Diagnosis and Tuning of observation error in 1DVAR(MIRS) in all sky conditions

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Cost function in variational retrieval:

$$J(x)=[\tfrac{1}{2}(x\ -x_b)^T\times B^{-1}\times(x\ -x_b)]+[\tfrac{1}{2}(y_o-H(x))^T\times R^{-1}\times(y_o-H(x))]$$

The solution to minimization of cost function

$$x_a=x_b+\{(B^{-1}+\mathrm{H}^T R^{-1}\mathrm{H}\ )^{-1}\mathrm{H}^T R^{-1}\}[y_o-H(x_b)]$$

Another form of χ_a

$$x_a=x_b+\sigma x_a=x_b+Kd_b^0$$

Difference between observation and background: d_b^o

$$d_b^o=y^o-H(x_b)=y_o-H(x_t)+H(x_t)-H(x_b)\approx\varepsilon_o-H\varepsilon_b$$

$$E[d_b^o(d_b^o)^T]=R+\mathrm{HBH}^T \qquad (1)$$

The difference of analysis and background:

$$d_b^a = H(x_a) - H(x_b) \approx \mathrm{H}\sigma x_a = \mathrm{HK}d_{\mathrm{b}}^o$$

Considering of (1)

$$E[d_b^a (d_b^o)^T] = \mathrm{HBH}^T(\mathrm{HBH}^T + R)^{-1} E[d_b^o (d_b^o)^T] \qquad (2)$$

The difference of analysis and observation:

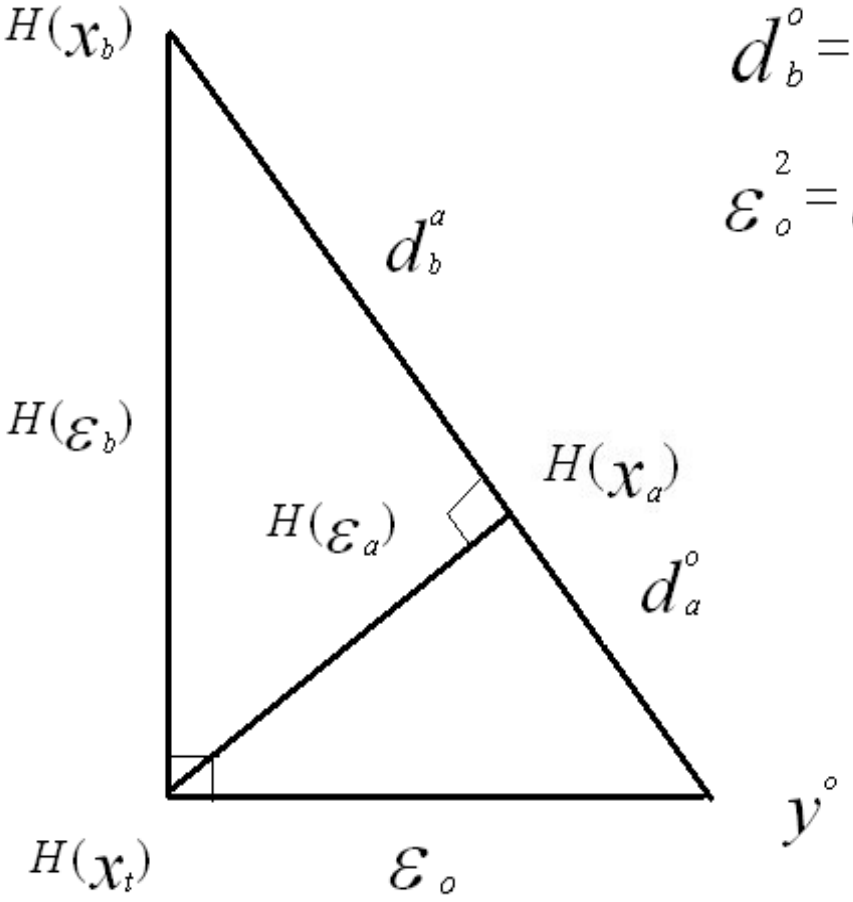
$$d_a^o = y_o - H(x^b + \sigma x_a) \approx y_o - H(x_b) - \mathrm{HK}d_b^o$$

Combination (1) and (2)

$$E[d_a^o d_b^{oT}] = R \qquad (3)$$

Interpretation of equations (1)-(3) in geometry

Observation error and background error are orthogonal.



$$d_b^o = d_a^o + d_b^a$$

$$\varepsilon_o^2 = d_b^o * d_a^o$$

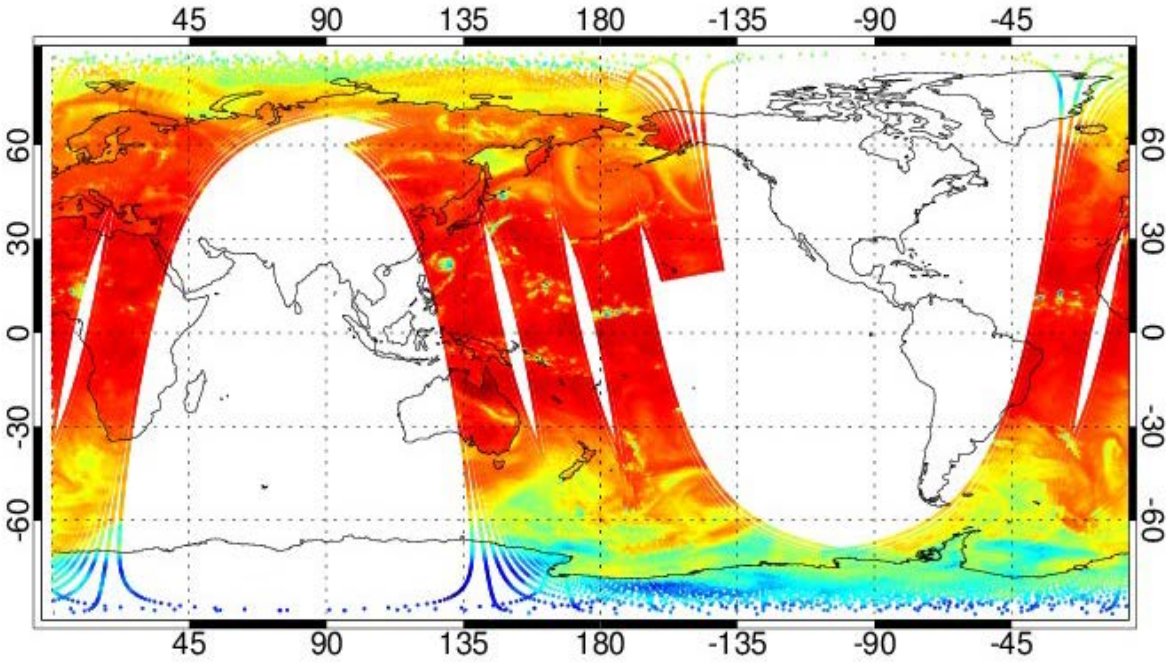
By G.Desroziers, et.al 2005, Q.J.R. Meteorol

Observation of NOAA-19 to typhoon ‘FAPIYA’ .

