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Development of Pointwise Probabilistic Prediction Guidance based on Statistical Downscaling Technique

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Outline

1. Objective
2. Performance of current forecast
3. Statistical downscaling
4. Results of precipitation downscaling
5. Methods of producing probabilistic distribution
6. Evaluation of precipitation probabilistic forecast
7. Future plan

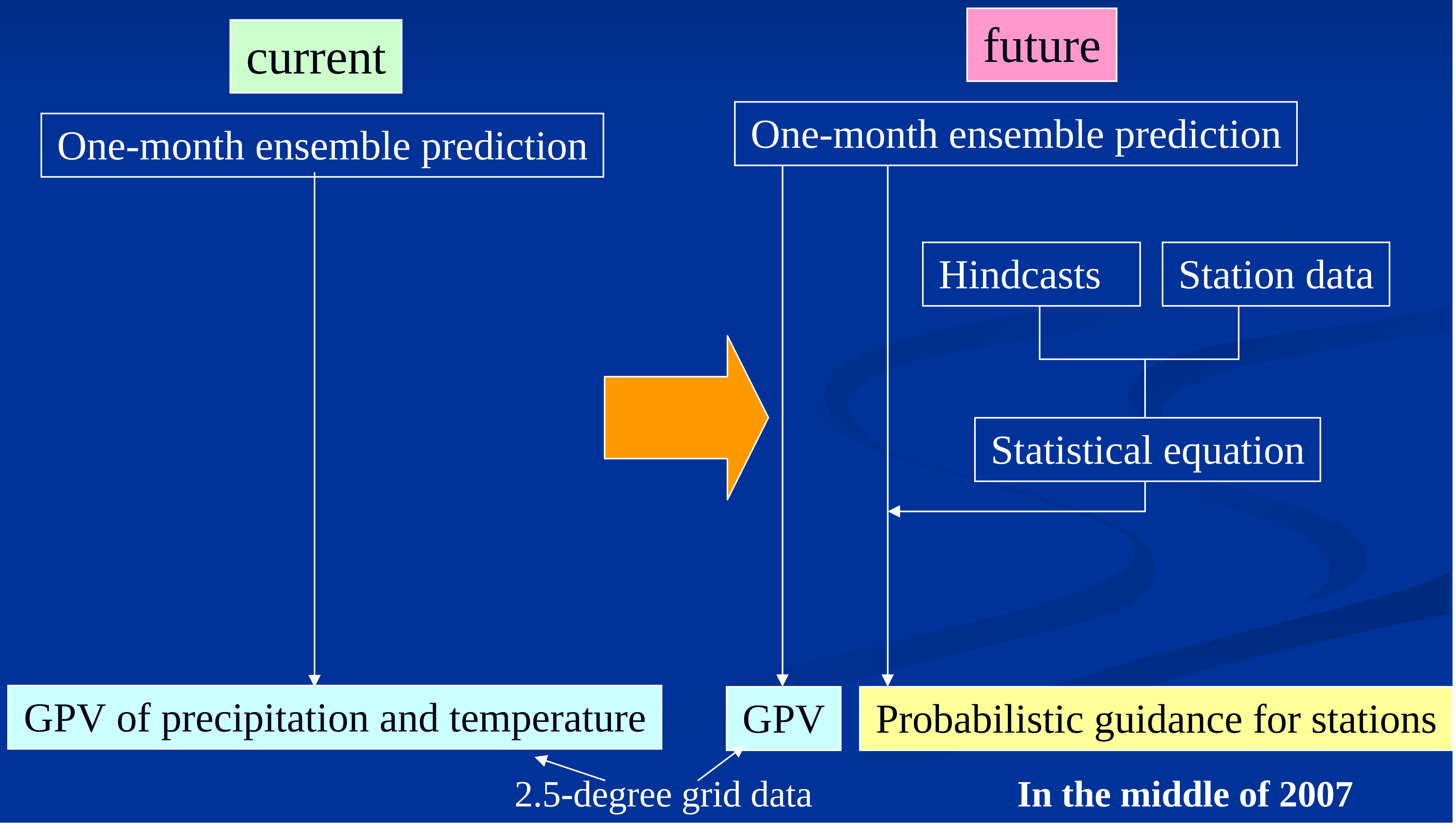
1. Objective

- TCC has a mission to assist NMHSs in the Asia-Pacific region with facilitating climate services, including climate information application.
- To advance the application of climate forecast in socio-economic activities, it is necessary to provide detailed forecast.
- However, there is no detailed forecast that can meet various user's needs.

- In 2004, TCC launched a research project to develop **pointwise probabilistic forecast** of precipitation and temperature up until one-month ahead, consigning the main part of the development to **FUJITSU FIP Co (expert: Mr. Okura).**

1. Objective

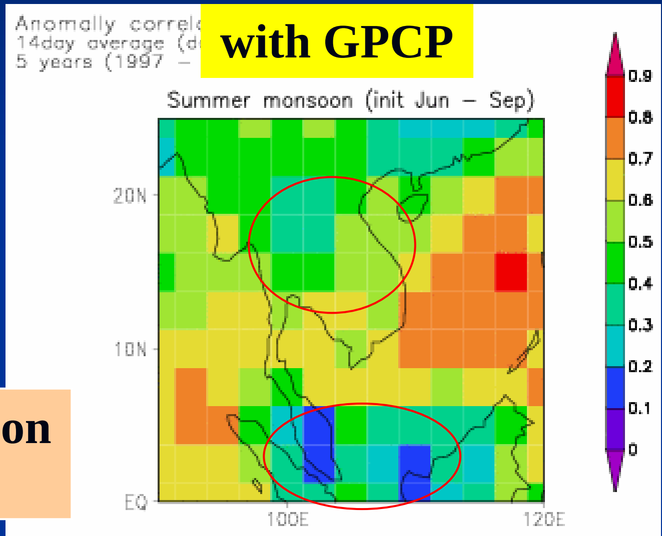
For overseas users

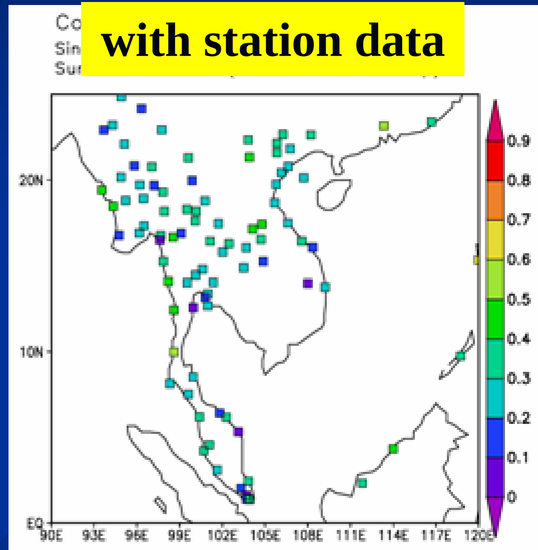


2. Performance of current forecast (14-day prep.)

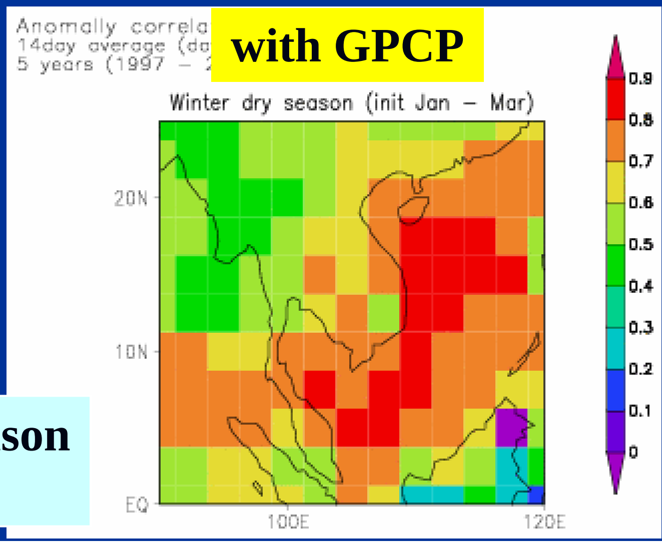
Correlation coefficients of 14-day-average precipitation (Day 2-15) between hindcast and observation

