

The Rainfall Estimation Using the X-band Radar Data during SoWMEX/TiMREX

Xin-Hao Liao Tai-Chi Chen Wang Wei-Yu Chang

National Central University

Introduction

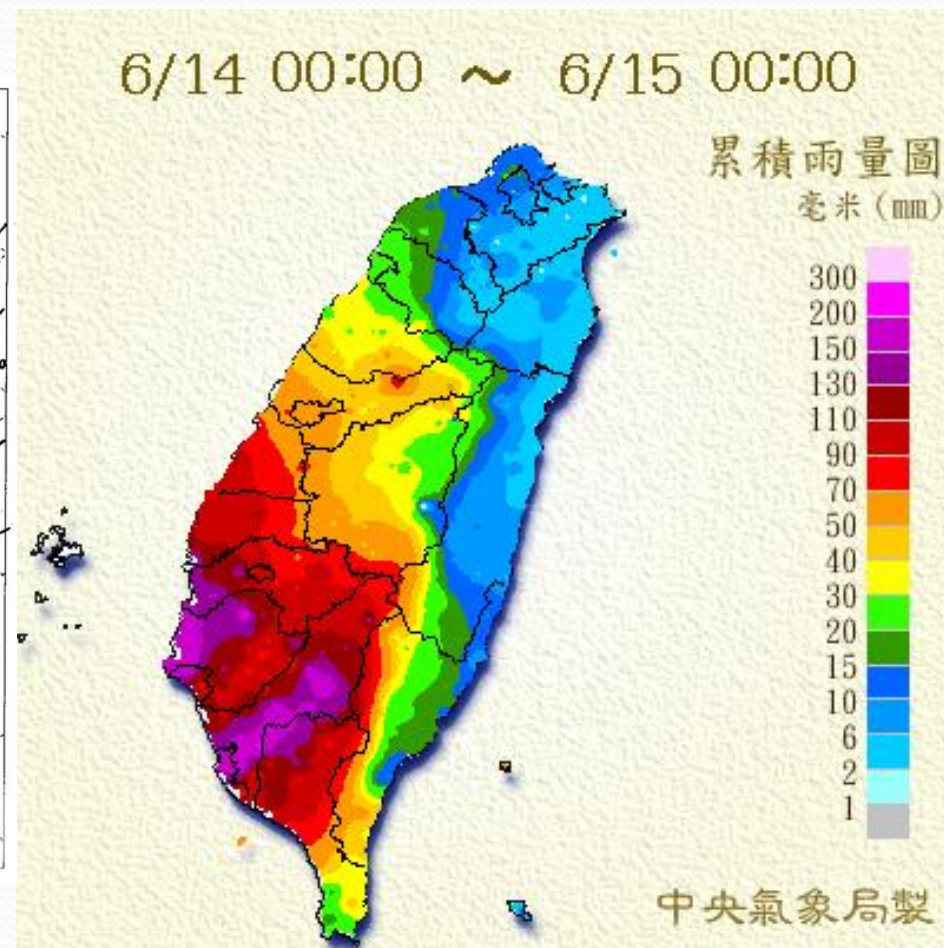
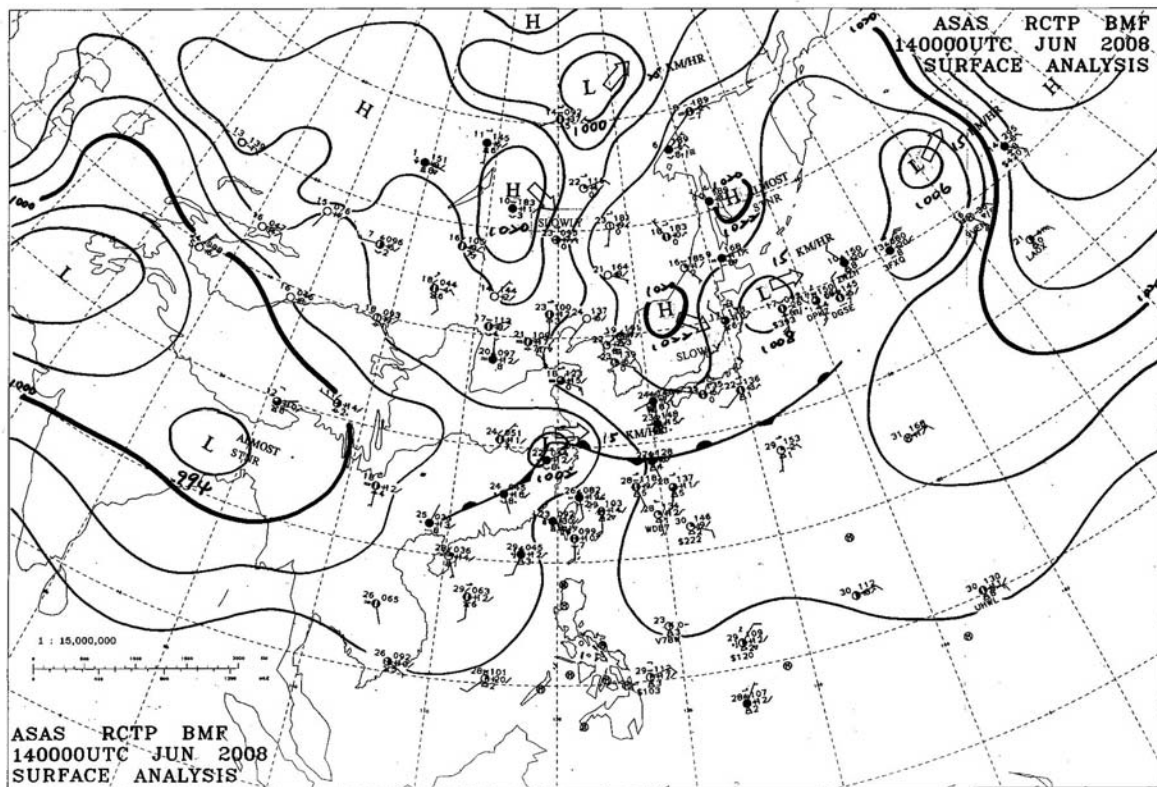
- A number of rainfall estimation algorithms utilizing polarimetric parameters, e.g., $R(Z, Z_{DR})$ and $R(K_{DP})$, are applied to X-band polarimetric radar (TEAM-R)
- Instruments :
 - USA NCAR SPOL
 - NCU TEAM-R
 - Disdrometer (2-DVD & JWD)
 - CWB raingauge



- TEAM-R (22.7527°N 、 120.4687°E)
- wave length 3 .12 cm
- observation distance 100 km

Weather review

- Case : 2008/06/14 (IOP8)



Radar data QC

filter Non-meteorological information & Φ_{DP} corrected

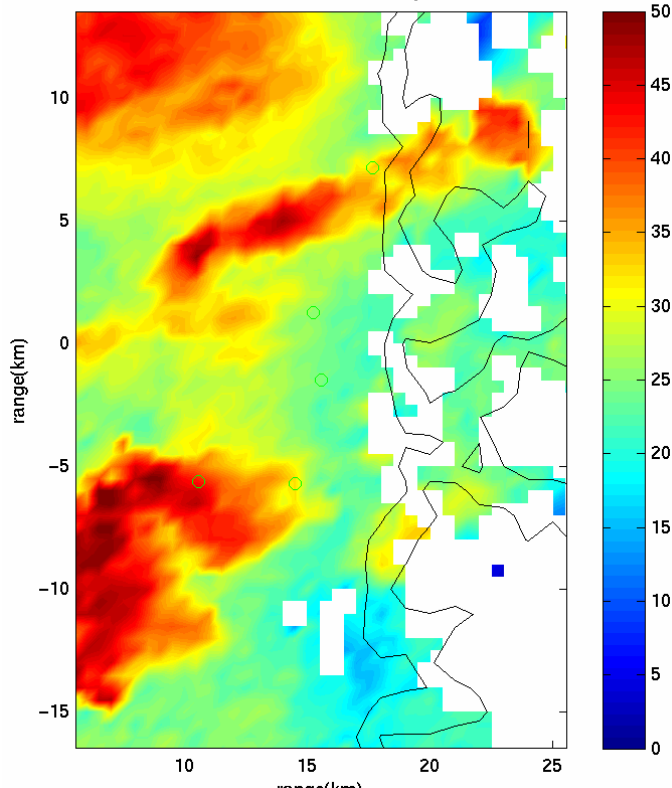
Z_{DR} bias corrected

Z & Z_{DR} attenuation correction

Z bias corrected

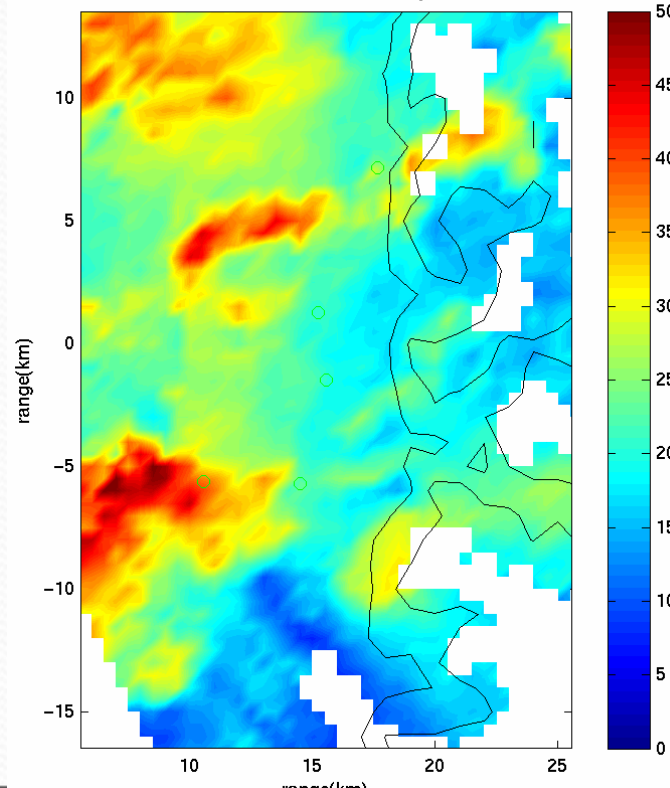
SPOL

080614 093003 CAPPI ZH Height:1.00 km



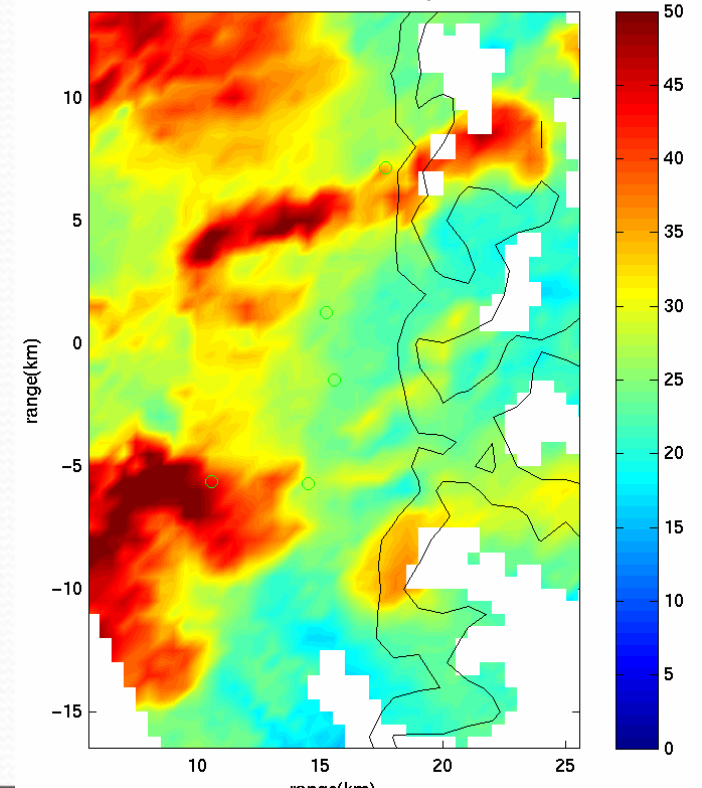
TEAM-R before QC

080614 092843 CAPPI ZH Height:1.00 km



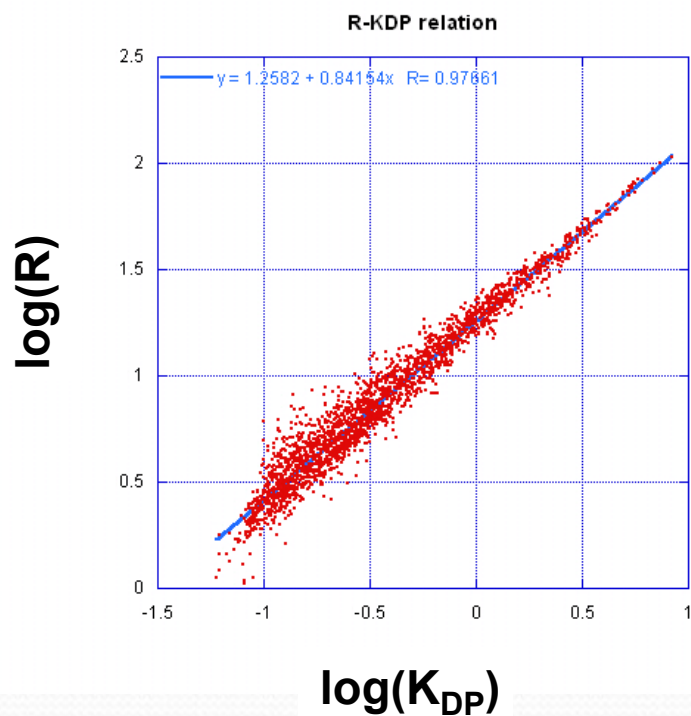
TEAM-R after QC

080614 092843 CAPPI ZH Height:1.00 km

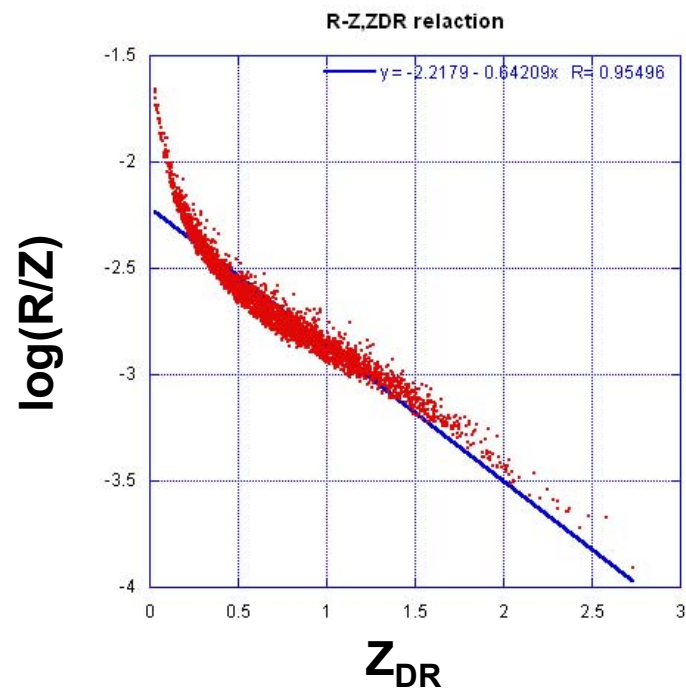


Rainfall estimation equation

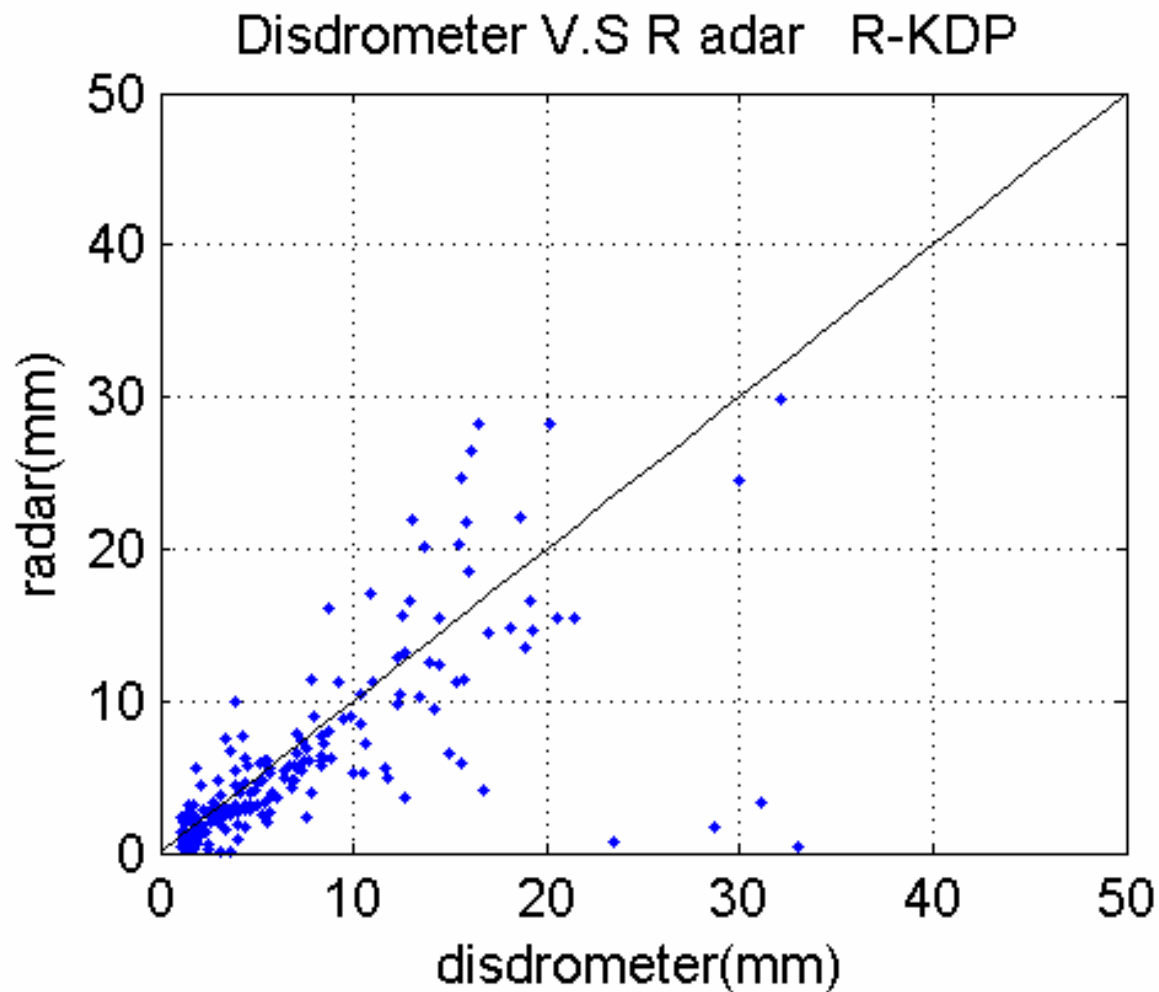
$$R = 18.1217 K_{DP}^{0.84154}$$



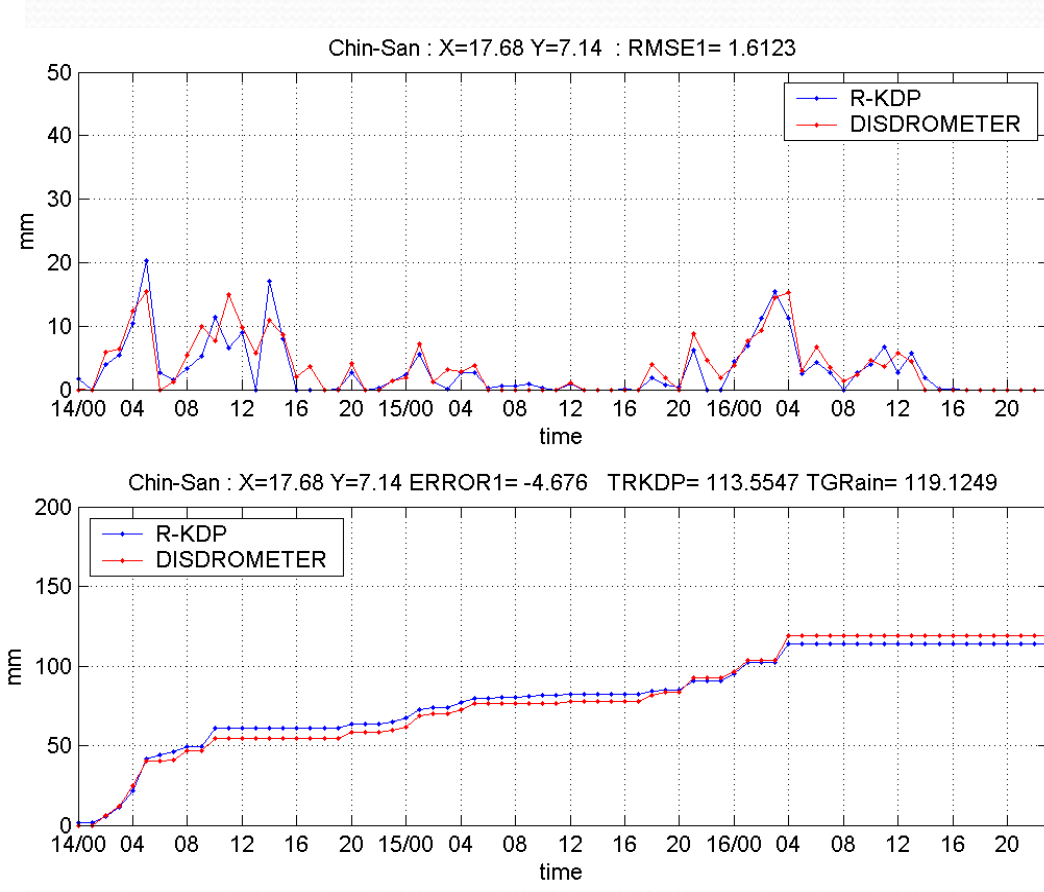
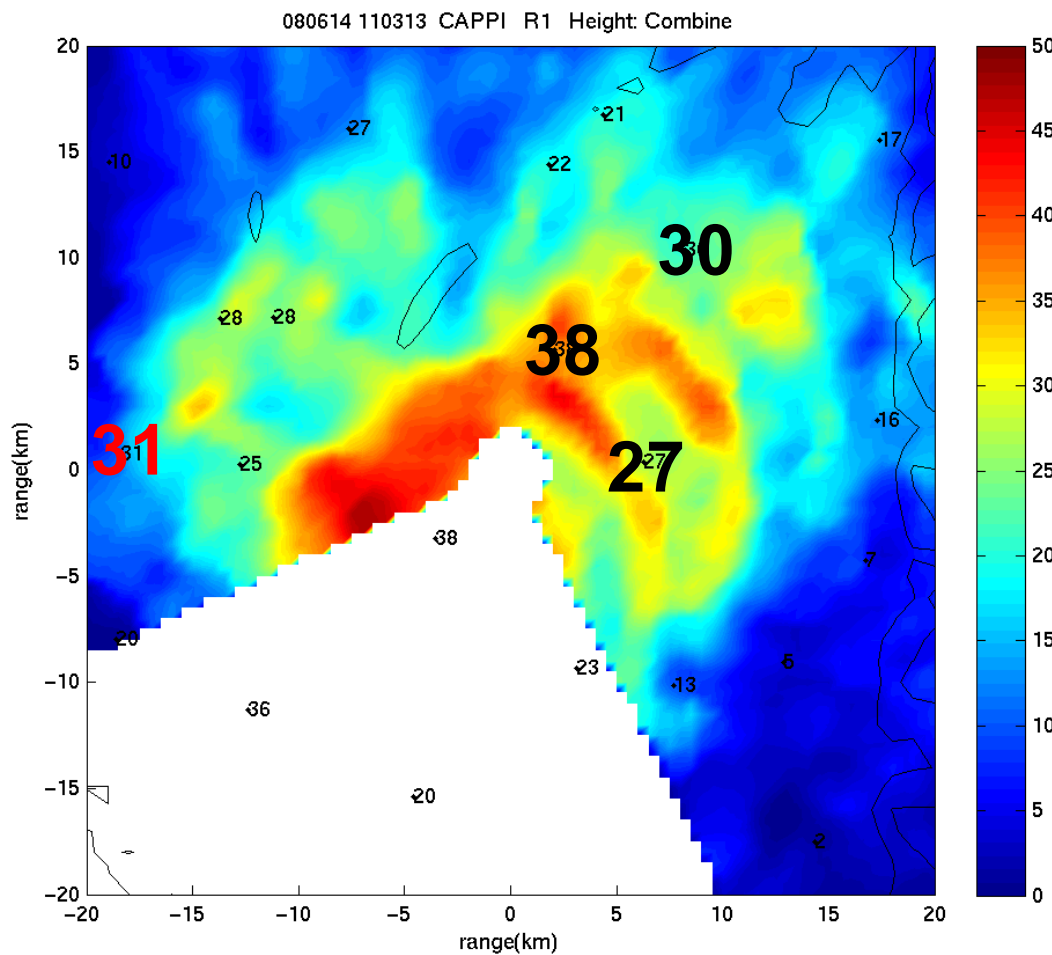
$$R = 0.0061Z * \ln Z_{DR}^{-6.4209}$$



