WGNE inter-comparison of Tropical Cyclone Track forecast 2018-2019

Prepared by ARAI Hiroaki
Presenter: UJIIE Masashi
Numerical Prediction Division,
Japan Meteorological Agency

STANDARD VERIFICATION

Verification of Global Models

Data Specifications in 2018-2019

NWP centre	Year of verification commencement	Horizontal resolution of provided data (degrees in longitude and latitude)	Model resolution as of 2019
BoM	2003	0.3516 x 0.2344	25kmL70(APS2,-Jul.22 2019) 13kmL70(APS3,Jul.23 2019-)
CMA	2004	0.2813 x 0.2813	T_L639L60
CMC	1994	1.0 x 1.0	25km L80(-Jul.2 2019) 15km L84(Jul.3 2019-)
DWD	2000	0.25 x 0.25	13kmL90
ECMWF	1991	0.125 x 0.125	TCo1280L137
FRN	2004	0.25 x 0.25(-Jul.4 2019) 0.1×0.1(Jul.5 2019-)	T_L1198C2.2L105(-Jul.4 2019) T_L1798C2.2L105(Jul.5 2019-)
JMA	1991	0.25 x 0.25	T_L959L100
KMA	2010	0.2344 x 0.1563 (-Jun. 5 2018) 0.1406 x 0.094 (Jun. 6 2018-)	17kmL70 (-Jun. 5 2018) 10kmL70 (Jun 6 2018-)
NCEP	2003	0.5 x 0.5	T1534L64
NRL	2006	0.5 x 0.5	T425L60
UKMO	1991	0.1406 x 0.094	10kmL70

Improvement of models for each centres in 2018-2019 (1/4)

BOM

- 2019.07.23 upgraded from version APS2 to APS3(verification using version APS2).

CMC

- 2017.11.01 Upgrade to Version 6.0.0 of the GDPS
  - Introduction of two-way coupling with an ice-ocean model.
- 2018.06.07 Replacement of the GOES-13 satellite by GOES-16 and Meteosat-10 satellite by Meteosat-11 in the data assimilation system.
- 2018.09.18 Upgrade to Version 6.1.0 of the GDPS
  - Changes to the forecast model
  - Changes to the data assimilation component
- 2019.07.03 GDPS7.0.0
  - Changes to the atmospheric component of the forecast model Horizontal resolution from 25km to 15km, Number of vertical levels from 80 to 84
  - Changes to the oceanic component of the forecast model
  - Changes to the atmospheric component of the data assimilation
  - Changes to the oceanic component of the data assimilation
- 2019.07.03 Addition of various satellite observation

Improvement of models for each centres in 2018-2019 (2/4)

DWD

- 2017.09.29 start to use NCEP high-resolution SST analysis
- 2017.10.11 update weather interpretation code tables
- 2017.10.25 improve method of using observation data (SYNOP 2m RH, 10m wind)
- 2017.11.29 start to use Dual-Metop AMV
- 2018.03.14 New version of the ICON model and improvements of the assimilation system
- 2018.06.06 New version of the ICON model and improvements of the assimilation system
- 2018.07.11 New version of the ICON model and improvements of the assimilation system
- 2018.09.19 New version of the ICON model and improvements of the assimilation system
- 2018.12.05 Advances to the assimilation of humidity sensitive microwave radiances of ATMS and MHS
- 2019.01.22 New version of the ICON model
  - Interpolation method for lat-lon output changed
  - Bug fix in aerosol climatology.
- 2019.02.27 Updates to the data assimilation scheme and ICON
- 2019.04.10 Assimilation of observations from Metop-C,ScatSat
- 2019.06.04 Updates to the data assimilation scheme
- 2019.07.30 New ICON version (2.5.0-nwp0) and improvements to the assimilation scheme
- 2019.10.22 New ICON version (2.5.0-nwp1) and improvements to the assimilation scheme
- 2019.11.27 Improvements to the assimilation scheme

Improvement of models for each centres in 2018-2019 (3/4)

ECMWF

- 2018.06.05 upgrade with many scientific contributions, including changes in data assimilation (both in the EDA and the 4DVAR), in the use of observations, and in modelling such as enhanced dynamic coupling between the ocean, sea ice and the atmosphere (Cycle 45r1)
- 2019.06.11 upgrade with many scientific contributions, including changes in data assimilation (both in the EDA and the 4DVAR), in the use of observations, and in modelling (Cycle 46r1)

JMA

- 2018.10.18 Usage of Clear-Sky Radiance (CSR) data was enhanced.
    - ➢ assimilation of surface-sensitive CSR data from Himawari-8 Band 9 and 10 and Meteosat-8, 11 Channel 6
    - ➢ assimilation of hourly CSR data from Meteosat-8, 11 and GOES-15 with cessation of data thinning every two hours.
- 2019.03.05 Assimilation of the ATMS and CrIS data from NOAA-20 was started
- 2019.06.18 Assimilation of GOES-16 CSR data was started
- 2019.12.11
    - ➢ 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

Improvement of models for each centres in 2018-2019 (4/4)

KMA

- 2018.06.06 improve horizontal resolution (from 17km to 10km)

NCEP

- 2019.06.12 GFS V15.1 Upgrade
  - the spectral dynamical core is replaced by the finite-volume cubed-sphere (FV3) dynamical core
  - improve physical processes (convection, boundary layer, land, sea)
  - improve data assimilation system(IASI moisture channel, ATMS all-sky radiance, ASCAT from Metop-C, CrIS radiance, Meteosat-11 SEVIRI channels 5 and 6, NPP OMPS profile and total column ozone)

TCs in 2018

TC season

Northern Hemisphere : 1 January 2018 to 31 December 2018

Southern Hemisphere : 1 September 2017 to 31 August 2018

Number of TCs [best track data provider]

29 Western North Pacific [RSMC Tokyo]

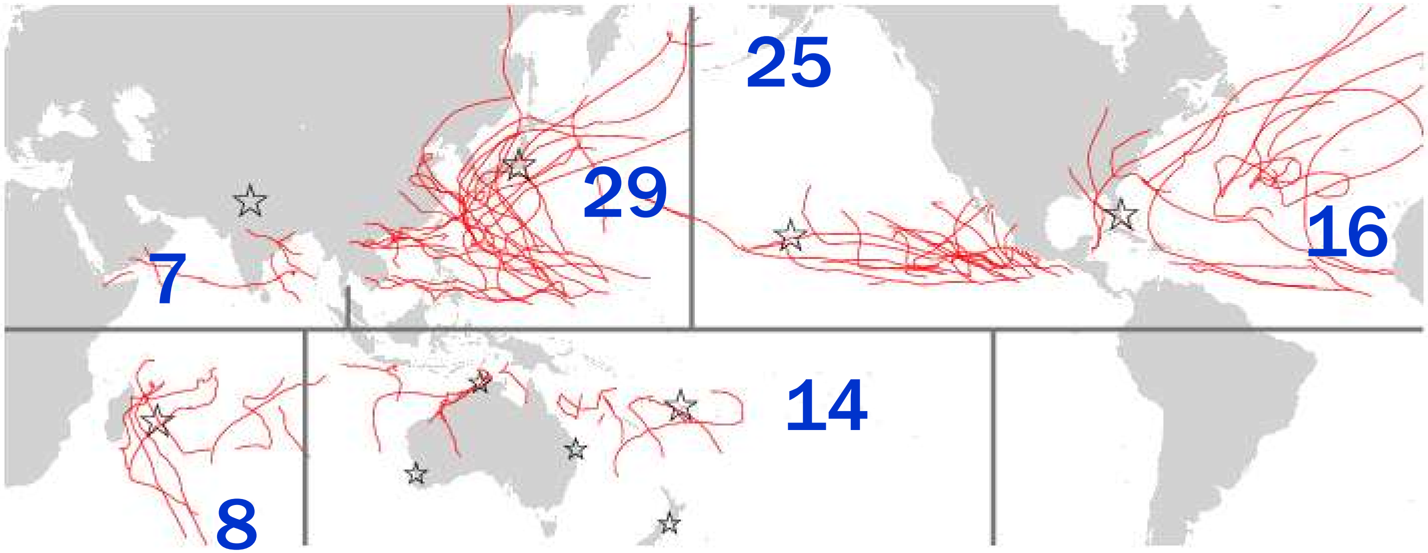
25 Eastern North Pacific (including Central North Pacific) [RSMC Miami, Honolulu]

16 North Atlantic [RSMC Miami]

7 North Indian Ocean [RSMC New Delhi]

8 South Indian Ocean [RSMC La Reunion]

14 Around Australia [RSMC Nadi and 4 TCWCs]



TCs in 2019

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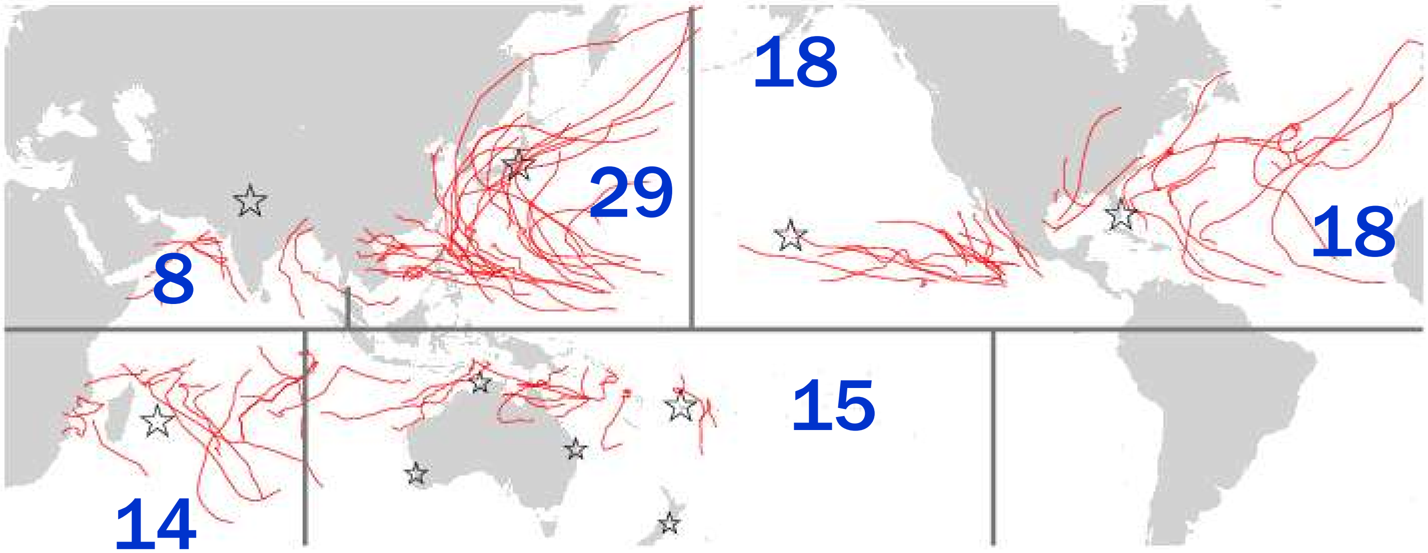
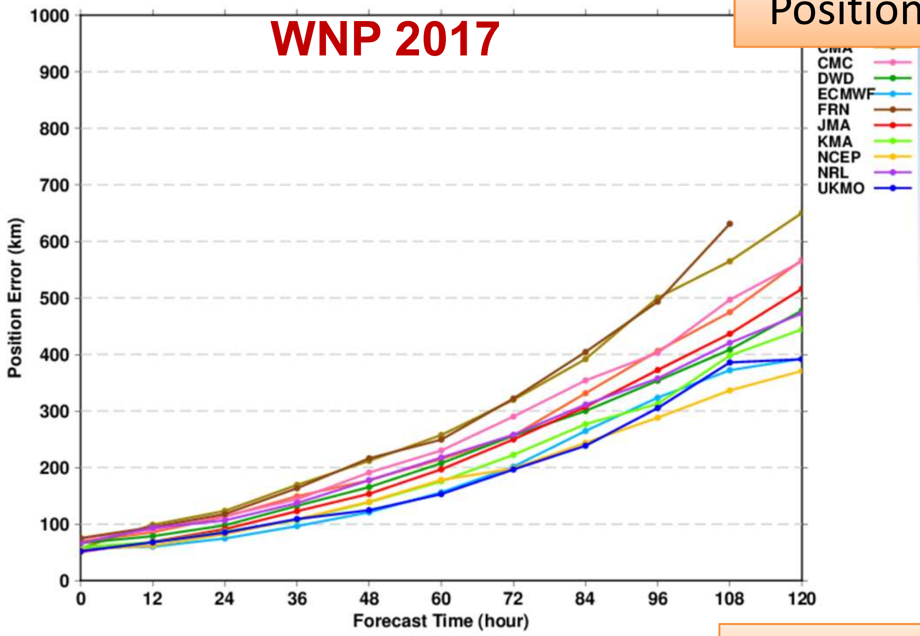
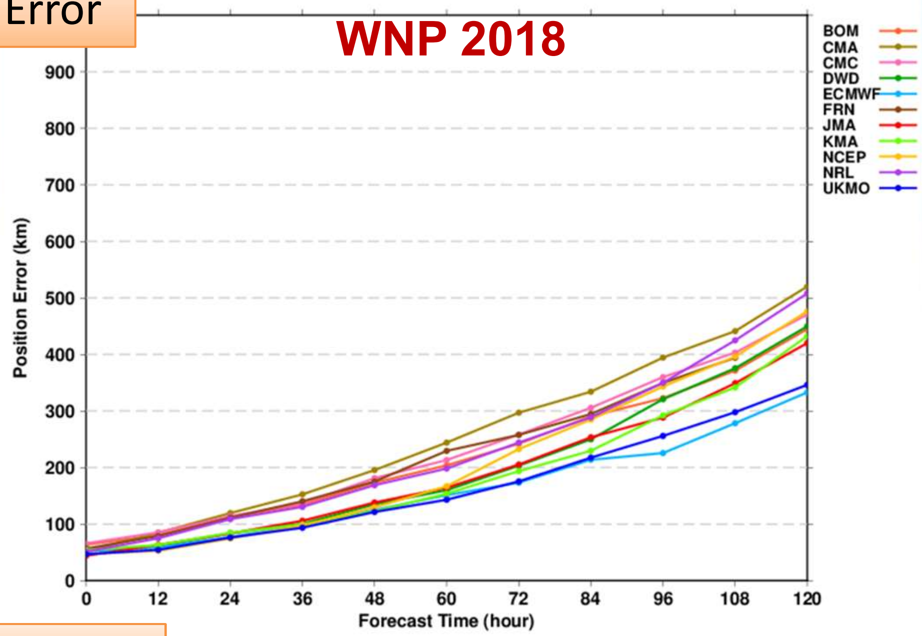
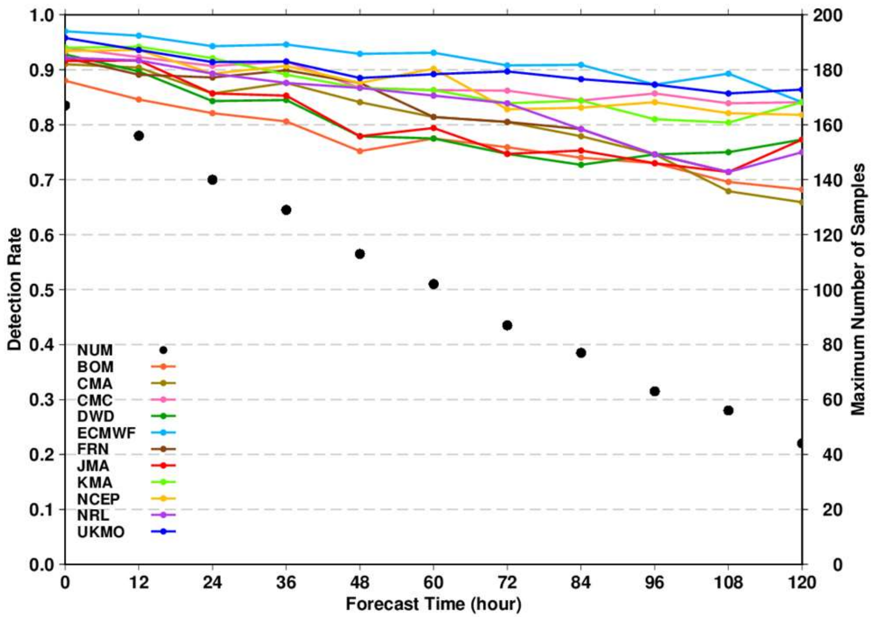


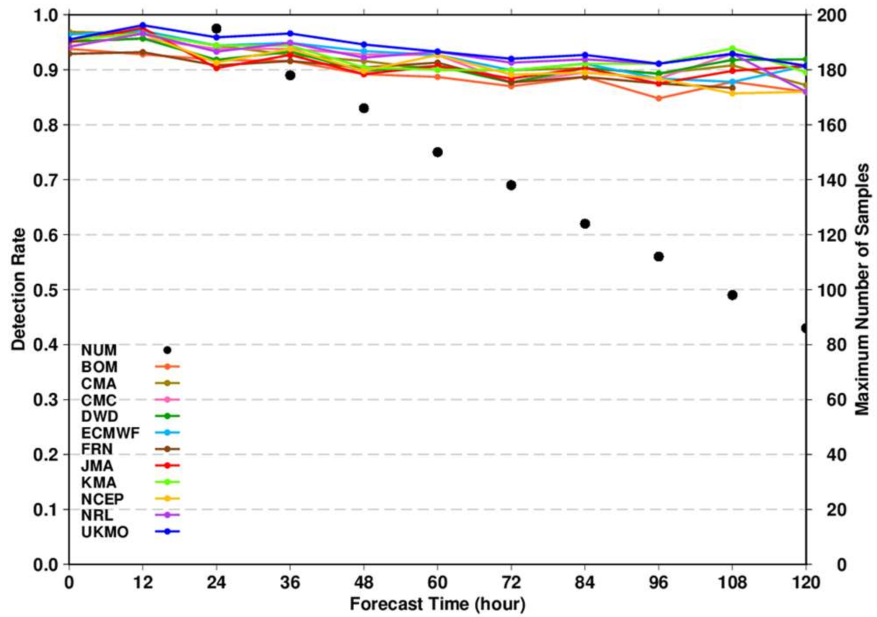
Position Error





Detection Rate





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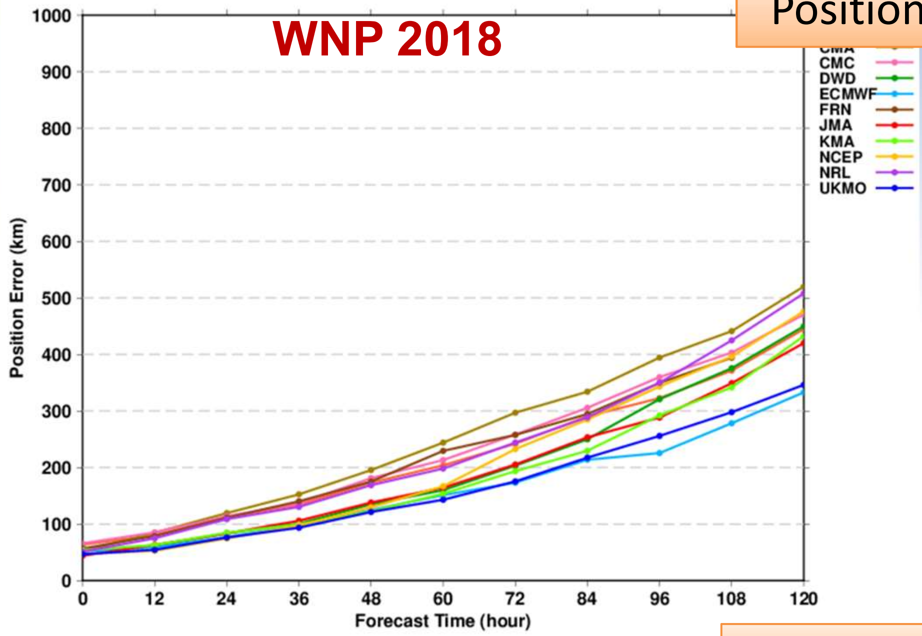

