Use of TIGGE in Tropical Cyclone Forecasting

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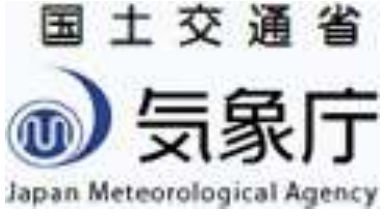
WORLD METEOROLOGICAL ORGANIZATION



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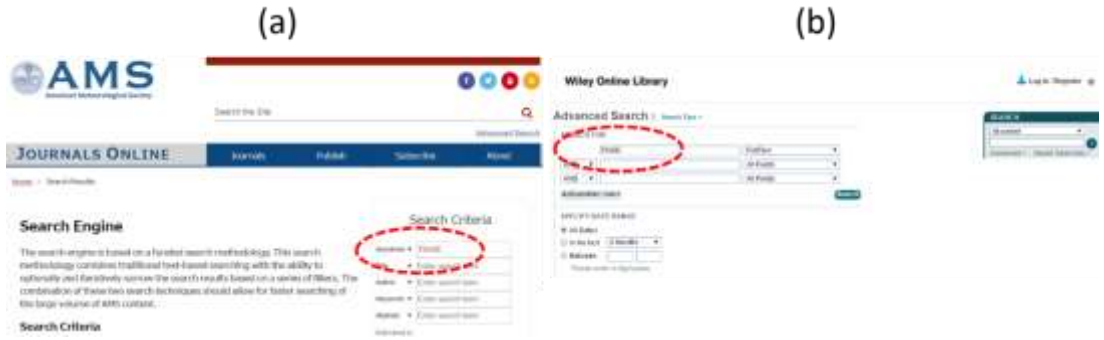
1. Literature search for papers using TIGGE data

The PDEF WG carries out literature search for papers using TIGGE data as its action item and the results are presented at each WG meeting.

Methodology

Peer-reviewed papers in which the TIGGE data were used were searched on the American Meteorological Society (AMS) and Wiley websites.

- Using an advanced search function, papers including the word “TIGGE” were first selected.



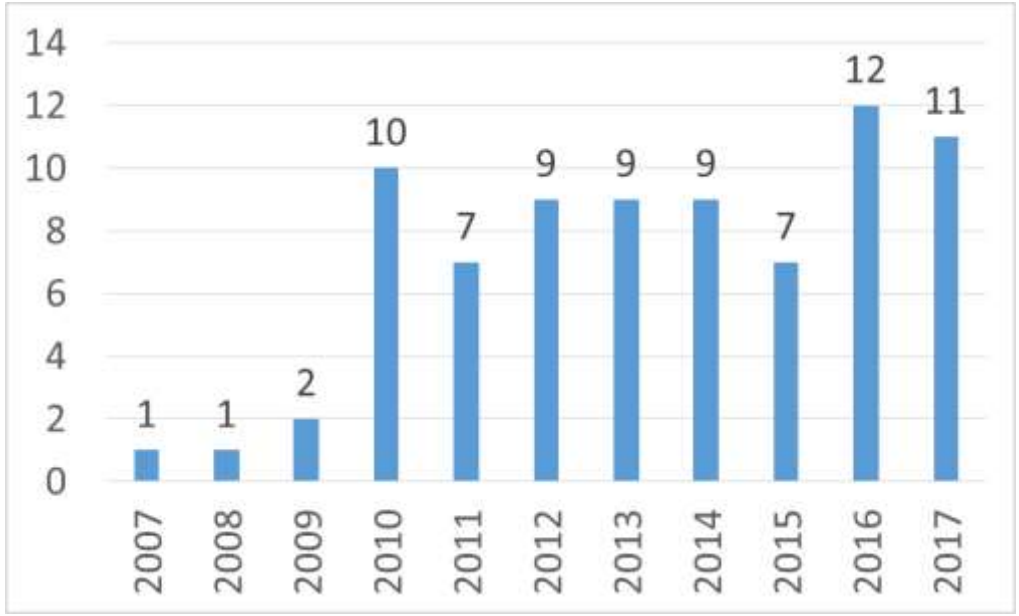
- Then each paper was examined if it actually made use of the TIGGE data.