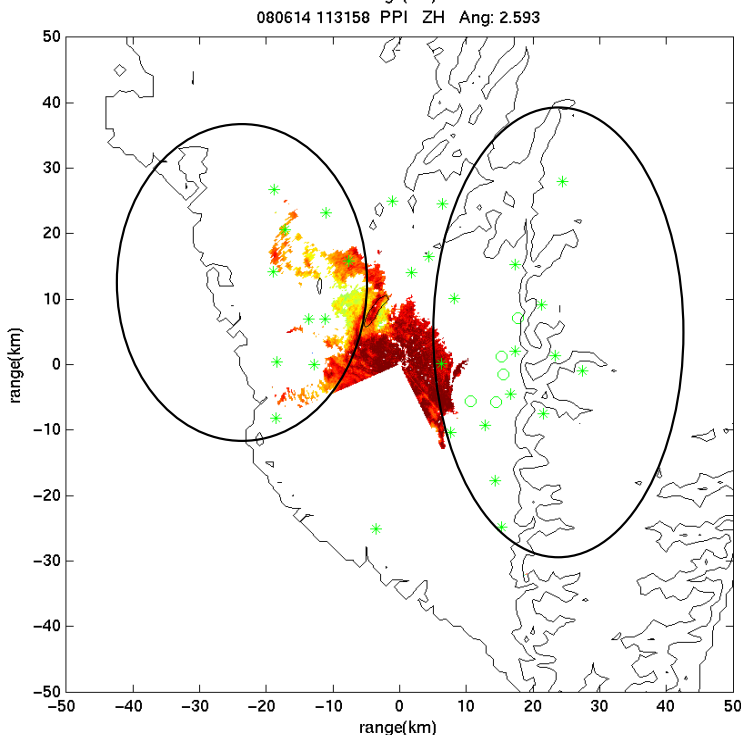
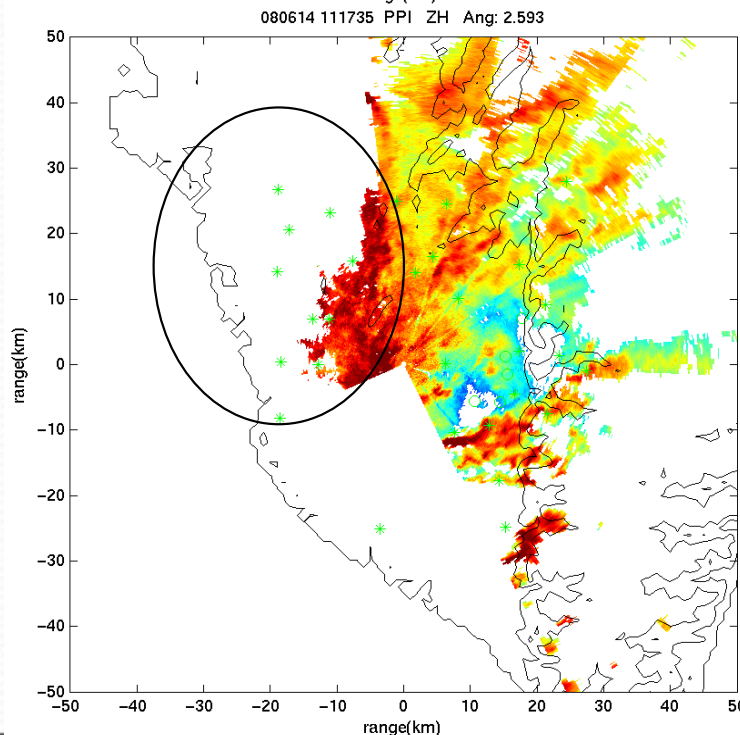
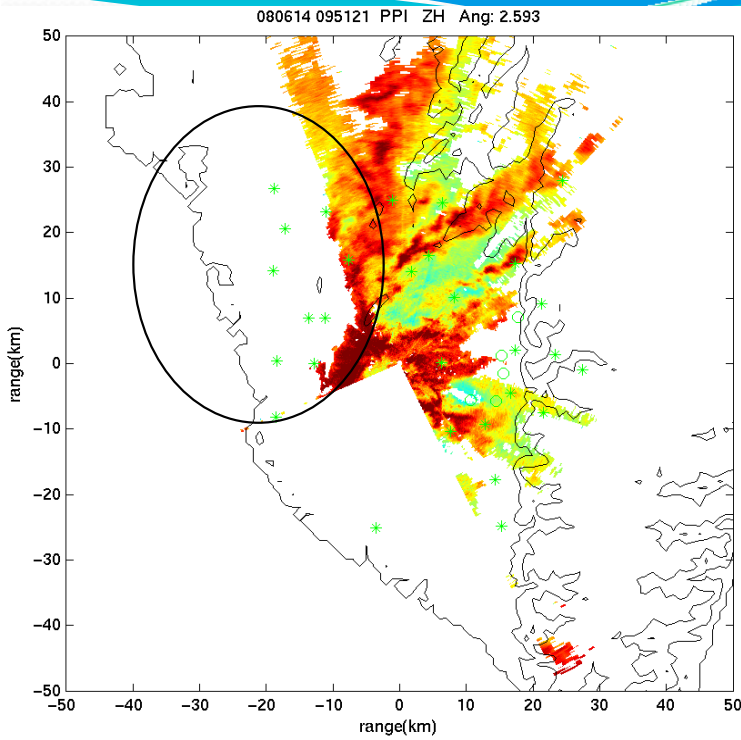
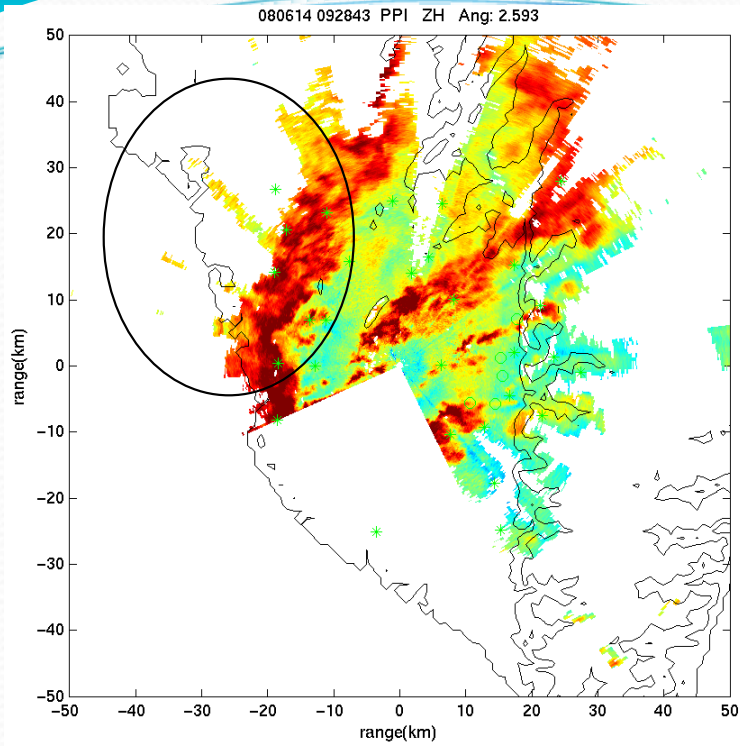
Radar QPE comparison with disdrometer (2DVD) data



Radar QPE result $\sim R(K_{DP})$



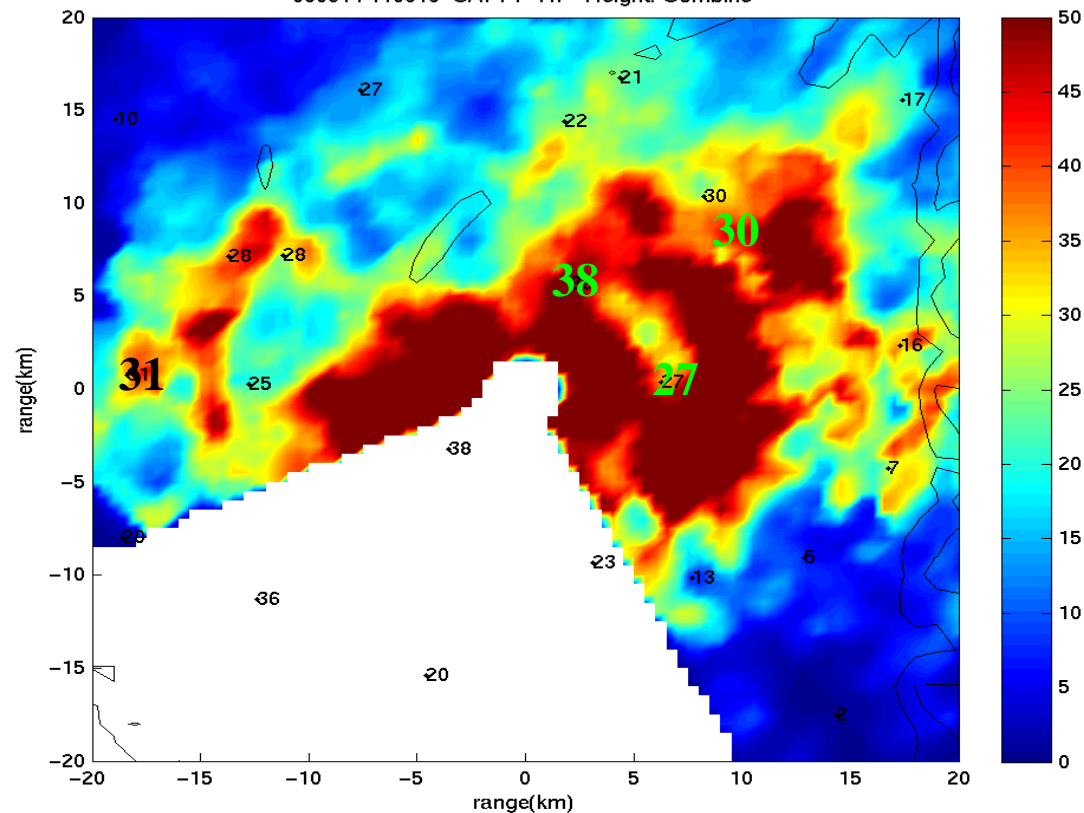
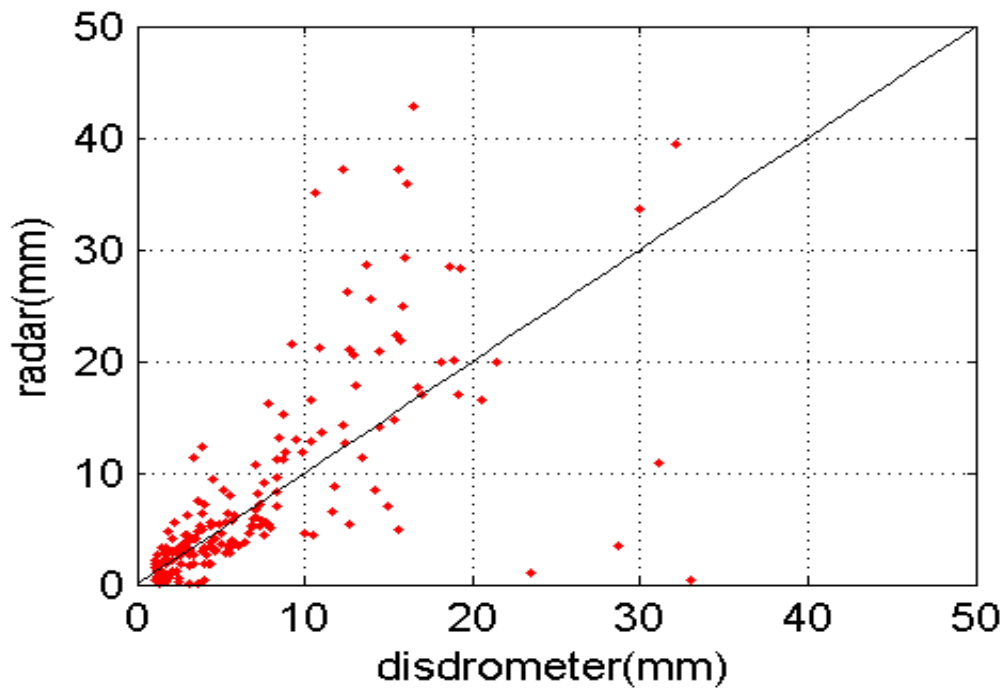
attenuation effect



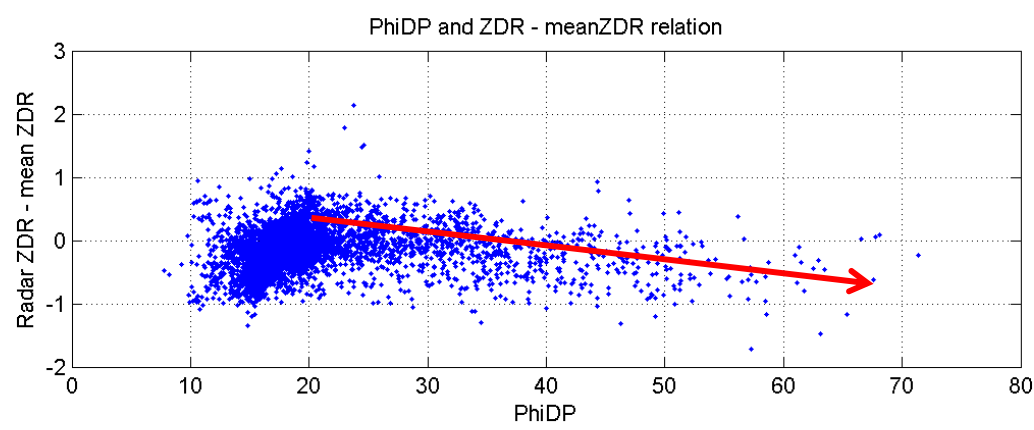
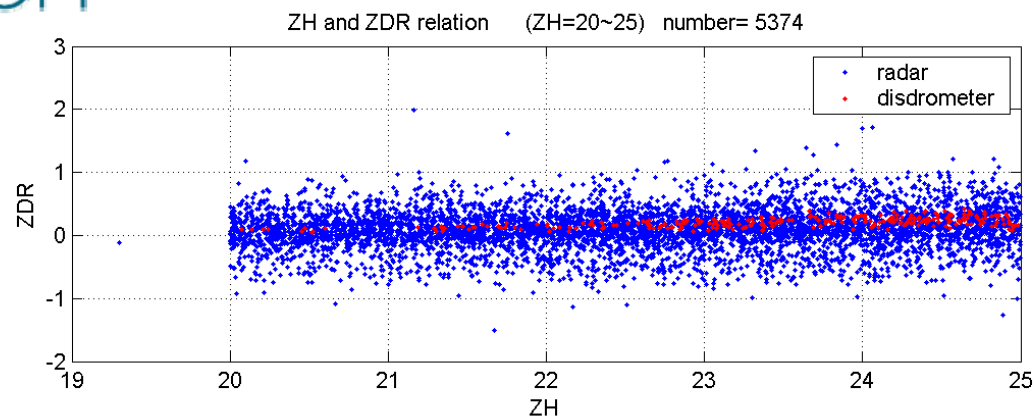
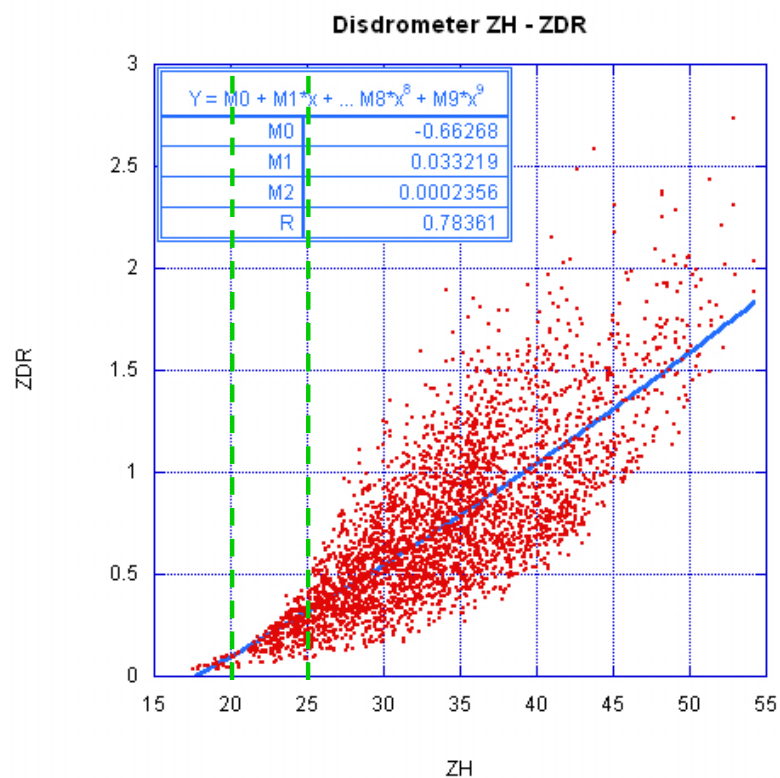
Radar QPE result $\sim R(Z, Z_{DR})$

080614 110313 CAPPI R7 Height: Combine

Disdrometer V.S R adar R-ZZDR



Z_{DR}-K_{DP}-Φ_{DP} relation

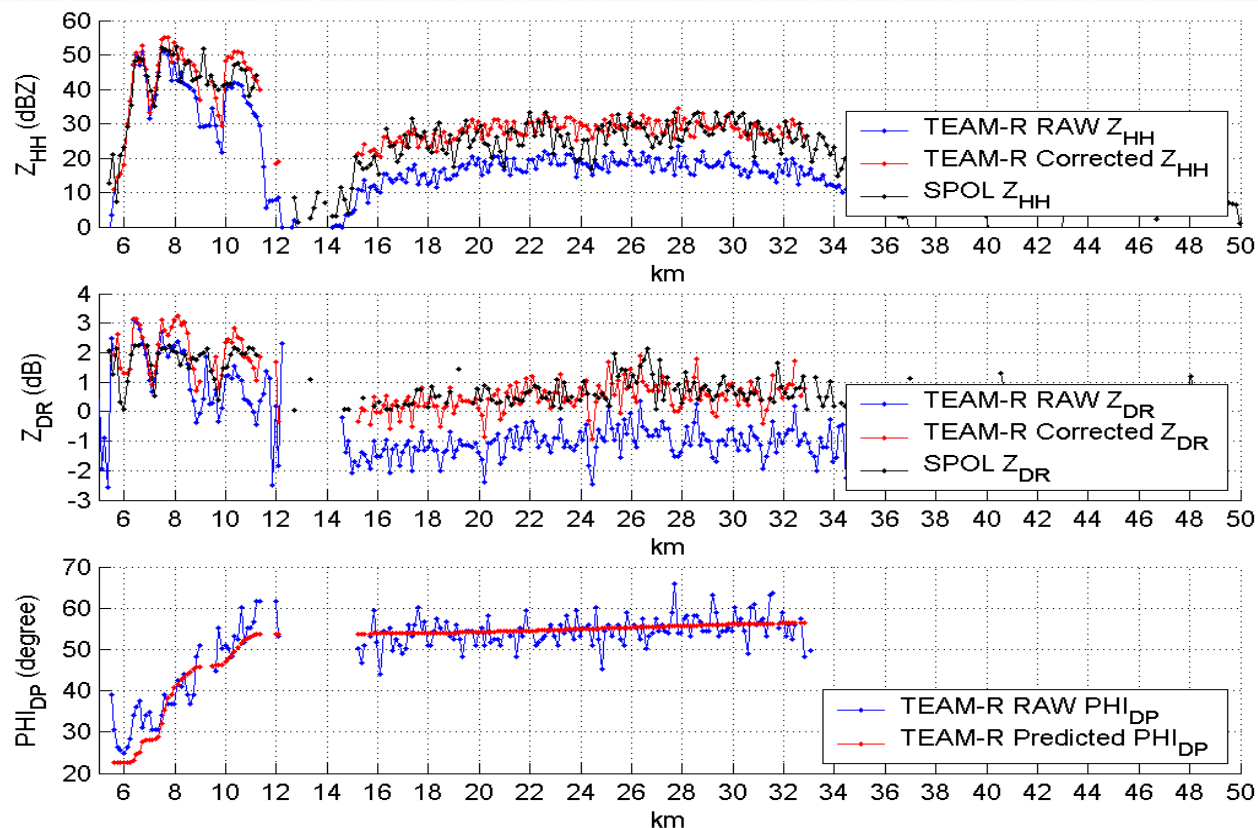


RHI real case from TEAM-R & NCAR SPOL

Variational-based att. correction

3.2° ray example

Chang W.Y., J. Vivekanandan, T.C.C. Wang, P.L. Lin: Estimation of Attenuation at X-band Using Propagation Phase and Differential Reflectivity. (*submitted*)



summary

- first time using X-band radar data for rainfall estimation in Taiwan.
- In rainfall estimation, **$R(K_{DP})$ is shown to perform better than $R(Z, Z_{DR})$.**
- In addition, $R(Z, Z_{DR})$ usually overestimates the rainfall due to insufficient correction for the attenuation of Z_{DR} .



