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

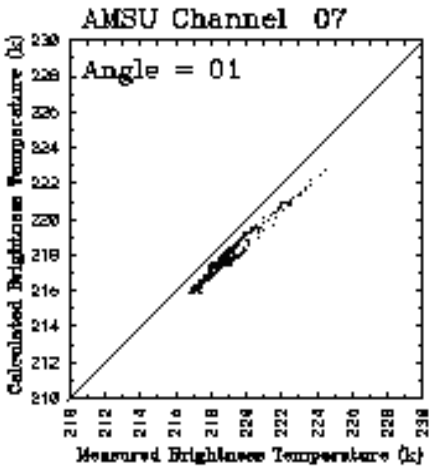
- Minimize Cost function(Rodgers,1976)

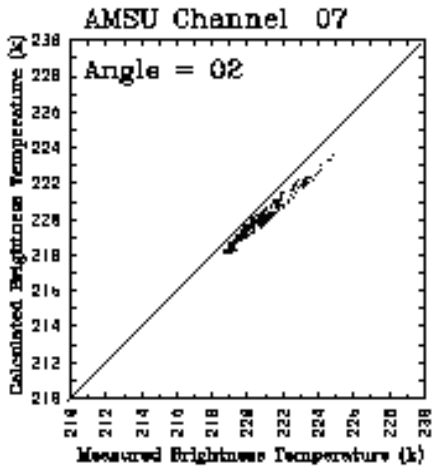
$$J(x)=\left(x-x^{b}\right)^{T}C^{-1}\left(x-x^{b}\right)+\left\{y^{m}-y(x)\right\}^{T}E^{-1}\left\{y^{m}-y(x)\right\}$$

- 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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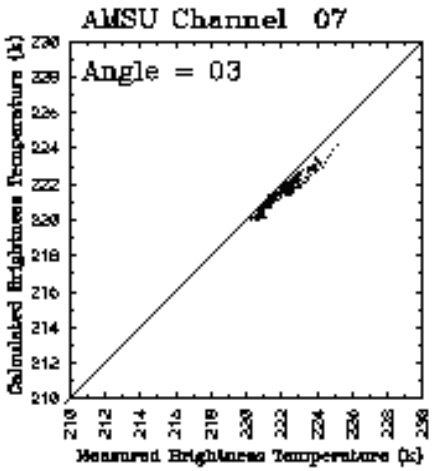
Angle = 02
Calculated Brightness Temperature (k)
Measured Brightness Temperature (k)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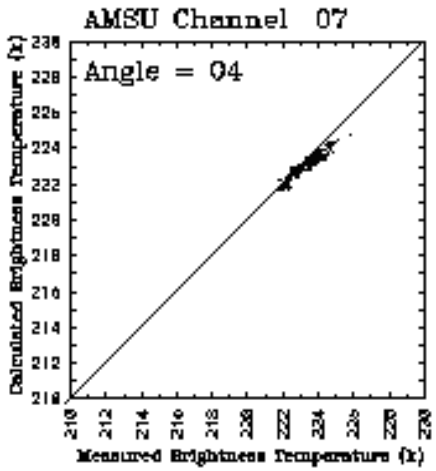
Angle = 03
Calculated Brightness Temperature (k)
Measured Brightness Temperature (k)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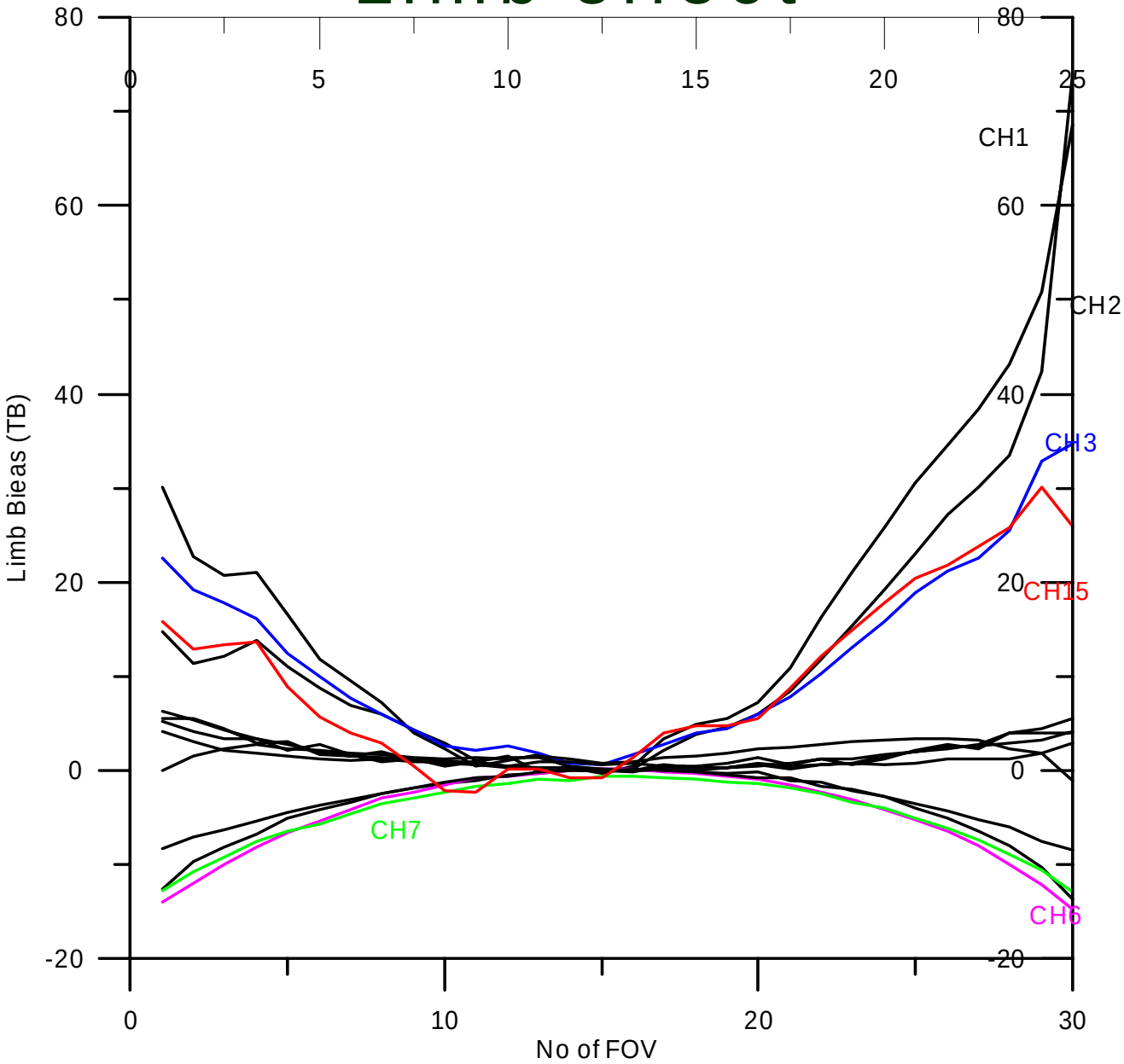
Calculated Brightness Temperature (k)
Measured Brightness Temperature (k)

