Bias Correction of Satellite Data in GRAPES-VAR

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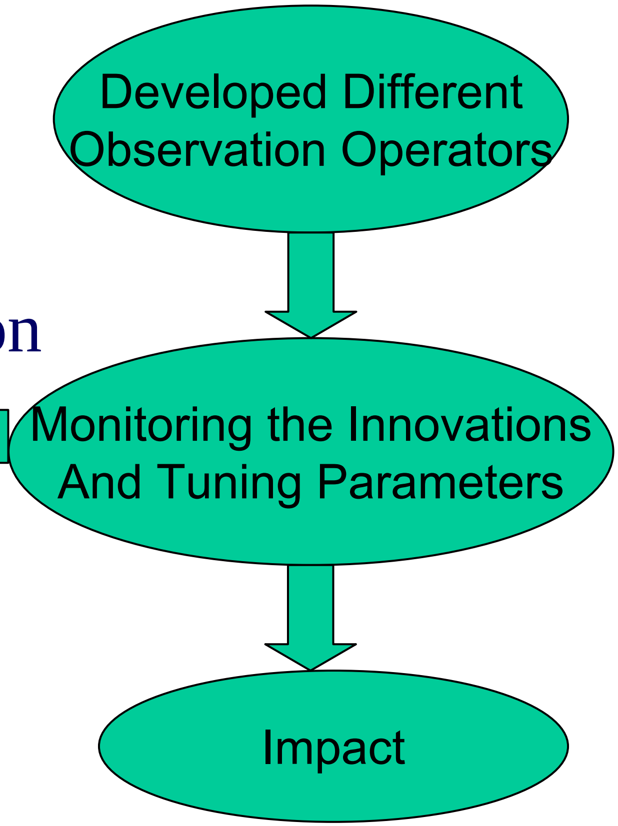
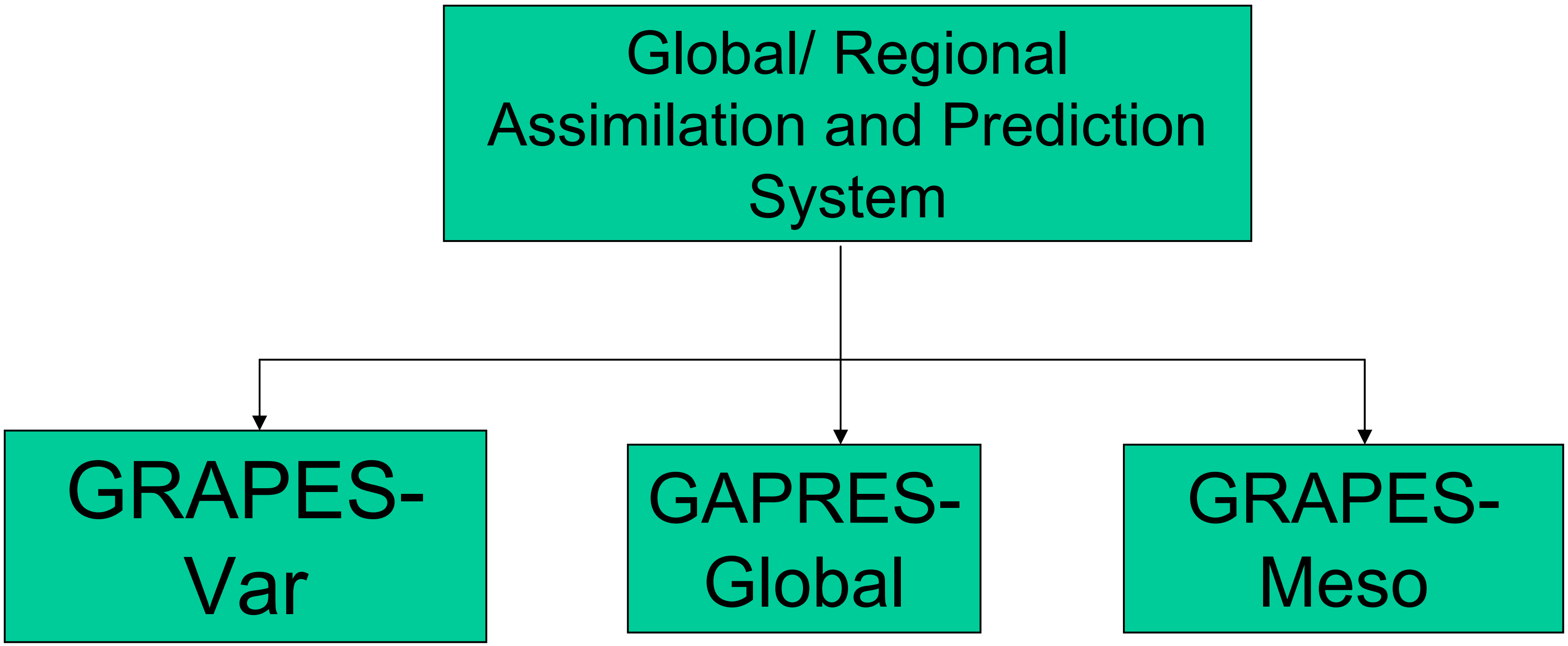
ITSC15, 2006-10, Italy

OUTLINE

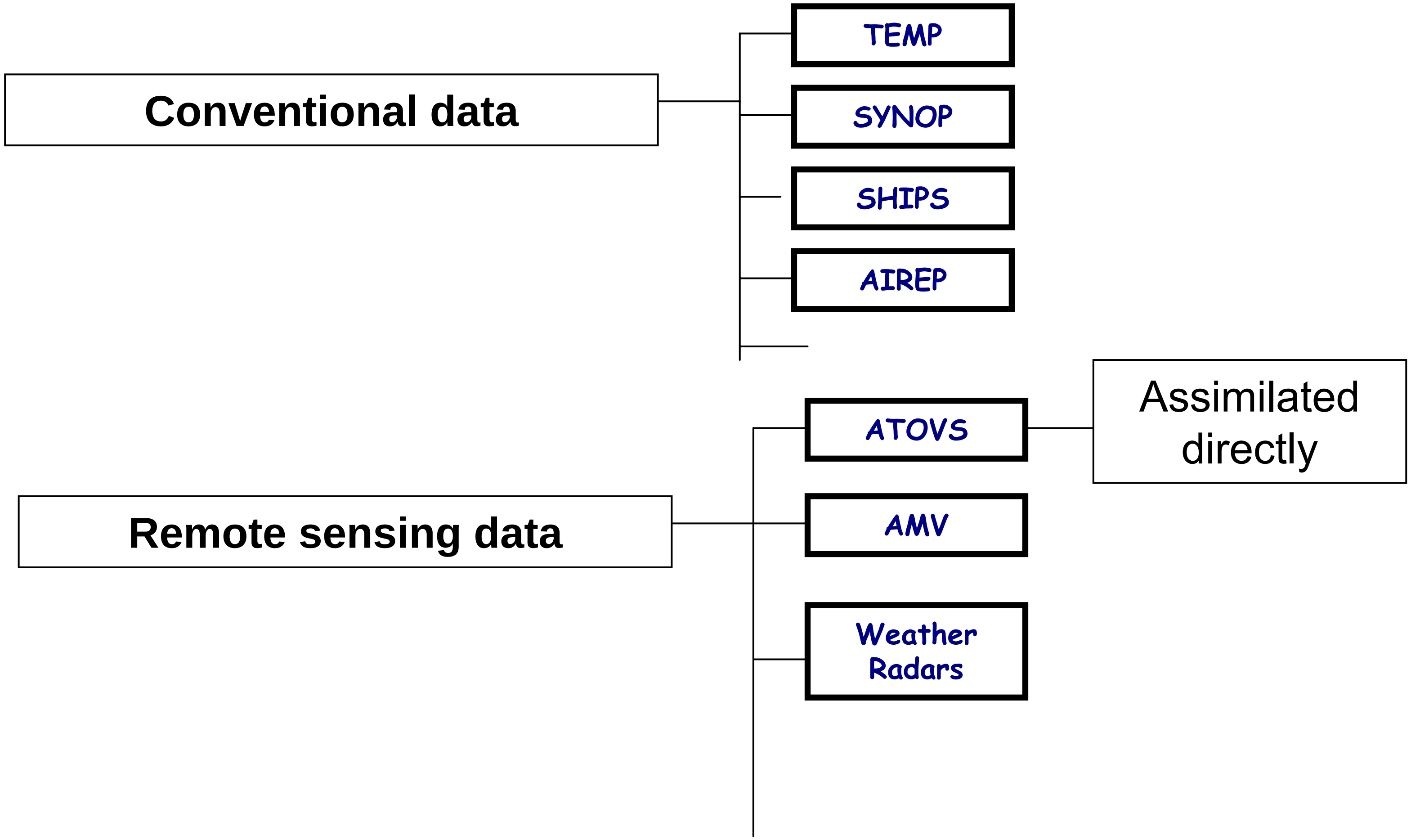
- Status of GRAPES-3DVAR
  - Main components of GRAPES
  - Usage of satellite data in GRAPES-Var
- Improvement of satellite data assimilation
  - **Bias Correction**
  - **Error Tuning**
- Impact on Analysis and Forecast
  - Global Model
  - Typhoon Forecast
- Discussions and Ongoing Work