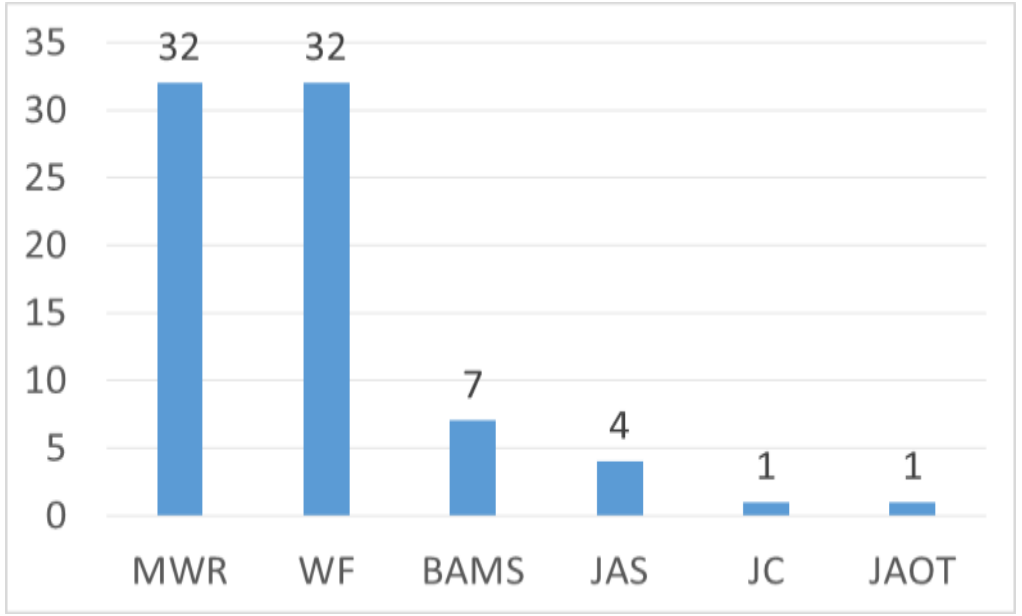
Note that papers that included the word “TIGGE, but just introduced TIGGE project/archive were excluded in the statistics.

Also note that in the search on the Wiley website, the following five journals were considered: Quarterly Journal of the Royal Meteorological Society (QJRMS), Atmospheric Science Letters (ASL), Meteorological Applications (MA), Journal of Geophysical Research (JGR) and Geophysical Research Letters (GRL).

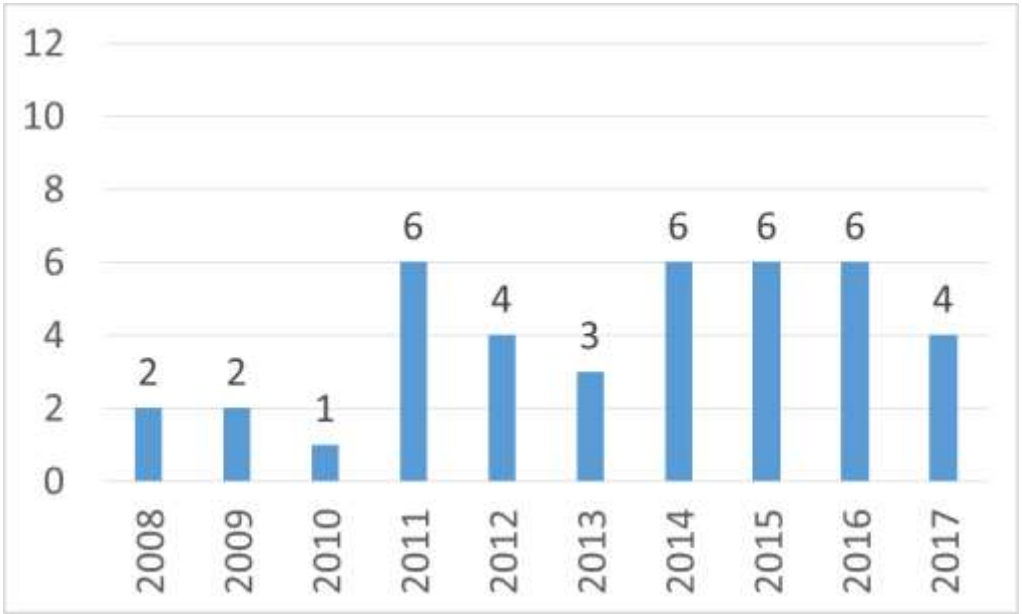
Results

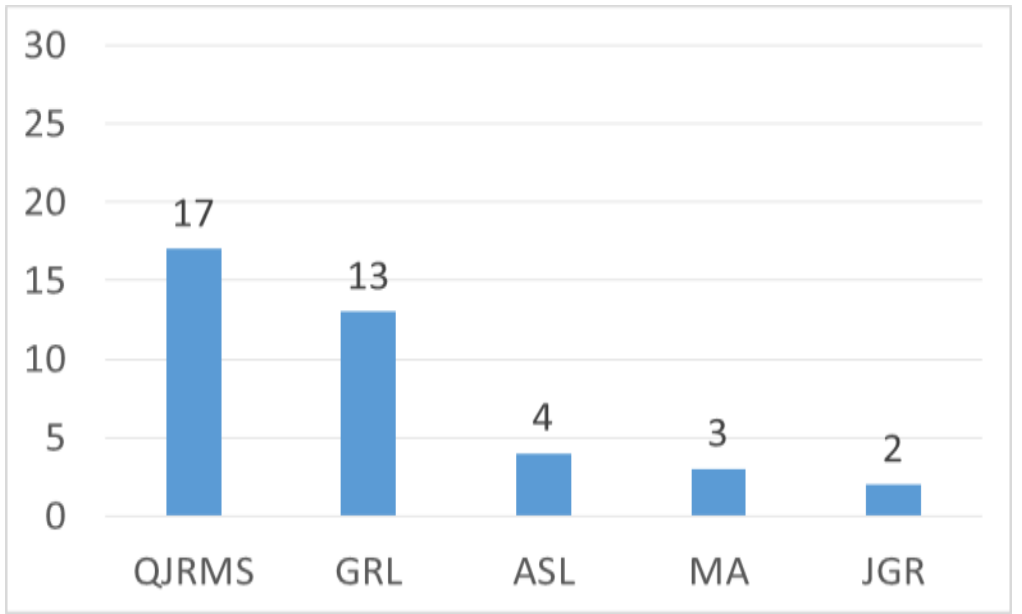
AMS





Wiley





Results: Research Areas

Table below shows the statistics on what weather/climate phenomena were studied using the TIGGE data.

