



WGNE inter-comparison of Tropical Cyclone Track forecast 2017

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Japan Meteorological Agency

STANDARD VERIFICATION

Verification of Global Models

Data Specifications in 2017

NWP centre	Year of verification commencement	Horizontal resolution of provided data (degrees in longitude and latitude)	Model resolution as of 2017
BoM	2003	0.3516 x 0.2344	25kmL70
CMA	2004	0.2813 x 0.2813	T _L 639L60
CMC	1994	1.0 x 1.0	25km L80
DWD	2000	0.25 x 0.25	13kmL90
ECMWF	1991	0.125 x 0.125	TCo1280L137
FRN	2004	0.5 x 0.5	T _L 1198C2.2L105
JMA	1991	0.25 x 0.25	T _L 959L100
KMA	2010	0.2344 x 0.1563	17kmL70
NCEP	2003	0.5 x 0.5	T1534L64
NRL	2006	0.5 x 0.5	T425L60
UKMO	1991	0.2344 x 0.1563 (-Jul. 10) 0.1406 x 0.094 (Jul. 11-)	17kmL70 (-Jul. 10) 10kmL70 (Jul. 11-)

Improvement of models for each centres in 2017 (1/2)

CMC

- 2017.11.01 introduction of two-way coupling with an ice-ocean model.

DWD

- 2016.09.28 improve physical process (convection)
- 2016.11.30 improve data assimilation method
- 2017.01.31 improve data assimilation method
- 2017.03.15 improve physical processes and start to use Meteosat-8 AMV
- 2017.05.10 improve physical processes
- 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

ECMWF

- 2016.11.22 improve data assimilation method, method of using observation data, and physical processes (Cycle 43r1)
- 2017.07.11 improve data assimilation method, method of using observation data, and physical processes (Cycle 43r3)

Improvement of models for each centres in 2017 (2/2)

JMA

- 2016.09.28 improve method of using typhoon bogus data
- 2016.12.15 improve method of using observation data (Himawari-8 AMV) and start to use GRACE-B/BlackJack RO data
- 2017.03.29 start to use Suomi-NPP/ATMS, Suomi-NPP/CrIS, DMSP-F17,18/SSMIS, and Meteosat-8/AMV,CSR
- 2017.05.25 improve physical processes (convection, cloud, radiation, land, sea; introduction of stratospheric methane oxidation scheme) and data assimilation system (update background error statistics)
- 2017.07.25 improve method of using observation data (GNSS RO)

NCEP

- 2017.07.19 improve physical processes (convection, boundary layer, land, sea), data assimilation system, and method of using observation data

NRL

- 2016.10 model update

UKMO

- 2017.07.11 improve horizontal resolution (from 17km to 10km)

TCs in 2017

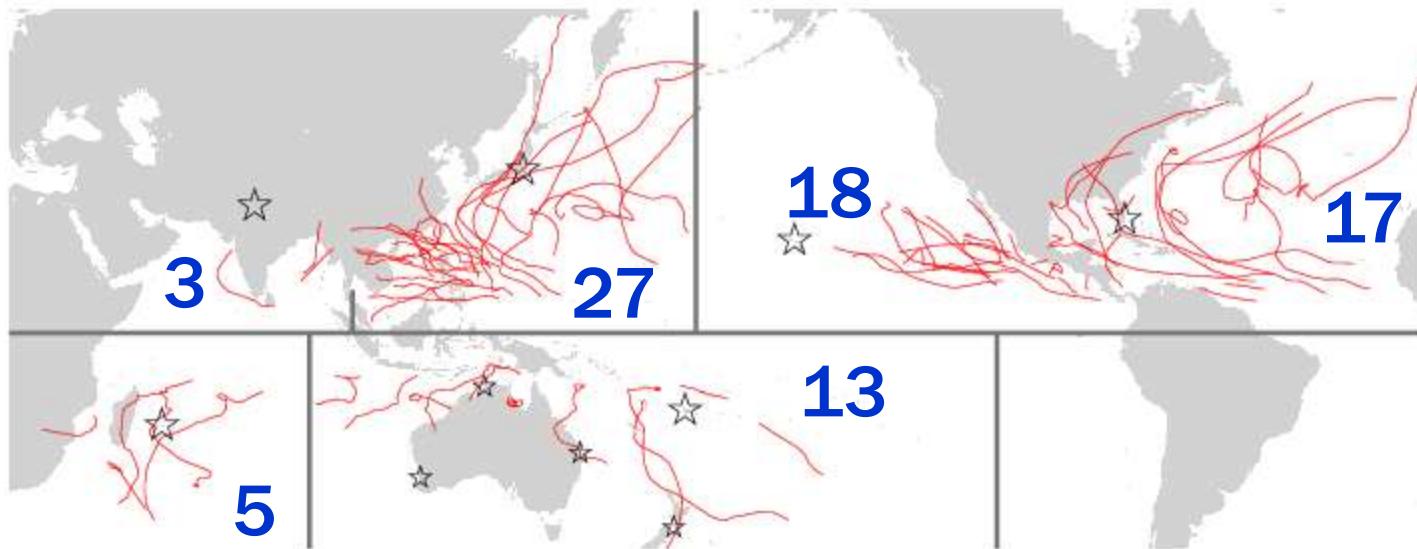
TC season

Northern Hemisphere : 1 January 2017 to 31 December 2017

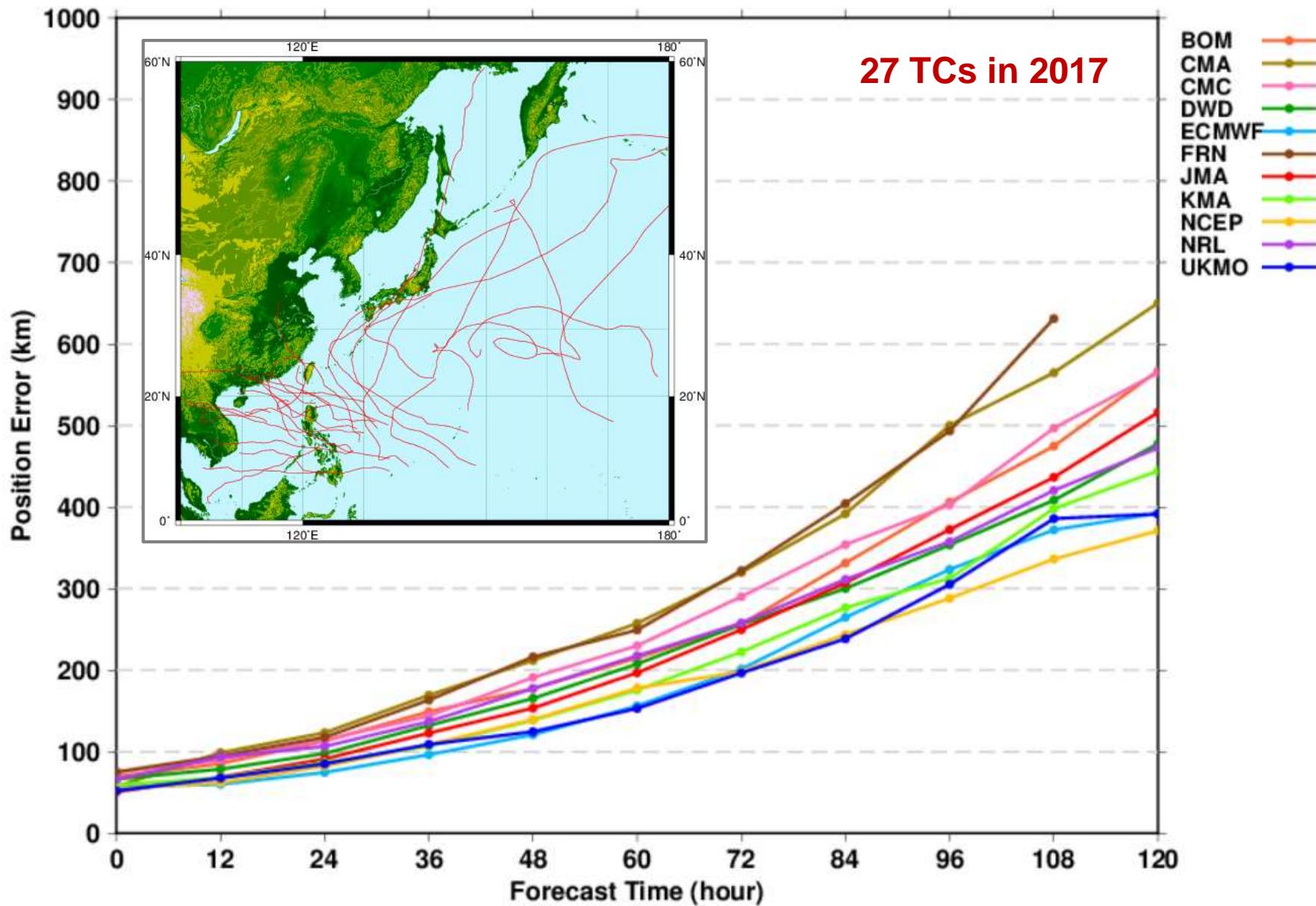
Southern Hemisphere : 1 September 2016 to 31 August 2017

Number of TCs [best track data provider]

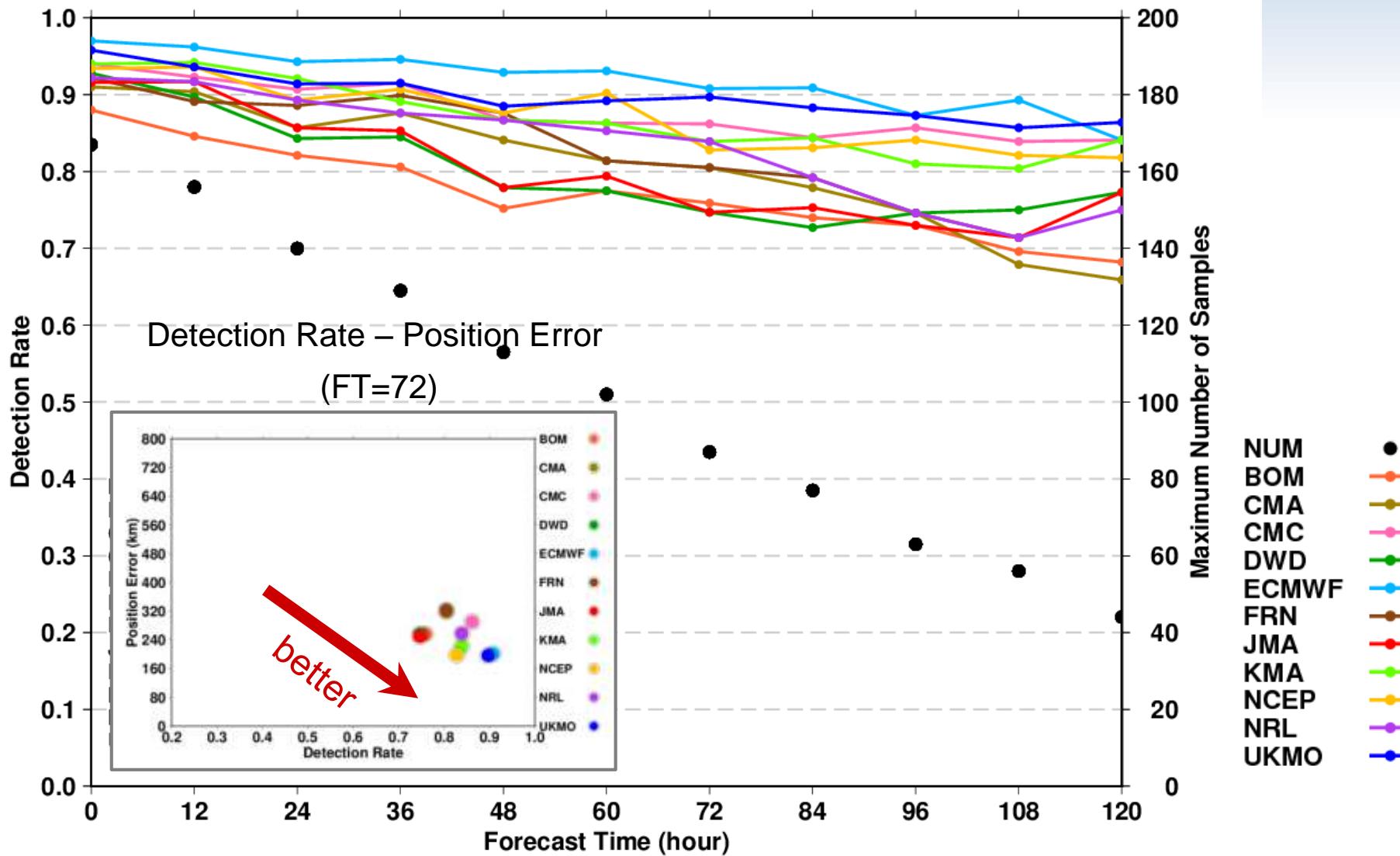
- 27 Western North Pacific [RSMC Tokyo]
- 18 Eastern North Pacific (including Central North Pacific) [RSMC Miami, Honolulu]
- 17 North Atlantic [RSMC Miami]
- 3 North Indian Ocean [RSMC New Delhi]
- 5 South Indian Ocean [RSMC La Reunion]
- 13 Around Australia [RSMC Nadi and 4 TCWCs]



(a) Western North Pacific (WNP) Position Error

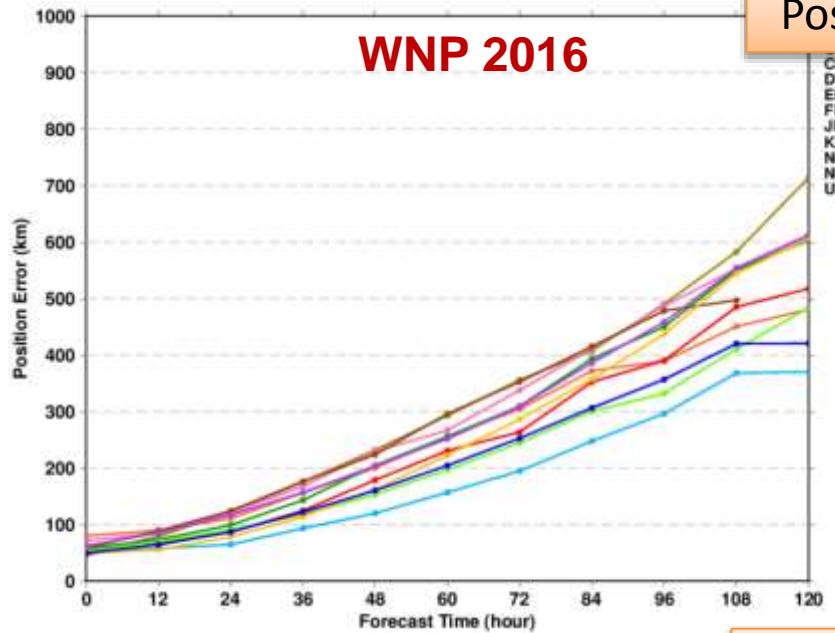


(a) WNP Detection Rate

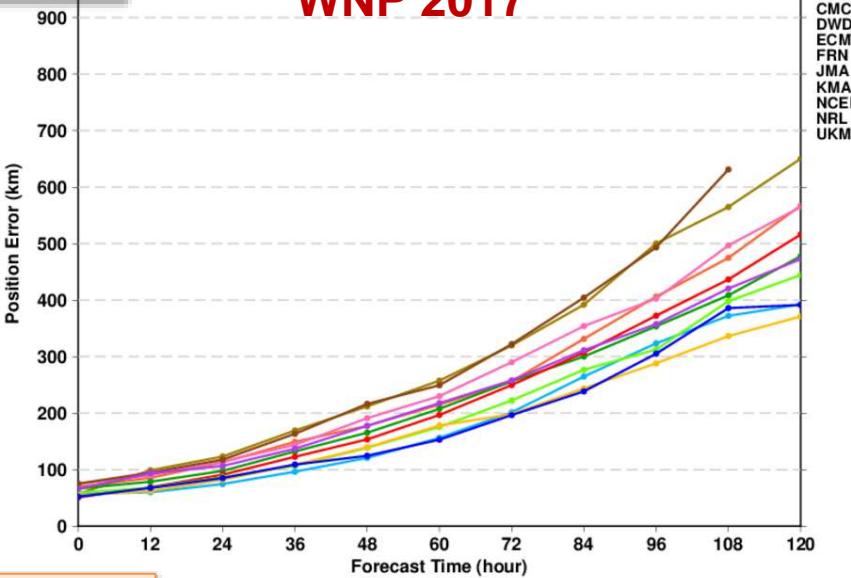


Position Error

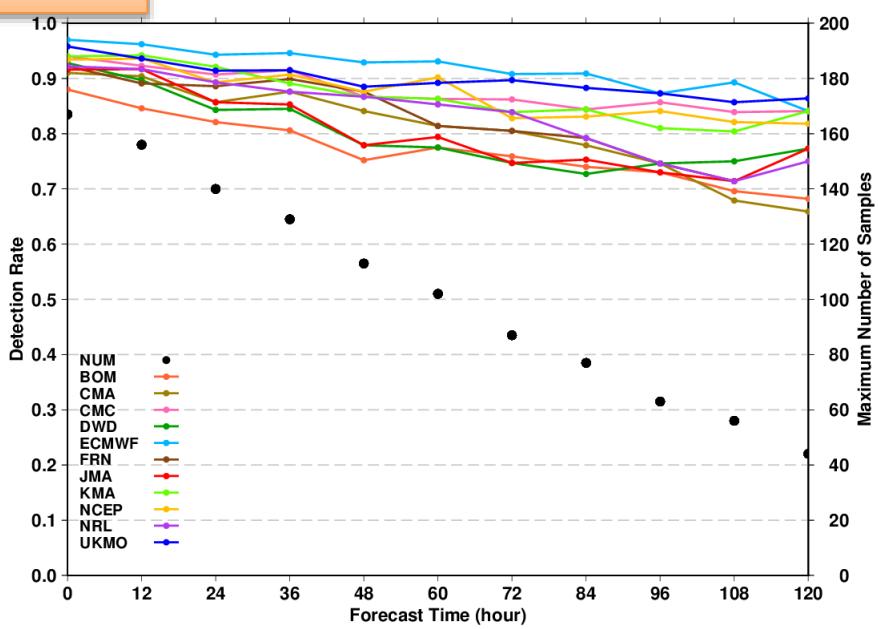
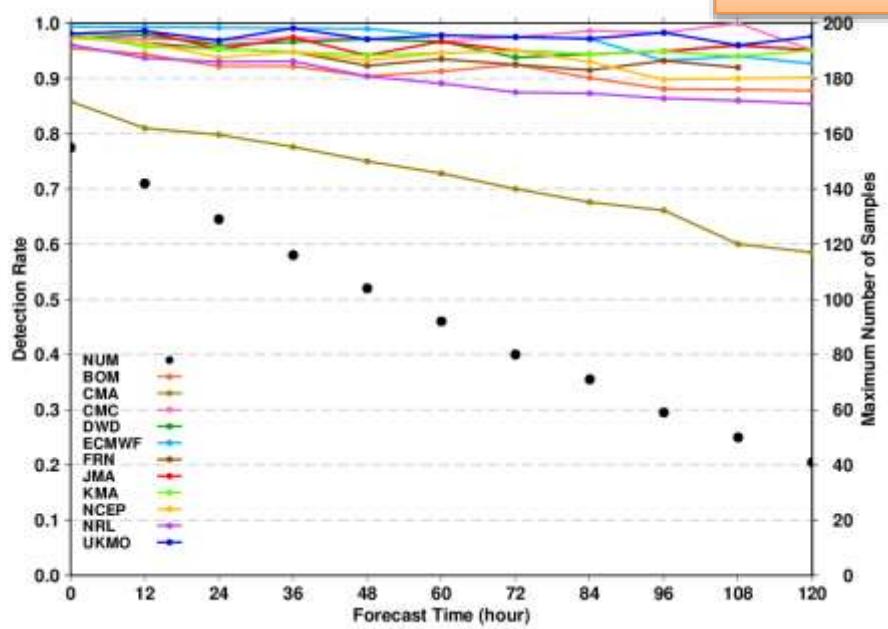
WNP 2016



