The AMSU Observation Bias Correction and Its Application Retrieval Scheme, and Typhoon Analysis

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Introduction

- Variational Retrieval Scheme can get better result under good precision initial guess(Eyre, 1989)
- Important factor is the correction of satellite observation bias and estimated random error
- Obs err = Sat Obs Tb– Simulation Tb
- Establish a statistical correction model along FOV

Methodology

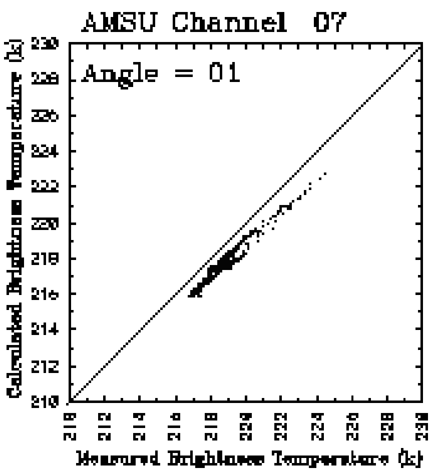
- Minimize Cost function(Rodgers,1976)

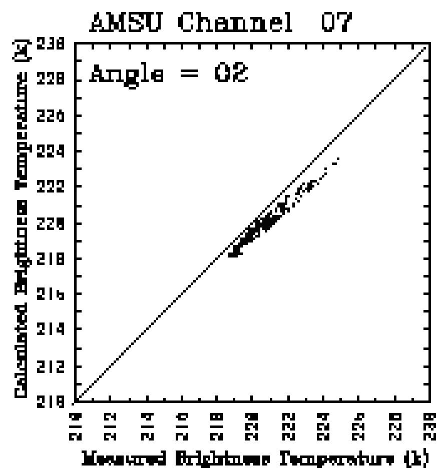
$$J(x) = (x - x^b)^T C^{-1} (x - x^b) + \{y^m - y(x)\}^T E^{-1} \{y^m - y(x)\}$$

- Using Newtonian iteration method(Eyre,1989)
- Surface emissivity (grody 1988)
- Retrieval parameters: profile of temp. and humility, surf. air temp., surf. Pres., ozone, cloud height, cloud amount.

Error covariance

- Back ground error C: 12 hours forecast error by statistic. Prior 24 forecast analysis minus prior 12 hours forecast analysis.(NMC method)
- Obs. Error E = Instrument bias, data proc. Err, RTE model err.,Input parameters’ err. => System err + Random err.


AMSU Channel 07
Angle = 01
Calculated Brightness Temperature (k)
Measured Brightness Temperature (k)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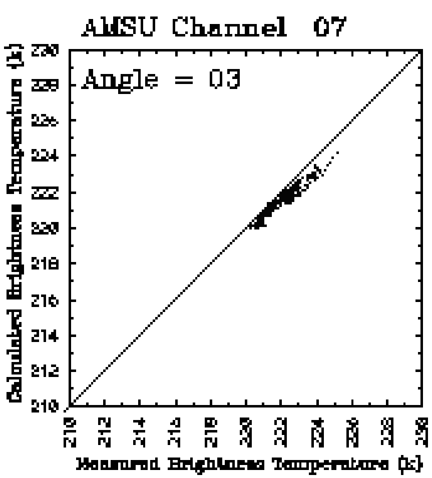
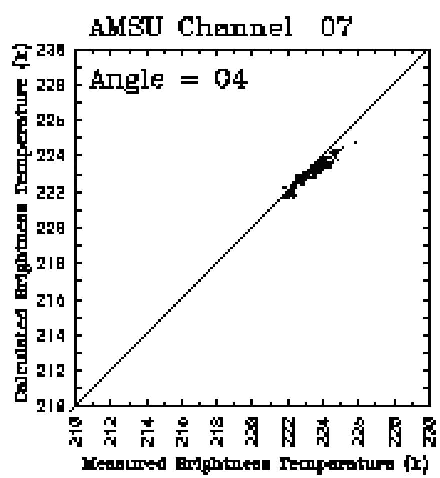
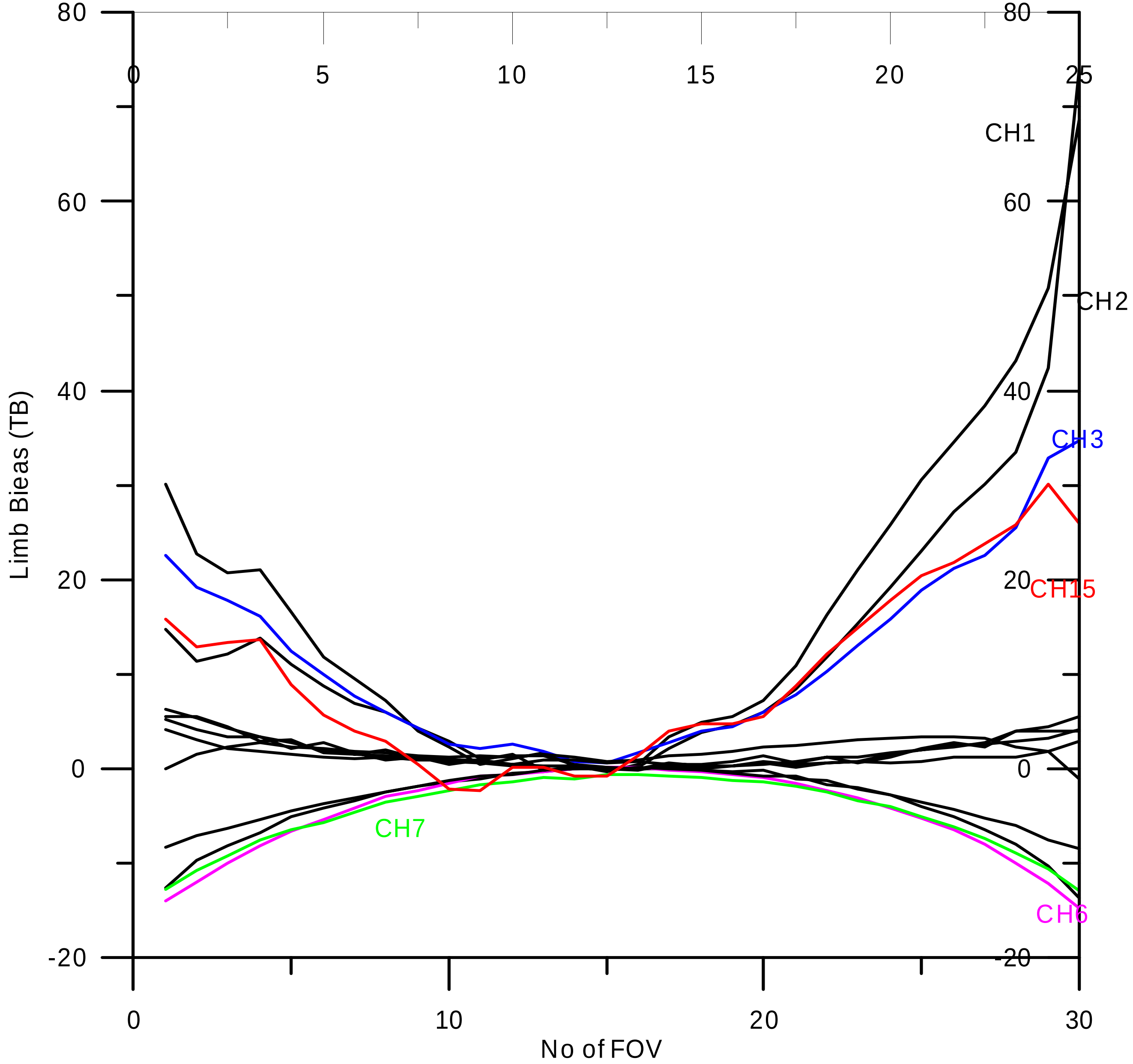
Angle = 02
Calculated Brightness Temperature (k)
Measured Brightness Temperature (k)


AMSU Channel 07
Angle = 03
Calculated Brightness Temperature (k)
Measured Brightness Temperature (k)


AMSU Channel 07
Angle = 04
Calculated Brightness Temperature (k)
Measured Brightness Temperature (k)

Limb effect



Limb Bieas (TB)
No of FOV
CH1
CH2
CH3
CH15
CH7
CH6
80
60
40
20
0
-20
0
5
10
15
20
25
30