AMS	
Tropical cyclone	29
Heavy Precipitation and flood	13
Extratropical cyclone/transition	5
High temperature	3
Blocking	2
Asian summer monsoon	1
Atmospheric river	1
Polar prediction	1
Thunderstorm	1
MJO	1

Wiley	
Tropical cyclone	10
Heavy Precipitation and flood	9
Polar prediction	3
Extratropical cyclone/transition	2
High temperature	2
North Atlantic jet	2
Rossby wave	2
MJO	2
Blocking	1
Surface wind	1

Brief Summary

- Although there is a limitation in the methodology in this survey as it considers only AMS journals and five journals on Wiley, TIGGE is found to have been utilized for a wide range of scientific studies over the world.

- Tropical cyclone is the most studied research area, followed by heavy precipitation and flood.

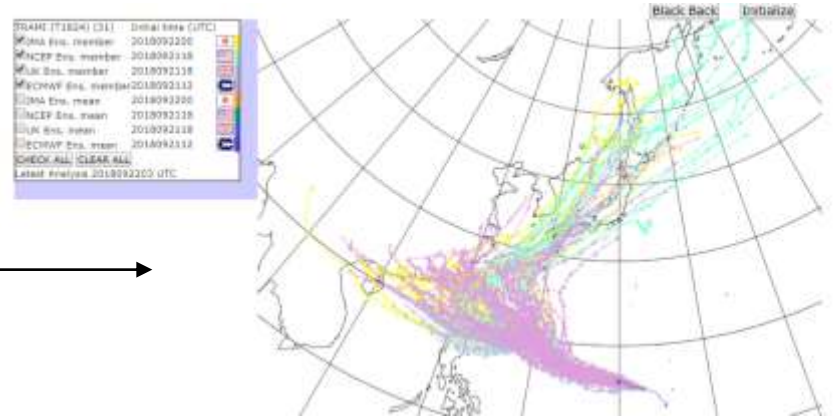
- TIGGE has also been used for development/assessment of ensemble prediction system, coastal ocean and ice ocean modelling and data assimilation.

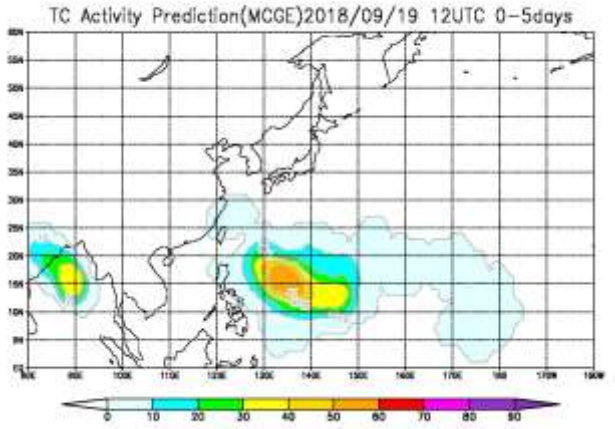
- Since 2011, TIGGE papers have been constantly published at a pace of approximately 15 papers per year.

2. An example of Research to Operation (R2O) transfer in TC forecasting with TIGGE

Typhoon Committee Members

Cambodia, China, Democratic People's Republic of Korea, Hong Kong, China, Japan, Lao People's Democratic Republic, Macao, China, Malaysia, Philippines, Republic of Korea, Singapore, Thailand, United States of America, Viet Nam

