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National Applied Research Laboratories



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台灣颱風洪水研究中心
Taiwan Typhoon and Flood Research Institute

WRF-Var資料同化系統之 GPS掩星折射率資料處理對 颱風路徑預報之影響

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Original WRF-Var QC:

Error Percentage Check:

$$\text{Reject if } \textit{percnt} = \left| \frac{O - B}{\frac{O+B}{2}} \right| > \textit{threshold}$$

height (km)	<i>threshold</i>
$h > 25$	0.10
$7 < h < 25$	0.04
$h < 7$	0.05



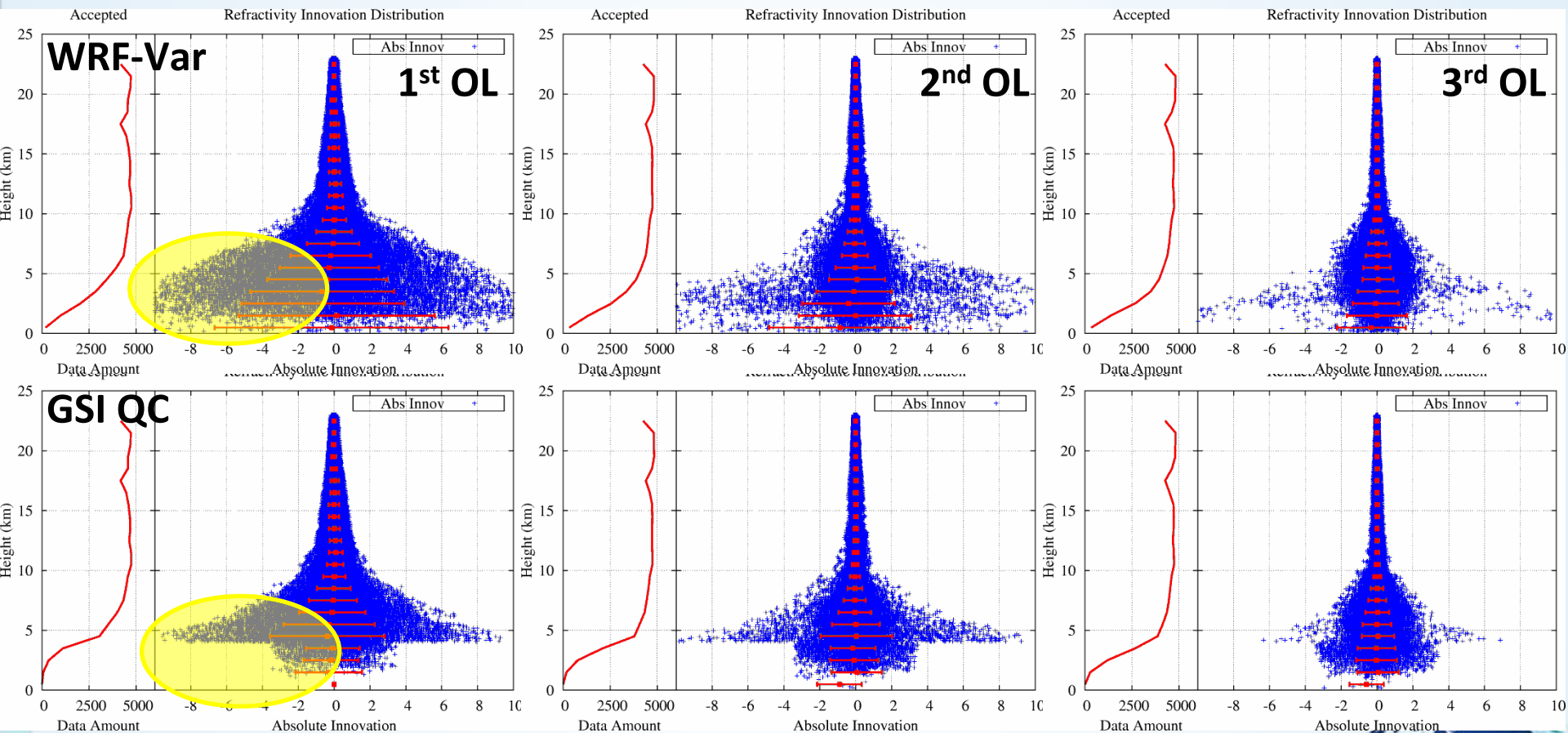
Original GSI QC

Reject if $|O - B| > std_dev \times cut_off$

height (km)	<i>std_dev</i>	<i>cut_off</i>
$h > 30$	undefined	0
$11 < h < 30$	C_1	3
$9 < h < 11$	$\frac{11-h}{2} \cdot C_2 + \frac{h-9}{2} \cdot C_1$	3
$6 < h < 9$	$C_2(T)$	3
$4 < h < 6$	$\frac{6-h}{2} \cdot C_3 + \frac{h-4}{2} \cdot C_2$	3
$h < 4$	C_3	1

$$C_1 = 0.25 + 0.5 \cos \lambda, \quad C_2 = \begin{cases} 0.5 & \text{if } T \leq 240K \\ 0.001T^2 - 0.455T + 52.075 & \text{if } T > 240K \end{cases}, \quad C_3 = 1 + 2.5 \cos \lambda$$

