Overview of the TRMM/EOM experimental data analysis

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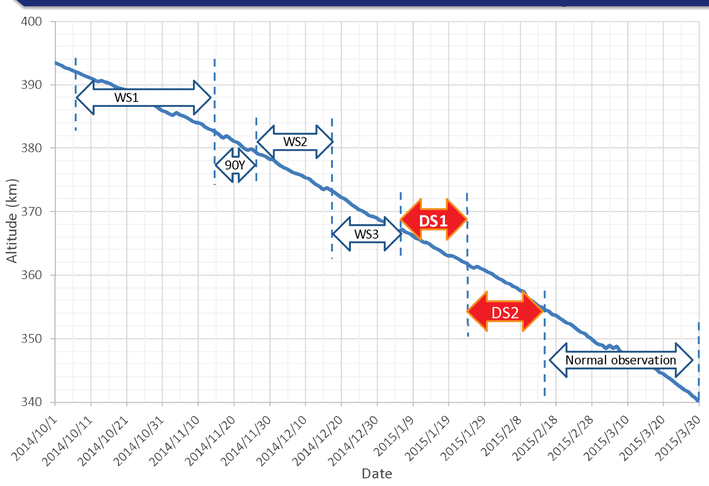
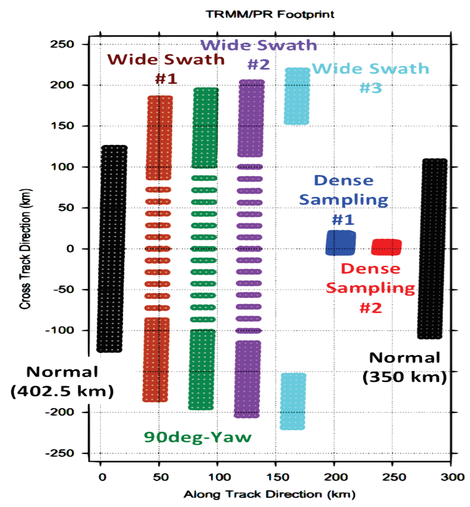
TRMM/EOM experiments



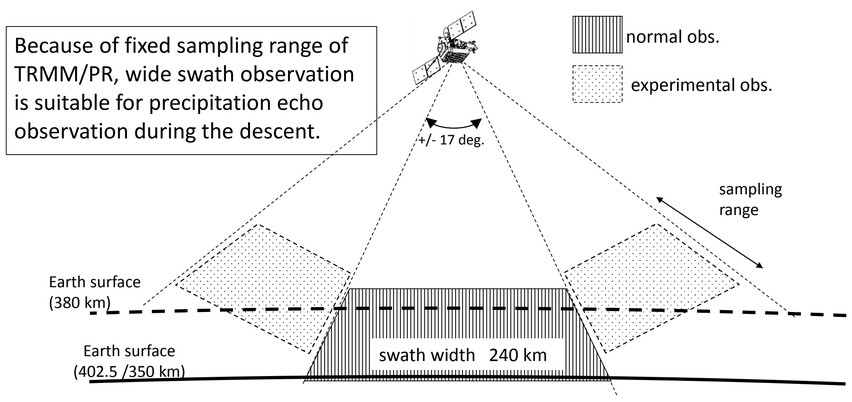
experiment	description	purpose
wide swath	change the swath width up to 400 km	Test for future mission
90-degree yaw	along-track scan	Evaluation of σ0 estimation Evaluation of NUBF effect
dense sampling	3-, 4-times spatial over-sampling	Evaluation of NUBF effect Test for future mission

NUBF: non-uniform beam filling
σ0 : normalized scattering cross section of the earth surface



wide swath experiment

- ◯Range profile of surface echo for various incident angle
  - ◯estimation of mean σ0 for higher angles
  - ◯clutter height statistics (detectability of shallow precipitation)
  - ◯comparison of clutter height against the precipitation rate
- △Availability of surface reference technique for wide swath angles.
  - △dynamic range of PIA (path integrated attenuation)
  - △availability of NUBF within the footprint
- △Reconstruction of vertical profile for higher incident angle.



Range profile of the earth surface echo (left) and σ0 (right) (Takahashi, 2017)