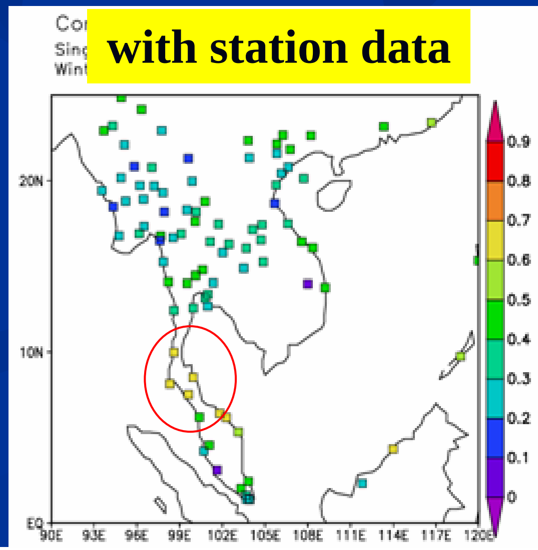
Summer monsoon (Jun.-Sep.)





Winter dry season (Jan.-Mar.)





3. Statistical downscaling (1)

Target forecast elements and periods

- precipitation to power of one-quarter (14-day and 28-day average)
- 2 m temperature (7-day average)

Four seasons

winter dry season (January-March)
pre-monsoon (April-May)
summer monsoon (June-September)
post-monsoon (October-December)

3. Statistical downscaling (2)

Observation data

- Integrated dataset composed of
  ASEAN project on climate statistics,
  APN Workshop data, GSN,
  SYNOP reports and GAME project.

130 stations

Forecast (hindcast) data

- JMA one-month ensemble prediction system hindcast
  Resolution : T106 (roughly 100km)
  Ensemble number: 11 members
  Experimental period: 1992-2001 (10 years)
  The number of forecasts: three times a month,
  3 x 12 forecasts a year,
  360 x 11 = 3960 total samples

3. Statistical downscaling (3)

Statistical method

- Model Output Statistics (MOS), using the hindcast data

Regression formula

➢ Multiple regression $Y = A1X1 + A2X2 + \cdots + B$

  - Method of variable selection : stepwise method.
  - Selected variables vary in points and seasons.

Verification method

- Cross validation method: independent sample verification

3. Statistical downscaling (4)

Selectable predictors:

- model forecasted precipitation (to power of 1/4) or 2 m temperature
- topographically-forced upward motion (U850 x slope of terrain) (eight kinds of terrain data from 0.083 to 2.573 degree)
- MJO indices (RMM1 and RMM2) (Wheeler and Hendon, 2004)

All above are forecasted values

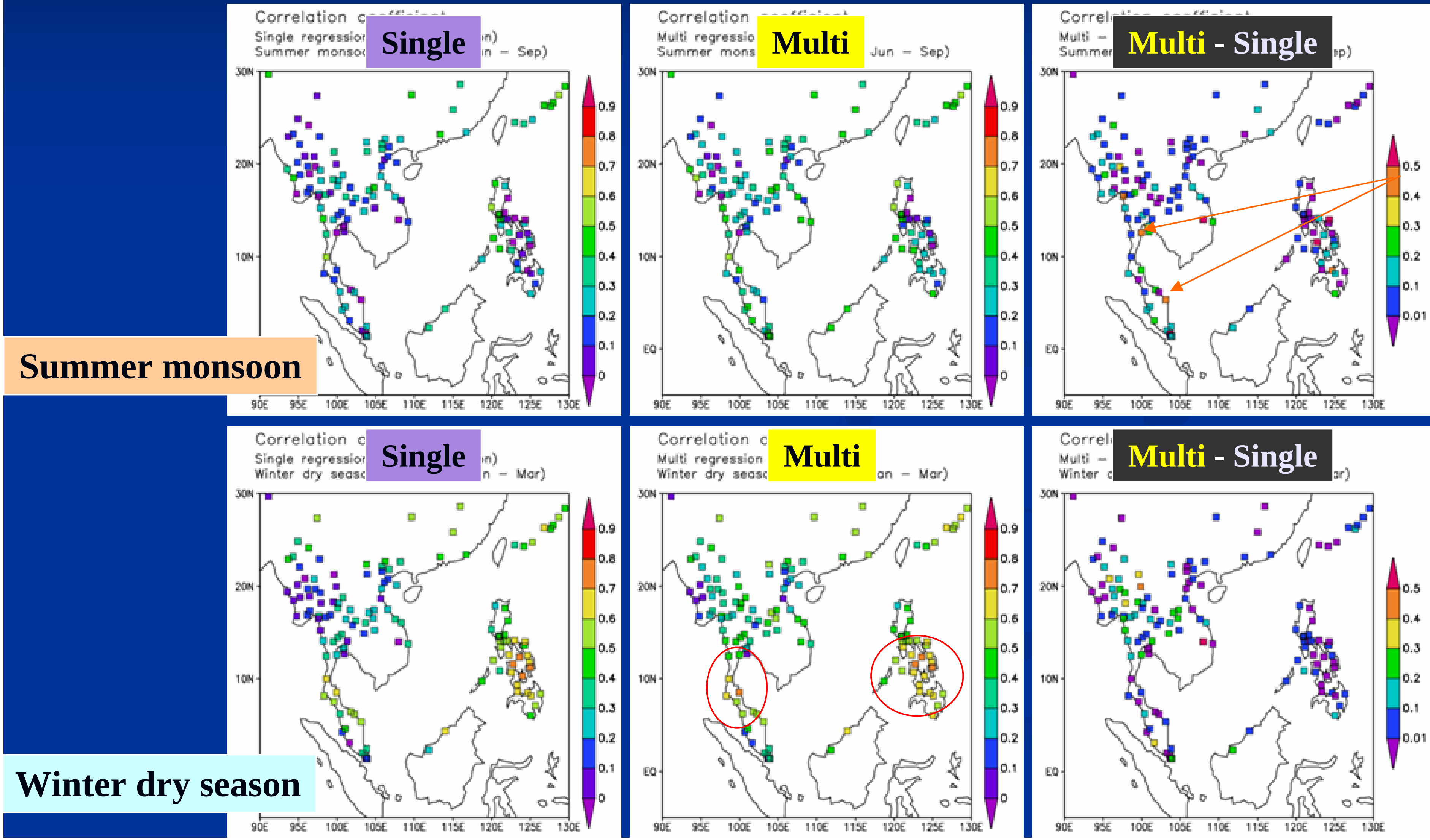
- NINO.3 SST index (5S-5N, 150W-190W)

