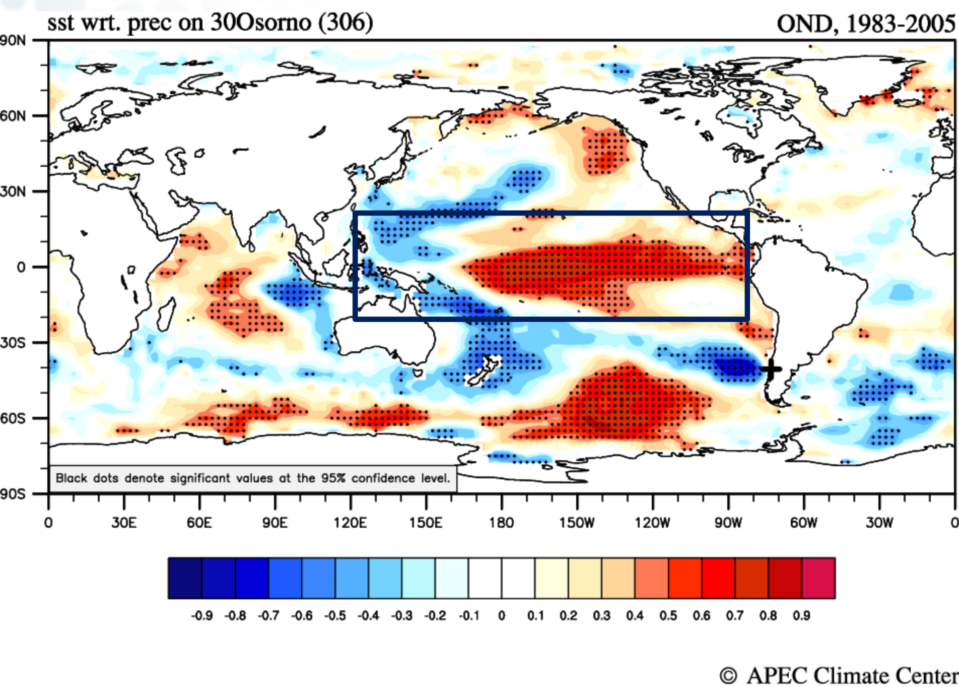
SON [Jakarta]



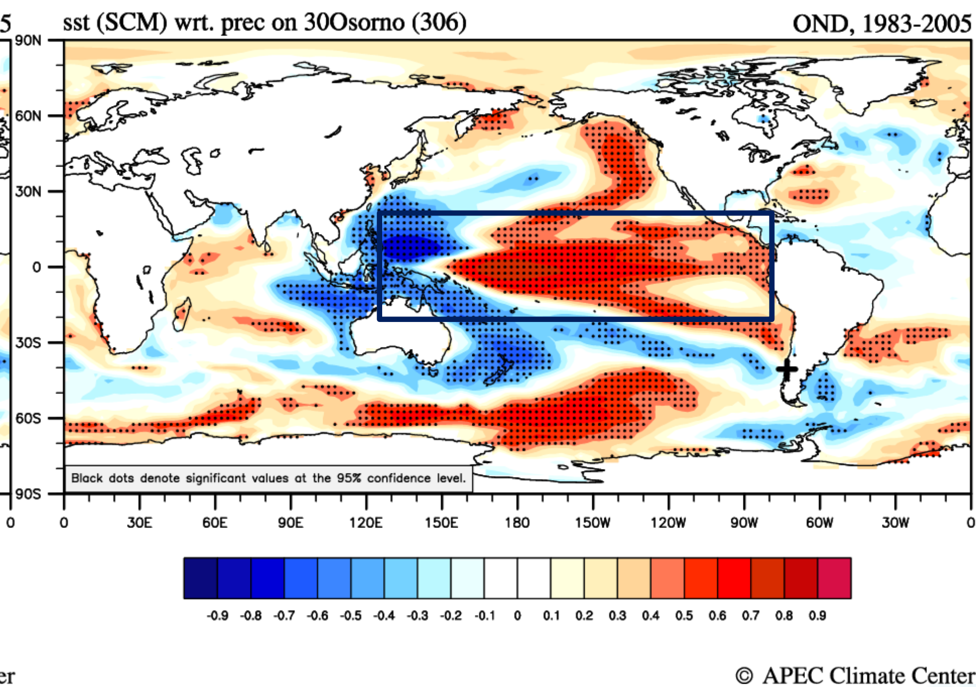
La Nina (and negative IOD) signature

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



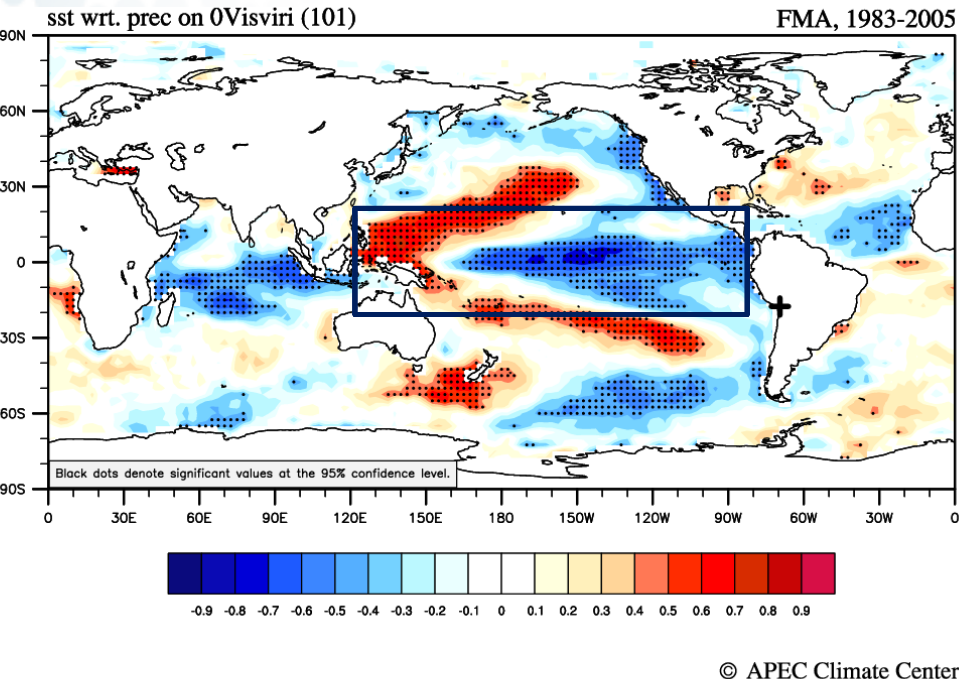
ENSO system:

El Nino → Osorno rain ↑

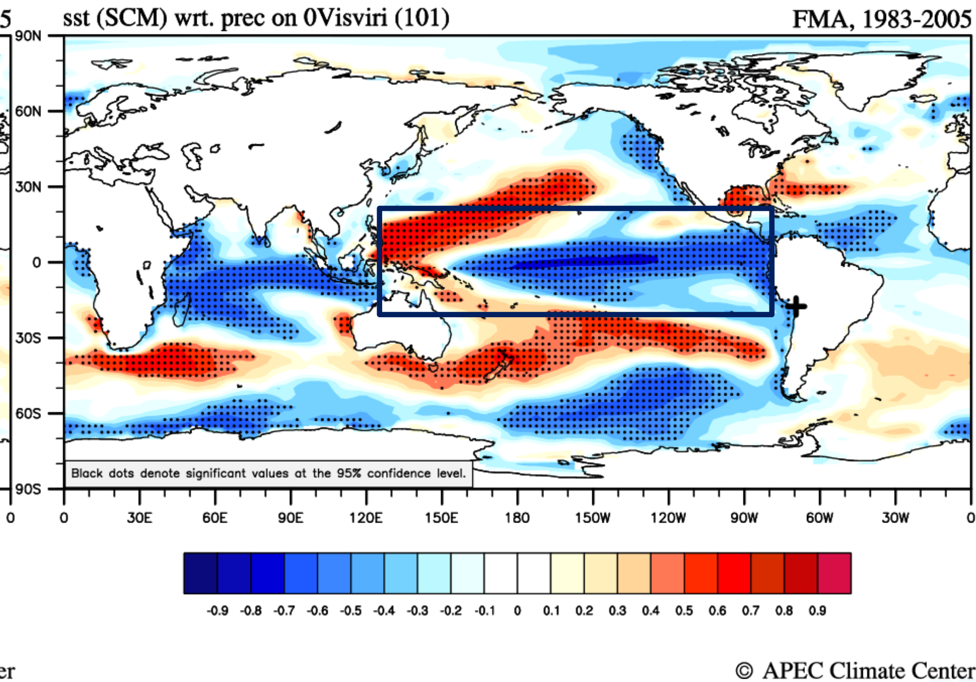
La Nina → Osorno rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



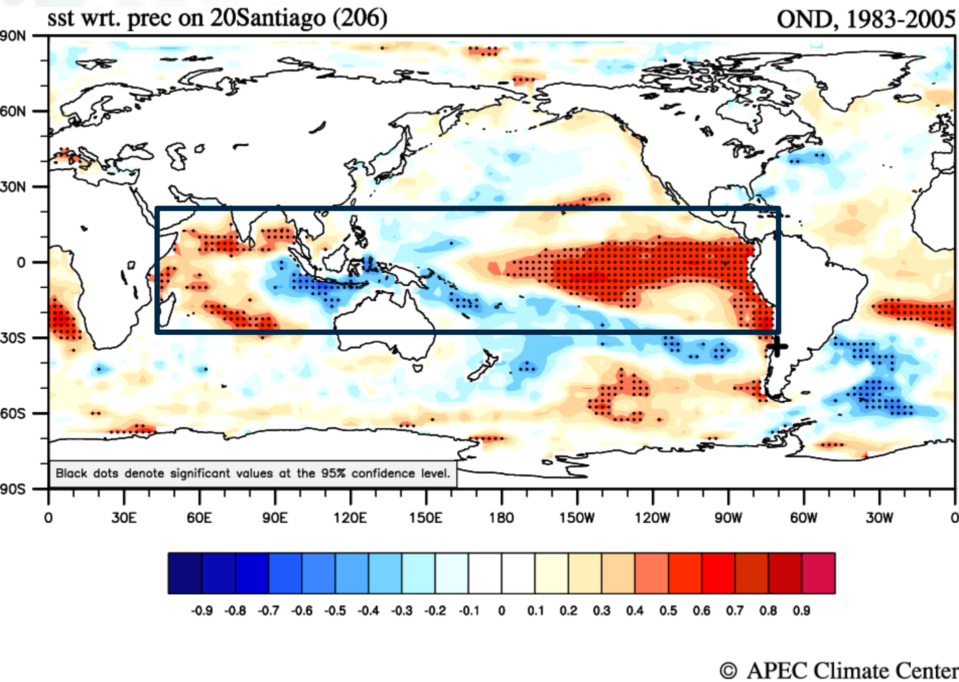
ENSO + IOBM:

La Nina + Indian Ocean Basin Warming → Visviri rain ↑

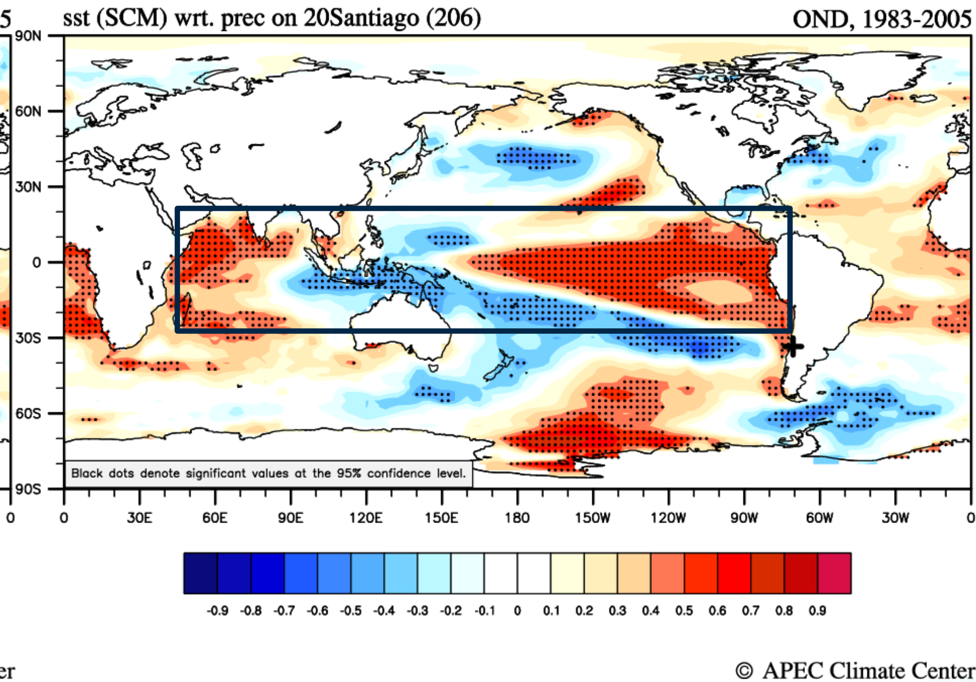
El Nino + Indian Ocean Basin Cooling → Visviri rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



