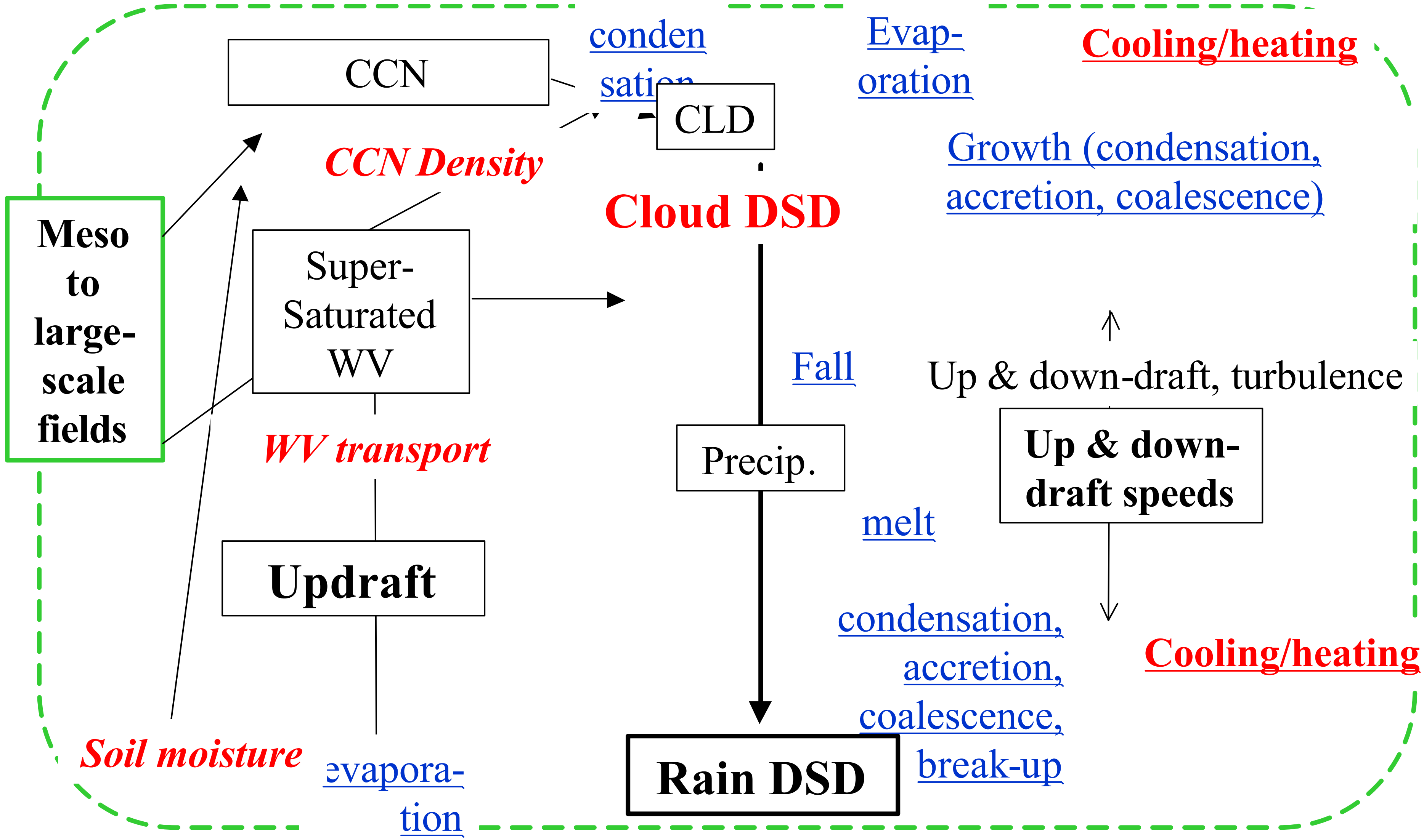
Objectives of DSD Studies at Koto Tabang

1. To obtain information for cloud & precipitation physics.

2. To relate DSD characteristics with larger-scale rain properties; *i.e.* ways to estimate DSD (and IRP relations) from ancillary information.

3. To develop statistical and/or physical models of vertical DSD profile.

Processes for DSD formation



Possible Approaches to relate m-scale and "macro-scale" rain properties

Koto Tabang data

Detailed case studies

Statistics of TRMM data and disdrometer data world-wide

Crude categorization: season, time of day, etc.

macro-scale parameters (echo top & area, wind field, Doppler width, temp / humid. profile, etc.)

m-**physical parameters**

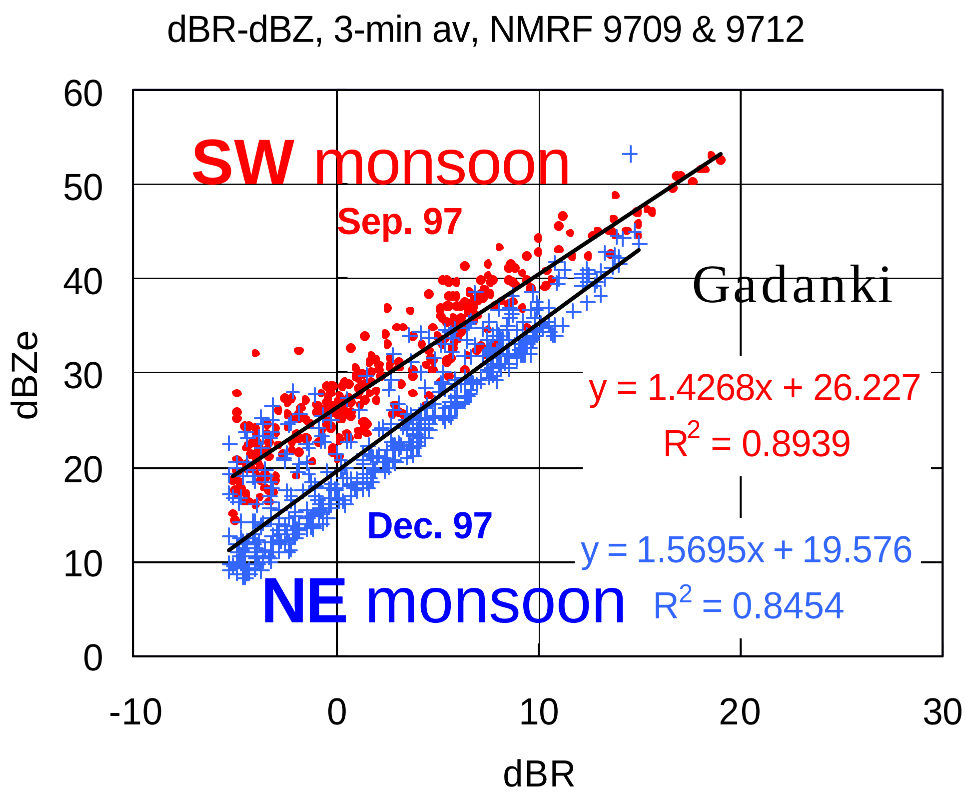
(DSD, *Z*-*R*, etc.)

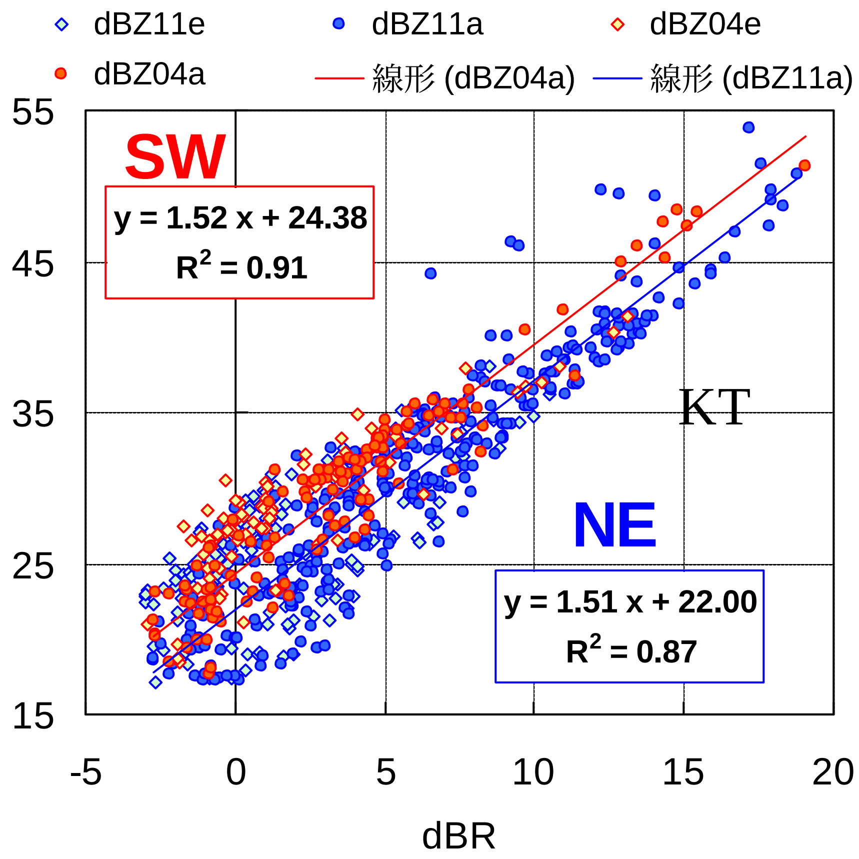
Climatological similarities

More information from scientists for each disdrometer site.

General relations between DSD (or *Z*-*R*) vs. "macro-scale" rain properties?

Seasonal variation of Z-R relation, Gadanki & Koto Tabang

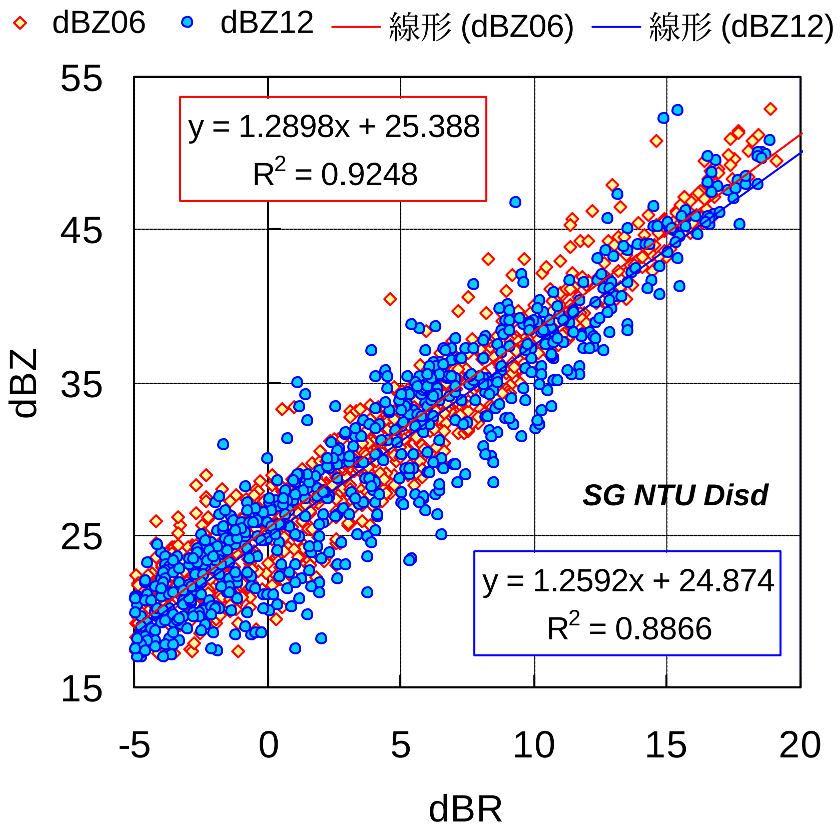


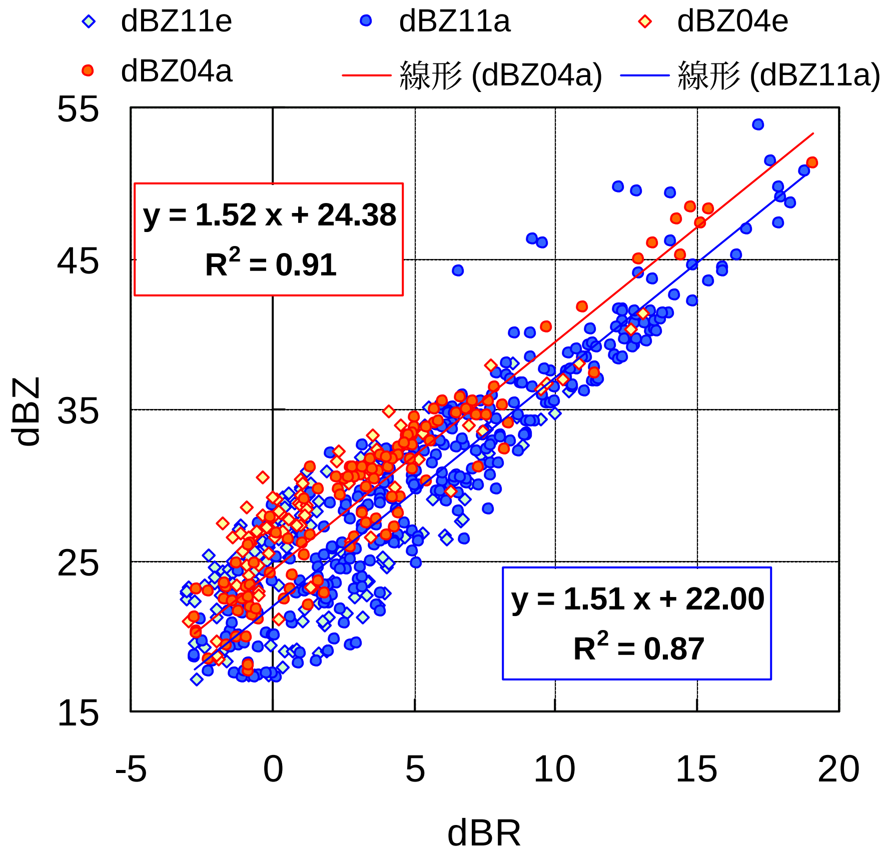


Note: When DSD is broader (larger number of large drops), dBZe is enhanced for a given dBR.

Gadanki DSD has clearer seasonal variation.

Seasonal variation of Z-R relation, Singapore & Koto Tabang

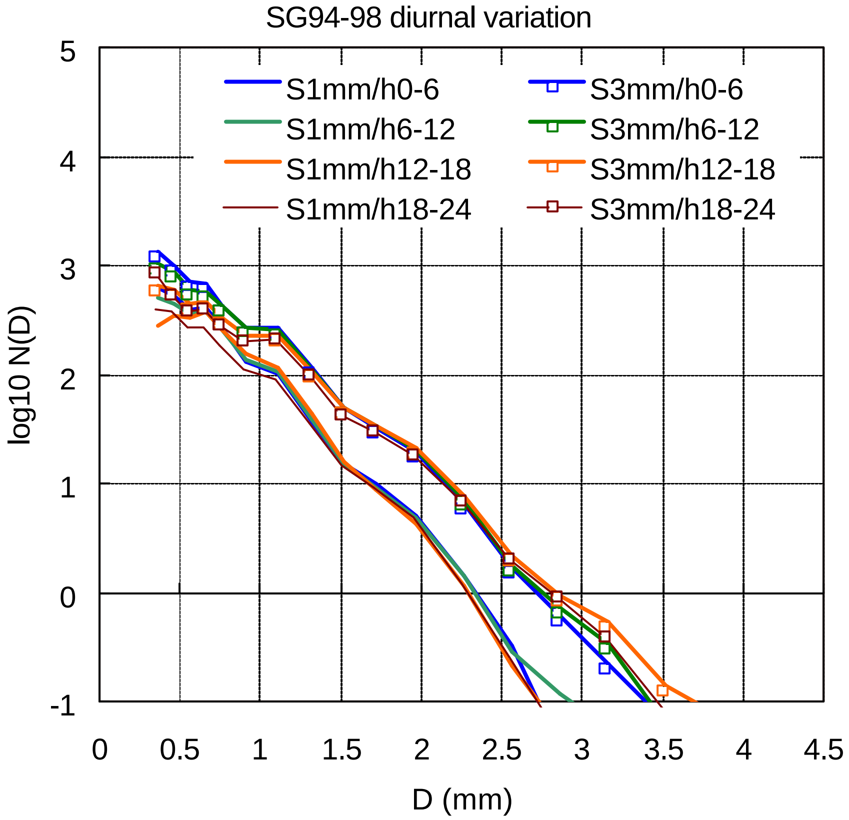


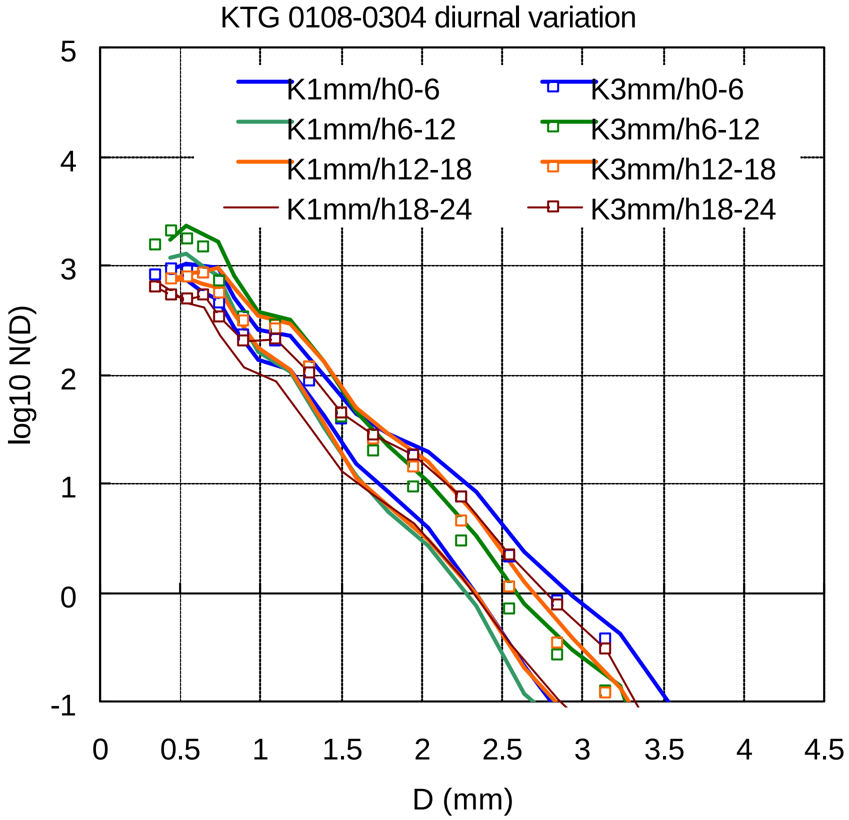


Singapore DSD has little seasonal variation.