not forecasted value: immediately previous month value

4. Results of precipitation downscaling (1)

Correlation coefficients

between 14-day-average forecast (Day 2-15) and observation

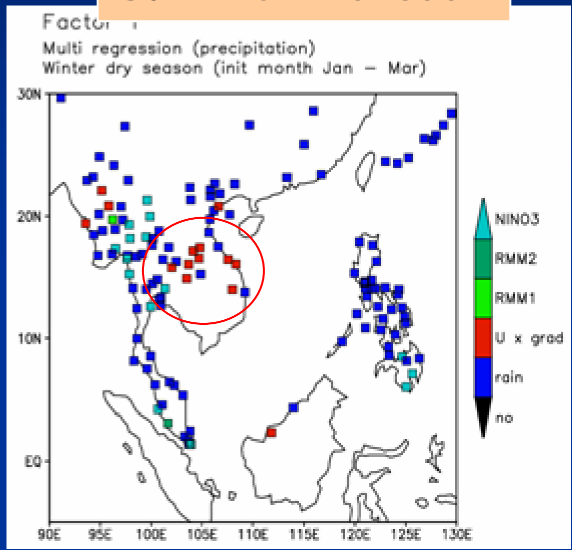


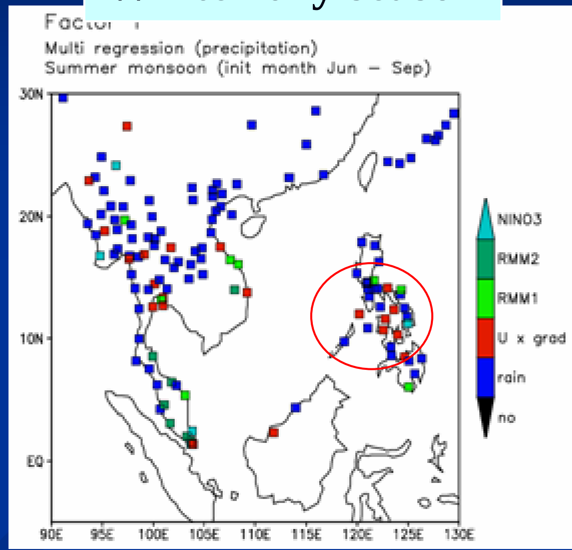
4. Results of precipitation downscaling (2)

The first selected predictor in multiple regression

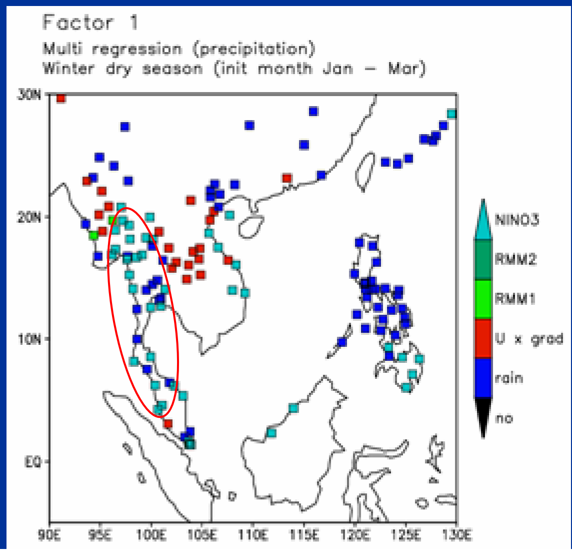
Summer monsoon | **Winter dry season**

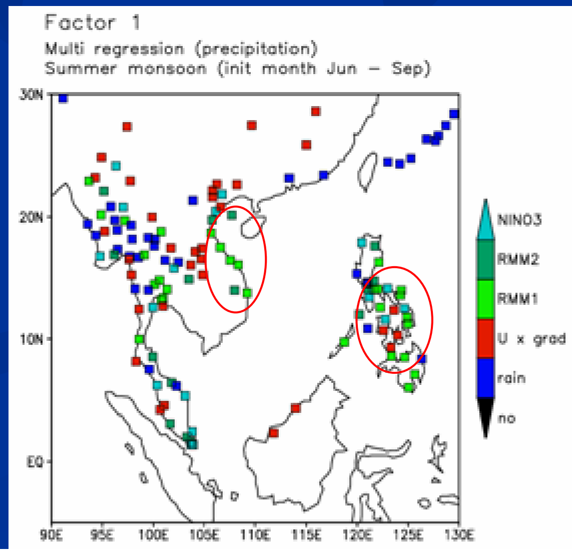
14-day-average





28-day-average





4. Results of precipitation downscaling (3)

Conclusion

- Correlation coefficient between the observation and estimate by a multiple regression is superior to that by a single regression at most of the stations for any of the seasons.

- The MJO indices contribute to the increase of the correlation coefficient in Thailand for the post monsoon season.

- The NINO.3 index contributes to the increase of the correlation coefficient at most of the stations in Southeast Asia for the winter dry season.

- The topographical factors contribute to the increase of the correlation coefficient in the western coast of Thailand for the summer monsoon and post monsoon seasons.

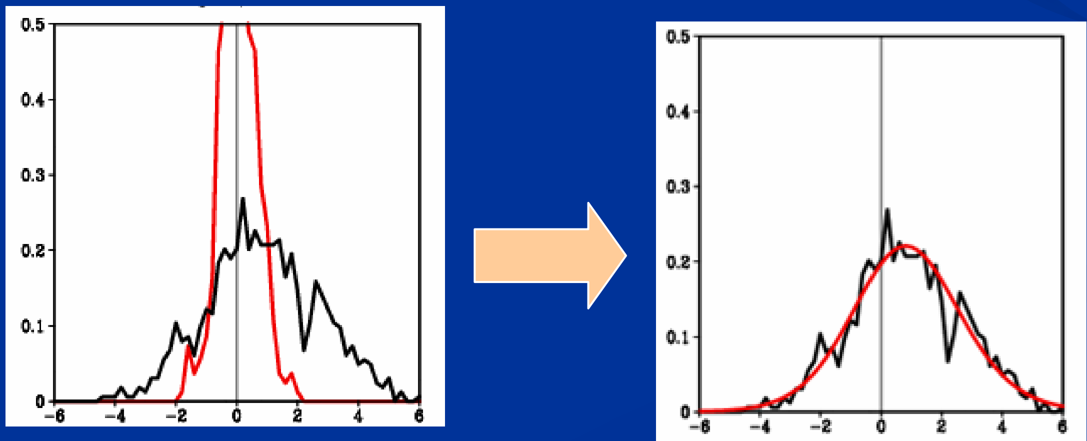
5. Method of producing probabilistic distribution (1)

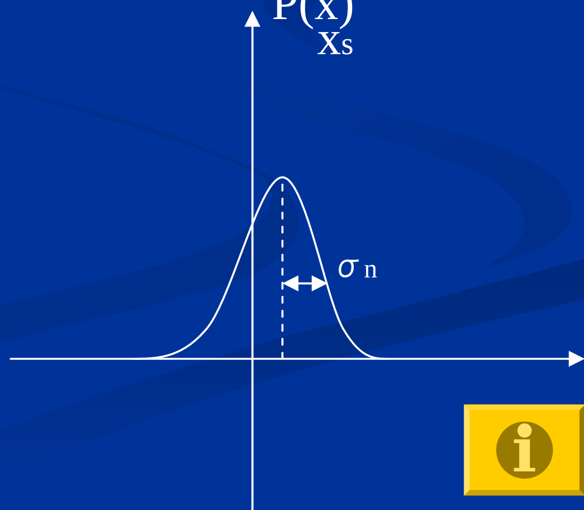
1. Base method

- Probabilistic forecast is produced directly from 11 ensemble members without using single or multiple regression

2. Gauss-distribution method

- Assumption: all of observation, ensemble mean forecast and noise are normally distributed.
- Signal: ensemble mean.
- Noise: error between ensemble mean and observation.