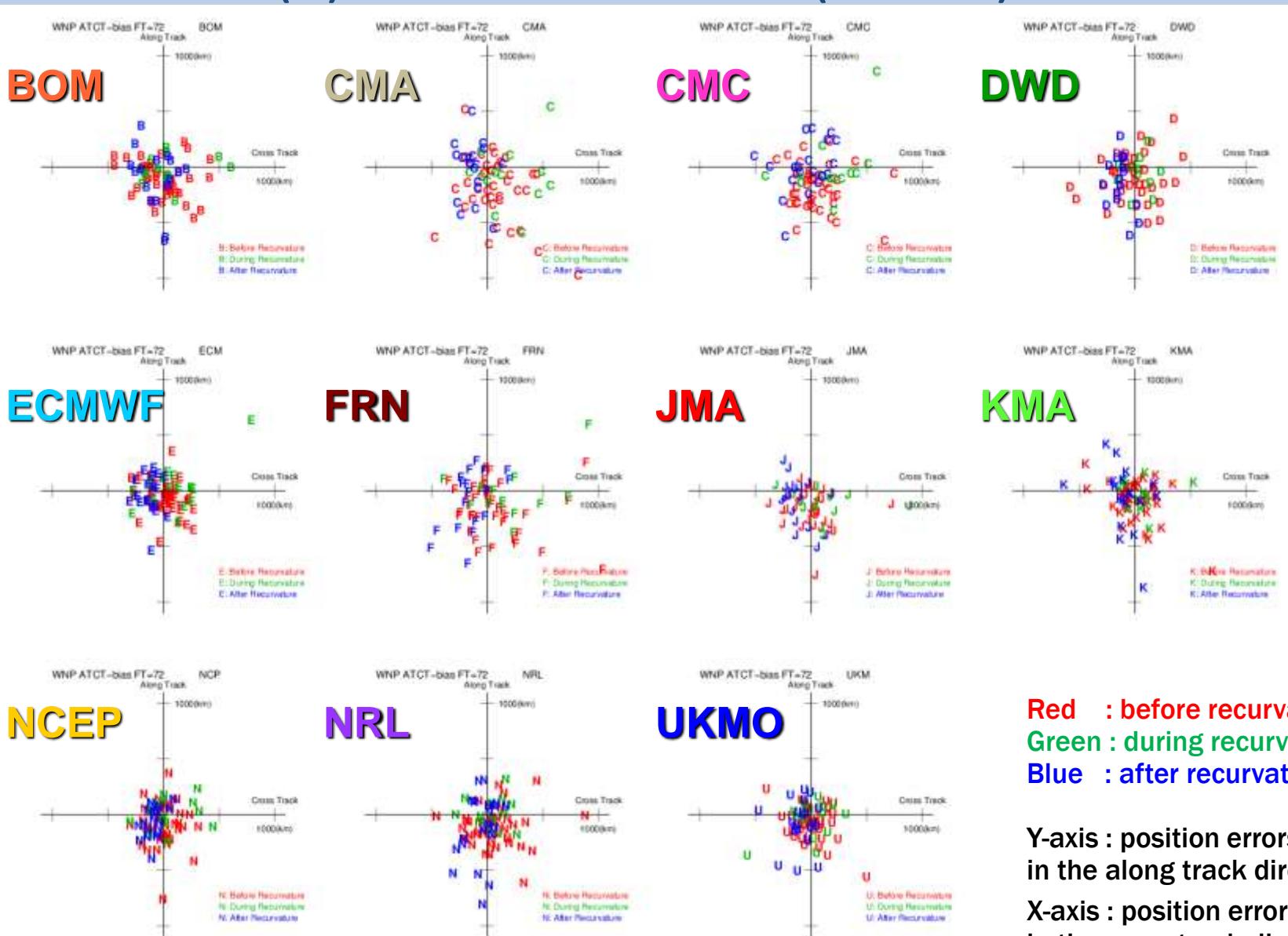
WNP 2017



Detection Rate



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

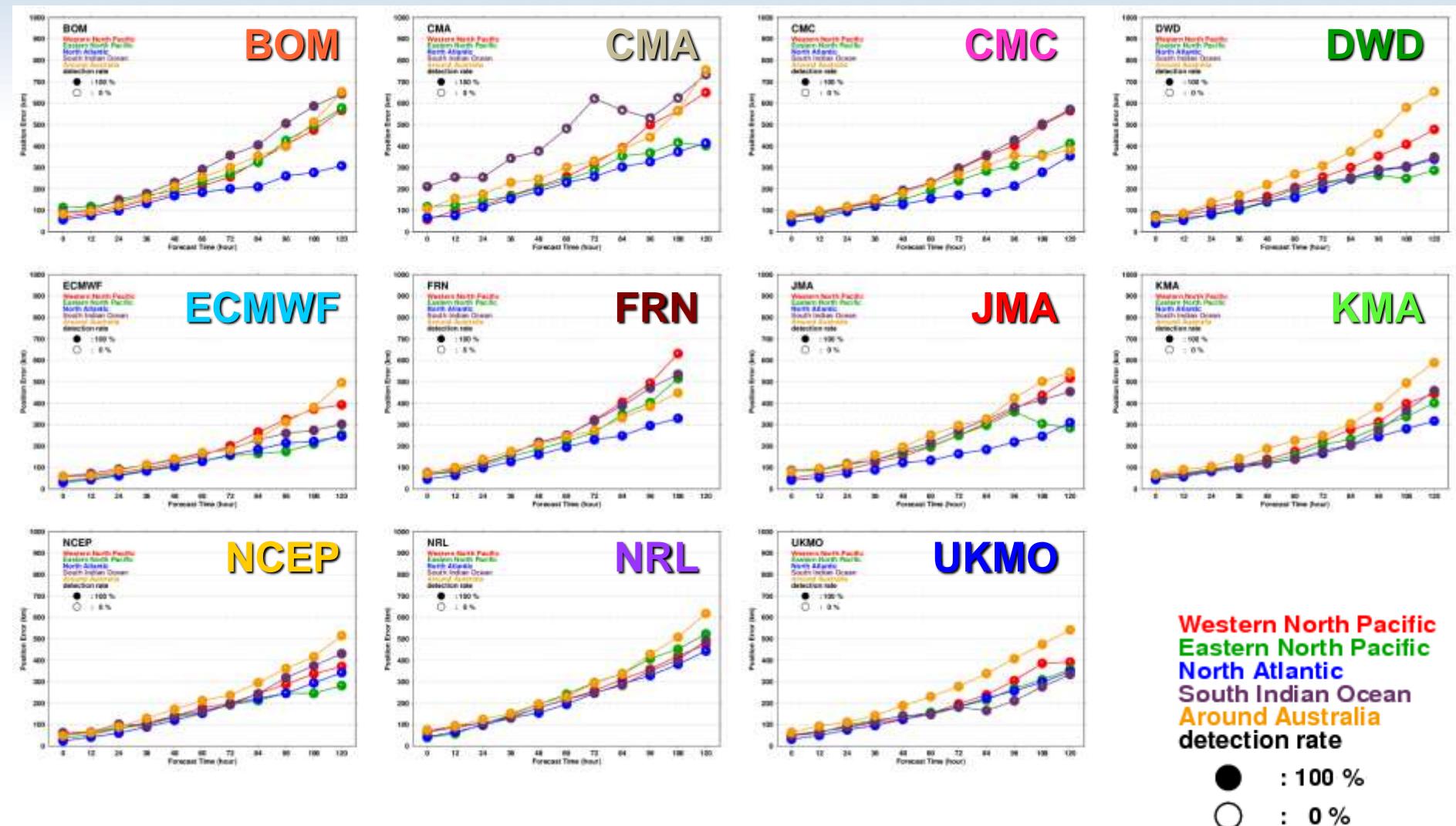


Red : before recurvature
 Green : during recurvature
 Blue : after recurvature

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

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

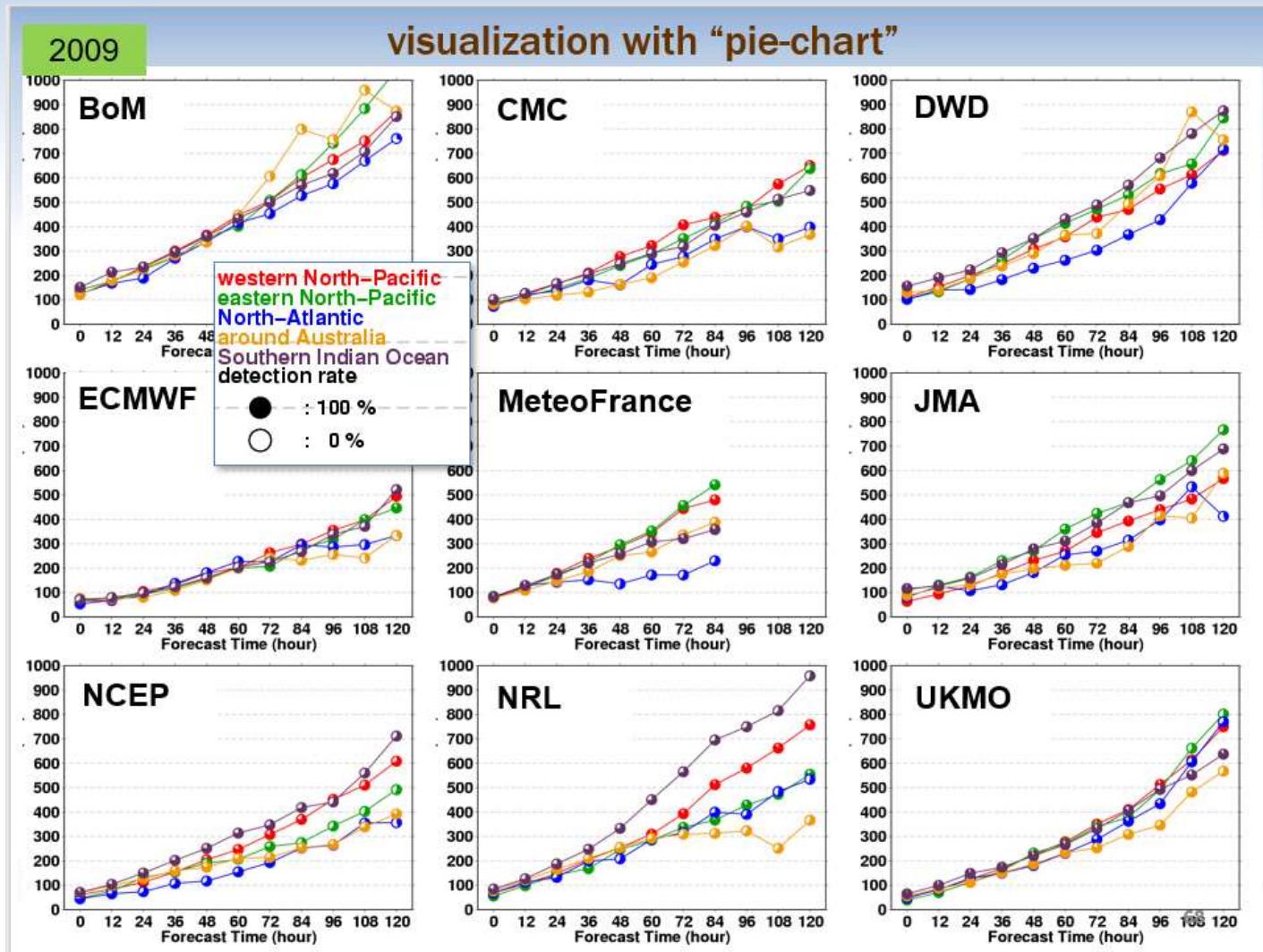
Visualization with “Pie-chart”



Western North Pacific
Eastern North Pacific
North Atlantic
South Indian Ocean
Around Australia
detection rate

- : 100 %
- : 0 %

Visualization with “Pie-chart” (10 years ago)



Western North Pacific
Eastern North Pacific
North Atlantic
South Indian Ocean
Around Australia
detection rate

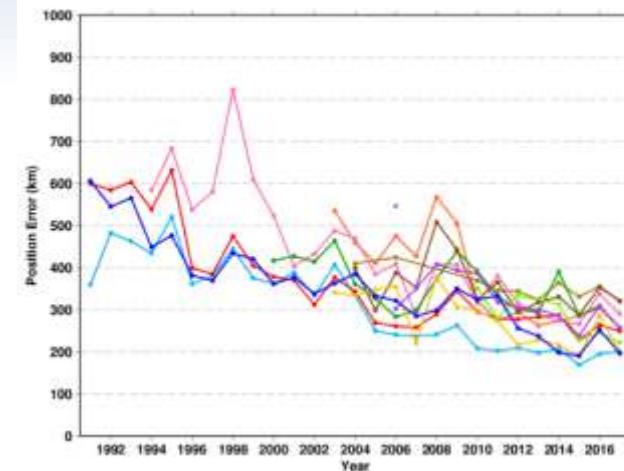
● : 100 %
○ : 0 %

In the backup slides, verification in other years are plotted.

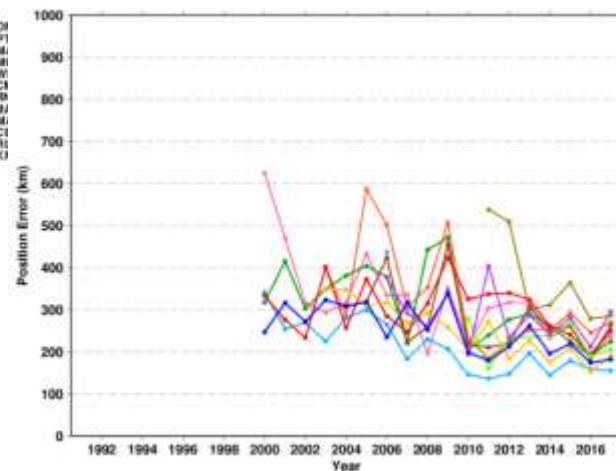


Transition of FT=72 Position Error over Decade(s)

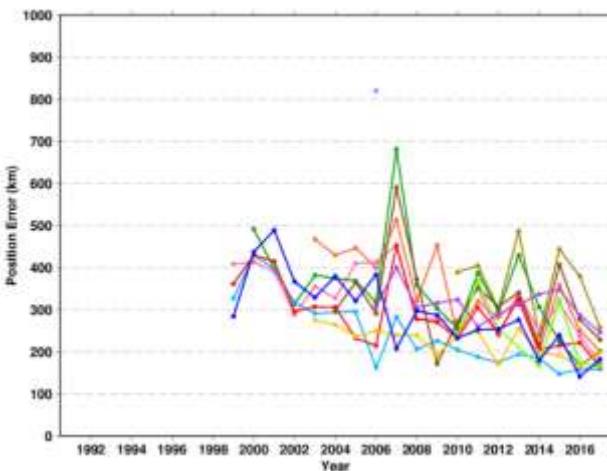
WNP



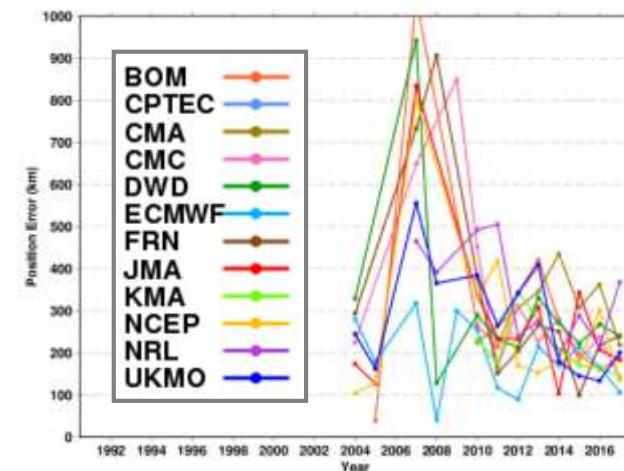
ENP



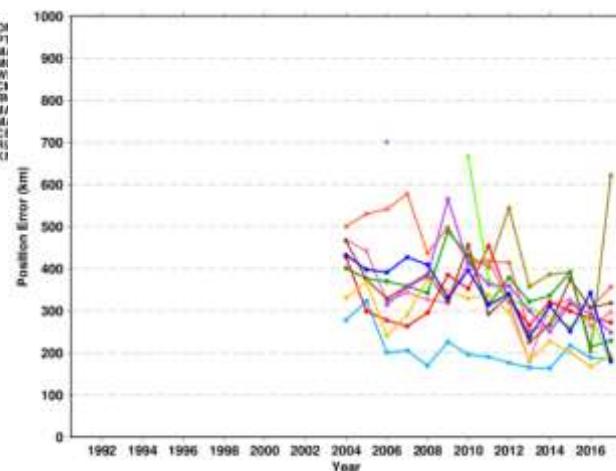
NAT



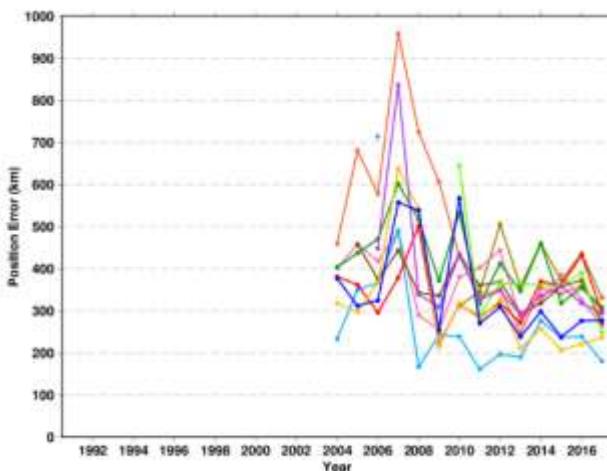
NIO



SIO



AUR



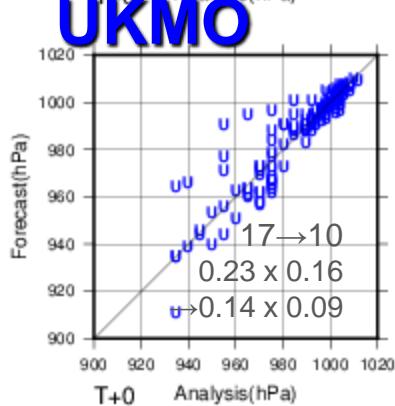
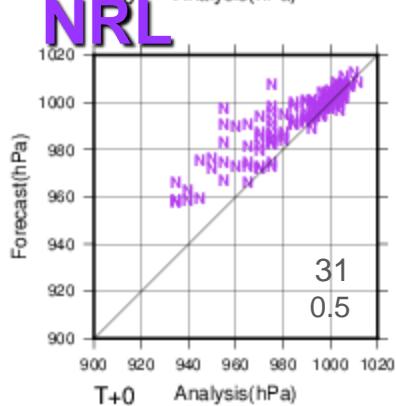
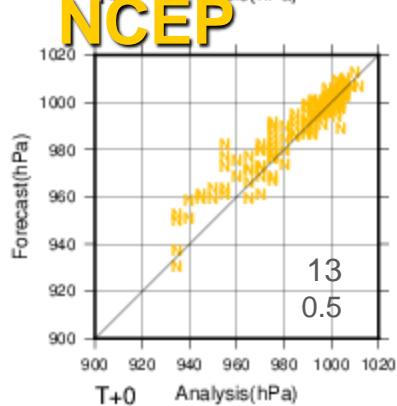
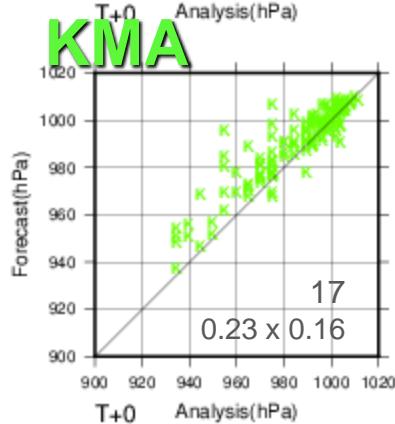
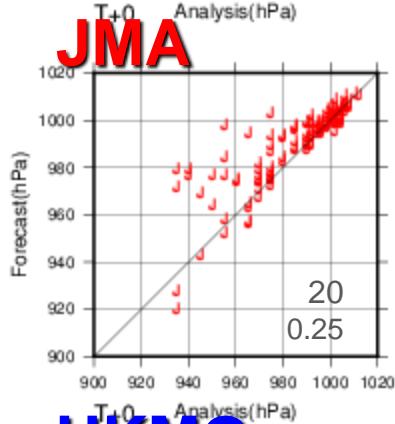
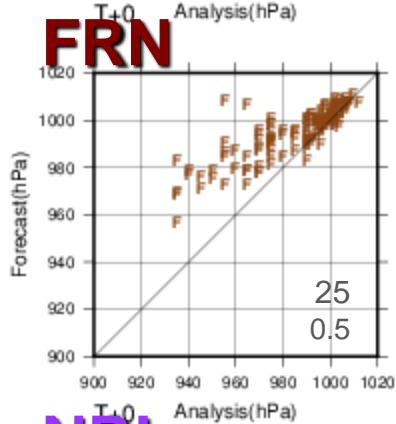
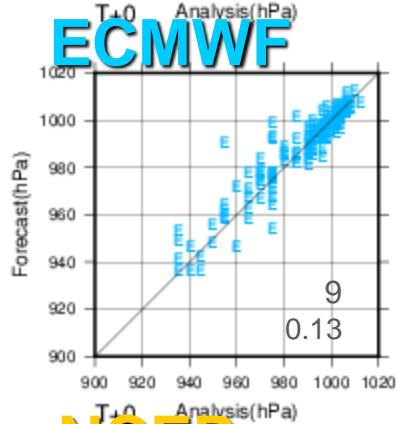
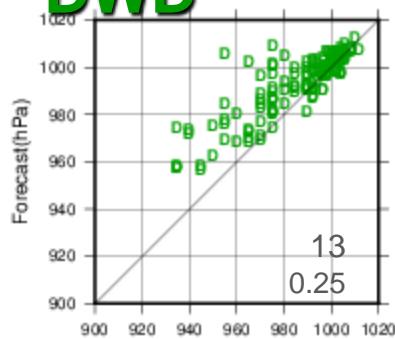
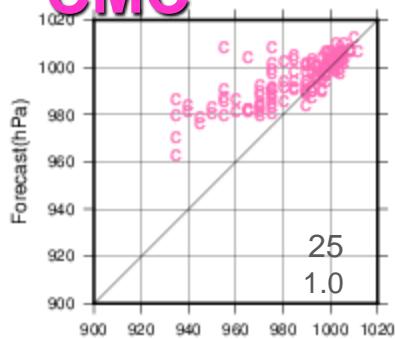
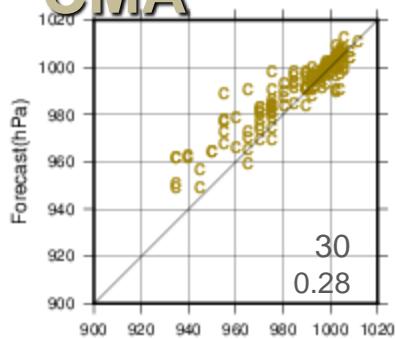
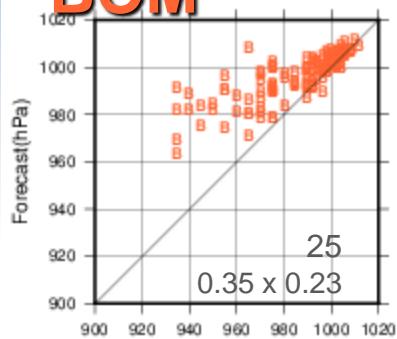
(a) WNP Central Pressure Scatter Diagram (FT +0)

BOM

CMA

CMC

DWD

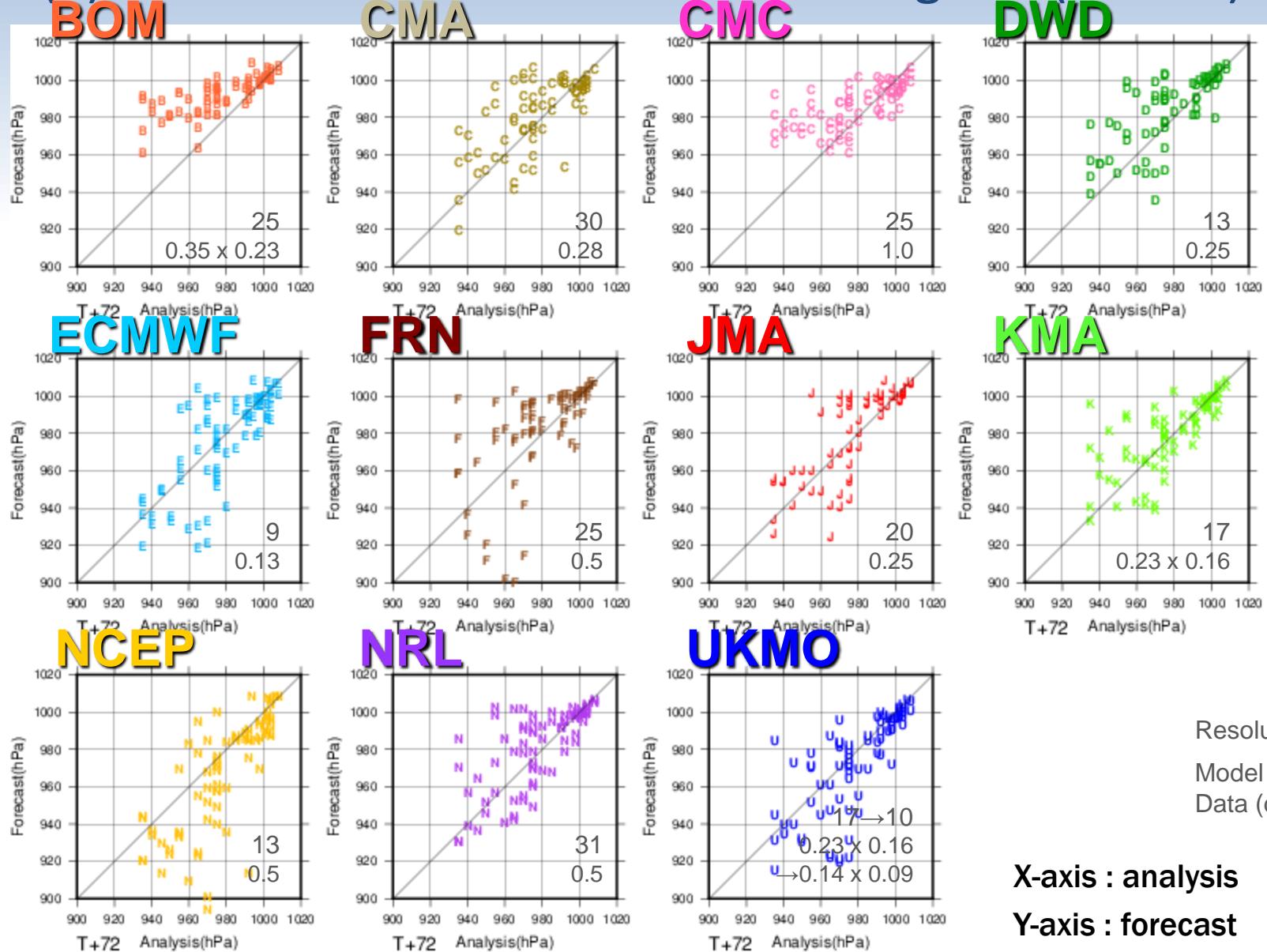


Resolution
Model (km)
Data (deg)

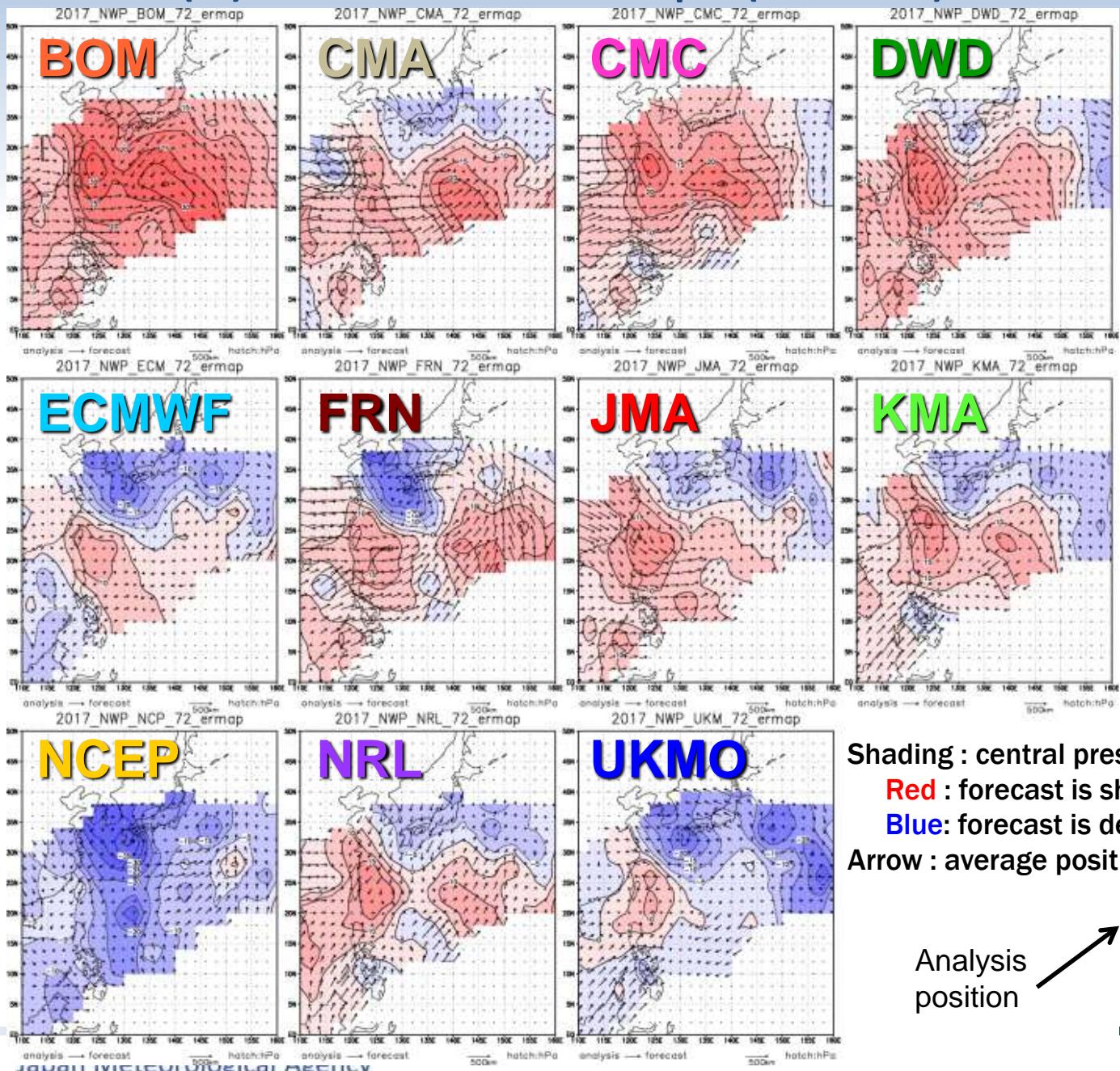
X-axis : analysis
Y-axis : forecast



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



(a) WNP Error Map (FT=72)



Shading : central pressure error (hPa)