Estimate bias correction and random error

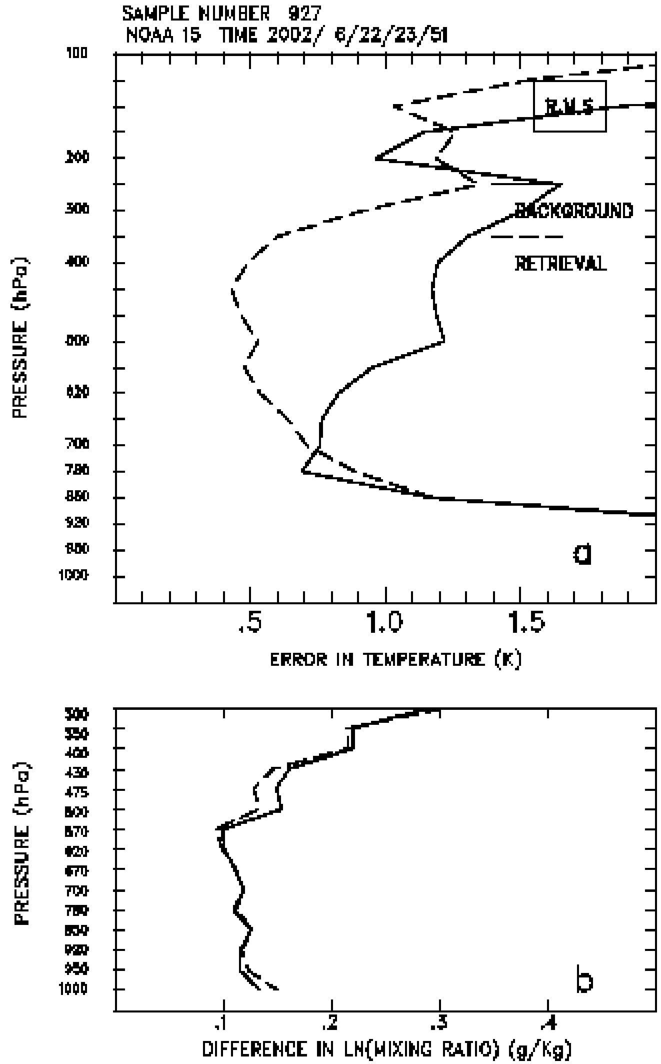
- Make sure Obs Tb and Est Tb between –20K & 20K
- If (Est Tb – Obs Tb) > 3*RMSE then is bad data
- Tb*=aTb+b for each channel and FOV on 900,000 points
- Concern about input parameters err(12 hours forecast)

Real data retrieval

- 2002.6.22-23 NOAA-15
- Point was selected when retrieval successful and there are sounding data within 200Km away, SI<20

2002.6.22

927points

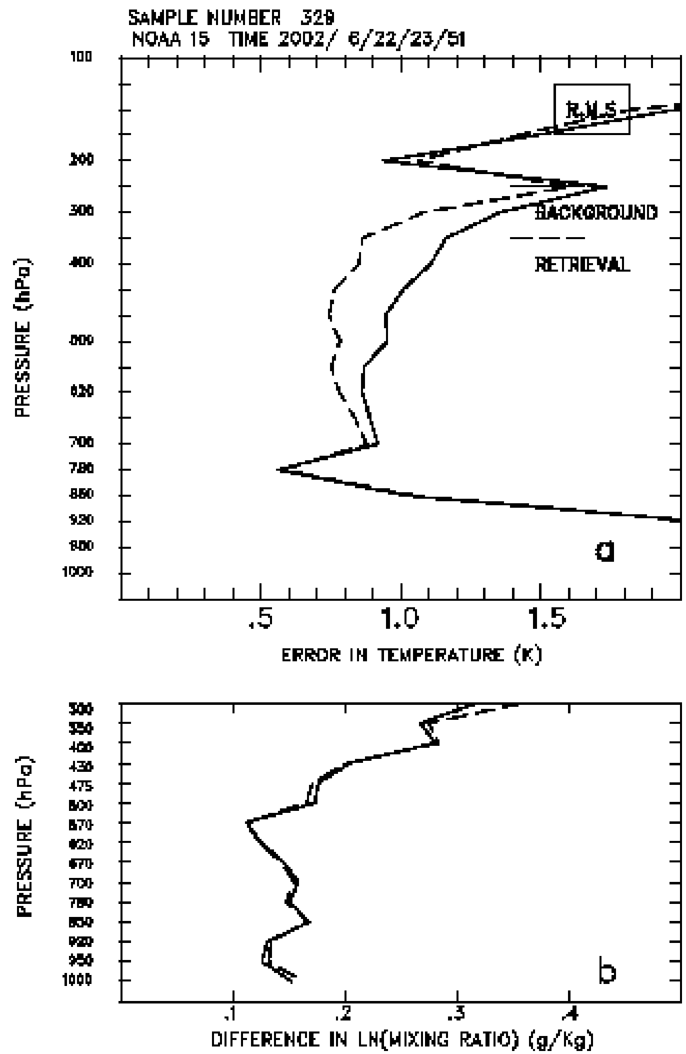


2002.6.22

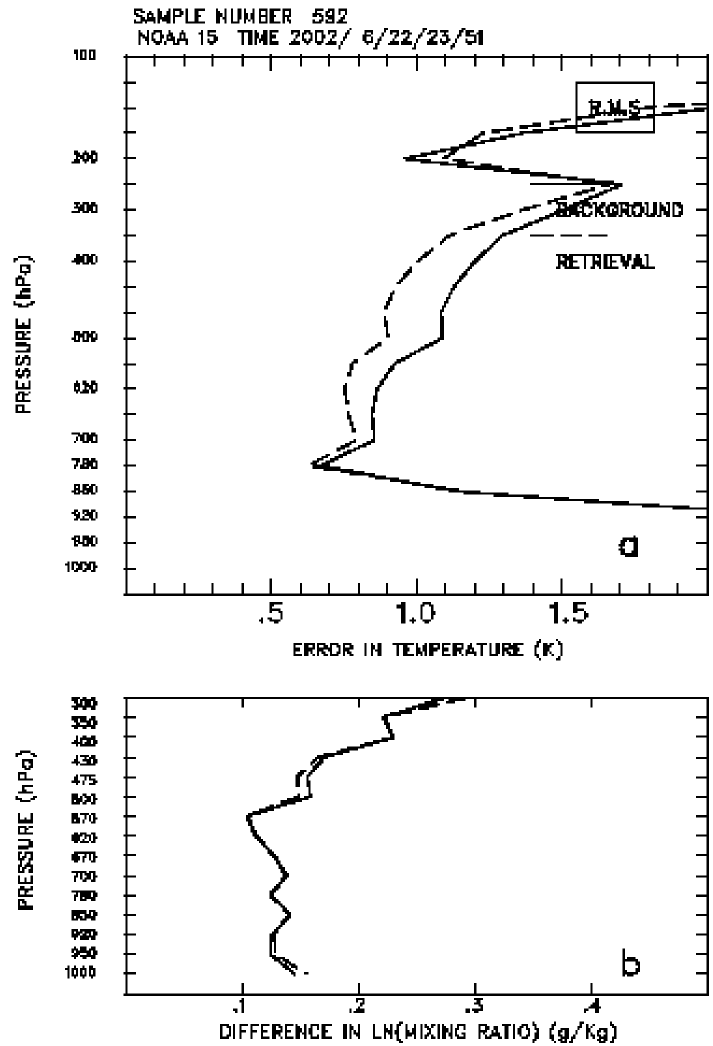
Random

Error*6

(329points)



- 2003.6.2
- 592point
- Random
- Error*7



Successful retrieval convergence rate when random error enlarged

Case	correction	x5	x6	x7	x8	x9	x10
1	99.61 %	4.97%	45.12 %	68.07 %	95.10 %	99.10 %	99.57 %
2	96.29 %	3.87%	39.13 %	63.66 %	85.17 %	96.29 %	99.28 %
3	99.35 %	0.27%	8.11%	42.55 %	86.82 %	98.30 %	98.70 %