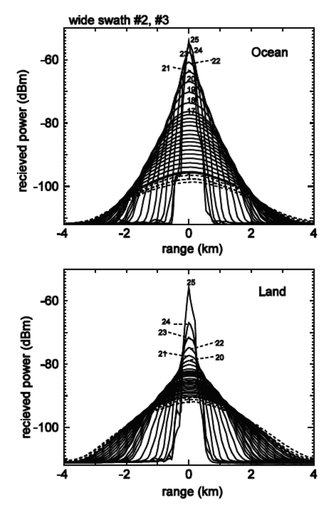


Fig. 1. (Top and bottom) Average range profile of surface echo relative to the surface peak over ocean and land, respectively, during the wide swath experiment #2 (solid lines). Numbers indicate the angle bin number (1: 30.2°, 2: 29.4°, 3: 28.7°, 4: 27.9°, 5: 27.2°, 6: 26.4°, 7: 25.6°, 8: 24.9°, 9: 24.1°, 10: 23.4°, 11: 22.6°, 12: 21.9°, 13: 21.1°, 14: 20.4°, 15: 19.6°, 16: 18.8°, 17: 18. 1°, 18: 15.8°, 19: 13. 6°, 20: 11.3°, 21: 9.1°, 22: 6.8°, 23: 4.6°, 24: 2.3°, and 25: nadir) of wide swath #2 experiment. Surface profiles of wide swath #3 are also displayed by dashed lines for angles wider than 30° up to 32.5° (three angles: 31.0°, 31.7°, and 32.5°).

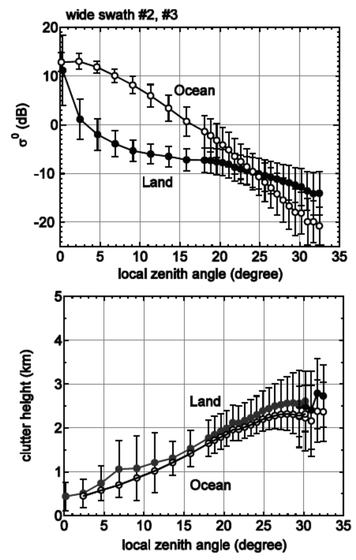


Fig. 2. (Top) Normalized backscattering cross section (σ^0) calculated from the mean surface peak echo power over ocean (white circles) and land (solid circles). (Bottom) Clutter height with threshold of −110.5 dBm over ocean (white circles) and land (black circles) versus the incident angle. Bars indicate the standard deviation.

Clutter height (Takahashi 2017)

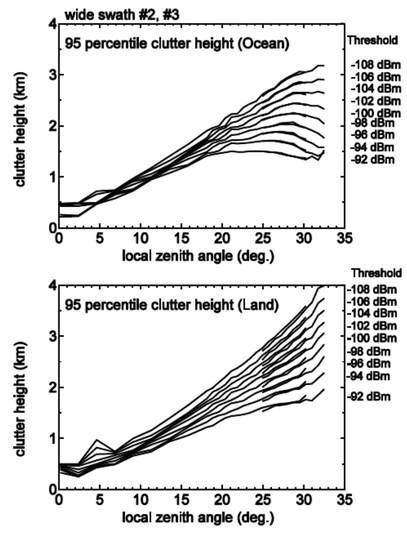
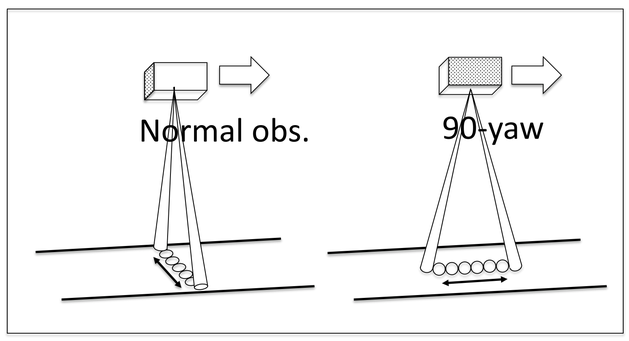
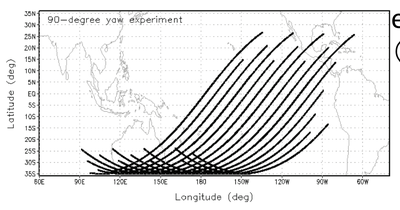


Fig. 3. Clutter height versus incident angle for various thresholds using 95-percentile value of surface echo profile statistics from wide swath #2 (nadir to 30°) and wide swath #3 (24°–32.5°).

90-degree yaw experiment



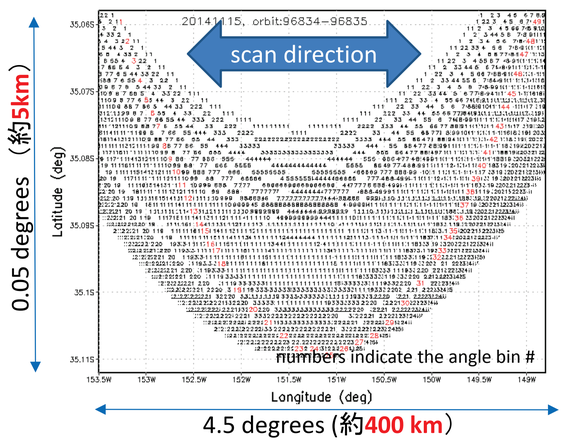
- ◯Incident angle dependency of σ0
  - ◯90-deg. yaw data can be regarded as the response from point target
  - ◯σ0 against wind speed and direction
  - △effect of precipitation
- △Estimation of PIA distribution within a footprint
  - ◯Preliminary analysis was implemented using 180-deg. yaw maneuver data
- △Evaluation of bright band structure
  - △incident angle dependency
  - △detectability of bright band peak for wide scan observation.
- △Detectability of evolution process
  - △comparison of forward looking beam and backward looking beam