5. Method of producing probabilistic distribution (2)

3. Gauss-Kernel method

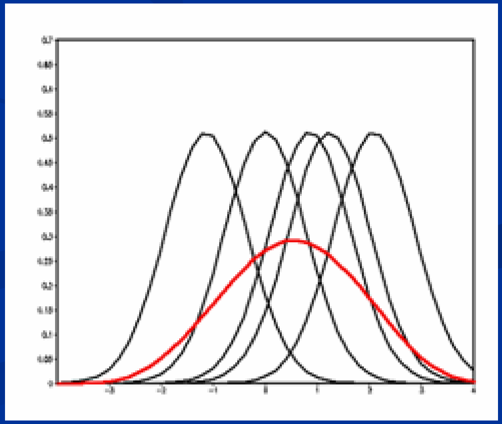
- Assumption: observation, 11 ensemble members and noise are normally distributed.
- The regression coefficients and the noise are derived from one member.
- These values are applied to all the members and averaged.

Verification target

- Probability of forecast is above- or below-median of observation.
- Tercile probability (upper category)

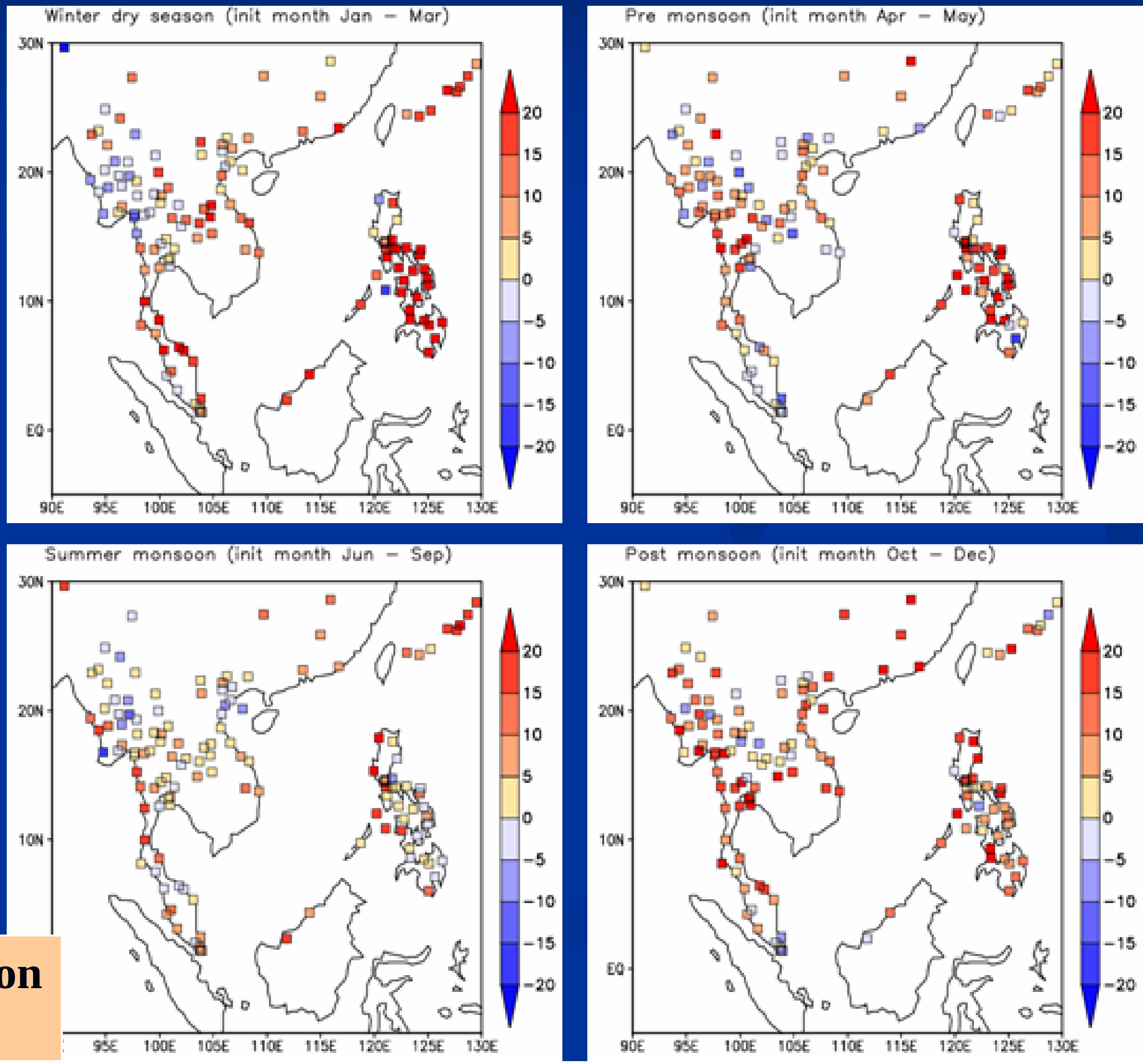
Evaluation method

- Brier Skill Score (BSS)
- Reliability diagram (Wilks, 1995)



6. Evaluation of precipitation probabilistic forecast (1)

BSS 14-day (Day2-15), Gauss-distribution method



Winter dry (JFM)

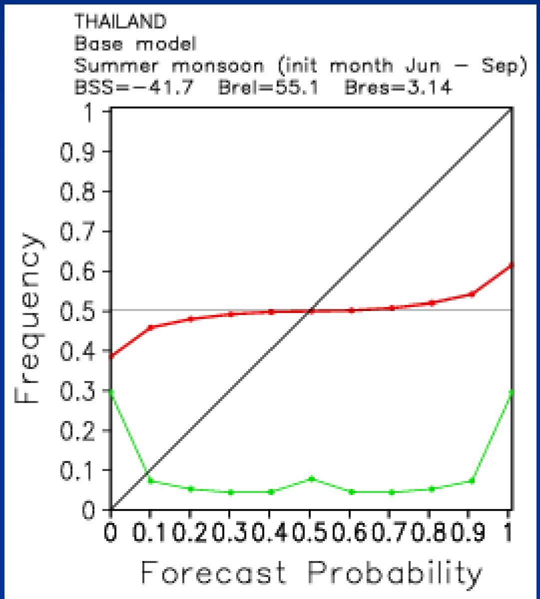
Pre monsoon (AM)

Summer monsoon (JJAS)

Post monsoon (OND)

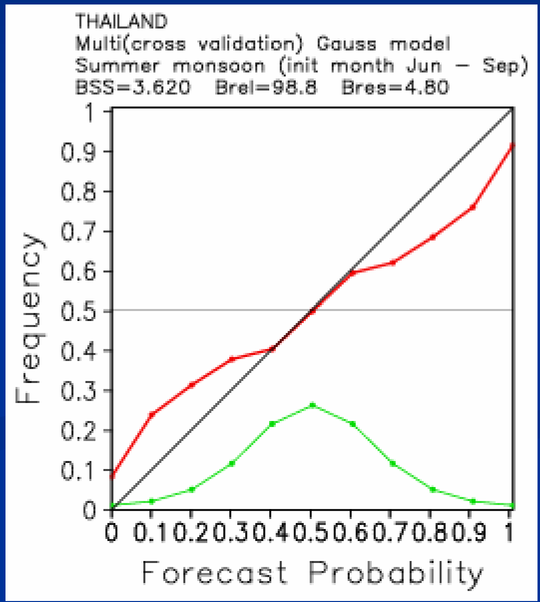
6. Evaluation of precipitation probabilistic forecast (2)