The kinematic, thermodynamic and microphysical analysis of a convective system during SoWMEX/iMREX - June 14, 2008

Wei-Yu Chang TaiChi Chen Wang Yu-Chieng Liou

National Central University

Motivation

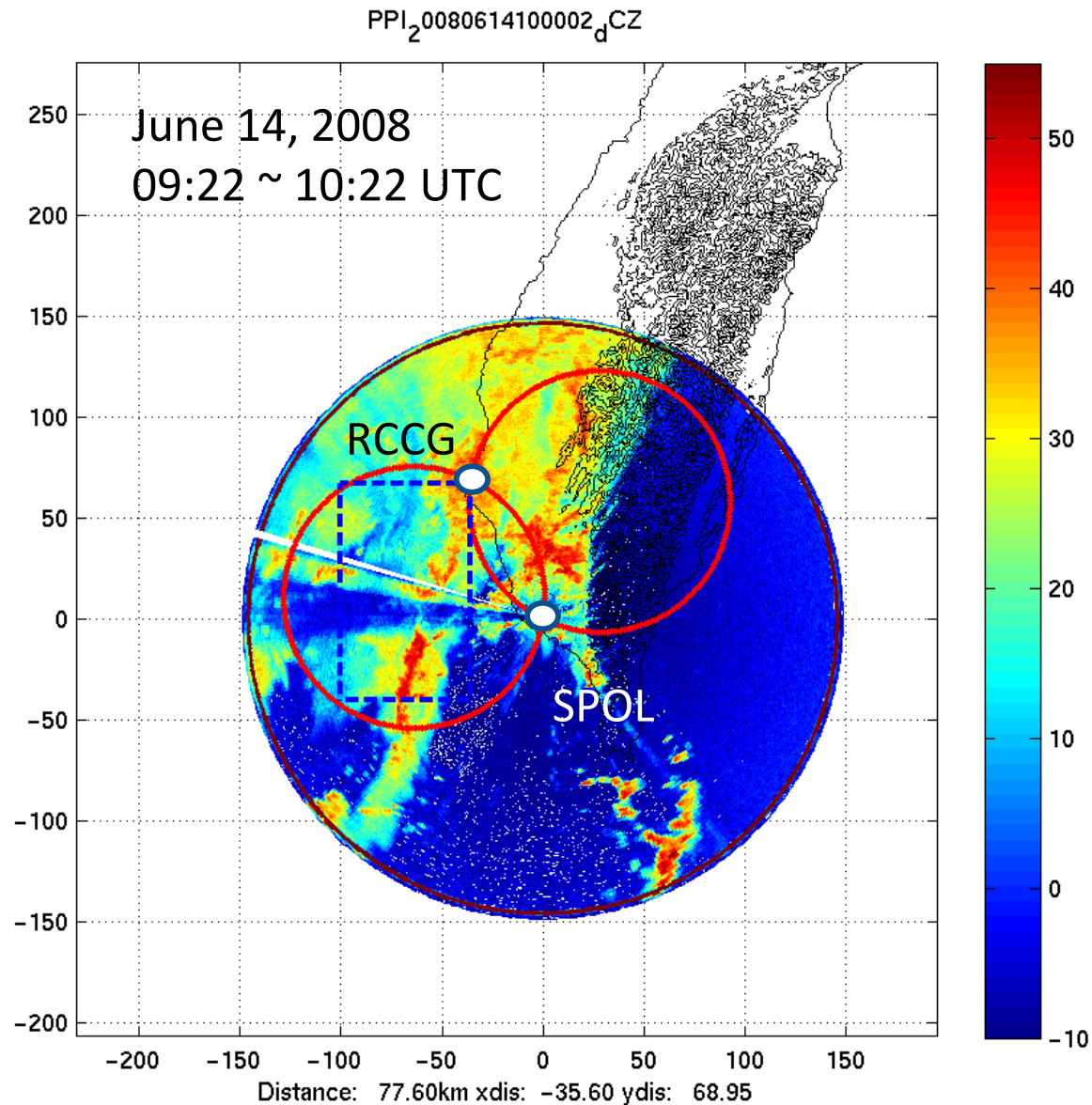
- Investigate the interactions between the kinematic, thermodynamic and microphysical fields.
- Kinematic field → Liou and Chang 2009
Variational-based dual-synthesis

$$J_{vorticity} = \sum \left\{ \frac{\partial \zeta}{\partial t} + \overline{ \left[u \frac{\partial}{\partial x} + v \frac{\partial \zeta}{\partial y} + w \frac{\partial \zeta}{\partial z} + (+f) \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) + \left(\frac{\partial w}{\partial x} \frac{\partial v}{\partial y} - \frac{\partial w}{\partial y} \frac{\partial u}{\partial z} \right) \right] } \right\}^2$$

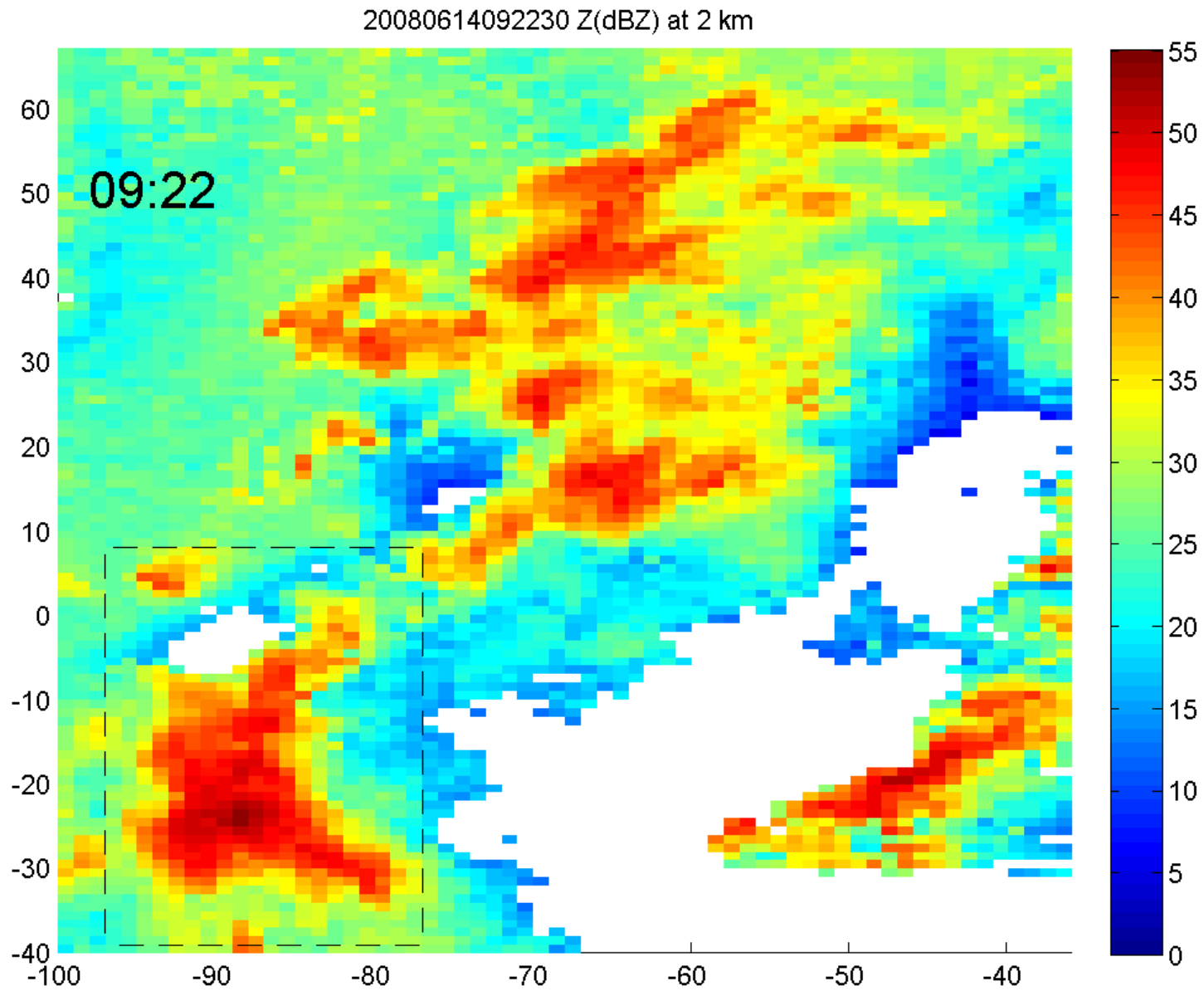
- Thermodynamic field → Gal-Chen 1978 + Sounding
- Microphysical field → Vivekanandan et al. 1999
 - Fuzzy logical particle identification
 - Rain, Graupel separated via Z_{DP} - Z_{HH}
 - Water content estimated via Z_{HH} - $M_{\text{snow, ice, graupel}}$

Case: June 14, 2008

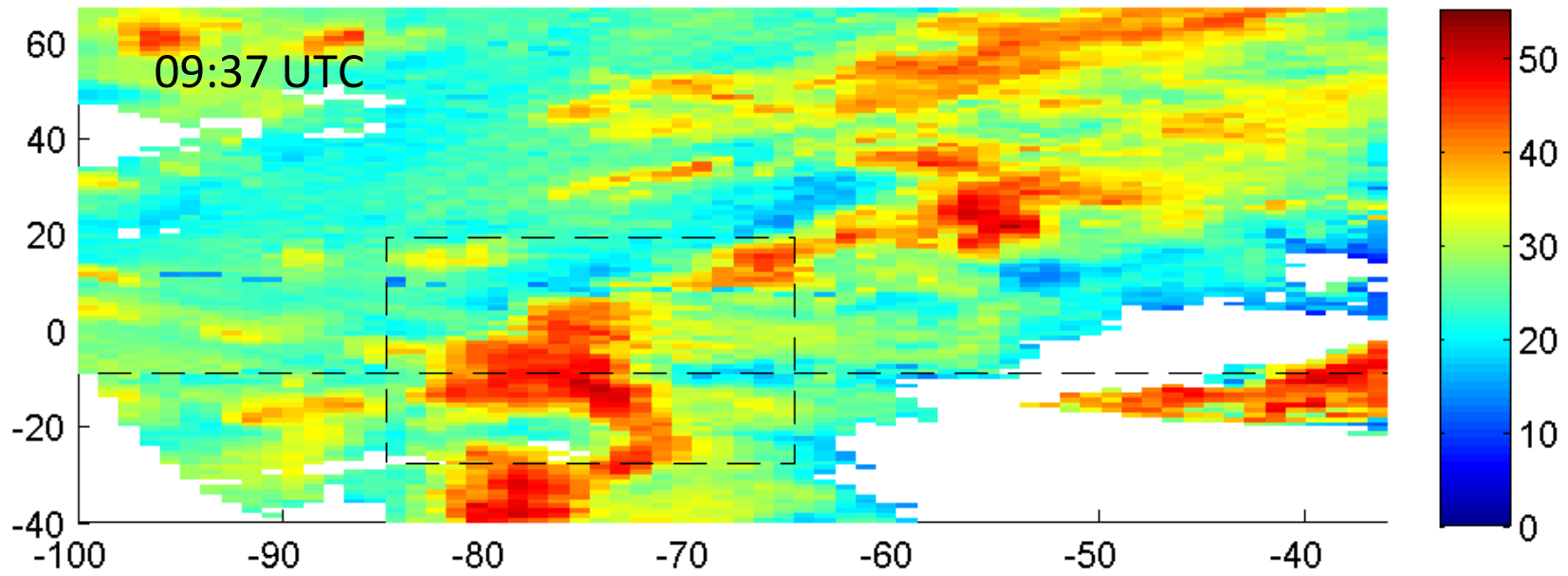
System speed:
U ~ 9-11 m/sec
V ~ 9-11 m/sec