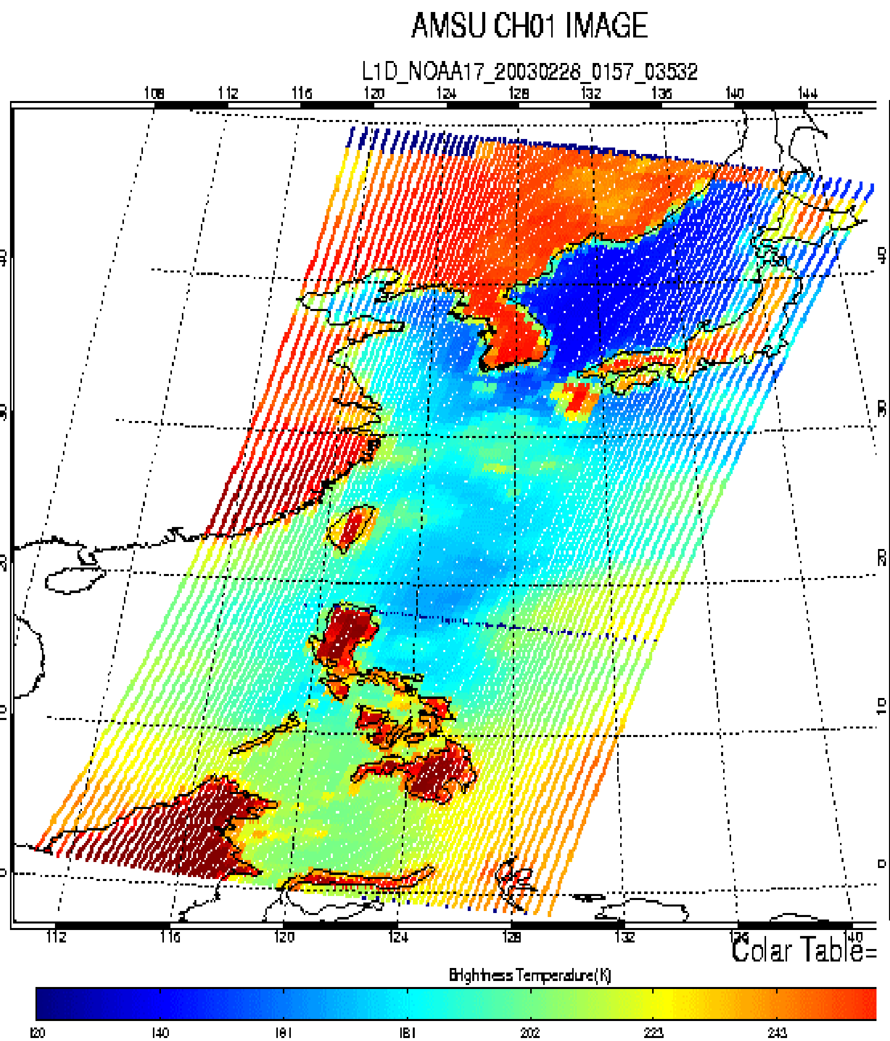
Sub conclusion

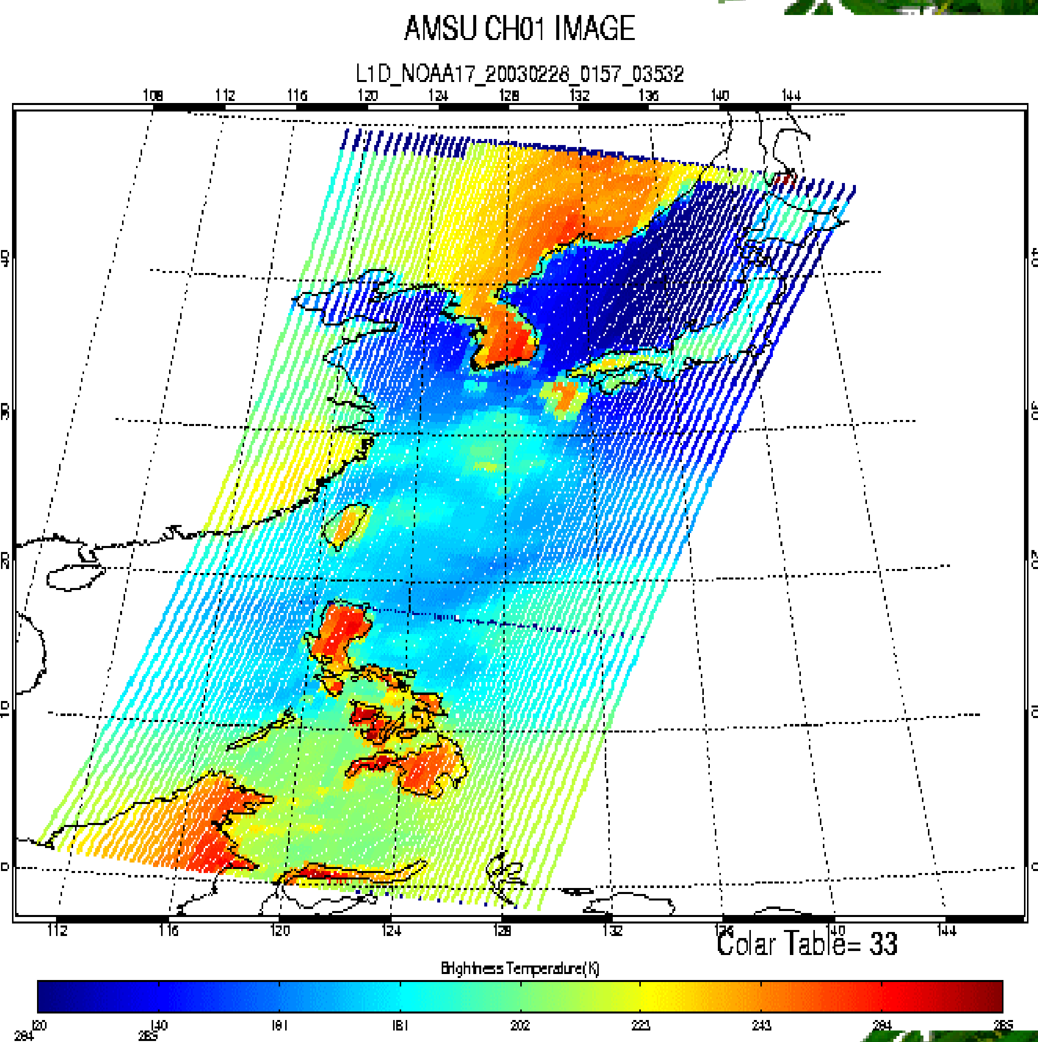
- Observation error is smaller then background error.
- Over ocean the results of retrieval is better than over land, for surface emissivity is more complicated.
- This adjustment procedure is significant in improvement of the utilization on AMSU data.

Monitoring Typhoon

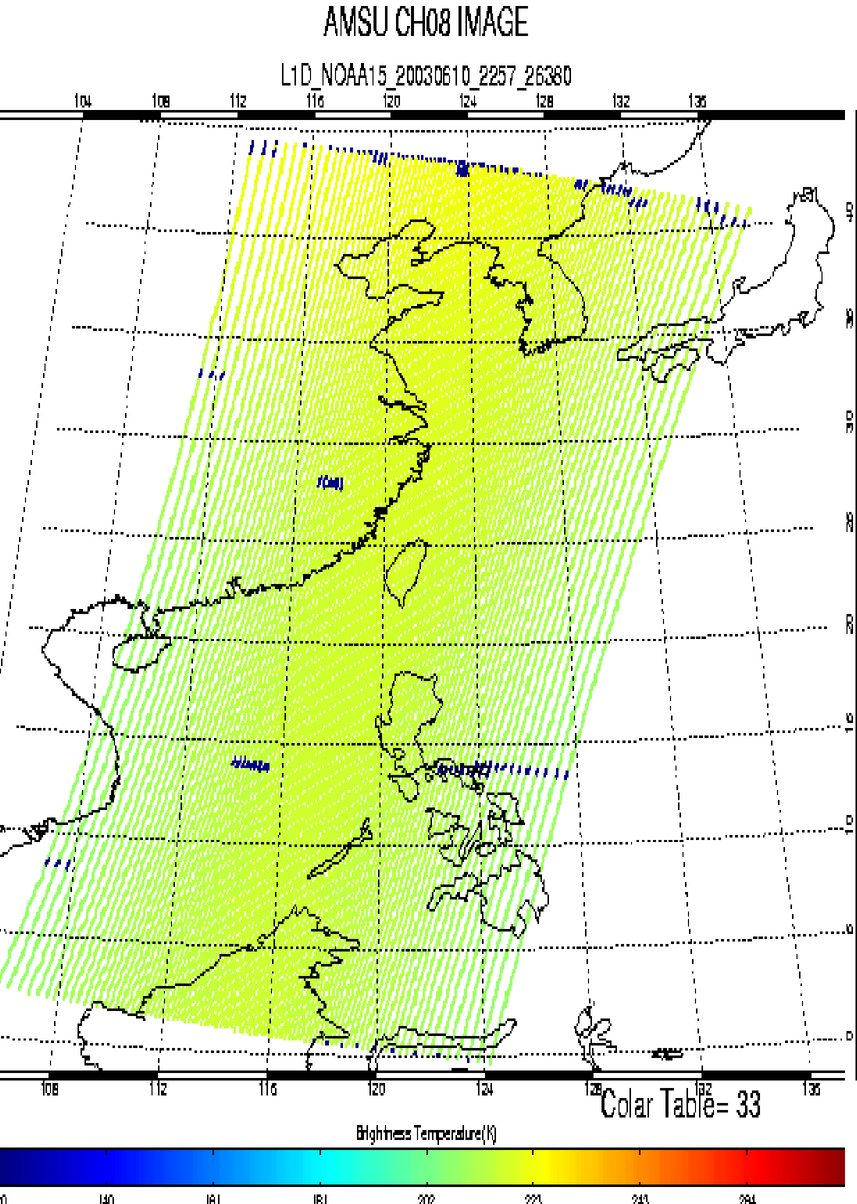
- It has been examined the relationship between temperature anomalies and the surface wind and central pressure of tropical cyclones.(Kidder, 2000)
- Make Limb Correction to each FOV before retrieval or make different set of coefficient to each FOV. Retrieved RMS error < 1.75K(Zhu,2002)