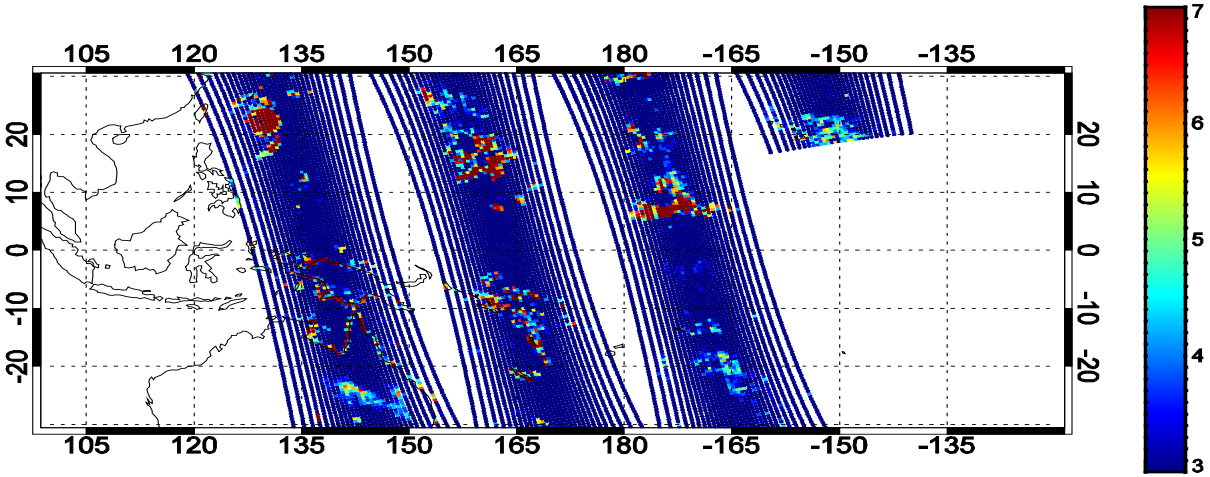
1D-var retrieval by MIRS.

Channel used: AMSU-A 5-11, MHS 3-5.

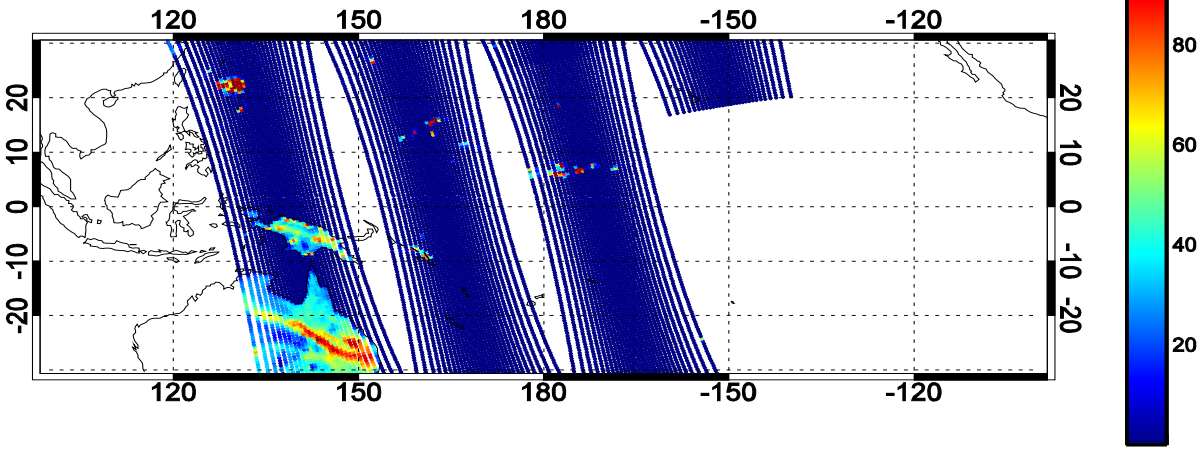
On open sea.



Difference between observation and background in Ch3 and rain probability- approach to divide observation into clear sky, cloudy and precipitation.