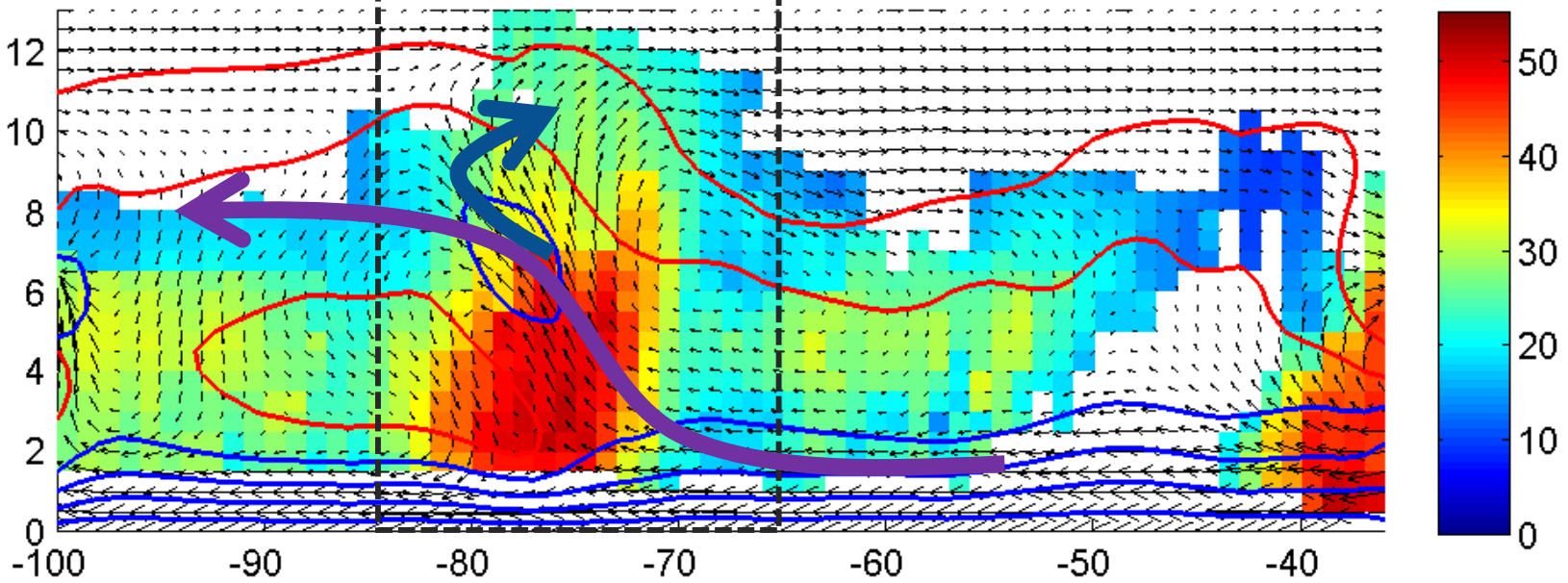
Case: June 14, 2008



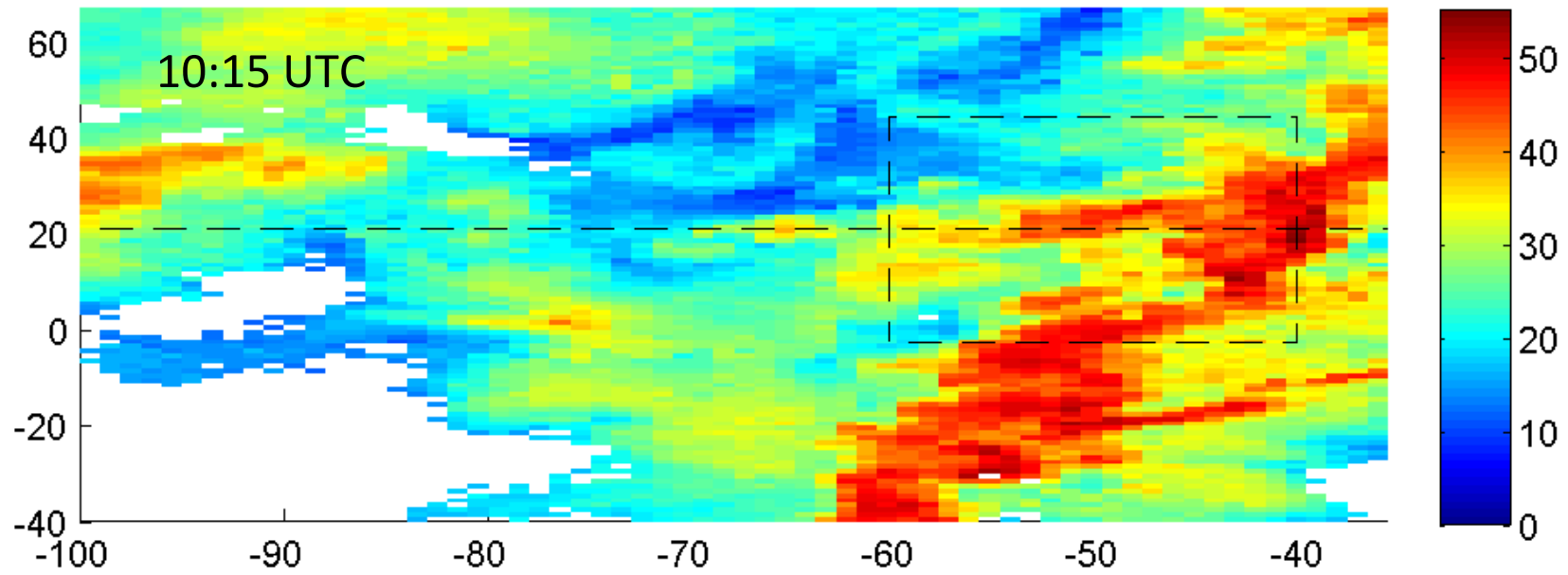
20080614093733 Z(dBZ) at 1.5 km



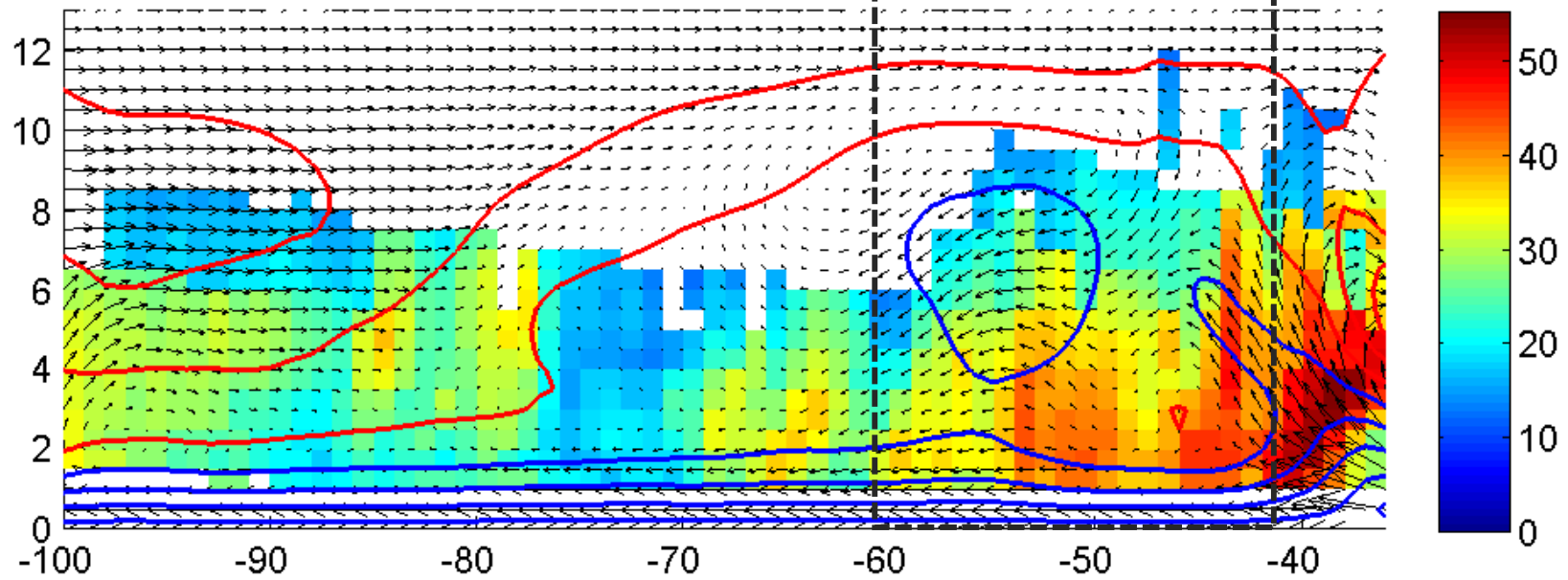
20080614093733 Z(dBZ)+UW at -9 km



20080614101503 Z(dBZ) at 1.5 km

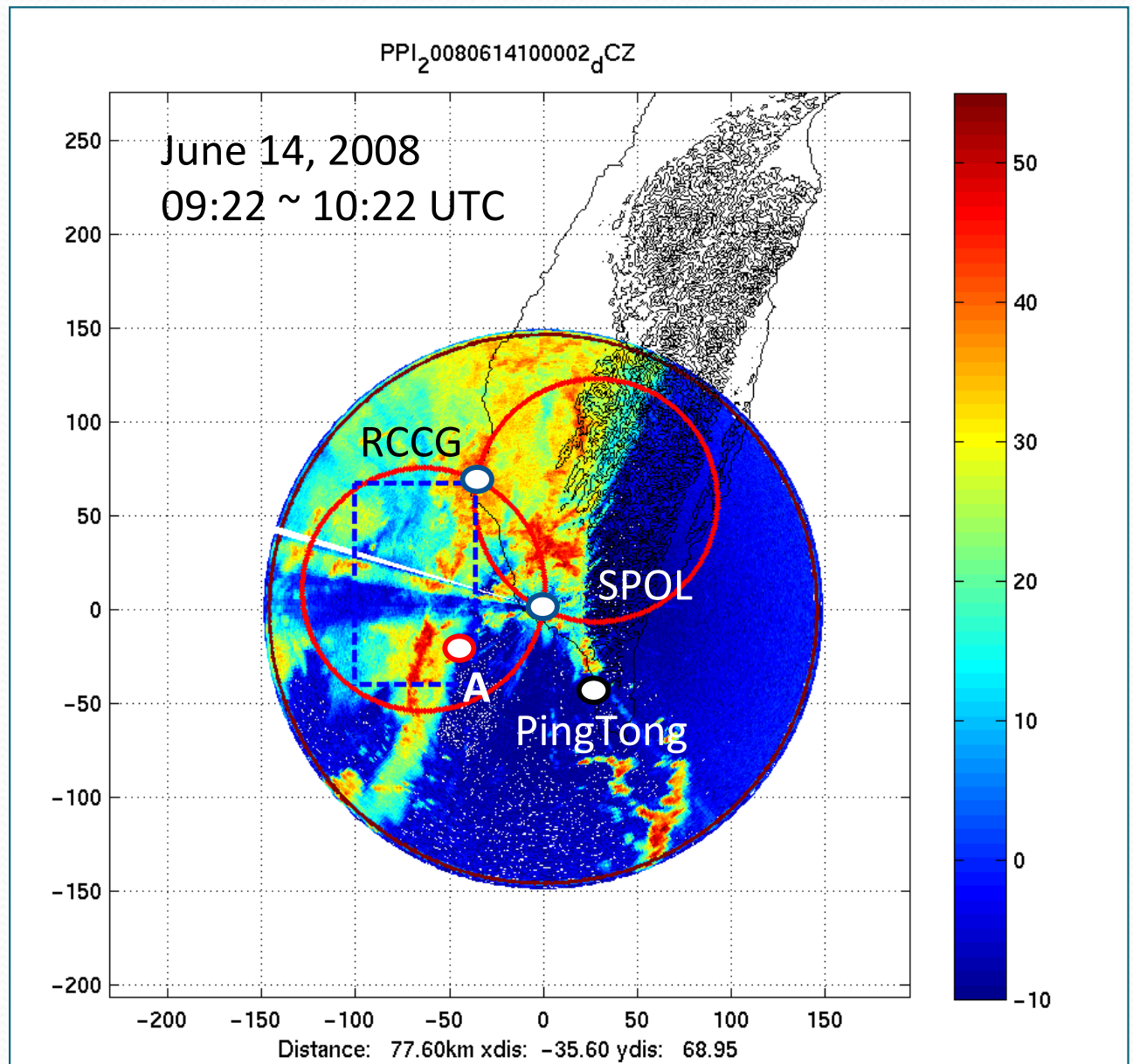


20080614101503 Z(dBZ)+UW at 21 km

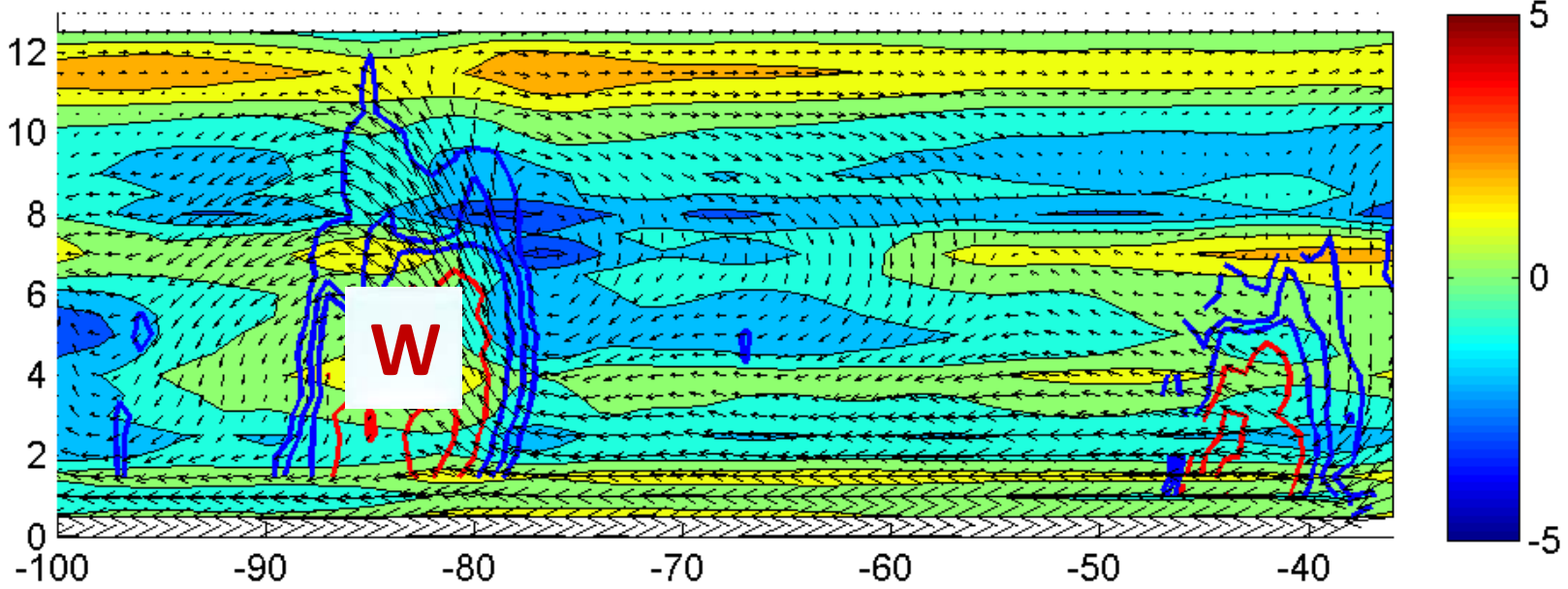


Thermodynamic field

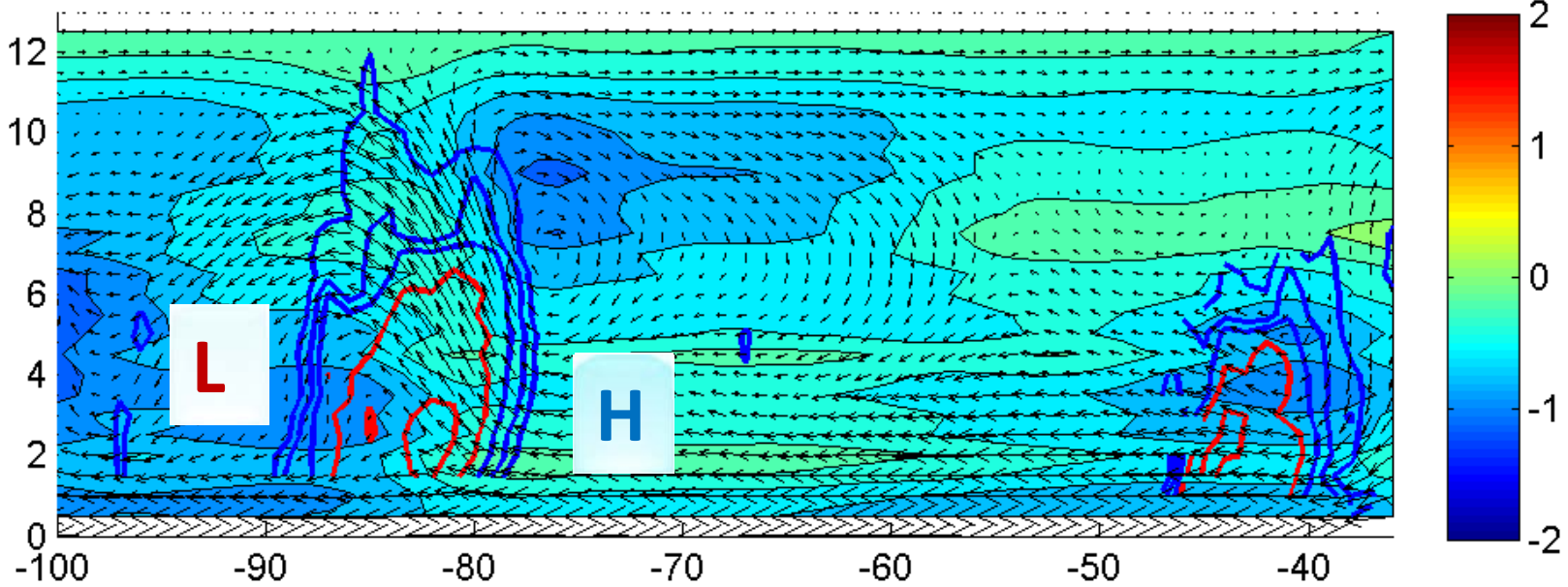
- $[T' - \langle T' \rangle]$ & $[P' - \langle P' \rangle]$
derived via Gal-Chen 1978 at
each level
- PingTong Sounding:
2008061406 UTC $\rightarrow P_0$ & T_0
2008061409 UTC $\rightarrow P$ & T



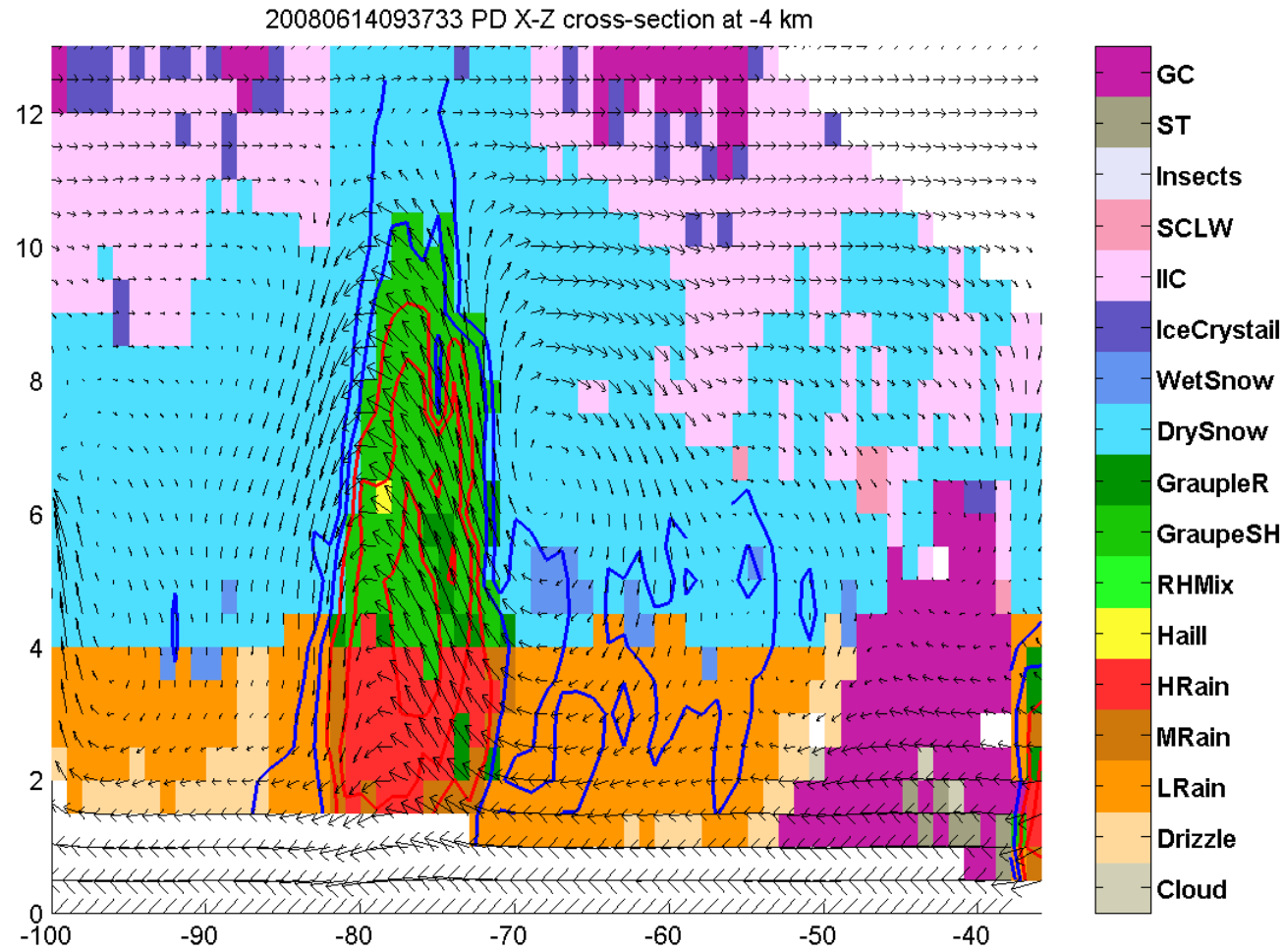
20080614093003 T at -15 km



20080614093003 P at -15 km

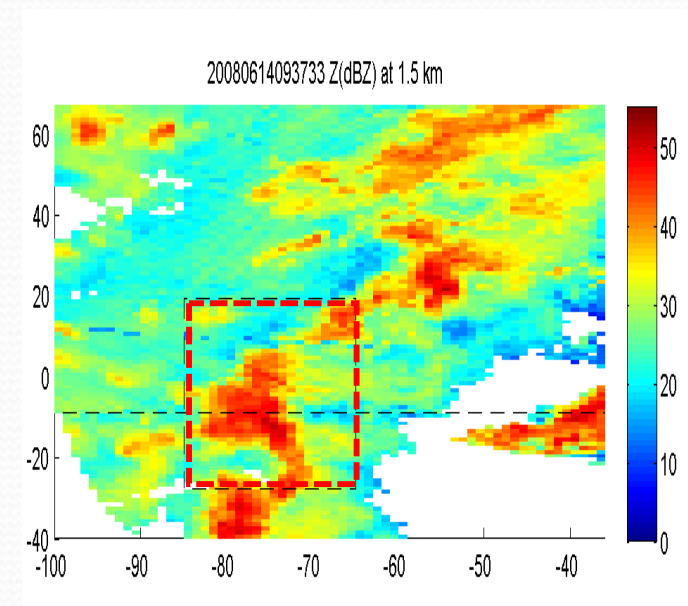
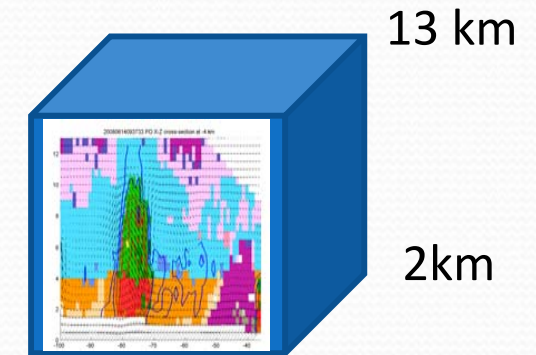
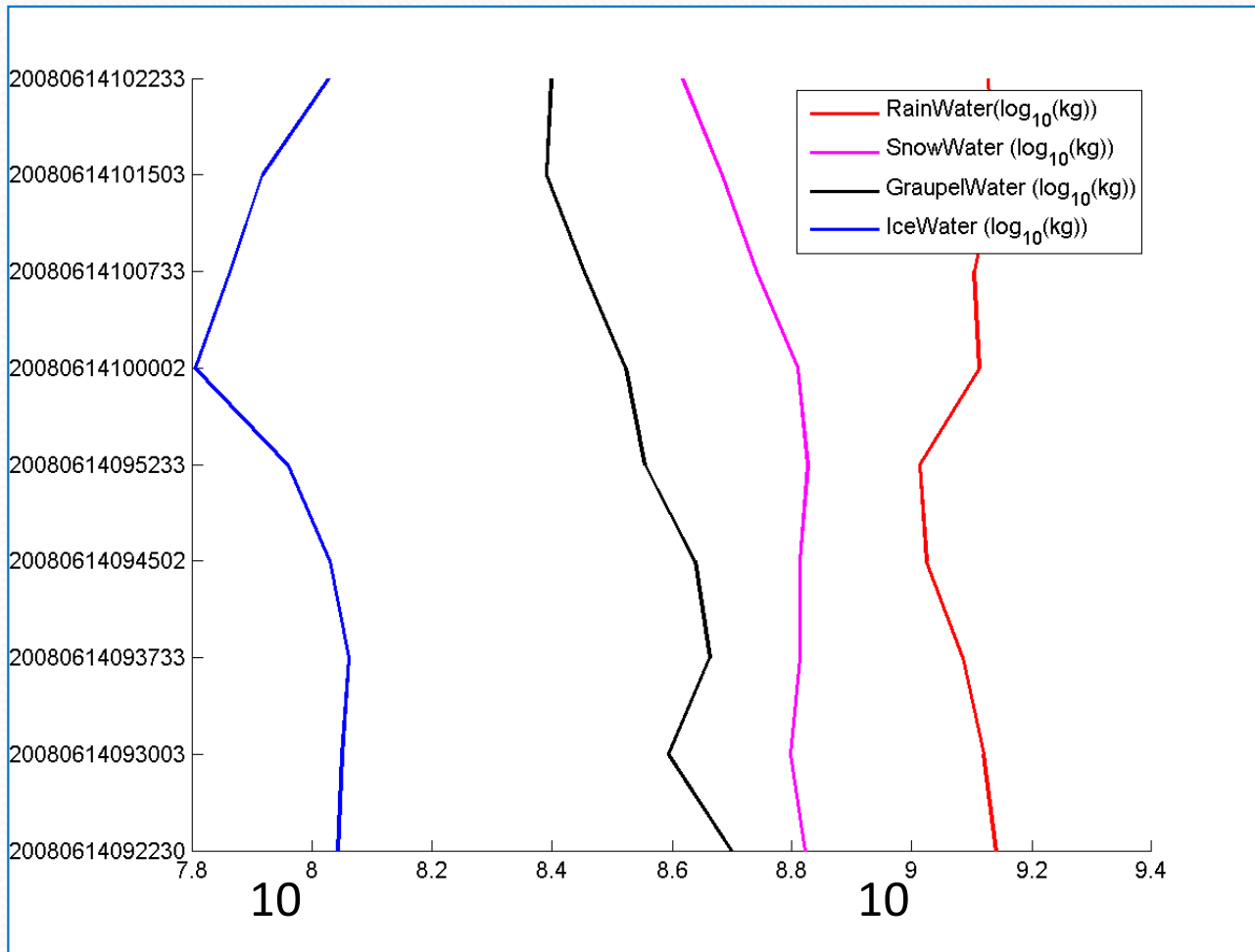


Microphysical field

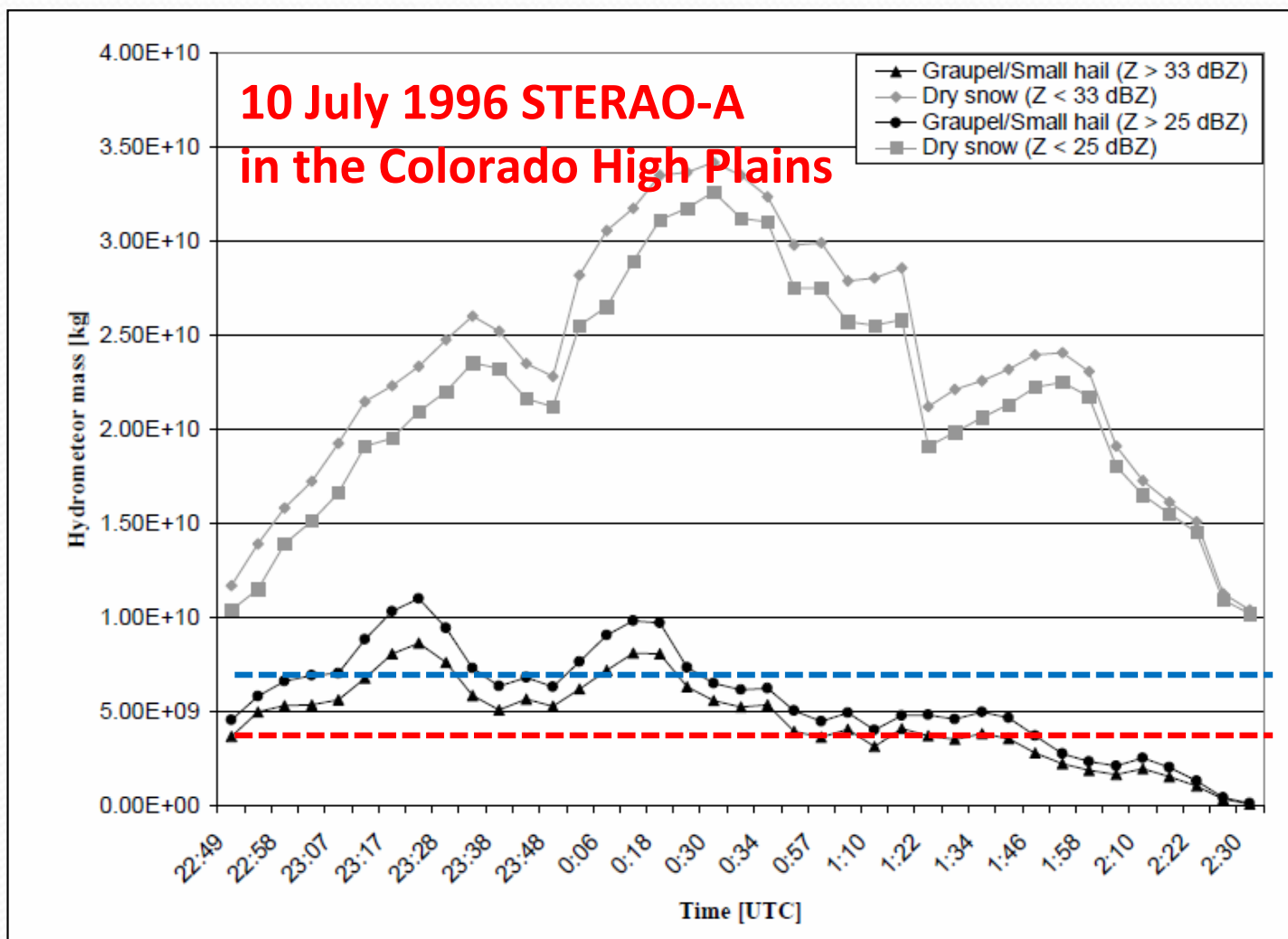


Vivekanandan et al. 1999

Microphysical field

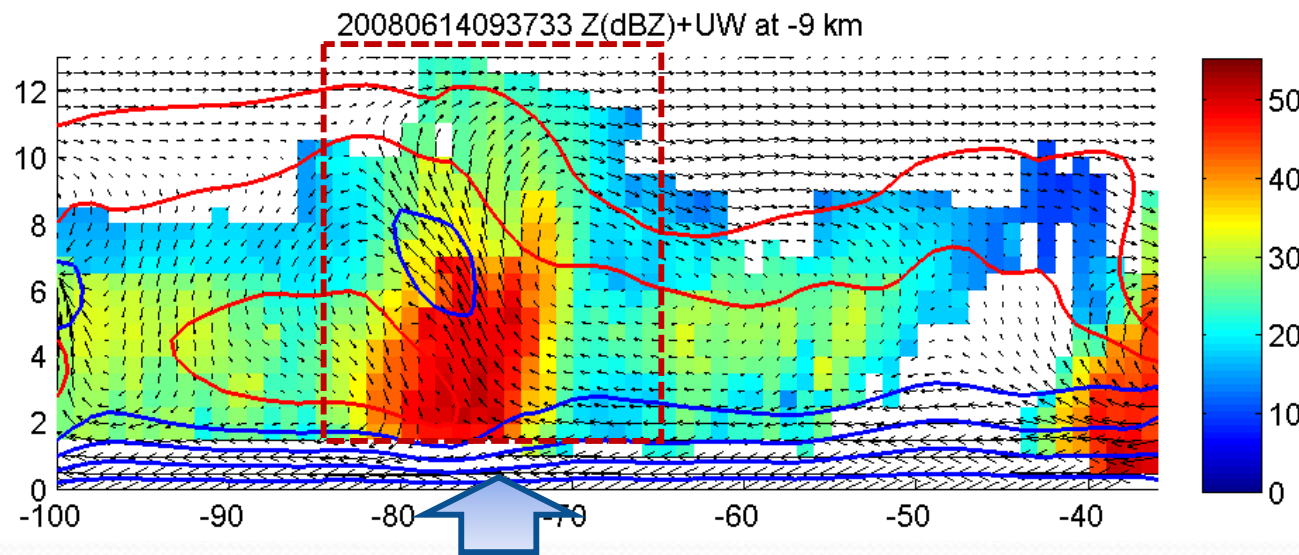
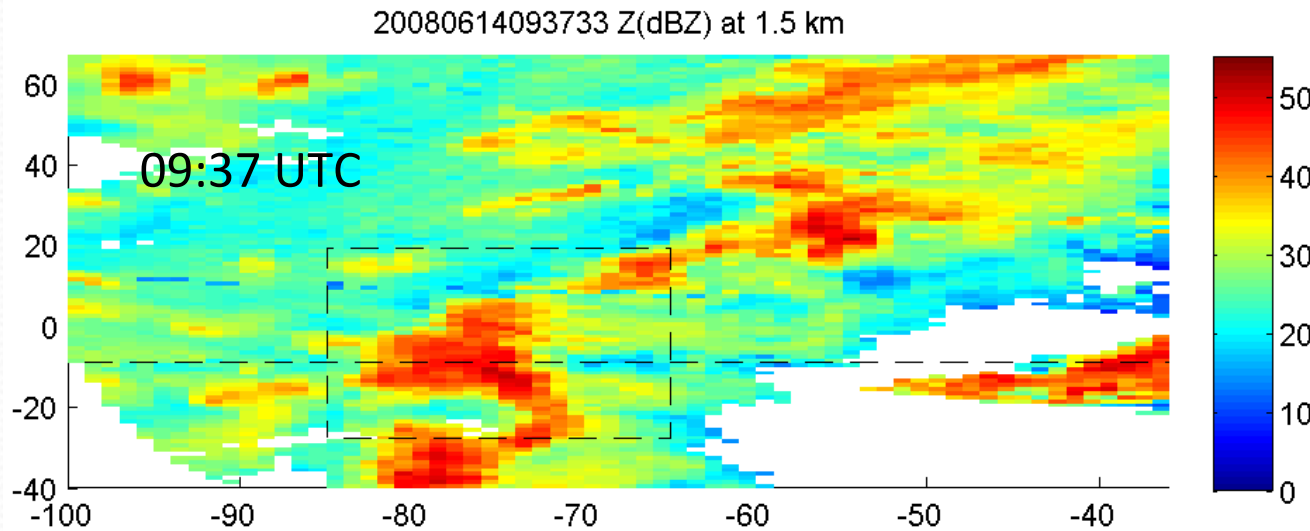