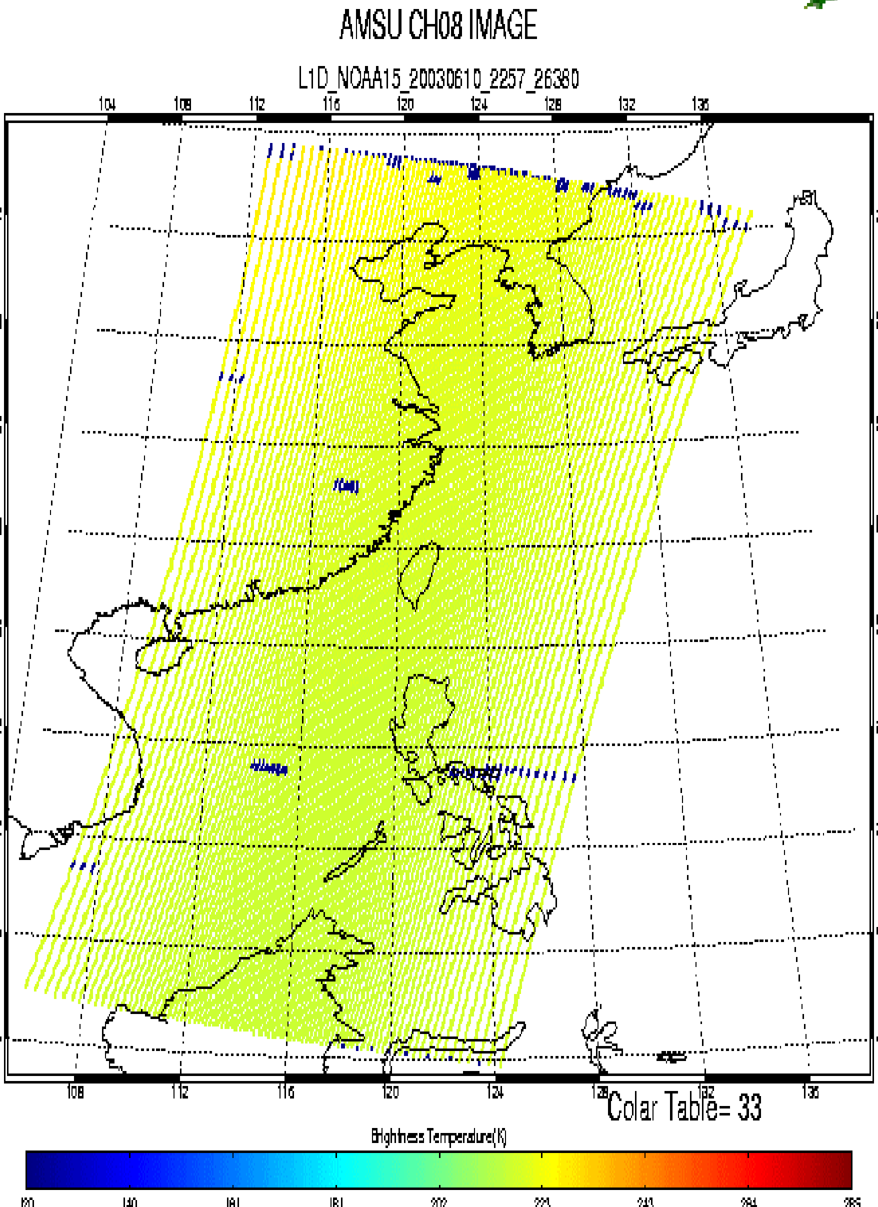
Real Images before & after Limb correction





Real image before & after Limbcorrection





How to do Limb Correction

1. Radiation transfer Model
2. Statistical Methods

For the Limb effect is asymmetry

a)Mitchell D. Goldberg (The Limb Adjustment of AMSU-A Observation: Methodology and Validation)

b)Nesdis: NOAA Satellite and information service, Michael Chalfant

The methodology of Limb correction

$$y = X^T b$$

- b is a vector of coefficients $y = X^T b$
- X are means over latitude bands from a large time period
- Y The limb adjusted brightness temperature

Least squares fit to the measured data. Define a penalty function

$$F(b)=(X^Tb-y)^T(X^Tb-y)+\gamma(b-b_p)^T(b-b_p)+2\lambda(1-u^Tb)$$

λ, γ are Lagrange multipliers. X is a matrix of x, y is a vector of means for all latitude bands. u is a vector of ones. b_p is the set of physical coefficients derived from weighting function.

To minimize F with respect to b, derivative and equate to zero

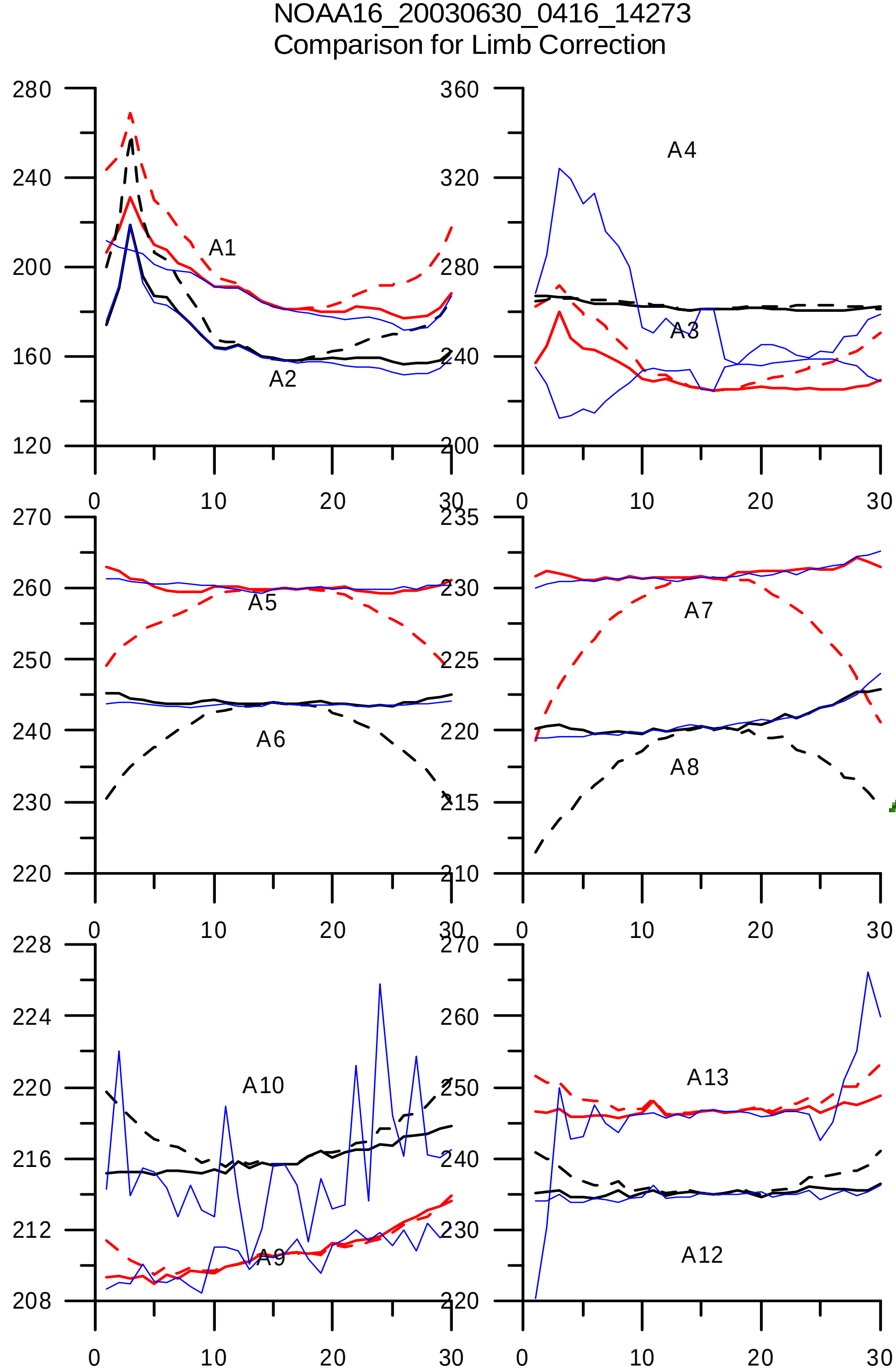
$$2X(X^Tb-y)+2\gamma(b-b_p)-2\lambda u=0$$