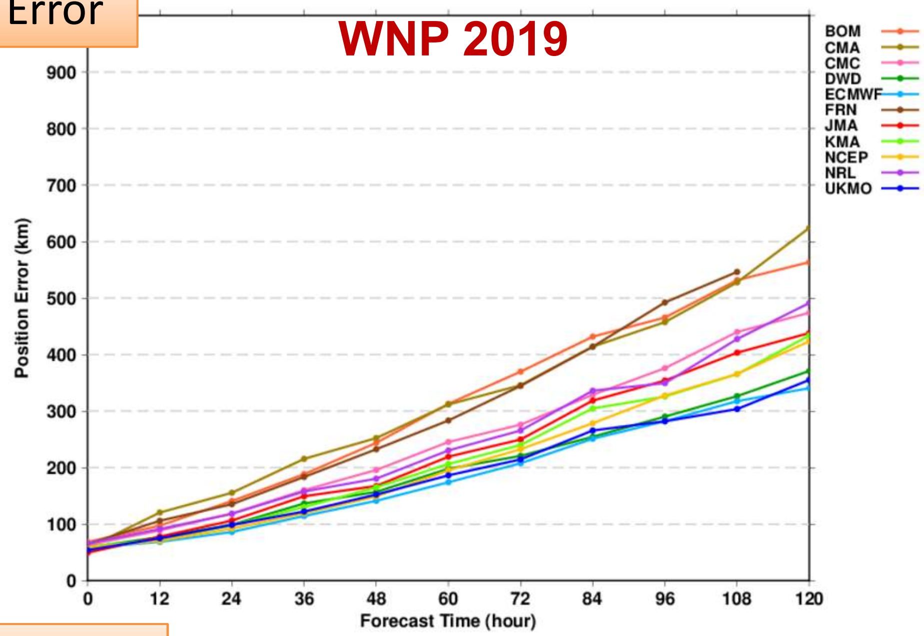

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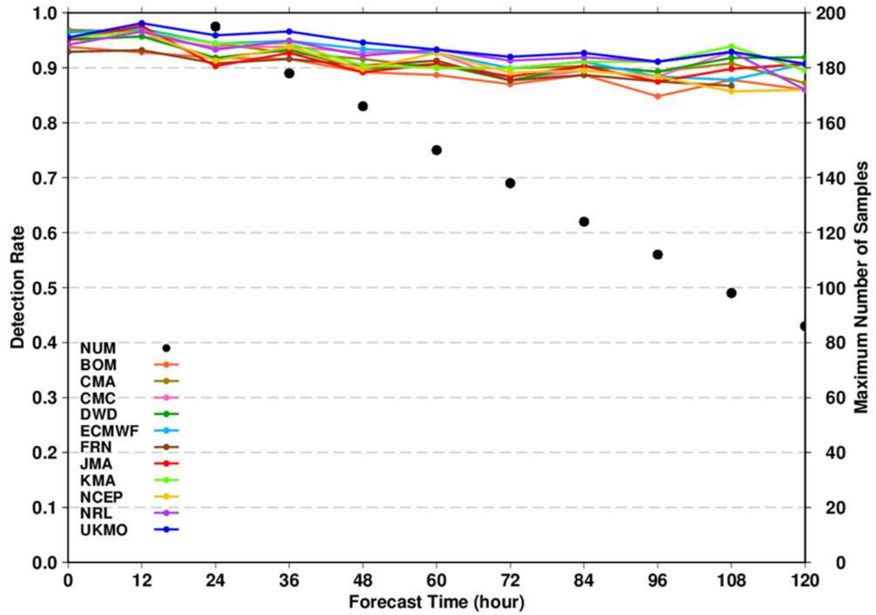
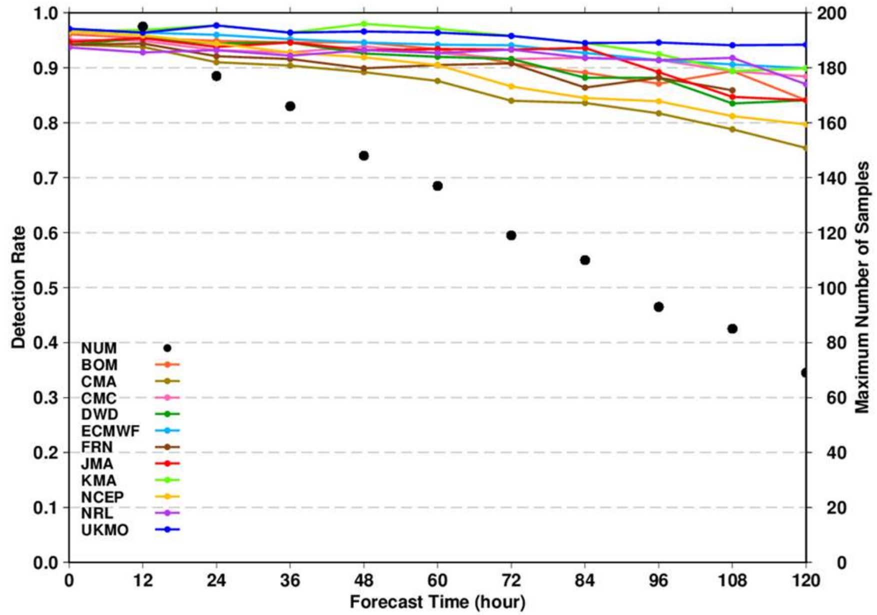
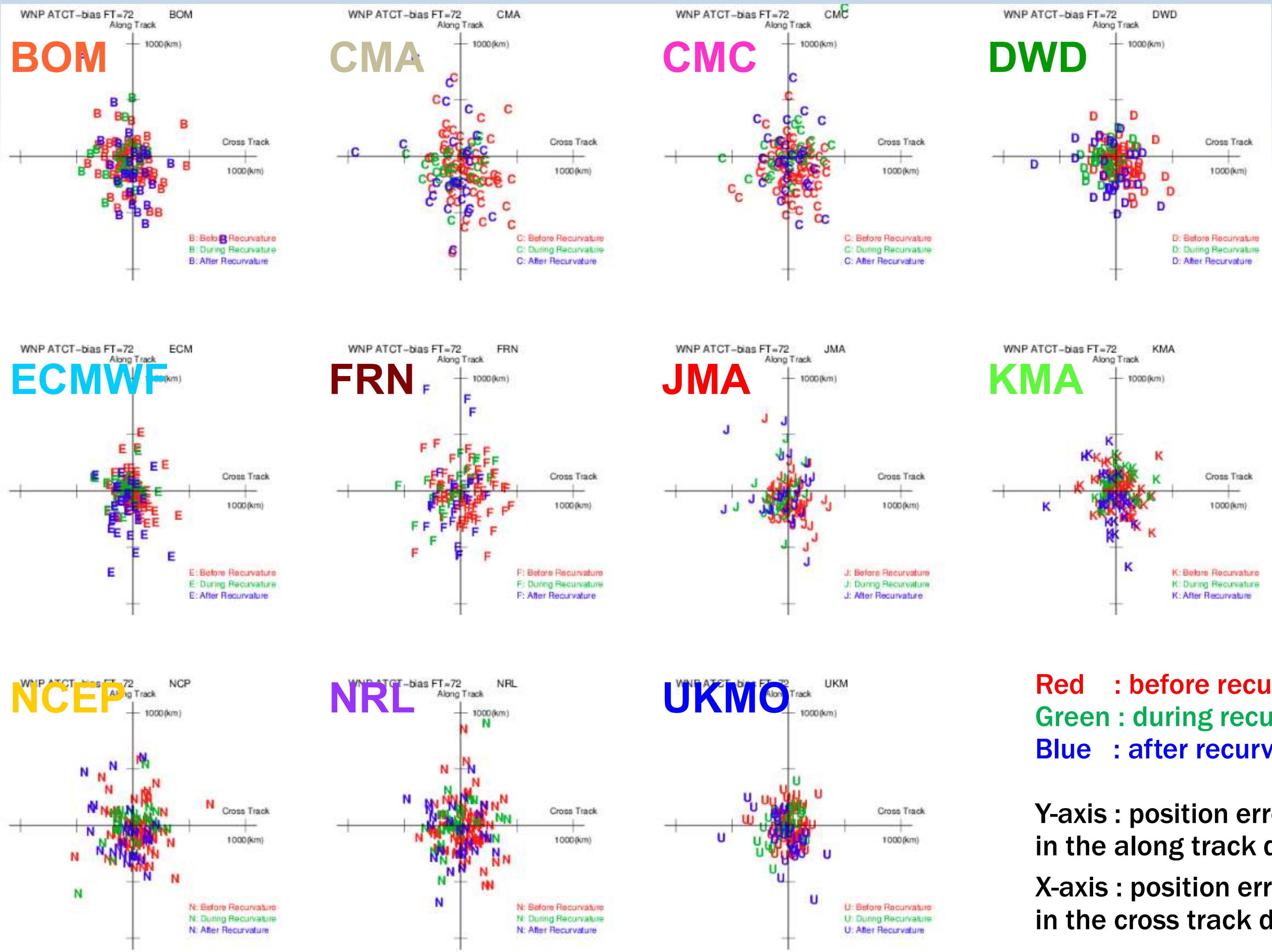




(a) WNP AT-CT Bias (FT=72) 2018



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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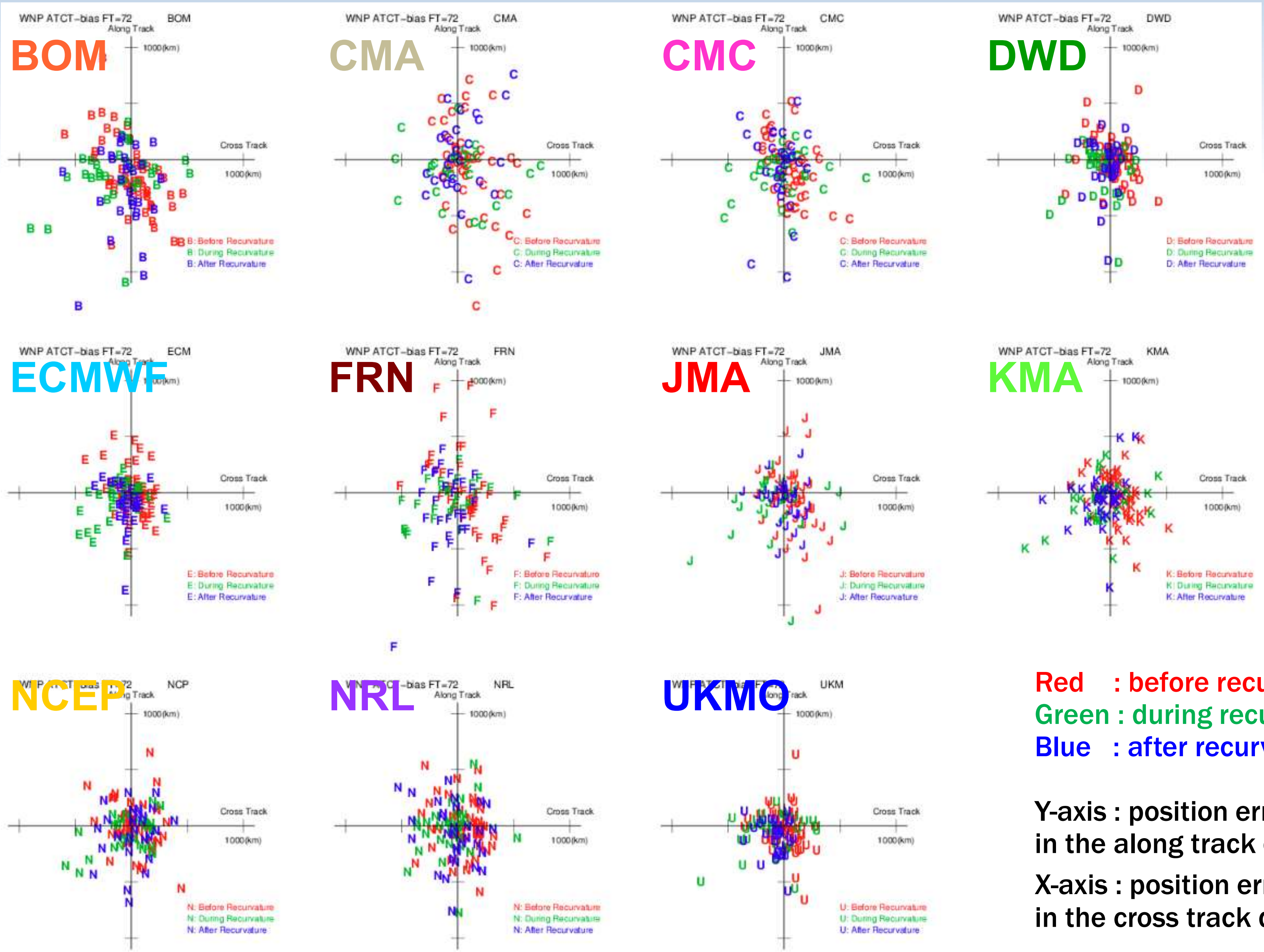

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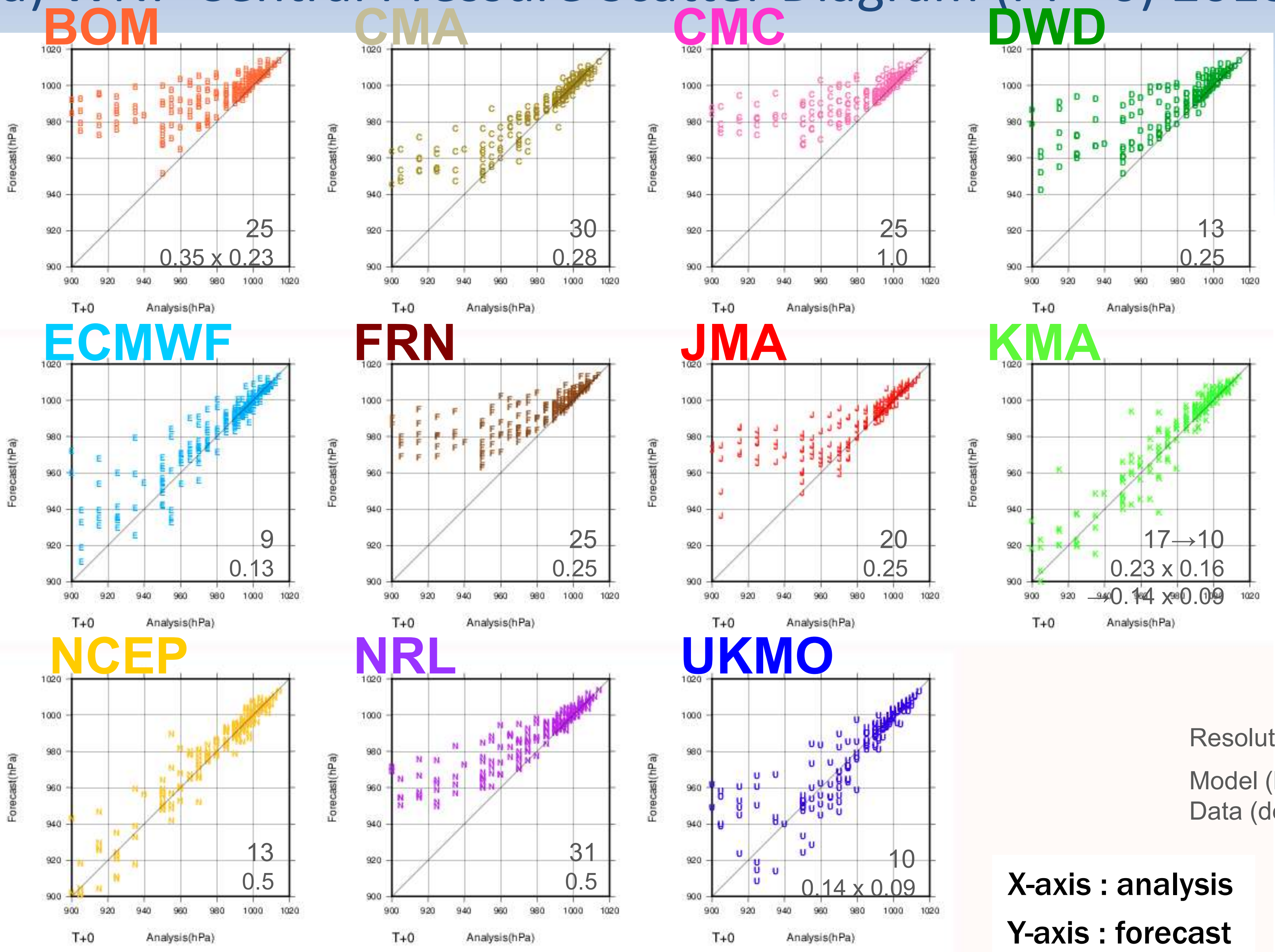
(a) WNP Central Pressure Scatter Diagram (FT +0) 2018



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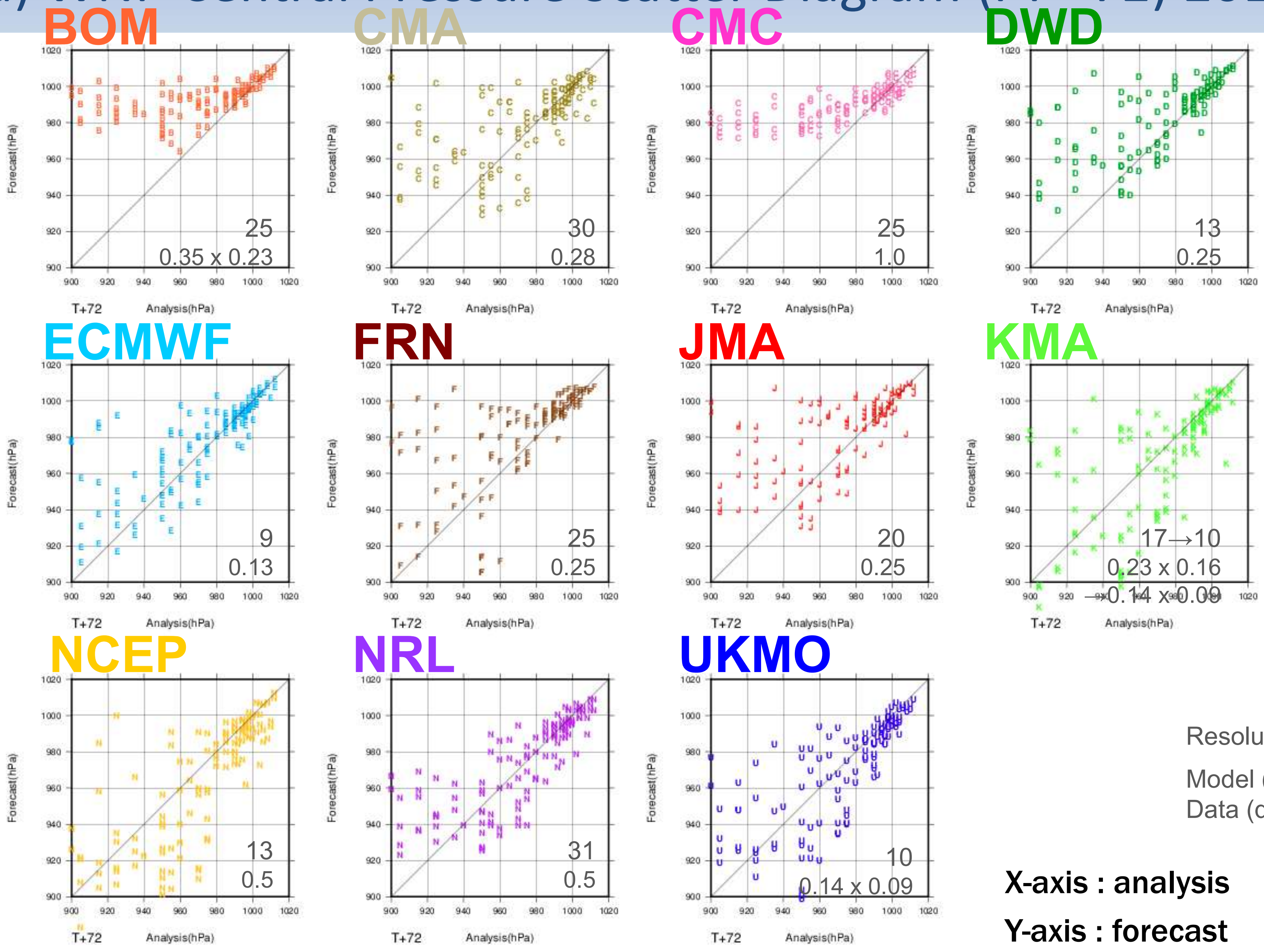

Resolution

Model (km)
Data (deg)