Microphysical field



From Deierling 2006

Precipitation efficiency



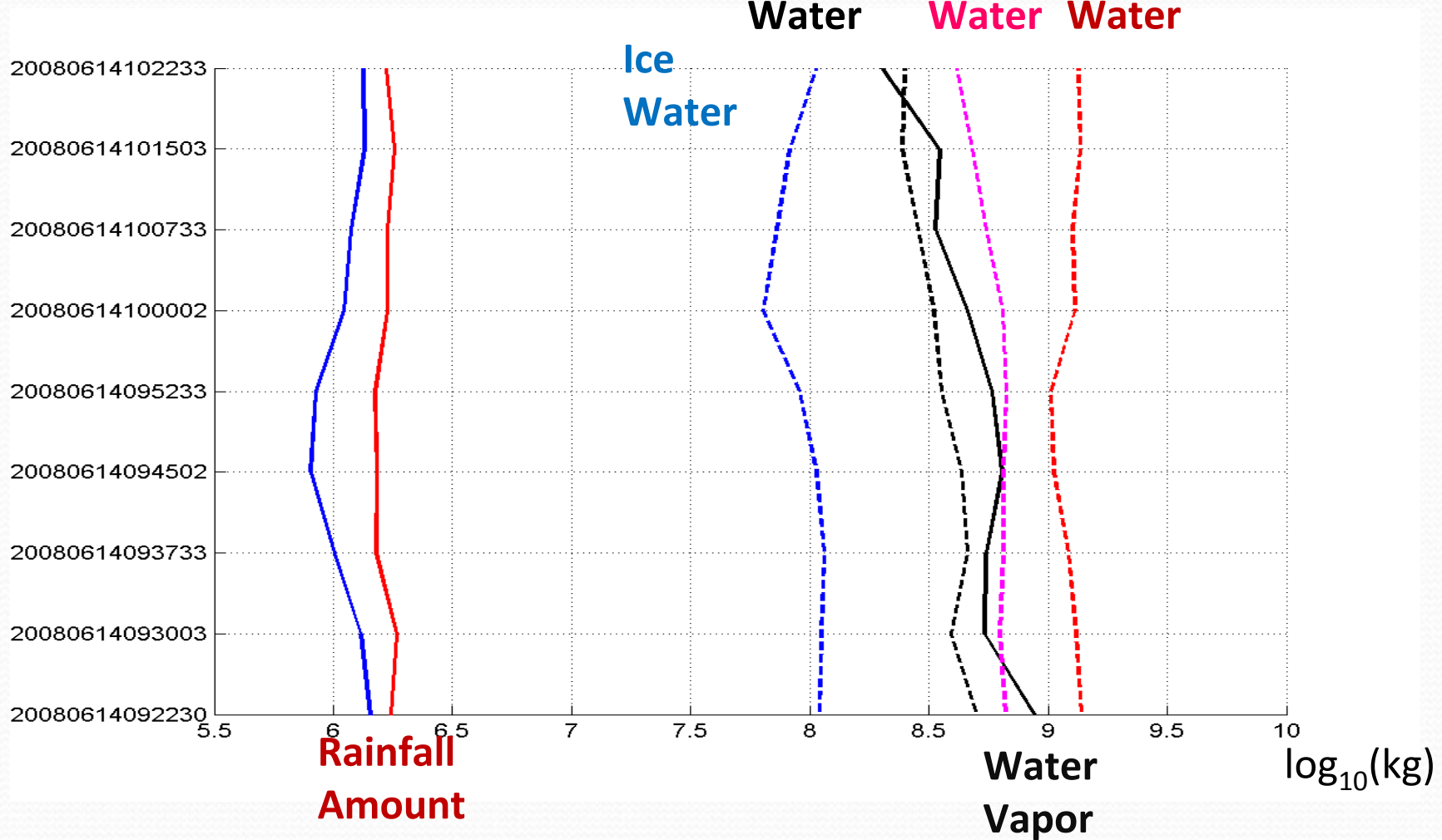
$$\varepsilon = \frac{R_{total}}{V_{total}} = \frac{\rho_w \iint R dt dA}{\rho_a q_v \iint W dt dA}$$

- V_{total} & R_{total} calculated at 2km
- Water content of rain, snow, ice, graupel estimated above 2 km.

Precipitation efficiency

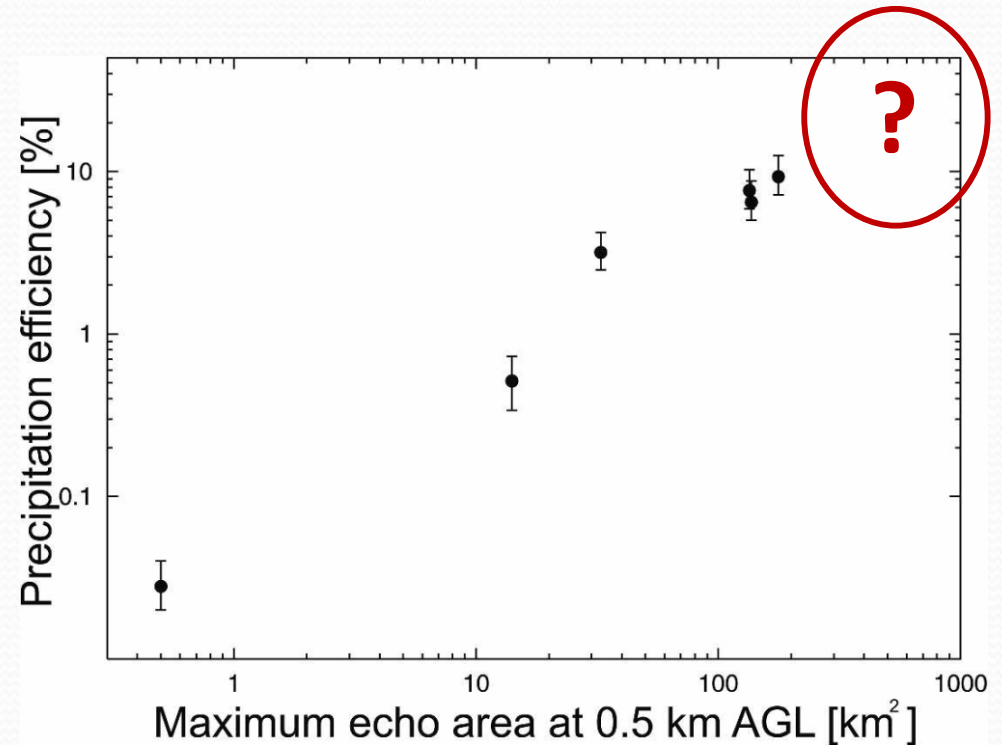
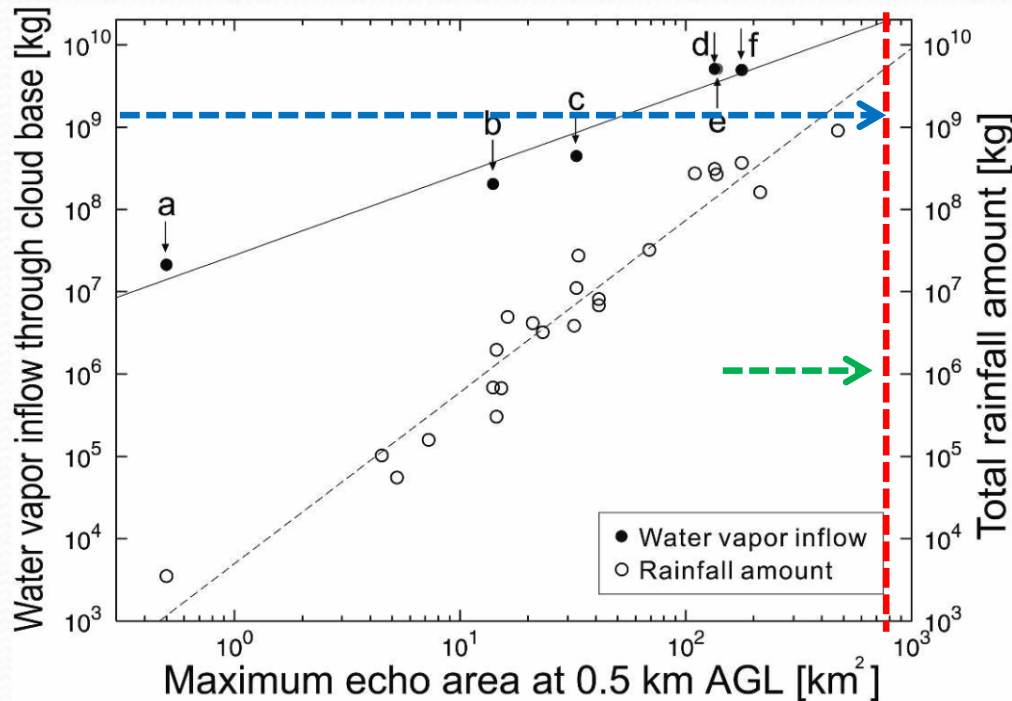
■ PingTong Sounding:
2008061409 UTC → water vapor

Graupel Water Snow Water Rain Water



Precipitation efficiency

Shusse, Yukari, Kazuhisa Tsuboki, 2006: Dimension Characteristics and Precipitation Efficiency of Cumulonimbus Clouds in the Region Far South from the **Mei-Yu Front over the Eastern Asian Continent**. *Mon. Wea. Rev.*, 134, 1942–1953.

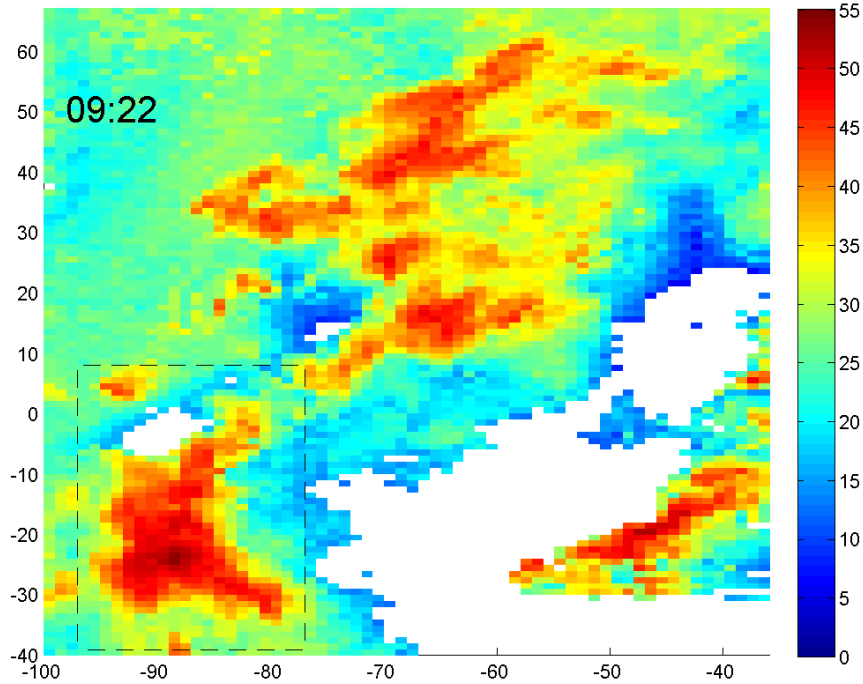


Total life time ↔ 7.5 min

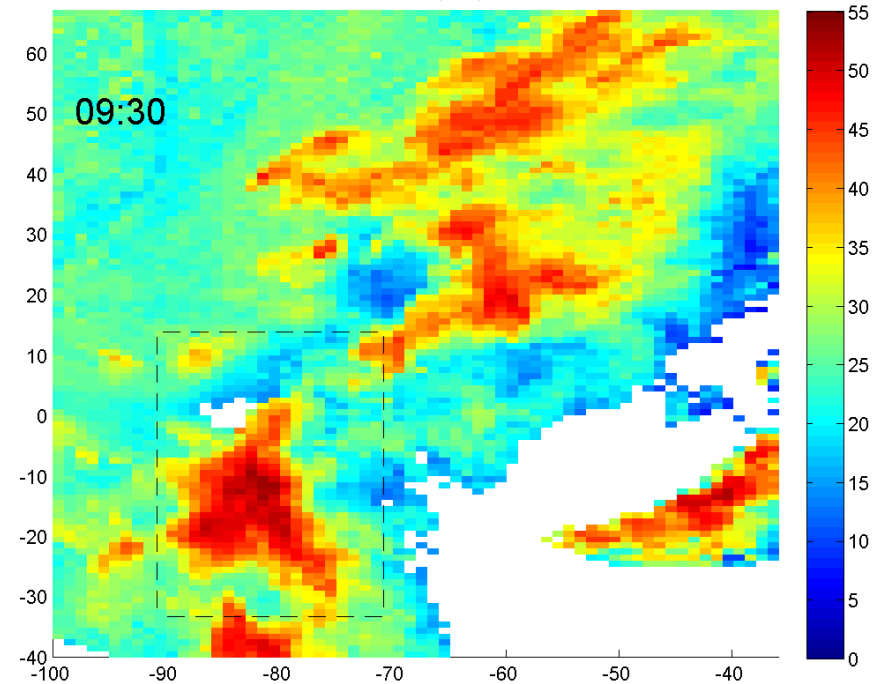
Future Work

- Further study will focus on the relation and interaction between kinematic, thermodynamic and microphysical fields.
- More case investigations and various observation comparisons will be conducted.
(e.g. Disdrometer, VertiX, ISS profiler).
- Comparison with numerical model with Double-Moment microphysics scheme (e.g. WRF)

