

# GIFS-TIGGE Products for SWFDP

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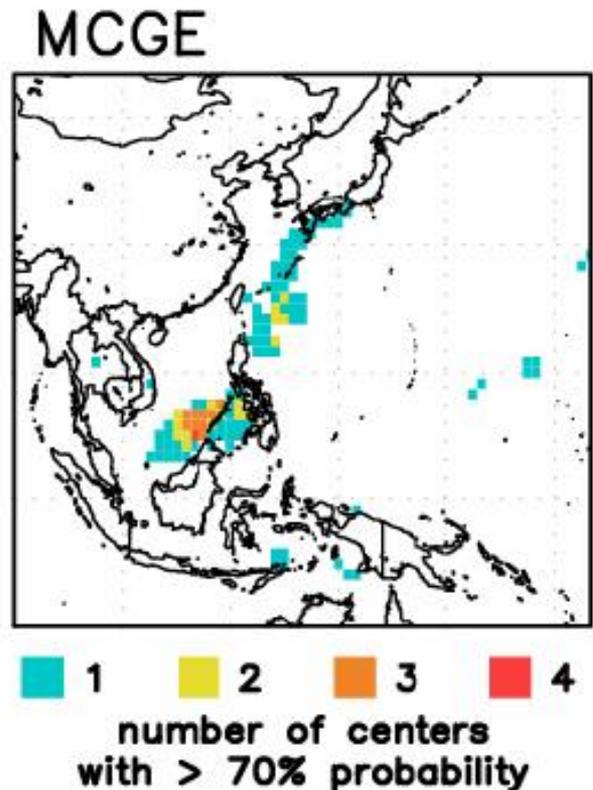
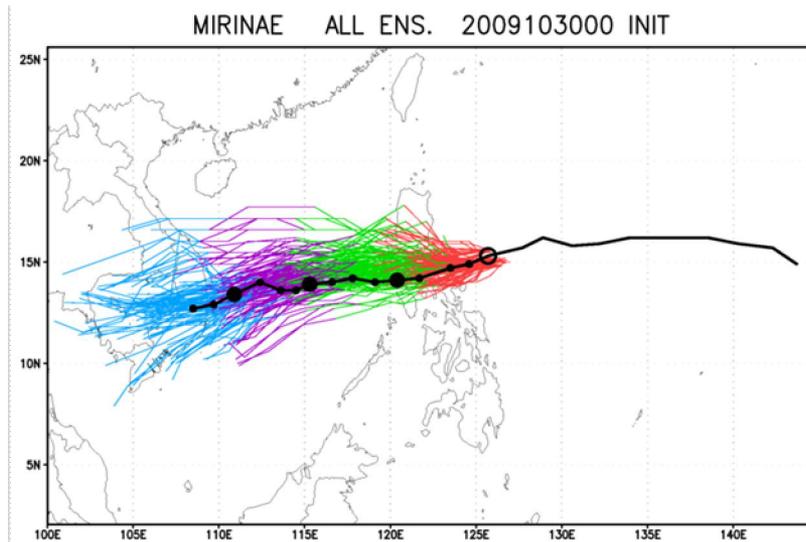
4: World Weather Research Division, Research Department, World Meteorological Organization

# GIFS-TIGGE Products for SWFDP

The MRI/JMA has developed **two** types of GIFS-TIGGE products for the Severe Weather Forecast Demonstration Project (SWFDP) in Southeast Asia.

## 1. Tropical cyclone track in the western North Pacific

## 2. Severe weather potential such as heavy precipitation



# WWRP-RDP

## “North Western Pacific Tropical Cyclone Track Ensemble Forecast (NWP-TCTEF)”

The NWP-TCTEF is a five-year research project, starting in 2009. This project intends to build on the TIGGE concept and take advantage of the **TIGGE CXML** data provided by multiple organizations for **improving TC track forecast skill**. MRI/JMA created a website for the NWP-TCTEF at:

**URL: <http://tparc.mri-jma.go.jp/cyclone/>**

### Main Page

#### Tropical Cyclone Ensemble Forecast Information HomePage

User   
Password

##### 1. Purpose

The purpose of this homepage is to provide a guidance of tropical cyclone forecasts in near real-time for the ESCAP/WMO Typhoon Committee Members, based on the TIGGE (THORPEX Interactive Grand Global Ensemble) Cyclone XML (CXML) data, under the joint project of World Weather Research Program (WWRP) and Tropical Cyclone Program (TCP); North Western Pacific Tropical Cyclone (TC) Ensemble Forecast (NWP-TCTEF) Project. The data providers are shown [here](#). The homepage is also set up for interested researchers to develop the TIGGE related applications/products for tropical cyclone studies. The homepage is password protected. You can send a request with your information to get ID and password to [thorpex@mri-jma.go.jp](mailto:thorpex@mri-jma.go.jp).

##### 2. Background

A WWRP-RDP project “North Western Pacific Tropical Cyclone (TC) Ensemble Forecast (NWP-TCTEF) Project” intends to build on the TIGGE concept and take advantage of the TIGGE CXML data provided by multiple organizations for improving TC track forecast skill over the North western Pacific, starting from 2009, as a five-year project. The objectives of the NWP-TCTEF Project are

- to explore and develop effective ways of obtaining and utilizing the track forecast data from TIGGE data providers to improve medium range forecast of TC track forecast
- to develop software for a real time multi-model tropical cyclone forecasting system from data transfer to verification
- to evaluate the utility of multi-model forecasts of tropical cyclones track predictions and provide recommendations on future multi-model ensemble systems and on future GFS-RDPs
- to encourage forecasters of involved Members to utilize the information on this Web and to exchange their experience in use of TIGGE ensembles data for tropical cyclone forecast via “Discussion” page.

The implementation of the Project should under the participation of GFS-TIGGE WG, TIGGE data providers, TIGGE archive centers, TC Warning Centers, TC RSMCs etc. The Project will first show its visibility and preliminary evaluation of the data during the Shanghai EXPO 2010, May 1 to October 31, 2010. It is followed by the enhancement of the data utilization, which may includes the extension of the CXML database (intensity, wind speed, and precipitation) and better guidance for operational purposes in the rest of the period through examining the value of the CXML database and training activities for the member countries in the Typhoon Committee.

##### 3. Outline

The homepage provides the following information.

- Deterministic and Ensemble TC track forecasts.
- Strike Probability Map (if a TC will approach within 120 km range in certain periods (currently 4 days), based on Ensemble TC track forecasts, with three different ways (“In 4 days”, “each time”, and “time series at cities”)
- For verification purposes, the best track data by JMA are embedded on the forecast track and strike probability maps.

Track

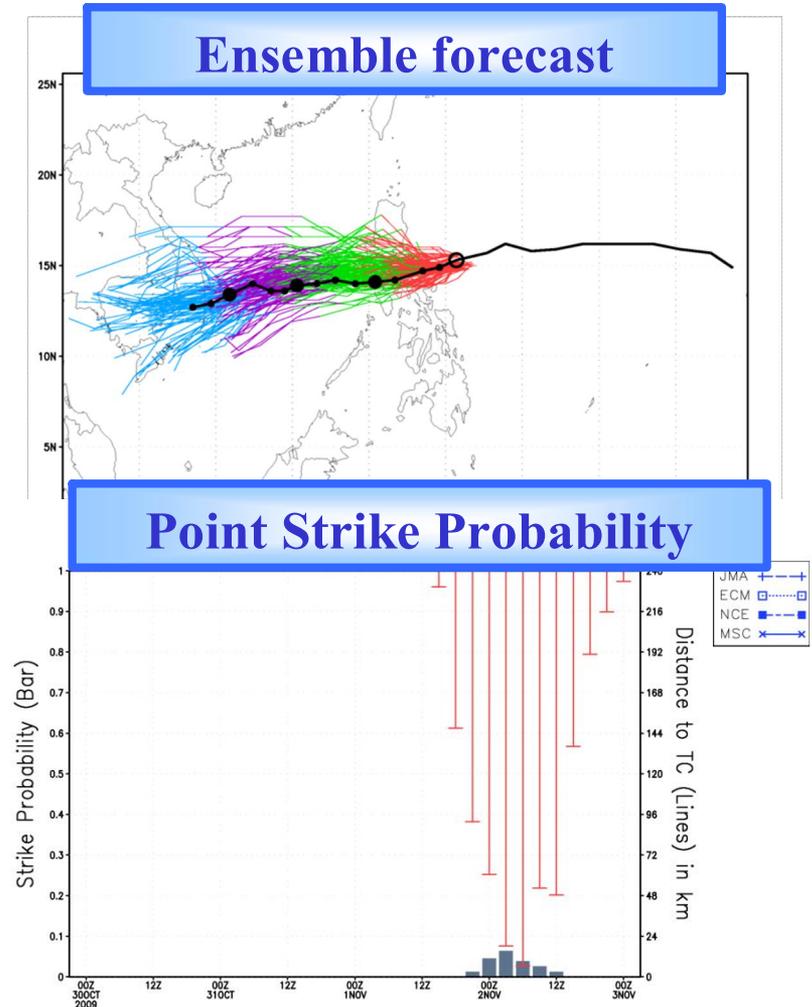
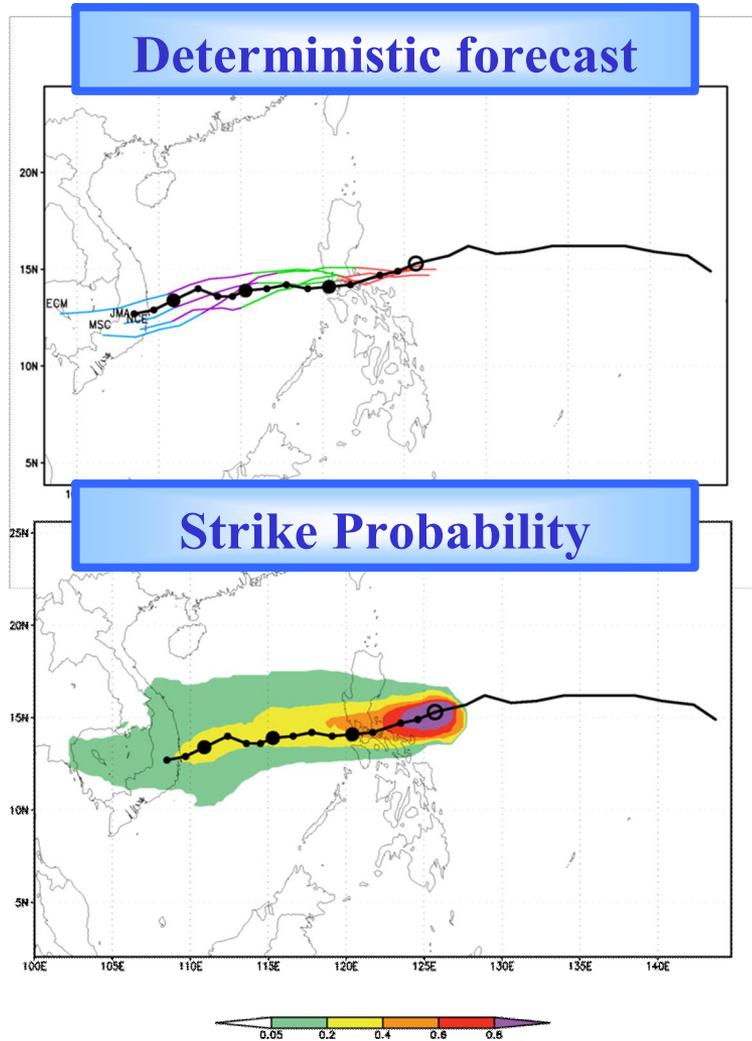
Strike Prob.

2009+ Oct 20 12UTC

Send email to  
[thorpex@mri-jma.go.jp](mailto:thorpex@mri-jma.go.jp) to get  
ID and password

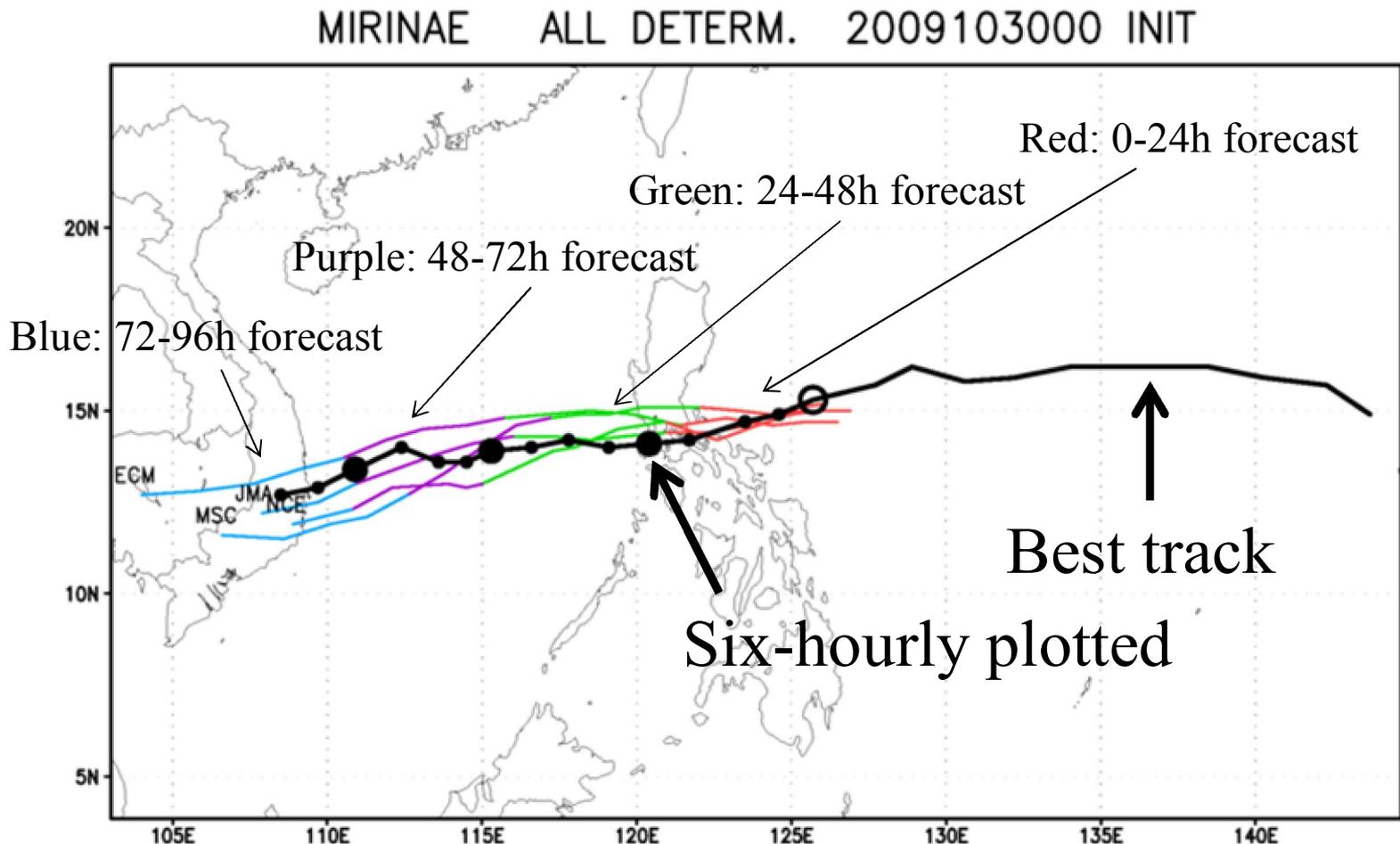
# List of available products - TC track -

The SWFDP is an good opportunity to evaluate the usefulness of GIFS-TIGGE products in operational forecasting. The NWP-TCTEF project is willing to provide the products for the SWFDP.



