One-month probabilistic forecasts at station points

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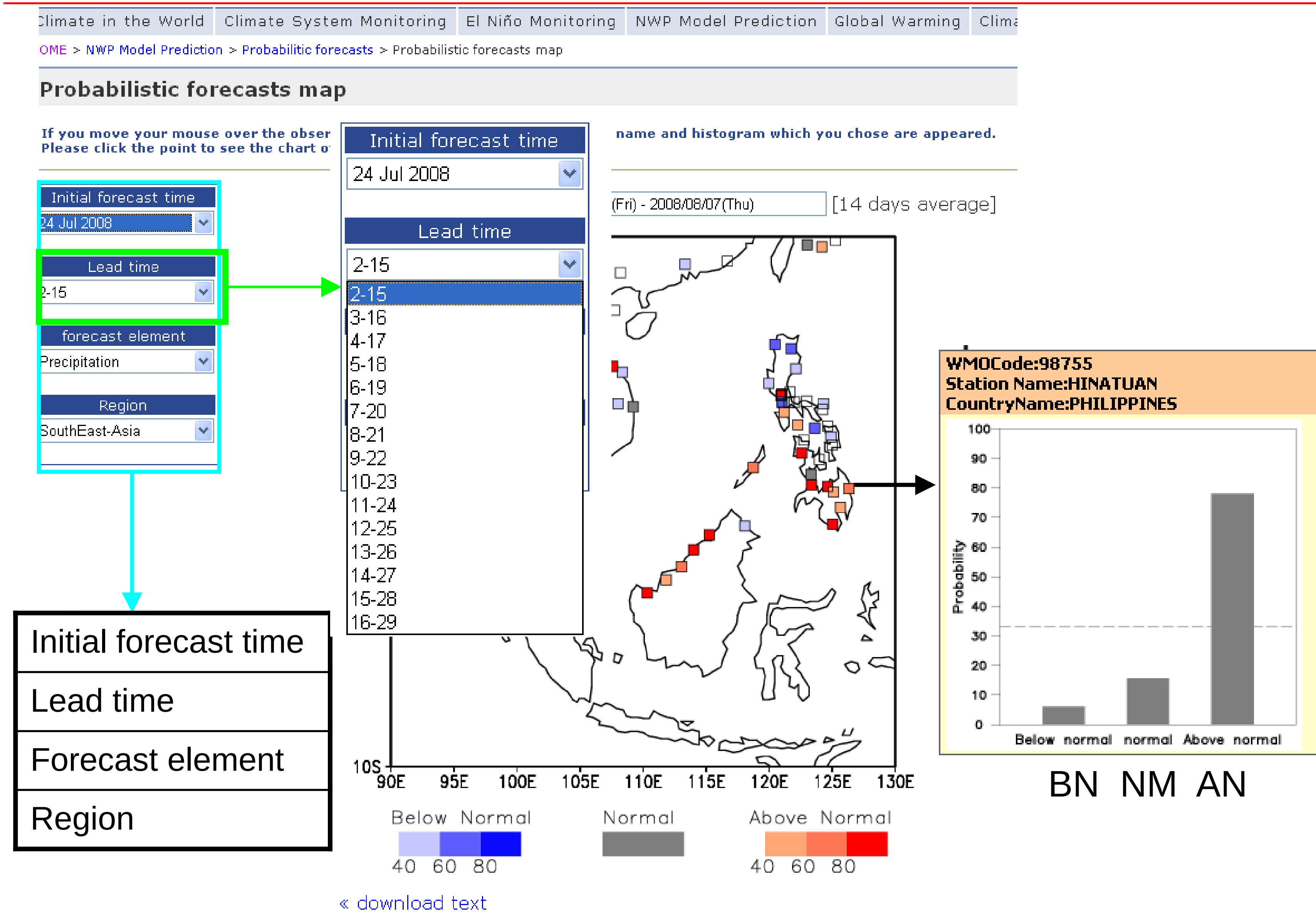
Contents

1. Introduction of TCC downscaling product
2. Specification of one-month EPS product
3. Statistical downscaling method
   for TCC product

1.Introduction of TCC downscaling product

- **Japan Meteorological Agency (JMA) has started probabilistic one-month forecast at stations in the southeast Asia for 7day-average surface temperature and 14day-avearge precipitation.**
- **The Model Output Statistics (MOS) technique based on the 20 years (1982-2001) hindcasts generate the forecasts.**
- **The Gauss-distribution method is used as the statistical tool of the MOS. The thresholds of tercile are determined as making each category become 33.3% of station's observation in 1982-2002.**

Information on TCC web page

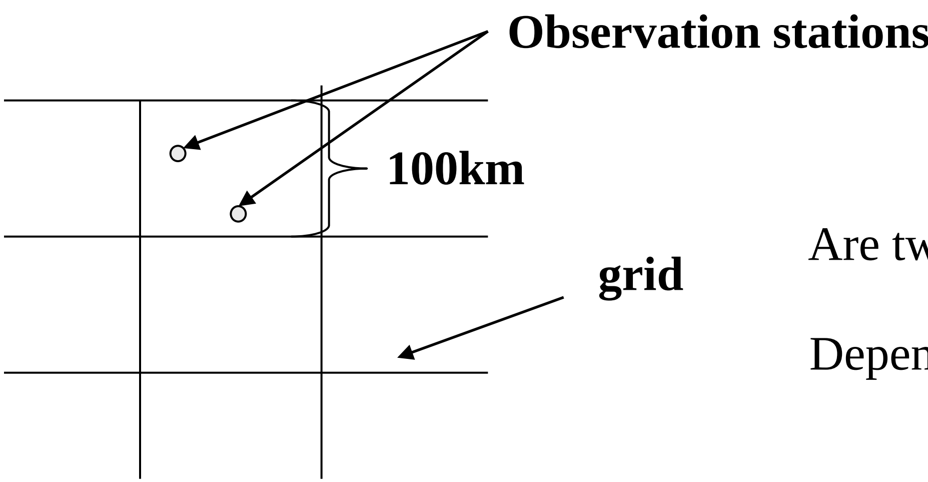


Why should we use statistical downscaling ?

Resolution of forecast model is not enough, roughly 100km.

⇩

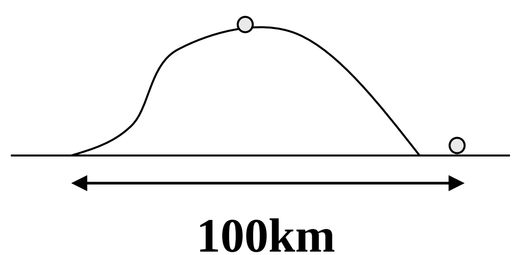
It is difficult to predict accurately at station scale.



Are two stations same in temperature ?

Depending on the land feature, climate might be different.

Example :



Method of Downscaling

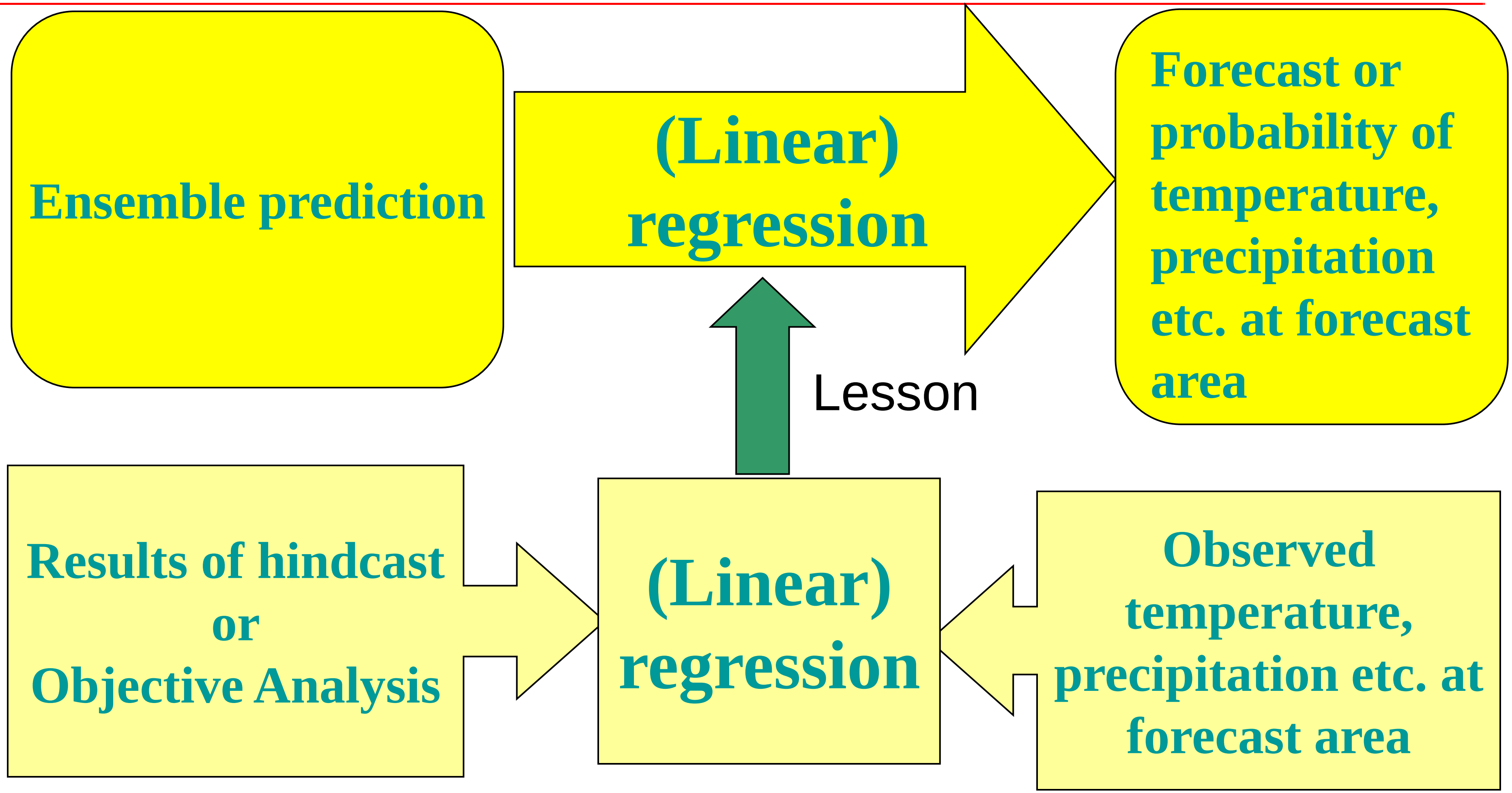
- From global to regional/local scale

  - Downscaling by Regional model (Dynamical downscaling)
  - Downscaling by Statistical method

  - Statistical guidance to forecasters

Statistical procedure should be important even if you use dynamical downscaling.

Outline of Statistical downscaling



2. Specification of one-month EPS product

Horizontal resolution	TL159 (about 1.125º Gaussian grid ~110km)
Vertical Layers	60 (Top Layer Pressure:0.1hPa)
Time integration range	34 days
Executing frequency	Once a week
Ensemble size	50 members
Perturbation method	Breeding of Growing Mode (BGM) & Lagged Average Forecast (LAF) method
SST	Persisted anomaly
Land surface Parameters	Initial conditions of land parameters are provided by a land surface analysis system. Observation of snow depth reported in SYNOP is assimilated.

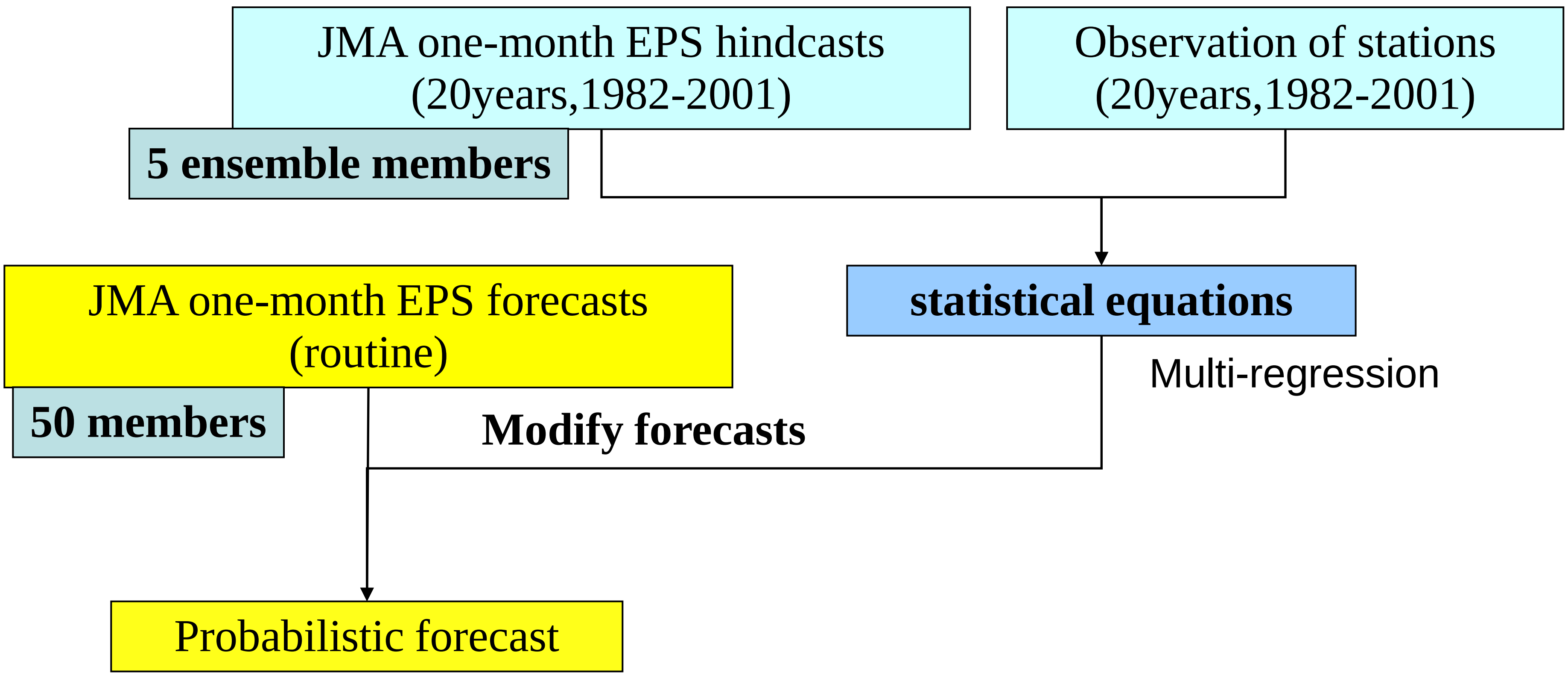
Specification of Hindcast Experiment for one-month forecast