Red : forecast is shallow

Blue: forecast is deep

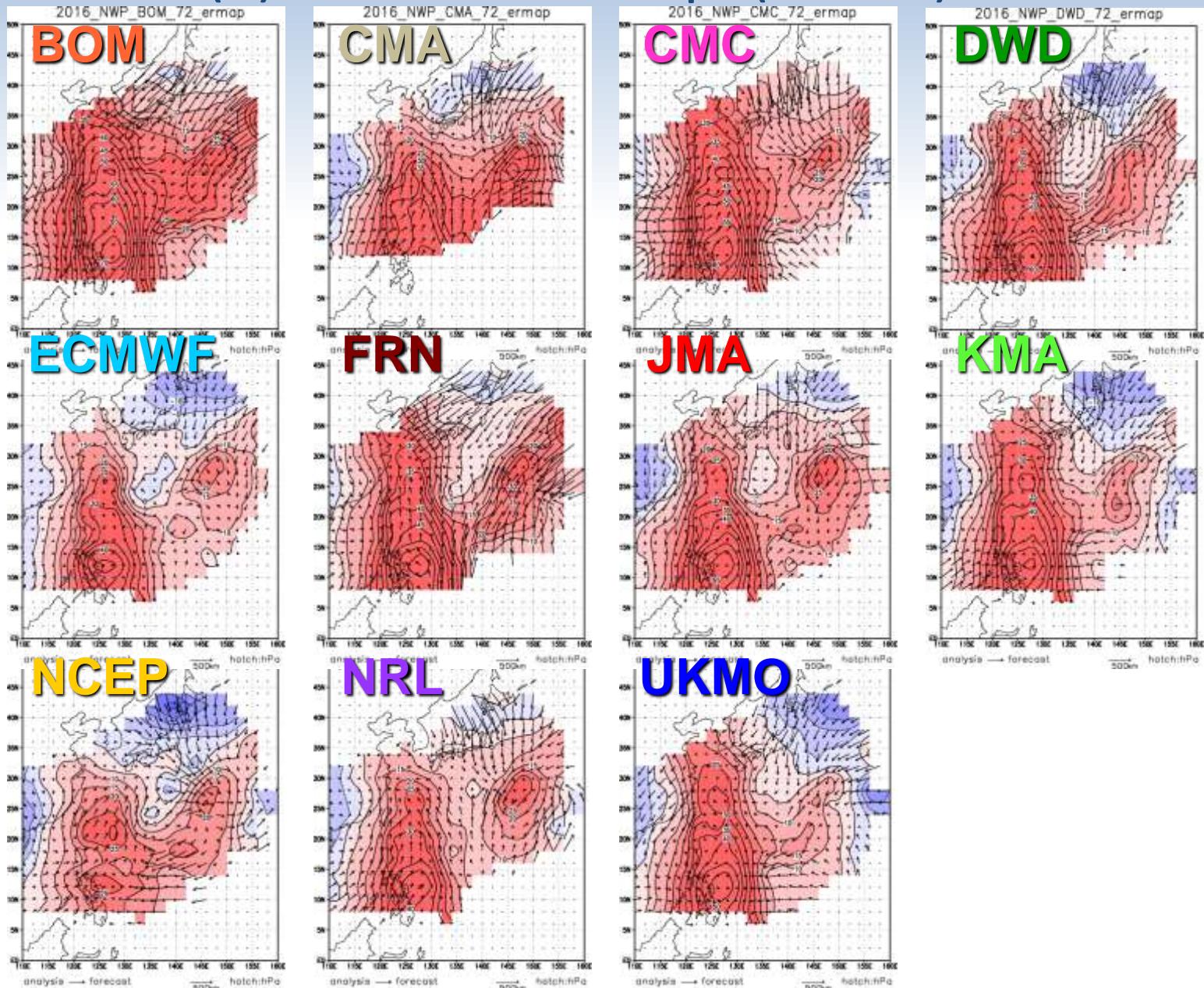
Arrow : average position error

Forecast
position

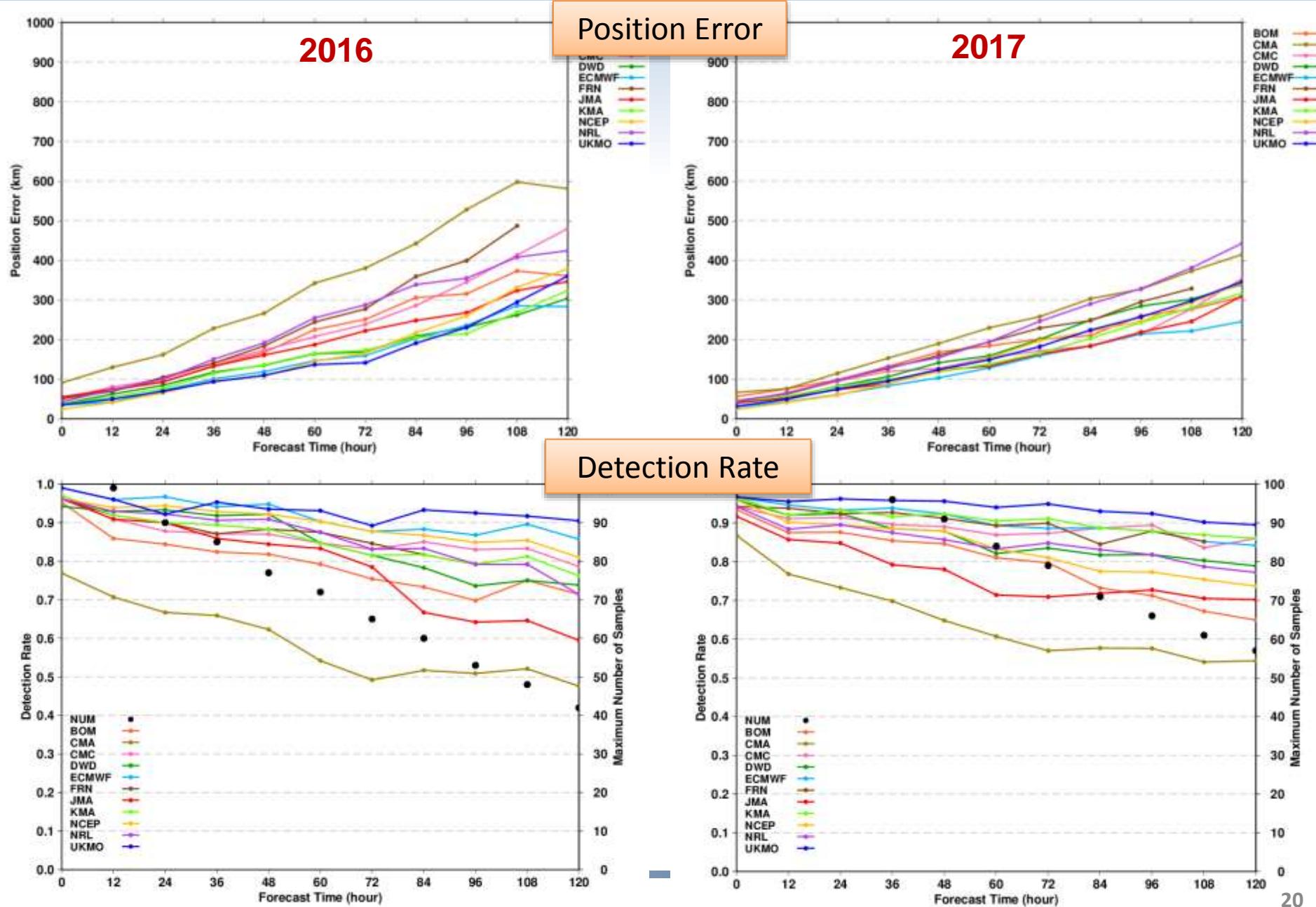
Analysis
position

(a) WNP Error Map (FT=72)

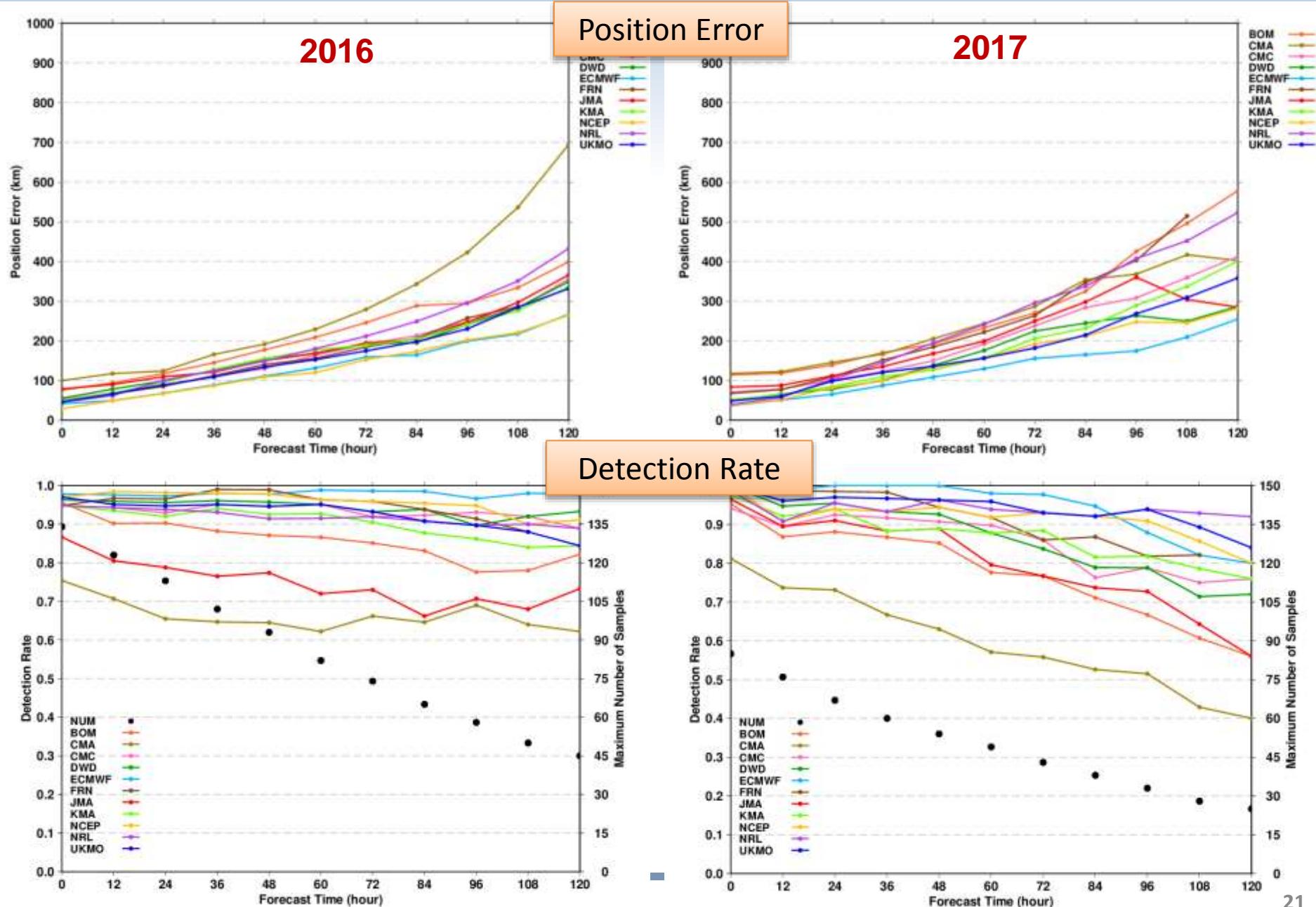
Verification in 2016



(b) North Atlantic (NAT)



(c) Eastern North Pacific (ENP)



Summary of verification 2017 (1/2)

- Position errors
 - Except cases of drastic changes in model characteristics, year-by-year variation is seen in the position errors.
 - Slow bias after re-curvature, a well-known common bias, is not clear in 2017.
 - Multiple year TC verification might be required if TC position errors are included in headline scores.
 - TC position errors have decreased gradually in each region.
 - "Areas where position errors are relatively large/small" look common among centres recently.

Summary of verification 2017 (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.
 - Model upgrades can change characteristics drastically (e.g. NCEP 2017)

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](#)

Verification Result

Click on a region of the map to show a pop-up verification.

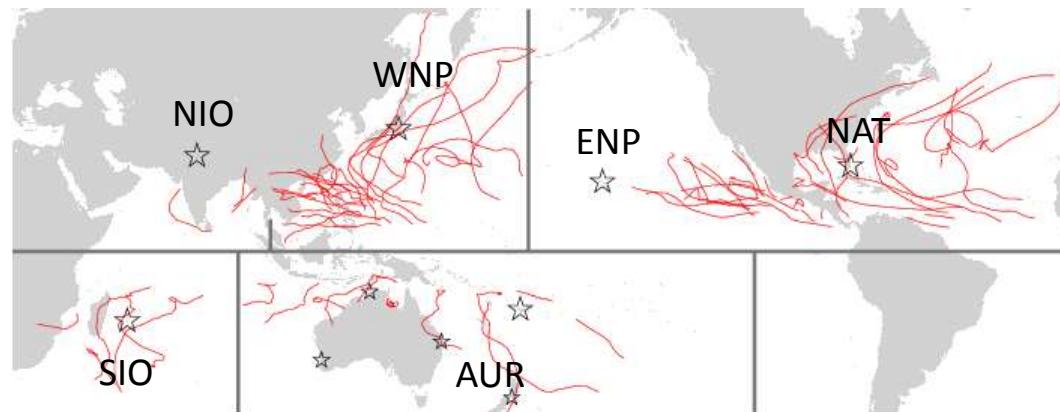
<http://nwp-verif.kishou.go.jp/wgne_tc/index.html>
Login ID: verif
Password: wgne2019 (beyond 26 September 2019)
Contact: globalnwp@naps.kishou.go.jp

ADDITIONAL VERIFICATION

Verification of Regional Models

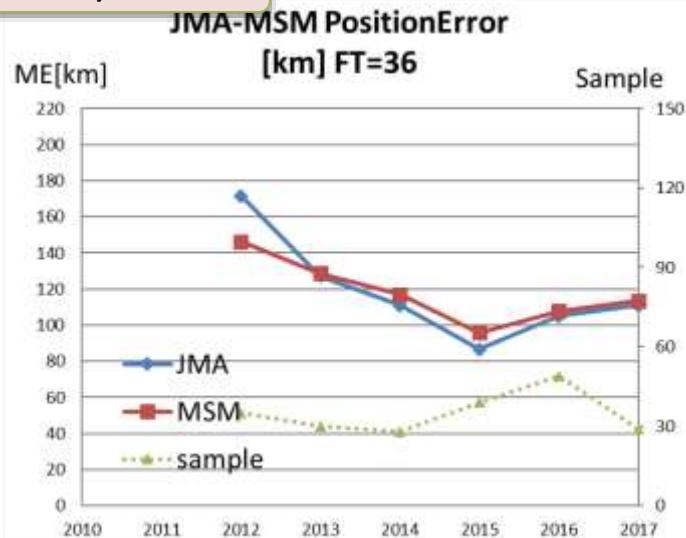
Participants of regional models TC verif. 2017

NWP centers	Name of Model	Verification Region	Boundary	Bogus data	Model Res. as of 2017
JMA	MSM (asuca)	WNP	GSM	Used	5kmL76
KMA	RDAPS	WNP	GDAPS	Used	12kmL70
Meteo France	AROME	NAT SIO, AUR	IFS		2.5kmL90

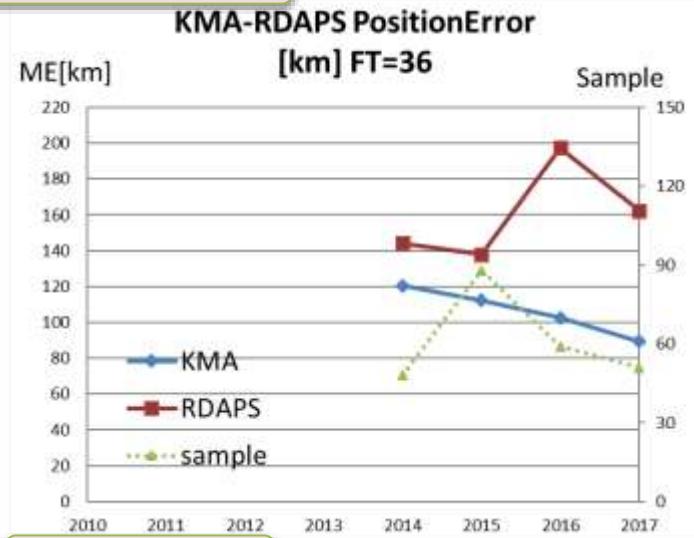


Position errors

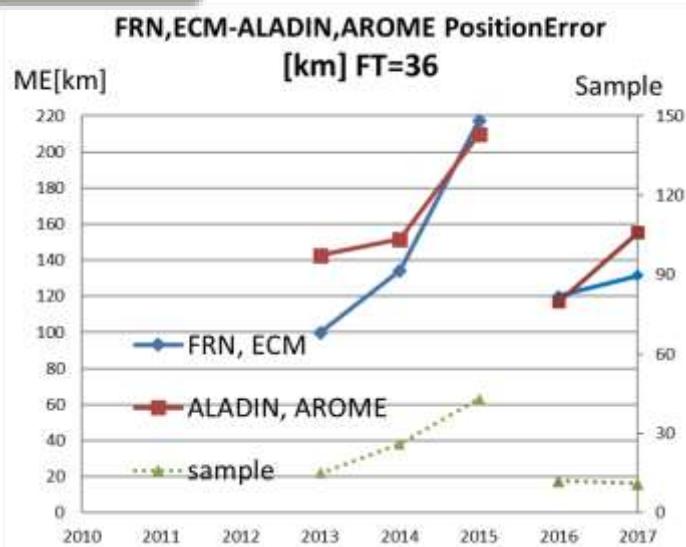
JMA/WNP



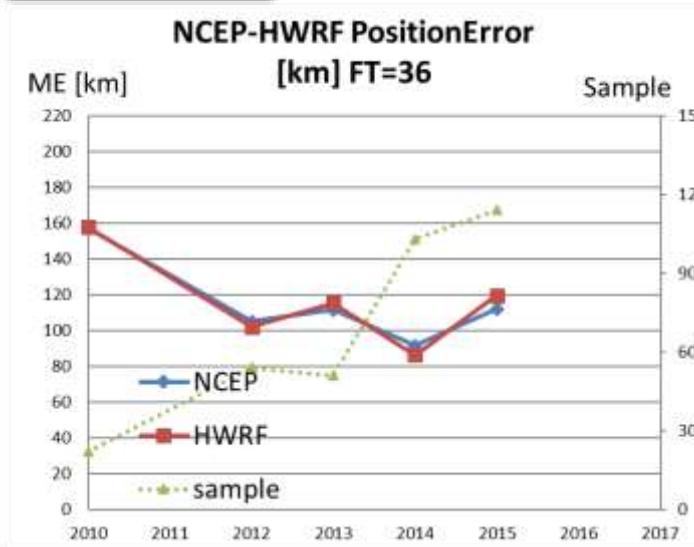
KMA/WNP



FRN/SIO

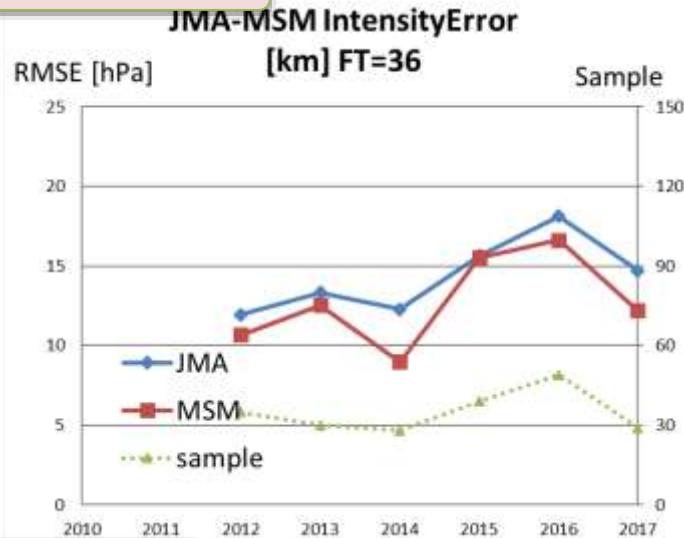


NCEP/ENP

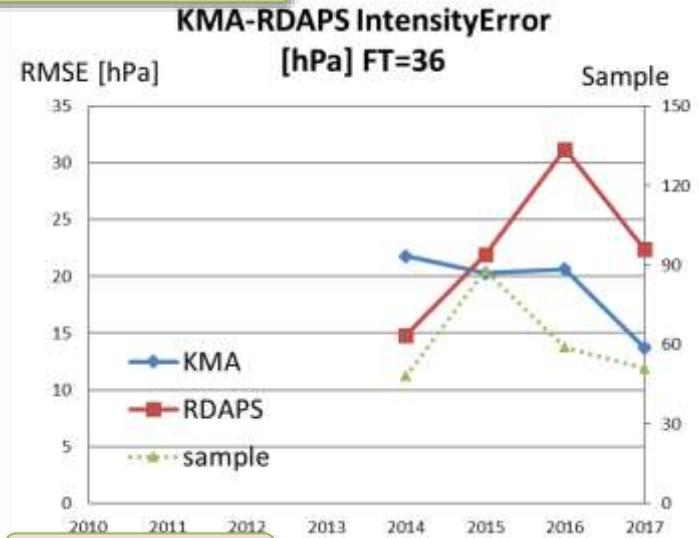


Intensity errors(RMSE)

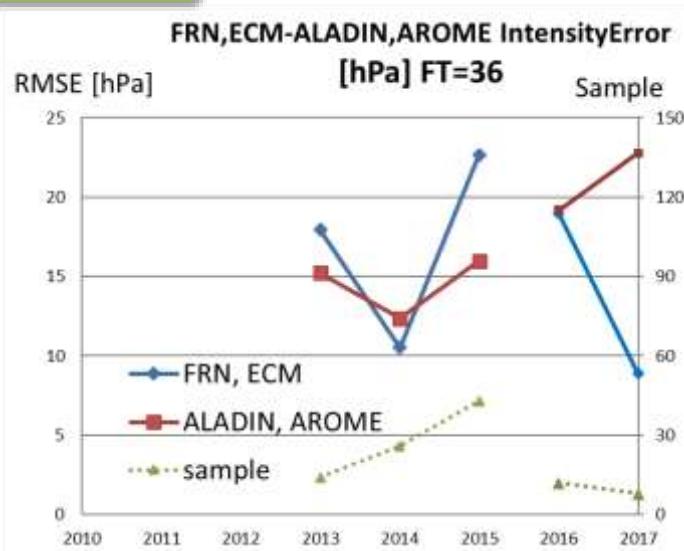
JMA/WNP



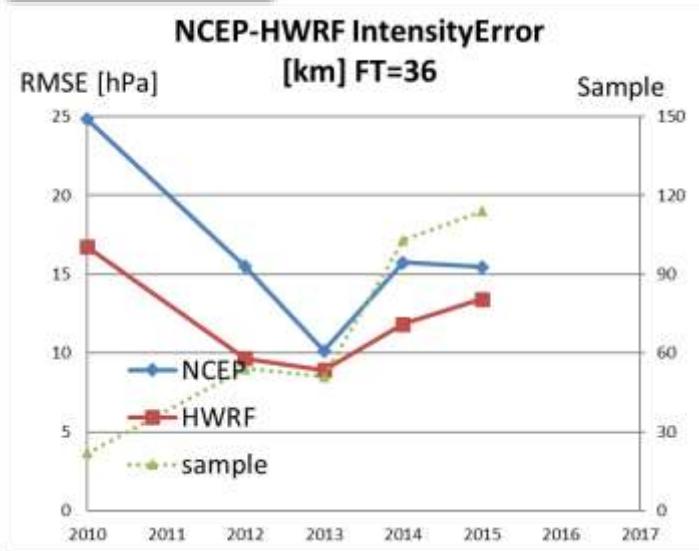
KMA/WNP



FRN/SIO



NCEP/ENP



Regional model verification: Summary

- Questions at the beginning of regional models TC verif. :
 - Do high-resolution regional models outperform TC forecasts to driving global models and give additional information ?
- WGNE regional model TC verif. and recent studies have answered:
 - Position: TC position performance of regional models tend to be neutral to, or worse than, those of driving global models.
 - Intensity: Regional models can outperform driving global models.
 - Other similar studies : Ito et al. (2015, Mon. Wea. Rev.), Short and Petch (2018, Mon. Wea Rev.) etc.

BACKUP SLIDES

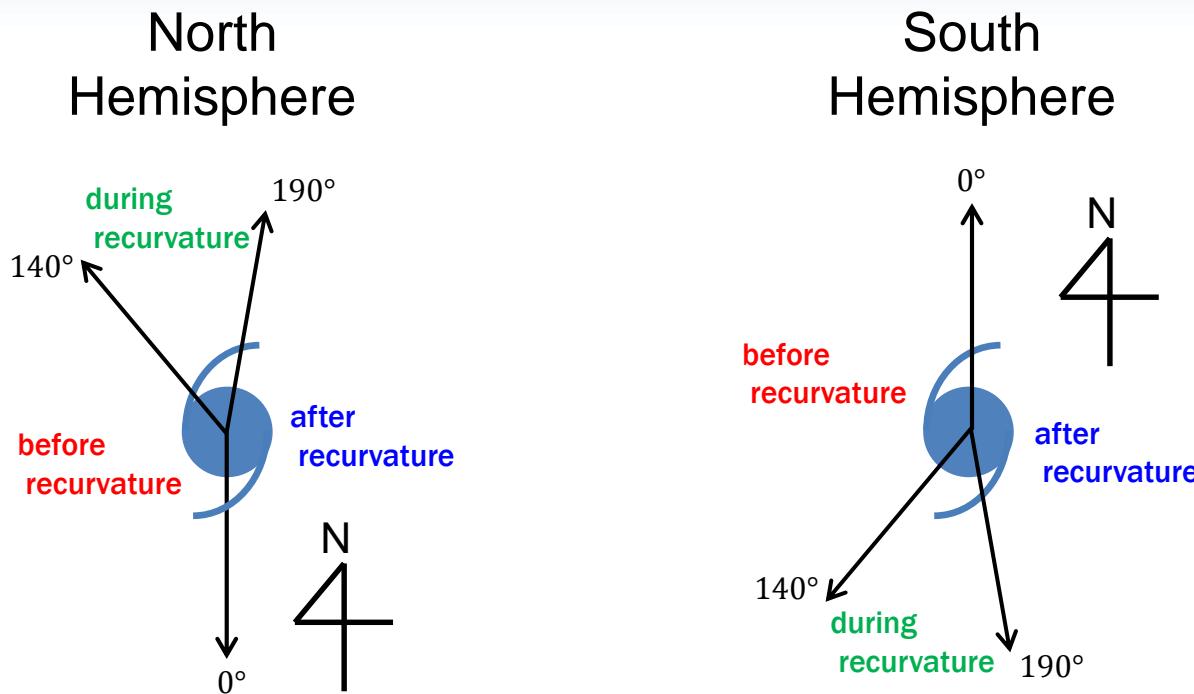
History of the Project

- 1991 : Commencement with 3 centres: ECMWF, UKMO and JMA.
The verification area was only western North Pacific (WNP).
- 1994 : CMC joined.
- 1999 : Verification for North Atlantic (NAT) started.
- 2000 : DWD joined. Verification for eastern North Pacific (ENP) started.
- 2002 : Verification for 2 regions in the Southern Hemisphere (SIO and AUR),
North Indian Ocean (NIO) and central North Pacific (CPC) started.
- 2003 : NCEP and BoM joined. A website for this project was launched.
- 2004 : Météo-France (FRN) and CMA joined.
- 2006 : CPTEC and NRL joined.
- 2011 : KMA joined.

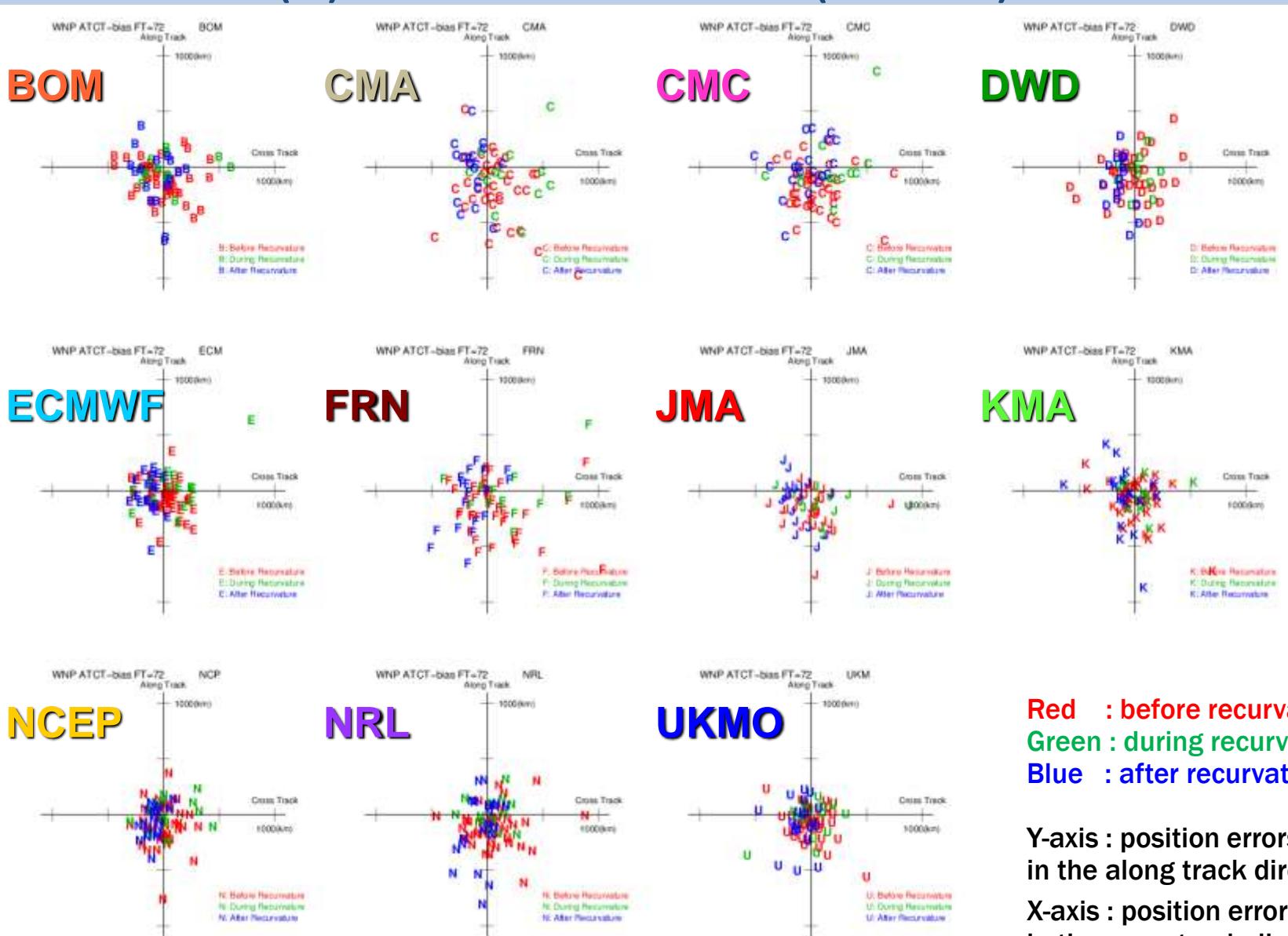
2019 : 11 NWP centres (BoM, CMA, CMC, DWD, ECMWF, FRN, JMA, KMA,
NCEP, NRL, UKMO) are now involved in the project.