Limb effect


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

Estimate bias correction and random error

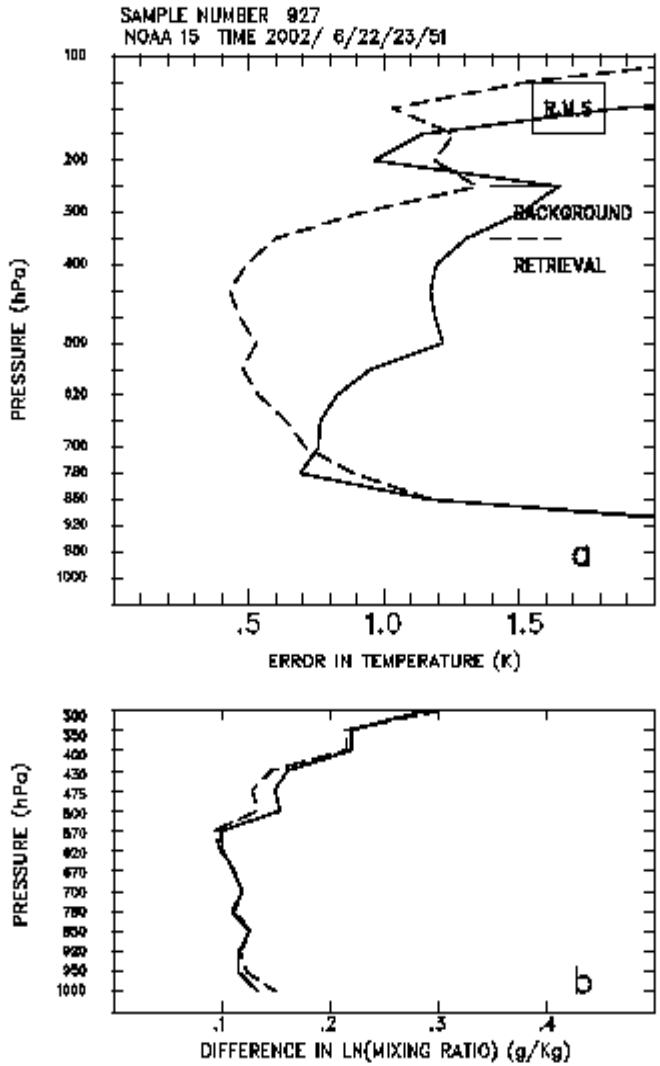
- Make sure Obs Tb and Est Tb between –20K & 20K
- If (Est Tb – Obs Tb) > 3*RMSE then is bad data
- Tb*=aTb+b for each channel and FOV on 900,000 points
- Concern about input parameters err(12 hours forecast)

Real data retrieval

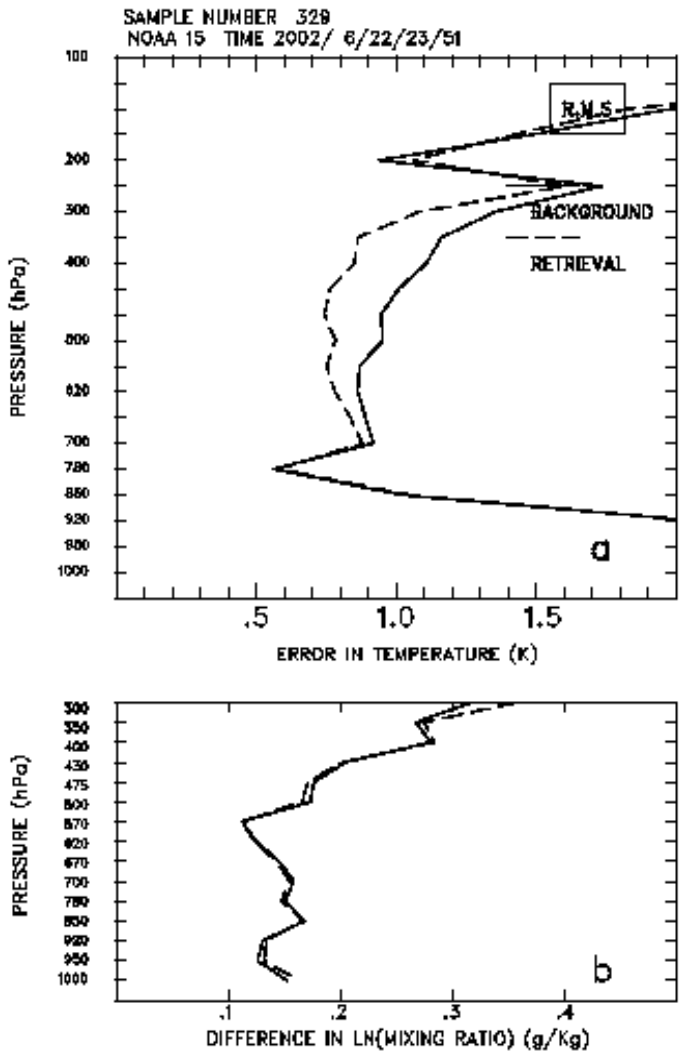
- 2002.6.22-23 NOAA-15
- Point was selected when retrieval successful and there are sounding data within 200Km away, SI<20

