

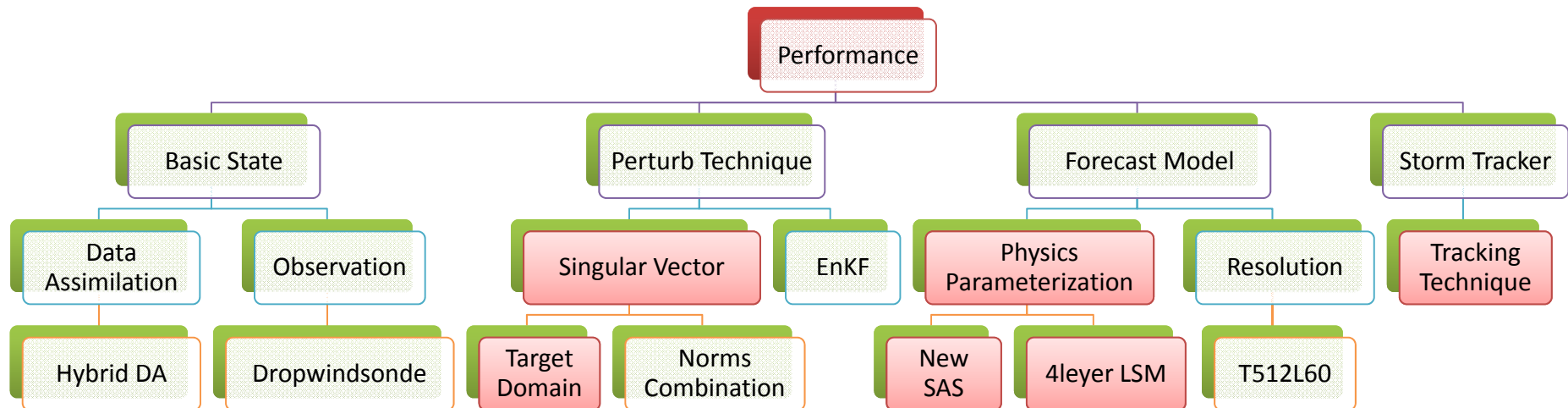
# 中央氣象局全球模式 系集颱風路徑預報系統（二）

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# GEPS for Typhoon-track



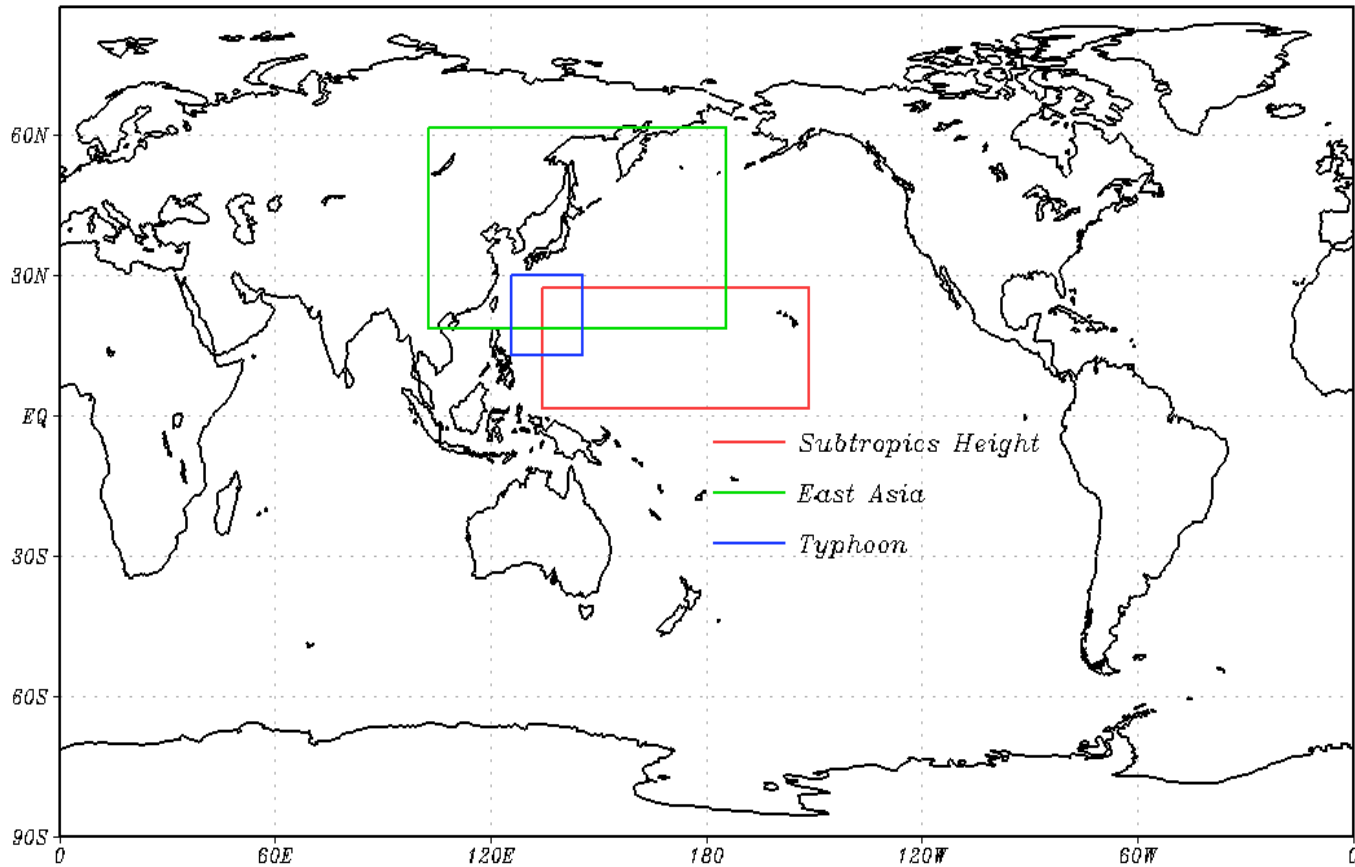
# Typhoon Track Ensemble System

CWB GFS EPS for Typhoon track (GET)			
resolution	deterministic model		T319L40
	ensemble		T319L40
initial perturbation, singular vector	global		T42L40
	nested typhoon domain	east Asia	20 <sup>0</sup> N-60 <sup>0</sup> N, 100 <sup>0</sup> E-180 <sup>0</sup> E
		typhoon	15 <sup>0</sup> × 10 <sup>0</sup>
