8P.16 Precipitation Measurements in Singapore and South India for TRMM Ground Validation and TRMM PR Algorithm Improvements

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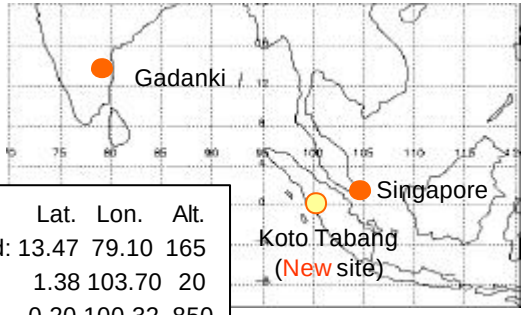
1. Objectives

1. To investigate space/time characteristics of raindrop size distribution (DSD).
2. To model vertical and 3D precipitation structures.
3. To apply the results to improve PR algorithms and m-wave link design.
4. To use the observed data for TRMM product validation.

2. Approach

1. Continuous ground-based rainfall observations at two tropical sites, south India and Singapore, and analyses for the above objectives.
2. Comparison with TRMM data (presently mainly Level 3 products).

3. Site Locations



	Lat.	Lon.	Alt.
Gad:	13.47	79.10	165
SG:	1.38	103.70	20
KT:	-0.20	100.32	850

4. Instruments and facilities

4.1 Gadanki instruments

MST Radar (NMRF, Gadanki, India)

Frequency	53 MHz
Antenna aperture	130 m x 130 m
Antenna beamwidth	3 deg.
Transmit power	2 MW
Range resolution	150 m

Lower Atmospheric Wind Profiler (CRL, Japan)

Frequency	1.357 GHz
Antenna aperture	4 m x 4 m
Antenna beamwidth	4 deg.
Transmit power	1 kW
Range resolution	75 m/150 m/300 m

Joss-Disdrometer and lidar (CRL), ORG (NASDA)

4.2 Singapore instruments

S-band Doppler radar (SPIDAR; RAL/NASDA)

Frequency	3 GHz
Polarization	Co-pol and X-pol
Antenna	3 m parabolic
Beamwidth	2.3 deg.
Transmit power	600 KW
Range resolution	150 m

Joss-Disdrometers, Raingages (NTU, RAL)
IOR beacon receivers (NTU, 12 GHz)

Met. Service, Singapore (MSS) provides raingage network, S-band radar and sonde data for many years.

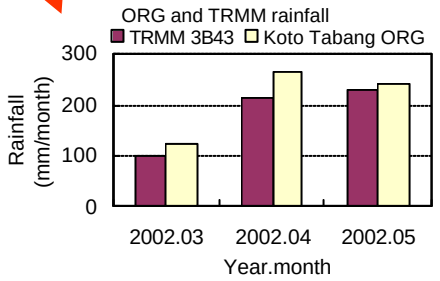
4.3 Koto Tabang (new) instruments

Equatorial Atmosphere Radar (EAR)

Frequency	47 MHz
Ant. aperture	110 m x 110 m
Transmit power	100 kW
Sensitivity to rain	about 5 mm/h

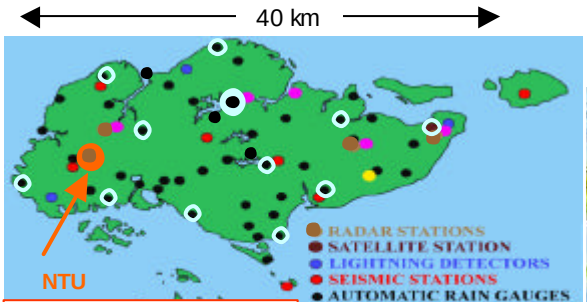
RASS, ORG-815, Micro rain radar (MRR2), Water vapor radiometer (WVP-1500), micro-barographs, 2DVD disdrometer (from Feb. 2003), and X-band rain radar (from Sept. 2002)

This site is at the center of the "hot tower" region, the key is the Kyoto Univ. / LAPAN, Indonesia, Equatorial Atmospheric Radar (EAR).



