Recent Research and Development at MRI/JMA to Improve Typhoon Forecasts

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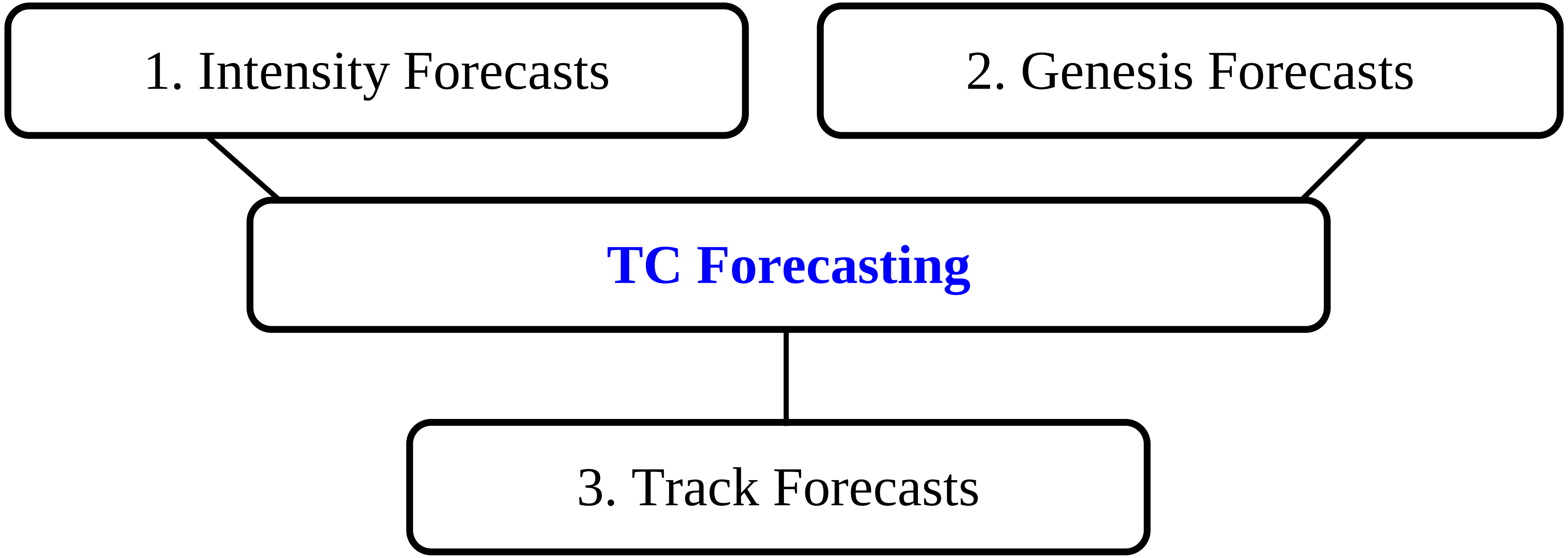
Collaborators (abroad): Mark DeMaria (NHC), Buck Sampson (NRL), John Knaff (CSU), Kate Musgrave (CSU), John Kaplan (AOML), Jason Dunion (AOML), Frederic Vitart (ECMWF)

Outline of the talk

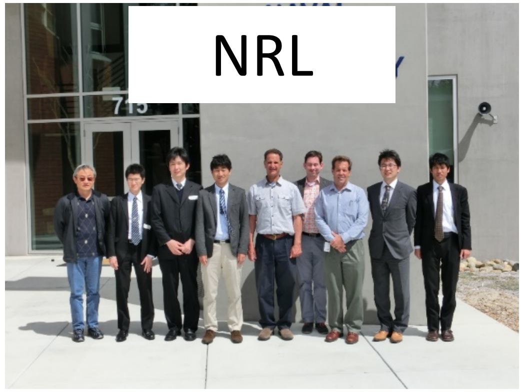
We will present recent research and development at the MRI/JMA to improve forecasts of tropical cyclone (TC) intensity, genesis and track, respectively.



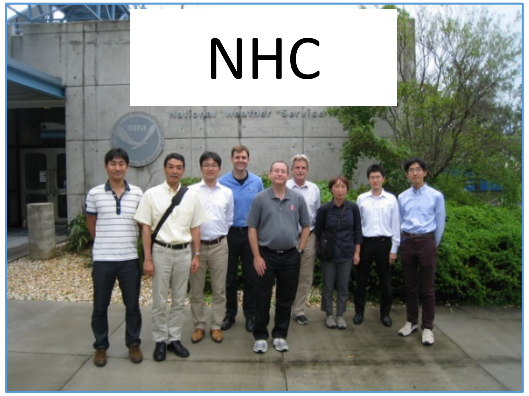
Intensity Forecasts

Implementing TC Intensity Guidance at JMA

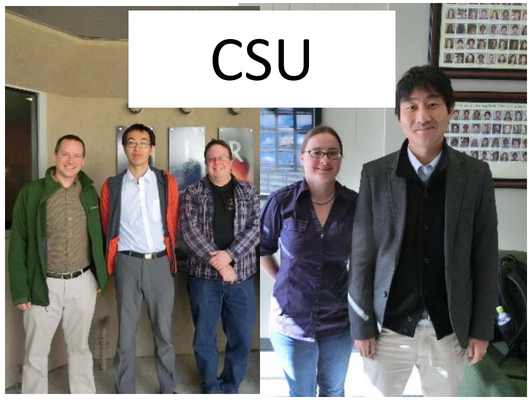
April 2015



October 2015



October 2016



With great support of guidance developers in the US, the MRI/JMA has transported the codes of **SHIPS, LGEM, RI Index and CHIPS** so that they can run from the output ... M). The **JMA/GSM-based** ... JMA's Forecast Division for a trial u...

Verification ... 013 to 2015 ... in

The improvement rate ... eft, but for central pressure foreca...