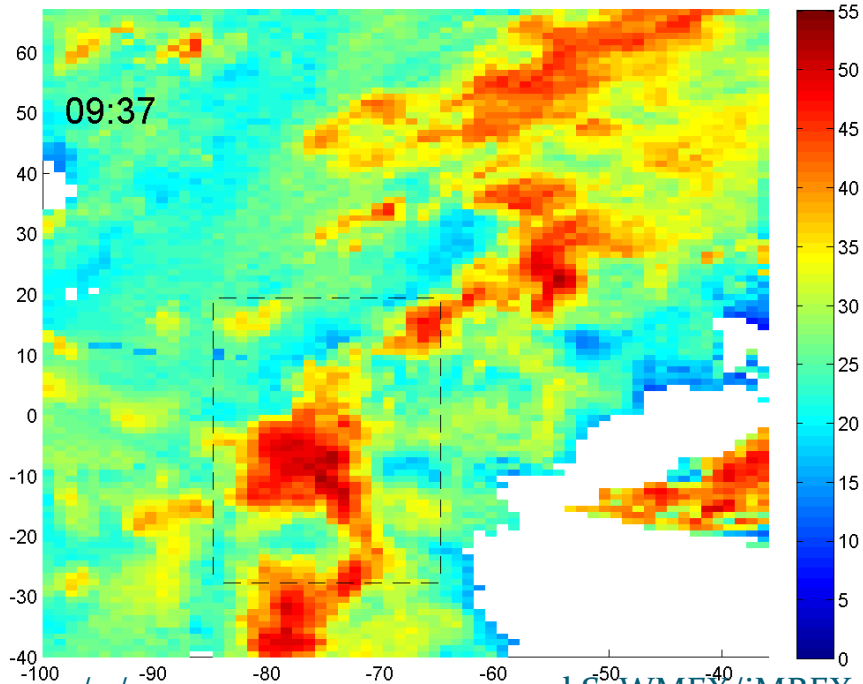
20080614092230 Z(dBZ) at 2 km



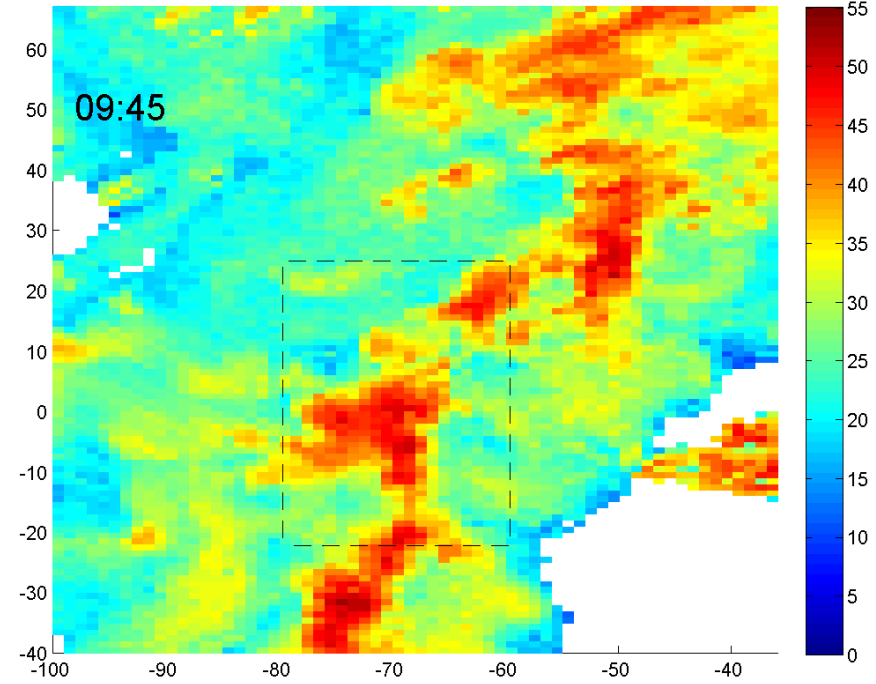
20080614093003 Z(dBZ) at 2 km



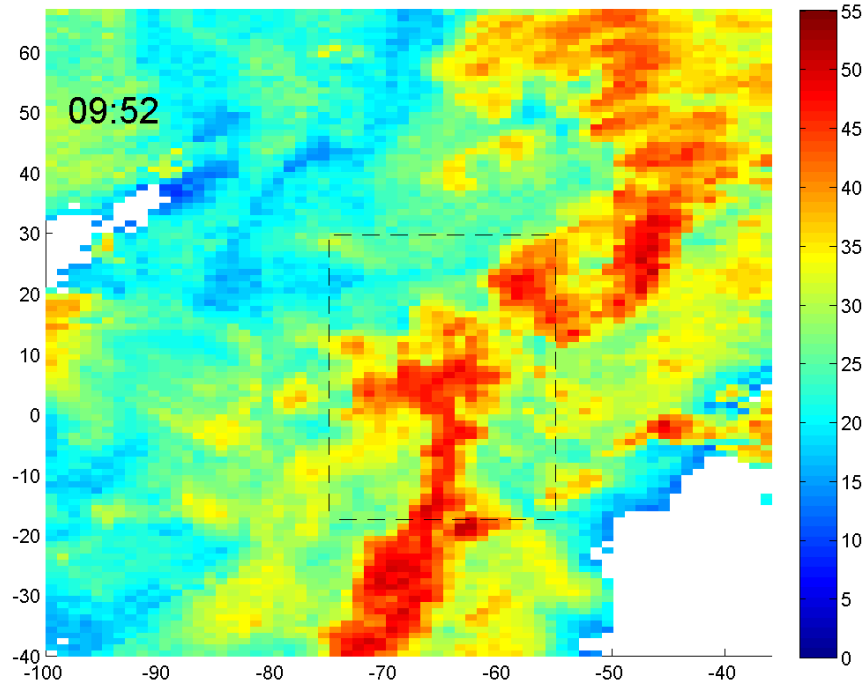
20080614093733 Z(dBZ) at 2 km



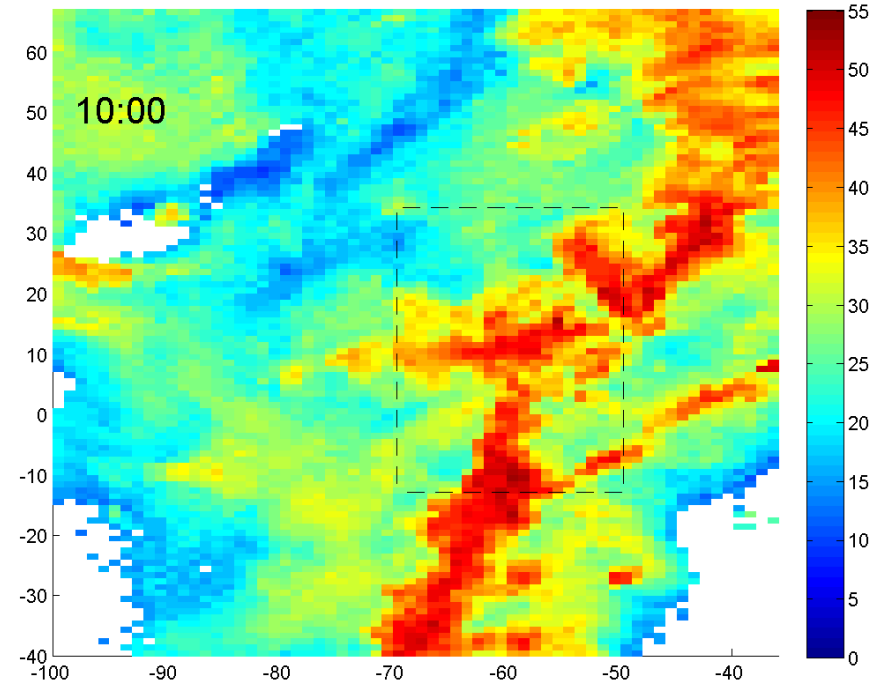
20080614094502 Z(dBZ) at 2 km



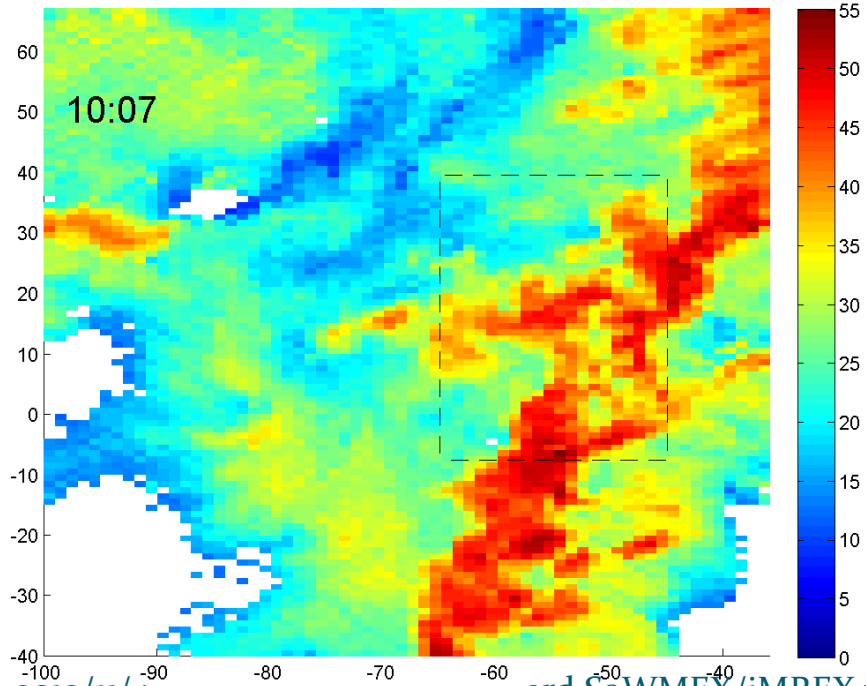
20080614095233 Z(dBZ) at 2 km



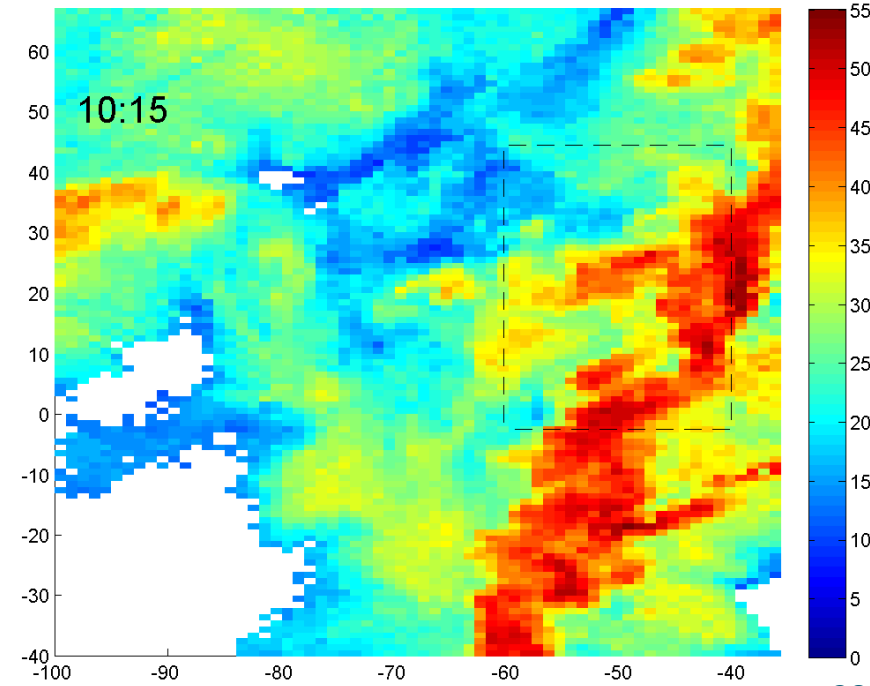
20080614100002 Z(dBZ) at 2 km

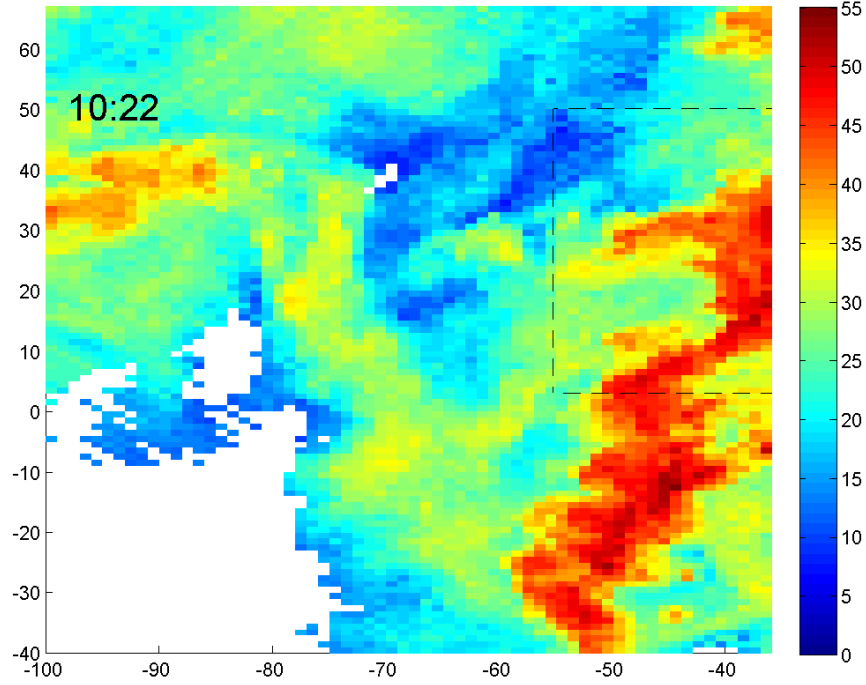


20080614100733 Z(dBZ) at 2 km

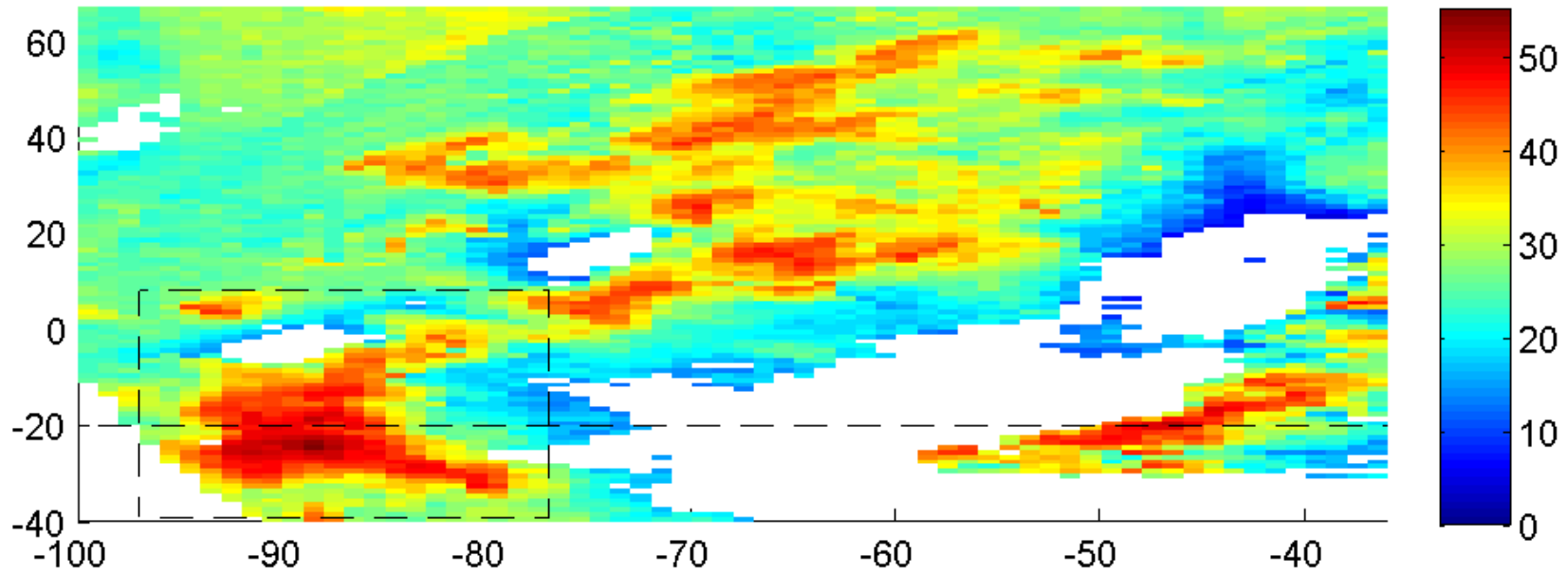


20080614101503 Z(dBZ) at 2 km

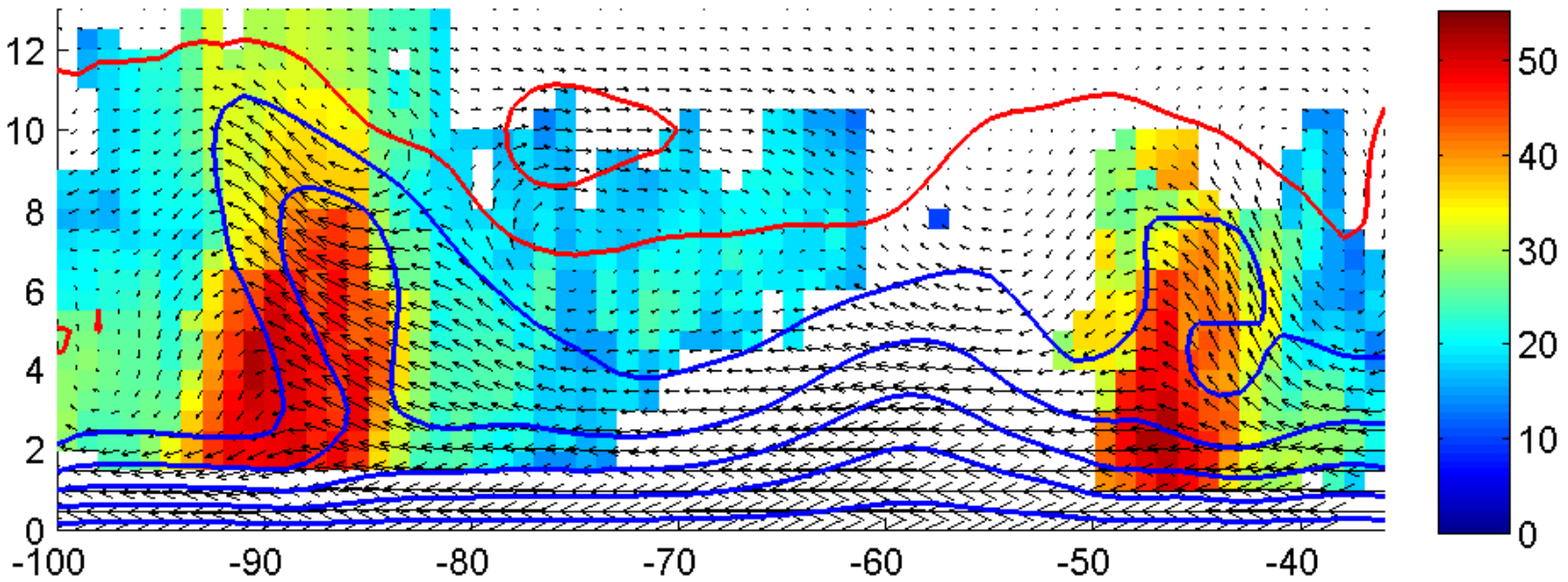




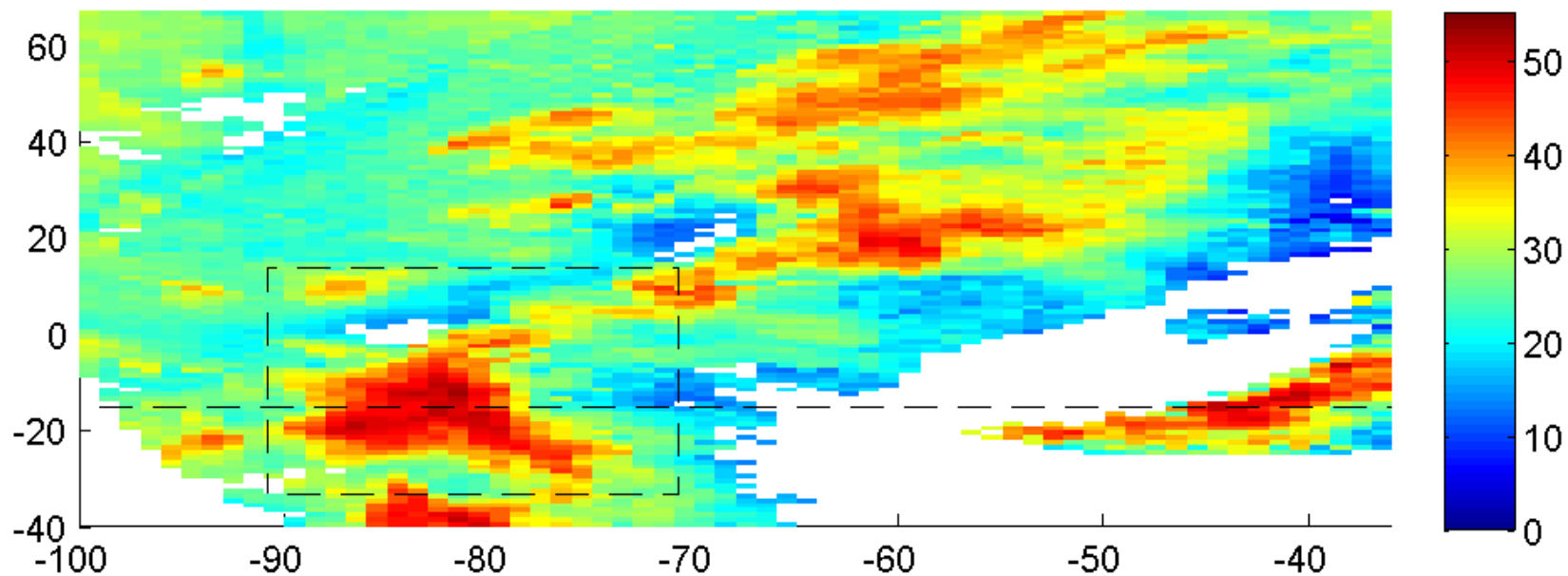
20080614092230 Z(dBZ) at 1.5 km



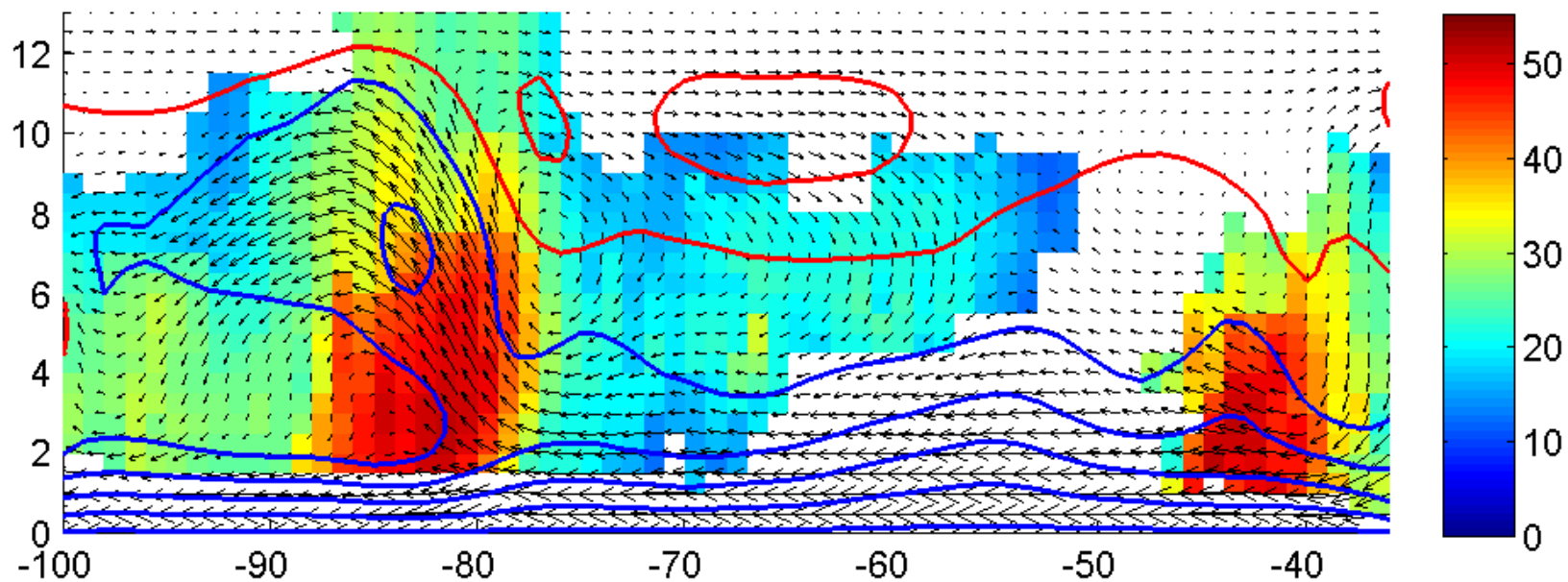
20080614092230 Z(dBZ)+UW at -20 km



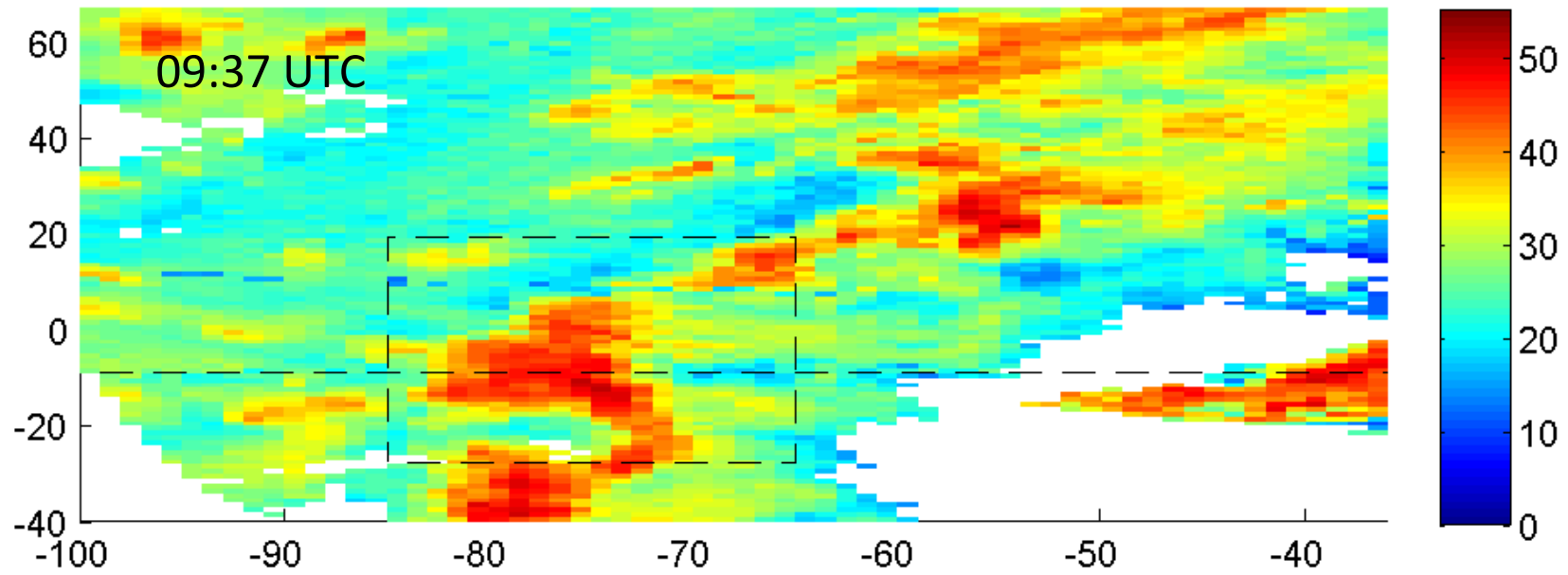