X-axis : analysis

Y-axis : forecast

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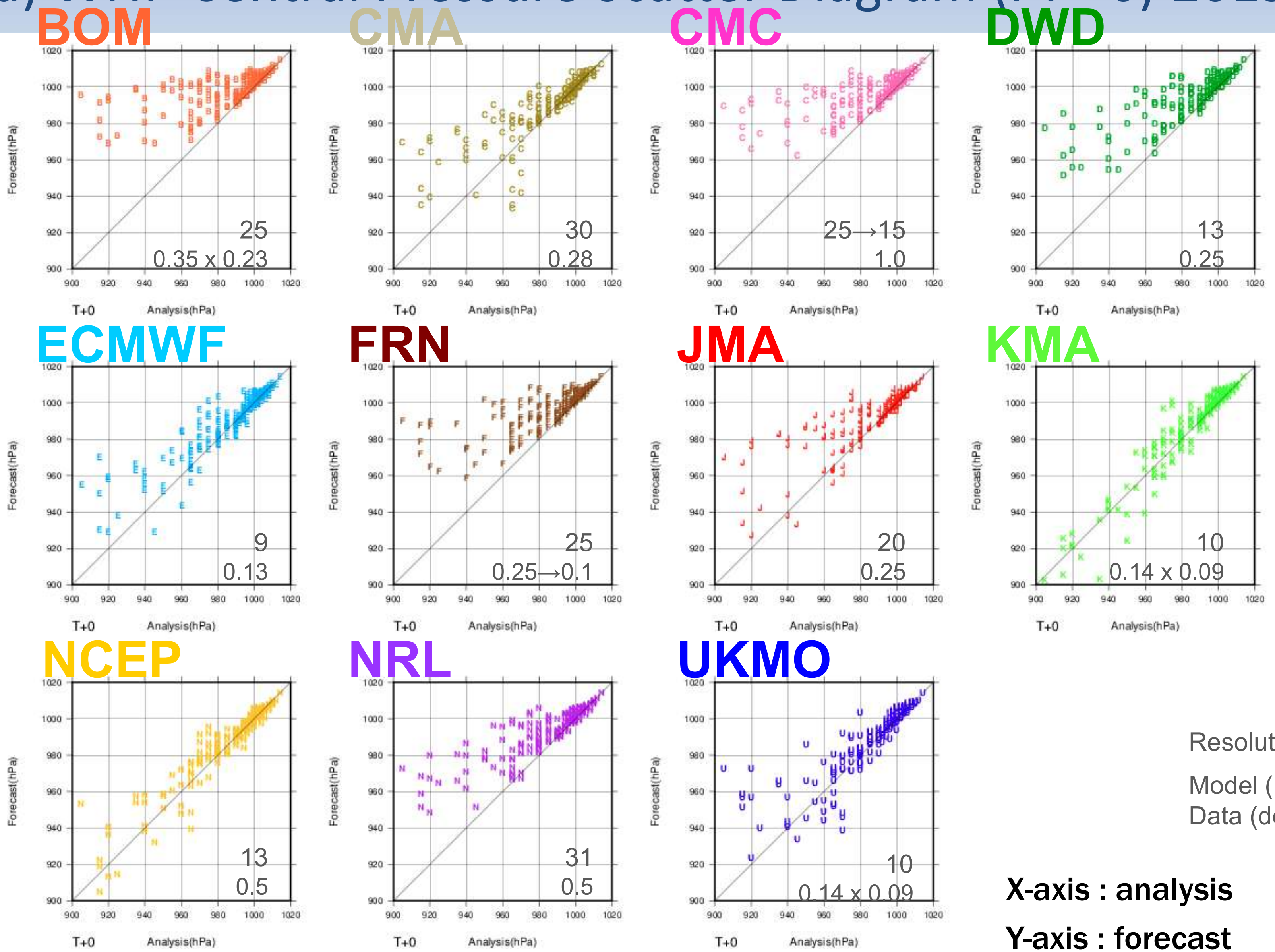

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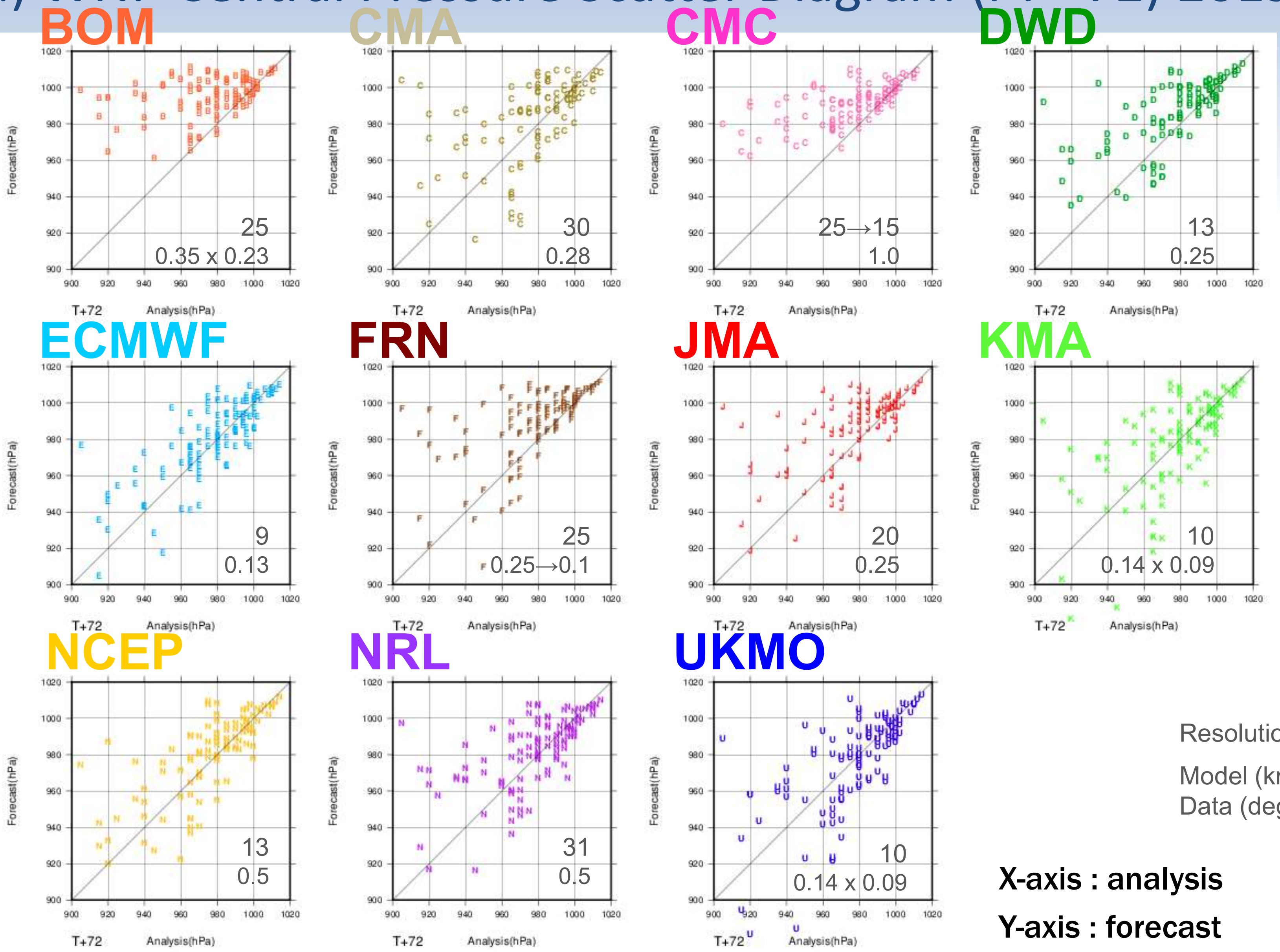

Resolution

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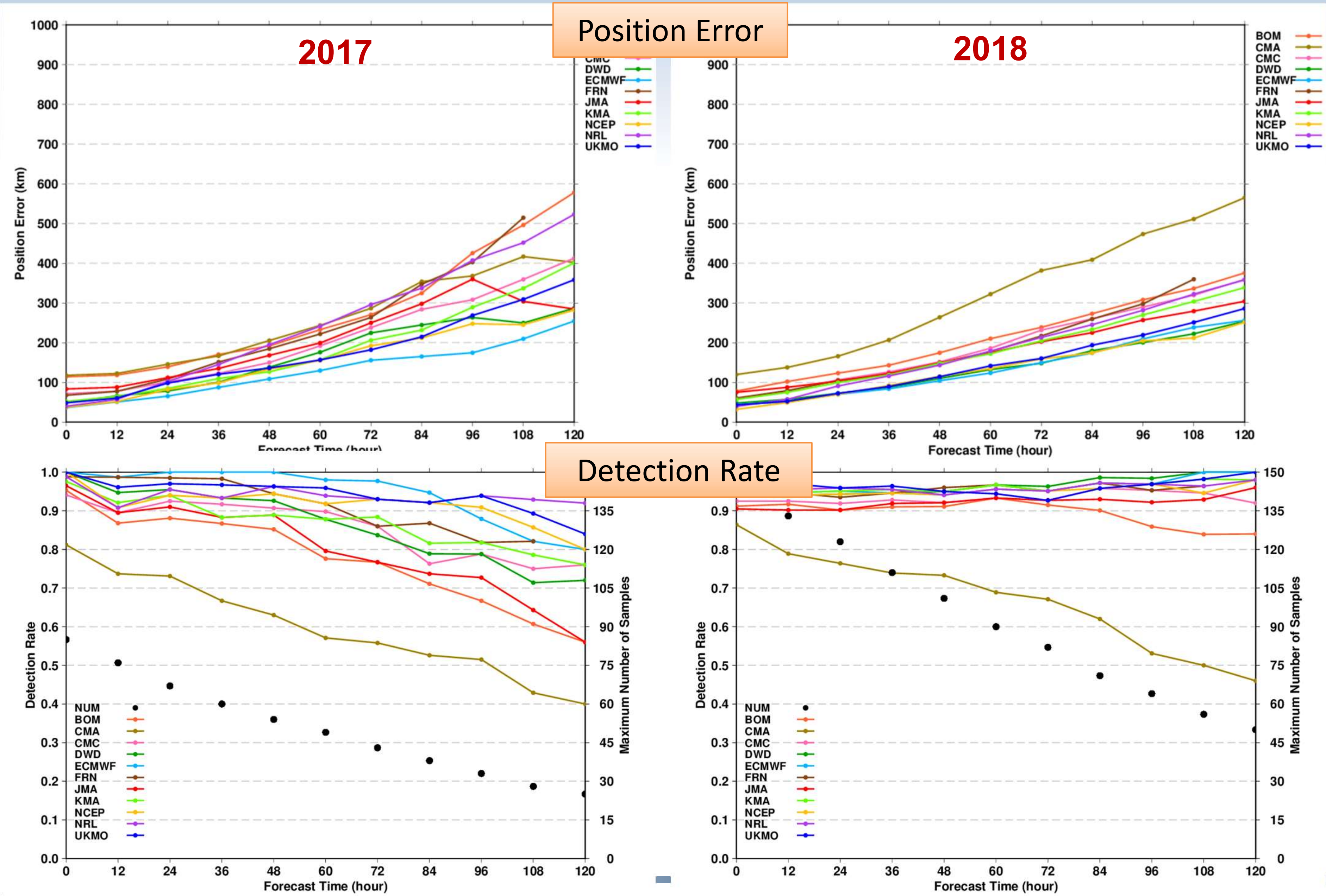
(c) Eastern North Pacific (ENP)



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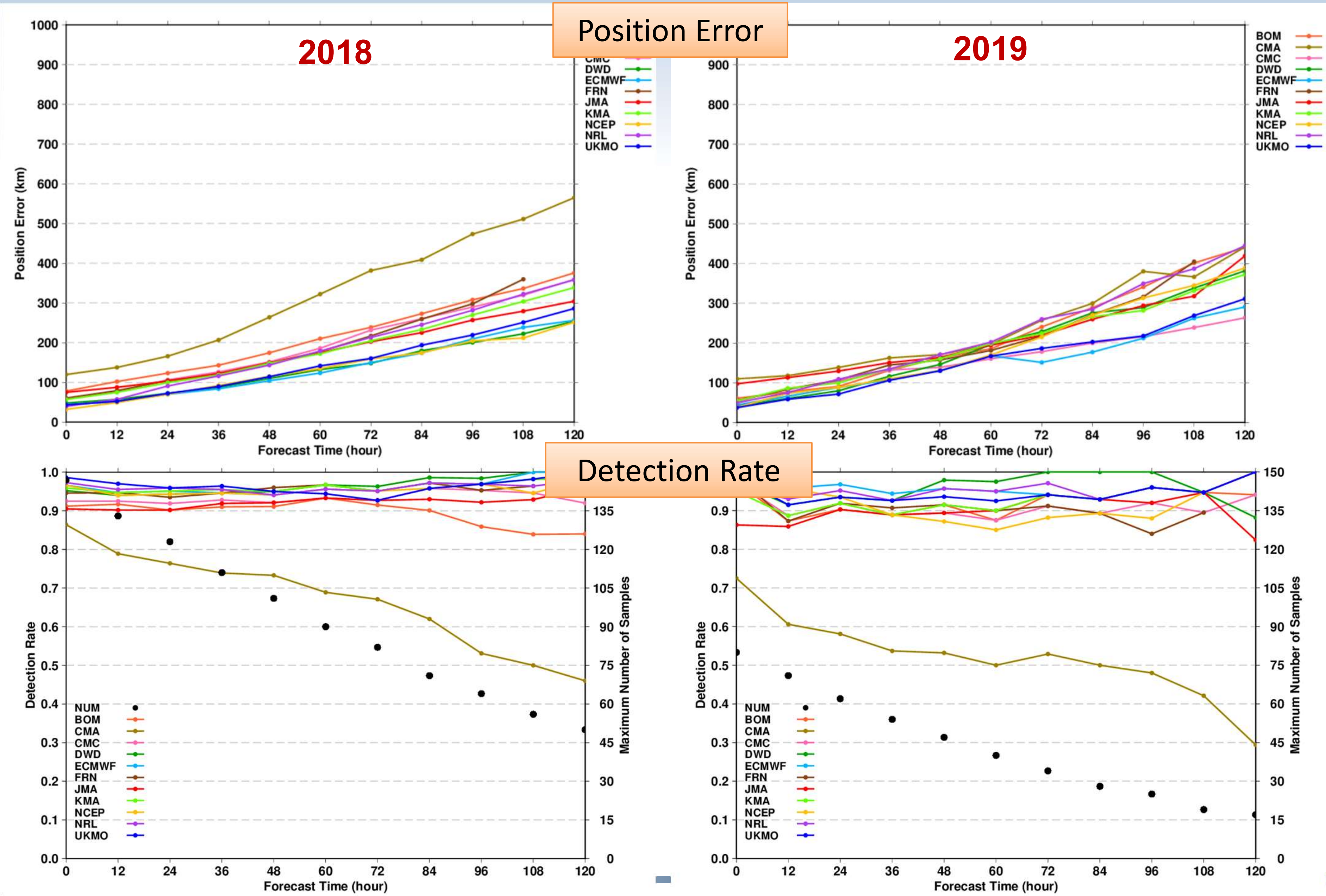
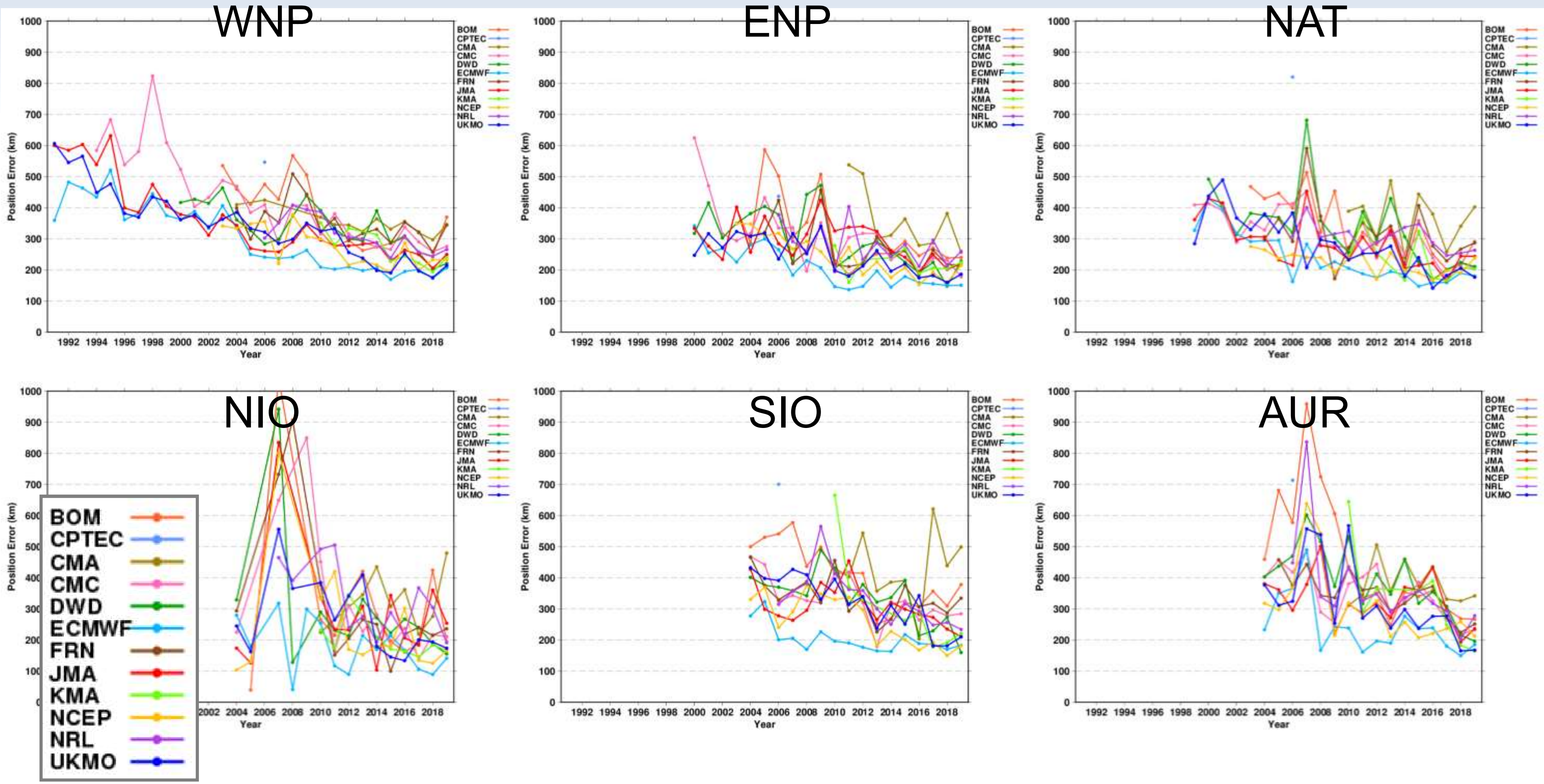


Transition of FT=72 Position Error over Decades



Summary of verification 2018 and 2019 (1/2)

- Position errors
  - Smaller track errors and spreads and higher detection rates are seen in WNP 2018.
  - Slow bias after re-curvature, a well-known common bias, was not been clear in 2018 and was seen again in 2019.
  - TC position errors have decreased gradually in each region.
    - However, the position errors start to be saturated recently?
  - ECMWF and Met Office performed well at most of regions, particularly at T+120.

Summary of verification 2018 and 2019 (2/2)

- Intensity errors
  - Except for a few centres, global NWP systems tend to analyze and predict shallower TCs than those of the best tracks.
  - Some models tend to over-deepen TCs.
    - NCEP reduced frequency of the over-deepening in 2019 compared with that in 2018
      - Due to model upgrade?

TC intercomparison website will be available soon!

WGNE Intercomparison of Tropical Cyclone Track Forecasts Using Operational Global Models

Updated: 2 November 2020

Forecast | Verification | Introduction | Read Me | Data | Contact | Link

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Welcome to
WGNE intercomparison of
Tropical Cyclone Track forecast
website.

<http://nwp-verif.kishou.go.jp/wgne_tc/index.html>
Login ID: [redacted]
Password: [redacted]
Contact: globalnwp@met.kishou.go.jp

Updates on TC initialization efforts

- Action from WGNE-34
  - Collaboration with DAOS
  - DAOS are preparing a TC initialization review paper and shared the draft of the paper with WGNE
- What WGNE (and TC experts in member’s centres) could contribute to the review paper:
  - Trend in choice of TC initialization among operational centres
  - Experience in development of TC initialization

TC initialization schemes employed in the participating centres

TC initialization scheme	subtype	centres
Bogus	vortex insertion	None
	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 TC-specialized 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 representation of TCs

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

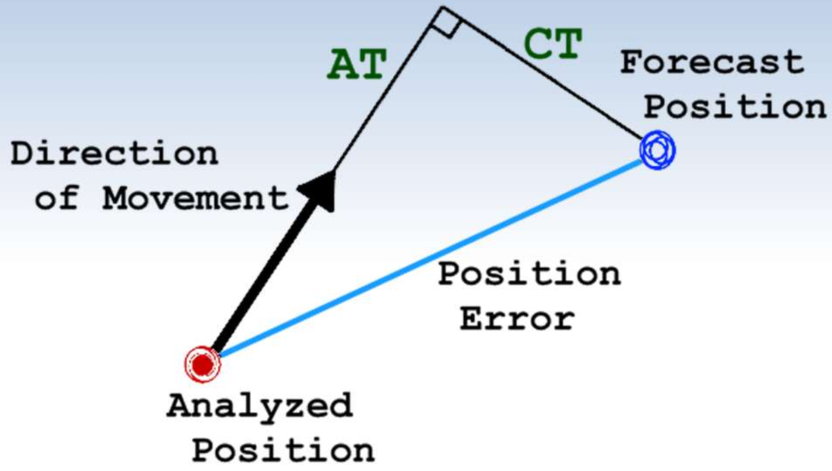
TCs are tracked using mean sea level pressure data provided by participating NWP centres. Under this method, the minimum pressure point is identified as the initial or predicted TC position.