Weights giving the largest improvement rate

	GSM	CHIPS	SHIPS	LGEM	SHIFOR
T+1 day	0.1	0.1	0.4	0.4	0.0
T+3 days	0.2	0.1	0.3	0.4	0.0
T+5 days	0.3	0.1	0.3	0.2	0.1

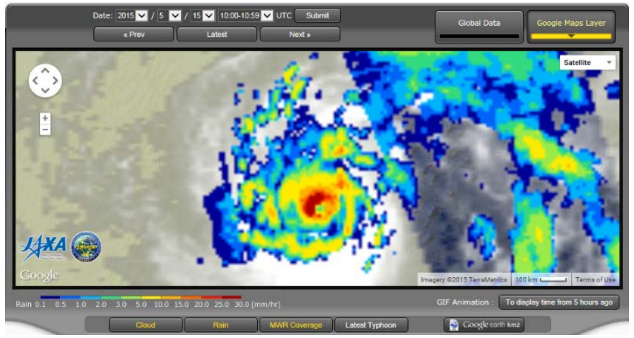
	T+1 day	T+3 days	T+5 days
GSM	-56.3	-2.1	**+1.4**
CHIPS	-25.2	**+2.6**	-1.5
SHIPS	**+22.9**	**+25.4**	**+21.9**
LGEM	**+23.2**	**+24.1**	**+8.0**

	T+1 day	T+3 days	T+5 days
Simple Mean	+18.1	+27.5	+24.5
Simple Mean + Tendency	+30.4	+24.3	+17.3
Weighted Mean	+26.6	**+29.2**	**+25.8**
Weighted Mean + Tendency	**+33.1**	+28.5	+21.2