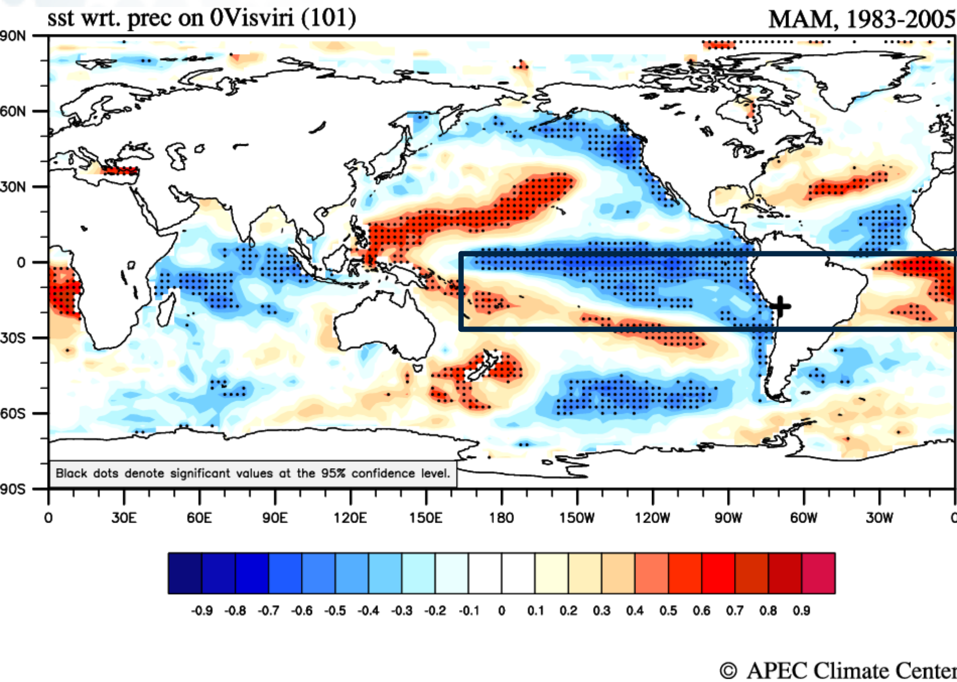
ENSO + Indian Ocean Dipole :

El Nino + Pos. IOD → Santiago rain ↑

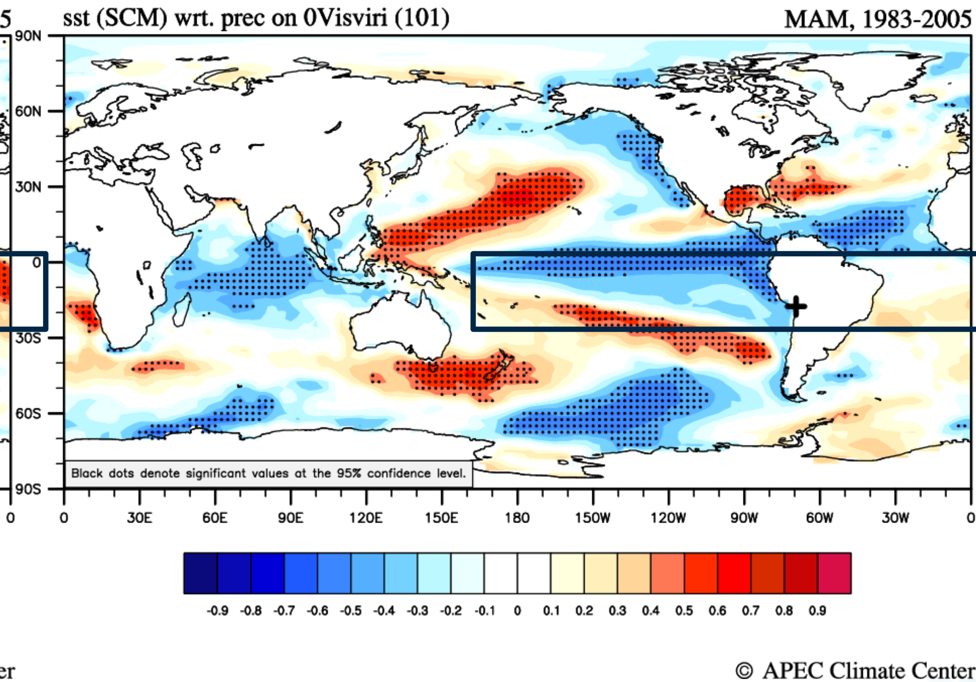
La Nina + Neg. IOD → Santiago rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



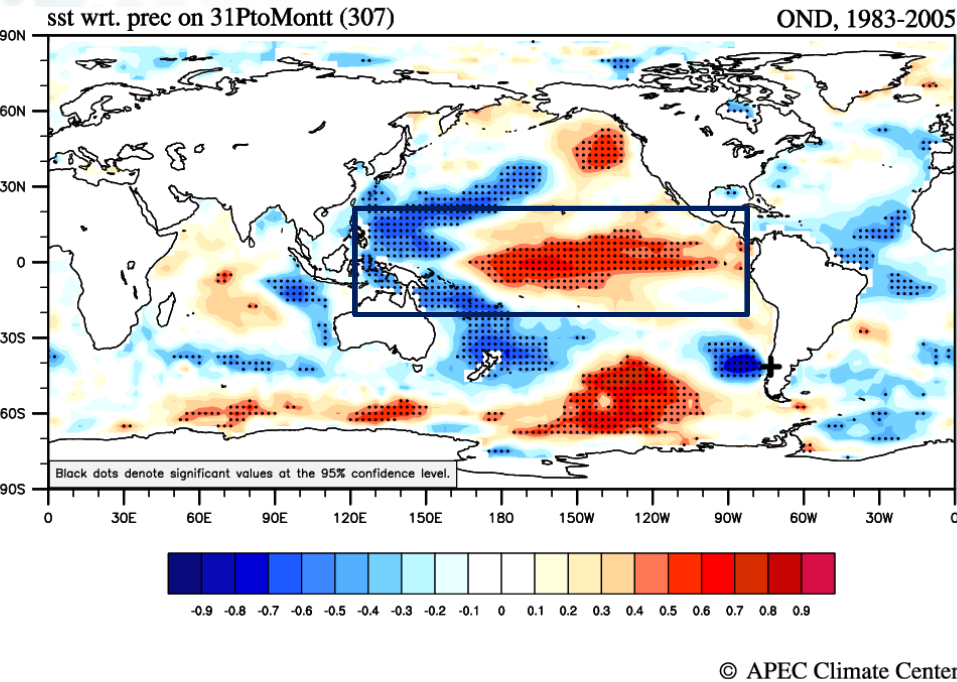
ENSO + Tropical Atlantic Ocean Variability:

La Nina + Atlantic Nino → Visviri rain ↑

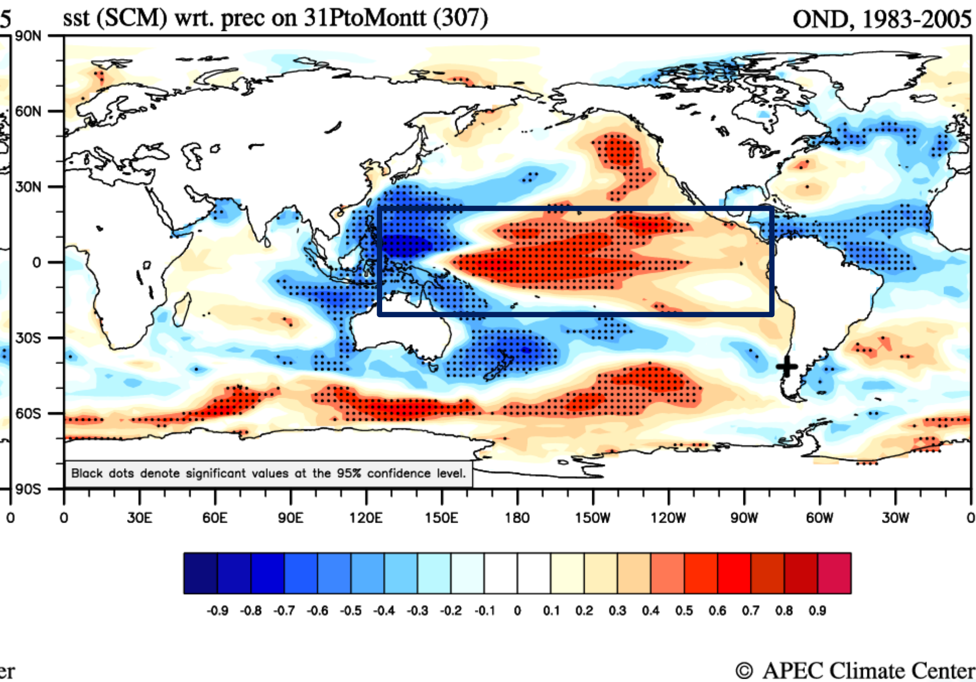
El Nino + Atlantic Nina → Visviri rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



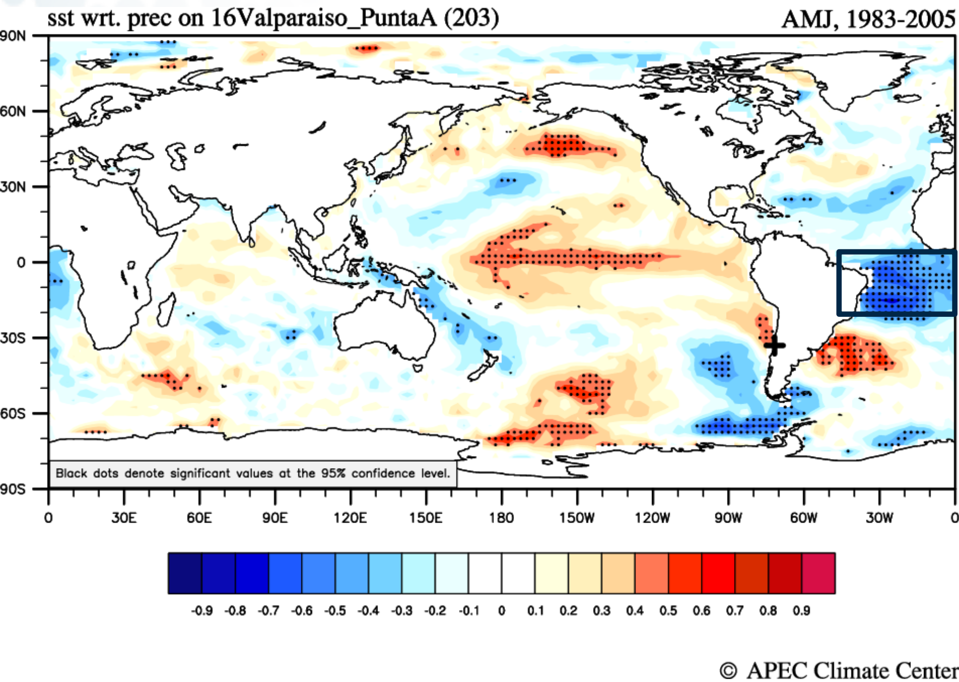
Non-canonical ENSO system:

CP-type El Nino → Puerto Montt rain ↑

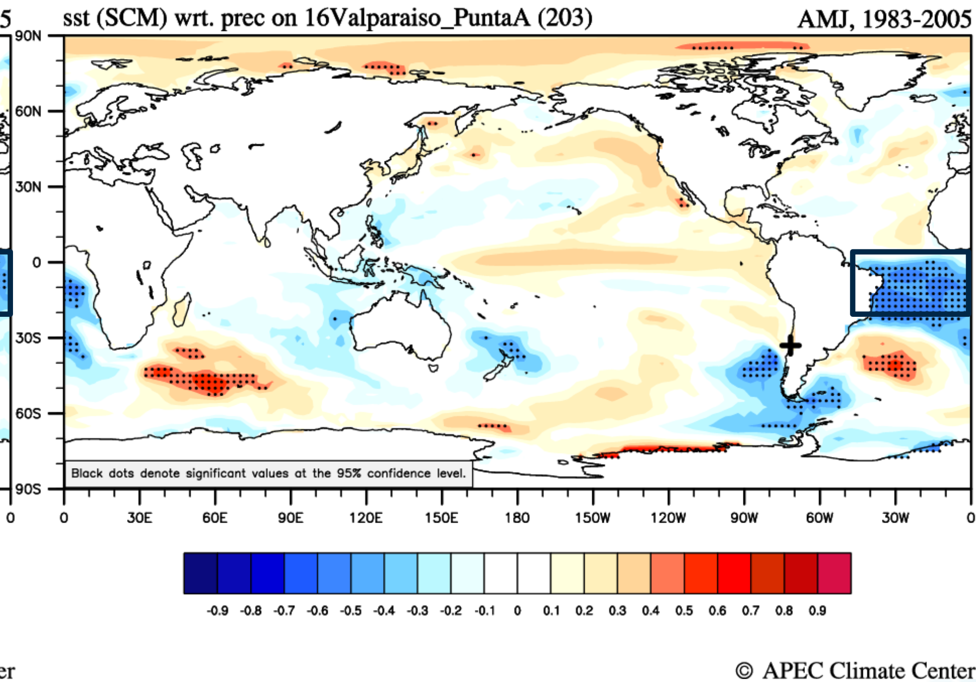
CP-type La Nina → Puerto Montt rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