solution $b=(XX^T+\gamma I)^{-1}(Xy-\gamma b_p-\lambda u)$

constrain $u^Tb=1$

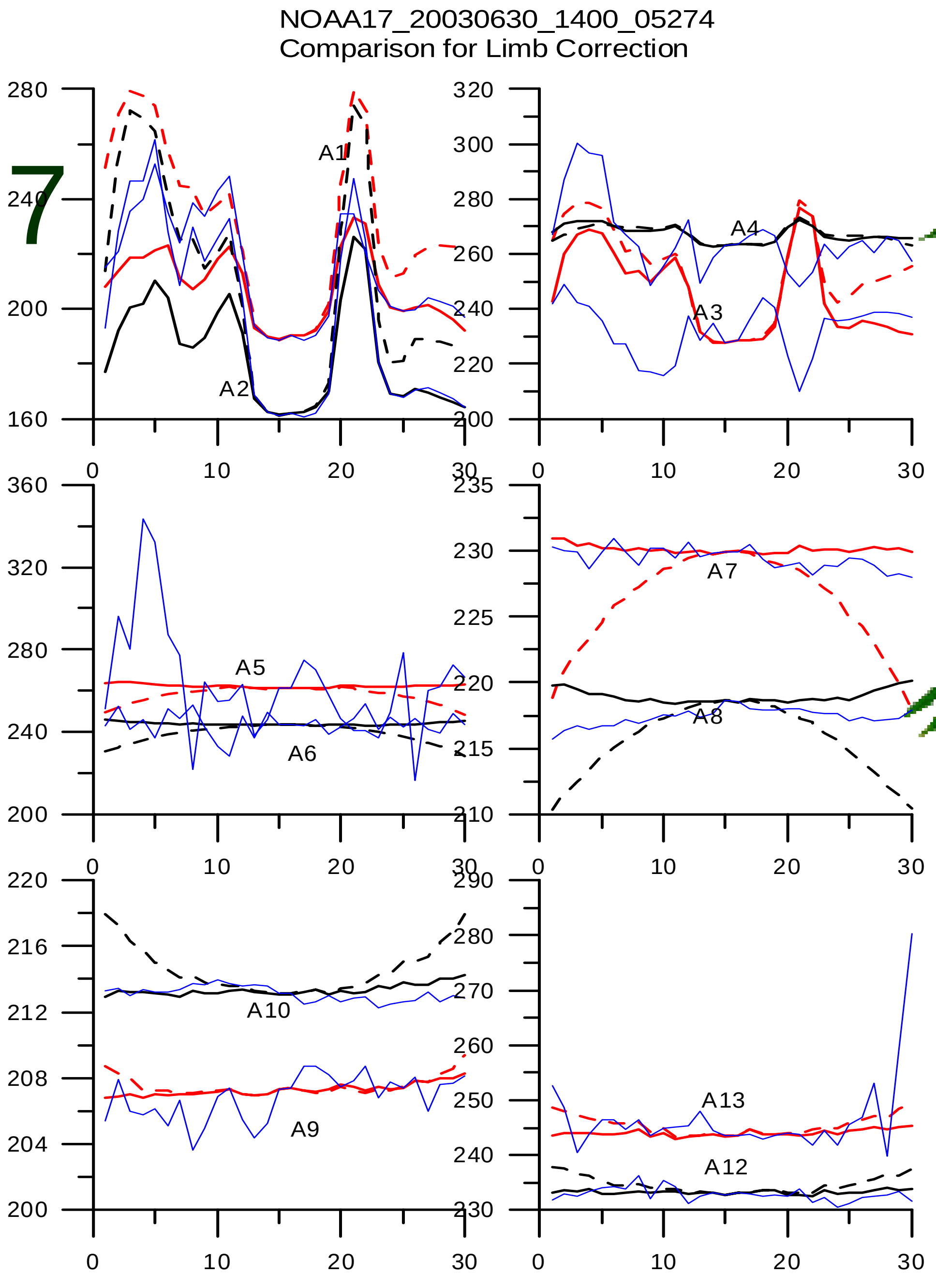
$$\lambda=\left[1-(XX^T+\gamma I)^{-1}(Xy-\gamma b_p)\right]/\left[u^T(XX^T+\gamma I)^{-1}u\right]$$

NOAA-16



NOAA16_20030630_0416_14273
Comparison for Limb Correction
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A12
A13
280
240
200
160
120
360
320
280
240
200
270
260
250
240
230
220
235
230
225
220
215
210
228
224
220
216
212
208
270
260
250
240
230
220
0
10
20
30

NOAA-17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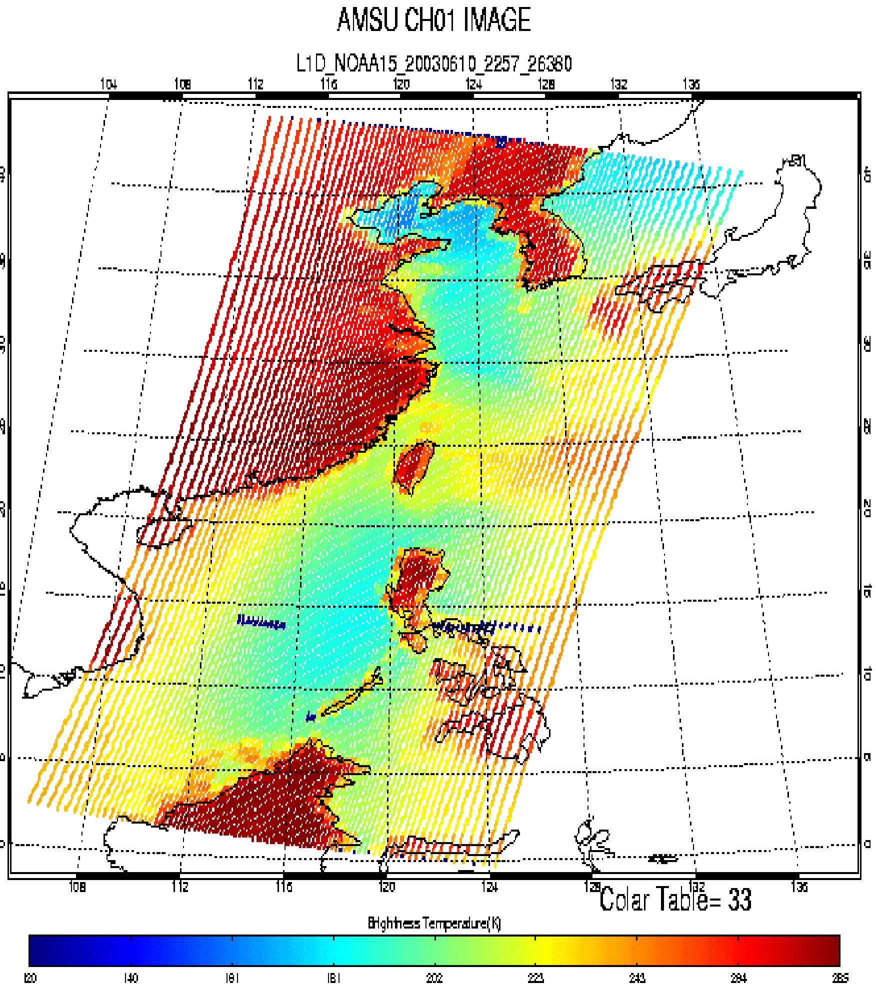
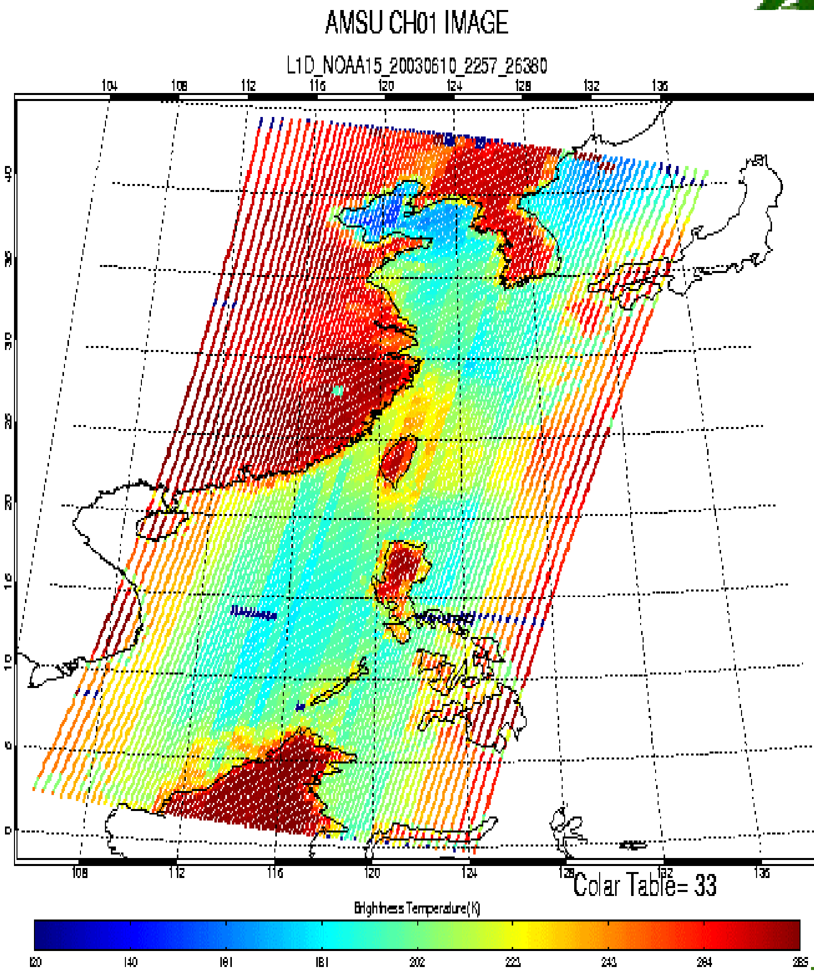
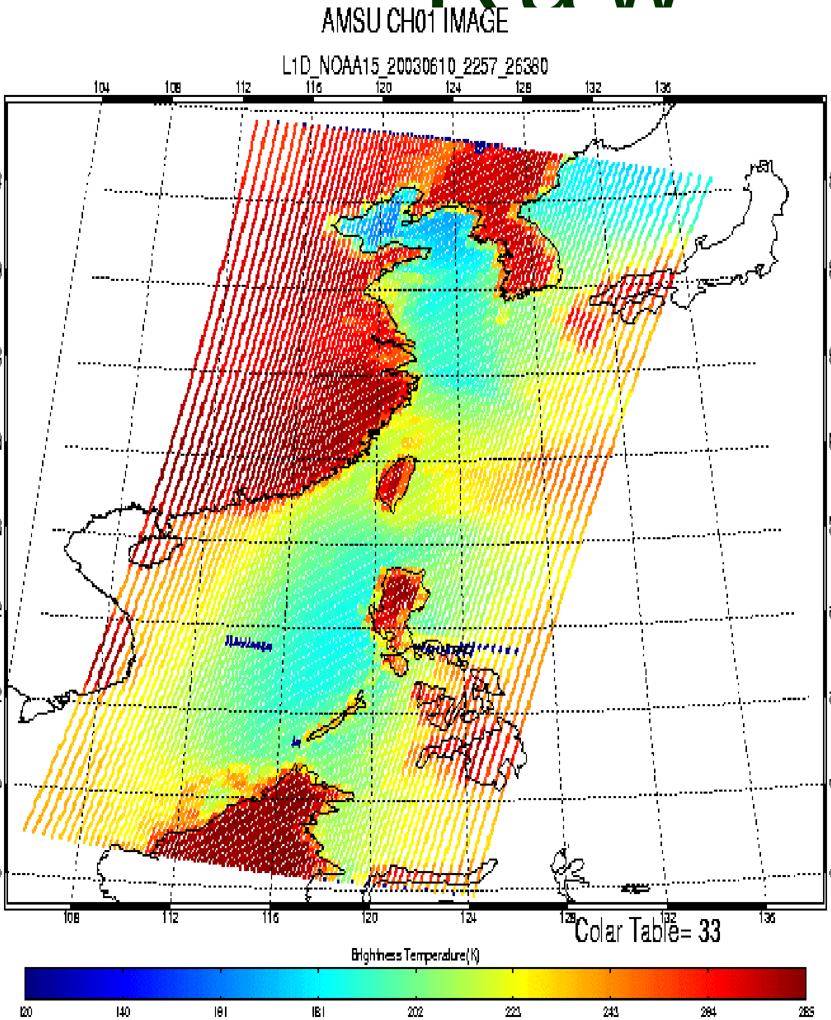
Comparison for Limb Correction
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A12
A13
0
10
20
30
280
240
200
160
320
300
260
220
360
235
230
225
215
210
290
270
250
216
212
208
204