1) First position (FT+0hr) 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.

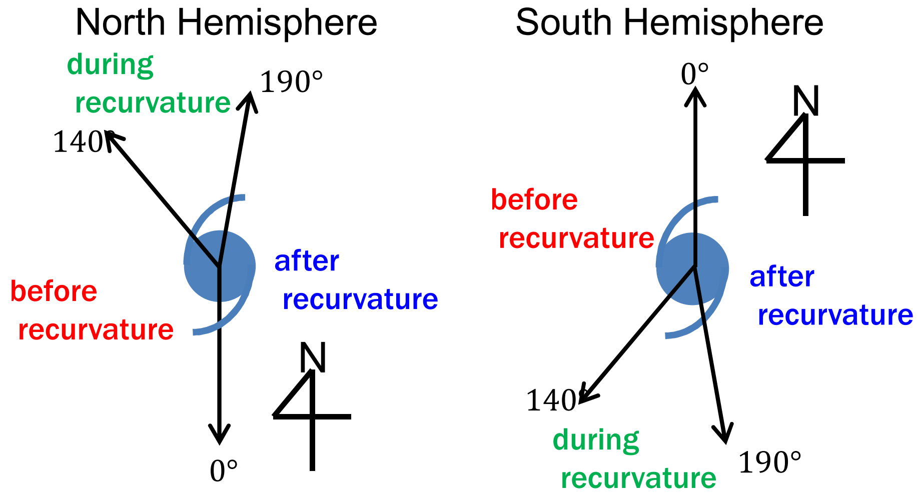
Definitions

- **Position Error〔km〕:**
  distance between the best track (analyzed) position and the forecast position



- **Along Track – Cross Track bias**
  AT (along-track) bias : bias in the direction of TC movement
  CT (cross-track) bias : bias in the direction perpendicular to TC movement

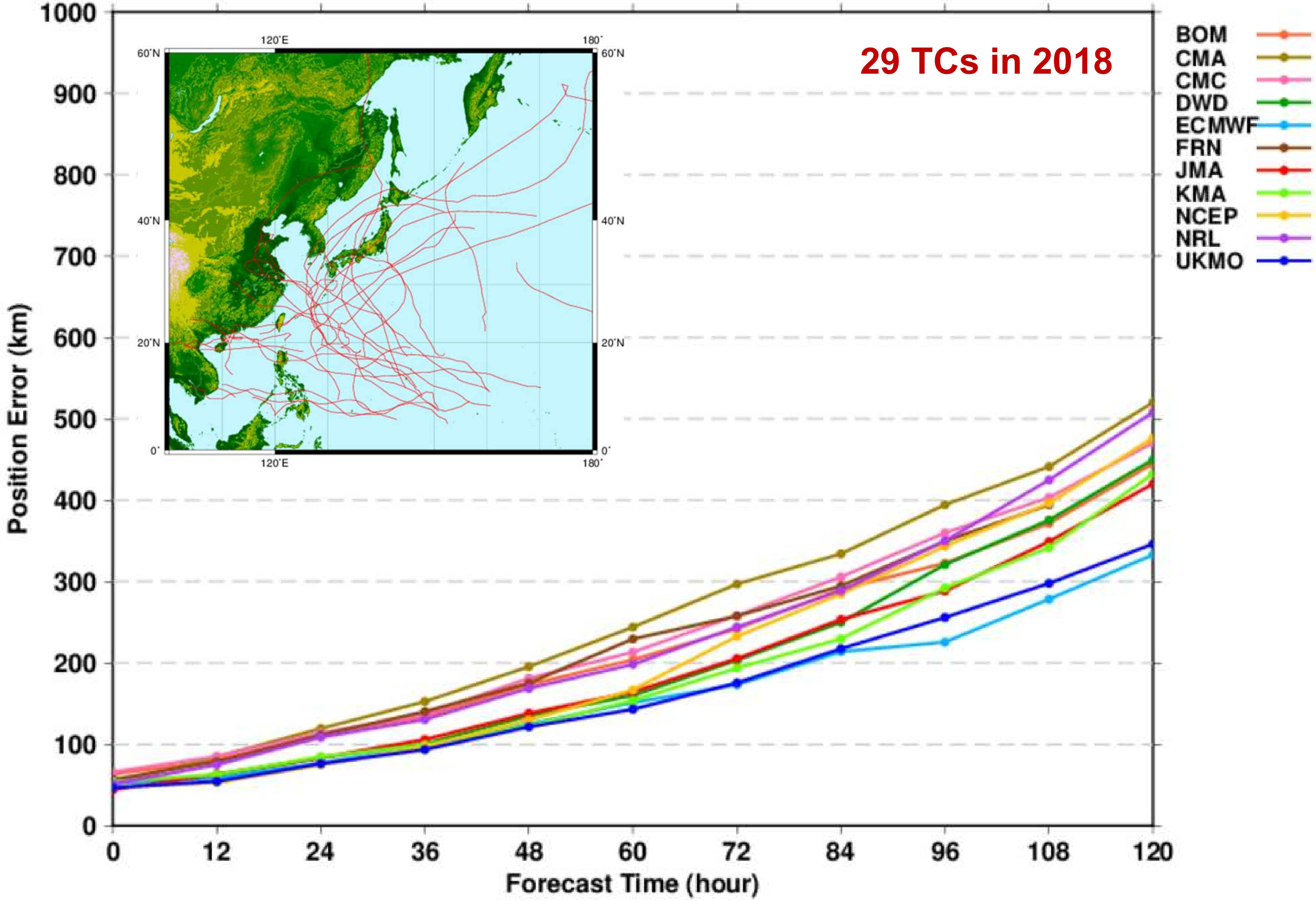
- **Recurvature**
  Before
  During
  After



- **Detection Rate**
  Detection Rate (t) = A(t)/ B(t) , where:

  A(t) : number of events in which a TC is analyzed at time t with the condition 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.

Western North Pacific (WNP) Position Error



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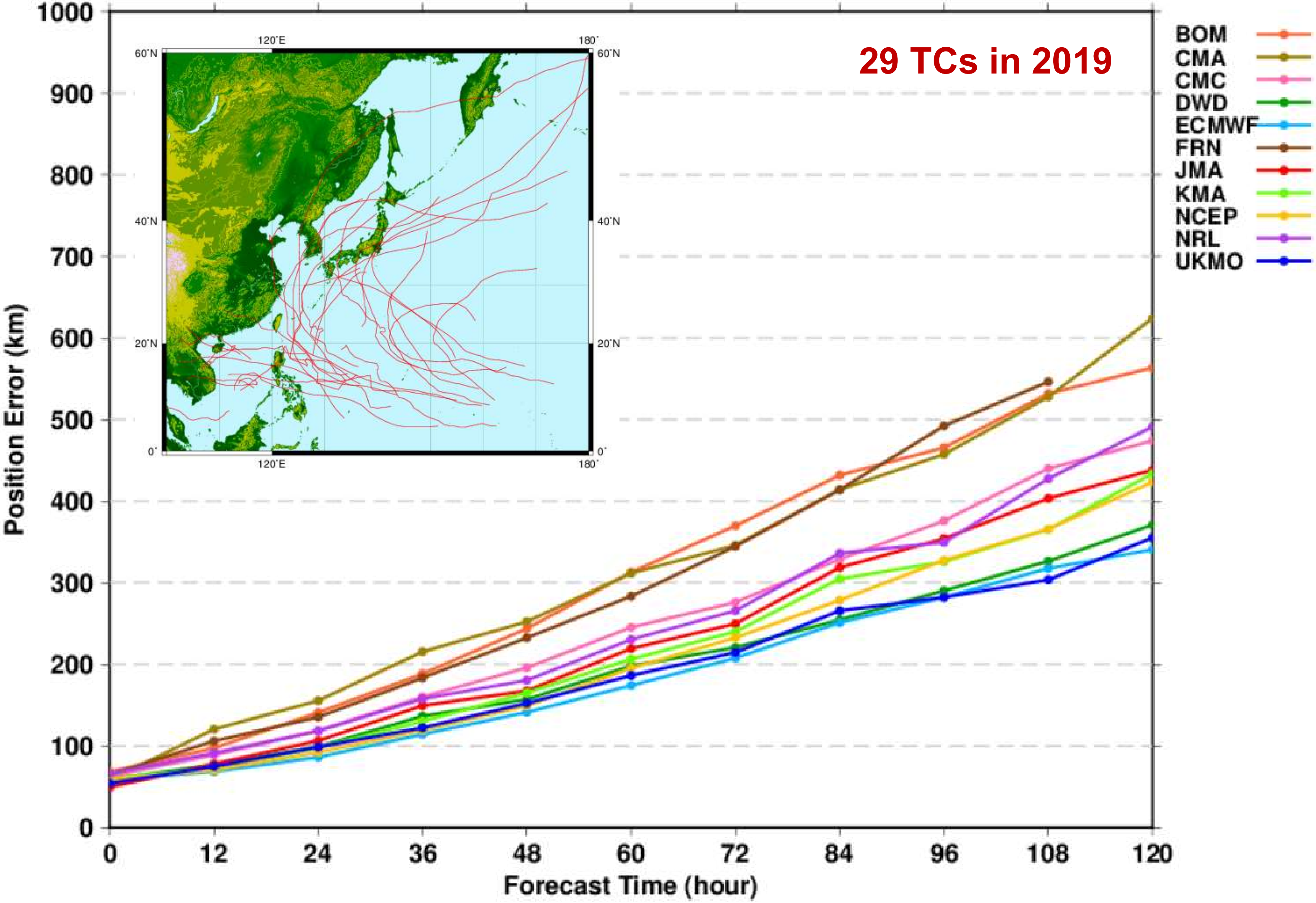
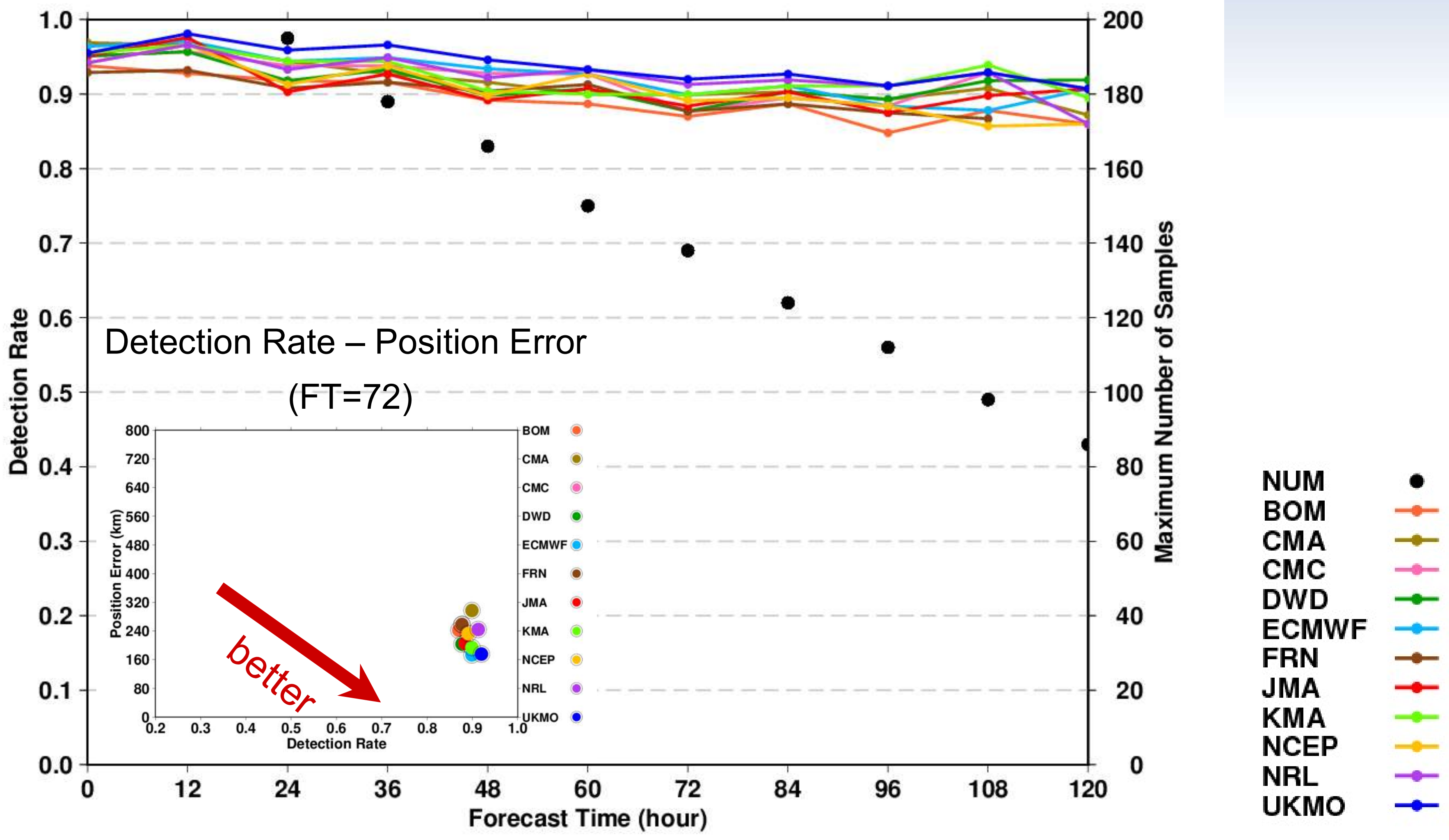
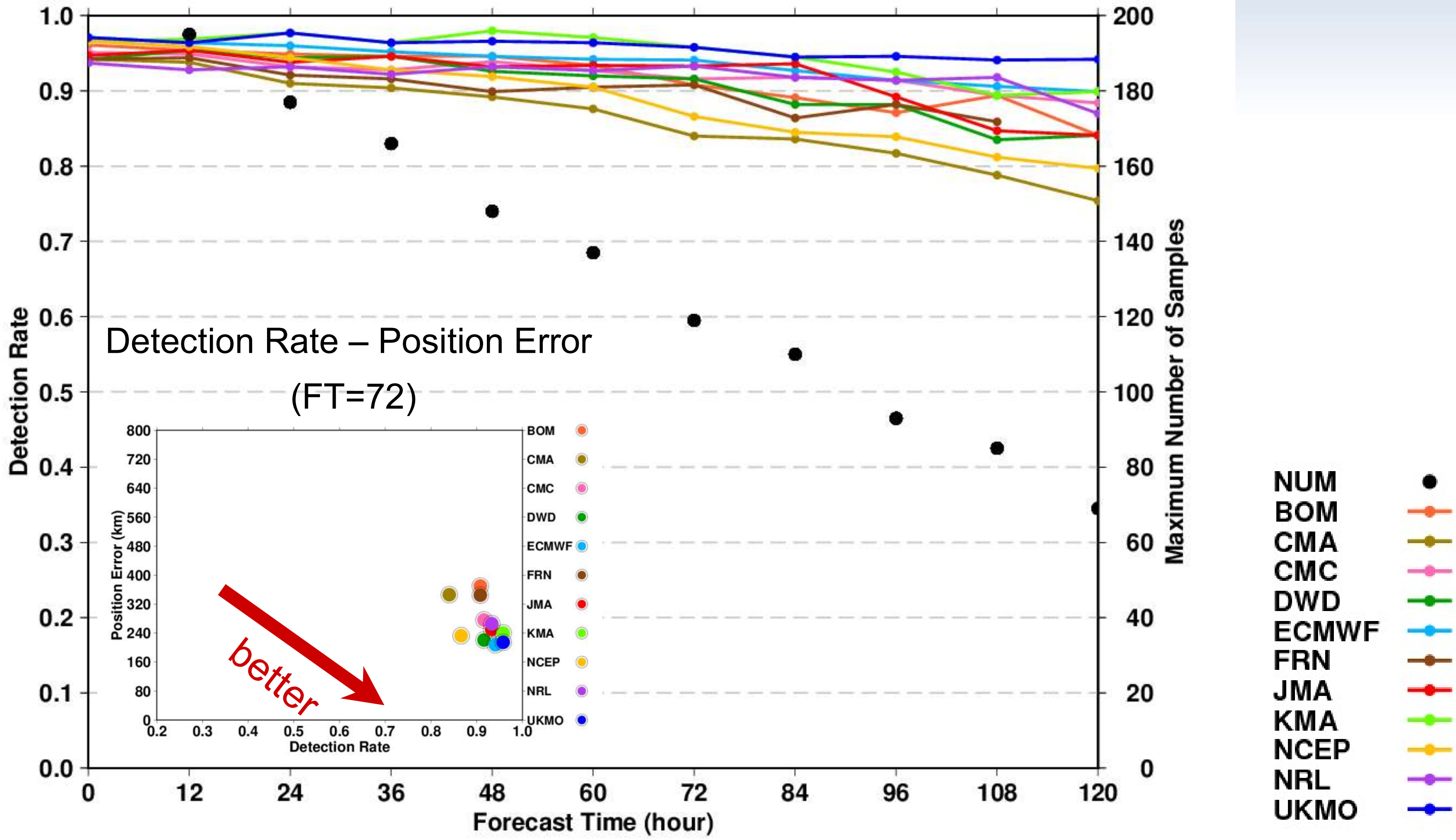


WNP Detection Rate 2018

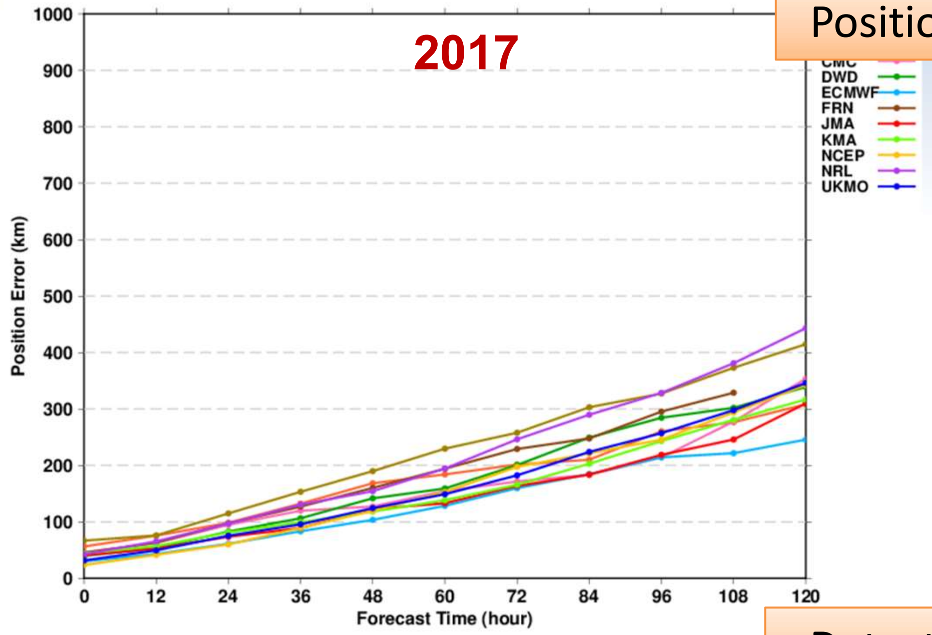


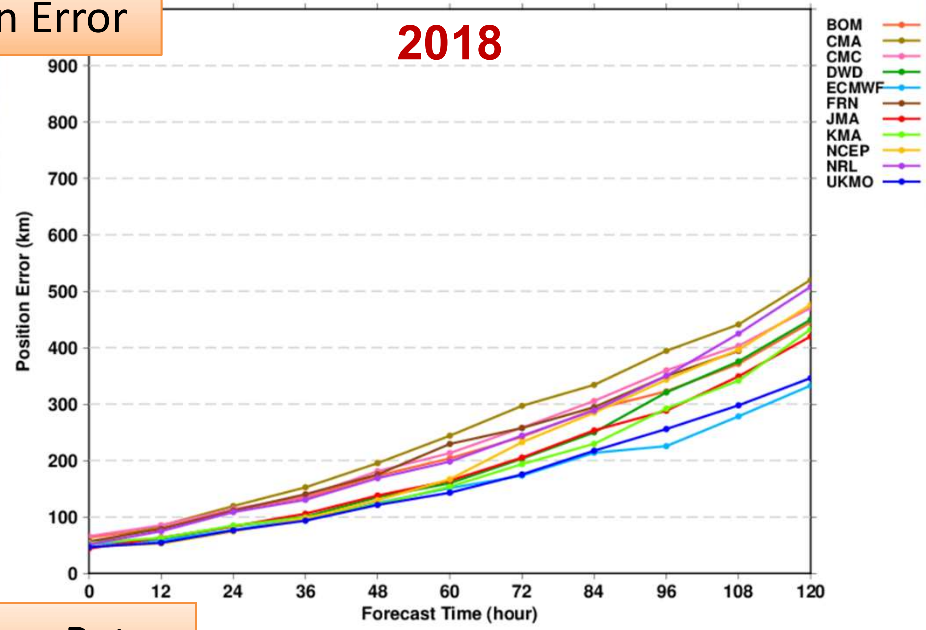
WNP Detection Rate　2019



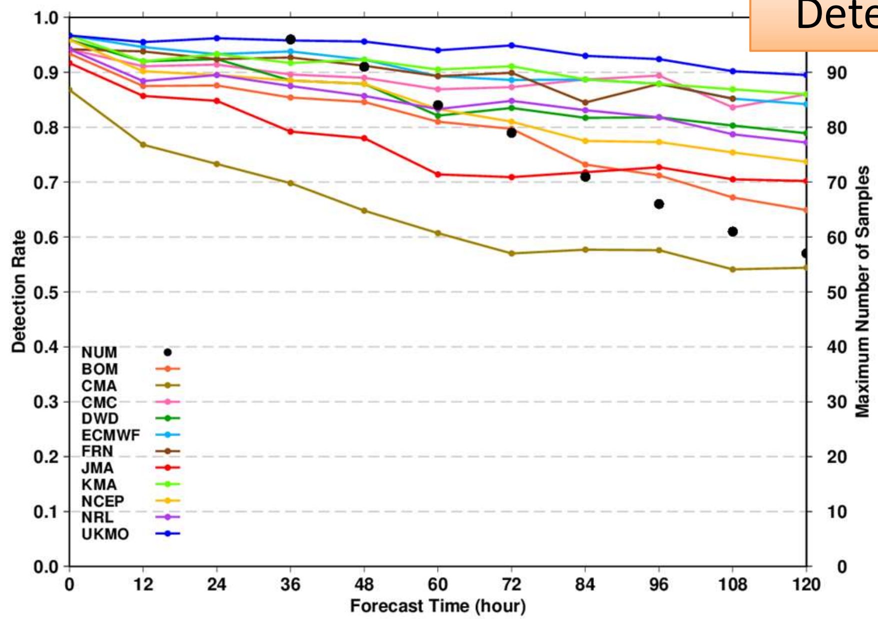
(b) North Atlantic (NAT)