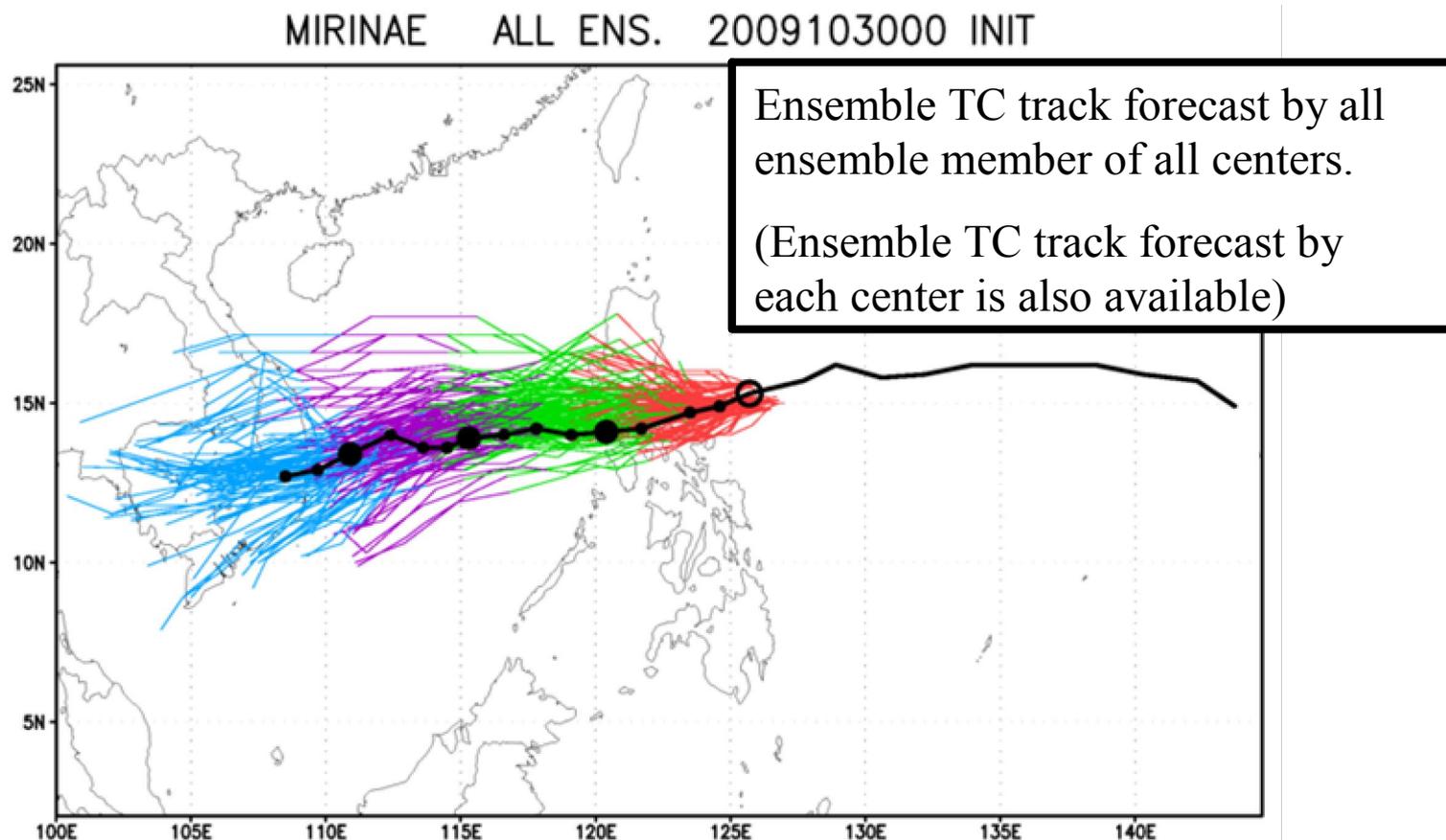
# Deterministic TC track forecast

Track forecasts from ECMWF, JMA, MSC and NCEP are available as of December 2011.



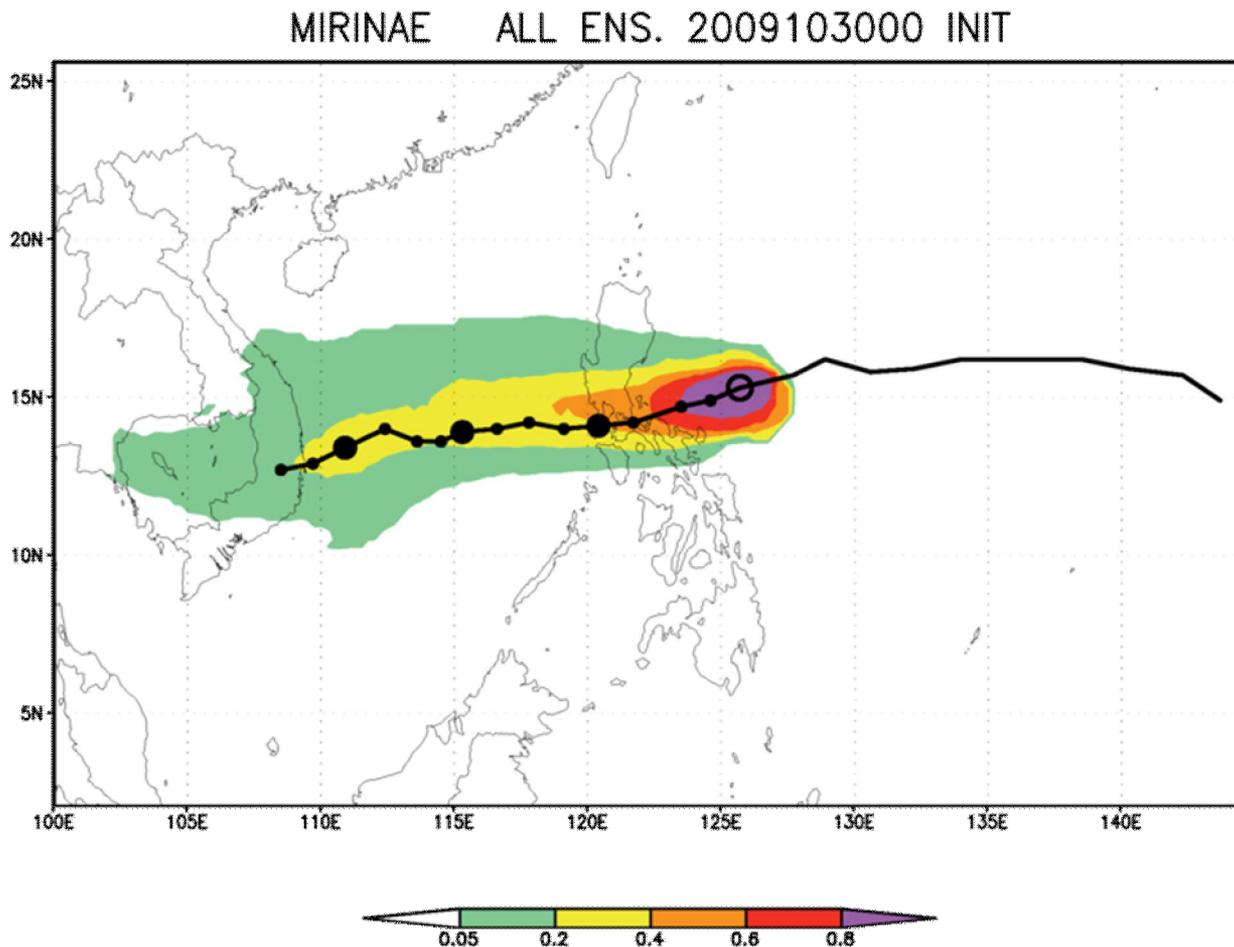
# Ensemble TC track forecast

Track forecasts from **CMA** (ensemble size is 15), **ECMWF** (51), **JMA Typhoon EPS** (11), **JMA One-week EPS** (51), **KMA** (17), **MSC** (21), **NCEP** (21), **STI** (9) and **UKMO** (24) are available as of December 2011.



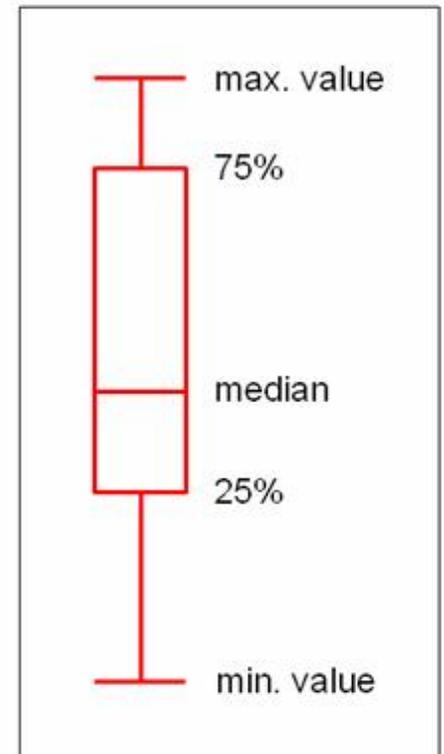
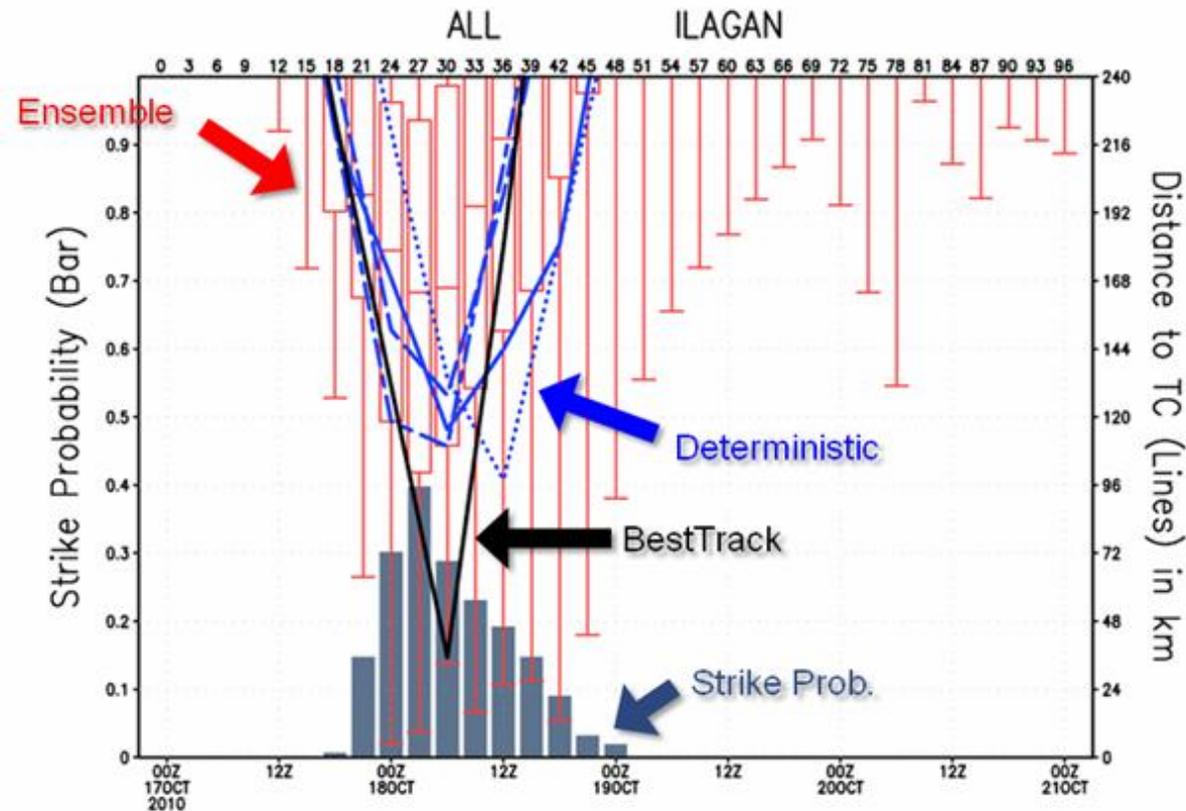
# Strike probability map

Probability that the center of a storm will pass within 120 km of a location during a 96 hour time interval is shown. Contour levels shown are 5-20% (green), 20-40% (yellow), 40-60% (orange), 60-80% (red) and 80-100% (purple).



# Point strike probability map

Time series of strike probability at a selected location (city). Y-axis on the left shows the strike probability at city ILAGAN, and the Y-axis on the right shows the distance between ILAGAN and a TC center.



