

# WGNE inter-comparison of Tropical Cyclone Track forecast 2020

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## STANDARD VERIFICATION .

### Verification of Global Models

## Data Specifications in 2020

NWP centre	Year of verification commencement	Horizontal resolution of provided data (degrees in longitude and latitude)	Model resolution as of 2020
BoM	2003	0.176 x 0.117	12kmL70
СМА	2004	No Data	No Data
СМС	1994	1.0 x 1.0	15km L84
DWD	2000	0.25 x 0.25	13kmL90
ECMWF	1991	0.125 x 0.125	TCo1280L137
FRN	2004	0.1×0.1	T <sub>L</sub> 1798C2.2L105
JMA	1991	0.25 x 0.25	T <sub>L</sub> 959L100
KMA	2010	0.1406 x 0.094	10kmL70
NCEP	2003	0.5 x 0.5	T1534L64
NCMRWF	2020	0.18 x 0.12	12kmL70
NRL	2006	0.5 x 0.5	T425L60(-28/4/20) T681L60(29/4/20-)
UKMO	1991	0.1406 x 0.094	10kmL70

### Improvement of models for each centres in 2020 (1/2)

#### BOM

- 23/7/2019 upgraded from version APS2 to APS3.
  - ➤ UM8.2->UM10.6
  - horizontal resolution:N512 (0.234375° x 0.351562°) -> N1024 (0.117788° x 0.17578°)
  - Dataset for WGNE TC verification was switched from APS2 to APS3 in 2020

#### CMC

• 21/1/2020 (Migration to a new High Performance Computing infrastructure)

DWD

- 22/10/2019 New ICON version (2.5.0-nwp1) and improvements to the assimilation scheme
- 27/11/2019 Improvements to the assimilation scheme
- 19/2/2020 New ICON version (2.5.0-nwp2) and improvements to the assimilation scheme
- 21/4/2020 New ICON version (2.6.0-nwp0) and improvements to the assimilation scheme
- 19/5/2020 Improvements to the global assimilation system and ICON

#### ECMWF

 30/6/2020 This cycle includes changes in the treatment of observations and improvements in the data assimilation and to the model. Quintic vertical interpolation in the semi-Lagrangian advection scheme has been introduced as well as the inclusion of a better surface albedo climatology making use of more data from the MODIS instrument.(Cycle47r1)



### Improvement of models for each centres in 2020 (2/2)

#### JMA

- 11/12/2019
  - All-sky assimilation of microwave imager (AMSR2/GCOM-W, GMI/GPM, SSMIS/DMSP F-17, F-18, WindSat/Coriolis, MWRI/FY-3C) and microwave water-vapor sounder (GMI/GPM, MHS/NOAA-19, Metop-A, -B) was started
  - Assimilation of ASCAT from Metop-C was started
  - Hybrid background error covariances estimated with LETKF and outer-loop iteration were introduced in 4D-Var system
- 24/3/2020
  - > Revision of parameterization schemes such as gravity wave and boundary layer
  - Improvement of land surface process
  - > Adjustment of sea ice albedo and cloud processes in polar regions
- 29/7/2020 Assimilation of ScatSat-1/OSCAT and GOES-16 AMV data was started

#### NRL

• 29/4/2020 NAVGEM 2.0 runs at T681L60

# TCs in 2020

#### **TC** season

Northern Hemisphere: 1 January 2020 to 31 December 2020

Southern Hemisphere : 1 September 2019 to 31 August 2020

### Number of TCs (LY) [best track data provider]

- 23 (29) Western North Pacific [RSMC Tokyo]
- 17 (25) Eastern North Pacific (including Central North Pacific) [RSMC Miami, Honolulu]
- 30 (16) North Atlantic [RSMC Miami]
- 5 (7) North Indian Ocean [RSMC New Delhi]
- 10 (8) South Indian Ocean [RSMC La Reunion]
- 13 (14) Around Australia  $\ [RSMC Nadi and 4 TCWCs ]$







### (a) WNP AT-CT Bias (FT=72) 2020





### Tropical Cyclone "Chan-hom": environmental conditions





•Before recurvature : between subtropical high and high pressure over China.

 Known as a environmental condition in which TC track errors tend to be large (e.g. Tang et al. 2019, 2021)

•After recurvature : interaction with another upper cold low may make TC track difficult.



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### Impact of model upgrade on TC intensity forecast



X-axis : analysis Y-axis : forecast





### (b) North Atlantic (NAT)

### (c) Eastern North Pacific (ENP)



#### Transition of FT=72 Position Error over Decades WNP NAT ENP BOM CPTEC CMA CMC DWD ECMWF FRN JMA KMA KMA NCEP NRL UKMO BOM CPTEC CMA CMC DWD ECMW FRN JMA KMA NCMP NCEP CPTEC CMA CMC OWD ECMW FRN JMA KMA +++++++ +++++ 900 800 80 70 700 700 600 600 600 50 500 500 400 400 300 200 100 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 Year Vear BOM CPTEC CMA CMC DWD ECMW FRN JMA KMA NCMR NCEP NRL BOM CPTEC GMA CMC DWD ECMW FRN JMA KMA NCMR NCEP NRL +++++++ CPTEC CMA CMC DWD ECMWD FRN JMA KMA NCMRN NCEP NRL UKMO +++++ SIO **AUR** NIO 900 800 800 BOM 700 CPTEC 600 600 CMA 500 CMC 400 DWD 300 200 ECMWF 200 100 FRN JMA 002 2004 2006 2008 2010 2012 2014 2016 2018 202 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 Vear Vear Ven KMA NCMRWF NCEP NRL UKMO

# Summary of verification 2020 (1/2)

- NCMRWF newly joined verification.
- Position errors
  - Smaller track errors are seen over WNP 2020 than 2019.
  - Slow bias after re-curvature, a well-known common bias, was still seen in 2020.
  - TCs which contribute to the annual mean track error (large error with a number of samples) are common among centres possibly due to environmental conditions. e.g. Tropical cyclone "Chan-hom"
  - TC position errors have decreased gradually in each region.
    - However, the error reduction has been slow-down recently.
    - "200km barrier" at T+72 in the annual mean errors?