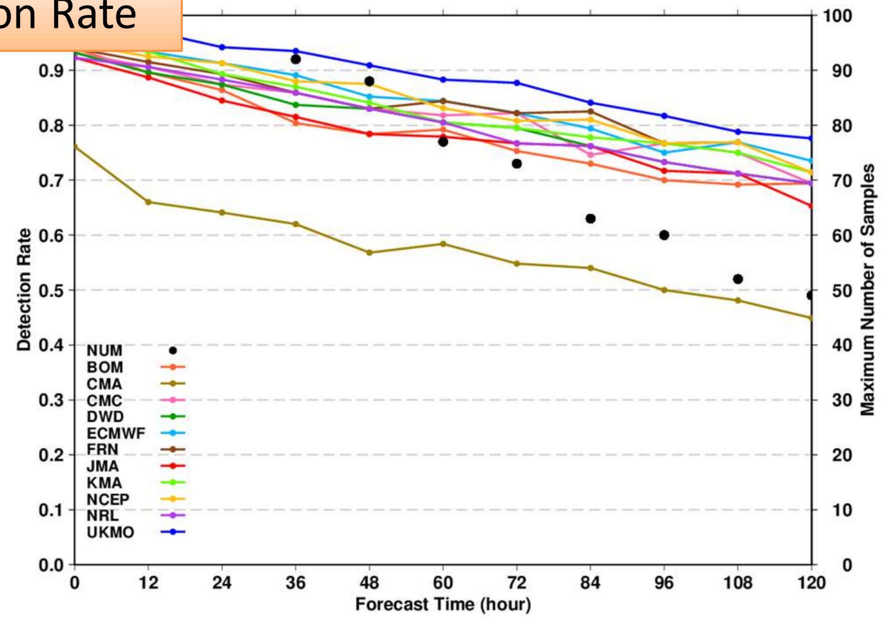
Position Error





Detection Rate





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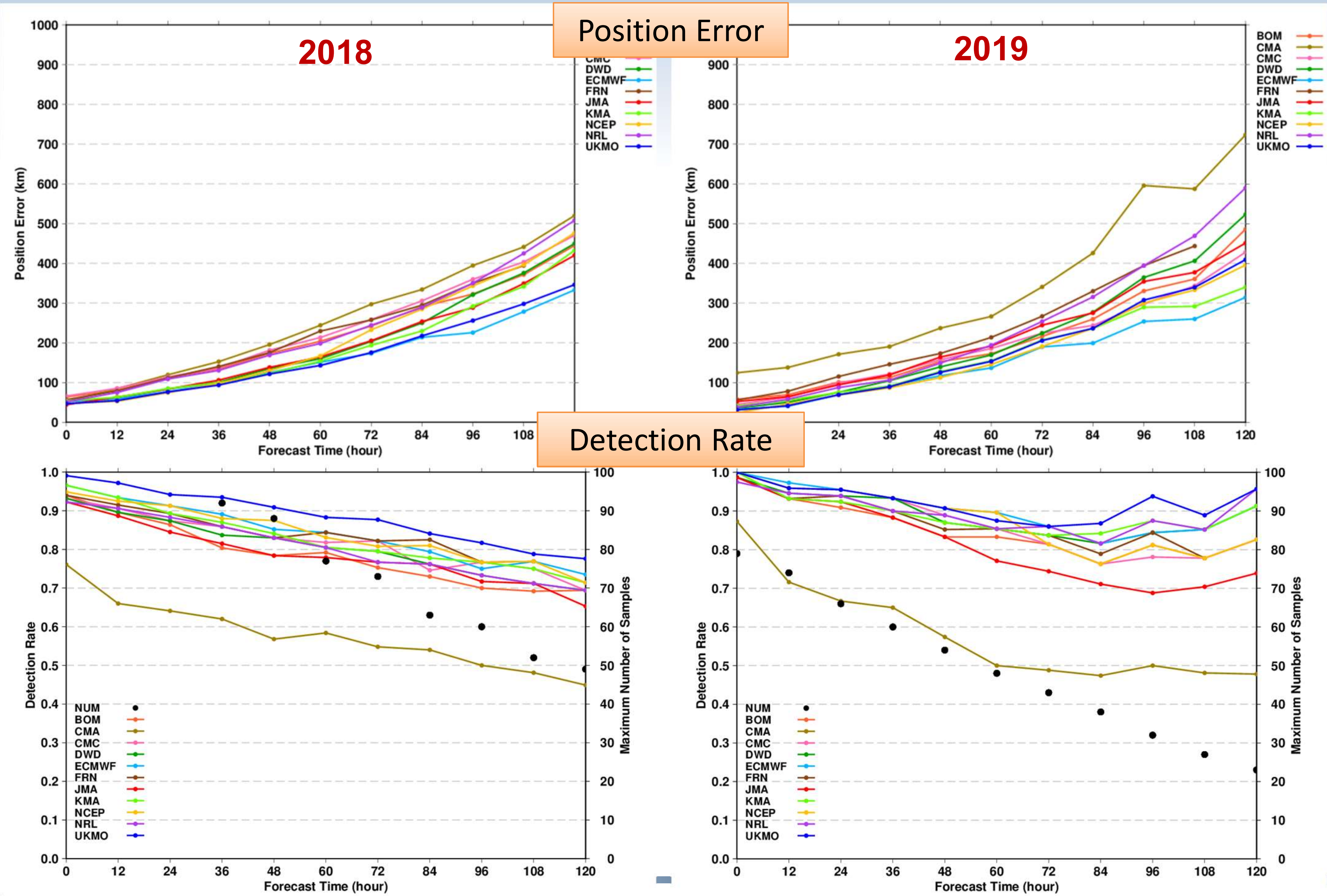
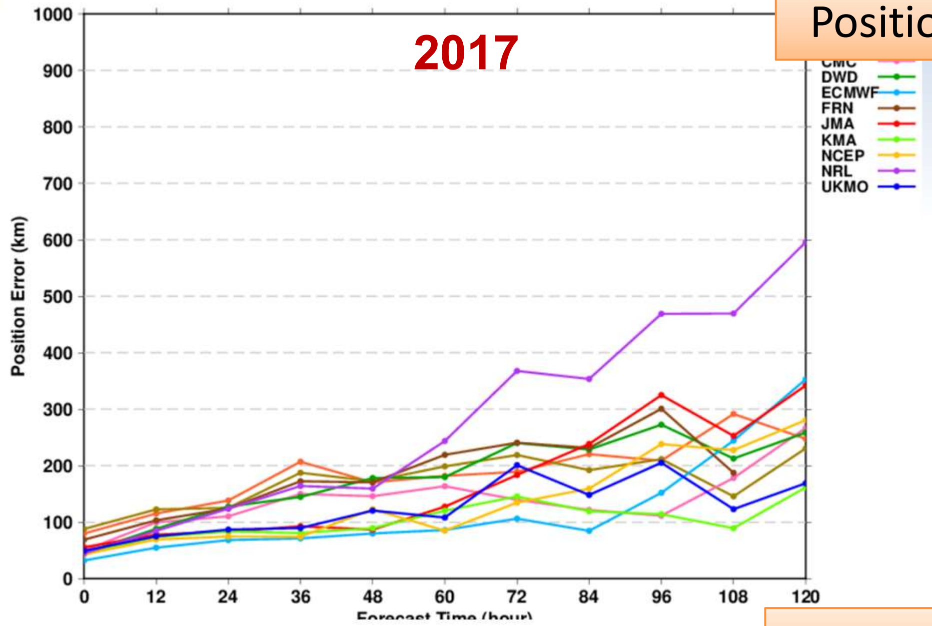
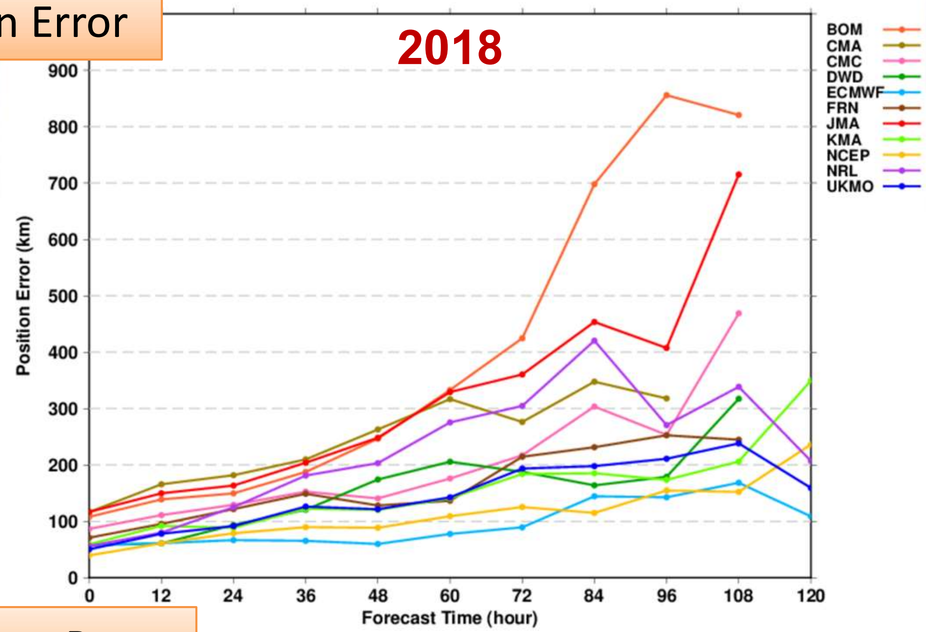


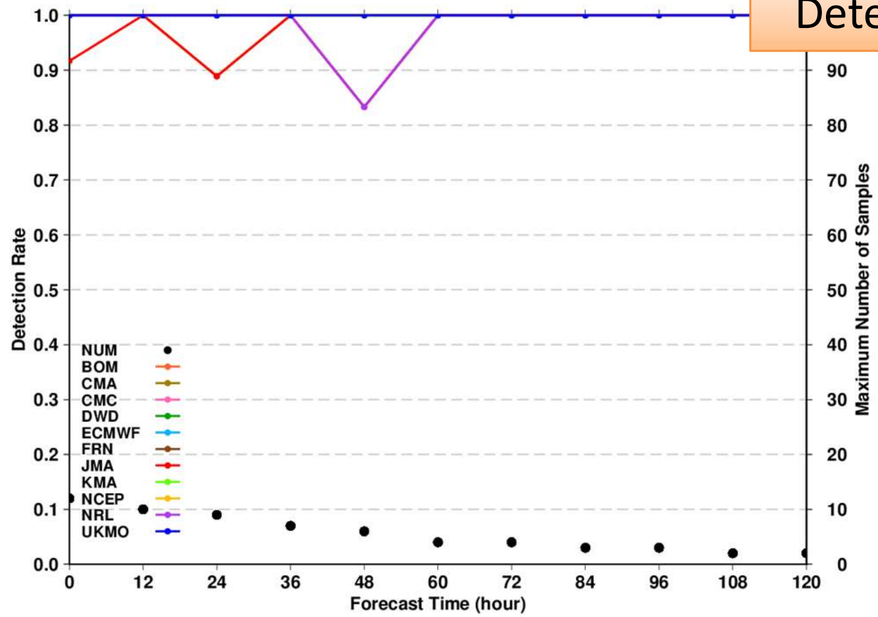
(d) North Indian Ocean (NIO)

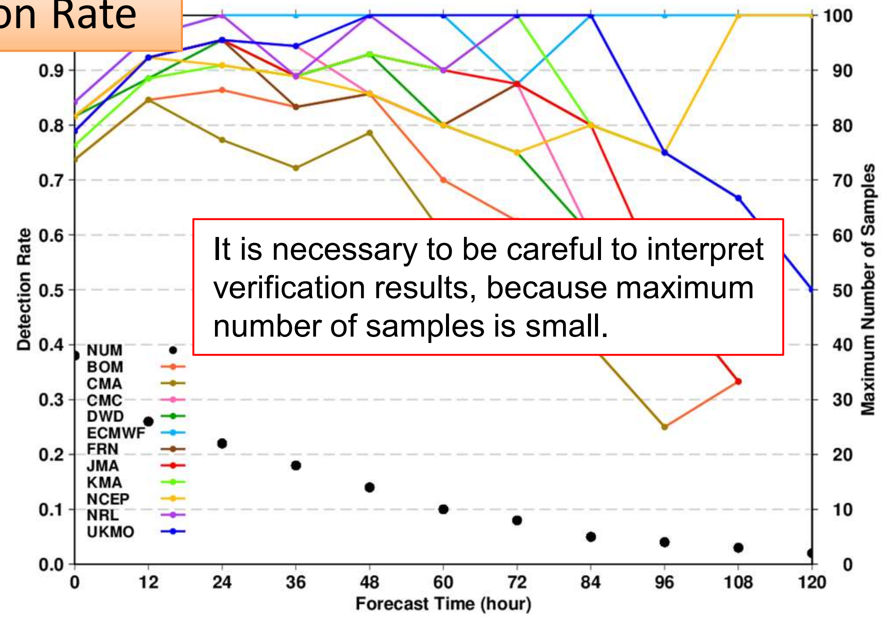
Position Error





Detection Rate





It is necessary to be careful to interpret verification results, because maximum number of samples is small.

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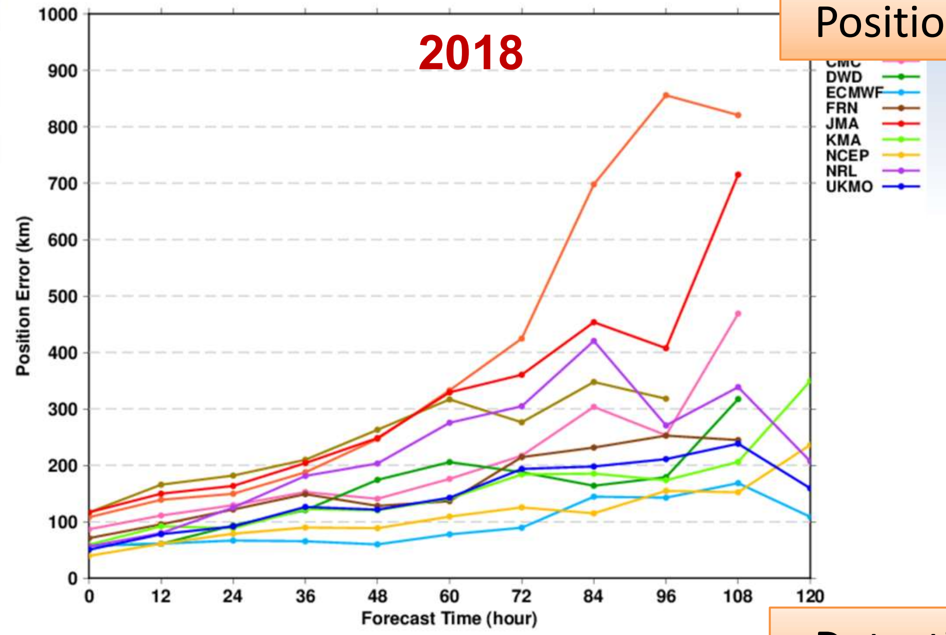

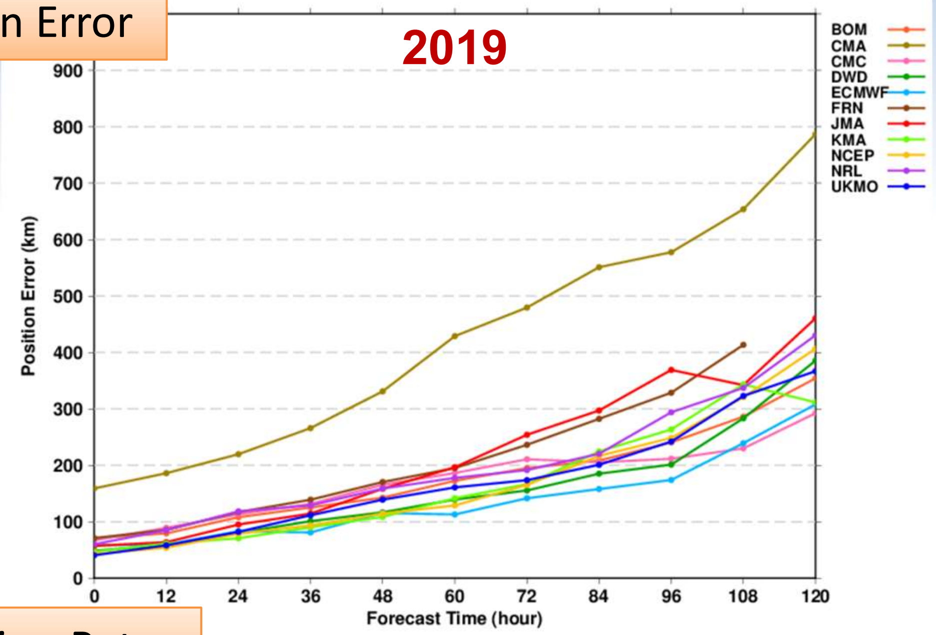

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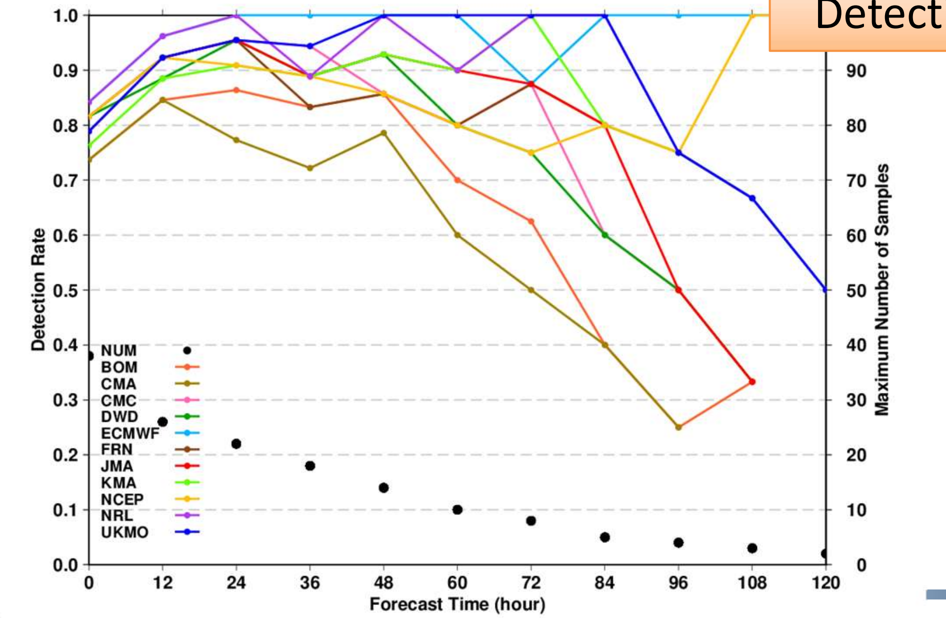