optimization time	48 hrs		
ensemble size	20		
forecast length	5-day		

# Target Domain Definition

*Soulik(2013)*

*SVs Target Domain*



# Ensemble Initial Perturbation

$$perturb = TY\_perturb + EA\_perturb$$

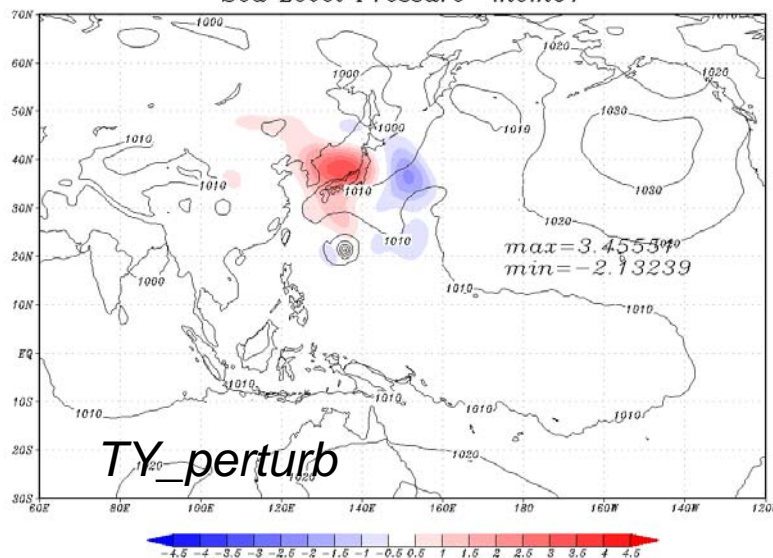
$$TY\_perturb = SV_{TY} / |SV_{TY}| \times |NMC| \times TY\_factor$$

$$EA\_perturb = SV_{EA} / |SV_{EA}| \times |NMC| \times EA\_factor$$

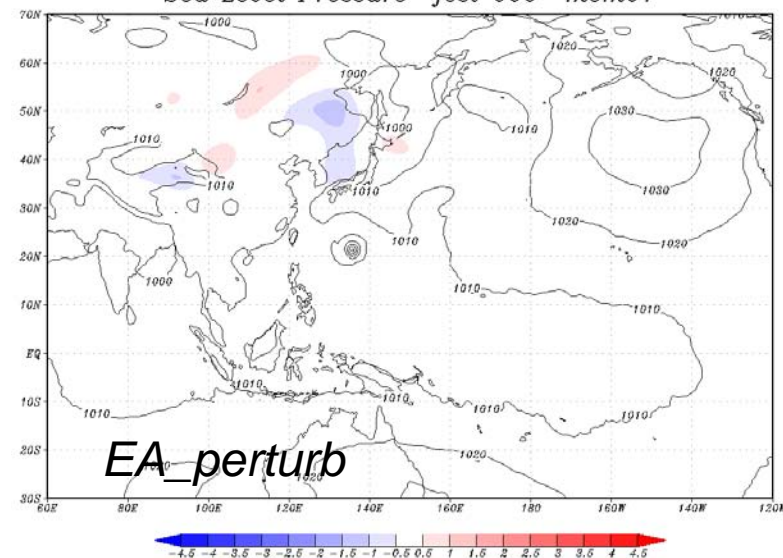
$$TY\_factor = 10, EA\_factor = 5$$

Soulik(2013)