20080614093003 Z(dBZ) at 1.5 km



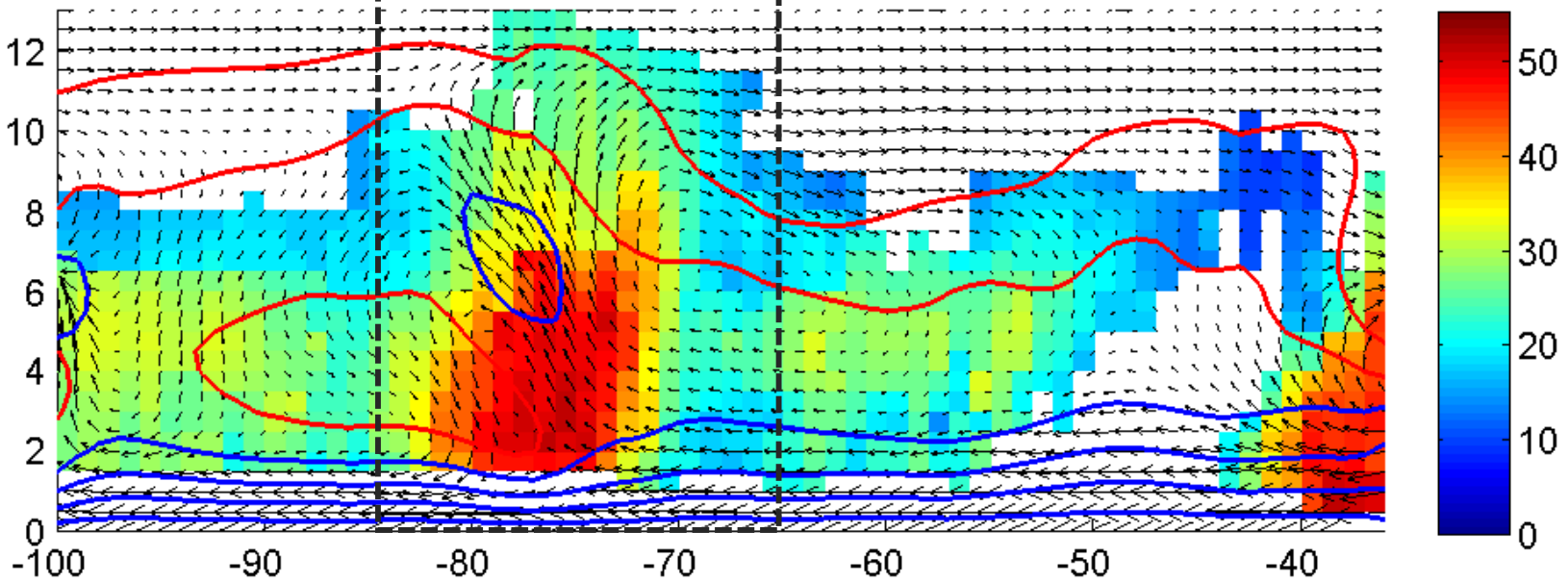
20080614093003 Z(dBZ)+UW at -15 km



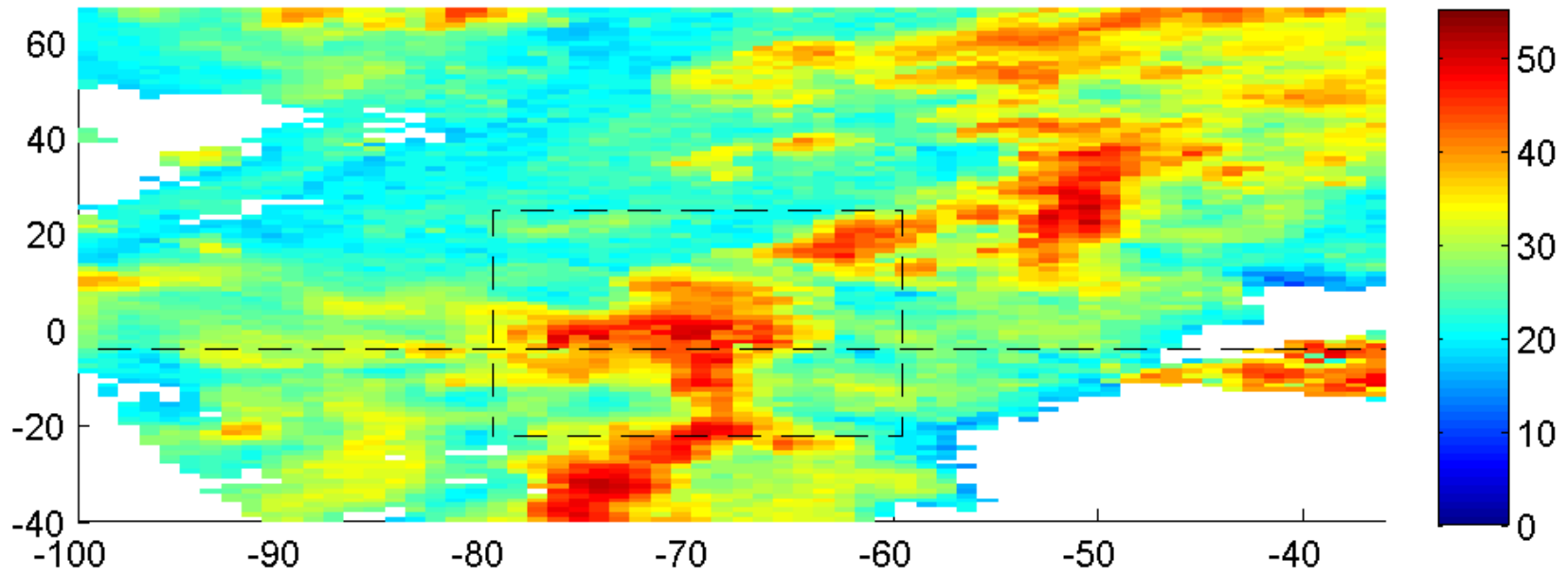
20080614093733 Z(dBZ) at 1.5 km



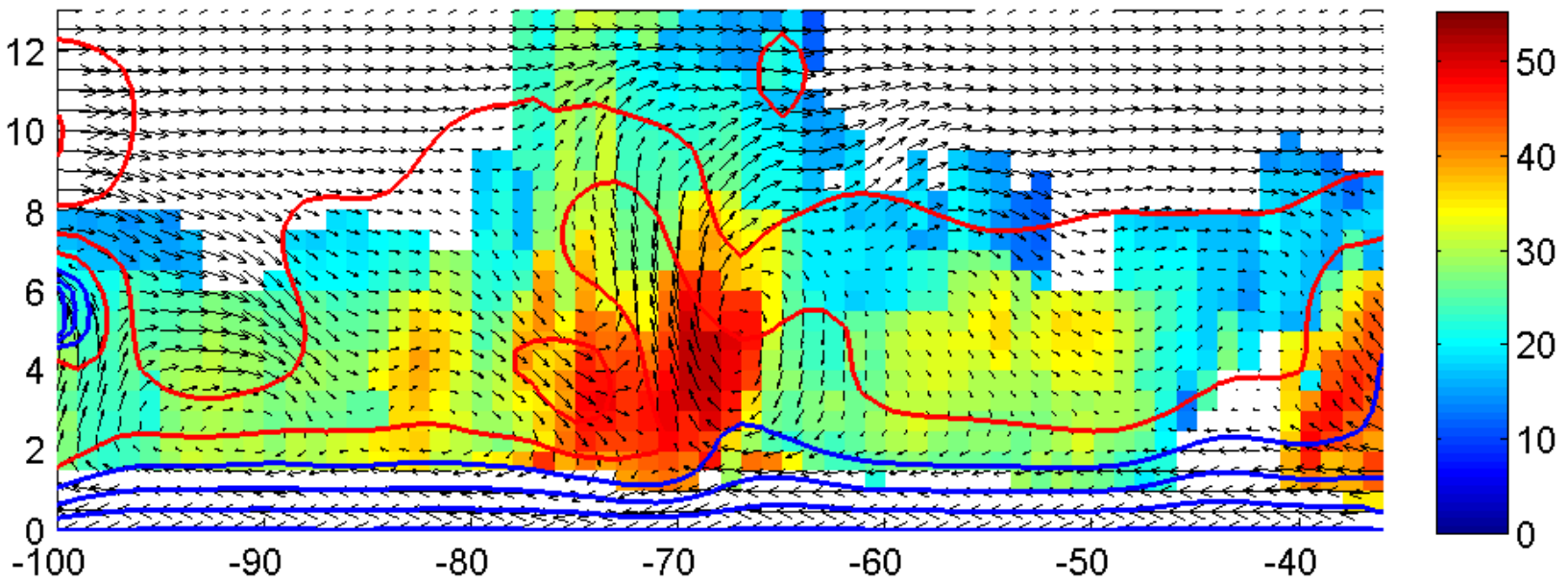
20080614093733 Z(dBZ)+UW at -9 km



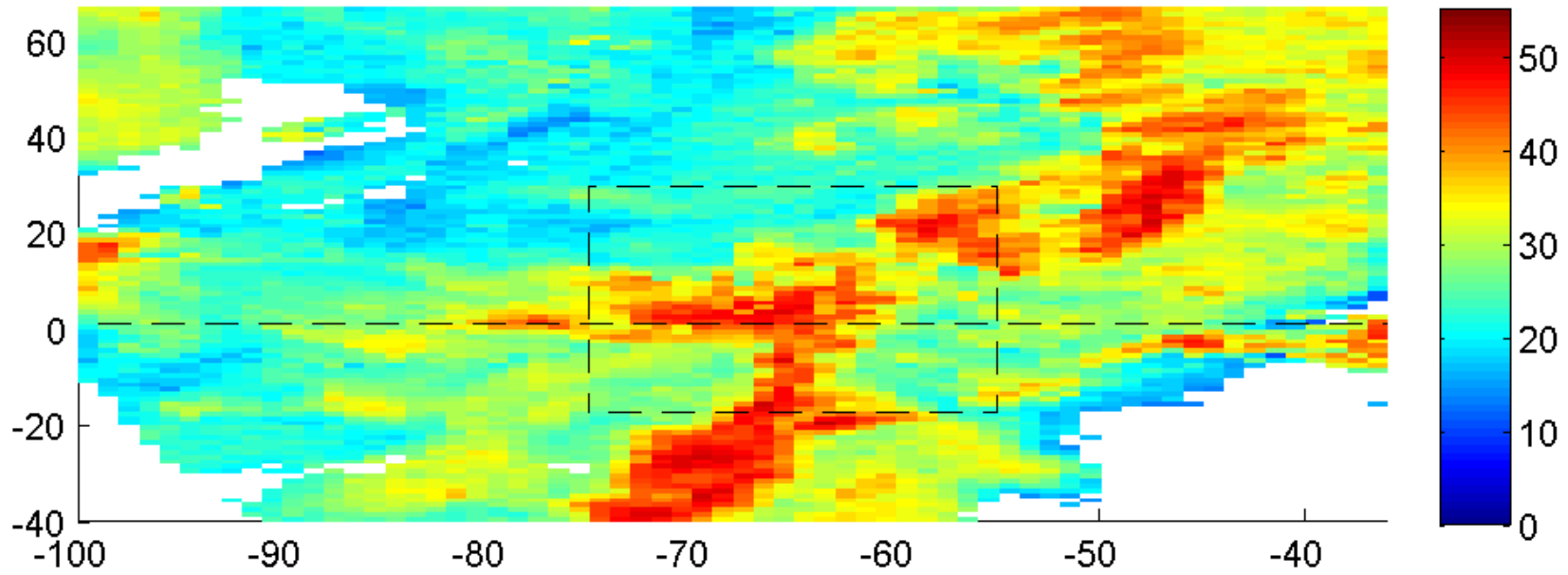
20080614094502 Z(dBZ) at 1.5 km



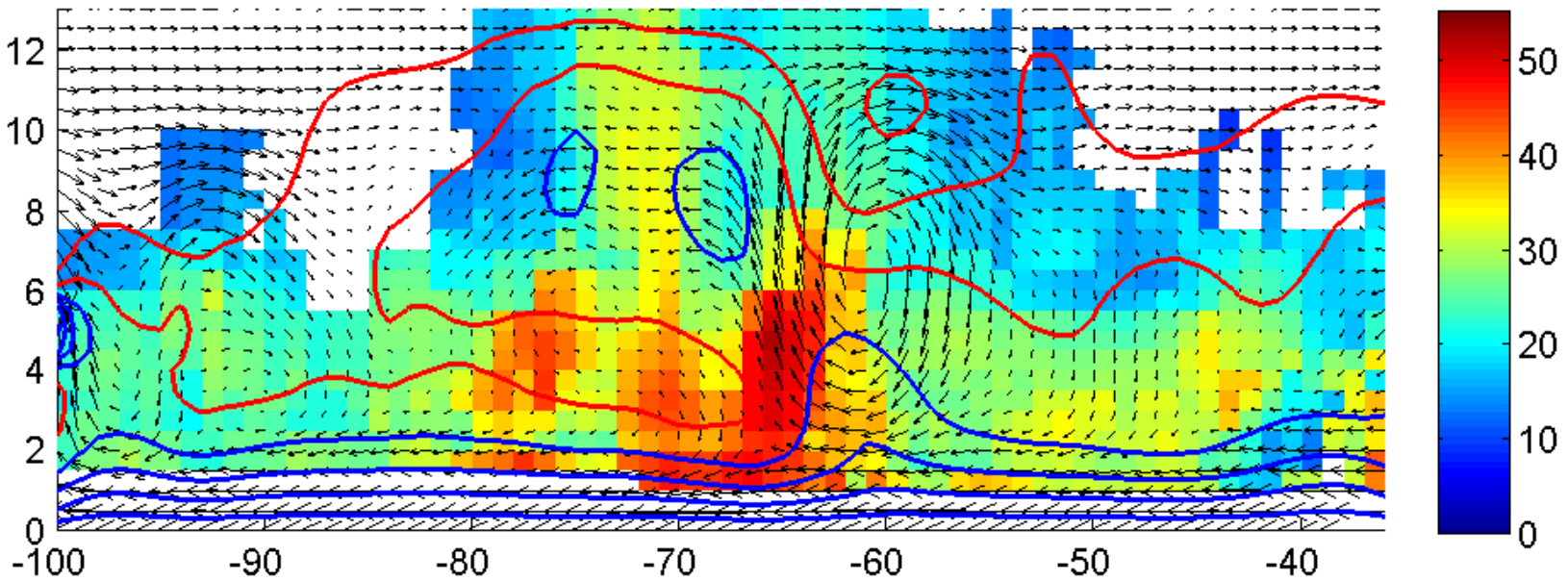
20080614094502 Z(dBZ)+UW at -4 km



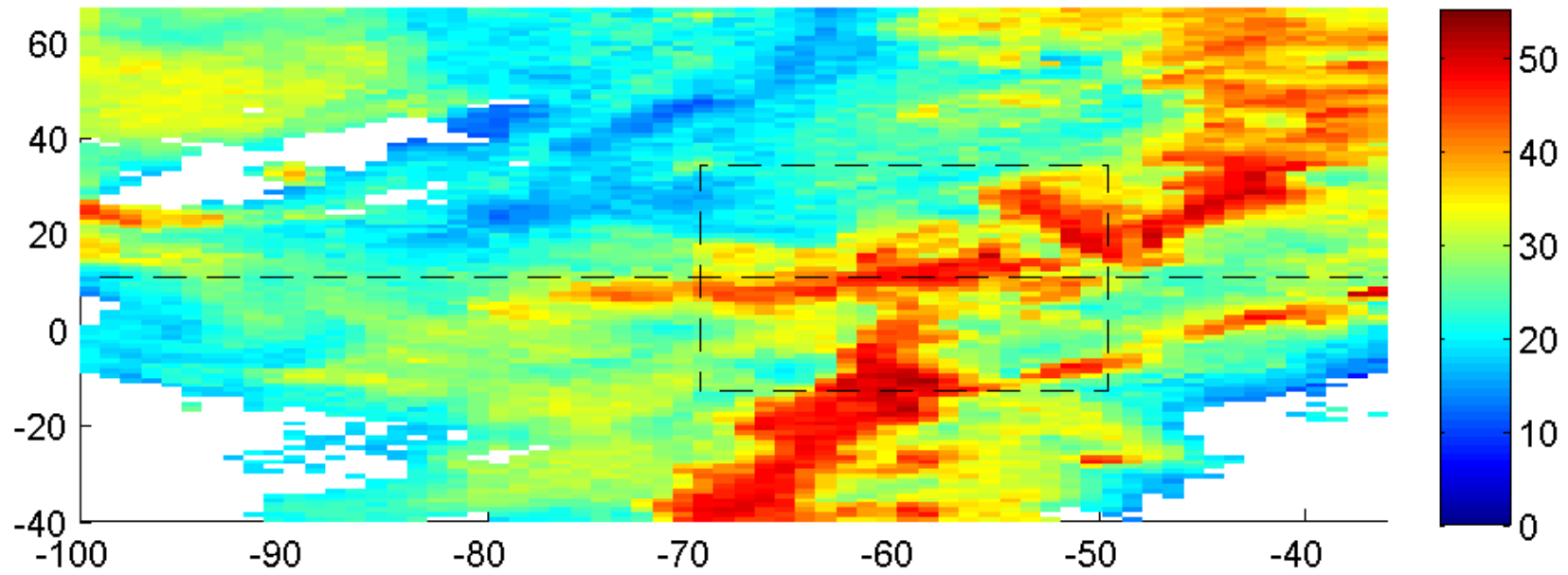
20080614095233 Z(dBZ) at 1.5 km



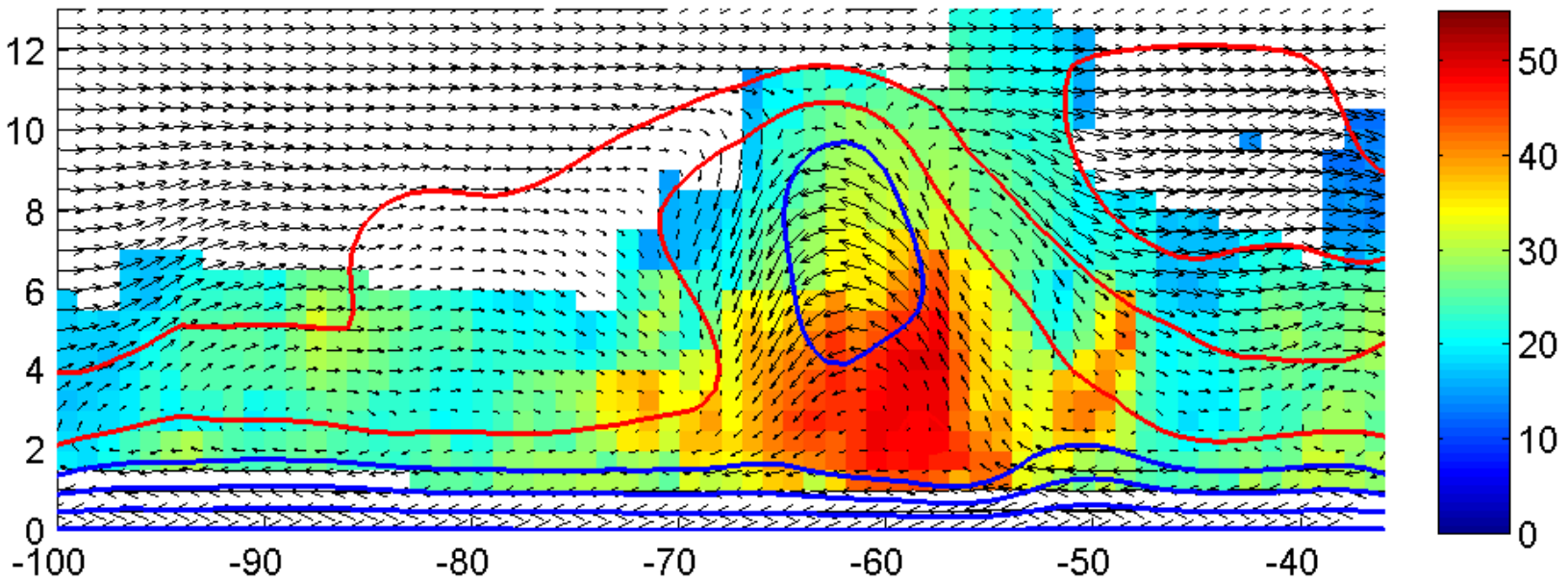
20080614095233 Z(dBZ)+UW at 1 km



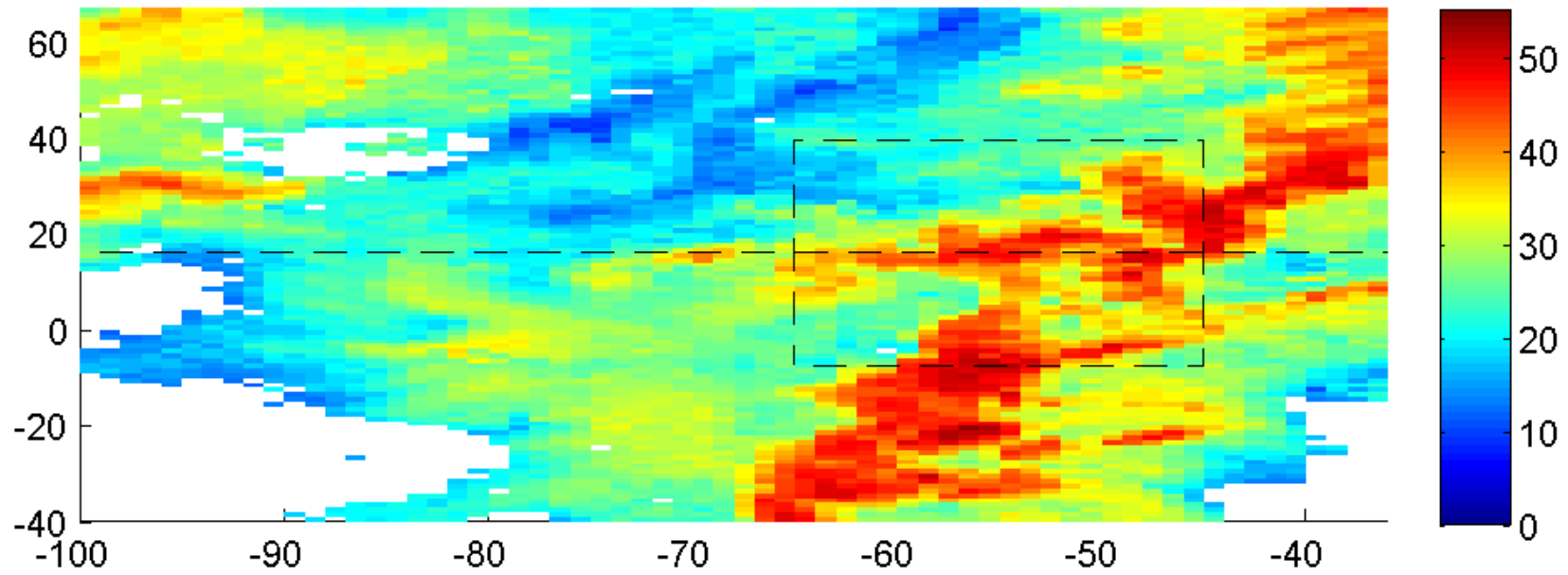
20080614100002 Z(dBZ) at 1.5 km



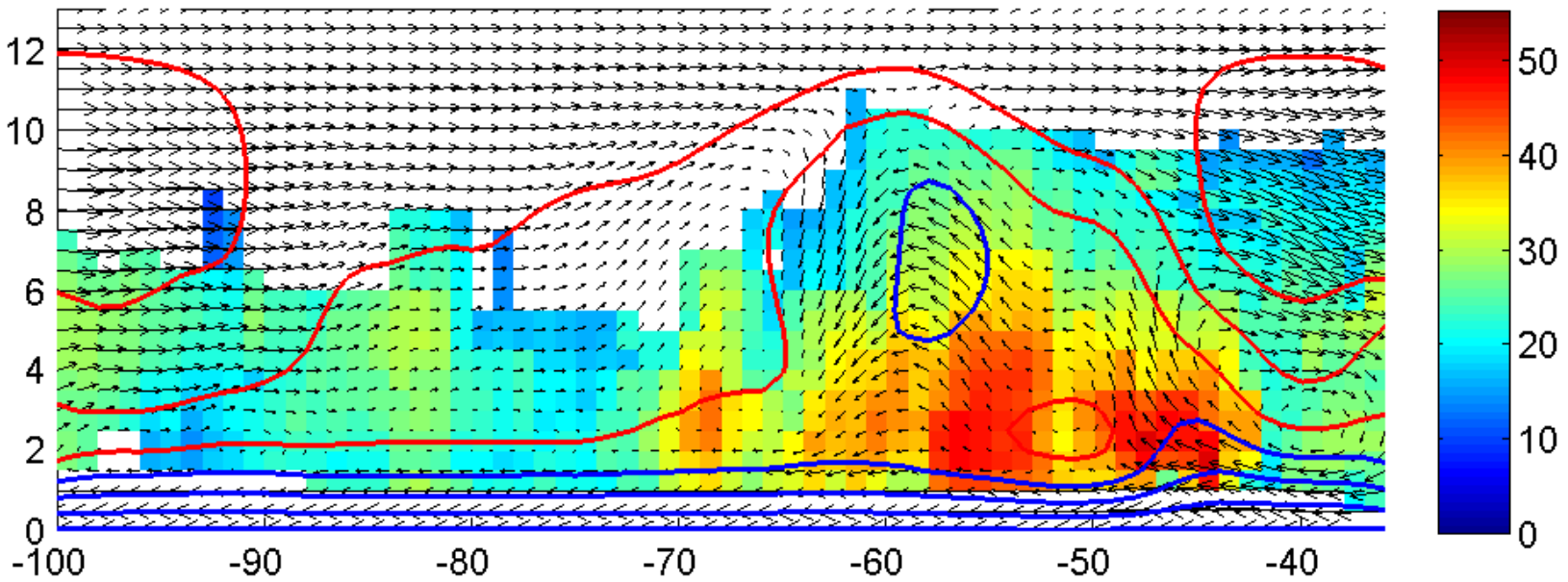
20080614100002 Z(dBZ)+UW at 11 km



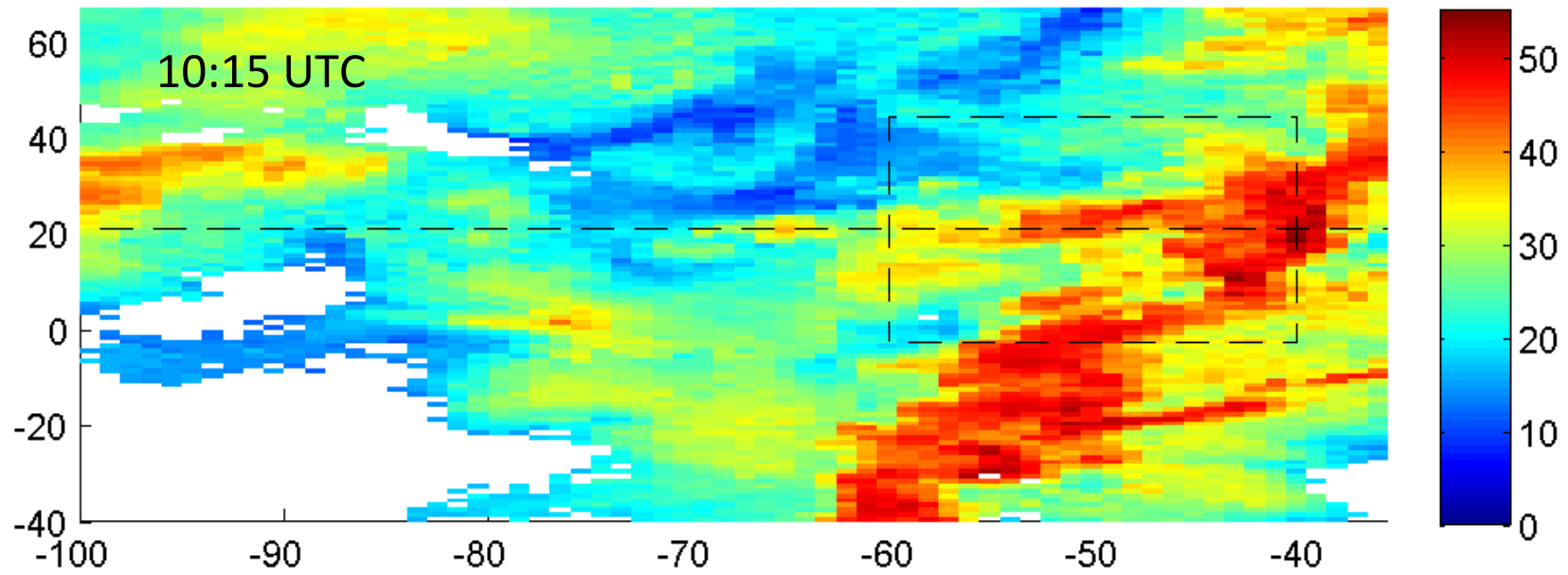
20080614100733 Z(dBZ) at 1.5 km



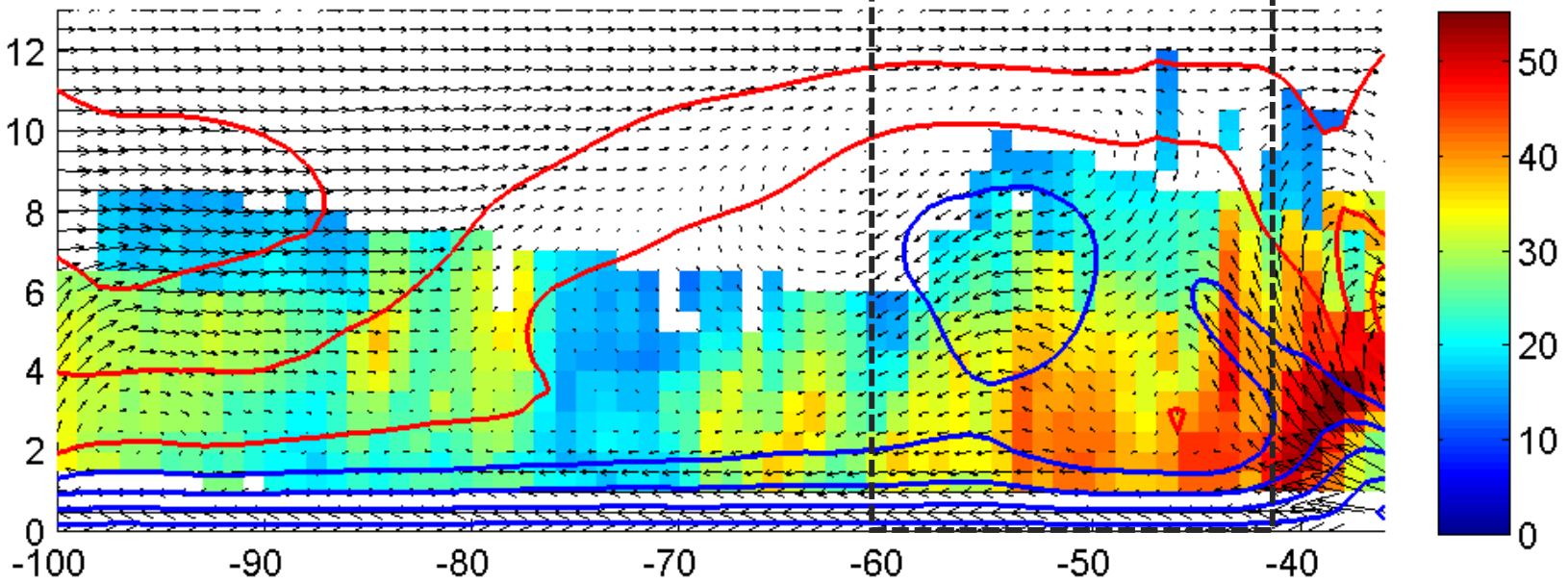