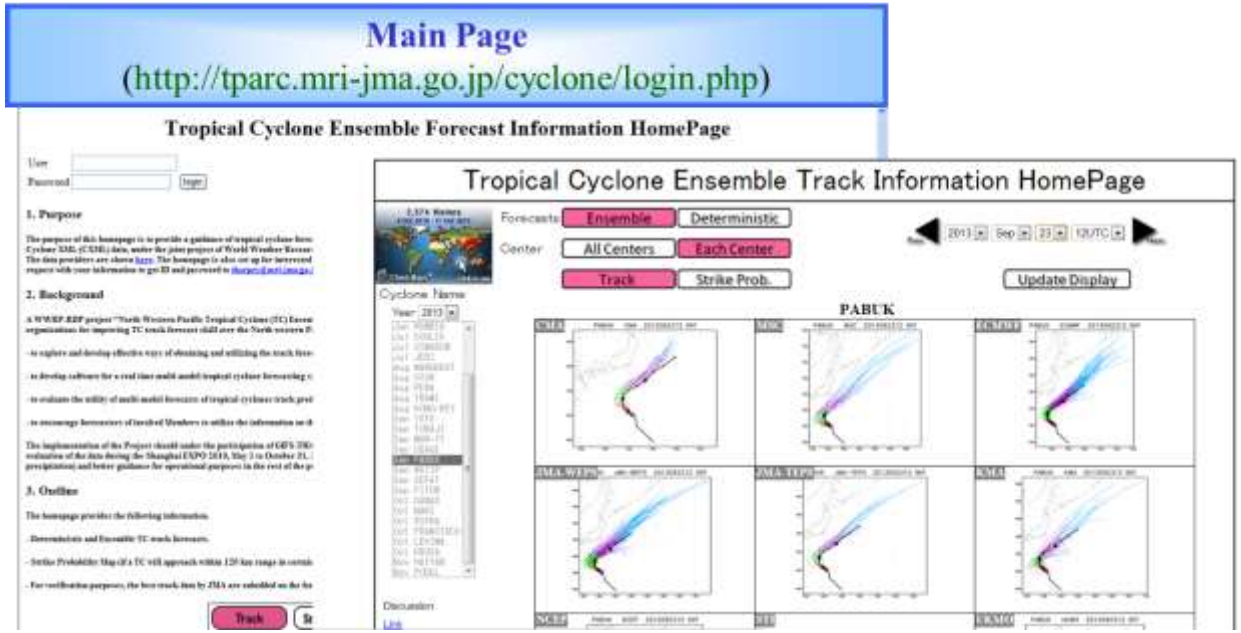




Forecasters at the Typhoon Committee Members can use multi-model ensemble TC products in real time through a website operated by RSMC Tokyo

WWRP RDP: NWP-TCEFP

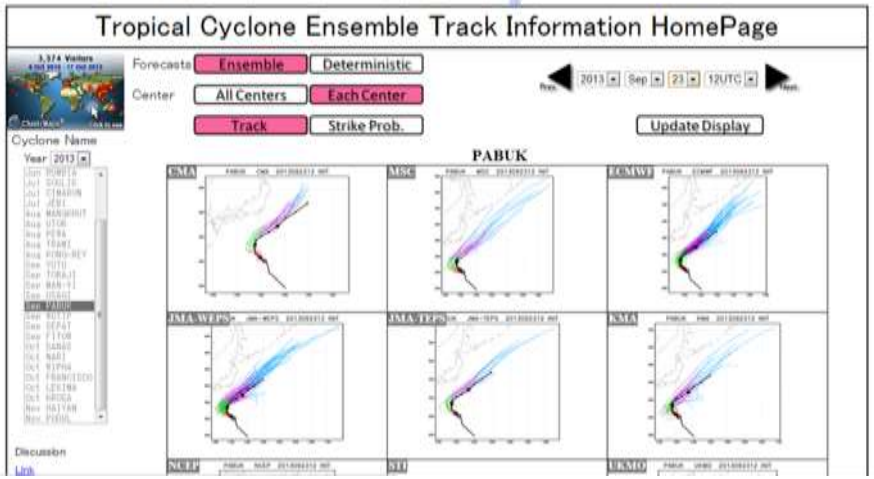
- NWP-TCEFP: the North Western Pacific Tropical Cyclone Ensemble Forecast Project
- Started in 2009 as a Research and Development Project (RDP) of WMO/WWRP
- Explored the utility of ensemble forecasts of TCs, including multi-model ensembles, and to promote such products for operational TC forecasting



<u>Project Paper</u>:
Yamaguchi, M., T. Nakazawa, and S. Hoshino, 2014: North Western Pacific Tropical Cyclone Ensemble Forecast Project, *Tropical Cyclone Research and Review*, **3**, 193-201.