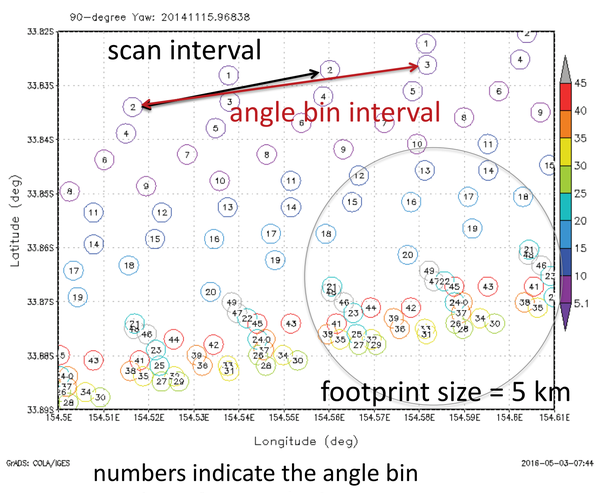
experimental area
(Nov. 15 to 25 , 2014)
11 days, 880 min

footprint trajectory @35S

- PR's actual scan pattern (conical scan)



Development of point target database (dataset of various incident angle)



numbers indicate the angle bin number of TRMM/PR's scan

target footprint
- angle bin (fixed)
- latitude
- longitude

re-sampling → 0.05 deg. X 0.05 deg. area

PR data
- surface echo power
- σ0
- system noise
- rain/no-rain

external data
- wind speed
- wind direction
- R (GSMaP)
- SST

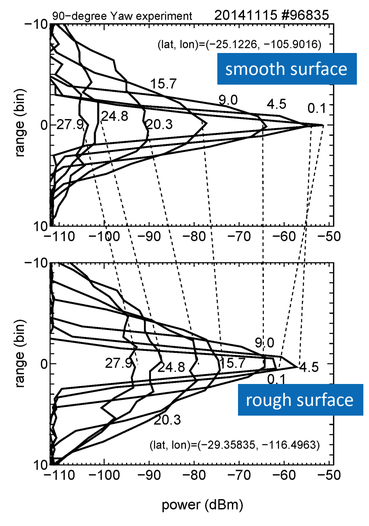
Database
- latitude, longitude
- rain/no rain (PR)
- R (GSMaP)
- system noise
- wind speed & direction
- SST
- Surface echo&σ0(49 angle bins)

angle bin	surface echo power	σ0
1	(dBm)	(dB)
2	(dBm)	(dB)
-	(dBm)	(dB)
-	(dBm)	(dB)
49	(dBm)	(dB)

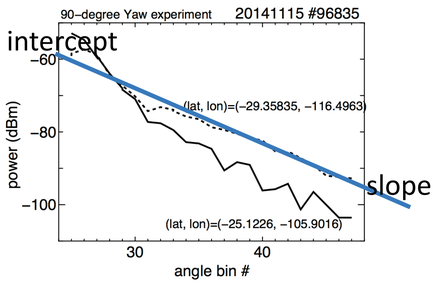
- slope & intercept

90-degree yaw experiment (continued)