20080614100733 Z(dBZ)+UW at 16 km



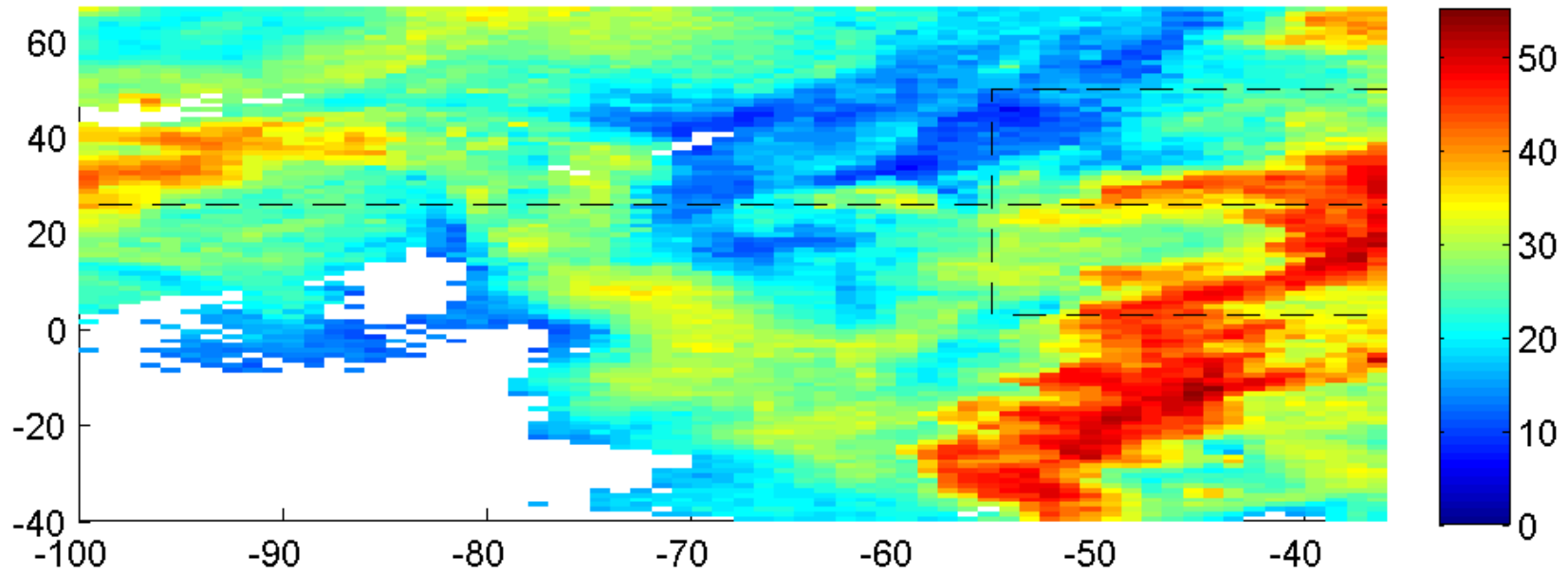
20080614101503 Z(dBZ) at 1.5 km



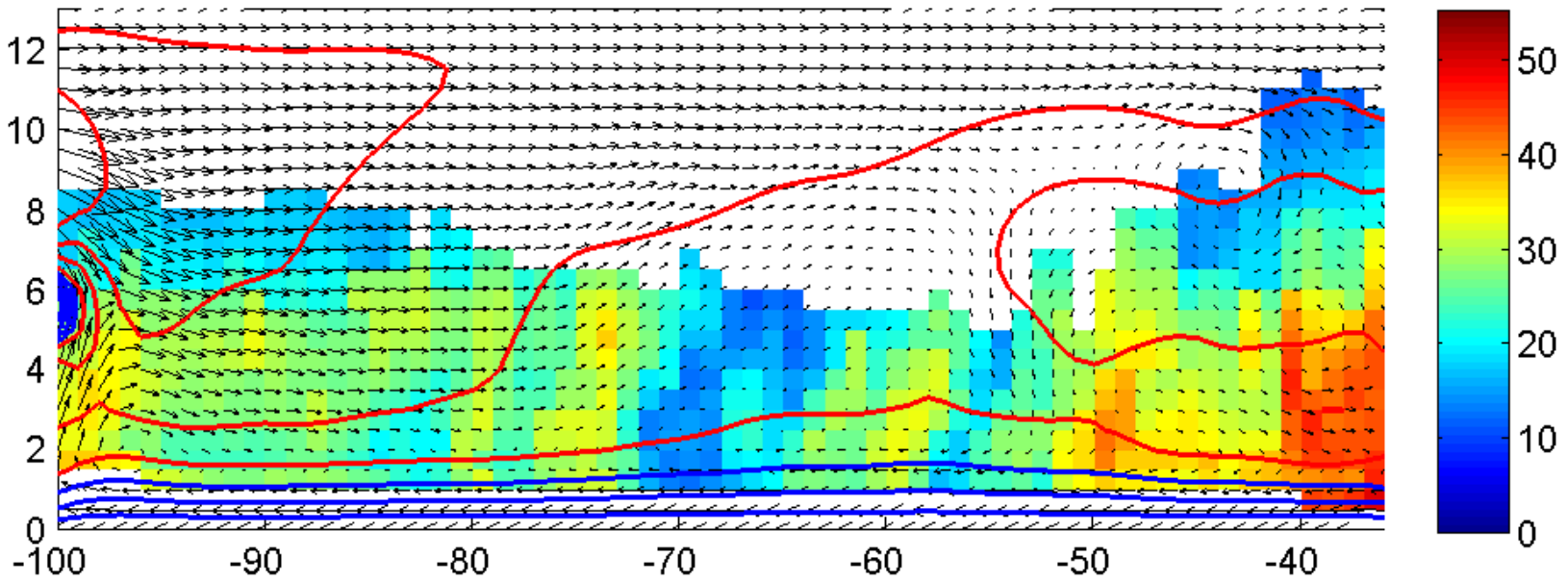
20080614101503 Z(dBZ)+UW at 21 km



20080614102233 Z(dBZ) at 1.5 km

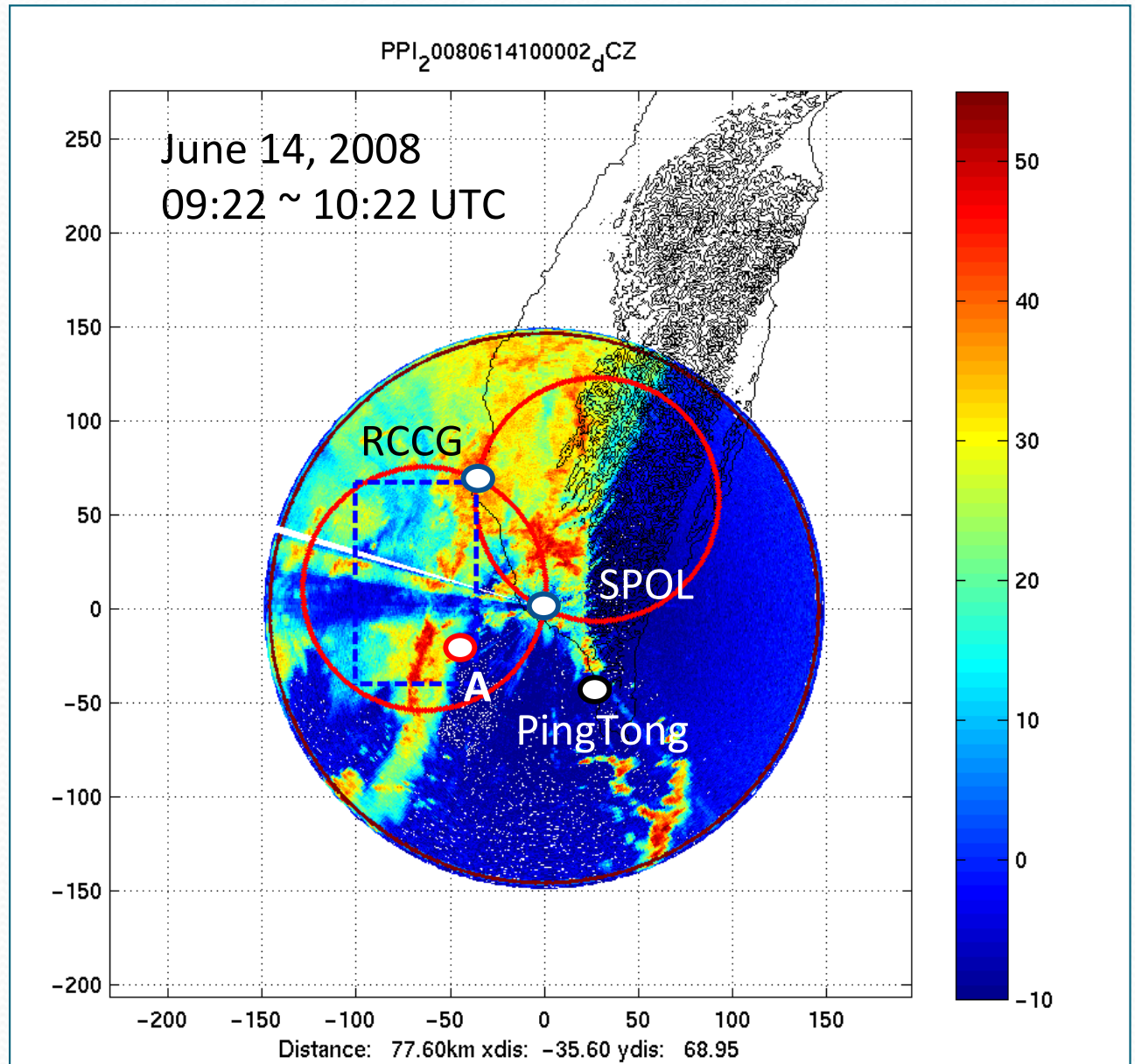


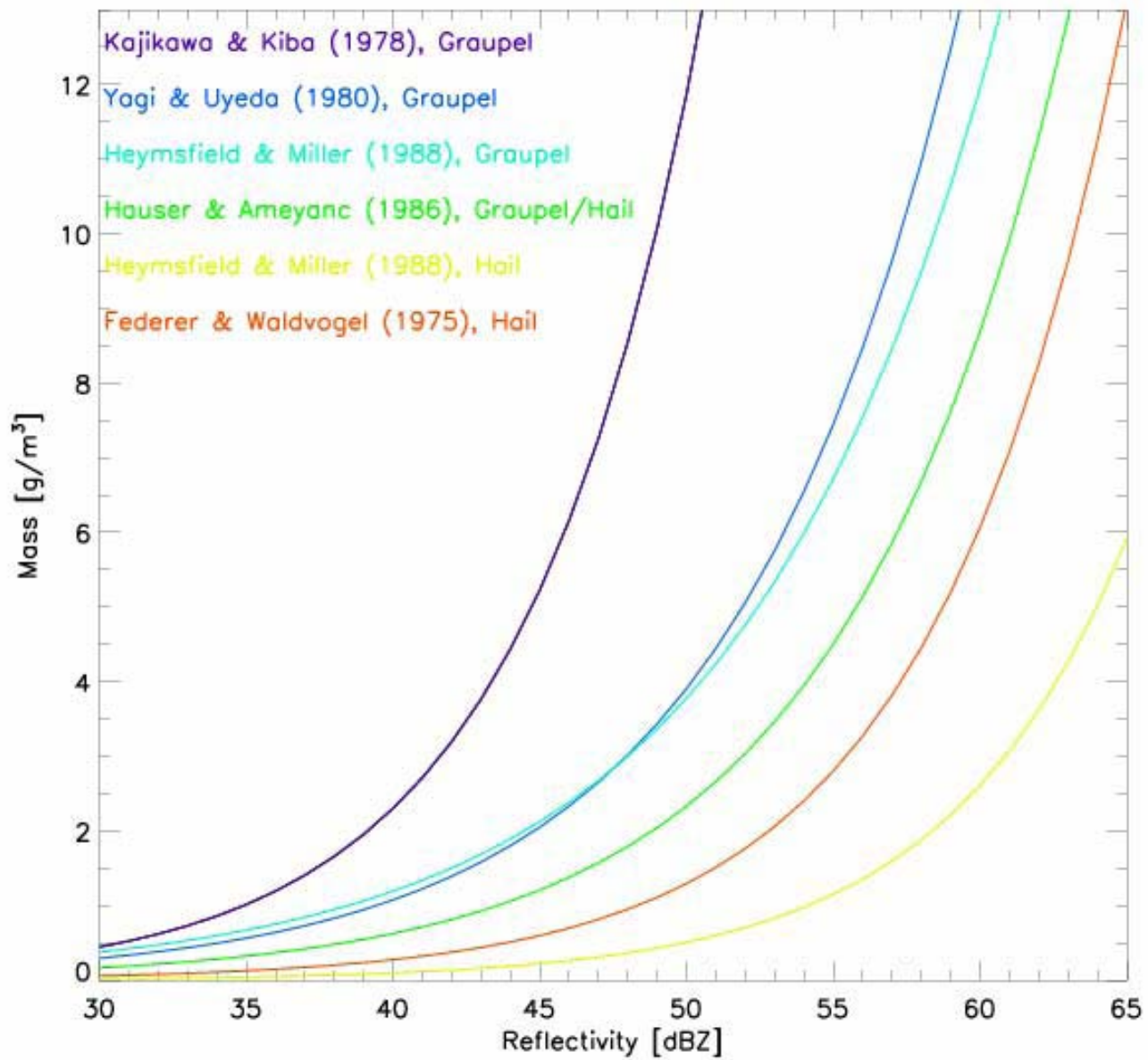
20080614102233 Z(dBZ)+UW at 26 km



Thermodynamic field

- $[T' - \langle T' \rangle] \& [P' - \langle P' \rangle]$
derived via Gal-Chen 1978 at
each level
- PingTong Sounding:
2008061406 UTC $\rightarrow P_0 \& T_0$
2008061409 UTC $\rightarrow P \& T$
- $T' = T - T_0$ at point A
- $\langle T' \rangle = T' - [T' - \langle T' \rangle]$ at point
A
- Apply $\langle T' \rangle$ to whole domain
- Samp as T for P





Thanks for your attention !!



National Central University, C-Band polarimetric radar,

since Nov. 2004

