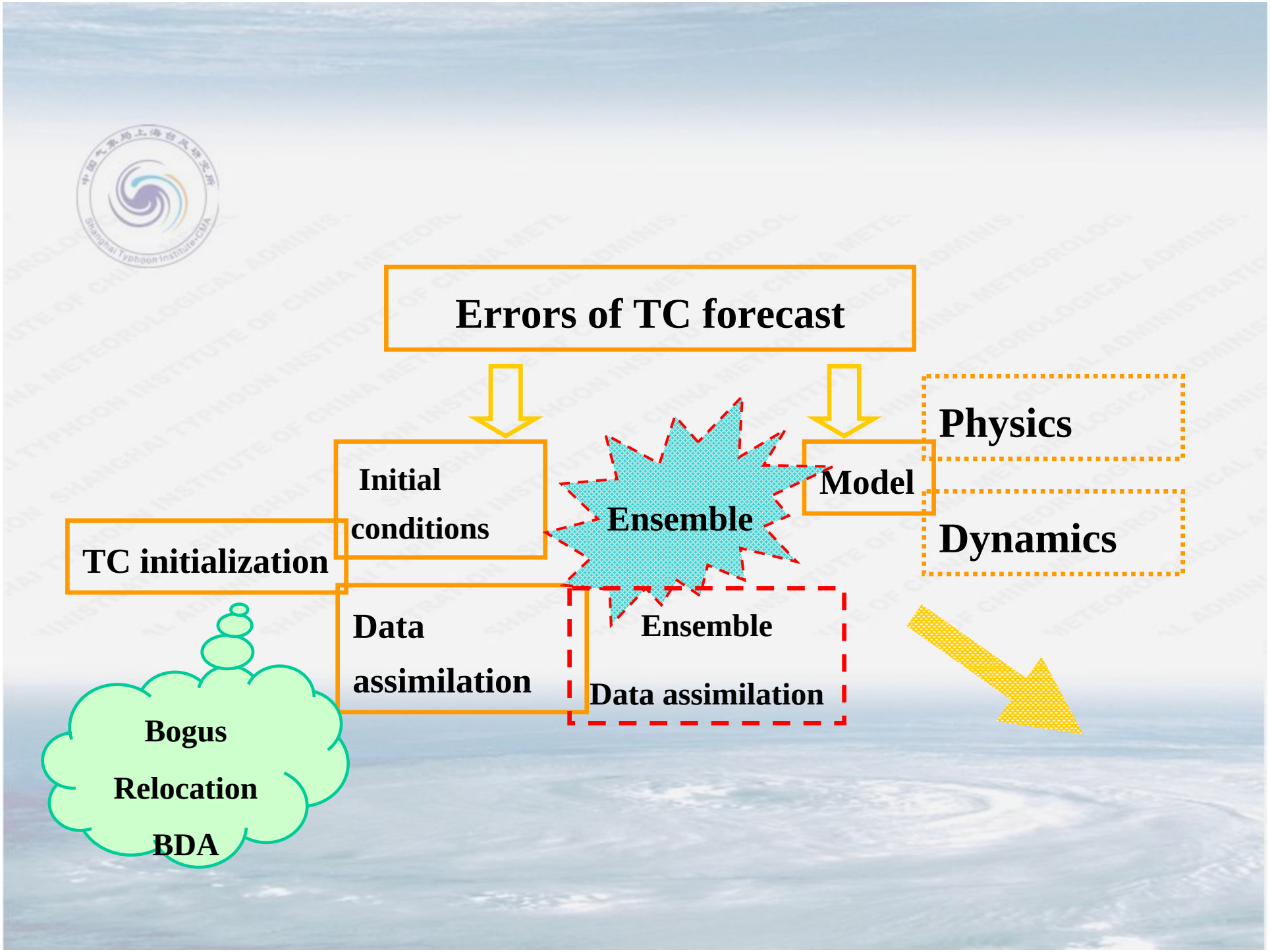
9IWW

Impact of Variational Data Assimilation of AMVs on Tropical Cyclone Track Forecasts

Dongliang WANG[1], Xudong LIANG[1], Bin WANG[2], Yihong DUAN[1], and Johnny C. L. CHAN[3]

[1]Shanghai Typhoon Institute/CMA
[2]LASG/Institute of Atmospheric Physics, Chinese Academy of Sciences
[3]City University of Hong Kong

April 15 2008, Annapolis, Maryland, USA


Errors of TC forecast
Initial conditions
TC initialization
Data assimilation
Bogus
Relocation
BDA
Ensemble
Ensemble
Data assimilation
Model
Physics
Dynamics

- **Impact of 4D-Var Data Assimilation of AMVs on TC Track Forecasts**

- **Impact of model-constrained 3D-Var Data Assimilation of AMVs, AMSU-A and QuikSCAT on TC Track Forecasts**

$$\mathbf{J} = \sum_{m=1,2} \mathbf{J}_m + \mathbf{J}_b$$

$$\mathbf{J}_b = \frac{1}{2}(\mathbf{X}_0 - \mathbf{X}_b)^{\mathrm{T}} \mathbf{B}^{-1} (\mathbf{X}_0 - \mathbf{X}_b)$$

$$J_m = \sum_r [(\boldsymbol{H}_l u - u^{sat})^{\mathrm{T}} \boldsymbol{W}_u (\boldsymbol{H}_l u - u^{sat})$$

$$+ (\boldsymbol{H}_l v - v^{sat})^{T} \boldsymbol{W}_v (\boldsymbol{H}_l v - v^{sat})]$$

MM5 4DVar **Assimilation window: 6 h**

Wang Dongliang, X. Liang, Y. Duan and J. Chan, 2006: Impact of Four-Dimensional Variational Data Assimilation of Atmospheric Motion Vectors on Tropical Cyclone Track Forecasts. ***Wea. and Fore., 21,*** 663-669.
wangdl@mail.typhoon.gov.cn

22 cases from 8 TCs in 2002

TC Name	No. of Forecasts	Initial time
Rammasun(0205)	4	062812,070112,070200,070312
Chataan(0206)	2	070112,070412
Fengshen(0209)	5	071900,072000,072400,072500,072600
Fungwong(0211)	2	072400,072500
Phanfone(0213)	2	081612,081712
Vonfong(0214)	1	081712
Rusa(0215)	2	082612,083012
Sinlaku(0216)	4	090212,090312,090412,090612

- Horizontal resolution: 45km
- Grid dimentions: 85X91X23
- Model top: 10 hPa
- Planetary boundary layer scheme: Blackadar (1979)
- explicit moisture scheme: Dudhia (1989)
- Cumulus Scheme: Kuo (1974)
- Background fields: NCEP GFS 12-h forecast

AMV data:

Provided by SMC/CMA

Derived from GMS-5 Water vapor and IR imageries

On average,

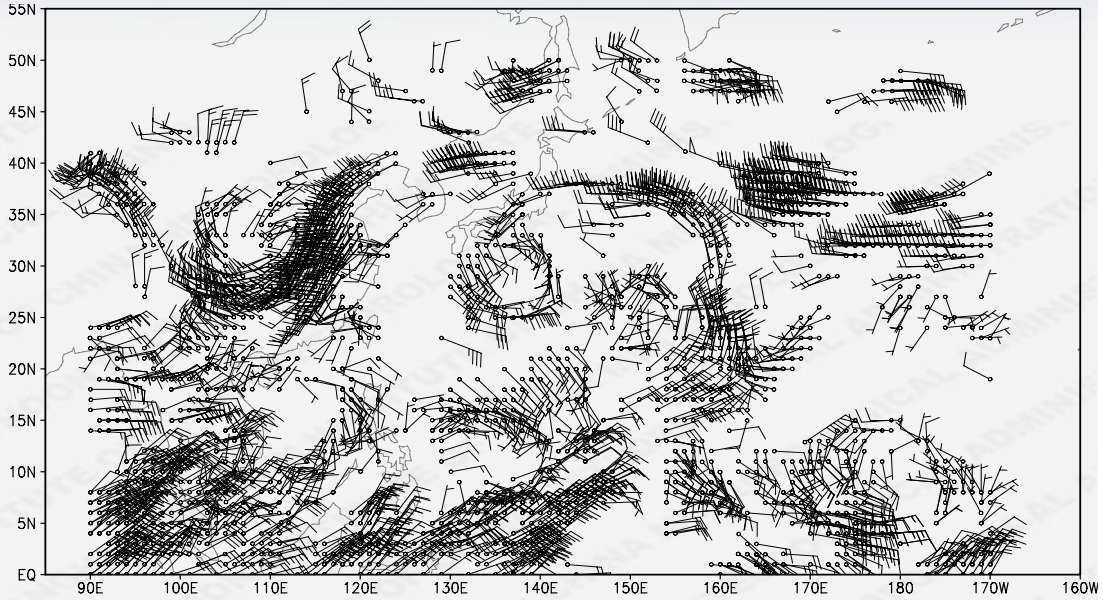
above 400 hPa : 95%

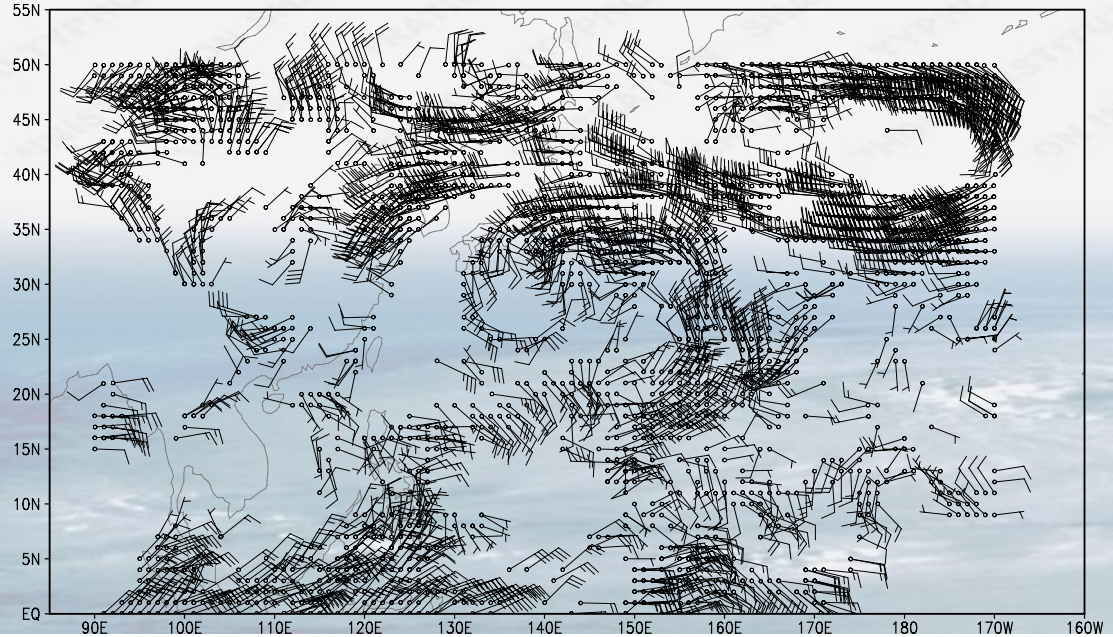
Between 200 and 300 hPa: 55%

1344 AMV observations are available within the model domain (about 3825 km X 4095 km),

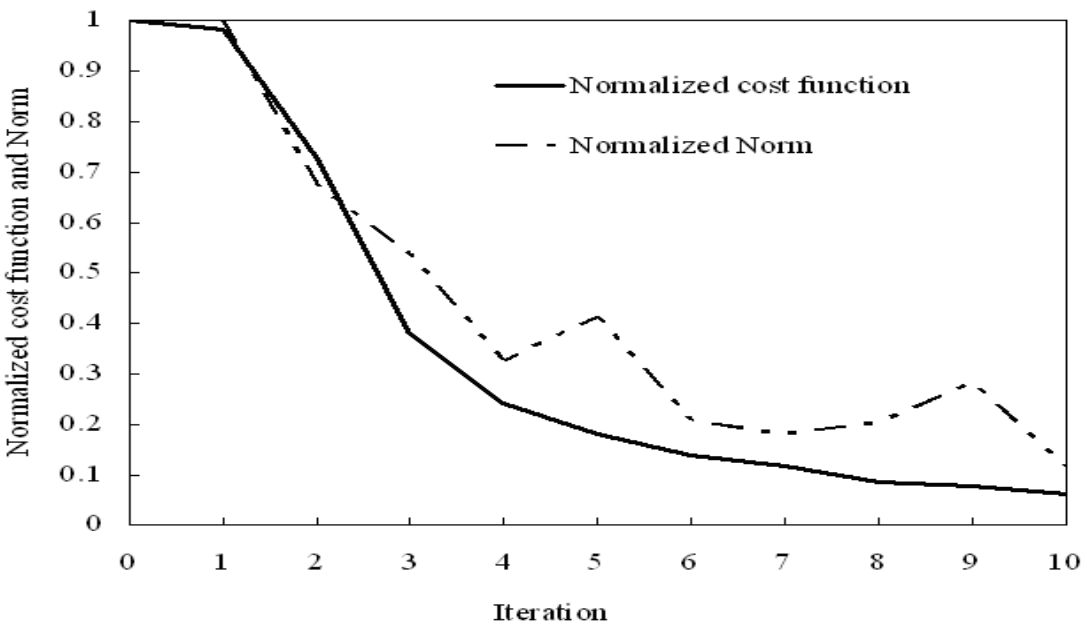
1200 UTC on 17 August GMS-5 infrared and water vapor AMVs