2002.6.22

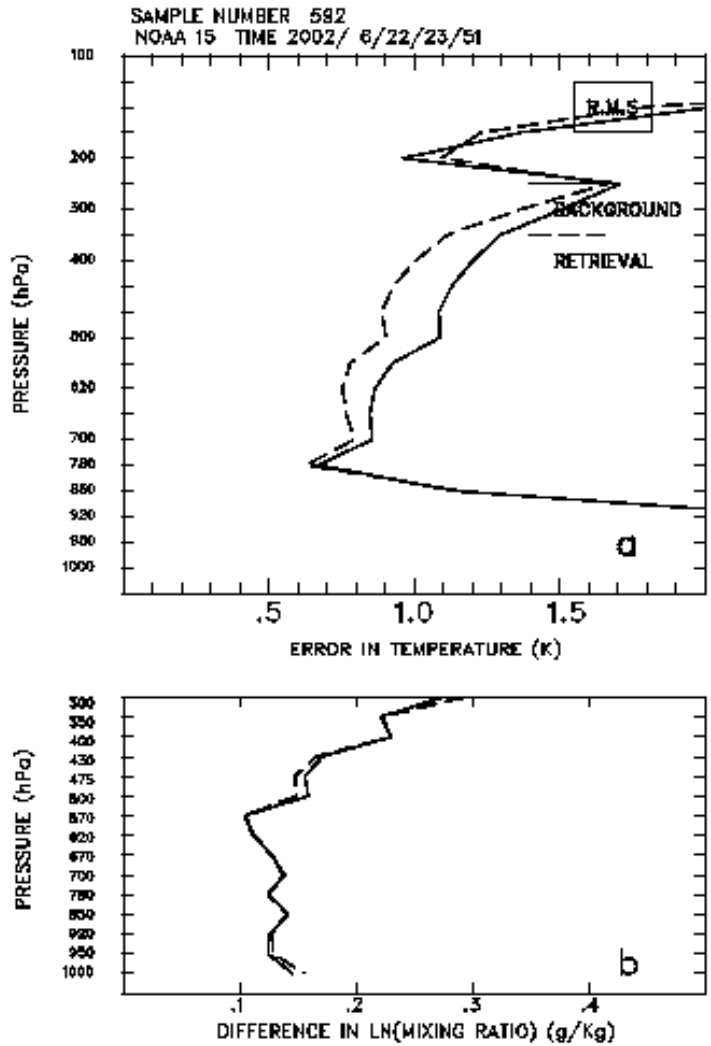
927points



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%

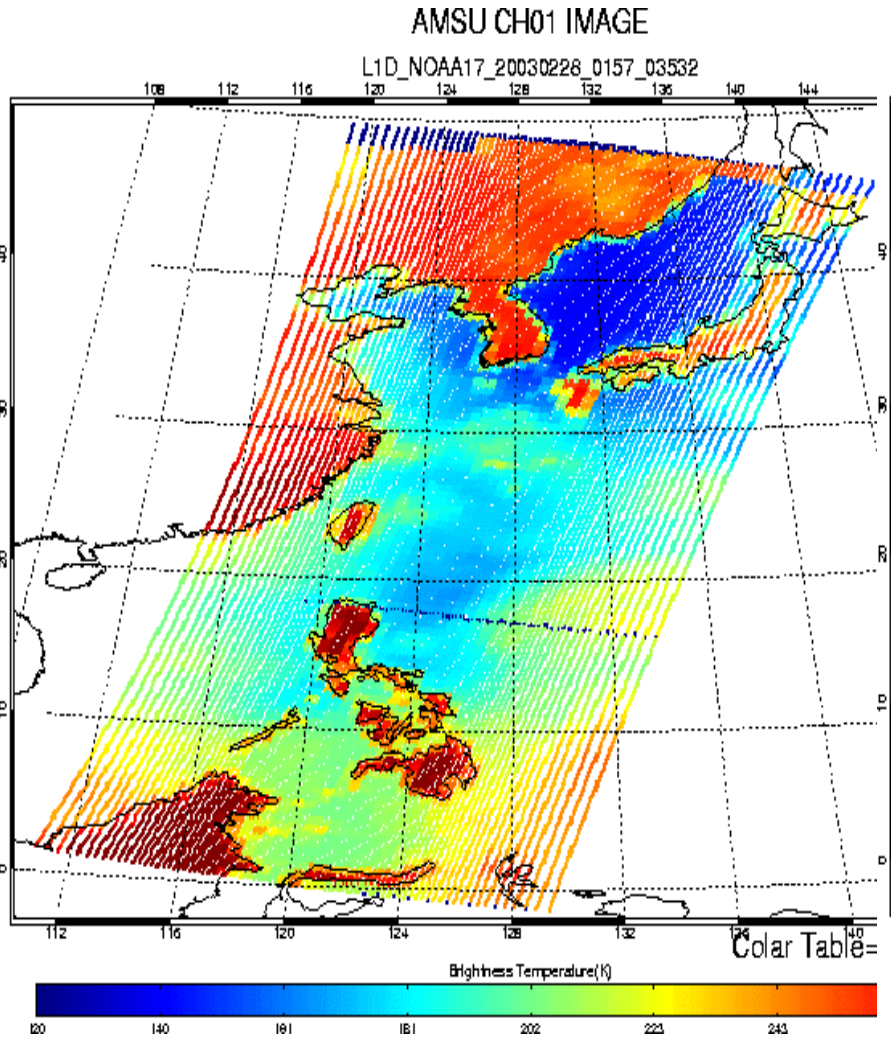
Sub conclusion

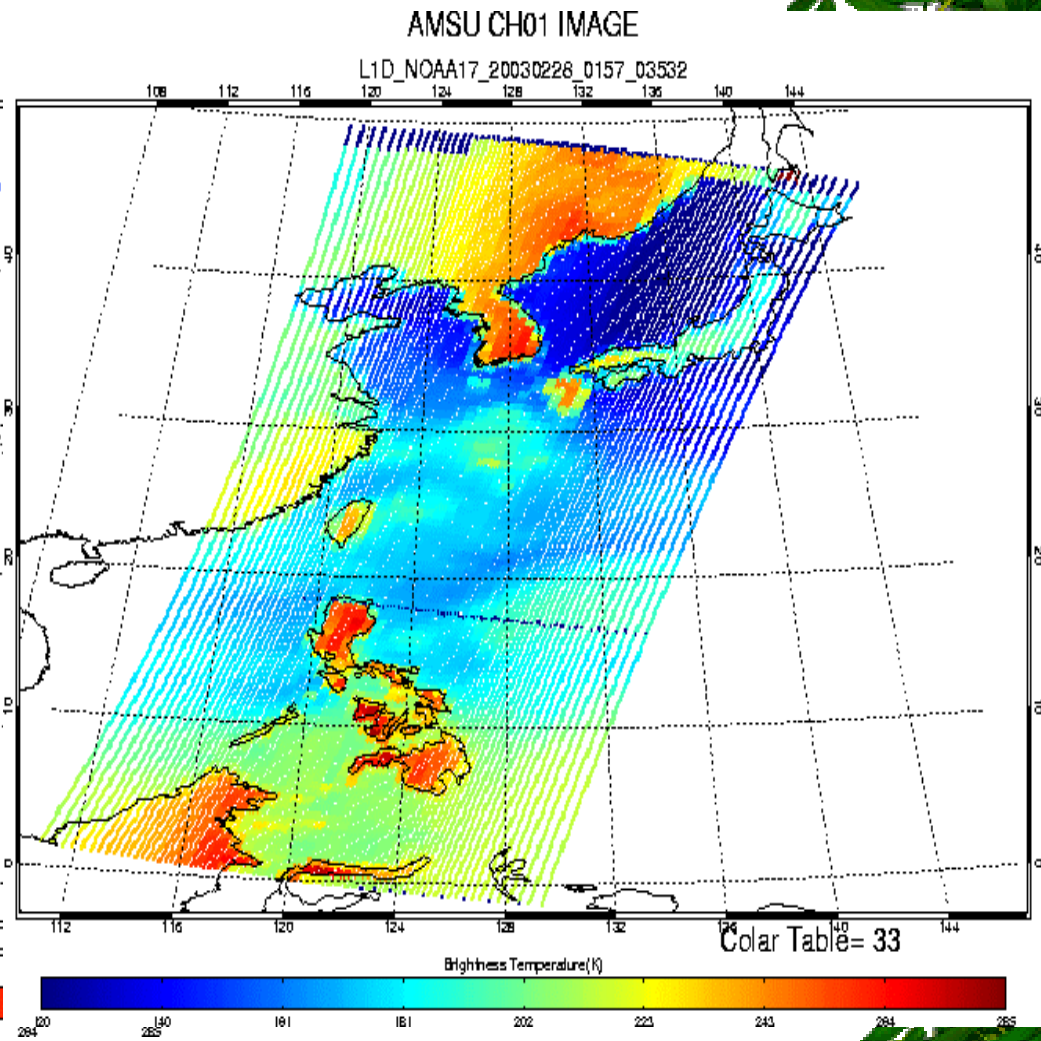
- Observation error is smaller then background error.
- Over ocean the results of retrieval is better than over land, for surface emissivity is more complicated.
- This adjustment procedure is significant in improvement of the utilization on AMSU data.

Monitoring Typhoon

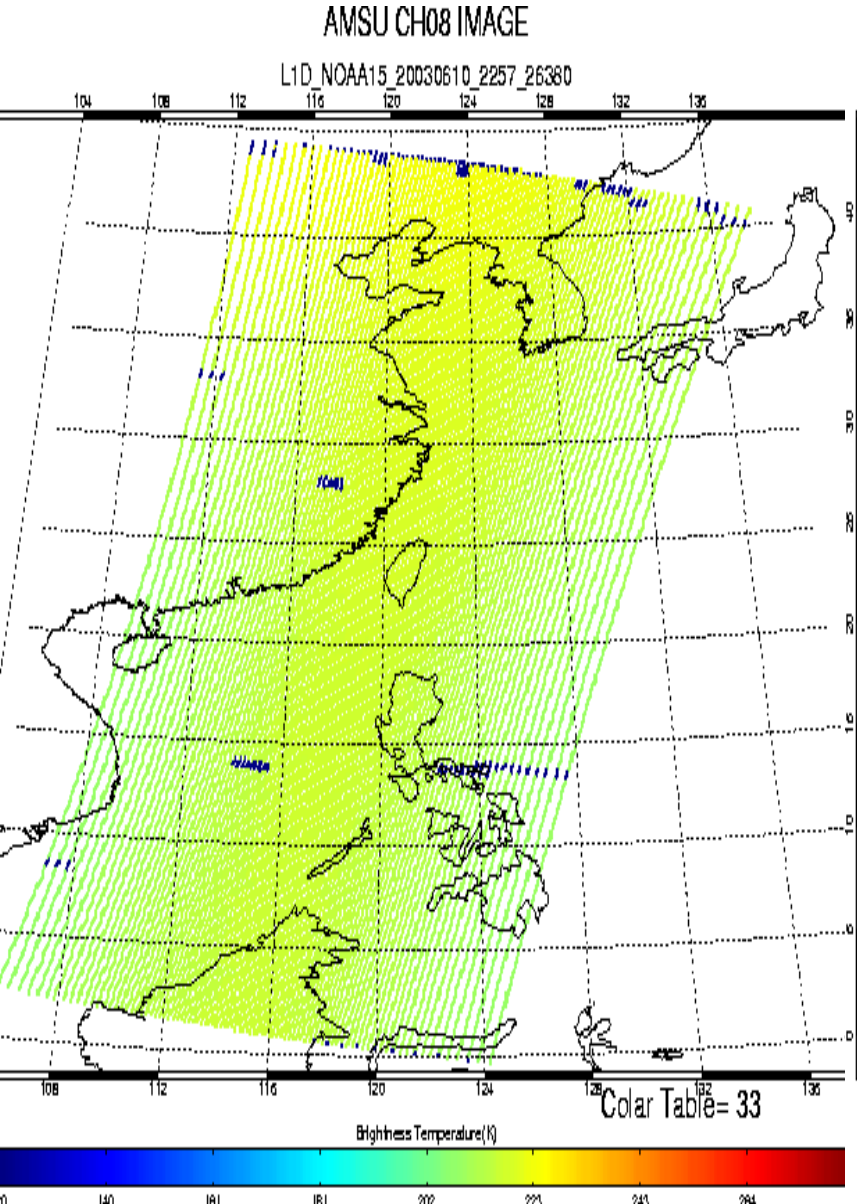
- It has been examined the relationship between temperature anomalies and the surface wind and central pressure of tropical cyclones.(Kidder, 2000)
- Make Limb Correction to each FOV before retrieval or make different set of coefficient to each FOV. Retrieved RMS error < 1.75K(Zhu,2002)