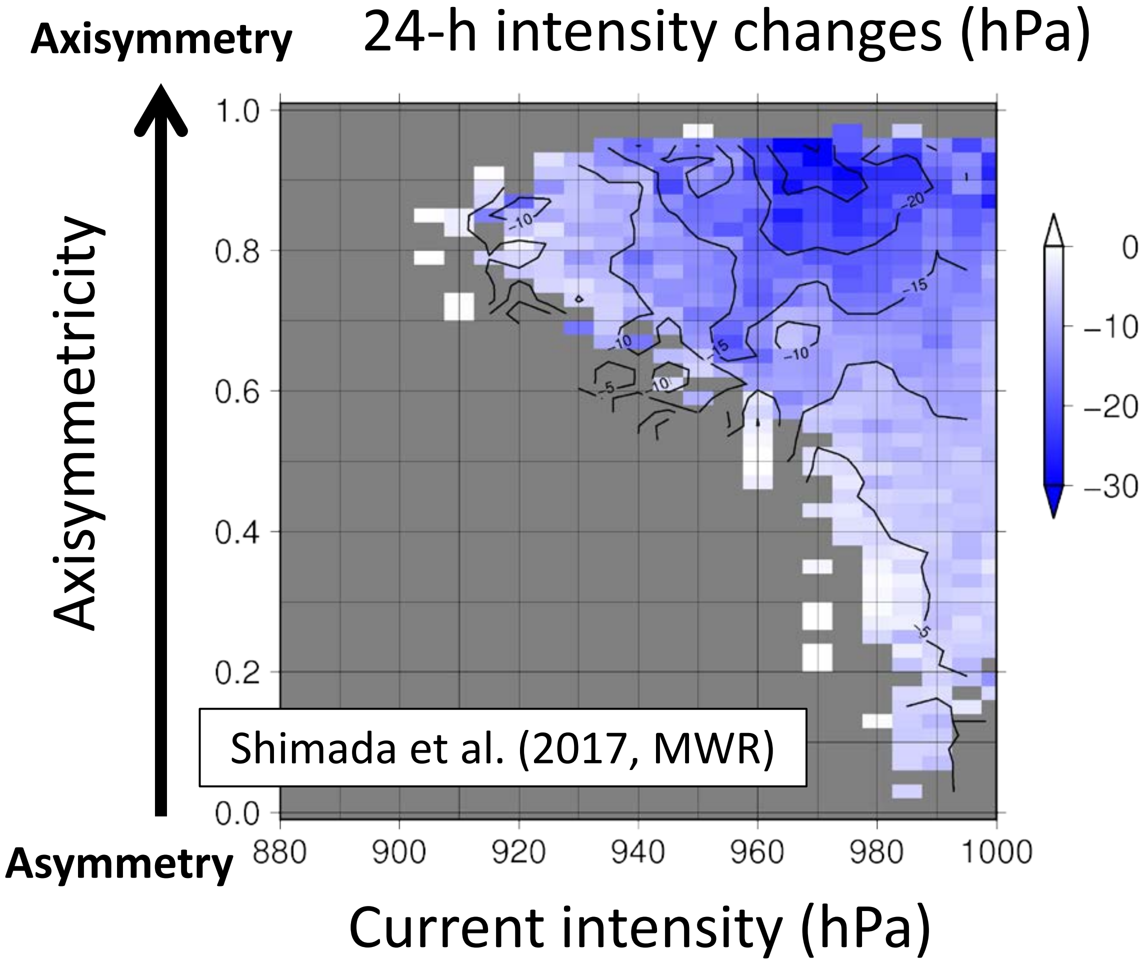
Adding new predictors to SHIPS

GSMaP

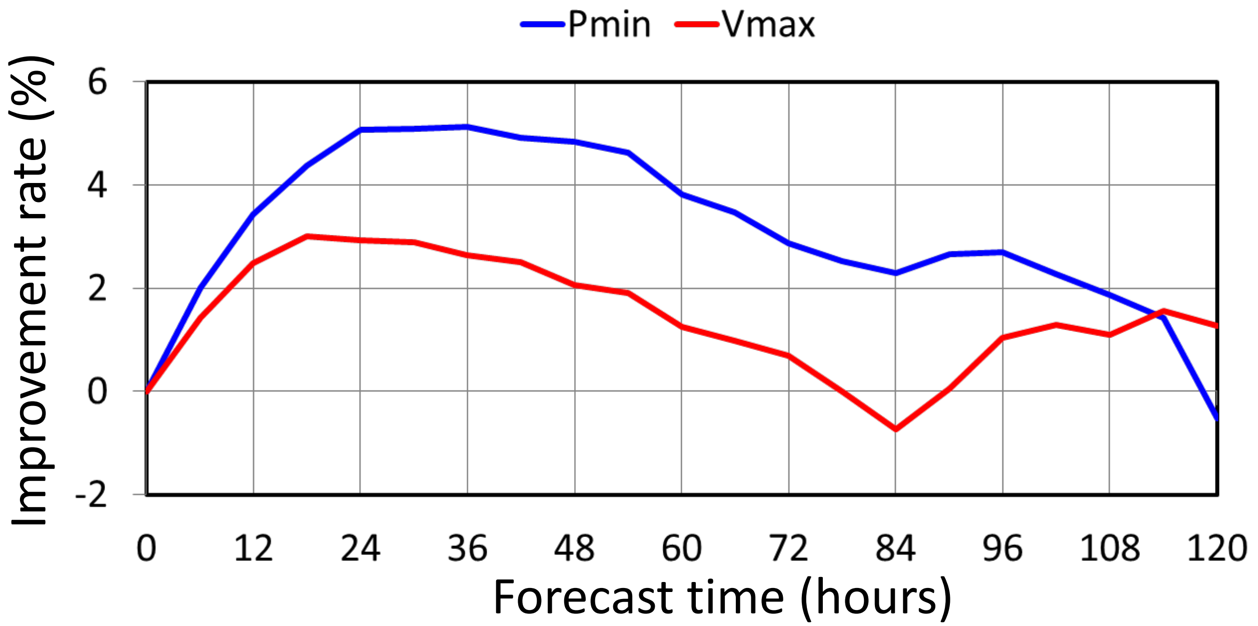
Shimada et al. (2017, MWR) investigated the relationship of TC future intensity change to current intensity and current axisymmetricity deduced from hourly Global Satellite Mapping of Precipitation (GSMaP).



http://sharaku.eorc.jaxa.jp/GSMaP/index_e.htm

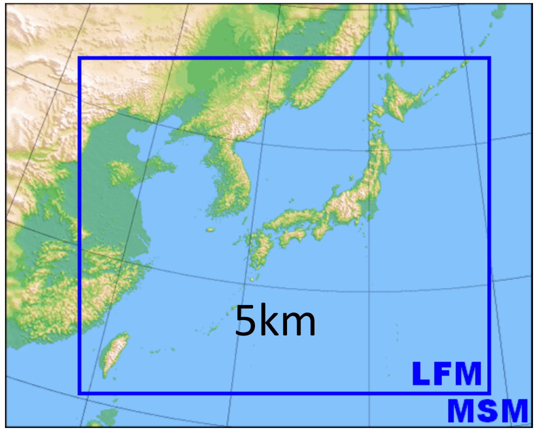


The improvement rate (%) of RMSE of TC central pressure forecasts by adding predictors derived from GSMaP



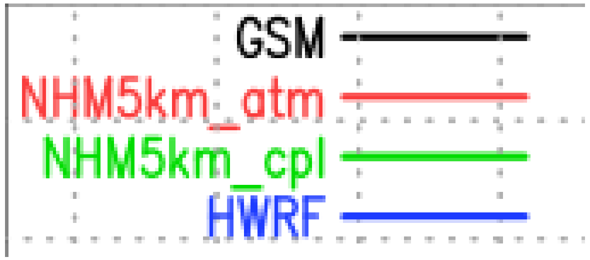
JMA Non-Hydrostatic Model (JMA/NHM) vs HWRF

JMA operates a regional NWP model, JMA Non-Hydrostatic Model (JMA/NHM, Saito et al. 2006, MWR). The model domain is Japan and its surrounding area.

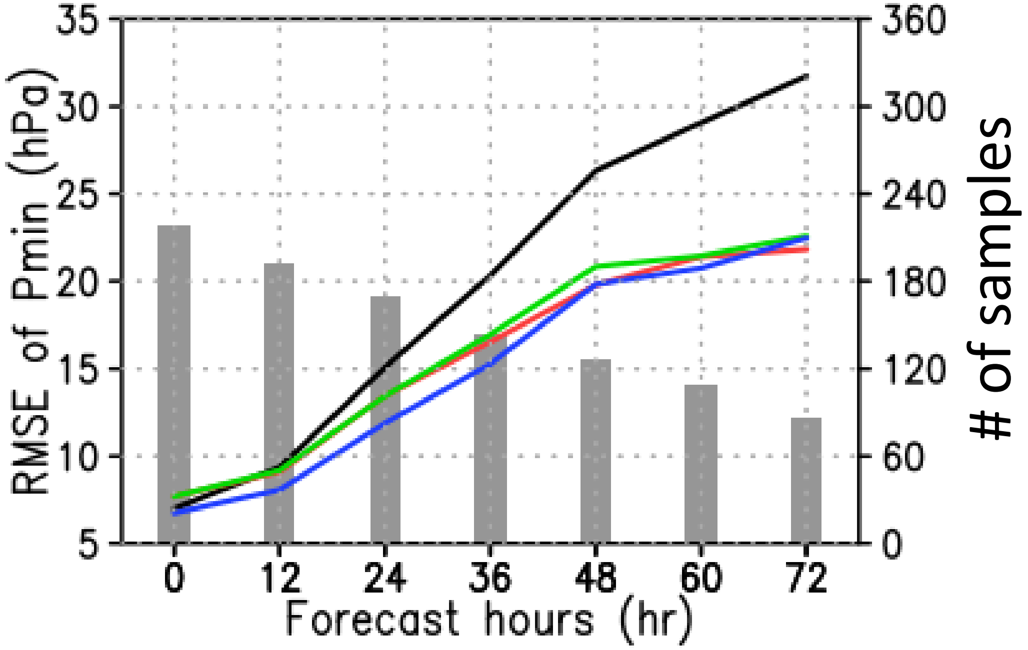


http://www.jma.go.jp/jma/en/Activities/nwp.html

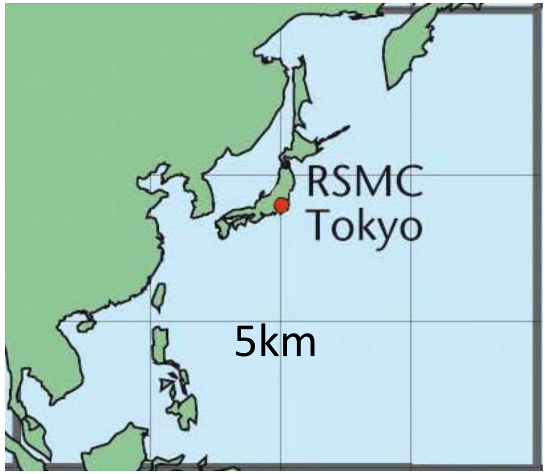
RMSE of TC central pressure forecasts



All TCs in 2012 to 2014 in WNP



The TC intensity forecasts by JMA/NHM are investigated for all TCs in 2012 to 2014 in the western North Pacific basin by enlarging the model domain.