Vertical Distribution of Absolute Innovation



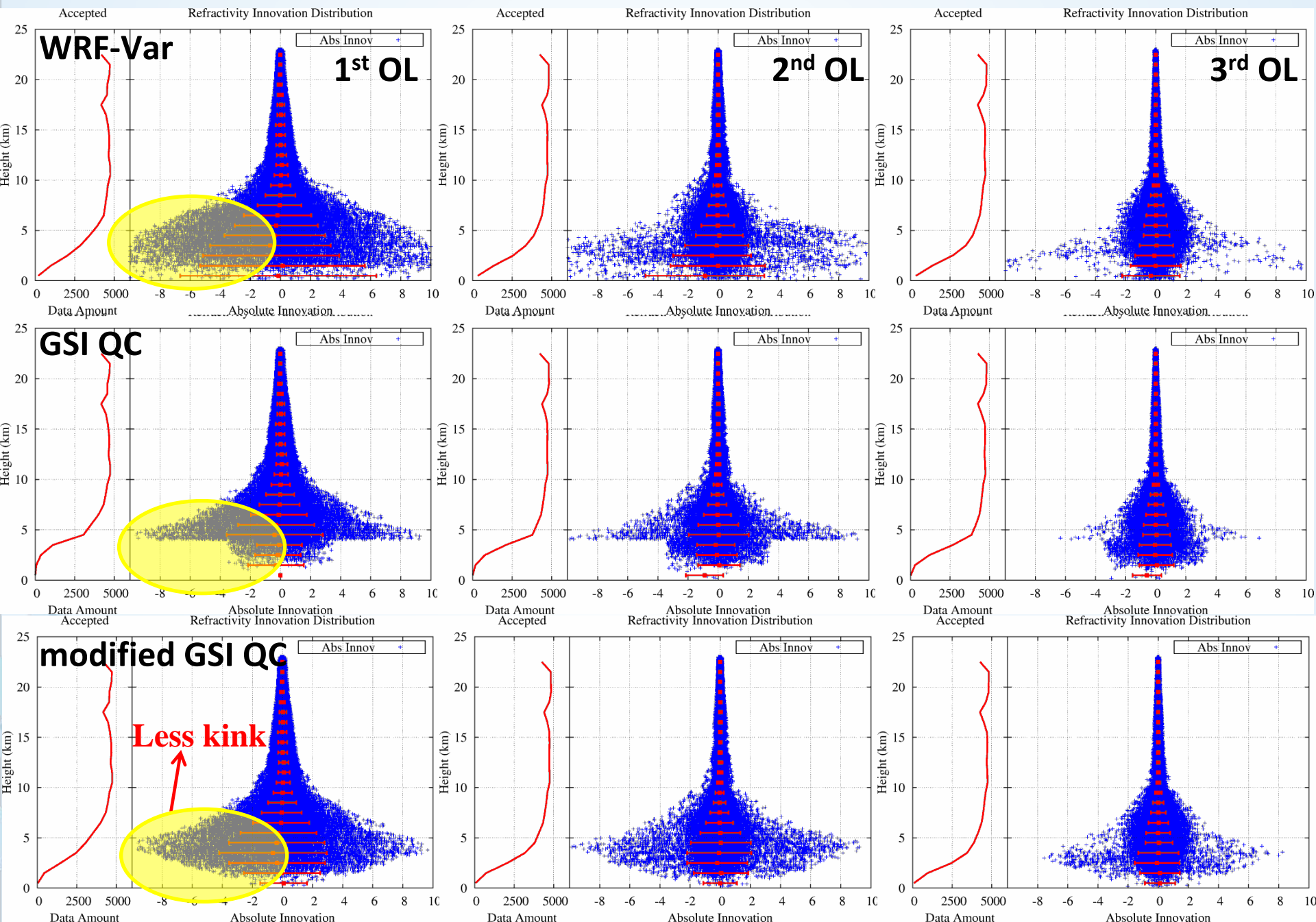
Modified GSI QC:

$$\mathbf{0-4\ km\ cut_off} = \frac{h}{4} \times 3 + \frac{4-h}{4} \times D$$

$D = \mathbf{0.5}$ (best performance)



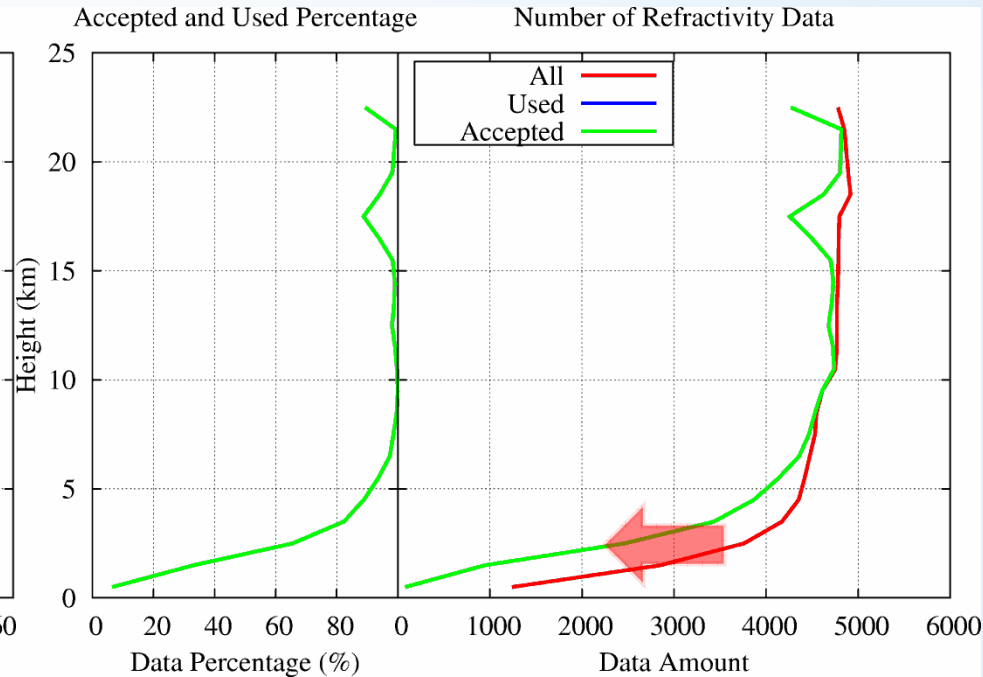
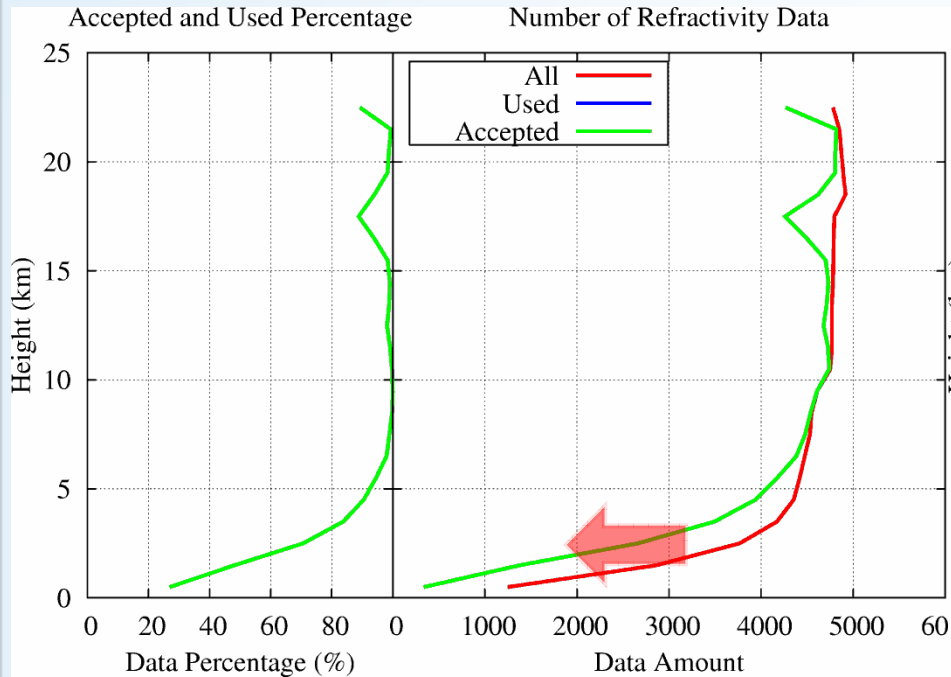
Vertical Distribution of Absolute Innovation



Number of Data Used for Cold Start Runs

Use original WRF-Var QC (3rd OL)