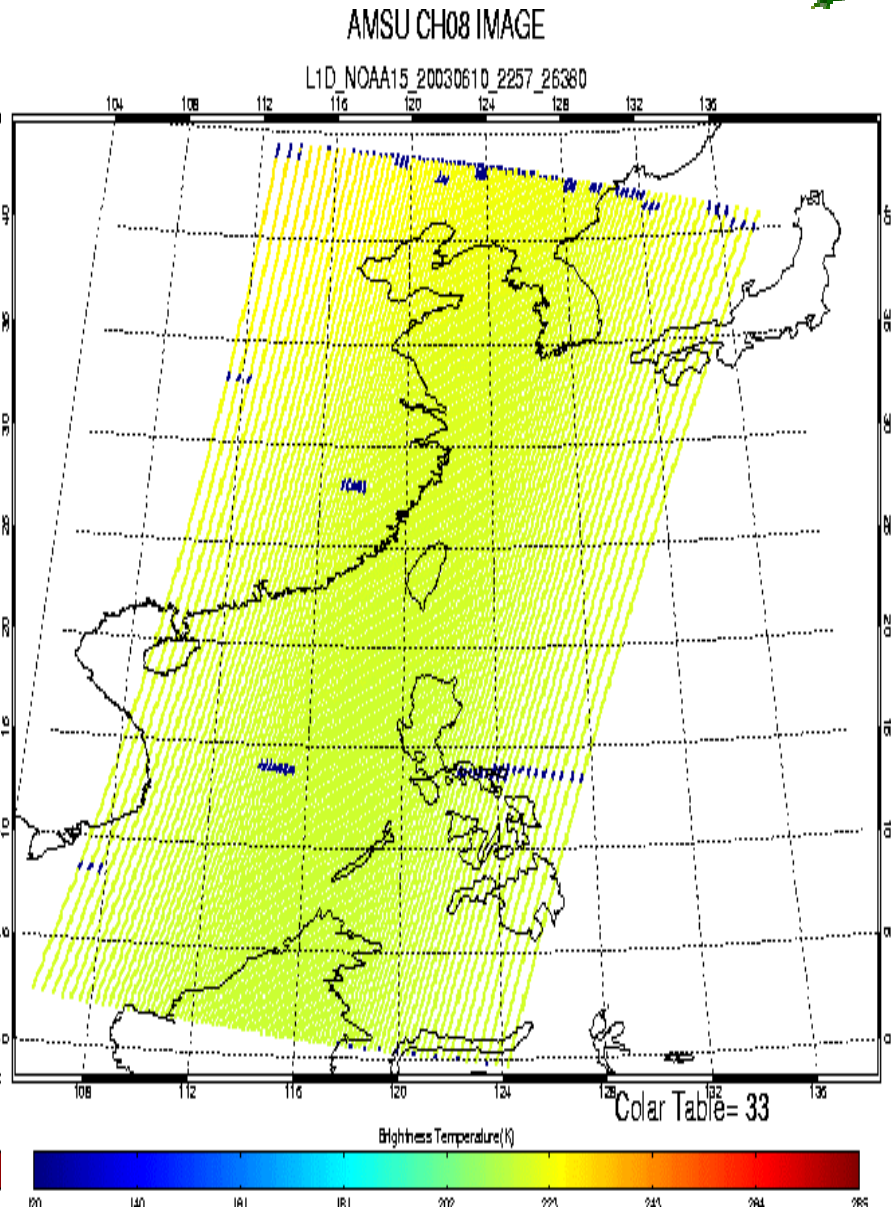
Real Images before & after Limb correction





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
- 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

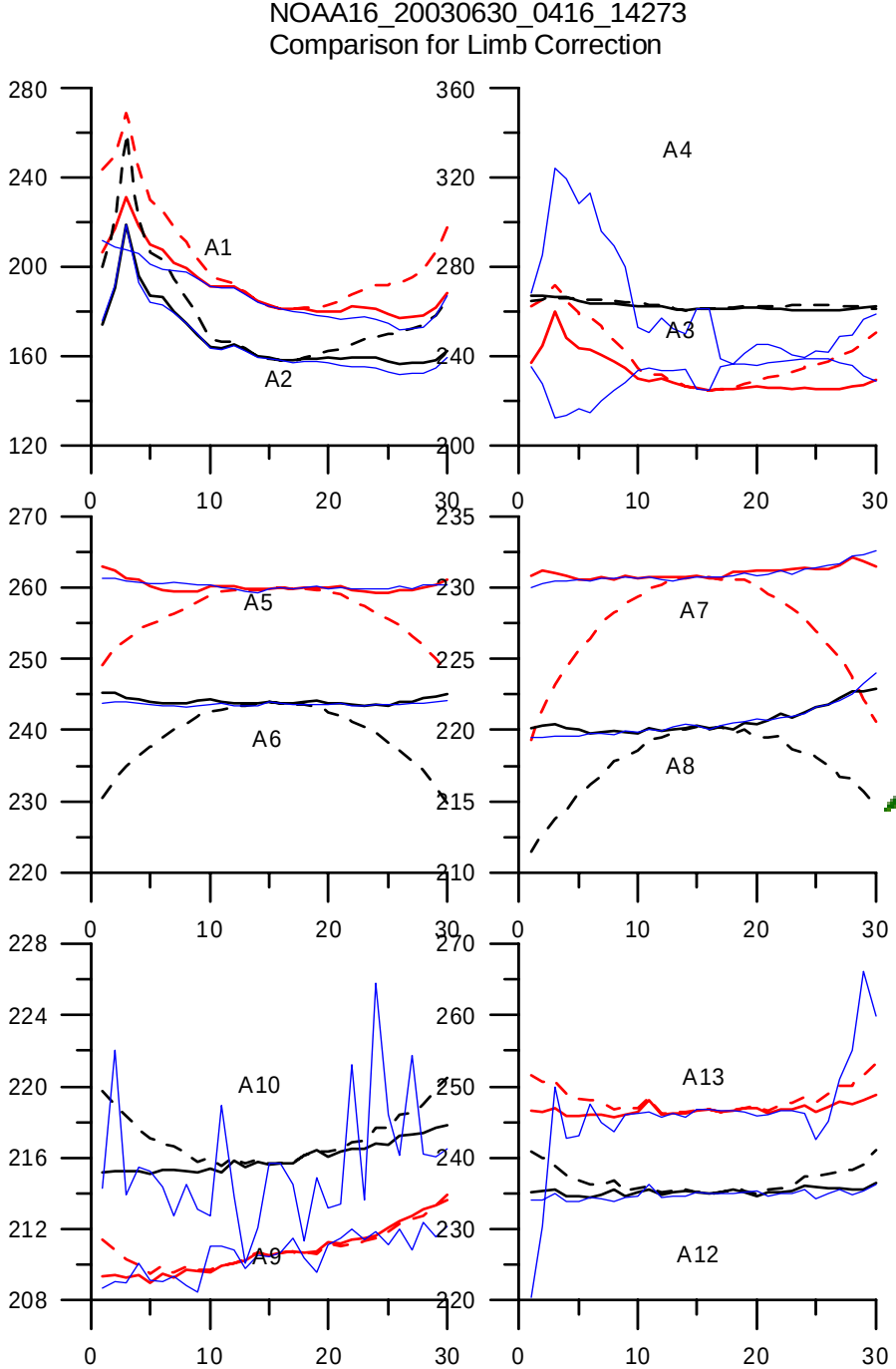
$$2X(X^Tb-y)+2\gamma(b-b_p)-2\lambda u=0$$