AT-CT Bias

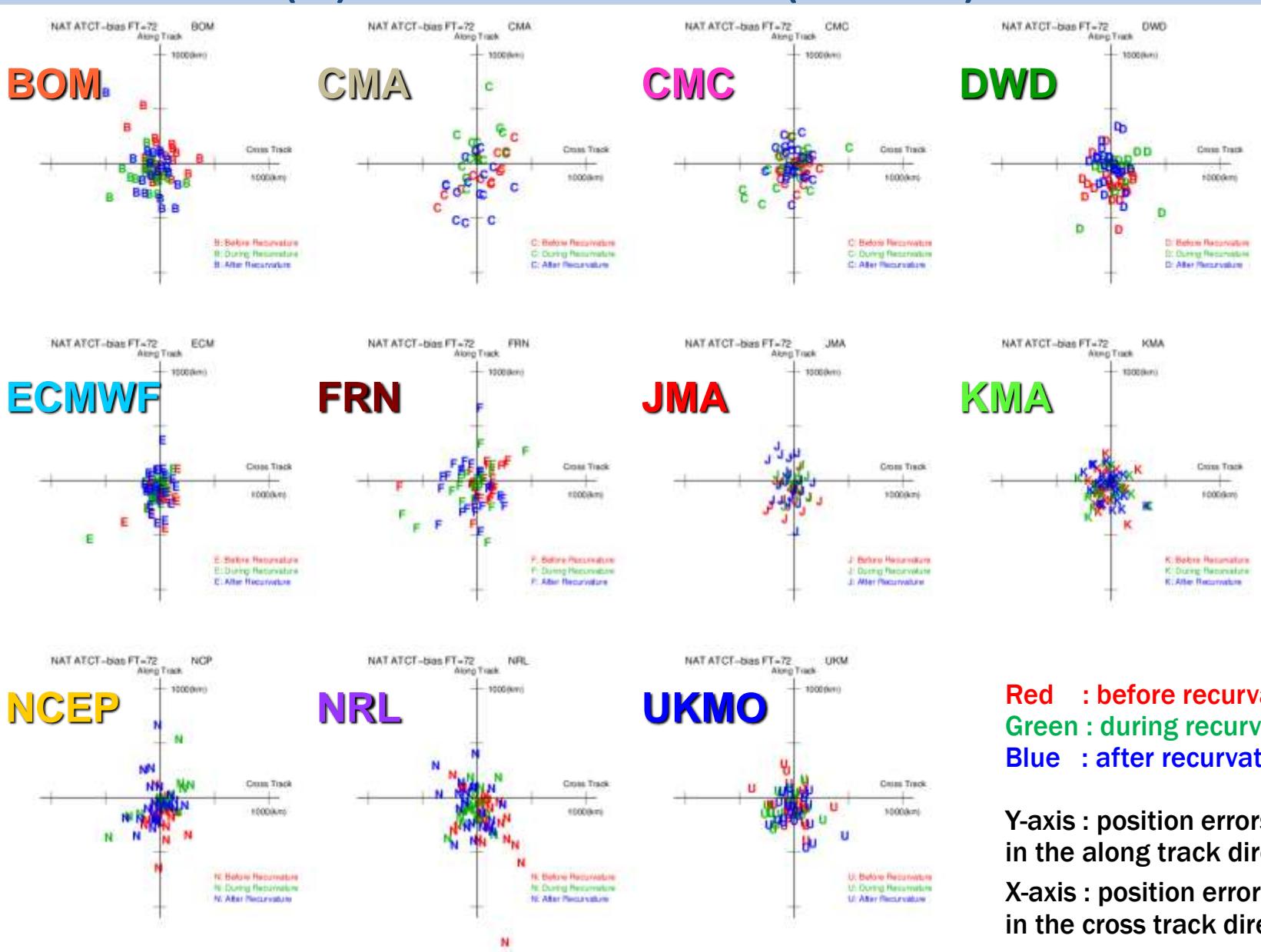
[Before, During, After] Recurvature



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



(b) NAT AT-CT Bias (FT=72)

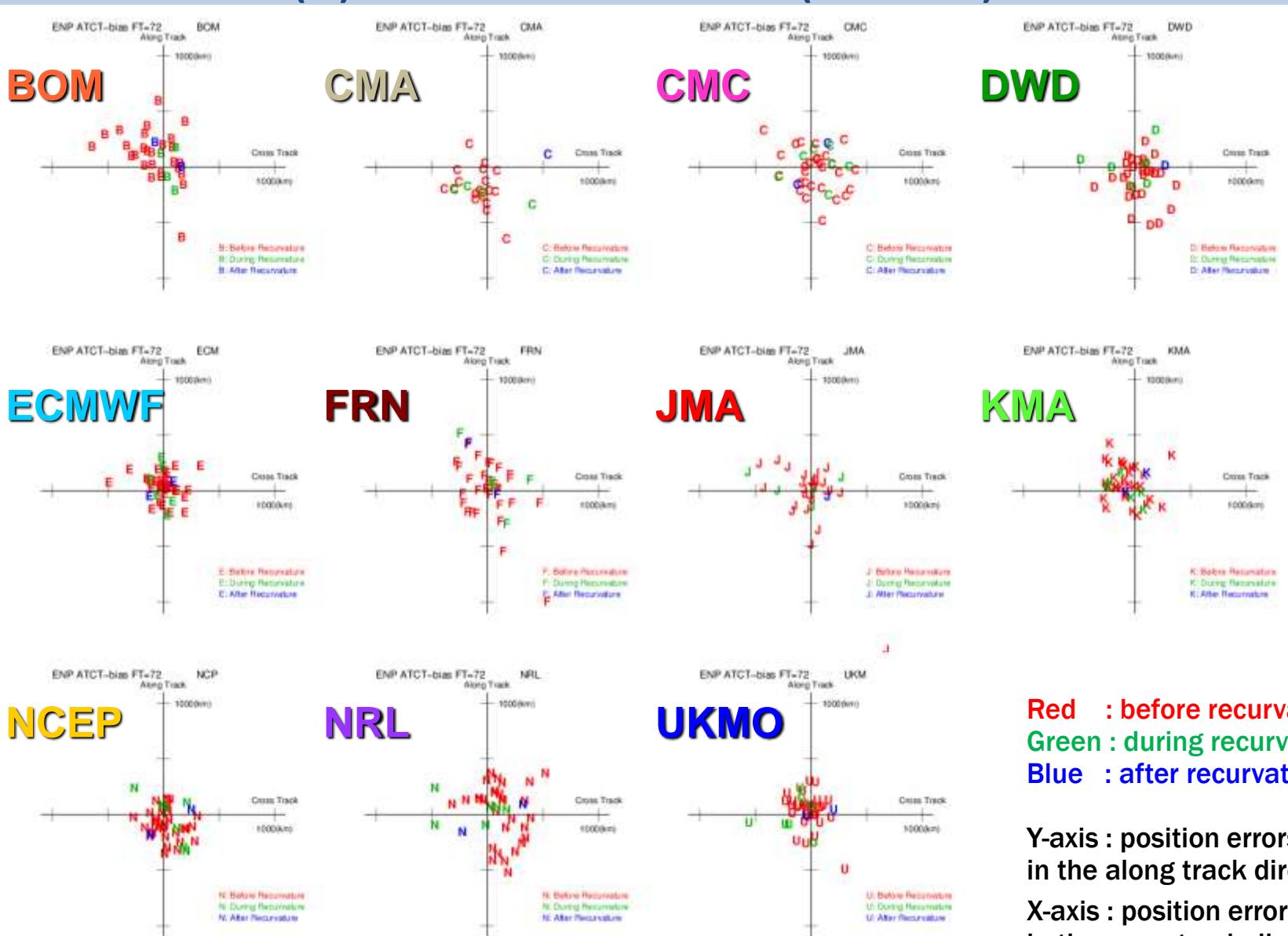


Red : before recurvature
 Green : during recurvature
 Blue : after recurvature

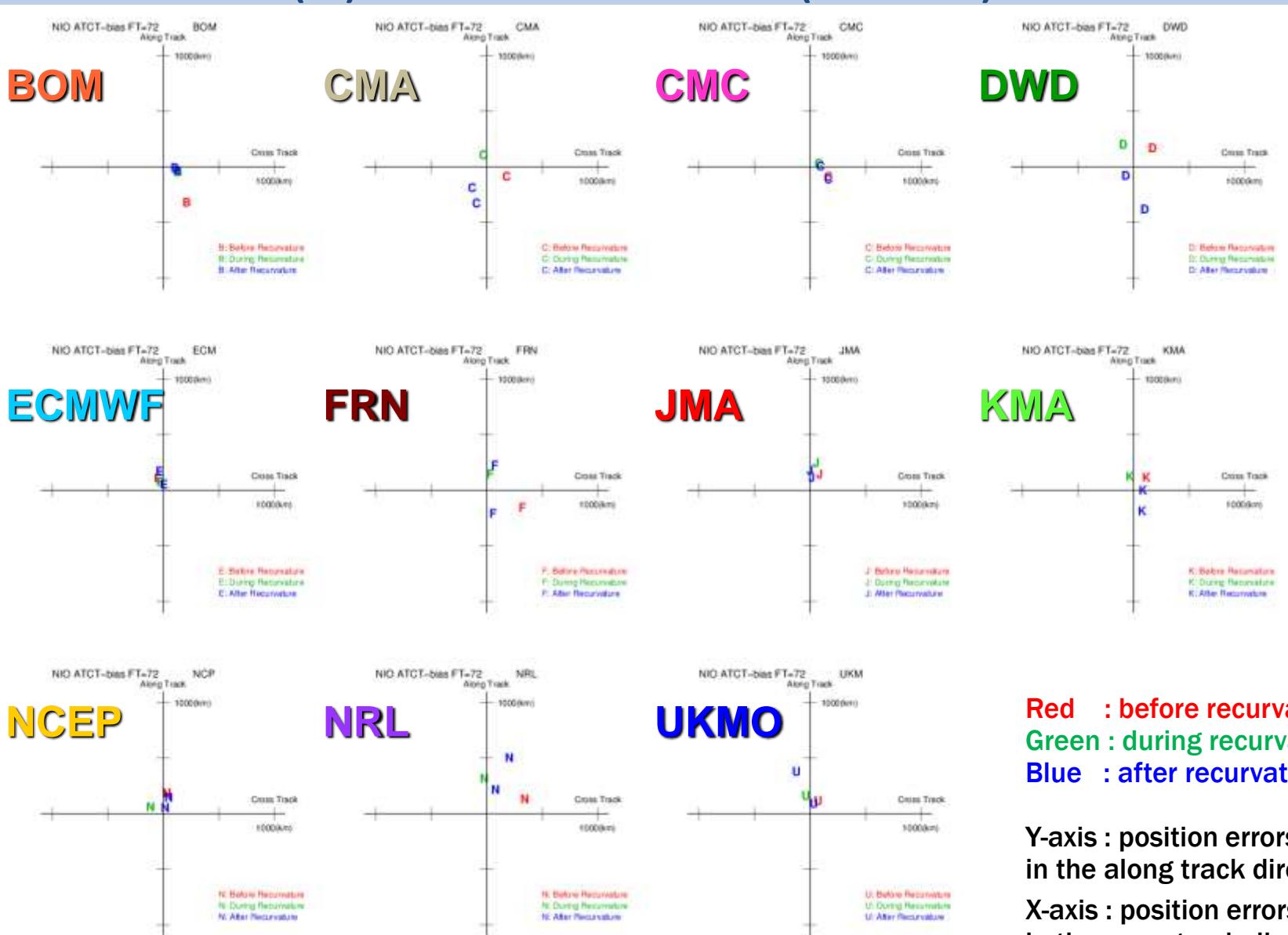
Y-axis : position errors (km)
 in the along track direction

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

(c) ENP AT-CT Bias (FT=72)



(d) NIO AT-CT Bias (FT=72)

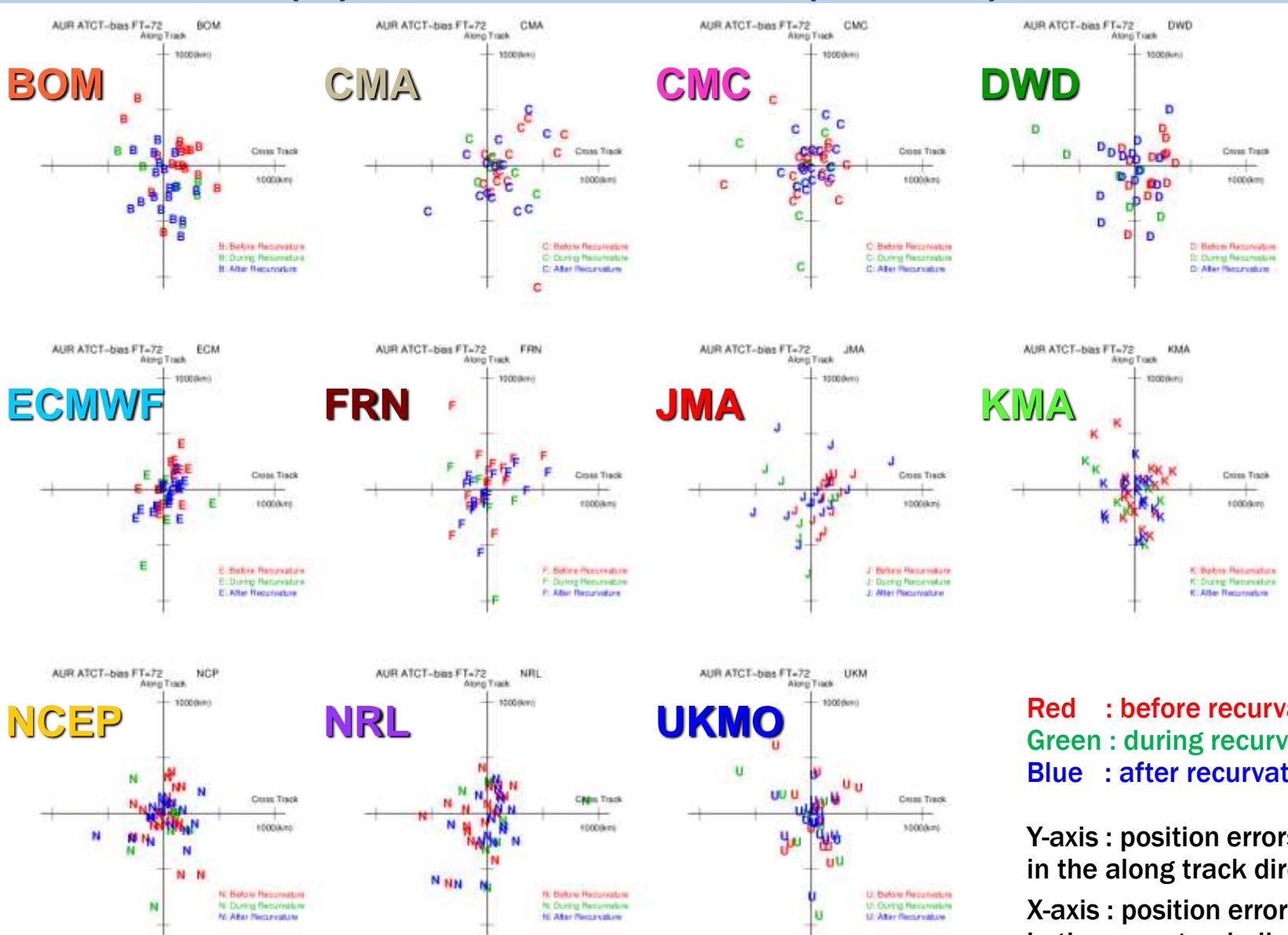


Red : before recurvature
Green : during recurvature
Blue : after recurvature

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

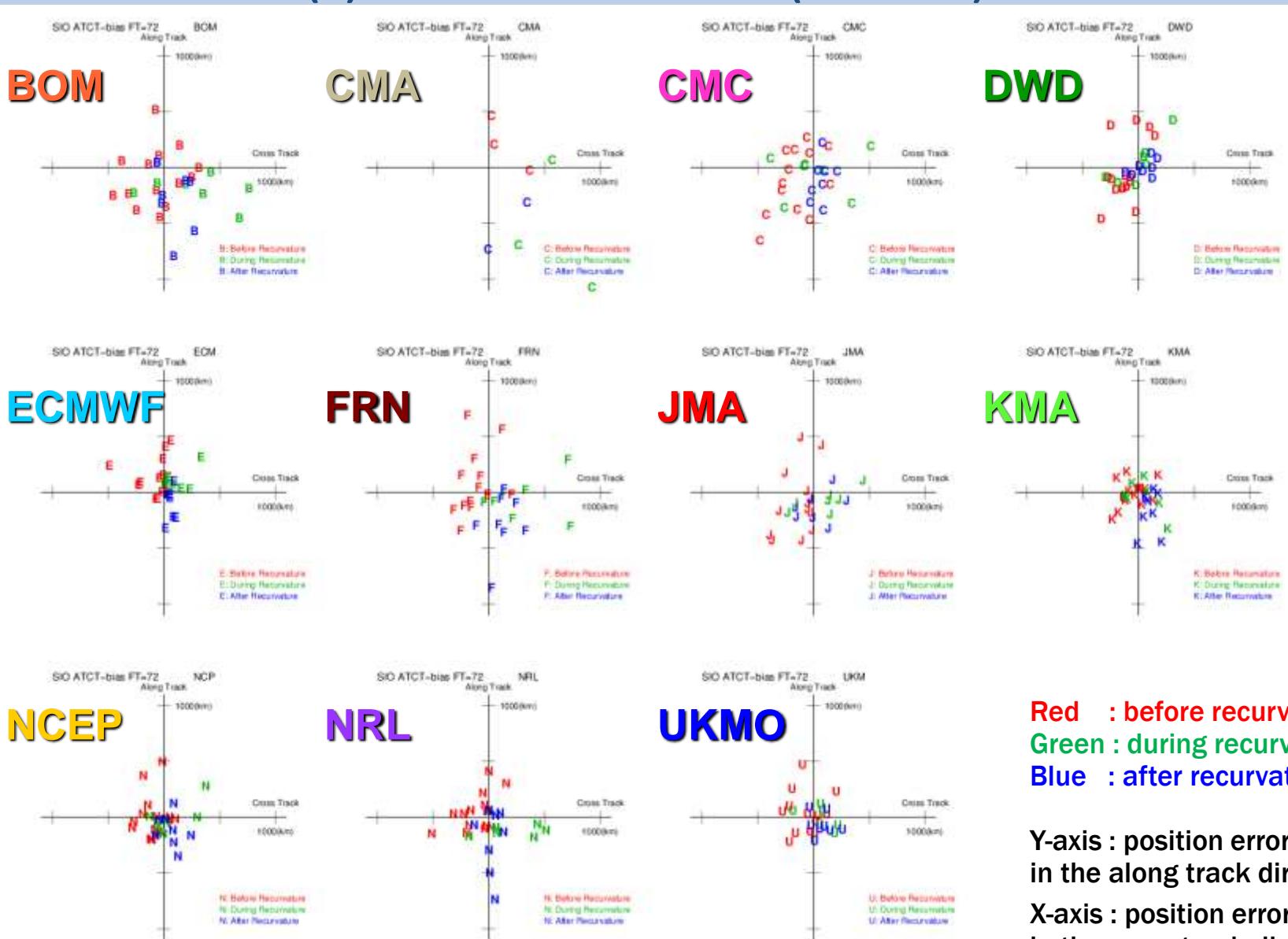
X-axis : position errors (km)
in the cross track direction

(e) AUR AT-CT Bias (FT=72)



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

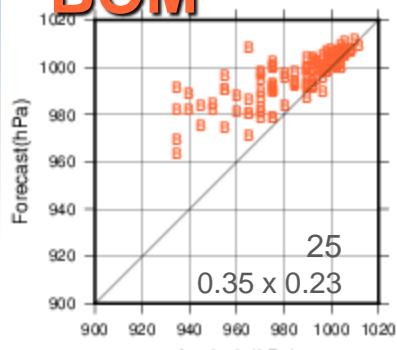
(f) SIO AT-CT Bias (FT=72)



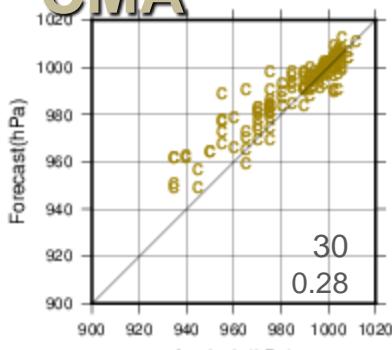
Central Pressure Scatter Diagram

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

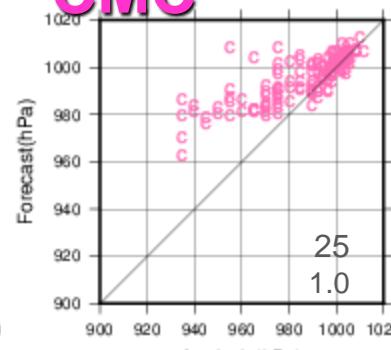
BOM



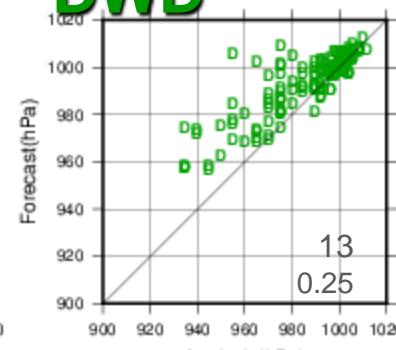
CMA



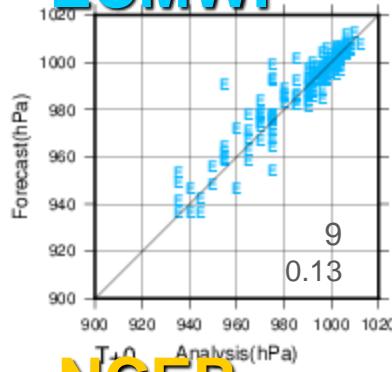
CMC



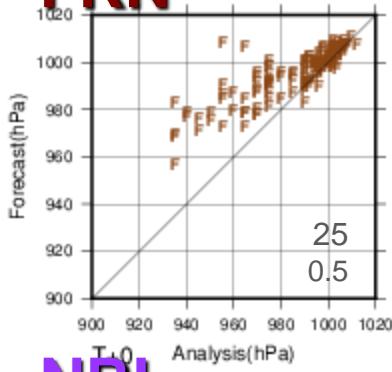
DWD



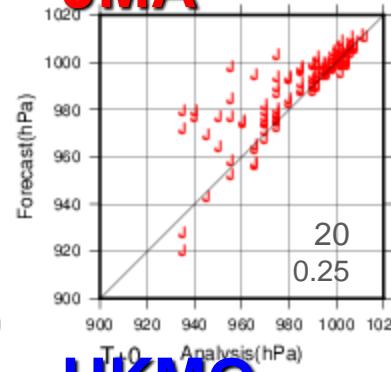
ECMWF



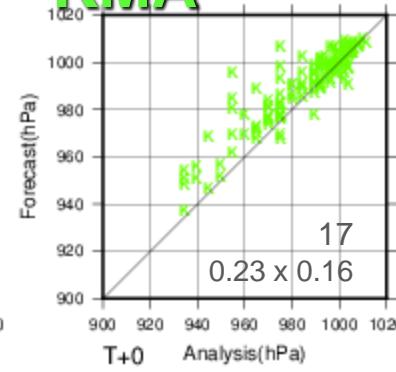
FRN



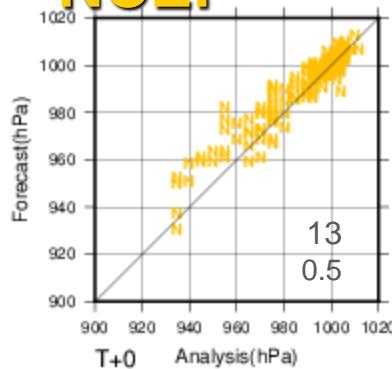
JMA



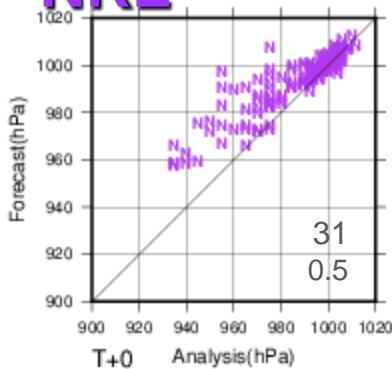
KMA



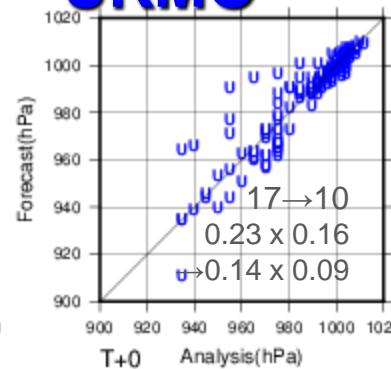
NCEP



NRL



UKMO

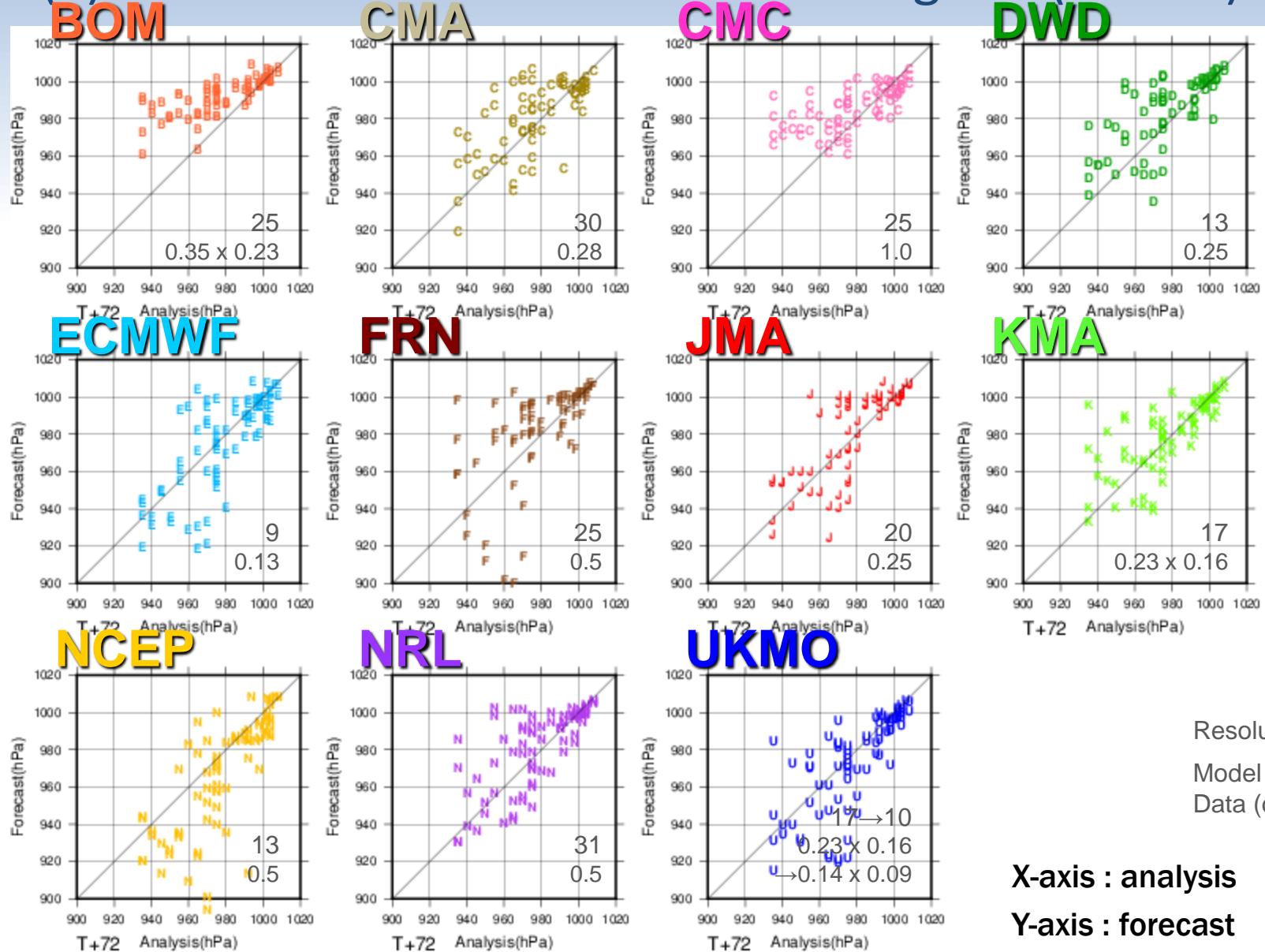


Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast

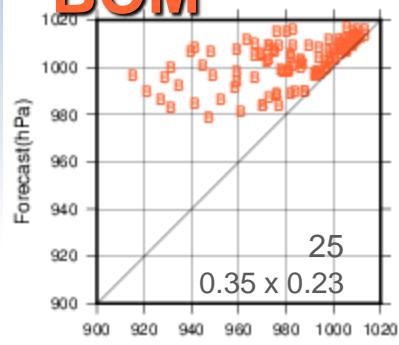


(a) WNP Central Pressure Scatter Diagram (FT +72)