Use WRF-Var + GSI QC (3rd OL)



Red arrow: number reduced by QC

- number of assimilated data is reduced for WRF-Var + GSI QC, especially at low level (similar for update cycles)



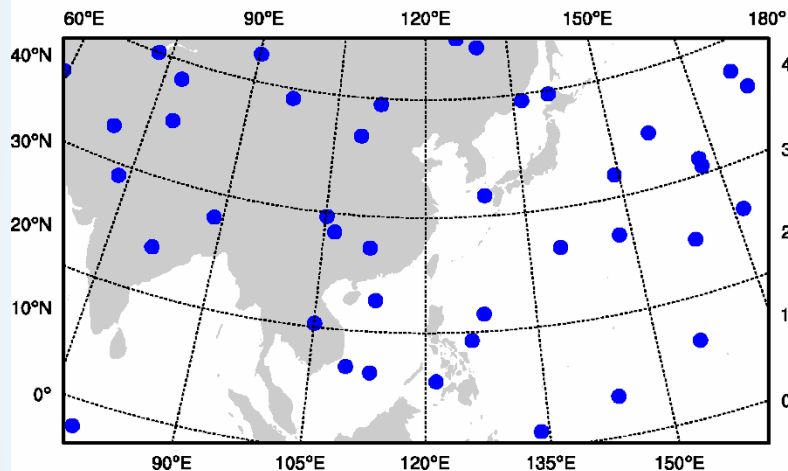
Number of Data Used between 2-5 km

2nd Update Cycle

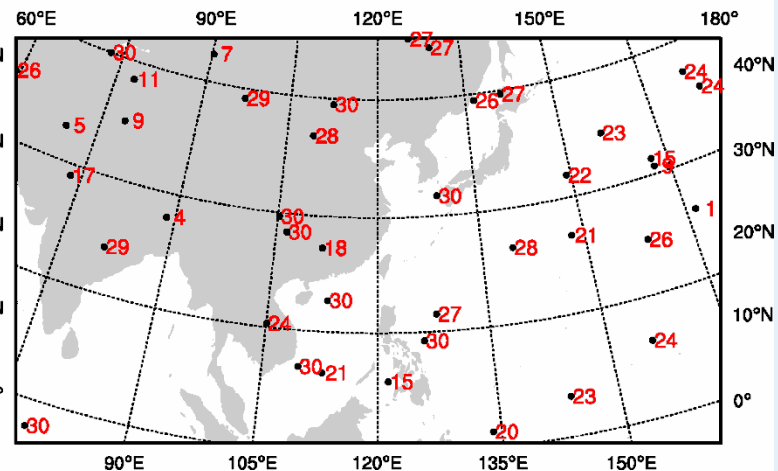
2009080318 GPSREF 2000 m - 5000 m

WRF-Var

GPSREF REF (All: 1107)

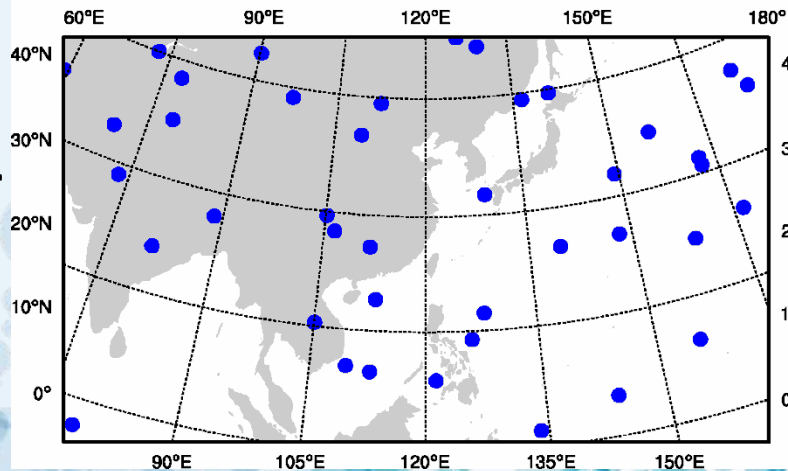


GPSREF REF (Used: 907)

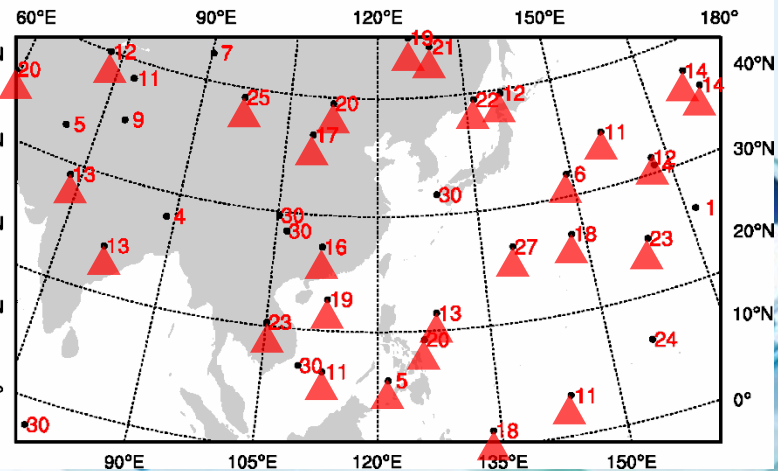


WRF-Var + GSI

GPSREF REF (All: 1107)



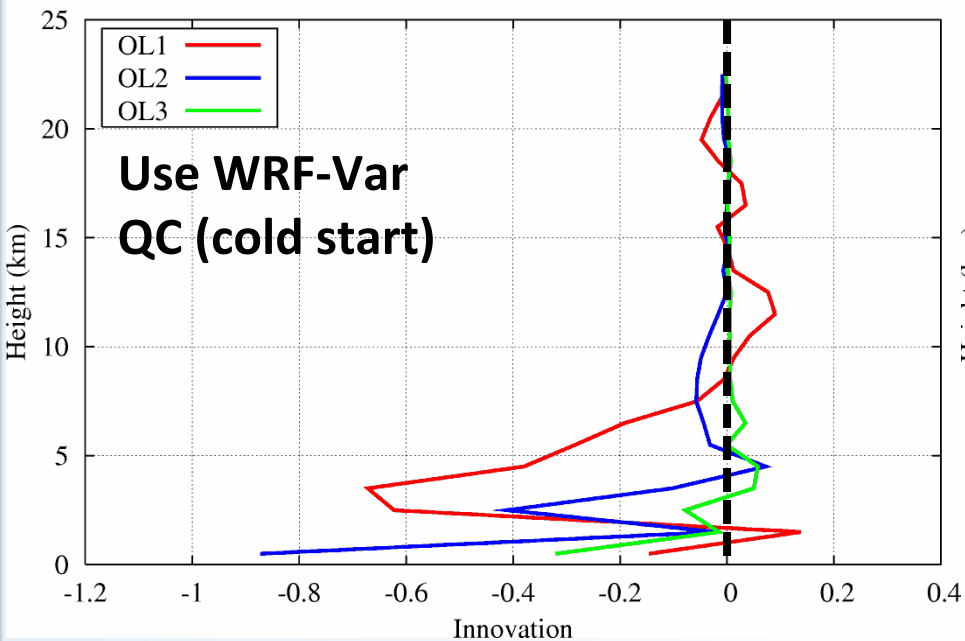
GPSREF REF (Used: 670)