Main components of Chinese new generation NWP system



Data usage of GRAPES-Var



ATOVS From Regional to Global Since Oct. 2005

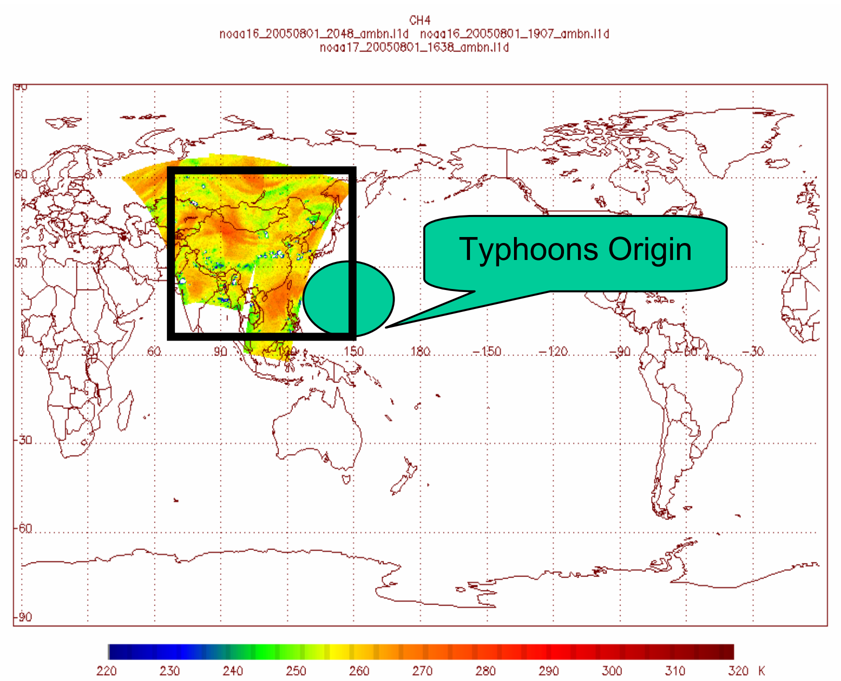
Global l1b data from NOAA/NESDIS

Local received HRPT data from NSMC

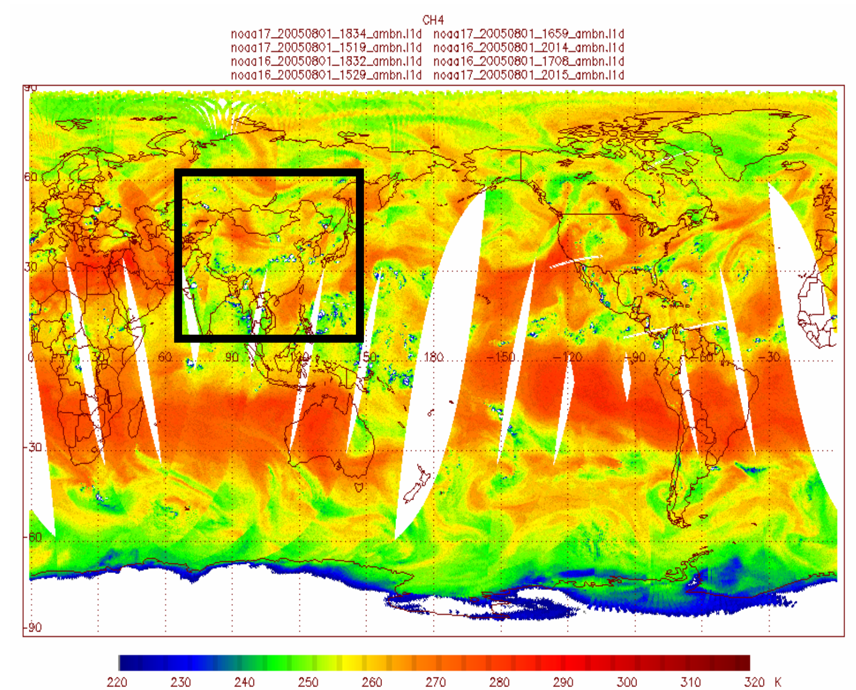
PREPROC

ATOVS Level 1C data

ATOVS Level 1D data



NOAA16/17 AMSUB CH4
2005080118(-3h~3h)□Local received

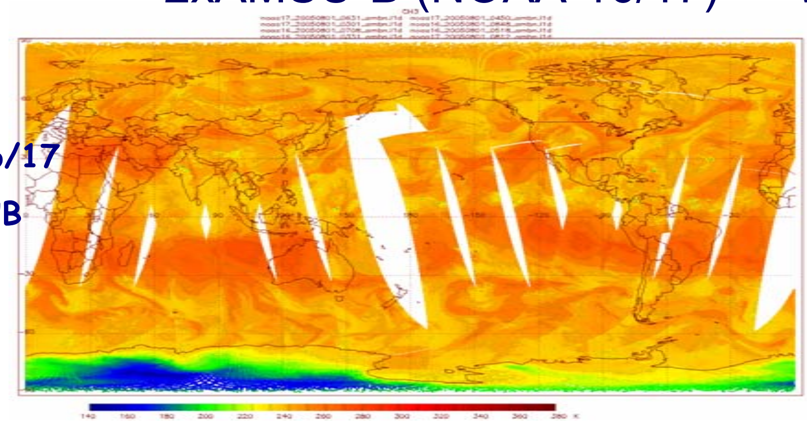


NOAA16/17 AMSUB CH4
2005080118(-3h~3h)□From NESDIS

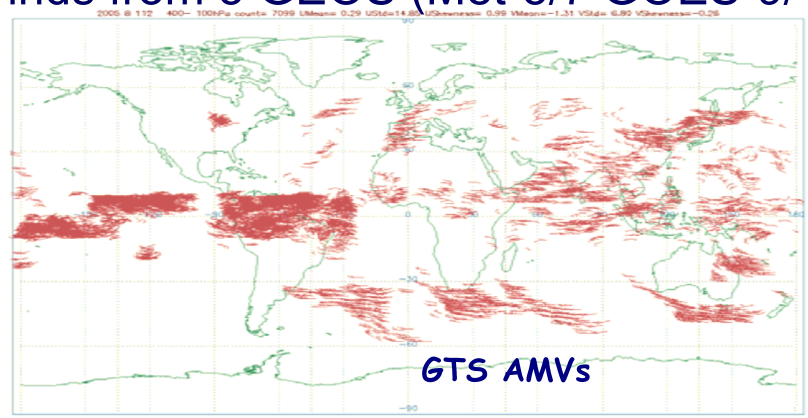
Satellite Data Assimilated In GRAPES in Nov. 2005

2xAMSU-B (NOAA-16/17)

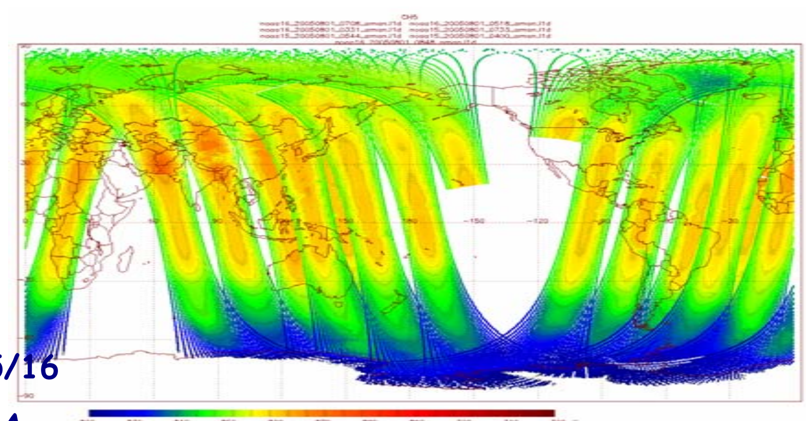
NOAA16/17 AMSUB



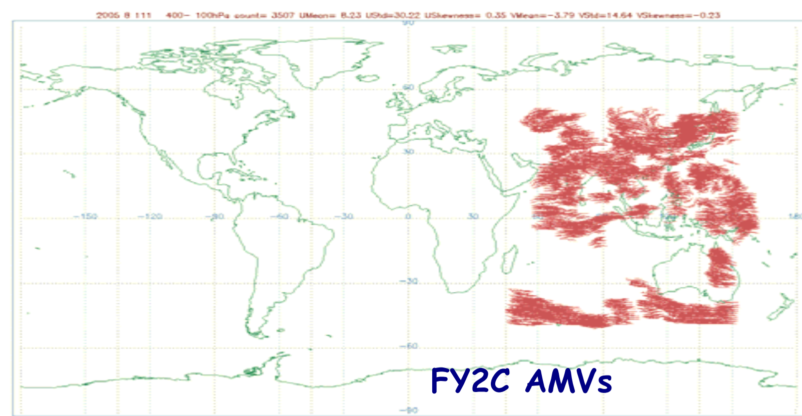
Winds from 5 GEOS (Met-5/7 GOES-9/10/12)



NOAA15/16 AMSUA



2xAMSU-A (NOAA-15/16)



Winds from FY2C

Preprocessing of Satellite Data in GRAPES-Var

- **Quality control (by NSMC)**
- **Thinning**
  - Error Correlation (Not represented in the obs. covariance)
  - To reduce data volume
- **Observational error Assignment**
  - Statistics of the Innovations
  - Tuning of the Error Setting
- **Bias correction**
  - Global Model
  - Regional Model

BIAS CORRECTION SCHEME IN PRACTICE: HARRIS AND KELLY(2001)'S SCHEME

- Scan Bias □s=<$d_j(\theta)$-$d_j(\theta=0)$>
- Air Mass Bias : $b=H(x_b)-y-s$
  - Least Square

$$\mathbf{b} = \mathbf{A}\mathbf{p} + \mathbf{c}$$

  - p (predictors)□b : Air Mass Bias
- Solution

$$\mathbf{A} = \mathbf{b}\mathbf{p}^{T}(\mathbf{p}\mathbf{p}^{T})^{-1}$$

$$\mathbf{c} = \mathbf{b} - \mathbf{A}\mathbf{p}$$

Predictors:

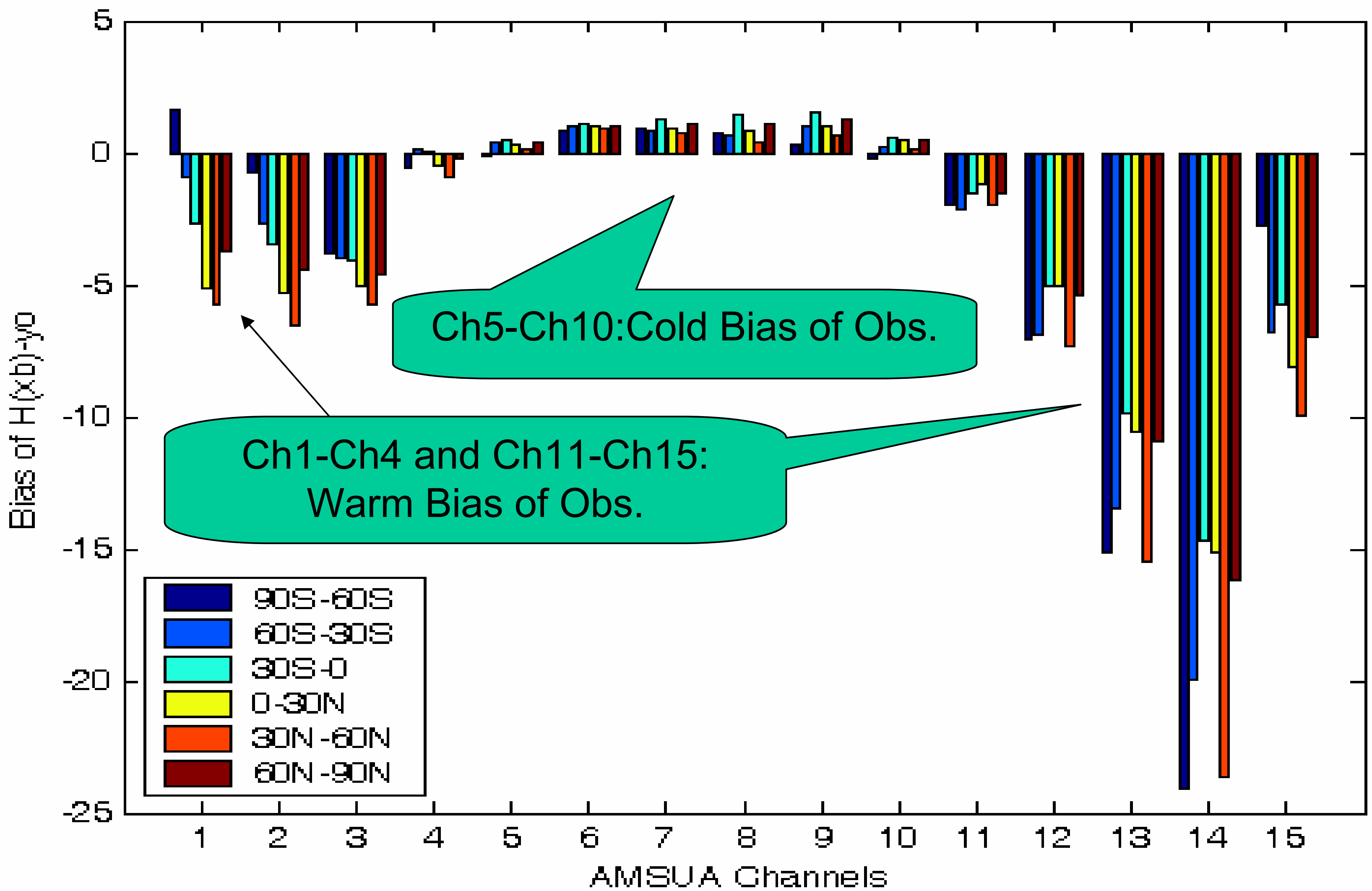
Scan Bias

- Latitude Band Average

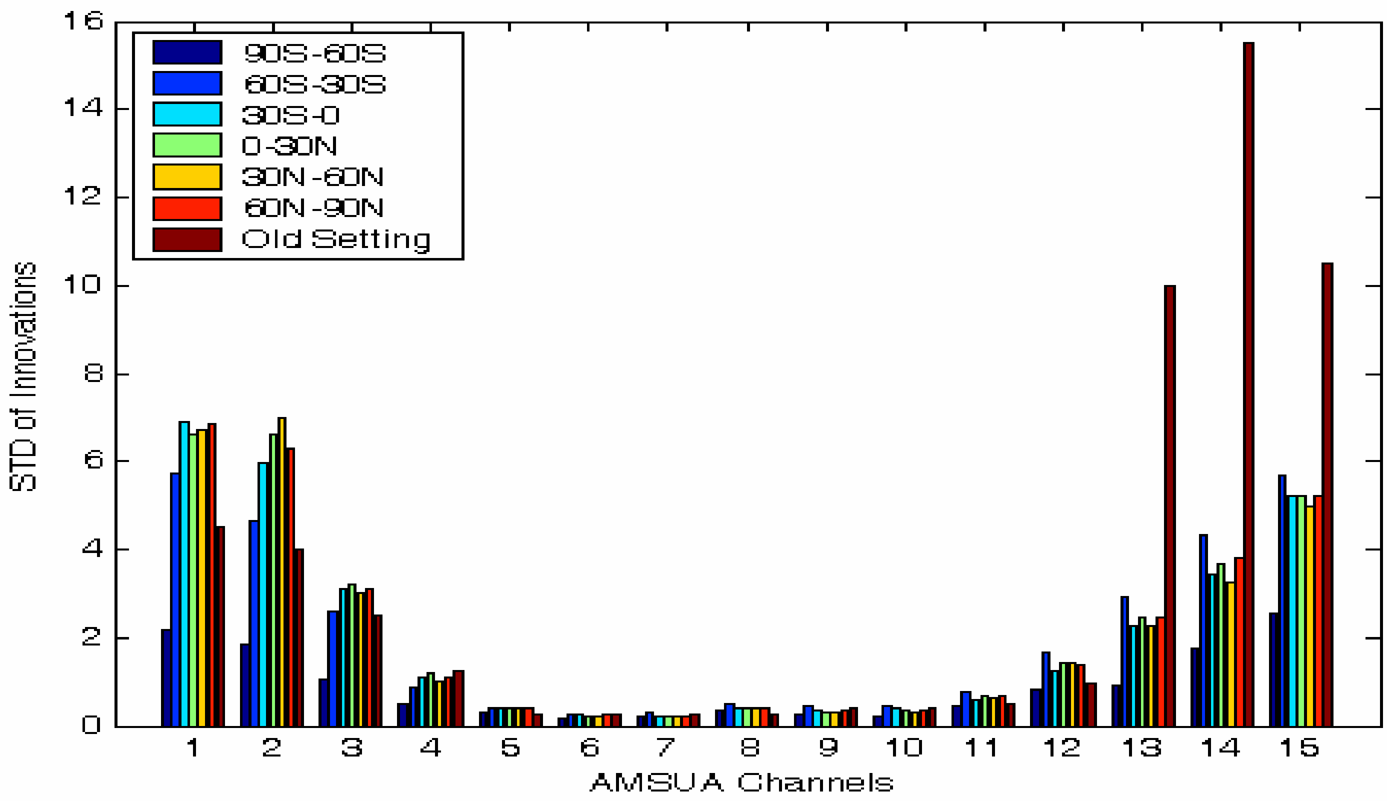
Air Mass Bias

- Thickness between 1000-300hPa
- Thickness between 200-50hPa
- Surface temperatures
- Integrated water vapor