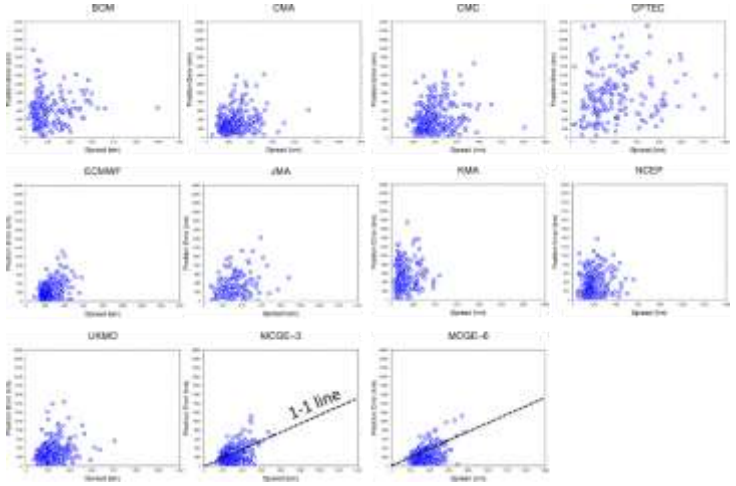
Action 1

Multi-model ensemble TC track predictions using TIGGE CXML



Action 2

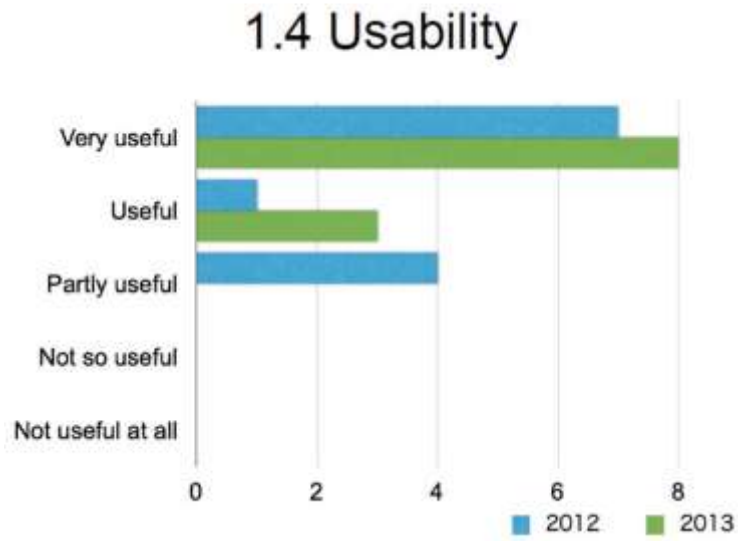
Demonstrate the relative benefits of multi-model ensembles wrt a single-model ensemble (Yamaguchi et al. 2012, QJRMS)



The spread – error relationship is improved in the multi-model ensembles.

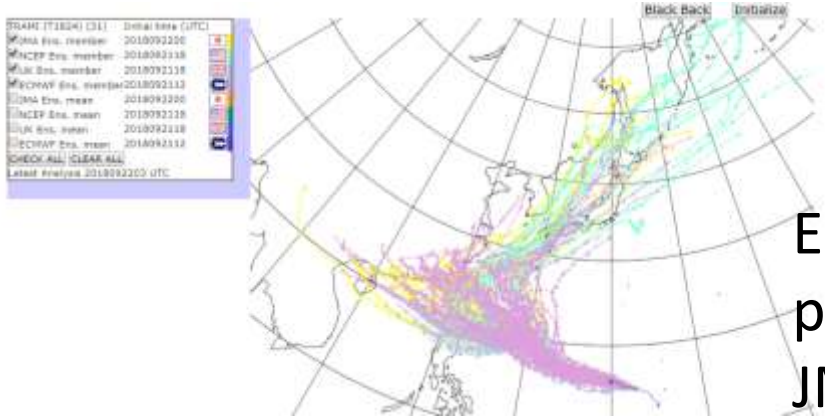
Action 3

Questionnaire survey to the Typhoon Committee Members regarding the project (Yamaguchi et al. 2014, TCRR)



Action 4

RSMC Tokyo currently provides the multi-model ensemble TC track predictions to the Typhoon Committee Members in real time.



Ensemble TC track predictions from ECMWF, JMA, NCEP and UKMO.

Tropical Cyclone Activity Map

RSMC Tokyo currently provides the multi-model ensemble TC activity (genesis and subsequent track) predictions to the Typhoon Committee Members in real time.

the

+8days)

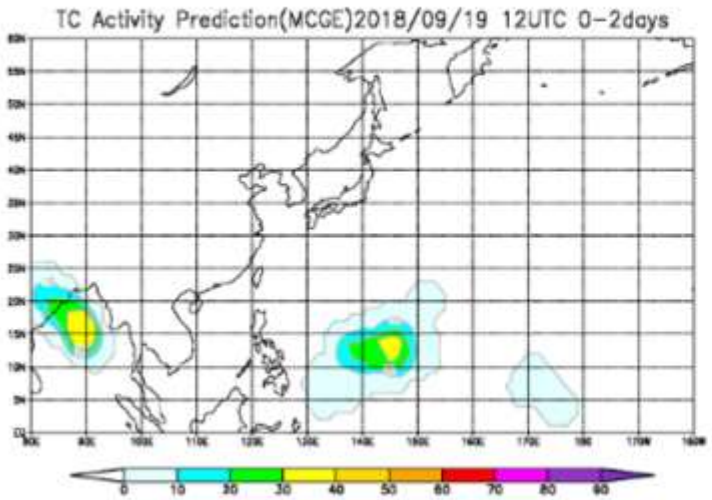
Numerical Typhoon Prediction Website

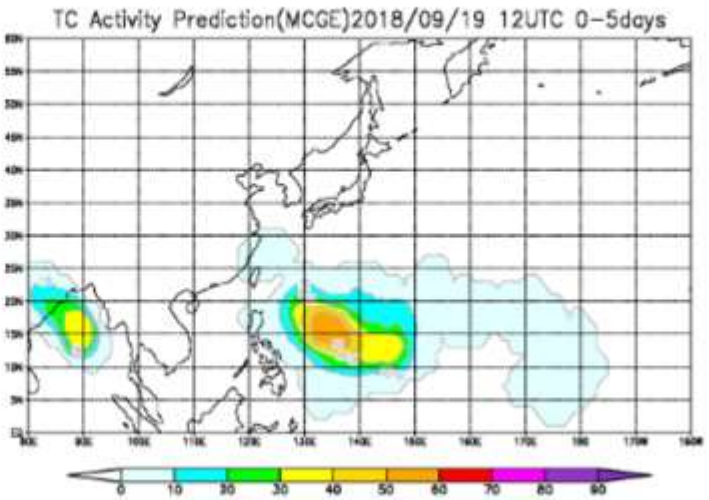
RSMC Tokyo - Typhoon Center

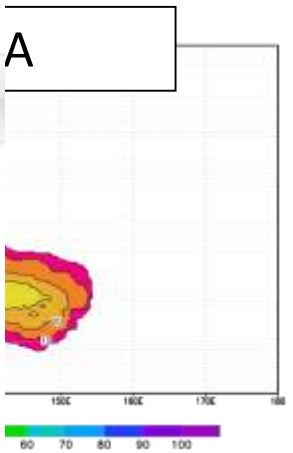
HOME | Advisories | Obs/Analysis | Forecast/NWP | Surge/Wave | Publication | Data