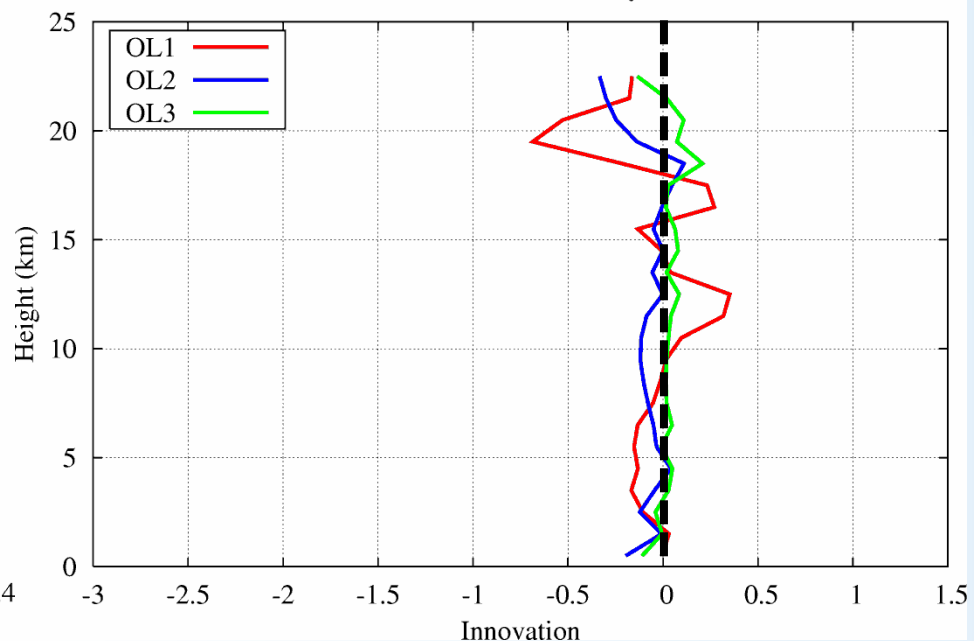
Mean of absolute innovation

Mean of Refractivity Innovation

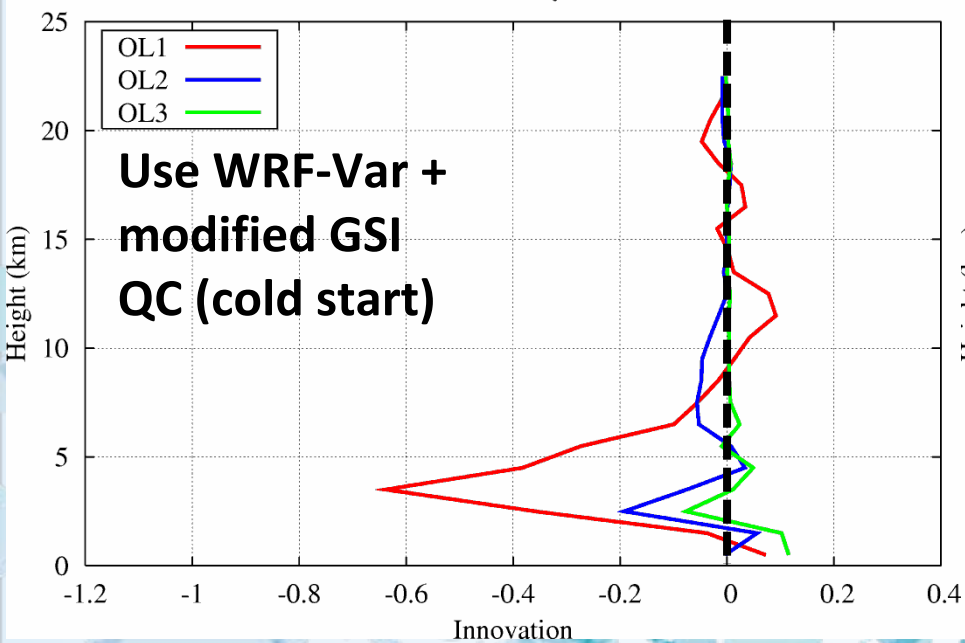


Mean of normalized innovation

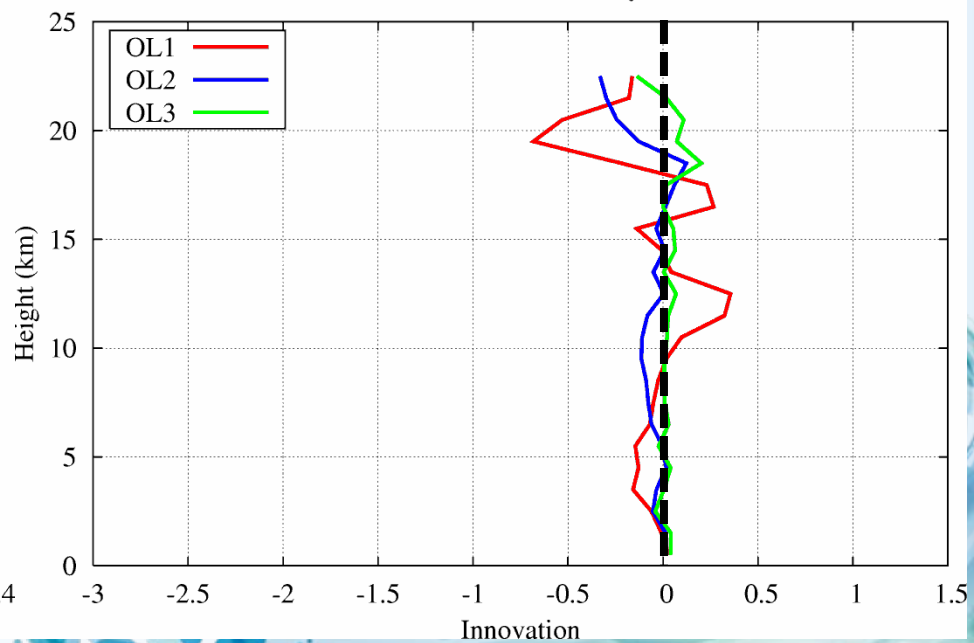
Mean of Normalized Refractivity Innovation