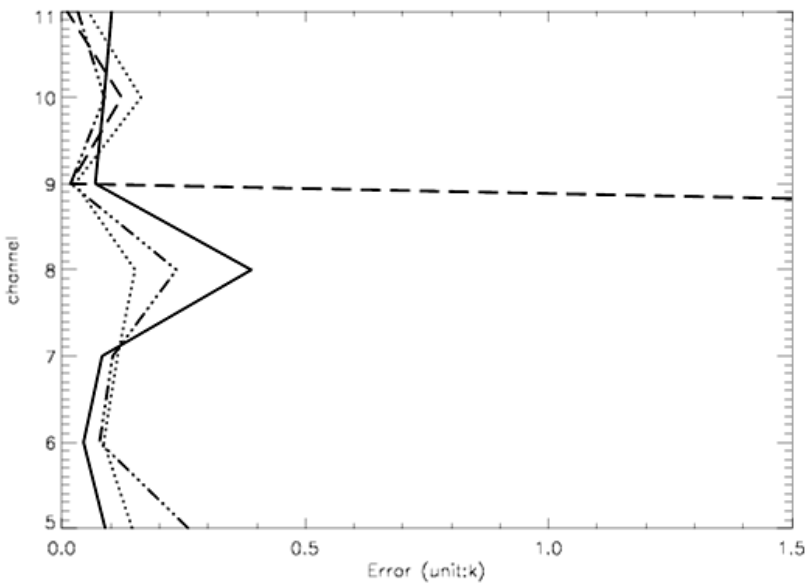


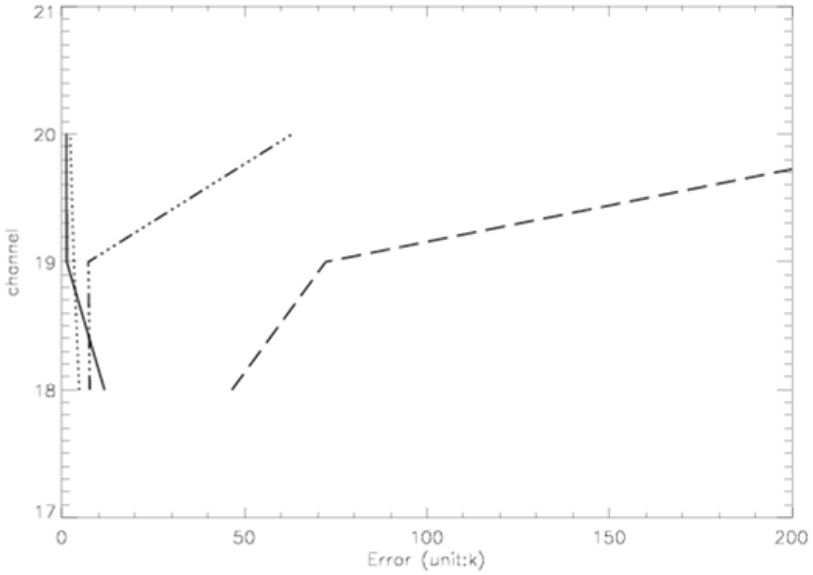
The absolute value of difference between observation and background BT on ch3 big than 5 means cloud exists.



Rain probability, big than 60 means precipitation exist.

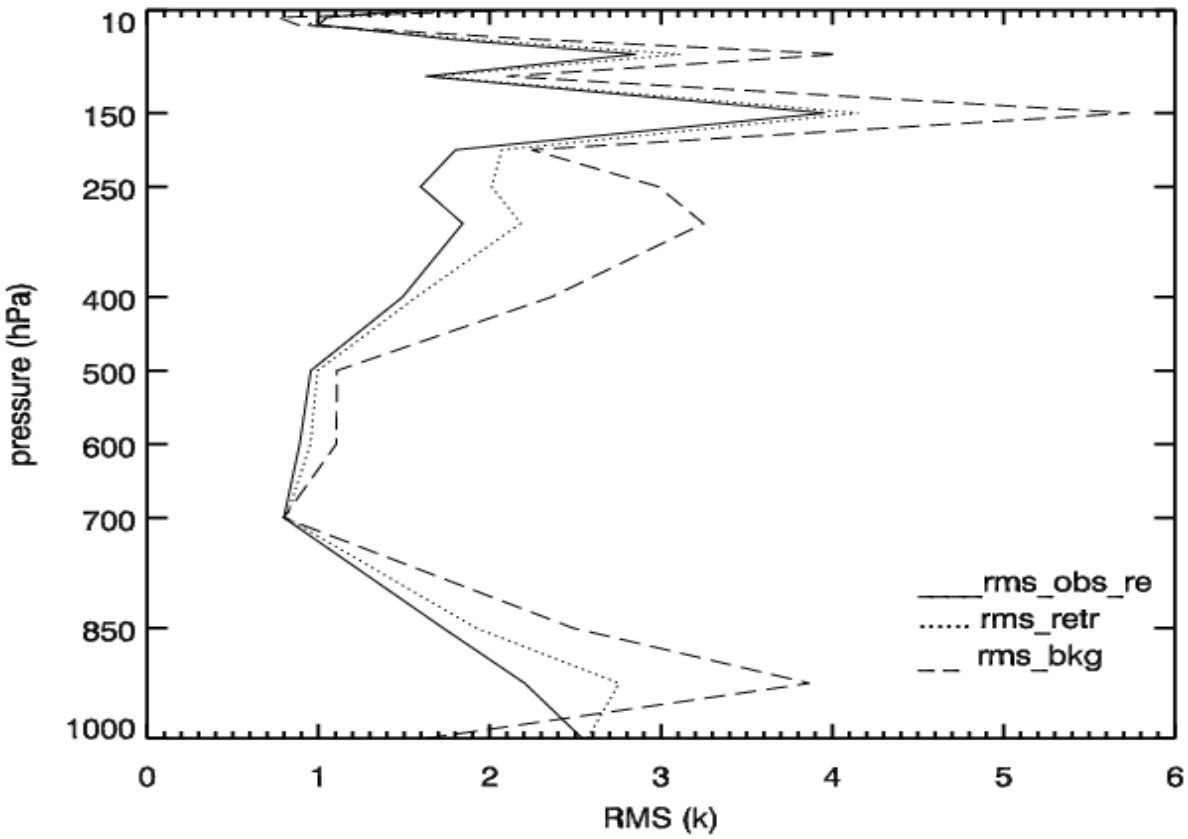
Comparison of R between tuned and original