AMSUA Bias : H(xb)-Yo

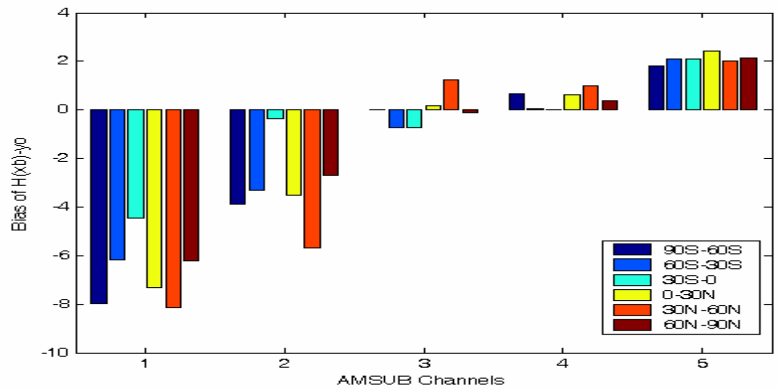


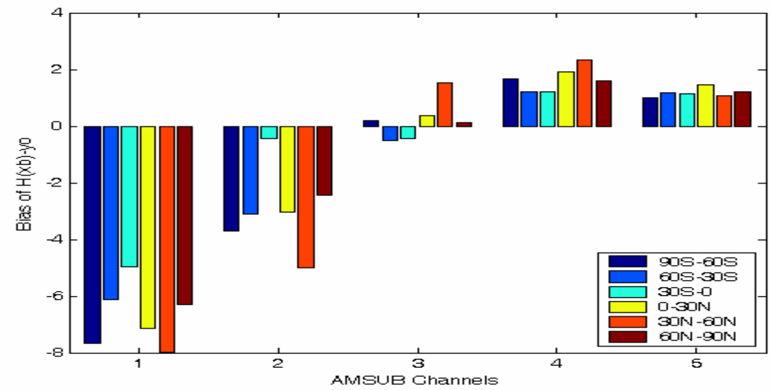
Estimation of std. of AMSUA Error



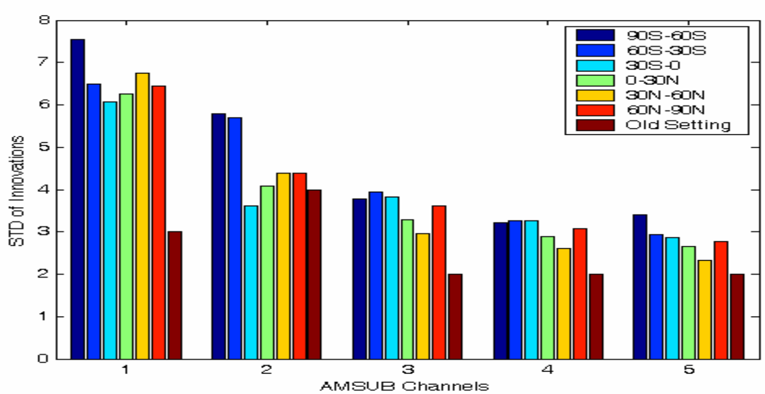
AMSUB Bias of H(xb)-Yo

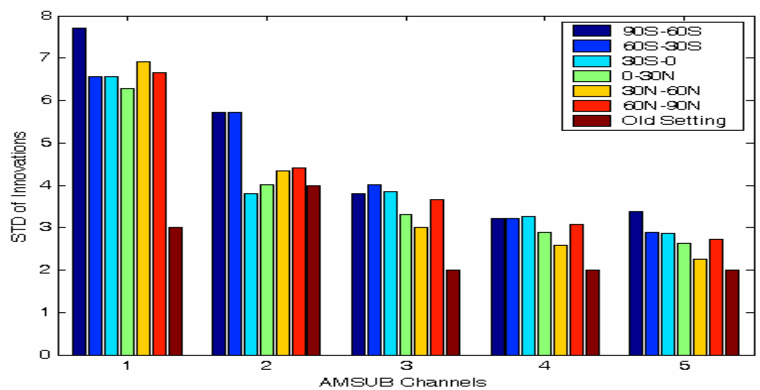
Bias





Std.





NOAA16

NOAA17

Tuning of Obs. Error

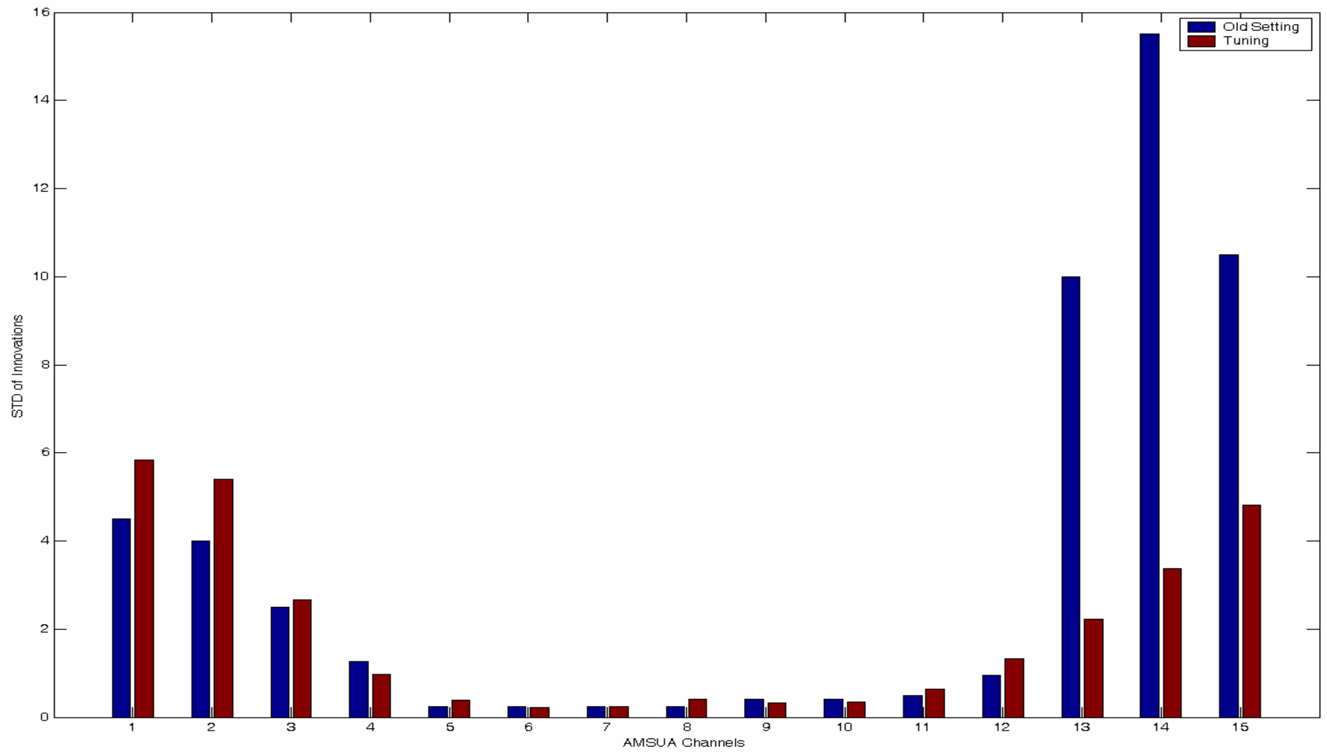
- Step1: Tuning of Obs. Error based on Innovation Statistics

$$\boldsymbol{\varepsilon}^{o}_{sound}, \boldsymbol{\varepsilon}^{o}_{synop}, \ldots, \boldsymbol{\varepsilon}^{o}_{amsu}, \ldots, \boldsymbol{\varepsilon}^{o}_{type_N}$$

- Step2: Tuning of Different Observations

$$J(\alpha) = J(\boldsymbol{\varepsilon}^{o}_{sound}, \alpha \boldsymbol{\varepsilon}^{o}_{amsu}) \Rightarrow J = \frac{p}{2}$$

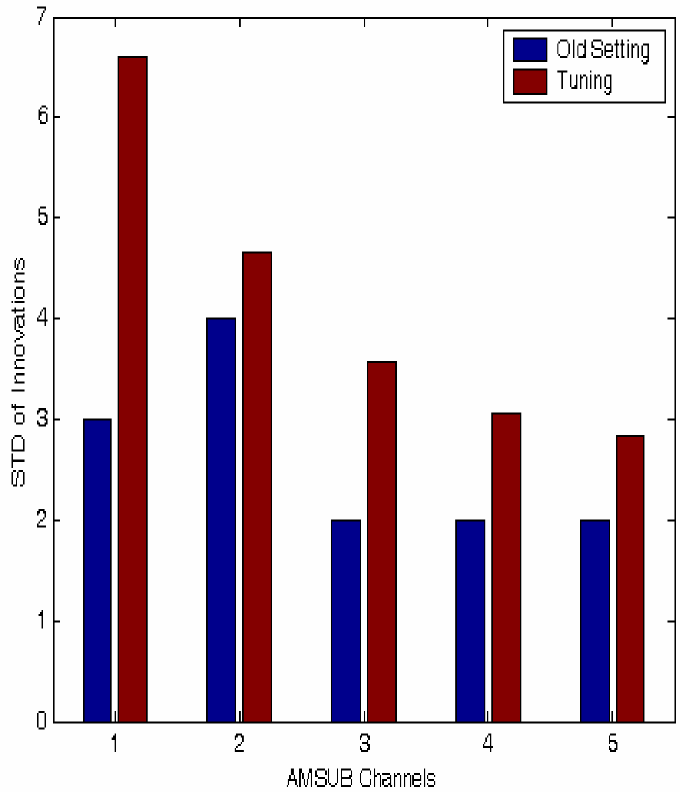
NOAA 16 AMSUA



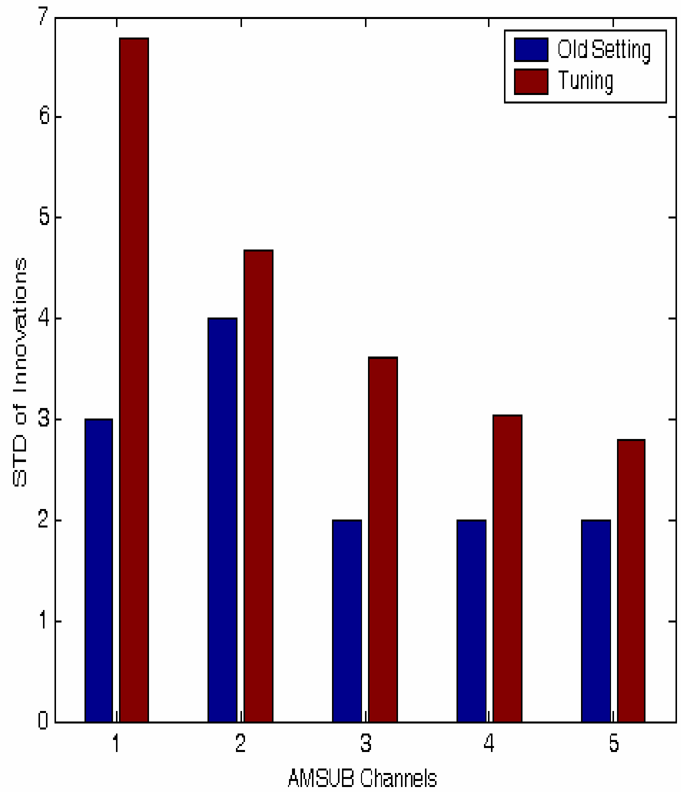
5.8323 5.4066 2.6716 0.9650 0.3840
0.2217 0.2326 0.4030 0.3273 0.3387 0.6327
1.3265 2.2177 3.3642 4.8095