Box plot of Ensemble forecast

Time

# Select the city and cyclone name on the website

The screenshot shows the 'Tropical Cyclone Ensemble Track Information Home Page' in a Mozilla Firefox browser window. The page title is 'Tropical Cyclone Ensemble Track Information Home Page'. The interface includes a 'Cyclone Name' dropdown menu with a list of names: ORATS, CONSON, CHANTHU, DIANMU, MINDULLE, LIONROCK, KOMPASU, NANTHEUN, MALOU, MERANTI, FANAPI, MALAKAS, MEGI, and CHABA. The year is set to 2010. Under 'Forecasts', 'Ensemble' is selected. Under 'Center', 'All Centers' is selected. A 'Track' button is highlighted in pink. A 'Strike Prob.' button is also highlighted in pink, with a 'time series' dropdown menu next to it. A 'Update Display' button is present. The main map shows the track of Cyclone MEGI over the Philippines. A city icon for Ilagan is highlighted on the map. To the right, a time series plot for Ilagan (17.1N - 122.1E) shows 'Strike Probability (bar)' and 'Distance to TC (km) (line)'. A 'Click city icon to get the time series at right.' callout points to the Ilagan icon on the map. Another callout says 'Enlarge Image by clicking the box.' pointing to the time series plot. A 'Click city name to get the time series at right.' callout points to the 'PHILIPPINES, Ilagan' entry in a city list dropdown at the bottom. A 'Currently Selected' callout points to 'MEGI' in the cyclone name list. Another 'Currently Selected' callout points to 'PHILIPPINES, Ilagan' in the city list.

Currently Selected

Tropical Cyclone Ensemble Track Information Home Page

Cyclone Name

Year 2010

Forecasts **Ensemble** Deterministic

Center **All Centers** Each Center

**Track** **Strike Prob.** time series

Update Display

MEGI

Ilagan (17.1N - 122.1E)

Click city icon to get the time series at right.

Enlarge Image by clicking the box.

Click city name to get the time series at right.

Currently Selected

Currently Selected

PHILIPPINES, Ilagan

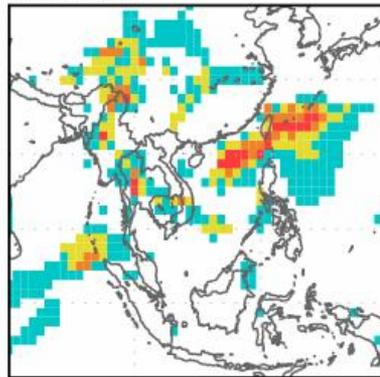
# Products on severe weather potential -heavy precipitation-

## Case for Thailand flood in 2011

**MCGE** stands for Multi  
Center Grand Ensemble

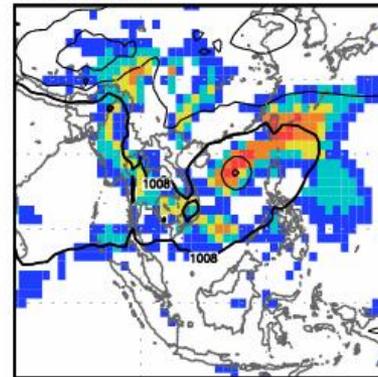
Occurrence probability of extreme 24-hr precipitation  
Valid: 2011092912UTC +3-4days

MCGE

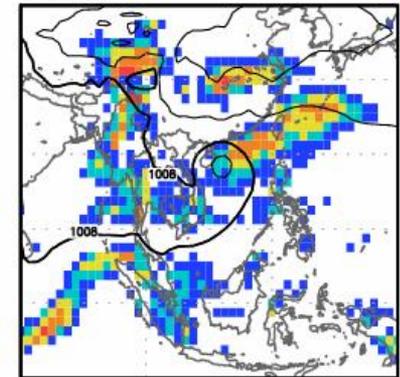


1 2 3 4  
number of centers  
with > 50% probability

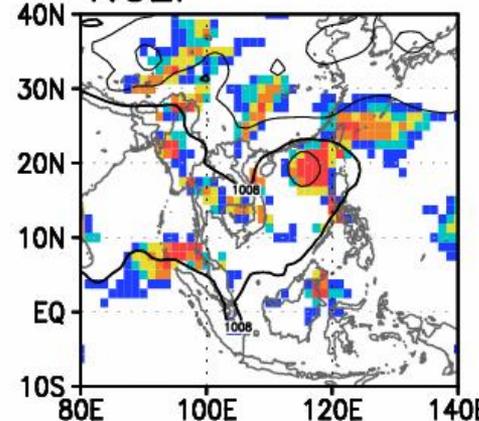
ECMWF



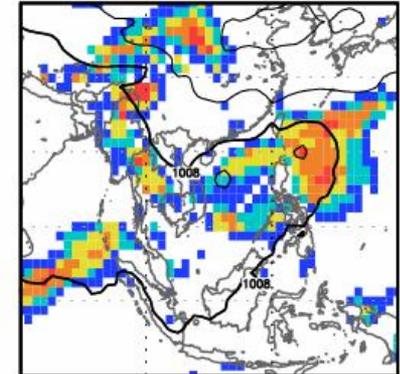
JMA



NCEP



UKMO



contour: control Pmsl

10 30 50 70 90  
probability falling above the 90th percentile [%]

If the 4 EPSs (ECMWF, JMA, NCEP and UKMO EPSs) predict heavy precipitation simultaneously, the area is plotted in red.

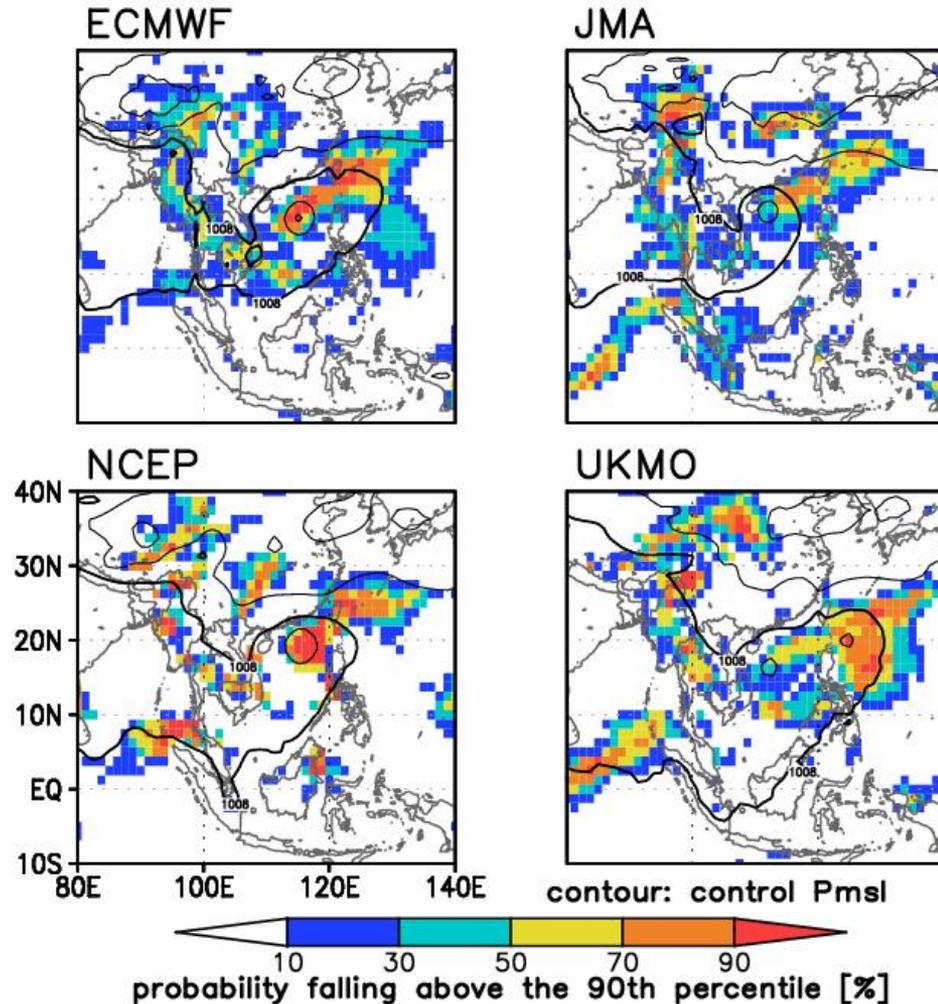
# Definition of the “heavy” precipitation

The heavy precipitation is defined as precipitation above 90<sup>th</sup>, 95<sup>th</sup> or 99<sup>th</sup> percentile of the climatology.

The climatology is the **model climatology**, not the climatology in the real atmosphere, being created for each NWP center using the TIGGE dataset.

**Note** that the users can change the threshold of the percentile (90<sup>th</sup>, 95<sup>th</sup>, or 99<sup>th</sup>) on the website.

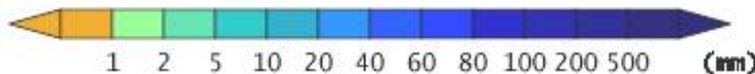
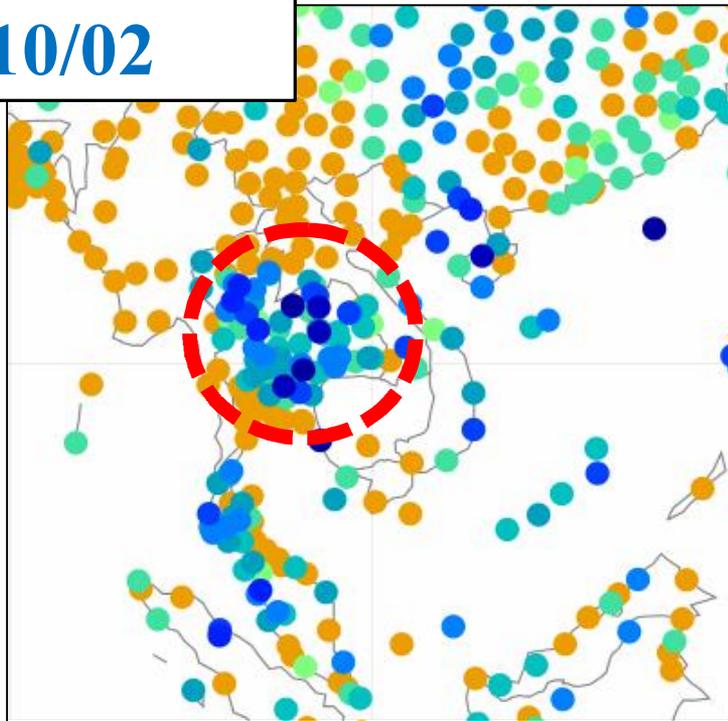
The rate of ensemble members that predict heavy precipitation is plotted



# Comparison with observations

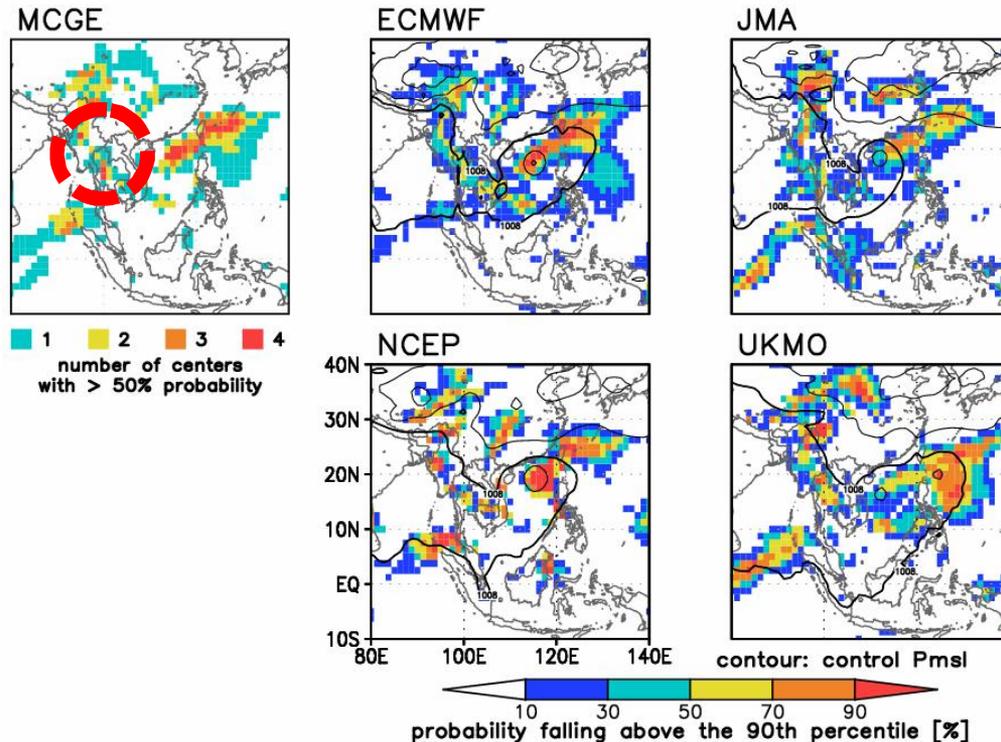
Observation: Precipitation (mm/day)  
based on SYNOP Reports

10/02



After Harada and  
Adachi (CPD/JMA)