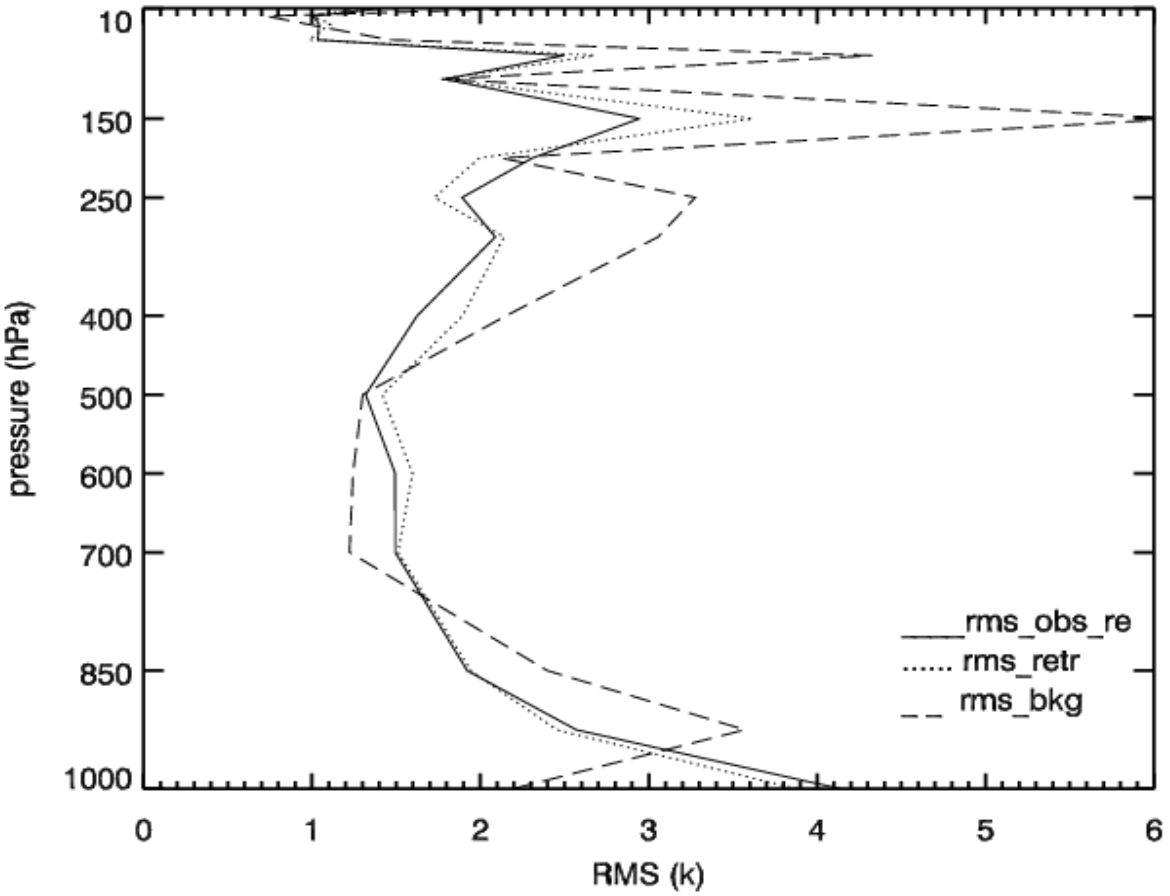


R of original (solid) and tuned in clear sky (dotted),
cloudy (dotted- dashed) and precipitation (dashed) on
AMSU-A ch5-11 (left) and MHS ch3-5 (right) (on diagonal)

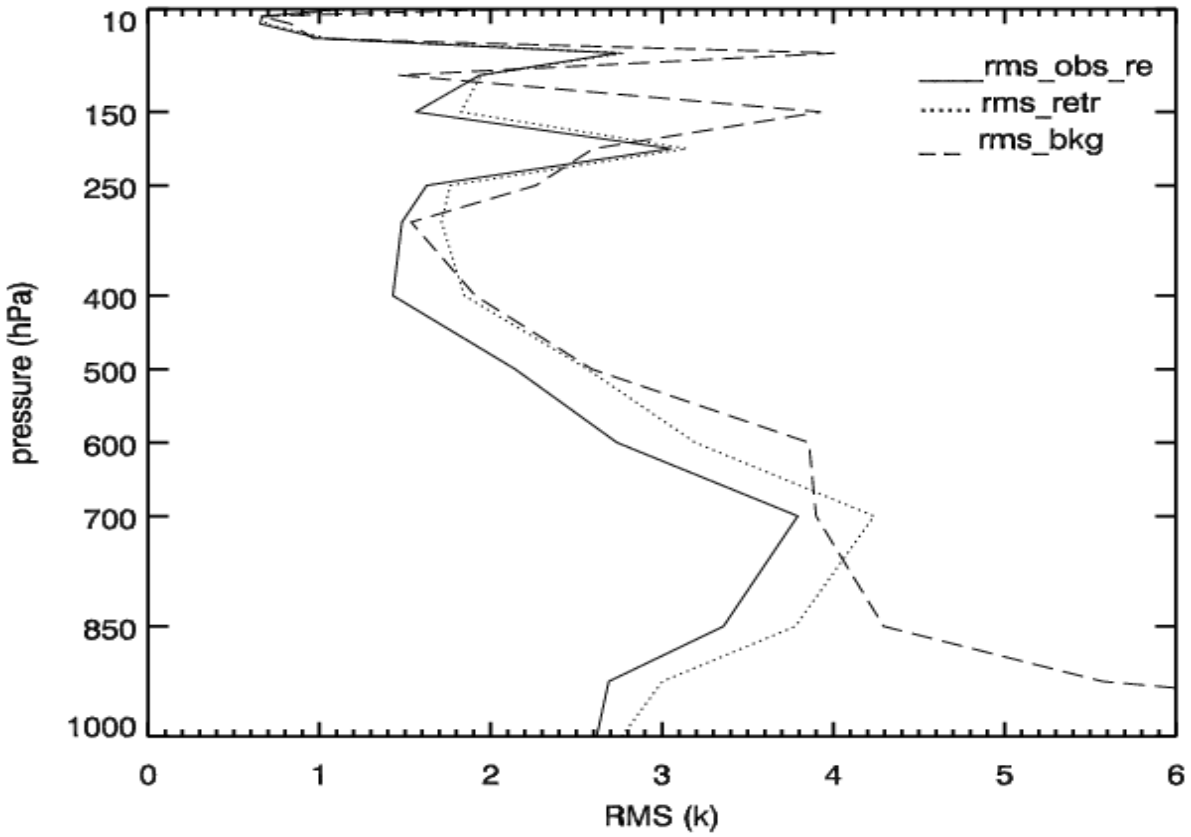
Comparison of retrieved temperature on RMS in clear sky