Reliability diagram, above/below median (50 %) , Day 2-15
Summer monsoon (JJAS)



Base method
(lower reliability)

Statistical downscaling (cross validation)



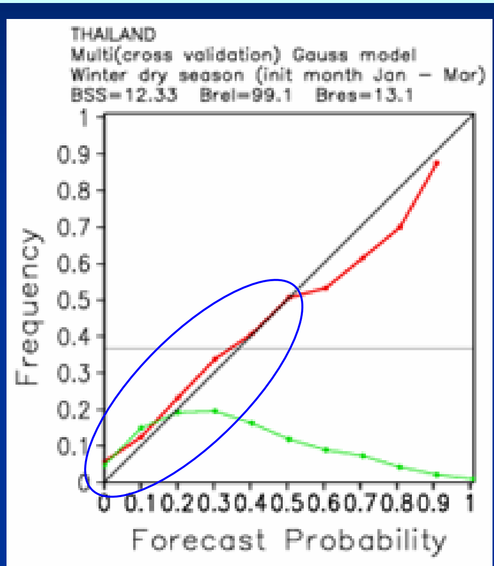
Gauss-distribution method
(higher reliability)

Red: reliability curve
Green: forecast frequency of each forecast probability

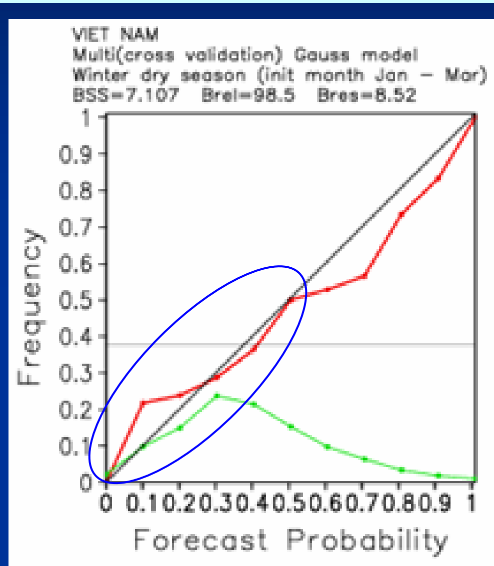
6. Evaluation of precipitation probabilistic forecast (3)

Reliability diagram, upper tercile (33 %), Day 2-15, Gauss-distribution, Winter dry (JFM)

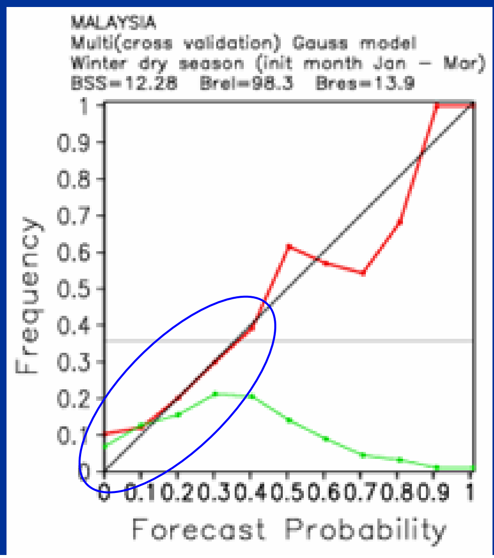
Tailand



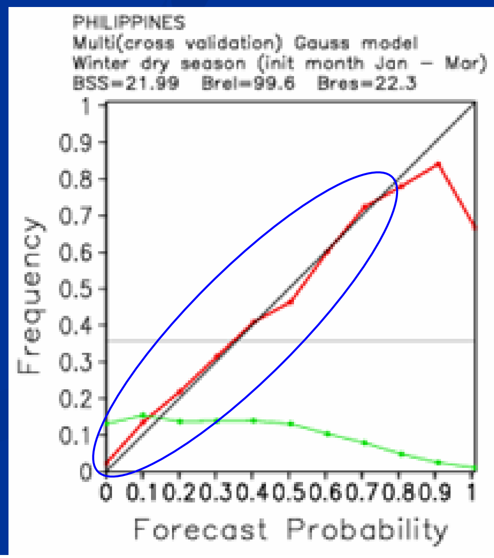
Viet Num



Malaysia



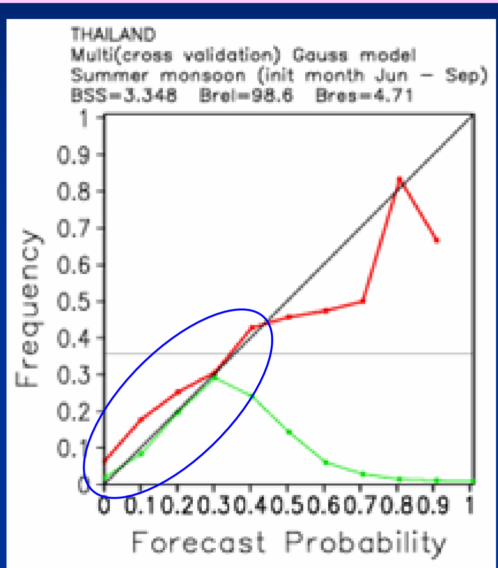
Philippines



6. Evaluation of precipitation probabilistic forecast (4)

Reliability diagram, upper category of tercile (33 %), Day 2-15, Gauss-distribution, Summer monsoon (JJAS)

Tailand



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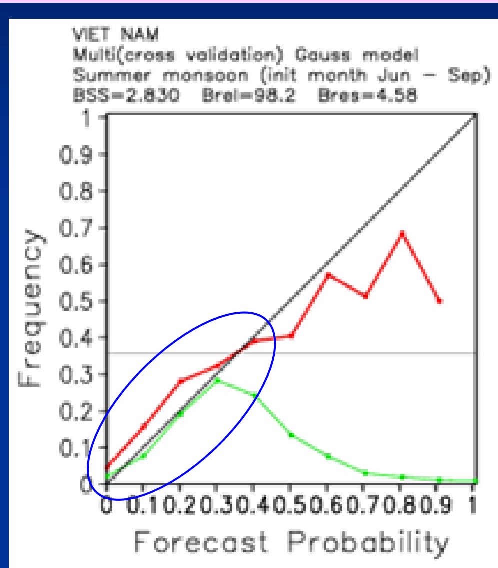
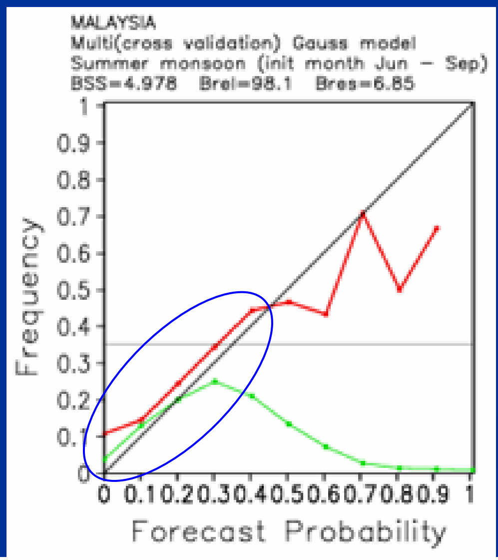
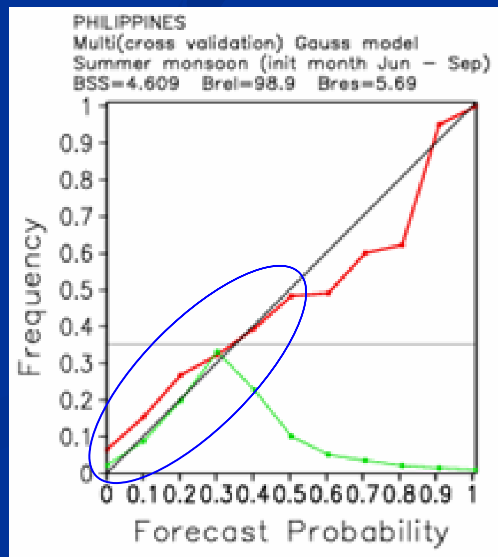