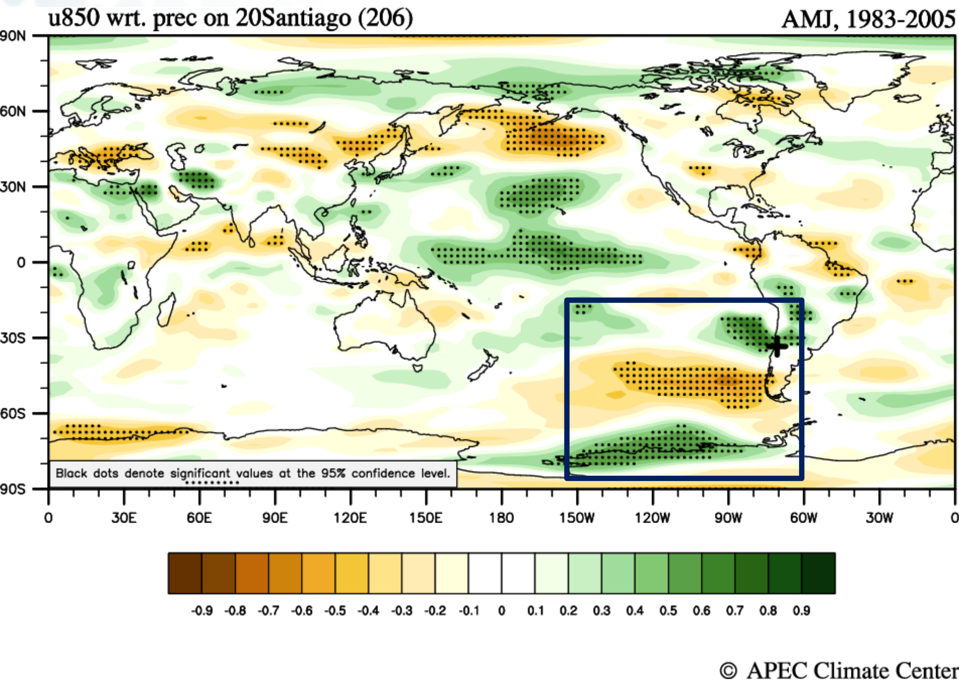
Southern Tropical Atlantic Ocean Variability:

Tropical Atlantic Cooling → Valparaiso rain ↑

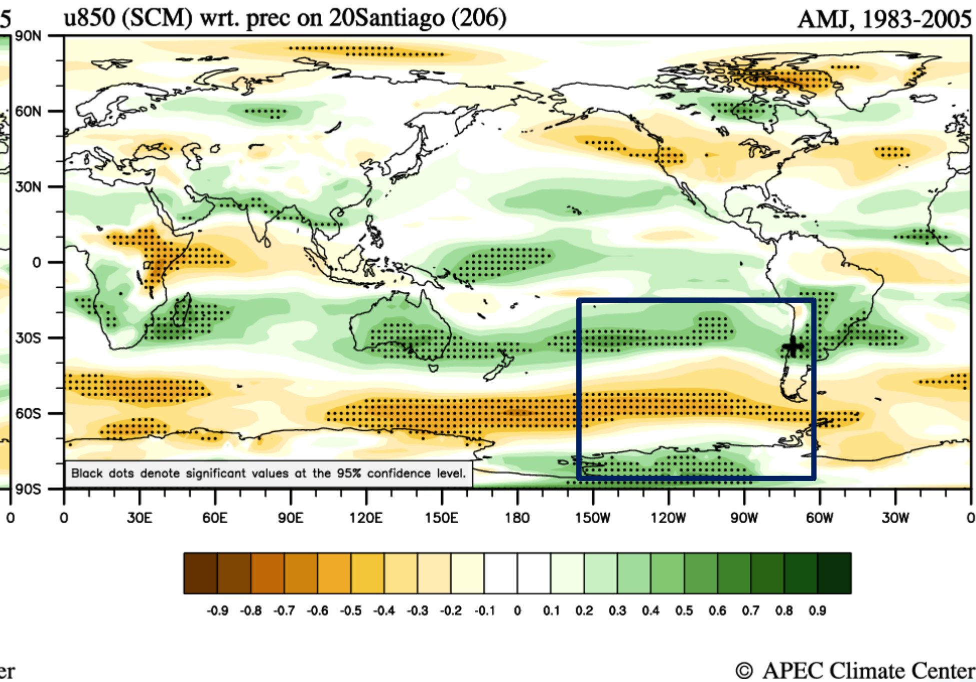
Tropical Atlantic Warming → Valparaiso rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



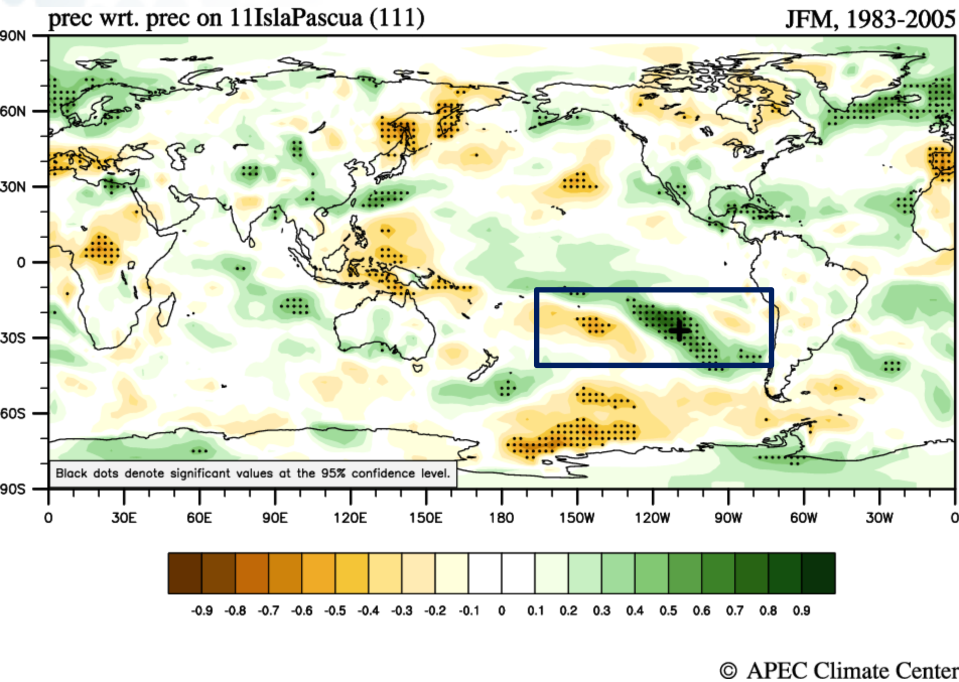
Rossby wave & warm easterly:

Easterly → Santiago rain ↑

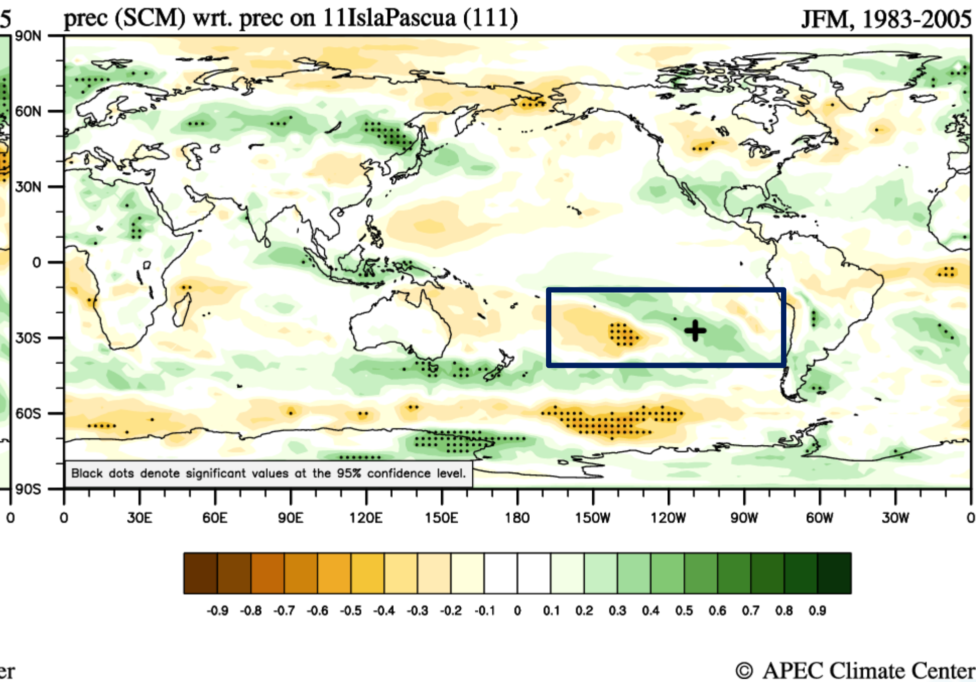
Westerly → Santiago rain ↓

Station to LSMP relationship

OBS (Reanalysis)



Model (SCM)



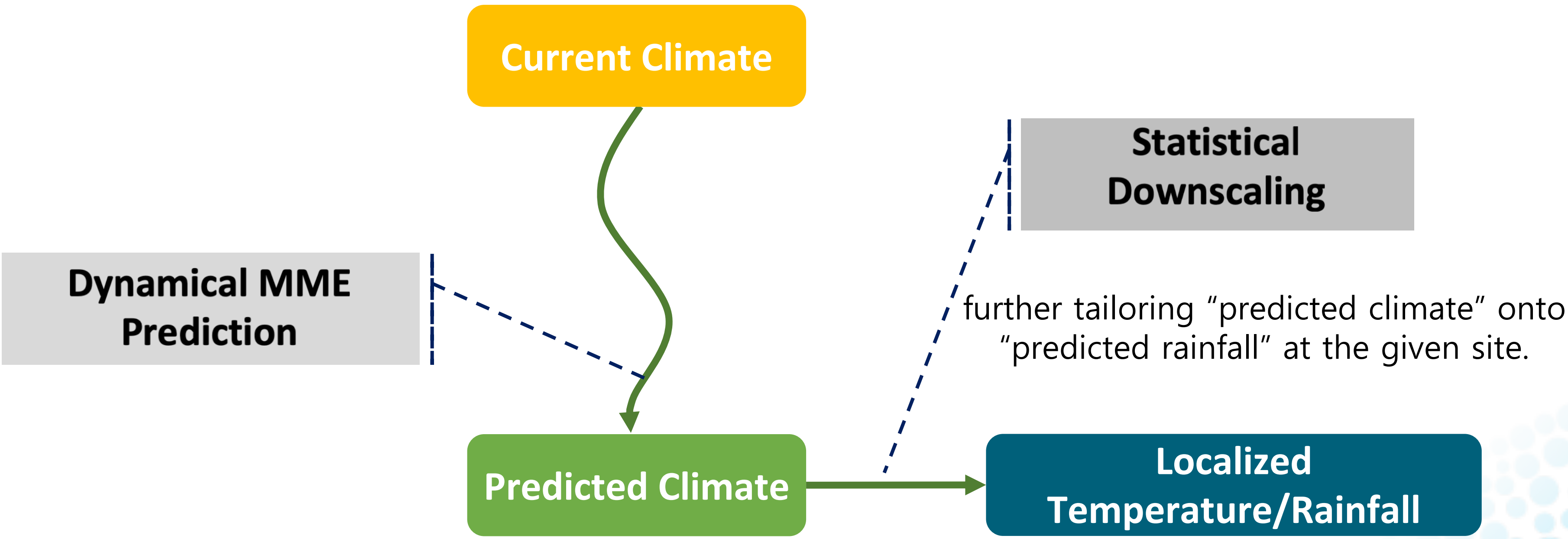
Large scale convective system:

Wet → Isla de Pascua rain ↑

Dry → Isla de Pascua rain ↓

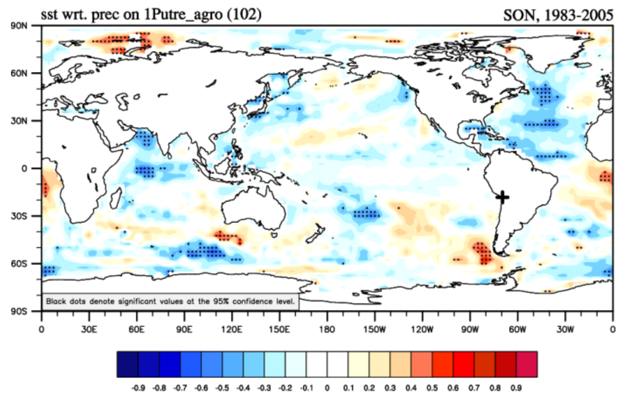
Downscaling/tailoring of dynamical MME

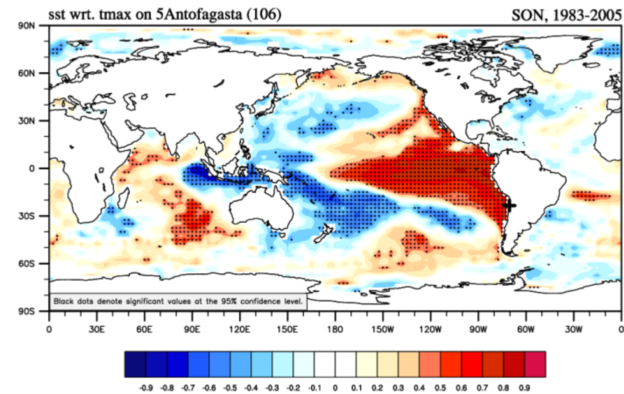
Climate Information Toolkit

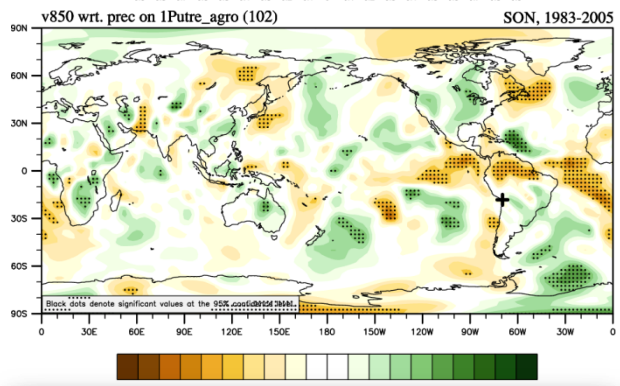


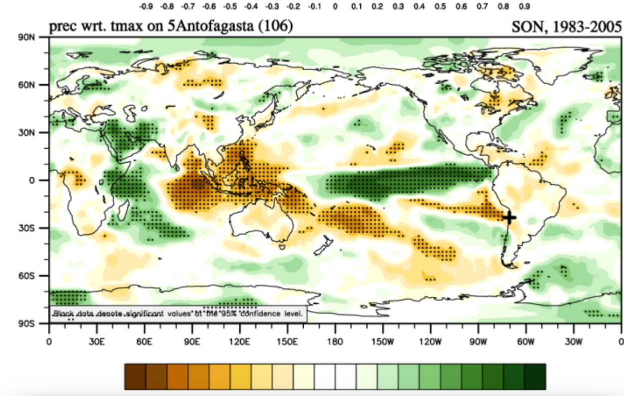
1) Physical/dynamical process
2) Model biases *vs* Observed dynamics