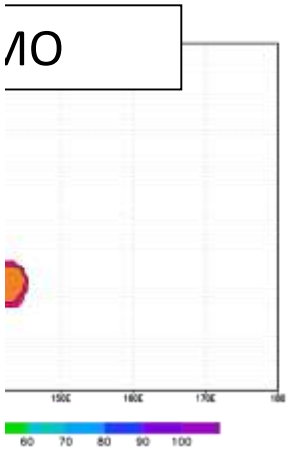
Tropical Cyclone Activity Prediction

Multi Center Grand Ensemble (MCGE)









Yamaguchi et al. 2015, WAF

Brief Summary

- NWP-TCEFP is one of the good examples that achieved a R2O transfer in TC forecasting with TIGEE.
- Promoting R2O transfer is a key component of the current WWRP implementation plan.
- It is of great importance for us to think about how we could achieve and further promote R2O transfer with TIGGE, S2S, etc.

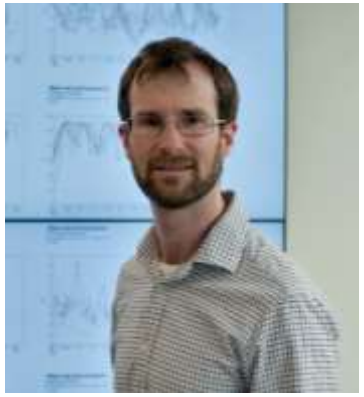
3. Questionnaire on the use of ensemble forecasts in operational tropical cyclone (TC) forecasting

HIWeather Questionnaire Survey

- HIWeather: WMO's 10 year research project aimed to enable increased global resilience to severe weather by improving forecasts of severe weather and its impacts, and the communication of information to users, especially emergency managers.

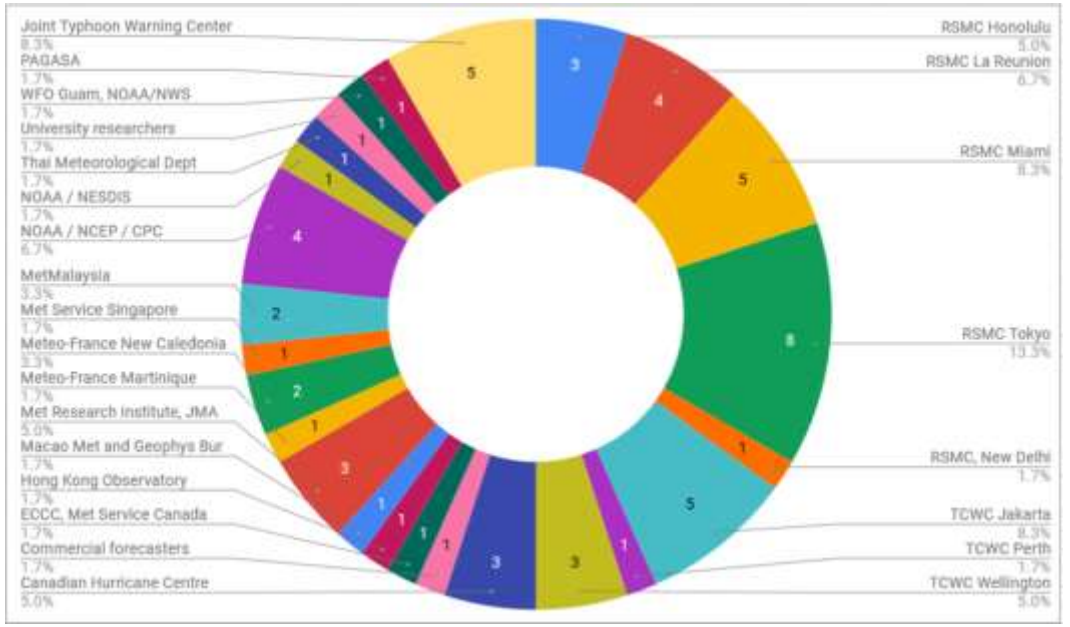
In the summer of 2018 a questionnaire was sent out to all operational tropical cyclone forecasting centers around the world asking about their use of dynamical ensemble forecast information.

Helen Titley (UKMO)



Linus Magnusson (ECMWF)

Munehiko Yamaguchi (JMA)



60 responders in all areas of the world !!