Malaysia



Philippines



6. Evaluation of precipitation probabilistic forecast (5)

Conclusion

- For the BSS, the Gauss-distribution method has the highest score on average among the three methods.

- For probabilistic forecast of 14-day precipitation, BSS of the above- or below-median probability is positive at most of the stations for Day 2-15 forecast.

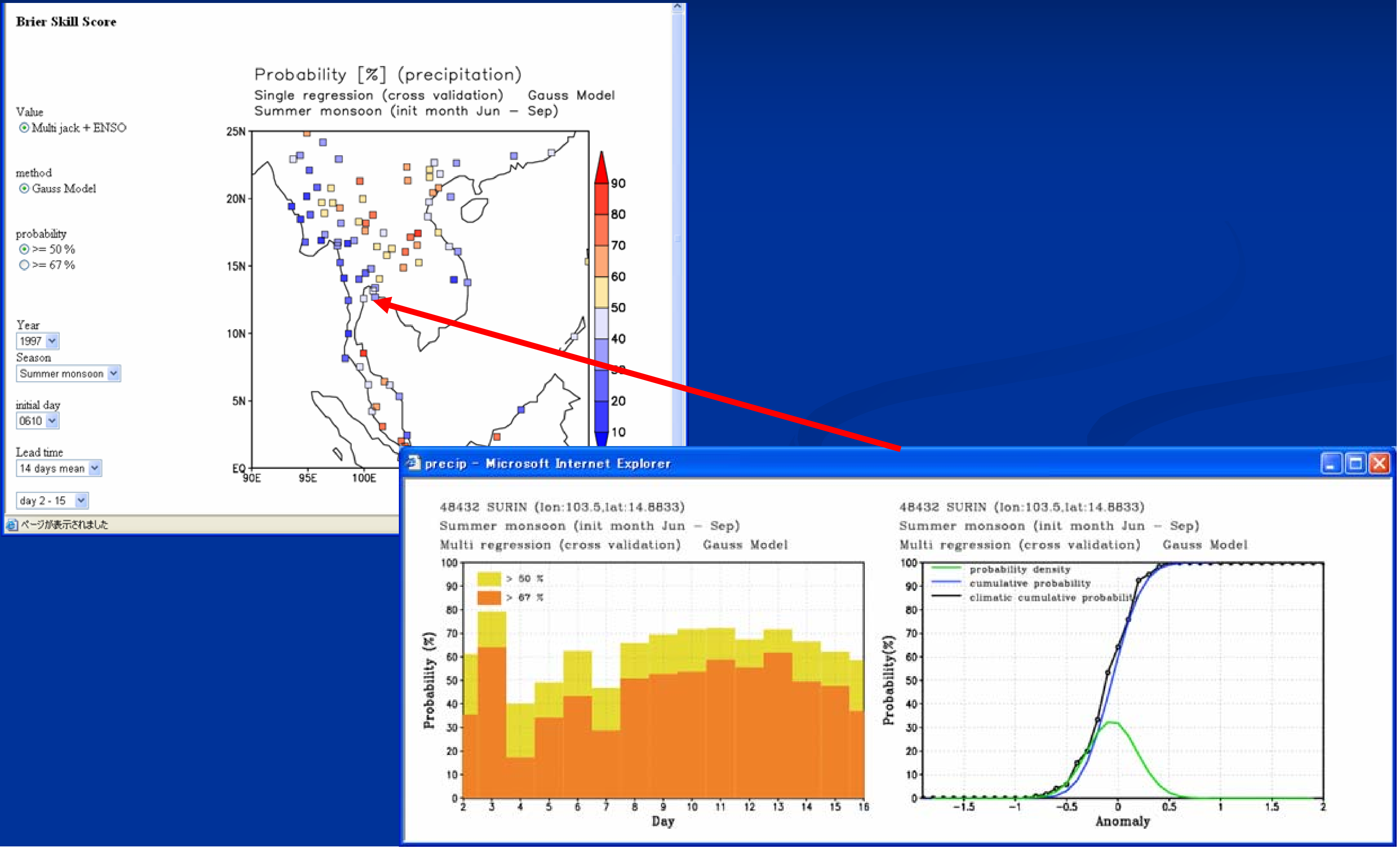
- According to the reliability diagrams of multiple regression formula, there is a possibility to predict the highest category (above normal) of the tercile probability with high reliability when it is predicted with 50 %.

7. Future Plan (1)

- In the middle of 2007, dissemination of the downscaled pointwise probabilistic forecast guidance is planned to start on a experimental basis through the TCC website.
- According to the feedback from NMHSs, the forecast guidance will be improved.

7. Future Plan (2)

Prototype of probabilistic guidance

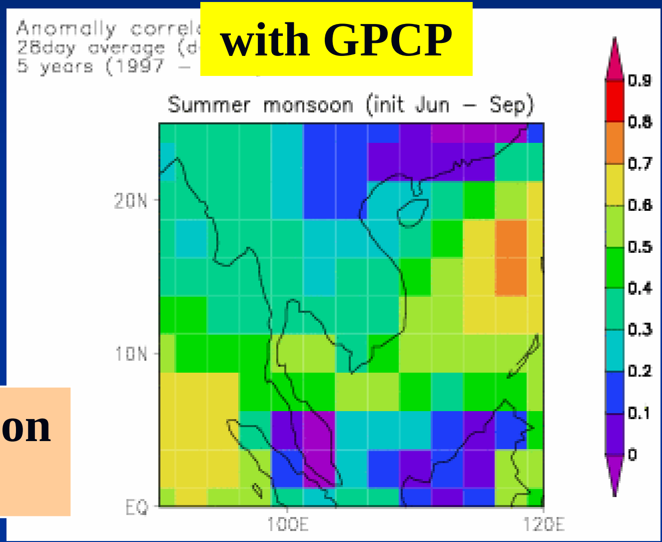


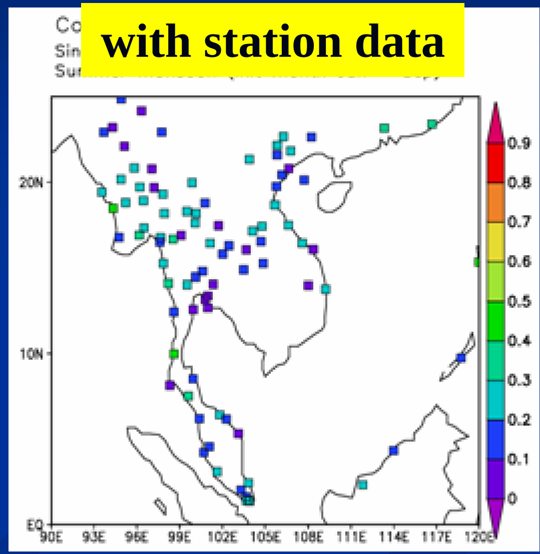
Thank you!