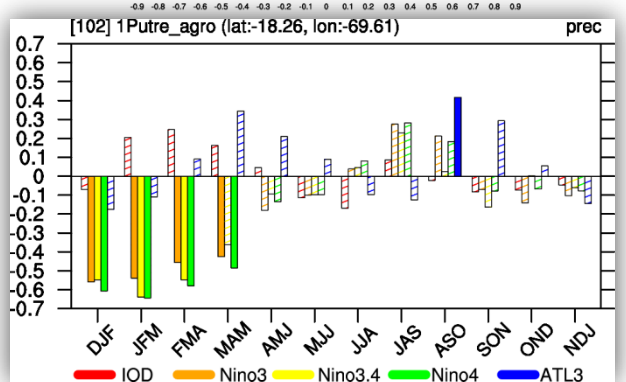
Northern arid region

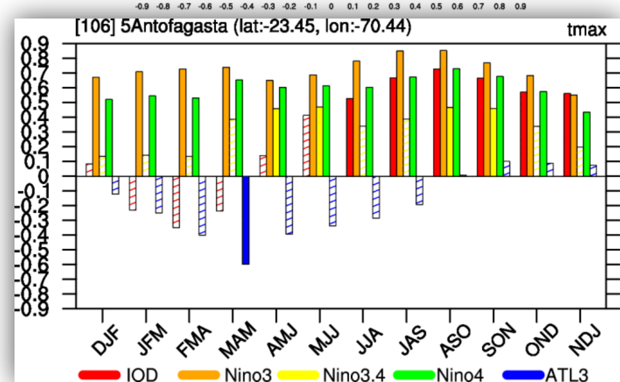




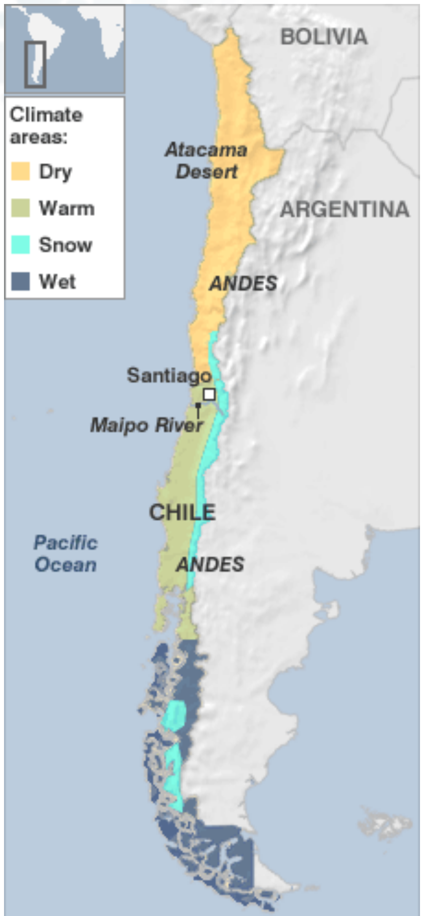


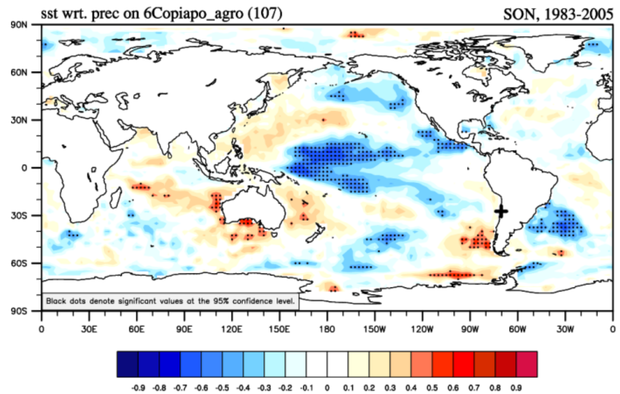


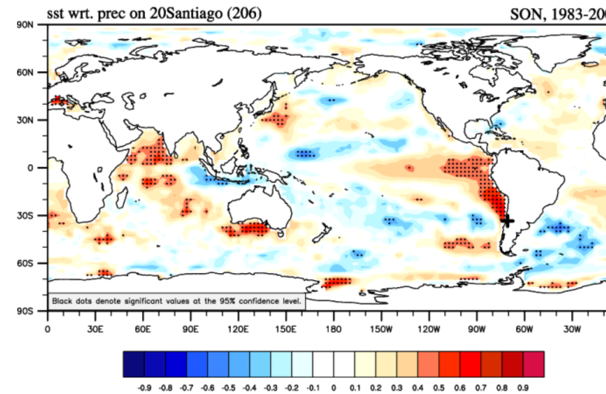


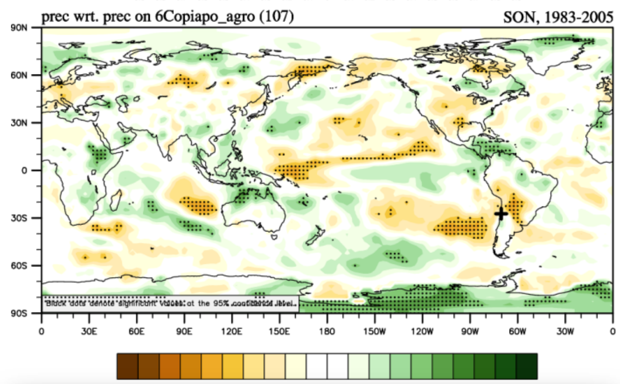


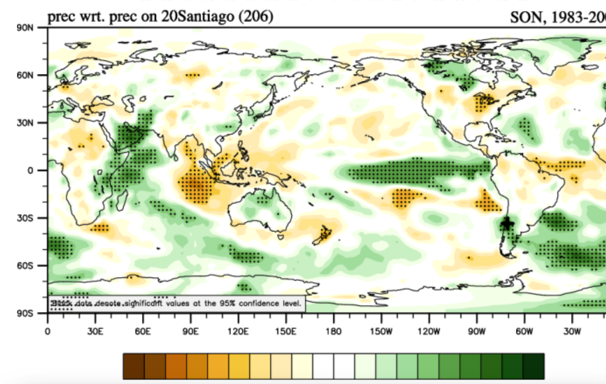
Central region

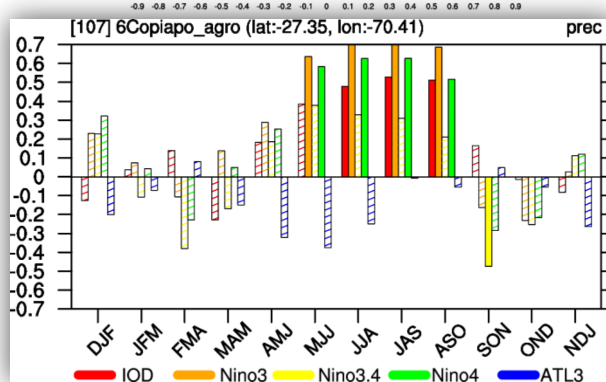


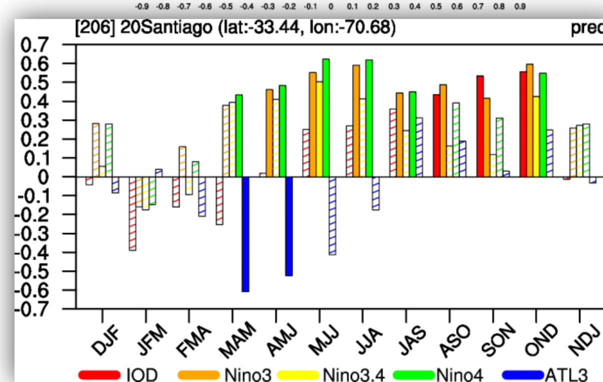




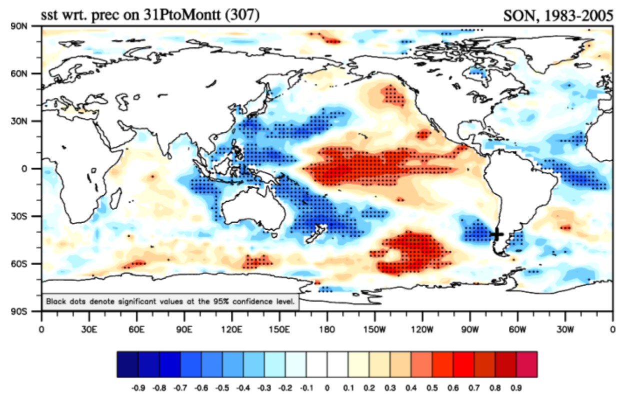


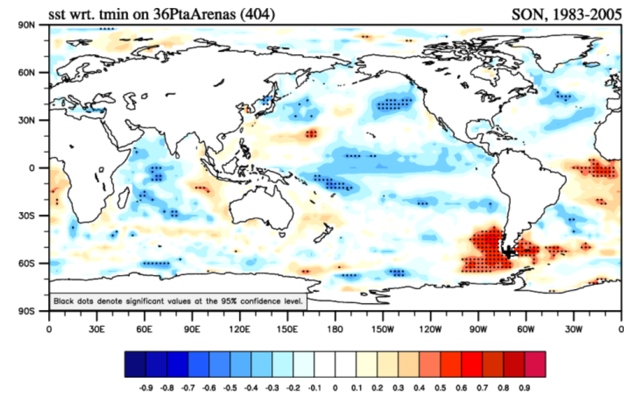


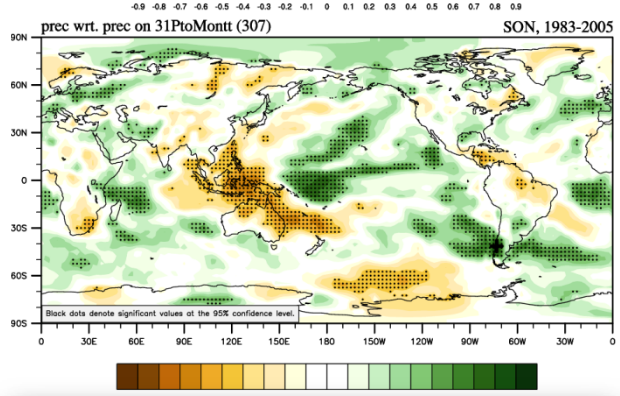


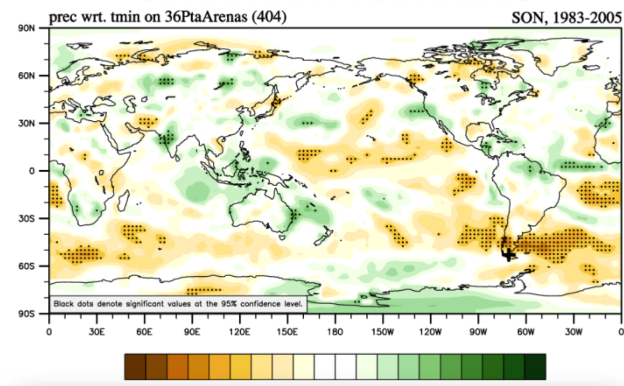


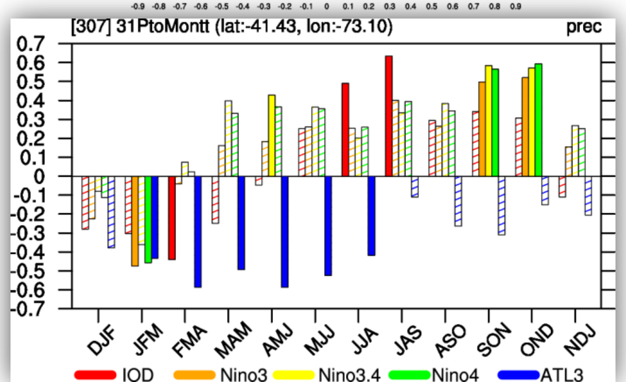
South region

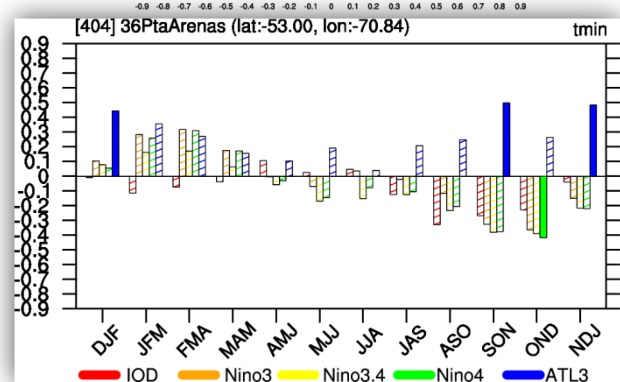












The most important things...

1. Physical understanding of,

- What weather event/system consists of your seasonal climate (LOCAL, predictand)
- What external (slow varying factor) controls the weather system (GLOBAL, predictor)

➔ Finding *predictors* (large scale meteorological patterns (circulations) **associated with** local prec/temp of your station)

2. whether GCM (MME) is able to reproduce those patterns/relationship?

➔ ***Applicability*** of downscaling

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.