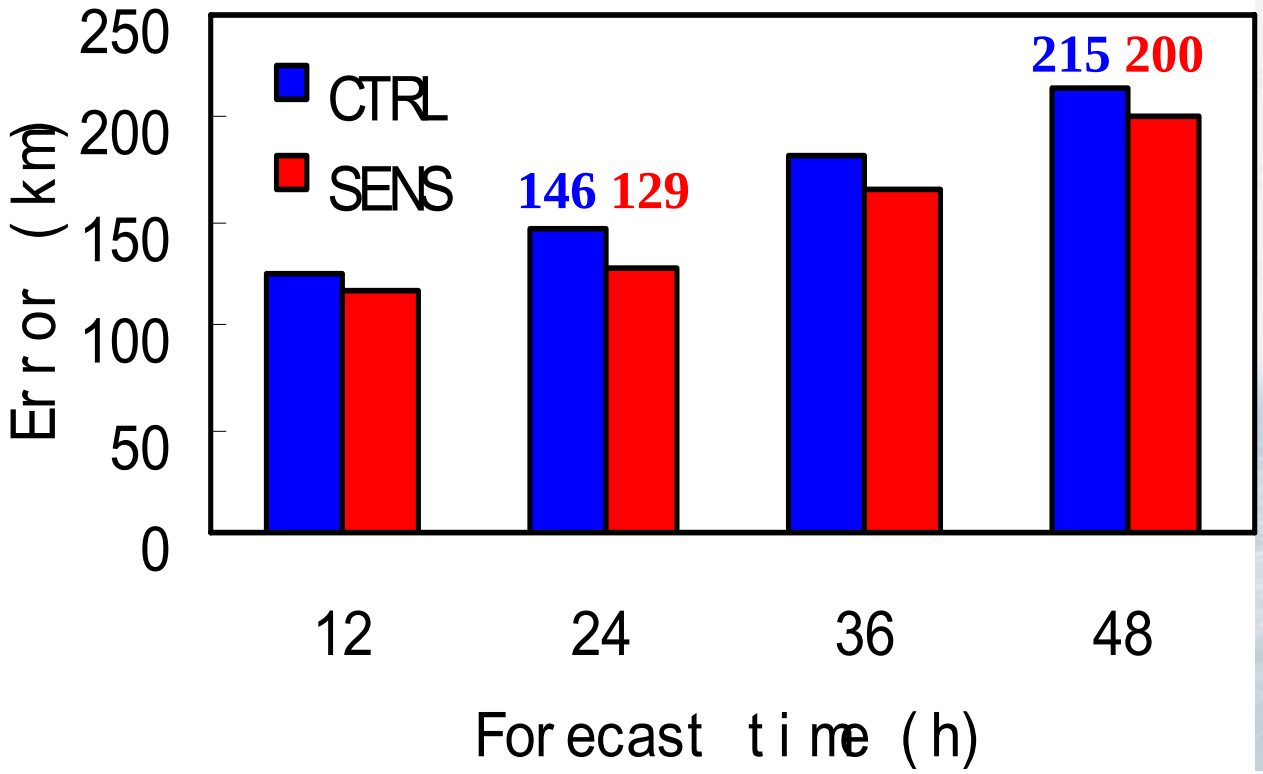
200-250 hPa



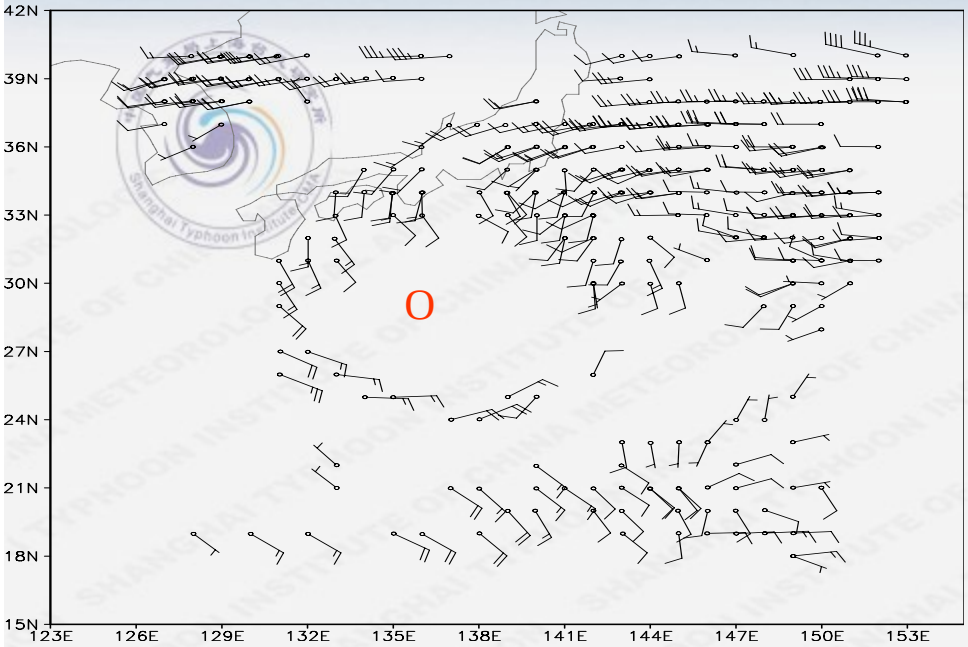


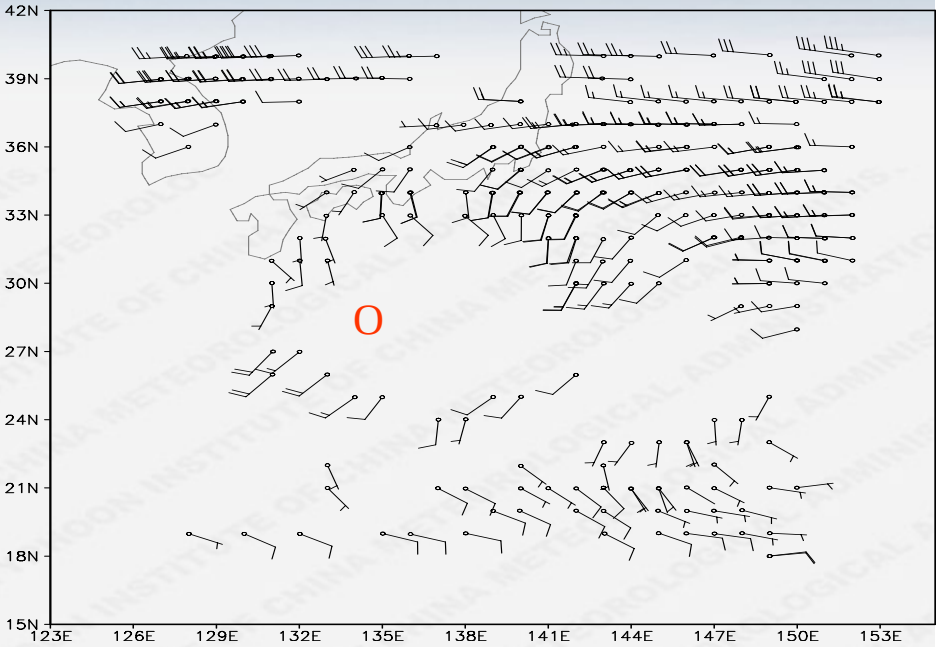
250-300 hPa


Normalized cost function and Norm
Iteration
Normalized cost function
Normalized Norm
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9
10