Model	JMA AGCM(TL159)
Target years	1982 to 2001, 20 years
Target months	All months (initial date is the 10^{th}, 20^{th} and end of every month)
Integration time	1 months
Ensemble size	5 members
Atmospheric initial condition	JRA-25 (the Japanese 25-year Reanalysis)
SST	Persisted anomaly
Land surface initial condition	Climatology; 10-year average of output from SiB forced by GANAL from 1997 to 2006

3. Statistical downscaling for TCC product

One month probabilistic forecasts at station points

For Forecasts



3. Statistical downscaling for TCC product
Multi-regression

Techniques used in statistical downscaling

Multiple regression formula:

-Multiple regression : $\mathbf{Y = A_1X_1 + A_2X_2 + \cdots + B}$

Y: dependent variable
X: independent variable (predictor)

Method of variable selection : **Stepwise selection**
selected variables vary in locations and seasons

Four seasons:

-winter dry season (Jan-Mar)
-pre-monsoon season (Apr-May)
-summer monsoon season (Jun-Sep)
-post-monsoon season (Oct-Dec)

For example

Modified forecast = $\mathbf{A_1}$ **forecast +** $\mathbf{A_2X_2}$ → station1

Modified forecast = $\mathbf{A_1}$ **forecast +** $\mathbf{A_2X_2 + A_3X_3}$ → station2

3. Statistical downscaling for TCC product

One month probabilistic forecasts at station points

<u>Selectable predictors in Multiple Regression:</u>

-**model precipitation (to power of 1/4)** or **model 2m temperature**

-**topographical upward motion (U850 x slope of terrain)**
(eight kinds of terrain data from 0.083 to 1.25 degree)

Topographical factor = $\vec{\mathbf{U}}\mathbf{850}\cdot\nabla\mathbf{h}$

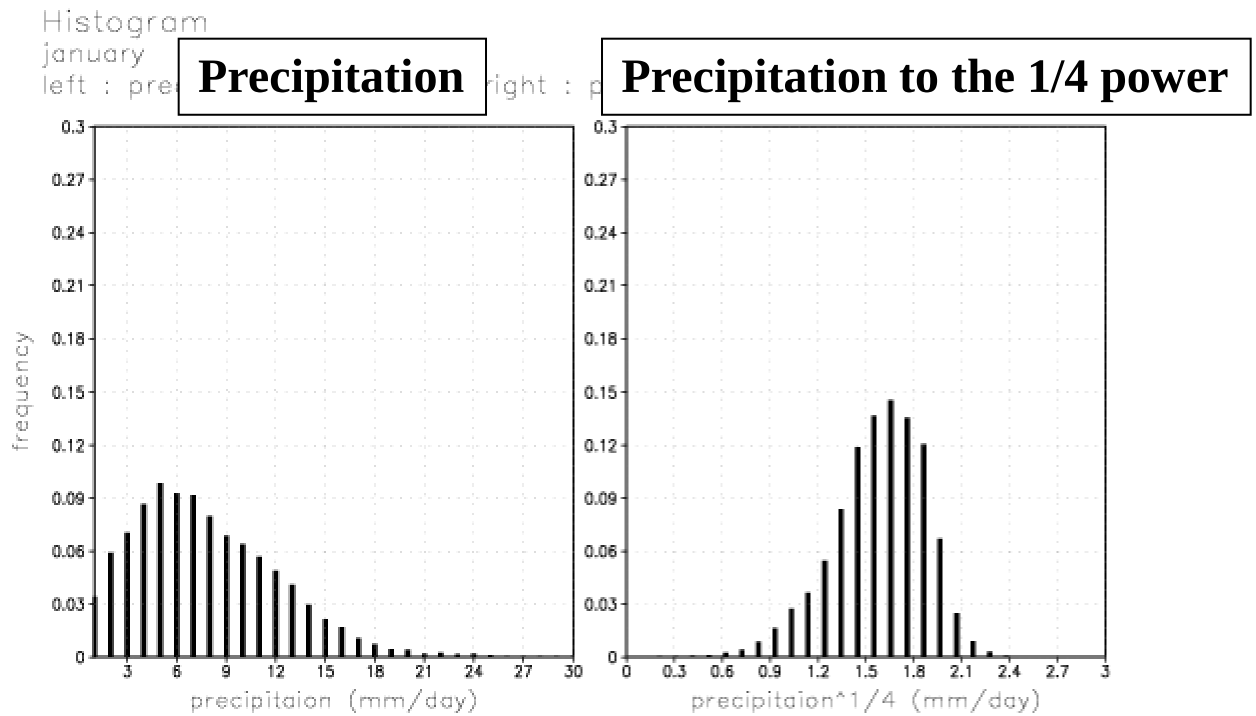
> 0 upward motion
< 0 downward motion

-**MJO-Index (RMM1 and RMM2)** (Wheeler and Hendon,2004)
EOFs of near-equatorially averaged 200hPa velocity potential and 850hPa and 200hPa U (zonal wind)
RMM1 and RMM2 are time coefficients of EOF1 and EOF2.

-**NINO.3.SST anomaly** (5S-5N,150W-190W)
using previous month value

3. Statistical downscaling for TCC product

Anomaly of temperature tends to be distributed like normal distribution, but precipitation doesn’t.
We use precipitation to the 1/4 power.

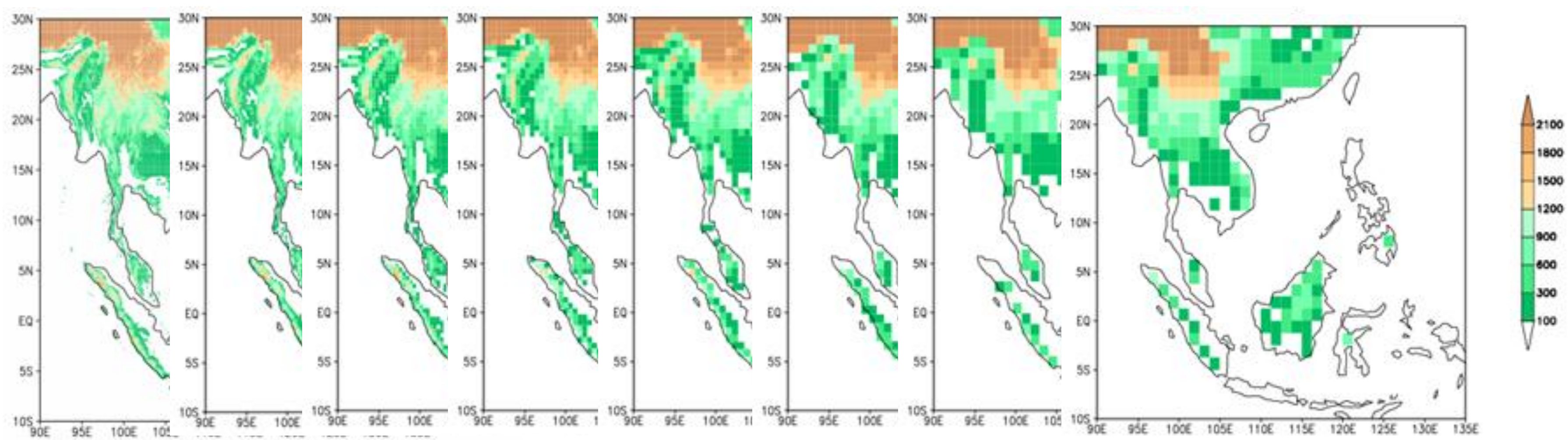


Averaged 0 – 10N , 90E – 150E , in January

3. Statistical downscaling for TCC product

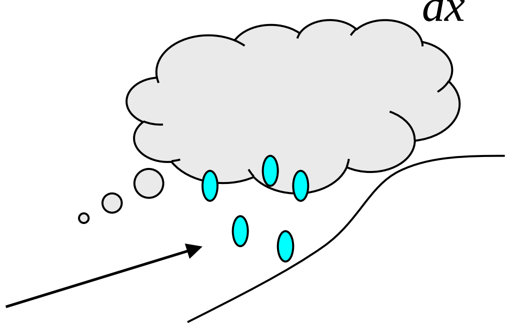
topographical upward motion (U850 x slope of terrain)

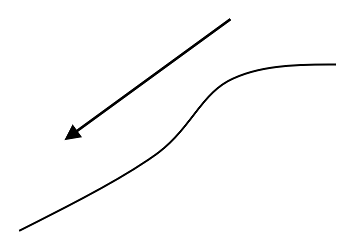
(eight kinds of terrain data from 0.083 to 1.25 degree)



0.083 degree → 1.25 degree

$$\text{Topographical factor} = u_{850}\frac{dh}{dx} + v_{850}\frac{dh}{dy} \quad \begin{array}{ll} > 0 & \text{upward motion} \\ < 0 & \text{downward motion} \end{array}$$

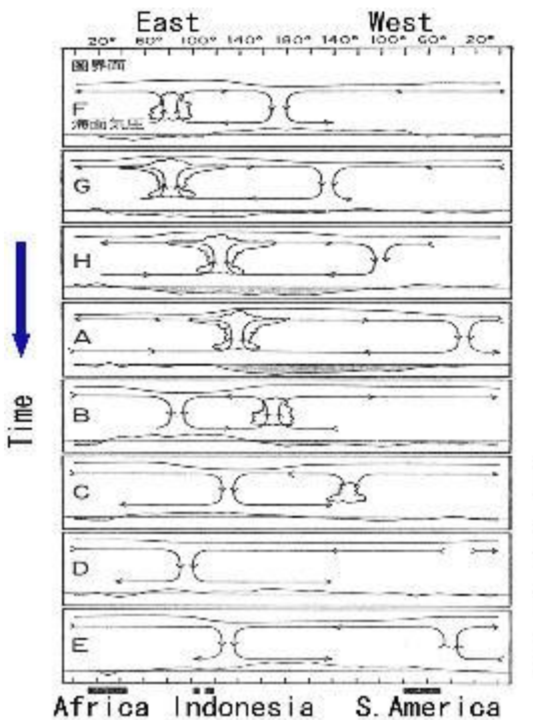




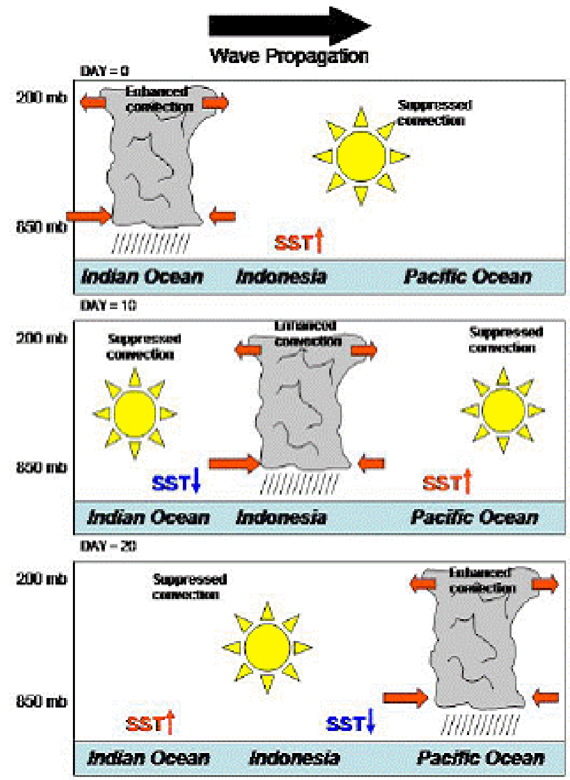
3. Statistical downscaling for TCC product

MJO : The Madden-Julian Oscillation (Madden and Julian,1971,1972)

The MJO is characterized by an eastward migration of large-scale convective activity with wave-number one. It is called as 30-60 day oscillation following the period.