5. Long term TRMM Rainfall (ver.5) Validation with Singapore (MSS) Raingage Network

SG MSS Raingage network

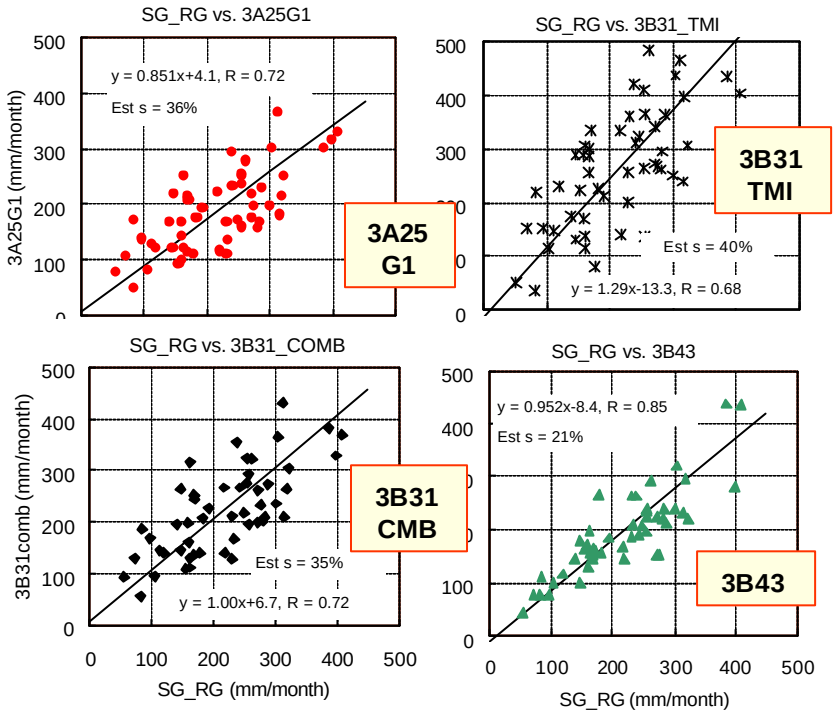


Data from 12 raingages are averaged.

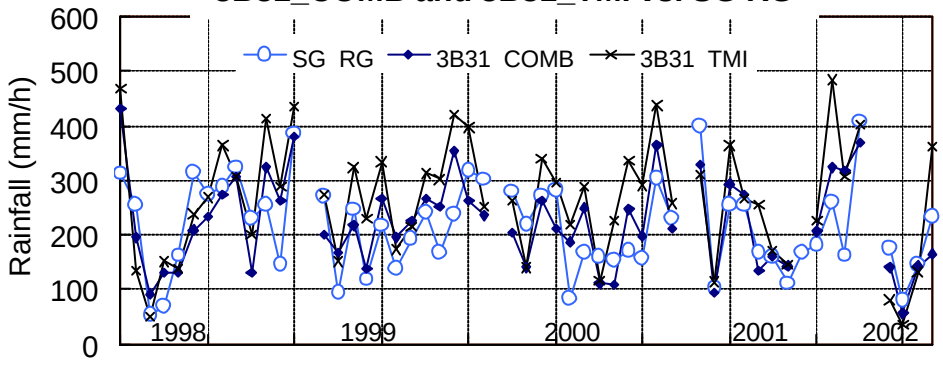
RG used for TRMM comparison

1x1 & 5x5 deg grids around Singapore.