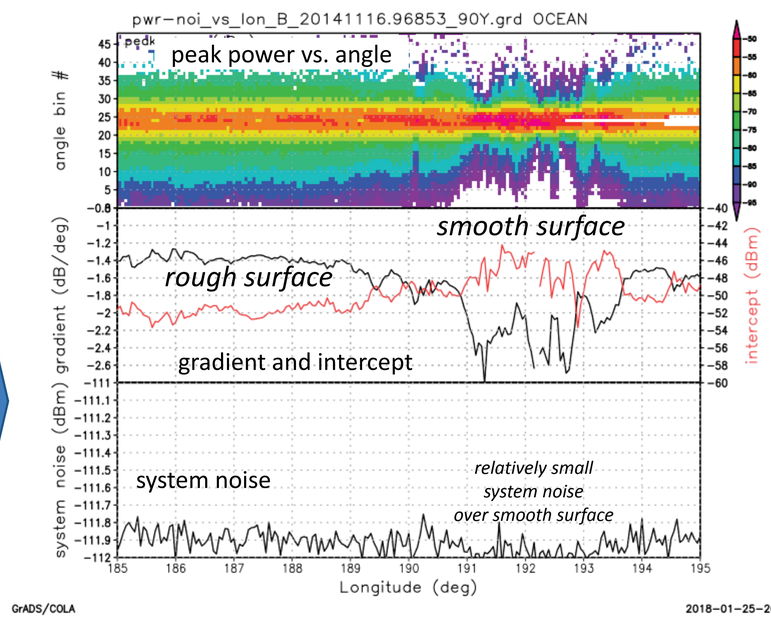
surface echo profiles of point target



echo power vs. incident angle

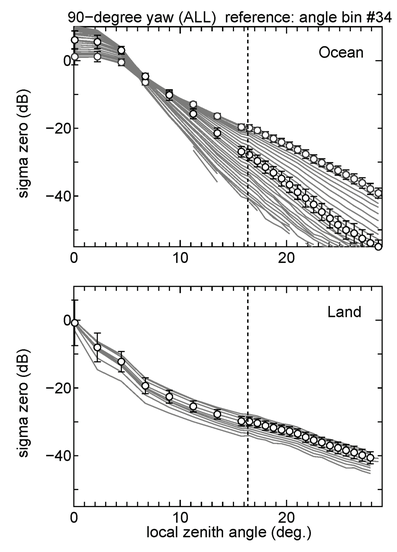


database

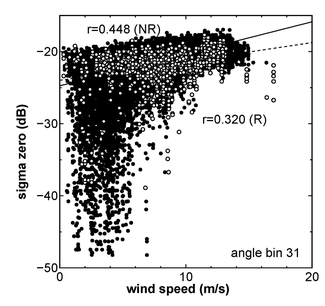


mean σ0 vs. incident angle

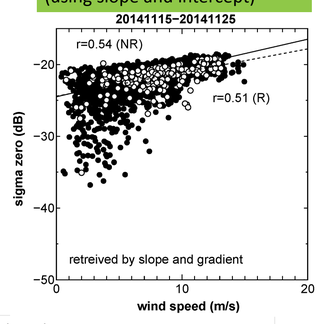
(averaged σ0-angle curve according to the σ0 at the incident angle of 16 degrees)



obs. σ0(16 deg.) vs. wind speed

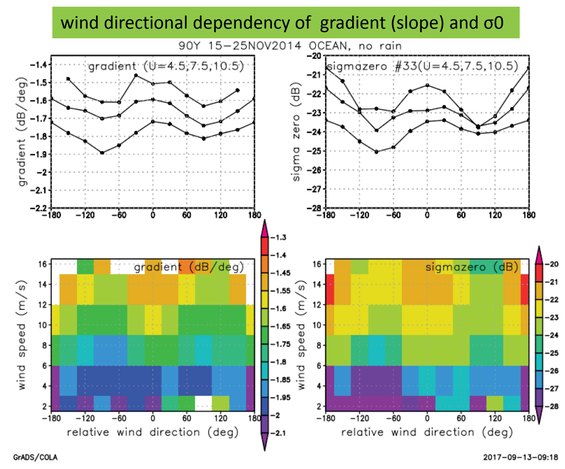


est. σ0(16 deg.) vs. wind speed (using slope and intercept)



- Wind data: NOAA satellite based product
  - 6 hourly/0.25 degree grid intervals
- rain/no-rain classification: similar to the TRMM algorithm

wind directional dependency of gradient (slope) and σ0



- ☐ slope and intercept data represent the surface condition.
- ☐ σ0 can be estimated from the slope and intercept except for near nadir directions.

Overview of the TRMM/EOM experimental data analysis (N. Takahashi)

dense sampling experiment, DS (overview)

- ◯Investigation of high resolution observation by spatial over-sampling
  - ◯Visual comparison (3D images)
  - ◯Investigation of high resolution data retrieval (2D)
  - △Study on the retrieval algorithm architecture
- ◯Evaluation of NUBF effect
  - ◯Characterization of spatial variability of various parameters
- ◯Evaluation of the rain profile retrieval algorithm
  - ◯Correlation of adjacent profiles