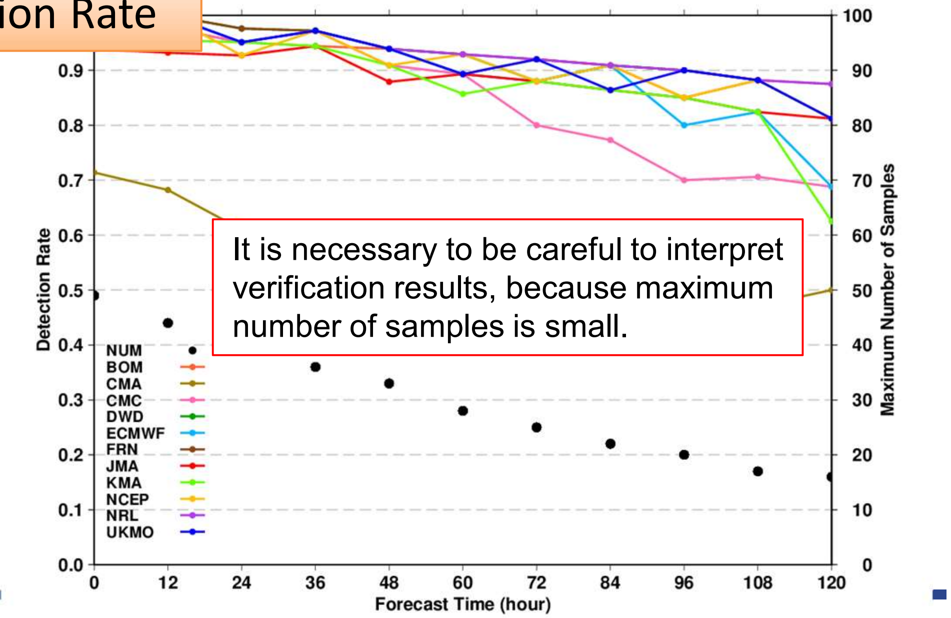

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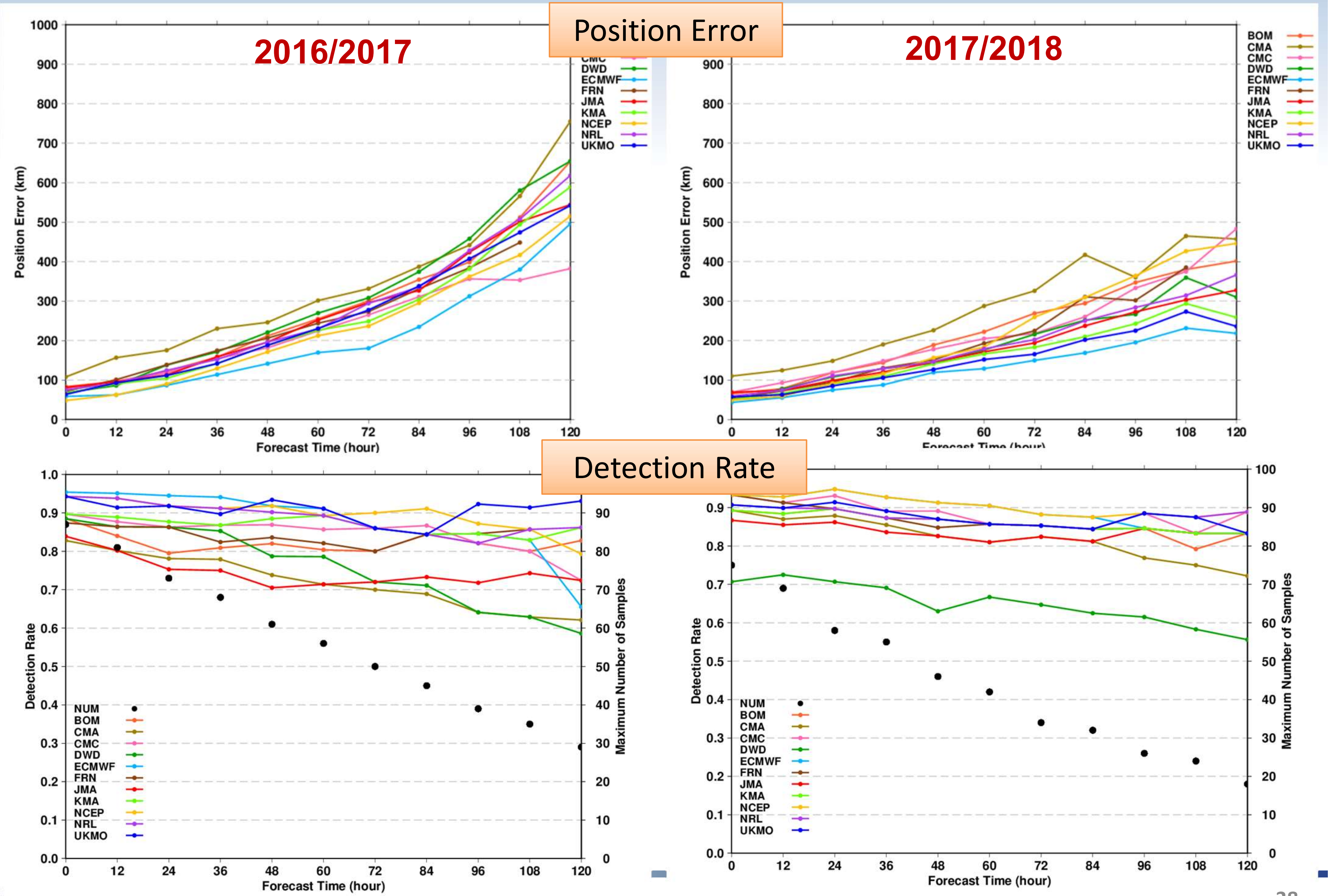
(e) “around Australia” (AUR)



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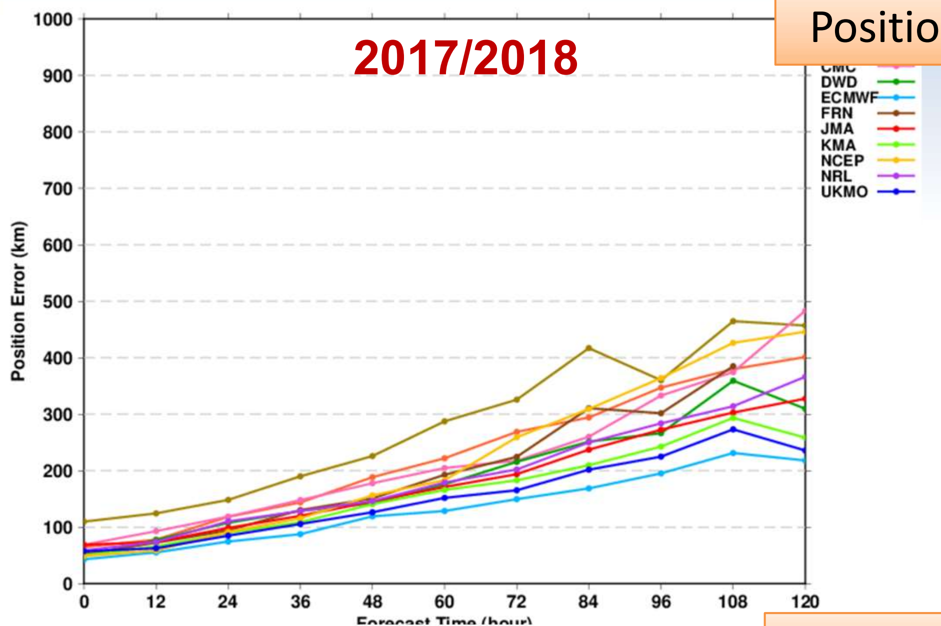
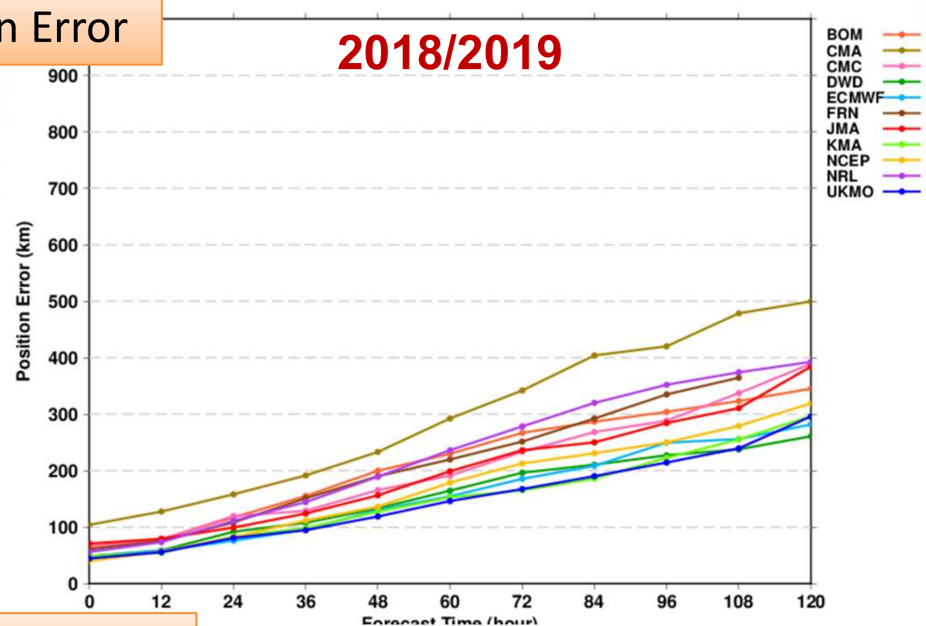
Position Error

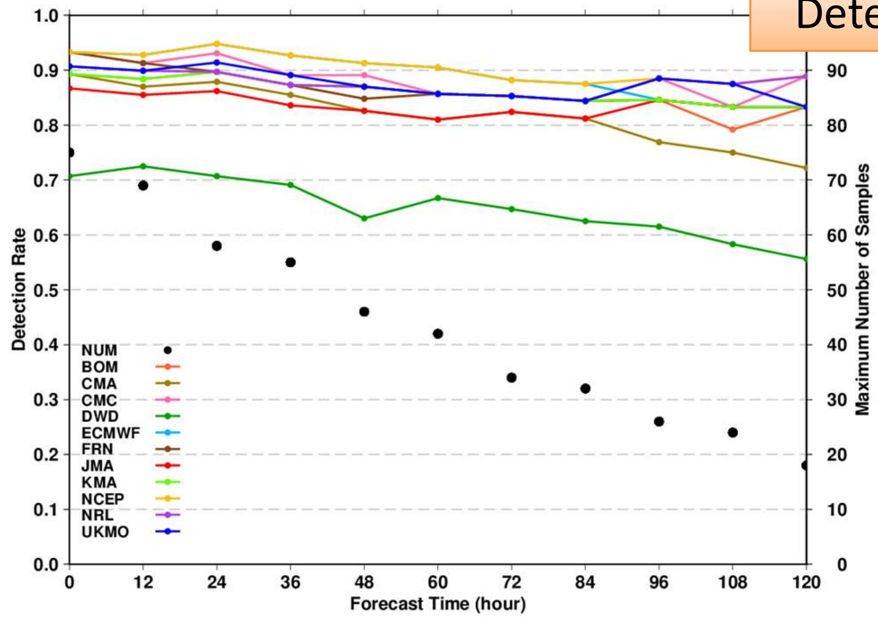
2017/2018

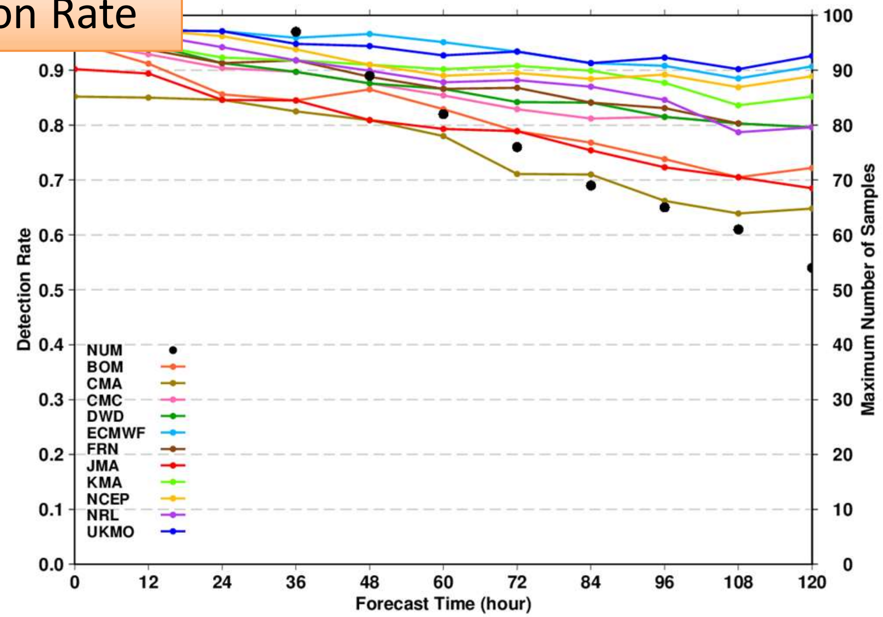


2018/2019

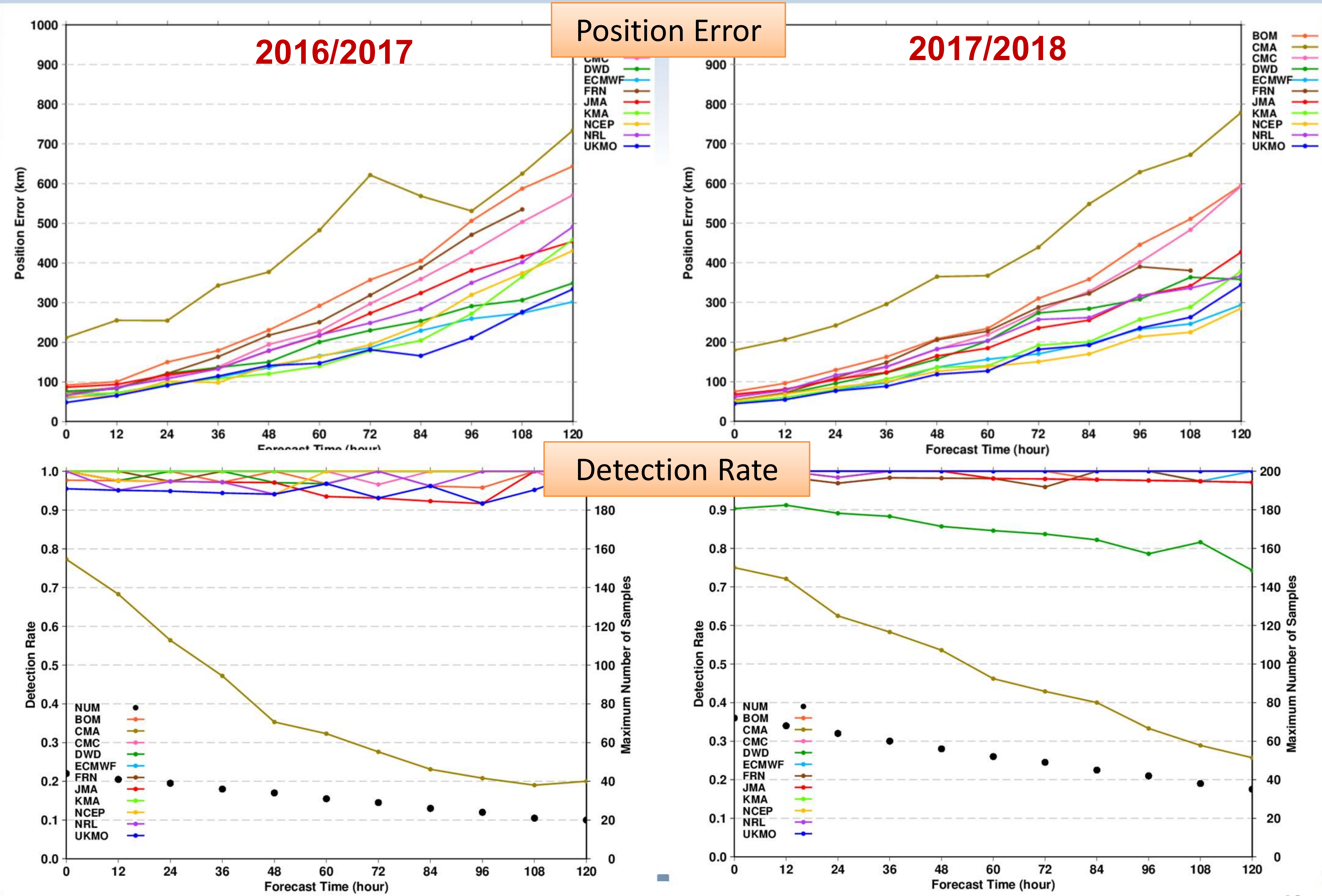


Detection Rate



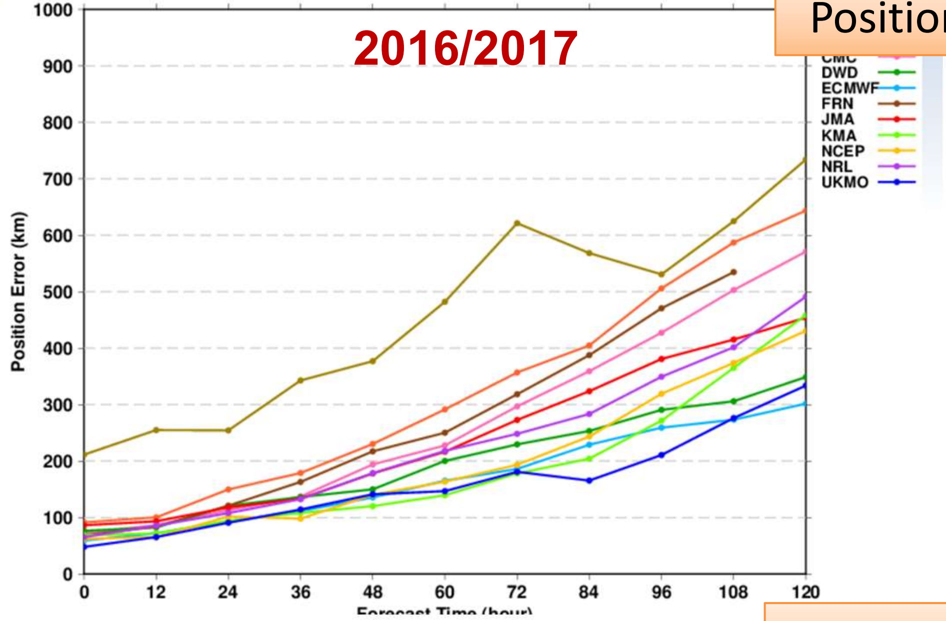


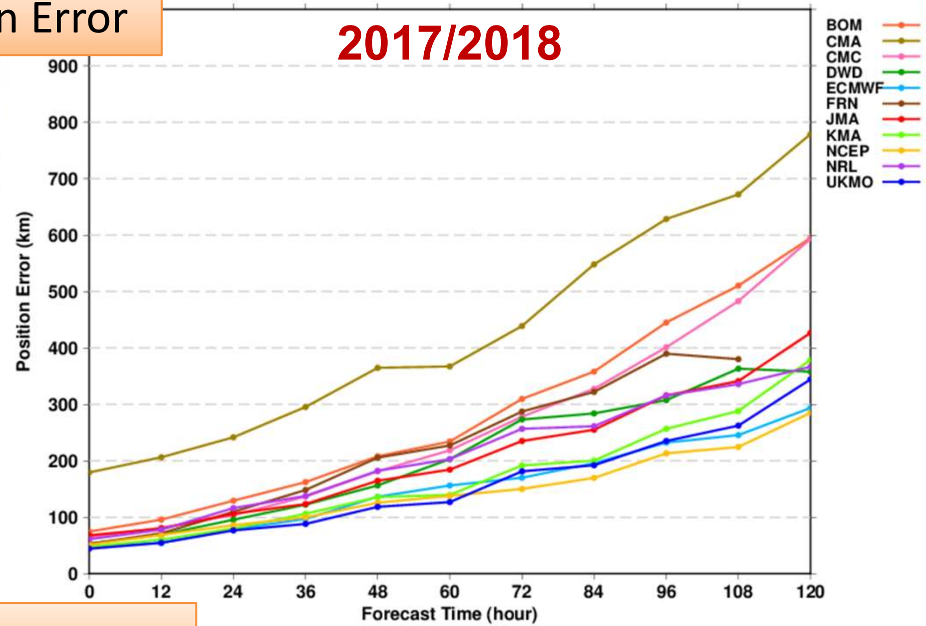
(f) South Indian Ocean (SIO)