2. Performance of current forecast (28-day prep.)

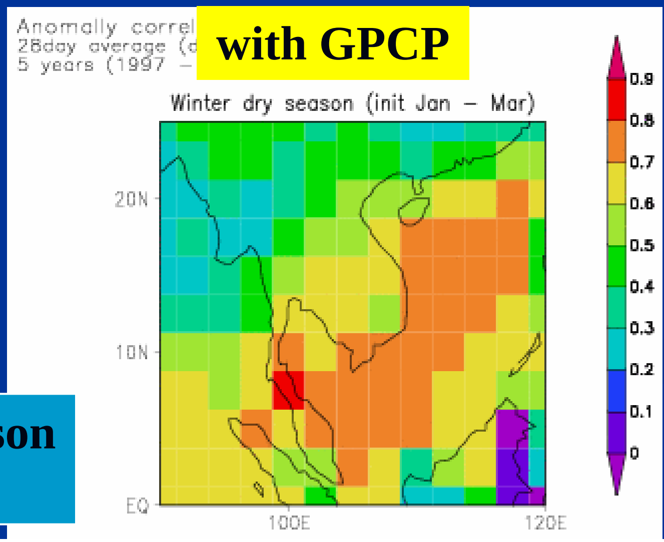
Correlation coefficients of 28-day-average precipitation (Day 2-29) between hindcast and observation

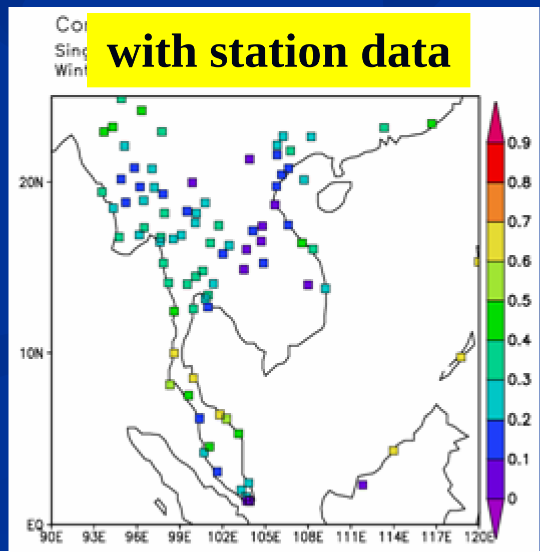
Summer monsoon (Jun.-Sep.)



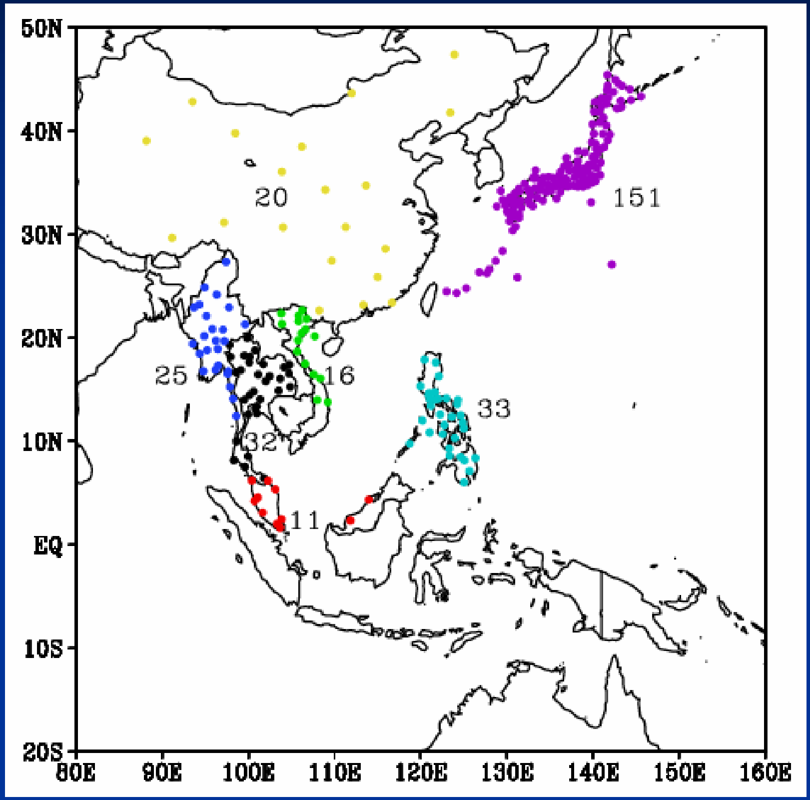


Winter dry season (Jan.-Mar.)





Selected Station

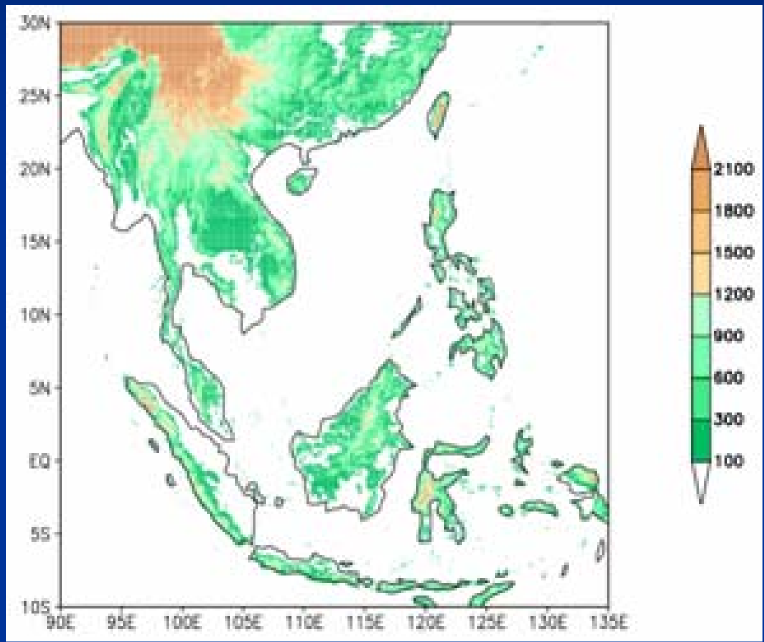


Observation stations of 14-day-averaged precipitation which are selected according to the following items:

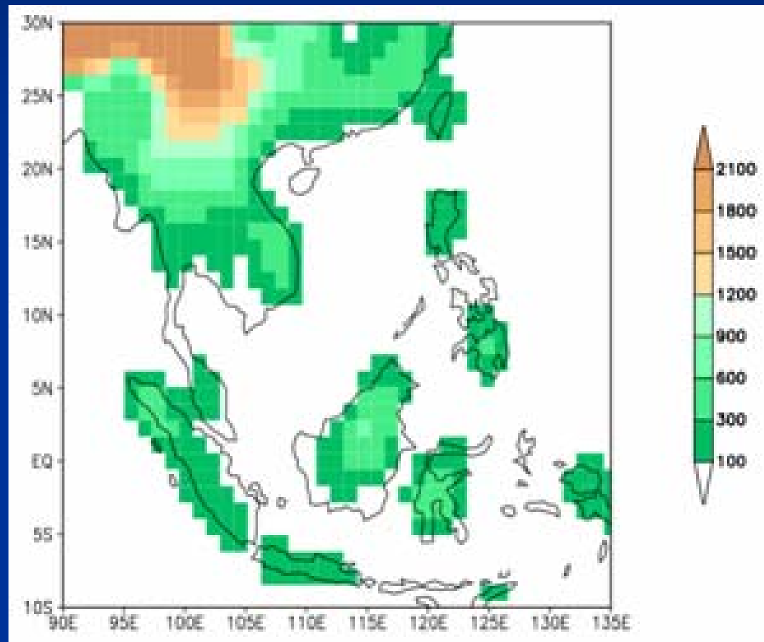
- period for making climatology
  1971 ~ 2001 : 330 days or more a year with available daily observation data >= 24 years
- period of hindcasts
  1992 ~ 2001 : 330 days or more a year with available daily observation data >= 9 years

288 station points (151 of which are Japan)

Topographical factor



Terrain data of the smallest resolution
(0.083 degree)



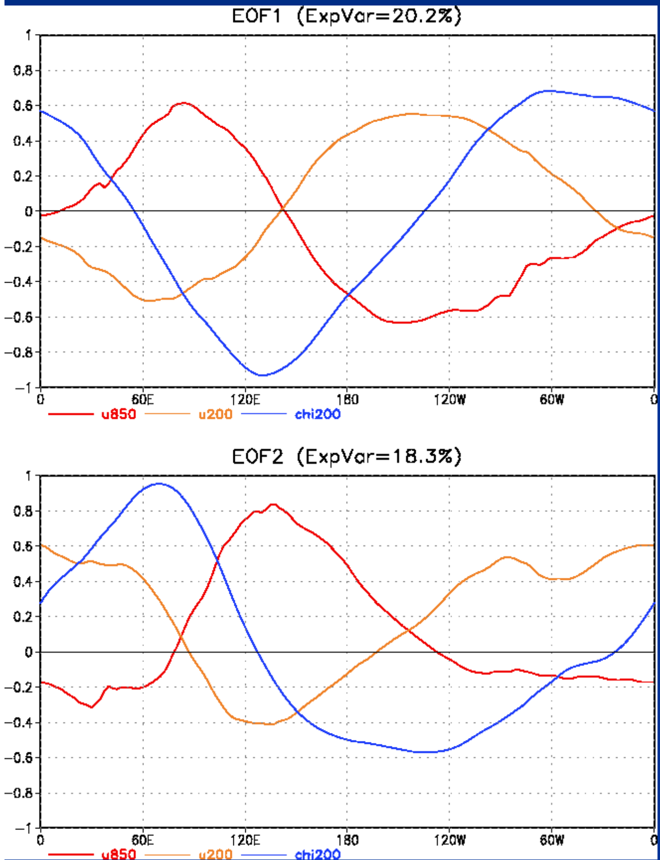
Terrain data of EPS
(1.125 degree)

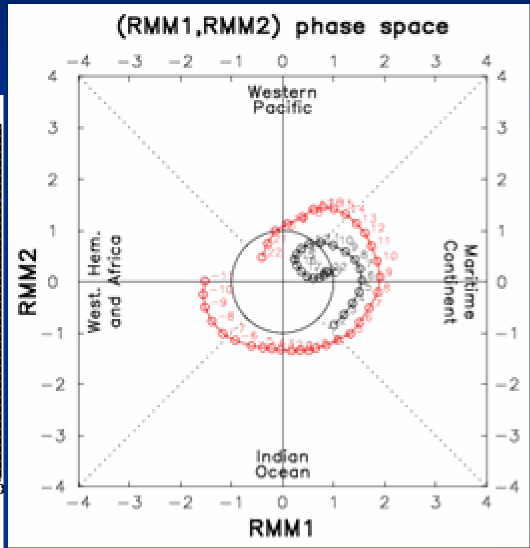
Topographical factor $u_{850}\frac{dh}{dx} + v_{850}\frac{dh}{dy}$

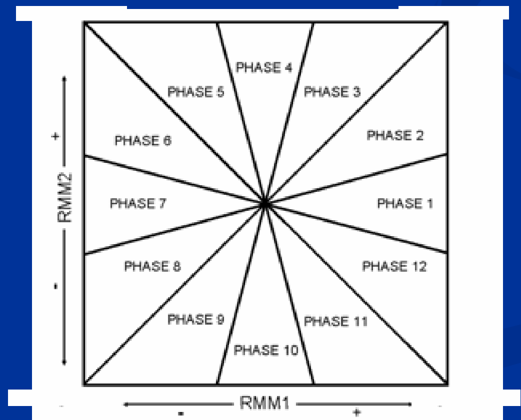
> 0 upward motion

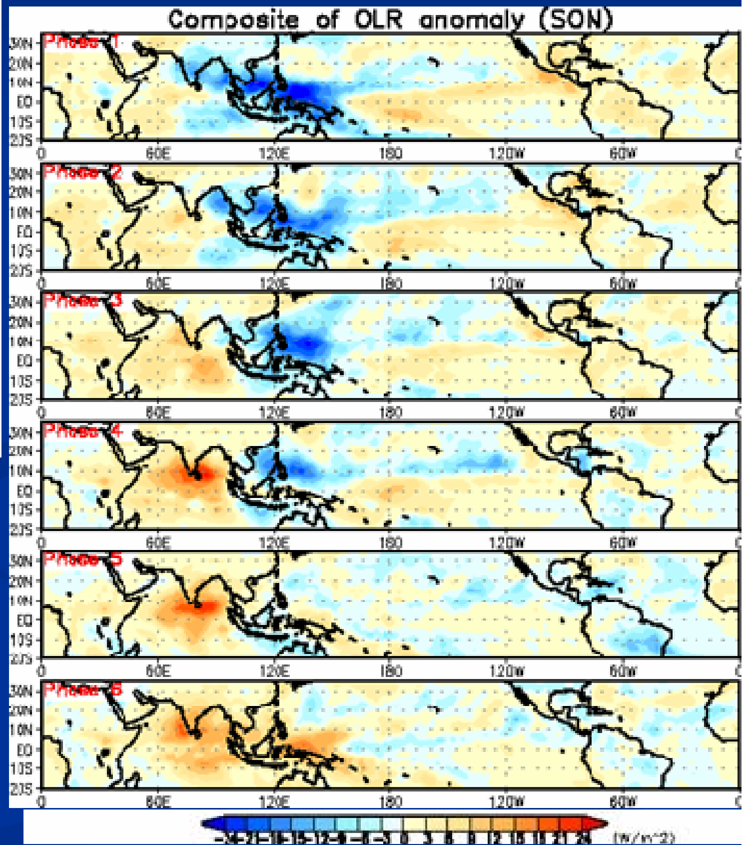
< 0 downward motion

MJO Indices (RMM1, RMM2)









Gauss-distribution method

$y = ax + \varepsilon = x_s + x_n$

$a = \sigma_y / \sigma_x \times r$

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

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

$P(y) = N(y, x_s, \sigma_n)$

$= 1/(2\pi)^{1/2}\ \sigma_n \exp(-(y-x_s)^2/2\sigma_n{}^2)$