Sea Level Pressure mem01



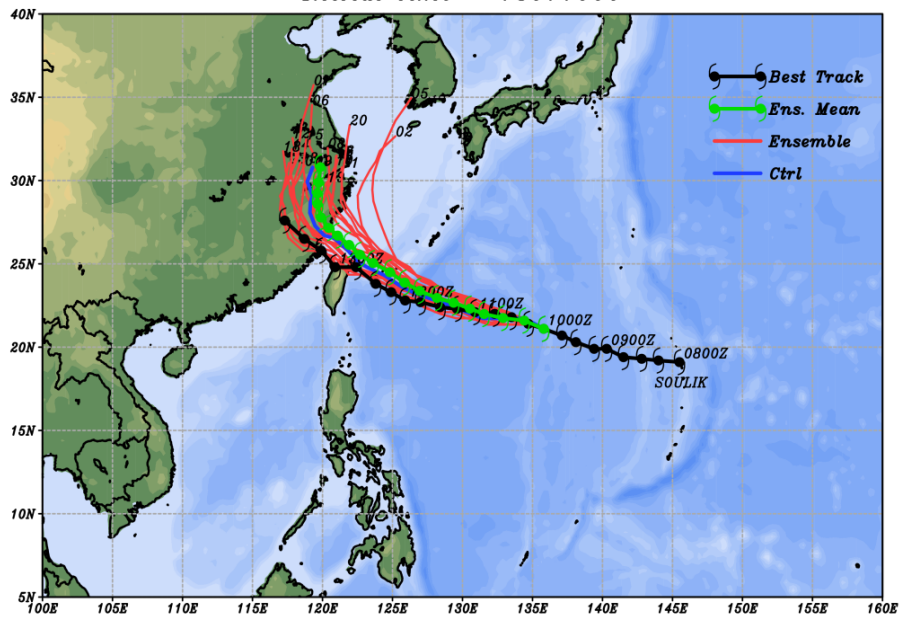
Sea Level Pressure fcst 000 mem01



# Target Domain Experiment

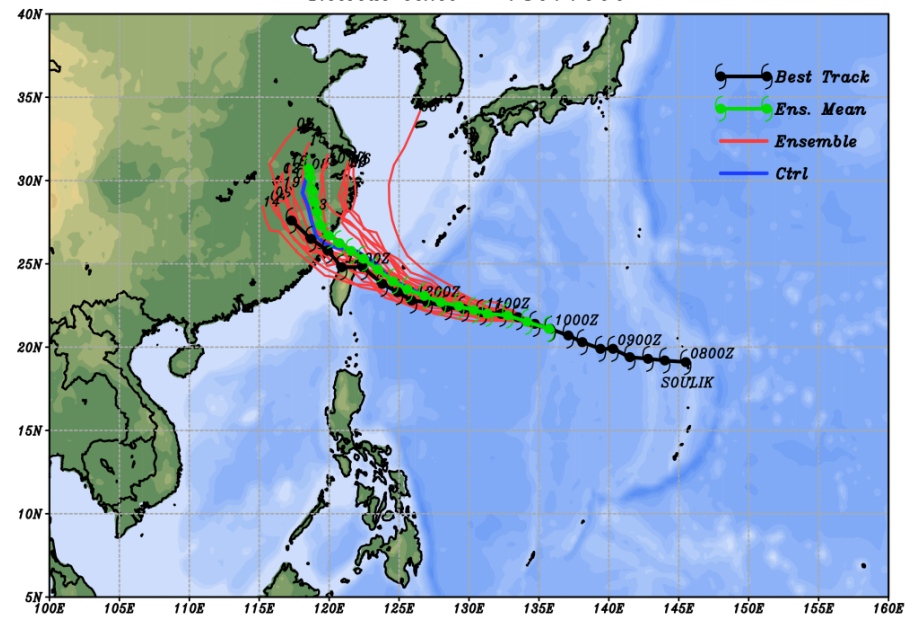
$perturb = TY\_perturb$

CWB GEps for Typhoon-track (GET)  
Initial time = 13071000

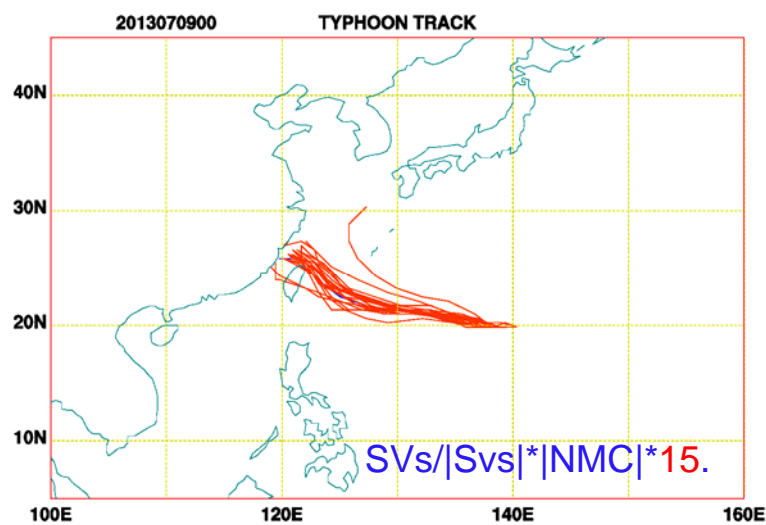
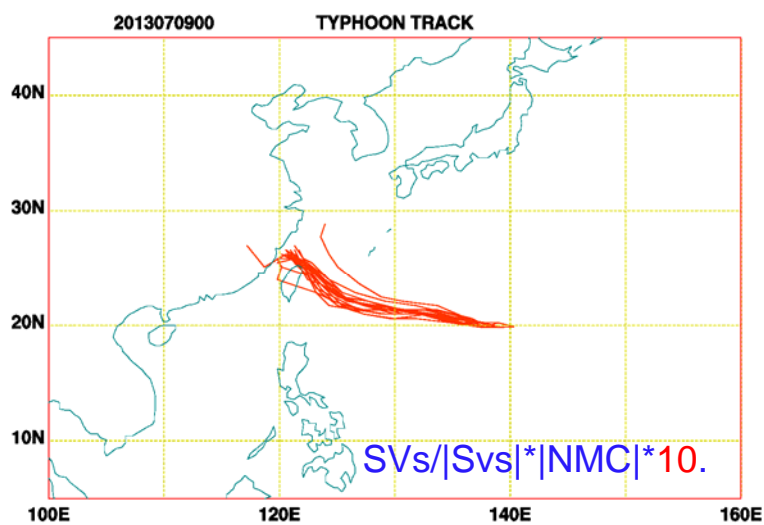
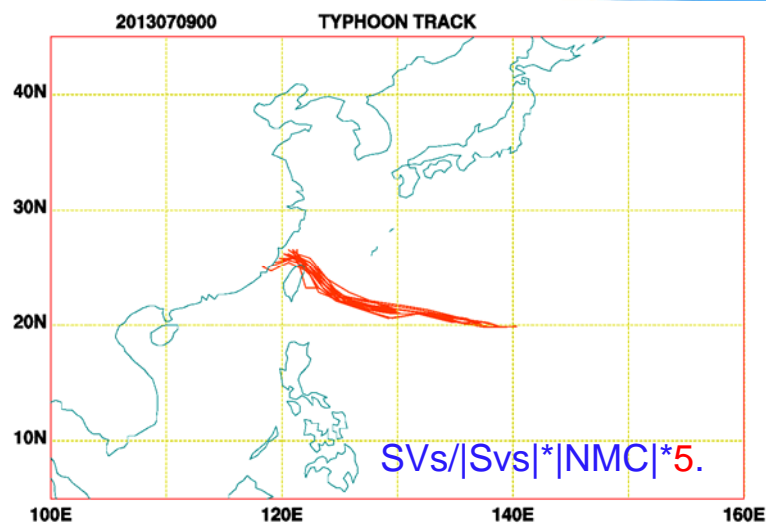
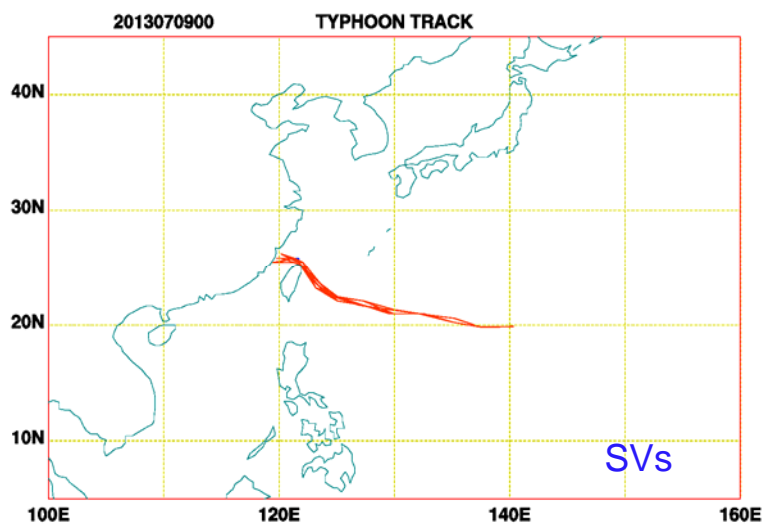