Ito et al. (2017, to be submitted)

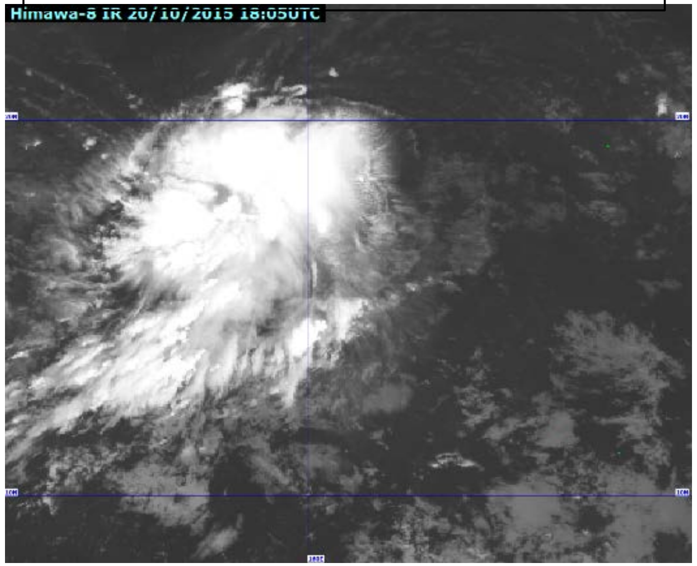
Genesis Forecasts

TC Genesis Guidance using Early Stage Dvorak Analysis (EDA) and Global Ensemble

Statistical Method (Cossuth et al. 2013, WAF)

They investigated the likelihood of TC genesis based on Dvorak analyses.

Tropical disturbance that was analyzed with T-Number 1.0



What is the probability that a tropical disturbance with T-Number 1.0 reaches a tropical storm intensity within 2 days?

T-Number	Pacific northwestern region	Pacific northwestern region (Global Ensemble)
0.0	**15**	**35**
0.5	**23**	**47**
1.0	**57**	**79**

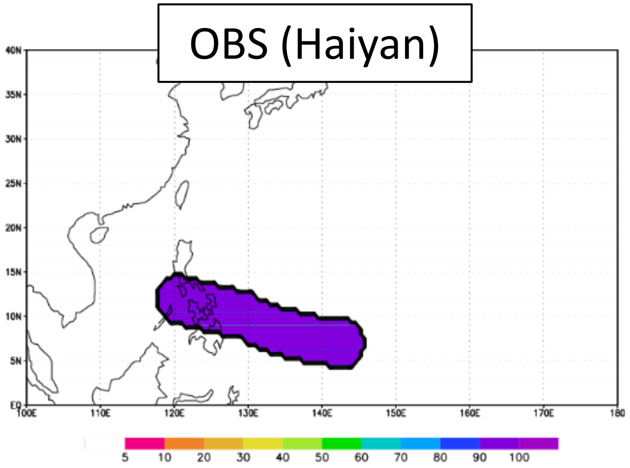
The EDA is a scheme that makes it possible to analyze tropical disturbances at earlier stages by adding a T-Number of 0.0 and 0.5 to the conventional classification of the Dvorak technique.

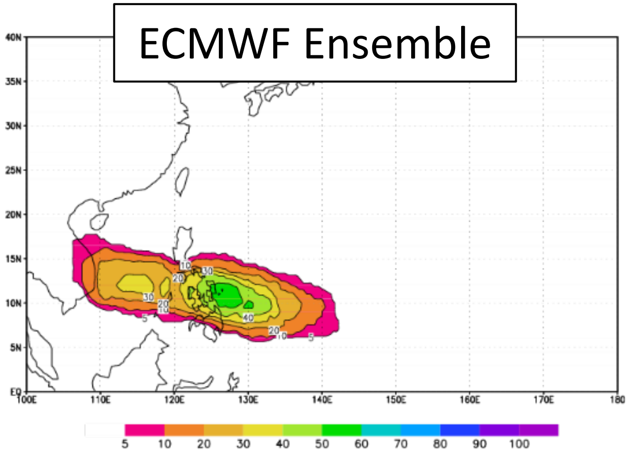
When a tropical disturbance is analyzed with T-Number of 1.0 AND more than 50 % of NCEP ensemble members predict it over the next 2 days, the hit rate increases from 57 % to 79 %.

Yamaguchi and Koide (2017, to be submitted)

TC Activity Forecasts using Global Ensembles (TIGGE)

Initial time of the forecasts: 2013/10/31 12 UTC (about **4 days before the genesis** and **8 days before the landfall** over the Philippines)