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

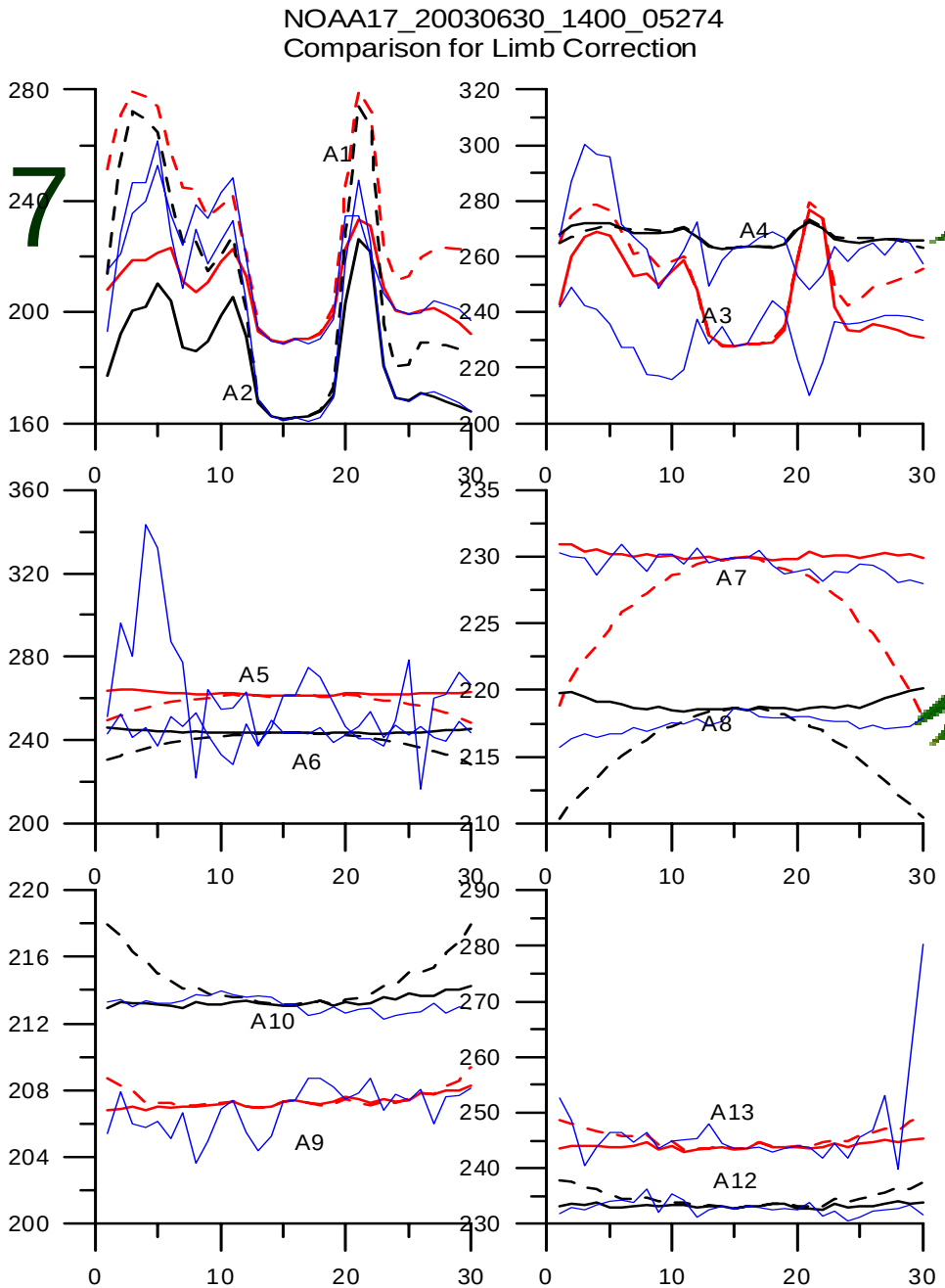
constrain $u^Tb=1$

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

NOAA-16


NOAA16_20030630_0416_14273
Comparison for Limb Correction
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A12
A13

NOAA-17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Comparison for Limb Correction
A1
A2
A3
A4
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A6
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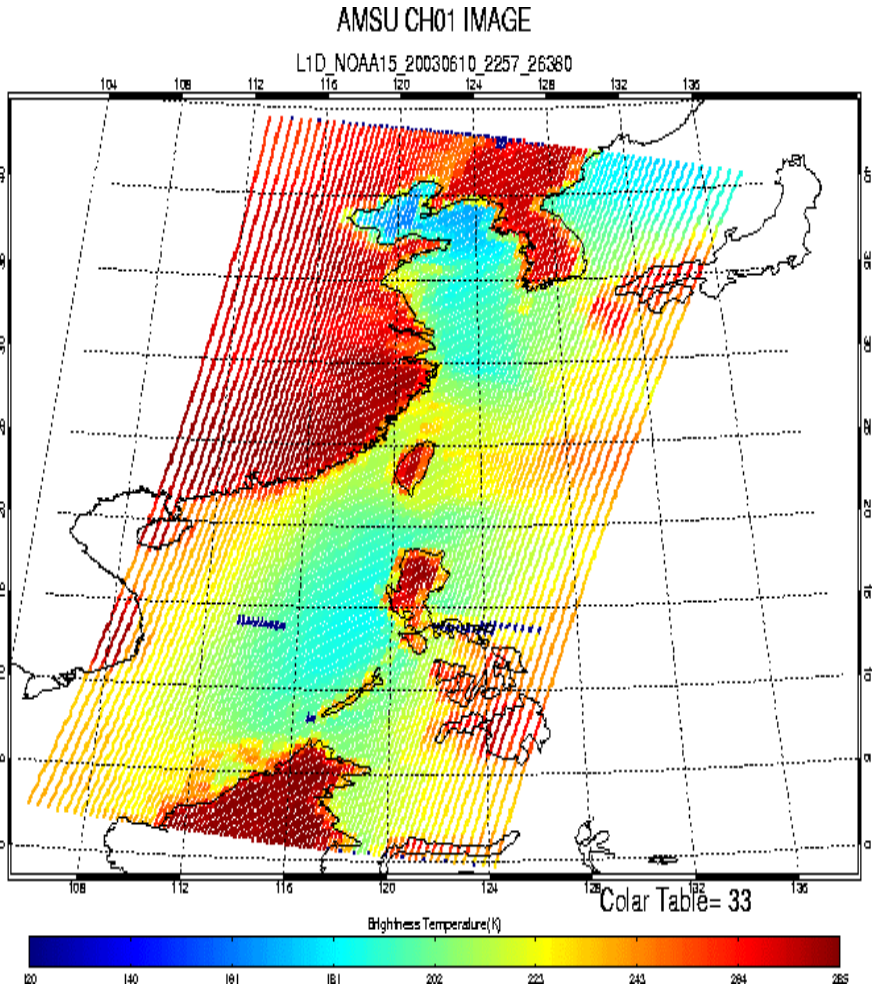
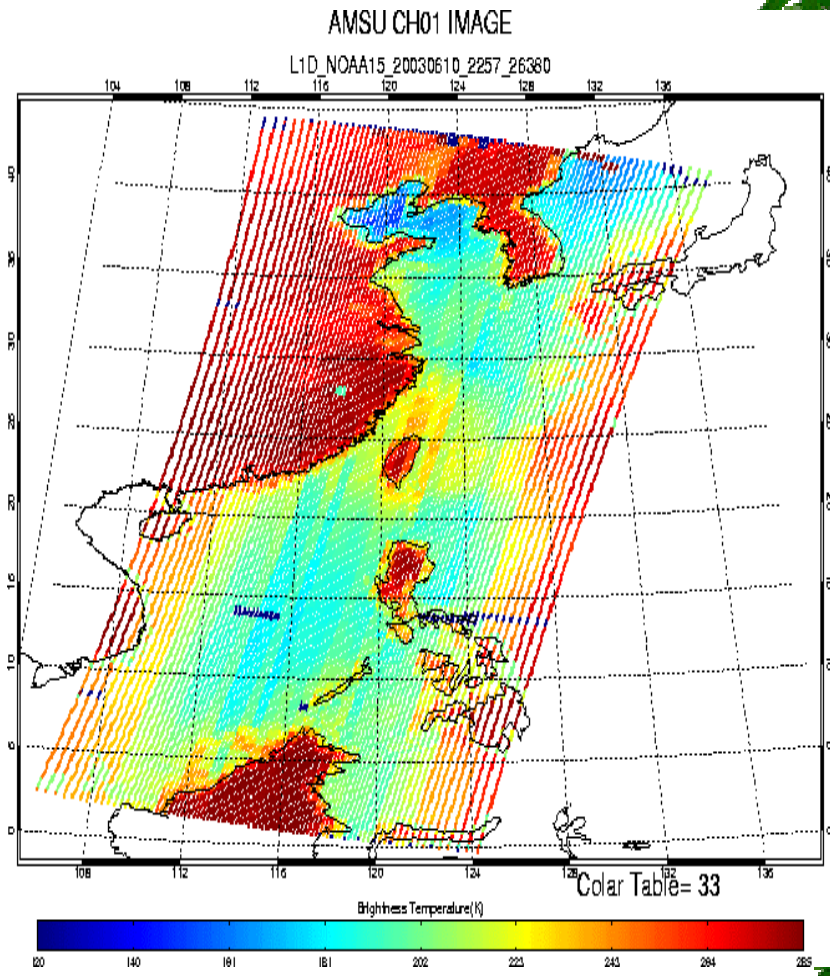
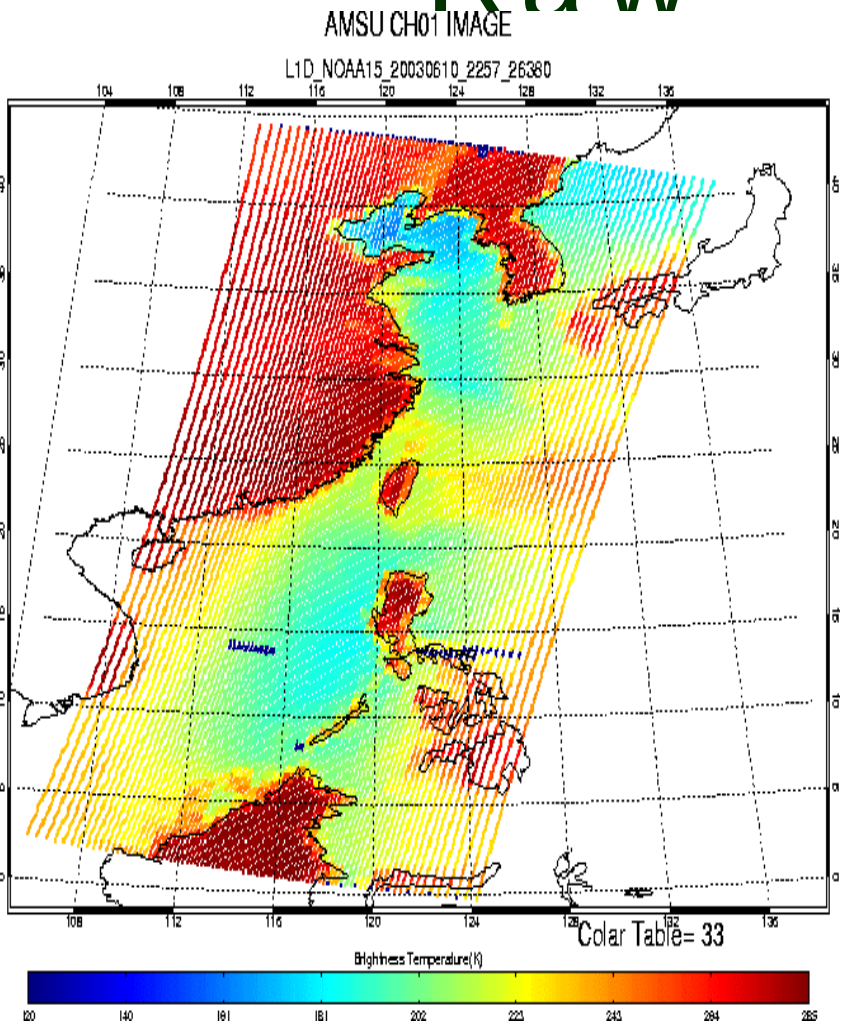
A8
A9
A10
A12
A13