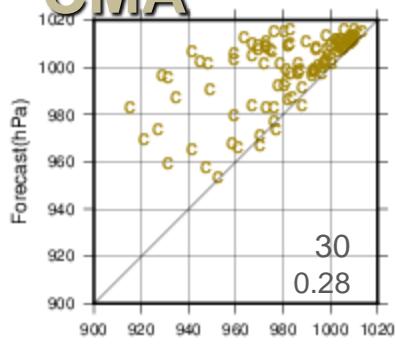


(b) NAT Central Pressure Scatter Diagram (FT +0)

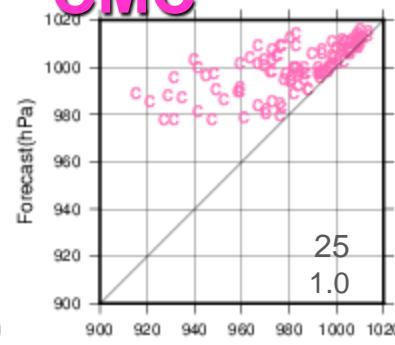
BOM



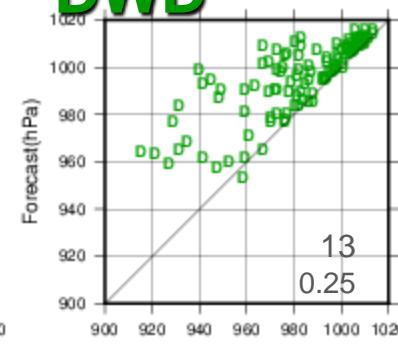
CMA



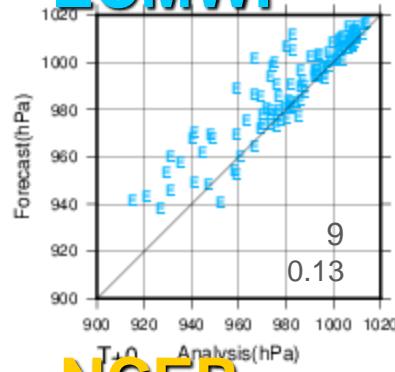
CMC



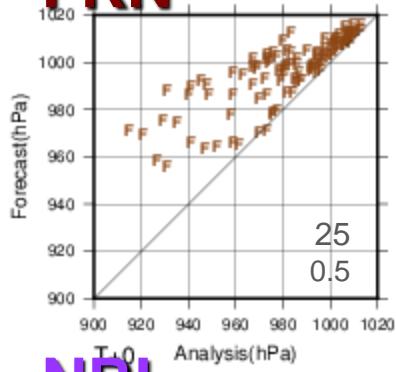
DWD



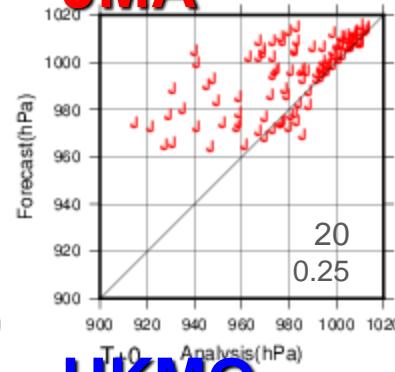
ECMWF



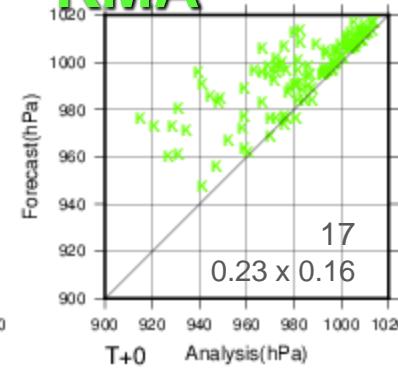
FRN



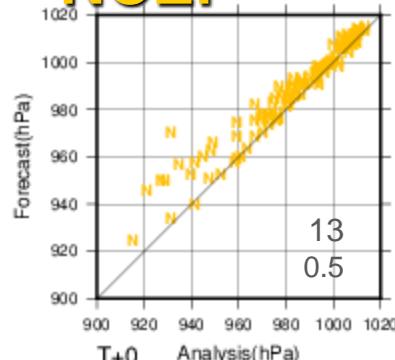
JMA



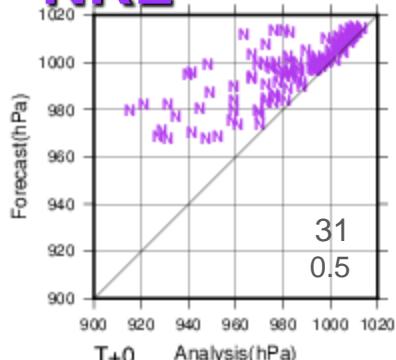
KMA



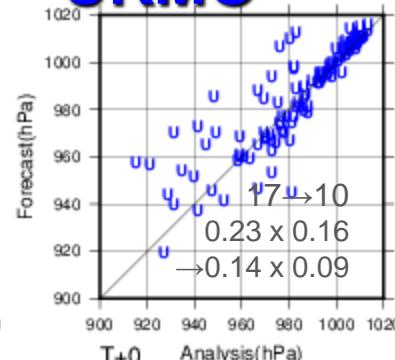
NCEP



NRL



UKMO

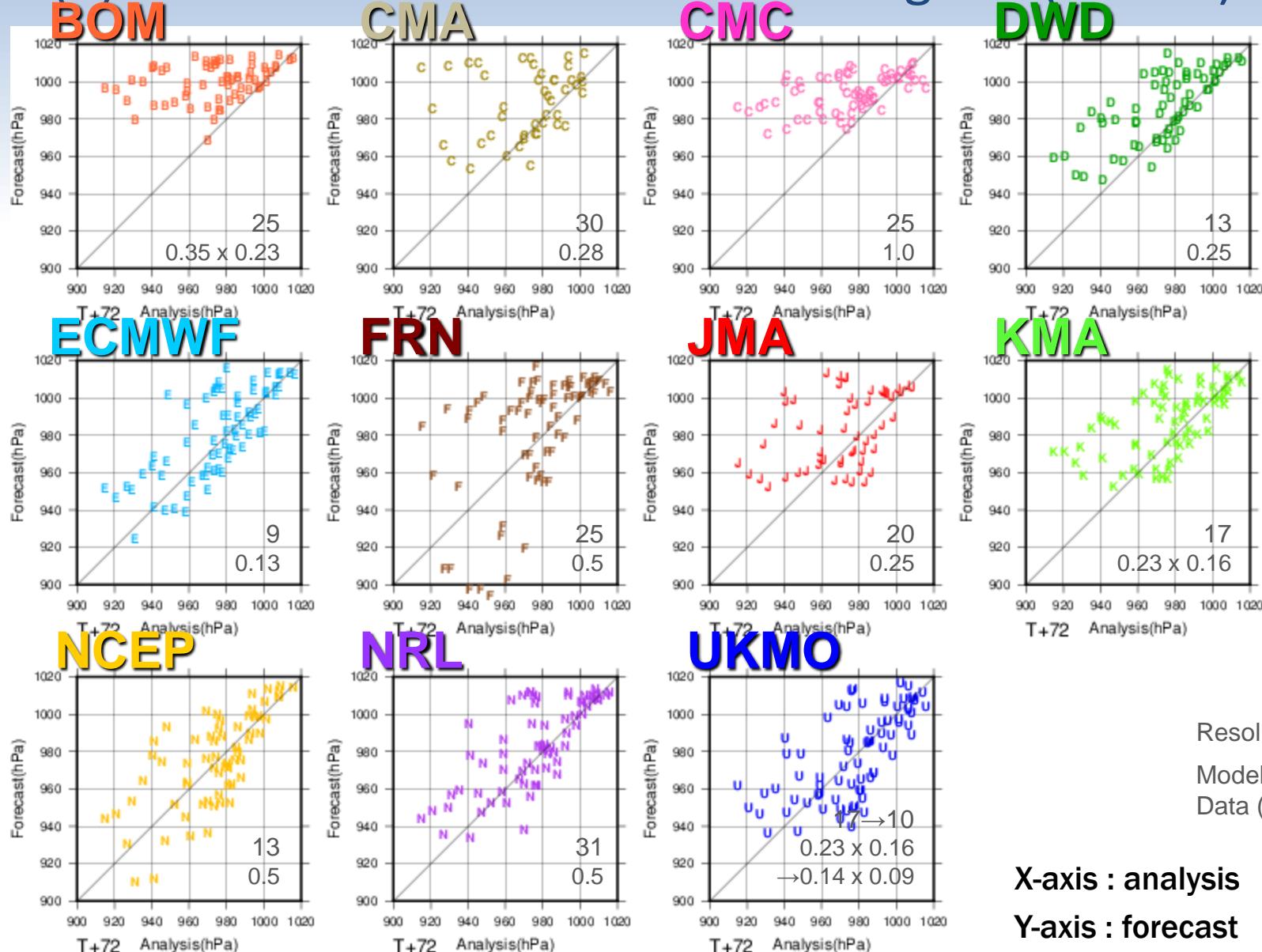


Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast

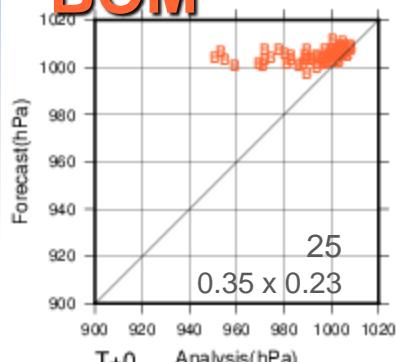


(b) NAT Central Pressure Scatter Diagram (FT +72)

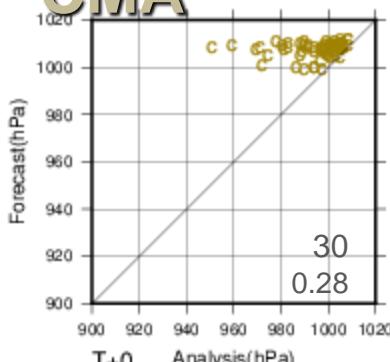


(c) ENP Central Pressure Scatter Diagram (FT +0)

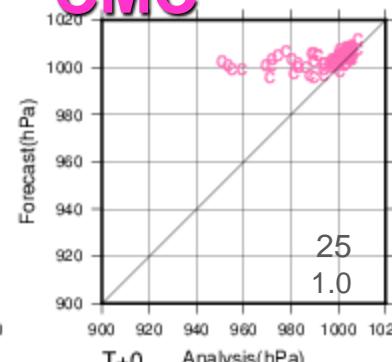
BOM



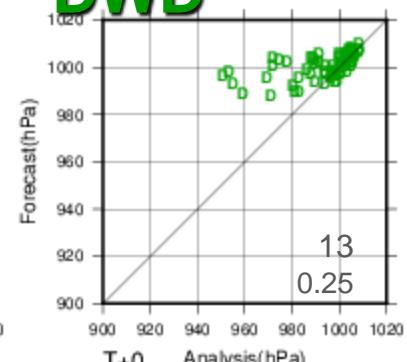
CMA



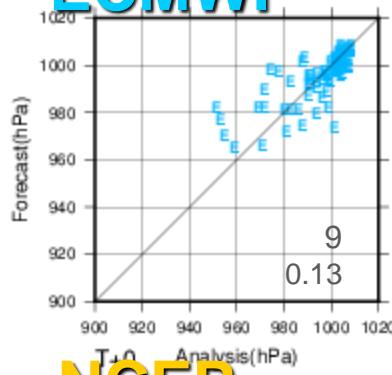
CMC



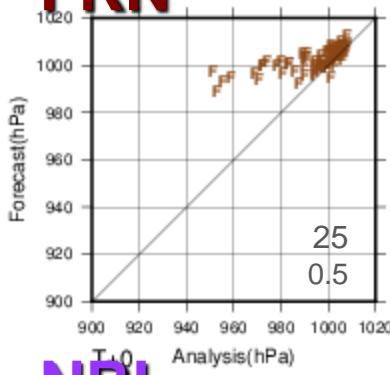
DWD



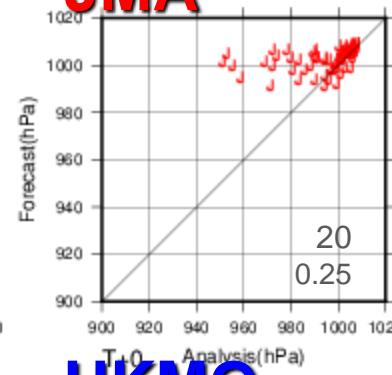
ECMWF



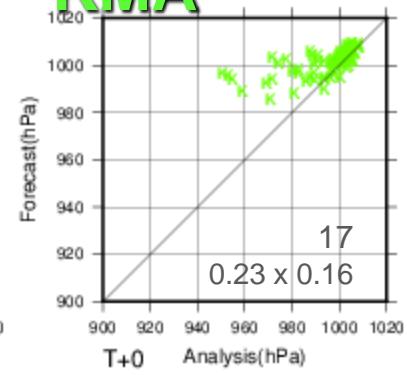
FRN



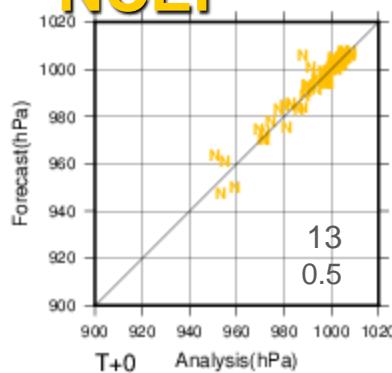
JMA



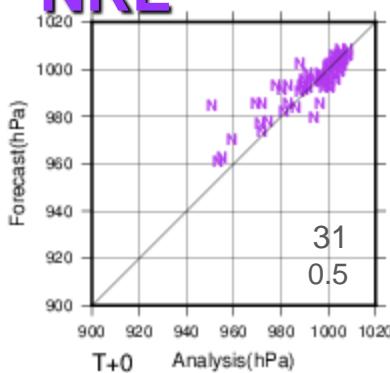
KMA



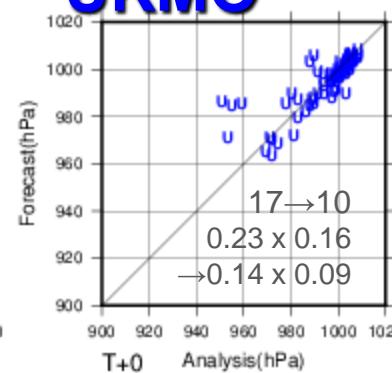
NCEP



NRL



UKMO



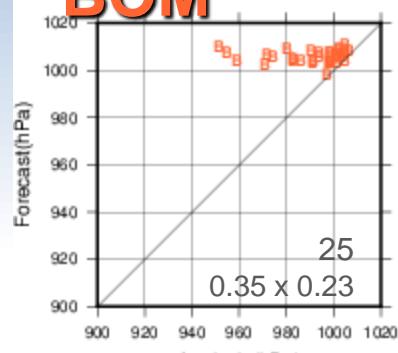
Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast

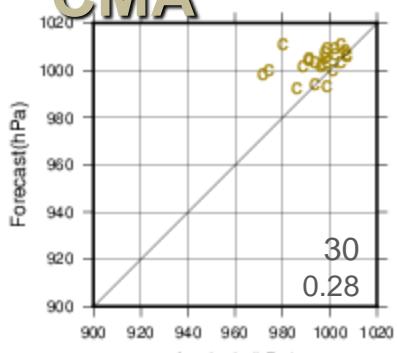


(c) ENP Central Pressure Scatter Diagram (FT +72)

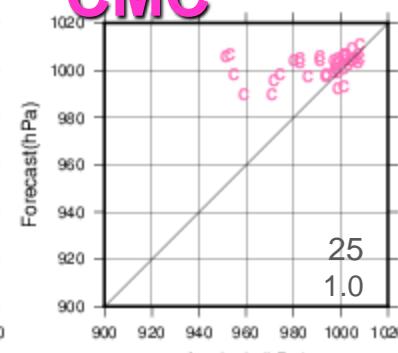
BOM



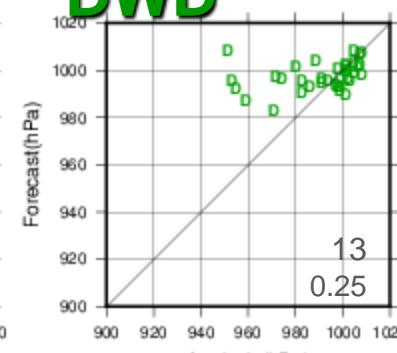
CMA



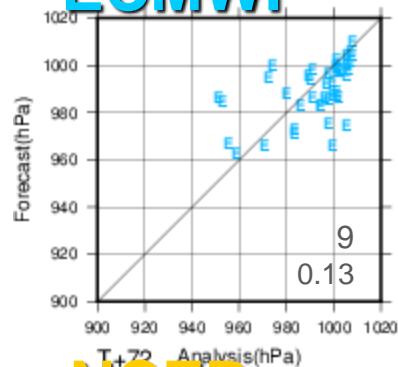
CMC



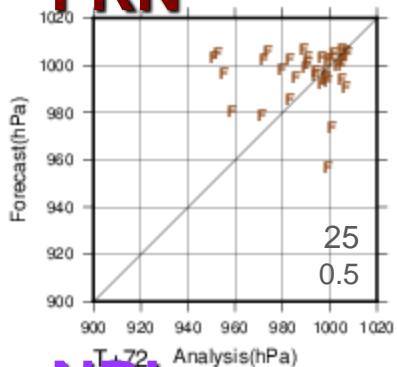
DWD



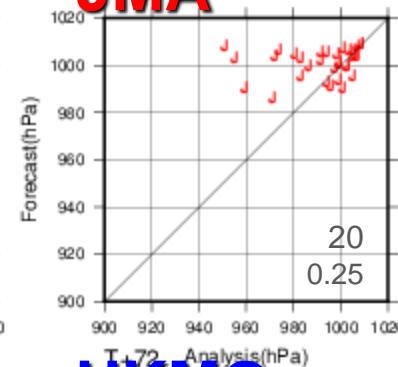
ECMWF



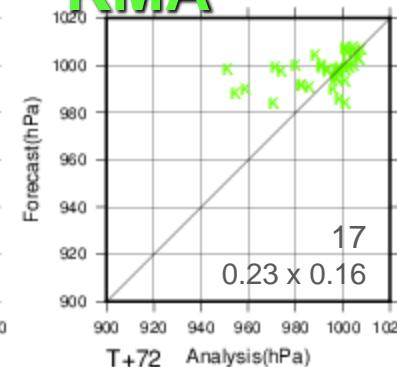
FRN



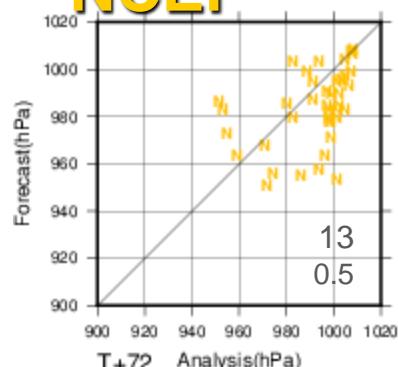
JMA



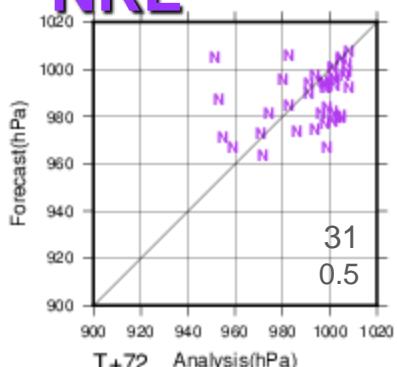
KMA



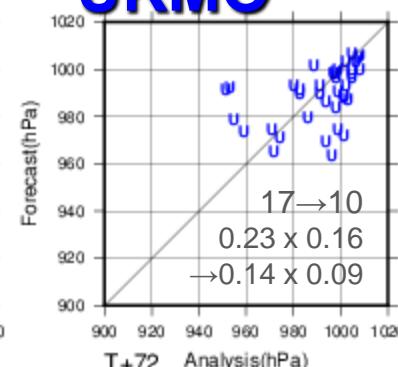
NCEP



NRL



UKMO



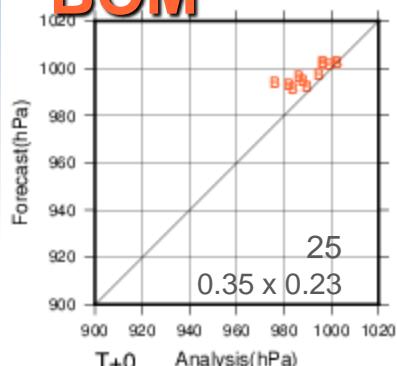
Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast

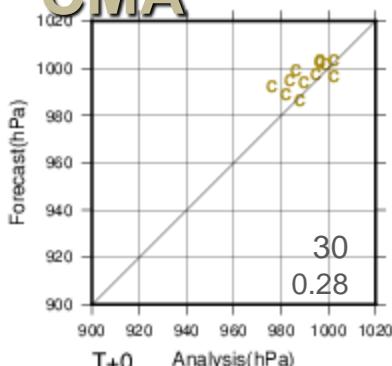


(d) NIO Central Pressure Scatter Diagram (FT +0)