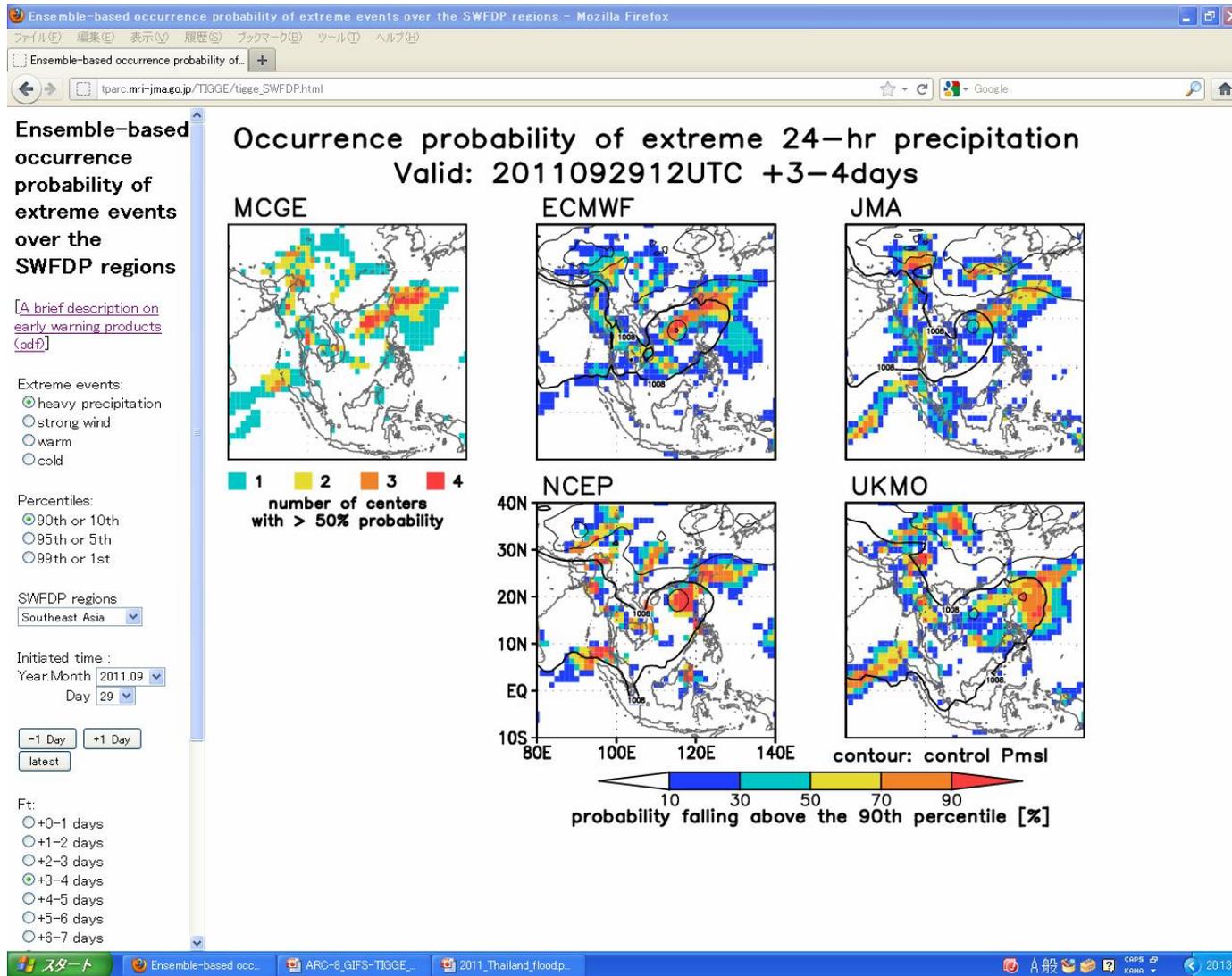
Occurrence probability of extreme 24-hr precipitation  
Valid: 2011092912UTC +3-4days



**Potential of heavy precipitation was  
predicted with a lead time of 3 to 4 days**

# Website

[http://tparc.mri-jma.go.jp/TIGGE/tigge\\_SWFDP.html](http://tparc.mri-jma.go.jp/TIGGE/tigge_SWFDP.html)



# How to use the GIFS-TIGGE products for SWFDP

## 1. Tropical cyclone track in the western North Pacific

- is available in near-real time and
- offers products with better performance.

## 2. Severe weather potential such as heavy precipitation

- allows the user to make a quick assessment of the high-risk areas.

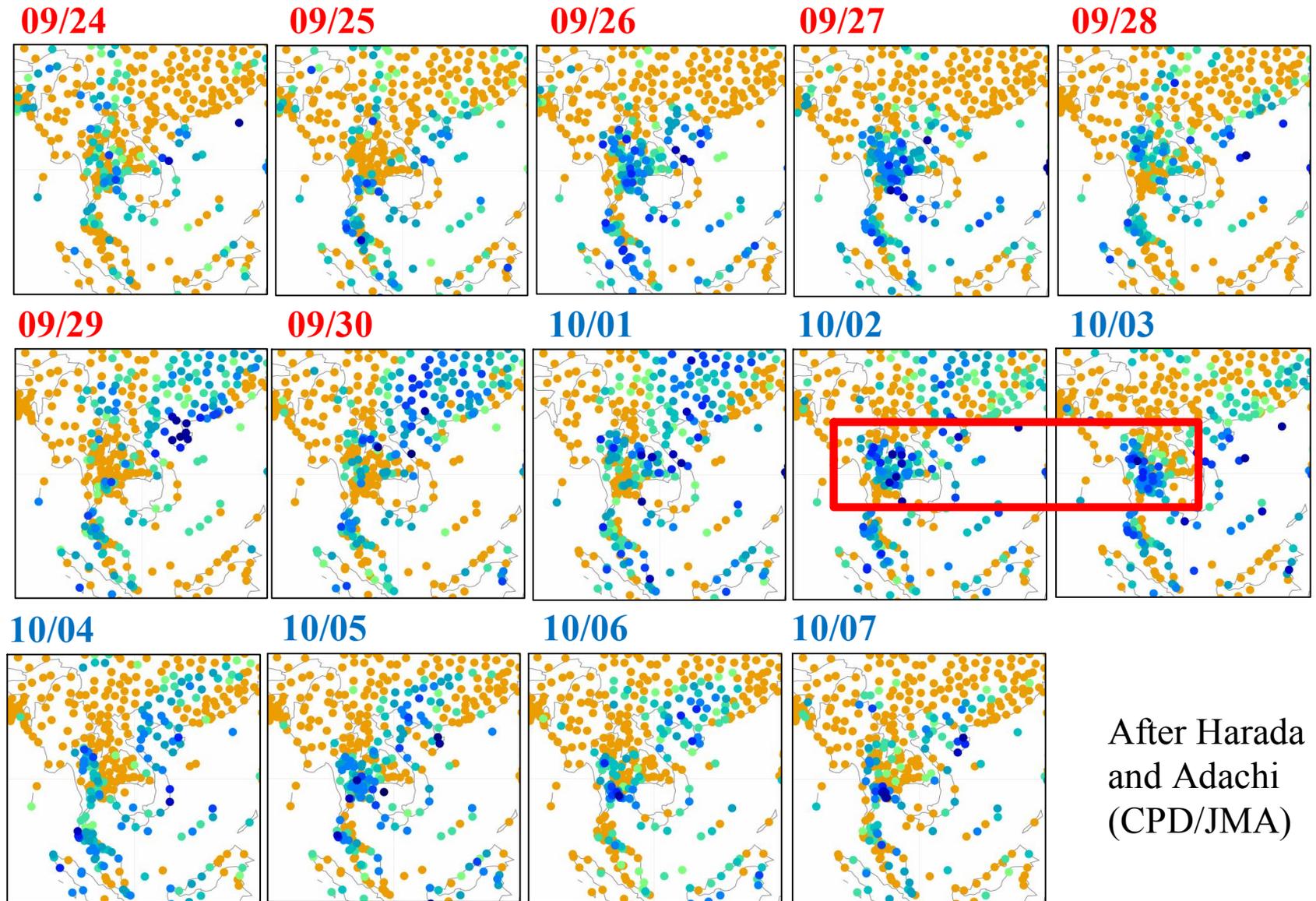
However

- needs more verification; and
- is available with 48-hour delay.

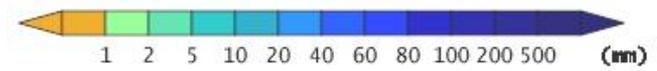
**While the TC track products are recommendable for the **real-time** operation of the SWFDP, the products on severe weather potential would be useful for the **post evaluation** due to the availability time issue of the TIGGE data.**

Thank you for your attention

# Observation: Precipitation (mm/day) Based on SYNOP Reports



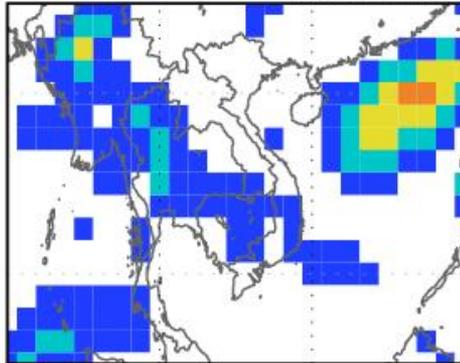
After Harada  
and Adachi  
(CPD/JMA)



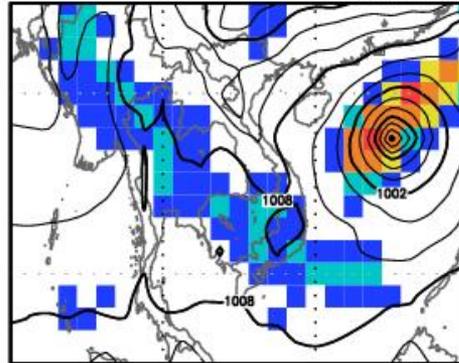
# Ensemble Prediction for Thailand flood in 2011

Occurrence probability of extreme 24-hr precipitation  
Valid: 2011092912UTC +3-4days

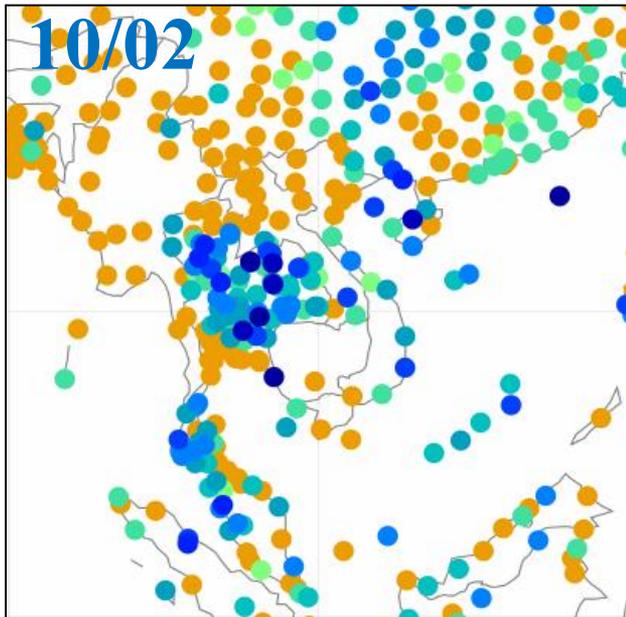
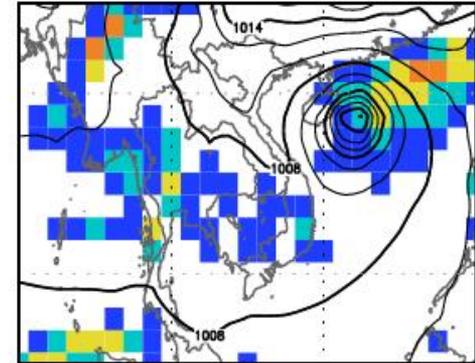
MCGE mem:147



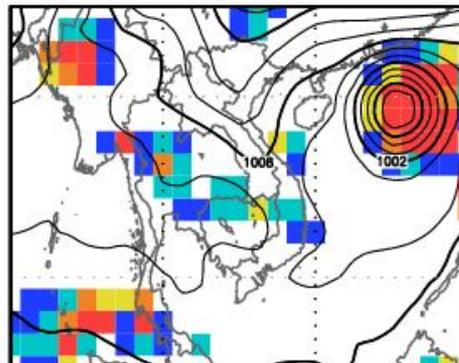
ECMWF mem:51



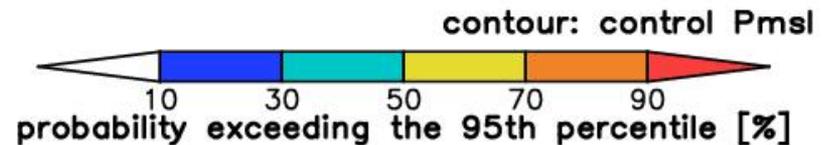
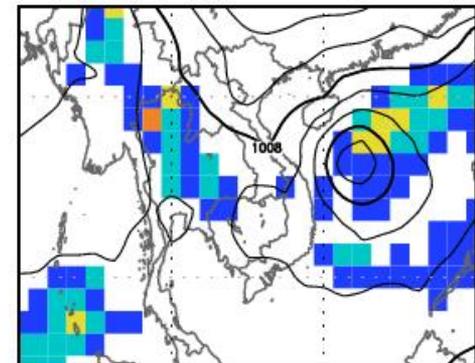
JMA mem:51