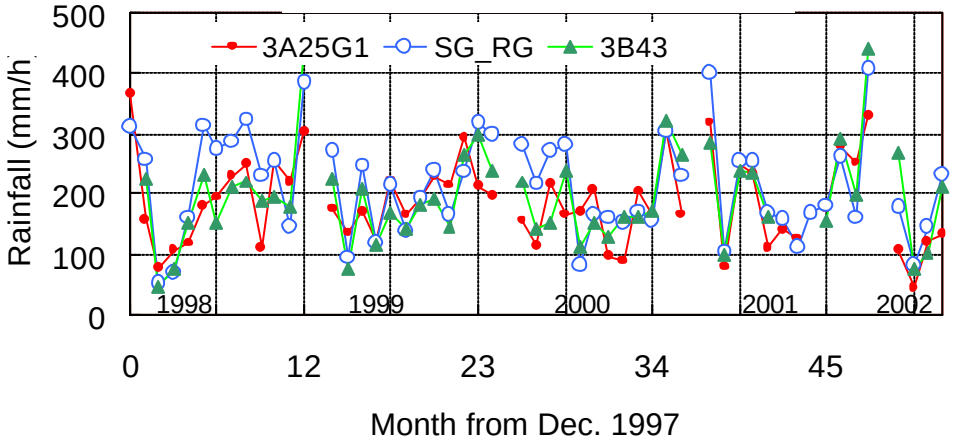
Correlation between SG RG and TRMM products



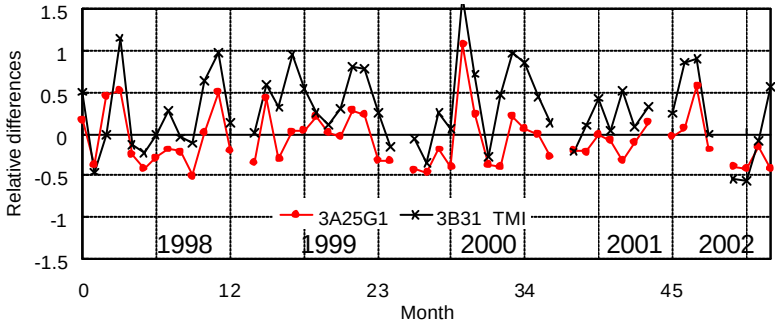
3B31_COMB and 3B31_TMI vs. SG RG



2A25 G1 and 3B43 vs. SG RG

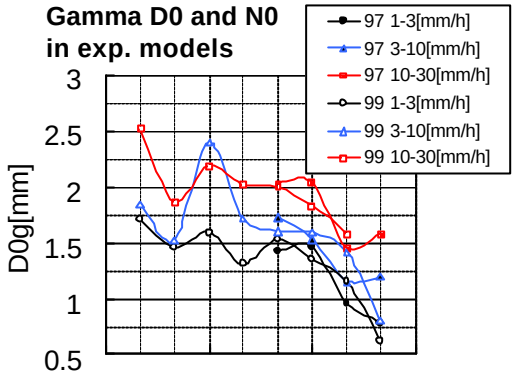


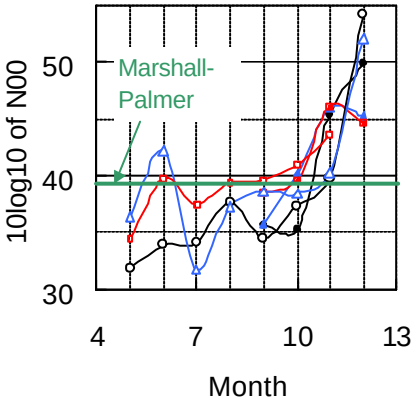
Relative differences between SG RG and 2A25 and 3B31_TMI