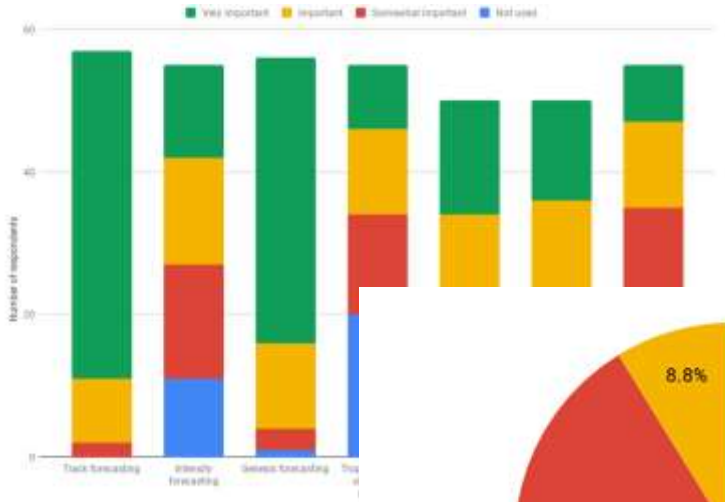
Objectives

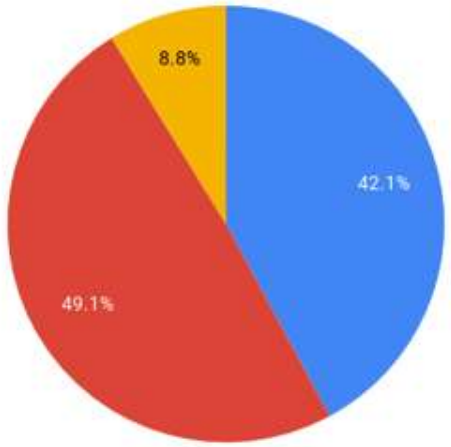
i) To document the current availability of ensemble forecasts in tropical cyclone forecast centers, and their use by operational forecasters.

ii) To ascertain how uncertainty is represented in the operational warnings for track, intensity, genesis and hazards from their center, and whether or not this uncertainty information is taken from dynamical ensemble forecasts.

iii) To obtain examples where probabilistic forecasts have been successfully integrated in to operations, but also occasions where hurdles have prevented them from being fully utilised.

iv) To collate forecaster feedback on where they would like to see future research and development focussed to enable them to make wider use of ensemble forecasts.





Center name	Forecast lengths / frequency	Is uncertainty represented, and if so how?
RSMC Tokyo	3 days / 8 times a day	No
RSMC Honolulu	5 days / 6 hourly	Yes, wind speed probabilities for 34/50/65 knots – Monte Carlo simulation
RSMC La Reunion	5 days / 6 hourly	No
RSMC Miami	5 to 7 days / 6 hourly	Yes, wind speed p
RSMC New Delhi	5 days / 6 hourly (and 3 hourly updates for intervening)	No
TCWC Jakarta	3 days / 6 hourly	No
TCWC Perth	7 days / 1, 3 or 6 hourly	No
	days if a rly	No
		No (only qualitati
	by	No
		No
	rly ion	No
		No
		No
		No
		No
		No

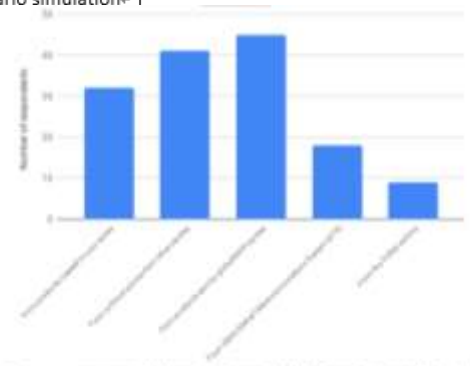


Figure 6: "How do you access ensemble forecast information?" NB. Respondents could select all that apply.

ach tropical cyclone forecasting center.

Figure 8: "Do you use multi-model ensemble forecast data i.e. multiple dynamical ensembles"

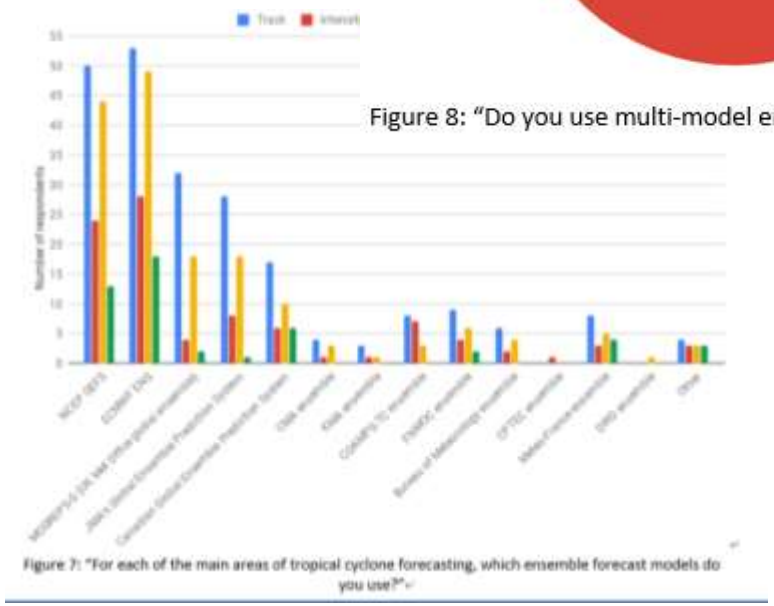


Figure 7: "For each of the main areas of tropical cyclone forecasting, which ensemble forecast models do you use?"