Mean of Refractivity Innovation



Mean of Normalized Refractivity Innovation



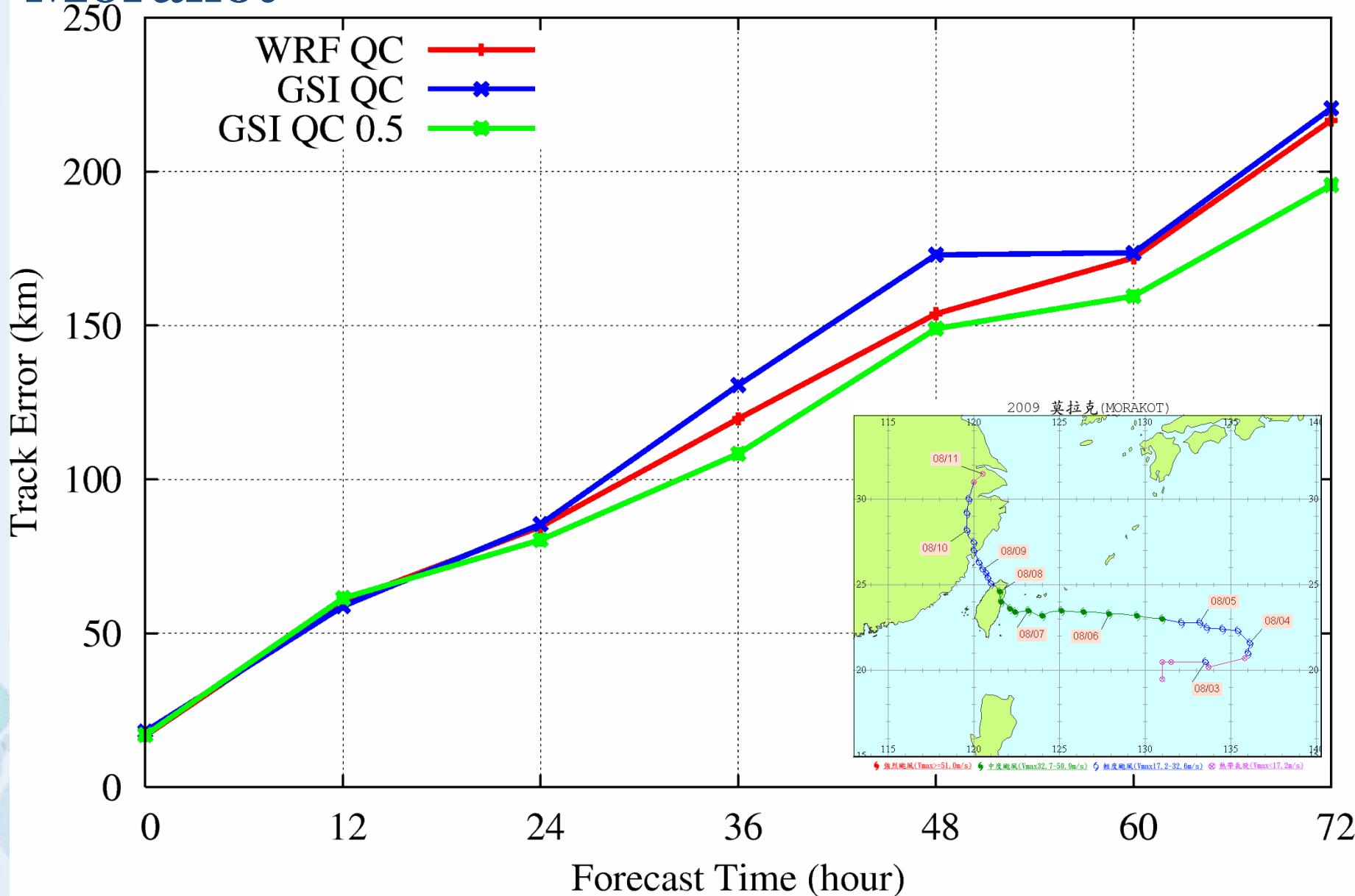
GSI QC Test

- **CWB OP24 (TWRF), partial cycling**
- 2009080318-2009080712, 16 dtgs
- 2009080318-2009080712, 78 dtgs
- Control: WRF-Var QC
- Exp1: WRF-Var + GSI QC
- Exp2: WRF-Var + modified GSI QC



