Comparison of Cloud Statistics Observed by Cloud and Precipitation Radars during DYNAMO/AMIE at Addu Atoll

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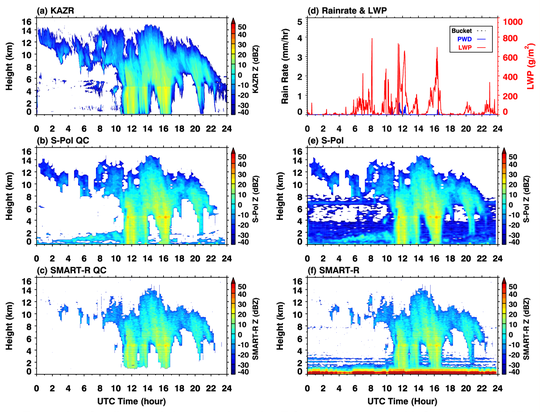
1. Objective

- Provide vertical cloud distribution statistics observed by AMF KAZR during DYNAMO/AMIE
- Compare S-Pol and SMART-R observed clouds to KAZR, and characterize the hydrometeor detecting capabilities of the S/C-band radars

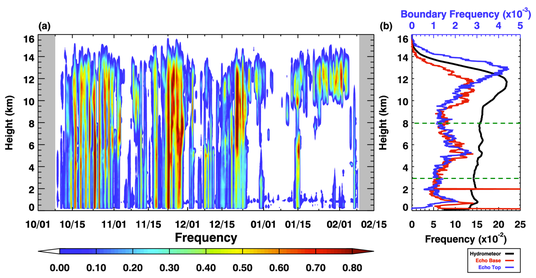
Geographic locations of the 3 radars at Addu Atoll

2. Data and Methodology

- AMF: KAZR ARSCL reflectivity, rain gauge
- Collocate S-Pol, SMART-R RHI scans over KAZR
- QC S-Pol/SMART-R to remove noise, ground clutter, then compare with KAZR

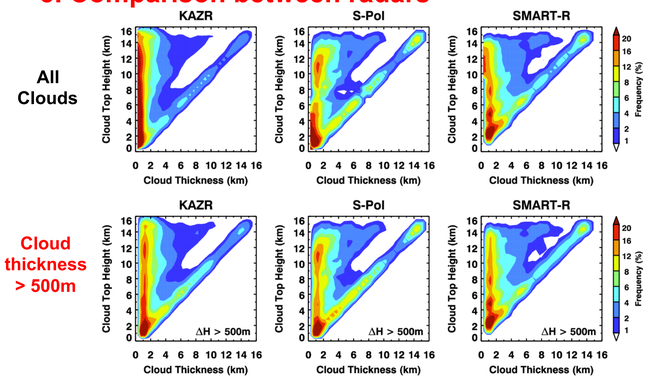


Example of collocated time-height radar Z from 3 radars on 28 Oct 2011 at AMF



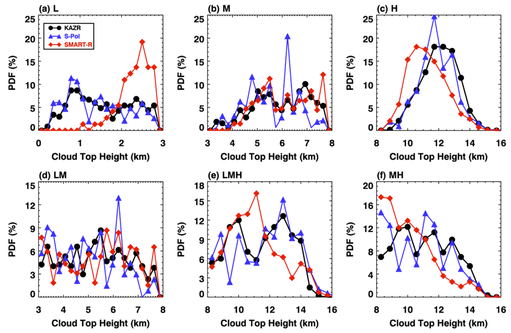
- 3 MJO events (Oct, Nov, Dec), suppressed in Jan 2013
- Cloud freq. peaks at 12-km, boundary layer, mid-level

3. Comparison between radars



Frequency distribution of cloud top height and cloud thickness

- Both S-Pol & SMART-R underestimated freq. of thin clouds (ΔH < 1-km)

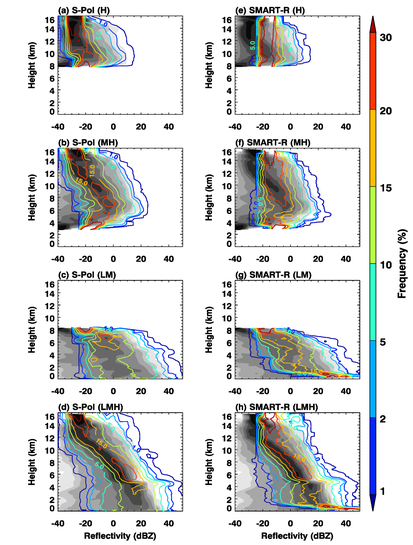


Cloud top height distribution comparison by cloud types

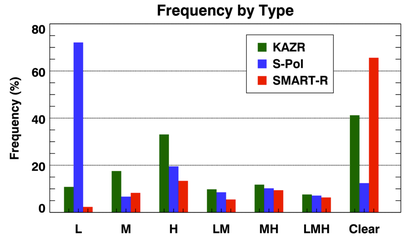
- Relative good agreement for high clouds, particularly for S-Pol
- SMART-R underestimated H, LMH by 2-3 km

Types	L	M	H	LM	MH	LMH
Definition	Low, base and top < 3 km	Mid, base and top 3–8 km	High, base and top > 8 km	Shallow convection, base < 3 km, top 3–8 km	Thick anvil, base 3–8 km, top > 8 km	Deep convective cloud, base < 3 km, top > 8 km
KAZR	0.108	0.175	0.331	0.098	0.118	0.076
S-Pol	0.721	0.067	0.195	0.085	0.102	0.071
SMART-R	0.023	0.083	0.134	0.055	0.094	0.063
ΔS-Pol	568%	-62%	-41%	-13%	-14%	-7%
ΔSMART-R	-79%	-53%	-60%	-44%	-20%	-17%

Definition by types and average freq. from the three radars



CFAD comparison. Same contour intervals.