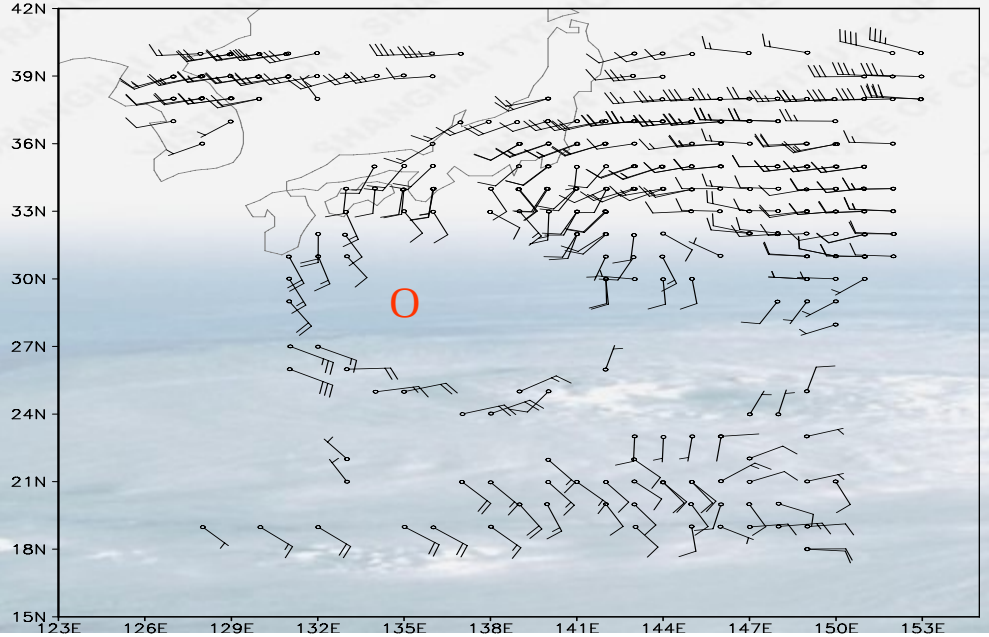

Error (km)
CTRL
SENS
215 200
146 129
250
200
150
100
50
0
12
24
36
48
Forecast time (h)

phanfone081712 250-300hPa





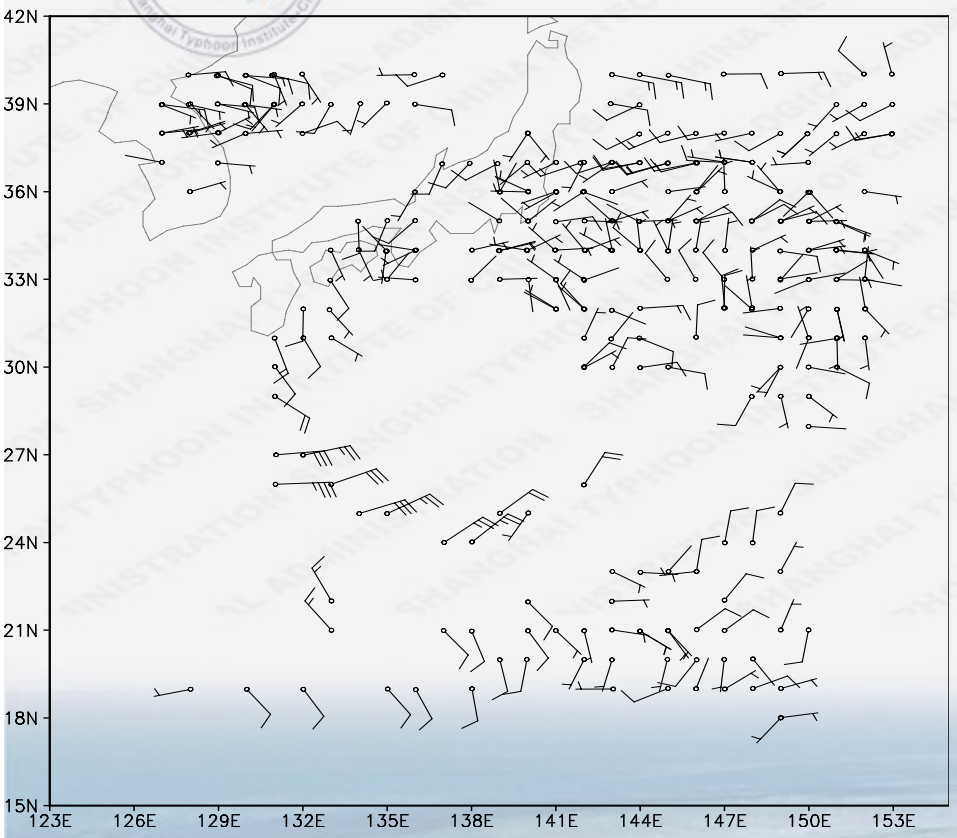
AMV observation

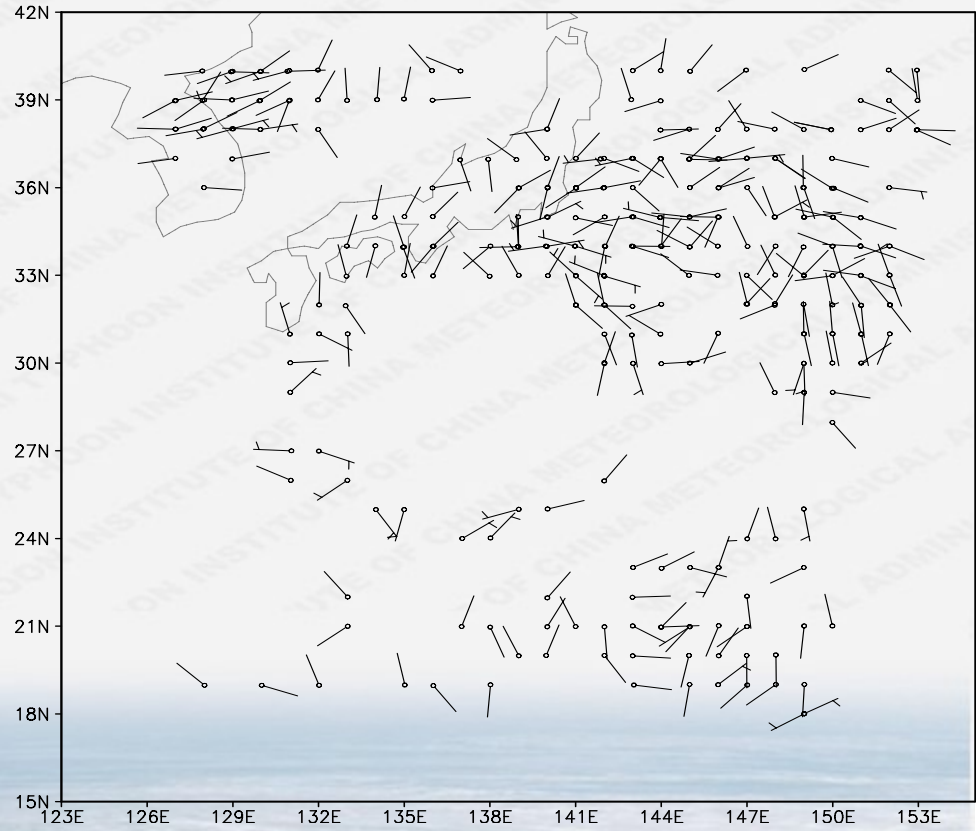


Background

Analysis

Phanfone081712 250-300hPa





innovation
(observation minus background)

residual
(observation minus analysis)