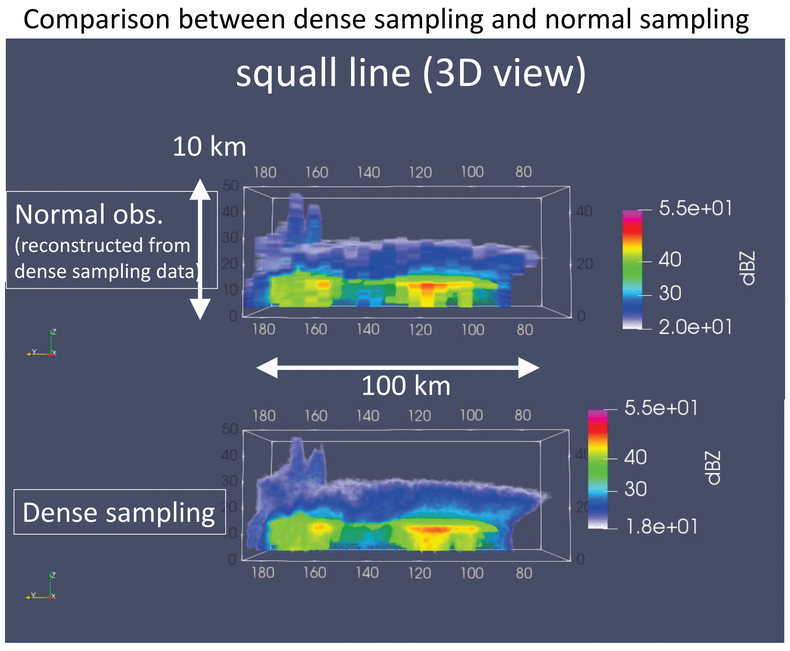
DS1: 3-times dense sampling
- Jan. 5, 2015 to Jan. 24, 2015
- swath width: about 25 km
- incident angle: nadir to 3.5°

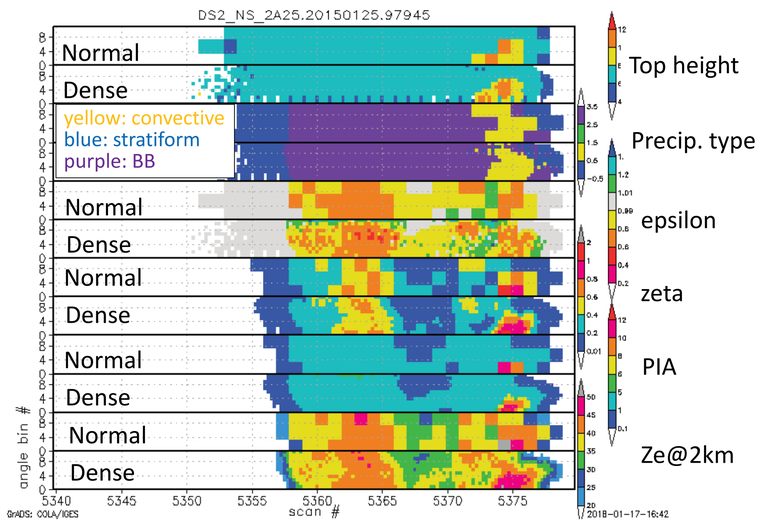
DS2: 4-times dense sampling
- Jan. 24, 2015 to Feb. 12, 2015
- swath width: about 15 km
- incident angle: nadir to 2.1°

◆Top of the echo might be missing because the satellite altitude was not in the nominal altitude.

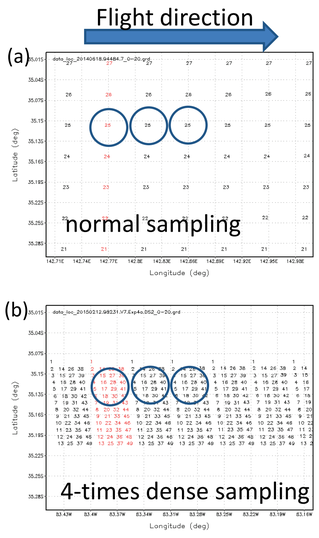
◆Data might be missing because PR was off during the shadow side of the Earth and low solar beta angle.

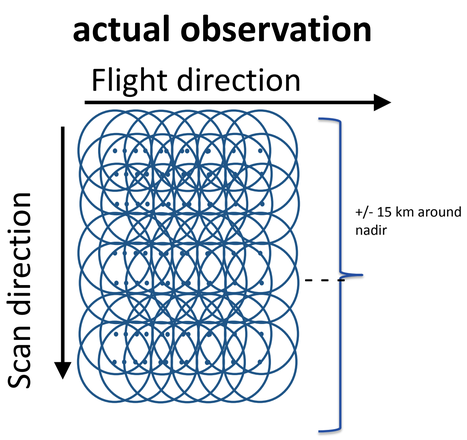
Comparison between dense sampling and normal sampling