AMSUB

NOAA16



NOAA17



6.7829 4.6709 3.6053 3.0412 2.7886

6.5990 4.6569 3.5632 3.0555 2.8246

Impact of Bias Correction

- On Analysis Increments

- On Forecast

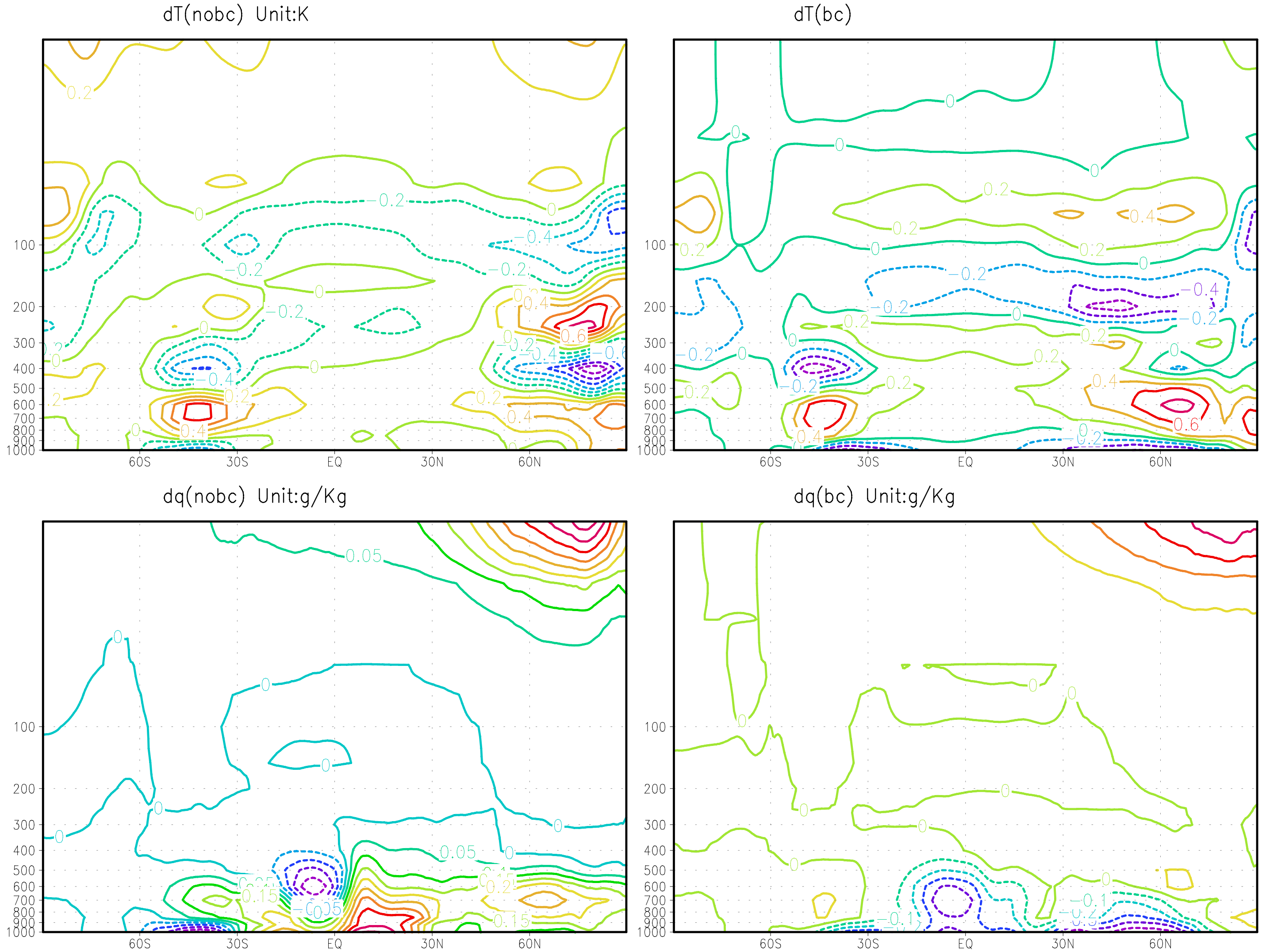
  - Global Model
    - Verification against its own analysis(15 days)
    - ACC: Anomaly Correlation Coefficient
    - Typhoon Track Forecast
  - Regional Model

dxa: T, q

Average of 2005080112—2005081512

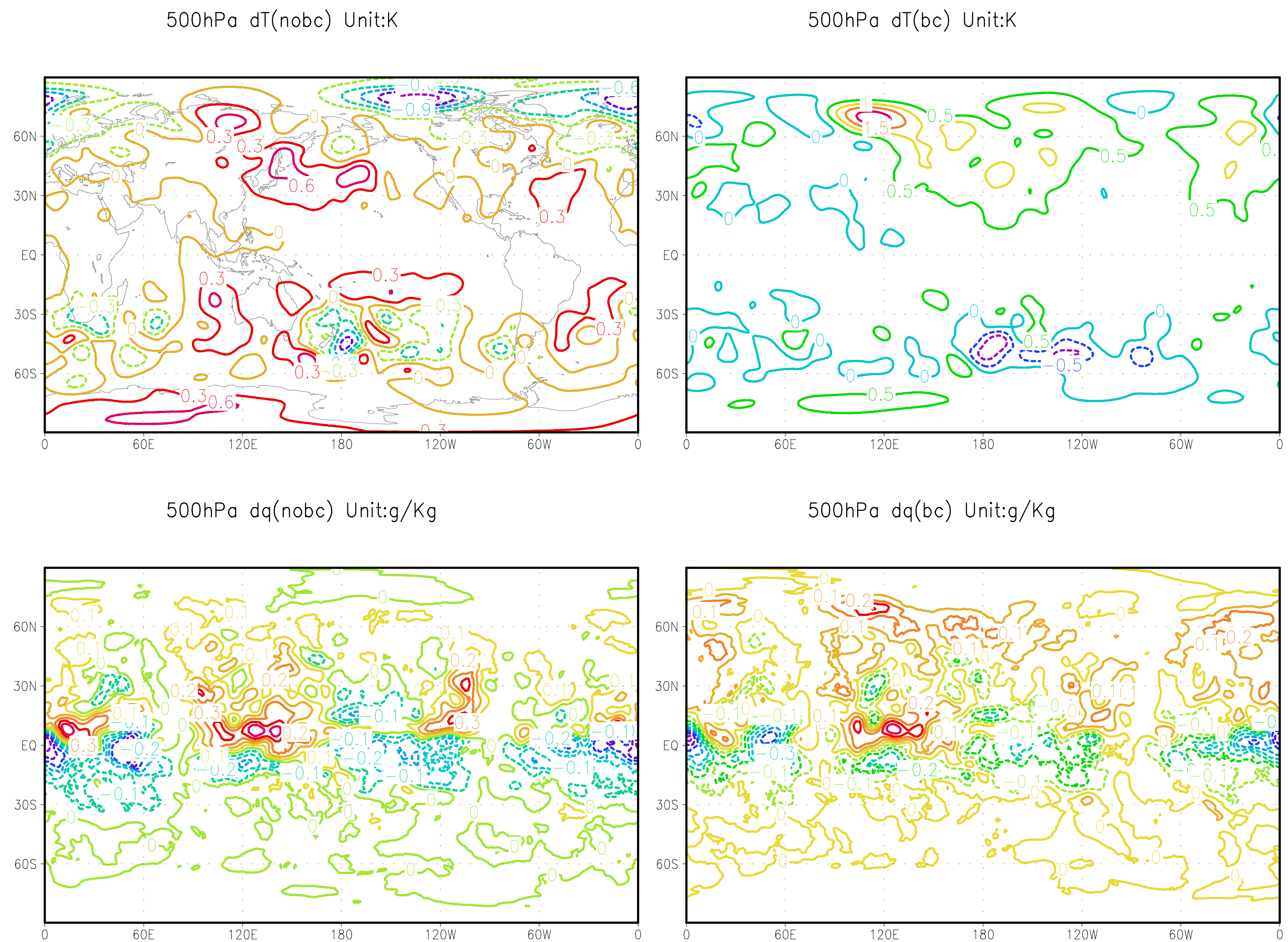
15 days

Ananlysis Increments

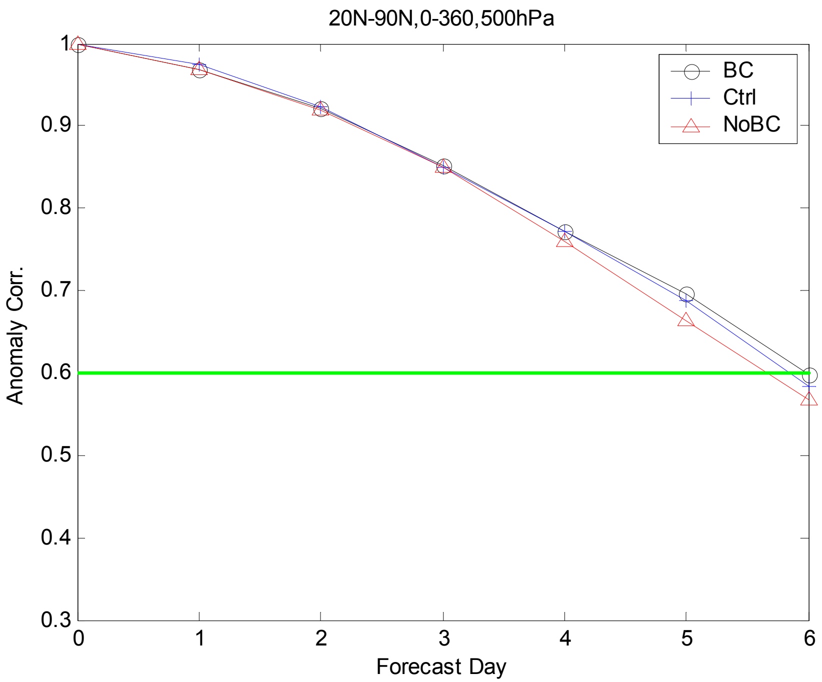


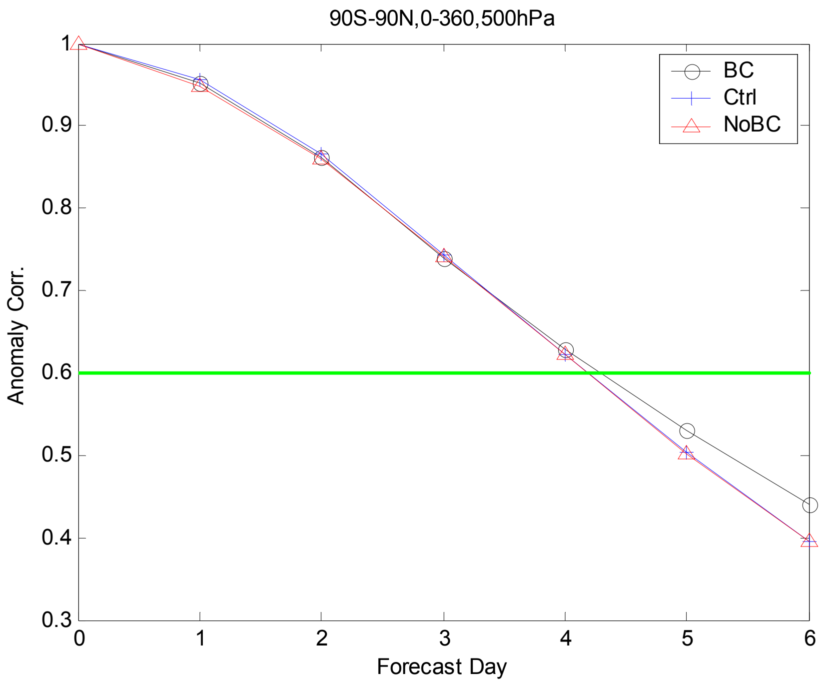
dxa: T, q
Average of 2005080112—2005081512
15 days

500HPA



500mb ACC (2005080112-2005081012, 144h Forecast)





	1	2	3	4	5	6
ctrl	0.9744	0.9232	0.8498	0.7708	0.6869	0.5829
NoBC	0.9691	0.9195	0.8487	0.7605	0.6624	0.5679
BC	0.9684	0.9217	0.8525	0.7722	0.6955	0.5987

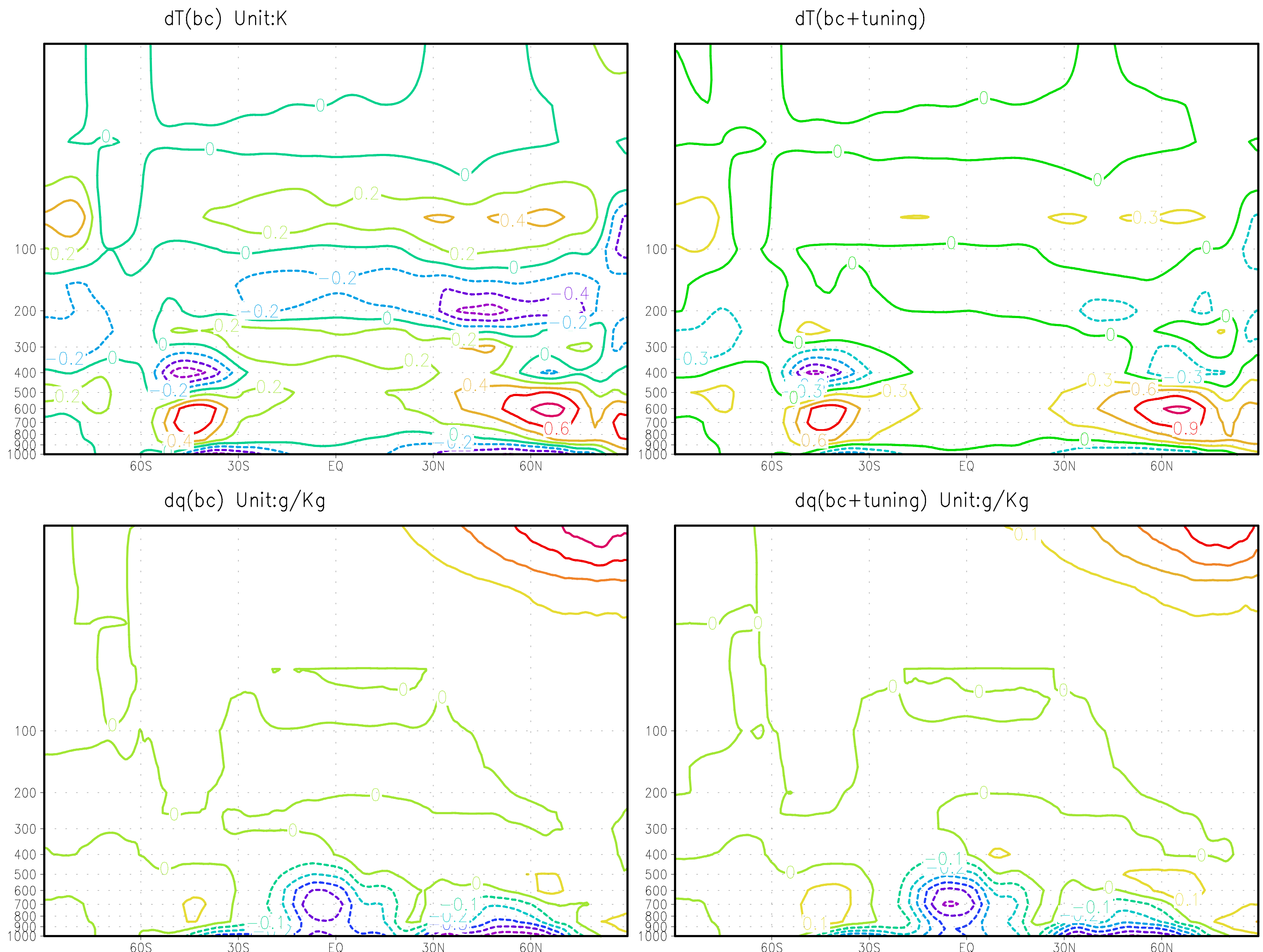
	1	2	3	4	5	6
ctrl	0.9521	0.8413	0.6972	0.5557	0.4220	0.3152
NoBC	0.9441	0.8345	0.6953	0.5575	0.4265	0.3159
BC	0.9467	0.8362	0.6903	0.5621	0.4545	0.3668