AMV Data at all levels, the average is 1344

Change of forecast error compared with CTRL	No. of cases with number of AMV observations	
	more than the average	less
Reduced	27	21
No change	12	9
Increased	5	14

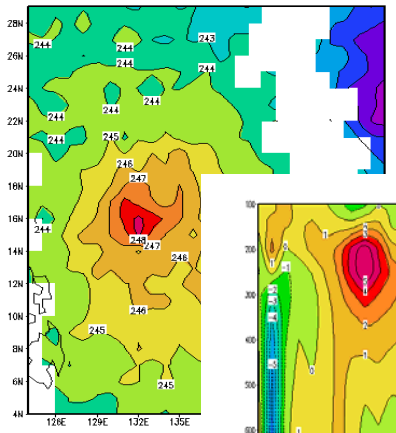
88 forecasts for the 22 cases (12-h interval)

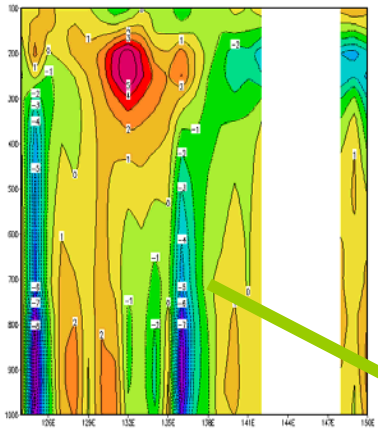
AMV Data below 400 hPa, the average is 57

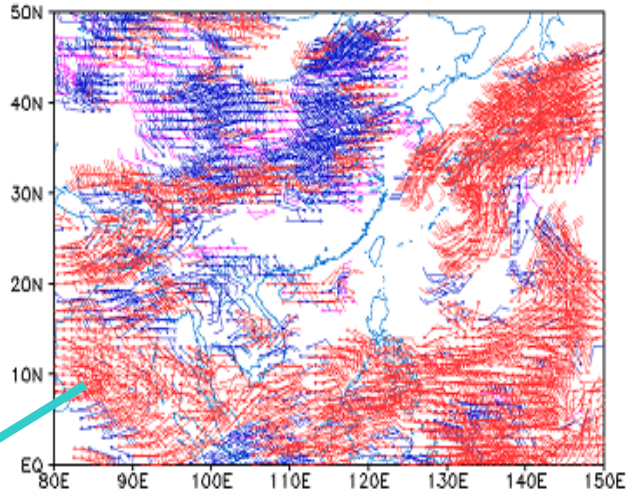
Change of forecast error compared with CTRL	No. of cases with number of AMV observations	
	more than the average	less than the average
Reduced	33	15
No change	2	19
Increased	1	18

88 forecasts for the 22 cases (12-h interval)

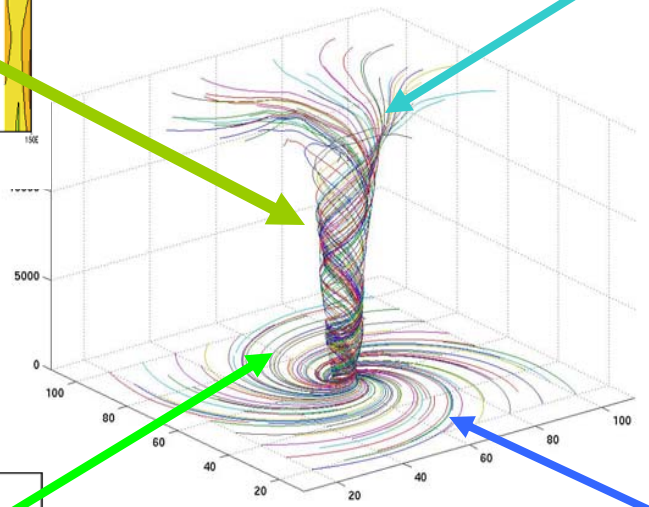
AMVs

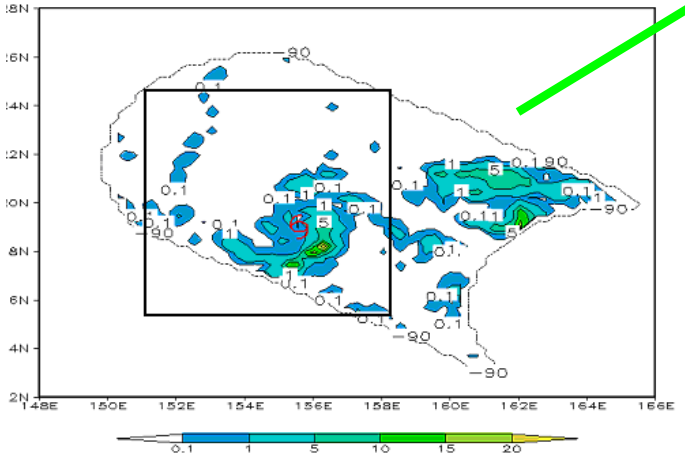






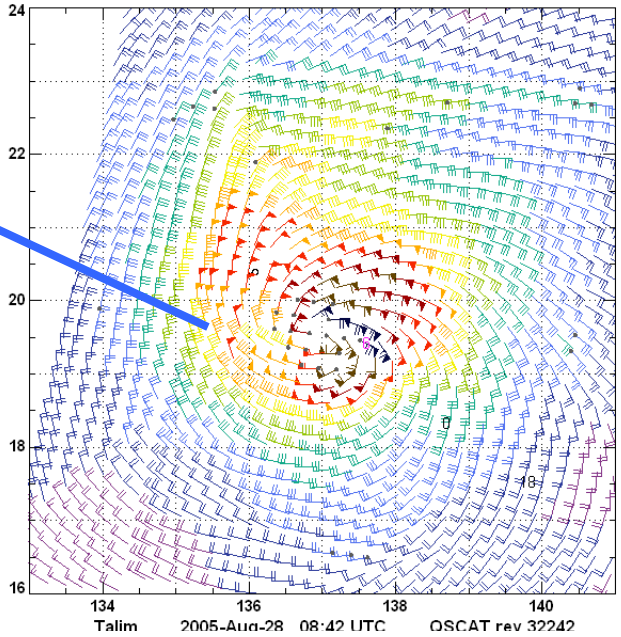
AMSU





TRMM

QuikSCAT



Outline

- **Impact of 4D-Var Data Assimilation of AMVs on TC Track Forecasts**

- **Impact of model-constrained 3D-Var Data Assimilation of AMVs, AMSU-A and QuikSCAT on TC Track Forecasts**