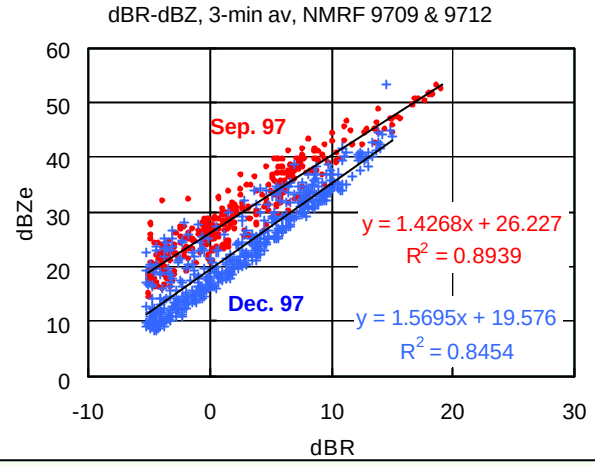


Summary: Singapore RG and TRMM products show very good agreements, and consistent with findings at other sites.

6. DSD Characteristics of India and Singapore, and comparison with DSDs at other sites (data provided from TRMM Office, NASA/GSFC)

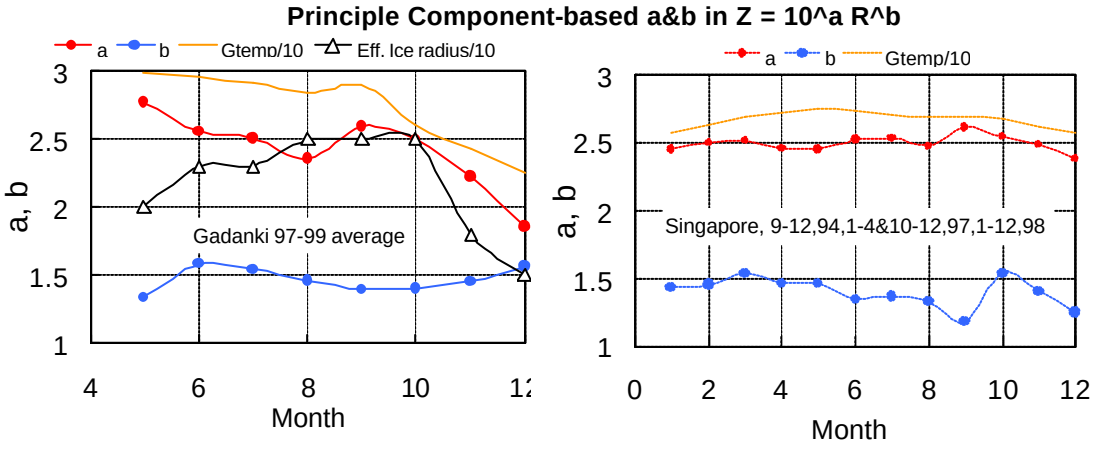


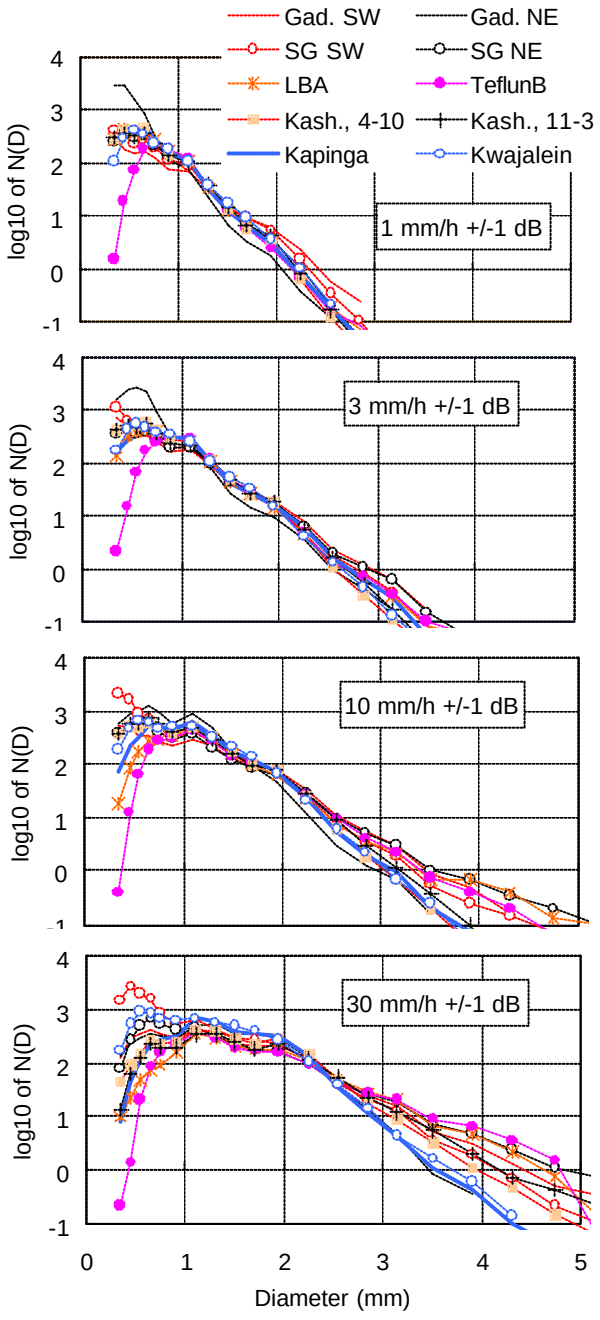