(Madden and Julian,1972)



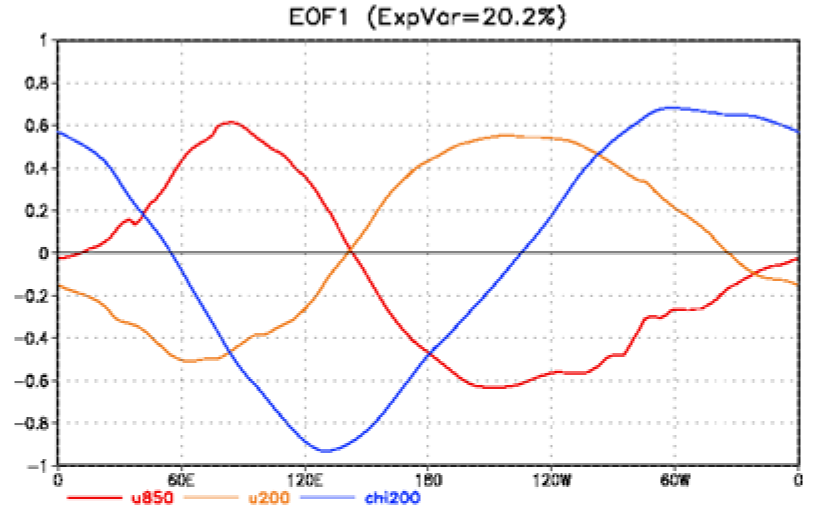
(NOAA)

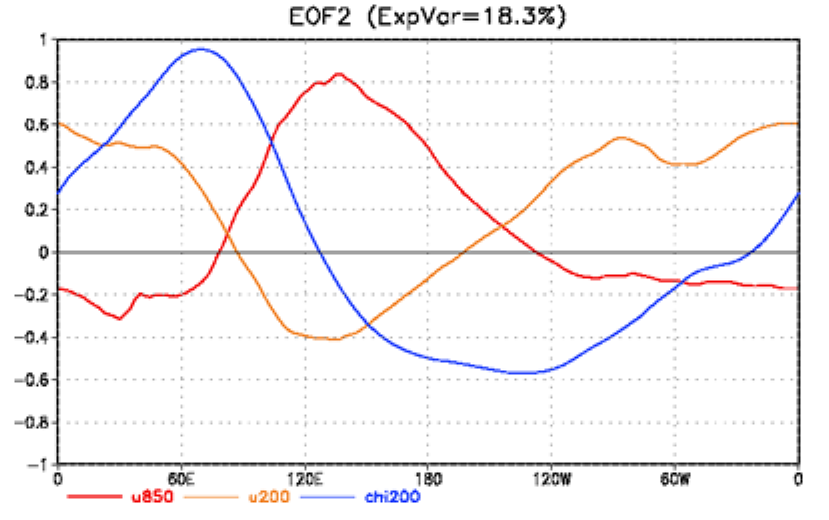
3. Statistical downscaling for TCC product

MJO-Index (RMM1 and RMM2)
(Wheeler and Hendon,2004)

200hPa velocity potential (original index is used OLR)
850hPa zonal wind
200hPa zonal wind

EOFs of near-equatorially averaged (5S – 5N)
RMM1 and RMM2 are time series of coefficients for EOF1 and EOF2.





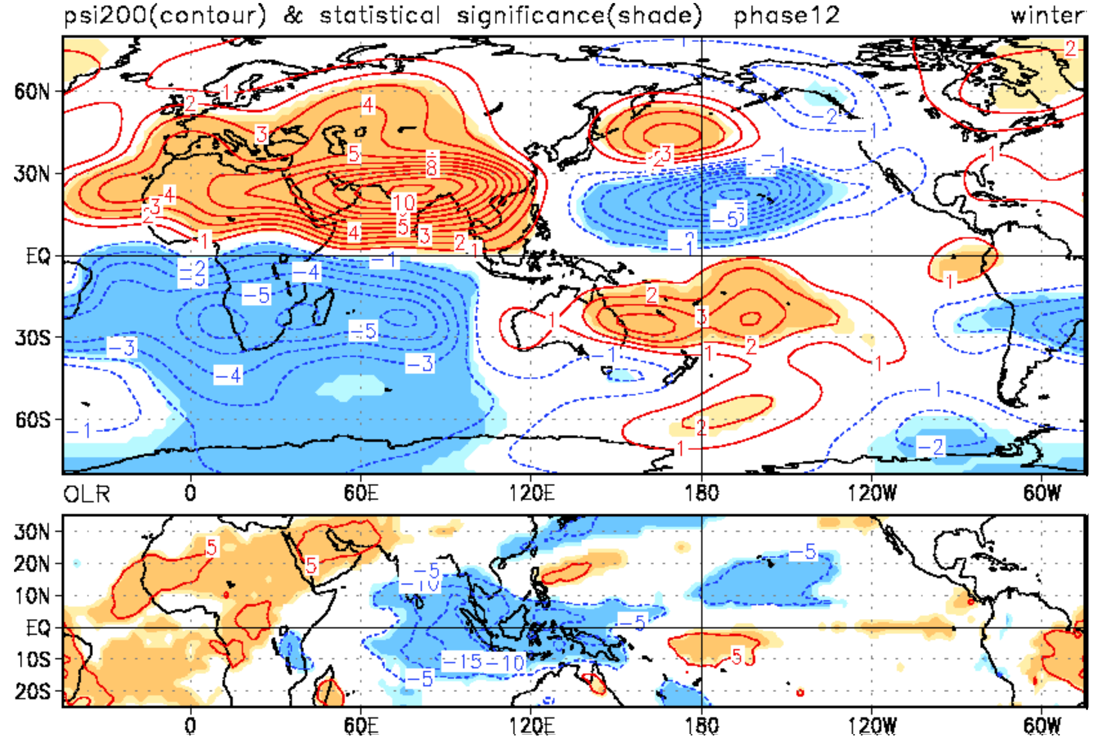
(Mr. Tanaka in JMA)

3. Statistical downscaling for TCC product

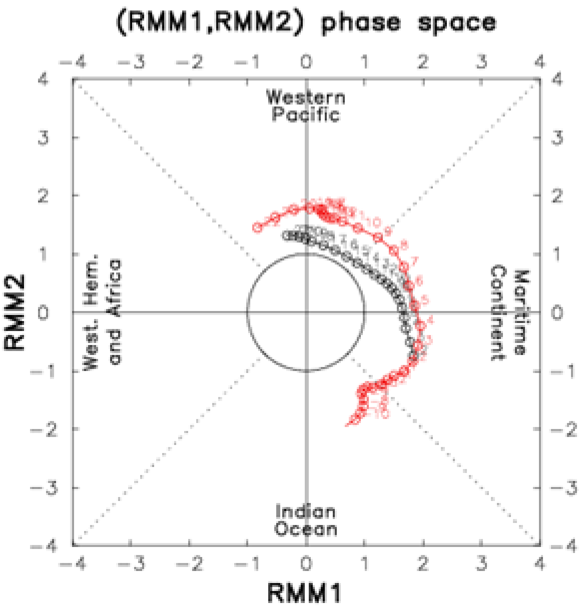
Composition maps of stream function at 200hPa and OLR at each phase (1-12) of MJO in winter

Stream function

at 200hPa



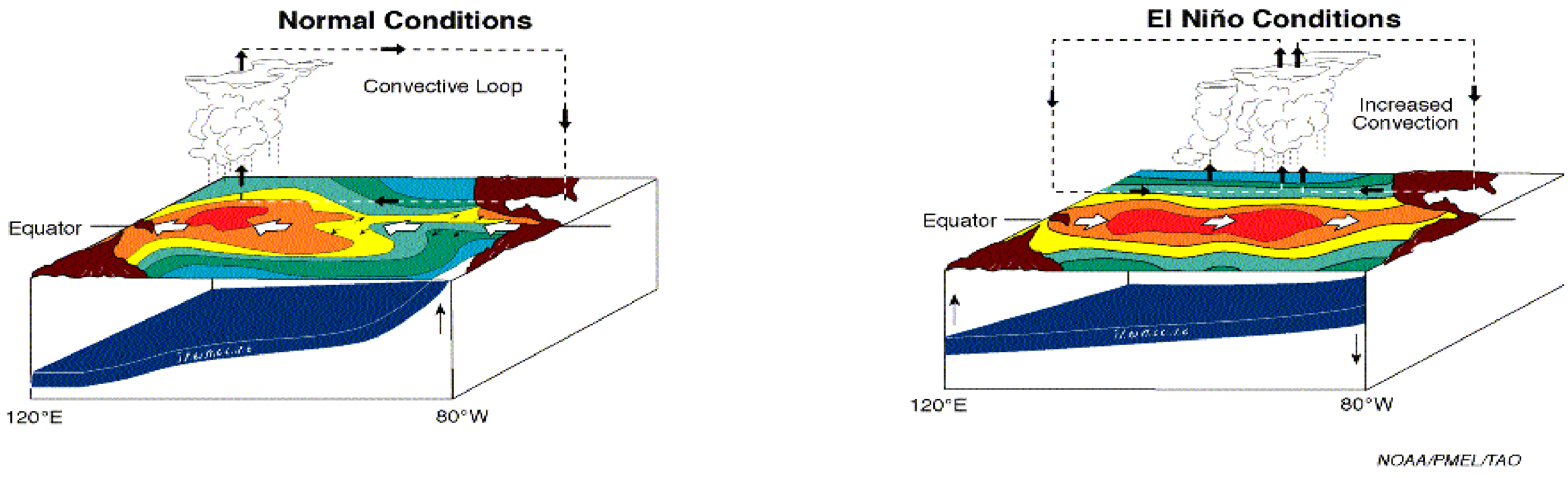
OLR



Endoh and Harada (2005)

3. Statistical downscaling for TCC product

NINO.3.SST Anomaly (5S-5N,150W-190W)
using SST anomaly at previous month



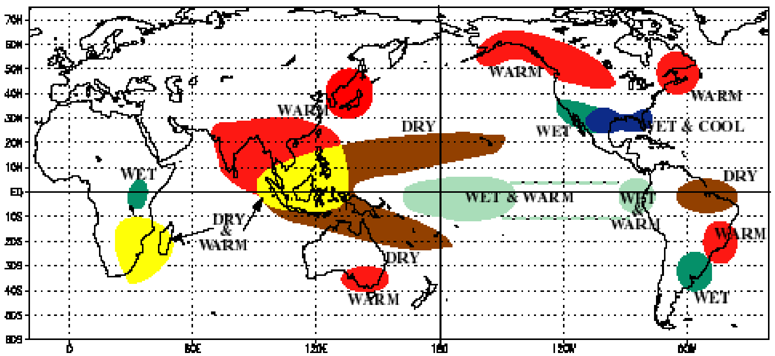
Taking the phase of ENSO into consideration

3. Statistical downscaling for TCC product

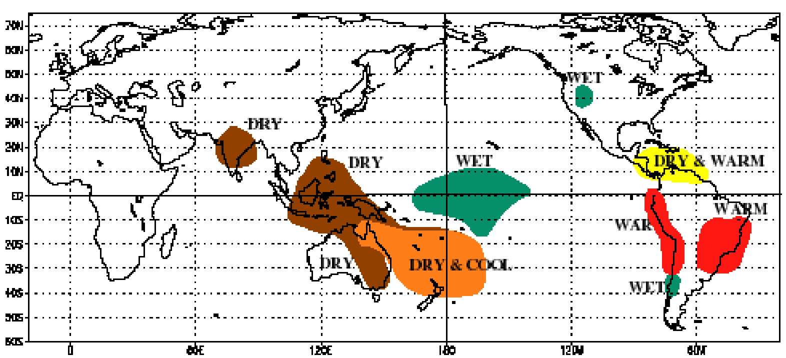
NINO.3.SST (5S-5N,150W-190W)

El Nino regional impacts

WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY

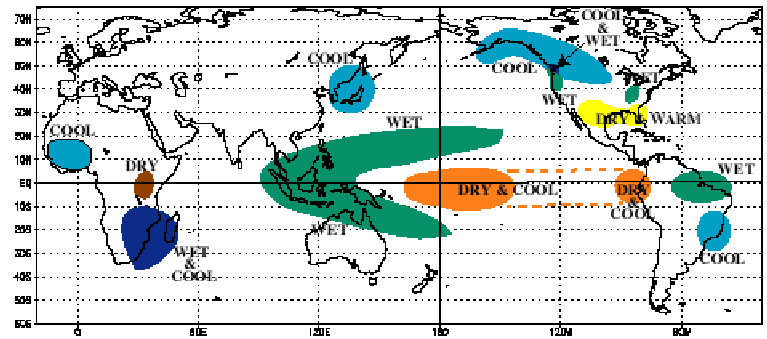


WARM EPISODE RELATIONSHIPS JUNE - AUGUST

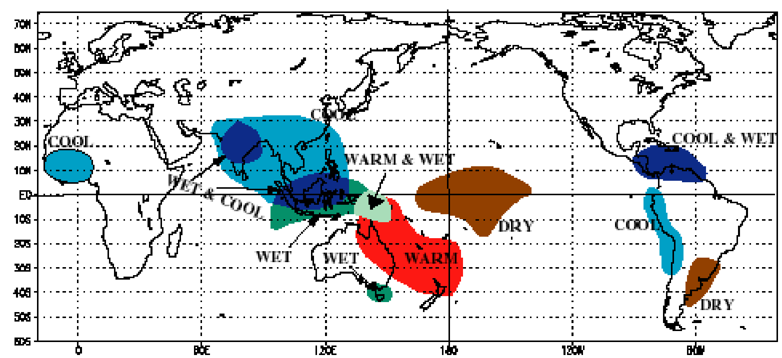


La Nina regional impacts

COLD EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



COLD EPISODE RELATIONSHIPS JUNE - AUGUST



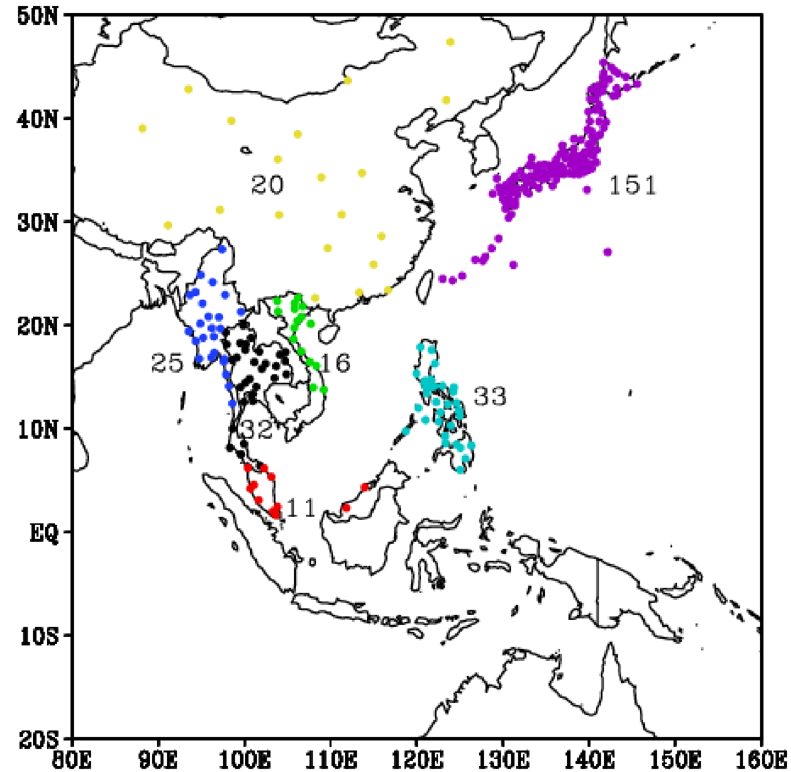
(NOAA)