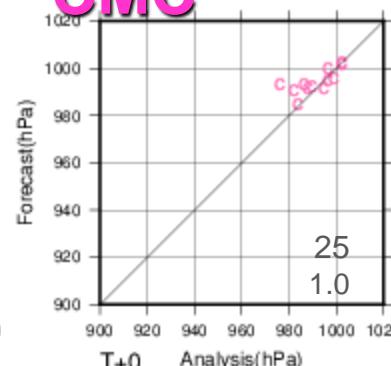
BOM



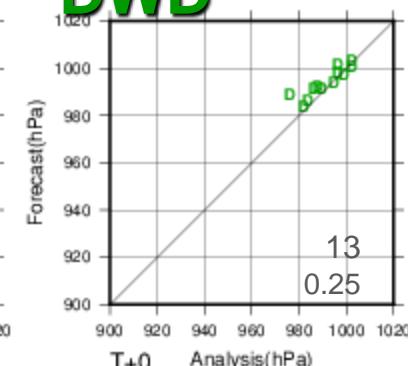
CMA



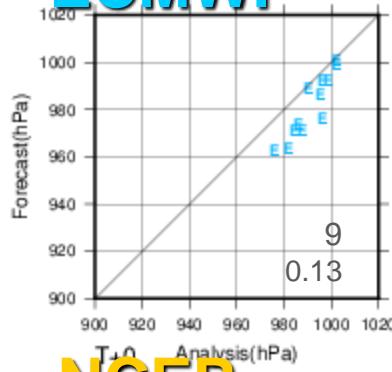
CMC



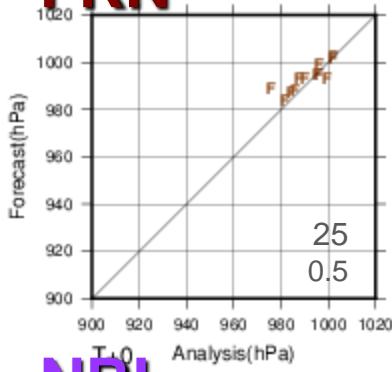
DWD



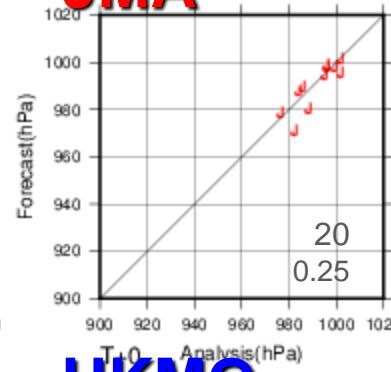
ECMWF



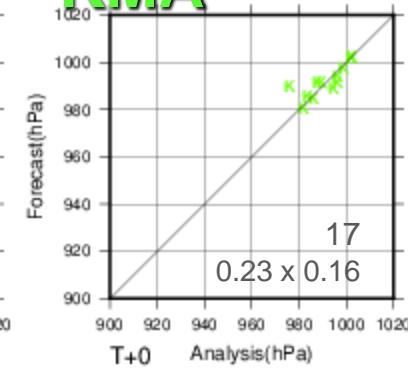
FRN



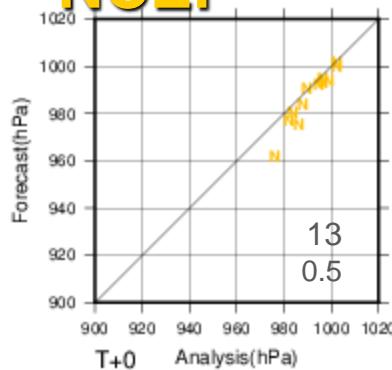
JMA



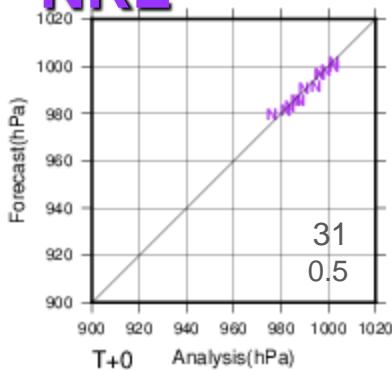
KMA



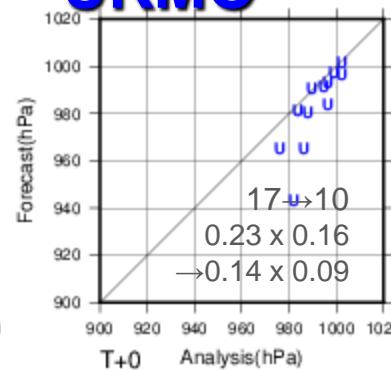
NCEP



NRL



UKMO

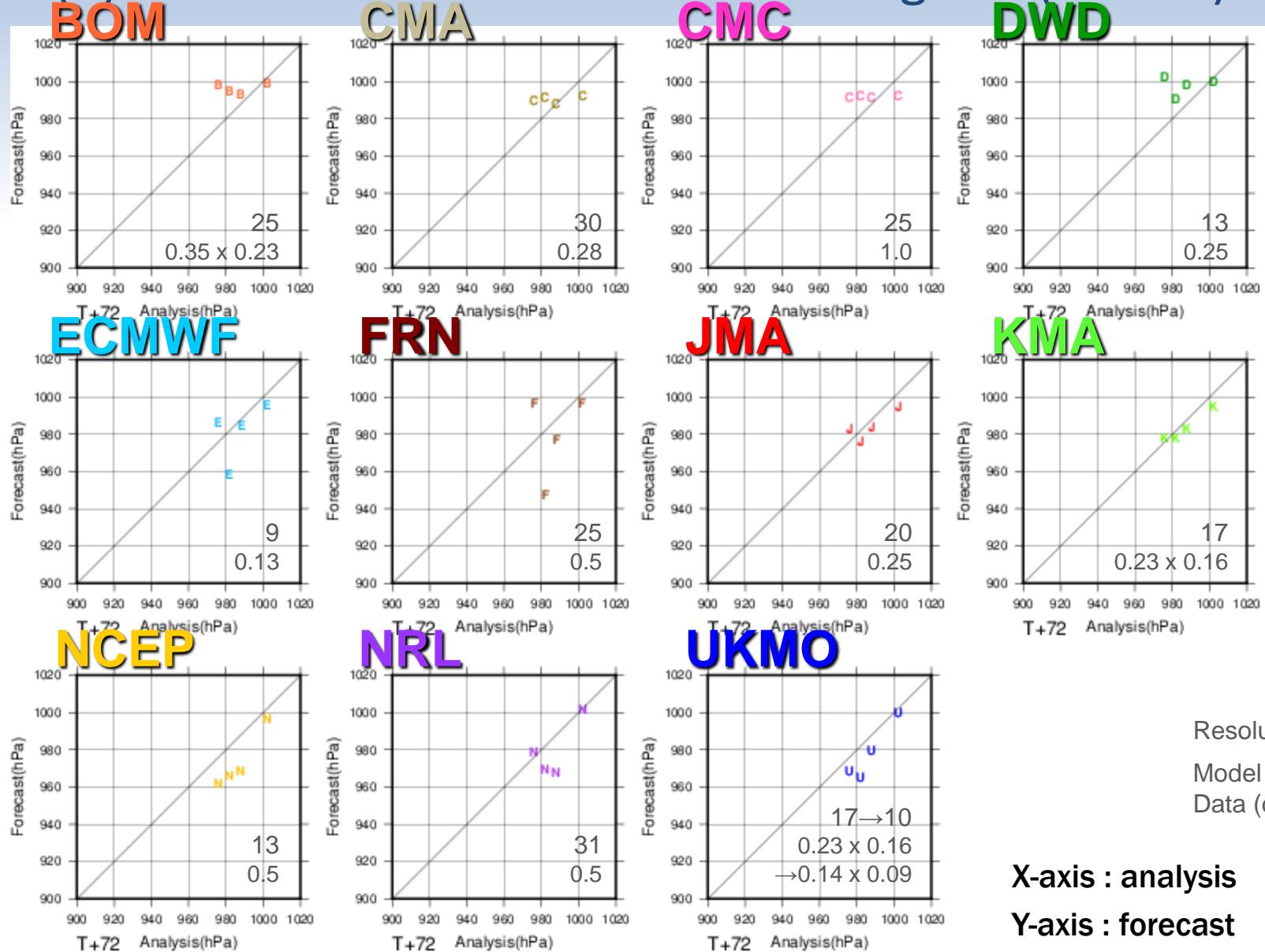


Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast

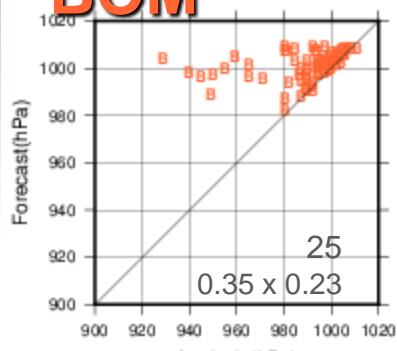


(d) NIO Central Pressure Scatter Diagram (FT +72)

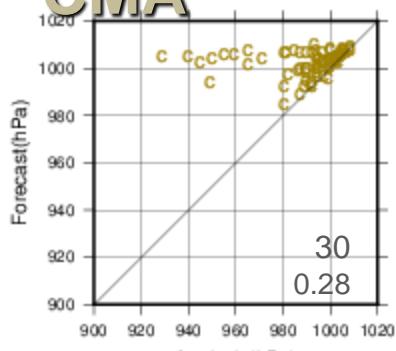


(e) AUR Central Pressure Scatter Diagram (FT +0)

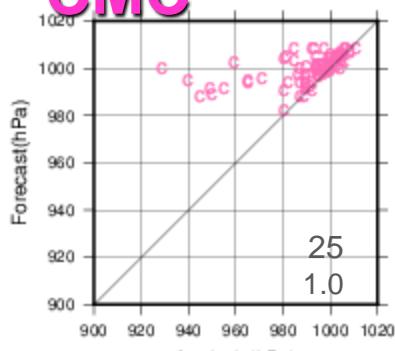
BOM



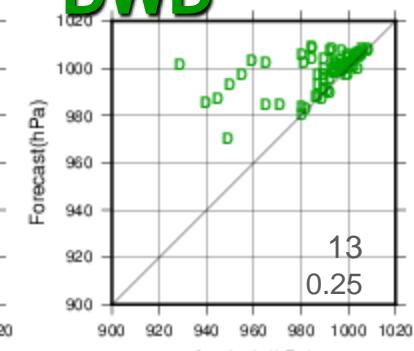
CMA



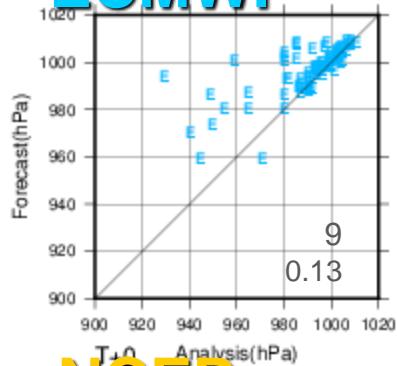
CMC



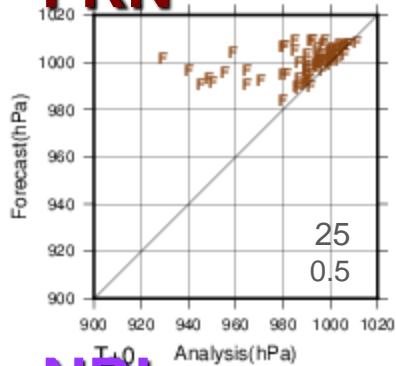
DWD



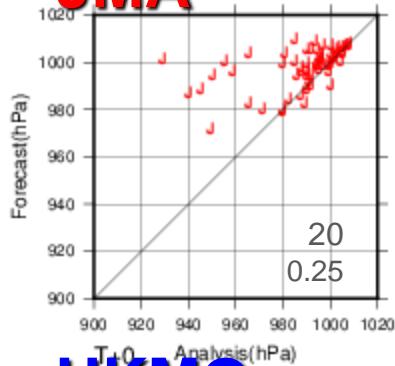
ECMWF



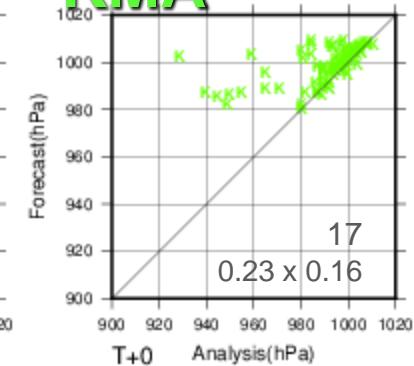
FRN



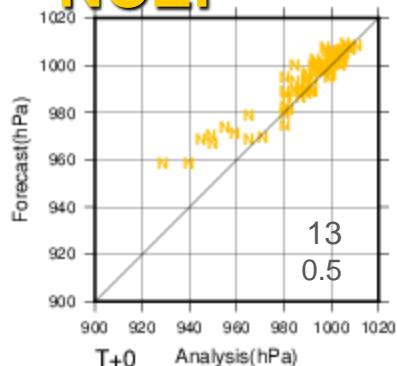
JMA



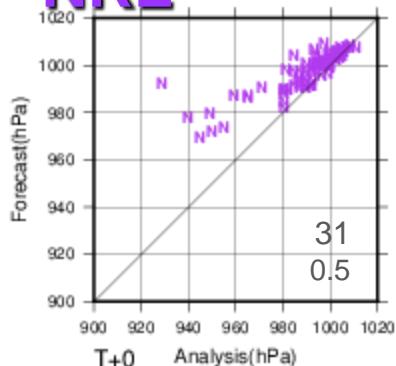
KMA



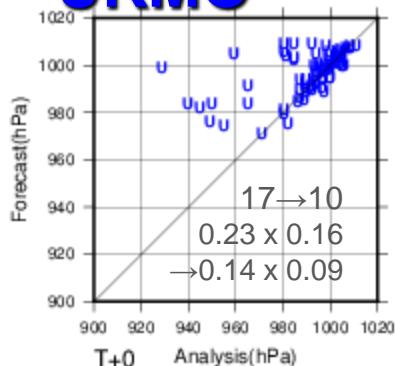
NCEP



NRL



UKMO

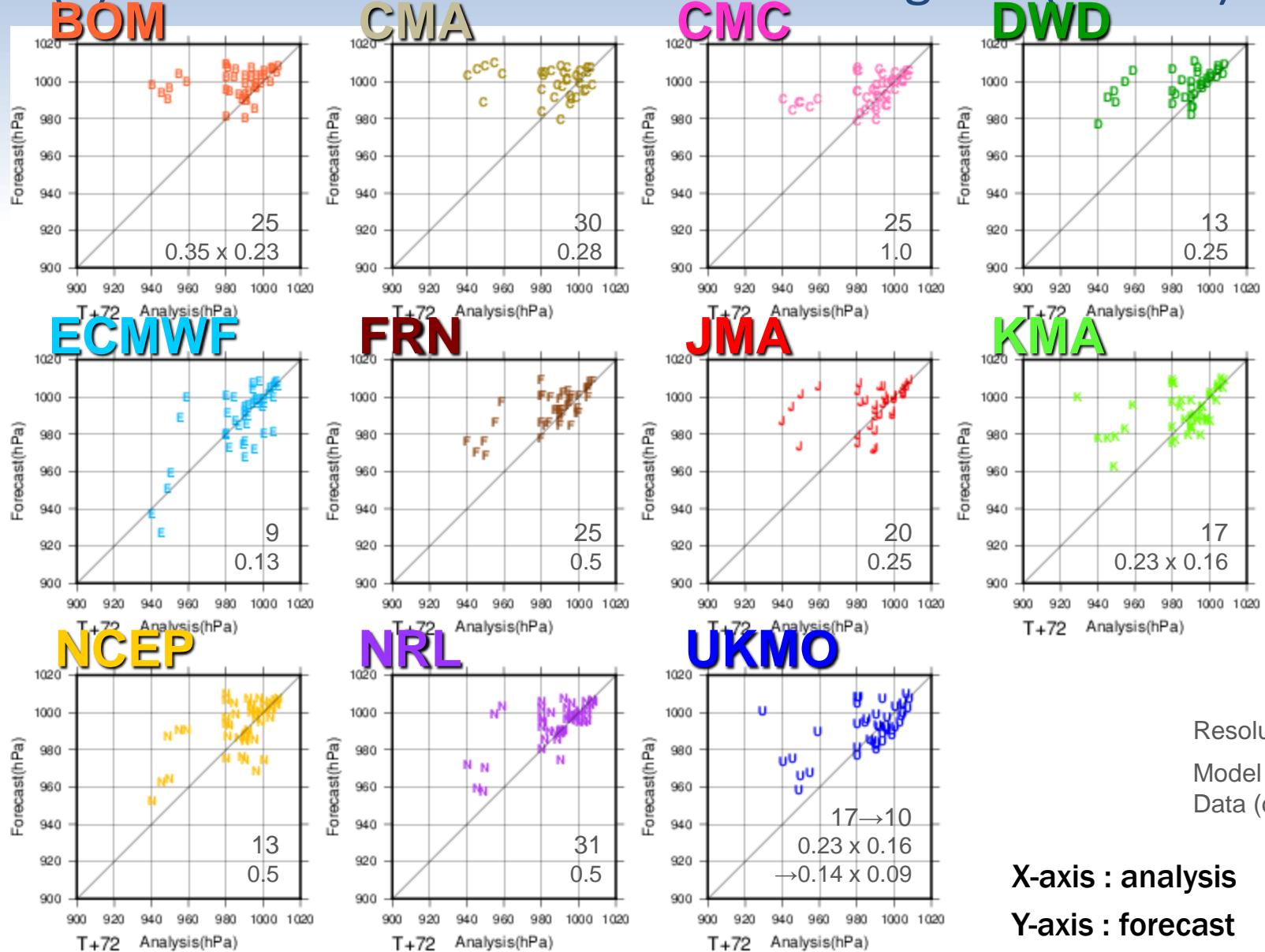


Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast

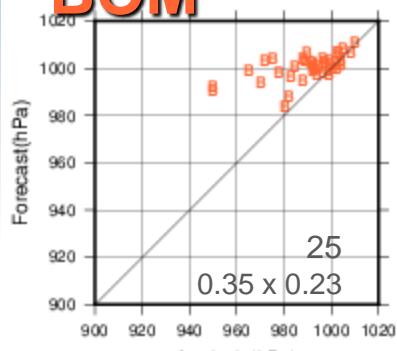


(e) AUR Central Pressure Scatter Diagram (FT +72)

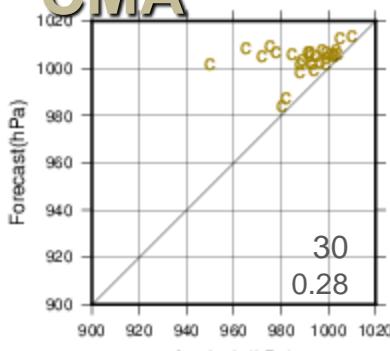


(f) SIO Central Pressure Scatter Diagram (FT +0)

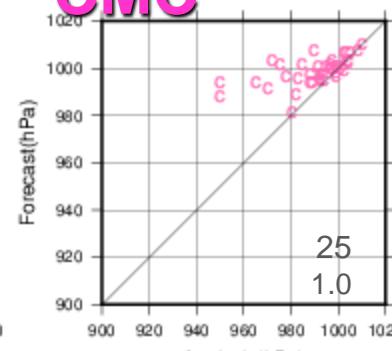
BOM



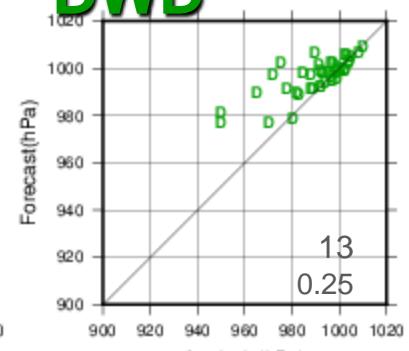
CMA



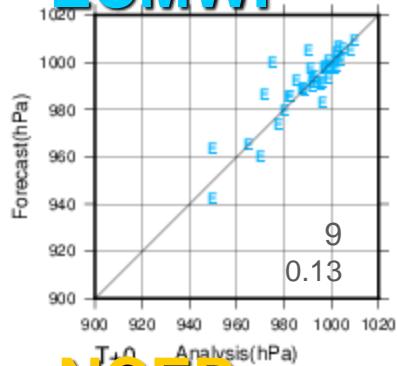
CMC



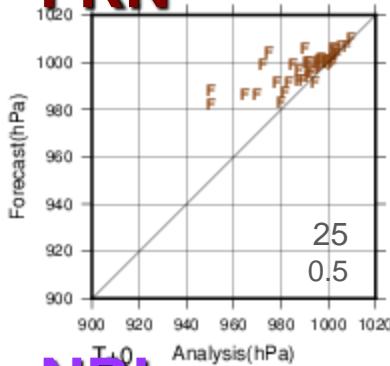
DWD



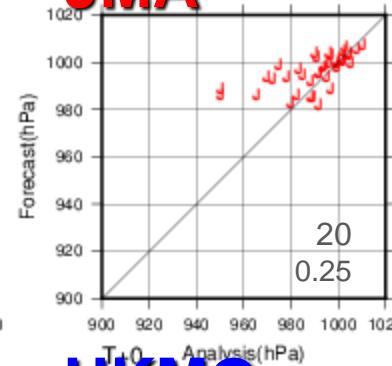
ECMWF



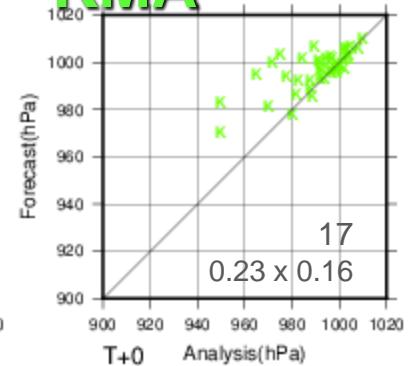
FRN



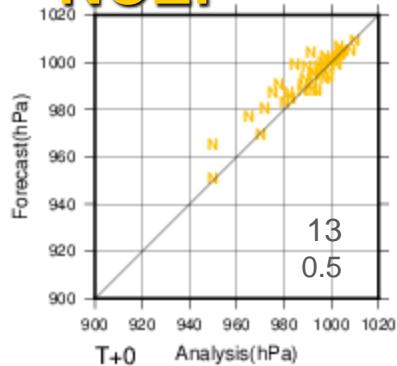
JMA



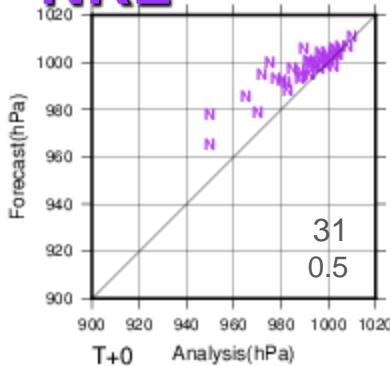
KMA



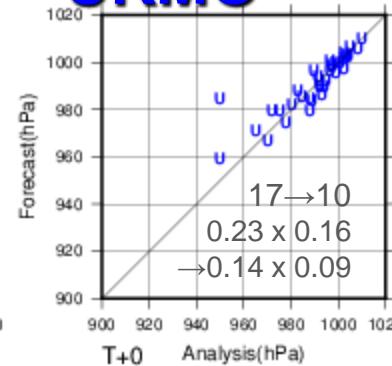
NCEP



NRL



UKMO



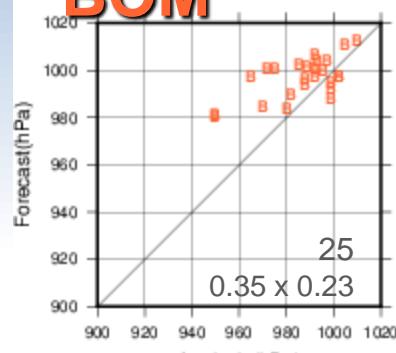
Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast

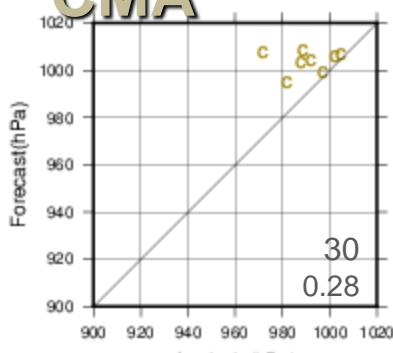


(f) SIO Central Pressure Scatter Diagram (FT +72)

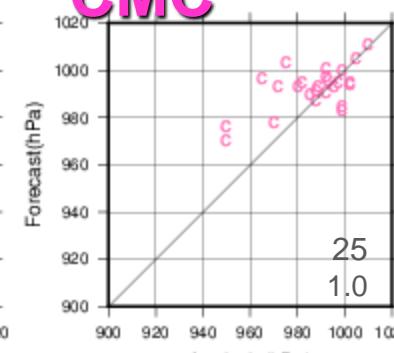
BOM



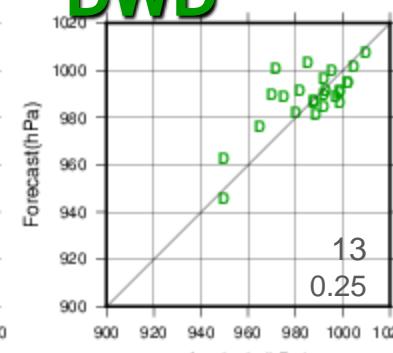
CMA



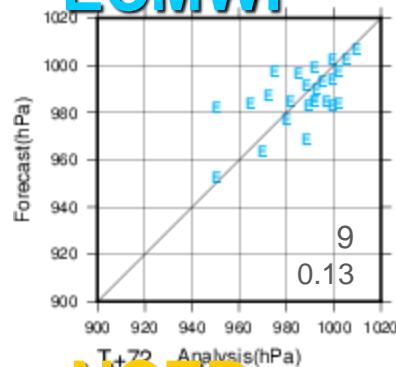
CMC



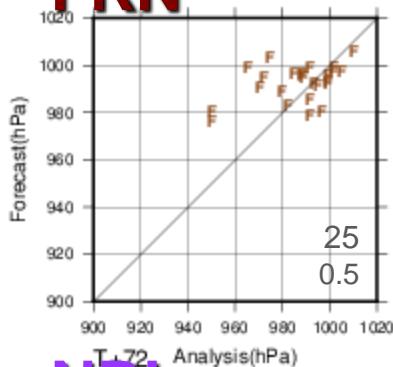
DWD



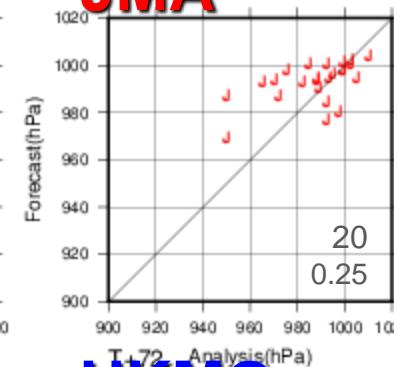
ECMWF



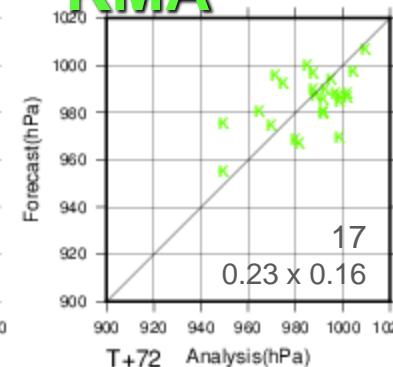
FRN



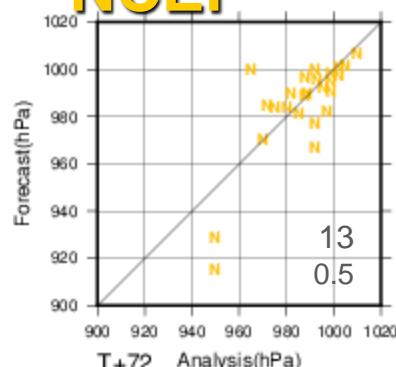
JMA



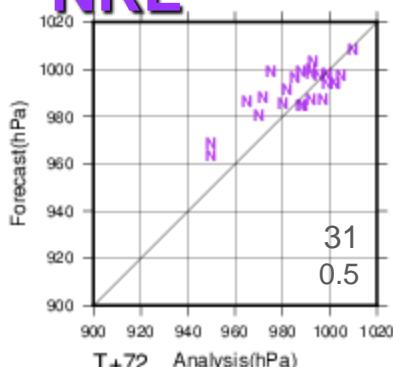
KMA



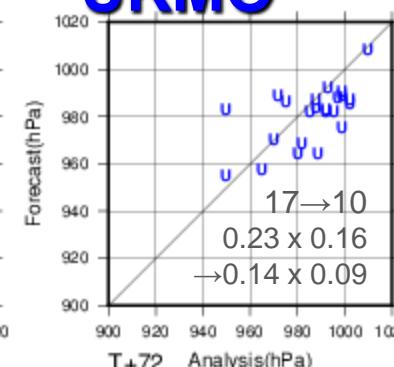
NCEP



NRL



UKMO



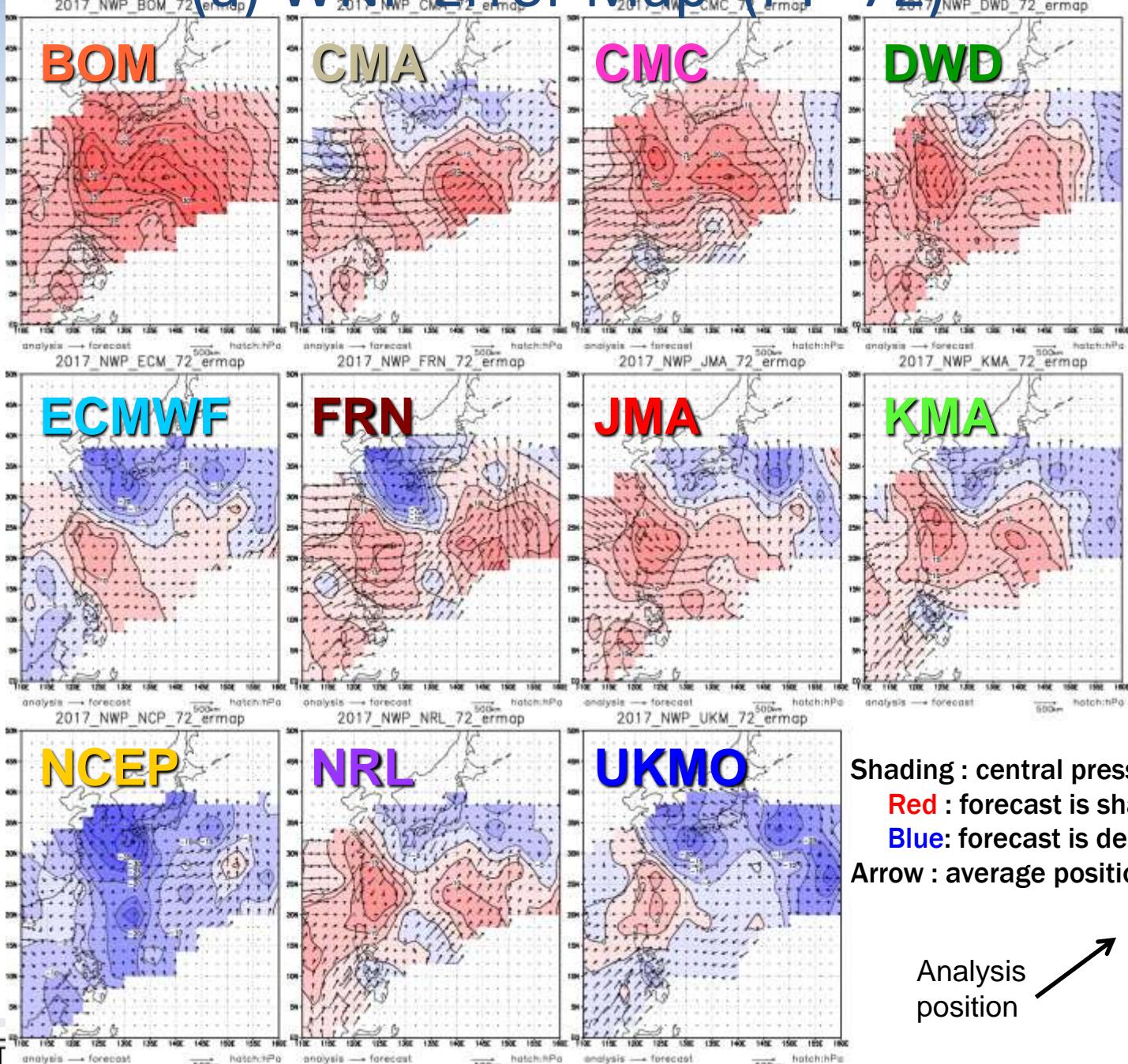
Resolution
Model (km)
Data (deg)