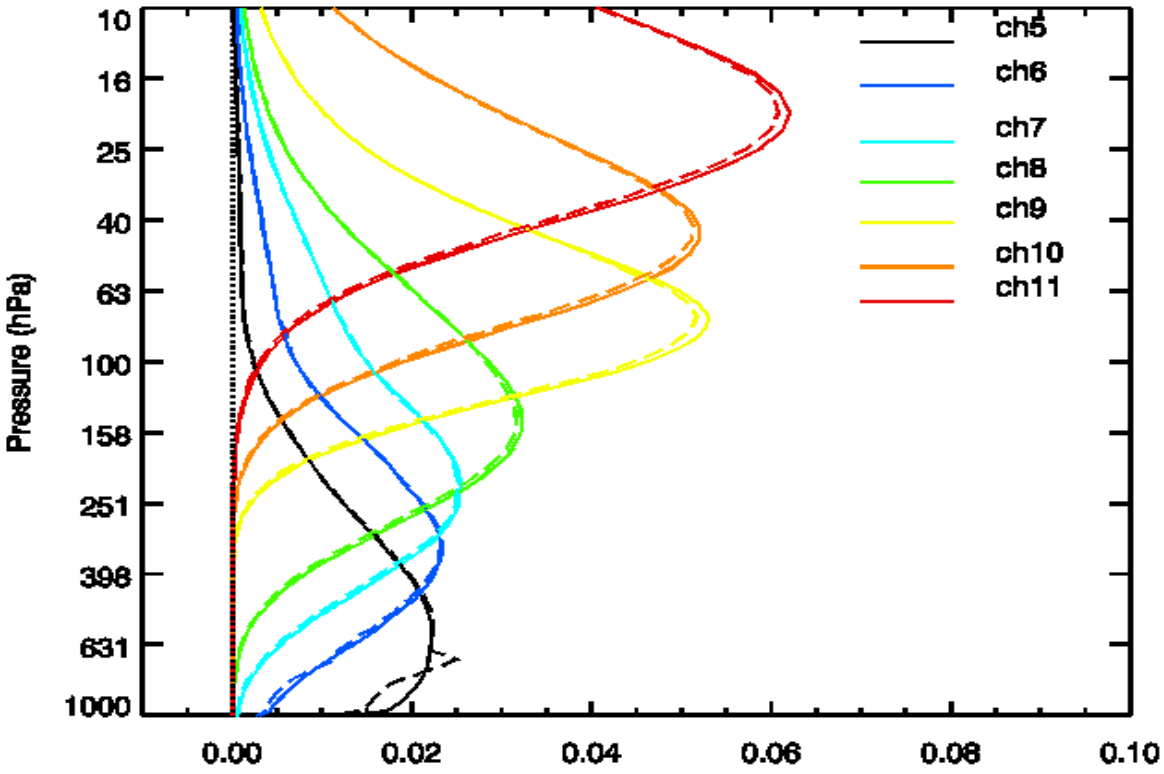
Comparison of retrieved temperature on RMS in cloudy



Comparison of retrieved temperature on RMS in precipitation

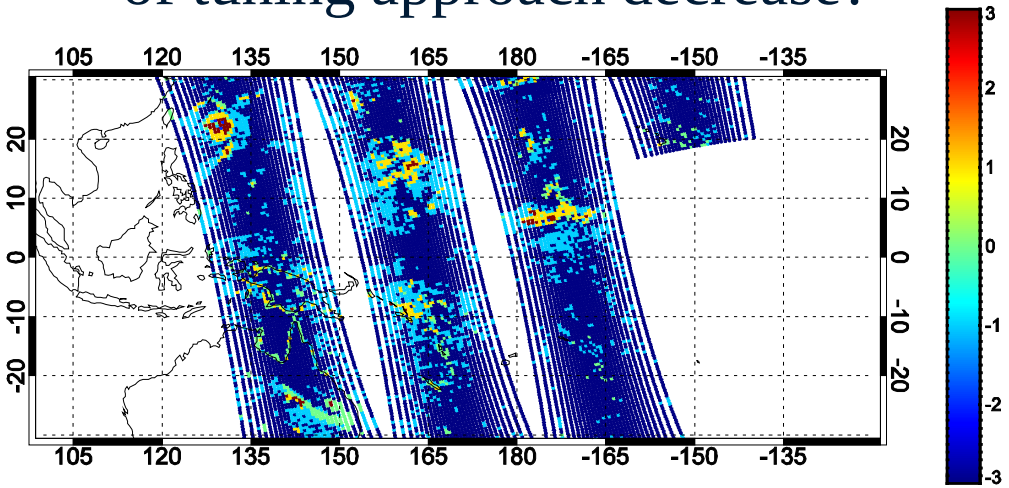


Reason of retrieved temperature un-ideal at 500-700hPa

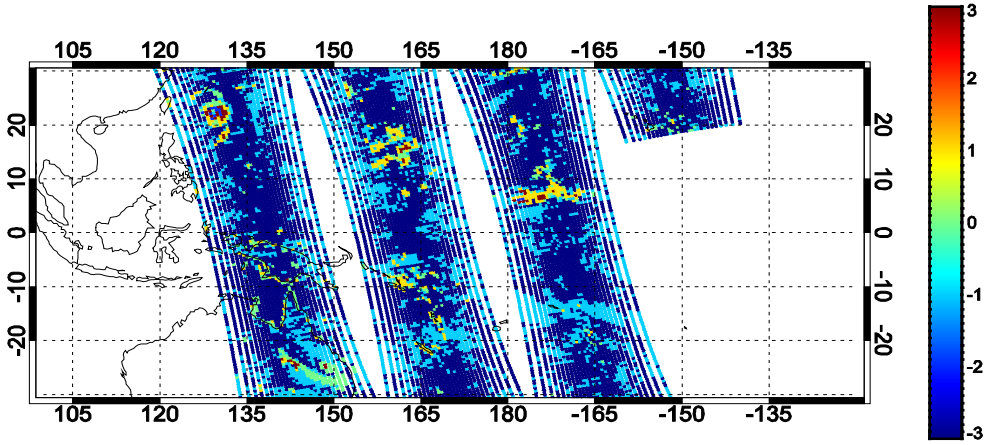


Temperature jacobian of ch5-11
in clear sky (solid) and cloudy (dashed) on AMSU-A

The percentage of analysis between observation and background decreases in unclear sky at all channels, which makes the effect of tuning approach decrease?

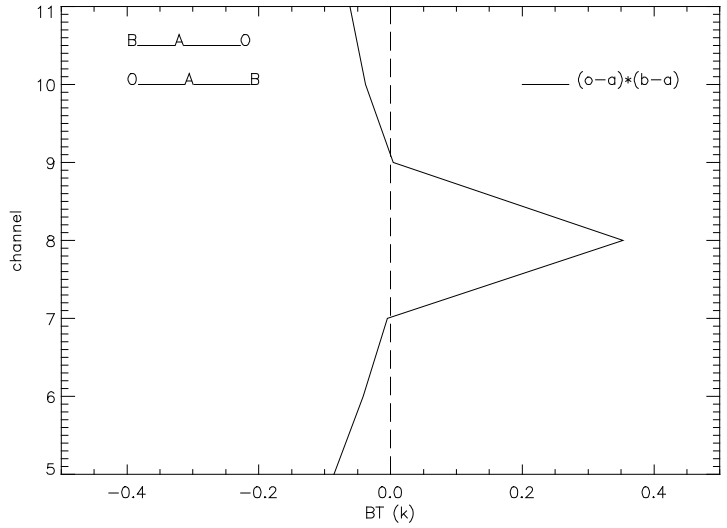


The percentage is 84%,57% and 30% in clear sky, cloudy and precipitation on channel 5 of AMSU-A