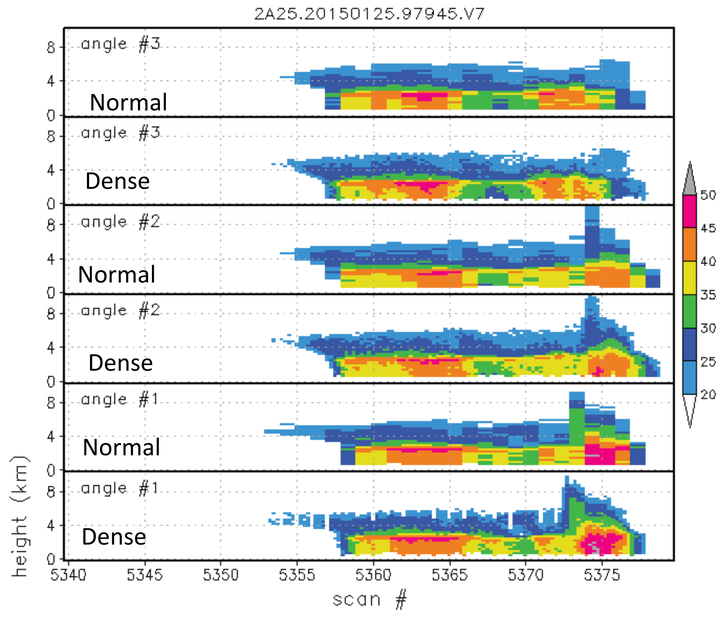


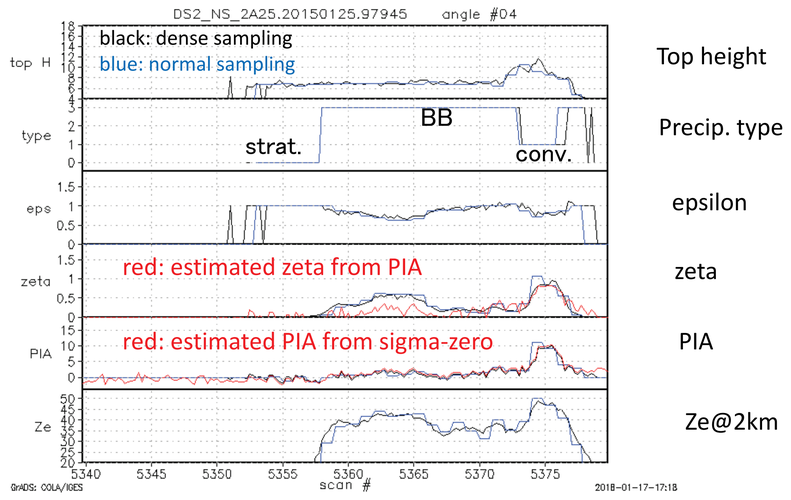


Footprint (center) arrangement



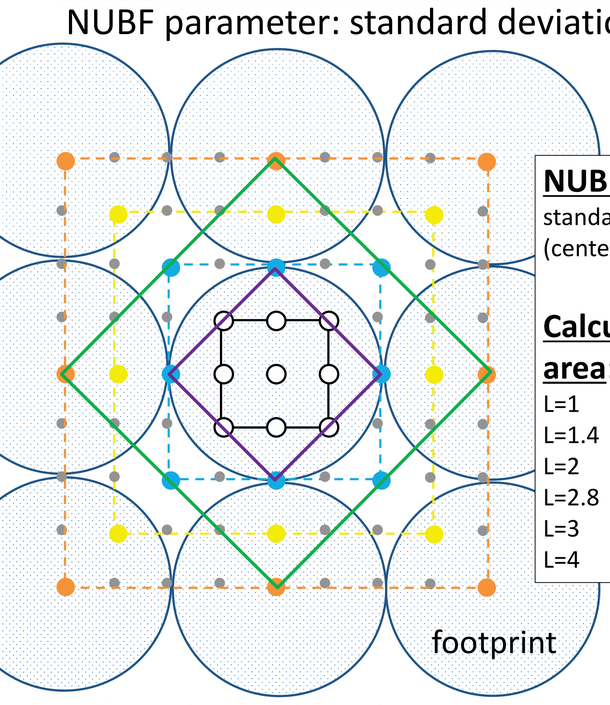






DS (NUBF effect)