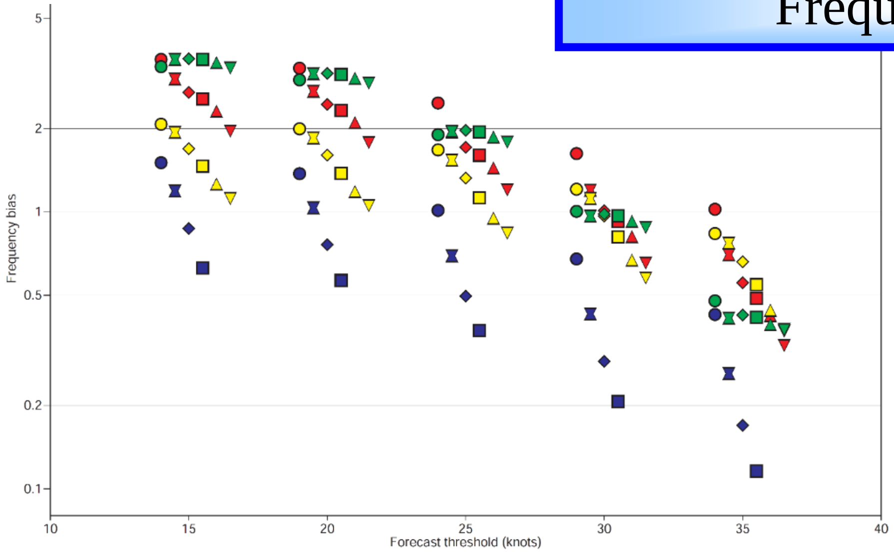


Key Findings

- In most of these basins, these operational global medium-range ensembles are capable of **providing skillful guidance of TC activity forecasts with a forecast lead time extending into week 2**;
- **The MCGEs have more skill (larger BSS) than the best single-model ensemble**, which is generally the ECMWF ensemble for most time windows and in most TC basins;

Yamaguchi et al. (2015, WAF)

Frequency Bias

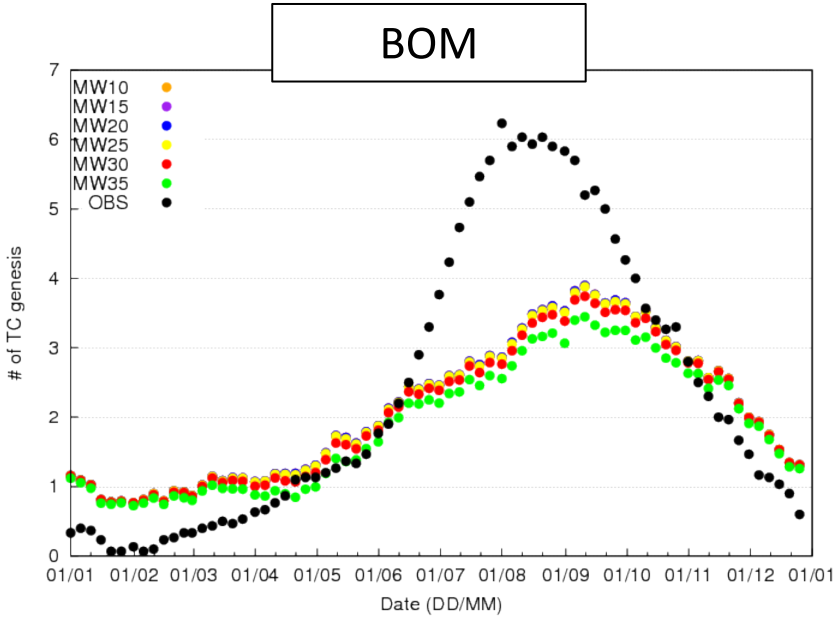


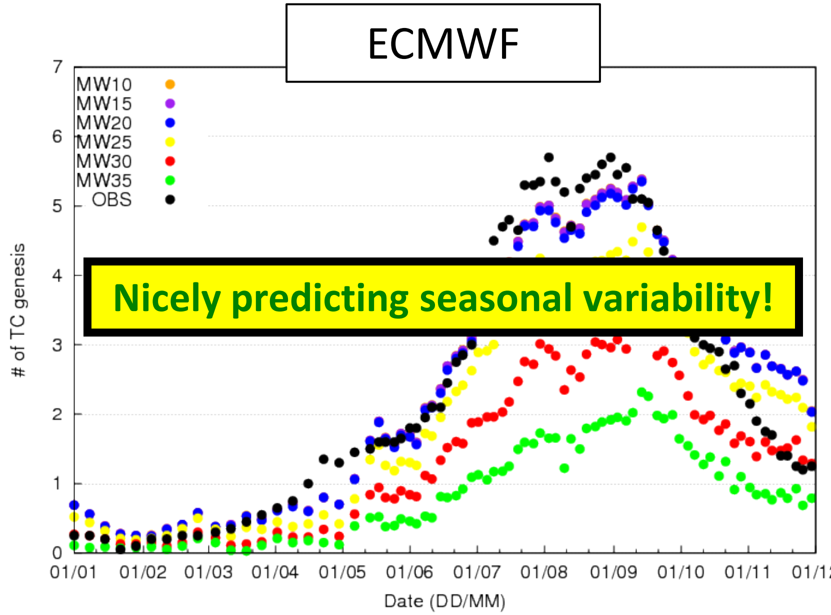
The frequency of correct forecasts of the TC activity decreases with increasing forecast interval and this is seen most notably for the ECMWF, JMA and NCEP ensembles.

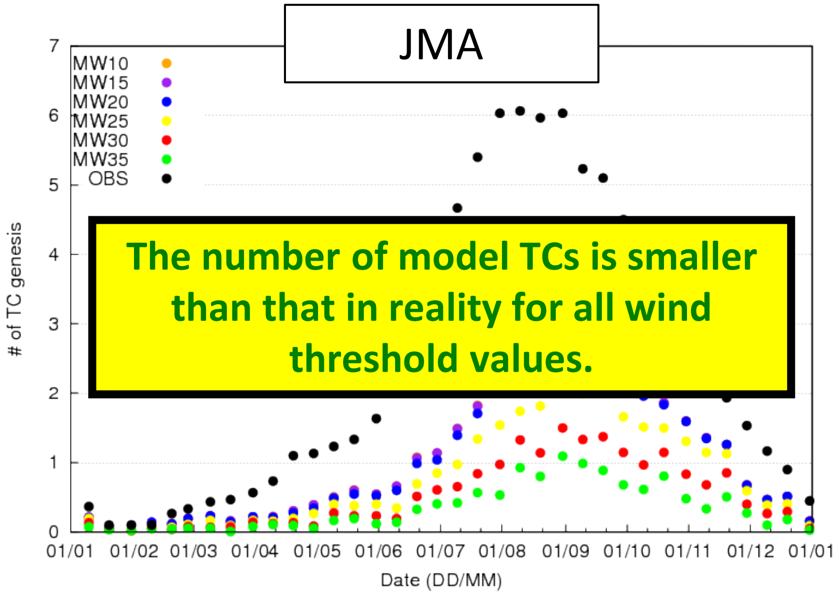
Using S2S data to investigate predictability of TC Genesis in a Month Time Scale