NCEP mem:21

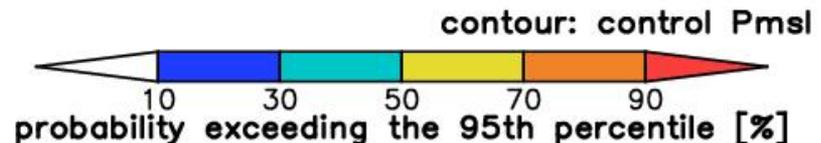
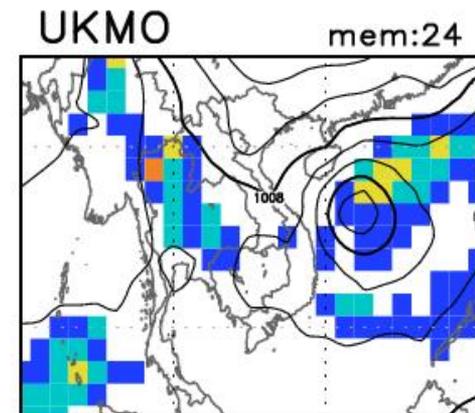
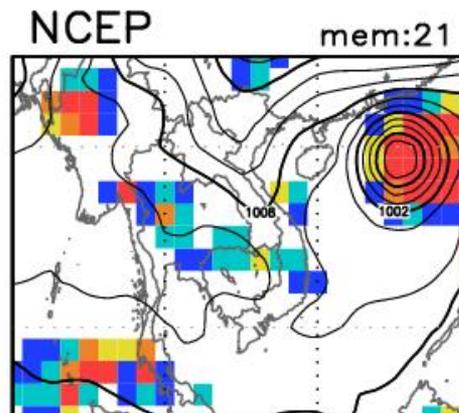
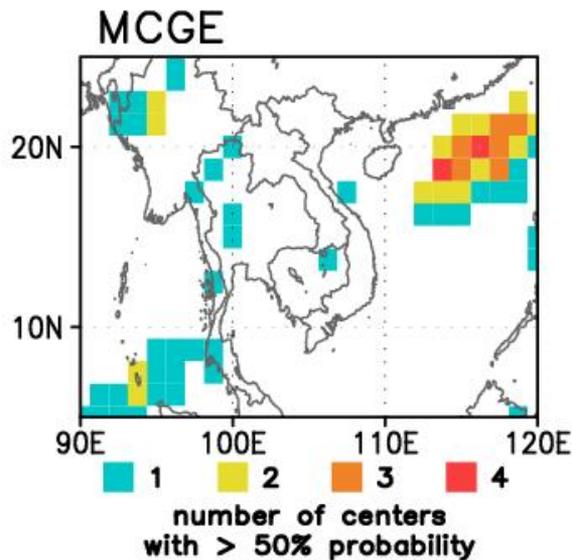
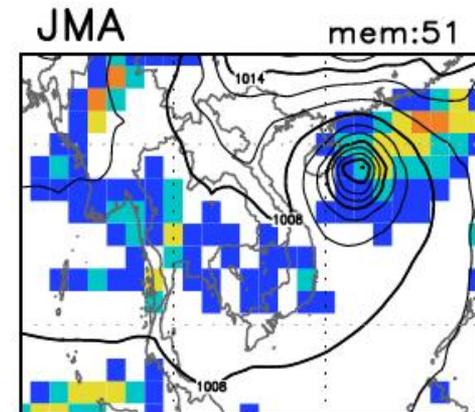
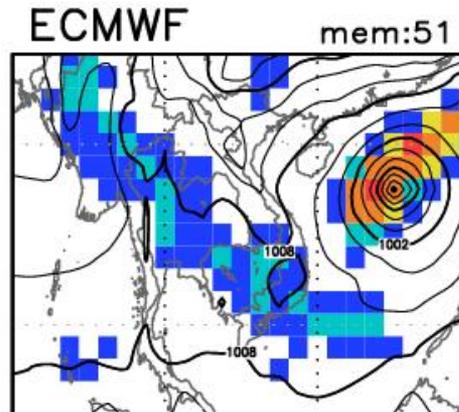
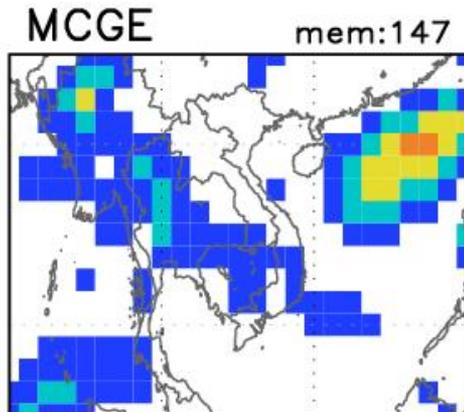


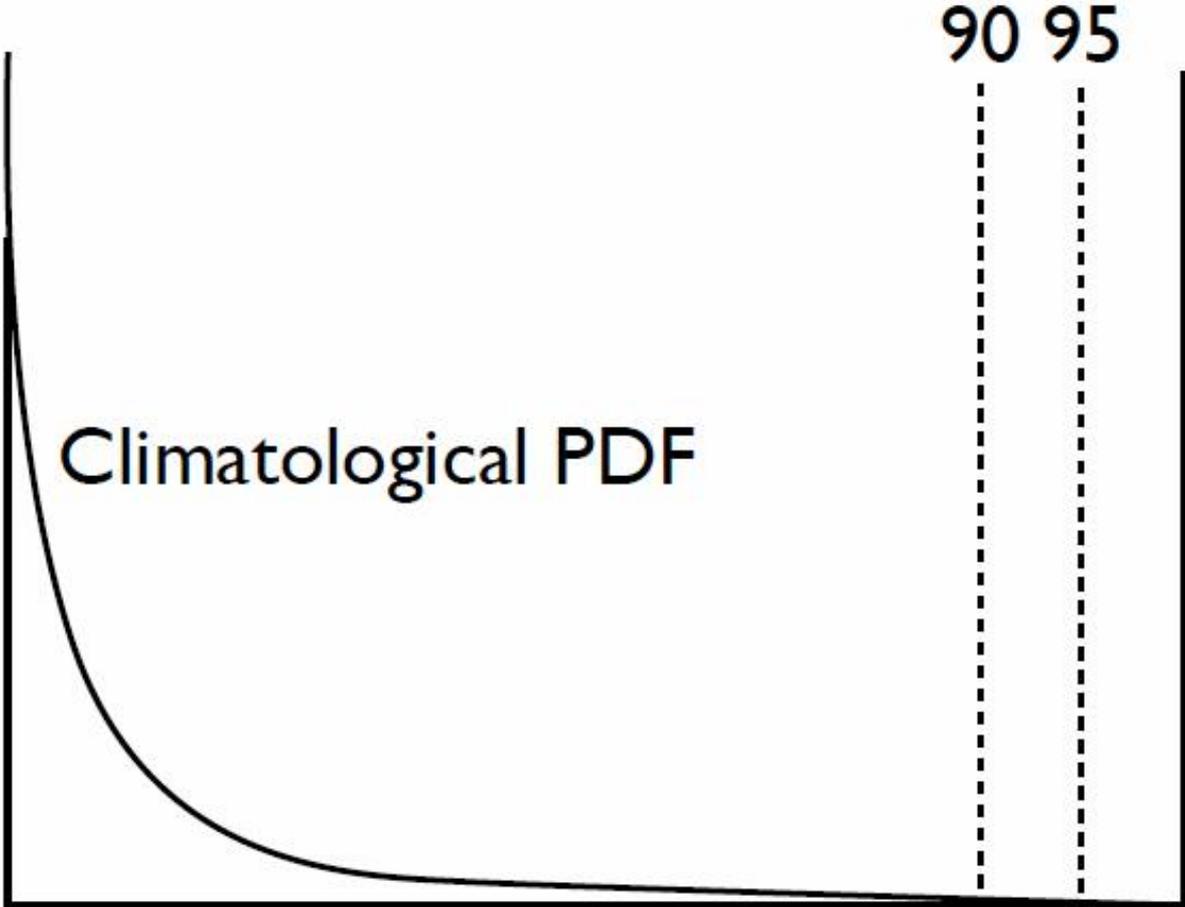
UKMO mem:24

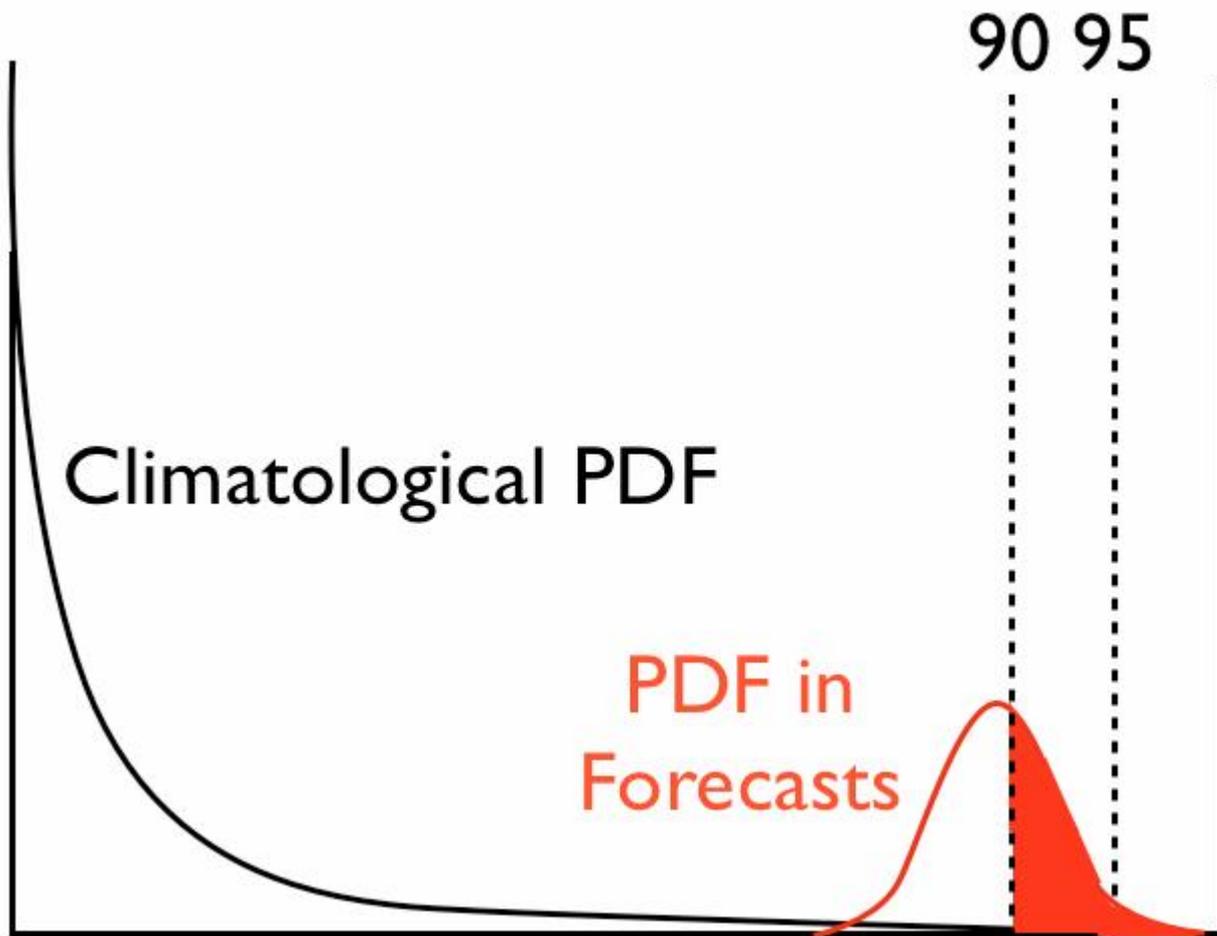


# Ensemble Prediction for Thailand flood in 2011

Occurrence probability of extreme 24-hr precipitation  
Valid: 2011092912UTC +3-4days







# Background

Past

Research Phase

TIGGE  
(started 2006)

TIGGE CXML  
(started 2008)

The screenshot shows the TIGGE website with a navigation menu including 'About Us', 'Products', 'Services', 'Research', 'Publications', and 'News&Events'. Below the menu, there are sections for 'TIGGE Data Retrieval' with options to select date ranges and forecast types, and a 'Select Origin and Base time' table.

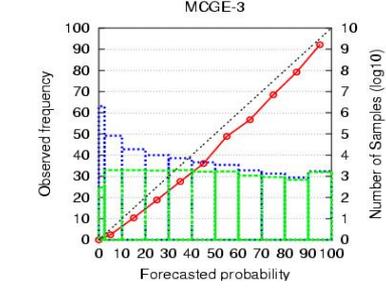
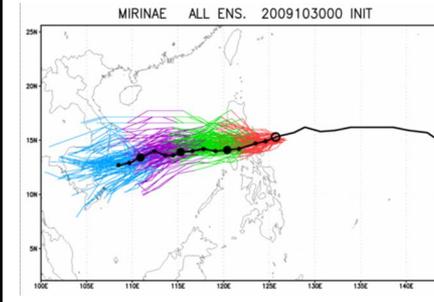
BASE	CMR	CMC	CFR	ECMWF	JMA	NMA	MeteoFrance	NCIP	NOAA	Other
980808	<input type="checkbox"/>									
980808	<input type="checkbox"/>									
980808	<input type="checkbox"/>									

The screenshot shows the TIGGE CXML website with a table listing participating countries and their contact information.

Country	IP	URL	URL
Canada Meteorological Centre (CMC)	CMC	http://www.cmc-met.gc.ca/	http://www.cmc-met.gc.ca/
China Meteorological Administration (CMA)	CMA	http://www.cma.gov.cn/	http://www.cma.gov.cn/
European Centre for Medium-Range Weather Forecasts (ECMWF)	ECMWF	http://www.ecmwf.int/	http://www.ecmwf.int/
Japan Meteorological Agency (JMA)	JMA	http://www.jma.go.jp/	http://www.jma.go.jp/
MeteoFrance	MeteoFrance	http://www.meteo.fr/	http://www.meteo.fr/
United Kingdom Met Office (UKMO)	UKMO	http://www.met.rdg.ac.uk/	http://www.met.rdg.ac.uk/
US National Centers for Environmental Prediction (NCEP)	NCEP	http://www.cgd.cma.gov.cn/	http://www.cgd.cma.gov.cn/

Future

Operational Phase



**Goal:** Enhanced use of ensemble prediction for operational purposes

Present

Various projects to **demonstrate the value of ensemble prediction** have been conducted.

Example 1. A WWRP-RDP project “North Western Pacific Tropical Cyclone (TC) Ensemble Forecast (**NWP-TCTEF**) Project”

Example 2. Severe Weather Forecast Demonstration Project (**SWFDP**)

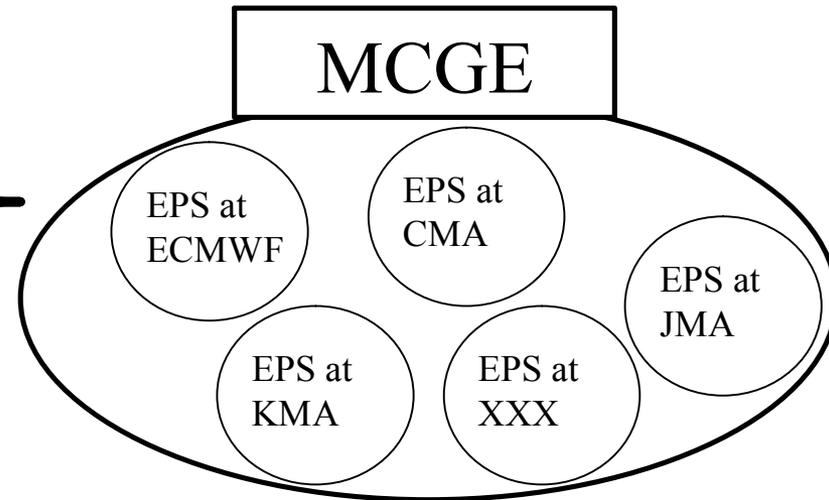
# Multi-Center Grand Ensemble

TIGGE has made it possible to construct a new ensemble, that is **Multi-Center Grand Ensemble**

## Past

## Research Phase

<h3>TIGGE (started 2006)</h3>	<h3>TIGGE CXML (started 2008)</h3>



MCGE is an ensemble of ensembles of major NWP centers.