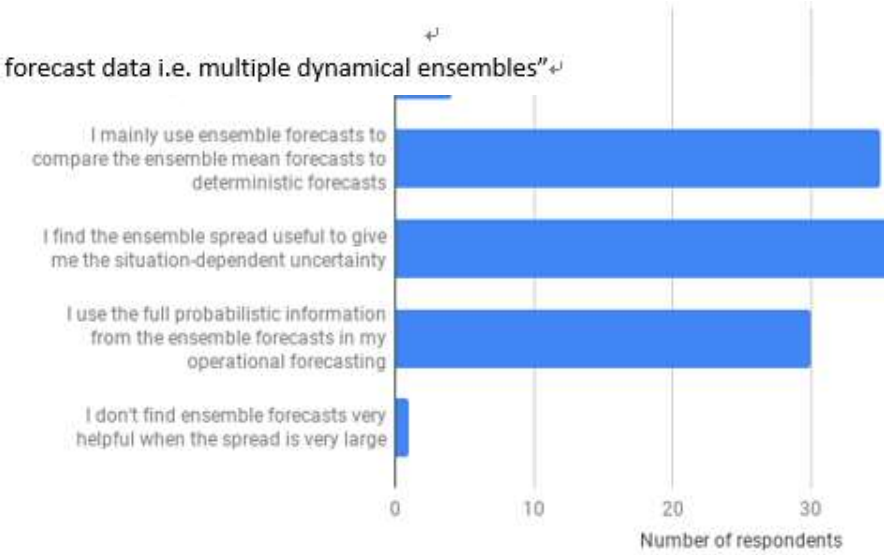


Figure 11: "Which of the following statements describe your use of ensemble forecasting?"

i) To document the current availability of ensemble forecasts in TC forecast centers, and their use by operational forecasters.

- Ensemble forecasts are currently used by nearly all forecasters and at tropical cyclone forecast centers around the world.
- They are seen to be particularly important in track and genesis forecasting.
- They are less well-used in intensity forecasting, and are used least in forecasting tropical cyclone size/structure and extra-tropical transition.
- The vast majority of forecasters also use multi-model ensemble forecasts (a combination of multiple dynamical ensembles) but less than half use any calibrated ensemble forecasts.

ii) To ascertain how uncertainty is represented in the operational warnings for track, intensity, genesis and hazards from their center, and whether or not this uncertainty information is taken from dynamical ensemble forecasts.

- For track forecasting, there is a clear discrepancy between the number of operational tropical cyclone forecasters who use and value ensemble forecast information, and the lack of pull-through in to operational forecast products of the probabilistic guidance that ensembles can provide. Although uncertainty is generally shown, this is based only on historical forecast error statistics in forecasts from most centers, with only two RSMCs and two other centers including ensemble forecasts in the calculation.

- No center uses dynamical ensemble forecasts in their operational intensity forecasts.

- The expression of uncertainty and the use of ensembles in operational hazard forecasts varies considerably, with products often taking the form of named or colour-coded categories assigned based on probabilities (statistical or dynamical).

iv) To collate forecaster feedback on where they would like to see future research and development focussed to enable them to make wider use of ensemble forecasts.

- Many respondents were keen to have future access to additional ensemble-based products such as landfall probability, storm surge, river discharge, flood risk and impact-based products.

- Other requests were an operational ensemble-based cone of probability, more useful intensity guidance including probability of intensity change and bias corrected intensity forecasts from multiple ensembles, and ensemble clustering with probabilities.

4. Discussion points for ways forward

The responses of those who put more weight in the traditional consensus approach using multiple deterministic model forecast in preference to ensemble forecast models were very interesting. It is clear that in addition to greater access to ensemble forecast data and tools, there is also a need for more direct verification comparisons of consensus vs ensemble forecasting, and research in to approaches that combine and maximise the benefit from both approaches.

Combined use of forecast data to maximize benefits

Deterministic Forecasts

Thank you for listening

TIGGE CXML

	BoM	CMA	CPTEC	ECCC	ECMWF	JMA	KMA	Météo France	NCEP	NCMRWF	UKMO
Data Period	n/a	2008.07 - 2014.12	n/a	2008.07 - 2018.05	2006.10 - 2018.05	2008.07 - 2018.05	2008.07 - 2010.10	2011.01 - 2018.05	2008.07 - 2018.05	n/a	2008.07 - 2018.05
As of 2018.05	No	No	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Deterministic (DTM)				Yes	Yes	Yes		No	Yes		Ongoing
Initial times of DTM				00, 12	00, 12	00, 06, 12, 18		n/a	00, 06, 12, 18		n/a
Ensemble (ENS)				Yes	Yes	Yes		Yes	Yes		Yes
Initial times of ENS				00, 12	00, 12	00, 12		06, 18	00, 06, 12, 18		00, 12
Basins				Globe	Globe	WNP		Globe	Globe		Globe
Named TCs				Yes	Yes	Yes		Yes	Yes		Yes
Developing TCs (genesis information)				No but for Invest	Yes	No but for Invest		No	No but for Invest		Yes