Singapore vs. Koto Tabang DSDs, **light rains**

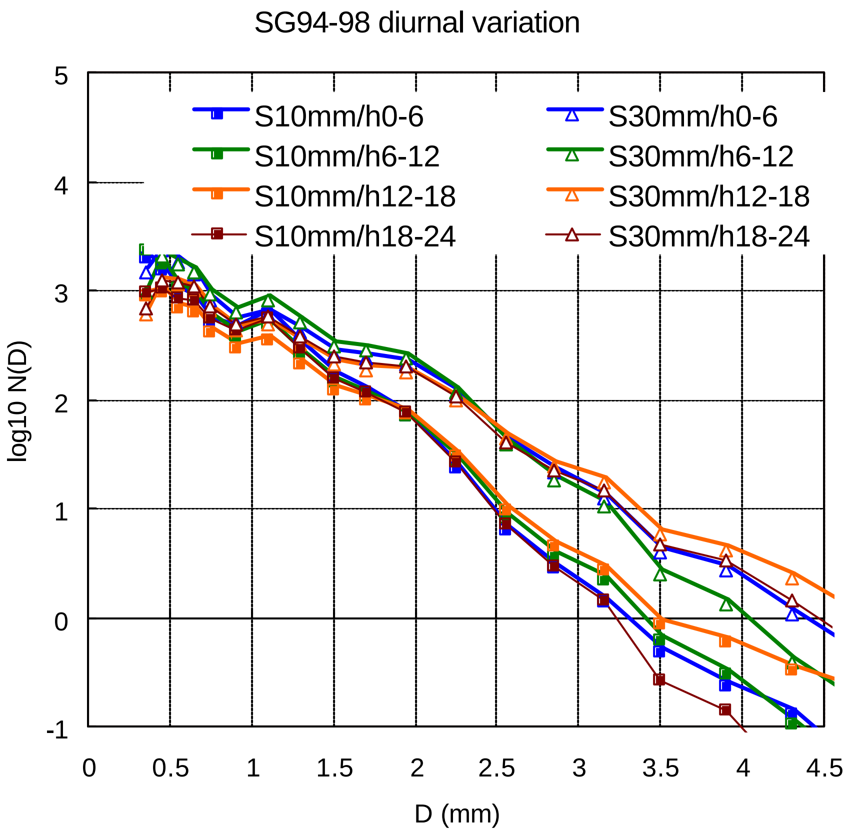
SG and KT DSDs are similar, but KT DSDs have more diurnal variation.

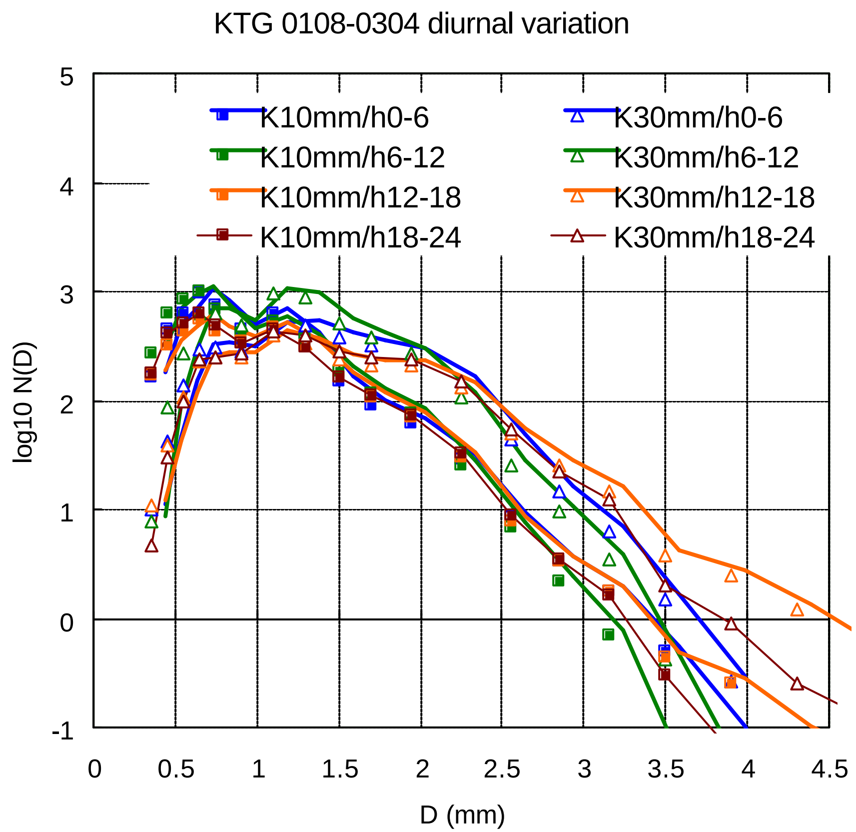




Singapore vs. Koto Tabang DSD, **heavy rains**

SG DSDs are broader than KT DSDs.





Model function of DSD and Doppler spectrum

- $N(D) = \Lambda^{m+7} m_6 D^m e^{-\Lambda D}$
- $S(v) = S_t(v) + S_p(v) * S_0(v) + P_n$

Gamma model with new parameterization

Turbulence spectrum, Gaussian model

Noise power density

Precipitation spectrum smeared and shifted by turbulence

DSD parameters

(Λ, m_6, m)

Shape parameter

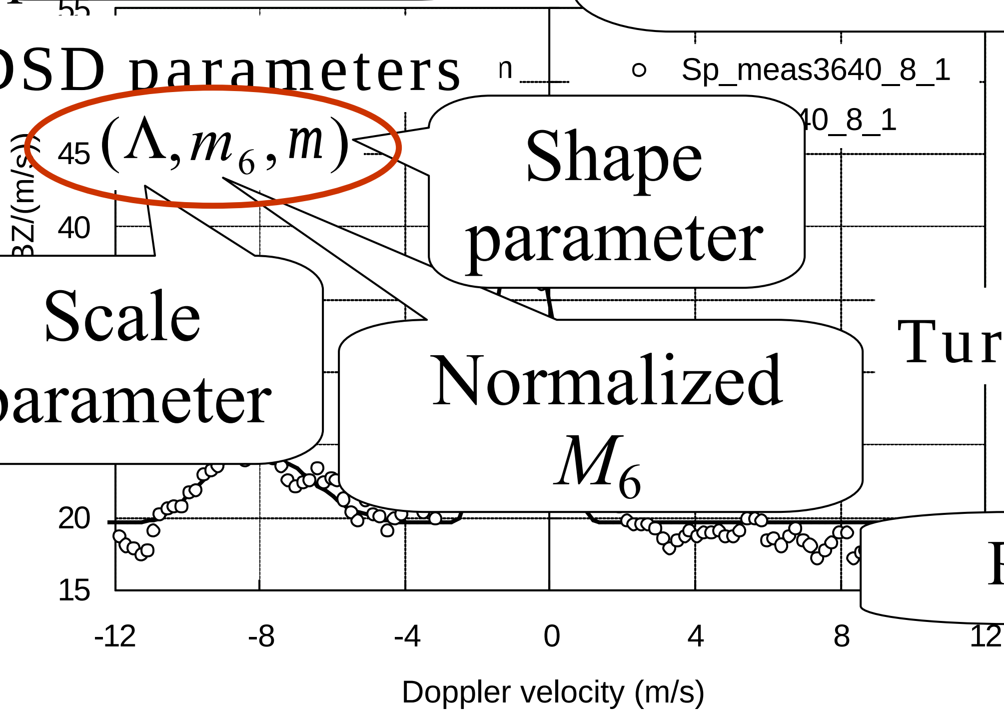
Scale parameter

Normalized M_6

Turbulence parameters

(p_0, w, s)

Peak value, mean and SD

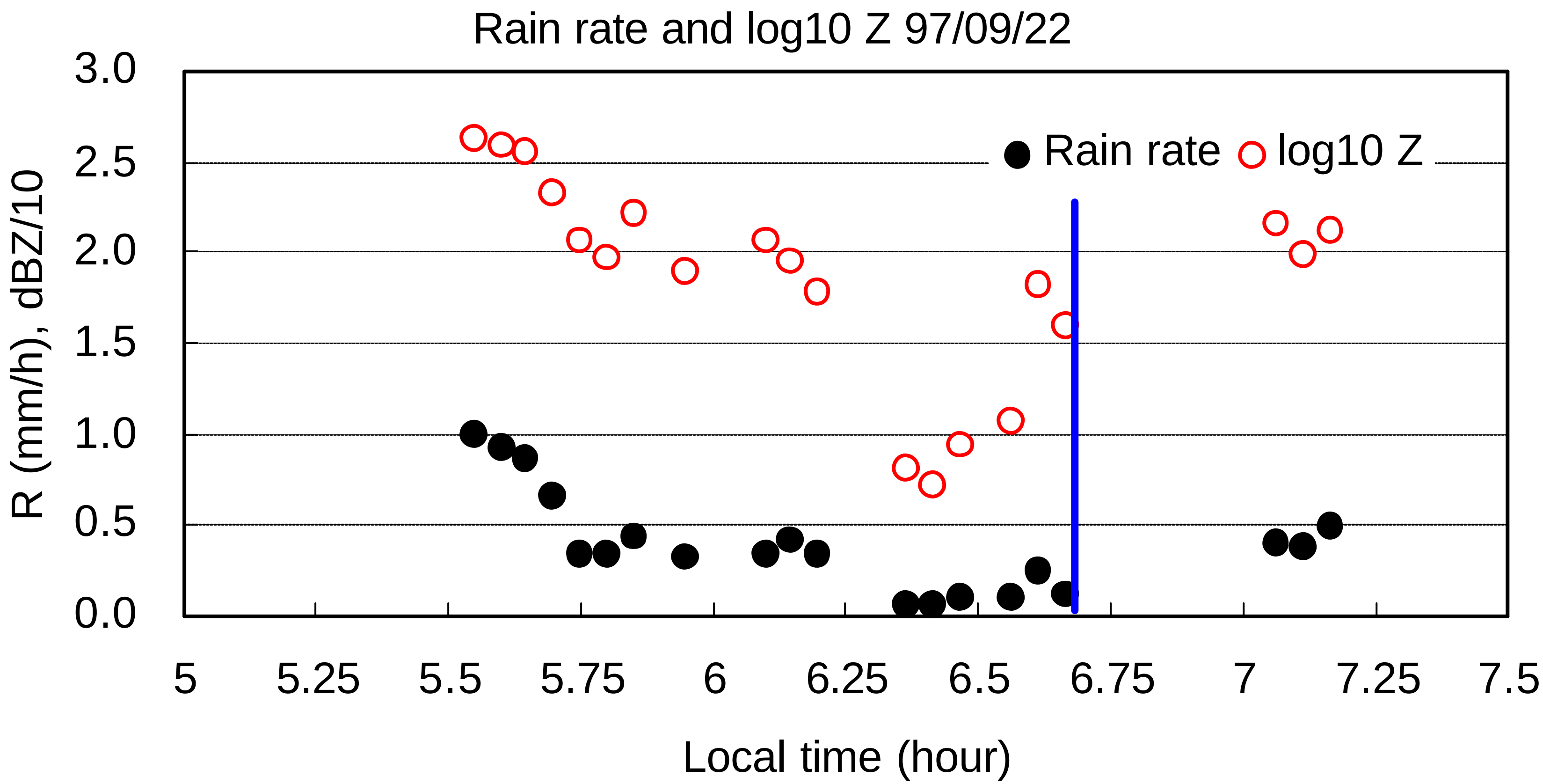


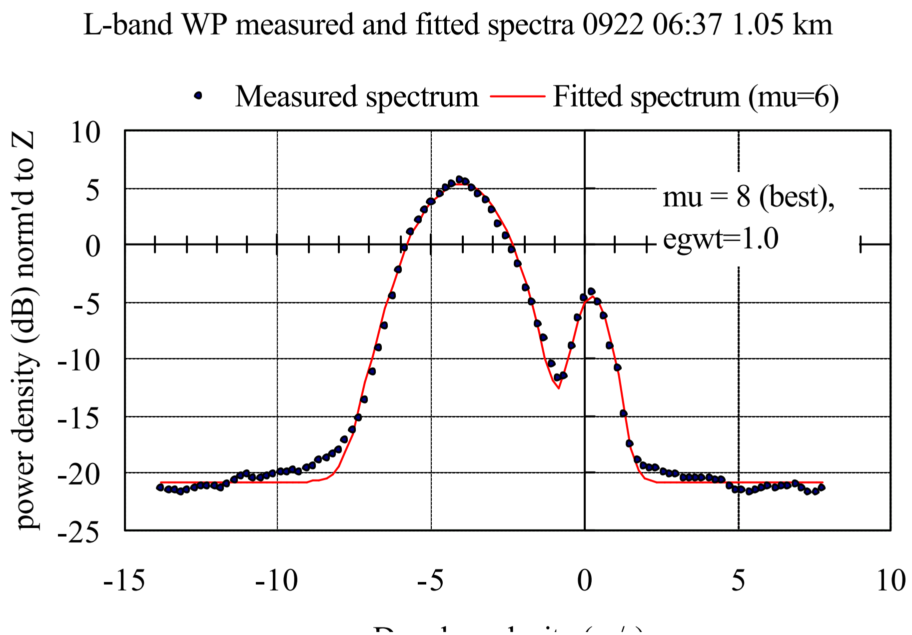
DSD Estimation method

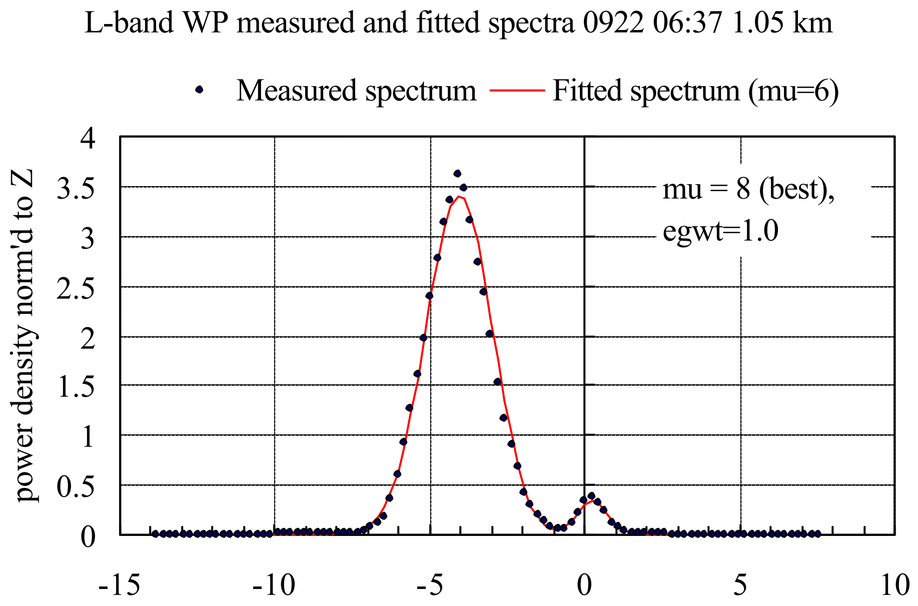
1. To estimate p_0, w, σ, P_n, m_y, L_{xy} with a non-linear least square fitting in log-power scale with a proper weighting.