Dynamical fcst	Statistical fcst
Simulated LSMF from Individual models	Station to LSMF regression relationship

- Hypothesis: The station to LSMF relationship is well replicated in individual models

- Predictor: LSMF
- Predictand: Prec. at specific station

A kind of hybrid system for point-wise seasonal forecast

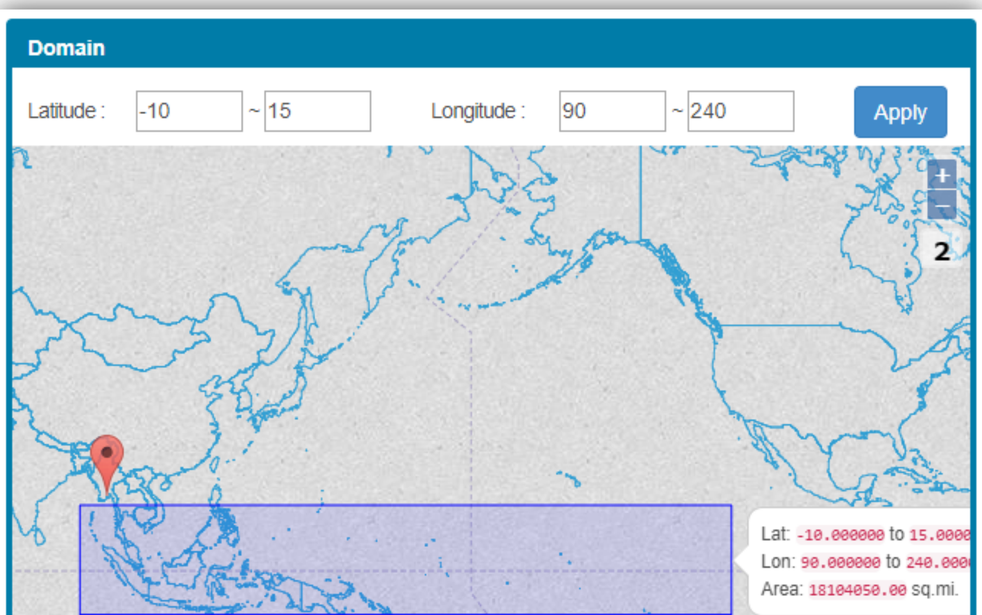
CLIK downscaling

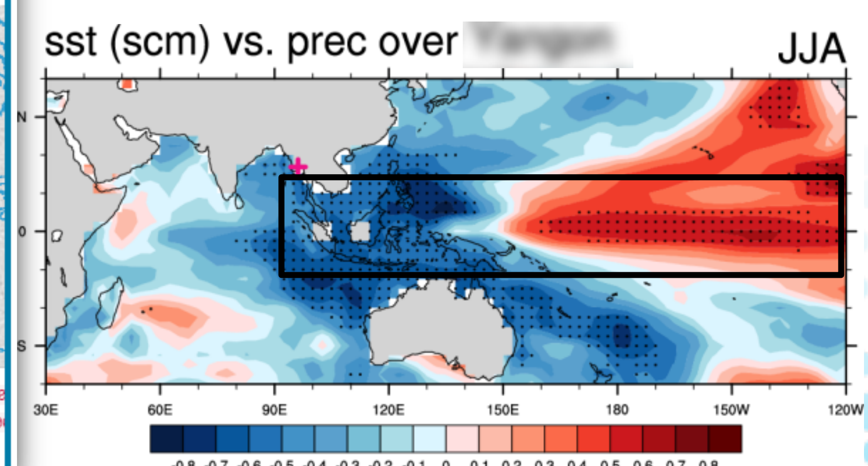
A way to localize existing coarse climate information

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 (OBS) ~ local station rainfall

LSMP (MME) → Local station rainfall



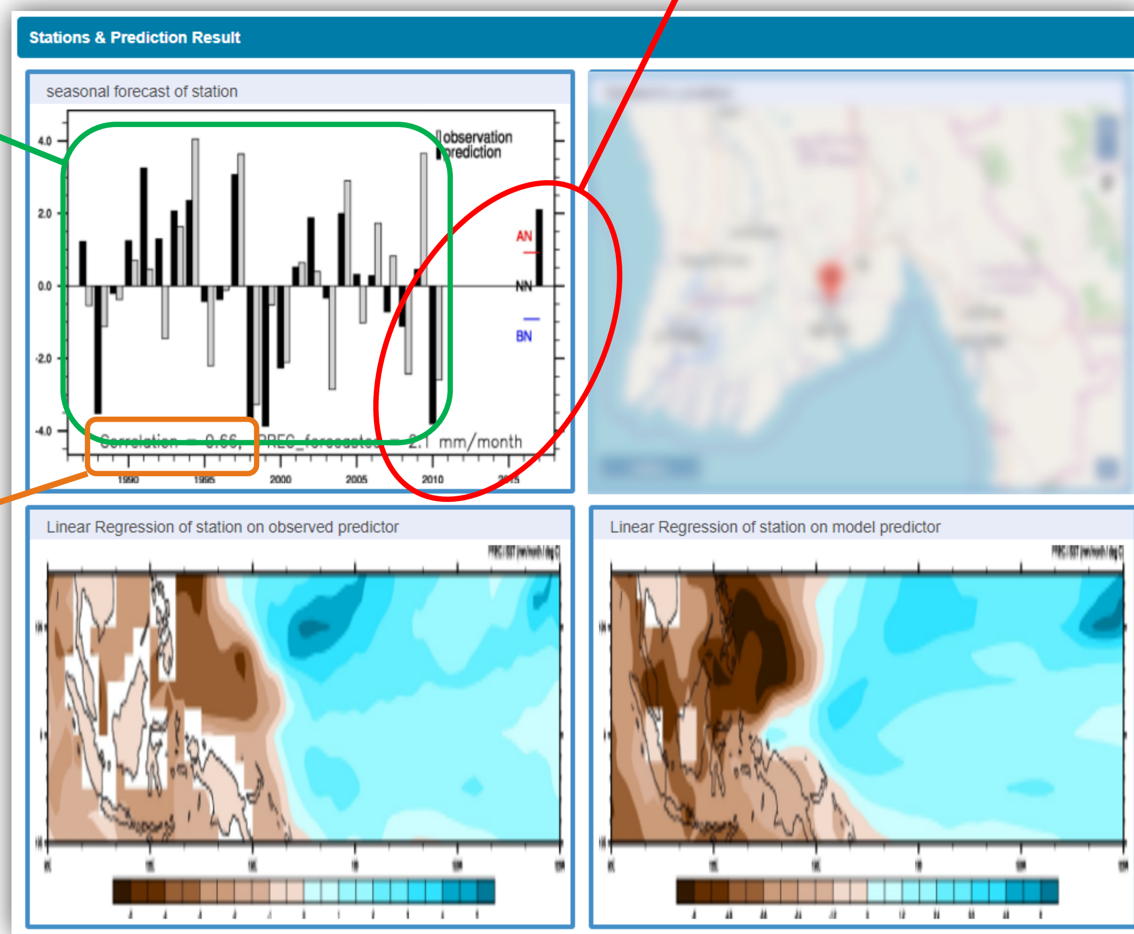


http://clik.apcc21.org

Downscaled forecast at a given site

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

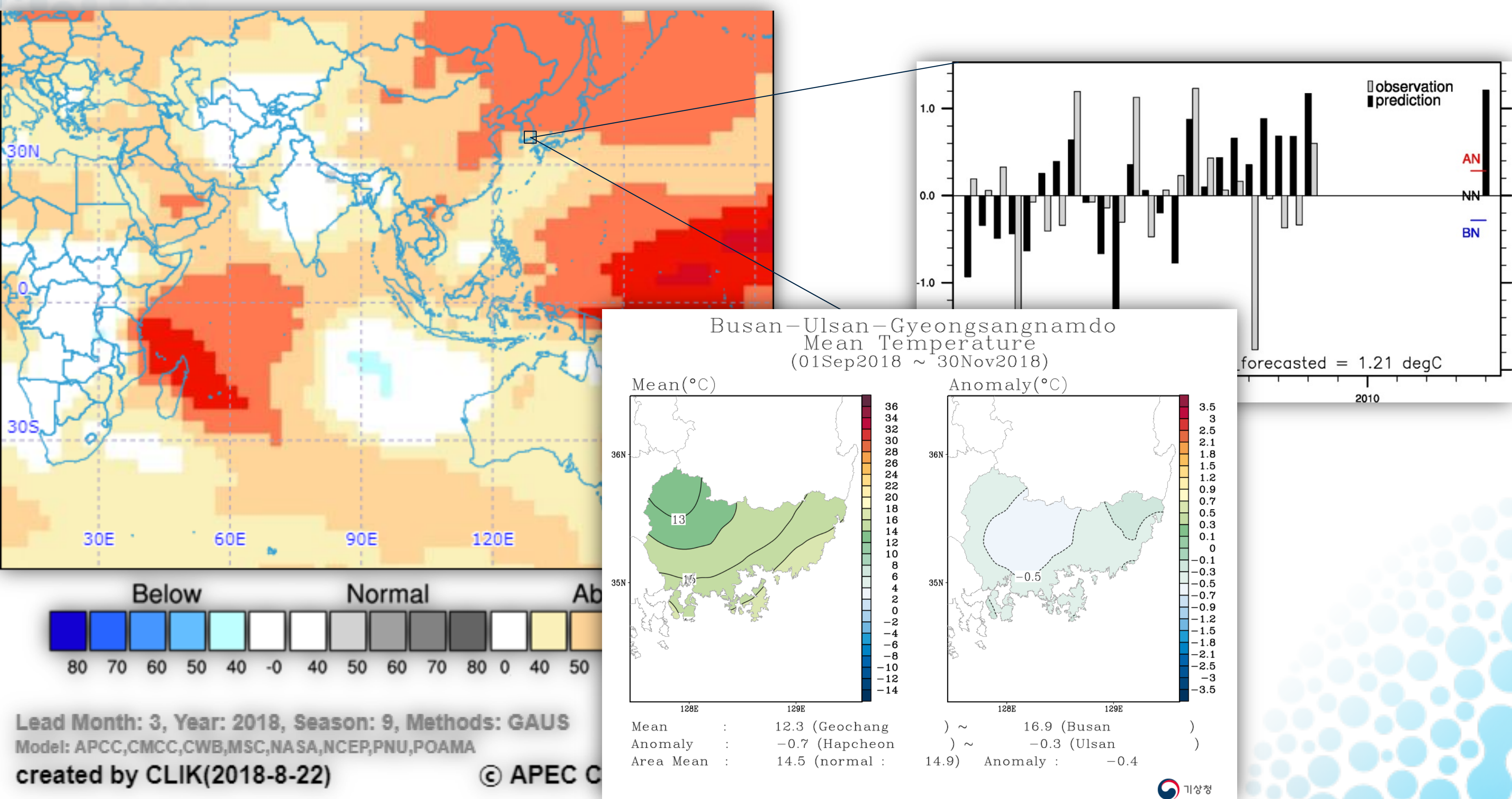
Historical time series:
obs & downscaled from MME



Temporal Correlation
Coefficient **(TCC) skill**

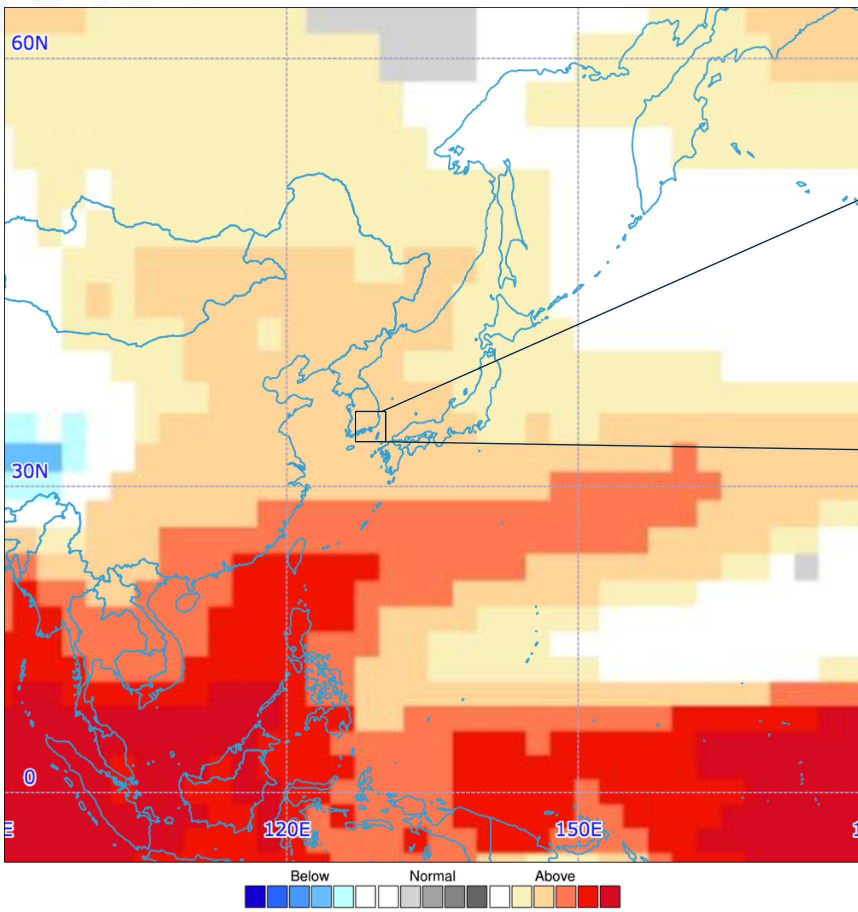
2018 SON Temp. forecast (Busan, KOREA)

PMME (dynamical, grid) & Downscaled (pointwise)