3. Statistical downscaling for TCC product

Observational data

-Observation data source
  APN Workshop data ,
  ASEAN project on climate statistics,
  GSN(GCOS Surface Network),
  SYNOP reports,
  GAME project

-Selection target stations
  -Period for making climatology
   1971 ~ 2001 : 24 years or longer with 330 days or more with available daily observation
  -Period of hindcasts
   1982 ~ 2001 : 16 years or longer with 330 days or more with available daily observation



312 station points including
151 Japanese stations

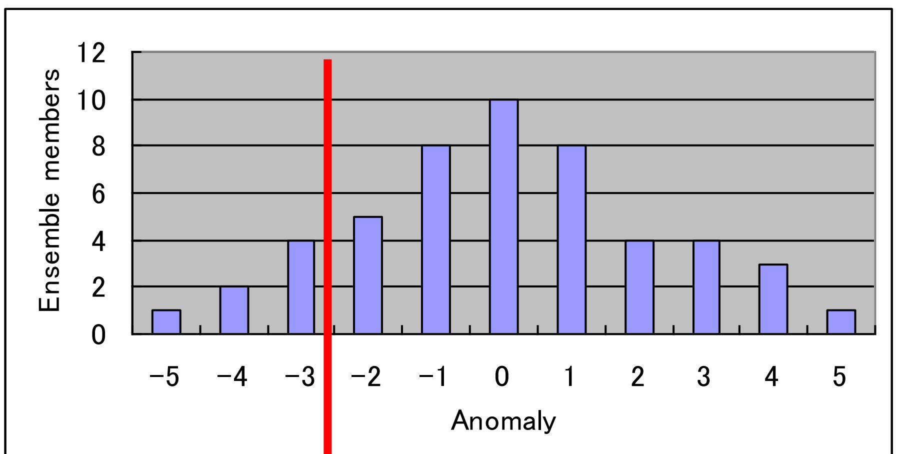
3. Statistical downscaling for TCC product

How to make probability

Base method

Make probability directly from the anomaly of all ensembles members of forecasts

For example : probability of below normal (< -2)



Probability of below normal

7 / 50 x 100 = 14 %

7 members 43 members = 50 members

3. Statistical downscaling for TCC product

How to make probability

Gauss-distribution method

Assumption : Observation ,ensemble mean forecast and noise are normally distributed.

$$\sigma_y{}^2 = \sigma_s{}^2 + \sigma_n{}^2$$

$$\sigma_n{}^2 = \left(1 - r^2\right)\sigma_y{}^2$$

$$\mathbf{r}^2 = \frac{\sigma_s{}^2}{\sigma_y{}^2} \quad \textbf{(size of ensemble} \rightarrow \infty\textbf{)}$$

(with the perfect model)

$\sigma_\mathbf{y}$: Standard deviation of observation

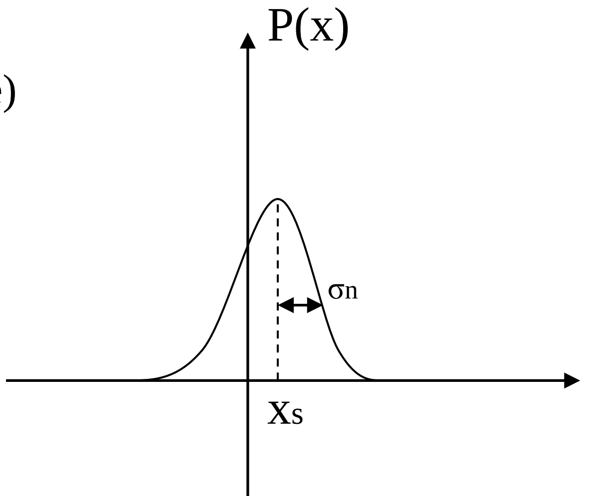
$\mathbf{x_s}$: Ensemble mean forecast (single or multiple regression)

$\sigma_\mathbf{s}$: Standard deviation of Ensemble mean forecast

σ_n : Standard deviation of noise

$\mathbf{r}$: Correlation coefficients (no-regression or single or multiple)

$$P(y) = \frac{1}{\sqrt{2\pi}\sigma_n} \exp\left(-\frac{(y - x_s)^2}{2\sigma_n{}^2} \right) \qquad \int_{-\infty}^{\infty} \mathbf{P(y)dy} = 1$$



3. Statistical downscaling for TCC product

How to make probability

Gauss-distribution method

$$P(y)=\frac{1}{\sqrt{2\pi}\sigma_n}\exp\left(-\frac{(y-x_s)^2}{2\sigma_n{}^2}\right)$$

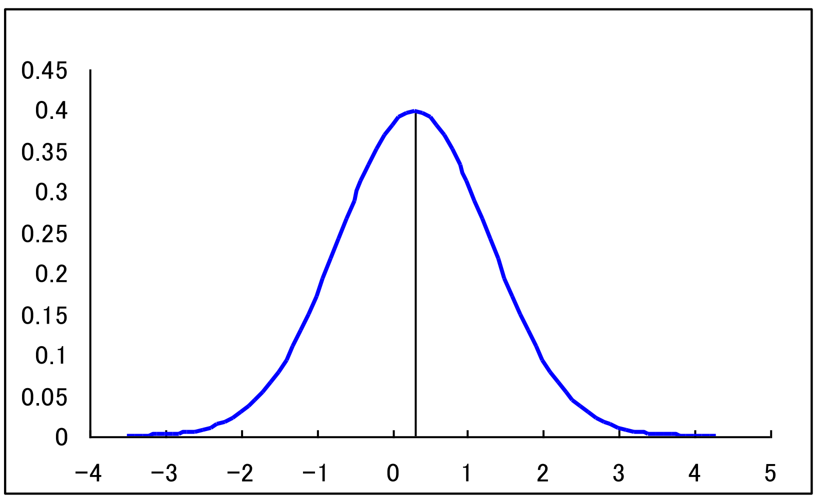
σ_n is from hindcast result

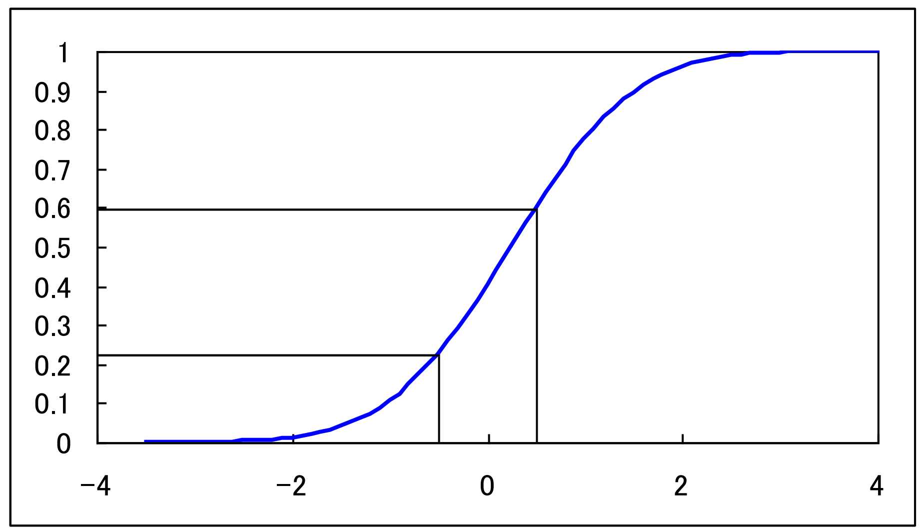
For example

At a station , below normal threshold is -0.5 , above normal is 0.5

Forecast is 0.3 , σ_n is 1

Below normal is 22 % normal is 38% Above normal is 40%





3. Statistical downscaling for TCC product

One month probabilistic forecasts at station points

For Verification : Cross validation method

Hindcasts and Observations except 1982 → **statistical equations** → Estimation (1982)

Hindcasts and Observations except 1983 → **statistical equations** → Estimation (1983)

Hindcasts and Observations except 1984 → **statistical equations** → Estimation (1984)

Hindcasts and Observations except 2001 → **statistical equations** → Estimation (2001)

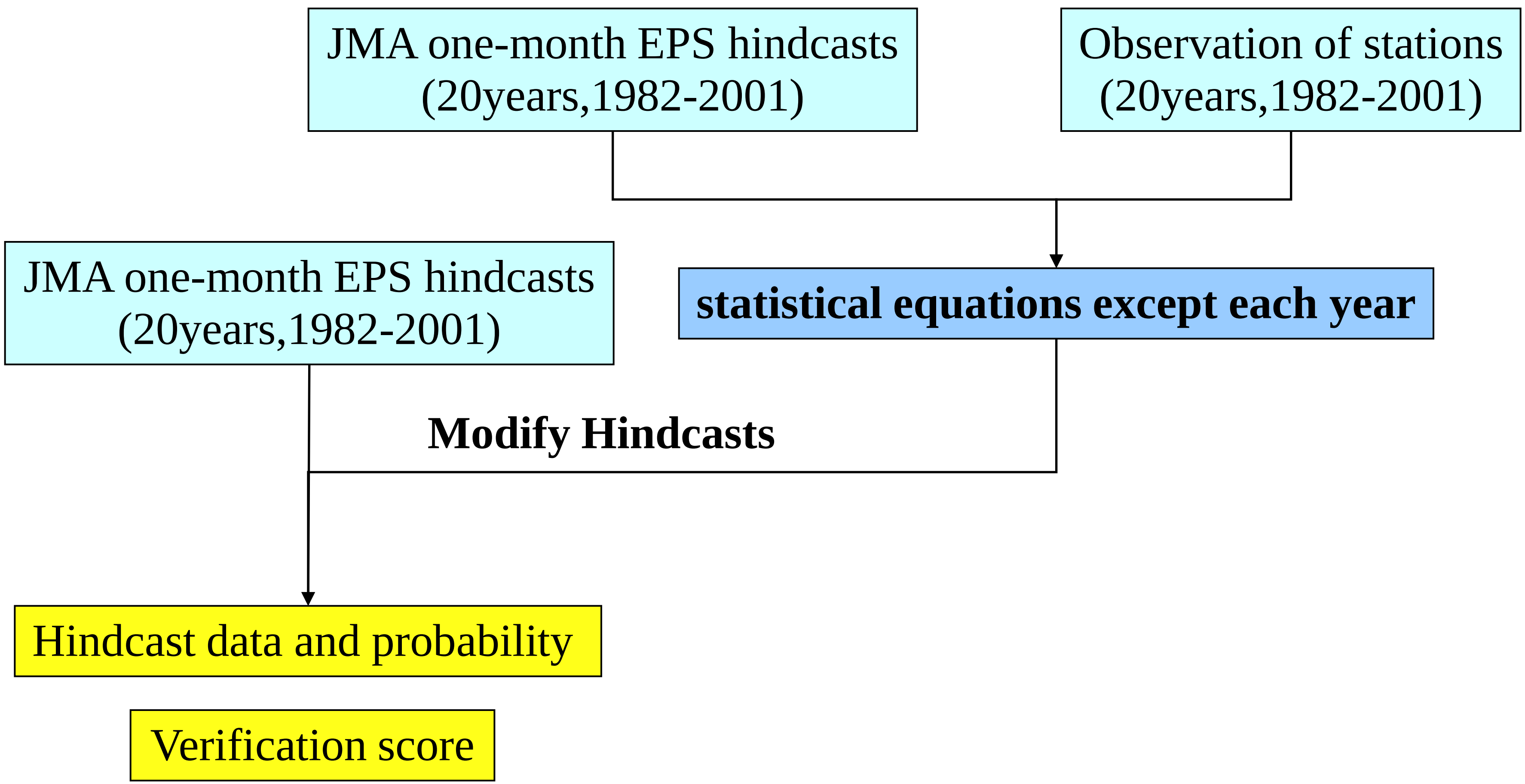
Modified Hindcasts (1982-2001)

Observations (1982-2001)

Correlation and Verification score

3. Statistical downscaling for TCC product

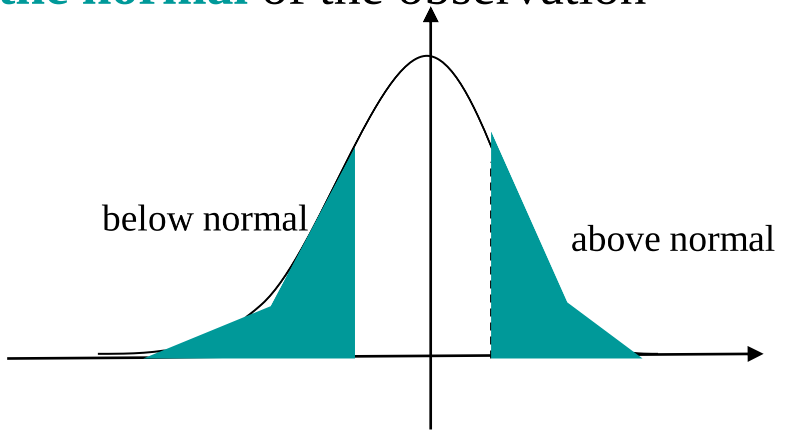
For Verification : Cross validation method



3. Statistical downscaling for TCC product

Verification score

Probability of forecast is **above or below the normal** of the observation



Evaluation method :

-Brier skill score (BSS)

-Reliability diagram (Wilks,1995)

$$BS_{\mathrm{f}} = \frac{1}{N}\sum_{i=1}^{N}\left(p_i - v_i\right)^2$$

$$BSS = \frac{BS_{\mathrm{clim}} - BS_{\mathrm{f}}}{BS_{\mathrm{clim}}}$$

BS : Brier skill

N : sample number

p_i : probability of forecast

v_i : binary probability of observations

BS_{clim} is calculated assuming the climatological forecast probabilities (50%).