$perturb = TY\_perturb + EA\_perturb$

CWB GEps for Typhoon-track (GET)  
Initial time = 13071000



# Sensitivity Test (20 SVs)

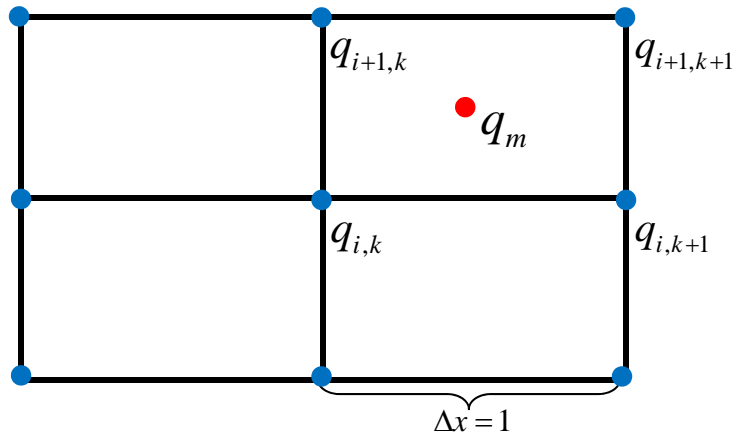


# Modification of tracker in GFS

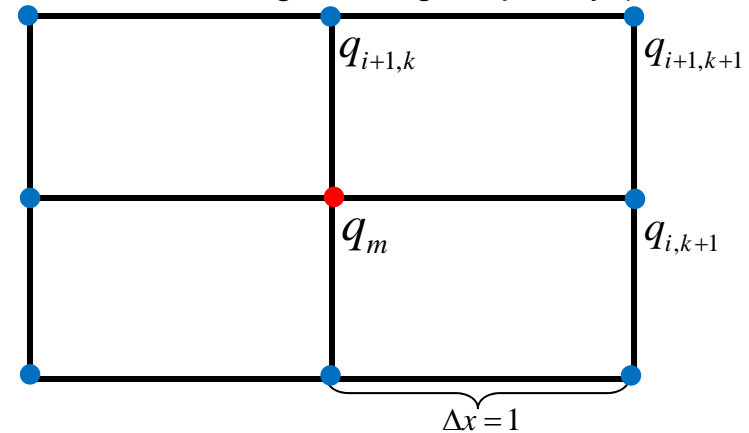
- Using five fields to find the TC center position
  1. SLP
  2. 850 hPa vorticity
  3. 700 hPa vorticity
  4. 850 hPa geopotential height
  5. 500 hPa geopotential height

## □ Grid resolving position

Before :



After : increasing tracking frequency (12 h  $\rightarrow$  3 h)