Gadanki, India DSDs show significant seasonal variations in two seasons; NE monsoon has many small drops. Related to cloud properties? SG DSD does not show such clear dependence.

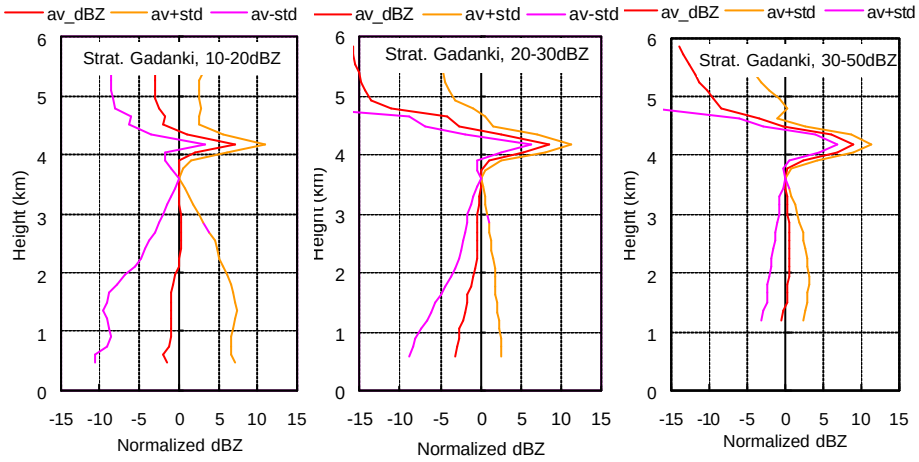
Av. DSD properties at various GV sites: DSDs in 1-3 mm/h are similar to each other. Clear oceanic-continental differences in 10-30 mm/h.