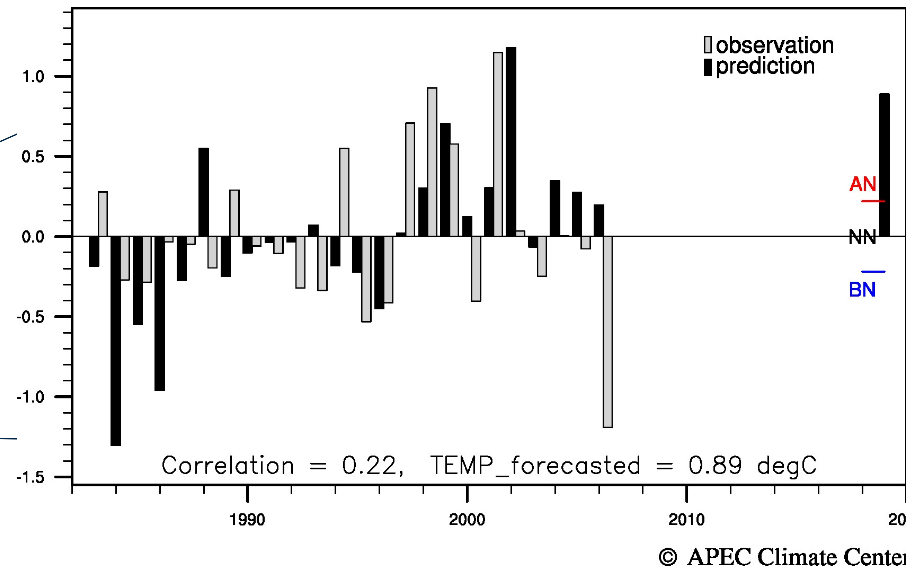


2019 AMJ Temp. forecast (Busan, KOREA)

PMME (dynamical, grid) & Downscaled (pointwise, SCM)



Lead Month: 3, Year: 2019, Season: 4, Methods: GAUS
Model: APCC,CWB,MSC,NASA,NCEP,PNU,POAMA
created by CLIK(2019-4-20)



Busan 2019 AMJ mean temp.	17.87 degC
Normal (median)	17.27 degC
	+ 0.6 degC

Availability of Downscaled information?


PICASO
Pacific Island Countries Advanced Seasonal Outlook

Downscaling/tailoring of dynamical MME

Current Climate

CLiK p
Climate Information Toolkit

Dynamical Prediction

PICASO

They further tailor "predicted climate"
onto
"predicted rainfall" at the given site.

Predicted Climate

Predicted Rainfall

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

ROK-PI CliPS: Overview

Republic **O**f **K**orea-**P**acific **I**slands **Cl**imate **P**rediction **S**ervices

- Objective:

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

- Working Pillars:

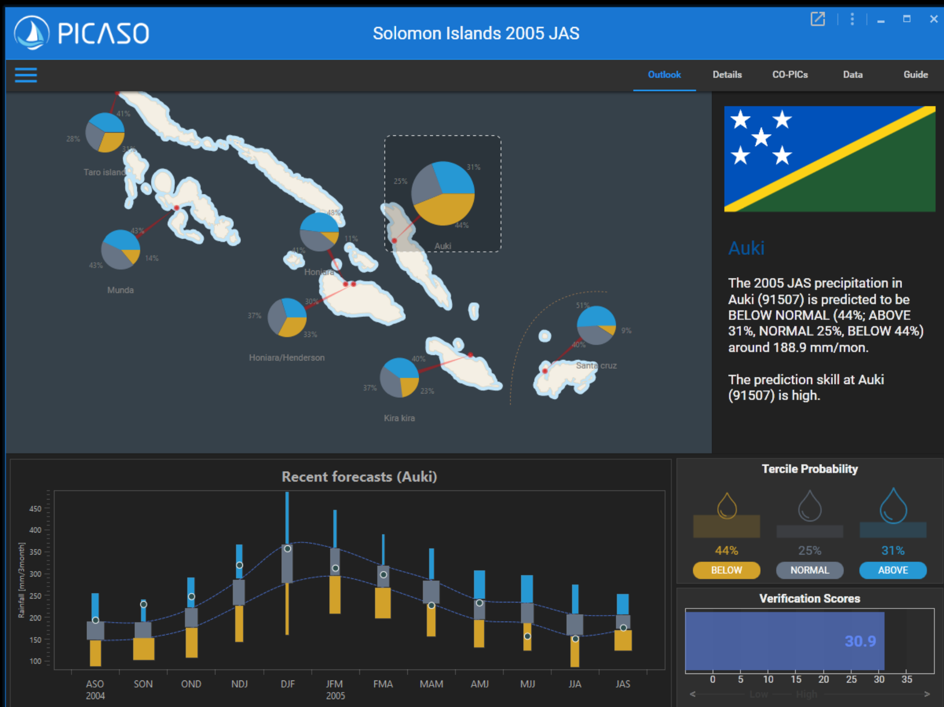
One Dynamical Seasonal Forecasting System
→ CLiKP Climate Information Toolkit

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



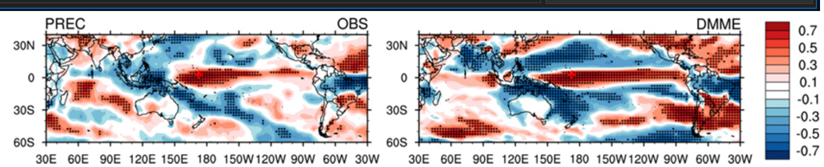


Figure 2.Temporal correlation coefficients (TCCs) between local precipitation of Butaritari(91601) and precipitation at each grid during the April – June(AMJ) for (left) observation and (right) DMME. The black dots indicate grid points for which TCC is significant at the 95% confidence level.

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
HSS	0.14	0.2	0.14	0.57	0.5	0.03	0	0.32	0.14	0.28	0.09
LEPS	33%	35%	27%	31%	35%	22%	35%	20%	22%	38%	38%

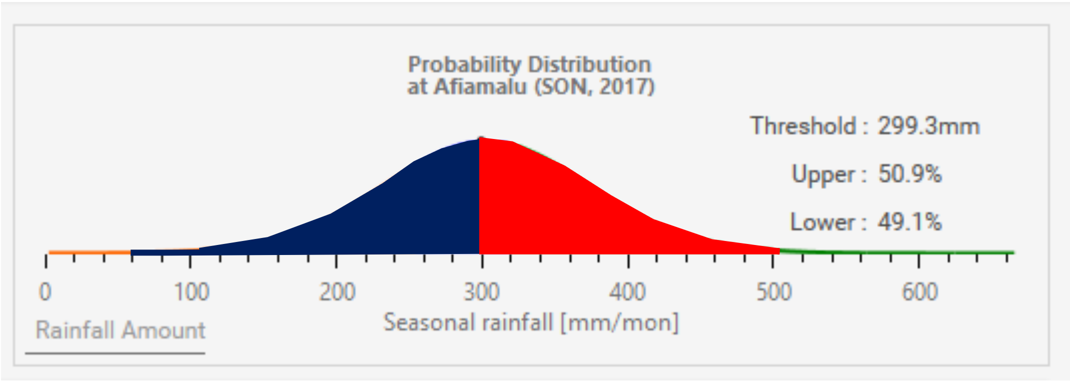
VALIDATION HISTORY (PREDICTION/OBSERVATION)

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

PICASO > 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

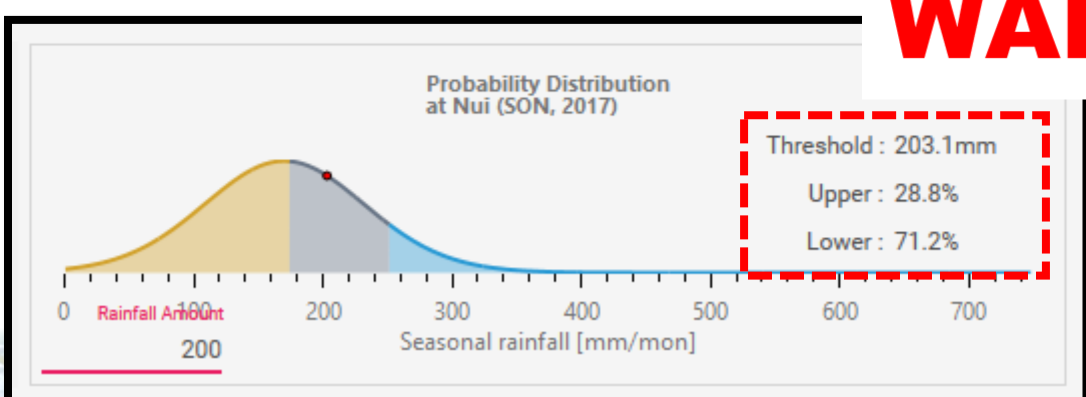
Tuvalu

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!



Samoa

Watershed Management Plans

Zoning regime

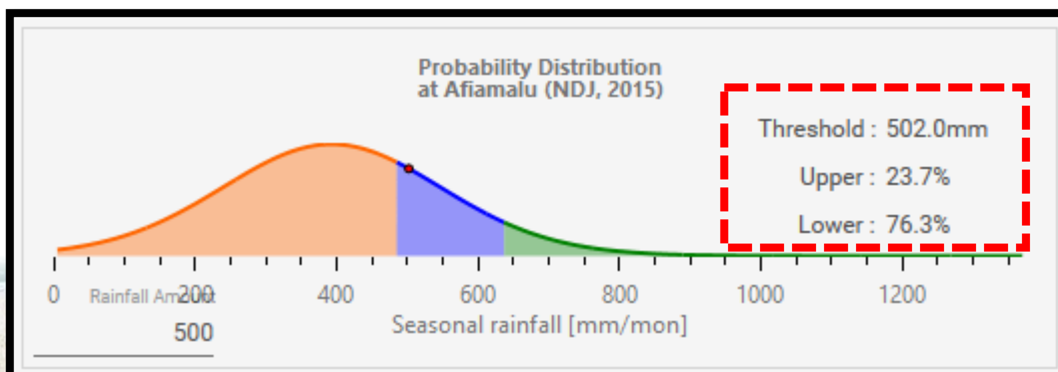
Zone 3: Exclusion Zone (above 600m altitude)
Zone 2: Restricted Zone (300m-600m above mean sea level)
Zone 1: Development Zone (0-300m above mean sea level)

- ✓ Zone 1 is the lower watershed area where population/development is concentrated and where the needs for watershed ecological services are greatest.
- ✓ Development planning is essential in implementing **flood hazard plans** and also in ensuring that activities have controlled impacts on the receiving coastal waters and soil resources.

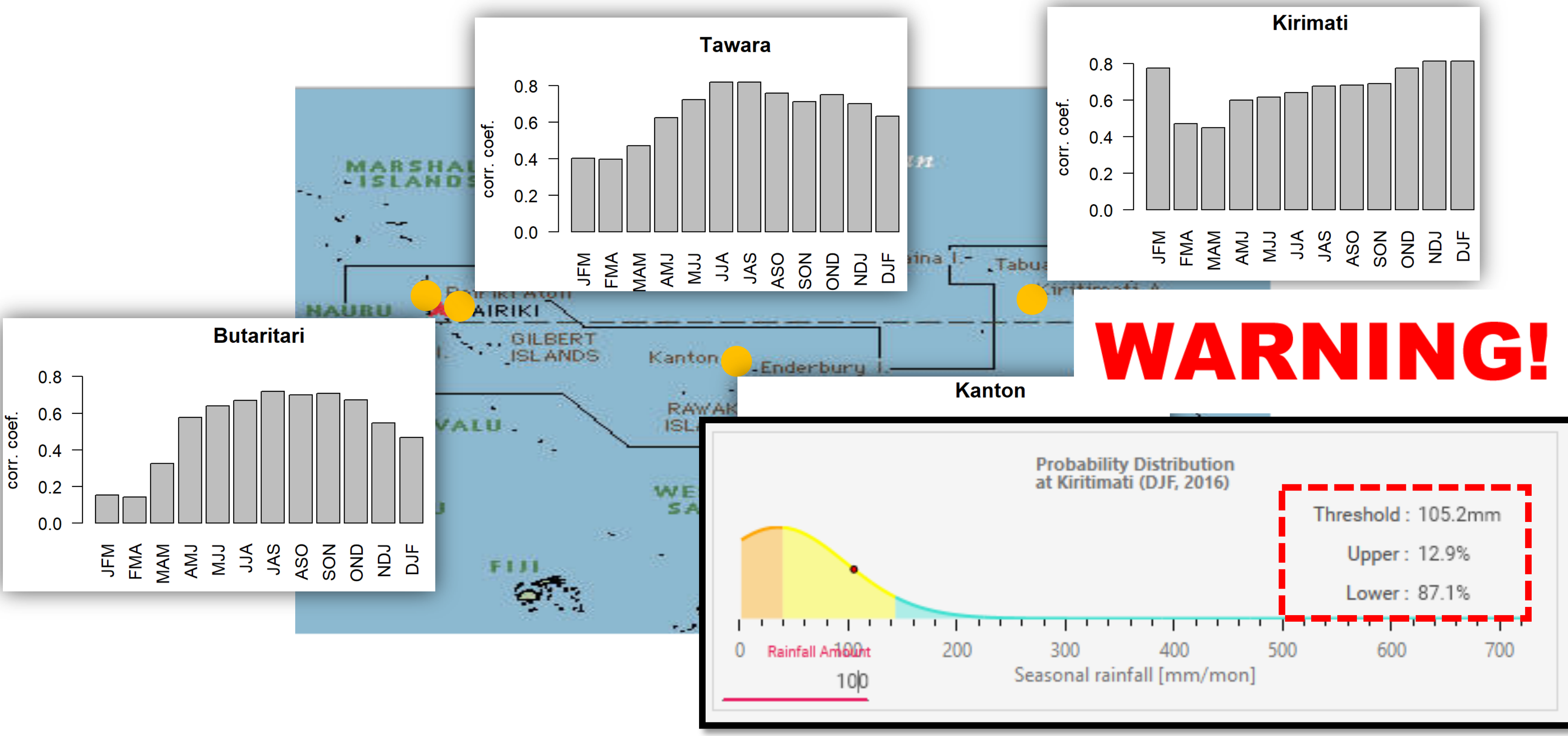
NO WORRIES!