BSS > 0 reliable

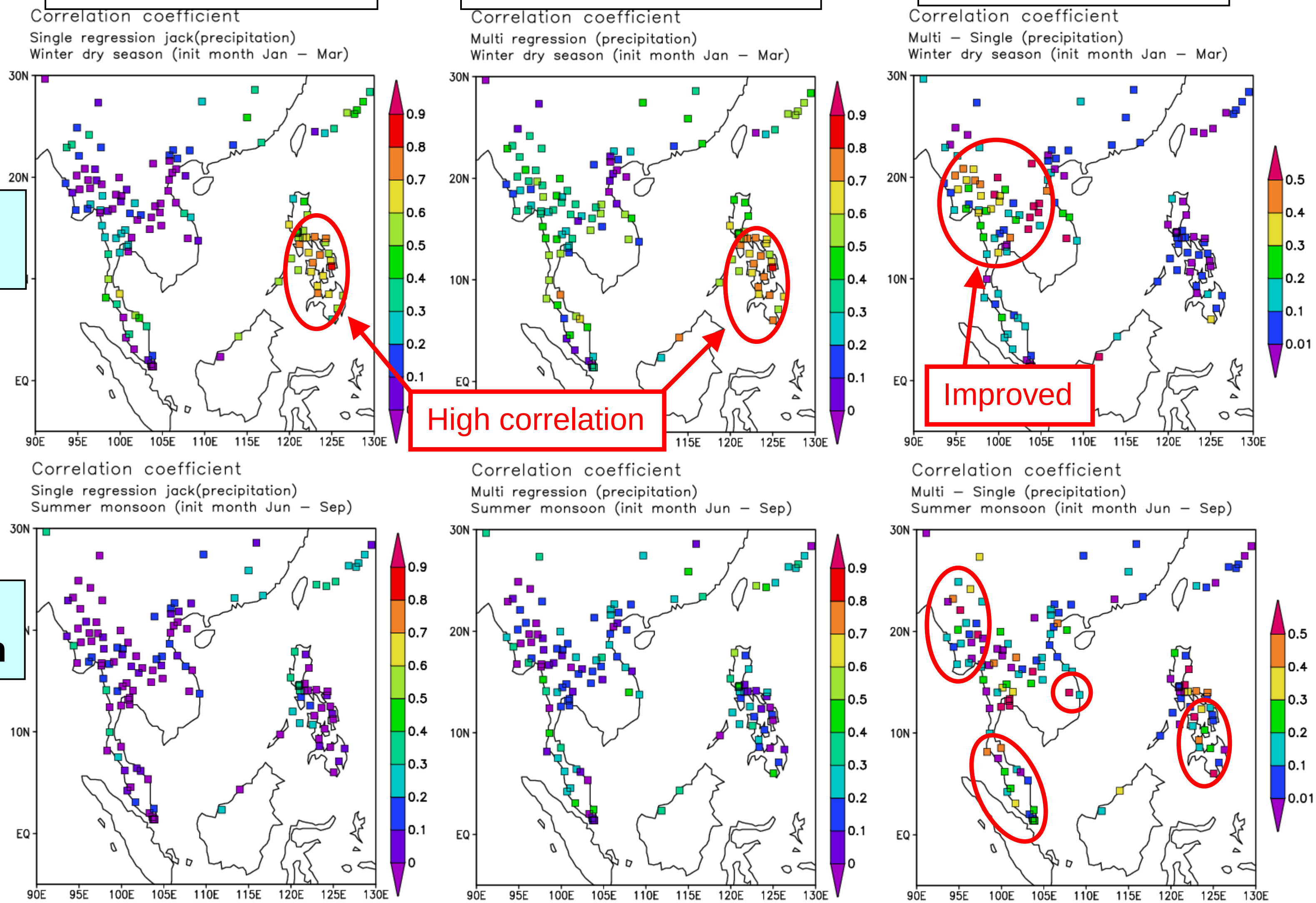
BSS < 0 not reliable (than the climatological forecast)

3. Statistical downscaling for TCC product

Correlation of 28days (2nd-29th day forecast) average of precipitation with station observation

Based on 10 years HC (11members)

	Single regression	**Multiple regression**	**Multiple－Single**
Winter dry season			
Summer monsoon			



3. Statistical downscaling for TCC product

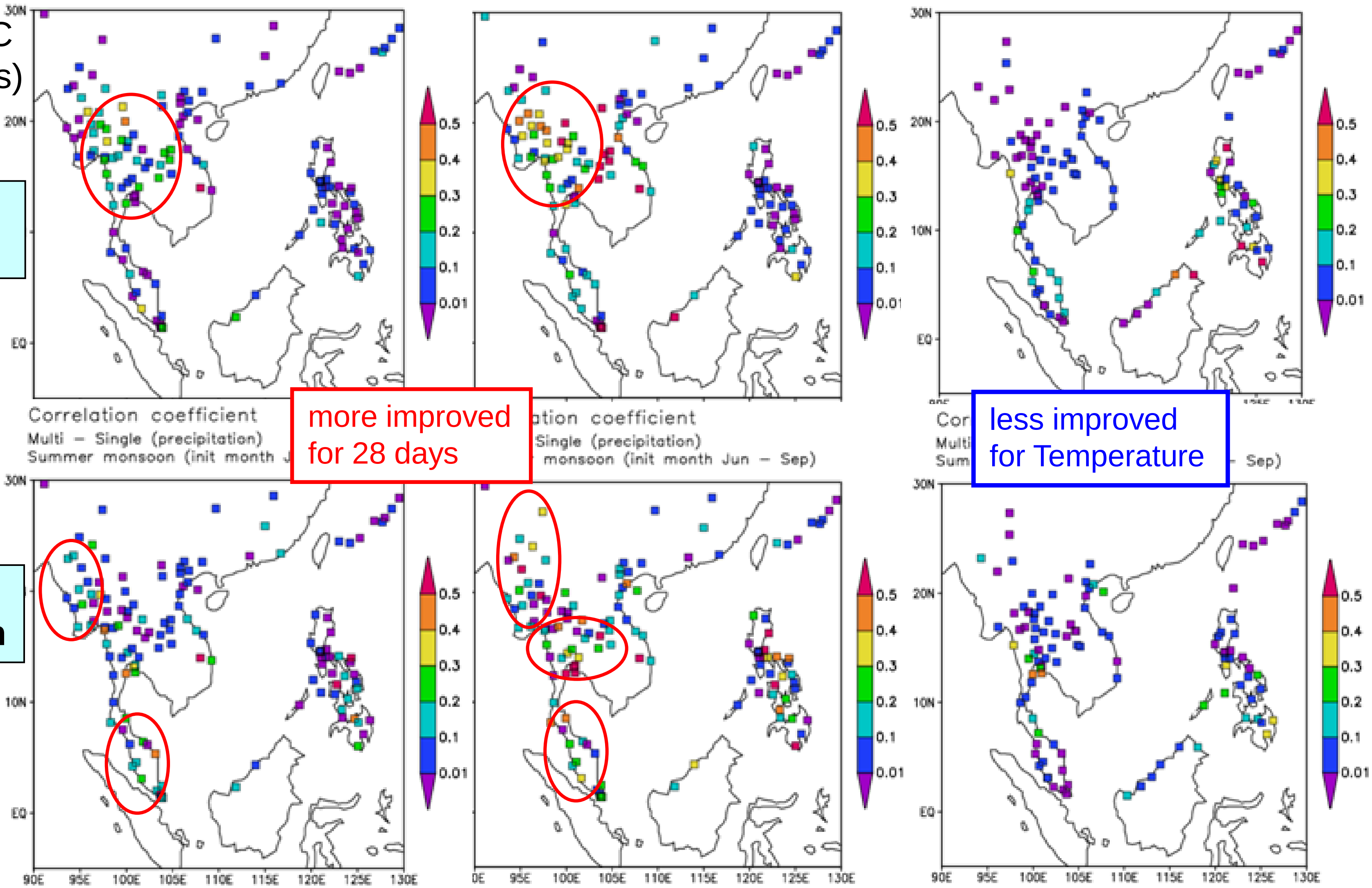
Difference of Correlation, Multiple – Single regression for 14 days (2^{nd}-15^{th}) and 28 days (2^{nd}-29^{th}) average with station observation

Based on 10 years HC (11members)

14 days Precipitation | 28 days Precipitation | 14 days Temperature

Winter dry season

Summer monsoon



more improved for 28 days

less improved for Temperature

3. Statistical downscaling for TCC product

Frequency ratio of selection of each predictor in the Southeast Asia and Japan

most frequent | secondly frequent

14 days average (2^{nd}-15^{th}) precipitation

Southeast Asia(%)	Model precipitation	Inner product of U and land slope gradient	MJO index	NINO3 SSTA
Winter dry season	93	45	32	51
Pre monsoon	80	43	60	46
Summer monsoon	83	59	61	22
Post monsoon	95	64	77	40

28 days average (2^{nd}-29^{th}) precipitation

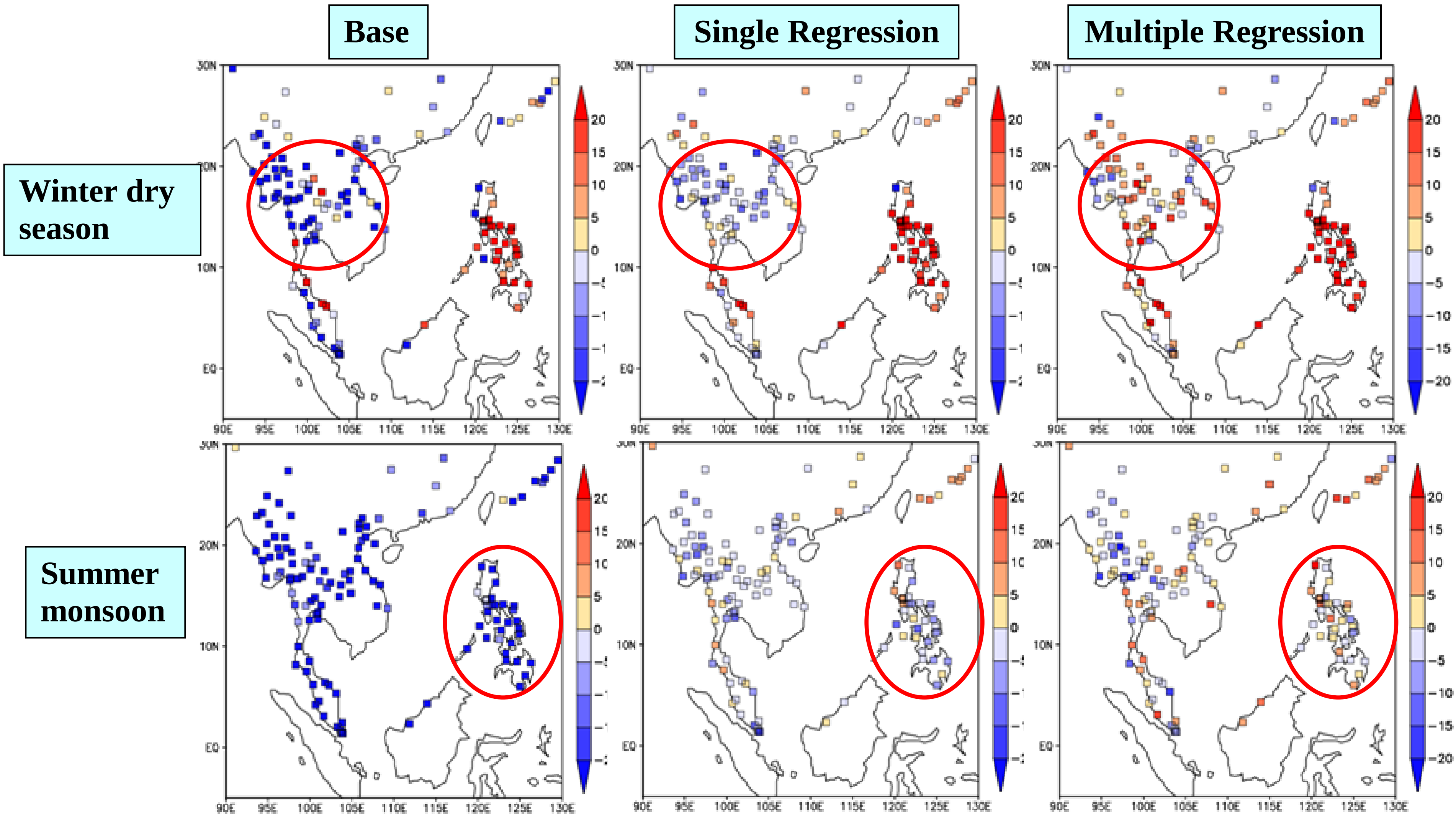
Southeast Asia(%)	Model precipitation	Inner product of U and land slope gradient	MJO index	NINO3 SSTA
Winter dry season	77	61	46	67
Pre monsoon	58	48	52	61
Summer monsoon	50	56	82	39
Post monsoon	89	66	70	50