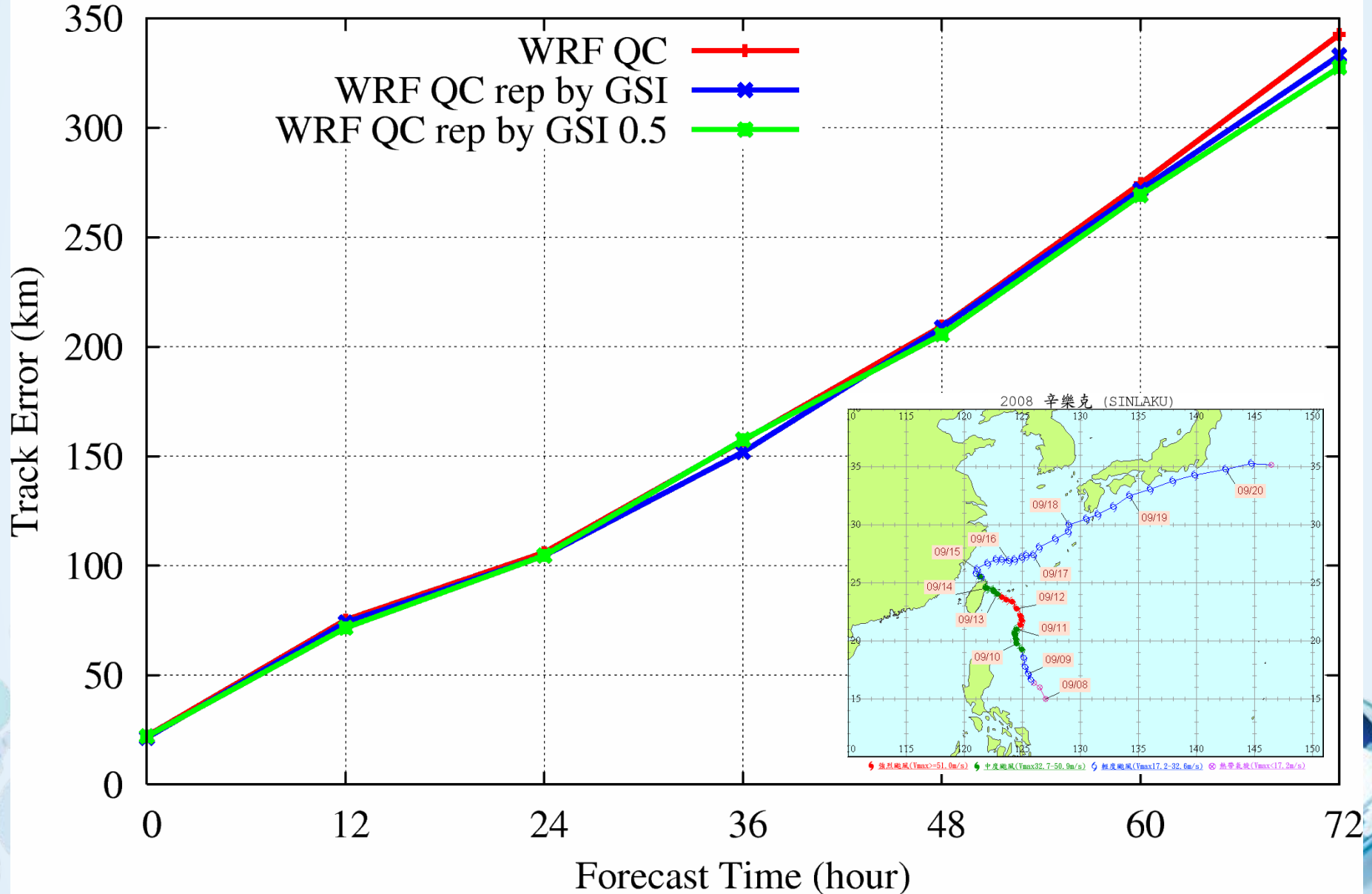
Morakot

Mean Track Error (2009/08/03 18Z - 2009/08/07 12Z)



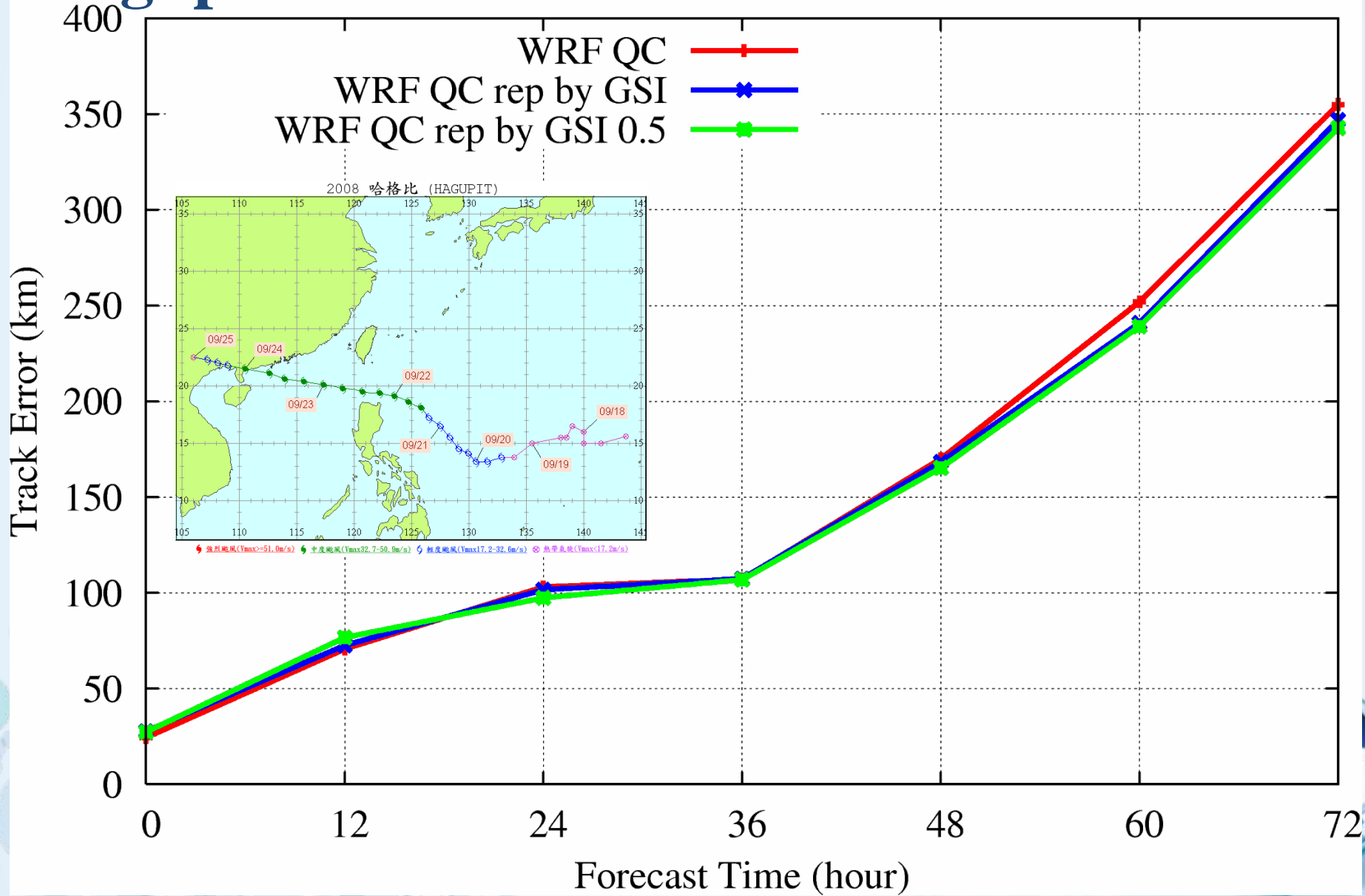
Sinlaku

Mean Track Error (2008/09/08 18Z - 2008/09/20 06Z)