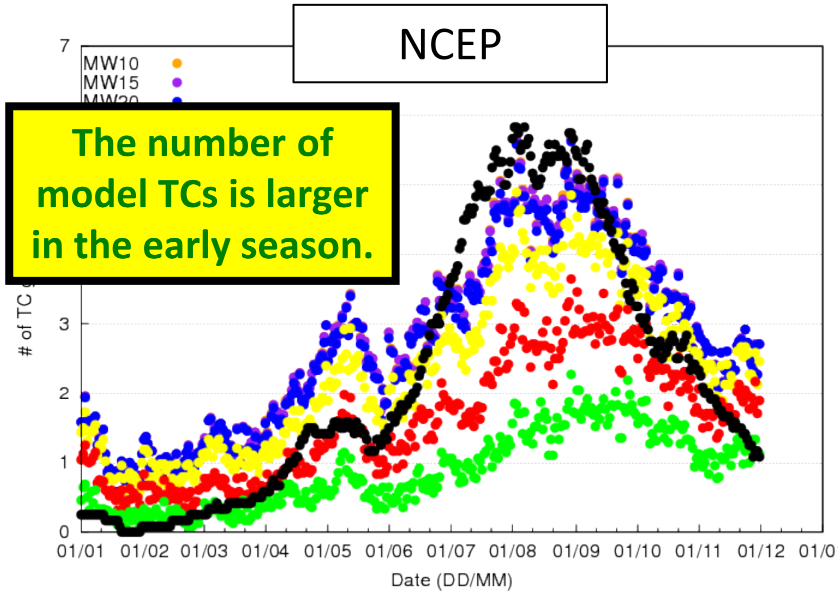
What I did:

1. Using TC tracking data set, I count the number of TC genesis over the 4 weeks starting form each initial date for each ensemble member
2. Calculate the ensemble mean at each initial date
3. Average the ensemble mean over hindcast years with the same initial day and month to obtain the model climatology of the day
4. Repeat 1-3 with a different wind thresholds (10 to 35 knots at a 5 knots interval) used to define model TCs (see color dots)
5. Using the RSMC Tokyo's best track data during the same period as the hindcast years, calculate the average number of TC genesis in reality (see black dots)