- Low cloud freq.: S-Pol bias high; SMART-R bias low (ground clutter, Bragg scattering)
- Thick clouds agree much better, particularly for S-Pol

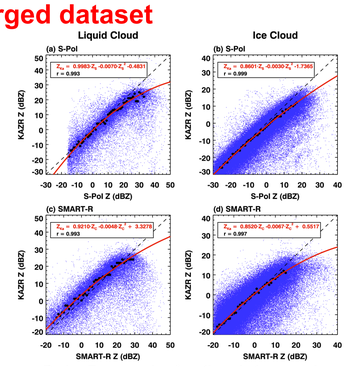
	L	M	H	LM	MH	LMH
S-Pol						
Hit Rate	0.89	0.25	0.51	0.69	0.74	0.83
Accuracy Rate	0.37	0.84	0.81	0.95	0.95	0.98
False Discovery Rate	0.86	0.35	0.12	0.22	0.13	0.06
SMART-R						
Hit Rate	0.10	0.26	0.30	0.47	0.57	0.72
Accuracy Rate	0.89	0.83	0.73	0.94	0.92	0.97
False Discovery Rate	0.53	0.44	0.27	0.16	0.28	0.09

Contingency table for S-Pol and SMART-R hydrometeor detection

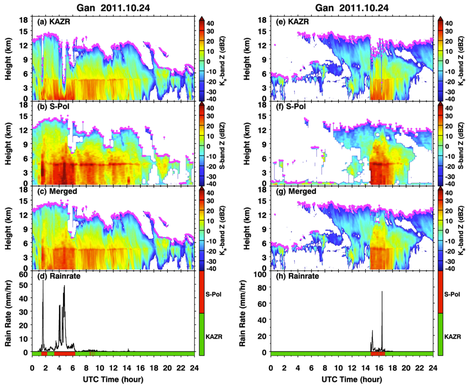
- S-Pol high clouds compare well with KAZR
- SMART-R has less vertical variability due to lower sensitivity
- Congestus agree well
- S-Pol provides excellent dynamic range at 10-km distance, suited for characterizing 3D cloud structures of convective and high clouds

4. Producing Merged dataset

- Convert S/C band Z to equivalent K_a band Z
- Correct KAZR attenuation, replace KAZR during heavy "rain events" (Feng et al. 2009) to produce seamless merged dataset

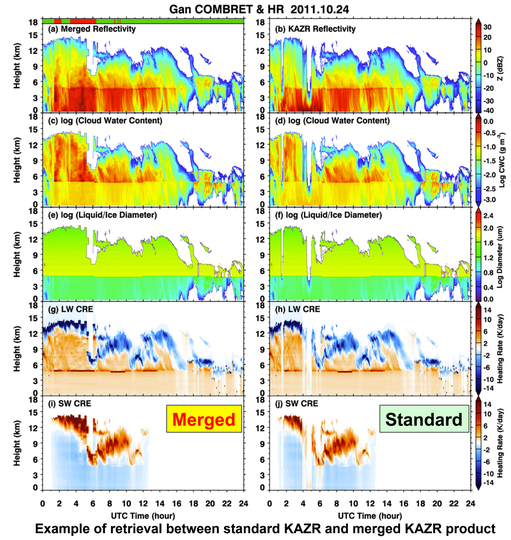


Derive Z conversion functions between radars



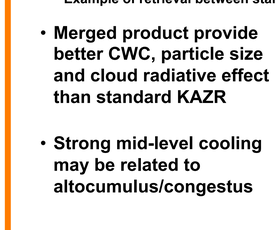
- Merged product provide better Z profiles and H_{top} during precipitation events

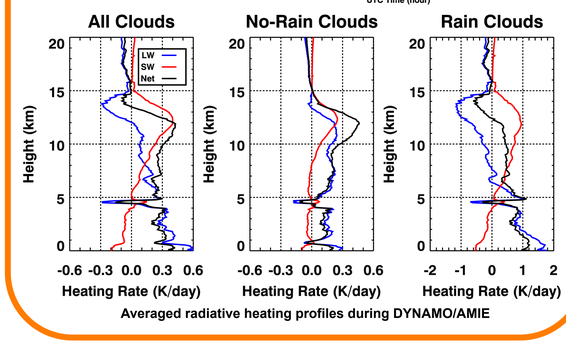
5. Cloud microphysics and radiative heating rate retrievals



Example of retrieval between standard KAZR and merged KAZR product

- Merged product provide better CWC, particle size and cloud radiative effect than standard KAZR
- Strong mid-level cooling may be related to altocumulus/congestus





Averaged radiative heating profiles during DYNAMO/AMIE

6. Summary

- Largest difference in cloud detection is low cloud, both S-Pol & SMART-R user should be cautious
- Precipitating convective & non-precipitating high clouds agree much better in cloud frequency, cloud top height and Z profiles, especially for S-Pol
- A merged KAZR/S-Pol PI data product, along with cloud microphysics and radiative heating rate retrievals were produced for evaluation

Reference

Feng et al. (2013) JTech, submitted.

Acknowledgement
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