NUBF parameter: standard deviation of adjacent footprint

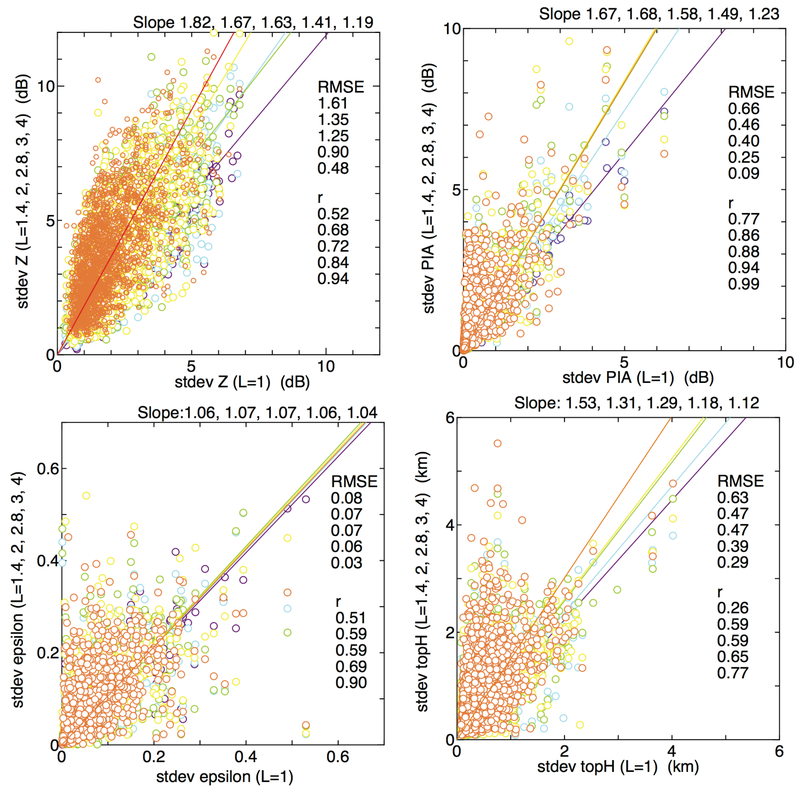


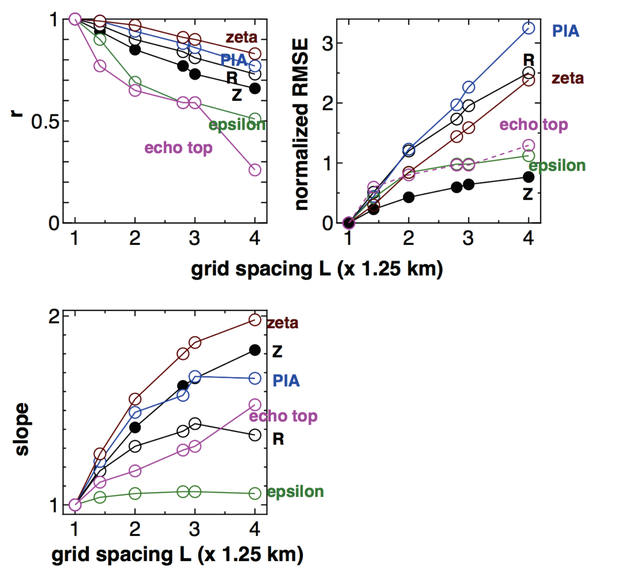
footprint configuration
(4-times dense sampling)

NUBF parameter:
standard deviation (stdev) of adjacent 9 footprints (center + 8 surrounding footprints)

Calculation of stdev for 6 different s area:
- L=1 4 times dense sampling (○)
- L=1.4 1.4 times large area (━)
- L=2 2 times dense sampling (●)
- L=2.8 2.8 times large area (━)
- L=3 4/3 times dense sampling (●)
- L=4 Normal sampling (●)

comparison of stdev. of various sizes against L=1

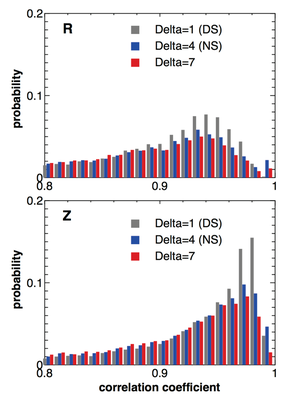


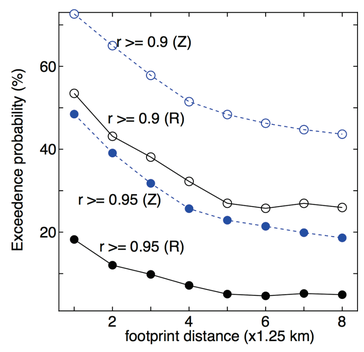


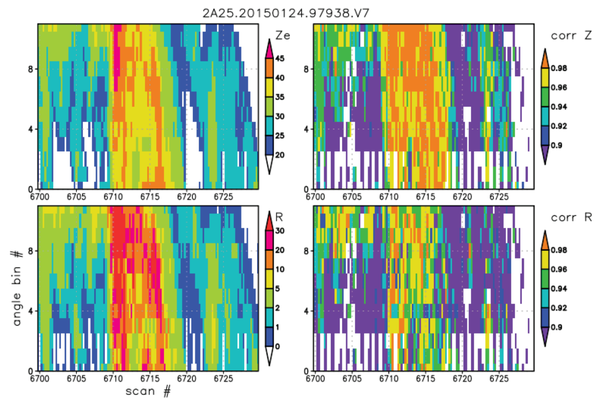
- Meaning of slope and correlation coefficient
  - [correlation coefficient (r)]
    - High r: larger scale phenomena → zeta, PIA, R, Z
    - Small r: small scale phenomena → epsilon (DSD), top height
  - [slope]
    - Large change with size: general precipitation system larger than e.g. 10 km → Z, PIA, top height
    - Constant with size: random or small dynamic range → epsilon(DSD)