Model-constrained 3D-Var : Proposed by Dr. Xudong LIANG

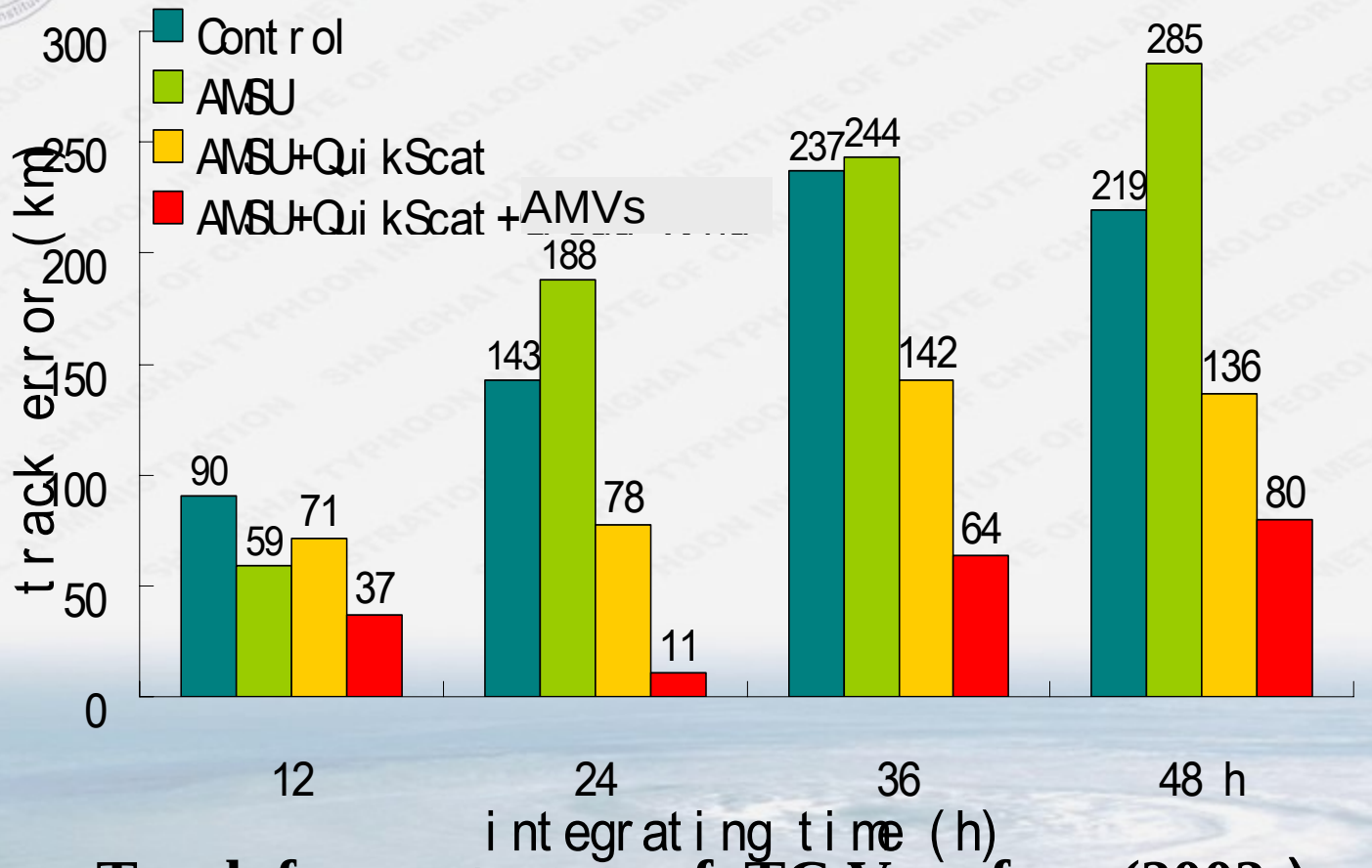
liangxd@mail.typhoon.gov

Introduce model physical and dynamical constraints into 3D-Var, to improve balance between analysis variables.

$$J=[x(t_0)-x_b(t_0)]^T B^{-1}[x(t_0)-x_b(t_0)]+[H(x(t_0))-y_o(t_0)]^T O^{-1}[H(x(t_0))-y_o(t_0)]+[\frac{\Delta x(t_0)}{\Delta t}]^T R^{-1}[\frac{\Delta x(t_0)}{\Delta t}]$$

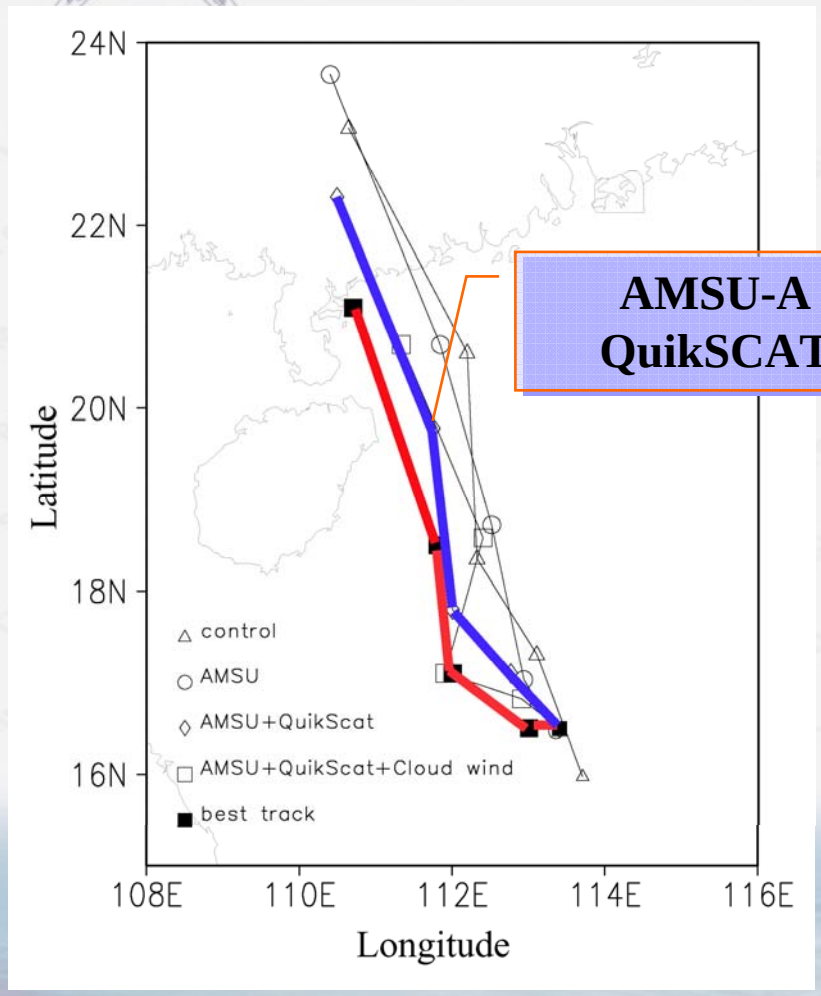
Liang Xudong, B. Wang, J. C L Chan, Y. Duan, D. Wang, Z. Zeng, and L. Ma, 2007: Tropical cyclone forecasting with a model-constrained 3D-Var, Part I: Description. ***Quart. J. Roy. Meteor. Soc.. 133,*** 147-153.