X-axis : analysis
Y-axis : forecast



Error Map

(a) WNP Error Map (FT=72)



Shading : central pressure error (hPa)

Red : forecast is shallow

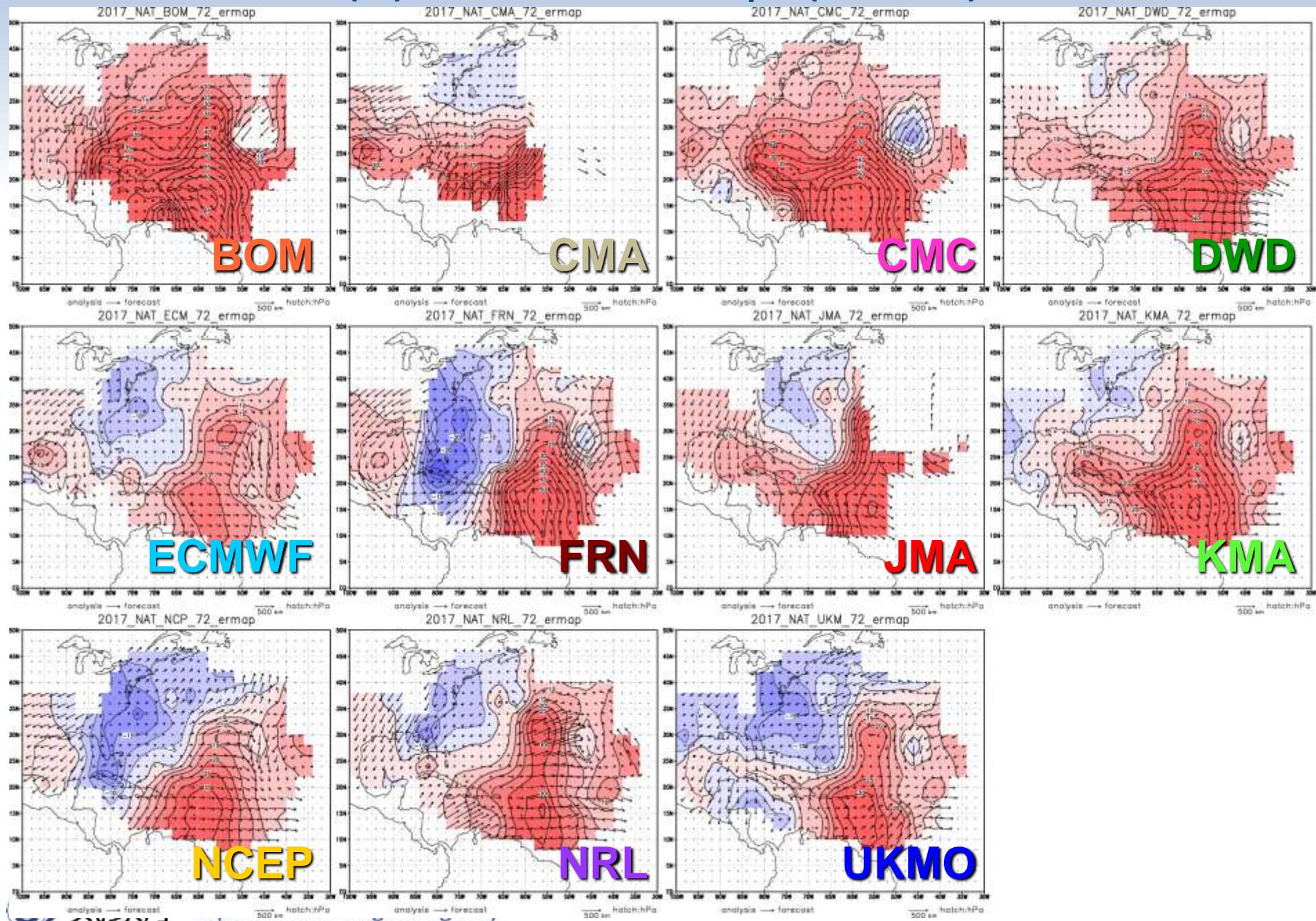
Blue: forecast is deep

Arrow : average position error

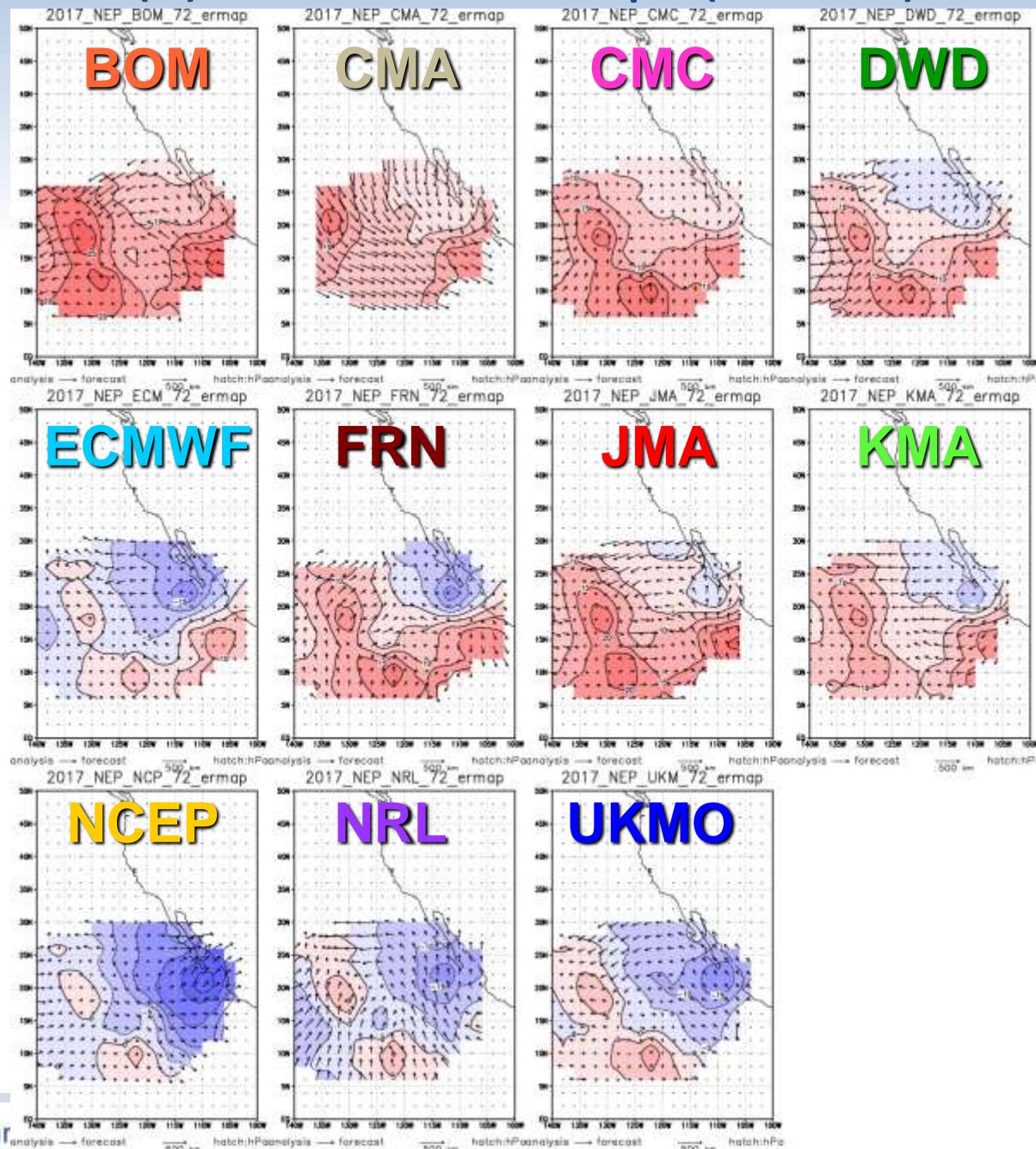
Forecast
position

Analysis
position

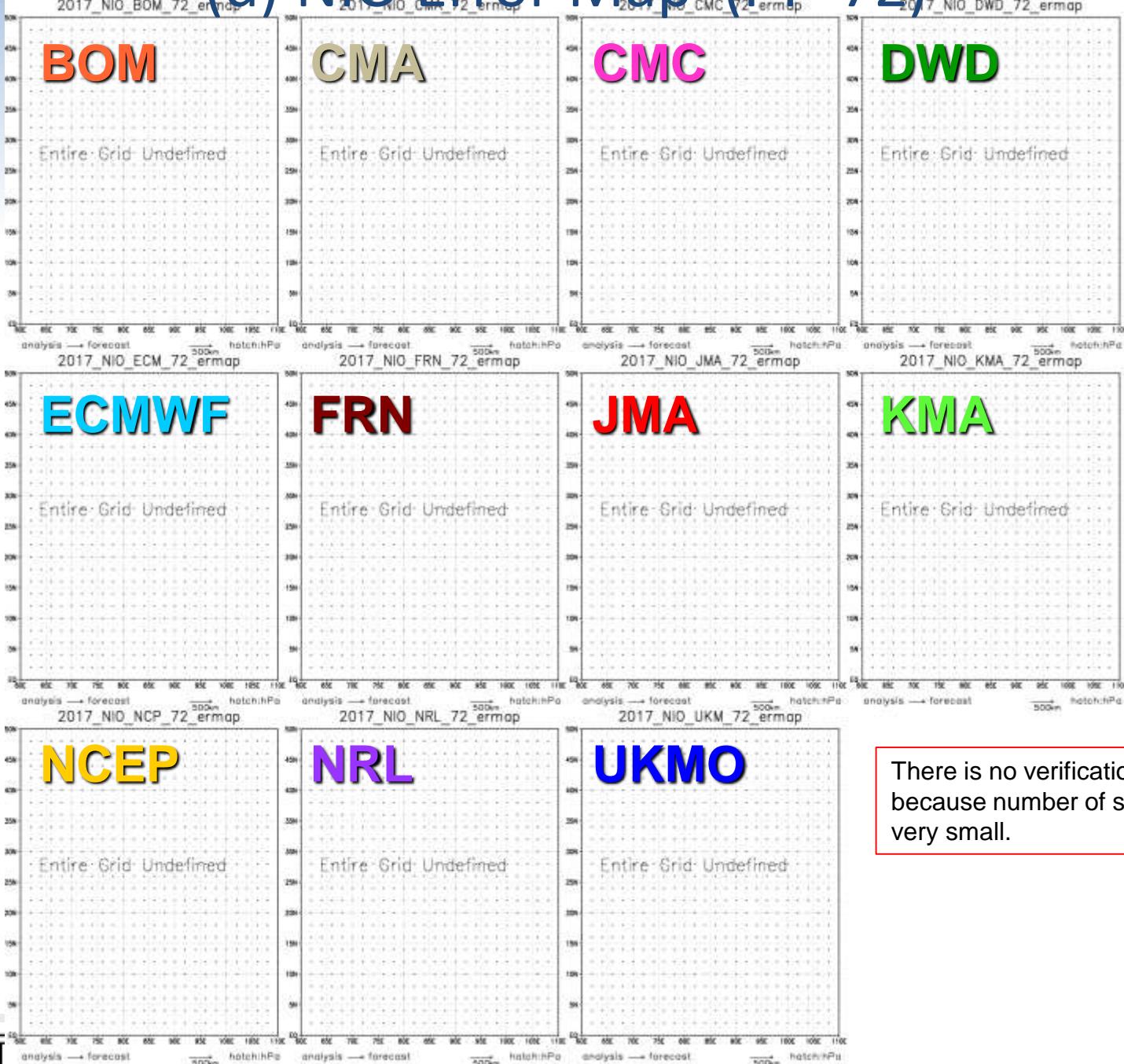
(b) NAT Error Map (FT=72)



(c) ENP Error Map (FT=72)

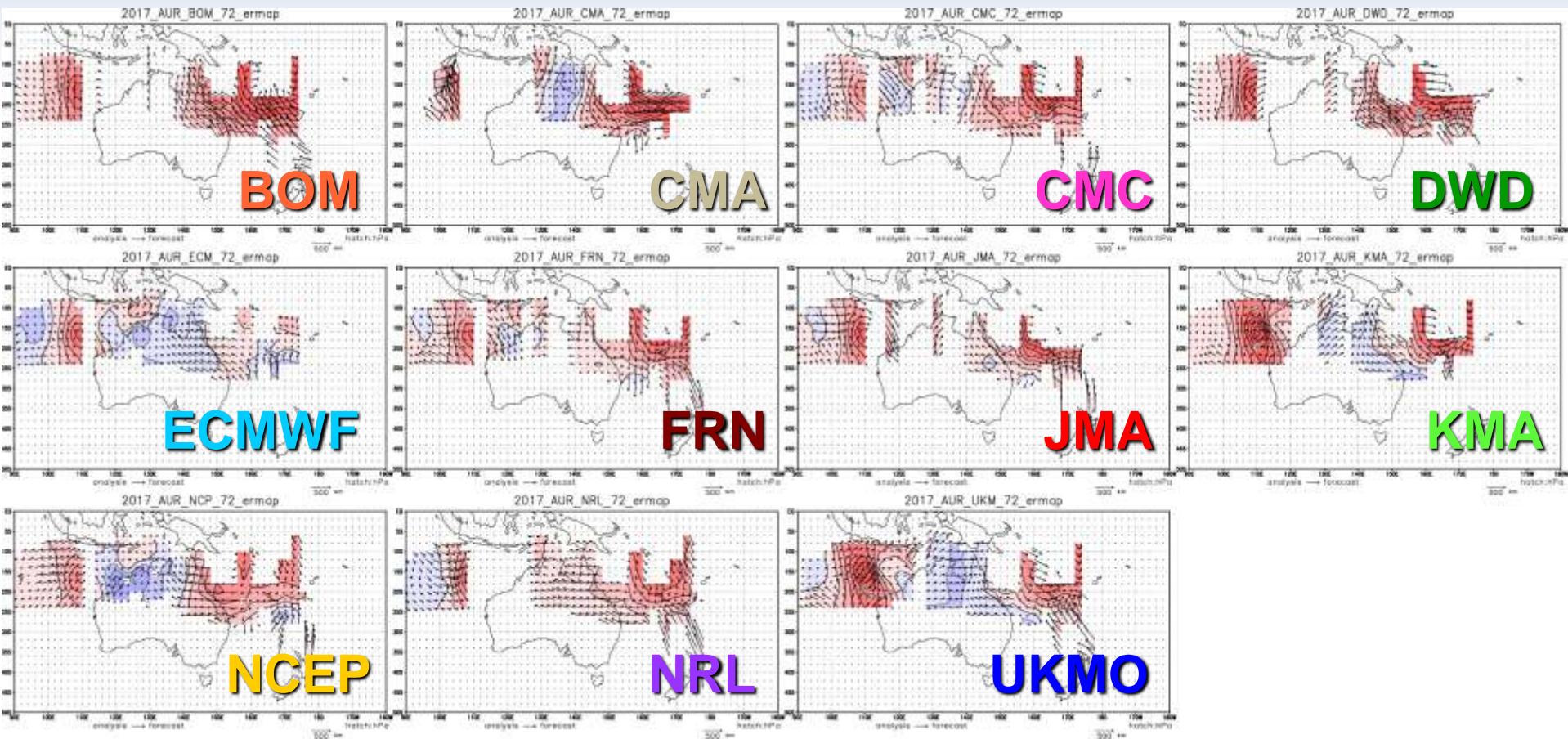


(d) NIO Error Map (FT=72)

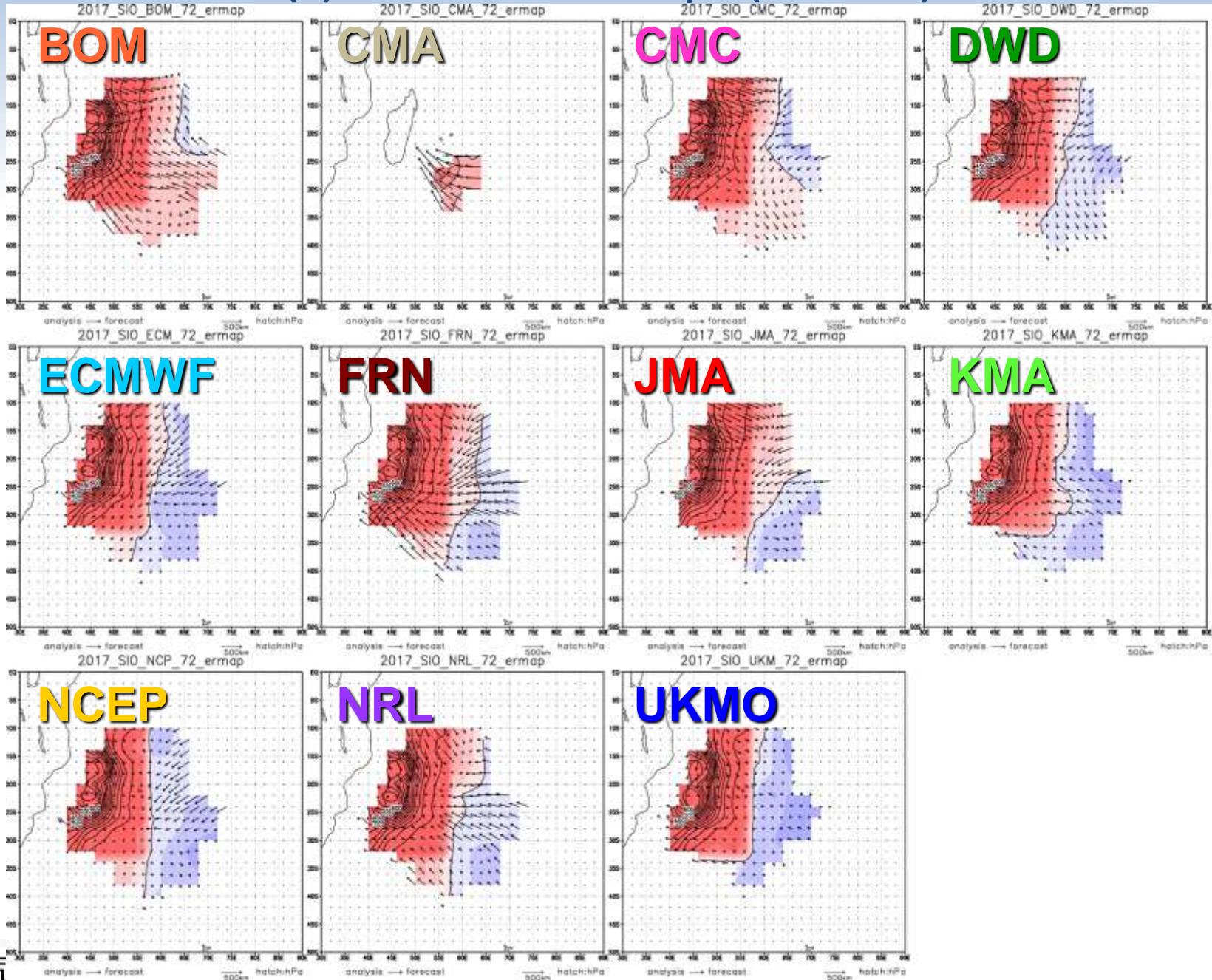


There is no verification result,
because number of samples is
very small.

(e) AUR Error Map (FT=72)



(f) SIO Error Map (FT=72)



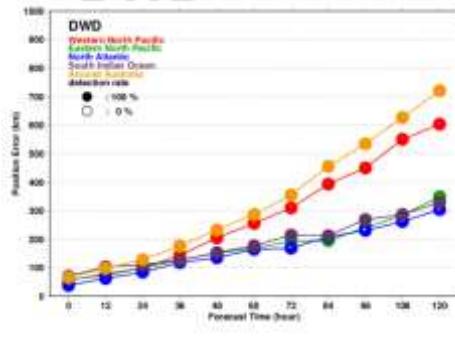
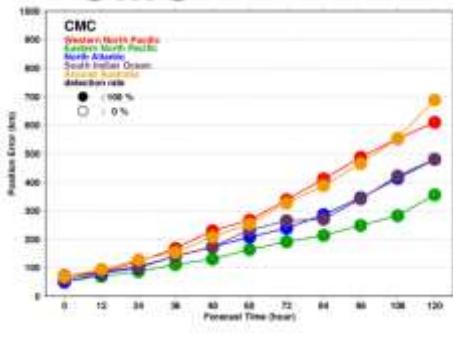
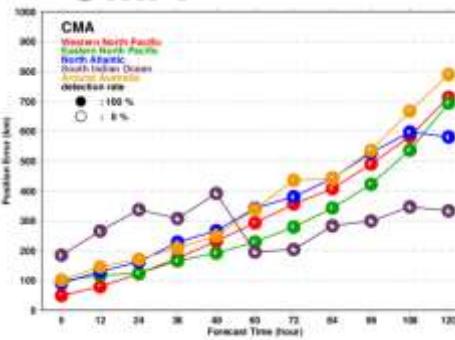
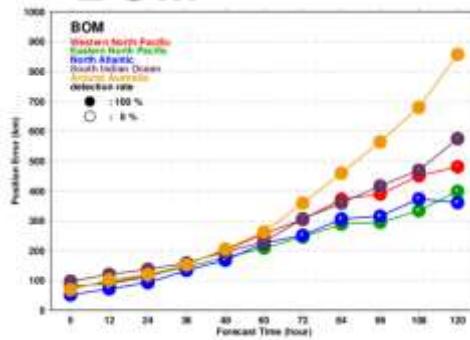
Visualization with “Pie-chart”

BOM

CMA

CMC

DWD

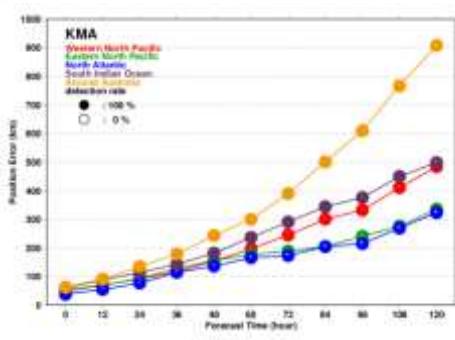
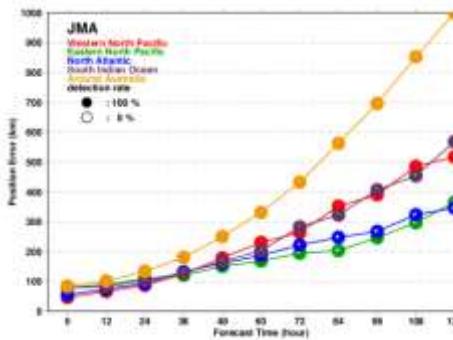
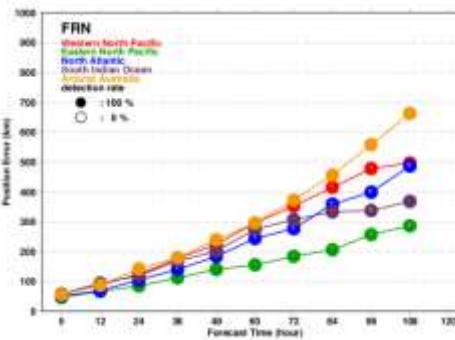
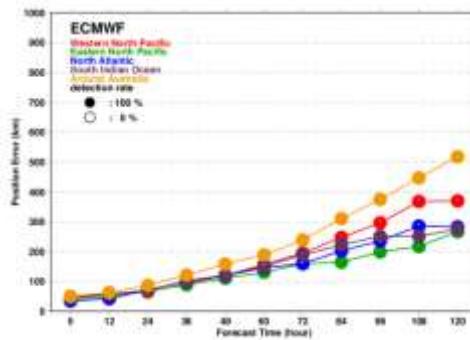