Abundant water resources

- The Average rainfall is over 3,000mm/year (2,500 mm in the north-west parts of the main islands to <u>6,000 mm in the highlands</u> of Savaii)
- 75 percent of the precipitation occurring during November-January.



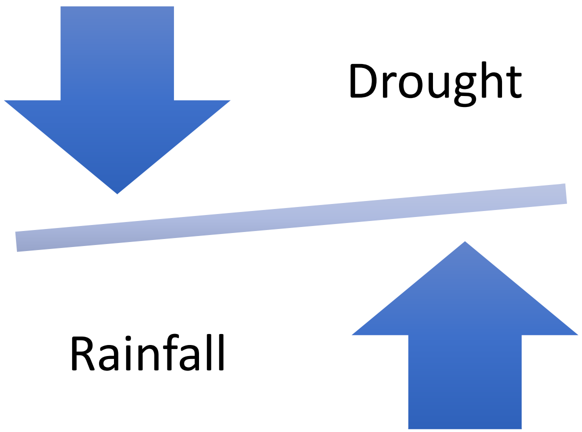
Kiribati



- A vast area of territory covering most equatorial Pacific
- Regionally/seasonally varying - ENSO dependent rainfall
- La Nina coming → Drought expected
  → Advise **the Drought Committee** on the status of the Water reserve

Tonga

Recharge to groundwater



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


TONGA'S FIRST COMMERCIAL CONSIGNMENT OF SQUASH PUMPKIN IS ON ITS WAY TO CHINA

File Footage

(Radio & TV Tonga, Nuku'alofa, 28/11/2016)

The Chinese Government has approved the export of Tonga's squash pumpkin into its market.

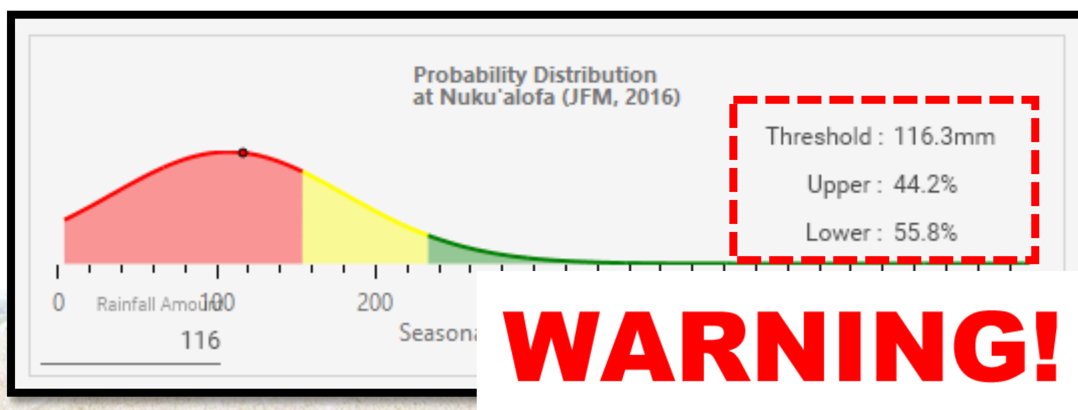
This is seen as an initiative that could encourage more growers to go back to the plantations they abandoned during the past years due to falling prices in overseas markets.

The CEO of Agriculture – Dr. Viliami Manu told Radio Tonga news, this is a result of an evaluation visit of a team from China's Quarantine Department to oversee the quality of squash pumpkin in Tonga.

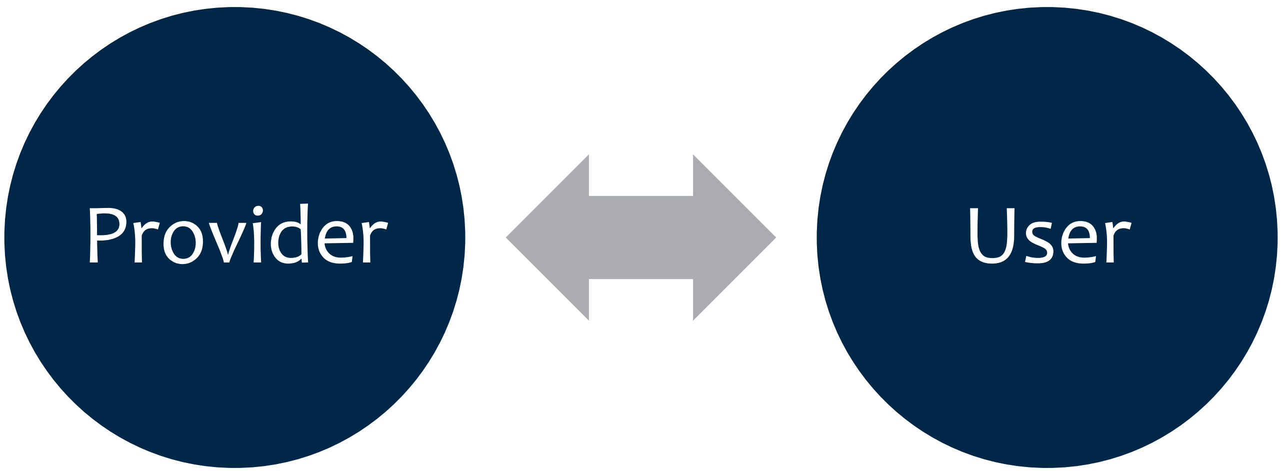
http://www.tonga-broadcasting.net/?p=3959

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

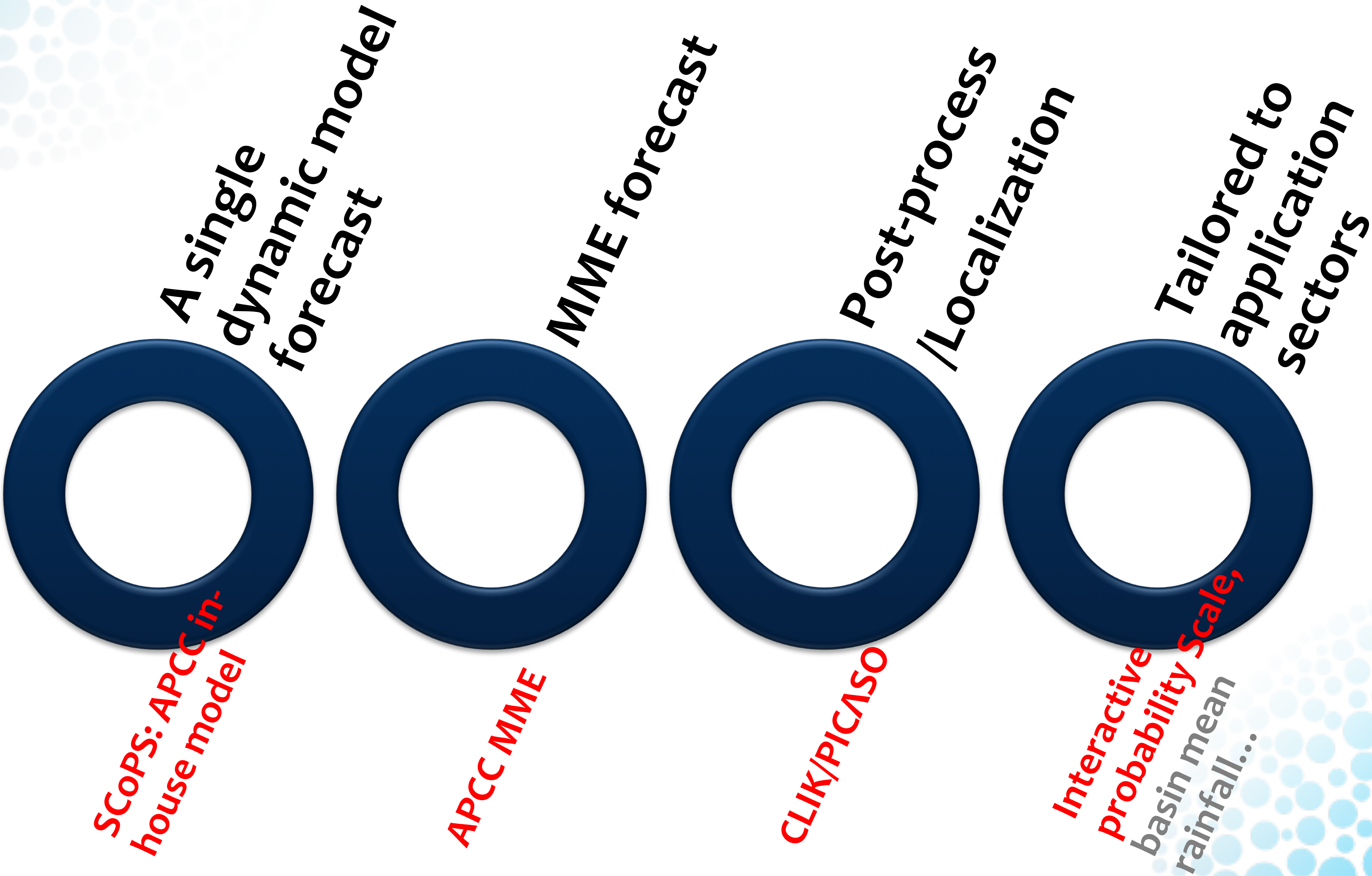


Fill the gap



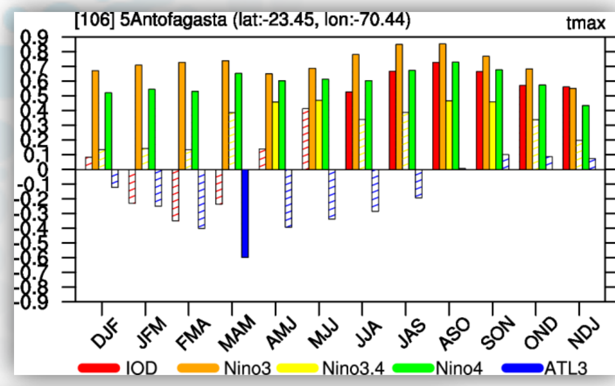
Accuracy
Resolution
Contents

Climate Prediction Service Enhancement



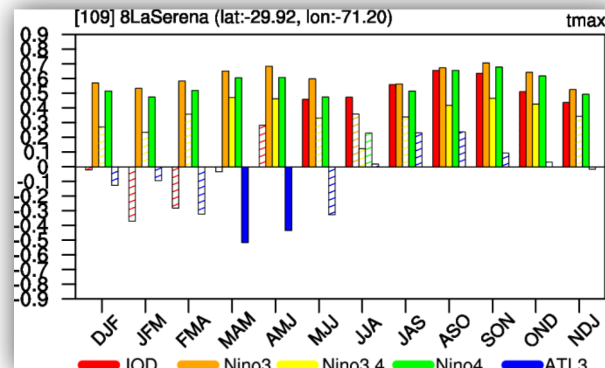

Thank you.

Tx

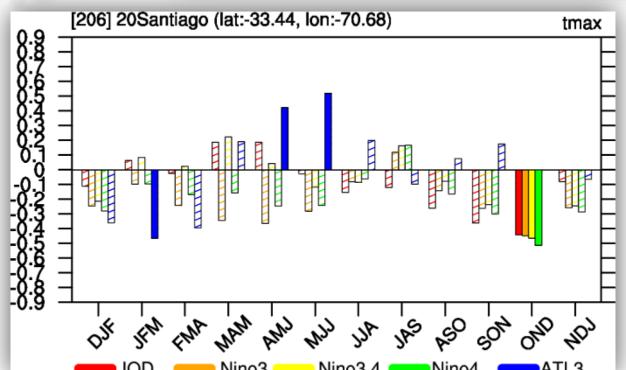


[106] 5Antofagasta (lat:-23.45, lon:-70.44)
tmax
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3

BOLIVIA
Climate areas:
Dry
Warm
Snow
Wet
Atacama Desert
ARGENTINA
ANDES
Santiago
Maipo River
CHILE
Pacific Ocean
ANDES



[109] 8LaSerena (lat:-29.92, lon:-71.20)
tmax
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3



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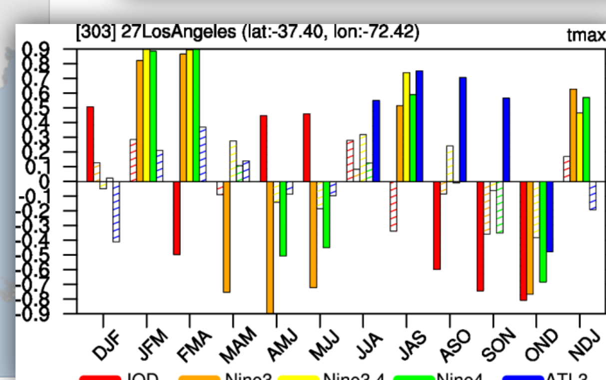
IOD Nino3 Nino3.4 Nino4 ATL3