dxa: T, q

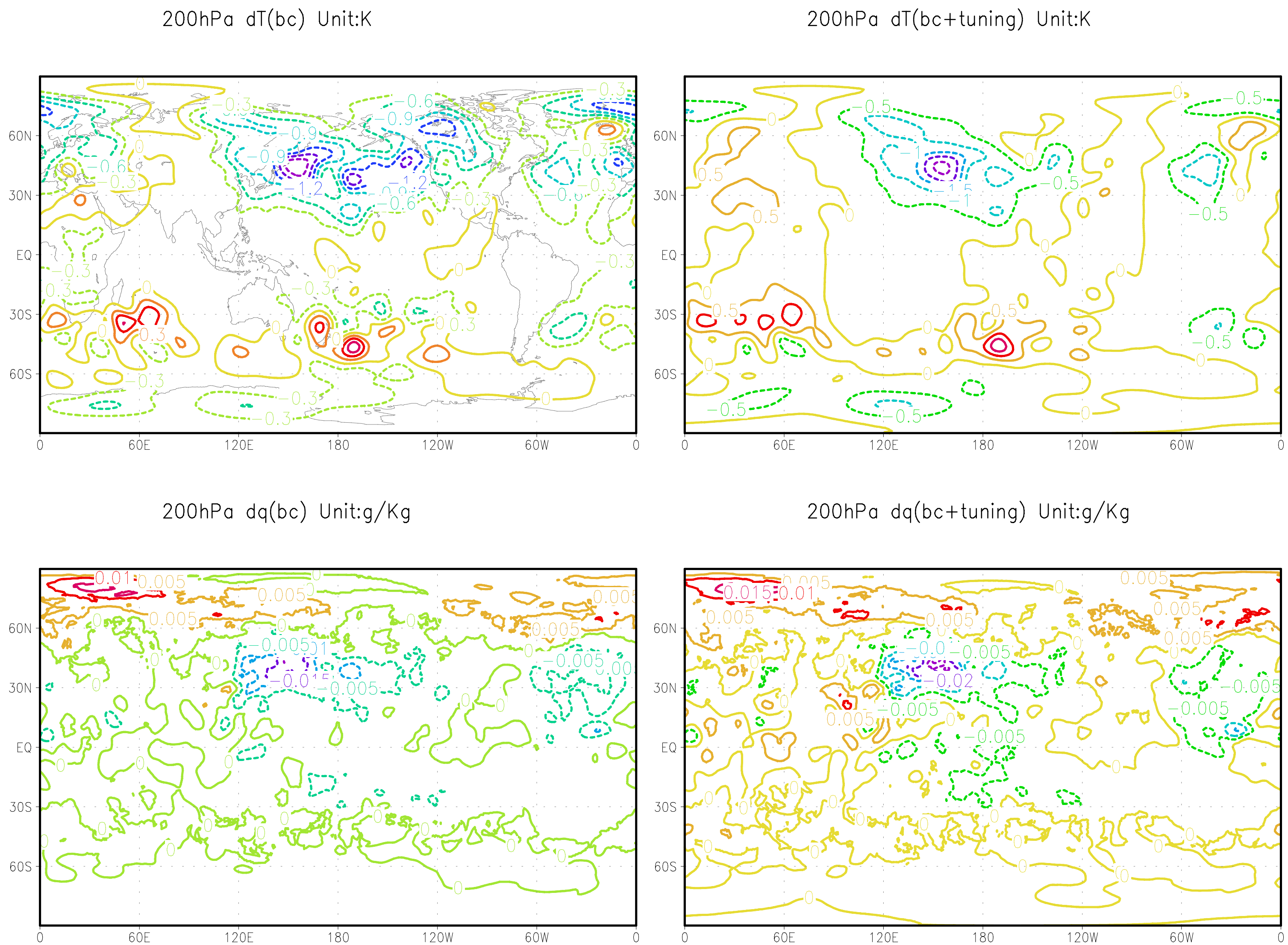
Average of 2005080112—2005081512

15 days

ANANLYSIS INCREMENTS



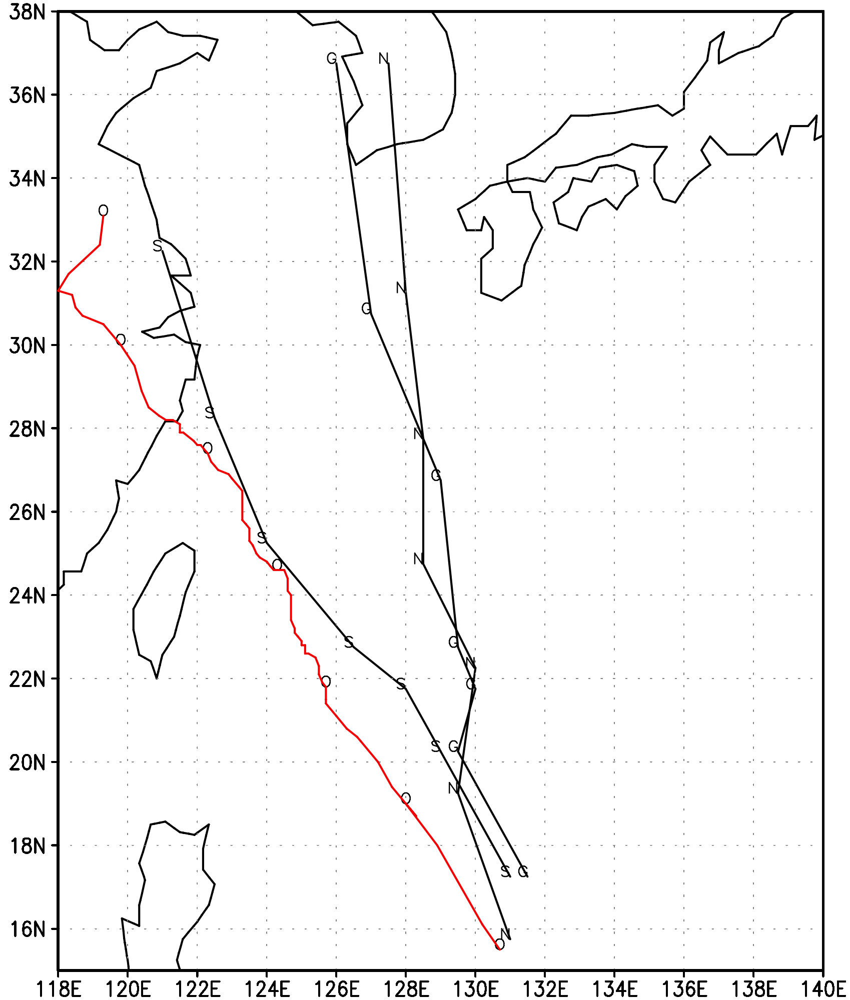
200hPa Analysis Increments



Bias Correction For Assimilation of ATOVS in GRAPES: Impact on Typhoon Forecast

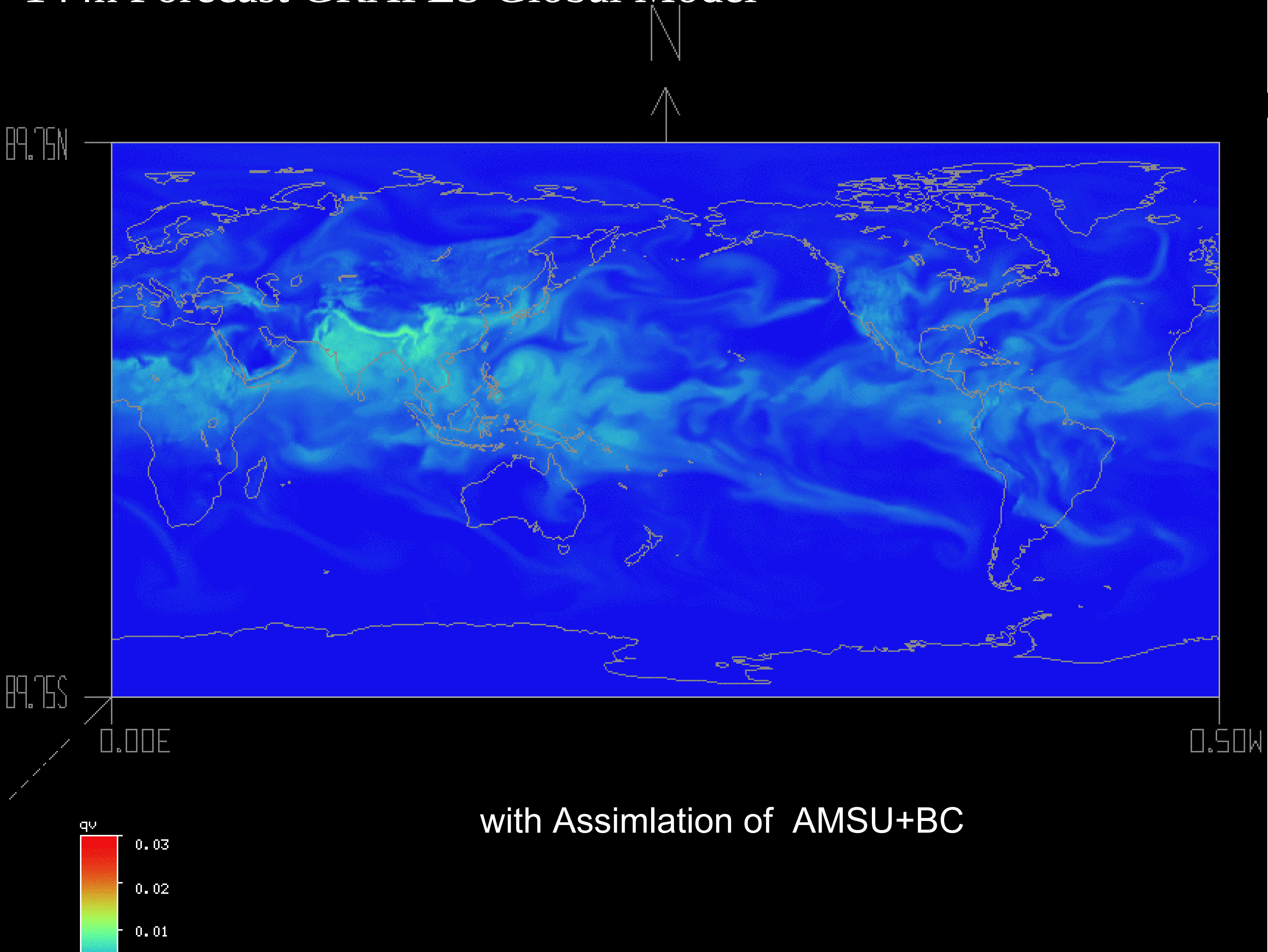
- Global Model (One Case: MATSA)
- Regional Model (One Case: RANANIM)