ECMWF

FRN

JMA

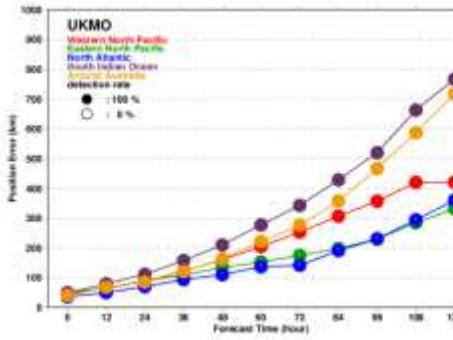
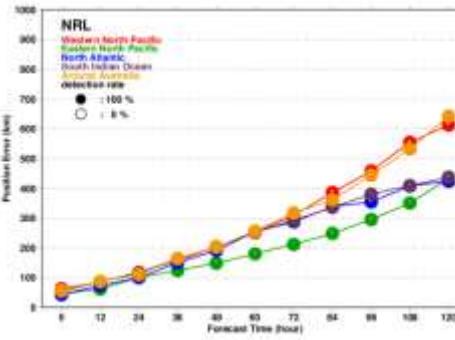
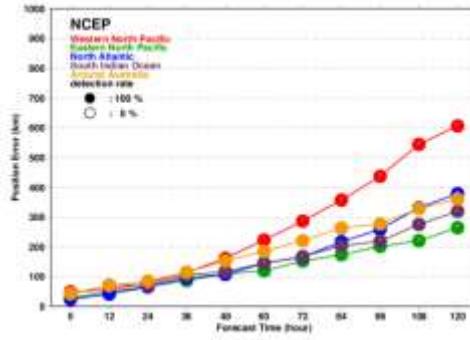
KMA



NCEP

NRL

UKMO

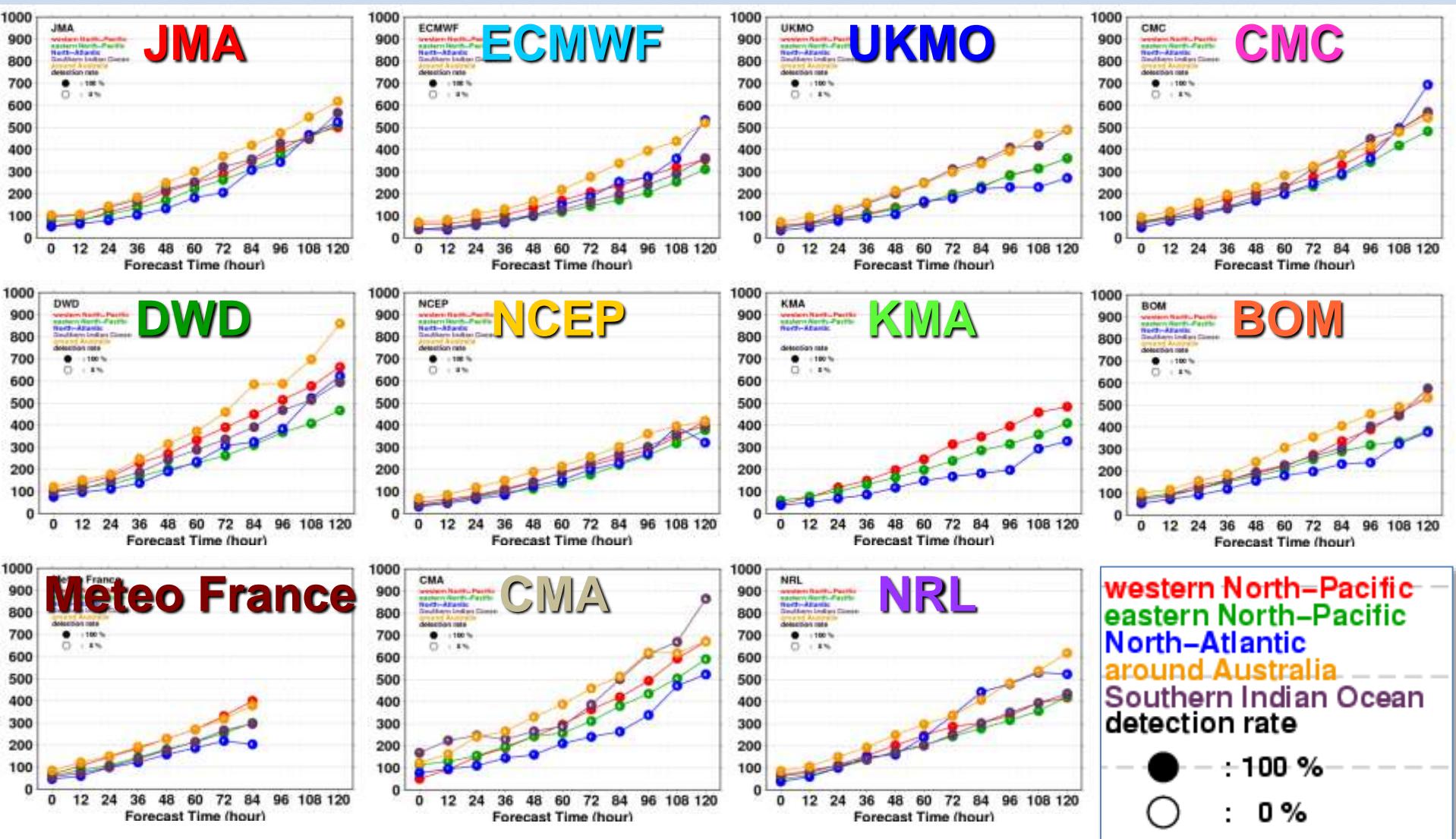


Western North Pacific
Eastern North Pacific
North Atlantic
South Indian Ocean
Around Australia
detection rate

- : 100 %
○ : 0 %

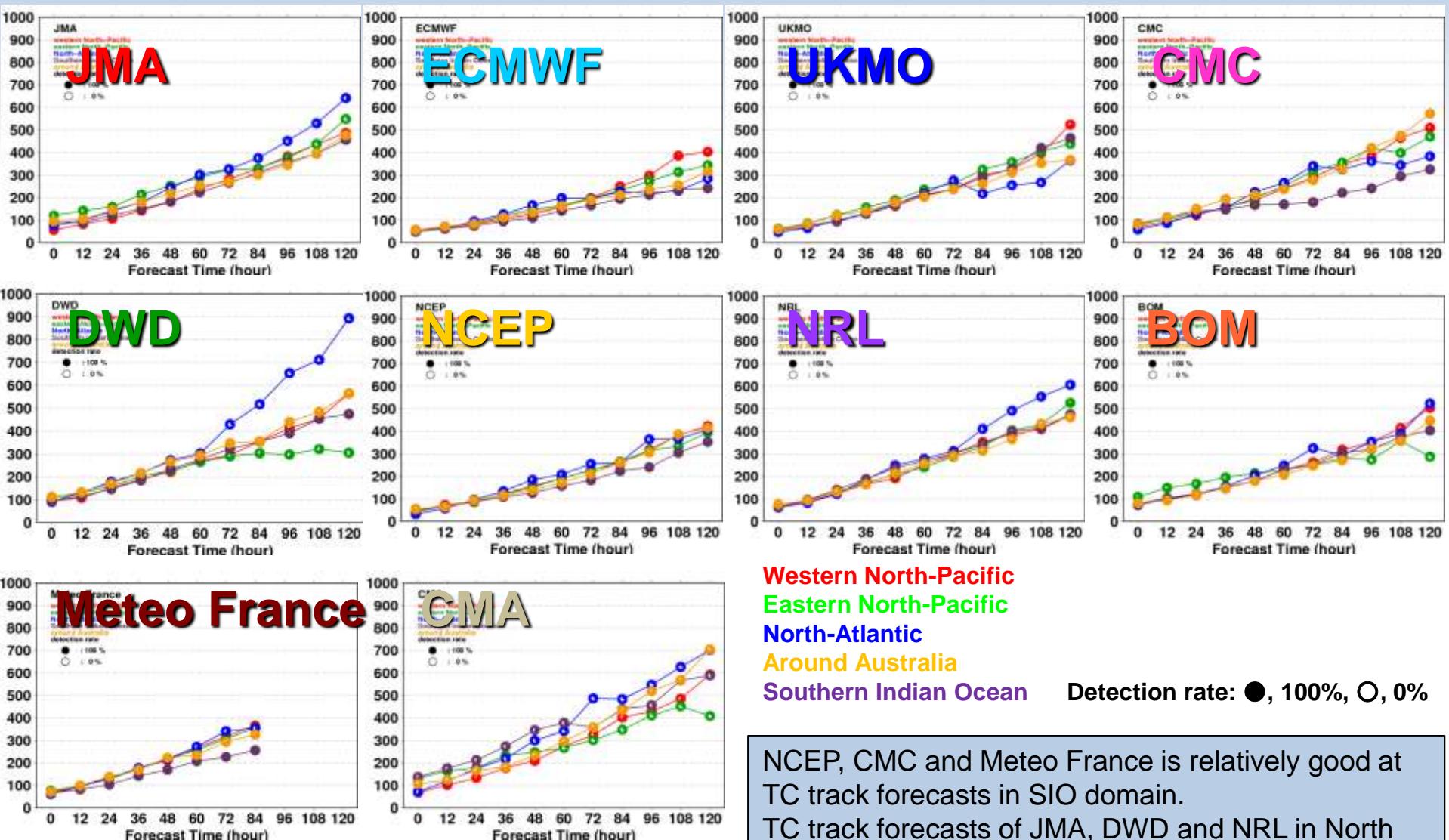


visualization with “pie-chart”



2013

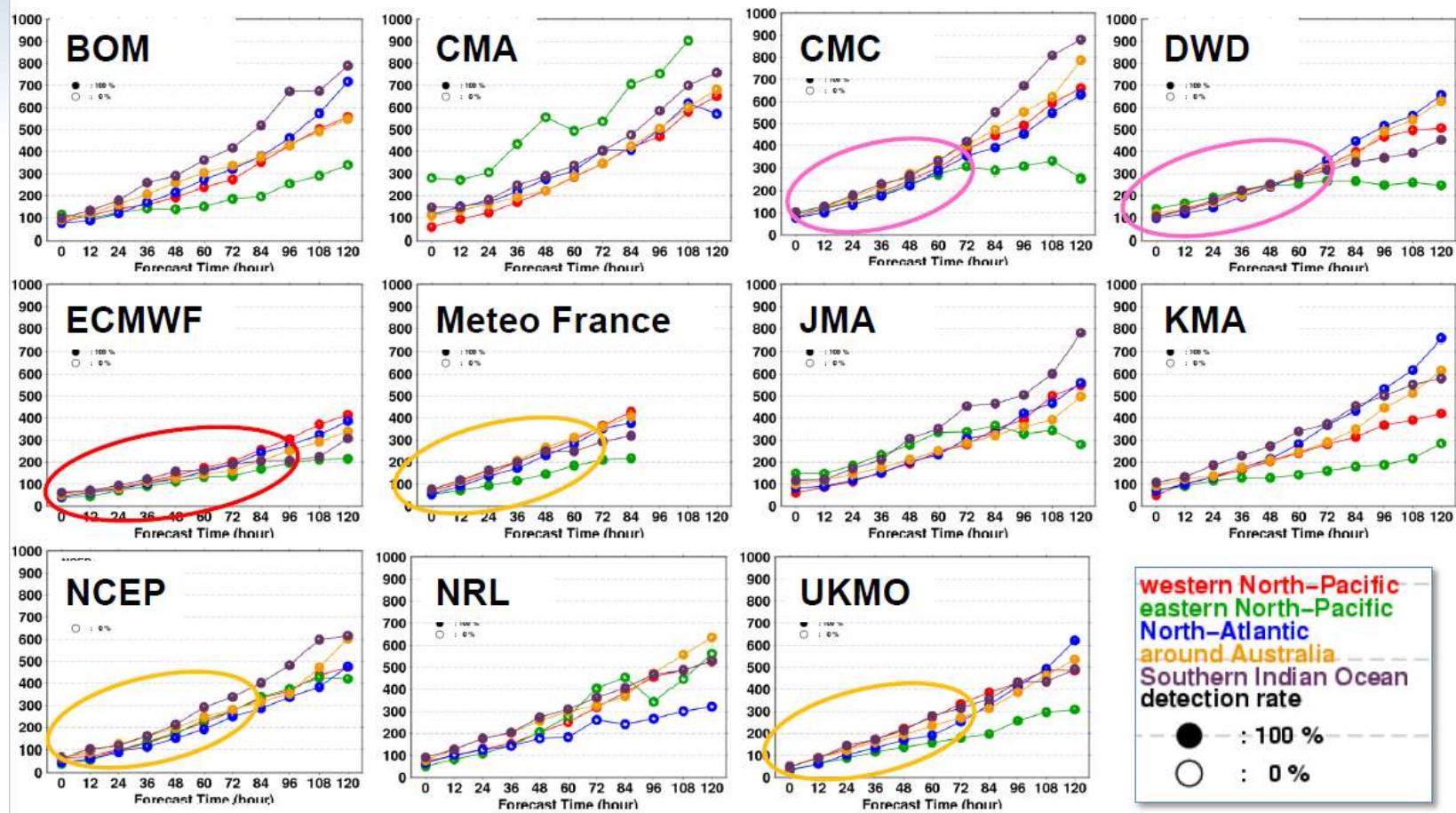
visualization with “pie-chart”



Western North-Pacific
Eastern North-Pacific
North-Atlantic
Around Australia
Southern Indian Ocean Detection rate: ●, 100%, ○, 0%

NCEP, CMC and Meteo France is relatively good at TC track forecasts in SIO domain.
TC track forecasts of JMA, DWD and NRL in North Atlantic are not as accurate as those in other basins.
ECMWF and NCEP provide the accurate TC track forecasts over the all basins.

visualization with “pie-chart”

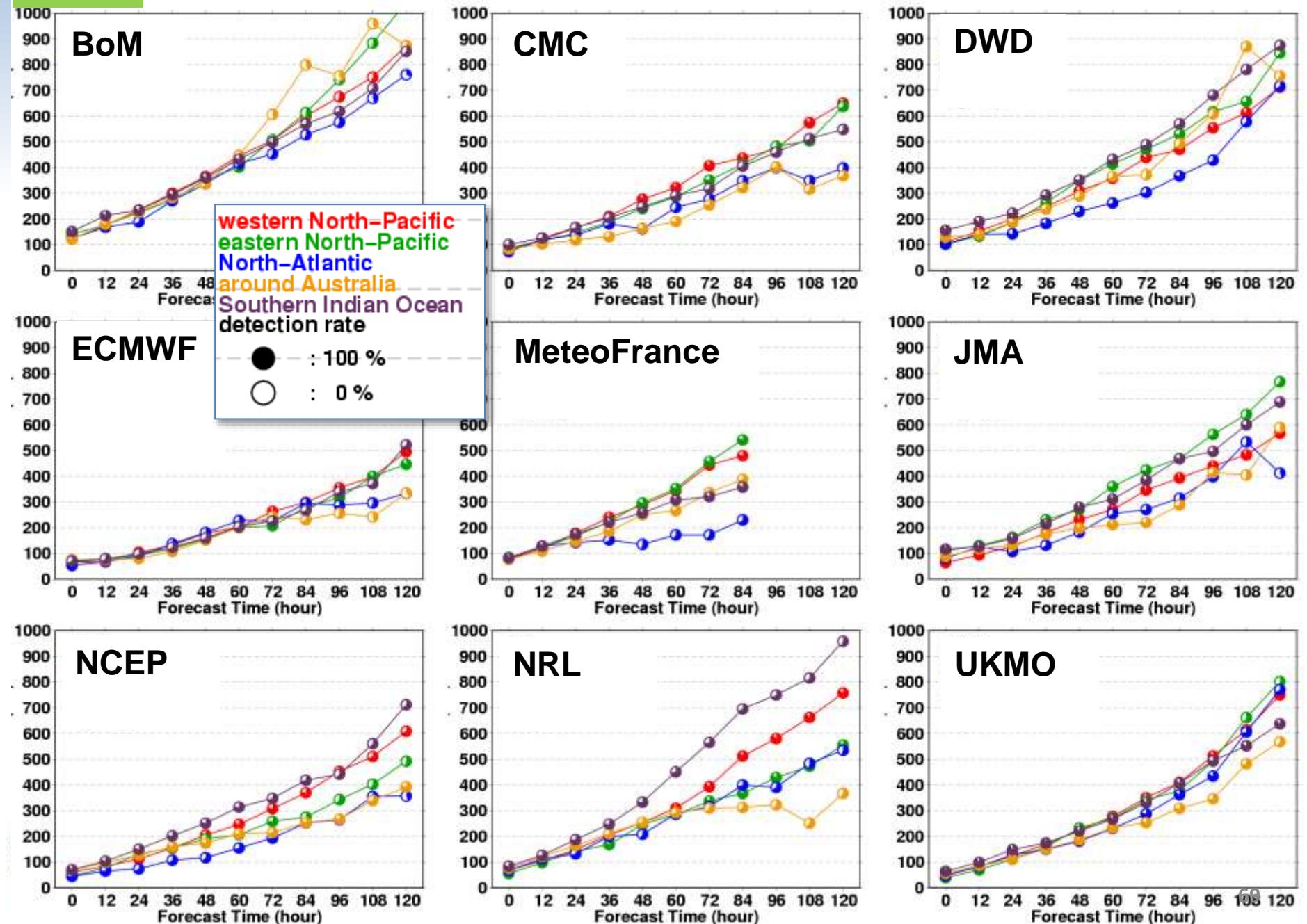


Japan Meteorological Agency

JMA

2009

visualization with “pie-chart”

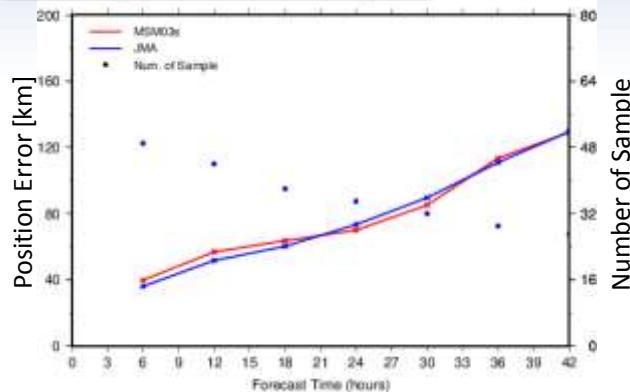


A landscape photograph of a city at sunset. In the foreground, there are numerous buildings of various sizes, mostly residential houses. In the middle ground, a large industrial complex with several tall chimneys is visible. In the background, the majestic Mount Fuji stands prominently against a sky transitioning from deep blue at the top to a warm orange and yellow at the horizon. A full moon is visible in the upper right quadrant of the sky.

REGIONAL MODELS

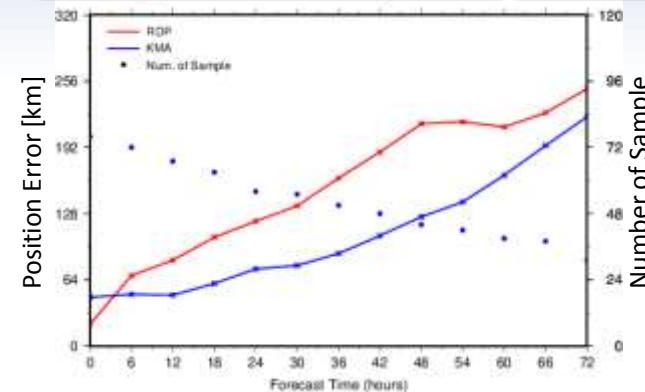
Position Error of homogeneous samples(2017)

MSM/GSM(WNP)



JMA

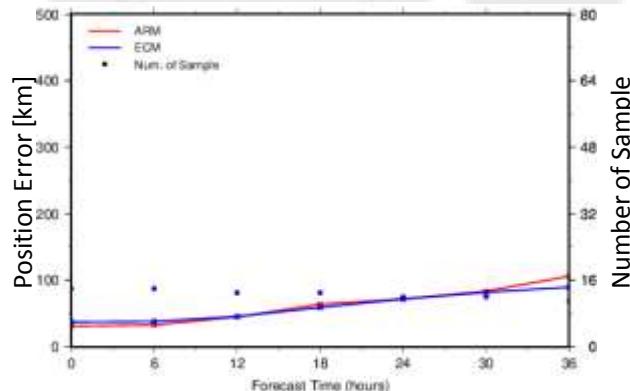
RDAPS/GDAPS(WNP)



KMA

AROME/IFS(SIO)

FRN

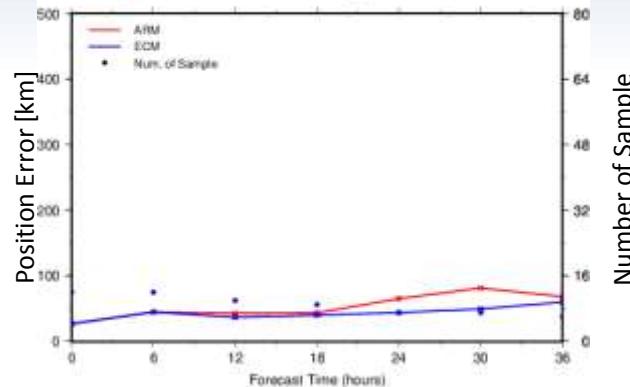


Position errors of regional models are comparable to or larger than those of driving global models.

Position Error of homogeneous samples(2017)

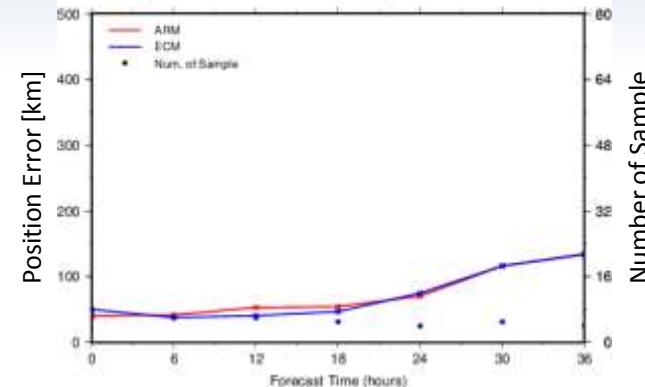
AROME/IFS(NAT)

FRN



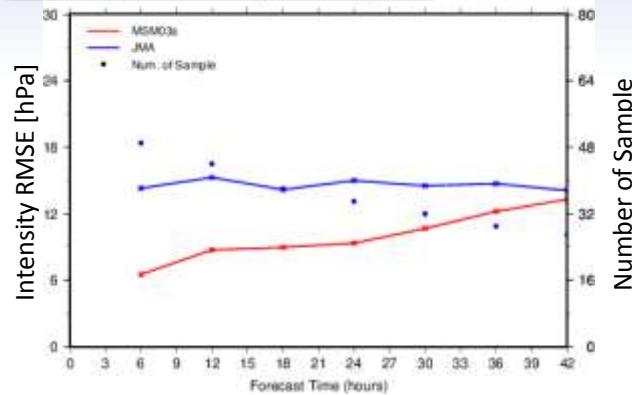
AROME/IFS(AUR)

FRN



Intensity RMSE of homogeneous samples(2017)

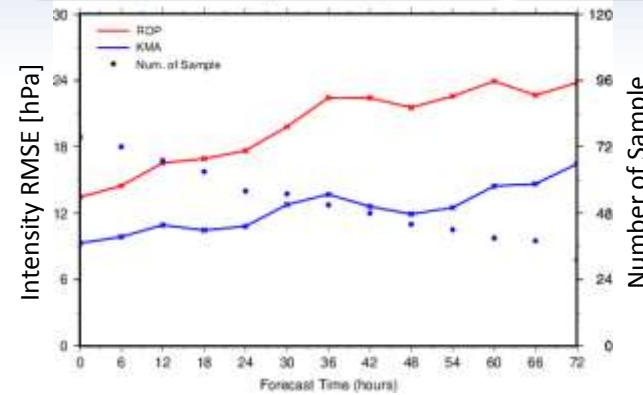
MSM/GSM(WNP)



JMA

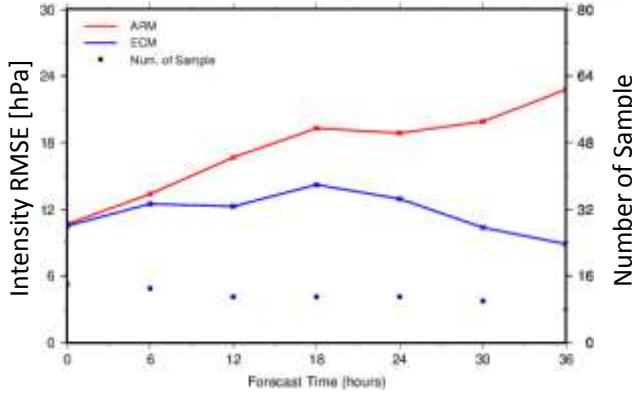
RDAPS/GDAPS(WNP)

KMA

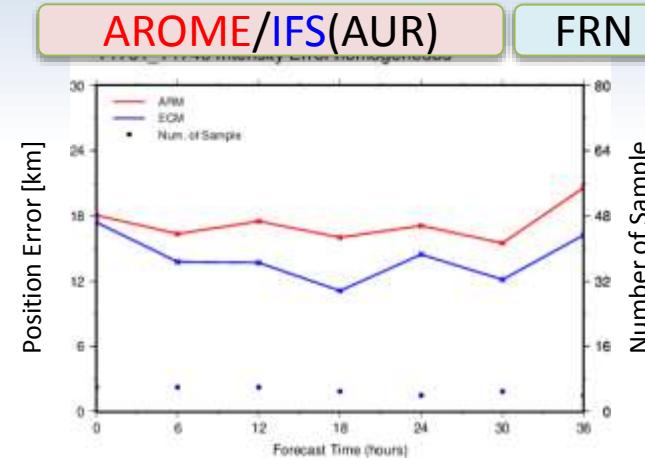
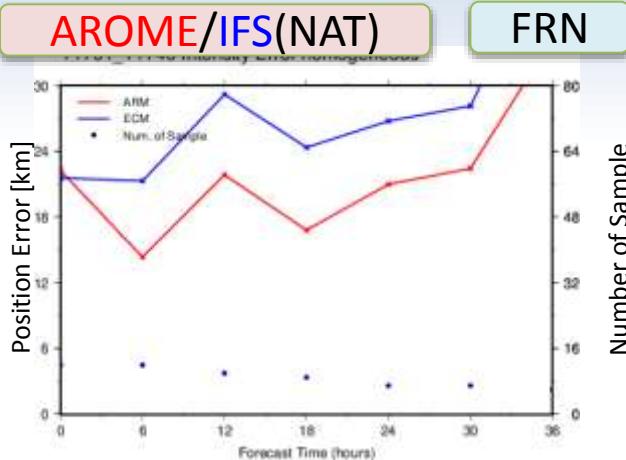


AROME/IFS(SIO)

FRN



Intensity RMSE of homogeneous samples(2017)



AT-CT bias