**Relative benefits of MCGE over single model ensemble (SME), that is ensemble prediction system (EPS) at each NWP center, have yet to be verified from a perspective of typhoon track predictions.**

# SME vs MCGE

Using the TIGGE dataset, the relative benefits of MCGE over SME are investigated from both **deterministic** and **probabilistic** perspectives.

**Verified TCs**: 58 TCs in the western North Pacific basin from 2008 to 2010

**Verified items**:

**1. TC strike probability**

(verification of probabilistic forecasting)

**2. Confidence information**

(verification of ensemble spread)

**3. Ensemble mean track prediction**

(verification of deterministic forecasting)

# TIGGE providers

Table: Operational global ensemble prediction systems as of December 2010.

	BOM <sup>1</sup> Australia	CMA <sup>2</sup> China	CMC <sup>3</sup> Canada	CPTEC <sup>4</sup> Brazil	ECMWF <sup>5</sup> Europe	JMA <sup>6</sup> Japan	KMA <sup>7</sup> Korea	Meteo France France	NCEP <sup>8</sup> USA	UKMO <sup>9</sup> UK
Model Uncertainty	N/A	N/A	SP, SKEB, MP	N/A	SP	SP	N/A	MP	SP	SP, SKEB
Initial Perturbation (Model Resolution)	SVs (TL42L19)	BVs (T213L??)	EnKF (0.9degL28)	EOF-based (T126L28)	EDA&SVs (TL42L62)	SVs (TL63L40)	BVs ?	SVs (T44L65, T95L65)	ETR (T126L28)	ETKF ?
Forecast Model Resolution	TL119L19	TL213L31	0.9degL28	T126L28	TL639L62 (0-10d) TL319L62 (10-15d)	TL319L60	T213L40	TL358L65	T126L28	0.5555°(lat)× 0.8333°(lon)L70
Initial UTC	00, 12	00, 12	00, 12	00, 12	00, 12	12	00, 12	06, 18	00, 06, 12, 18	00, 12
Member/run	33	15	21	15	51	51	17	35**	21***	24

- Verifications are conducted for the forecasts initiated at **00 and 12 UTC only**.
- **Meteo France** is eliminated from the verifications since their forecasts are initiated at 06 and 18 UTC only.
- **NCEP**'s forecasts initiated at 06 and 18UTC are not included in the verifications.
- The verification results of **BOM** is based on the data in 2008 and 2009 only because the data in 2010 is not available.
- The number of verification samples of **JMA** is smaller because JMA's forecasts are initiated at 12 UTC only.

# TC strike probability

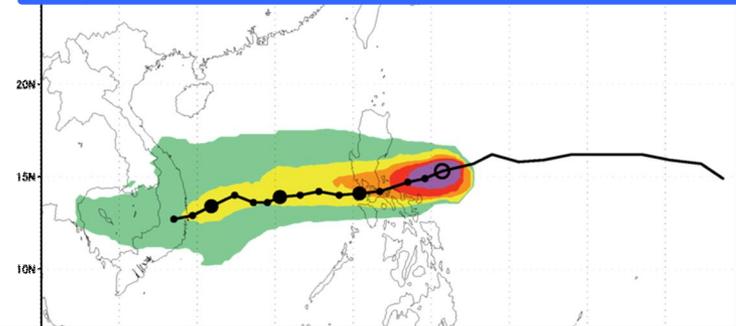
**Original idea** by Van der Grijn (2002, ECMWF Tech. Memo):

“A forecaster is often more interested in *whether* a TC will affect a certain area than *when* that TC will hit a specific location.”

He defined the strike probability as “the probability that a TC will pass within a 65 nm radius from a given location at **anytime** during the next 120 hours”.

**It allows the user to make a quick assessment of the high-risk areas regardless of the exact timing of the event.**

## Example -TC strike probability map-

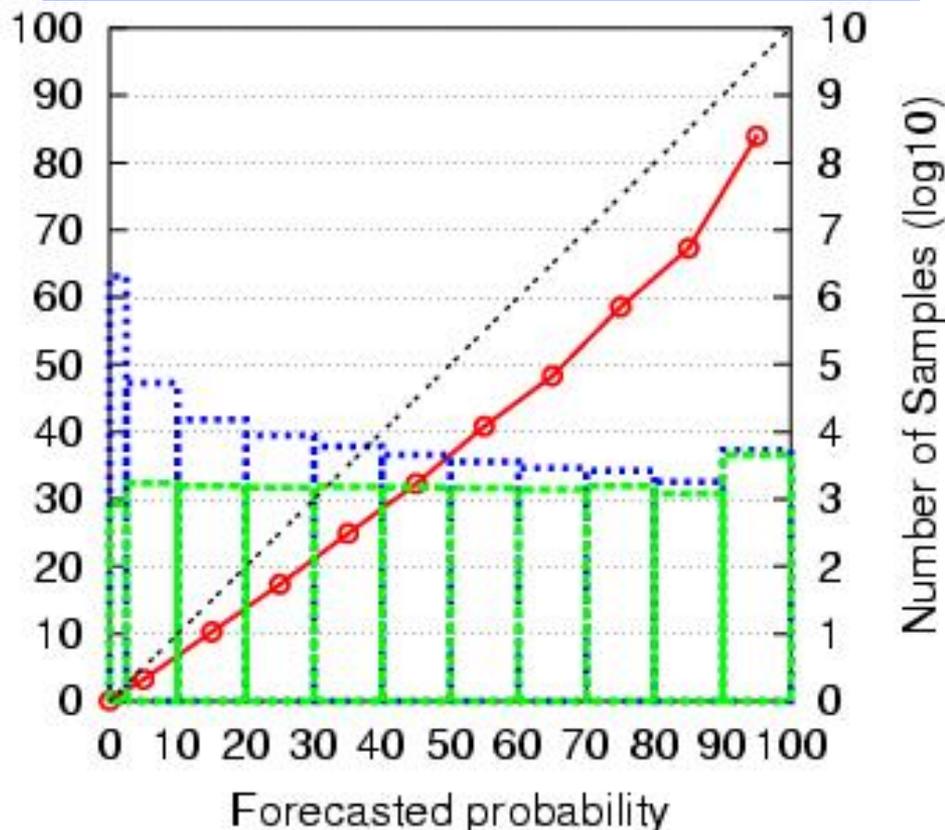


The strike probability is based on the number of members that predict the event with each member having an equal weight.

# Verification result of TC strike probability -1-

Strike prob. is computed at every 1 deg. over the responsibility area of RSMC Tokyo - Typhoon Center (0°-60°N, 100°E-180°) based on the same definition as Van der Grijn (2002). Then the reliability of the probabilistic forecasts is verified.

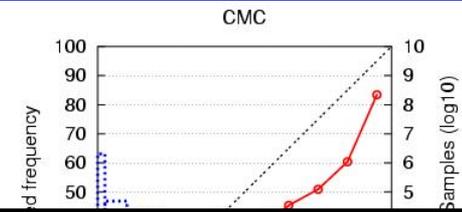
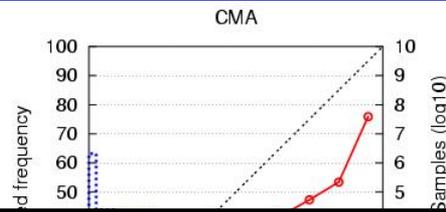
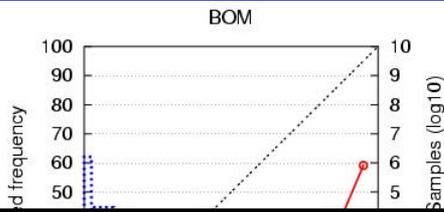
**Reliability Diagram**  
**-Verification for ECMWF EPS-**



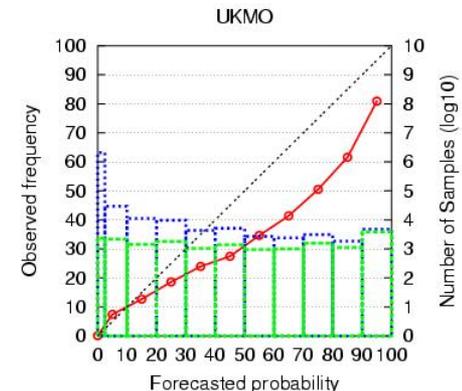
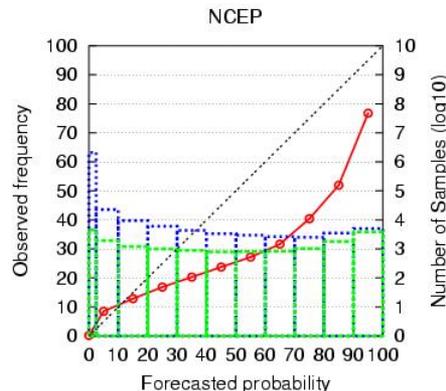
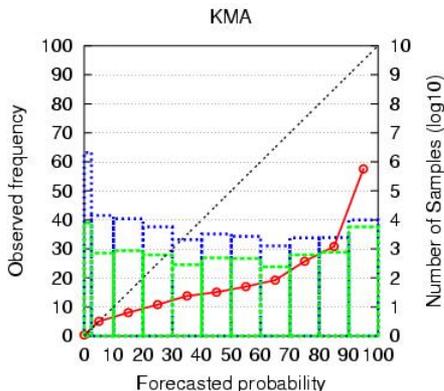
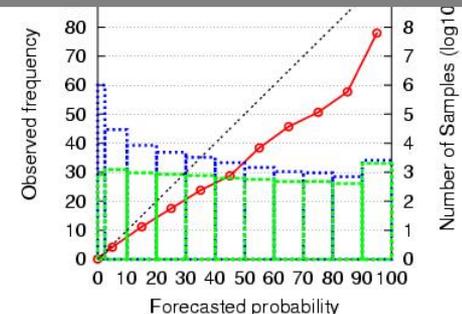
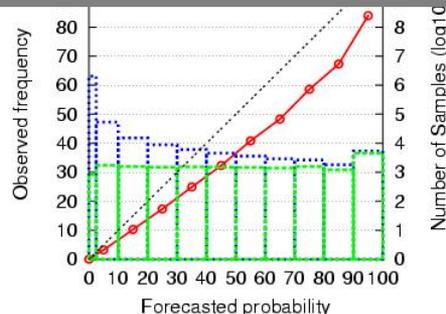
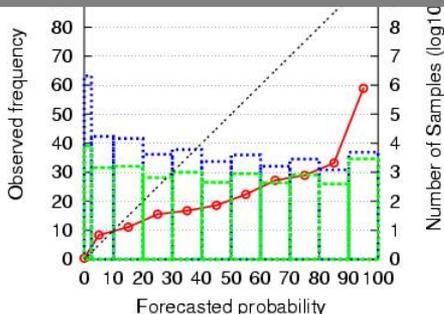
**In an ideal system, the red line is equal to a line with a slope of 1 (black dot line).**

The number of samples (grid points) predicting the event is shown by **dashed blue boxes**, and the number of samples that the event actually happened is shown by **dashed green boxes**, corresponding to y axis on the right.

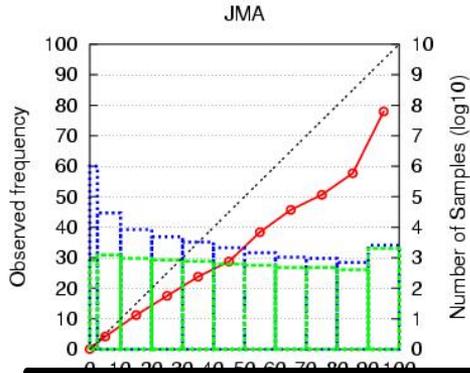
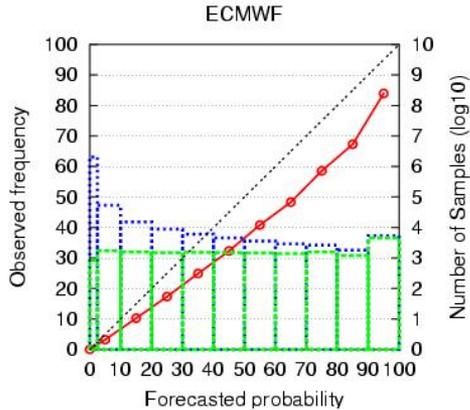
# Verification result of TC strike probability -2-



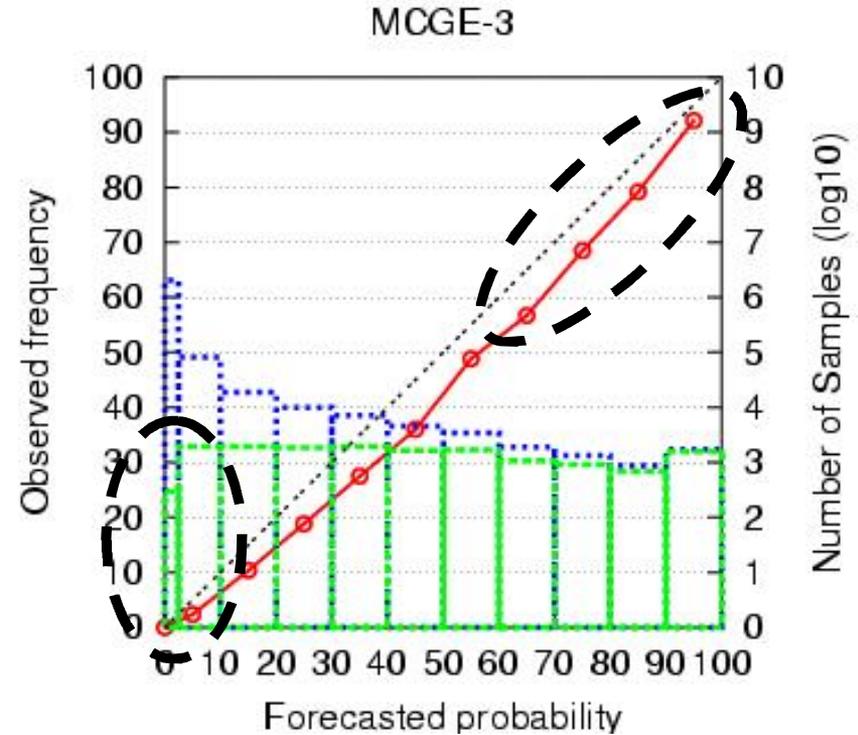
All SMEs are over-confident (forecasted probability is larger than observed frequency), especially in the high-probability range.