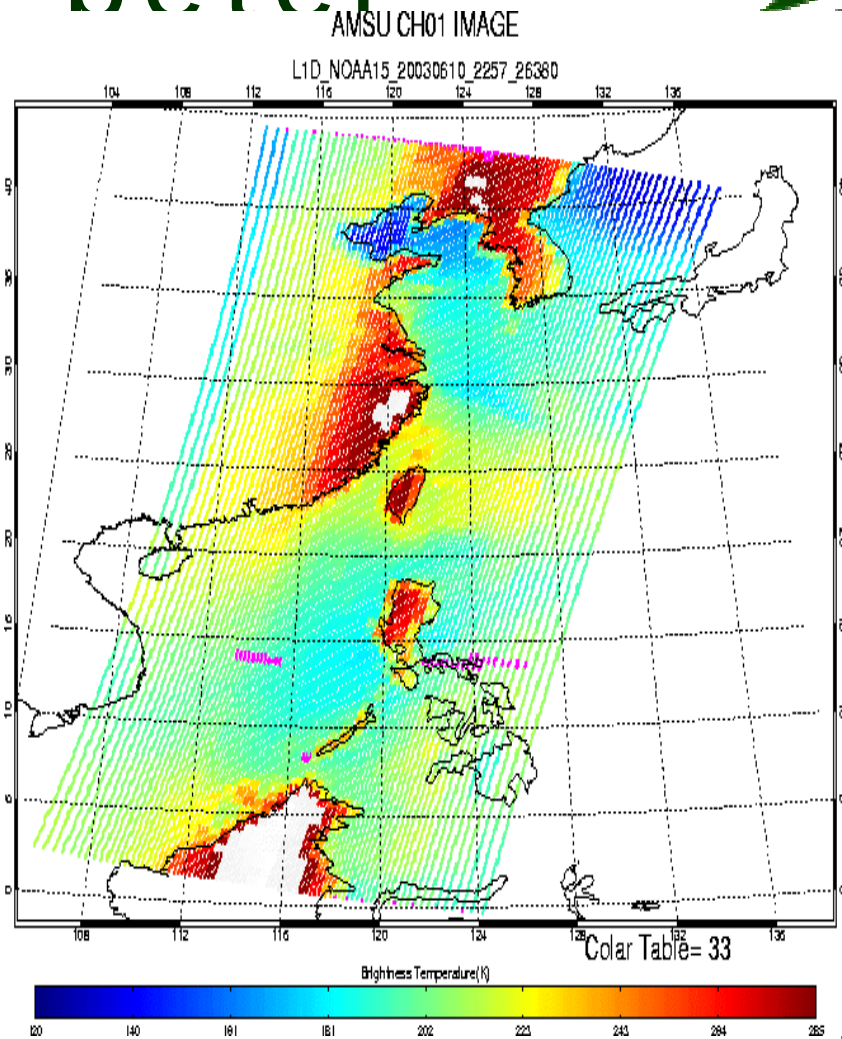
NOAA-15 ch 1 Raw - Michael



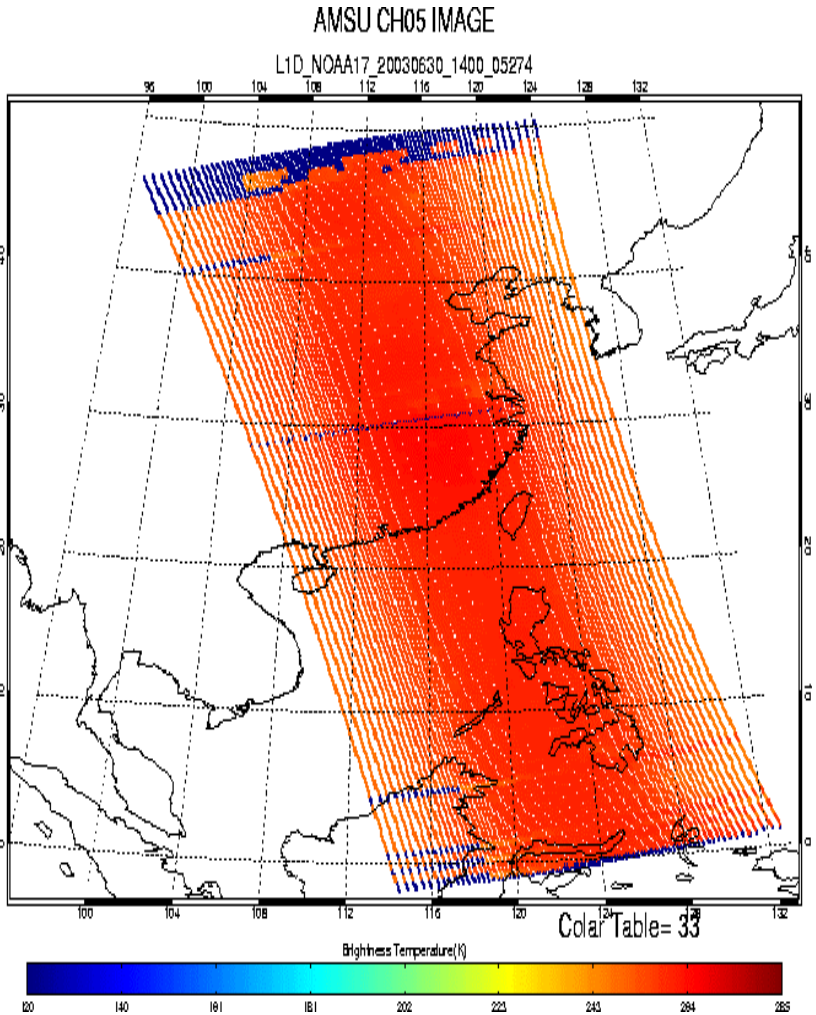


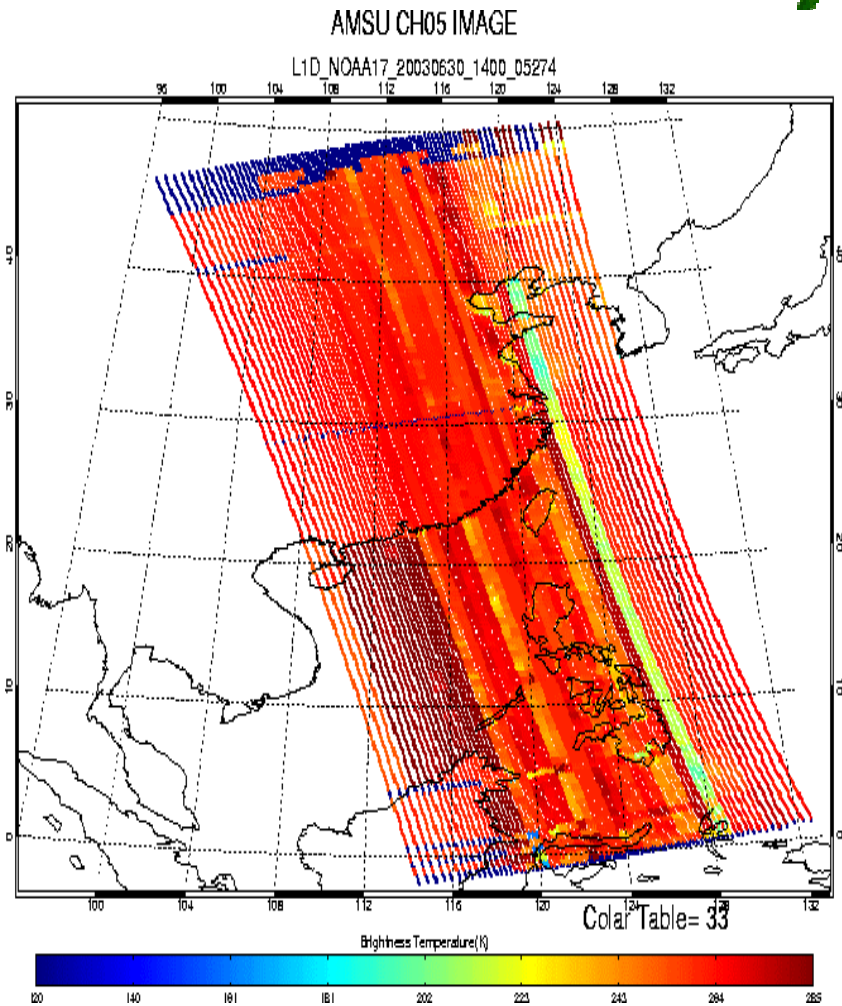
NOAA-15
Raw - peter





NOAA17 Ch5 Raw - Peter

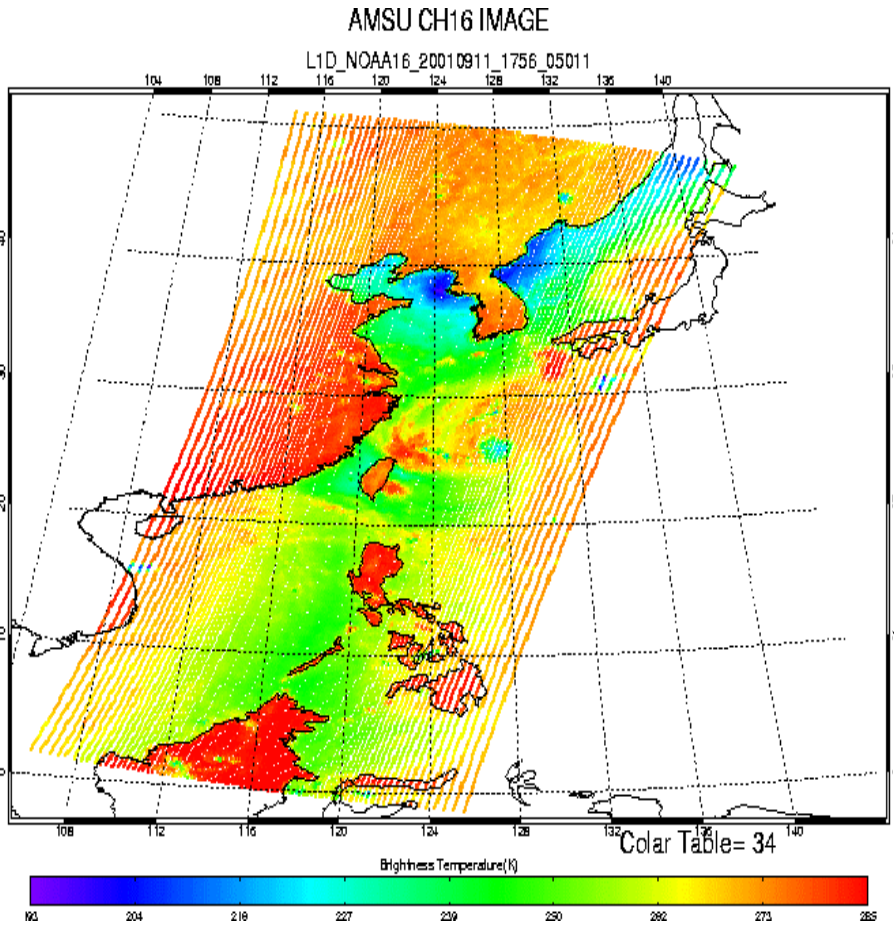