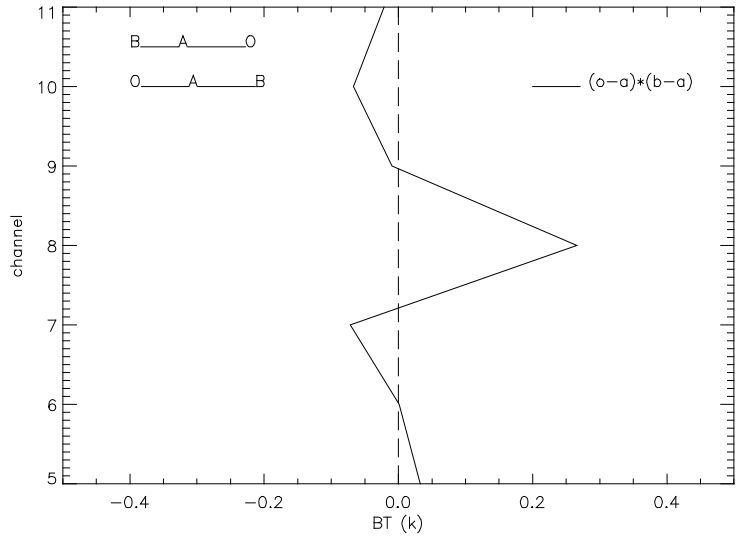


81%,62% and 25% on channel 4 of MHS

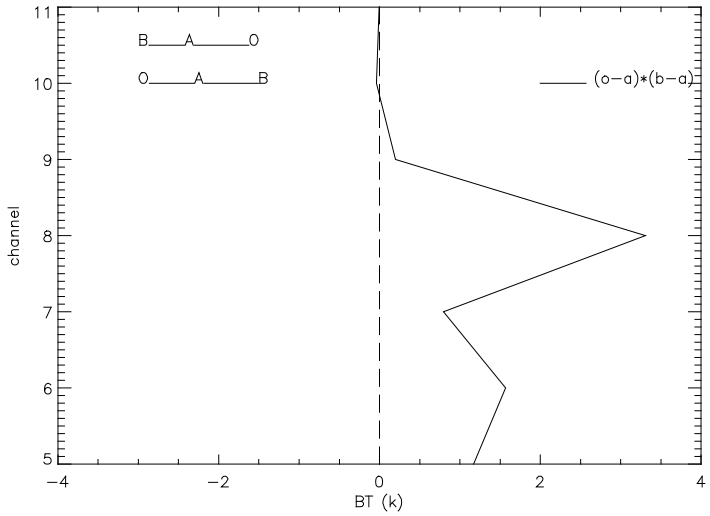
The relative position of analysis between observation and background on channel 5-11