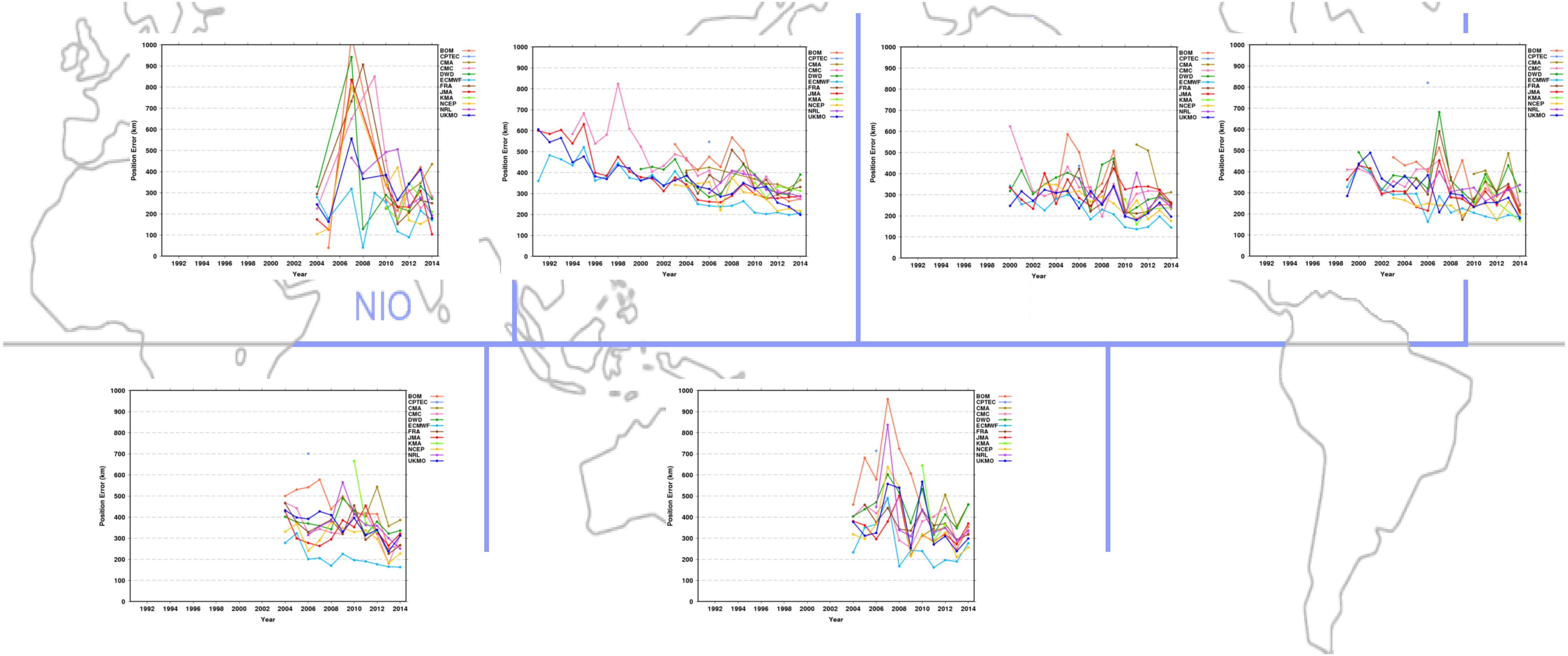






Track Forecasts

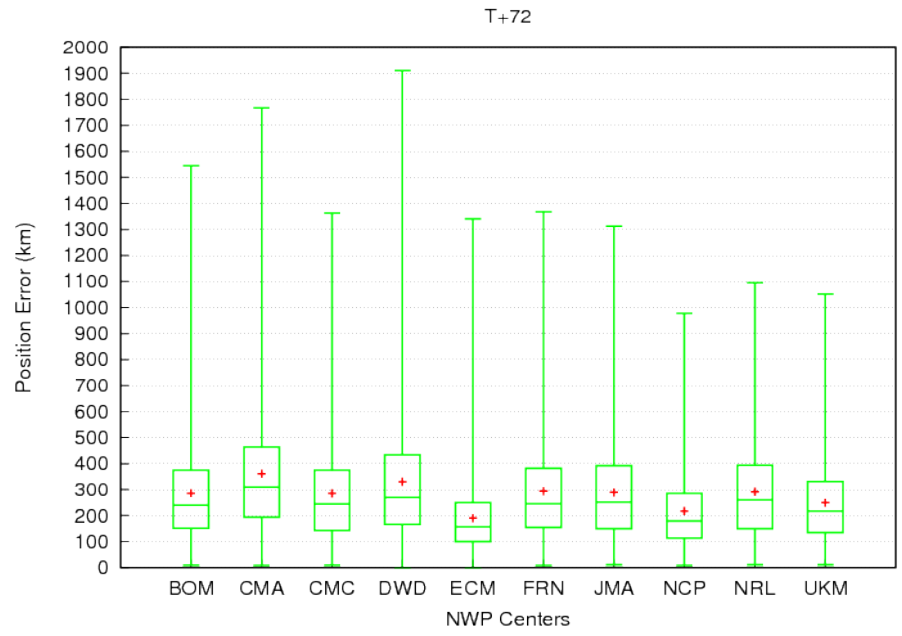
WGNE Intercomparison of TC Forecasts by Operational NWP Models



Yamaguchi et al. (2017, submitted to BAMS)

Reduction of forecast bust cases

Typhoon Halong (2014)

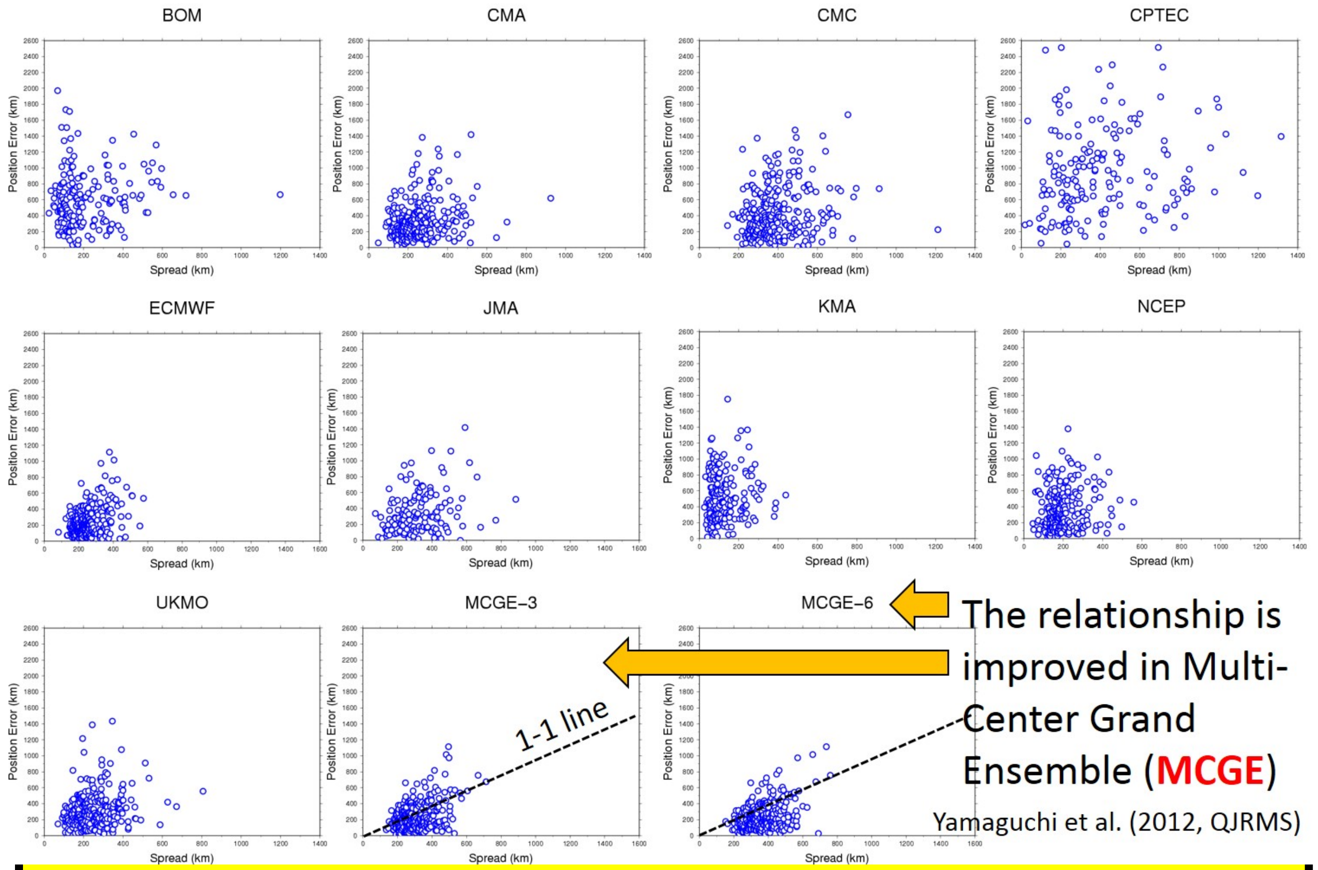


Box plots of TC position errors of 3-day forecasts of each NWP center. The red point is the mean value.

