

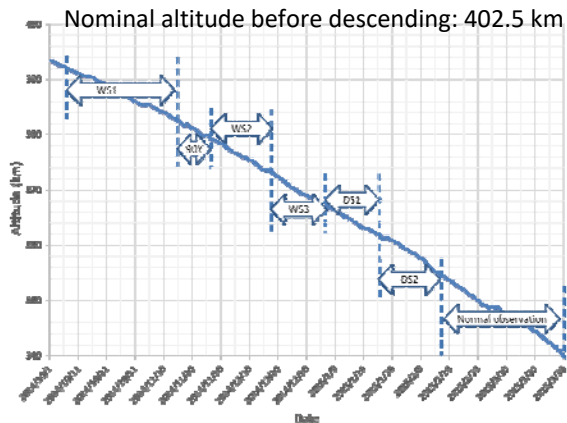
39 Incident angle dependency of the normalized surface cross section during TRMM end of mission experiment

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Introduction: TRMM end of mission (EOM) Experiment

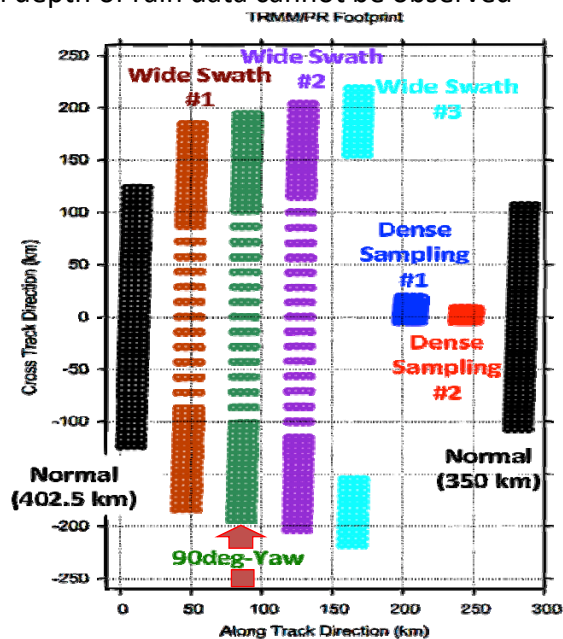
Experimental schedule and satellite altitude



- TRMM EOM Experiment: October 2014-February 2015
 - Satellite was descending
 - Not suitable for nominal operation
- Three types of experiments for the Precipitation Radar (PR)
 - wide swath (WS1, 2, and 3) --- Nov. to Dec., 2014 (1.5 months)
 - 90-degree yaw maneuver (90Y) --- 11 days, from Nov. 15 to 25, 2014.
 - day side of orbit and the US day time only: 80 min./day
 - Total 880 minutes of data
 - dense sampling (DS1 and 2) --- Jan. 5 to Feb. 12, 2015

Cross-track scan settings

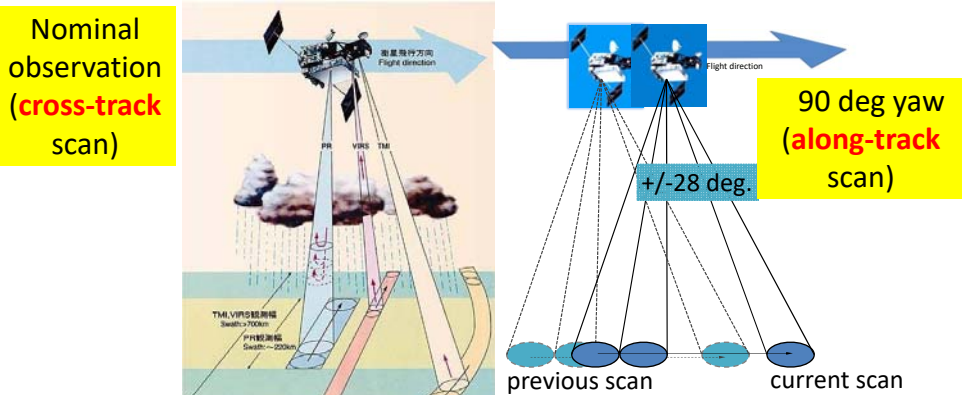
- 49 angle bins for one scan (angle bin #25 = nadir)
- fixed onboard sampling range (50 km window)
- successive 35 km range data are downlinked
- Full depth of rain data cannot be observed