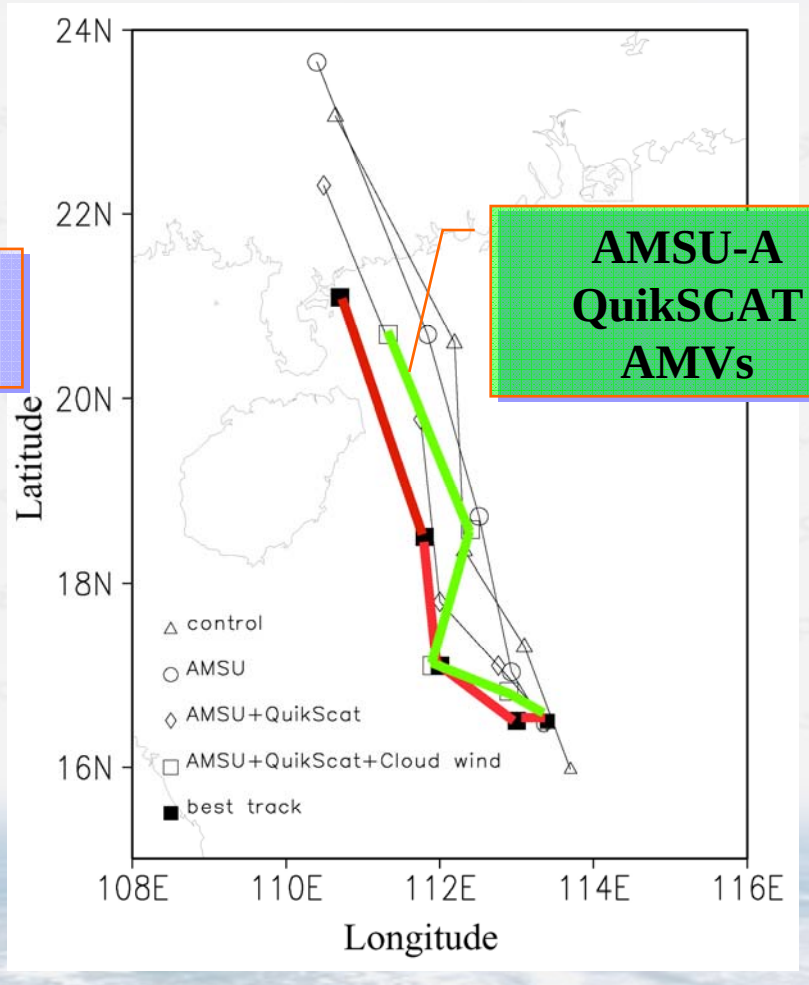
Liang Xudong, B. Wang, J. C L Chan, Y. Duan, D. Wang, Z. Zeng, and L. Ma, 2007: Tropical cyclone forecasting with a model-constrained 3D-Var, Part II: Improved cyclone track forecasting using AMSU-A, QuikSCAT and cloud-drift wind data. ***Quart. J. Roy. Meteor. Soc.. 133,*** 155-165.



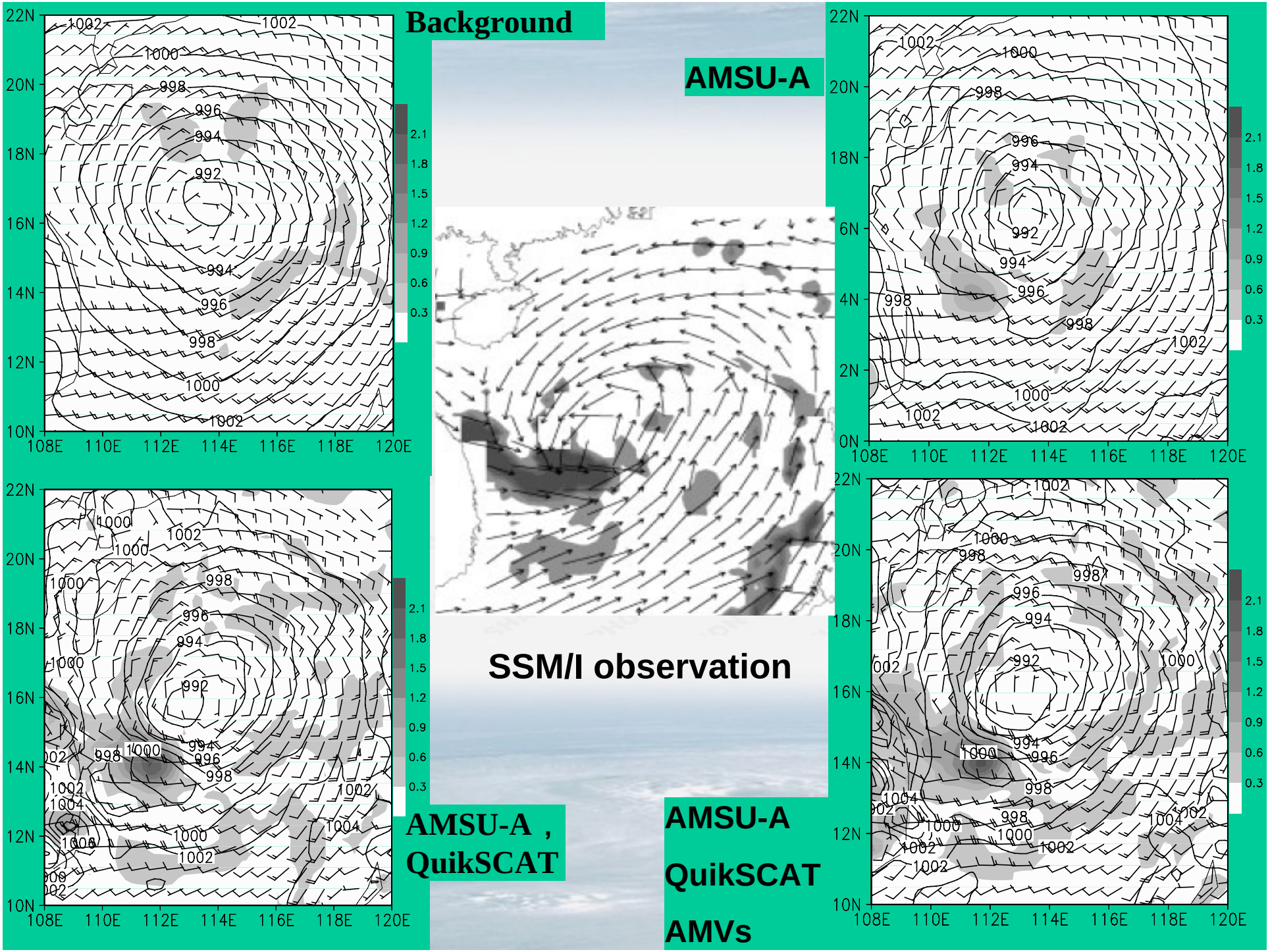
Track forecast error of TC Vongfeng (2002)