Japan(%)	Model precipitation	Inner product of U and land slope gradient	MJO index	NINO3 SSTA
Winter dry season	91	35	58	56
Pre monsoon	76	28	48	36
Summer monsoon	96	52	58	34
Post monsoon	87	30	66	19

3. Statistical downscaling for TCC product

Verification of one month probabilistic forecasts at station points

28 days (2nd–29th) average precipitation Cross-validation BSS (Above Median)



3. Statistical downscaling for TCC product

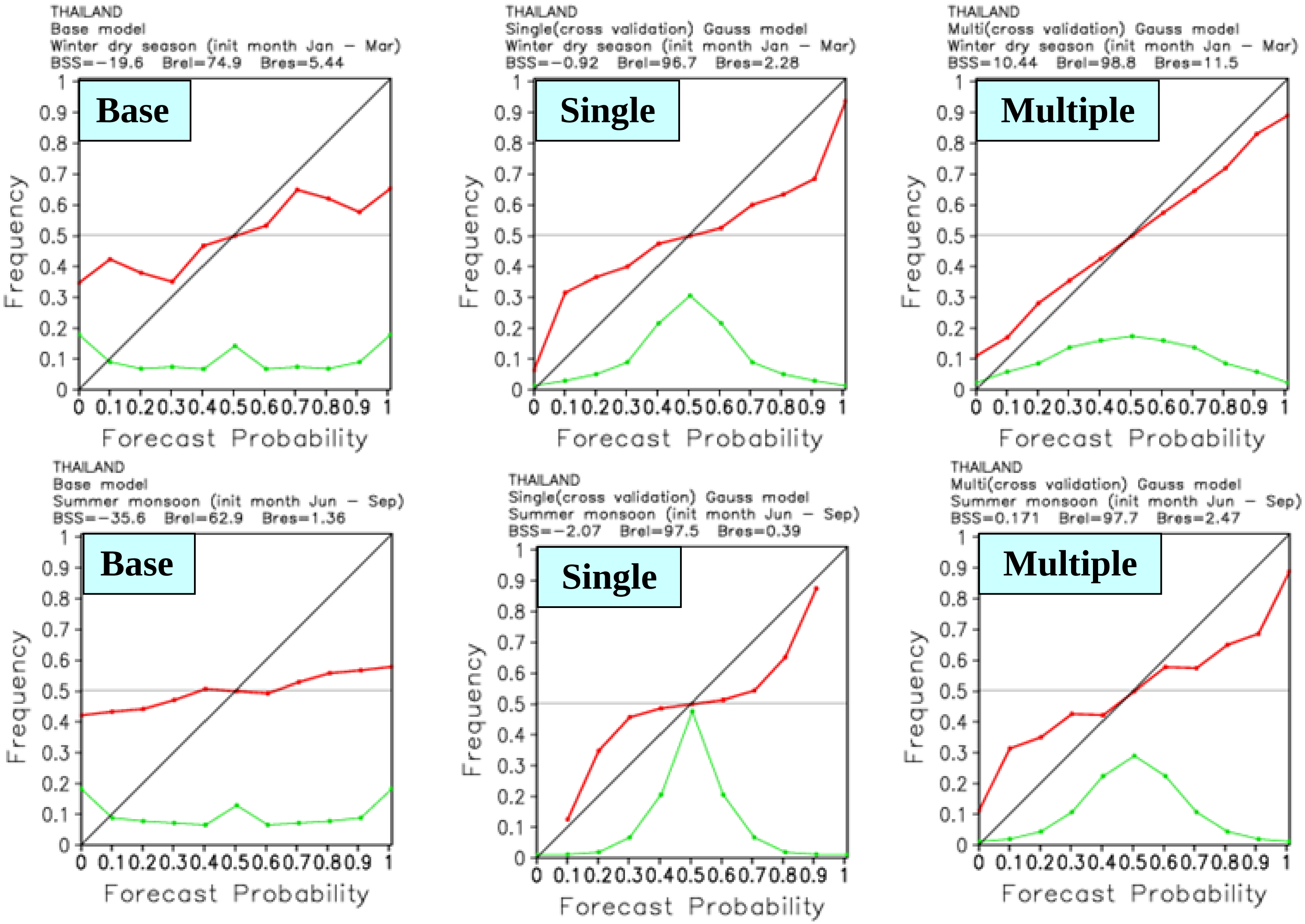
Verification of one month probabilistic forecasts at station points

28 days (2nd–29th) average precipitation   Cross-validation Reliability Diagram (Above Median)

Thailand

Winter dry season

Summer monsoon



3. Statistical downscaling for TCC product

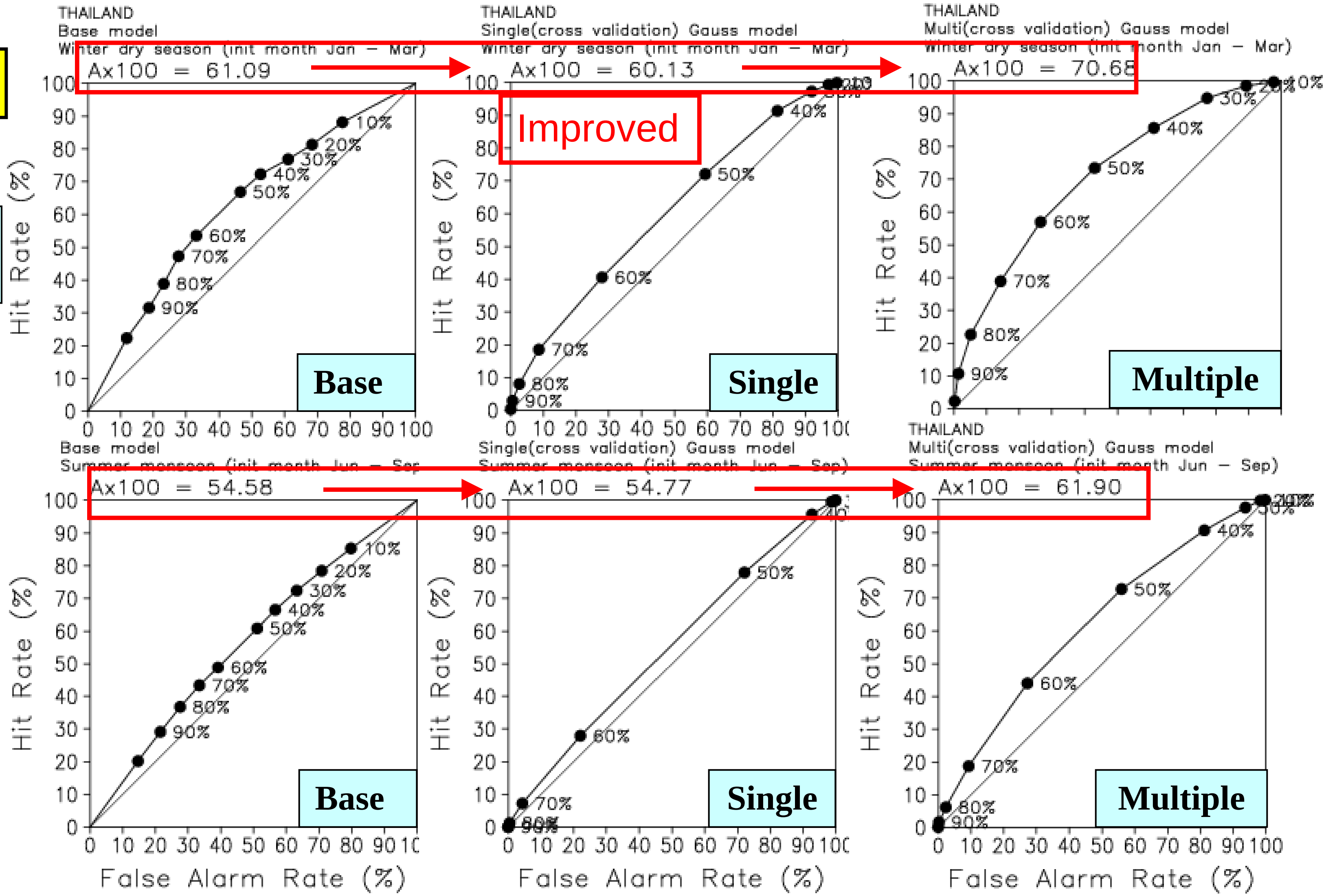
Verification of one month probabilistic forecasts at station points

28 days (2nd–29th) average precipitation Cross-validation ROC curve (Above Median)

Thailand

Winter dry season

Summer monsoon



3. Statistical downscaling for TCC product

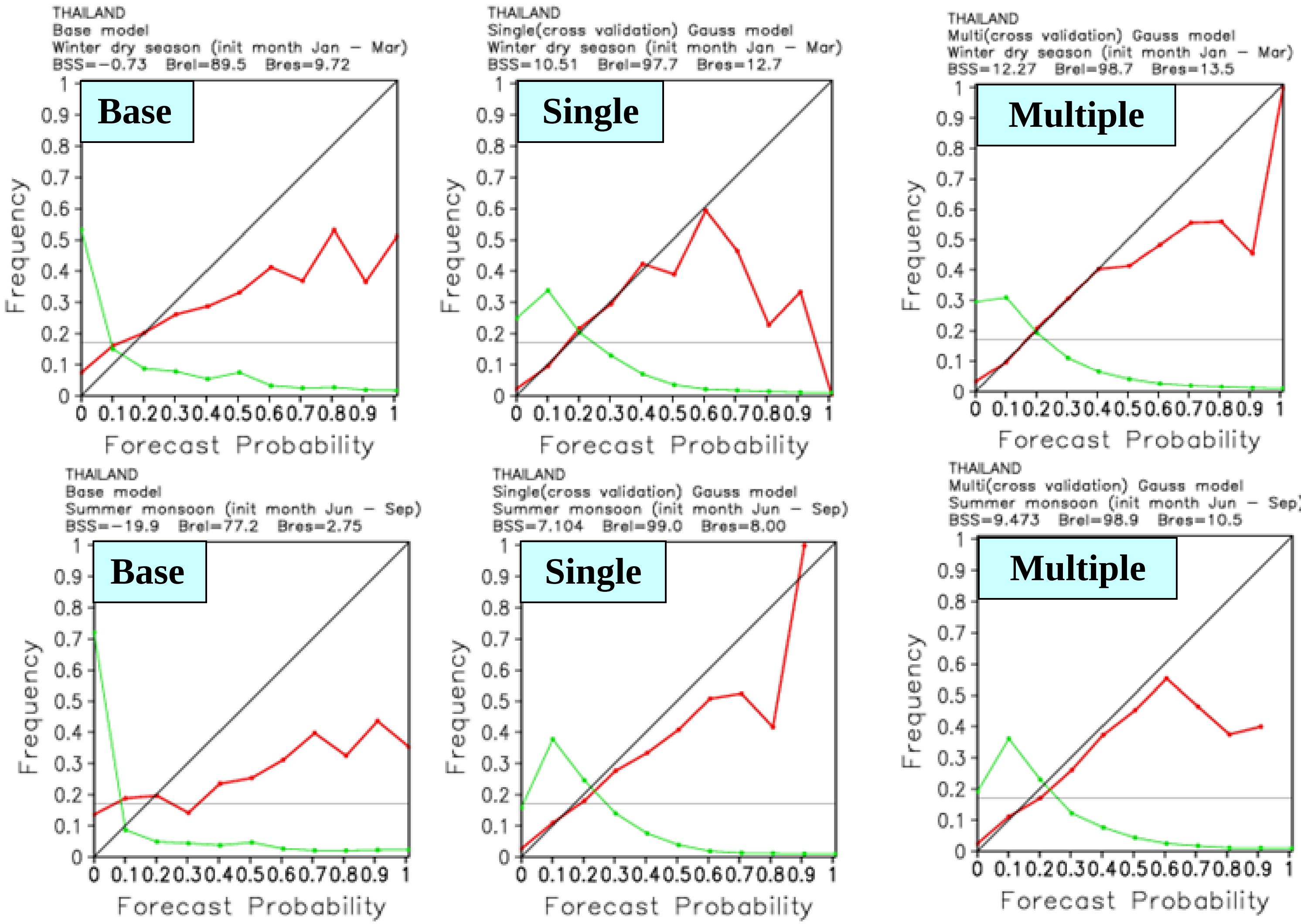
Verification of one month probabilistic forecasts at station points

7 days (9^{th}–15^{th}) average 2mT Cross–validation Reliability Diagram (Above/Blow SD)