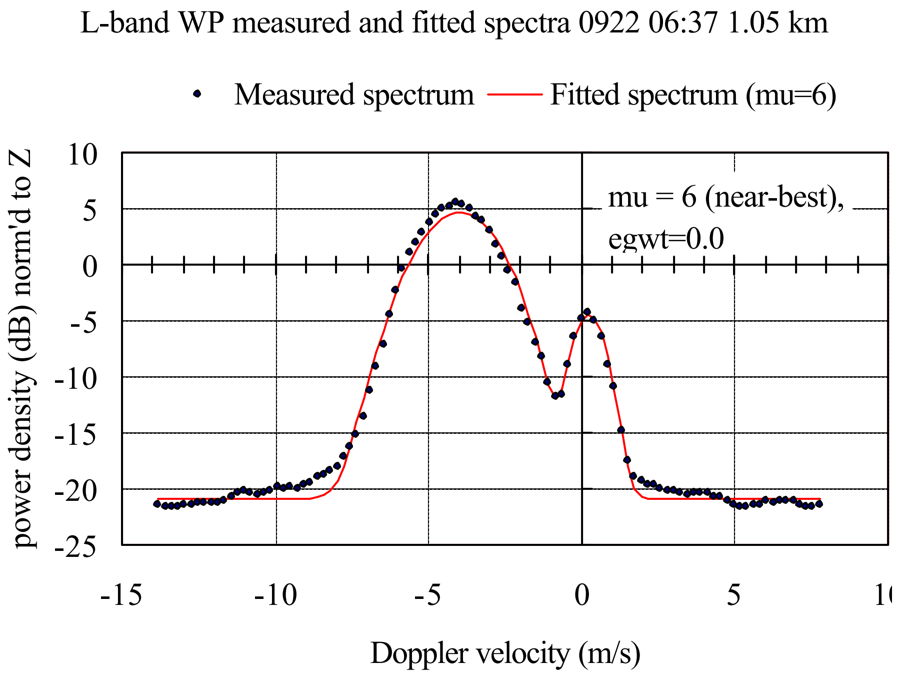
2. To calculate the RMS difference between measured and fitted spectra over the S_p*S_0 region for a fixed μ, and select the μ value giving the minimum RMS difference.

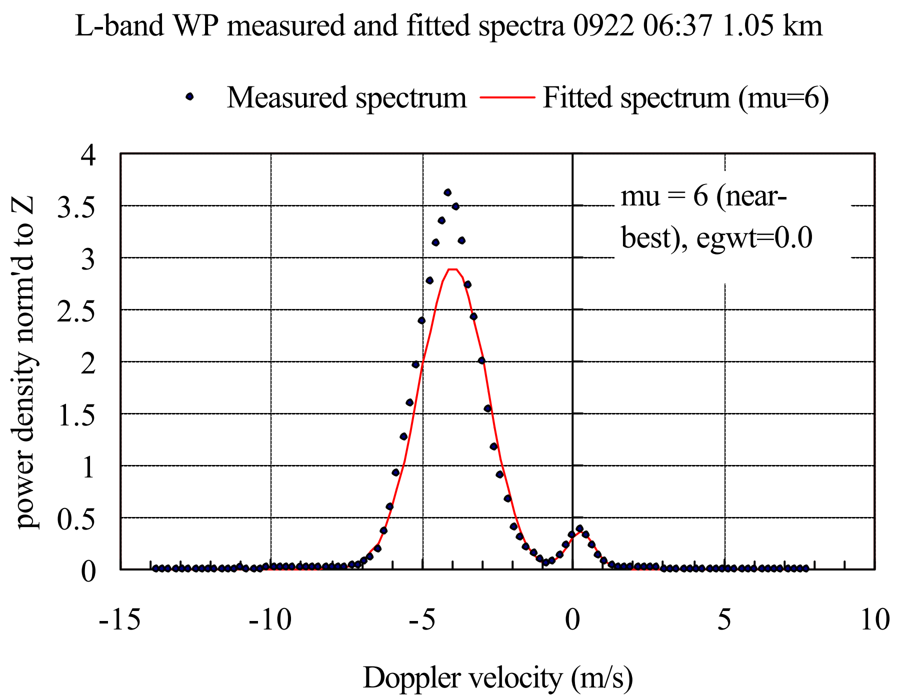
Rain rate and $\log_{10} Z$ in 97/09/22, Gadanki





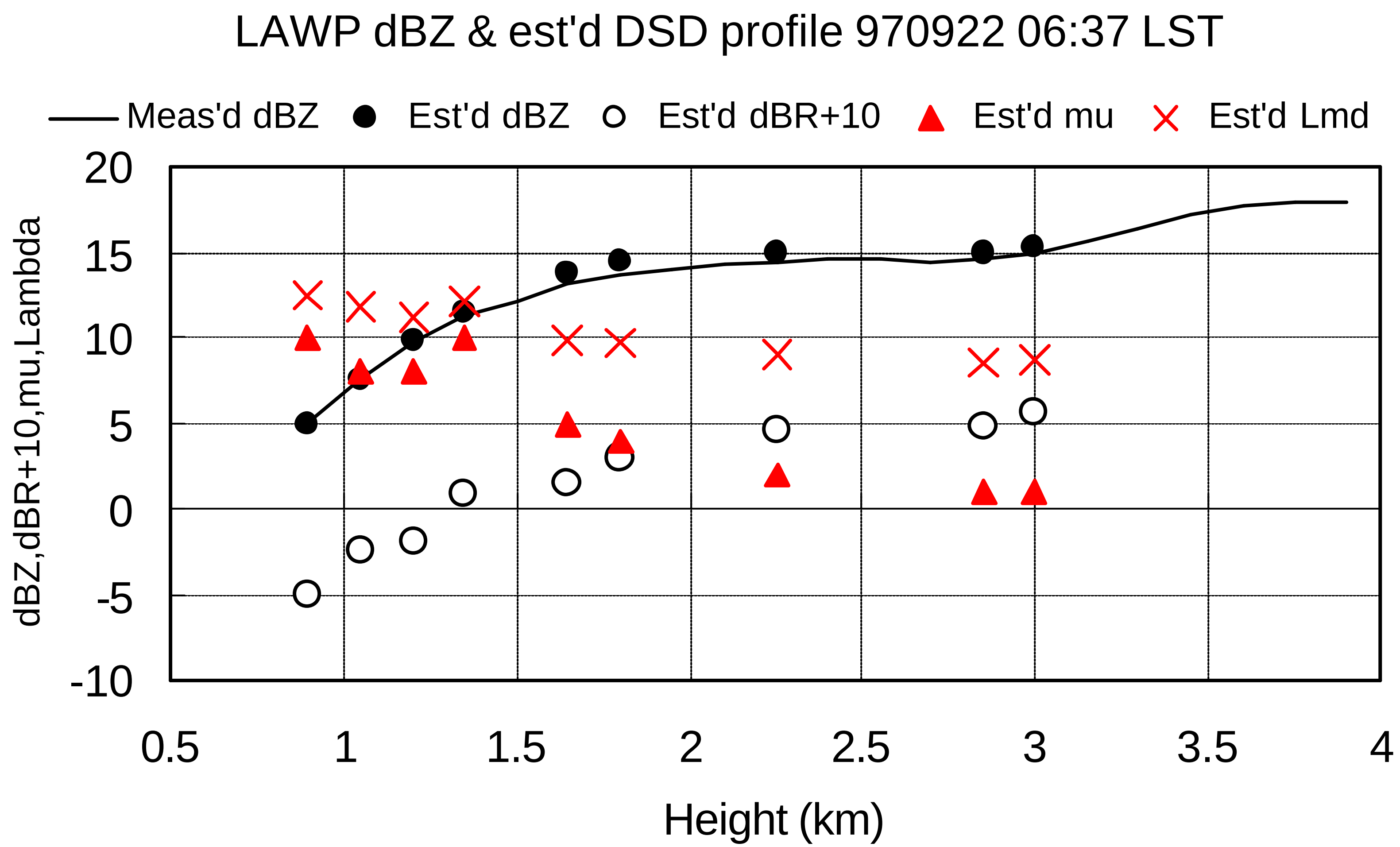




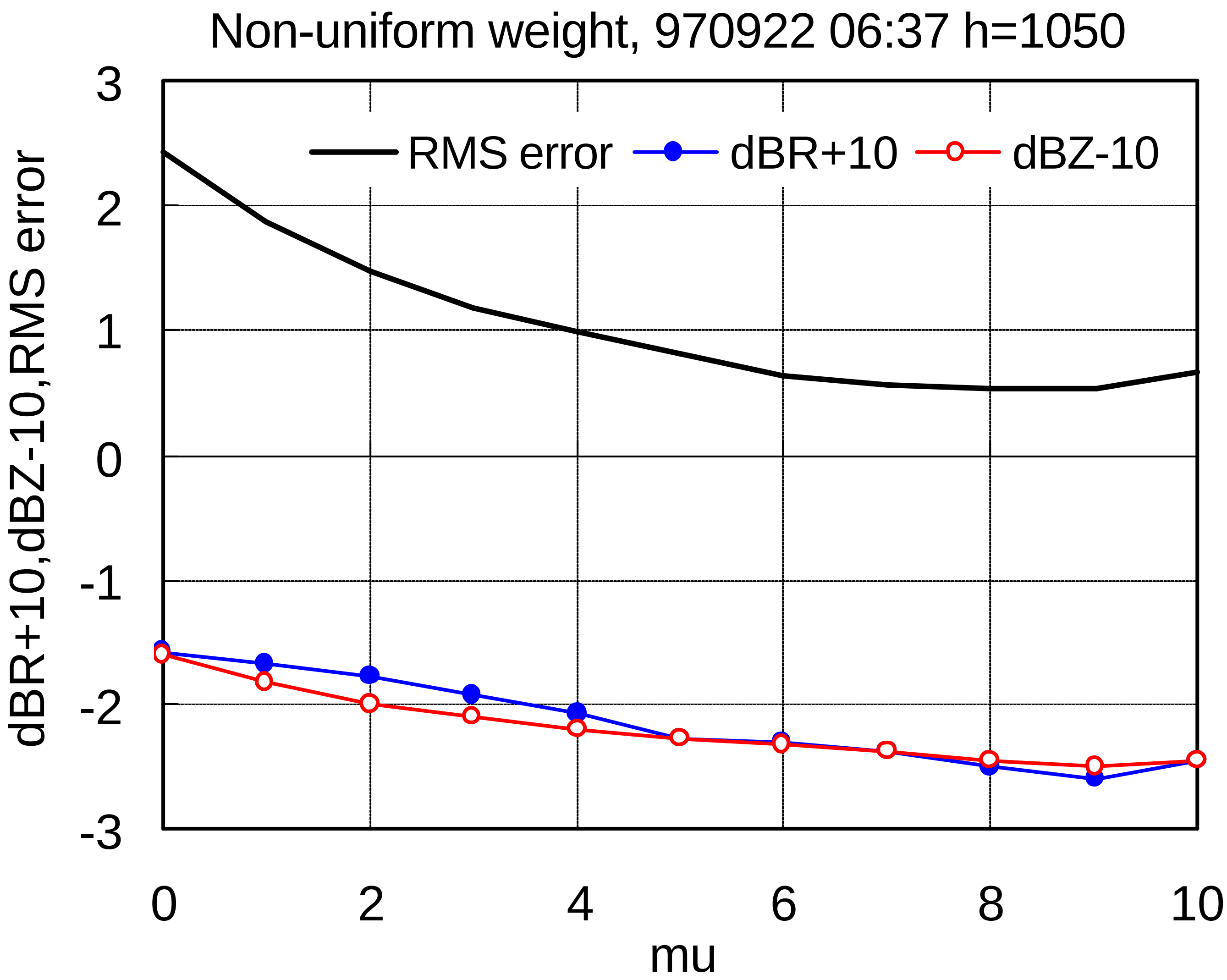


T. Kozu Dec. 24, 2003

Estimated DSD parameter profile

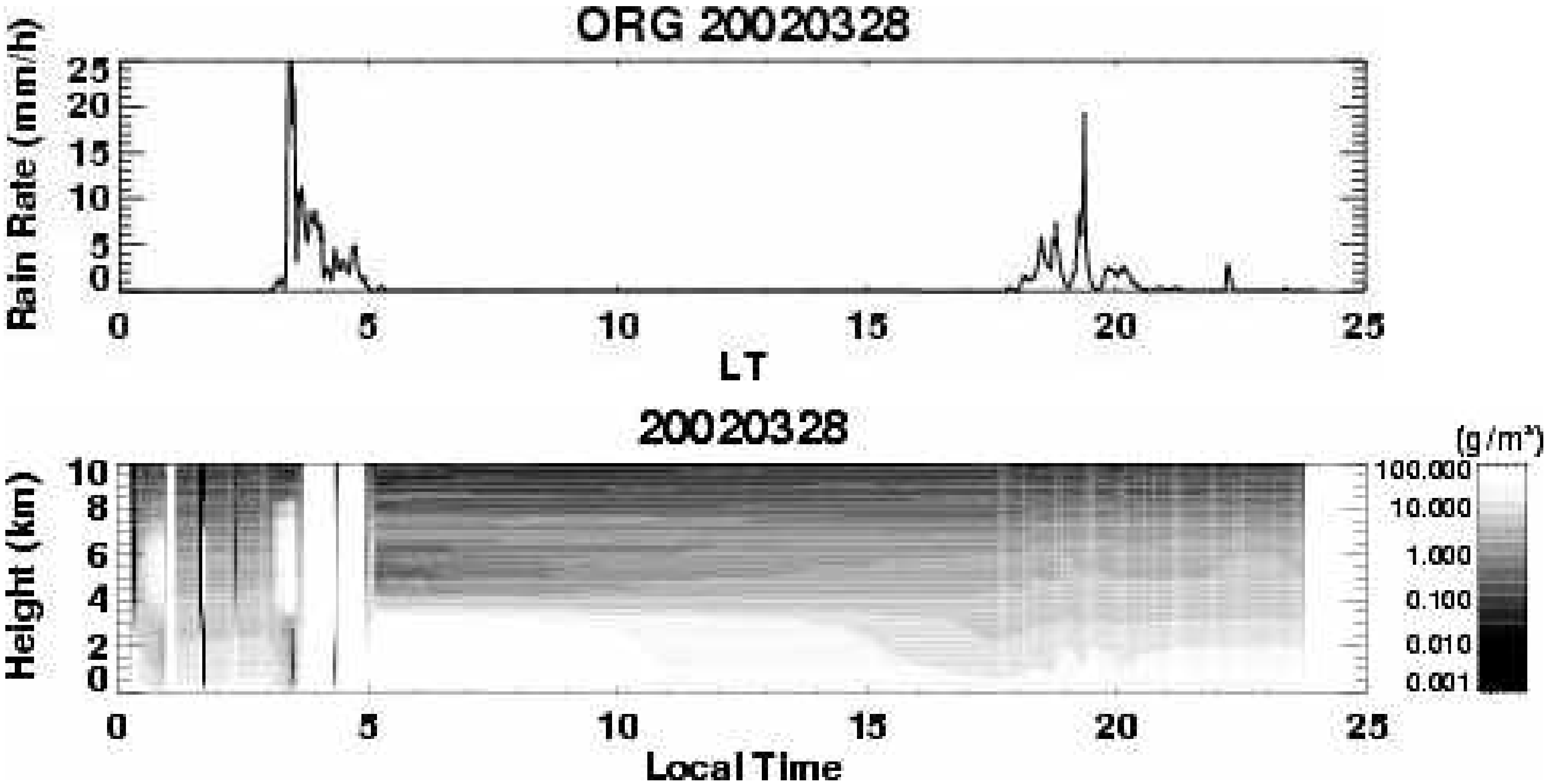


Example of μ dependence of RMS error: LAWP

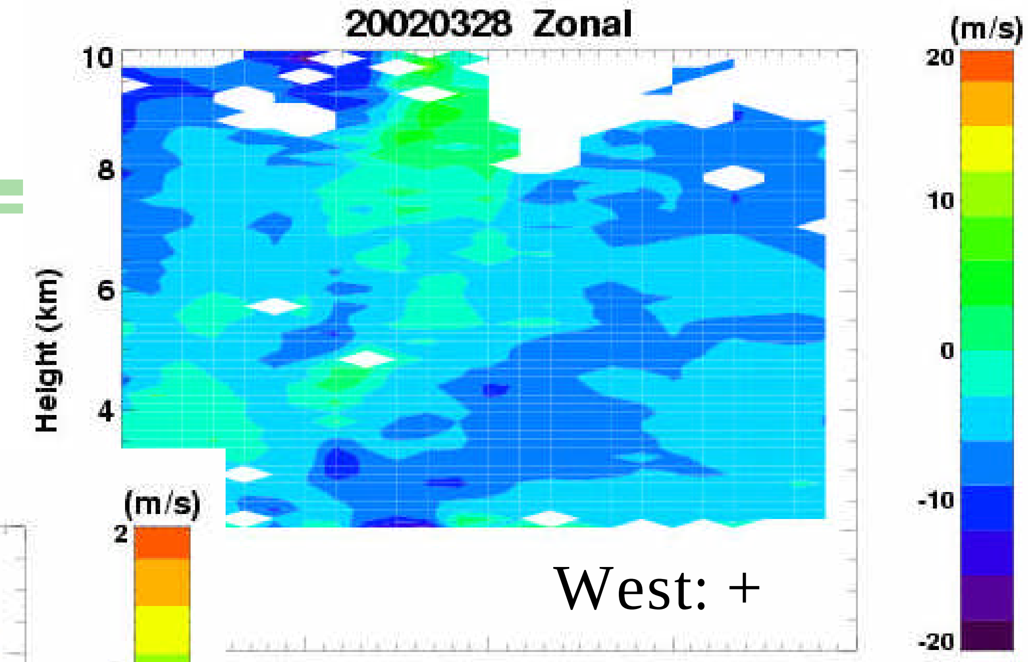


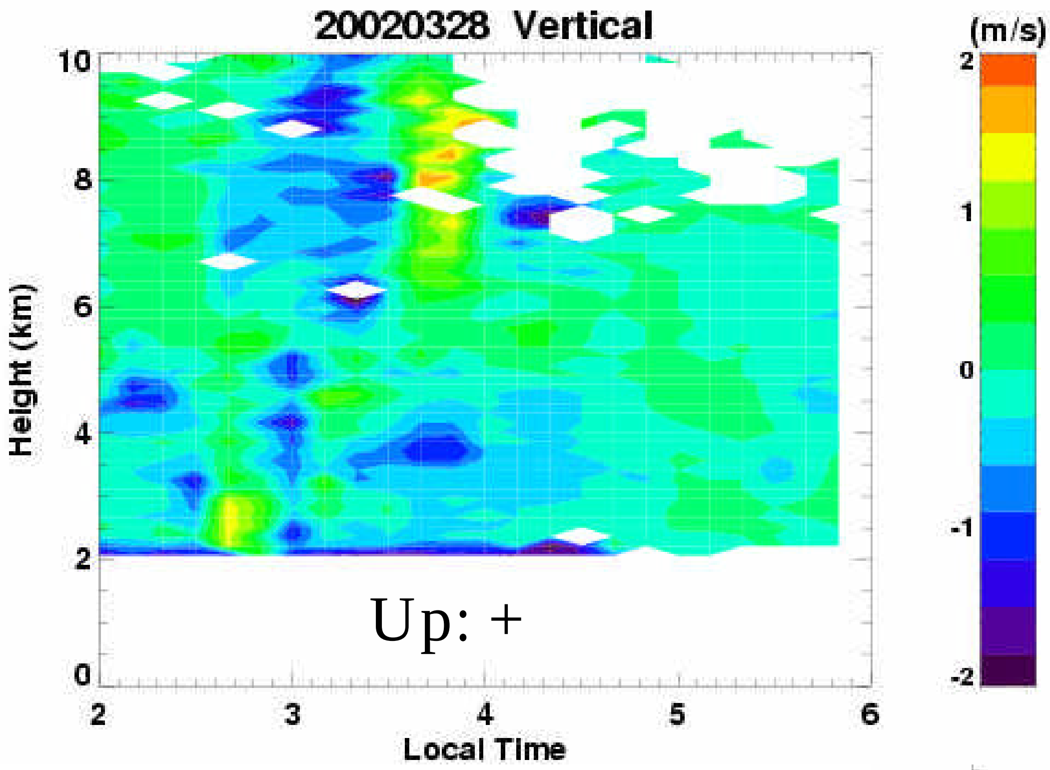
ORG and WV profiler browse at CPEA A03 Web site