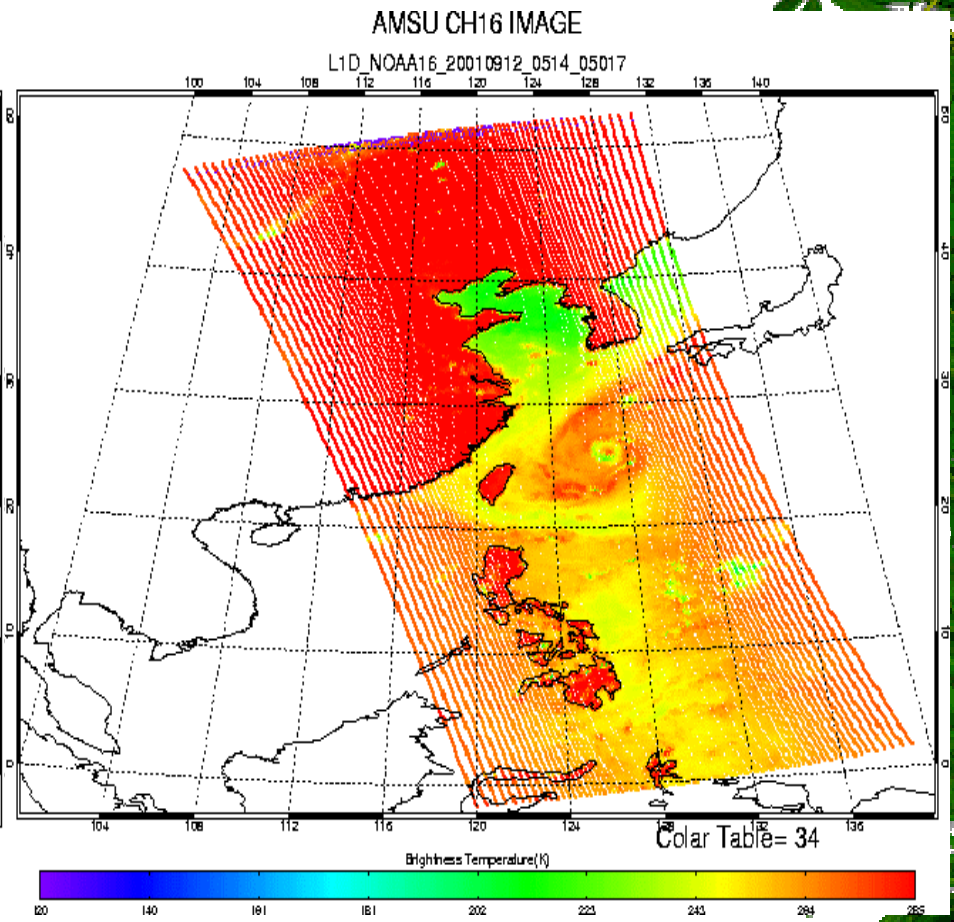


Typhoon monitoring &2D & 3D wind vector retrieval

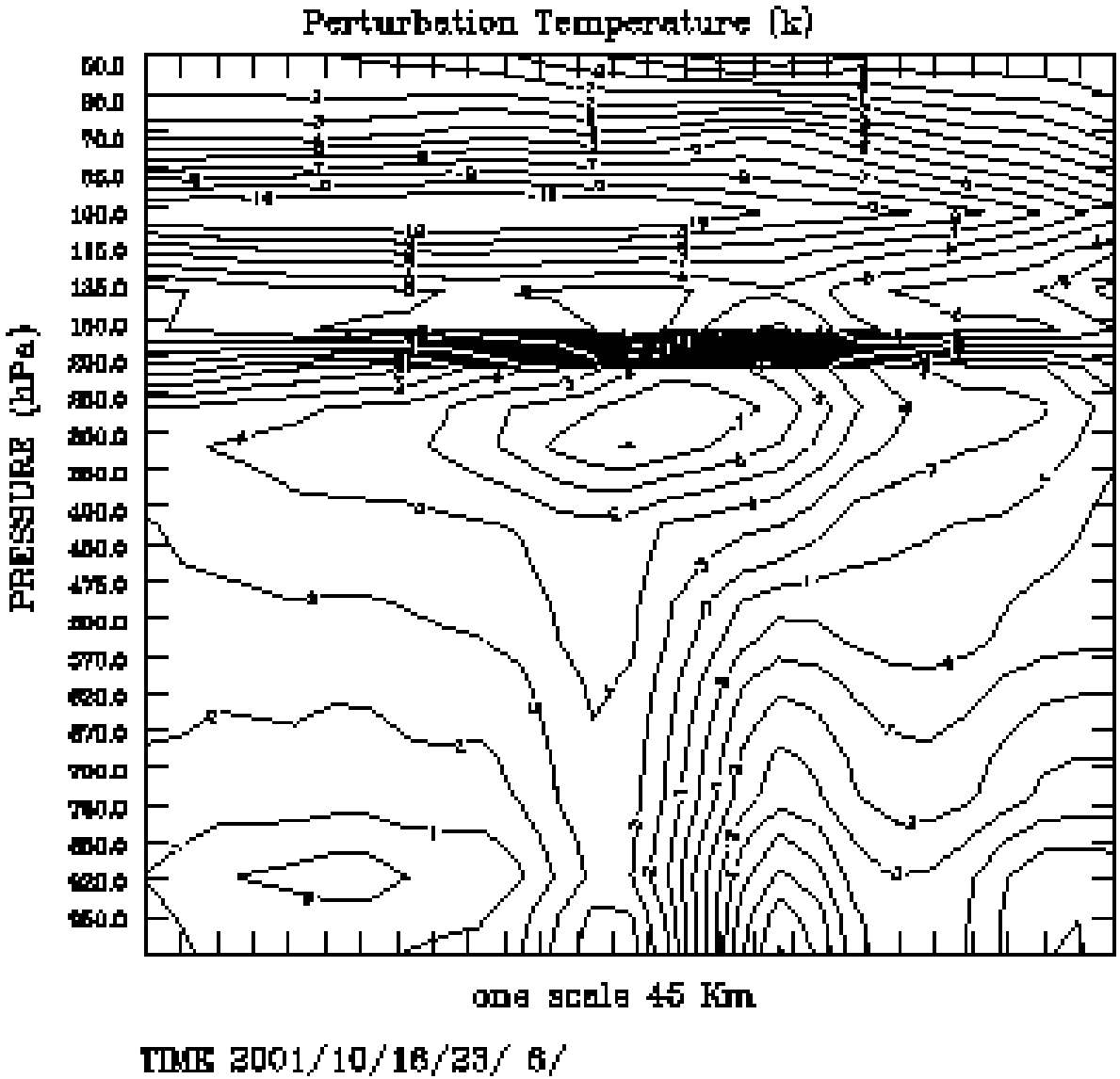
- 2D wind retrieval algorithm followed Kidder's (2000) paper
- According 250hPa Max. anomalies Temp to define center of typhoon