Thailand

Winter dry season

Summer monsoon



3. Statistical downscaling for TCC product

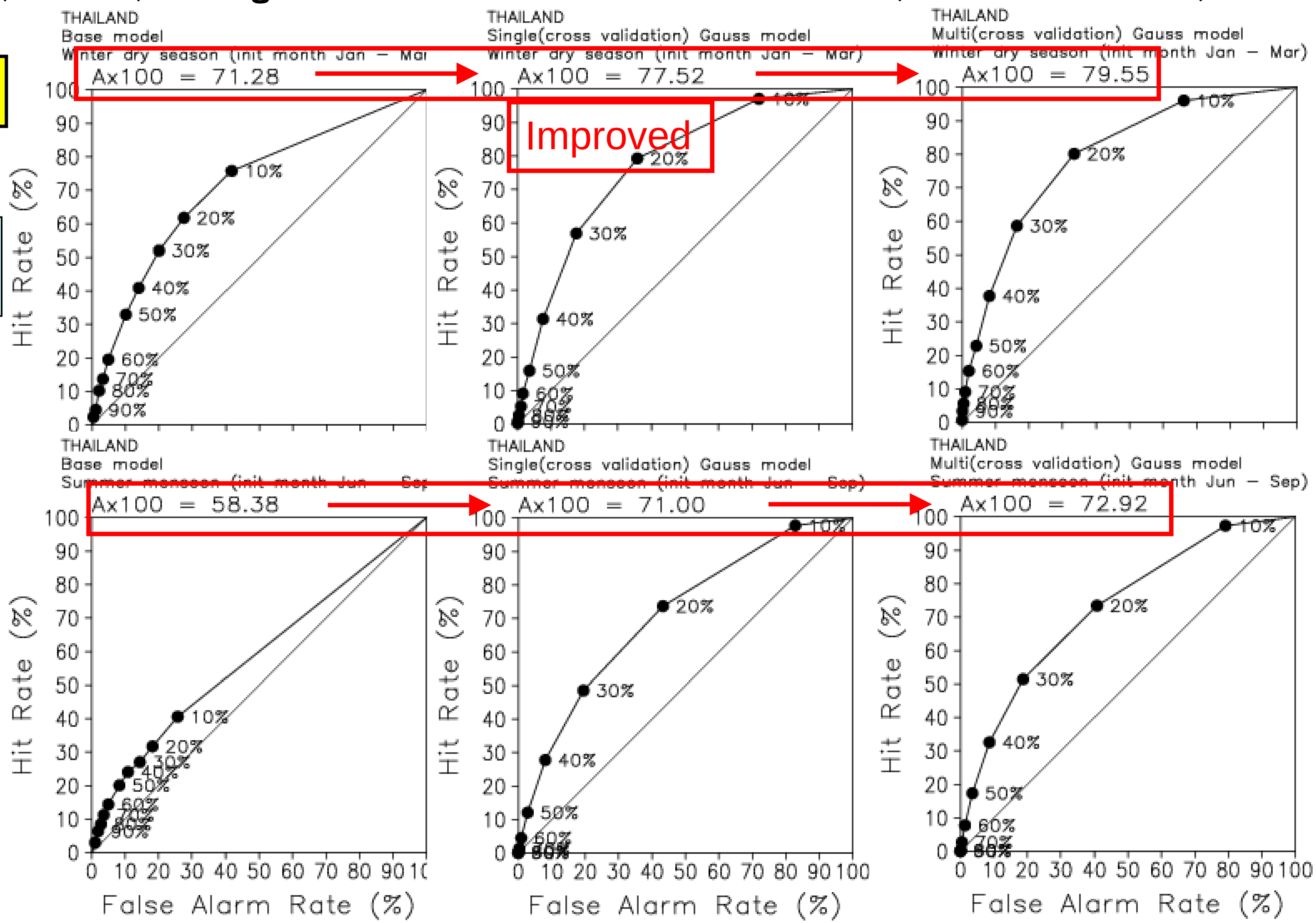
Verification of one month probabilistic forecasts at station points

7 days (9^{th}–15^{th}) average 2mT Cross-validation ROC curve (Above/Blow SD)

Thailand

Winter dry season

Summer monsoon



3. Statistical downscaling TCC products

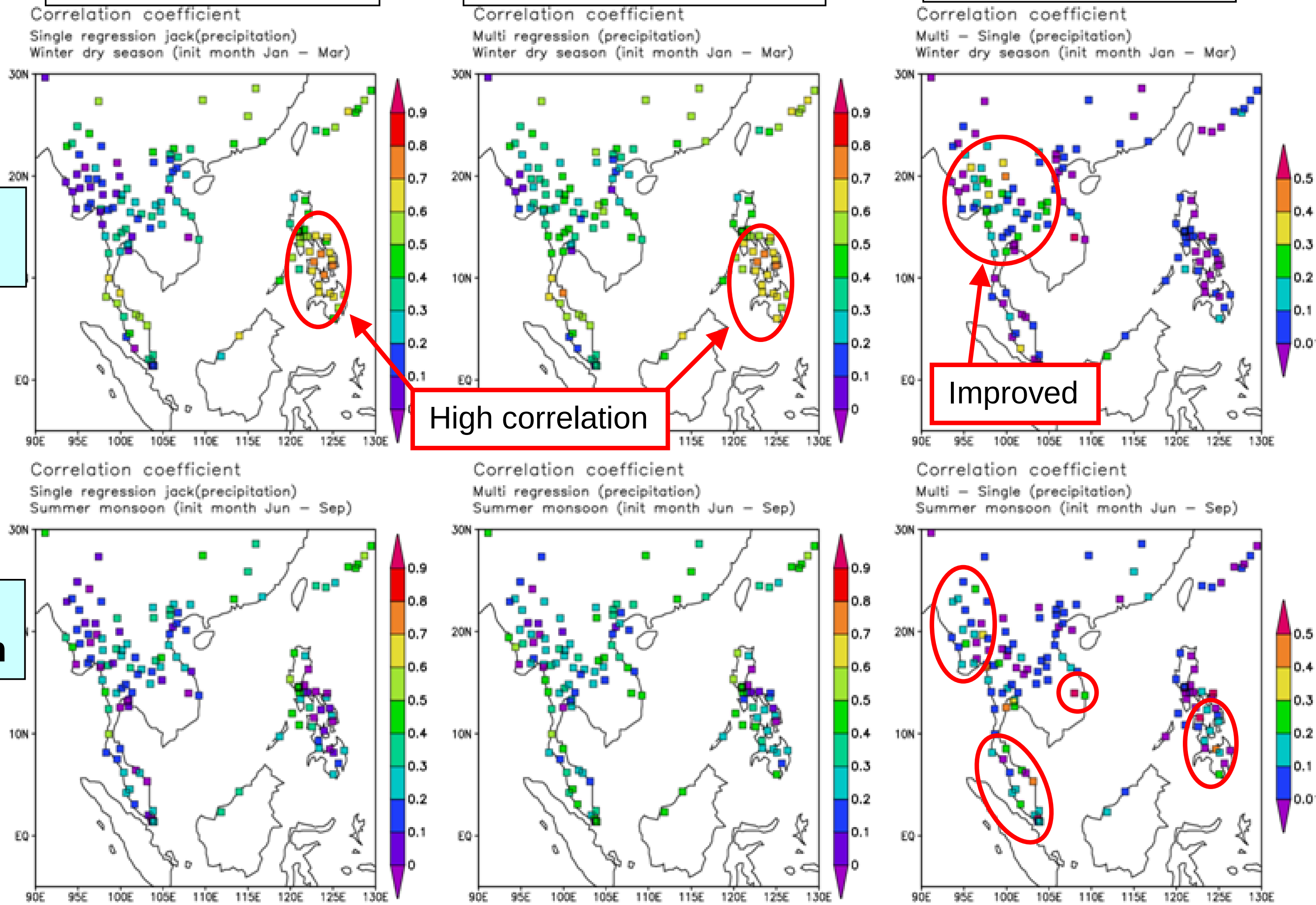
Correlation of 14days (2nd-15th day forecast) average of precipitation with station observation

Based on 10 years HC (11members)

Winter dry season

Summer monsoon

Single regression | **Multiple regression** | **Multiple－Single**



3. Statistical downscaling TCC products

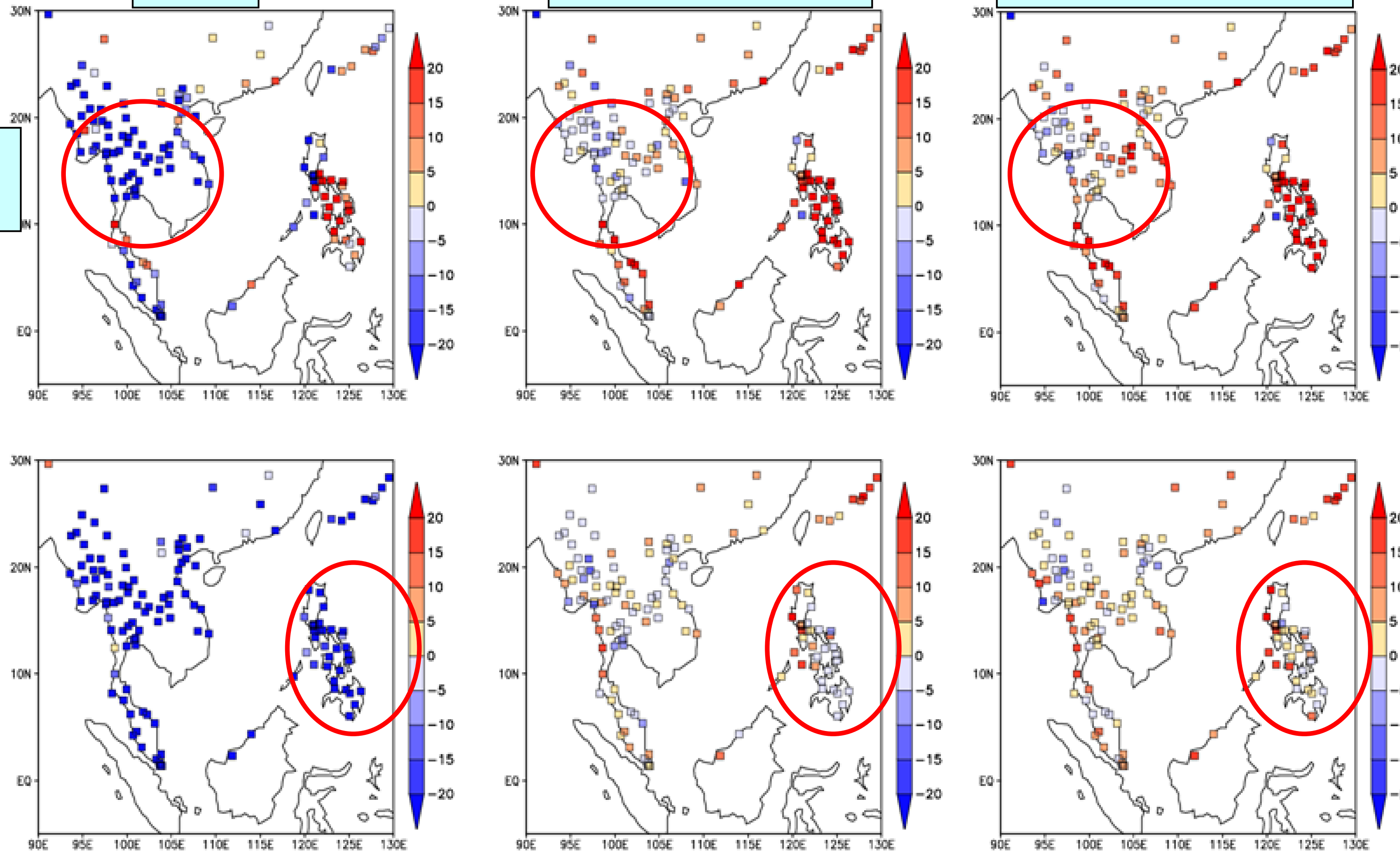
Verification of one month probabilistic forecasts at station points

14 days (2nd–15th) average precipitation Cross-validation BSS (Above Median)

Base **Single Regression** **Multiple Regression**

Winter dry season

Summer monsoon



3. Statistical downscaling TCC products

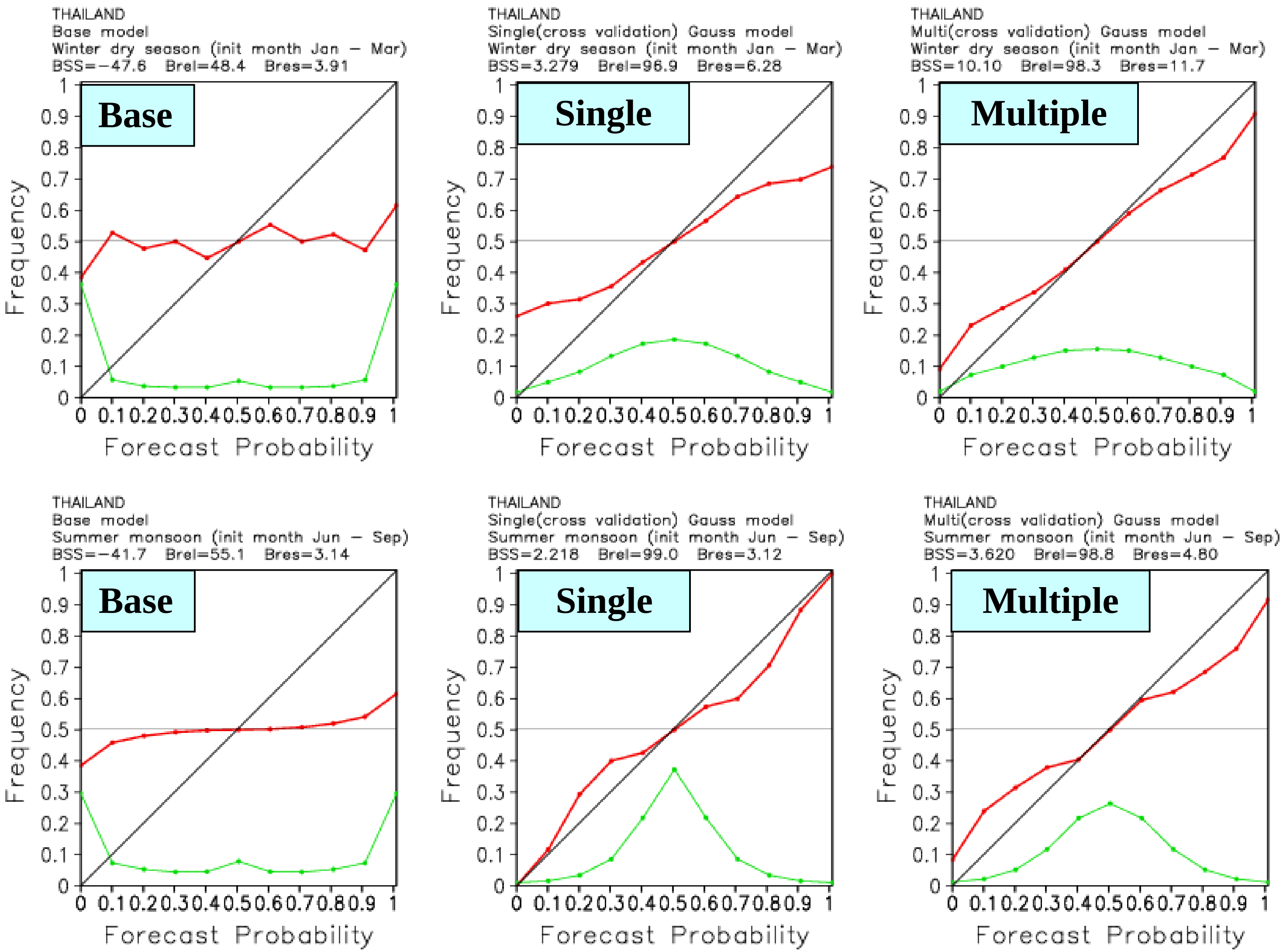
Verification of one month probabilistic forecasts at station points