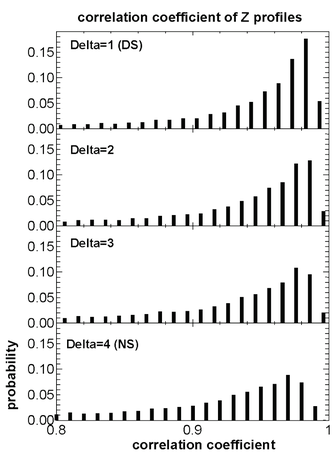
DS (validation of retrieval algorithm)

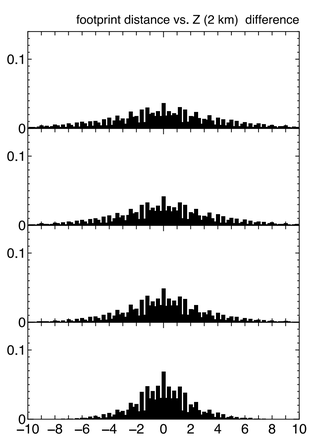
Using dense sampling data, correlation coefficient between adjacent profiles (Z and R) are calculated.

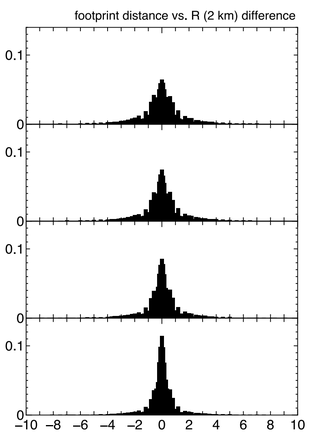


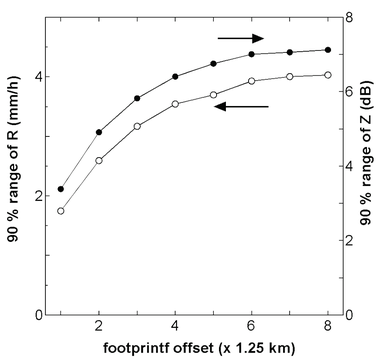






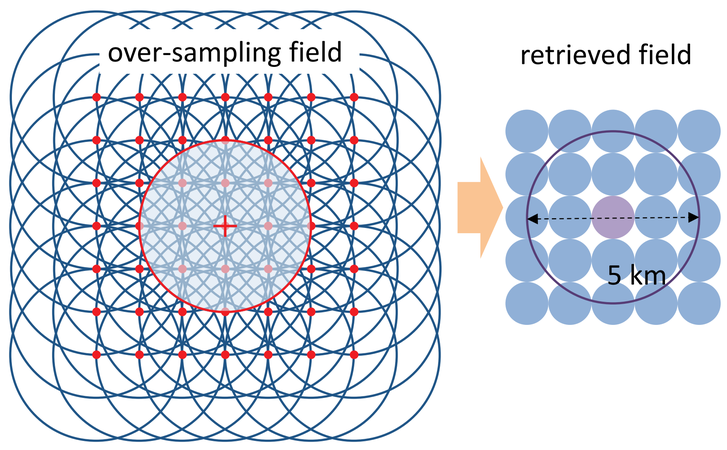
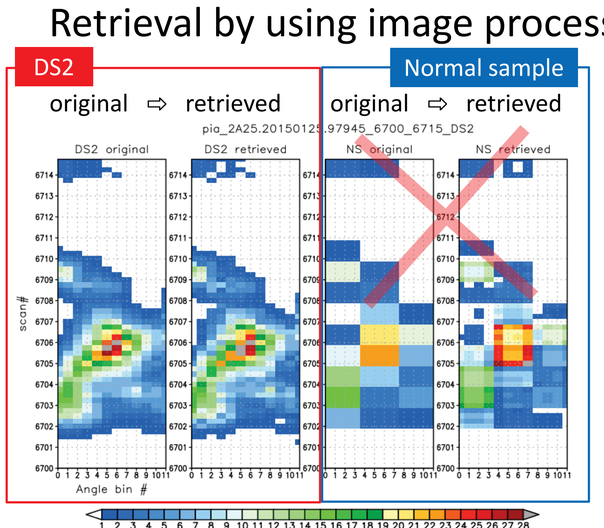
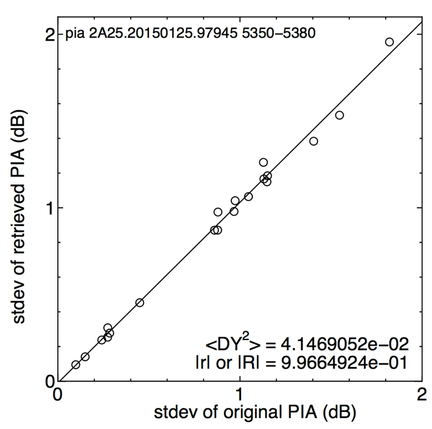






DS (fine scale retrieval)

How the retrieved profile changes by the footprint offset



Retrieval by using image processing technique