# Modification of tracker in GFS

## Newton-Raphson Method

$$q(x) = q(x_k) + q'(x_k)(x - x_k) + q''(x_k)(x - x_k)^2,$$

$$\frac{dq(x)}{dx} = 0,$$

$$q'(x_k) + q''(x_k)(x_m - x_k) = 0,$$

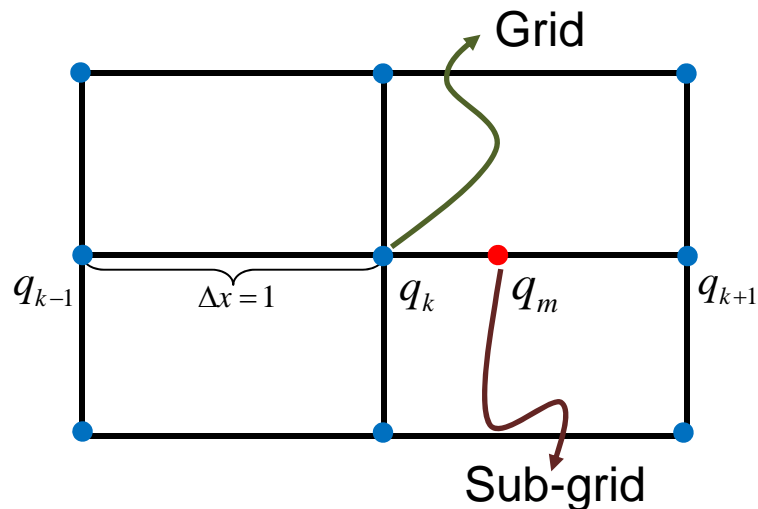
$$x_m = x_k - \frac{q'(x_k)}{q''(x_k)}$$

## Numerical form

$$x_m = x_k - \frac{\frac{q_{k+1} - q_{k-1}}{2\Delta x}}{\frac{q_{k+1} - q_k}{\Delta x} - \frac{q_k - q_{k-1}}{\Delta x}},$$

$$= x_k - \frac{1}{2\Delta x} \frac{q_{k+1} - q_{k-1}}{q_{k+1} - 2q_k + q_{k-1}}, \Delta x = 1$$

## □ Sub-grid resolving position



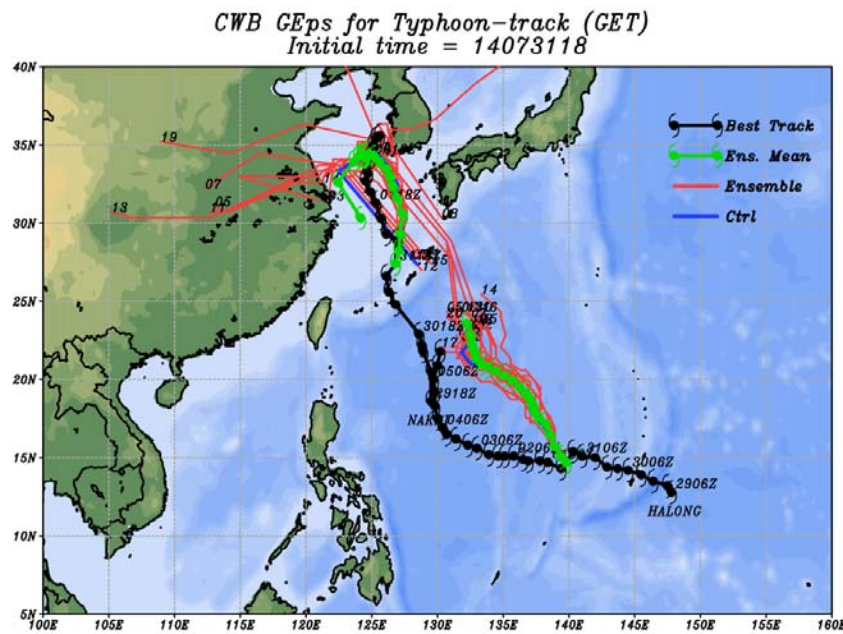
## Central difference Method

$$q'(x_k) = \frac{q_{k+1} - q_{k-1}}{2\Delta x}$$

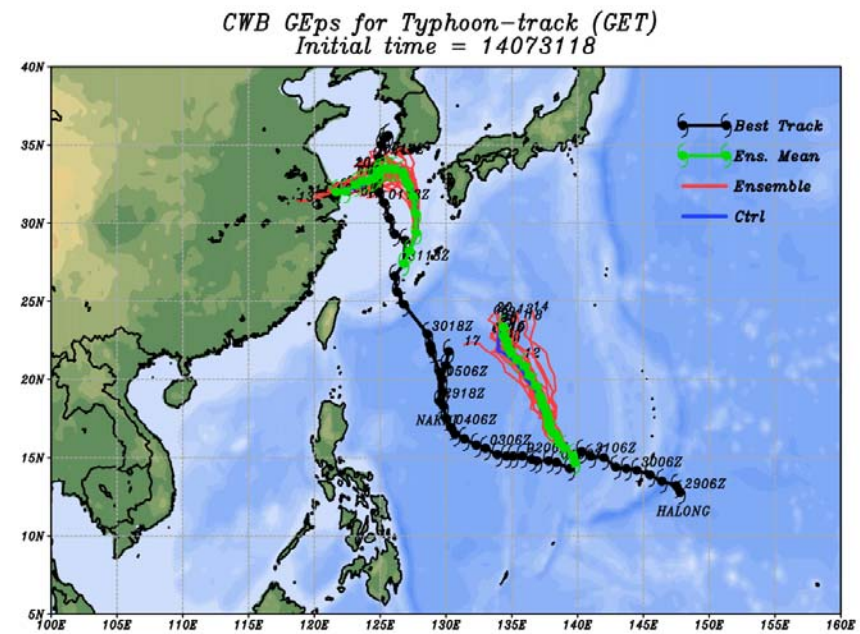
$$q''(x_k) = \frac{\frac{q_{k+1} - q_k}{\Delta x} - \frac{q_k - q_{k-1}}{\Delta x}}{\Delta x}$$