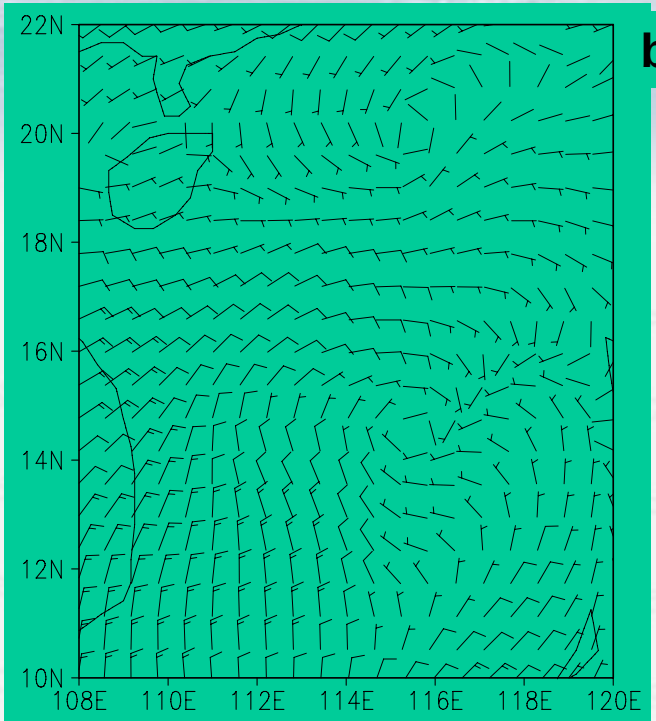
Initial time: 12 00 UTC 17 Aug..





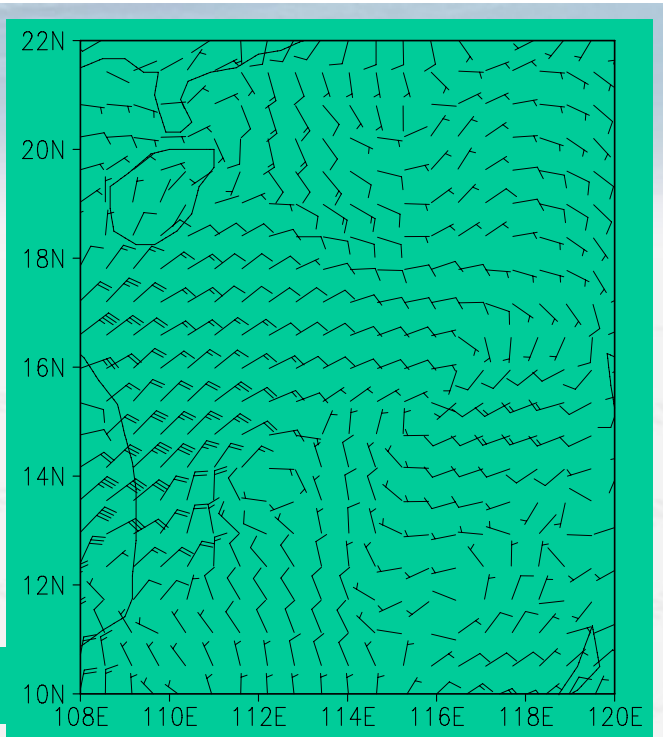
12 00 UTC 17 Aug ~ 12 00 UTC 19 Aug.


Background
AMSU-A
SSM/I observation
AMSU-A , QuikSCAT
AMSU-A QuikSCAT AMVs

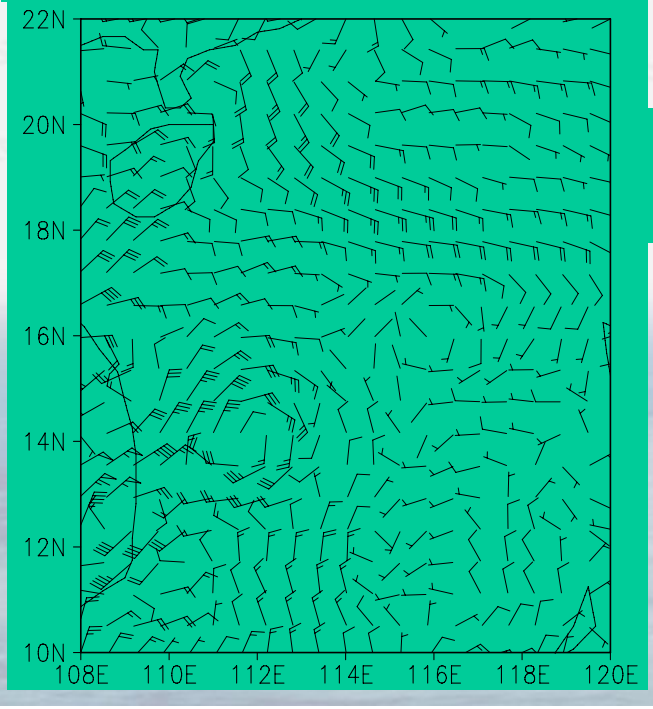


background

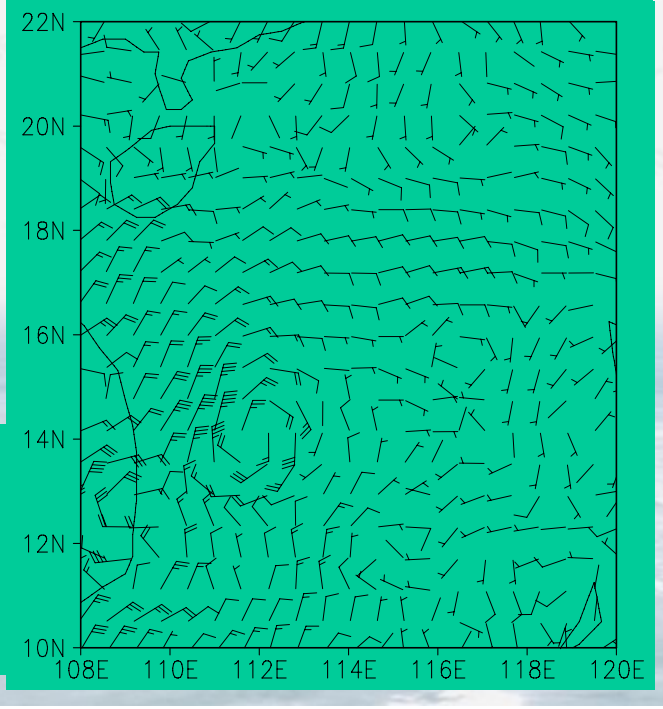
200 hPa



AMSU-A



AMSU-A ,
QuikSCAT



AMSU-A

QuikSCAT

AMVs

Thanks!