14 days (2nd–15th) average precipitation Cross–validation Reliability Diagram (Above Median)

Thailand

Winter dry season

Summer monsoon



3. Statistical downscaling TCC products

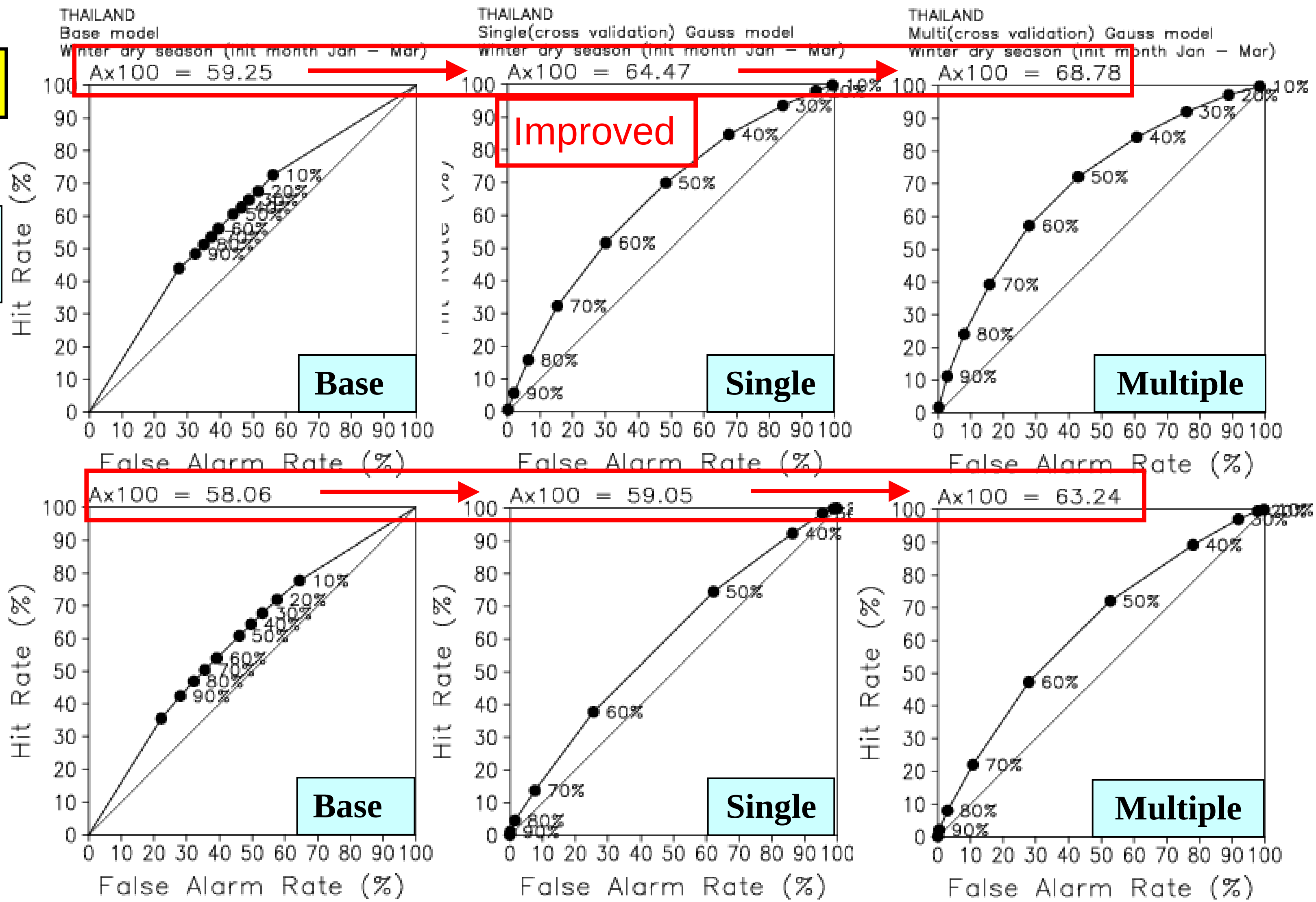
Verification of one month probabilistic forecasts at station points

14 days (2nd–15th) average precipitation Cross-validation ROC curve (Above Median)

Thailand

Winter dry season

Summer monsoon



3. Statistical downscaling TCC products

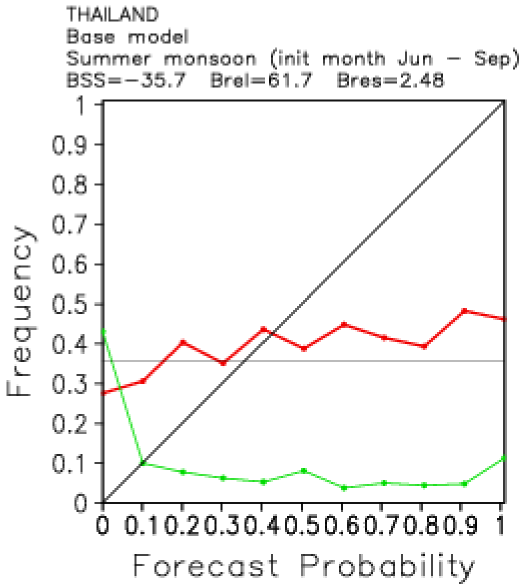
Verification of one month probabilistic forecasts at station points

14 days (2nd–15th) average Precipitation Cross-validation Reliability Diagram (Upper 33.3%)

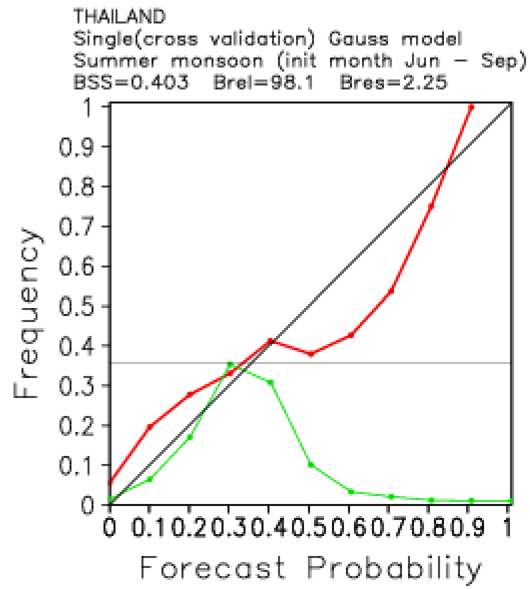
Thailand

Summer monsoon

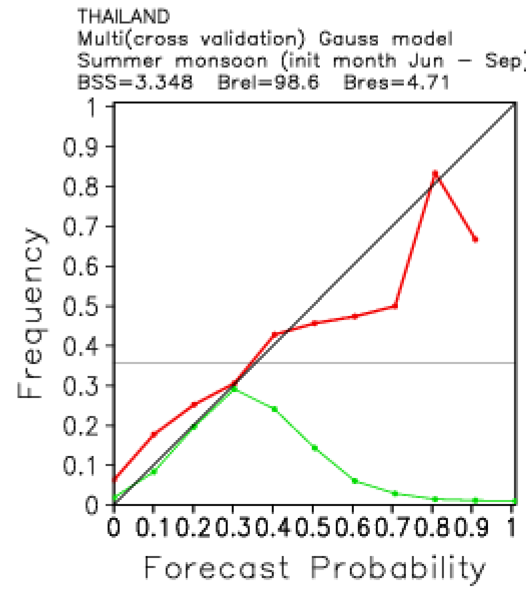
Base



Single Regression



Multiple Regression



3. Statistical downscaling TCC products

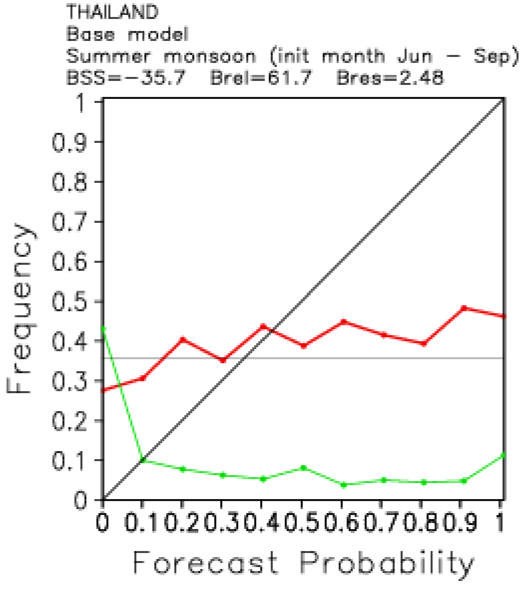
Verification of one month probabilistic forecasts at station points

14 days (2nd–15th) average Precipitation Cross-validation Reliability Diagram (Upper 33.3%)

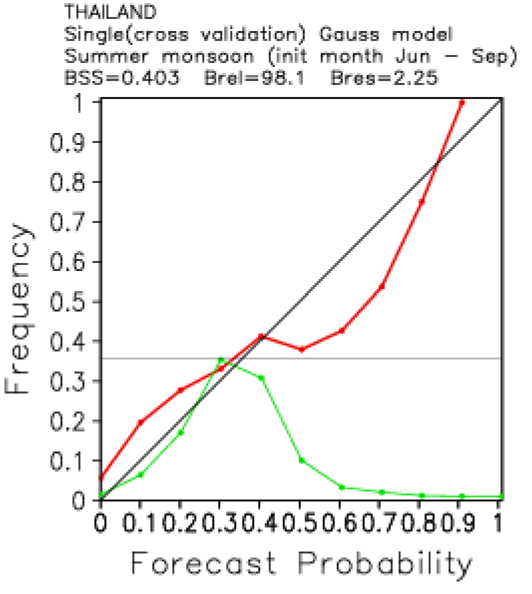
Thailand

Summer monsoon

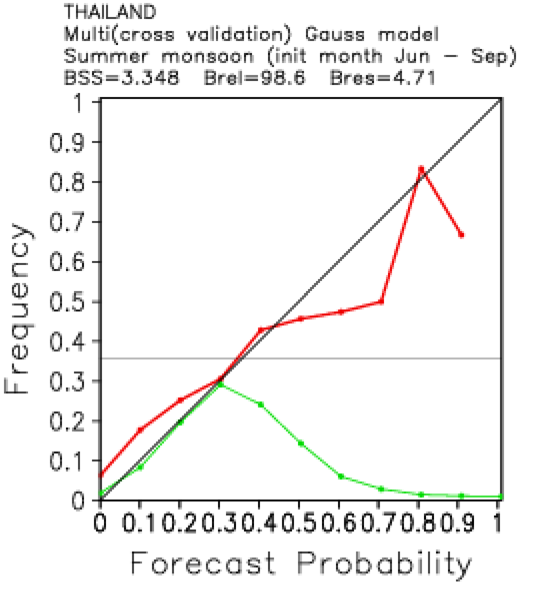
Base



Single Regression



Multiple Regression

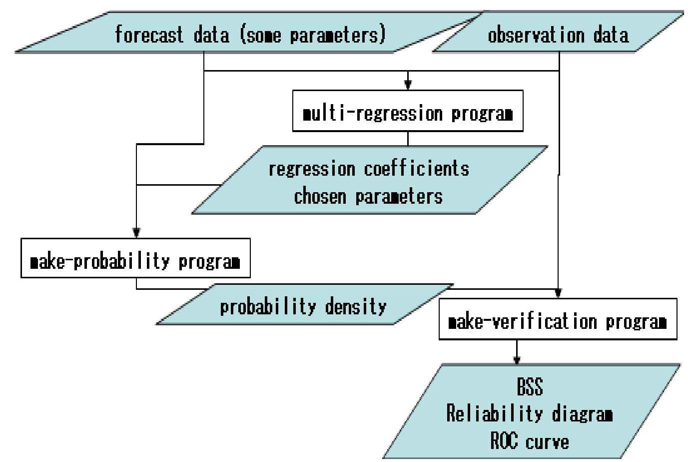


3. Statistical downscaling for TCC product

TCC's Support to NHMSs

- Through the TCC web page, users can access to the latest probabilistic forecast at selected stations over the Southeast Asia and Japan.

- Users can download a sample code for the statistical downscaling through the TCC web page
http://ds.data.jma.go.jp/tcc/tcc/products/guidancetst/download_src.html
with the manual documentation.



- TCC disseminates the use of this services through seminars and training courses.

Meeting in TMD on 6 March


Thank you
for your attention