# Benefit of MCGE over SME -1-

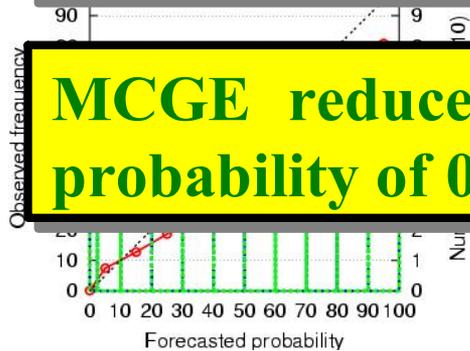


Combine 3  
SMEs



**Reliability is improved, especially in the high-probability range.**

**MCGE reduces the missing area (see green dash box at a probability of 0 %).**



# Benefit of MCGE over SME -2-

## Best SME (ECMWF)

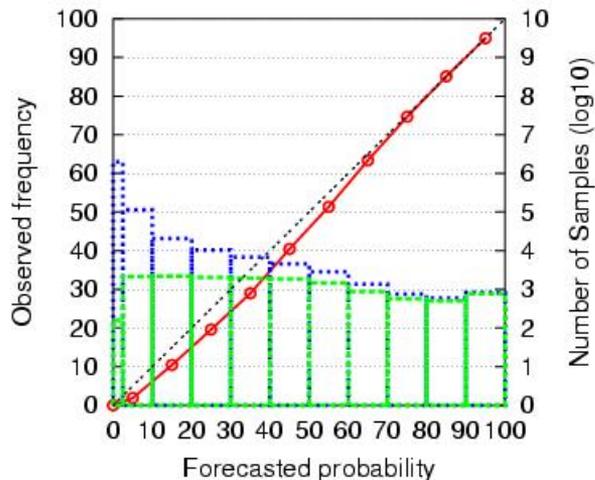


## MCGE-3 (ECMWF+JMA+UKMO)

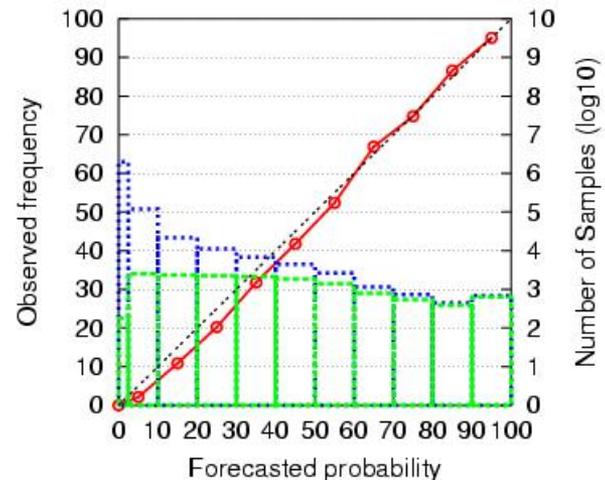


**MCGEs reduce the missing area! The area is reduced by about 1/10 compared with the best SME. Thus the MCGEs would be more beneficial than the SMEs for those who need to avert missing TCs and/or assume the worst-case scenario.**

## MCGE-6 (CMA+CMC+ECMWF+JMA+NCEP+UKMO)



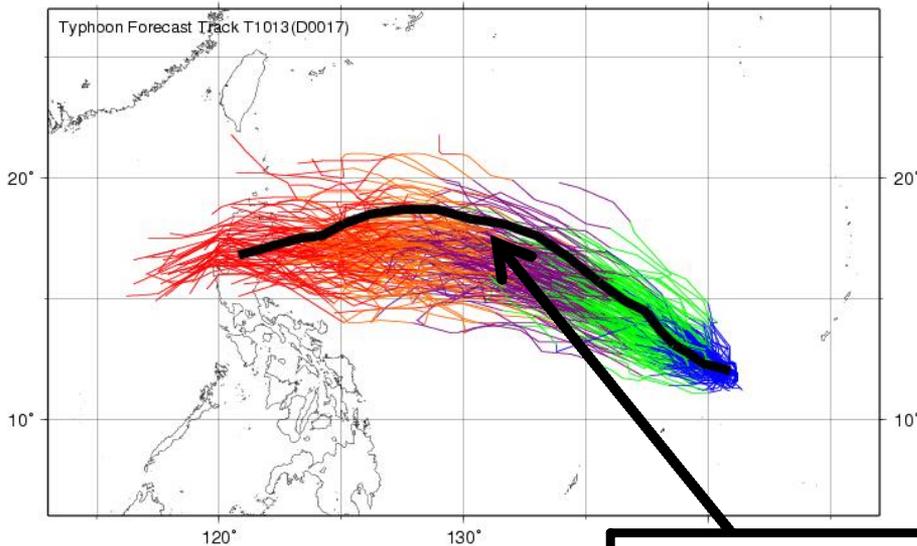
## MCGE-9 (All 9 SMEs)



# Typhoon track prediction by MCGE-9

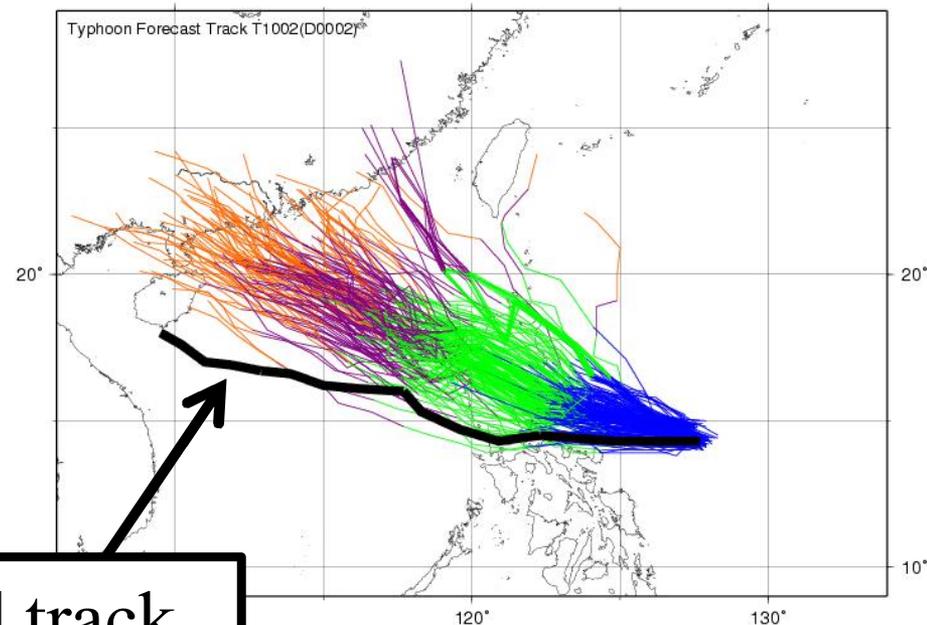
Good example

Typhoon **Megi** initiated at  
1200 UTC 25<sup>th</sup> Oct. 2010



Bad example

Typhoon **Conson** initiated at  
1200 UTC 12<sup>th</sup> Jul. 2010

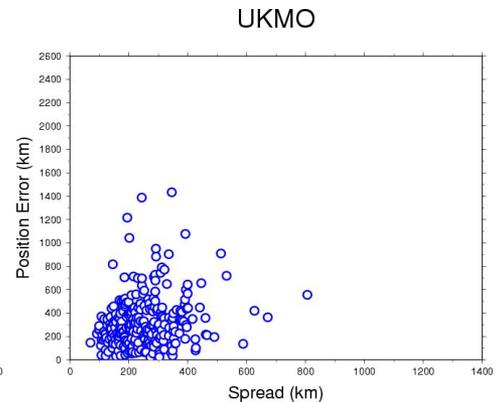
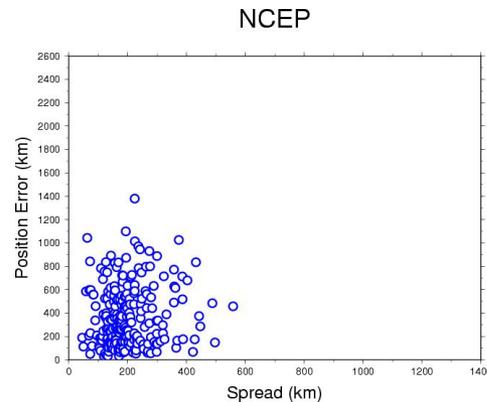
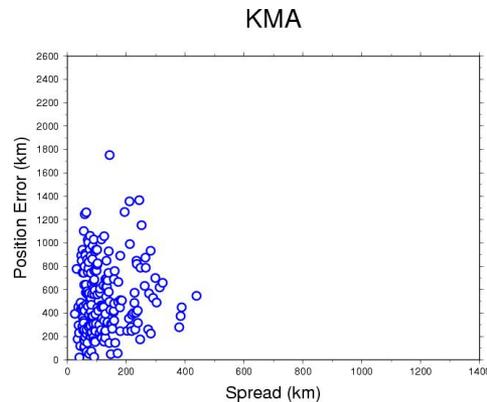
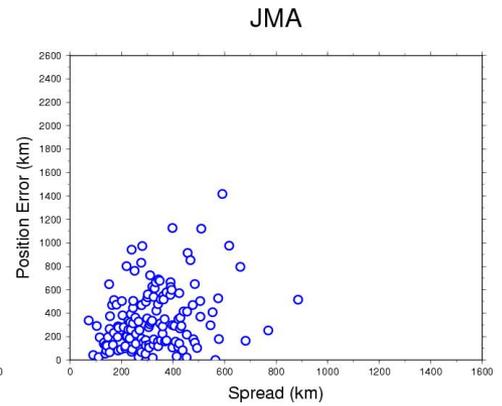
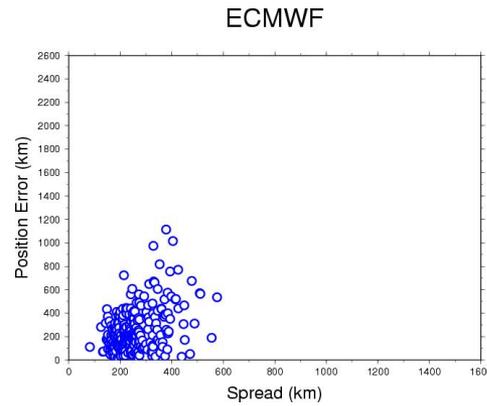
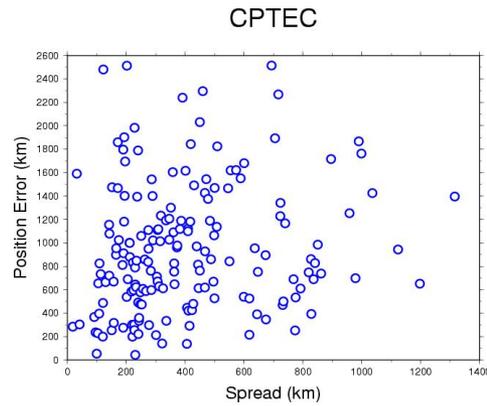
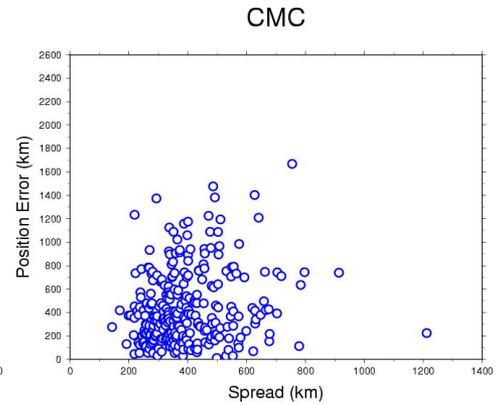
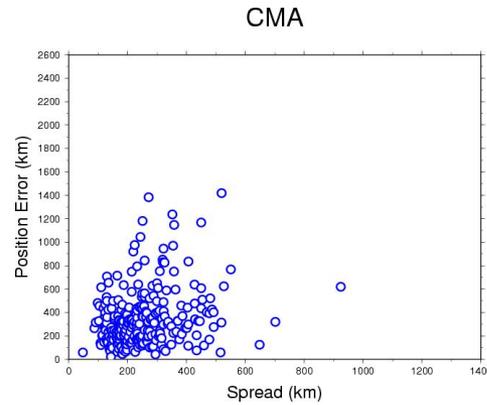
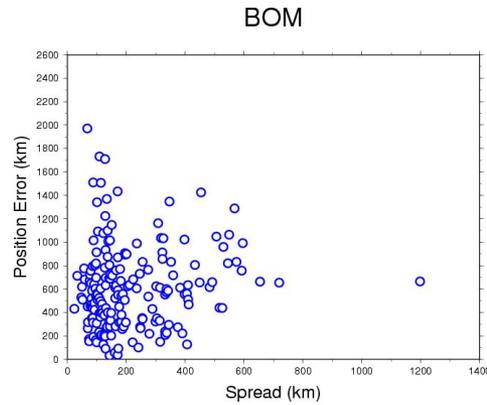


Observed track

**There are prediction cases where any SMEs cannot capture the observed track.  
=> It would be of great importance to identify the cause of these events and  
modify the NWP systems including the EPSs for better probabilistic forecasts.**