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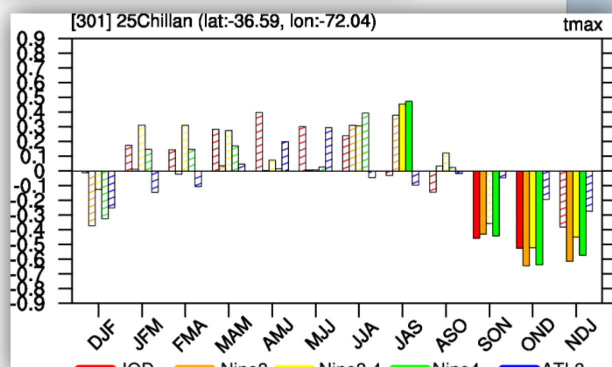
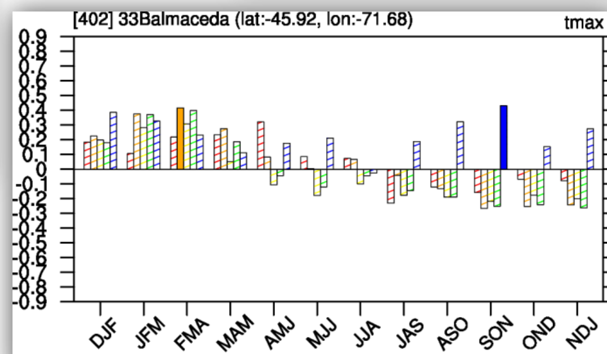
IOD Nino3 Nino3.4 Nino4 ATL3

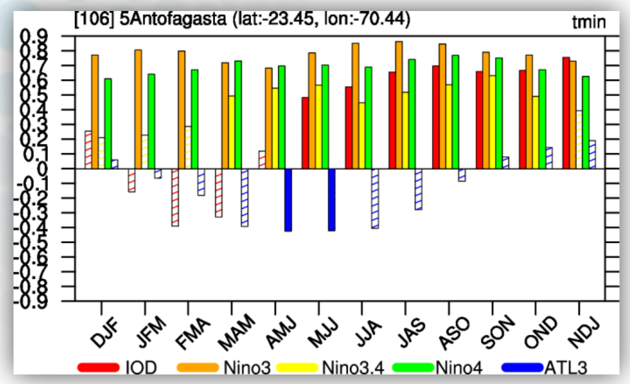


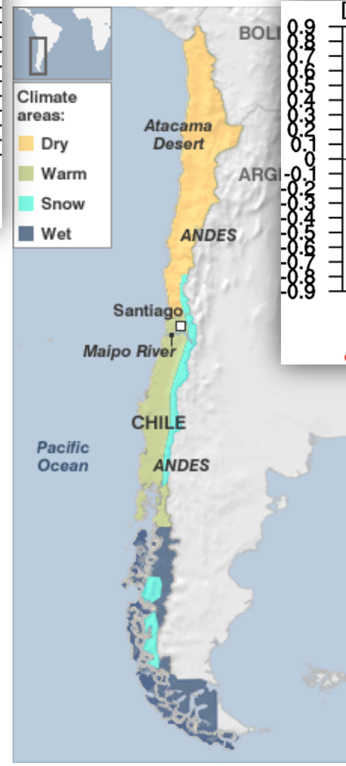
[301] 25Chillan (lat:-36.59, lon:-72.04)
tmax
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3

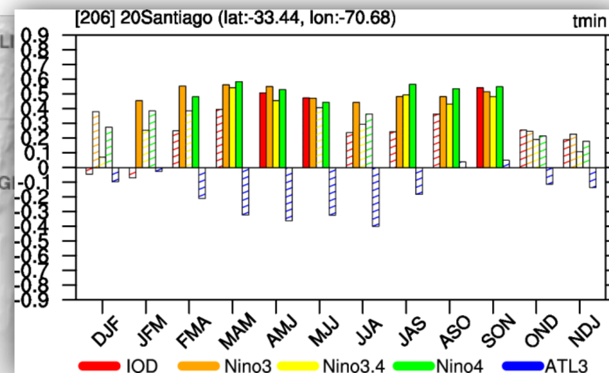


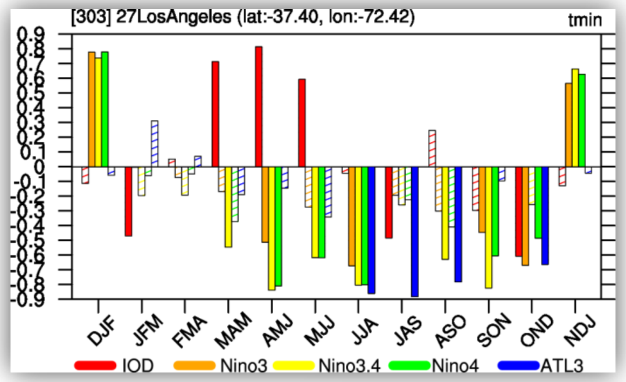
[402] 33Balmaceda (lat:-45.92, lon:-71.68)
tmax
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ

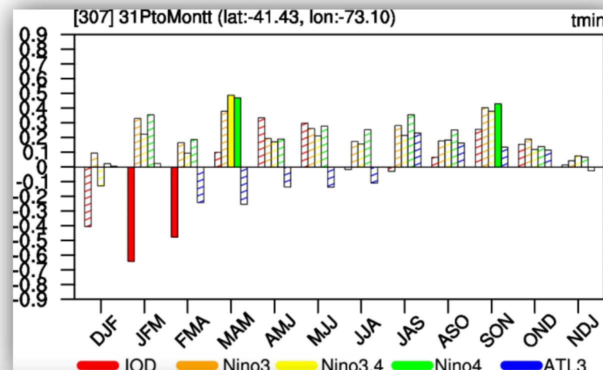
Tn

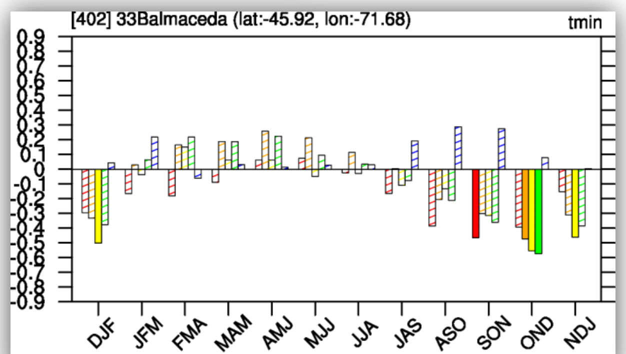

[106] 5Antofagasta (lat:-23.45, lon:-70.44)
tmin
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3

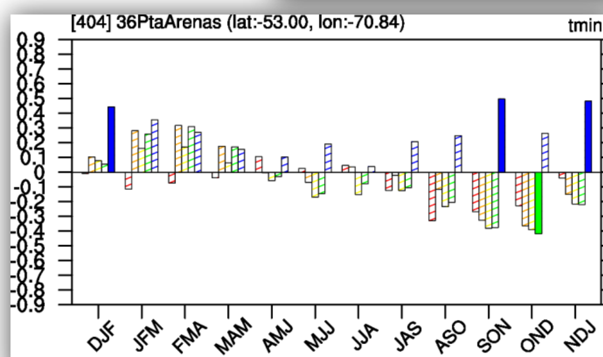

Climate areas:
Dry
Warm
Snow
Wet
Atacama Desert
ANDES
Santiago
Maipo River
CHILE
Pacific Ocean
ANDES


[206] 20Santiago (lat:-33.44, lon:-70.68)
tmin
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3

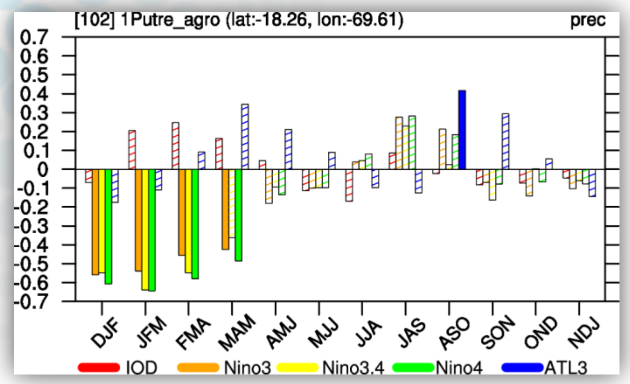

[303] 27LosAngeles (lat:-37.40, lon:-72.42)
tmin
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3

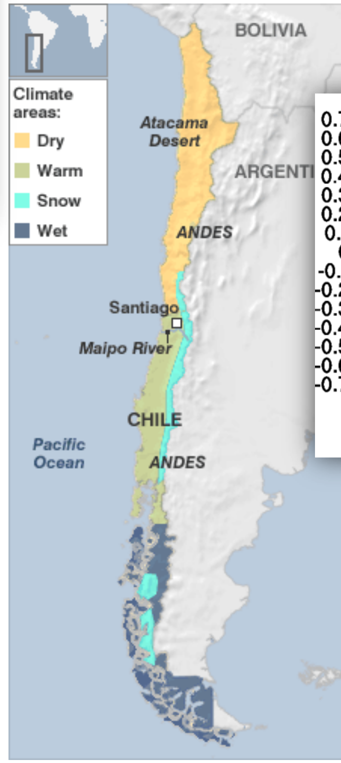

[307] 31PtoMontt (lat:-41.43, lon:-73.10)
tmin
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3

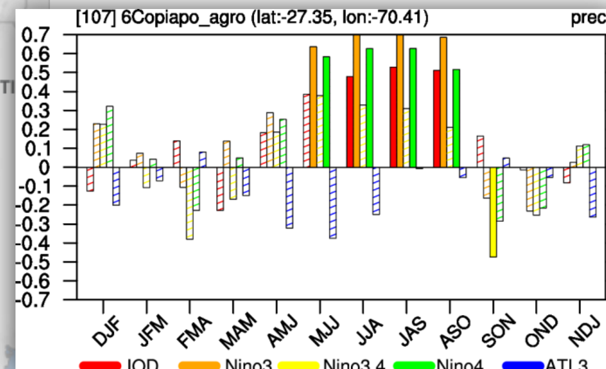

[402] 33Balmaceda (lat:-45.92, lon:-71.68)
tmin
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ

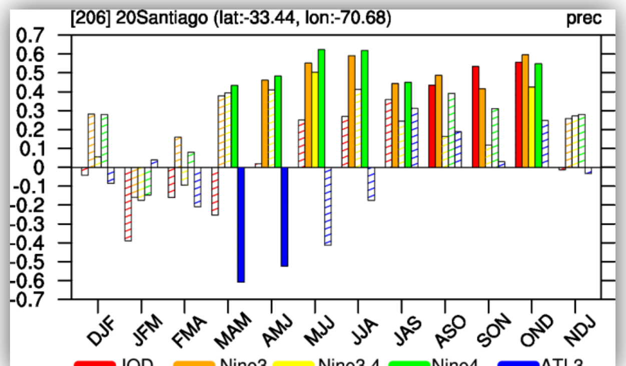

[404] 36PtaArenas (lat:-53.00, lon:-70.84)
tmin
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ

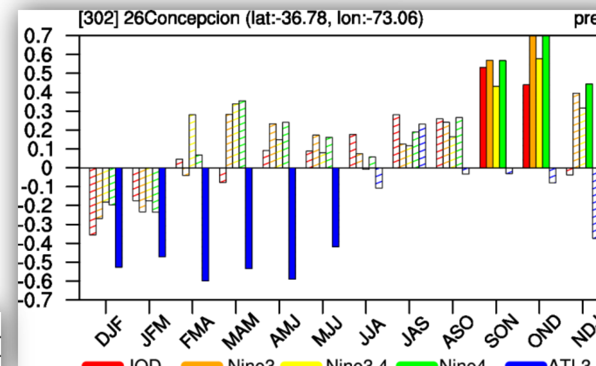
RR

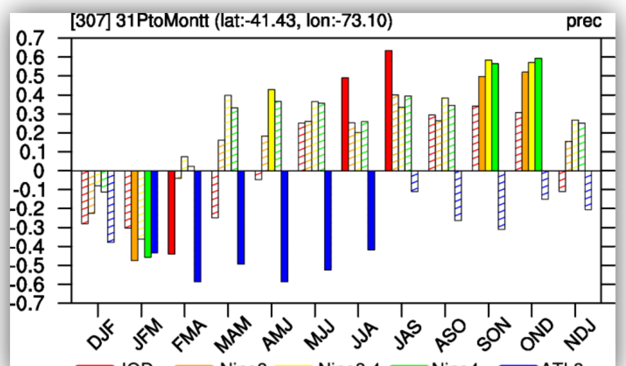

[102] 1Putre_agro (lat:-18.26, lon:-69.61)
prec
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3

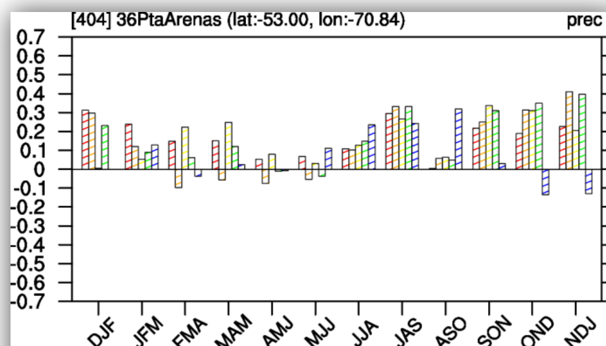

BOLIVIA
ARGENTI
Climate areas:
Dry
Warm
Snow
Wet
Atacama Desert
ANDES
Santiago
Maipo River
CHILE
Pacific Ocean
ANDES


[107] 6Copiapo_agro (lat:-27.35, lon:-70.41)
prec
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3


[206] 20Santiago (lat:-33.44, lon:-70.68)
prec
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3


[302] 26Concepcion (lat:-36.78, lon:-73.06)
prec
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3


[307] 31PtoMontt (lat:-41.43, lon:-73.10)
prec
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ
IOD Nino3 Nino3.4 Nino4 ATL3


[404] 36PtaArenas (lat:-53.00, lon:-70.84)
prec
DJF JFM FMA MAM AMJ MJJ JJA JAS ASO SON OND NDJ