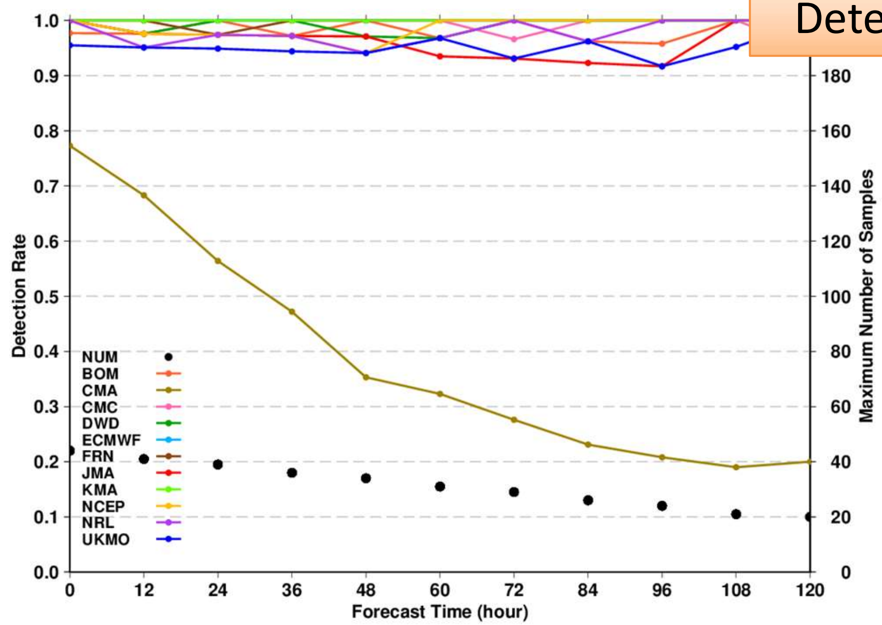
(f) South Indian Ocean (SIO)

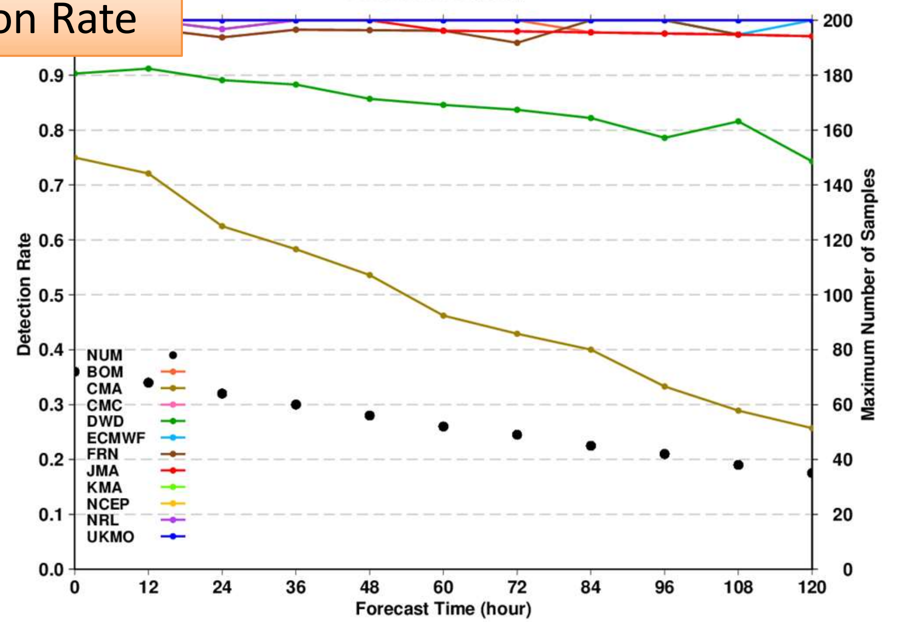
Position Error



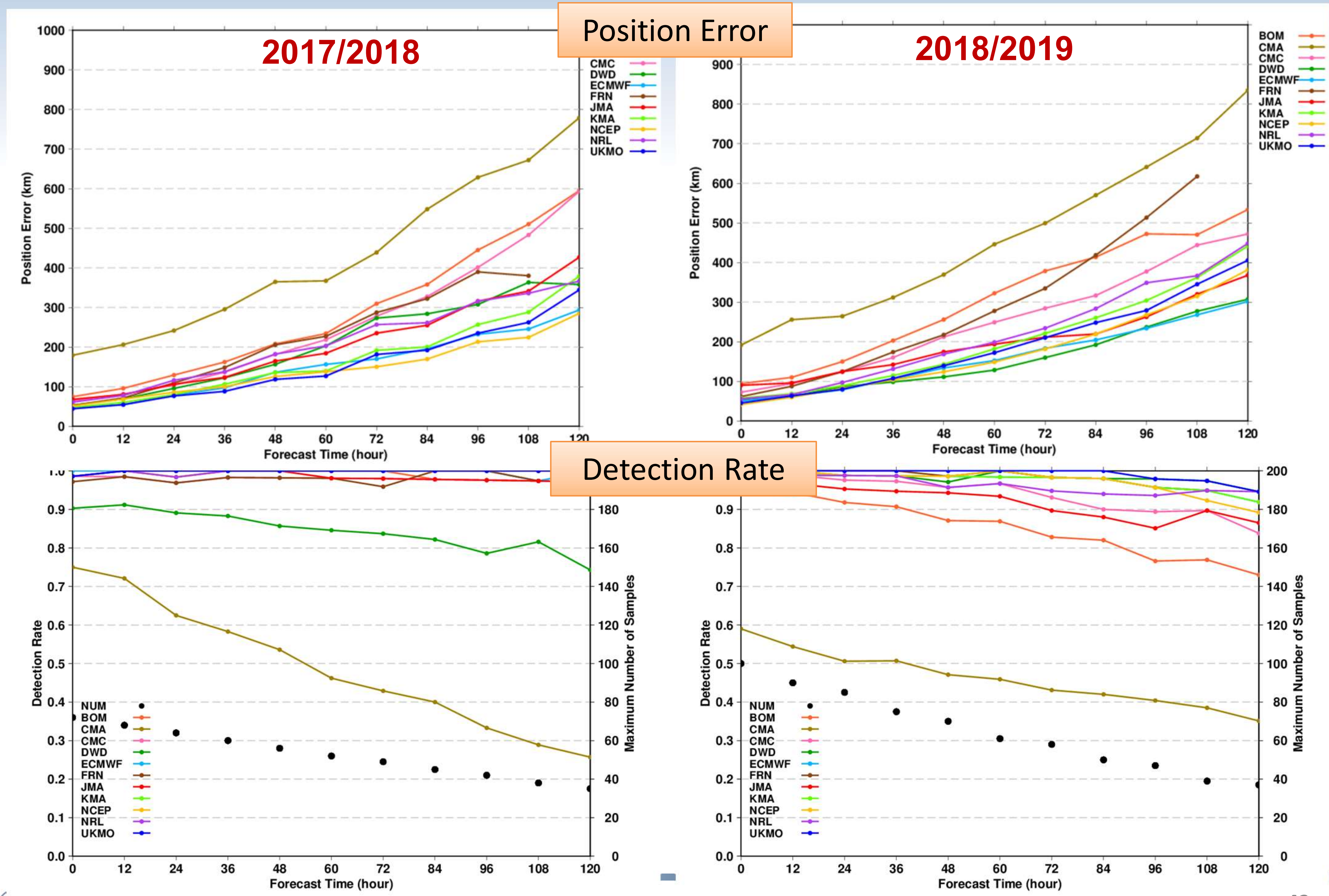


Detection Rate

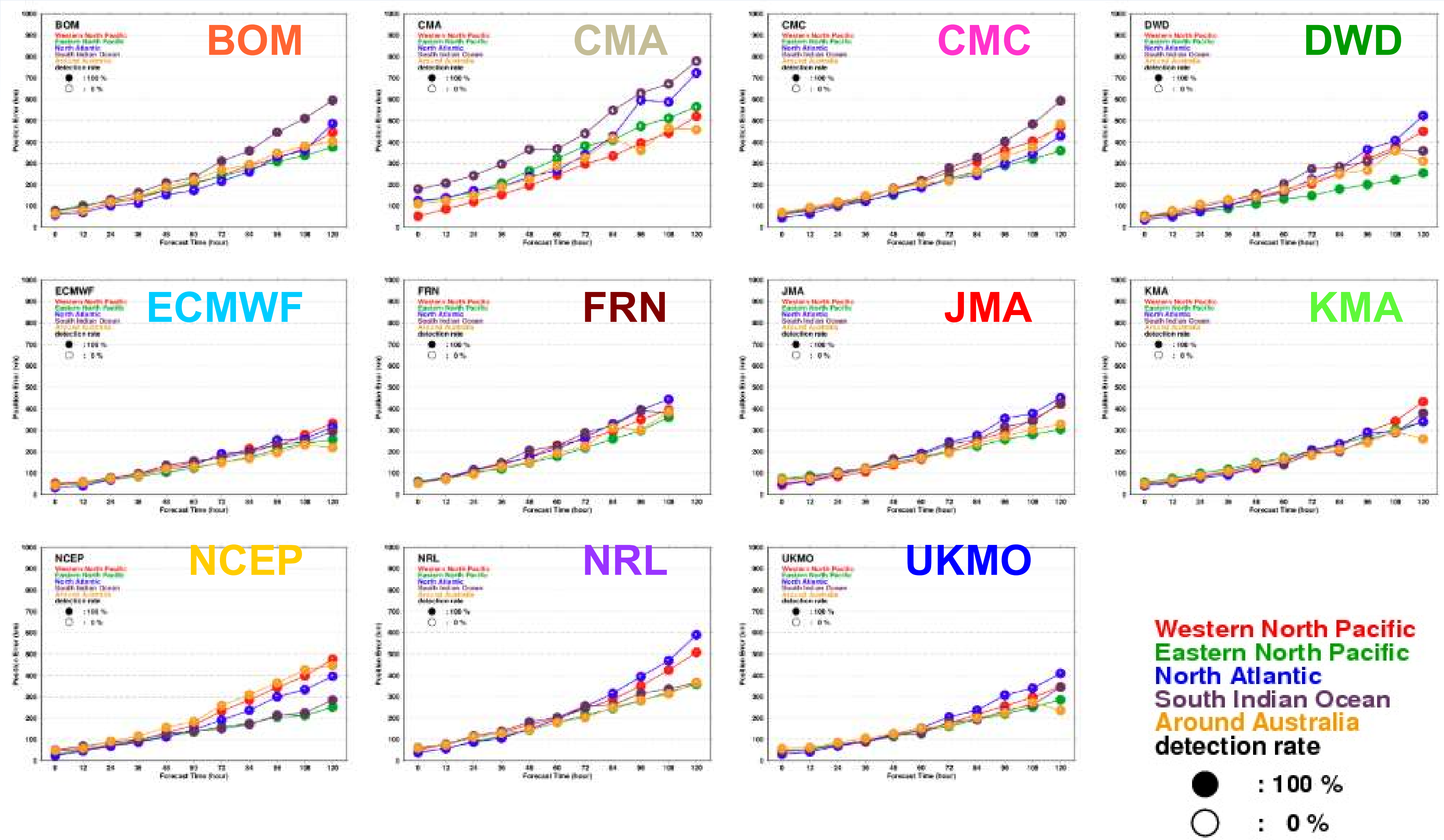




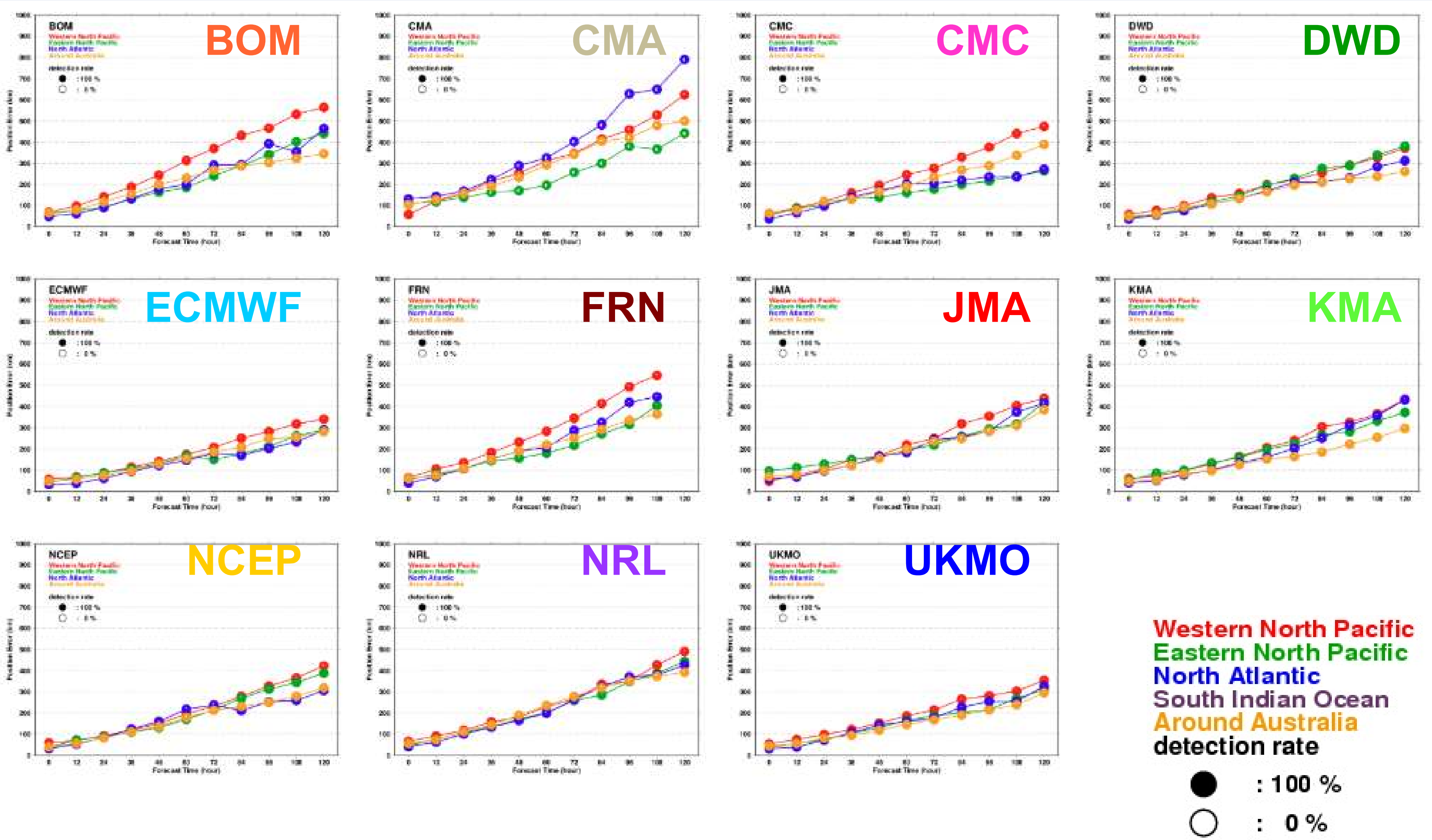
(f) South Indian Ocean (SIO)