# Modification of tracker in GFS

Before



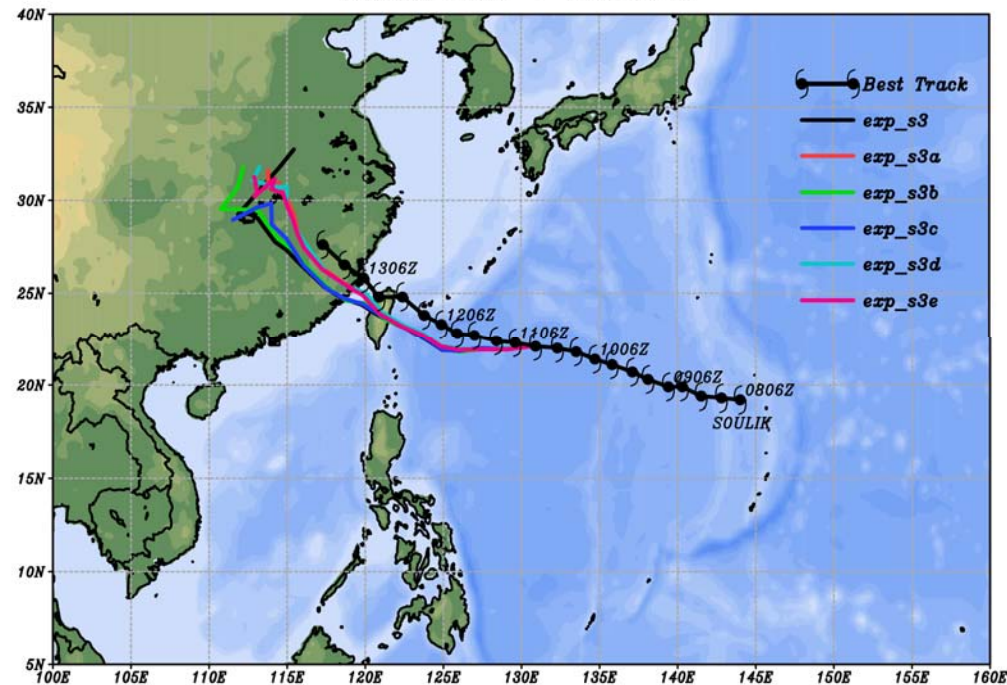
After



# Physics Sensitivity Test

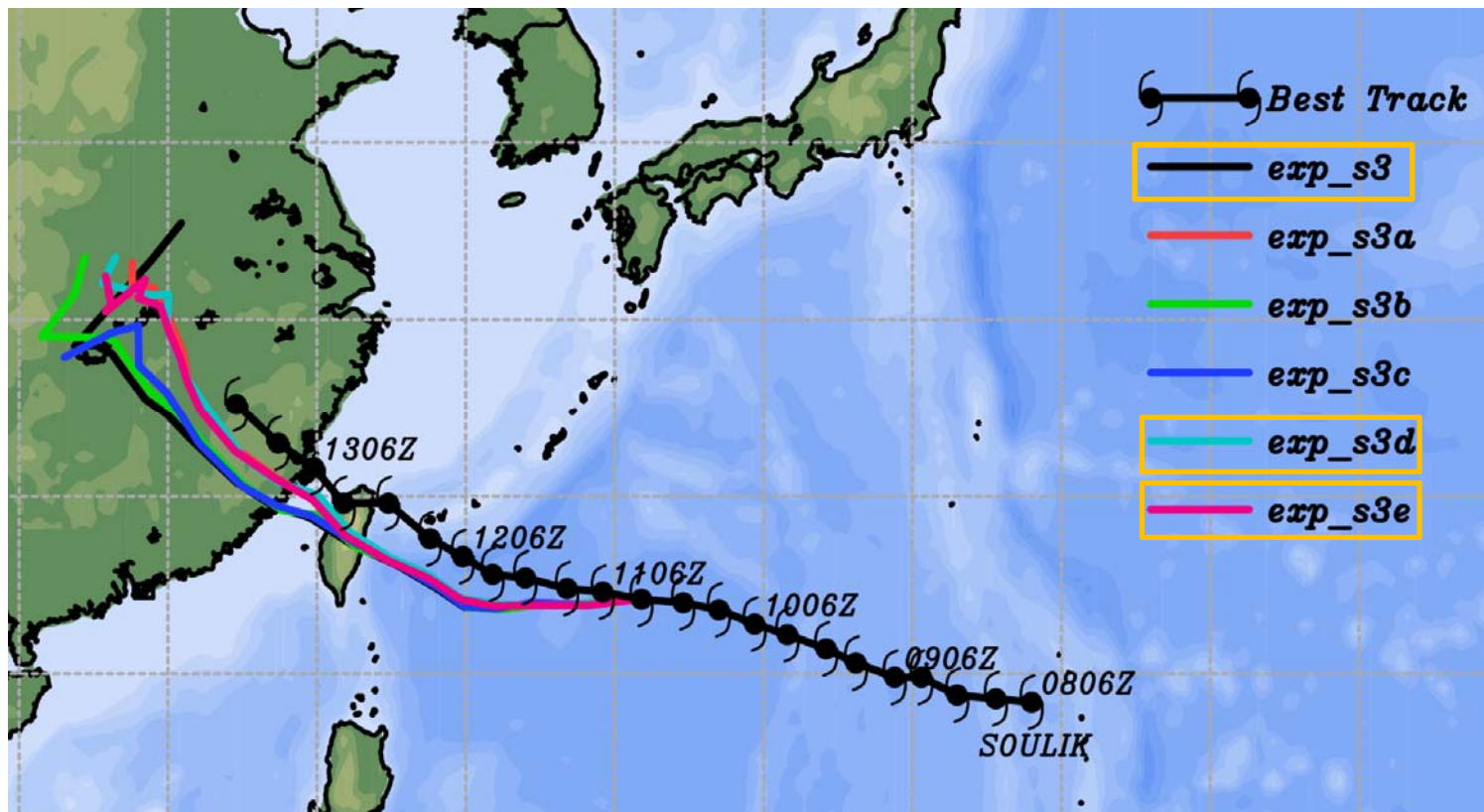
	Exp_s3a	Exp_s3b	Exp_s3c	Exp_s3d	Exp_s3e
nmcup	3	2	2	3	3
nmpbl	2	3	2	3	2
nmslh	1	1	2	2	2