a. clear sky

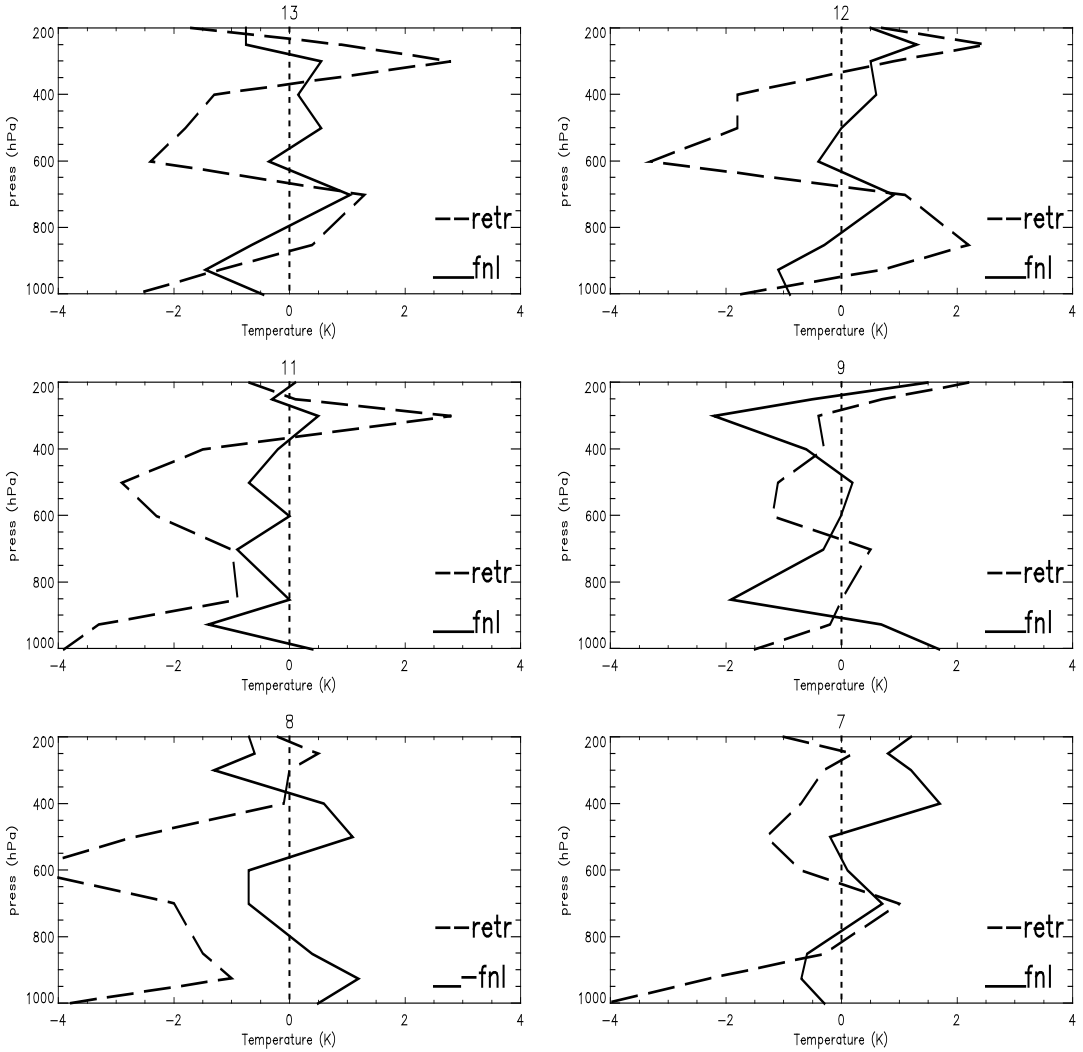


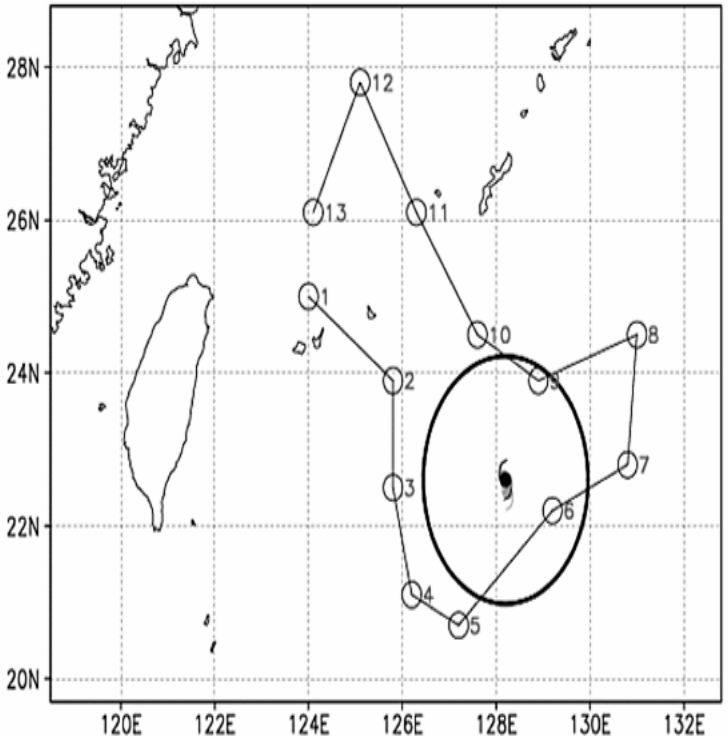
b. cloudy



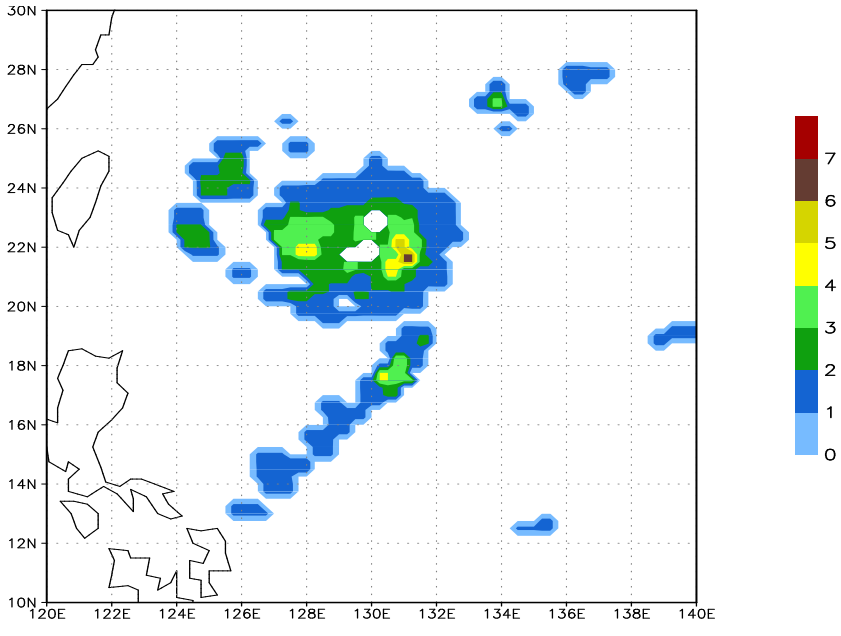
c. precipitation

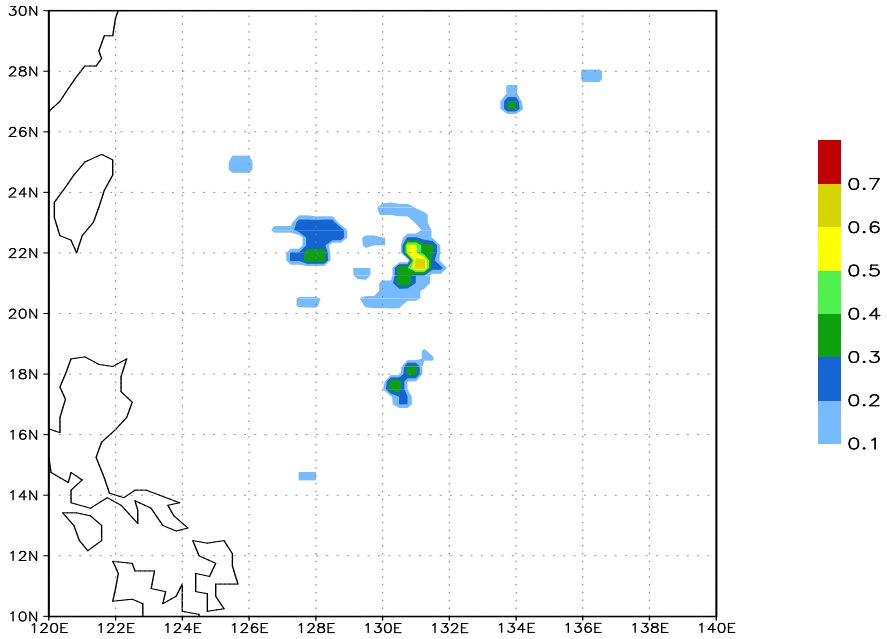
Comparison retrieved temperature with dropsounde