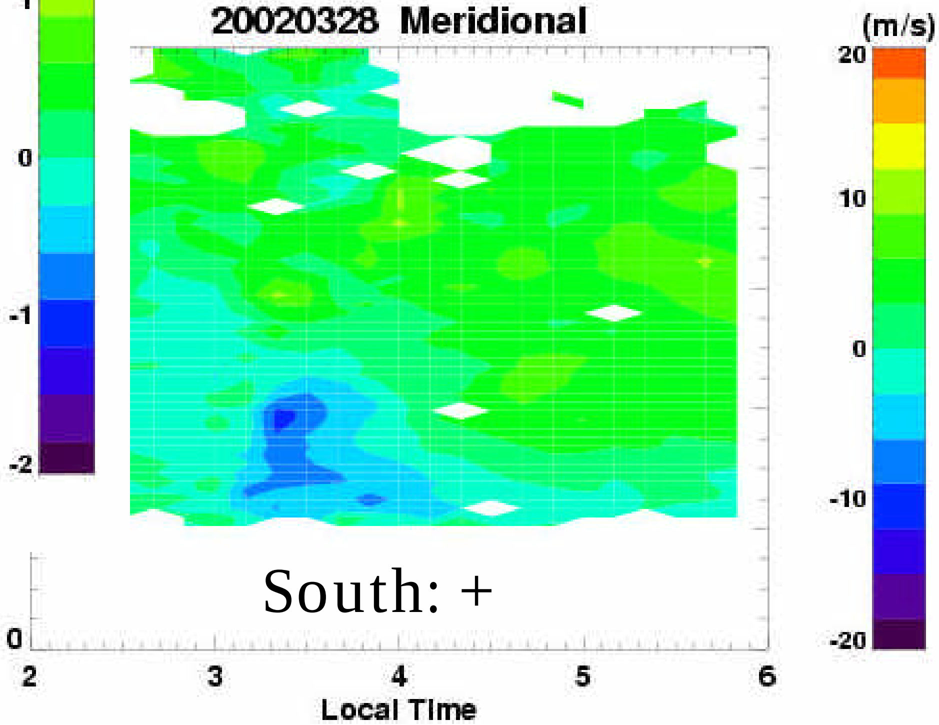
http://rslab.riko.shimane-u.ac.jp/CPEA/data/index.html



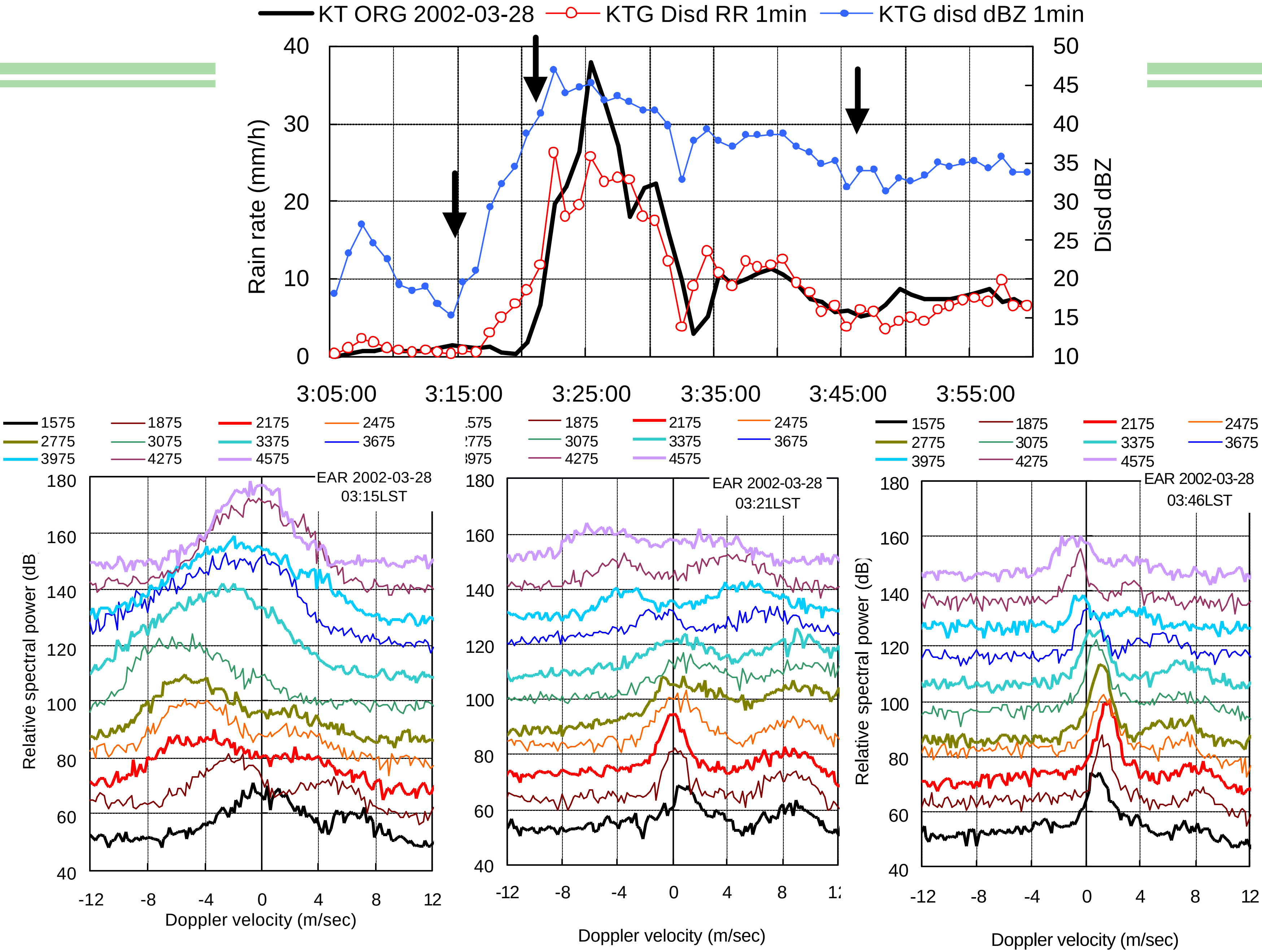
Wind condition in the midnight, 2002/03/28



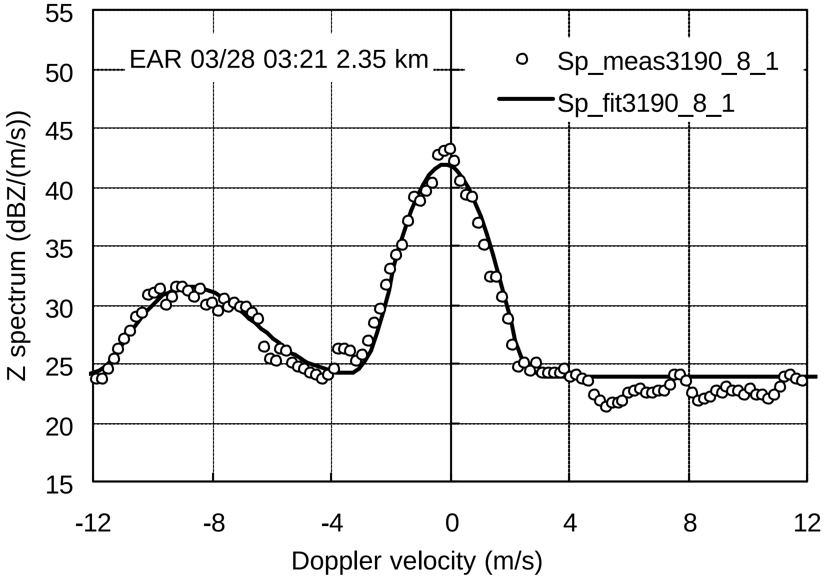


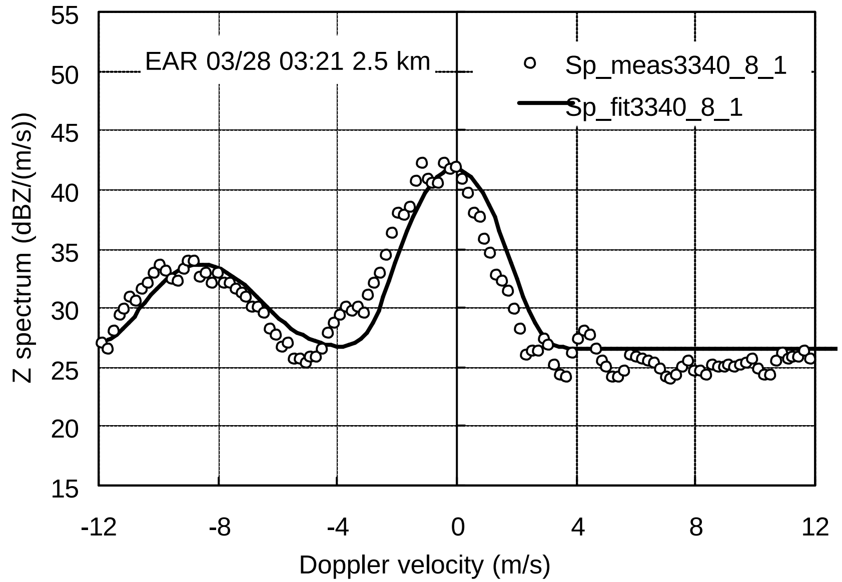


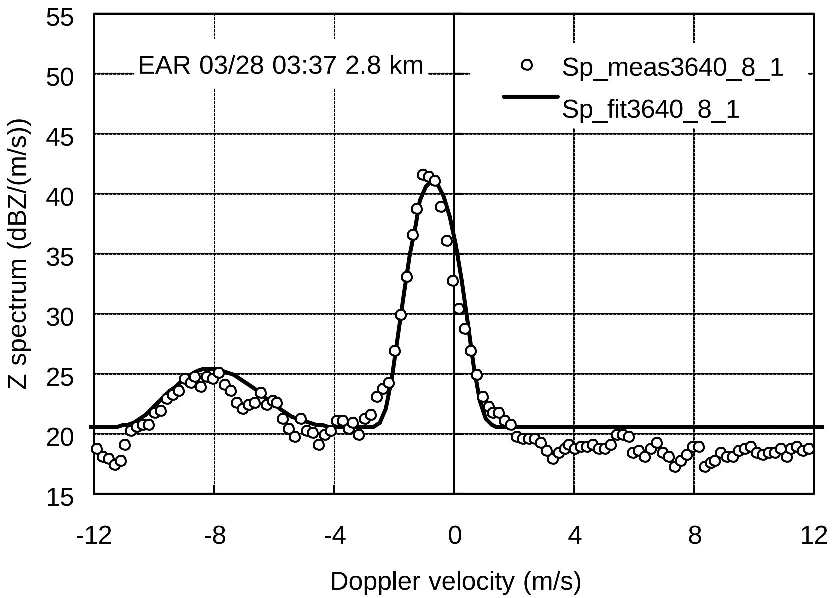
Rain rate and Radar reflectivity: 03 – 04 LT