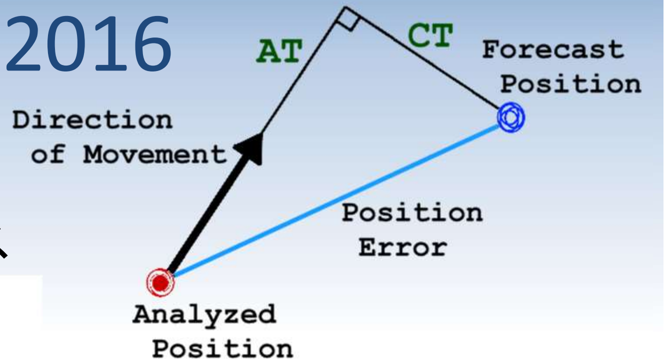
Visualization with “Pie-chart” 2018



Visualization with “Pie-chart” 2019

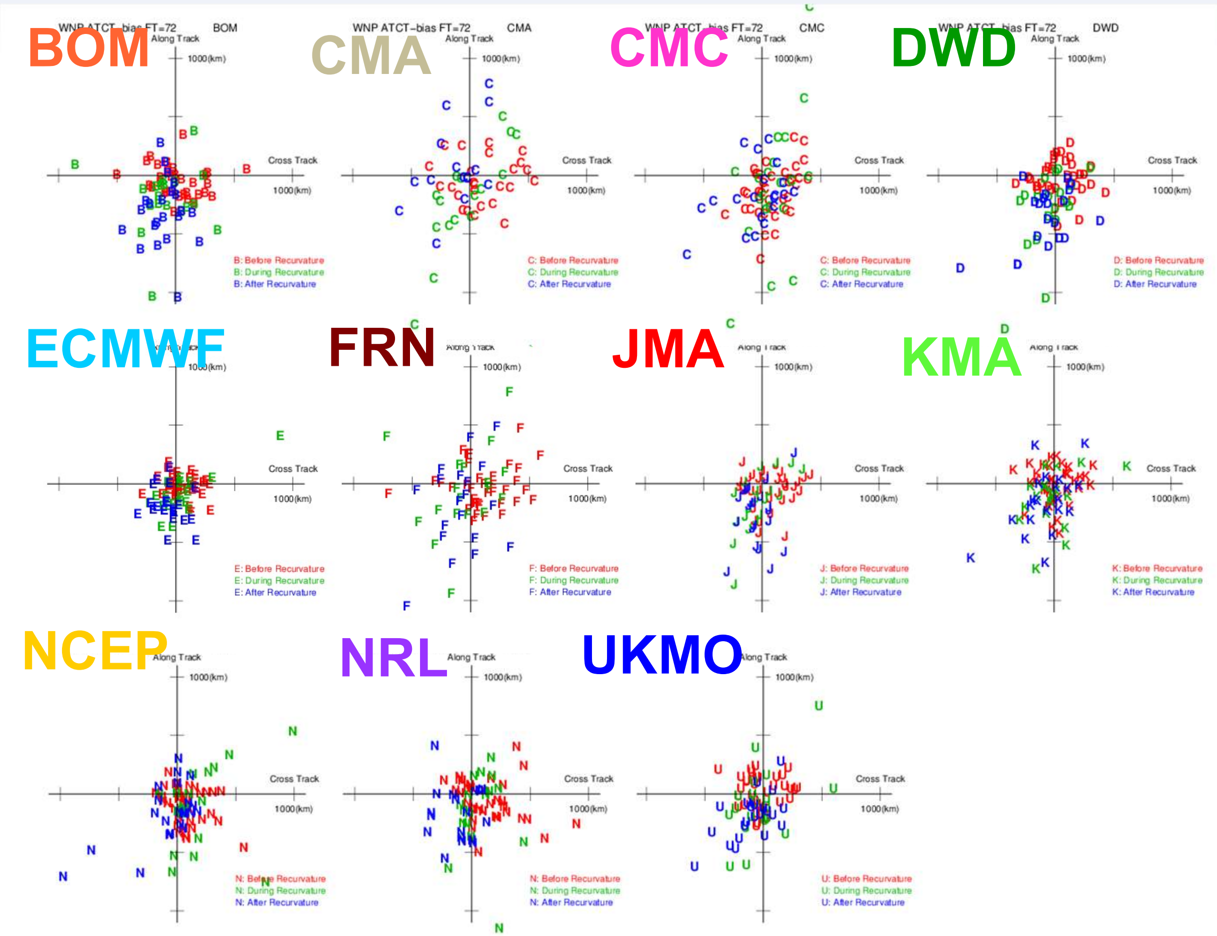


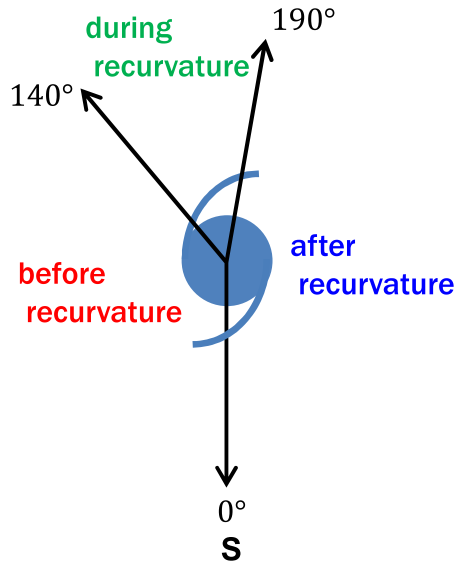
(a) WNP AT-CT Bias (FT=72)　2016



AT – CT bias

AT (along-track) bias : 進行方向のバイアス
CT (cross-track) bias : 進行方向に直交する方向のバイアス



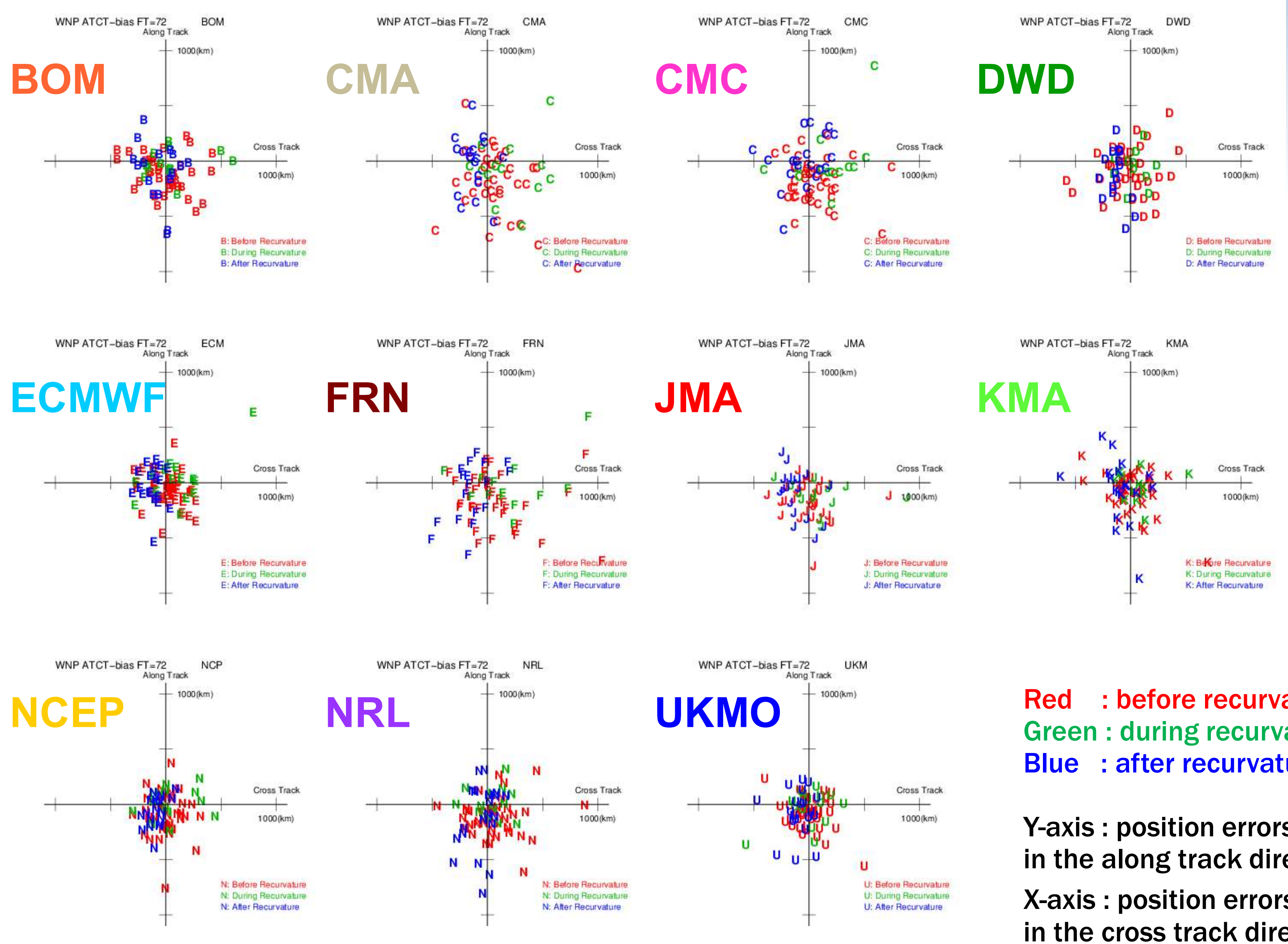


Y-axis : position errors (km) in the along track direction

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

転向後に進行が遅い誤差傾向は比較的多くのモデルに共通。
昨年の検証で指摘されていた、転向前に進行方向の右(北)に寄る誤差傾向ははっきりとは見られない。

(a) WNP AT-CT Bias (FT=72) 2017

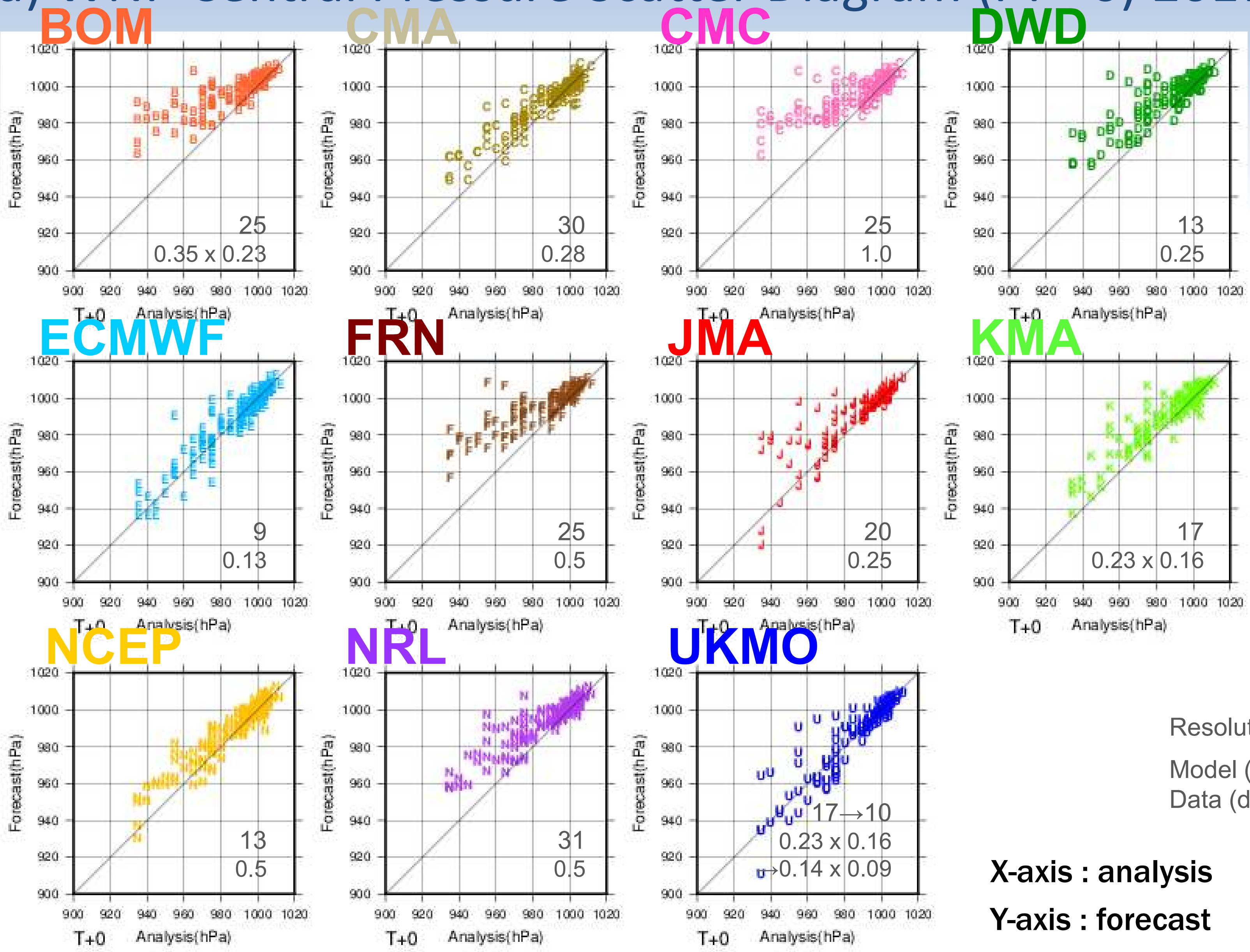


Red : before recurvature
Green : during recurvature
Blue : after recurvature

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

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

(a) WNP Central Pressure Scatter Diagram (FT +0) 2017



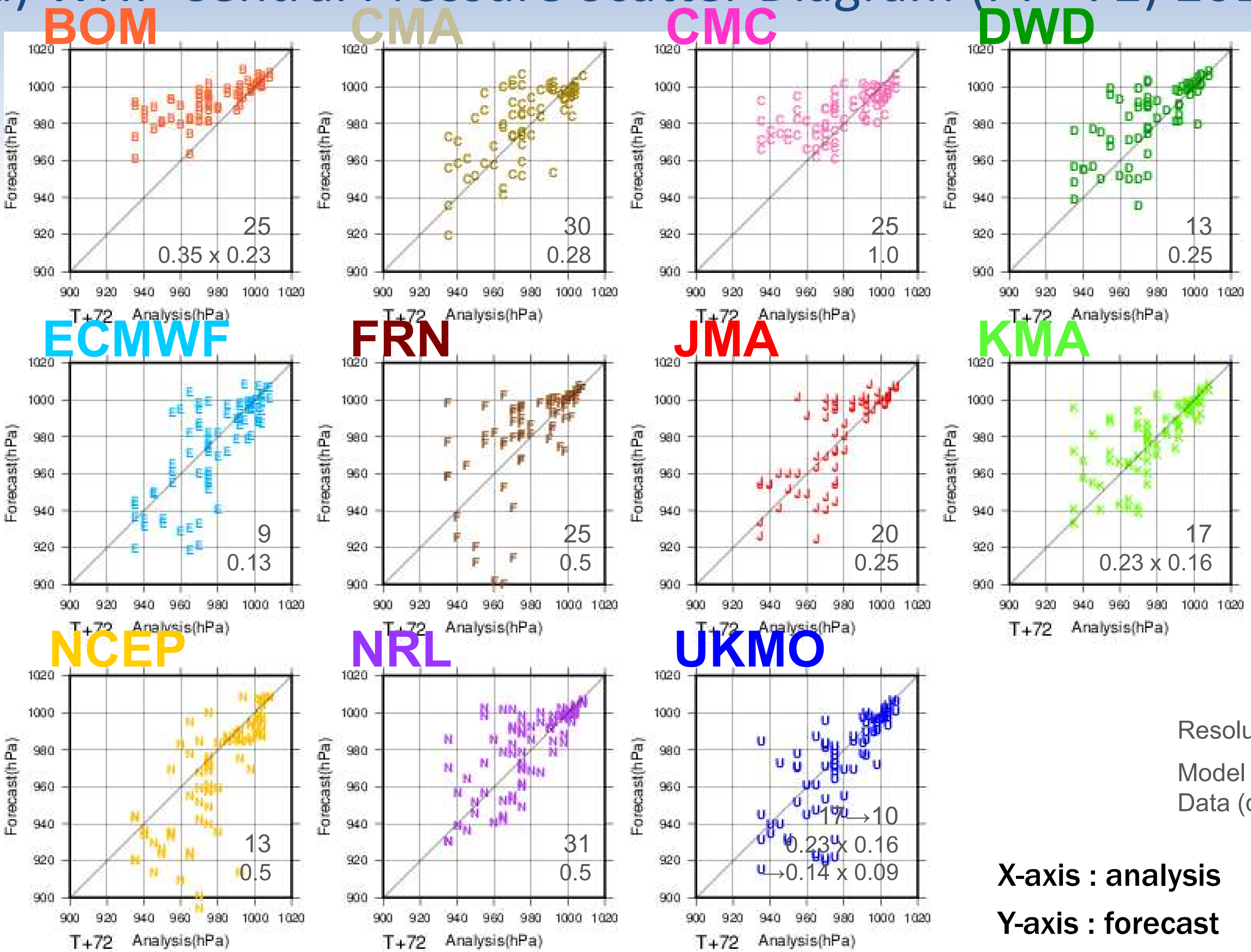
Resolution

Model (km)
Data (deg)

X-axis : analysis

Y-axis : forecast

(a) WNP Central Pressure Scatter Diagram (FT +72) 2017



Resolution

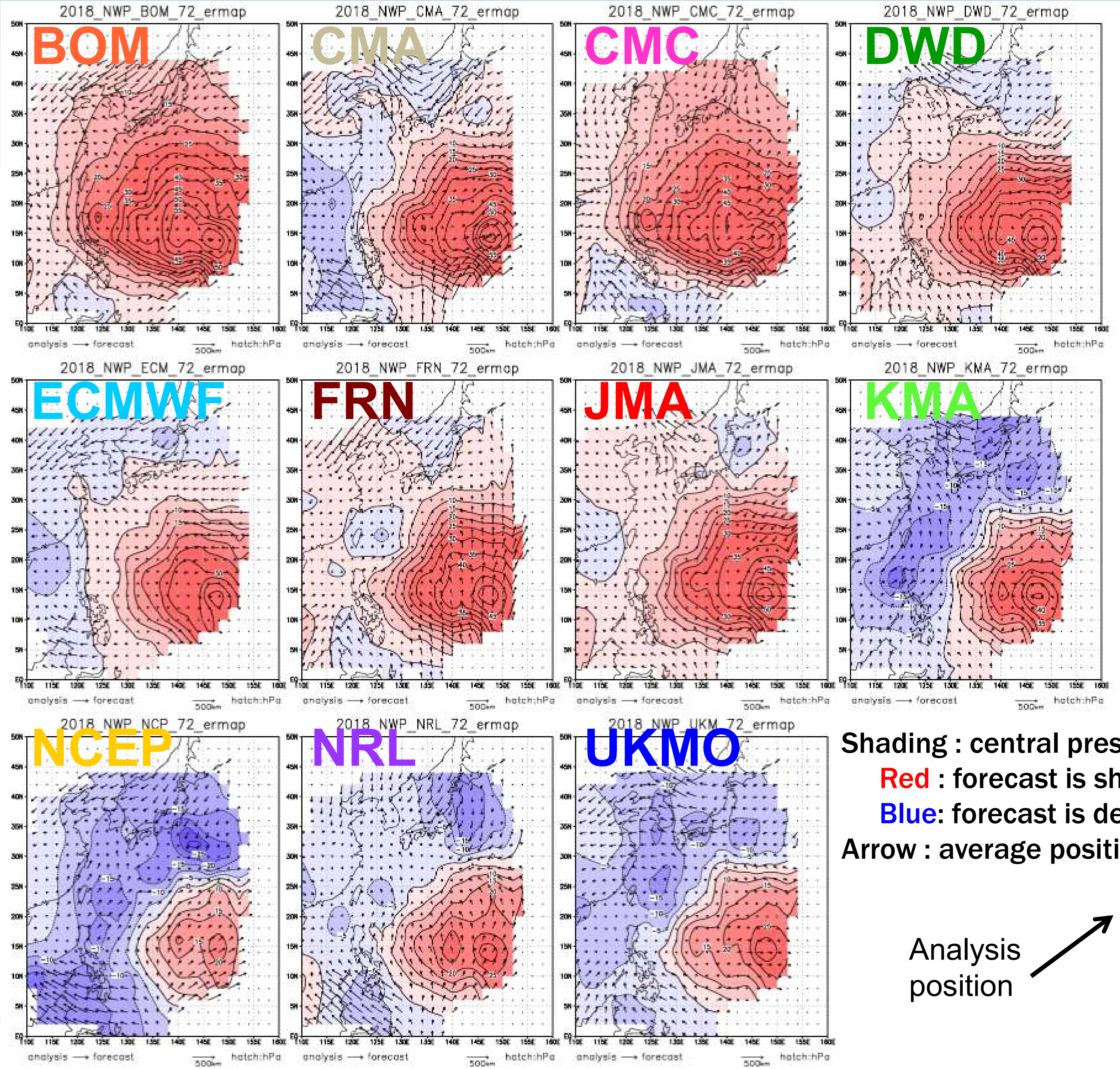
Model (km)
Data (deg)

X-axis : analysis

Y-axis : forecast

(a) WNP Error Map (FT=72)

Verification in 2018



Shading : central pressure error (hPa)

Red : forecast is shallow

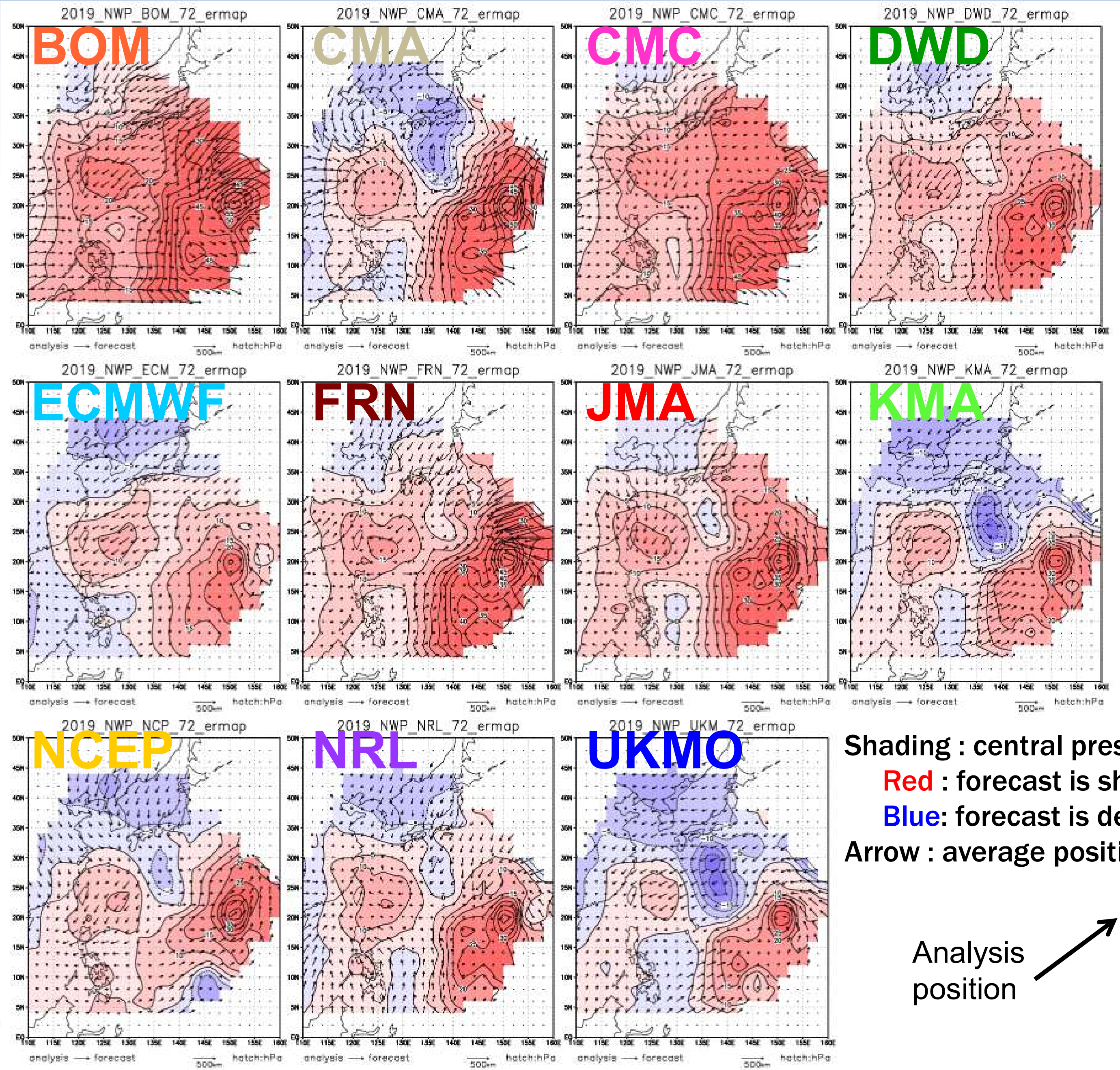
Blue: forecast is deep

Arrow : average position error

Analysis position → Forecast position

(a) WNP Error Map (FT=72)

Verification in 2019



Shading : central pressure error (hPa)

Red : forecast is shallow

Blue: forecast is deep

Arrow : average position error

Analysis position → Forecast position

気象庁