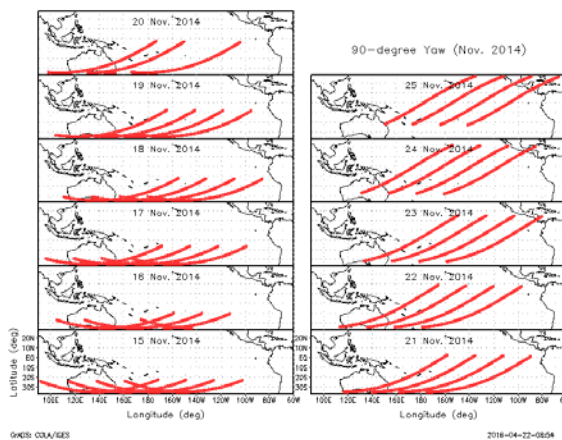
90 degree yaw experiment: Rotate the satellite by 90 degrees to realize dense along track observation

- purpose**
- Incident angle dependency of the surface echo (**sigma zero**), bright band, and rain retrieval
 - 90-deg yaw observation enables to obtain the incident angle dependency of **single target**.
 - Short time changes in the precipitation structure.

concept of the experiment

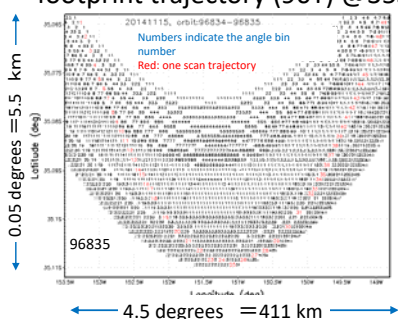


experimental area



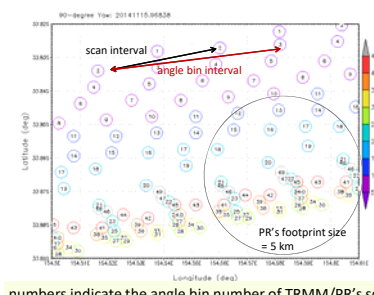
scanning issue

- 90-deg. yaw observation is not a perfect linear observation.
 - Conical scan of PR (antenna tilted mechanically by 4°)
 - Earth's rotation during scan.



resampling within 5km range

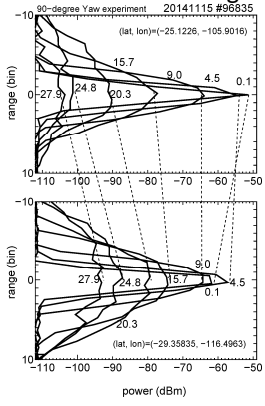
- Almost all incident angle data can be sampled within 5km in radius



Analysis: Incident angle dependency of surface echo

range profile of surface echo example

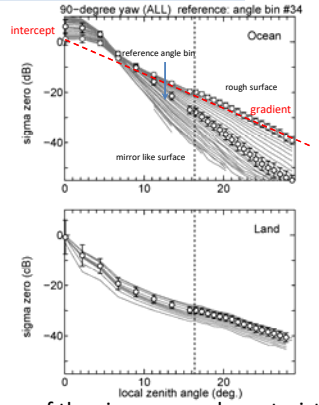
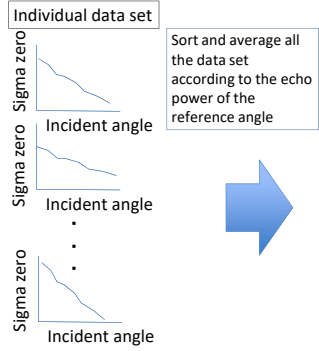
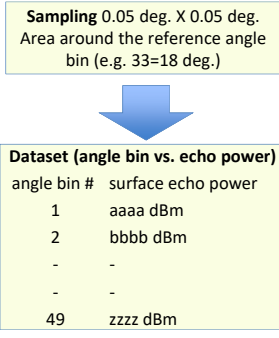
(numbers: incident angle in degrees)



nadir: high wide: low

nadir: low wide: high

angle bin dependency of surface echo: general characteristics



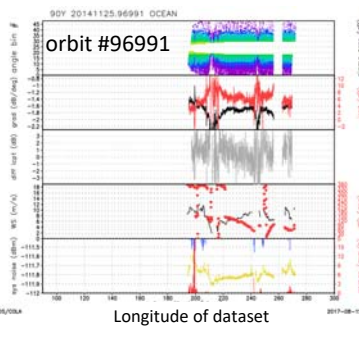
Gradient and intercept are good proxy of the sigma-zero characteristics.