The cause of such a large error should be explored and the NWP systems should be improved accordingly to further strengthen our ability to forecast TC positions.

Enhanced use of ensemble forecasts

Ensemble spread vs error (3-day Fcst, WNP 2008-2010)

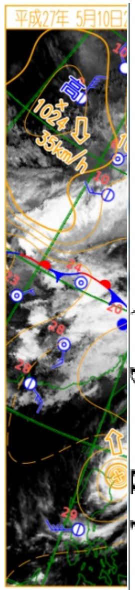


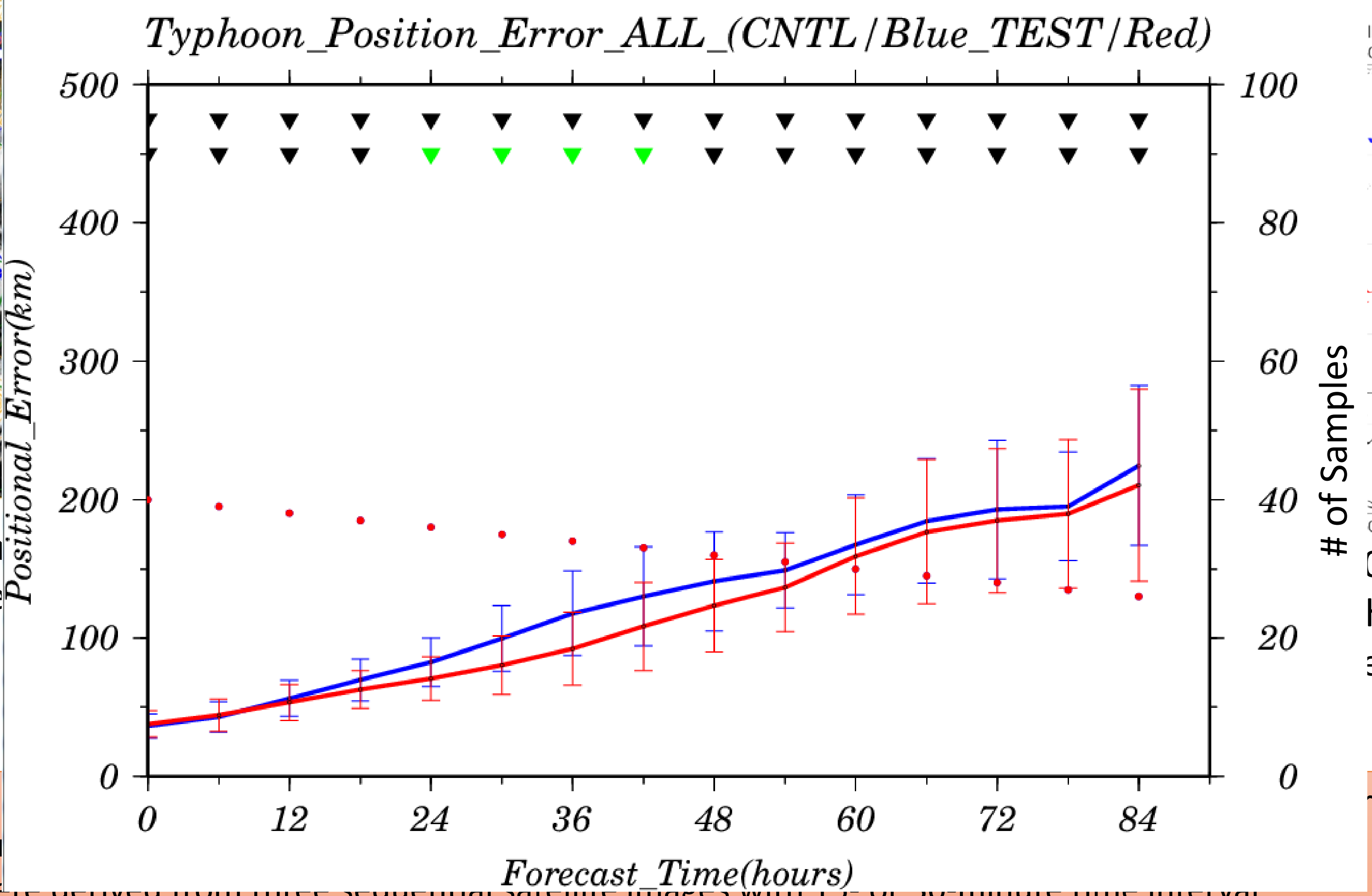
The relationship is improved in Multi-Center Grand Ensemble (**MCGE**)

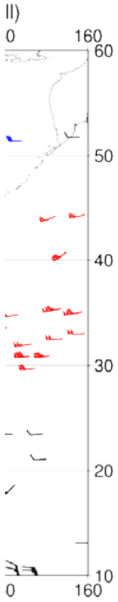
Yamaguchi et al. (2012, QJRMS)

TC track is the most fundamental component in issuing warnings, communicating the forecast uncertainty to the public is of great importance.

Observing System Experiment using Himawari







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e test

Himawari-8 AMVs … retrieval method
based on maximu…
MTSAT-2 AMVs were derived from three sequential satellite images with 15- or 30-minute time interval.
（Himawari-8 and MTSAT-2 AMVs used for this study were produced by Meteorological Satellite Center of JMA.）

Courtesy of Koji Yamashita (JMA)

Summary

Intensity Forecasts

Current status

Experimental use of SHIPS in 2016

Future plan

Use of other guidance

Use of consensus forecasts

Extension of a forecast range from 3 to 5 days

Future challenges

Adding new predictors

TC intensity forecasts by NWP models (e.g., regional and/or next generation global models)

Genesis Forecasts

Current status

Development of genesis guidance using EDA and global ensembles

Future plan

Implementation of TCGI

Future challenges

Long-term TC genesis forecasts using medium-range and 1-month ensembles.

Track Forecasts

Current status

In 2016, the size of the uncertainty cone was reduced 10 – 20 % in line with recent progresses in TC track forecasting.

Future challenges

Optimizing the size of uncertainty cone based on multiple ensembles.

Exploring the cause of forecast bust cases and improving the NWP system accordingly.