GRAPES Global Model: 2005080112(UTC), 120h Forecast



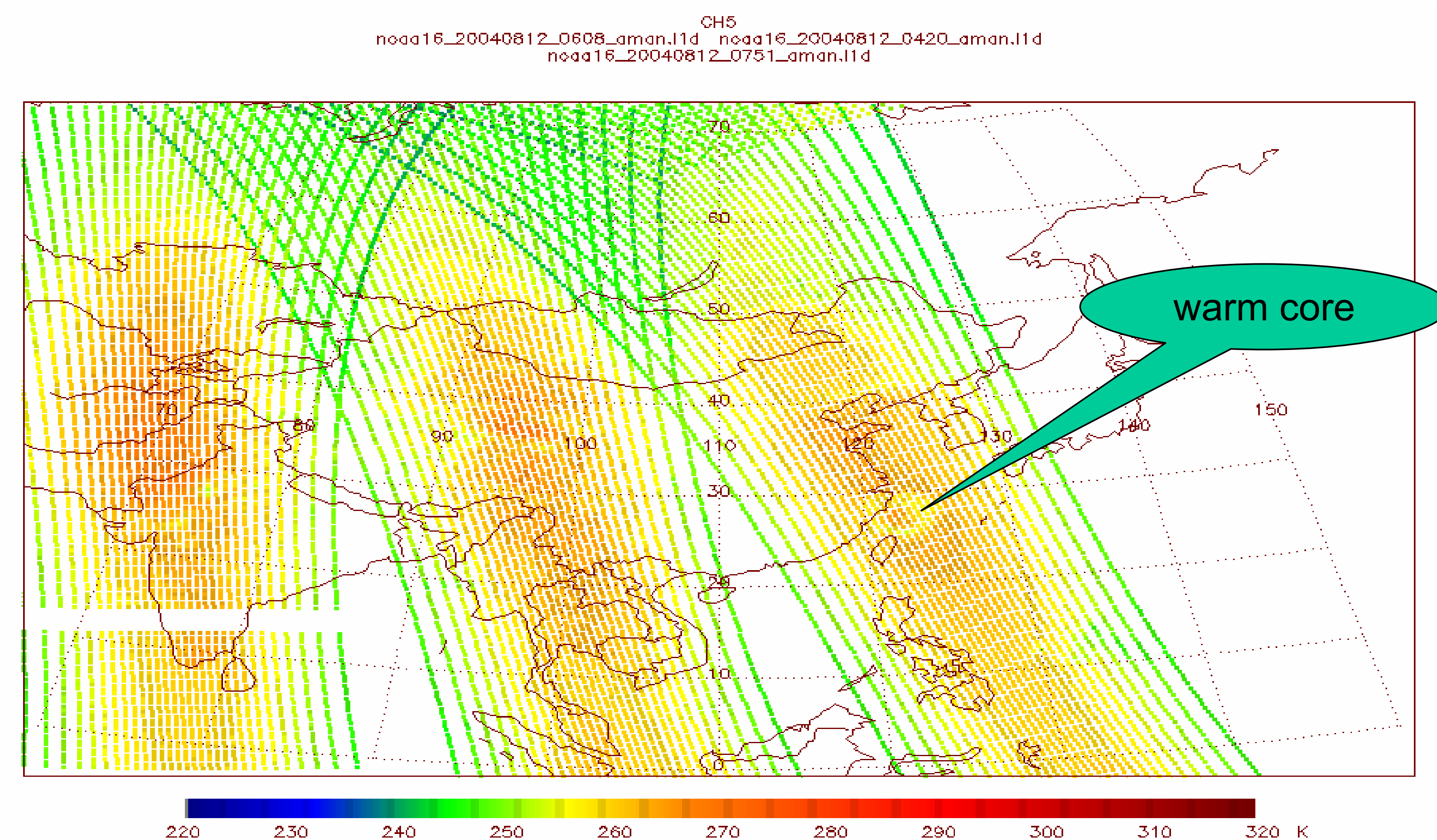
- Different Initial Value only
  - N: NCEP Analysis
  - G: GTS
  - S: GTS+AMSU+BC
  - O: Obs.