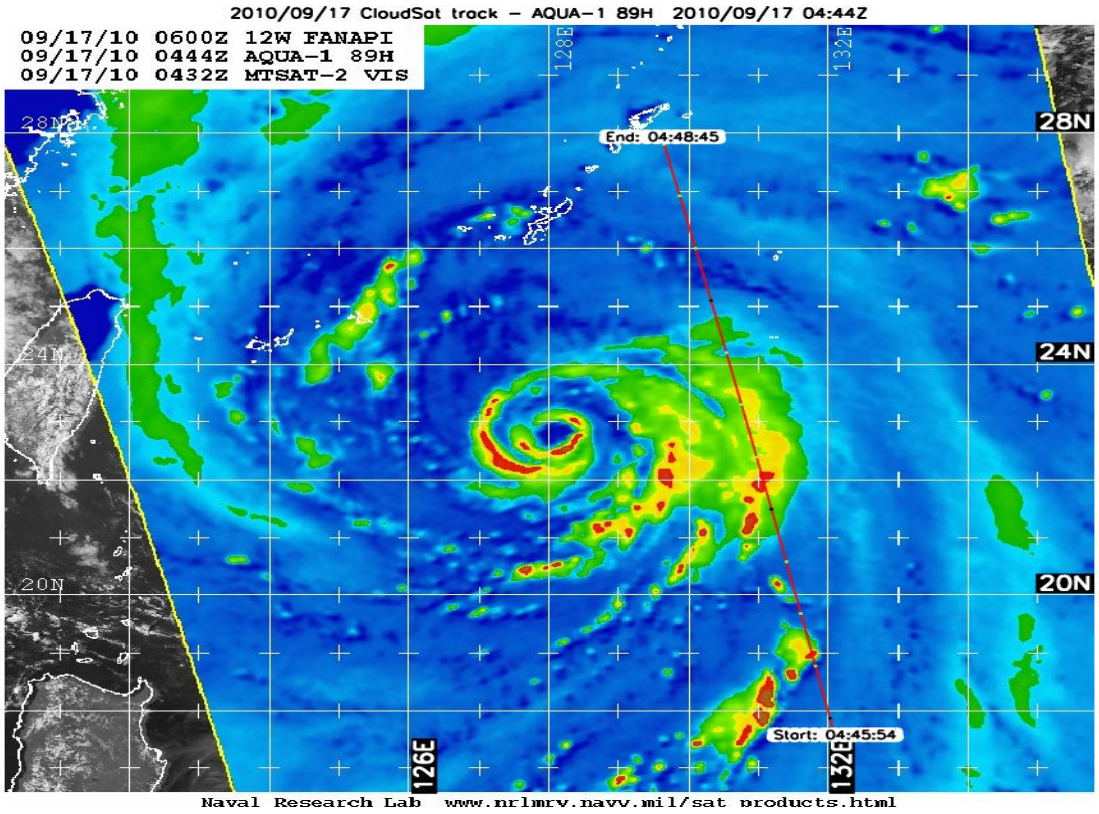
Retrieved water contents





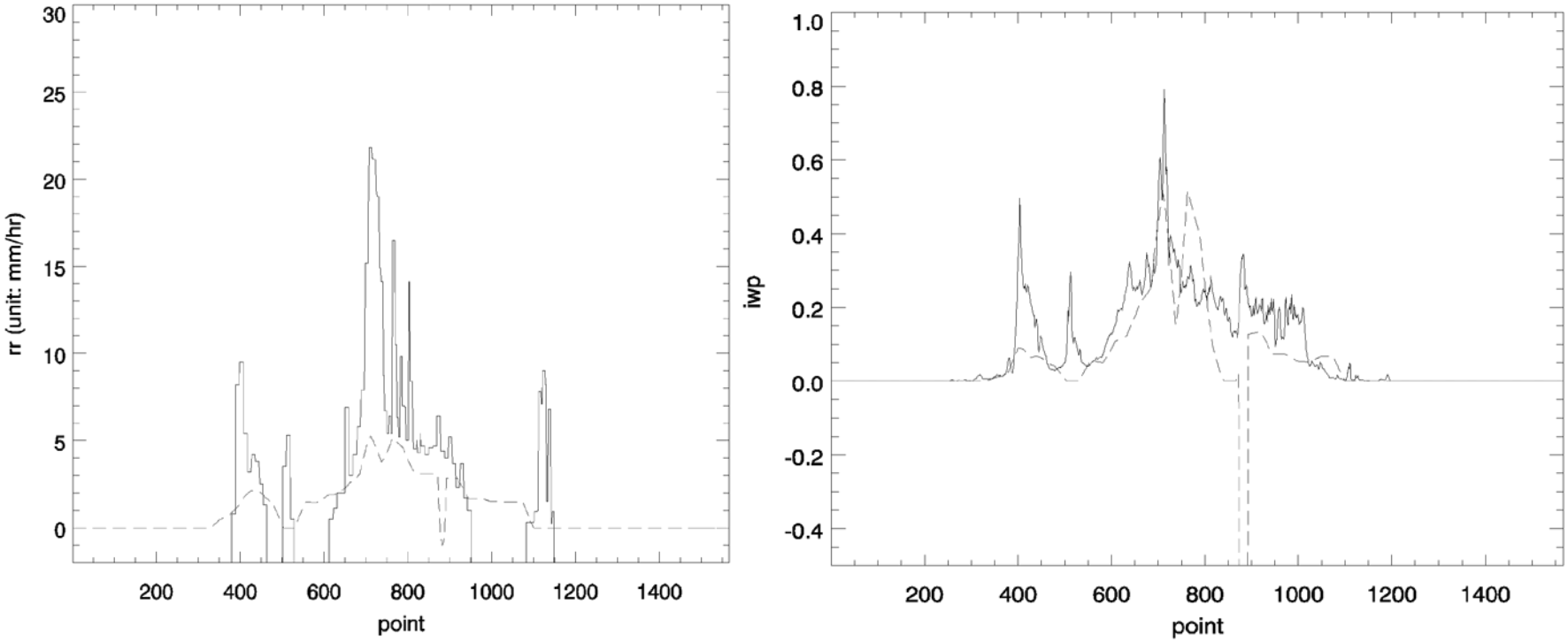
Retrieved rain rate (left) and ice water path (right)

Observation orbit of CloudSat to ‘FAPIYA’



Observation orbit of CloudSat (red line)

Comparison of retrieved water contents and CloudSat data



Comparison of retrieved water contents (dashed) and CloudSat (solid),left is rain rate and right is ice water path.

Conclusion

1.Observation error diagnosis and tuning could refine observation error in all sky conditions such as clear sky, cloudy and precipitation, making temperature retrieval of MIRS improved.

2.The application of error tuning approach needs more verification in unclear sky.

3.To water contents such as ice water path (IWP), variational retrieval of MIRS could generate results of close to CloudSat.

THANKS !