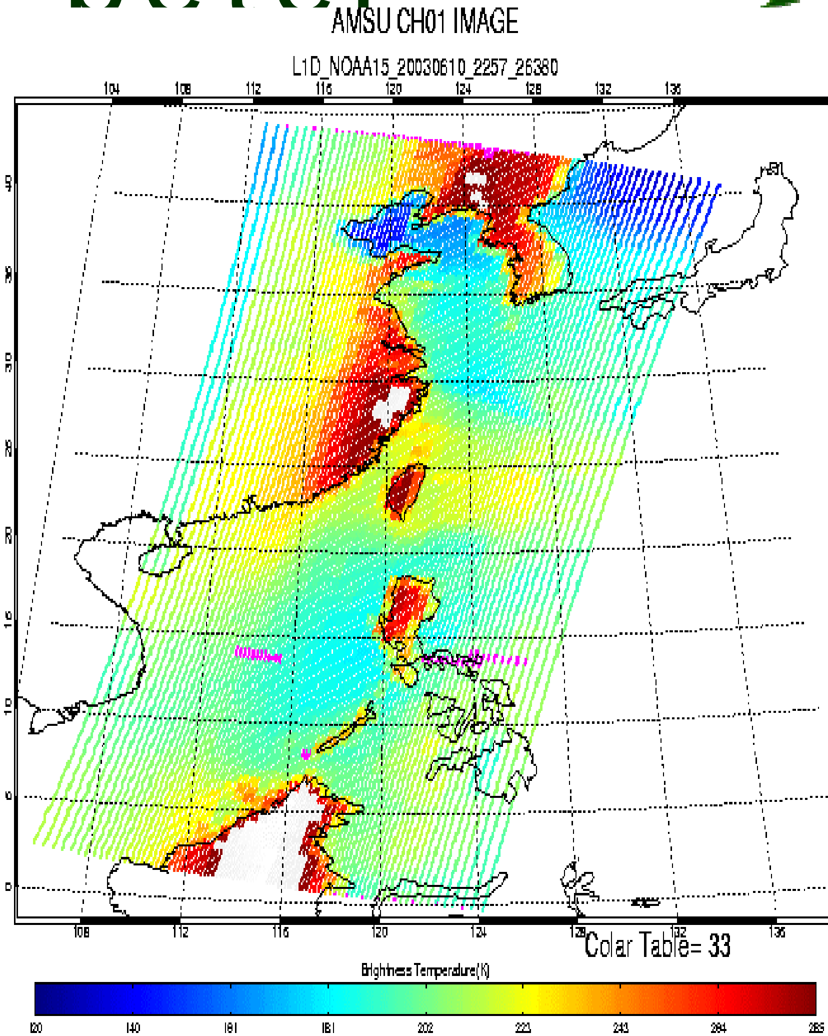
NOAA-15 ch 1
Raw - Michael



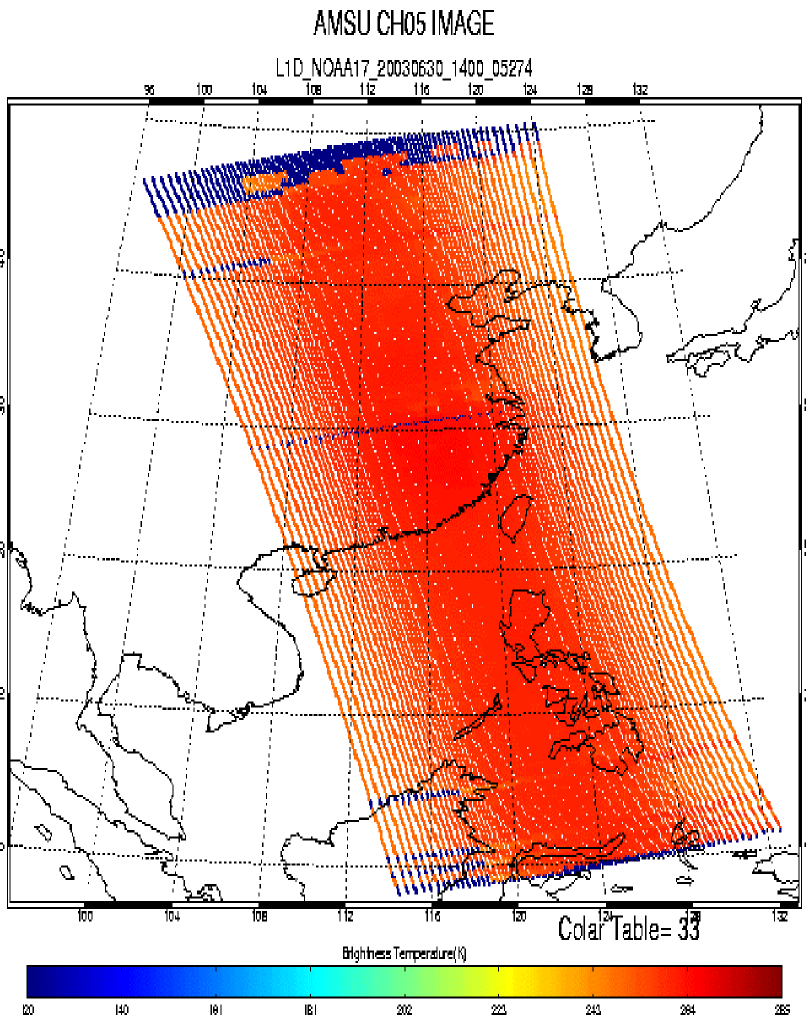


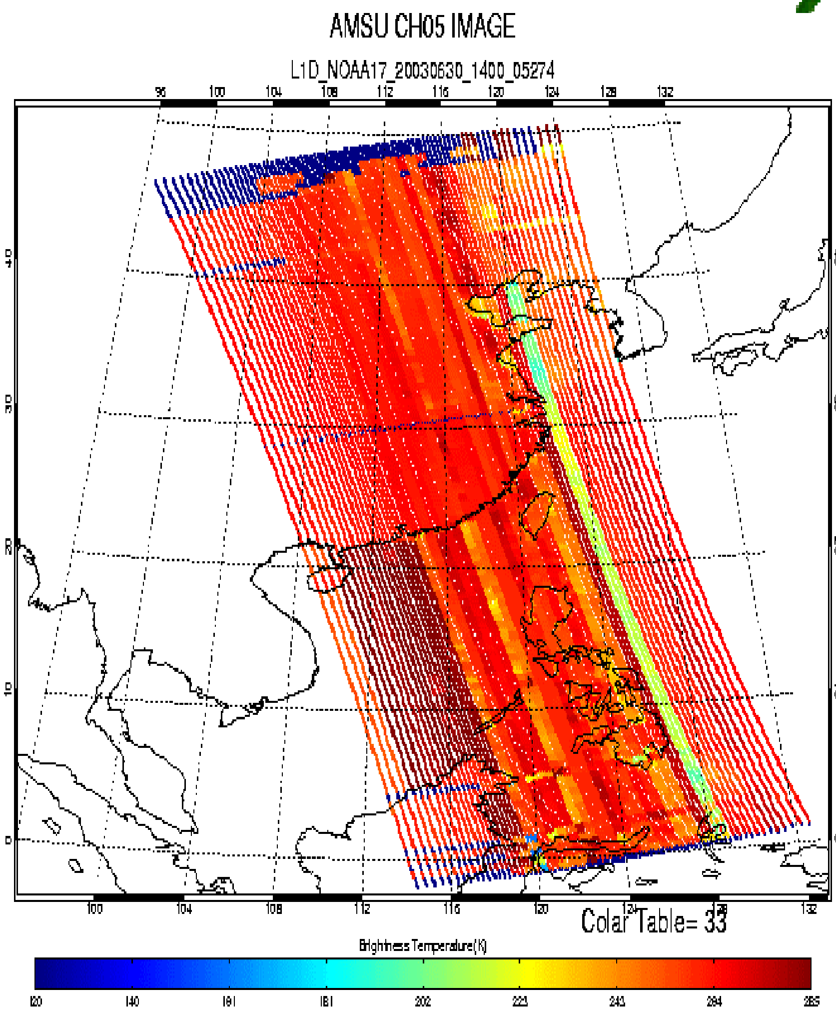
NOAA-15
Raw - peter





NOAA17 Ch5 Raw - Peter

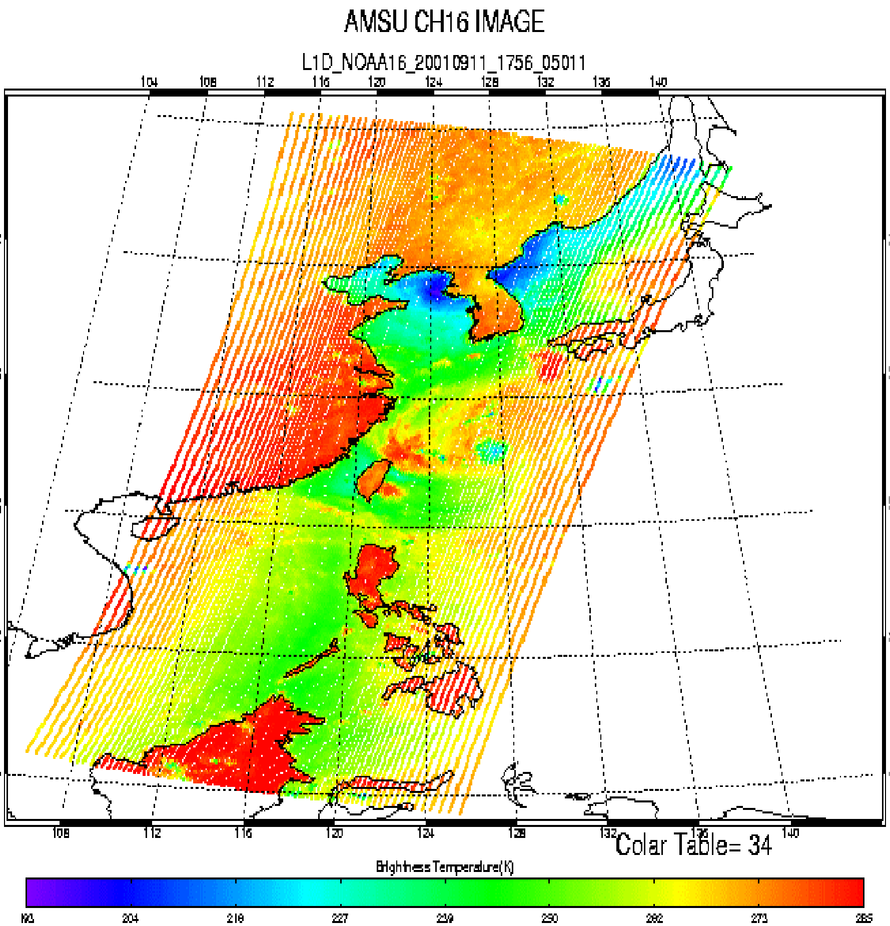


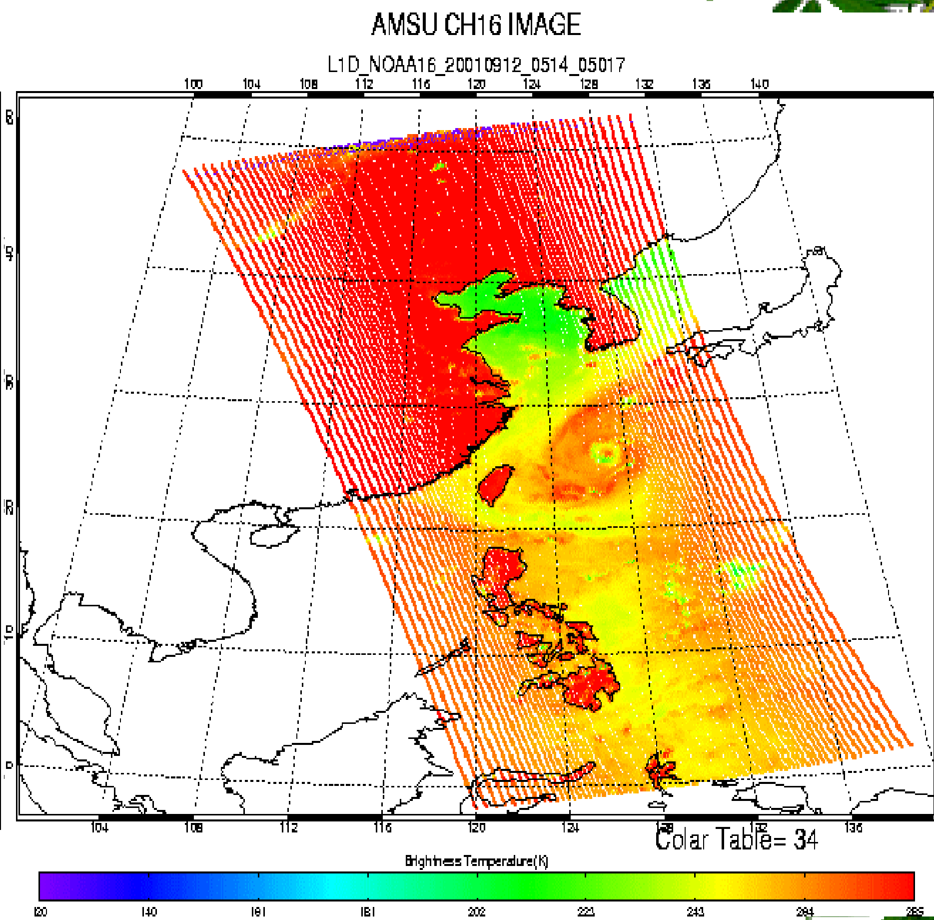


Typhoon monitoring &2D & 3D wind vector retrieval

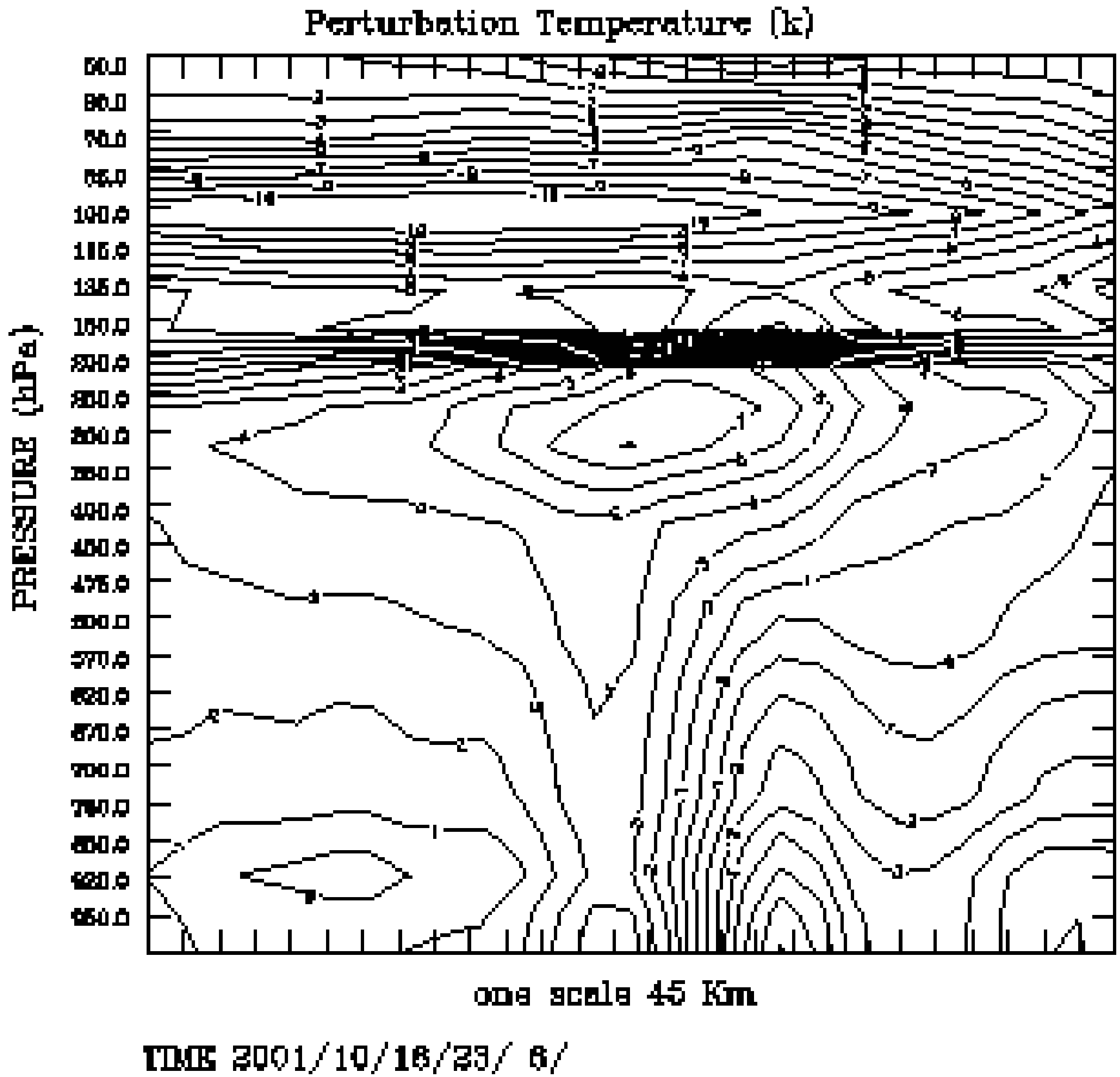