Animation of 700hpa humidity
144h Forecast GRAPES Global Model



with Assimlation of AMSU+BC

NOAA16:AMSUA-CH5,200408126

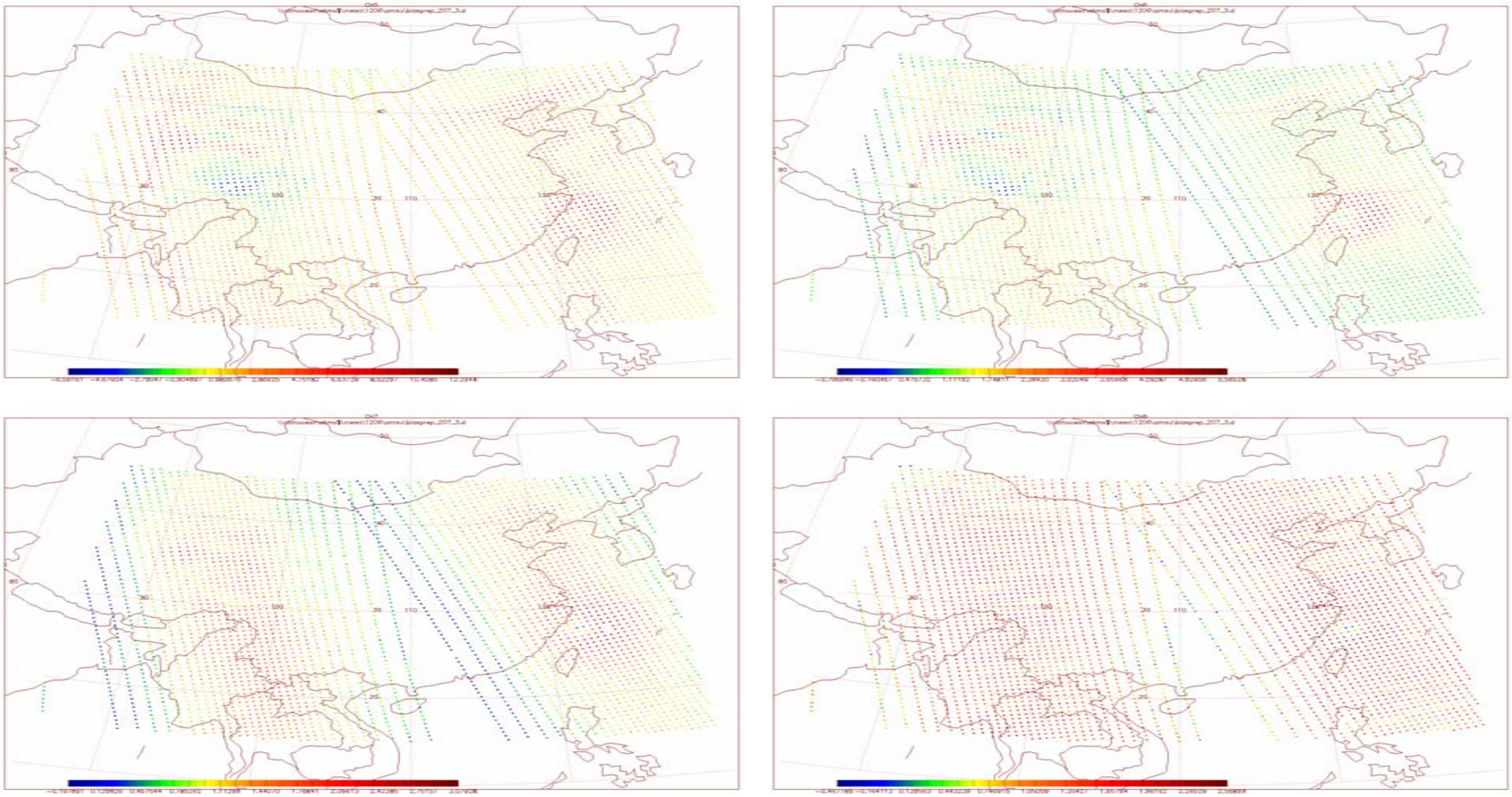


Ch5,6,7,8

Innovation of AMSUA(NOAA16) Ch5-Ch8

Ch5

Ch6



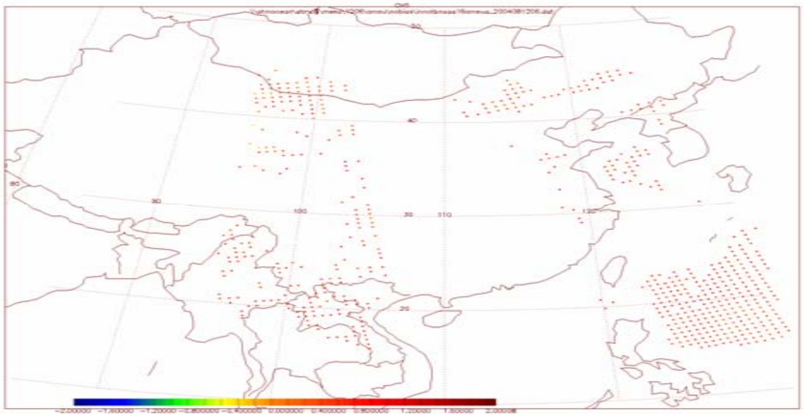
Ch7

Ch8

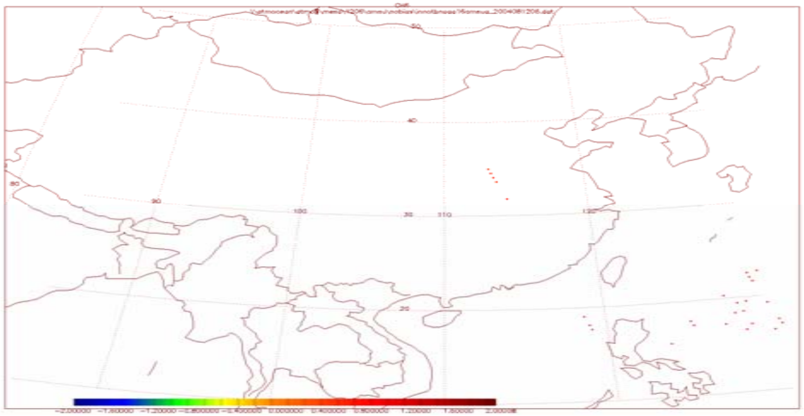
Ch5,6,7,8

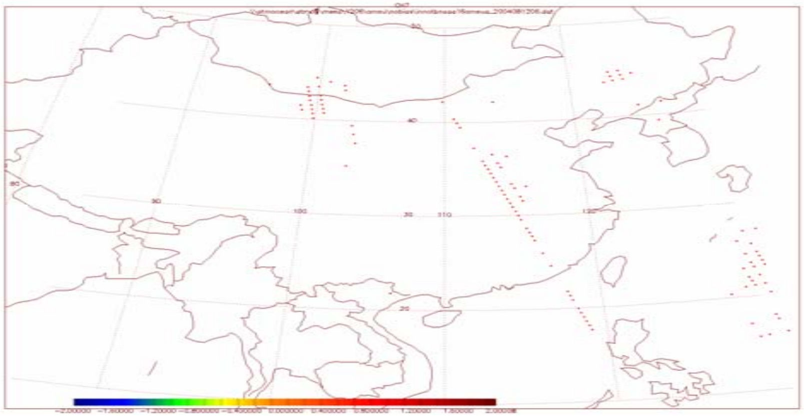
After Q.C.
Without B.C

Ch5

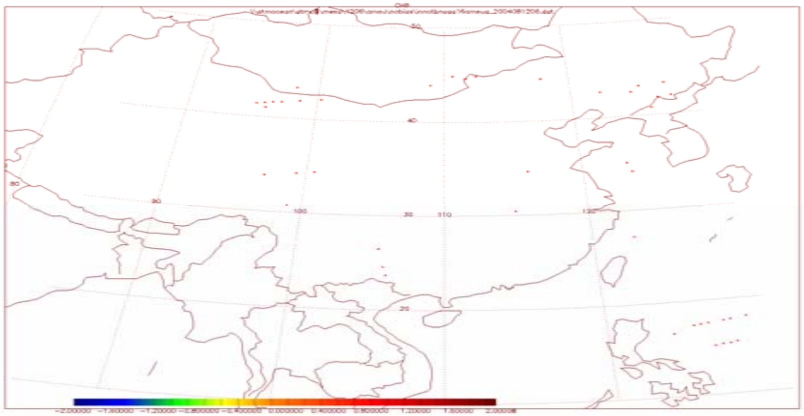


Ch6





Ch7

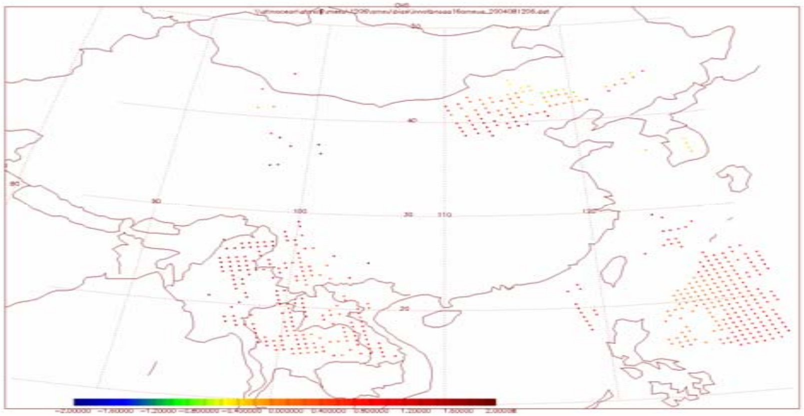


Ch8

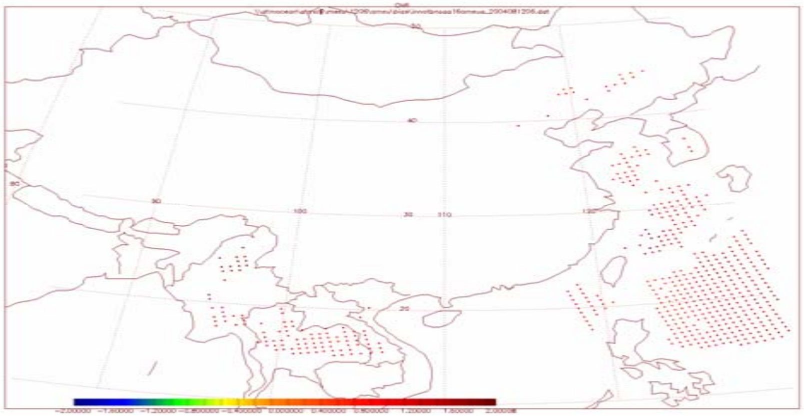
Ch5,6,7,8

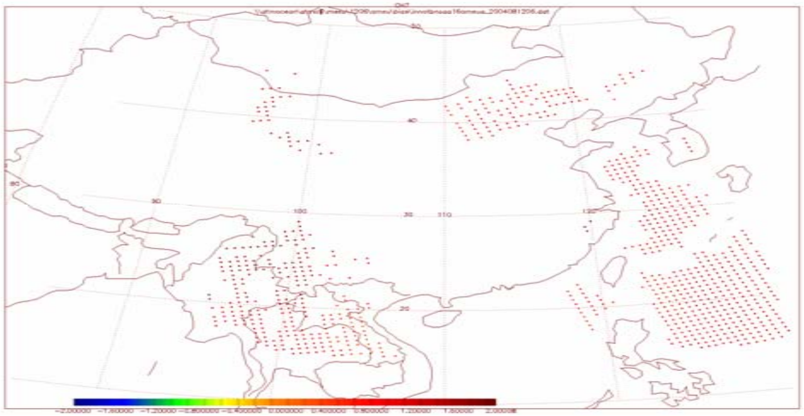
After Q.C. With B.C

Ch5

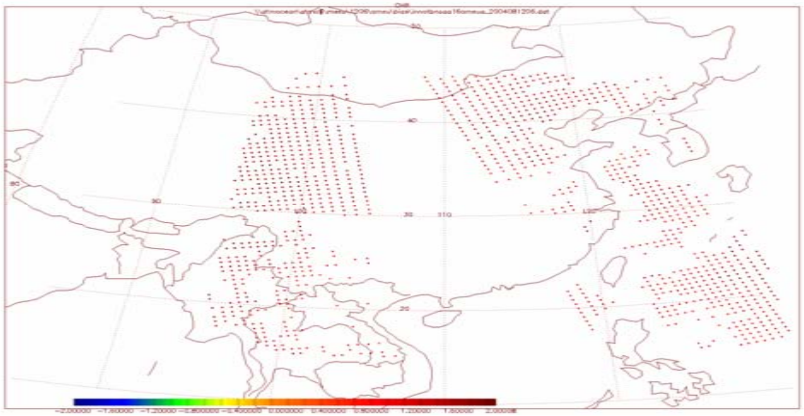


Ch6





Ch7



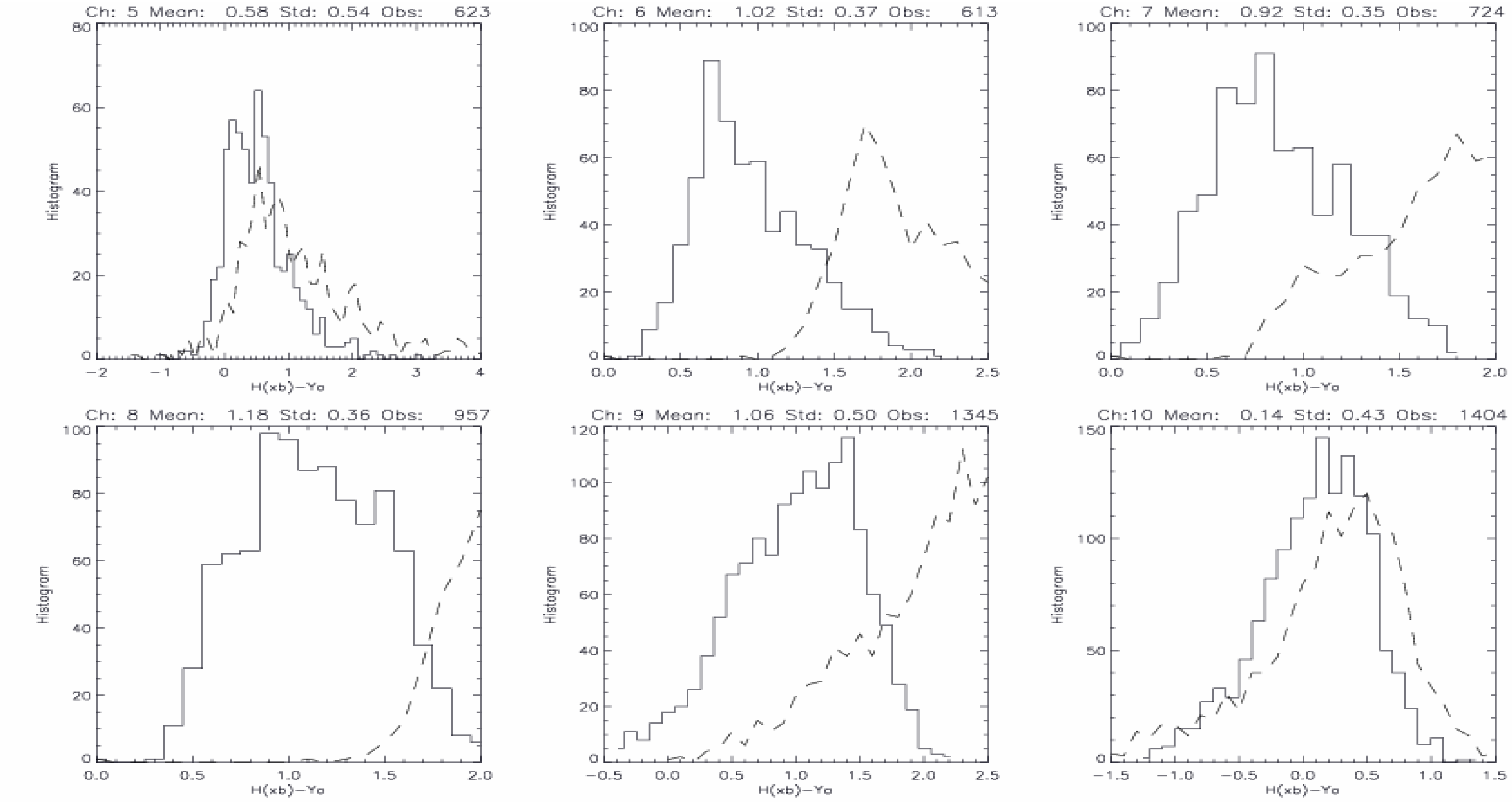
Ch8

Distribution of innovation of effective obs.

Dashed line: without B.C

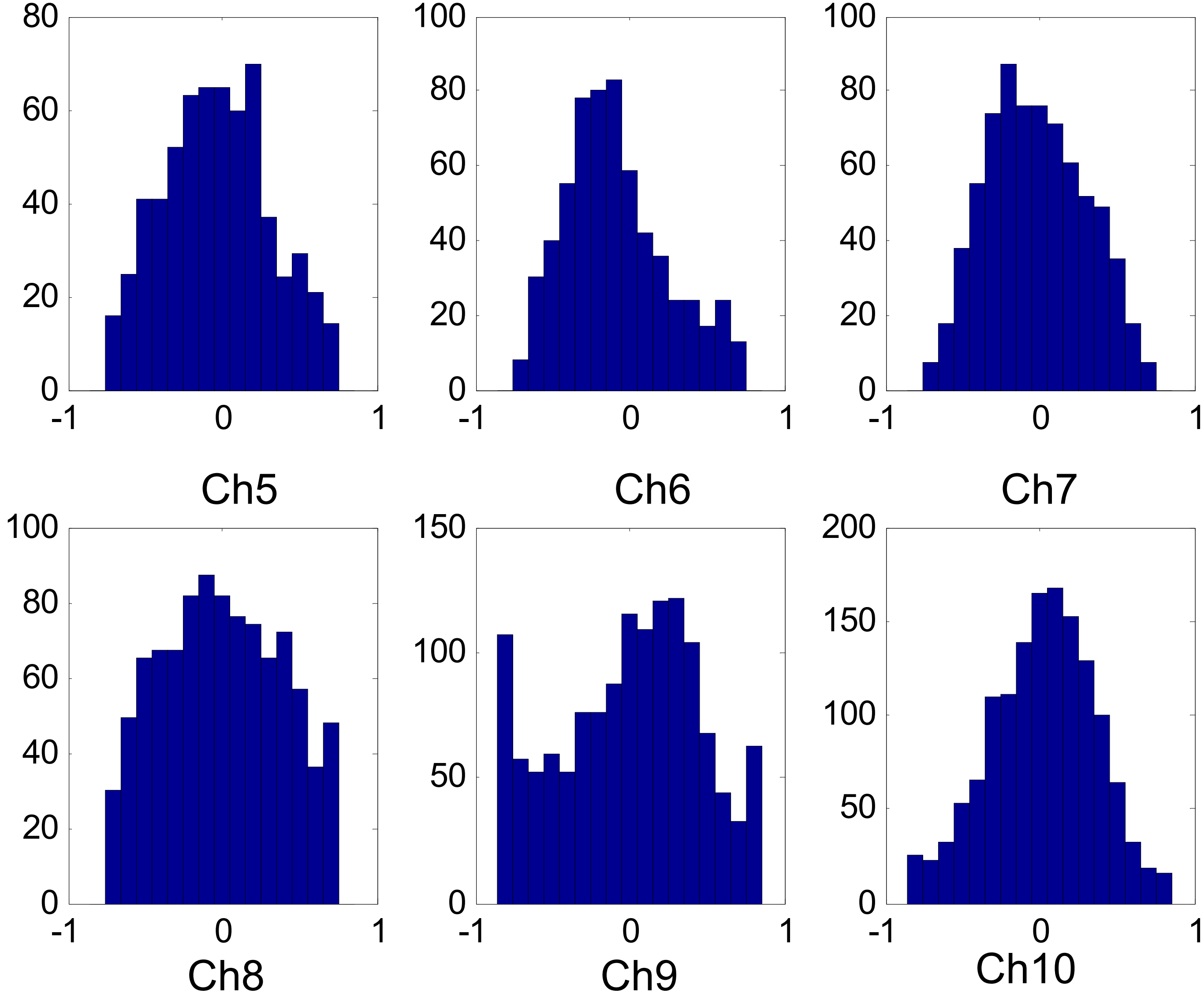
Solid Line : with B.C.

AFTER Q.C.