Ocean: if nadir sigma-zero is high, sigma-zero of wider angle is low. → wind driven surface
 Land: nadir sigma-zero is high. Sigma-zero gradually decrease with angle.

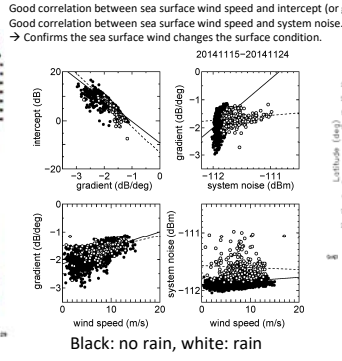
Analysis: comparison with other observations (sea surface wind, precipitation)

- Incident angle dependency of the sigma-zero is determined by the surface condition, such as surface wind, precipitation etc..
- Comparison with other observations: sea surface wind (NOAA satellite based wind), Precipitation (GSMaP and rain flag from TRMM/PR), SST (NOAA AVHRR data)
- Other parameters relating to the surface wind and precipitation (system noise of PR)

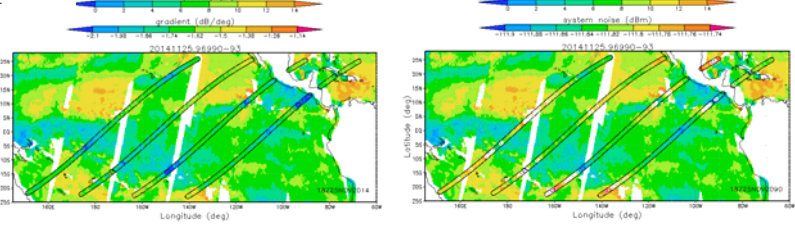
plots against the longitude



scatter plot

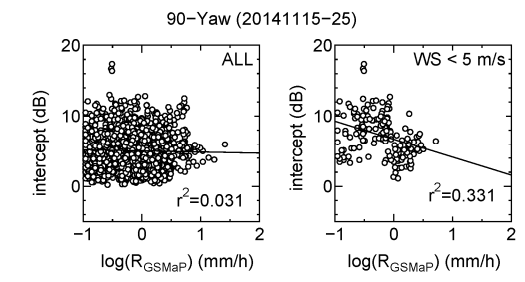
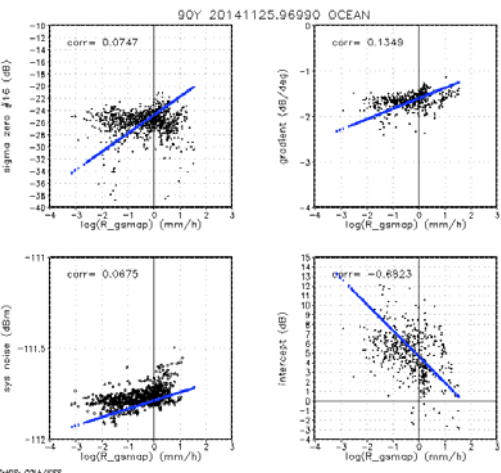
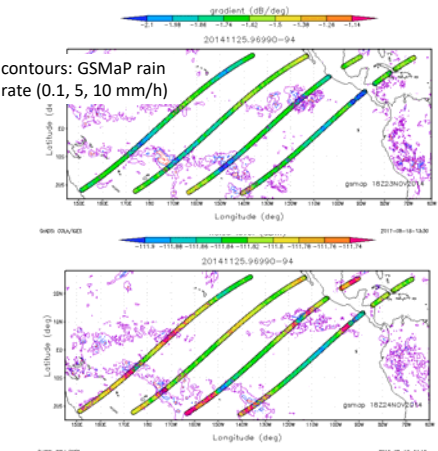


spatial distribution of high gradient area over wind speed map



This case shows good agreement between wind speed and gradient, also between system noise and wind speed. Other cases may not show such good agreements.

Precipitation effect



Gradients and intercepts are not correlate well with precipitation. If wind speed is less than 5 m/s, the intercept correlates with precipitation ratio. This result indicates the precipitation may change the surface condition.

Summary

- 90 degree yaw experimental data are very unique and give fundamental information of surface echoes.
- It was confirmed that the surface echo depends on the surface condition (e.g. wind speed, precipitation?).
- Sigma-zero mainly depends on the wind speed and the wind direction (not shown) and precipitation are secondary effect.