- 3D wind is calculated by gradient wind equation
- Appreciate Tong Zhu, Da-Lin Zhang and Allen Huang assistance

2001.0911-0912

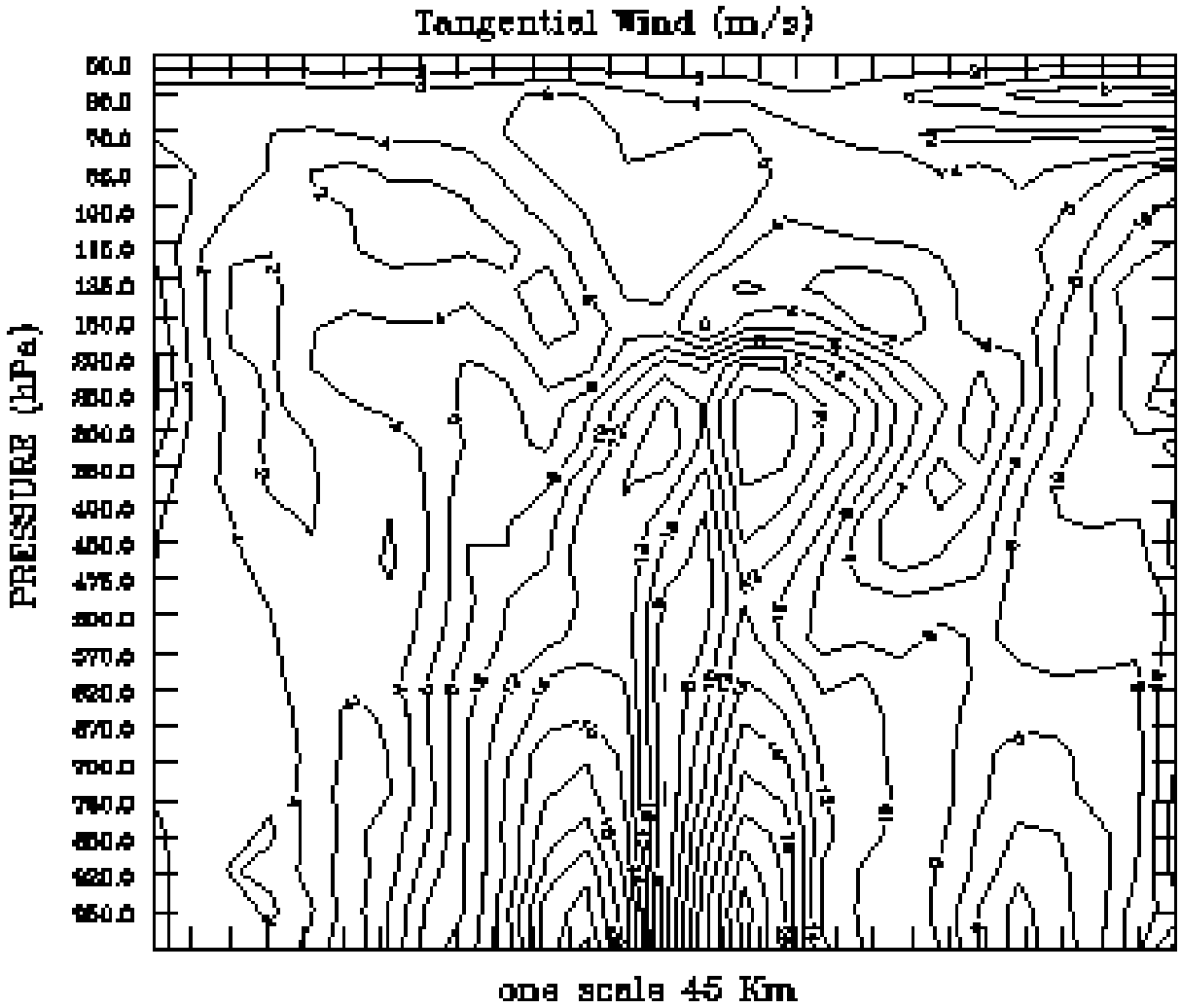




Typhoon 2001.10.16



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.