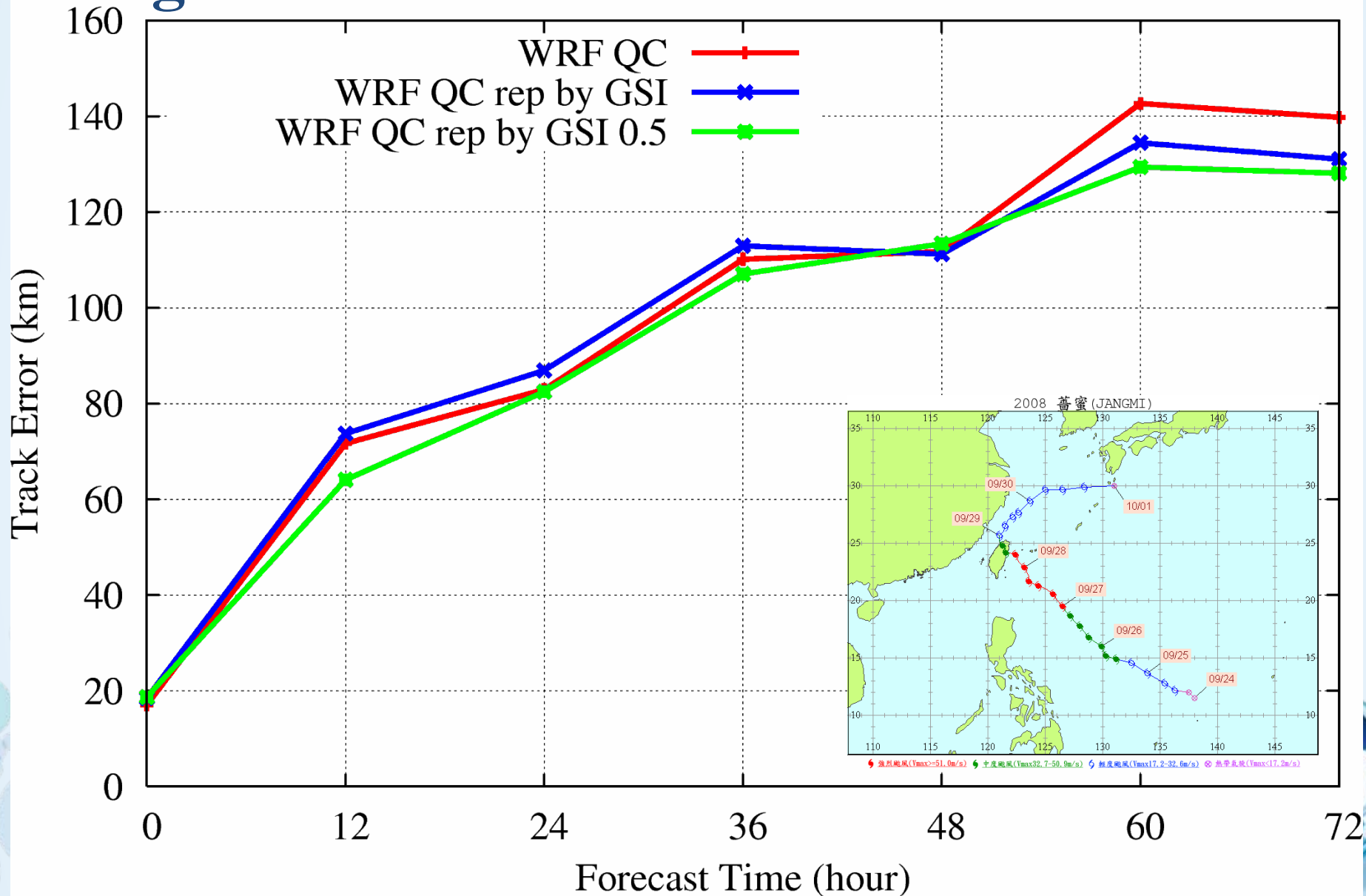
Hagupit

Mean Track Error (2008/09/19 12Z - 2008/09/24 18Z)