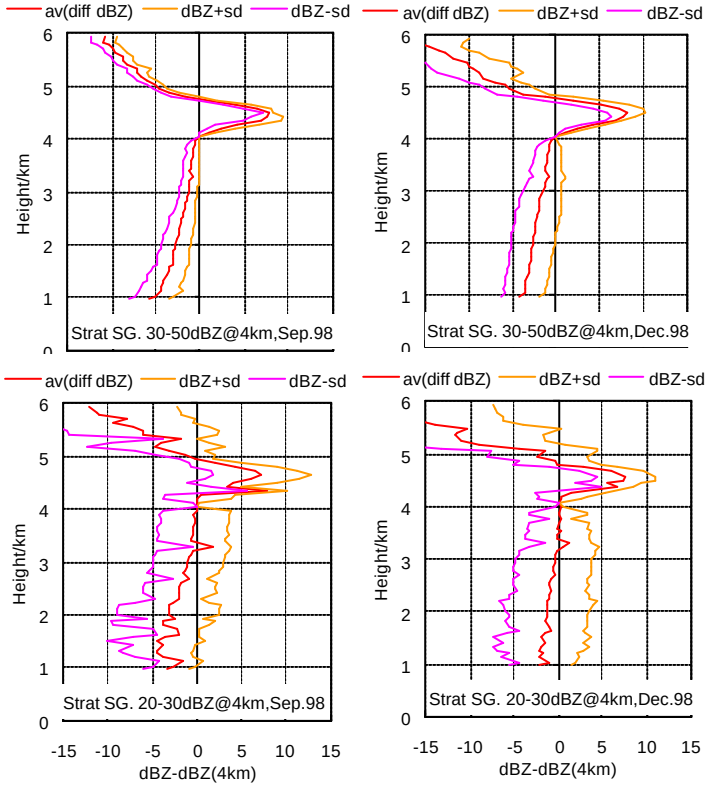


7. Vertical *Z* Profile and *k-Ze* relations for 2A25v6 algorithm (DSD data provided from TRMM Office)

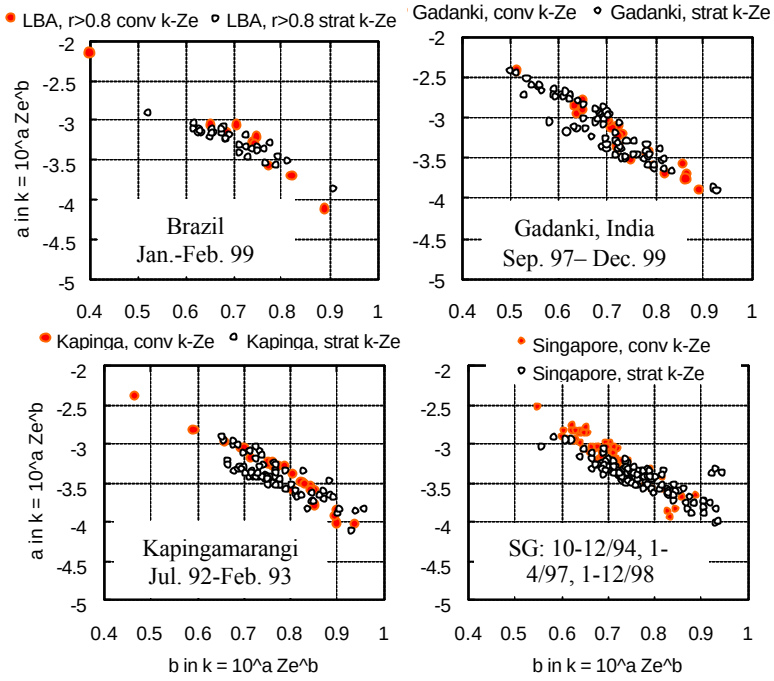
Gadanki stratiform events by BLR in May, Jul., Nov. 1999



Singapore stratiform events by S-band radar in '99



"Event-scale" *k-Ze* coefficients, *k* = 10^*a* *Ze*^*b*



Vertical profile statistics: Mean gradient is necessary to estimate *Ze* at low altitude (blind zone of PR). Stratiform profiles show negative gradients at both sites (0.5 to 1dB/km), with some dependence on rain intensity. Convective events have (not shown here) more variabilities. Rain-type classification and more data analyses are needed. Bright-band model evaluation is on-going.

Coefficients in 13.8 GHz *k-Ze* relations: Refinements may be necessary to improve rain attenuation correction, better *R* and DSD estimates from PR. Joss-disdrometer data are processed for each event to derive *k-Ze* coefficients by a principle component analysis. "*b*" is distributed around 0.75 (consistent with the v.5 model), and clear correlations between *a* and *b* are found. Some oceanic-continental dependences are also found.