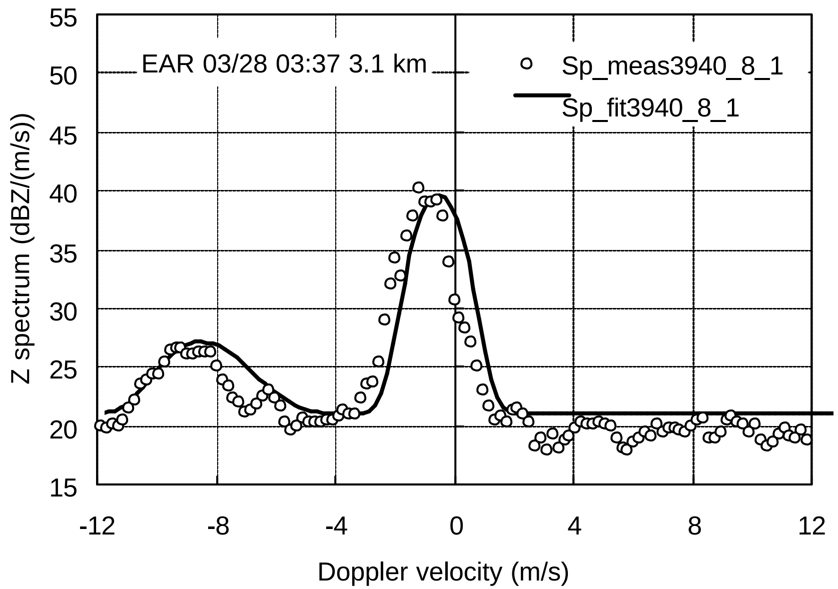


Example of EAR spectrum fitting

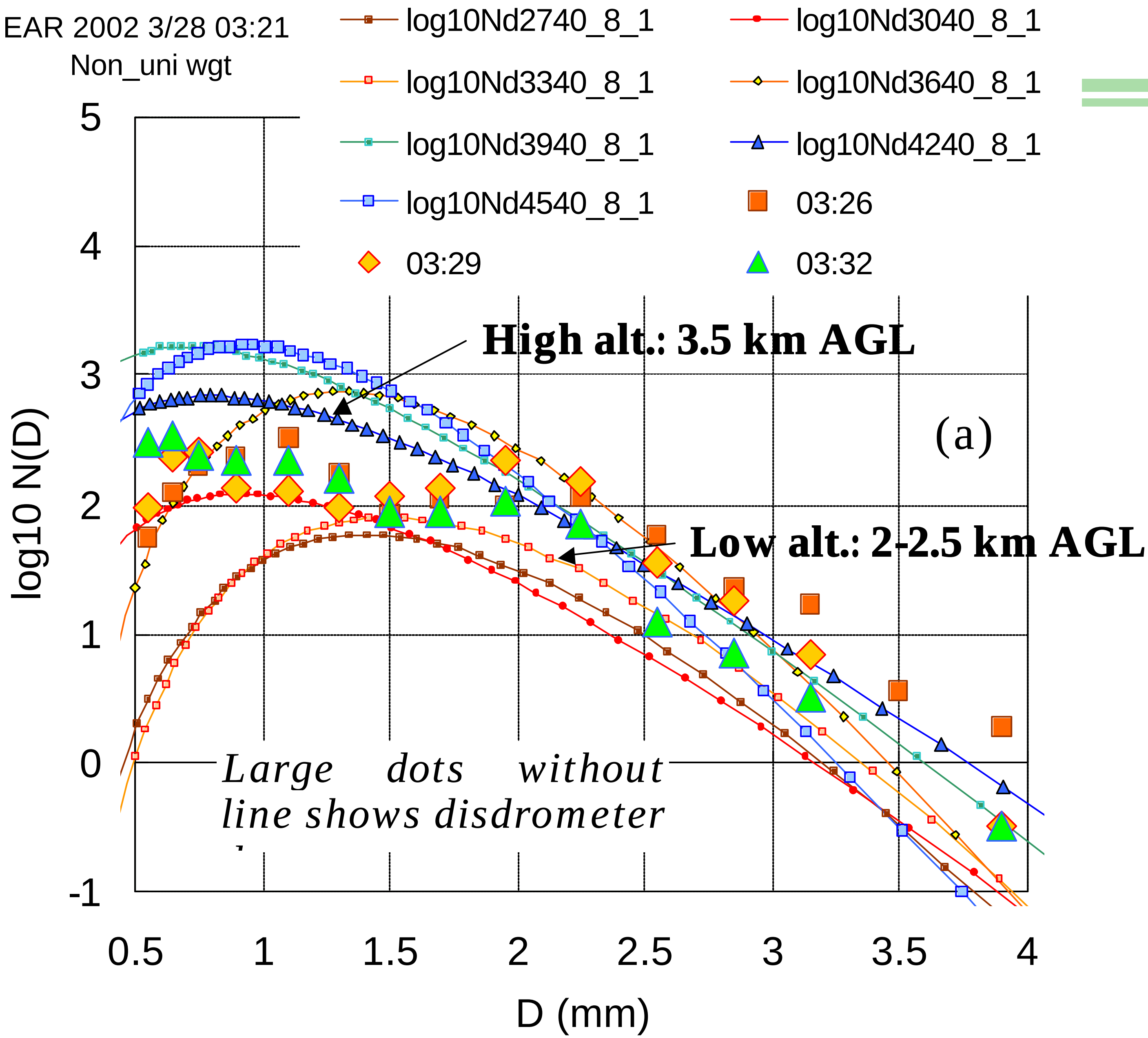








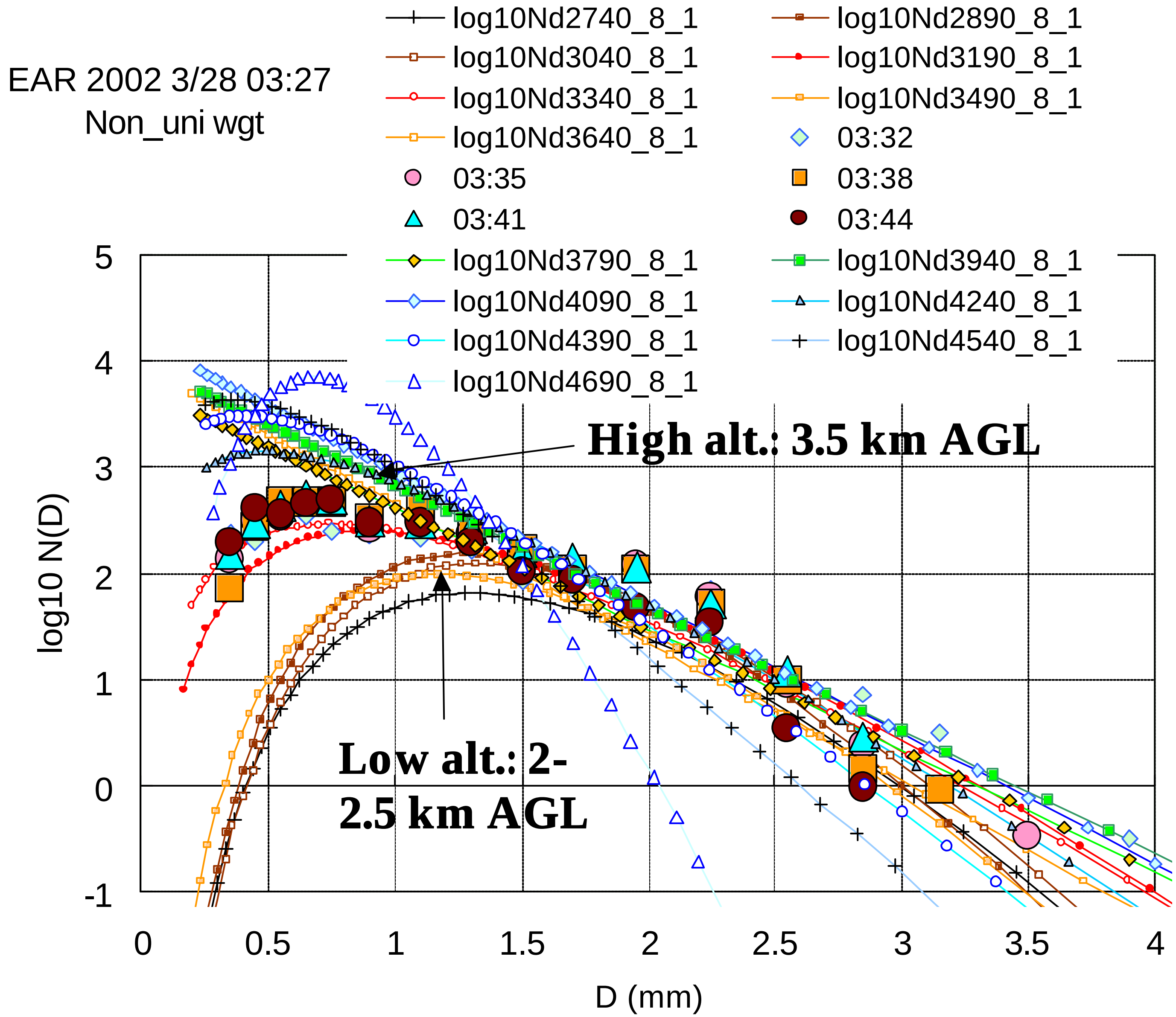
Estimated DSDs at early stage



High alt.: broad -->

Low alt.: slightly narrow.c

Estimated DSDs at "mid" stage



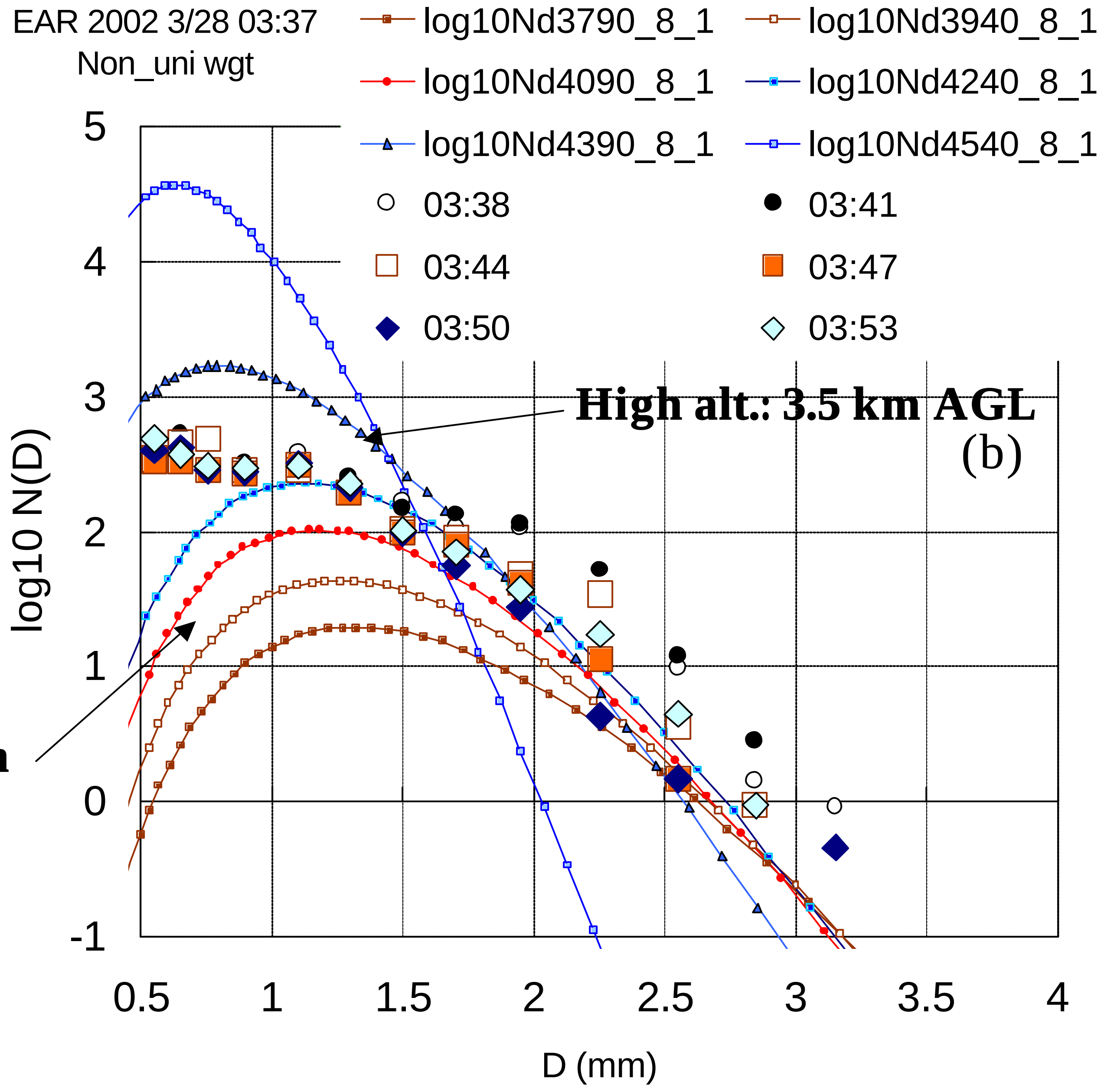
High alt. & low alt.: almost stationary.

Estimated DSDs at trailing stage

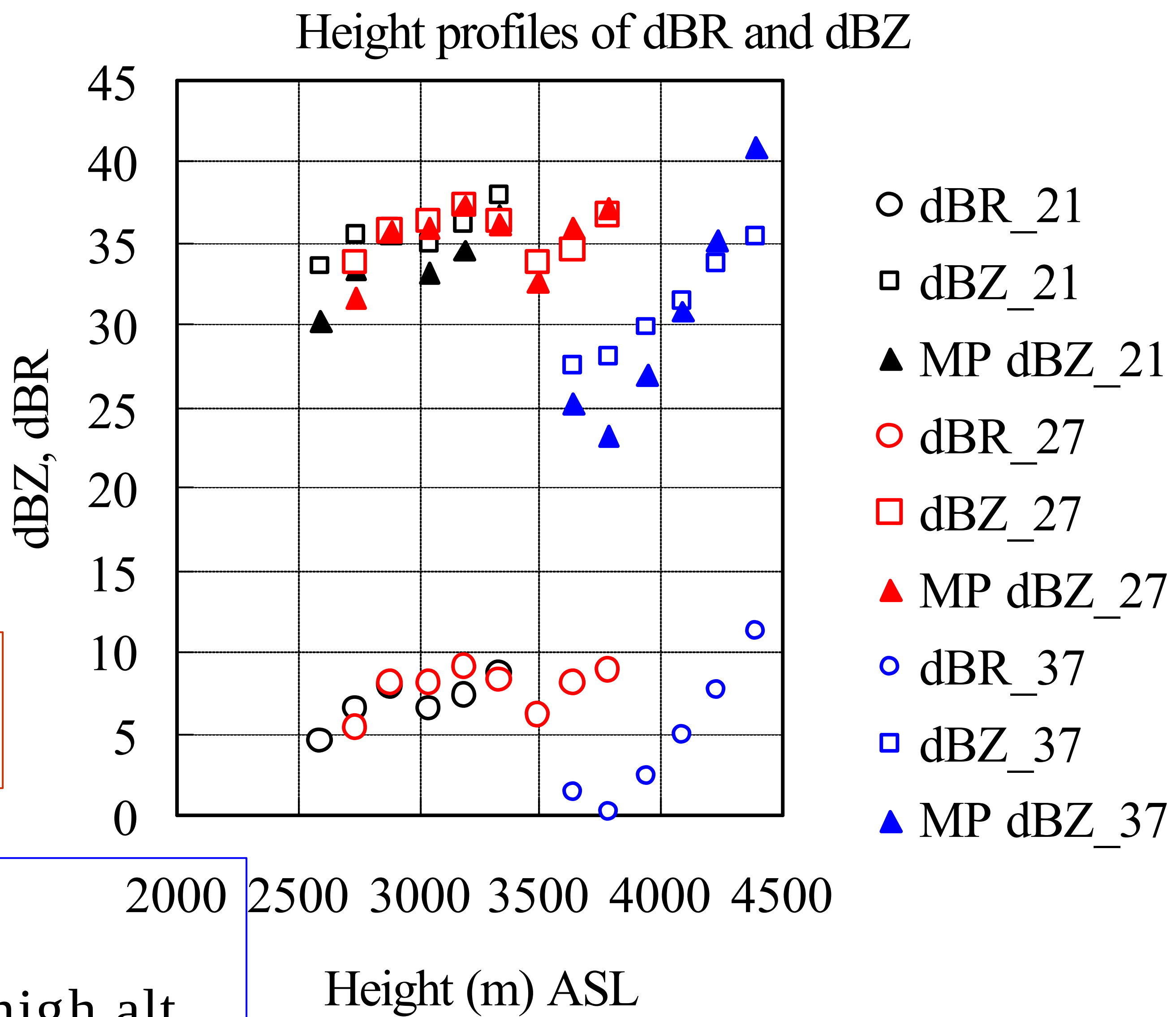
High alt.: narrow -->

Low alt.: slightly broad.

Low alt.: 3 km AGL



Estimated dBR and dBZ, with dBZ from dBR assuming MP Z-R relation



Early:
$dBZ > dBZ_{MP}$

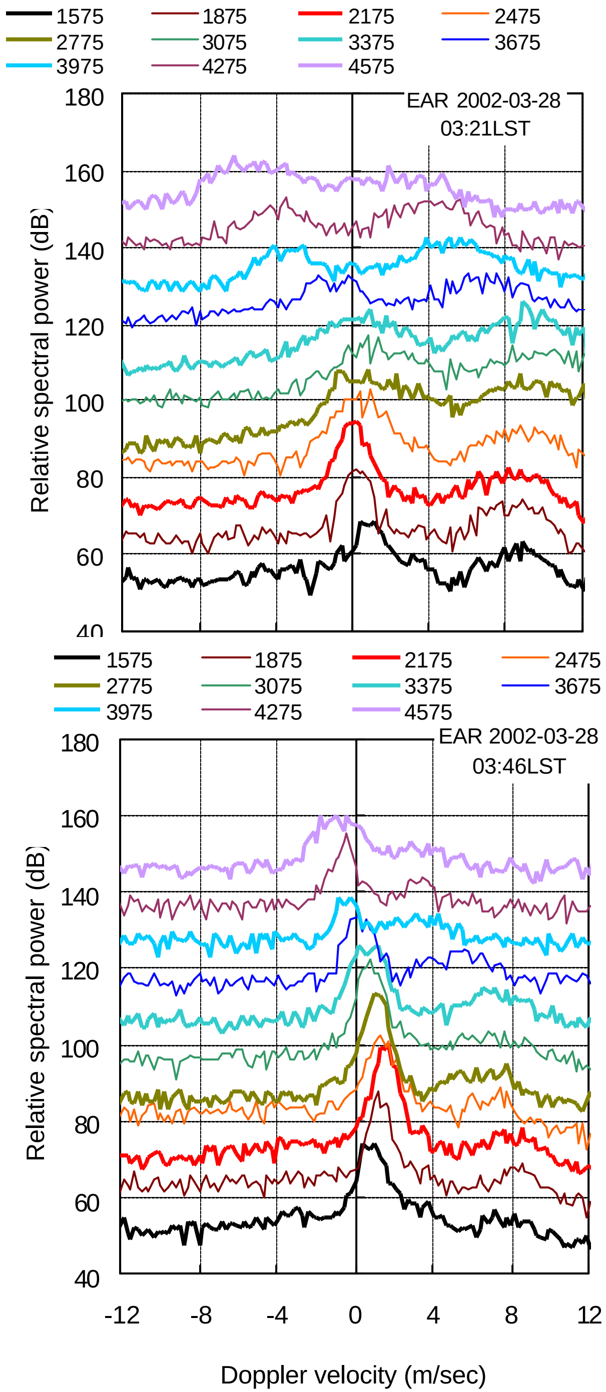
Mid:
$dBZ \approx dBZ_{MP}$

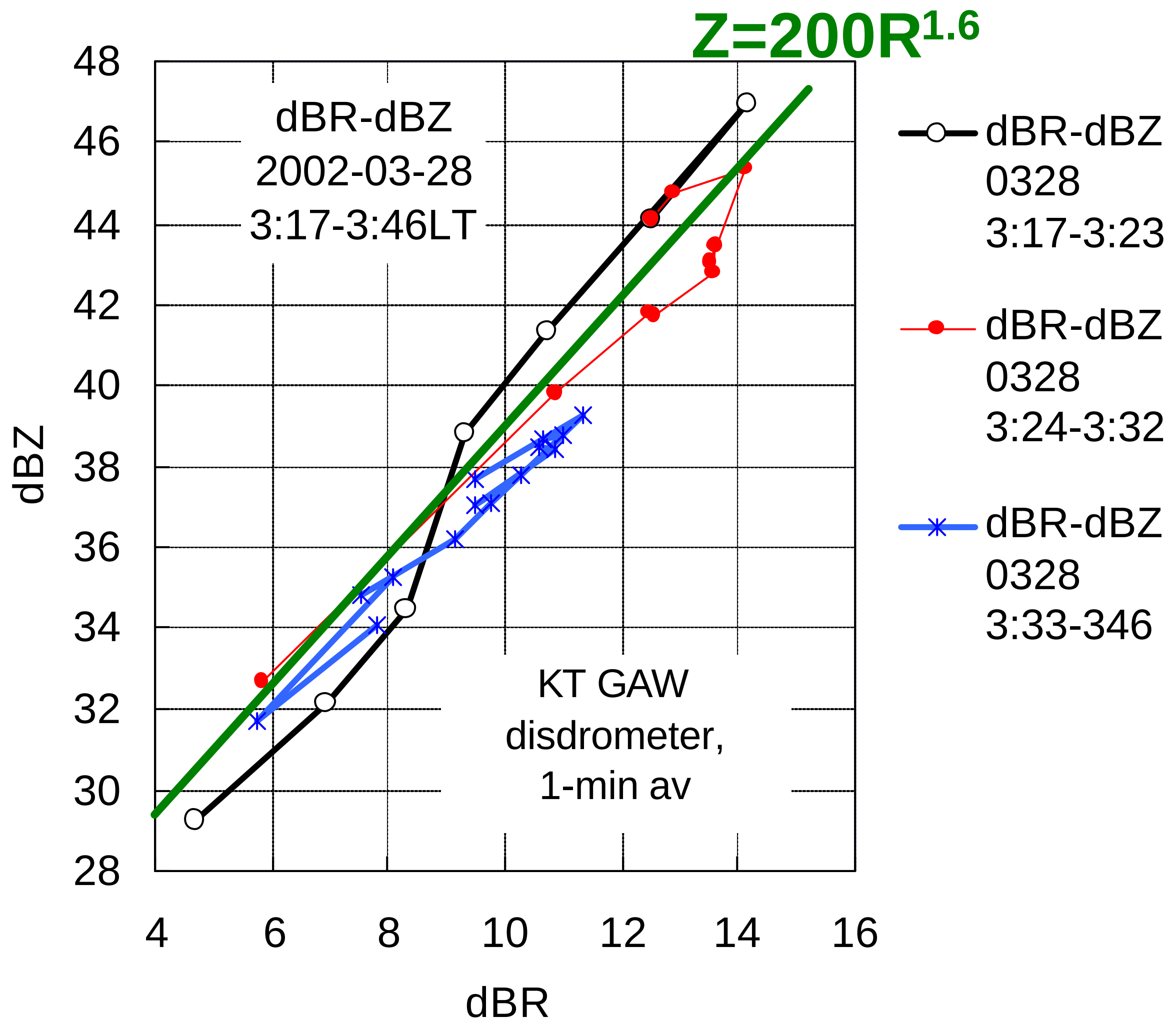
Trail:

$dBZ \approx dBZ_{MP}$ at high alt.