# Summary of verification 2020 (2/2)

- Intensity errors
  - Centres which conducted major model upgrades (e.g. BoM and NRL in 2020) reduced shallow biases in central pressure at T+0.
    - Model's upgrade can influence the TC initialization
  - However, these models tend to over-deepen TCs.



# TC intercomparison website will be available soon!

WGNE Intercomparison of Tropical Cyclone Track Forecasts Using Operational Global Models

Updated: 28 August 2018

Forecast Verification (verification (regional) Introduction Read Me Data Data (regional) Contact Link



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# EXTRA SLIDES



# Verification Method using MSLP

### Target TCs

TC best track data provided by individual RSMCs are used in verification, with focus on cyclones reaching tropical storm (TS) intensity with maximum sustained winds of 34 knots or stronger. The tropical depression (TD) stage of targeted TCs is also included in this verification, and TCs remaining at TD level throughout their lifespan are excluded.

### **Tracking Method**

TCs are tracked using mean sea level pressure data provided by participating NWP centres. Under this method, the minimum pressure point is identified as the initial or predicted TC position.

- 1) First position (FT+Ohr) is searched within a 500 km radius of a best track position.
- 2) Second position (FT+6hr) is searched within a 500 km radius of the first position.
- 3) Subsequently (FT+12hr~), a TC position within a 500 km radius of a reference point determined from linearly extrapolation of the latest two positions is identified.

Tracking ends when no appropriate minimum pressure point is found.

### Definitions



that the NWP model successively expresses the TC until time t

B(t) : number of events in which a TC is analyzed at time t.

# TC initialization schemes employed in the participating centres

TC initialization scheme	subtype	centres
	vortex insertion	None
Bogus	synthetic observation	CMA, JMA, KMA, NCEP, NRL
TC relocation		None
Assimilating central pressure obs. from TC warning centres		BoM, Met Office, NCEP
None		CMC, DWD, ECMWF, Meteo France

source: WGNE-31 presentation on TC verification, BoM(2019), Heming (2016) and Heming et al. (2019) and input from participating centres

Notes

\* NCEP employees combination of multiple initialization schemes (Kleist et al. 2016).

\* JMA, CMA: only over Western Pacific Ocean

- Synthetic observation, using central pressure, and no TCspecialized initialization are major choice
- No participating centre employees vortex insertion or TC relocation type schemes.

# Trends in choice of TC initialization schemes

- As models and/or data assimilation systems can represent TCs better, TC initialization schemes tend to be less artificial or less specialized for TCs.
- Examples:
  - Heming et al. (2016) : Met Office has upgraded the TC initialization schemes to harness with the model's capability.
  - Kadowaki (2005): JMA switched the TC initialization scheme from a vortex-insertion type TC bogus to a synthetic observation type TC bogus along with introduction of 4DVAR
  - Kazumori and Kadowaki (2017) and Geer et al. (2018) : Introduction of all-sky assimilation improved the

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### Western North Pacific (WNP) Position Error



### WNP Detection Rate 2020







### (f) South Indian Ocean (SIO)





#### Visualization with "Pie-chart" 2019 DWD BOM BOM CMA CMC CMC DWD СМА -80 901 90 Western Month Paul Instance North Paul Masters Marth Paul Destan Hard, Paul Westwise Sector Frank Forestore Reads, Start -. 900 -detection rate ● :100 % ○ : 8 % 700 708 100 70 1 .... --800 801 800 100 100 -400 340 - 410 304 30 -. 120 . 130 ECMWF FRN JMA КМА **ECMWF** FRN **JMA KMA** 80 -800 30 Western North Parts Colors North I Rom Abartic Castorn North Pacific North Attantic Capetore Hearth Frank 10 100 -406 100 - 110 0 - 110 % deluction rele date-tion rais 100 • :00% • 1808 % O ± 0% ne 100 100 E .... 1 000 3 40 908 - se 500 \$ 500 500 400 400 400 400 100 300 30 200 20 12 . 13 48 6) T2 Forecast Time Proce Forecast Time Pr **UKMO** NRL NCEP NRL UKMO 101 800 Western Harts Pauls Evolution Barth Faults North Atlantic 800 Lostern Harth Ventore North Paulle Rombre Harth Paulle North Alla Mic -800 800 800 0 :025 distant from white 796 • 100% 700 704 1 .... Western North Pacific **Eastern North Pacific** 90 --901 -2 North Atlantic 304 South Indian Ocean 201 Around Australia detection rate . 12 24 All 60 T2 Forecast Time Prove 84 100 120 12 100 120 45 80 T2 Forecast Time (hour) : 100 %

: 0%

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### (a) WNP AT-CT Bias (FT=72) 2019









### (a) NAT AT-CT Bias (FT=72) 2020



















#### Red : before recurvature Green : during recurvature Blue : after recurvature

Y-axis : position errors (km) in the along track direction X-axis : position errors (km) in the cross track direction







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### Pressure Error Vs Position Error(WNP T+72)





### (a) WNP Error Map (FT=72) Verification in 2019