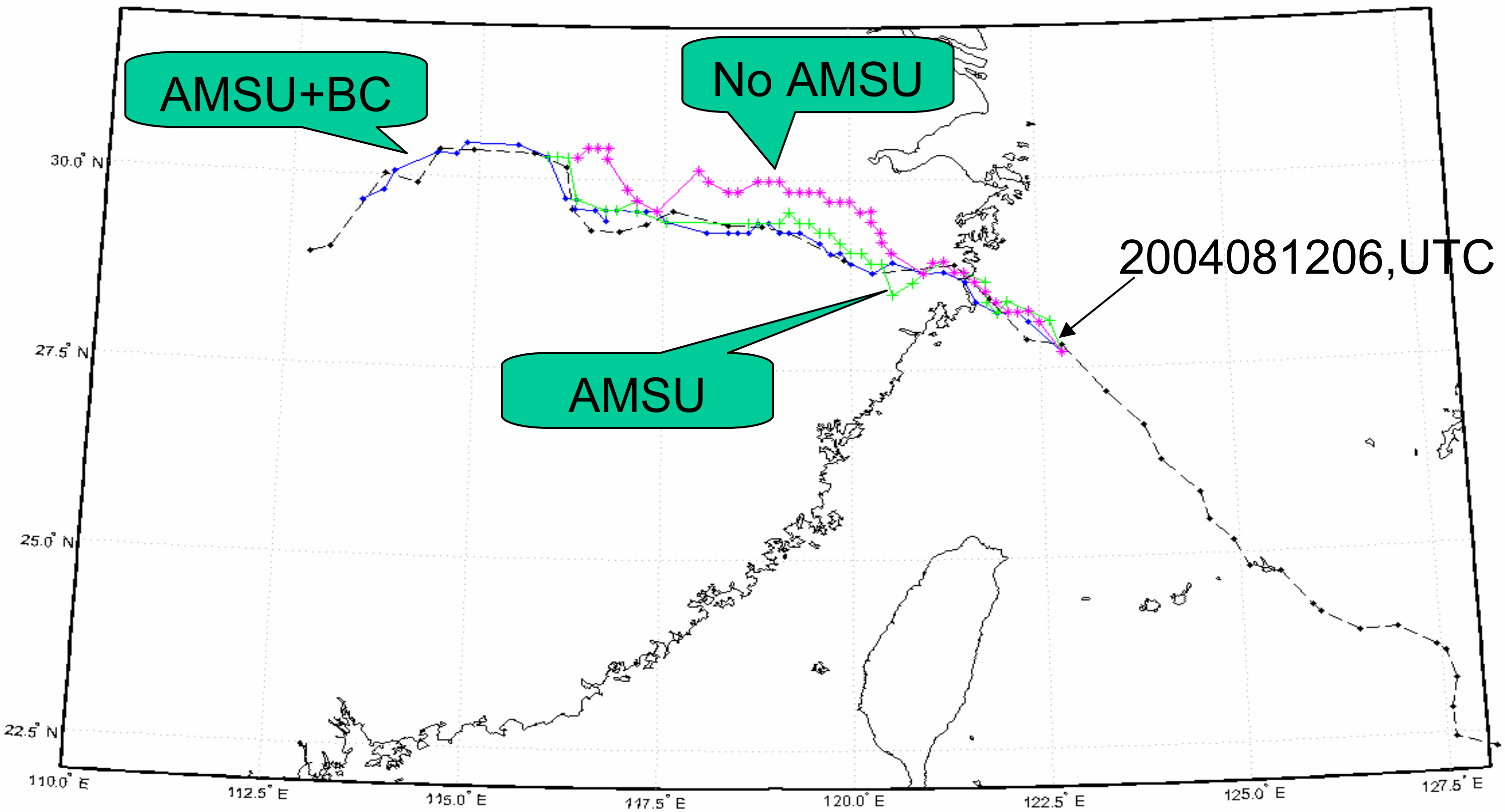


Residual

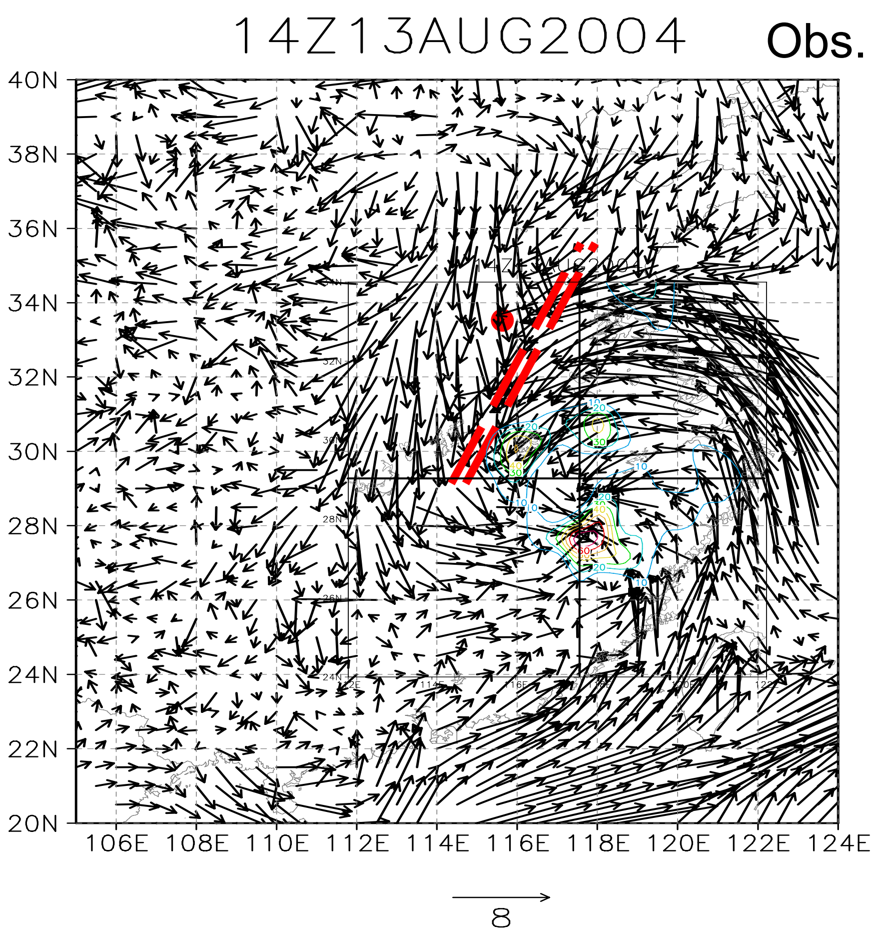
H(xa)-Yo

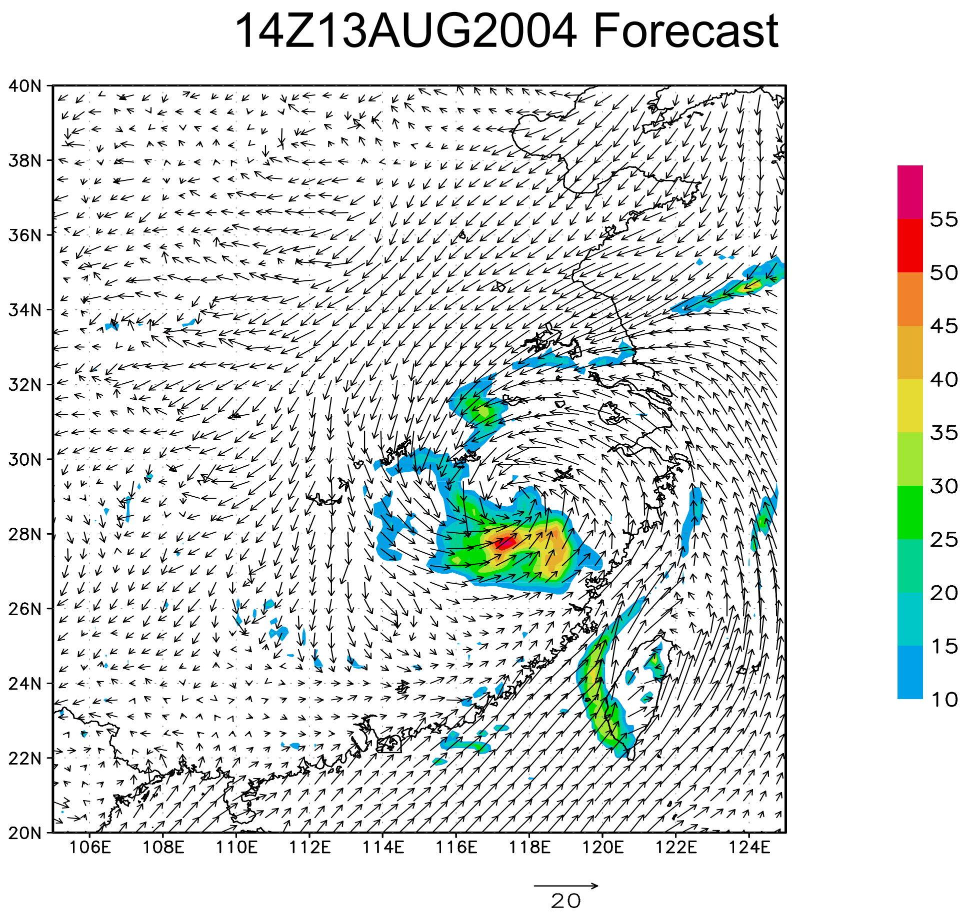


RANANIM:0414



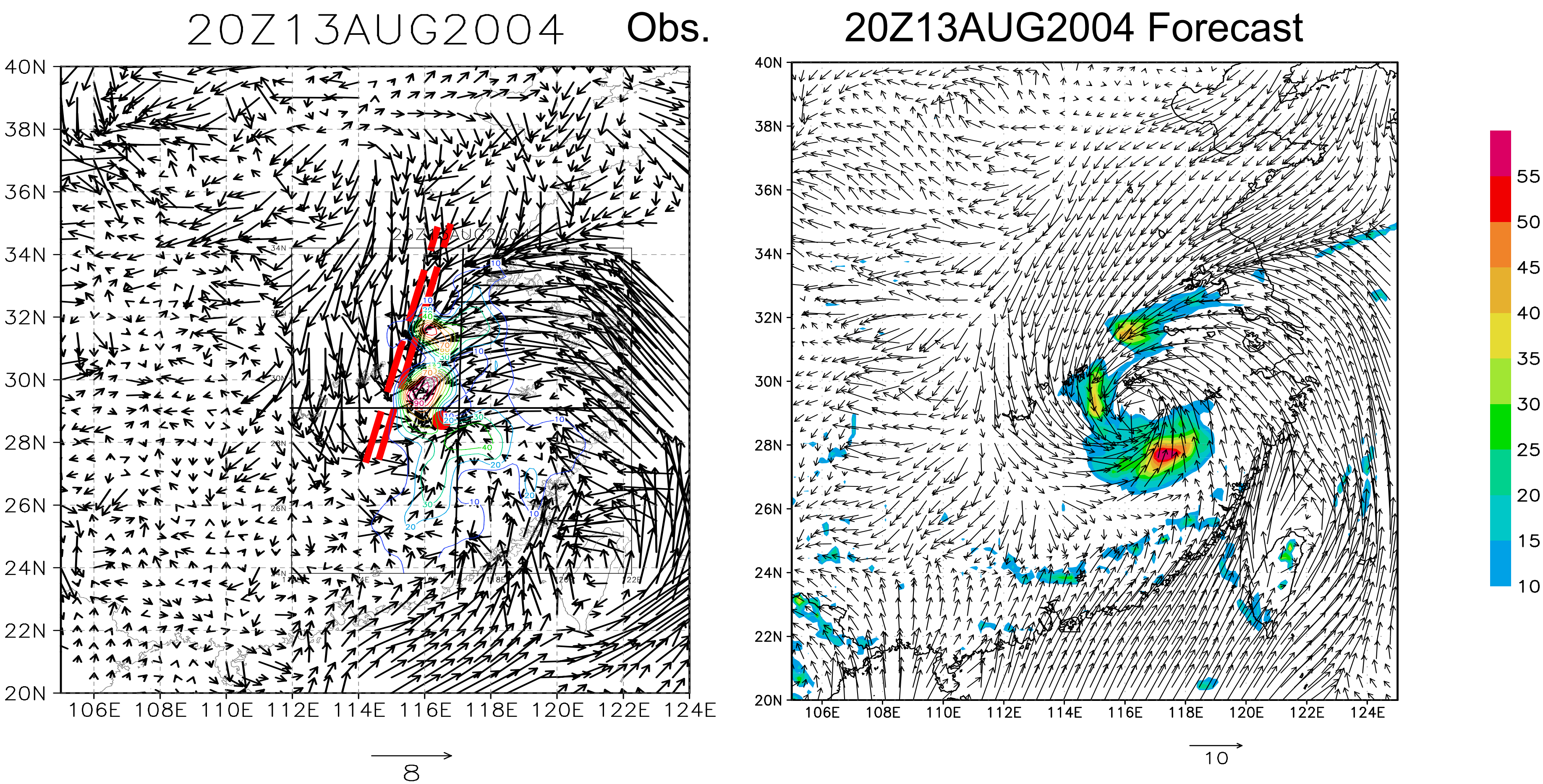
Precip. Forecast Durinig Rananim Landfall,24h





Arrows: 10m Wind Vectors
Shaded 6-hour Accumulated Rainfall

Precip. Forecast Durinig Rananim Landfall, 30h

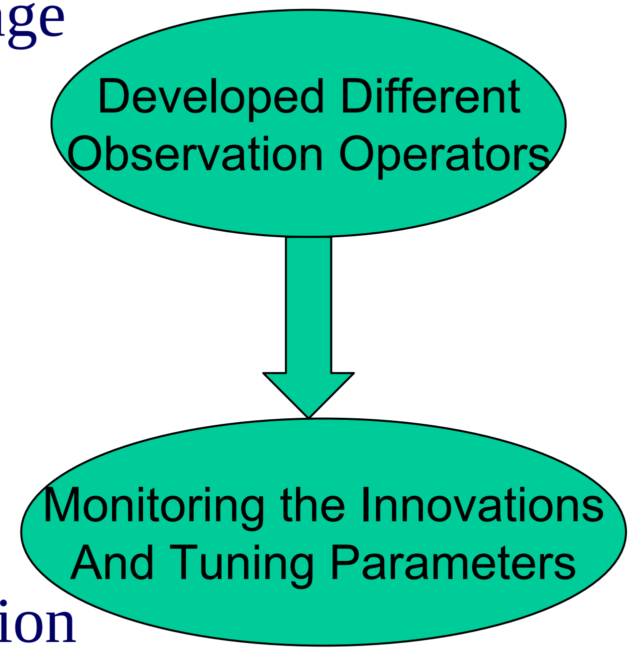


Arrows: 10m Wind Vectors

Shaded 6-hour Accumulated Rainfall

DISCUSSION

- GRAPES-3DVAR is Moving to a New Stage
  - Operational implementation
  - Refinement
- Bias Correction and Obs. Error Tuning
  - VERY Important
  - Preliminary results is promising
  - Need More Work
- Positive Impact of Satellite Data Assimilation
  - Global Medium Forecast
  - Typhoon Forecasts
  - Other Verifications is Ongoing(Precip.,etc.)



Ongoing Work

- Thinning(Resolution of Obs., Analysis and Model)
  - Global Model
  - Regional and Mesoscale Model
  - Constant Distance Thinning

- Bias Correction
  - Predictors
  - Parameter Estimation Method
  - Bias Model
  - Treatment of Coast (No Options in RTTOV)

- Observation Error Setting and Online Tuning
  - Interaction with Q.C.
  - Diagnosis of $E(J_{min})=p/2$ (Talagrand,1999; Chapnik,2006)

Thank you for Attention