$dBZ > dBZ_{MP}$ at mid alt.

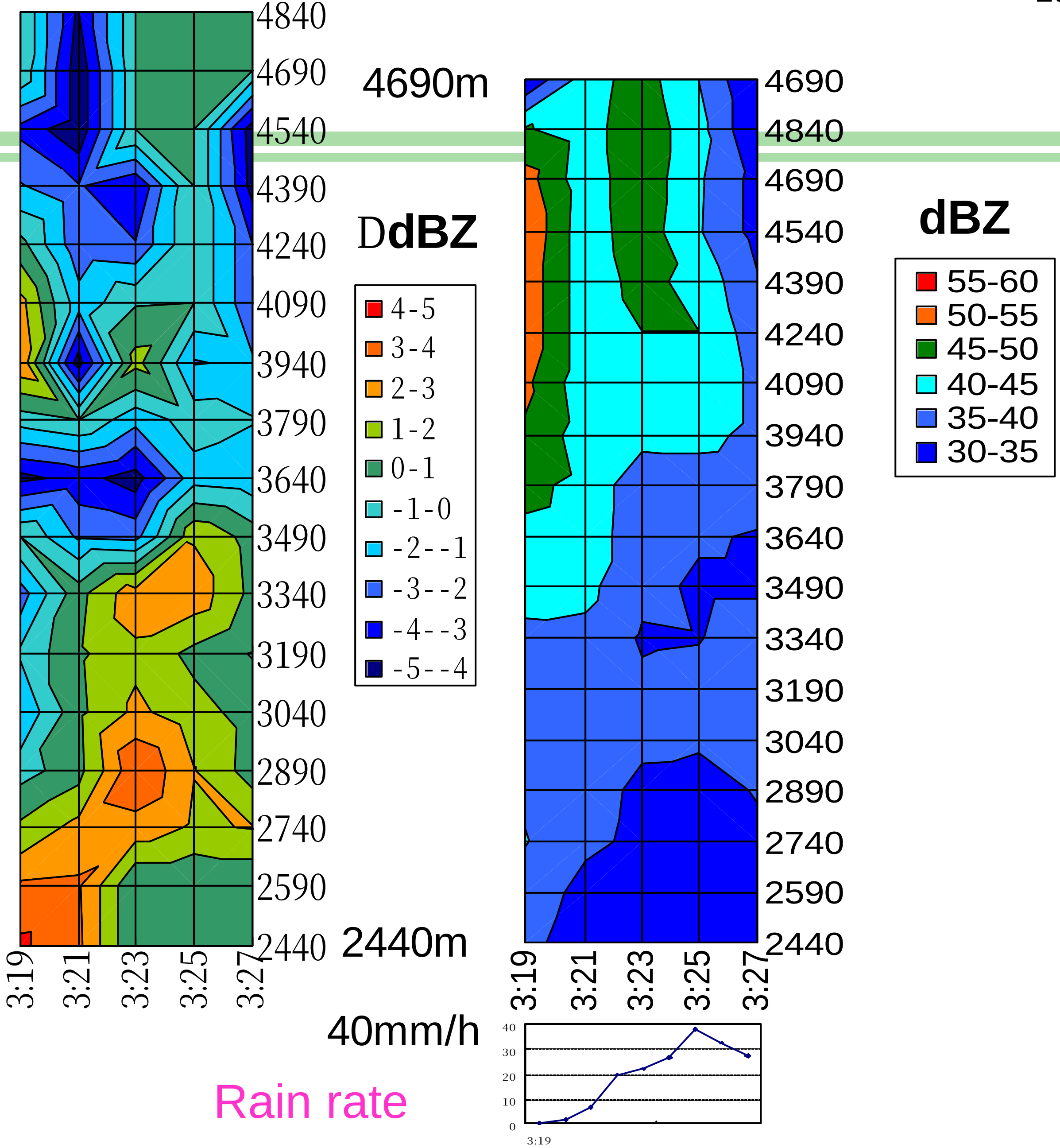
Disdrometer Z-R relation vs. Doppler Spectra



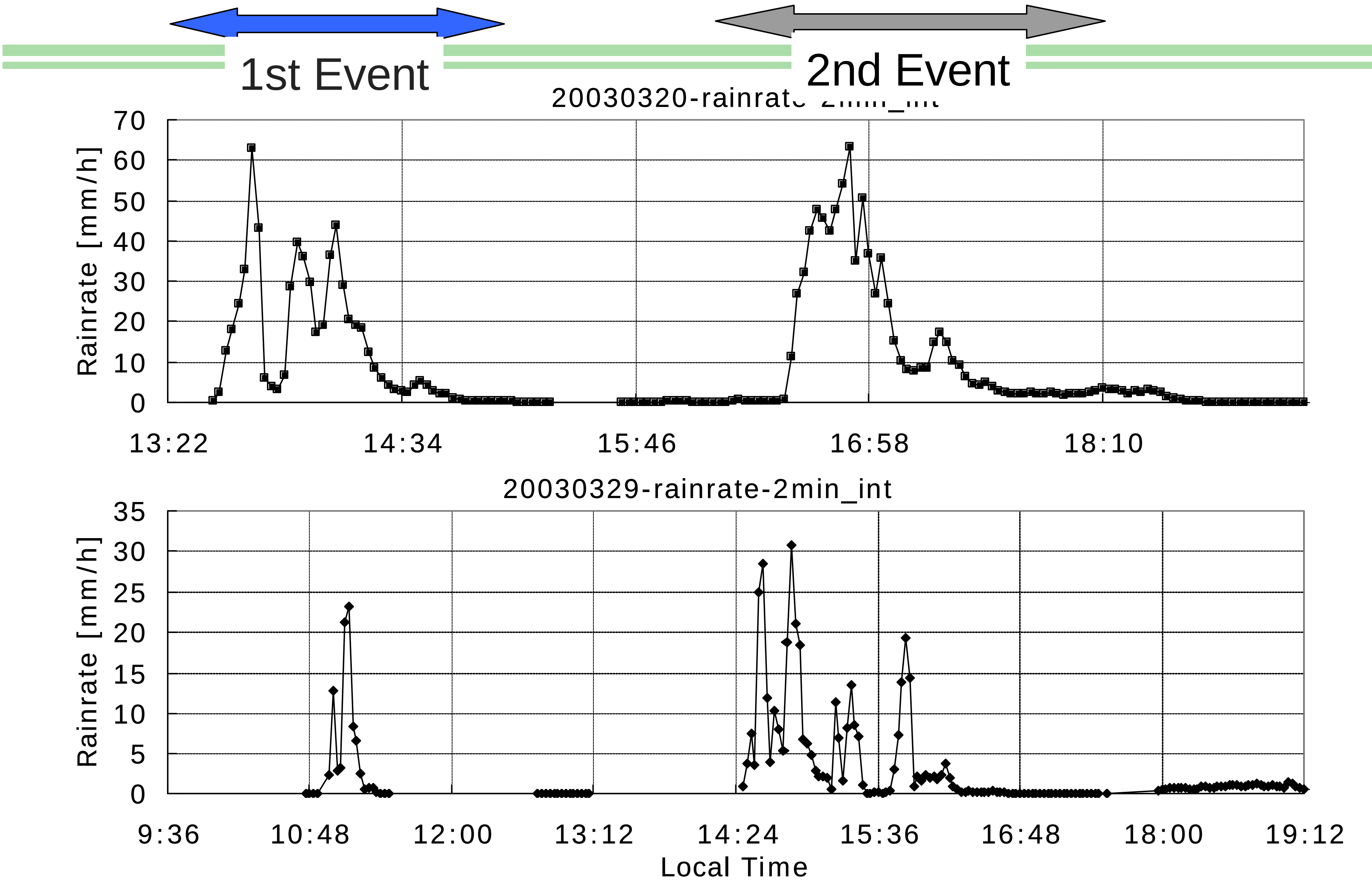


ΔdBZ (Meas – MP) and dBZ

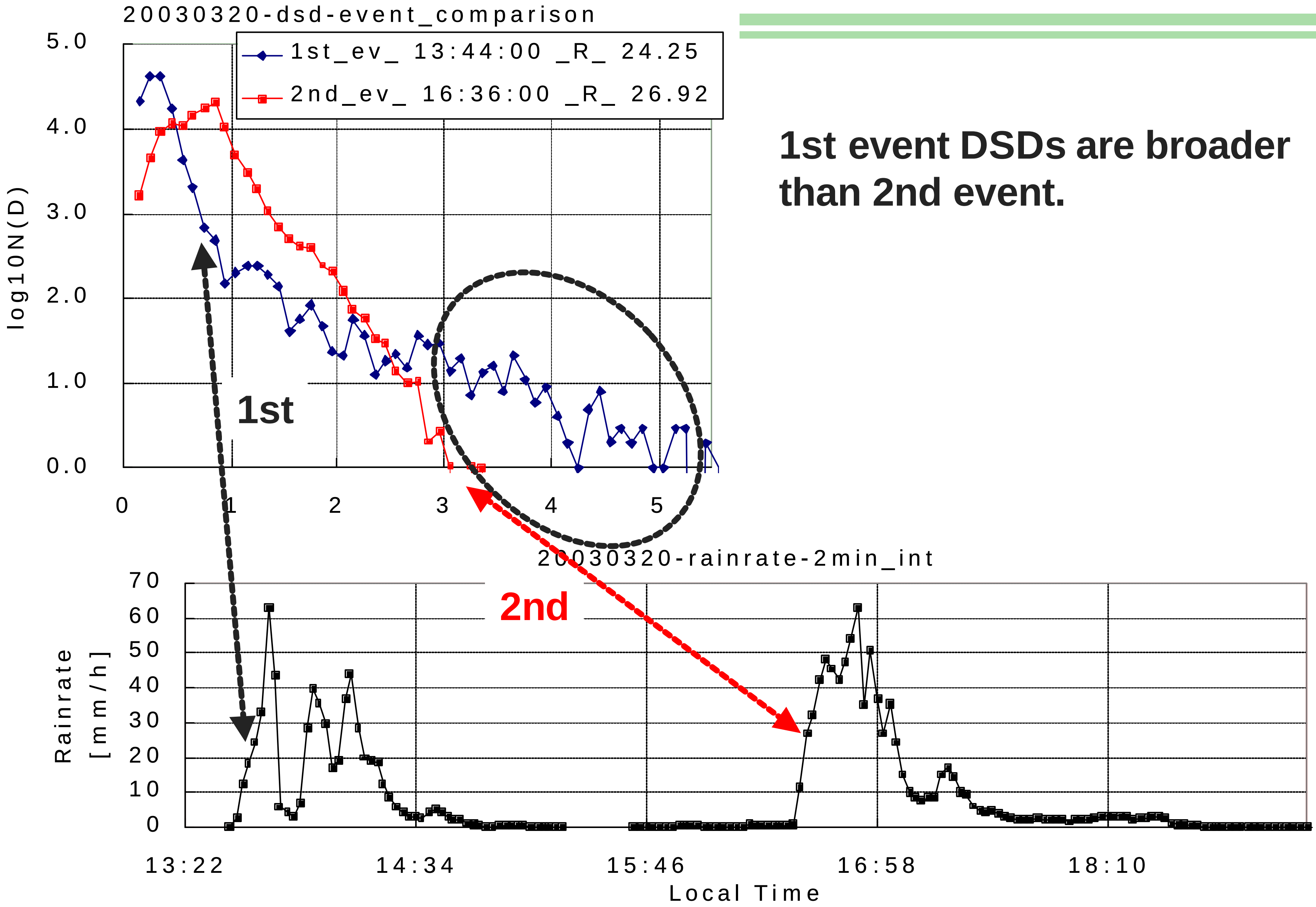
2002/3/28 3:20-3:30



Example of 2-event convection

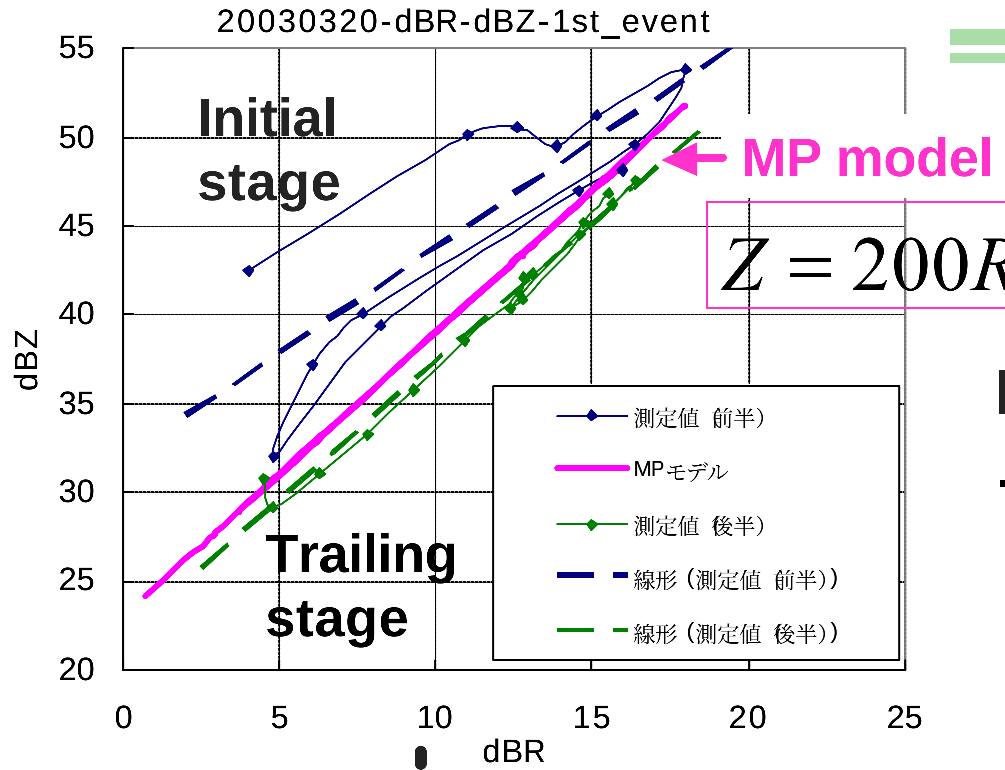


Initial DSDs for each event on 2003/03/20



1st event DSDs are broader than 2nd event.