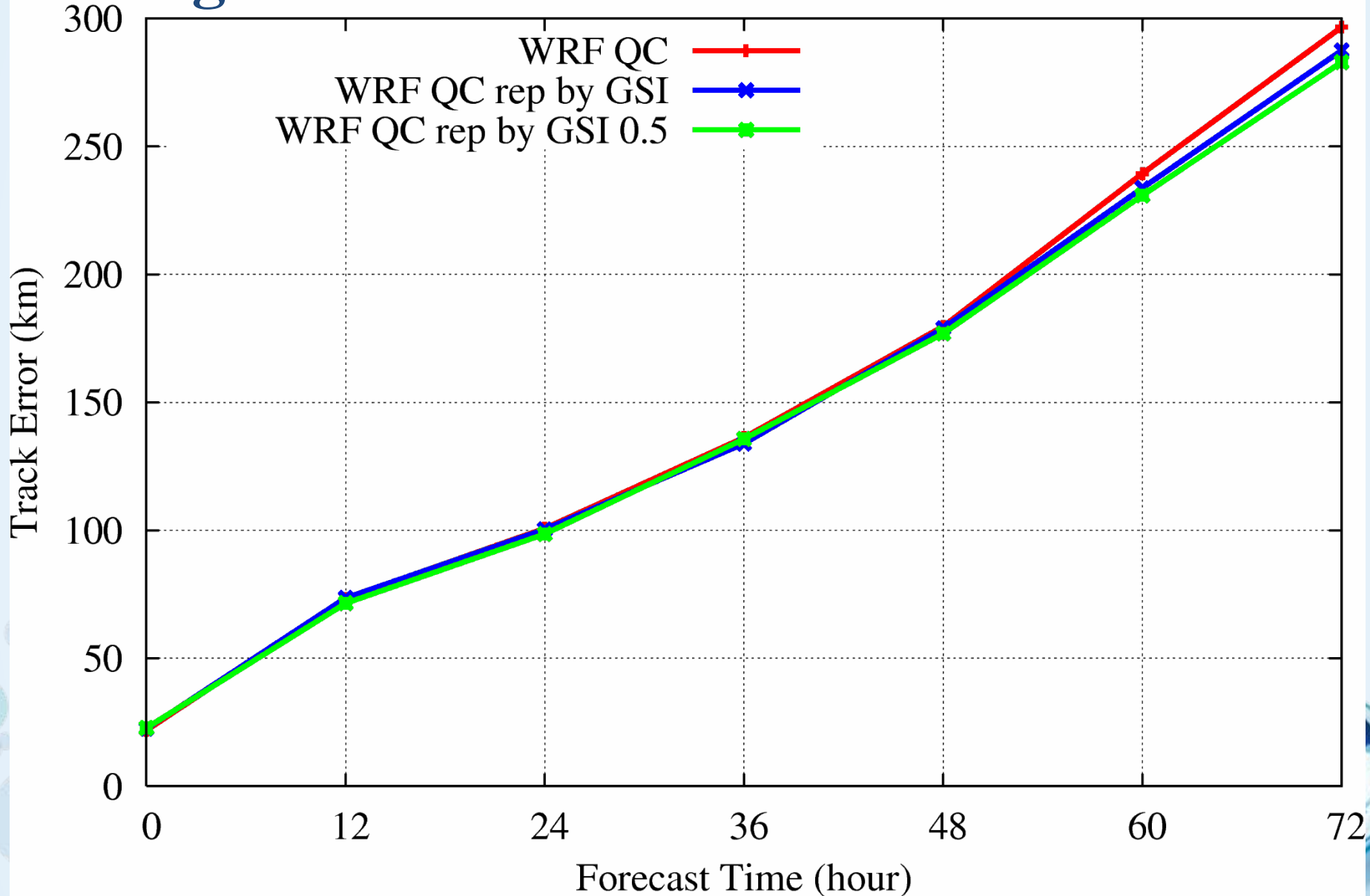
Jangmi

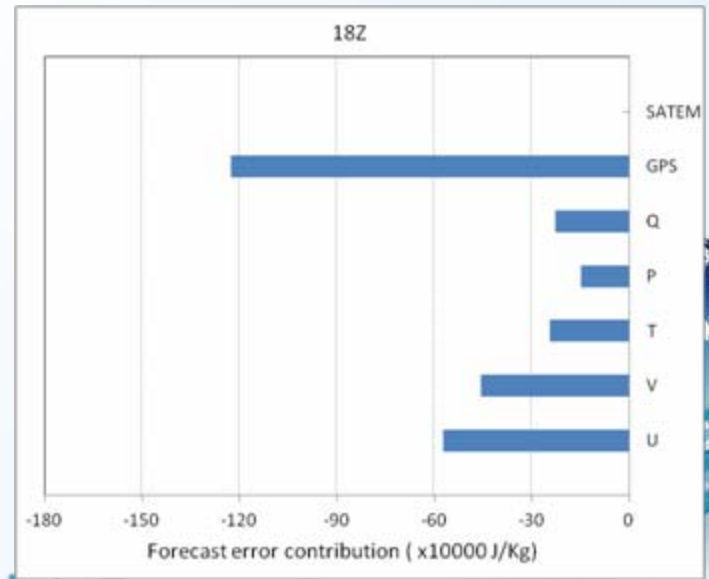
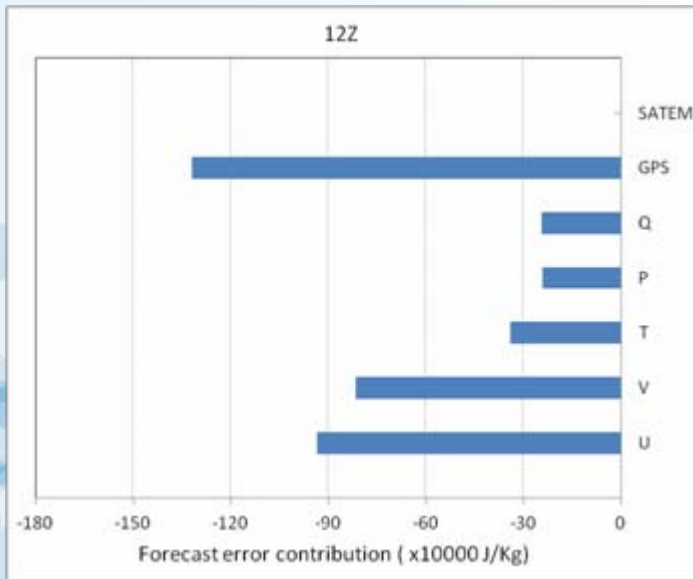
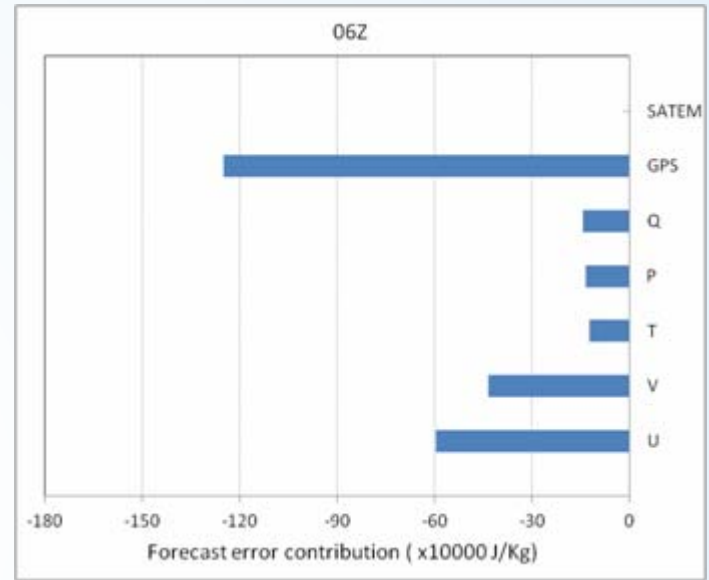
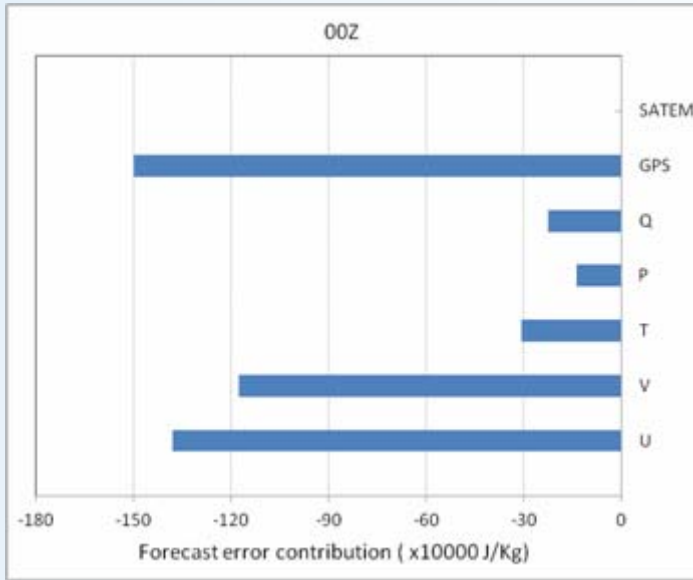
Mean Track Error (2008/09/24 12Z - 2008/09/28 00Z)



78 dtgs

Mean Track Error (2008/09/08 18Z - 2008/09/28 00Z)





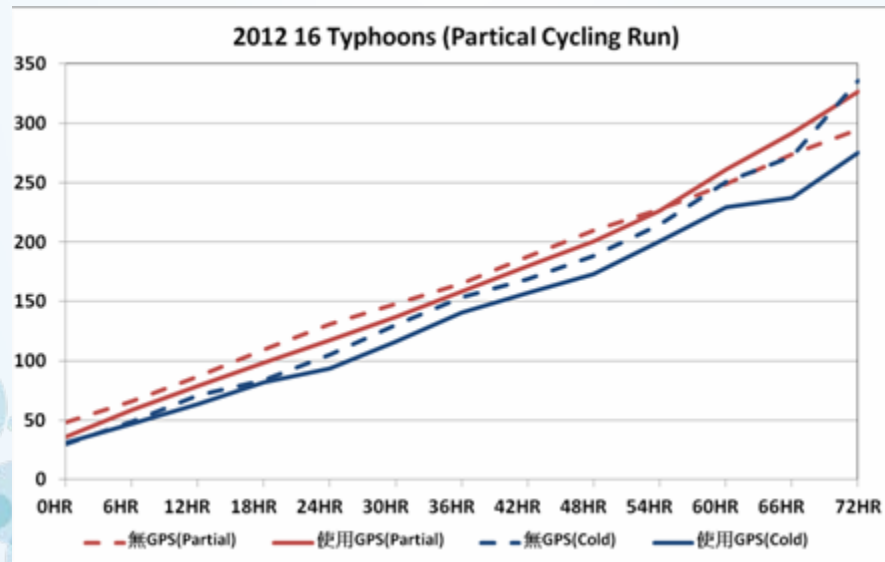
Summary

- ➔ The low level bias of innovation is reduced with GSI QC in WRF-Var and reduced further with modified GSI QC.
- ➔ The modified GSI QC with $D=0.5$ gives the best track forecast in average.
- ➔ GPS RO data play an important role to reduce the forecast error.



Ongoing Work

- ➔ More detail analyses on the impact of improvement of refractivity quality control in WRF-Var.
- ➔ Systematic verification of GPS RO data to severe weather (typhoon, Mei-yu ...), in both real-time cases and historic case.



Thanks for Your Attention



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