CWB GEps for Typhoon-track (GET)  
Initial time = 13071100



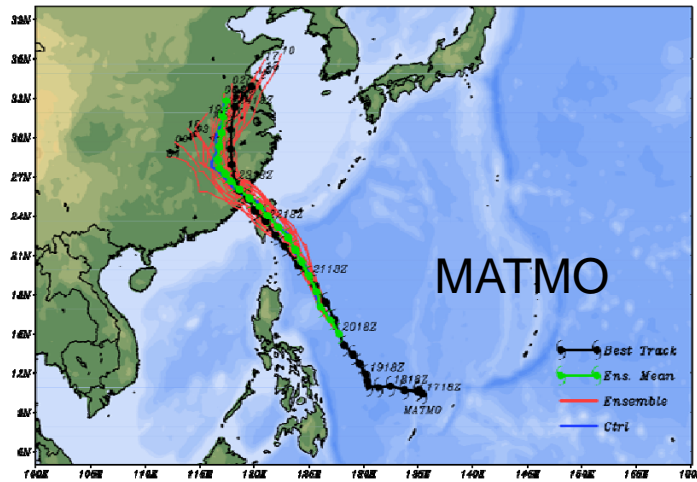
# Physics Sensitivity Test

	Exp_s3a	Exp_s3b	Exp_s3c	Exp_s3d	Exp_s3e
nmcup	New_SAS	SAS	SAS	New_SAS	New_SAS
nmpbl	2	3	2	3	2
nmslh	1	1	2	2	2

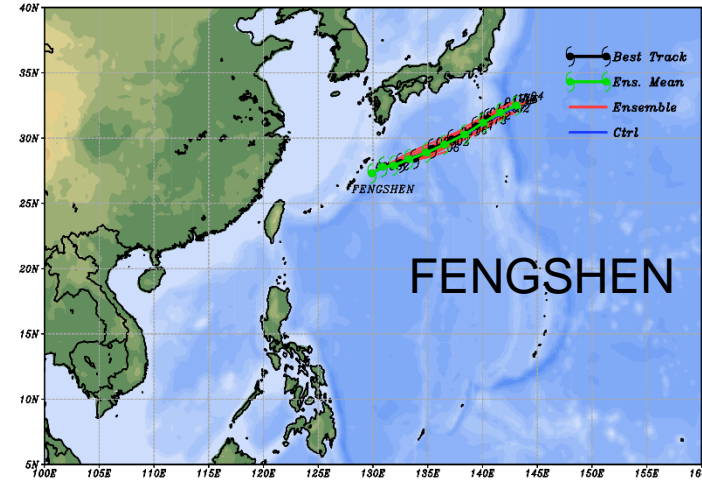


# Ensemble Prediction in 2014

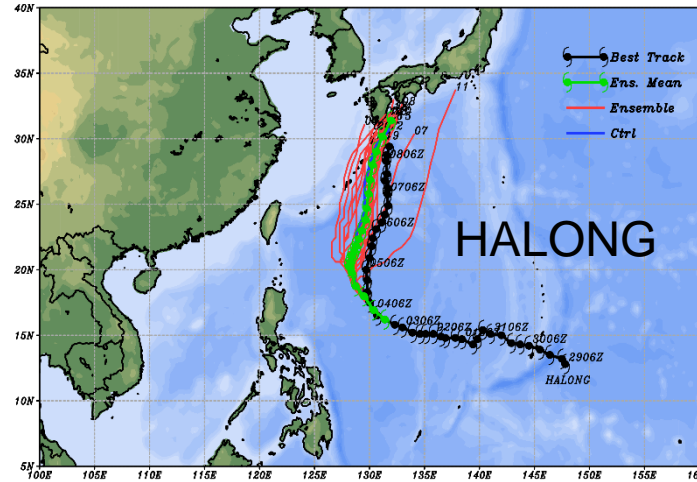
CWB GEps for Typhoon tracks (GET)  
Initial time = 14072018