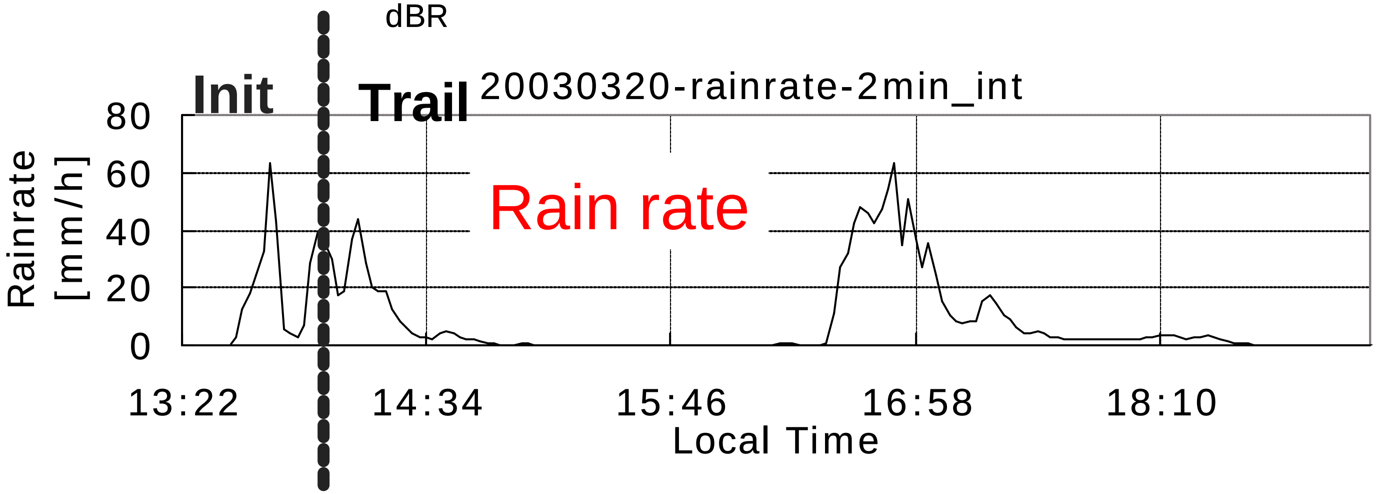
dBZ-dBR Relations (1st Event), 2003/03/20



$$Z = 200R^{1.6}$$

Initial: dBZ_m > dBZ_MP

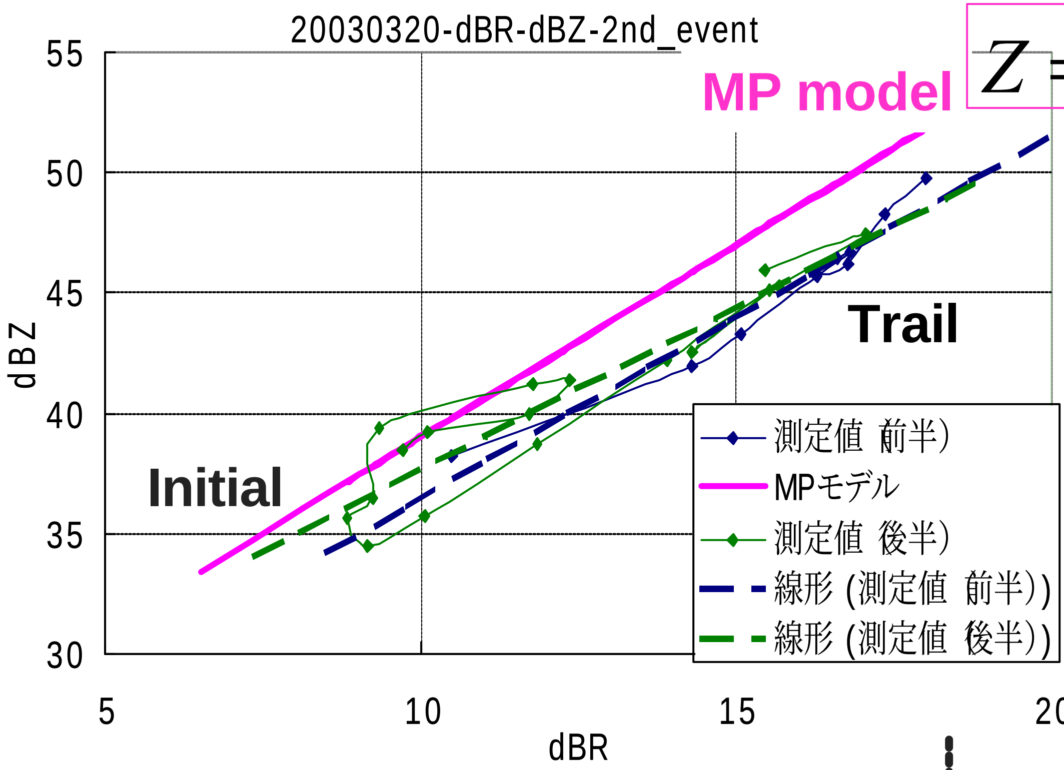
Trail: dBZ_m » dBZ_MP

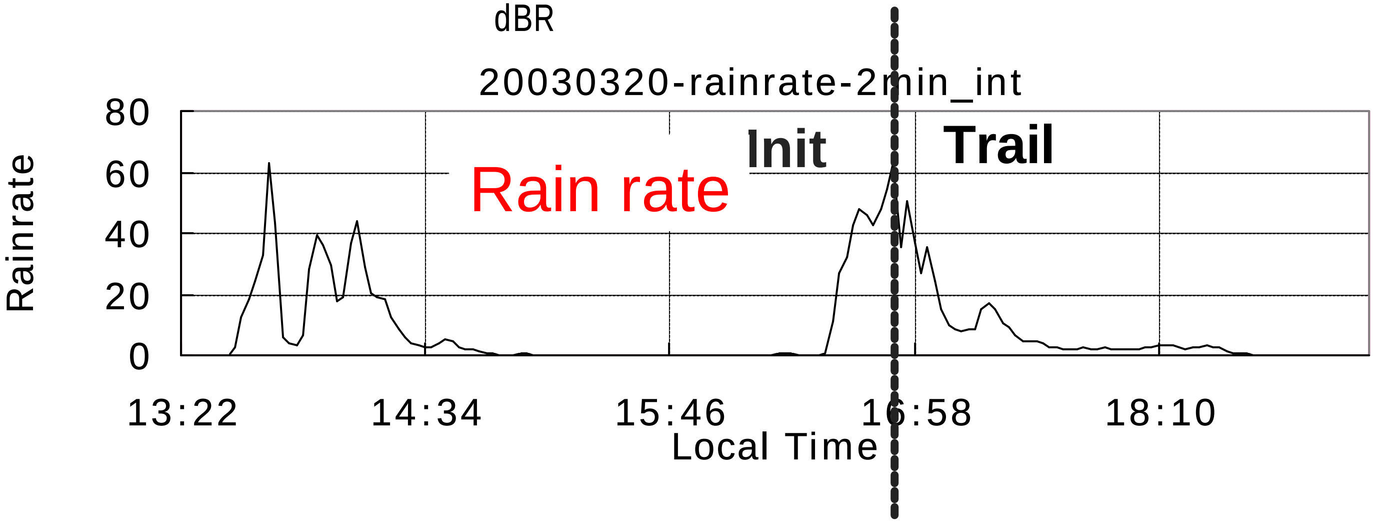


dBZ-dBR Relations (2nd Event), 2003/03/20

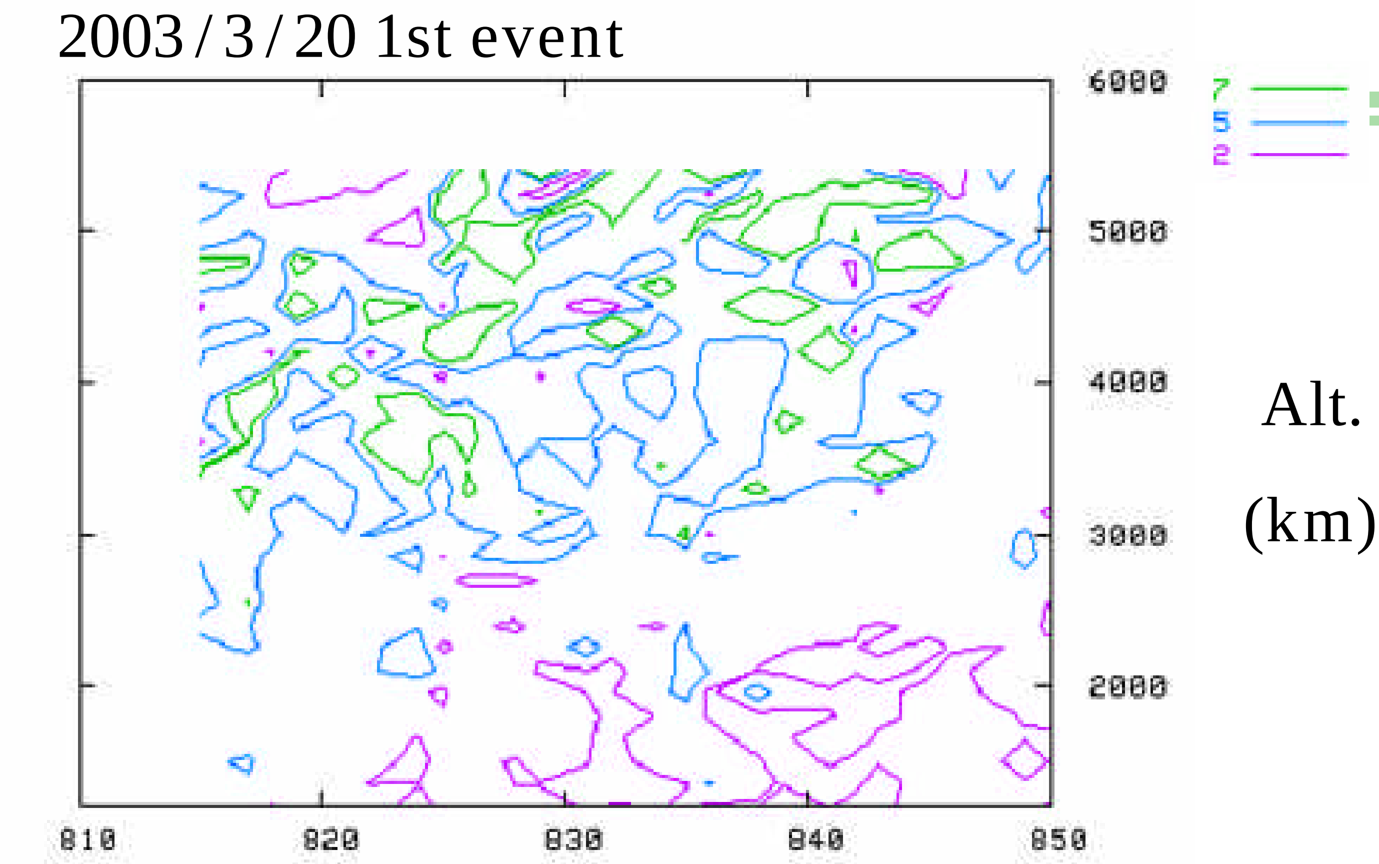
$$Z = 200R^{1.6}$$

dBZ_m < dBZ_MP





Time-height plot of Doppler width, 2003/3/20 1st Ev.



Alt.

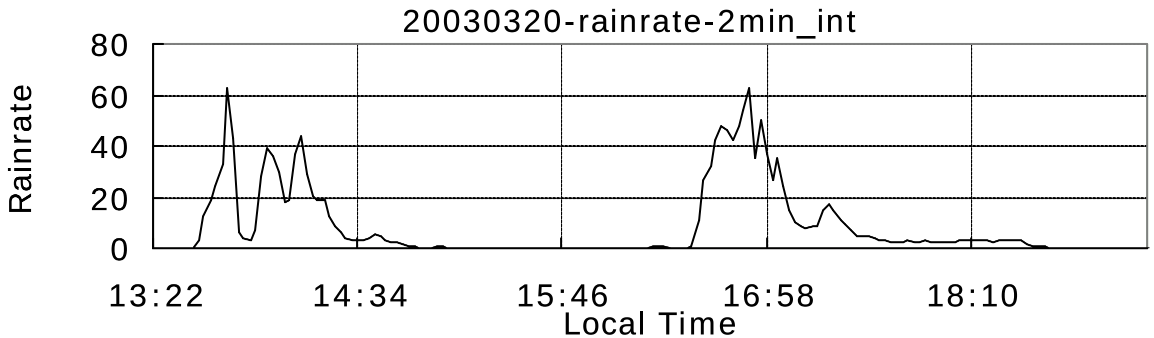
(km)

13:30

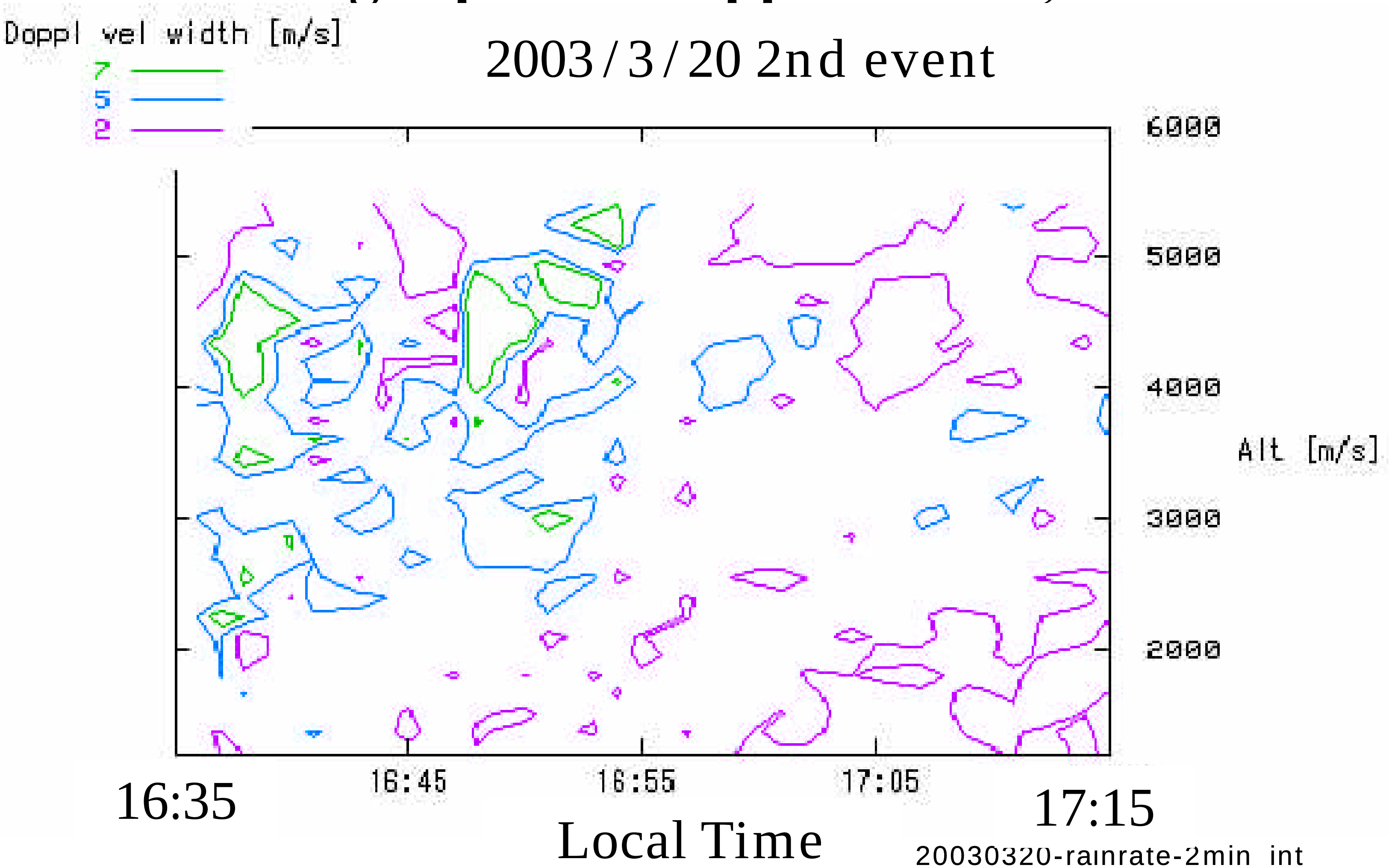
Local Time

14:10

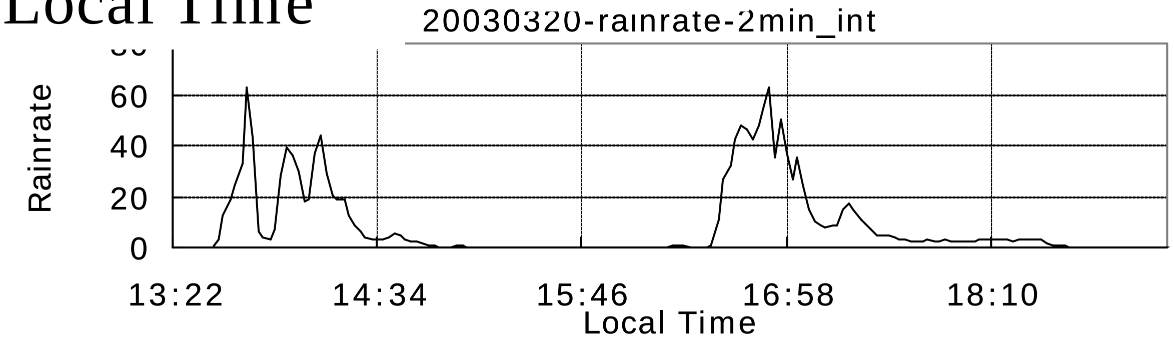
Rain rate



Time-height plot of Doppler width, 2003/3/20 2nd Ev.