# Verification of ensemble spread

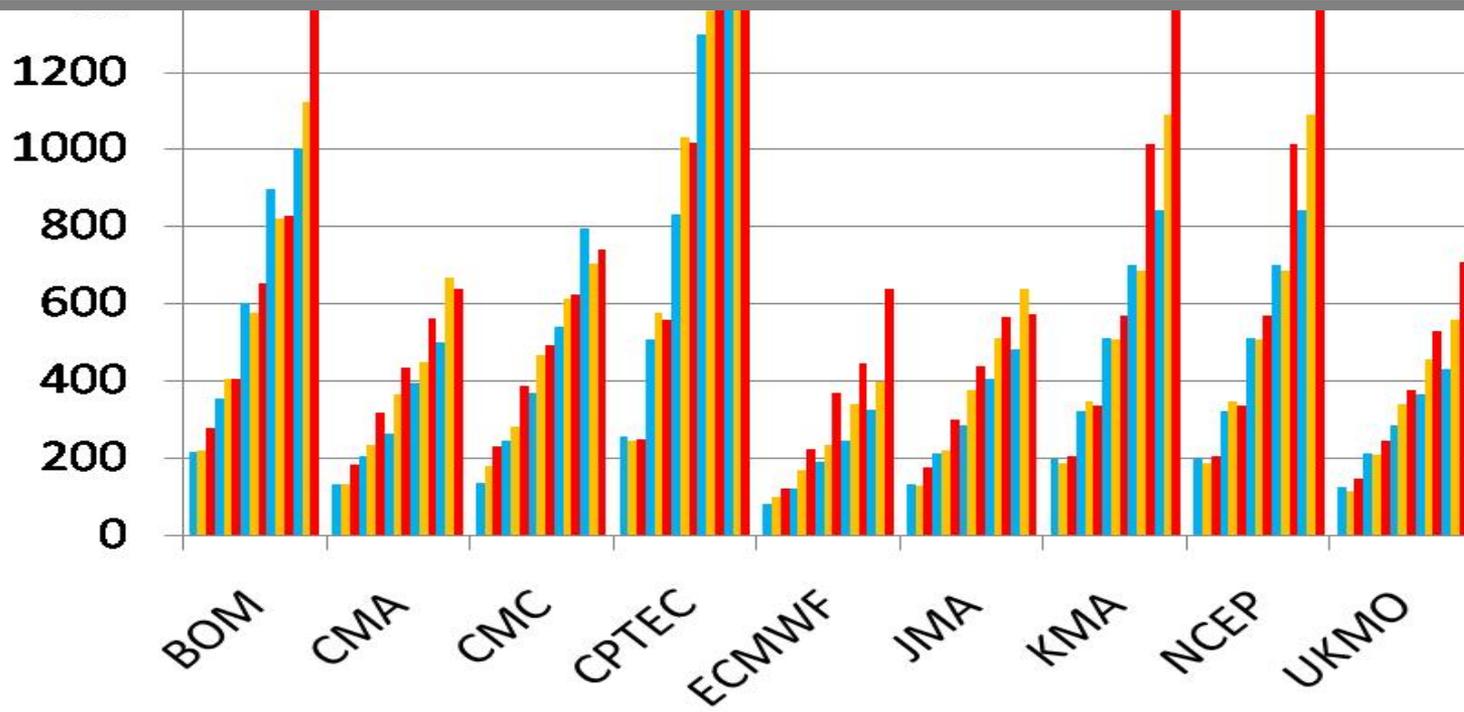
Verification at 3 day predictions  
x axis: ensemble spread  
y axis: position error of ensemble mean track prediction



# Verification of confidence information

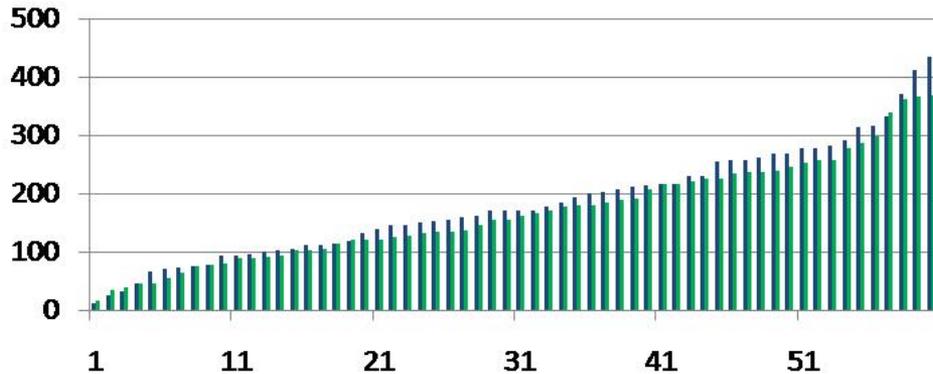
Position errors (km) of 1 to 5 day ensemble mean TC track predictions with small (**blue**), medium (**orange**) and large (**red**) ensemble spread. Each color has five filled bars, corresponding to the position errors of 1 to 5 day predictions from left to right.

**If a SME is successful in extracting the TC track confidence information, the average position error of small-spread cases would be smaller than that of medium-spread cases, and the average position error of large-spread cases would be larger than that of medium-spread cases. The frequency of each category is set to 40%, 40% and 20%, respectively (Yamaguchi et al. 2009).**



# Relative benefit of MCFE over SME

3 days



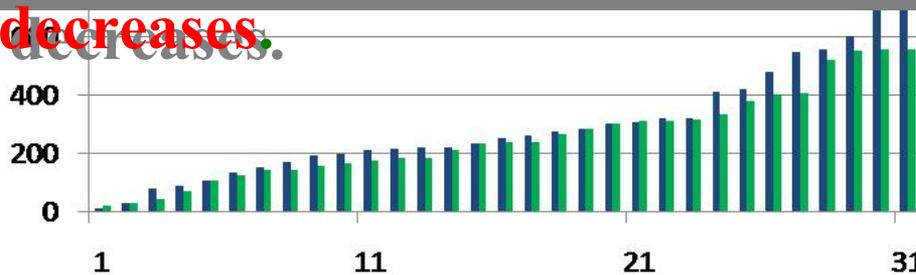
Position errors (km) of the ECMWF EPS (blue) and the MCFE-3 (green) for extremely small ensemble spread cases (20% of the total number of prediction cases).

4 days



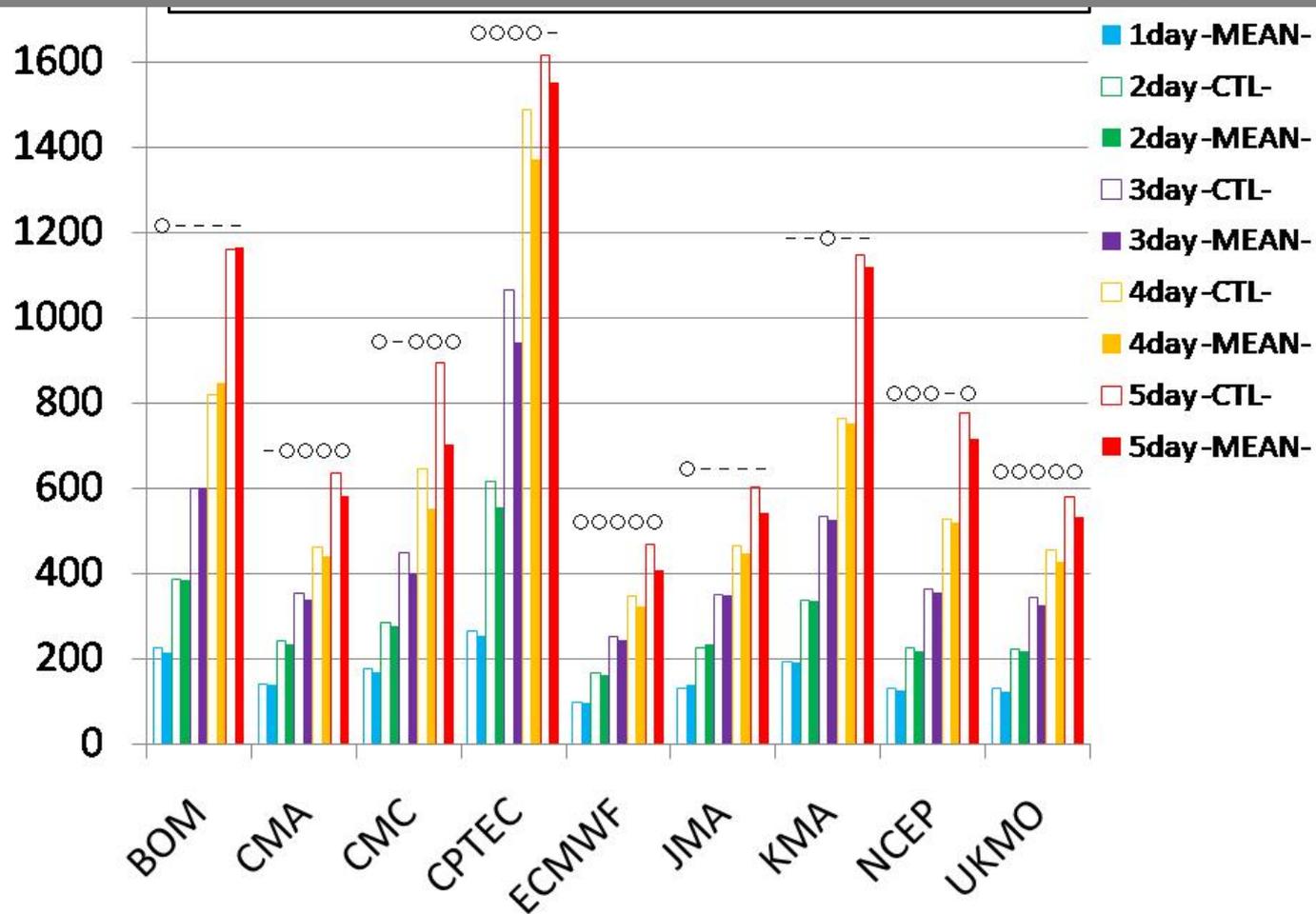
**The position error of MCFE is generally smaller than that of the best SME, indicating that when multiple SMEs simultaneously predict the low uncertainty, the confidence level increases and a chance to have a large position error decreases.**

5 days



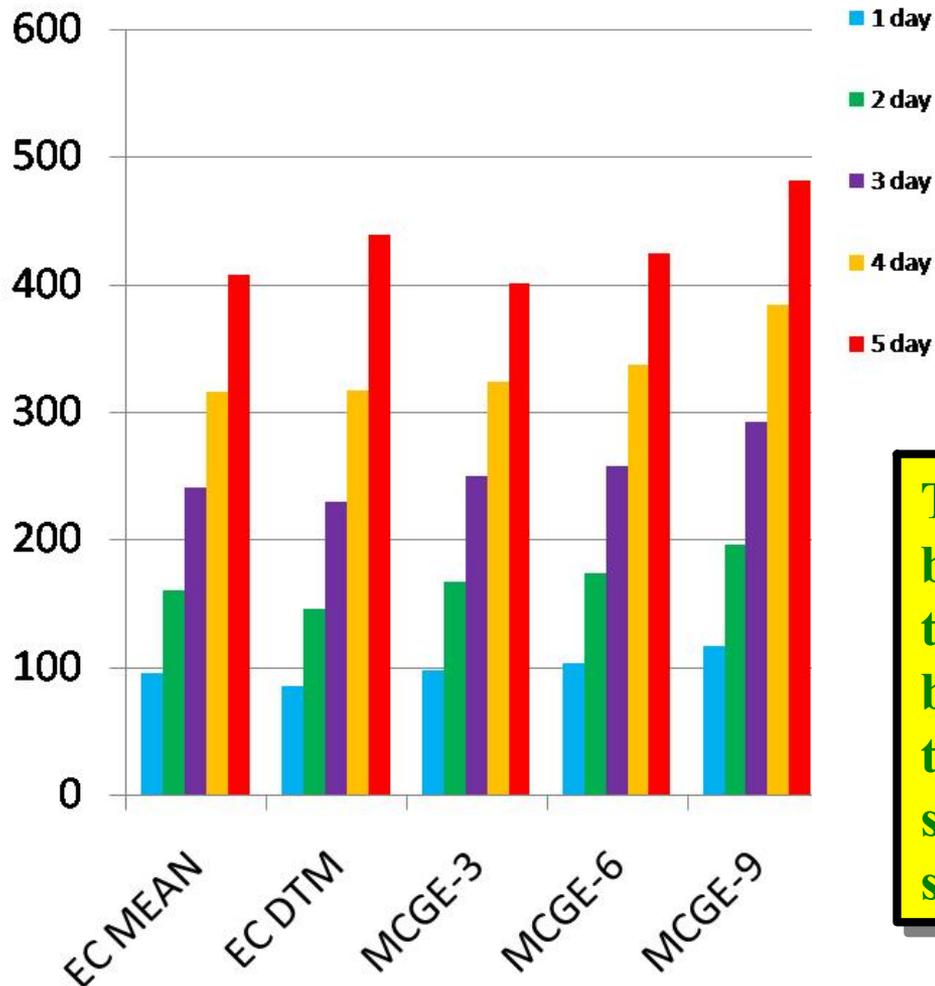
# Verification of ensemble mean track prediction

**The ensemble mean has better performance than the control prediction in general and the improvement rate is relatively large for the longer prediction times.**



# Verification of ensemble mean track prediction

Position errors (km) of 1- to 5-day TC track predictions by the ensemble mean (EC MEAN) and high-resolution deterministic model of ECMWF (EC DTM) and the ensemble mean of the MCGEs and MCEs.



**The TC track prediction by the high-resolution deterministic model of ECMWF has better performance than the ensemble mean of the ECMWF EPS up to 3 days.**

**The position error of 5-day predictions by the MCGE-3 is slightly smaller than that of the ensemble mean of the best SME, which is the ECMWF EPS, though the difference is not statistically significant at the 90 % significance level.**

# Summary

**The relative benefits of MCGE over SME are investigated from both deterministic and probabilistic perspectives. 58 TCs in the western North Pacific from 2008 to 2010 are verified.**

## **1. TC strike probability**

Reliability is improved in MCGE, especially in the high-probability range. MCGE reduces the missing area by about 10 %.

## **2. Confidence information**

When multiple SMEs simultaneously predict the low uncertainty, the confidence level increases and a chance to have a large position error decreases.

## **3. Ensemble mean track prediction**

The position error of 5-day predictions by the MCGE-3 is slightly smaller than that of the ensemble mean of the best SME though the difference is not statistically significant.