- 2D wind retrieval algorithm followed Kidder's (2000) paper
- According 250hPa Max. anomalies Temp to define center of typhoon
- 3D wind is calculated by gradient wind equation
- Appreciate Tong Zhu, Da-Lin Zhang and Allen Huang assistance

2001.0911-0912

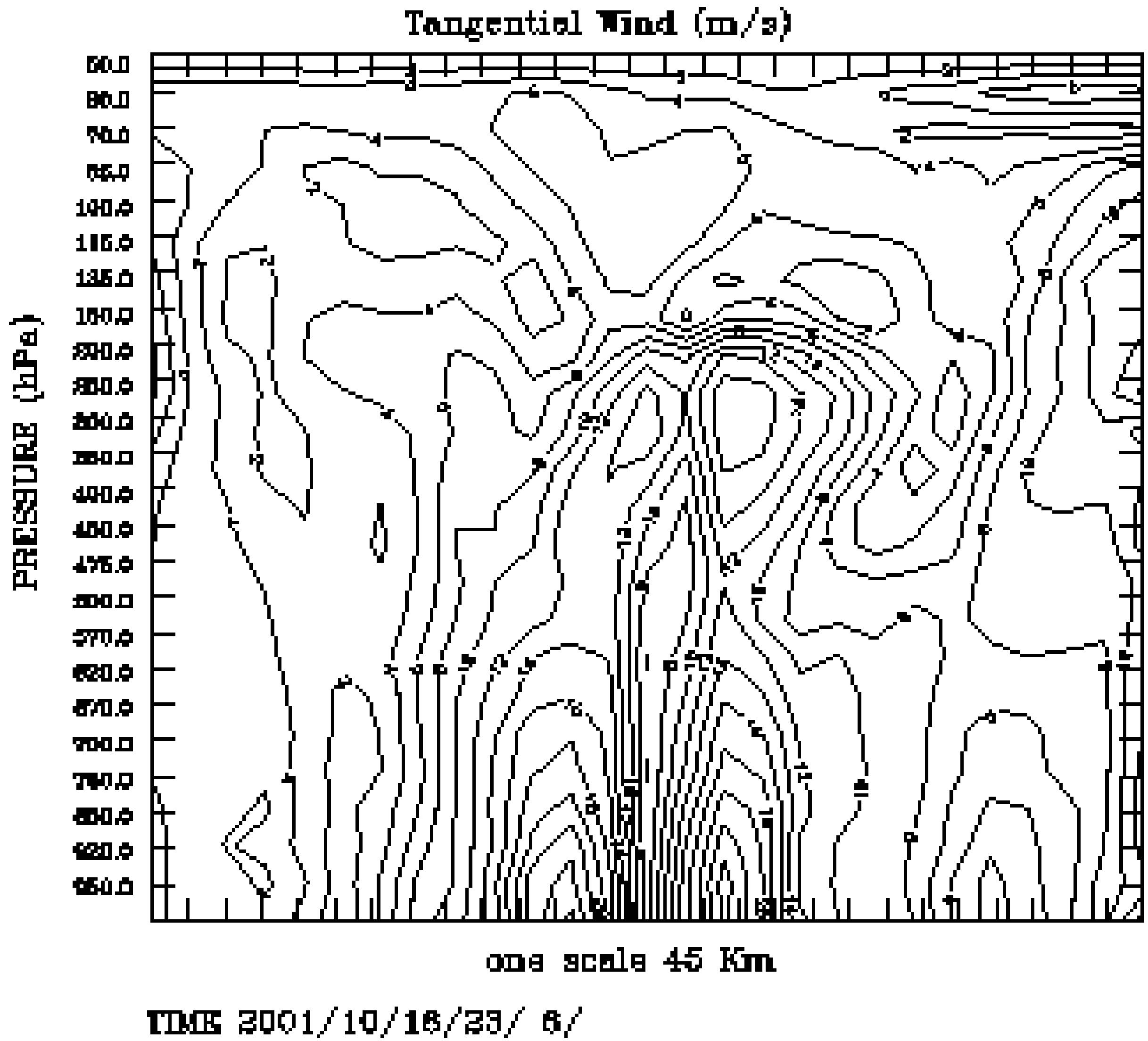




Typhoon 2001.10.16



2001.10.16.2306



Conclusion

- AMSU can be an auxiliary instrument on tropical cyclone observation
- Identify no eye typhoon is useful even with poor resolution
- After significant adjusted AMSU data may improved weather analysis.

International TOVS Study Conference, 13th, TOVS-13, Sainte Adele, Quebec, Canada, 29 October-4 November 2003. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2003.