Rain rate



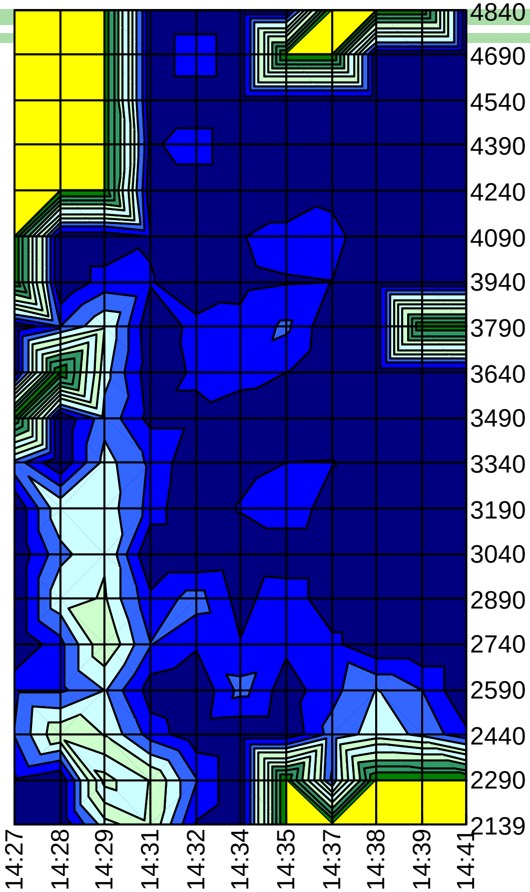
ΔdBZ

(Meas–MP)

and dBZ

2003/3/29

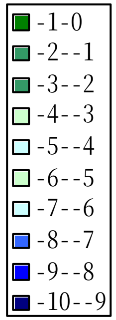
14:27-41



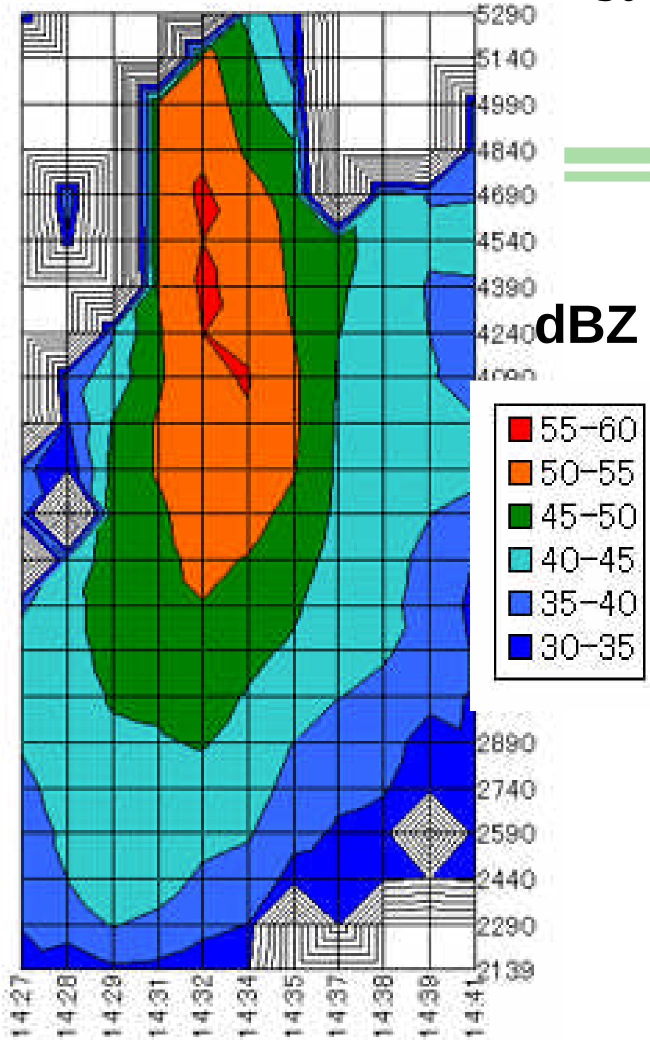
14:27 14:41

4840m

DdBZ

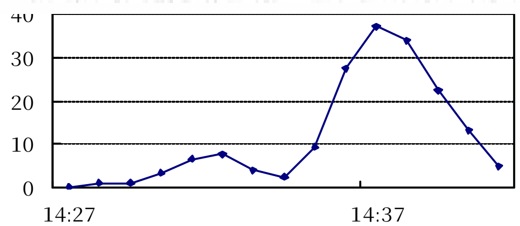


2440m

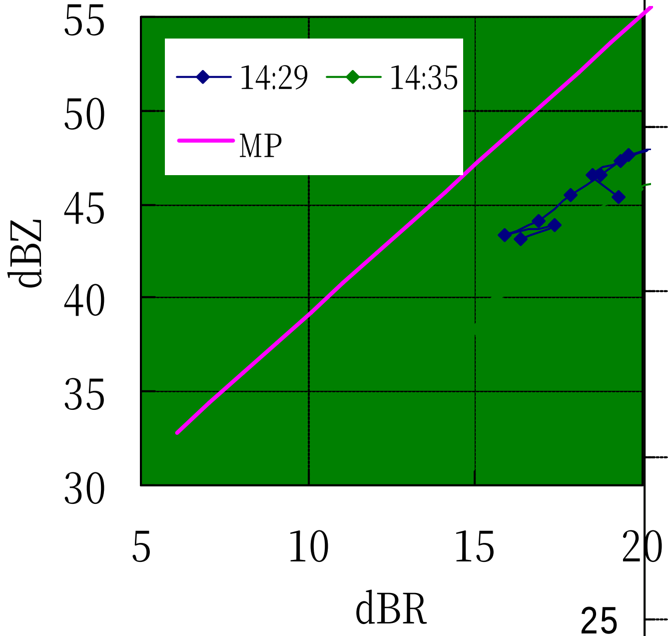


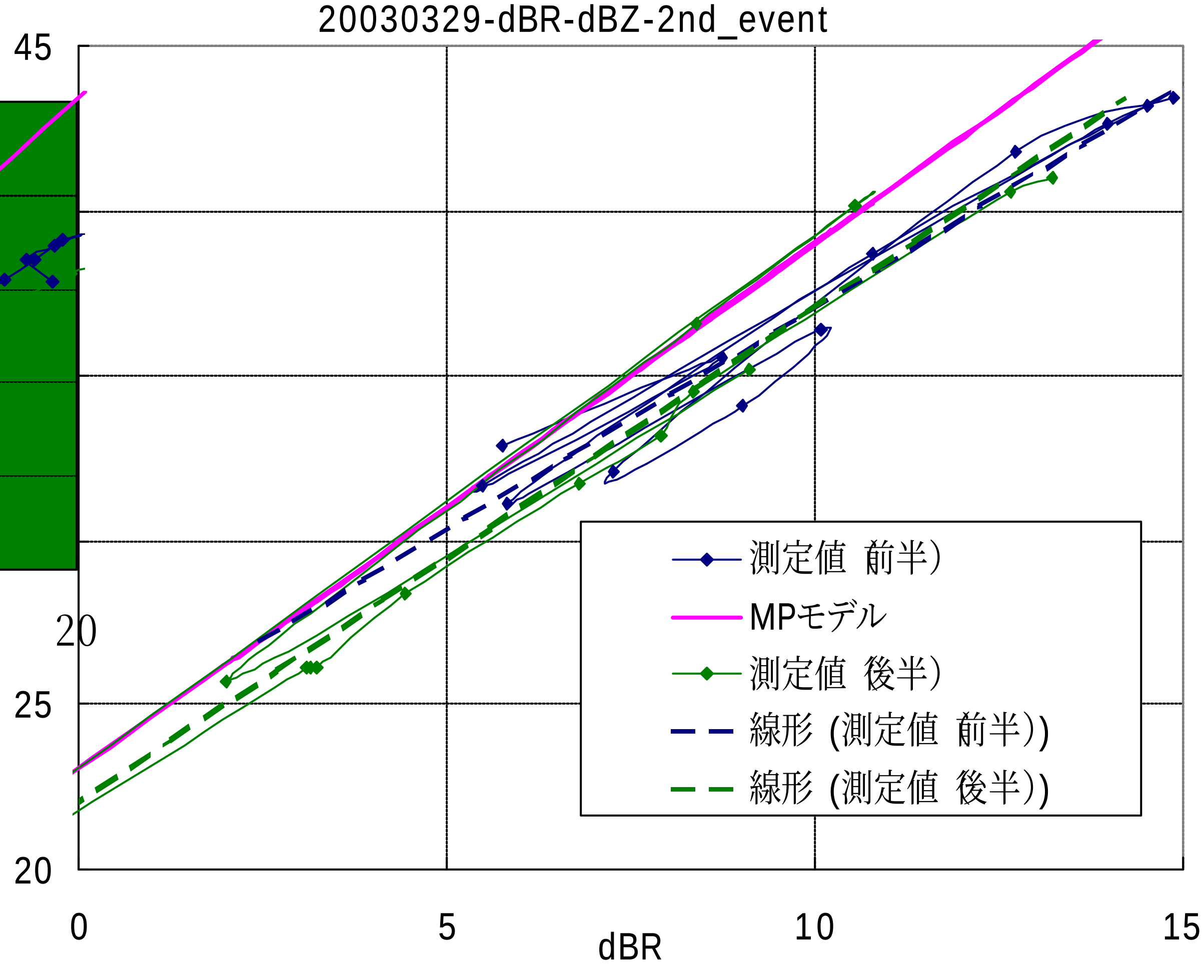
40mm/h

Rain rate

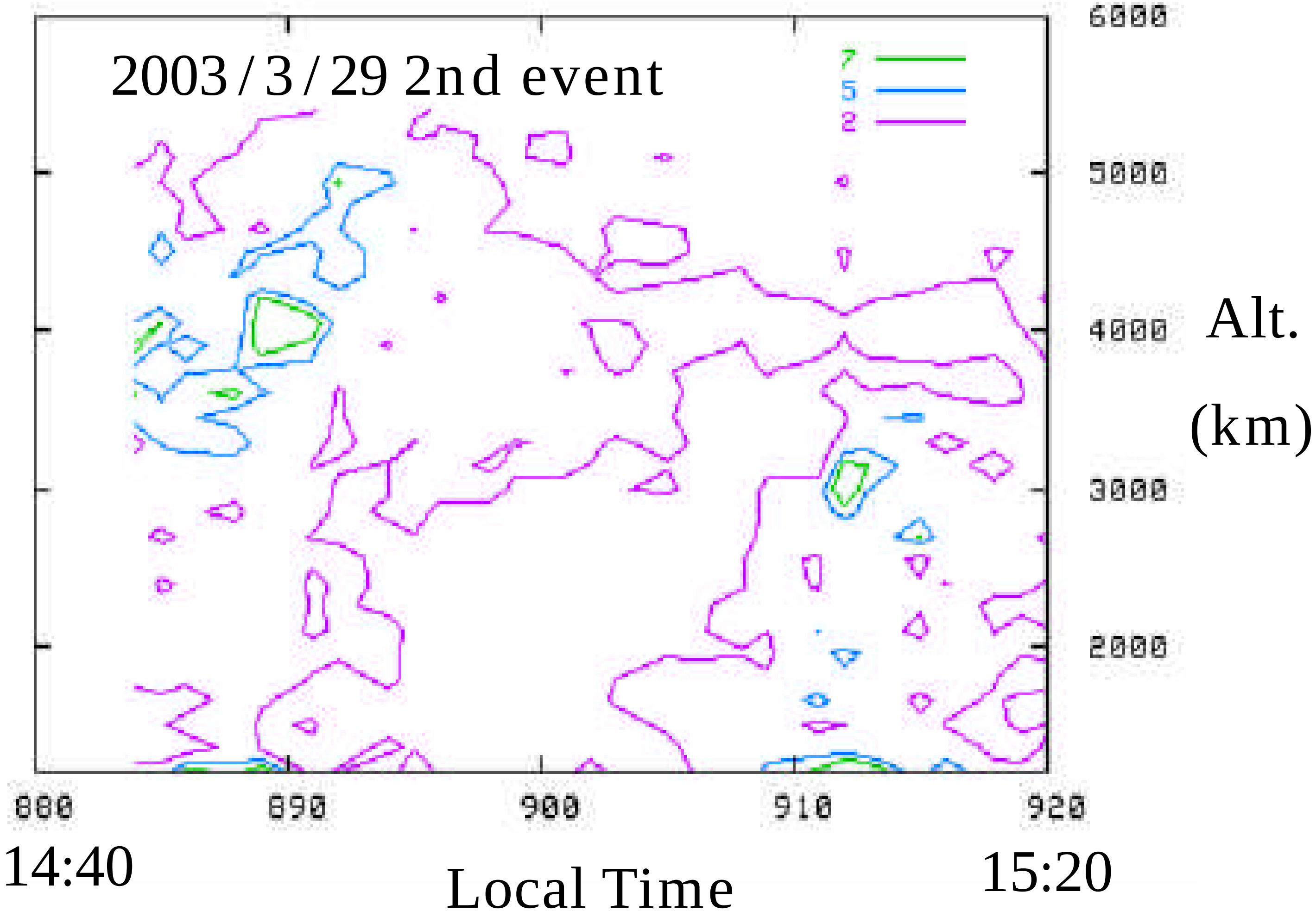


Time trend of Z-R relation, 2003/3/29 2nd Event





Time-height plot of Doppler width, 2003/3/29 2nd Ev.



Summary and Issues

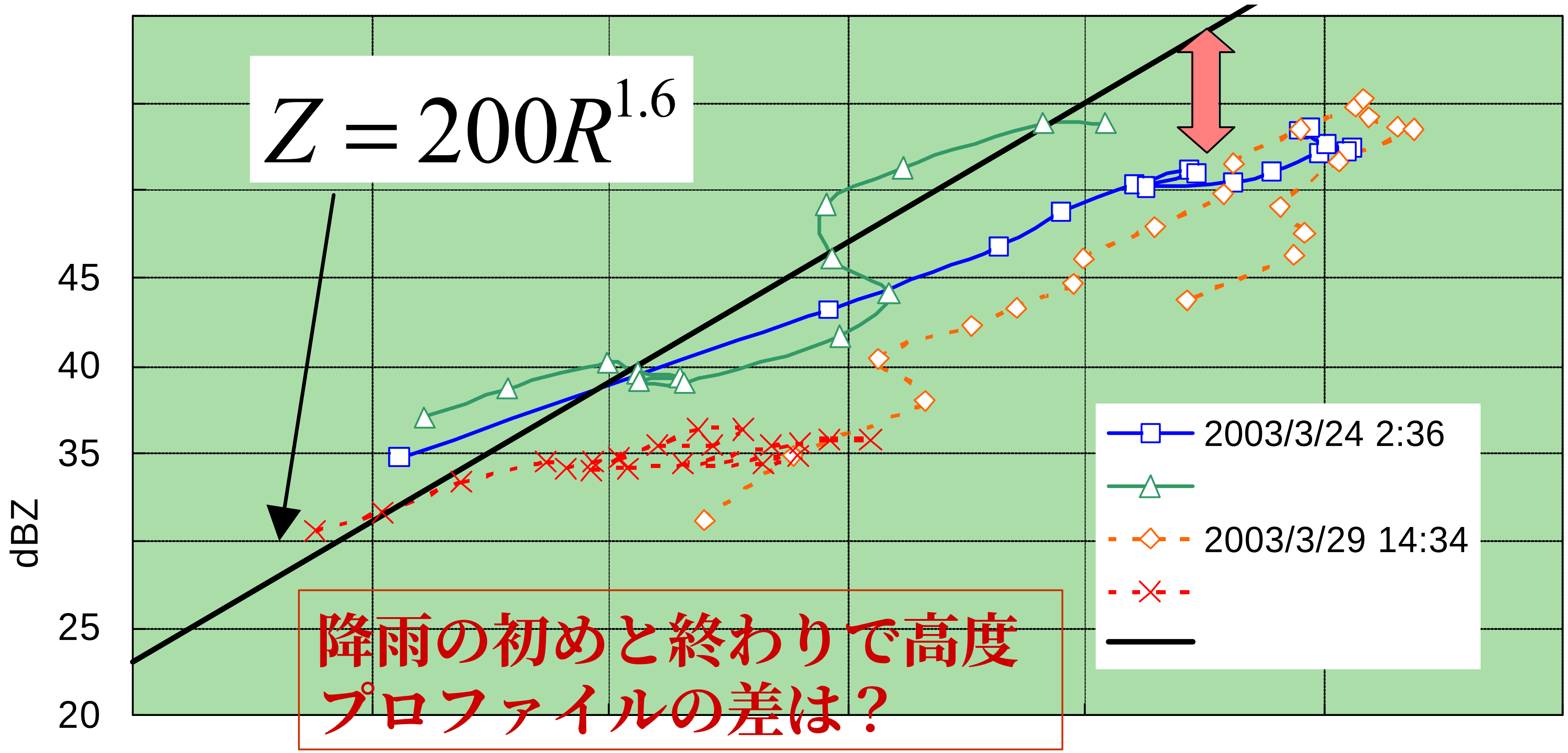
1. EAR, 2DVD, and Joss-disdrometer (GAW) can provide information of vertical DSD profiles. BLR and Micro-rain radar (MRR-2) will add more.

2. KT DSD has both diurnal and seasonal variations, suggesting the influences by local convection as well as large scale (long-term) atmospheric field (monsoon, etc.)

3. DSD may be related to Doppler width of EAR vertical beam, *i.e.* intensity of atmospheric turbulence.

4. For more understanding of the micro-physical processes coupled with larger scale environments, combined analyses using various instruments are necessary.

dBR-dBZ関係でみた雨滴粒径分布の変化



粒径が大きい傾向があるとZが大きくなる

MP分布との差がDSDの違いを示唆