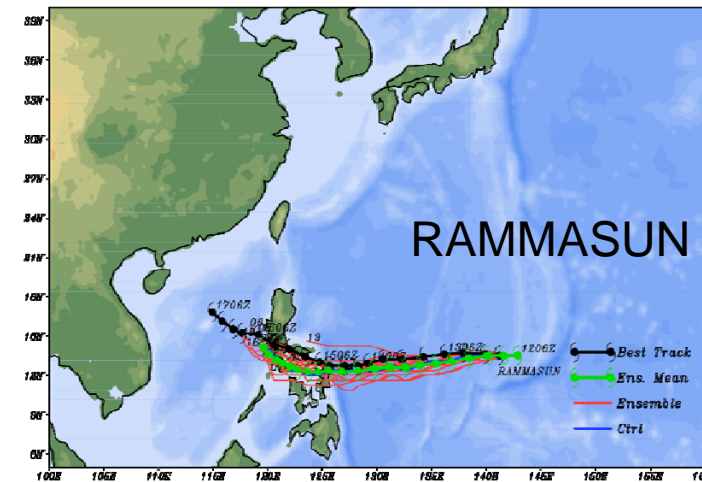
CWB GEps for Typhoon-track (GET)  
Initial time = 14090700



CWB GEps for Typhoon-track (GET)  
Initial time = 14080318

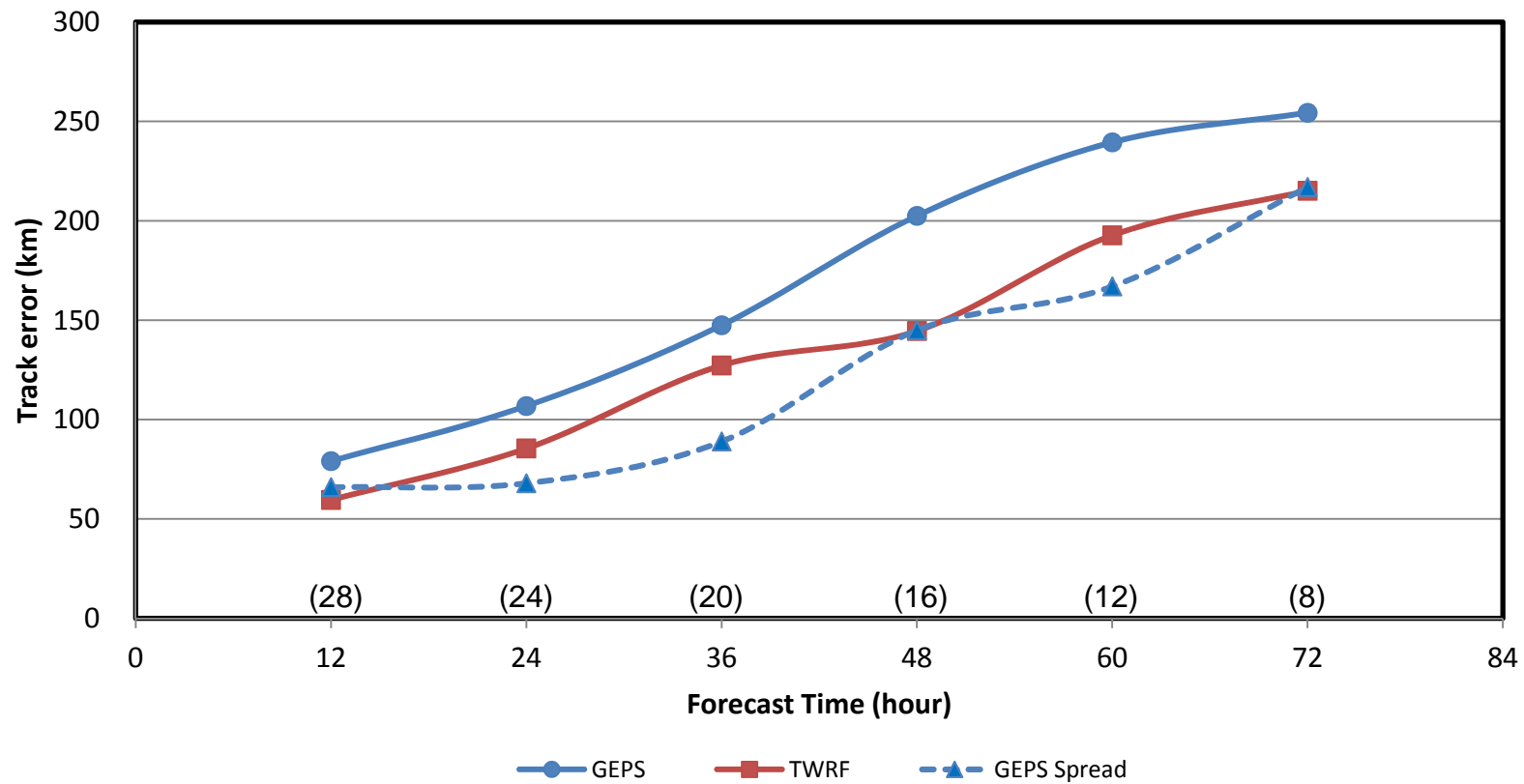


CWB GEps for Typhoon tracks (GET)  
Initial time = 14071206



# Spread and Track Error

## Ensemble Spread and Mean Track Error



# Summary and Conclusion

- 4 ingredients of GEPS for typhoon-track
  1. Good enough basic state
  2. Suitable perturb technique
  3. Reliable forecast model
  4. Accurated tracker
- $Perturbation = TY\_perturb + EA\_perturb$

$$TY\_perturb = SV_{TY} / |SV_{TY}| \times |NMC| \times TY\_factor$$

$$EA\_perturb = SV_{EA} / |SV_{EA}| \times |NMC| \times EA\_factor$$

$$TY\_factor = 10, EA\_factor = 5$$

- Tracker have been improved.
- Model physics may effect ensemble track predition.
- Althouth **CWB GET** need a lot of improvement, it still provide useful statistical information.